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WESTERN STAR TRUCKS®

# WESTERN STAR WORKSHOP MANUAL

## Models: 4700 Series
## 4800 Series
## 4900 Series
## 5900 Series
## 6900 Series

STI-458, S16 (9/11)

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# Foreword

The purpose of this manual is to assist the service technician when the vehicle is serviced. Major drivetrain component service information is not included in this manual, but is located in each manufacturer's service manual.

Instructions and procedures are those recommended by Western Star Trucks or the component manufacturer.

Maintenance schedules and additional service information are included in the *Western Star Maintenance Manual*.

IMPORTANT: Descriptions and specifications in this manual were in effect at the time of printing. Western Star Trucks reserves the right to discontinue models, and to change specifications or design at any time without notice and without incurring obligation. Descriptions and specifications contained in this publication provide no warranty, expressed or implied, and are subject to revision and editions without notice.

Refer to **www.Daimler-TrucksNorthAmerica.com** and **www.WesternStarTrucks.com** for more information, or contact Daimler Trucks North America LLC at the address below.

# Environmental Concerns and Recommendations

Whenever you see instructions in this manual to discard materials, you should attempt to reclaim and recycle them. To preserve our environment, follow appropriate environmental rules and regulations when disposing of materials.

# NOTICE: Parts Replacement Considerations

Do not replace suspension, axle, or steering parts (such as springs, wheels, hubs, and steering gears) with used parts. Used parts may have been subjected to collisions or improper use and have undetected structural damage.

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## Descriptions of Service Publications

Daimler Trucks North America LLC distributes the following major service publications in paper and electronic (via ServicePro®) formats.

**Workshop/Service Manual**

Workshop/service manuals contain service and repair information for all vehicle systems and components, except for major components such as engines, transmissions, and rear axles. Each workshop/service manual section is divided into subjects that can include general information, principles of operation, removal, disassembly, assembly, installation, specifications, and troubleshooting.

**Maintenance Manual**

Maintenance manuals contain routine maintenance procedures and intervals for vehicle components and systems. They have information such as lubrication procedures and tables, fluid replacement procedures, fluid capacities, specifications, procedures for adjustments and for checking the tightness of fasteners. Maintenance manuals do not contain detailed repair or service information.

**Driver's/Operator's Manual**

Driver's/operator's manuals contain information needed to enhance the driver's understanding of how to operate and care for the vehicle and its components. Each manual contains a chapter that covers pretrip and post-trip inspections, and daily, weekly, and monthly maintenance of vehicle components. Driver's/operator's manuals do not contain detailed repair or service information.

**Service Bulletins**

Service bulletins provide the latest service tips, field repairs, product improvements, and related information. Some service bulletins are updates to information in the workshop/service manual. These bulletins take precedence over workshop/service manual information, until the latter is updated; at that time, the bulletin is usually canceled. The service bulletins manual is available only to dealers. When doing service work on a vehicle system or part, check for a valid service bulletin for the latest information on the subject.

IMPORTANT: Before using a particular service bulletin, check the current service bulletin validity list to be sure the bulletin is valid.

**Parts Technical Bulletins**

Parts technical bulletins provide information on parts. These bulletins contain lists of parts and BOMs needed to do replacement and upgrade procedures.

Web-based repair, service, and parts documentation can be accessed using the following applications on the AccessWesternStar.com website.

**ServicePro**

ServicePro® provides Web-based access to the most up-to-date versions of the publications listed above. In addition, the Service Solutions feature provides diagnostic assistance with Symptoms Search, by connecting to a large knowledge base gathered from technicians and service personnel. Results for both documents and service solutions can be narrowed by initially entering vehicle identification data.

**PartsPro**

PartsPro® is an electronic parts catalog system, showing the specified vehicle's build record.

**EZWiring**

EZWiring™ makes Freightliner, Sterling, Western Star, Thomas Built Buses, and Freightliner Custom Chassis Corporation products' wiring drawings and floating pin lists available online for viewing and printing. EZWiring can also be accessed from within PartsPro.

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## Descriptions of Service Publications

Warranty-related service information available on the AccessWesternStar.com website includes the following documentation.

**Recall Campaigns** Recall campaigns cover situations that involve service work or replacement of parts in connection with a recall notice. These campaigns pertain to matters of vehicle safety. All recall campaigns are distributed to dealers; customers receive notices that apply to their vehicles.

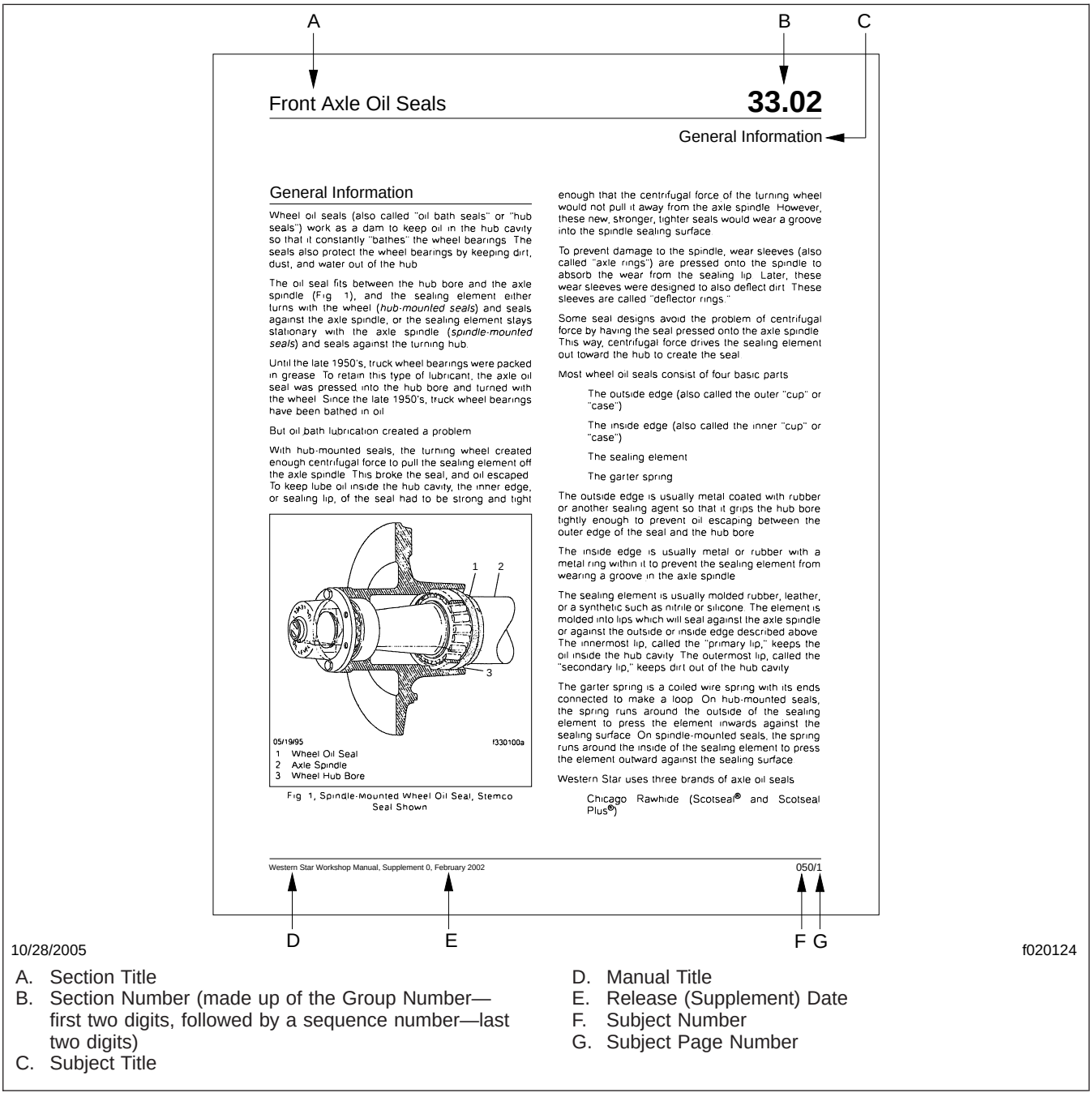
**Field Service Campaigns** Field service campaigns are concerned with non-safety-related service work or replacement of parts. All field service campaigns are distributed to dealers; customers receive notices that apply to their vehicles.

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# Page Description

For an example of a *Western Star Workshop Manual* page, see **Fig. 1**.




A. Section Title
B. Section Number (made up of the Group Number—first two digits, followed by a sequence number—last two digits)
C. Subject Title
D. Manual Title
E. Release (Supplement) Date
F. Subject Number
G. Subject Page Number

**Fig. 1, Example of a Western Star Workshop Manual Page**

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## Workshop Manual Contents


| Group No. | Group Title |
|---|---|
| 00 | General Information |
| 01 | Engine |
| 09 | Air Intake |
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| 15 | Alternators and Starters |
| 20 | Engine Cooling/Radiator |
| 25 | Clutch |
| 26 | Transmission |
| 30 | Throttle Control |
| 31 | Frame and Frame Components |
| 32 | Suspension |
| 33 | Front Axle |
| 35 | Rear Axle |
| 40 | Wheels and Tires |
| 41 | Driveline |
| 42 | Brakes |
| 46 | Steering |
| 47 | Fuel |
| 49 | Exhaust |
| 54 | Electrical, Instruments, and Controls |
| 60 | Cab |
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| 82 | Windshield Wipers and Washer |
| 83 | Heater and Air Conditioner |
| 88 | Hood, Grille, and Cab Fenders |
| 91 | Seats and Restraint Systems |
| 98 | Paint |

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## List of Abbreviations

The following is a list of definitions for abbreviations and symbols used in Freightliner publications.

**A** ..... amperes
**AAVA** ..... auxiliary air valve assembly
**ABS** ..... antilock braking system
**ABS** ..... acrylonitrile-butadiene-styrene
**A/C** ..... air conditioner
**AC** ..... alternating current
**acc** ..... accessories
**ACM** ..... aftertreatment control module
**ACPU** ..... air conditioning protection unit
**ADLO** ..... auto-disengagement lockout
**AGM** ..... absorbed glass mat
**AGS** ..... automated gear shift
**AG2** ..... Aluminum Generation 2
**a.m.** ..... *ante meridiem* (midnight to noon)
**AM** ..... amplitude modulation
**amp(s)** ..... ampere(s)
**AMT** ..... automated mechanical transmission
**AMU** ..... air management unit
**ANSI** ..... American National Standards Institute
**API** ..... American Petroleum Institute
**API** ..... application programming interface
**ARI** ..... Air Conditioning and Refrigeration Institute
**ASA** ..... American Standards Association
**ASF** ..... American Steel Foundries
**ASR** ..... automatic spin regulator
**assy.** ..... assembly
**ASTM** ..... American Society for Testing and Materials
**ATC** ..... automatic temperature control
**ATC** ..... automatic traction control
**ATC** ..... automatic transmission control
**ATD** ..... aftertreatment device
**ATF** ..... automatic transmission fluid
**ATS** ..... aftertreatment system
**attn** ..... attention
**aux.** ..... auxiliary
**av** ..... *avoirdupois* (British weight system)
**AWD** ..... all-wheel drive
**AWG** ..... American wire gauge
**AWS** ..... American Welding Society
**BAT** ..... battery
**BBC** ..... bumper-to-back-of-cab
**BHM** ..... bulkhead module
**BOC** ..... back-of-cab
**BOM** ..... bill of material
**BTDC** ..... before top dead center
**Btu(s)** ..... British thermal unit(s)
**C** ..... common (terminal)
**CAC** ..... charge air cooler
**CAN** ..... controller area network
**CARB** ..... California Air Resources Board
**CAT** ..... Caterpillar
**CB** ..... circuit breaker
**CB** ..... citizens' band
**CBE** ..... cab behind engine
**CCA** ..... cold cranking amperes
**CCR** ..... California Code of Regulations
**CD-ROM** .. compact-disc/read-only memory
**CDTC** ..... constant discharge temperature control
**CEL** ..... check-engine light
**CFC** ..... chlorofluorocarbons (refrigerant-12)
**cfm** ..... cubic feet per minute
**CFR** ..... Code of Federal Regulations
**CGI** ..... clean gas induction
**CGW** ..... central gateway
**CHM** ..... chassis module
**CIP** ..... cold inflation pressure
**CLDS** ..... cab load disconnect switch
**CLS** ..... coolant level sensor
**cm** ..... centimeters
**$cm^3$** ..... cubic centimeters
**CMVSS** .... Canadian Motor Vehicle Safety Standard
**Co.** ..... company
**COE** ..... cab over engine
**Corp.** ..... corporation
**CPC** ..... common powertrain controller
**CPU** ..... central processing unit
**CRT** ..... cathode ray tube
**cSt** ..... centistokes (unit of measurement for describing the viscosity of general liquids)
**cu ft** ..... cubic feet
**cu in** ..... cubic inches
**CUM** ..... Cummins
**CVSA** ..... Commercial Vehicle Safety Alliance
**CWS** ..... collision warning system
**DC** ..... direct current
**DCA** ..... diesel coolant additive
**DCDL** ..... driver-controlled differential lock
**DDA** ..... Detroit Diesel Allison (obs)
**DDC** ..... Detroit Diesel Corporation
**DDDL** ..... Detroit Diesel Diagnostic Link
**DDE** ..... Detroit Diesel Engines
**DDEC** ..... Detroit Diesel Electronic (engine) Control
**DDR** ..... diagnostic data reader
**DDU** ..... driver display unit
**def** ..... defrost
**DEF** ..... diesel exhaust fluid
**DFI** ..... direct fuel injection
**DGPS** ..... differential global positioning system
**DHD** ..... dealer help desk
**dia.** ..... diameter
**DIAG** ..... diagnosis
**DIP** ..... dual inline package (switch)
**DIU** ..... driver interface unit
**DLA** ..... datalink adaptor
**DLM** ..... datalink monitor
**DLU** ..... data logging unit
**DMM** ..... digital multimeter
**DOC** ..... diesel oxidation catalyst
**DOT** ..... Department of Transportation
**DPF** ..... diesel particulate filter
**DRL** ..... daytime running lights
**DRM** ..... dryer reservoir module
**DSM** ..... district service manager
**DTC** ..... diagnostic trouble code
**DTC** ..... discharge temperature control
**DTNA** ..... Daimler Trucks North America
**DVOM** ..... digital volt/ohm meter
**ea.** ..... each
**EBS** ..... electronic braking system
**ECA** ..... electric clutch actuator
**ECAP** ..... electronic control analyzer programmer
**ECAS** ..... electronically controlled air suspension

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# List of Abbreviations

**ECI** ..... electronically controlled injection
**ECL** ..... engine coolant level
**ECM** ..... electronic control module
**ECT** ..... engine coolant temperature
**ECU** ..... electronic control unit
**EDM** ..... electronic data monitor
**EEPROM** .. electrically erasable programmable read-only memory
**EFG** ..... electric fuel gauge
**EFPA** ..... electronic foot pedal assembly
**EGR** ..... exhaust gas recirculation
**ELC** ..... extended-life coolant
**EMC** ..... electromagnetic compatibility
**EMI** ..... electromagnetic interference
**EOA** ..... electric over air
**EP** ..... extreme pressure (describes an antiwear agent added to some lubricants)
**EPA** ..... Environmental Protection Agency
**EPS** ..... engine position sensor
**ESC** ..... electronic stability control
**ESC** ..... enhanced stability control
**ESD** ..... electrostatic discharge
**ESS** ..... engine syncro shift (transmission)
**etc.** ..... *et cetera* (and so forth)
**ETEC** ..... electronic truck engine control
**EUI** ..... electronic unit (fuel) injectors
**EVA** ..... electronic vibration analyzer
**EXM** ..... (chassis) expansion module
**E85** ..... 85% ethanol fuel
**FAS** ..... Freightliner air suspension
**FCCC** ..... Freightliner Custom Chassis Corporation
**FCU** ..... forward control unit
**FET** ..... field effect transistor
**Fig.** ..... figure
**fl oz** ..... fluid ounces
**FLA** ..... post-1984 advancements Freightliner COE
**FLB** ..... enhanced Freightliner FLA COE
**FLC** ..... steel-cab Freightliner 112 Conventional
**FLD** ..... post-1984 advancements Freightliner 112/120 aluminum-cab Conventional
**FLR** ..... forward-looking radar
**FM** ..... frequency modulation
**FMCSA** .... Federal Motor Carrier Safety Administration
**FMEA** ..... failure mode effects analysis
**FMI** ..... failure mode indicator
**FMSI** ..... Friction Materials Standards Institute
**FMVSS** .... Federal Motor Vehicle Safety Standard
**FRP** ..... fiberglass reinforced plastic
**FSA** ..... field service authorization
**FSM** ..... fleet service manager
**ft** ..... feet
**$ft^3$** ..... cubic feet
**$ft^3$/min** ..... cubic feet per minute
**FTL** ..... Freightliner
**F.U.E.L.** .... fuel usage efficiency level
**g** ..... grams
**gal** ..... gallons
**GAWR** ..... gross axle weight rating
**GHG** ..... greenhouse gas
**GHG14** .... greenhouse gas and fuel efficiency regulations
**GL** ..... gear lubricant
**GND** ..... ground
**gpm** ..... gallons per minute
**GPS** ..... global positioning system
**GVWR** ..... gross vehicle weight rating
**HBED** ..... hard-braking event data
**HCM** ..... hybrid control module
**HCOE** ..... high cab over engine
**HCU** ..... hydraulic control unit
**HD** ..... heavy-duty
**HDU** ..... hybrid drive unit
**HEPA** ..... high-efficiency particulate air (filter)
**HEST** ..... high exhaust system temperature
**HEV** ..... hybrid electric vehicle
**HFC** ..... hydrogenated fluorocarbons (refrigerant-134a)
**hp** ..... horsepower
**hp** ..... high pressure
**HRC** ..... Rockwell "C" hardness
**hr(s)** ..... hour(s)
**HSA** ..... hill start aid
**HSD** ..... high-side driver
**htr.** ..... heater
**HVAC** ..... heating, ventilating, and air conditioning
**HVLP** ..... high velocity, low pressure
**H/W** ..... hardware
**Hz** ..... hertz
**IAD** ..... interaxle differential
**ICS** ..... integrated child seat
**ICU** ..... instrumentation control unit
**i.d.** ..... inside diameter
**ID** ..... identification
**IFI** ..... Industrial Fasteners Institute
**IFS** ..... independent front suspension
**IGN** ..... ignition
**ILB** ..... intelligent lightbar
**ILO** ..... *in lieu of* (in the place of)
**in** ..... inches
**$in^3$** ..... cubic inches
**Inc.** ..... incorporated
**in$H_2O$** ..... inches of water
**inHg** ..... inches of mercury
**I/O** ..... input/output
**IP** ..... instrument panel
**ISO** ..... International Organization for Standardization
**IVS** ..... idle validation switch
**k** ..... kilo (1000)
**kg** ..... kilograms
**km** ..... kilometers
**km/h** ..... kilometers per hour
**kPa** ..... kilopascals
**kW** ..... kilowatts
**L** ..... liters
**lb** ..... pounds
**LBCU** ..... lightbar control unit
**lbf·ft** ..... pounds force feet
**lbf·in** ..... pounds force inches
**LCD** ..... liquid crystal display
**LCOE** ..... low cab over engine
**LED** ..... light-emitting diode
**LFL** ..... lower flammability limit
**LH** ..... left-hand
**LHD** ..... left-hand drive
**LH DR** ..... left-hand-drive
**LHK** ..... liters per hundred kilometers
**LHS** ..... low-hydrogen steel
**LIN** ..... Local Interconnect Network
**LLC** ..... limited liability company
**L/min** ..... liters per minute
**LNG** ..... liquefied natural gas
**LPG** ..... liquefied petroleum gas

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## List of Abbreviations

**LPG** ..... liquid propane gas
**LPI** ..... liquid propane injection
**LPR** ..... low pressure reservoir
**LRR** ..... low-rolling resistance
**LSD** ..... low-side driver
**LVD** ..... low-voltage disconnect
**m** ..... meters
**max.** ..... maximum
**M-B** ..... Mercedes-Benz
**MCM** ..... motor control module
**MESA** ..... Mining Enforcement Safety Act
**mfr.** ..... manufacturer
**mi** ..... miles
**MID** ..... message identifier
**MIL** ..... malfunction indicator lamp (light)
**MIL** ..... military specification
**min.** ..... minutes
**min.** ..... minimum
**misc.** ..... miscellaneous
**mL** ..... milliliters
**mm** ..... millimeters
**mod.** ..... module
**mpg** ..... miles per gallon
**mph** ..... miles per hour
**MSF** ..... modular switch field
**MMT** ..... methylcyclopentadienyl manganese tricarbonyl
**MSHA** ..... Mining Safety and Health Administration
**MVDA** ..... Motor Vehicle Dealers Association
**n** ..... negative (front axle wheel alignment specification)
**N** ..... nitrogen
**N/A** ..... not applicable
**N·cm** ..... Newton-centimeters
**NC** ..... normally closed (terminal or switch)
**NCG** ..... noncondensable gases
**NHTSA** ..... National Highway Traffic Safety Administration
**NIOSH** ..... National Institute for Occupational Safety and Health
**NITE** ..... no idle thermal environment
**NLA** ..... no longer available
**NLGI** ..... National Lubricating Grease Institute
**N·m** ..... Newton-meters
**NO** ..... normally open (terminal or switch)
**NOAT** ..... Nitrited Organic Acid Technology
**NOx** ..... nitrogen oxides
**no.** ..... number
**NPT** ..... national pipe thread
**NPTF** ..... national pipe thread fitting
**NT** ..... nylon tube or nylon tubing
**NTSB** ..... National Transportation Safety Board
**OAT** ..... Organic Acid Technology
**OBD(s)** ..... on-board diagnostic(s)
**obs** ..... obsolete
**OC** ..... open circuit
**OCV** ..... open circuit voltage
**o.d.** ..... outside diameter
**O.D.** ..... overdrive
**OEM** ..... original equipment manufacturer
**OPD** ..... overfill protection device
**OSHA** ..... Occupational Safety and Health Administration
**oz** ..... ounces
**ozf·in** ..... ounces force inches
**p** ..... positive (front axle wheel alignment specification)
**PACE** ..... programmable electronically controlled engine
**PAG** ..... polyalkylene glycol (oil)
**parm** ..... parameter
**PAS** ..... passenger advisory system
**PC** ..... personal computer
**PCB** ..... printed circuit board
**PDC(s)** ..... parts distribution center(s)
**PDI** ..... pre-delivery inspection
**PDM** ..... power distribution module
**PEC** ..... power electronics carrier
**PEEC** ..... programmable electronic engine control
**PID** ..... parameter identifier
**PKP** ..... Purple-K powder
**PLC** ..... power line carrier
**PLD** ..... *Pumpe-Linie-Düse* (pump-line-nozzle)
**PNDB** ..... power-net distribution box
**PM** ..... particulate matter
**p.m.** ..... *post meridiem* (noon to midnight)
**p/n** ..... part number
**PO** ..... purchase order
**POE** ..... polyol ester
**PRD** ..... pressure relief device
**PRD** ..... product requirements document
**PSA** ..... pressure-sensitive adhesive
**PSG** ..... pressure sensor governor
**psi** ..... pounds per square inch
**psia** ..... pounds per square inch, atmosphere
**psig** ..... pounds per square inch, gauge
**pt** ..... pints
**PTCM** ..... pressure time control module
**PTO** ..... power takeoff
**PTP** ..... powertrain protection
**PTPDM** ..... powertrain power distribution module
**pvc** ..... polyvinyl chloride
**PWM** ..... pulse width modulation
**pwr** ..... power
**qt** ..... quarts
**qty.** ..... quantity
**R & O** ..... rust inhibitors and oxidants
**R–12** ..... refrigerant-12 (CFC)
**R–134a** ..... refrigerant-134a (HFC)
**RAM** ..... random access memory
**RC** ..... reserve capacity
**recirc.** ..... recirculation
**Ref(s).** ..... reference(s)
**regen** ..... regeneration
**RELS** ..... reduced engine load at stop
**RFI** ..... radio frequency interference
**RH** ..... right-hand
**RHD** ..... right-hand drive
**RH DR** ..... right-hand-drive
**R/I** ..... removal and installation
**RMA** ..... return material authorization
**ROM** ..... read-only memory
**rpm** ..... revolutions per minute
**R/R** ..... removal and replacement
**RSA** ..... roll-stability advisor
**RSG** ..... road speed governor
**RSM** ..... regional service manager
**RTS** ..... ready-to-spray
**RTV** ..... room temperature vulcanizing
**RV** ..... recreational vehicle
**SA** ..... source address
**S-ABA** ..... self-setting automatic brake adjusters

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# List of Abbreviations

**SAE** ..... Society of Automotive Engineers
**SB** ..... service bulletin
**SBT** ..... seat back thickness
**SBW** ..... shift-by-wire
**SCA(s)** .... Supplemental Coolant Additive(s)
**SCR** ..... selective catalytic reduction
**SCU** ..... system control unit (speedometer)
**SD** ..... severe-duty
**SDU** ..... step deployment unit
**SEL** ..... shutdown engine light
**SEM** ..... switch expansion module
**SEO** ..... stop engine override
**SHM** ..... switch hub module
**SI** ..... service information
**SI** ..... *Système International*
**SID** ..... subsystem identifier
**SM** ..... system malfunction
**SMC** ..... sheet molded compound
**S/N** ..... serial number
**SOC** ..... state-of-charge
**SPACE** .... seat pretensioner activation for crash survival enhancement
**SPG** ..... special purpose grease
**SPN** ..... suspect parameter number
**sq in** ..... square inches
**SRP** ..... seating reference point
**SRS** ..... supplemental restraint system
**SRS** ..... synchronous reference sensor
**SRT** ..... standard repair time
**SSD** ..... side sensor display
**SSID** ..... smart switch identification
**SST** ..... stainless steel
**std.** ..... standard
**S/W** ..... software
**SW** ..... switch
**TAM** ..... thermocouple amplifier module
**TBB** ..... Thomas Built Buses
**TBS** ..... turbo boost sensor
**TCM** ..... transmission control module
**TCU** ..... transmission control unit
**TDC** ..... top dead center
**TDR** ..... technician diagnostic routine
**TEM** ..... truck equipment manufacturer
**temp** ..... temperature
**TIG** ..... tungsten inert gas
**TIR** ..... total indicator reading
**TMC** ..... Technology and Maintenance Council
**TPMS** ..... tire pressure monitoring system
**TPS** ..... thermal protection switch
**TPS** ..... throttle position sensor
**TRS** ..... timing reference sensor
**TSO** ..... truck specification order
**TSU** ..... transmission shift unit
**TXV** ..... thermal expansion valve
**U.D.** ..... underdrive
**ULSD** ..... ultralow-sulfur diesel
**UNC** ..... unified national coarse
**UNF** ..... unified national fine
**U.S.** ..... United States
**U.S.A.** ..... United States of America
**USC** ..... United States customary (measures)
**V** ..... volts
**VCU** ..... vehicle control unit
**VDC** ..... vehicle data computer
**Vdc** ..... volts, direct current
**VIMS** ..... vehicle information management system
**VIN** ..... vehicle identification number
**VIP** ..... vehicle instrumentation and protection (Kysor)
**VIW** ..... vehicle interface wiring (connector)
**VOC** ..... volatile organic compounds
**VOM** ..... volt-ohmmeter
**VRS** ..... variable resistance sensor
**VSG** ..... variable speed governor
**VSS** ..... vehicle speed sensor
**VSU** ..... vehicle security unit
**WB** ..... wire braid
**WI** ..... work instructions
**WIF** ..... water-in-fuel
**WOT** ..... wide open throttle
**–** ..... minus or negative
**+** ..... plus or positive
**±** ..... plus-or-minus
**>** ..... greater than
**<** ..... less than
**x** ..... by (used in fastener size descriptions)
**"** ..... inches
**°** ..... degrees (of an angle)
**°C** ..... degrees Celsius (centigrade)
**°F** ..... degrees Fahrenheit
**#** ..... number
**%** ..... percent
**&** ..... and
**©** ..... copyright
**™** ..... trademark
**®** ..... registered trademark

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| U.S. Customary to Metric | | | Metric to U.S. Customary | | |
|---|---|---|---|---|---|
| **When You Know** | **Multiply By** | **To Get** | **When You Know** | **Multiply By** | **To Get** |
| **Length** | | | | | |
| inches (in) | 25.4 | millimeters (mm) | 0.03937 | inches (in) | |
| inches (in) | 2.54 | centimeters (cm) | 0.3937 | inches (in) | |
| feet (ft) | 0.3048 | meters (m) | 3.281 | feet (ft) | |
| yards (yd) | 0.9144 | meters (m) | 1.094 | yards (yd) | |
| miles (mi) | 1.609 | kilometers (km) | 0.6215 | miles (mi) | |
| **Area** | | | | | |
| square inches ($in^2$) | 645.16 | square millimeters ($mm^2$) | 0.00155 | square inches ($in^2$) | |
| square inches ($in^2$) | 6.452 | square centimeters ($cm^2$) | 0.15 | square inches ($in^2$) | |
| square feet ($ft^2$) | 0.0929 | square meters ($m^2$) | 10.764 | square feet ($ft^2$) | |
| **Volume** | | | | | |
| cubic inches ($in^3$) | 16387.0 | cubic millimeters ($mm^3$) | 0.000061 | cubic inches ($in^3$) | |
| cubic inches ($in^3$) | 16.387 | cubic centimeters ($cm^3$) | 0.06102 | cubic inches ($in^3$) | |
| cubic inches ($in^3$) | 0.01639 | liters (L) | 61.024 | cubic inches ($in^3$) | |
| fluid ounces (fl oz) | 29.54 | milliliters (mL) | 0.03381 | fluid ounces (fl oz) | |
| pints (pt) | 0.47318 | liters (L) | 2.1134 | pints (pt) | |
| quarts (qt) | 0.94635 | liters (L) | 1.0567 | quarts (qt) | |
| gallons (gal) | 3.7854 | liters (L) | 0.2642 | gallons (gal) | |
| cubic feet ($ft^3$) | 28.317 | liters (L) | 0.03531 | cubic feet ($ft^3$) | |
| cubic feet ($ft^3$) | 0.02832 | cubic meters ($m^3$) | 35.315 | cubic feet ($ft^3$) | |
| **Weight/Force** | | | | | |
| ounces (av) (oz) | 28.35 | grams (g) | 0.03527 | ounces (av) (oz) | |
| pounds (av) (lb) | 0.454 | kilograms (kg) | 2.205 | pounds (av) (lb) | |
| U.S. tons (t) | 907.18 | kilograms (kg) | 0.001102 | U.S. tons (t) | |
| U.S. tons (t) | 0.90718 | metric tons (t) | 1.1023 | U.S. tons (t) | |
| **Torque/Work Force** | | | | | |
| inch-pounds (lbf·in) | 11.298 | Newton-centimeters (N·cm) | 0.08851 | inch-pounds (lbf·in) | |
| foot-pounds (lbf·ft) | 1.3558 | Newton-meters (N·m) | 0.7376 | foot-pounds (lbf·ft) | |
| **Pressure/Vacuum** | | | | | |
| inches of mercury (inHg) | 3.37685 | kilo Pascals (kPa) | 0.29613 | inches of mercury (inHg) | |
| pounds per square inch (psi) | 6.895 | kilo Pascals (kPa) | 0.14503 | pounds per square inch (psi) | |

| When You Know | Subtract | Then Divide By | To Get | When You Know | Multiply By | Then Add | To Get |
|---|---|---|---|---|---|---|---|
| degrees Fahrenheit (°F) | 32 | 1.8 | degrees Celsius (°C) | 1.8 | 32 | degrees Fahrenheit (°F) | |

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## General Information

Daimler Trucks North America LLC distributes service and repair information for all vehicle systems, except major components such as engines, transmissions, and rear axles. Information on major components can often be found on the orignial equipment manufacturers' (OEM) website, many of which are listed below. The list also includes OEM websites for a number of other vehicle component or system providers, but is not comprehensive, and does not include websites for all OEMs.

## OEM Websites

Click on the website address.

**AC Delco** www.acdelco.com

**Accuride Corp.** www.accuride.com

**Aisin Transmission** www.aisin.com

**Allied Signal Inc.** www.honeywell.com

**Allison Transmission** www.allisontransmission.com

**Arctic Fox** www.arctic-fox.com

**Arvin Meritor** www.arvinmeritor.com

**AxleTech International** www.axletech.com

**Bendix** www.bendix.com

**Borg Warner** www.borgwarner.com

**Bosch** www.bosch.com

**Bostrom** www.bostromseating.com

**Caterpillar Inc.** www.ohe.cat.com

**Chicago Rawhide** www.skf.com

**ConMet** www.conmet.com

**Cummins Engine** www.cummins.com

**Dana Corp.** www.dana.com

**DAVCO** www.davcotec.com

**Delco Remy** www.delcoremy.com

**Denso Corp.** www.densocorp-na.com

**Detroit Diesel** www.detroitdiesel.com

**Dometic-Tundra Refrigerators** www.dometic.com

**Donaldson Company** www.donaldson.com

**Eaton Corp.** www.eaton.com

**Espar Heating Systems** www.espar.com

**Fleetguard** www.cumminsfiltration.com

**Fontaine** www.fontaineintl.com

**Grote** www.grote.com

**Haldex Brake Systems** www.haldex.com

**Hendrickson** www.hendrickson-intl.com

**Holland Fifth Wheels** www.thehollandgroupinc.com

**Horton, Inc.** www.hortonww.com

**Jost 5th Wheels** www.jostinternational.com

**Lang Mekra** www.lang-mekra.com

**Marmon Group** www.marmon-herrington.com

**Meritor-WABCO** www.meritorwabco.com

**MGM Brakes** www.mgmbrakes.com

**National Seating** www.cvgrp.com

**Parker (Racor)** www.parker.com

**Rimex** www.rimex.com

**RoadRanger** www.roadranger.com

**Rober A. Miller Antenna** www.rami.com

**Sears Seating** www.searsseating.com

**Simplex Fifth Wheels** www.thehollandgroupinc.com

**Truck-Lite** www.truck-lite.com

**TRW Inc.** www.trucksteering.com

**Visteon** www.visteon.com

**ZF** www.zf.com

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## VIN for Vehicles Built through July 10, 2001

IMPORTANT: See **Subject 060** for the vehicle identification numbering system for vehicles built July 11, 2001, or later.

Federal Motor Vehicle Safety Standard 115 specifies that all vehicles sold in the U.S.A. be assigned a 17-character Vehicle Identification Number (VIN). Using a combination of letters and numerals, the VIN defines the manufacturer, model, and major characteristics of the vehicle. See **Table 1** for the character positions of a typical Western Star VIN, 2WKECD3H81K929876.

The VIN can be found on the Vehicle Specification Decal (see the driver's manual for decal location) and stamped on the right frame rail or both left and right frame rail, over the front axle about 2 inches (50 mm) from the bottom of the web or on the top flange of the left frame rail.

IMPORTANT: A new VIN-code structure will be used for all vehicles built after July 10, 2001. Character positions 1 through 4 and 9 through 17 are nearly the same in both versions, but positions 5 through 8 have been assigned slightly different parameters. As a result, the build date of a vehicle must be determined before the VIN can be decoded.

For all vehicles, a check digit (9th character) is determined by assignment of weighted values to the other 16 characters. These weighted values are processed through a series of equations designed to check validity of the VIN and to detect VIN alteration.

NOTE: Always specify the VIN when ordering parts.

| Seventeen-Character Vehicle Identification Number (VIN) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Typical VIN** | **2** | **W** | **K** | **E** | **C** | **D** | **3** | **H** | **8** | **1** | **K** | **929876** |
| **Character Position** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9*** | **10** | **11** | **12 thru 17** |
| **Decoding Table†** | **Table 2** | **Table 3** | **Table 4** | **Table 5** | **Table 6** | **Table 7** | **Table 8** | **Table 9** | **—** | **Table 10** | **Table 11** | **Table 12** |
| **Code Description** | | | | | | | | | | | | |
| Country | | | | | | | | | | | | |
| Manufacturer | | | | | | | | | | | | |
| Type and Completeness | | | | | | | | | | | | |
| Model | | | | | | | | | | | | |
| Axle Configuration | | | | | | | | | | | | |
| GVWR Class | | | | | | | | | | | | |
| Engine | | | | | | | | | | | | |
| Horsepower | | | | | | | | | | | | |
| Check Digit | | | | | | | | | | | | |
| Year | | | | | | | | | | | | |
| Plant Location | | | | | | | | | | | | |
| Manufacturing Number | | | | | | | | | | | | |

* VIN position 9 is a check verification digit.

† For correcponding decoding information, see the applicable tables in this subject.

**Table 1, Seventeen-character Vehicle Identification Number (VIN)**

| VIN Position 1 (country) | |
|---|---|
| **Code** | **Vehicle Manufacturer** |
| 2 | Canada |

| VIN Position 1 (country) | |
|---|---|
| **Code** | **Vehicle Manufacturer** |
| 3 | Mexico |

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## VIN for Vehicles Built through July 10, 2001

| VIN Position 1 (country) | |
|---|---|
| **Code** | **Vehicle Manufacturer** |
| 5 | United States |

**Table 2, VIN Positions 1, Country**

| VIN Position 2 (manufacturer) | |
|---|---|
| **Code** | **Manufacturer** |
| W | Western Star Trucks Inc. (Kelowna) |
| C | Western Star Trucks US Inc. (North Charleston) |
| B | Western Star Trucks (Sahagun, Mexico) |

**Table 3, VIN Position 2, Manufacturer**

| VIN Position 3 (type) | |
|---|---|
| **Code** | **Completeness and Type** |
| E | Western Star Warrior |
| K | Complete–Kelowna & North Charleston (LSVW or Tractor with 5th Wheel) |
| H | Complete Tractor–Mexico |
| J | Incomplete–North Charleston and Mexico |
| L | Incomplete–Kelowna ONLY (all other vehicles) |
| M | Glider–Kelowna ONLY |

**Table 4, VIN Position 3, Type**

| VIN Position 4 (model) | |
|---|---|
| **Code** | **Model** |
| E | 4900E |
| H | 3700 |
| K | 3800 |
| L | 5800 |
| N | 4800 |
| P | 4900* |
| R | 5900 |
| T | 6900 |
| V | LSVW |
| W | Warrior |

* Includes RTL-OD for Australia

**Table 5, VIN Position 4, Model**

| VIN Position 5 (axle configuration) | |
|---|---|
| **Code** | **Axle Configuration** |
| A | 4 x 2 |
| B | 4 x 2 Tractor |
| C | 6 x 4 |
| D | 6 x 4 Tractor |
| E | 4 x 4 |
| F | 4 x 4 Tractor |
| G | 6 x 6 |
| H | 6 x 6 Tractor |
| K | 6 x 2 |
| L | 6 x 2 Tractor |
| M | 8 x 4 |
| N | 8 x 4 Tractor |
| S | 8 x 6 |
| T | 8 x 6 Tractor |

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## VIN for Vehicles Built through July 10, 2001

| VIN Position 5 (axle configuration) | |
|---|---|
| **Code** | **Axle Configuration** |
| U | 8 x 8 |
| V | 8 x 8 Tractor |
| W | 10 x 6 |
| Y | 10 x 6 Tractor |

| VIN Position 5 (axle configuration) | |
|---|---|
| **Code** | **Axle Configuration** |
| Z | 2 x 0 Glider |

**Table 6, VIN Position 5, Axle Configuration**

| VIN Position 6 (GVWR class) | | | |
|---|---|---|---|
| **Code** | **Cab Configuration** | **Brake System** | **GVW Class** |
| A | Conventional | Air | Class 6 |
| B | Conventional | Air | Class 7 |
| C | Conventional–Heritage | Air | Class 8 |
| D | Conventional–Constellation | Air | Class 8 |
| F | Conventional | Hydraulic | Class 3 |

**Table 7, VIN Position 6, GVWR Class**

| VIN Positions 7 (engine manufacturer, series) | | | |
|---|---|---|---|
| **Code** | **Engine Manufacturer** | **Series** | **Type** |
| A | Caterpillar | 3208 | Diesel |
| B | Caterpillar | 3306 | Diesel |
| C | Caterpillar | 3406 | Diesel |
| D | Caterpillar | 3408 | Diesel |
| E | Caterpillar | 3126 | Diesel |
| F | Caterpillar | 3176 | Diesel |
| G | Caterpillar | 3116 | Diesel |
| H | Caterpillar | 3306G | Propane |
| J | Cummins | N14, NTC, F & PT | Diesel |
| K | Cummins | K | Diesel |
| L | Cummins | 903 | Diesel |
| M | Cummins | L-10, ISL | Diesel |
| N | Cummins | C-Series, ISC | Diesel |
| P | Cummins | M-11, ISM | Diesel |
| R | Cummins | AHD, ISX | Diesel |
| S | Detroit Diesel | 6-71 | Diesel |
| T | Detroit Diesel | 8V-71 | Diesel |
| U | Detroit Diesel | 6V-92 | Diesel |
| V | Detroit Diesel | 8V-92 | Diesel |

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## VIN for Vehicles Built through July 10, 2001

| VIN Positions 7 (engine manufacturer, series) | | | |
|---|---|---|---|
| **Code** | **Engine Manufacturer** | **Series** | **Type** |
| W | Detroit Diesel | 642 | Diesel |
| X | Detroit Diesel | Series-60 | Diesel |
| Y | Iveco | 8142.47 | Diesel |
| Z * | None | None | Diesel |
| 1 | Caterpillar | C-10 | Diesel |
| 2 | Caterpillar | C-12 | Diesel |
| 3 | Caterpillar | C-15 | Diesel |
| 4 | Caterpillar | C-16 | Diesel |
| 5 | John Deere | JD-6081 | CNG |
| 6 | Mercedes-Benz | MBE4000 | Diesel |

* Glider

**Table 8, VIN Positions 7, Engine Manufacturer, Series**

| VIN Position 8 (horsepower range) | |
|---|---|
| **Code** | **Horespower Range** |
| A | 135–164 |
| B | 165–194 |
| C | 195–224 |
| D | 225–274 |
| E | 275–324 |
| F | 325–374 |
| G | 375–424 |
| H | 425–474 |
| J | 475–524 |
| K | 525–574 |
| L | 575–625 |
| M | 626–675 |
| N | 676–725 |
| V | 75–104 |
| W | 105–134 |
| Z * | None |

* Glider

**Table 9, VIN Position 8, horsepower range**

VIN Position 9 is a check verification digit.

| VIN Position 10 (vehicle model year) | |
|---|---|
| **Code** | **Model Year** |
| A | 1980 |
| B | 1981 |
| C | 1982 |
| D | 1983 |
| E | 1984 |
| F | 1985 |
| G | 1986 |
| H | 1987 |
| J | 1988 |
| K | 1989 |
| L | 1990 |
| M | 1991 |
| N | 1992 |
| P | 1993 |
| R | 1994 |
| S | 1995 |
| T | 1996 |
| V | 1997 |
| W | 1998 |
| X | 1999 |
| Y | 2000 |

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## VIN for Vehicles Built through July 10, 2001

| VIN Position 10 (vehicle model year) | |
|---|---|
| **Code** | **Model Year** |
| 1 | 2001 |
| 2 | 2002 |
| 3 | 2003 |
| 4 | 2004 |
| 5 | 2005 |
| 6 | 2006 |

| VIN Position 10 (vehicle model year) | |
|---|---|
| **Code** | **Model Year** |
| 7 | 2007 |
| 8 | 2008 |
| 9 | 2009 |

**Table 10, VIN Position 10, vehicle model year**

| VIN Position 11 (plant of manufacture) | |
|---|---|
| **Code** | **Plant Location** |
| K | Kelowna, British Columbia, Canada |
| C | North Charleston, South Carolina, United States of America |
| A | Brisbane, Queensland, Australia |
| N | Auckland, New Zealand |
| M | Sahagun, Mexico |

**Table 11, VIN Position 11, plant of manufacture**

| VIN Positions 12-17 (sequential) | |
|---|---|
| **Sequential Number** | **Plant Used at** |
| 100001 – 499999 | North Charleston, South Carolina |
| 500001 – 599999 | Kelowna, British Columbia |
| 800001 – 899999 | Sahagun, Mexico |
| 900001 – 999999 | Kelowna, British Columbia |
| The first two digits of LSVW vehicles are 'LS' | |

**Table 12, VIN Positions 12 thru 17, sequential**

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## VIN for Vehicles Built from July 11, 2001

IMPORTANT: See **Subject 050** for the vehicle identification numbering system for vehicles built before July 11, 2001. The VIN-code structure was revised for all vehicles built after July 10, 2001. As a result, the build date of a vehicle must be determined before the VIN can be decoded.

Federal Motor Vehicle Safety Standard 115 specifies that all vehicles sold in the U.S.A. be assigned a 17-character Vehicle Identification Number (VIN). Using a combination of letters and numerals, the VIN defines the manufacturer, model, and major characteristics of the vehicle. See **Table 1** for the character positions of a typical Western Star VIN, 2WKHABAV11KK12345.

The VIN can be found on the Vehicle Specification Decal (see the driver's manual for decal location) and stamped on the right frame rail over the front axle about 2 inches (50 mm) from the bottom of the web.

For all vehicles, a check digit (9th character) is determined by assignment of weighted values to the other 16 characters. These weighted values are processed through a series of equations designed to check validity of the VIN and to detect VIN alteration.

NOTE: Always specify the VIN when ordering parts.

| Seventeen-Character Vehicle Identification Number (VIN) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Typical VIN** | **2 W K** | **H** | **A B** | **A V** | **1** | **1** | **K** | **A 1 2 3 4 5** |
| Character Position | 1, 2, 3 | 4 | 5, 6 | 7, 8 | 9 | 10 | 11 | 12–17 |
| Code Description | World Manufacturer Identification | Chassis Configuration | Model, Cab, GVWR | Engine, Brakes | Check Digit Calculation | Model Year | Build Location | Production Serial Number |
| Decoding Table* | **Table 2** | **Table 3** | **Table 4** | **Table 5** | — | **Table 6** | **Table 7** | — |

* For corresponding decoding information, see the applicable tables in this subject.

**Table 1, Seventeen-Character Vehicle Identification Number (VIN)**

| VIN Positions 1, 2, and 3 (World Manufacturer Identification) | | | |
|---|---|---|---|
| **Code** | **Vehicle Manufacturer** | **Vehicle Make** | **Vehicle Type** |
| 2WL | Western Star Trucks | Western Star | Incomplete Vehicle |
| 2WK | Western Star Trucks | Western Star | Truck-Tractor |
| 2WM | Western Star Trucks | Western Star | Glider |
| 5KK | Freightliner | Western Star | Incomplete Vehicle |
| 5KJ | Freightliner | Western Star | Truck |

**Table 2, VIN Positions 1, 2, and 3 (World Manufacturer Identification)**

| VIN Position 4 (Chassis Configuration) | |
|---|---|
| **Code** | **Chassis** |
| A | 4 x 2 Truck |
| B | 4 x 2 Truck - Tractor |
| C | 8 x 8 Truck |
| D | 4 x 4 Truck |
| E | 4 x 4 Truck - Tractor |

| VIN Position 4 (Chassis Configuration) | |
|---|---|
| **Code** | **Chassis** |
| F | 6 x 2 Truck |
| G | 6 x 2 Truck - Tractor |
| H | 6 x 4 Truck |
| J | 6 x 4 Truck - Tractor |
| K | 6 x 6 Truck |

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## VIN for Vehicles Built from July 11, 2001

| VIN Position 4 (Chassis Configuration) | |
|---|---|
| **Code** | **Chassis** |
| L | 6 x 6 Truck - Tractor |
| M | 8 x 4 Truck |
| N | 8 x 4 Truck - Tractor |
| P | 8 x 6 Truck |
| R | 8 x 6 Truck - Tractor |
| S | 10 x 4 Truck |
| T | 10 x 4 Truck - Tractor |
| U | 10 x 6 Truck |

| VIN Position 4 (Chassis Configuration) | |
|---|---|
| **Code** | **Chassis** |
| V | 10 x 6 Truck - Tractor |
| W | 12 x 4 Truck |
| X | Glider |
| Y | 8 x 2 Truck |
| Z | 14 x 4 Truck |

**Table 3, VIN Position 4 (Chassis Configuration)**

| VIN Positions 5 and 6 (Model, Cab, Class/GVWR) | | | |
|---|---|---|---|
| **Code** | **Model** | **Cab** | **Class (GVWR)** |
| AA | 4900 EX | Conventional | 26,001 to 33,000 pounds, Class 7 |
| AB | | | 33,001 pounds and over, Class 8 |
| AC | | | Glider |
| AD | 4900 SF* | Conventional | 26,001 to 33,000 pounds, Class 7 |
| AE | | | 33,001 pounds and over, Class 8 |
| AF | | | Glider |
| AG | 4900 | Conventional | 26,001 to 33,000 pounds, Class 7 |
| AH | | | 33,001 pounds and over, Class 8 |
| AJ | | | Glider |
| AK | 4900 SB† | Conventional | 26,001 to 33,000 pounds, Class 7 |
| AL | | | 33,001 pounds and over, Class 8 |
| AM | | | Glider |
| AN | 5900 | Conventional | 26,001 to 33,000 pounds, Class 7 |
| AP | | | 33,001 pounds and over, Class 8 |
| AR | | | Glider |
| AS | 6900 XD | Conventional | 33,001 pounds and over, Class 8 |
| AT | | | Glider |
| AU | 4700 SF | Conventional | 26,001 to 33,000 pounds, Class 7 |
| AV | | | 33,001 pounds and over, Class 8 |
| AY | | | Glider |
| AW | 4700 SB | Conventional | 26,001 to 33,000 pounds, Class 7 |
| AX | | | 33,001 pounds and over, Class 8 |
| AZ | | | Glider |

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## VIN for Vehicles Built from July 11, 2001

| VIN Positions 5 and 6 (Model, Cab, Class/GVWR) | | | |
|---|---|---|---|
| **Code** | **Model** | **Cab** | **Class (GVWR)** |
| BA | 4800 SB | Conventional | 26,001 to 33,000 pounds, Class 7 |
| BB | | | 33,001 pounds and over, Class 8 |
| BC | | | Glider |
| BD | 4800 SF | Conventional | 26,001 to 33,000 pounds, Class 7 |
| BE | | | 33,001 pounds and over, Class 8 |
| BF | | | Glider |

* In mid 2011, the model suffix changed from "FA" to "SF" for 4900 models with set-forward axles.

† In mid 2011, the model suffix changed from "SA" to "SB" for 4900 models with set-back axles.

**Table 4, VIN Positions 5 and 6 (Model, Cab, Class/GVWR)**

| VIN Positions 7 and 8 (Engine and Brakes) | | | | | |
|---|---|---|---|---|---|
| **Code** | **Engine** | **Fuel** | **Displacement (L)** | **Configuration** | **Brakes** |
| AA | Caterpillar 3176 | Diesel | 10.3 | I–6 | Air |
| AD | Caterpillar 3406 | Diesel | 14.6 | I–6 | Air |
| AG | Caterpillar 3406E | Diesel | 15.8 | I–6 | Air |
| AK | Caterpillar 3126/CFE | Diesel | 7.2 | I–6 | Air |
| AN | Caterpillar C10 | Diesel | 10.3 | I–6 | Air |
| AS | Caterpillar C12 | Diesel | 12.0 | I–6 | Air |
| AV | Caterpillar C15 | Diesel | 14.6 | I–6 | Air |
| AY | Caterpillar C16 | Diesel | 15.8 | I–6 | Air |
| A2 | Cummins L10 | Diesel | 10.8 | I–6 | Air |
| A8 | Cummins ISM | Diesel | 10.8 | I–6 | Air |
| BA | Cummins NTC | Diesel | 14.0 | I–6 | Air |
| BD | Cummins N14 | Diesel | 14.0 | I–6 | Air |
| BG | Cummins ISX/Signature | Diesel | 14.9 | I–6 | Air |
| CD | Detroit Series 60 | Diesel | 11.1 | I–6 | Air |
| CG | Detroit Series 60 | Diesel | 12.7 | I–6 | Air |
| CK | Detroit Series 60 | Diesel | 14.0 | I–6 | Air |
| CV | MBE4000 | Diesel | 12.8 | I–6 | Air |
| CY | Cummins ISL | Diesel | 8.3 | I–6 | Air |
| DC | Caterpillar C7 | Diesel | 7.2 | I–6 | Air |
| DE | Caterpillar C13 | Diesel | 12.5 | I–6 | Air |
| DL | Caterpillar C11 | Diesel | 11.1 | I–6 | Air |
| DR | Detroit DD15 | Diesel | 14.8 | I–6 | Air |
| D1 | Detroit DD16 | Diesel | 15.6 Liter | I-6 | Air |
| DV | Detroit DD13 | Diesel | 12.8 Liter | I-6 | Air |

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## VIN for Vehicles Built from July 11, 2001

| VIN Positions 7 and 8 (Engine and Brakes) | | | | | |
|---|---|---|---|---|---|
| **Code** | **Engine** | **Fuel** | **Displacement (L)** | **Configuration** | **Brakes** |
| 00 | No Engine | — | — | — | — |

**Table 5, VIN Positions 7 and 8 (Engine and Brakes)**

| VIN Position 10 (Model Year) | |
|---|---|
| **Code** | **Model Year** |
| Y | 2000 |
| 1 | 2001 |
| 2 | 2002 |
| 3 | 2003 |
| 4 | 2004 |
| 5 | 2005 |
| 6 | 2006 |
| 7 | 2007 |
| 8 | 2008 |
| 9 | 2009 |
| A | 2010 |
| B | 2011 |
| C | 2012 |
| D | 2013 |

**Table 6, VIN Position 10 (Model Year)**

| VIN Position 11 (Build Location) | |
|---|---|
| **Code** | **Build Location** |
| K | Kelowna, British Columbia, Canada |
| S | Charleston, South Carolina, United States |
| P | Portland, Oregon, United States |

**Table 7, VIN Position 11 (Build Location)**

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## General Information

The majority of threaded fasteners used throughout the vehicle have U.S. customary threads (diameter and pitch are measured in inches). See **Fig. 1**. However, the engine and some items attached to the cab use metric fasteners (diameter and pitch are measured in millimeters).

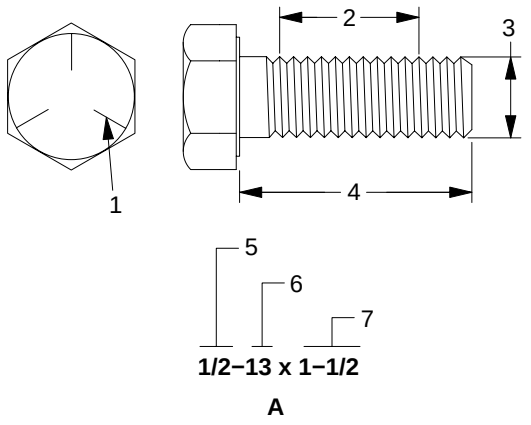
Most fasteners used on the vehicle that are 1/2-inch diameter or larger are plain hex-type fasteners (non-flanged); *all* metric fasteners are non-flanged. Special hardened flatwashers are used under the bolt head, and between the part being attached and the hexnut, to distribute the load, and to prevent localized overstressing of the parts. The washers are cadmium- or zinc-plated, and have a hardness rating of 38 to 45-HRC.

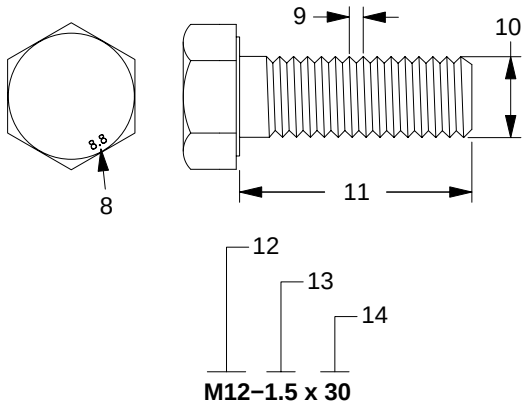
Some fasteners smaller than 1/2-inch diameter are flanged fasteners, which have integral flanges that fit against the parts being fastened. The flanges eliminate the need for washers.

## Fastener Grades and Classes

Fasteners with U.S. customary threads are divided into grades established by the Society of Automotive Engineers (S.A.E.) or the International Fastener Institute (I.F.I.). The fastener grades indicate the relative strength of the fastener; the higher the number (or letter), the stronger the fastener. Bolt (capscrew) grades can be identified by the number and pattern of radial lines forged on the bolt head. See **Fig. 2**. Hexnut (and locknut) grades can be identified by the number and pattern of lines and dots on various surfaces of the nut. See **Fig. 3, Fig. 4, Fig. 5, Fig. 6, Fig. 7, Fig. 8,** or **Fig. 9.** Nearly all of the bolts used on the vehicle are grades 5, 8, and 8.2. Matching grades of hexnuts are always used: grade 5 or grade B hexnuts are used with grade 5 bolts; grade 8, grade C, or grade G (flanged) hexnuts are used with grade 8 or 8.2 bolts.

Fasteners with metric threads are divided into classes adopted by the American National Standards Institute (ANSI). The higher the class number, the stronger the fastener. Bolt classes can be identified by the numbers forged on the head of the bolt. See **Fig. 10**. Hexnut (and locknut) classes can be identified by the marks or numbers on various surfaces of




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A. 1/2–13 x 1-1/2 U.S. Customary Thread Bolt
B. M12–1.5 x 30 Metric Thread Bolt

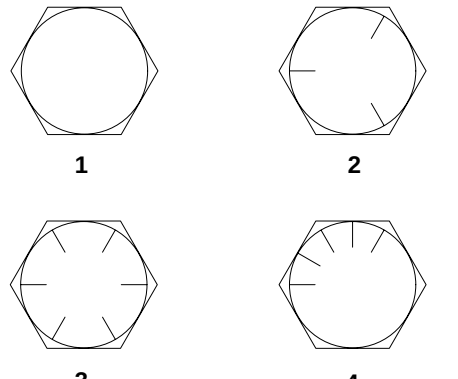
1. S.A.E. Grade Marking
2. Thread Pitch
3. Nominal Diameter
4. Bolt Length
5. Nominal Diameter in Inches
6. Thread Pitch in Threads per Inch
7. Bolt Length in Inches
8. Metric Class Marking
9. Thread Pitch
10. Nominal Diameter
11. Bolt Length
12. Nominal Diameter in Millimeters
13. Thread Pitch (Thread Width from Crest to Crest in Millimeters)
14. Bolt Length in Millimeters

**Fig. 1, Bolt Nomenclature**

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## General Information

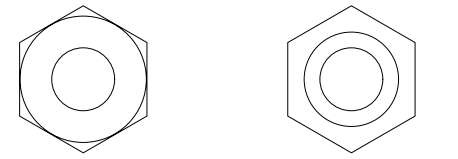



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NOTE: Grade 2 bolts have no grade markings; grade 2 bolts are rarely used by Western Star Trucks. These grade markings are used on plain hex-type and flanged bolts (capscrews). In addition to the grade markings, the bolt head must also carry the manufacturer's trademark or identification.

1. Grade 2
2. Grade 5
3. Grade 8
4. Grade 8.2

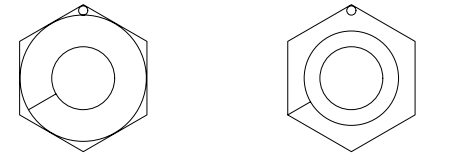
**Fig. 2, S.A.E. Hexbolt Grade Marking**



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NOTE: S.A.E. grade 2 nuts have no identification marks or notches; they are rarely used by Western Star Trucks. Their strength is compatible with grade 2 bolts.

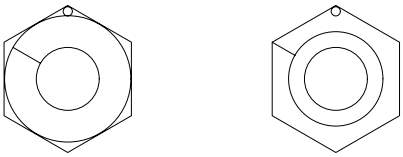
**Fig. 3, S.A.E. Grade 2 Nuts**



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NOTE: The strength of grade 5 nuts is compatible with grade 5 bolts.

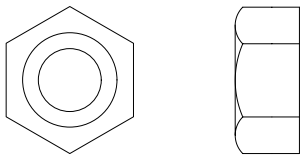
**Fig. 4, S.A.E. Grade 5 Nuts**



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NOTE: The strength of grade 8 nuts is compatible with grade 8 or 8.2 bolts.

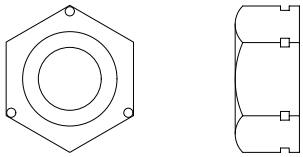
**Fig. 5, S.A.E. Grade 8 Nuts**



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NOTE: I.F.I. grade A nuts have no identification marks or notches; they are rarely used by Western Star Trucks. Their strength is compatible with grade 2 bolts.

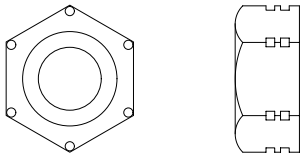
**Fig. 6, I.F.I. Grade A Nuts**



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NOTE: I.F.I. grade B nuts have three identification marks at 120°, or 6 notches. Their strength is compatible with grade 5 bolts.

**Fig. 7, I.F.I. Grade B Nuts**



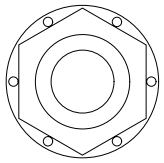
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NOTE: I.F.I. grade C nuts have six identification marks at 60°, or 12 notches. Their strength is compatible with grade 8 or 8.2 bolts.

**Fig. 8, I.F.I. Grade C Nut**

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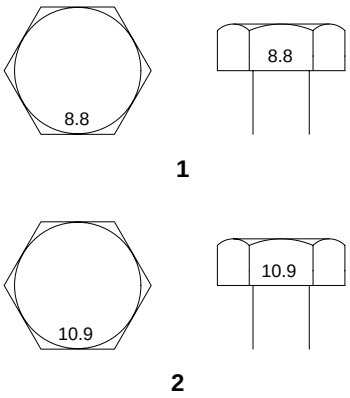


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NOTE: I.F.I. grade G (flanged) nuts have six identification marks as shown; each identification mark may be a dot, line, pair of dots or lines, or any other symbol at the manufacturer's option. Their strength is compatible with grade 8 or 8.2 bolts.

**Fig. 9, I.F.I. Grade G Nut**

the nut. See **Fig. 11**. Class 8 hexnuts are always used with class 8.8 bolts; class 10 hexnuts with class 10.9 bolts.




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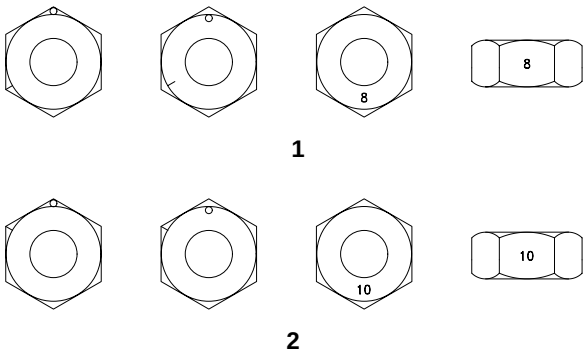
NOTE: In addition to the grade markings, the bolt head must carry the manufacturer's trademark or identification.

1. Class 8.8
2. Class 10.9

**Fig. 10, ANSI Metric Bolt Grade Marking**

## Frame Fasteners

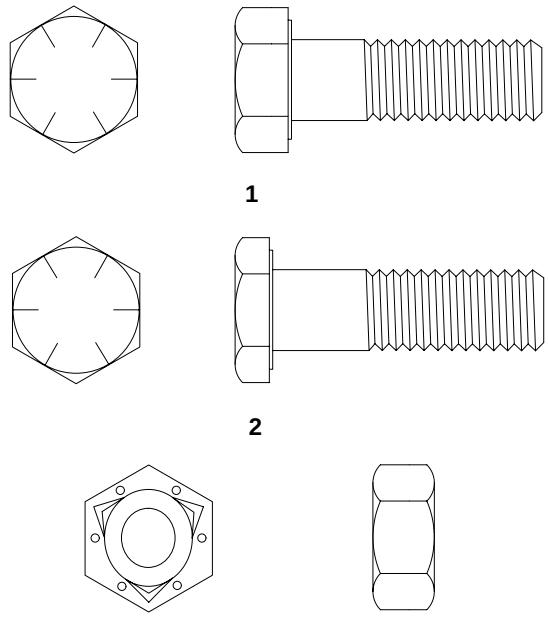
For most components attached to the frame, grade 8 and 8.2 phosphate-and oil-coated hexhead bolts and grade C cadmium-plated and wax-coated prevailing torque locknuts are used. The prevailing torque locknuts have distorted sections of threads to provide torque retention. For attachments where clearance is minimal, low-profile hexhead bolts and grade C prevailing torque locknuts are used. See **Fig. 12**.




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1. Class 8 Nut
2. Class 10 Nut

**Fig. 11, ANSI Metric Nut Grade Marking**




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1. Grade 8 hexhead Bolt
2. Grade 8 Low-Profile hexhead Bolt
3. Grade C Prevailing Torque Locknut

**Fig. 12, Low Profile and Prevailing Torque Hexbolt and Hexnut Markings**

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## Tightening Fasteners

When a capscrew is tightened to its torque value in a threaded hole, or a nut is tightened to its torque value on a bolt, the shank of the capscrew or bolt is stretched slightly. This stretching (tensioning) results in a preload that reduces fatigue of the fasteners. The torque values given in the tables in **Specifications 400** have been calculated to provide enough clamping force on the parts being fastened, and the correct tensioning of the bolt to maintain the clamping force.

Use of a torque wrench to tighten fasteners will help prevent overtensioning them. Overtensioning causes permanent stretching of the fasteners, which can result in breakage of the parts or fasteners.

When torquing a fastener, typically 80 to 90 percent of the turning force is used to overcome friction; only 10 to 20 percent is used to stretch the capscrew or bolt. About 40 to 50 percent of the turning force is needed to overcome the friction between the underside of the capscrew head or nut and the washer. Another 30 to 40 percent is needed to overcome the friction between the threads of the capscrew and the threaded hole, or the friction between the threads of the nut and bolt.

The amount of torque required to tighten a fastener is reduced when the amount of friction is reduced. If a fastener is dry (unlubricated) and plain (unplated), the amount of friction is high. If a fastener is wax-coated or oiled, or has a zinc phosphate coating or cadmium plating, the amount of friction is reduced. Each of these coatings and combinations of coatings has a different effect. Using zinc-plated hardened flatwashers under the bolt (capscrew) head and nut reduces the amount of friction. Dirt or other foreign material on the threads or clamping surfaces of the fastener or clamped part also changes the amount of friction.

Even though each different condition affects the amount of friction, a different torque value cannot be given for each different condition. To ensure they are always torqued accurately, Western Star recommends that all fasteners be lubricated with oil (unless specifically instructed to install them dry), then torqued to the values for lubricated- and plated-thread fasteners. When locking compound or anti-seize compound is recommended for a fastener, the compound acts as a lubricant, and oil is not needed.

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## Fastener Replacement

When replacing fasteners, use only identical bolts, washers, and nuts; they must be the same size, strength, and finish as originally specified. See the Freightliner *Parts Book* for fastener specifications.

When replacing graded (or metric class) bolts and capscrews, use only fasteners that have the manufacturer's trademark or identification on the bolt head; don't use substandard bolts. Inferior, counterfeit fasteners are difficult to identify; buy your fasteners from a reputable supplier.

## Fastener Selection and Installation

When using nuts with bolts, use a grade (or class) of nut that matches the bolt.

When installing non-flanged fasteners, use hardened steel flatwashers under the bolt (capscrew) head, and under the hexnut or locknut.

For bolts 4-inches (100-mm) or less in length, make sure that at least 1-1/2 threads and no more than 5/8-inch (16-mm) bolt length extends through the nut after it has been tightened. For bolts longer than 4-inches (100-mm), allow a minimum of 1-1/2 threads and a maximum of 3/4-inch (19-mm) bolt length.

Never hammer or screw bolts into place. Align the holes of the parts being attached, so that the nut and bolt surfaces are flush against the washers, and the washers are flush against the parts.

When installing fasteners in aluminum or plastic parts with threaded holes, start the fasteners by hand, to ensure straight starting and to prevent damaged threads.

Don't use lockwashers (split or toothed) next to aluminum surfaces.

When installing studs that don't have an interference fit, install them with thread locking compound, as instructed in this subject.

When installing parts that are mounted on studs, use free-spinning (non-locking) nuts and helical-spring (split) lockwashers or internal-tooth lockwashers. Don't use locknuts, because they tend to loosen the studs during removal. Don't use plain washers (flatwashers).

Don't use lockwashers and flatwashers in combination (against each other); each defeats the other's purpose.

Use stainless steel fasteners against chrome plating, unpainted aluminum, or stainless steel.

## Fastener Tightening

Before installing fasteners, clean all fastener (and parts) threads, and all surfaces being clamped.

To ensure they are always torqued accurately, Western Star recommends that *all* fasteners be lubricated with oil (unless specifically instructed to install them dry), then torqued to the values for lubricated and plated thread fasteners. When locking compound or antiseize compound is recommended for a fastener, the compound acts as a lubricant, and oil is not needed.

Bring parts and fasteners into contact, with no gaps between them, before using a torque wrench to tighten fasteners to their final torque values.

Tighten the nut, not the bolt head. This will give a truer torque reading by eliminating bolt body friction.

Always use a torque wrench to tighten fasteners, and use a slow, smooth, even pull on the wrench. Don't overtorque fasteners; overtightening causes permanent stretching of the fasteners, which can result in breakage of the parts or fasteners.

If specific torque values aren't given for countersunk bolts, use the torque value for the corresponding size and grade of regular bolt, as given in **Specifications 400**.

Always follow the torque sequence or torque interval when provided, to ensure that clamping forces are even, and parts and fasteners aren't distorted.

Tighten frame fasteners periodically to offset the effects of "bedding in" (seating). Continued vehicle operation with loose frame fasteners could result in component, bracket, and frame damage. See the Maintenance Schedule (**Group 00**) and **Group 31** of the *Western Star Maintenance Manual* for intervals.

## Thread Locking Compound Application

When the use of thread locking compound is recommended or desired, for studs, capscrews, and bolts

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## General Instructions

with a thread diameter of 1-inch (25-mm) or less, use Loctite® 271 or Perma-Lok® HM-128.

For thread diameters over 1 inch (25 mm), use Loctite 277.

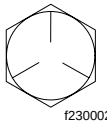
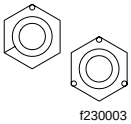
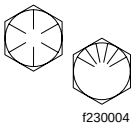
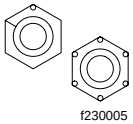
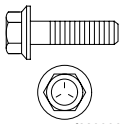
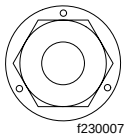
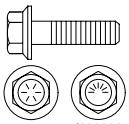
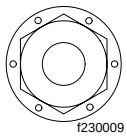
NOTE: Follow the safety precautions given on the locking compound container.

1. Clean the male and female threads of the fasteners, removing all dirt, oil, and other foreign material. If parts are contaminated, use Stoddard solvent for cleaning; then allow the fasteners to air dry for 10 minutes. Be sure solvent is completely gone before applying adhesive.
2. Transfer a small amount of the locking compound from the container to a paper cup or small non-metal dish.
3. Using a plastic brush (a metal brush will contaminate the compound), apply a small amount of compound to the entire circumference of 3 or 4 of the male threads that will be covered by the nut after it has been tightened. Be sure enough compound is applied to fill the inside of the nut threads, with a slight excess.
4. Install and torque the nut. Readjustment of the nut position is not possible after installation is complete, without destroying the locking effect.

NOTE: To disassemble the fasteners, heat the bond line to 400°F (200°C) before removing the nut. Every time the fasteners are disassembled, replace them. If any parts are damaged by overheating, replace the parts.

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| Torque Values for U.S. Customary Thread Fasteners With Lubricated* or Plated Threads† | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Thread Diameter–Pitch | Regular Hex | | | | Flanged | | | |
| | Grade 5 Bolt | Grade 5 or B Nut | Grade 8 or 8.2 Bolt | Grade 8 or C Nut | Grade 5 Bolt | Grade B Nut | Grade 8 or 8.2 Bolt | Grade G Nut |
| | Torque: lbf·ft (N·m) | | Torque: lbf·ft (N·m) | | Torque: lbf·ft (N·m) | | Torque: lbf·ft (N·m) | |
| |  f230002 |  f230003 |  f230004 |  f230005 |  f230006 |  f230007 |  f230008 |  f230009 |
| 1/4–20 | 7 (9) | | 8 (11) | | 6 (8) | | 10 (14) | |
| 1/4–28 | 8 (11) | | 9 (12) | | 7 (9) | | 12 (16) | |
| 5/16–18 | 15 (20) | | 16 (22) | | 13 (18) | | 21 (28) | |
| 5/16–24 | 16 (22) | | 17 (23) | | 14 (19) | | 23 (31) | |
| 3/8–16 | 26 (35) | | 28 (38) | | 23 (31) | | 37 (50) | |
| 3/8–24 | 30 (41) | | 32 (43) | | 25 (34) | | 42 (57) | |
| 7/16–14 | 42 (57) | | 45 (61) | | 35 (47) | | 60 (81) | |
| 7/16–20 | 47 (64) | | 50 (68) | | 40 (54) | | 66 (89) | |
| 1/2–13 | 64 (87) | | 68 (92) | | 55 (75) | | 91 (123) | |
| 1/2–20 | 72 (98) | | 77 (104) | | 65 (88) | | 102 (138) | |
| 9/16–12 | 92 (125) | | 98 (133) | | 80 (108) | | 130 (176) | |
| 9/16–18 | 103 (140) | | 110 (149) | | 90 (122) | | 146 (198) | |
| 5/8–11 | 128 (173) | | 136 (184) | | 110 (149) | | 180 (244) | |
| 5/8–18 | 145 (197) | | 154 (209) | | 130 (176) | | 204 (277) | |
| 3/4–10 | 226 (306) | | 241 (327) | | 200 (271) | | 320 (434) | |
| 3/4–16 | 253 (343) | | 269 (365) | | 220 (298) | | 357 (484) | |
| 7/8–9 | 365 (495) | | 388 (526) | | 320 (434) | | 515 (698) | |
| 7/8–14 | 402 (545) | | 427 (579) | | 350 (475) | | 568 (770) | |
| 1–8 | — | | 582 (789) | | — | | — | |
| 1–12 | — | | 637 (863) | | — | | — | |
| 1–14 | — | | 652 (884) | | — | | — | |

* Freightliner recommends that all plated and unplated fasteners be coated with oil before installation.

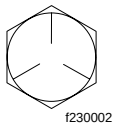
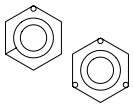
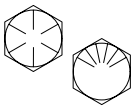
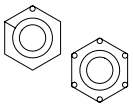
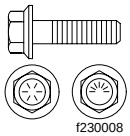
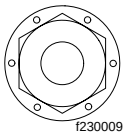
† Use these torque values if either the bolt or nut is lubricated or plated (zinc-phosphate conversion-coated, cadmium-plated, or waxed).

**Table 1, Torque Values for U.S. Customary Thread Fasteners With Lubricated or Plated Threads**

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## Specifications

| Torque Values for U.S. Customary Thread Fasteners With Dry (Unlubricated)* Plain (Unplated) Threads† | | | | | | |
|---|---|---|---|---|---|---|
| Thread Diameter–Pitch | Regular Hex | | | | Flanged | |
| | Grade 5 Bolt | Grade 5 or B Nut | Grade 8 or 8.2 Bolt | Grade 8 or C Nut | Grade 8 or 8.2 Bolt | Grade G Nut |
| | Torque: lbf·ft (N·m) | | Torque: lbf·ft (N·m) | | Torque: lbf·ft (N·m) | |
| |  f230002 |  f230003 |  f230004 |  f230005 |  f230008 |  f230009 |
| 1/4–20 | 8 (11) | | 10 (14) | | — | |
| 1/4–28 | 9 (12) | | 12 (16) | | — | |
| 5/16–18 | 15 (20) | | 22 (30) | | 22 (30) | |
| 5/16–24 | 17 (23) | | 25 (34) | | — | |
| 3/8–16 | 28 (38) | | 40 (54) | | 40 (54) | |
| 3/8–24 | 31 (42) | | 45 (61) | | — | |
| 7/16–14 | 45 (61) | | 65 (88) | | 65 (88) | |
| 7/16–20 | 50 (68) | | 70 (95) | | — | |
| 1/2–13 | 70 (95) | | 95 (129) | | 95 (129) | |
| 1/2–20 | 75 (102) | | 110 (149) | | — | |
| 9/16–12 | 100 (136) | | 140 (190) | | 140 (190) | |
| 9/16–18 | 110 (149) | | 155 (210) | | — | |
| 5/8–11 | 135 (183) | | 190 (258) | | 190 (258) | |
| 5/8–18 | 155 (210) | | 215 (292) | | — | |
| 3/4–10 | 240 (325) | | 340 (461) | | 340 (461) | |
| 3/4–16 | 270 (366) | | 380 (515) | | — | |
| 7/8–9 | 385 (522) | | 540 (732) | | — | |
| 7/8–14 | 425 (576) | | 600 (813) | | — | |
| 1–8 | 580 (786) | | 820 (1112) | | — | |
| 1–12 | 635 (861) | | 900 (1220) | | — | |
| 1–14 | 650 (881) | | 915 (1241) | | — | |

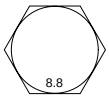
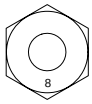
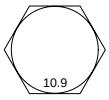
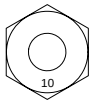
* Threads may have residual oil, but will be dry to the touch.

† Male and female threads (bolt and nut) must both be unlubricated and unplated; if either is plated or lubricated, use **Table 1**. Freightliner recommends that all plated and unplated fasteners be coated with oil before installation.

**Table 2, Torque Values for U.S. Customary Thread Fasteners With Dry (Unlubricated) Plain (Unplated) Threads**

https://truckmanualshub.com/



| Torque Values for Metric Thread Fasteners With Lubricated* or Plated Threads† | | | | |
|---|---|---|---|---|
| Thread Diameter–Pitch | Class 8.8 Bolt | Class 8 Nut | Class 10.9 Bolt | Class 10 Nut |
| | Torque: lbf·ft (N·m) | | Torque: lbf·ft (N·m) | |
| |  f230010 |  f230011 |  f230012 |  f230013 |
| M6 | 5 (7) | | 7 (9) | |
| M8 | 12 (16) | | 17 (23) | |
| M8 x 1 | 13 (18) | | 18 (24) | |
| M10 | 24 (33) | | 34 (46) | |
| M10 x 1.25 | 27 (37) | | 38 (52) | |
| M12 | 42 (57) | | 60 (81) | |
| M12 x 1.5 | 43 (58) | | 62 (84) | |
| M14 | 66 (89) | | 95 (129) | |
| M14 x 1.5 | 72 (98) | | 103 (140) | |
| M16 | 103 (140) | | 148 (201) | |
| M16 x 1.5 | 110 (149) | | 157 (213) | |
| M18 | 147 (199) | | 203 (275) | |
| M18 x 1.5 | 165 (224) | | 229 (310) | |
| M20 | 208 (282) | | 288 (390) | |
| M20 x 1.5 | 213 (313) | | 320 (434) | |
| M22 | 283 (384) | | 392 (531) | |
| M22 x 1.5 | 315 (427) | | 431 (584) | |
| M24 | 360 (488) | | 498 (675) | |
| M24 x 2 | 392 (531) | | 542 (735) | |
| M27 | 527 (715) | | 729 (988) | |
| M27 x 2 | 569 (771) | | 788 (1068) | |
| M30 | 715 (969) | | 990 (1342) | |
| M30 x 2 | 792 (1074) | | 1096 (1486) | |

* Freightliner recommends that all plated and unplated fasteners be coated with oil before installation.

† Use these torque values if either the bolt or nut is lubricated or plated (zinc-phosphate conversion-coated, cadmium-plated, or waxed).

**Table 3, Torque Values for Metric Thread Fasteners With Lubricated or Plated Threads**

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# Principles of Operation

## EPA 2007

The Environmental Protection Agency (EPA) mandated that all engines built after December 31, 2006 meet lower exhaust emissions levels:

- 1.1 grams per brake horsepower hour (g/bhp-hr) of nitrogen oxides (NOx)
- 0.01 g/bhp-hr of particulate matter (PM)

To meet the EPA07 requirements, most engine manufacturers developed an aftertreatment system (ATS). The ATS varies according to engine and vehicle configuration, but instead of a muffler, an ATS has an aftertreatment device (ATD) that outwardly resembles a muffler.

Inside the ATD on Cummins, Detroit Diesel, and Mercedes-Benz engines, the exhaust first passes over the diesel oxidation catalyst (DOC), which uses a chemical process to break down pollutants into less harmful components. The exhaust then passes through the diesel particulate filter (DPF), which traps soot particles. See **Fig. 1**.

Caterpillar ATDs have a DPF, but do not have a DOC. Instead, CAT engines burn diesel fuel at the regeneration head to superheat the exhaust and reduce it to less harmful components. CAT engines also utilize Clean Gas Induction (CGI), a process in which some of the exhaust gas downstream of the DPF is recirculated into the air intake system. See **Fig. 2**.

The DPF core in all ATDs is comprised of ceramic channels that are blocked off at alternate ends to force the exhaust through the porous walls.

As soot accumulates in the DPF, it periodically needs to be converted to its basic parts: carbon dioxide, water, and ash. The conversion takes place through an event in the ATD referred to as regeneration (regen). If the exhaust temperature is high enough, the trapped soot is reduced to ash in a process called passive regen, which occurs as the vehicle is driven normally.

Passive regen, however, cannot always keep the DPF clean, so the ATD must also periodically undergo active regen. During active regen, extra fuel is injected into the exhaust stream to superheat and reduce the soot trapped in the DPF to ash. Active regen happens only when the vehicle is moving above a certain speed, as determined by the engine manufacturer.

Both active and passive regen happen automatically, without driver input. When operating conditions do not allow for active or passive regen, the vehicle may require a driver-activated parked regen, which takes 20 to 60 minutes, depending on ambient conditions.

Over time, ash collects in the ATS and needs to be removed through cleaning at specific intervals. For ATS maintenance and repair information, see the engine manufacturer's service literature.

## EPA 2010

The Environmental Protection Agency (EPA) mandated that all engines built after December 31, 2009 must reduce the level of emissions exhausted by the engine to 0.2 grams per brake horsepower hour (g/bhp-hr) of nitrogen oxides (NOx).

To meet the EPA10 requirements, Daimler Trucks North America is using technology known as Selective Catalytic Reduction (SCR) in the exhaust aftertreatment system (ATS). The ATS will rely on existing EPA07 technology, which includes an aftertreatment device (ATD), with the addition of SCR. See **Fig. 3**. The SCR process requires the introduction of diesel exhaust fluid (DEF) into the exhaust stream.

The ATS is always chassis-mounted, with several different installation options available to fit various vehicle configurations. ATS exhaust piping is made of stainless steel. The ATS includes all piping and equipment between the turbocharger outlet and the end of the exhaust pipe, including the aftertreatment device (ATD), SCR catalyst, DEF tank, DEF tank header unit, DEF pump, DEF metering unit, and the DEF, coolant, and air lines that run between each component.

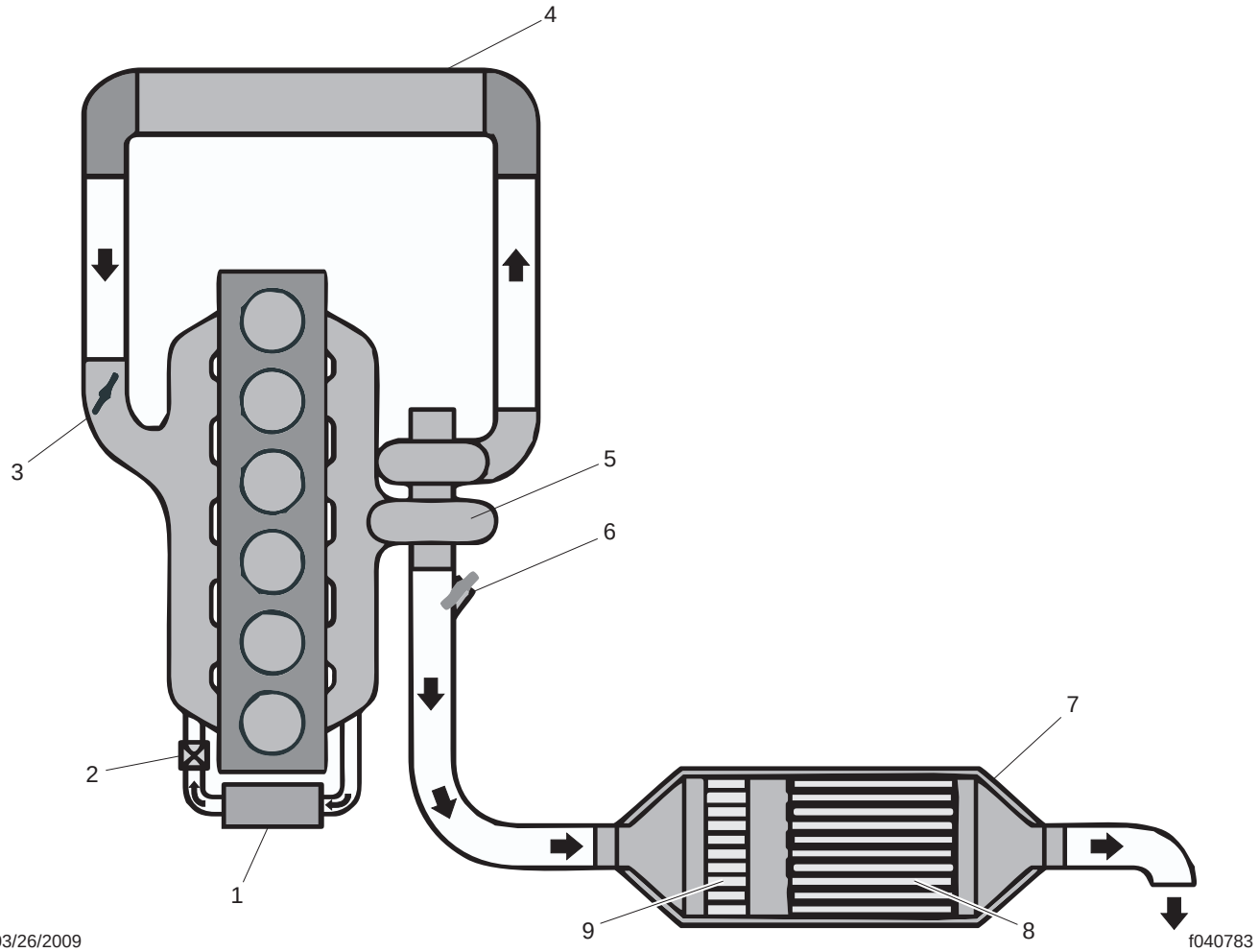
All EPA10-compliant DTNA vehicles require the use of ultra-low sulfur diesel (ULSD) fuel with a sulfur content of 15 parts per million (ppm) for low emissions and long life of the diesel particulate filter (DPF) in the ATD. In addition, DTNA vehicles require the use of CJ-4 engine oils with less than 1% ash.

Inside the ATD, the exhaust first passes over the diesel oxidation catalyst (DOC), where combustion gases are chemically broken down into water and carbon dioxide. The exhaust then passes through the DPF, a honeycomb-like filter that traps solid soot par-

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## General Information




1. Exhaust Gas Recirculation (EGR) Cooler
2. EGR Valve
3. Intake Throttle Valve
4. Charge Air Cooler (CAC)
5. Turbocharger
6. Hydrocarbon Doser
7. Aftertreatment Device (ATD)
8. Diesel Particulate Filter (DPF)
9. Diesel Oxidation Catalyst (DOC)

**Fig. 1, EPA07 ATS (Detroit Diesel engine shown)**

ticles. The soot particles trapped in the DPF are reduced to ash during regeneration (regen).

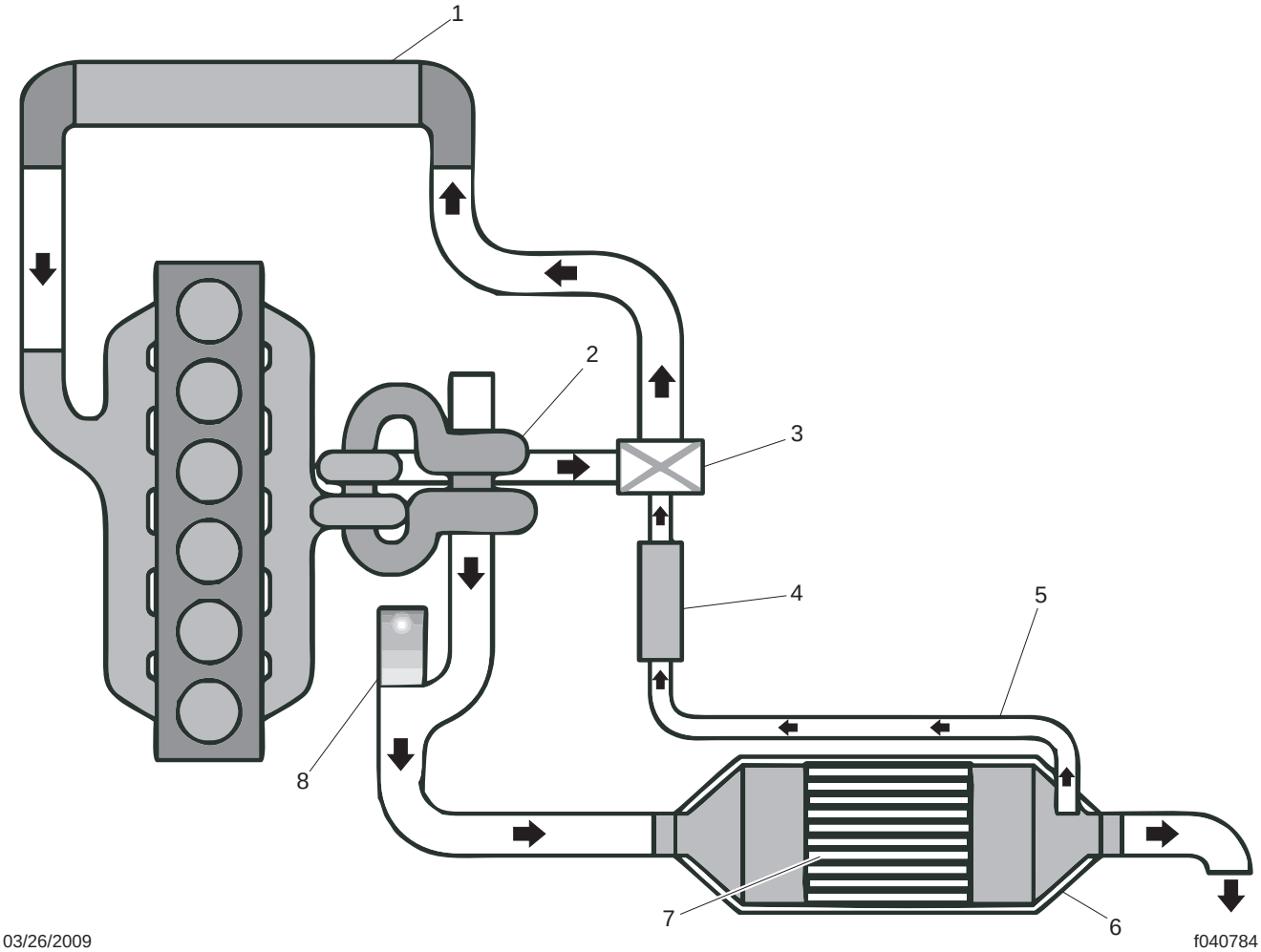
If the exhaust temperature is high enough, a process called passive regen occurs as the vehicle is driven normally. Passive regen, however, cannot always keep the DPF clean, so the ATD must also periodically undergo active regen. During active regen, extra fuel is injected into the exhaust stream to superheat and reduce the soot trapped in the DPF to ash. Active regen happens only when the vehicle is moving above a certain speed, as determined by the engine manufacturer.

Both active and passive regen happen automatically, without driver input. When operating conditions do not allow for active or passive regen, the vehicle may require a driver-activated parked regen, which takes 20 to 60 minutes, depending on ambient conditions.

Despite the regen process, ash collects in the DPF over time and needs to be removed through cleaning at specific intervals. For DPF maintenance intervals

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1. Charge Air Cooler (CAC)
2. Dual-Stage Turbocharger
3. Clean Gas Induction (CGI) Mixing Valve
4. CGI Cooler
5. CGI Line
6. Aftertreatment Device (ATD)
7. Diesel Particulate Filter (DPF)
8. Regeneration Head

**Fig. 2, EPA07 ATS (Caterpillar engine shown)**

and repair information, see the engine manufacturer's service literature.

After exhaust gases leave the ATD, a controlled quantity of diesel exhaust fluid (DEF) is injected into the exhaust stream. In the presence of heat, DEF is converted to ammonia gas, which reacts with NOx in the selective catalyst chamber to yield nitrogen and water vapor, which exit through the tailpipe.

EPA10-compliant DTNA vehicles are equipped with an additional tank to carry the DEF necessary for the SCR process. DEF is colorless, non-toxic, and biodegradable. DEF consumption will vary depending on ambient conditions and vehicle application.

## Service Literature Coverage

Engine service procedures in this manual are limited to components installed by Daimler Trucks North America. See the following sections for information

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on EPA07/10-compliant parts and systems installed by Daimler Trucks North America:

- **Section 01.00**, Engine Mounts
- **Section 20.00**, Radiator Assembly
- **Section 49.00**, Aftertreatment System, EPA07
- **Section 49.01**, Aftertreatment System, EPA10
- **Section 49.02**, Diesel Exhaust Fluid System, EPA10

Complete engine coverage including engine adjustment, preventive maintenance, and engine repair are covered in each engine manufacturer's service literature:

- Caterpillar: www.cat.com
- Cummins: www.cummins.com
- Detroit Diesel: www.detroitdiesel.com
- Mercedes-Benz: www.detroitdiesel.com

Periodic inspection of the ATS is required. For instructions, see the *Western Star Maintenance Manual*.

For driver pre- and post-trip inspection information, see the *Western Star Driver's Manual*.

## Definition of Terms

Refer to the following terms for a better understanding of EPA07/10 engines.

**Ash** Unburnable solids that remain after regeneration in the ATD.

**Aftertreatment Device (ATD)** A device that removes pollutants from exhaust gas after the gas leaves the combustion chamber.

**Aftertreatment System (ATS)** The entire exhaust system from the turbocharger to the exhaust stack or tail pipe.

**Diesel Exhaust Fluid (DEF)** A colorless, non-toxic, and biodegradable fluid used in the SCR process.

**Diesel Oxidation Catalyst (DOC)** A flow-through device that enhances the oxidation of hydrocarbons in the ATD on Cummins, Detroit Diesel, and Mercedes-Benz engines.

**Diesel Particulate Filter (DPF)** A component in the ATD that captures particulate matter from the exhaust gas, preventing discharge from the tailpipe.

**Exhaust Gas Recirculation (EGR)** A process whereby exhaust is recirculated into the air intake system, creating lower cylinder temperatures.

**Nitrogen Oxides (NOx)** Air pollutants composed of nitrogen and oxygen in various forms that contribute to the formation of smog.

**Particulate Matter (PM)** Soot particles formed by incomplete combustion of fuel that contribute to atmospheric pollution.

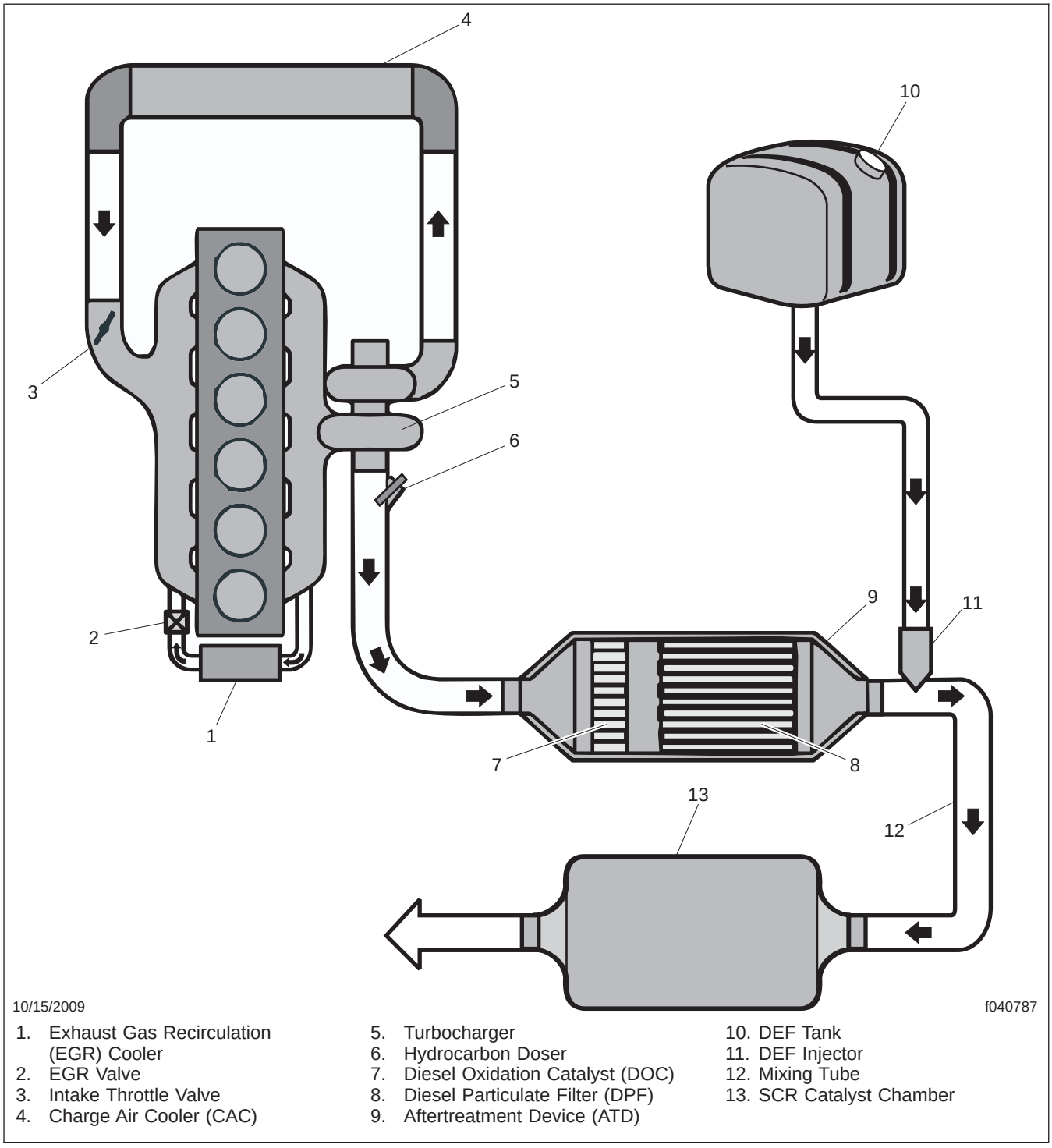
**Regeneration (Regen)** A process that occurs inside the ATD whereby accumulated soot is superheated and burned to ash, carbon dioxide, and water.

**Selective Catalytic Reduction (SCR)** A vehicle emissions control technology to reduce diesel engine emissions for passenger cars, and light and heavy-duty trucks.

**ULSD (Ultra-Low Sulfur Diesel) Fuel** A clean burning diesel fuel containing a maximum of 15-ppm sulfur. To meet EPA requirements, all highway diesel fuel sold in the U.S. must be ULSD.

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1. Exhaust Gas Recirculation (EGR) Cooler
2. EGR Valve
3. Intake Throttle Valve
4. Charge Air Cooler (CAC)
5. Turbocharger
6. Hydrocarbon Doser
7. Diesel Oxidation Catalyst (DOC)
8. Diesel Particulate Filter (DPF)
9. Aftertreatment Device (ATD)
10. DEF Tank
11. DEF Injector
12. Mixing Tube
13. SCR Catalyst Chamber

**Fig. 3, EPA10 ATS (Detroit Diesel engine shown)**

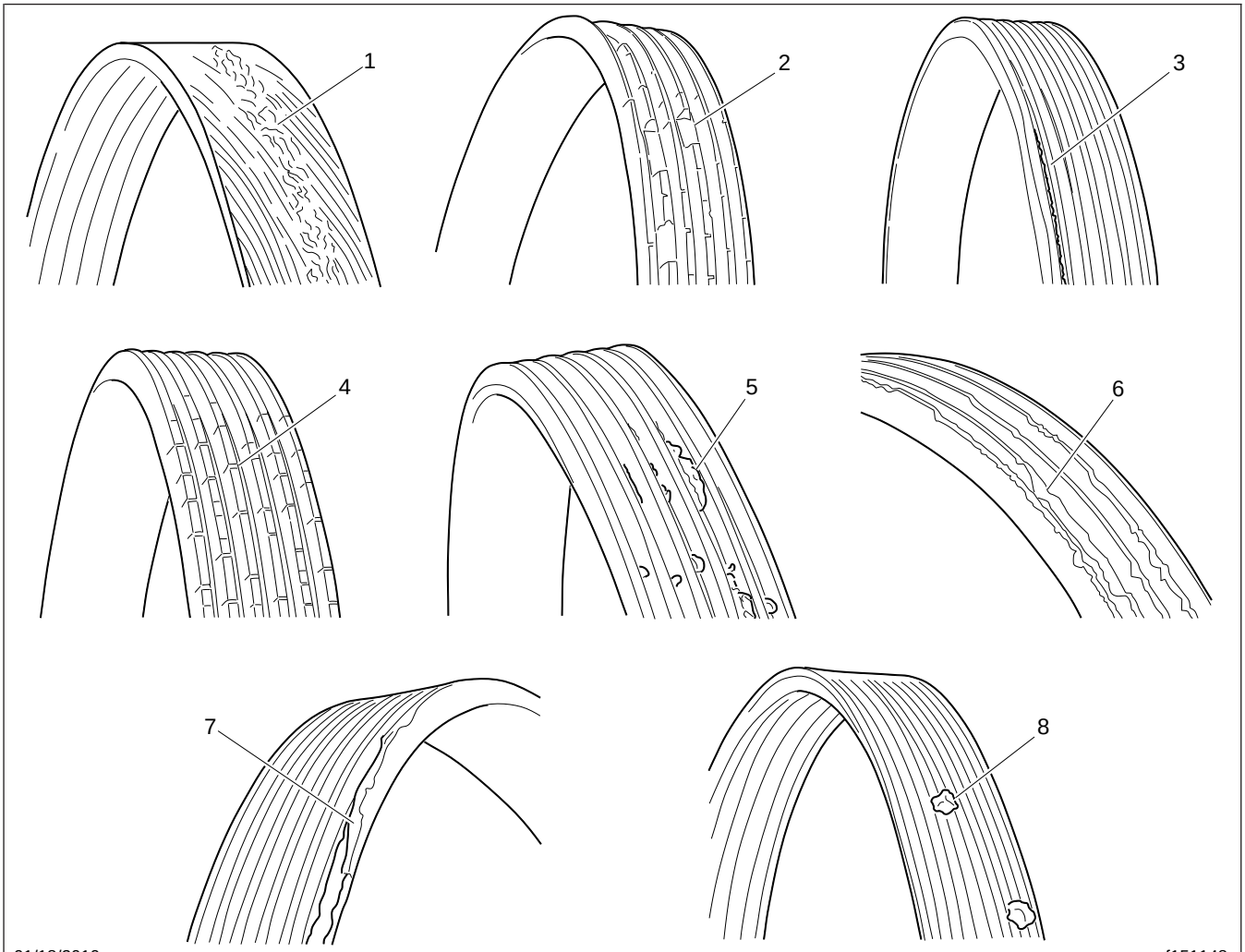
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## Pulley and Drive Belt Inspection

## Inspection

1. Inspect the belt contact surfaces for chips, flaking, cracks, discoloration, and other damage. See **Fig. 1**.
2. Inspect the bearings in the idler pulleys, and accessories, by rotating the pulleys to look for bearing slop, or choppy feeling bearings.
3. Inspect the springs on the belt tensioner. If the spring is damaged, change the belt tensioner following the engine manufacturer's instructions.
4. Inspect the pulleys for damage. If the pulleys are damaged, change both the damaged pulley and the belt. See **Fig. 2**.




1. Abrasion
2. Chunk-out
3. Improper Install
4. Cracking
5. Pilling
6. Uneven Rib Wear
7. Misalignment
8. Gravel Penetration

**Fig. 1, Damaged Belts**

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## Pulley and Drive Belt Inspection

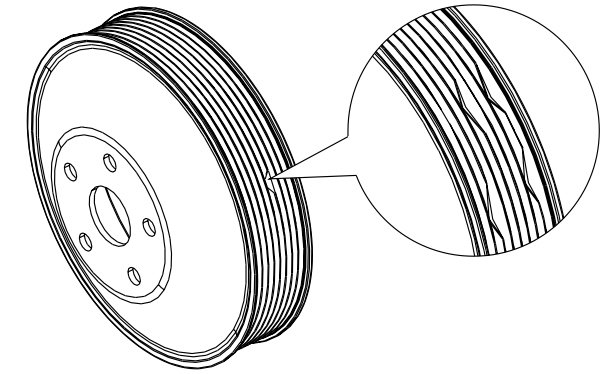
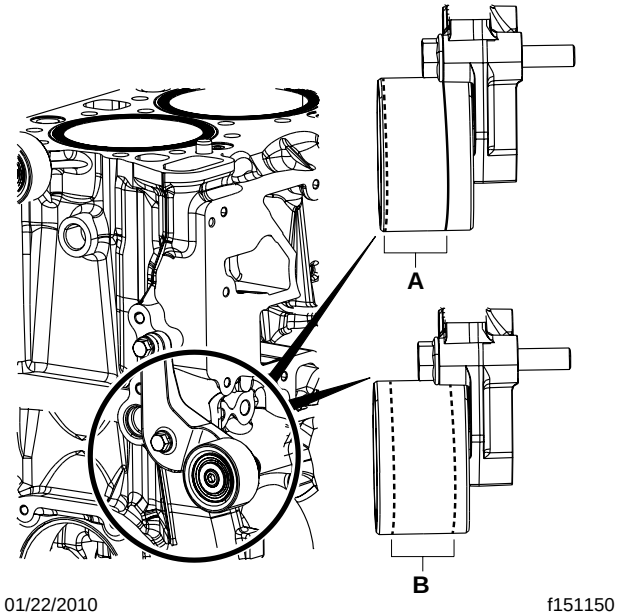



**Fig. 2, Damaged Pulley**

5. Check the belt allignment on all idler pulleys. If the alignment is incorrect as shown in **Fig. 3**, and pulley wear is visible, replace the pulley and bracket.




A. Incorrect Belt-Alignment Area
B. Correct Belt-Alignment Area

**Fig. 3, Idler-Pulley Belt Alignment**

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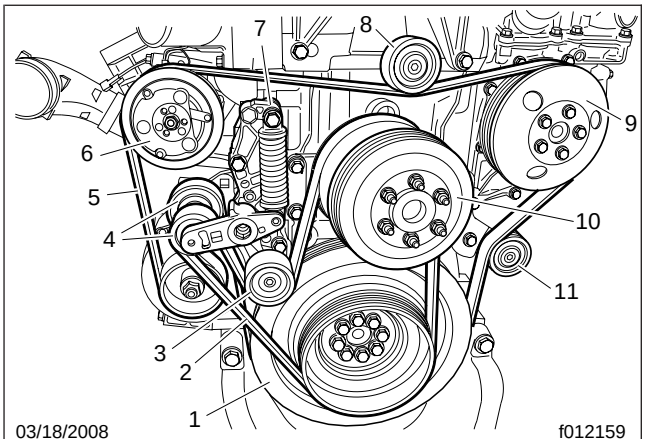


# Drive Belt Replacement, DD13/15/16 Engines

Detroit Diesel engines are equipped with two serpentine poly-V drive belts. The rear belt (closest to the engine block surface) drives the alternator, the A/C compressor, and the water pump. The front belt drives the engine fan. Both drive belts are kept at the correct tension with pulleys and a dual automatic belt-tensioner assembly. See **Fig. 1**.

## NOTICE

**When replacing the drive belts for the DD engine, it is crucial to use the correct procedure for releasing and locking the belt tensioners. Because they are part of the same assembly, it may appear that both belt tensioners can be released at the same time by releasing just one, but this is not the case. They must be released and locked separately, and in the correct sequence, or the assembly may be damaged.**

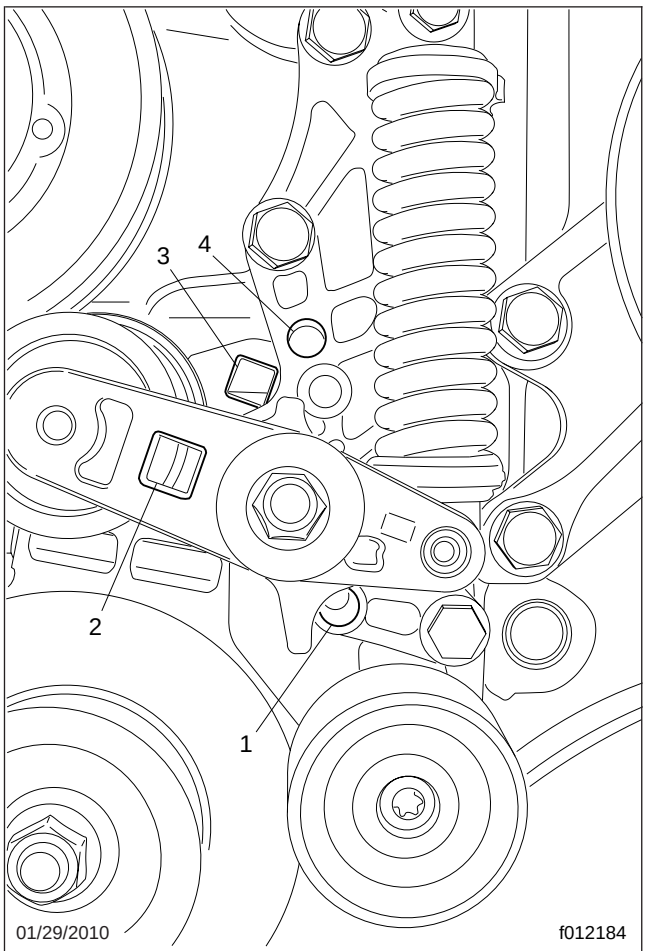



1. Crankshaft Vibration Damper
2. Front Poly-V Drive Belt
3. Idler Pulley
4. Tensioner Pulleys (front is grooved; rear is smooth)
5. Rear Poly-V Drive Belt
6. A/C Compressor
7. Dual Automatic Belt Tensioner Assembly
8. Idler Pulley
9. Water Pump
10. Fan Pulley and Clutch
11. Idler Pulley

**Fig. 1, DD15 Drive Belt Configuration**

## Replacement

1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Disconnect the batteries at the negative terminals.
3. Raise the hood.
4. Locate the automatic belt tensioner assembly, on the left (passenger) side of the engine, as you are facing it. Familiarize yourself with the location of the square, front and rear 1/2-inch drive holes, and the round, front and rear holes for the locking bolts. See **Fig. 2**.




1. Front Round Hole for 10 mm Locking Bolt
2. Front Square1/2-inch Drive Hole
3. Rear Square 1/2-inch Drive Hole
4. Rear Round Hole for 10 mm Locking Bolt

**Fig. 2, Belt Tensioners Assembly**

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## Drive Belt Replacement, DD13/15/16 Engines

### NOTICE

**Never rotate the automatic belt tensioners clockwise. To do so may damage them, and require replacement of the entire assembly. To prevent damage to the belt tensioners, always rotate them counterclockwise. Never use more force than 66 to 73 lbf (90 to 100 N), or you could damage the tensioner.**

IMPORTANT: When releasing the automatic belt tensioners and removing the drive belts, always work on the front tensioner and belt (fan drive) first, then the rear tensioner and belt (alternator, A/C compressor, and water pump). When you unlock the belt tensioners, reverse the procedure; unlock the rear belt tensioner first, then front one.

5. Insert a 1/2-inch breaker bar, or 1/2-inch ratchet into the square hole in the idler arm of the front belt tensioner (grooved pulley), then smoothly rotate it downward (counterclockwise) until you feel resistance. See **Fig. 3**.

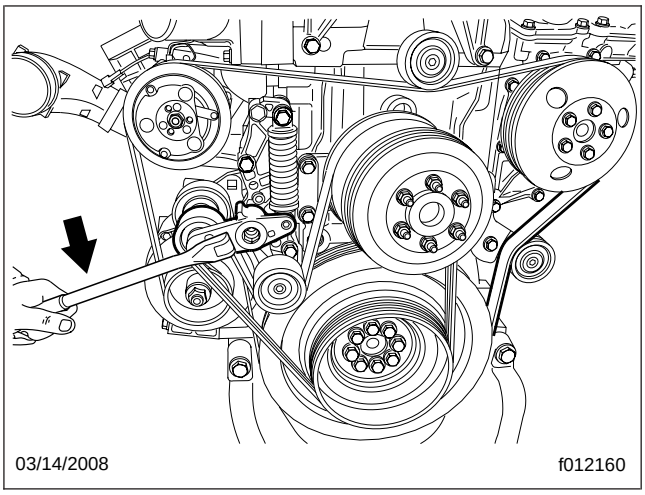
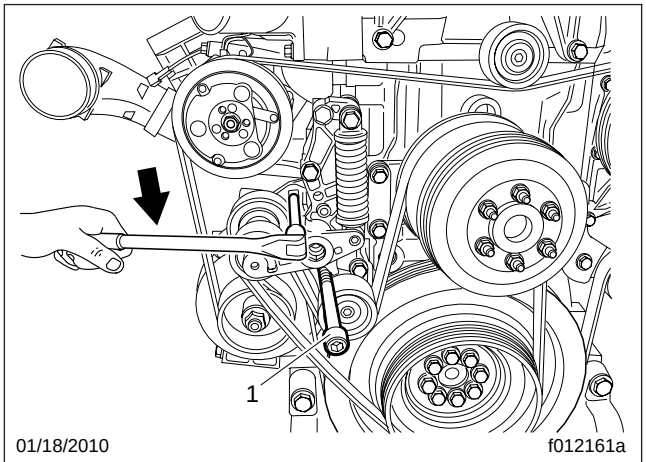



**Fig. 3, Releasing the Front Tensioner**

6. Insert a 10 mm diameter x 80 mm long bolt into the round hole on the idler arm of the tensioner as shown in **Fig. 4**, then push it all the way in. After the bolt is pushed all the way in, the tensioner will be locked in the released position. Remove the socket wrench from the square hole.
7. Insert a 1/2-inch breaker bar, or 1/2-inch ratchet, into the square hole in the idler arm of the rear belt tensioner (smooth pulley), then smoothly rotate it downward (counterclockwise) until you feel resistance. See **Fig. 4**.




Note: To show the location of the locking bolt, it is shown in position but not pushed all the way in.

1. Locking Bolt Position for Front Belt Tensioner

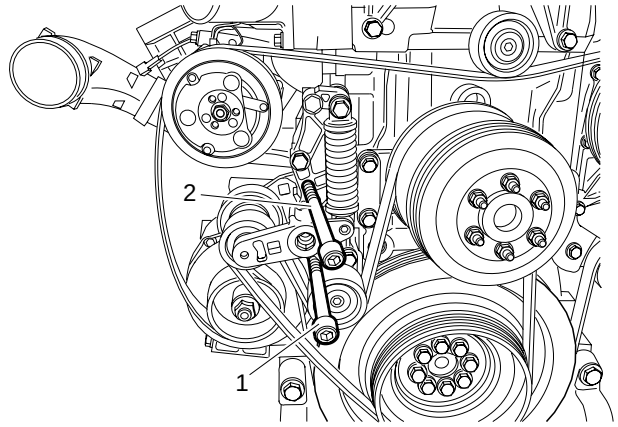
**Fig. 4, Releasing the Rear Tensioner (smooth pulley)**

8. Insert a second 10 mm diameter x 80 mm long bolt into the round hole on the idler arm of the rear tensioner as shown in **Fig. 5**, then push it all the way in. After the bolt is pushed all the way in, the tensioner will be locked in the released position. Remove the wrench from the square hole.
9. Replace the drive belts, making sure the new belts are correctly installed on all the pulleys.
10. Using the 1/2-inch breaker bar, or 1/2-inch ratchet, rotate the idler arm on the rear (smooth pulley) tensioner downward (counterclockwise), until you can remove the locking bolt. Smoothly release the idler arm all the way up, being careful not to jerk it.
11. In the same manner as the previous step, remove the locking bolt from the front tensioner.
12. Do a final check to make sure both drive belts are configured correctly, and correctly installed on all the pulleys.
13. Close the hood, connect the batteries, then remove the chocks.

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## Drive Belt Replacement, DD13/15/16 Engines




Note: To show the location of the locking bolts, they are shown in position but not pushed all the way in.

1. Locking Bolt for Front Belt Tensioner
2. Locking Bolt for Rear Belt Tensioner

**Fig. 5, Position for Locking Bolts**

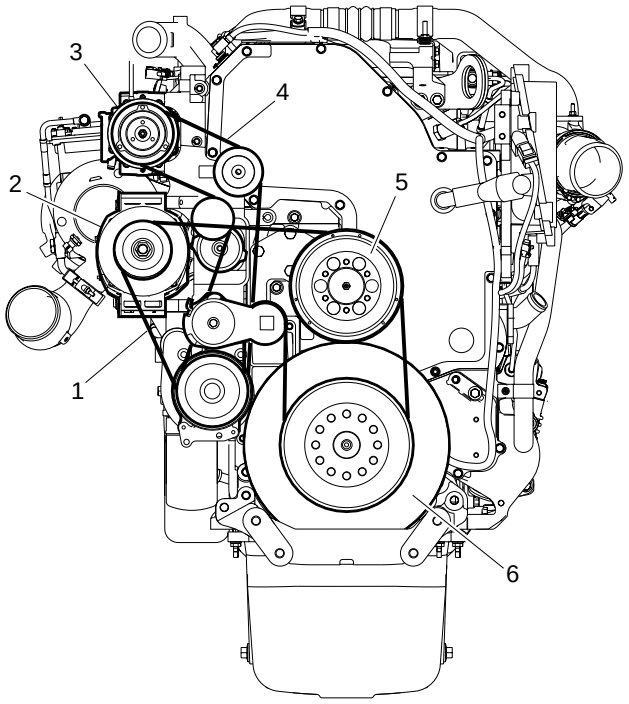
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# Drive Belt Replacement, Cummins Engines

## Cummins ISX

Cummins ISX engines are equipped with two serpentine poly-V drive belts, and two automatic belt tensioners. The accessory drive belt drives the fan, alternator, and water pump. The A/C drive belt drives the A/C compressor. See **Fig. 1**. The drive belts are kept at the correct tension by a system of pulleys and two automatic belt tensioners.




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1. Accessory Drive Belt
2. Alternator
3. A/C Compressor
4. A/C Drive Belt
5. Fan Drive
6. Crank Shaft Pulley

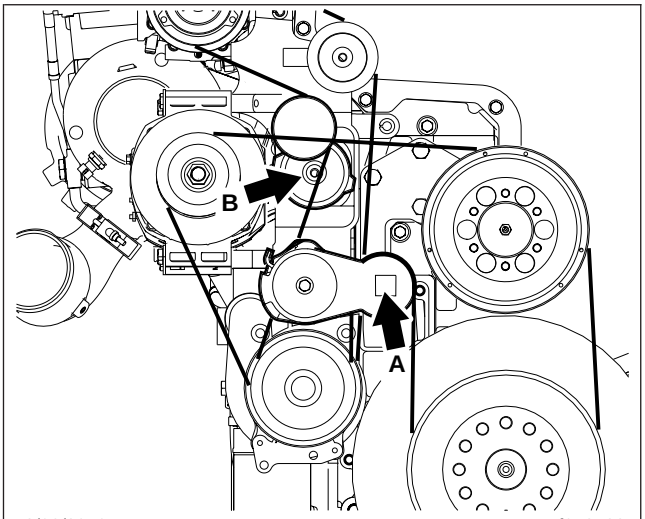
**Fig. 1, Cummins ISX Drive Belt Routing**

## Belt Replacement

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Disconnect the batteries at the negative terminals.
3. Raise the hood.

IMPORTANT: When replacing drive belts on the Cummins ISX engine, the accessory drive belt must be removed before you can remove the A/C drive belt.

4. Locate the accessory drive belt tensioner on the left (passenger) side of the engine. Insert a 1/2-inch ratchet, or 1/2-inch breaker bar end, into the pivot point on the small end of the tensioner. See **Fig. 2**. Pull up on the wrench, turning the tensioner clockwise until resistance is felt, and the tensioner is released.




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A. Pivot Point for Accessory Drive Belt Tensioner (rotate clockwise with a 1/2-inch ratchet or breaker bar end)
B. Pivot Point for A/C Drive Belt Tensioner (rotate counterclockwise with a 15-mm box wrench)

**Fig. 2, Releasing the Tensioners**

5. With the tensioner released, remove the accessory drive belt, then smoothly return the tensioner to its original position.

### NOTICE

**Never allow the tensioner to slam back against the stop, or damage may occur.**

6. Using a 15-mm box wrench on the pivot bolt of the A/C drive belt tensioner, apply pressure downward, turning the tensioner counterclockwise until resistance is felt. See **Fig. 2**.

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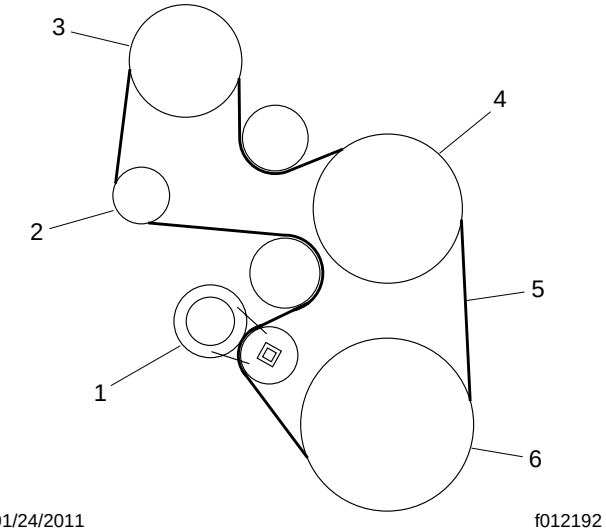


## Drive Belt Replacement, Cummins Engines

7. With the tensioner released, replace the A/C drive belt, making sure it is correctly installed on the pulleys. Smoothly return the tensioner to its original position.
8. Release the tensioner from the accessory drive belt again (refer to Step 4), then install a new accessory drive belt. Smoothly return the tensioner to its original position.
9. Perform a final check to make sure both drive belts are routed correctly, and centered on the pulleys.
10. Start the engine, standing clear of belts and accessories. Check the belt tracking on all pulleys to ensure correct belt operation.
11. Close the hood and connect the batteries.

# Cummins ISC/ISL

Cummins ISC/ISL engines are equipped with one serpentine, poly-V drive belt. See **Fig. 3**. The drive belt is kept at the correct tension by a system of pulleys and an automatic belt tensioner.

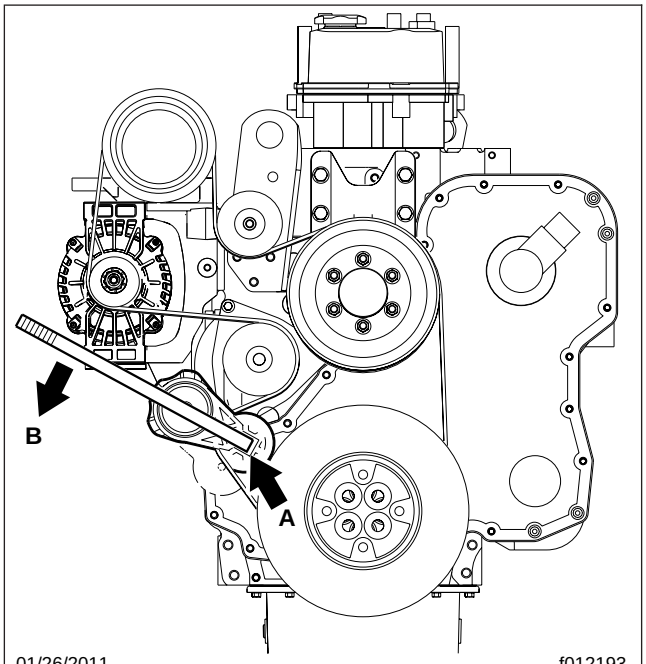



1. Belt Tensioner
2. Alternator
3. A/C Compressor
4. Fan Clutch
5. Drive Belt
6. Crank Shaft Pulley

**Fig. 3, Cummins ISC/ISL Drive Belt Routing**

## Belt Replacement

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Disconnect the batteries at the negative terminals.
3. Raise the hood.
4. Locate the belt tensioner on the left (passenger) side of the engine. Insert a 1/2-inch ratchet, or 1/2-inch breaker bar end, into the pivot point on the small end of the tensioner. See **Fig. 4**. Push downward on the breaker bar, rotating the tensioner counter clockwise until resistance is felt and the tensioner is released.




A. Insert Breaker Bar at Pivot Point
B. Push Downward

**Fig. 4, Releasing the Tensioner**

5. With the tensioner released, remove the drive belt.
6. Install a new drive belt, ensuring it is routed correctly, and centered on the pulleys. Smoothly return the tensioner to its original position.

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## Drive Belt Replacement, Cummins Engines

### NOTICE

**Never allow the tensioner to slam back against the stop, or damage may occur.**

7. Start the engine, standing clear of belts and accessories. Check the belt tracking on all pulleys to ensure correct belt operation.
8. Close the hood and connect the batteries.

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## Removal and Installation, 4900/6900 Models

# Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake.
2. Chock the tires and open the hood.

**WARNING**

**Do not operate the engine with any component of the air intake system removed. Serious physical injury can occur if the turbocharger impeller is touched when it is rotating.**

**NOTICE**

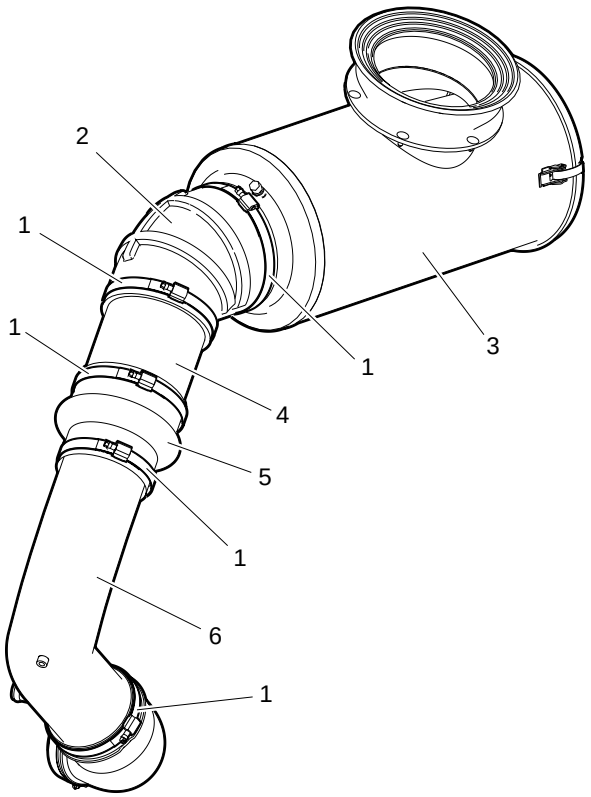
**Do not operate the vehicle with the air filter element or any air intake component removed. All air intake components and connections must be air- and water-tight. Dirt or dust entering the engine can cause internal engine damage. Most of the dirt and dust particles are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners.**

NOTE: Various configurations of the air intake assembly are available. The air intake ducting assembly may consist of multiple parts, including the duct, one or more hump hoses, and one or more elbows. See **Fig. 1** for a typical configuration.

3. Remove the hose clamps that attach the air intake duct assembly to the air cleaner and the turbocharger. If the vehicle is equipped with dual air cleaners, loosen the clamps on the second air cleaner.
4. Remove the air compressor suction hose, if equipped.
5. Disconnect the air restriction indicator hose, if equipped.
6. Remove the air intake duct assembly.

# Installation

1. Determine which new air intake duct assembly to install. Use PartsPro® to determine specific part numbers.




06/30/2011 f090487

1. Hose Clamps
2. Elbow
3. Air Cleaner
4. Air Intake Connector
5. Hump Hose
6. Air Intake Duct

**Fig. 1, Common Air Intake Configuration**

2. Inspect the new air intake duct assembly for debris that may have collected during shipping. Remove any debris or dirt before installation.
3. Install the air intake duct assembly between the air cleaner and the turbocharger. If the vehicle is equipped with more than one piece of air intake ducting, install the elbows, hump hoses, and duct between the air cleaner and the turbocharger.

   P80® Rubber Lubricant Emulsion, or equivalent rubber lubricant, should be used to ease assembly.

NOTE: To locate your local International Products Corporation distributor, call 1-609-386-877 or visit **www.ipcol.com**.

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## Removal and Installation, 4900/6900 Models

4. Check the duct assembly for any interference or contact with adjacent components. Loosen and adjust as necessary.

NOTE: Be sure all hose connections are square and have proper overlap before tightening the clamps.

5. Tighten the hose clamps 90 to 100 lbf·in (1017 to 1130 N·cm).
6. Connect the air restriction indicator hose, if equipped.
7. Connect the air compressor suction line, if equipped, to the air compressor outlet on the duct.
8. Start the engine and bring it up to operating temperature, then shut the engine down. Check all clamps for correct torque value.

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## Removal and Installation, 4700 Models

## Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake.
2. Chock the tires and open the hood.

**⚠ WARNING**

**Do not operate the engine with any component of the air intake system removed. Serious physical injury can occur if the turbocharger impeller is touched when it is rotating.**

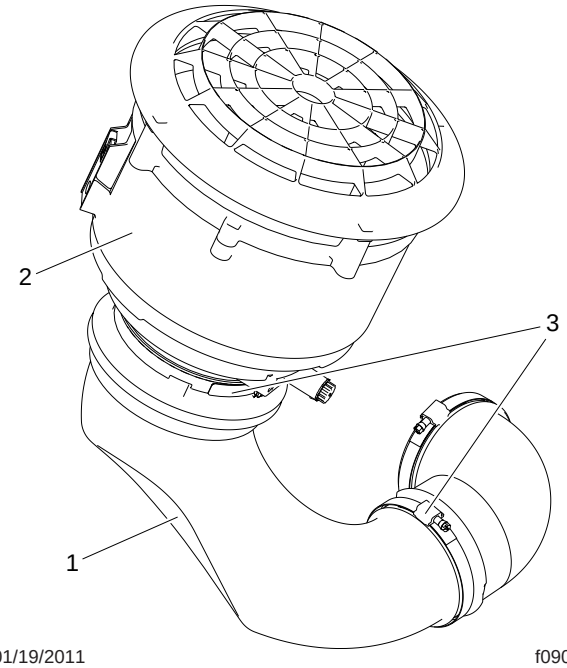
**NOTICE**

**Do not operate the vehicle with the air filter element or any air intake component removed. All air intake components and connections must be air- and water-tight. Dirt or dust entering the engine can cause internal engine damage. Most of the dirt and dust particles are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners.**

3. Remove the hose clamps that attach the air intake duct assembly to the air cleaner and the turbocharger. See **Fig. 1**.
4. Remove the air compressor suction hose, if equipped.
5. Disconnect the air restriction indicator hose, if equipped.
6. Remove the air intake duct.

## Installation

1. Determine which new air intake duct assembly to install. Use PartsPro® to determine specific part numbers.
2. Inspect the new air intake duct assembly for debris that may have collected during shipping. Remove any debris or dirt before installation.
3. Install the air intake duct on each connection so that it overlaps by at least 1 inch (25 mm). P80® Rubber Lubricant Emulsion, or equivalent rubber lubricant, should be used to ease assembly.




1. Air Intake Duct
2. Air Cleaner
3. Hose Clamps

**Fig. 1, Air Intake Duct Assembly**

NOTE: To locate your local International Products Corporation distributor, call 1-609-386-877 or visit **www.ipcol.com**.

4. Check the duct for any interference or contact with adjacent components. Loosen and adjust as necessary.

NOTE: Be sure all hose connections are square and have proper overlap before tightening the clamps.

5. If the elbow to the turbocharger was removed, install it and tighten the clamp 95 lbf·in (1074 N·cm).

   Tighten the air cleaner hose clamp per the specs below:

   - Plastic duct: 40 lbf·in (450 N·cm)
   - Metal duct: 95 lbf·in (1074 N·cm)

6. Connect the air compressor suction line, if equipped, to the air compressor outlet on the duct.

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## Removal and Installation, 4700 Models

7. Connect the air restriction indicator hose, if equipped.
8. Start the engine and bring it up to operating temperature, then shut the engine down. Check all clamps for correct torque value.

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## NOTICE

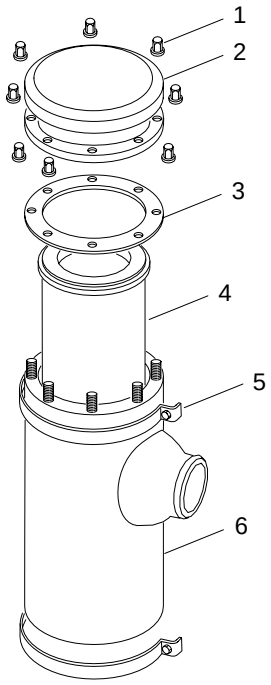
**All air intake components and connections must be air- and water-tight. Dirt or dust entering the engine can cause internal engine damage. Most of the dirt and dust particles are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners. Do not operate the engine with the air cleaner element or any air intake component removed.**

IMPORTANT: Do not modify, or use modified air cleaners or duct components.

NOTE: The air cleaner(s) may be installed on the cowl or on the frontwall. Use the appropriate replacement procedure below for the vehicle configuration. If the vehicle is equipped with dual air cleaners, replace both air cleaner elements at the same time.

# Cowl-Mounted Air Cleaner Element Replacement

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Check the air cleaner housing for damage, and check all ducts and connections for leakage. Adjust or replace parts as necessary.
3. Remove the capnuts that attach the cap to the air cleaner housing, and remove the cap. See **Fig. 1**. Inspect the capnuts for wear and replace them if necessary.
4. Remove the air cleaner element from the air cleaner housing.
5. Wipe the inside of the air cleaner housing with a clean, damp cloth. Check the housing and sealing surfaces for damage or dirt buildup that could cause sealing problems. Remove any dirt buildup.
6. Check the sealing area on the cap; see **Fig. 2**.
7. Check the surfaces outside the gaskets on both ends of the element. Make sure the gasket sealing surfaces of the air cleaner housing and cap are clean.
8. Remove and discard the air cleaner gasket.




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1. Capnut
2. Cap
3. Air Cleaner Gasket
4. Air Cleaner Element
5. Band Clamp
6. Air Cleaner Housing

**Fig. 1, Cowl-Mounted Air Cleaner Components**

9. Make sure the threaded studs on the air cleaner housing are clean and free of any gasket material, corrosion, or particles. Apply a light coating of oil to the threads on the studs.

## NOTICE

**Do not clean or reuse air filter elements. Cleaning and reusing the elements increases the chances of dirt entering the engine. Always replace with a new one.**

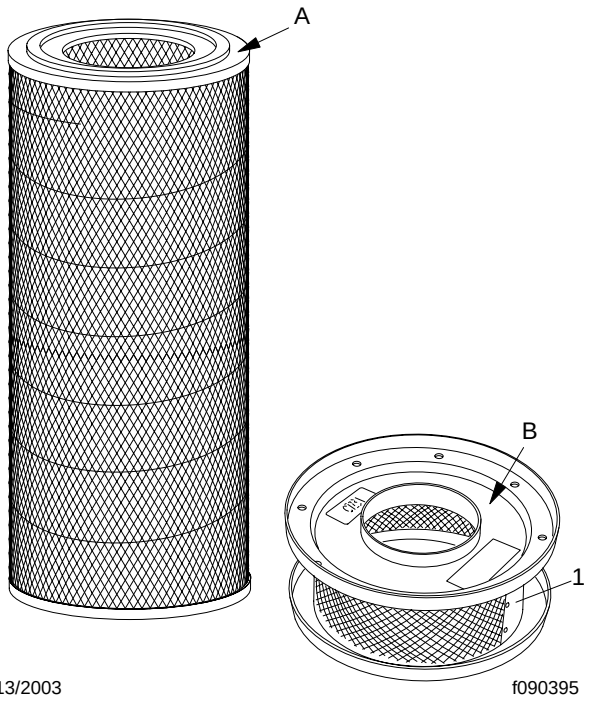
10. Inspect the new air cleaner element and gaskets for damage or holes. Install a new gasket on the air cleaner housing.
11. Install the new element in the housing and make sure that the bottom gasket seats firmly.

NOTE: The element will extend beyond the housing until the cap is installed and the capnuts are tightened.

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## Element Replacement




A. Check the surface outside the gasket.
B. Check the sealing area on the cap.

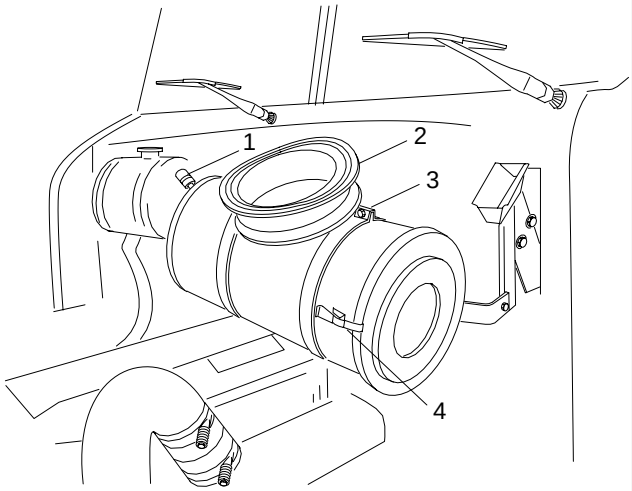
1. Unperforated Area of Cap

**Fig. 2, Air Cleaner Element and Cap**

12. Install the cap on the air cleaner housing so that the perforated area of the cap faces outboard and the shielded side faces inboard.
13. Secure the cap to the air cleaner housing by installing the four nuts on the hold-down bolts. Tighten the nuts 7 to 9 lbf·ft (10 to 12 N·m).
14. Press the reset button on the air restriction indicator. If the vehicle is not equipped with an air restriction indicator or a dash-mounted gauge, check that the 1/4-inch (6-mm) pipe plugs located in the air cleaner or in the piping just before the turbocharger are tight.

# Frontwall-Mounted Air Cleaner Element Replacement

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake.
2. Chock the tires and open the hood.
3. Check the air cleaner housing for damage, and check all ducts and connections for leakage. Adjust or replace parts as necessary.
4. Open the spring clamps on the air cleaner housing and remove the air cleaner cover.
5. Remove the air cleaner element from the air cleaner housing; see **Fig. 3**.




1. Air Restriction Indicator
2. Air Intake Boot
3. Band Clamp
4. Spring Clamp

**Fig. 3, Frontwall-Mounted Air Cleaner Components**

6. Wipe the inside of the air cleaner housing with a clean, damp cloth. Check the housing and sealing surfaces for damage or dirt buildup that could cause sealing problems. Remove any dirt buildup.

## NOTICE

**Do not clean or reuse air filter elements. Cleaning and reusing the elements increases the chances of dirt entering the engine. Always replace with a new one.**

7. Inspect the new air cleaner element for damage or holes.
8. Install the new element in the housing, making sure the element is properly seated in the housing. Be careful not to damage the paper pleats on the element.

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9. Place the air cleaner cover on the housing and close the spring clamps.
10. Press the reset button on the air restriction indicator.

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## NOTICE

**All air intake components and connections must be air- and water-tight. Dirt or dust entering the engine can cause internal engine damage. Most of the dirt and dust particles are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners. Do not operate the engine with the air cleaner element or any air intake component removed.**

IMPORTANT: Do not modify, or use modified air cleaners or duct components.

NOTE: The air cleaner(s) may be installed on the cowl or on the frontwall. Use the appropriate replacement procedure below for the vehicle configuration.

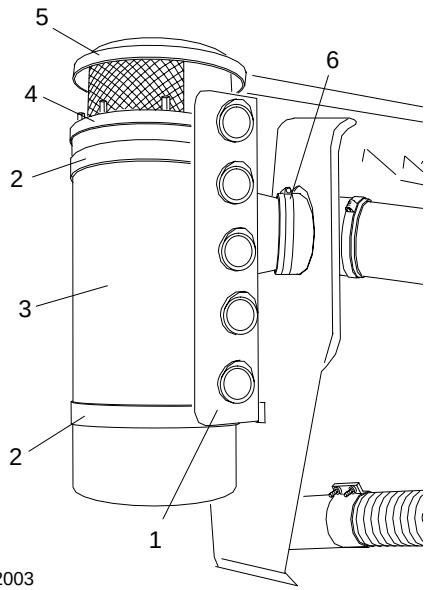
# Cowl-Mounted Air Cleaner

## Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Remove the screws and washers that attach the marker lights to the mounting brackets and remove the marker lights; see **Fig. 1**.
3. Loosen the clamp that secures the elbow to the air cleaner.
4. Remove the capscrews and washers that attach the band clamps to the mounting brackets.
5. Remove the air cleaner assembly from the elbow.

## Installation

1. Check the new air cleaner for damage, and check all ducts and connections for leakage. Adjust or replace parts as necessary.
2. Install the air cleaner on the elbow so that the perforated area of the cap faces outboard and the shielded side faces inboard. See **Fig. 1**.
3. Using capscrews and washers, secure the air cleaner by attaching the band clamps to the mounting brackets. Make sure the upper band clamp is not in contact with the flange on the air cleaner. See **Fig. 1**.
4. Tighten the clamp that secures the elbow to the air cleaner.
5. Using screws and washers, attach the marker lights to the mounting brackets.




1. Marker Lights
2. Band Clamp
3. Air Cleaner
4. Flange
5. Cap
6. Clamp

**Fig. 1, Cowl-Mounted Air Cleaner**

# Frontwall-Mounted Air Cleaner

## Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Remove the hose clamp that secures the elbow to the air cleaner outlet port. Disconnect the elbow from the air cleaner outlet. See **Fig. 2**.
3. Remove the capscrews, washers, and nuts that secure the band clamps around the air cleaner assembly.
4. Remove the air cleaner assembly.

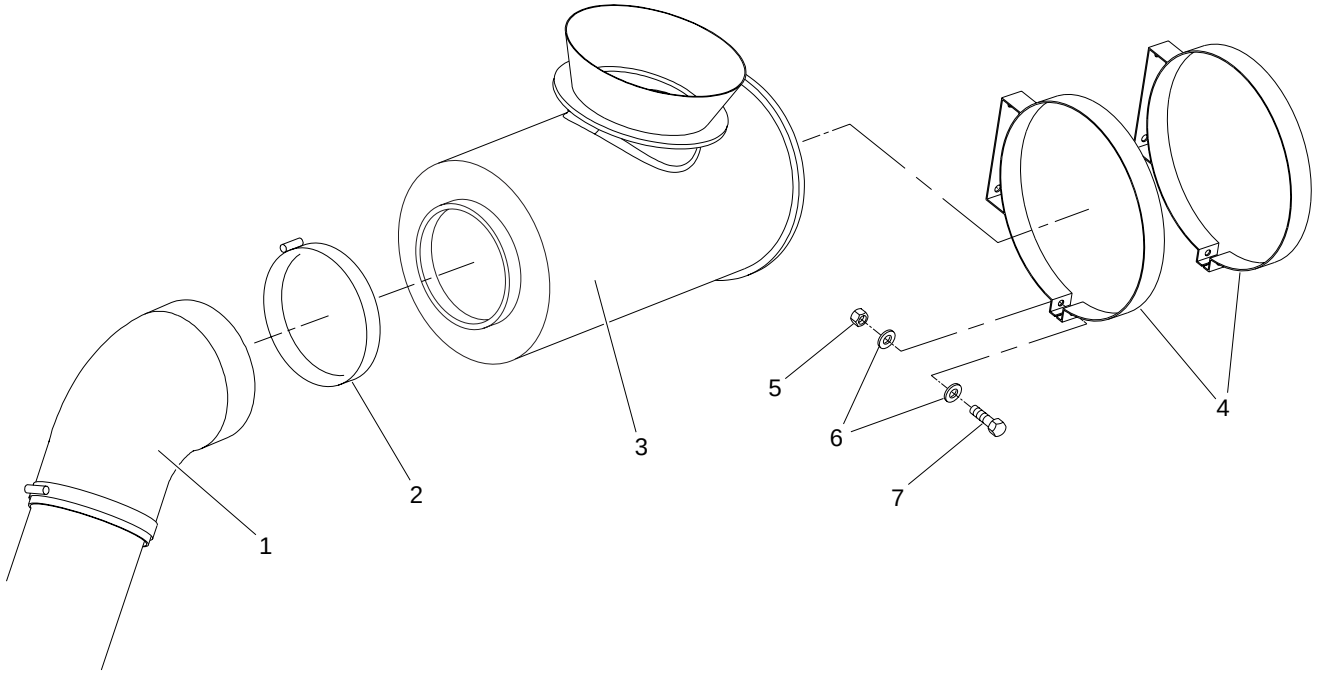
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## Assembly Removal and Installation

# Installation

1. Check the new air cleaner for damage, and check all ducts and connections for leakage. Adjust or replace parts as necessary.
2. Install the new air cleaner assembly on the mounting bracket, with the air cleaner inlet centered between the bands.
3. Install the mounting capscrews, washers, and nuts on the band clamps and tighten the band clamps 54 to 72 lbf·in (610 to 814 N·cm).
4. Install the elbow on the air cleaner outlet port.
5. Install the hose clamp and tighten it 90 to 100 lbf·in (1017 to 1130 N·cm).




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1. Elbow
2. Hose Clamp
3. Air Cleaner Housing
4. Band Clamps
5. Nuts (qty 2)
6. Washers (qty 4)
7. Capscrews (qty 2)

**Fig. 2, Air Cleaner Removal and Installation**

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## Restriction Checking

Restriction of air flow through the air cleaner element is measured at the tap in the air cleaner outlet. Check the restriction indicator at the air cleaner or in the cab if the vehicle is equipped with a dash-mounted restriction gauge.

### NOTICE

**Use the air intake restriction gauge rather than visual inspection to determine if servicing the air filter element is necessary. Removal of the air filter element can cause damage to the primary seal, which may allow contaminants into the engine, potentially causing engine damage.**

Vehicles may be equipped with either a manual-reset restriction indicator with graduations (**Fig. 1**), or a go/no-go restriction indicator without graduations (**Fig. 2**).

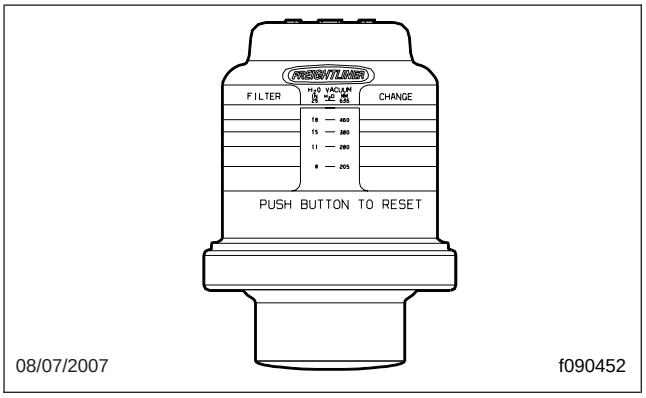



**Fig. 1, Manual-Reset Air Restriction Indicator, Graduated**

1. For vehicles equipped with a manual-reset indicator with graduations, check the indicator with the engine off to see if air restriction equals or exceeds the value shown in **Table 1** for maximum air restriction.

   For vehicles equipped with a go/no-go restriction indicator without graduations, check the indicator with the engine off to see if the colored bar shows through the clear window.

2. If air restriction is below the maximum, no further work is necessary.

   If air restriction is at or above the maximum, push the reset button on the indicator.

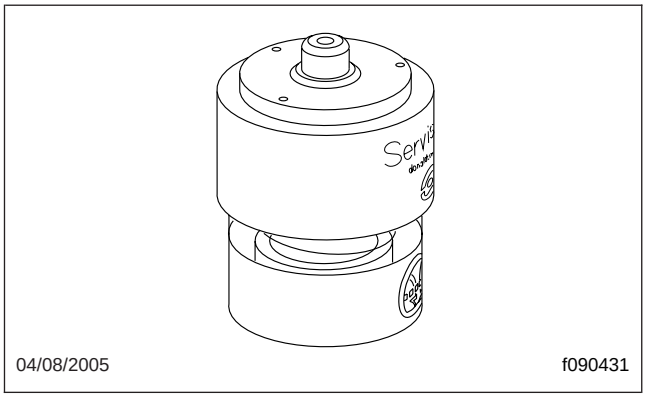



**Fig. 2, Manual-Reset Air Restriction Indicator, Go/No-Go**

3. Operate the engine to see if air restriction exceeds recommended values again. This can be done by running the vehicle on a dynamometer at **full-load and rated rpm**, or by driving the vehicle for one day in the vehicle's typical operating environment while not exceeding the rated rpm. See the engine manufacturer's service literature for information on rated rpm for your engine.
4. Check the indicator again. If air restriction continues to equal or exceed the maximum air restriction value in **Table 1** on an indicator with graduations, or if the colored bar shows through the clear window on a go/no-go indicator, replace the air cleaner element, then reset the indicator.

   For air cleaner element replacement instructions, see **Subject 100**.

| Air Cleaner Element Maximum Restriction | | |
|---|---|---|
| **Engine** | **Pre-EPA07 Engines** | **EPA07/EPA10 Engines** |
| Caterpillar | 25 in$H_2O$ | — |
| Cummins | 25 in$H_2O$ | 25 in$H_2O$ |
| Detroit Diesel | 20 in$H_2O$ | 22 in$H_2O$ |
| Mercedes-Benz | 22 in$H_2O$ | 22 in$H_2O$ |

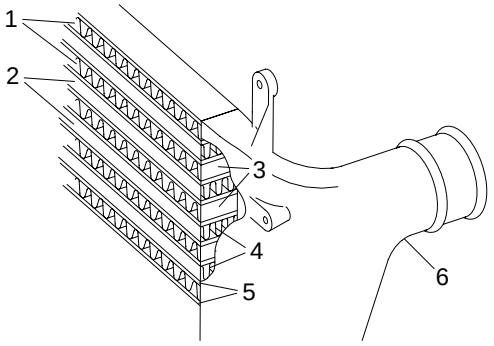
**Table 1, Air Cleaner Element Maximum Restriction**

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## General Information

The charge air cooler (CAC) is attached to the front of the radiator and is similar to a radiator. See **Fig. 1**. Outside ambient air passing through the CAC core cools the engine's intake air charge. The air charge leaving the turbocharger is hot compressed air, about 275 to 325°F (135 to 162°C), depending on the ambient temperature. The CAC reduces the air charge temperature before the air charge enters the engine intake manifold. This temperature decrease lowers exhaust emissions, improves fuel economy, and increases horsepower.




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1. Cold Fins
2. Hot Bars
3. Cold Bars
4. Hot Fins
5. Tube Plates
6. Header Tank

**Fig. 1, CAC Construction**

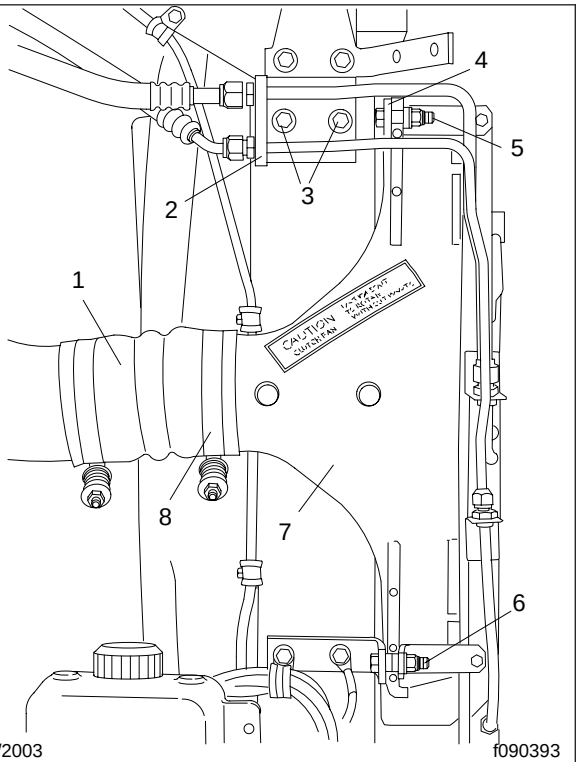
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## Pre-EPA07 CAC Removal and Installation

# Removal

1. Apply the parking brakes and chock the tires.
2. Remove the bolts that attach the recirculation shields to the mounting brackets. Remove the recirculation shields.
3. Remove the fasteners that attach the grille to the hood or radiator, and remove the grille.
4. Loosen the constant tension hose clamps at both ends of the convoluted hoses that attach the inlet and outlet air piping to the charge air cooler (CAC) connections. Push the clamps and hoses back onto the piping, until they are not touching the CAC connections. See **Fig. 1**.




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1. Convoluted Hose
2. Refrigerant Line Bracket
3. Capscrew and Washer
4. L-Shaped Bracket
5. Upper Mounting Bolt
6. Lower Mounting Bolt
7. CAC
8. Constant Tension Hose Clamp

**Fig. 1, CAC Assembly**

5. Allow extra slack in the refrigerant line by removing the refrigerant line bracket and L-shaped bracket from the right side of the radiator.
6. Remove the bolts that attach the condenser and CAC to the radiator. Remove the fasteners that attach the condenser to the CAC, and swing the condenser out of the way.
7. Remove the CAC.

# Installation

1. Install the two lower mounting bolts on the CAC mounting brackets.
2. Install the CAC on the lower mounting bolts.
3. Swing the A/C condenser around, and install it on the front of the CAC on the lower mounting bolts.
4. Attach the L-shaped bracket and refrigerant line bracket to the radiator.
5. Pull the convoluted hoses and constant tension hose clamps forward until the hoses cover the CAC tube ends up to the cast hose stops.
6. Turn the constant tension hose clamps so their tightening screws are under the hoses or facing inboard. Tighten the clamp screws 60 lbf·in (680 N·cm).

IMPORTANT: Vehicles built on or after February 26, 2007, have modified constant tension clamps that adjust to changes in diameter at the hose connection. When installing a new clamp or reinstalling a modified clamp, tighten the fastener 98 lbf·in (1100 N·cm). Do not retighten the clamp unless the measured torque drops below 50 lbf·in (560 N·cm), at which time it should be tightened again 98 lbf·in (1100 N·cm).

7. Attach the grille to the hood or radiator.
8. Attach the recirculation shields to the mounting brackets.

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## CAC Inspection and Leakage Test

# Inspection

1. Apply the parking brakes and chock the tires.
2. Check the charge air cooler (CAC) convoluted hoses and the inlet and outlet piping for holes or other damage. Also check for loose or damaged constant tension hose clamps. Replace damaged parts. If hose clamps are loose, turn them so their tightening screws are under the hoses or facing inboard. Tighten the screws 60 lbf·in (680 N·cm).

IMPORTANT: Vehicles built on or after February 26, 2007, have modified constant tension clamps that adjust to changes in diameter at the hose connection. When installing a new clamp or reinstalling a modified clamp, tighten the fastener 98 lbf·in (1100 N·cm). Do not retighten the clamp unless the measured torque drops below 50 lbf·in (560 N·cm), at which time it should be tightened again 98 lbf·in (1100 N·cm).

3. Check the CAC core fins. If the fins are bent, use a small pair of needlenose pliers or a small screwdriver to straighten them.
4. Check the CAC core for clogged fins. Use compressed air or water to dislodge any material restricting airflow through the core.
5. Perform the "CAC Core Leakage Test."

# CAC Core Leakage Test

Charge air coolers are designed in such a way that they may bleed an insignificant amount of air. The allowable leakage mentioned in **Table 1** represents a loss of less than 0.1 percent of charge airflow. Based on this rate, there should be no measurable loss of performance.

The CAC core leakage test should be performed using a CAC test kit, part number 5039, which can be purchased from Kent-Moore/SPX at 1–800–328–6657.

| Leakage Rate Specifications | | |
|---|---|---|
| **Engine** | **Pressure Drop in 15 Seconds: psi (kPa)** | **Start Pressure: psi (kPa)** |
| Caterpillar | 5 (34) | 30 (207) |
| Cummins | 7 (48) | 30 (207) |
| Detroit Diesel | 5 (34) | 25 (172) |
| Mercedes-Benz | 5 (34) | 30 (207) |

**Table 1, Leakage Rate Specifications**

1. Apply the parking brakes and chock the tires.
2. Connect the test equipment to the CAC core as follows. See **Fig. 1**.
   - 2.1 Remove the inlet and outlet air piping from the convoluted hoses that attach them to the CAC air inlet and air outlet.
   - 2.2 Slip a safety ring with thumbscrew over each convoluted hose and onto the CAC air inlet and air outlet. Turn the rings so the thumbscrews are facing outboard and the safety chains are inboard. Tighten the thumbscrews securely.
   - 2.3 Install an additional constant tension hose clamp on each convoluted hose.
   - 2.4 Install the test plug without an adapter in the CAC air inlet and turn the plug so the safety chain is inboard. Tighten each constant tension hose clamp 72 lbf·in (810 N·cm).
   - 2.5 Install the test plug with adapter in the CAC air outlet and turn the plug so the safety chain is inboard. Tighten each constant tension hose clamp 72 lbf·in (810 N·cm).

**⚠ WARNING**

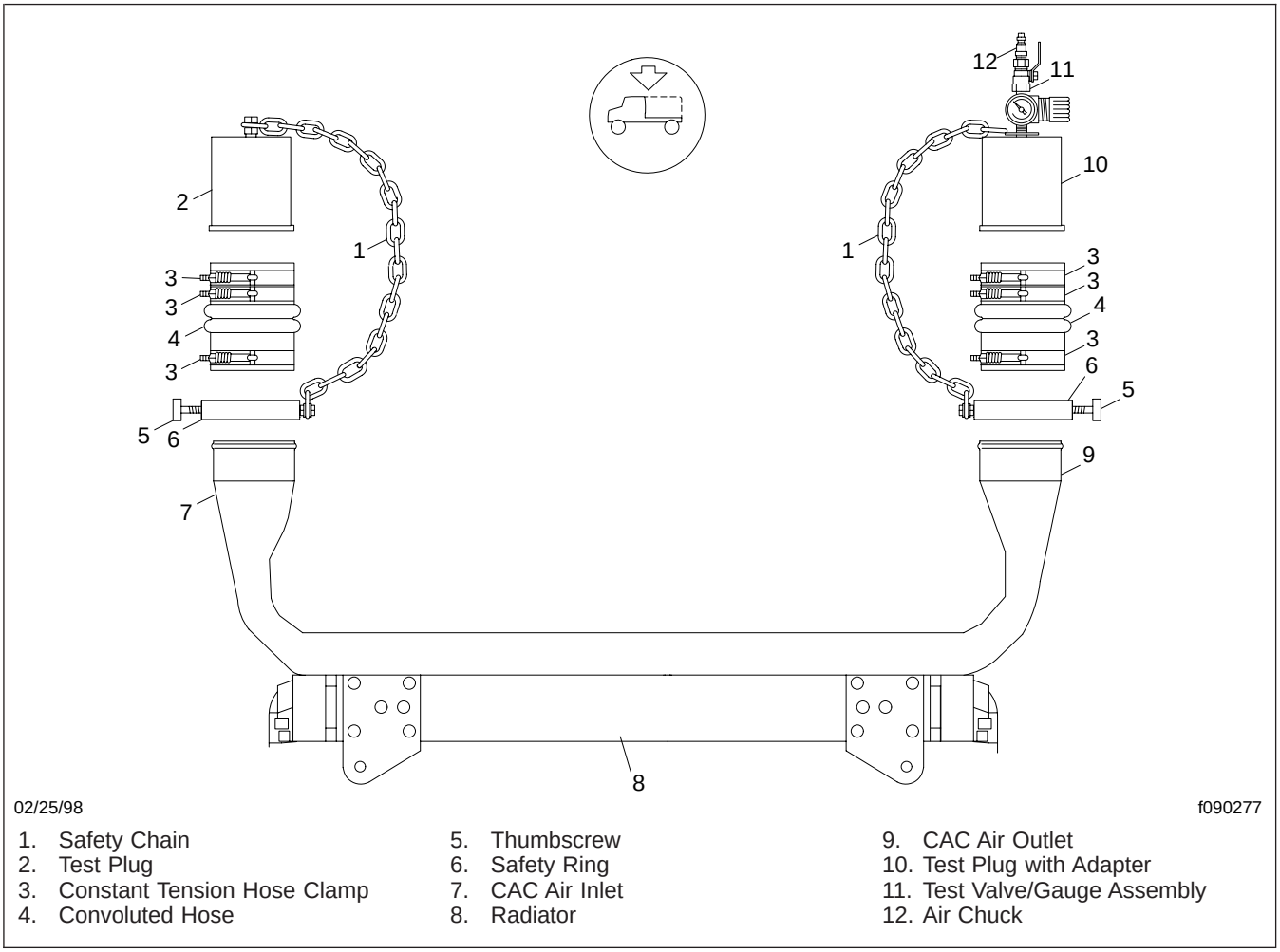
**Always secure the test plugs with the safety rings. Test pressures could blow out an unsecured test plug at high speed, possibly causing eye injury or other serious personal injury.**

   - 2.6 If not already installed, install a test valve/gauge assembly and air chuck in the test plug with adapter.
   - 2.7 Attach a pressurized air line to the air chuck on the pressure regulator valve.

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## CAC Inspection and Leakage Test




1. Safety Chain
2. Test Plug
3. Constant Tension Hose Clamp
4. Convoluted Hose
5. Thumbscrew
6. Safety Ring
7. CAC Air Inlet
8. Radiator
9. CAC Air Outlet
10. Test Plug with Adapter
11. Test Valve/Gauge Assembly
12. Air Chuck

**Fig. 1, CAC Core Testing**

3. Test the CAC core as follows.

**⚠ WARNING**

**Always wear safety glasses when doing this procedure. Do not stand in front of the test plugs while the core is pressurized. A plug could suddenly release debris at high speed, possibly resulting in eye injury or other serious personal injury.**

3.1 Open the test valve, then slowly open the pressure regulator valve and allow the CAC to gradually fill with air to the start pressure. See **Table 1**.

3.2 Close the test valve and watch the gauge for 15 seconds. If there is more than the specified drop in the CAC pressure in 15 seconds, replace the CAC. See **Table 1**.

IMPORTANT: Do not attempt to repair the CAC.

3.3 When testing is completed, reduce the pressure on the pressure regulator valve to bleed air from the CAC.

4. Remove the test equipment (and the additional constant tension hose clamps) from the convoluted hoses.
5. Pull the convoluted hoses and constant tension hose clamps rearward until the hoses cover

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about 1-1/2 inches (38 mm) of the CAC air inlet and air outlet piping.

6. Turn the clamps so their tightening screws are under the hoses or facing inboard. Tighten the screws 60 lbf·in (680 N·cm).

IMPORTANT: Vehicles built on or after February 26, 2007, have modified constant tension clamps that adjust to changes in diameter at the hose connection. When installing a new clamp or reinstalling a modified clamp, tighten the fastener 98 lbf·in (1100 N·cm). Do not retighten the clamp unless the measured torque drops below 50 lbf·in (560 N·cm), at which time it should be tightened again 98 lbf·in (1100 N·cm).

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## Flushing

If the charge air cooler (CAC) is suspected of being contaminated, flush the CAC.

1. Apply the parking brakes and chock the tires.
2. Remove the CAC. For instructions, see **Subject 100** for pre-EPA07 engines, or **Subject 140** for EPA07 engines.
3. Set the CAC in a horizontal position with the inlet and outlet ports facing up.

IMPORTANT: Use only naphtha or mineral spirits to clean the charge air cooler. Do not use caustic solutions such as those that are commonly used in radiator shops. Do not use steam or high-temperature cleaning operations. Caustic solutions, steam, and high-temperature cleaning operations will damage the RTV that seals the charge air cooler tubes to the headers, which may result in leaking.

4. Pour a filtered naphtha or mineral spirits solution into the CAC until it is 40 percent full.
5. Cap the inlet and outlet ports on the CAC.
6. Rock the CAC back and forth so that the solvent travels from one tank, through the tubes, to the other tank and back. Repeat this process ten times.

NOTE: Do not leave the solvent in the CAC for more than 10 minutes.

7. Remove the caps from the inlet and outlet ports.
8. Drain the CAC and properly dispose of the solvent.
9. Leave the caps off and allow the residual solvent to evaporate.
10. Install the CAC. For instructions, see **Subject 100** for pre-EPA07 engines, or **Subject 140** for EPA07 engines.

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## Restriction Test

After flushing the charge air cooler (CAC) because of turbocharger or engine damage, test the pressure drop across the CAC and air piping.

1. Remove the pipe plug (if equipped) from the tapped hole in the turbocharger air outlet elbow.

   Remove the pipe plug, or the nylon tube and atomizer for the ether start system (if equipped), or the air line to the turbocharger air-pressure gauge (if equipped), from the tapped hole in the left-hand rear of the intake manifold.

   Install an air pressure gauge in each tapped hole.

2. Operate the engine at rated speed and horsepower; there is no need to operate the engine at its peak torque rating. While operating the engine, read both air pressure gauges.

   Because of the turbulence of the air at the turbocharger outlet, subtract 0.3 inHg (1 kPa) from the pressure measurement taken at the turbocharger outlet, to make it a true reading.

   From that reading, subtract the reading taken at the intake manifold. This is the pressure drop of the CAC.

   If the pressure drop is more than 4 inHg (14 kPa), flush or replace the CAC as needed.

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## EPA07 CAC Removal and Installation

# Removal

1. Apply the parking brakes and chock the tires.
2. Remove the four corner fasteners that attach the grille and remove the grille, see **Fig. 1**. Open the hood.

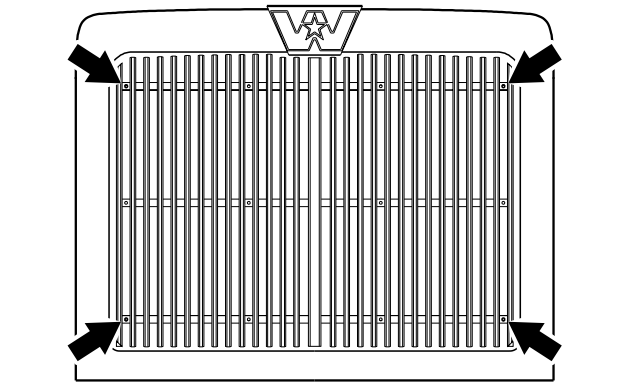
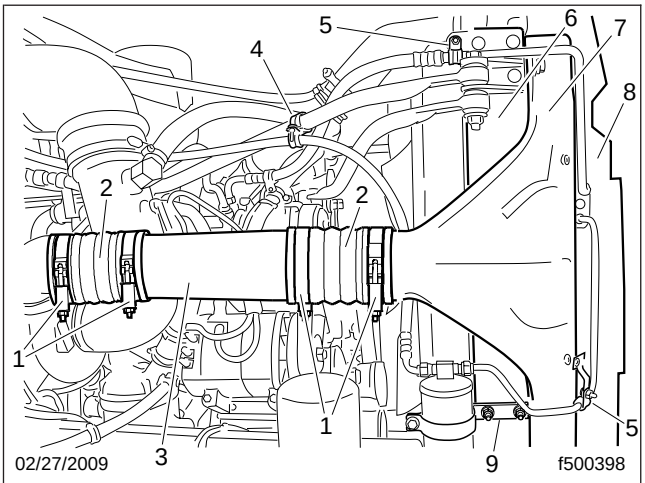



**Fig. 1, Grille Mounting Fasteners**

3. Remove the constant tension hose clamps from the convoluted hoses, see **Fig. 2**. Remove the convoluted hoses, then remove the charge air cooler (CAC) inlet and outlet air piping.
4. Remove the side air-recirculation baffles from the CAC.

NOTE: Do not open or remove any A/C hoses. Opening the A/C system is not necessary for this procedure.

5. Allow extra slack in the A/C condenser hoses by removing the receiver dryer mounting bracket and the A/C hose support clamps that secure the hoses near the right side of the radiator.
6. Remove the A/C condenser mounting fasteners, see **Fig. 3**.
7. With the A/C hoses still connected, swing the condenser around, and carefully set it on top of the right-side tire, see **Fig. 4**.
8. Loosen the two upper screws that hold the CAC to the radiator and completely remove the two lower screws.
9. Support the CAC, then remove the two upper screws.




1. Constant Tension Hose Clamp
2. Convoluted Hose
3. CAC Tube
4. A/C Line Clamp
5. A/C Line Support Clamp
6. Radiator
7. CAC
8. Side Air Recirculation Baffle
9. Receiver-Drier Mounting Bracket

**Fig. 2, CAC Side View**

10. While someone else supports the left side of the CAC, slightly raise the right side of the CAC. Then, with the left side held close to the radiator, pull the right side away from the cooling package. See **Fig. 5**.

# Installation

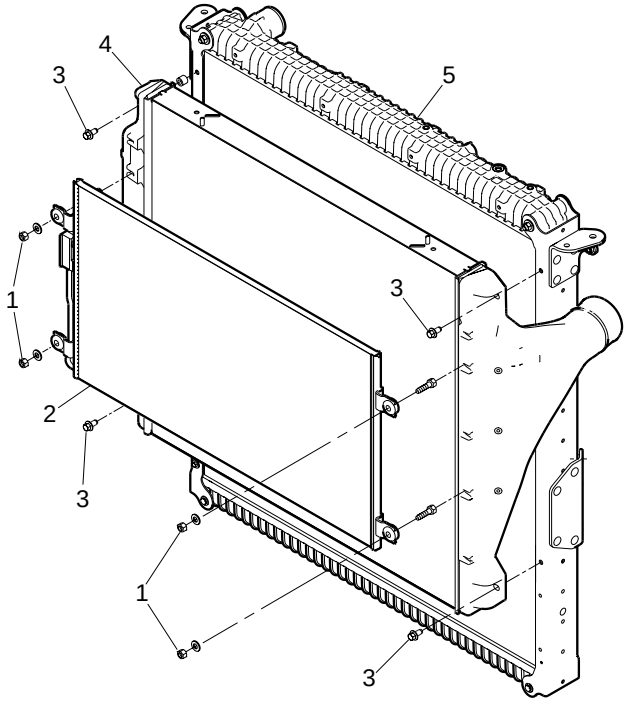
NOTE: Installing the CAC may be more difficult than removing it, and the fit may be tight. Be sure nothing hinders the fit between the CAC and the radiator.

1. With someone supporting the left side of the CAC, hook the left end tube on the cooling package, then adjust the angle of the CAC to allow the right end tube to slip past the cooling package frame.
2. Install the CAC mounting fasteners, see **Fig. 3**. Tighten all CAC mounting fasteners 52 to 59 lbf·ft (70 to 80 N·m).
3. Swing the A/C condenser around, and install it on the front of the CAC. Tighten the condenser mounting fasteners 12 lbf·ft (16 N·m). Install the

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## EPA07 CAC Removal and Installation




1. A/C Condenser Mounting Fastener
2. A/C Condenser
3. CAC Mounting Fastener
4. CAC
5. Radiator

**Fig. 3, CAC Removal**

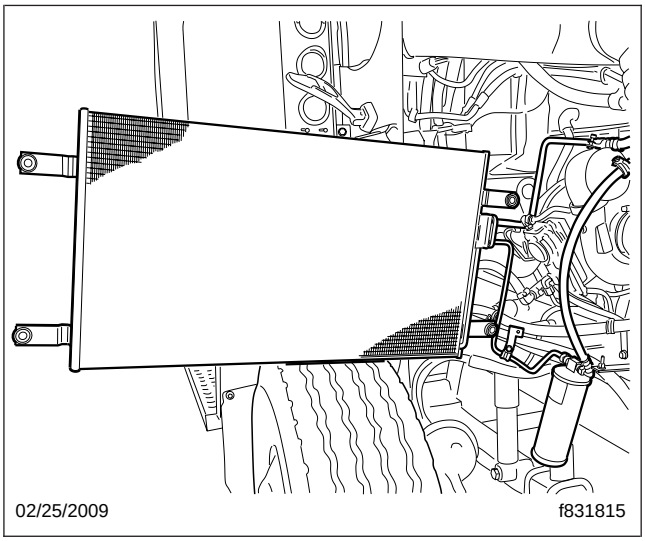



**Fig. 4, A/C Condenser Removal**

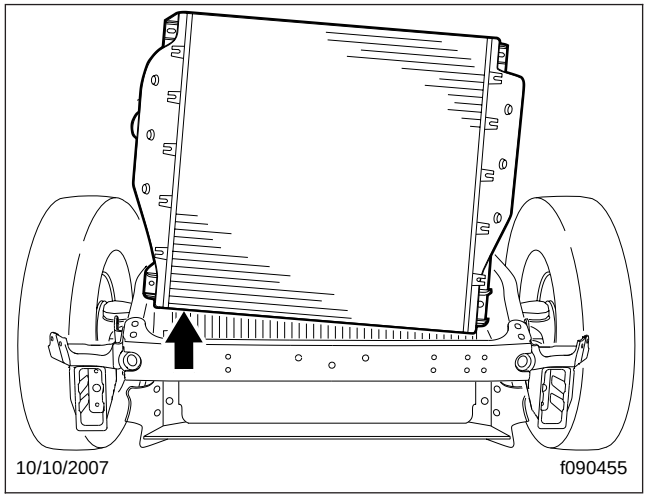



**Fig. 5, 47-Tube CAC Tilted for Removal, Front View**

receiver dryer mounting bracket and A/C condenser hose support clamps that were removed.

4. Install the side air-recirculation baffles on the CAC and tighten the fasteners 96 lbf·in (1080 N·cm).
5. Install the convoluted hoses on the CAC inlet and outlet air piping. Install the convoluted hose and piping assemblies on the charge air cooler, turbocharger, and engine intake manifold.
6. Install the constant tension hose clamps on the convoluted hoses. Turn the constant tension hose clamps so their tightening screws are under the hoses or facing inboard. Tighten the clamp screws 45 lbf·in (500 N·cm).

IMPORTANT: Vehicles built on or after February 26, 2007, have modified constant tension clamps that adjust to changes in diameter at the hose connection. When installing a new clamp or reinstalling a modified clamp, tighten the fastener 98 lbf·in (1100 N·cm). Do not retighten the clamp unless the measured torque drops below 50 lbf·in (560 N·cm), at which time it should be tightened again 98 lbf·in (1100 N·cm).

7. Close the hood and install the grille.

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## Removal

IMPORTANT: Do not modify, or use modified air cleaners or duct components.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake.
2. Chock the tires and open the hood.

### NOTICE

**All air intake components and connections must be air- and water-tight. Dirt or dust entering the engine can cause internal engine damage. Most of the dirt and dust particles are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners. Do not operate the engine with the air cleaner element or any air intake component removed.**

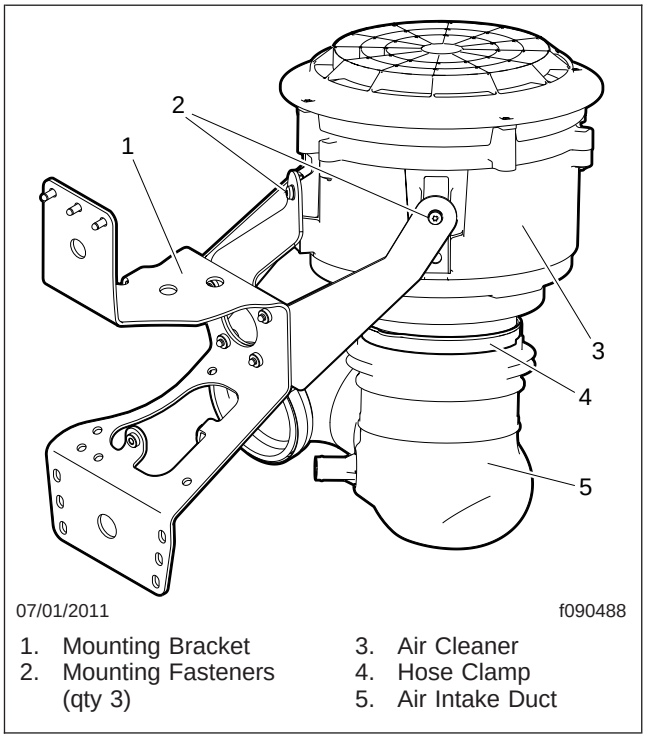
3. Remove the air restriction indicator or sensor, if equipped.
4. Loosen the hose clamp that attaches the air intake duct to the air cleaner outlet port, then pull the duct off the port. See **Fig. 1**.
5. Remove the three capscrews that attach the air cleaner to the air cleaner mounting bracket.

## Installation

1. Check the air cleaner housing for damage, and check all ducts and connections for leakage. Adjust or replace parts as necessary.
2. Using three capscrews, install the air cleaner housing on the mounting bracket.
3. Install the air intake duct on the air cleaner outlet port so that it overlaps by at least 1 inch (25 mm). P80® Rubber Lubricant Emulsion, or equivalent rubber lubricant, can be used to ease assembly.

NOTE: To locate your local International Products Corporation distributor, call 1-609-386-877 or visit **www.ipcol.com**.

4. Check the duct for any interference or contact with adjacent components. Loosen and adust as necessary.




1. Mounting Bracket
2. Mounting Fasteners (qty 3)
3. Air Cleaner
4. Hose Clamp
5. Air Intake Duct

**Fig. 1, Air Cleaner Installation**

5. Tighten the hose clamp at the air cleaner outlet 40 lbf·in (450 N·cm).
6. Install the air restriction indicator on the air cleaner, if equipped.

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## Replacement

IMPORTANT: Do not modify, or use modified air cleaners or duct components.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake.
2. Chock the tires and open the hood.

### NOTICE

**All air intake components and connections must be air- and water-tight. Dirt or dust entering the engine can cause internal engine damage. Most of the dirt and dust particles are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners. Do not operate the engine with the air cleaner element or any air intake component removed.**

3. Check the air cleaner housing for damage, and check all ducts and connections for leakage. Adjust or replace parts as necessary.
4. Remove the capscrews that secure the primary air cleaner element in the air cleaner housing.

   Remove the primary air cleaner element. See **Fig. 1**.

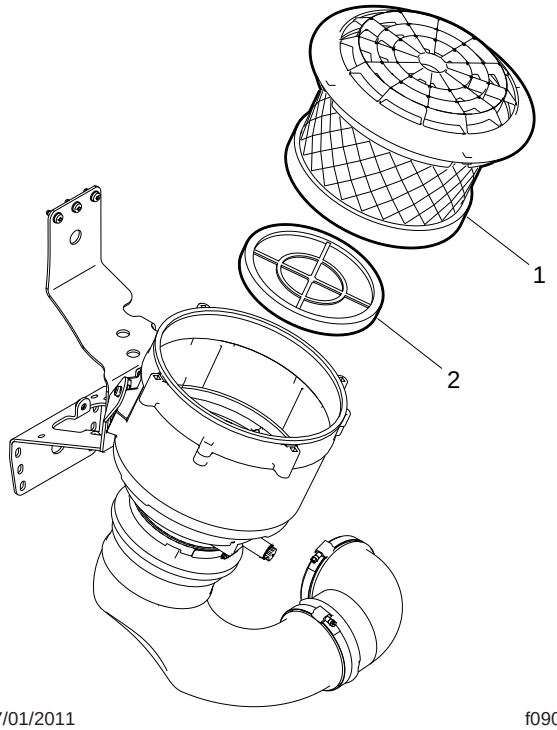
NOTE: The vehicle is equipped with either a stainless steel safety screen or a safety air cleaner element. Replace the safety screen or the safety element with every third primary air cleaner element replacement.

5. Remove the safety screen or element from the air cleaner and wipe the inside of the air cleaner with a clean, damp cloth. Check the housing and sealing surfaces for damage, dust, or foreign matter that could cause sealing problems. Clean surfaces or replace parts as necessary.

### NOTICE

**Do not clean or reuse air filter elements. Cleaning and reusing the elements increases the chances of dirt entering the engine. Always replace with a new one.**

6. Inspect the safety screen or element for damage. Replace if necessary, or according to the recommended maintenance interval (see the NOTE before step 5).




07/01/2011 f090489

1. Primary Air Cleaner Element
2. Stainless Steel Safety Screen or Safety Air Cleaner Element

**Fig. 1, Air Cleaner Elements**

7. Install the safety screen or element in the air cleaner housing.
8. Inspect the new primary air cleaner element for damage or holes.
9. Using capscrews, install the air cleaner element in the air cleaner housing. Tighten the capscrews 25 to 35 lbf·in (280 to 400 N·cm).
10. Check all connections for tightness.

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## Restriction Checking

Restriction of air flow through the air cleaner element is measured at the tap in the air cleaner outlet. Check the restriction indicator at the air cleaner or in the cab if the vehicle is equipped with a dash-mounted restriction gauge.

### NOTICE

**Use the air intake restriction gauge rather than visual inspection to determine if servicing the air filter element is necessary. Removal of the air filter element can cause damage to the primary seal, which may allow contaminants into the engine, potentially causing engine damage.**

Vehicles may be equipped with either a manual-reset restriction indicator with graduations (**Fig. 1**), or a go/no-go restriction indicator without graduations (**Fig. 2**).

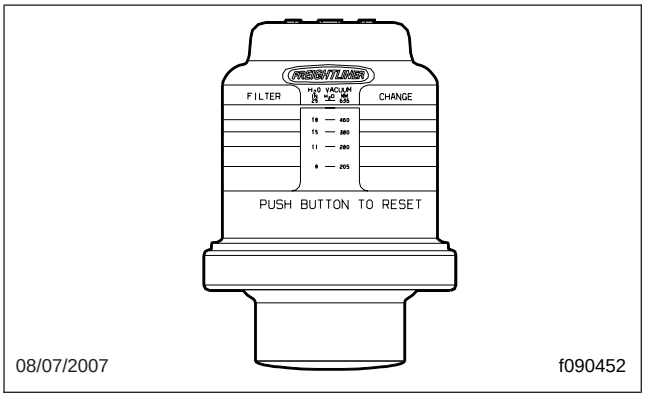



**Fig. 1, Manual-Reset Air Restriction Indicator, Graduated**

1. For vehicles equipped with a manual-reset indicator with graduations, check the indicator with the engine off to see if air restriction equals or exceeds the value shown in **Table 1** for maximum air restriction.

   For vehicles equipped with a go/no-go restriction indicator without graduations, check the indicator with the engine off to see if the colored bar shows through the clear window.

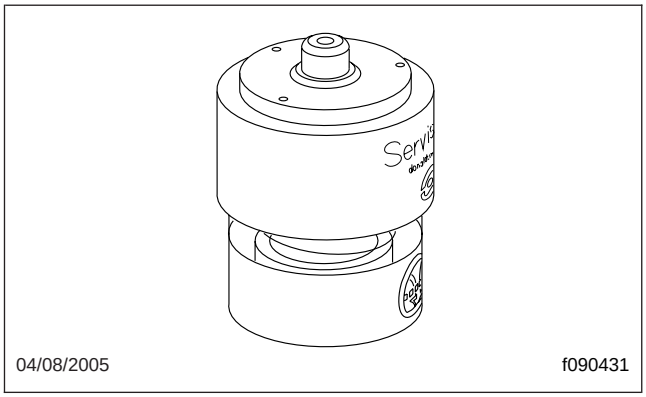



**Fig. 2, Manual-Reset Air Restriction Indicator, Go/No-Go**

| Air Cleaner Element Maximum Restriction | |
|---|---|
| **Engine** | **Maximum Restriction** |
| Cummins | 25 in$H_2O$ |
| Detroit Diesel | 22 in$H_2O$ |

**Table 1, Air Cleaner Element Maximum Restriction**

2. If air restriction is below the maximum, no further work is necessary.

   If air restriction is at or above the maximum, push the reset button on the indicator.

3. Operate the engine to see if air restriction exceeds recommended values again. This can be done by running the vehicle on a dynamometer at **full-load and rated rpm**, or by driving the vehicle for one day in the vehicle's typical operating environment while not exceeding the rated rpm. See the engine manufacturer's service literature for information on rated rpm for your engine.

4. Check the indicator again. If air restriction continues to equal or exceed the maximum air restriction value in **Table 1** on an indicator with graduations, or if the colored bar shows through the clear window on a go/no-go indicator, replace the air cleaner element, then reset the indicator.

   For air cleaner element replacement instructions, see **Subject 110** for instructions.

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## NOTICE

**All air intake components and connections must be air- and water-tight. Dirt or dust entering the engine can cause internal engine damage. Most of the dirt and dust particles are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners. Do not operate the engine with the air cleaner element or any air intake component removed.**

IMPORTANT: Do not modify, or use modified air cleaners or duct components.

NOTE: The air cleaner(s) may be installed on the cowl or on the fender. Use the appropriate replacement procedure below for the vehicle configuration.

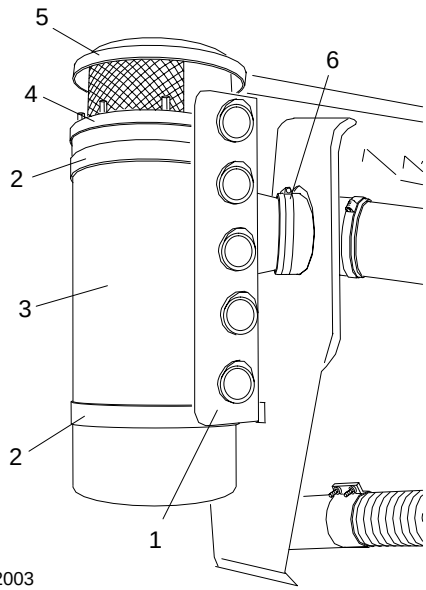
# Cowl-Mounted Air Cleaner

## Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Remove the screws and washers that attach the marker lights to the mounting brackets and remove the marker lights. See **Fig. 1**.
3. Loosen the clamp that secures the elbow to the air cleaner.
4. Remove the capscrews and washers that attach the band clamps to the mounting brackets.
5. Remove the air cleaner assembly from the elbow.

## Installation

1. Check the new air cleaner for damage, and check all ducts and connections for leakage. Adjust or replace parts as necessary.
2. Install the air cleaner on the elbow so that the perforated area of the cap faces outboard and the shielded side faces inboard. See **Fig. 1**.
3. Using capscrews and washers, secure the air cleaner by attaching the band clamps to the mounting brackets. Make sure the upper band clamp is not in contact with the flange on the air cleaner. See **Fig. 1**.
4. Tighten the clamp that secures the elbow to the air cleaner.
5. Using screws and washers, attach the marker lights to the mounting brackets.




1. Marker Lights
2. Band Clamp
3. Air Cleaner
4. Flange
5. Cap
6. Clamp

**Fig. 1, Cowl-Mounted Air Cleaner**

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## NOTICE

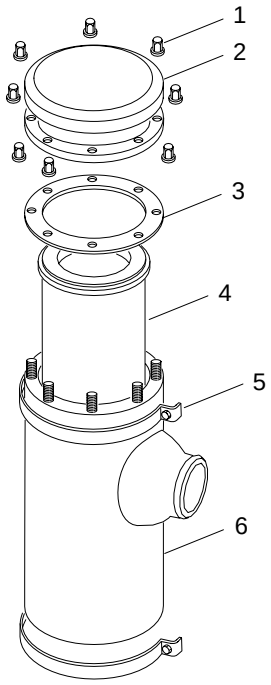
**All air intake components and connections must be air- and water-tight. Dirt or dust entering the engine can cause internal engine damage. Most of the dirt and dust particles are silicates, which fuse into abrasive glass-like particles when exposed to engine combustion. These particles can grind piston rings, pistons, and cylinder liners. Do not operate the engine with the air cleaner element or any air intake component removed.**

IMPORTANT: Do not modify, or use modified air cleaners or duct components.

NOTE: The air cleaner(s) may be installed on the cowl or on the fender. Use the appropriate replacement procedure below for the vehicle configuration. If the vehicle is equipped with dual air cleaners, replace both air cleaner elements at the same time.

# Cowl-Mounted Air Cleaner Element Replacement

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Check the air cleaner housing for damage, and check all ducts and connections for leakage. Adjust or replace parts as necessary.
3. Remove the capnuts that attach the cap to the air cleaner housing, and remove the cap. See **Fig. 1**. Inspect the capnuts for wear and replace them if necessary.
4. Remove the air cleaner element from the air cleaner housing.
5. Wipe the inside of the air cleaner housing with a clean, damp cloth. Check the housing and sealing surfaces for damage or dirt buildup that could cause sealing problems. Remove any dirt buildup.
6. Check the sealing area on the cap. See **Fig. 2**.
7. Check the surfaces outside the gaskets on both ends of the element. Make sure the gasket sealing surfaces of the air cleaner housing and cap are clean.
8. Remove and discard the air cleaner gasket.




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1. Capnut
2. Cap
3. Air Cleaner Gasket
4. Air Cleaner Element
5. Band Clamp
6. Air Cleaner Housing

**Fig. 1, Cowl-Mounted Air Cleaner Components**

9. Make sure the threaded studs on the air cleaner housing are clean and free of any gasket material, corrosion, or particles. Apply a light coating of oil to the threads on the studs.

## NOTICE

**Do not clean or reuse air filter elements. Cleaning and reusing the elements increases the chances of dirt entering the engine. Always replace with a new one.**

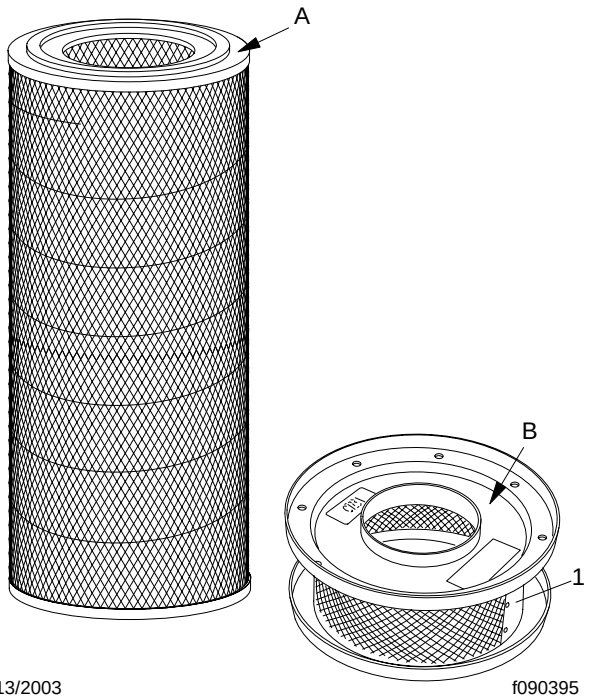
10. Inspect the new air cleaner element and gaskets for damage or holes. Install a new gasket on the air cleaner housing.
11. Install the new element in the housing and make sure that the bottom gasket seats firmly.

NOTE: The element will extend beyond the housing until the cap is installed and the capnuts are tightened.

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## Element Replacement




A. Check the surface outside the gasket.
B. Check the sealing area on the cap.

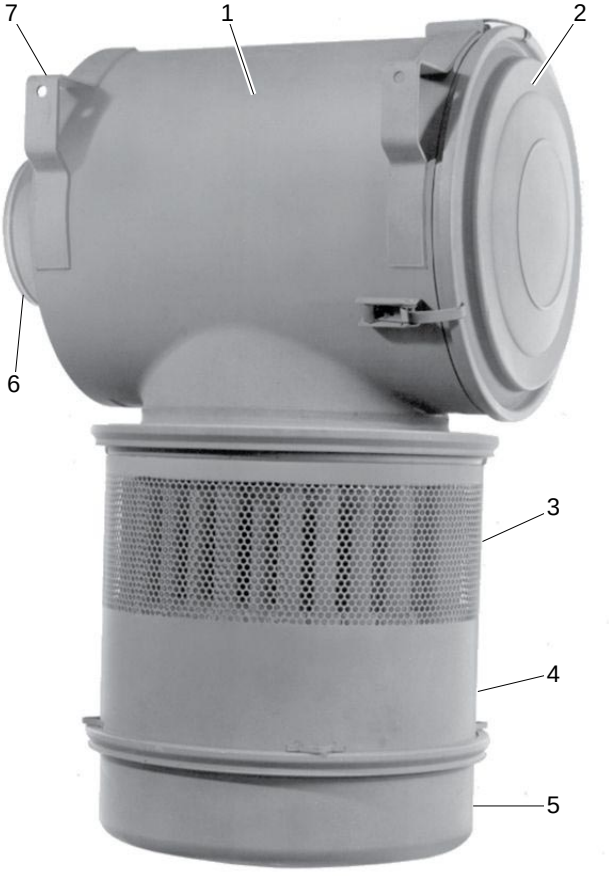
1. Unperforated Area of Cap

**Fig. 2, Air Cleaner Element and Cap**

12. Install the cap on the air cleaner housing so that the perforated area of the cap faces outboard and the shielded side faces inboard.
13. Secure the cap to the air cleaner housing by installing the four nuts on the hold-down bolts. Tighten the nuts 7 to 9 lbf·ft (10 to 12 N·m).
14. Press the reset button on the air restriction indicator. If the vehicle is not equipped with an air restriction indicator or a dash-mounted gauge, check that the 1/4-inch (6-mm) pipe plugs located in the air cleaner or in the piping just before the turbocharger are tight.

# Fender-Mounted Air Cleaner Element Replacement

The fender-mounted air cleaner contains two filters, a primary filter and a safety filter that fits inside the primary filter. Proper filter changes and dust cup maintenance assist the air cleaner in keeping the engine air free of harmful contaminants. See **Fig. 3**.




1. Primary Filter Housing
2. Filter Access Cover
3. Perforated Air Inlet
4. Pre-cleaning Section
5. Dust Cup
6. Outlet to Engine
7. Mounting Bracket

**Fig. 3, Air Cleaner**

## NOTICE

**Use the air intake restriction gauge rather than visual inspection to determine if servicing the air filter element is necessary. Removal of the air filter element can cause damage to the primary seal, which may allow contaminants into the engine, potentially causing engine damage.**

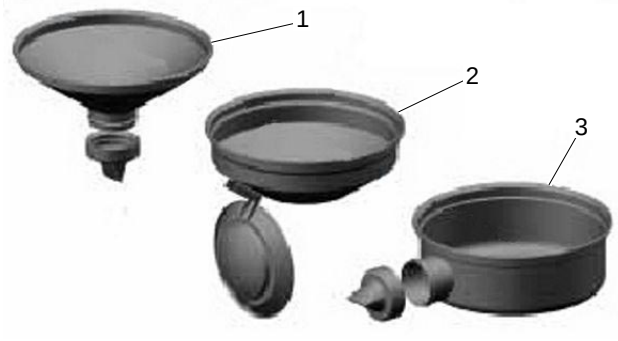
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1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Check the air cleaner housing for damage, and check all ducts and connections for leakage. Adjust or replace parts as necessary.
3. Check the visual restriction indicator window. It will illuminate bright red when filter servicing is needed. The standard visual restriction indicator will be mounted directly onto the air cleaner or remotely on the instrument panel or firewall.

NOTE: The dust cups are available in different types and styles. See **Fig. 4**

4. Check the dust cup daily. Empty if excessive dust/dirt is found. See **Fig. 5**.




04/02/2013 f090508

1. Dust Cup for Vertical Mount (Alternate Style)
2. Quick Release Dust Cup
3. Dust Cup for Horizontal Mount (Alternate Style)

**Fig. 4, Tube Varieties**

## NOTICE

**Do not clean the tubes with compressed air unless both the primary and safety filters are installed in the air cleaner. Never steam clean the tubes, as heat from the steam cleaner can cause damage.**

5. Inspect the tubes (see **Fig. 5**) for blockage and clean with compressed air or warm water. Tubes may be cleaned with a stiff brush if light dust is found. If the tubes are plugged, remove the lower body of the tube assembly.

NOTE: Replace the body gaskets anytime the lower body of the tube assembly is removed.




03/28/2013 f090501

1. Tubes
2. Dust Cup

**Fig. 5, Dust Cup and Tubes**

Make sure the dust cup seals a complete 360° around the air cleaner body.

## NOTICE

**Dirt left in the air cleaner housing is harmful to the engine and can cause damage. Make sure all hardened dirt is also removed.**

6. Unlatch the filter access cover to gain access to the filters.
7. Remove the primary air filter wingnut. See **Fig. 6**.

NOTE: The filter fits tightly over the outlet tube, causing internal resistance during removal. Gently move the filter from side to side using caution to not hit the filter against the housing. Damage to the housing could occur.

8. Remove the primary filter. See **Fig. 7**.
9. Inspect the safety filter but do not remove it unless there is damage or a filter change is due. Safety filters should be replaced during every third primary filter change or as indicated by the service indicator wingnut (if a service indicator wingnut is present). See **Fig. 8**
10. Clean the air cleaner housing with a clean, damp cloth. See **Fig. 9**.

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## Element Replacement




03/28/2013 f090503

1. Wingnut

**Fig. 6, Primary Air Filter Wingnut**




04/02/2013 f090507

1. Primary Filter
2. Safety Filter

**Fig. 7, Air Filter Locations**

11. If installing a new safety filter, inspect it for damage and make sure the gasket fits correctly.
12. Install the new safety filter immediately or keep the inlet covered with a cloth to prevent dirt ingestion.
13. If using a service indicator wingnut, secure it in place with a cotter (split) pin when installing the safety filter.




03/28/2013 f090506

1. Service Indicator

**Fig. 8, Safety Filter Service Indicator**




03/28/2013 f090505

1. Air Cleaner Housing (Inside)

**Fig. 9, Air Cleaner Housing**

14. Using a new gasket washer, secure the primary filter in place by hand-tightening the wing nut.
15. Reset the visual restriction indicator using the rubber button located on top of the indicator.
16. Replace the filter access cover onto the filter housing.
17. Inspect and tighten all air cleaner system connections.

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## Restriction Checking

Restriction of the air flow through the air cleaner element is measured at the tap in the air cleaner outlet. Check the restriction indicator at the air cleaner or in the cab if the vehicle is equipped with a dash-mounted restriction gauge.

### NOTICE

**Use the air intake restriction gauge rather than visual inspection to determine if servicing the air filter element is necessary. Removal of the air filter element can cause damage to the primary seal, which may allow contaminants into the engine, potentially causing engine damage.**

Vehicles may be equipped with either a manual-reset restriction indicator with graduations (**Fig. 1**), or a go/no-go restriction indicator without graduations (**Fig. 2**).

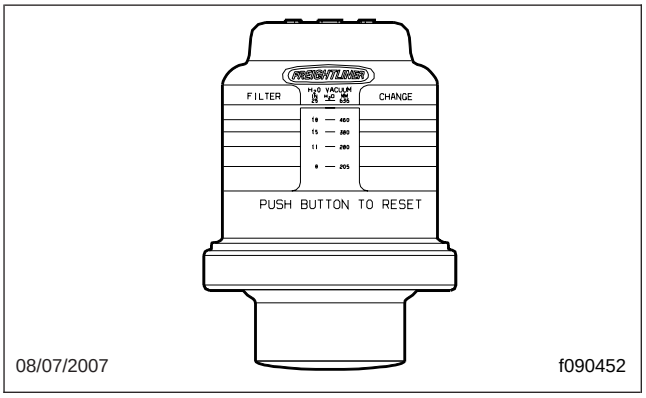



**Fig. 1, Manual-Reset Air Restriction Indicator, Graduated**

1. For vehicles equipped with a manual-reset indicator with graduations, check the indicator with the engine off to see if air restriction equals or exceeds the value shown in **Table 1** for maximum air restriction.

   For vehicles equipped with a go/no-go restriction indicator without graduations, check the indicator with the engine off to see if the colored bar shows through the clear window.

2. If air restriction is below the maximum, no further work is necessary.

   If air restriction is at or above the maximum, push the reset button on the indicator.

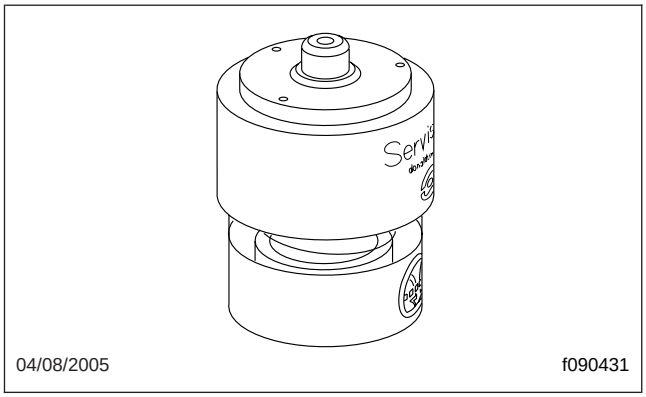



**Fig. 2, Manual-Reset Air Restriction Indicator, Go/No-Go**

3. Operate the engine to see if air restriction exceeds recommended values again. This can be done by running the vehicle on a dynamometer at **full-load and rated rpm**, or by driving the vehicle for one day in the vehicle's typical operating environment while not exceeding the rated rpm. See the engine manufacturer's service literature for information on rated rpm for your engine.
4. Check the indicator again. If air restriction continues to equal or exceed the maximum air restriction value in **Table 1** on an indicator with graduations, or if the colored bar shows through the clear window on a go/no-go indicator, replace the air cleaner element, then reset the indicator.

   For air cleaner element replacement instructions, see **Subject 100**.

| Air Cleaner Element Maximum Restriction | | |
|---|---|---|
| **Engine** | **Pre-EPA07 Engines** | **EPA07/EPA10 Engines** |
| Caterpillar | 25 in$H_2O$ | — |
| Cummins | 25 in$H_2O$ | 25 in$H_2O$ |
| Detroit Diesel | 20 in$H_2O$ | 22 in$H_2O$ |
| Mercedes-Benz | 22 in$H_2O$ | 22 in$H_2O$ |

**Table 1, Air Cleaner Element Maximum Restriction**

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# General Information

The Tu-Flo 550 and the Tu-Flo 750 are two-cylinder, single-stage, reciprocating air compressors, which supply compressed air to the vehicle air system. The Tu-Flo 550 has a rated displacement of 13.2 cfm (374 L/min) of air at 1250 rpm. The Tu-Flo 750 has a rated displacement of 16.5 cfm (468 L/min) of air at 1250 rpm.

The compressor draws air from the air intake pipe, compresses the air, and delivers it to the air system supply reservoir. The compressor runs continuously but has "loaded" and "unloaded" modes, which are regulated by the air governor and the compressor loading assembly. When the governor sends an air signal to the unloader assembly, the unloader assembly holds the compressor air intake valve open so that no more compressed air is forced into the air system. As air in the system is used, its pressure drops, and at 90 psi (620 kPa), the air governor stops the signal to the compressor. Without the signal, the unloader assembly automatically closes the compressor air intake valve to force more air into the system.

On vehicles with air dryers, when the system reaches the cut-out pressure of 120 psi (825 kPa), the air governor also sends an air signal to open the sludge ejector in the air dryer.

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# Air Compressor Removal and Installation

## Removal

1. Apply the parking brakes, chock the tires, and open the hood.
2. Drain the air system.

**⚠ WARNING**

**Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.**

3. Using a cleaning solvent, remove road dirt and grease from the outside of the compressor, then dry the compressor with compressed air.
4. Drain the radiator coolant; see **Group 20** for instructions.
5. Loosen the constant-torque hose clamps at both ends of the charge air cooler outlet air piping. Remove the piping to access the air compressor.
6. Marking their locations and positions, disconnect all air, coolant, and oil lines attached to the compressor. Remove tie straps as needed to move the lines out of the way.

NOTE: On vehicles with combined air dryers and air reservoir modules, the air governor is mounted on the module not the air compressor.

7. If the air governor is mounted on the compressor, remove it and the governor mounting gasket.
8. On Cummins and Detroit Diesel engines, disconnect the wire to the fuel shutoff valve (if so equipped). Remove the fuel pump and gasket; see the engine shop manual or rebuild manual for instructions.
9. Remove the compressor support bracket, if so equipped.
10. Support the compressor, and remove the bolts that attach it to the auxiliary drive housing, accessory drive, or timing gear plate. Remove the compressor, gasket, and splined coupling.
11. Discard all mounting gaskets.

## Installation

IMPORTANT: Be sure the gasket surfaces are cleaned and not damaged.

1. Install the splined coupling (if so equipped) and a new compressor gasket. Hold the compressor in place, and install the bolts that attach it to the auxiliary drive housing, accessory drive, or timing gear plate. See the engine shop manual or rebuild manual for final torque specification.
2. Install the compressor support bracket, if so equipped.
3. On Cummins and Detroit Diesel engines, install a new gasket, install the fuel pump. Connect the wire to the fuel shutoff valve (if so equipped). See the engine shop manual or rebuild manual for instructions.
4. If applicable, use a new air governor mounting gasket, install the air governor on the compressor.
5. Identify and connect all air, coolant, and oil lines to the compressor. Secure the lines as needed with tie straps.
6. Install the charge air cooler outlet air piping. Tighten the constant-torque hose clamp screws 45 lbf·in (500 N·cm).
7. Fill the engine cooling system; see **Group 20** for instructions.
8. Operate the engine and check for leaks.
9. Remove the chocks from the tires and lower the hood.

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## Removal

1. Apply the parking brakes, chock the tires, and open the hood.
2. Remove the compressor from the vehicle, if necessary.

**⚠ WARNING**

**Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.**

3. Remove the compressor from the vehicle. For instructions, see **Subject 100**.
4. Remove the cylinder head from the crankcase. See **Fig. 1**.

   4.1 Scribe an alignment mark across the cylinder head and the crankcase, for assembly alignment.

   IMPORTANT: Do not use a marking method, such as chalk, that can be wiped off during assembling.

   4.2 Note positions of any attached components, then remove the cylinder head capscrews.

   4.3 Tap the cylinder head with a soft mallet to break the gasket seal. Remove the cylinder head.

## Installation

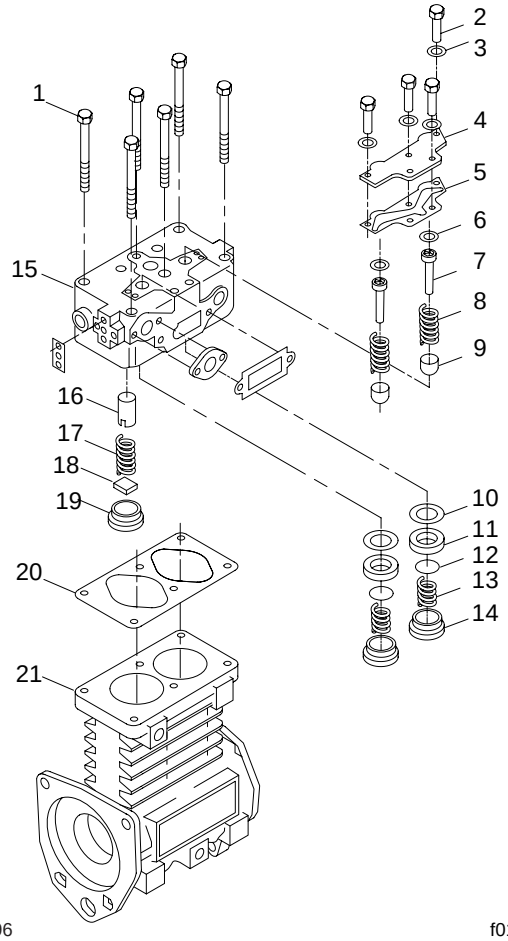
1. Scrape off any gasket material from the cylinder head and the crankcase.

**⚠ WARNING**

**Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.**

2. Using compressed air, blow dirt particles or gasket material from all cylinder cavities.
3. Install the cylinder head on the compressor crankcase.

   3.1 Place a new cylinder head gasket on the crankcase. If the cylinder head gasket has a bead on one side, install the gasket with the bead side up.




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1. Cylinder Head Capscrew
2. Unloader Plate Capscrew
3. Unloader Plate Lockwasher
4. Unloader Plate
5. Unloader Plate Gasket
6. O-Ring
7. Unloader Piston
8. Spring
9. Unloader Bushing
10. Gasket
11. Inlet Valve Seat
12. Inlet Valve
13. Inlet Valve Spring
14. Inlet Valve Stop
15. Cylinder Head
16. Discharge Valve Stop
17. Discharge Valve Spring
18. Discharge Valve
19. Discharge Valve Seat
20. Cylinder Head Gasket
21. Crankcase

**Fig. 1, Cylinder Head (exploded view)**

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## Cylinder Head Removal and Installation

3.2 Using the previously marked alignment, position the cylinder head on the crankcase.

3.3 Position on the cylinder head any brackets, spacers, or clamps that were removed; then install the cylinder head capscrews and tighten them evenly, in a cross pattern 37 to 42 lbf·ft (50 to 57 N·m).

4. Install the compressor on the engine. For instructions, see **Subject 100**.
5. Operate the engine and make sure there are no coolant leaks.
6. Remove the chocks from the tires and lower the hood.

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# Cylinder Head Disassembly, Cleaning and Inspection, and Assembly

## Disassembly

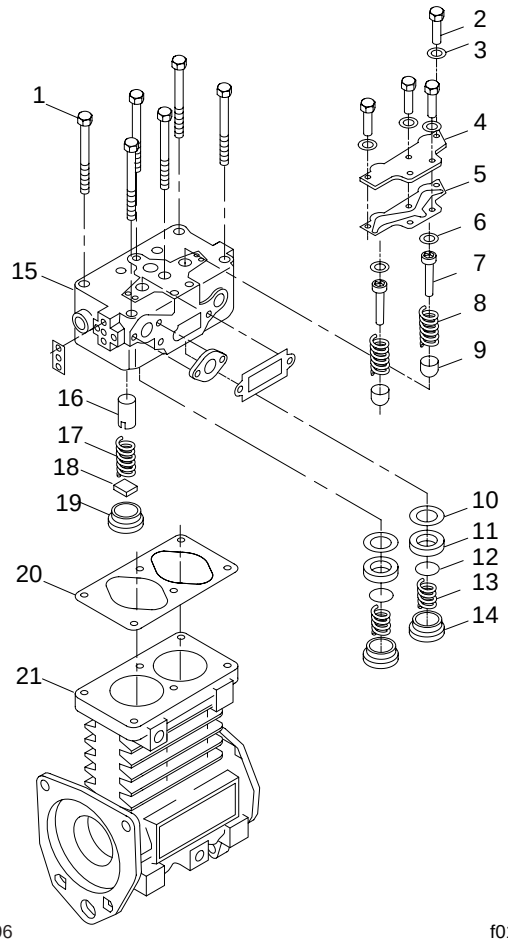
1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Remove the compressor from the vehicle. For instructions, see **Subject 100**.
3. Place the compressor on a suitable work surface. Remove the cylinder head from the crankcase. See **Fig. 1**. For instructions, refer to **Subject 110**.
4. Remove the unloader mechanism.
   - 4.1 Remove the unloader plate capscrews, lockwashers, and the unloader plate. Scrape off any gasket material from the unloader plate and the cylinder head.
   - 4.2 Remove and discard the unloader pistons, O-rings, and springs.
5. Check the unloader piston bushings. If damaged or worn excessively, replace the compressor.

NOTE: Before disassembling the discharge valve mechanism, measure and record the discharge valve travel from closed to completely open. If the measurement exceeds 0.046 inch (1.17 mm), replace the compressor. If the measurement is within 0.046 inch, proceed to the next step.

6. Using a 9/16-inch Allen wrench, remove and discard the discharge valve seats, discharge valves, and discharge valve springs.
7. Remove and discard the inlet valve stops and springs, along with the inlet valves, inlet valve seats, and gaskets.

## Cleaning and Inspection

1. Remove carbon deposits from the discharge cavity, rust and scale from the cooling cavities.
2. Clean carbon and dirt from the inlet and unloader passages.
3. Scrape all foreign material from the body surfaces.




1. Cylinder Head Capscrew
2. Unloader Plate Capscrew
3. Unloader Plate Lockwasher
4. Unloader Plate
5. Unloader Plate Gasket
6. O-Ring
7. Unloader Piston
8. Spring
9. Unloader Bushing
10. Gasket
11. Inlet Valve Seat
12. Inlet Valve
13. Inlet Valve Spring
14. Inlet Valve Stop
15. Cylinder Head
16. Discharge Valve Stop
17. Discharge Valve Spring
18. Discharge Valve
19. Discharge Valve Seat
20. Cylinder Head Gasket
21. Crankcase

**Fig. 1, Cylinder Head (exploded view)**

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## Cylinder Head Disassembly, Cleaning and Inspection, and Assembly

**⚠ WARNING**

**Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.**

4. Using solvent, thoroughly clean all metal parts removed from the cylinder head. Using shop air, blow the dirt particles from the cavities and passages.
5. Check that all cavities and passages are clear, including the inlet and unloader.
6. Check that all mating surfaces are clean of old gasket material. Remove any old material.
7. Inspect the cylinder head for cracks or damage.
8. With the cylinder head and head gasket secured to a flat surface or to the crankcase, apply shop air pressure to one of the coolant ports with all other ports plugged.
9. Check for leaks by applying a soap solution to the exterior of the body. If leakage is detected, replace the compressor.

## Assembly

1. Install the unloader mechanism. See **Fig. 1**.
   - 1.1 With the unloader pistons being prelubricated from the manufacturer, install the new unloader springs, and the new unloader pistons. The unloader piston O-rings are pre-installed on the unloader pistons.
   - 1.2 Install the new unloader plate gasket and the unloader plate.
   - 1.3 Install the unloader plate lockwashers and capscrews. Tighten the capscrews 15 to 18 lbf·ft (20 to 25 N·m) in a cross pattern.
2. Install the inlet valve mechanism.
   - 2.1 Install the new inlet valve gaskets, new inlet valve seats, new inlet valves, and the new inlet valve springs into their bores.
   - 2.2 Install the new inlet valve stops and tighten 70 to 90 lbf·ft (95 to 122 N·m).
3. Install the new discharge valve springs, new discharge valves, and the new discharge valve seats into their bores. Tighten the seats 70 to 90 lbf·ft (95 to 122 N·m). The discharge valve travel should be 0.030 inches to 0.046 inch (0.762 mm to 1.17 mm).
4. Test for leakage at the discharge valves by applying 100 psi (690 kPa) shop air through the cylinder head discharge port and apply soap solution to the discharge valve and seat. Leakage in the form of soap bubbles is permissible.

   If there's extreme leakage, leave the air pressure applied and with a hardwood dowel and a hammer, tap the discharge valves off of their seats several times. This will improve the seal between the discharge valve and the valve seat and should reduce leakage.

   If there's still extreme leakage, replace the discharge valve seats.

   With the air pressure still applied at the discharge port of the cylinder head, check for leakage around the discharge valve stop on top of the cylinder head. No leakage is permitted.
5. Install the compressor cylinder head. For instructions, see **Subject 110**.
6. Tighten the unloader plate capscrews 15 to 18 lbf·ft (20 to 25 N·m).
7. Install the compressor on the engine. For instructions, see **Subject 100**.
8. Remove the chocks from the tires and lower the hood.

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# Crankcase Disassembly, Cleaning and Inspection, and Assembly

## Disassembly

1. Apply the parking brakes, chock the tires, and open the hood.
2. Remove the compressor from the vehicle and place it on a suitable work surface. For instructions, see **Subject 100**.
3. Remove the air compressor cylinder head. For instructions, see **Subject 110**.
4. Before disassembling the compressor, use a metal scribe to mark the parts with matching numbers or lines.

IMPORTANT: Do not use a marking method, such as chalk, that can be wiped off during assembling.

5. Remove the pistons and connecting rods. See **Fig. 1**.
   - 5.1 Remove the base plate capscrews.
   - 5.2 Tap the base plate with a soft mallet to break the gasket seal.
   - 5.3 Scrape off any gasket material from the crankcase and base plate.
   - 5.4 Remove the connecting rod bolts and connecting rod caps.
   - 5.5 Push the pistons and connecting rods out through the cylinder bore of the crankcase. Discard the pistons and connecting rod assemblies including the connecting rod caps and the connecting rod bolts.
6. Remove the crankshaft.
   - 6.1 Remove the key or keys from the crankshaft and any burrs from the crankshaft where the key or keys were removed.

   NOTE: Some compressors may have a crankshaft key at each end.

   - 6.2 Remove the end-cover capscrews, the end cover, end-cover seal, and the rear thrustwasher.
   - 6.3 If the compressor has sleeve bearings, remove and discard the sleeve bearings from the crankcase and the end cover.
   - 6.4 If the compressor has a ball-type main bearing, remove the rear snap ring (if so equipped). Press the crankshaft and ball bearing from the crankcase, then press the ball bearing from the crankshaft.
   - 6.5 Remove and discard the front and rear thrustwashers.

## Cleaning and Inspection

1. Scrape off any gasket material from the top and bottom of the crankcase.

**⚠ WARNING**

**Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.**

2. Clean all parts with solvent, before inspecting them, and dry the parts with compressed air.
3. Clean all oil passages through the crankshaft, crankcase, end cover, and base plate. Inspect the passages with a wire to be sure they are clear.
4. Check the fit of the new pistons, piston rings, and connecting rods.
   - 4.1 The pistons for the Tu-Flo 750 compressor are similar to the Tu-Flo 550 and may be identified by the distance from the center of the wrist pin hole to the top of the piston. See **Fig. 2**.
   - 4.2 To check the ring gap, place the ring in the top of the cylinder bore and, using a piston, push the ring to mid-point of the cylinder bore and check the ring gap. The gap for compression rings must be 0.002 to 0.013 inch (0.050 to 0.330 mm).

     The gap for oil ring and expander ring must be 0.010 to 0.040 inch (0.254 to 1.016 mm). See **Fig. 3**, and **Table 1**.

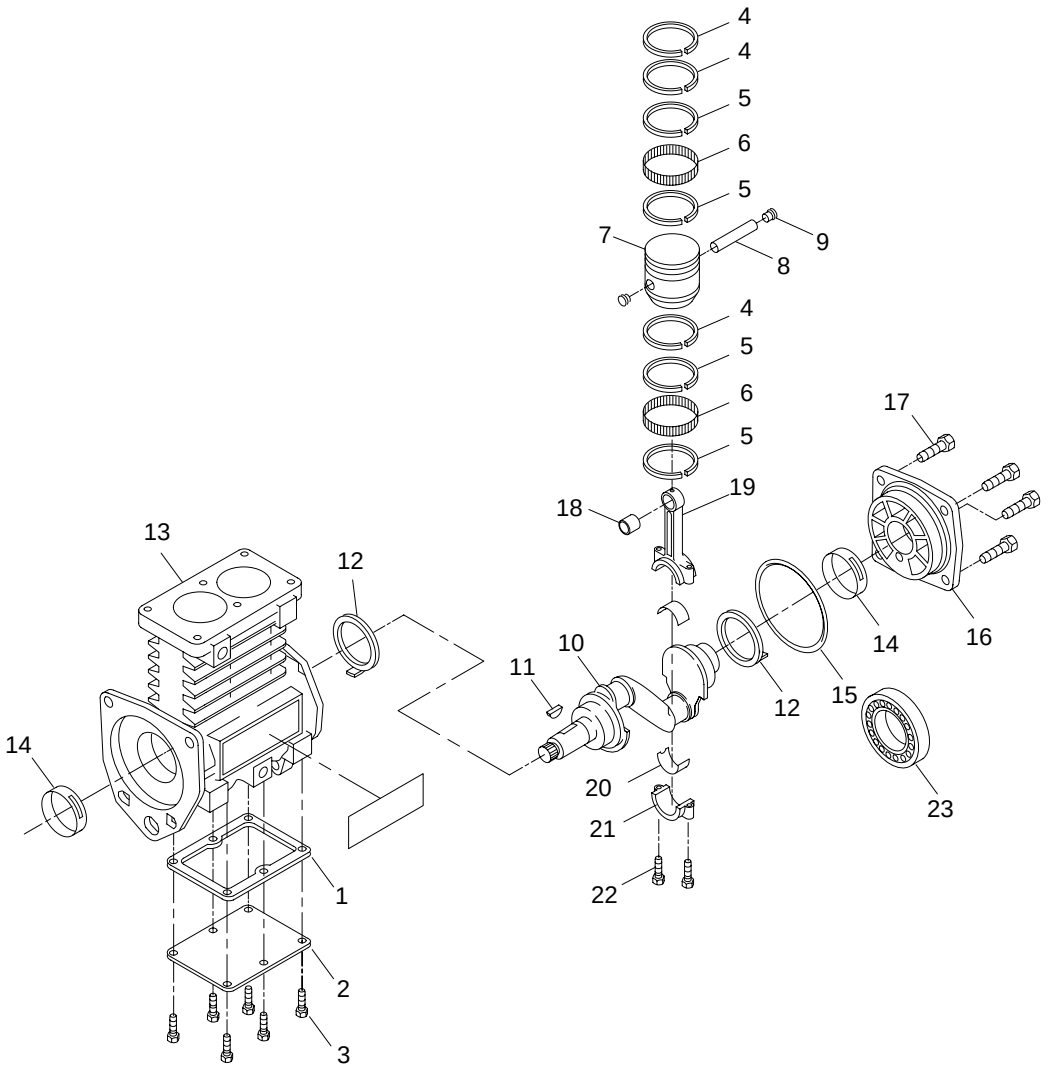
| Allowable End Gap | |
|---|---|
| **Ring** | **End Gap in inch (mm)** |
| Compression | 0.002–0.013 (0.050–0.330) |
| Oil and Expander | 0.010–0.040 (0.254–1.016) |

**Table 1, Allowable End Gap**

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## Crankcase Disassembly, Cleaning and Inspection, and Assembly




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1. Base Gasket
2. Base Plate
3. Base Plate Capscrew
4. Compression Ring
5. Oil Ring
6. Expander Ring
7. Piston
8. Wrist Pin
9. Wrist Pin Button
10. Crankshaft
11. Crankshaft Key
12. Thrust Washer
13. Crankcase
14. Sleeve Bearing
15. End Cover Seal
16. End Cover
17. End Cover Capscrew
18. Wrist Pin Bushing
19. Connecting Rod
20. Connecting Rod Bearing (Sets)
21. Connecting Rod Cap
22. Connecting Rod Bolt
23. Ball Bearing

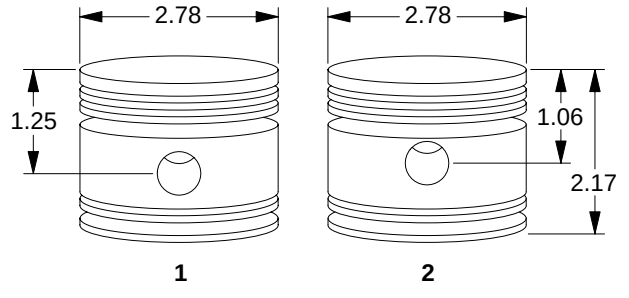
**Fig. 1, Crankcase (exploded view)**

4.3 Check the fit of the piston rings in the piston ring grooves. Groove clearance for the compression ring is 0.002 to 0.004 inch (0.051 to 0.101 mm). Groove clearance for the expander and oil rings is 0.000 to 0.006 inch (0.000 to 0.152 mm).

5. Inspect the crankcase.

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1. Tu-Flo 550 Compressor Piston
2. Tu-Flo 750 Compressor Piston

**Fig. 2, Piston Comparison**

5.1 Check the crankcase surfaces for cracks and damage.

5.2 On compressors with ball-type main bearings, measure the difference between the outside diameter of the ball bearing outer race and the inside diameter of the crankcase bore. The measurement should be 0.0003 inch (0.008 mm) tight to 0.0023 inch (0.058 mm) loose. This is to maintain a correct fit. Replace the compressor if the fit is too loose.

5.3 Check the end cover for cracks and damage. Replace them as necessary.

5.4 Check the cylinder bore with an inside micrometer or with calipers. Cylinder bores which are scored, out-of-round, or tapered more than 0.0005 inch (0.013 mm) should be rebored and honed oversize. Oversized pistons and piston rings are available in 0.010 inch (0.254 mm), 0.020 inch (0.508 mm), and 0.030 inch (0.762 mm) oversize.

6. Inspect the crankshaft.

6.1 Check the crankshaft splines, gear teeth, tapered ends, and all machined and ground surfaces for wear, scoring, or damage. Repair the damage, or replace the crankshaft if needed.

6.2 Check the crankshaft connecting rod journals for extreme scoring, and measure them for out-of-round wear. Standard crankshaft journals are 1.1242 to 1.1250 inches (28.555 to 28.575 mm) in diameter. If the crankshaft is extremely scored or worn out-of-round, and cannot be reground, replace it.

NOTE: If the crankshaft needs to be reground or replaced, do so before proceeding to the next step. For compressors having reground crankshafts, connecting rod bearing inserts are available in 0.010 inch (0.254 mm), 0.020 inch (0.508 mm), and 0.030 inch (0.762 mm) undersize.

## Assembly

1. For a compressor with sleeve bearings, install the crankshaft and end cover. See **Fig. 1** for instructions.

1.1 Press the new sleeve bearings into the end cover and crankcase. Make sure the slot in the bearings line up with the oil passages in the end cover and crankcase.

If there is no oil passage present in the crankcase, press the sleeve bearing into the crankcase with the slot located 90 degrees from vertical.

1.2 Install the new front thrustwasher with the tang inserted in the slot toward the flange.

1.3 Insert the crankshaft and the rear thrustwasher with the tang toward the end cover of the compressor.

1.4 Place the end-cover seal on the boss of the end cover.

IMPORTANT: When installing the end cover, ensure that the end cover seal is not pinched and that the rear thrustwasher tang is inserted in the end cover slot.

1.5 Install the end cover. Install the capscrews and tighten the capscrews 15 to 18 lbf·ft (20 to 25 N·m) in a cross pattern.

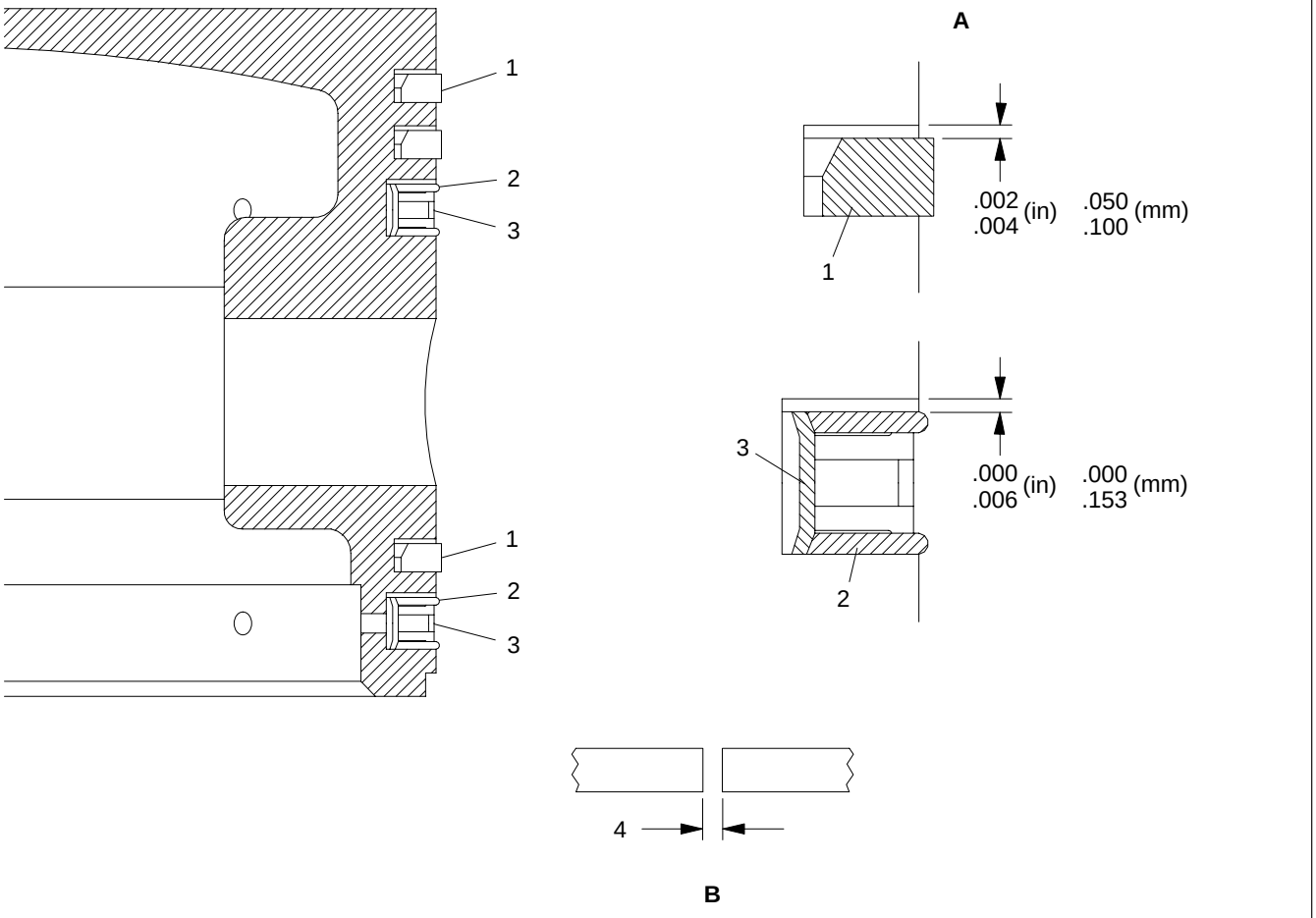
2. If one end of the compressor uses a ball-type main bearing, install the crankshaft and end-covers.

2.1 Press the new sleeve bearings into the crankcase. Make sure the slots in the bearings line up with the oil passage in the end cover and crankcase.

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## Crankcase Disassembly, Cleaning and Inspection, and Assembly




A. Side Clearance
1. Compression Ring
2. Oil Ring
B. Ring End Gap With Ring in the Cylinder Bore
3. Expander Ring
4. End Gap

**Fig. 3, Piston Specifications**

If there is no oil passage present in the crankcase, press the sleeve bearing into the crankcase with the slot located 90 degrees from vertical.

2.2 Install the new front thrustwasher with the tang inserted in the slot toward the flange.

2.3 Press the ball bearing onto the correct end of the crankshaft, so that the drive end of the crankshaft will be positioned in the crankcase as marked before disassembly. Using an arbor press, carefully press the ball bearing and the crankshaft into the crankcase. Install the retainer ring, if so equipped.

3. Install the new piston rings on the new pistons.

IMPORTANT: To properly test a compressor under operating conditions, a test rack is necessary for correct mounting, cooling, lubricating, and driving the compressor.

NOTE: Install the piston rings on the pistons starting at the center of the piston and moving outward. Rotate the piston rings in their

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respective grooves so that the end gap is at least 90 degrees from the previous ring's end gap.

3.1 Install the compression rings in the correct grooves, with the bevel or "pip" mark (if any) toward the top of the piston.

3.2 Install the expander rings in the oil ring grooves. The ends of the expander rings must butt and must not overlap.

3.3 Install the bottom oil ring by inserting one end below the expander ring in the ring groove, and wind the ring into position. Install the top oil ring in the same manner above the expander ring making sure the gap is staggered from the bottom oil ring and the expander ring.

4. Attach the new connecting rods to the new pistons.

4.1 Lubricate the wrist pins and the wrist pin bushings in the connecting rods with clean engine oil.

4.2 Position the connecting rods in the pistons and press in the wrist pins. Secure the wrist pins by installing the wrist pin buttons in the ends of the wrist pins.

5. Install the new pistons and new connecting rods.

5.1 Apply clean engine oil to both pistons, the piston rings, the wrist pins, the connecting rod caps and the new connecting rod bearings.

5.2 Turn the crankshaft so that the number-one rod journal (the one nearest the drive end) is down and centered.

5.3 Using a piston ring compressor, insert the number-one connecting rod and piston through the top of the number-one cylinder bore.

NOTE: The connecting rods and connecting rod caps are matched sets, therefore the caps must not be switched or rotated end for end.

5.4 Install the connecting rod bearings on the connecting rod and connecting rod cap.

5.5 Tighten the new connecting rod bolts evenly in increments of 11 to 13 lbf·ft (15 to 17 N·m).

5.6 Turn the crankshaft so that the number-two connecting rod journal is in the downward, center position.

5.7 Install the number-two connecting rod and piston in the same manner as described above.

6. Before installing the cylinder head on the crankcase, ensure that the correct pistons have been used. Turn the crankshaft one complete revolution, so that each piston moves to the uppermost position. On the upward stroke, each piston should move to the top of the crankcase. If the piston does not approach the top of the crankcase, the piston is incorrect and must be replaced or compressor damage could result.

7. Install the base plate.

7.1 Position the gasket on the crankcase. Install the base plate on the crankcase as marked before disassembly.

7.2 Tighten the six capscrews 15 to 18 lbf·ft (20 to 25 N·m) in a cross pattern.

8. Install the cylinder head on the crankcase. For instructions, see **Subject 110**.

9. Install the compressor on the engine. For instructions, see **Subject 100**.

10. Operate the engine and check for leaks.

11. Remove the chocks from the tires and lower the hood.

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# Troubleshooting Tables

**Problem—Excessive Oil Passage**

| Problem—Excessive Oil Passage | |
|---|---|
| **Possible Cause** | **Remedy** |
| Restricted air intake. | Check engine air filter and replace if necessary. Check compressor air inlet for kinks and excessive bends. Repair as needed. |
| Restricted oil return line to engine. | Check for excessive bends, kinks, and restrictions in oil return line. Return line must descend from compressor to engine crankcase. Repair as needed. |
| Damaged oil seal ring or loose end cover. | Inspect oil seal ring for wear or damage. Repair as needed. Check the end cover capscrew torques and tighten as necessary. |
| Insufficient compressor cooling (compressor runs hot). | Remove grease, grime, or dirt from the cooling fins of the compressor. Check for damaged cooling fins. Replace components found damaged. Check for correct coolant line sizes. Check the coolant flow through the compressor. Minimum allowable flow is 2.5 gallons per minute at maximum engine governed speed, and minimum allowable flow is 0.5 gallons per minute at engine idle. If low, inspect the coolant lines for rust scale, kinks, and restrictions. Repair or replace as necessary. |
| Compressor runs loaded an excessive amount of time. | Check air lines and connections for leakage. Repair or replace lines and connections until leakage is eliminated. |
| Back pressure from the engine crankcase. | Check for excessive engine crankcase pressure. Repair or replace ventilation components as necessary.<br>NOTE: An indication of crankcase pressure is a loose or partially lifted dipstick. |
| Excessive engine oil pressure. | Check the engine oil pressure with a test gauge, and compare the reading to the engine specification. Do not restrict the compressor oil supply line. |
| Malfunctioning compressor. | Replace or repair the compressor after making certain none of the preceding conditions exist. |

**Problem—Noisy Compressor Operation**

| Problem—Noisy Compressor Operation | |
|---|---|
| **Possible Cause** | **Remedy** |
| Loose drive coupling or gear (as indicated). | Inspect the fit of the drive coupling and gear on the compressor crankshaft. Tighten or replace the components. If the crankshaft keyway is damaged, replace the compressor. |
| Compressor cylinder head or discharge line restrictions. | Inspect the compressor discharge port and discharge line for carbon build-up. If carbon is detected, remove the carbon and check for proper coolant flow to the compressor. Inspect the discharge line for kinks and restrictions. Replace the discharge line as necessary. |
| Air compressor bearing damaged or worn. | Replace the bearings. |
| Malfunctioning compressor. | Rebuild or replace the compressor after making certain none of the preceding conditions exist. |

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## Troubleshooting

**Problem—Excessive Build-Up and Recovery Time**

| Problem—Excessive Build-Up and Recovery Time | |
|---|---|
| **Possible Cause** | **Remedy** |
| Restricted air intake. | Check engine air filter and replace if necessary. Check compressor air inlet for kinks and excessive bends. Repair as needed. |
| Restricted discharge or compressor discharge cavity. | Inspect the compressor discharge port and line for restrictions and carbon build-up. If carbon is detected, remove the carbon. Check for proper cooling to the compressor. Inspect the discharge line for kinks and restrictions. Replace the discharge line as necessary. |
| Slipping drive components. | Check for faulty drive gears and coupling, and replace as necessary. |
| Excessive air system leakage (not including the air compressor). | Check all valves, air lines, and connections for leakage. Repair or replace valves and lines until leakage is eliminated. |
| Unloader pistons seized. | Check the operation of the unloading mechanism. Check for corrosion and contamination of unloader pistons. Check for correct operation of the compressor air governor. If the governor is operating properly, repair or replace the unloading mechanism. |
| Malfunctioning compressor. | Rebuild or replace the compressor after making certain none of the preceding conditions exist. |

**Problem—Compressor Fails to Unload**

| Problem—Compressor Fails to Unload | |
|---|---|
| **Possible Cause** | **Remedy** |
| Faulty or worn unloader pistons or bores. | Inspect for worn, dirty, or corroded unloader pistons and bores. Replace as necessary. |
| Malfunctioning governor. | Check the setting with an accurate test gauge. Repair or replace the air governor. |
| Unloader air lines from governor damaged. | Inspect the air lines to and from the governor for kinks or restrictions. Repair or replace the air lines. |

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| Fastener Torque Values | |
|---|---|
| **Description** | **Torque: lbf·ft (N·m)** |
| Cylinder Head | 37 to 42 (50 to 57) |
| Unloader Cover Plate | 15 to 18 (20 to 25) |
| Discharge Valve Seat | 70 to 90 (95 to 122) |
| Inlet Valve Stop | 70 to 90 (95 to 122) |
| End Cover | 15 to 18 (20 to 25) |
| Connecting Rod | 11 to 13 (15 to 17) |
| Bottom Cover | 15 to 18 (20 to 25) |
| Inlet Fitting | 15 to 18 (20 to 25) |
| Discharge Fitting | 15 to 8 (20 to 25) |
| Governor or Governor Adaptor | 15 to 18 (20 to 25) |

**Table 1, Fastener Torque Values**

| Compressor Specifications | |
|---|---|
| **Description** | **inches (mm)** |
| Discharge Valve Travel (minimum/maximum) | 0.030/0.046 (0.762/1.168) |
| Fit Between Crankcase Bore and Ball-Type Main Bearing (minimum/maximum) | 0.0003/0.0023 (0.008/0.058) |
| Clearance for Crankshaft Main Journals to I.D. of Sleeve-Type Main Bearing (maximum) | 0.005 (0.13) |
| Crankshaft Main Journal Standard Diameter | 1.1242 to 1.1250 (28.555 to 28.575) |
| Clearance Between Crankshaft Rod Journals and Connecting Rod Bearing (minimum/maximum) | 0.0003/0.0021 (0.008/0.053) |
| Crankshaft Rod Journal Standard Diameter* | 1.1242 to 1.1250 (28.555 to 28.575) |
| Cylinder Bore Out-of-Round (maximum) | 0.0005 (0.013) |
| Cylinder Bore Taper (maximum) | 0.0005 (0.013) |
| Clearance Between Cylinder Bore and Cast Iron Piston (minimum/maximum)† | 0.002/0.004 (0.050/0.101) |
| Clearance Between Wrist Pins and Connecting Rod Bushings (maximum) | 0.0007 (0.0178) |
| Compression Ring Groove Clearance | 0.002 to 0.004 (0.050 to 0.101) |
| Oil and Expander Ring Groove Clearance | 0.00 to 0.006 (0.00 to 0.152) |
| Compression Ring Gap (installed in cylinder) | 0.002 to 0.013 (0.050 to 0.330) |
| Oil and Expander Ring Gap (installed in cylinder) | 0.010 to 0.040 (0.254 to 1.016) |

* For compressors having reground crankshafts, undersize connecting rod bearing inserts are available in 0.010 inch (0.254 mm), 0.020 inch (0.508 mm), and 0.030 inch (0.762 mm).

† Oversized pistons and piston rings are available in 0.010 inch (0.254 mm), 0.020 inch (0.508 mm), and 0.030 inch (0.762 mm).

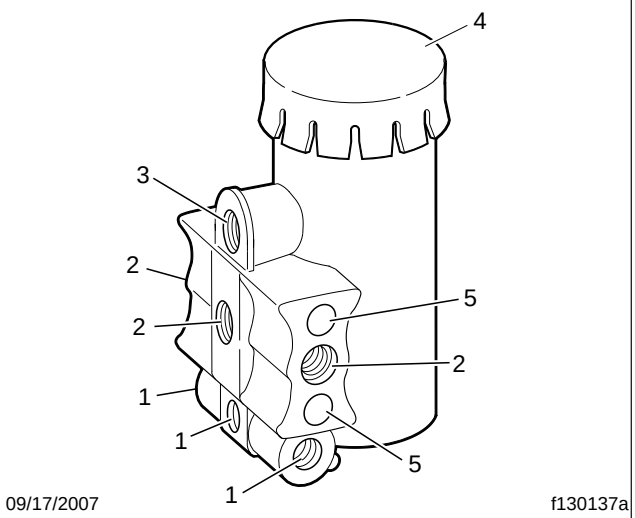
**Table 2, Compressor Specifications**

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## General Description

The air governor may be mounted on the air compressor, on the air dryer, or remote-mounted on the engine block. The governor has three reservoir ports, three unloader ports, and one exhaust port. See **Fig. 1**.




1. Reservoir Port
2. Unloader Port
3. Exhaust Port
4. Top Cover
5. Mounting Hole

**Fig. 1, Air Governor**

The air governor operates in conjunction with the air compressor to maintain pressure in the air brake or air supply system between a maximum (cut-out) and minimum (cut-in) pressure.

The cut-out setting of the air governor is typically 130 psi (896 kPa). When pressure in the air system reaches that point, the governor releases a signal to the air compressor and air dryer. The signal shifts the compressor to the unloaded cycle and opens the air dryer purge valve.

The cut-in setting of the governor is typically 105 psi (724 kPa). When pressure in the air system drops to that point, the governor stops the signal to the air compressor and the air dryer. At that time, the compressor shifts to the loaded cycle and closes the air dryer purge valve, building pressure in the air system.

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# Air Governor Operation and Leakage Tests

The following tests should be performed whenever the vehicle air pressure is incorrect and the causes are unknown, and whenever the air governor has been replaced or reinstalled.

## Operation Test

NOTE: The governor may be mounted on the air compressor, on the air dryer, or remote-mounted on the engine block.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake.
2. Chock the tires and open the hood.
3. Start the engine and build up air pressure in the air system.

IMPORTANT: Make sure the test gauge is registering accurately before using it to check the air governor. Do not use the vehicle's dash pressure gauge to check the governor pressure setting.

4. Using a test gauge attached to the supply reservoir, check the pressure at the time the air governor cuts out. For vehicles with a dryer reservoir module (DRM), install the pressure gauge in either the primary or secondary reservoir.

   The cut-out pressure should be 125 to 135 psi (860 to 930 kPa).

5. With the engine still running, make a series of brake applications to reduce the air pressure and observe at what pressure the air governor cuts in.

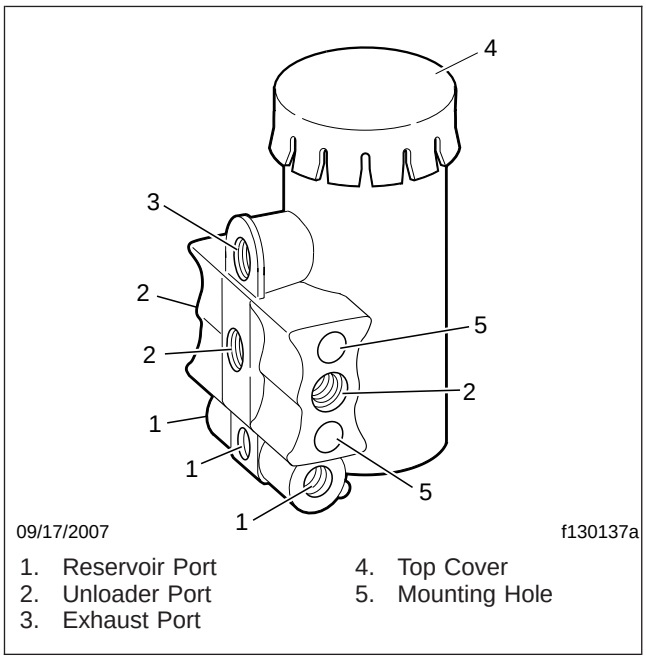
   For vehicles without a DRM, the minimum cut-in pressure should be 100 psi (689 kPa).

   For vehicles with a DRM, the minimum cut-in pressure should be 105 psi (724 kPa).

6. If the air governor does not function as described, replace it. See **Subject 110** for instructions.

## Leakage Test

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake.
2. Chock the tires, start the engine, and open the hood.
3. With the compressor in the cut-in position, apply a soap solution to the air governor exhaust port and around the governor top cover. See **Fig. 1**. Slight bubble leakage is permitted. Excessive leakage indicates that the inlet valve or lower piston O-ring is worn out.




1. Reservoir Port
2. Unloader Port
3. Exhaust Port
4. Top Cover
5. Mounting Hole

**Fig. 1, Air Governor**

4. With the compressor in the cut-out position, apply a soap solution to the air governor exhaust port and around the governor top cover. See **Fig. 1**. Slight bubble leakage is permitted. Excessive leakage indicates that the exhaust valve seat, exhaust stem O-ring, or upper piston O-ring is worn out.
5. If leakage is excessive, replace the governor. See **Subject 110** for instructions.

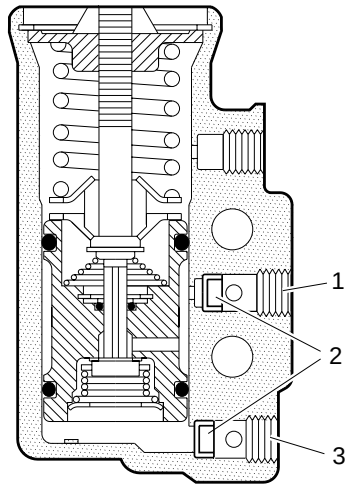
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## Removal

NOTE: The governor may be mounted on the air compressor, on the air dryer, or remote mounted on the engine block.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake.
2. Drain the air system, then chock the tires and open the hood.
3. Disconnect the reservoir and unloader port air lines. See **Fig. 1**. Mark the lines for later reference. Cap the air lines tightly to keep out contaminants.




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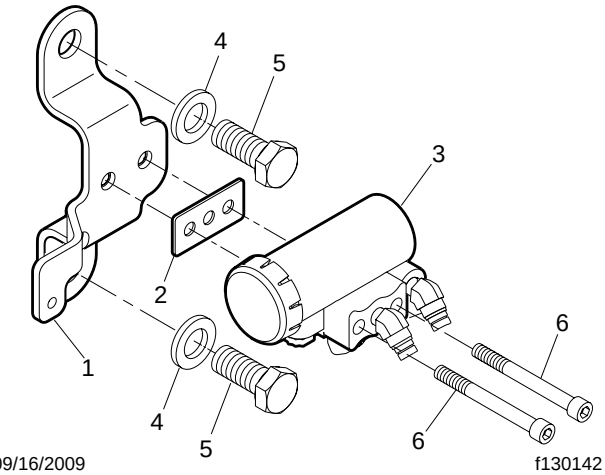
1. Unloader Port
2. Port Filters
3. Reservoir Port

**Fig. 1, Air Governor Ports**

4. Remove and discard the governor mounting capscrews and lockwashers (see **Fig. 2**), then remove the governor.

## Installation

1. Clean the mating surfaces on the air governor and the component it mounts to (air compressor, air dryer, or engine block). Ensure the governor unloading port is free of dirt and debris.




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1. Governor Mounting Bracket
2. Governor Mounting Gasket
3. Air Governor
4. Mounting Bracket Lockwasher (2 Qty)
5. Mounting Bracket Capscrew (2 Qty)
6. Governor Mounting Capscrew (2 Qty)

**Fig. 2, Air Governor Installation**

2. If the governor requires a governor adaptor, install a new governor mounting gasket between the governor and the adaptor.
3. Apply Loctite® Threadlocker Red 271™ to the threads new capscrews and lockwashers, then install the governor, or governor and adaptor assembly. Tighten the capscrews 14 to 16 lbf·ft (19 to 22 N·m).
4. If necessary, install new filters (see **Fig. 1**) in the reservoir and unloader ports. The cup-shaped filters can be installed with the eraser end of a pencil.
5. Clean the reservoir and unloader port air lines after removing the caps, and apply sealant in small quantities to the fittings.

### NOTICE

**Make sure excess sealant does not get inside the fittings. Loose material inside the plumbing may clog the governor or other components, causing damage.**

6. Connect the reservoir and unloader port air lines. Tighten the fittings 11 to 13 lbf·ft (15 to 18 N·m).

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## Air Governor Removal and Installation

7. Perform the operating and leakage tests in **Subject 100**.

NOTE: The top cover may snap on or screw on, depending on the governor model.

8. After the tests have been completed and the governor is operating properly, install the top cover tightly on the governor body to prevent the entry of any foreign matter.

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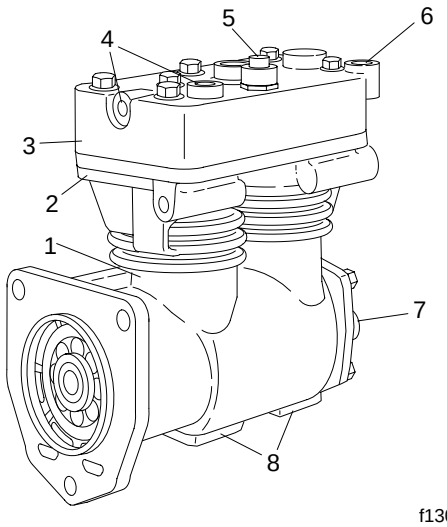
# General Information

The DuraFlo™ 596 air compressor is a two-cylinder reciprocating compressor with a rated displacement of 27 cubic feet per minute. The compressor consists of a water-cooled cylinder head and valve body assembly and an air-cooled integral crankcase and cylinder block. See **Fig. 1**. The cylinder head is an aluminum casting that contains the required air and water ports as well as inlet check valves for each cylinder. The valve body assembly consists of steel upper and lower halves, each of which incorporates various valve openings and channels for conducting air and engine coolant in to and out of the cylinder head. The discharge valves for each cylinder are part of the valve body assembly.

The DuraFlo 596 compressor incorporates an unloader system that features and energy saving system (ESS) which reduces compressor power consumption by approximately 80 percent in the unloaded mode. The ESS also reduces compressor oil consumption (oil passing) when the compressor is in the unloaded mode.

# Operation

The compressor is driven by the vehicle engine and functions continuously while the engine is in operation. Actual compression of air is controlled by the compressor unloading mechanism operating in conjunction with a remote mounted governor and synchro valve. The governor and synchro valve combination maintains brake system air pressure between a preset maximum and minimum pressure level.




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1. Crankcase
2. Valve Body Assembly
3. Cylinder Head
4. Water Inlet Port
5. Discharge Safety Valve
6. Water Outlet Port
7. Rear Cover Oil Port
8. Crankcase Bottom Cover

**Fig. 1, DuraFlo 596 Air Compressor**

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## Replacement

1. Apply the parking brakes, chock the tires, shut down the engine, and open the hood.
2. Drain the air system.
3. Disconnect the batteries.

**⚠ WARNING**

**Wear goggles when using compressed air to clean or dry parts, as permanent eye injury could result from flying debris.**

4. Using a cleaning solvent, remove road dirt and grease from the outside of the compressor, then dry the compressor with compressed air.
5. Drain the radiator coolant. For instructions, see **Group 20**.
6. Identify and disconnect all air, water, and oil lines attached to the compressor. Remove tie straps as needed to move the lines out of the way.
7. Note the position of the discharge and inlet fittings before removing the fittings.
8. Remove the signal booster valve that is mounted on the air compressor.
9. Remove the nuts that attach the air compressor to the engine and remove the compressor.

IMPORTANT: The replacement air compressor may not have a drive gear. If the replacement air compressor does not have a drive gear, follow the instructions in the next step. If the replacement air compressor does have a drive gear, skip the next step.

10. Use a gear puller to remove the drive gear from the air compressor crankshaft and install it on the replacement air compressor. Torque the crankshaft nut 125 lbf·ft (169 N·m).
11. Install the gasket on the drive flange of the compressor. Make sure that the oil supply or return holes in the gasket are properly aligned with the compressor and engine.
12. Install the compressor on the engine using nuts.
13. Make sure the threads on the discharge and inlet fittings are clean and free of corrosion. Replace the fittings if necessary. Install the discharge and inlet fittings on the compressor in the same positions as noted earlier.
14. Inspect all air and water lines and fittings before attaching them to the compressor. Make sure the O-rings are in good condition. Replace the O-rings if necessary. Tighten all hose clamps and secure the lines with tie straps as needed.
15. Fill the engine cooling system. For instructions, see **Group 20**.
16. Connect the batteries.
17. Clean the oil supply line. Before connecting the oil line to the compressor, run the engine briefly to be sure oil is flowing freely through the supply line.
18. Install the signal booster valve on the compressor.
19. Turn on the engine and check for leaks.
20. Remove the chocks from the tires and lower the hood.

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# Troubleshooting Tables

**Problem—Excessive Oil Passage**

| Problem—Excessive Oil Passage | |
|---|---|
| **Possible Cause** | **Remedy** |
| Restricted air intake. | Check engine or compressor air filter and replace if necessary. Check compressor air inlet for kinks, excessive bends, and be certain inlet lines have the minimum specified inside diameter. Recommended maximum air inlet restriction is 25 inches of water. |
| Restricted oil return to engine. | Make certain oil drain passages in the compressor and mating engine surfaces are unobstructed and aligned. Correct gaskets must be used. Special care must be taken when sealants are used with, or instead of, gaskets. |
| Poorly filtered air inlet. | Check for a damaged or dirty air filter on the engine or compressor. Check for leaking or damaged compressor air intake components such as induction line, fittings, gaskets, and filter bodies. The compressor intake should not be connected to any part of the exhaust gas recirculation (E.G.R.) system on the engine. |
| Insufficient compressor cooling (compressor runs hot). | For air-cooled portions of the compressor:<br>• Remove accumulated grease and dirt from the cooling fins. Replace components found damaged.<br>• Check for damaged cooling fins. Replace compressor if found damaged.<br>For water-cooled portions of the compressor:<br>• Check for proper coolant line sizes. Minimum recommended line i.d. is 3/8 inch.<br>• Check the coolant flow through the compressor. Minimum allowable flow is 2.5 gallons per minute at engine governed speed. If low coolant flow is detected, inspect the coolant lines and fittings for accumulated rust scale, kinks, and restrictions.<br>• Water temperature should not exceed 200°F (93°C).<br>• Optimum cooling is achieved when engine coolant flows as shown in **Fig. 1**. |
| Contaminants not being regularly drained from system reservoirs. | Check reservoir drain valves to insure that they are functioning properly. It is recommended that the vehicle should be equipped with functioning automatic drain valves or have all reservoirs drained to zero psi daily, or optimally, to be equipped with a desiccant-type air dryer prior to the reservoir system. |
| Compressor runs loaded an excessive amount of time. | Vehicle system leakage should not exceed 1 psi pressure drop per minute without brakes applied and 3 psi pressure drop per minute with brakes applied. If leakage is excessive, check for system leaks and repair. |
| Excessive engine crankcase pressure. | Test for excessive engine crankcase pressure and repair or replace ventilation components as necessary.<br>Note: An indication of crankcase pressure is a loose or partially lifted dipstick. |
| Excessive engine oil pressure. | Check the engine oil pressure with a test gauge and compare the reading to the engine specifications. Do not restrict the compressor oil supply line. Minimum oil supply line size is 3/16-inch i.d. |

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## Troubleshooting

| Problem—Excessive Oil Passage | |
|---|---|
| **Possible Cause** | **Remedy** |
| Malfunctioning compressor. | Replace or repair the compressor only after making certain none of the preceding conditions exist. |

**Problem—Noisy Compressor Operation**

| Problem—Noisy Compressor Operation | |
|---|---|
| **Possible Cause** | **Remedy** |
| Loose drive gear or components. | Inspect the fit of the drive gear on the compressor crankshaft. The gear or coupling must be completely seated and the crankshaft nut must be tight. If the compressor crankshaft surface is damaged, it is an indication of loose drive components. If damage to the compressor crankshaft is detected, replace the compressor. When installing the drive gear or pulley, torque the crankshaft nut to the appropriate torque specifications and use care when pressing drive components on to the crankshaft.<br>Do not back off the crankshaft nut once it is tightened to the proper torque.<br>Do not use impact wrenches to install the crankshaft nut. |
| Excessively worn drive couplings or gears. | Inspect drive gear, couplings, and engine for excessive wear. Replace as necessary.<br>NOTE: Nonmetallic gears should be replaced when the compressor is changed. |
| Compressor cylinder head or discharge line restrictions. | Inspect the compressor discharge port and discharge line for carbon buildup. If carbon is detected, check for proper compressor cooling. See the remedy for insufficient compressor cooling in the previous table. Inspect the discharge line for kinks and restrictions. Replace the discharge line as necessary. |
| Worn or burned out bearings. | Check for proper oil pressure in the compressor. Minimum required oil pressure is 15 psi when engine is idling and 15 psi maximum at governed engine rpm. Check for excessive oil temperature; oil temperature should not exceed 240°F (115°C). |
| Malfunctioning compressor. | Repair or replace the compressor after making certain none of the preceding conditions exist. |

**Problem—Excessive Buildup and Recovery Time**

| Problem—Excessive Buildup and Recovery Time* | |
|---|---|
| **Possible Cause** | **Remedy** |
| Dirty induction air filter. | Inspect engine or compressor air filter and replace if necesary. |
| Restricted induction line. | Inspect the compressor air induction line for kinks and restrictions and replace as necessary. |
| Restricted discharge line or compressor discharge cavity. | Inspect the compressor discharge port and line for restrictions and carbon buildup. If carbon buildup is found, check for proper compressor cooling. Replace faulty sections of the discharge line. |
| Slipping drive components. | Check for faulty drive gears and couplings and replace as necessary. Check the condition of drive belts and replace or tighten, whichever is appropriate. |

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| Problem—Excessive Buildup and Recovery Time* | |
|---|---|
| **Possible Cause** | **Remedy** |
| Excessive air system leakage. | Test for excessive system leakage and repair as necessary. Use the following as a guide. Build system pressure to governor cutout and allow the pressure to stabilize for one minute. Using a test gauge, note the system pressure drop after two minutes. The pressure should not exceed:<br>• 2 psi in each reservoir for a single vehicle;<br>• 6 psi in each reservoir for a tractor and trailer;<br>• 8 psi in each reservoir for a tractor and two trailers. |
| Sticking unloader pistons. | Check the operation of the unloading mechanism. Check for proper operation of the compressor air governor and synchro valve. Make certain the air connections between the governor and synchro valve are correct. See **Fig. 2**. If the governor and synchro valve are operating properly, replace the unloader mechanism. Inspect for bent, linked, or blocked tubing leading to or from the governor and synchro valve. |
| Malfunctioning compressor. | Repair or replace the compressor after making certain none of the preceding conditions exist. |

* Compressor should be capable of building air system pressure from 85 to 100 psi in 40 seconds with engine at full governed rpm. Minimum compressor performance is certified to meet Federal requirements by the vehicle manufacturer. Do not downsize the original compressor.

**Problem—Compressor Does Not Unload**

| Problem—Compressor Does Not Unload | |
|---|---|
| **Possible Cause** | **Remedy** |
| Malfunctioning governor and synchro valve. | Test the governor and synchro valve for proper operation and inspect air lines to and from both components for kinks or restrictions. Repair or replace the governor, synchro valve, or connecting air lines. |
| Malfunctioning or worn unloader pistons or bores. | Inspect for worn, dirty, or corroded unloader pistons and their bores. Replace as necessary. |

**Problem—Compressor Leaks Oil**

| Problem—Compressor Leaks Oil | |
|---|---|
| **Possible Cause** | **Remedy** |
| Damaged mounting gasket. | Check the compressor mounting bolt torque. If the mounting bolt torque is low, replace the compressor mounting gasket before retorqueing the mounting bolts. |
| Cracked crankcase or end cover. | Visually inspect the compressor exterior for cracked or broken components. Cracked or broken crankcases or mounting flanges can be caused by loose mounting bolts. The end cover can be cracked by overtorquing fittings or plugs installed in the end cover. Repair or replace the compressor as necessary. |
| Loose crankcase end cover or bottom cover. | Check the capscrew torques and tighten as necessary. Replace gaskets or O-rings. |
| Loose oil supply or return line fittings. | Check the torque of external oil line fittings and tighten as necessary. |
| Porous compressor casting. | Replace the compressor if porosity is found. |

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## Troubleshooting

| Problem—Compressor Leaks Oil | |
|---|---|
| **Possible Cause** | **Remedy** |
| Mounting flange or end cover, O-ring or gasket missing, cut, or damaged. | Replace as necessary. |

**Problem—Compressor Constantly Cycles; Compressor Remains Unloaded for a Very Short Time**

| Problem—Compressor Constantly Cycles; Compressor Remains Unloaded for a Very Short Time | |
|---|---|
| **Possible Cause** | **Remedy** |
| Leaking compressor unloader pistons. | Repair or replace as necessary. |
| Malfunctioning governor and synchro valve. | Test the governor and synchro valve for proper operation and inspect air lines to and from both components for kinks or restrictions. Repair or replace the governor, synchro valve, or connecting air lines. |
| Excessive air system leakage. | Test for excessive system leakage and repair as necessary. Use the following as a guide. Build system pressure to governor cutout and allow the pressure to stabilize for one minute. Using a test gauge, note the system pressure drop after two minutes. The pressure should not exceed:<br>• 2 psi in each reservoir for a single vehicle;<br>• 6 psi in each reservoir for a tractor and trailer;<br>• 8 psi in each reservoir for a tractor and two trailers. |
| Excessive reservoir contaminants. | Drain reservoirs. |

**Problem—Compressor Leaks Coolant**

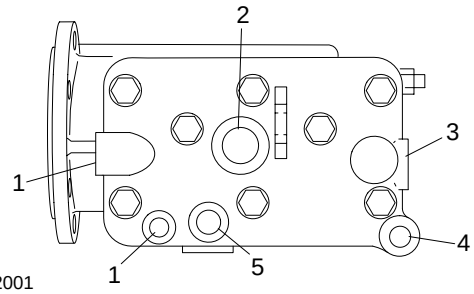
| Problem—Compressor Leaks Coolant | |
|---|---|
| **Possible Cause** | **Remedy** |
| Improperly installed plugs and coolant line fittings. | Check torque of fittings and plugs and tighten as necessary. Overtorqued fittings and plugs can crack the head or block casting. |
| Freeze cracks due to improper antifreeze strength. | Test antifreeze and strengthen as necessary. Check coolant flow through compressor to assure the proper antifreeze mixture reaches the compressor. |
| Malfunctioning compressor due to porous castings. | If casting porosity is detected, replace the compressor. |

**Problem—Compressor Head Gasket Malfunction**

| Problem—Compressor Head Gasket Malfunction | |
|---|---|
| **Possible Cause** | **Remedy** |
| Restricted discharge line. | Clear restriction or replace line. |
| Loose cylinder head capscrews. | Tighten evenly to a torque of 265 to 292 lbf·in (2990 to 3300 N·cm). |
| Malfunctioning compressor or head gasket. | Check for rough or poorly machined head or block surfaces. Replace compressor as necessary. |

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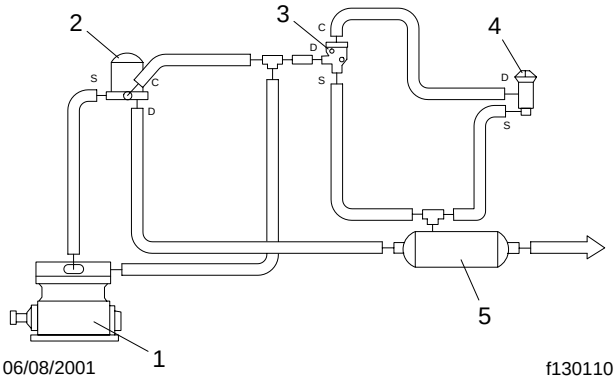





NOTE: The cylinder head connection ports are identified with the following numbers: 0-Atmospheric Air In; 2-Compressed Air Out; 91-Coolant In; 92-Collant Out

1. Coolant In or Out (One of the two ports is plugged.)
2. Inlet Port
3. Discharge Port
4. Coolant In or Out
5. Discharge Safety Valve

**Fig. 1, Cylinder Head Port Identification**




1. DuraFlo 596 Compressor
2. Air Dryer
3. Synchro Valve
4. Governor
5. Supply Reservoir

**Fig. 2, Plumbing Diagram**

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DuraFlo™ 596 Specifications

- Flow capacity at 1800 rpm and 120 psi: 21.4 cfm
- Operation: naturally aspirated
- Horsepower required at 1800 rpm and 120 psi: loaded 7.6, unloaded 1.1
- Swept air displacement at 1250 rpm: 27 cfm
- Maximum recommended rpm: 3000
- Minimum governor cutout pressure: 130 psi
- Maximum inlet air temperature: 250°F (121°C)
- Maximum inlet restriction: 25 in$H_2O$
- Maximum discharge air temperature: 400°F (204°C)
- Minimum oil pressure required at engine idle speed: 15 psi
- Minimum oil pressure required at maximum governed engine speed: 15 psi
- Number of cylinders: 2
- Weight: 50 pounds (23 kilograms)
- Length: 10.9 inches (28 centimeters)
- Height: 13.3 inches (34 centimeters)
- Width: 5.5 inches (14 centimeters)

| Fastener Torque Values | |
|---|---|
| **Description** | **Torque: lbf·in (N·cm)** |
| 13 mm Cylinder Head Capscrews | 265 to 292 (2990 to 3300) |
| 10 mm Valve Capscrews | 101 to 111 (1140 to 1250) |
| Rear End Cover Capscrews | 195 to 212 (2200 to 2400) |
| Bottom Cover Capscrews | 97 to 115 (1100 to 1300) |
| Crankshaft Nut | 148 to 184 lbf·ft (200 to 250 N·m) |

**Table 1, Fastener Torque Values**

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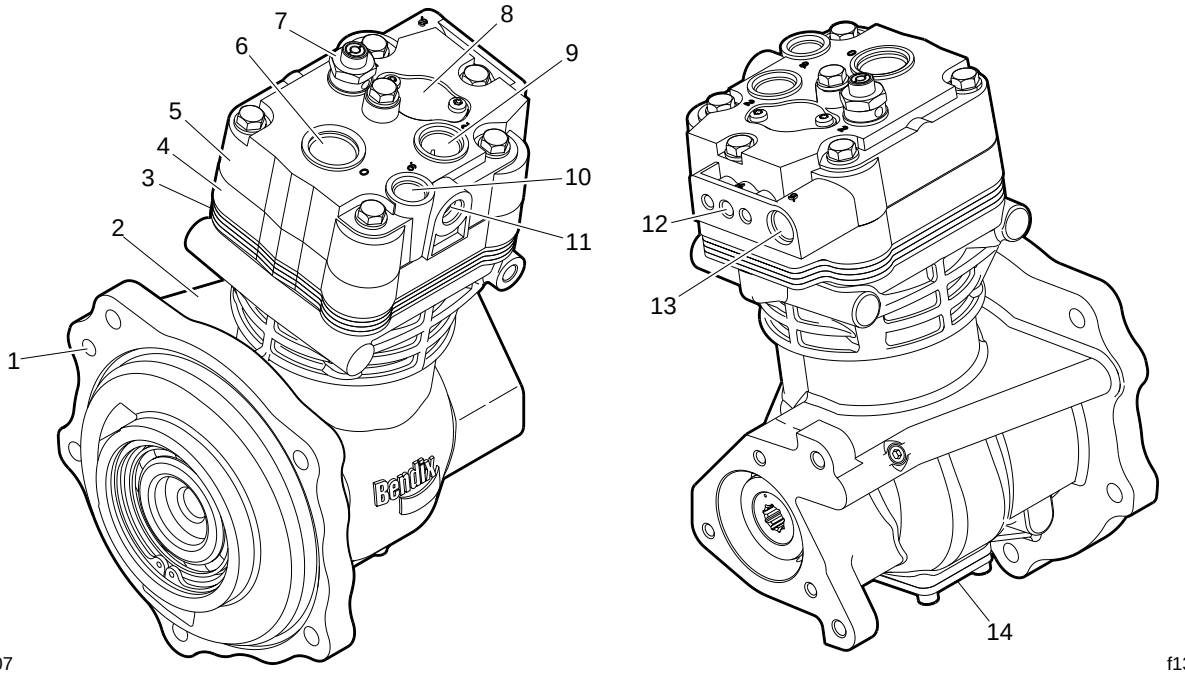


## General Description

The function of the Bendix air compressors is to provide and maintain air under pressure to operate devices in the air brake system. See **Fig. 1** and **Fig. 2**. The Bendix BA-921 and 360cc air compressors are both single-cylinder reciprocating compressors with a rated displacement of 15.8 cubic feet per minute (cfm) at 1250 rpm. The Bendix BA-922 compressor is very similar to the BA-921 compressor, but has two cylinders and a rated displacement of 31.6 cfm at 1250 rpm.

stops or starts based on the cut-in and cut-out pressure settings of the governor.

The cylinder head assembly is made up of the cylinder head, cooling plate, and a valve plate assembly. The cylinder head contains the air and coolant ports as well as an unloader piston. The cooling plate is located between the cylinder head and valve plate assemblies, and assists in cooling the cylinder head assembly. The valve plate assembly, consisting of brazed steel plates, has several valve openings and channels for conducting air and engine coolant into and out of the cylinder head. The compressor is




06/28/2007 f130135

1. Oil Supply Bore
2. Crankcase
3. Valve Plate Assembly
4. Cooling Plate
5. Cylinder Head
6. Air Supply Port
7. Discharge Safety Valve
8. Unloader Valve Cover
9. Discharge Port
10. Coolant Supply Port
11. Freeze Plug
12. Governor Connection Port
13. Coolant Return Port
14. Crankcase Cover

**Fig. 1, Bendix BA-921 Air Compressor**

The air governor operates in conjunction with the air compressor to maintain the air pressure in the air system between a maximum (cut-out) and minimum (cut-in) pressure. The air compressor turns continuously while the engine is on, but actual compression of air is controlled by the governor, which actuates the air compressor unloading mechanism. Unloading

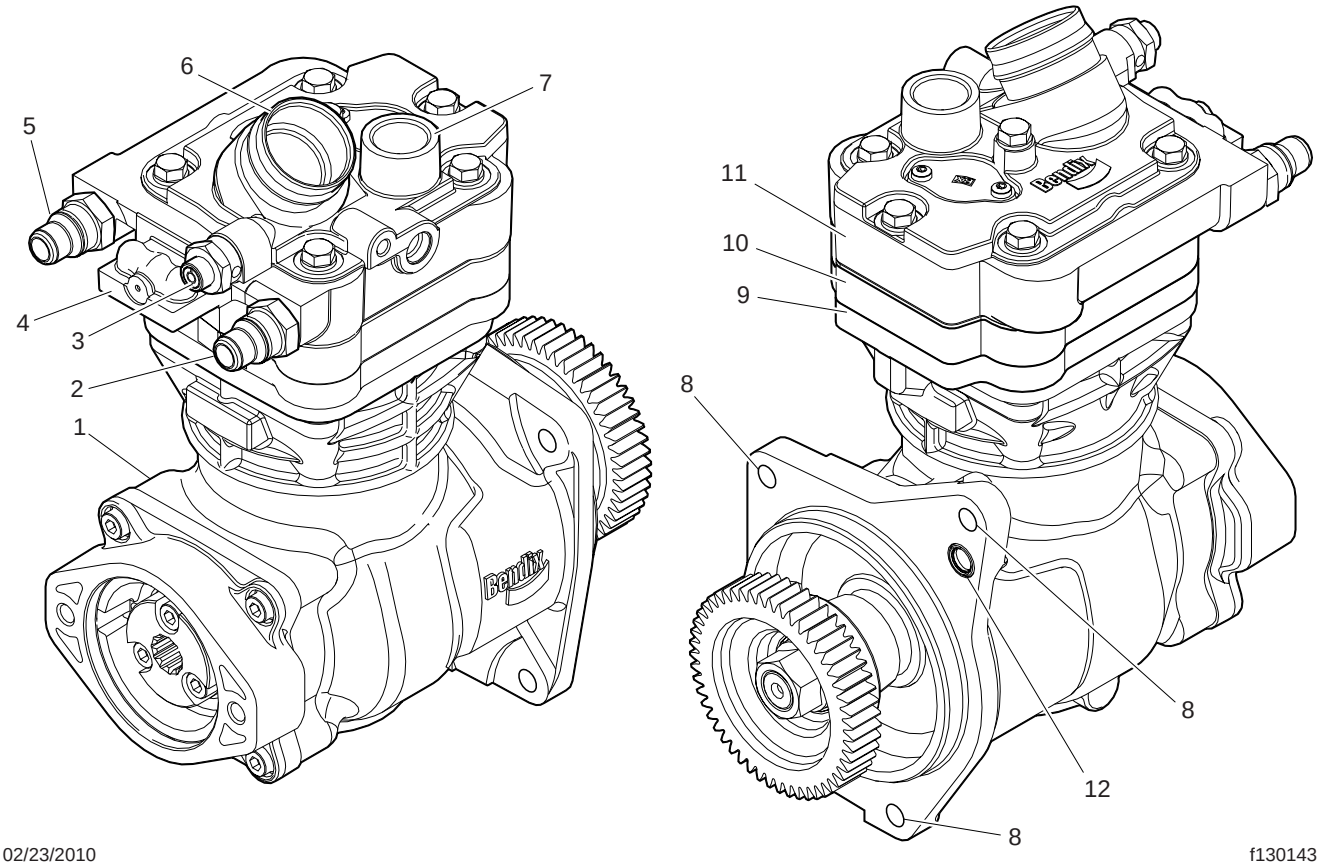
cooled by air flowing through the engine compartment as it passes the compressor's cooling fins, and by the flow of engine coolant through the cylinder head. The vehicle's engine provides a continuous supply of oil to lubricate the compressor.

Bendix air compressors are typically equipped with a safety valve in the cylinder head safety valve port,

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## General Information




1. Crankcase
2. Coolant Return Port
3. Pressure Relief Valve
4. Governor Connection Port
5. Coolant Supply Port
6. Air Supply Port
7. Discharge Port
8. Mounting Fastener Holes
9. Valve Plate Assembly
10. Cooling Plate
11. Cylinder Head
12. Oil Bore

**Fig. 2, Bendix 360cc Air Compressor**

directly connected to the discharge port. The safety valve protects the cylinder head assembly in the event of excessively high discharge line pressure. Excessive air pressure causes the safety valve to unseat, releases air pressure, and gives an audible alert to the operator.

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## Replacement

1. Shut down the engine, apply the parking brakes, chock the tires, and open the hood.
2. Drain the air system.
3. Disconnect the batteries.

**⚠ WARNING**

**Wear goggles when using compressed air to clean or dry parts, as permanent eye injury could result from flying debris.**

4. Using a cleaning solvent, remove road dirt and grease from the outside of the air compressor, then dry the compressor with compressed air.
5. Depending on the vehicle's engine and chassis specifications, the air compressor may be difficult to access behind the frame rail. It may be necessary to reposition or remove components above and below the frame rail that interfere with access to the compressor, such as battery cables and transmission oil cooler lines.

   Clear any wiring harnesses out of the way, removing P-clamps as necessary.
6. Remove any components attached to the air compressor, such as the fuel pump (Series 60 engines) or power steering pump (DD13/15/16 engines).
7. Drain the coolant from the radiator and cylinder block. For instructions, see **Group 20**.
8. Remove the coolant supply and return lines from the compressor. For a Bendix BA-921/922 compressor, see **Fig. 1**. For a Bendix 360cc compressor and line connections, see **Fig. 2** and **Fig. 3**.
9. Identify and disconnect all air and oil lines attached to the air compressor.
10. Remove the air governor and the air governor mounting gasket, if equipped, or remove the air governor remote line.

**NOTICE**

**Do not allow the air compressor drive gear to make contact with the gear train during removal. Damage to the seal surface could cause oil leakage.**

11. Support the air compressor and remove the mounting fasteners that attach the compressor to the engine. Remove the air compressor.
12. Discard all gaskets.

IMPORTANT: Ensure new gaskets are clean and not damaged.

13. Install a new air compressor gasket on the compressor.

**NOTICE**

**Ensure the correct mounting capscrews are used to install the air compressor. If the wrong length is used, the cup plugs installed in the cylinder block can be pushed out into the gear train, causing damage to the gear train.**

14. Using capscrews, attach the air compressor to the gear case. See **Table 1** for torque specifications.

| Mounting Fastener Torque Values | |
|---|---|
| **Description** | **Torque: lbf·ft (N·cm)** |
| BA-921 Mounting Capscrews<br>M10 1.50 x 85 (4 qty)<br>M10 1.50 x 35 (1 qty) | 43–54 (58–73) |
| 360cc Mounting Capcrews<br>1.37 in (35 mm) (4 qty) | 44 (60) |
| Power Steering Pump Mounting Fasteners | 27–32 (37–43) |
| Fuel Pump Mounting Fasteners | 22–28 (30–38) |
| Air Governor Mounting Fasteners | 11–15 (15–20) |

**Table 1, Mounting Fastener Torque Values**

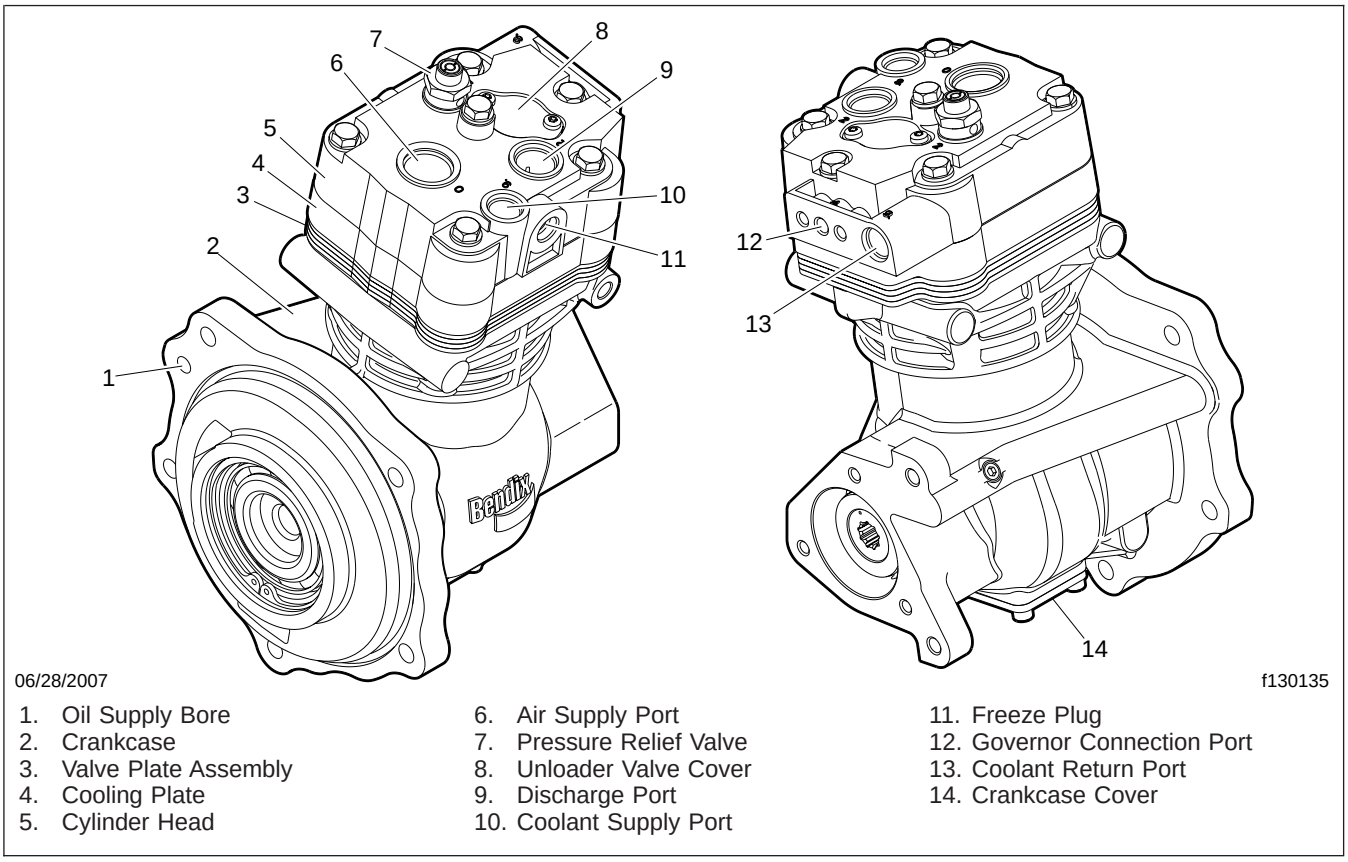
15. If equipped with a compressor-mounted air governor, install a new gasket on the air governor and install the air governor on the compressor. If the vehicle has a remote-mounted air governor, connect the air governor remote line to the compressor.

IMPORTANT: Ensure that coolant lines connected to a Bendix 360cc compressor are equipped with an O-ring and O-ring retainer on both ends. After installing the lines, ensure that

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## Air Compressor Replacement




1. Oil Supply Bore
2. Crankcase
3. Valve Plate Assembly
4. Cooling Plate
5. Cylinder Head
6. Air Supply Port
7. Pressure Relief Valve
8. Unloader Valve Cover
9. Discharge Port
10. Coolant Supply Port
11. Freeze Plug
12. Governor Connection Port
13. Coolant Return Port
14. Crankcase Cover

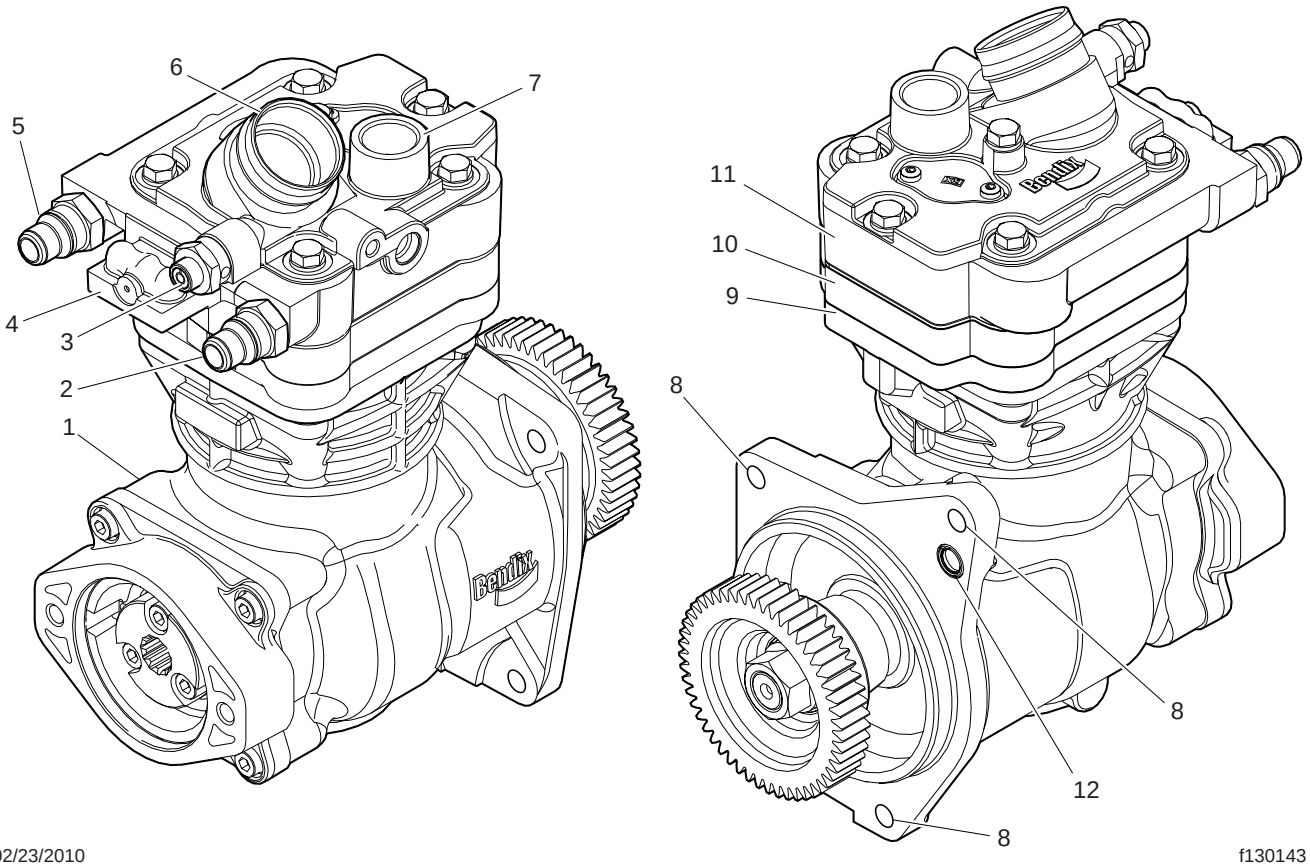
**Fig. 1, BA-921 Air Compressor**

each coolant line retainer is engaged in the locked position.

16. Connect the air and coolant lines to the air compressor. Connect the oil line, if equipped, to the compressor.
17. Install any components that were removed from the air compressor, such as the fuel pump (Series 60 engines) or power steering pump (DD13/15/16 engines). See **Table 1** for torque specifications.
18. Move all wiring harnesses back into place and install any wiring harness P-clamps that were previously removed.
19. Fill the engine cooling system. For instructions, see **Group 20**.
20. Connect the batteries.
21. Start the engine and check for leaks.

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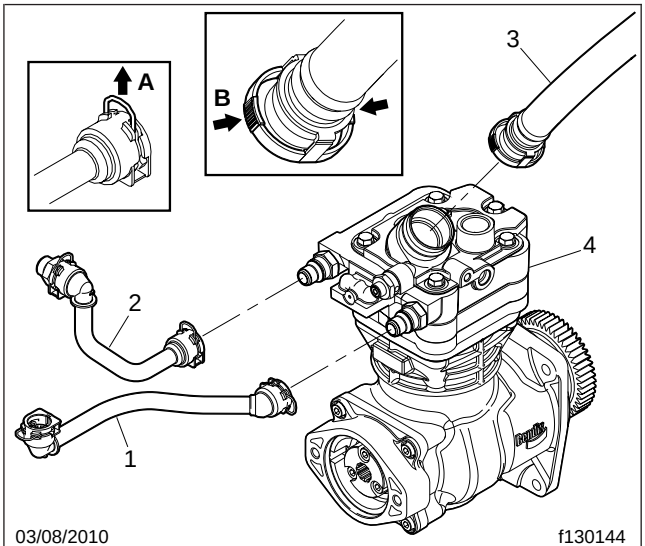

1. Crankcase
2. Coolant Return Port
3. Pressure Relief Valve
4. Governor Connection Port
5. Coolant Supply Port
6. Air Supply Port
7. Discharge Port
8. Mounting Fastener Holes (4 qty)
9. Valve Plate Assembly
10. Cooling Plate
11. Cylinder Head
12. Oil Bore

**Fig. 2, Bendix 360cc Air Compressor**

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## Air Compressor Replacement




A. Pull securing clip up in order to disconnect coolant lines.
B. Squeeze the two tabs on the air supply line to disconnect it from the compressor.

1. Coolant Return Line
2. Coolant Supply Line
3. Air Supply Line
4. Air Compressor

**Fig. 3, Bendix 360cc Air Compressor Line Connections**

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## Removal

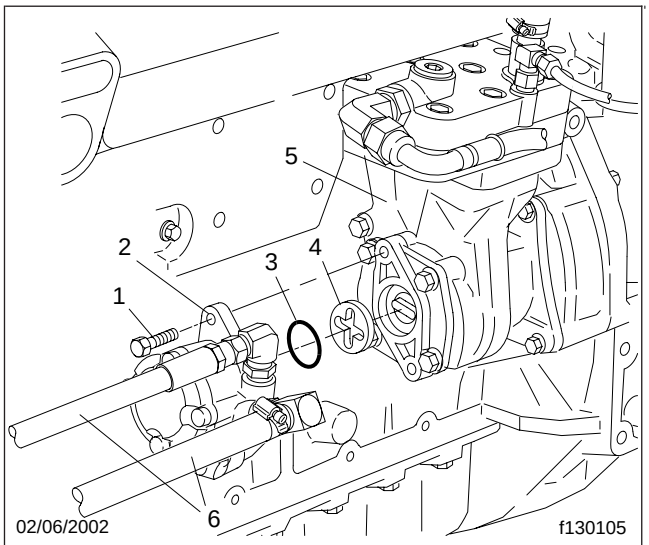
1. Apply the parking brakes and chock the tires.
2. Drain the air tanks.
3. Open the hood. Clean the fittings and hose connections on the air compressor and power steering pump.
4. Drain the radiator coolant. For instructions, see **Group 20**.

IMPORTANT: Do not remove the power steering lines. Secure the lines and the pump so that they are out of the way.

5. Remove the two capscrews that attach the power steering pump to the air compressor and move the pump away from the compressor. See **Fig. 1**.

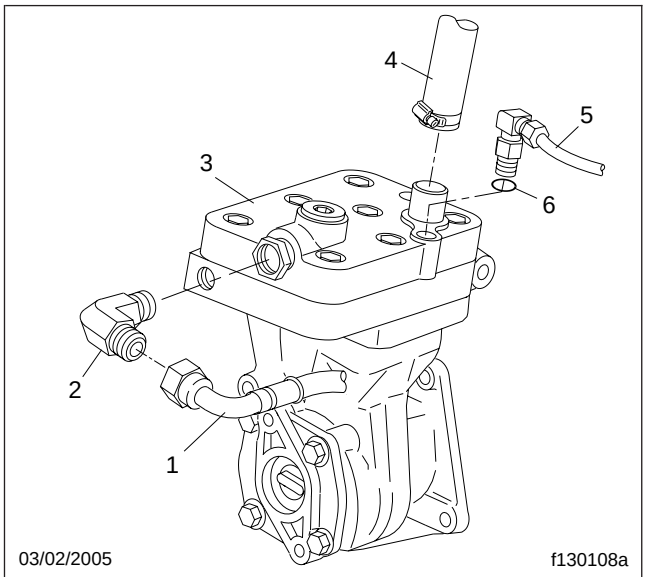
NOTE: Depending on vehicle configuration, it may be necessary to remove the brackets that attach the transmission cooler lines to the engine in order to obtain enough room to remove the compressor.

6. Remove and discard the O-ring located between the power steering pump and the cross plate.
7. Remove the cross plate located between the air compressor and the power steering pump.
8. Remove the three air lines from the air compressor (see **Fig. 2**), as follows.
   - 8.1 Remove the discharge air line and the elbow fitting. Check inside the discharge air line for carbon deposits and replace if necessary.
   - 8.2 Remove the unloader air line. Check the fittings for damage and replace if necessary.
   - 8.3 Loosen the hose clamp and remove the intake air line.
9. Remove all air fittings from the top of the compressor.
10. Remove the engine trim cover.
11. Remove the coolant delivery and return lines. Discard the seal rings. See **Fig. 3**.
12. Remove the four capscrews that attach the air compressor to the engine and remove the compressor. See **Fig. 4**.




1. Capscrew
2. Power Steering Pump
3. O-Ring
4. Cross Plate
5. Air Compressor
6. Hydraulic Lines

**Fig. 1, Power Steering Pump Removal**



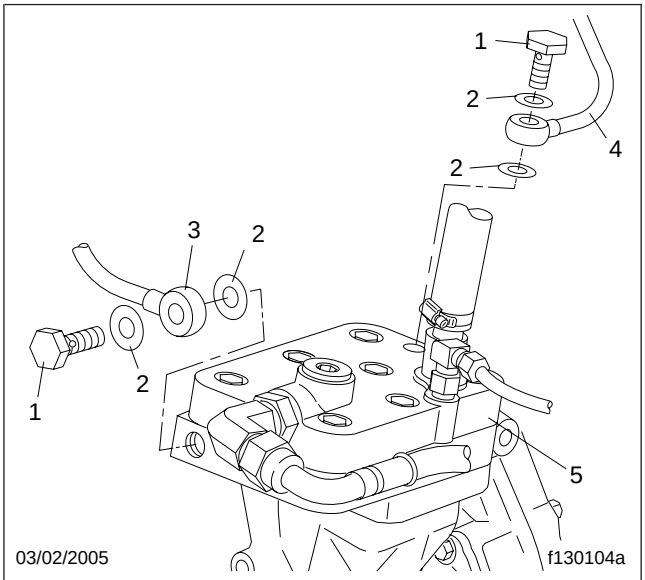

1. Discharge Air Line
2. Elbow Fitting
3. Air Compressor
4. Intake Air Line
5. Unloader Air Line
6. O-Ring

**Fig. 2, Air Compressor Air Lines**

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## Removal, Inspection, and Installation




1. Hollow-Core Banjo Capscrew
2. Seal Ring
3. Coolant Return Line
4. Coolant Delivery Line
5. Air Compressor

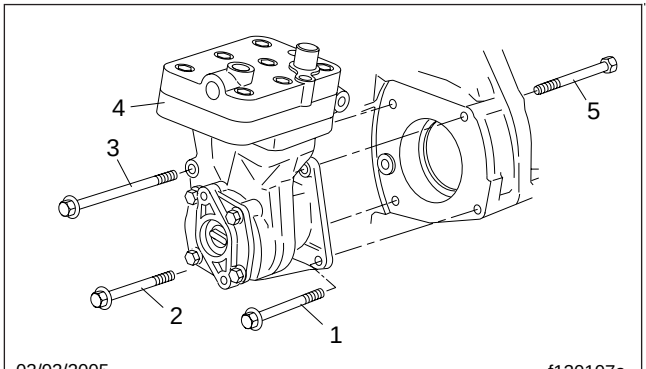
**Fig. 3, Air Compressor Coolant Lines**

NOTE: The capscrews that attach the air compressor to the engine are different lengths. Be sure to note where each capscrew is located.

13. Slide the drive gear away from the flywheel. Catch any oil that runs out and dispose of it properly.

## Inspection

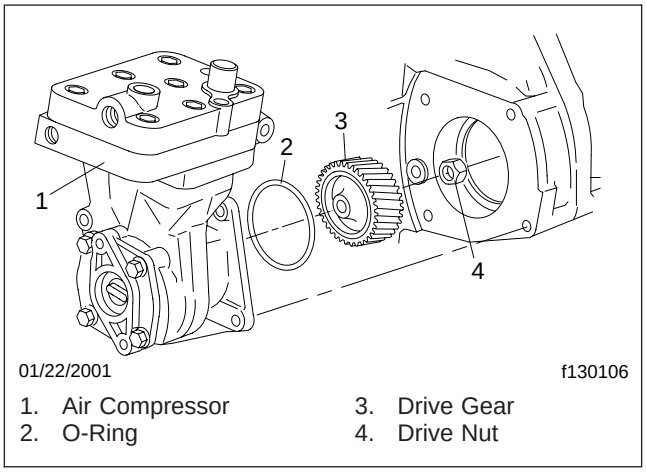
1. Install an SPX Kent-Moore locking device (J 46177) on the air compressor where the power steering pump connects to the air compressor. Tighten the capscrews until the air compressor drive is locked. This device locks the driveshaft to allow removal of the drive nut.
2. Remove the drive gear from the air compressor, as follows.
   - 2.1 Place the air compressor and locking device in a vise. Make sure the locking device is tightly secured and cannot slip out of the vise.
   - 2.2 Using an impact wrench, remove the drive nut from the drive gear.




1. Outboard Lower Capscrew
2. Inboard Lower Capscrew
3. Inboard Upper Capscrew
4. Air Compressor
5. Outboard Upper Capscrew

**Fig. 4, Air Compressor Removal**

   - 2.3 Remove the drive gear from the air compressor, using a gear puller if necessary.
   - 2.4 Discard the O-ring that seals the compressor housing to the engine block.
3. Inspect the drive gear for worn or broken teeth, spalling, and corrosion. If necessary, replace the drive gear.
4. Install a new O-ring on the air compressor housing. Install the drive gear. Tighten the drive nut 214 lbf·ft (290 N·m). See **Fig. 5**.




1. Air Compressor
2. O-Ring
3. Drive Gear
4. Drive Nut

**Fig. 5, Air Compressor Drive Gear Installation**

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## Installation

1. Using four capscrews, attach the air compressor to the engine. Tighten the capscrews 44 lbf·ft (60 N·m).

NOTE: Be sure to use the correct capscrew at each mounting location.

2. Install new seal rings on the coolant lines, then install the coolant lines on the air compressor. Tighten the hollow-core banjo capscrews 22 lbf·ft (30 N·m).
3. Install the engine trim cover.
4. Install the air fittings on top of the air compressor.
5. Install the three air lines on the air compressor, as follows.
   - 5.1 Install the discharge and unloader air lines. Make sure the O-rings are correctly installed on the fittings.
   - 5.2 Tighten the discharge and unloader air line fittings 60 lbf·ft (80 N·m).
   - 5.3 Install the intake air line and tighten the hose clamp.
6. Install the cross plate on the compressor output drive. Use grease to hold it in place while installing the power steering pump.
7. Install a new O-ring between the power steering pump and the cross plate.
8. Using two capscrews, attach the power steering pump to the air compressor. Tighten the capscrews 30 lbf·ft (40 N·m).
9. If the brackets that attach the transmission cooler lines to the engine were removed, install the brackets.
10. Fill the cooling system. For instructions, see **Group 20**.
11. Turn on the engine and check air line and coolant fittings for leaks. Correct any leaks as necessary.

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## Specifications

Special tools can be ordered from:

SPX Kent-Moore
28635 Mount Road
Warren, Michigan 48092-3499
1-800-328-6657

| SPX Kent-Moore Tools | |
|---|---|
| **Tool** | **Part Number** |
| Air Compressor Locking Device | J-46177 |

**Table 1, SPX Kent-Moore Tools**

| Torque Values | |
|---|---|
| **Description** | **Torque: lbf·ft (N·m)** |
| Air Compressor Capscrews | 44 (60) |
| Air Line Fittings | 60 (80) |
| Coolant Line Hollow-Core Banjo Bolts | 22 (30) |
| Drive Nut | 214 (290) |
| Power Steering Pump Mounting Capscrews | 30 (40) |

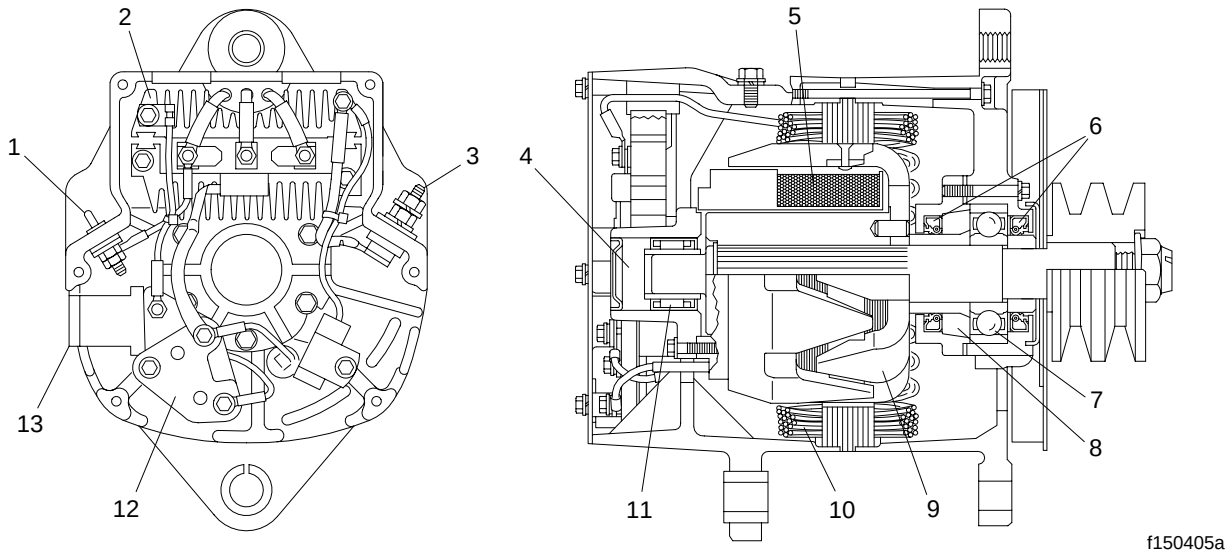
**Table 2, Torque Values**

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## General Information

Delco Remy SI series alternators feature internal integrated-circuit regulators. See **Fig. 1** for cutaway end and sectional views of a typical example (a 30SI), and **Fig. 2** for an end view, cut away to show the regulator of a 33SI model.




1. Relay Terminal
2. Rectifier Bridge
3. Output Terminal
4. Grease Reservoir
5. Stationary Field Coil (Brushless Construction)
6. Lip Seals
7. Ball Bearings
8. Grease Reservoir
9. Rotor
10. Stator
11. Roller Bearing with Lip Seal
12. Integrated Circuit Regulator
13. External Voltage Adjustment

**Fig. 1, Typical Delco Remy SI Series Alternator Components (30SI Hinge Mount Shown)**

Delco Remy SI series alternators have been updated over the years, to provide higher output and improved performance under more difficult operating conditions.

The rotor is mounted on a ball bearing at the drive end, and a roller bearing at the rectifier end; see **Fig. 3**.

A fan on the drive end of most alternators sucks air through the alternator from the rear for cooling. All bearings are sealed, so that no periodic lubrication is required.

On some models, only one wire and a ground return connect the alternator to the battery, but most have some combination of the terminals shown in **Fig. 4**, which shows terminal placement on the 30SI, and **Fig. 5**, which shows terminal placement on the 33SI and 34SI. The output terminal on all alternators connects to the battery's positive terminal.

Some SI series alternators have a relay terminal labeled "R," which provides a pulse signal to operate certain auxiliary equipment, such as a tachometer.

Some models have an "I" terminal, which can be wired to operate a dashboard indicator light.

Some models may be equipped with a Remote Sense terminal which is wired to the batteries to monitor their voltage and control alternator output, to keep the batteries at optimum charge.

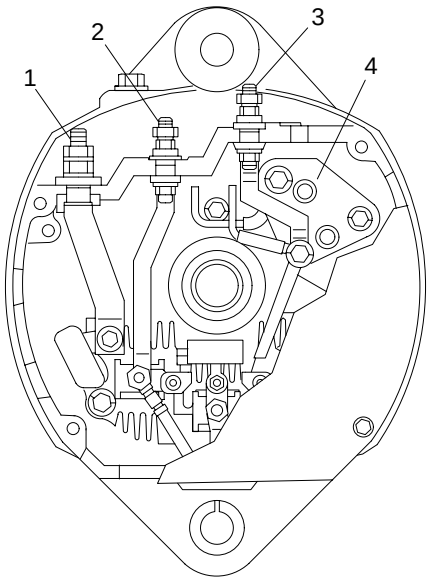
## Alternators for EPA07 and Later Engines

EPA07 emissions equipment creates the need for alternators that are more resistant to high underhood

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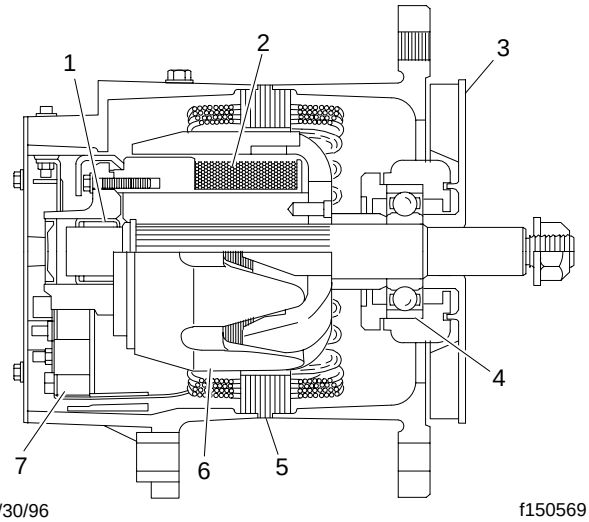
## General Information




04/30/96 f150568

1. Output Terminal
2. Relay Terminal
3. Indicator Light Terminal
4. Voltage Regulator

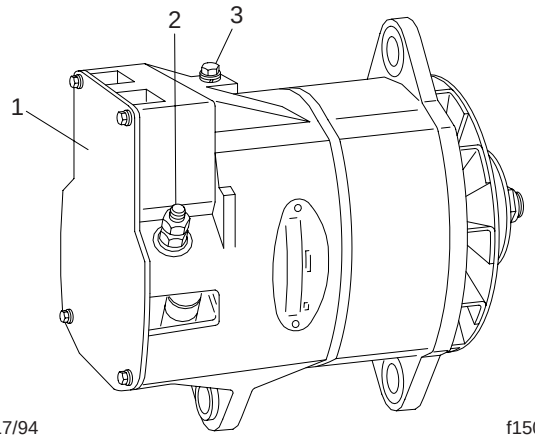
**Fig. 2, 33SI End View**




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1. Roller Bearing
2. Stationary Field Coil (brushless construction)
3. Fan
4. Ball Bearing
5. Stator
6. Rotor
7. Rectifier Bridge

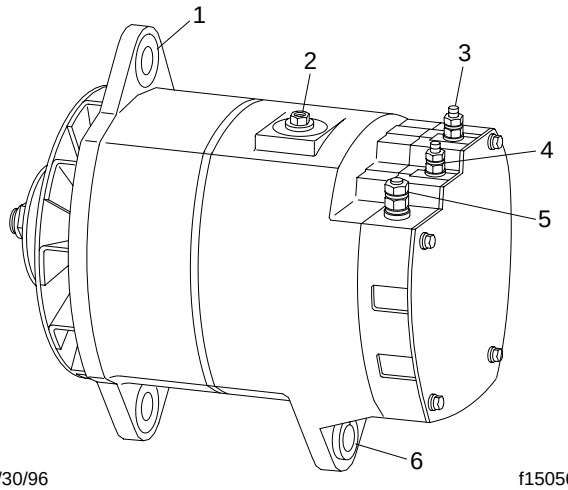
**Fig. 3, 33SI Sectional View**




10/17/94 f150403a

1. End Plate
2. Output Terminal
3. Ground Screw

**Fig. 4, 30SI Alternator Wiring Connectors**




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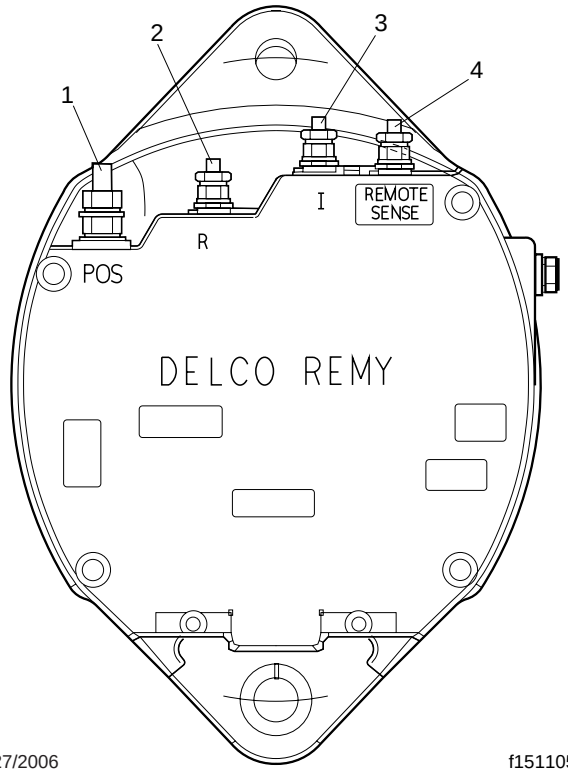
1. Adjusting Lug
2. Ground (G) Terminal
3. Indicator Light (I) Terminal
4. Relay (R) Terminal
5. Output (BAT) Terminal
6. Mounting Lug

**Fig. 5, 33SI Alternator Wiring Connectors**

temperatures. The 35SI and 36SI models for example, which are brushless, are designed to operate in temperatures up to 221°F (105°C). They may be used as direct replacements for earlier alternators, such as the 33SI and 34SI. The 36SI features high output at low engine speeds, to run auxiliary equipment with minimum exhaust emissions and maximum fuel efficiency. See **Fig. 6**.

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1. Output (BAT) Terminal
2. Relay (R) Terminal
3. Indicator Light (I) Terminal
4. Optional Remote Sense Terminal

**Fig. 6, 35SI and 36SI Wiring Connectors**

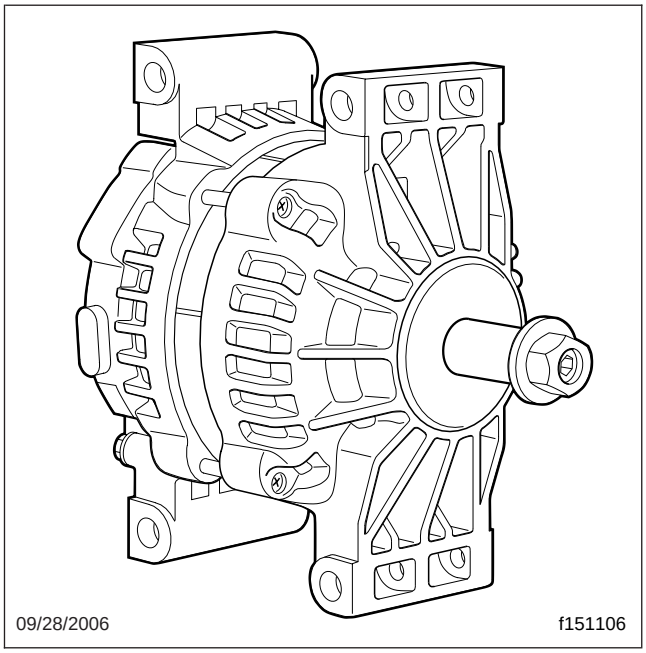



**Fig. 7, 24SI Pad Mount**

The 24SI (see **Fig. 7**) is a brush-type EPA07 alternator. Its design features twin fans in the center of the housing, sucking air in from each end, and exhausting it through openings around the middle of the housing. This is different from most alternators, where a fan at the drive end sucks air through the alternator from intakes at the rear.

Alternators should be kept clean to help heat dispersal.

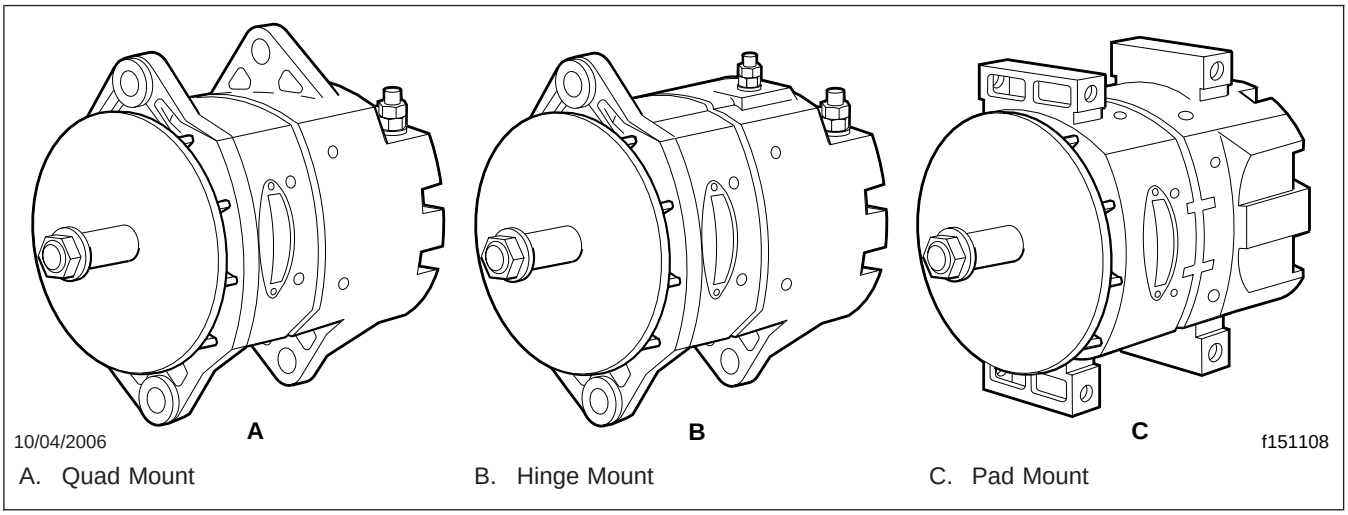
Exhaust leaks near the alternator should be repaired immediately, to avoid premature alternator failures.

There are three commonly available alternator mount configurations, as shown in **Fig. 8**. The pad mount is most common on late model vehicles.

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## General Information




A. Quad Mount
B. Hinge Mount
C. Pad Mount

**Fig. 8, Alternator Mounts (35SI Shown)**

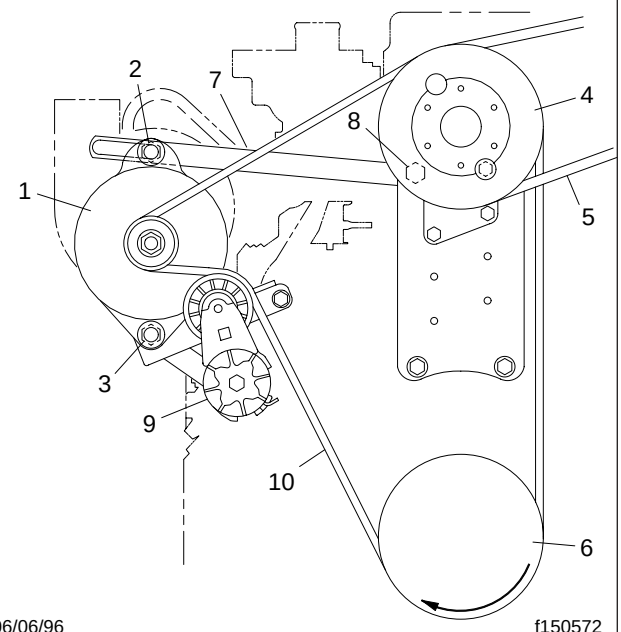
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# 30/33–SI Alternator Removal and Installation, Caterpillar C–10/C–12/C–15

## Removal

1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the tires.
2. Disconnect the batteries.
3. Mark all electrical leads and disconnect them from the alternator.
4. Insert a breaker bar in the belt tensioner and rotate the tensioner down and off the alternator drive belt. See **Fig. 1**.




Rotate the belt tensioner down and off the belt.

1. 30/33–SI Alternator
2. Alternator Mounting Capscrew, Top
3. Alternator Mounting Capscrew, Bottom
4. Fan Pulley
5. Refrigerant Compressor Drive Belt
6. Vibration Damper
7. Alternator Adjusting Strap
8. Adjusting Strap Mounting Capscrew
9. Belt Tensioner
10. Alternator Drive Belt

**Fig. 1, Alternator Installation, Caterpillar C-10/C-12/C-15 Engine**

NOTE: There are two drive belts to remove. Before removing the alternator belt, it is necessary to remove the refrigerant compressor belt from the fan pulley.

5. Holding the belt tensioner down, remove the drive belt from the alternator pulley. Slowly release the belt tensioner and remove the breaker bar.
6. Lower the drive belt, and take it off the vibration damper. It is not necessary to remove the belt from the vehicle.
7. Remove both alternator mounting capscrews. Remove the alternator from the vehicle.

NOTE: It is not necessary to remove the adjusting strap from the engine.

8. Inspect the drive belt. For instructions, see **Group 01**.

## Installation

1. Install the alternator on the engine. Install the alternator at the inboard edge of the slot initially. Install the top and bottom alternator mounting capscrews, but do not tighten them yet.
2. Install the drive belts on the pulleys, as removed. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m). For belt tightening procedures and specifications, see **Group 01**.
3. Verify that the edge of the tensioner arm is within the green zone on the decal. See **Fig. 2**. If within the red zone, pivot the alternator outboard until the tensioner arm enters the green zone.

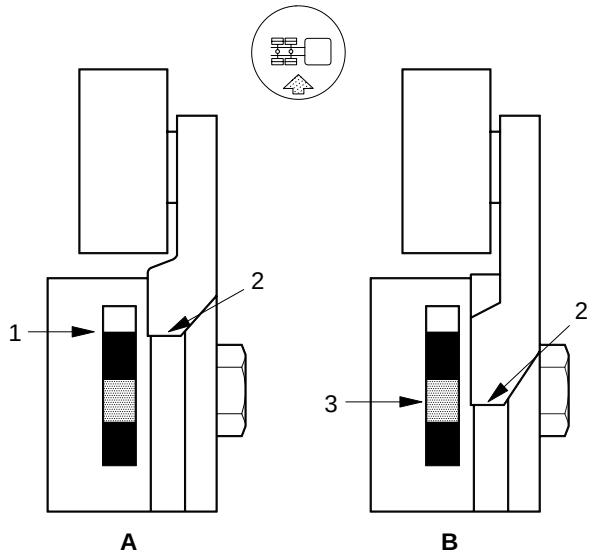
NOTE: If the belt slips, repair or replace the tensioner. For instructions, see the Caterpillar C–10, C–12, or C–15 Diesel Truck Engine Service Manual.

4. When the alternator is correctly positioned, tighten both alternator mounting capscrews 65 lbf·ft (88 N·m).
5. Check the torque of the adjusting strap mounting capscrew. If necessary, tighten it 65 lbf·ft (88 N·m).
6. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground

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## 30/33–SI Alternator Removal and Installation, Caterpillar C–10/C–12/C–15




A. Belt Off, No Tension
B. Belt On, Correct Tension
1. Decal
2. Edge of Tensioner Arm
3. Green Zone (operating range)

**Fig. 2, Belt Tensioner With Decal**

terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).

7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

| Protectant Material | Approved Brands |
|---|---|
| Spray-On Application | MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC |
| Brush-On Application | Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201 |

**Table 1, Approved Dielectric Red Enamel**

8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting, 300**.

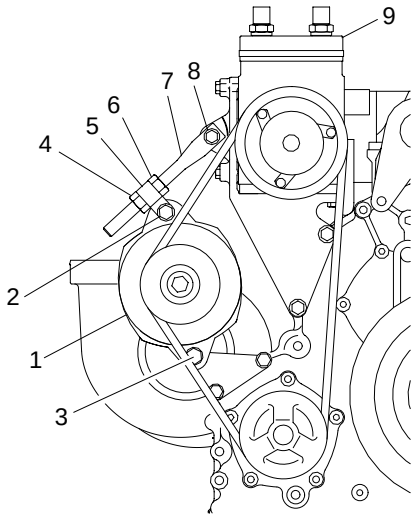
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# 30/34–SI and 34–SI QuadMount Alternator Removal and Installation, DDC 60

## 30/34–SI Removal

1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the tires.
2. Disconnect the batteries.
3. Mark all electrical leads and disconnect them from the alternator.
4. Loosen the adjusting rod mounting capscrew, the end link mounting capscrew, and the alternator mounting capscrew, see **Fig. 1** for detail. Loosen these three mounting capscrews enough to allow movement of the alternator.

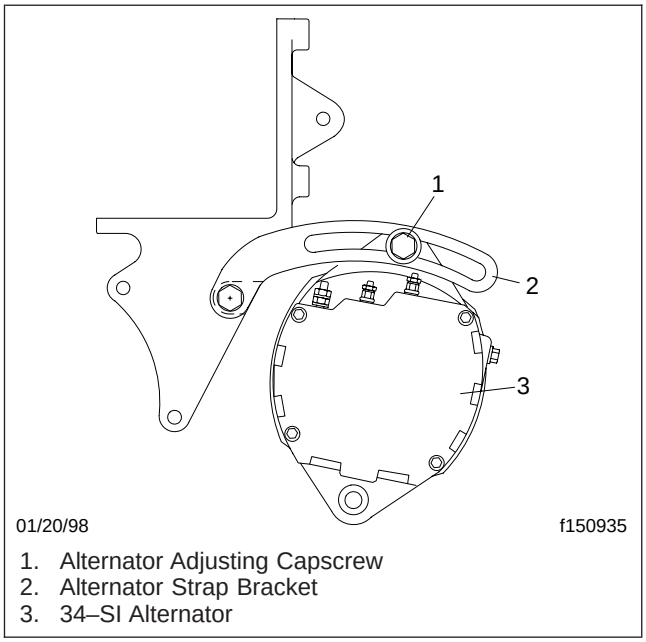



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1. 30/34–SI Alternator
2. End Link Mounting Capscrew
3. Alternator Mounting Capscrew
4. Adjusting Rod Jam Nut
5. End Link
6. Adjusting Nut
7. Adjusting Rod
8. Adjusting Rod Mounting Capscrew
9. Refrigerant Compressor

**Fig. 1, Alternator Installation, Detroit Diesel Series 60 Engine**

5. On vehicles with 34–SI alternators only, go to the rear of the alternator and loosen the alternator adjusting capscrew on the alternator strap bracket. See **Fig. 2**.
6. Loosen the tension on the drive belt by slightly loosening the adjusting nut, see **Fig. 1**. Push the loosened alternator far enough toward the fan drive pulley to allow removal of the drive belt without using force.




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1. Alternator Adjusting Capscrew
2. Alternator Strap Bracket
3. 34–SI Alternator

**Fig. 2, 34-SI Alternator Strap Bracket, Conventional**

7. Remove the drive belt from the pulleys without prying or twisting the belt.
8. On vehicles with 34–SI alternators only, remove the alternator adjusting capscrew from the alternator strap bracket.
9. Remove the end link mounting capscrew and the alternator mounting capscrew. Remove the alternator from the vehicle.
10. Inspect the drive belt. For instructions, see **Group 01**.

## 34–SI QuadMount Removal

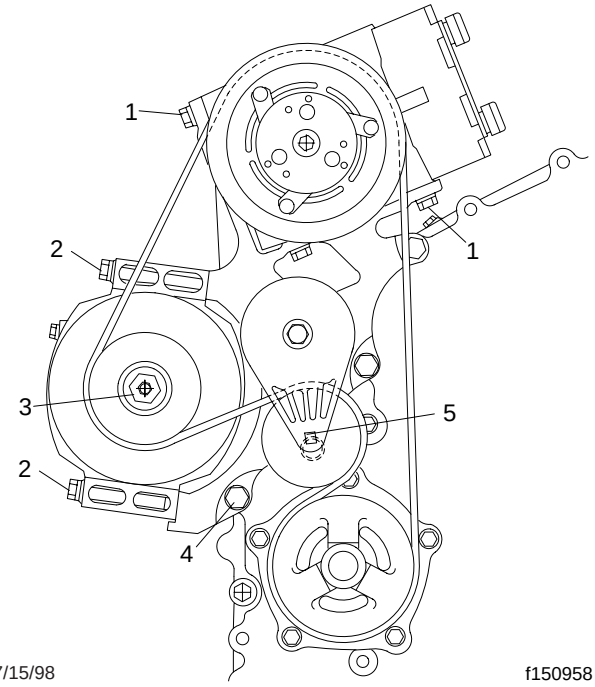
1. Park the vehicle on a level surface, turn off all electrical loads such as lights, ignition, and accessories, set the parking brake, and chock the tires.
2. Disconnect the batteries.
3. Open the hood.

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## 30/34–SI and 34–SI QuadMount Alternator Removal and Installation, DDC 60

4. Disconnect the electrical leads attached to the alternator. Mark the terminals and wires for ease of installation.
5. Using a 1/2-inch-drive wrench in the square hole of the belt tensioner, rotate the tensioner until the belt tension is relieved and remove the belt. See **Fig. 3**.
6. Support the alternator and remove the four mounting bolts and lockwashers that attach the alternator to the engine. See **Fig. 3**. Remove the alternator.




1. Refrigerant Compressor Mounting Capscrew, 3/8–16 x 1.75
2. Alternator Mounting Capscrew, M10 x 100
3. Alternator Pulley Nut
4. Alternator Bracket Bolt, 5/16–14 x 5.5
5. Tensioner Adjustment Hole, 1/2-inch Square

**Fig. 3, 34–SI QuadMount Installation**

## 30/34–SI Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 50 lbf·ft (68 N·m).
2. Position the alternator on the engine. Install the end link mounting capscrew and the alternator mounting capscrew, but do not tighten them yet.
3. On vehicles with 34–SI alternators only, install the alternator adjusting capscrew on the alternator strap bracket.
4. Loop the drive belt around the pulleys.
5. Install the drive belt on the pulleys without prying or rolling it into place. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m). For belt tightening procedures and specifications, see **Group 01**.
6. Tighten the adjusting rod jam nut after the belt has been correctly tensioned. Tighten the jam nut 95 lbf·ft (130 N·m).
7. Tighten the end link mounting capscrew and the alternator mounting capscrew 65 lbf·ft (88 N·m). Tighten the adjusting rod mounting capscrew 50 lbf·ft (68 N·m).
8. On vehicles with 34–SI alternators only, tighten the alternator adjusting capscrew 65 lbf·ft (88 N·m).
9. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
10. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

| Protectant Material | Approved Brands |
|---|---|
| Spray-On Application | MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC |
| Brush-On Application | Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201 |

**Table 1, Approved Dielectric Red Enamel**

11. Connect the batteries.
12. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Voltage Output Test" in **Troubleshooting 300**.

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## 34–SI QuadMount Installation

1. Locate and support the alternator.
2. Install the four mounting bolts and lockwashers that attach the alternator to the engine. Tighten the capscrews 43 to 54 lbf·ft (58 to 73 N·m).
3. Connect the wires to the alternator as previously marked. Torque the nut for the battery cable 80 to 120 lbf·in (900 to 1350 N·cm). Torque the nut for the ground cable 50 to 60 lbf·in (560 to 680 N·cm).
4. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.
5. Rotate the battery switch to the ON position or re-connect the batteries.
6. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see *Alternator Voltage Output Test* in **Troubleshooting 300**.
7. Return the hood to the operating position. Remove the chocks from the tires.

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# Troubleshooting

Many alternators have been replaced that later investigation reveals were working properly. This may be due to incorrectly diagnosing the problem.

IMPORTANT: Before testing, make sure:

- All belts are correctly tightened;
- The wiring and terminals are clean and in good condition;
- All terminal nuts are torqued and properly protected.

Delco Remy has an alternator testing tool called the Intelli-Check Alternator Analyzer. See **Fig. 1**. This tool (DR 10457848, a single tester, or DR 10457865, a four-pack of testers) is to be used as a quick check of the alternator to see if it is working correctly.

NOTE: If you do not have the Delco Intelli-Check Tester, or if the alternator rated output is above 145 amps, or if a total vehicle charging system analysis is required, see "Alternator/Charging System Testing."

## Intelli-Check Alternator Analyzer

The following information includes a pre-test procedure and operating instructions for the Delco Intelli-Check Tester, and is similar to the procedures provided by Delco with the Intelli-Check Tester.

### Pre-Test Procedure (Engine Off)

1. Inspect the alternator connections to verify that all terminals are secured and tight. Verify that the sense wire is connected to the sense terminal on vehicles equipped with remote-sense alternators.
2. With the engine off, connect the red alligator clip to the output terminal of the alternator. Connect the black alligator clip to the alternator ground. An optional ground connection is to the body of the alternator. The tester LEDs will illuminate and then go off as it performs a self-test.
3. After 4 seconds the tester will activate. The following LEDs may illuminate depending on the condition of the batteries:
    - **GOOD** (green) LED indicates the battery voltage is above 12.8 and has a surface charge. The surface charge must be removed before proceeding with the alternator test. To remove the surface charge, do the following:
        A. Turn on the headlights and blower motor for 2 minutes without restarting the engine.
        B. Reset the tester by disconnecting, then reconnecting the tester alligator clips. The analyzer will again perform its self-test.
        C. Repeat the applicable steps of the Pre-Test Procedure.
    - **NO CHARGE** (red) LED indicates the battery voltage is below 12.8. This LED should illuminate for most tests. Proceed with the alternator test.
    - **LOW BATTERY VOLTAGE** (blue) LED indicates the battery voltage is below 12.35. If the batteries will start the vehicle, proceed with the alternator test. However, after completing the Intelli-Check alternator test, perform the procedures under "Alternator/Charging System Testing" to determine the condition of the rest of the charging system.

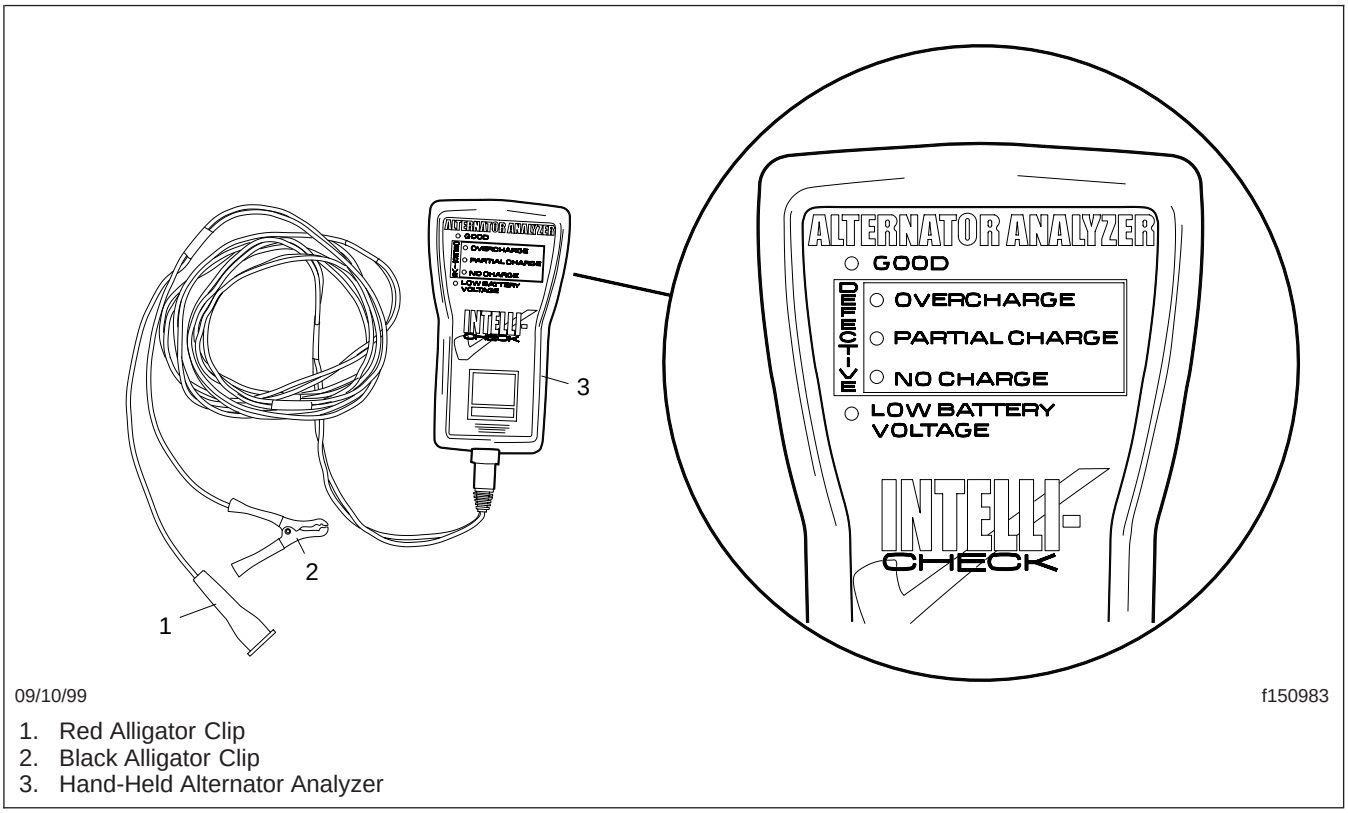
### Tester Operating Instructions (Engine Running)

1. Start the engine using onboard batteries only. If the batteries will not start the engine, they must be charged for 2 hours. Start the test again after charging the batteries.
2. Verify the engine is at idle and all electrical loads are off.
3. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
    - If the **GOOD** (green) LED illuminates, proceed to the next step.
    - If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
    - If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging sys-

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## Troubleshooting




1. Red Alligator Clip
2. Black Alligator Clip
3. Hand-Held Alternator Analyzer

**Fig. 1, Delco Remy Intelli-Check Alternator Analyzer**

tem using the instructions in "Alternator/ Charging System Testing."

4. With the engine running, turn on all electrical loads.
5. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
6. If the **GOOD** (green) LED illuminates, the alternator is OK and the test is complete.

NOTE: If the alternator tests OK in the above tests, and the customer's complaint is reduced battery or headlight life, see "Alternator/ Charging System Testing" to completely analyze the charging system.

7. If any LEDs illuminate indicating overcharge, partial charge or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
8. If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing".

# Alternator/Charging System Testing

## Battery Open Circuit Voltage Test, Alternator Output Voltage Test and Alternator Amperage Output Test

1. Use a digital volt-ohmmeter (VOM) set on the 2-20VDC (or similar) scale to test the battery open circuit voltage (OCV). With the engine shut down and the voltmeter set up as shown in **Fig. 2**, check for voltage of 12.4 volts or more.

   If the OCV is 12.4 volts or more, turn on the vehicle headlights for approximately 3 minutes.

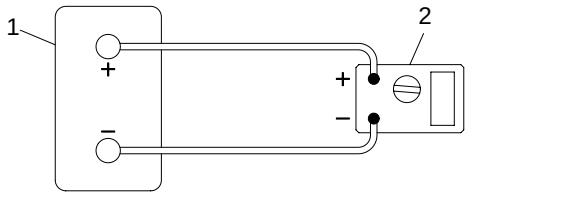
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If the OCV is less than 12.4 volts, charge the batteries properly. For instructions, see **Group 54**.

IMPORTANT: Be sure to disconnect the batteries or remove them from the vehicle before charging.

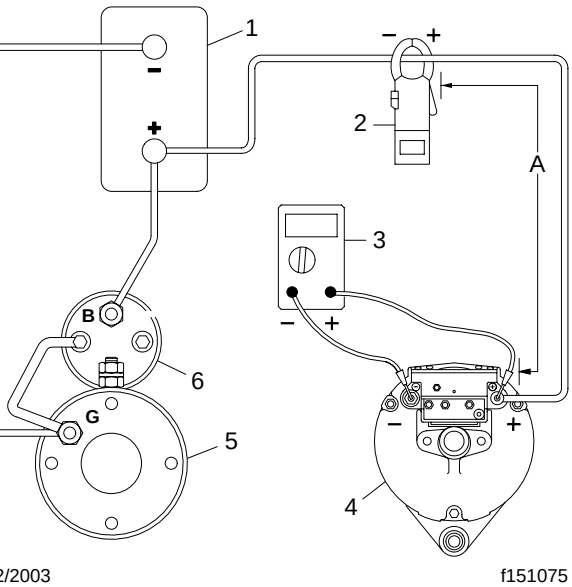
2. Check the alternator output without a load. See **Fig. 3**.




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1. Battery
2. Digital Voltmeter

**Fig. 2, Setup 1: Battery Open Circuit Voltage (and alternator amperage output)**




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A. Locate the ammeter at least 6 inches (15 cm) away from the alternator.

1. Battery
2. Ammeter
3. Digital Voltmeter
4. Alternator
5. Cranking Motor
6. Solenoid

**Fig. 3, Setup 2: Alternator Output Test**

2.1 Start the engine and run it at 1500 rpm for 3 to 5 minutes to stabilize the system before proceeding to the next step.

2.2 Connect the positive (+) lead of the digital voltmeter (still set on the 2-20VDC or similar scale) to the alternator (battery) terminal. Connect the negative (–) lead of the voltmeter to the alternator negative (–) ground terminal. See **Fig. 3**.

2.3 If the voltmeter reads from 13.8 to 14.2 volts, record this reading (V1) and go to the next step. If the alternator reads less than 13.8 volts and is adjustable, try to adjust the voltage regulator to 13.8 to 14.2 volts. If unable to obtain acceptable output, replace the alternator.

3. Check the alternator output under load. See **Fig. 3**.

3.1 Attach a clamp-on induction ammeter around the positive (+) wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

3.2 With the engine still running at 1500 rpm, turn on the following electrical accessories to load the alternator until the ammeter reads 60 to 75 amps.

- Both front and rear heater blowers (on HIGH)
- Headlights (high beams)
- Road lights
- Interior lights

NOTE: As an alternate method of putting load on the alternator, connect a carbon pile tester and set it to 60 to 75 amps.

3.3 Keep the voltmeter connected as in the previous step; positive (+) lead connected to the alternator positive (+) terminal; negative (–) lead connected to the alternator negative (–) terminal.

3.4 If the voltmeter reads from 13.6 to 14.2 volts, record this reading (V2) and go to the next step.

If the voltmeter reads less than 13.6 volts, replace the alternator.

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## Troubleshooting

4. Perform an alternator amperage output test.
   - 4.1 Connect a carbon pile tester across the vehicle batteries as shown in **Fig. 2**.

   NOTE: **Figure 2** shows a voltmeter, but the connections for the carbon pile tester are the same.

   - 4.2 Attach a clamp-on induction ammeter around the alternator output wire. See **Fig. 3**.

   NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

   - 4.3 Start the engine and make sure all vehicle electrical accessories are turned off. Run it at fast speed and adjust the tester to the alternator maximum current output. Record this output value.

   NOTE: Ensure that the alternator is turning at maximum available rpm and keep adjusting the tester dial until the ammeter reads its highest value.

   - 4.4 Turn off the tester and shut down the engine.
   - 4.5 If the output value recorded is less than 85 percent of the rated amperage output, repeat the test. If the output value recorded is still less than 85 percent of the rated amperage output, replace the alternator.
   - 4.6 Make sure that all test instruments are removed and that the vehicle wiring is returned to its operational state.
5. To identify other problem areas within the vehicle, check the operation of the charging system. Set up the voltmeter as shown in **Fig. 2** and **Fig. 3**.

   NOTE: For any load at 1500 rpm or more, battery voltage must be within 0.5 volts of the alternator voltage.

   - 5.1 If readings at the batteries are within 0.5 volts of the readings at the alternator, the charging system is working correctly. Check other areas of the vehicle to locate the problem.
   - 5.2 If the reading at the batteries is more than 0.5 volts lower than the reading at the alternator, do the next step.
6. Check charging system connections, cables, and terminals.
   - 6.1 Check all connections between the battery, starter, and alternator for tightness and signs of corrosion. Tighten and clean as necessary.
   - 6.2 Check all cables for breaks or partial breaks. Repair or replace as necessary.
   - 6.3 Check each ring terminal for breakage at the point where it attaches to its wire or cable.

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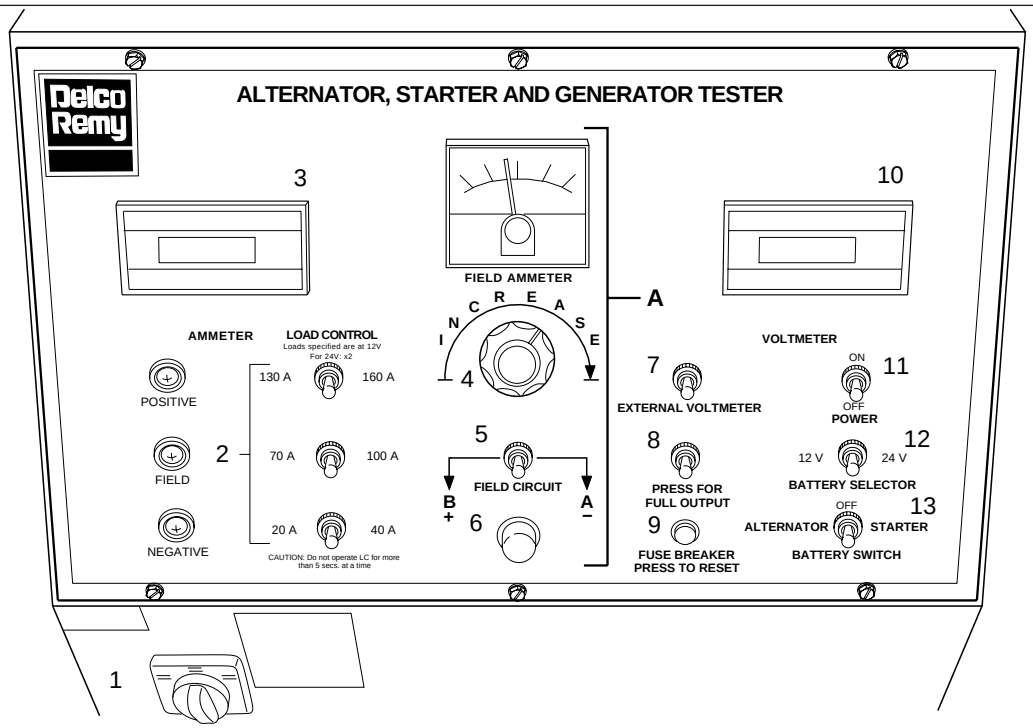


## Required Equipment

See **Fig. 1** for a standard Delco Remy Tester.

NOTE: This equipment and the following tests may also be used to test Leece Neville alternators.

- Delco Remy alternators require a 2-1/2 inch V-belt pulley, p/n DR 10503932 (supplied with the Delco Remy tester).
- Leece-Neville alternators require a 3-1/2 inch V-belt pulley, p/n LN 107 22, and a 5/8-inch washer, p/n LN 120 129.




A. These controls are not used when testing alternators with internal voltage regulators.

1. Motor Switch: Forward–Off–Reverse
2. Load Control Switches
3. Ammeter
4. Variable Field Control
5. Field Selector Switch
6. DTL Lamp
7. External Voltmeter Switch
8. Full Field Switch
9. Circuit Breaker (Press to Reset)
10. Voltmeter
11. Power Switch
12. 12–24-Volt Selector
13. Alternator/Battery Test Switch

**Fig. 1, Alternator Tester Control Panel (typical)**

The tests in this subject require the following equipment:

- Alternator tester with the battery charged to at least 12.4 V (Delco Remy shown).
- Alternator to be tested.
- V-belt.
- Jumper lead to connect the BAT (+) alternator terminal to the remote sense terminal.
- Standard 5/8–18 hexnut, for mounting the pulley on the alternator. Use a standard hexnut, not the self-locking nut that is supplied with the alternator.

### NOTICE

**Repeatedly using self-locking nuts may damage the threads on the pulley shaft.**

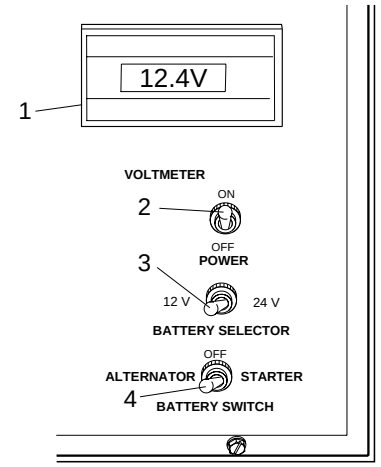
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## Alternator Bench Testing

## Test Preparation

1. Set the battery voltage selector switch to 12V. See **Fig. 2**.




1. Voltmeter
2. Power Switch
3. Battery Voltage Selector
4. Battery Switch

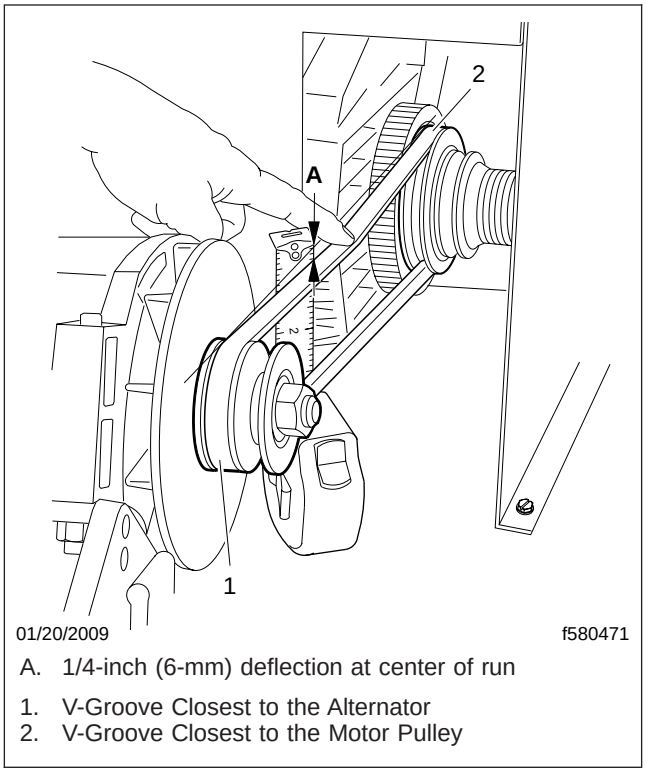
**Fig. 2, Alternator Tester Power Switches**

2. Set the battery switch to "Alternator." See **Fig. 2**.

### NOTICE

**The next step supplies battery voltage to the alternator tester power and ground cables. Ensure that they are separated and insulated from each other, and that they are not touching conductive materials. Failure to observe this precaution could cause component damage.**

3. Turn the tester power switch ON. See **Fig. 2**. Check the battery voltage in the voltmeter on the tester. The tester battery voltage must be at least 12.4V; if it is below 12.4V, charge or replace the tester battery as necessary. Turn the power switch OFF.
4. Mount the appropriate manufacturer's pulley on the alternator.
5. Mount the alternator on the tester.
   - 5.1 Run the belt from the largest V-groove of the bench motor drive pulley to the V-groove closest to the alternator on the alternator pulley. See **Fig. 3**. Do not use the serpentine belt groove.




A. 1/4-inch (6-mm) deflection at center of run

1. V-Groove Closest to the Alternator
2. V-Groove Closest to the Motor Pulley

**Fig. 3, Belt Deflection with Alternator Mounted on Tester**

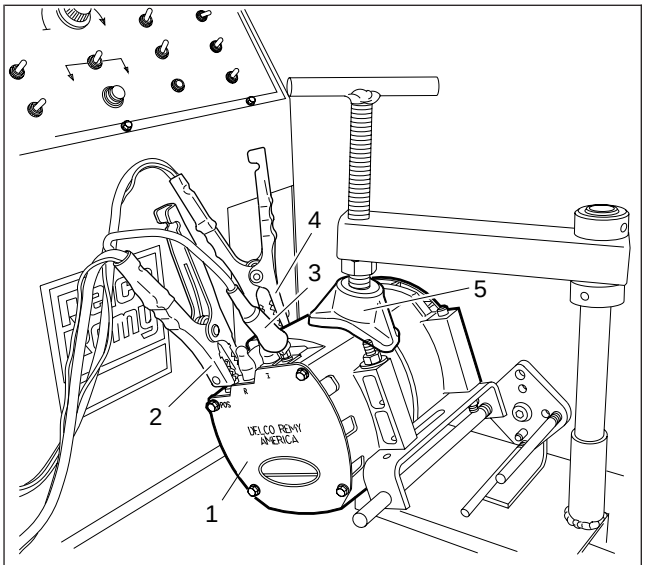
   - 5.2 Move the vise to align the pulleys, so that the belt runs straight between the V-groove on the motor pulley and the V-groove closest to the alternator.
   - 5.3 Tension the V-belt with the hand wheel, so that it deflects 1/4-inch (6 mm) under hand pressure at the center of the run, then clamp the alternator in position.
6. Connect the electrical leads from the tester to the alternator. See **Fig. 4**. Take care that the tester power and ground cables are separated and insulated from each other, and that they are not touching conductive materials.
   - 6.1 Connect the red positive lead from the tester to the output terminal (BAT or +) on the alternator.

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6.2 Connect the black negative lead from the tester to the output ground terminal (-) or to a mounting ear of the alternator.

7. Attach a jumper lead from the output terminal (BAT or +) to the remote sense terminal. Some testers have this jumper built-in on the positive lead, as shown in **Fig. 4**, Item 3; others may require a separate jumper as shown in **Fig. 5**.




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1. Alternator
2. Positive Lead
3. Remote Sense Jumper
4. Negative Lead
5. Clamp

**Fig. 4, Alternator Clamped on Tester with Leads Connected**

## Voltage Test

### NOTICE

**Ensure that the alternator tester power and ground cables are separated and insulated from each other, and that they are not touching conductive materials. Failure to do so could cause damage to the tester.**

1. Turn the tester power switch ON. See **Fig. 2**, Item 2.

### WARNING

**The following steps involve spinning the alternator with the open V-belt; be careful that all loose objects, garments, hair, and hands are well clear of the alternator and belt, and use safety shields properly, or serious personal injury may occur.**

2. Turn the motor switch (located on the lower left-hand portion of the tester) to the FORWARD position, to start the alternator free-spinning. See **Fig. 1**, Item 1.

NOTE: The voltage output limit applies only to a non-loaded alternator. The purpose of this test is to ensure that the alternator produces the proper voltage with no load (free-spin).

3. Record the alternator voltage output during free-spin. See **Fig. 2**, Item 1.
   - If the alternator output is between 13.5V and 14.7V, the alternator is functioning properly; proceed to the *Load Test*.
   - If the alternator output is not between 13.5V and 14.7V, the alternator is faulty and must be replaced.

## Load Test

1. Calculate the test load for the alternator being tested. The test load is 80 percent of the alternator-output rating.

   Multiply the alternator-output rating by **0.8**, to calculate the test load.

   For example, an alternator with 100-amp output rating has an 80-amp test load (100 x 0.8 = 80).

NOTE: Contact a Delco Remy or Leece-Neville representative if you are unsure of the calculation.

2. Determine the appropriate load-control-switch setting to use for the alternator being tested. See **Fig. 1**, Item 2.

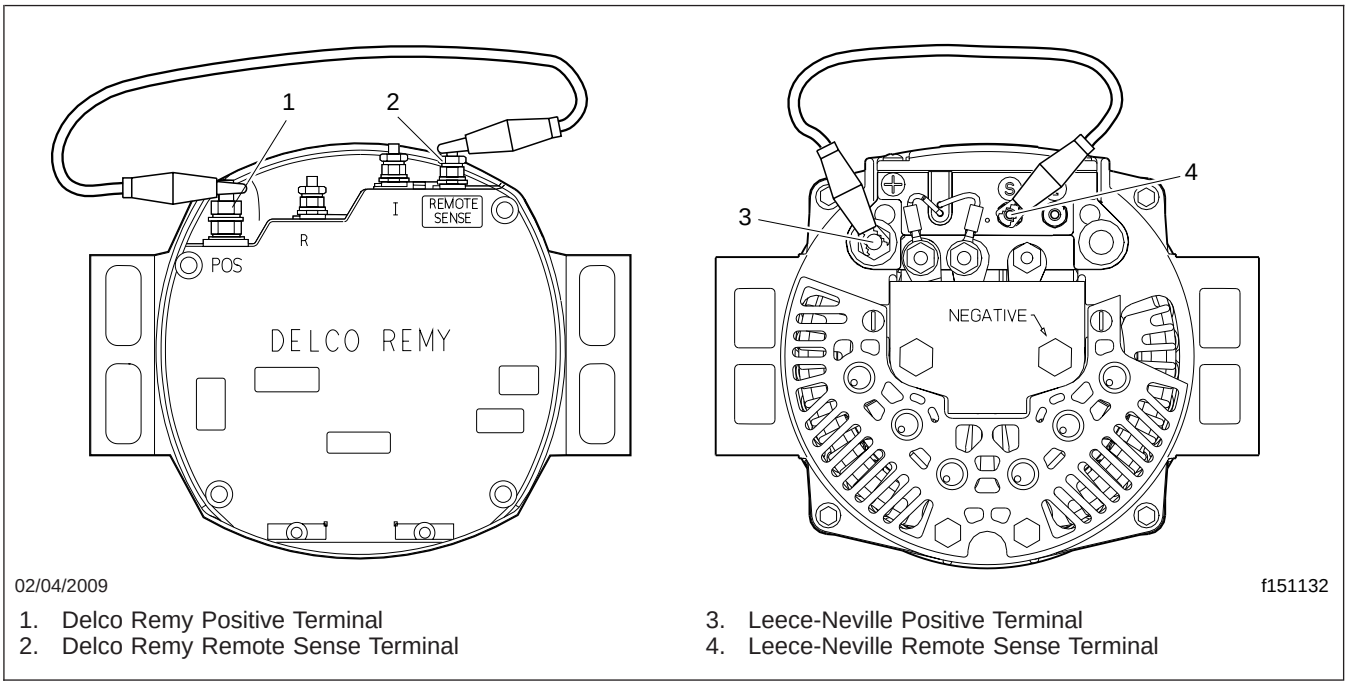
   Use the load-control-switch setting **equal to, or the next level below** the test load calculation.

   For example, on this tester the available settings are 20/40, 70/100, and 130/160 amp. The load-control-switch setting for the 100-amp alternator

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## Alternator Bench Testing




1. Delco Remy Positive Terminal
2. Delco Remy Remote Sense Terminal
3. Leece-Neville Positive Terminal
4. Leece-Neville Remote Sense Terminal

**Fig. 5, Installed Jumper Leads (Typical)**

would be 70 amp, because it is the available setting just below 80 amp.

### NOTICE

**Do not operate the alternator under load for more than 5 continuous seconds or damage to the alternator may occur.**

3. Apply the appropriate load switch for 5 seconds then release.
4. Record the **difference** in voltage output between when the alternator is free-spinning, and under load.
   - For all alternators except Delco Remy 22SI, if the voltage difference between free-spin and loaded is more than 0.5V, the alternator is faulty and must be replaced. If the voltage difference between free-spin and loaded is less than 0.5V, the alternator is functioning properly.
   - For Delco Remy 22SI, if the voltage difference between free-spin and loaded is more than 1.0V, the alternator is faulty and must be replaced. If the voltage difference between free-spin and loaded is less than 1.0V, the alternator is functioning properly.
5. Turn the tester power switch OFF, then disconnect the electrical leads and jumper from the alternator.

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See **Fig. 1** for a charging circuit wiring diagram. The charging circuit consists of the battery, starter, alternator, and magnetic switch.

See **Table 1** for Mounting Fastener Torques for Caterpillar C–10/C–12/C–15 Engines.

See **Table 2** for Mounting Fastener Torques, Detroit Diesel Series 60 Engines.

See **Table 3** for Terminal Fastener Torques, for All Engines.

See **Table 4** for Pulley Nut Torque, All Engines

| Mounting Fastener Torques, Caterpillar C–10/C–12/C–15 Engines | | | |
|---|---|---|---|
| **Description** | **Grade/Class** | **Size** | **Torque: lbf·ft (N·m)** |
| Alternator Mounting Capscrews | 8PO | 1/2–13 | 65 (88) |
| Adjusting Strap Mounting Capscrew | 10.9PO | M12 | 65 (88) |

**Table 1, Mounting Fastener Torques, Caterpillar Engines**

| Mounting Fastener Torques, Detroit Diesel Series 60 Engines | | | |
|---|---|---|---|
| **Description** | **Grade/Class** | **Size** | **Torque: lbf·ft (N·m)** |
| End Link Mounting Capscrew | 8PO | 1/2–13 | 65 (88) |
| Alternator Mounting Capscrew | 8PO | 1/2–13 | 65 (88) |
| Adjusting Rod Mounting Capscrew | 10.9PO | M10 | 50 (68) |
| Adjusting Rod Jam Nut | 5 | 5/8 | 95 (130) |
| Alternator Bracket Fasteners | 10.9PO | M10 | 50 (68) |
| Alternator Adjusting Capscrew | 8PO | 1/2–13 | 65 (88) |

**Table 2, Mounting Fastener Torques, Detroit Diesel Engines**

| Terminal Fastener Torques, All Engines | | | |
|---|---|---|---|
| **Description** | **Grade/Class** | **Size** | **Torque: lbf·in (N·cm)** |
| Alternator Output ("BAT") Terminal Nut | 5 | 5/16–18 | 100 (1140) |
| Alternator Ground ("G") Terminal Nut | 5 | 1/4–20 | 65 (740) |
| Alternator Instrument ("I") Terminal Nut | 8.8 | M4 | 20 (220) |

**Table 3, Terminal Fastener Torques, All Engines**

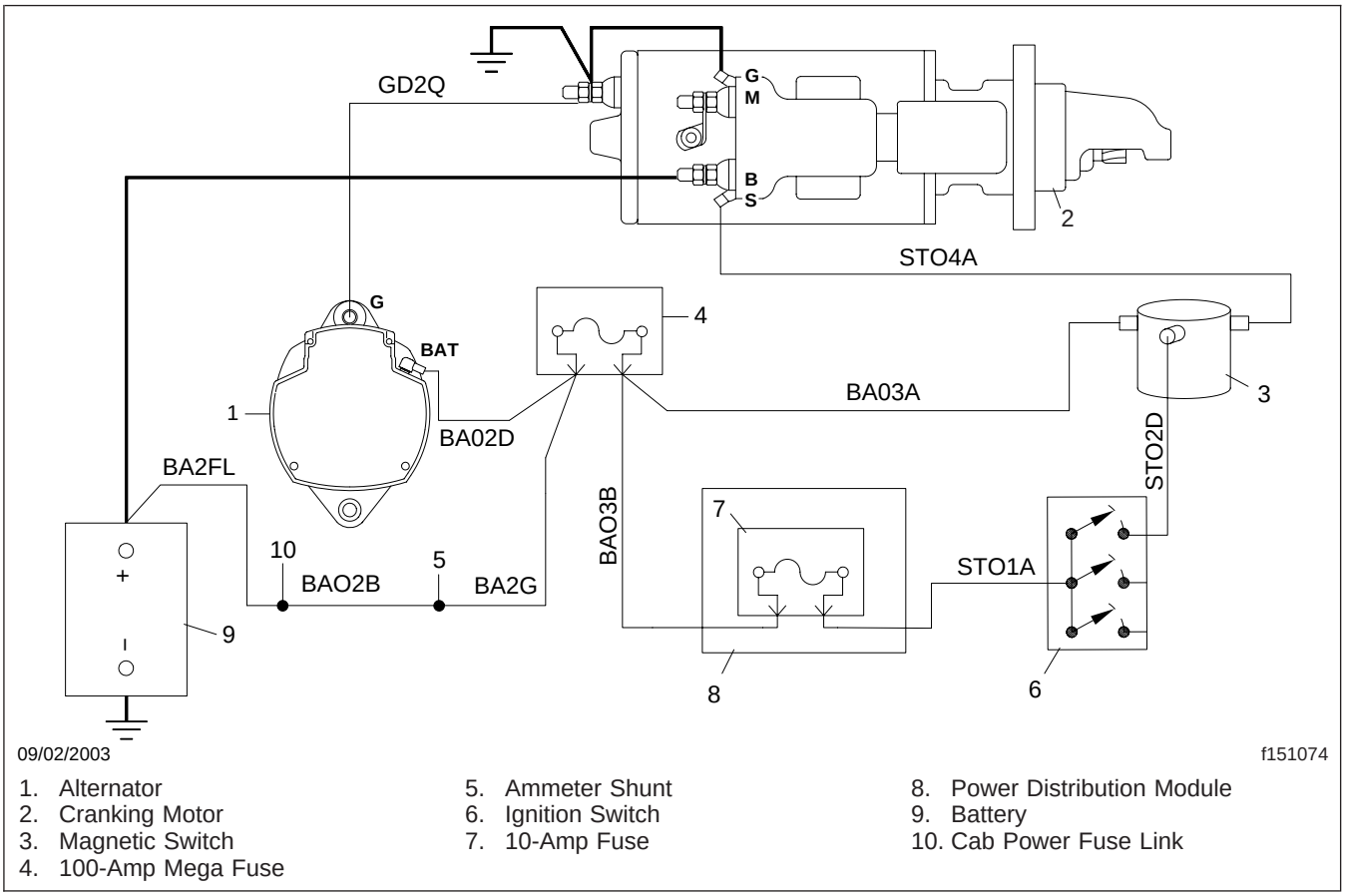
| Pulley Nut Torque, All Engines | | | |
|---|---|---|---|
| **Description** | **Grade** | **Size** | **Torque: lbf·ft (N·m)** |
| Pulley Nut | 8PO | 1/2–20 | 75 (102) |

**Table 4, Pulley Nut Torque, All Engines**

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## Specifications




1. Alternator
2. Cranking Motor
3. Magnetic Switch
4. 100-Amp Mega Fuse
5. Ammeter Shunt
6. Ignition Switch
7. 10-Amp Fuse
8. Power Distribution Module
9. Battery
10. Cab Power Fuse Link

**Fig. 1, Charging Circuit Wiring Diagram**

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## General Description

The Leece-Neville JB series alternator is a 14-volt self-load-limiting alternator equipped with a three-step adjustable voltage regulator. See **Fig. 1**. For voltage regulator adjustment procedures, see **Subject 120**.

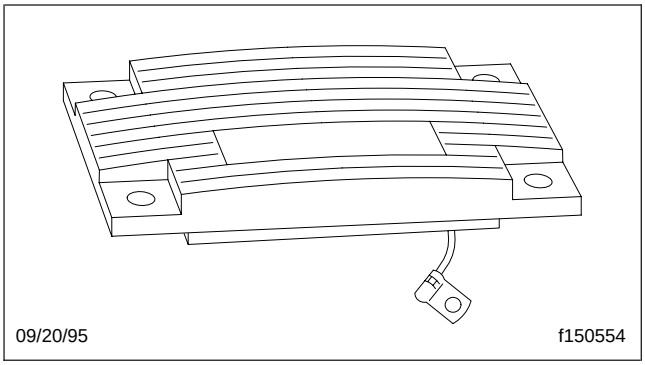



**Fig. 1, Three-Step Adjustable Voltage Regulator**

The optional SmartChek™ models feature a light-emitting diode (LED) that changes color to simplify troubleshooting. When the LED is green, the alternator is OK. When the LED is red, the alternator needs replacing.

Six silicon diodes mounted in heat sinks convert alternating current from the delta-wound stator into direct current. A capacitor connected between the heat sinks helps suppress transient voltage spikes, which could possibly damage the diodes.

The brushes and voltage regulator are located in a waterproof housing that may be removed for replacement or inspection. An external relay terminal is also provided for operation of a 7V battery isolator relay or other accessories that might require power from such a source.

The voltage regulator is also equipped with transient voltage protection and will withstand instantaneous opening of the charging circuit under full load conditions.

The LC models are identical to the JB models but are improved in the following ways:

- The rear rotor bearings are stronger and more durable;
- The diode post installation has been improved;
- The rectifier heat sink has a larger capacity.

The LCF models have all the same improvements as the LC models. In addition, the front bearing is secured with five bolts instead of four.

Mounting hardware and vehicle wiring require periodic inspection. See **Group 15** of the *Western Star Maintenance Manual* for instructions.

## Principles of Operation

Current is produced by rotating a magnet inside a stationary winding. The rotating magnet is called a rotor and the stationary winding is called a stator. See **Fig. 2**.

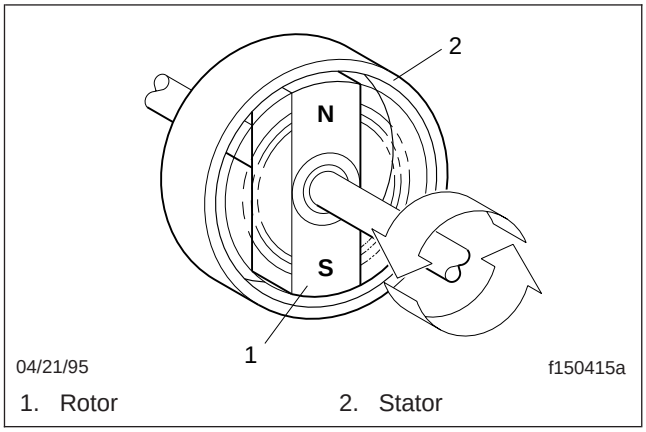



**Fig. 2, Producing the Current**

The rotor is electrically magnetized by a small current flowing through the brushes, riding on smooth slip rings. See **Fig. 3**. Alternating current is then produced as the magnetic poles of the rotor pass the coil windings of the stator.

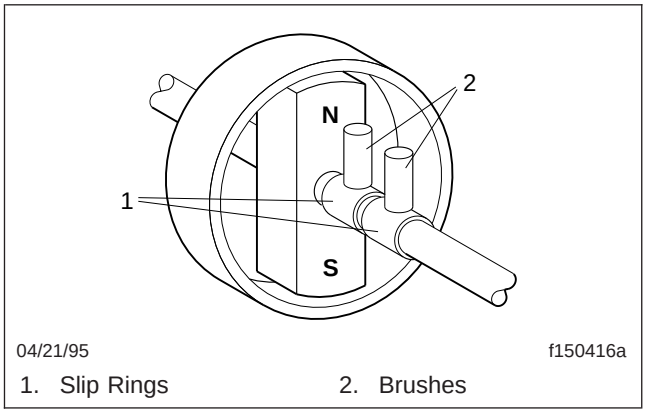



**Fig. 3, Magnetizing the Rotor**

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## General Information

These alternators have 12 magnetic poles in the rotor (see **Fig. 4**) and three separate windings in the stator (see **Fig. 5**). Since the rotor produces alternating current as it passes the coil windings of the stator, increased engine speed produces more current.

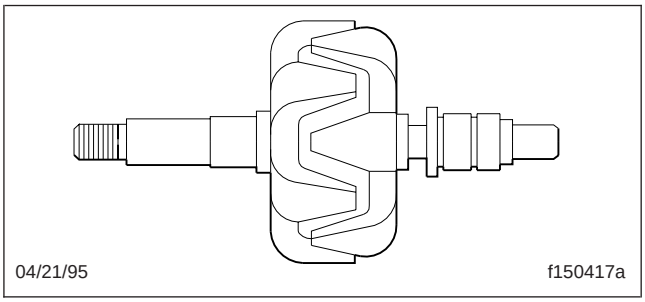



**Fig. 4, Rotor**

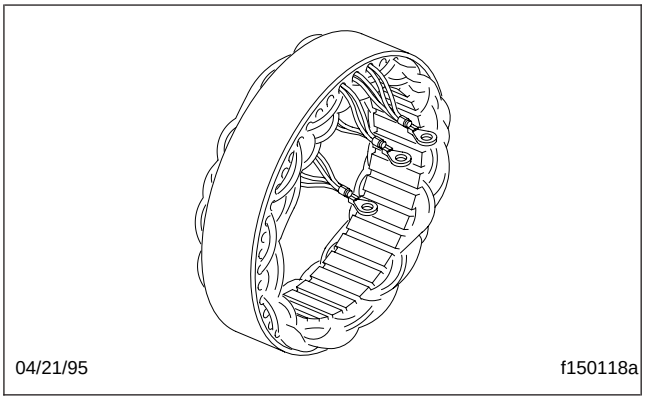



**Fig. 5, Stator**

Rectifier assemblies convert alternating current to direct current for storage in the batteries. Rectifiers consist of silicon diodes that work as electrical switches and permit current flow in only one direction. They are mounted in an aluminum casting, which is finned to dissipate heat. This is called a heat sink. See **Fig. 6**.

The voltage regulator (see **Fig. 1**) controls the alternator output and the state of charge of the batteries. It is used in the charging system to regulate the battery voltage to the vehicle.

The diode trio converts a small amount of alternating current from the stator into direct current which is used as a signal to turn on the regulator.

When the battery has charged, the regulator reduces the field current flow to the rotor. Reducing the field current flow, in turn, reduces the alternator output.

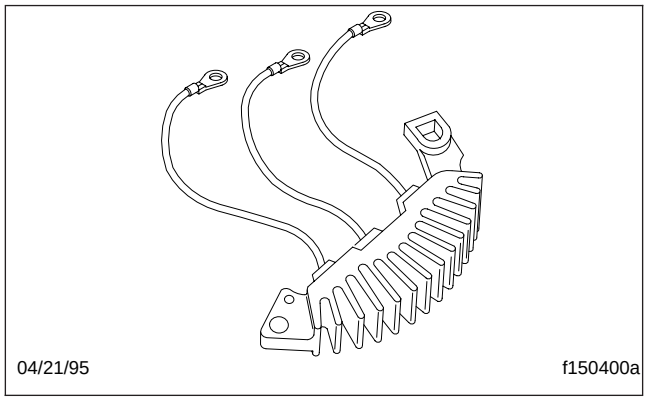



**Fig. 6, Heat Sink**

When the headlights or accessories place a load on the battery, the regulator increases the current flow to the rotor, and alternator output increases, to maintain voltage.

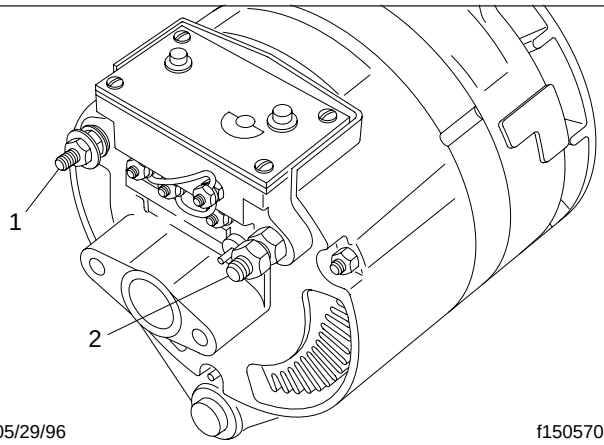
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# Alternator Removal and Installation, Caterpillar C–10/C–12

## Removal

1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the tires.
2. Disconnect the batteries.
3. Mark all electrical leads and disconnect them from the alternator. See **Fig. 1**.




1. Ground (G) Terminal
2. Output (BAT) Terminal

**Fig. 1, Battery Lead Connections**

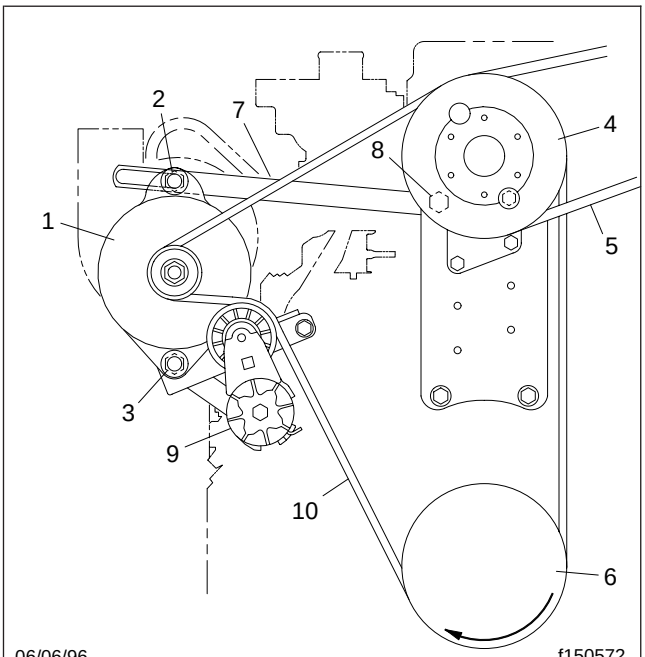
4. Insert a breaker bar in the belt tensioner and rotate the tensioner down and off the alternator drive belt. See **Fig. 2** for installation.

NOTE: There are two drive belts to remove. Before removing the alternator belt, it is necessary to remove the refrigerant compressor belt from the fan pulley.

5. Holding the belt tensioner down, remove the drive belt from its pulleys. Slowly release the belt tensioner and remove the breaker bar.
6. Lower the alternator drive belt, and take it off the vibration damper. It is not necessary to remove the belt from the vehicle.
7. Remove both alternator mounting capscrews. Remove the alternator from the vehicle.

NOTE: It is not necessary to remove the adjusting strap from the engine.

8. Inspect the drive belt. For instructions, see **Group 01**.




Rotate the belt tensioner down and off the belt.

1. Alternator
2. Alternator Mounting Capscrew, Top
3. Alternator Mounting Capscrew, Bottom
4. Fan Pulley
5. Refrigerant Compressor Drive Belt
6. Vibration Damper
7. Alternator Adjusting Strap
8. Adjusting Strap Mounting Capscrew
9. Belt Tensioner
10. Alternator Drive Belt

**Fig. 2, Alternator Installation**

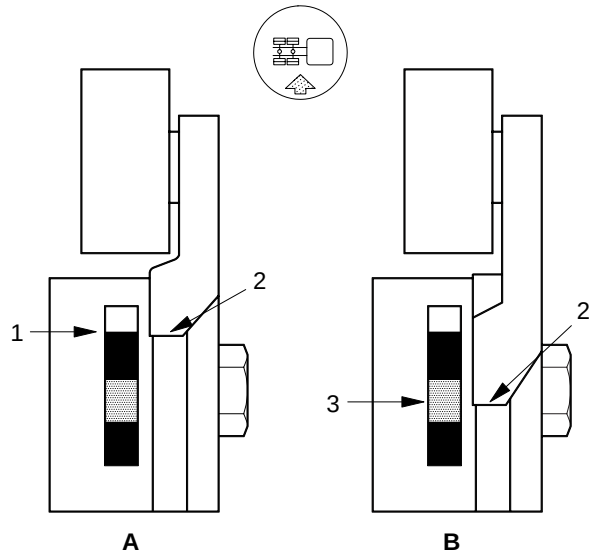
## Installation

1. Install the alternator on the engine. Install the alternator at the inboard edge of the slot initially. Install the top and bottom alternator mounting capscrews, but do not tighten them yet.
2. Install the drive belts on the pulleys, as removed. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m). For belt tightening procedures and specifications, see **Group 01**.
3. Verify that the edge of the tensioner arm is within the green zone on the decal. See **Fig. 3**. If within the red zone, pivot the alternator outboard until the tensioner arm enters the green zone.

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## Alternator Removal and Installation, Caterpillar C–10/C–12




A. Belt Off, No Tension
B. Belt On, Correct Tension

1. Decal
2. Edge of Tensioner Arm
3. Green Zone (operating range)

**Fig. 3, Belt Tensioner With Decal**

NOTE: If the belt slips, repair or replace the tensioner. For instructions, see the Caterpillar C–10 & C–12 Diesel Truck Engine Service Manual.

4. When the alternator is correctly positioned, tighten both alternator mounting capscrews 65 lbf·ft (88 N·m).
5. Check the torque of the adjusting strap mounting capscrew. If necessary, tighten it 65 lbf·ft (88 N·m).
6. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
7. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.
8. Connect the batteries.
9. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Output Voltage Test" in **Troubleshooting, 300**.

| Protectant Material | Approved Brands |
|---|---|
| Spray-On Application | MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC |
| Brush-On Application | Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201 |

**Table 1, Approved Dielectric Red Enamel**

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## Alternator Removal and Installation, DDC 60

# Removal

1. Park the vehicle on a level surface, turn off all electrical loads such as lights, ignition, and accessories, set the parking brake, and chock the tires.
2. Disconnect the batteries.
3. Open the hood.
4. Disconnect the electrical leads attached to the alternator. Mark the terminals and wires for ease of installation.
5. Using a 1/2-inch drive tool in the square hole of the belt tensioner, rotate the tensioner until the belt tension is relieved and remove the belt. See **Fig. 1**.
6. Support the alternator and remove the four mounting bolts and lockwashers that attach the alternator to the engine. Remove the alternator.

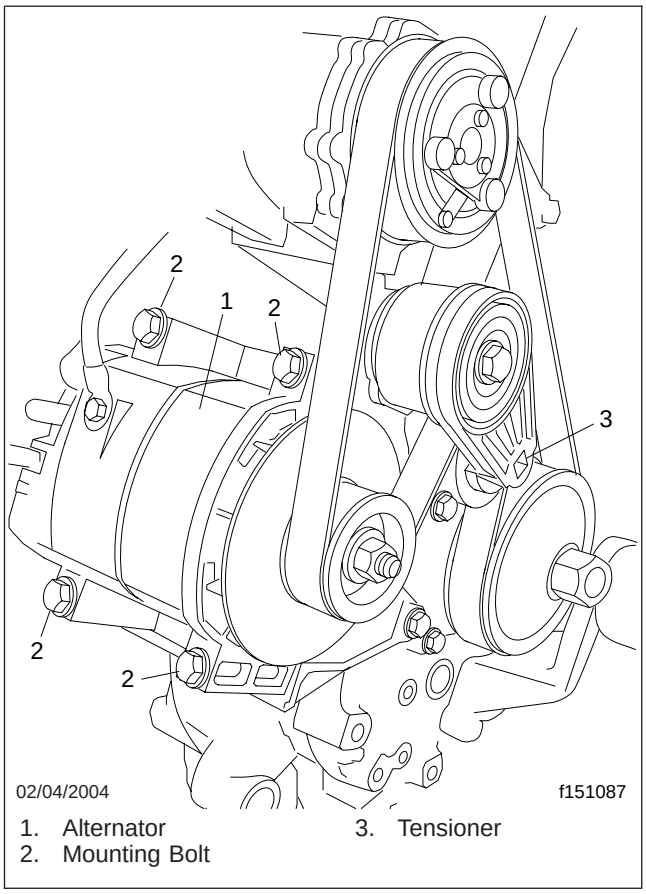
# Installation

1. Position and support the alternator.
2. Install the four mounting bolts and lockwashers that attach the alternator to the engine. Torque the bolts 31 to 39 lbf·ft (42 to 53 N·m).
3. Connect the wires to the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
4. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

| Protectant Material | Approved Brands |
|---|---|
| Spray-On Application | MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC |
| Brush-On Application | Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201 |

**Table 1, Approved Dielectric Red Enamel**

5. Connect the batteries.
6. Before returning the vehicle to operation, test the alternator DC output voltage or use the Delco Intelli-Check Alternator Analyzer. For instructions, see "Alternator Output Voltage Test" in **Troubleshooting 300**.
7. Return the hood to the operating position.




1. Alternator
2. Mounting Bolt
3. Tensioner

**Fig. 1, Alternator Installation**

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## Adjustment

NOTE: Before checking or adjusting the alternator voltage, check the wiring, connections, and belt tension.

1. Turn off all accessories. Run the engine at fast idle (approximately 1200 RPM) and charge the batteries.
2. Connect an accurate voltmeter across the batteries to determine the charging voltage. If the voltage is below 13.8V, or above 14.1V, adjust the voltage regulator.
3. Shut down the engine.
4. If needed, adjust the charging voltage.
   - 4.1 Remove the small black cap on the regulator cover to expose the adjustment screw.
   - 4.2 Using a small screwdriver, turn the adjusting screw until the voltage is between 13.8V and 14.1V.
     - To increase the voltage, turn the adjusting screw clockwise.
     - To decrease the voltage, turn the adjusting screw counterclockwise.
5. Run the engine at fast idle (approximately 1200 RPM) and check the voltage again to make sure it has been properly adjusted. Readjust as necessary.

NOTE: If adjustment does not bring the voltage into the proper range, replace the voltage regulator.

6. Shut down the engine.
7. Install the plastic cap on the access hole over the adjusting screw.

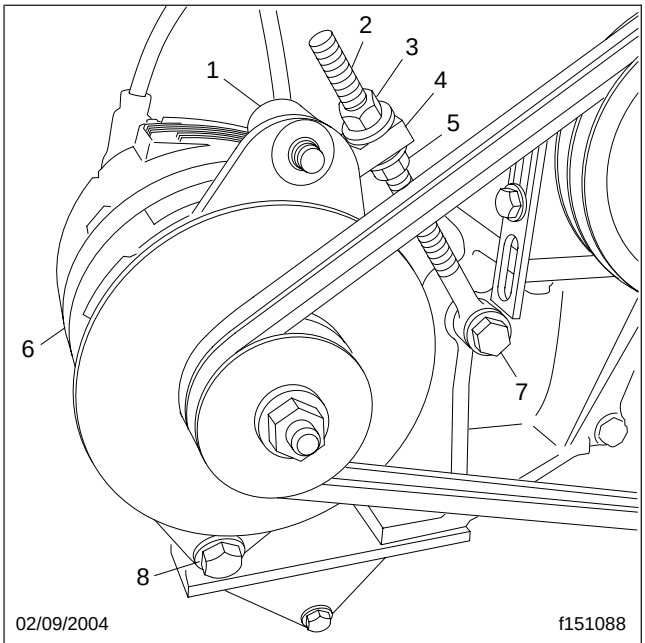
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# Alternator Removal and Installation, Caterpillar C–15

## Removal

1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the tires.
2. Disconnect the batteries.
3. Mark all electrical leads and disconnect them from the alternator.
4. Loosen the adjusting rod mounting capscrew, the end link mounting capscrew, and the alternator mounting capscrew. See **Fig. 1**. Loosen them enough to allow movement of the alternator.




1. End Link Mounting Capscrew (head not visible)
2. Adjusting Rod
3. Adjusting Rod Jam Nut
4. End Link
5. Adjusting Nut
6. Alternator
7. Adjusting Rod Mounting Capscrew
8. Alternator Mounting Capscrew

**Fig. 1, Alternator Installation, Caterpillar C-15**

5. Back off the adjusting nut. See **Fig. 1**. Push the loosened alternator far enough toward the fan drive pulley to allow removal of the drive belts without using force.
6. Remove the drive belts from the pulley without prying or twisting the belt.
7. Remove the end link mounting capscrew and the alternator mounting capscrew. Remove the alternator from the vehicle.
8. Inspect the drive belt. For instructions, see **Group 01**.

## Installation

1. Check the torque of the alternator bracket fasteners. If necessary, tighten them 50 lbf·ft (68 N·m).
2. Install the alternator on the engine. Install the end link mounting capscrew and the alternator mounting capscrew, but do not tighten them yet.
3. Loop the drive belts around the pulleys.
4. Install the drive belts on the pulleys without prying or rolling them into place. If installing a new pulley or a new alternator, tighten the pulley nut 75 lbf·ft (102 N·m). For belt tightening procedures and specifications, see **Group 01**.
5. After the belt has been correctly tensioned, tighten the adjusting rod jam nut 95 lbf·ft (130 N·m).
6. Tighten the end link mounting capscrew and the alternator mounting capscrew 65 lbf·ft (88 N·m). Tighten the adjusting rod mounting capscrew 50 lbf·ft (68 N·m).
7. Connect all leads to the back of the alternator as previously marked. Tighten the output terminal nut 100 lbf·in (1140 N·cm). Tighten the ground terminal nut 65 lbf·in (740 N·cm). For other terminals, tighten the nut 20 lbf·in (220 N·cm).
8. Spray any exposed terminal connectors with dielectric red enamel. See **Table 1**.

| Protectant Material | Approved Brands |
|---|---|
| Spray-On Application | MMM 1602 IVI–Spray Sealer, Red Electric Grade; order from the PDC |
| Brush-On Application | Glyptal 1201EW– Low VOC, Red; order at www.glyptal.com or 1-800-GLP-1201 |

**Table 1, Approved Dielectric Red Enamel**

9. Connect the batteries.

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## Alternator Removal and Installation, Caterpillar C–15

10. Before returning the vehicle to operation, test the alternator DC output voltage. For instructions, see "Alternator Output Voltage Test" in **Trouble-shooting, 300**.

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# Troubleshooting

Many alternators have been replaced that later investigation reveals were working properly. This may be due to incorrectly diagnosing the problem.

IMPORTANT: Before testing, make sure:

- All belts are correctly tightened;
- The wiring and terminals are clean and in good condition;
- All terminal nuts are torqued and properly protected.

To troubleshoot the SmartChek™ diagnostic alternator perform the following steps:

1. With the engine off, clean the top of the regulator using a shop cloth until you can see the SmartChek indicator.
2. Start the engine. If the SmartChek indicator glows red, replace the alternator.

   If the indicator glows green, go to the next step.
3. Turn on several vehicle accessories, such as lights and heater fans. If the green indicator changes to red, replace the alternator.

   If the indicator continues to glow green, the alternator is OK. Check the other components of the electrical system.

Delco Remy has an alternator testing tool called the Intelli-Check Alternator Analyzer. See **Fig. 1**. This tool (DR 10457848, a single tester, or DR 10457865, a four-pack of testers) is to be used as a quick check of the alternator to see if it is working correctly.

NOTE: If you do not have the Delco Intelli-Check Tester, or if the alternator rated output is above 145 amps, or if a total vehicle charging system analysis is required, see "Alternator/Charging System Testing."

## Intelli-Check Alternator Analyzer

The following information includes a pre-test procedure and operating instructions for the Delco Intelli-Check Tester, and is similar to the procedures provided by Delco with the Intelli-Check Tester.

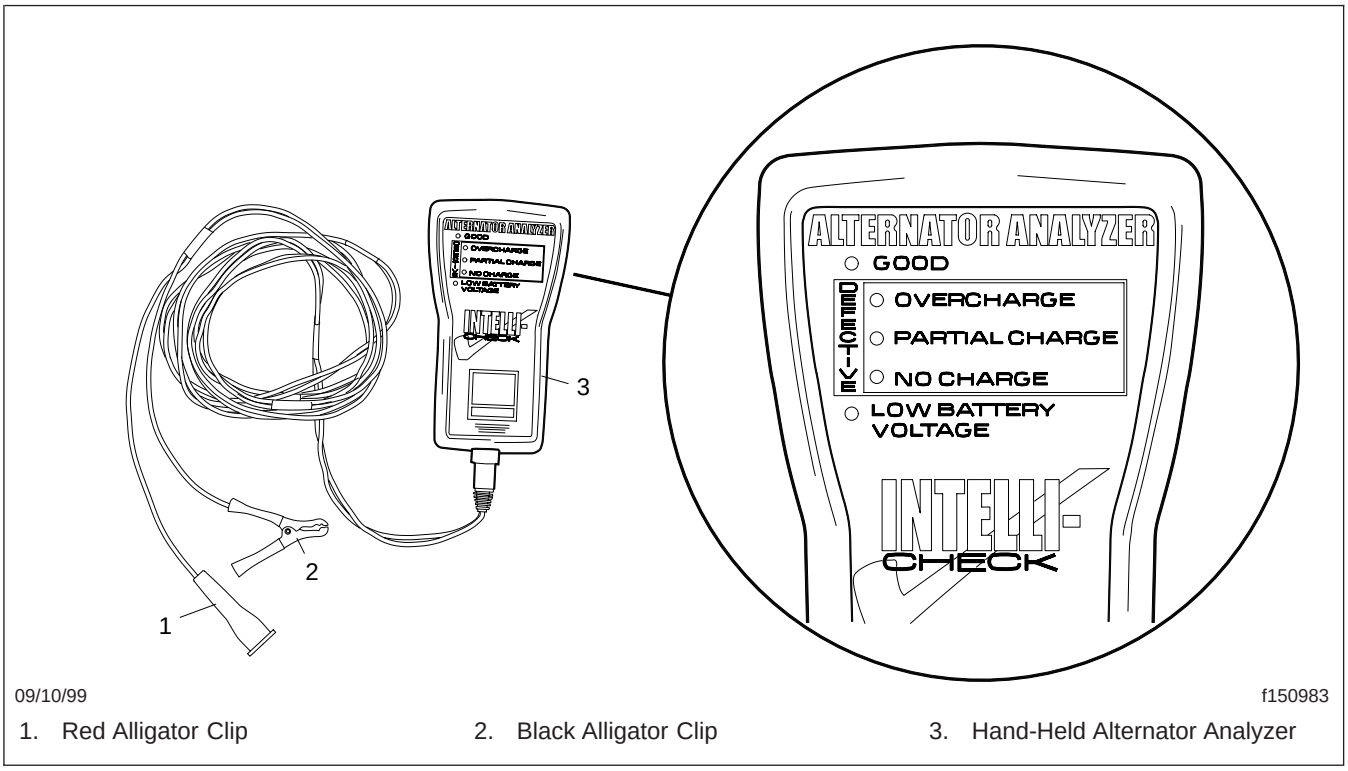
### Pre-Test Procedure (Engine Off)

1. Inspect the alternator connections to verify that all terminals are secured and tight. Verify that the sense wire is connected to the sense terminal on vehicles equipped with remote-sense alternators.
2. With the engine off, connect the red alligator clip to the output terminal of the alternator. Connect the black alligator clip to the alternator ground terminal, or to the body of the alternator. The tester LEDs will illuminate and then go off as it performs a self-test.
3. After 4 seconds the tester will activate. The following LEDs may illuminate depending on the condition of the batteries:
   - **GOOD** (green) LED indicates the battery voltage is above 12.8 and has a surface charge. The surface charge must be removed before proceeding with the alternator test. To remove the surface charge, do the following:
     A. Turn on the headlights and blower motor for 2 minutes without restarting the engine.
     B. Reset the tester by disconnecting, then reconnecting the tester alligator clips. The analyzer will again perform its self-test.
     C. Repeat the applicable steps of the Pre-Test Procedure.
   - **NO CHARGE** (red) LED indicates the battery voltage is below 12.8. This LED should illuminate for most tests. Proceed with the alternator test.
   - **LOW BATTERY VOLTAGE** (blue) LED indicates the battery voltage is below 12.35. If the batteries will start the vehicle, proceed with the alternator test. However, after completing the Intelli-Check alternator test, perform the procedures under "Alternator/Charging System Testing" to determine the condition of the rest of the charging system.

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## Troubleshooting




1. Red Alligator Clip
2. Black Alligator Clip
3. Hand-Held Alternator Analyzer

**Fig. 1, Delco Remy Intelli-Check Alternator Analyzer**

## Tester Operating Instructions (Engine Running)

1. Start the engine using onboard batteries only. If the batteries will not start the engine, they must be charged for 2 hours. Start the test again after charging the batteries.
2. Verify the engine is at idle and all electrical loads are off.
3. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
   - If the **GOOD** (green) LED illuminates, proceed to the next step.
   - If any LEDs illuminate indicating overcharge, partial charge, or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
   - If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/ Charging System Testing."
4. With the engine running, turn on all electrical loads.
5. Depress the accelerator to governed speed, hold for 10 seconds, then return to idle.
6. If the **GOOD** (green) LED illuminates, the alternator is OK and the test is complete.

NOTE: If the alternator tests OK in the above tests, and the customer's complaint is reduced battery or headlight life, see "Alternator/ Charging System Testing" to completely analyze the charging system.

7. If any LEDs illuminate indicating overcharge, partial charge, or no charge (the three red lights in the **DEFECTIVE** section), replace the alternator and run the complete test again.
8. If the **LOW BATTERY VOLTAGE** (blue) LED illuminates, evaluate the charging system using the instructions in "Alternator/Charging System Testing."

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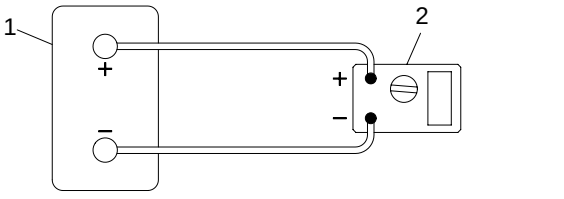
# Alternator/Charging System Testing

## Battery Open Circuit Voltage Test, Alternator Output Voltage Test, and Alternator Amperage Output Test

1. Use a digital volt-ohmmeter (VOM) set on the 2-20VDC (or similar) scale to test the battery open circuit voltage (OCV). With the engine shut down and the voltmeter set up as shown in **Fig. 2**, check for voltage of 12.4 volts or more.

   If the OCV is 12.4 volts or more, turn on the vehicle headlights for approximately 3 minutes.

   If the OCV is less than 12.4 volts, charge the batteries properly. For instructions, see **Group 54**.




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1. Battery
2. Digital Voltmeter

**Fig. 2, Setup 1: Battery Open Circuit Voltage (and alternator amperage output)**

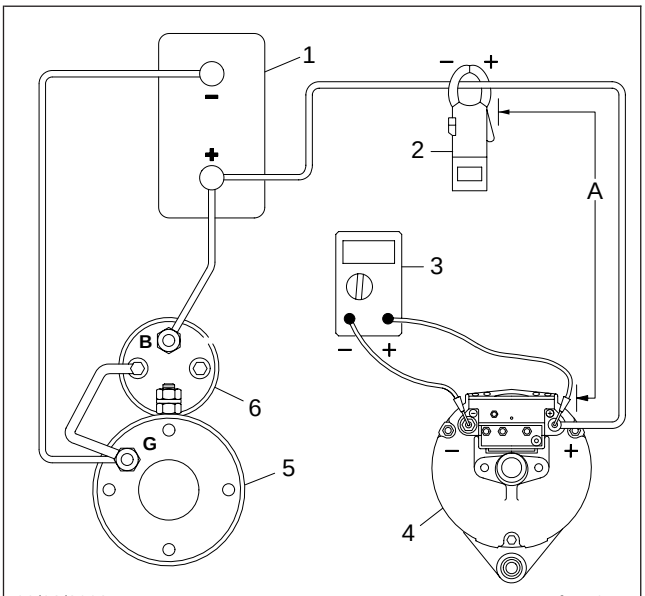
IMPORTANT: Be sure to disconnect the batteries or remove them from the vehicle before charging.

2. Check the alternator output without a load. See **Fig. 3**.

   2.1 Start the engine and run it at 1500 rpm for 3 to 5 minutes to stabilize the system before proceeding to the next step.

   2.2 Connect the positive (+) lead of the digital voltmeter (still set on the 2-20VDC or similar scale) to the alternator (battery) terminal. Connect the negative (–) lead of the voltmeter to the alternator negative (–) ground terminal. See **Fig. 3**.

   2.3 If the voltmeter reads from 13.8 to 14.2 volts, record this reading (V1) and go to the next step. If the alternator reads less than 13.8 volts and is adjustable, try to adjust the voltage regulator to 13.8 to 14.2 volts. If unable to obtain acceptable output, replace the alternator.




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A. Locate the ammeter at least 6 inches (15 cm) away from the alternator.

1. Battery
2. Ammeter
3. Digital Voltmeter
4. Alternator
5. Cranking Motor
6. Solenoid

**Fig. 3, Setup 2: Alternator Output Voltage**

3. Check the alternator output under load. See **Fig. 3**.

   3.1 Attach a clamp-on induction ammeter around the positive (+) wire. See **Fig. 3**.

   NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

   3.2 With the engine still running at 1500 rpm, turn on the following electrical accessories to load the alternator until the ammeter reads 60 to 75 amps.

   - Both front and rear heater blowers (on HIGH)
   - Headlights (high beams)
   - Road lights
   - Interior lights

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## Troubleshooting

NOTE: As an alternate method of putting load on the alternator, connect a carbon pile tester and set it to 60 to 75 amps.

3.3 Keep the voltmeter connected as in the previous step; positive (+) lead connected to the alternator positive (+) terminal; negative (–) lead connected to the alternator negative (–) terminal.

3.4 If the voltmeter reads from 13.6 to 14.2 volts, record this reading (V2) and go to the next step.

If the voltmeter reads less than 13.6 volts, replace the alternator.

4. Perform an alternator amperage output test.

4.1 Connect a carbon pile tester across the vehicle batteries as shown in **Fig. 2**.

NOTE: **Figure 2** shows a voltmeter, but the connections for the carbon pile tester are the same.

4.2 Attach a clamp-on induction ammeter around the alternator output wire. See **Fig. 3**.

NOTE: Locate the ammeter at least 6 inches (15 cm) away from the alternator.

4.3 Start the engine and make sure all vehicle electrical accessories are turned off. Run it at fast speed and adjust the tester to the alternator maximum current output. Record this output value.

NOTE: Ensure that the alternator is turning at maximum available rpms and keep adjusting the tester dial until the ammeter reads its highest value.

4.4 Turn off the tester and shut down the engine.

4.5 If the output value recorded is less than 85 percent of the rated amperage output, repeat the test. If the output value recorded is still less than 85 percent of the rated amperage output, replace the alternator.

4.6 Make sure that all test instruments are removed and that the vehicle wiring is returned to its operational state.

5. To identify other problem areas within the vehicle, check the operation of the charging system. Set up the voltmeter as shown in **Fig. 2** and **Fig. 3**.

NOTE: For any load at 1500 rpm or more, battery voltage must be within 0.5 volts of the alternator voltage.

5.1 If readings at the batteries are within 0.5 volts of the readings at the alternator, the charging system is working correctly. Check other areas of the vehicle to locate the problem.

5.2 If the reading at the batteries is more than 0.5 volts lower than the reading at the alternator, do the next step.

6. Check charging system connections, cables, and terminals.

6.1 Check all connections between the battery, starter, and alternator for tightness and signs of corrosion. Tighten and clean as necessary.

6.2 Check all cables for breaks or partial breaks. Repair or replace as necessary.

6.3 Check each ring terminal for breakage at the point where it attaches to its wire or cable.

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## Specifications

See **Fig. 1** for a charging circuit wiring diagram. The charging circuit consists of the battery, starter, alternator, and magnetic switch.

See **Table 1** for Mounting Fastener Torques for Caterpillar C–10/C–12/C–15 Engines.

See **Table 2** for Mounting Fastener Torques for Detroit Diesel Series 60 Engines.

See **Table 3** for Terminal Fastener Torques, for All Engines.

See **Table 4** for Pulley Nut Torque, for All Engines.

| Mounting Fastener Torques, Caterpillar C–10/C–12/C–15 Engines | | | |
|---|---|---|---|
| **Description** | **Grade/Class** | **Size** | **Torque: lbf·ft (N·m)** |
| Alternator Mounting Capscrews | 8PO | 1/2–13 | 65 (88) |
| Adjusting Strap Mounting Capscrew | 10.9PO | M12 | 65 (88) |

**Table 1, Mounting Fastener Torques, Caterpillar Engines**

| Mounting Fastener Torques, Detroit Diesel Series 60 Engines | | | |
|---|---|---|---|
| **Description** | **Grade/Class** | **Size** | **Torque: lbf·ft (N·m)** |
| End Link Mounting Capscrew | 8PO | 1/2–13 | 65 (88) |
| Alternator Mounting Capscrew | 8PO | 1/2–13 | 65 (88) |
| Adjusting Rod Mounting Capscrew | 10.9PO | M10 | 50 (68) |
| Adjusting Rod Jam Nut | 5 | 5/8 | 95 (130) |
| Alternator Bracket Fasteners | 10.9PO | M10 | 50 (68) |
| Alternator Adjusting Capscrew | 8PO | 1/2–13 | 65 (88) |

**Table 2, Mounting Fastener Torques, Detroit Diesel Engines**

| Terminal Fastener Torques, All Engines | | | |
|---|---|---|---|
| **Description** | **Grade/Class** | **Size** | **Torque: lbf·in (N·cm)** |
| Alternator Output ("BAT") Terminal Nut | 5 | 5/16–18 | 100 (1140) |
| Alternator Ground ("G") Terminal Nut | 5 | 1/4–20 | 65 (740) |
| Alternator Instrument ("I") Terminal Nut | 8.8 | M4 | 20 (220) |

**Table 3, Terminal Fastener Torques, All Engines**

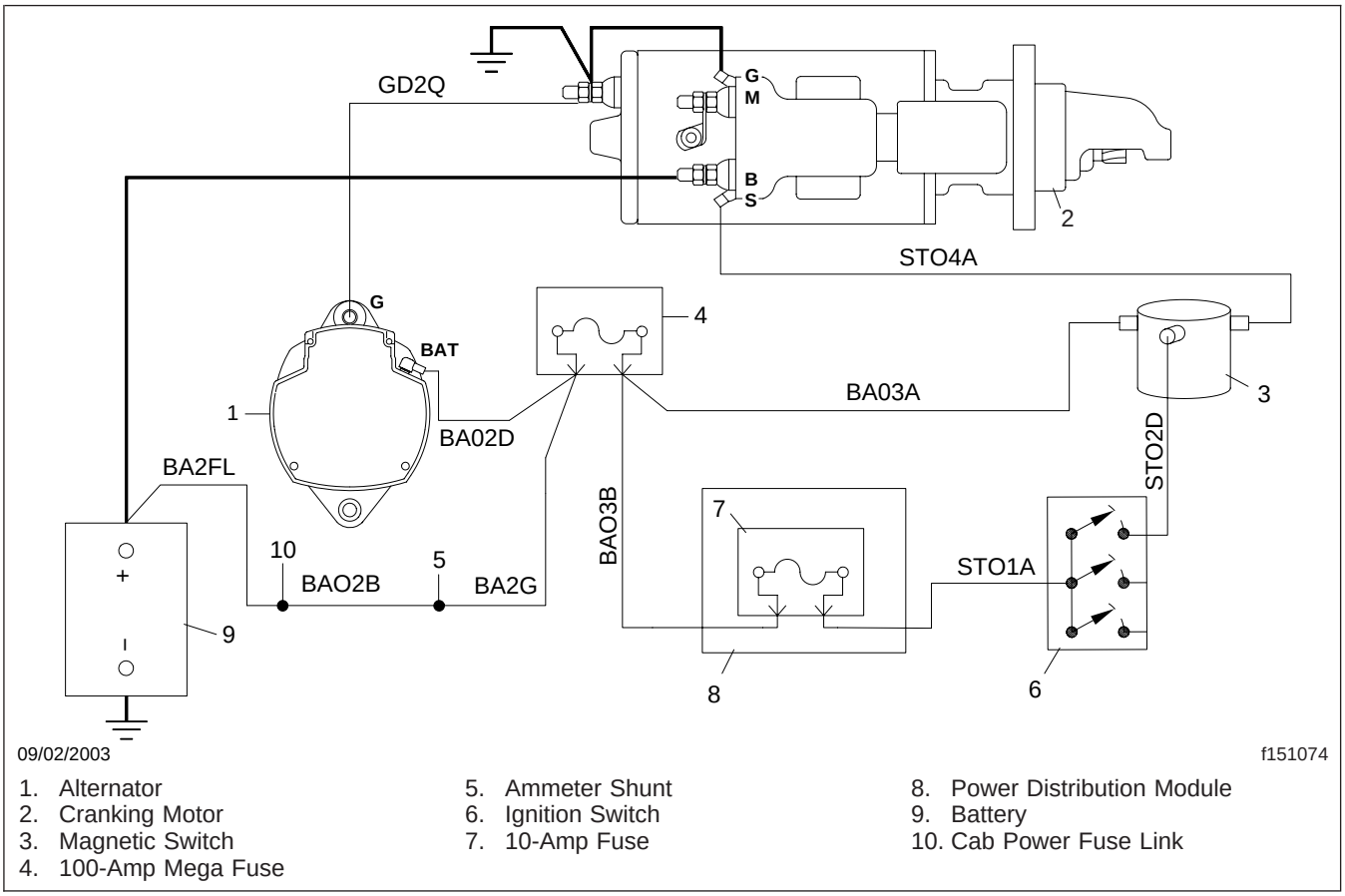
| Pulley Nut Torque, All Engines | | | |
|---|---|---|---|
| **Description** | **Grade** | **Size** | **Torque: lbf·ft (N·m)** |
| Pulley Nut | 8PO | 1/2–20 | 75 (102) |

**Table 4, Pulley Nut Torque, All Engines**

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## Specifications




1. Alternator
2. Cranking Motor
3. Magnetic Switch
4. 100-Amp Mega Fuse
5. Ammeter Shunt
6. Ignition Switch
7. 10-Amp Fuse
8. Power Distribution Module
9. Battery
10. Cab Power Fuse Link

**Fig. 1, Charging Circuit Wiring Diagram**

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# General Information

The starting system converts electrical energy into mechanical rotation, to crank the engine. When the starter is cranked, the pinion gear extends outward to mesh with the ring gear on the engine flywheel. A clutch prevents the starter from spinning too fast.

The starter is capable of drawing over 2000 amps, which can cause quick heat build-up and possible damage. Never crank the starter continuously for more than 30 seconds, and always wait at least 2-minutes between cranking attempts.

The starter system may have an optional overcranking-protection circuit with a thermoswitch that cuts power to the starter if the starter motor begins to overheat. After the starter motor cools (usually within 6 minutes) the thermoswitch will allow the starter motor to crank again.

When properly operated under normal conditions, the starter requires no maintenance.

## Principles of Operation

Turning the keyswitch to "Start" sends battery power to the magnetic switch. Depending on the vehicle options, there may be a thermal cut-out switch, gear position switch, or theft-deterrent interrupt in the magnetic-switch circuit. The magnetic switch sends power to the starter solenoid. The solenoid moves a lever which causes the pinion gear to engage with the ring gear on the fly wheel. As the gears engage, battery power cranks the starter motor.

See **Fig. 1** for a typical starting circuit for pre-EPA07 compliant vehicles, where the positive circuit from the keyswitch is routed through the interlock switches. See **Fig. 2** for a typical starting circuit for vehicles that are EPA07 compliant, and the ground side of the magnetic switch is interrupted by the interlock switches.

When diagnosing starting problems, always begin with fully charged batteries, and perform a voltage-drop test on the battery cables and magnetic-switch circuit. Once the engine is running, check that the alternator output is sufficient to charge the batteries.

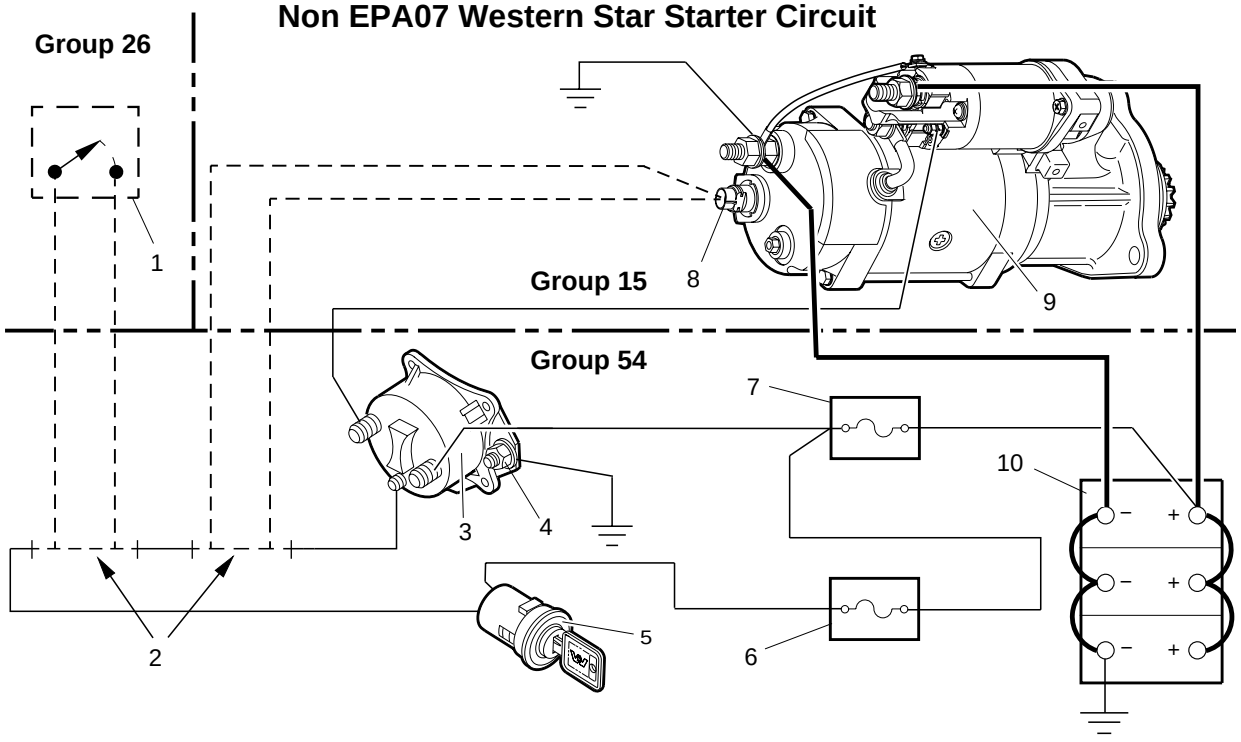
A starter that cranks slowly, or just clicks when the keyswitch is turned, typically indicates a problem with adequate power to the starter. Corrosion and loose connections in the battery cables cause significant voltage drop, and may prevent the starter from cranking the engine.

If there is no starter activity when turning the ignition keyswitch, there may be a fault in the circuitry to the magnetic switch, or to the starter solenoid.

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## General Information

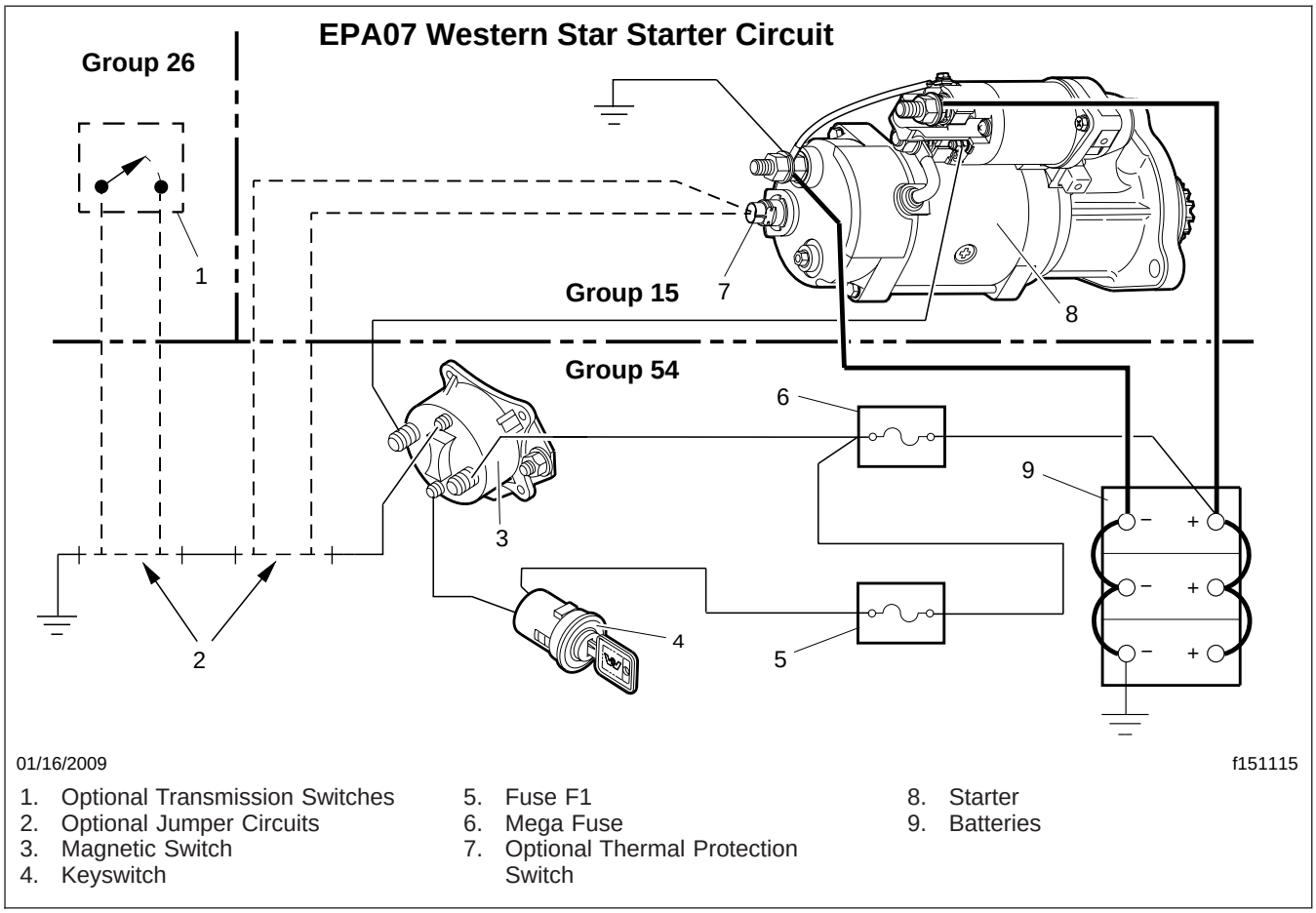



1. Optional Transmission Switches
2. Optional Jumper Circuits
3. Magnetic Switch
4. Magnetic Switch Ground
5. Keyswitch
6. Fuse F1
7. Mega Fuse
8. Optional Thermal Protection Switch
9. Starter
10. Batteries

**Fig. 1, Pre-EPA07 Compliant Vehicle Starter Circuit**

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1. Optional Transmission Switches
2. Optional Jumper Circuits
3. Magnetic Switch
4. Keyswitch
5. Fuse F1
6. Mega Fuse
7. Optional Thermal Protection Switch
8. Starter
9. Batteries

**Fig. 2, EPA07 Compliant Vehicle Starter Circuit**

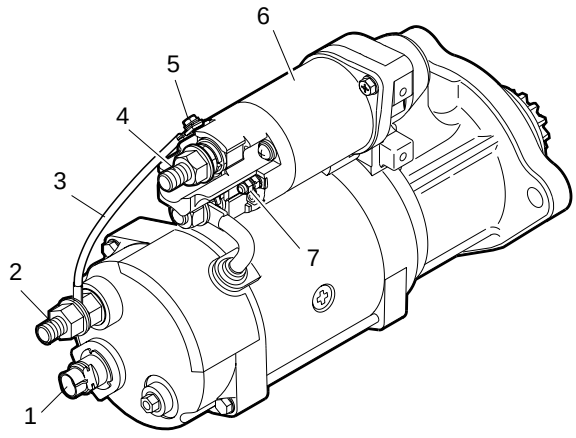
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## Removal

Before removing the starter, perform the checks in **Troubleshooting 300**.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Disconnect the negative battery cables at the batteries, and open the hood.
3. Disconnect and label the wiring that connects to the starter. See **Fig. 1**.
4. Support the starter, then remove the bolts that mount it to the flywheel housing. See **Fig. 2**.




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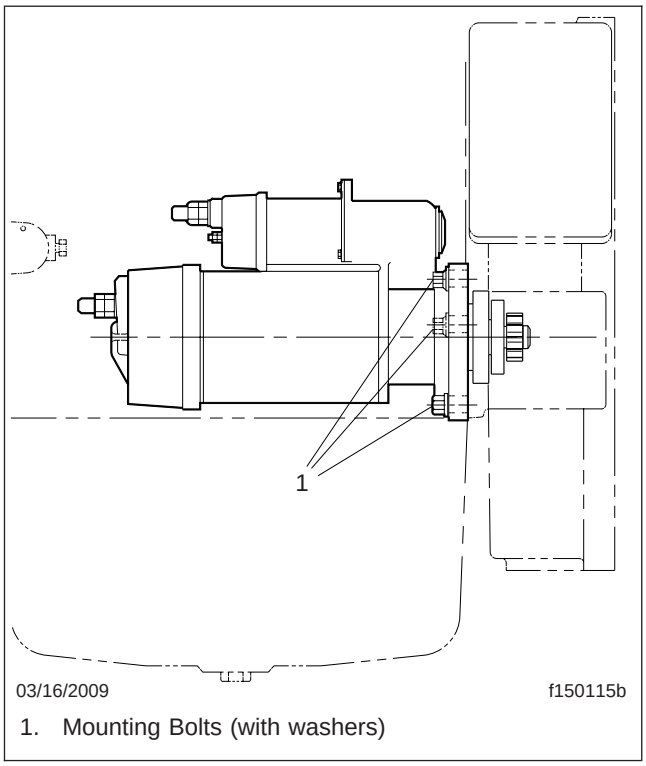
1. Thermal Overcrank Protection Terminal
2. Insulated/Ground Terminal
3. Solenoid Ground Wire
4. Solenoid Battery (+) Terminal
5. Solenoid Ground (-) Terminal
6. Solenoid
7. Solenoid Switch (+) Terminal

**Fig. 1, Starter Connections**

5. Remove the starter from the vehicle.

## Installation

1. Place the starter into the mounting hole in the flywheel housing.




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1. Mounting Bolts (with washers)

**Fig. 2, Starter Mounting**

2. Hand start the three mounting bolts, then hand tighten them until snug. Using a torque wrench, tighten them to the torque values shown in **Specifications 400**.
3. Connect the wiring to the solenoid and starter as previously marked. Tighten the terminals to the torque values shown in **Specifications 400**.
4. Protect all exposed terminal connectors with di-electric red enamel.
5. Connect the batteries.

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## Troubleshooting Tables

Use troubleshooting tables 1 through 3 to perform system diagnosis, to reduce the likelihood of replacing a starter that is not defective.

See **Table 1** for troubleshooting problems relating to the starter slow cranking, or making a repeated clicking sound, but the engine does not start.

See **Table 2** for troubleshooting problems relating to the starter doing nothing, or making only a single click.

See **Table 3** for troubleshooting problems relating to the starter making spinning or grinding sounds, but the engine does not crank.

| Slow Cranking or Repeated Clicking Sound, but the Engine Does Not Start. | | | |
|---|---|---|---|
| This symptom often indicates low voltage at the starter, or worn and binding starter components. | | | |
| **Step** | **Test Procedure** | **Test Result** | **Action** |
| 1. | Check the ambient temperature.<br>Is the temperature extremely cold? | Yes | Slow cranking due to extreme cold may be a normal condition. Do not mistake slow cranking due to cold for slow cranking due to equipment malfunction. |
| | | No | Go to step 2. |
| 2. | Test the voltage at the batteries.<br>Is the voltage below 12 volts? | Yes | Charge the batteries then go to step 3. Perform an alternator test when the vehicle is able to start. |
| | | No | Go to step 3. |
| 3. | Test the batteries individually with the battery tester.<br>Are any batteries defective? | Yes | Replace any batteries that tested defective. |
| | | No | Go to step 4. |
| 4. | Perform a voltage drop test on the positive and negative battery cables from the starter to the batteries, while cranking.<br>Is excessive voltage drop present? | Excessive voltage drop | Inspect for corroded and loose connections. Clean, tighten and repair all connections, then protect all exposed terminal connectors with dielectric red enamel. |
| | | Ok | Go to step 5. |
| 5. | Measure the voltage at the solenoid engage terminal during cranking.<br>Is battery voltage present? | No voltage, or intermittent voltage | Use the vehicle schematics to work back through the circuitry from the starter solenoid to the magnetic switch, through any optional switches, to the keyswitch and fuses, to locate the fault. |
| | | Ok | Replace the starter. |

**Table 1, Slow Cranking or Repeated Clicking Sound but the Engine Does Not Start**

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## Troubleshooting

| Starter Does Nothing, or Makes Only a Single Click. | | | |
|---|---|---|---|
| **This symptom often indicates a problem with the magnetic switch or starter solenoid circuit. Worn components in the starter or engine can also create binding and result in this symptom.** | | | |
| **Step** | **Test Procedure** | **Test Result** | **Action** |
| 1. | Check the ambient temperature.<br>Is the temperature extremely cold? | Yes | Slow cranking due to extreme cold may be a normal condition. Do not mistake slow cranking due to cold for slow cranking due to equipment malfunction. |
| | | No | Go to step 2. |
| 2. | Test the voltage at the batteries.<br>Is the voltage below 12 volts? | Yes | Charge the batteries then go to step 3. Perform an alternator test when the vehicle is able to start. |
| | | No | Go to step 3. |
| 3. | Test the voltage at the solenoid engage terminal while the key is in the crank position.<br>Is battery voltage present? | Yes | Go to step 4. |
| | | No or low | Use the vehicle schematics to work back through the circuitry from the starter solenoid to the magnetic switch, through any optional switches, to the keyswitch and fuses, to locate the fault. An open fuse usually indicates a short in the circuitry. It may be necessary to follow the wiring to find an intermittent short that causes the fuse to open. |
| 4. | Test the voltage at the starter positive and negative battery cable connections while the key is in the crank position.<br>Is battery voltage present? | Yes | Replace the starter. |
| | | No or low | Go to step 5. |
| 5. | Perform a voltage drop test on the positive and negative batttery cables while cranking.<br>Is excessive voltage drop present? | Yes | Inspect for corroded and loose connections. Clean, tighten and repair all connections, then protect all exposed terminal connectors with dielectric red enamel. |
| | | No | Test the starter on a bench tester. Replace the starter if it fails the testing. Troubleshooting may indicate the need to check for a seized engine. |

**Table 2, Starter Does Nothing or Makes Only a Single Click**

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| Starter Makes Spinning or Grinding Sounds, but the Engine Does Not Crank. | | | |
|---|---|---|---|
| This symptom often indicates a mechanical problem with the starter or the ring gear. | | | |
| **Step** | **Test Procedure** | **Test Result** | **Action** |
| 1. | Test the voltage at the starter battery cable connections while cranking.<br>Is battery voltage present? | Low or No | Go to step 2. |
| | | Yes | Go to step 3. |
| 2. | Perform a voltage drop test on the positive and negative battery cables, between the starter and the batteries, while cranking.<br>Is excessive voltage drop present? | No | Go to step 3. |
| | | Excessive voltage drop | Inspect for corroded and loose connections. Clean, tighten and repair all connections, then protect all exposed terminal connectors with dielectric red enamel |
| 3. | Remove the starter and bench test it. The bench tester can confirm problems with the solenoid and gear reduction mechanisms. | Ok | Go to step 4. |
| | | Defective | Replace the starter. |
| 4. | Inspect the starter pinion gear for milling. | Ok | Go to step 5. |
| | | Damaged | Replace the starter. |
| 5. | Bar the engine over to inspect the three positions on the ring gear where the starter pinion gear engages. | Damaged | Replace the ring gear. |

**Table 3, Starter Makes Spinning or Grinding Sounds but the Engine Does Not Crank**

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## Specifications

| Torque Values, Starter-Motor to Flywheel-Housing Bolts | | |
|---|---|---|
| **Fastener Description** | **Size** | **Torque Value: lbf·ft (N·m)** |
| Detroit Diesel (steel housing) | 5/8–16 | 137–147 (186–199) |
| Detroit Diesel (aluminum housing) | 5/8–16 | 85–95 (115–129) |
| Caterpillar (steel or aluminum housing) | 5/8–16 | 130–170 (176–230) |
| Cummins (steel or aluminum housing) | 5/8–16 | 130–170 (176–230) |

**Table 1, Torque Values, Starter-Motor to Flywheel-Housing Bolts**

See **Subject 100**, **Fig. 1**, for location of the terminals listed in **Table 2**.

| Torque Values, Delco Remy Starter Connections | | | | |
|---|---|---|---|---|
| **Starter** | **Terminal** | | | |
| | **Solenoid Switch (+)** | **Solenoid Battery (+)** | **Solenoid Ground (–)** | **Starter Ground (–)** |
| 12 Volt<br>37MT, 41MT, 42MT | 16 to 30 lbf·in<br>1.8 to 3.4 N·m | 20 to 25 lbf·ft<br>37 to 34 N·m | 16 to 30 lbf·in<br>1.8 to 3.4 N·m | 20 to 25 lbf·ft<br>37 to 34 N·m |
| 24 Volt<br>37MT, 41MT, 42MT | 16 to 30 lbf·in<br>1.8 to 3.4 N·m | 15 to 20 lbf·ft<br>20 to 27 N·m | 16 to 30 lbf·in<br>1.8 to 3.4 N·m | 15 to 20 lbf·ft<br>20 to 27 N·m |
| 29MT, 39MT | 18 to 20 lbf·in<br>2.0 to 2.25 N·m | 18 to 20 lbf·ft<br>24.5 to 27.5 N·m | 18 to 20 lbf·in<br>2.0 to 2.25 N·m | 18 to 20 lbf·ft<br>24.5 to 27.5 N·m |
| 29MT | 18 to 20 lbf·in<br>2.0 to 2.25 N·m | 10 to 13 lbf·ft<br>14.7 to 17.7 N·m | 18 to 20 lbf·in<br>2.0 to 2.25 N·m | 10 to 13 lbf·ft<br>14.7 to 17.7 N·m |
| 28MT | 22 to 27 lbf·in<br>2.5 to 3.1 N·m | 12 to 14 lbf·ft<br>15.7 to 19.6 N·m | 14 to 19 lbf·in<br>1.6 to 2.1 N·m | NA. |

**Table 2, Torque Values, Delco Remy Starter Connections**

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## General Information

The fan drive is a temperature-controlled, air-operated clutch for the engine cooling fan. Its purpose is to maintain engine temperature by engaging or disengaging the fan.

Air pressure to the fan clutch is controlled by a solenoid valve; the solenoid valve is controlled by a temperature switch that is installed in the thermostat housing. See **Fig. 1**.

## Horton Advantage

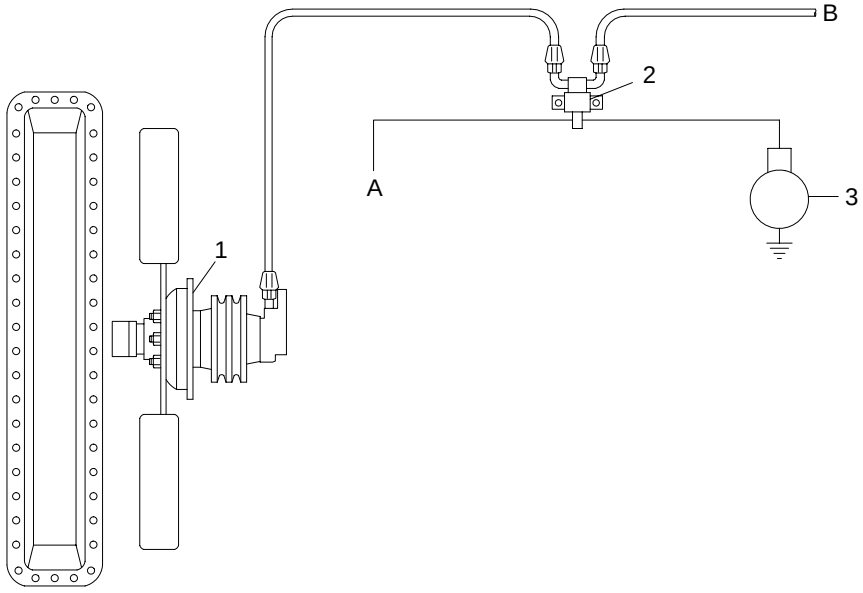
Internal spring pressure disengages the Horton fan clutch when the coolant temperature is below the specified temperature range; internal air pressure engages the fan clutch when the coolant temperature rises above that range.

With the Horton fan clutch, when you start a cold engine, the solenoid valve restricts air pressure to the cylinder, and the fan clutch remains disengaged. The fan does not turn.

When the coolant temperature rises to the temperature switch setting, the switch provides power to the solenoid valve, and the valve releases compressed air to engage the fan clutch.

When the coolant temperature drops to the temperature switch cutoff setting, the solenoid stops the compressed air, and the clutch disengages.

On vehicles with air conditioning, the fan clutch solenoid valve is connected to a fan cycling switch at the receiver-dryer. If the refrigerant pressure exceeds the setting of the fan cycling switch, the switch supplies




A. To the circuit breaker.
B. From the secondary air tank.
1. Fan Clutch
2. Solenoid Valve
3. Temperature Switch

**Fig. 1, Fan Clutch Piping and Wiring, Vehicle Without Air Conditioning**

On vehicles with air conditioning, the fan clutch solenoid valve is connected to a fan cycling switch at the receiver-dryer. If the refrigerant pressure exceeds the setting of the fan cycling switch, the switch supplies power to the solenoid valve. See **Fig. 2**.

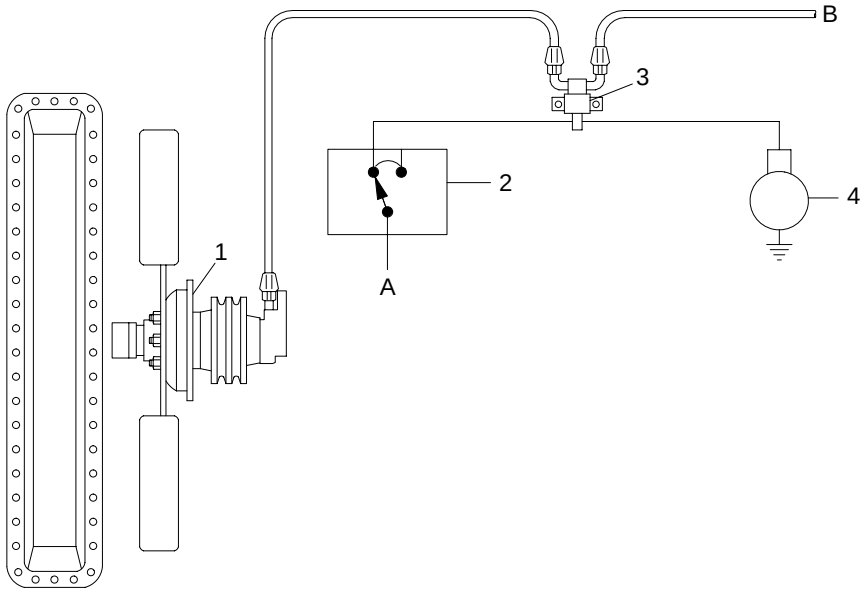
Western Star vehicles use two types of fan clutches:

- Horton Advantage
- Kysor K22RA

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## General Information




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A. To the circuit breaker.
B. From the secondary air tank.
1. Fan Clutch
2. Fan Cycling Switch at the Receiver-Drier
3. Solenoid Valve
4. Temperature Switch

**Fig. 2, Fan Clutch Piping and Wiring, Vehicle With Air Conditioning**

power to the solenoid valve, which supplies air to engage the fan clutch.

Horton Advantage fan clutches include System Sentry™ fuses that protect the fan clutch from overheating. See **Fig. 3**. The System Sentry fuse is a brass fitting in the piston friction disc; the fitting uses lead alloy solder to hold a brass plug. If anything causes the fan clutch to slip excessively, heat from the slippage will melt the solder and release the plug. Air pressure inside the clutch will escape, and the clutch will release before heat build-up can damage the clutch bearings. The fuse is balanced by two counterweights.

If the fan clutch will not engage, check to see if the fuse is melted, and check to see what might be making the fan clutch slip excessively.

For the fan clutch model number and serial number, see the side of the air chamber. See **Fig. 4**.

## Kysor K22RA

Internal spring pressure engages the Kysor fan clutch when the coolant temperature is above the specified temperature range; internal air pressure disengages the fan clutch when the coolant temperature drops below that range.

With the Kysor fan clutch, when you start a cold engine, the solenoid valve releases air pressure to the cylinder, and the fan clutch remains disengaged. The fan does not turn.

When the coolant temperature rises to the temperature switch setting, the switch provides power to the solenoid valve, and the valve stops the flow of compressed air to the fan clutch. A spring within the fan engages the clutch, and the fan turns.

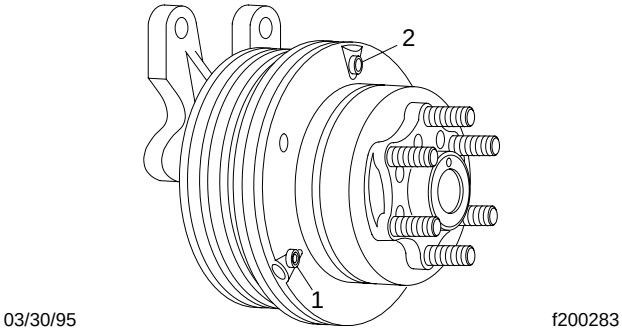
When the coolant temperature drops to the temperature switch cutoff setting, the solenoid releases compressed air to the clutch, and the clutch disengages.

On vehicles with air conditioning, the fan clutch solenoid valve is connected to a fan cycling switch at the receiver-drier. If the refrigerant pressure exceeds the

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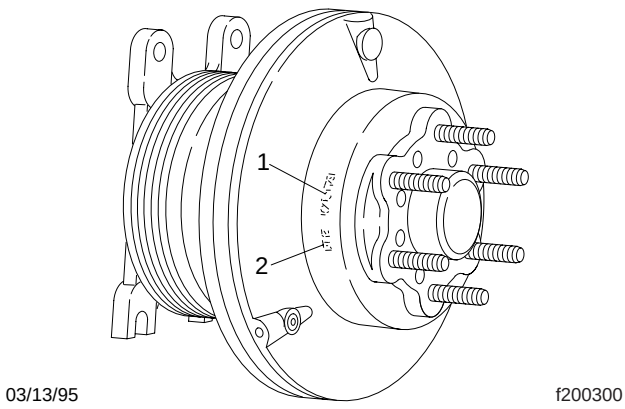


setting of the fan cycling switch, the switch supplies power to the solenoid valve, which stops air flow and allows the internal spring to engage the fan clutch.




1. System Sentry Fuse
2. Counterweight

**Fig. 3, Horton Fan Clutch with System Sentry Fuse**




1. Model Number
2. Serial Number

**Fig. 4, Fan Clutch Information, Horton**

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# Fan Clutch Major Rebuild, Horton Advantage

## Disassembly

NOTE: This procedure involves a major rebuild of the Horton Advantage fan clutch (**Fig. 1**), using parts from the manufacturer's Major or Super Kit. If you are replacing just the air cartridge, System Sentry® fuse, or the face seal, go to **Subject 130**.

1. Remove the fan and clutch assembly from the vehicle.
2. Clamp the fan clutch in a vise. See **Fig. 2**.
3. On some vehicles, the fan clutch has threaded studs on the air chamber and the fan is attached with nuts. On other vehicles, the fan is attached to the air chamber with hexbolts.

   If hexbolts were used to attach the fan, install two of the removed hexbolts in the air chamber so that a screwdriver can be used to keep the air chamber from rotating. See **Fig. 3**.

   Remove the socket-head capscrews from the air chamber.
4. If applicable, remove the two hexbolts previously installed.

**⚠ WARNING**

**Apply air pressure slowly to the fan clutch. A sudden blast of air might blow the air chamber off the clutch, resulting in possible injury.**

5. Connect a shop air hose to the cylinder inlet. See **Fig. 4** . Slowly apply air pressure, and remove the air chamber assembly.
6. Remove and discard the O-rings from the air chamber and the piston friction disc. Clean the O-ring contact surfaces.
7. Remove the face seal from the air chamber.
8. Remove the System Sentry fuse from the piston friction disc. *Note that it is a left-hand thread.*
9. Remove the rubber umbrella valve from the air chamber.
10. Remove the adjusting nut. See **Fig. 5**.
11. Remove the disc and piston assembly, and the journal spacer. See **Fig. 6**.
12. Slide the sheave and bearings off the mounting bracket assembly. See **Fig. 7**.
13. Remove the socket-head capscrews from the friction facing. Remove the friction facing.
14. Remove the retaining ring from the air cartridge assembly. See **Fig. 8**.

    Remove the cartridge assembly from the mounting bracket assembly. See **Fig. 9**.
15. Support the sheave and press out the bearings.

## Assembly

1. Coat the new sheave bearings with grease and press them into the sheave.

NOTE: Some models have a spacer between the bearings. Install the spacer if equipped.

2. Install a new air cartridge assembly in the mounting bracket assembly. Note that the retaining ring is curved. Make sure the ring is installed with the convex surface toward the air cartridge. See **Fig. 10** .
3. Slide the sheave and bearings onto the mounting bracket assembly.
4. Install a new friction facing onto the sheave. Following a star pattern, tighten the socket-head capscrews 60 lbf·in (680 N·cm).

**⚠ CAUTION**

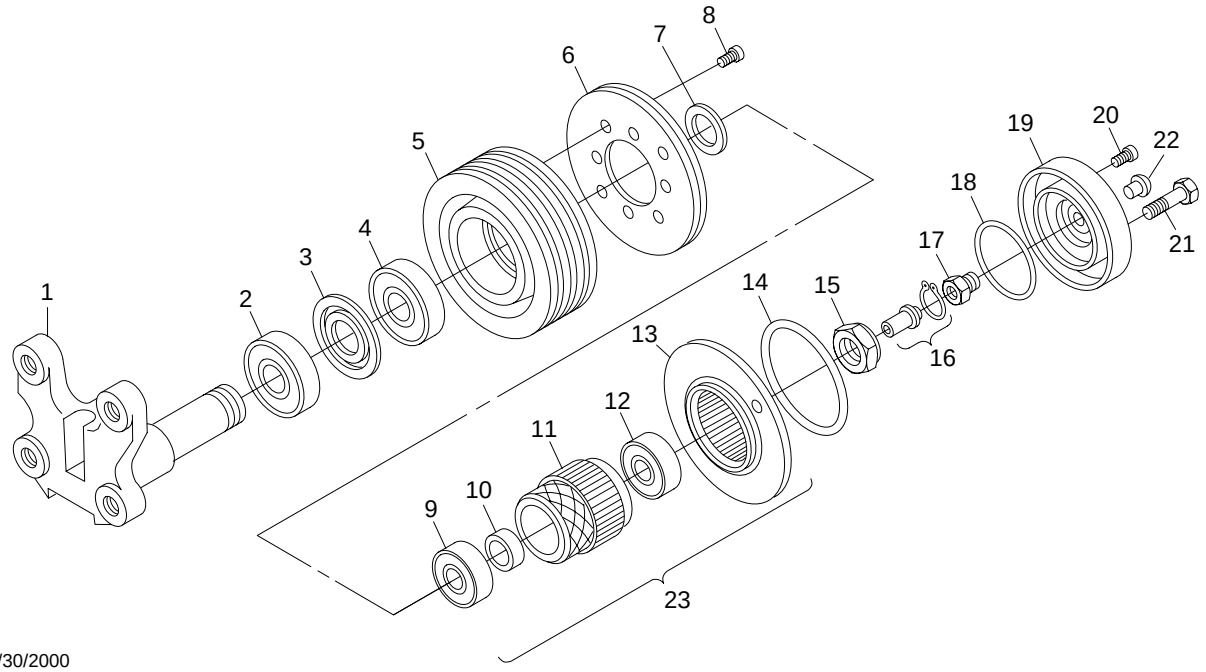
**Never fill more than one-third of the bearing void with grease. Too much grease can cause overheating and possible bearing damage.**

5. Install the journal spacer, and the disc and piston assembly. Make sure that the lip on the journal spacer is facing up. See **Fig. 11**.
6. Install the adjusting nut. Tighten 150 lbf·ft (203 N·m).
7. Remove any dust and debris from the air chamber.
8. Coat the new O-rings with an approved lubricant and install them. See **Fig. 12**.
9. Install the new face seal in the air chamber. Tighten 50 lbf·in (565 N·cm).

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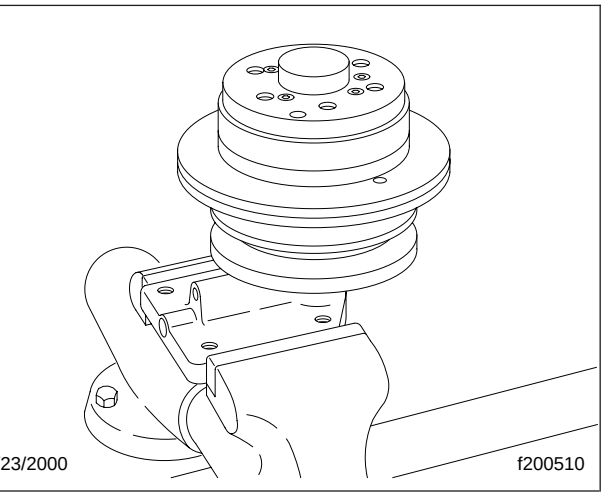
## Fan Clutch Major Rebuild, Horton Advantage




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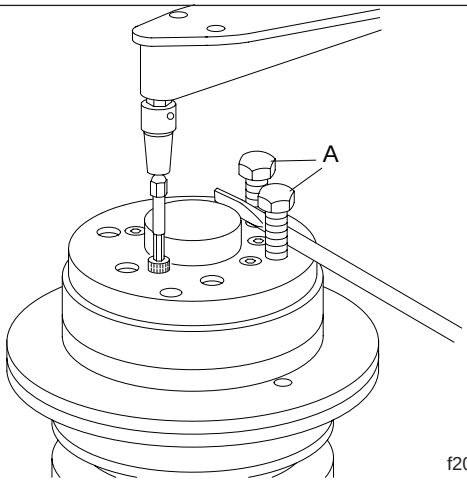
1. Mounting Bracket Assembly
2. Rear Sheave Bearing
3. Inner and Outer Bearing Spacers
4. Forward Sheave Bearing
5. Sheave
6. Friction Facing
7. Journal Spacer
8. Socket-Head Capscrew
9. Rear Hub Bearing
10. Bearing Spacer
11. Splined Hub
12. Forward Hub Bearing
13. Piston Friction Disc
14. Large O-Ring
15. Locknut
16. Air Cartridge Assembly
17. Face Seal
18. Small O-Ring
19. Air Chamber
20. Socket-Head Capscrew
21. Hexbolt (some vehicles equipped with studs)
22. Rubber Umbrella Valve
23. Disc and Piston Assembly

**Fig. 1, Horton Advantage Fan Clutch**



03/23/2000 f200510

**Fig. 2, Fan Clutch Placed in a Vise**




03/27/2000 f200511

A. Installed Hexbolts

**Fig. 3, Remove the Socket-Head Capscrews**

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## Fan Clutch Major Rebuild, Horton Advantage

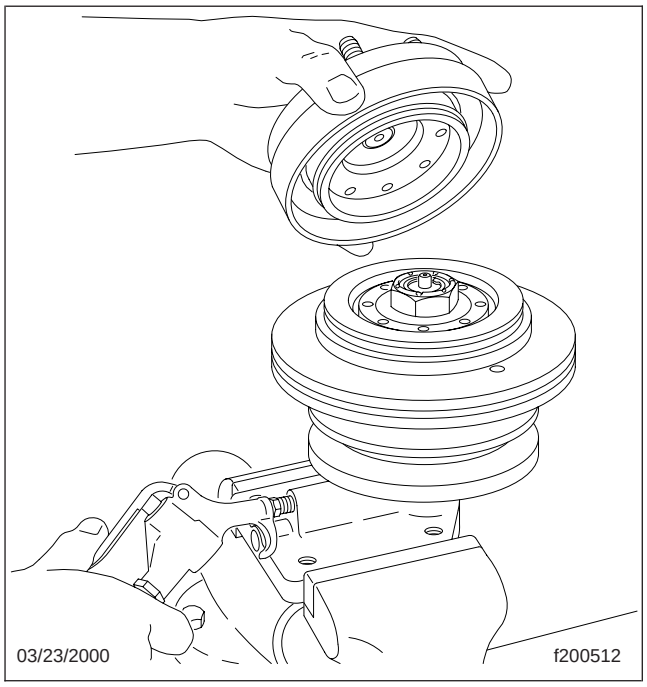



**Fig. 4, Remove the Air Chamber**

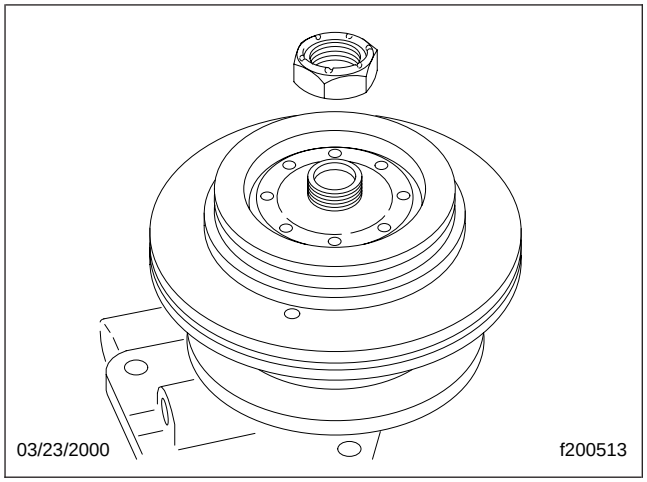



**Fig. 5, Remove the Adjusting Nut**

10. Install the new rubber umbrella valve in the air chamber.
11. Install the new System Sentry fuse in the piston friction disc. *Note that it is a left-hand thread.*
12. Slide the air chamber assembly onto the clutch. If applicable, install two of the hexbolts that hold the fan in place.

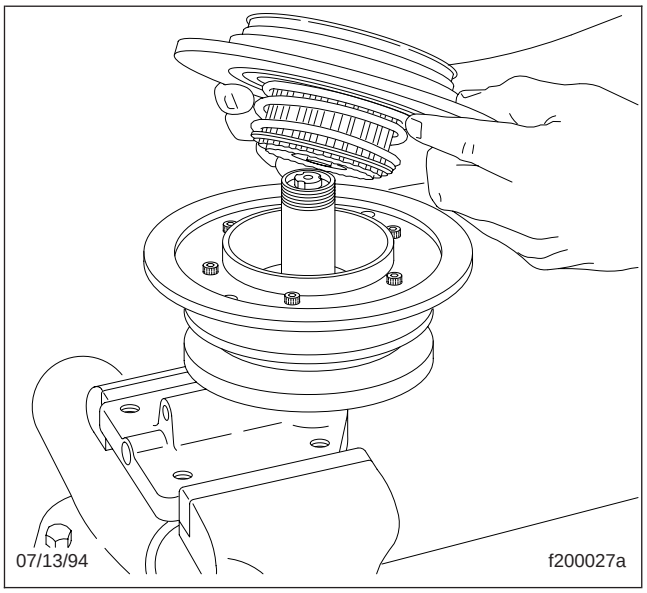



**Fig. 6, Remove the Disc and Piston**

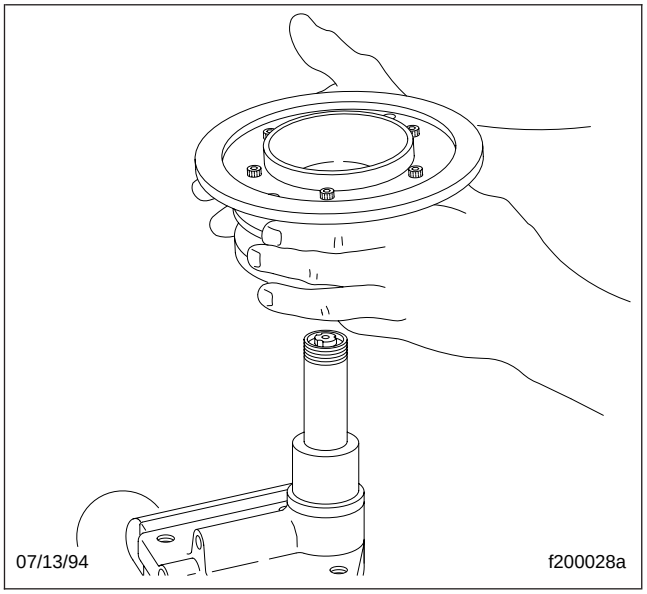



**Fig. 7, Slide Off the Sheave and Bearings**

13. Using a screwdriver to keep the air chamber from rotating, install the socket-head capscrews. Following a star pattern, tighten 15 lbf·ft (20 N·m).
14. If applicable, remove the two hexbolts previously installed.

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## Fan Clutch Major Rebuild, Horton Advantage

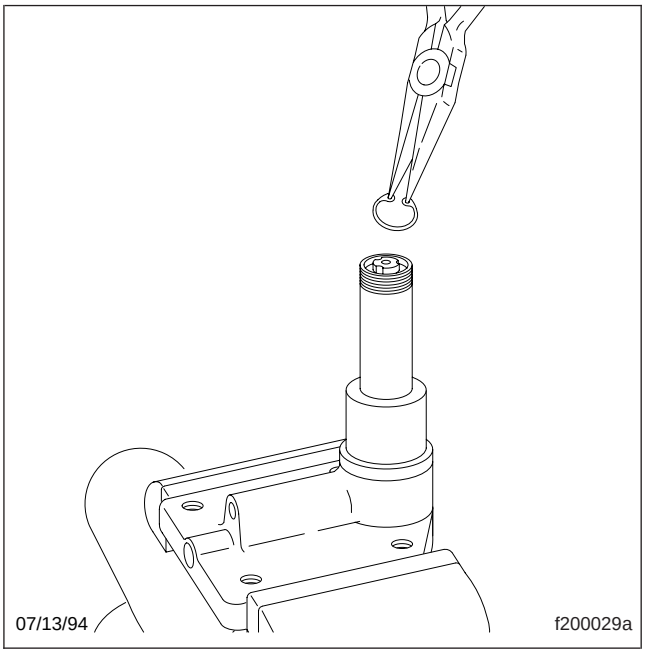



**Fig. 8, Remove the Retaining Ring**

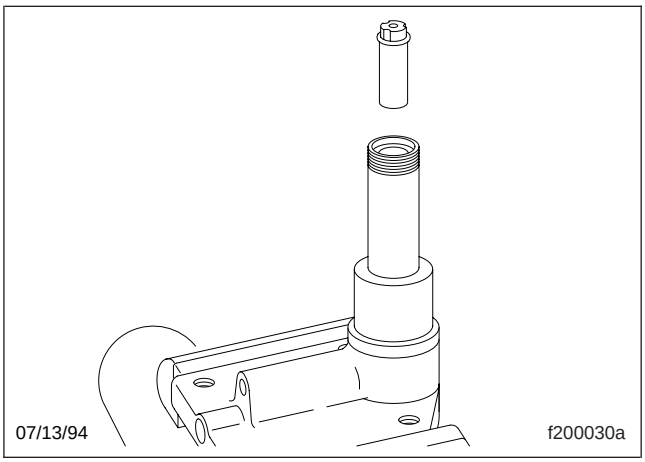
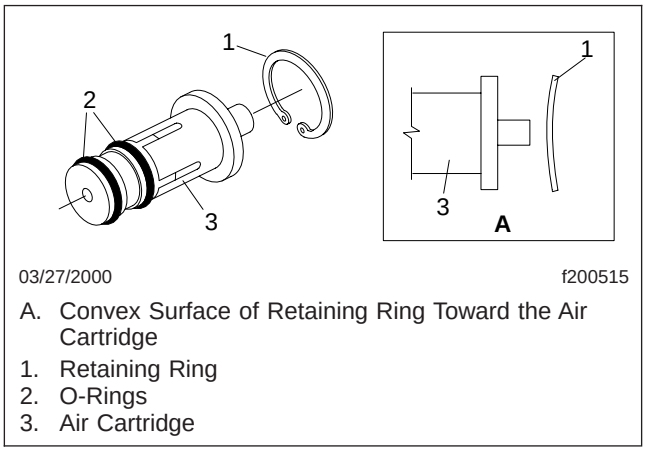



**Fig. 9, Remove the Air Cartridge Assembly**

15. Install the fan and clutch assembly on the engine.




A. Convex Surface of Retaining Ring Toward the Air Cartridge
1. Retaining Ring
2. O-Rings
3. Air Cartridge

**Fig. 10, Air Cartridge Assembly**

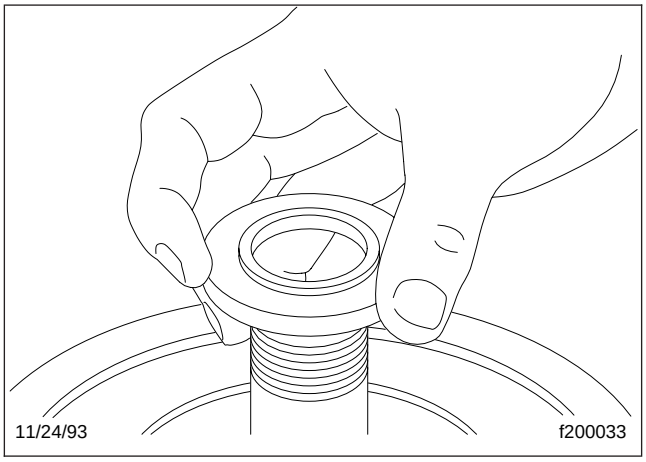



**Fig. 11, Check the Journal Lip**

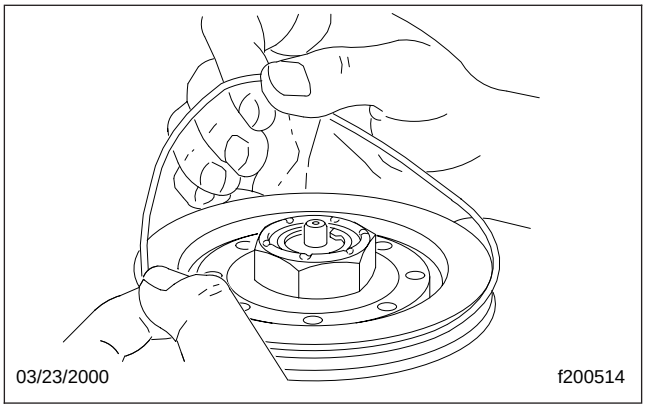



**Fig. 12, Install New O-Rings**

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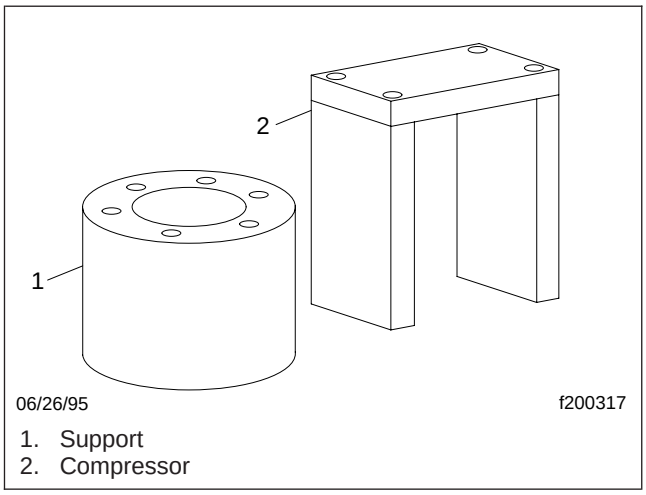
# Fan Clutch Minor Rebuild, Kysor K22RA

## Special Tools

IMPORTANT: Special tools are recommended, but not required for this procedure. See **Table 1** for the special tool set.

| Special Tools | | |
|---|---|---|
| **Description** | **Part Number** | **Order From** |
| Support and Compressor (see **Fig. 1**) | 1090-00000-02 | Wright Brothers Enterprises<br>8171 Hibma<br>Marion, MI 49665<br>Telephone: 231-825-2939 |

**Table 1, Special Tools**




1. Support
2. Compressor

**Fig. 1, Special Tools**

## Rebuild

1. Park the vehicle, apply the parking brakes, and chock the tires.
2. Remove the fan clutch from the vehicle.

**CAUTION**

**When caging and compressing the engagement spring of the fan clutch, depress the clutch shaft only enough to relieve the pressure on the retaining plates (about 1/16-inch, or 1.5 mm). Applying additional force after the clutch shaft bottoms in the housing will damage the housing and render it unserviceable.**

NOTE: There are two methods of caging the engagement spring. One uses the special tools and a press. The other uses carriage bolts, washers, and wingnuts. Either method is effective.

3. Cage the engagement spring.

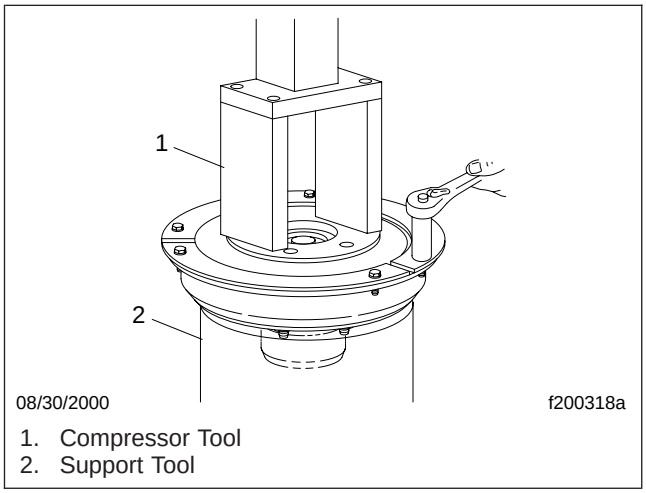
   If using the special support and compressor tools, place the fan clutch in a press to cage the engagement spring. See **Fig. 2**.

   If using the optional method of caging the engagement spring, do the following:

   3.1 With the access holes in the housing assembly aligned with those in the shaft assembly, install two 3-1/2-inch (89-mm) long carriage bolts and suitable washers on opposite sides of the clutch assembly.

   3.2 On the shaft assembly side, install about a 1/2-inch (13-mm) thickness of washers onto each carriage bolt.

   3.3 Install a wingnut on the end of each carriage bolt and tighten the wingnuts evenly until the engagement spring is caged.




1. Compressor Tool
2. Support Tool

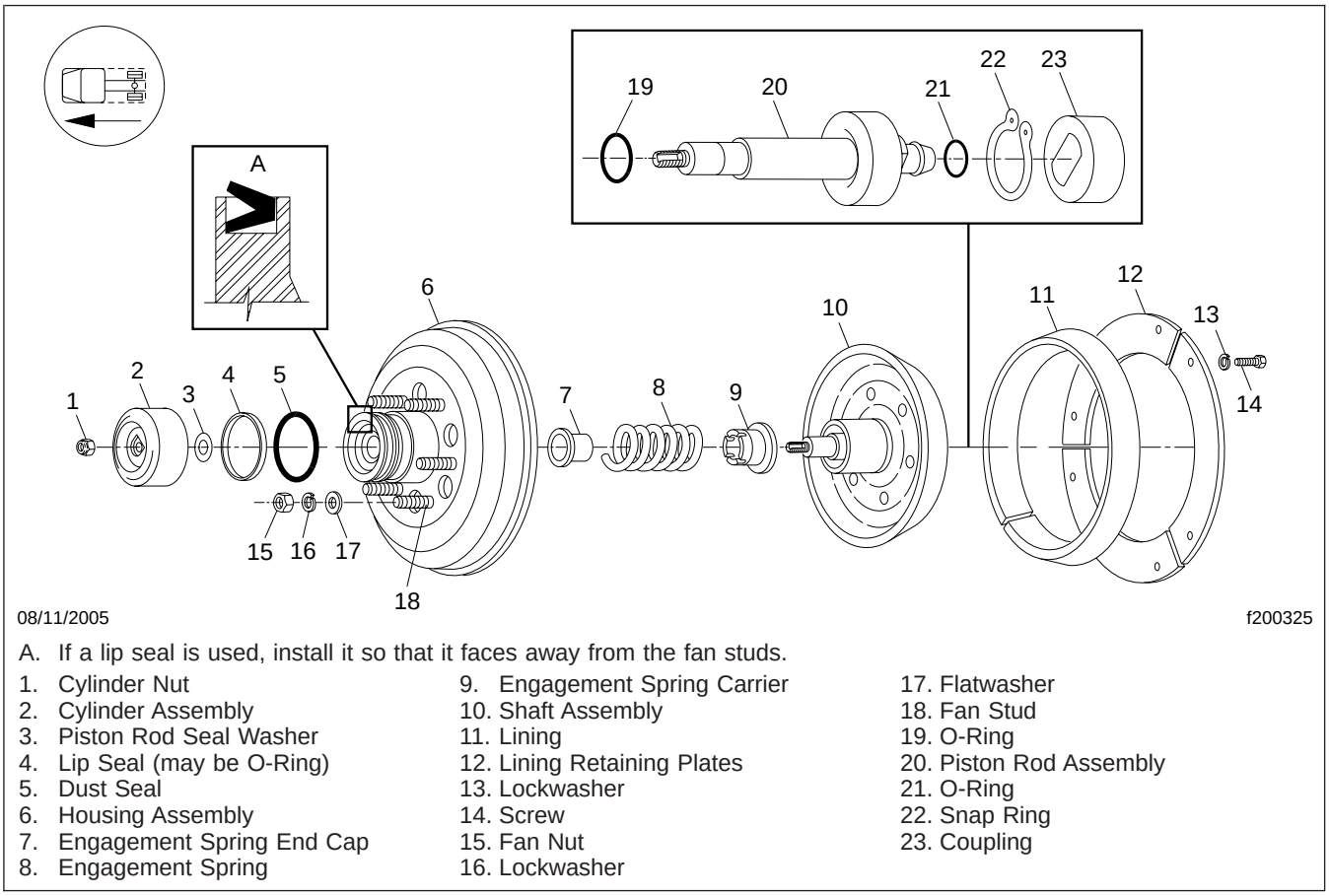
**Fig. 2, Caging the Engagement Spring and Removing the Lining Retaining Plates**

4. Remove the lining retaining plates and the lining. See **Fig. 2** and **Fig. 3**.

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## Fan Clutch Minor Rebuild, Kysor K22RA




A. If a lip seal is used, install it so that it faces away from the fan studs.

1. Cylinder Nut
2. Cylinder Assembly
3. Piston Rod Seal Washer
4. Lip Seal (may be O-Ring)
5. Dust Seal
6. Housing Assembly
7. Engagement Spring End Cap
8. Engagement Spring
9. Engagement Spring Carrier
10. Shaft Assembly
11. Lining
12. Lining Retaining Plates
13. Lockwasher
14. Screw
15. Fan Nut
16. Lockwasher
17. Flatwasher
18. Fan Stud
19. O-Ring
20. Piston Rod Assembly
21. O-Ring
22. Snap Ring
23. Coupling

**Fig. 3, Kysor K22RA Fan Clutch (exploded view)**

### ⚠ CAUTION

**Do not press on the cylinder during this step, or the cylinder will be damaged. Use a 5/8-inch wrench as shown in Fig. 4 on the piston rod flats.**

5. If applicable, turn the clutch over in the press, and use the special compressor tool to cage the engagement spring while removing the cylinder nut and cylinder. See **Fig. 4**.
6. Inspect the fan clutch. See **Fig. 3**
   - 6.1 Inspect the two surfaces where the lining rides.
   - 6.2 Inspect the needle bearing race on the shaft.
   - 6.3 Inspect the needle bearings inside the clutch housing.

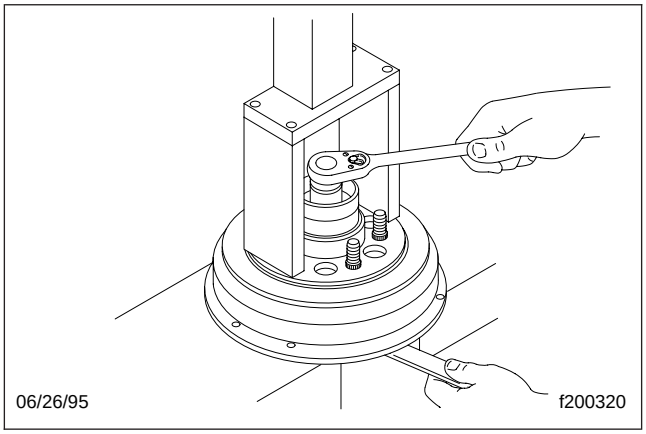



**Fig. 4, Removing the Cylinder Nut and Cylinder**

- 6.4 Inspect the piston bearing by rotating the piston.

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## Fan Clutch Minor Rebuild, Kysor K22RA

7. If you find cracking or scoring on any surface, or if the bearings are rough, loose, or missing, replace the fan clutch.

NOTE: If you find metal particles in the existing grease, replace the fan clutch or contact Kysor for the training needed to perform a major fan clutch rebuild. Kysor will not provide parts for a major rebuild until the technician has completed rebuild training provided by Kysor.

IMPORTANT: Do not wash the clutch parts in solvent.

8. Using **Fig. 3** as a reference, lubricate the following rebuild parts with lubricant supplied with the rebuild kit (if the lubricant is unavailable, use one of the approved lubricants listed in **Specifications, 400)** :
    - The piston seal (pack the seal groove also)
    - The dust seal (pack the seal groove also)
    - The needle bearings inside the housing
    - The inside of the engagement spring
    - The outside of the piston rod assembly
    - The inside of the piston rod assembly
    - The inside of the cylinder assembly
    - Pack the lip of the grease seal

**⚠ CAUTION**

**When caging the engagement spring, make sure the bottom edges of the housing assembly and the shaft assembly are flush and aligned all the way around. Failure to do so will cause the engagement spring pressure to affect the torque of the cylinder nut. This could result in the cylinder nut not being tight enough to effectively compress the piston seal washer, which could cause leakage and eventual fan clutch failure.**

IMPORTANT: When caging the engagement spring, compress the clutch shaft only 1/16-inch (1.5 mm).

9. Assemble the fan clutch parts according to **Fig. 3**. Using either the special tools and a press, or carriage bolts, washers, and wingnuts, cage the engagement spring when installing the cylinder and lining. Be careful to depress the clutch shaft only 1/16-inch (1.5 mm).

   The piston rod seal washer is the last item to install before the cylinder goes on. See **Fig. 5**.

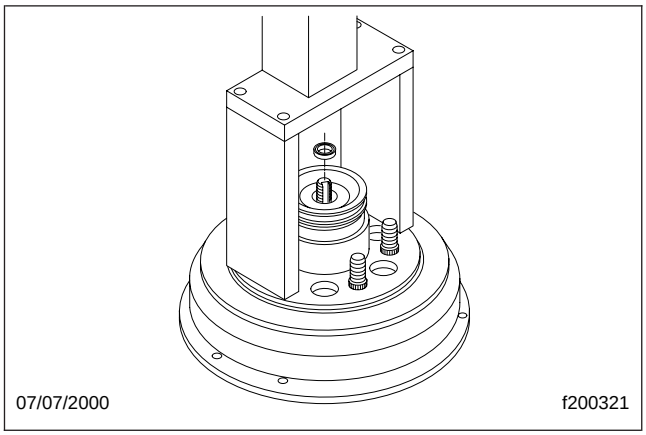



**Fig. 5, Installing the Piston Rod Seal Washer**

10. Tighten the cylinder nut 84 lbf·in (940 N·cm).
11. Tighten the lining screws 30 lbf·in (340 N·cm).
12. As applicable, remove the fan clutch from the press or remove the carriage bolts, washers, and wing nuts.
13. Install the fan clutch on the engine.
14. Close the hood and remove the chocks from the tires.

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## Relining

IMPORTANT: Premature wearing of the fan clutch lining is due to either insufficient air pressure necessary to fully disengage the clutch (allowing the clutch to remain partially engaged, thus increasing wear), or a problem in the control circuit for the fan. Before putting the fan clutch back in service, check the fan control and air supply systems and make any necessary repairs.

1. Park the vehicle on a level surface, apply the parking brake, and shut down the engine. Chock the tires.

**⚠ WARNING**

**If the fan clutch engages during the next step, it could cause personal injury. Keep the fan clutch disengaged throughout this procedure by maintaining between 90 and 120 psi (620 and 827 kPa) of air pressure.**

2. Bleed all the air from the primary and secondary tanks.
3. Disconnect the air line from the fan drive, and apply 90 to 110 psi (620 to 760 kPa) shop air pressure to the fan drive.
4. Remove the six lining plate screws, and remove the three lining plates. See **Fig. 1**.
5. Remove the old lining. If the lining sticks, use a hammer and a screwdriver to free it by tapping on the dividing cut in the lining.
6. Inspect the clutch shaft. If lining residue is present, or if the surface appears glazed over (non-metallic), temporarily release the air pressure from the clutch to allow shaft to protrude, and use a ScotchBrite to break the glaze.

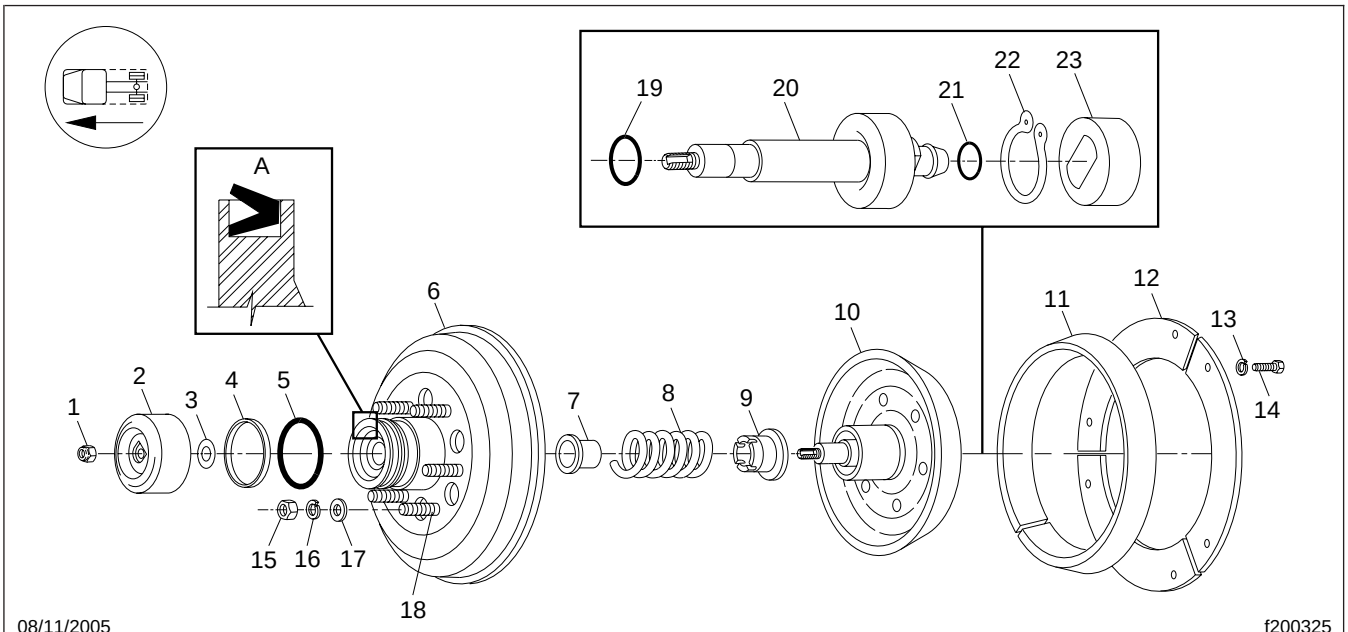
NOTE: Some applications may be too tight to spread the lining and slip it over the pulley. If necessary, the lining can be cut in half with a hacksaw for installation.

7. Apply air pressure to the clutch again, and install the new lining. See **Fig. 2**.
8. Install the new lining plates. Tighten the screws 30 lbf·in (340 N·cm).
9. Remove the air pressure from the fan clutch, and allow the fan to engage.
10. Disconnect the shop air, and connect the air line to the fan drive.

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## Fan Clutch Relining, Kysor K22RA




A. If a lip seal is used, install it so that it faces away from the fan studs.

1. Cylinder Nut
2. Cylinder Assembly
3. Piston Rod Seal Washer
4. Lip Seal (may be O-Ring)
5. Dust Seal
6. Housing Assembly
7. Engagement Spring End Cap
8. Engagement Spring
9. Engagement Spring Carrier
10. Shaft Assembly
11. Lining
12. Lining Retaining Plates
13. Lockwasher
14. Screw
15. Fan Nut
16. Lockwasher
17. Flatwasher
18. Fan Stud
19. O-Ring
20. Piston Rod Assembly
21. O-Ring
22. Snap Ring
23. Coupling

**Fig. 1, Kysor K22RA Fan Clutch (exploded view)**

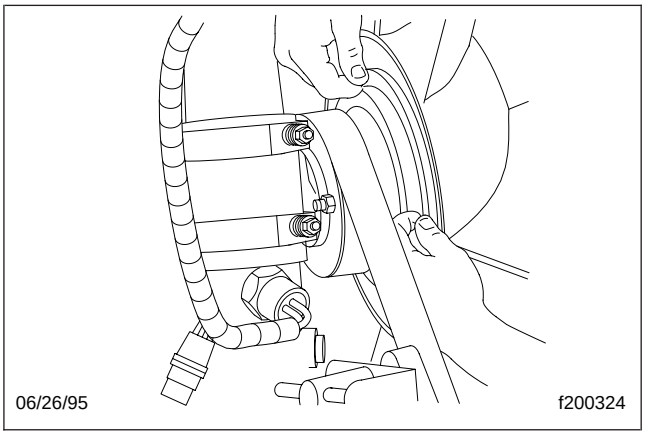



**Fig. 2, Removing the Lining Plates**

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## Fan Clutch Minor Rebuild, Horton Advantage

# Disassembly

NOTE: This procedure involves replacing only the air cartridge, System Sentry® fuse, the face seal, and the O-rings, using parts from the manufacturer's Seal Kit. If doing a major rebuild, go to **Subject 100**.

1. Clamp the fan clutch in a vise. See **Fig. 1**.

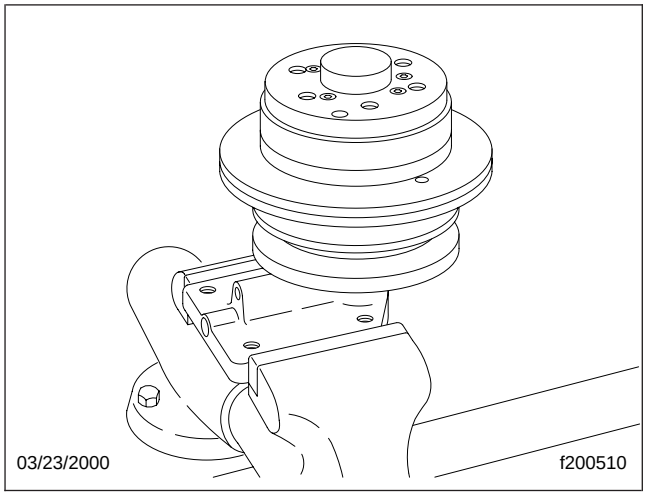



**Fig. 1, Fan Clutch Placed in a Vise**

2. On some vehicles, the fan clutch has threaded studs on the air chamber and the fan is attached with nuts. On other vehicles, the fan is attached with hexbolts.

   If hexbolts were used to attach the fan, install two of the removed hexbolts in the air chamber so a screwdriver can be used to keep the air chamber from rotating. See **Fig. 2**.

   Remove the socket-head capscrews from the air chamber.

3. If applicable, remove the two hexbolts previously installed.

**⚠ WARNING**

**Apply air pressure slowly to the fan clutch. A sudden blast of air might blow the air chamber off the clutch, resulting in possible injury.**

4. Connect a shop air hose to the cylinder inlet. See **Fig. 3**. Slowly apply air pressure, and remove the air chamber assembly.

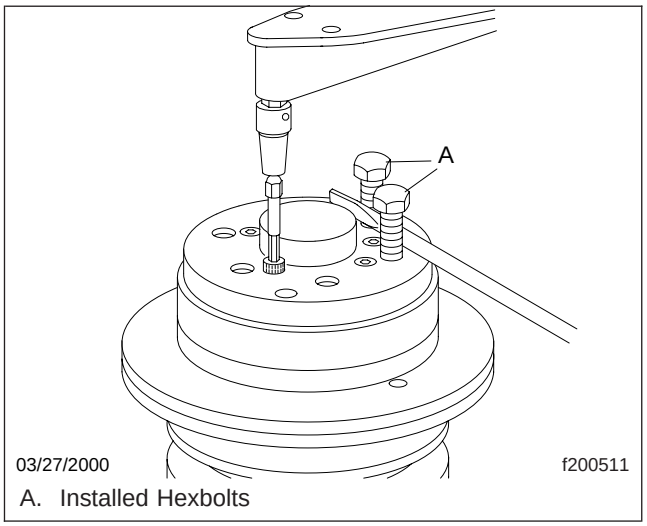



**Fig. 2, Remove the Socket-Head Capscrews**

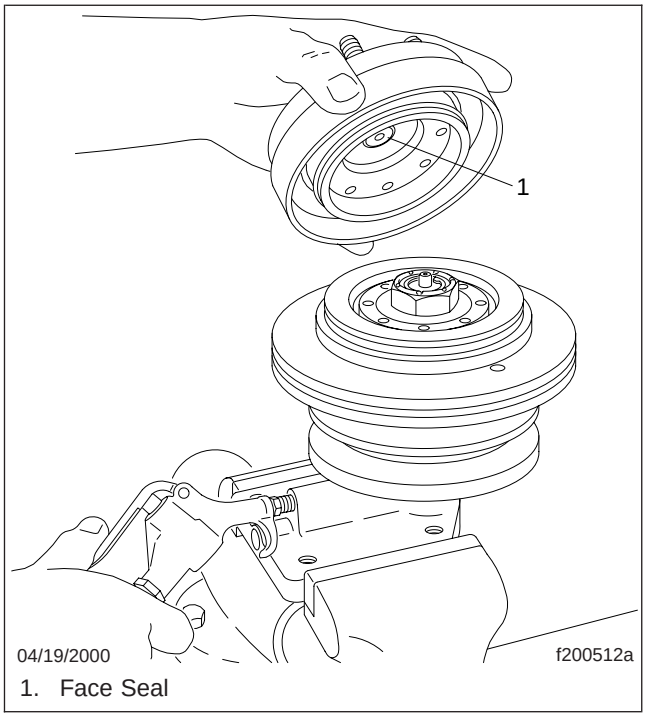



**Fig. 3, Remove the Air Chamber**

5. Remove and discard the O-rings from the air chamber and the piston friction disc. Clean the O-ring contact surfaces.

6. Remove the face seal from the air chamber. See **Fig. 3**.

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## Fan Clutch Minor Rebuild, Horton Advantage

7. Remove the System Sentry fuse from the piston friction disc. *Note that it is a left-hand thread.*
8. Remove the rubber umbrella valve from the air chamber.
9. Remove the adjusting nut. See **Fig. 4**.

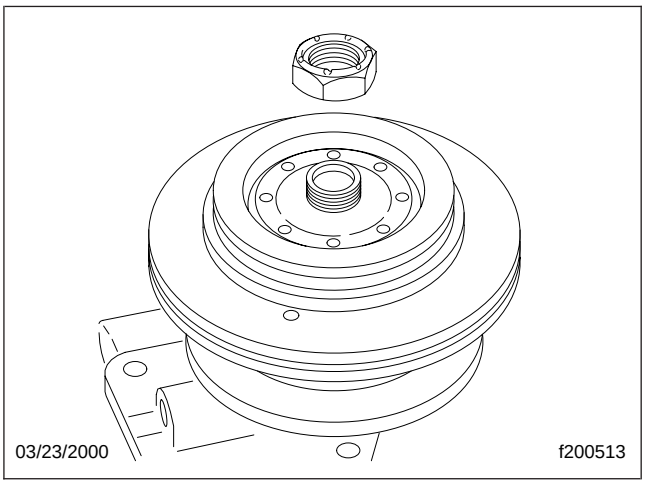



**Fig. 4, Remove the Adjusting Nut**

10. Remove the retaining ring from the air cartridge assembly. See **Fig. 5**.

    Remove the cartridge assembly from the mounting bracket assembly. See **Fig. 6**.

## Assembly

1. Install a new air cartridge assembly in the mounting bracket assembly. Note that the retaining ring is curved. Make sure the ring is installed with the convex surface toward the air cartridge. See **Fig. 7**.
2. Install the adjusting nut. Tighten 150 lbf·ft (203 N·m).
3. Remove any dust and debris from the air chamber.
4. Coat the new O-rings with an approved lubricant and install them. See **Fig. 8**.
5. Install the new face seal in the air chamber. Tighten 50 lbf·in (565 N·cm).
6. Install the new rubber umbrella valve in the air chamber.

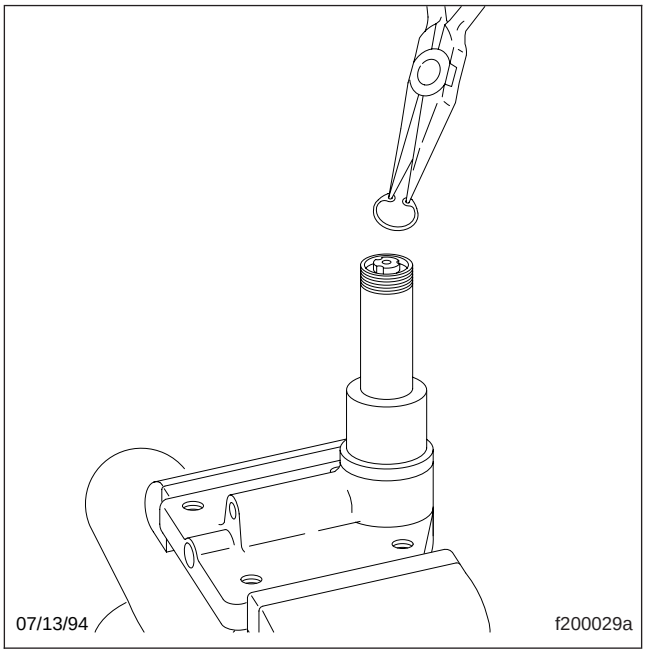



**Fig. 5, Remove the Retaining Ring**

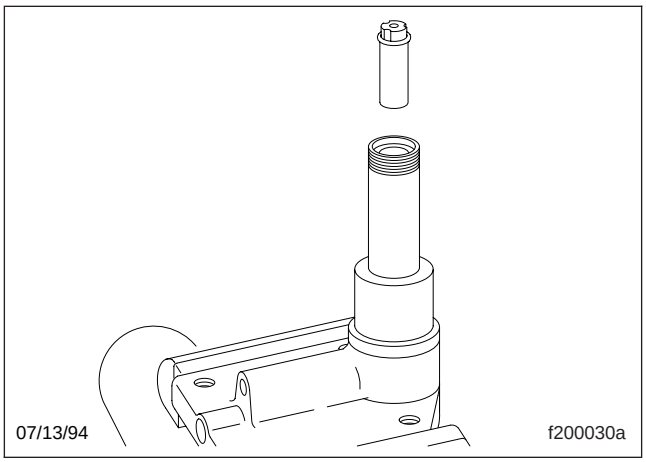
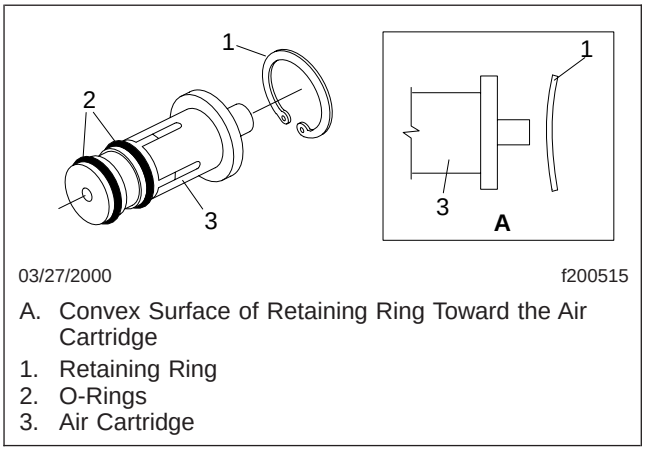



**Fig. 6, Remove the Air Cartridge Assembly**

7. Install the new System Sentry fuse in the piston friction disc. *Note that it is a left-hand thread.*
8. Slide the air chamber assembly onto the clutch. If applicable, install two of the hexbolts that held the fan in place.
9. Using a screwdriver to keep the air chamber from rotating, install the socket-head capscrews. Following a star pattern, tighten 15 lbf·ft (20 N·m).

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A. Convex Surface of Retaining Ring Toward the Air Cartridge
1. Retaining Ring
2. O-Rings
3. Air Cartridge

**Fig. 7, Air Cartridge Assembly**

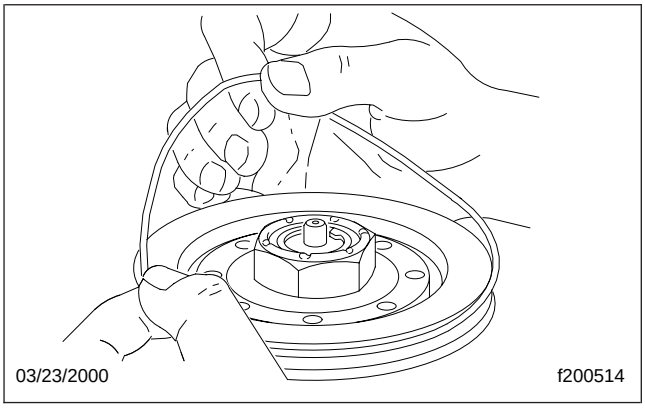



**Fig. 8, Install New O-Rings**

10. If applicable, remove the two hexbolts previously installed.
11. Install the fan and clutch assembly on the engine.

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## Solenoid Valve Testing (12-Volt)

If the solenoid valve has a red lead and a black lead, it indicates the solenoid valve is polarity sensitive and has an internal diode for voltage spike suppression. The red wire is the 12-volt hot wire, and the black wire is the ground. If this solenoid valve is hooked up backwards, damage will occur, and the solenoid valve must be replaced. If the solenoid valve wires are the same color, it can be wired either way.

1. With air to the inlet of the solenoid valve, and with it hooked up to a 12-volt source and ground, disconnect one of the solenoid valve wires. Every time you disconnect the wire, the solenoid valve should operate. If not, the solenoid valve must be replaced.
2. If air exhausts slowly, or not at all, remove the exhaust muffler and test again. If air still exhausts slowly, or not at all, replace the solenoid valve. If air exhausts quickly, clean or replace the exhaust muffler.

## Thermal Switch Testing

The thermal switch setting must be at least 10°F (4°C) higher than the full open temperature of the engine thermostat. If not, replace with the correct switch.

A normally closed switch must be used with a normally closed series electrical system, and a normally open switch must be used with a normally open parallel electrical system. Make sure you have the correct switch for your application.

Place an accurate thermometer in the fill opening of the radiator.

**⚠ WARNING**

**Extreme care must be taken when removing the radiator cap when the engine is hot. Hot coolant may cause severe personal injury due to scalding.**

1. Start the engine and run until the engine temperature reaches the set point of the thermal switch. The fan clutch should engage.

NOTE: The set point of the thermal switch is usually stamped on the side of the switch.

It may be necessary to close the winterfront or place an obstruction in front of the radiator to bring the engine up to temperature.

2. If you cannot get the engine up to temperature, the same test can be performed by removing the switch from the engine, and setting it in a pan of water, along with a thermometer. Heat the water up to the set point temperature of the switch and check the set point by using a self-powered test light between the two terminals. The light will be on until the switch reaches its set point for a normally closed switch, or off for a normally open switch.
3. Observe the temperature on the thermometer once the switch sets. The switch tolerances are ±3°F (2°C), on the set and reset points, and ±7°F (4°C), from the set to reset.
4. If the switch is set all the time, fails to set or does not meet tolerance, replace it.

## Air Conditioning Switch Testing

The A/C switch should be mounted on the high pressure side of the A/C system. Check the switch setting against the manufacturer's recommendations.

1. Start the engine and turn the cab air conditioning to maximum, and the blower fan to high. The engine fan should engage after a short period of time.
2. Hook up and observe the high side pressure gauge to determine what the pressure is when the switch reaches its set point.

   The tolerances for the A/C switch are ±10 psi (68 kPa) on the set and reset points, and ±50 psi (345 kPa) from the set to reset.
3. If the switch is set all the time, fails to set or does not meet tolerance, replace it.

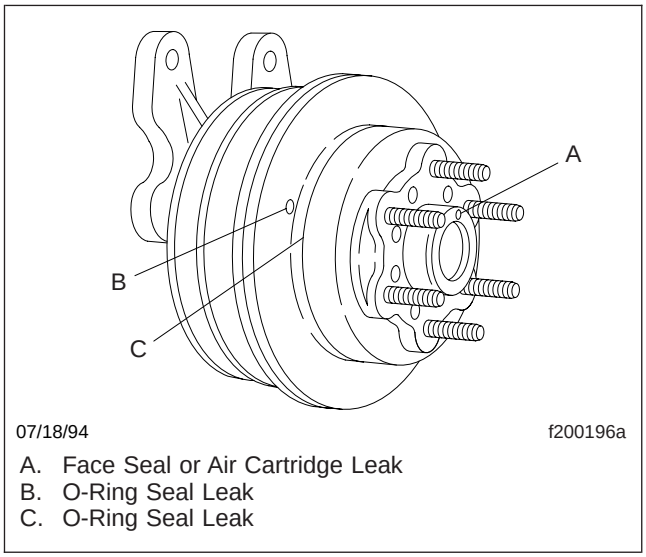
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# Troubleshooting Tables

**Problem—Air Is Leaking from the Fan Clutch**

| Problem—Air Is Leaking from the Fan Clutch | |
|---|---|
| **Possible Cause** | **Remedy** |
| The face seal or air cartridge (**Fig. 1**) has failed, Horton Advantage | Install a new seal kit. |
| The O-ring seals (**Fig. 1**) have failed, Horton Advantage | Install a new seal kit. |




A. Face Seal or Air Cartridge Leak
B. O-Ring Seal Leak
C. O-Ring Seal Leak

**Fig. 1, Possible Fan Clutch Air Leaks, Horton Advantage Fan Clutch**

**Problem—The Fan Clutch Fails to Engage**

| Problem—The Fan Clutch Fails to Engage | |
|---|---|
| **Possible Cause** | **Remedy** |
| There's no power to the fan clutch control circuit. | Check all electrical connections, and repair or replace wiring as needed. Check the circuit breaker for the engine fan and repair or replace as needed. |
| The engine temperature switch is damaged or an incorrect sensor has been installed. | For Horton fan clutches, make sure the switch is normally open, not normally closed. For Kysor fan clutches, make sure the switch is normally closed, not normally open. Replace the switch if it is damaged or if the switch is the wrong type. |
| The solenoid valve is malfunctioning. | Replace the solenoid valve. |
| The fan clutch is leaking. | Install a new seal kit. |
| The air supply to the fan clutch is restricted. | Make sure the fan clutch air lines are not leaking or pinched. Repair the lines as needed. |

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## Troubleshooting

**Problem—The Fan Clutch Does Not Disengage**

| Problem—The Fan Clutch Does Not Disengage | |
|---|---|
| **Possible Cause** | **Remedy** |
| The engine temperature switch is damaged or an incorrect sensor has been installed. | For Horton fan clutches, make sure the switch is normally open, not normally closed. For Kysor fan clutches, make sure the switch is normally closed, not normally open. Replace the switch if it is damaged or if the switch is the wrong type. |
| A restricted air line doesn't allow air to vent from the clutch. | Make sure the air lines are not pinched or plugged. Repair the air lines as needed. |
| The solenoid is not exhausting. | Make sure the solenoid exhaust port is not plugged. |
| The piston friction disc is seized due to contamination or worn splines. | Reline or replace the piston friction disc, and make sure the fan clutch air supply is clean. |

**Problem—The Fan Clutch Cycles Frequently**

| Problem—The Fan Clutch Cycles Frequently | |
|---|---|
| **Possible Cause** | **Remedy** |
| The fan clutch control circuit has a loose connection or is poorly grounded. | Check all wiring connections, and repair the circuit as needed. Check the circuit breaker for the engine fan and repair or replace as needed. |
| The temperature control settings are incorrect. | Check the fan clutch control setting of the temperature switch, according to the engine installed in the vehicle. Repair or replace the temperature switch as needed. |
| The fan cycling switch at the receiver-drier is set too low. | Check the switch at the receiver-drier, and if needed, replace the switch with a switch with a higher setting. Check the ACPU switch and unit. |
| There is an air restriction in front of the fan clutch. | Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions. |
| The engine temperature is too high. | Check the programmable engine control parameters, and reprogram as needed. |
| The temperature switch is malfunctioning. | Replace the temperature switch. |

**Problem—The Fan Clutch Engages, But the Engine Still Overheats**

| Problem—The Fan Clutch Engages, But the Engine Still Overheats | |
|---|---|
| **Possible Cause** | **Remedy** |
| There is an air restriction in front of the fan clutch. | Check for incorrect radiator shutter operation, winterfronts, or any other air restrictions. |

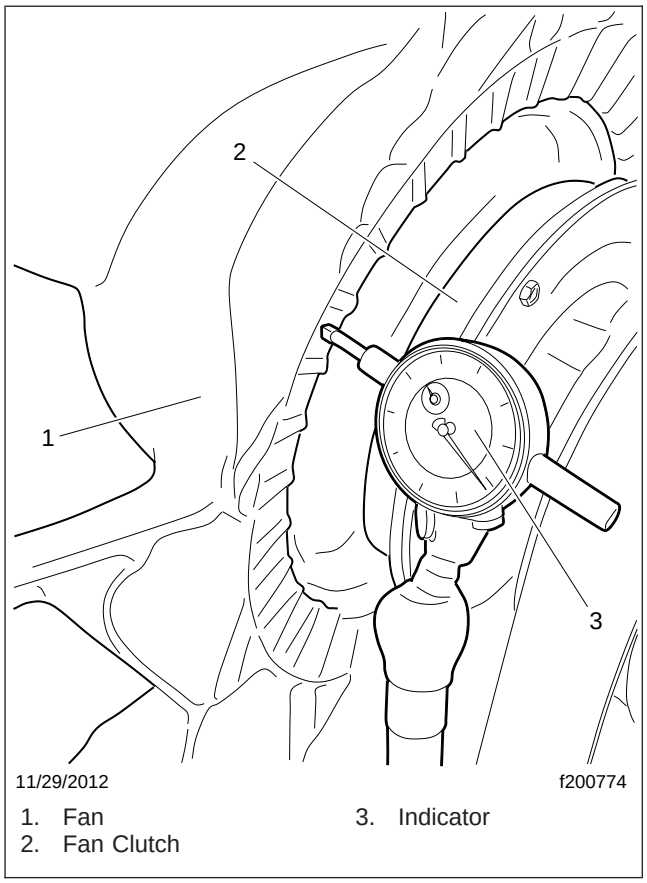
# Fan Clutch Rock Runout Measurement

NOTE: Do not try to measure the fan rock runout at the end of the fan blade. An inaccurate reading will result.

1. Park the vehicle on a level surface, shut down the engine, and set parking brake. Chock the tires.
2. Position the indicator on a flat surface near the outside diameter (OD) of the clutch hub section of the fan as shown in **Fig. 2**.
3. Drain the air from the air system.
4. Disconnect the air line to the fan clutch.

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1. Fan
2. Fan Clutch
3. Indicator

**Fig. 2, Positioning the Indicator**

5. Disengage the clutch. Apply, and maintain, 90 to 120 psi (620 to 830 kPa) shop air to the fan clutch for the test.
6. Grasp the fan at the hub and gently rock the fan fore and aft. See **Fig. 3**.

   The total indicator reading should not exceed 0.050 in (1.27 mm).

   If reading is greater than 0.050 in (1.27 mm), replace the fan clutch. For instructions, see **Subject 100**.
7. Remove the indicator.
8. Connect the air line to the fan clutch.
9. Pressurize the system, and check for leaks. Repair as needed.

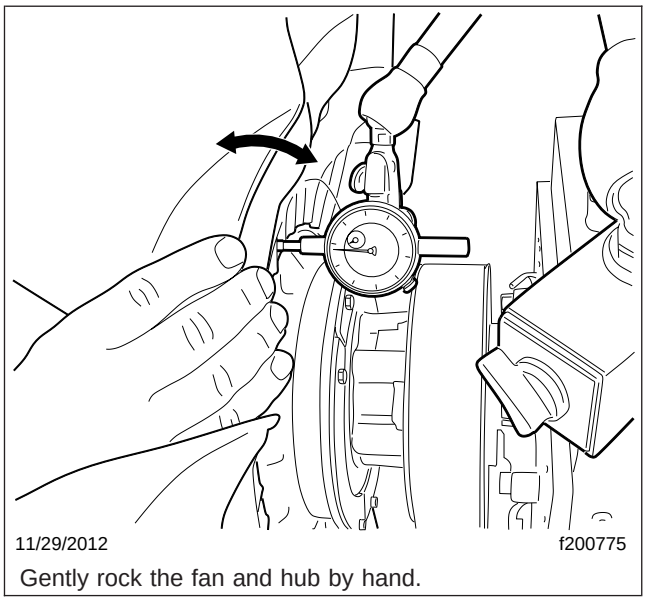



**Fig. 3, Checking the Rock Runout Measurement**

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## Specifications

If the lubricant that comes with the rebuild kit for the Kysor K22RA fan clutch is unavailable, use one of the following approved lubricants:

- Aeroshell 5
- Shell Alvania R3
- Chevron SR12
- Amoco Rykon Premium #2EP
- Texaco RB Premium

| Kysor K22RA Fan Clutch Torques | | |
|---|---|---|
| **Description** | **Torque** | |
| | **lbf·ft (N·m)** | **lbf·in (N·cm)** |
| Clutch-to-Hub Fasteners | 45 (61) | — |
| Fan-to-Clutch Fasteners | 26 (35) | — |
| Front Piston Nut | — | 84 (950) |
| Lining Plate Screws | — | 30 (340) |

**Table 1, Kysor K22RA Fan Clutch Torques**

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## General Information

An engine block heater keeps the engine coolant about 80°F (27°C) warmer than the ambient air temperature. In cold weather, the heater helps engine starting, and improves compression and lubrication at start-up.

The diesel fuel in a running engine normally ignites when the compressing air/fuel mixture within the cylinder reaches about 725°F (385°C), on the compression stroke of each piston. However, during cold weather starts, the heat of the compressed fuel mixture dissipates into the surrounding engine block. Also, the compression rings are designed to work with the oil to seal the combustion chamber, and cold oil does not seal compression as well as warm oil. As a result, the engine may not be able to start from very cold conditions.

With the engine block heater, the engine block is prewarmed, so heat and compression in the cylinder are sufficient to ignite the diesel fuel.

By warming the oil film on the piston walls, the block heater improves start-up lubrication and compression, and reduces piston drag caused by cold oil.

The heater consists of an element that attaches to the engine block, and protrudes into the engine water jacket. See **Fig. 1** for a typical installation. A cord plugs into the outside end of the element, and the cord runs to an external plug, typically below the front bumper, or under the side of the cab. External AC electricity powers the element through the plug.

To turn on the heater, connect the heater cord to a power source. The heater has no thermostat. Heat dissipation through the engine block prevents overheating.

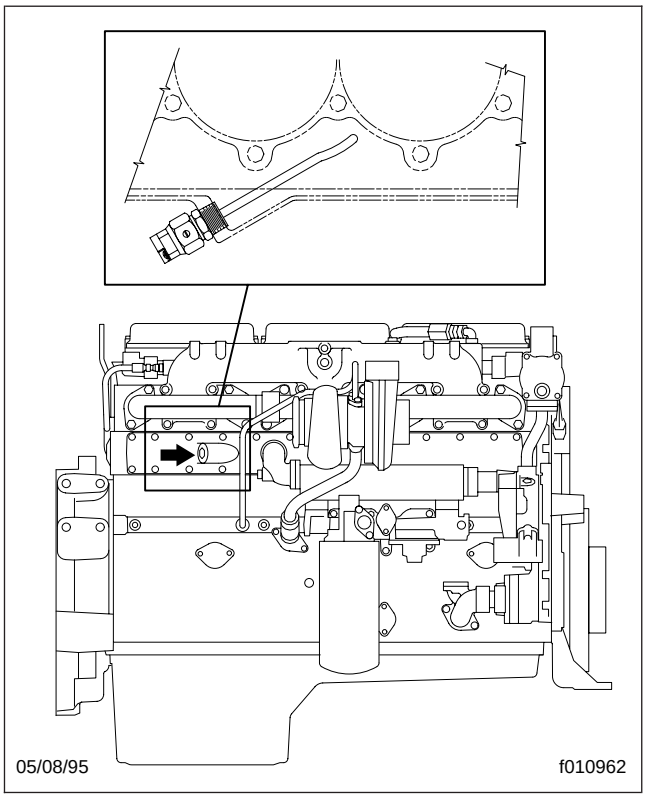



**Fig. 1, Typical Block Heater Installation, Caterpillar 3176 Engine**

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## Block Heater Removal and Installation

# Removal

NOTE: Due to the wide variety of engines fitted over the years, and the different block heaters that might fit a given engine, typical installations are shown. Individual vehicles may vary, but should be similar to the figures.

See the figures illustrating typical block heater installations for your engine, or one similar to it.

- For a Caterpillar 3176 engine, see **Fig. 1**.
- For a Caterpillar 3406 engine, see **Fig. 2**.
- For a Cummins L10 engine, see **Fig. 3**.
- For a Detroit Diesel Series 50 or 60 engine, see **Fig. 4**.
- For a Mercedes-Benz MBE4000 engine, see **Fig. 5**.
- For a Caterpillar C15 engine, see **Fig. 6**.

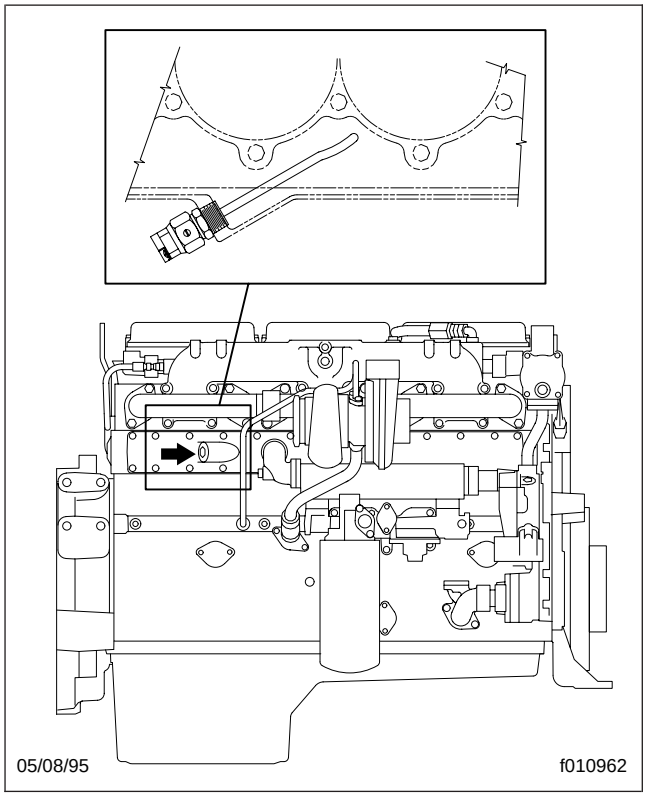



**Fig. 1, Block Heater Installation, Caterpillar 3176**

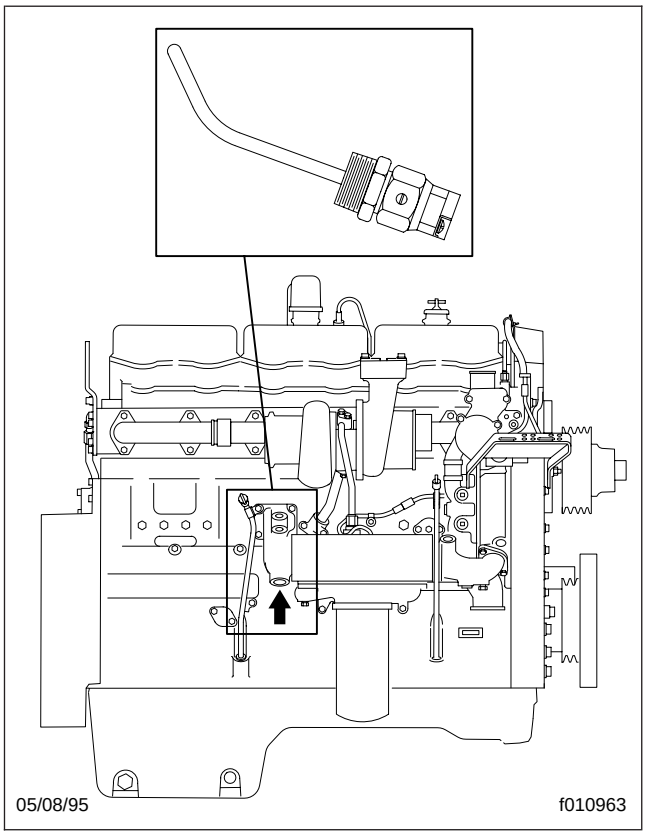



**Fig. 2, Block Heater Installation, Caterpillar 3406**

1. Park the vehicle, set the parking brake, and chock the tires.
2. Tilt the hood.

**WARNING**

**Do not drain coolant from a hot engine. Opening the cooling system when the engine and coolant are hot can cause severe personal injury due to scalding by the hot, pressurized coolant.**

3. Drain the radiator, so that the coolant level is below the level of the block heater.
4. If there is a threaded cover that secures the cord to the block heater, unscrew it.
5. Pull the cord off the block heater.
6. If the block heater is retained by a jam nut, loosen the jam nut. Unscrew the block heater from the engine block.

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## Block Heater Removal and Installation

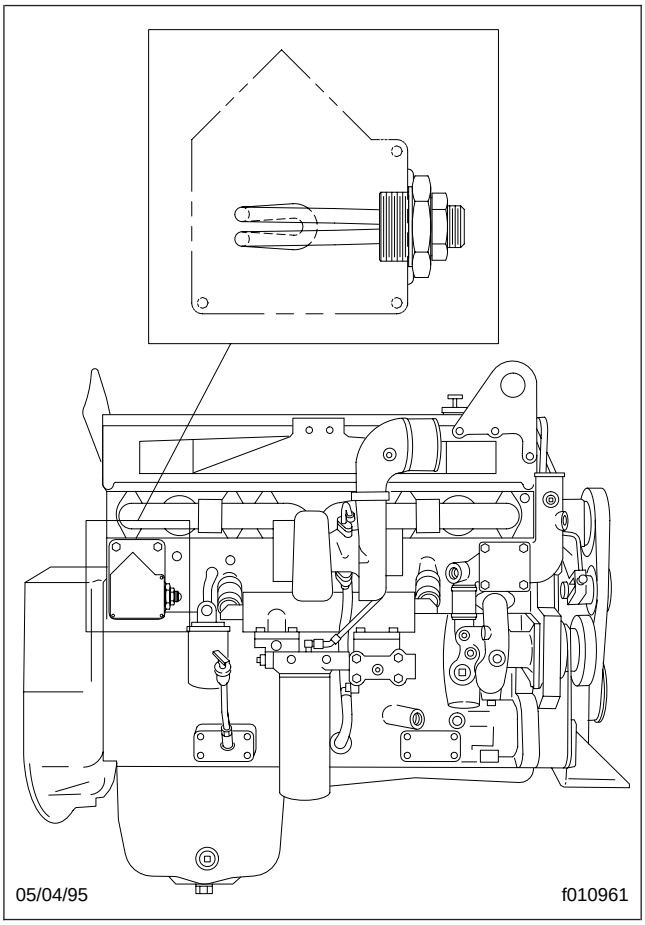



**Fig. 3, Block Heater Installation, Cummins L10**

7. If the block heater is held by capscrews, remove the capscrews, and remove the block heater.

# Installation

1. On block heaters held by jam nuts, coat the threads with a small amount of sealant. Refer to **Specifications, 400** for a list of approved sealants.

   On block heaters held by capscrews, make sure the gasket is in place between the cover plate and the engine, and that the gasket sealing surfaces are clean.

2. On block heaters held by jam nuts, screw the block heater into the engine block hand-tight, then use a wrench to turn the block heater 1-1/2 turns more, except as noted below.

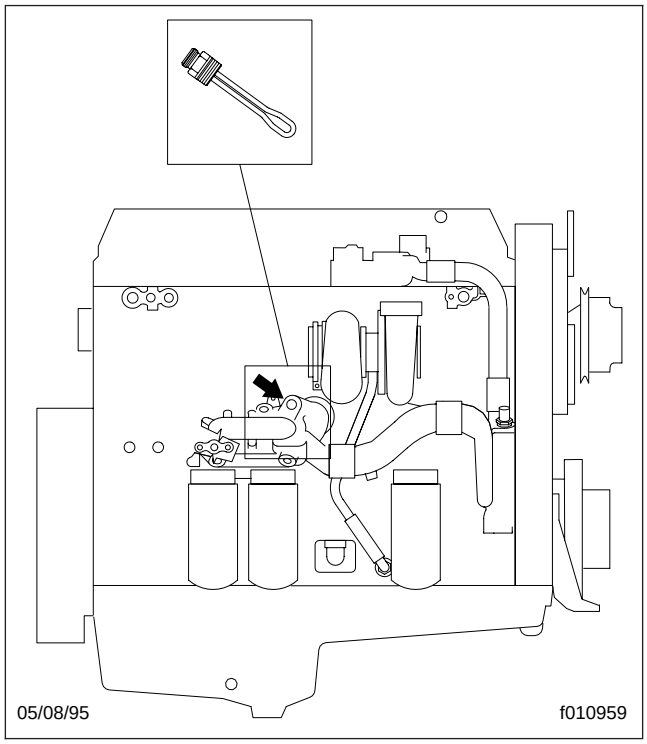



**Fig. 4, Block Heater Installation, Detroit Diesel Series 50 and 60**

   On Caterpillar 3406 and C15 engines, tighten the jam nut 50 to 60 lbf·ft (67 to 81 N·m).

   On Cummins L10 engines, tighten the jam nut 20 to 30 lbf·ft (27 to 40 N·m).

   On block heaters held by capscrews, install the cover plate capscrews, then tighten them 60 to 84 lbf·in (680 to 940 N·cm).

3. Plug the cord into the block heater, and if there is a threaded cord retainer, screw it into place.

4. Fill the cooling system.

5. Start the engine and check for leaks. Repair any leaks.

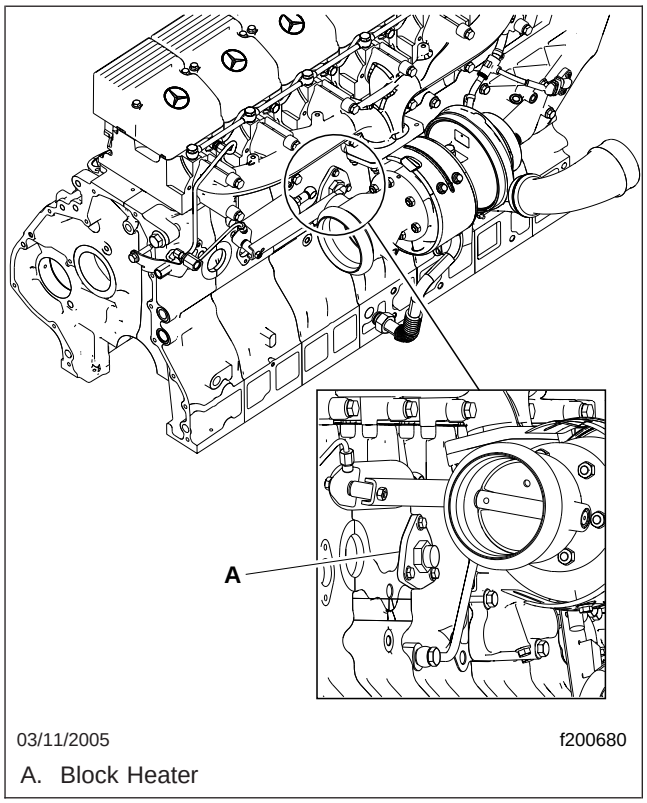
   Run the engine for half an hour, to purge air from the cooling system.

6. Test the heater. Plug a watt meter into a power source, and connect the heater cord to the meter. A reading on the meter indicates that the heater is working.

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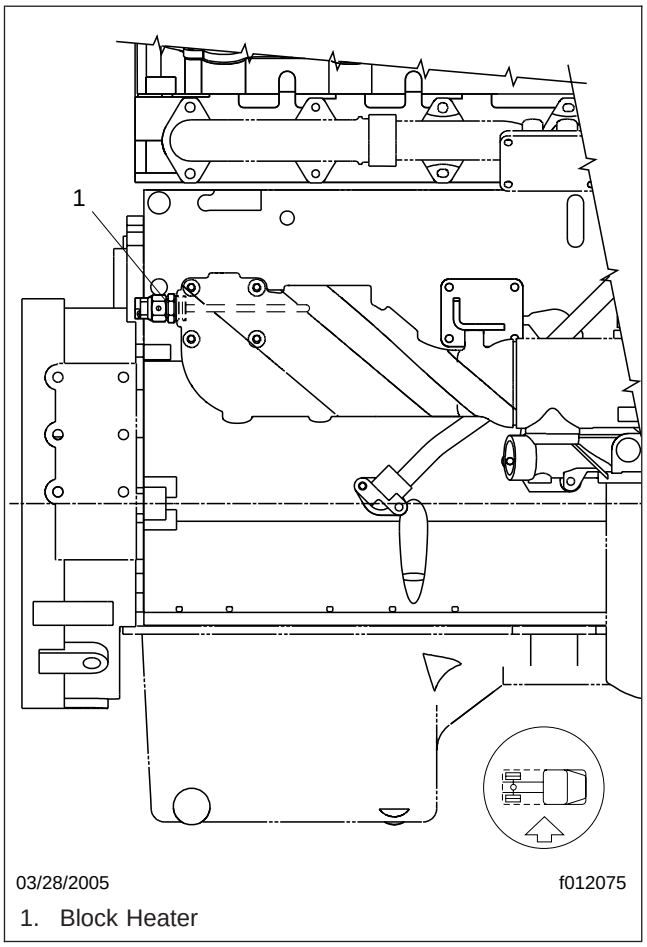


## Block Heater Removal and Installation




A. Block Heater

**Fig. 5, Block Heater Installation, Mercedes MBE 4000**




1. Block Heater

**Fig. 6, Block Heater Installation, Caterpillar C15**

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# Troubleshooting

Use the following procedures to check for the most common engine block heater problems.

## Wiring Problems

1. Park the vehicle, set the parking brake, and chock the tires.
2. Tilt the hood.
3. Unscrew the threaded cover that secures the cord to the element. Pull the cord off the element.
4. Using an ohmmeter, check the continuity between the two poles of the element. The resistance should be very low, typically between 9 and 10 ohms. If there is no reading, the element is burned out. If the reading is very high, the element is about to burn out.
5. If the element is good, plug the cord into it, and secure the cord with the threaded cover.
6. Using an ohmmeter at the receptacle, check the continuity between the two power terminals. The resistance should be low, typically between 9 and 10 ohms. If there is no reading or a very high reading, the cord is damaged. If the cord is damaged, replace it.
7. Check the continuity between each power terminal and the ground terminal. The ohmmeter should read zero. If there is a reading, replace the cord.
8. Check the ohmmeter reading between the ground terminal and a good vehicle ground. The reading should be zero; if it is not, replace the cord.

## Fouled Element

1. Park the vehicle, apply the parking brake, and chock the tires.
2. Tilt the hood.

**⚠ WARNING**

**Do not drain coolant from a hot engine. Opening the cooling system when the engine and coolant are hot can cause severe personal injury due to scalding by the hot, pressurized coolant.**

3. Drain the radiator enough for the coolant level to fall below the block heater.
4. Unscrew the threaded cover that secures the cord to the block heater. Pull the cord off the element.
5. Remove the block heater from the engine. For instructions, refer to **Subject 100**.
   - Inspect the block heater element for residue deposits, discoloration, or damage.
   - Greenish residue indicates that the coolant solution contains too much antifreeze. If the block heater works, clean and install it, and refer to the vehicle maintenance manual for the recommended antifreeze to water ratio.

     Fill the cooling system until coolant is visible in the surge tank sight glass.
   - Gray or black residue indicates anti-leak coolant additives have been added to the system. If the block heater works, clean and install it, and refer to the vehicle maintenance manual for the recommended coolant additives.

     Fill the cooling system until coolant is visible in the surge tank sight glass.
   - Blue or black discoloration on the element indicates the cooling system needs more coolant. If the block heater works, clean and install it, and

     Fill the cooling system until coolant is visible in the surge tank sight glass.
   - Holes in the element indicate the coolant solution contains too little antifreeze. The weak solution is boiling inside the engine block and causing pitting of the element and block. Install the block heater, and refer to the vehicle maintenance manual for the recommended antifreeze to water ratio.

     Fill the cooling system until coolant is visible in the surge tank sight glass.
   - For block heater installation instructions, refer to **Subject 100**.

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## Specifications

| Approved Sealants | |
|---|---|
| **Brand** | **Type** |
| Henkel | 790 Pipegrip |
| Loctite | 567 |
| Perma-Loc | LH-150 |

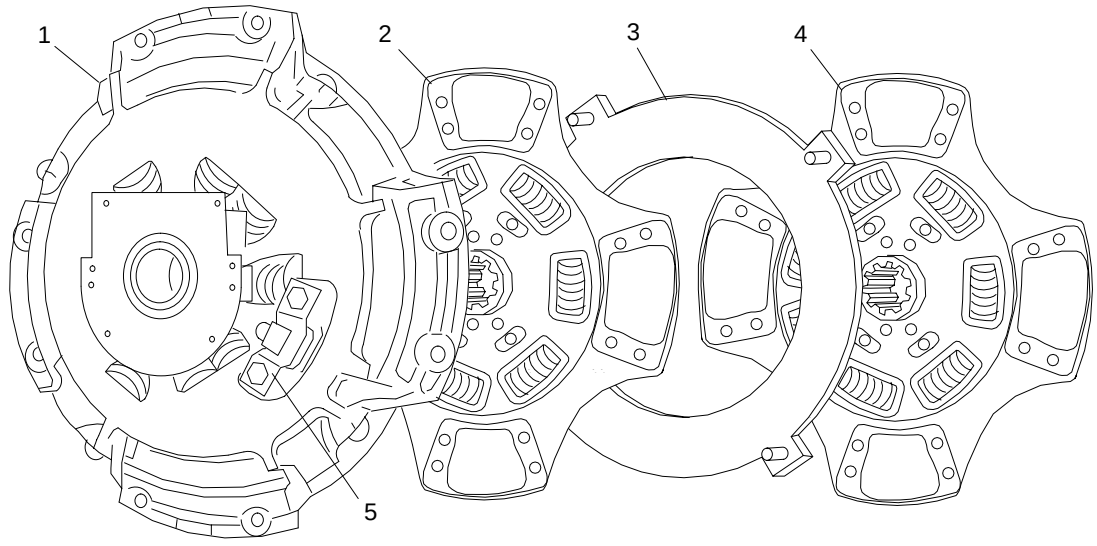
**Table 1, Approved Sealants for Engine Block Heaters**

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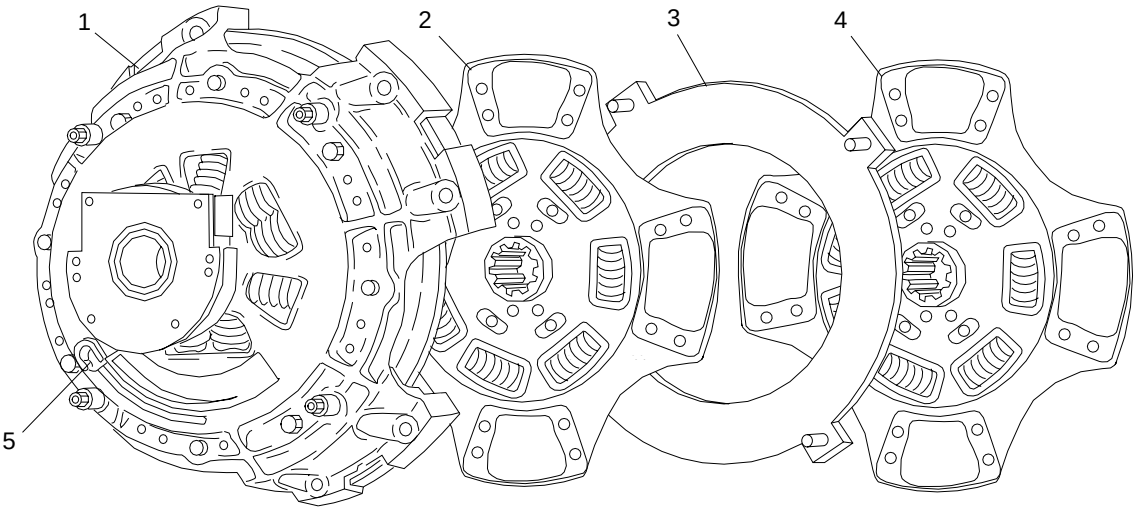


Eaton® Fuller® Easy Pedal™ and Solo™ clutches are pull-type clutches of a dry-disc design. See **Fig. 1** and **Fig. 2**.




1. Clutch Cover
2. Rear Driven Disc
3. Intermediate Plate
4. Front Driven Disc
5. Kwik-Adjust Mechanism

**Fig. 1, Easy Pedal Heavy-Duty Clutch**




1. Clutch Cover
2. Rear Driven Disc
3. Intermediate Plate
4. Front Driven Disc
5. Wear Indicator

**Fig. 2, Solo Heavy Duty Clutch**

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## Easy Pedal

Easy Pedal clutches are available in 15.5-inch dual-disc assemblies. These clutches are adjustable using the Kwik-Adjust™ mechanism. See **Fig. 1**.

Easy Pedal clutch discs are available in a standard configuration of seven spring dampers with four ceramic facings and an optional VCT™plus design that has seven spring dampers with six ceramic facings. See **Fig. 3** and **Fig. 4**.

## Solo

Eaton Fuller Solo clutches are available in 14-inch and 15.5-inch dual-disc assemblies. See **Fig. 2**.

Solo clutches are adjustment-free: as the clutch wears, its wear-adjusting technology monitors clutch components and makes necessary adjustments. The wear-adjusting technology comes from two sliding cams, which rotate to maintain the proper adjustment. Atop the upper cam, a wear indicating tab mirrors the cam movement to let you know when it's time to replace the clutch. See **Fig. 5**. The wear indicating tab cannot be used as a mechanism for adjusting the clutch.

The intermediate plate separating the driven discs is mounted directly to the flywheel. Four separator pins ensure an equal gap on all sides of the intermediate plate and increase the life of the clutch.

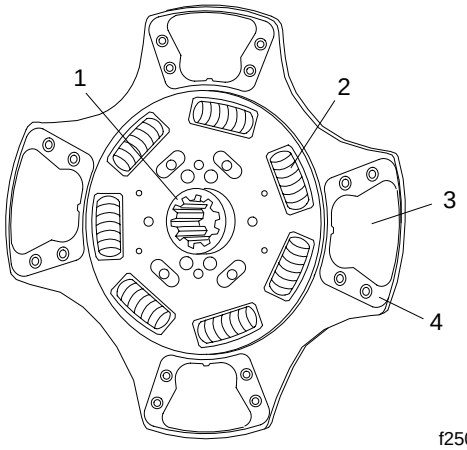



**Fig. 3, Driven Disc With Four Ceramic Facings**

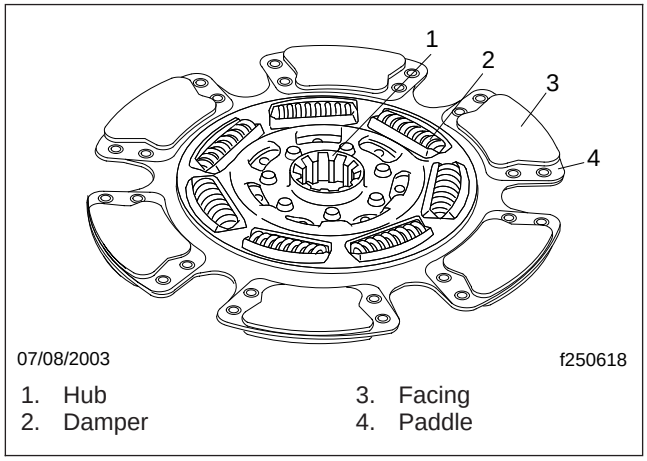



**Fig. 4, Driven Disc With Six Ceramic Facings**

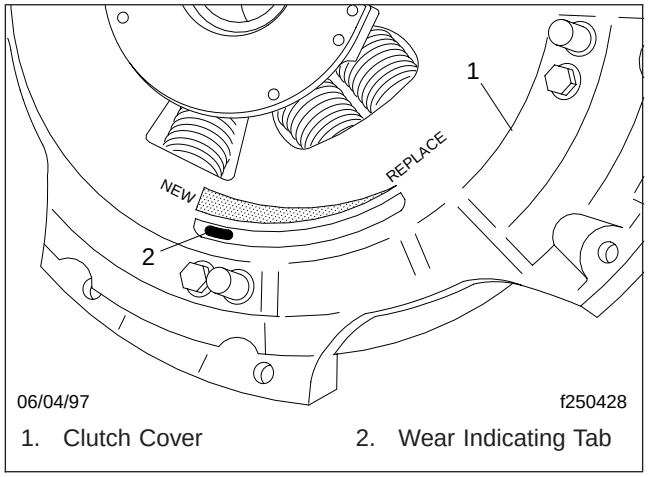



**Fig. 5, Wear Indicator**

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NOTE: The following procedures apply only to Eaton Fuller Easy Pedal clutches. Solo clutches are adjustment-free.

Release yoke free-travel is the distance between the release bearing wear pads and the release yoke. At the factory, the release yoke free-travel is set to 0.105 to 0.145 inch (2.7 to 3.7 mm). This setting produces approximately 1-1/2 inches (38 mm) of clutch free-pedal.

IMPORTANT: When clutch free pedal is less than about 3/4 inch (19 mm), adjust the clutch internally according to the procedures in this subject. Take care to do all procedures in the proper order.

Release bearing travel is the clearance between the aft end of the release bearing housing and the forward surface of the clutch brake disc. For the clutch to release properly, the release bearing travel measurement must be between 1/2 and 9/16 inch (12.7 to 14.3 mm).

As the clutch wears, the release bearing moves towards the engine flywheel, reducing release yoke free-travel and increasing release bearing travel. If internal clutch adjustments are not made, the release yoke fingers will eventually ride against the wear pads. This could cause the following problems:

- Worn bearing wear pads and release yoke
- Damaged release bearing and housing
- Eventual clutch slippage and burn-up

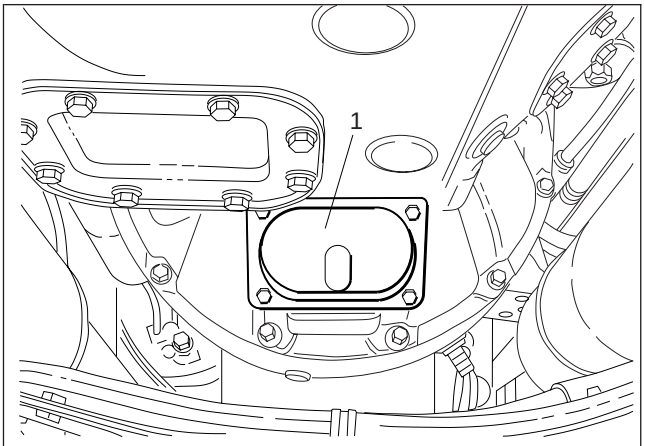
## Release Bearing Travel

### Measurement

**NOTICE**

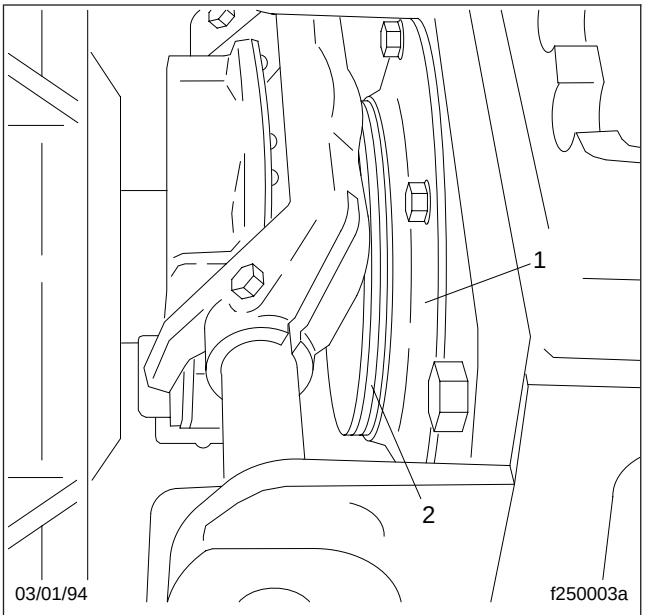
**Make sure the clutch adjustment is correct before making any linkage adjustments. Incorrect adjustments can cause transmission gear clash, slipping, and burning of clutch components.**

1. Apply the parking brakes and chock all the tires.
2. Remove the clutch inspection cover from the bottom of the bell housing. See **Fig. 1**.
3. Slide the clutch brake (either the one-piece torque-limiting clutch brake, or the two-piece disc-type clutch brake with washer) tight against the transmission input-shaft bearing cap. See **Fig. 2**. Also, slide the release bearing as far as possible towards the transmission.




1. Clutch Inspection Cover

**Fig. 1, Clutch Inspection Cover**




1. Transmission Input-Shaft Bearing Cap
2. Clutch Brake

**Fig. 2, Clutch Brake, Positioned for Measurements**

IMPORTANT: Release bearing travel tool A02–12419 is available through the PDCs. One end of the tool has green tape on it and is 0.50 inch

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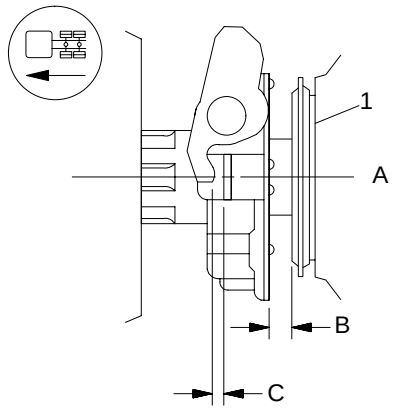


## Easy Pedal Clutch Adjustments

(12.7 mm) in diameter; the other end has blue tape on it and is 0.56 inch (14.3 mm) in diameter.

4. Measure the release bearing travel. See **Fig. 3** for the correct dimension to measure. Using both ends of the release bearing travel tool (**Fig. 4**), check this gap as follows:

   4.1 Position the tool so that the legs straddle the transmission input shaft.

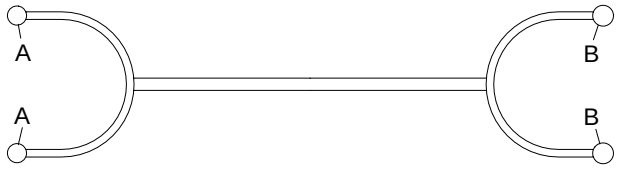



03/01/94 f250172a

A. Check both dimensions: release bearing travel (B) and release yoke free-travel (C).
B. Release bearing travel: 1/2 to 9/16 inch (12.7 to 14.3 mm) between release bearing housing and clutch brake.
C. Release yoke free-travel: approximately 0.105 to 0.145 inch (2.7 to 3.7 mm) between yoke and wear pads.

1. Torque-Limiting Clutch Brake

**Fig. 3, Clutch Dimensions**




03/26/96 f580133

A. 0.50 inch (12.7 mm) B. 0.56 inch (14.3 mm)

**Fig. 4, Release Bearing Travel Tool A02-12419**

   4.2 Insert the blue 0.56-inch (14.3-mm) end. If it fits loosely, the gap is too wide and adjustment is needed. See "Adjustment."

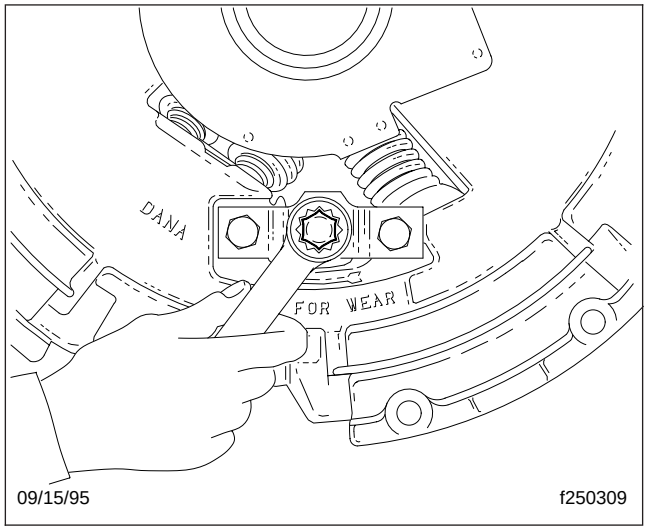
   4.3 If the blue 0.56-inch (14.3-mm) end can't be inserted in the gap, then try to insert the green 0.50-inch (12.7-mm) end. If the green end of the tool fits, snug or loose, then no adjustment is needed.

   4.4 If the green end of the tool can't be inserted in the gap, adjustment is needed. See "Adjustment."

5. If no internal clutch adjustment is necessary, go to "Release Yoke Free-Travel."

## Adjustment

To adjust Easy Pedal clutches, use the Eaton Fuller Kwik-Adjust® mechanism (see **Fig. 5**).




09/15/95 f250309

**Fig. 5, Adjustment with Kwik-Adjust**

1. Turn the engine flywheel until the lockstrap is aligned with the clutch inspection-cover opening. See **Fig. 1** and **Fig. 5**.
2. Release the clutch by depressing the pedal. Block the pedal in the released position, or have someone assist you by holding the pedal down during the adjustment procedure.

NOTE: An open-end wrench is not recommended for the following step.

3. Adjust the clutch, using a 5/8-inch box-end or socket wrench on the adjustment bolt.

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3.1 Insert the 5/8-inch box-end or socket wrench through the inspection cover opening.

3.2 To begin the adjustment, release the adjustment bolt by pressing down on the bolt head.

NOTE: Normal wear increases the gap between the release bearing and the transmission.

3.3 *To decrease the gap*: If clearance between the release bearing housing and the clutch brake is *more than* 9/16 inch (14.3 mm), turn the adjustment bolt clockwise (the release bearing moves toward the transmission).

*To increase the gap*: If clearance between the release bearing housing and the clutch brake is *less than* 1/2 inch (12.7 mm), turn the adjustment bolt counterclockwise (the release bearing moves toward the engine).

3.4 When the adjustment is complete, make sure the adjustment bolt is locked (pulled up flush with the mounting bolts).

NOTE: On Easy Pedal clutches, each complete turn of the adjustment bolt represents about 1/8 inch (3.2 mm) of release bearing movement. On earlier Easy Pedal models, each complete turn of the adjustment bolt represents about 0.02 inch (0.5 mm) of release bearing movement.

4. After adjusting, release the pedal and check the clearance between the release bearing housing and the clutch brake. When the clearance is 1/2 to 9/16 inch (12.7 to 14.3 mm), the adjustment is complete.

## Release Yoke Free-Travel

IMPORTANT: Release yoke free-travel tool A02–12254 is available through the PDCs. The legs on one end of the tool have green tape on them and are 0.105-inch (2.7-mm) thick; the legs on the other end have blue tape on them and are 0.145-inch (3.7-mm) thick.

1. Measure the release yoke free-travel. See **Fig. 3** for the correct dimension to measure. Using both ends of the free-travel tool (**Fig. 6**), check the gap as follows:

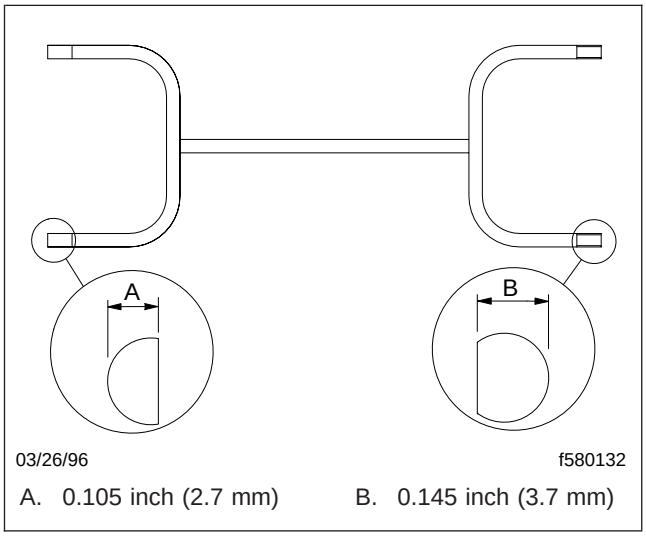



**Fig. 6, Release Yoke Free-Travel Tool A02-12254**

2. Position the tool so that the legs straddle the release yoke.
3. Insert the blue 0.145-inch (3.7-mm) end. If it fits loosely, the gap is too wide and linkage adjustment is needed. See **Section 25.02, Subject 100**.
4. If the blue 0.145-inch (3.7-mm) end can't be inserted in the gap, then try to insert the green 0.105-inch (2.7-mm) end. If the green end of the tool fits, snug or loose, then no adjustment is needed.
5. If the green end of the tool can't be inserted in the gap, linkage adjustment is needed. See **Section 25.02, Subject 100**.

## Clutch Brake Squeeze

NOTE: This procedure requires two persons: one under the vehicle with access to the release bearing, and the other in the vehicle to depress the clutch pedal and measure the pedal travel.

The distance the pedal moves (from the fully depressed position) to free the feeler gauge is the clutch brake squeeze measurement.

1. Apply the parking brakes and chock all the tires.

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## Easy Pedal Clutch Adjustments

2. Remove the clutch inspection cover from the bottom of the bell housing. See **Fig. 1**.
3. Insert a 0.010-inch (0.25-mm) feeler gauge (a business card works well if a feeler gauge is not available) between the release bearing and clutch brake.
4. Depress the clutch pedal to the end of its stroke.
5. Slowly let the pedal up. Stop when the feeler gauge can be pulled out. The pedal should be 1/2 to 1 inch (12.7 to 25.4 mm) from the end of the stroke.
6. If necessary, adjust the clutch brake squeeze by changing the length of the lower clutch pedal stop.

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# Removal

## Solo Heavy-Duty Clutch

Use the following procedure if you need to temporarily remove and then reinstall an Eaton Fuller Solo Heavy-Duty 15.5" adjustment-free clutch. Failure to follow these steps could cause the Solo clutch to drag or not release upon installation.

IMPORTANT: Check the position of the wear indicating tab on the clutch cover. If the wear indicating tab is near the REPLACE position on the indicator, it is time to replace the clutch.

### NOTICE

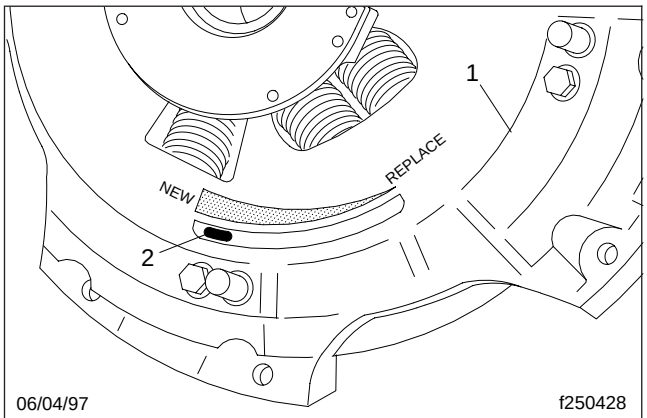
**For proper installation of the Solo clutch, the wear indicating tab must be reset. Failure to reset this tab will prevent clutch release and result in possible clutch damage.**

NOTE: This step requires two persons: one under the vehicle with access to the wear indicating tab, and the other in the vehicle to press the clutch pedal.

1. Reset the wear indicating tab with the clutch in the vehicle, as follows.
   - 1.1 From inside the cab, press the clutch pedal all the way down. Hold the clutch pedal down until the wear indicating tab is reset.
   - 1.2 Through the clutch inspection cover, slide the wear indicating tab to the left until it is at the "NEW" position on the indicator. See **Fig. 1**.
   - 1.3 From inside the cab, release the clutch pedal. Check to be sure the wear indicating tab stays at the "NEW" position on the indicator.

NOTE: Before pulling the transmission from the bell housing, disconnect the external clutch linkage and rotate the release yoke so the yoke will clear the release bearing when it is removed.

2. Remove the transmission. See **Section 26.01**.




With the clutch pedal down, set the tab to the "NEW" position on the indicator.

1. Clutch Cover
2. Wear Indicating Tab

**Fig. 1, Resetting the Wear Indicating Tab**

### NOTICE

**Do not let the rear of the transmission drop, and do not let the transmission hang unsupported in the splined hubs of the clutch discs. Taking these precautions will prevent bending and distortion of the clutch discs.**

3. Remove the clutch brake from the transmission input shaft. See **Fig. 2**.

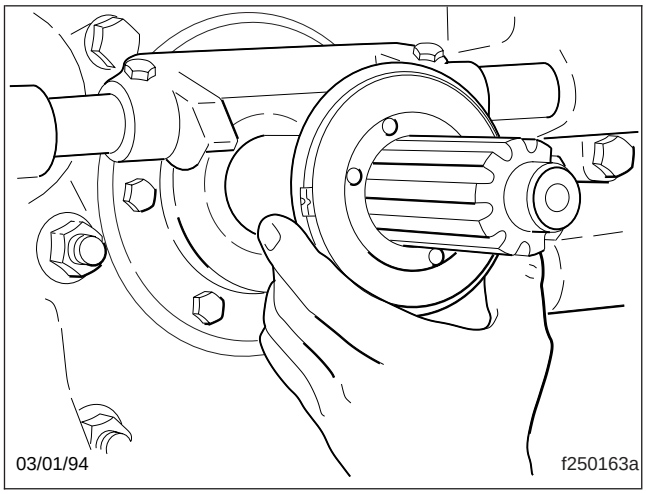



**Fig. 2, Clutch Brake Removal**

4. Install a spline aligning tool into the release bearing assembly, and through the driven discs. See

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## Clutch Removal

**Fig. 3**. An old transmission input shaft may be used for this purpose.

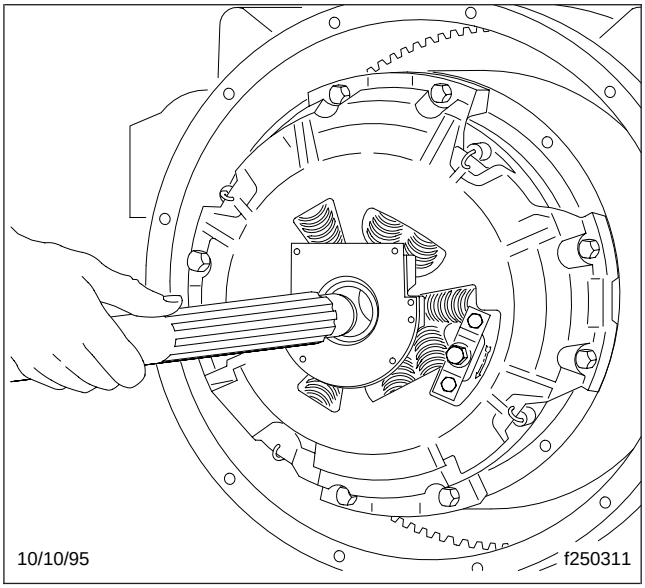



**Fig. 3, Installing a Spline Aligning Tool**

NOTE: Shipping bolts are installed on the clutch cover prior to installation to prevent the clutch adjustment mechanism from unloading.

5. Install four 7/16–14 x 1-3/4 shipping bolts (if available) or hexhead machine screws into the four clutch cover holes, and tighten them finger-tight plus one full turn. See **Fig. 4**.

   These bolts will cage the pressure plate, preventing the four plate spacers from moving out of position when the clutch is removed from the flywheel.

6. Progressively loosen each of the mounting capscrews in the pattern shown in **Fig. 5**. This will prevent warping or bending within the clutch, and will ease removal of the clutch mounting capscrews.

7. Remove the two top mounting capscrews from the cover assembly. Install two 7/16–14 x 5 guide studs in the open holes to help support the clutch assembly during removal. See **Fig. 6**.

NOTE: For installation, mark the proper position of the discs and intermediate plate adaptor ring.

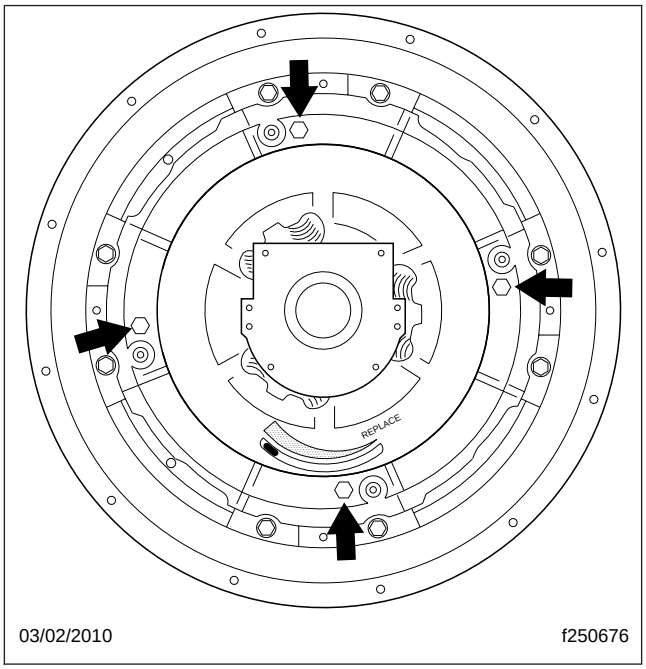



**Fig. 4, Installed Shipping Bolts**

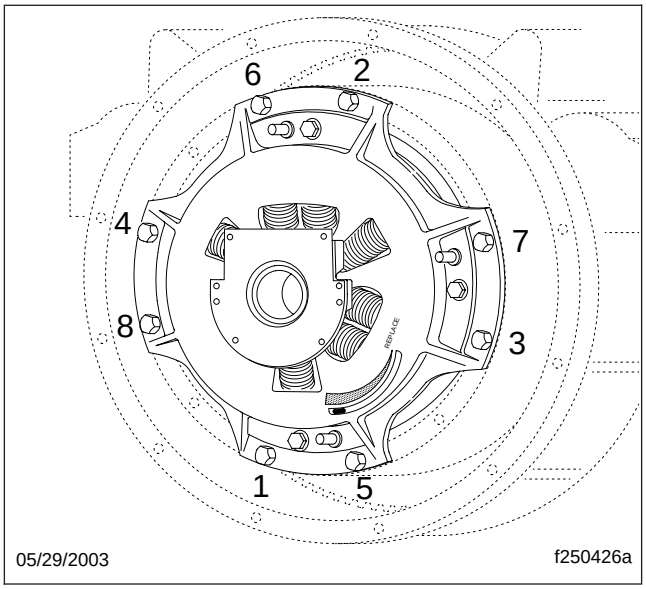



**Fig. 5, Loosening Sequence, Solo**

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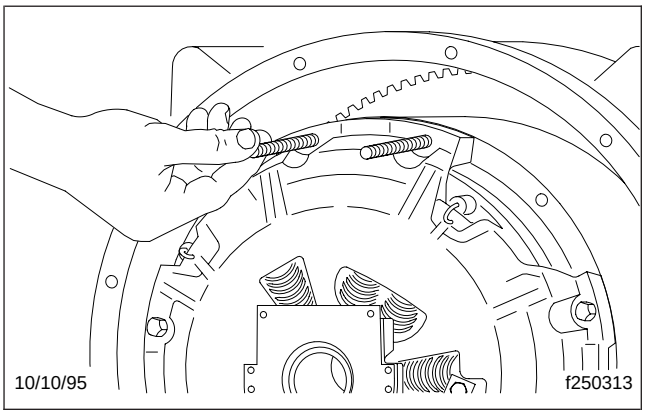
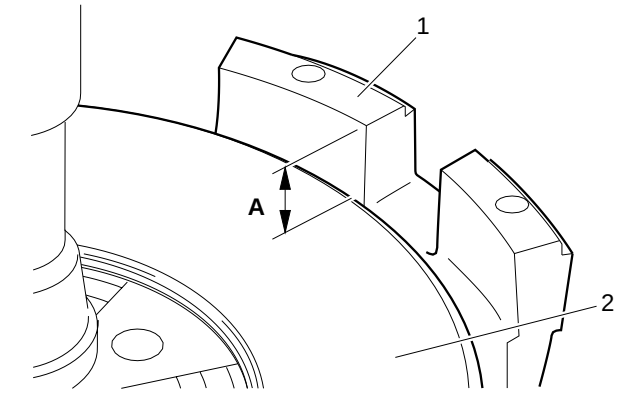



**Fig. 6, Install the Guide Studs**

**WARNING**

**The clutch assembly is heavy. It should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.**

8. Remove the mounting capscrews, and carefully remove the clutch assembly together with the spline aligning tool.
9. Reset the pressure plate, as follows. See **Fig. 7**.




NOTE: The pressure plate will be reset when it is 1.75 to 1.78 inches (44.4 to 45.2 mm) below the mounting surface of the clutch cover.

A. 1.75 to 1.78 inches (44.4 to 45.2 mm)

1. Mounting Surface
2. Pressure Plate

**Fig. 7, Reset Pressure Plate**

9.1 Progressively tighten the four shipping bolts in a crisscross pattern.

9.2 Measure the depth of the pressure plate. When the face of the pressure plate is 1.75 to 1.78 inches (44.4 to 45.2 mm) below the mounting surface of the clutch cover, the pressure plate is reset.

NOTE: Resetting the pressure plate will allow the clutch to release after installation.

10. Use an appropriate puller to remove the pilot bearing. Inspect the old pilot bearing for any unusual wear or damage. Discard the pilot bearing.

## Easy Pedal Clutch

NOTE: Before pulling the transmission from the bell housing, disconnect the external clutch linkage and rotate the release yoke so the yoke will clear the release bearing when it is removed.

1. Remove the transmission. See **Section 26.01**.

**NOTICE**

**Do not let the rear of the transmission drop, and do not let the transmission hang unsupported in the splined hubs of the clutch discs. Taking these precautions will prevent bending and distortion of the clutch discs.**

2. Remove the clutch brake from the transmission input shaft. See **Fig. 2**.
3. Install a spline aligning tool into the release bearing assembly, and through the driven discs. See **Fig. 3**. An old transmission input shaft may be used for this purpose.
4. Use a release tool and two 5/8-inch (16 mm) spacer blocks to pull the bearing back. See **Fig. 8**. The spacer blocks relieve the internal spring load in the clutch assembly, and facilitate clutch removal.
5. Remove the two top mounting bolts from the cover assembly. Install 7/16-14 x 5 guide studs in the open holes to help support the clutch assembly during removal. See **Fig. 6**.
6. Progressively loosen each of the mounting bolts in the pattern shown in **Fig. 9**. This will prevent warping or bending within the clutch, and will ease removal of the clutch mounting bolts.

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## Clutch Removal

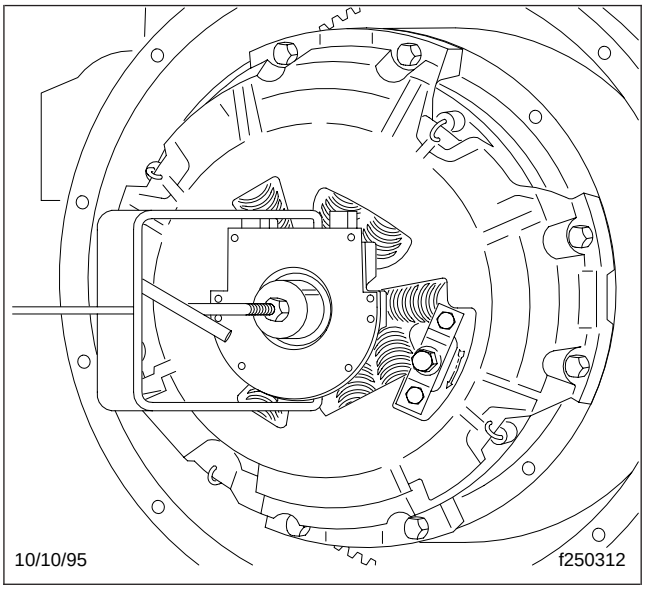



**Fig. 8, Pulling the Bearing**

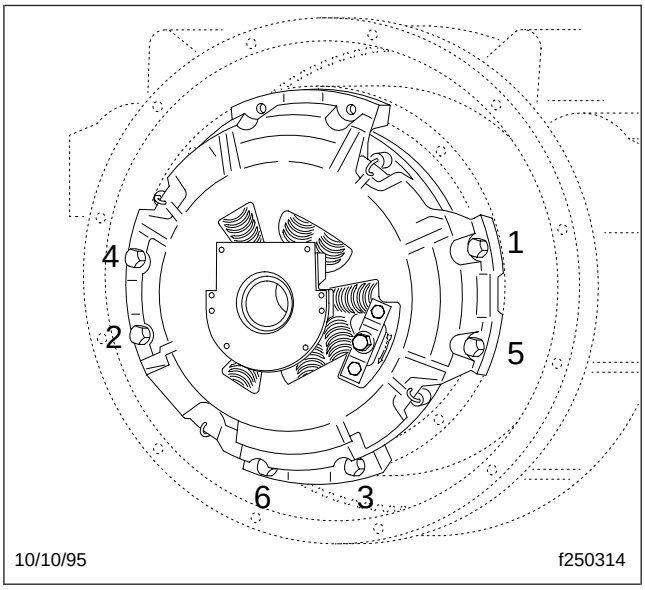



**Fig. 9, Loosening Sequence, Easy Pedal**

**⚠ WARNING**

**The clutch assembly is heavy. It should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.**

7. Remove the mounting bolts, and carefully remove the clutch assembly.

   Be careful to keep the spline aligning tool in place to retain the discs and intermediate plate. Remove the spline aligning tool, the rear driven disc, the intermediate plate, and the front driven disc.

8. Use an appropriate puller to remove the pilot bearing. Inspect the old pilot bearing. Correct the cause of any unusual wear or damage. Discard the bearing.

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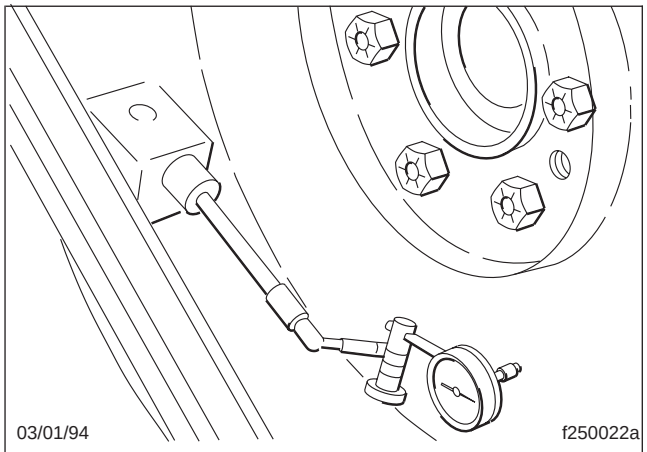
# Clutch Inspection

## NOTICE

**Misalignment of any parts described in these procedures will cause premature wear of drivetrain components.**

IMPORTANT: When taking the following readings, rotate the engine by hand; do not crank the engine with the starter. The engine may be rotated by the pulley nut at the front of the crankshaft, the flywheel mounting bolts, or the starter ring-gear on the flywheel.

1. Clean the surfaces being measured to ensure accurate measurements.
2. Measure the runout of the flywheel face (friction surface). See **Fig. 1** for the correct set-up.




Secure the dial indicator to the flywheel housing, with the gauge finger against the flywheel face, and near the outer edge.

**Fig. 1, Measuring the Flywheel Face**

2.1 Secure the dial indicator to the flywheel housing, with the gauge finger against the face of the flywheel near the outer edge.

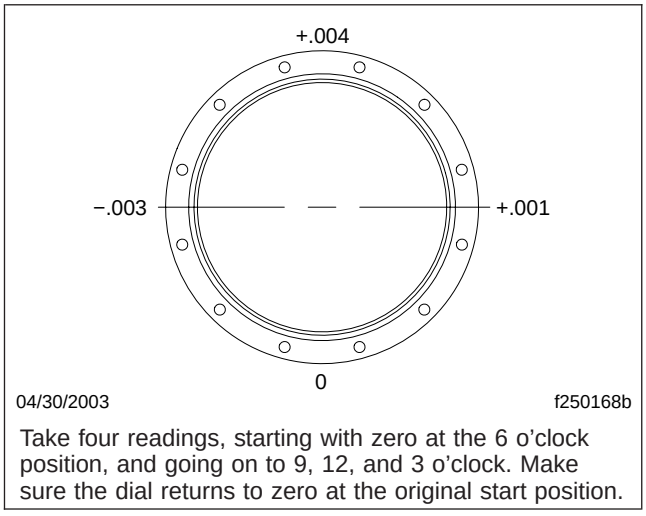
2.2 Turn the flywheel through one complete revolution. With chalk or soapstone, mark the high and low points on the flywheel face.

2.3 The total runout will be the difference between the highest plus and minus readings. To calculate the runout, see **Fig. 2**.

*Example:* The highest reading is +0.004 at 12 o'clock. The lowest reading is –0.003 at 9 o'clock. Therefore the total runout is 0.007 inch.

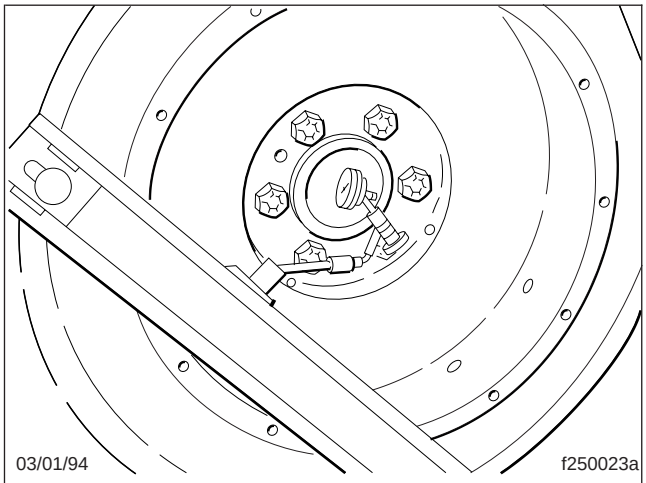
2.4 The SAE maximum total runout for the flywheel face is 0.008 inch (0.20 mm). If the readings are higher, see the engine manufacturer's manual for instructions.

3. Measure the runout of the pilot-bearing bore in the flywheel. See **Fig. 3** for the correct set-up.




Take four readings, starting with zero at the 6 o'clock position, and going on to 9, 12, and 3 o'clock. Make sure the dial returns to zero at the original start position.

**Fig. 2, Measurements for Calculating Runout**




Secure the dial indicator to the flywheel housing, with the gauge finger on the surface of the pilot-bearing bore.

**Fig. 3, Measuring the Pilot-Bearing Bore**

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## Clutch Inspection and Pre-Installation Procedures

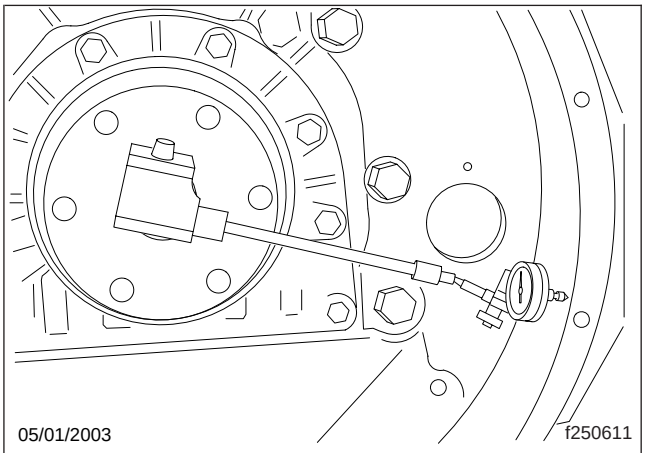
3.1 With the indicator still secured to the flywheel housing, move the gauge finger to contact the surface of the pilot-bearing bore.

3.2 Turn the flywheel through one complete revolution. With chalk or soapstone, mark the high and low points on the bore of the pilot bearing.

3.3 Calculate the runout as before.

3.4 The SAE maximum total runout for the pilot-bearing bore is 0.005 inch (0.13 mm). If the readings are higher, see the engine manufacturer's manual for instructions.

4. Measure the runout of the flywheel housing bore. See **Fig. 4** for the correct set-up.




Secure the dial indicator to the crankshaft, with the gauge finger against the side of the flywheel housing.

**Fig. 4, Measuring the Flywheel Housing Bore**

4.1 Secure the dial indicator to the crankshaft, with the gauge finger against the side of the flywheel housing.

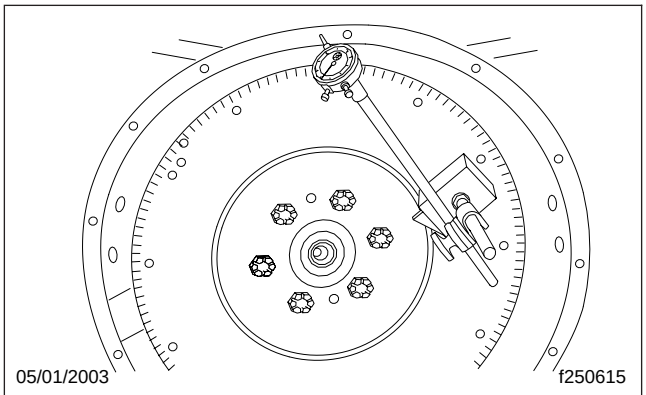
4.2 Turn the flywheel through one complete revolution. With chalk or soapstone, mark the high and low points on the side of the flywheel housing.

4.3 Calculate the runout as before.

NOTE: Only if you have to reposition the flywheel housing is it necessary to mark the high and low runout readings in clock positions.

4.4 The SAE maximum total runout for the flywheel-housing bore is 0.008 inch (0.20 mm). If readings are higher, replace the flywheel housing. For instructions, see the engine manufacturer's manual.

5. Measure the runout of the face of the flywheel housing. See **Fig. 5** for the correct set-up.




Secure the dial indicator to the outer diameter of the flywheel, with the gauge finger against the face of the flywheel housing.

**Fig. 5, Measuring Runout of the Flywheel Housing Face**

5.1 With the dial indicator secured to the outer diameter of the flywheel, move the gauge finger to contact the face of the flywheel housing.

5.2 Turn the flywheel through one complete revolution. With chalk or soapstone, mark the high and low points on the face of the flywheel housing.

5.3 Calculate the runout as before.

NOTE: Only if you have to reposition the flywheel housing is it necessary to mark the high and low runout readings in clock positions.

5.4 The SAE maximum total runout for the flywheel-housing face is 0.008 inch (0.20 mm). If the readings are higher, replace the housing. For instructions, see the engine manufacturer's manual.

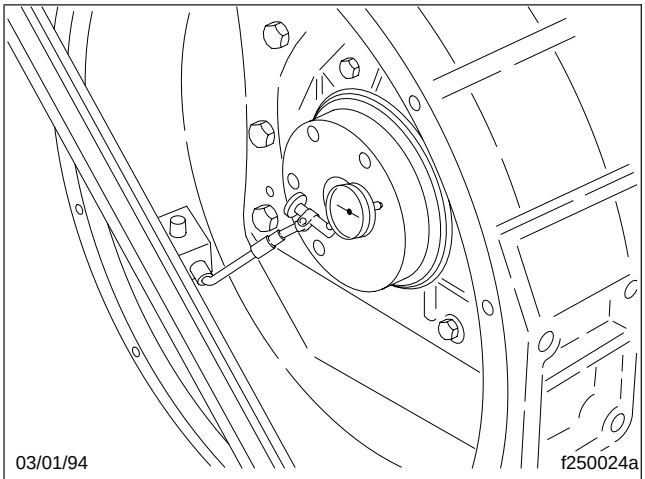
NOTE: Use a case-bore plug and shaft set to measure the bell-housing face and pilot. Case-bore plugs are tapped into the front and rear bores of the transmission case, and have very

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close tolerances. The shaft runs through the center of the plugs, and extends to the front far enough to secure a dial indicator and obtain a reading on the bell housing.

6. Measure the runout of the bell housing face and pilot.
   - 6.1 Secure the dial indicator to the case-bore shaft, with the gauge finger against the face of the bell housing.
   - 6.2 Turn the case-bore shaft through one complete revolution. With chalk or soapstone, mark the high and low points on the face of the bell housing.
   - 6.3 Calculate the runout as before.
   - 6.4 The SAE maximum total runout for the bell-housing face is 0.008 inch (0.20 mm). If the readings are higher, replace the bell housing. See the transmission manufacturer's service manual for instructions.
7. Remove the flywheel (see the engine manufacturer's manual), and measure the runout of the flywheel crankshaft face. See **Fig. 6**.




Secure the dial indicator to the flywheel housing, with the gauge finger against the crankshaft face, and near the outer edge.

**Fig. 6, Measuring the Crankshaft Face Runout**

   - 7.1 Secure the dial indicator to the flywheel housing, with the gauge finger against the crankshaft face, and near the outer edge.
   - 7.2 Turn the crankshaft through one complete revolution. With chalk or soapstone, mark the high and low points on the face of the crankshaft.
   - 7.3 Calculate the runout as before.
   - 7.4 See the engine manufacturer's manual for maximum runout, corrective measures, and flywheel installation instructions.

## Resetting a Solo Clutch (clutch out of vehicle)

### NOTICE

**Use this procedure if the clutch was removed without caging the pressure plate. Resetting the pressure plate allows the clutch to release after installation and prevents possible clutch damage.**

1. Remove the four shipping bolts if they have been installed. See **Fig. 7**.

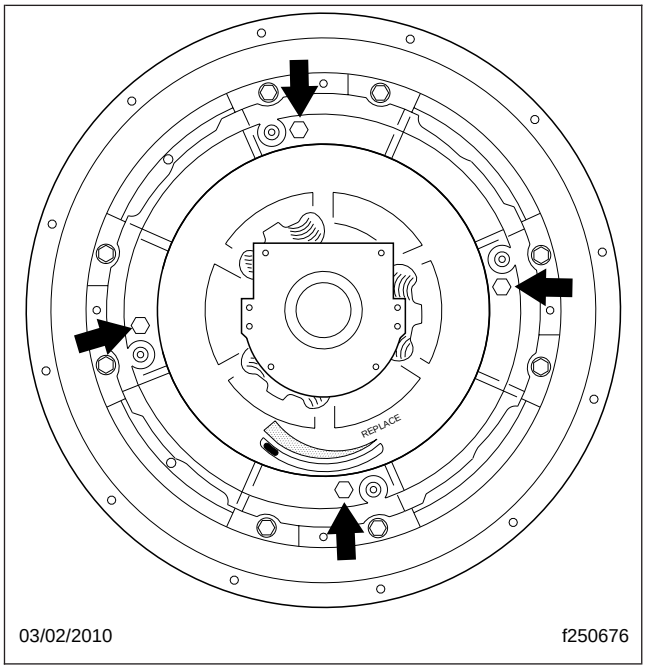



**Fig. 7, Installed Shipping Bolts**

2. Support the clutch cover in an arbor press with the release bearing facing down. When setting up the arbor press, allow at least 1 inch (25 mm)

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## Clutch Inspection and Pre-Installation Procedures

clearance for both movement of the release bearing and access to install shipping bolts. See **Fig. 8**.

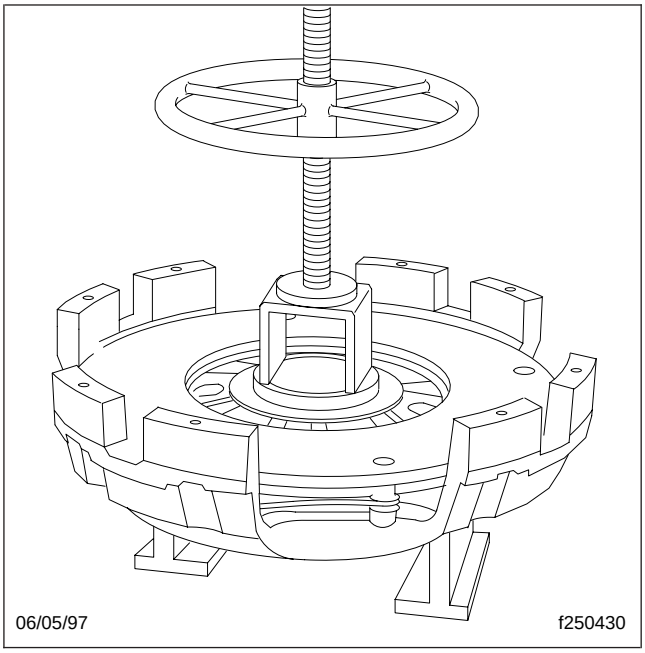



**Fig. 8, Arbor Press Setup**

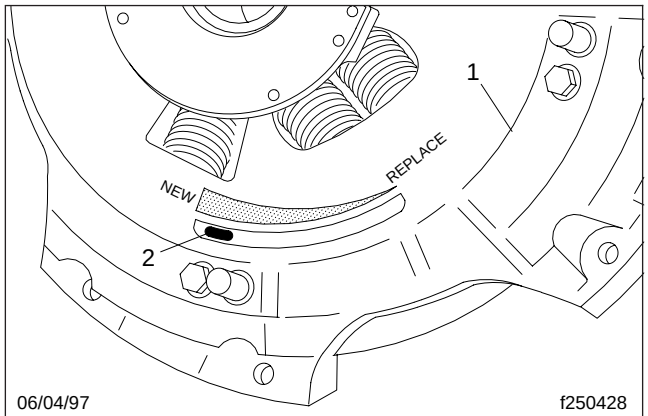
3. Center the ram and press downward on the retainer until it comes to a stop. Lock the ram in position.
4. Slide the wear indicating tab to the left until it is at the NEW position of the indicator (**Fig. 9**) and hold it in position with a magnet.

NOTE: Shipping bolts are installed on the clutch cover prior to installation to prevent the clutch adjustment mechanism from unloading. See **Fig. 7**.

5. *For 14-inch clutches*, install four 3/8–16 x 1-1/4 shipping bolts (if available) or hexhead machine screws into the four clutch cover holes, and tighten them finger-tight plus one full turn.

   *For 15.5-inch clutches*, install four 7/16–14 x 1-3/4 shipping bolts (if available) or hexhead machine screws into the four clutch cover holes, and tighten them finger-tight plus one full turn.

NOTE: You may need to temporarily install slightly longer bolts to allow access of the shipping bolts.




1. Clutch Cover
2. Wear Indicating Tab

**Fig. 9, Resetting the Wear Indicating Tab**

6. Reset the pressure plate, as follows.

   6.1 Progressively tighten the four shipping bolts in a crisscross pattern.

   6.2 Measure the depth of the pressure plate. See **Fig. 10**.

   *For 14-inch clutches*, the pressure plate is reset when the face of the pressure plate is 0.50 inch (12.7 mm) below the mounting surface of the clutch cover.

   *For 15.5-inch clutches*, the pressure plate is reset when the face of the pressure plate is 1.75 to 1.78 inches (44.4 to 45.2 mm) below the mounting surface of the clutch cover.

## Pre-Installation Procedures

Before installing a new, rebuilt, or used clutch, do the following procedures:

1. Install a new pilot bearing. Be sure that the pilot bearing has a press-fit in the flywheel.

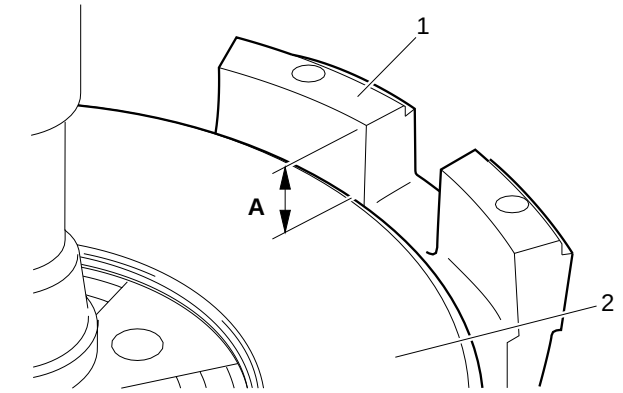
### NOTICE

**Tap on the outer race only. Tapping on the inner race could damage the pilot bearing.**

NOTE: To discourage warranty claims for drag or clutch noise, use a premium grade C3/C4 pilot bearing. Due to increased operating tem-

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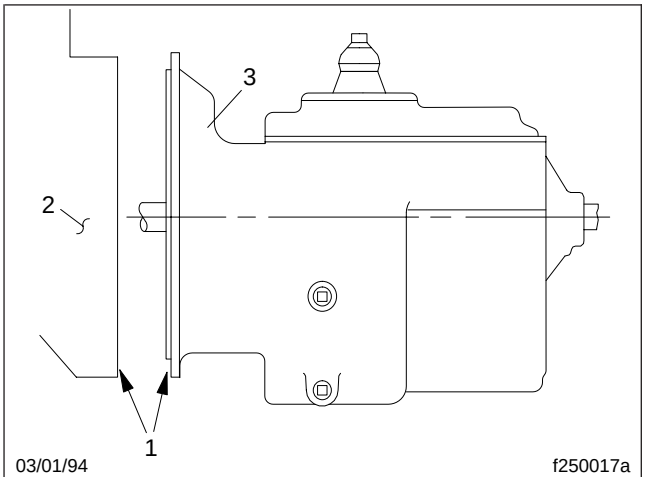

A. 0.50 inch (12.7 mm) for 14-inch clutches; 1.75 to 1.78 inches (44.4 to 45.2 mm) for 15.5-inch clutches

1. Mounting Surface
2. Pressure Plate

**Fig. 10, Reset Pressure Plate**

peratures and longer clutch life, the standard pilot bearings and grease are no longer acceptable.

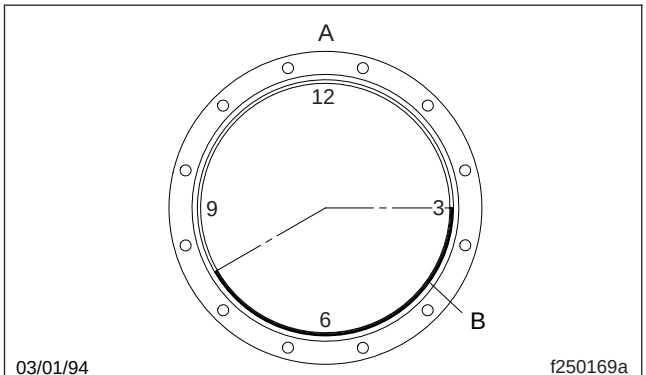
2. Check for wear on the mating surfaces of the flywheel housing and the transmission bell housing. Any noticeable wear on either part causes misalignment. If worn, replace the part. See **Fig. 11**.




1. Mating Surfaces
2. Engine Flywheel Housing
3. Transmission Bell Housing

**Fig. 11, Inspecting the Mating Surfaces**

3. Check the flywheel for wear caused by the bell housing pilot (projecting lip of the bell housing). The correct dimension is 1/8-inch (3.2-mm). Wear is most likely to appear between the 3 o'clock and 8 o'clock positions. See **Fig. 12**.




A. Top
B. The most common areas of wear are between the 3 o'clock and 8 o'clock positions.

**Fig. 12, Checking the Flywheel Housing for Wear**

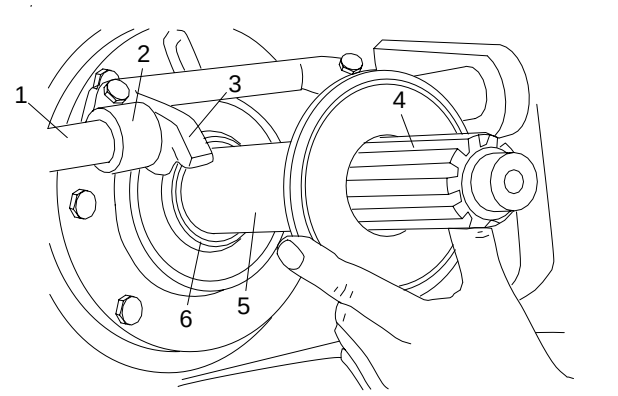
NOTE: The pilot (lip) of the bell housing can wear into the flywheel housing. This can be caused by the transmission loosening up, or by road and engine vibration after high mileage.

4. Inspect the flywheel. Replace or repair the flywheel if the wear is extreme.
   - 4.1 Visually inspect the friction surface of the flywheel for heat checks and scoring.
   - 4.2 Measure the friction surface wear with a straightedge and feeler gauge. For instructions, see the engine manufacturer's manual.
5. Inspect the input shaft, both the splined and the smooth area. See **Fig. 13**.
   - 5.1 Check the fit of the splined hubs of the driven discs by sliding them along the splines of the input shaft. The hubs must slide freely so the clutch will release cleanly. If necessary, use a hand stone to dull the sharp edges of the splines.
   - 5.2 If the input shaft splines are worn or notched, or if the hubs still do not slide freely, replace the input shaft. For instruc-

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## Clutch Inspection and Pre-Installation Procedures




05/01/2003 f250613

1. Cross-Shaft
2. Sleeve Bushing
3. Release Yoke Finger
4. Input Shaft (splined area)
5. Input Shaft (smooth area)
6. Bearing Cap

**Fig. 13, Clutch Inspection Points**

tions, see the transmission manufacturer's service manual.

5.3 Inspect the smooth area of the input shaft for wear and/or rough spots. Replace the input shaft if necessary.

6. To prevent side-loading, inspect all pivot points of the clutch linkage for excessive wear and replace them if necessary. See **Fig. 13**. Pay special attention to the following points:

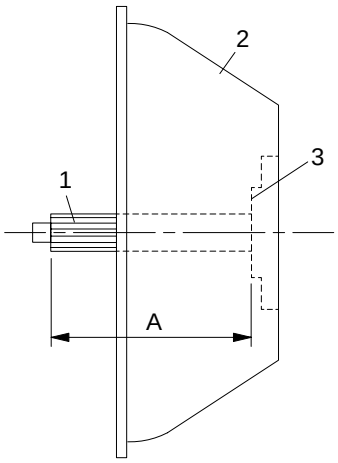
6.1 Check for excessive wear at the fingers of the release yoke where they contact release bearing wear pads.

6.2 Check the clutch cross-shaft and sleeve bushings for excessive wear. Check the sleeve bushings for walk-out.

7. To prevent clutch brake wear, check the input-shaft bearing cap and measure it as shown in **Fig. 14**.

7.1 Visually check the bearing cap for excessive wear.

7.2 Measure the distance between the splined end of the input shaft and the bearing cap (dimension A). If dimension A is greater than 8.71 inches (221.5 mm), replace the bearing cap.




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A. Length of Input Shaft, from the Splined End to the Bearing Cap

1. Input Shaft
2. Bell Housing
3. Bearing Cap

**Fig. 14, Measuring the Input Shaft**

NOTE: A torque-limiting clutch brake has facings on both sides. When installing it, orient the shallow side toward the transmission, and the deep side toward the engine to allow clearance for the release bearing.

8. On unsynchronized transmissions, install a new clutch brake on the transmission input shaft, as shown in **Fig. 15**. Slide it tight against the input-shaft bearing cap.

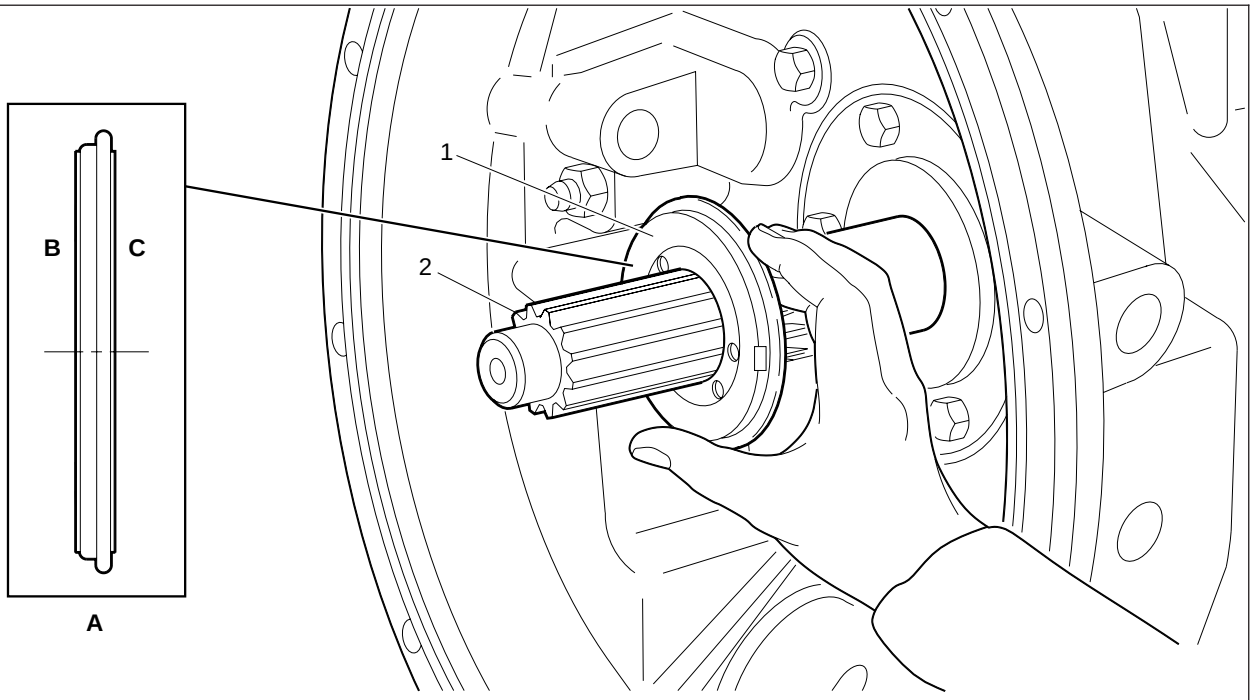
9. Measure the diameter of the flywheel bore opening (this is the recessed area for the flywheel bolt circle). See **Table 1** for minimum flywheel bore diameters for each disc type.

| Minimum Flywheel Bores | |
|---|---|
| **Disc Type** | **Flywheel Bore in inch (mm)** |
| 10-Spring | 8.562 (217.48) |
| 9-Spring | 9.750 (247.65) |
| 8-Spring | 7.250 (184.15) |
| 7-Spring | 9.750 (247.65) |
| 6-Spring | 9.750 (247.65) |

**Table 1, Minimum Flywheel Bores**

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A. Cross section of clutch brake
B. Install deep side toward release bearing
C. Install shallow side toward the transmission
1. Clutch Brake
2. Input Shaft

**Fig. 15, Installing the Clutch Brake**

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## Installation

1. Do the clutch inspection and pre-installation procedures in **Subject 120**.
2. If not already installed, insert two 7/16–14 x 5 guide studs in the upper mounting holes of the flywheel. See **Fig. 1**. Rotate the flywheel to level the guide studs.

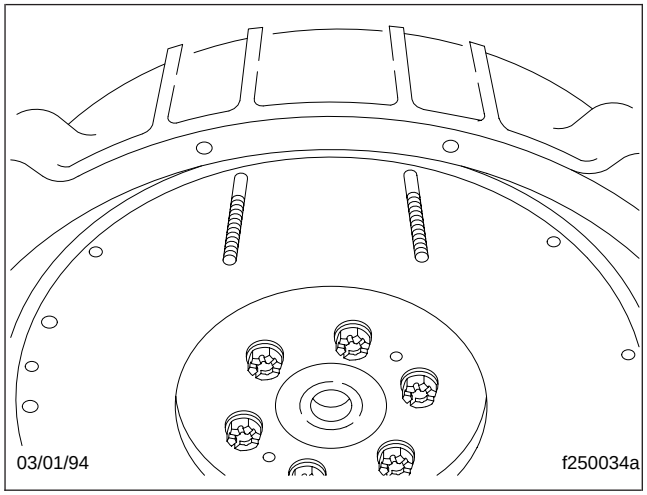



**Fig. 1, Guide Studs, Installed**

3. If the clutch is new, remove the protective coating from the pressure plate and the intermediate plate.
4. Set the clutch cover upright, and insert a spline aligning tool through the release bearing sleeve. See **Fig. 2**.
5. Install the rear driven disc and intermediate plate.
   - 5.1 Install the rear driven disc on the aligning tool. Follow the orientation instructions on the disc. See **Fig. 3**.
   - 5.2 Place the intermediate plate in the clutch cover. Align the drive lugs of the plate with the notches in the cover. See **Fig. 4**.
   - 5.3 Make sure the positive separator pins protrude toward the flywheel side. See **Fig. 4**. The pins should be flush on the pressure-plate side.

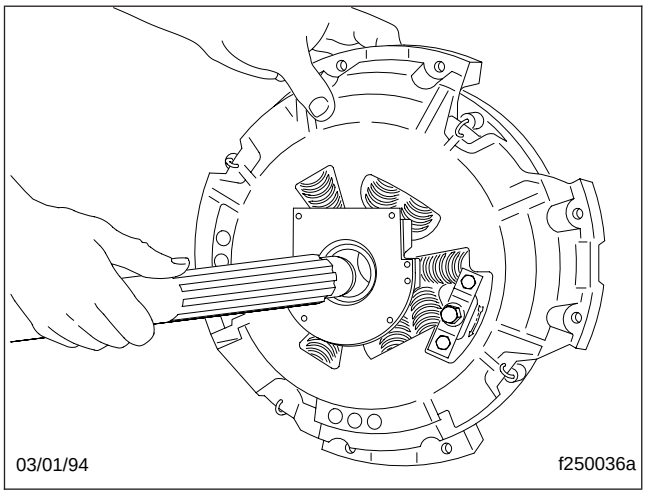



**Fig. 2, Inserting an Aligning Tool**

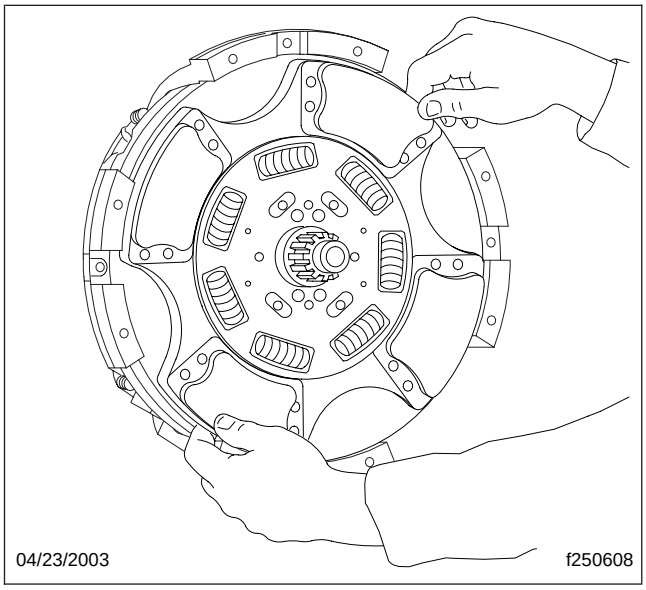



**Fig. 3, Installing the Rear Driven Disc**

6. Install the front driven disc on the aligning tool. Follow the orientation instruction on the disc. Ensure that both driven discs are aligned as shown in **Fig. 5**.

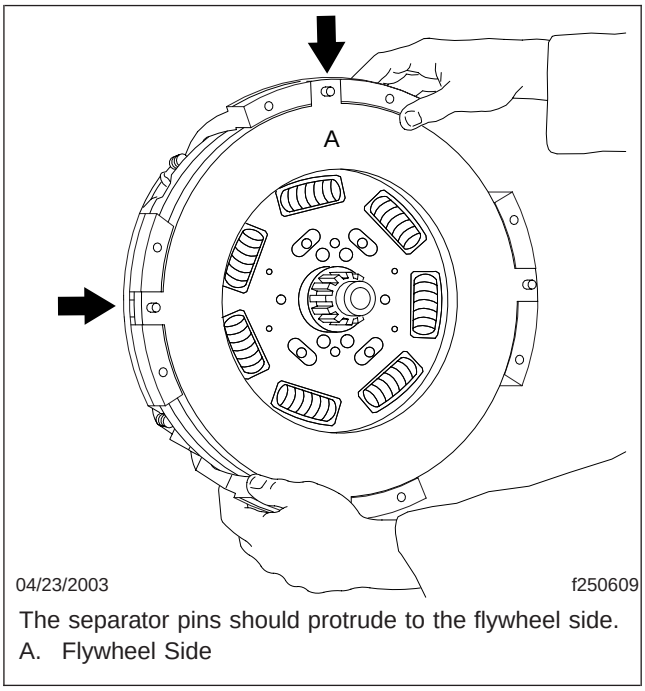
**⚠ WARNING**

**The clutch assembly is heavy. It should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.**

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## Easy Pedal Clutch Installation




The separator pins should protrude to the flywheel side.
A. Flywheel Side

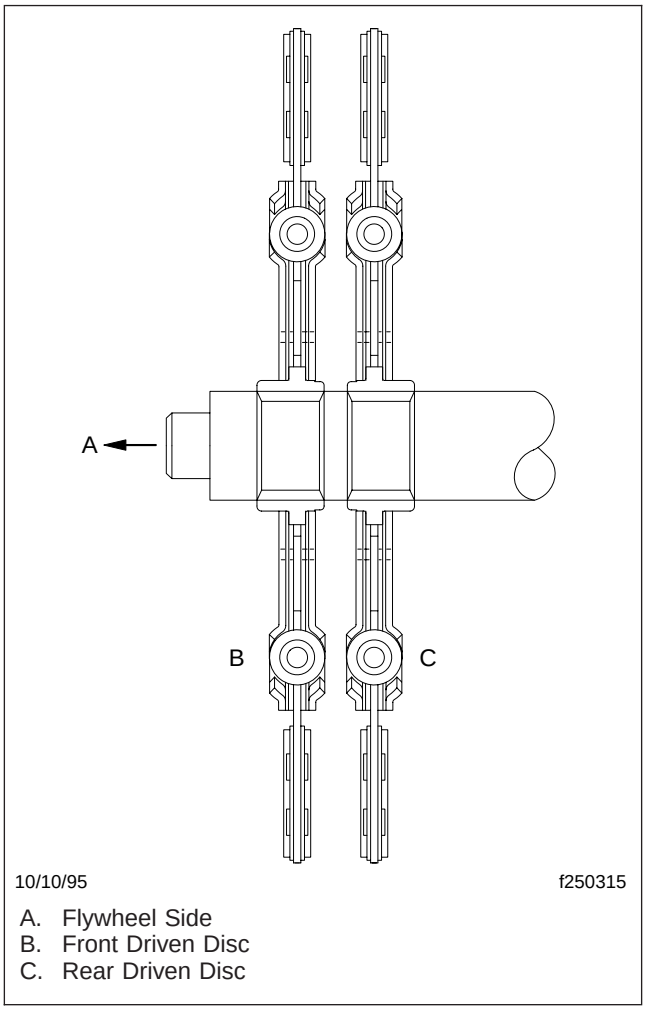
**Fig. 4, Positioning the Intermediate Plate**

7. Position the clutch over the two guide studs, and slide the assembly forward until it starts in the flywheel pilot. See **Fig. 6**.
8. Start six 7/16–14 x 2-1/4 (grade 5 or better) mounting bolts with lockwashers, and fasten them finger-tight. Tap the aligning tool to make sure it is centered and seated in the pilot bearing, then remove the two guide studs and replace them with 7/16–14 x 2-1/4 bolts and lockwashers.
9. Using the sequence shown in **Fig. 7**, progressively tighten the eight clutch mounting bolts. The final torque is 40 to 50 lbf·ft (54 to 68 N·m).

### NOTICE

**If the bolts are not tightened in sequence, it may cause permanent damage to the clutch cover and create an out-of-balance condition.**

10. As the capscrews are tightened, the release bearing spacers should fall free. If they don't, remove them. This may require light taps with a mallet on the end of the aligning tool.
11. Remove the aligning tool.




A. Flywheel Side
B. Front Driven Disc
C. Rear Driven Disc

**Fig. 5, Checking Disc Alignment**

12. Set the positive separator pins.
    12.1 Locate the pin access holes. See **Fig. 8**.

### WARNING

**Wear safety goggles when tapping the pins. If any of the metal parts were to chip, flying pieces of metal could possibly cause eye injury.**

    12.2 To ensure that all four separator pins are flush against the flywheel, insert a 1/4-inch (6-mm) diameter flat-nose punch through the access holes and *lightly* tap each of them toward the flywheel. See **Fig. 9**.

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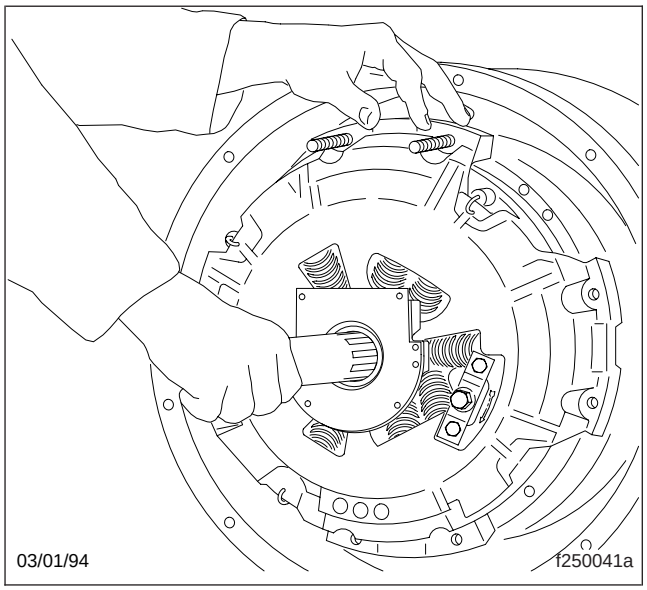



**Fig. 6, Positioning an Easy Pedal Clutch**

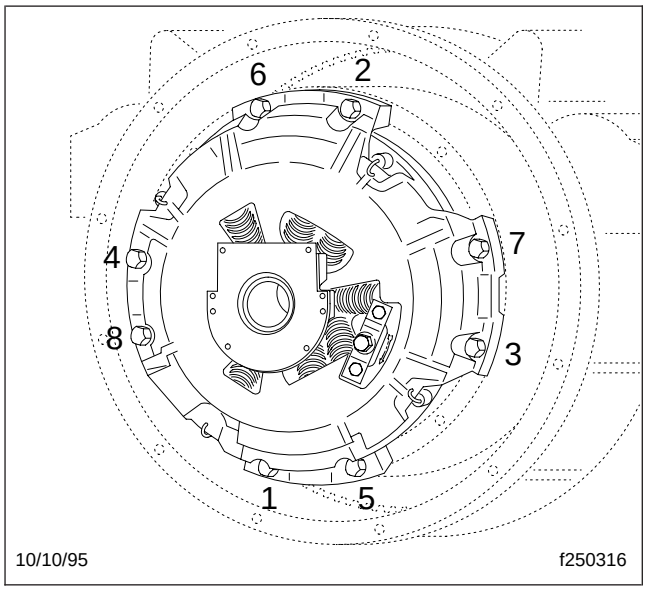



**Fig. 7, Easy Pedal Tightening Sequence**

NOTE: Failure to perform this step properly may cause the clutch to drag (clutch does not release). If necessary, after the transmission has been installed, the four pins can be set through the inspection opening of the transmission bell housing.

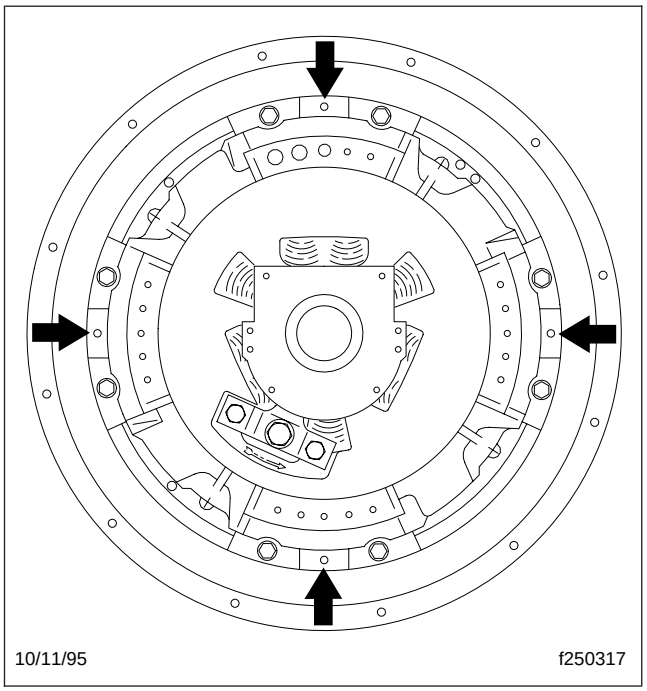
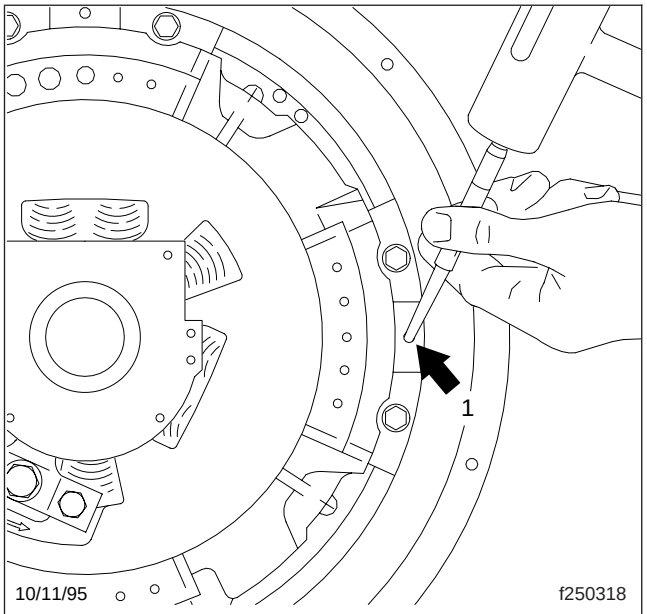



**Fig. 8, Pin Access Holes, Easy Pedal**




1. Pin Access Hole

**Fig. 9, Tapping the Pin, Easy Pedal**

13. Using a clean cloth, remove all grease from the input shaft.

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## Easy Pedal Clutch Installation

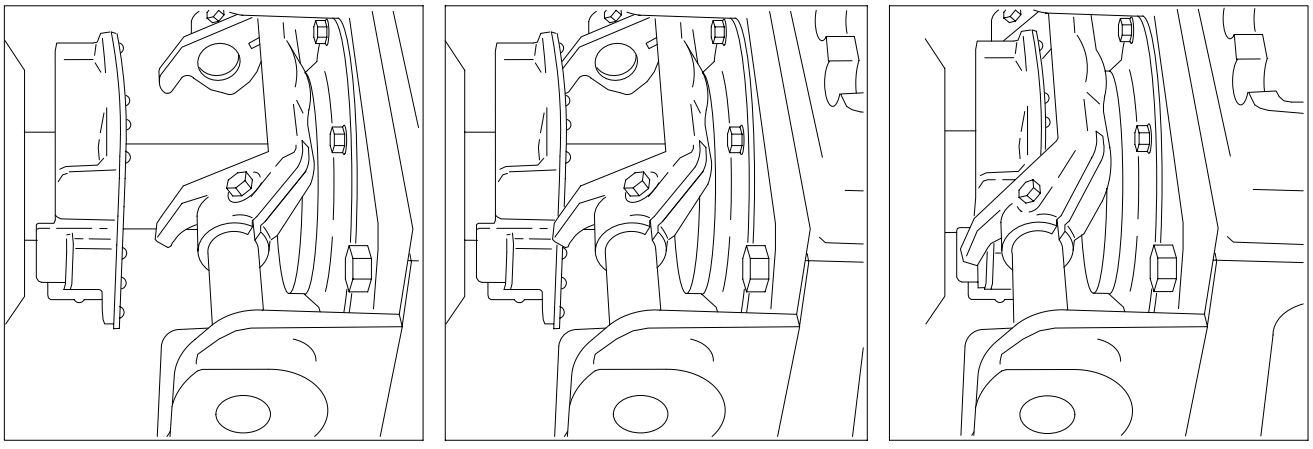
14. Shift the transmission into gear. Rotate the transmission input shaft to line up with the clutch driven-disc hub splines during assembly.
15. Install the transmission and attach the clutch linkage.

IMPORTANT: On vehicles equipped with a mechanical clutch linkage, ensure the release yoke clears the bearing, and is rotated over the wear pads as the transmission is moved forward. See **Fig. 10**. Align the splines by turning the transmission output shaft.

### NOTICE

**Do not excessively force the transmission into the clutch assembly or engine housing. If it doesn't enter freely, investigate the cause of the problem and then make any necessary changes. Don't let the transmission drop or hang unsupported in the driven discs. If this should occur, the rear disc will become bent or distorted, causing the clutch to drag (not release).**

16. Lubricate the release bearing and release shafts. For instructions and recommended lubricants, see **Group 25** of the *Western Star Maintenance Manual*.
17. Adjust the clutch according to the procedures in **Subject 100**.



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On vehicles equipped with a mechanical clutch linkage, ensure the release yoke clears the bearing and is rotated over the wear pads as the transmission is moved forward.

**Fig. 10, Release Yoke and Bearing**

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## Installation

1. Do the clutch pre-installation procedures in **Subject 120** before installing the clutch.
2. If not already installed, insert two 7/16–14 x 5 guide studs in the upper mounting holes of the flywheel. See **Fig. 1**. Rotate the flywheel to level the guide studs.

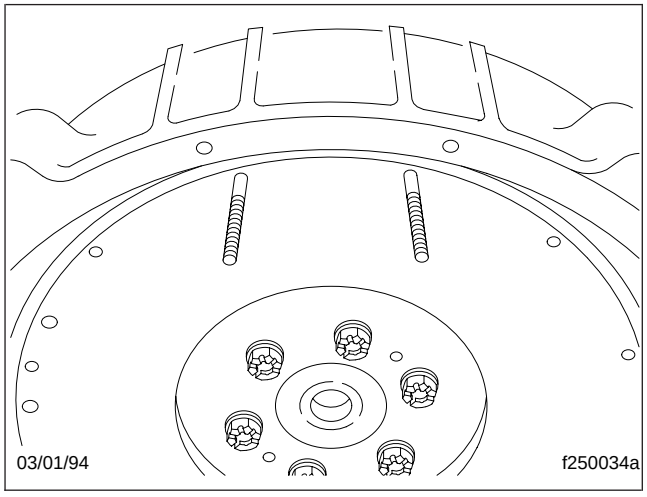



**Fig. 1, Installing the Guide Studs**

3. If installing a new clutch, remove the protective coating from the pressure plate and the intermediate plate.
4. Set the clutch cover upright, and insert a spline aligning tool through the release bearing sleeve. See **Fig. 2**.
5. Install the rear driven disc and intermediate plate, as follows.
   - 5.1 Install the rear driven disc on the aligning tool, with the side stamped *INTERMEDIATE PLATE SIDE* facing away from the clutch cover. See **Fig. 3**.
   - 5.2 Place the intermediate plate in the clutch cover. Align the drive lugs of the plate with the notches in the cover. See **Fig. 4**.
   - 5.3 Make sure the separator pins protrude toward the flywheel side. See **Fig. 4**. The pins should be flush on the pressure-plate side.

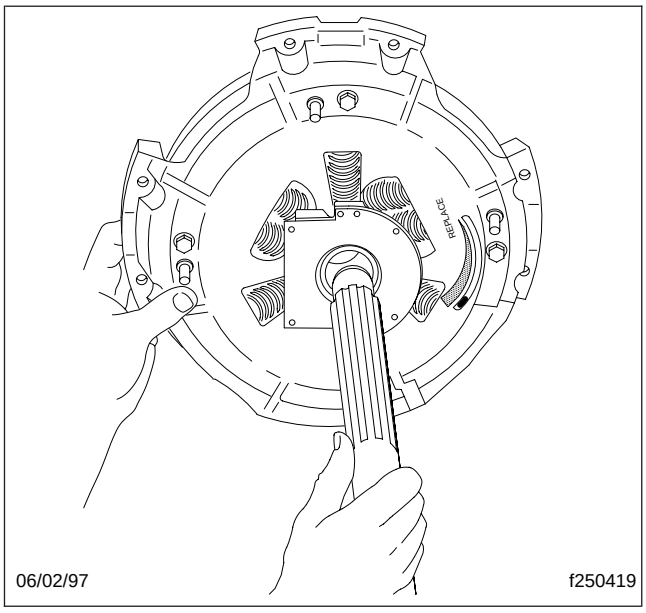



**Fig. 2, Inserting an Aligning Tool**

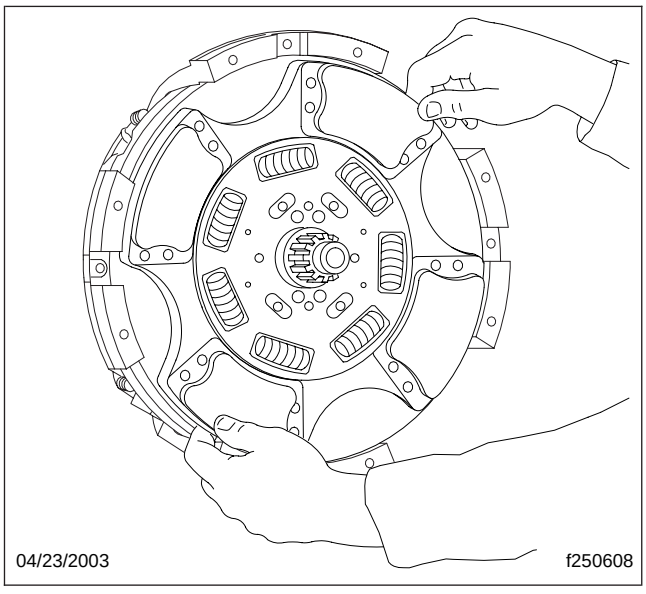


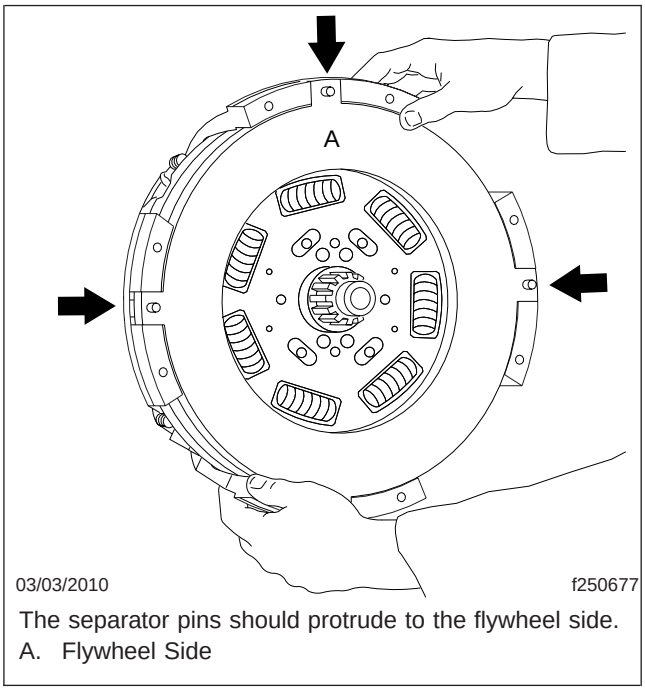

**Fig. 3, Installing the Rear Driven Disc**

6. Install the front driven disc on the aligning tool, with the side stamped *INTERMEDIATE PLATE SIDE* facing the intermediate plate. See **Fig. 5**.

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## 15.5-Inch Solo Clutch Installation




The separator pins should protrude to the flywheel side.
A. Flywheel Side

**Fig. 4, Positioning the Intermediate Plate**

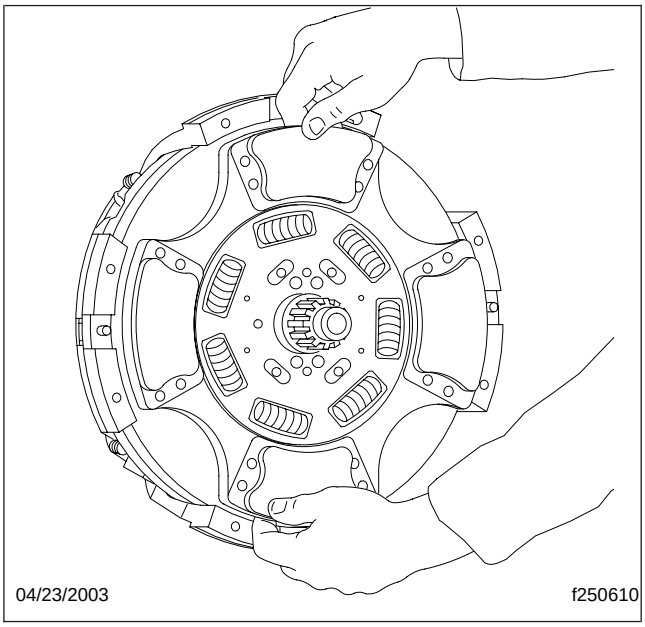



**Fig. 5, Installing the Front Driven Disc**

**WARNING**

**The clutch assembly is heavy. It should be removed and installed only with a lifting device. If the assembly is lifted incorrectly or dropped, it could cause serious personal injury.**

7. Position the clutch over the two guide studs, and slide the assembly forward until contact is made with the flywheel surface. See **Fig. 6**.

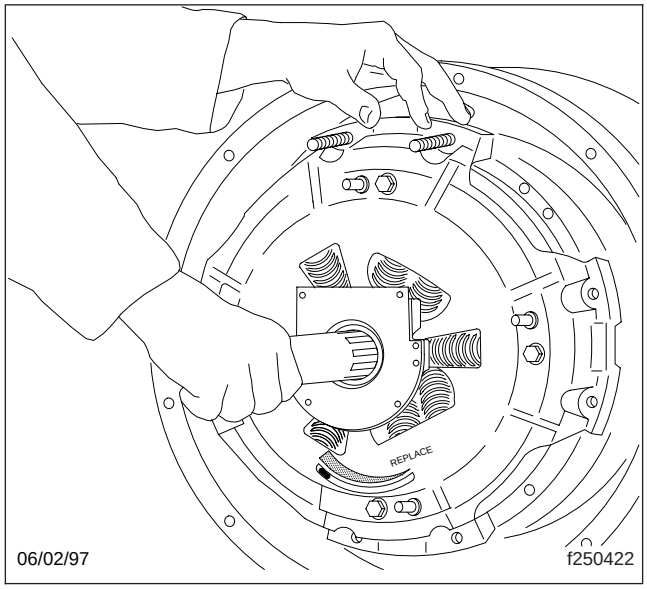



**Fig. 6, Positioning the Clutch Cover**

8. Install the mounting capscrews, as follows.
   - 8.1 Start six 7/16–14 x 2-1/4 (grade 5 or better) mounting capscrews with lockwashers, and tighten them finger-tight.
   - 8.2 Tap the aligning tool to make sure it is centered and seated in the pilot bearing. See **Fig. 7**.
   - 8.3 Remove the two guide studs and replace them with the two remaining 7/16–14 x 2-1/4 mounting capscrews and lockwashers.
9. Tighten the eight mounting capscrews progressively, in a crisscross pattern as shown in **Fig. 8**. Final torque is 40 to 50 lbf·ft (54 to 68 N·m).

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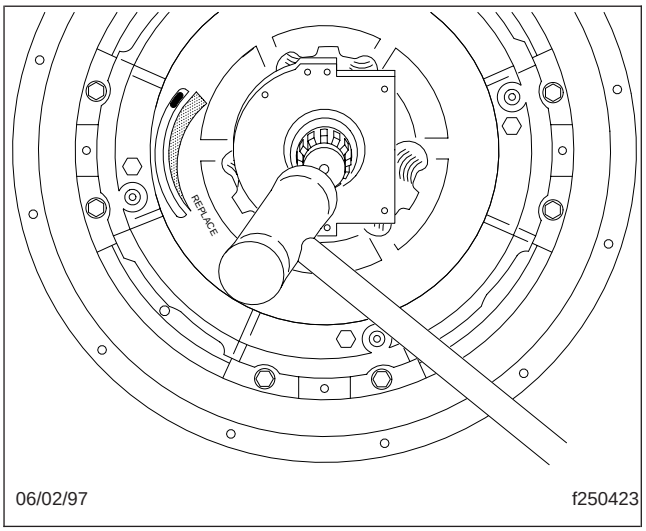



**Fig. 7, Tap Aligning Tool**

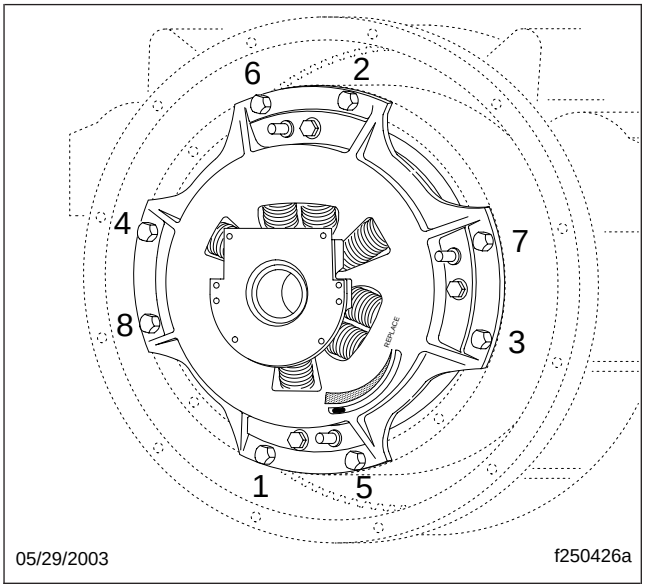



**Fig. 8, Tightening Sequence**

## NOTICE

**Failure to tighten the bolts according to this procedure can have the following effects:**

- preventing the clutch cover from centering into the pilot area of the flywheel;
- causing the clutch assembly to be out-of-balance with the flywheel;
- causing permanent damage to the clutch cover.

10. Following a crisscross pattern, remove and retain the four shipping bolts from the clutch cover. See **Fig. 9**.

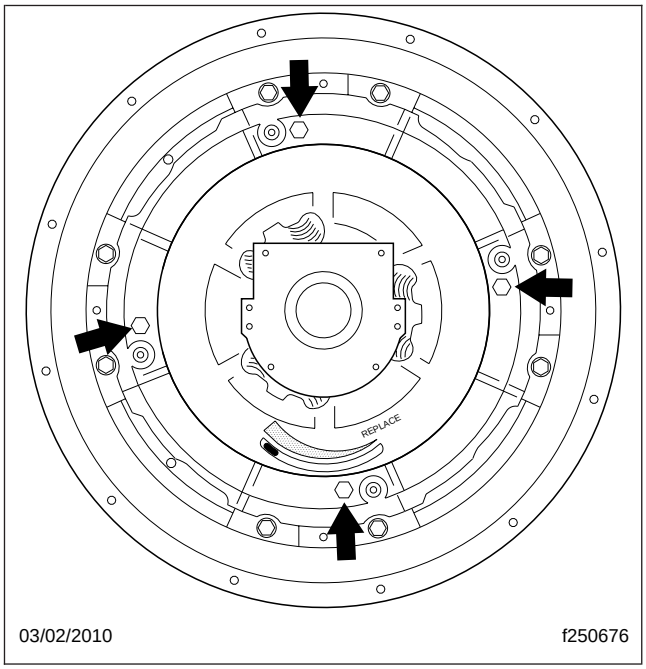



**Fig. 9, Installed Shipping Bolts**

NOTE: These bolts will be needed to secure future clutch assemblies during removal and installation.

11. Remove the aligning tool.

NOTE: Do not be concerned if the release bearing housing touches the clutch cover.

## WARNING

**Wear safety goggles when tapping the pins. If any of the metal parts were to chip, flying pieces of metal could cause eye injury.**

12. To ensure that all four separator pins are flush against the flywheel, insert a 1/4-inch (6-mm) diameter flat-nose punch through the access holes and *lightly* tap each of them toward the flywheel. See **Fig. 10** and **Fig. 11**.

NOTE: Failure to perform this step properly may cause the clutch to drag or not release.

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## 15.5-Inch Solo Clutch Installation

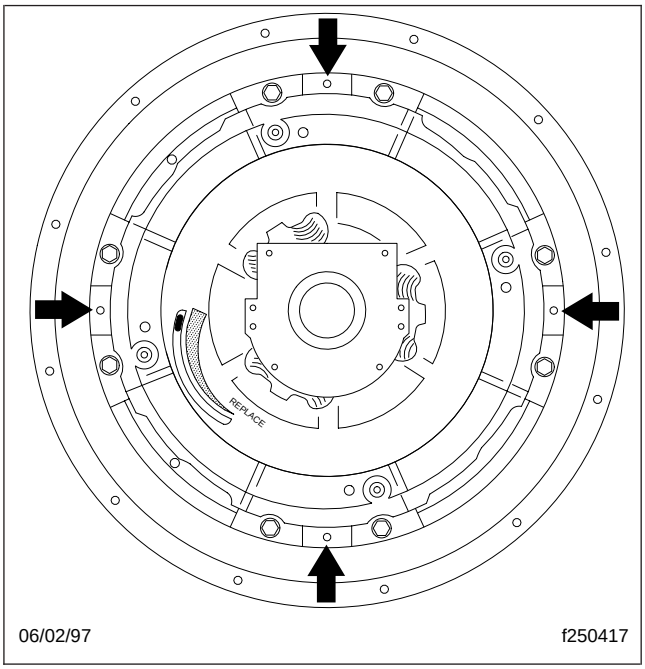
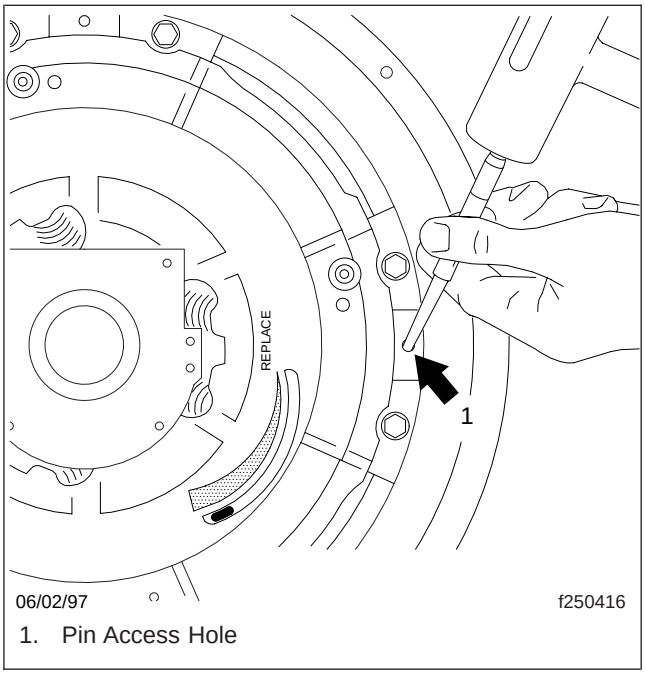



**Fig. 10, Separator Pin Access Holes**




1. Pin Access Hole

**Fig. 11, Tapping A Separator Pin**

13. Using a clean cloth, remove all grease from the input shaft.

NOTE: For lubrication of the release fork fingers, Eaton Fuller recommends a lithium-base grease that can operate up to at least 325°F (163°C) and meets the NLGI Grade 1 or 2 specification.

14. Lubricate the release fork fingers.
15. Shift the transmission into gear so that during assembly the transmission input shaft can be rotated into line with the clutch driven-disc hub splines.
16. Install the clutch brake.

### NOTICE

**Do not excessively force the transmission into the clutch assembly or engine housing. If it doesn't enter freely, investigate the cause of the problem and then make any necessary changes. Don't let the transmission drop or hang unsupported in the driven discs. If this should occur, the rear disc will become bent or distorted, causing the clutch to drag (not release).**

17. Install the transmission and attach the clutch linkage.
18. Lubricate the release bearing as needed; for instructions and recommended lubricants, see **Group 25** of the *Western Star Maintenance Manual*.

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## Installation

1. Do the clutch pre-installation procedures in **Subject 120**.
2. If not already in place, install two 3/8–16 x 3 guide studs in the two upper mounting holes of the flywheel. See **Fig. 1**.

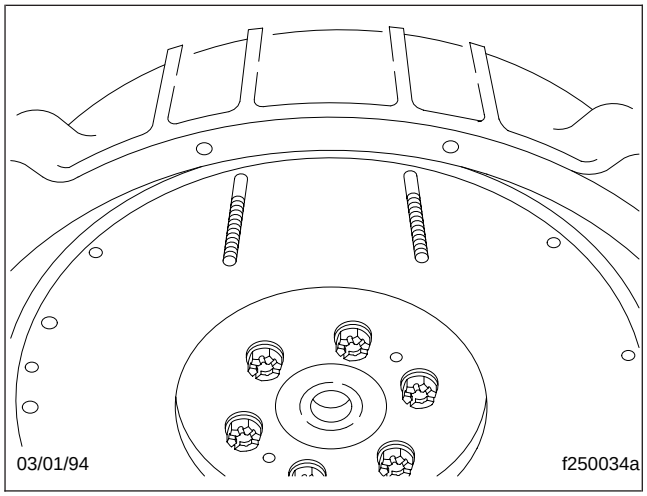



**Fig. 1, Guide Studs, Installed**

3. If the clutch is new, remove any protective coating applied to the pressure plate and the intermediate plate.
4. Insert an aligning tool through the splines of the front disc and, with the side marked *FLYWHEEL SIDE* facing the flywheel, install the front driven disc on the flywheel.

IMPORTANT: The drivestraps of the intermediate plate must face the pressure plate.

5. Install the intermediate plate assembly over the two guide studs and slide it forward until it touches the flywheel. Make sure the side marked PRESSURE PLATE SIDE faces the pressure plate. See **Fig. 2**.
6. Make sure the separator pins protrude toward the flywheel side. The pins should be flush on the pressure-plate side.
7. Remove the aligning tool.
8. Insert the aligning tool through the splines of the rear driven disc and, with the side of the rear disc marked *PRESSURE PLATE SIDE* facing the pressure plate, install the rear driven disc. See **Fig. 3**.

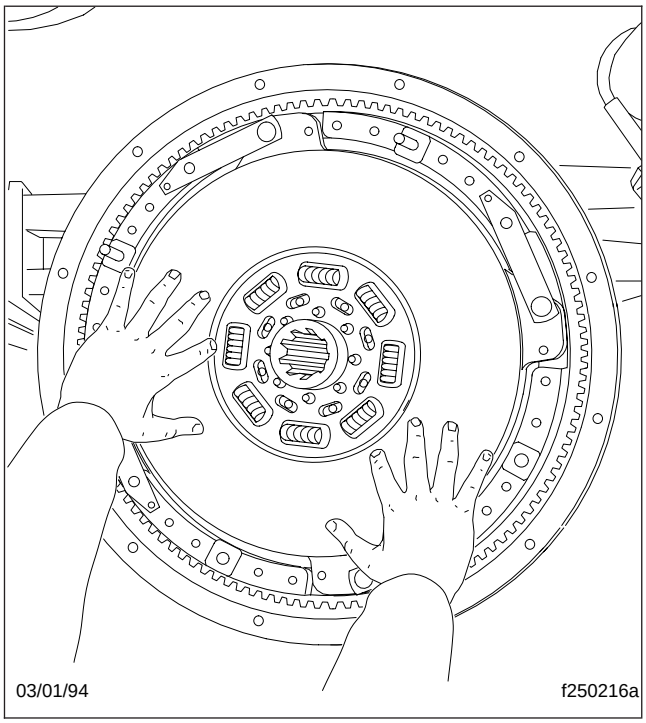



**Fig. 2, Installing the Intermediate Plate**

9. Make sure that the ceramic buttons on each disc are as closely aligned as possible. See **Fig. 4**.

NOTE: Aligning the discs aids the function of the separator pins.

10. With the aligning tool still in place, slide the cover assembly over the aligning tool and the two guide studs until it rests against the intermediate plate assembly.
11. Install the clutch mounting capscrews, as follows. See **Fig. 5** for the tightening sequence.

### NOTICE

**If the capscrews are not tightened in sequence, it may cause permanent damage to the clutch cover and create an out-of-balance condition.**

11.1 Start six 3/8–16 (grade 5 or better) mounting capscrews with lockwashers, and tighten them finger-tight.

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## 14-Inch Dual Disc Solo Clutch Installation

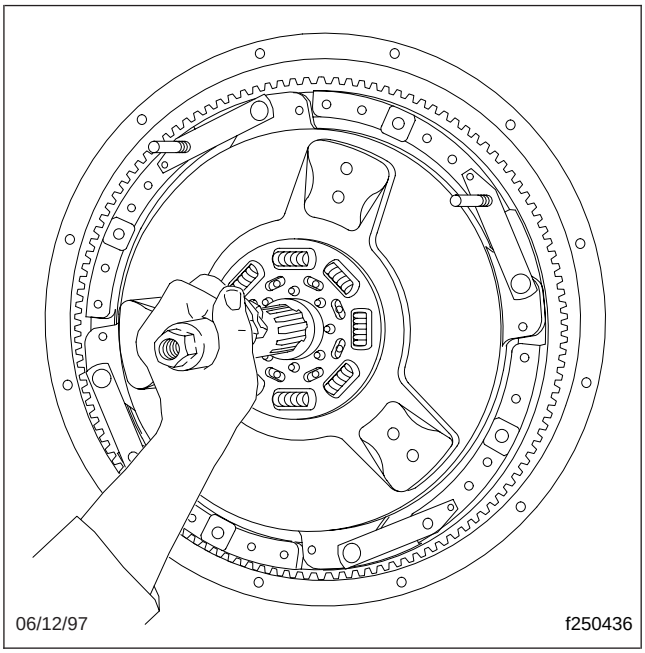
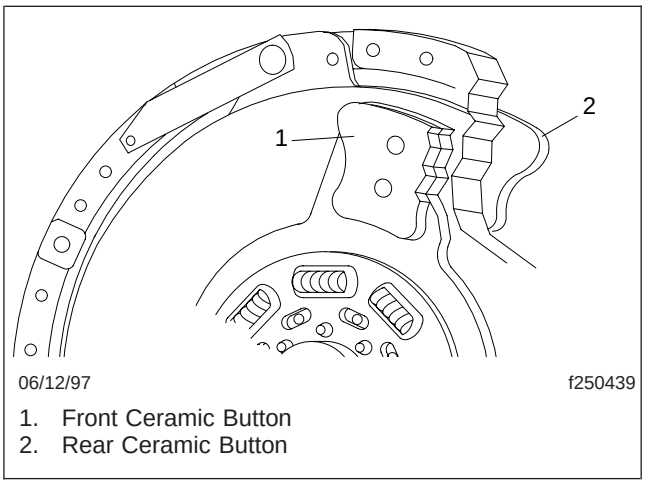



**Fig. 3, Positioning the Rear Disc**




1. Front Ceramic Button
2. Rear Ceramic Button

**Fig. 4, Driven Disc Alignment**

11.2 Remove the guide studs and replace them with the two remaining mounting capscrews, as above.

11.3 Tighten the eight capscrews progressively. The final torque is 30 to 35 lbf·ft (40 to 47 N·m).

12. Remove the aligning tool.

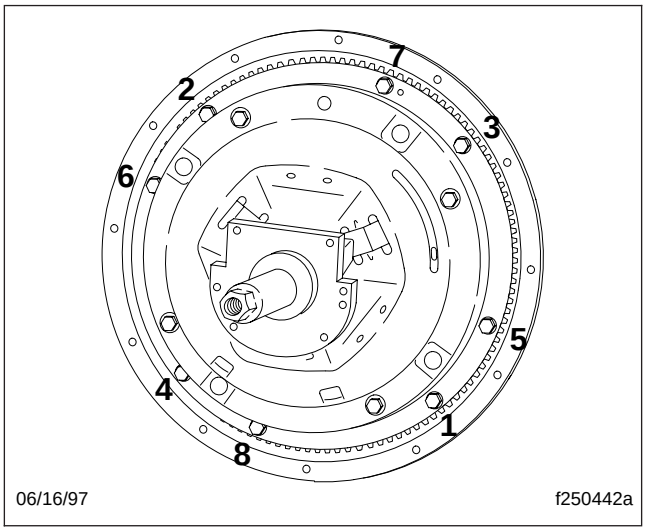



**Fig. 5, Tightening Sequence**

13. Follow a crisscross pattern to remove the four shipping bolts from the clutch cover. See **Fig. 6**.

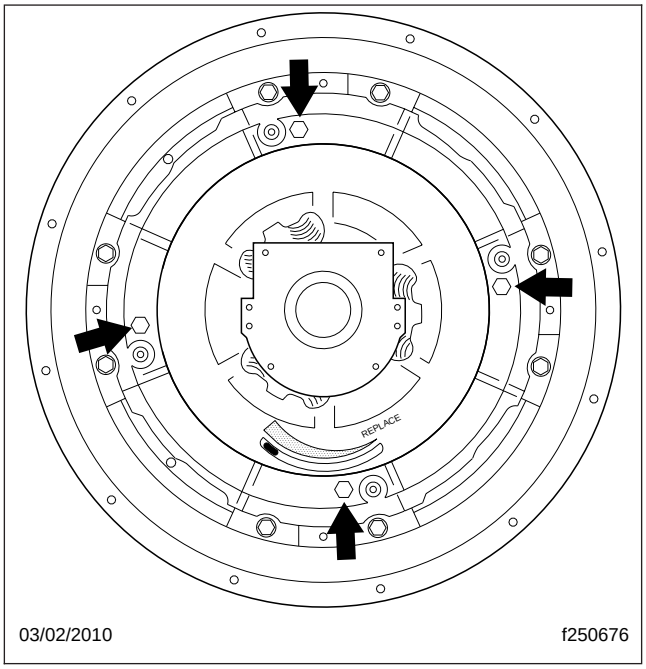



**Fig. 6, Installed Shipping Bolts**

NOTE: Retain the four shipping bolts. These bolts will be needed in the future to secure the clutch assembly during removal and installation.

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**WARNING**

**Wear safety goggles when tapping the pins. If any of the metal parts were to chip, flying pieces of metal could cause eye injury.**

NOTE: Only a small portion of each separator pin is visible through the access hole. See **Fig. 7** and **Fig. 8**.

14. To ensure that all four separator pins are flush against the flywheel, insert a 1/4-inch (6-mm) diameter flat-nose punch through the access holes and lightly tap each of them toward the flywheel. See **Fig. 9**.

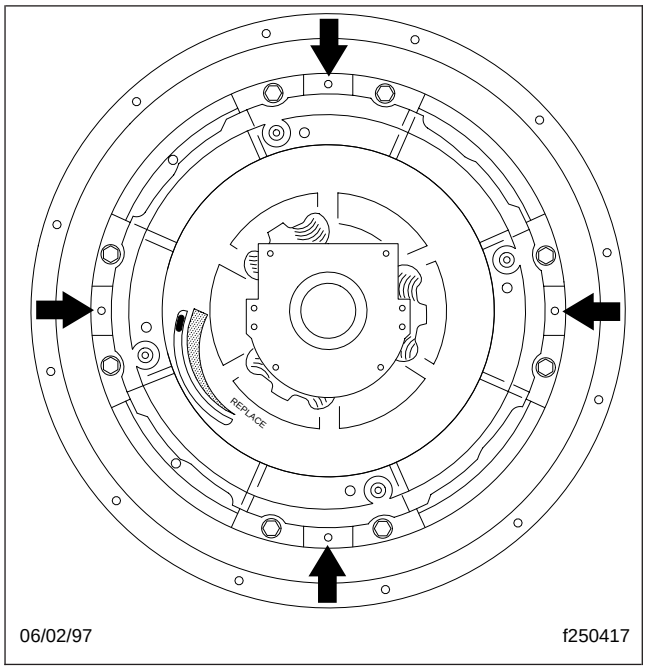
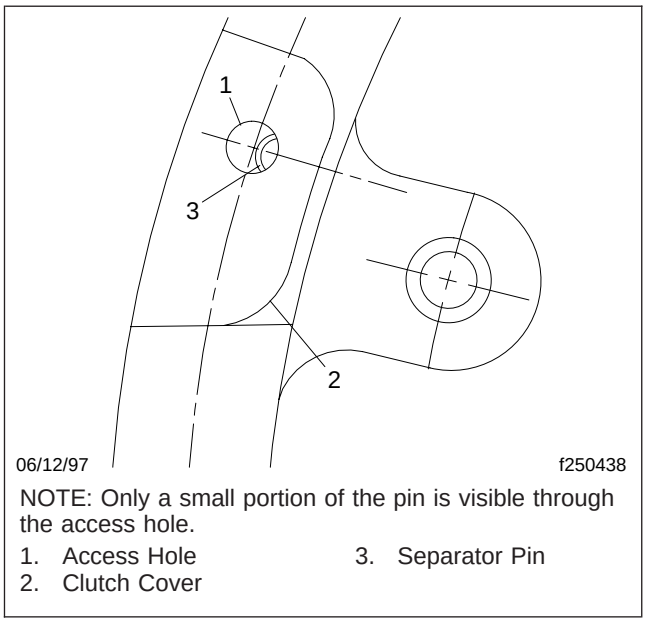



**Fig. 7, Separator Pin Access Holes**

NOTE: Do this step to ensure that all four pins are flush against the flywheel. This allows an equal gap on all sides of the intermediate plate during clutch disengagement.

15. Using a clean cloth, remove all grease from the input shaft.
16. Lubricate the release fork.




NOTE: Only a small portion of the pin is visible through the access hole.

1. Access Hole
2. Clutch Cover
3. Separator Pin

**Fig. 8, Separator Pin Access**

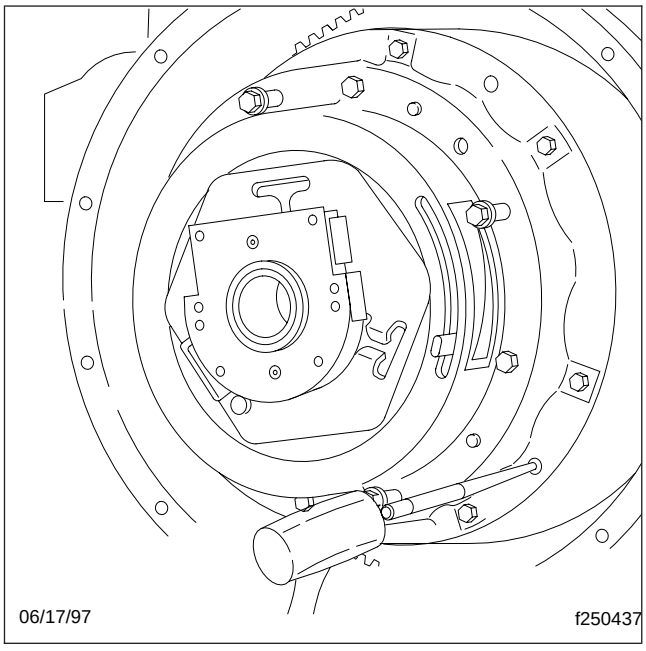



**Fig. 9, Setting the Separator Pins**

17. Shift the transmission into gear so that during assembly the transmission input shaft can be rotated into line with the clutch driven-disc hub splines.
18. Install the clutch brake, if equipped.

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## 14-Inch Dual Disc Solo Clutch Installation

### NOTICE

**Do not excessively force the transmission into the clutch assembly or engine housing. If it does not enter freely, investigate the cause of the problem and then make any necessary changes. Do not let the transmission drop or hang unsupported in the driven discs. If this should occur, the rear disc will become bent or distorted, causing the clutch to drag (not release).**

19. Install the transmission and attach the clutch linkage. For instructions, see **Group 26**.
20. Lubricate the release bearing as needed; for instructions and recommended lubricants, see **Group 25** of the *Western Star Maintenance Manual*.

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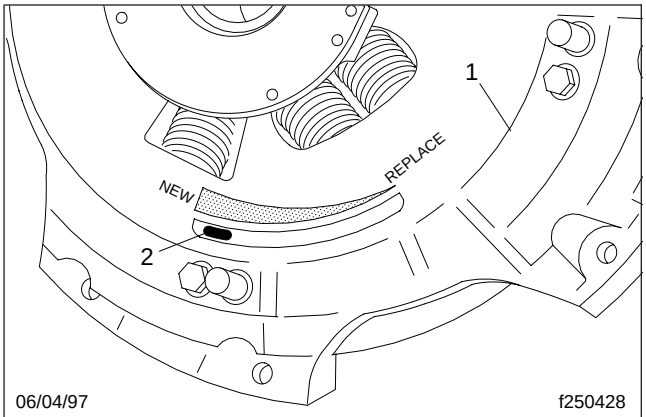


For vehicles equipped with a Solo clutch, when there is excessive free pedal, try resetting the clutch.

## Resetting

NOTE: This procedure requires two persons; one under the vehicle with access to the wear indicating tab, and the other in the vehicle to operate the clutch pedal.

1. Park the vehicle on a level surface. Shut down the engine, set the parking brake, and chock the tires.
2. Inside the cab, press the clutch pedal all the way down, and hold it there until instructed to release it later in this procedure.
3. Through the clutch cover inspection panel, use moderate force to slide the wear indicating tab leftward until it is at the NEW position on the indicator. See **Fig. 1**. If the tab does not move, use the clutch reset tool as described later in this subject.




With the clutch pedal down, set the tab to the "NEW" position on the indicator.

1. Clutch Cover
2. Wear Indicating Tab

**Fig. 1, Resetting the Wear Indicating Tab**

4. Release the clutch pedal.
5. Through the clutch inspection cover, remove the gap between the sleeve and the pin, as follows. See **Fig. 2**.

   *For a 14-inch clutch*, install four 3/8–16 x 1-1/4 shipping bolts (if available) or hexhead machine screws into the four clutch cover holes, and use a hand tool to tighten them until the gap is removed and the bolts are snug.

   *For a 15.5-inch clutch*, install four 7/16–14 x 1-3/4 shipping bolts (if available) or hexhead machine screws into the four clutch cover holes, and use a hand tool to tighten them until the gap is removed and the bolts are snug.
6. Remove the bolts.
7. Press the clutch pedal all the way down, and squeeze the clutch brake five times to reposition the bearing.

NOTE: The release bearing travel tool A02–12419 may be used in the following step. This tool is available through the PDCs.

8. Measure the distance between the clutch brake and the release bearing. It should be between 0.49 and 0.56 inch (12.5 to 14.2 mm). If it is not within this range, refer to the literature available on the Roadranger website, **www.roadranger-.com**.

   If you are using the release bearing travel tool A02–12419 (see **Fig. 3**) for this measurement, position it so that the legs at the blue 0.56-inch (14.3-mm) end straddle the transmission input shaft. If it fits loosely, the gap is too wide. If it does not fit in the gap, try inserting the green 0.50-inch (12.7-mm) end. If the green end of the tool fits, snug or loose, then no adjustment is needed. If the gap is too wide or the green end does not fit in the gap, refer to literature available on the Roadranger website, **www.roadranger-.com**.

## Using the Clutch Reset Tool

See **Table 1** for more information about the clutch reset tool.

1. While an assistant holds down the clutch pedal, insert the tip of the clutch reset tool through the access panel and position it under the bearing. Align the tool so that the threaded bolt extends into the slot in the cam. See **Fig. 4**.

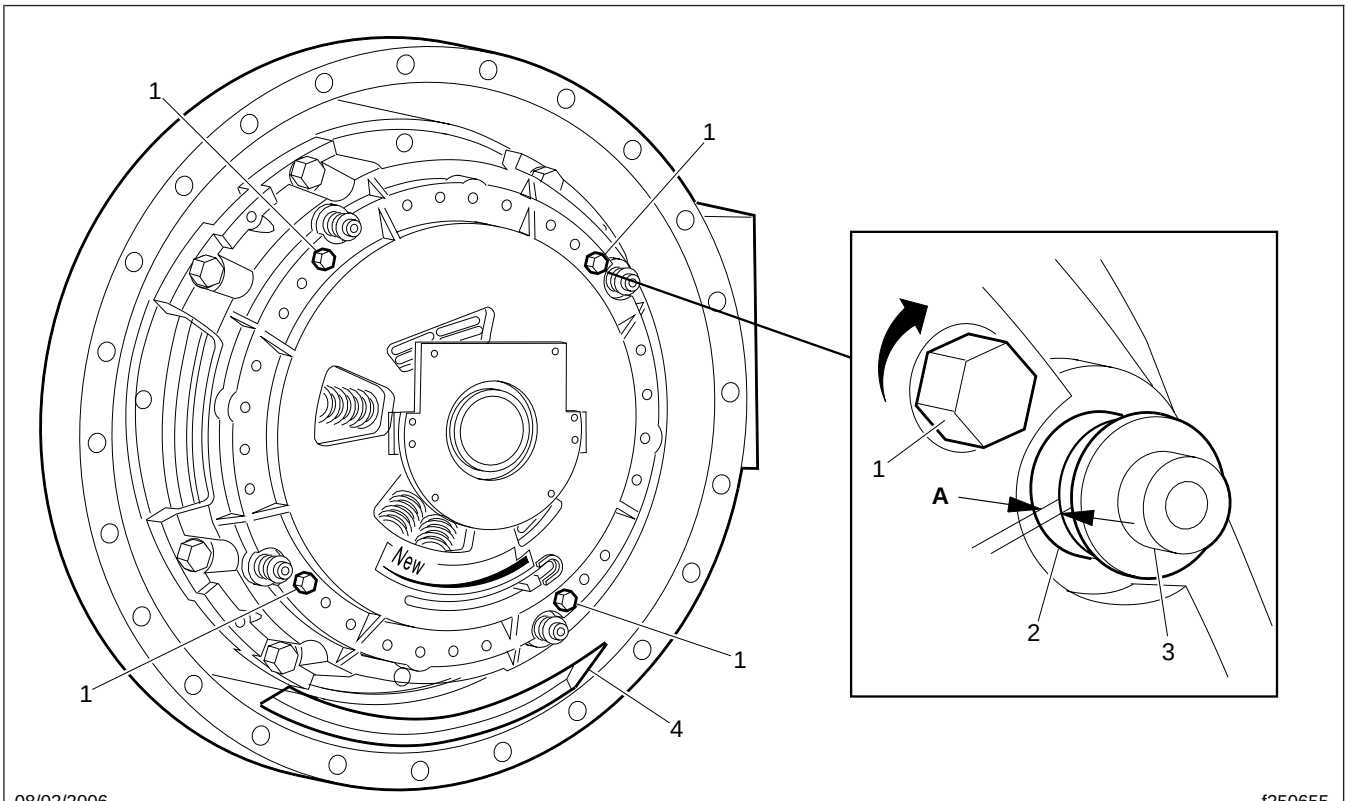
### NOTICE

**Use the clutch reset tool carefully. Do not use heavy force on it; heavy force can break the cam.**

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## Resetting a Solo Clutch



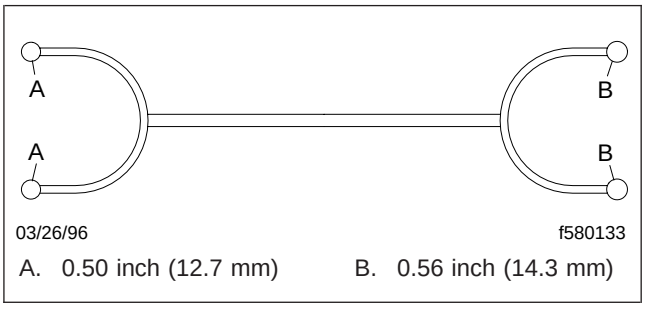

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NOTE: The bell housing is shown transparent to provide a clear view of clutch components.

A. Gap Between the Sleeve and the Pin

1. Bolt
2. Sleeve
3. Pin
4. Access Panel

**Fig. 2, Removing the Gap Between the Sleeve and the Pin**




03/26/96 f580133

A. 0.50 inch (12.7 mm) B. 0.56 inch (14.3 mm)

**Fig. 3, Release Bearing Travel Tool A02–12419**

2. Using the tool, carefully try to move the cam toward the NEW position.

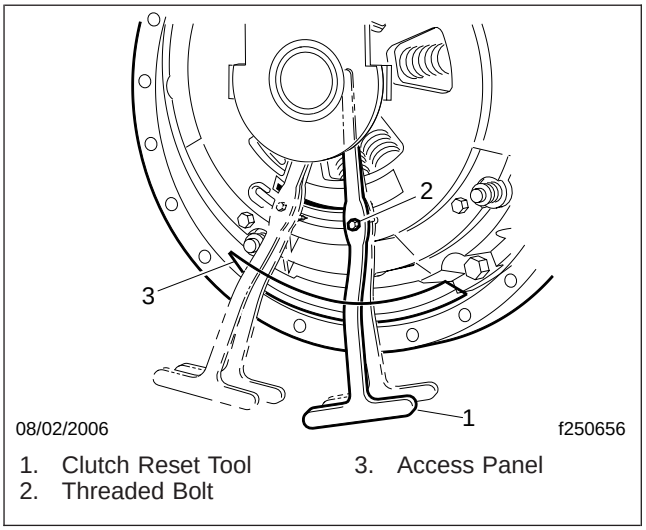
   **If the cam moves easily**, resume the resetting procedure.

   **If the cam does not move**, go to the next step.

3. Loosen the transmission, and install 1/4" spacers between the flywheel housing and bell housing.
4. While an assistant holds down the clutch pedal, use the clutch reset tool to move the tab to the NEW position.
5. Once the tab is in the NEW position, release the clutch pedal and remove the spacers.
6. Tighten the transmission mounting bolts; see **Group 26** for torque values.
7. Resume the resetting procedure.

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1. Clutch Reset Tool
2. Threaded Bolt
3. Access Panel

**Fig. 4, Resetting the Clutch with the Clutch Reset Tool**

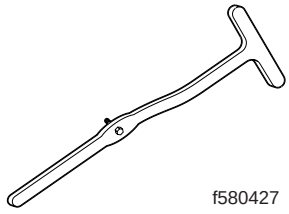
| Clutch Reset Tool | | |
|---|---|---|
| **Tool** | **Description** | **Eaton Tool Part Code** |
|  f580427 | Clutch Reset Tool | CLPI-SOLOTOOL |

**Table 1, Clutch Reset Tool**

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# Troubleshooting Tables

**Problem—The Clutch Does Not Release Completely**

| Problem—The Clutch Does Not Release Completely | |
|---|---|
| **Possible Cause** | **Remedy** |
| The clutch pedal height is incorrect. | Adjust the clutch to obtain the following settings:<br>• 1/2 to 9/16 inch (12.7 to 14.3 mm) release bearing travel;<br>• 1/2 to 1 inch (12.7 to 25.4 mm) clutch brake squeeze.<br>For clutches with mechanical linkage, also make adjustments to obtain 0.105 to 0.145 inch (2.7 to 3.7 mm) release yoke free-travel. (Clutches with hydraulic linkage will have constant contact between the yoke and clutch bearing pads.) |
| The bushing in the release bearing sleeve assembly is damaged. | Replace the clutch cover. |
| The clutch cover assembly is not properly seated into the flywheel. | Re-seat the clutch cover assembly into the flywheel. Use a crisscross pattern when tightening the mounting bolts. |
| The intermediate plate and/or pressure plate is cracked or broken. | Replace any damaged parts. |
| The cross shafts protrude through the release yoke (a side-loading condition exists). | Check for protruding cross shafts. Repair or replace as necessary. |
| The release yoke fingers are bent or worn (a side-loading condition exists). | Install a new release yoke. |
| The engine housing and bell housing are misaligned (a side-loading condition exists). | Check for loose transmission mounting bolts. Tighten the transmission mounting bolts to the proper torque. |
| The clutch linkage is set up improperly (a side-loading condition exists). | Thoroughly examine the clutch linkage and adjust as necessary. |
| The driven discs are distorted or warped. | Replace any distorted or warped driven discs. If the transmission is allowed to hang unsupported during clutch installation, the driven discs may become distorted. |
| The driven discs are installed backwards, or the front and rear driven discs were switched with each other. | Install new driven discs. Also, check the clutch cover for any damage. Replace the clutch cover if damaged. |
| The input shaft spline is worn. | Replace the input shaft. Also, check the driven disc hubs for wear. Replace the driven discs if worn. |
| The input shaft spline is coated with grease, anti-seize compound, etc. | Clean and dry the input shaft spline before installation. |
| The input shaft splines are twisted. | Select a new driven disc and slide it along the full length of the splines. If the disc does not slide freely, replace the input shaft. |
| The input-shaft bearing cap is worn. | Replace the input-shaft bearing. |
| The flywheel pilot bearing fits either too tight or too loose in the flywheel and/or end of input shaft. | Check the pilot bearing for proper fit and replace it if worn. |
| The pilot bearing is dry or damaged. | Replace the pilot bearing. |

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## Troubleshooting

| Problem—The Clutch Does Not Release Completely | |
|---|---|
| **Possible Cause** | **Remedy** |
| The positive separator pins are bent, damaged or incorrectly set. | Be sure to use the proper tool when setting the positive separator pins. Also, take great care when handling the intermediate plate. For procedures, see the appropriate clutch installation subject. |
| The clutch brake is damaged and/or not functioning. | Install a new clutch brake. |
| The driven disc faces are coated with oil or grease. | Replace the driven disc assemblies. Cleaning the old driven discs is not recommended. |
| There is foreign material (dirt, chaff, salt, etc.) inside the clutch cover. | Remove the foreign material and make sure the clutch inspection cover is installed. |
| The drive pins are cocked, causing the intermediate plate to stick on the drive lugs (Easy Pedal only). | The drive pins must be ninety degrees square to the flywheel surface with a 0.006-inch (0.15-mm) minimum clearance between drive pins and intermediate plate slots. Repair or replace as necessary. |
| The pressure plate is not fully retracting (Easy Pedal only). | Check the pressure plate return springs through the clutch inspection cover. If any are bent, stretched, or broken, replace them as necessary. |
| The release bearing travel is excessive and is causing the lever to contact the pressure plate (Easy Pedal only). | Adjust the release bearing travel from 1/2 to 9/16 inch (12.7 to 14.3 mm). |
| The three anti-rattle springs were installed backwards (Easy Pedal only). | Install the anti-rattle springs so the rounded sections are pointed toward the flywheel/engine. |

**Problem—The Clutch Rattles or Is Noisy**

| Problem—The Clutch Rattles or Is Noisy | |
|---|---|
| **Possible Cause** | **Remedy** |
| There is excessive flywheel runout. | Repair or replace the flywheel. For procedures, see the engine manufacturer's manual. |
| There is corrosion between the input shaft spline and the driven disc hubs. | Clean the mating parts between the input shaft and driven discs to ensure that the discs slide freely over the input shaft spline. |
| The engine idle is too fast. | Readjust engine idle to proper idling speed. |
| The clutch release bearing is dry or damaged. | Lubricate the clutch release bearing. If the noise persists, install a new clutch cover. |
| The flywheel pilot bearing is dry or damaged. | Replace the flywheel pilot bearing. |
| The bridge of the release yoke is hitting the clutch cover (an over-stroking condition exists). | Check for a worn, broken or missing clutch brake. Also, check the release yoke and input-shaft bearing cap for wear. Replace any worn parts. |
| The release yoke fingers are hitting the clutch cover. | Check if the release bearing, clutch cover, or release yoke fingers are worn or broken. Replace worn parts. |
| The clutch inspection cover is not installed. | Re-install the clutch inspection cover. |
| The sleeve bushings are worn. | Investigate for any side-loading conditions on the release bearing housing. If there is a side-loading condition, determine its cause. Also, before installing the new clutch, make sure that the side-loading condition has been corrected. |
| The clutch linkage is rattling excessively. | Clean, lubricate and reassemble or replace missing/worn parts. |

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| Problem—The Clutch Rattles or Is Noisy | |
|---|---|
| **Possible Cause** | **Remedy** |
| An idle gear rattle is coming from the transmission. | Specify low-vibration driven discs. Check the engine for correct idle speed. For procedures, consult the engine manufacturer's manual. |
| The damper spring cover of the driven disc assembly is interfering with the flywheel. | Install the correct clutch assembly. |
| The rivets of the rear driven disc are interfering with the retainer assembly (Easy Pedal only). | Adjust the clutch internally (via the adjustment bolt). For procedures, see **Subject 100**. |

**Problem—The Clutch Vibrates**

| Problem—The Clutch Vibrates | |
|---|---|
| **Possible Cause** | **Remedy** |
| The flywheel is loose. | Retighten the flywheel mounting bolts to the proper specifications. |
| The universal joints are worn. | Replace the worn parts. |
| The driveshaft is not properly phased. | Investigate and correct the phasing of the driveshaft. |
| The driveshaft is not balanced. | Balance and straighten the driveshaft. |
| The driveline angles are incorrect. | Shim the drivetrain components to equalize universal joint angles. |
| The flywheel is not balanced. | Balance the flywheel. |
| The pilot area of the clutch is not completely seated into the flywheel. | Ensure that no dirt, burrs, etc., are preventing the clutch cover from completely seating into the flywheel mounting surface. |
| The engine mounts are loose, damaged, or worn out. | Replace any worn or damaged parts. Retighten all bolts to proper specifications. |
| The engine is misfiring. | The engine is not in tune. To correct the problem, see the engine manufacturer's manual. |
| There is excessive flywheel runout. | Repair or replace the flywheel. For procedures, see the engine manufacturer's manual. |
| The rivets of the rear driven disc are interfering with the retainer assembly (Easy Pedal only). | Adjust the clutch internally (via the adjustment bolt). For procedures, see **Subject 100**. |

**Problem—The Clutch Needs Frequent Adjustments**

| Problem—The Clutch Needs Frequent Adjustments | |
|---|---|
| **Possible Cause** | **Remedy** |
| The release yoke free-travel is insufficient. | After first adjusting the clutch for 1/2 to 9/16 inch (12.7 to 14.3 mm) release bearing travel, adjust the clutch linkage to obtain release yoke free-travel of 0.105 to 0.145 inch (2.7 to 3.7 mm). |
| The clutch specification is incorrect. | Check the clutch specifications in **Subject 400**. Install a new clutch with the proper specifications, if necessary. |
| The cross shafts and/or clutch linkage system is worn. | Investigate the entire clutch linkage system to determine if it is binding or operating sporadically and/or worn excessively. |

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## Troubleshooting

| Problem—The Clutch Needs Frequent Adjustments | |
|---|---|
| **Possible Cause** | **Remedy** |
| The clutch driven discs are worn down to the rivets. | Install a new clutch. For procedures, see the appropriate clutch installation subject. |
| The crankshaft has excessive end play. | Repair or replace the crankshaft. Consult the engine manufacturer's manual for procedures. |

**Problem—The Clutch Slips**

| Problem—The Clutch Slips | |
|---|---|
| **Possible Cause** | **Remedy** |
| The clutch pedal has no free travel. | Readjust the clutch. |
| The clutch is overloaded. | Verify that the proper clutch has been specified for the particular vehicle application. |
| The release mechanism is binding. | Free up the release mechanism and linkage. Also, check the clutch linkage adjustment. |
| The driven disc faces are coated with oil or grease. | Replace the driven disc assembly. |
| The driver is riding the clutch pedal. | Use correct driving procedures. |
| The input shaft spline is worn. | Replace the input shaft. |

**Problem—The Clutch Grabs or Chatters**

| Problem—The Clutch Grabs or Chatters | |
|---|---|
| **Possible Cause** | **Remedy** |
| The clutch is worn out. | Replace the clutch and all worn components. |
| The linkage system is not operating freely. | Check the clutch linkage for binding or excessive wear. Replace all worn parts. |
| The driven disc faces are coated with oil or grease. | Replace the driven disc assembly. |
| The engine mounts are loose. | Retighten the engine mounts to manufacturer's specifications. |
| The release yoke fingers and/or the release bearing wear pads are worn excessively. | Replace all the worn parts. |

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## Specifications

| Clutch Torque Values | | | |
|---|---|---|---|
| **Description** | **Size** | **Grade** | **Torque: lbf·ft (N·m)** |
| Mounting Bolts, Clutch Cover to Flywheel on 14-inch clutch | 3/8–16 x 1-1/4 | 5 | 30–35 (40–47) |
| Mounting Bolts, Clutch Cover to Flywheel on 15.5-inch clutch | 7/16–14 x 2-1/4 | 5 | 40–50 (54–68) |

**Table 1, Clutch Torque Values**

| Minimum Flywheel Bores | |
|---|---|
| **Disc Type** | **Minimum Flywheel Bore in inch (mm)** |
| 10-Spring | 8.562 (217.48) |
| 9-Spring | 9.750 (247.65) |
| 8-Spring | 7.250 (184.15) |
| 7-Spring | 9.750 (247.65) |
| 6-Spring | 9.750 (247.65) |

**Table 2, Minimum Flywheel Bores**

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## General Description

Meritor clutches (**Fig. 1**) are available in 14-inch and 15-1/2 inch models in Western Star trucks. An identification plate is located on the front cover. Meritor clutches feature the following design characteristics:

- Two-plate
- Diaphragm-spring
- Pull-type
- Dry-disc
- Eight-hole installation pattern

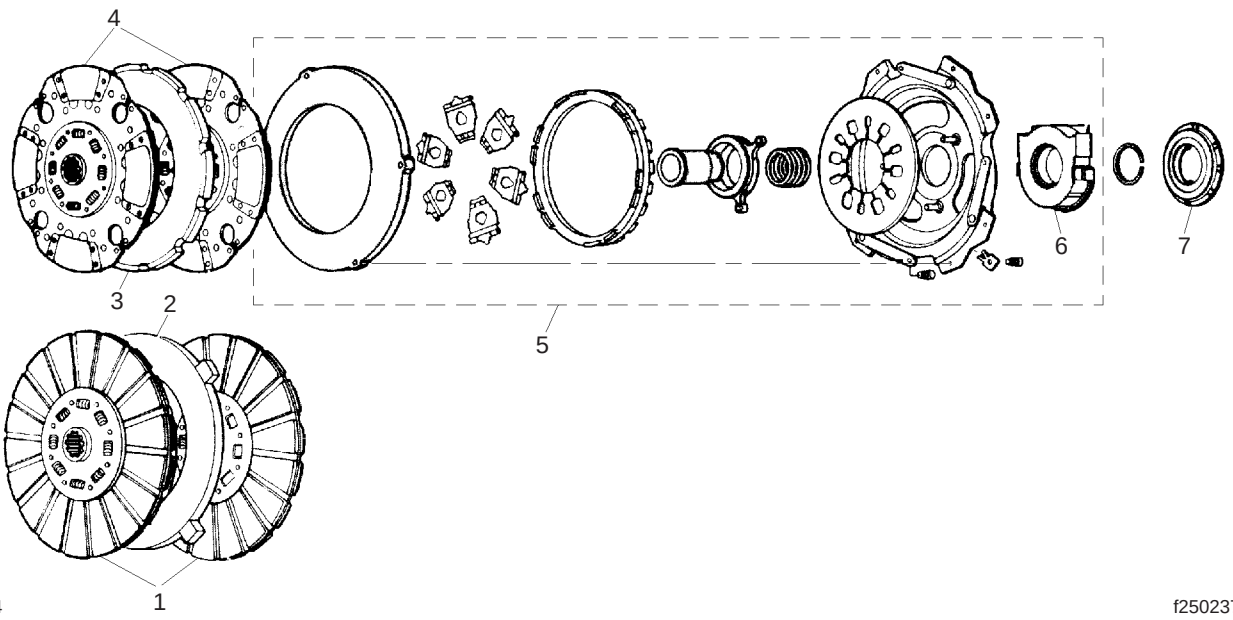
Mounted directly on the flywheel, the clutch cover assembly houses most of the components, including the pressure plate. A diaphragm-type spring provides the force necessary to push the pressure plate forward and engage the clutch.

In the 14-inch model, the center plate, which separates the driven discs, is carried on drive pins mounted on the flywheel. In the 15-1/2 inch model, the center plate has tabs that fit into slots on the clutch cover assembly.

A splined transmission input shaft projects through the cover assembly and driven discs and rests in a pilot bearing in the center of the flywheel. The splined hubs of the driven discs mesh with the splined input shaft to transmit power from the engine to the transmission. The rest of the clutch assembly can spin freely around the input shaft when the clutch pedal is depressed.

A clutch brake stops the transmission gears from rotating when the truck is stopped and when shifting into first or reverse gears. This lets the gears engage quickly without gear clash.

The release bearing assembly transfers the movement of the clutch linkage to engage or disengage the clutch. The release bearing assembly is available with a grease fitting or as a "lubed for life" assembly. Ball bearings permit the release bearing to rotate freely. A coil spring is installed on the sleeve between the release bearing and the hub. The coil spring holds the sleeve on the retainer in a "ball joint" arrangement. This prevents vibration and allows for minor misalignment that may occur between the




1. Molded Organic Discs
2. Center Plate (15-1/2 Inch Clutch)
3. Center Plate (14-Inch Clutch)
4. Ceramic Discs
5. Pressure Plate and Cover Assembly
6. Release Bearing
7. Clutch Brake

**Fig. 1, Meritor Two-Plate Clutch**

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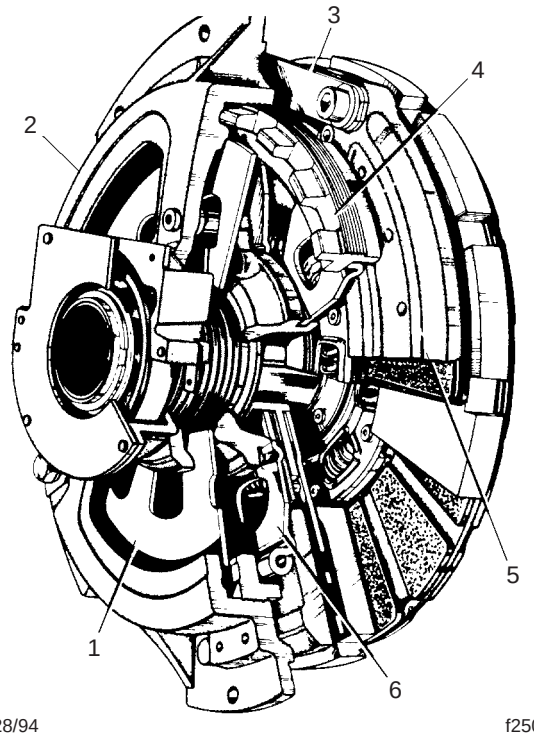


## General Information

transmission and the engine due to tolerances between the mounting surface dimensions.

The pressure plate and cover assembly apply the force necessary to engage the clutch. The following parts are in the pressure plate and cover assembly. See **Fig. 2**.

- The *cover* is the housing for the diaphragm spring, adjusting ring, levers, retainer, and the release bearing sleeve. Three holes in the cover provide air flow to remove heat from the clutch.



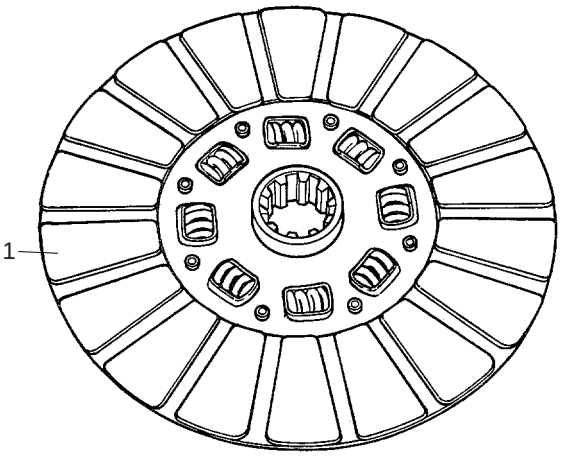

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1. Diaphragm Spring
2. Cover
3. Strap
4. Adjusting Ring
5. Pressure Plate
6. Lever

**Fig. 2, Clutch Components**

- The *diaphragm spring* is a one-piece unit that produces the pressure to lock the discs between the pressure plate, the center plate, and the flywheel. The spring is located and held in the cover by the retainer. The diaphragm spring design reduces the clutch pedal effort as compared to a coil spring design.
- Six *levers* connect the cover assembly to the release bearing sleeve. The levers multiply and transfer the force of the diaphragm spring from the retainer to the pressure plate.
- The *adjusting ring*, located inside the cover and in front of the pressure plate, controls the release bearing clearance. The clearance must be adjusted periodically to compensate for clutch lining wear.
- The *pressure plate* applies the force from the diaphragm spring and locks the clutch discs between the center plate and the flywheel.

The clutch discs are splined to allow movement along the transmission input shaft. Power is transmitted from the flywheel, pressure plate, and center plate through the discs to the transmission. Both dampened and rigid discs are available. See **Fig. 3** and **Fig. 4**. Dampened clutch discs absorb vibration with spring washers, friction material, and co-axial torsion springs. The co-axial torsion springs also absorb torque shock during engagement. Rigid discs do not use any material to absorb vibration or torque shock.




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1. Molded Organic Lining

**Fig. 3, Dampened Disc**

Two kinds of lining are available on the discs: molded organic linings (on rigid and dampened discs) and ceramic linings (on dampened discs only).

Molded organic linings (**Fig. 3**), are made from a non-asbestos material. The organic material is integrally molded directly onto the disc. The groove pat-

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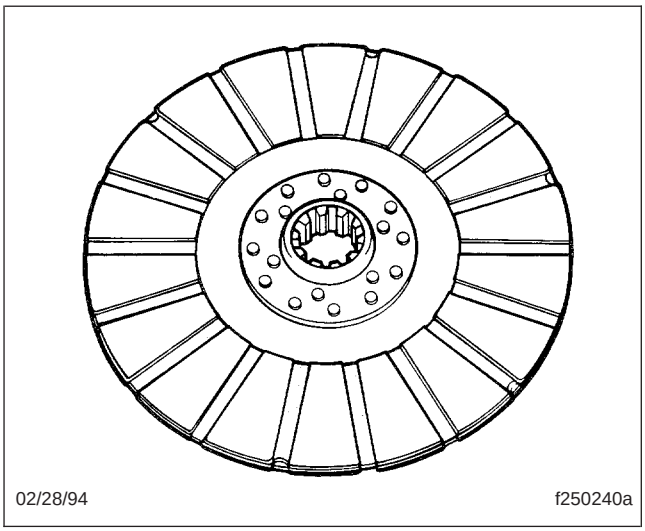
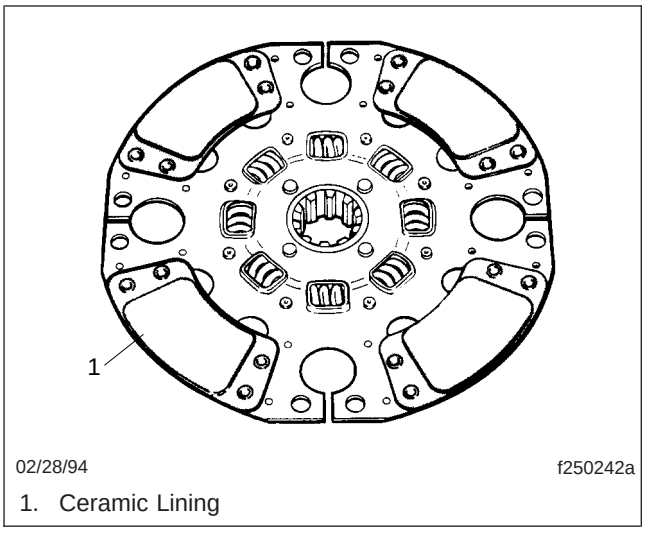



**Fig. 4, Rigid Disc**

tern of the molded organic lining removes dust formed during lining wear and also promotes cooling. Clutch engagement with the organic lining is less abrupt than with the ceramic lining.

Ceramic disc linings (**Fig. 5**), are made from ceramic and bronze material. Rivets fasten the ceramic lining to the disc. The ceramic lining provides positive clutch engagement.




1. Ceramic Lining

**Fig. 5, Ceramic-Lined Disc**

The center plate increases the service life of the clutch by increasing the surface area for power transfer. The 14-inch clutch center plate is driven by pins in the flywheel housing, which fit into slots on the plate. The 15-1/2 inch clutch center plate is driven by tabs on the plate which fit into slots on the clutch cover.

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## Clutch Internal Adjustments

NOTE: Clutch linkage adjustment is required only after repair or replacement of the clutch or clutch linkage components.

Internal clutch adjustments should be done whenever:

- the clutch is removed or installed
- any component of the clutch linkage is serviced
- the free travel of the clutch pedal is less than 1/2 inch (13 mm).

Make sure of the following before adjusting the clutch:

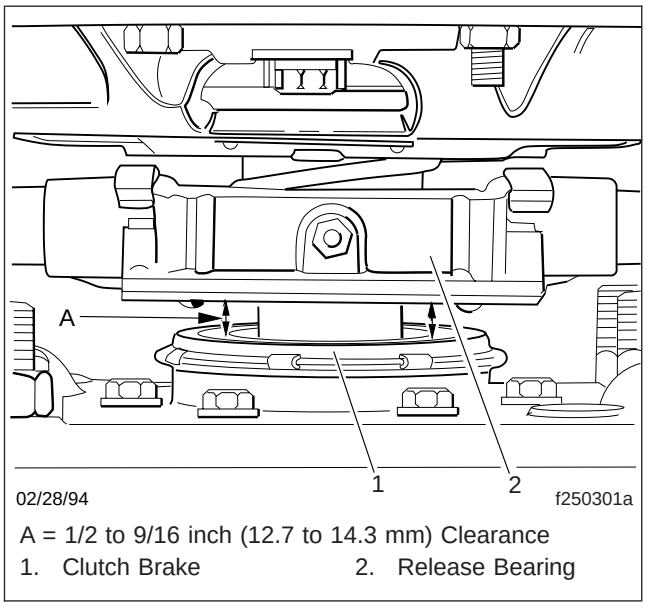
- The clutch system is in good condition.
- The linkage is tight but moves freely during operation.
- There is no "false" free travel. Keep the clutch lever from moving and depress the clutch pedal. If the pedal moves more than 1/2 inch (13 mm), "false free travel" is in the linkage. Inspect the linkage and all pivot points for wear or damage. Repair or replace worn or damaged parts.
- The release fork moves when the clutch pedal moves.

## Release-Bearing Clearance Check

1. Remove the inspection hole cover on the clutch housing.
2. Measure the distance between the end of the release bearing and the clutch brake. See **Fig. 1**. This distance must be 1/2 to 9/16 inch (12.7 to 14.3 mm).

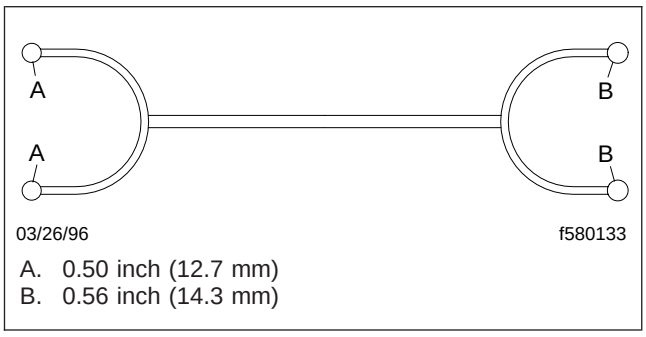
NOTE: While checking this dimension, pull the release bearing toward the transmission, using your hand or a screwdriver.

IMPORTANT: An inspection tool A02–12419 (available through the PDCs) can be used to check the distance between the release bearing and the clutch brake. See **Fig. 2**. One end of the tool has green tape on it and is 0.50 inch (12.7 mm) in diameter; the other end has blue tape on it and is 0.56 inch (14.3 mm) in diameter.




A = 1/2 to 9/16 inch (12.7 to 14.3 mm) Clearance
1. Clutch Brake
2. Release Bearing

**Fig. 1, Measure the Distance Between the Release Bearing and the Clutch Brake**




A. 0.50 inch (12.7 mm)
B. 0.56 inch (14.3 mm)

**Fig. 2, Inspection Tool A02-12419**

3. If using tool A02–12419 to check the distance between the release bearing and the clutch brake, position the tool so that the legs straddle the transmission input shaft. Check the gap with both ends of the tool as follows:
   - 3.1 Insert the blue 0.56-inch (14.3-mm) end. If it fits loosely the gap is too wide and adjustment is needed. Go to the next step.
   - 3.2 If the blue 0.56-inch (14.3-mm) end can't be inserted in the gap, then try to insert the green 0.50-inch (12.7-mm) end. If the

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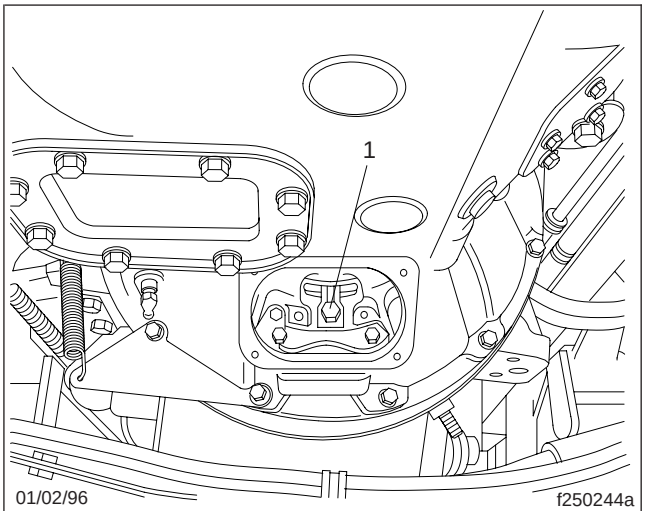
## Clutch Internal Adjustments

green end of the tool fits, snug or loose, then no adjustment is needed.

3.3 If the green end of the tool can't be inserted in the gap, adjustment is needed. Go to the next step.

4. If the release bearing clearance is not correct, adjust the clutch.

4.1 Turn the flywheel so that the lock plate is seen through the inspection cover. See **Fig. 3**.




1. Lock Plate

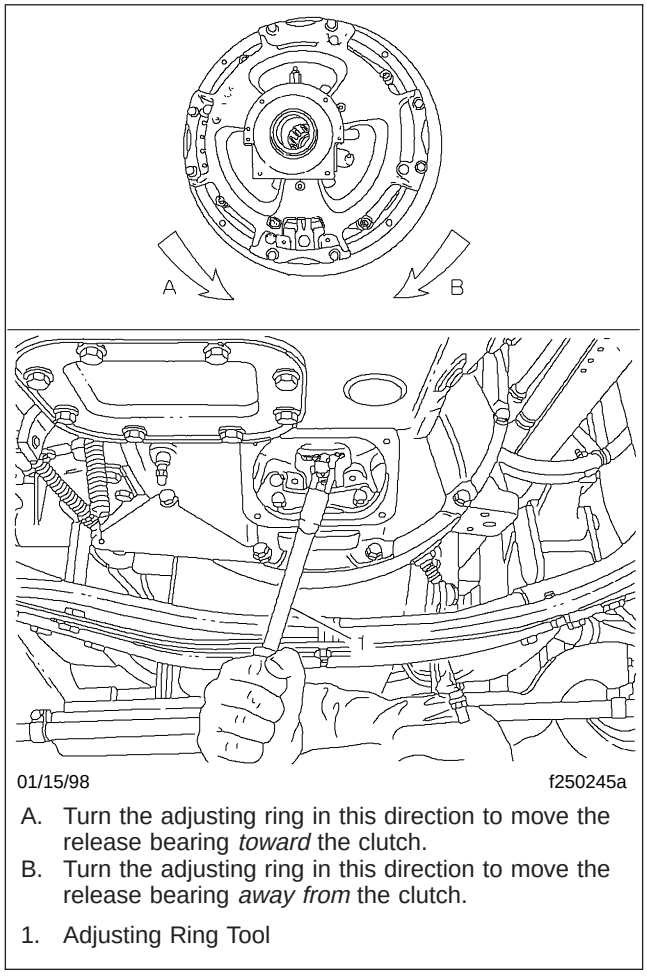
**Fig. 3, Remove the Lock Plate**

NOTE: Do not use the starter to move the flywheel. Turn the crankshaft with a socket wrench on the front pulley. If the front pulley is difficult to turn, use a spanner wrench on the teeth of the flywheel. See the engine manufacturer's manual for further information.

4.2 Push the clutch pedal to the bottom of its travel. Have another person hold the pedal at the bottom of its travel (or use a block of wood to hold the pedal).

4.3 Remove the capscrew and lockwasher that fasten the lock plate to the clutch cover. See **Fig. 3**.

4.4 Turn the adjusting ring to obtain the specified release bearing clearance. Using a screwdriver or an adjusting tool as a lever against the notches in the ring, move the adjusting ring. See **Fig. 4**. When the adjusting ring is moved one notch, the release bearing will move 1/32 inch (about 0.5 mm).




A. Turn the adjusting ring in this direction to move the release bearing *toward* the clutch.
B. Turn the adjusting ring in this direction to move the release bearing *away from* the clutch.

1. Adjusting Ring Tool

**Fig. 4, Turn the Adjusting Ring**

NOTE: The adjusting tool is available from: Kent-Moore Tools, part number J 36216; Owatonna Tools, part number 7028; or, Snap-on Tools, part number GA454.

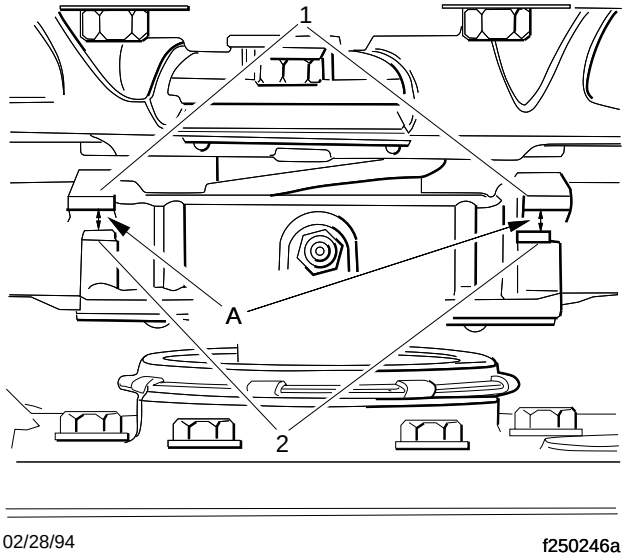
4.5 Install the lock plate. Install the capscrew that fastens the lock plate to the clutch cover. Tighten the capscrew 25 to 30 lbf·ft (34 to 40 N·m).

4.6 Release the clutch pedal.

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5. Check the clearance between the tips of the release fork and the bosses on the release bearing. The distance must be 0.105 to 0.145 inch (2.7 to 3.7 mm). See **Fig. 5**. If necessary, adjust the clutch linkage.




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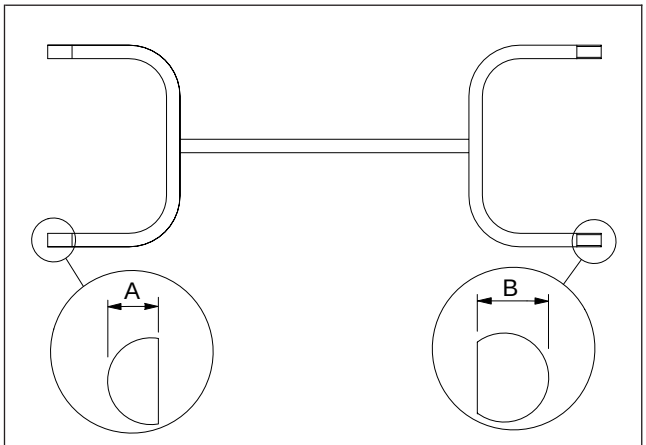
NOTE: A = 0.105–0.145 inch (2.7–3.7 mm) Clearance
1. Release Fork
2. Boss on Release Bearing

**Fig. 5, Check the Clearance**

NOTE: The pedal must be released to check the release bearing clearance.

IMPORTANT: An inspection tool A02–12254 (available through the PDCs) can be used to check the distance between the bosses on the release bearing and the tips of the release fork (free travel). See **Fig. 6**. The legs on one end of the tool have green tape on them and are 0.105 inch (2.7 mm) thick; the legs on the other end have blue tape on them and are 0.145 inch (3.7 mm) thick.

6. If using tool A02–12254 to check the distance between the release bearing and the release fork, position the tool so it straddles the fork to ensure that there won't be any misalignment. Check the distance with both ends of the tool as follows:




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A. 0.105 inch (2.7 mm)
B. 0.145 inch (3.7 mm)

**Fig. 6, Inspection Tool A02-12254**

6.1 Insert the blue 0.145-inch (3.7-mm) end. If it fits loosely the gap is too wide and adjustment is needed. Go to the section on clutch linkage adjustment in this group.

6.2 If the blue 0.145-inch (3.7-mm) end can't be inserted in the gap, then try to insert the green 0.105-inch (2.7-mm) end. If the green end of the tool fits, snug or loose, then no adjustment is needed.

6.3 If the green end of the tool can't be inserted in the gap, adjustment is needed. Go to the section on clutch linkage adjustment in this group.

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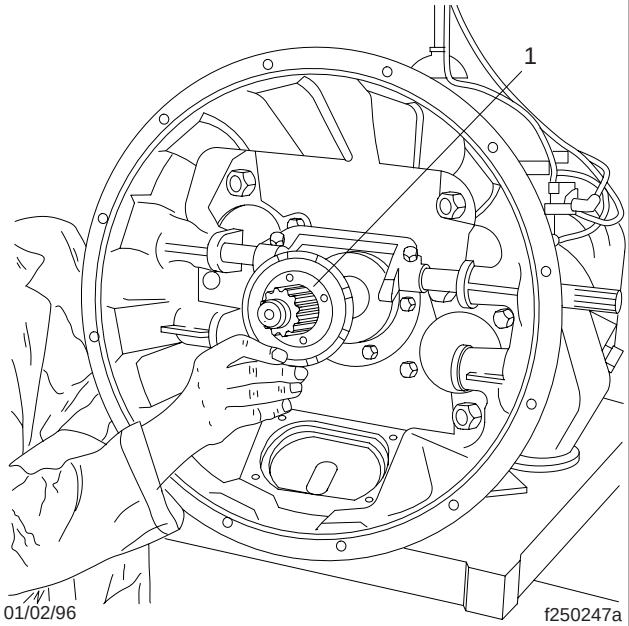
## Removal

1. Remove the transmission.

**CAUTION**

**Do not let the rear of the transmission drop, and do not let the transmission hang unsupported by the input shaft in the pilot bearing bore in the flywheel. Taking these precautions will prevent damage to the clutch assembly and the pilot bearing.**

2. Remove the clutch brake assembly from the transmission input shaft. See **Fig. 1**.

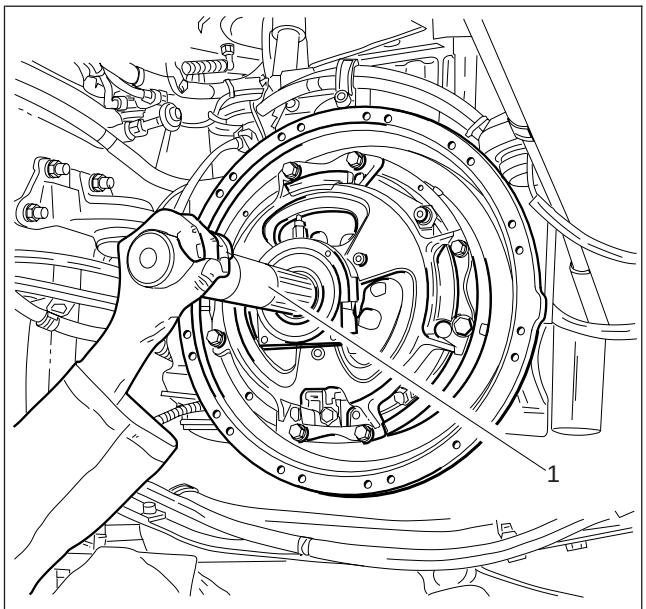



1. Clutch Brake

**Fig. 1, Remove the Clutch Brake Assembly**

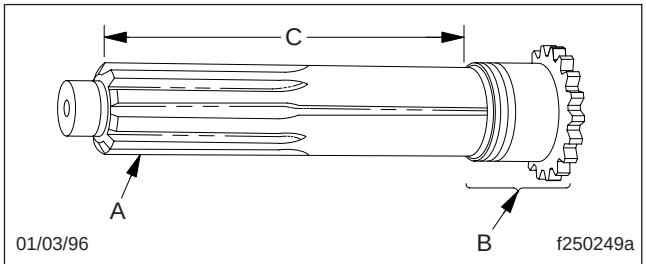
3. Install a clutch alignment tool through the clutch and into the flywheel pilot bearing to support the clutch assembly during removal. Use the correct tool so that the splines of the tool match the splines in the clutch. See **Fig. 2**.

NOTE: If an alignment tool is not available, use an input shaft from a manual transmission. Remove the gear from the end of the input shaft. See **Fig. 3**.




1. Alignment Tool

**Fig. 2, Install the Clutch Alignment Tool**




A. Make sure the splines are not damaged.
B. Remove the gear assembly from an input shaft.
C. 13 Inches (33 cm)

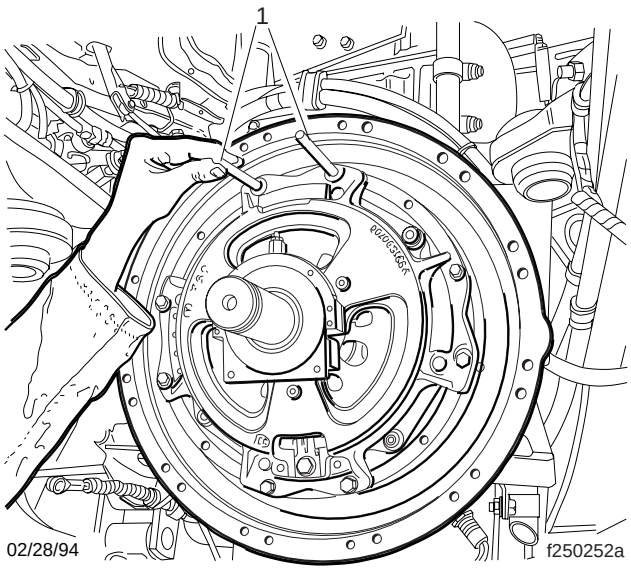
**Fig. 3, Manual Transmission Input Shaft**

4. Remove the top two bolts that fasten the pressure plate and cover assembly to the flywheel. Install two guide studs in the holes. See **Fig. 4**. The studs can be made by removing the head from two capscrews. Use 3/8-inch capscrews for the 14-inch clutch and 7/16-inch capscrews for the 15-1/2 inch clutch.
5. Make two wooden spacer blocks 1/2 to 5/8 inch (13 to 16 mm) thick. Insert them between the release bearing assembly and the clutch cover. The wooden spacer blocks ease removal and installation of the clutch. See **Fig. 5**.

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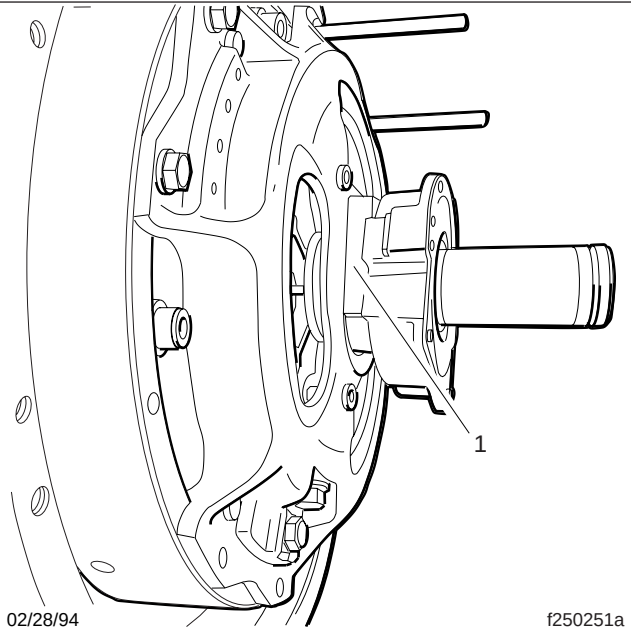


## Clutch Removal




1. Guide Studs

**Fig. 4, Remove the Two Top Bolts**



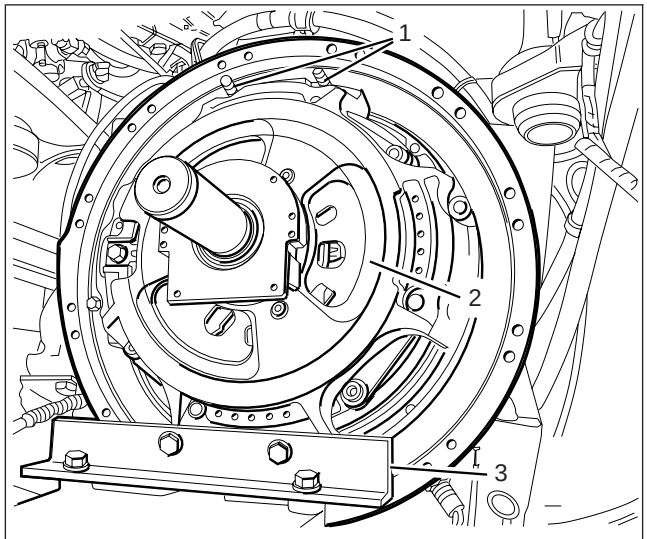

1. 1/2 to 5/8-inch (13 to 16 mm) Spacers

**Fig. 5, Spacer Block**

**WARNING**

**The pressure plate and cover assembly is heavy and should be removed only with a lifting device. If the assembly is lifted improperly or dropped, it could cause serious physical injury.**

6. On 15-1/2 inch clutches, connect a lifting device to the pressure plate and cover assembly because of the weight. See **Fig. 6**.




1. Guide Studs
2. 15-1/2 Inch Clutch Assembly
3. Lifting Device

**Fig. 6, Connect a Lifting Device**

7. Remove the remaining bolts that fasten the pressure plate and cover assembly to the flywheel.

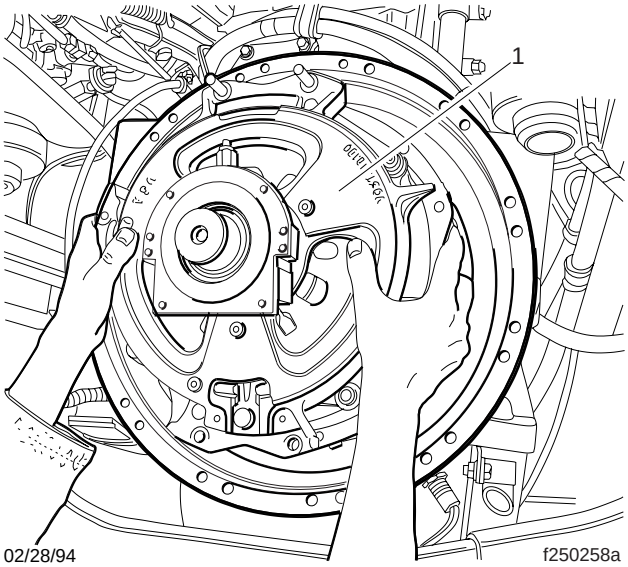
NOTE: When removing the 15-1/2 inch clutch, the discs and the pressure plate can stay in the cover.

8. Lift the pressure plate and cover assembly over the alignment tool and off the flywheel. See **Fig. 7**.
9. Remove the rear disc, the center plate, and the front disc. See **Fig. 8**.
10. Remove the alignment tool from the flywheel.
11. Whenever the clutch assembly is serviced or the engine is removed, the pilot bearing in the flywheel should be removed and replaced. Use an

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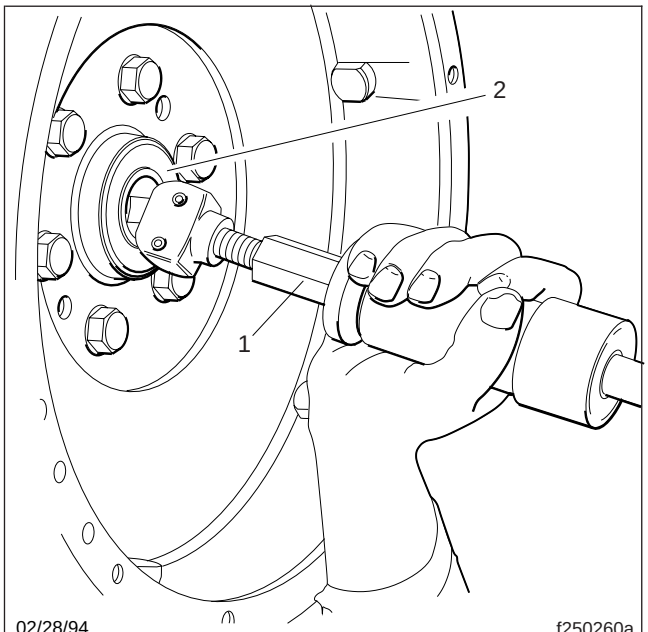


appropriate internal puller to remove the pilot bearing. Discard the pilot bearing. See **Fig. 9**.



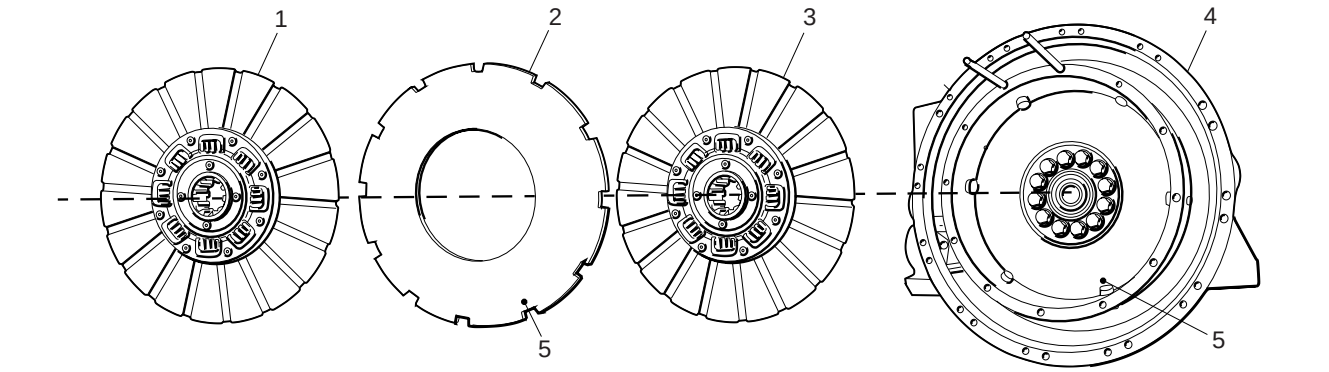

1. 14-Inch Clutch Housing

**Fig. 7, Lift the Pressure Plate and Cover Assembly**




1. Puller Tool
2. Pilot Bearing

**Fig. 9, Replace the Pilot Bearing**




1. Front Clutch Disc
2. Center Plate
3. Rear Clutch Disc
4. Flywheel Housing
5. Alignment Mark

**Fig. 8, Remove the Rear Disc, Front Disc, and Center Plate**

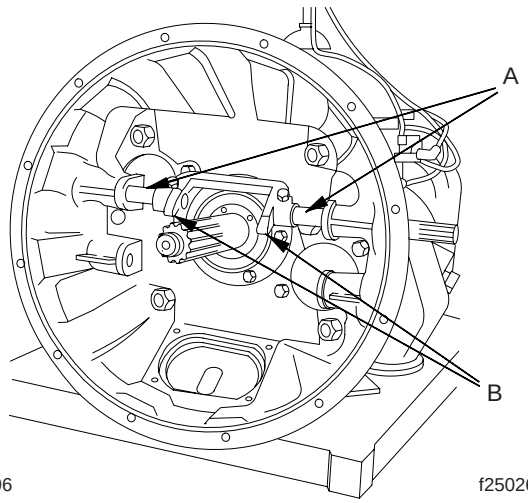
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## Clutch Inspection

1. Remove the clutch from the vehicle. See **Subject 100** for instructions.
2. Inspect the release fork and the cross shaft. See **Fig. 1**. Make sure the release fork is straight and the tips of the fork are not worn or damaged. Replace forks that are worn or damaged.

   Make sure the cross shaft rotates freely and doesn't have any side-to-side movement in the transmission housing. If used, inspect the bushings for the shaft in the housing. Replace any parts that are worn or damaged.

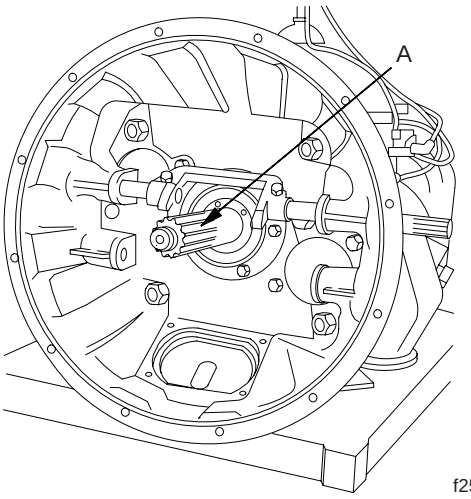



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A. The cross shaft must rotate freely.
B. The tips on the fork must not be worn or damaged.

**Fig. 1, Inspect the Cross Shaft and Release Fork**

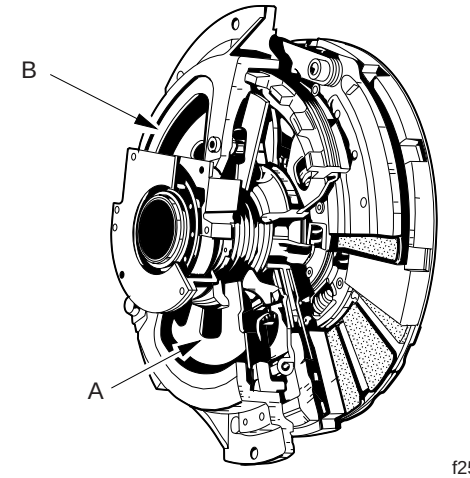
3. Inspect the splines on the input shaft. See **Fig. 2**. Make sure the splines are not worn or damaged. Inspect the release bearing area of travel for damage. Using an emery cloth, remove small scratches from the input shaft. If the input shaft is worn or damaged, replace it. Any wear or damage on the input shaft causes the clutch to work incorrectly.
4. Remove dirt and contamination from the pressure plate and cover assembly with non-petroleum based cleaning solvents.
5. Inspect the cover for wear and damage. Make sure the diaphragm spring inside the cover is not broken. See **Fig. 3**. If the diaphragm spring is broken, the clutch cover must be disassembled to replace the spring.




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A. The splines must not be worn or damaged.

**Fig. 2, Inspect the Splines**




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A. Make sure the diaphragm spring is not broken.
B. Make sure the cover is not worn or damaged.

**Fig. 3, Inspect the Cover**

6. Inspect the pressure plate.

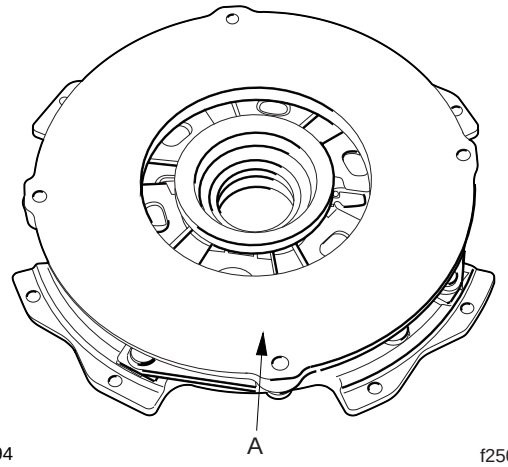
   6.1 Visually check the pressure plate for wear or damage. See **Fig. 4**. If the plate is cracked, replace it. Heat marks are normal, and can usually be removed with an

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## Clutch Inspection

emery cloth. If the heat marks can't be removed, replace the pressure plate.




A. Inspect the pressure plate surface for wear, cracks, or heat damage.

**Fig. 4, Inspect the Pressure Plate**

6.2 Put the pressure plate and cover assembly on a bench with the plate facing up.

6.3 Using a caliper, measure any scratches or scoring on the pressure plate. See **Fig. 5**. If the damage to the surface of the plate is more than 0.015 inch (0.38 mm), replace the pressure plate.

6.4 Make sure the surface of the pressure plate is flat. Put a straightedge on the surface of the pressure plate, making sure it crosses the center of the plate. See **Fig. 6**. Using feeler gauge, measure each gap that appears between the straightedge and the pressure plate. Rotate the straightedge through at least four positions. If any gap is more than 0.004 inch (0.10 mm), replace the pressure plate.

6.5 Measure the runout of the pressure plate to make sure the surfaces are parallel to each other. Put marks on a capscrew, strap, and pressure plate location to ensure that the pressure plate is installed in the original position on the cover. Remove the capscrews that fasten the pressure plate to the strap. See **Fig. 7**. Put the pressure plate on a bench so that the

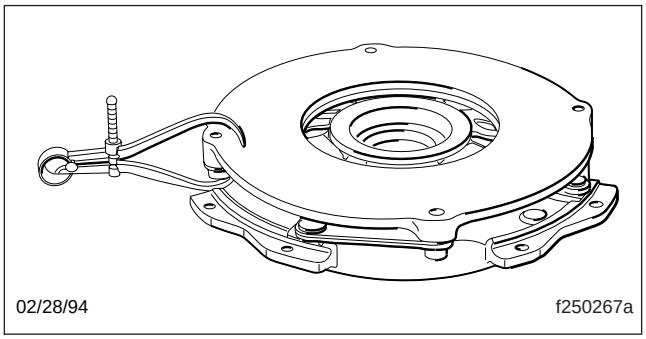
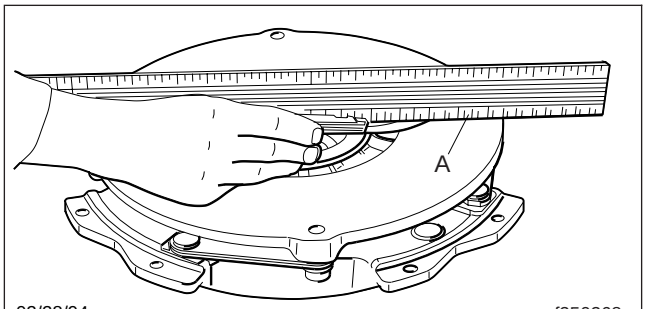



**Fig. 5, Measure Scratches or Scoring**




A. Pressure plate flatness gap must not be more than 0.004 inch (0.10 mm).

**Fig. 6, Check the Pressure Plate Surface**

smooth surface is up. Put the base of a dial indicator inside the center of the plate.

See **Fig. 8.** Put the tip of the dial indicator on the surface of the plate. Set the dial indicator to zero. Rotate the dial indicator one complete turn around the surface of the pressure plate. If the reading on the indicator is more than 0.002 inch (0.05 mm), replace the pressure plate.

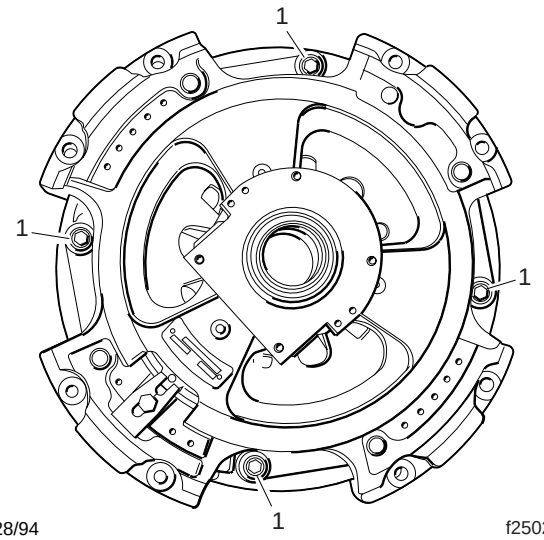
7. Inspect the clutch discs.

7.1 Visually check for wear or damage. If any disc is worn, replace it.

7.2 Make sure the co-axial springs are not loose in the hub. See **Fig. 9**. Springs that rattle are not necessarily loose; springs that have any movement are. If any disc has loose springs, replace it.

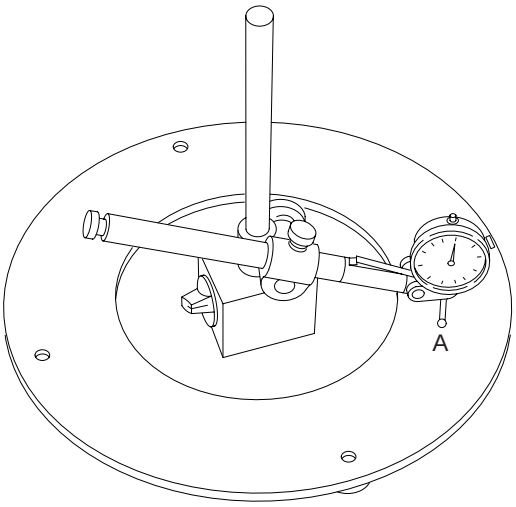
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1. Capscrews

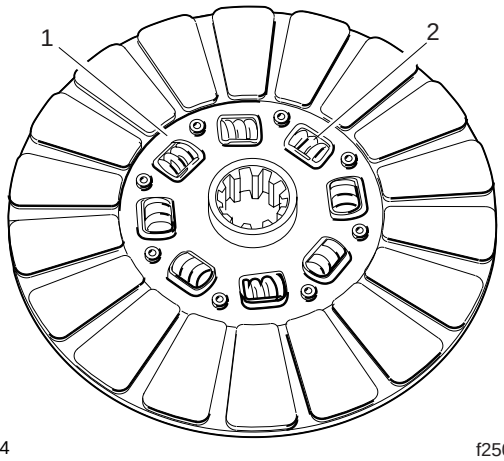
**Fig. 7, Remove the Capscrews**




A. Pressure plate runout must not be more than 0.002 inch (0.05 mm).

**Fig. 8, Check Pressure Plate Runout**

7.3 Make sure the splines in the hub are not damaged. Make sure the hub is fastened to the disc. Replace any disc that is damaged.




1. Hub
2. Co-Axial Spring

**Fig. 9, Check the Co-Axial Springs**

7.4 Using a cleaning solvent with a non-petroleum base, remove grease and oil from the discs. If the grease and oil cannot be removed, replace the disc.

7.5 Ceramic linings are fastened to the disc with rivets. On clutches with ceramic linings, replace the disc if the lining is loose, damaged, or worn to the top of the rivets. See **Fig. 10**.

Organic linings are integrally molded onto the disc. Using a micrometer, measure the thickness of the organic lining on the disc. Replace the disc if the organic lining is loose, damaged, or less than 0.283 inch (7.2 mm) thick. See **Fig. 11**.

8. Inspect the center plate.

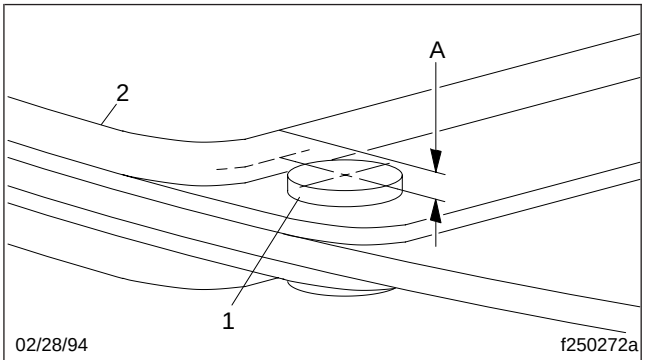
8.1 On 14-inch clutches, check the slots for the drive pins in the center plate. See **Fig. 12**. If the slots are worn, replace the center plate. Go on to the next step and inspect the center plate.

On 15-1/2 inch clutches, inspect the tabs on the outer edge of the center plate. See **Fig. 13**. If the tabs are worn or damaged, replace the center plate. Go on to the next step and inspect the center plate.

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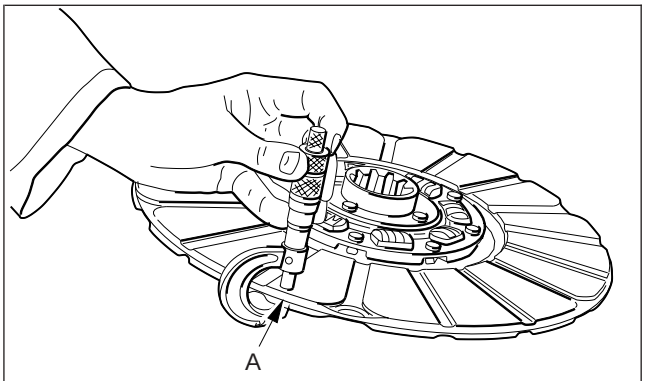
## Clutch Inspection




A. Replace the ceramic disc if the lining is even with or below the top of the rivet.

1. Rivet
2. Lining

**Fig. 10, Check the Linings**

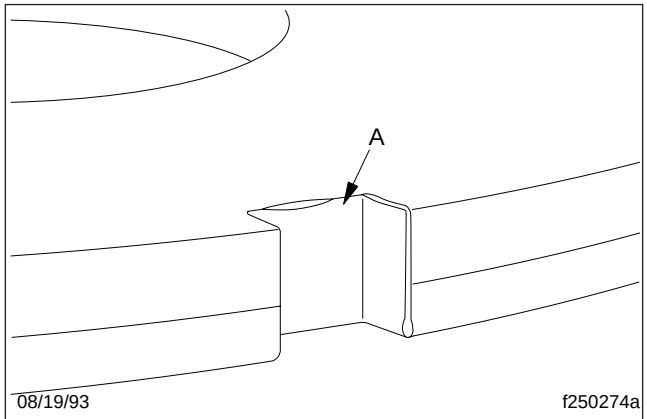



A. Minimum thickness: 0.283 inch (7.2 mm).

**Fig. 11, Measure Thickness of the Lining**

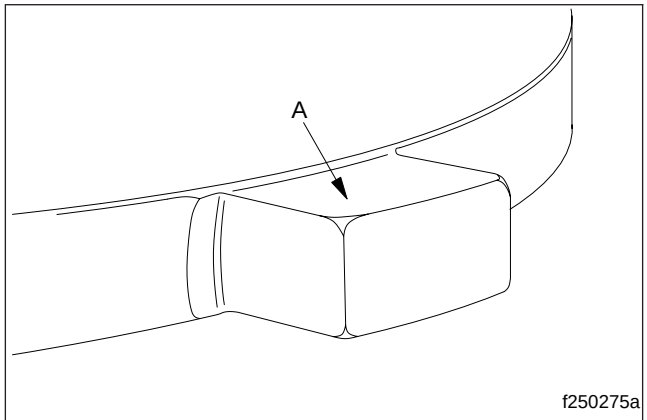
8.2 Inspect the center plate for wear or damage. If the plate is cracked, replace it. Heat marks are normal, and can usually be removed with an emery cloth. If the heat marks cannot be removed, replace the center plate.

8.3 Using a micrometer or a caliper, measure the thickness of the center plate. See **Table 1** for minimum thickness by clutch type. If the center plate measures less than the minimum thickness, replace it. See **Fig. 14**.




A. Make sure the slots are not worn or damaged.

**Fig. 12, Check the Slots**




A. Make sure the tabs are not worn or damaged.

**Fig. 13, Inspect the Tabs**

| Clutch Type | Minimum Thickness: inches (mm) |
|---|---|
| 14-Inch With Ceramic Linings | 0.805 (20.07) |
| 14-Inch With Organic Linings | 0.672 (17.27) |
| 15-1/2 Inch With Ceramic or Organic Linings | 0.742 (18.84) |

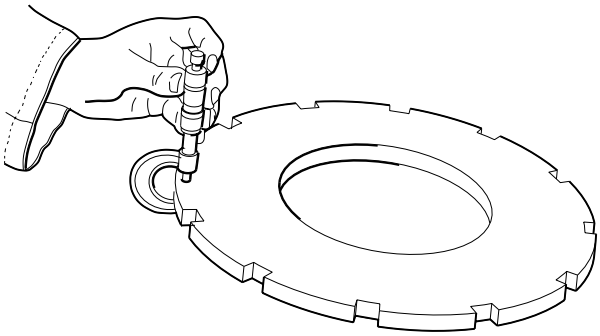
**Table 1, Minimum Center Plate Thickness**

8.4 Make sure the surface of the center plate is flat. Put a straightedge on the surface of the center plate, making sure it crosses the center of the plate. See **Fig. 15**. Using a feeler gauge, measure each gap that appears between the straightedge and the

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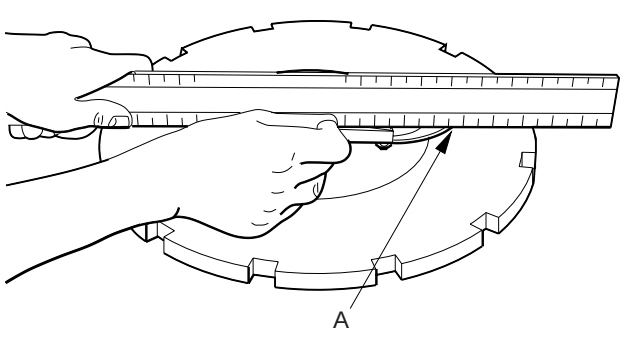


pressure plate. Rotate the straightedge through at least four positions. If any gap is more than 0.002 inch (0.05 mm), grind a new surface on the center plate; if not, go on to the next step.



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**Fig. 14, Check Center Plate Thickness**

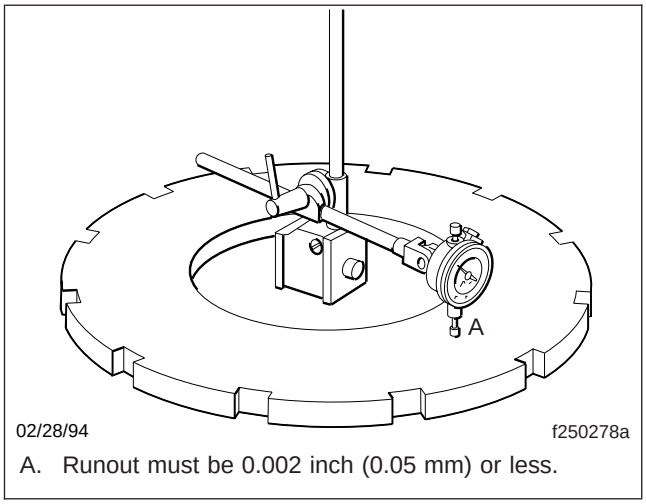



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A. The gap must be 0.002 inch (0.05 mm) or less.

**Fig. 15, Check Center Plate Gap**

8.5 Measure the runout of the center plate to make sure the surfaces are parallel to each other. See **Fig. 16**. Put the base of the dial indicator inside the center of the plate. Put the tip of the dial indicator on the surface of the plate. Set the dial indicator to zero. Rotate the dial indicator one complete turn around the surface of the center plate. If the reading on the indicator is more than 0.002 inch (0.05 mm), grind a new surface on the center plate; if not, go on to the next step.




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A. Runout must be 0.002 inch (0.05 mm) or less.

**Fig. 16, Measure Center Plate Runout**

8.6 If either the runout or the flatness of the center plate is more than 0.002 inch (0.05 mm), grind enough material so that the plate is flat, but do not go below the minimum thickness. See the table for minimum thickness by clutch type. Re-check the flatness and runout of the center plate.

9. Although the pilot bearing must be replaced whenever the clutch is removed, inspect the old pilot bearing for wear or damage. See **Fig. 17**. If worn or damaged, correct the cause.

10. Inspect the surface of the flywheel for wear or damage. If the flywheel is cracked, replace it. Heat marks are normal, and can usually be removed with an emery cloth. Some wear or damage can be removed by grinding a new surface on the flywheel. If wear or damage on the surface of the flywheel cannot be removed, replace the flywheel.

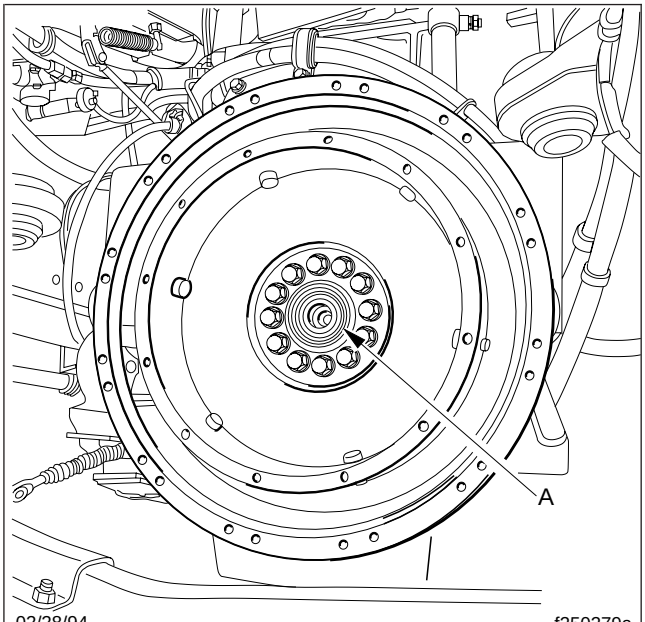
    See the engine manufacturer's service manual for flywheel service procedures.

IMPORTANT: If the flywheel surface is reground, make sure there is still adequate thickness for the capscrews to hold the clutch to the flywheel. The threads for these capscrews are below the surface of some flywheels, requiring the use of capscrews with a shoulder. If some of the flywheel surface is removed, the capscrews may not hold. Use new capscrews that are the correct length.

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## Clutch Inspection




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A. Make sure the pilot bearing is not worn or damaged.

**Fig. 17, Inspect the Pilot Bearing**

11. On 14-inch clutches, inspect the drive pins in the flywheel housing.

    11.1 Remove the flywheel. See the engine manufacturer's service manual for instructions.

    11.2 Remove the setscrew(s) that fasten each drive pin in the flywheel housing. See **Fig. 18**.

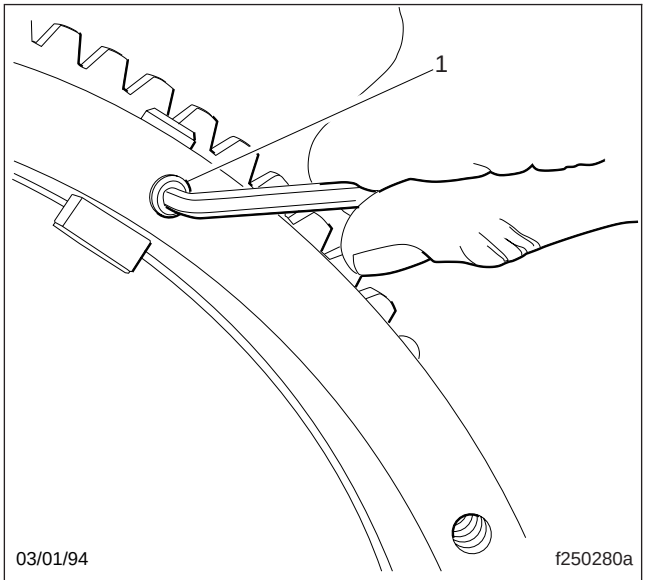
**⚠ WARNING**

**Wear eye protection. Do not hit steel parts with a steel hammer. Parts can break and cause injury.**

    11.3 Using a hammer and punch, remove the drive pins from the flywheel housing. See **Fig. 19**.

    11.4 Replace any worn or damaged drive pins.

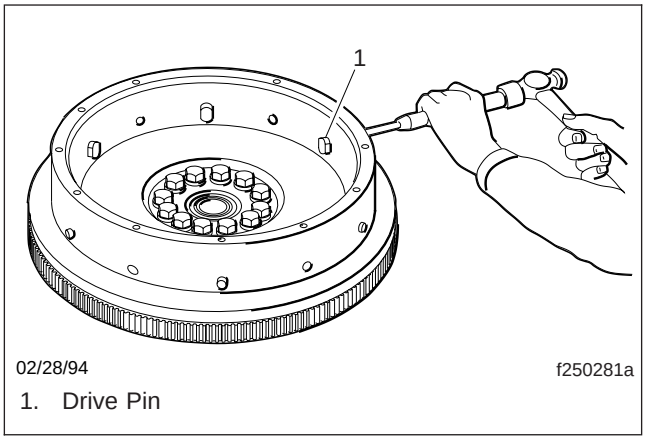
    11.5 Put each new drive pin in the flywheel so that the round sides of the head are toward the top and bottom of the flywheel. Make sure that the flat sides of the pin are at a right angle to the top of the flywheel face. See **Fig. 20**.




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1. Setscrew

**Fig. 18, Remove the Setscrew**




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1. Drive Pin

**Fig. 19, Remove the Drive Pins**

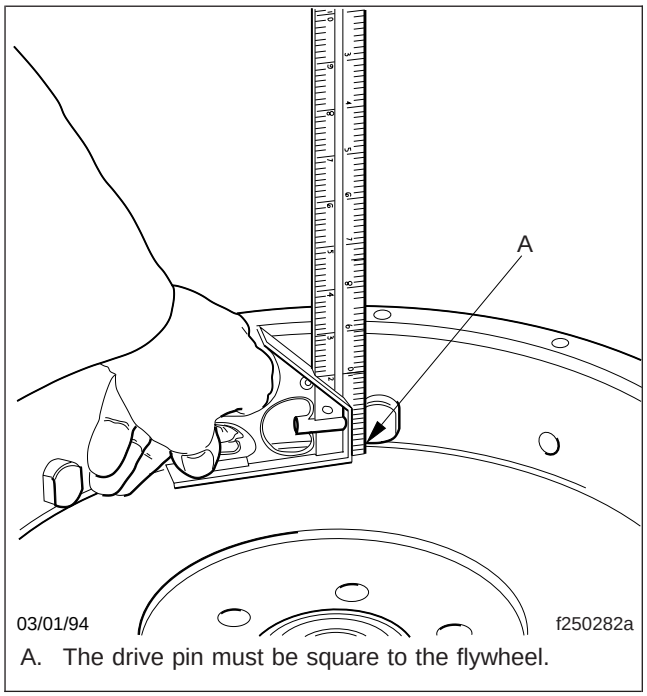
    11.6 Using a drive-pin installation tool and a brass hammer, install the drive pins in the flywheel. See **Fig. 21**.

    If a drive-pin tool is not available, use a C-clamp to install the drive pins in the flywheel.

    Press each pin into the flywheel until the head of the pin bottoms in the bore. See **Fig. 22**.

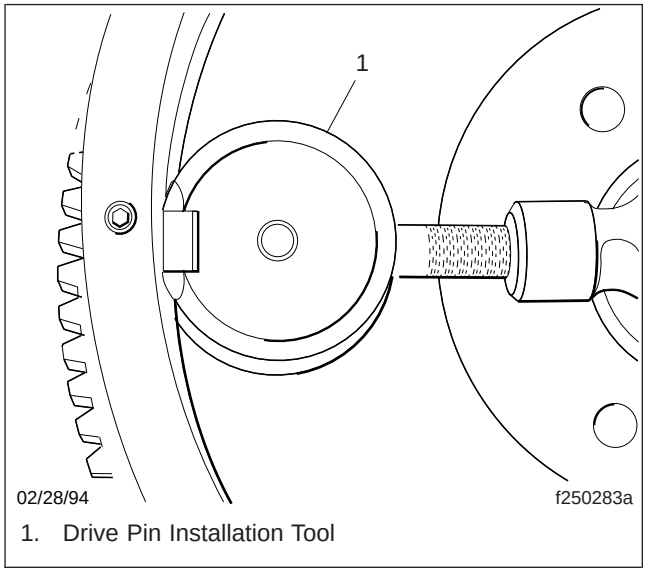
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A. The drive pin must be square to the flywheel.

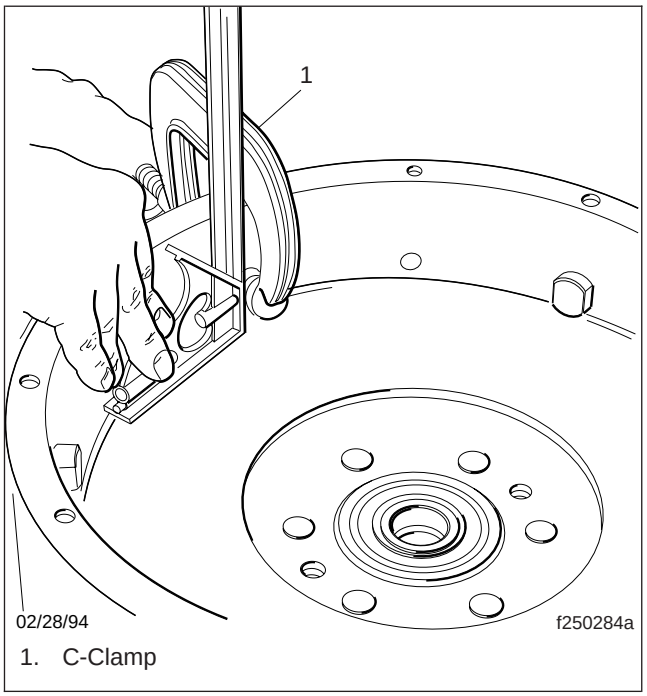
**Fig. 20, Check the Drive Pin Angle**




1. Drive Pin Installation Tool

**Fig. 21, Install the Drive Pins**

11.7 Making sure the slots in the center plate are installed over the drive pins, install the center plate in the flywheel. Rotate the plate so that one side of each slot touches a drive pin.




1. C-Clamp

**Fig. 22, Press Each Pin Into the Flywheel**

11.8 Using a feeler gauge, check the clearance between the slot and the opposite side of each drive pin. See **Fig. 23**. The minimum clearance between the drive pin and the slot is 0.006 inch (0.152 mm). If the clearance is less than specified, remove the drive pin and install it again. Do not file the drive pins or the slots in the center plate.

11.9 Install and tighten the setscrew(s) that fasten each drive pin in the flywheel housing.

11.10 Install the flywheel housing. See the engine manufacturer's service manual for instructions.

12. Inspect the ring gear teeth on the outer surface of the flywheel. If the teeth are worn or damaged, replace the ring gear or the flywheel. See the engine manufacturer's service manual for instructions.

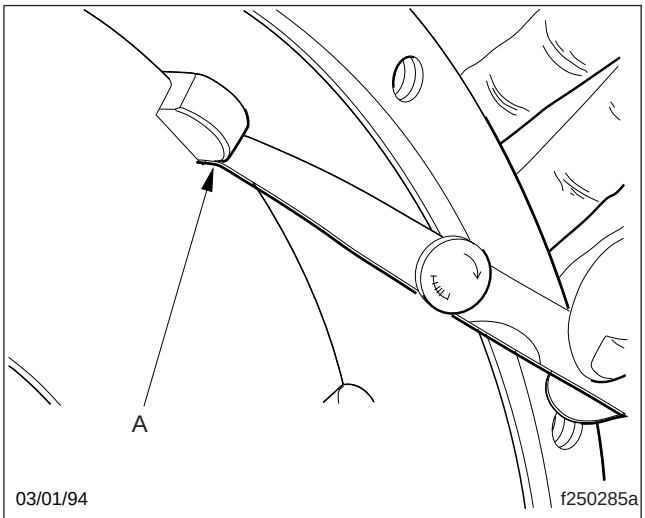
    On 15-1/2 inch clutches, check the tabs on the outer edge of the flywheel. Replace the flywheel if the tabs are worn or damaged.

13. The flywheel surface must be flat for correct clutch operation. Check the runout of the outer

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## Clutch Inspection




A. Drive pin-to-center plate minimum clearance: 0.006 inch (0.152 mm).

**Fig. 23, Check the Clearance**

surface of the flywheel. See the engine manufacturer's service manual for instructions.

NOTE: In general, maximum runout is 0.0005 inch times the flywheel diameter in inches.

14. See the engine manufacturer's service manual for instructions and check the following:
    - pilot bearing bore runout
    - crankshaft end play
    - runout of the outer surface of the flywheel housing
    - runout of the inside of the flywheel housing
15. Clean the disassembled parts.

    15.1 Using a cleaning solvent or kerosene, clean all ground or polished parts or surfaces.

**⚠ CAUTION**

**Do not clean ground or polished parts in a hot solution tank or with water, steam, or alkaline solutions. These solutions will cause the parts to corrode.**

    15.2 Rough parts can be cleaned with the ground or polished parts. The rough parts can also be cleaned in hot solution tanks with a weak alkaline solution. The parts must remain in the tank until they are completely cleaned and heated.

    15.3 Dry the parts with clean paper, shop towels, or compressed air immediately after cleaning.

16. Apply lubricant to the cleaned and dried parts that are not damaged and are to be immediately assembled. *Do not* apply lubricant to the linings.

    If parts are to be stored, apply a special material that prevents corrosion and rust to all surfaces. *Do not* apply the material to the linings. Store the parts inside special paper or other material that prevents corrosion and rust.

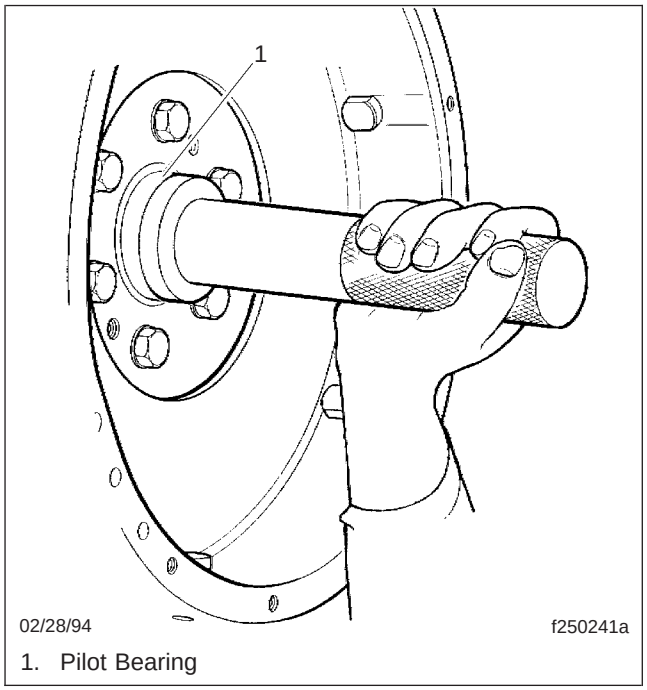
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## Installation

NOTE: During clutch removal, spacers or wooden blocks are installed between the release bearing and the clutch cover to facilitate removal. Do not remove the spacers or wooden blocks until after the clutch is installed. The spacers or blocks make installation of the clutch easier by holding the clutch components in position.

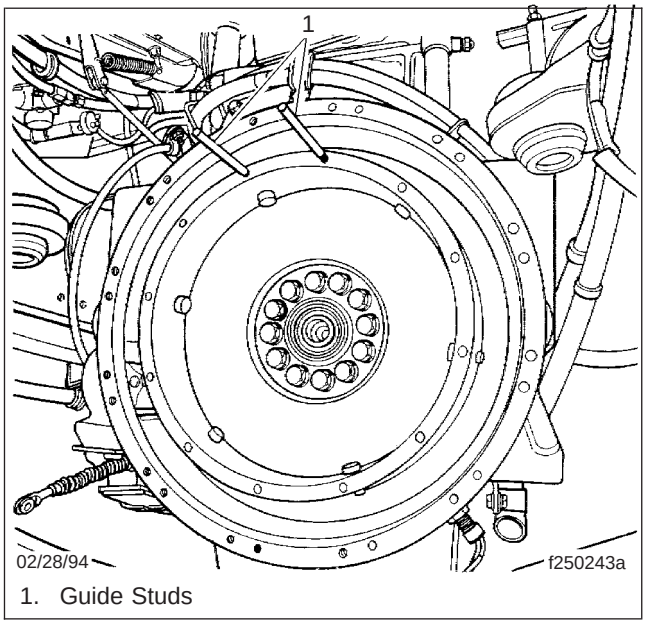
1. Lubricate the bore in the crankshaft for the pilot bearing with the specified lubricant. Do not use too much lubricant. Excess lubricant can contaminate the discs and cause the clutch to slip.
2. Use the correct size of driver to install the pilot bearing in the crankshaft bore. See **Fig. 1**. See the engine manufacturer's service manual for instructions.




1. Pilot Bearing

**Fig. 1, Install the Pilot Bearing**

3. Do the following on 14-inch clutches (go to the next step for 15-1/2 inch clutches):
   - 3.1 Install 7/16-inch guide studs in two of the upper mounting holes for the cover and pressure plate assembly. See **Fig. 2**.




1. Guide Studs

**Fig. 2, Install the Guide Studs**

**WARNING**

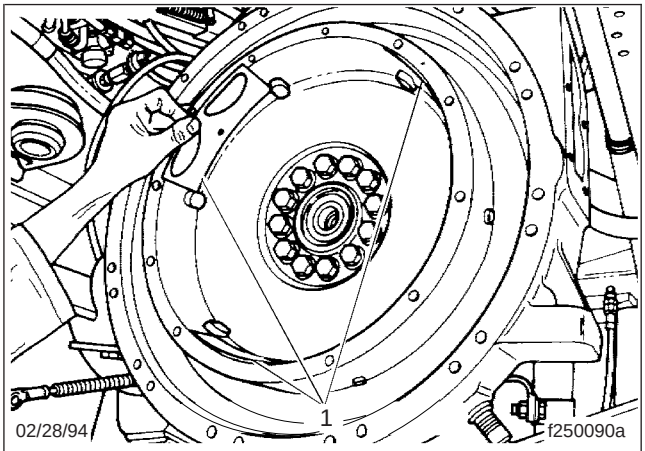
**Wear gloves when handling anti-rattle clips. Anti-rattle clips are very sharp, and may cut your hands.**

- 3.2 Install the anti-rattle clips in the inner bore of the flywheel housing. See **Fig. 3**. The round portion of the holes must face toward the flywheel. Make sure the clips are spaced evenly around the housing.
- 3.3 Install the alignment tool in the flywheel pilot bearing. See **Fig. 4**.
- 3.4 Install the front disc over the alignment tool. See **Fig. 4**. Make sure the words *FLYWHEEL SIDE* on the disc are toward the flywheel.
- 3.5 Install the center plate in the flywheel housing. Make sure the slots in the plate are installed over the drive pins in the housing. See **Fig. 3**. Make sure facings of ceramic clutches are aligned.
- 3.6 Install the rear disc over the alignment tool. Make sure the words *PRESSURE PLATE SIDE* on the disc will be toward the pressure plate. See **Fig. 4**.

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## Clutch Installation




1. Anti-Rattle Clips

**Fig. 3, Install the Anti-Rattle Clips**

3.7 Install the pressure plate and cover assembly over the alignment tool and on to the guide studs.

Skip the step on installing 15-1/2 inch clutches, and go on.

4. Do the following on 15-1/2 inch clutches:

4.1 Install 3/8-inch guide studs in two of the upper mounting holes for the cover and pressure plate assembly. See **Fig. 2**.

**⚠ WARNING**

**The pressure plate and cover assembly is heavy and should be installed only with a lifting device. If the assembly is lifted improperly or dropped, it could cause serious physical injury.**

4.2 Connect a lifting device to the pressure plate and clutch cover assembly. See **Fig. 5**.

4.3 Install the rear disc in the pressure plate and cover assembly. Make sure the words *PRESSURE PLATE SIDE* on the disc are toward the pressure plate. See **Fig. 4**.

4.4 Install the center plate over the disc in the pressure plate and clutch cover assembly. Make sure the tabs on the plate are in the slots on the cover.

4.5 Install the front disc against the center plate. Make sure the words *FLYWHEEL SIDE* on the disc are toward the flywheel. See **Fig. 4**. Make sure the facings of ceramic clutches are aligned.

4.6 Install the alignment tool through the assembly. Rotate the discs so that the splines in the hub are aligned with the splines on the tool. See **Fig. 4**.

**⚠ WARNING**

**Tilt the front of the alignment tool up when the clutch assembly is installed. If the tool is not tilted up, components will fall off the tool, causing personal injury and component damage.**

4.7 Using a lifting device, lift the clutch assembly on to the guide studs. See **Fig. 5**. Make sure the alignment tool is installed in the flywheel pilot bearing.

4.8 Install the clutch assembly against the flywheel. remove the lifting device.

5. Install and hand-tighten the capscrews that fasten the clutch to the flywheel.

6. Remove the guide studs. Install and hand-tighten the remaining capscrews.

NOTE: When the capscrews are tightened, the wooden blocks or spacers will fall from between the release bearing and the cover.

7. Tighten the capscrews in the pattern shown in **Fig. 6**. See the torque table in **Specifications 400** for torque values.

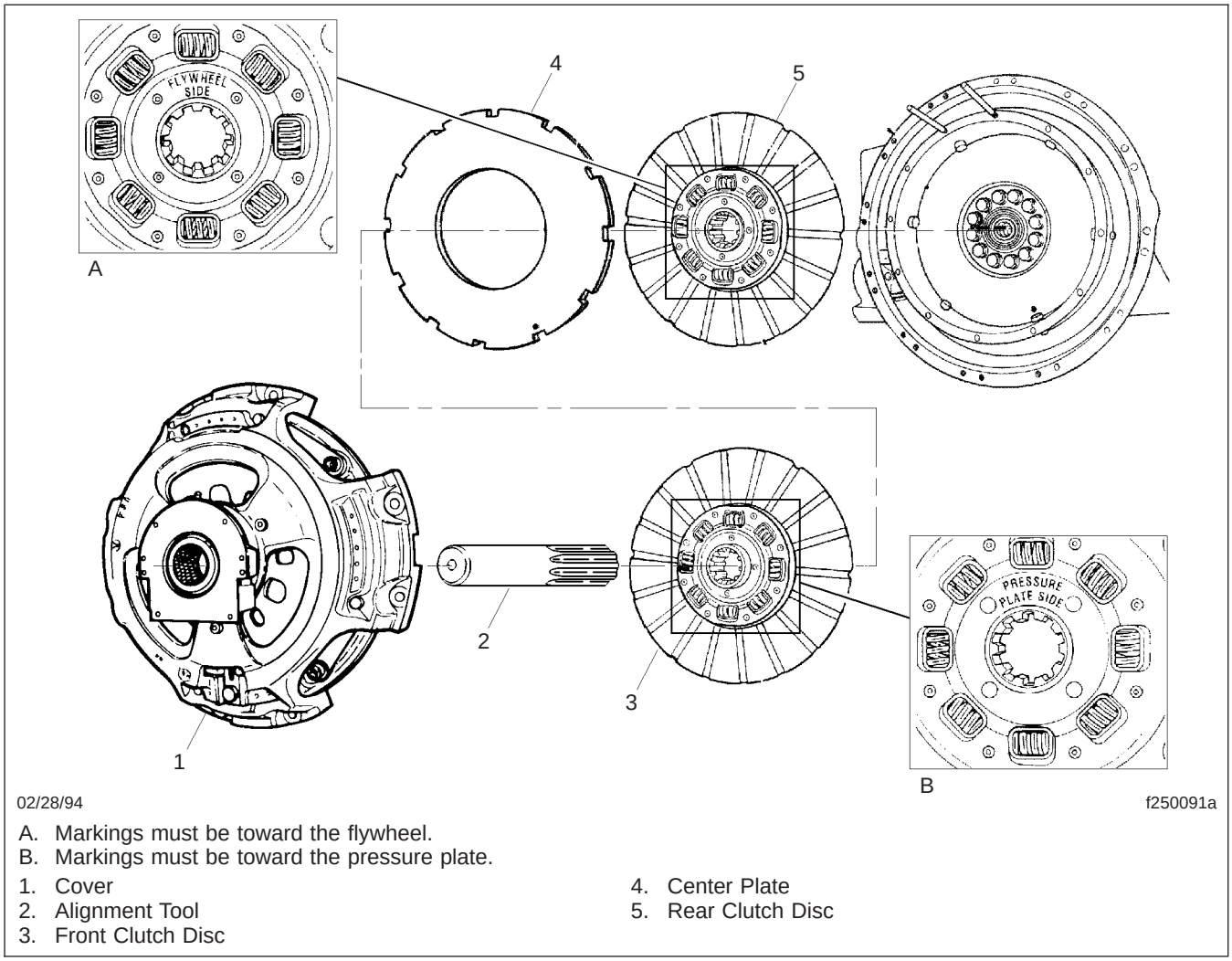
8. Remove the alignment tool (or the input shaft used as an alignment tool).

9. If used, install the clutch brake on the transmission input shaft. Make sure the tabs on the clutch brake engage the slots on the input shaft. See **Fig. 7**.

10. Install the transmission.

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A. Markings must be toward the flywheel.
B. Markings must be toward the pressure plate.

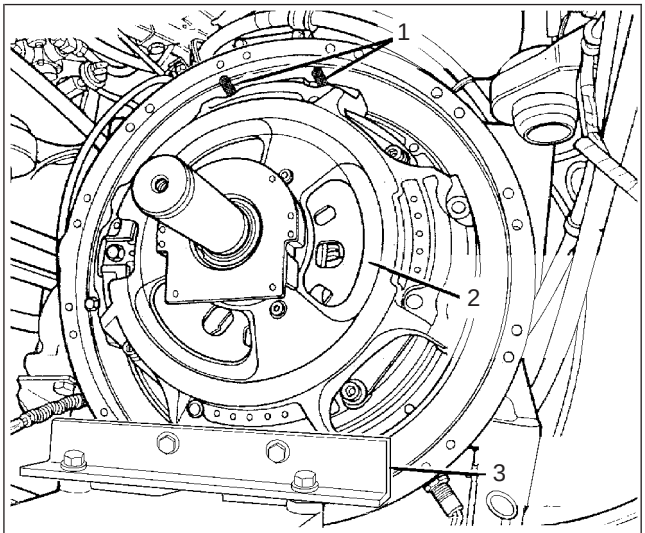
1. Cover
2. Alignment Tool
3. Front Clutch Disc
4. Center Plate
5. Rear Clutch Disc

**Fig. 4, Install the Front Disc, Rear Disc, and Center Plate**

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## Clutch Installation




1. Guide Studs
2. 15-1/2 Inch Clutch Assembly
3. Lifting Device

**Fig. 5, Connect a Lifting Device**

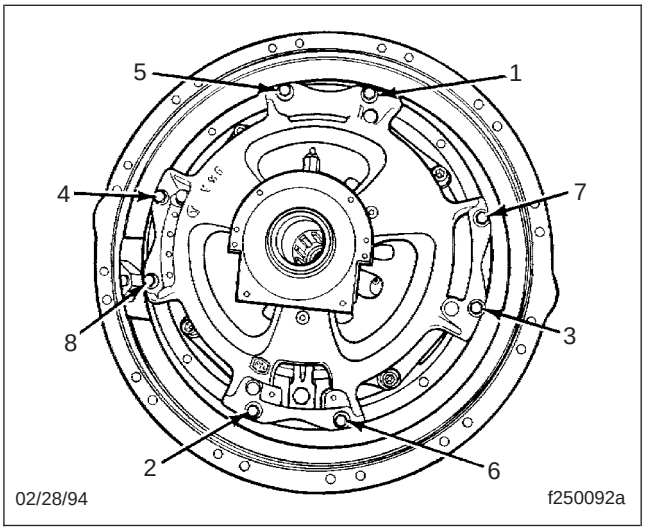
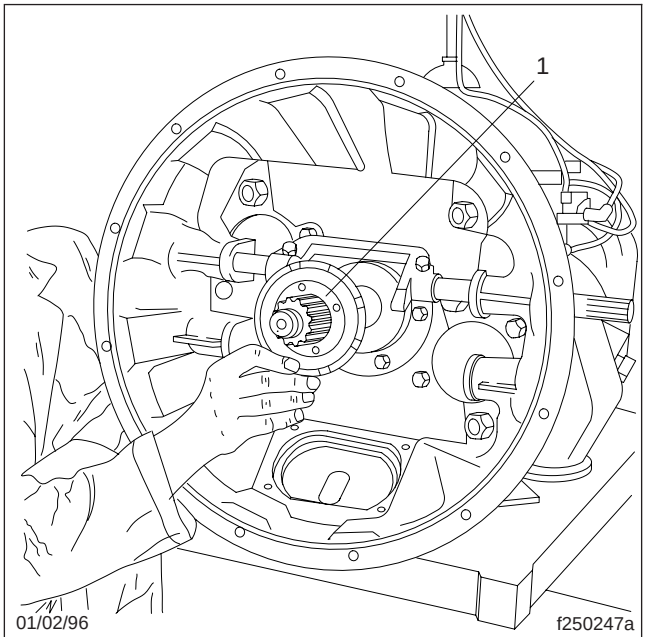



**Fig. 6, Clutch Housing Torque Sequence**




1. Clutch Brake

**Fig. 7, Install the Clutch Brake**

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# Troubleshooting Tables

## Troubleshooting—Functional Problems

NOTE: Problem entries in the troubleshooting tables in this subject refer to functional or operational problems. Before troubleshooting the clutch, make sure that:

- the engine is operating correctly
- the engine mounts are in good condition
- the driveline angles of the engine, transmission, driveshaft, and rear axle are correct

**Problem—The Clutch Does Not Disengage Completely**

| Problem—The Clutch Does Not Disengage Completely | |
|---|---|
| **Possible Cause** | **Remedy** |
| The clutch linkage and release bearing need adjustment. | Adjust the clutch linkage and release bearing. |
| The linkage is worn or damaged. | Lubricate the linkage. Make sure the linkage linkage is not loose. If the condition persists, replace the linkage. |
| The release bearing is worn or damaged. | Lubricate the release bearing. If the condition persists, replace the release bearing. |
| The input shaft splines are worn or damaged. | Replace the input shaft. |
| The clutch housing is loose. | Tighten the fasteners to the specified torque. If necessary, replace the fasteners. |
| The pressure plate is worn or damaged. | Replace the pressure plate and cover assembly. |
| The center plate is worn or damaged. | Replace the center plate. |
| The center plate binds. | 14–inch clutch: Inspect the drive pins in the flywheel and the slots in the center plate. Service as needed.<br>15–1/2 inch clutch: Inspect the tabs on the center plate and the slots in the cover. Service as needed. |
| Damaged clutch disc hub(s). | Replace the clutch discs. |
| The linings are worn beyond specification. | Replace the clutch discs. |
| The linings are damaged. | Replace the clutch. |
| Oil or grease on the linings. | Clean the linings. If the oil or grease cannot be removed, replace the clutch discs. |
| A clutch with incorrect lining for the vehicle application is installed. | Install a clutch with the correct type of lining. |
| The pilot bearing is damaged. | Replace the pilot bearing. |

**Problem—Clutch Pedal Hard to Operate**

| Problem—The Clutch Pedal is Hard to Operate | |
|---|---|
| **Possible Cause** | **Remedy** |
| Damaged bosses on the release bearing assembly. | Replace the bearing assembly. Make sure the clutch is adjusted correctly. |
| The clutch linkage is worn or damaged. | Lubricate the linkage. If the condition still exists, replace the linkage. |

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## Troubleshooting

| Problem—The Clutch Pedal is Hard to Operate | |
|---|---|
| **Possible Cause** | **Remedy** |
| The pressure plate and cover assembly components are worn or damaged. | Replace the pressure plate and cover assembly. |
| The clutch cross shaft binds. | Lubricate the cross shaft. If the condition persists, replace the cross shaft and bushings as required. |

**Problem—The Clutch Slips**

| Problem—The Clutch Slips | |
|---|---|
| **Possible Cause** | **Remedy** |
| The driver keeps his foot on the clutch pedal. | Use correct driving procedures. |
| The clutch linkage or release bearing need adjustment. | Adjust the clutch linkage or release bearing. |
| Pressure plate and cover assembly components are worn or damaged. | Replace the pressure plate and cover assembly. |
| Linings are worn or damaged. | Replace the clutch discs. |
| Oil or grease on the linings. | Clean the linings. If the oil or grease cannot be removed, replace the clutch discs. |
| A clutch with incorrect lining for the vehicle application is installed. | Install a clutch with the correct type of lining. |
| The flywheel is worn or damaged. | Service the flywheel as needed. For instructions, see the engine manufacturer's service manual. |

**Problem—The Clutch is Noisy**

| Problem—The Clutch is Noisy | |
|---|---|
| **Possible Cause** | **Remedy** |
| The clutch linkage or release bearing need adjustment. | Adjust the clutch linkage or release bearing. |
| The linkage is worn or damaged. | Lubricate the linkage. If the condition persists, replace the linkage. |
| The release bearing is worn or damaged. | Lubricate the release bearing. If the condition persists, replace the release bearing.. |
| The clutch housing is worn or damaged. | Replace the clutch housing. |
| The clutch housing is loose. | Tighten the fasteners to the specified torque. If necessary, replace the fasteners. |
| The hub is damaged, or the co-axial spring(s) are broken in the clutch disc. | Replace the clutch discs. |
| Linings are worn below specified dimensions. | Replace the clutch discs. |
| Linings are damaged. | Replace the clutch discs. |
| Oil or grease on the linings. | Clean the linings. If the oil or grease cannot be removed, replace the clutch discs. |
| The pilot bearing is damaged. | Replace the pilot bearing. |

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**Problem—The Clutch Vibrates**

| Problem—The Clutch Vibrates | |
|---|---|
| **Possible Cause** | **Remedy** |
| The input shaft splines are damaged. | Replace the input shaft. |
| The pressure plate and cover assembly are out of balance. | Remove the pressure plate and cover assembly. Check their balance and install them. If the problem persists, replace the pressure plate and cover assembly. |
| The splines are damaged in the clutch disc hub(s). | Replace the clutch discs. |
| The flywheel is loose. | Tighten the fasteners to the specified torque. If necessary, replace the fasteners. Check the flywheel mounting surface for damage. If necessary, replace the flywheel. |

# Troubleshooting—Component Problems

NOTE: Problem entries in the troubleshooting tables in this subject refer to damage to components.

**Problem—Broken Tabs on the Clutch Brake**

| Problem—Broken Tabs on the Clutch Brake | |
|---|---|
| **Possible Cause** | **Remedy** |
| Vibration. | Inspect the clutch disc hubs; check the installation of the clutch. Make sure dampened discs are used. |
| The clutch linkage is incorrectly adjusted. | Adjust the clutch linkage. Also, check the installation of the clutch. |
| The driver used the clutch brake while the vehicle is moving. | Use correct driving technique. |

**Problem—Worn or Damaged Release Bearing Housing**

| Problem—Worn or Damaged Release Bearing Housing | |
|---|---|
| **Possible Cause** | **Remedy** |
| The driver keeps his foot on the pedal. | Use correct driving technique. |
| The clutch linkage is incorrectly adjusted. | Adjust the clutch linkage. Also, check the installation of the clutch. |

**Problem—Worn Bosses on the Release Bearing Housing**

| Problem—Worn Bosses on the Release Bearing Housing | |
|---|---|
| **Possible Cause** | **Remedy** |
| The linkage is damaged or out of adjustment. | Lubricate and adjust the linkage. Inspect the linkage for wear or damage. |
| The release yoke is binding. | Lubricate the release yoke shaft. If the yoke does not move freely, replace the shaft and yoke assembly. |
| The free travel is out of adjustment. | Adjust the free travel to specification. |

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## Troubleshooting

**Problem—Worn or Damaged Input Shaft Splines**

| Problem—Worn or Damaged Input Shaft Splines | |
|---|---|
| **Possible Cause** | **Remedy** |
| The transmission is not aligned. | Make sure the flywheel housing and the clutch housing are aligned to specification. |
| The transmission is not installed correctly. | Install the transmission correctly. |
| The clutch disc hubs are damaged. | Replace the clutch discs. |
| The pilot bearing is worn or damaged. | Replace the pilot bearing. |
| Engine vibration. | Make sure dampened discs are used. |

**Problem—Pressure Plate Cracked or Damaged by Heat**

| Problem—Pressure Plate Cracked or Damaged by Heat | |
|---|---|
| **Possible Cause** | **Remedy** |
| The driver engages the clutch while coasting. | Use correct driving techniques. |
| The driver uses the clutch as a brake. | Use correct driving techniques. |
| The clutch free travel is not adjusted correctly. | Adjust the free travel to specifications. |
| There is oil or grease on the clutch linings. | Clean the clutch discs. If the oil or grease cannot be removed, replace the clutch discs. Repair the cause of the grease or oil. |
| The diaphragm spring is worn or damaged. | Replace the pressure plate and the cover assembly. |
| The driver slips the clutch excessively during engagement. | Use correct driving techniques. |

**Problem—Grooves Worn in the Pressure Plate**

| Problem—Grooves Worn in the Pressure Plate | |
|---|---|
| **Possible Cause** | **Remedy** |
| The clutch discs are worn or damaged. | Replace the clutch discs. If damaged, replace the center plate and flywheel. |

**Problem—The Clutch Disc Hub is Warped**

| Problem—The Clutch Disc Hub is Warped | |
|---|---|
| **Possible Cause** | **Remedy** |
| The transmission was not installed correctly. | Replace the clutch discs. Install the transmission correctly. |

**Problem—The Hub Separates From the Clutch Disc**

| Problem—The Hub Separates From the Clutch Disc | |
|---|---|
| **Possible Cause** | **Remedy** |
| Excessive engine vibration. | Repair the engine. |

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| Problem—The Hub Separates From the Clutch Disc | |
|---|---|
| **Possible Cause** | **Remedy** |
| The transmission was not installed correctly. | Install the transmission correctly. |
| The clutch housing is loose. | Tighten the clutch housing to the specified torque. |
| The driver engages the clutch while the vehicle is coasting. | Use correct driving techniques. |
| Shock loading. | Use correct driving techniques. |

**Problem—Heat Damage to the Clutch Disc**

| Problem—Heat Damage to the Clutch Disc | |
|---|---|
| **Possible Cause** | **Remedy** |
| The driver keeps his foot on the clutch pedal or slips the clutch. | Use correct driving techniques. |
| The clutch does not engage or disengage completely. | See "Troubleshooting—Functional Problems: Clutch Does Not Disengage Completely." |
| The free travel is not adjusted correctly. | Adjust the free travel. |
| The diaphragm spring is worn or damaged. | Replace the pressure plate and cover assembly. |
| There is oil or grease on the clutch linings. | Clean the clutch discs. If the oil or grease cannot be removed, replace the clutch discs. Repair the cause of the grease or oil. |

**Problem—The Linings Separate From the Disc**

| Problem—The Linings Separate From the Disc | |
|---|---|
| **Possible Cause** | **Remedy** |
| The linings are worn below the specified dimension. | Replace the clutch discs. |
| The driver allows the vehicle to coast downhill with the transmission in gear and the clutch pedal depressed. | Use correct driving techniques. |

**Problem—Heat Damage to the Clutch Disc**

| Problem—Heat Damage to the Clutch Disc | |
|---|---|
| **Possible Cause** | **Remedy** |
| The driver does not start the vehicle in the correct gear. | Use correct driving techniques. |
| The driver engages the clutch while the vehicle is coasting. | Use correct driving techniques. |
| 14–inch clutch: The drive pins on the flywheel housing are worn or damaged. | Make sure the drive pins are correctly installed. Service the drive pins as needed. |
| 15–1/2 inch clutch: The tabs on the center plate are binding in the clutch cover. | Replace the pressure plate and cover assembly. |

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## Troubleshooting

| Problem—Heat Damage to the Clutch Disc | |
|---|---|
| **Possible Cause** | **Remedy** |
| The clutch does not release. | See "Troubleshooting—Functional Problems: Clutch Does Not Disengage Completely." |

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## Specifications

| General Specifications | | | |
|---|---|---|---|
| **Description** | | **14-Inch Diameter Clutch** | **15-1/2 Inch Diameter Clutch** |
| Actuation Type | | Pull | |
| Minimum Clutch Housing Size for Mounting (SAE) | | Number 2 | |
| Pressure Plate Actuation | | Single Diaphragm Spring | |
| Clamp Load | | 2800 lbf (12 454 N) | 2800 lbf (12 454 N) |
| | | 3200 lbf (14 234 N) | 3200 lbf (14 234 N) |
| | | — | 3600 lbf (16 013 N) |
| Adjustment | | Manual | |
| Facing Size | | 13.78 x 7.48 in (350 x 190 mm) | 15.35 x 8.66 in (390 x 220 mm) |
| Lining Availability | | Ceramic & Organic (non-asbestos) | |
| Lining-to-Disc Fastener: | Ceramic | Rivet | |
| | Organic | Integrally Molded to Plate | |

**Table 1, General Specifications**

| Pressure Plate Specifications for 14-Inch and 15-1/2 Inch Clutches | |
|---|---|
| **Description** | **Specification** |
| Pressure Plate Runout | 0.000 to 0.002 inch (0.00 to 0.05 mm) |
| Pressure Plate Flatness | 0.002 to 0.004 inch (0.05 to 0.10 mm) |
| Maximum Allowable Wear | 0.015 inch (0.38 mm) |

**Table 2, Pressure Plate Specifications for 14-Inch and 15-1/2 Inch Clutches**

| Center Plate Specifications | | | |
|---|---|---|---|
| **Description** | | **14-Inch Diameter Clutch** | **15-1/2-Inch Diameter Clutch** |
| Center Plate Runout | | 0.000 to 0.002 inch (0.00 to 0.05 mm) | |
| Center Plate Flatness | | 0.000 to 0.002 inch (0.00 to 0.05 mm) | |
| Center Plate Minimum Thickness: | Ceramic Linings | 0.805 inch (20.07 mm) | 0.742 inch (18.84 mm) |
| | Organic Linings | 0.672 inch (17.27 mm) | |
| Center Plate Drive | | Drive Pin | Tabs on Center Plate in Clutch Cover |
| Clearance Between Drive Pin and Center Plate | | 0.006 inch (0.152 mm) | — |

**Table 3, Center Plate Specifications**

| Clutch Disc Specifications | | |
|---|---|---|
| **Description** | **14-Inch Diameter Clutch** | **15-1/2 Inch Diameter Clutch** |
| Number of Splines on Disc | 10 | |
| Spline Diameter | 1.75 or 2.00 inch (44.5 or 51.0 mm) | 2.00 inch (51.0 mm) |

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## Specifications

| Clutch Disc Specifications | | | |
|---|---|---|---|
| **Description** | | **14-Inch Diameter Clutch** | **15-1/2 Inch Diameter Clutch** |
| Minimum Disc Thickness: | Ceramic linings | To Top of Rivet | |
| | Organic linings | 0.283 inch (7.2 mm) | |

**Table 4, Clutch Disc Specifications**

| Torque Values | | |
|---|---|---|
| **Description** | | **Torque: lbf·ft (N·m)** |
| Adjusting Ring Lock Capscrew | | 25 to 30 lbf·ft (34 to 40 N·m) |
| Capscrew Between Cover Assembly and Flywheel: | 14-Inch Clutches | 25 to 30 lbf·ft (34 to 40 N·m) |
| | 15-1/2 Inch Clutches | 45 to 50 lbf·ft (62 to 67 N·m) |

**Table 5, Torque Values**

| Clutch Pedal Free-Travel Specifications | | |
|---|---|---|
| **Vehicle Model** | **Initial Adjustment inches (mm)** | **Wear Limit* inches (mm)** |
| COE | 3/4 (19) at the stop | 1/2 (13) |
| Conventional | | |

* Adjust the clutch internally if the free-travel is less than the wear limit.

**Table 6, Clutch Pedal Free-Travel Specifications**

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## General Information

The clutch linkage transfers the motion of the clutch pedal to the clutch release bearing. The clutch linkage may be adjusted to maintain clutch free-pedal, but only after internal clutch adjustments are made.

Clutch free-pedal is required to ensure that the release bearing does not run against the fingers of the release yoke. The rod must be tight in the vertical direction, but some rotational play in the clutch rod is desirable to keep the joints from binding.

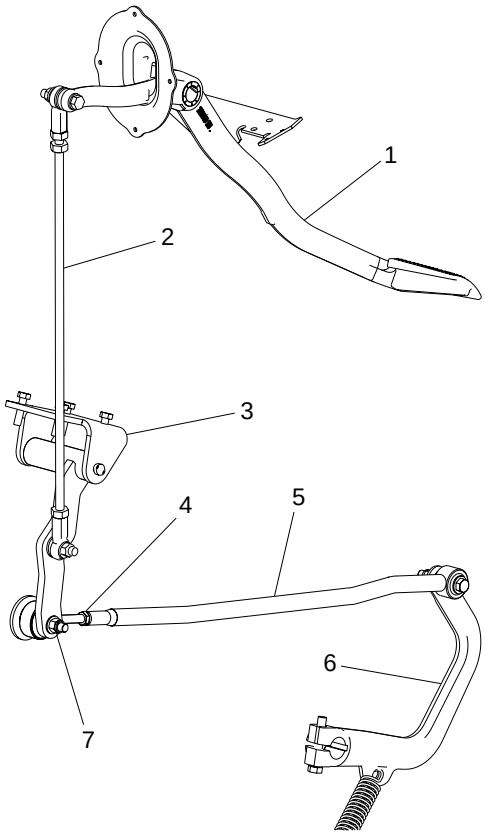
IMPORTANT: Release bearing travel is an internal clutch adjustment. It *can not be corrected* by adjusting the clutch linkage. See **Section 25.00, Subject 100**, to adjust Eaton clutches and **Section 25.01, Subject 100**, to adjust Meritor clutches. (Eaton Fuller Solo clutches are adjustment-free; for more information, refer to the service literature available on the Roadranger website, **www.roadranger-.com**.)

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## Clutch Linkage Adjustment

IMPORTANT: Always check the clutch linkage (see **Fig. 1**) after repair or replacement of the clutch or clutch linkage components, or if free-pedal is not 1 to 1-1/2 inches (25 to 38 mm) from the top end of the pedal stroke (see **Fig. 2**).




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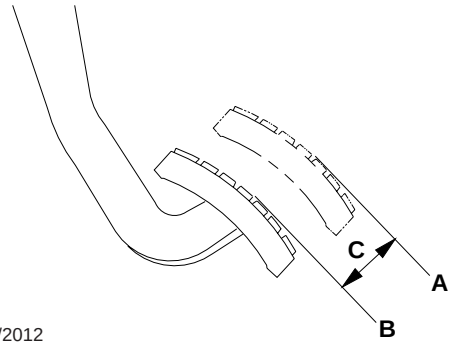
1. Clutch Pedal
2. Upper Clutch Rod
3. Clutch Relay
4. Jam Nut
5. Lower Clutch Rod
6. Clutch Release Lever
7. Hex Nut

**Fig. 1, Clutch Linkage, Typical LHD Assembly**

# Adjustment

1. Raise the hood, set the parking brake, and chock the front tires.

IMPORTANT: If the cab is equipped with an air suspension, be sure the air springs are properly inflated. If the air springs are not inflated, the clutch linkage can not be adjusted correctly.




04/25/2012 f250597a

Optimal clutch free-pedal is 1 to 1-1/2 inches (25 to 38 mm) from the top end of the pedal stroke.

A. Top of Pedal Stroke
B. Start of Clutch Disengagement
C. Clutch Free-Pedal

**Fig. 2, Clutch Free-Pedal Measurement**

2. Remove the clutch inspection cover from the bottom of the bell housing.
3. Ensure the clutch pedal is all the way up, against the upper stop.
4. Check the release bearing travel. See **Section 25.00, Subject 100**, to check Eaton clutches and **Section 25.01, Subject 100** to check Meritor clutches.
5. Measure the release yoke free-travel (the distance between the release yoke and the release bearing). See **Fig. 3**.

   If this measurement is between 0.105 and 0.145 inch (2.7 to 3.7 mm), no further work is needed. If it is not, complete all of the remaining steps.
6. Adjust the clutch linkage, as follows.

   IMPORTANT: Do not adjust the upper clutch rod. Adjusting the upper clutch rod adversely affects pedal effort.

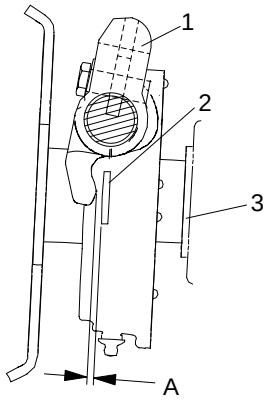
   6.1 Loosen the jam nut on the *lower* clutch rod. See **Fig. 1**.

   6.2 Remove the fasteners holding the lower rod to the clutch relay assembly.

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## Clutch Linkage Adjustment




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A. Release Yoke Free-Travel

1. Release Yoke
2. Release Bearing
3. Clutch Brake

**Fig. 3, Release Yoke Free-Travel**

6.3 Adjust the rod length in or out, as needed: shorten the rod to decrease the clearance; lengthen the rod to increase the clearance.

6.4 Install the fasteners holding the lower rod to the clutch relay; tighten the hex nut finger tight.

6.5 Measure the distance between the release yoke and the release bearing. If this measurement is at least 0.105 inch (2.7 mm) and no more than 0.145 inch (3.7 mm), go to the next step. If the measurement is not within these limits, adjust the rod length until it is.

6.6 Tighten the hex nut 26 lbf·ft (35 N·m).

6.7 Tighten the jam nut 14 lbf·ft (19 N·m).

7. After adjusting the linkage, check the clutch brake squeeze. See **Section 25.00, Subject 100**, to check Eaton clutches. For Meritor clutches, see the clutch manufacturer's manual.
8. Install the inspection cover on the bottom of the bell housing.

NOTE: If the clutch pedal feels excessively heavy or doesn't have enough range of travel to meet all the adjustment criteria, ensure the length of the upper clutch rod matches the dimension listed for it in PartsPro.

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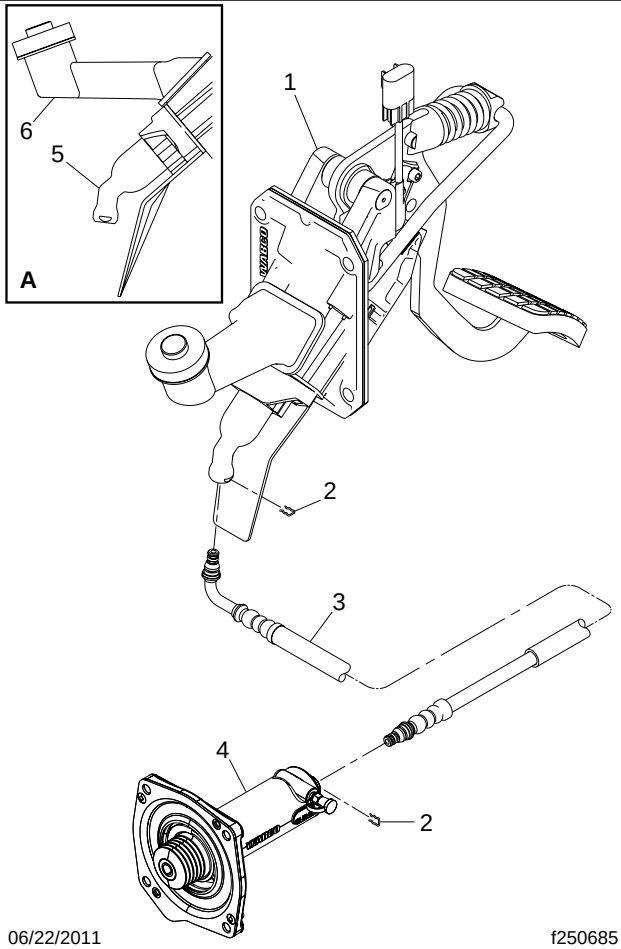
# General Information

The hydraulic clutch control system consists of a pedal unit and a slave cylinder, connected by a hydraulic hose that is fastened with quick-disconnect clips. See **Fig. 1**. The hydraulic system is self-adjusting, and it uses DOT 4 brake fluid.

The pedal unit includes a hydraulic subassembly, composed of the master cylinder and reservoir, which can be removed from the pedal unit for service purposes; see **Subject 110** for instructions.

## Principles of Operation

When the clutch pedal is pressed, the fluid in the master cylinder is forced through a hydraulic line to the slave cylinder. The fluid pressure moves the slave cylinder piston, pushing the plunger rod and clutch release lever, which disengages the clutch.




A. Hydraulic Subassembly

1. Pedal Unit
2. Clip
3. Hydraulic Hose
4. Slave Cylinder
5. Master Cylinder
6. Reservoir

**Fig. 1, Components, Hydraulic Clutch Control**

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## Pedal Unit Removal and Installation

# Removal

**WARNING**

**Clutch hydraulic fluid (DOT 4 brake fluid) is hazardous. It may be a skin irritant and can cause blindness if it gets in your eyes. Always wear safety glasses when handling clutch hydraulic fluid or bleeding hydraulic lines. If you get clutch hydraulic fluid on your skin, wash it off as soon as possible.**

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Open the hood.
3. Remove the lower steering column cover, if needed.
4. As needed, cut zip ties to allow the hydraulic hose to move freely when the pedal unit is removed.

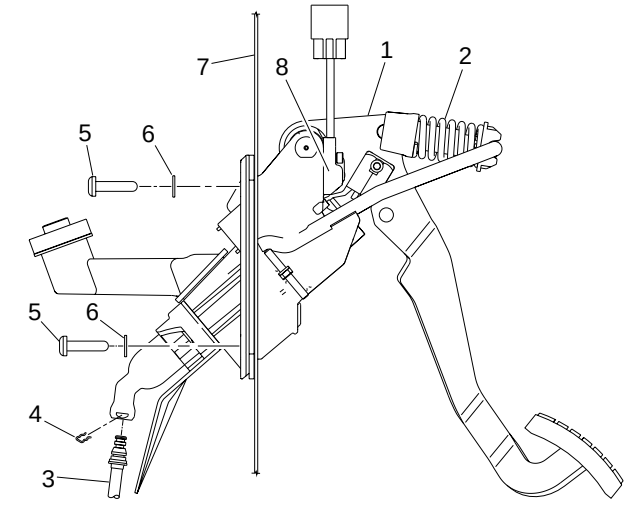
**WARNING**

**Do not attempt to disassemble the preloaded assist spring. Sudden release of the assist spring could cause property damage and serious personal injury.**

5. Remove the fasteners that attach the pedal unit to the frontwall, and withdraw the unit until you can access the clutch control switch. Retain the fasteners for later installation. See **Fig. 1**.
6. Disconnect the clutch control switch, as follows.
   - 6.1 Retract the secondary lock. See **Fig. 2**.
   - 6.2 Depress the latch to unlock the switch connector, then separate the clutch control switch from the wire harness.
7. Remove the pedal unit from the vehicle.

IMPORTANT: To avoid spilling fluid when the hose is removed from the master cylinder, turn the pedal unit upside down so that the fluid drains into the master cylinder and reservoir.

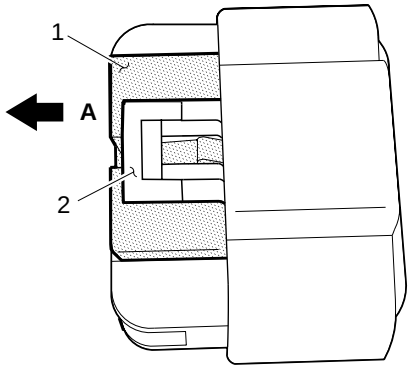
8. Use a flat-tip screwdriver to remove the quick-disconnect clip that locks the hydraulic hose into the master cylinder. See **Fig. 3**. Remove the hose and, with the end pointing upwards to prevent fluid spillage, secure it temporarily to a safe point on the vehicle. Retain the clip for later installation.




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1. Pedal Unit
2. Assist Spring
3. Hydraulic Hose
4. Clip
5. Bolt
6. Washer
7. Frontwall
8. Clutch Control Switch

**Fig. 1, Pedal Unit Installation**




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A. Retract the secondary lock, then depress the latch to release the connector.

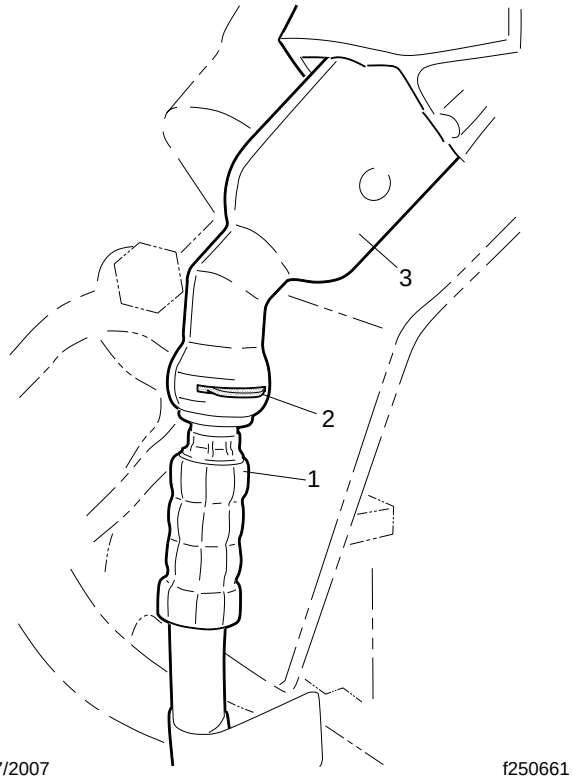
1. Secondary Lock
2. Latch

**Fig. 2, Clutch Control Switch Connector**

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## Pedal Unit Removal and Installation




1. Hydraulic Hose
2. Quick-Disconnect Clip
3. Master Cylinder

**Fig. 3, Quick-Disconnect Clip at the Master Cylinder**

# Installation

1. Install the pedal unit, and tighten the four mounting plate capscrews 11 lbf·ft (15 N·m).
2. Install the quick-disconnect clip and hydraulic hose, as follows.
   - 2.1 Insert the clip arms into the recessed areas on the nozzle of the master cylinder.
   - 2.2 Snap the hydraulic hose into place.
   - 2.3 Tug on the hose to make sure it is installed correctly. The hose should not pull out.

   IMPORTANT: Do not force the hose into the slave cylinder. If the clip is incorrectly installed, the hose will not snap into place.
3. As removed, brace the hydraulic hose with zip ties.
4. Connect the clutch control switch.
5. Install the lower steering column cover, if removed.

**WARNING**

**Use only approved clutch hydraulic fluid (DOT 4 brake fluid). Do not mix different types of brake fluid. The wrong fluid will damage the rubber parts of the system, causing loss of clutch function and the risk of serious personal injury.**

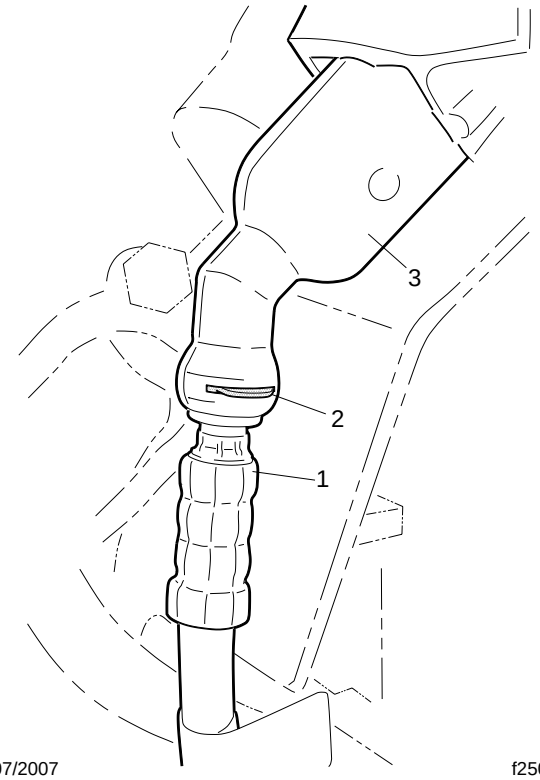
6. Fill the reservoir with approved DOT 4 hydraulic brake fluid and bleed the system as instructed in **Subject 130**.
7. Check the function of the clutch actuation system as instructed in **Subject 300**.

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## Replacement

1. Place a suitable container under the master cylinder to collect the fluid that will drain as the hose is removed from the master cylinder.
2. Use a flat-tip screwdriver to remove the quick-disconnect clip that locks the hydraulic hose into the master cylinder. See **Fig. 1**. Remove the hose and, with the end pointing upwards to prevent fluid spillage, secure it temporarily to a safe point on the vehicle. Retain the clip for later installation.

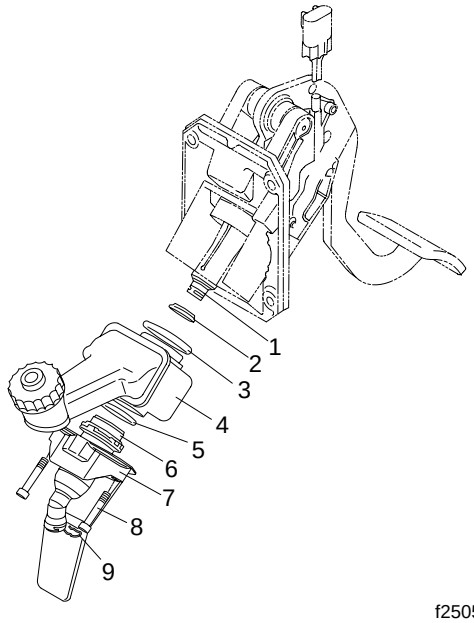



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1. Hydraulic Hose
2. Quick-Disconnect Clip
3. Master Cylinder

**Fig. 1, Quick-Disconnect Clip at the Master Cylinder**

3. Drain the fluid from the master cylinder.
4. Remove the two screws that attach the hydraulic subassembly to the mounting plate. See **Fig. 2**.




10/21/2002 f250598

1. Piston
2. Lip Seal
3. Reservoir O-Ring
4. Reservoir
5. Body O-Ring
6. Hydraulic Body
7. Base
8. Screw
9. Clip

**Fig. 2, Hydraulic Subassembly**

5. Pull carefully on the hydraulic subassembly until it comes loose from the pedal unit. Discard the old hydraulic subassembly.
6. Carefully remove the lip seal from the piston of the master cylinder. Discard the lip seal.

NOTE: Avoid damaging the piston.

7. Lubricate a new lip seal and mount it on the piston. See **Fig. 3**.

### NOTICE

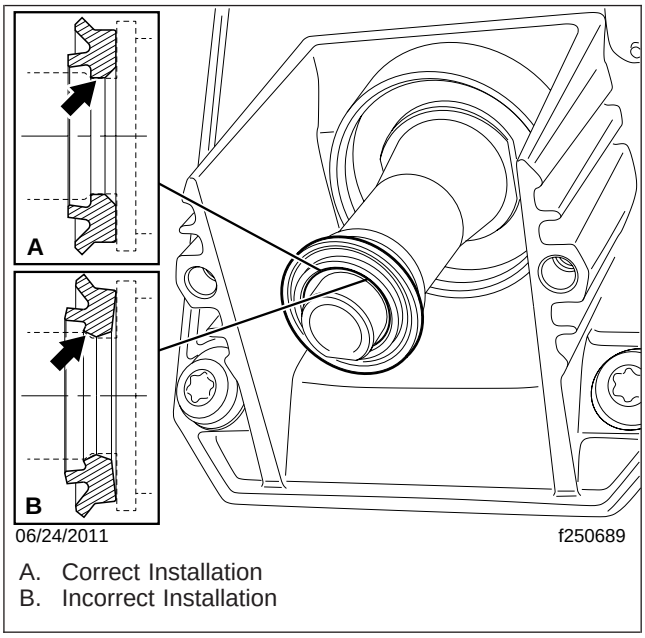
**Use only the special grease provided in the assembly kit. Do not use mineral oil or any other lubricant which could damage the seals and cause loss of clutch function.**

8. Lubricate the new O-rings and the O-ring seats in the new reservoir and hydraulic body.
9. Put the reservoir and hydraulic body together with the O-rings properly seated and lubricated.

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## Hydraulic Subassembly Replacement




A. Correct Installation
B. Incorrect Installation

**Fig. 3, Hydraulic Subassembly**

10. While holding the reservoir and hydraulic body together, insert the base over the hydraulic body.
11. Install the screws, and tighten them to 44 lbf·in (500 N·cm).
12. Install the quick-disconnect clip and hydraulic hose, as follows.
    - 12.1 Insert the clip arms into the recessed areas on the nozzle of the master cylinder.
    - 12.2 Snap the hydraulic hose into place.
    - 12.3 Tug on the hose to make sure it is installed correctly. The hose should not pull out.

    IMPORTANT: Do not force the hose into the slave cylinder. If the clip is incorrectly installed, the hose will not snap into place.

**⚠ WARNING**

**Use only approved clutch hydraulic fluid (DOT 4 brake fluid). Do not mix different types of brake fluid. The wrong fluid will damage the rubber parts of the system, causing loss of clutch function and the risk of serious personal injury.**

13. Fill the reservoir with approved DOT 4 hydraulic brake fluid and bleed the system as instructed in **Subject 130**.
14. Check the function of the clutch actuation system as instructed in **Subject 300**.

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## Replacement

**WARNING**

**Clutch hydraulic fluid (DOT 4 brake fluid) is hazardous. It may be a skin irritant and can cause blindness if it gets in your eyes. Always wear safety glasses when handling clutch hydraulic fluid or bleeding hydraulic lines. If you get clutch hydraulic fluid on your skin, wash it off as soon as possible.**

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Open the hood.
3. Using a flat-tip screwdriver, remove the quick-disconnect clip that attaches the hydraulic hose to the slave cylinder. See **Fig. 1**. Retain the clip for later installation.

**WARNING**

**Do not depress the clutch pedal while the slave cylinder is removed from the clutch housing. The slave cylinder piston could be ejected, causing component damage or serious personal injury.**

4. Drain the hydraulic fluid from the entire system.
5. Loosen the four slave cylinder mounting capscrews that attach the slave cylinder to the clutch housing.
6. After bracing the slave cylinder so that it does not fall, remove and save the four slave cylinder mounting capscrews.

IMPORTANT: Handle the slave cylinder carefully to prevent spillage.

IMPORTANT: Be sure to mount the slave cylinder with the bleed valve on top of the unit and horizontal to the ground, as shown in **Fig. 1**.

7. Mount a new slave cylinder on the clutch housing, as follows.
   - 7.1 Make sure that the pushrod is attached to the clutch fork and inserted into the pushrod bore in the slave cylinder.
   - 7.2 Push the slave cylinder against the clutch housing to compress the internal spring.
8. Install the four slave cylinder mounting capscrews and tighten them 13 lbf·ft (18 N·m).
9. Install the quick-disconnect clip and hydraulic hose, as follows.
   - 9.1 Insert the clip arms into the recessed areas on the nozzle of the master cylinder.
   - 9.2 Snap the hydraulic hose into place.
   - 9.3 Tug on the hose to make sure it is installed correctly. The hose should not pull out.

   IMPORTANT: Do not force the hose into the slave cylinder. If the clip is incorrectly installed, the hose will not snap into place.

**WARNING**

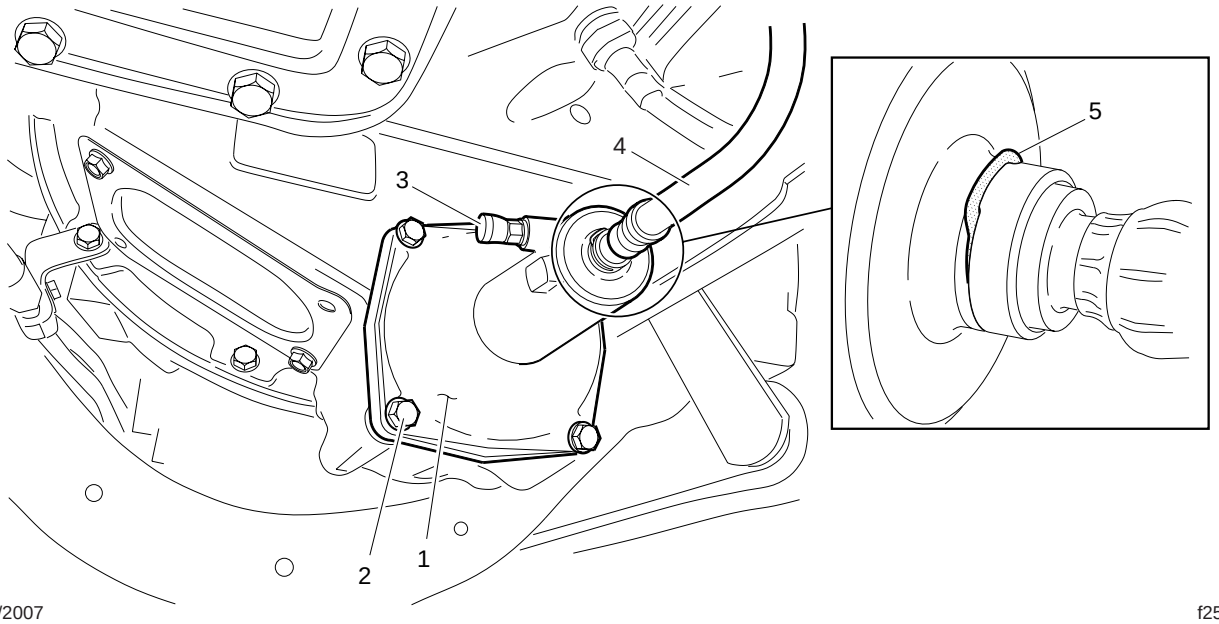
**Use only approved clutch hydraulic fluid (DOT 4 brake fluid). Do not mix different types of brake fluid. The wrong fluid will damage the rubber parts of the system, causing loss of clutch function and the risk of serious personal injury.**

10. Fill the reservoir with approved DOT 4 hydraulic brake fluid, and bleed the system as instructed in **Subject 130**.
11. Check the function of the clutch actuation system as instructed in **Subject 300**.

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## Slave Cylinder Replacement




1. Slave Cylinder
2. Capscrew
3. Bleed Valve
4. Hydraulic Hose
5. Quick-Disconnect Clip

**Fig. 1, Clutch Slave Cylinder**

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**⚠ WARNING**

**Hydraulic clutch control fluid (DOT 4 brake fluid) is hazardous. It may be a skin irritant and can cause blindness if it gets in your eyes. Always wear safety glasses when handling it or bleeding hydraulic lines. If you get it on your skin, wash it off as soon as possible.**

**NOTICE**

**Do not spill hydraulic clutch control fluid on the cab paint. Clean it off immediately if any is spilled. Brake fluid can damage paint.**

## Filling

The hydraulic system holds approximately 0.5 quart (0.5 liter) of fluid. Use new DOT 4 brake fluid from a tightly sealed container to fill the system until the fluid level is between the MIN and MAX lines marked on the side of the reservoir. See **Fig. 1**.

## Bleeding

The hydraulic clutch control can be bled by using a pressure adaptor or manual bleeding. Pressure bleeding can be done by one person and manual bleeding requires two.

IMPORTANT: When bleeding the system, the pressure line must slope continuously downward from the master cylinder to the slave cylinder. On vehicles where the hydraulic hose slopes upward (see **Fig. 2**), unclamp the hose before bleeding the system; when finished, fasten the hose as removed.

### Pressure Bleeding

NOTE: A bleeder system (J-29532) and a bleed adaptor (J-35798) for the fluid reservoir are available through SPX Kent-Moore Tools and may be used to complete the following procedure. To order these parts, call Kent-Moore at 1-800-328-6657.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires and open the hood.

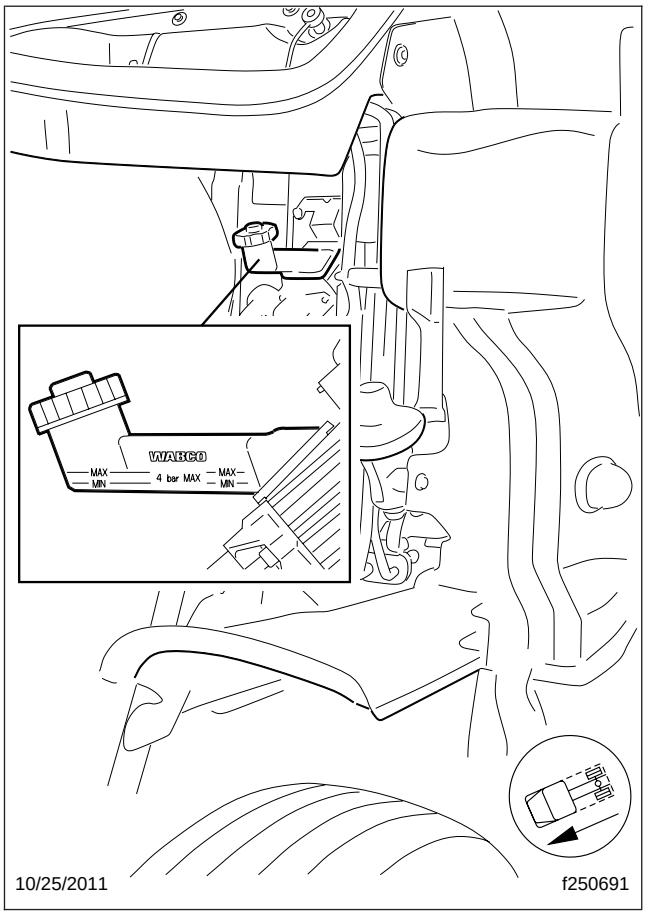


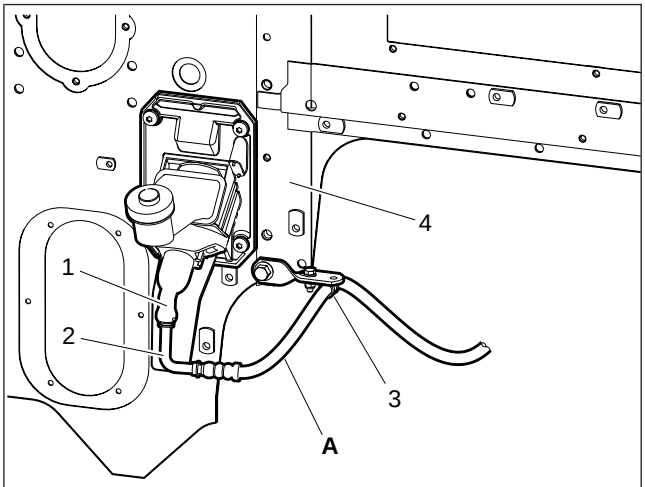

**Fig. 1, Reservoir, Hydraulic Clutch Control**

2. Prepare the pressure bleeding equipment according to the manufacturer's instructions. Use new DOT 4 brake fluid from a tightly sealed container. Pressurize the bleed adaptor to 15 psi (103 kPa).
3. Remove the reservoir lid, and install the pressure bleed adaptor on the reservoir. See **Fig. 1**.
4. Bleed the hydraulic system, as follows.
   - 4.1 Open the bleed valve on the bleed tank to pressurize the reservoir.
   - 4.2 Remove the cap from the bleed valve of the slave cylinder. See **Fig. 3**. On the valve, install a transparent drain hose connected to a catch bottle. The hose needs to fit the bleed valve tight enough so it does not fall off when fluid is pumped out.

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## Fluid Filling and Bleeding




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A. On vehicles where the pressure line slopes upward, unclamp the hose before bleeding the system; when finished, fasten the hose as removed.

1. Master Cylinder
2. Hydraulic Hose
3. Bracket and P-Clamp Assembly
4. Frontwall

**Fig. 2, Hydraulic Hose, Upward Slope Installation**

4.3 Open the bleed valve on the slave cylinder.

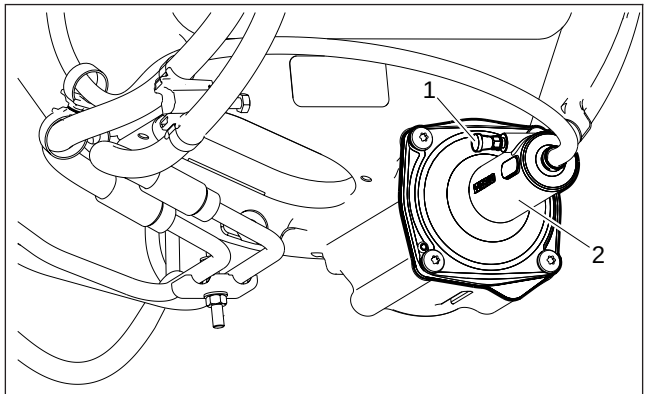
4.4 When the draining fluid is clear and free of air bubbles, close the bleed valve.

5. Check the fluid level in the reservoir. If necessary, add or drain fluid to bring the fluid level to between the MIN and MAX lines marked on the side of the reservoir.
6. Install the reservoir lid.
7. Disconnect the transparent hose. Tighten the bleed valve 88 lbf·in (1000 N·cm) and install the cap on the slave cylinder bleed valve.
8. Depress the clutch pedal a few times. There should be resistance over the full pedal stroke.

## Manual Bleeding

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires and open the hood.

NOTE: The hydraulic system holds approximately 0.5 quart (0.5 liter) of fluid. It may need to be refilled during the bleeding process to prevent air from re-entering the system.




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1. Bleed Valve
2. Slave Cylinder

**Fig. 3, Slave Cylinder, Hydraulic Clutch Control**

2. Remove the reservoir lid and fill the reservoir (see **Fig. 1**) with new DOT 4 brake fluid from a tightly sealed container.
3. Remove the cap from the bleed valve of the slave cylinder. See **Fig. 3**. On the valve, install a transparent drain hose connected to a catch bottle. The hose needs to fit the bleed valve tight enough so it does not fall off when fluid is pumped out.

NOTE: The following steps require two people—one in the cab to work the clutch pedal, and one to open and close the bleed valve and watch the fluid.

4. Bleed the system, as follows.

4.1 Open the bleed valve.

4.2 Depress the clutch pedal until it stops.

4.3 Close the bleed valve.

4.4 Return the pedal to the upper position.

4.5 Repeat the previous steps until the fluid is clear and free of air bubbles.

4.6 Depress the clutch pedal. There should be resistance over the full pedal stroke.

5. Check the fluid level in the reservoir. If necessary, add or drain fluid to bring the fluid level to between the MIN and MAX lines marked on the side of the reservoir. Install the reservoir lid.

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6. Disconnect the transparent hose. Tighten the bleed valve 88 lbf·in (1000 N·cm) and install the cap on the slave cylinder bleed valve.

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## Replacement

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Open the hood.

**WARNING**

**Clutch hydraulic fluid (DOT 4 brake fluid) is hazardous. It may be a skin irritant and can cause blindness if it gets in your eyes. Always wear safety glasses when handling clutch hydraulic fluid or bleeding hydraulic lines. If you get clutch hydraulic fluid on your skin, wash it off as soon as possible.**

3. Using a flat-tip screwdriver, remove the quick-disconnect clip that attaches the hydraulic hose to the slave cylinder. Retain the clip. See **Fig. 1**.
4. Drain the hydraulic fluid from the entire system.
5. At the quick-disconnect clip that attaches the hydraulic hose to the master cylinder, note the position of the clip for later installation, then remove it using a flat-tip screwdriver. See **Fig. 2**.
6. Route the new hydraulic hose between the slave cylinder and the master cylinder.
7. Install the quick-disconnect clip and hydraulic hose, as follows.

   7.1 Insert the clip arms into the recessed areas on the nozzle of the master cylinder.

   IMPORTANT: Do not force the hose into the slave cylinder. If the clip is incorrectly installed, the hose will not snap into place.

   7.2 Snap the hydraulic hose into place.

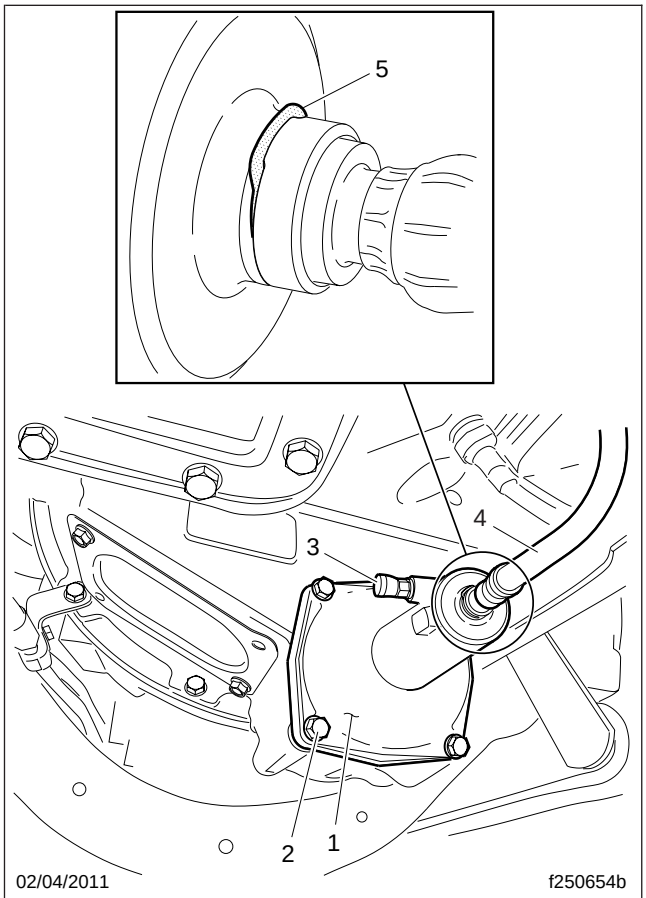
   7.3 Tug on the hose to make sure it is installed correctly. The hose should not pull out.

   7.4 Insert the clip at the slave cylinder, and install the hose as described above.

**WARNING**

**Use only approved clutch hydraulic fluid (DOT 4 brake fluid). Do not mix different types of brake fluid. The wrong fluid will damage the rubber parts of the system, causing loss of clutch function and the risk of serious personal injury.**

8. Fill the reservoir with approved DOT 4 hydraulic brake fluid and bleed the system as instructed in **Subject 130**.
9. Check the function of the clutch actuation system as instructed in **Subject 300**.



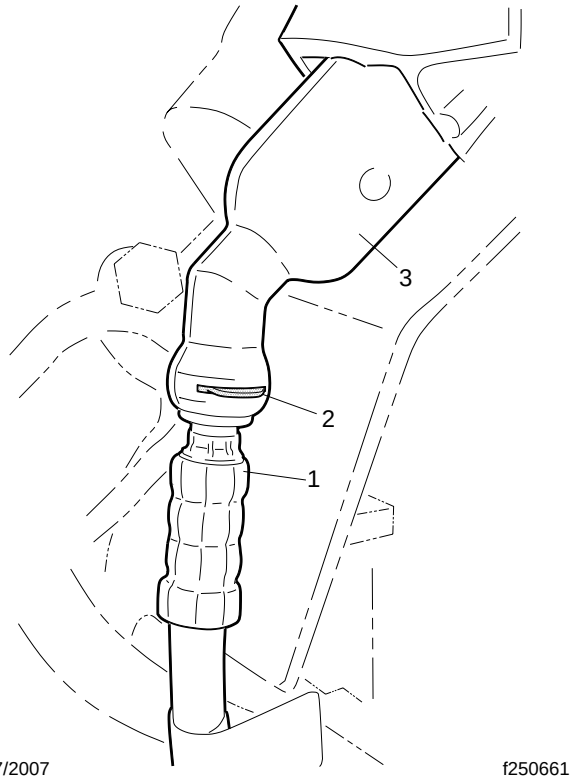

1. Slave Cylinder
2. Capscrew
3. Bleed Valve
4. Hydraulic Hose
5. Quick-Disconnect Clip

**Fig. 1, Clutch Slave Cylinder**

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## Hydraulic Hose Replacement




1. Hydraulic Hose
2. Quick-Disconnect Clip
3. Master Cylinder

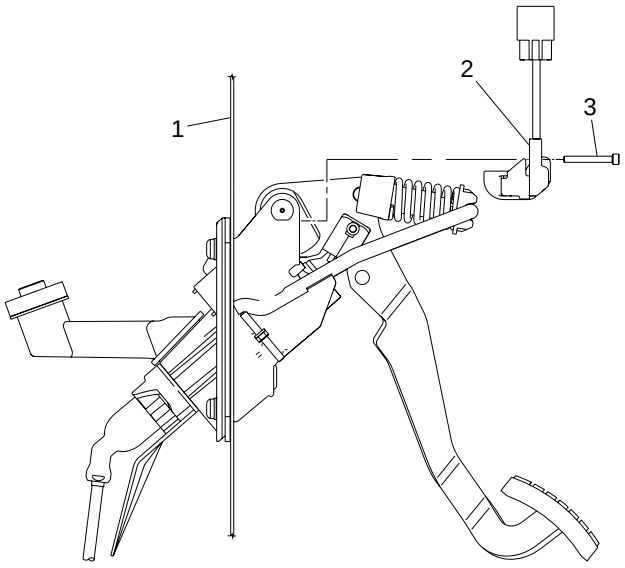
**Fig. 2, Quick-Disconnect Clip at the Master Cylinder**

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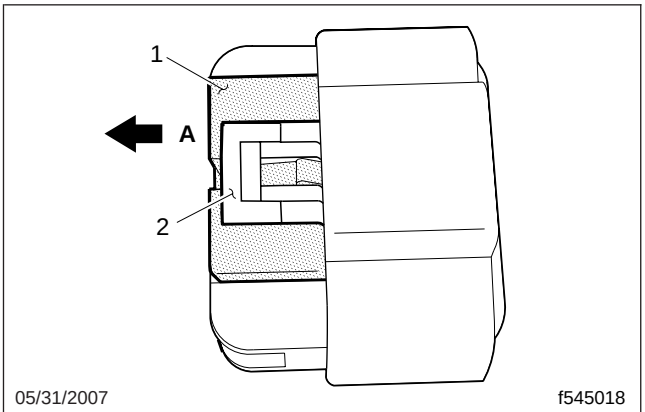
## Replacement

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Open the hood.
3. Remove the lower steering column cover, if needed.
4. Disconnect the clutch control switch located under the dash and above the clutch pedal, as follows. See **Fig. 1**.
   - 4.1 Retract the secondary lock. See **Fig. 2**.
   - 4.2 Depress the latch to unlock the switch connector, then separate the clutch control switch from the wire harness.
5. Remove the screw that holds the switch assembly to the pedal unit, and remove the switch.
6. Mount the new switch assembly on the connector and tighten the M5 screw 23 lbf·in (260 N·cm).
7. Check the function of the clutch actuation system as instructed in **Subject 300**.
8. Install the lower steering column cover, if removed.




1. Frontwall
2. Clutch Control Switch
3. Screw

**Fig. 1, Clutch Control Switch**




A. Retract the secondary lock, then depress the latch to release the connector.

1. Secondary Lock
2. Latch

**Fig. 2, Clutch Control Switch Connector**

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## Diagnostic Checks

IMPORTANT: If any problems are noticed during these diagnostic checks, take corrective action using the information under the heading "Troubleshooting Tables."

When repairing any components, bleed the clutch hydraulic system before restoring the vehicle to service. This will prevent air from remaining in the system. See **Subject 130** for instructions.

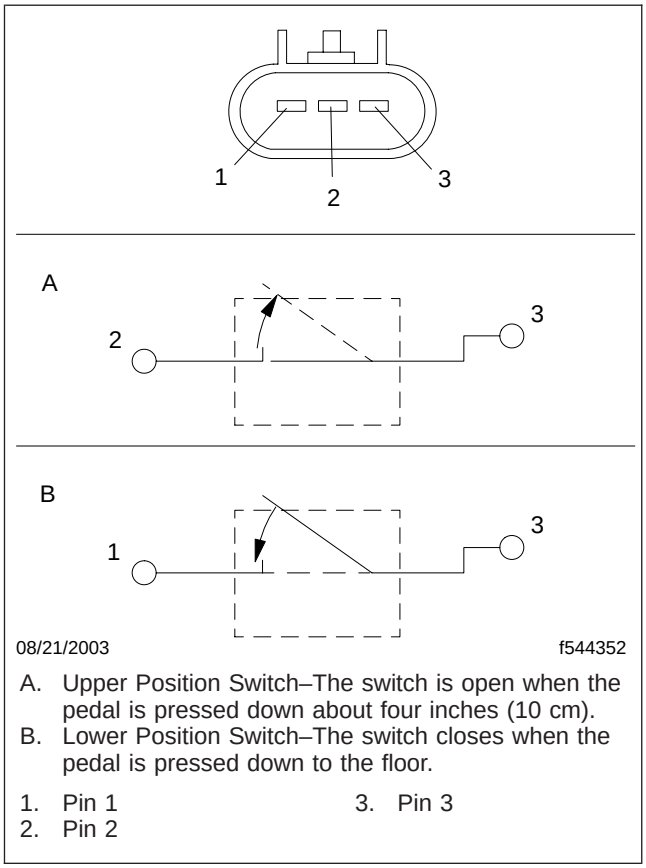
### Clutch Switch Check

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Disconnect the clutch control switch connector located under the dash just above the clutch pedal.
3. To check the upper position switch, do a continuity check between pin 2 and pin 3 of the connector. See **Fig. 1**.
   - 3.1 With the pedal not pressed, the circuit should be closed (continuity should be present).
   - 3.2 With the pedal pressed down about 4 inches (10 cm), the circuit should be open (no indication of continuity).
4. To check the lower position switch, do a continuity check between pin 1 and pin 3 of the connector.
   - 4.1 With the pedal not pressed, the circuit should be open (no indication of continuity).
   - 4.2 With the pedal pressed down all the way to the floor, the circuit should be closed (continuity should be present).
5. If either check gives an incorrect result, replace the clutch switch.

### Clutch Actuation System Check

**WARNING**

**Air in the clutch hydraulic system can prevent the gears from engaging properly, and cause a serious accident resulting in personal injury.**




A. Upper Position Switch–The switch is open when the pedal is pressed down about four inches (10 cm).
B. Lower Position Switch–The switch closes when the pedal is pressed down to the floor.

1. Pin 1
2. Pin 2
3. Pin 3

**Fig. 1, Clutch Switch**

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Press the pedal all the way to the floor several times and check the action of the pedal. The pedal should be easy to operate and return without difficulty to its original position. It should feel firm and responsive, not soft or spongy.
3. With both the brake and the clutch pedals pressed down, start the engine.
   - If the engine does not start, take corrective action using the information under the heading "Troubleshooting Tables."
   - If the clutch does not disengage properly, take corrective action using the information under the heading "Troubleshooting Tables."
4. Remove the chocks from the front and rear tires.

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5. Test drive the vehicle.
   5.1 Check for proper clutch functioning while shifting gears.
   5.2 With cruise control on, press the clutch pedal down. If cruise control does not deactivate, take corrective action using the information under the heading "Troubleshooting Tables."

## Troubleshooting Tables

**Problem–The Clutch Pedal Feels Soft or Spongy**

| Problem–The Clutch Pedal Feels Soft or Spongy | |
|---|---|
| **Possible Cause** | **Remedy** |
| There is air in the hydraulic system. | Bleed the hydraulic system. See **Subject 130** for instructions. |
| There is a hydraulic fluid leak. | Check the fluid level. Check for leakage and replace any components found to be leaking. Fill and bleed the hydraulic system. |

**Problem–The Clutch Pedal Is Unusually Hard To Operate**

| Problem–The Clutch Pedal Is Unusually Hard To Operate | |
|---|---|
| **Possible Cause** | **Remedy** |
| The clutch is damaged. | Remove the clutch and inspect it for damage. Replace the clutch if damaged, or make any necessary repairs. |
| The clutch is not functioning properly. | Check clutch function and make any necessary repairs. See the instructions under the heading "Clutch Actuation System Check." |
| The return or assist spring is broken. | Replace the pedal unit. See **Subject 100** for instructions.<br>**⚠ WARNING**<br>**Do not attempt to disassemble the preloaded assist spring. Sudden release of the assist spring could cause property damage and serious personal injury.** |
| The pedal assembly is worn or jammed. | Replace the pedal unit. See **Subject 100** for instructions. |
| The master cylinder has components that are jammed or broken. | Replace the hydraulic subassembly. See **Subject 110** for instructions. |

**Problem–The Clutch Does Not Completely Disengage; Shifting Is Difficult and Noisy**

| Problem–The Clutch Does Not Completely Disengage; Shifting Is Difficult and Noisy | |
|---|---|
| **Possible Cause** | **Remedy** |
| There is air in the hydraulic system. | Bleed the hydraulic system. See **Subject 130** for instructions. |
| There is a hydraulic fluid leak. | Check the fluid level. Check for leakage and replace any components found to be leaking. Fill and bleed the hydraulic system. |
| Components of the pedal unit are defective. | Replace the pedal unit. See **Subject 100** for instructions. |
| The slave cylinder is defective. | Replace the slave cylinder. See **Subject 120** for instructions. |
| The slave cylinder is loose. | Tighten the slave cylinder mounting capscrews. See **Subject 400** for torque values. |
| The wrong type of brake fluid was used. | Replace the complete system. Fill only with approved DOT 4 brake fluid. |

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**Problem–The Clutch Is Slipping**

| Problem–The Clutch Is Slipping | |
|---|---|
| **Possible Cause** | **Remedy** |
| The clutch is worn. | Replace the clutch. |
| Contamination (e.g. oil, grease, etc.). | Replace the clutch. |
| The clutch actuation system is "preloading." | Check the clutch actuation system. See the procedures under the heading "Clutch Actuation System Check." |

**Problem–The Clutch Switch Does Not Activate**

| Problem–The Clutch Switch Does Not Activate | |
|---|---|
| **Possible Cause** | **Remedy** |
| The switch contacts are damaged or worn. | Replace the clutch switch assembly. See **Subject 150** for instructions. |
| The switch wiring is damaged. | Repair the wiring. See **Section 54.00**. |
| The switch cam is damaged. | Replace the pedal unit. See **Subject 100** for instructions. |

**Problem–The Clutch Pedal Does Not Return**

| Problem–The Clutch Pedal Does Not Return | |
|---|---|
| **Possible Cause** | **Remedy** |
| The return or assist spring is broken. | Replace the pedal unit. See **Subject 100** for instructions.<br>**WARNING**<br>**Do not attempt to disassemble the preloaded assist spring. Sudden release of the assist spring could cause property damage and serious personal injury.** |

**Problem–Cruise Control or Engine Brake Does Not Deactivate When the Clutch Pedal Is Pressed Down**

| Problem–Cruise Control or Engine Brake Does Not Deactivate When the Clutch Pedal Is Pressed Down | |
|---|---|
| **Possible Cause** | **Remedy** |
| The upper position switch is damaged. | Check switch function and make any necessary repairs. See the instructions under the heading "Clutch Switch Check." |

**Problem–Starter Does Not Operate**

| Problem–Starter Does Not Operate | |
|---|---|
| **Possible Cause** | **Remedy** |
| The lower position switch is damaged. | Check switch function and make any necessary repairs. See the instructions under the heading "Clutch Switch Check." |

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## Specifications

| Torque Values | | | | |
|---|---|---|---|---|
| **Description** | **Size** | **Grade/Class** | **Torque: lbf·ft (N·m)** | **Torque: lbf·in (N·cm)** |
| Bleed Valve | M7 | — | — | 88 (1000) |
| Clutch Switch Mounting Screw | M5 | — | — | 23 (260) |
| Hydraulic Sub-Assembly Retainer | — | — | — | 44 (500) |
| Pedal Unit Mounting Plate Capscrews | M8 | 8.8 | 13 (18) | — |
| Slave Cylinder Mounting Capscrews | M8 | 10.9 | 13 (18) | — |
| Standoff Bracket Mounting Capscrews | 1/4–20 | 8 | 10 (14) | — |

**Table 1, Torque Values**

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# General Information

The Fuller rear mount multi-speed PTO neutral interlock system is designed to provide a neutral position in the auxiliary section of a Fuller Roadranger transmission (except RT–6610/6613 series) for the purpose of using an extended rear countershaft power take-off (PTO) in a stationary vehicle mode. A locking mechanism, which is interlocked to the neutral position of the unit's front section, ensures that the auxiliary section cannot be re-engaged to an in-gear position unless the front section is in neutral. This feature prevents accidental or inadvertent transmission operation which could result in the vehicle moving under power.

The standard range cylinder assembly is modified to include a positioning piston and neutral plunger with mating ramps, for stationary mode operation. The air shut-off valve of this neutral/range cylinder assembly renders the shifting controls in the cab inoperable when the neutral plunger is down, locking the range yoke bar in the centered position during stationary mode operation. Even in the event that air to the range system is accidentally restored, an air line becomes severed, or other malfunctions of the system occur, the auxiliary section will remain in neutral once the neutral plunger is down and locked in the neutral position. Once the neutral plunger is down and locked in the neutral position, the only way it can be overcome is with a mobile air signal sent from the stationary/mobile control valve and directed through the sequencing protection valve.

The design of the Fuller rear mount multi-speed simplifies the procedure of engaging and disengaging an extended rear countershaft PTO. It also provides the operator with the additional safety afforded by the neutral/range cylinder when in the stationary mode.

# Unit Identification

## Model and Serial Number Identification

All Fuller transmissions are identified by model and serial number. This information is stamped on the transmission identification tag and permanently affixed to the case. For a detailed explanation of the model designations, refer to the manufacturer's service literature.

## Rear Mounted PTO System Identification

Easy identification of a transmission for the purpose of specifying a rear-mounted PTO system is essential for the truck dealer, PTO distributor, vehicle body builder, and transmission technician to determine which PTO and related systems are required to complete the installation.

The following code system (**Fig. 1**) is used to identify any Fuller model transmission epuipped with a complete rear mount multi-speed PTO neutral interlock system, or partial system. This information is to be stamped in the upper left hand corner PTO Code block of the transmission identification tag.

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## General Information

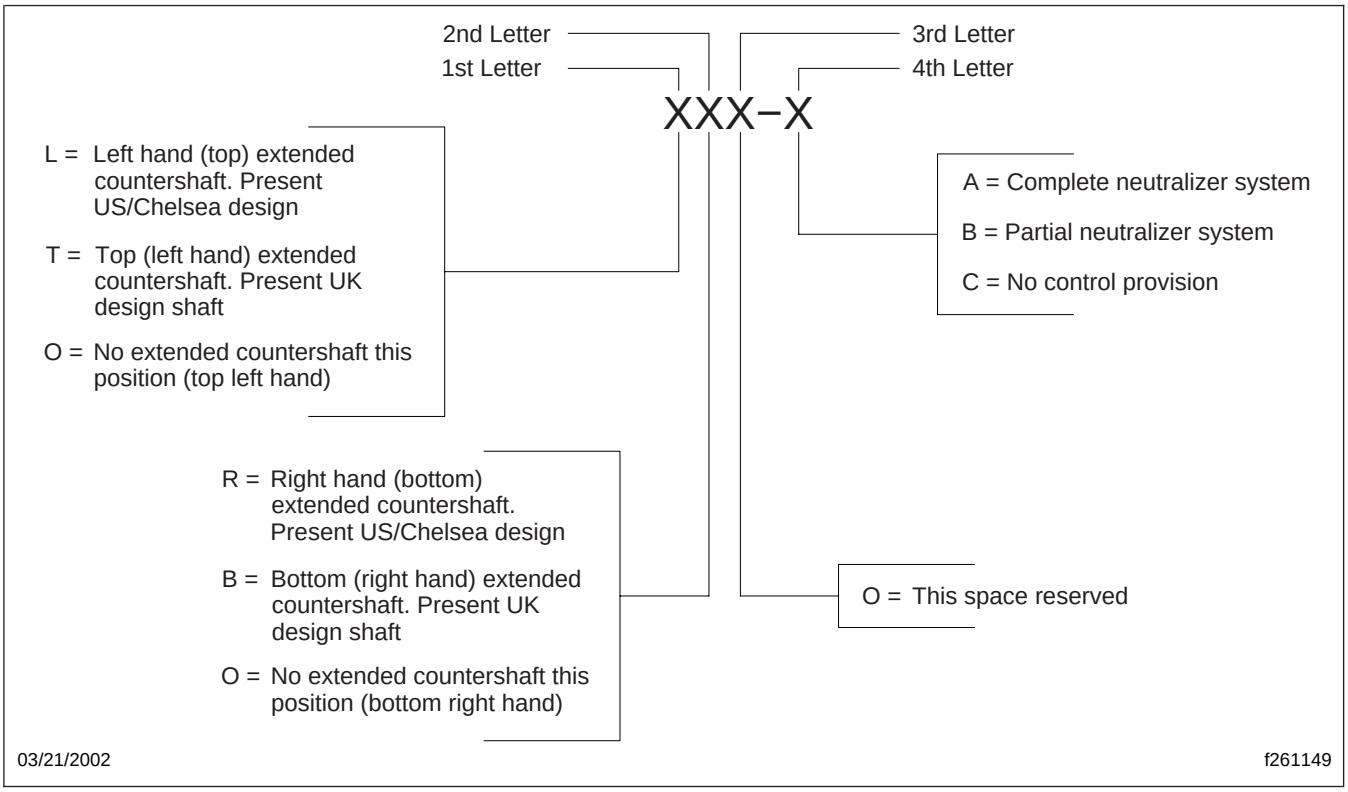



**Fig. 1, PTO Code Block**

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# Installation

## Preparation of Unit for Modification

A shift bar housing with a neutral switch provision, and Pt. 20332, slave air valve actuating plunger, is required when modifying any unit to include the Fuller rear mount multi-speed PTO neutral interlock system. In some instances, their installation can be performed without removing the transmission from the vehicle chassis. However, the lubricant should always be drained from the transmission when removal of an auxiliary section is necessary.

It is assumed in the following instructions, that when removal of the transmission from the chassis is planned, the lubricant has been drained from the transmission case; the gear shift lever housing assembly has been removed from the shift bar housing; and all other external connections, such as clutch linkage, driveline, speedometer cable, etc., have been disconnected. Make sure the air hose from the vehicle supply source, and all air lines to the shift controls in the cab, including the deep reduction valve and extended rear countershaft PTO control valve if so equipped, and slave air valve on transmission case have also been disconnected.

NOTE: Unless otherwise stated, the following instructions pertain to all Fuller Roadranger models to be modified with the Fuller rear mount multi-speed PTO neutral interlock system.

## Disassembly and Reassembly of Unit for Modification

1. Turn out the retaining capscrews, break the gasket seal, and remove the shift bar housing assembly from the case (if the shift bar housing has a neutral switch provision and can be reused).
2. Remove the neutral switch or plug from the threaded hole in the housing.
3. Secure the housing in a vise, using caution to avoid marring the machined mounting surface.
4. Remove only those parts of the assembly which make it possible to remove Pt. 17177, slave air valve actuating plunger, from the bore in the shift bar housing.
5. Replace it with Pt. 20332, actuating plunger, and reassemble the shift bar housing assembly.

NOTE: During reassembly, do not reinstall the neutral switch or plug.

6. Disconnect all 1/4-inch i.d., and 1/8-inch o.d. air system lines (range splitter and deep reduction), at the slave air valve and the auxiliary section.
7. If an extended auxiliary countershaft assembly is to be installed, do the following.

   7.1 Remove the output shaft stop nut, companion flange or yoke, and speedometer drive gear or replacement spacer.

   7.2 Turn out the retaining capscrews and remove the auxiliary section.

   7.3 Mount the auxiliary section upright in a vise, and secure using caution to avoid marring the machined surface of the housing flange.

   7.4 Remove the air filter regulator assembly, the range cylinder cover, the nut from the end of the yoke bar, and the piston and range cylinder housing.

   NOTE: Only Pt. 14341, range piston, removed from models with a two-speed auxiliary section can be reused.

   7.5 Remove the countershaft rear bearing cover, the bearing and auxiliary countershaft assembly to be replaced by the extended auxiliary countershaft assembly, and related parts.

   NOTE: For auxiliary sections of 13-speed splitter models only, removal of the range yoke and bar, synchronizer assembly, and low range mainshaft gear must be performed to remove the auxiliary countershaft assembly.

   7.6 Mark the tooth of the extended auxiliary countershaft assembly (which is stamped with an "O" on the low range gear of models with a twospeed auxiliary section), the splitter gear of 13-speed splitter models, and the reduction gear of deep reduction models.

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7.7 Place the extended auxiliary countershaft assembly into position with the marked tooth between the two marked teeth of the mating gear on the mainshaft. Make sure that the "timing marks" of the other countershaft are still in proper mesh.

7.8 Install the countershaft rear bearing, making sure that both countershafts are still in time.

NOTE: For auxiliary sections of 13-speed splitter models only, installation of the low range mainshaft gear and synchronizer assembly must be performed prior to installing the rear countershaft bearing. The range yoke and bar only should then be installed.

8. If an extended auxiliary countershaft assembly is not to be installed:

   Remove the air filter/regulator assembly, the range cylinder cover, the nut from the end of the yoke bar, and the piston and range cylinder housing, leaving the yoke bar to protrude in the bore of the auxiliary section.

9. When applicable, turn out the retaining capscrews and remove the splitter or deep reduction cover only.

## Precautions

To ensure proper operation and expected life from the parts contained in the Fuller rear mount multi-speed PTO neutral interlock system, use the following precautions during assembly and installation.

1. Gaskets: Make sure new gaskets are installed throughout the unit as it is being rebuilt. The omission of any gasket can result in oil leakage or misalignment of parts.
2. Capscrews/threaded fasteners: To prevent air and oil leakage, apply Loctite 242 sealant to threads of all capscrews, Pt. 20435, adaptor, Pt. 12639, neutral switch, Pt. 20849, hex pilot, and at both ends of Pt. 20424 or Pt. 20439, range piston spacer. Torque the fasteners to recommended ratings as noted in the following procedures.
3. O-Rings: Apply silicone lubricant 71206 to all O-rings so that a film of lubricant covers the entire surface of each O-ring.
4. Air fittings/hoses: To prevent air leakage, apply sealant 71205 to all air fittings and hose connections. Sealant must cover at least three complete and consecutive threads beginning with the first three threads of each part to be installed.
5. Cylinder bores: Apply rust preventative to the cylinder bores of Pt. 20418 or Pt. 20438, neutral/range cylinder housing (neutral plunger, range yoke bar and piston bores), Pt. 20442, splitter/deep reduction position sensing cylinder cover (valve actuating pin and piston-pin bores), and Pt. 20849, hex pilot (piston-pin bore). A film of rust preventative should completely cover these finished bore surfaces.
6. Initial lubrication: To prevent premature wear, an application of *Moly Kote "G"* should completely cover the areas specified on the following parts.
   - The shanks and bores of actuating pins used with Pt. 21052, sequencing protection valve, Pt. 20430, air shut-off valve, Pt. 18734, splitter/deep reduction position sensing valve, and Pt. 12639, neutral switch.
   - The shank and point of Pt. 20422, neutral plunger, and shank bore of cylinder housing.
   - The chamfered edges of Pt. 20425, reaction washers.
   - The surfaces of Pt. 20424 or Pt. 20439, range piston spacer, that contact with reaction washers.
   - The o.d. of Pt. 14341 or Pt. 20440, front, and Pt. 20426, rear range pistons.
   - The o.d.'s of Pt. 20444, splitter/deep reduction position sensing piston-pin.

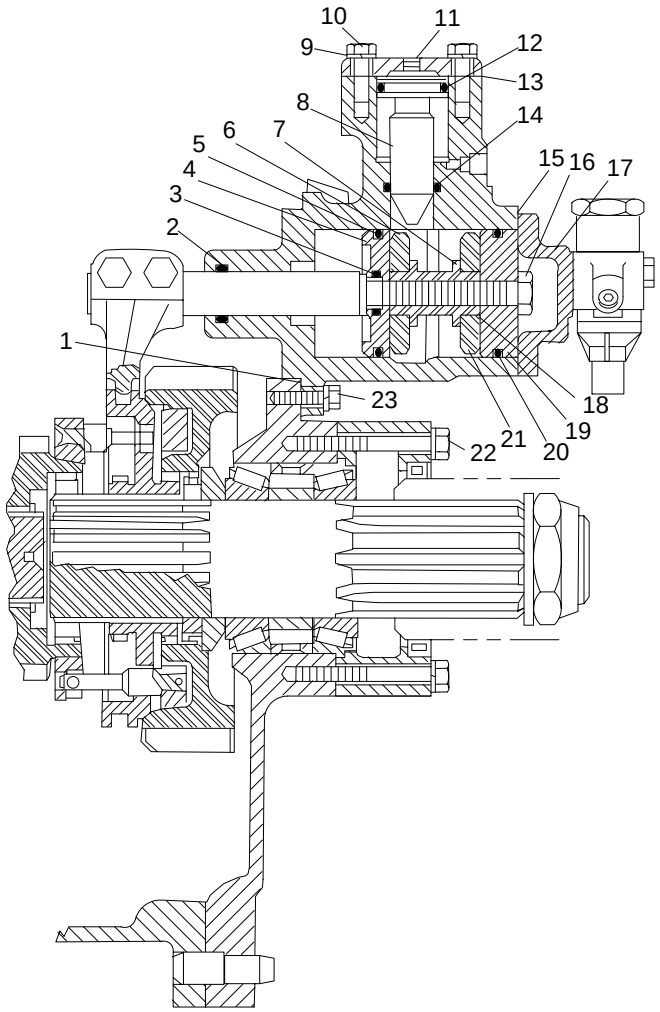
# Assembly and Installation of Parts for Modification

## Neutral/Range Cylinder Assembly

See **Fig. 1** for a cross section view thru the neutral cylinder mainshaft and dowel of an extended auxiliary countershaft and neutral interlock system, on models with a two-speed auxiliary.

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NOTE: Model RT-14609 shown.

1. Gasket 14347
2. O-Ring 14765
3. O-Ring 14345
4. Range Piston 14341
4. O-Ring 14344
6. Reaction Washer 20425
7. Spacer 20424
8. Neutral Plunger 20422
9. Lockwasher X-3-500
10. Capscrew X-8-505
11. Neutral Cylinder Cover 20419
12. O-Ring 20423
13. Gasket 14349
14. O-Ring 14785
15. Gasket 14349
16. Capscrew X-7-1005
17. Range Cylinder Cover
18. Gasket 20427
19. Rear Range Piston 20426
20. O-Ring 14344
21. Reaction Washer 20425
22. Neutral Range Cylinder Housing 20418
23. Capscrew X-8L-604

**Fig. 1, Two-Speed Auxiliary Model, Sectional View**

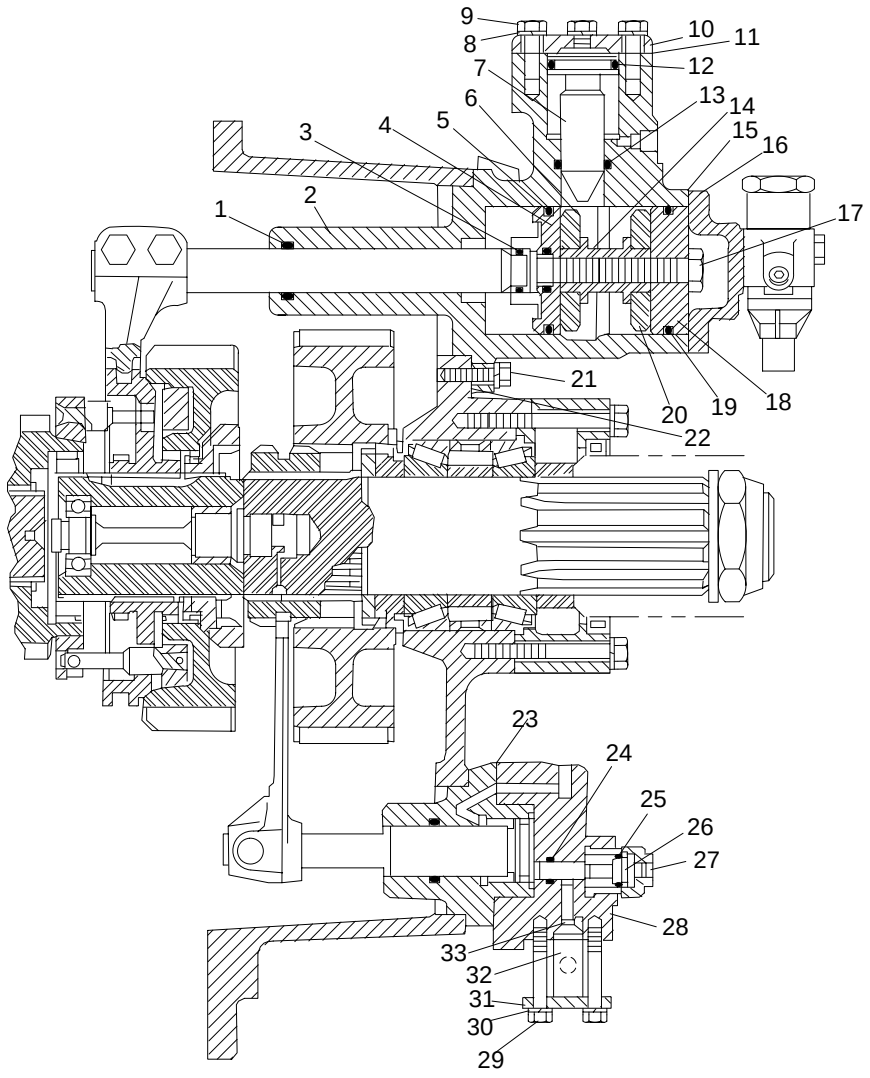
See **Fig. 2** for a cross section view thru the neutral cylinder, mainshaft and deep reduction cylinder of an extended auxiliary and neutral interlock system, on models with deep reduction.

See **Fig. 3** for a cross section view thru the neutral cylinder, mainshaft, and splitter cylinder of an extended auxiliary and neutral interlock system, on models with a 13-speed splitter.

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## Installation




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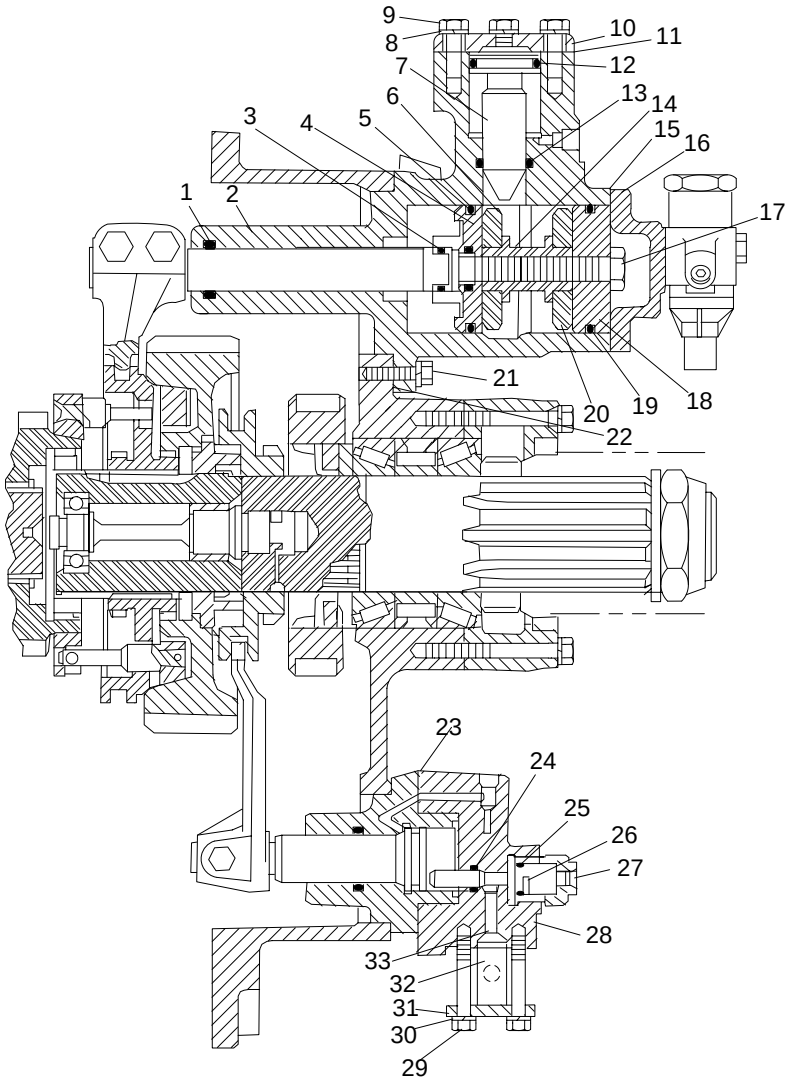
NOTE: Model RT-14615 shown.

1. O-Ring 14785
2. Neutral Range Cylinder Housing 20438
3. O-Ring 14345
4. Front Range Piston 20440
5. O-Ring 14344
6. Reaction Washer 20425
7. Neutral Plunger 20422
8. Lockwasher X-3-500
9. Capscrew X-8-505
10. Neutral Cylinder Cover 20419
11. Gasket 20421
12. O-Ring 20423
13. O-Ring 14765
14. Spacer 20439
15. Gasket 14379
16. Range Cylinder Cover
17. Capscrew X-7-1005
18. Rear Range Piston 20426
19. O-Ring 14344
20. Reaction Washer 20425
21. Capscrew X-8L-604
22. Gasket 14347
23. Gasket 17073
24. O-Ring 13642
25. O-Ring 19462
26. Sensing Piston Pin 20444
27. Hex Pilot 20849
28. Splitter/Deep Reduction Piston Sensing Cylinder Cover 20442
29. Capscrew X-8-434
30. Lockwasher 20428
31. Valve Plate 20199
32. Splitter/Deep Reduction Position Sensing Valve 18734
33. Actuating Pin 15899

**Fig. 2, Deep Reduction Model, Sectional View**

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NOTE: Model RT-14613 shown

1. O-Ring 14765
2. Gasket 14347
3. O-Ring 14345
4. Front Range Piston 20440
5. O-Ring 14344
6. Reaction Washer 20425
7. Neutral Plunger 20422
8. Lockwasher X-3-500
9. Capscrew X-8-505
10. Gasket 20421
11. Neutral Cylinder Cover 20419
12. O-Ring 20423
13. O_Ring 14785
14. Spacer 20439
15. Gasket 14349
16. Range Cylinder Cover 19690
17. Capscrew X-7-1005
18. Rear Range Piston 20426
19. O-Ring 14344
20. Reaction Washer 20425
21. Capscrew X-8L-604
22. Neutral/Range Cylinder Housing 20438
23. Gasket 17073
24. O-Ring 13642
25. O-Ring 13642
26. Sensing Piston Pin 20444
27. Hex Pilot 20849
28. Splitter/Deep Reduction Piston Sensing Cylinder Cover 20442
29. Capscrew X-8-434
30. Lockwasher 20428
31. Valve Plate 20199
32. Splitter/Deep Reduction Piston Sensing Valve 18734
33. Actuating Pin 15899

**Fig. 3, Models with 13-Speed Splitter, Sectional View**

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## Installation

1. Install the two Pt. 14765, O-rings, in position in the neutral plunger bore and the range yoke bar bore of Pt. 20418 or Pt. 20438, neutral/range cylinder housing.
2. Thread one Pt. 14249, stud, to full depth of 3/4-inch length threads into the upper left tapped hole of the auxiliary housing for mounting the neutral/range cylinder housing in the vertical position.

NOTE: If the cylinder housing is to be mounted in the horizontal position, Pt. 14249, stud, must be threaded into the upper right tapped hole in the manner described.

3. Using the stud to position one Pt. 14347, gasket, on the auxiliary housing, install the neutral/range cylinder housing, piloting it on the yoke bar. Secure with one X-3-600, lockwasher, and X-1-600, hex nut, on the stud, and three X-8L-604, capscrews, using 35 to 45 lbf·ft (47 to 61 N·m) of torque.

NOTE: In most cases, the cylinder housing mounted in the vertical position will provide sufficient frame clearance under the vehicle for the transmission to be installed properly. However, should it become necessary to mount the housing in the horizontal position, different air hoses from those noted in these instructions will be required.

4. Install one Pt. 14345, O-ring, in the i.d,.and one Pt. 14344, O-ring, on the o.d. of Pt. 14341 or Pt. 20440, front range piston.

NOTE: The Pt. 14341, range piston, is used on models with a two-speed auxiliary section only.

5. Install the front range piston on the yoke bar in the cylinder bore with the o.d. chamfer of Pt. 14341, or the shoulder of Pt. 20440, facing forward.
6. Install one Pt. 20425, reaction washer, on either shank of Pt. 20424, range piston spacer (models with a two-speed auxiliary section only), or on the longest shank of Pt. 20439, range piston spacer. Thread this two-piece assembly onto the yoke bar using 70 to 85 lbf·ft (94 to 115 N·m) of torque to secure the washer against the piston
7. Install the other Pt. 20425, reaction washer, on the shank of the range piston spacer protruding in the cylinder bore.
8. Install one Pt. 14344, O-ring, on the o.d. of Pt. 20426, rear range piston.
9. Install the rear range piston and one Pt. 20427, gasket, on the X-7-1005, capscrew. Thread the capscrew of this three-piece assembly into the range piston spacer, making sure that the gasket is between the spacer and piston, then tighten with 60 to 75 lbf·ft (81 to 101 N·m) of torque.
10. Position one Pt 14349, gasket, on the range cylinder cover mounting surface and reinstall Pt. 19690, range cylinder cover, so that the 45° elbow air fitting is to the upper left. Secure with the four capscrews that were removed earlier using 35 to 45 lbf· ft (47 to 61 N·m) of torque.
11. Install one Pt. 20423, O-ring, on the piston o.d. of Pt. 20422, neutral plunger.
12. Empty the entire contents (4 cc tube) of silicone lubricant 71206 into the neutral plunger bore, applying lubricant to the bottom of the range cylinder bore between the reaction washers.
13. Install Pt. 20422, neutral plunger, in the cylinder bore of the neutral/range cylinder housing.
14. Position one Pt. 20421, gasket, on the neutral cylinder cover mounting surface and install Pt. 20419, neutral cylinder cover. Secure with four X-8-505 capscrews and X-3-500 lockwashers, using 20 to 25 lbf·ft (27 to 33 N·m) of torque.
15. Thread one Pt. 7935, breather, in the threaded bore on the lower right side of the neutral/range cylinder housing.

## Air Shut-Off Valve Assembly

1. Thread one Pt. 7935, breather, in the threaded bore on the lower right side of the neutral/range cylinder housing.
2. Thread the following air fittings into ports of Pt. 20430, air shut-off valve.
   - 2.1 One Pt. 12880, 45° elbow, into the "IN" port on the bottom of the valve. Tighten so that the opening of the air fitting points forward and 45 degrees to the right (as if the valve was installed).

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2.2 One Pt. 12845, 90 degree street elbow, into the "C1" port on the top right of the valve. Tighten so that the opening of the air fitting points forward. For models with a three-speed auxiliary section only: Add one Pt. 12769, 1/8-inch nipple, to the street elbow, and one Pt. 12881, street tee, to the nipple. Tighten so that the openings of the tee are to the left and right.

2.3 One Pt. 12769, 1/8-inch nipple, into the "C2" port on top left of valve. Add one Pt. 12845, 90 degree street elbow, and tighten so that the opening of air fitting points forward.

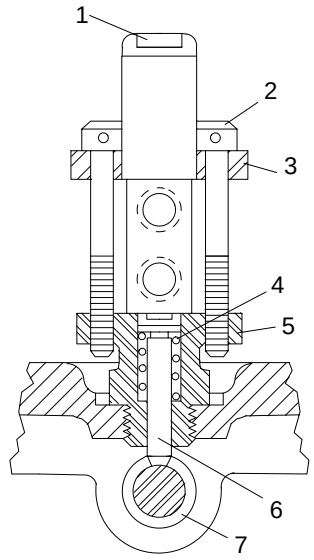
3. Position Pt. 20430, air shut-off valve, on the mounting surface of neutral/range cylinder housing with the "IN" port side down and valve plunger contacting Pt. 20429, actuating pin, in the bore. Secure with assembly of two X-8-412, capscrews, Pt. 20428, lockwasher, and Pt. 20199, valve plate, using 8 to 12 lbf·ft (11 to 16 N·m) of torque on the capscrews.
4. With the valve secured in the proper mounted position, bend the locking tabs of Pt. 20428, lockwasher, over to retain the capscrews.

## Neutral Switch

1. Install (**Fig. 4**) on the adaptor so that the "CYL" port side is to the left of transmission and valve plunger is contacting the actuating pin in the bore of the adaptor. Secure with Pt. 21053, valve plate, and two X-8-436, capscrews, using 8 to 12 lbf·ft (11 to 16 N·m) of torque.

NOTE: To ensure the valve will operate properly, make sure the valve plunger is centered on the head of the actuating pin when mounted.

2. With the valve secured in the proper mounted position, use the lockwasher to retain the capscrews.
3. Thread one Pt. 7935, breather, into the "NO" port of the sequencing protection valve and tighten.
4. Thread one Pt. 12769, nipple, into the "NC" port of the sequencing protection valve. Add one Pt. 12881, street tee, and tighten so that the openings of the tee are to the front and right of the transmission.




1. Sequencing Protection Valve 21052
2. Capscrew X-8-436
3. Valve Plate 21053
4. Spring
5. Adaptor 20435
6. Actuating Pin 20432
7. Slave Air Valve Actuating Plunger 20332

**Fig. 4, Position the Sequencing Protection Valve**

5. Thread one Pt. 12845, 90 degree street elbow, into the pilot port on top of the valve and tighten so that the opening of the air fitting points to the front. Use caution when tightening to not collapse the valve neck.

## Gear Shift Lever Housing Assembly

1. Position the gasket on the mounting surface of the shift bar housing and reinstall the gear shift lever housing assembly. Secure with the same four capscrews removed earlier and tighten using 35 to 45 lbf·ft (48 to 61 N·m) of torque.
2. For deep reduction models only, remove the range control valve or A-5010, Roadranger valve, from the mounted position on the gear shift lever and replace with A-5015, Roadranger valve.

NOTE: The deep reduction valve mounted in the dash or elsewhere in the cab is not to be used when such models are equipped with the Fuller rear mount multi-speed neutral interlock system.

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All other models, however, make use of existing shift controls when modified.

## Stationary/Mobile Control Valve

1. Install Pt. 20436, stationary/mobile control valve, on the vehicle dash or elsewhere in the cab so that the green light provision in the base plate is forward and provides easy access to the valve ports for connecting air lines.

NOTE: Mounting the valve on a separate bracket with the bracket secured to the vehicle dash or floor may be preferred. This valve should be mounted in close proximity to the extended rear countershaft PTO control valve.

2. Install Pt. 20445, control valve dial, on the valve base plate and Pt. 20454, indicator light, in the hole provided
3. Mount the following adhesive-backed operating instructions label in the vehicle cab and in clear view of the operator.
   - 3.1 Pt. 20446, label, for models with a modified two-speed auxiliary section only.
   - 3.2 Pt. 20447, label, for modified 13-speed splitter models only.
   - 3.3 Pt. 20448, label, for modified deep reduction models only.

   NOTE: The appropriate label must be mounted on a noncombustible material which complies with Federal Motor Vehicle Safety Standard No. 302.

## Air System (Refer to Air System Schematics)

NOTE: The following procedures are performed with the transmission installed in the vehicle.

1. Thread one Pt. 85002, 90 degree elbow, into the engage inlet (bottom left port) of the stationary/mobile control valve, and one Pt. 85002, 90 degree elbow, into the rear opening of the tee fitting at the supply outlet on the air filter/regulator assembly. Tighten and connect a 1/4-inch o.d. air line between the fittings.
2. Thread one Pt. 85002, 90 degree elbow, into the return inlet (bottom right port) of the stationary/mobile control valve, and one Pt. 12769, nipple, into the opening of the elbow fitting at the "C2" port on the air shut-off valve. Tighten and connect a 1/4-inch o.d. air line between the fittings.
3. Thread one Pt. 12769, nipple, into the engage outlet (upper left port) of the stationary/mobile control valve and tighten.
   - 3.1 For models with a two-speed auxiliary section only, thread one Pt. 85002, 90 degree elbow, into the port of Pt. 20419, neutral cylinder cover, and tighten the fitting so that the opening is to the front of transmission.
   - 3.2 For 13-speed splitter, and deep reduction models, thread one Pt. 85002, 90 degree elbow, or one Pt. 12769, nipple, into the rear opening of the tee fitting at the "NO" port on the splitter/deep reduction position sensing valve, and tighten with the opening of the elbow fitting upwards. Connect a 1/4-inch o.d. air line between the fittings.
4. Thread one Pt. 12769, nipple, into the return outlet (upper right port) of the stationary/mobile control valve, and one Pt. 12769, nipple, into the right opening of the tee fitting at the "NC" port on the sequencing protection valve. Tighten and connect a 1/4-inch o.d. air line between the fittings.
5. Connect one Pt. 55517, 1/4-inch i.d. air hose, from the front opening of the tee fitting at the "NC" port, to the pilot port elbow fitting on top of the sequencing protection valve.
6. If not previously done, thread one Pt. 12845, 90 degree street elbow, into the rear port at the bottom of the neutral plunger and tighten so that the opening is to the left. Connect one Pt. 55518, 1/4-inch i.d. air hose (models with a two-speed auxiliary section only), or one Pt. 55509, 1/4-inch i.d. air hose, from this fitting on the neutral/range cylinder housing to the "CYL" port of the sequencing protection valve.
7. For 13-speed splitter and deep reduction models only:
   - 7.1 Thread one Pt. 12845, 90 degree street elbow, into port of Pt. 20419, neutral cylinder cover, and tighten the fitting so that the opening is to the left of the transmission. Connect one Pt. 55526, 1/4-inch i.d.

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air hose, from this fitting to the street elbow at the "CYL" port of the splitter/deep reduction position sensing valve.

7.2 Connect one Pt. 55513, 1/4-inch i.d. air hose, from the elbow fitting in the front opening of the tee fitting at the "NO" port of the splitter/deep reduction position sensing valve, to the elbow fitting at the hex pilot port of the splitter/deep reduction position sensing cover.

7.3 Connect one Pt. 55509, 1/4-inch i.d. air hose, from the supply port of the sensing cover, to the right opening in the tee fitting at the "C1" port of the air shut-off valve. Loop the hose under the neutral range cylinder housing when doing so, and secure it with one Pt. 1166, hose clamp, to the bottom flange of the auxiliary housing.

8. Connect one Pt. 55513, 1/4-inch i.d. air hose, from the 45 degree elbow fitting at the "IN" port of air shut-off valve, to the front opening in the tee fitting at the supply outlet of the air filter regulator assembly. The hose should be looped under the neutral/range cylinder housing when doing so.

9. For deep reduction models only:

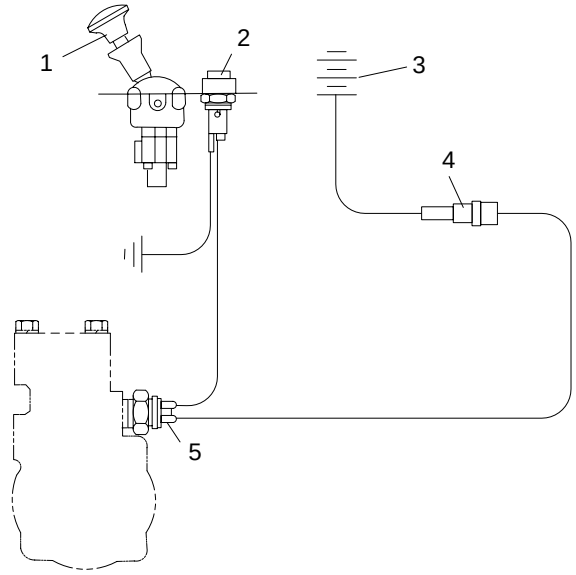
9.1 Remove Pt. 12881, street tee, and Pt. 12769, nipple, from the "S" or supply port of the slave air valve.

9.2 Remove Pt. 12845, street elbow, from the "L" (low range) port of the slave air valve.

9.3 Reinstall Pt. 12769, nipple, in the "L" (low range) port of the slave air valve, adding Pt. 12881, street tee, to the nipple. Tighten the tee fitting so that the openings are to the front and rear of the transmission.

9.4 Thread one Pt. 85002, 90 degree elbow, into the supply port of A-4688, slave air valve, only. For models equipped with Pt. 19470, or A-5000 slave air valve, reinstall Pt. 12845, street elbow, in the "S" (supply) port. Tighten the fitting specified so that the opening is to the rear of the **Fig. 5**.

10. Connect one lead wire from the remaining terminal at Pt. 20454, indicator light, to the terminal of Pt. 12639, neutral switch.




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1. Stationary/mobile Control Valve 20436 (Ref.)
2. Indicator Light 20454 (Ref.)
3. 12-Volt Power Source
4. Fuse and Fuse Holder
5. Neutral Switch 12639 (Ref.)

**Fig. 5, Electrical Schematic, Neutral Light Circuit**

11. Connect one fuse wire from the positive terminal of the vehicle power source, to the remaining terminal at Pt 12639, neutral switch.

## Preparation of Modified Unit for Operation

When applicable, an extended rear countershaft PTO control valve should be mounted in close proximity to the stationary/mobile control valve in the cab. Connect all other external components to the transmission, such as the clutch linkage, driveline, speedometer cable, etc. Refill the modified unit with the proper type, grade and quantity of lubricant, as recommended in your Fuller transmission service manual or lubrication recommendations form no. 121.

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## System Check List

Prior to placing the vehicle into operation, make the following system checks of the transmission to ensure it will function properly with the installation of the Fuller rear-mount multi-speed PTO neutral interlock system. Unless otherwise stated in the following check list, each system check with the corresponding result applies to any Fuller Roadranger model so modified.

**⚠ WARNING**

**Do not attempt to operate the vehicle if the result of any check is other than that given in the following tables. Personal injury or damage to the unit may result from improper installation and function of this system.**

| **With gear shift lever in the neutral position and mobile/stationary control valve knob in "Mobile":** | | | |
|---|---|---|---|
| A. | Does it range shift properly? | Yes | — |
| B. | Does it complete splitter/deep-reduction shift properly? (Not applicable for models with a two-speed auxiliary section.) | Yes | — |

| **With gear shift lever still in the neutral position and mobile/stationary control valve knob moved to "Stationary":** | | | |
|---|---|---|---|
| A. | Does neutral switch close contacts? | Yes | — |
| B. | Does it range shift? | — | No |
| C. | Does it complete splitter/deep-reduction shift while in low range? (Not applicable for models with a two-speed auxiliary section and 13-speed splitter models.) | — | No |
| D. | Does it complete splitter/deep-reduction shift while in high range? (Not applicable for models with a two-speed auxiliary section and deep-reduction models.) | — | No |

| **With gear shift lever moved to an in-gear position and mobile/stationary control valve knob still in "Stationary":** | | | |
|---|---|---|---|
| A. | Is output shaft permitted to turn freely while in low-range and high-range? (When applicable, with splitter deep-reduction forward and rearward.) | Yes | — |

| **With gear shift lever still in an in-gear position and mobile/stationary control valve knob moved to "Mobile":** | | | |
|---|---|---|---|
| A. | Are neutral switch contacts closed? | Yes | — |
| B. | Does it range shift? | — | No |
| C. | Does it complete splitter/deep-reduction shift while in low range? (Not applicable for models with a two-speed auxiliary section and deep-reduction models.) | — | No |
| D. | Does it complete splitter/deep-reduction shift while in high range? (Not applicable for models with a two-speed auxiliary section and deep-reduction models.) | — | No |

| **With gear shift lever moved to the neutral position and mobile/stationary control valve knob still in "Mobile":** | | | |
|---|---|---|---|
| A. | Does neutral switch close contacts? | — | No |
| B. | Does it range shift properly? | Yes | — |
| C. | Does it complete splitter/deep-reduction shift properly? (Not applicable for models with a two-speed auxiliary section.) | Yes | — |
| B. | Does it range shift properly? | Yes | — |

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## Air Line Schematics

### Vehicles with Roadranger Valve Plus an Optional Two Valve System

For vehicles with a Roadranger valve plus an optional two valve system, see **Fig. 1** for the "MOBILE" position. See **Fig. 2** for the "STATIONARY" position. See **Fig. 3** for the "STATIONARY TO MOBILE" position.

### Vehicles with Roadranger Valve Plus an Optional Range Valve

For vehicles with a Roadranger valve plus an optional range valve, see **Fig. 4** for the "MOBILE" position. See **Fig. 5** for the "STATIONARY" position. See **Fig. 6** for the "STATIONARY TO MOBILE" position.

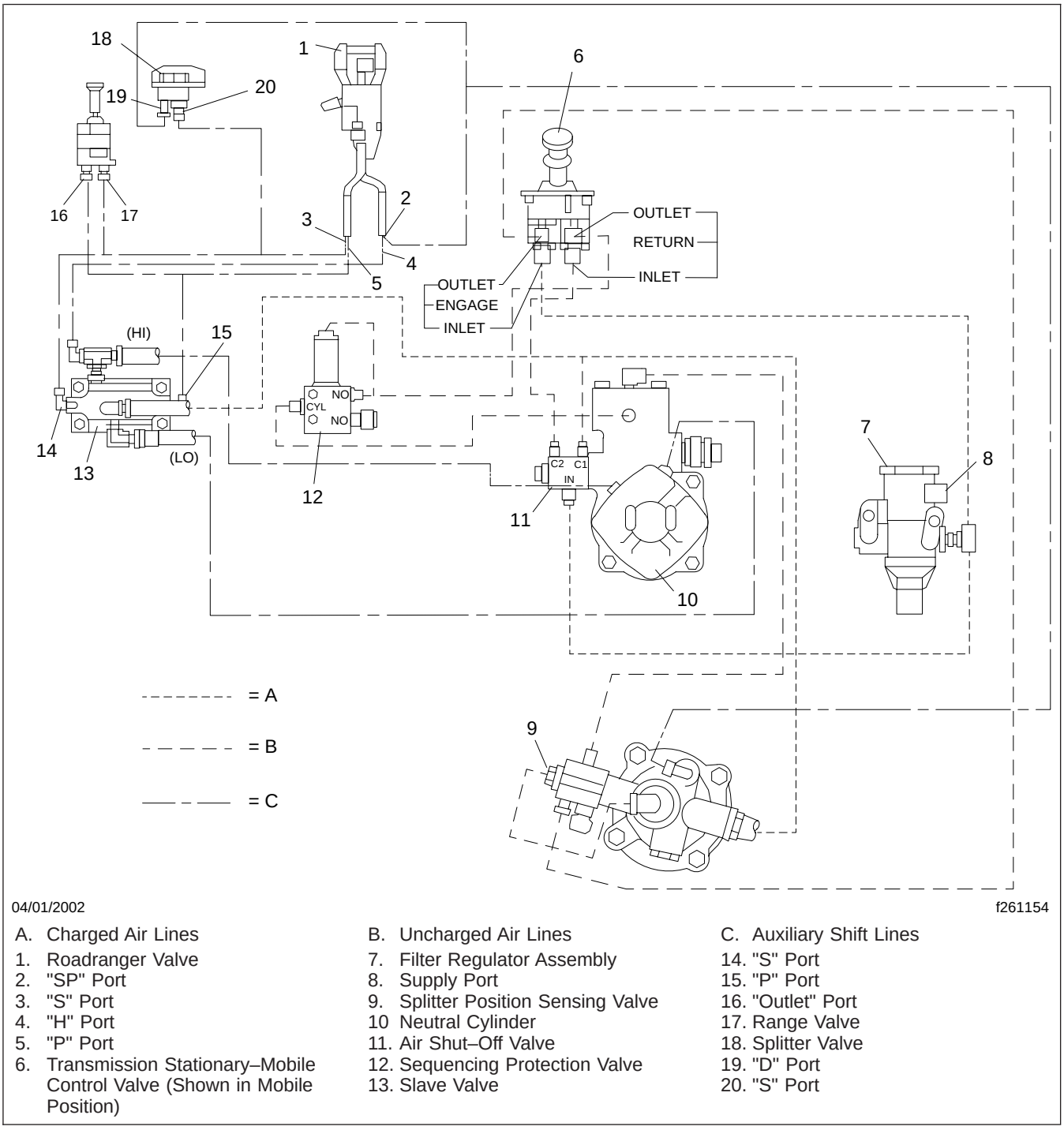
### Vehicles with Roadranger Valve Only

For vehicles with a Roadranger valve only, see **Fig. 7** for the "MOBILE" position. See **Fig. 8** for the "STATIONARY" position. See **Fig. 9** for the "STATIONARY TO MOBILE" position.

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## Specifications

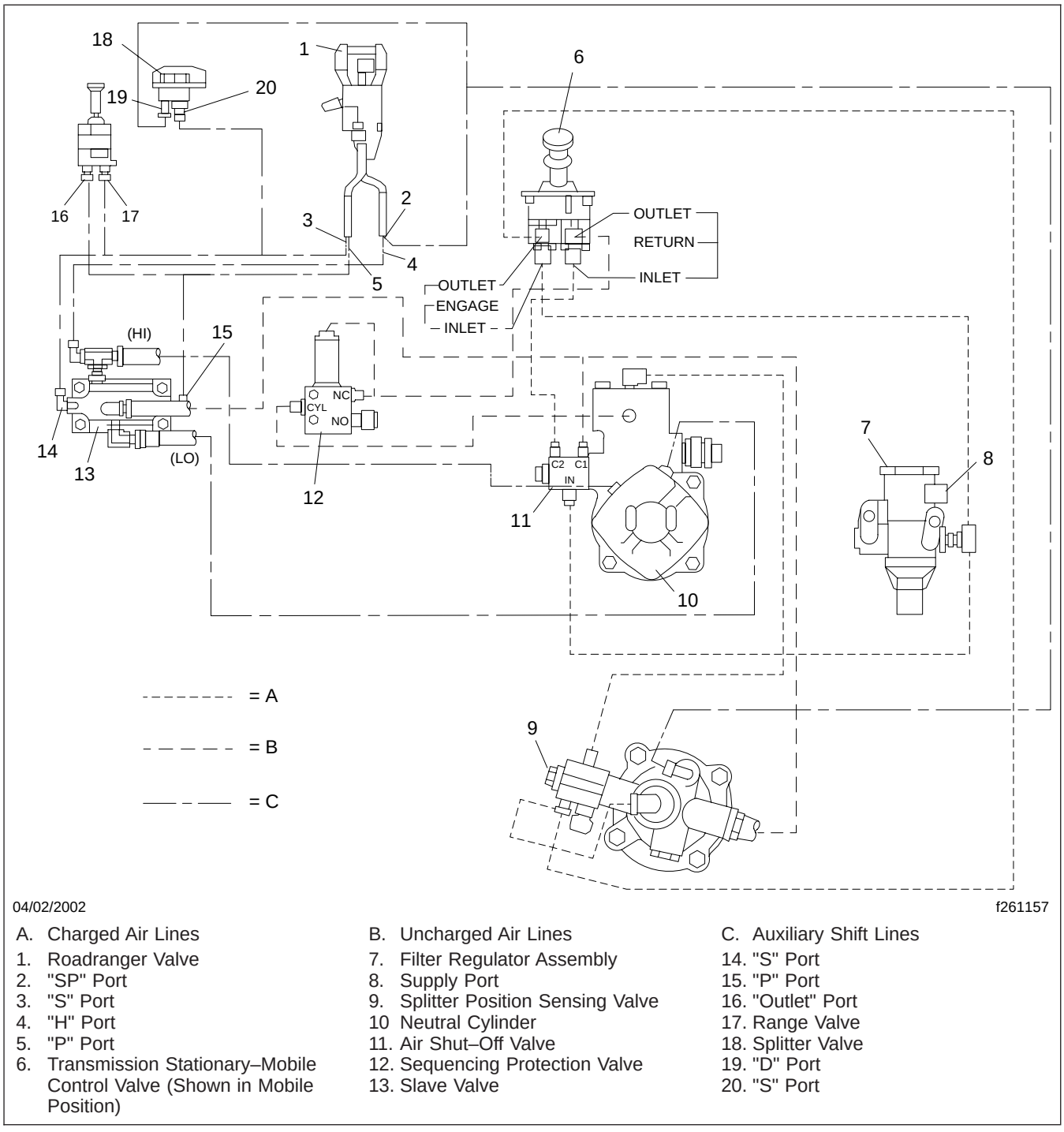



A. Charged Air Lines
B. Uncharged Air Lines
C. Auxiliary Shift Lines
1. Roadranger Valve
2. "SP" Port
3. "S" Port
4. "H" Port
5. "P" Port
6. Transmission Stationary–Mobile Control Valve (Shown in Mobile Position)
7. Filter Regulator Assembly
8. Supply Port
9. Splitter Position Sensing Valve
10 Neutral Cylinder
11. Air Shut–Off Valve
12. Sequencing Protection Valve
13. Slave Valve
14. "S" Port
15. "P" Port
16. "Outlet" Port
17. Range Valve
18. Splitter Valve
19. "D" Port
20. "S" Port

**Fig. 1, Vehicles with Roadranger Valve Plus an Optional Two Valve System, "MOBILE" Position**

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A. Charged Air Lines
B. Uncharged Air Lines
C. Auxiliary Shift Lines

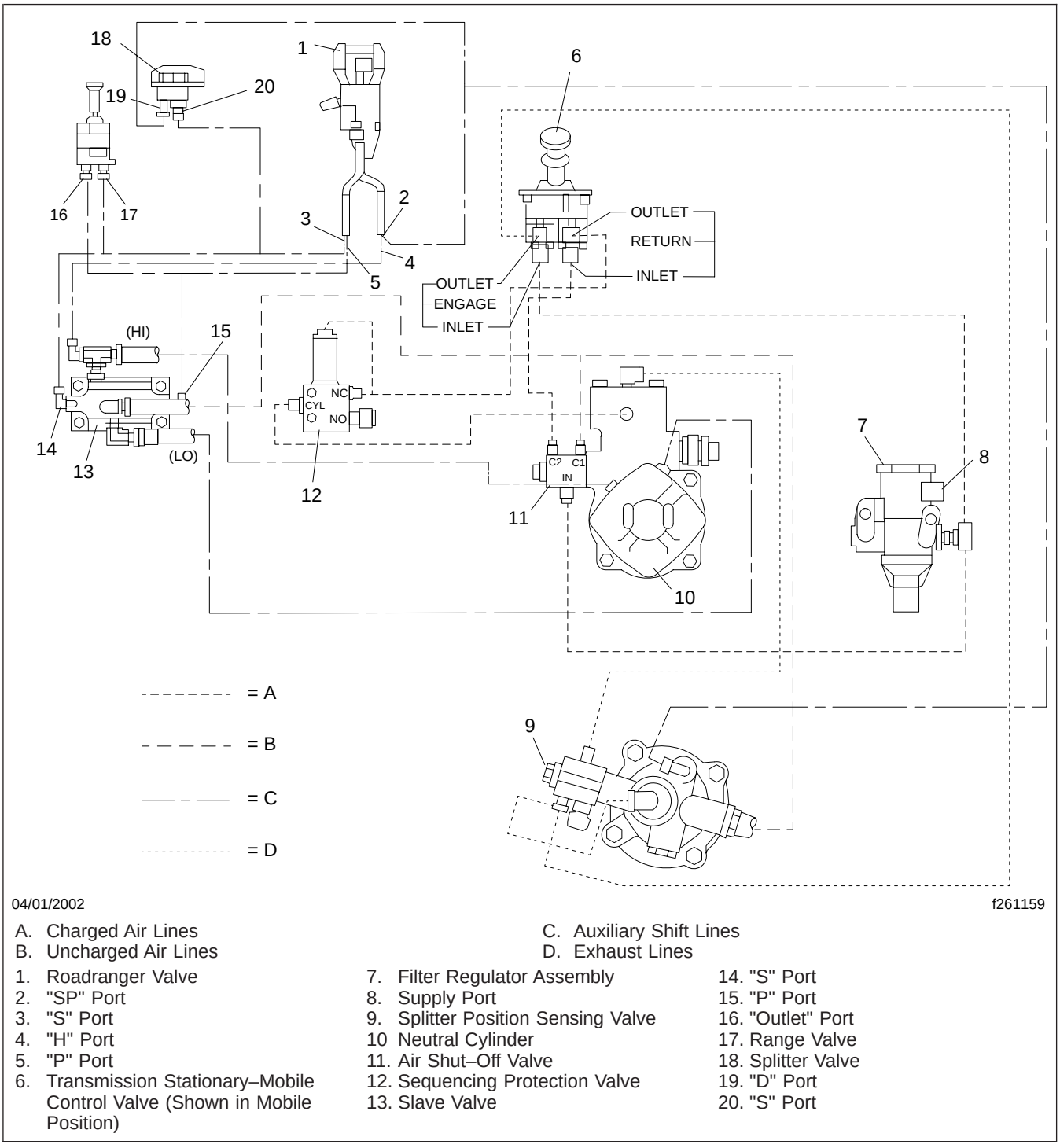
1. Roadranger Valve
2. "SP" Port
3. "S" Port
4. "H" Port
5. "P" Port
6. Transmission Stationary–Mobile Control Valve (Shown in Mobile Position)
7. Filter Regulator Assembly
8. Supply Port
9. Splitter Position Sensing Valve
10 Neutral Cylinder
11. Air Shut–Off Valve
12. Sequencing Protection Valve
13. Slave Valve
14. "S" Port
15. "P" Port
16. "Outlet" Port
17. Range Valve
18. Splitter Valve
19. "D" Port
20. "S" Port

**Fig. 2, Vehicles with Roadranger Valve Plus an Optional Two Valve System, "STATIONARY" Position**

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## Specifications



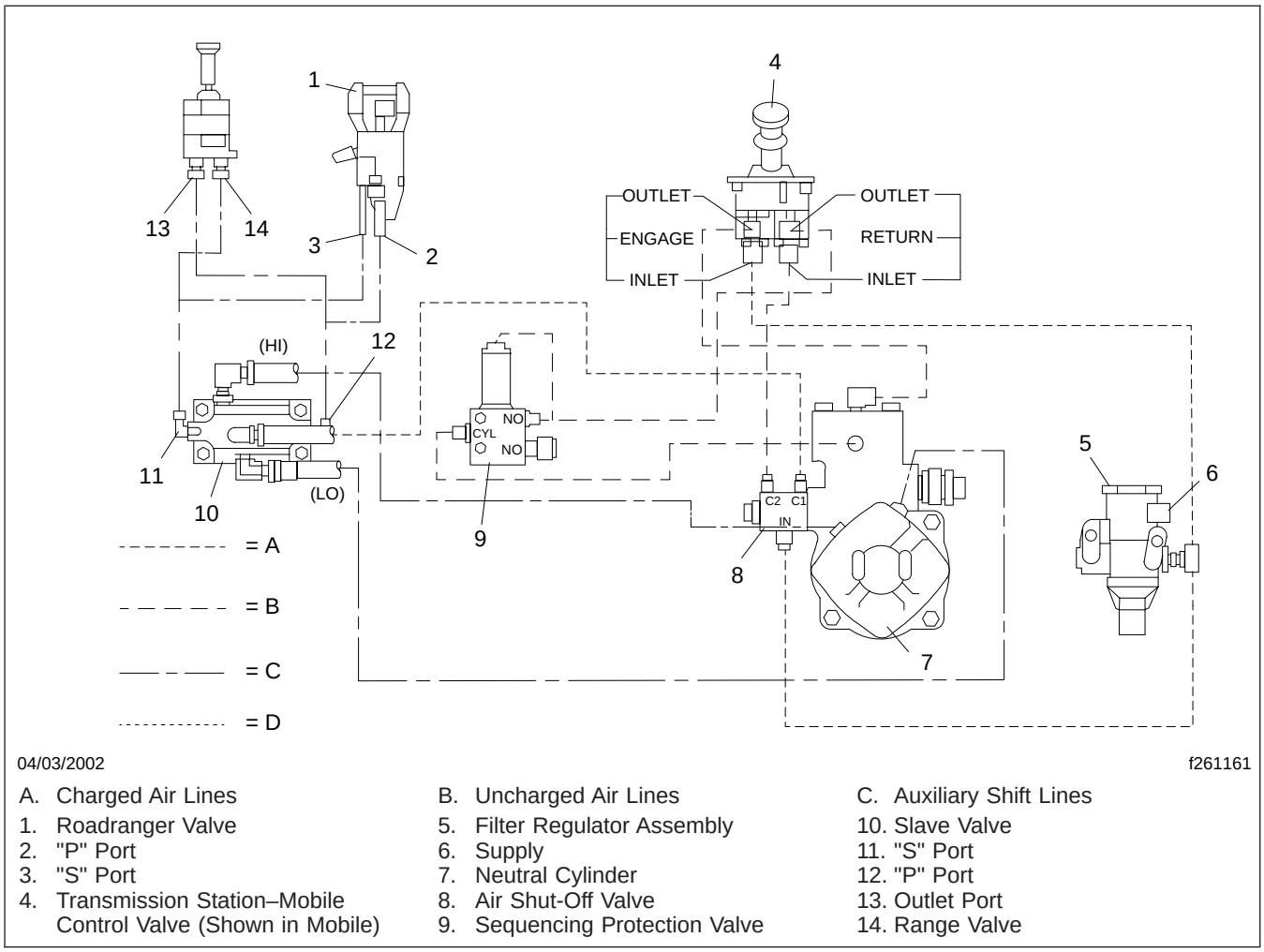

A. Charged Air Lines
B. Uncharged Air Lines
C. Auxiliary Shift Lines
D. Exhaust Lines

1. Roadranger Valve
2. "SP" Port
3. "S" Port
4. "H" Port
5. "P" Port
6. Transmission Stationary–Mobile Control Valve (Shown in Mobile Position)
7. Filter Regulator Assembly
8. Supply Port
9. Splitter Position Sensing Valve
10 Neutral Cylinder
11. Air Shut–Off Valve
12. Sequencing Protection Valve
13. Slave Valve
14. "S" Port
15. "P" Port
16. "Outlet" Port
17. Range Valve
18. Splitter Valve
19. "D" Port
20. "S" Port

**Fig. 3, Vehicles with Roadranger Valve Plus an Optional Two Valve System, "MOBILE to STATIONARY" Position**

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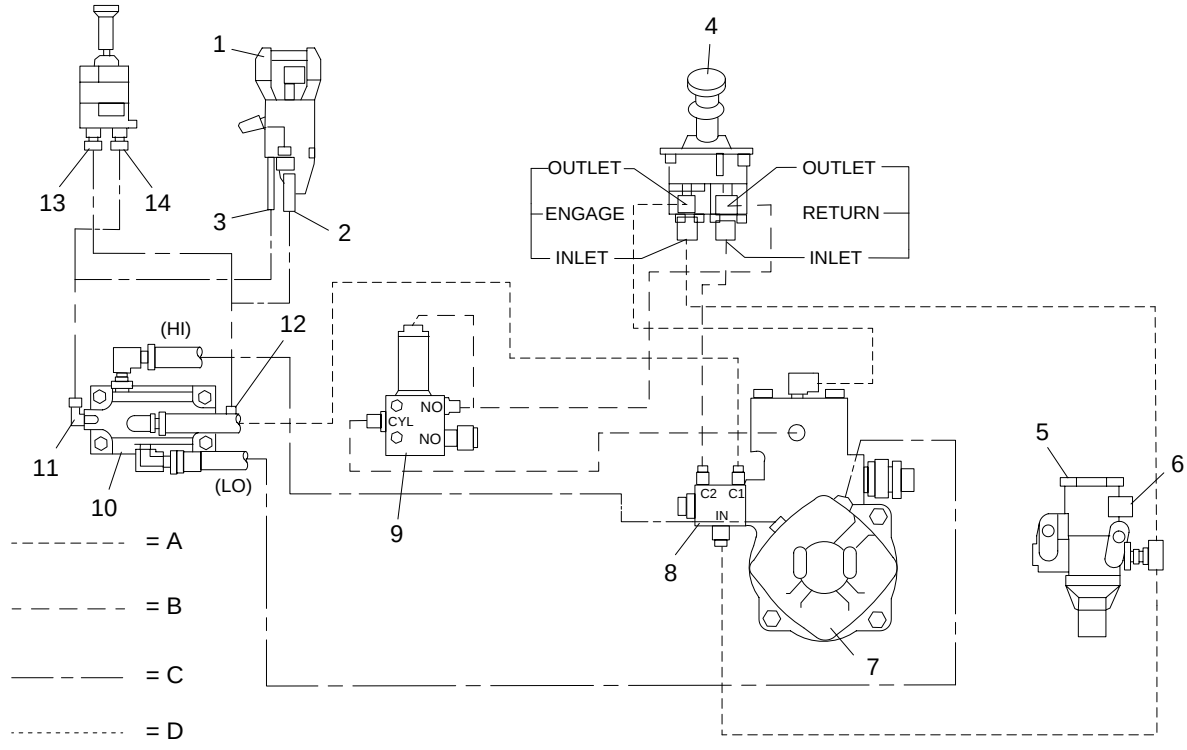

A. Charged Air Lines
B. Uncharged Air Lines
C. Auxiliary Shift Lines
1. Roadranger Valve
2. "P" Port
3. "S" Port
4. Transmission Station–Mobile Control Valve (Shown in Mobile)
5. Filter Regulator Assembly
6. Supply
7. Neutral Cylinder
8. Air Shut-Off Valve
9. Sequencing Protection Valve
10. Slave Valve
11. "S" Port
12. "P" Port
13. Outlet Port
14. Range Valve

**Fig. 4, Vehicles with Roadranger Valve Plus an Optional Range Valve, "MOBILE" Position**

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## Specifications



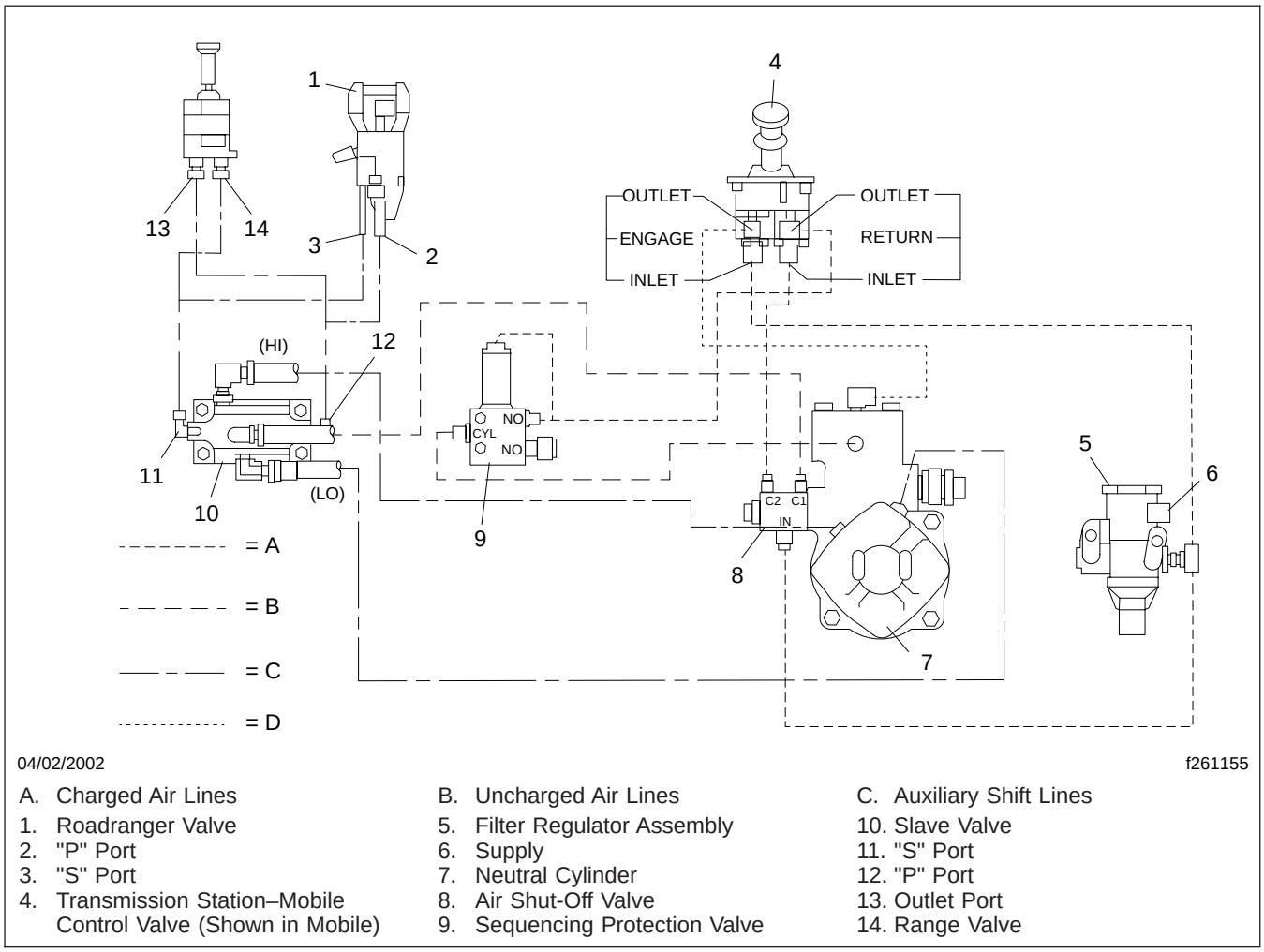

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A. Charged Air Lines
B. Uncharged Air Lines
C. Auxiliary Shift Lines
1. Roadranger Valve
2. "P" Port
3. "S" Port
4. Transmission Station–Mobile Control Valve (Shown in Mobile)
5. Filter Regulator Assembly
6. Supply
7. Neutral Cylinder
8. Air Shut-Off Valve
9. Sequencing Protection Valve
10. Slave Valve
11. "S" Port
12. "P" Port
13. Outlet Port
14. Range Valve

**Fig. 5, Vehicles with Roadranger Valve Plus an Optional Range Valve, "STATIONARY" Position**

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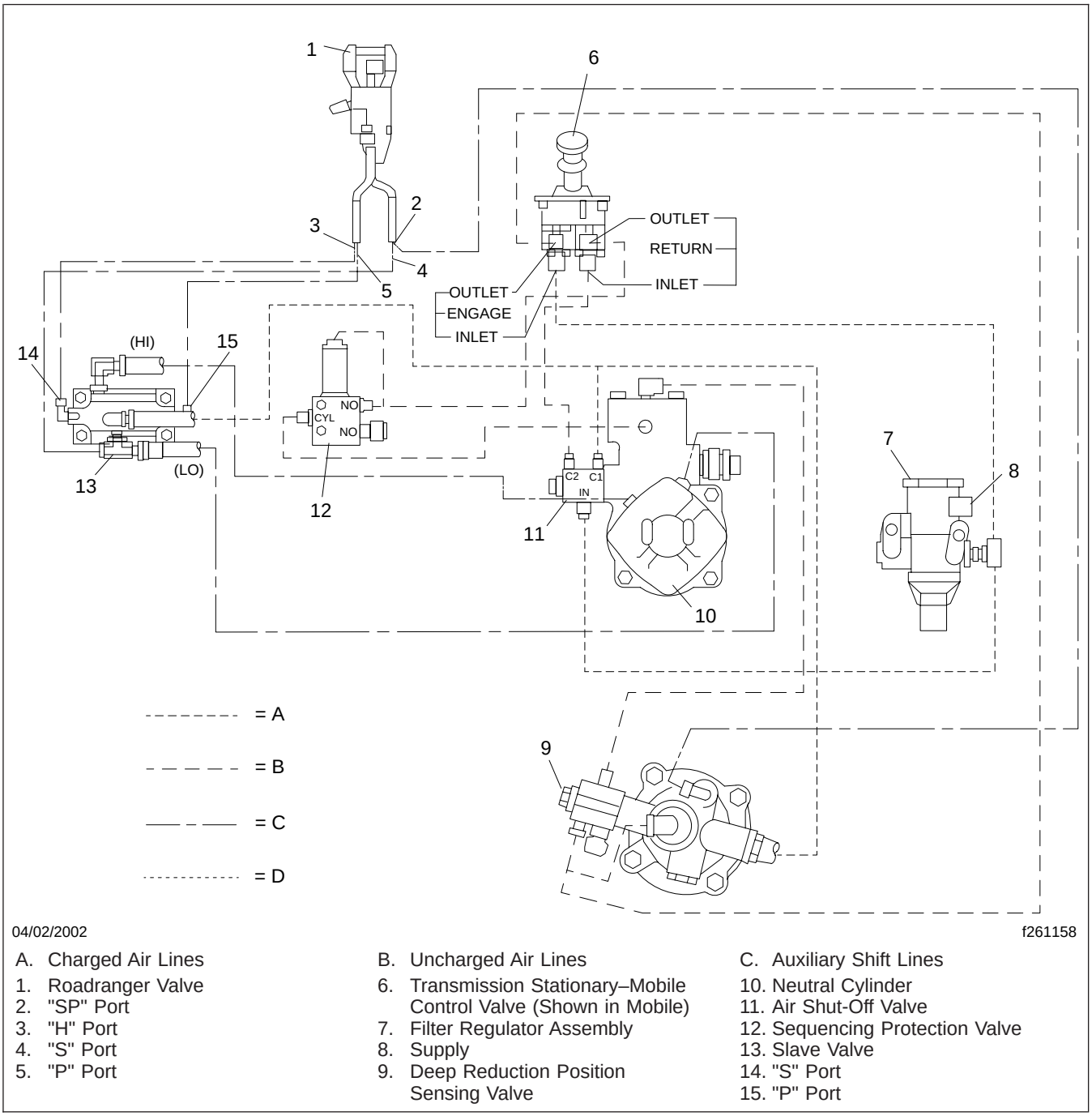

A. Charged Air Lines
B. Uncharged Air Lines
C. Auxiliary Shift Lines
1. Roadranger Valve
2. "P" Port
3. "S" Port
4. Transmission Station–Mobile Control Valve (Shown in Mobile)
5. Filter Regulator Assembly
6. Supply
7. Neutral Cylinder
8. Air Shut-Off Valve
9. Sequencing Protection Valve
10. Slave Valve
11. "S" Port
12. "P" Port
13. Outlet Port
14. Range Valve

**Fig. 6, Vehicles with Roadranger Valve Plus an Optional Range Valve, "MOBILE to STATIONARY" Position**

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## Specifications

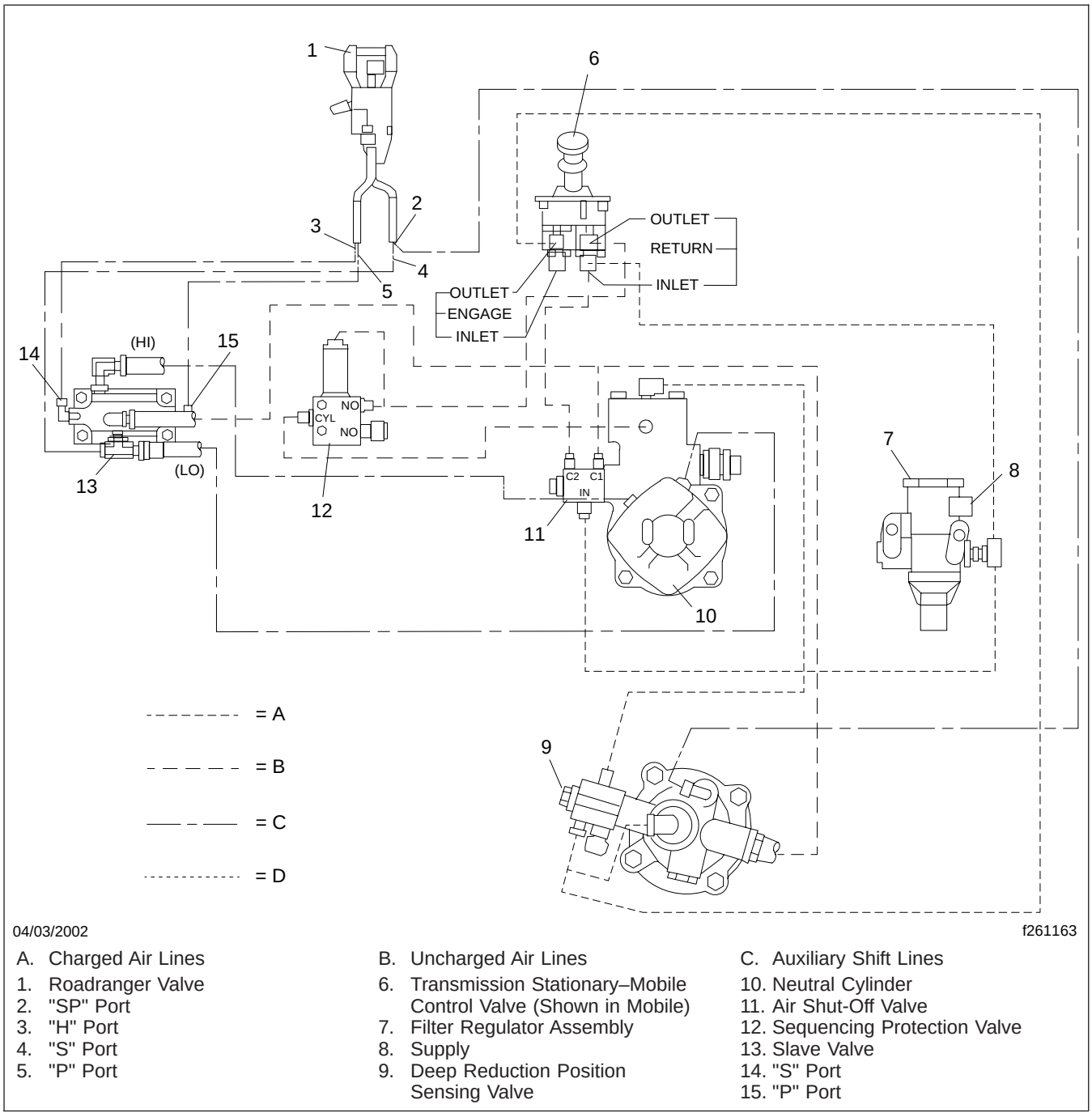



A. Charged Air Lines
B. Uncharged Air Lines
C. Auxiliary Shift Lines
1. Roadranger Valve
2. "SP" Port
3. "H" Port
4. "S" Port
5. "P" Port
6. Transmission Stationary–Mobile Control Valve (Shown in Mobile)
7. Filter Regulator Assembly
8. Supply
9. Deep Reduction Position Sensing Valve
10. Neutral Cylinder
11. Air Shut-Off Valve
12. Sequencing Protection Valve
13. Slave Valve
14. "S" Port
15. "P" Port

**Fig. 7, Vehicles with Roadranger Valve Only, "MOBILE" Position**

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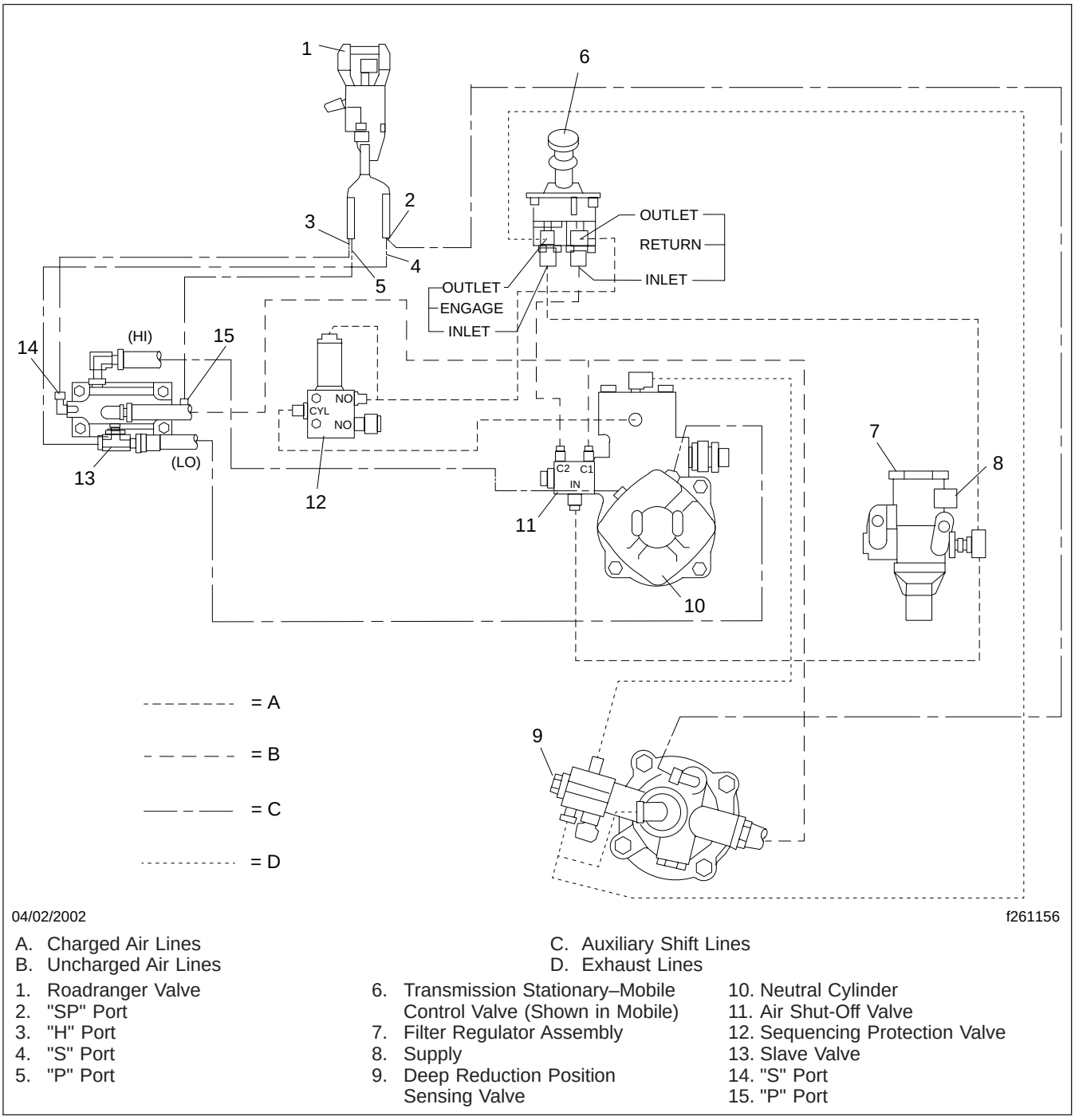

A. Charged Air Lines
B. Uncharged Air Lines
C. Auxiliary Shift Lines
1. Roadranger Valve
2. "SP" Port
3. "H" Port
4. "S" Port
5. "P" Port
6. Transmission Stationary–Mobile Control Valve (Shown in Mobile)
7. Filter Regulator Assembly
8. Supply
9. Deep Reduction Position Sensing Valve
10. Neutral Cylinder
11. Air Shut-Off Valve
12. Sequencing Protection Valve
13. Slave Valve
14. "S" Port
15. "P" Port

**Fig. 8, Vehicles with Roadranger Valve Only, "STATIONARY" Position**

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## Specifications




A. Charged Air Lines
B. Uncharged Air Lines
C. Auxiliary Shift Lines
D. Exhaust Lines

1. Roadranger Valve
2. "SP" Port
3. "H" Port
4. "S" Port
5. "P" Port
6. Transmission Stationary–Mobile Control Valve (Shown in Mobile)
7. Filter Regulator Assembly
8. Supply
9. Deep Reduction Position Sensing Valve
10. Neutral Cylinder
11. Air Shut-Off Valve
12. Sequencing Protection Valve
13. Slave Valve
14. "S" Port
15. "P" Port

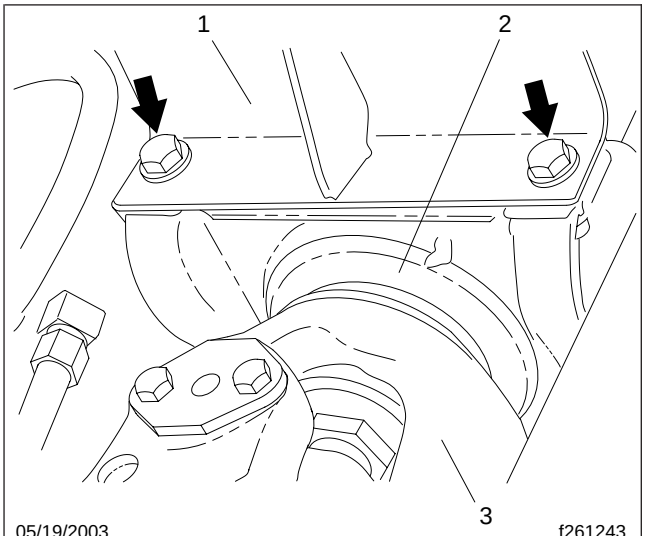
**Fig. 9, Vehicles with Roadranger Valve Only, "MOBILE to STATIONARY" Position**

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## Removal

1. Set the parking brakes, chock all the tires, put the transmission into high gear, and raise the hood.
2. Disconnect the batteries.
3. Disconnect the midship bearing from the midship bearing bracket. See **Fig. 1**.



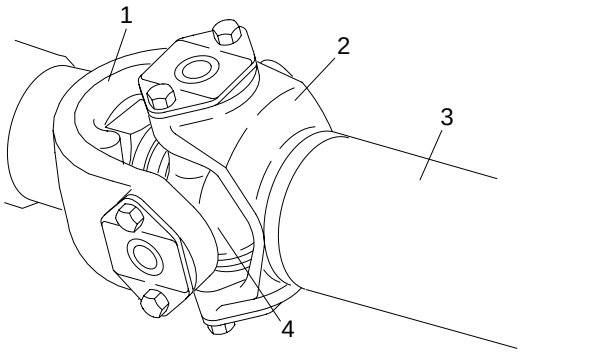

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Remove the midship bracket mounting bolts (arrows).

1. Midship Bracket
2. Bearing Housing
3. Driveshaft

**Fig. 1, Midship Bearing**

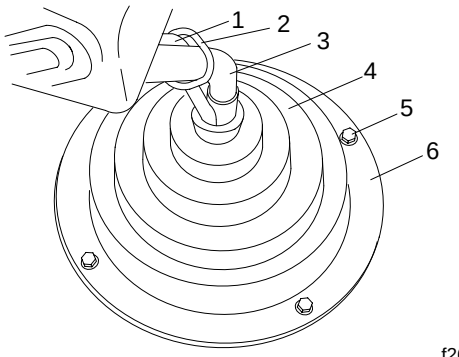
4. Disconnect the driveline from the transmission output yoke and move it out of the way. See **Fig. 2**. For instructions, see **Section 41.00**.
5. Remove the shift linkage. See **Fig. 3**.
   - 5.1 From inside the cab, remove the shift lever boot and harness.
   - 5.2 Disconnect the air lines from the shift lever at the slave cylinder. Mark the air lines for reassembly.
   - 5.3 If installed, disconnect the electrical harness from the transmission.
   - 5.4 Remove the shift lever from the shift tower.
6. Remove the shift tower from underneath the cab. See **Fig. 4**.




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1. Output Yoke
2. Drive Yoke
3. Driveshaft
4. Universal Joint

**Fig. 2, Driveline**




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1. Shift Lever Harness
2. O-Ring
3. Shift Lever
4. Shift Lever Boot
5. Retaining Ring Capscrew
6. Retaining Ring

**Fig. 3, Shift Linkage**

- 6.1 Remove the shift tower from the transmission top cover.
- 6.2 Cover the shift tower hole in the top of the transmission to prevent dirt or foreign objects from entering the transmission.

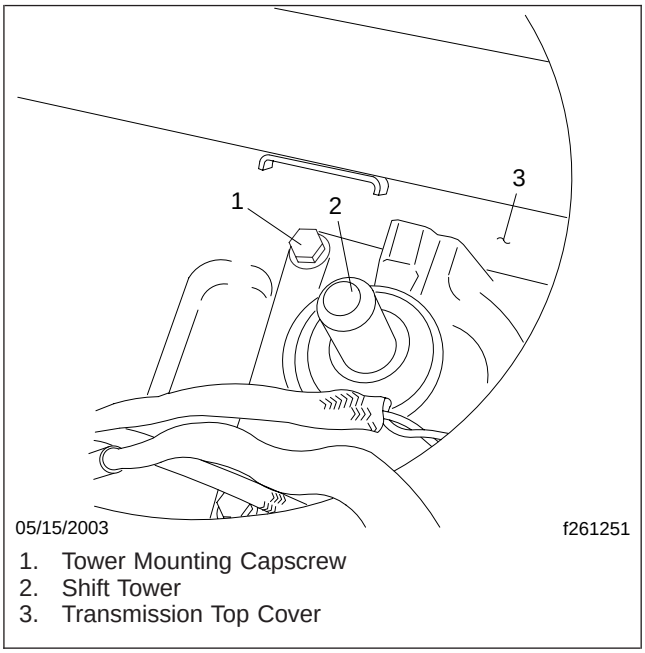
IMPORTANT: Do not allow any material of any kind to fall into the gear box.

7. Disconnect the fuel lines and brackets from the top of the transmission.

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## Manual Transmission Removal and Installation

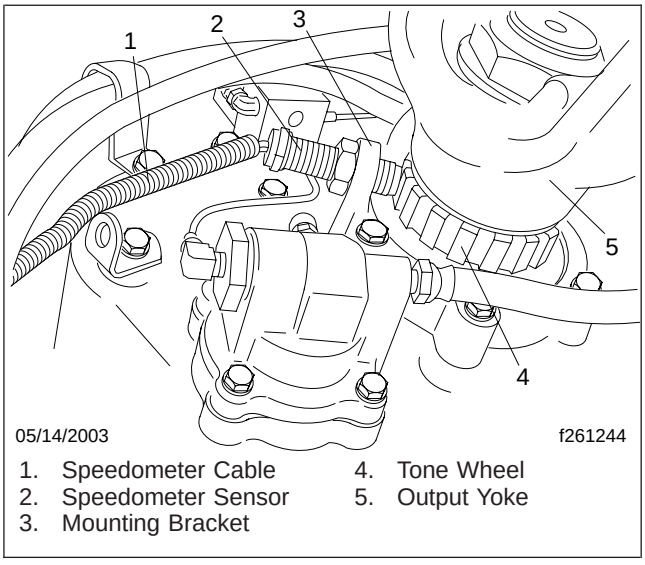



1. Tower Mounting Capscrew
2. Shift Tower
3. Transmission Top Cover

**Fig. 4, Shift Tower**

8. Disconnect all wiring at the transmission, as applicable. Mark all wires, connectors, and sensors for reassembly.

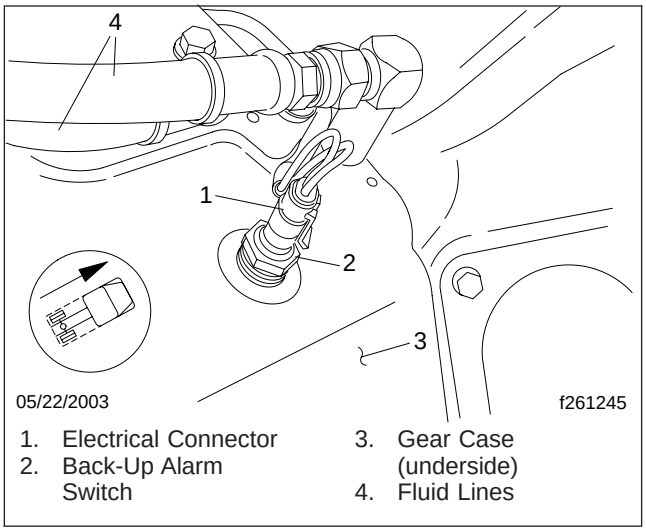
   8.1 Disconnect the speedometer sensor at the output yoke. See **Fig. 5**.




1. Speedometer Cable
2. Speedometer Sensor
3. Mounting Bracket
4. Tone Wheel
5. Output Yoke

**Fig. 5, Speedometer Sensor**

   8.2 Disconnect the back-up alarm switch on the underside of the gear case near the transmission fluid lines. See **Fig. 6**.




1. Electrical Connector
2. Back-Up Alarm Switch
3. Gear Case (underside)
4. Fluid Lines

**Fig. 6, Back-Up Alarm**

   8.3 Disconnect the oil temperature sensor from the top of the transmission. See **Fig. 7**.

   8.4 Disconnect the neutral start switch on the transmission top cover. See **Fig. 7**.

9. Disconnect all air lines from the transmission, and mark those lines for reassembly. Plug all air lines, and cap all transmission air fittings.

10. Drain the transmission fluid, if necessary. See **Fig. 8**. Tighten the drain plug 50 lbf·ft (68 N·m).

NOTE: It is not necessary to drain the transmission if the transmission is being removed to service the clutch.

11. Disconnect the transmission fluid lines and cap them to prevent spillage. If coolant lines are attached, do not disconnect them. Instead, remove the transmission cooler and set it aside with the coolant lines still connected. See **Fig. 9**.

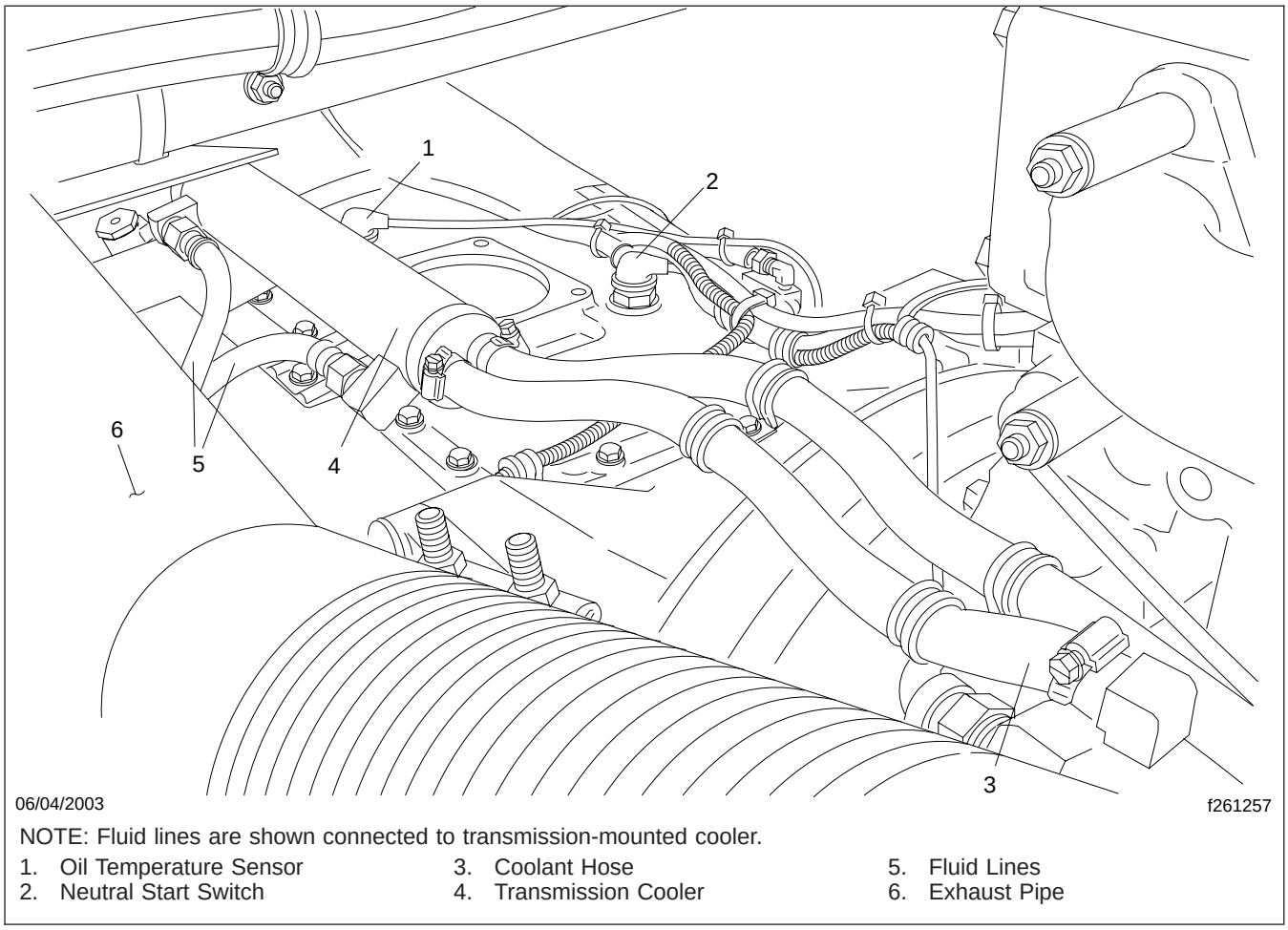
NOTE: On standard coolers mounted on the radiator, remove the lines at the transmission gear case, not at the radiator.

12. Disconnect the clutch mechanism. See **Fig. 10**.

13. If necessary, remove the exhaust pipe. See **Fig. 11** for the front clamp located aft of the tur-

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NOTE: Fluid lines are shown connected to transmission-mounted cooler.

1. Oil Temperature Sensor
2. Neutral Start Switch
3. Coolant Hose
4. Transmission Cooler
5. Fluid Lines
6. Exhaust Pipe

**Fig. 7, Top of Transmission**

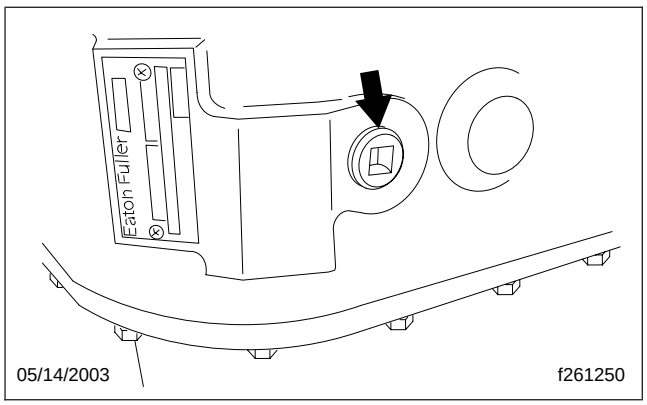



**Fig. 8, Transmission Drain Plug**

bocharger and **Fig. 12** for the rear clamp located below the frame rail.

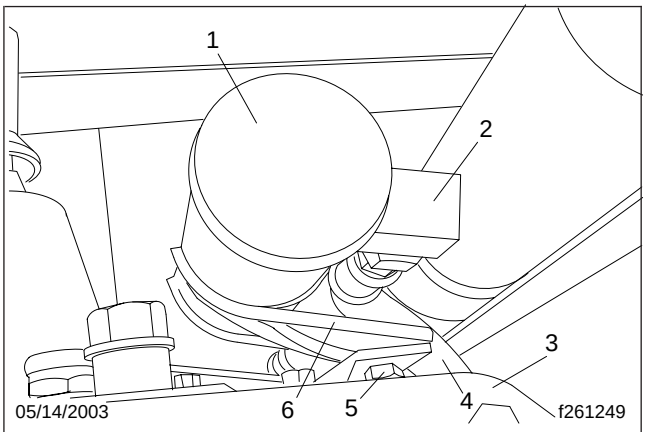
NOTE: On certain vehicles with "C" exhausts (horizontal under-frame muffler with dual vertical stacks) and "H" exhausts (horizontal under-frame muffler with horizontal exhaust pipe), remove the exhaust pipe when necessary. On other vehicles, it should not be necessary to remove the exhaust pipe.

14. Position a transmission jack under the transmission, and raise its support plate against the bottom of the transmission. Adjust the support plate to the same angle as the bottom of the transmission.
15. If installed, remove the transmission rear auxiliary support.

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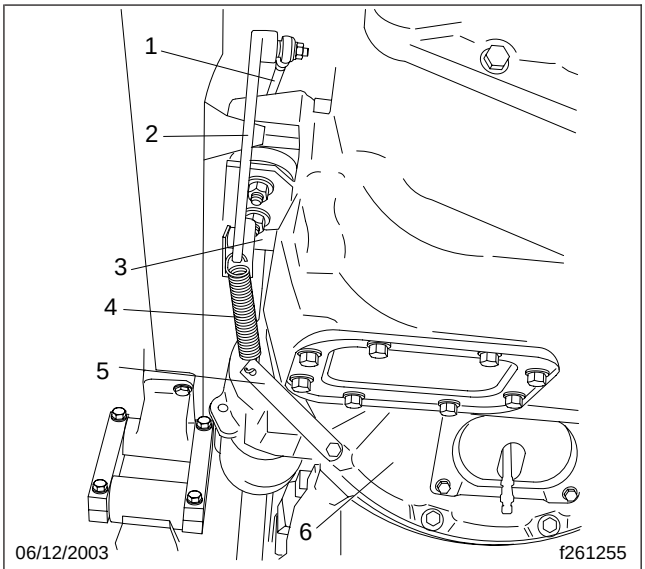


## Manual Transmission Removal and Installation



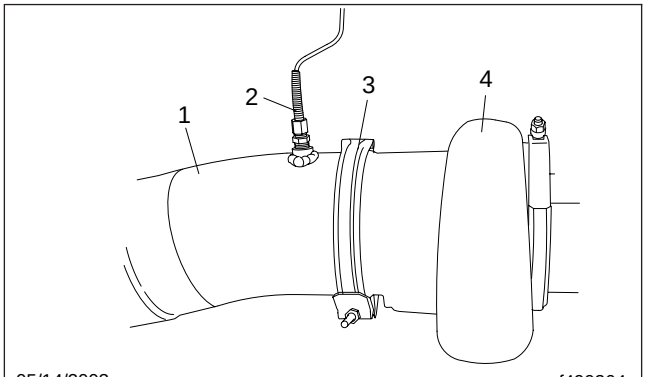

1. Transmission Cooler
2. Pipe Fitting
3. Gear Case
4. Fluid Line
5. Mounting Bolt, 5/16–18
6. Mounting Bracket

**Fig. 9, Transmission Cooler (transmission-mounted)**



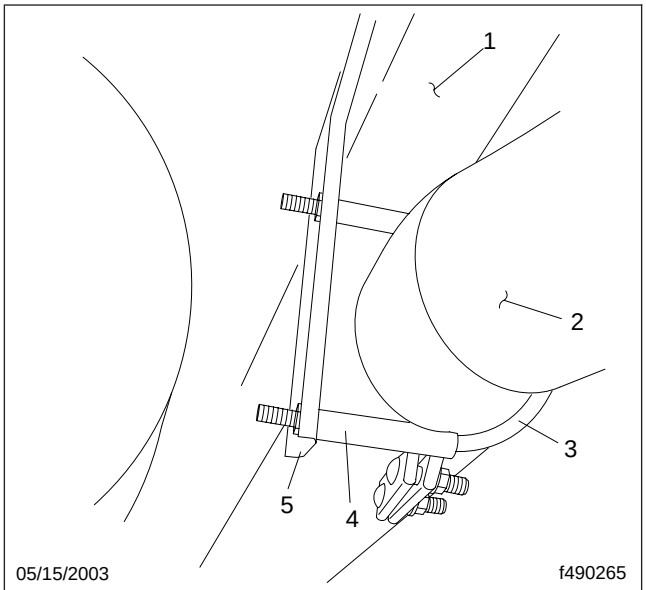

1. Lower Clutch Rod
2. Release Lever
3. Cross-Shaft
4. Spring
5. Spring Attachment
6. Bell Housing

**Fig. 10, Clutch Linkage**




1. Exhaust Pipe
2. Pyrometer
3. Clamp
4. Turbocharger

**Fig. 11, Exhaust Pipe (front clamp)**




1. Frame Rail
2. Exhaust Pipe
3. U-Bolt
4. Clamp
5. Bracket

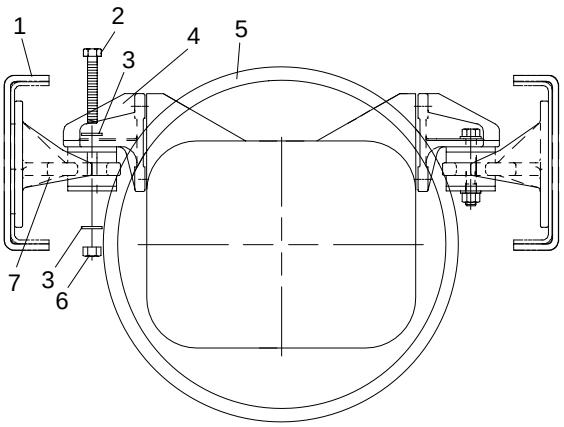
**Fig. 12, Exhaust Pipe Rear Clamp (Millennium Edition only)**

16. Raise the transmission jack until it fits securely against the bottom of the transmission, then secure the transmission to the jack with a chain.
17. Install a bottle jack or stand to support the rear of the engine when the transmission is removed.

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18. Remove the transmission nodal mount bolts. See **Fig. 13**.




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1. Frame Rail
2. Bolt, 5/8–18
3. Washer, 5/8
4. Transmission Bracket
5. Transmission
6. Locknut, 5/8–18
7. Frame Bracket

**Fig. 13, Nodal Mount**

19. Remove the bolts attaching the flywheel housing to the bell housing. Keep the flange of the bell housing even (all the way around) with the flange of the flywheel housing, until the input shaft is clear of the clutch.

## NOTICE

**Do not let the rear of the transmission drop, and do not let the transmission hang unsupported in the splined hubs of the clutch discs. Taking these precautions will prevent damage to the clutch discs.**

20. Pull the transmission away from the engine. See **Fig. 14**.
    - 20.1 Pull the transmission and jack straight back, until the transmission input shaft is clear of the clutch and the engine flywheel housing.
    - 20.2 Rotate the fingers of the clutch release fork to clear the clutch release bearing.
    - 20.3 Make sure that the nodal mount brackets attached to the transmission bell housing are clear of the nodal mount brackets attached to the frame rail.
    - 20.4 Lower the transmission.
21. If necessary, remove the steps on the passenger's side.
22. Remove the transmission by rolling it out underneath the cab, or from under the frame rails.

# Installation

1. If not already done, apply the parking brakes, chock the tires, and tilt the hood.
2. Check for wear on the fingers of the clutch release fork, release shafts, and the release shaft bushings. Replace any worn parts as necessary.
3. Shift the transmission into gear, so that the transmission output shaft can be rotated during assembly, to line up the splined end of the input shaft with the clutch driven-disc hubs.
4. Roll the transmission and jack into position behind the engine, as removed.
5. Raise the transmission jack support plate until the flange of the clutch housing is even (all the way around) with the flange of the flywheel housing. Align the transmission input shaft with the hole in the release bearing sleeve. See **Fig. 15**.

NOTE: If necessary, wipe the input shaft clean with a clean, dry cloth. It is not necessary to lubricate the input shaft.

6. Push the transmission and jack straight forward, while making sure the flanges remain parallel, until the transmission input shaft begins to enter the clutch release bearing.

NOTE: When trying to align the input shaft with the splined clutch plate, it might be necessary to lift the engine to get the nodal mounts to clear the frame-mounted brackets.

7. Rotate the top of the clutch release fork rearward, and rotate the release bearing until the flat portion is at the top. Roll the transmission slowly forward. Raise or lower the transmission as required to maintain alignment.

IMPORTANT: Be sure that the release fork clears the release bearing, and is rotated over the wear pads as the transmission is moved

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## Manual Transmission Removal and Installation

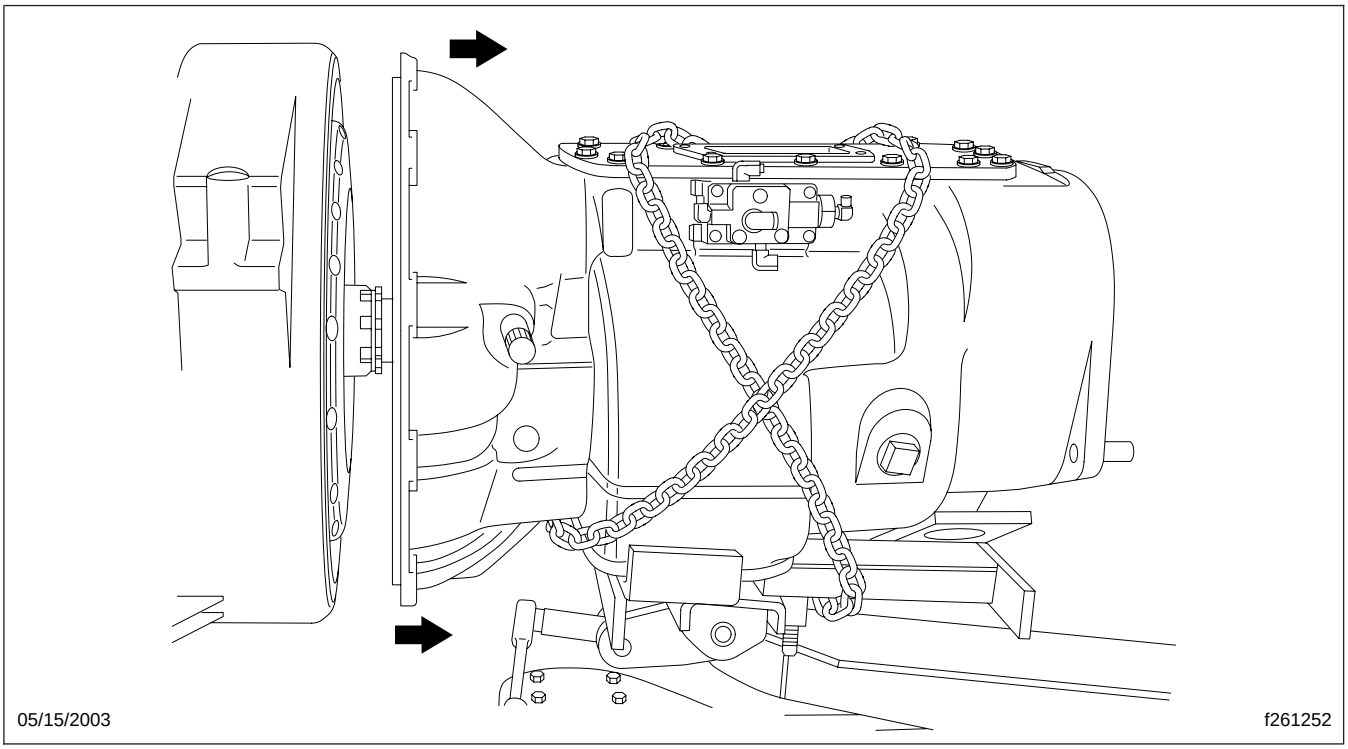



**Fig. 14, Transmission Removal**

forward. See **Fig. 16**. Align the input shaft splines with the clutch disc splines by turning the transmission output shaft.

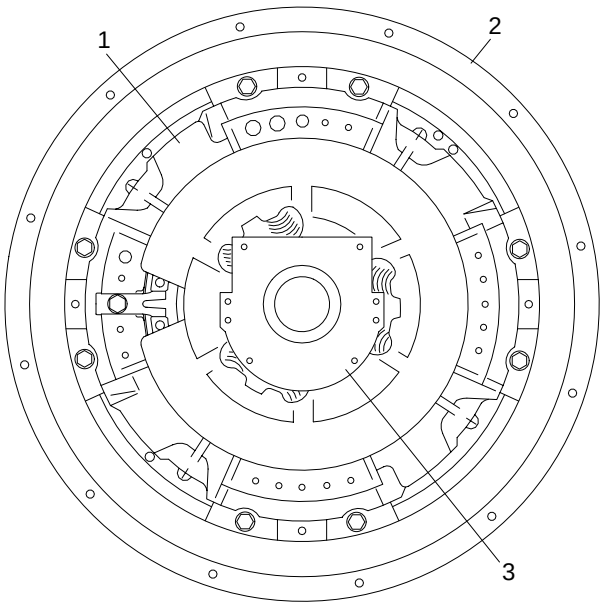
### NOTICE

**Use care to avoid springing the drive discs when the transmission is being installed. Do not force the transmission into the clutch or flywheel housing if it does not enter freely. Do not let the transmission drop or hang unsupported in the driven discs. These practices can damage the clutch assembly.**

8. Push the transmission forward until the clutch housing pilot flange enters the flywheel housing pilot bore. Install the flywheel-housing-to-clutch-housing attachment capscrews, and using a crisscross pattern, tighten them finger-tight. Then, using the same crisscross pattern, tighten the capscrews either 43 to 53 lbf·ft (58 to 72 N·m) for Patch-Lok capscrews, or 38 to 45 lbf·ft (52 to 61 N·m) for non-locking capscrews with lockwashers.
9. If removed, install the transmission rear auxiliary support.
10. Remove the chain that secures the transmission to the jack, and remove the jack from under the vehicle.
11. Install the transmission nodal mount bolts. Tighten the 5/8–18 x 4 mounting fasteners 165 lbf·ft (224 N·m). See **Fig. 13**.
12. Remove the engine support.
13. Connect the electrical wiring, sensors, and harness clamps to the transmission, as previously marked.
14. Install the transmission fluid cooler, if removed, and all the fluid lines at the cooler and transmission, as removed. Tighten the transmission cooler mounting bolts 13 lbf·ft (18 N·m). See **Fig. 7**.
15. Connect the air lines to the transmission as previously marked.
16. Connect the fuel lines and bracket to the top of the transmission. Open the fuel shut-off valves or fill the fuel tanks as applicable.

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1. Clutch
2. Flywheel Housing
3. Release Bearing

**Fig. 15, Aligning the Transmission and Release Bearing**

17. Install the shift linkage. See **Fig. 17**.
    - 17.1 Install the shift tower on the transmission top cover. Apply Loctite® 242 to the shift tower mounting bolts and tighten them 40 lbf·ft (60 N·m).
    - 17.2 Attach the shift lever to the shift tower at the noise isolator. Tighten the shift lever mounting bolt 50 lbf·ft (68 N·m).
    - 17.3 Install the electrical harness on the transmission, if removed.
    - 17.4 From inside the cab, install the air lines and shift boot. Tighten the shift lever retaining ring screws 28 lbf·ft (38 N·m).
18. Connect the clutch mechanism. Tighten the clutch release lever pinch bolt 13 lbf·ft (18 N·m). See **Fig. 18**.
19. Install the exhaust pipe, if removed. See **Fig. 11** for the front clamp located aft of the turbocharger and **Fig. 12** for the rear clamp located below the frame rail.
20. Connect the driveline to the transmission output yoke. See **Fig. 2**. Tighten the U-joint bolts 37 lbf·ft (50 N·m) for 3/8-inch bolts and 110 lbf·ft (149 N·m) for 1/2-inch bolts. For instructions, see **Section 41.00**.
21. Connect the midship bearing to the midship bearing bracket. See **Fig. 1**. Tighten the midship bearing bracket capscrews 77 lbf·ft (104 N·m). For instructions, see **Section 41.00**.
22. If removed, install the steps on the passenger's side.
23. Connect the batteries.
24. Check the clutch and clutch linkage for proper clutch pedal free-travel and clutch brake operation. For instructions, see the *Western Star Driver's Manual*.

    To adjust the clutch, see **Section 25.00**, Subject 100.
25. Add transmission fluid. Fill the transmission until the lubricant is level with the bottom of the fill hole, with the vehicle in the usual operating position. For approved fluids and approximate fluid capacities, see the *Western Star Maintenance Manual*. Tighten the fill plug as follows:
    - 25 to 35 lbf·ft (34 to 48 N·m) for Eaton Fuller transmissions with 0.75-inch pipe threads
    - 60 to 75 lbf·ft (81 to 102 N·m) for Eaton Fuller transmissions with 1.25-inch pipe threads
    - 35 to 50 lbf·ft (48 to 68 N·m) for Meritor transmissions
26. Start the engine and run it long enough to pressurize the air system to at least 80 psi (550 kPa). Check the transmission for fluid leaks and repair as necessary.
27. Lower the hood, and remove the chocks from all the tires.

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## Manual Transmission Removal and Installation

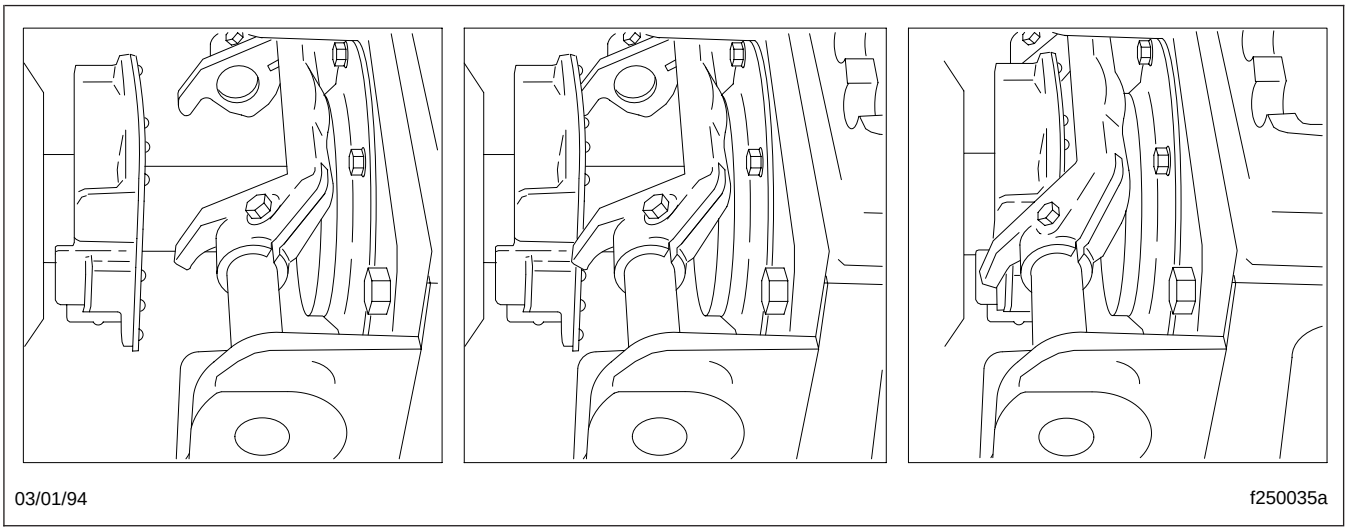
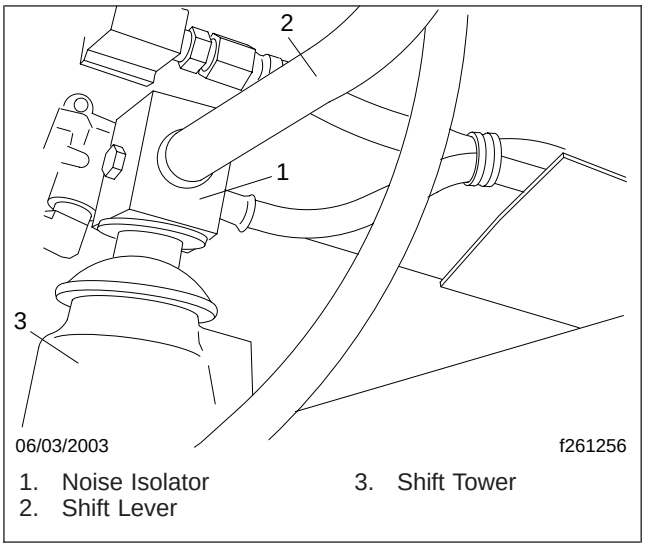
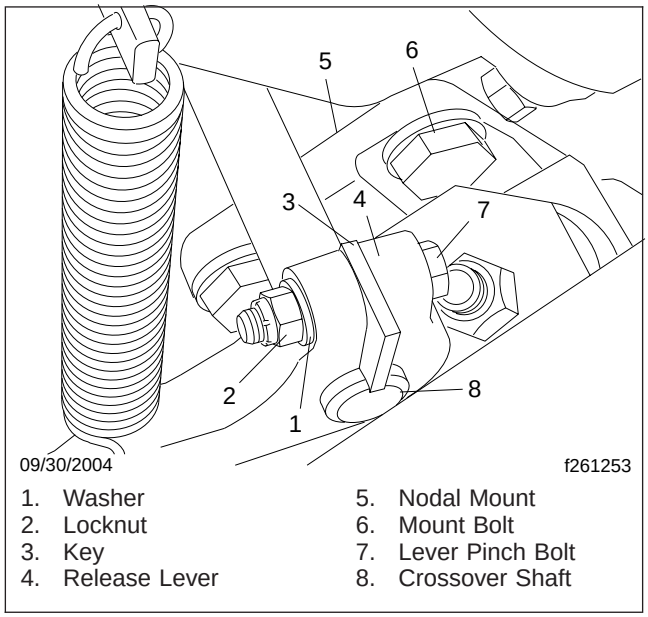



**Fig. 16, Release Yoke Clearing the Release Bearing**




1. Noise Isolator
2. Shift Lever
3. Shift Tower

**Fig. 17, Attach the Shift Lever**




1. Washer
2. Locknut
3. Key
4. Release Lever
5. Nodal Mount
6. Mount Bolt
7. Lever Pinch Bolt
8. Crossover Shaft

**Fig. 18, Clutch Mechanism**

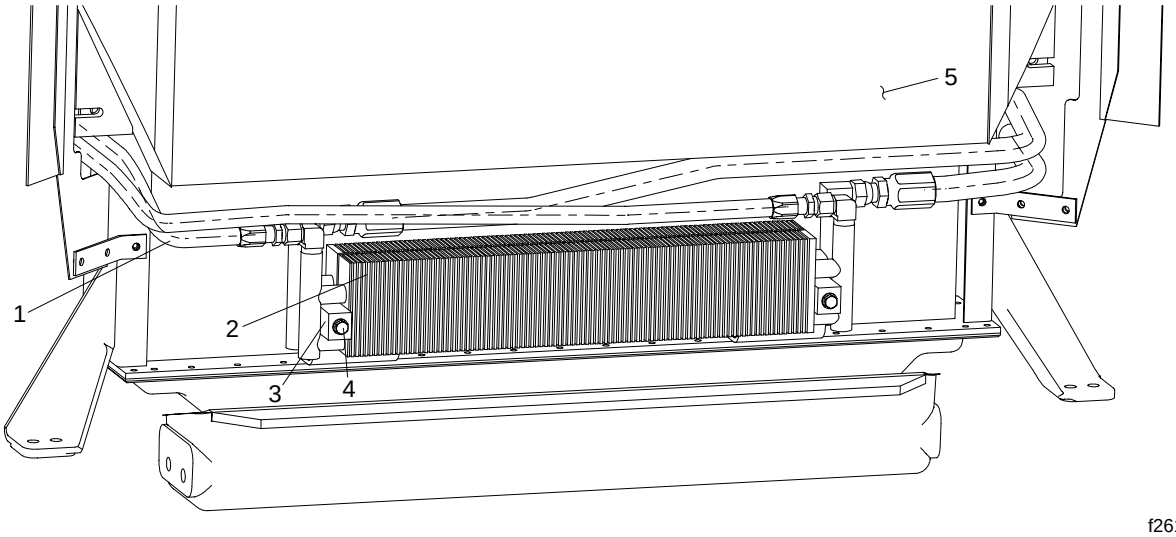
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# Radiator-Mounted Transmission Cooler Replacement

## Replacement

1. Apply the parking brakes, chock the front tires, and raise the hood.
2. Disconnect the batteries.
3. Disconnect and cap the transmission fluid lines to prevent spillage. See **Fig. 1**. Catch any fluid that runs out of the cooler in an appropriate container.
4. Remove the fasteners attaching the cooler to the cooler bracket attached to the radiator. Discard the rubber blocks.
5. Position the new cooler on the cooler brackets. Insert new rubber blocks in the spaces provided. Tighten the 5/16–18 mounting fasteners 13 lbf·ft (18 N·m).
6. Attach the fluid lines. Tighten the 1/2-inch NPT fittings.
7. Check the transmission fluid level and add fluid as necessary.
8. Run the engine and check for leaks around the fluid and coolant fittings.
9. Lower the hood, and remove the chocks from the front tires.




1. Fluid Line
2. Transmission Cooler
3. Rubber Block (biscuit)
4. Mounting Bolt, 5/16–18
5. Radiator

**Fig. 1, Transmission Cooler (radiator-mounted)**

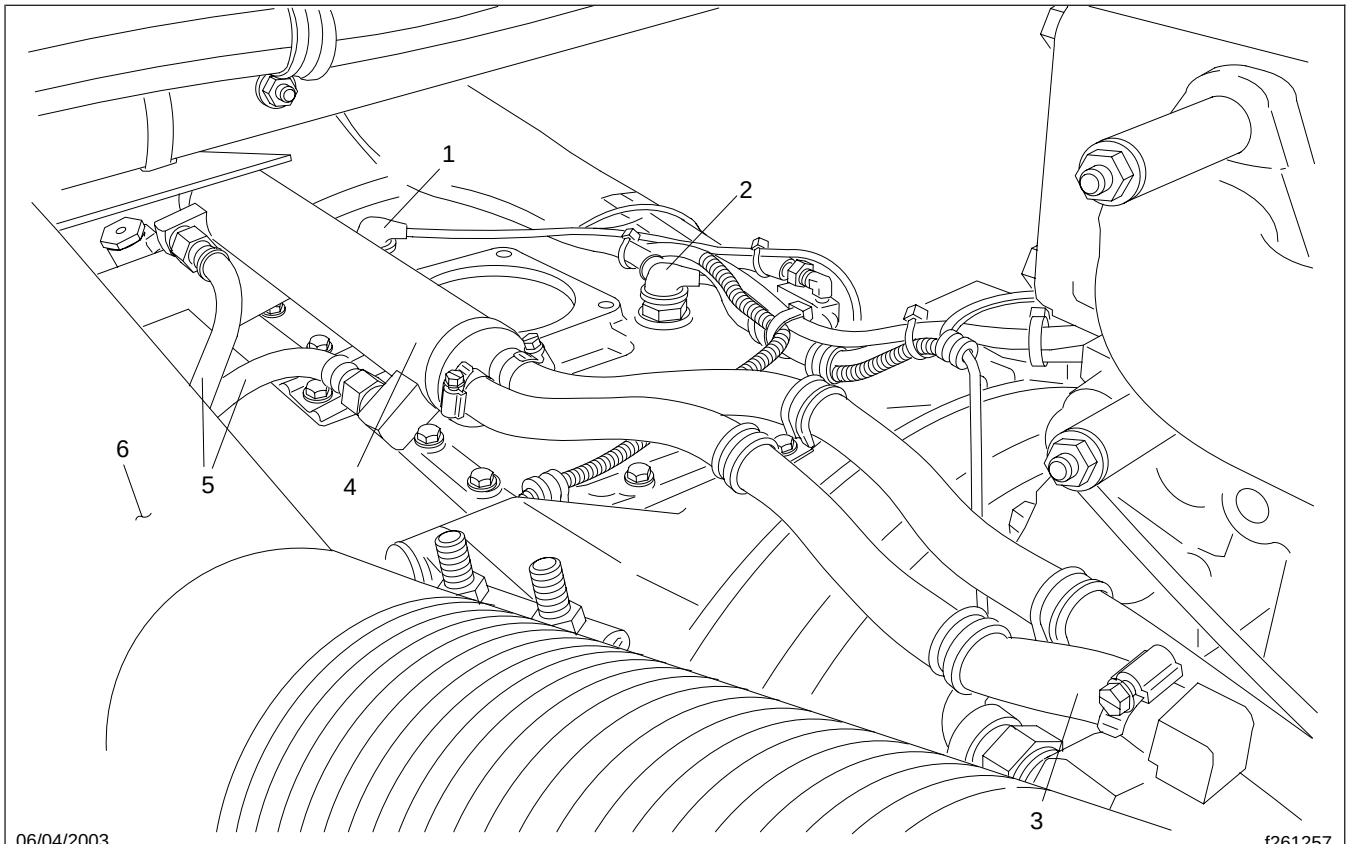
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# Transmission-Mounted Cooler Replacement

## Replacement

1. Apply the parking brakes, chock the front tires, and raise the hood.
2. Disconnect the batteries.
3. Disconnect the screw clamps attaching the coolant hoses to the transmission cooler. See **Fig. 1**. Cap the hoses to prevent spillage. Catch any coolant in a separate container.
4. Disconnect the transmission fluid lines at the cooler and cap them to prevent spillage. See **Fig. 2**. Catch any fluid that runs out of the cooler in an appropriate container.
5. Remove the mounting fasteners attaching the transmission cooler to the mounting bracket on the transmission. See **Fig. 3**.
6. Position the new cooler on the mounting bracket. Tighten the 5/16–18 mounting fasteners 13 lbf·ft (18 N·m).
7. Attach the coolant hoses. Tighten the screw clamps.
8. Attach the fluid lines. Tighten the 1/2-inch NPT fittings.
9. Check the transmission fluid level and add fluid as necessary.
10. Check the coolant level and add coolant as necessary.
11. Run the engine and check for leaks around the fluid fittings and coolant hoses.
12. Lower the hood, and remove the chocks from the front tires.



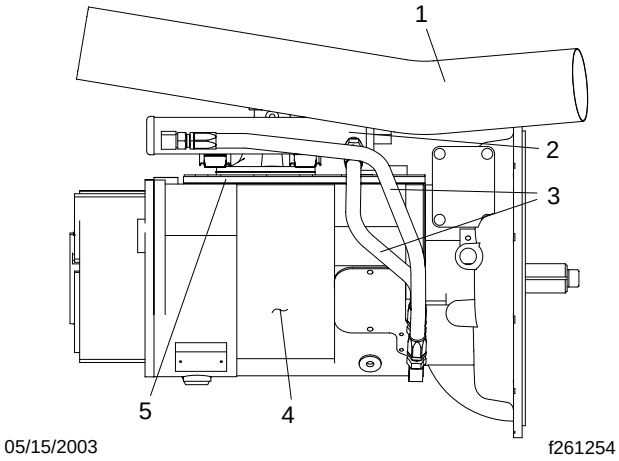

1. Oil Temperature Sensor
2. Neutral Start Switch
3. Coolant Hoses
4. Transmission Cooler
5. Fluid Lines
6. Exhaust Pipe

**Fig. 1, Coolant Hoses**

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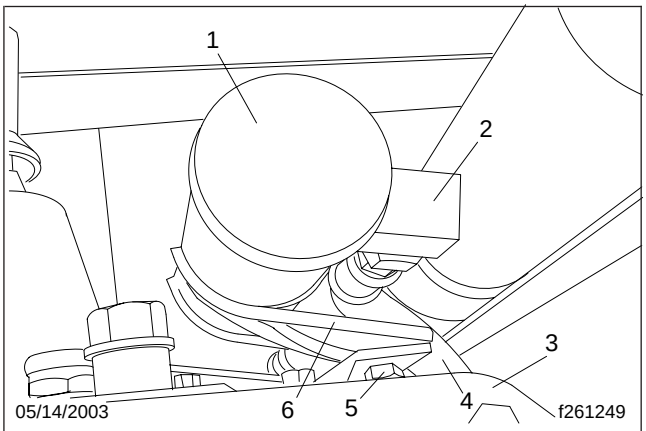


## Transmission-Mounted Cooler Replacement




1. Exhaust Pipe
2. Transmission Cooler
3. Fluid Lines
4. Gear Case
5. Top Cover

**Fig. 2, Transmission Fluid Lines**




1. Transmission Cooler
2. Pipe Fitting
3. Gear Case
4. Fluid Line
5. Mounting Fastener, 5/16–18
6. Mounting Bracket

**Fig. 3, Transmission Cooler (transmission-mounted)**

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## Specifications

| Torque Values, Manual Transmissions | | | |
|---|---|---|---|
| **Description** | **Size** | **Grade** | **Torque: lbf·ft (N·m)** |
| Flywheel-Housing-to-Clutch-Housing Attachment, Patch-Lok Capscrews | — | — | 43–53 (58–72) |
| Flywheel-Housing-to-Clutch-Housing Attachment, Non-Locking Capscrews with Lockwashers | — | — | 38–45 (52–61) |
| Clutch Release Lever Pinch Bolts | 5/16–18 | 5 | 13 (18) |
| Midship Bearing Bracket Capscrews | 1/2–20 | 8 | 77 (104) |
| Shift Lever Mounting Bolt | 7/16–20 | 8 | 50 (68) |
| Shift Lever Retaining Ring Screws | 3/8–16 | 8 | 28 (38) |
| Transmission Cooler Mounting Bolts | 5/16–18 | 5 | 13 (18) |
| Transmission Fluid Drain Plug | — | — | 50 (68) |
| Transmission Fluid Fill Plug (Eaton® Fuller® with 0.75-inch pipe threads) | — | — | 25–35 (34–48) |
| Transmission Fluid Fill Plug (Eaton Fuller with 1.25-inch pipe threads) | — | — | 60–75 (81–102) |
| Transmission Fluid Fill Plug (Meritor™) | — | — | 35–50 (48–68) |
| Transmission Nodal Mount Bolts | 5/8–18 | 5 | 165 (224) |
| U-Joint End Cap Bolts | 3/8–24 | 8 | 37 (50) |
| | 1/2–20 | 8 | 110 (149) |

**Table 1, Torque Values, Manual Transmissions**

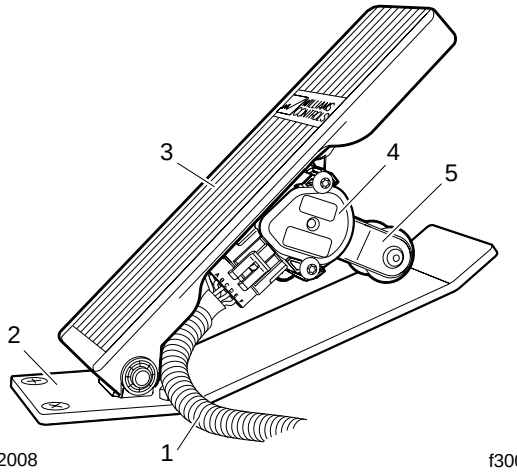
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## Accelerator Pedal Assembly

The Williams electronic accelerator pedal provides an electrical signal to the engine in response to the driver's demand for more engine power. The pedal converts downward pressure into an electrical signal via the pedal position sensor.

Vehicles built before May 4, 2009, have a spring-loaded treadle lever and roller mounted to the underside of the pedal to support it in the upright idle position. See **Fig. 1**.




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1. Wire Harness
2. Baseplate
3. Pedal
4. Pedal Position Sensor
5. Treadle Lever

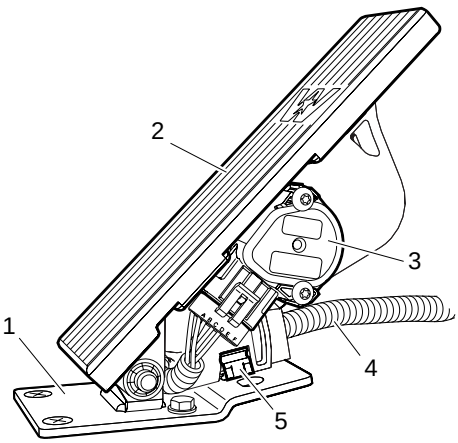
**Fig. 1, Williams WM526 Throttle Pedal**

Vehicles built on or after May 4, 2009, have a machined treadle enclosed in a plastic housing mounted to the underside of the pedal. The pedal is secured to the baseplate in an upright position by a spring clip. See **Fig. 2**.

## Pedal Position Sensor

Western Star uses various pedal position sensors, depending on the engine. The pedal position sensor is mounted to the side of the pedal assembly. The sensor and the pedal assembly are both separately replaceable.

There are three basic technologies employed on pedal position sensors used with electronic engines.




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1. Baseplate
2. Pedal
3. Pedal Position Sensor
4. Wire Harness
5. Spring Clip

**Fig. 2, Williams WM532 Throttle Pedal**

- A ratiometric sensor that generates a DC voltage output in proportion to the pedal position. The ratiometric sensor is used on Detroit Diesel, Mercedes-Benz, and pre-EPA07 Cummins engines.
- A pulse-width-modulating (PWM) sensor that generates a series of discrete voltage pulses. The width of the pulses is proportional to the pedal position. A narrower pulse width indicates a smaller accelerator pedal request and a wider pulse width indicates a larger pedal request. The PWM sensor is used on Caterpillar engines.
- A dual ratiometric sensor that uses Hall effect technology to generate two analog outputs that are proportional to the pedal position. The primary output is twice the voltage of the secondary output. The dual sensor is used on EPA07 Cummins engines.

An idle validation switch (IVS) is integrated into some ratiometric pedal position sensors. The IVS is a single-pole, double-throw switch. Some engine models monitor both switched poles, and some monitor only one pole. When the accelerator pedal returns to idle, the IVS moves to the "idle" position to signal the engine that the pedal has returned to idle. The

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## General Information

IVS is not a serviceable part. If the IVS malfunctions, the sensor must be replaced.

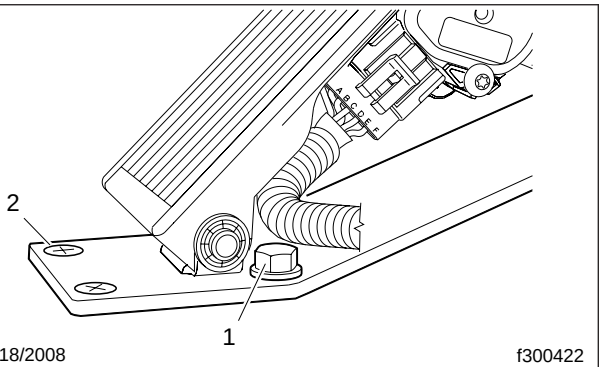
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# Accelerator Pedal Removal and Installation

## Removal

1. Apply the parking brakes and chock the tires.
2. Disconnect the batteries.
3. Disconnect the pedal position sensor wiring harness.
4. Remove the four fasteners that secure the accelerator pedal baseplate to the floor of the cab. The baseplate is secured with two hexhead capscrews and two Phillips screws. See **Fig. 1**.




1. Hexhead Capscrew 2. Phillips Screw

**Fig. 1, Accelerator Pedal Assembly**

NOTE: Vehicles built after May 4, 2009, have a spring clip on the baseplate that secures the pedal down. Release the pedal from the spring clip in order to remove the capscrews behind the pedal.

5. Remove the pedal assembly.

## Installation

1. Align the accelerator pedal assembly with the mounting holes on the floor of the cab.
2. Hand-tighten two Phillips screws into the baseplate, rearward of the pedal.
3. Hand-tighten two hexhead capscrews into the baseplate, forward of the pedal.
4. Continue tightening all four screws until the baseplate is snug against the floor.

NOTE: Vehicles built after May 4, 2009, have a spring clip on the baseplate that secures the pedal down. Secure the pedal to the spring clip.

5. Connect the pedal position sensor wiring harness.
6. Depress the accelerator pedal several times and ensure that the pedal does not stick or bind.
7. Connect the batteries.
8. Test the pedal operation using the service software tool specified in **Table 1**.

| Diagnostic Software Tools | |
|---|---|
| **Engine Manufacturer** | **Software Tool** |
| Caterpillar | Caterpillar Electronic Technician (CAT ET) |
| Cummins | INSITE |
| Detroit Diesel | Detroit Diesel Diagnostic Link |
| Mercedes-Benz | Detroit Diesel Diagnostic Link |

**Table 1, Diagnostic Software Tools**

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## Replacement

1. Apply the parking brakes and chock the tires.
2. Disconnect the batteries.
3. Disconnect the pedal position sensor wiring harness.

NOTE: If the vehicle is equipped with a Caterpillar engine, the wiring harness is attached to the sensor and must be removed with the sensor.

4. Remove the two sensor mounting fasteners that connect the sensor to the pedal assembly. Remove the pedal position sensor from the pedal assembly.
5. Align the new sensor with the actuator on the pedal, then install the mounting fasteners and tighten them 25 to 30 lbf·in (280 to 340 N·cm).
6. Connect the sensor wiring harness.
7. Connect the batteries.
8. Test the pedal operation using the service software tool specified in **Table 1**.

| Diagnostic Software Tools | |
|---|---|
| **Engine Manufacturer** | **Software Tool** |
| Caterpillar | Caterpillar Electronic Technician (CAT ET) |
| Cummins | INSITE |
| Detroit Diesel | Detroit Diesel Diagnostic Link |
| Mercedes-Benz | Detroit Diesel Diagnostic Link |

**Table 1, Diagnostic Software Tools**

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Complete the following procedures to diagnose accelerator pedal assembly and pedal position sensor problems.

## Common Problems and Indications

The accelerator pedal assembly was designed so that the pedal position sensor will not reach the internal stop points when it is mounted to the pedal assembly. Attempting to modify the sensor or forcing the sensor shaft beyond the internal stop points will result in severe damage to the sensor.

A number of symptoms may be reported that can indicate a problem with the accelerator pedal, pedal position sensor, or wiring to the engine, including:

- low power or poor acceleration
- slow deceleration
- vehicle does not reach top speed
- engine is stuck at idle
- engine brake does not function
- check engine light comes on
- engine fault code indicates a pedal position sensor problem

A thorough diagnosis of the entire sensor system must be performed to ensure that a pedal position sensor is faulty. Symptoms may disappear when the pedal position sensor is replaced even if the sensor is not faulty.

## Diagnostics

1. Connect the vehicle to the appropriate diagnostic software tool. See **Table 1** for a list of diagnostic software tools for each engine.

NOTE: All desired signal values are approximate. Each individual vehicle and electrical system will exhibit some variation in signal values. The engine control system compensates for this variation. These diagnostic procedures are designed to identify malfunctioning components of the pedal assembly and electrical system.

2. Make a note of the signal values at idle. See **Table 2** for the correct signal values.

| Diagnostic Software Tools | |
|---|---|
| **Engine Manufacturer** | **Software Tool** |
| Caterpillar | Caterpillar Electronic Technician (CAT ET) |
| Cummins | INSITE |
| Detroit Diesel | Detroit Diesel Diagnostic Link |
| Mercedes-Benz | Detroit Diesel Diagnostic Link |

**Table 1, Diagnostic Software Tools**

3. Slowly depress the accelerator pedal and monitor the signals.

NOTE: There is a short time delay between pedal movement and display of the corresponding data.

4. Make a note of all signal values when the pedal has been pressed halfway.
5. Make a note of all signal values at full throttle.
6. Verify idle validation signal (IVS) inputs, if equipped.

NOTE: The pedal position sensor used with Caterpillar engines is a pulse-width modulated (PWM) sensor. It cannot be diagnosed using a digital multimeter set to measure voltage or resistance. A multimeter capable of measuring "duty cycle" may be used to view the sensor output.

The pedal position sensor used with EPA07 Cummins engines uses Hall effect technology. Attempting to measure resistance across the sensor will not provide valid results and may damage the sensor.

7. If any signal does not change, measure the sensor voltage supply and ground circuits with a digital multimeter as follows.

   7.1 Use EZWiring™ in ServicePro or PartsPro to identify the circuit(s) that supplies voltage to the pedal position sensor.

   IMPORTANT: The ignition key must be in the ON position.

   7.2 Disconnect the connector nearest the pedal and measure the voltage supply.

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## Troubleshooting

8. If a 5-volt supply is not present, look for a fault in the circuit between the pedal and the common powertrain controller (Detroit Diesel and Mercedes-Benz) or the motor control module (Caterpillar and Cummins engines).
9. Inspect and ensure that all connector pins at the pedal position sensor, frontwall, and the engine controller are free of corrosion and are not bent or damaged. Inspect and ensure that the connections between the pins and the wires are secure and also free of corrosion.
10. If the problem has not been resolved, the problem is not with the pedal position sensor. See the engine manufacturer's service literature for further guidance.

| Diagnostic Software Values* | | | |
|---|---|---|---|
| **Engine** | **Signal** | **Pedal Position** | **Desired Value†** |
| Caterpillar, pre-EPA07 | Throttle Position | Idle | 0% |
| | | Full throttle | 100% |
| | | Between idle/full throttle | Varies smoothly between 0% and 100% |
| | Duty Cycle | Idle | 15% |
| | | Full throttle | 85% |
| | | Between idle/full throttle | Varies smoothly between 15% and 85% |
| Caterpillar, EPA07 | Accelerator Pedal Position | Idle | 0% |
| | | Full throttle | 100% |
| | | Between idle/full throttle | Varies smoothly between 0% and 100% |
| | Throttle Position | Idle | 0% |
| | | Full throttle | 100% |
| | | Between idle/full throttle | Varies smoothly between 0% and 100% |
| | Duty Cycle | Idle | 15% |
| | | Full throttle | 85% |
| | | Between idle/full throttle | Varies smoothly between 15% and 85% |
| Cummins, pre-EPA07 | Accelerator Pedal Position | Idle | 0% |
| | | Full throttle | 100% |
| | | Between idle/full throttle | Varies smoothly between 0% and 100% |
| | Accelerator Pedal Sensor | Idle | 0.5 volts |
| | | Full throttle | 4.5 volts |
| | | Between idle/full throttle | Varies smoothly between 0.5 and 4.5 volts |
| | IVS | Idle | ON |
| | | Full throttle | OFF |
| | Sensor Supply | Idle | 5.0 volts |
| | | Full throttle | 5.0 volts |
| | | Between idle/full throttle | 5.0 volts |

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| Diagnostic Software Values* | | | |
|---|---|---|---|
| **Engine** | **Signal** | **Pedal Position** | **Desired Value†** |
| Cummins, EPA07 | Accelerator Pedal Position | Idle | 0% |
| | | Full throttle | 100% |
| | | Between idle/full throttle | Varies smoothly between 0% and 100% |
| | Accelerator Pedal Sensor | Idle | 1.0 volts |
| | | Full throttle | 4.5 volts |
| | | Between idle/full throttle | Varies smoothly between 1.0 and 4.5 volts |
| | Accelerator Pedal Sensor 2 | Idle | 0.5 volts |
| | | Full throttle | 2.25 volts |
| | | Between idle/full throttle | Varies smoothly between 0.5 and 2.25 volts |
| | Sensor Supply (both) | Idle | 5.0 volts |
| | | Full throttle | 5.0 volts |
| | | Between idle/full throttle | 5.0 volts |
| Detroit Diesel and Mercedes-Benz, pre-EPA07 | Accelerator Pedal Raw Sensor | Idle | 15% |
| | | Full throttle | 75% |
| | | Between idle/full throttle | Varies smoothly between 15% and 75% |
| | Accelerator Pedal Position | Idle | 0% |
| | | Full throttle | 100% |
| | | Between idle/full throttle | Varies smoothly between 0% and 100% |
| | IVS | Idle | ON (grounded) |
| | | Full throttle | OFF (open) |
| | Supply Analog Accelerator Pedal | Idle | 5.0 volts |
| | | Full throttle | 5.0 volts |
| | | Between idle/full throttle | 5.0 volts |

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## Troubleshooting

| Diagnostic Software Values* | | | |
|---|---|---|---|
| **Engine** | **Signal** | **Pedal Position** | **Desired Value†** |
| Detroit Diesel and Mercedes-Benz, EPA07 | Accelerator Pedal Raw Sensor | Idle | 15% |
| | | Full throttle | 75% |
| | | Between idle/full throttle | Varies smoothly between 15% and 75% |
| | Accelerator Pedal Position | Idle | 0% |
| | | Full throttle | 100% |
| | | Between idle/full throttle | Varies smoothly between 0% and 100% |
| | IVS1 | Idle | ON (grounded) |
| | | Full throttle | OFF (open) |
| | IVS2 | Idle | OFF (open) |
| | | Full throttle | ON (grounded) |
| | Supply Analog Accelerator Pedal | Idle | 5.0 volts |
| | | Full throttle | 5.0 volts |
| | | Between idle/full throttle | 5.0 volts |

* All desired signal values are approximate. Each individual vehicle and electrical system will exhibit some variation in signal values.

† There is a short time delay between pedal movement and display of the corresponding data.

**Table 2, Diagnostic Software Values**

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## General Information

All frame equipment is attached with 1/2-inch or 5/8-inch SAE Grade 8 NFT bolts, nuts and washers. See **Fig. 1**. If clearance is minimal, low-profile hexhead bolts and grade C prevailing torque locknuts are used. Prevailing torque locknuts of both bolt types have distorted sections of threads to provide torque retention.

When hexhead bolts and locknuts are used on an attached part, a hardened flatwasher is required to prevent the bolt head or nut from embedding in the part. In general, hardened washers are used to distribute the load, and to prevent localized overstressing of the frame rails, brackets, and other parts. Washers are placed directly against the part, under the nut or bolt head. These special hardened washers are used on the frame rails and for the engine rear supports, rear suspension brackets, and fifth wheel mountings. They are cadmium or zinc plated, and have a hardness rating of 38 to 45 HRC.

## Hexhead Bolt Replacement

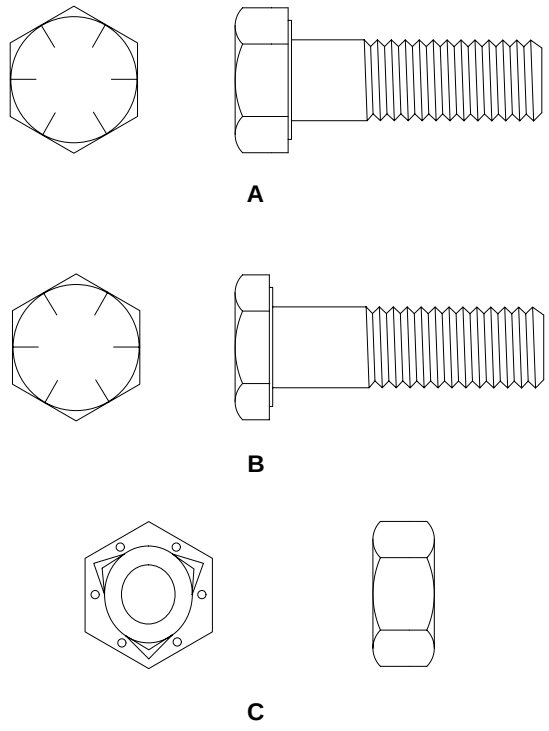
Replace hexhead bolts with identical fasteners.

Apply Alumilastic® compound, or an equivalent, to all surfaces where steel and aluminum parts contact each other.

**CAUTION**

**Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the frame or parts.**

Never hammer or screw bolts into place. Align the holes of the frame and the part being attached to it so that the nut and bolt surfaces are flush against the frame and the part. For bolts that are 4-inches (102 mm) or less in length, make sure that at least 1-1/2 threads and no more than 5/8-inch (16-mm) bolt length extends through the self-locking nut after it has been tightened. For bolts longer than 4-inches (102 mm), allow a minimum of 3 threads and a maximum of 3/4-inch (19-mm) bolt length.




A. Grade 8 NFT Hexhead Bolt
B. Grade 8 Low-Profile NFT Hexhead Bolt
C. Grade C Prevailing Torque Locknut

**Fig. 1, Hexhead Fasteners**

## Frame Fastener Tightening

**CAUTION**

**Tighten standard frame fasteners periodically. Continued vehicle operation with loose fasteners could result in component, bracket, and frame damage.**

Tighten hexhead bolts and locknuts periodically to offset the effects of "bedding in" (seating). Refer to **Group 00** and **Group 31** of the *Western Star Maintenance Manual* for intervals.

When tightening the fasteners, tighten the nut, not the bolt head. This will give a true torque reading by eliminating bolt body friction. For frame fastener torque specifications, see **Table 1**.

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## General Information

| Frame Fastener Torque Values | |
|---|---|
| **Size: inch (mm)** | **Torque: lbf·ft (N·m)** |
| 1/2 (13) | 75 to 90 (100 to 120) |
| 5/8 (15) | 150 to 180 (203 to 240) |

**Table 1, Frame Fastener Torque Values**

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# General Information

Fontaine H5092 series fifth wheels couple to trailers having a standard 2-inch kingpin. When installed as a stationary mount, the fifth wheel is bracket-mounted to the tractor frame in a position that best distributes the trailer load over the tractor axles. Sliding fifth wheels (**Fig. 1**), are mounted on the Fontaine HAWB or HMWS (previously called 5AWB and 5MWS) model slide mounts.

The Fontaine fifth wheel lock mechanism for the trailer kingpin consists of a spring-loaded jaw and sliding wedge. Kingpin release is accomplished by pulling a manual lock control handle located on either the right side (curbside) or left side (roadside) of the fifth wheel. Kingpin coupling occurs when the kingpin enters the throat of the fifth wheel, triggers the jaw and wedge to slide into place behind the kingpin, and moves the lock control handle into the locked position.

As the kingpin enters the lock mechanism, the jaw is moved first with the spring-loaded wedge sliding in place against the jaw. The jaw will move behind the kingpin, followed by the wedge. The wedge reinforces the jaw and automatically adjusts for slack around the kingpin. See **Fig. 2** for an illustration of the jaw and wedge in the locked position.

Placing the lock control handle in the unlocked position moves the wedge and jaw out from behind the kingpin and unlocks the fifth wheel. See **Fig. 3** for an illustration of the jaw and wedge in the unlocked position.

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## General Information

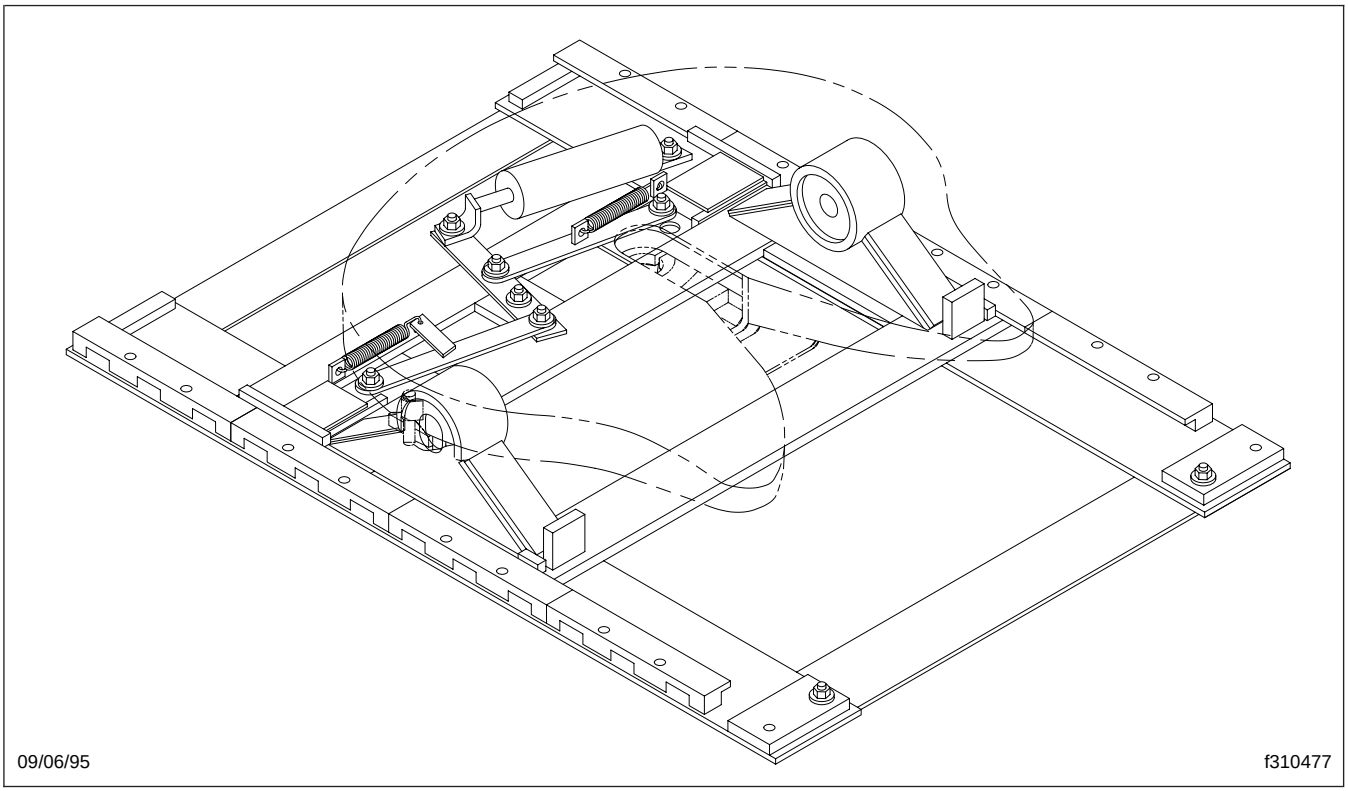



**Fig. 1, Fontaine H5092 Series Air Slide Fifth Wheel**

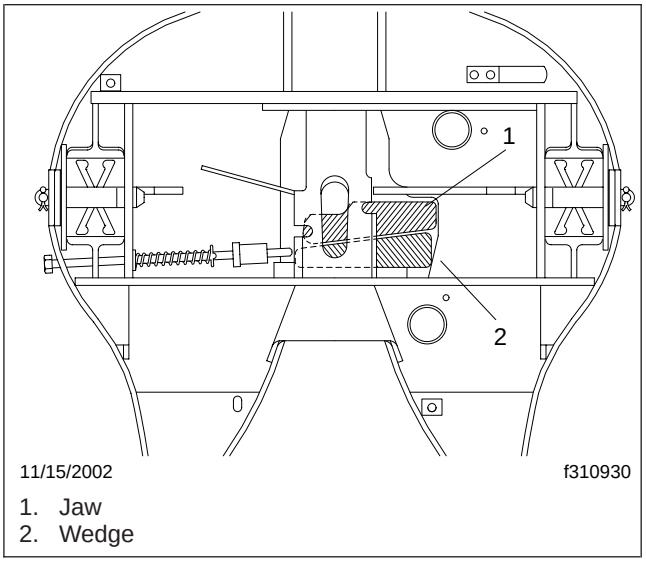



**Fig. 2, Locked Position**

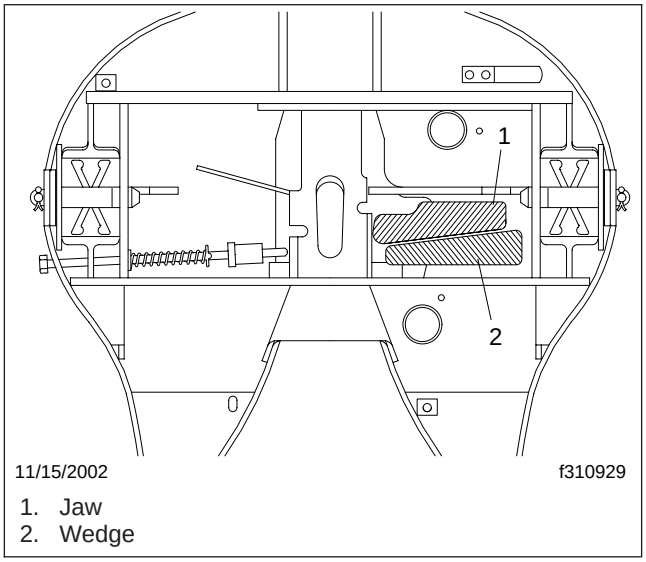



**Fig. 3, Unlocked Position**

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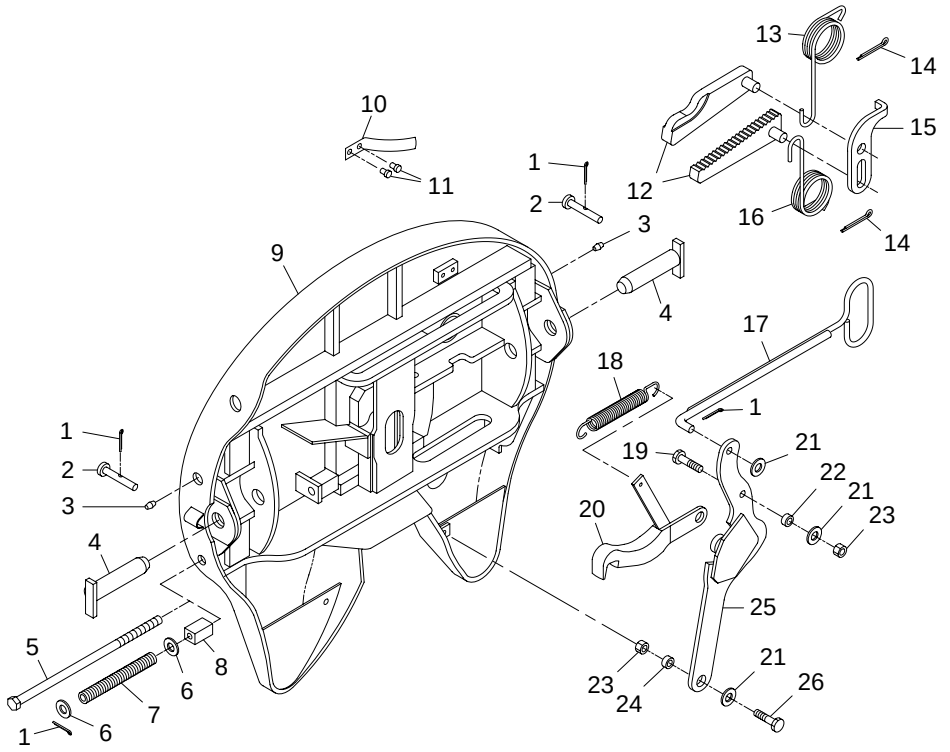


## Fifth Wheel Removal and Disassembly

See **Fig. 1** for an exploded view of a Fontaine H5092 fifth wheel.

**⚠ WARNING**

**All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in disengagement of the trailer from the tractor, leading to personal injury or property damage.**




09/18/95 f310476

1. Cotter Pin, 3/16" x 1"
2. Lower Bracket Retainer Pin
3. Grease Fitting
4. Lower Bracket Pin
5. Wedge Stop Rod
6. Flatwasher
7. Wedge Stop Rod Spring
8. Nut, Wedge Stop Rod
9. Upper Assembly, Side-Release
10. Leaf Spring
11. Thread-Cutting Screw, 1/4–20 x 3/8"
12. Step Jaw and Wedge
13. Jaw Spring
14. Cotter Pin, 1/4" x 3"
15. Timer
16. Wedge Spring
17. Pull Handle
18. Bumper Handle Spring
19. Hexhead Bolt, 1/2–13 x 2", Bumper Pivot
20. Bumper
21. Flatwasher
22. Bushing, 5/16", Bumper Pivot
23. Hex Locknut, 1/2–13
24. Bushing, 7/16", Handle Pivot
25. Operating Handle, Side-Release Only
26. Hexhead Bolt, 1/2–13 x 2", Handle Pivot

**Fig. 1, Fontaine H5092 Series Fifth Wheel (left-side release shown)**

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## Removal and Disassembly

**Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.**

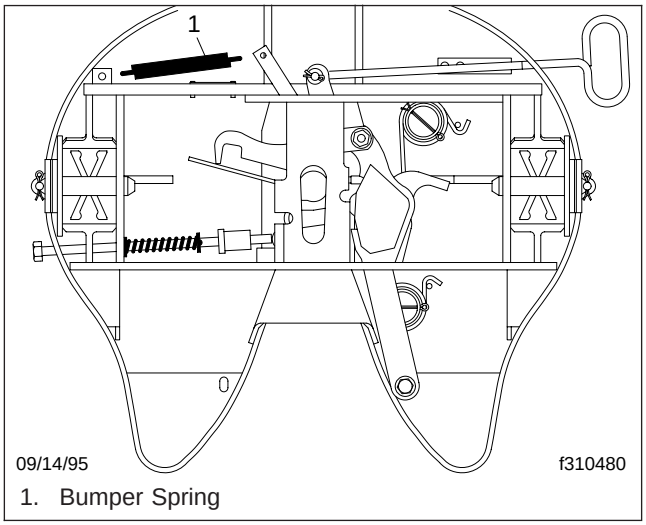
1. Steam clean the top plate. Remove it from the sliding mount by removing the cotter pins from the retaining pins. Remove the retaining pins and bushing pins from both sides of the top plate.
2. Using an overhead hoist, lift the fifth wheel off the sliding mount and tractor frame.
3. Turn the fifth wheel upside down.

NOTE: While disassembling the fifth wheel, check it for cracks and for missing or damaged parts.

**⚠ WARNING**

**Do not attempt to repair or rebuild the top plate if it is cracked or if parts are damaged. The top plate or parts could malfunction. This could result in disengagement of the trailer during vehicle travel, possibly causing personal injury and property damage.**

4. Set the fifth wheel in a locked position, then unhook the bumper spring from the bumper tang and the tab on the side of the fifth wheel substructure. See **Fig. 2**. Remove the bumper spring.
5. Remove the two bolts on the operating handle. See **Fig. 3**. Each bolt has a nut, washer, and bushing. Discard the bushings.
6. Remove the cotter pin and washer that holds the pull handle to the operating handle. Slide the pull handle out through the side of the fifth wheel. See **Fig. 4**.
7. Slide the operating handle over to the side of the fifth wheel. Slide the bottom part first. This will allow the handle to clear the jaw and wedge studs on the underside and clear the timer. See **Fig. 5**.
8. Remove the timer by lifting upward. See **Fig. 6**.
9. Slide the operating handle out through the slot in the rear crossmember of the fifth wheel. See **Fig. 7**.
10. Slide the bumper toward the operating handle slot and to the rear of the fifth wheel until the bumper tang clears the operating handle slot. Lift upward and remove. See **Fig. 8**.




1. Bumper Spring

**Fig. 2, Bumper Spring Removal**

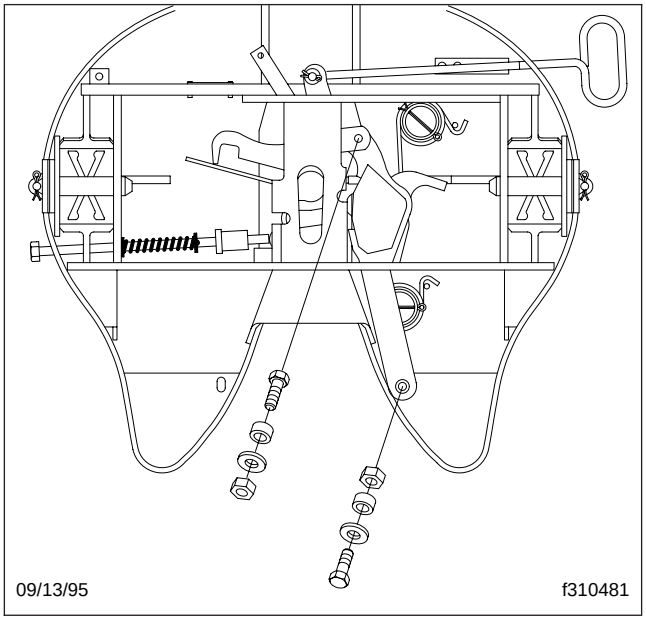



**Fig. 3, Bolt Removal**

**⚠ WARNING**

**The wedge spring is under extreme tension. Always wear safety glasses. Do not stand directly over the springs. A flying spring could cause personal injury.**

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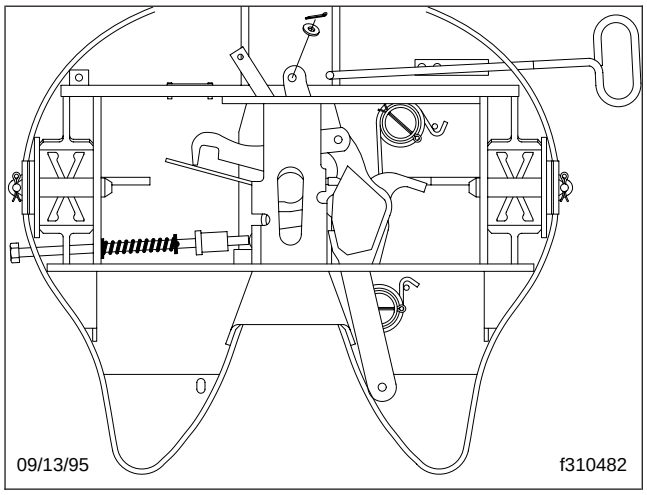



**Fig. 4, Pull Handle Removal**

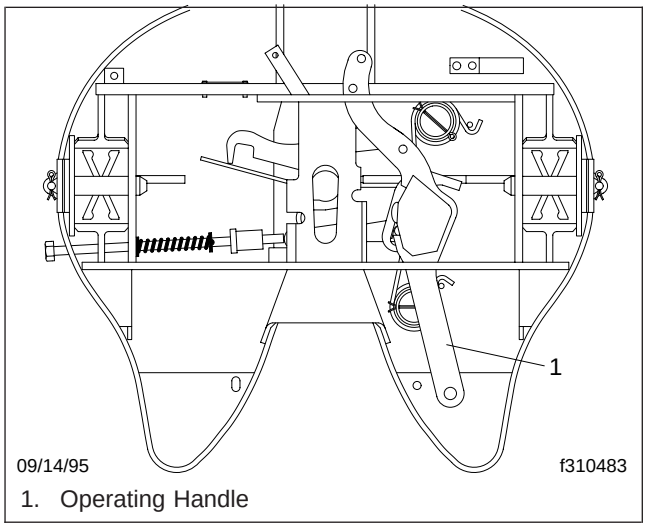



**Fig. 5, Operating Handle Positioning**

11. Remove the cotter pins from the jaw and wedge springs. Discard the cotter pins, and pry the small hooked tail of the jaw and wedge spring up over the jaw and wedge studs. Remove and discard both springs. See **Fig. 9**.
12. Remove the wedge first, and then the jaw. Discard the jaw and wedge. See **Fig. 10**.

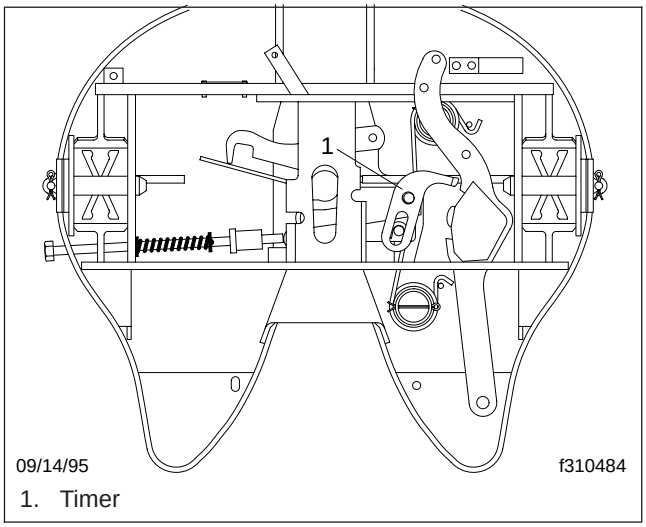



**Fig. 6, Timer Removal**

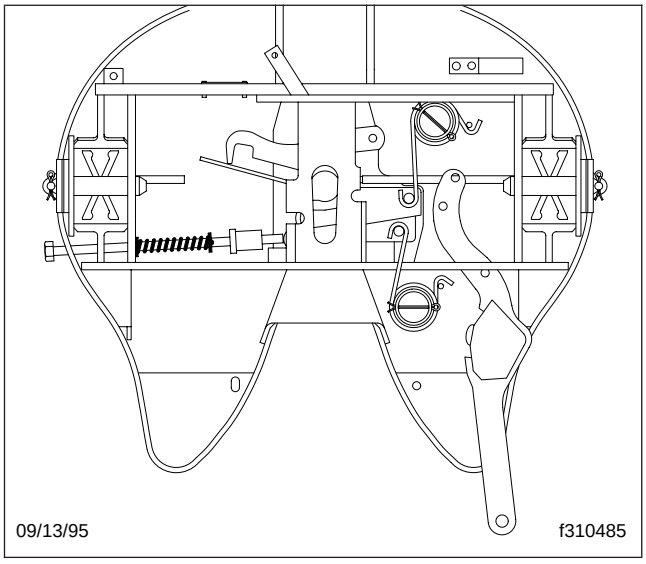
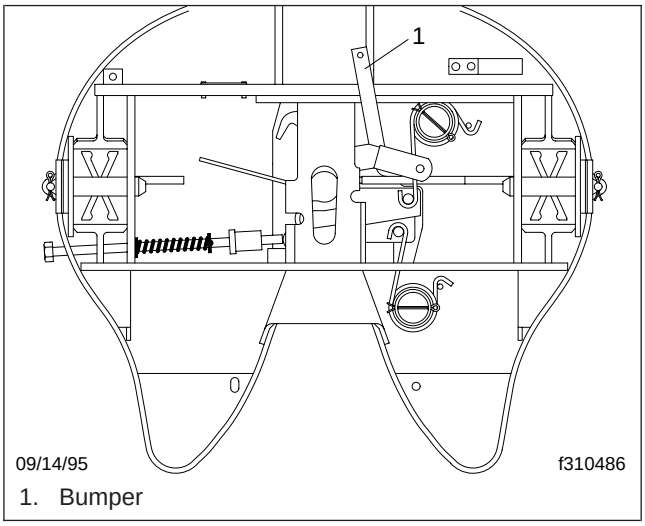



**Fig. 7, Operating Handle Removal**

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## Removal and Disassembly




1. Bumper

**Fig. 8, Bumper Removal**

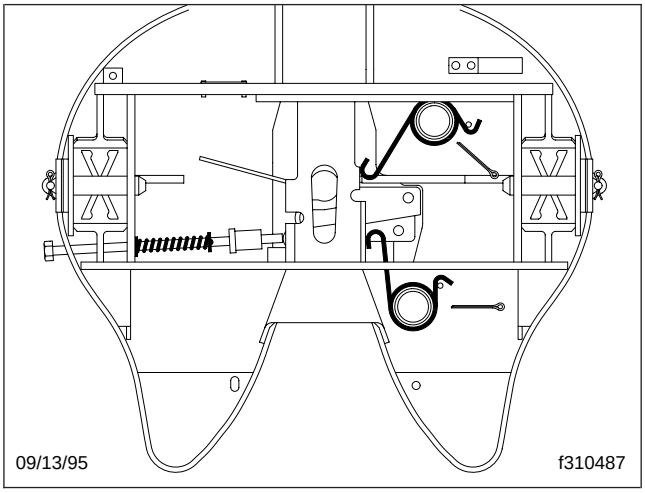



**Fig. 9, Spring Removal**

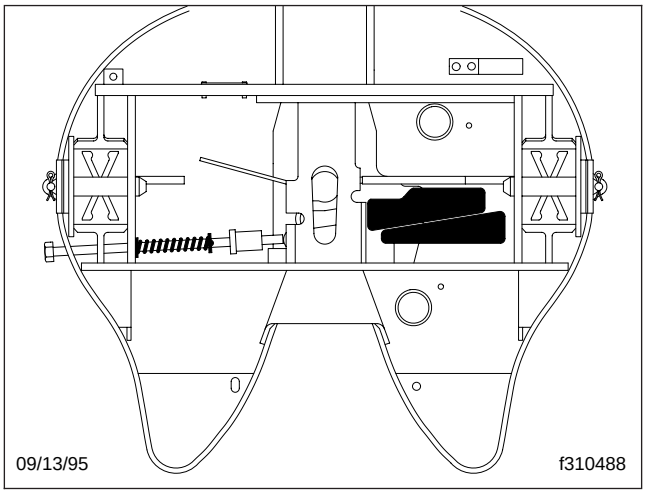



**Fig. 10, Jaw and Wedge Removal**

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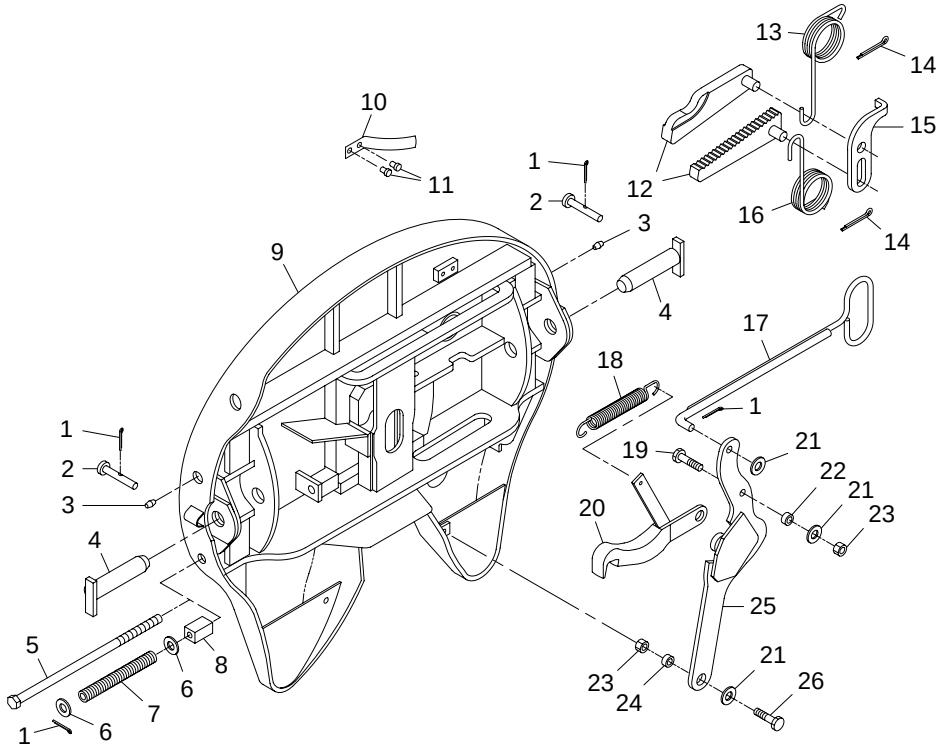


## Assembly and Installation

See **Fig. 1** for an exploded view of a Fontaine H5092 fifth wheel.

**⚠ WARNING**

**All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in possible disengagement of the trailer from the tractor, leading to personal injury and property damage.**




09/18/95 f310476

1. Cotter Pin, 3/16" x 1"
2. Lower Bracket Retainer Pin
3. Grease Fitting
4. Lower Bracket Pin
5. Wedge Stop Rod
6. Flatwasher
7. Wedge Stop Rod Spring
8. Nut, Wedge Stop Rod
9. Upper Assembly, Side Release
10. Leaf Spring
11. Thread-Cutting Screw, 1/4–20 x 3/8"
12. Step Jaw and Wedge
13. Jaw Spring
14. Cotter Pin, 1/4" x 3"
15. Timer
16. Wedge Spring
17. Pull Handle
18. Bumper Handle Spring
19. Hexhead Bolt, 1/2–13 x 2", Bumper Pivot
20. Bumper
21. Flatwasher
22. Bushing, 5/16", Bumper Pivot
23. Hex Locknut, 1/2–13
24. Bushing, 7/16", Handle Pivot
25. Operating Handle, Side Release Only
26. Hexhead Bolt, 1/2–13 x 2", Handle Pivot

**Fig. 1, Fontaine H5092 Series Fifth Wheel (left-side release shown)**

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## Fifth Wheel Assembly and Installation

**Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.**

IMPORTANT: Replace any parts that show signs of wear, damage, or deterioration.

1. Clean all moving parts with no. 2 diesel fuel before assembly.
2. Always assemble the parts around a 2-inch kingpin or a shaft with a 2-inch diameter. Insert the jaw first and then the new wedge below it. Apply a moderate amount of grease having EP (extra pressure) additives to the sides and serrated edges of the jaw and wedge. Also apply grease to the stationary jaw in the throat of the fifth wheel. See **Fig. 2**.
3. Insert the new wedge spring through the slot in the rear crossmember and lay the coil over the spring boss. Using a spring tool, engage the small hooked tail of the wedge spring and wind it around until it is directly over the small stud at the back of the bracket. Using a hammer, nudge the spring downward allowing it to catch on the stud. Insert a new cotter pin. See **Fig. 3**.

   Repeat these steps to replace the jaw spring.

NOTE: The jaw spring has minimal tension and can be replaced by hand.

4. Place the bumper back in position, sliding the bumper tang through the operating handle guide slot and toward the tab on the side of the fifth wheel substructure. See **Fig. 4**.
5. Apply a liberal amount of grease to the grooved middle section of the operating handle, then insert the operating handle and move it over to the side of the wheel. See **Fig. 5**.
6. Insert the timer over the jaw and wedge studs. The small hole on the timer fits over the jaw stud, and the slotted hole fits over the wedge stud. Be certain the small bent arm of the timer is facing downward. See **Fig. 6**.
7. Slide the operating handle toward the center of the wheel to engage the handle with the studs on the jaw and wedge. Slide the top part first. This will ensure that the grooves on the operating handle are aligned with the studs. A correctly aligned operating handle should be in a vertical position once it goes over the studs. See **Fig. 7**.

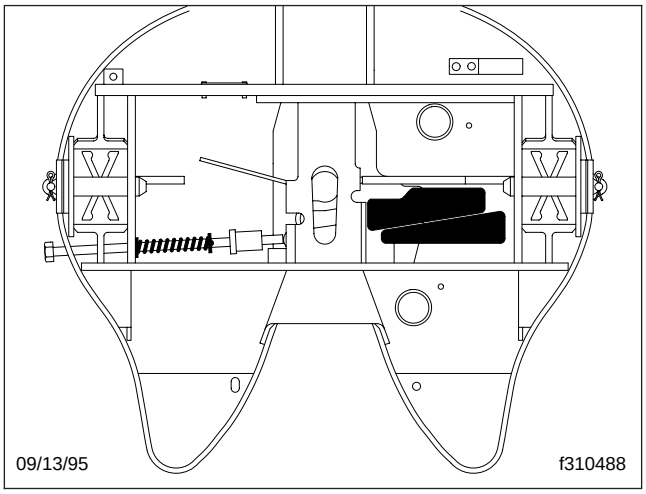



**Fig. 2, Wedge and Jaw Installation**

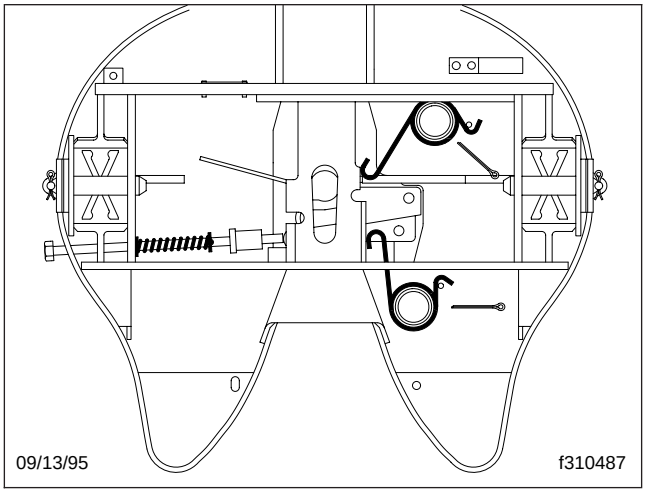
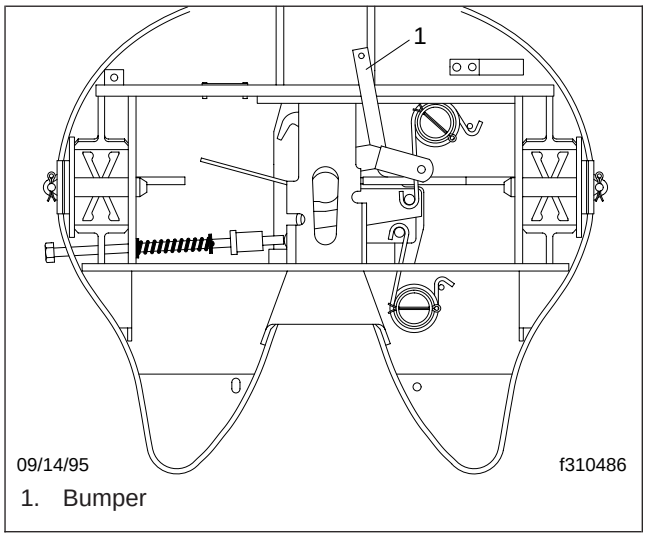



**Fig. 3, Spring Installation**

8. Slide the pull handle in through the safety lock and using the cotter pin and washer, fasten it in the top hole of the operating handle. See **Fig. 8**.
9. Align the bumper hole with the hole in the operating handle. Replace the bolts on the operating handle. The bolt which fastens the operating handle to the bumper must be inserted with the threads facing toward you to prevent interference with the jaw springs. The other bolt should be positioned with the threads facing downward. Each bolt has a nut, washer, and new bushings. Apply grease to the bolt parts and where there is metal to metal contact with the operating handle.

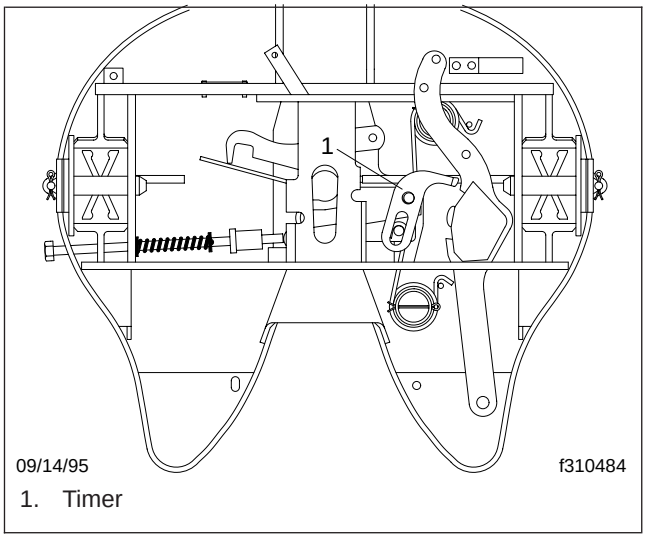
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1. Bumper

**Fig. 4, Bumper Installation**




1. Timer

**Fig. 6, Timer Installation**

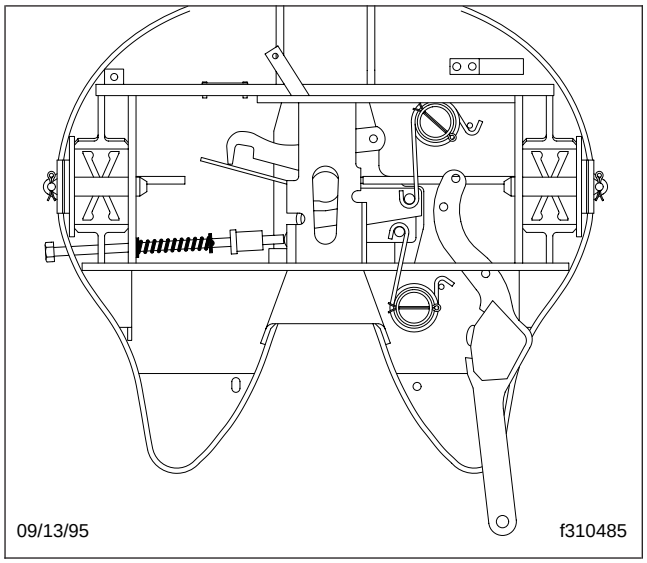
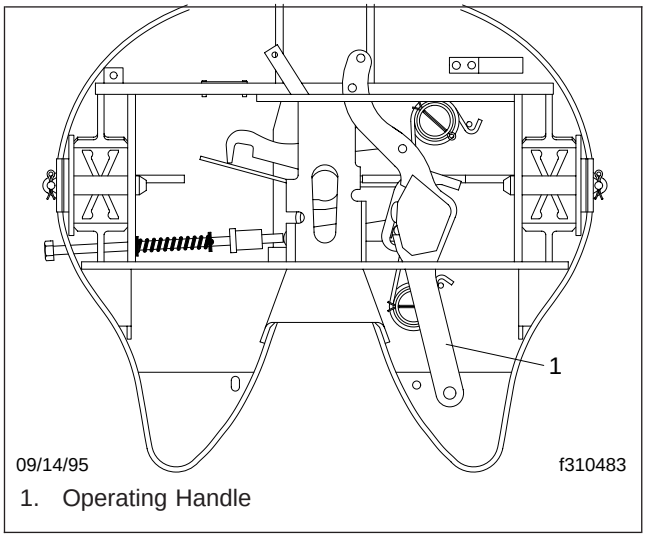



**Fig. 5, Operating Handle Installation**




1. Operating Handle

**Fig. 7, Operating Handle Positioning**

See **Fig. 9**. Do not overtighten the bolts. Lubricate all pivot points.

IMPORTANT: The fifth wheel must be well lubricated to operate correctly. Refer to **Group 31** of the *Western Star Maintenance Manual* for complete maintenance and lubrication instructions for the fifth wheel assembly.

10. Connect the bumper spring to its clasp. See **Fig. 10**. Apply grease to the bracket pockets and to the grease fittings on the side of the fifth wheel until grease flows into the upper brackets. Also apply a liberal amount of grease to the top plate.

**⚠ WARNING**

**If the fifth wheel does not operate properly, do not use it. The fifth wheel could malfunction, resulting in personal injury or property damage due to possible disengagement of the trailer from the tractor.**

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## Fifth Wheel Assembly and Installation

11. Using an overhead hoist, position the fifth wheel on the sliding mount assembly. Insert the bushing pins. Install the retaining pins and the 1-inch-long cotter pins.

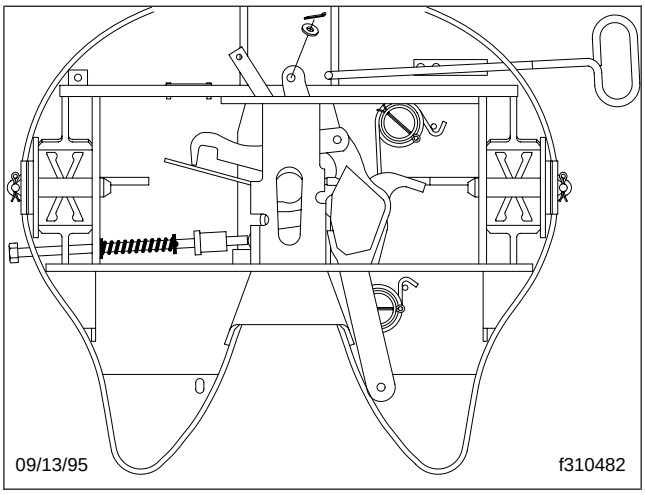



**Fig. 8, Pull Handle Installation**

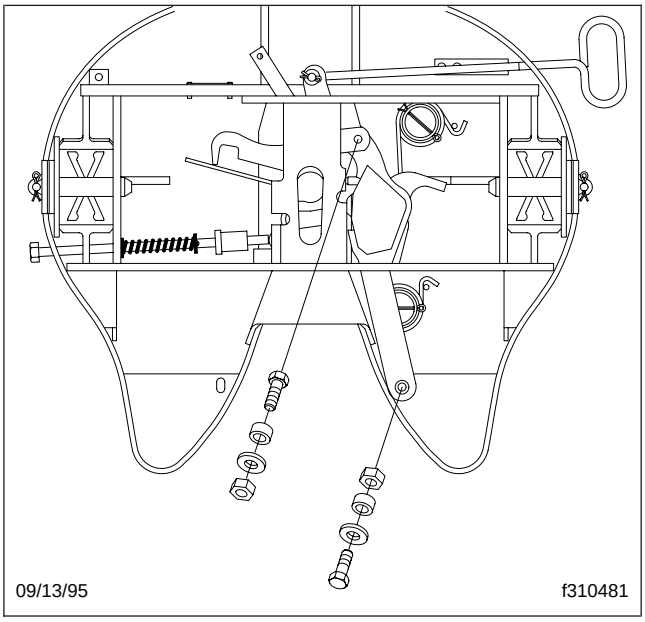
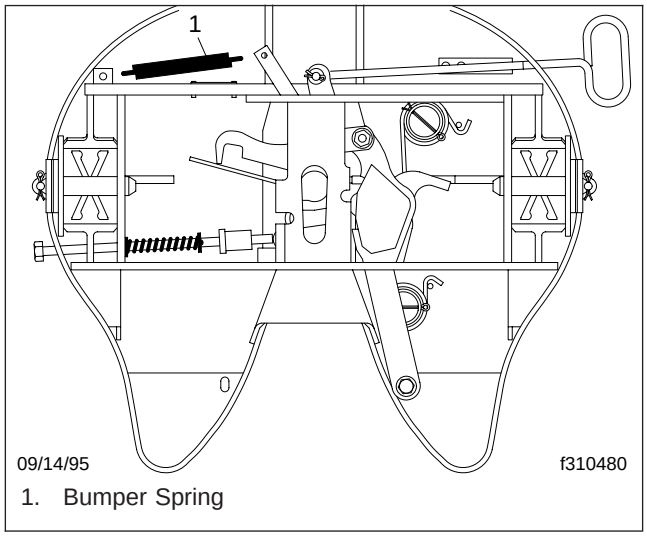



**Fig. 9, Bolt Installation**




1. Bumper Spring

**Fig. 10, Spring Installation**

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# Troubleshooting Tables

**Problem—Difficulty Coupling**

| Problem—Difficulty Coupling | |
|---|---|
| **Possible Cause** | **Remedy** |
| The kingpin is too high to trip the latch | Lower the landing gear. |
| The trailer plate or kingpin is damaged | Check the trailer plate for flatness. Check the kingpin for squareness with the trailer plate. |

**Problem—Excessive Wear on the Fifth Wheel Top Plate**

| Problem—Excessive Wear on the Fifth Wheel Top Plate | |
|---|---|
| **Possible Cause** | **Remedy** |
| Damaged trailer plate | If the trailer plate is not flat, replace it. |

**Problem—Difficulty Uncoupling**

| Problem—Difficulty Uncoupling | |
|---|---|
| **Possible Cause** | **Remedy** |
| Pressure on the locking mechanism caused by the truck drifting apart from the trailer putting excess pressure on the lock | Back up the trailer and set the brakes. Strike the wedge stop rod which protrudes through the side of the fifth wheel. This spring-loaded rod will release the pressure on the locking mechanism. |
| Oval-shaped kingpin | Lower the landing gear. |
| Debris build-up in the grease | |

**Problem—Slack**

| Problem—Slack | |
|---|---|
| **Possible Cause** | **Remedy** |
| Undersized kingpin | Replace the kingpin if worn greater than 1/8 inch (3 mm) at the 2 inch (5 cm) diameter. |
| Worn jaw and wedge | Jaw and wedge could have excessive wear. Replace them. |

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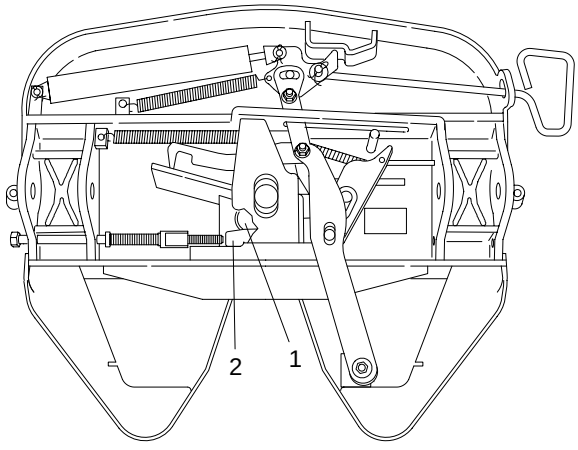


# General Information

Fontaine 6000 and 7000 series fifth wheels couple to trailers having the standard 2-inch kingpin. When installed as a stationary mount, the fifth wheel is bracket-mounted to the tractor frame in a position that best distributes the trailer load over the tractor axles. Sliding fifth wheels are mounted on the Fontaine AWB or MWS model slide mounts.

The Fontaine fifth wheel lock mechanism for the trailer kingpin consists of a spring-loaded jaw and sliding wedge. Kingpin release is accomplished by pulling a manual lock control handle located on either the right side (curbside) or left side (roadside) of the fifth wheel. Kingpin coupling occurs when the kingpin enters the throat of the fifth wheel, triggers the jaw and wedge to slide into place behind the kingpin, and moves the lock control handle into the locked position.

As the kingpin enters the lock mechanism, the jaw is moved first with the spring-loaded wedge sliding in place against the jaw. The jaw will move behind the kingpin, followed by the wedge. The wedge reinforces the jaw and automatically adjusts for slack around the kingpin. See **Fig. 1** for an illustration of the jaw and wedge in the locked position.

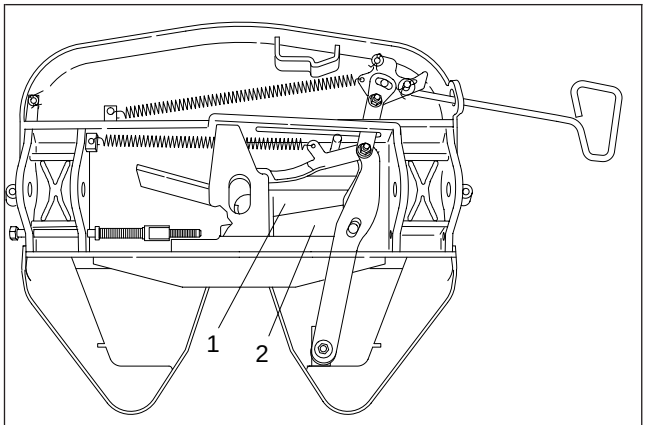



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1. Jaw
2. Wedge

**Fig. 1, Locked Position**

Placing the lock control handle in the unlocked position moves the wedge and jaw out from behind the kingpin and unlocks the fifth wheel. See **Fig. 2** for an illustration of the jaw and wedge in the unlocked position.




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1. Jaw
2. Wedge

**Fig. 2, Unlocked Position**

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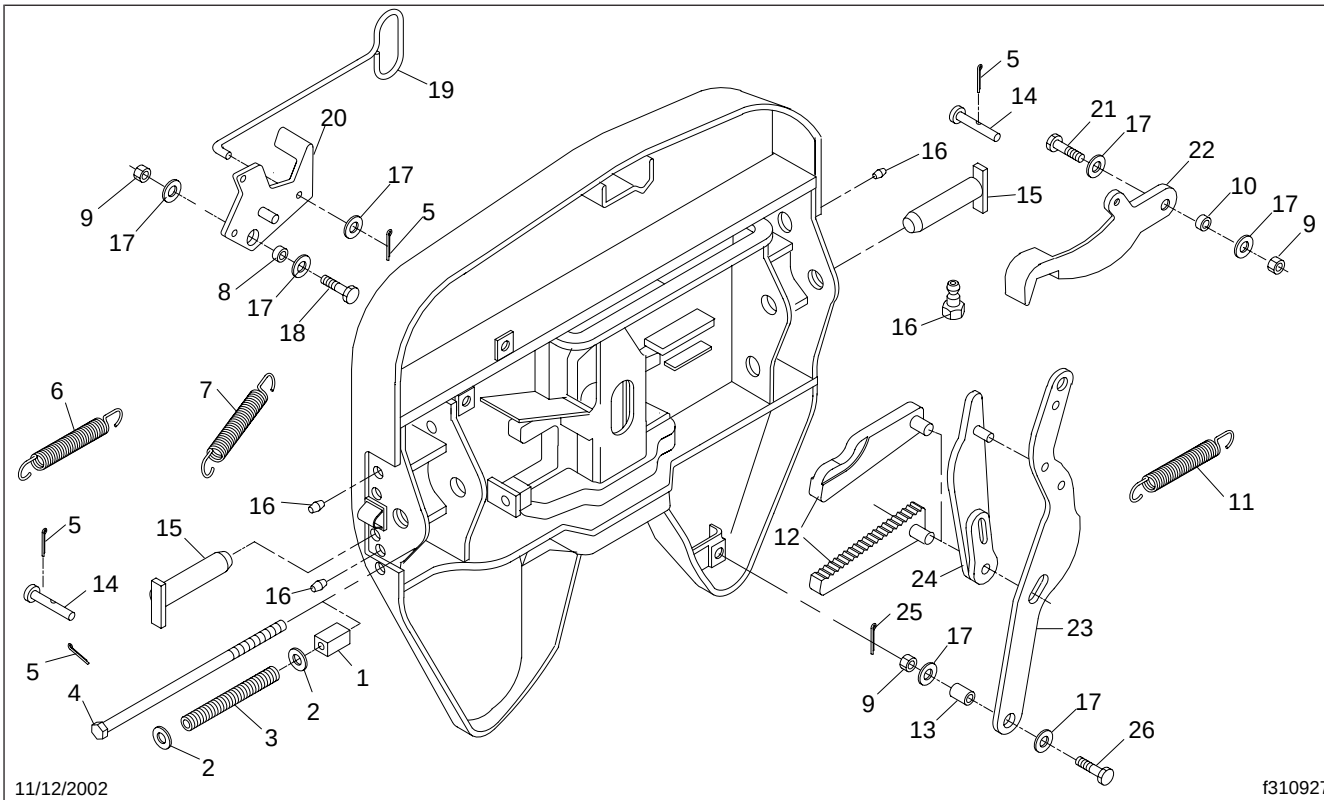


## Fifth Wheel Removal and Disassembly

See **Fig. 1** for an exploded view of a Fontaine® 6000 or 7000 No-Slack II series fifth wheel.

**⚠ WARNING**

**All fifth wheel maintenance, adjustment, and rebuilding must be done only by a qualified mechanic. Improper or incomplete procedures could result in disengagement of the trailer from the tractor, leading to personal injury or property damage.**




1. Wedge Stop Rod Nut
2. Flatwasher, 5/8", Plain
3. Wedge Stop Rod Spring
4. Wedge Stop Rod
5. Cotter Pin, 3/16 x 1"
6. Bumper Spring
7. Handle Spring
8. Bushing, 7/16"
9. Hex Locknut, 1/2–13
10. Bushing, 5/16"
11. Timer Spring
12. Step Jaw and Wedge Set
13. Bushing
14. Bracket Retainer Pin
15. Bracket Pin
16. Grease Fitting
17. Flatwasher, 1/2" I.D. x 1-3/4" O.D., Plain
18. Hexhead Bolt, 1/2–13 x 1-1/2", Grade 5
19. Pull Handle
20. Secondary Lock
21. Hexhead Bolt, 1/2–13 x 1-3/4", Grade 5
22. Bumper
23. Operating Handle
24. Timer
25. Hairpin Cotter Pin
26. Hexhead Bolt, 1/2–13 x 2-3/4", Grade 5

**Fig. 1, Fontaine 6000 and 7000 No-slack II Series Fifth Wheel (left-side release shown)**

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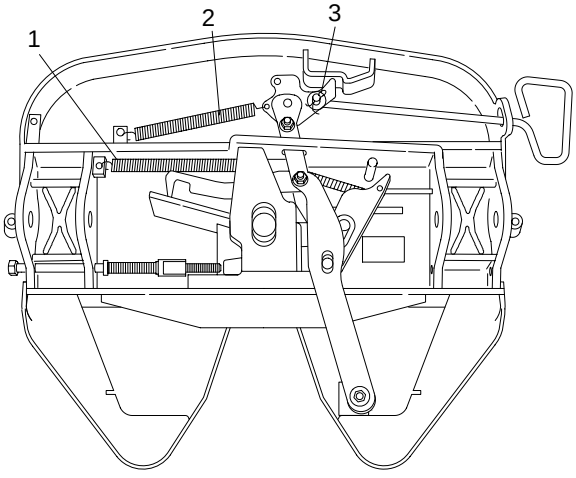
## Removal and Disassembly

**Parts are under spring compression. Wear safety goggles during disassembly and assembly. Failure to do so can result in personal injury, due to parts ejecting with force.**

1. Steam clean the top plate. Remove it from the sliding mount by removing the cotter pins from the retaining pins. Remove the retaining pins and bushing pins from both sides of the top plate.
2. Using an overhead hoist, lift the fifth wheel off the sliding mount and tractor frame.
3. Turn the fifth wheel upside down.

NOTE: While disassembling the fifth wheel, check it for cracks and for missing or damaged parts.

4. Remove the secondary lock spring and bumper spring. See **Fig. 2**. Remove the pull handle cotter pin and washer, then slide out the pull handle.

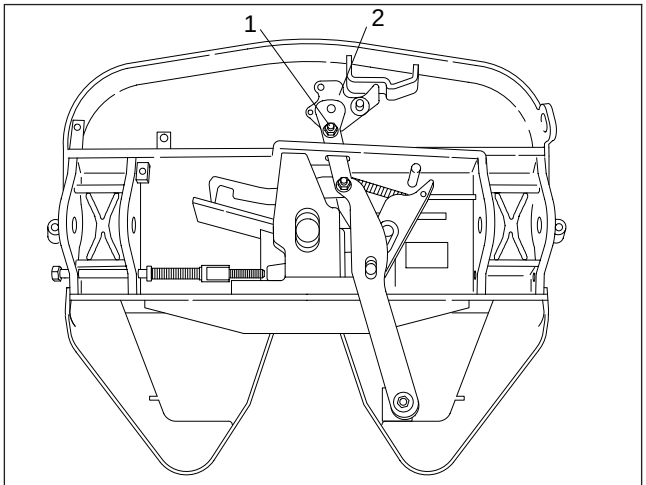



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1. Bumper Spring
2. Secondary Lock Spring
3. Pull Handle Cotter Pin

**Fig. 2, Pull Handle**

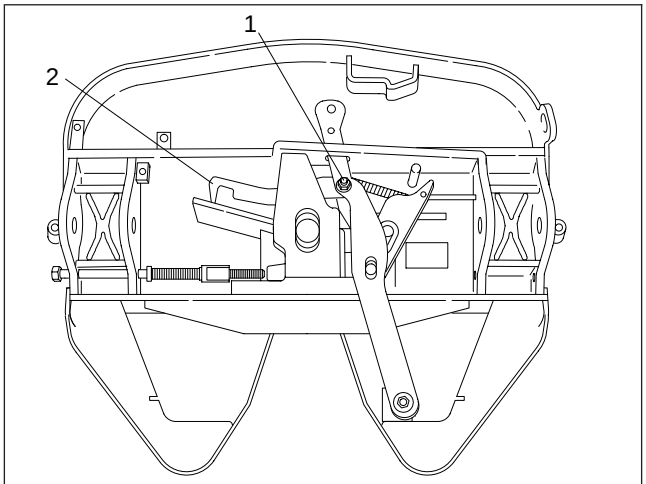
5. Unbolt and remove the secondary lock from the operating handle. Discard the locknut and bushing. See **Fig. 3**.
6. Unbolt and remove the bumper from the operating handle. Discard the locknut and bushing. See **Fig. 4**.




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1. Bolt
2. Secondary Lock

**Fig. 3, Secondary Lock**




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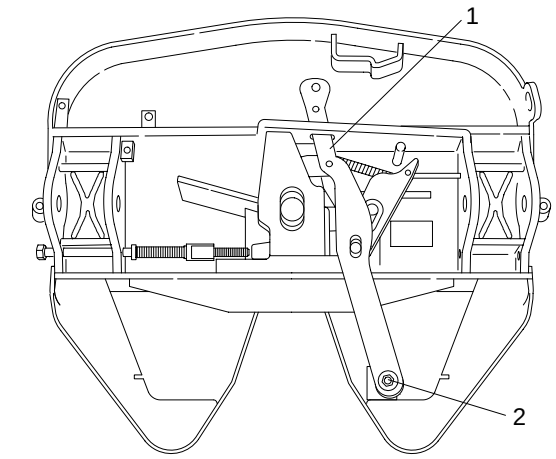
1. Bolt
2. Bumper

**Fig. 4, Bumper**

7. Unbolt the operating handle from the pivot mount and remove. Discard the locknut. See **Fig. 5**.
8. Remove the timer spring and timer. See **Fig. 6**.
9. Remove the jaw and wedge. See **Fig. 7**.

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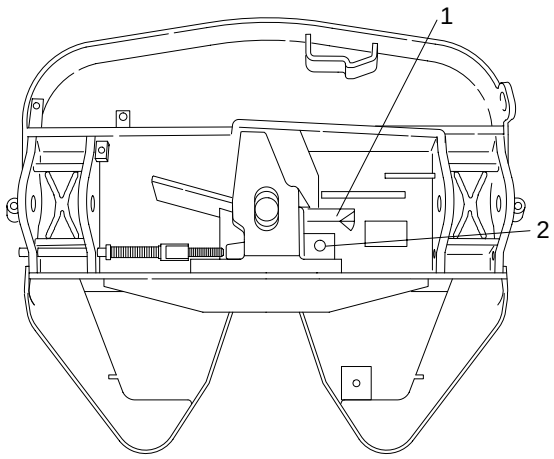





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1. Operating Handle
2. Bolt

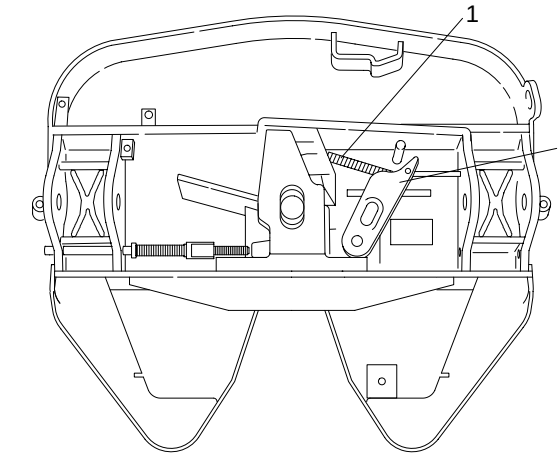
**Fig. 5, Operating Handle**




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1. Jaw
2. Wedge

**Fig. 7, Jaw and Wedge**




11/12/2002 f310924

1. Timer Spring
2. Timer

**Fig. 6, Timer Spring and Timer**

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## Assembly and Installation

**WARNING**

**Before rebuilding the assembly, check to make sure that there are no cracks in the crossmembers or other components. Also check the bracket pin holes to ensure they are not worn oversize (pins should fit snugly). Under no circumstances should a fifth wheel be repaired or used if any component (crossmember, saddle bearing, etc.) is cracked. Operating a fifth wheel with damaged components could result in disengagement of the trailer from the tractor, leading to personal injury or property damage.**

Use a Moly-based lubricant such as Mobil grease Moly 50 or equivalent when applying lubricant to the locking jaw and wedge. Lightly oil other moving parts in the fifth wheel.

See **Fig. 1** for an exploded view of a Fontaine® 6000 or 7000 No-Slack II series fifth wheel.

1. Always assemble parts around a 2-inch kingpin or a 2-inch-diameter shaft. Insert the jaw first, then the wedge below it. See **Fig. 2**. Grease the jaw and wedge on the top and bottom.
2. Install the timer and the timer spring. See **Fig. 3**.
3. Install the operating handle and bolt to the pivot mount. See **Fig. 4**. Use the existing bolt, washer, hairpin cotter pin and bushing. Inspect the bushing for wear before using it and replace it if necessary. Use the new locknut that is supplied in the repair kit. Note the orientation of the bolt (**Fig. 1**).
4. Install the bumper and bolt it to the operating handle. See **Fig. 5**. Use the existing bolt and washers (inspect for wear before using and replace if necessary). Use the new locknut and bushing that is supplied in the repair kit. Note the orientation of the bolt (**Fig. 1**). After installing the bumper, check to make sure that it can pivot freely.
5. Insert the secondary lock and bolt it to the operating handle. See **Fig. 6**. Use the existing bolt and washers (inspect for wear before using and replace if necessary). Use the new locknut and bushing that is supplied in the repair kit. Note the orientation of the bolt (**Fig. 1**).
6. Install the pull handle. See **Fig. 7**. Use the existing washer and cotter pin (inspect for wear before using and replace if necessary). Attach the new secondary lock/bumper spring that is supplied in the repair kit. Open and close the fifth wheel to ensure that it works properly. The fifth wheel must be properly lubricated before opening and closing the wheel.

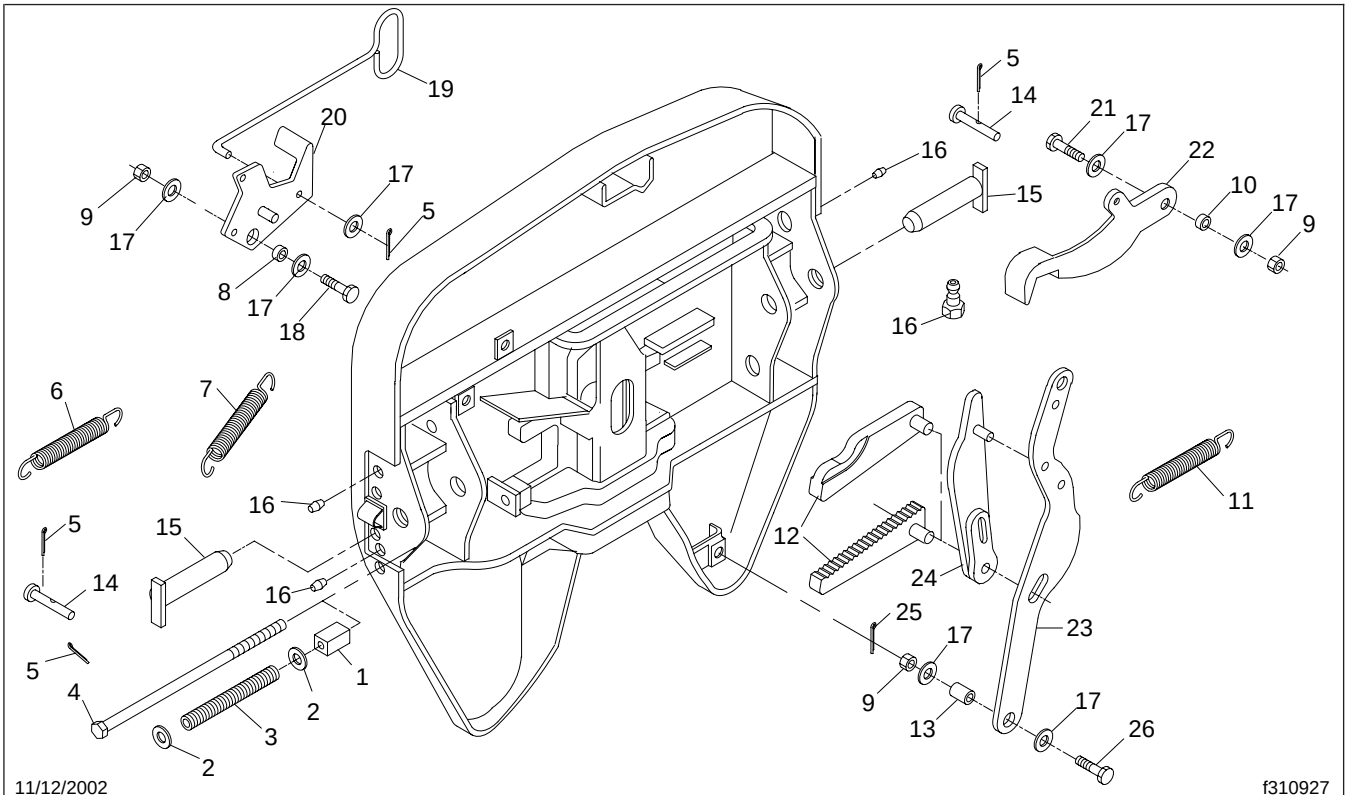
Use a Moly-based lubricant such as Mobil grease Moly 50 or equivalent when applying lubricant to the locking jaw and wedge. Lightly oil other moving parts in the fifth wheel.

7. Close the fifth wheel several times with a standard 2-inch kingpin tool. With the lock closed, adjust the wedge stop rod so that the end is 1/4 inch (6 mm) from the wedge. See **Fig. 8**.
8. Using an overhead hoist, position the fifth wheel on the sliding mount assembly. Insert the bushing pins. Install the retaining pins and the 1-inch-long cotter pins.

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## Assembly and Installation

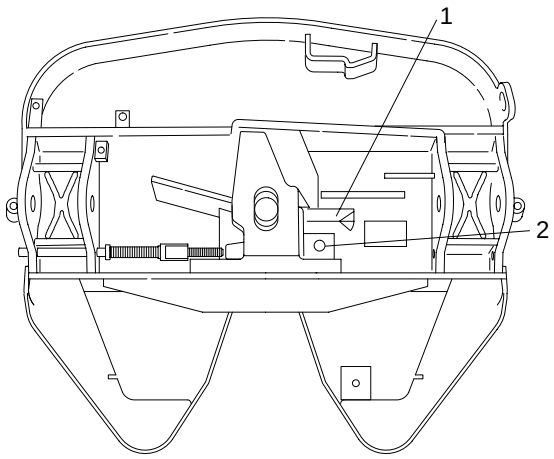



1. Wedge Stop Rod Nut
2. Flatwasher, 5/8", Plain
3. Wedge Stop Rod Spring
4. Wedge Stop Rod
5. Cotter Pin, 3/16 x 1"
6. Bumper Spring
7. Handle Spring
8. Bushing, 7/16"
9. Hex Locknut, 1/2–13
10. Bushing, 5/16"
11. Timer Spring
12. Step Jaw and Wedge Set
13. Bushing
14. Bracket Retainer Pin
15. Bracket Pin
16. Grease Fitting
17. Flatwasher, 1/2" I.D. x 1-3/4" O.D., Plain
18. Hexhead Bolt, 1/2–13 x 1-1/2", Grade 5
19. Pull Handle
20. Secondary Lock
21. Hexhead Bolt, 1/2–13 x 1-3/4", Grade 5
22. Bumper
23. Operating Handle
24. Timer
25. Hairpin Cotter Pin
26. Hexhead Bolt, 1/2–13 x 2-3/4", Grade 5

**Fig. 1, Fontaine 6000 and 7000 No-slack II Series (left side release shown)**

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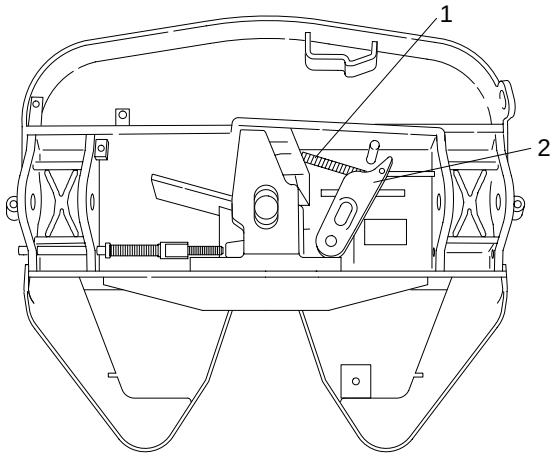





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1. Jaw
2. Wedge

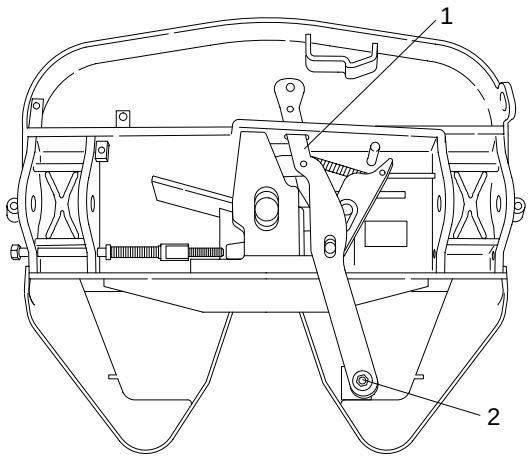
**Fig. 2, Jaw and Wedge**




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1. Timer Spring
2. Timer

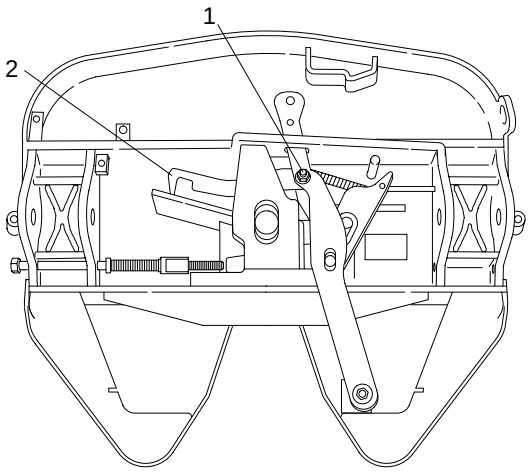
**Fig. 3, Timer Spring and Timer**




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1. Operating Handle
2. Bolt

**Fig. 4, Operating Handle**




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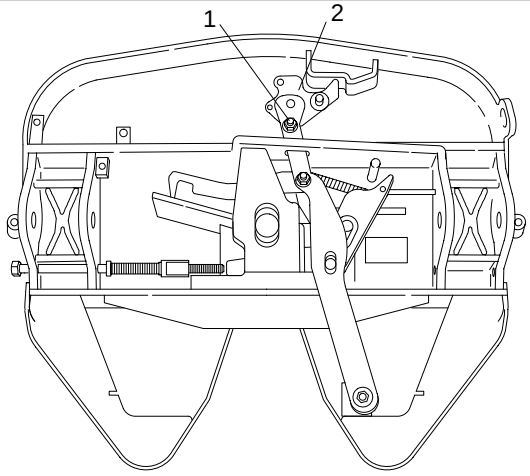
1. Bolt
2. Bumper

**Fig. 5, Bumper**

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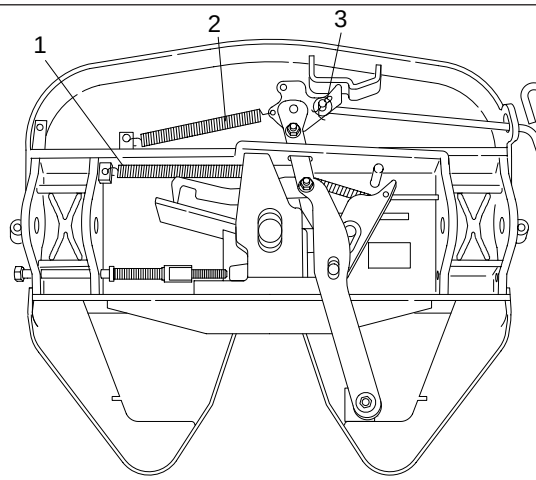
## Assembly and Installation




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1. Bolt
2. Secondary Lock

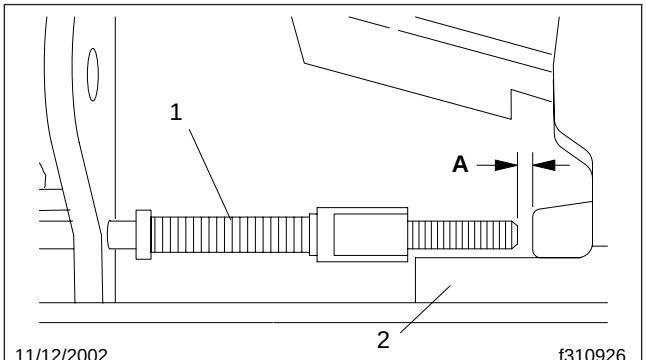
**Fig. 6, Secondary Lock**




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1. Bumper Spring
2. Secondary Lock Spring
3. Pull Handle Cotter Pin

**Fig. 7, Pull Handle**




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A. 1/4 inch (6 mm)
1. Stop Rod
2. Wedge

**Fig. 8, Wedge Stop Rod Adjustment**

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# Troubleshooting Tables

**Problem—Difficulty Coupling**

| Problem—Difficulty Coupling | |
|---|---|
| **Possible Cause** | **Remedy** |
| The kingpin is too high to trip the latch | Lower the landing gear. |
| The trailer plate or kingpin is damaged | Check the trailer plate for flatness. Check the kingpin for squareness with the trailer plate. |

**Problem—Excessive Wear on the Fifth Wheel Top Plate**

| Problem—Excessive Wear on the Fifth Wheel Top Plate | |
|---|---|
| **Possible Cause** | **Remedy** |
| Damaged trailer plate | If the trailer plate is not flat, replace it. |

**Problem—Difficulty Uncoupling**

| Problem—Difficulty Uncoupling | |
|---|---|
| **Possible Cause** | **Remedy** |
| Pressure on the locking mechanism caused by the truck drifting apart from the trailer, putting excess pressure on the lock | Back up the trailer and set the brakes. Strike the wedge stop rod which protrudes through the side of the fifth wheel. This spring-loaded rod will release the pressure on the locking mechanism. |
| Oval-shaped kingpin | Lower the landing gear. |
| Debris build-up in the grease | |

**Problem—Slack**

| Problem—Slack | |
|---|---|
| **Possible Cause** | **Remedy** |
| Undersized kingpin | Replace the kingpin if it is worn greater than 1/8 inch (3 mm) at the 2-inch (5-cm) diameter. |
| Worn jaw and wedge | The jaw and wedge could have excessive wear. Replace them. |

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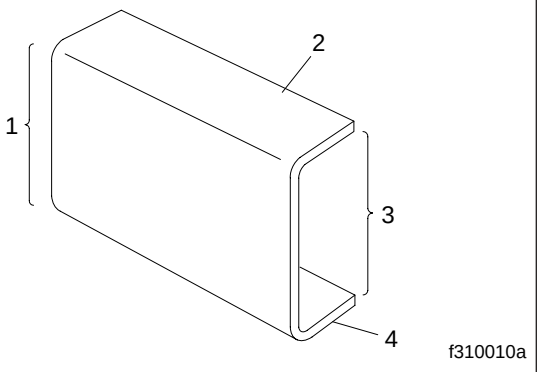


## General Description

IMPORTANT: This workshop manual *does not cover* the procedures and calculations necessary to do frame modifications. Before doing any modification to the frame rails, consult with the your regional service representative for approval.

The main body of the frame consists of two frame rails connected by a series of crossmembers. The frame supports the rest of the chassis and body.

Each rail has an upper flange, lower flange, and web (the surface area between the flanges). The inside area of the frame rail is called the channel. See **Fig. 1**.




1. Web
2. Upper Flange
3. Channel
4. Lower Flange

**Fig. 1, Frame Terminology**

The crossmembers control axial rotation and longitudinal motion of the rails, and reduce torsional stress transmitted from one rail to the other. Crossmembers are also used for vehicle component mounting, and protecting the wires and tubing that are routed from one side of the vehicle to the other.

Follow the guidelines in this section when servicing the frame. For information on installation of specialized equipment on the frame, refer elsewhere in this section.

## Handling

Whenever the frame rails are lifted or moved, take care to avoid anything that may scratch, cut, or damage the exposed frame assembly. Cushion all chain hoists or cable slings with a section of heavy hose. If the frame rail is raised with a jack, place a block of wood between the jack and the frame rail.

Never heat the frame rails for straightening purposes. Such work should be done cold, as the frame rails have been heat-treated.

**⚠ CAUTION**

**Heating the frame rail for straightening purposes will reduce the strength of the rail in localized areas, which can result in structural failure of the frame rail.**

Use pencil lines or soapstone marking for any work that requires marking of the frame rail. High visibility can be obtained by first chalking the surface of the frame rail, then making the pencil marks.

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## Repairing Cracks

IMPORTANT: In most cases cracked or damaged frame rails should be replaced. In some cases it may be necessary to repair minor damage; before attempting any repairs, contact your regional service representative for approval.

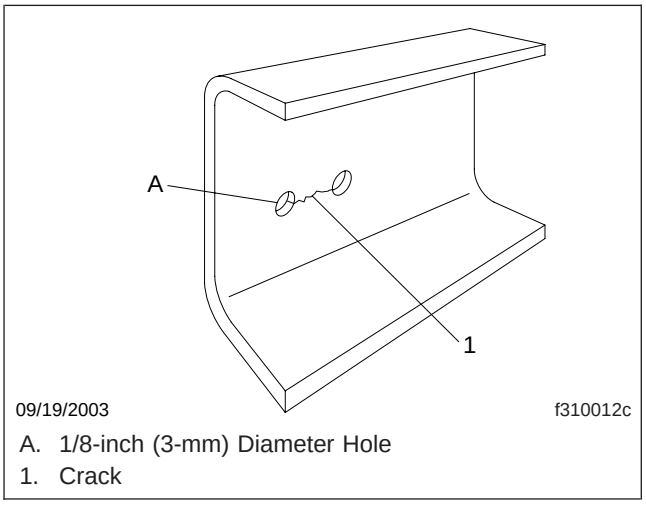
**CAUTION**

**Before performing any electric welding on a vehicle, read and understand the welding procedures in Subject 110.**

**Disconnect the battery power and ground cables and any electronic control units (ECUs) installed on the vehicle. Electric currents produced during electric welding can damage various electrical components on the vehicle, such as alternator diodes and ECUs. Vehicle components that typically use ECUs include electronic engine, electronic automatic transmission, and ABS (antilock braking system).**

**For any ECU with a battery power harness, disconnect its ground terminal from the chassis ground, and disconnect its power terminal from the battery positive post, or disconnect the main connection at the ECU.**

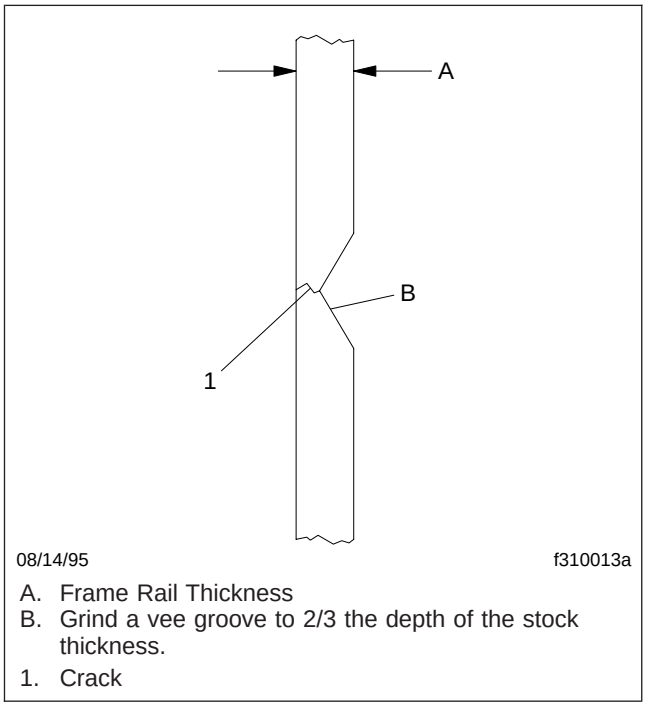
1. Drill a 1/8-inch (3-mm) diameter hole at each end of the crack to prevent further spreading of the crack. See **Fig. 1**.




A. 1/8-inch (3-mm) Diameter Hole
1. Crack

**Fig. 1, Preventing Cracks from Spreading**

2. Vee out the crack to a depth of two thirds of the stock thickness. See **Fig. 2**.




A. Frame Rail Thickness
B. Grind a vee groove to 2/3 the depth of the stock thickness.
1. Crack

**Fig. 2, Cross-Section View**

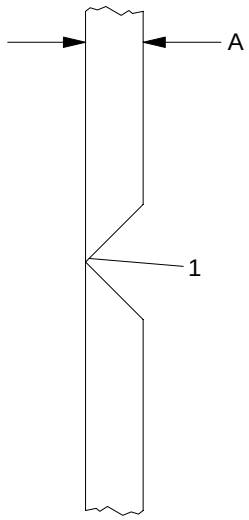
NOTE: If it will not be possible to grind both sides of the frame rail, then grind the vee groove on one side to the full depth of the stock thickness. See **Fig. 3**.

3. Clamp a copper or aluminum bar on the opposite side of the groove. The bar will act as a "chill" strip, keeping the heat from spreading to the surrounding area of the frame rail. See **Fig. 4**. Deposit the weld material using the applicable welding method described in this section.
4. Grind the weld flush with the frame rail. See **Fig. 5**.
5. Cut a deep enough vee groove on the opposite side of the frame rail to reach the weld metal. See **Fig. 6**.
6. Clamp the "chill" strip on the opposite side of the groove. See **Fig. 7**. Weld the vee groove, as instructed above. Make full penetration of the weld.
7. Grind the weld flush with the frame rail. See **Fig. 8**.

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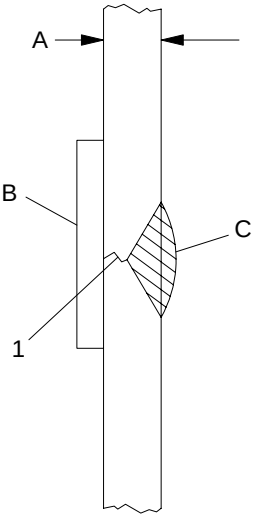
## Repairing Frame Rails




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A. Frame Rail Thickness
1. Vee Groove (Full Depth)

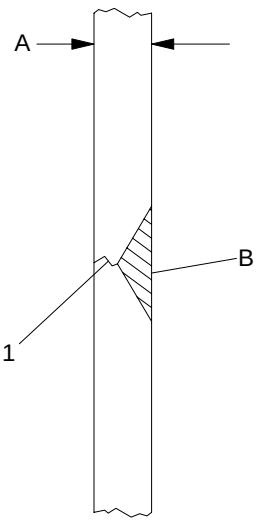
**Fig. 3, Full Depth Groove**




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A. Frame Rail Thickness
B. Clamp the "chill" strip on the opposite side of the groove.
C. Deposit weld material.
1. Crack

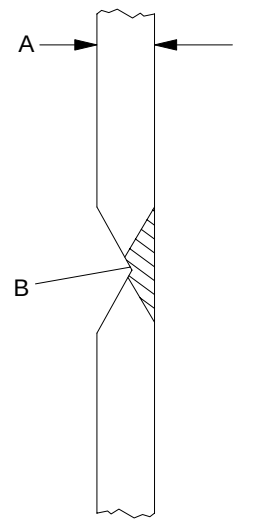
**Fig. 4, Using a Chill Strip**




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A. Frame Rail Thickness
B. Grind the weld flush with the frame rail.
1. Crack

**Fig. 5, Weld Ground Flush**



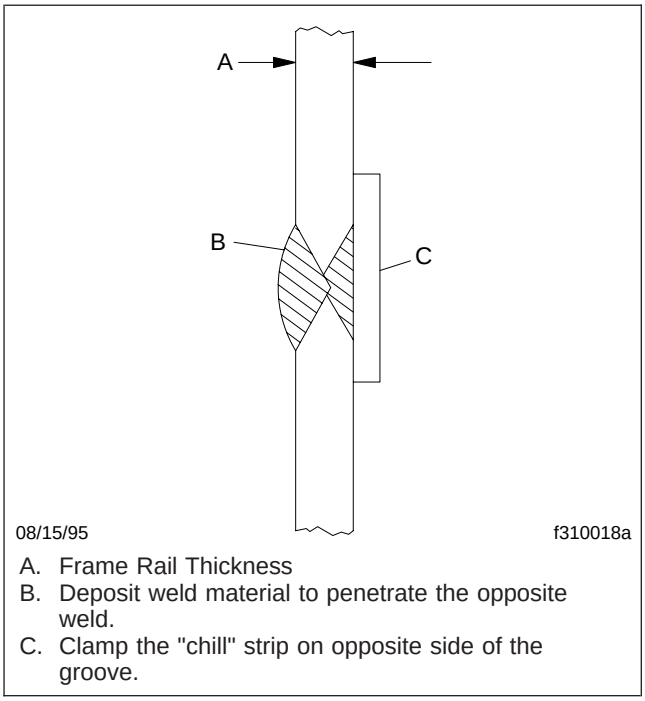

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A. Frame Rail Thickness
B. Grind a vee groove deep enough to reach the weld.

**Fig. 6, Cross-Section View**

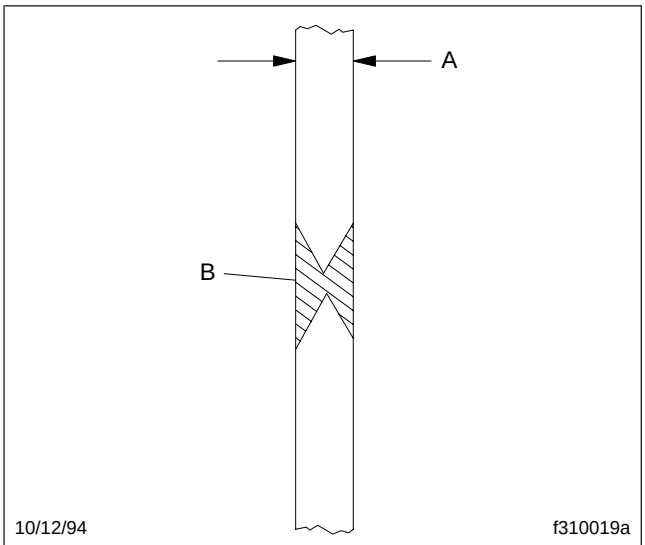
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A. Frame Rail Thickness
B. Deposit weld material to penetrate the opposite weld.
C. Clamp the "chill" strip on opposite side of the groove.

**Fig. 7, Second Weld**




A. Frame Rail Thickness
B. Grind the weld flush with the frame rail.

**Fig. 8, Second Weld Ground Flush**

## Filling Unused Holes

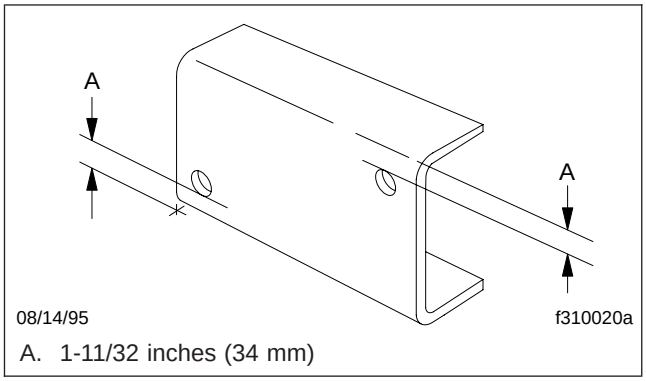
1. Fill all unused holes in the frame assembly with the applicable nut, washer, and bolt combination.
2. If the diameter of a hole is less than 3/8 inch (9.5 mm), enlarge it to 3/8 inch (9.5 mm), and fill it with the applicable nut, washer, and bolt combination.
3. Tighten the fasteners to the applicable torque value. For proper frame fastening instructions, refer elsewhere in this group.

## Drilling Holes

During vehicle manufacture, holes are drilled or punched in the frame rail only as specified on the vehicle frame drilling chart. If any additional holes need to be drilled, contact your regional service representative for approval.

A single exception to this rule is that holes may be drilled for tubing clips and the like through the web portion of the channel only, with the following restrictions:

- The *edge* (not the center) of the hole must be no closer than 1-11/32 inches (34 mm) from the outer face of the flange. See **Fig. 9**.




A. 1-11/32 inches (34 mm)

**Fig. 9, Minimum Distance for Drilling Holes**

- Material between the centerline of the hole and the outside of the upper or lower flange must be at least 2-13/32 inches (60 mm).
- Minimum material between hole centerlines must be 2 inches (50 mm).

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## Repairing Frame Rails

- All attaching fasteners must be Grade 8. Flat washers must be made with high strength steel.
- The minimum material between the rear suspension bracket and the end of the frame must be at least 2 inches (50 mm).
- Holes between the front axle centerline and the rear axle centerline cannot exceed 3/4 inches (19 mm).

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**CAUTION**

**Before performing any electric welding on a vehicle, read and understand the welding procedures in this section.**

**Disconnect the battery power and ground cables and any electronic control units (ECUs) installed on the vehicle. Electric currents produced during electric welding can damage various electrical components on the vehicle, such as alternator diodes and ECUs. Vehicle components that typically use ECUs include electronic engine, electronic automatic transmission, and ABS (antilock braking system).**

**For any ECU with a battery power harness, disconnect its ground terminal from the chassis ground, and disconnect its power terminal from the battery positive post, or disconnect the main connection at the ECU.**

## Welding Frame Rails

IMPORTANT: There are very few cases in which welding a heat-treated frame rail is allowable. If possible, avoid direct welding of the frame rail web. Before any welding is done, contact your regional service representative for approval.

**CAUTION**

**Weld only as instructed in this section; all precautions and methods must be strictly followed. Failure to do so can reduce the structural strength in the welded area of the frame rail.**

**WARNING**

**Wear protective welding masks and gloves when welding. Failure to do so could result in personal injury, due to the intensity of heat, sparks, and flying debris.**

1. Do not weld attachments to the frame rail. For guidelines on the attachment of equipment on the frame rails, refer elsewhere in this group.
2. Use only the applicable welding method under "Welding Methods."
3. Before welding, clean off any oil, grease, paint, scale, and other contaminants. Wipe dry with a clean cloth.
4. Do not weld in an area that allows drafts from any source such as windows, engines, or fans, as it will affect the soft flow of gas from the welding gun.
5. Do not weld into the radius of the frame rail flanges or along the edge of the flange.
6. Do not weld square with the frame side rail. Make all reinforcing welds at least 30 degrees from square. This will distribute the weld stresses over a larger area.
7. Do not notch, undercut, or leave craters during the welding process.
8. Keep as close to the weld centerline as possible.

## Welding Methods

Gas-metal arc welding is the recommended method. If gas-metal arc welding is not available, coated-electrode arc welding can be used. For both gas-metal arc welding and coated-electrode arc welding, direct current reverse polarity is recommended, however, alternating current can be used. Use either a short arc beading technique or a narrow weave technique.

1. For the gas-metal arc welding method, use the following requirements and specifications:
   - 1.1 Use weld wire that meets American Welding Society (AWS) specification A 5.28, Class E110S.
   - 1.2 Use Linde M-5 gas or an equivalent argon-oxygen mixture of 5 percent oxygen.
   - 1.3 For machine settings, refer to the applicable table under **Specifications, 400**.
2. For the coated-electrode arc welding method, use 1/8-inch-thick AWS-E-11018 type weld rod. For amperage and voltage settings of each weld position, refer to the applicable table under **Specifications, 400**.

IMPORTANT: Always keep the weld rod free of moisture. The welding rod being used should come directly from a hermetically sealed container, or be dried at least one hour in a 700° to

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## Welding Frame Rails

800°F (371° to 427°C) oven. Immediately after removal from a sealed container or after drying, store the welding rod in an oven at 250°F (121°C). A welding rod that has been exposed to the atmosphere longer than one-half hour must be dried before use.

NOTE: On 1/4-inch-thick frame rails only, AWS-E-9018 type weld rod can be used, however, AWS-E-11018 type weld rod is recommended.

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## Frame Rail Alignment

Frame rail alignment is checked by measuring the distances from two sets of points on the upper flanges of the frame rails. See **Fig. 1**. The rear set of points must be as far back as possible from the forward set of points. There must be no interference, along or between the frame rails, that would prevent measuring from any one of the four points to the other three points; the fifth wheel and deck plate (as equipped) must be removed.

There are no marks or bolt holes in the top flanges of the frame rails. Therefore, the points must be projected from the bolt holes on the frame rail webs.

IMPORTANT: Use a pencil or soapstone to make all lines, points, or other marks. Do not use any marker or tool that will scratch the surface of the frame rail. Use a machinist's square to project all points from the webs to the upper flanges, and to measure inboard from the outside face of the frame rails.

1. Choose and mark a matched set of points, as follows:
   - 1.1 Determine how far forward the upper flanges of both frame rails are clear.
   - 1.2 Find a matched set of bolt holes on the frame rail webs, that are aligned with, or just rearward of, the front of the clear area on the flanges. The bolt holes must be in exactly the same location in each frame rail.
   - 1.3 Project the exact vertical centerline of each bolt hole, and mark a line across the top flange of its respective frame rail.
2. Find the exact center of the width of each upper flange, and mark the point on each projected line. This will be the forward set of points. The forward points must be in identical locations on both frame rails.
3. As equipped, remove the fifth wheel and deck plate from the frame. Refer to the fifth wheel section in this manual for instructions.
4. Measure back along each frame rail, to find a set of bolt holes *at least* 72 inches (183 cm) rearward from the forward set of points. The bolt holes must be in exactly the same location in each frame rail.

IMPORTANT: If, because of interference, the distance must be less than 72 inches (183 cm), the distance must be the maximum that is possible.

5. Project the exact vertical centerline of each bolt hole, and mark a line across the top flange of its respective frame rail.
6. Along each line, measure and mark a point 2 inches (5 cm) inboard from the outside face of its respective frame rail. The rear points must be in identical locations on both frame rails.
7. At the forward set of points, and again at the rear set of points, measure the distance across the frame, from the outside face of each frame rail. At both locations, this distance must be 34.00 inches (864 mm). See **Fig. 1**.

   If the distance at either location is incorrect, determine which thickness of frame spacers, if any, belong between the crossmembers and the frame rails. Check for the correct spacers, and add or remove spacers as needed.
8. Measure the distance from the forward point on one frame rail to the rear point on the opposite frame rail. See **Fig. 1**. Then measure the distance from the other forward point to the rear point on its opposite frame rail. Compare the two measurements.

   If the values differ by more than 1/8 inch (3mm), proceed to the next step.

   If the measurements are within 1/8 inch (3 mm) of each other, the frame rails do not need to be aligned. If any frame fasteners are loose, tighten as described below. If no fasteners are loose, install the fifth wheel and proceed as described below.
9. Loosen all of the frame fasteners just enough to allow movement of the parts when force is applied.

IMPORTANT: To align the frame rails, the frame assembly must be assembled with all of the crossmembers in place, but the attachment fasteners not tightened.

10. Using a large hammer and a large wooden block, place the block against the rear end of the

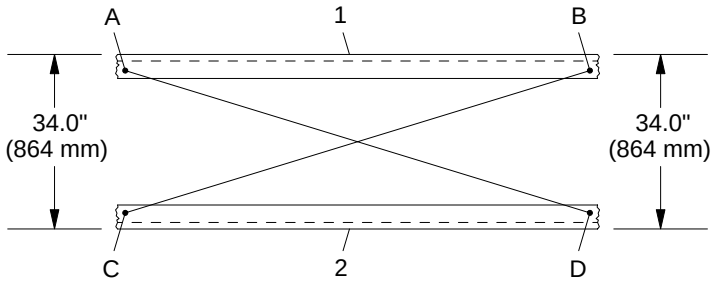
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## Frame Rail Alignment

frame rail that had its rear point the greater distance from its opposite rail's front point. Tap the block until the measurements are within 1/8 inch (3 mm) of each other.

11. Tighten the fasteners for the front-and rear-closing crossmembers to their applicable torque values; refer to the general information section in the vehicle maintenance manual. Again, check the frame rail alignment (described above).
12. When the measurements are within specifications, install the fifth wheel and deck plate (as equipped); refer to the fifth wheel section in this manual for instructions.
13. Tighten all of the frame fasteners, starting at the middle of the frame and working alternately toward both ends. First, tighten the fasteners that attach crossmembers to the frame. Then, tighten the fasteners that attach the upper and lower struts or gussets to the frame. Finally, tighten the fasteners that attach the lower struts or gussets to the crossmembers. Tighten all fasteners to their applicable torque values, as specified in the general information section in the vehicle maintenance manual.
14. If the frame rails needed aligning, check the axle alignment; refer to the rear axle section in this manual for instructions.




A. Right Forward Point or Bolt Hole
B. Right Rear Point or Hole
C. Left Forward Point or Bolt Hole
D. Left Rear Point or Bolt Hole
1. Right Frame Rail
2. Left Frame Rail

**Fig. 1, Frame Rail Squaring**

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## Specifications

| Wire Diameter | Current: amperes | | Wire Extention | |
|---|---|---|---|---|
| | | | Optimum | Maximum |
| inches (mm) | Minimum | Maximum | inches (mm) | inches (mm) |
| 0.045 (1.14) | 160 | 320 | 1/2 (13) | 3/4 (19) |
| 1/16 (1.6) | 300 | 600 | 3/4 (19) | 1-1/8 (29) |
| 5/64 (2.0) | 480 | 960 | 1 (25) | 1-1/2 (38) |

**Table 1, Machine Settings for Gas-Metal Arc Welding**

| Weld Position | Amperes | Volts |
|---|---|---|
| Downhand | 130/140 | 21/23 |
| Overhead | 130/140 | 21/23 |
| Vertical Up | 110/120 | 22/24 |

**Table 2, Amperage and Voltage Settings for Coated-Electrode Arc Welding**

| Size | Torque:* lbf·ft (N·m) |
|---|---|
| 1/2–13 | 68 (92) |
| 9/16–12 | 98 (133) |
| 5/8–11 | 136 (184) |
| 3/4–10 | 241 (327) |
| 3/4–16 | 269 (365) |
| 7/8–9 | 388 (526 |
| 7/8–14 | 427 (579) |

* Lubricated or plated threads.

**Table 3, Torque Values for Frame Fasteners**

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## General Information

The Premier model 690 trailer coupling is a non-air-adjusted, heavy-duty coupling. It is used for load capacities up to 90,000 lbs, and is available with either right- or left-hand operation. See **Fig. 1**.

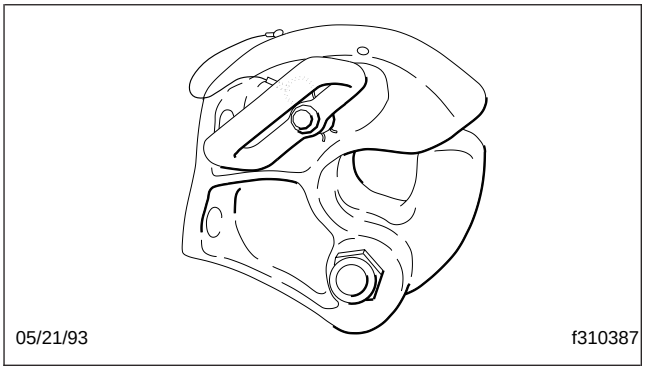



**Fig. 1, Premier 690 Trailer Coupling**

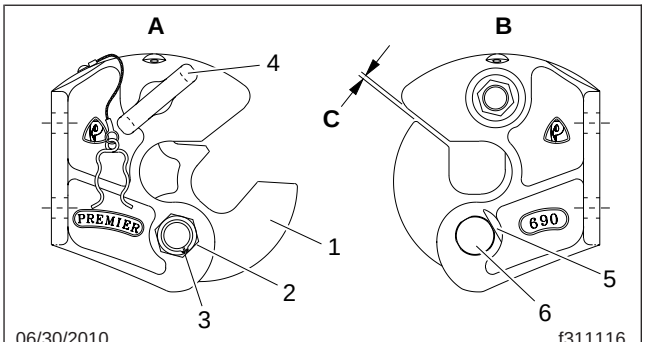
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## Inspection

With the 690 coupling in the closed position, pull outward on the 692 pintle:

- The measured gap between the top of the 692 pintle and the adjacent face of the 690 coupling body must be less than 3/8 inch (9.52 mm). See **Fig. 1**.
- A 3/8 inch (9.52 mm) or greater gap indicates that the coupling is no longer suitable for service. A repair kit will be necessary to return the coupling to service, or a new 690 coupling may be installed.




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A. Left Side, Open Position
B. Right Side, Closed Position
C. 3/8 inch (9.52 mm) or less

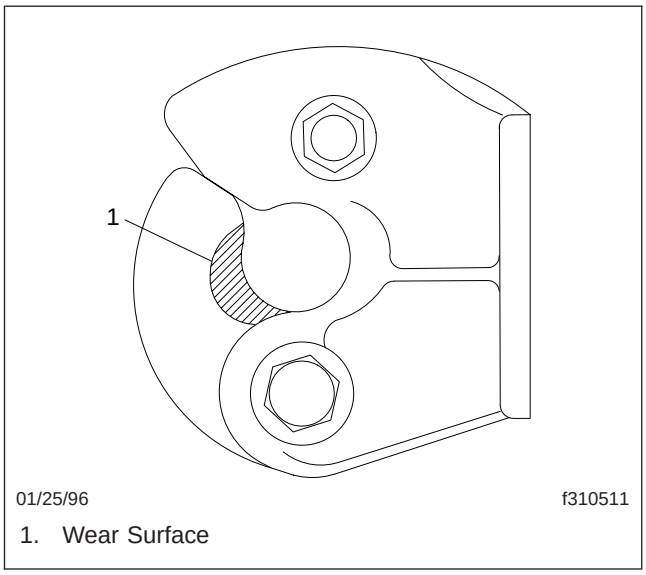
1. 692 Pintle
2. 297 Locknut
3. 295Z-87 Snap Ring
4. 691 Release Handle
5. Bolt Stop
6. 294 Bolt

**Fig. 1, 690 Coupling**

Using Premier wear gauge, part number 14014, check the percentage of wear on the pintle hook. See **Fig. 2** and **Fig. 3**.

**⚠ WARNING**

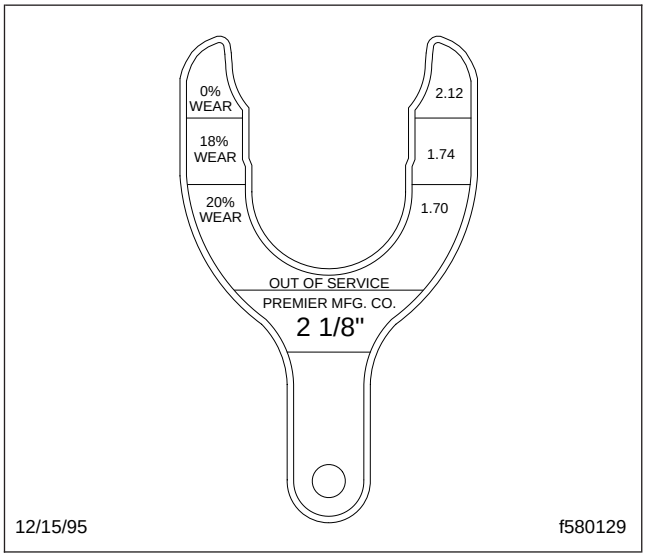
**WARNING: If the pintle hook is damaged, has stress cracks, or if it's worn beyond 20% of its original diameter, replace the entire coupling; don't repair it. Using a worn or damaged trailer coulpling could cause the trailer to disconnect from the vehicle, which could result in an accident causing serious personal injury and property damage.**




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1. Wear Surface

**Fig. 2, Wear Checking**




12/15/95 f580129

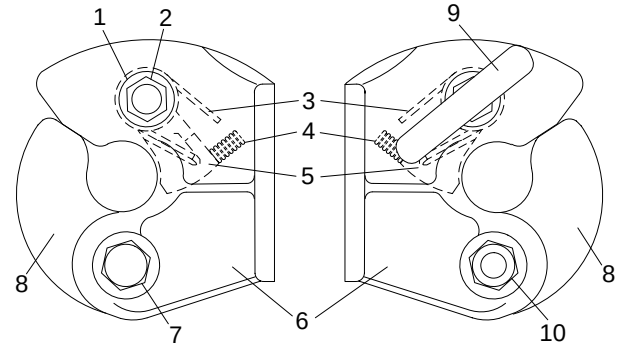
**Fig. 3, Wear Gauge**

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## Disassembly

1. Remove the coupling from the vehicle.
2. Remove the pintle-hook nut and bolt, then remove the pintle hook from the coupling body. See **Fig. 1**.
3. With the handle pushed in, remove the nut from the end of the handle.
4. Remove the bushing, then the handle from the body.
5. From the bottom of the coupling body, remove the small pawl spring, then the pawl and the large pawl spring. Discard the two springs.
6. Remove the locking pin assembly from the coupling body, and discard it. See **Fig. 2**.



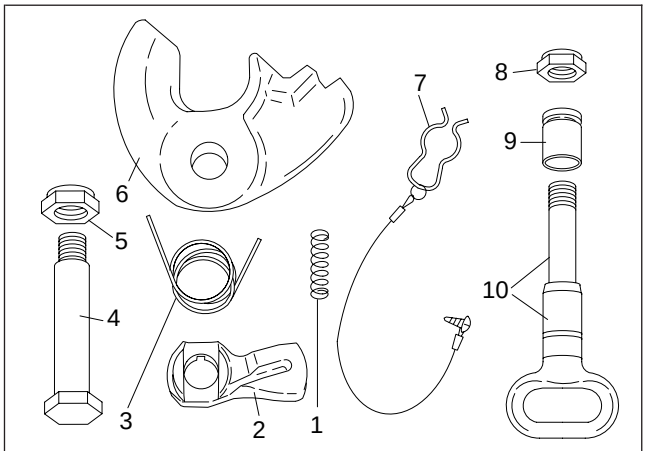

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1. Bushing
2. Nut
3. Large Pawl Spring
4. Small Pawl Spring
5. Pawl
6. Coupling Body
7. Pintle-Hook Bolt
8. Pintle Hook
9. Handle
10. Pintle-Hook Nut

**Fig. 1, Trailer Coupling Parts**

## Assembly

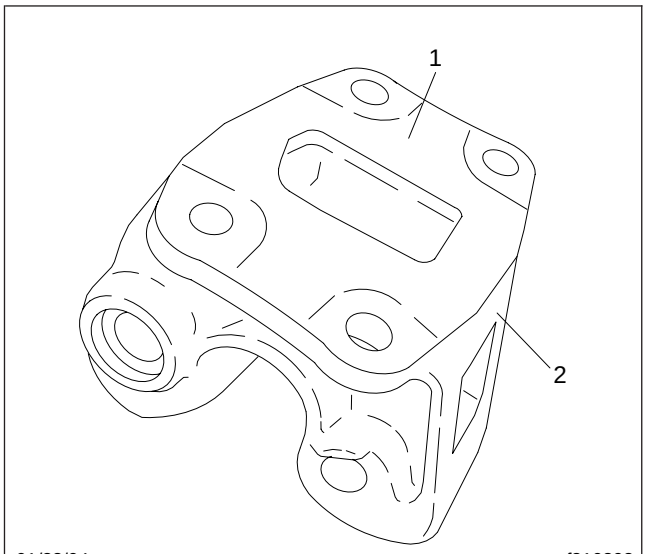
1. Check for wear on any parts that aren't included in the new repair kit. Replace them if needed.
2. Place the coupling body on its face, with the mounting surface up and the bottom of the coupling body toward you. See **Fig. 3**.
3. Place a new large spring on the pawl, so that one leg of the spring fits into the groove in the pawl. See **Fig. 4**.




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1. Small Pawl Spring
2. Pawl
3. Large Pawl Spring
4. Pintle-Hook Bolt
5. Pintle-Hook Nut
6. Pintle Hook
7. Locking-Pin Assembly
8. Nut
9. Bushing
10. Handle

**Fig. 2, Repair Kit Parts**




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1. Mounting Surface
2. Bottom Surface

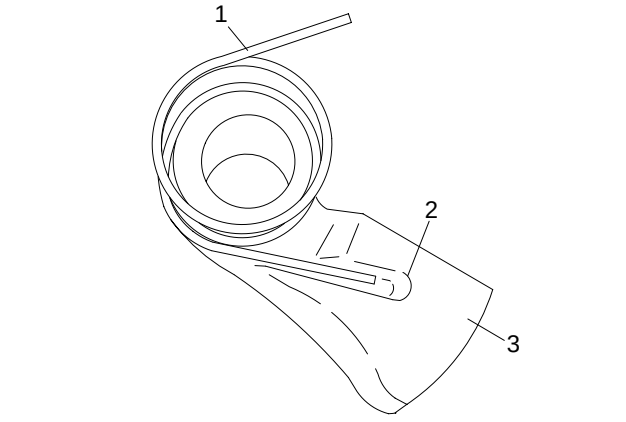
**Fig. 3, View of the Mounting Surface**

4. Install the pawl and spring in the bottom of the coupling body, with the spring to your left. **See Fig. 5**. Make sure the other leg of the spring sits in the slot inside the body.

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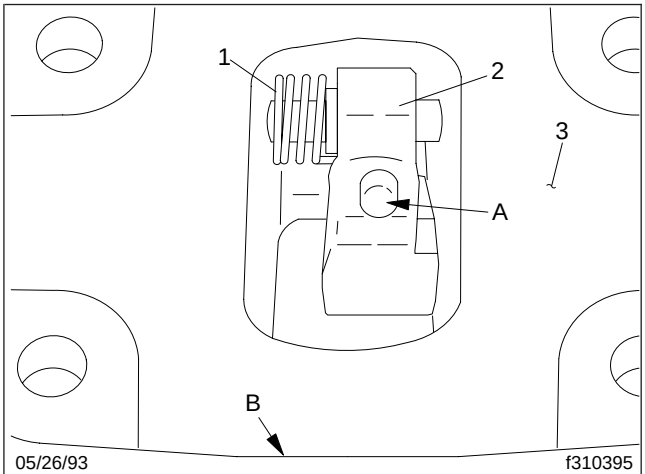


## Disassembly and Assembly




1. Large Pawl Spring
2. Groove
3. Pawl

**Fig. 4, Pawl and Pawl Spring**




A. Install small pawl spring in here.
B. Bottom of Coupling Body

1. Large Pawl Spring
2. Pawl
3. Mounting Surface

**Fig. 5, Pawl Spring Installation**

5. Install the new handle into the coupling body and the pawl. Make sure the taper of the handle matches the taper of the hole in the pawl, and that the handle locks into place. See **Fig. 2**.
6. Install the bushing over the threaded end of the handle, then install the nut.
7. Turn the handle toward yourself, then—from the bottom of the coupling body—install the small pawl spring in the depression on the pawl. See **Fig. 5**. Make sure the other end of the spring fits into the depression inside the coupling body.
8. Rotate the pawl up and lock it into position by turning the handle away from you, then pushing it in.

### NOTICE

**Do not overtighten the nuts for the pintle hook and the handle or it may cause the parts to bind, which could result in unnecessary wear on the coupling.**

9. Set the coupling body on its mounting surface, then install the new pintle hook, bolt, and nut. Tighten the nuts on the pintle hook bolt and the handle snugly.
10. Install the new locking pin assembly on the top of the coupling body. See **Fig. 2**.
11. Lubricate all the moving parts with light penetrating oil. Don't lubricate the wear surface of the pintle hook. Open and close the pintle hook several times to distribute the oil.
12. Install the coupling on the vehicle. Tighten the mounting bolts 320 lbf·ft (434 N·m).

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NOTE: Before performing the 294 bolt replacement procedure, first verify that the 690 coupling is not in need of a complete repair kit. Perform the inspection procedure in **Subject 100**.

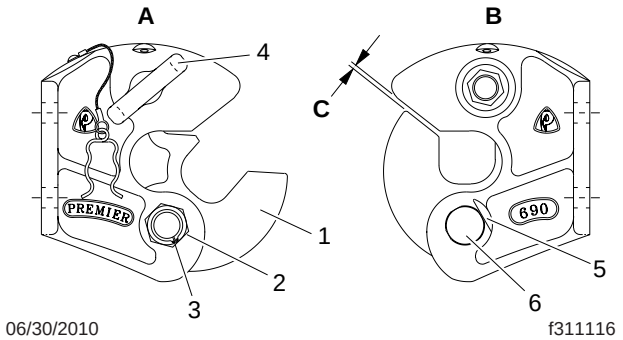
## Bolt Replacement

See **Table 1** for new parts required. Parts can be ordered from Premier Manufacturing Company at: (800) 255-5387 or (503) 234-9202.

| Parts Required | | |
|---|---|---|
| **Description** | **Part Number** | **Qty.** |
| Bolt | 294 | 1 |
| Locknut | 297 | 1 |

**Table 1, Parts Required**

1. Place the 690 coupling into the OPEN position as shown in **Fig. 1**.




A. Left Side, Open Position
B. Right Side, Closed Position
C. 3/8 inch (9.52 mm) or less

1. 692 Pintle
2. 297 Locknut
3. 295Z-87 Snap Ring
4. 691 Release Handle
5. Bolt Stop
6. 294 Bolt

**Fig. 1, 690 Coupling**

2. If the bolt is an old style with a snap ring, remove the 295Z-87 snap ring from the end of the 294 bolt, then discard it.
3. Remove the 297 locknut and discard it.
4. Firmly gripping the 692 pintle, slide the 294 bolt out of the 690 coupling body.
5. Using a hammer or file, destroy the threaded end of the 294 bolt and discard it.
6. Thoroughly clean the 690 coupling body holes where the 294 bolt was inserted, as well as the interior surfaces of the 690 coupling body. Clean the hole and all surfaces of the 692 pintle.
7. On each side of the coupling body, measure the hole diameters where the 294 bolt was inserted. If a hole diameter exceeds 1.156 inches (29.36 mm) the coupling body is considered out-of-service and must be replaced.
8. Inspect the holes around the 691 release handle for wear. If there is a gap of 1/32-inch (0.79 mm) or greater between the 691 handle shaft and hole circumference, remove the handle assembly, then measure the hole diameters. If a hole diameter exceeds 1.30 inches (33.02 mm), the coupling is to be considered out-of-service and must be replaced.
9. Test fit the 294 bolt by inserting it from the right side through the holes of the 690 coupling body, without the 692 pintle in place. Make certain that the new 294 bolt head is flush with the outer 690 coupling body side wall.

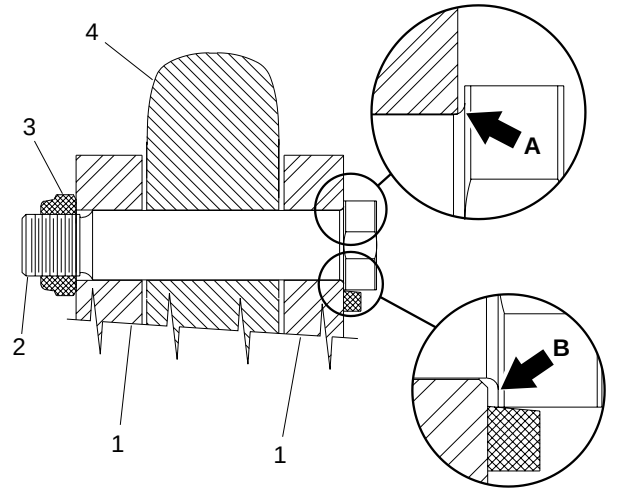
   If the new 294 bolt head and the 690 coupling body are not flush, two possible causes are shown in **Fig. 2**.

   - Arrow A indicates a gap between the new 294 bolt head and the 690 coupling body caused by the hole in the 690 coupling body not being chamfered. This can be resolved by grinding a 45 degree chamfer, no larger than 1/16 inch (1.59 mm), around the entire circumference of the 690 coupling body hole.
   - Arrow B indicates a gap because the bolt stop is preventing the bolt from sitting flush to the coupling body. This can be corrected by grinding or filing the bolt stop until the bolt head clears it.
10. For final assembly, remove the 294 bolt and apply heavy grease to the the 692 pintle hole, the 690 coupling body holes, and the shank of the new 294 bolt (do not lubricate the threads).
11. Place the 692 pintle into the 690 coupling body, aligning the pintle hole with the body holes. From the right side, insert the new 294 bolt through the aligned holes. Clean all signs of lubrication from

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## 294 Bolt Replacement




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A. Gap caused by 690 body hole not chamfered. Correct by chamfering hole.
B. Gap caused by bolt stop preventing the bolt head from seating flush to the coupling body. Correct by grinding or filing the bolt stop until the bolt head clears it.

1. 690 Body
2. 294 Bolt
3. 297 Locknut
4. 692 Pintle

**Fig. 2, Bottom Section View**

the threads of the 294 bolt. Align one of the four flatheads adjacent to the bolt stop as shown in **Fig. 1**.

12. Securing the 294 bolt head with a wrench, thread a new 297 locknut onto the bolt. Ensure that no lubricant is present on the bolt threads, then torque to 50 lbf·ft (68 N·m).
13. Open and close the 690 coupling several times, making sure it operates smoothly and correctly.

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# General Information

There are two styles of front leaf springs; standard springs or slippered springs.

## Standard Springs

Standard spring assemblies are either tapered leaf or flat leaf. The leaves of the tapered-leaf spring are all the same length, and are separated with delrin spacers. On flat leaf springs, the leaves decrease in length from top to bottom, and they do not have separators.

Both spring assemblies are attached to the axle with U-bolts, hardened washers, and high nuts. See **Subject 110** for an installation diagram.

The spring eyes on each end have a bushing in the center. Threaded pins are installed through the bushings and are used to mount the spring to the frame bracket on the front, and to a pair of spring shackles attached to the frame bracket on the rear. The spring shackles allow for variations in spring length as the spring flexes.

The threaded spring pins require a special socket for removal and installation. The socket tools and the different styles of pins are shown in **Specifications, 400**.

## Slippered Springs

For severe-duty applications a slippered spring front suspension is available. It is a floating spring that sits on a wear pad inside the frame brackets, with radius rods used to help keep the axle aligned.

See **Subject 120** for an installation diagram.

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## Standard Springs

1. Using a wire brush and solvent or steam cleaning equipment, wash all parts to remove dirt, grease, and scale.
2. Inspect the shackle bracket and the spring shackles for cracks, wear, or other damage. Replace damaged parts.
3. Inspect the spring for cracks and corrosion. If any leaves are cracked or broken, replace the entire spring assembly.
4. If the protective coating is gone from some areas of the spring, paint the cleaned areas with a rust-inhibiting paint. If rusting or corrosion is severe, replace the spring.
5. Inspect the spring and bracket bushings. The spring eye bushings and the shackle bracket bushings are not replaceable. Replace the spring or bracket if they are gouged, cracked, pitted, or otherwise damaged.

## Slippered Springs

1. Using a wire brush and solvent or steam cleaning equipment, wash all parts to remove dirt, grease, and scale.
2. Check the spring for cracks and excessive wear at the wear pads. Check for wear at the leaf ends, and oil the top at the front of the slipper area.
3. If leaf wear or cracks can be seen, replace the springs. If the wear pad has worn excessively, replace it.
4. If the protective coating is gone from some areas of the spring, paint the cleaned areas with a rust-inhibiting paint. If rusting or corrosion is severe, replace the spring.
5. Check the radius rod for worn bushings. There should be no more than 1/16 of an inch (1.6 mm) movement between the rod and the bolt.

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## Standard Spring With Drop Style Front Hanger (EPA07)

**WARNING**

**Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. On front spring assemblies, if cracks or breaks exist in the two top leaves, a loss of vehicle control could occur. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.**

### Removal

1. Shut off the engine, set the parking brake, and chock the tires. Open the hood.
2. Disconnect both shock absorbers. See **Fig. 1**.
3. Raise the vehicle, and support the frame rails with jack stands behind the rear hanger of the front suspension.

IMPORTANT: Make sure the frame rails are level and an equal distance off the ground.

4. Remove the grease zerk fittings from the spring pins.
5. Using the floor jack, support the axle underneath the center of the spring, then remove the U-bolts and the axle stop/shock absorber mount.
6. Lower the axle and remove the spring spacer and caster shim. Note the taper direction of the caster shim so that it will not be reversed during the installation.
7. Raise the axle back up to support the spring and remove some of the load from the spring.
8. Disconnect the front of the spring from the spring drive bracket.
   - 8.1 Remove the 4 retaining bolts from the retainers at the front spring drive bracket.
   - 8.2 Using the proper tool, (see **Specifications, 400**), unthread the front spring pin from the spring eye. See **Fig. 1**.
9. Disconnect the rear of the spring from the shackle bracket.
   - 9.1 Remove the lower retaining bolts from the inboard and outboard shackle links.
   - 9.2 Using the proper tool, (see **Specifications, 400**), unthread the lower rear spring pin from the spring eye and shackle links.
10. Lower the spring and the axle, then remove the spring.

### Installation

**WARNING**

**Failure to install identical spring assemblies could affect the balance of the front suspension and cause difficult handling of the vehicle, resulting in personal injury or property damage.**

1. Using multipurpose chassis grease, lubricate both spring pins, the shackle pin, and the inside surfaces of the bushings.

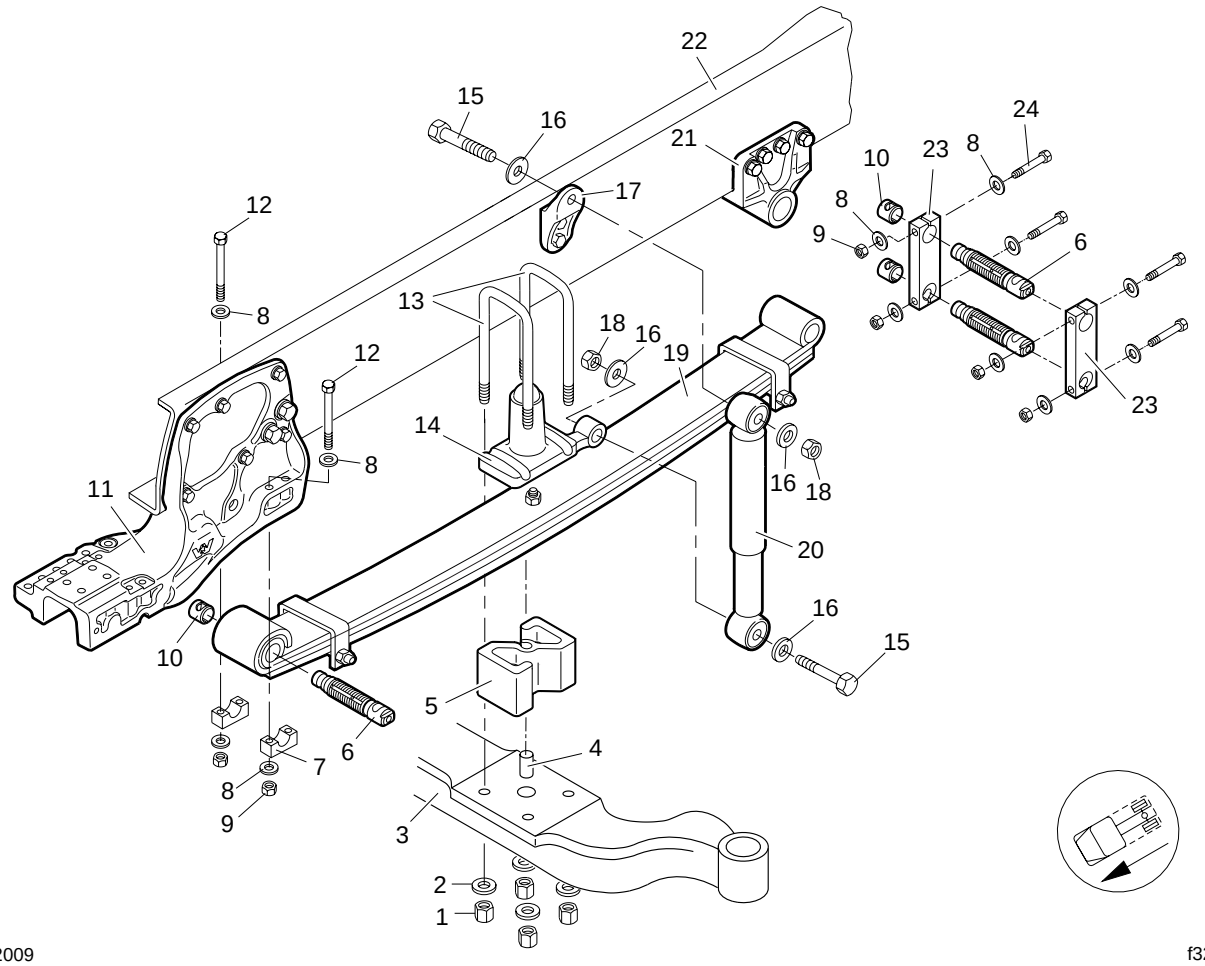
NOTE: All suspension bracket (frame) fasteners require periodic retorquing. Refer to **Group 32** of the *Western Star Maintenance Manual* for instructions.

2. Loosely position the spring on top of the axle, with the alignment pin in the hole in the top of the axle.
3. Connect the rear of the spring as follows.
   - 3.1 Place the floor jack under the axle, then raise it until the rear spring eye aligns with the holes in the shackles.
   - 3.2 Using the proper tool, (see **Specifications, 400**), thread the rear spring pin through the outboard shackle link, the spring eye, then the inboard shackle link. Take care not to push the split ring out of the inboard shackle link.
   - 3.3 Apply Alumilastic® or similar compound to all areas of the aluminum shackle link that contacts other metal. This includes all capscrews, washers, and locknuts that contact the aluminum shackle link.
   - 3.4 Insert the lower retaining bolt, with a hardened washer, through the inboard shackle

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## Removal and Installation, Standard Spring




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1. High Nut, 7/8–14
2. Flatwasher, Hardened 7/8 x 1.48 x 0.16
3. Axle
4. Dowel Pin, 0.75 o.d. x 4.00
5. Spacer
6. Spring Pin
7. Retainer
8. Hardened Washer, 0.53 x 1.06 x 0.177
9. Hexnut, 1/2–20
10. Split Ring
11. Spring Drive Bracket
12. Retaining Bolt,1/2–20
13. U-Bolt, 7/8–14 x 10.12
14. Axle Stop/Shock Absorber Mount
15. Hexbolt, 3/4–16 x 4.25
16. Flatwasher, Hardened, 3/4 x 1.39 x 0.16
17. Shock Absorber Mounting Bracket
18. Hexnut, 3/4–16 UNF
19. Spring
20. Shock Absorber
21. Shackle Bracket
22. Frame Rail
23. Shackle Link
24. Retaining Bolt, 1/2–20

**Fig. 1, Drop Hanger Front Suspension with Threaded Spring Pins**

link. Do not install the retaining bolt though the outboard shackle link at this time.

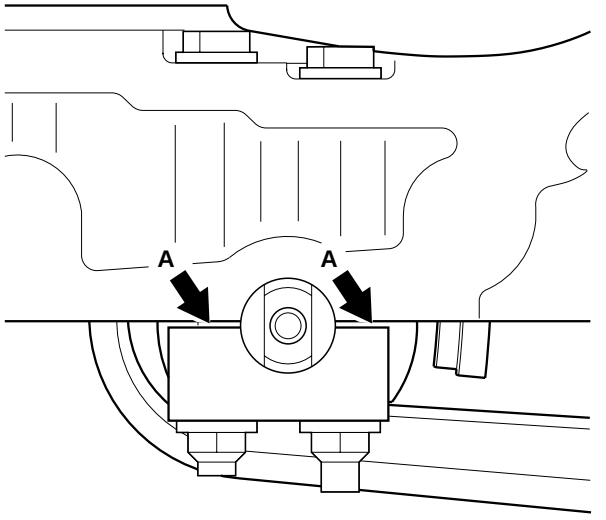
**NOTICE**

**Failure to apply Alumilastic or similar compound will result in electrolytic corrosion of dissimilar metal components, and will damage the suspension system.**

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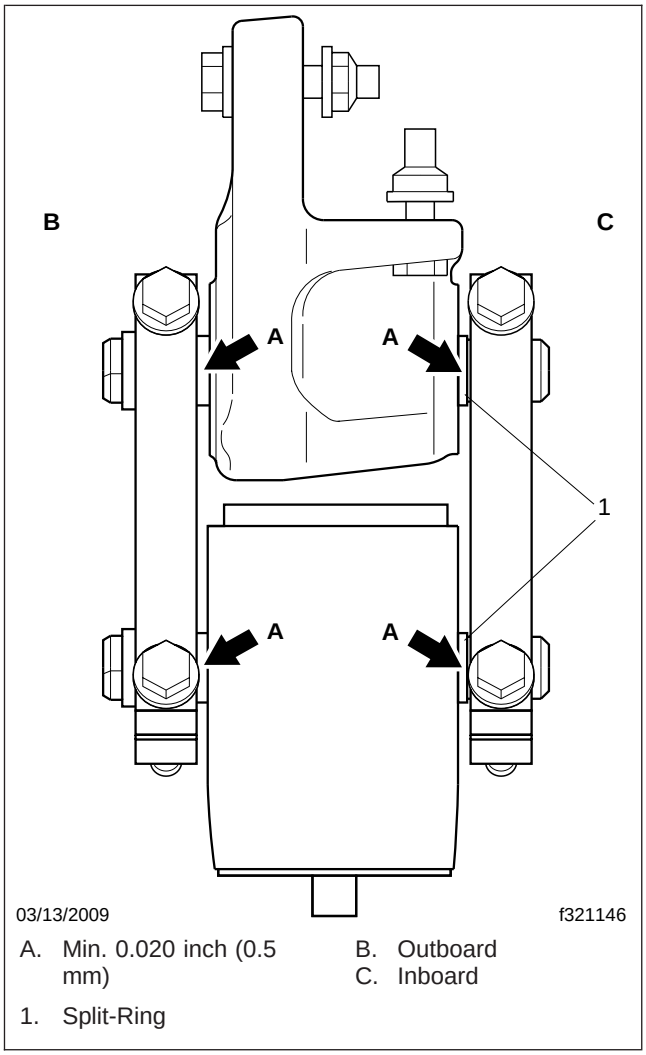
4. Connect the front of the spring as follows.
   - 4.1 Align the forward spring eye in the spring drive bracket.
   - 4.2 Thread the spring pin through the spring eye, then set the split-ring on the inboard end of the spring pin.
   - 4.3 Install the retaining bolts down through the spring drive bracket and attach the retainers. Tighten the nuts evenly to maintain equal clearance between the retainers and the spring drive bracket, but do not fully tighten them at this time. They need to be loose enough to adjust. See **Fig. 2**.




A. Equal Distances

**Fig. 2, Spring Drive Bracket and Retainer Installation**

5. Using the floor jack, lower the axle until the spring hangs freely.
6. Attach the rear of the spring as follows.
   - 6.1 Using the threaded spring pin, center the lower rear spring pin in the shackle bracket. The gap on each side should be within 0.080 inch (20 mm) of the other side. The minimum gap on each side is 0.020 inch (0.5 mm). See **Fig. 3**.
   - 6.2 After the spring is correctly positioned, install the lockbolt through the outboard shackle link, then tighten the bolts in both the inboard and outboard shackle links 45 lbf·ft (61 N·m).




A. Min. 0.020 inch (0.5 mm)
B. Outboard
C. Inboard
1. Split-Ring

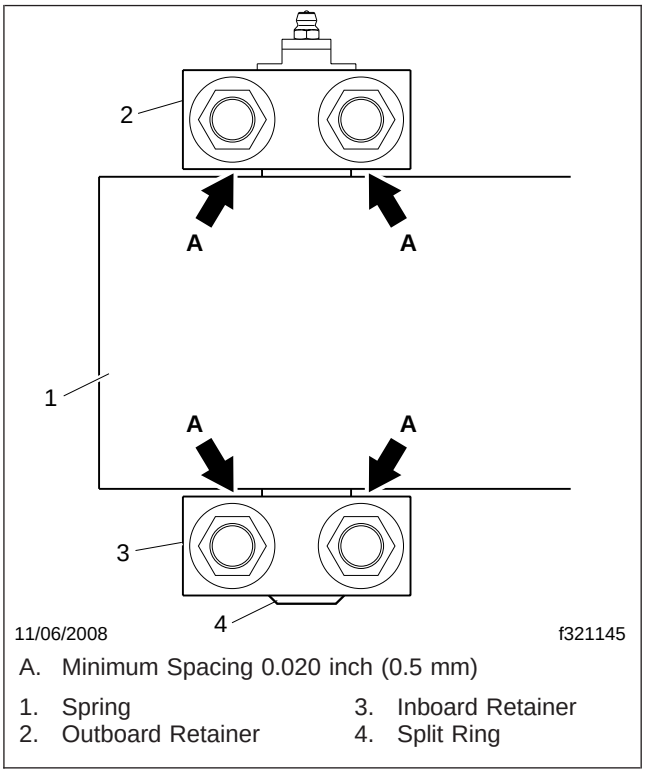
**Fig. 3, View from Rear of Spring Looking Forward**

7. Adjust the front of the spring.
   - 7.1 Using the threaded spring pin to adjust the position, center the front spring pin in the drive bracket. The nominal gap on each side is 0.063 inch (1.60 mm). Maintain a minimum gap of 0.020 inch (0.5 mm) on each side. See **Fig. 4**.
   - 7.2 Tighten the nuts on the retainer bolts 60 to 76 lbf·ft (81 to 103 N·m).
8. Install the grease zerks into the spring pins.

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## Removal and Installation, Standard Spring




A. Minimum Spacing 0.020 inch (0.5 mm)

1. Spring
2. Outboard Retainer
3. Inboard Retainer
4. Split Ring

**Fig. 4, View From Underneath the Forward Spring Eye**

9. Lower the axle and place the spacer and/or caster shim on the front axle in the position referenced during removal.
10. Using the jack, raise the axle until the spring spacer touches the spring, then place the axle stop/shock-absorber mount on top of the spring.
11. Install the U-bolts. For U-bolt tightening instructions and torque values, see **Specifications, 400**.

**NOTICE**

**Failure to retighten the U-bolt fasteners as instructed could result in spring breakage or abnormal tire wear.**

12. Remove the jack stands and lower the vehicle to the ground.
13. Wipe all dirt from the grease fittings on the spring pins and the shackle pin. Apply multipurpose chassis grease with a pressure gun until grease appears at the opposite end of the pin.
14. Remove the jack stands from the chassis, and lower the vehicle.
15. Install both front shock absorbers, and tighten the bolts 200 lbf.ft (271 N·m).
16. Close the hood.

## Standard Springs, Pre-EPA07

### Removal

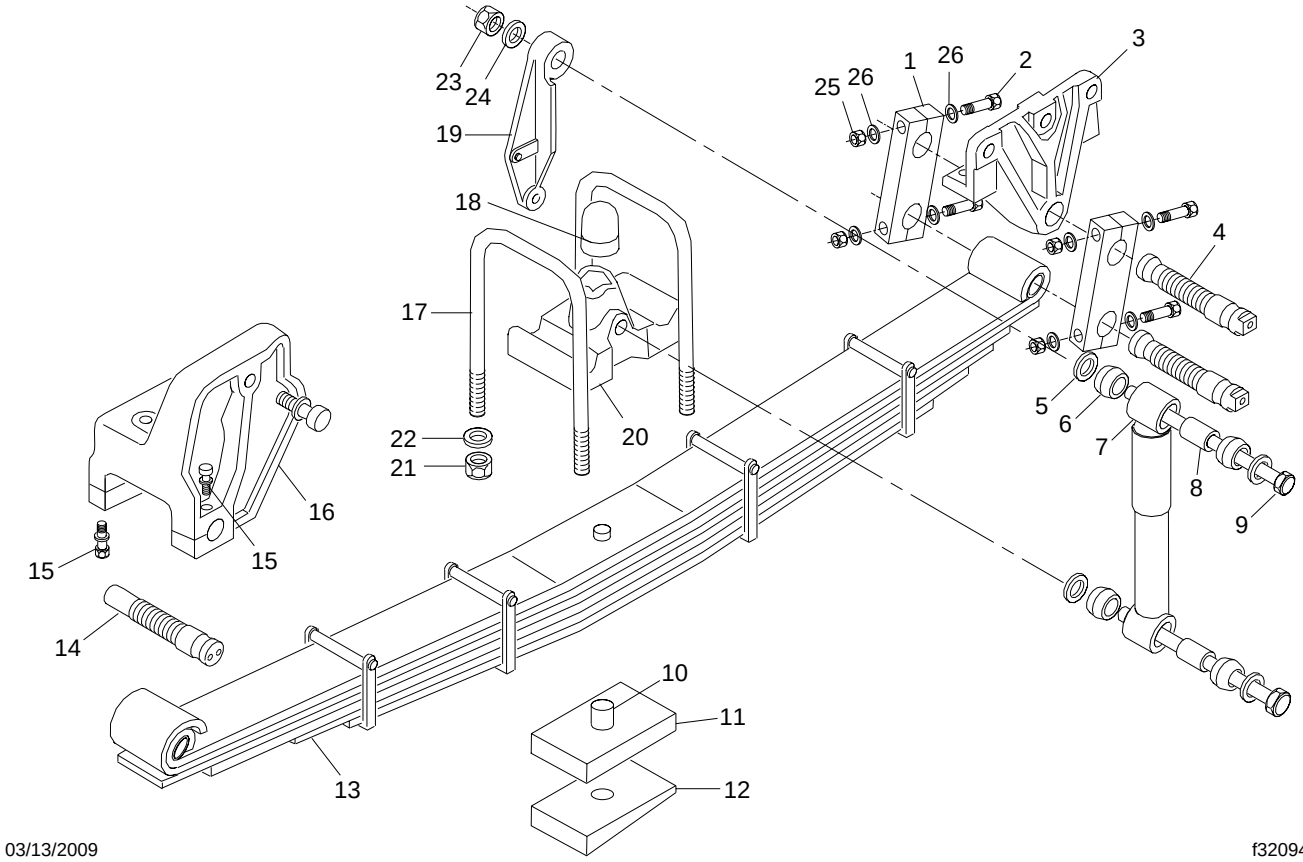
1. Shut off the engine, set the parking brake, and chock the tires. Open the hood.
2. Disconnect both front shock absorbers. See **Fig. 5**.
3. Raise the vehicle, and support the frame rails with jack stands behind the rear hanger of the front suspension.,

IMPORTANT: Make sure the frame rails are level and an equal distance off the ground.

4. Remove the grease zerks from the spring pins.
5. Using the floor jack, support the axle underneath the center of the spring, then remove the U-bolts and the axle stop/shock absorber mount.
6. Lower the axle and remove the spring spacer and caster shim. Note the taper direction of the caster shim so that it will not be reversed during installation.
7. Raise the axle back up to support the spring, and remove some of the load.
8. Disconnect the front of the spring from the spring drive bracket.
   - 8.1 Remove the retaining bolts from the spring drive bracket.
   - 8.2 Using the proper tool, (see **Specifications, 400**), unthread the front spring pin from the spring eye. See **Fig. 5**
9. Disconnect the rear of the spring from the shackle bracket.
   - 9.1 Remove the lower retaining bolts from the inboard and outboard shackle links.
   - 9.2 Using the proper tool, (see **Specifications, 400**), unthread the rear spring pin from the spring eye and shackle links.

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1. Shackle Link
2. Retaining Bolt, 1/2–20
3. Shackle Bracket
4. Rear Threaded Spring Pin
5. Flatwasher, Hardened, 3/4 x 1.39 x 0.16
6. Rubber Bushing
7. Shock Absorber
8. Spacer Sleeve
9. Bolt, 3/4–16 x 6-1/2
10. Dowel
11. Spacer, Iron
12. Caster Shim
13. Spring
14. Front Threaded Spring Pin
15. Retaining Bolt
16. Spring Drive Bracket
17. U-Bolt
18. Rubber Bumper
19. Shock Absorber Mounting Bracket
20. Axle Stop/Shock Absorber Mount
21. HighNut, 7/8-14
22. Flatwasher, Hardened, 7/8 x 1.48 x 0.16
23. Hexnut, 3/4–16 UNF
24. Flatwasher, Hardened, 3/4–1.39 x 0.16
25. Hexnut, 1/2–20
26. Hardened Washer, 0.53 x 1.06 x 0.177

**Fig. 5, Front Suspension with Threaded Spring Pins**

10. Lower the axle slightly and slide the spring forward in the front drive bracket as far as possible, then lower the rear of the spring out of the shackle links and remove it.

## Installation

**⚠ WARNING**

**Failure to install identical spring assemblies could affect the balance of the front suspension and cause difficult handling of the vehicle, resulting in personal injury or property damage.**

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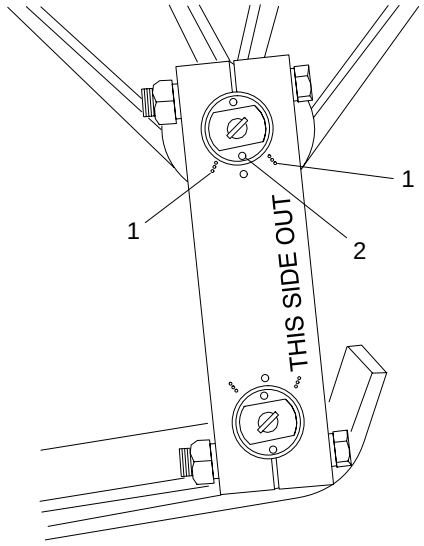


## Removal and Installation, Standard Spring

1. Using multipurpose chassis grease, lubricate the spring pins, and the inside surfaces of the bushings.

NOTE: All suspension bracket (frame) fasteners require periodic retorquing. Refer to **Group 32** of the *Western Star Maintenance Manual* for instructions.

2. Put the front of the spring into the front spring drive bracket, and slide the spring as far forward as it will go.
3. Lift the rear of the spring and put it into the rear shackle bracket, then slide the spring rearward.
4. With the grease zerk hole facing outboard, thread the rear spring pin into the spring eye and bushing.
5. Slide the shackle links onto the rear spring pins, making sure that the side labeled "THIS SIDE OUT" faces away from the spring and bracket. See **Fig. 6**.




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1. Alignment Markers
2. Dimple

**Fig. 6, Rear Spring Pin Alignment**

6. Apply Alumilastic® or similar compound to all areas of the aluminumshackle link that contacts metal. This includes all capscrews, washers, and locknuts that contact the aluminum shackle link. Do not apply the compound to the inner (bearing) surface of the bushing or on fastener threads.

### NOTICE

**Failure to apply Alumilastic or similar compound will result in electrolytic corrosion of dissimilar metal components, and will damage the suspension system.**

7. Install hardened washers on the retaining bolts, then thread them through the shackle links. Attach the nuts but do not tighten them.
8. Center the spring, then turn the rear spring pins until one of the dimples on the end of the pin is between the alignment marks on the shackle link, to ensure the grease gallery is not in the load bearing area. See **Fig. 6**.
9. Tighten the nuts on the retainer bolts in the shackle links 45 lbf·ft (61 N·m).
10. Lower or raise the front axle to align the front spring eye in the front spring drive bracket.
11. Thread the front spring pin through the drive bracket and the spring eye.
12. Center the spring inside the bracket, then turn the front spring pin until the two holes on the end of the pin are horizontal, to ensure the grease galleries are not in the load bearing zones.
13. Insert the retaining bolt, with a hardened washer, downward through the outer flange of the drive bracket to lock the spring pin in place. Torque to 60 to 76 lbf·ft (81 to 103 N·m). See **Fig. 5**.
14. Install the retaining bolt, with a hardened washer, upward into the inboard side of the front drive bracket. Torque to 60 to 76 lbf·ft (81 to 103 N·m). See **Fig. 5**.

NOTE: It may be necessary to turn the spring pin a slight amount to allow the bolt to slide past the flat spot on the pin.

15. Install grease zerks into the spring pins.
16. Lower the axle and place the spacer or caster shim on the front axle in the position referenced earlier.

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17. Raise the axle until the spring spacer touches the spring, then place the axle stop/shock absorber mount assembly on top of the spring assembly.
18. Install the U-bolts. For U-bolt tightening instructions and torque values, see **Specifications, 400**.

## NOTICE

**Failure to tighten the U-bolt fasteners as instructed could result in spring breakage or abnormal tire wear.**

19. Install the front wheel and tire.
20. Remove the jack stands, and lower the vehicle to the ground.
21. Torque the wheel studs to specifications in group **40**.
22. Install both front shock absorbers, then tighten the bolts 200 lbf.ft (271 N·m).
23. Close the hood.

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## Slippered Spring Removal and Installation

# Removal

1. Apply the parking brakes and chock the rear tires. Open the hood.
2. Remove both front shock absorbers if installed.
3. Raise the vehicle until both wheels are off the ground, then support the frame with jack stands. The axle and springs can then be manipulated with the floor jack.

IMPORTANT: Make sure the frame rails are level and an equal distance off the ground.

4. Remove the front wheel and tire from the side of the vehicle that the front spring is going to be removed from.

**WARNING**

**Never remove a radius rod without lifting and supporting the frame with safety stands. Detaching the radius rod with any weight load on the front axle could cause the front axle to shift, or the frame to drop suddenly, resulting in serious personal injury.**

5. Remove the radius rod. See **Fig. 1**.
6. Remove the four clamp bolts, then remove the upper spring clip plate.
7. Remove the retainer pins and the vertical wear pads.
8. Remove the rebound bolts and sleeves from the spring hangers.
9. Lower the axle slightly, then slide the spring as far forward as possible in the front spring hanger, and lower the rear of the spring out of the rear spring hanger.
10. Slide the spring rearward out of the front spring hanger to remove it.

# Installation

**WARNING**

**Failure to install identical spring assemblies could affect the balance of the front suspension and cause difficult handling of the vehicle, resulting in personal injury or property damage.**

1. Place the front of the spring into the front hanger, then slide the spring as far forward as possible.
2. Lift the rear of the spring into the rear hanger, then slide the spring rearward.
3. Install the vertical wear pads and the two retainer pins, replacing the cotter pins.
4. Install the rebound bolt sleeve and 3/4–16 rebound bolt. Tighten the rebound bolt 269 lbf·ft (365 N·m).
5. Install the upper spring clip plate and clamp bolts. Tighten the clamp bolt nuts 427 lbf·ft (579 N·m).

   For U-bolt (or clamp bolt) tightening instructions and torque values, see **Specifications, 400**.

**NOTICE**

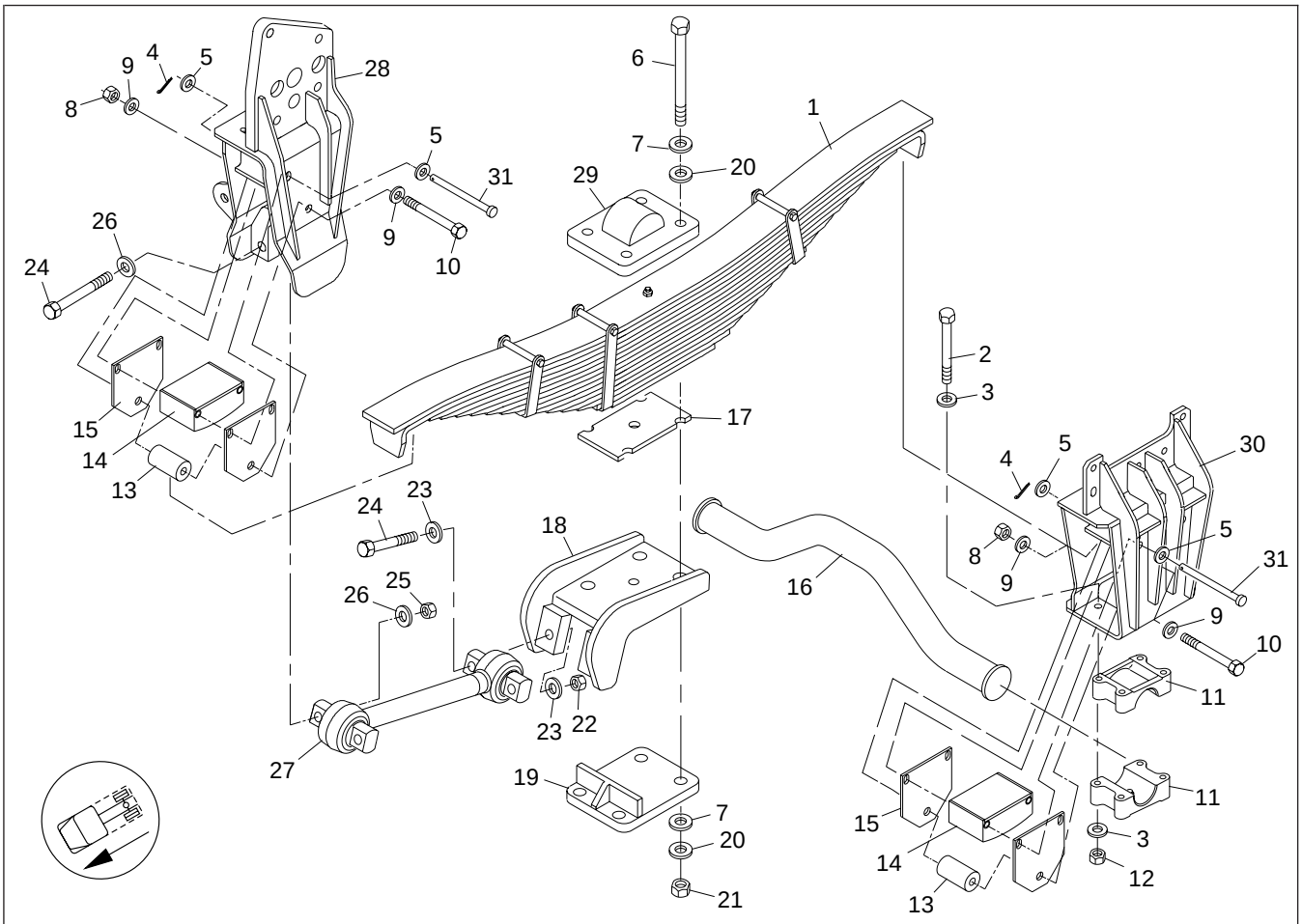
**All suspension bracket (frame) fasteners require periodic retorquing. Refer to Group 32 in the *Western Star Maintenance Manual* for instructions. Failure to retorque the fasteners as instructed could result in spring breakage and abnormal tire wear.**

6. Install the radius rod. Tighten the four bolts 427 lbf·ft (579 N·m).
7. Install the front tire.
8. Lower the vehicle to the ground.
9. Install both front shocks, then tighten the nuts 200 lbf·ft (271 N·m).
10. Close the hood.

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## Slippered Spring Removal and Installation




1. Slippered Spring
2. Hexbolt, 1/2–20, GR8
3. Hardened Washer
4. Cotterpin, 3/16 x 2.00, Zinc
5. Hardened Washer
6. Clamp Bolt, 7/8–14
7. Hardened Washer
8. Hexnut, 3/4–14
9. Hardened Washer
10. Hexbolt, 3/4–16 GR8
11. Cast Iron Bracket, Underslung Crossmember
12. Hexnut, 1/2–20
13. Rebound Bolt Sleeve
14. Vertical Wear Pad
15 Lateral Wear Pad
16. Underslung Crossmember
17. Spacer
18. Radius Rod Bracket
19. Upper Spring Clip Plate
20. Flatwasher
21. High Hexnut, 7/8, Oiled
22. Hexnut, 7/8–14
23. Hardened Washer
24. Hexbolt, 7/8–14
25. Hexnut, 7/8–14
26. Hardened Washer
27. Radius Rod
28. Front Spring Bracket
29. Springclip Plate
30. Rear Spring Bracket
31. Wearpad Retainer Pin

**Fig. 1, Front Slippered Suspension**

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## Vehicle Lean Inspection

IMPORTANT: Chassis lean can be caused by several factors such as uneven vehicle weight distribution, mismatched springs, or improper spacer installation. The following instructions detail inspecting for and correcting chassis lean due to improper spring or spacer installation.

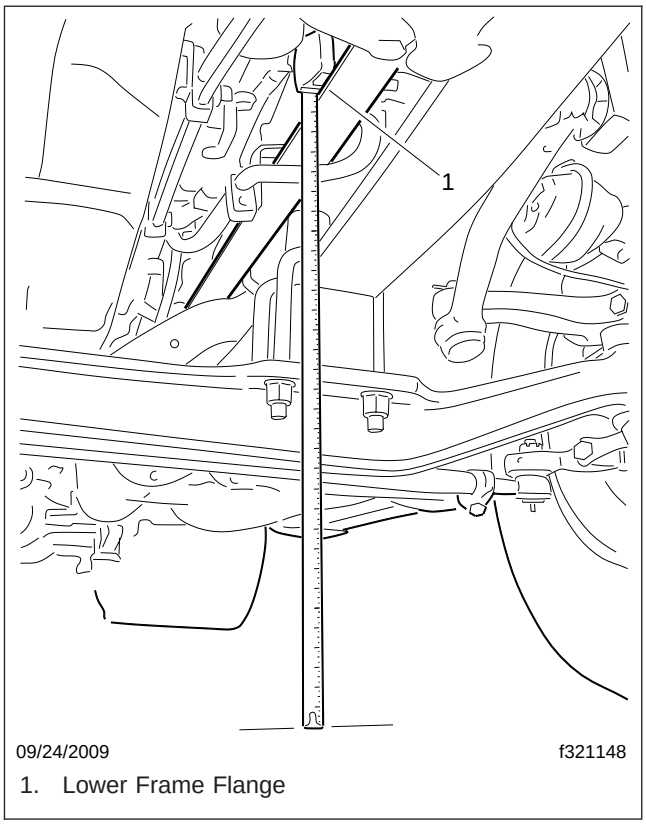
Additional troubleshooting procedures may also be found at **Hendrickson International**.

1. Park the vehicle on a level surface with the wheels pointing straight ahead. Set the parking brake, turn off the engine, and chock the tires. When exiting the vehicle, try not to rock the vehicle.

NOTE: The vehicle should be unloaded when performing the following inspection.

2. Check tire pressure and tire size. Pressures should be within 2 psi of each other. Tire size should be the same on each axle.
3. Check that the rear axle alignment and rear suspension ride height are within specification. Refer to the applicable sections in **Group 32** or **Group 35** in this manual.
4. Check the springs, bushings and spring mounting hardware for damage. Replace damaged components before checking for chassis lean.
5. Measure the weight of the vehicle at each wheel position. Weight imbalance will cause the vehicle to lean. If the vehicle weight differs from side to side, check for added equipment to one side of the chassis and the fuel tank levels, and correct if necessary.
6. Measure the distance from the bottom of the lower frame flange to the ground, forward of the front axle center line. This is frame height. See **Fig. 1**.
7. If the frame height differs from side to side by 3/8 inch (9.53 mm) or more, inspect the spring part numbers, and (if present) markings on the top side of the springs with a label marking plus (+) or minus (–). Verify that both spring labels match.

   If the labels or part numbers do not match, replace one or both springs so the vehicle has matching springs. See **Fig. 2**.




1. Lower Frame Flange

**Fig. 1, Measuring Frame Height**

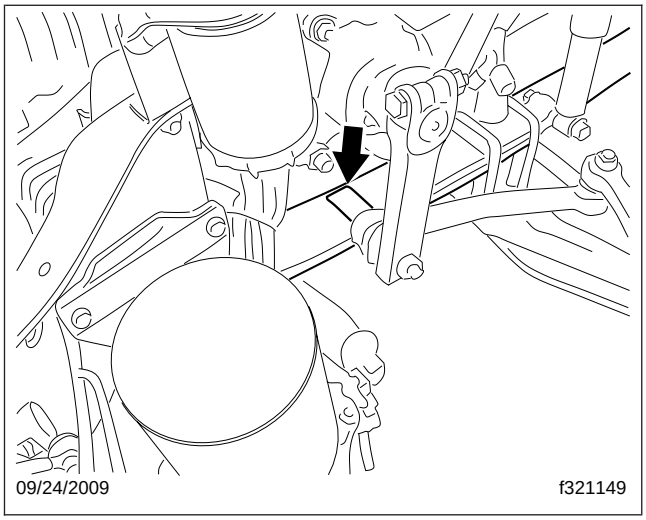



**Fig. 2, Spring Label Location**

8. Measure the height difference at the end of the frame rails to ground. If this measurement is greater than 3/8 inch (9.53 mm), the front axle

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## Troubleshooting

spacer adjustments will have minimal effect on lean and other actions are required. If the end of frame to ground measurements are less than 3/8 inch (9.53 mm) difference, correct the lean by increasing the low side front axle spacer thickness by no more than 1/2 inch (13 mm). Use a 45, 55, or 65-mm spacer in place of the existing spacer.

See **Table 1** for parts information.

| Parts Information | | |
|---|---|---|
| **Part Description** | **Part Number** | **Quantity** |
| Axle Spacer, 45 mm | 16-15015-045 | As Required |
| Axle Spacer, 55 mm | 16-15105-055 | As Required |
| Axle Spacer, 65 mm | 16-15105-065 | As Required |

**Table 1, Parts Information**

9. Check the frame height again. If the difference between measurements is still equal to or greater than 3/8 inch (9.53 mm), swap springs from side to side and check the measurements again.

   If the chassis lean is still the same, the problem is with the vehicle. If the lean has changed sides, replace both springs.

10. **Figure 3** represents a checklist for weak or sagging springs.

    Use this checklist as the information may be requested when filing a warranty claim.

## Troubleshooting Tables

**Problem—Vehicle Wanders**

| Problem—Vehicle Wanders | |
|---|---|
| **Possible Cause** | **Remedy** |
| One or more spring leaves are broken. | Replace the spring assembly. |
| The wheels are out of alignment. | Adjust the wheel alignment using the instructions in **Group 33** of this manual. |
| Caster is incorrect. | Install correct caster shims. Refer to **Group 33** of this manual for specifications. |
| Steering gear is not centered. | Adjust steering using the instructions in **Group 46** of this manual. |
| Drive axles are out of alignment. | Align the drive axles using the instructions in **Group 35** of this manual. |

**Problem—Vehicle Bottoms Out**

| Problem—Vehicle Bottoms Out | |
|---|---|
| **Possible Cause** | **Remedy** |
| Excessive weight on the vehicle is causing an overload. | Reduce the loaded vehicle weight to the maximum spring capacities. |
| One or more spring leaves are broken. | Replace the spring assembly. |
| The spring assembly is weak or fatigued. | Replace the spring assembly. |

**Problem—Frequent Spring Breakage**

| Problem—Frequent Spring Breakage | |
|---|---|
| **Possible Cause** | **Remedy** |
| The vehicle is overloaded or operated under severe conditions. | Reduce the loaded vehicle weight to the maximum spring capacities. Caution the driver on improper vehicle handling. |
| There is insufficient torque on the U-bolt high nuts. | Torque the U-bolt high nuts to the value listed in the torque table in **Specifications, 400**. |

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| Problem—Frequent Spring Breakage | |
|---|---|
| **Possible Cause** | **Remedy** |
| A loose center bolt is allowing the spring leaves to slip. | Check the spring leaves for damage. If damaged, replace the spring assembly. If not, tighten the center-bolt nut to the value listed in torque table in **Specifications, 400**. |
| Worn or damaged spring pin bushings are allowing spring end-play. | Replace the spring pin and bushing. |

**Problem—Noisy Spring**

| Problem—Noisy Spring | |
|---|---|
| **Possible Cause** | **Remedy** |
| A loose U-bolt nut or center bolt is allowing spring leaf slippage. | Inspect the components for damage. Replace damaged components as necessary. Torque the fasteners to the values listed in the torque table in **Specifications, 400**. |
| A loose, bent, or broken spring shackle or front suspension bracket is impairing the spring flex. | Inspect the shackles and brackets for damage. Replace damaged components as necessary. Torque the fasteners to the values listed in the torque table in **Specifications, 400**. |
| Worn or damaged spring pins are allowing spring end-play. | Replace any worn or damaged spring pins. |

**Problem—Rough Ride**

| Problem—Rough Ride | |
|---|---|
| **Possible Cause** | **Remedy** |
| Refer to the applicable suspension section in this manual. | |

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## Troubleshooting

The following is a checklist for weak or sagging springs. This information may be requested when filing for warranty.

**Conditions**

☐ Is the ground level?

*(If ground is not level move the truck to a level location)*

☐ Is the vehicle loaded?

*(Vehicle should be measured unloaded)*

☐ Are the spring part numbers the same?

*(Part numbers should be the same)*

☐ Is there any visible damage to the spring or bushings?

*(Any damage to the springs, bushings, shocks, or suspension brackets should be repaired)*

**Tires**

☐ Are the tire pressures and sizes the same?

*(Tire pressure should be within 2 psi from side to side)*

☐ Do the tires have the same amount of wear?

☐ Are the tires the same size?

**Measurements**

☐ Measure the distance from the floor to the bottom of the frame rail on each side of the truck as close to the front axle as possible.

Passenger Side _____

Driver Side _____

*(Measurements should be within 3/8” from side to side)*

**Weight**

☐ Measure the weight of the vehicle at each forward axle position.

Passenger Side _____

Driver Side _____

*(Weight should be equal from side to side. If weight is more on one side, check that the cab is centered on the frame rails, and if equipped with dual tanks, that the fuel level is equal on both sides. Due to the many options available for mounting components, the vehicle may have a weight bias to one side. If the vehicle does have a weight bias to one side, the spring can be shimmed to level the vehicle.)*

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**Fig. 3, Checklist for Weak or Sagging Springs**

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## Specifications

| Front Suspension Fastener Torque Values | | |
|---|---|---|
| **Description** | **Size** | **Torque: lbf·ft (N·m)** |
| Shackle Lockbolt | 1/2–13 | 35–55 (47–74) |
| Front Pin Retainer Bolt | 1/2–13 | 60–76 (80–103) |
| Shackle Bracket-to-Frame Locknut | 3/4–10 | 240 (325) |
| Axle U-Bolt (or clamp bolt) High Nuts (Tighten in a diagonal pattern as shown in **Fig. 1**.) | 5/8–18 | Stage 1: Hand-tighten<br>Stage 2: 60 (81)<br>Stage 3: 180–230 (245–313) |
| | 3/4–16 | Stage 1: Hand-tighten<br>Stage 2: 60 (81)<br>Stage 3: 200 (271)<br>Stage 4: 270–330 (367–449) |
| | 7/8–14 | Stage 1: Hand-tighten<br>Stage 2: 60 (81)<br>Stage 3: 200 (271)<br>Stage 4: 420–500 (571–680) |
| | 1–14 | Stage 1: Hand-tighten<br>Stage 2: 60 (81)<br>Stage 3: 200 (271)<br>Stage 4: 520–600 (707–816) |
| Spring Assembly Center-Bolt Nut | 1/2–20 | 65 (88) |
| Shock Absorber Upper and Lower Mounting Locknut | 3/4–10 | 140 (190) |

**Table 1, Front Suspension Fastener Torque Values**

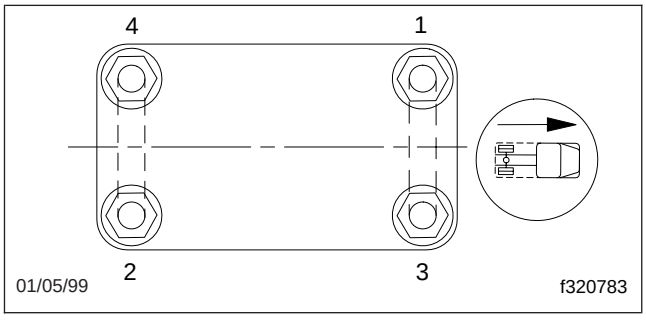
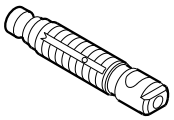
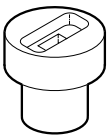
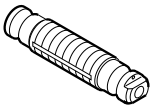
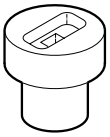
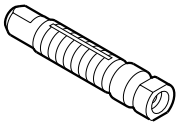
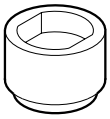
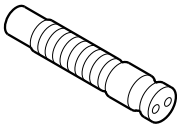
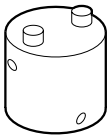
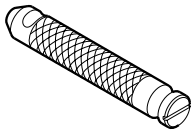
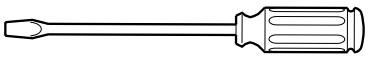
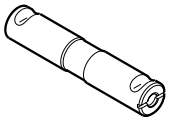
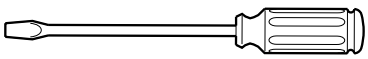



**Fig. 1, Tightening Pattern for U-Bolt (or Clamp Bolt) High Nuts**

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## Specifications

| | | |
|---|---|---|
| Drive/Shackle Pin 16−08213−000  | Removal Tool J−49860  | From January 2007 |
| Shackle Pin 37121−3419  | Removal Tool 37121−4401  | August 2000 to January 2007 |
| Drive Pin 37121−3418 (Rev A)  | Removal Tool J−47378  | March 2004 to January 2007 |
| Drive Pin 37121−3418  | Removal Tool 37121−4400  | August 2000 to March 2004 |
| Drive Pin 37121−3412  | Removal Tool − Flathead Screwdriver  | Prior to August 2000 |
| Shackle Pin 37121−3413  | Removal Tool − Flathead Screwdriver  | Prior to August 2000 |

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**Fig. 2, Spring Pins and Removal Tools**

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## General Information

There are two terms used to describe rough ride conditions: harmonic and harsh. Harmonic ride problems are those in which the once-per-revolution energy input from such things as bent or imbalanced wheels match the natural frequency of the frame flexing. This produces a fore-and-aft motion in the cab, which continues as long as the critical road speed is maintained. Harmonic ride problems can occur on smooth roads.

Harsh ride problems are those in which the suspension transfers, rather than absorbs, the momentary energy inputs produced when the tires hit bumps or holes in the road. Wavy asphalt, or a series of bumps, may cause repetition of the harsh, jarring motion in the cab, but the motion stops after the tires pass over the bumps. Harsh ride problems occur on rough roads.

This section is designed for use as an aid in locating and correcting rough ride problems. It is not intended for use as a replacement for the detailed service information located in the applicable subjects in this manual, or in the component manufacturer's service manuals.

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## Harmonic Ride Checks

1. Visually check the vehicle for signs of damaged or missing suspension components. Repair or replace the components using the instructions in the applicable sections in this manual.
2. Test drive the vehicle.

NOTE: When test driving the vehicle, duplicate as closely as possible the conditions under which the problem occurs. Note the area of the vehicle where the problem seems to be coming from. Pay special attention to this area during the service operations.

**WARNING**

**Use safety stands to securely support all of the wheel and frame weight during suspension repairs. Unsecured components may drop when the fasteners are loosened or removed, causing serious personal injury and component damage.**

3. Raise the vehicle until the tires are off the ground, and all of the weight is removed from the leaf springs. Block the axle and frame with safety stands. Perform the corrections under "Harmonic Ride, Tires Off the Ground" in **Troubleshooting, 300**.
4. Remove the safety stands from under the frame and axle, then lower the vehicle. Perform the corrections under "Harmonic Ride, Tires On the Ground" in **Troubleshooting, 300**.

## Harsh Ride Checks

1. Visually check the vehicle for signs of damaged or missing suspension components. Repair or replace the components using the instructions in the applicable sections in this manual.
2. Test drive the vehicle.

NOTE: When test driving the vehicle, duplicate as closely as possible the conditions under which the problem occurs. Note the area of the vehicle where the problem seems to be coming from. Pay special attention to this area during the service operations.

**WARNING**

**Use safety stands to securely support all of the wheel and frame weight during suspension repairs. Unsecured components may drop when the fasteners are loosened or removed, causing serious personal injury and component damage.**

3. Raise the vehicle until the tires are off the ground, and all of the weight is removed from the leaf springs. Block the axle and frame with safety stands. Perform the corrections under "Harsh Ride, Tires Off the Ground" in **Troubleshooting, 300**.
4. Remove the safety stands from under the frame and axle, then lower the vehicle. Perform the corrections under "Harsh Ride, Tires On the Ground" in **Troubleshooting, 300**.
5. If the problem persists, perform the harmonic ride checks in this subject. Occasionally, ride problems associated with rough roads are harmonic ride problems masked by the road conditions.

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## Troubleshooting Tables

**Problem—Harmonic Ride, Tires Off the Ground**

| Problem—Harmonic Ride, Tires Off the Ground | |
|---|---|
| **Possible Cause** | **Remedy** |
| Bent, distorted, or out-of-round wheels or rims are causing a rough ride. | Inspect and repair the assemblies using the instructions in **Group 40**. |
| Bent, distorted, or out-of-round brake drums or hubs are causing a rough ride. | Replace damaged components using the instructions in **Group 33** and **Group 35**. |
| An improperly seated tire-to-rim bead is causing an out-of-round assembly. | Inspect the tires and rims for proper bead seating. Correct the problem using the instructions in **Group 40**. |
| A tire and rim assembly on spoke wheels is improperly installed, causing an out-of-round assembly. | Remove and install the tire and rim assembly using the instructions in **Group 40**. |
| Worn or distorted rim spacers are causing an out-of-round assembly. | Replace damaged spacers using the instructions in **Group 40**. |
| The wheels, brake drums, or hub assemblies are out of balance. | Inspect the components for missing balance weights. Balance, as necessary. |
| Radial force variations in the tires are causing a rough ride. | Exchange the tires and wheels with a set that is known to cause no ride problems. If this corrects the problem, discard the old tires. For instructions, see **Group 40**. |

**Problem—Harmonic Ride, Tires On the Ground**

| Problem—Harmonic Ride, Tires On the Ground | |
|---|---|
| **Possible Cause** | **Remedy** |
| Worn or loose cab mounts allow the cab to bounce. | With a long bar, lever the cab legs up and down. If there is looseness, replace or tighten the mounts, as necessary. |
| Forces from the trailer suspension are pushing on the tractor fifth wheel. | Review the ride problems that apply to the trailer suspension. Refer to the trailer manufacturer for instructions. Perform the corrections, as necessary. |

**Problem—Harsh Ride, Tires Off the Ground**

| Problem—Harsh Ride, Tires Off the Ground | |
|---|---|
| **Possible Cause** | **Remedy** |
| Seized front spring shackle pins are not allowing the springs to flex. | Replace seized shackle pins. For instructions, refer elsewhere in this group. |

**Problem—Harsh Ride, Tires On the Ground**

| Problem—Harsh Ride, Tires On the Ground | |
|---|---|
| **Possible Cause** | **Remedy** |
| The tires are improperly inflated. | Adjust the tire pressure using the instructions in **Group 40** of the *Western Star Maintenance Manual*. |

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## Troubleshooting

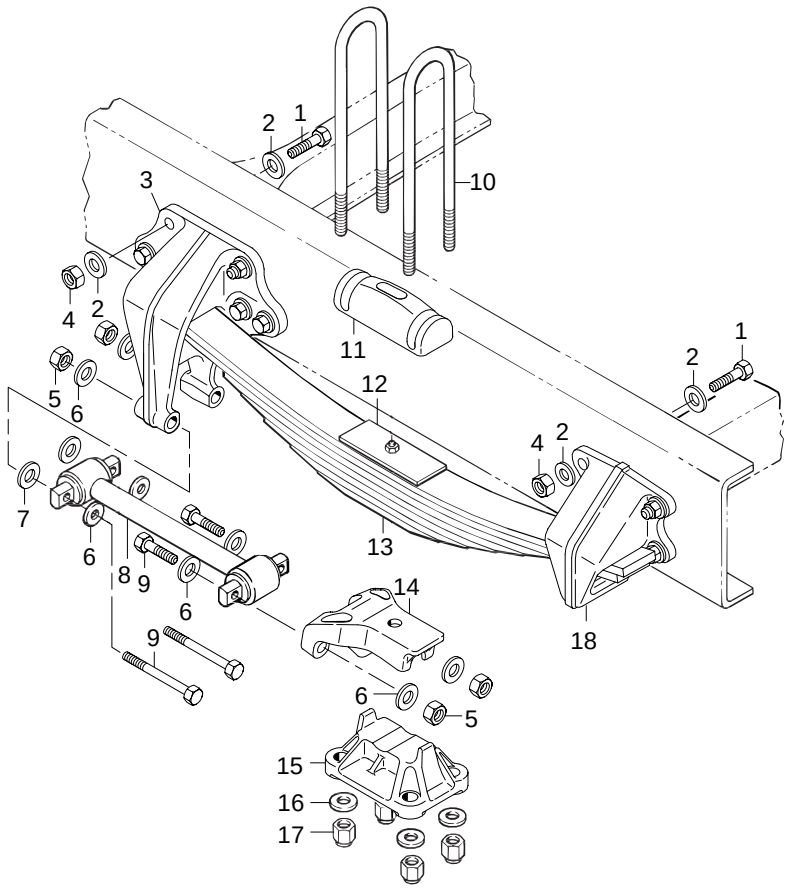
| Problem—Harsh Ride, Tires On the Ground | |
|---|---|
| **Possible Cause** | **Remedy** |
| The frame is bottoming out against the suspension. | Check the suspension for weak or damaged springs or components. Inspect the springs for "gull-winging" when the vehicle is loaded. Replace the spring assembly, as necessary, using instructions found elsewhere in this group. |
| | Reduce the overall loaded weight on each axle to conform with the maximum spring load capacities on the vehicle specification sheet. Do not exceed the maximum spring load capacities. |
| | Adjust the air spring height using the instructions in the applicable suspension section of this manual. |
| The vehicle normal loaded weight is markedly below the spring load capacity. | Contact the Service Operations Regional Office for the correct application of a lower rated spring. Replace the spring assembly using instructions found elsewhere in this group. |
| When the vehicle is loaded, the front axle spring shackle angle is not within the rearward 3 to 18-degree angle. | Contact the Service Operations Regional Office for shackle angle corrective measures. Refer elsewhere in this group for service instructions. |
| The weight on the tractor fifth wheel is causing overloading on the front axle springs. | If possible, move the fifth wheel toward the rear of the vehicle; otherwise, change the loading pattern on the trailer. |
| There is a loaded weight differential between the rear axles greater than 800 pounds (363 kg). | Contact the Service Operations Regional Office for corrective measures. |
| Forces from the trailer suspension are pushing on the tractor fifth wheel causing a rough ride condition. | Review the ride problems that apply to the trailer suspension. Refer to the trailer manufacturer for instructions. Perform the corrections, as necessary. |

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## General Description

The single-axle rear spring suspension (**Fig. 1**) uses a full-floating spring design. Semi-elliptical spring assemblies are attached to the axles with U-bolt assemblies. The spring ends ride in aluminum brackets that are mounted on the frame rails. Steel wear shoes are cast into each bracket. Radius rods attached to the axle seats and the forward spring brackets hold the axle in alignment.




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1. Suspension Bracket Hexhead Bolt
2. Hardened Washer
3. Forward Spring Bracket
4. Suspension Bracket Hex Locknut
5. Radius Rod Hexhead Bolt
6. Hardened Washer
7. Axle Alignment Washer
8. Radius Rod
9. Radius Rod Hexhead Bolt
10. U-Bolt
11. U-Bolt Pad
12. Spring Liner
13. Leaf Spring Assembly
14. Spring Seat
15. U-Bolt Retainer
16. Hardened Washer
17. U-Bolt High Nut
18. Rear Spring Bracket

**Fig. 1, Single-Axle Spring Suspension**

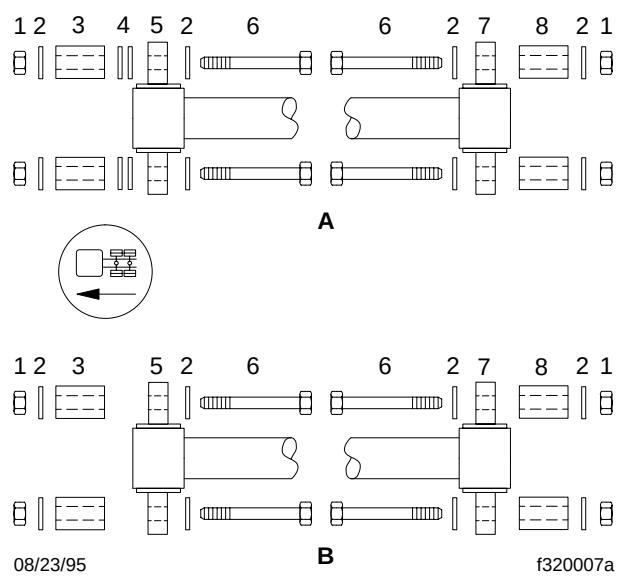
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## Radius Rod Removal and Installation

## Removal

1. Apply the parking brakes, and chock the tires.
2. Note the number of axle alignment washers (Ref. 4) at the forward end of the radius rod that is being removed. See **Fig. 1**.
3. Remove the fasteners that attach the radius rod to the forward spring bracket and to the axle seat.
4. Remove the radius rod and any axle alignment washers.




A. Right-Side Radius Rod
B. Left-Side Radius Rod

1. Hex Locknut
2. Hardened Washer
3. Forward Spring Bracket
4. Alignment Washers (install only on one side; right-side installation shown.)
5. Radius Rod Front Pin
6. Hexbolt
7. Radius Rod Rear Pin
8. Axle Seat

**Fig. 1, Radius Rod Attachment (top view)**

## Installation

IMPORTANT: At all points where steel parts contact the aluminum forward spring bracket, apply Alumilastic® compound, or an equivalent, on the mating surfaces.

**CAUTION**

**Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the suspension.**

1. Place the radius rod pins between the rear side of the forward spring bracket, and the front side of the axle seat. See **Fig. 1**.
2. Install the hexhead bolts, hardened washers, and locknuts in the axle seat and the radius rod rear pin.
3. Install any previously removed axle alignment washers between the radius rod front pin and the forward spring bracket. Install the hexhead bolts, hardened washers, and locknuts in the radius rod front pin and the forward spring bracket.
4. Tighten the radius rod locknuts to the torque value in **Specifications, 400**.
5. Check the axle alignment. For instructions, refer to **Group 35**. If necessary, adjust the rear axle alignment, using the instructions in **Subject 130**.

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## Replacement

**WARNING**

**Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.**

1. Chock the front tires.
2. Raise the frame so that all weight is removed from the leaf springs, then block the frame with safety stands. Raise the rear axle until the spring no longer contacts the spring bracket wear shoes, then block the axle. Make sure the stands will securely support the weight of the axles and frame. To gain easy access to the suspension system, remove the wheel assembly; refer to the wheels and tires section in this manual for instructions.
3. Remove the U-bolt high nuts, hardened washers, U-bolt retainer, U-bolts, and upper U-bolt pad. See **Fig. 1**.
4. Lift the spring assembly off the axle seat, then move it to the rear, out of the forward spring bracket. Lift the front of the spring, then move it forward, out of the rear spring bracket.
5. Using chassis grease, lubricate the ends of the new spring where they contact the stationary wear shoes in the spring brackets.
6. Work the new spring assembly into the spring brackets, and place it on the axle seat. Make sure the spring center-bolt head seats in the axle seat hole.
7. Place the upper U-bolt pad on the spring assembly. Place the U-bolts over the upper U-bolt pad and the spring assembly.
8. Install the U-bolt retainer, hardened washers, and U-bolt high nuts. Tighten the high nuts until snug.
9. In a diagonal pattern, hand tighten the axle U-bolt high nuts. In the same pattern, tighten them 100 lbf·ft (136 N·m); then, 200 lbf·ft (270 N·m); then, 300 lbf·ft (407 N·m); then, torque to the final value of 420 lbf·ft (569 N·m).

**CAUTION**

**Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.**

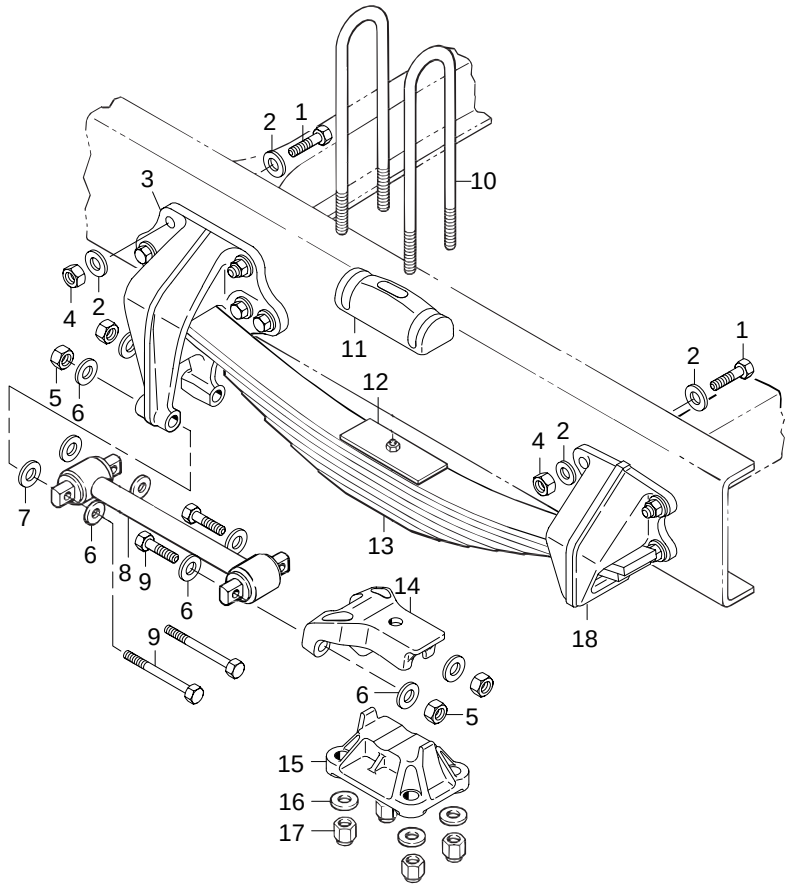
IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see **Group 32** of the *Western Star Maintenance Manual*.

10. Install the wheel assembly, using the instructions in **Group 40**. Remove the safety stands from under the frame and axle, and lower the vehicle.
11. Check the axle alignment. For instructions, see **Group 35**. If necessary, adjust the rear axle alignment, using the instructions in **Subject 130**.

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## Spring Assembly Replacement




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1. Suspension Bracket Hexhead Bolt
2. Hardened Washer
3. Forward Spring Bracket
4. Suspension Bracket Hex Locknut
5. Radius Rod Hexhead Bolt
6. Hardened Washer
7. Axle Alignment Washer
8. Radius Rod
9. Radius Rod Hexhead Bolt
10. U-Bolt
11. U-Bolt Pad
12. Spring Liner
13. Leaf Spring Assembly
14. Spring Seat
15. U-Bolt Retainer
16. Hardened Washer
17. U-Bolt High Nut
18. Rear Spring Bracket

**Fig. 1, Single-Axle Spring Suspension**

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## Replacement

**WARNING**

**Replace worn, cracked, or damaged spring brackets. Failure to do so could result in bracket breakage, possibly leading to loss of vehicle control and resulting in personal injury or property damage.**

IMPORTANT: At all points where steel parts (including bolts, washers, and nuts) contact the aluminum spring brackets, apply Alumilastic® compound, or an equivalent, on the mating surfaces.

**CAUTION**

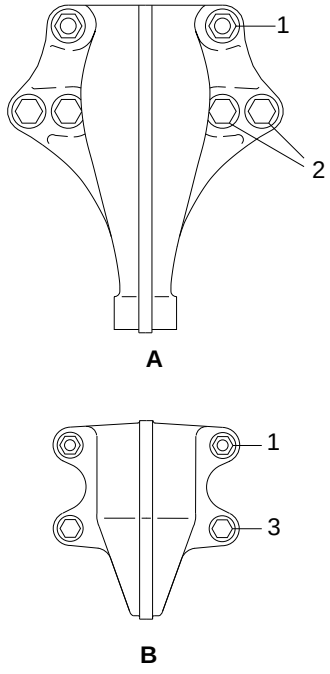
**Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the suspension.**

1. Chock the front tires.
2. Raise the rear of the vehicle, and block the rear axle with safety stands. Raise the vehicle frame so that all weight is removed from the leaf springs, then block the frame with safety stands. Make sure the stands will securely support the weight of the axle and frame.
3. If removing the forward spring bracket, note the number of axle alignment washers, if any, between the bracket and the radius rod front pin. Remove the fasteners that attach the radius rod to the bracket, and remove any axle alignment washers.
4. Remove the fasteners that attach the spring bracket to the frame rail, and remove the spring bracket.
5. Place the new spring bracket on the frame rail. Align the mounting holes, and install the spring bracket bolts, hardened washers, and locknuts.

NOTE: If installing the forward spring bracket, install the nuts for the top two bolts on the outboard side of the frame rail, and install the nuts for the bottom four bolts on the inboard side of the frame rail. See **Fig. 1**.

If installing the rear spring bracket, install the nuts for the top two bolts on the outboard side of the frame rail, and install the nuts for the bottom two bolts on the inboard side of the frame rail. See **Fig. 1**.

6. Tighten the locknuts to the applicable torque value in **Specifications, 400**.




A. Forward Spring Bracket
B. Rear Spring Bracket
1. Nut (outboard)
2. Bolt Heads (outboard)
3. Bolt Head (outboard)

**Fig. 1, Frame Brackets**

**CAUTION**

**Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.**

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking inter-

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## Spring Bracket Replacement

vals and instructions, refer to **Group 32** of the *Western Star Maintenance Manual*.

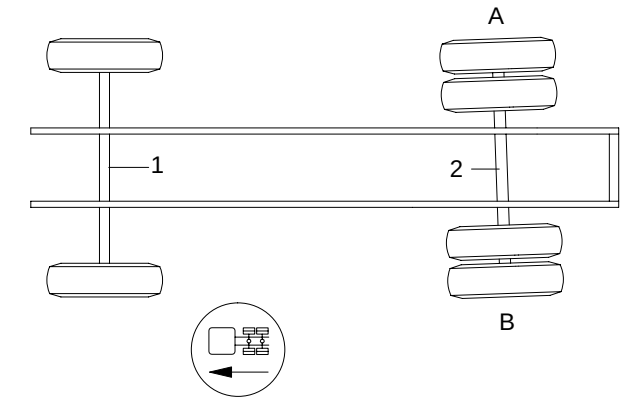
7. If replacing the forward spring bracket, position any previously removed axle alignment washers between the bracket and the radius rod front pin-.Install the bolts, hardened washers, and locknuts in the radius rod front pin and the forward spring bracket. Tighten the locknuts to the torque value in **Specifications, 400**.
8. Remove the safety stands from under the frame and axle, and lower the vehicle.
9. Check the axle alignment. For instructions, refer to **Group 35** of this manual. If necessary, adjust the rear axle alignment, using the instructions in **Subject 130**.

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## Adjustment

1. Using a straightedge and a tape measure, determine the amount of adjustment needed to align the axle at a right angle to the frame. For instructions, refer to **Group 35**. The difference in measurements between the sides of the vehicle is the approximate amount that the trailing end of the axle will have to be brought forward, or the leading end will have to be moved back to align it at a right angle to the frame. See **Fig. 1**.




A. Leading End
B. Trailing End
1. Front Axle
2. Rear Axle

**Fig. 1, Single Axle, Shown Out of Alignment**

NOTE: To adjust the axle alignment, add washers between the radius rod front pin and the forward spring bracket on the leading end, to adjust the leading end backward. Or, remove washers from the trailing end, to bring the trailing end forward. When possible, alignment washers should be removed instead of added.

2. On both sides of the axle, loosen the axle U-bolts enough to allow the springs to shift on the axle seats.
3. On the side of the vehicle that is to be adjusted, remove the fasteners that attach the radius rod to the forward spring bracket. Remove any axle alignment washers.
4. Raise the frame just enough to relieve the weight from the springs. Place safety stands under the frame. Make sure the stands will support the weight of the frame.
5. Move the loosened end of the axle forward or backward as needed, by rolling the wheels.
6. Insert the correct thickness of axle alignment washers between the radius rod front pin and the forward spring bracket.
7. Install the hexhead bolt, hardened washers, and locknut in the radius rod pin and forward spring bracket. Place an equal thickness of washers on the other end of the radius rod pin, and install the fasteners.
8. Tighten the locknuts to the applicable torque value in **Specifications, 400**.
9. Remove the safety stands, and lower the vehicle. Remove the chocks from the front tires.
10. Check the axle alignment with the straightedge and the tape measure. If alignment is within specifications, center the spring in the forward spring bracket, if needed, then tighten the axle U-bolt nuts to the torque value in **Specifications, 400**.

    If not in alignment, repeat the procedure above.

**CAUTION**

**Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.**

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, refer to **Group 32** of the *Western Star Maintenance Manual*.

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## Specifications

| Torque Values | | | |
|---|---|---|---|
| **Description** | **Size** | **IFI Grade** | **Torque: lbf·ft (N·m)** |
| Forward Spring Bracket-to-Frame Rail Locknut* | 3/4–10 | C | 240 (325) |
| Axle U-Bolt High Nuts (see **Fig. 1** for tightening pattern) | 7/8–14 | C | Stage 1: Hand tighten<br>Stage 2: 60 (81)<br>Stage 3: 200 (271)<br>Stage 4: 420 to 500 (571 to 680) |
| | 1–14 | C | Stage 1: Hand tighten<br>Stage 2: 60 (81)<br>Stage 3: 200 (271)<br>Stage 4: 520 to 600 (707 to 816) |
| Rear Spring Bracket-to-Frame Rail Locknut | 5/8–11 | C | 135 (184) |
| Radius Rod Locknut* | 5/8–18 | C | 135 (184) |

* Cadmium-plated, wax-coated nuts, and grade 8 hexbolts with phosphate- and oil-coated threads; both used with hardened washers.

**Table 1, Torque Values**

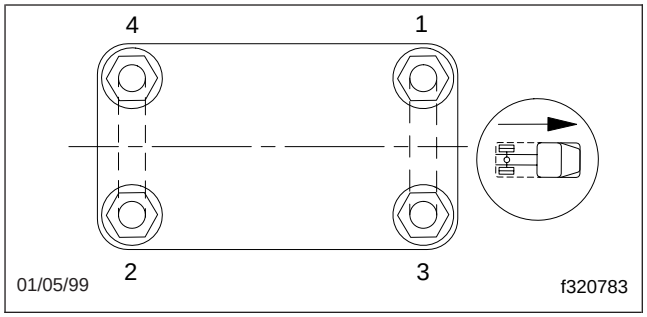



**Fig. 1, Tightening Pattern for U-Bolt High Nuts**

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## General Description

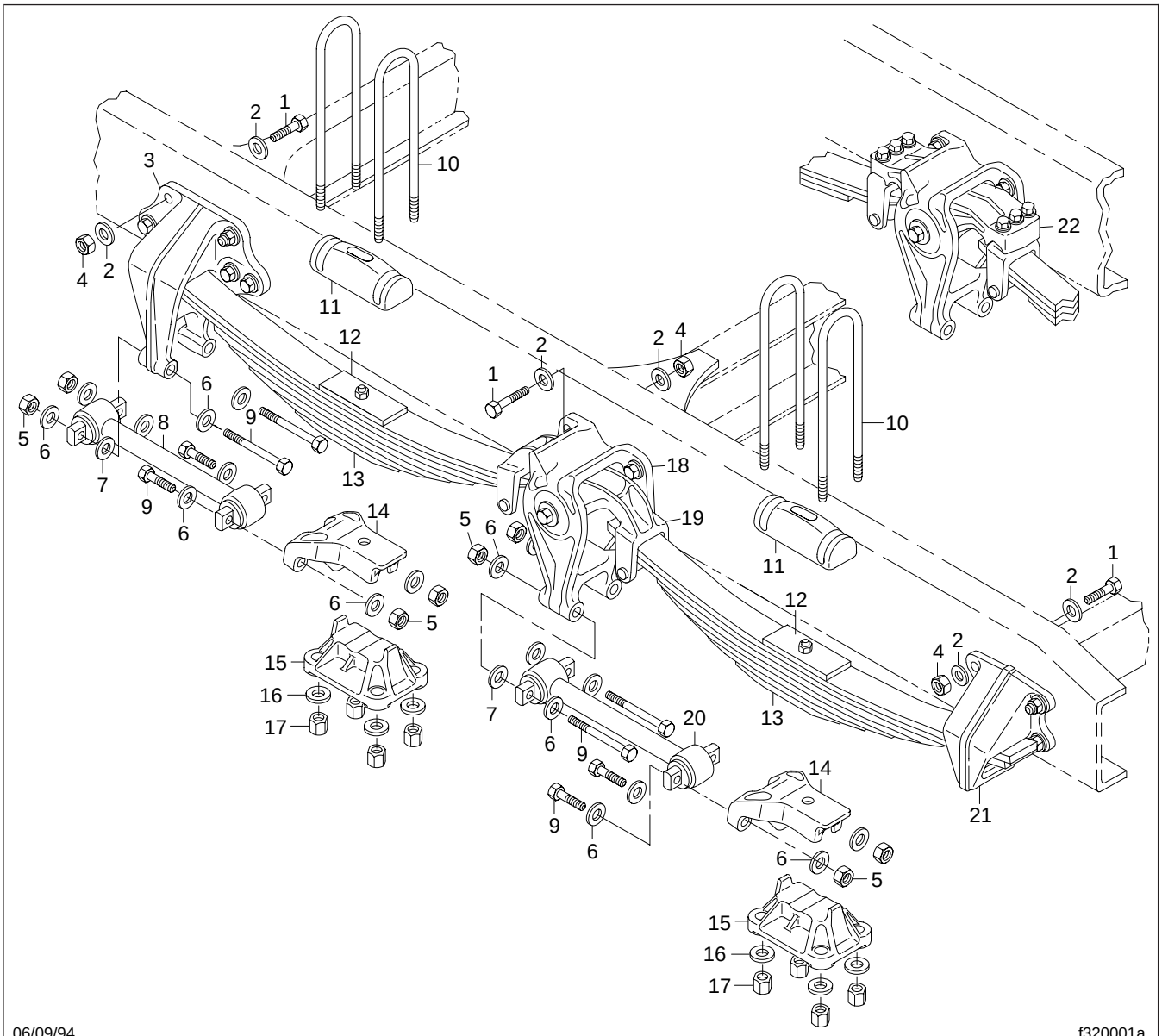
The tandem-axle rear spring suspension (**Fig. 1**) uses a six-point equalizing leaf spring design, which compensates for axle articulation, from side to side, and front to rear. Four semi-elliptical spring assemblies are attached to the axles with U-bolts. On both sides of the vehicle, the forward end of the forward spring and the rear end of the rear spring ride in aluminum brackets that are mounted on the frame rails. Steel wear shoes are cast into each bracket.

At the center, between the forward and rear springs, the springs ride on an equalizer, which pivots on a sleeve in the equalizer bracket. Equalizer travel is stopped when the top of the equalizer and equalizer bracket make contact. Each axle is held in alignment by a pair of radius rods that extend forward from the axle seats to the forward spring brackets for the forward-rear axle, and to the equalizer brackets for the rearmost axle.

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## General Information




1. Suspension Bracket Hexbolt
2. Hardened Washer
3. Forward Spring Bracket
4. Suspension Bracket Hex Locknut
5. Radius Rod Hex Locknut
6. Hardened Washer
7. Axle Alignment Washer
8. Forward Radius Rod
9. Radius Rod Hexbolt
10. U-Bolt
11. U-Bolt Pad
12. Spring Liner
13. Leaf Spring Assembly
14. Spring Seat
15. U-Bolt Retainer
16. Hardened Washer
17. U-Bolt High Nut
18. Equalizer Bracket
19. Equalizer, One-Piece (tandem drive axles)
20. Rear Radius Rod
21. Rear spring Bracket
22. Equalizer, Three-Piece (tag or pusher axle)

**Fig. 1, Tandem-Axle Spring Suspension**

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# Radius Rod Removal and Installation

## Removal

1. Apply the parking brakes, and chock the tires.
2. Note the number of axle alignment washers (**Fig. 1**) at the forward end of each radius rod that is being removed.
3. Remove the fasteners that attach the radius rod to the forward spring bracket or equalizer bracket, and to the axle seat.
4. Remove the radius rod and any axle alignment washers.

## Installation

IMPORTANT: At all points where steel parts (including bolts, washers, and nuts) contact aluminum brackets, apply Alumilastic compound, or an equivalent, on the mating surfaces.

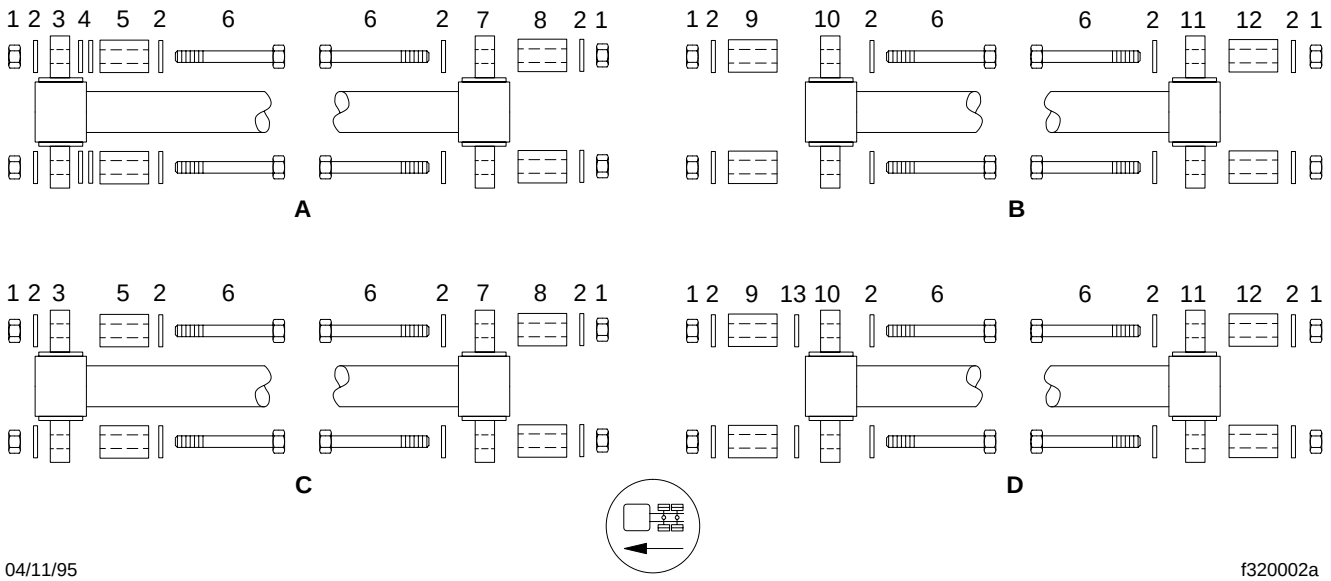
**CAUTION**

**Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the suspension.**

If installing forward and rear radius rods (**Fig. 1**), install the forward radius rod before installing the rear radius rod.

1. If installing a forward radius rod, place the radius rod front pin on the front side of the forward spring bracket, and place the radius rod rear pin in front of the axle seat.

   If installing a rear radius rod, place the radius rod pins between the rear side of the equalizer bracket and the front side of the axle seat.




A. Forward Right-Side Radius Rod
B. Rear Right-Side Radius Rod
C. Forward Left-Side Radius Rod
D. Rear Left-Side Radius Rod

1. Hex Locknut
2. Hardened Washer
3. Forward Radius-Rod Front Pin
4. Alignment Washers (Install only on one side of front axle; right-side installation shown.)
5. Forward Spring Bracket
6. Hexbolt
7. Forward Radius Rod Rear Pin
8. Forward Axle Seat
9. Equalizer Bracket
10. Rear Radius-Rod Front Pin
11. Rear Radius-Rod Rear Pin
12. Rear Axle Seat
13. Alignment Washers (Install only on one side of rear axle; left-side installation shown.)

**Fig. 1, Radius Rod Attachment (top view)**

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## Radius Rod Removal and Installation

2. Install a hexhead bolt with a hardened washer through each end of the radius rod rear pin and the axle seat ears. Install the hardened washers and locknuts.
3. If installing a forward radius rod, install any previously removed axle alignment washers between the radius rod front pin and the forward spring bracket. Install the hexhead bolts, hardened washers, and locknuts.

   If installing a rear radius rod, install any previously removed axle alignment washers between the radius rod front pin and the equalizer bracket. Install the hexhead bolts, hardened washers, and locknuts.
4. Tighten the radius rod locknuts to the torque value in **Specifications, 400**.
5. After all of the radius rods are installed, check the rear axle alignment. For instructions, see **Group 35**. If necessary, adjust the axle alignment, using the instructions in **Subject 140**.

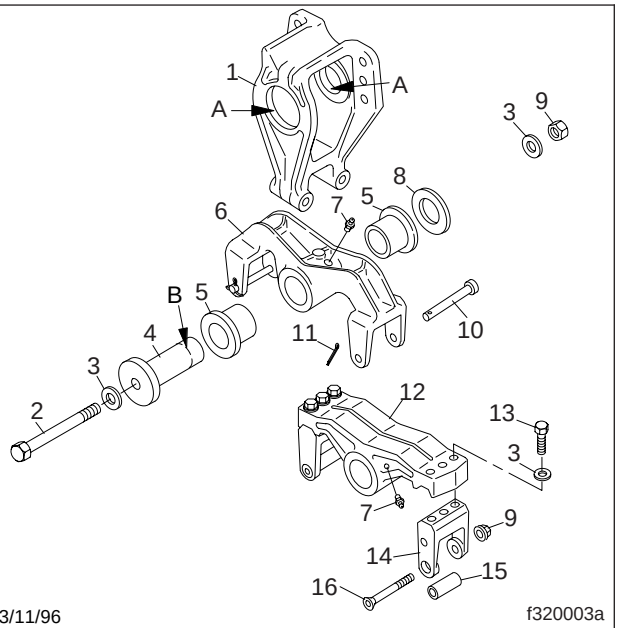
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## Equalizer Removal, Inspection, and Installation

# Removal

1. Chock the front tires.
2. Raise the rear of the vehicle, and block the axles with safety stands. Raise the vehicle frame so that all weight is removed from the leaf springs, then block the frame with safety stands. Make sure the stands will securely support the weight of the axles and frame. To allow access to the equalizer (**Fig. 1**), remove the wheel assemblies on that side, using the instructions in **Group 40**.




A. Apply Loctite here.
B. No grease.
1. Equalizer Bracket
2. Hexhead Bolt
3. Bearing Washer
4. Cap and Tube Assembly
5. Equalizer Assembly Bushing
6. Equalizer (used on vehicles with two drive axles)
7. Grease Fitting
8. Wear Washer(s)
9. Locknut
10. Spring Retainer Pin
11. Cotter Pin
12. Equalizer (used on vehicles with a tag or pusher axle)
13. Capscrew
14. Wear-Shoe Side-Restraint
15. Side-Restraint Sleeve
16. Flathead Bolt

**Fig. 1, Equalizer Assembly**

3. If removing an equalizer from a vehicle with two drive axles, remove the cotter pin from the outboard end of each spring retainer pin, then remove the retainer pins.

   If removing an equalizer from a vehicle with a pusher or tag axle, remove the nuts from the flathead bolts in the wear-shoe side-restraints, on each end of the equalizer. Remove the flathead bolts and side-restraint sleeves. Remove the six capscrews and washers, and remove both wear-shoe side-restraints from the equalizer.
4. Remove the cap and tube assembly locknut, inboard bearing washer, bolt, and outboard bearing washer.
5. Insert a bar between the bottom of the equalizer and the equalizer bracket. Gently lever the weight of the equalizer off the cap and tube assembly. Insert a piece of barstock through the inboard cap and tube assembly bolt hole, and lightly tap the cap and tube assembly out of the equalizer.
6. Remove the equalizer from the equalizer bracket. Remove the wear washer(s) and equalizer bushings from the equalizer.

# Inspection

1. Thoroughly clean the equalizer with steam or a hot soap solution. Inspect it for wear, cracks,or other damage. Replace the equalizer if any of these conditions are present.

**⚠ CAUTION**

**Failure to replace the equalizer if it is cracked or otherwise damaged could result in progressive damage to, and eventual breakage of the equalizer. Breakage of the equalizer could cause a loss of vehicle control, resulting in personal injury or property damage.**

2. Inspect the equalizer bushings, cap and tube assembly, and the equalizer bracket for wear, cracks, or other damage. If any of these conditions are present, replace the bushings or the cap and tube assembly.

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## Equalizer Removal, Inspection, and Installation

## Installation

1. Apply a thin film of multipurpose chassis grease to the outside of the equalizer bushings, then install the bushings in the equalizer. See **Fig. 1**.
2. Install the equalizer in the equalizer bracket.

NOTE: The next four steps must be completed before the Loctite begins to cure (approximately 5 to 10 minutes).

3. Apply Loctite 680 to both interior surfaces of the equalizer bracket, where the cap and tube assembly is inserted. Apply multipurpose chassis grease to the cap and tube assembly, except the last inch which connects to the equalizer bracket. Start the cap and tube assembly into the equalizer, through the equalizer bracket.
4. Push the cap and tube assembly part way through the equalizer, then place the wear washer(s) between the inboard equalizer bushing and the equalizer bracket. Push the cap and tube assembly the rest of the way into the equalizer bracket.
5. Place the outboard bearing washer on the equalizer cap and tube assembly bolt, and install the bolt in the cap and tube assembly.
6. Install the inboard bearing washer and locknut on the cap and tube assembly bolt. Tighten the locknut to the torque value in **Specifications, 400**.
7. Lubricate the equalizer assembly by applying multipurpose chassis grease at the grease fitting. Lubricate with a hand gun or pressure gun until grease is forced past the bushing seals, or if equipped with a pressure-relief grease fitting, until grease is forced out from the base of the pressure relief fitting.
8. If installing an equalizer on a vehicle with two drive axles, apply Alumilastic compound, or an equivalent, to the spring retainer pins, then install them from the inboard side. Be sure the hooked ends of the spring leaves are above the retainer pins. Install a cotter pin in the outboard end of each retainer pin, and lock it in place.

   If installing an equalizer on a vehicle with a pusher or tag axle, apply Alumilastic compound, or an equivalent, to the surfaces where the wear-shoe side-restraints contact the equalizer. Attach the side-restraints to the equalizer, offsetting them toward the inboard side of the equalizer. Tighten the equalizer wear-shoe capscrews to the torque value in **Specifications, 400**. Install the side-restraint sleeves and flathead bolts in the wear-shoe side-restraints. Be sure the hooked ends of the spring leaves are above the side-restraint sleeves. Install the nuts, and tighten them to the applicable torque value in **Specifications, 400**.

**⚠ CAUTION**

**Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel contact each other, could lead to corrosion of the metals, resulting in suspension damage.**

9. Install the wheel assemblies, using the instructions in **Group 40**. Remove the safety stands from under the frame and axle, and lower the vehicle.
10. If the radius rods have been loosened, or the equalizer bracket has been removed, check the rear axle alignment. For instructions, see **Group 35**. If necessary, adjust the axle alignment using the instructions in **Subject 140**.

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## Replacement

**WARNING**

**Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.**

1. Chock the front tires.
2. Raise the frame so that all weight is removed from the leaf springs; then block the frame with safety stands. Raise the rear axle until the spring no longer contacts the spring bracket wear shoes and the spring retainer pin (or side-restraint sleeve); then block the axle. Make sure the stands will securely support the weight of the axles and frame. To access the spring assembly, remove the wheel assembly. See **Group 40** for instructions.
3. If equipped with two drive axles, remove the cotter pin from the spring retainer pin on the end of the equalizer where the spring is being replaced. See **Fig. 1**. Drive the spring retainer pin out of the equalizer.

   If equipped with a pusher or tag axle, remove the nut from the flathead bolt on the end of the equalizer where the spring is being replaced. Remove the bolt and the side-restraint sleeve from the wear-shoe side-restraint.
4. Remove the U-bolt high nuts, hardened washers, U-bolt retainer, U-bolts, and upper U-bolt pad.
5. Remove the spring assembly by lifting it off the axle seat, then moving it toward the equalizer, out of the forward or rear spring bracket.
6. Using chassis grease, lubricate the new spring assembly where the ends will contact the stationary wear shoes in the spring bracket and equalizer.
7. Place the new spring assembly in the spring bracket and on the axle seat. Make sure the spring center-bolt head seats in the axle seat hole.
8. If the upper U-bolt pad is aluminum, apply Alumilastic compound, or an equivalent, to those areas of the pad that will come in contact with the U-bolts and with the upper spring leaf.

**CAUTION**

**Failure to apply Alumilastic® compound, or an equivalent, to areas where aluminum and steel contact each other, could lead to corrosion of the metals, resulting in suspension damage.**

9. Place the upper U-bolt pad on the spring assembly. Place the U-bolts over the upper U-bolt pad and the spring assembly.
10. Install the U-bolt retainer, hardened washers, and U-bolt high nuts. Tighten the high nuts until snug.
11. If installing a spring assembly on a vehicle with two drive axles, apply Alumilastic compound, or an equivalent, to the spring retainer pins, then install them from the inboard side. Be sure the hooked ends of the spring leaves are above the retainer pins. Install a cotter pin in the outboard end of each retainer pin, and lock it in place.

    If installing a spring assembly on a vehicle with a pusher or tag axle, install the side-restraint sleeves and flathead bolts in the wear-shoe side-restraints. Be sure the hooked ends of the spring leaves are above the side-restraint sleeves. Install the nuts, and tighten them to the applicable torque value in **Specifications, 400**.
12. In a diagonal pattern, hand tighten the axle U-bolt high nuts. In the same pattern, tighten them 100 lbf·ft (136 N·m); then, 200 lbf·ft (270 N·m); then, 300 lbf·ft (407 N·m); then, torque to the final value of 420 lbf·ft (569 N·m).

**CAUTION**

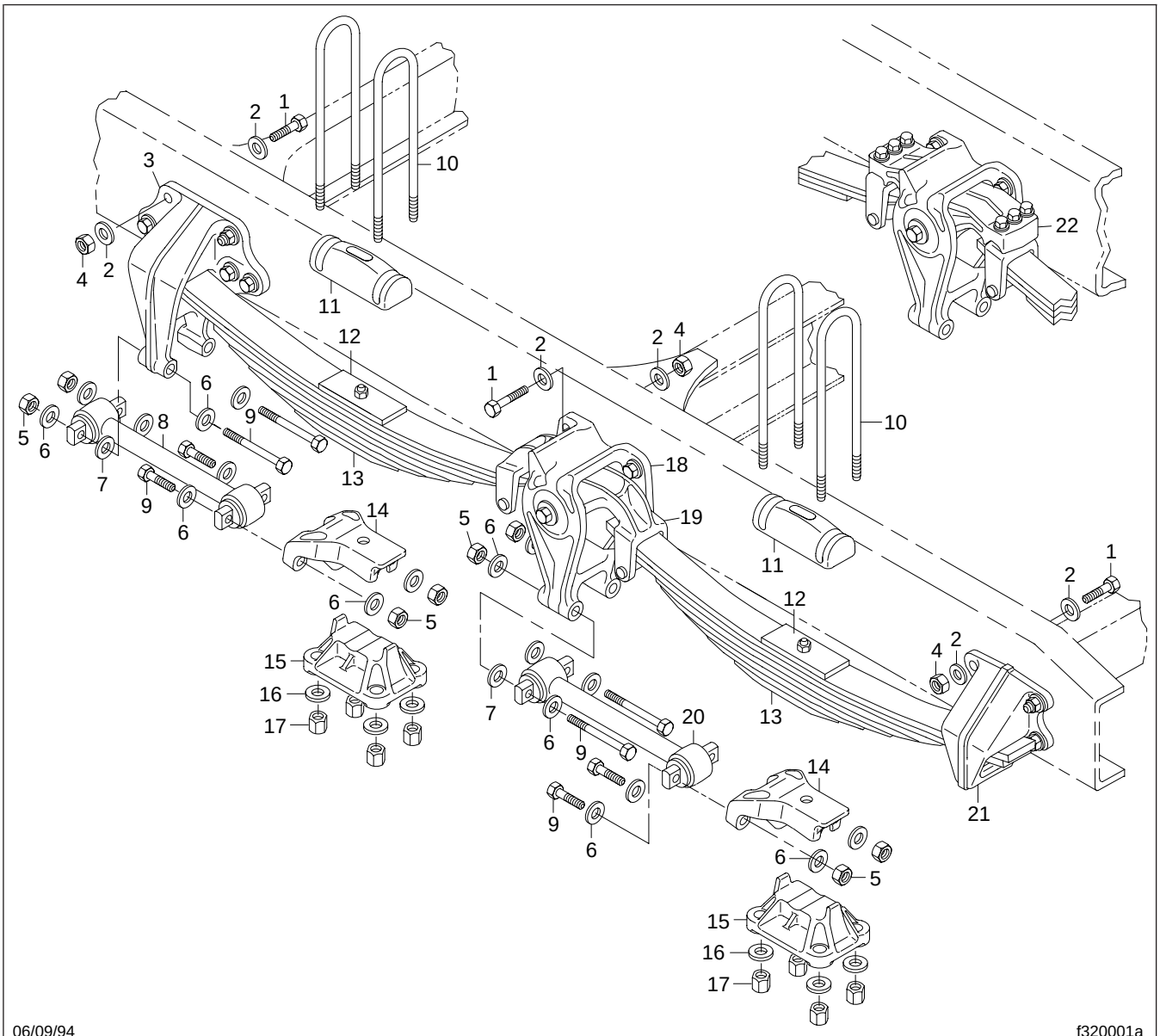
**Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.**

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see **Group 32** of the *Western Star Maintenance Manual*.

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## Spring Assembly Replacement




1. Suspension Bracket Hexbolt
2. Hardened Washer
3. Forward Spring Bracket
4. Suspension Bracket Hex Locknut
5. Radius Rod Hex Locknut
6. Hardened Washer
7. Axle Alignment Washer
8. Forward Radius Rod
9. Radius Rod Hexbolt
10. U-Bolt
11. U-Bolt Pad
12. Spring Liner
13. Leaf Spring Assembly
14. Spring Seat
15. U-Bolt Retainer
16. Hardened Washer
17. U-Bolt High Nut
18. Equalizer Bracket
19. Equalizer, One-Piece (tandem drive axles)
20. Rear Radius Rod
21. Rear spring Bracket
22. Equalizer, Three-Piece (tag or pusher axle)

**Fig. 1, Tandem-Axle Spring Suspension**

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13. Install the wheel assembly, using the instructions in **Group 40**. Remove the safety stands from under the frame and axle, and lower the vehicle.
14. Check the rear axle alignment. For instructions, see **Group 35**. If necessary, adjust the axle alignment, using the instructions in **Subject 140**.

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# Spring Bracket and Equalizer Bracket Replacement

## Replacement

**⚠ WARNING**

**Replace worn, cracked, or damaged spring brackets or equalizer brackets. Failure to do so could result in breakage of the bracket, possibly leading to loss of vehicle control and resulting in personal injury or property damage.**

IMPORTANT: At all points where steel parts contact the aluminum spring brackets, apply Alumilastic compound, or an equivalent, on the mating surfaces.

**⚠ CAUTION**

**Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the suspension.**

1. Chock the front tires.
2. Raise the rear of the vehicle, and block the axles with safety stands. Raise the vehicle frame so that all weight is removed from the leaf springs, then block the frame with safety stands. Make sure the stands will securely support the weight of the axles and frame.
3. If removing the forward spring bracket or the equalizer bracket, note the number of any axle alignment washers, then remove the fasteners that attach the radius rod to the forward spring bracket or equalizer bracket. Remove any axle alignment washers. See **Fig. 1**.
4. If removing an equalizer bracket, remove the equalizer. For instructions, see **Subject 110**.
5. Remove the fasteners that attach the forward or rear spring bracket, or equalizer bracket, to the frame rail. Remove the bracket.
6. Place the new spring bracket or equalizer bracket on the frame rail. Align the mounting holes, and install the bracket bolts, hardened washers, and locknuts.

NOTE: If installing the forward spring bracket, install the nuts for the top two bolts on the outboard side of the frame rail, and install the nuts for the bottom four bolts on the inboard side of the frame rail. See **Fig. 2**.

If installing the equalizer bracket, for clearance, install all of the nuts on the inboard side of the frame rail. See **Fig. 2**.

If installing the rear spring bracket, install the nuts for the top two bolts on the outboard side of the frame rail, and install the nuts for the bottom two bolts on the inboard side of the frame rail. See **Fig. 2**.

7. Tighten the bracket mounting locknuts to the applicable torque value in **Specifications, 400.**

**⚠ CAUTION**

**Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.**

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see **Group 32** of the *Western Star Maintenance Manual*.

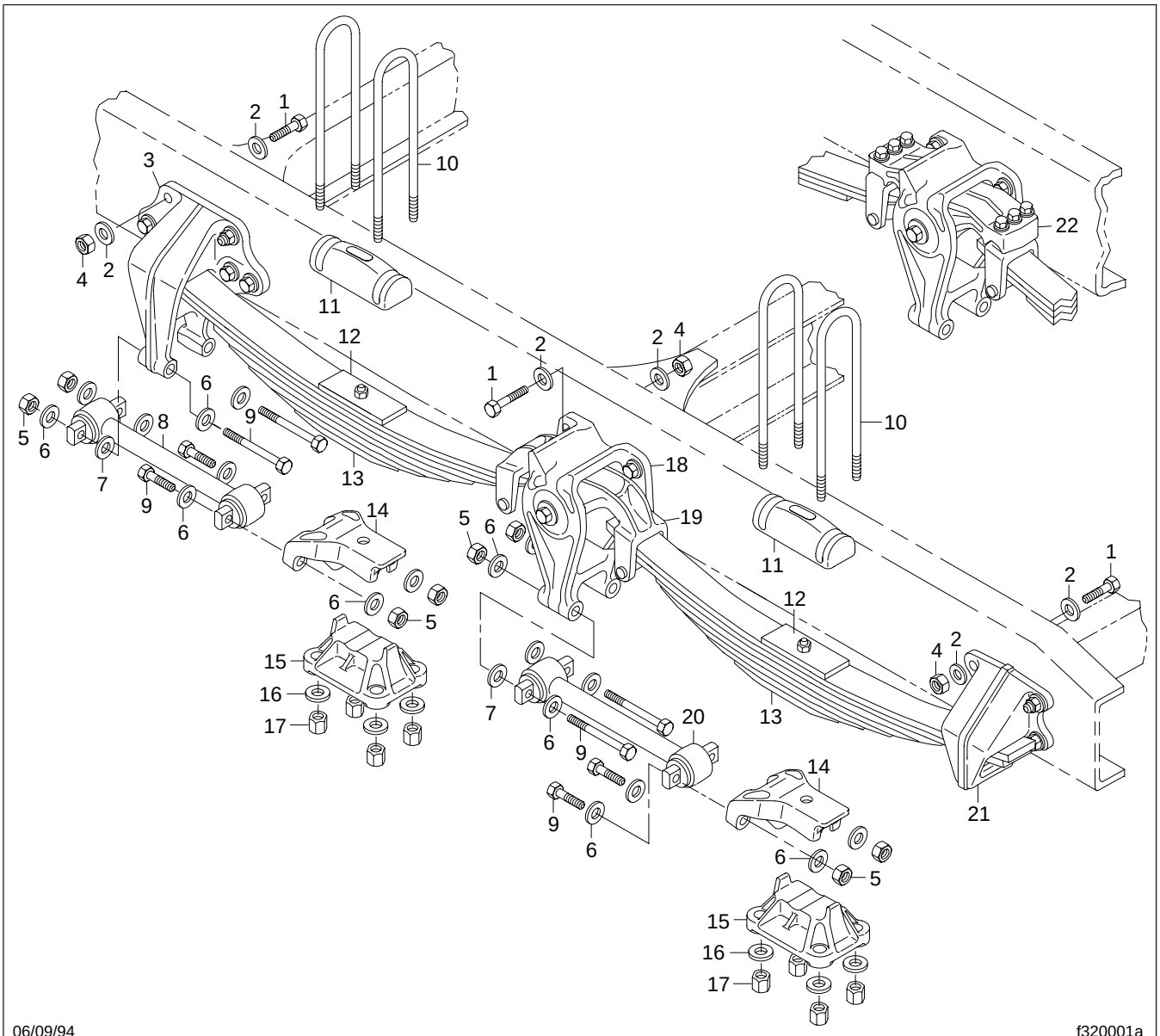
8. When replacing the forward spring bracket or equalizer bracket, install any previously removed axle alignment washers between the forward radius rod front pin and the forward spring bracket, or between the rear radius rod front pin and the equalizer bracket, as applicable. See **Fig. 3**.

   Install bolts with hardened washers in the radius rod front pin, and the forward spring bracket or equalizer bracket. Install the hardened washers and locknuts, and tighten the locknuts to the torque value in **Specifications, 400**.
9. If replacing an equalizer bracket, install the equalizer. For instructions, see **Subject 110**.
10. Remove the safety stands from under the frame and axle, and lower the vehicle.
11. Check the rear axle alignment. For instructions, see **Group 35** in this manual. If necessary,adjust the axle alignment, using the instructions in **Subject 140**.

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## Spring Bracket and Equalizer Bracket Replacement



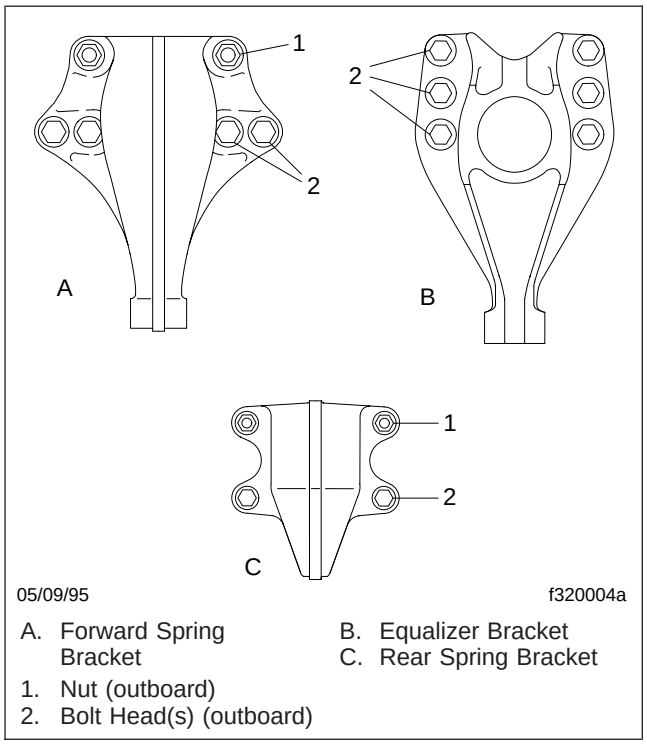

1. Suspension Bracket Hexbolt
2. Hardened Washer
3. Forward Spring Bracket
4. Suspension Bracket Hex Locknut
5. Radius Rod Hex Locknut
6. Hardened Washer
7. Axle Alignment Washer
8. Forward Radius Rod
9. Radius Rod Hexbolt
10. U-Bolt
11. U-Bolt Pad
12. Spring Liner
13. Leaf Spring Assembly
14. Spring Seat
15. U-Bolt Retainer
16. Hardened Washer
17. U-Bolt High Nut
18. Equalizer Bracket
19. Equalizer, One-Piece (tandem drive axles)
20. Rear Radius Rod
21. Rear spring Bracket
22. Equalizer, Three-Piece (tag or pusher axle)

**Fig. 1, Tandem-Axle Spring Suspension**

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## Spring Bracket and Equalizer Bracket Replacement



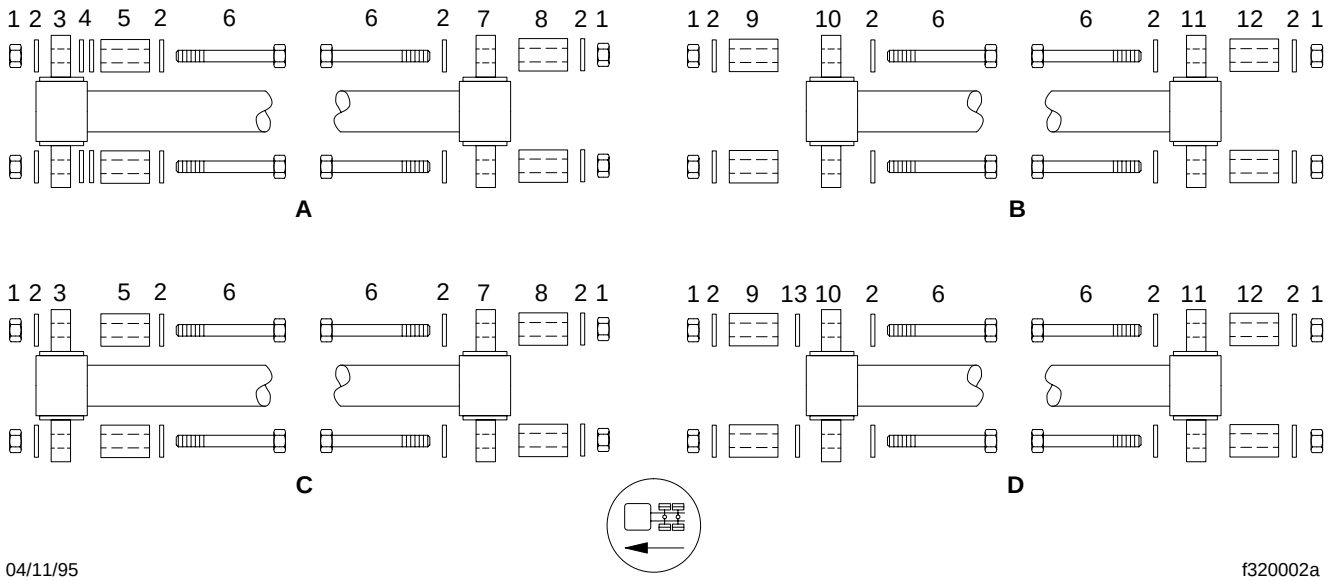

A. Forward Spring Bracket
B. Equalizer Bracket
C. Rear Spring Bracket
1. Nut (outboard)
2. Bolt Head(s) (outboard)

**Fig. 2, Frame Brackets**

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## Spring Bracket and Equalizer Bracket Replacement




A. Forward Right-Side Radius Rod
B. Rear Right-Side Radius Rod
C. Forward Left-Side Radius Rod
D. Rear Left-Side Radius Rod

1. Hex Locknut
2. Hardened Washer
3. Forward Radius-Rod Front Pin
4. Alignment Washers (Install only on one side of front axle; right-side installation shown.)
5. Forward Spring Bracket
6. Hexbolt
7. Forward Radius Rod Rear Pin
8. Forward Axle Seat
9. Equalizer Bracket
10. Rear Radius-Rod Front Pin
11. Rear Radius-Rod Rear Pin
12. Rear Axle Seat
13. Alignment Washers (Install only on one side of rear axle; left-side installation shown.)

**Fig. 3, Radius Rod Attachment (top view)**

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## Rear Axle Alignment Adjustment

## Adjustment

1. Using a straightedge and a tape measure, determine the amount of adjustment needed to align the forward-rear axle at a right angle to the frame. For instructions, see the rear axle section in this manual. The difference in measurements between the sides of the vehicle is the approximate amount that the trailing end of the forward-rear axle will have to be brought forward, or the leading end will have to be moved back to align it at a right angle to the frame. See **Fig. 1**.

   If the forward-rear axle alignment is within specifications, go to the step that begins "Using a center-point bar, determine...".

2. Chock the front tires. On both sides of the forward-rear axle, loosen the axle U-bolts enough to allow the springs to shift on the axle seats.

3. On the side of the vehicle that is to be adjusted, remove the fasteners that attach the forward radius rod to the forward spring bracket. Remove any axle alignment washers.

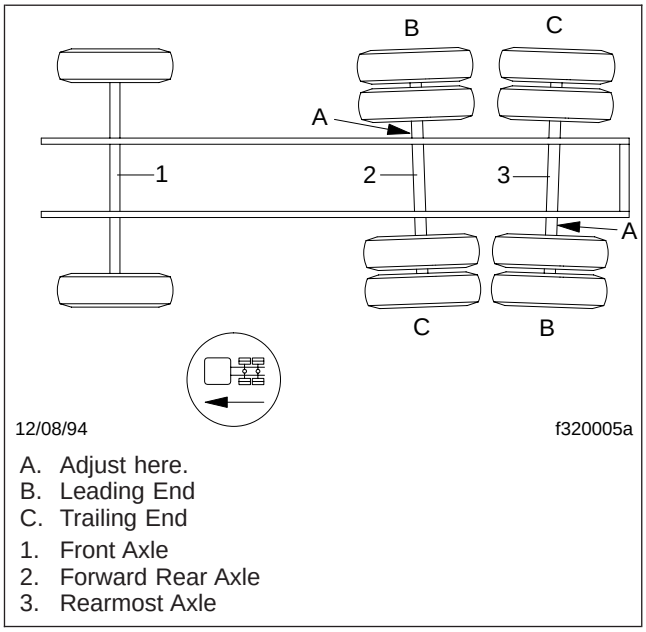
NOTE: To adjust the forward-rear axle alignment, add alignment washers between the radius rod and the forward spring bracket on the leading end, to adjust the leading end backward. Or, remove alignment washers from the trailing end, to bring the trailing end forward. When possible, alignment washers should be removed instead of added.

4. Raise the frame just enough to relieve the weight from the springs. Place safety stands under the frame. Make sure the stands will securely support the weight of the frame.

5. Move the loosened end of the axle forward or backward as needed, by rolling the wheels.

6. Between one end of the radius rod front pin and the forward spring bracket, insert the correct thickness of axle alignment washers needed to bring the forward-rear axle into alignment. Install the hexhead bolt, hardened washers, and locknut in the radius rod pin and forward spring bracket.

7. Place an equal thickness of washers on the other end of the radius rod pin, and install the fasteners.




A. Adjust here.
B. Leading End
C. Trailing End
1. Front Axle
2. Forward Rear Axle
3. Rearmost Axle

**Fig. 1, Tandem Axle, Shown Out of Alignment**

8. Tighten the radius rod locknuts to the torque value in **Specifications, 400**.

9. Remove the safety stands, and lower the vehicle.

10. Check the forward-rear axle alignment with the straightedge and the tape measure. If alignment is within specifications, center the spring in the forward spring bracket, if needed, then tighten the axle U-bolt nuts to the torque value in **Specifications, 400**.

    If not in alignment, repeat all of the steps above.

**CAUTION**

**Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.**

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see **Group 32** of the *Western Star Maintenance Manual*.

11. Using a center-point bar, determine the difference between the forward-rear and the rearmost axles' center-to-center measurements on each

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## Rear Axle Alignment Adjustment

side of the vehicle. For instructions, see **Group 35** in this manual. This difference is the approximate distance that the leading end of the rearmost axle will have to be adjusted rearward, or that the trailing end will have to be adjusted forward, to align it at a right angle to the frame, and to align it parallel to the forward-rear axle. See **Fig. 1**.

12. On both sides of the rearmost axle, loosen the axle U-bolts enough to allow the springs to shift on the axle seats.
13. On the side of the vehicle that is to be adjusted, remove the fasteners that attach the rear radius rod to the equalizer bracket. Remove any axle alignment washers.
14. Raise the frame just enough to relieve the weight from the springs. Place safety stands under the frame. Make sure the stands will securely support the weight of the frame.
15. Move the loosened end of the axle forward or backward, by rolling the wheels. Move the axle just enough to provide space to allow installation of alignment washers between the equalizer bracket and the radius rod pin.
16. Between one end of the radius rod pin and the equalizer bracket, insert the additional thickness of alignment washers needed to make up for the difference in center-point bar measurements.

    For example, if one end of the axle was equipped with a 3/16-inch (4.5-mm) thickness of washers, and the difference in the center-point bar measurements is 1/4 inch (6 mm) less on that side, add an additional 1/4 inch (6 mm) of washers (for a total of 7/16 inch [10.5 mm]) to correct the alignment.

    Or, if one end of the axle was equipped with a 1/4-inch thickness of washers, and the difference in center-point bar measurements is 3/16 inch (4.5 mm) more on that side, install a 1/16-inch (1.6-mm) thickness of washers in place of the 1/4-inch (6-mm) thickness.
17. Install the bolt, hardened washers, and locknut in the equalizer bracket and the radius rod pin. Place an equal thickness of alignment washers on the other end of the radius rod pin, and install the fasteners at that end.
18. Tighten the radius rod locknuts to the torque value in **Specifications, 400**.
19. Remove the safety stands, and lower the vehicle. Remove the chocks from the front tires.
20. Using the center-point bar, check the rearmost axle alignment. If alignment is within specifications, center the spring in the rear spring bracket, if needed, then tighten the axle U-bolt nuts to the applicable torque value in **Specifications, 400**.

    If not in alignment, repeat the applicable steps above.

**CAUTION**

**Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the springs, spring brackets, and frame rail.**

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see **Group 32** of the *Western Star Maintenance Manual*.

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## Specifications

| Torque Values | | | |
|---|---|---|---|
| **Description** | **Size** | **IFI Grade** | **Torque: lbf·ft (N·m)** |
| Forward Spring Bracket-to-Frame Rail Locknut* | 3/4–10 | C | 240 (325) |
| Axle U-Bolt High Nuts (see **Fig. 1** for the tightening pattern) | 7/8–14 | C | Stage 1: Hand tighten<br>Stage 2: 60 (81)<br>Stage 3: 200 (271)<br>Stage 4: 420 to 500 (571 to 680) |
| | 1–14 | C | Stage 1: Hand tighten<br>Stage 2: 60 (81)<br>Stage 3: 200 (271)<br>Stage 4: 520 to 600 (707 to 816) |
| Rear Spring Bracket-to-Frame Rail Locknut* | 5/8–11 | C | 135 (184) |
| Radius Rod Locknut* | 5/8–18 | C | 135 (184) |

* Cadmium-plated, wax-coated nuts, and grade 8 hexbolts with phosphate- and oil-coated threads; both used with hardened washers.

**Table 1, Torque Values**

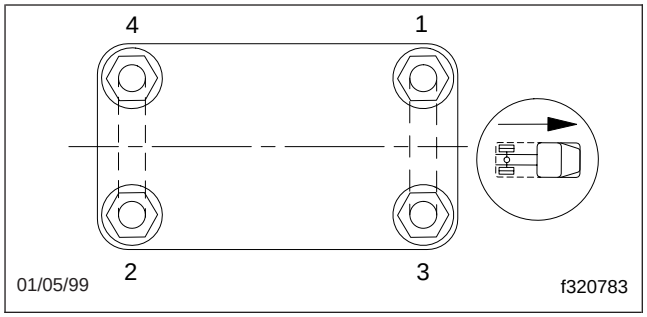



**Fig. 1, Tightening Pattern for U-Bolt High Nuts**

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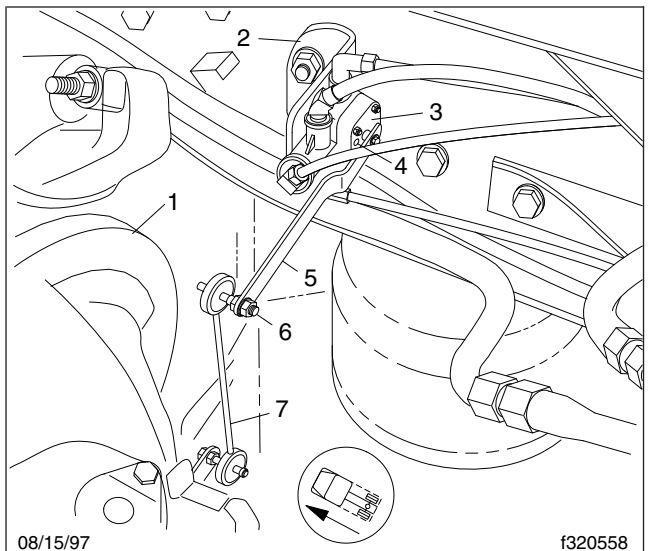
## General Information

The Freightliner AirLiner Suspension is a single-axle, tandem-axle, or tridem-axle suspension that uses a combination of air and leaf springs. The suspension is manufactured at numerous weight ratings up to 69,000 pounds (31 297 kg). The top of the air spring is bolted to a bracket on the frame rail, or through the bottom flange of the frame rail; the bottom is bolted to the rear end of the tapered leaf spring assembly or, for the 23,000-pound (10 433 kg) and 46,000-pound (20 865 kg) suspensions, to a cross bar. The axle housing is fastened to the leaf spring assembly by U-bolts. A control rod, mounted between the axle housing and the frame rail, can be used to help locate the assembly laterally.

The air springs compensate for changes in road conditions and vehicle load, maintaining vehicle height. The air springs also absorb road shock.

A height-control valve (**Fig. 1**) regulates the air flow into or out of all the air springs. As the air spring compresses or expands, changes in the clearance between the vehicle frame and the differential housing activate the height-control valve.

A pressure holding valve, located in the air line to the height-control valve, is preset to maintain a minimum pressure of 65 psi (448 kPa) in the vehicle secondary air system if a leak should occur in the air suspension system.




1. Forward Drive Axle
2. Valve Mounting Bracket
3. Height-Control Valve
4. Neutral-Position Hole
5. Horizontal Control Lever
6. Stud Bolt
7. Vertical Linkage

**Fig. 1, Barksdale Height-Control Valve Assembly**

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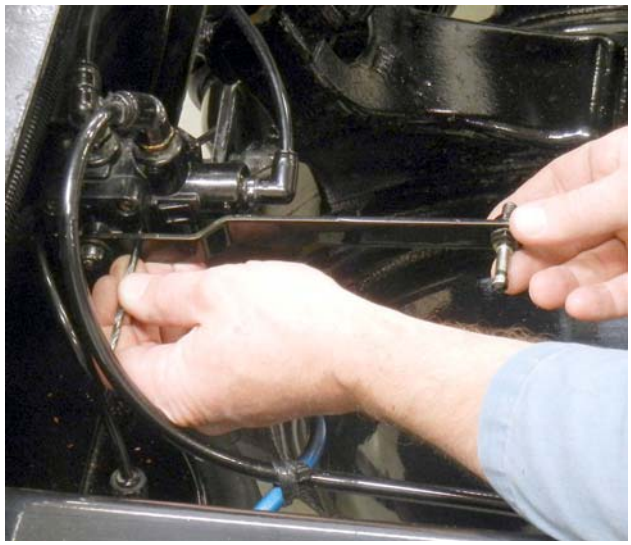


## Ride Height Adjustment

IMPORTANT: Before checking the suspension height, make sure there is no load on the chassis. For tractors, unhitch the trailer. Trucks must be empty.

Vehicles with dual ride height control valves follow the same procedure as single valves, but with two height gauge blocks, and both height control valves adjusted simultaneously. Both linkages should be disconnected when adjusting, and both valves should be repositioned once the correct ride height has been reached on both sides.

1. Park the vehicle on a level surface, using a light application of the brakes. Set the parking brake and chock the tires. Put the transmission in neutral. Build the secondary air pressure to at least 100 psi (690 kPa). Shut down the engine.
2. Space the tire chocks 2 inches (5 cm) ahead and behind the tire so the vehicle can roll 2 inches in either direction.
3. Release the parking brake and verify by hand that the vehicle can roll forward and aft. This should remove any load from the suspension.
4. Determine the correct ride height for the suspension:
    - Some common suspensions and ride height dimensions are shown in **Table 1**, **Table 2**, **Table 3**, **Table 4**, and **Table 5**.
    - In PartsPro, enter the VIN and Module "622" (Rear Suspension), and retrieve the Parts List. The installation drawing will be listed as a part with a D16 prefix. Use the EZ Wiring icon to view this drawing, which will specify where to measure the ride height and the target ride height distance for that suspension. This dimension is usually labelled the "E" dimension; the target ride height should be in a table on the same page of the drawing.
5. Measure the distance between either forward-most axle stop and the suspension using the dimension indicated in the drawing or figure for the suspension.
6. If the distance is within the acceptable range, no adjustment is needed. Apply the parking brakes. If the measurement is not within the acceptable range, go to the next step.
7. Disconnect the height-control valve linkage at the lever stud. (For dual valves, disconnect both.)
8. If there is not enough room for the block between the axle stop and the top pad, lift the valve lever to inflate the airbags enough to fit the block. (For dual valves, lift both levers.) Do not install the block yet.
9. Pin the lever in neutral position with a 5/32-inch drill bit or nylon rod to lock the lever in neutral position. See **Figure 1**.



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**Fig. 1, Inserting a 5/32-inch drill bit or nylon rod to lock the lever in neutral position.**

10. Install the height gauge block. (For dual valves, install a block on both sides.)
11. Unpin the valve lever and use it to lower the suspension until the axle stop rests on the block. (For dual valves, unpin and lower with both valves.)
12. Move the lever to neutral and pin. (For dual valves, pin both.) The vehicle should now be at the target ride height.

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## Ride Height Adjustment

### NOTICE

**When loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.**

13. While holding the height-control valve mounting studs in place with an Allen wrench, loosen the nuts that attach the valve to the mounting bracket. See **Figure 2**.



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**Fig. 2, Holding the height control valve mounting stud in place with an Allen wrench when loosening the nut.**

14. Adjust the position of the valve body until the lever—still pinned in neutral position—can connect to the linkage. Attach the linkage. The linkage rod should be vertical, and the valve body should now be in the correct position for the vehicle's ride height. (For dual valves, adjust and connect both.)

    If the linkage cannot reach the stud, check the surrounding components for bent or damaged parts and remedy as needed.

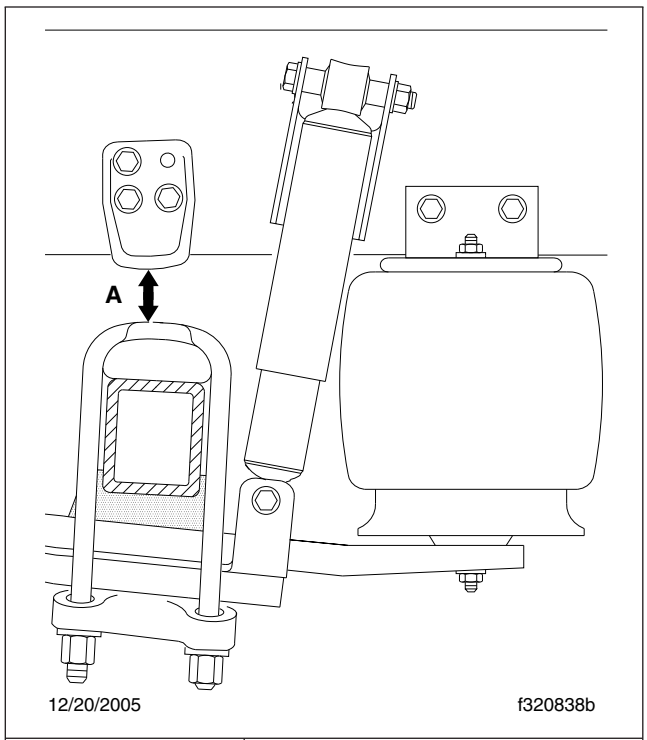
15. While holding the height-control valve mounting studs in place with an Allen wrench, tighten the nuts 95 lbf·in (1100 N·cm). Do not overtighten, as that could damage the valve. (For dual valves, tighten both.)
16. Disconnect the linkage from the valve lever stud. (For dual valves, disconnect both.)
17. Raise the valve lever to raise the suspension enough to remove the block, then pin the valve lever in neutral position. (For dual valves, raise and pin both valves.)
18. Remove the block. (For dual valves, remove both blocks.)
19. Remove the pin or drill bit holding the height-control lever in neutral position, then connect the valve lever to the linkage. (For dual valve, unpin and connect both valve levers.)
20. Drive the vehicle unloaded for about 1/4 mile (1/2 km), then park the vehicle on a level surface using a light brake application. Chock the tires on one axle only, and put the transmission in neutral. Do not apply the parking brakes.
21. Check the ride height of the vehicle again, measuring where indicated in the drawing or figure for the suspension.

    If the distance is within the acceptable range, the ride height is correctly set. Apply the parking brakes.

    If the distance is not within the acceptable range, repeat the adjustment procedure.

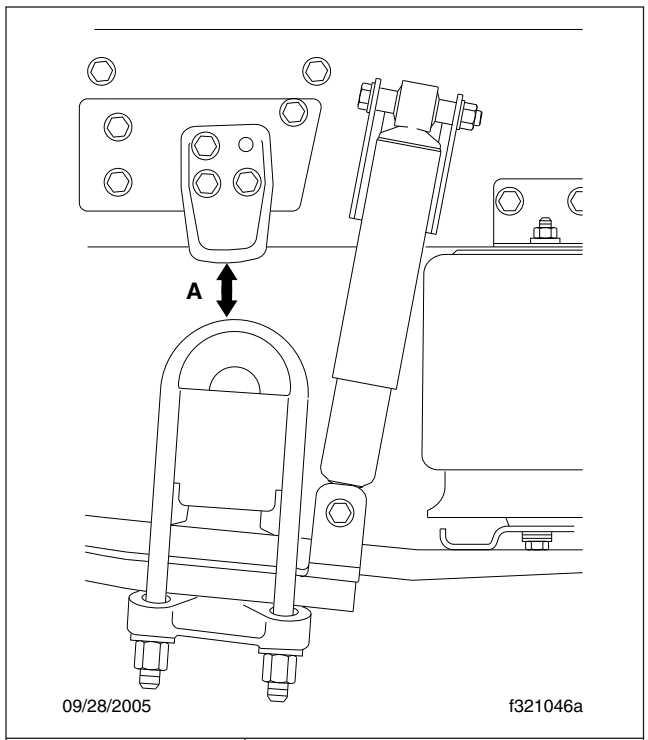
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| Measure Point | Height Measurement (A) Inches (mm) | | |
|---|---|---|---|
| | Min. | Target | Max. |
| A = Measure Here | 2-3/8 (60) | 2-5/8 (67) | 2-7/8 (73) |

**Table 1, Suspension Ride-Height Measurement, Dual-Leaf Spring, 20k/21k/22k/40k High-Ride**



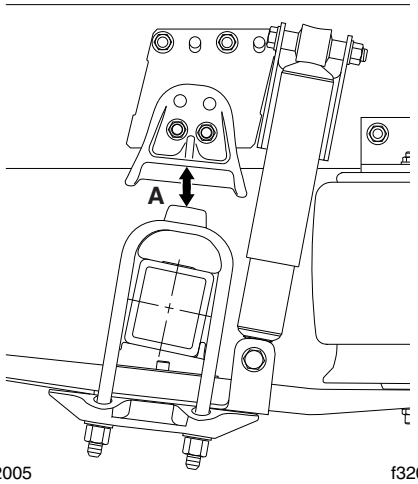

| Measure Point | Height Measurement (A) Inches (mm) | | |
|---|---|---|---|
| | Min. | Target | Max |
| A = Measure Here | 2-3/4 (70) | 3 (76) | 3-1/4 (83) |

**Table 2, Suspension Ride-Height Measurement, Dual-Leaf Spring, 23k/46k/69k High-Ride**

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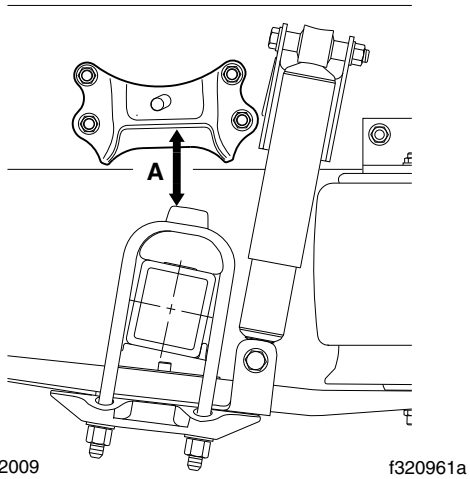


## Ride Height Adjustment




| Measure Point | Height Measurement (A) Inches (mm) | | |
|---|---|---|---|
| | Min. | Target | Max. |
| A = Measure Here | 2-3/8 (60) | 2-5/8 (67) | 2-7/8 (73) |

**Table 3, Suspension Ride-Height Measurement, Single-Leaf Spring, 20k/40k, High-Ride Height**

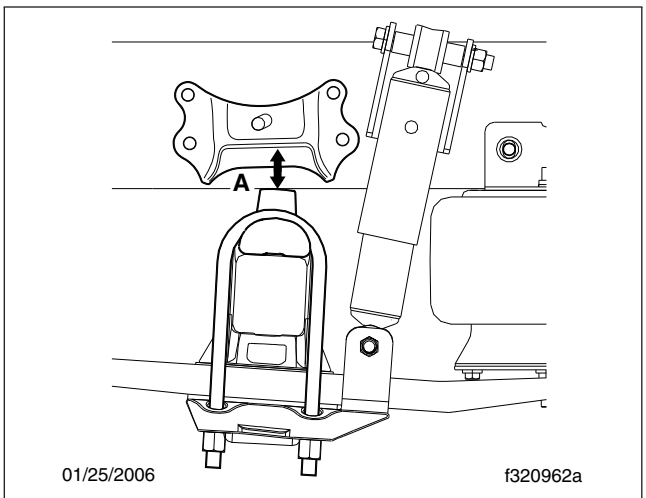



| Measure Point | Height Measurement (A) Inches (mm) | | |
|---|---|---|---|
| | Min. | Target | Max. |
| A = Measure Here | 2-3/8 (60) | 2-1/2 (64) | 2-7/8 (73) |

**Table 4, Suspension Ride-Height Measurement, Single-Leaf Spring, 10k/12k/15k/18k Mid-Ride Height and 40k Low- and Mid-Ride Height**

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| Measure Point | Height Measurement (A) Inches (mm) | | |
|---|---|---|---|
| | Min. | Target | Max. |
| A = Measure Here | 2-1/8 (54) | 2-9/32 (58) | 2-5/8 (67) |

**Table 5, Suspension Ride-Height Measurement, Single-Leaf Spring, 10k/12k/15k Low or Extra-Low Ride-Height**

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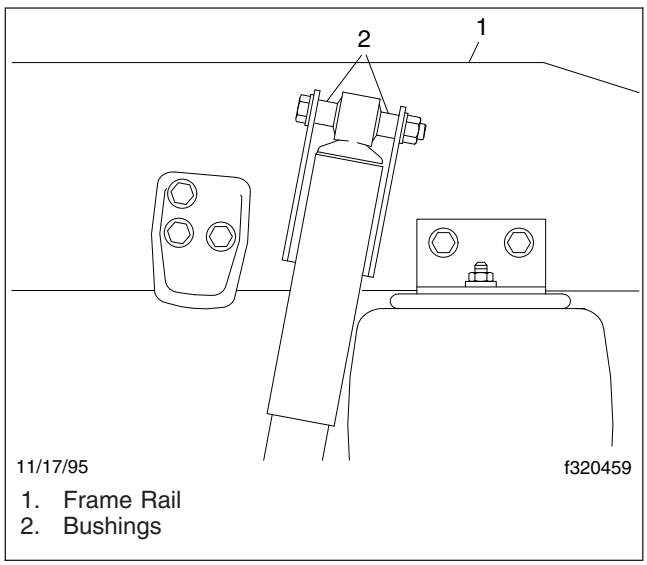
## Replacement

1. Chock the tires.
2. Remove the locknut, bolt, and spacer from the shock absorber lower mounting bracket.
3. Remove the nut, upper retainer, and upper bushing from the top of the shock absorber.
4. Pull the shock absorber out of the upper mounting bracket, and remove the retainer and bushing.
5. Install the replacement shock absorber, making sure the new bushings and retainers are correctly positioned. See **Fig. 1**.

**⚠ WARNING**

**Use only the retainers included with the replacement shock absorber. Do not use washers. They can be extruded over the nut and be ejected violently, possibly causing personal injury and property damage.**

6. Tighten the shock absorber lower mounting locknut 170 lbf·ft (230 N·m).
7. Tighten the shock absorber upper mounting nut to compress the bushings as shown in **Fig. 1**.




1. Frame Rail
2. Bushings

**Fig. 1, Shock Absorber Installation**

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## Air Spring Replacement

IMPORTANT: Effective March 2011, the steel bead on the inside of the air bag where it attaches to the piston, changed to a square bead to increase the pull-off force between the air bag and piston. The new air bag is stamped “BD8” and “Do Not Re-Assemble Rubber Bellow to Piston.” See **Fig. 1**. With this design change it is not possible to reseat the air bag to the piston. In the event of an air bag failure, or separation from the piston, the complete air-spring assembly must be replaced. For service it is acceptable to have a replacement air-spring assembly on one side of the vehicle, and an older style on the other side.

NOTE: The air-spring-to-frame-rail mounting bracket is not supplied with the air-spring assembly. If it needs to be replaced it must be ordered separately.

Follow these steps to replace the air-spring and piston assembly.

1. Chock the front tires. Raise the vehicle frame and support it with safety stands to remove all weight from the air springs. The leveling valve automatically releases air from the air springs when all weight is removed from the suspension.
2. Disconnect the air supply line,including the brass tee, from the air spring. Using tape, cover the ends of the air supply line and the fitting to prevent dirt or foreign material from entering.
3. Remove the locknuts and washers that connect the air spring to the upper mounting bracket, or to the frame rail flange. See **Fig. 2** and **Fig. 3**.
4. Remove the capscrews and lockwashers that connect the air spring to the rear of the leaf spring. Remove the air spring. See **Fig. 4**.

NOTE: Suspensions manufactured to a 46,000-pound (20 865 kg) or 23,000-pound (10 433 kg) weight rating have a different leaf spring, and an additional cross bar attached between the air spring and rear of the leaf spring. See **Fig. 5**.

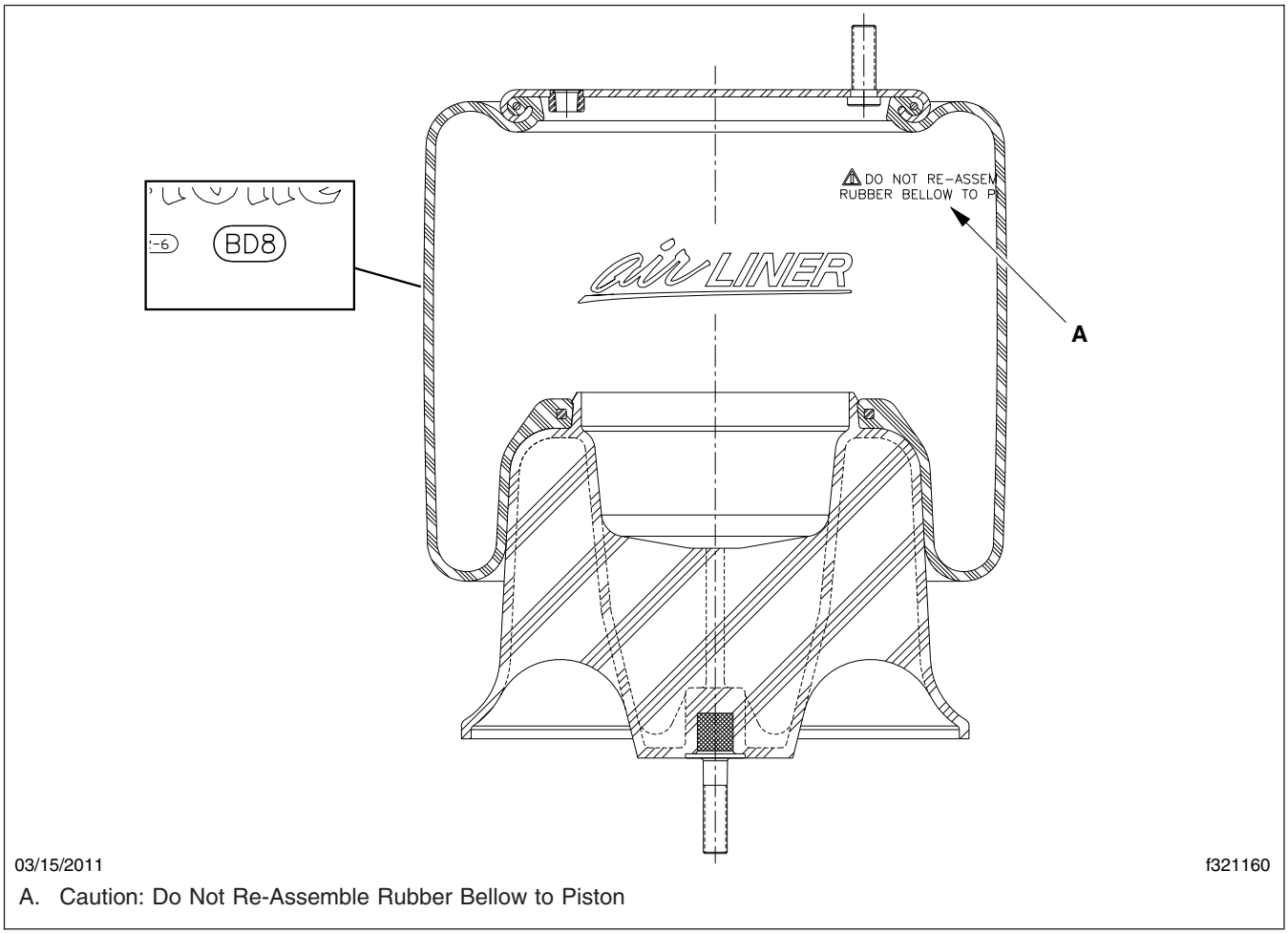
5. Place the new air spring on the rear of the leaf spring (or the cross bar on the 23,000- and 46,000-pound suspensions), and install the washer and locknut that hold the air spring (and cross bar) in place. See **Fig. 4**. Tighten the locknut 55 lbf·ft (75 N·m).
6. *For bracket-mounted air springs:* Attach the air spring to the upper mounting bracket, using the 1/2–13 locknut on the outside of the frame rail and the 3/4–16 locknut on the inside. See **Fig. 2**. Tighten the 3/4–16 locknut 45 lbf·ft (61 N·m); tighten the 1/2–13 locknut 23 lbf·ft (31 N·m).

   *For flange-mounted air springs:* Attach the air spring to the frame rail flange, using the 3/4–16 locknut on the forward stud of the air spring, and the 1/2–13 locknut on the rear stud. See **Fig. 3**. Tighten the 3/4–16 locknut 45 lbf·ft (61 N·m); tighten the 1/2–13 locknut 23 lbf·ft (31 N·m).
7. Remove the tape from the ends of the air supply line, the fitting, and the brass tee. Connect the air supply line to the air spring. Tighten nylon tube air fittings until only two threads show on the fitting. On wire-braid hose fittings, tighten the nut with a wrench until there is firm resistance, then tighten one-sixth turn more.
8. Remove the safety stands, and lower the vehicle. Remove the chocks from the tires.

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## Air Spring Replacement

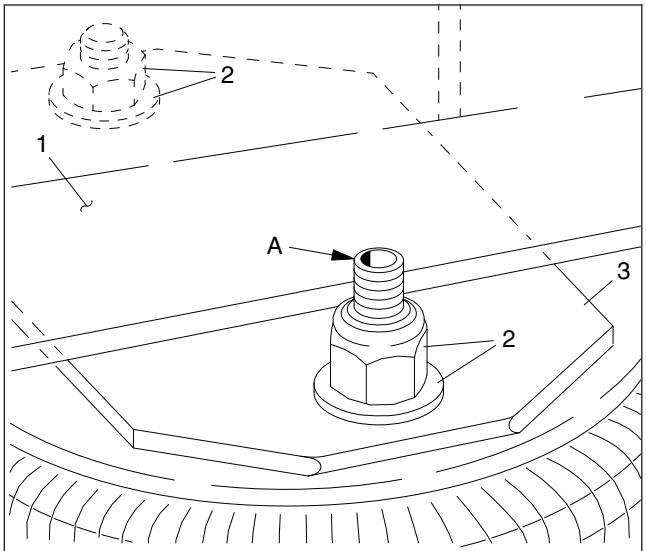



A. Caution: Do Not Re-Assemble Rubber Bellow to Piston

**Fig. 1, Air-Spring and Piston Assembly**

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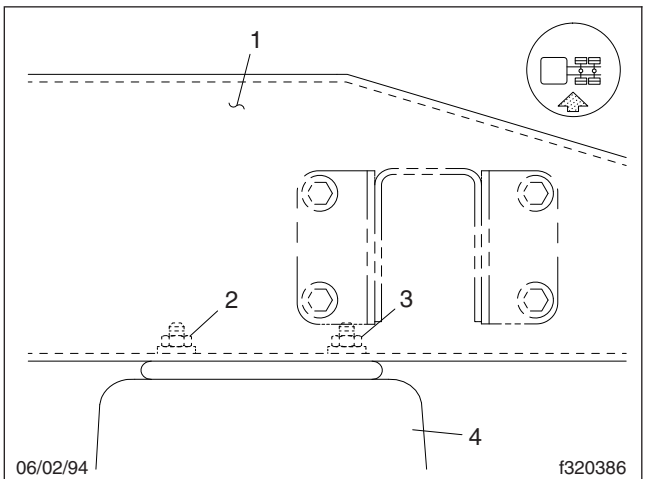





A. Air line connects here.

1. Right Frame Rail Flange
2. Locknut and Washer
3. Upper Mounting Bracket

**Fig. 2, Bracket-Mounted Air Spring**




1. Frame Rail (left)
2. 3/4–16 Locknut and Washer
3. 1/2–13 Locknut and Washer
4. Air Spring

**Fig. 3, Flange-Mounted Air Spring**

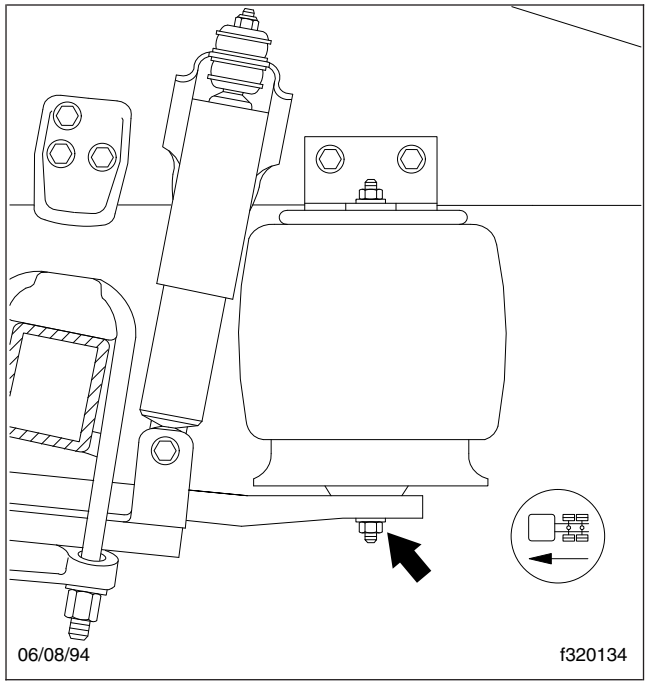
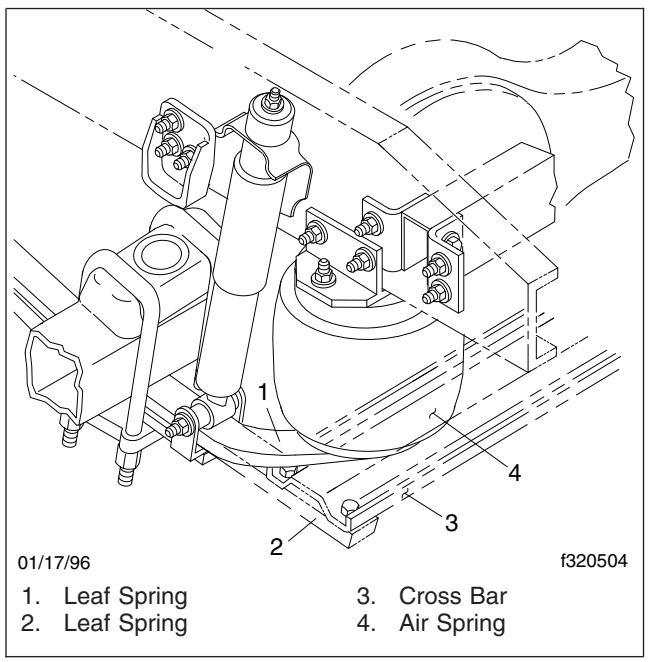



**Fig. 4, Capscrew Connecting Leaf Spring and Air Spring**




1. Leaf Spring
2. Leaf Spring
3. Cross Bar
4. Air Spring

**Fig. 5, Leaf Spring and Air Spring Assembly (23,000- and 46,000-pound suspensions)**

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## Leaf Spring Replacement

**WARNING**

**Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.**

1. Chock the front tires.
2. Raise the rear of the vehicle, and support the rear axle(s) with safety stands. Raise the vehicle so that all weight is removed from the leaf springs, then securely support the frame with safety stands. Remove the wheel and tire assembly to easily access the suspension. See the wheels and tires section in this manual for instructions.
3. Remove the nut, bolt, and washers from the shock absorber lower mounting bracket. See **Fig. 1**. Remove the high nuts, flatwashers, and axle clamp from each U-bolt. Support the leaf spring assembly with a jack.
4. If the air spring mounts to the leaf spring, disconnect the bottom of the air spring from the leaf spring.

   If the air spring mounts to a cross bar, disconnect the cross bar from the leaf spring by removing the capscrews, nuts, and washers. See **Fig. 2**.
5. Note the number and position of the alignment shims (see **Fig. 1**) on the spring mounting bolt.
6. Remove the hexnut, washers, alignment shim(s), spring mounting bolt, and wear shoe clip from the spring hanger. See **Fig. 1**.

**WARNING**

**The leaf spring assembly is heavy. Use care when handling it to prevent injury.**

7. Remove and discard the leaf spring assembly.
8. While supporting a new leaf spring assembly with a jack, position the assembly on the spring hanger. Install the bolts, wear shoe clips, washers, alignment shims, and hexnuts. Tighten the bolts just enough to hold the leaf spring assembly in place.
9. If the air spring mounts to the leaf spring, attach the air spring to the leaf spring assembly. Install the washer and locknut. Tighten the locknut 55 lbf·ft (75 N·m).

   If the air spring mounts to a cross bar, attach the cross bar to the leaf spring assembly. The longer capscrews attach in the forwardmost holes; the shorter capscrews attach in the aft holes.
10. Making sure that the U-bolt pads are in place on the top of the axle, fasten the leaf spring assembly to the axle using the U-bolts, axle clamp, washers, and high nuts making sure the U-bolt pads and axle clamps are positioned correctly.

NOTE: On single-drive axles angled 5 degrees, the arrow on the U-bolt pads must point to the front of the axle housing. See **Fig. 3**. On single-drive axles angled 3 degrees, there is no arrow. Make sure that the axle bump stop on the U-bolt pad is positioned toward the vehicle centerline. See **Fig. 4.**

With both 5- and 3-degree single-drive axle angles, the arrow on the bottom of the axle clamp (see **Fig. 1**) must point toward the rear of the vehicle.

On tandem axle suspensions, see **Table 1** for U-bolt pad orientation. The arrow on the bottom of the axle clamp must point toward the rear of the vehicle on the forward rear axle and toward the front of the vehicle on the rearmost axle.

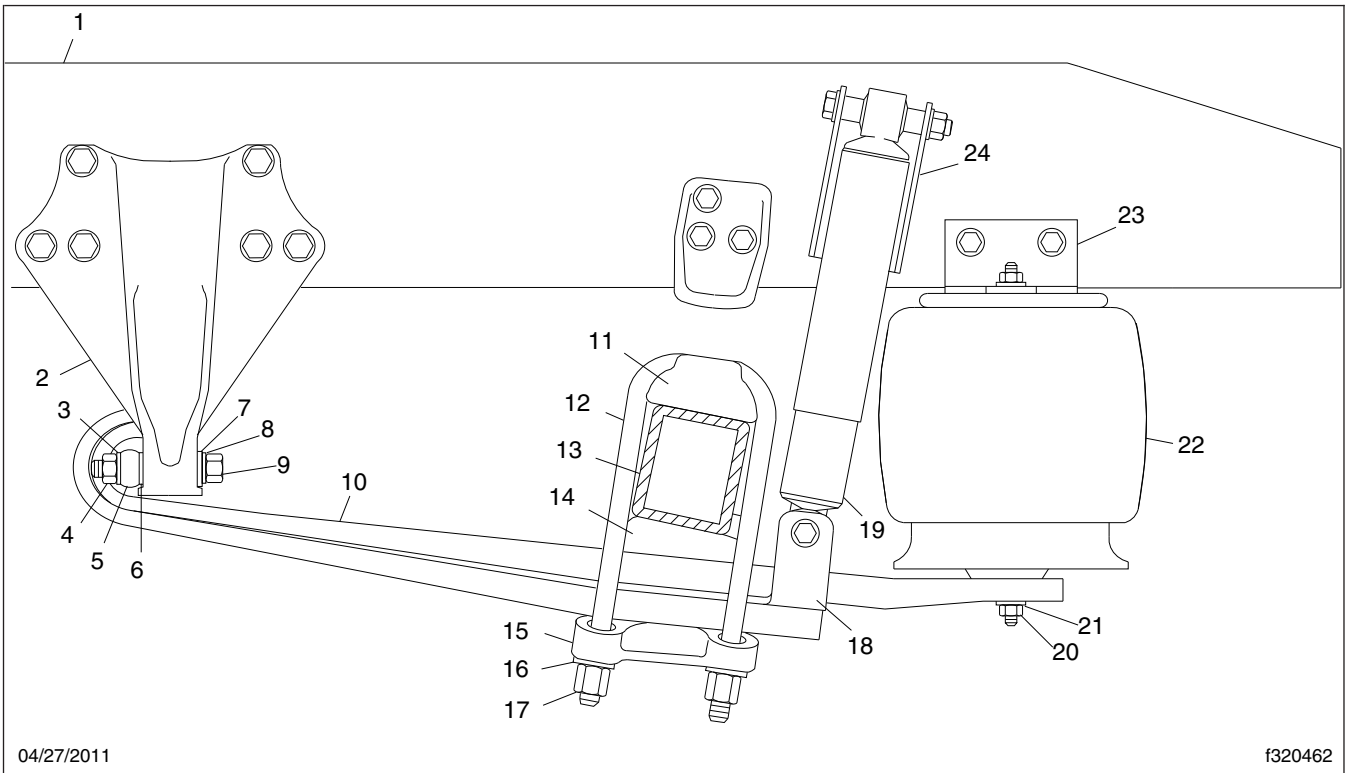
11. Hand tighten the high nuts. In a diagonal pattern, tighten the axle U-bolt high nuts 60 lbf·ft (81 N·m). Then, in the same pattern, tighten them 200 lbf·ft (271 N·m); then, torque to the final value of 400 to 460 lbf·ft (542 to 624 N·m).

    For the 23,000-pound and 46,000-pound suspensions, tighten the high nuts in a diagonal pattern to a final torque value of 520 to 600 lbf·ft (705 to 813 N·m).
12. Install the bolt, washers, and hexnut to connect the shock absorber to its lower mounting bracket. Tighten the hexnut 170 lbf·ft (230 N·m).

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## Leaf Spring Replacement




1. Frame Rail
2. Spring Hanger
3. Washer
4. Hexnut
5. Spring Mounting Eye Pin
6. Alignment Shim
7. Wear Shoe Clip
8. Washer
9. Spring Mounting Bolt
10. Leaf Spring Assembly
11. U-Bolt Pad
12. U-Bolt
13. Axle
14. Axle Seat
15. Axle Clamp
16. Flatwasher
17. High Nut
18. Shock Absorber Lower Mounting Bracket
19. Shock Absorber
20. Nylon Locknut
21. Washer
22. Air Spring
23. Air Spring Mounting Bracket
24. Shock Absorber Upper Mounting Bracket

**Fig. 1, AirLiner Leaf Spring Assembly**

| U-Bolt Pad Orientation for Axles | | |
|---|---|---|
| **Axle Designation** | | **U-Bolt Pad Orientation** |
| Rockwell SQ 100, SSHD | Forward Rear Axle | No arrow; axle bump stop toward vehicle centerline. |
| | Rearmost Axle | No arrow; axle bump stop toward vehicle centerline. |
| Rockwell RT40-145, RT44-145, RT46-160 | Forward Rear Axle | No arrow; axle bump stop toward vehicle centerline. |
| | Rearmost Axle | Arrow toward front of vehicle. |
| Eaton 402, 461 | Forward Rear Axle | No arrow; axle bump stop toward vehicle centerline. |
| | Rearmost Axle | No arrow; axle bump stop toward vehicle centerline. |

**Table 1, U-Bolt Pad Orientation for Axles**

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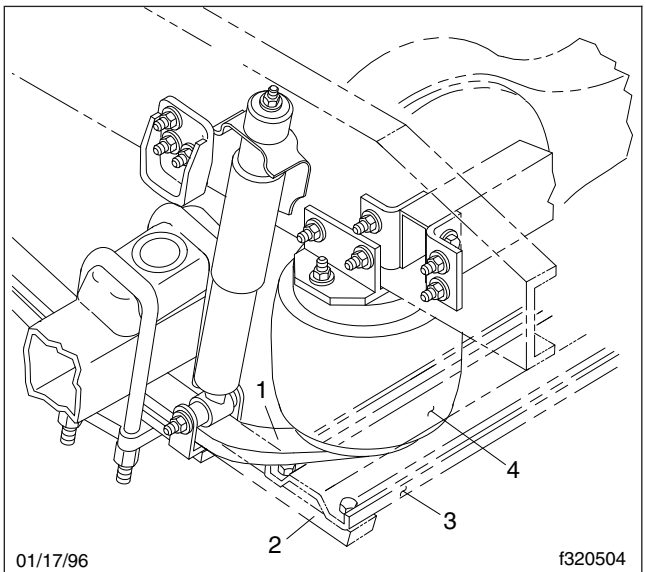
13. Tighten the locknut on the bottom of the air spring 55 lbf·ft (75 N·m).

    On 23,000-pound and 46,000-pound suspensions, tighten the locknuts on the bottom of the cross bar 241 lbf·ft (327 N·m).

14. Tighten the hexnuts at the front of the leaf spring 170 lbf·ft (230 N·m).

15. Install the wheel and tire assembly. For instructions, see **Group 40**. Remove the safety stands, and lower the vehicle.

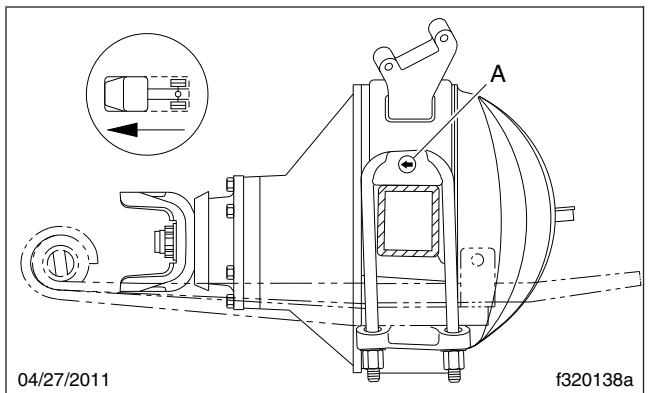
16. Check the rear axle alignment. For instructions, see the rear axle section in this manual. If necessary, adjust the rear axle alignment using the instructions in **Subject 160**.




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1. Leaf Spring
2. Leaf Spring
3. Cross Bar
4. Air Spring

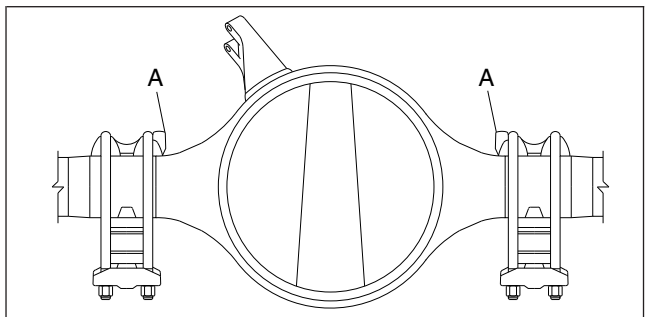
**Fig. 2, Leaf Spring and Air Spring Assembly (23,000- and 46,000-pound suspensions)**




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A. Arrow on U-Bolt Pad

**Fig. 3, U-Bolt Pad Arrow Positioning**




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A. Axle Bump Stop

**Fig. 4, Axle Bump Stop Positioning**

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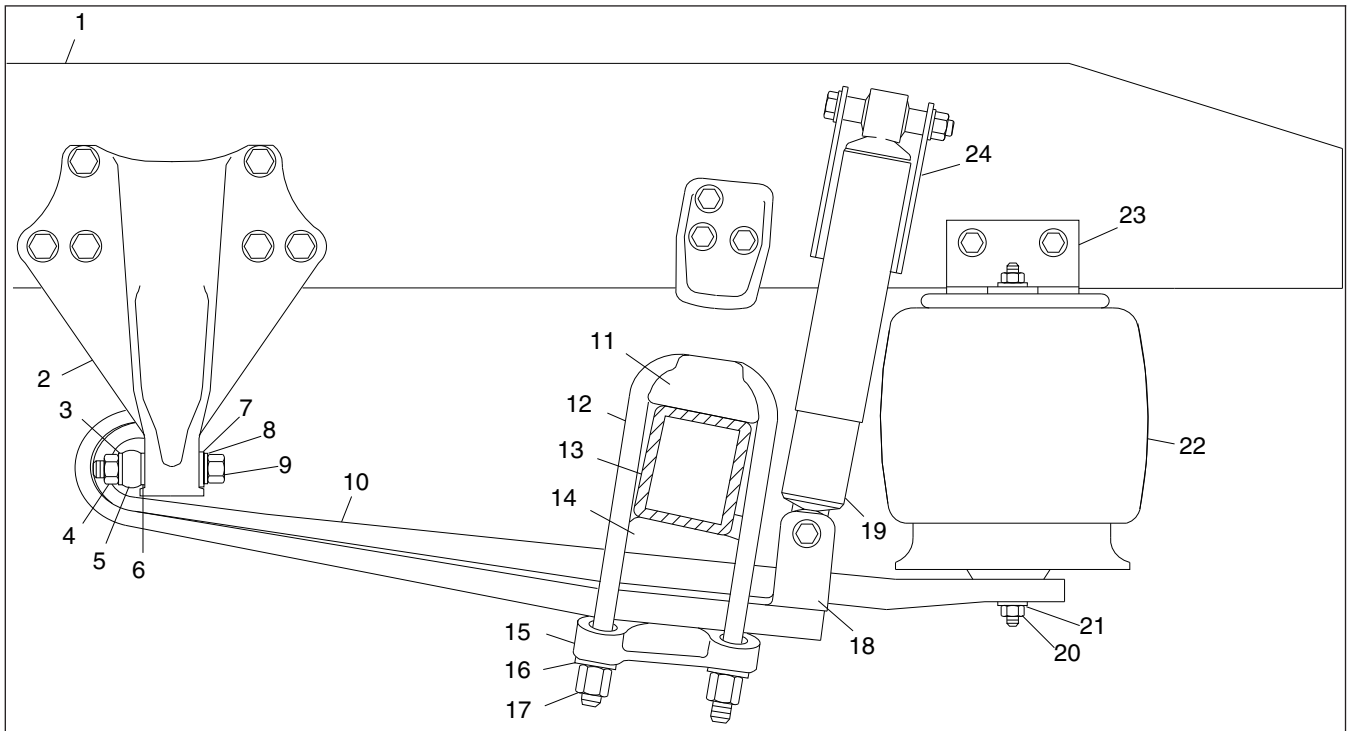
## Alignment Adjustment

See **Group 35** to determine if axle alignment adjustment is needed. If so, proceed as follows:

1. Loosen the spring pinch bolts to allow the forward end of the leaf spring to slide fore and aft in the spring hanger. See **Fig. 1**.
2. Move the axle forward or backward until it is aligned within the tolerances in **Group 35**.
3. Install alignment shim(s) to take up the slack between the spring hanger and the spring pin.

IMPORTANT: Make sure the same number of shims is installed on both ends of the spring pin.

4. Tighten the spring pinch bolts 170 lbf·ft (230 N·m).
5. Check axle alignment again. If necessary, repeat the above procedure.




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1. Frame Rail
2. Spring Hanger
3. Washer
4. Hexnut
5. Spring Pin
6. Alignment Shim
7. Wear Shoe Clip
8. Washer
9. Spring Pinch Bolt
10. Leaf Spring Assembly
11. U-Bolt Pad
12. U-Bolt
13. Axle
14. Axle Seat
15. Axle Clamp
16. Flatwasher
17. High Nut
18. Shock Absorber Lower Mounting Bracket
19. Shock Absorber
20. Nylon Locknut
21. Washer
22. Air Spring
23. Air Spring Mounting Bracket
24. Shock Absorber Upper Mounting Bracket

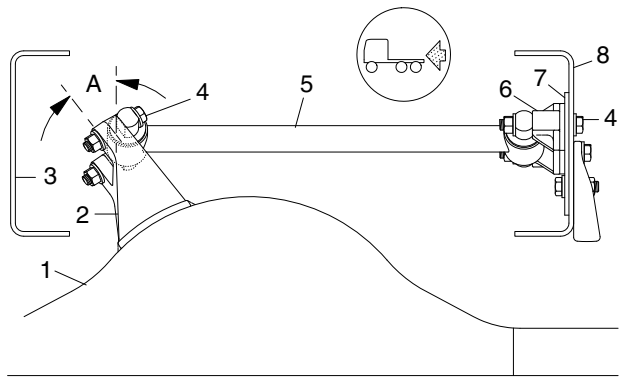
**Fig. 1, Rear Axle Suspension**

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## Replacement

1. Park the vehicle. Shut down the engine, and apply the brakes.
2. Chock the tires. Raise the vehicle. Support the frame rails with jack stands.
3. Remove the fasteners holding the control rod to the frame rail bracket. Remove the shims, and set the shims aside.
4. Remove the control rod.
5. Position the new control rod so that the end with the fasteners angled up at 35 degrees is installed in the axle housing bracket. See **Fig. 1**.



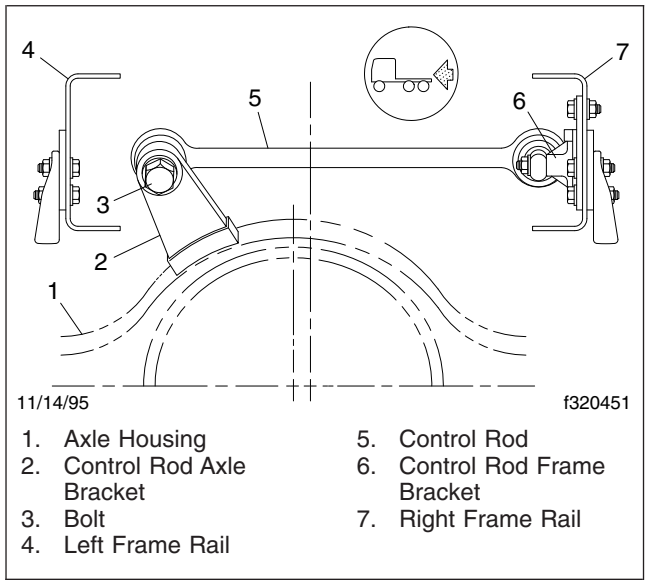

A. Angle: 35 degrees

1. Axle Housing
2. Control Rod Axle Bracket
3. Left Frame Rail
4. Bolt
5. Control Rod
6. Control Rod Frame Bracket
7. Shim
8. Right Frame Rail

**Fig. 1, AirLiner Control Rod Installation**

6. Install the fasteners with the bolt heads facing up. Tighten the fasteners enough to hold the control rod in place.
7. Install the shims that were previously removed.
8. Install the other end of the control rod in the frame rail bracket; then, install the fasteners. Tighten the fasteners enough to hold the control rod in place.
9. Tighten all the fasteners 136 lbf·ft (184 N·m).
10. Remove the jack stands. Lower the vehicle. Remove chocks.

NOTE: Control rods on suspensions manufactured to a 23,000-pound (10 433 kg) or 46,000-pound (20 865 kg) weight rating are larger and are attached to the axle bracket with a single bolt. Tighten the fasteners attaching the control rod frame bracket to the frame rail 160 to 170 lbf·ft (217 to 230 N·m), and the bolt connecting the control rod to the axle housing 175 to 225 lbf·ft (237 to 305 N·m). See **Fig. 2**.




1. Axle Housing
2. Control Rod Axle Bracket
3. Bolt
4. Left Frame Rail
5. Control Rod
6. Control Rod Frame Bracket
7. Right Frame Rail

**Fig. 2, Control Rod Installation on 23,000- and 46,000-pound AirLiner Suspensions**

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## Replacement

**WARNING**

**Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.**

1. Park the vehicle on a level surface. Shut down the engine. Set the parking brake and chock the front tires.
2. Raise the rear of the vehicle, and support the rear axle(s) with safety stands. Raise the vehicle so that all weight is removed from the leaf springs, then securely support the frame with safety stands.
3. Remove the wheel and tire assembly to easily access the suspension. For instructions, see the information in **Group 40**.
4. Remove the leaf spring assembly. See removal information in **Subject 150**.

**WARNING**

**The leaf spring assembly is heavy. Use care when handling it to prevent injury.**

5. Remove the bushing from the leaf spring eye.

**WARNING**

**Do not use a cutting torch to remove the outer metal of the bushing from the spring eye. Welding, torching or cutting the leaf spring assembly can damage the leaf spring material, which may result in the failure of the components and cause serious personal injury, death, or property damage.**

   5.1 Using a shop press with a capacity of at least 10 tons (9 072 kg), place the spring assembly in the shop press with the spring assembly squarely supported on the press bed for safety and to avoid bending the spring assembly.

   5.2 Center the bushing tool on the outer metal of the bushing and push the bushing from the spring eye.

   5.3 Remove any burrs or material left behind by the old bushing.

6. Install the new bushing in the leaf spring eye.

   6.1 Position the bushing on the shop press.

   6.2 Apply a bonding agent, either Perma-bond HM–160 or Loctite RC–609 or 680, liberally around the outside surface of the bushing.

   6.3 Press the bushing into place.

   6.4 Allow the bonding agent to cure for 24 hours.

   NOTE: After the curing time, the bushing must resist a minimum 7,700 lb (3 490 kg) pushout force.

7. Install the leaf spring assembly. See the information in **Subject 150**.
8. Install the wheel and tire assembly. For instructions, see **Group 40**. Remove the safety stands, and lower the vehicle.
9. Check the rear axle alignment. For instructions, see **Group 35**. If necessary, adjust the rear axle alignment using the instructions in **Subject 160**.
10. Remove the chocks from the tires.

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## Height-Control Valve Checking

It is normal to hear air escaping from the height-control valve for as much as 10 minutes after getting out of the vehicle when it is in an unladen condition. This air "leaking" is just the height-control valve exhausting air from the suspension air springs in order to return to the neutral mode.

The height-control valves used on the Western Star are Barksdale valves. Two methods are available to check the operation of the Barksdale height-control valves. A leak in the valve may be discovered without using a test kit, but a test kit is necessary to determine if the valve has an unacceptable rate of leakage.

Some Barksdale height-control valves have been returned for warranty because the four bolts in the valve housing were overtightened, often, enough to crack the valve housing. These bolts should not be loose, and should not normally require tightening, as there are no serviceable parts in the valve.

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing if you detect leaks in the housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

### NOTICE

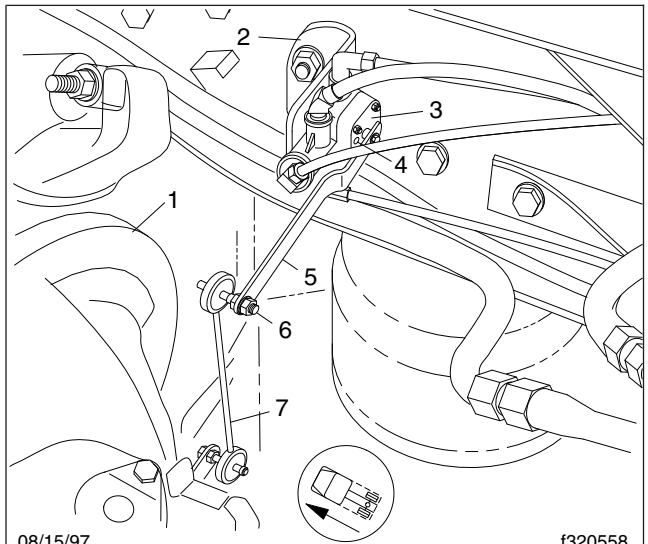
**When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.**

## Checking the Height-Control Valve Without Using a Test Kit

1. Apply the parking brakes and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa).
3. Shut off the engine and wait 5 to 10 minutes for the air suspension system to equalize.

NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal, and does not indicate a defective valve.

4. Disconnect the vertical linkage from the control lever; see **Fig. 1**.




1. Forward Drive Axle
2. Valve Mounting Bracket
3. Height-Control Valve
4. Neutral-Position Hole
5. Horizontal Control Lever
6. Stud Bolt
7. Vertical Linkage

**Fig. 1, Barksdale Height-Control Valve Assembly**

5. Pull the control lever up about 45 degrees for 6 to 8 seconds. If air passes through the valve, that section of the valve is working.

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6. Return the control lever to the neutral position. Air should stop flowing. If so, that section of the valve is working.
7. Push the control lever down about 45 degrees for 6 to 8 seconds. If air exhausts from the valve, that section of the valve is working.
8. Return the control lever to the neutral position. If the air stops again in the neutral position, the valve is working correctly.
9. If the valve works as stated in all of the above steps, then no further checking is necessary. Connect the vertical linkage to the control lever, then tighten the linkage nut.

   If needed, adjust the ride height or replace the height-control valve. For adjustment of the ride height, see **Subject 110**. For replacement of the height-control valve, see **Subject 200**.

NOTE: If a leak is detected on a Barksdale height-control valve, go to "Checking the Height-Control Valve Using a Test Kit". Barksdale valves have an acceptable leak rate of 3 cubic inches (50 cc) per minute. You can determine if a leak is acceptable only by using the Barksdale test kit.

## Checking the Height-Control Valve Using a Test Kit

IMPORTANT: The procedure described below is for use on Barksdale height-control valves only.

NOTE: The Barksdale field test kit is designed to be used with the height-control valve installed on the vehicle. Refer to **Specifications 400** for information on ordering the Barksdale height-control valve test kit KD2264.

1. If not already done, park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa).
3. Shut off the engine and wait 5 to 10 minutes for the air suspension system to equalize.

NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal, and does not indicate a defective valve.

4. For valves without an integral dump port, go to the next step.

   For valves with an integral dump port, check the rubber exhaust flapper at the back of the valve housing for leaks; see **Fig. 2**. Use a soapy solution.

   If a leak is found, there may be contaminants blocking the piston. Cycle the height-control valve switch inside the cab for two-second bursts, four or five times, to clear away any contaminants.

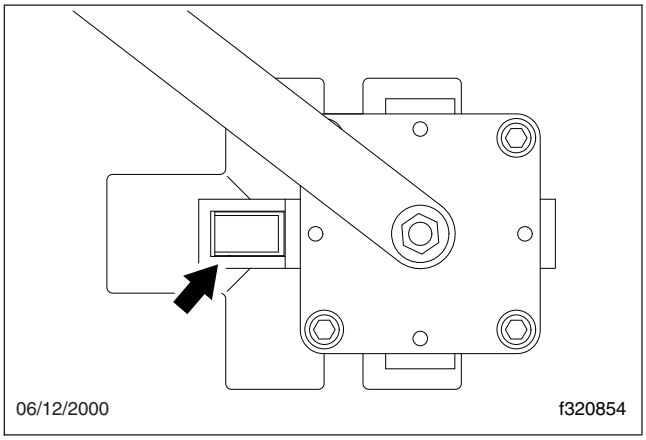


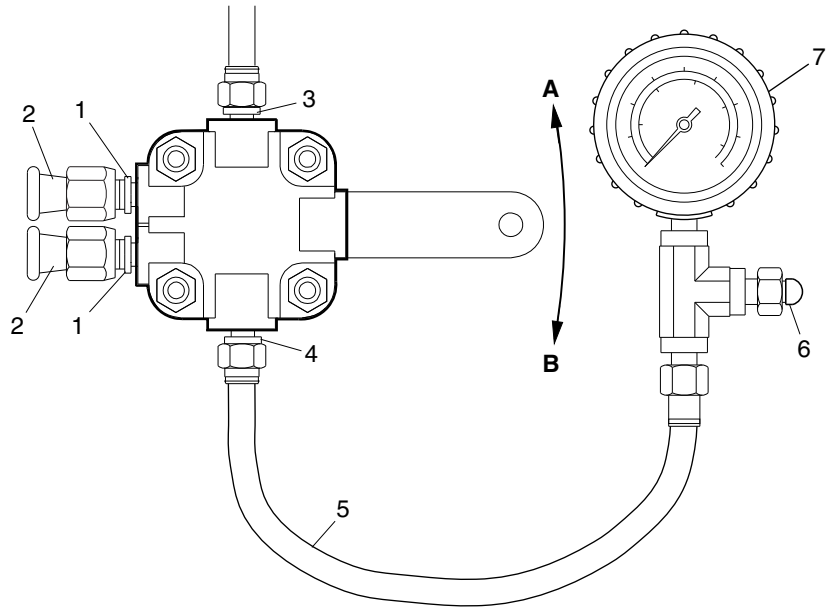

**Fig. 2, Exhaust Flap Location (height-control valve with integral dump port)**

5. Disconnect the vertical linkage from the horizontal control lever.
6. Rotate and hold the horizontal control lever down at about 45 degrees to exhaust air from the air springs.
7. *If equipped with an integral dump port,* turn on the quick dump switch on the dash. Leave the switch on until testing is complete.

   *If not equipped with an integral dump port,* disconnect the air lines from the air spring ports on the height-control valve. Leave the elbow fittings (if equipped) in place. Install a Parker plug into each air spring port (or elbow fitting); see **Fig. 3**.
8. If a flapper is present on the exhaust port of the height-control valve, remove it using needlenose pliers.

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A. Fill
B. Exhaust

1. Air Spring Port
2. Parker Plug
3. Air Intake Port
4. Exhaust Port Test Fitting
5. Air Line
6. Reset Button
7. Test Gauge Assembly

**Fig. 3, Test Connections**

9. Clean the surface around the exhaust port, then install the test fitting into the exhaust port. The centering pin on the fitting must align with the slot on the exhaust port. Rotate the test fitting 45 degrees clockwise to lock it in place; see **Fig. 3**.

NOTE: It may be necessary to cut the tie straps that hold the chassis wiring running below the height-control valve, in order to access the exhaust port.

10. Connect one end of the air hose from the kit to the test connector on the exhaust port, and the other end to the test gauge.
11. Check the height-control valve in the fill mode, as follows.
    - 11.1 Rotate the valve control lever up 45 degrees from the horizontal to the fill position.
    - 11.2 Press the reset button on the test gauge.
    - 11.3 Observe the test gauge for 30 seconds. Refer to **Fig. 4** for the maximum allowable exhaust pressure change versus inlet pressure.

      The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

      If the gauge reads less than the maximum allowable pressure change in 30 seconds, the valve is okay.

NOTE: The test gauge will register the exhausting air. *This does not indicate a defective valve.*

12. Check the height-control valve in the exhaust mode, as follows.
    - 12.1 Rotate the valve control lever down 45 degrees from the horizontal to the exhaust position.
    - 12.2 Press the reset button on the test gauge.
    - 12.3 Observe the test gauge for 30 seconds. Refer to **Fig. 4** for the maximum allowable

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## Height-Control Valve Checking

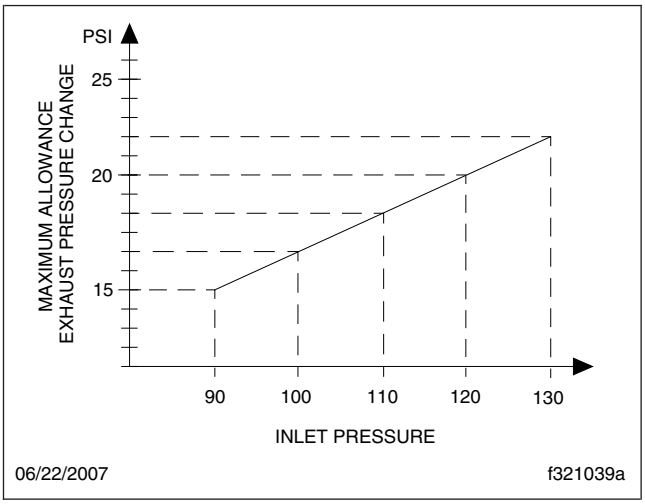



**Fig. 4, Inlet Pressure vs. Exhaust Pressure Change in 30 Seconds**

exhaust pressure change versus inlet pressure.

The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

If the gauge reads less than the maximum allowable pressure change in 30 seconds, the valve is okay.

NOTE: The test gauge will register the exhausting air. *This does not indicate a defective valve.*

13. Disconnect the test gauge and connector from the valve exhaust port.
14. If the height-control valve is defective, replace it; see **Subject 200**.
15. Install the flapper on the exhaust port by pressing it into place.
16. *For height-control valves with an integral dump port,* connect the vertical linkage to the height-control valve control lever. Turn off the quick dump switch on the dash. The ride height will automatically return to the correct position.

    *For height-control valves without an integral dump port,* remove the two Parker plugs from the air spring ports, and connect the air lines to the air spring ports (or elbow fittings). Connect the vertical linkage to the height-control valve control lever. The ride height will automatically return to the correct position.

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## Replacement

The Barksdale valve does not use an adjustable linkage rod. To adjust the Barksdale valve, see **Subject 110**.

1. Apply the parking brakes and chock the tires.

**⚠ WARNING**

**Keep your hands and all objects away from the area under and around the slack adjusters and suspension components when removing the pressure from the air system. These parts will move as the air is released and can cause personal injury or damage to any objects that are between the moving parts.**

2. Drain all air from the air tanks.

**⚠ WARNING**

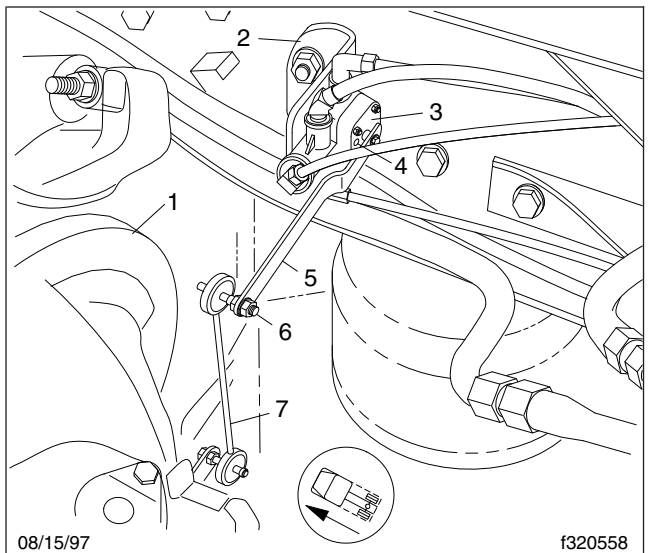
**Air lines under pressure can whip dangerously if disconnected. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.**

3. Remove the nut and washer that attaches the vertical linkage to the horizontal control lever. Disconnect the vertical linkage from the control lever; see **Fig. 1**.
4. Rotate and hold the horizontal control lever down until all air is exhausted from the air springs.
5. Disconnect the air lines at the height-control valve, and mark the lines for later reference. Using tape, cover the open ends of the air lines and fittings to prevent dirt or foreign material from entering.

IMPORTANT: For quick-connect tube fittings, do not remove the tube by cutting it close to the fitting. If the remaining part of the tube cannot be pulled from the fitting, the fitting will not be reusable and the warranty on that unit will be void.

**NOTICE**

**When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.**




1. Forward Drive Axle
2. Valve Mounting Bracket
3. Height-Control Valve
4. Neutral-Position Hole
5. Horizontal Control Lever
6. Stud Bolt
7. Vertical Linkage

**Fig. 1, Barksdale Height-Control Valve**

6. While holding the height-control valve mounting studs in place with an Allen wrench, remove the nuts and washers that attach the valve to the mounting bracket. Remove the height-control valve.
7. Position the new height-control valve on the height-control bracket. While holding the height-control valve mounting studs in place with an Allen wrench, install the nuts and washers, and tighten the nuts 95 lbf·in (1100 N·cm). Do not overtighten.
8. Remove the tape from the air lines and fittings, and connect the air lines to the height-control valve as marked earlier. Tighten nylon tube air fittings until only two threads show on the fitting.

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## Height-Control Valve Replacement

On wire-braid hose fittings, tighten the nut with a wrench until there is firm resistance, then tighten one-sixth turn more.

9. Close the drain cocks on all reservoirs.
10. Build up normal operating pressure in the air system. Check all air lines and connections for leaks. Eliminate all leaks.
11. Adjust the height-control valve; see **Subject 110**.

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## Torque Specifications

For fastener torque values, see **Table 1**.

| Torque Values for AirLiner Suspension, 40,000 lb or Less | | | |
|---|---|---|---|
| **Description** | **Size** | **Torque** | |
| | | **lbf·ft (N·m)** | **lbf·in (N·cm)** |
| Height-Control Valve Housing Bolts* | 1/4–20 | — | 45 (500) |
| Height-Control Valve Mounting Locknuts* | 1/4–20 | — | 95 (1100) |
| Shock Absorber Mounting Locknuts | 3/4–10 | 165 (220) | — |
| Air Spring Upper Mounting Locknuts | 3/4–16 | 45 (61) | — |
| | 1/2–13 | 23 (31) | — |
| Air Spring Lower Mounting Locknuts | 1/2–13 | 55 (75) | — |
| Leaf Spring Mounting Eye Bolt Locknuts | 3/4–10 | 241(327) | — |
| Control Rod Mounting Bolt Locknuts | 5/8–11 | 136 (184) | — |
| Axle U-Bolt High Nuts (tighten in a diagonal pattern as shown in **Fig. 1**) | 7/8–14 | Stage 1: Hand tighten<br>Stage 2: 60 (81)<br>Stage 3: 200 (271)<br>Stage 4: 420 to 500 (571 to 680) | — |
| | 1–14 | Stage 1: Hand tighten<br>Stage 2: 60 (81)<br>Stage 3: 200 (271)<br>Stage 4: 520 to 600 (707 to 816) | — |
| Air Spring Upper Mounting Bracket | 5/8–11 | 136 (184) | — |
| Spring Hanger Mounting Locknuts | 3/4–10 | 240 (325) | — |

* See the cautionary statements below.

**Table 1, Torque Values for AirLiner Suspension, 40,000 lb or Less**

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

### NOTICE

**When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can**

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## Specifications

**back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.**

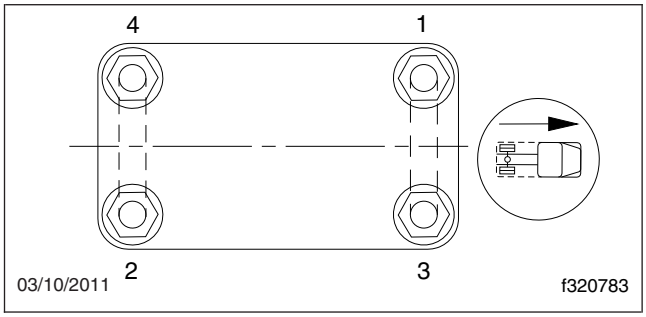


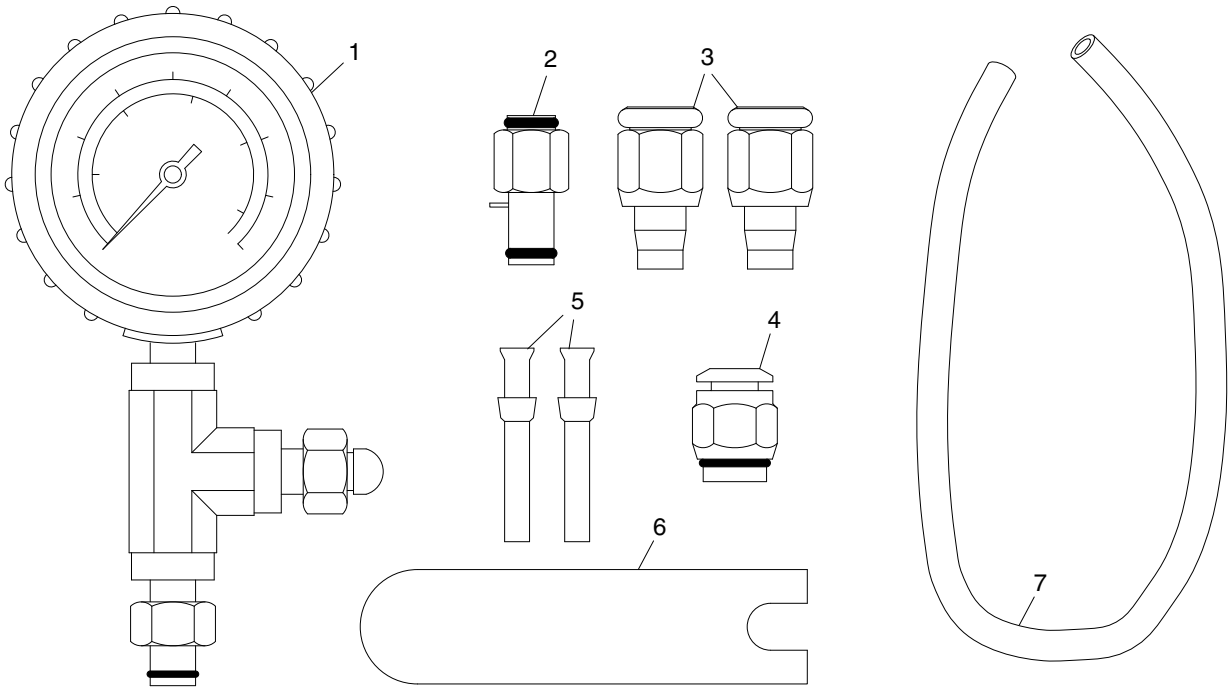

**Fig. 1, Tightening Pattern for U-Bolt High Nuts**

## Special Tools

Use the kit shown in **Fig. 2** to test a Barksdale height-control valve. Test kit BKS KD2264 is available via the Direct Ship program in Paragon.

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NOTE: Parts for cab suspension valve testing included.

1. Test Gauge Assembly with Reset Button
2. Exhaust Port Test Connector for Cab Suspension Valve (used for cab suspension valve testing)
3. Parker Plugs
4. Exhaust Port Test Connector for Chassis Suspension Valve
5. Test Plugs for Cab Suspension Valve (used for cab suspension valve testing)
6. Special Tool for Disconnecting Air Line
7. Air Line

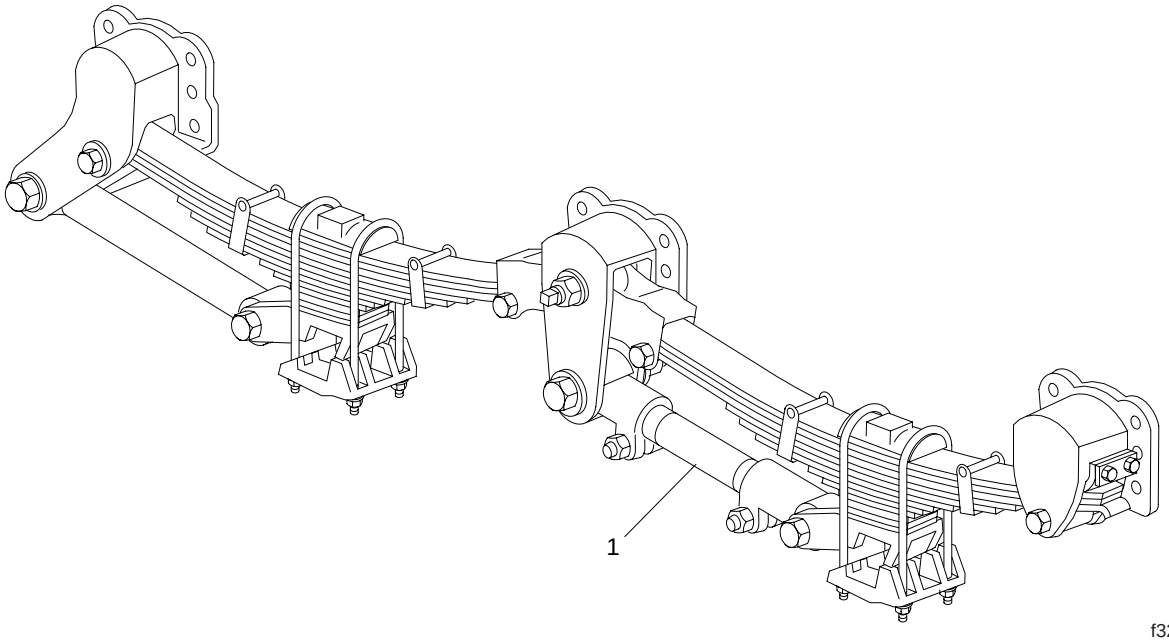
**Fig. 2, Barksdale Height-Control Valve Test Kit BKS KD2264**

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## General Information

The Reyco suspension has two springs at each side of the vehicle frame. See **Fig. 1**. These springs are supported and held in place by three frame-mounted brackets. The two forward brackets also serve as mounts for the axle radius rod eyes. The middle bracket is a two-piece assembly that supports one end of each tandem spring. The two pieces are fastened together in a pivoting manner, permitting movement of the individual leaf springs as they adjust to varying load and changing road contours. The distribution of the vehicle load is equalized between the axles by the leveling action of this pivoting assembly.




1. Adjustable Torque Tracking Rod

**Fig. 1, Reyco Suspension**

Driving and braking forces are transmitted to the vehicle frame through radius rods or torque leaves. Eccentric bushings at the forward end (or eye) of each radius rod permit alignment of each axle independently of the other. A total adjustment of 7/16 inch (11 mm) can be made on each side of the vehicle.

Road shock is cushioned by rubber bushings and cushions at most points of movement. Lubrication of suspension parts is not necessary. The rear end of each spring assembly is formed into a hook which catches on a spring roller and rebound bolt to prevent excessive forward movement of the axle if a radius rod were to break.

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## Suspension Removal, Inspection, and Installation

# Removal

If the suspension system is being overhauled, remove the suspension using the following procedure:

1. Chock the front tires. Drain the vehicle air system. Disconnect all air lines leading to the rear axles, marking the lines for later assembly reference. Plug all lines and fittings to prevent dirt or foreign material from entering the lines.
2. Disconnect the driveline rear universal joint from the forward-rear axle. For instructions see **Group 41**.
3. Manually cage the parking brake chambers. For instructions, see **Group 42**.
4. Using an overhead hoist, raise the rear of the vehicle enough to relieve the weight from the suspension. Support the frame and axle with safety stands.

**⚠ WARNING**

**Securely support all axle and frame weight with safety stands during suspension repairs. Unsecured components may drop when fasteners are loosened or removed, causing serious personal injury and component damage.**

NOTE: Do not raise the vehicle to the point where the suspension and axles hang from the vehicle.

5. On both sides of the vehicle, remove the forward rear spring bracket rebound bolt, spring roller, radius rod eye bolt, large flatwashers, and eccentric rubber bushings. See **Fig. 1.**

NOTE: The radius rod eye bushing is a two-piece unit. Insert a punch into the inside of the bushing and drive out one side of the bushing. Insert the punch from the opposite side to remove the remaining half of the bushing.

6. On both sides of the vehicle, remove the rebound bolts and the spring rollers from the equalizer arm.

NOTE: For clarity, only one of each of the rebound components is shown in **Fig. 1** even though two are used on the equalizer arm.

7. Secure all radius rods to the spring assemblies.
8. On both sides of the vehicle, remove the rear spring bracket rebound bolt, spring roller, and bushing.
9. Using the hoist, raise the frame high enough to remove the tandem assembly out from under the frame.

# Inspection

1. Clean the suspension parts and inspect all parts carefully for cracks, excessive wear, or damage.
2. Inspect the rubber bushings for damage or wear.
3. Replace components as required, following the instructions in this subject.

NOTE: When repairs are made on the removed tandem suspension that involve removal and installation of the spring U-bolts or radius rods, the mounting nuts should be tightened only partially before installation. When the tandem suspension is installed, do a preliminary alignment of the axles to the frame as described below. Then tighten the rear axle U-bolt nuts to the final torque. Tighten the radius rod bolts to the final torque only after the final alignment of the axles.see **Specifications, 400** for the torque settings.

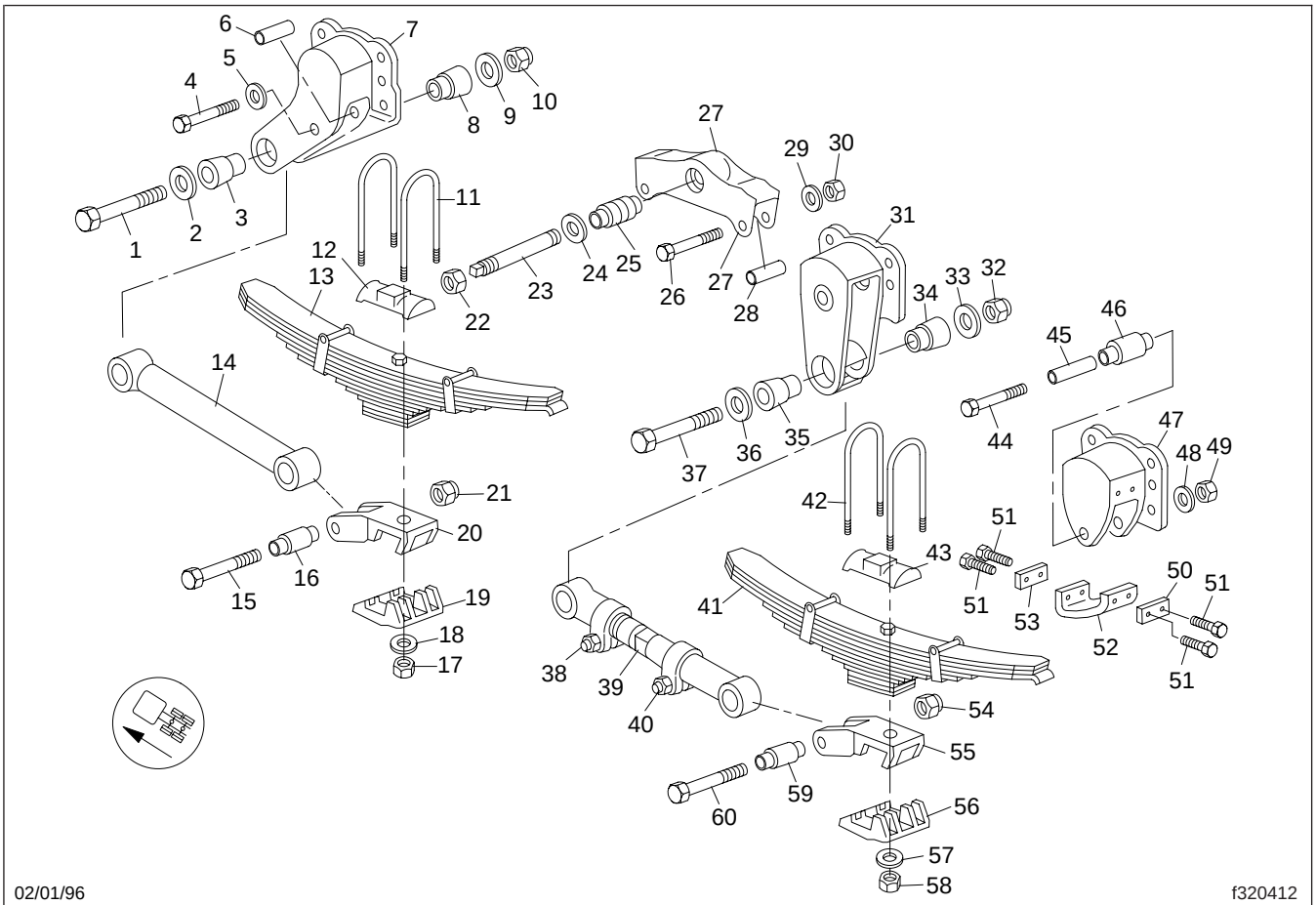
# Installation

1. With the frame raised on a hoist and a hydraulic floor jack under the forward rear axle differential carrier, roll the axles and suspension assembly into position under the frame; then, lower the frame.
2. On both sides of the vehicle install the rear spring bracket bushing, spring roller, and rebound bolt, washer, and nut. Tighten the nut 75 lbf·ft (102 N·m).
3. On both sides of the vehicle install the spring rollers, rebound bolts, washers, and nuts in the center spring equalizer arm. Tighten the nuts 75 lbf·ft (102 N·m).
4. On both sides of the vehicle install the forward spring bracket rebound bolt, washer, and spring roller. There is no nut on the forward spring

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## Suspension Removal, Inspection, and Installation




1. Radius Rod Eye Bolt
2. Flatwasher
3. Rubber Bushing (half)
4. Rebound Bolt
5. Rebound Bolt Washer
6. Spring Roller
7. Forward Spring Bracket
8. Rubber Bushing (half)
9. Flatwasher
10. Radius Rod Eye Bolt Nut
11. U-Bolts
12. U-Bolt Pad
13. Forward Rear Spring Assembly
14. Radius Rod (rigid type)
15. Radius Rod Bolt
16. Bushing
17. U-Bolt Nut
18. U-Bolt Washer
19. U-Bolt Anchor Plate
20. Forward Rear Axle Seat
21. Locknut
22. Pivot Shaft Nut
23. Pivot Shaft
24. Lockwasher
25. Pivot Shaft Bushing
26. Rebound Bolt
27. Equalizer Arm
28. Spring Roller
29. Rebound Bolt Washer
30. Rebound Bolt Nut
31. Equalizer Bracket
32. Radius Rod Eye Bolt Nut
33. Flatwasher
34. Rubber Bushing (half)
35. Rubber Bushing (half)
36. Flatwasher
37. Radius Rod Eye Bolt
38. Capscrew, Washer, and Nut
39. Radius Rod (adjustable type)
40. Capscrew, Washer, and Nut
41. Rearmost Spring Assembly
42. U-Bolts
43. U-Bolt Pad
44. Rebound Bolt
45. Spring Roller
46. Bushing
47. Rear Spring Bracket
48. Rebound Washer
49. Rebound Bolt Nut
50. Clamp Plate
51. Capscrew
52. Plastic Pad
53. Clamp Plate
54. Locknut
55. Rearmost Axle Seat
56. U-Bolt Anchor Plate
57. U-Bolt Washer
58. U-Bolt Nut
59. Bushing
60. Radius Rod Bolt

**Fig. 1, Reyco Suspension (exploded view)**

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bracket rebound bolt. Tighten the bolt 75 lbf·ft (102 N·m).

5. Connect the driveline rear universal joint to the forward-rear axle. See **Group 41**. Remove the hydraulic floor jack.
6. Lower each radius rod and align the radius rod eye with the spring bracket. Install both halves of the rubber eccentric bushing into the spring bracket from the outside with the flat of the bushing insert in the down position, or with the arrow pointing up. Install the large flatwasher onto the bolt and insert the bolt into the bushing with the arrow on the bolt head also pointing up. Install the large flatwasher and nut on the bolt. Tighten the nut, but not to its final torque.

NOTE: With all four radius rod eccentric bushings and bolts installed with the arrows pointing up, the suspension is in its base alignment to the frame.

7. Tighten the rear axle U-bolt nuts to the final torque listed in **Specifications, 400** in the sequence shown in **Fig. 2**.

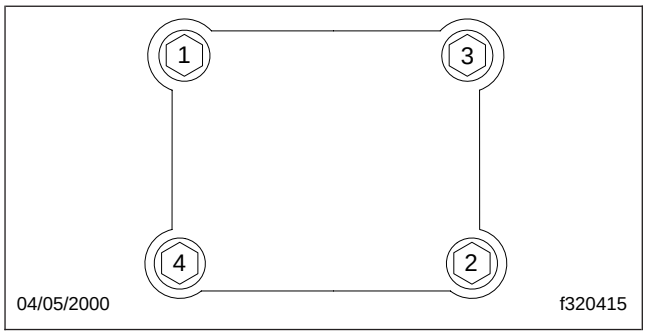



**Fig. 2, U-Bolt Tightening Sequence**

8. Taking care to prevent dirt and other foreign material from entering the lines or fittings, connect the air brake lines leading to the axles. Close the air system drain valve.
9. Check the axle pinion angle. For instructions, see **Group 41**. Adjust the angle if it is not according to specifications.
10. Check the axle alignment and adjust it if needed.
11. Make sure the radius rod eye bolt nuts are tightened to the applicable torque value in **Specifications, 400**.

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## Forward Rear Spring Removal

1. Park the vehicle and chock the tires.
2. Raise the vehicle and block the axles with safety stands. Raise the vehicle frame so that all weight is removed from the leaf springs, then block the frame with safety stands. Make sure the stands will support the weight of the axles and frame securely. Remove the wheel assembly to gain easy access to the suspension system.
3. Remove the U-bolts and the U-bolt anchor plate. Remove the front rebound bolt, washer, and spring roller from the front spring bracket. See **Fig. 1**.
4. Remove the rebound bolt, nut, washer, and spring roller from the front of the equalizer arm in the equalizer bracket.

NOTE: Some references in **Fig. 1** are shown at the rear of the equalizer arm. For clarity, they have been omitted at the front of the equalizer arm.

5. Slide the spring forward until it clears the equalizer arm. Lift the spring assembly at the rear to clear the equalizer arm; then, slide the spring to the rear and remove it.

## Forward Rear Spring Installation

1. Locate the spring in the front spring bracket and slide it forward until the rear of the spring is in position to clear the equalizer arm.
2. Slide the spring rearward into position in the equalizer arm.
3. Install the rebound bolts, washers, spring rollers, and nuts in the front spring bracket and in the equalizer arm. There is no nut on the rebound bolt in the front spring bracket. Tighten the fasteners 75 lbf·ft (102 N·m).
4. Place the spring assembly on the axle spring seat with the center bolt head in the locating hole of the lower spring seat.
5. Place the upper U-bolt spacer pad on top of the spring. Install the U-bolts and the U-bolt anchor plate. Install the U-bolt washers and nuts. Partially tighten the nuts until preliminary adjustment of the suspension has been made; then, tighten them in sequences shown in **Fig. 2.**
6. Install the wheels. Remove all safety stands. Remove the chocks from the tires.

## Rearmost Spring Removal

1. Park the vehicle and chock the tires.
2. Raise the vehicle and block the axles with safety stands. Raise the vehicle frame so that all weight is removed from the leaf springs, then block the frame with safety stands. Make sure the stands will support the weight of the axles and frame securely. Remove the wheel assembly to gain easy access to the suspension system.
3. Remove the U-bolt nuts and washers, the U-bolt anchor plate, the U-bolts, and the upper U-bolt spacer pad.
4. Remove the rear rebound bolt, nut, washer, spring roller, and bushing from the rear spring bracket.
5. Remove the rear rebound bolt, nut, washer, and spring roller from the equalizer arm in the equalizer bracket.
6. Slide the spring rearward until it clears the equalizer arm. Lift the spring assembly at the front to clear the equalizer arm and remove the spring.

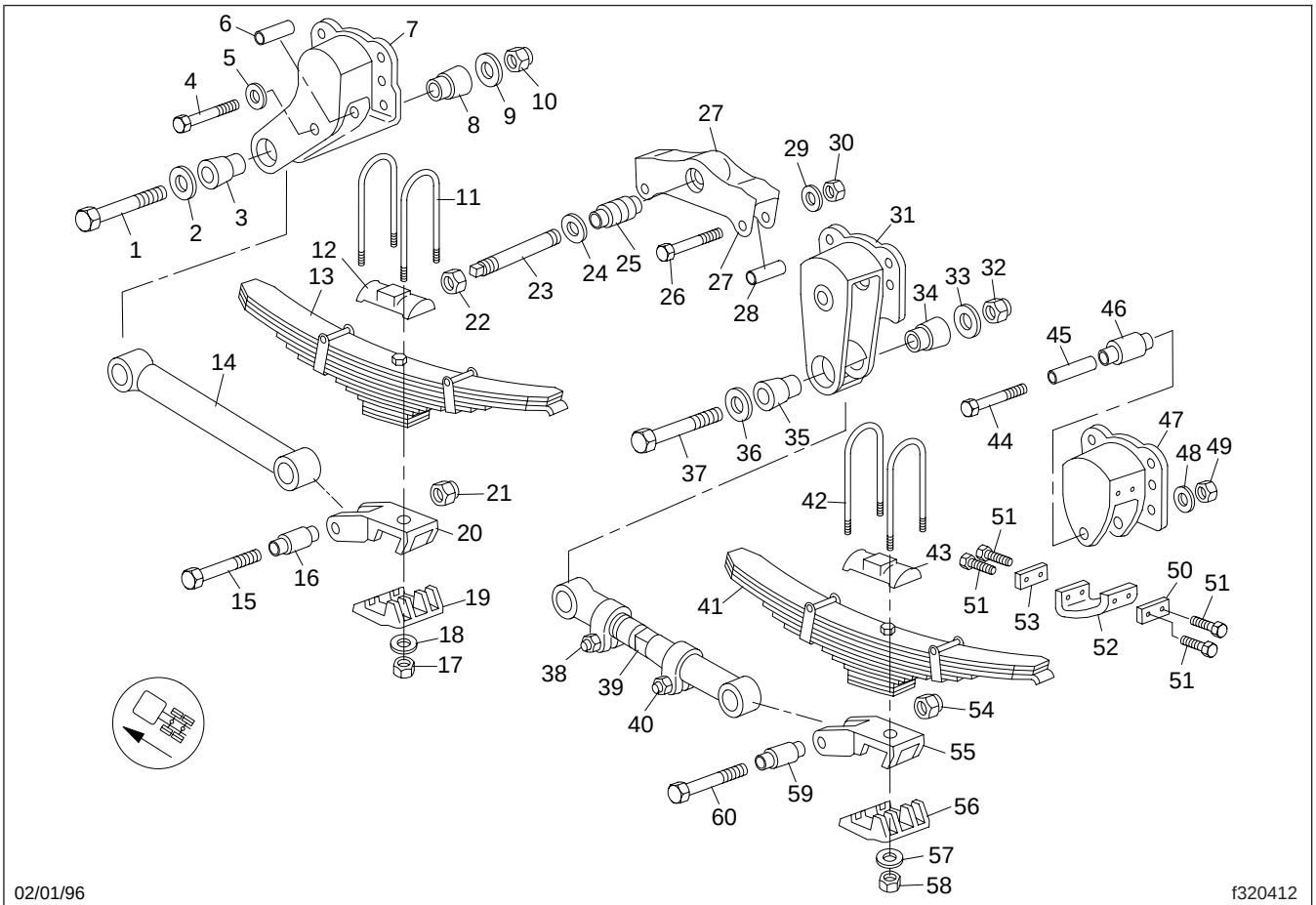
## Rearmost Spring Installation

1. Locate the spring in the front spring bracket and slide it to the rear until the front of the spring is in position to clear the equalizer arm.
2. Slide the spring forward into position in the equalizer arm.
3. Install the rebound bolts, washers, and spring rollers in the rear spring bracket and in the equalizer arm. Tighten the nuts 75 lbf·ft (102 N·m).
4. Place the spring assembly on the axle spring seat with the center bolt head in the locating hole of the lower spring seat.
5. Place the upper U-bolt spacer plate on top of the spring. Install the U-bolts and the U-bolt anchor plate. Install the U-bolt washers and nuts. Partially tighten the nuts until preliminary adjustment

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## Spring Removal and Installation




1. Radius Rod Eye Bolt
2. Flatwasher
3. Rubber Bushing (half)
4. Rebound Bolt
5. Rebound Bolt Washer
6. Spring Roller
7. Forward Spring Bracket
8. Rubber Bushing (half)
9. Flatwasher
10. Radius Rod Eye Bolt Nut
11. U-Bolts
12. U-Bolt Pad
13. Forward Rear Spring Assembly
14. Radius Rod (rigid type)
15. Radius Rod Bolt
16. Bushing
17. U-Bolt Nut
18. U-Bolt Washer
19. U-Bolt Anchor Plate
20. Forward Axle Seat
21. Locknut
22. Pivot Shaft Nut
23. Pivot Shaft
24. Lockwasher
25. Pivot Shaft Bushing
26. Rebound Bolt
27. Equalizer Arm
28. Spring Roller
29. Rebound Bolt Washer
30. Rebound Bolt Nut
31. Equalizer Bracket
32. Radius Rod Eye Bolt Nut
33. Flatwasher
34. Rubber Bushing (half)
35. Rubber Bushing (half)
36. Flatwasher
37. Radius Rod Eye Bolt
38. Capscrew, Washer, and Nut
39. Radius Rod (adjustable type)
40. Capscrew, Washer, and Nut
41. Rearmost Spring Assembly
42. U-Bolts
43. U-Bolt Pad
44. Rebound Bolt
45. Spring Roller
46. Bushing
47. Rear Spring Bracket
48. Rebound Washer
49. Rebound Bolt Nut
50. Clamp Plate
51. Capscrew
52. Plastic Pad
53. Clamp Plate
54. Lock Nut
55. Rearmost Axle Seat
56. U-Bolt Anchor Plate
57. U-Bolt Washer
58. U-Bolt Nut
59. Bushing
60. Radius Rod Bolt

**Fig. 1, Reyco Suspension (exploded view)**

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of the suspension has been made; then, tighten them in the sequence as shown in **Fig. 2.**

6. Install the wheels. Remove all safety stands. Remove the chocks from the tires.

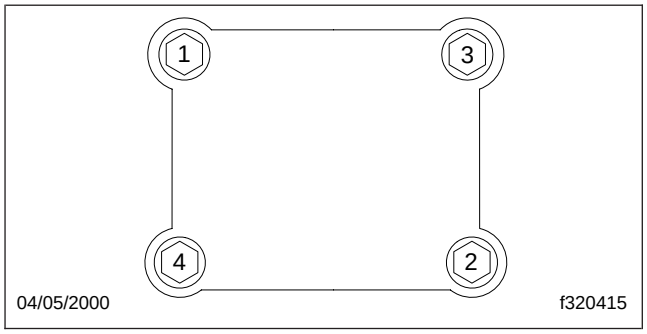



**Fig. 2, U-Bolt Tightening Sequence**

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## Disassembly, Inspection, and Assembly

1. To disassemble, use chalk or a grease pencil to make a mark down the side of the spring pile so the spring leaves can be assembled in the same relative position.
2. Anchor the spring at a point near the center bolt in a vise or arbor press. Tighten the vise or arbor press firmly.
3. Remove the bolts, nuts, and sleeve from the spring clips. Observe the spring leaves. Pay special attention to the top three leaves, since the spring easily can be assembled incorrectly even though reference marks are used.
4. Prior to inspection, wash all parts in a suitable solvent. Remove any scale, rust, or deposits from the spring leaves.
5. Inspect all the leaves for breaks and small cracks. If any are found, replace the entire spring assembly

**⚠ WARNING**

**Do not replace individual leaves of a damaged leaf spring assembly; replace the complete spring assembly. Visible damage (cracks or breaks) to one leaf causes hidden damage to other leaves. Replacement of only the visibly damaged part(s) is no assurance that the spring is safe. Failure to replace a damaged spring assembly could cause an accident resulting in serious personal injury or property damage.**

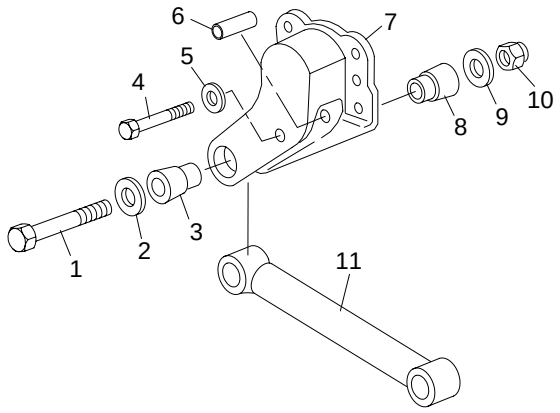
6. Inspect the spring assembly for loose or broken rebound clips. Rebound clips should be tight enough to hold the spring leaves in alignment, but not tight enough to restrict the free movement of the leaves.
7. Inspect the center bolt for distortion and wear. Replace the bolt if it is not in good condition.
8. Inspect the U-bolts and spring spacer plates. Replace them if they are damaged or cracked.
9. Inspect the spring brackets at the reinforcing webs and in the corners. Do not weld or braze cracks. If the bracket is cracked, replace it.
10. For assembly, stack the spring leaves using care to position them in the proper sequence.
11. Using a long punch or other suitable tool, align the center bolt holes. Anchor the spring at a point near the center bolt hole in a vise or arbor press. Tighten the vise or arbor press firmly. Remove the alignment tool.
12. Install the center bolt and nut. Tighten the nut 70 lbf·ft (95 N·m) and peen the end of the bolt.
13. Install the bolts, nuts, and spacer sleeves to the spring clips. Tighten the nuts firmly. Peen the ends of the bolts.
14. Remove the assembly from the vise or arbor press.

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## Bracket Removal and Installation

1. Raise the frame until all weight is off the forward spring, and safely block it in position.
2. Remove the rebound bolt, washer, and spring roller from the front spring bracket. See **Fig. 1**.

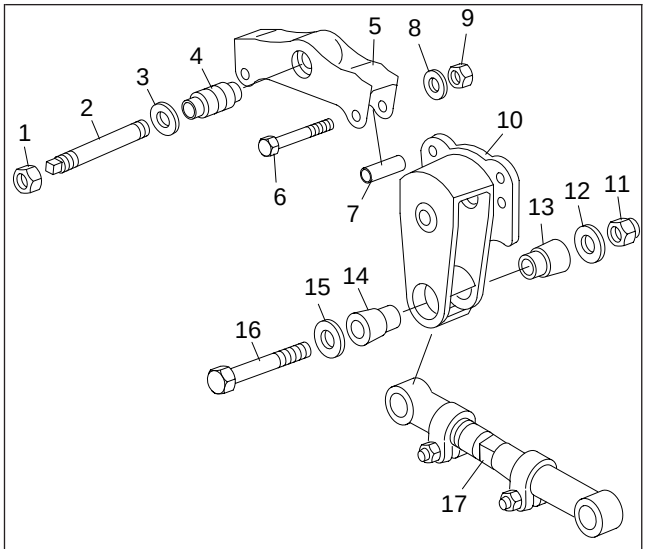



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1. Radius Rod Eye Bolt
2. Flatwasher
3. Rubber Bushing (half)
4. Rebound Bolt
5. Rebound Bolt Washer
6. Spring Roller
7. Forward Spring Bracket
8. Rubber Bushing (half)
9. Flatwasher
10. Radius Rod Eye Bolt Nut
11. Radius Rod

**Fig. 1, Forward Spring Bracket Assembly**

3. Remove the radius rod eye bolt nut and large flatwasher from the eye bolt.
4. Using a brass drift, drive the eye bolt with the remaining flatwasher from the spring bracket. Secure the radius rod to the spring.
5. Using a brass drift inside the rubber bushing, drive out one half of the bushing. Reverse the position of the drift and drive out the other half of the bushing from the opposite side of the bracket.
6. Remove all the bolts, nuts, and washers securing the spring bracket to the frame.
7. Remove the spring bracket and spacer plate, moving it away from the spring end and lifting it straight up from the frame.
8. Raise the frame until all weight is off the rear spring, then safely block it in position.
9. Remove the bolts, nuts, and washers that secure the rear spring bracket to the frame.
10. Remove the spring bracket and spacer plate.
11. To remove the equalizer bracket (center spring bracket), raise the frame until all weight is off the spring, then safely block it in position.
12. Remove the rebound nuts, washers, bolts, and spring rollers from the ends of the equalizer arm. See **Fig. 2**.




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1. Pivot Shaft Nut
2. Pivot Shaft
3. Lockwasher
4. Pivot Shaft Bushing
5. Equalizer Arm
6. Rebound Bolt
7. Spring Roller
8. Rebound Bolt Washer
9. Rebound Bolt Nut
10. Equalizer Bracket
11. Radius Rod Eye Bolt Nut
12. Flatwasher
13. Rubber Bushing (half)
14. Rubber Bushing (half)
15. Flatwasher
16. Radius Rod Eye Bolt
17. Radius Rod

**Fig. 2, Equalizer Arm and Bracket Assembly**

13. Remove the radius rod eye bolt nut and large flatwasher from the eye bolt.
14. Using a brass drift, drive the eye bolt with the remaining flatwasher from the equalizer bracket.
15. Secure the radius rod to the spring.

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## Spring Bracket Removal and Installation

16. Using a brass drift inside the rubber bushing, drive out one half of the bushing. Reverse the position of the drift and drive out the other half of the bushing from the opposite side of the bracket.
17. Remove the equalizer pivot nut, lockwasher, and shaft.
18. Slide the equalizer back and forth as necessary to gain access to the mounting bracket bolts.
19. Remove all the bolts, nuts, and washers that secure the equalizer bracket to the frame.
20. Remove the equalizer bracket and the spacer plate.
21. To install spring or equalizer brackets, reverse the removal procedure. Make sure the spacer plates are installed between the frame and bracket. Check the axle alignment and correct it if necessary, before tightening the radius rod eye bolt nuts to the final torque.

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# Radius Rod and Radius Rod Bushing Replacement

## Radius Rod Replacement

1. Raise the frame until all weight is off the spring, then safely block the frame in position.
2. Remove the locknut, washer (if so equipped), and bolt from the radius rod at the axle seat. Lower the rod. See **Fig. 1**.
3. Remove the nut and large flatwasher from the radius rod eye bolt. Using a brass drift tool, drive the eye bolt with the remaining flatwasher from the forward spring bracket or equalizer bracket.
4. Using a brass drift inside the rubber bushing, drive out one half of the bushing. Reverse the position of the drift and drive out the other half of the bushing from the opposite side of the bracket.
5. Remove the radius rod.
6. Place the eye of the new radius rod into the front spring or equalizer bracket.
7. Install both halves of the rubber eccentric bushing into the bracket from the outside with the flat of the bushing insert pointing down or the arrow pointing up.
8. Install the large flatwasher onto the radius rod eye bolt and insert the bolt into the bushing with the arrow on the bolt head pointing up.
9. Install the large flatwasher and the nut on the radius rod eye bolt. Tighten the nut, but not to its final torque.
10. Check the axle alignment and adjust it if necessary.
11. After the adjustment has been made, lower the vehicle and tighten the radius rod eye bolt nut to the applicable torque value in **Specifications, 400**.

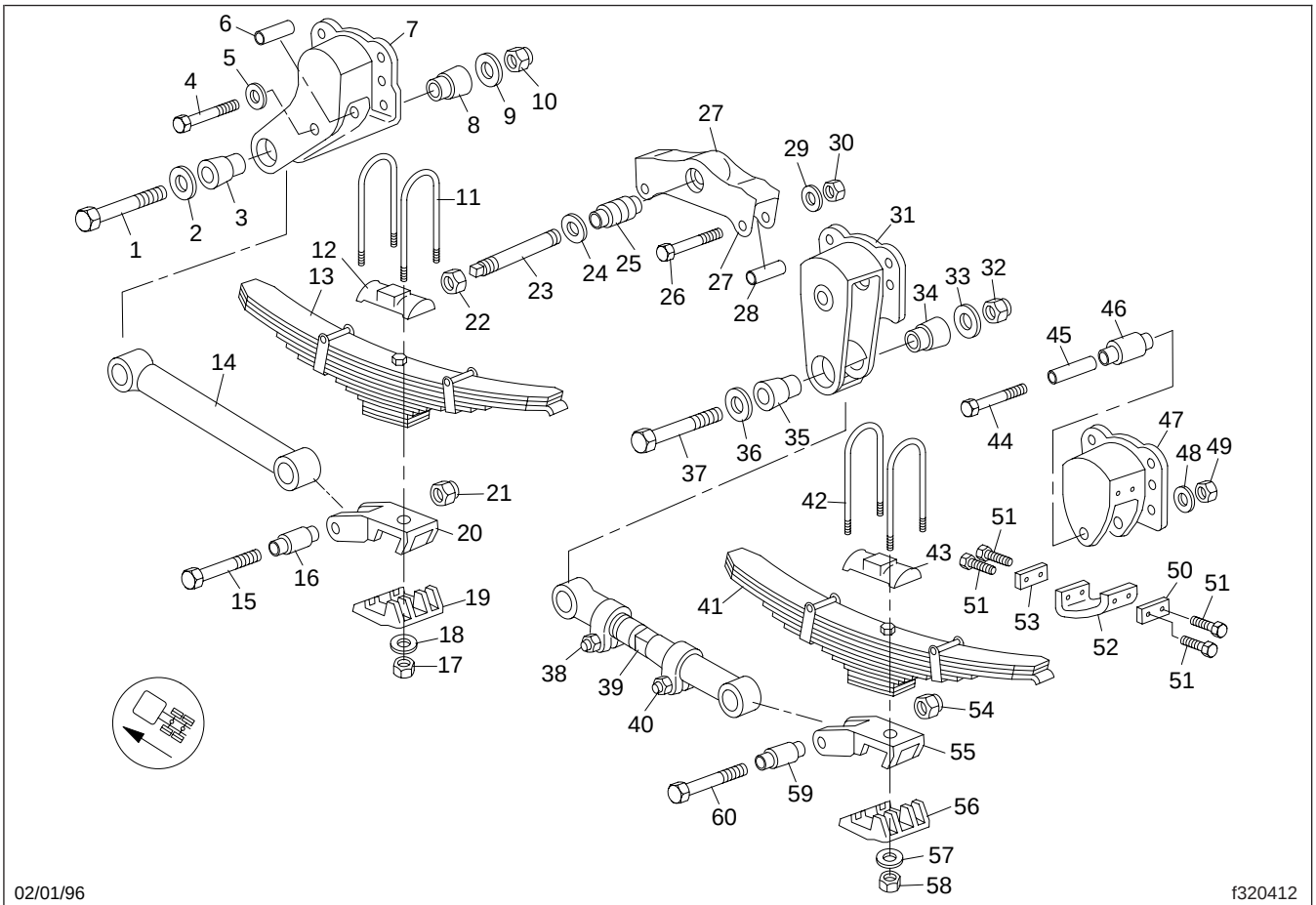
## Radius Rod Bushing Replacement

1. Raise the frame until all weight is off the spring, then safely block the frame in position.
2. Remove the radius rod as follows:
   - 2.1 Remove the locknut, washer (if so equipped), and bolt from the radius rod at the axle seat. Lower the rod. See **Fig. 1**.
   - 2.2 Remove the nut and large flatwasher from the radius rod eye bolt. Using a brass drift tool, drive the eye bolt with the remaining flat washer from the front spring or equalizer bracket.
   - 2.3 Using a brass drift inside the rubber bushing, drive out one half of the bushing. Reverse the position of the drift and drive out the other half of the bushing from the opposite side of the bracket.
   - 2.4 Remove the radius rod.
3. Press the old bushing out of the radius rod.
4. Coat the new bushing with a rubber lubricant and press it in so that the bushing is equal on both sides of the rod.
5. Install the radius rod:
   - 5.1 Place the eye of the radius rod into the front spring or equalizer bracket.
   - 5.2 Install both halves of the rubber eccentric bushing into the bracket from the outside with the flat of the bushing insert pointing down or the arrow pointing up.
   - 5.3 Install the large flatwasher onto the radius rod eye bolt and insert the bolt into the bushing with the arrow on the bolt head pointing up.
   - 5.4 Install the large flatwasher and the nut on the radius rod eye bolt. Tighten the nut, but not to its final torque.
6. Check the axle alignment and adjust it if necessary.
7. After the adjustment has been made, lower the vehicle and tighten the radius rod eye bolt nut to the applicable torque value in **Specifications, 400**.

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## Radius Rod and Radius Rod Bushing Replacement




1. Radius Rod Eye Bolt
2. Flatwasher
3. Rubber Bushing (half)
4. Rebound Bolt
5. Rebound Bolt Washer
6. Spring Roller
7. Forward Spring Bracket
8. Rubber Bushing (half)
9. Flatwasher
10. Radius Rod Eye Bolt Nut
11. U-Bolts
12. U-Bolt Pad
13. Forward Rear Spring Assembly
14. Radius Rod (rigid type)
15. Radius Rod Bolt
16. Bushing
17. U-Bolt Nut
18. U-Bolt Washer
19. U-Bolt Anchor Plate
20. Forward Rear Axle Seat
21. Locknut
22. Pivot Shaft Nut
23. Pivot Shaft
24. Lockwasher
25. Pivot Shaft Bushing
26. Rebound Bolt
27. Equalizer Arm
28. Spring Roller
29. Rebound Bolt Washer
30. Rebound Bolt Nut
31. Equalizer Bracket
32. Radius Rod Eye Bolt Nut
33. Flatwasher
34. Rubber Bushing (half)
35. Rubber Bushing (half)
36. Flatwasher
37. Radius Rod Eye Bolt
38. Capscrew, Washer, and Nut
39. Radius Rod (adjustable type)
40. Capscrew, Washer, and Nut
41. Rearmost Spring Assembly
42. U-Bolts
43. U-Bolt Pad
44. Rebound Bolt
45. Spring Roller
46. Bushing
47. Rear Spring Bracket
48. Rebound Washer
49. Rebound Bolt Nut
50. Clamp Plate
51. Capscrew
52. Plastic Pad
53. Clamp Plate
54. Locknut
55. Rearmost Axle Seat
56. U-Bolt Anchor Plate
57. U-Bolt Washer
58. U-Bolt Nut
59. Bushing
60. Radius Rod Bolt

**Fig. 1, Reyco Suspension (exploded view)**

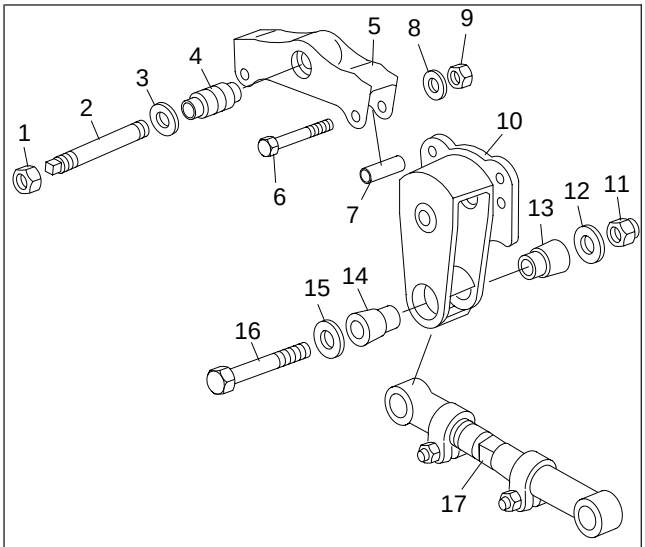
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# Equalizer Arm Bushing Replacement

## Replacement

1. Raise the frame until all the weight is off the springs, then safely block the frame into position.
2. Remove the rebound nuts, washers, bolts, and spring rollers from the ends of the equalizer arm. See **Fig. 1**.




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1. Pivot Shaft Nut
2. Pivot Shaft
3. Lockwasher
4. Pivot Shaft Bushing
5. Equalizer Arm
6. Rebound Bolt
7. Spring Roller
8. Rebound Bolt Washer
9. Rebound Bolt Nut
10. Equalizer Bracket
11. Radius Rod Eye Bolt Nut
12. Flatwasher
13. Rubber Bushing (half)
14. Rubber Bushing (half)
15. Flatwasher
16. Radius Rod Eye Bolt
17. Radius Rod

**Fig. 1, Equalizer Arm and Bracket Assembly**

NOTE: For clarity, only one of each of the rebound components is shown, even though two are used on the equalizer arm.

3. Remove the nut and large flatwasher from the radius rod eye bolt. Using a brass drift, drive the eye bolt with the remaining flatwasher from the equalizer bracket.
4. Secure the radius rod to the spring.
5. Remove the equalizer pivot nut, washer, and shaft.
6. Move the equalizer arm forward over the forward rear spring. Raise the frame. Slide the equalizer arm rearward through the bracket, then up and out.
7. Using a suitable press, press out the equalizer bushing.
8. Coat the new bushing with a rubber lubricant.
9. Press the bushing into the equalizer arm.
10. With the frame raised and the equalizer arm properly positioned, slide the equalizer arm into the equalizer bracket and forward over the front spring assembly.
11. Lower the frame and slide the equalizer arm over the rear spring until the center hole aligns with the hole in the equalizer bracket.
12. Apply anti-seize compound to the pivot shaft threads; then, install the pivot shaft by hand in the bracket. With steel crossmembers, install the bolt with the nut inside the frame; with aluminum crossmembers, install it with the nut outside the frame. When the shaft reaches the frame rail, back it out one-half turn. Install the lockwasher and nut. Tighten the nut 975 lbf·ft (1330 N·m).
13. Install the radius rod as follows (see **Fig. 1**):
    - 13.1 Place the radius rod eye into the equalizer bracket. Install both halves of the rubber eccentric bushing into the bracket from the outside, with the flat of the bushing insert pointing down or the arrow pointing up.
    - 13.2 Install the large flatwasher onto the radius rod eye bolt and insert the bolt into the bushing with the arrow on the bolt head pointing up.
    - 13.3 Install the large flatwasher and the nut on the bolt. Tighten the nut, but not to its final torque.
    - 13.4 Check the axle alignment and adjust it if necessary. After the adjustment has been made, lower the vehicle and tighten the radius rod eye bolt nut to the applicable torque value shown in **Specifications, 400**.

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## Equalizer Arm Bushing Replacement

14. Install the spring rollers and rebound bolts in the equalizer arm and tighten the nuts 45 lbf·ft (61 N·m).

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## Axle Alignment Checking

Manufacturers of axle alignment equipment offer a variety of systems to precisely measure and correct rear axle alignment. If access to this type of equipment is not available, check the axle alignment using the following procedure:

1. Position the vehicle on a level surface. Using the engine, rock the vehicle back and forth several times with the brakes applied lightly. This will release any "set" of the suspension joint.
2. Obtain a piece of bar stock, angle iron, or other suitable material about 96 in (2.5 m) long. Inspect the material for straightness. The bar should be long enough to extend past the outside edge of one outside dual tire to a similar point on the opposite dual tire.
3. Measure from the center point of the equalizer bracket to any open part of the frame in front of the wheels where the bar stock can be placed across the frame. This point must be accessible for the use of C-clamps. A point in front of the forward rear axle is recommended; however, a point behind the rearmost axle will work if none is available in front of the axle.
4. Using a square, mark a chalk line across the top of the frame rail.
5. Repeat previous steps for the opposite side of the vehicle.
6. Position the bar stock across the frame rails so that it extends an equal distance beyond the frame rail on each side. Line up the bar stock with the chalk lines and secure it with C-clamps.
7. Measure the distance from the outside edge of the secured bar stock to the center of the rearmost axle shaft.
8. Repeat previous steps on the opposite side of the vehicle. Compare the measurements taken on both sides. If they are equal or vary no more than 1/8-in (3 mm), the axle alignment is correct. If the measurements differ by more than 1/8-in (3 mm), adjust the axle alignment.
9. If the rearmost axle alignment is correct, check the forward rear axle alignment as follows:
   - 9.1 Measure the distance from the rearmost axle shaft center to the center of the forward rear axle or the bar stock.
   - 9.2 Repeat the measurement for the opposite side and compare the measurements. If they are equal or vary no more than 1/8-in (3 mm), the axle alignment is correct. If the measurements differ by more than 1/8-in (3 mm), adjust the axle alignment as described above.

## Axle Alignment Adjustment (Models 101 and 101A)

1. Loosen the nut on the radius rod eye bolt three full turns.
2. Using a soft brass or lead hammer to avoid damage to the eye bolt threads, tap the end of the eye bolt and the end of the rod between the front spring bracket casting. This should loosen the components so the adjustment can be made.

NOTE: The maximum adjustment on each side of the vehicle is 7/16 inch (11 mm). In most cases, the axle alignment can be corrected by adjusting one side only; however, additional adjustment can be made from the other side of the axle if necessary.

3. Jack up the frame on the side to be corrected to remove the weight from the springs.
4. To adjust the axle forward, rotate the radius rod eye bolt forward. To adjust the axle rearward, rotate the radius rod eye bolt to the rear.
5. Lower the vehicle and check the axle alignment as described above. Repeat the adjustment as needed.
6. After the final adjustment has been made, lower the vehicle and tighten the radius rod eye bolt nut to the applicable torque value in **Specifications, 400**.

## Axle Alignment Adjustment (Models 102 and 102W)

1. Jack up the frame on the side to be corrected to remove the weight from the springs.

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## Axle Alignment Checking and Adjusting

2. Loosen the clamp nuts on the radius rod being adjusted.
3. Using a wrench on the radius rod flats, turn the adjustable section to move the axle forward or rearward.
4. Lower the vehicle and check the axle alignment. Repeat the adjustment as needed.
5. After the adjustment has been made, lower the vehicle and tighten the radius rod clamp nuts 190 lbf·ft (258 N·m).
6. Tighten the radius rod eye bolt nuts to the applicable torque value in **Specifications, 400**.

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# Troubleshooting Tables

**Problem—Spring is Noisy**

| Problem—Spring is Noisy | |
|---|---|
| **Possible Cause** | **Remedy** |
| The U-bolts are loose. | Tighten the U-bolts to the recommended torque |
| The radius rod eye bushings are worn. | Replace the radius rod eye bushings. |
| The shock absorbers are worn or damaged. | Replace the shock absorbers. |

**Problem—Spring Sags or Bottoms Out**

| Problem—Spring Sags or Bottoms Out | |
|---|---|
| **Possible Cause** | **Remedy** |
| The shock absorbers are not working properly. | Replace the shock absorbers. |
| A spring leaf is broken. | Replace the spring leaf assembly. |
| The vehicle is overloaded. | Check the load capacity rating and correct if needed. |

**Problem—Springs Break**

| Problem—Springs Break | |
|---|---|
| **Possible Cause** | **Remedy** |
| The U-bolts are loose. | Tighten the U-bolts to the recommended torque. |
| The springs are experiencing normal fatigue. | Replace the springs. |
| The vehicle is overloaded. | Check the load capacity rating and correct if needed. |

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## Specifications

| Torque Values | | |
|---|---|---|
| **Description** | **Model** | **Torque lbf·ft (N·m)** |
| Equalizer Pivot Shaft | 101A, 102 | 600 (814) |
| Equalizer Nut | 102W | 975 (1330) |
| Equalizer Arm Rebound Bolt | — | 45 (61) |
| Rebound Bolt | — | 60–80 (80–110) |
| Spring Center Bolt Nut | — | 75–80 (105–110) |
| Spring-Bracket-to-Frame Bolt | — | 180 (244) |
| Radius Rod Clamp Nut, 5/8" bolt | 101A | 125–150 (170–205) |
| | 102 | 125–150 (170–205) |
| Radius Rod Clamp Nut | 102W | 175–200 (240–275) |
| Radius Rod Eye Bolt | 101A | 160 (217) |
| | 102 | 500–525 (670–704) |
| | 102W | 160–200 (220–271) |
| Radius Rod Bolt | 101A | 250 (339) |
| | 102 | 200 (271) |
| | 102W | 400–425 (550–580) |
| Axle U-Bolt High Nuts: 3/4–16 (tighten in a diagonal pattern as shown in **Fig. 1**) | — | Stage 1: Hand tighten |
| | | Stage 2: 60 (81) |
| | | Stage 3: 200 (271) |
| | | Stage 4: 270 to 330 (367 to 449) |
| Axle U-Bolt High Nuts: 7/8–14 (tighten in a diagonal pattern as shown in **Fig. 1**) | — | Stage 1: Hand tighten |
| | | Stage 2: 60 (81) |
| | | Stage 3: 200 (271) |
| | | Stage 4: 420 to 500 (571 to 680) |

**Table 1, Torque Values**

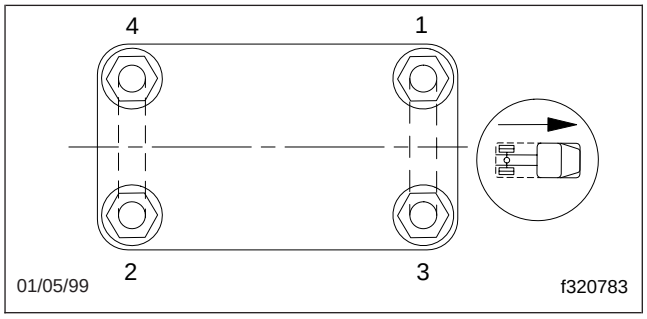



**Fig. 1, Tightening Pattern for U-Bolt High Nuts**

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## General Description

The Hendrickson RT2 series suspension (**Fig. 1**) uses leaf springs to lessen road shocks. The forward and rear ends of the spring assembly ride in hangers. At the forward end, the springs are attached to the hanger with pins. At the rear end, the springs have no rigid attachment to the hangers, and are free to move forward and backward to compensate for spring deflection.

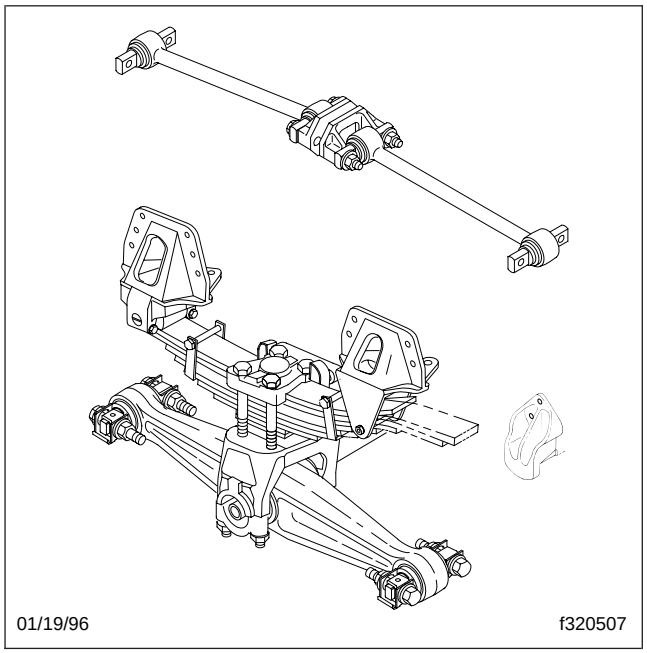



**Fig. 1, RT2 and RTE2 Series Suspension**

The RTE2 series suspension is basically the same as the RT2 suspension. However, the RTE2 series uses a different spring assembly and a third spring hanger. This design provides a two-stage spring rate, depending on vehicle load condition. When the vehicle is unloaded, a gap exists between the top spring leaf and the no. 2 spring hanger. The weight of the vehicle is then carried through the no. 3 spring hanger, and most of the spring deflection through the top extended leaves. When the vehicle is loaded, the top extended leaf contacts the no. 2 spring hanger and the spring weight is carried through the nos. 1 and 2 spring hangers.

The RTE2A series suspension is similar to the RTE2 suspension, but the RTEA series uses aluminum equalizer beams instead of steel.

**⚠ CAUTION**

**Failure to apply Alumilastic® compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the components or parts.**

The axles are attached to beam hangers at the ends of the equalizer beams, allowing an articulating action between the axles to lessen road shock. Torque rods, mounted between the axles and frame rails, stabilize axle and vehicle movement caused by accelerating and braking.

All suspension fasteners require periodic tightening. For suspension inspecting, lubricating, and fastener torque checking instructions, see **Group 32** of the *Western Star Maintenance Manual*.

**⚠ WARNING**

**Periodically, torque the suspension fasteners. Failure to do so could result in damage to the frame hangers or separation of components. This could cause a loss of vehicle control, resulting in personal injury or property damage.**

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## Removal

1. Chock the front tires.
2. Drain the vehicle air system.
3. Disconnect all air lines leading to the rear axles, marking the lines for later assembly.

   Plug or cap all lines and fittings to prevent dirt from entering the system.
4. Disconnect the driveline rear universal joint from the forward-rear axle. Then, remove the interaxle driveline. For instructions, see **Group 41**.
5. Manually release the spring brake chambers. For instructions, see **Group 42**.

**⚠ WARNING**

**When the torque rods are disconnected from the axle brackets, the axles become free to pivot on the equalizer beam end bushings. Keep clear of the beam hangers and beam ends to avoid possible injury.**

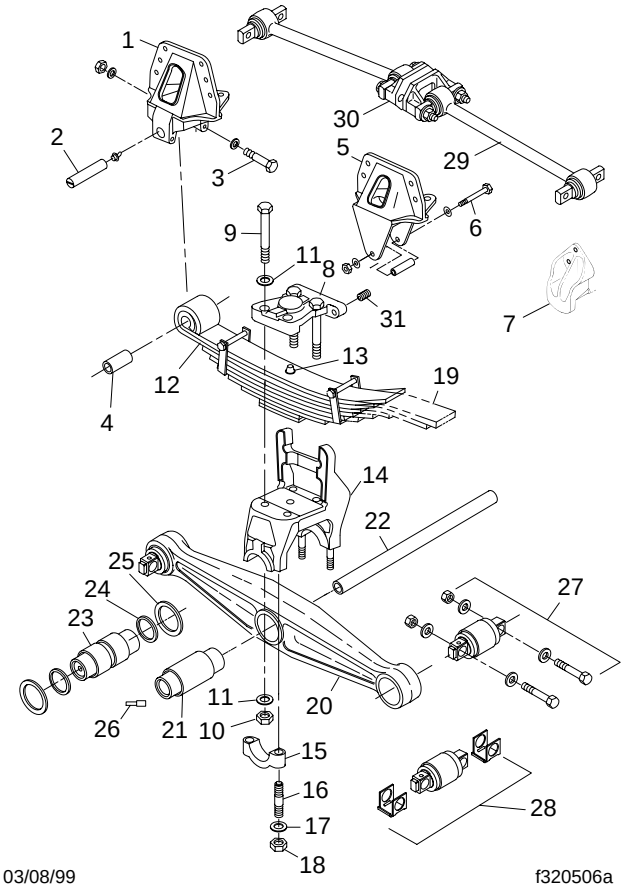
6. Remove the torque rods. For instructions, see **Subject 160**.
7. Raise the rear of the vehicle so that all weight is removed from the suspension. Then, block the axles and the frame with safety stands. Make sure the stands will securely support the weight of the axles and the frame.

NOTE: Do not raise the vehicle to the point where the weight of the suspension and axles hangs from the vehicle.

8. Remove the saddle cap nuts and washers from each side of the vehicle, and remove the saddle caps. See **Fig. 1**.

NOTE: If the saddle cap studs are damaged, replace them.

9. Raise the rear of the vehicle frame until there is enough clearance to roll the axles out from under the vehicle. Install safety stands under the frame, then roll the axles—with the equalizer beams attached—out from under the vehicle.




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1. Forward Spring Hanger
2. Spring Pin
3. Lock Bolt
4. Spring Eye Bushing
5. Rear Spring Hanger
6. Set Screw
7. Spring Hanger (RTE2 suspension)
8. Top Pad
9. Top Pad Bolt
10. Nut
11. Washer
12. Spring Assembly
13. Spring Center Bolt and Nut
14. Saddle
15. Saddle Cap
16. Saddle Cap Stud
17. Washer
18. Locknut
19. Spring (RTE2 suspension)
20. Equalizer Beam
21. Rubber Center Bushing
22. Cross Tube
23. Bronze Center Bushing
24. Bushing Grease Seal
25. Thrustwasher
26. Grease Fitting
27. Bar Pin Bushing (non-shim type)
28. Bar Pin Bushing (shim type)
29. Torque Rod
30. Torque Rod Frame Bracket
31. Set Screw

**Fig. 1, RT2 and RTE2 Series (exploded view)**

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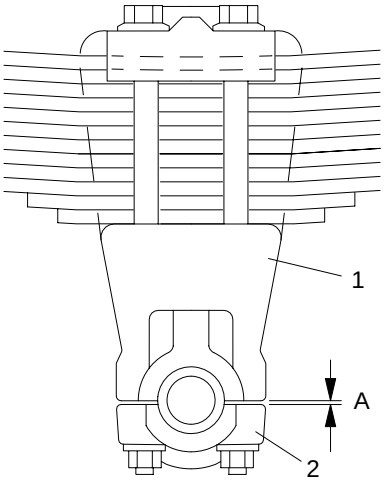
## Suspension Removal and Installation

# Installation

1. Roll the axles under the vehicle frame. Align the center bushing of each equalizer beam with the center of the saddle legs.
2. Raise the vehicle frame off the safety stands, then remove the safety stands.
3. Lower the frame, centering the saddles on the beam center bushings.
4. Lubricate the saddle cap studs with SAE 20 oil. Install the saddle caps, washers and new self-locking nuts. Do not tighten.
5. Install the torque rods. For instructions, see **Subject 160**.
6. Tighten the saddle cap locknuts 225 to 275 lbf·ft (305 to 373 N·m).

NOTE: Maintain an even gap between the saddle cap and the saddle when tightening the self-locking nuts (**Fig. 2**).

7. Remove the safety stands from under the frame and axle, and lower the vehicle.
8. Manually reset the spring brake chambers. For instructions, see **Group 42**.
9. Connect the driveline rear universal joint to the forward-rear axle. Connect the interaxle driveline. For instructions, see **Group 41**.
10. Uncap all air lines and fittings, then connect the lines leading to the rear axles.
11. Check the axle pinion angle. For instructions, see **Group 41**.




A. Maintain an even gap
1. Saddle
2. Saddle Cap

**Fig. 2, Tightening Self-Locking Nuts**

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## Removal

1. Remove the suspension. For instructions, see **Subject 100**.
2. Support the spring and saddle assembly with a floor jack.
3. Remove the locknuts from the spring pin lockbolts; then remove the lockbolts and washers from the number one spring hanger.
4. Using a suitable drift, drive the spring pin through the no. 1 spring hanger and out the inboard side of the spring hanger (**Fig. 1**).

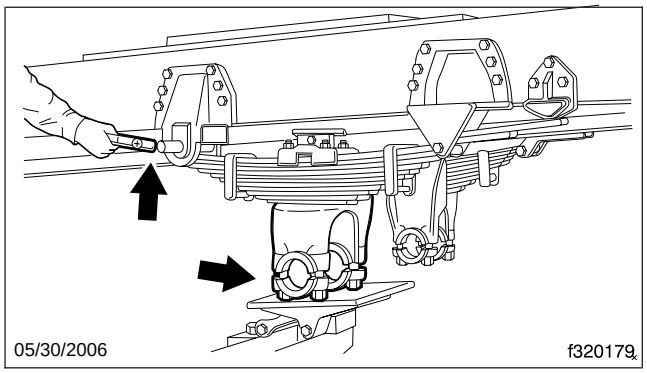



**Fig. 1, Spring Hanger**

5. Remove the locknut and lockwasher from the rebound spacer bolt in the no. 2 spring hanger. Remove the rebound spacer bolt and the spacer.

**⚠ WARNING**

**The leaf spring assembly is heavy. Use care when handling it to prevent personal injury.**

6. Lower the spring and saddle assembly from the spring hangers.
7. Loosen the spring alignment setscrews on the top pad. Remove the top pad nuts, washers, and bolts.
8. Remove the top pad from the spring assembly, then remove the spring from the saddle.

## Installation

1. Seat the leaf spring assembly on the saddle.
2. Position the top pad on the spring assembly. Check that the top pad is properly seated.

NOTE: The main leaf has a cup that is forged upward at the center bolt. This cup serves as a pilot when installing the top pad, and ensures correct alignment of the spring assembly.

3. Lubricate the threads on the top pad bolts with SAE 20 oil, then install the washers and bolts through the top pad and saddle. Install new nuts and washers finger-tight. Do not tighten at this time.
4. Lubricate the threads on the spring setscrews with SAE 20 oil. Hand-tighten the spring setscrews against the leaf springs. Tighten the setscrews 100 to 150 lbf·ft (135 to 203 N·m), then tighten the setscrew locknuts until the lockwasher is locked.
5. Tighten the top pad nuts 275 to 400 lbf·ft (373 to 542 N·m). Use the tightening sequence shown in **Fig. 2**.

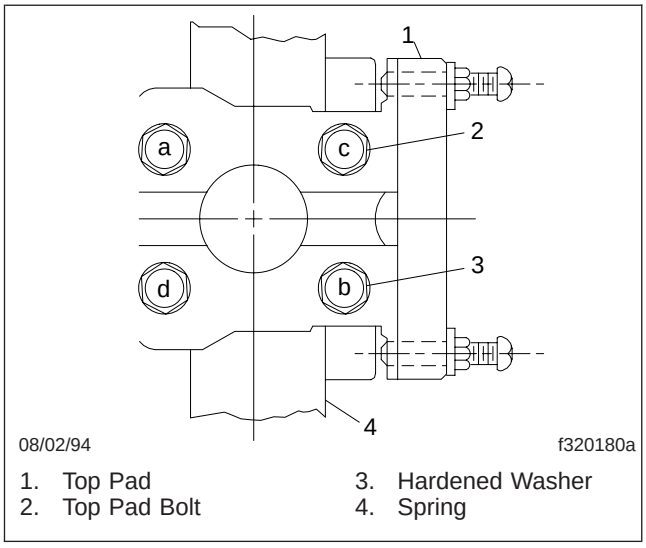



**Fig. 2, Top Pad Bolt Tightening Sequence**

6. Position the spring and saddle assembly into the no. 1 and no. 2 spring hangers.
7. Coat the spring pin and the inside diameter of the spring eye bushing with multipurpose chassis grease.
8. Align the spring pin with the spring eye bushing in the forward spring hanger.
9. From the outboard side of the spring hanger, tap the spring pin into the bushing with a soft ham-

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## Spring and Saddle Removal and Installation

mer. If necessary, adjust the spring to assist spring pin entry.

10. Place washers on the spring pin lockbolts, and insert the lockbolts through the spring hanger. If necessary, use a screwdriver to turn the spring pin until the lockbolts can slide past it.
11. Lubricate the lockbolt threads with SAE 20 oil. Install the lockwashers and locknuts. Tighten the locknuts 45 to 63 lbf·ft (61 to 85 N·m).
12. Position the rebound spacer in the no. 2 spring hanger leg, then install the rebound spacer bolt, lockwasher, and locknut. Tighten the locknut 38 to 45 lbf·ft (51 to 61 N·m).
13. Install the grease fittings in both spring eye pins. Apply multipurpose chassis grease to the grease fittings until grease appears on both sides of the spring eye bushings.
14. Install the suspension. See **Subject 100** for instructions.

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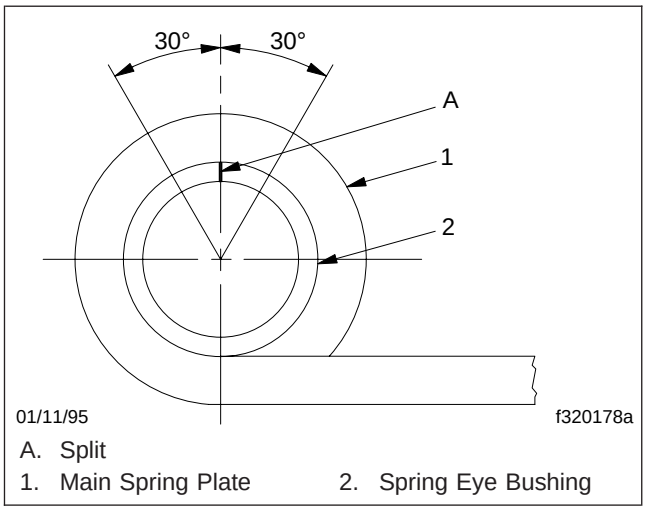
# Spring Leaf, Spring Pin, and Spring Eye Bushing Replacement

## Replacement

1. Remove the spring and saddle assembly. For instructions, see **Subject 110**.
2. Using a C-clamp to hold the spring leaves together, remove the center bolt and nut, and the spring alignment clips. Remove the C-clamp and separate the leaves.
3. Using a wire brush and solvent, clean all grease, dirt, and rust from the spring leaves. Inspect the spring leaves for cracks, gouges, wear, or abnormal bends. The no. 1 main and no. 2 wrapper spring leaves (the top two spring leaves) may each be replaced; if equipped with the RTE series suspension, the nos. 1, 2, and 3 spring leaves (the top three spring leaves) may each be replaced. If a spring leaf is damaged below these numbers in a pack, replace the spring assembly. Replace both spring assemblies to ensure even spring deflection.
4. Inspect the spring pin and spring eye bushing for wear or damage. If the pin diameter is less than 1.367 inch, replace it. If the inside diameter of the spring eye bushing is more than 1.395 inch, replace it.

NOTE: If necessary, press out the bushing with a hydraulic press. Install the new bushing with the split of the bushing positioned at the top (30 degrees) of the spring eye (**Fig. 1**).

5. Position the spring leaves in order, then insert a drift through the center bolt hole to align the leaves.
6. Compress the leaves with a C-clamp, then install the spring alignment clips on the spring leaves. Install the spring alignment clip nuts and bolts. Tighten the nuts 15 lbf·ft (20 N·m).
7. Remove the drift punch. At the bottom of the spring, insert a new center bolt. Install a new center bolt nut and tighten to the value in the table under **Specifications, 400**.
8. Install the spring and saddle assembly. For instructions, see **Subject 110**.




A. Split
1. Main Spring Plate
2. Spring Eye Bushing

**Fig. 1, Bushing Split Position**

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## Equalizer Beam Removal and Installation

# Removal

1. Chock the front tires.
2. Remove the saddle cap nuts and washers, then remove the saddle cap. Support the equalizer beam with safety stands.
3. Raise the rear of the vehicle until the saddle studs clear the equalizer beam. Block the axles and frame with safety stands.
4. Remove the wheels and tires. For instructions, see **Group 40**.
5. Remove the brake shoes, brake spider, and brake backing plate (dust shield). See **Group 42** for instructions.
6. Apply a penetrating oil to all beam end connections.
7. Remove the bar pins.

NOTE: The bar pin-style beam end connection is a rubber bushing assembly consisting of a rubber insert, and outer metal tube and inner casting. It is fastened to the axle by two 1-inch (25 mm) bolts and locknuts. The bolts are positioned parallel to the vehicle's longitudinal axis making removal and installation easy.

**⚠ WARNING**

**Do not use a cutting torch to remove the equalizer beams from the beam hangers. The equalizer beams are heat-treated, and using a cutting torch could weaken them, causing them to break. This could result in a loss of vehicle control, possible personal injury and property damage.**

8. Remove the ends of the equalizer beams from the axle beam hangers.
9. Lower the equalizer beams and the crosstube to the ground. Remove the thrustwashers and pull the beams from the crosstube.

# Installation

1. Install the crosstube and thrustwashers in both equalizer beam center bushings. Install the bar pins, then install the crosstube and thrustwashers in both equalizer beam center bushings.
2. Position the equalizer beam assembly under the axles, then raise the assembly and place the forward ends of each beam in the forward-rear axle beam hangers. Align the beam end bushings with the beam hangers.
3. Place the rear ends of each beam in the rearmost axle beam hangers. Align the beam end bushings with the beam hangers.
4. Position the saddle caps on the saddle cap studs, then install the washers and new self-locking nuts. Tighten the nuts 225 to 275 lbf·ft (305 to 373 N·m).
5. Install the bar pin bolt locknuts, and tighten 450 to 600 lbf·ft (610 to 813 N·m).

**⚠ WARNING**

**Tighten the bar pin locknuts to the specified torque values. Otherwise, component wear will occur. This could result in separation of suspension components, loss of vehicle control, and possible personal injury or property damage.**

6. Install the brake backing plate (dust shield), brake spider, and brake shoes. See **Group 42** for instructions.
7. Install the wheels and tires. For instructions, see **Group 40**.

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# Equalizer Beam Rubber Center Bushing Removal and Installation

## Removal

NOTE: If using Owatonna tools, removal of the equalizer beam is not required for removal or installation of the rubber center bushing.

1. Chock the front tires.
2. Raise the rear of the vehicle so that all weight is removed from the suspension. Block the axles and the frame with safety stands. Make sure the stands will securely support the weight of the axles and the frame.

NOTE: Do not raise the vehicle to the point where the weight of the suspension and axles hangs from the vehicle.

3. Remove the saddle cap nuts and washers from each side of the vehicle, and remove the saddle caps.
4. Raise the rear of the truck frame until the saddle studs clear the equalizer beam. Install safety stands under the frame.
5. Using a 2-1/2 inch diameter hole saw (**Fig. 1**), cut out the end plug from the center bushing on each side of the suspension, and remove the crosstube.

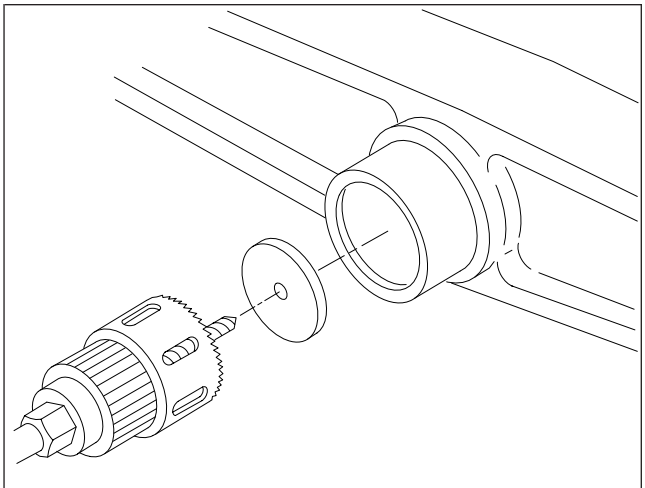
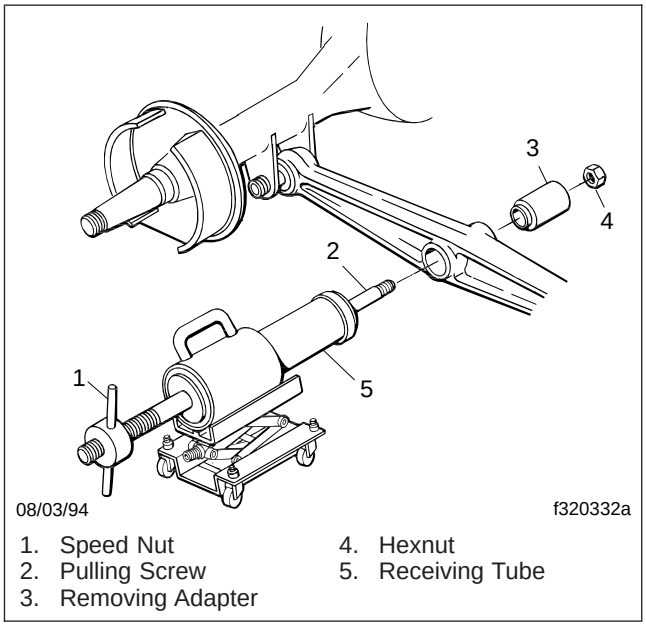



**Fig. 1, Removing End Plug**

6. On the inboard side of the equalizer beam, inspect the exposed edge of the bushing's outer sleeve.
7. Chisel or grind off any portion of the outer sleeve that has flared over the surface of the equalizer beam.
8. If using Owatonna tools, remove the rubber center bushings as follows (**Fig. 2**):




1. Speed Nut
2. Pulling Screw
3. Removing Adapter
4. Hexnut
5. Receiving Tube

**Fig. 2, Removal of Rubber Center Bushing**

8.1 Position the hydraulic ram and slide the pulling screw through the center bushing.

8.2 Install the center bushing removing adapter on the inboard side of the beam eye.

IMPORTANT: Align the receiving tube so that the bushing will clear the edges of the tube when force is exerted against the beam. Align the removing adapter so that force is exerted only on the bushing to ensure a clean pull through the beam.

8.3 Install the hexnut on the pulling screw. Full thread engagement is needed.

8.4 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.

8.5 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

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## Equalizer Beam Rubber Center Bushing Removal and Installation

8.6 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely remove the bushing.

NOTE: If the pressure gauge on the hydraulic pumping unit reads 10,000 psi (68 950 kPa) and the bushing has not broken loose, stop and check the alignment of the receiving tool and removal adapter. If both tools are aligned correctly, attach a sledging adapter on the speed nut end of the pulling screw. Maintaining hydraulic pressure, strike the sledging adapter with a heavy hammer. A loud noise followed by a sudden drop of the pressure gauge reading indicate that the bushing has broken loose.

9. If using shop-made adapters, remove the equalizer beams. For instructions, see **Subject 130**.

9.1 Position the equalizer beam on a 50-ton vertical hydraulic press.

9.2 Center the shop-made adapter (see the table under **Specifications, 400**) on the trimmed end of the equalizer beam bushing. Press the center bushing from the beam eye.

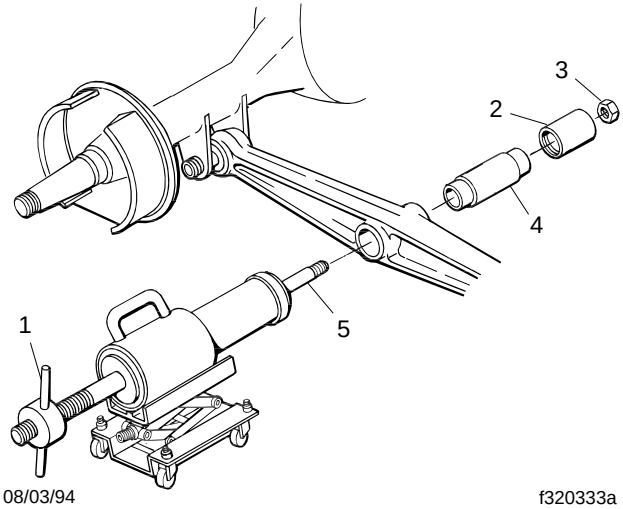
# Installation

1. Using emery cloth, remove all scale, rust, or corrosion from the beam eyes. Inspect the equalizer beam eyes for cracks, gouges, or damage. Replace the equalizer beam if any of these conditions exist.
2. Using emery cloth, clean the outer sleeves of the new equalizer beam center bushings. Apply a thin coating of Texaco Compound L, or an equivalent rust preventive lubricant, to the surface of the outer sleeves on the new bushing.
3. If using Owatonna tools, install the rubber center bushings as follows (see **Fig. 3**):

3.1 Center the hydraulic ram and slide the pulling screw through the beam eye.

3.2 Position the bushing on the inboard side of the beam eye.

IMPORTANT: Center the new bushing to ensure a clean pull through the beam eye.




1. Speed Nut
2. Installing Adapter
3. Hexnut
4. Bushing
5. Pulling Screw

**Fig. 3, Installing Rubber Center Bushing**

3.3 Fit the installing adapter over the inner sleeve and against the outer sleeve of the bushing.

3.4 Install the hexnut on the pulling screw. Full thread engagement is needed.

3.5 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.

3.6 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

3.7 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely install the center bushing.

NOTE: The pressure gauge on the pumping unit should read 4000 to 5500 psi (27 580 to 37 920 kPa) during installation. If the reading reaches the operating limit of 10,000 psi (68 950 kPa) and the bushing is not going into the beam, check the alignment of the bushing, tooling, and hydraulic equipment. Installation is complete when the installing adapter is flush against the beam.

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3.8 Position the crosstube in the center bushings.

3.9 Arc weld new end plugs to the tire side of each center bushing inner sleeve.

NOTE: Heat from welding the end plugs will not affect the beam or the new rubber bushings because of their distance from the point of welding.

4. Position the saddle caps on the saddle cap studs, then install the washers and new self-locking nuts. Tighten the nuts 225 to 275 lbf·ft (305 to 373 N·m).

5. If using shop-made adapters, position the equalizer beam on a 50-ton hydraulic press.

   5.1 Using standard center bushings with the end plugs welded in place, position the shop-made adapter (refer to the table under **Specifications, 400**) over the inner sleeve of the bushing. Check that the adapter bottoms against the bushing outer sleeve, then press the new bushing into the beam eye.

   5.2 Install the equalizer beams. For instructions, see **Subject 130**.

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# Equalizer Beam Bronze Center Bushing Removal and Installation

## Removal

NOTE: If using Owatonna tools, you can remove or install the bronze center bushing without removing the equalizer beam.

1. Chock the front tires.
2. Raise the rear of the vehicle so that all weight is removed from the suspension. Block the axles and the frame with safety stands.Make sure the stands will securely support the weight of the axles and the frame.

NOTE: Do not raise the vehicle to the point where the weight of the suspension and axles hangs from the vehicle.

3. Remove the saddle cap nut and washers from each side of the suspension, and remove the saddle caps.
4. Raise the rear of the truck frame until the saddle studs clear the equalizer beam. Install safety stands under the frame.
5. Using a 2-1/2 inch diameter hole saw, cut out the retaining disk from the center bushing on each side of the suspension, and remove the cross-tube.

**⚠ CAUTION**

**Do not use a cutting torch to burn out the retaining disk. The equalizer beams are heat treated, and the use of a cutting torch could weaken the beam.**

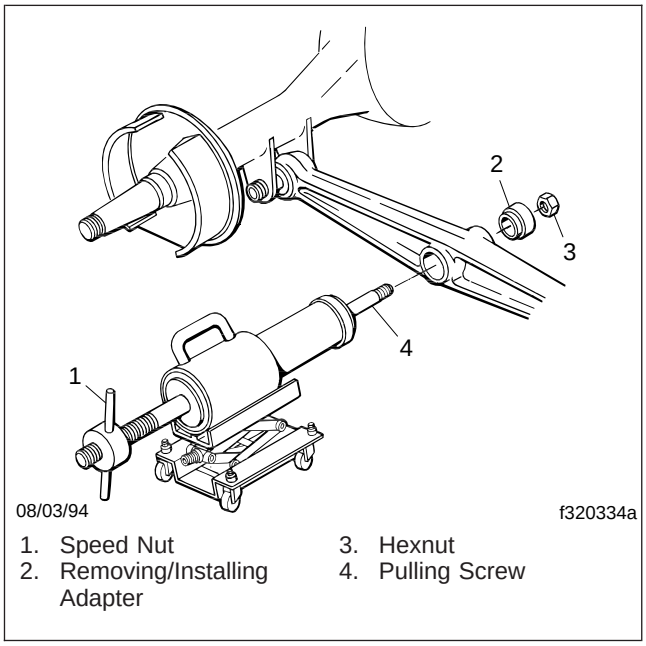
6. If using Owatonna tools, remove the bronze center bushing as follows (see **Fig. 1**):

   6.1 Position the hydraulic ram and slide the pulling screw through the center bushing.

   6.2 Install the center bushing removing adapter on the inboard side of the beam eye.

   IMPORTANT: Align the receiving tube so that the bushing will clear the edges of the tube when force is exerted against the beam. Align the removing adapter so that force is exerted only on the bushing to ensure a clean pull through the beam.

   6.3 Install the hexnut on the pulling screw. Full thread engagement is needed.




1. Speed Nut
2. Removing/Installing Adapter
3. Hexnut
4. Pulling Screw

**Fig. 1, Removal of Bronze Center Bushing**

   6.4 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.

   6.5 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

   6.6 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely remove the center bushing.

   NOTE: If the pressure gauge on the hydraulic pumping unit reads 10,000 psi (68 950 kPa) and the bushing has not broken loose, stop and check the alignment of the receiving tool and removal adapter. If both tools are aligned correctly, attach a sledging adapter on the speed nut end of the pulling screw. Maintaining hydraulic pressure, strike the sledging adapter with a heavy hammer. A loud noise followed by a sudden drop of the pressure gauge reading indicate that the bushing has broken loose.

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## Equalizer Beam Bronze Center Bushing Removal and Installation

7. If using shop-made adapters, remove the equalizer beams. For instructions, see **Subject 130**.

   7.1 Position the equalizer beam on a 50-ton vertical hydraulic press.

   7.2 Center the shop-made adapter (see the table under **Specifications, 400**) on the center bushing. Press the bushing from the beam eye.

## Installation

1. Using emery cloth, remove all scale, rust, or corrosion from the beam eyes. Inspect the equalizer beam eyes for cracks, gouges, or damage. Replace the equalizer beam if any of these conditions exist.
2. Using emery cloth, clean the outer sleeves of the new equalizer beam center bushings. Apply a thin coating of Texaco Compound L, or an equivalent rust preventive lubricant, to the surface of the outer sleeves on the new bushing, and to the inside surface of the beam eye.
3. Position the bushing on the equalizer beam eye.
4. If using Owatonna tools, install the bronze center bushings as follows (see **Fig. 2**):

   4.1 Center the hydraulic ram and slide the pulling screw through the beam eye.

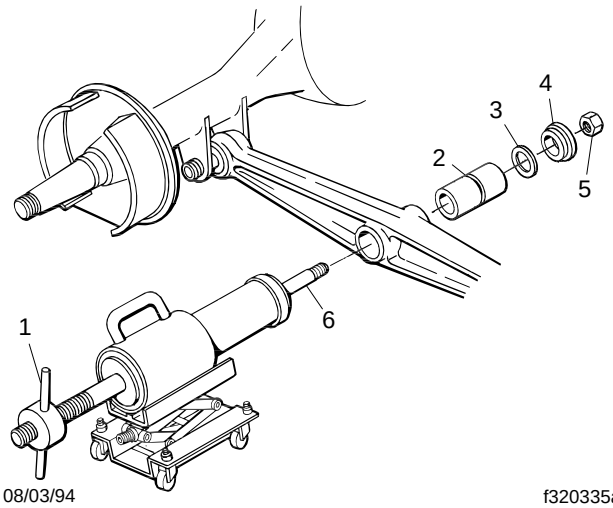
   4.2 Position the bushing on the inboard side of the beam eye. Check that the grooves of the bushing are aligned with the vertical centerline of the equalizer beam (**Fig. 3**).

   4.3 Fit the installing adapter and the removing/installing adapter against the outer sleeve of the bushing. Make sure the deep ridge on the installing adapter is positioned against the bronze bushing (**Fig. 4**).

   4.4 Install the hexnut on the pulling screw. Full thread engagement is needed.

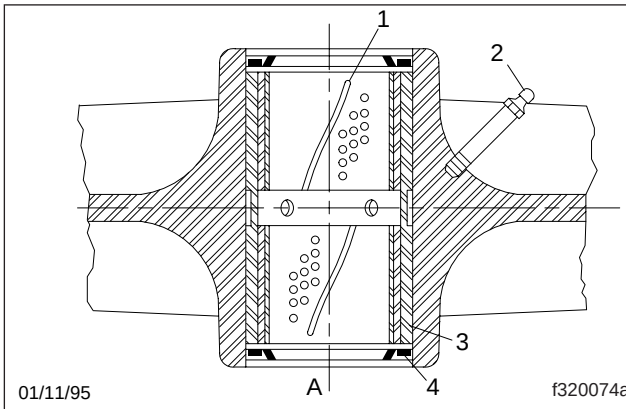
   4.5 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.

   4.6 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.




1. Speed Nut
2. Bushing
3. Installing Adapter
4. Removing/Installing Adapter
5. Hexnut
6. Pulling Screw

**Fig. 2, Installing the Bronze Center Bushing**




A. Vertical Centerline of Beam

1. Bushing Lube Grooves
2. Grease Fitting
3. Center Bushing Assembly
4. Seal

**Fig. 3, Check Bushing Grooves**

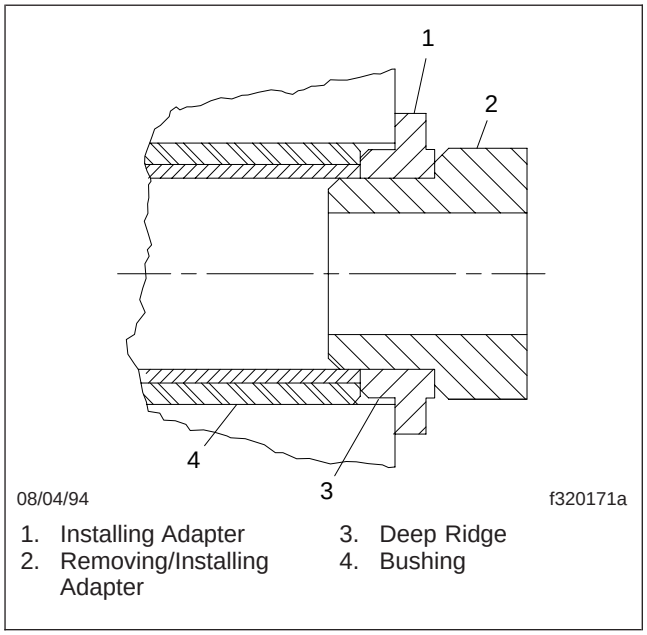
   4.7 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely install the center bushing.

NOTE: The pressure gauge on the pumping unit should read 4000 to 5500 psi (27 580 to

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## Equalizer Beam Bronze Center Bushing Removal and Installation




1. Installing Adapter
2. Removing/Installing Adapter
3. Deep Ridge
4. Bushing

**Fig. 4, Position of Adapter**

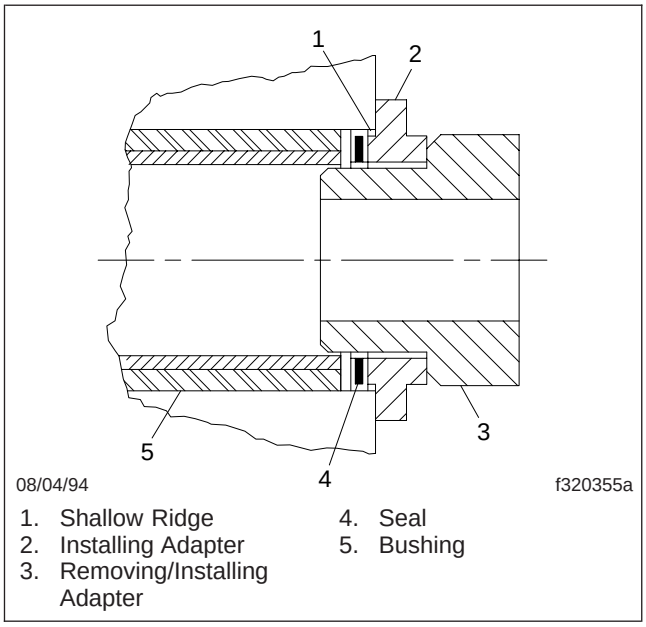
37 920 kPa) during installation. If the reading reaches the operating limit of 10,000 psi (68 950 kPa) and the bushing is not going into the beam, check the alignment of the bushing, tooling, and hydraulic equipment. Installation is complete when the installing adapter is flush against the beam.

4.8 On the inboard side of the beam, position a grease seal and installing adapter against the center bushing. Make sure the shallow end of the adapter is against the grease seal (**Fig. 5**). Using a hammer, tap the installing adapter until it is flat against the beam. Using the same procedure, install a grease seal on the outboard side of the beam.

5. If using shop-made adapters, position the equalizer beam on a 50-ton hydraulic press.

5.1 Center the new bushing in the beam eye. Using a standard bushing driver, press the bushing in until there is equal spacing between both bushing ends and the sides of the beam eye.

5.2 Install the new grease seals (with the seal lips facing out).




1. Shallow Ridge
2. Installing Adapter
3. Removing/Installing Adapter
4. Seal
5. Bushing

**Fig. 5, Seating Adapter and Seal**

NOTE: Check that the new seals are 1/6 inch (4 mm) inside the beam hub surface to ensure clearance and protection of the seals when the saddle cap is installed.

6. Apply a thin coating of multipurpose chassis grease to the inside surface of the center bushing. Slide the bushing center sleeve into the bushing.

7. Install the grease fitting into the beam hub. Rotate the center sleeve and apply multipurpose chassis grease in the grease fitting.Lubricate until clean grease appears at both ends of the grease seals.

8. Install the crosstube.

9. Install the saddle caps or the equalizer beam (if removed) on the axle beam hangers. For instructions, see **Subject 130**.

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# Torque Rod and Bushing Removal and Installation

## Removal

IMPORTANT: To ensure that the required tools are available, see the table under **Specifications, 400**, before beginning these procedures. Special tools are available from the Owatonna Tool Company, Owatonna, Minnesota, or an affiliated dealer.

**⚠ WARNING**

**When the torque rods are disconnected from the axle brackets, the axles become free to pivot on the equalizer beam end bushings. Keep clear of the beam hangers and beam ends to avoid possible injury.**

1. On fore and aft torque rods, remove the flanged bolts and nuts from the torque rod axle brackets, and the crossmember mounting brackets (**Fig. 1**). Remove the torque rods.

   On transverse torque rods, remove the nuts and washers from the axle brackets, and remove the flanged bolts and nuts from the frame rail mounting brackets (**Fig. 1**). Remove the torque rods.

NOTE: If necessary, use an impact hammer and tap the top of the axle bracket to disengage the rod stud from the axle bracket.

2. Inspect the torque rods. If bent or cracked, replace. Check the torque rod bushings. If one of the bushings is loose or damaged, replace both of the bushings.
3. Position the press plate on the hydraulic press. Check that the small counterbore of the plate hole is facing up.

NOTE: Some tapered stud torque rod bushings have a large non-removable washer on the stud that will not fit though the press plate hole. Loosen the press plate capscrews and separate the halves (**Fig. 2**) until the washer clears the counterbore, and the torque rod sets on the press plate. Tighten the capscrews until the press plate halves are closed.

4. Position the tapered stud removal tool (using the end with the larger inside diameter) on the torque rod stud. Apply lubricating oil (**Fig. 3**), then press the stud out of the bushing.
5. Position the bushing remover/replacer tool (using the end with the larger outside diameter) on the bushing. Install the cap, then apply lubricating oil to the torque rod bushing.
6. Press the rubber bushing out of the torque rod eye.
7. Position the straddle mount end of the torque rod into the hole of the press plate. Tighten the press plate capscrews.
8. Position the straddle mount pin remover on the straddle mount pin (**Fig. 4**).
9. Apply lubricating oil to the straddle mount pin. Press the straddle mount pin out of the bushing.
10. Position the end of the rubber bushing remover/replacer tool (using the end that has the larger outside diameter) on the bushing. Install the cap, then apply lubricating oil to the torque rod bushing.
11. Press the rubber bushing out of the torque rod eye.

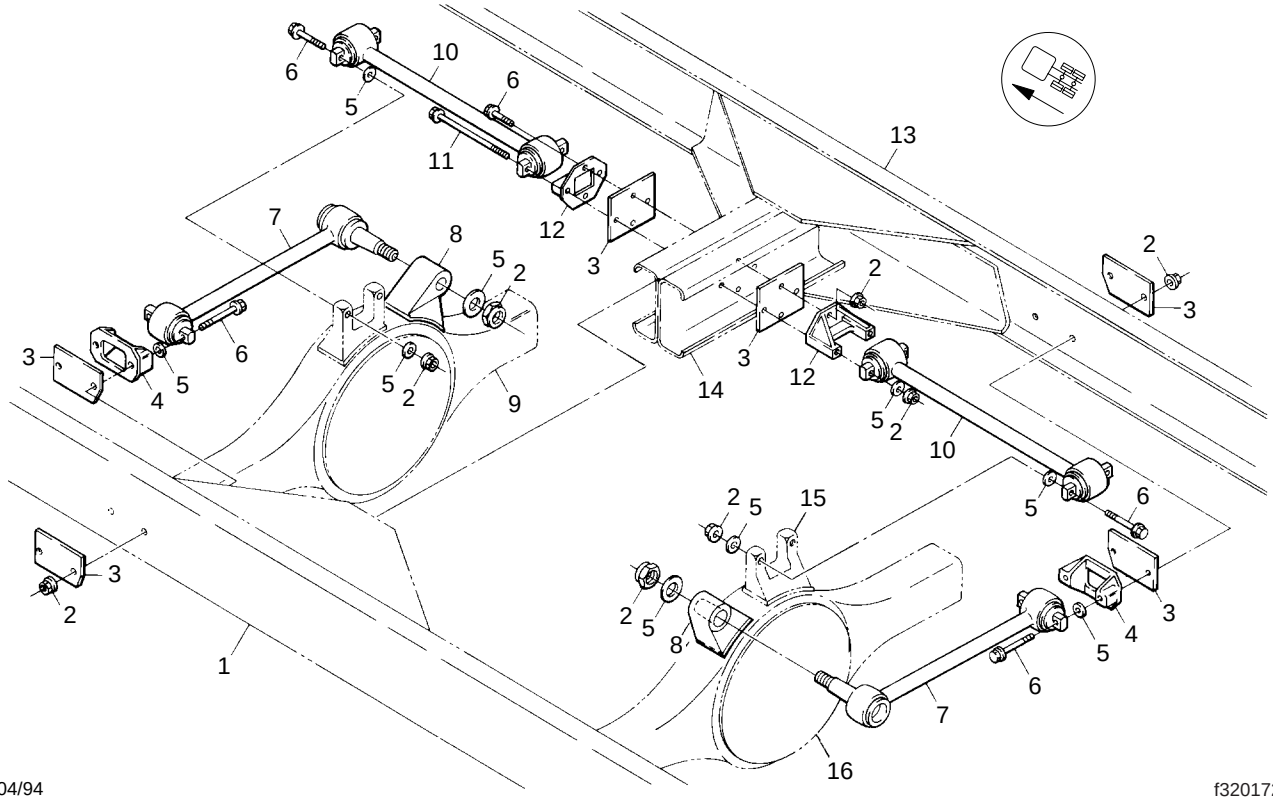
## Installation

1. Remove all dirt and grease from the torque rod ends. Apply lubricant on the new bushings and in the torque rod eyes.
2. Position the press plate on the hydraulic press. Check that the small counterbore of the plate hole is facing up.
3. Position the new bushing on the tapered stud of transverse torque rods. Position the clamp and tighten it to compress the rubber (**Fig. 5**).
4. Place the torque rod end, the bushing, and the clamp on the press plate.
5. Place the remover/replacer tool (**Fig. 6**) and cap on top of the clamping tool and press the bushing in the torque rod end. Check that the bushing sleeve protrudes equally on each side of the torque rod end.
6. On straddle mount end assemblies, align the clamping tool on the bushing as shown in **Fig. 7**. Tighten the clamp to compress the rubber of the new straddle mount bushing.

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## Torque Rod and Bushing Removal and Installation




1. Left-Hand Frame Rail
2. Flanged Hexnut
3. Spacer
4. Transverse Torque Rod Mounting Bracket
5. Hardened Washer
6. Flanged Hexbolt
7. Transverse Torque Rod
8. Transverse Torque Rod Axle Mounting Bracket
9. Forward Rear-Axle
10. Fore and Aft Torque Rod
11. Capscrew
12. Fore and Aft Torque Rod Mounting Bracket
13. Right-Hand Frame Rail
14. Crossmember
15. Fore and Aft Torque Rod Axle Mounting Bracket
16. Rearmost Axle

**Fig. 1, Torque Rod Mounting Assembly**

NOTE: When tightening the clamp, make sure that the position of the bushing pin is at a right angle to the center line of the torque rod shank (**Fig. 8**).

7. Place the torque rod end, the bushing, and the clamp on the press plate.
8. Using the larger end of the remover/ replacer tool, position the tool and cap on top of the clamp assembly.
9. Press the bushing in the torque rod end. Check that the bushing's outer sleeve protrudes equally on each side of the torque rod end.
10. Install the fore and aft torque rods as follows (see **Fig. 1**):
    - 10.1 Position a torque rod straddle mount pin in the forward-rear axle bracket. Install the flanged bolts through the axle bracket and the straddle mount pin. Install a spacer and nut on each bolt, and tighten 190 lbf·ft (260 N·m).
    - 10.2 Position a torque rod straddle mount pin in the rearmost axle bracket. Install the flanged bolts through the axle bracket and the straddle mount pin. Install a spacer and nut on each bolt, and tighten 190 lbf·ft (260 N·m).

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## Torque Rod and Bushing Removal and Installation

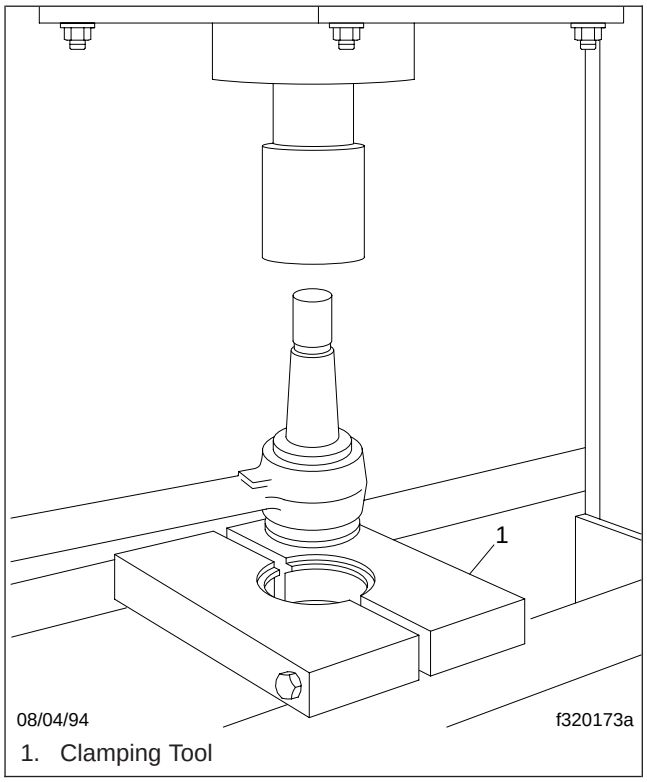



**Fig. 2, Tool for Separating Halves**

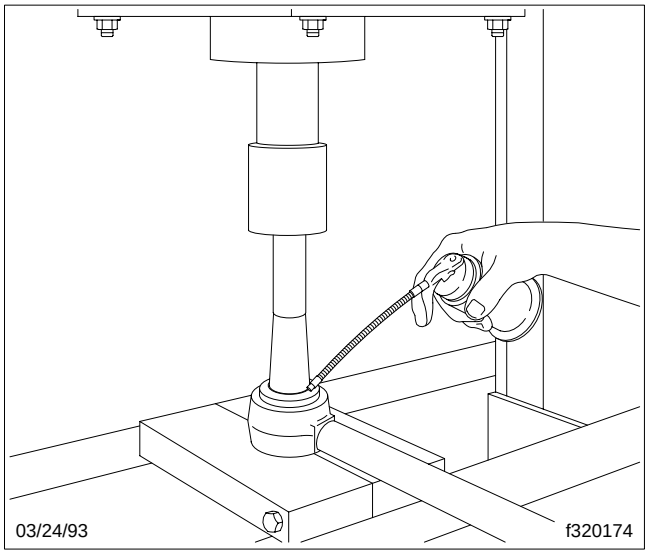



**Fig. 3, Applying Lubrication Oil**

10.3 Position a torque rod spacer and straddle mount bracket on each side of the cross-member. Insert bolts through the upper and lower holes of the forward mounting bracket. Install nuts and tighten 95 lbf·ft (130 N·m).

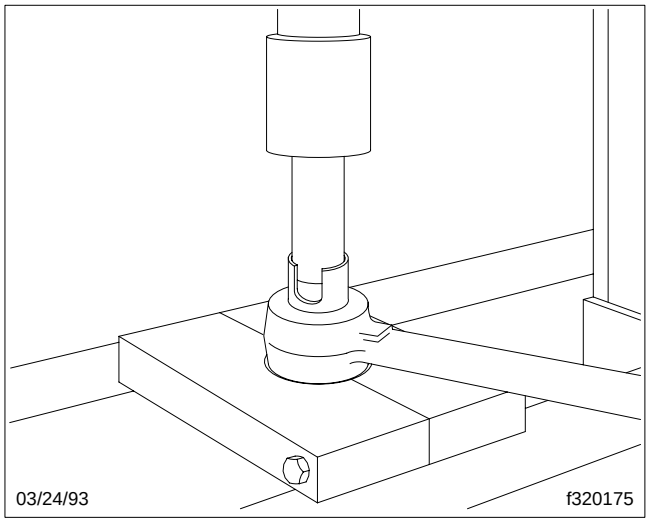



**Fig. 4, Straddle Mount Pin Position**

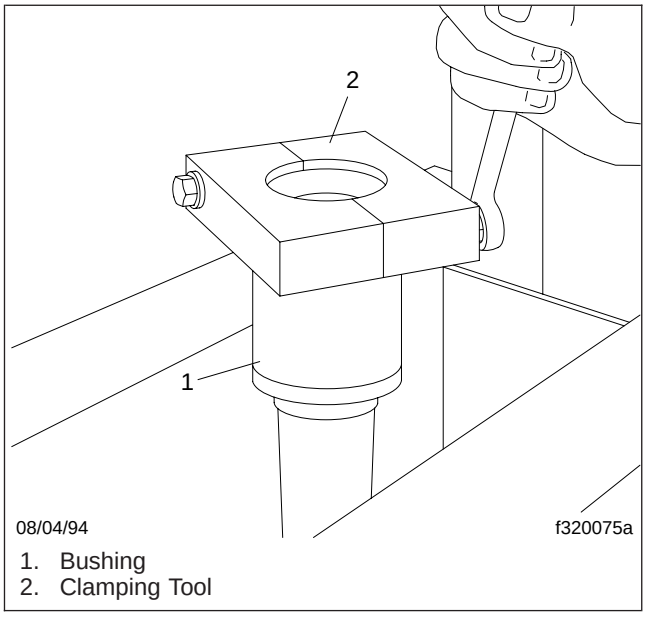


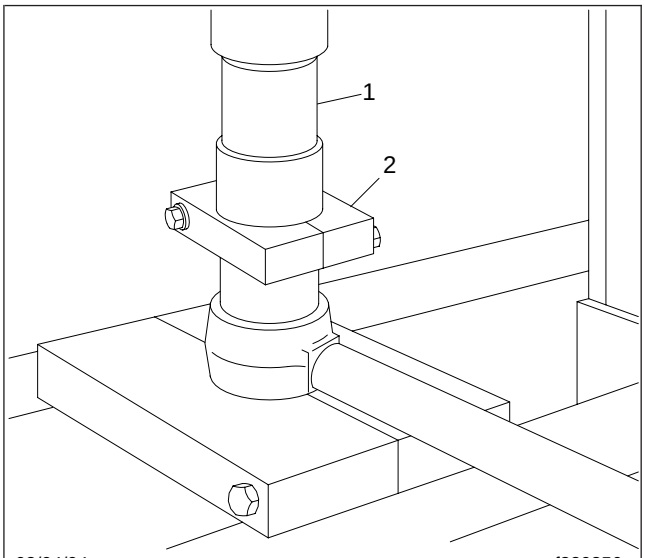

**Fig. 5, Rubber Compression**

10.4 Position the straddle mount pin of the forward torque rod in the mounting bracket. Insert bolts through the forward pin, both bracket assemblies, and the straddle mount pin of the rear torque rod. Install

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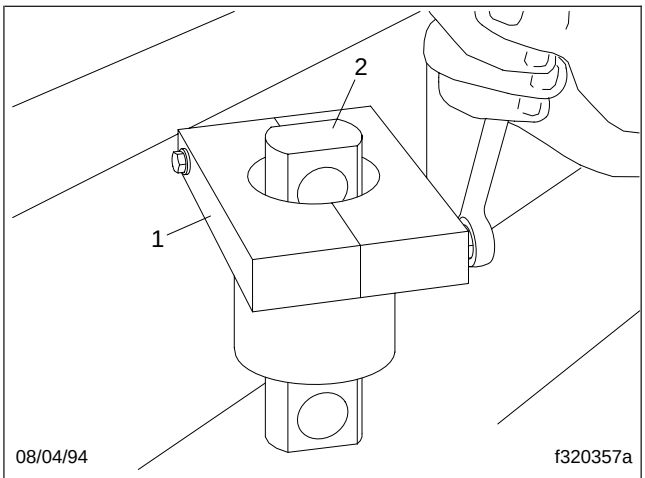


## Torque Rod and Bushing Removal and Installation




1. Remover/Replacer Tool
2. Clamping Tool

**Fig. 6, Pressing Bushing into Torque Rod End**




1. Clamping Tool
2. Pin

**Fig. 7, Clamping Tool Alignment**

the nuts and bearing washers. Tighten the nuts 190 lbf·ft (260 N·m).

11. Install the transverse torque rods as follows (see **Fig. 1**):

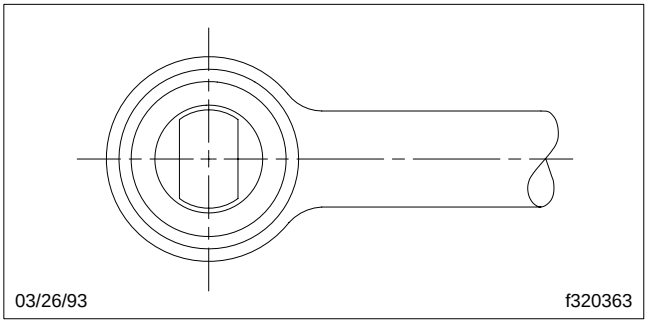



**Fig. 8, Bushing Pin Positioning**

11.1 Check that the tapered stud end and the tapered stud bracket hole are clean. Lubricate the tapered stud ends with SAE 20 oil.

11.2 Install the tapered stud in the axle bracket. Install a washer and nut. Tighten the nut 175 to 225 lbf·ft (235 to 305 N·m).

11.3 Align the straddle mount end, the mounting bracket, and the spacer against the inside frame rail.

11.4 On the inboard side of the frame rail, install the bolts through the mounting assembly and the frame rail.

11.5 On the outboard side of the frame rail, install a spacer over the mounting bolt studs. Install the nuts and tighten them 190 lbf·ft (260 N·m).

12. Check the axle pinion angle. For instructions, see **Group 41**.

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## Specifications

| Part Number | Tool | Usage |
|---|---|---|
| 1761 | Torque Rod Set | Torque Rod Bushing Removal and Installation |
| 28536 | Installing Adapter (5-3/4" o.d.) | Bronze Center Bushing and Seal Removal and Installation |
| 44119 | Receiving Tube | Center and End Bushing Removal and Installation |
| 51678 | 80-Ton Hydraulic Ram | All Operations |
| 51695 | Jack | All Operations |
| 302018 | Spacer (3 qty.) | Center and End Bushing Removal and Installation |
| 302023 | Pulling Screw | All Operations |
| 302024 | Removing and Installing Adapter | Bronze Center Bushing Removal and Installation |
| 302026 | Installing Adapter | Rubber Center Bushing Removal and Installation |
| 302027 | Removing Adapter | Rubber Center Bushing Removal and Installation |
| 302028 | Hexnut | All Operations |
| 302029 | Speed Nut | All Operations |

**Table 1, Special Tools (Owatonna Tool Company)**

| Tool Number | Dimensions | Usage |
|---|---|---|
| 3 | 4-5/8 inch o.d. by 7 inch | Beam Center Bushing Removal and Installation |

**Table 2, Shop-Made Adapters**

| Description | Size | Torque: lbf·ft (N·m) |
|---|---|---|
| Top Pad to Spring Aligning Setscrew | — | 100–150 (135–200) |
| Top Pad Nut | — | 275–400 (375–542) |
| Spring Pin Locknut | 1/2–13 | 45–63 (61–85) |
| Torque Rod Straddle Mount Nut | 5/8–11 | 190 (260) |
| Torque Rod Stud Locknut | 1-1/4–12 | 175–225 (235–305) |
| Saddle Cap Stud | 7/8–14 | 55–65 (75–90) |
| Saddle Cap Locknut | 7/8–14 | 225–275 (305–373) |
| Bar Pin Locknut | 1–8 | 450–600 (610–813) |
| Spring Center Bolt | 7/16–20 | 50–60 (70–80) |
| | 1/2–20 | 65–75 (90–100) |
| Rebound Spacer Locknut | 1/2–13 | 38–45 (51–61) |
| Spring Alignment Clip | — | 15 (20) |
| Fore and Aft Torque Rod Mount Nut | — | 95 (130) |

**Table 3, Torque Values**

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## General Information

The Hendrickson RS suspension (**Fig. 1**) is a heavy-duty tandem drive that uses six rubber load cushions in place of leaf springs to lessen road shocks. Frame hangers above the four outside cushions have vertical drive pins and bushings (**Fig. 2**) that extend down through the cushions. All driving, braking, and cornering forces are transmitted and controlled through these pins and bushings.

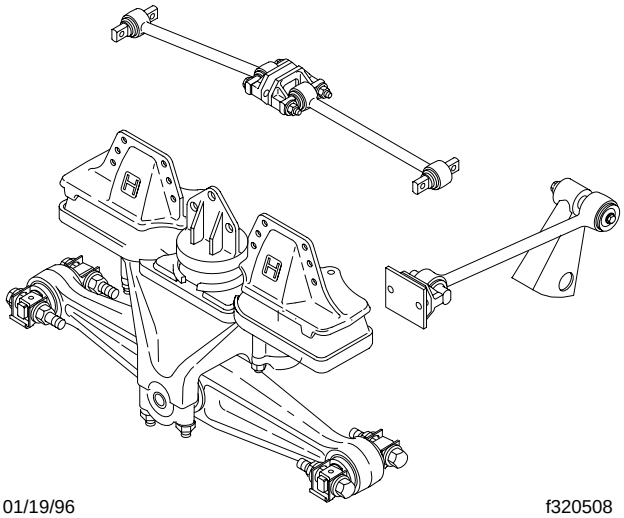
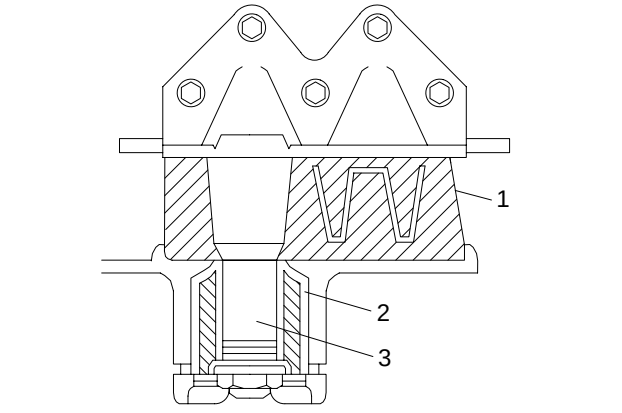



**Fig. 1, Hendrickson RS Heavy-Duty Suspension**




1. Load Cushion
2. Vertical Drive Pin Bushing
3. Vertical Drive Pin

**Fig. 2, Load Cushion Assembly**

The axles are attached to beam hangers at the ends of the equalizer beams, allowing an articulating action between the axles to absorb road shock. Torque rods, mounted between the axles and frame rails, stabilize axle and vehicle movement caused by accelerating and braking.

All suspension fasteners require periodic tightening. For suspension inspecting, lubricating, and fastener torque checking instructions, see **Group 32** of the *Western Star Maintenance Manual*.

**⚠ WARNING**

**Torque suspension fasteners on a periodic schedule as suggested in the vehicle maintenance manual. Failure to to do so could result in damage to the frame hangers or separation of components. This could cause a loss of vehicle control, resulting in personal injury or property damage.**

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## Removal

1. Chock the front tires.
2. Drain the vehicle air system.
3. Disconnect all air lines leading to the rear axles, marking the lines for later assembly reference. Plug or cap all lines and fittings to prevent dirt from entering the system.
4. Disconnect the driveline rear universal joint from the forward-rear axle. Then, remove the interaxle driveline. For instructions see **Group 41**.
5. Manually release the spring brake chambers. For instructions see **Group 42**.
6. Remove the torque rods. For instructions see **Subject 160**.

**⚠ WARNING**

**When the torque rods are disconnected from the axle brackets, the axles become free to pivot on the equalizer beam end bushings. Keep clear of the beam hangers and beam ends to avoid possible injury.**

7. Raise the rear of the vehicle so that all weight is removed from the suspension. Then, block the axles and the frame with safety stands. Make sure the stands will securely support the weight of the axles and the frame.

NOTE: Do not raise the vehicle to the point where the weight of the suspension and axles hangs from the vehicle.

8. Remove the saddle cap nuts and washers from each side of the vehicle, and remove the saddle caps. See **Fig. 1**.
9. Raise the rear of the vehicle frame until there is enough clearance to roll the axles out from under the vehicle. Install safety stands under the frame, then roll the axles—with the equalizer beams attached—out from under the vehicle.

## Installation

1. Roll the axles under the vehicle frame. Align the center bushing of each equalizer beam with the center of the saddle legs.
2. Raise the vehicle frame off the safety stands, then remove the safety stands.
3. Lower the frame, centering the saddles on the beam center bushings.
4. Install the saddle caps, washers and new self-locking nuts. Do not tighten.
5. Install the torque rods. For instructions see **Subject 160**.
6. Tighten the saddle cap locknuts 225 to 275 lbf·ft (300 to 375 N·m).

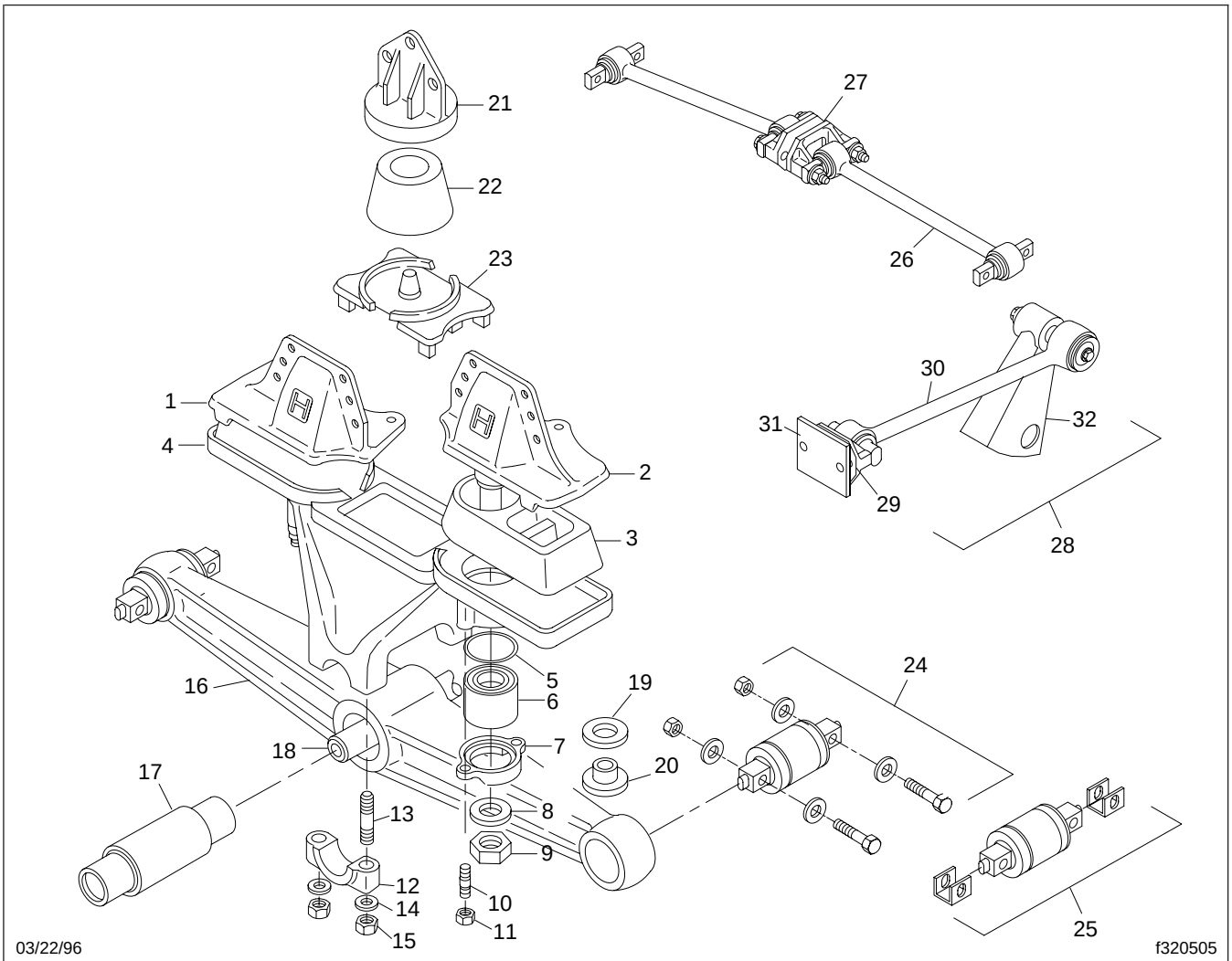
NOTE: Maintain an even gap between the saddle cap and the saddle when tightening the self-locking nuts.

7. Remove the safety stands from under the frame and axle, and lower the vehicle.
8. Manually reset the spring brake chambers. For instructions see **Group 42**.
9. Connect the driveline rear universal joint to the forward-rear axle. Connect the interaxle driveline. For instructions see **Group 41**.
10. Uncap all air lines and fittings, then connect the lines leading to the rear axles.
11. Check the axle pinion angle. For instructions see **Group 41**.

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## Suspension Removal and Installation




1. Frame Hanger
2. Frame Hanger and Vertical Drive Pin
3. Load Cushion
4. Saddle Assembly
5. Saddle Bearing Ring
6. Bushing
7. Cap
8. Washer
9. Nut
10. Stud
11. Nut
12. Saddle Cap
13. Stud
14. Washer
15. Saddle Cap Stud Nut
16. Equalizing Beam
17. Center Bushing
18. Cross Tube
19. Rebound Bumper
20. Stop Nut
21. Frame Hanger
22. Heavy-Duty Load Cushion
23. Saddle Plate
24. Bar Pin Bushing Kit (non-shim type)
25. Bar Pin Bushing Kit (shim type)
26. Torque Rod
27. Torque Rod Frame Bracket
28. Transverse Torque Rod Asssembly
29. Transverse Torque Rod Frame Bracket
30. Transverse Torque Rod
31. Backup Plate
32. Axle Bracket

**Fig. 1, Hendrickson RS Heavy-Duty Suspension**

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## Removal

1. Remove the suspension. For instructions see **Subject 100**.
2. Support the saddle assembly with a floor jack.
3. Remove the vertical drive pin locknuts and the concave washers (**Fig. 1**).

   On rebound control kit installations, use a 3/4–inch drive socket to remove the stop nuts. Then remove the bumper and the concave washers (**Fig. 2**).

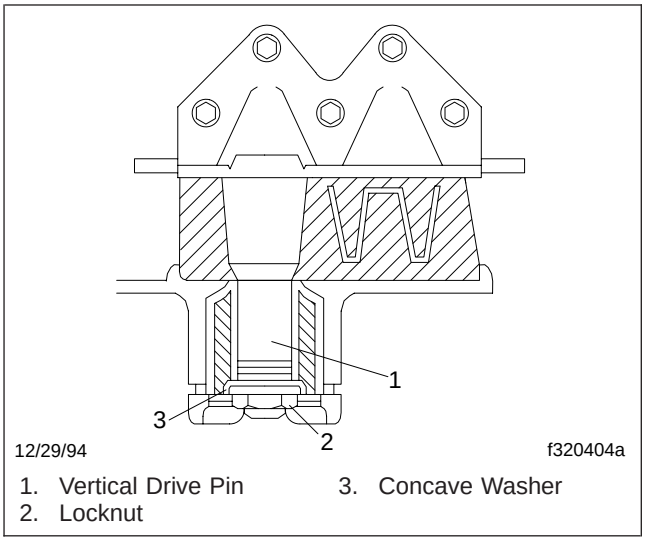



**Fig. 1, Vertical Drive Pin Assembly**

4. Lower the saddle and load cushions from the frame hanger and the vertical drive pins.

## Installation

1. Apply Texaco Compound L, or an equivalent rust preventive lubricant, on the vertical drive pins and the vertical drive pin bushings.
2. Position the rubber load cushions on the saddle. Raise the saddle assembly, guiding the vertical drive pin bushings over the vertical drive pin.
3. Install the drive pin washers (with the concave end pointing down) over the threaded ends of the drive pins.
4. Install the vertical drive pin locknuts and tighten 175 to 225 lbf·ft (235 to 300 N·m).

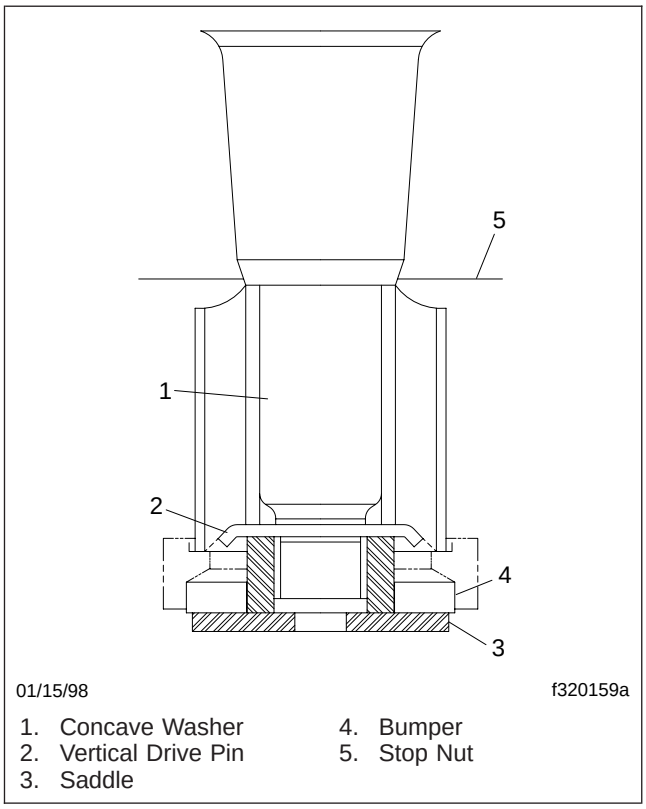



**Fig. 2, Rebound Control Kit**

5. On rebound control kit installations, install the stop nuts, bumpers, and the concave washers. Tighten the stop nuts 175 to 225 lbf·ft (235 to 300 N·m).
6. Install the suspension. For instructions, see **Subject 100**.

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# Load Cushion and Vertical Drive Pin Bushing Replacement

1. Remove the saddle assembly. For instructions, see **Subject 110**.

NOTE: If replacing only the heavy-duty load cushions, removal of the saddle assembly is not needed. These cushions can be forced out after raising the frame to open the area between the saddle and the frame hanger brackets.

2. Inspect all of the rubber load cushions for cuts or other damage. Replace a load cushion if these conditions exist.
3. Measure each load cushion. If the height of a load cushion is less than 3-11/16 inches (94 mm), replace it.
4. Remove the retainer locknuts from the drive pin bushing retainer cap, and remove the retainer cap.
5. Using a hydraulic press, press the vertical drive pin bushings out of the saddle from the top.
6. If the outer sleeve of the bushing is frozen in the saddle bore, press out the inner sleeve and rubber insert, then work the outer sleeve out of the saddle bore.

**⚠ WARNING**

**Do not use a cutting torch to remove the vertical drive pin bushings. Using high heat will weaken the saddle, which could cause the saddle to break. This could result in a loss of vehicle control, possible personal injury, and property damage.**

7. Using emery cloth, remove small nicks or scratches from the vertical drive pin and the vertical drive pin bushing. Clean the saddle bores with a solvent.
8. Apply Texaco Compound L, or an equivalent rust-preventive lubricant, on the drive pin bushings and the saddle bores.
9. Fit the bushings into the saddle bores. Position the drive pin bushing retainer cap and install the retainer cap locknuts. Tighten the locknuts 100 to 125 lbf·ft (135 to 170 N·m).
10. Install the rubber load cushions.
11. Install the saddle assembly. For instructions, see **Subject 110**.

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# Equalizer Beam Removal and Installation

## Removal

1. Chock the front tires.
2. Remove the saddle cap nuts and washers, then remove the saddle cap. Support the equalizer beam with safety stands.
3. Raise the rear of the vehicle until the saddle studs clear the equalizer beam. Block the axles and frame with safety stands.
4. Remove the wheels and tires. For instructions, see **Group 40**.
5. Apply a penetrating oil to all beam end connections.
6. Remove the bar pins.

NOTE: The bar pin-style beam end connection is a rubber bushing assembly consisting of a rubber insert and outer metal tube with inner casting. It is fastened to the axle by two 1-inch (25 mm) bolts and locknuts. The bolts are positioned parallel to the vehicle's longitudinal axis, making removal and installation easy.

**⚠ WARNING**

**Do not use a cutting torch to remove the equalizer beams from the beam hangers. The equalizer beams are heat-treated, and using a cutting torch could weaken them, causing them to break. This could result in a loss of vehicle control, possible personal injury and property damage.**

7. Remove the ends of the equalizer beams from the axle beam hangers.
8. Lower the equalizer beams and the crosstube to the ground. Remove the thrustwashers and pull the beams from the crosstube.

## Installation

1. Install the crosstube and thrustwashers in both equalizer beam center bushings.
2. Install the bar pins, then install the crosstube and thrustwashers in both equalizer beam center bushings.

   Position the equalizer beam assembly under the axles, then raise the assembly and place the forward ends of each beam in the forward-rear axle beam hangers. Align the beam end bushings with the beam hangers.
3. Place the rear ends of each beam in the rearmost-axle beam hangers. Align the beam end bushings with the beam hangers.
4. Position the saddle caps on the saddle cap studs, then install the washers and new self-locking nuts. Tighten the nuts 225 to 275 lbf·ft (300 to 375 N·m).
5. Install the bar pin bolt locknuts, and tighten 450 to 600 lbf·ft (610 to 813 N·m).

**⚠ WARNING**

**Tighten the bar pin locknuts to the specified torque values. Otherwise, excessive component wear could result. This could result in separation of suspension components, loss of vehicle control, and possible personal injury or property damage.**

6. Install the wheels and tires. For instructions, see **Group 40**.

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# Equalizer Beam Rubber Center Bushing Removal and Installation

## Removal

NOTE: If using Owatonna tools, removal of the equalizer beam is not required for removal or installation of the rubber center bushing.

1. Chock the front tires.
2. Raise the rear of the vehicle so that all weight is removed from the suspension. Block the axles and the frame with safety stands. Make sure the stands will securely support the weight of the axles and the frame.

NOTE: Do not raise the vehicle to the point where the weight of the suspension and axles hangs from the vehicle.

3. Remove the saddle cap nuts and washers from each side of the vehicle, and remove the saddle caps.
4. Raise the rear of the truck frame until the saddle studs clear the equalizer beam. Install safety stands under the frame.
5. Using a 2-1/2-inch diameter hole saw (**Fig. 1**), cut out the end plug from the center bushing on each side of the suspension, and remove the crosstube.

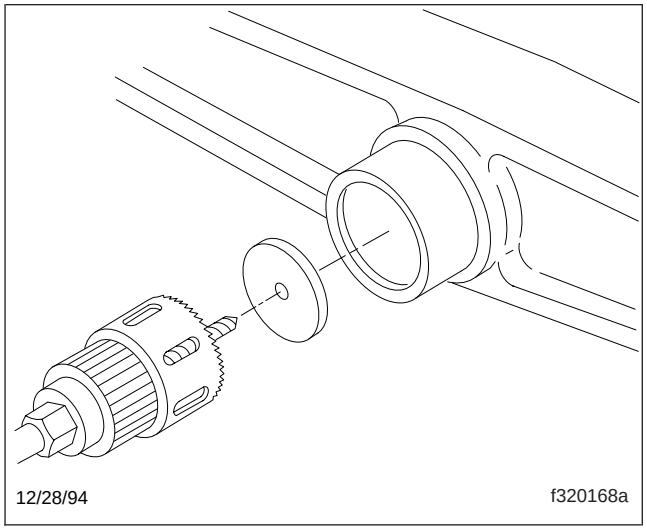
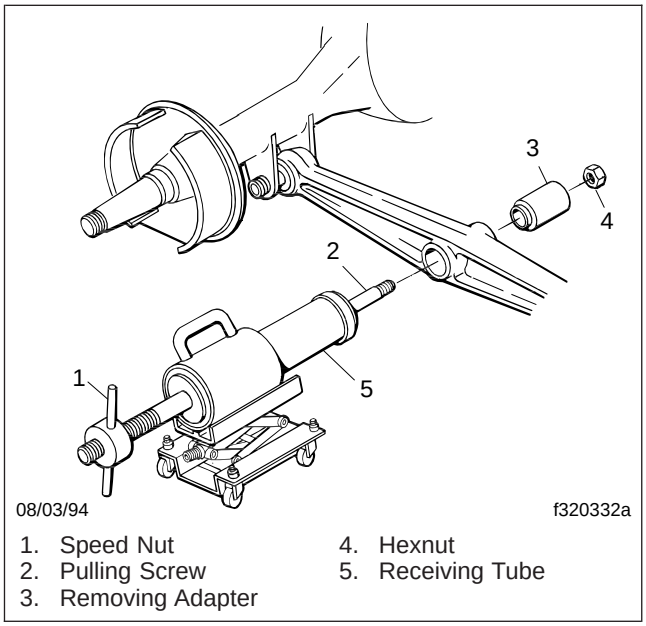



**Fig. 1, End Plug Removal**

**WARNING**

**Don't use a cutting torch to remove the beam end bushing. Equalizer beams are heat-treated by the manufacturer. Using a cutting torch could weaken the beams, which could cause the beams to break. This could cause a loss of vehicle control, resulting in injury or property damage.**

6. On the inboard side of the equalizer beam, inspect the exposed edge of the bushing's outer sleeve.
7. Chisel or grind off any portion of the outer sleeve that has flared over the surface of the equalizer beam.
8. If using Owatonna tools, remove the rubber center bushings (see **Fig. 2**):




1. Speed Nut
2. Pulling Screw
3. Removing Adapter
4. Hexnut
5. Receiving Tube

**Fig. 2, Rubber Center Bushings Removal**

8.1 Position the hydraulic ram and slide the pulling screw through the center bushing.

8.2 Install the center bushing removing adapter on the inboard side of the beam eye.

IMPORTANT: Align the receiving tube so that the bushing will clear the edges of the tube when force is exerted against the beam. Align the removing adapter so that

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## Equalizer Beam Rubber Center Bushing Removal and Installation

force is exerted only on the bushing to ensure a clean pull through the beam.

8.3 Install the hexnut on the pulling screw. Full thread engagement is needed.

8.4 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.

8.5 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

8.6 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely remove the bushing.

NOTE: If the pressure gauge on the hydraulic pumping unit reads 10,000 psi (68 900 kPa) and the bushing has not broken loose, stop and check the alignment of the receiving tool and removal adapter. If both tools are aligned correctly, attach a sledging adapter on the speed nut end of the pulling screw. Maintaining hydraulic pressure, strike the sledging adapter with a heavy hammer. A loud noise followed by a sudden drop of the pressure gauge reading indicate that the bushing has broken loose.

9. If using shop-made adapters, remove the equalizer beams. For instructions, see **Subject 130**.

9.1 Position the equalizer beam on a 50-ton vertical hydraulic press.

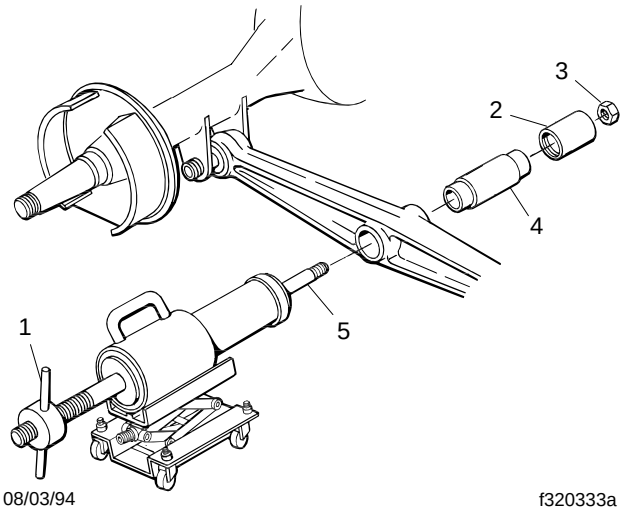
9.2 Position the shop-made adapter (see **Specifications, 400**) on the outer metal edge of the equalizer beam bushing. Press the center bushing from the beam eye.

## Installation

1. Using emery cloth, remove all scale, rust, or corrosion from the beam eyes. Inspect the equalizer beam eyes for cracks, gouges, or damage. Replace the equalizer beam if any of these conditions exist.

2. Using emery cloth, clean the outer sleeves of the new equalizer beam center bushings. Apply a thin coating of Texaco Compound L, or an equivalent rust preventive lubricant, to the surface of the outer sleeves on the new bushing.

3. If using Owatonna tools, install the rubber center bushings (see **Fig. 3**):




1. Speed Nut
2. Installing Adapter
3. Hexnut
4. Bushing
5. Pulling Screw

**Fig. 3, Rubber Center Bushings Installation**

3.1 Center the hydraulic ram and slide the pulling screw through the beam eye.

3.2 Position the bushing on the inboard side of the beam eye.

IMPORTANT: Center the new bushing to ensure a clean pull through the beam eye.

3.3 Fit the installing adapter over the inner sleeve and against the outer sleeve of the bushing.

3.4 Install the hexnut on the pulling screw. Full thread engagement is needed.

3.5 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.

3.6 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

3.7 Release the pressure, add spacers, and tighten the speed nut. About three adjust-

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ments are needed to completely install the center bushing.

NOTE: The pressure gauge on the pumping unit should read 4000 to 5500 psi (27 560 to 37 895 kPa) during installation. If the reading reaches the operating limit of 10,000 psi (68 900 kPa) and the bushing is not going into the beam, check the alignment of the bushing, tooling, and hydraulic equipment. Installation is complete when the installing adapter is flush against the beam.

3.8 Position the crosstube in the center bushings.

3.9 Arc weld new end plugs to the tire side of each center bushing inner sleeve.

NOTE: Heat from welding the end plugs will not affect the beam or the new rubber bushings because of their distance from the point of welding.

4. Position the saddle caps on the saddle cap studs, then install the washers and new self-locking nuts. Tighten the nuts 225 to 275 lbf·ft (300 to 375 N·m).

5. If using shop-made adapters, position the equalizer beam on a 50-ton hydraulic press.

5.1 Using standard center bushings with the end plugs welded in place, position the shop-made adapter (see **Specifications, 400**) over the inner sleeve of the bushing. Check that the adapter bottoms against the bushing outer sleeve, then press the new bushing into the beam eye.

5.2 Install the equalizer beams. For instructions, see **Subject 130**.

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# Equalizer Beam Bronze Center Bushing Removal and Installation

## Removal

NOTE: If using Owatonna tools, you can remove or install the bronze center bushing without removing the equalizer beam.

1. Chock the front tires.
2. Raise the rear of the vehicle so that all weight is removed from the suspension. Block the axles and the frame with safety stands. Make sure the stands will securely support the weight of the axles and the frame.

NOTE: Do not raise the vehicle to the point where the weight of the suspension and axles hangs from the vehicle.

3. Remove the saddle cap nuts and washers from each side of the suspension, and remove the saddle caps.
4. Raise the rear of the truck frame until the saddle studs clear the equalizer beam. Install safety stands under the frame.
5. Using a 2-1/2-inch diameter hole saw, cut out the retaining disk from the center bushing on each side of the suspension, and remove the cross-tube.

**⚠ WARNING**

**Do not use a cutting torch to burn out the retaining disk. The equalizer beams are heat treated, and the use of a cutting torch could weaken the beam, causing it to break, which could result in loss of vehicle control, and possible personal injury or property damage.**

6. If using Owatonna tools, remove the bronze center bushing as follows (see **Fig. 1**):

   6.1 Position the hydraulic ram and slide the pulling screw through the center bushing.

   6.2 Install the center bushing removing adapter on the inboard side of the beam eye.

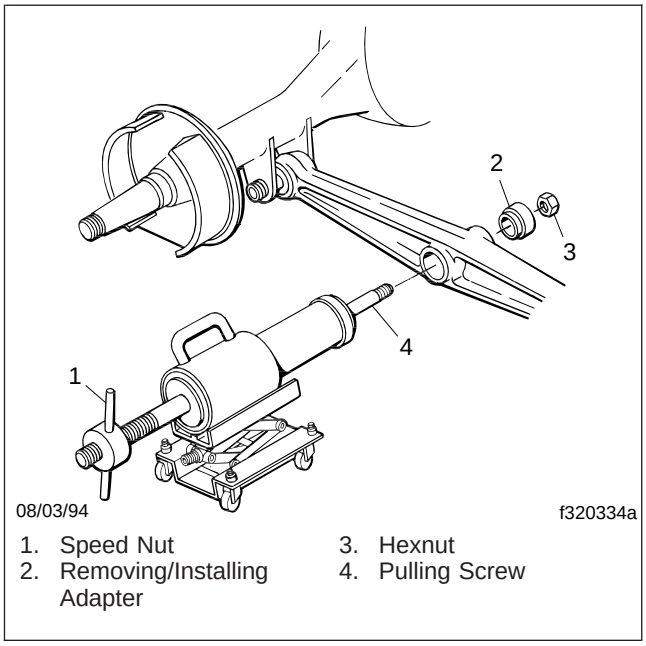
   IMPORTANT: Align the receiving tube so that the bushing will clear the edges of the tube when force is exerted against the beam. Align the removing adapter so that force is exerted only on the bushing to ensure a clean pull through the beam.

   6.3 Install the hexnut on the pulling screw. Full thread engagement is needed.

   6.4 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.

   6.5 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.

   6.6 Release the pressure, add spacers, and tighten the speed nut. About three adjustments are needed to completely remove the center bushing.




1. Speed Nut
2. Removing/Installing Adapter
3. Hexnut
4. Pulling Screw

**Fig. 1, Bronze Center Bushings Removal**

NOTE: If the pressure gauge on the hydraulic pumping unit reads 10,000 psi (68 900 kPa) and the bushing has not broken loose, stop and check the alignment of the receiving tool and removal adapter. If both tools are aligned correctly, attach a sledging adapter on the speed nut end of the pulling screw. Maintaining hydraulic pressure, strike the sledging adapter with a heavy hammer. A loud noise followed by a

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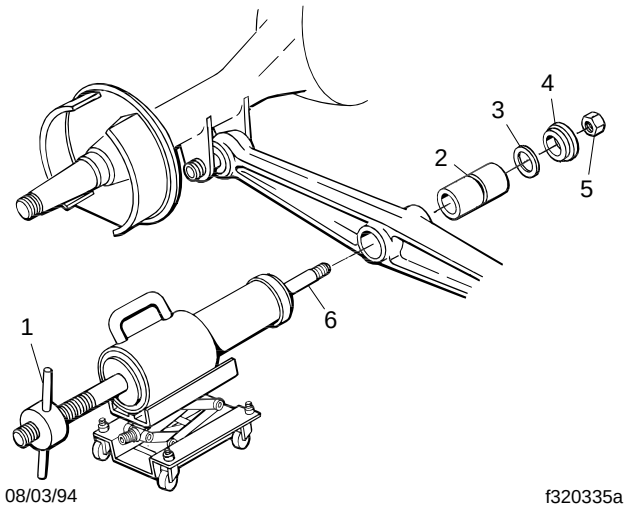
## Equalizer Beam Bronze Center Bushing Removal and Installation

sudden drop of the pressure gauge reading indicate that the bushing has broken loose.

7. If using shop-made adapters, remove the equalizer beams. For instructions,see **Subject 130**.
   - 7.1 Position the equalizer beam on a 50-ton vertical hydraulic press.
   - 7.2 Center the shop-made adapter (see **Specifications, 400**) on the center bushing. Press the bushing from the beam eye.

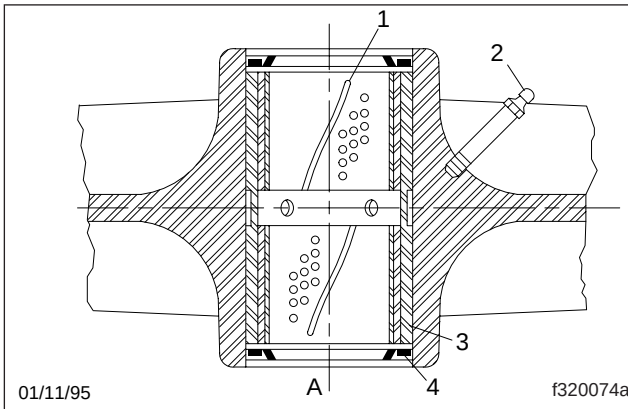
## Installation

1. Using emery cloth, remove all scale, rust, or corrosion from the beam eyes. Inspect the equalizer beam eyes for cracks, gouges, or damage. Replace the equalizer beam if any of these conditions exist.
2. Using emery cloth, clean the outer sleeves of the new equalizer beam center bushings. Apply a thin coating of Texaco Compound L, or an equivalent rust-preventive lubricant, to the surface of the outer sleeves on the new bushing, and to the inside surface of the beam eye.
3. Position the bushing on the equalizer beam eye.
4. If using Owatonna tools, install the bronze center bushings (see **Fig. 2**):
   - 4.1 Center the hydraulic ram and slide the pulling screw through the beam eye.
   - 4.2 Position the bushing on the inboard side of the beam eye. Check that the grooves of the bushing are aligned with the vertical centerline of the equalizer beam (**Fig. 3**).
   - 4.3 Fit the installing adapter and the removing/installing adapter against the outer sleeve of the bushing. Make sure the deep ridge on the installing adapter is positioned against the bronze bushing (**Fig. 4**).
   - 4.4 Install the hexnut on the pulling screw. Full thread engagement is needed.
   - 4.5 Install spacers between the ram cylinder and the speed nut. Tighten the speed nut and remove any slack in the assembly.




1. Speed Nut
2. Bushing
3. Installing Adapter
4. Removing/Installing Adapter
5. Hexnut
6. Pulling Screw

**Fig. 2, Bronze Center Bushings Installation**




A. Vertical Centerline of Beam

1. Bushing Lube Grooves
2. Grease Fitting
3. Center Bushing Assembly
4. Seal

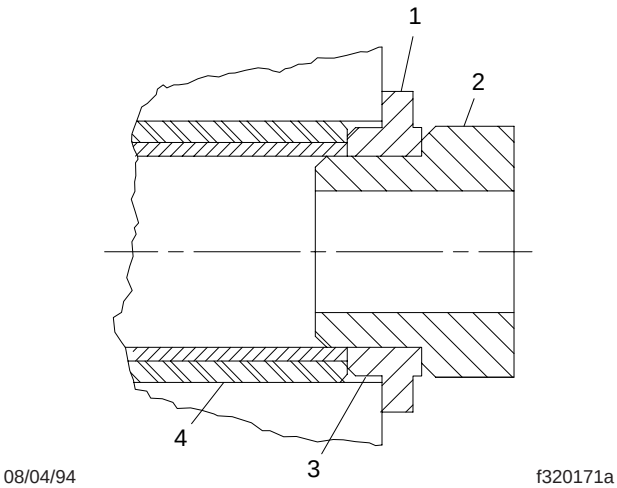
**Fig. 3, Bushing Groove Alignment**

- 4.6 Connect a hydraulic pumping unit to the ram and apply force until the ram cylinder reaches its stroke limit.
- 4.7 Release the pressure, add spacers, and tighten the speed nut. About three adjust-

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## Equalizer Beam Bronze Center Bushing Removal and Installation




1. Installing Adapter
2. Removing/Installing Adapter
3. Deep Ridge
4. Bushing

**Fig. 4, Installing Adapter Positioning**

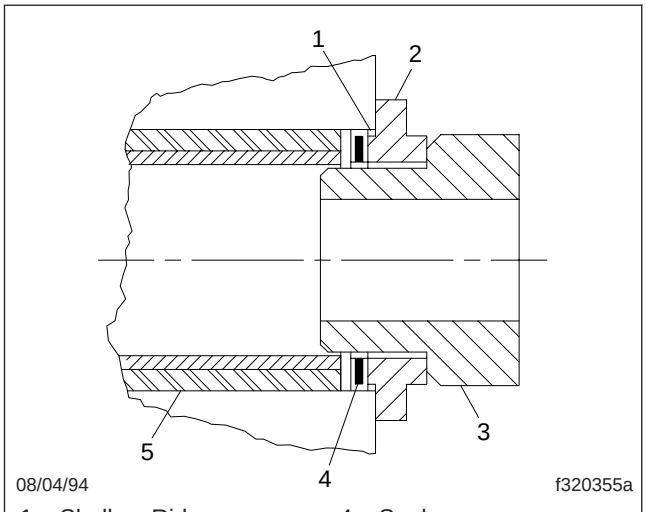
ments are needed to completely install the center bushing.

NOTE: The pressure gauge on the pumping unit should read 4000 to 5500 psi (27 560 to 37 895 kPa) during installation. If the reading reaches the operating limit of 10,000 psi (68 900 kPa) and the bushing is not going into the beam, check the alignment of the bushing, tooling, and hydraulic equipment. Installation is complete when the installing adapter is flush against the beam.

4.8 On the inboard side of the beam, position a grease seal and installing adapter against the center bushing. Make sure the shallow end of the adapter is against the grease seal (**Fig. 5**). Using a hammer, tap the installing adapter until it is flat against the beam. Using the same procedure, install a grease seal on the outboard side of the beam.

5. If using shop-made adapters, position the equalizer beam on a 50-ton hydraulic press.

5.1 Center the new bushing in the beam eye. Using a standard bushing driver, press the bushing in until there is equal spacing between both bushing ends and the sides of the beam eye.




1. Shallow Ridge
2. Installing Adapter
3. Removing/Installing Adapter
4. Seal
5. Bushing

**Fig. 5, Adapter and Grease Seal Positioning**

5.2 Install the new grease seals (with the seal lips facing out).

NOTE: Check that the new seals are 1/6 inch (4 mm) inside the beam hub surface to ensure clearance and protection of the seals when the saddle cap is installed.

6. Apply a thin coating of multipurpose chassis grease to the inside surface of the center bushing. Slide the bushing center sleeve into the bushing.
7. Install the grease fitting into the beam hub. Rotate the center sleeve and apply multipurpose chassis grease in the grease fitting. Lubricate until clean grease appears at both ends of the grease seals.
8. Install the crosstube.
9. Install the saddle caps or the equalizer beam (if removed) on the axle beam hangers. For instructions, see **Subject 130**.

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# Torque Rod Removal, Bushing Replacement, and Installation

## Removal

IMPORTANT: To ensure that the required tools are available, see **Specifications, 400**, before beginning these procedures. Special tools are available from the Owatonna Tool Company, Owatonna, Minnesota, or an affiliated dealer.

**⚠ WARNING**

**When the torque rods are disconnected from the axle brackets, the axles become free to pivot on the equalizer beam end bushings. Keep clear of the beam hangers and beam ends to avoid possible injury.**

1. On fore and aft torque rods, remove the flanged bolts and nuts from the torque rod axle brackets, and the crossmember mounting brackets (**Fig. 1**). Remove the torque rods.

   On transverse torque rods, remove the nuts and washers from the axle brackets, and remove the flanged bolts and nuts from the frame rail mounting brackets (**Fig. 1**). Remove the torque rods.

NOTE: If necessary, use an impact hammer and tap the top of the axle bracket to disengage the rod stud from the axle bracket.

2. Inspect the torque rods. If bent or cracked, replace. Check the torque rod bushings. If one of the bushings is loose or damaged, replace both of the bushings.
3. Position the press plate on the hydraulic press. Check that the small counterbore of the plate hole is facing up.

NOTE: Some tapered stud torque rod bushings have a large non-removable washer on the stud that will not fit though the press place hole. Loosen the press plate capscrews and separate the halves (**Fig. 2**) until the washer clears the counterbore, and the torque rod sets on the press plate. Tighten the capscrews until the press plate halves are closed.

4. Position the tapered stud removal tool (using the end with the larger inside diameter) on the torque rod stud. Apply lubricating oil (**Fig. 3**), then press the stud out of the bushing.
5. Position the bushing remover/replacer tool (using the end with the larger outside diameter) on the bushing. Install the cap, then apply lubricating oil to the torque rod bushing.
6. Press the rubber bushing out of the torque rod eye.
7. Position the straddle mount end of the torque rod into the hole of the press plate. Tighten the press plate capscrews.
8. Position the straddle mount pin remover on the straddle mount pin (**Fig. 4**).
9. Apply lubricating oil to the straddle mount pin. Press the straddle mount pin out of the bushing.
10. Position the end of the rubber bushing remover/replacer tool (using the end that has the larger outside diameter) on the bushing. Install the cap, then apply lubricating oil to the torque rod bushing.
11. Press the rubber bushing out of the torque rod eye.

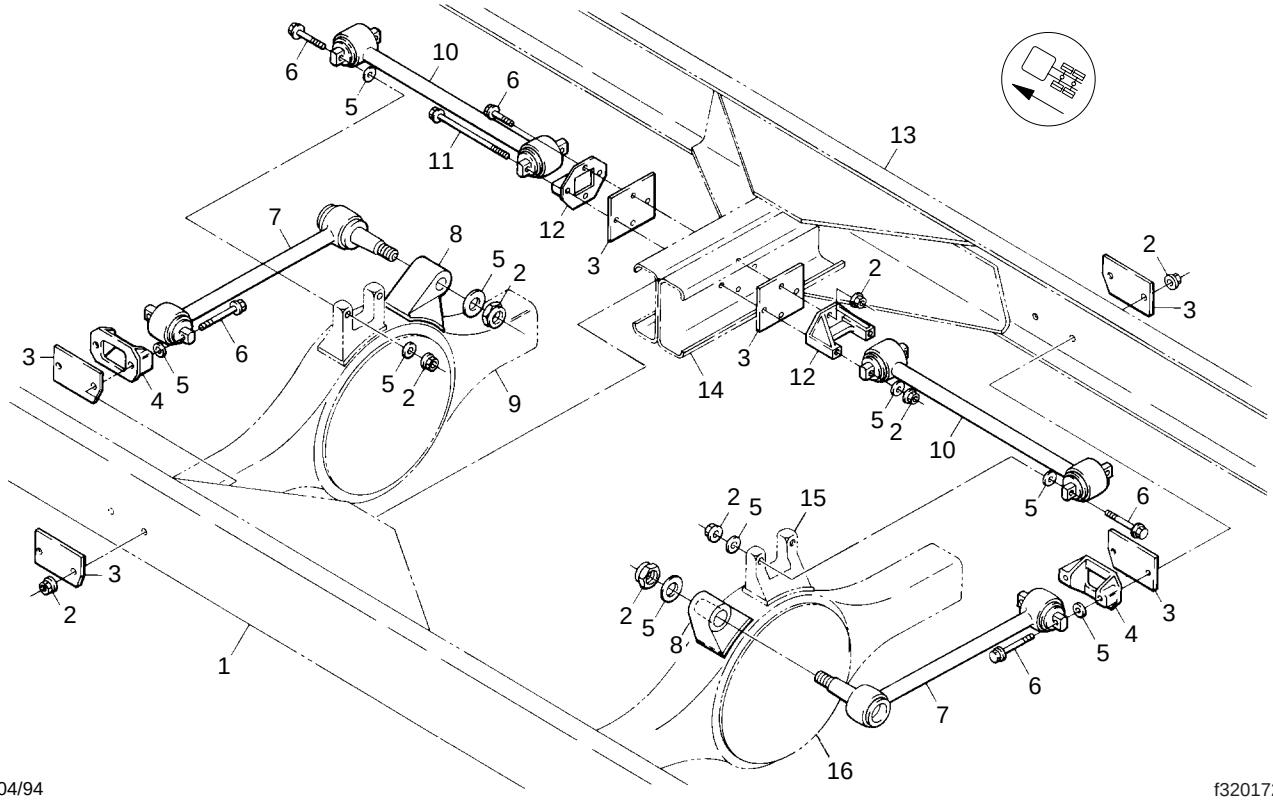
## Installation

1. Remove all dirt and grease from the torque rod ends. Apply lubricant on the new bushings and in the torque rod eyes.
2. Position the press plate on the hydraulic press. Check that the small counterbore of the plate hole is facing up.
3. Position the new bushing on the tapered stud of transverse torque rods. Position the clamp and tighten it to compress the rubber (**Fig. 5**).
4. Place the torque rod end, the bushing, and the clamp on the press plate.
5. Place the remover/replacer tool (**Fig. 6**) and cap on top of the clamping tool and press the bushing in the torque rod end. Check that the bushing sleeve protrudes equally on each side of the torque rod end.
6. On straddle mount end assemblies, align the clamping tool on the bushing as shown in **Fig. 7**. Tighten the clamp to compress the rubber of the new straddle mount bushing.

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## Torque Rod Removal, Bushing Replacement, and Installation




1. Left-Hand Frame Rail
2. Flanged Hexnut
3. Spacer
4. Transverse Torque Rod Mounting Bracket
5. Hardened Washer
6. Flanged Hex Bolt
7. Transverse Torque Rod
8. Transverse Torque Rod Axle Mounting Bracket
9. Forward Rear-Axle
10. Fore and Aft Torque Rod
11. Capscrew
12. Fore and Aft Torque Rod Crossmember Mounting Bracket
13. Right-Hand Frame Rail
14. Crossmember
15. Fore and Aft Torque Rod Axle Mounting Bracket
16. Rearmost Axle

**Fig. 1, Torque Rod Mounting Assembly**

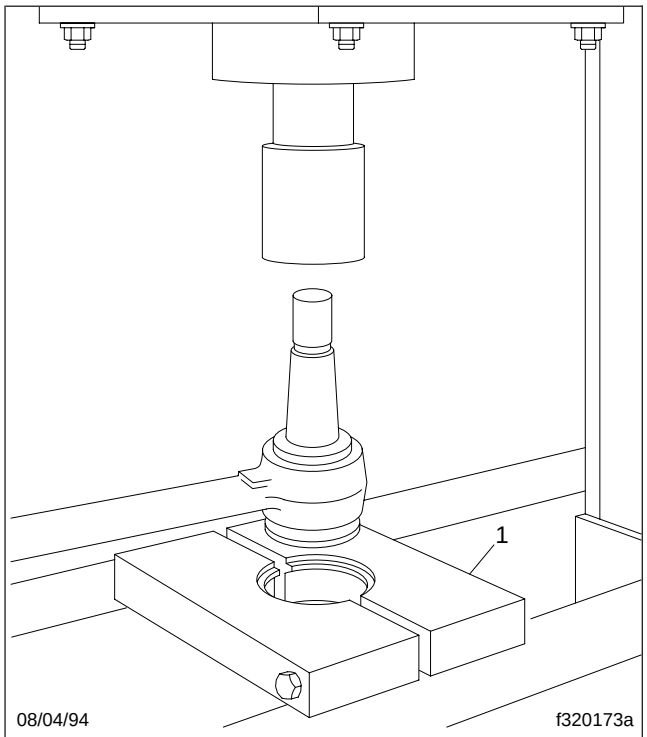
NOTE: When tightening the clamp, make sure that the position of the bushing pin is at a right angle to the center line of the torque rod shank (**Fig. 8**).

7. Place the torque rod end, the bushing, and the clamp on the press plate.
8. Using the larger end of the remover/replacer tool, position the tool and cap on top of the clamp assembly.
9. Press the bushing in the torque rod end. Check that the bushing's outer sleeve protrudes equally on each side of the torque rod end.
10. Install the fore and aft torque rods (**Fig. 1**):
    - 10.1 Position a torque rod straddle mount pin in the forward-rear axle bracket. Install the flanged bolts through the axle bracket and the straddle mount pin. Install a spacer and nut on each bolt, and tighten 190 lbf·ft (260 N·m).
    - 10.2 Position a torque rod straddle mount pin in the rearmost axle bracket. Install the flanged bolts through the axle bracket and the straddle mount pin. Install a spacer and nut on each bolt, and tighten 190 lbf·ft (260 N·m).

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## Torque Rod Removal, Bushing Replacement, and Installation




1. Clamping Tool

**Fig. 2, Positioning the Torque Rod**

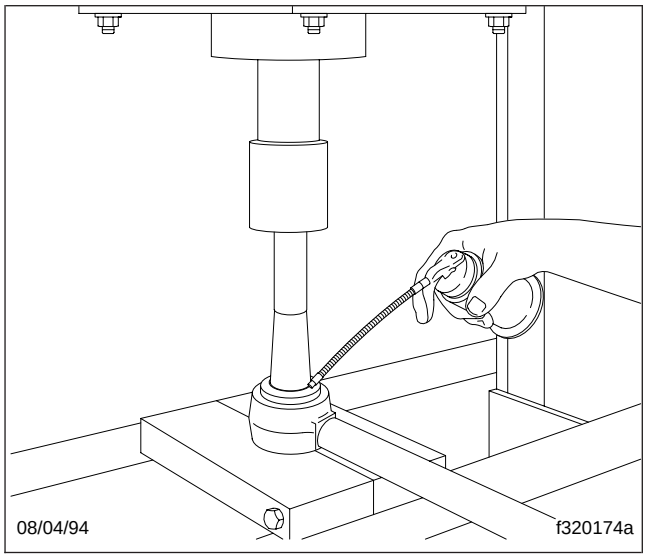



**Fig. 3, Applying Lubricating Oil**

10.3 Position a torque rod spacer and straddle mount bracket on each side of the cross-member. Insert bolts through the upper and lower holes of the forward mounting bracket. Install nuts and tighten 95 lbf·ft (130 N·m).

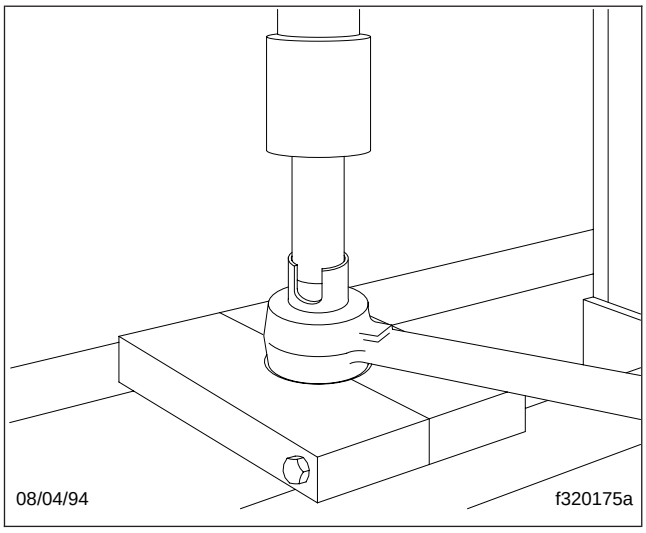
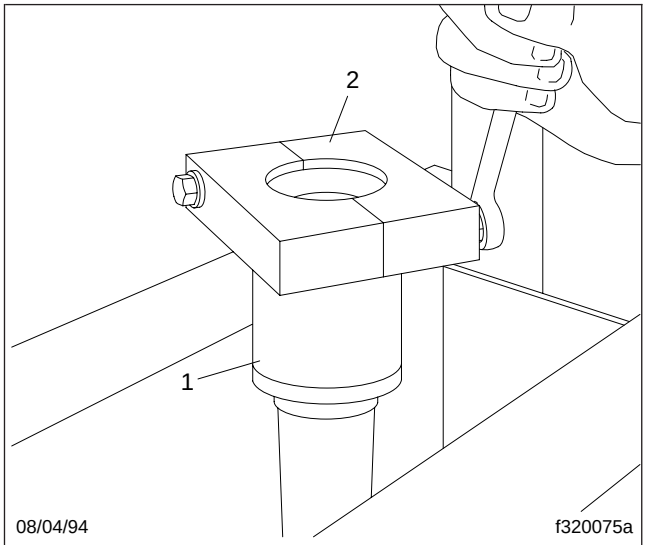



**Fig. 4, Straddle Mount Pin Position**




1. Bushing
2. Clamping Tool

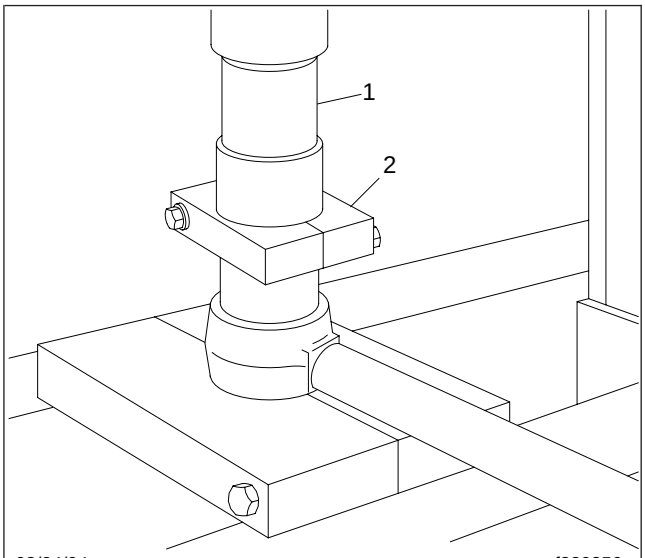
**Fig. 5, Tighten Clamping Tool**

10.4 Position the straddle mount pin of the forward torque rod in the mounting bracket. Insert bolts through the forward pin, both bracket assemblies, and the straddle mount pin of the rear torque rod. Install

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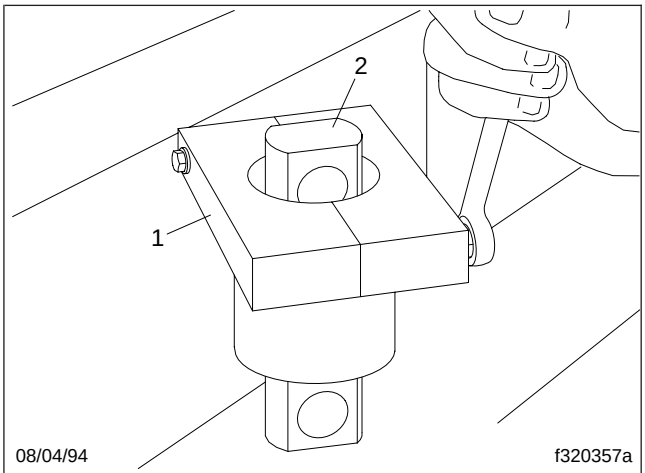


## Torque Rod Removal, Bushing Replacement, and Installation




1. Remover/Replacer Tool
2. Clamping Tool

**Fig. 6, Remover/Replacer Tool Positioning**




1. Clamping Tool
2. Pin

**Fig. 7, Clamping Tool Alignment**

the nuts and bearing washers. Tighten the nuts 190 lbf·ft (260 N·m).

11. Install the transverse torque rods (**Fig. 1**):

    11.1 Check that the tapered stud end and the tapered stud bracket hole are clean. Lubricate the tapered stud ends with SAE 20 oil.

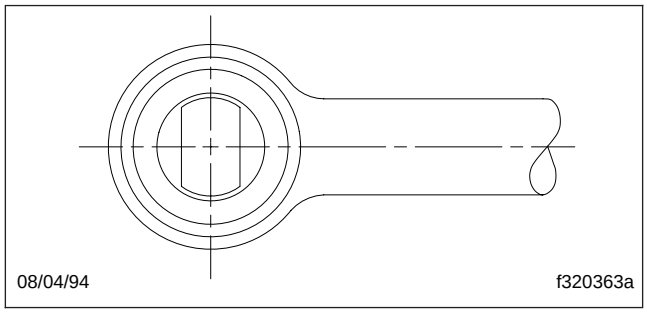



**Fig. 8, Bushing Pin Alignment**

    11.2 Install the tapered stud in the axle bracket. Install a washer and nut. Tighten the nut 175 to 225 lbf·ft (235 to 300 N·m).

    11.3 Align the straddle mount end, the mounting bracket, and the spacer against the inside frame rail.

    11.4 On the inboard side of the frame rail, install the bolts through the mounting assembly and the frame rail.

    11.5 On the outboard side of the frame rail, install a spacer over the mounting bolt studs. Install the nuts and tighten them 190 lbf·ft (260 N·m).

12. Check the axle pinion angle. For instructions, see **Group 41**.

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## Specifications

| Part Number | Tool | Usage |
|---|---|---|
| 1761 | Torque Rod Set | Torque Rod Bushing Removal and Installation |
| 28536 | Installing Adapter (5-3/4" o.d.) | Bronze Center Bushing and Seal Removal and Installation |
| 44119 | Receiving Tube | Center and End Bushing Removal and Installation |
| 51678 | 80-Ton Hydraulic Ram | All Operations |
| 51695 | Jack | All Operations |
| 302018 | Spacer (3 qty.) | Center and End Bushing Removal and Installation |
| 302023 | Pulling Screw | All Operations |
| 302024 | Removing and Installing Adapter | Bronze Center Bushing Removal and Installation |
| 302026 | Installing Adapter | Rubber Center Bushing Removal and Installation |
| 302027 | Removing Adapter | Rubber Center Bushing Removal and Installation |
| 302028 | Hexnut | All Operations |
| 302029 | Speed Nut | All Operations |

**Table 1, Special Tools (Owatonna Tool Company)**

| Tool Number | Dimensions | Usage |
|---|---|---|
| 3 | 4-5/8 inch o.d. by 7 inch | Beam Center Bushing Removal and Installation |

**Table 2, Shop-Made Adapters**

| Description | Size | Torque: lbf·ft (N·m) |
|---|---|---|
| Top Pad to Spring Aligning Setscrew | — | 100–150 (135–200) |
| Top Pad Nut | — | 275–400 (375–542) |
| Spring Pin Locknut | 1/2–13 | 45–63 (61–85) |
| Torque Rod Straddle Mount Nut | 5/8–11 | 190 (260) |
| Torque Rod Stud Locknut | 1-1/4–12 | 175–225 (235–305) |
| Saddle Cap Stud | 7/8–14 | 55–65 (75–90) |
| Saddle Cap Locknut | 7/8–14 | 225–275 (305–373) |
| Bar Pin Locknut | 1–8 | 450–600 (610–813) |
| Spring Center Bolt | 7/16–20 | 50–60 (70–80) |
| | 1/2–20 | 65–75 (90–100) |
| Rebound Spacer Locknut | 1/2–13 | 38–45 (51–61) |
| Spring Alignment Clip | — | 15 (20) |
| Fore and Aft Torque Rod Mount Nut | — | 95 (130) |

**Table 3, Torque Values**

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## General Description

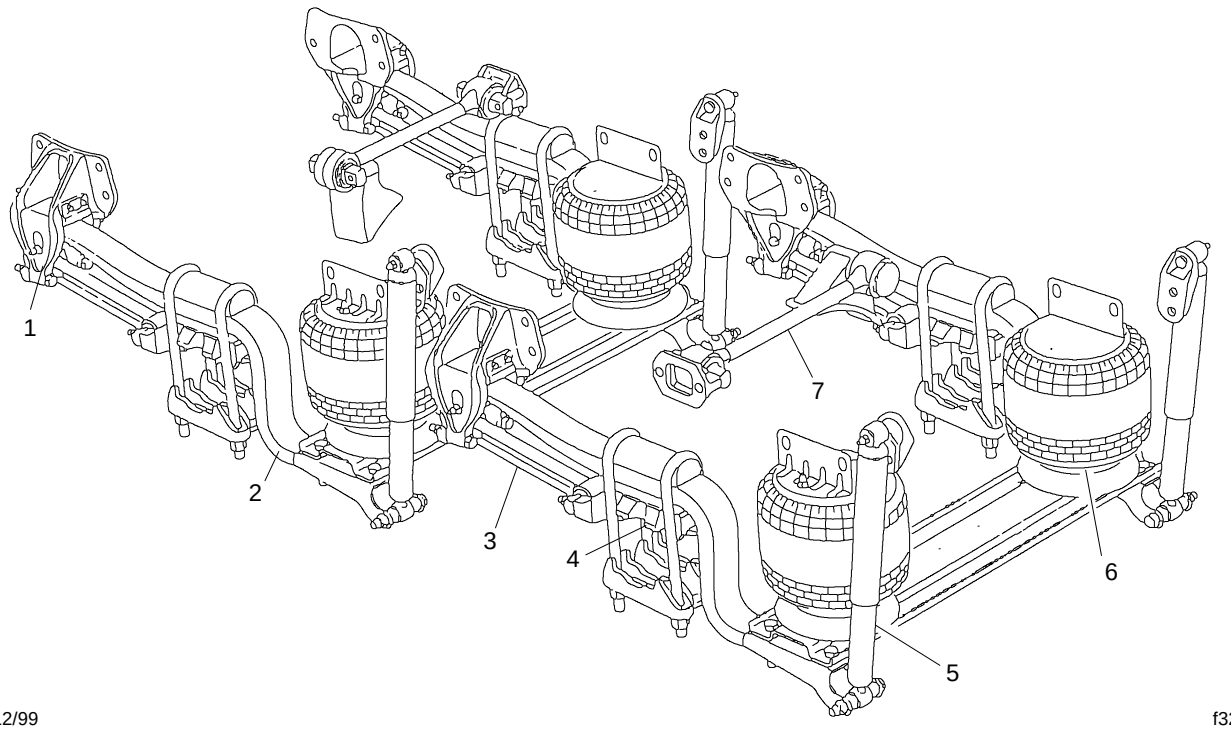
The Hendrickson HAS suspension (see **Fig. 1**) uses air bags to support the sprung weight on vehicles with both single and tandem axles. The air bags (air springs) mount on a crossmember between the two main support beams that are fastened to the axle housing and pivot on forward-mounted hanger brackets on the frame. Torque rods, running from the hanger brackets to the axle seats, transfer vehicle motion to the frame. Lateral stability is provided by transverse torque rods from the inside of the frame rails to brackets on the axle housings. The shock absorbers help to dampen the oscillations of the air springs and control the torque reaction of the axle housings on acceleration.

## Air Control System

The Hendrickson HAS air suspension system allows for a smooth ride while maintaining a constant ride height, even with varying loads. An optional suspension dump system permits the driver to temporarily lower the frame for trailer coupling or uncoupling without having to leave the cab. See **Specifications, 400** for a schematic of the air control system.

The suspension air control system uses air supplied from the secondary air brake system. A pressure proptection valve located at the vehicle's air storage tanks protects the vehicle's primary air system should a failure occur in the suspension system.

The vehicle ride height is maintained by a height control valve mounted on the frame and linkage that connects the valve to the suspension crossmember. See **Fig. 2**. As the frame-to-axle housing clearance




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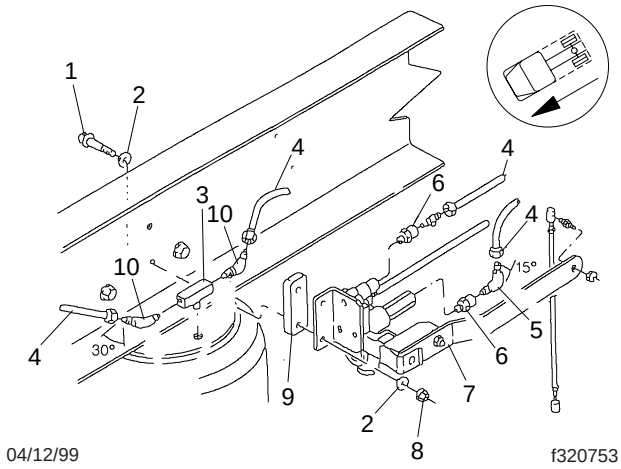
1. Hanger Bracket
2. Main Support Beam
3. Torque Rod
4. Axle Seat
5. Shock Absorber
6. Air Spring
7. Transverse Rod

**Fig. 1, Rear Suspension, Hendrickson HAS-Series**

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changes due to a change in the vehicle load, the linkage moves the lever on the height control valve, causing air to move in or out of the air bags. A slight delay in the operation of the height control valve prevents the system from trying to adjust the ride height for each suspension movement.




1. Bolt
2. Washer
3. Tee
4. Tube Assembly
5. Elbow
6. Adapter
7. Height Control Valve
8. Nut
9. Bracket
10. Elbow

**Fig. 2, Height Control Valve Assembly (typical)**

The optional air suspension dump system is used to deflate the rear suspension air springs during trailer coupling and uncoupling operations. The dump control valve is located on the dash in the cab. When the dump control valve is toggled, supply air flows through the dump control valve delivery port and pressurizes the signal line to the relay valve. The pressurization of the signal line closes the relay valve supply port while opening the ports from the air bags to the atmosphere. Air from the air bags exhausts through the relay valve until the dump control valve is released or until the frame rests on the stops inside the air bags. A pressure switch in the signal line to the relay valve senses the signal pressure and switches on an optional red status light on the dash. To allow the air springs to inflate after being dumped, the dump control valve must be first toggled downward to exhaust the pressure in the signal line.

The pilot-operated relay valve is used for rapid deflation of the air bags for trailer coupling and uncoupling. When pilot pressure from the dump control valve is applied to the relay valve, the supply air from the height control valve is stopped from flowing through the relay valve and, simultaneously, the air spring pressure is exhausted directly to the atmosphere through passages in the relay valve.

## Rear Suspension Components

The axle housing, the lower shock mounts and the lower air bag mounts are all solidly attached to the HAS main support arms. See **Fig. 3** and **Fig. 4**. The main support arm hanger brackets, the upper shock mounts and the upper air bag mounts are all solidly mounted to the frame rails. The torque rods, with flexible bushings in each end, connect the hangers to the axle seats. When the vehicle travels over a bump, the axle housing suddenly rises and compresses the air bags. The pressure in the air bags increases immediately, which absorbs most of the energy of the upward-moving axle housing without transferring that movement to the frame. The shock absorbers then help absorb the release of that higher pressure by slowing the downward movement of the axle housing after the bump.

The front of each main support arm is allowed to pivot and slide on replaceable slipper pads in the hanger brackets. A torque rod is attached to each hanger bracket and to each axle seat bracket by rubber bushings with internal pins, installed in the torque rods at specified angles. Shims are used for adjustment at the front of each torque rod to make sure that the wheels run parallel to the frame rails.

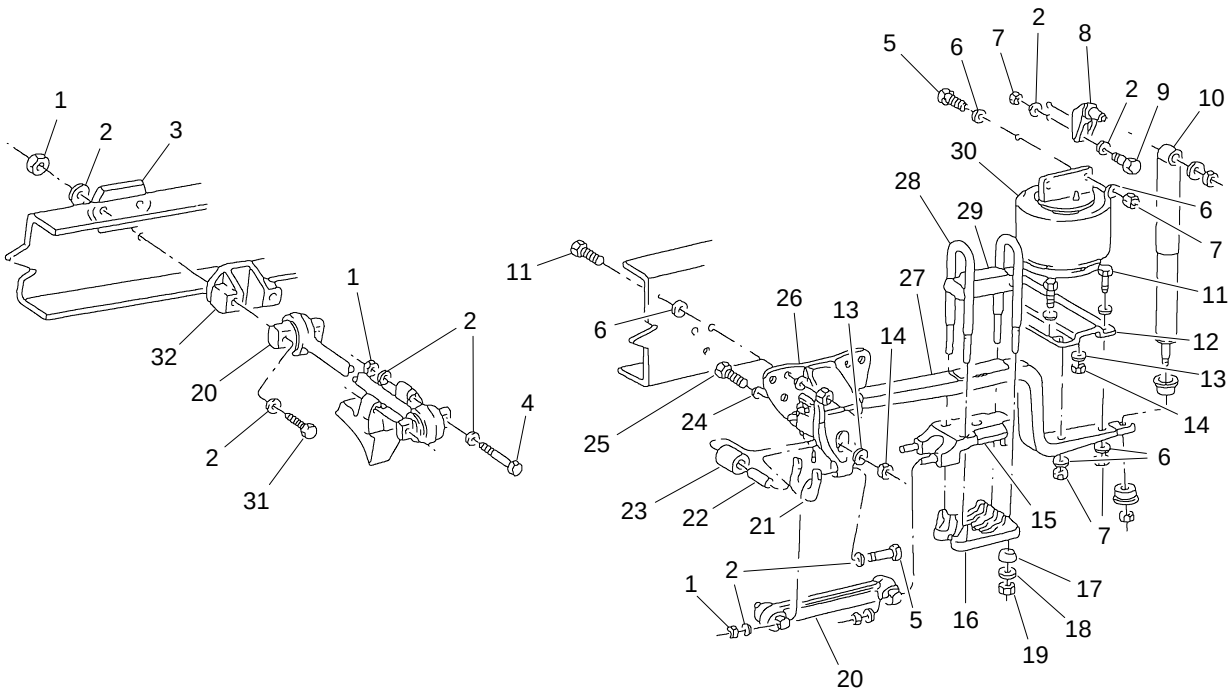
The torque rods control the forward and aft movement of the unsprung pieces during suspension travel. The flexible rubber bushings in the torque rods allow vertical movement of the axle housing while limiting its forward and aft movement. The driveline angles are kept within the specified limits by the torque rods' control of the rotational forces on the axle housings during acceleration and deceleration. The torque rods transfer the forward motion of the axle housing to the frame rails on acceleration and pull back on the frame during braking.

The transverse rods, also with rubber bushings in each end, connect the brackets on the axle housings to the brackets on the frame rails. The transverse rods keep a constant lateral relationship of the frame to the axle housing, while still allowing vertical movement of the axle housings.

The Hendrickson HAS suspension is available in varying capacities and for limited off-highway use.

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1. Nut
2. Washer
3. Reinforcement
4. Bolt
5. Bolt
6. Washer
7. Nut
8. Shock Absorber Mounting Bracket
9. Bolt
10. Shock Absorber
11. Bolt
12. Suspension Support
13. Washer
14. Nut
15. Axle Seat
16. Bottom Cap Assembly
17. Spherical Washer
18. Washer
19. Nut
20. Transverse Rod Assembly
21. Alignment Shims
22. Spacer
23. Rebound Roller
24. Washer
25. Bolt
26. Hanger
27. Main Support Beam
28. U-Bolt
29. Top Pad
30. Air Spring Assembly
31. Bolt
32. Bracket

**Fig. 3, Rear Suspension Components, Hendrickson HAS-40LH Series**

The heavy-duty or off-highway suspensions have thicker main support arms, heavier crossmembers and torque rods, and heavy-duty air bags and shock absorbers. There are two HAS ride height specifications (measured from the bottom of the frame rail to the bottom of the main support arm at the axle seat) depending on which suspension is used. The HAS suspensions are available for single or tandem axle vehicles and can be ordered with or without the suspension dump feature.

## Rear Suspension Service Notes

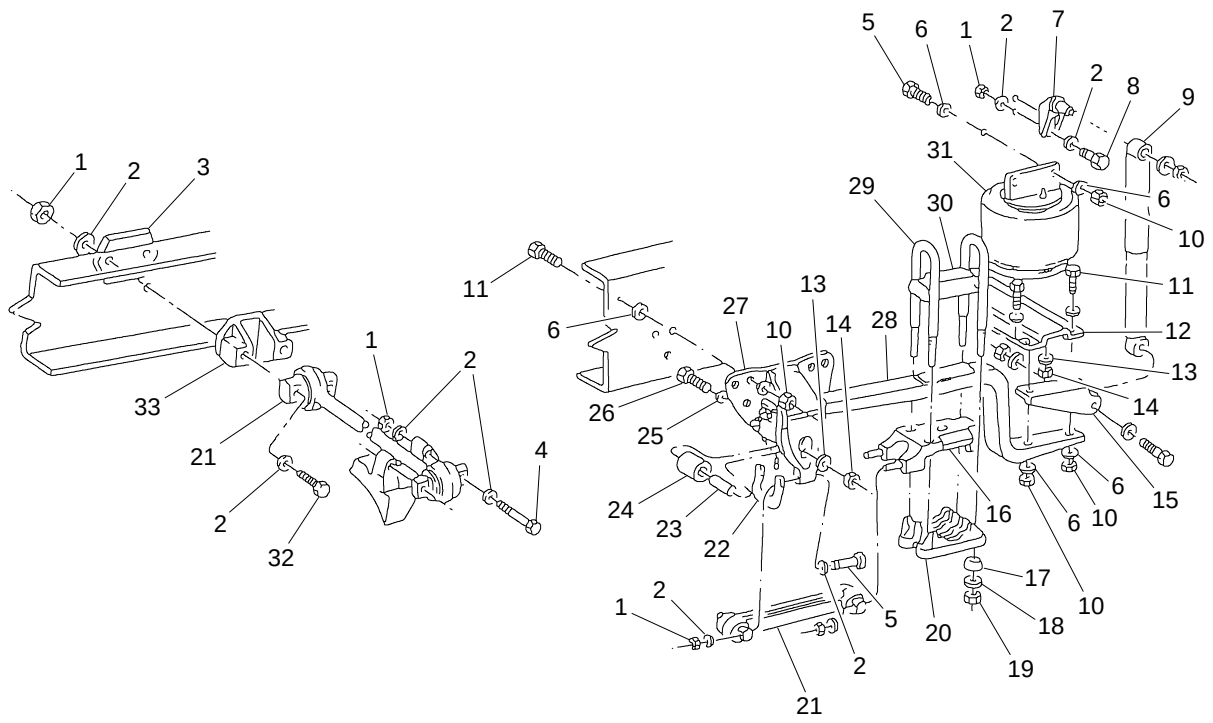
**⚠ WARNING**

**A main support member that has been subjected to heat, nicks or gouges can fail, causing loss of vehicle control and possible personal injury or property damage.**

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## General Information




1. Nut
2. Washer
3. Reinforcement
4. Bolt
5. Bolt
6. Washer
7. Shock Absorber Mounting Bracket
8. Bolt
9. Shock Absorber
10. Nut
11. Bolt
12. Suspension Support
13. Washer
14. Nut
15. Shock Absorber Mounting Bracket
16. Axle Seat
17. Spherical Washer
18. Washer
19. Nut
20. Bottom Cap Assembly
21. Transverse Rod Assembly
22. Alignment Shims
23. Spacer
24. Rebound Roller
25. Washer
26. Bolt
27. Hanger
28. Main Support Beam
29. U-Bolt
30. Top Pad
31. Air Spring Assembly
32. Bolt
33. Bracket

**Fig. 4, Rear Suspension Components, Hendrickson HAS-400, HAS-402, and HAS-460 Series**

**⚠ CAUTION**

**Do not use an arc welder on the suspension parts or use a cutting torch to remove any fasteners. The use of heat on suspension components will adversely affect the strength of these parts. Never reinstall used suspension fasteners. Always use the same part number or an exact equivalent part number when replacing any suspension fastener. All fasteners must be tightened to their specified torque and the U-bolts must be tightened in stages as described in Specifications, 400.**

Check the axle alignment after replacing components that affect alignment, such as a main support beam, a torque rod or a hanger.

During installation, apply pipe sealant with Teflon D8AZ–19554–A or equivalent meeting specification WSK–M2G350–A2 or ESR–M18P7–A to the air fitting threads.

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NOTE: When replacing the torque rod bushings, lubricate the new bushings with a vegetable-based oil only. Make sure the new bushings are centered in the torque rod bores.

NOTE: A shim pack of three 0.11 inch (2.8 mm) thick spacers are used to adjust axle lateral tracking offset. Install the spacers as required to adjust tracking.

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## Main Support Member Removal and Installation

# Removal

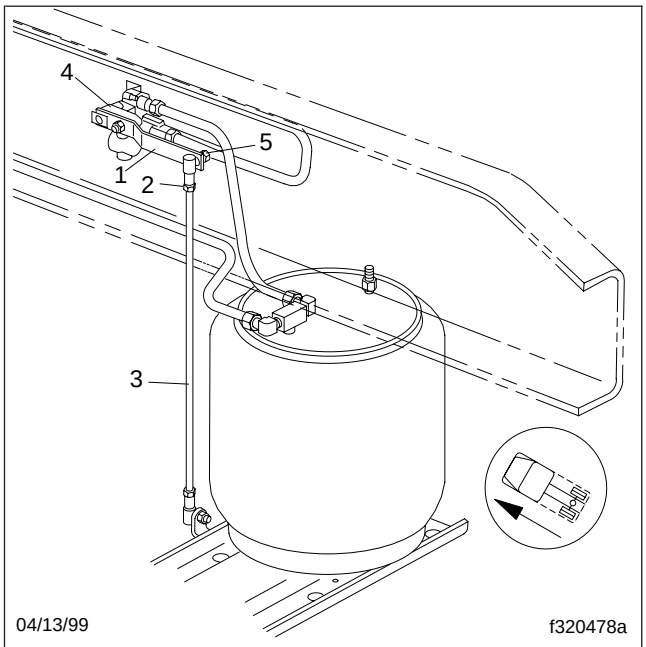
NOTE: Operation of the HAS suspension will result in wear between the main support member and the spring hanger slipper pad. In normal use, these components will function satisfactorily even though they show some wear. Premature wear may occur, however, and requires the replacement of one or both parts. A main support member should be replaced if it has 3/8 inch (9.5 mm) or more wear at the hanger cam contact area.

1. Stop the vehicle on a level surface, shut down the engine and apply the park brakes. Chock the front and rear tires.
2. Support the axle housing with a jack stand under the pinion nose to prevent the axle housing from rotating when the U-bolts are removed.

**⚠ WARNING**

**The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.**

3. Disconnect the vertical linkage for the height control valve at the end of the horizontal lever. See **Fig. 1**. Lift the lever on the height control valve so that the air bags raise the frame about 3 inches (75 mm). Support the frame at that position with jack stands.
4. Remove the locknuts, washers and bolts that connect the cross channel and shock absorber brackets to both main support members. See **Fig. 2**. Remove the lower shock mount fasteners on the HAS–40LH models.
5. Use a floor jack to raise the cross channel about 3 inches (75 mm). Support the cross channel assembly with jack stands.
6. Remove the locknut, washers and bolt from the rebound roller assembly at the front hanger. See **Fig. 3**. Remove the rebound roller and spacer.
7. Remove the U-bolt high nuts and washers, then remove the bottom cap, U-bolts and the top pad and Delrin liner.




1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

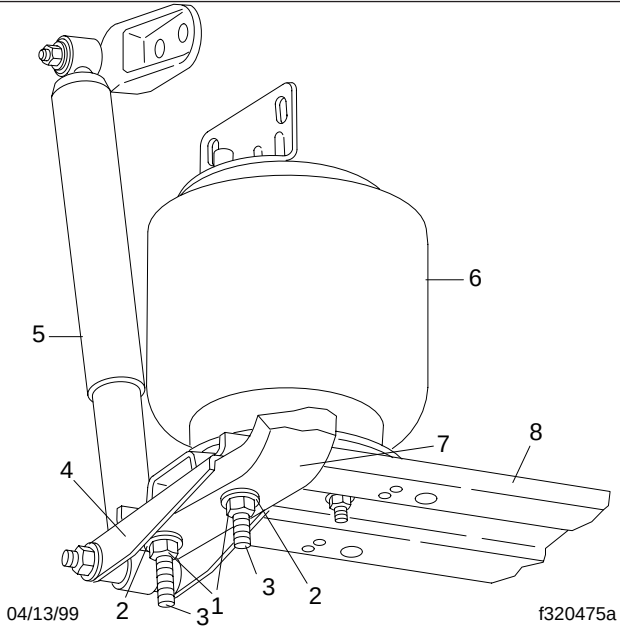
**Fig. 1, Ride Height Control Linkage**

8. Slide the main support member out of the hanger and remove the main support assembly from the vehicle.
9. Inspect the main support member for wear. Replace the main support member if worn more than 3/8 inch (9.5 mm) at the hanger end where it contacts the slipper pad or if it has cracks, nicks or signs of the application of heat from a torch or welder.
10. Inspect the slipper pad for wear. Replace the slipper pad if worn. Remove the four bolts and washers that hold the slipper pad to the hanger. If rivets were installed instead of bolts to hold the slipper pad, use a grinder to remove the rivet heads.

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## Main Support Member Removal and Installation




1. Locknut
2. Washer
3. Bolt
4. Lower Shock Bracket
5. Shock Absorber
6. Air Spring
7. Main Support Member
8. Cross Channel

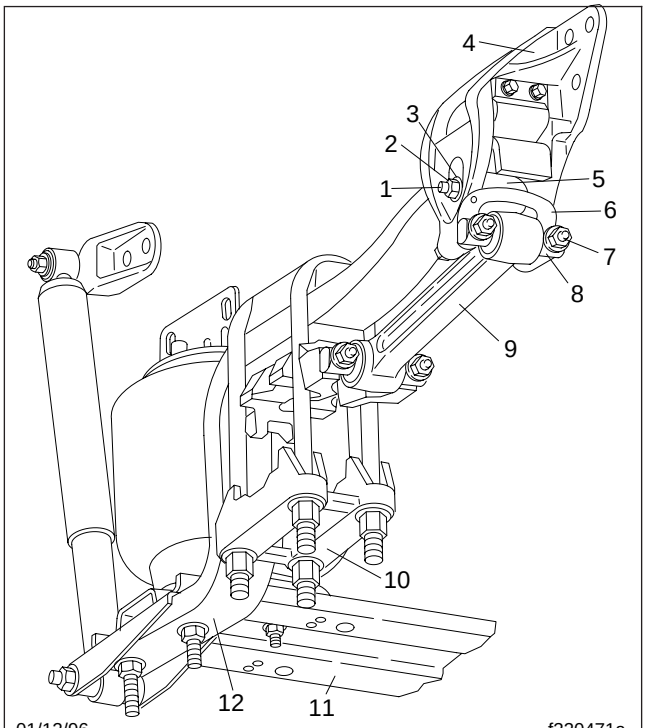
**Fig. 2, Main Support Member**

# Installation

**⚠ WARNING**

**Always use new fasteners when installing suspension components. Reuse of fasteners can lead to component damage and loss of vehicle control, possibly resulting in personal injury or property damage.**

1. Install the slipper pad, bolts and washers into the hanger. Tighten the bolts 25 lbf·ft (34 N·m). Install new rivets if so equipped.
2. Slide the main support member into the hanger assembly.
3. Position the main support member on the axle seat, or on the spacer plate if the vehicle is so equipped, with the main support member center dowel sliding into the hole in the axle seat or spacer plate.




1. Rebound Bolt
2. Locknut
3. Washer
4. Hanger
5. Rebound Roller
6. Alignment Shim(s)
7. Bolt
8. Bar Pin
9. Torque Rod
10. Bottom Cap
11. Cross Channel
12. Main Support Member

**Fig. 3, Removing the Rebound Roller**

4. The Delrin liner must be positioned on the top of the main support member. Install the U-bolt top pad on the Delrin liner. Install the U-bolts over the top pad and liner and around the main support member, the spacer (if so equipped), the axle seat assembly, the axle housing, and the bottom cap. Install the washers and high nuts and tighten with your fingers, but do not fully tighten the U-bolt high nuts at this time.
5. Lower the floor jack under the cross channel until the cross channel is against the main support members. Install the shock absorber bracket (if so equipped) and bolts into the cross channel and main support members. See **Fig. 2**. Install the washers and tighten the locknuts 280 lbf·ft (380 N·m). On the HAS–40LH models, install the

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lower shock absorber mount bolts, washers and nuts. Tighten the shock absorber nut 60 lbf·ft (82 N·m).

6. Install the rebound roller into the hanger. Install the bolt, washer and locknut. Tighten the locknut 60 lbf·ft (82 N·m).
7. Center the main support member between the hanger legs. Move the lever for the height control valve up to lift the frame from its jack stands. Remove the jack stands from the frame.
8. Tighten the U-bolt locknuts in stages as described in **Specifications 400**. Rap the top of the U-bolts with a hammer and then retighten the high nuts 500 lbf·ft (680 N·m).

IMPORTANT: Do not exceed the specified torque on the U-bolt high nuts. Retighten the U-bolt high nuts after 1000 miles (1600 km).

9. Move the lever for the height control valve down to lower the frame until the upper ball joint stud in the vertical linkage exactly aligns with the hole in the lever when the lever is in the horizontal position. Install the height control valve ball joint stud, washer and locknut. Tighten the locknut 10 lbf·ft (14 N·m).
10. Remove the jack stand from under the nose of the axle housing.
11. Check and adjust the ride height as described in **Subject 240**.
12. Check the alignment after new main support members are installed.

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## Axle Seat Removal and Installation

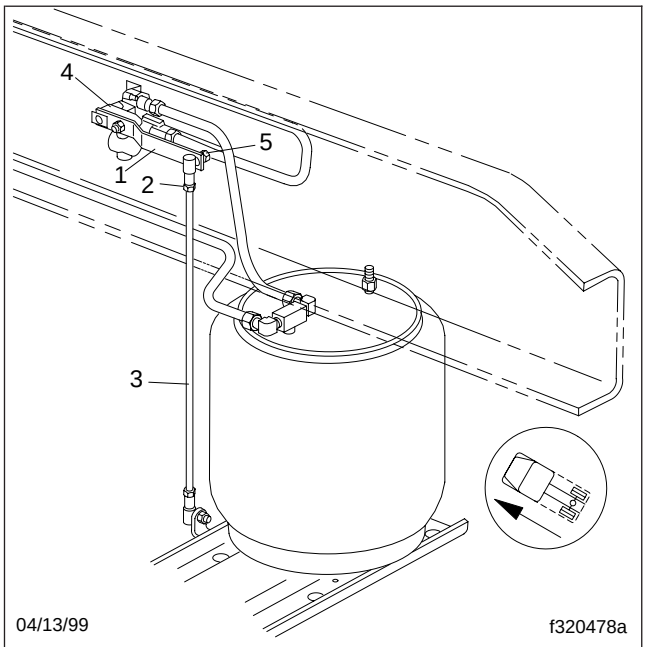
# Removal

1. Stop the vehicle on a level surface, shut down the engine and apply the park brakes. Chock the front and rear tires.
2. Support the axle housing with a jack stand under the pinion nose to prevent the axle housing from rotating when the U-bolts are removed.

**⚠ WARNING**

**The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.**

3. Disconnect the vertical linkage for the height control valve at the end of the horizontal lever. See **Fig. 1**. Lift the lever on the height control valve so that the air bags raise the rear of the frame about 3 inches (75 mm). Support the frame at that position with jack stands.
4. Remove the nuts, washers and bolts that hold the torque rod to the hanger legs.
5. Remove the nuts and washers that hold the torque rod to the axle seat. Remove the torque rod.
6. Remove the high nuts from the U-bolts and remove the bottom cap and top pad and Delrin liner.
7. Use a floor jack to raise the cross channel and main support member just enough to remove the axle seat.
8. Remove the axle seat. See **Fig. 2**.
9. If the axle seat studs need replacement, remove them with a hammer and brass drift.




1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

**Fig. 1, Ride Height Control Linkage**

# Installation

**⚠ WARNING**

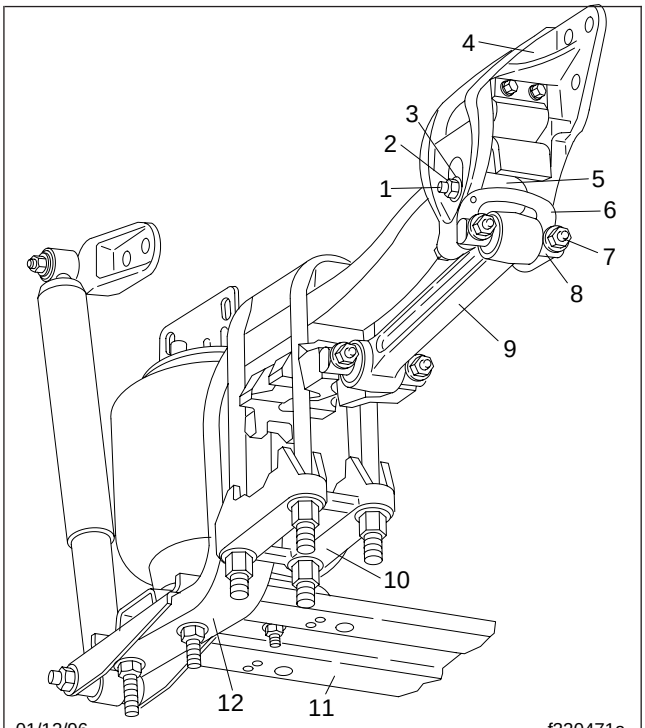
**Always use new fasteners when installing suspension components. Reuse of fasteners can lead to component damage and loss of vehicle control, possibly resulting in personal injury or property damage.**

1. Install the new studs with a stud driver. Insert the stud in the hole of the axle seat and tap into position with a hammer and brass drift.
2. Lift the main support member with a floor jack and install the axle seat on the top of the axle housing. Install the spacer (if so equipped) above the axle seat.
3. Position the main support member on the axle seat, or on the spacer plate if the vehicle is so equipped, with the main support member center dowel sliding into the hole in the axle seat or spacer plate.
4. The Delrin liner must be positioned on the top of the main support member. Install the U-bolt top pad on the Delrin liner. Install the U-bolts over the top pad and liner and around the main support member, the spacer (if so equipped), the axle seat assembly, the axle housing, and the bottom cap. Install the washers and high nuts

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## Axle Seat Removal and Installation




1. Rebound Bolt
2. Locknut
3. Washer
4. Hanger
5. Rebound Roller
6. Alignment Shim(s)
7. Bolt
8. Bar Pin
9. Torque Rod
10. Bottom Cap
11. Cross Channel
12. Main Support Member

**Fig. 2, Removing the Axle Seat**

and tighten with your fingers, but do not fully tighten the U-bolt high nuts at this time.

5. Install the torque rod on the axle seat so that the holes in the bushing pin align with the axle seat studs. Install the washers and nuts, but do not tighten at this time.
6. Install the front end of the torque rod onto the hanger legs and install any shims that were removed. Install the bolts through the hanger legs, shims, and the front bushing pin.
7. Tighten the nuts on the front of the torque rod 175 lbf·ft (237 N·m).
8. Tighten the nuts for the torque rod pin at the axle seat 175 lbf·ft (237 N·m).
9. Move the lever for the height control valve up to lift the frame from its jack stands, Remove the jack stands from the frame.
10. Tighten the U-bolt locknuts in stages as described in **Specifications 400**. Rap the top of the U-bolts with a hammer and then retighten the high nuts 500 lbf·ft (680 N·m).

IMPORTANT: Do not exceed the specified torque on the U-bolt high nuts. Retighten the U-bolt high nuts after 1000 miles (1600 km).

11. Move the lever for the height control valve down to lower the frame until the upper ball joint stud in the vertical linkage exactly aligns with the hole in the lever when the lever is in the horizontal position. Install the height control valve ball joint stud, washer and locknut. Tighten the locknut 10 lbf·ft (14 N·m).
12. Remove the jack stand from under the nose of the axle housing.
13. Check and adjust the ride height as described in **Subject 240**.
14. Check the alignment after new axle seats are installed.

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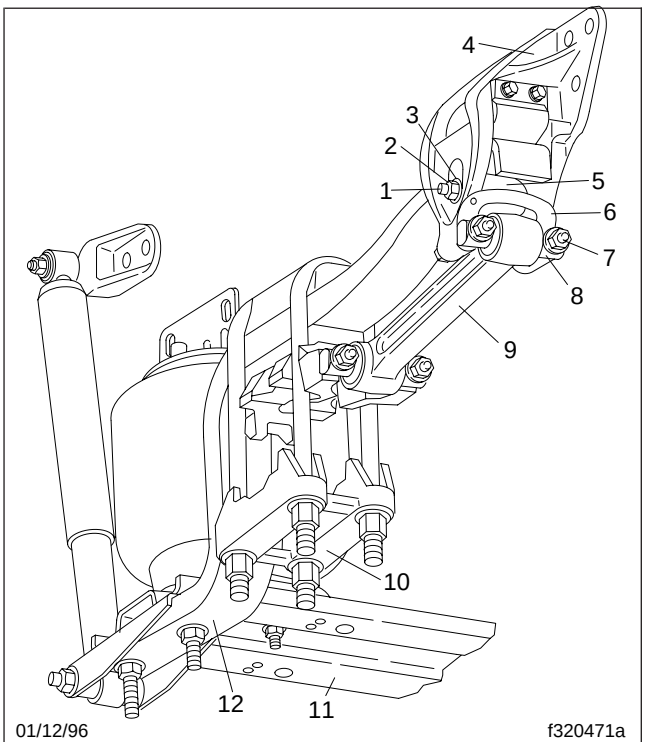


## Torque Rod Bushing Replacement

## Replacement

Use the following procedure to replace the torque rod bushing.

1. Chock the front tires, and the tires of the drive axles.
2. Remove the bushing pin locknuts and washers at the axle end of the torque rod. See **Fig. 1**.




1. Rebound Bolt
2. Locknut
3. Washer
4. Hanger
5. Rebound Roller
6. Alignment Shim(s)
7. Bolt
8. Bar Pin
9. Torque Rod
10. Bottom Cap
11. Cross Channel
12. Main Support Member

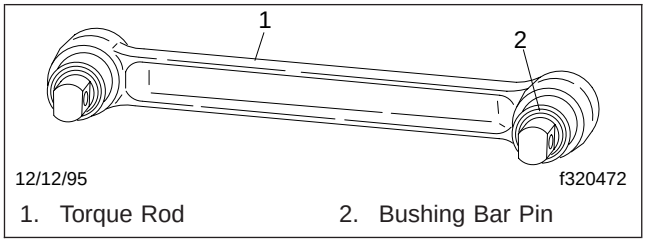
**Fig. 1, Torque Rod Installation**

3. Loosen the rebound bolt locknut in the hanger.
4. Remove the bushing pin locknuts, bolts and washers, and any alignment shims at the hanger end of the torque rod. Note the number of shims, as the same thickness shim pack must be reinstalled to avoid affecting the vehicle's alignment.
5. Push out the old bushings. Use a vertical shop press with a capacity of at least 10 tons. A 5-inch (127 mm) piece of 2-inch by 1/4-inch (50-mm by 6-mm) wall, steel-tubing receiving tool is required. The bushings are not cartridge-type bushings and do not have a metal outer sleeve.
6. Support the torque rod end on the receiving tool with the end tube of the torque rod centered on the tool.

**⚠ WARNING**

**Do not use heat or a cutting torch to remove the bushings from the torque rod. The use of heat will weaken the torque rod, which could cause the rod to break. This could result in a loss of vehicle control, personal injury, or property damage.**

7. Push directly on the bushing pin until the bushing is pushed out of the torque rod end tube.
8. Clean and inspect the torque rod ends. Remove any nicks with emery cloth.
9. Lubricate the torque rod ends and the new rubber bushings with a vegetable-based oil. Do not use a petroleum-based or soap-based lubricant.
10. Press in the new bushings while supporting the torque rod end on the receiving tool with the end tube of the torque rod centered on the receiving tool. The bushings must be installed with the mounting flats on the bar pin positioned 90 degrees to the shank of the torque rod. See **Fig. 2**.




1. Torque Rod
2. Bushing Bar Pin

**Fig. 2, Positioning the Bar Pin Mounting Flats**

11. Press directly on the bar pin of the bushings, which must be centered within the torque rod end tubes. When pressing in the new bushings, overshoot the final position by approximately 3/16 inch (5 mm).
12. Press the bushing again from the opposite side to center the bushing within the torque rod end.

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## Torque Rod Bushing Replacement

13. Position the torque rod into the axle seat and attach it with the washers and locknuts. Handtighten the locknuts.
14. Position the torque rod onto the forward face of the hanger legs. Assemble the bolts, washers and locknuts, and any alignment shims. Tighten locknut 175 lbf·ft (237 N·m). See **Fig. 1**.
15. Tighten locknuts at the axle end of the torque rods 175 lbf·ft (237 N·m).
16. Tighten rebound bolt locknut 60 lbf·ft (81 N·m).

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# Height Control Valve Removal and Installation

## Removal

1. Chock the front tires.
2. Drain the vehicle's air system.

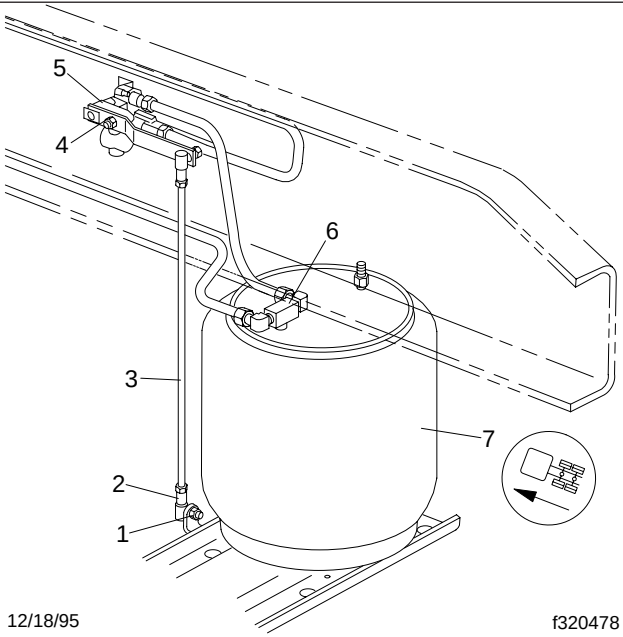
**⚠ WARNING**

**The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.**

3. Remove the height control valve vertical rod from the valve lever by removing the nut and lock washer. Push down on the lever of the height control valve to exhaust the air from the rear suspension air bags.
4. Remove the air lines attached to the height control valve. See **Fig. 1**.
5. Remove the locknuts, washers, and bolts that attach the height control valve to the frame.
6. Remove the brass air fittings from the height control valve.

## Installation

1. Install the brass air fittings into the height control valve ports.
2. Install the bolts, washers, and locknuts that attach the valve to the frame rail.
3. Attach the air lines to the height control valve.
4. Attach the height control valve vertical linkage rod to the height control valve lever, and install the lock washer and nut. See **Fig. 1**.
5. Return air to the system.
6. Adjust the height control valve for proper ride height as described in **Subject 240**.




1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut
6. Brass Air Fitting
7. Air Spring

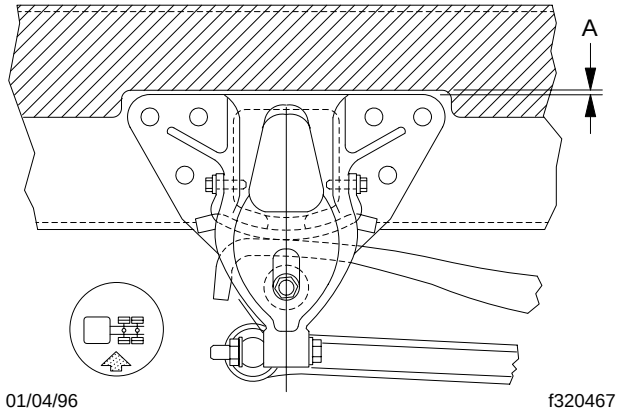
**Fig. 1, Height Control Valve System**

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## General Information

The HAS front hangers must have at least 1/4-inch (6 mm) clearance between the top of the hanger and the bottom of the fifth wheel mounting bracket on the sides of the frame rails. In some cases, the fifth wheel mounting bracket may have to be cut out to provide the correct clearance. See **Fig. 1** for an example of a fifth wheel mounting bracket that has been modified.




A. Clearance: 1/4 inch (6 mm)

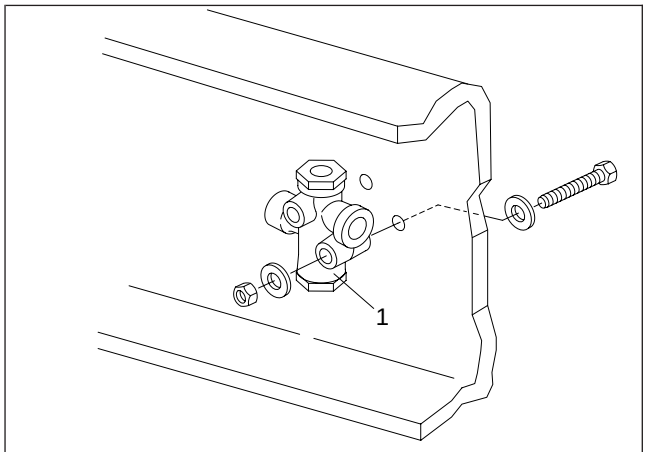
**Fig. 1, Fifth Wheel Mounting Angle Clearance**

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## Replacement

1. Chock the front tires.
2. Drain the vehicle's air system.
3. Disconnect the air lines from the quick release valve. Identify the air line at the top of the valve. See **Fig. 1**.
4. Remove the quick release valve from the frame or crossmember.
5. Remove the brass air fittings from the valve.
6. Attach the brass air fittings to the replacement quick release valve.
7. Attach the valve to the frame or crossmember.




1. Quick Release Valve

**Fig. 1, Quick Release Valve Installation**

8. Connect the air lines to the valve, making sure to attach the identified line to the top of the valve.
9. Build up pressure in the air system.
10. Remove the chocks from the front tires.

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## Slipper Pad Removal and Installation

# Removal

NOTE: Operation of the HAS suspension will result in wear between the main support member and the hanger slipper pad. In normal use, these components will function satisfactorily even though the components indicate some wear.

1. Chock the front tires.

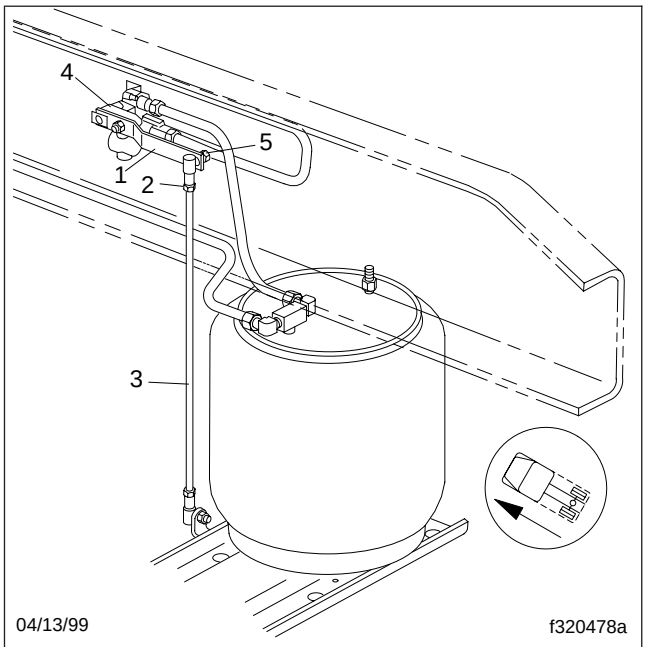
**⚠ WARNING**

**The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.**

2. Disconnect the vertical linkage from the lever of the height control valve and lift the lever to raise the rear of the frame about 3 inches (75 mm). See **Fig. 1**.
3. Support the frame with jack stands.
4. Apply an upward force on the cross channel with a jack or, on single axles, by pushing down on the height control lever to lift the cross channel. This will cause the tips of the main support members to drop away from the slipper pad. See **Fig. 2**.

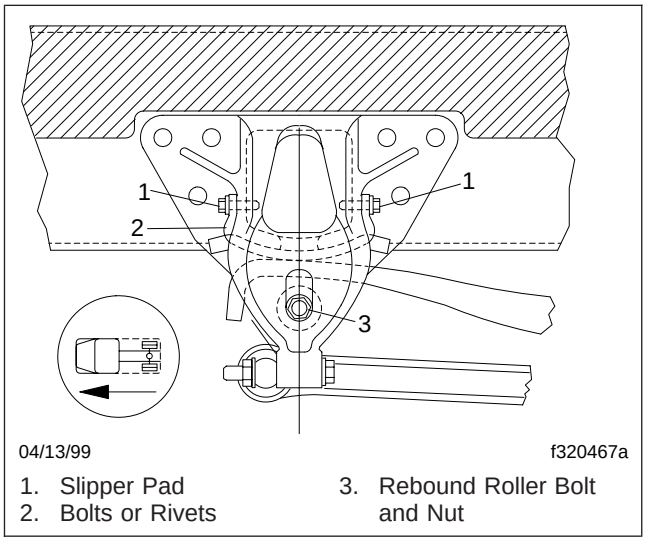
IMPORTANT: Do not nick or gouge the cross channel.

5. Remove the fasteners and the slipper pad. In some instances, the screws may have to be drilled out. See **Fig. 3**.
6. In some instances, remove the rebound roller to gain enough clearance to remove the slipper pad. Loosen the rebound bolt locknut, remove the washer, the bolt, and the rebound roller assembly.
7. For rivets, remove the four 1/4-inch (6-mm) rivets by grinding away the rivet heads. With a drift pin, punch the rivets through the holes and remove the slipper pad.




1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

**Fig. 1, Ride Height Control Linkage**



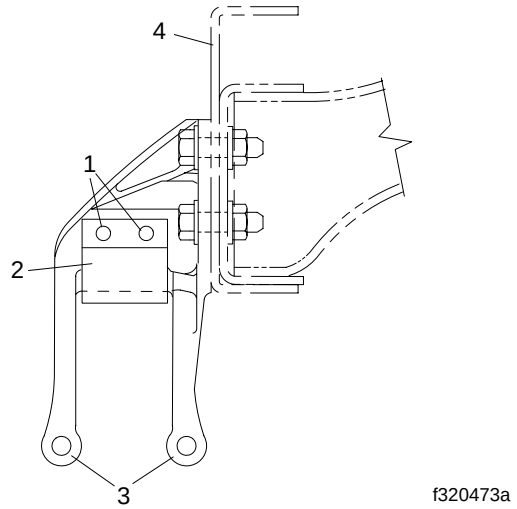

1. Slipper Pad
2. Bolts or Rivets
3. Rebound Roller Bolt and Nut

**Fig. 2, Slipper Pad Installation**

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## Slipper Pad Removal and Installation




1. Bolts or Rivets
2. Slipper Pad
3. Hanger Legs
4. Frame Rail

**Fig. 3, Hanger Assembly**

# Installation

1. Position the slipper pad and retainer plate on the frame hanger.
2. Tighten the hexhead self-tapping screws 25 lbf·ft (34 N·m).
3. Or, install the rivets using a rivet gun.
4. Raise the frame off the jack stands by pulling up on the height control valve lever. Remove the jack stands.
5. Push down on the height control valve lever to lower the frame until the upper ball stud on the vertical linkage rod exactly aligns with the hole in the lever when the lever is horizontal.
6. Install the ball stud into the hole in the lever and install the washer and nut. Tighten the nut 10 lbf·ft (14 N·m).
7. Remove the chocks from the tires.

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## Cross Channel Removal and Installation

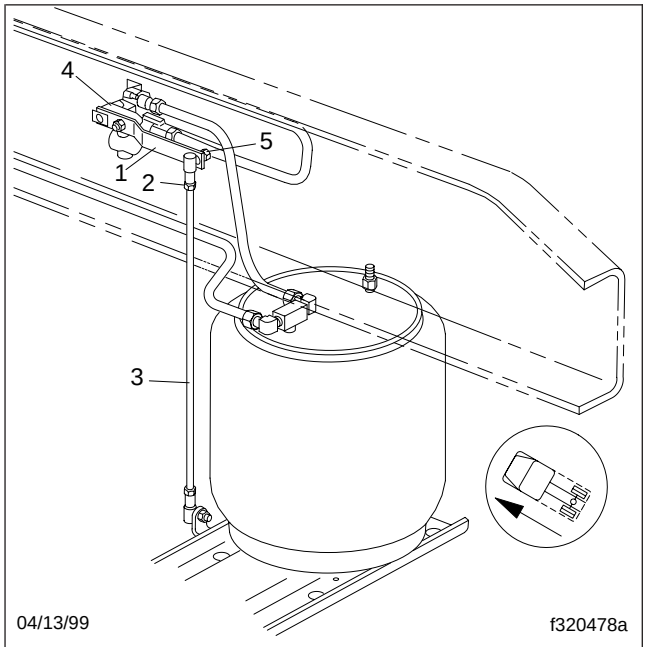
# Removal

1. Stop the vehicle on a level surface and shutdown the engine. Chock the front and rear tires.

**⚠ WARNING**

**The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.**

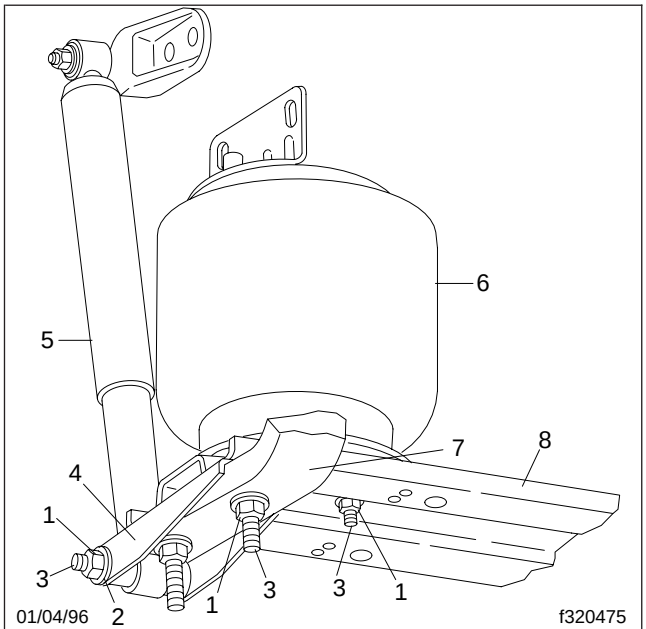
2. Disconnect the vertical linkage for the height control valve at the end of the horizontal lever. See **Fig. 1**. Lift the lever on the height control valve so that the air bags raise the rear of the frame about 3 inches (75 mm). Support the frame at that position with jack stands.




1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

**Fig. 1, Height Control Linkage**

3. Remove the locknuts and washers that attach both air springs to the cross channel. See **Fig. 2**.




1. Locknut
2. Washer
3. Bolt
4. Lower Shock Bracket
5. Shock Absorber
6. Air Spring
7. Main Support Member
8. Cross Channel

**Fig. 2, Main Support Member**

4. Remove the locknuts, washers, and bolts that attach the cross channel to the main support members and to the shock absorber lower mounting brackets.

5. Raise the cross channel by pushing down on the height control lever to compress the air springs just enough to clear the studs on the bottom of the air springs. Remove the cross channel.

# Installation

1. Position the cross channel so that the holes in the cross channel are aligned under the studs of the air springs. Install the washers and nuts. Tighten the nuts on the air spring studs 25 lbf·ft (34 N·m).

2. Lower the cross channel assembly onto the main support members by pushing down on the height control valve lever.

3. Install the bolts, washers and locknuts that connect the cross channel to the main support mem-

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## Cross Channel Removal and Installation

ber and lower shock absorber mounts. Tighten the locknuts 290 lbf·ft (393 N·m).

4. Raise the frame by lifting the height control valve lever and remove the jack stands.
5. Attach the ball joint stud of the vertical linkage rod to the height control valve link, and tighten the locknut on the ball joint stud 10 lbf·ft (14 N·m).
6. Remove the chocks from the tires.

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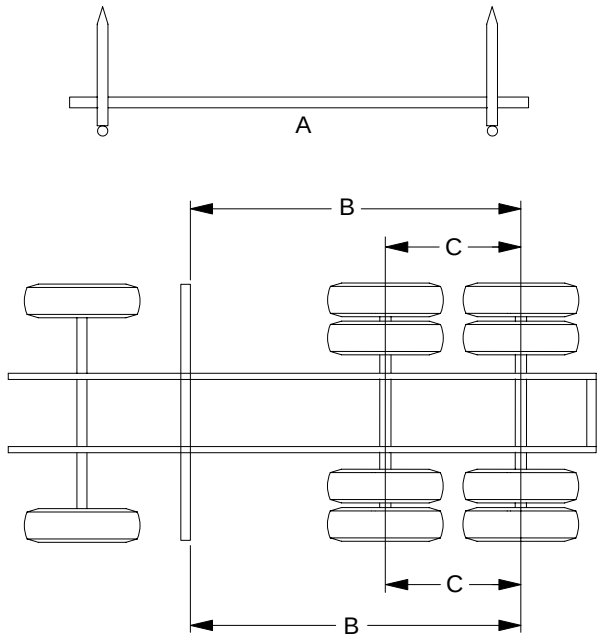
## Checking and Adjustment

Use the following procedure after all repairs to the suspension:

1. Park vehicle on a level surface. Free and center all suspension joints by slowly moving the vehicle back and forth several times without applying the brakes.
2. Chock the front tires and the tires of drive axles.
3. C-clamp a nine-foot (2.74-m) piece of straight bar stock or angle iron across the frame. Select a location as far forward of the forward drive axle as possible where components will not interfere. The lower frame flange may be preferred on some vehicles, otherwise use the upper frame flange.
4. Align the straight bar stock or angle iron on the frame using a carpenter's square.
5. Check the rear drive axle first. See **Fig. 1** . Use a trammel bar or its equivalent to measure from the straight edge to the center line of the rear axle on both sides of the vehicle. If both sides measure within 3/16 inch (5 mm) of being the same, the alignment of the rear drive axle is acceptable. If the sides differ by more than 3/16-inch (5 mm), first loosen the rebound locknut, and then adjust the rear drive axle by loosening up the torque rod bar pin locknuts on the hangers. Add or remove drop-in shims as needed.

NOTE: The torque rod bar pin must be mounted to the forward face of the hanger legs. No more than four shims may be used (for a maximum thickness of 1/4 inch (6 mm).

6. Snug the torque rod bar pin locknuts but do not torque to specification.
7. With the rear drive axle properly aligned, the front drive axle alignment can be checked by measuring forward from the center of the axle shafts on the rear drive axle using a trammel bar. If the forward drive axle spacing measurements differ by more than 1/8 inch (3 mm), add or subtract shims at the forward hangers.
8. Following the adjustment of both axles, move the vehicle back and forth several times prior to removing the straight edge from the frame. Recheck the alignment.




A. Trammel Bar
B. Each side must be within 3/16 inch (5 mm) of each other.
C. Distances between axles must be within 1/8 inch (3 mm) of each other.

**Fig. 1, Drive Axle Tracking Alignment**

9. Tighten the torque rod bar pin locknuts 180 lbf·ft (244 N·m).
10. Remove the chocks from the tires.

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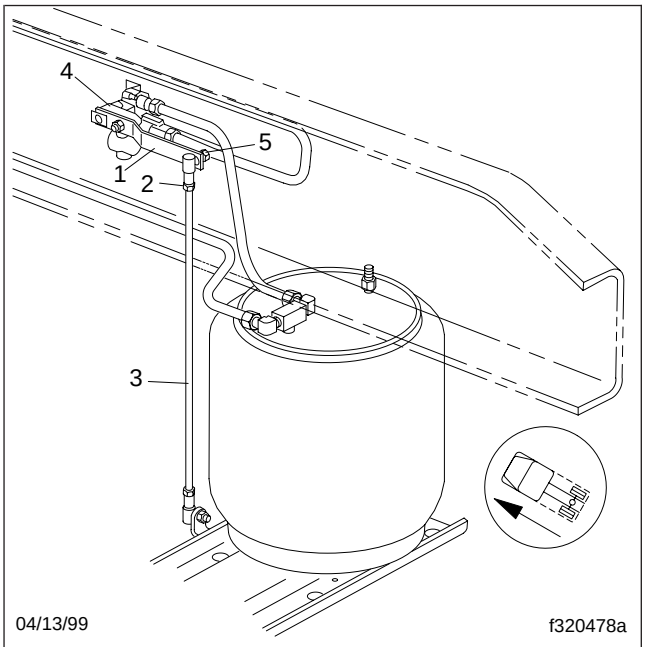
## Replacement

1. Chock the front tires.
2. Support the frame with jack stands.
3. Drain the vehicle's air system.

**⚠ WARNING**

**The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.**

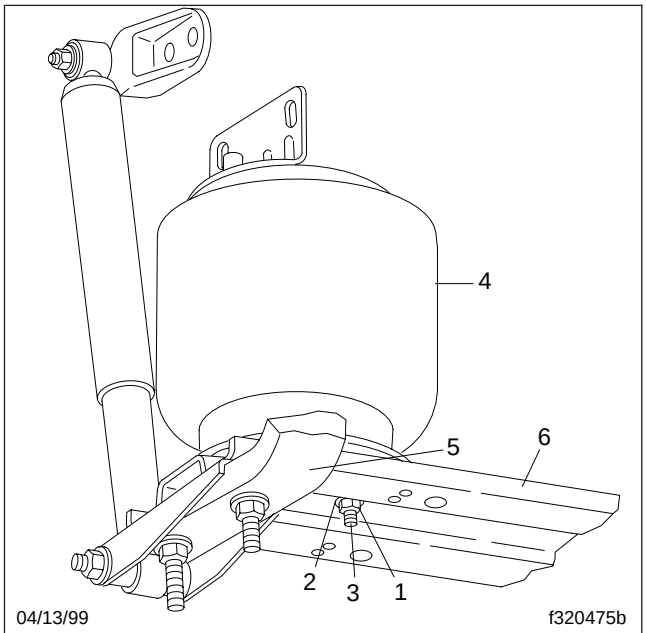
4. Remove the upper ball joint nut and stud from the lever on the height control valve. See **Fig. 1**. Move the height control valve lever down to exhaust all the air from the air bags.




1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

**Fig. 1, Ride Height Control Linkage**

5. Remove the locknuts and washers that attach the air spring to the cross channel. See **Fig. 2**.
6. Disconnect the air lines to the air spring.
7. Remove the brass air fittings from the air spring.
8. Remove the locknuts and washers that attach the air spring to the upper air spring frame hanger.
9. Remove the air spring.
10. Attach the new air spring to the air spring frame hanger by inserting the studs into the appropriate holes.
11. Attach the air spring to the cross channel. Tighten the nuts 25 lbf·ft (34 N·m).
12. Tighten the outboard locknut that attaches the air spring to the air spring frame hanger 25 lbf·ft (34 N·m).




1. Locknut
2. Washer
3. Bolt
4. Air Spring
5. Main Support Member
6. Cross Channel

**Fig. 2, Air Spring Mounting**

13. Attach the brass fittings to the air spring using a Teflon thread seal.
14. Connect the air lines to the air spring.

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## Air Spring Replacement

15. Connect the ball stud on the vertical linkage rod to the lever for the height control valve. Install the washer and tighten the nut 10 lbf·ft (14 N·m).
16. Remove the jack stands.
17. Build up pressure in the air system and check the ride height as described in **Subject 240**.
18. Remove the chocks from the tires.

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# Air Spring Frame Hanger Removal and Installation

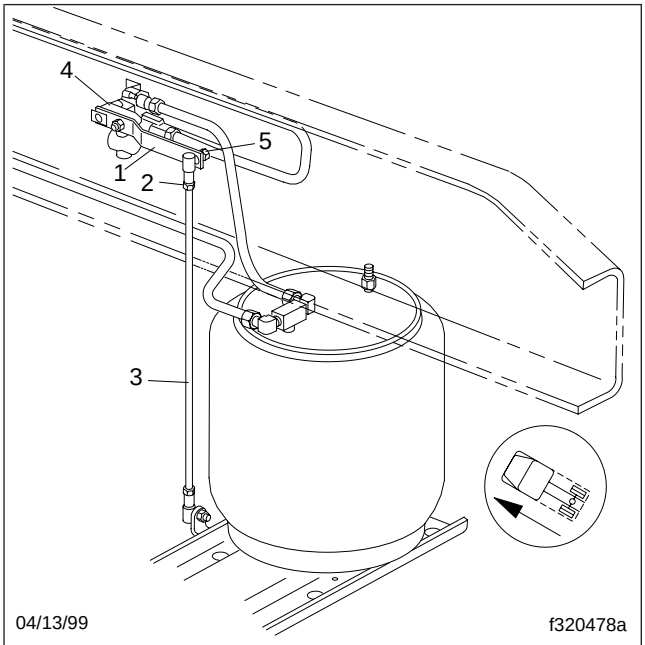
## Removal

1. Chock the front tires.

**⚠ WARNING**

**The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.**

2. Disconnect the vertical linkage for the height control valve at the end of the horizontal lever. See **Fig. 1**. Lift the lever on the height control valve so that the air bags raise the rear of the frame about 3 inches (75 mm). Support the frame at that position with jack stands.



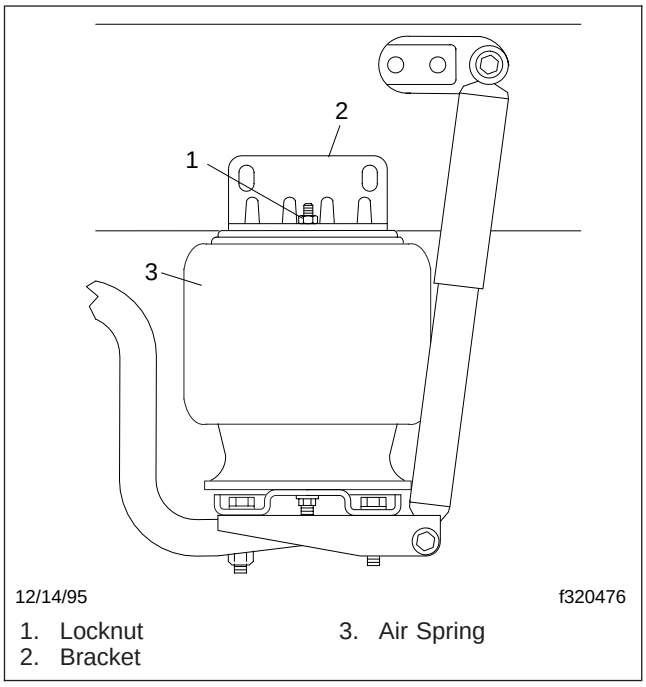

1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

**Fig. 1, Height Control Valve Linkage**

3. Drain the air from the vehicle's air system then lower the lever on the height control valve to exhaust the air from the air springs.
4. Disconnect the air lines from the air spring fittings.
5. Remove the brass air fittings from the air spring.
6. Remove the locknuts and washers that attach the air springs studs to the upper bracket on the frame rail. See **Fig. 2**.
7. Remove the nuts, washers and bolts that hold the upper air spring bracket to the frame rail. Remove the air spring bracket.

## Installation

1. Position the air spring upper bracket on the frame rails. Install the bolts through the frame rail and upper bracket and install the washers, and locknuts. Tighten the locknuts 340 lbf·ft (461 N·m).
2. Attach the air spring to the air spring frame bracket. Tighten the outboard locknut 25 lbf·ft (34 N·m).




1. Locknut
2. Bracket
3. Air Spring

**Fig. 2, Air Spring Installation**

3. Attach the brass air fittings to the air spring port using Teflon thread sealant.
4. Connect the air lines to the air spring fittings.

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## Air Spring Frame Hanger Removal and Installation

5. Build up pressure in the air system and raise the height control lever to lift the frame off the jack stands. Remove the jack stands and lower the vehicle.
6. Align the ball joint stud in the vertical linkage rod with the hole in the height control lever. Install the ball joint stud, the washer and locknut. Tighten the locknut 10 lbf·ft (14 N·m).
7. Remove the chocks from the tires.

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# Shock Absorber Bracket Removal and Installation

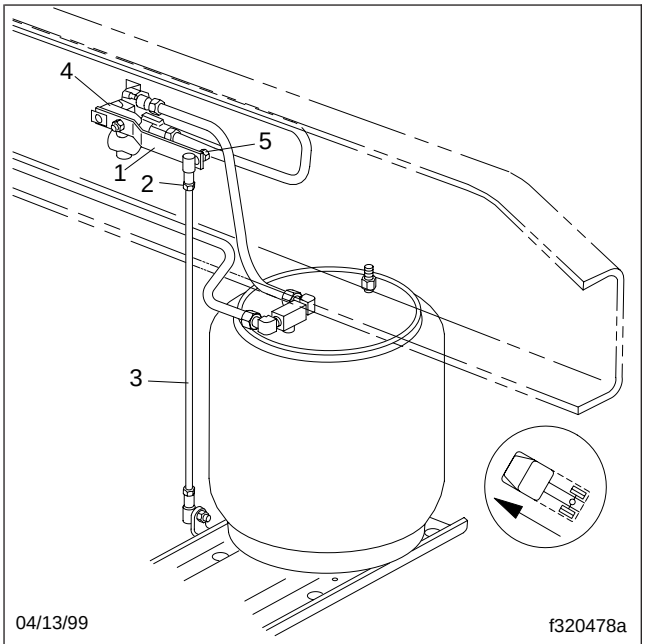
## Removal

1. Chock the front tires.

**⚠ WARNING**

**The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.**

2. Remove the locknut and washer and disconnect the ball joint stud on the top of the vertical linkage rod from the height control valve lever. See **Fig. 1**.




1. Lever
2. Ball Joint and Jam Nut
3. Vertical Linkage Rod
4. Height Control Valve
5. Locknut

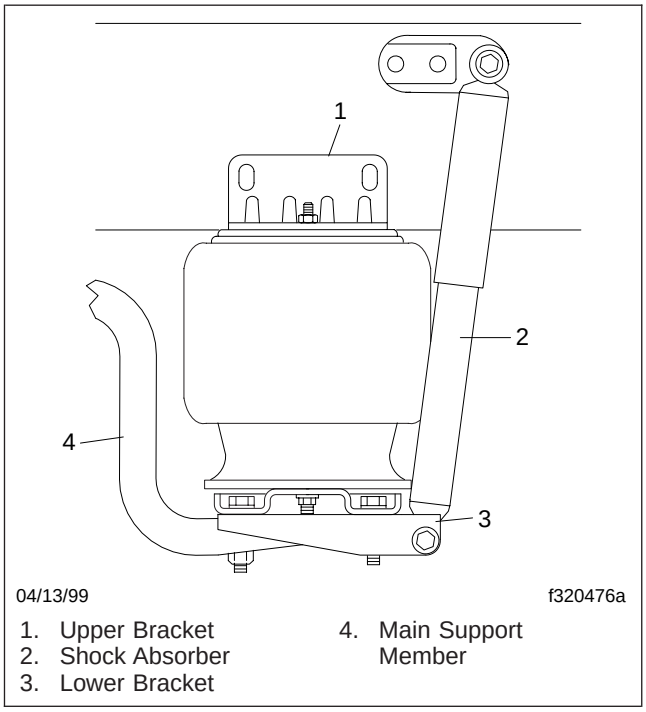
**Fig. 1, Height Control Valve Linkage**

3. Lift the height control lever to raise the rear of the frame enough to remove the load from the suspension.

   NOTE: The front of the main support member will move downward as the load is removed. Support the frame in this position with jack stands.

4. Remove the shock absorber. Refer to **Subject 230**.

5. Remove nuts, washers and bolts from the shock absorber frame hanger bracket. See **Fig. 2**. Remove the top shock absorber bracket from the frame.




1. Upper Bracket
2. Shock Absorber
3. Lower Bracket
4. Main Support Member

**Fig. 2, Shock Absorber Mounts (typical)**

6. Remove the nuts, washers and bolts that attach the cross channel and lower shock absorber bracket to the rear of the main support member.

7. Remove the lower bracket by sliding the bracket to the rear.

## Installation

1. Install the bolts and washers that attach the frame hanger bracket from the inboard side of the frame. Install the brackets, washers and locknuts. Tighten the nuts 340 lbf·ft (461 N·m).

2. Position the lower bracket between the cross channel and the main support member.

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## Shock Absorber Bracket Removal and Installation

3. Install the bolts and washers from the top of the cross channel, through the shock bracket and main support member. Install the washers and locknuts and tighten the locknuts attaching the cross channel to the main support member 290 lbf·ft (393 N·m).
4. Install the shock absorber. Install the washers at both sides of each shock bushing for a total of four washers per shock absorber.
5. Tighten shock absorber locknuts 60 lbf·ft (81 N·m).
6. Lift the lever of the height control valve to raise the rear of the frame off the jack stands. Remove the jack stands and lower the frame by pushing down on the height control valve lever.
7. Align the ball joint stud in the vertical linkage rod with the hole in the height control valve lever. Install the washer and locknut. Tighten the locknut 10 lbf·ft (14 N·m).
8. Remove the chocks from the tires.

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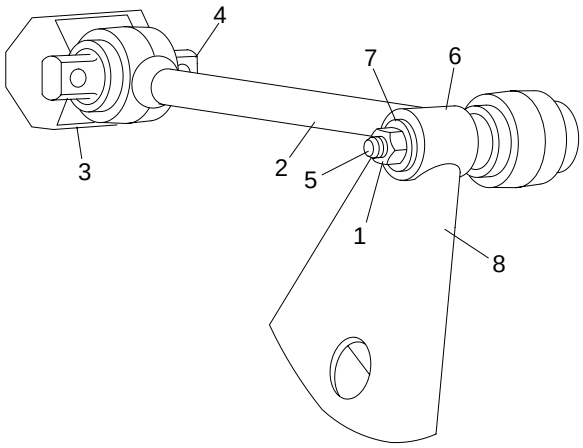


## Transverse Rod Removal and Installation

## Removal

NOTE: This procedure is for replacement of a transverse rod with a tapered stud at the axle connection and a straddle mount pin at the frame bracket end. Some installations have straddle mounts at both ends of the transverse rod.

1. Chock the front and rear tires.
2. Remove the nuts and washers from the bolts that fasten the pin in the transverse rod bushing to the frame bracket. Disconnect the transverse rod where it is attached to the frame bracket bracket. See **Fig. 1**.
3. Remove the nut from the tapered stud in the tube bracket on the axle housing. Hit the top of the axle bracket tube hard with a large hammer to momentarily distort the tube and loosen the tapered stud. Remove the stud and transverse rod from the bracket on the axle housing.




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1. Locknut
2. Transverse Rod
3. Frame Bracket
4. Straddle Mount Pin
5. Tapered Stud End
6. Axle Bracket Tube
7. Washer
8. Axle Bracket

**Fig. 1, Transverse Rod Assembly**

## Installation

1. Clear the tapered hole in the axle bracket of all foreign matter.
2. Insert the tapered stud and torque rod bushing into the bracket.
3. Attach the washer and locknut to the stud. Tighten 200 lbf·ft (271 N·m).
4. After tightening, hit the top of the axle bracket tube with a hammer to seat the tapered stud. Retighten.
5. Position the straddle mount end of the transverse rod at the frame bracket, and tighten 200 lbf·ft (271 N·m).
6. Remove the chocks from the tires.

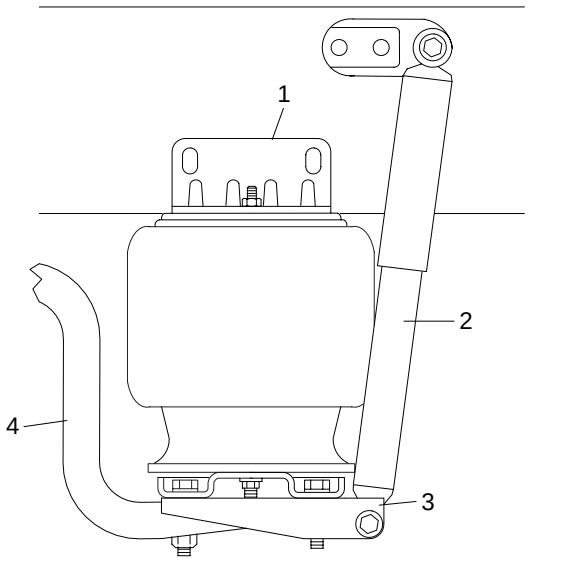
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## Replacement

NOTE: Shock absorbers are 1 3/8 inches (35 mm) in diameter with a compressed length of 18 1/3 inches (466 mm) and an extended length of 30 inches (762 mm).

1. Chock the front tires.
2. Remove the nut, washer and bolts that attach the shock absorber to the frame hanger bracket. See **Fig. 1**.




1. Upper Bracket
2. Shock Absorber
3. Lower Bracket
4. Main Support Member

**Fig. 1, Shock Absorber Mounts (typical)**

3. Remove the fasteners that attach the shock absorber to the lower bracket.
4. Remove the shock absorber.
5. Install the new shock absorber with the rod and shield tube at the top. Install the bolts, washers and nuts in the lower bracket and the frame hanger bracket. Install washers at both sides of each shock bushing, that is four washers per shock absorber.
6. Tighten the fasteners 60 lbf·ft (81 N·m).

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## General Information

NOTE: This subject applies only to Hendrickson series HAS 190/210/230/40LH/400/402/460 suspensions.

Adjust the vehicle ride height with the unloaded vehicle on a level surface. The frame slope, driveline angles, and axle mounting alignment should be checked after the ride height has been changed.

**⚠ CAUTION**

**Failure to adjust the vehicle ride height could adversely affect driveline angles. Also, if the air springs are set too high, the driver may have difficulty (or be prevented from) backing the vehicle under a trailer. If the air springs are set too low, rapid wear of driveline parts will result.**

## Ride Height Adjustment

The vehicle ride height for Hendrickson HAS air suspension systems is changed by adjusting the length of the vertical linkage at the ride height control valve. Use the following procedure to adjust the ride height of the frame rails.

IMPORTANT: Before checking the ride height, make sure there is no load on the chassis. For tractors, unhitch the trailer. Trucks must be empty when checking the ride height.

1. Stop the vehicle on a level surface, using a light application of the brakes. Slowly move the vehicle forward and back several times without using the brakes to center the suspension joints. Do not apply the parking brakes.
2. Put the transmission in neutral. Build the secondary air pressure to at least 100 psi (690 kPa). Shut down the engine.

   NOTE: Allow several minutes for the air pressure to equalize in the system before checking the ride height.
3. Mark the location of the front and rear tires on the floor so that the vehicle can be checked in the same location after a test drive. Chock the front tires.

IMPORTANT: Any difference in height between the two sides of the vehicle must be corrected using spacers between the main support arm and the rear axle housing before setting the vehicle ride height.

4. Measure the distance from the bottom of the frame rail to the bottom of the main support arm at the rear axle U-bolts. See **Fig. 1**. The correct measurement for Hendrickson HAS suspension systems is 4-1/4 ±1/8 inches (108 ±3 mm) for vehicles with a specified ride height of 8-1/2 inches (215 mm) or greater.

   If the measurement is the same as the specification at each support arm, the ride height is correctly adjusted. If the distance measured is not the same at each rear axle mount on the vehicle, correct this alignment problem before attempting to adjust the ride height.

**⚠ WARNING**

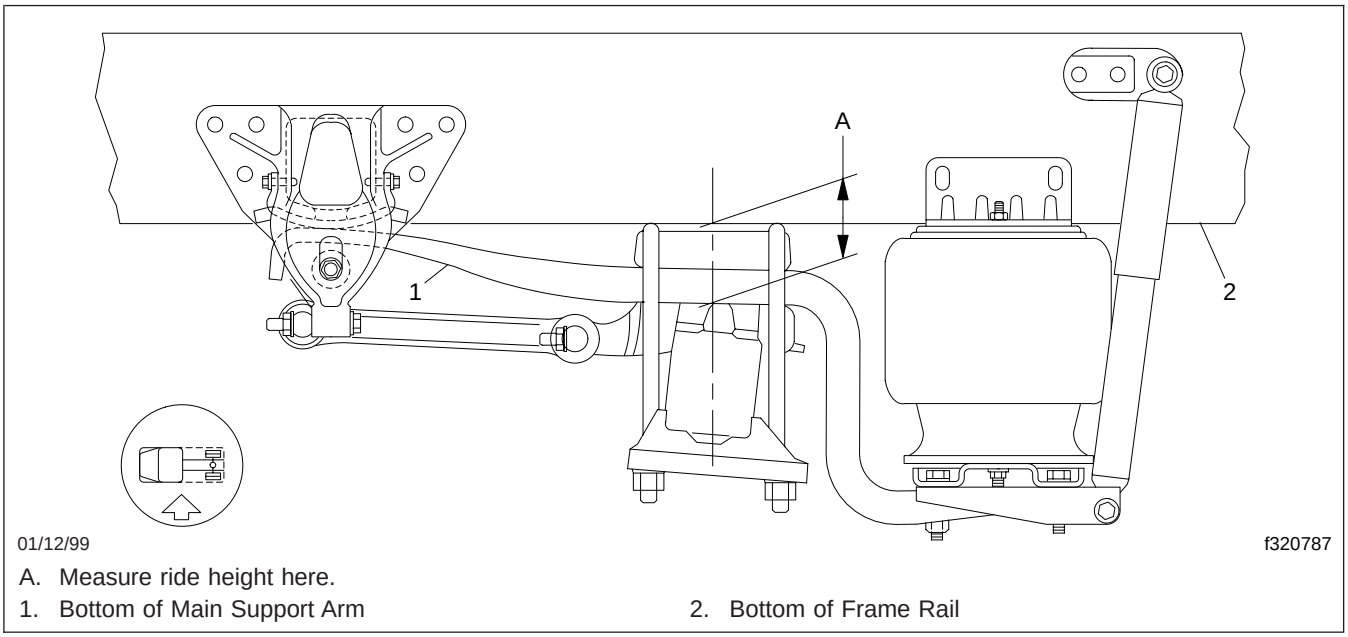
**The air suspension system will start moving the frame when the lever for the ride height control valve is moved from its center position. To avoid injury or property damage, make sure that your hands and all objects are away from any pinch points when the lever is moved.**

5. Remove the nut and lockwasher from the ball joint stud at the end of the lever on the ride height control valve. See **Fig. 2**. Separate the vertical rod assembly from the lever, being careful to avoid moving the lever while disconnecting the ball joint.
6. Push the lever down to lower the frame by removing the air in the suspension air bags.
7. Slowly pull the lever up to raise the frame until the ride height measurement is exactly correct for the specified ride height.
8. Make sure that the centering hole in the lever near its pivot aligns with the centering hole in the height control valve body. Check the height control valve to make sure that no air flows through the ride height control valve when the lever is in the centered position.
9. Loosen the jam nuts a few turns at the top and bottom ball joints on the vertical rod that attaches to the height control lever. Note that one of the ball joints and jam nuts has left-hand threads.

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## Ride Height Adjustment




A. Measure ride height here.
1. Bottom of Main Support Arm
2. Bottom of Frame Rail

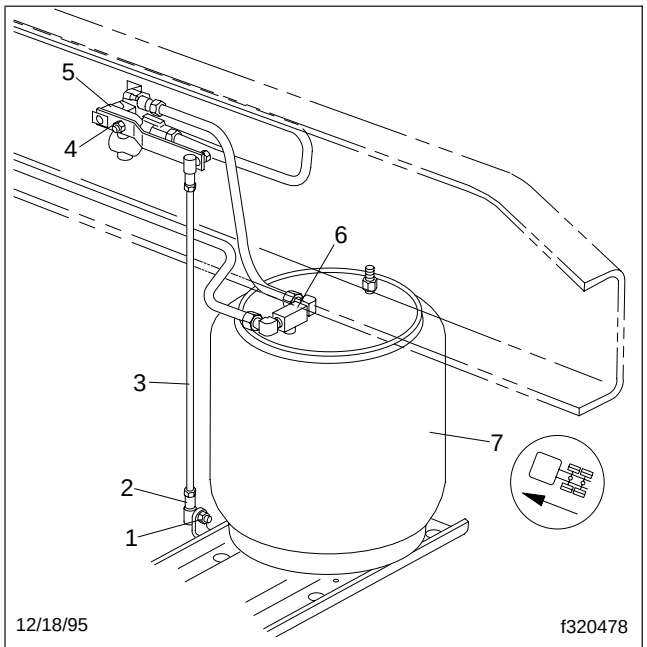
**Fig. 1, Measuring the Ride Height**

Hold the top ball joint with your hand and turn the vertical rod with a wrench until the top ball joint stud exactly aligns with the hole in the end of the lever when the lever is centered horizontally on the control valve.

10. Install the ball joint stud in the lever and install the lockwasher and nut on the stud. Tighten the nut on the stud to 125 lbf·in (11 N·cm).
11. Tighten the jam nut on each ball joint without changing the length of the vertical rod.
12. Apply the parking brakes; then remove the chocks from the tires. Drive the vehicle unloaded for about 1/4 mile (1/2 km); then stop the vehicle in the exact location (as previously marked) of the original measurement.
13. Park the vehicle using only a light brake application. Chock the tires on one axle only and put the transmission in neutral. Do not apply the parking brakes.
14. Check the adjusted distance between the bottom of the frame and the bottom of the main support arm at the U-bolts. See **Fig. 2**.
15. If the distance is still not correct, loosen the ball joint jam nuts on the vertical rod and turn the rod to adjust the ride height. Lengthen the vertical rod to raise the frame or shorten the rod to lower the frame to the correct ride height. Drive the vehicle and again check the ride height.
16. Apply the parking brakes; then remove the chocks from the tires.

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1. Lockwasher and Nut
2. Ball Joint and Jam Nut
3. Vertical Rod
4. Leveling Arm Locknut
5. Ride Height Control Valve
6. Brass Air Fitting
7. Air Spring

**Fig. 2, Ride Height Control System**

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# Troubleshooting Tables

**Problem—All Air Bags are Deflated**

| Problem—All Air Bags are Deflated | |
|---|---|
| **Possible Cause** | **Remedy** |
| The vehicle air system pressure is too low. | Run the engine until the air gauge indicates 100 psi (690 kPa). |
| Air is leaking from the vehicle air system. | Listen for air leakage at the air fittings, tanks, and brake components. Repair or replace fittings as needed. |
| The linkage for the height control valve is disconnected or misadjusted. | Connect the linkage and adjust as described in **Subject 240**. |
| The suspension dump valve is activated. | Toggle the dump control valve to the normal position. |
| The relay valve is stuck open. | Check and repair the relay valve. |
| The air bags have a leak. | Listen for leaks at the air bags, tubes, and fittings. |
| The height control valve is not operating correctly. | Disconnect the linkage and raise and lower the lever to check the operation of the height control valve. Make sure that no air flows through the valve when the lever is in the center position. Replace the valve if it is bad. |
| There is a obstruction in the lines to the height control valve. | Check the air pressure at the height control valve supply port. Remove any obstruction or restriction to air flow to the valve. |
| The pressure protection valve is not allowing air to flow to the height control valve. | Check the operation of the pressure protection valve between the secondary air tank and the height control valve. Replace the valve if it is not operating correctly. |

**Problem—One Side of the Vehicle is Higher Than the Other**

| Problem—One Side of the Vehicle is Higher Than the Other | |
|---|---|
| **Possible Cause** | **Remedy** |
| The axle seat spacer thickness is not the same on each side. | Adjust the spacers so that the frame is level before adjusting the ride height. |
| The load on the vehicle is not distributed evenly. | Change the position of the load to ensure equal weight on each side. |
| There is an obstruction to air flow to the air bags on one side of the vehicle. | Disconnect the fittings and test the flow to the air bags on the lower side of the vehicle. |
| The height control valve or relay valve has an internal restriction. | Check for the same pressure at the ports on each side of the valve. Replace the valve if the pressure is not the same. |
| The air bags or fittings have a leak. | Listen for leaks at the air bags, tubes, and fittings. Tighten the fittings, if loose, or replace any bad parts. |

**Problem—The Ride Height is Not Constant**

| Problem—The Ride Height is Not Constant | |
|---|---|
| **Possible Cause** | **Remedy** |
| Air is leaking from the air bags or lines. | Listen or use soap bubbles to find air leaks. Tighten or replace leaking fittings or air bags. |

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## Troubleshooting

| Problem—The Ride Height is Not Constant | |
|---|---|
| **Possible Cause** | **Remedy** |
| The height control valve is not working correctly. | Make sure that no air is exhausted from the height control valve when the lever is in the horizontal position and that the air bags inflate when the lever is raised. The bags must deflate when the lever is pushed down. There must be a slight delay between the lever movement and the valve operation. Check for fluid leaks from the height control valve. Replace the valve if damaged. |
| There is an obstruction to air flow to the air bags. | Disconnect the fittings and test the flow to the air bags. |
| The height control valve has a restriction at the exhaust port. | Check for air exhausting from the valve when the height control lever is pushed down. |
| The height control linkage is loose. | Make sure that all the jam nuts are tight and that the ball sockets are not worn. |

**Problem—The Ride Height Measurement is Not Correct**

| Problem—The Ride Height Measurement is Not Correct | |
|---|---|
| **Possible Cause** | **Remedy** |
| The vehicle is loaded. | The ride height of a loaded vehicle will be slightly lower than that of an unloaded vehicle. Adjust the ride only when the vehicle is unloaded. |
| The ride height adjustment is not correct. | Adjust the ride height as described in **Subject 240**. |
| Air is leaking from the air bags or lines. | Listen or use soap bubbles to find air leaks. Tighten or replace leaking fittings or air bags. |
| The height control valve is not working correctly. | Make sure that no air is exhausted from the height control valve when the lever is in the horizontal position and that the air bags inflate when the lever is raised. The bags must deflate when the lever is pushed down. There must be a slight delay between the lever movement and the valve operation. Check for fluid leaks from the height control valve. Replace the valve if damaged. |
| There is an obstruction to air flow to the air bags. | Disconnect the fittings and test the flow to the air bags. |
| The height control valve has a restriction at the exhaust port. | Check for air exhausting from the valve when the height control lever is pushed down. |
| The height control linkage is loose. | Make sure that all the jam nuts are tight and that the ball sockets are not worn. |

**Problem—The Air Springs Have Cuts**

| Problem—The Air Springs Have Cuts | |
|---|---|
| **Possible Cause** | **Remedy** |
| The ride height is adjusted too high. | Adjust the ride height so that the air bags are not continually overinflated. |
| The tires are too wide and are rubbing the air bags. | Install the correct tires. |
| A shock absorber or mount is broken. | Replace any broken components. |

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**Problem—The Vehicle Does Not Track Straight**

| Problem—The Vehicle Does Not Track Straight | |
|---|---|
| **Possible Cause** | **Remedy** |
| The axle alignment is not correct. | Adjust the alignment with shims at the front of the torque rods. |
| The bushings in the torque rods are worn. | Replace the worn bushings. |
| The bushings in the transverse rods are worn. | Replace the worn bushings. |
| A shock absorber or mount is broken. | Replace any broken components. |
| The U-bolt high nuts are loose. | Periodically tighten the nuts as described in **Specifications 400**. |
| The suspension fasteners are loose or damaged. | Tighten or replace the fasteners. |

**Problem—The Vehicle Vibrates When Driven**

| Problem—The Vehicle Vibrates When Driven | |
|---|---|
| **Possible Cause** | **Remedy** |
| The ride height is not correct. | Adjust the ride height as described in **Subject 240**. |
| The axle housing rotational alignment is not correct. | Adjust the rotational alignment of the axle housing with wedge-shaped shims at the axle seats. The driveline U-joint angles must be with 1 per cent of each other. |
| The shock absorbers are worn or disconnected. | Replace the shock absorbers, if worn, or tighten the mounting fasteners. |
| The bushings in the torque rods are worn. | Replace the worn bushings. |
| The U-bolt high nuts are loose. | Periodically tighten the nuts as described in **Specifications 400**. |
| The suspension fasteners are loose or damaged. | Tighten or replace the fasteners. |
| The frame is not level from front to rear. | Check and adjust the ride height at the front suspension and each rear axle. The frame should not slope more than 1/2 inch (13 mm). Correct the ride height if not at specifications. |

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## Specifications

For an overview of the Hendrickson HAS air system plumbing, see **Fig. 1** and **Fig. 2**.

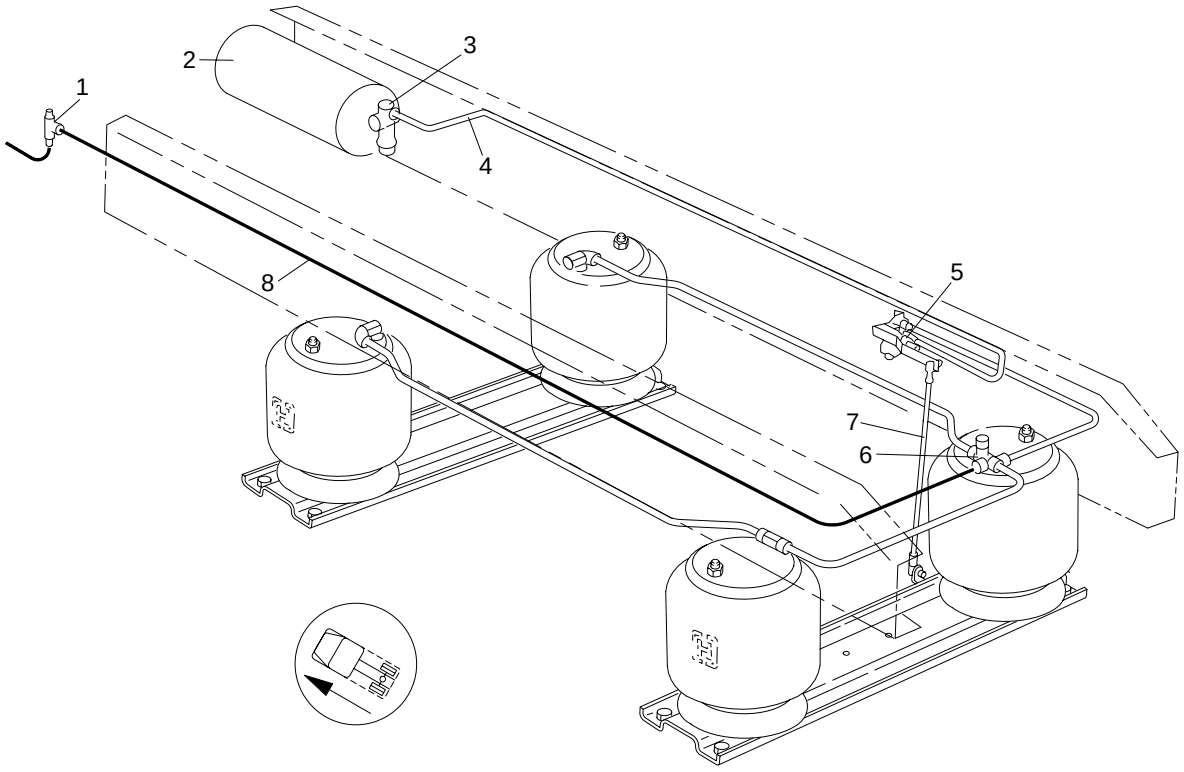
| Torque Values | | |
|---|---|---|
| **Description** | **Size** | **Torque: lbf·ft (N·m)** |
| U-Bolt High Nuts (tighten in a diagonal pattern as shown in **Fig. 3**) | 7/8–14 | Stage 1: Hand tighten<br>Stage 2: 60 (81)<br>Stage 3: 200 (271)<br>Stage 4: 420 to 500 (571 to 680) |
| | 1–14 | Stage 1: Hand tighten<br>Stage 2: 60 (81)<br>Stage 3: 200 (271)<br>Stage 4: 520 to 600 (707 to 816) |
| Torque Rod Bar Pin Locknut | 5/8–11 | 180 (244) |
| Axle Seat Stud | 5/8–11 | 65 (88) |
| Rebound Bolt Locknut | 1/2–13 | 60 (81) |
| Shock Absorber Locknut, Upper | 1/2–13 | 60 (81) |
| Shock Absorber Locknut, Lower | 3/4–10 | 60 (81) |
| Cross Channel to Main Support Member Locknut | 3/4–10 | 290 (393) |
| Air Spring to Frame Hanger Locknut | 1/2–13 | 25 (34) |
| Air Spring to Cross Channel Locknut | 1/2–13 | 25 (34) |
| Transverse Rod Locknut | 1-1/4–12 | 200 (271) |
| Extension Arm Jam Nut | 5/16–24 | 125 (169) |
| Extension Arm Locknut | 5/16–24 | 125 (169) |

**Table 1, Torque Values**

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## Specifications




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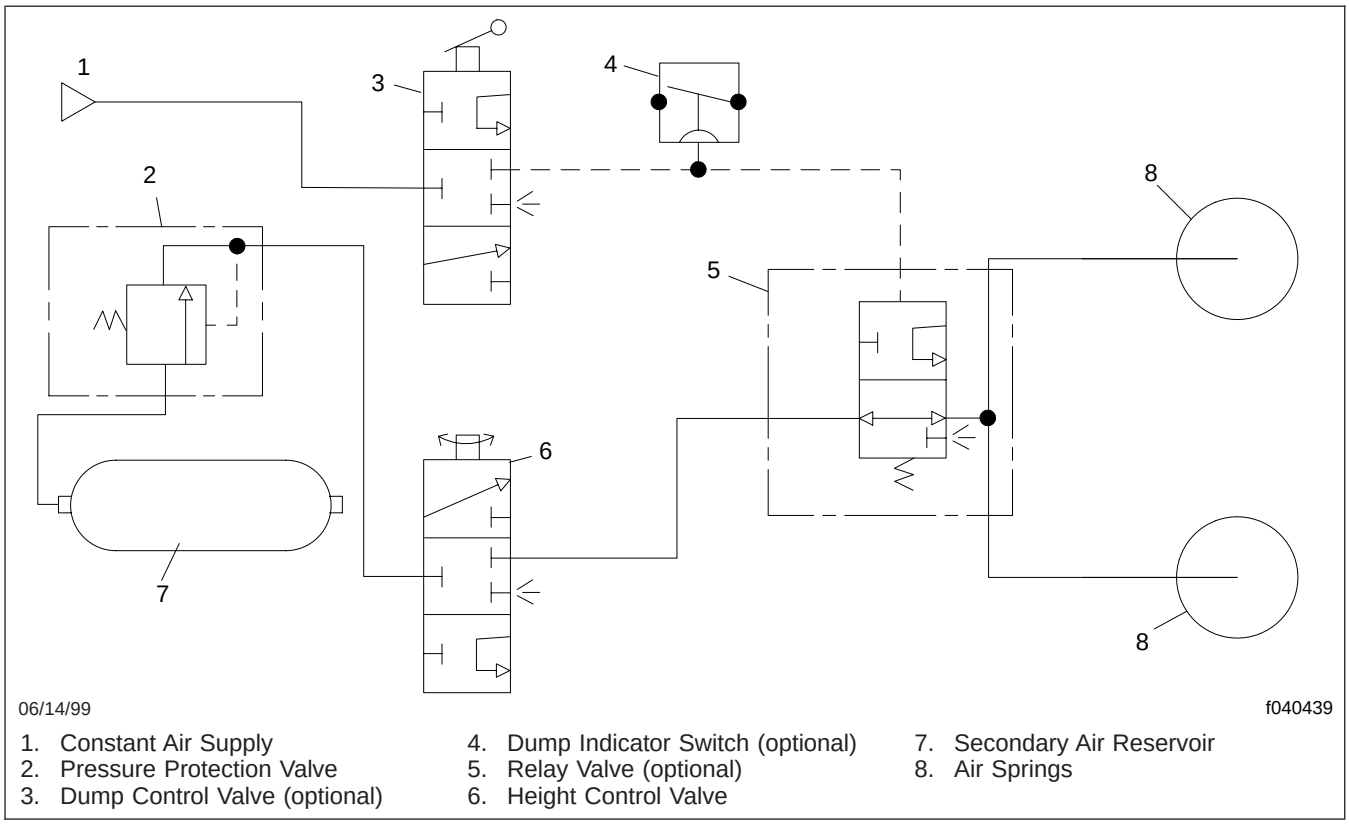
NOTE: The height control valve was moved to the forward axle on later HAS systems.

1. Switch Control Valve
2. Air Tank
3. Pressure Protection Valve
4. Air Supply Line
5. Height Control Valve
6. Quick Release Valve
7. Leveling Valve Extension Arm
8. Air Signal Line

**Fig. 1, Suspension Air Plumbing**

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1. Constant Air Supply
2. Pressure Protection Valve
3. Dump Control Valve (optional)
4. Dump Indicator Switch (optional)
5. Relay Valve (optional)
6. Height Control Valve
7. Secondary Air Reservoir
8. Air Springs

**Fig. 2, Air Suspension Dump System Schematic (typical)**

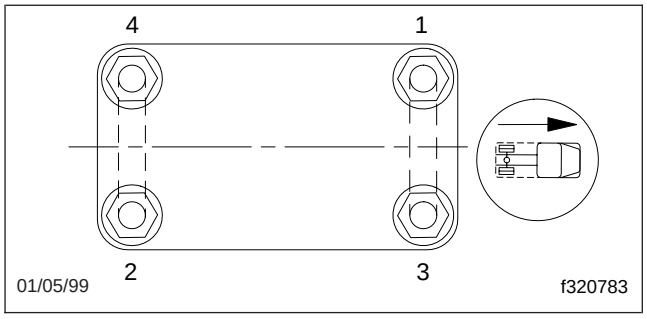



**Fig. 3, Tightening Pattern for U-Bolt High Nuts**

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## General Description

The Neway Air Ride Suspension is a single axle (Model AD-123) or tandem axle (Model AD-246) suspension that uses air springs. See **Fig. 1** or **Fig. 2**. The top of each air spring is bolted to a frame-rail bracket, and the bottom of each spring is attached to a suspension crossmember. The suspension crossmember is attached to the rear ends of two equalizing beams which carry the axle. The forward ends of the equalizing beams are journaled to brackets bolted on the frame rail.

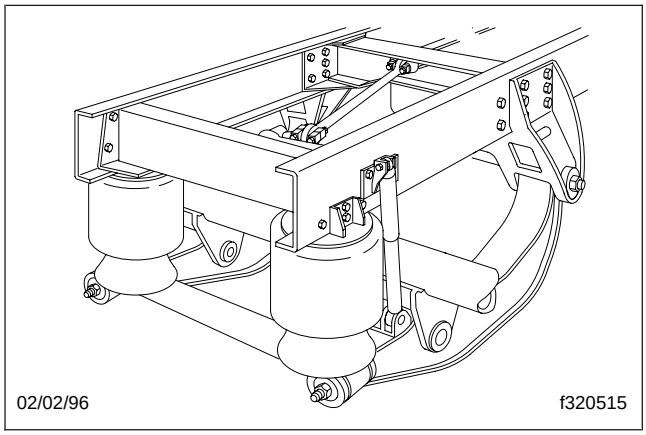



**Fig. 1, Single Axle Suspension, Model AD-123**

Both models of the suspension allow for vertical travel. The maximum loading capacity of the single axle model is 22,500 pounds (10 000 kg); and the maximum loading capacity for the tandem axle model is 44,000 pounds (20 000 kg).

The Neway suspension maintains a stable, level ride by adjusting the air spring height according to vehicle load and road conditions. A height control valve mounted inside the frame rail is linked to the suspension crossmembers and monitors ride height in relation to the crossmember. See **Fig. 3**. If the load is riding too high, the suspension crossmember pulls the valve's control lever down, and the valve lowers the load by venting air from the springs. See **Fig. 4**. If the load rides too low, the suspension crossmember pushes the valve's control lever up, and the valve raises the load by delivering air to the springs. The air springs and the shocks mounted between the axle and the frame rails absorb road shock.

The design of the height control valve allows a several second delay between delivering air to and venting air from the air springs. This prevents the valve from reacting to abrupt axle movements caused by the condition of the road surface.

A torque rod (**Fig. 3**) connects each axle housing to a frame crossmember to prevent torque-induced rotation of the axle. A similar control rod (**Fig. 3**) connects each axle housing to a frame rail to prevent the axle from moving laterally.

If the air springs lose pressure, a solid rubber bumper inside the spring will support the vehicle until it can be repaired. Do not drive the vehicle over 30 mph (50 km/h) with the air springs deflated, and drive it only as far as the nearest service facility. To deflate the air springs, disconnect the control lever arm from the linkage rod, and press the valve's control lever down to simulate overinflated air springs. The valve will vent the air from the springs.

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## General Information

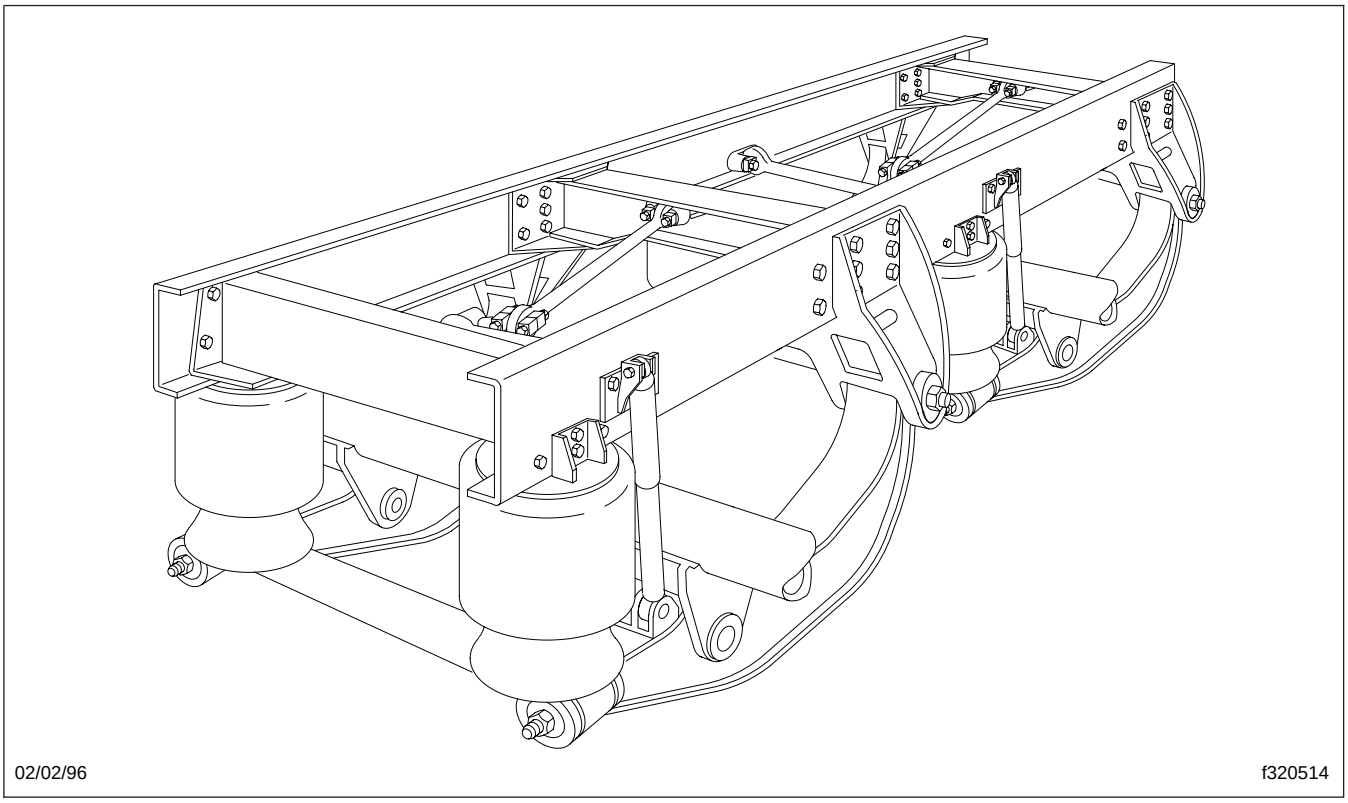
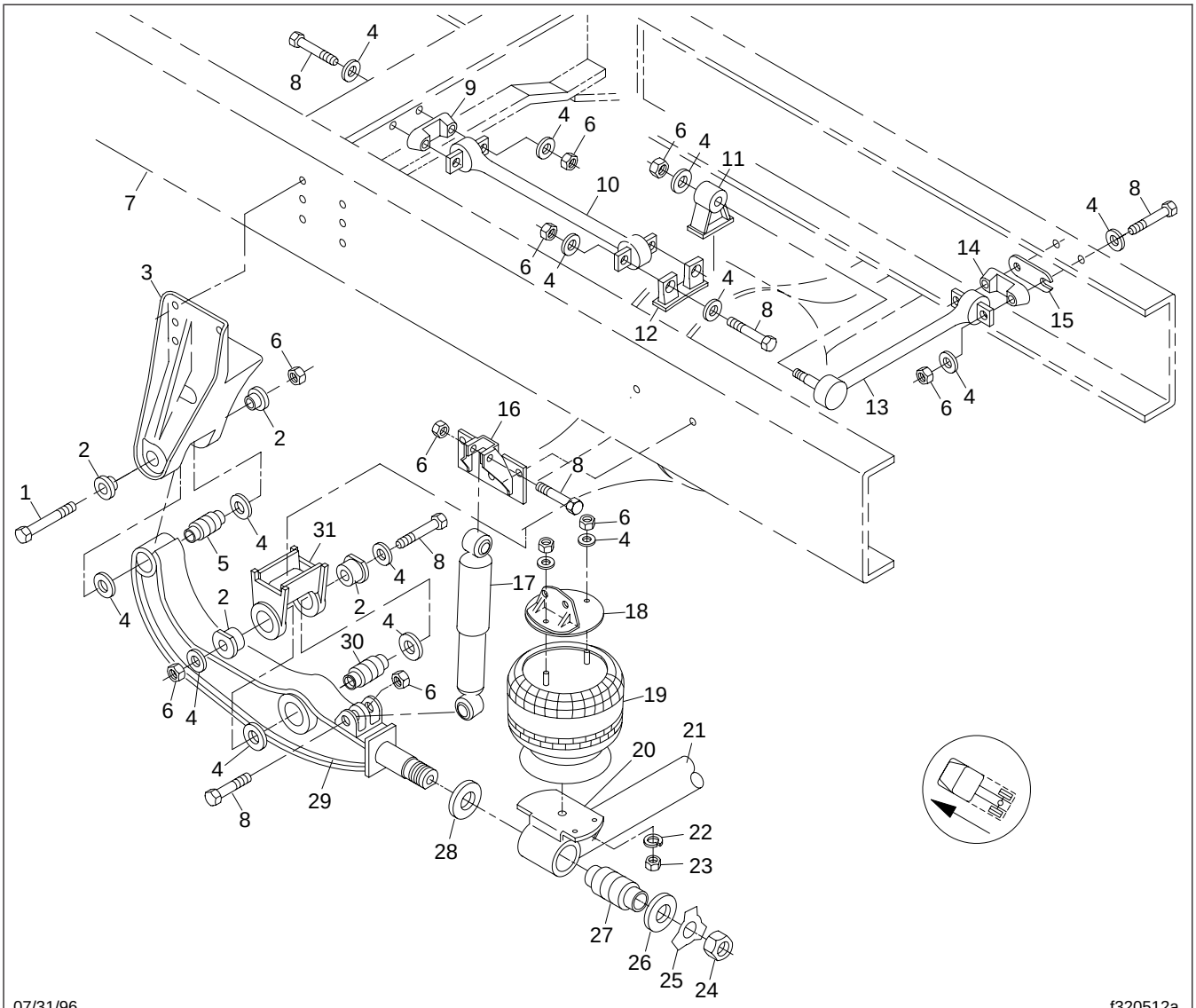



**Fig. 2, Tandem Axle Suspension, Model AD-246**

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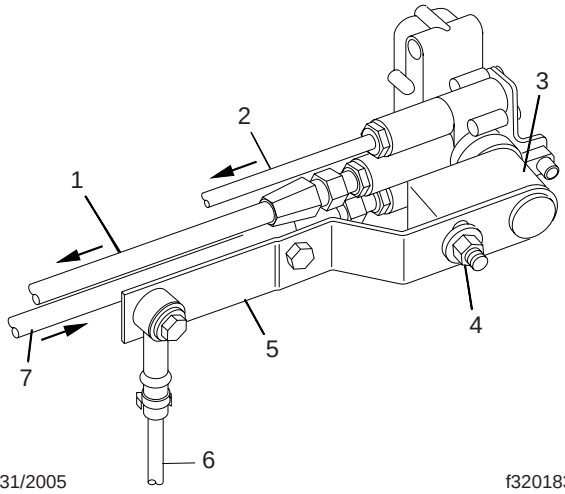

1. Rod Bolt, 1-1/8–7 x 9-1/4
2. Adaptor Bushing
3. Frame Bracket
4. Spacer Washer
5. Equalizing Beam Front Bushing
6. Locknut
7. Frame Rail
8. Rod Bolt, 3/4–10 x 7-1/2
9. Torque Rod Crossmember Bracket
10. Torque Rod
11. Control Rod Axle Bracket
12. Torque Rod Axle Bracket
13. Control Rod
14. Control Rod Frame Bracket
15. Axle Alignment Shim(s)
16. Shock Absorber Frame Bracket
17. Shock Absorber
18. Air Spring Upper Mounting Plate
19. Air Spring
20. Air Spring Lower Mounting Plate
21. Transverse Beam
22. Lockwasher
23. Hexnut, 1/2–13
24. Hexnut, 2-1/4–8
25. Tab Washer
26. Spacer Washer
27. Transverse Beam Bushing
28. Spacer Washer
29. Equalizing Beam
30. Equalizing Beam Center Bushing
31. Beam Hanger Bracket

**Fig. 3, Neway Suspension Components**

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## General Information




1. Airflow to Spring
2. Exhaust to Atmosphere
3. Nylon Block
4. Adjustment Locknut
5. Control Lever
6. Linkage
7. Airflow from Air Reservoir

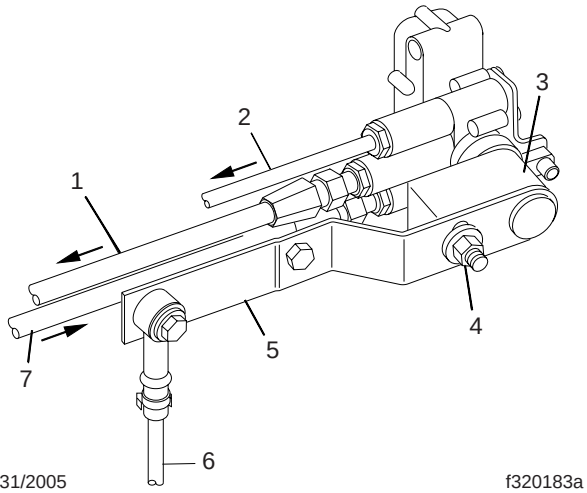
**Fig. 4, Height Control Valve**

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## Adjustment

1. Park the unloaded or evenly loaded vehicle on a level surface. Run the engine until the air brake system is fully charged. Chock the tires.
2. Remove the bolt that secures the height control valve linkage to the control lever of each valve. See **Fig. 1**. Disconnect the linkages from the control levers.
3. Exhaust all air from the air springs by pushing the control levers down to the vertical position.
4. Connect one of the control levers to its respective linkage, and allow the air spring(s) controlled by the lever to fill until the valve shuts off.
5. Measure the distance from the underside of the frame rail to the centerline of the axle nearest the inflated spring. This dimension should be 10 inches (25 cm). Adjust the height control valve by loosening the adjustment locknut (see **Fig. 1**) and moving the control lever slightly, relative to the nylon block. When the 10-inch (25-cm) height dimension is achieved, retighten the adjustment locknut.




1. Airflow to Spring
2. Exhaust to Atmosphere
3. Nylon Block
4. Adjustment Locknut
5. Control Lever
6. Linkage
7. Airflow from Air Reservoir

**Fig. 1, Height Control Valve**

6. Disconnect the control lever from the linkage, and press it down to deflate the air springs about halfway. Reconnect the linkage to inflate the air springs, then check the height dimension. Repeat the step above and this step until the height dimension measures 10 inches (25 cm).
7. When the height control valve is adjusted, disconnect the control lever from the height control valve linkage, and push it down to the vertical position to fully deflate the air spring.
8. Repeat the previous four steps on the other height control valve(s).
9. Connect all linkage assemblies to the control levers. All height dimensions should now be equal. If they aren't, check for loose mounting bolt nuts on the height control valves. Tighten any loose nuts or capscrews. Repeat the adjustment procedures until all height dimensions are 10 inches (25 cm).

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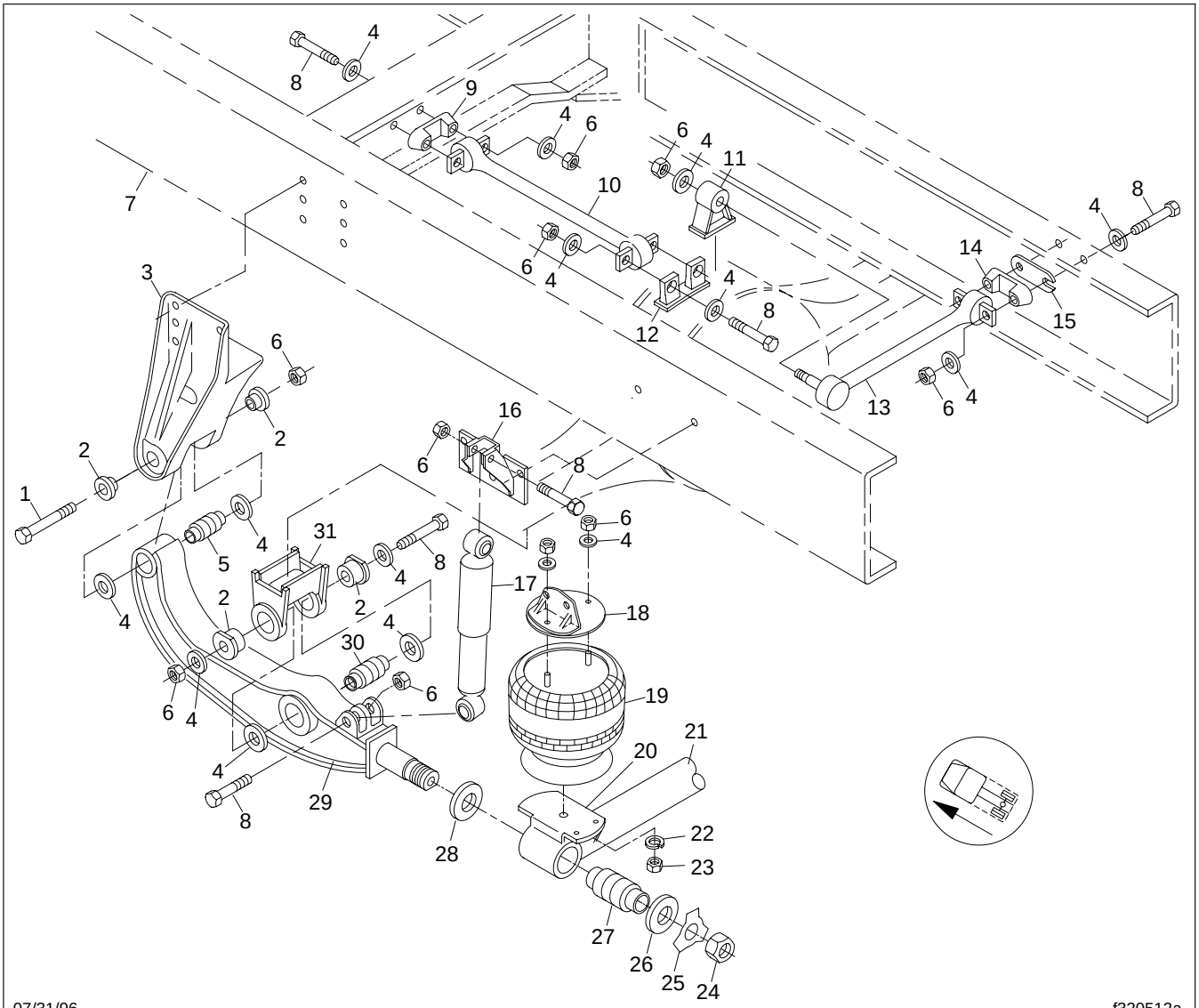
## Replacement

1. Chock the front tires to prevent vehicle movement. Open the stopcocks on the air tanks to drain the air system.
2. Raise the rear of the vehicle to remove all weight from the rear axles, and place safety stands to secure the vehicle in its raised position. When raised, the height control valves will vent all air from the air springs.
3. Taking care to prevent foreign substances from entering the line or fitting, disconnect the air supply line from the air spring.
4. Remove the locknut (**Fig. 1**), hexnut, and washers that secure the air spring to the air spring upper mounting plate.
5. Remove the capscrews and lockwashers that connect the air spring to the air spring lower mounting plate on the transverse beam. Remove the air spring.
6. Position the new air spring on the air spring lower mounting plate, then install the capscrews and lockwashers to secure the air spring to the lower mounting plate. Tighten the capscrews to the torque under **Specifications, 400.**
7. Install the locknut, hexnut, and washers previously removed, to connect the air spring to the air spring upper mounting plate. Tighten the nuts to the torque under **Specifications, 400**.
8. Connect the air supply line to the air spring.
9. Remove the safety stands from under the vehicle, then lower the vehicle.
10. There must be 10 inches (25 cm) between the bottom of the frame rail and the centerline of the axle. Adjust the height control valve adjustment; for instructions, see **Subject 100**.

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## Air Spring Replacement




1. Rod Bolt, 1-1/8–7 x 9-1/4
2. Adaptor Bushing
3. Frame Bracket
4. Spacer Washer
5. Equalizing Beam Front Bushing
6. Locknut
7. Frame Rail
8. Rod Bolt, 3/4–10 x 7-1/2
9. Torque Rod Crossmember Bracket
10. Torque Rod
11. Control Rod Axle Bracket
12. Torque Rod Axle Bracket
13. Control Rod
14. Control Rod Frame Bracket
15. Axle Alignment Shim(s)
16. Shock Absorber Frame Bracket
17. Shock Absorber
18. Air Spring Upper Mounting Plate
19. Air Spring
20. Air Spring Lower Mounting Plate
21. Transverse Beam
22. Lockwasher
23. Hexnut, 1/2–13
24. Hexnut, 2-1/4–8
25. Tab Washer
26. Spacer Washer
27. Transverse Beam Bushing
28. Spacer Washer
29. Equalizing Beam
30. Equalizing Beam Center Bushing
31. Beam Hanger Bracket

**Fig. 1, Neway Suspension Components**

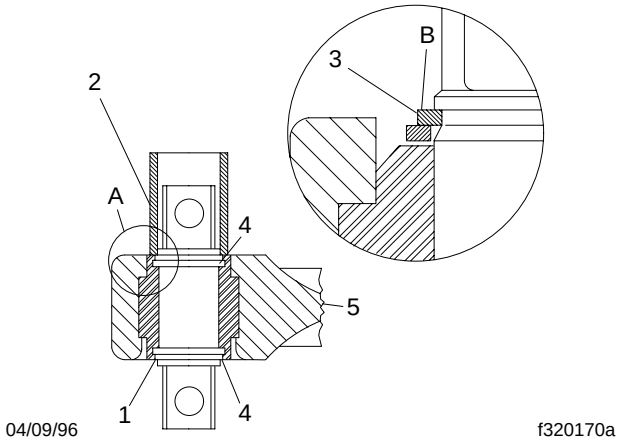
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## Replacement

NOTE: In order to replace the torque rod polyurethane bushings, you need special installation tool kit P-097-009. This tool kit can be purchased from Freightliner, or it can be machined, using the dimensions given in **Specifications, 400.**

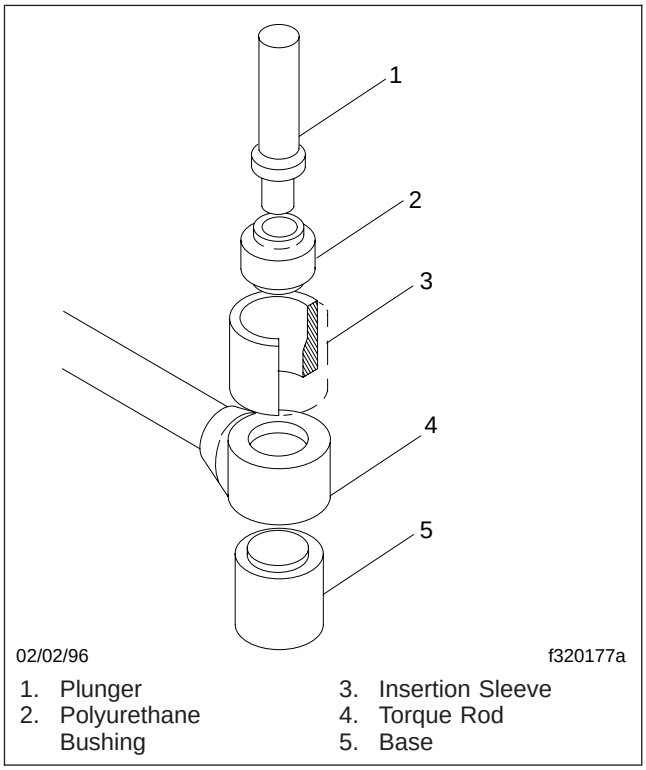
1. Remove the snap ring and washer from each side of the bushing to be removed. See **Fig. 1**. Note that the torque rod eye has a smaller shoulder on one side than on the other, and the larger shoulder has a rounded edge around the inside of the eye. The polyurethane bushing must be pressed in and out through the larger side.




A. Detail
B. Install washer and snap ring with sharp edges to outside.
1. Snap Ring
2. Pressing Sleeve
3. Snap Ring
4. Washer
5. Torque Rod

**Fig. 1, Bushing Snap Ring Installation**

2. Using the plunger from the special tool kit on a hydraulic press, press the old bushing out of the torque rod eye. Clean all dirt, grease, or foreign matter from the torque rod.
3. Coat the replacement bushing with a non-mineral lubricant, such as rubber lubricant or waterless hand cleaner. Position the bushing in the larger end of the insertion sleeve from the tool kit, then fit the beveled (smaller) end of the sleeve into the larger side of the torque rod eye.
4. Center the torque rod eye on the tool base, and insert the plunger tool into the polyurethane bushing. See **Fig. 2**. Press the bushing into the torque rod eye.




1. Plunger
2. Polyurethane Bushing
3. Insertion Sleeve
4. Torque Rod
5. Base

**Fig. 2, Torque Rod Bushing Installation**

5. Install the snap ring and flatwasher on one end of the torque rod pin, with the sharp edges of the washer and the snap ring facing the outward end of the pin. See **Fig. 1**.
6. Press the torque rod pin into the torque rod bushing from the same side as the bushing was pressed into the torque rod eye. Make sure the snap ring seats. Do not lubricate the torque rod pin.
7. Turn the torque rod over and install a flatwasher, with the sharp edge facing away from the bushing; then install the other snap ring onto the outer shoulder of the pin, with the sharp edge facing outward.

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## Torque Rod Bushing Replacement

8. Place a pressing sleeve over the end of the torque rod pin, then seat the snap ring. See **Fig. 1**.
9. After assembly, press the torque rod pin slightly to center it in the torque rod eye.

   There should be no slack on either side of the polyurethane bushing, and the bushing should be compressed by about half the thickness of the snap ring. If necessary, install a second washer under one of the snap rings to compress the bushing.

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# Equalizing Beam Removal and Installation

## Removal

1. Chock the front tires.
2. Raise the rear of the vehicle to remove all weight from the rear suspension, and place safety stands to secure the vehicle in its raised position.
3. Remove the rear wheels and tires for access to the suspension. Block the axle securely to prevent it from dropping away from the vehicle as the equalizing beam (**Fig. 1**) is removed.
4. With the weight removed from the suspension, the air springs should be fully deflated. If they aren't, disconnect the height control valve linkage from the height control valve control lever. Push the lever down to the vertical position to deflate the air springs.
5. Remove the capscrews and lockwashers that secure the air springs to the air spring lower mounting plates on both ends of the transverse beam. See **Fig. 1**.
6. Remove the cotter pins, locknuts, flatwashers, and retainer washers from the studs in the ends of the equalizing beams. Tap the transverse beam back from the ends of the equalizing beams.

NOTE: In some cases, the transverse beam bushings will stick, making it difficult to remove the transverse beam from the equalizing beams. Use a Porta-Power, or equivalent tool, between the axle housing and the transverse beam at a point as near to the end of the transverse beam as possible to remove the beam.

7. Remove the locknut and washer from the outboard end of the rod bolt. Support the equalizing beam on a floor jack, then extract the equalizing beam center bushing bolt from the beam hanger bracket.
8. Use a drift to tap the adaptor bushings from the beam hanger bracket. Lower the equalizing beam to the floor.
9. Remove the locknut from the inboard end of the bolt. Note the positions of the spacer washers at either side of the equalizing beam so they can be reassembled in their original positions. Use a drift to drive the rod bolt out of the frame bracket. Remove the equalizing beam from the vehicle.

## Installation

1. Make sure the adaptor bushings are installed in the frame bracket.
2. Position the equalizing beam with its front bushing centered in the frame bracket. Push the rod bolt into the frame bracket while inserting the spacer washers into their original positions between the equalizing beam and the frame bracket.

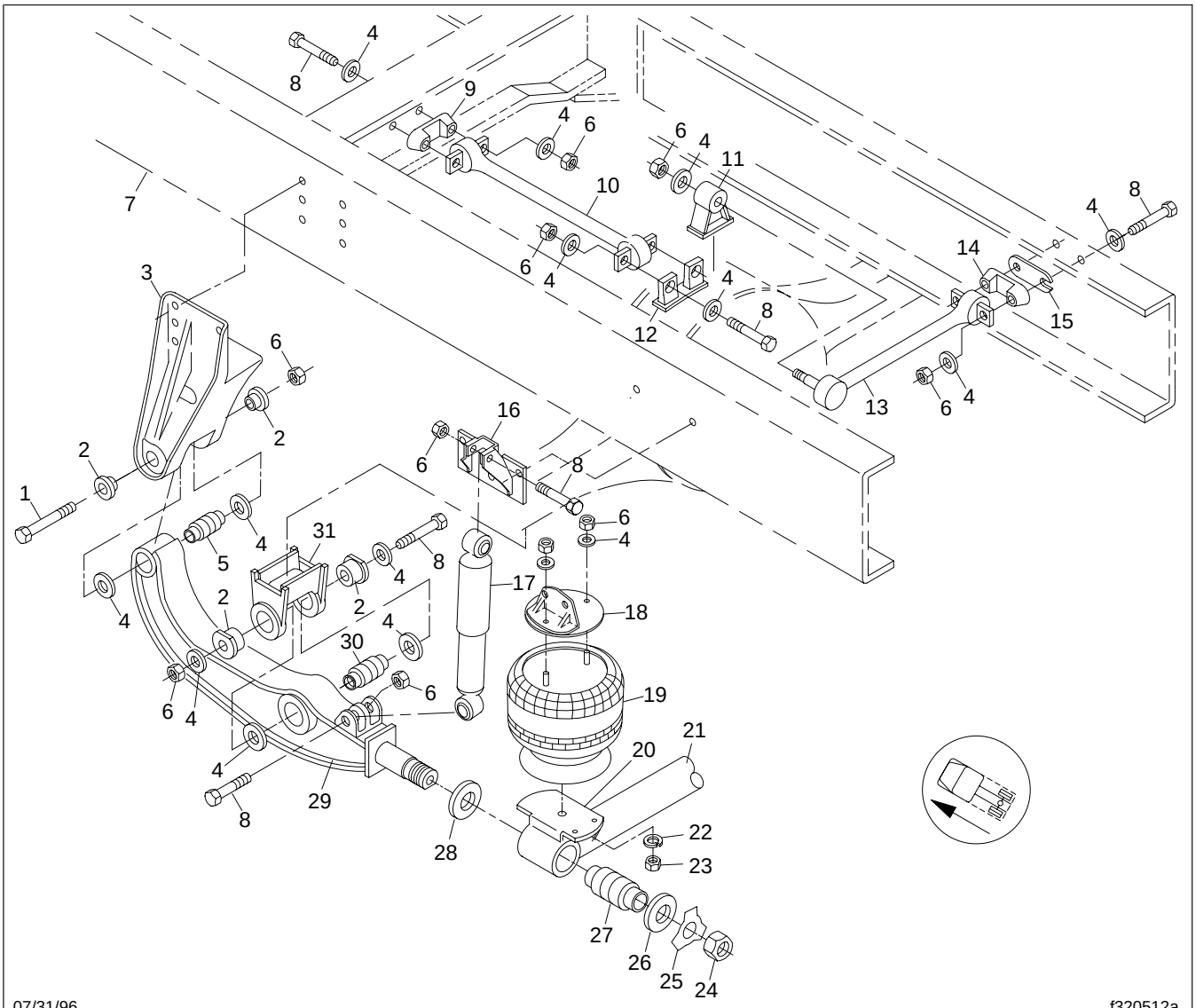
NOTE: See **Subject 190** for placement of the spacer washers if their positions were not recorded during removal of the equalizer beam.

3. Lubricate the threads of the rod bolt with SAE-20 oil, then install the locknut. Tighten the locknut to the torque under **Specifications 400**.
4. Raise the equalizing beam so the center bushing is centered in the beam hanger bracket. Insert the beam hanger adaptor bushings through the beam hanger bracket and into the equalizing beam center bushing.
5. With a flatwasher under the head,insert the rod bolt through the beam hanger adaptor bushings with the threaded end on the outboard side of the suspension.
6. Lubricate the center bushing bolt threads with SAE-20 oil, then install the flatwasher and locknut on the bolt. Tighten the locknut to the torque under **Specifications 400**.
7. Lubricate the transverse beam bushings with rubber lubricant,soap and water solution, or a waterless hand cleaner. Install the inner halves of the bushings with their thicker ends toward the front of the vehicle.
8. Install the transverse beam on the equalizing beams, with the air spring lower mounting plates tilted toward the rear of the vehicle.Install the outer halves of the transverse beam bushings on the equalizer beam journals.
9. Apply SAE-20 oil to the threads on the studs at the rear of the equalizing beams. Install the retainer washers, flatwashers and locknuts on the studs. Tighten the locknuts to the low end of the torque ranges under **Specifications 400**. Install the cotter pins and lock them in place. Tighten the locknuts further if it's necessary in order to install the cotter pins.

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## Equalizing Beam Removal and Installation




1. Rod Bolt, 1-1/8–7 x 9-1/4
2. Adaptor Bushing
3. Frame Bracket
4. Spacer Washer
5. Equalizing Beam Front Bushing
6. Locknut
7. Frame Rail
8. Rod Bolt, 3/4–10 x 7-1/2
9. Torque Rod Crossmember Bracket
10. Torque Rod
11. Control Rod Axle Bracket
12. Torque Rod Axle Bracket
13. Control Rod
14. Control Rod Frame Bracket
15. Axle Alignment Shim(s)
16. Shock Absorber Frame Bracket
17. Shock Absorber
18. Air Spring Upper Mounting Plate
19. Air Spring
20. Air Spring Lower Mounting Plate
21. Transverse Beam
22. Lockwasher
23. Hexnut, 1/2–13
24. Hexnut, 2-1/4–8
25. Tab Washer
26. Spacer Washer
27. Transverse Beam Bushing
28. Spacer Washer
29. Equalizing Beam
30. Equalizing Beam Center Bushing
31. Beam Hanger Bracket

**Fig. 1, Neway Suspension Components**

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10. Apply SAE-20 oil to the threads of the capscrews that secure the air springs to the air spring lower mounting plates. Position the air springs on the plates and install the capscrews and lockwashers. Tighten the capscrews to the torque under **Specifications 400**.

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## Replacement

1. Remove the equalizing beam. See **Subject 130**.

**⚠ WARNING**

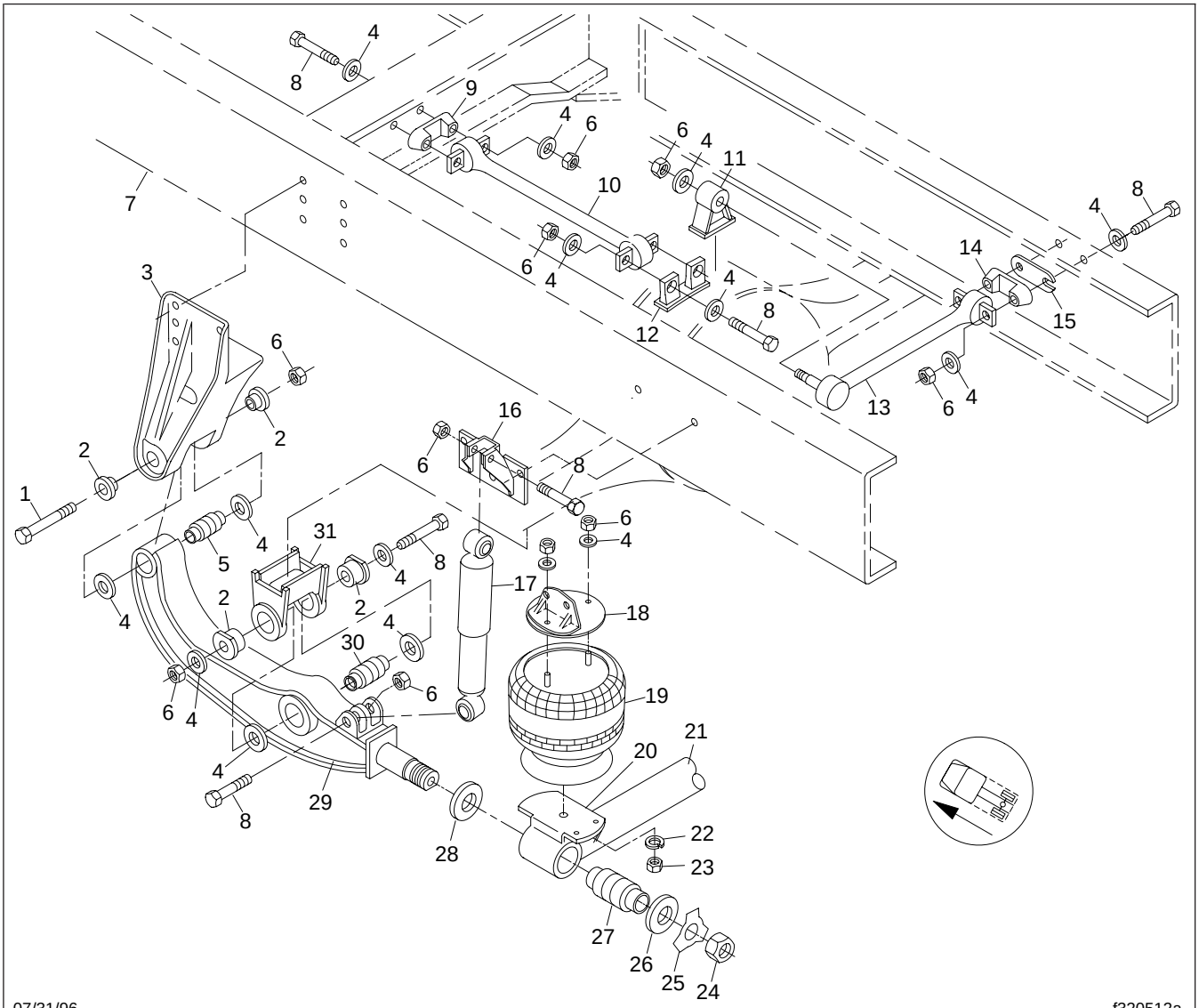
**Do not use a torch to cut the bushing sleeve out of the equalizing beam. To do so could weaken the casting, possibly resulting in loss of vehicle control and personal injury.**

2. Using a hydraulic press, apply 2000 to 3000 pounds (metric) pressure to remove the equalizing beam front and center bushings. See **Fig. 1**.
3. Using a wire brush and solvent, clean out the equalizing beam bushing receptacles. Inspect the entire beam for cracks or bends. Replace any damaged equalizing beam with a new one.
4. Lubricate the replacement bushings and the bushing receptacles with a non-mineral lubricant. If standard rubber lubricant is not available, use a soap and water solution or a waterless hand cleaner.
5. Press the replacement bushings into the bushing receptacles with a hydraulic press. Press the bushings slightly past center, then turn the equalizing beam over and press the bushings back to a centered position.
6. Install the equalizing beam. See **Subject 130**.

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## Equalizing Beam Bushing Replacement




1. Rod Bolt, 1-1/8–7 x 9-1/4
2. Adaptor Bushing
3. Frame Bracket
4. Spacer Washer
5. Equalizing Beam Front Bushing
6. Locknut
7. Frame Rail
8. Rod Bolt, 3/4–10 x 7-1/2
9. Torque Rod Crossmember Bracket
10. Torque Rod
11. Control Rod Axle Bracket
12. Torque Rod Axle Bracket
13. Control Rod
14. Control Rod Frame Bracket
15. Axle Alignment Shim(s)
16. Shock Absorber Frame Bracket
17. Shock Absorber
18. Air Spring Upper Mounting Plate
19. Air Spring
20. Air Spring Lower Mounting Plate
21. Transverse Beam
22. Lockwasher
23. Hexnut, 1/2–13
24. Hexnut, 2-1/4–8
25. Tab Washer
26. Spacer Washer
27. Transverse Beam Bushing
28. Spacer Washer
29. Equalizing Beam
30. Equalizing Beam Center Bushing
31. Beam Hanger Bracket

**Fig. 1, Neway Suspension Components**

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## Control Rod Removal, Inspection, and Installation

# Removal

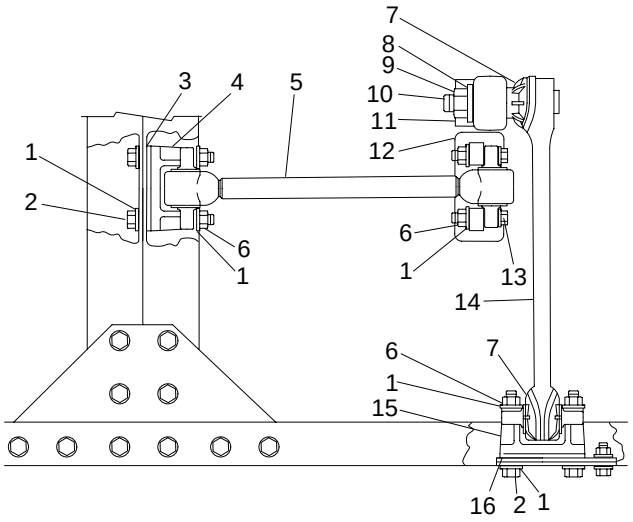
1. Apply the parking brakes.
2. Remove the locknuts and flatwashers (**Fig. 1**) from the bolts that secure the control rod frame bracket to the frame rail. To ease reassembly, note the order of the axle alignment shims between the control rod frame bracket and the backing plate.
3. Remove the control rod frame bracket bolts. Swing the control rod clear, and remove the axle alignment shims and the bracket.
4. Remove the locknut and flatwasher from the ball stud on the inboard end of the control rod. Rap the ball stud eye on the control rod axle bracket with a hammer to loosen the ball stud. If this fails to break it loose, use a tie-rod separator tool to remove the ball stud from the control rod axle bracket. Remove the control rod.
5. Remove the seals from both ends of the control rod. Clean the seals and rod to remove all dirt and grease.

# Inspection

Inspect the seals for dryness, cracks, or other signs of deterioration and wear. Replace damaged seals with new ones. Visually inspect the control rod for cracks or bends. Work the ball joint and control rod pin to check for looseness in the bushings. If the control rod is bent, cracked, or otherwise damaged, or if there is any slack in either of the bushings, replace the control rod with a new one.

# Installation

1. Lubricate all control rod and fastener threads with SAE-20 oil, and install the seals (**Fig. 1**) removed from the rod ends.
2. Insert the control rod ball stud through the control rod axle bracket, then install the flatwasher and locknut on the stud. Tighten the locknut to the torque under **Specifications, 400**, then rap the control rod axle mount with a hammer. Tighten the locknut again to the torque under **Specifications, 400**.




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1. Flatwasher, 5/8-inch
2. Bolt, 5/8-11 x 5-1/2 Inch
3. Axle Plane Shim(s)
4. Torque Rod Crossmember Bracket
5. Torque Rod
6. Locknut, 5/8-18
7. Seal
8. Flatwasher, 1-1/4 Inch
9. Locknut, 1-1/4-12
10. Ball Stud
11. Control Rod Axle Bracket
12. Torque Rod Axle Bracket
13. Bolt, 5/8-11 x 4 Inch
14. Control Rod
15. Control Rod Frame Bracket
16. Axle Alignment Shim(s)

**Fig. 1, Control Rod Mounting**

3. Position the control rod frame bracket and the axle alignment shims against the backing plate on the inside of the frame rail. Move the control rod into position on the control rod frame bracket.
4. Install flatwashers on the control rod frame bracket bolts, then install the bolts through the frame rail, the shims, the control rod frame bracket, and the control rod. Install the flatwashers and locknuts on the bolts, and tighten the locknuts to the torque under **Specifications, 400**.
5. Check the alignment of the axle. See **Subject 180** for instructions.

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## Torque Rod Removal, Inspection, and Installation

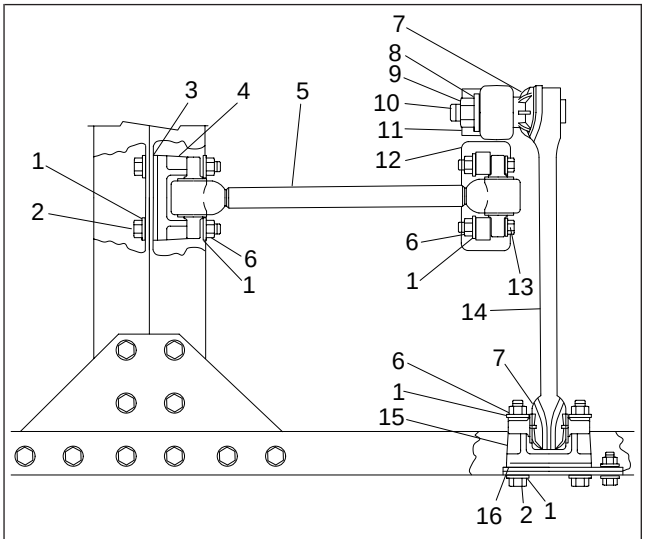
# Removal

1. Apply the parking brakes.

**⚠ WARNING**

**When the torque rods are disconnected from the axle brackets, the axles become free to pivot on the equalizer beam end bushings. Keep clear of the beam hangers and beam ends to avoid possible injury.**

2. Remove the locknuts and the flatwashers (**Fig. 1**) from the bolts that secure the torque rod crossmember bracket to the vehicle frame crossmember. For ease of installation, note the order of the axle plane shims between the torque rod crossmember bracket and the frame crossmember.




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1. Flatwasher, 5/8-inch
2. Bolt, 5/8–11 x 5-1/2 Inch
3. Axle Plane Shim(s)
4. Torque Rod Crossmember Bracket
5. Torque Rod
6. Locknut, 5/8–18
7. Seal
8. Flatwasher, 1-1/4 Inch
9. Locknut, 1-1/4–12
10. Ball Stud
11. Control Rod Axle Bracket
12. Torque Rod Axle Bracket
13. Bolt, 5/8–11 x 4 Inch
14. Control Rod
15. Control Rod Frame Bracket
16. Axle Alignment Shim(s)

**Fig. 1, Torque Rod Mounting**

3. Remove the torque rod crossmember bracket bolts. Swing the torque rod clear of the torque rod crossmember bracket, and remove the axle plane shims together with the torque rod crossmember bracket.
4. Remove the locknuts and flatwashers from the bolts that secure the torque rod to the torque rod axle bracket. Remove the bolts. Remove the torque rod from the vehicle.

# Inspection

Inspect the torque rod for bends or cracks. Work the torque rod pins to check for looseness in the polyurethane bushings. If the torque rod is bent, cracked, or otherwise damaged, replace it with a new one. If either of the polyurethane bushings is loose, replace the bushing with a new one. For instructions, see **Subject 170**.

# Installation

1. Lubricate all torque rod and fastener threads with SAE-20 oil.
2. Position the torque rod against the torque rod axle bracket (**Fig. 1**). Slip a flatwasher over each of the two bolts, then insert the bolts through the torque rod axle bracket and the torque rod.
3. Install the flatwashers and locknuts on the torque rod axle bracket bolts. Tighten the locknuts to the torque under **Specifications, 400**.
4. Position the torque rod crossmember bracket and the axle plane shims against the frame crossmember, and move the torque rod into place on the torque rod crossmember bracket.
5. Install flatwashers on the bolts, and install the bolts through the frame crossmember, the shims, the torque rod crossmember bracket, and the torque rod. Install flatwashers and locknuts on the bolts, and tighten the locknuts to the torque under **Specifications, 400**.

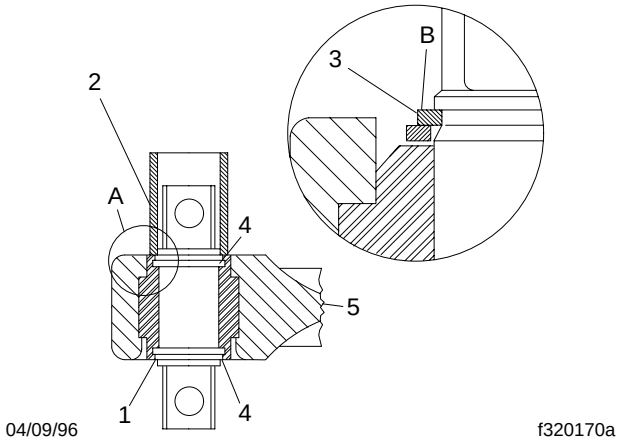
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## Replacement

NOTE: In order to replace the torque rod polyurethane bushings, you need special installation tool kit P-097-009. This tool kit can be purchased from Freightliner, or it can be machined, using the dimensions given in **Specifications, 400.**

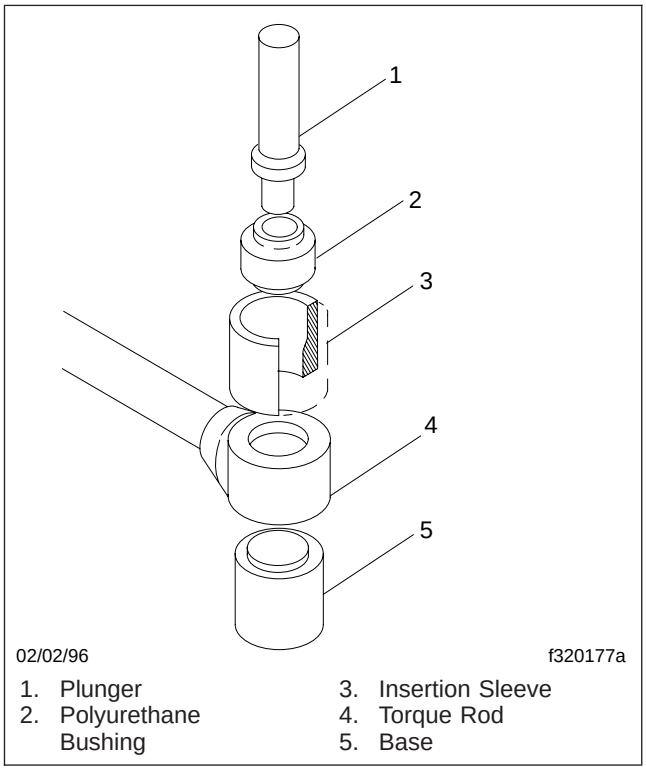
1. Remove the snap ring and washer from each side of the bushing to be removed. See **Fig. 1**. Note that the torque rod eye has a smaller shoulder on one side than on the other, and the larger shoulder has a rounded edge around the inside of the eye. The polyurethane bushing must be pressed in and out through the larger side.




A. Detail
B. Install washer and snap ring with sharp edges to outside.
1. Snap Ring
2. Pressing Sleeve
3. Snap Ring
4. Washer
5. Torque Rod

**Fig. 1, Bushing Snap Ring Installation**

2. Using the plunger from the special tool kit on a hydraulic press, press the old bushing out of the torque rod eye. Clean all dirt, grease, or foreign matter from the torque rod.
3. Coat the replacement bushing with a non-mineral lubricant, such as rubber lubricant or waterless hand cleaner. Position the bushing in the larger end of the insertion sleeve from the tool kit, then fit the beveled (smaller) end of the sleeve into the larger side of the torque rod eye.
4. Center the torque rod eye on the tool base, and insert the plunger tool into the polyurethane bushing. See **Fig. 2**. Press the bushing into the torque rod eye.




1. Plunger
2. Polyurethane Bushing
3. Insertion Sleeve
4. Torque Rod
5. Base

**Fig. 2, Torque Rod Bushing Installation**

5. Install the snap ring and flatwasher on one end of the torque rod pin, with the sharp edges of the washer and the snap ring facing the outward end of the pin. See **Fig. 1**.
6. Press the torque rod pin into the torque rod bushing from the same side as the bushing was pressed into the torque rod eye. Make sure the snap ring seats. Do not lubricate the torque rod pin.
7. Turn the torque rod over and install a flatwasher, with the sharp edge facing away from the bushing; then install the other snap ring onto the outer shoulder of the pin, with the sharp edge facing outward.

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## Torque Rod Bushing Replacement

8. Place a pressing sleeve over the end of the torque rod pin, then seat the snap ring. See **Fig. 1**.
9. After assembly, press the torque rod pin slightly to center it in the torque rod eye.

   There should be no slack on either side of the polyurethane bushing, and the bushing should be compressed by about half the thickness of the snap ring. If necessary, install a second washer under one of the snap rings to compress the bushing.

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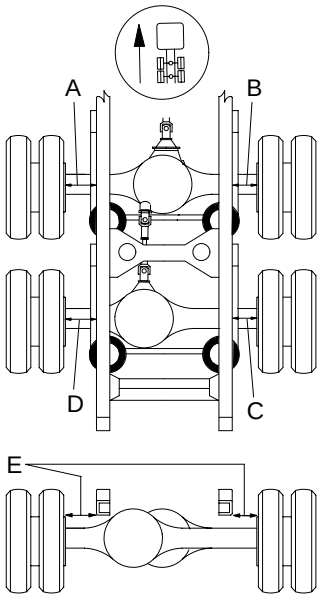
## Lateral Alignment

1. Park the vehicle on a level surface; then position the front tires straight ahead and chock them. Release the parking brakes, and place the transmission in neutral.
2. Raise the rear of the vehicle until the tires clear the ground, then place safety stands under the rear of the vehicle to hold it in this position.
3. Check the wheel bearing adjustment. For instructions see **Group 35** in this manual. Adjust or replace the wheel bearings as needed.
4. Measure the lateral runout of the rear wheels. If the runout on any wheel exceeds 0.18 inch (4.6 mm), replace the wheel before proceeding with the axle alignment check.
5. Remove the safety stands and lower the rear of the vehicle. Relieve any internal stresses in the suspension by jacking the axles up and letting them down; or, remove the tire chocks, then move the vehicle back and forth (with the interaxle differential disengaged).
6. On either rear axle, measure the distance between the left frame rail and the nearest point on the inside wheel rim. See **Fig. 1**, Dimension A.
7. On the same axle, measure the distance between the right frame rail and the nearest point on the inside wheel rim (**Fig. 1**, Dimension B).
8. Compare Dimension A with Dimension B. If they're within 1/8 inch (3.25 mm) of being equal, alignment is not necessary. However, if they're different by more than 1/8 inch (3.25 mm), adjust the lateral alignment.

   8.1 Loosen the locknuts on the bolts that secure the lateral rod mount to the frame rail.

   8.2 Add or remove one axle alignment shim for each 1/8 inch (3.25 mm) difference between Dimensions A and B. Adding shims will decrease the measurement on the side of the vehicle to which the lateral rod is attached, and removing shims will increase the measurement.

   8.3 After installing the shims, lubricate the threads on the lateral rod mount bolts with engine oil; tighten the locknuts to the torque under **Specifications 400**.




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NOTE: Dimension A equals Dimension B plus or minus 1/8-inch (3.25 mm)

A. Dimension A (forward rear axle)
B. Dimension B (forward rear axle)
C. Dimension C (rearmost axle)
D. Dimension D (rearmost axle)
E. Measure Here

**Fig. 1, Rear Axle Lateral Alignment**

9. On tandem axle installations, do the previous three steps on the other axle.
10. On suspensions equipped with an axle alignment feature (alignment bushings welded to slotted frame brackets), proceed to **Subject 190**.

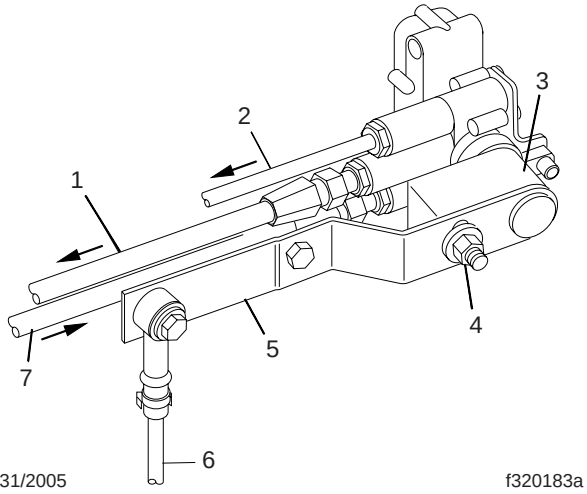
    On suspensions not equipped with an axle alignment feature, no further checking is required. Apply the parking brakes; then remove the chocks from the tires.

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## Parallel Alignment

1. Check and, if needed, adjust the lateral alignment of the rear axle(s) before checking parallel alignment. See **Subject 180** for instructions.
2. Check the axles for parallel alignment. See **Group 35** for instructions.
3. Adjust the rear axle, if necessary.
   - 3.1 Using jack stands, support the vehicle frame at normal ride height. Disconnect both height control valve linkages from their respective control levers. See **Fig. 1**. Then exhaust all air from all air springs by pushing the valve control levers down.
   - 3.2 Remove the equalizing beam pivot connection locknut and bolt, and both spacer washers. See **Fig. 2**. Lower the equalizing beam from the frame bracket.
   - 3.3 Cut the welds off of the alignment bushings on both sides of the frame bracket. Remove the alignment bushings; then grind any remaining weld material off of the frame bracket and alignment bushings.




1. Airflow to Spring
2. Exhaust to Atmosphere
3. Nylon Block
4. Adjustment Locknut
5. Control Lever
6. Linkage
7. Airflow from Air Reservoir

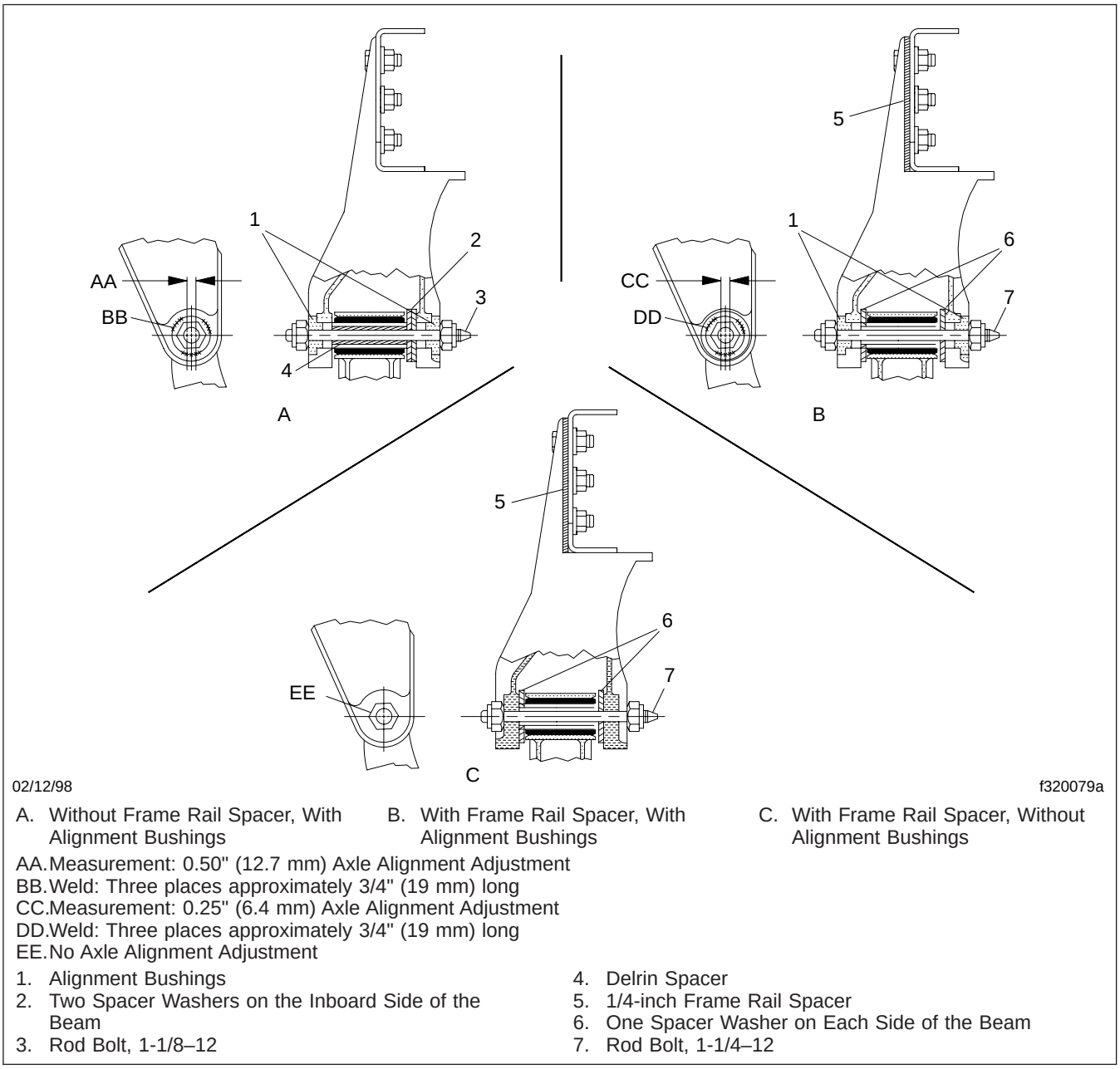
**Fig. 1, Height Control Valve**

   - 3.4 Position the alignment bushings in the frame bracket; then raise the equalizing beam until the front eye is aligned with the frame bracket. Install the spacer washers and pivot connection bolt and locknut. Position the spacer washers. See **Fig. 2**. Suspension installations which have a 1/4-inch (6-mm) frame-rail spacer between the forward frame-rail bracket and the frame rail will require one spacer washer on each side of the equalizing beam. Installations without a frame-rail spacer require two spacer washers on the inboard side of the equalizing beam.
   - 3.5 Move the axle forward or backward by rolling the wheels on that side of the vehicle (only that side), until the correct axle alignment is obtained.
   - 3.6 With the axle aligned and the vehicle frame supported at normal ride height, torque the equalizing beam front bushing locknut to the torque under **Specifications, 400**.
   - 3.7 Weld both of the alignment bushings to the frame bracket, using AWS spec E7018 welding rod or Linde 3/32 FC 72 wire weld, or an equivalent. Weld (1/4-inch fillet) each bushing with three, 3/4-inch (19-mm) long welds. See **Fig. 2**.
4. Connect the linkages to their respective control levers.
5. Apply the parking brakes; then remove the jack stands from the frame and the chocks from the tires.

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## Rear Axle Parallel Alignment




A. Without Frame Rail Spacer, With Alignment Bushings
B. With Frame Rail Spacer, With Alignment Bushings
C. With Frame Rail Spacer, Without Alignment Bushings

AA. Measurement: 0.50" (12.7 mm) Axle Alignment Adjustment
BB. Weld: Three places approximately 3/4" (19 mm) long
CC. Measurement: 0.25" (6.4 mm) Axle Alignment Adjustment
DD. Weld: Three places approximately 3/4" (19 mm) long
EE. No Axle Alignment Adjustment

1. Alignment Bushings
2. Two Spacer Washers on the Inboard Side of the Beam
3. Rod Bolt, 1-1/8–12
4. Delrin Spacer
5. 1/4-inch Frame Rail Spacer
6. One Spacer Washer on Each Side of the Beam
7. Rod Bolt, 1-1/4–12

**Fig. 2, Spacer Washer Installation and Alignment Bushing Welding**

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# Troubleshooting Tables

**Problem—Air Springs Are Flat**

| Problem—Air Springs Are Flat | |
|---|---|
| **Possible Cause** | **Remedy** |
| Low air pressure in the vehicle brake system. | Check the air pressure gauge on the instrument panel. If the air pressure is low, run the engine until a minimum pressure of 70 psi (483 kPa) is shown on the gauge. |
| Air leaking from the suspension air system or the air brake system. | Listen for leakage due to loose fittings or damaged air lines, air springs, brake actuators or control valves. Tighten loose fittings or replace work or damaged air lines with new ones. |

**Problem—Air Spring(s) Flat on One Side of the Vehicle**

| Problem—Air Spring(s) Flat on One Side of the Vehicle | |
|---|---|
| **Possible Cause** | **Remedy** |
| Air leakage between the pressure holding valve and the air spring(s). | Listen for leakage due to loose fittings or damaged air lines. Tighten loose fittings or replace damaged lines with new ones. |
| Air spring leaking. | Inspect the air spring for leaks caused by damage, wear, or deterioration. If any air spring is leaking, install a new one. |
| Bent, broken, or disconnected height control valve linkage. | Inspect the linkage for damaged or loose parts. Reconnect loose linkage parts or replace damaged parts with new ones. |
| Height control valve out of adjustment. | Disconnect the height control valve linkage from the height control valve control lever. Move the lever upward. If the air spring then inflates, adjust the height control valve. |
| Inoperative height control valve. | If movement of the control lever in the previous step fails to inflate the air spring, the height control valve is damaged. Replace the valve. |

**Problem—Tractor Leans Due to Unequal Inflation of the Air Springs**

| Problem—Tractor Leans Due to Unequal Inflation of the Air Springs | |
|---|---|
| **Possible Cause** | **Remedy** |
| Damaged height control valve linkage. | Inspect the height control valves and linkages for damage. Repair or replace damaged parts. |
| Loose or missing height control valve bolts or adjustment locknut. | Inspect for damage to the height control valve mounting bolts or adjustment locknut. Replace any missing bolts or nuts, then adjust the height control valve. |
| Height control valve out of adjustment. | Adjust the height control valve. |

**Problem—Air Springs Deflate Rapidly When the Vehicle Is Parked**

| Problem—Air Springs Deflate Rapidly When the Vehicle Is Parked | |
|---|---|
| **Possible Cause** | **Remedy** |
| Air leakage from the suspension air system. | Listen for leakage due to loose fittings or damaged air lines, air springs, or height control valves. Tighten loose fittings and replace worn or damaged parts with new ones. |

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## Troubleshooting

**Problem—Tractor Rides Too High or Too Low**

| Problem—Tractor Rides Too High or Too Low | |
|---|---|
| **Possible Cause** | **Remedy** |
| Height control valve out of adjustment. | Disconnect the height control valve linkage from the height control valve control lever. Move the lever upward. If the air spring then inflates, adjust the height control valve. |

**Problem—Air Spring Blown Out**

| Problem—Air Spring Blown Out | |
|---|---|
| **Possible Cause** | **Remedy** |
| Air spring cut or punctured | Locate large leaks by listening for escaping air, and locate small leaks by applying a soap and water solution to the suspected air spring and watching for bubbles. Temporarily repair punctures or cuts less than 1/8-inch (3-mm) long by applying hot patches on both sides of the hole. If the cut is more than 1/8-inch (3-mm) long, install a new air spring. |
| Tires, rims, or chains rubbing the air spring. | Check the clearance between the air spring and the tire. If the tire, rim, or chains contact the inflated air spring, change to narrower tires and rims to provide clearance for tires with chains. |
| Air brake actuator rubbing against the air spring. | Relocate the brake actuator with factory approved parts to provide adequate clearance. |

**Problem—Air Spring Deflated Due to Fatigue**

| Problem—Air Spring Deflated Due to Fatigue | |
|---|---|
| **Possible Cause** | **Remedy** |
| Driving the vehicle too long or too fast with the air springs deflated. | If the vehicle must be driven with the air springs deflated, maintain a speed of less than 30 mph (48 km/h), and drive only as far as the nearest repair facility. |
| Continual or repeated overextension of the air springs. | Inspect for broken or loose shock absorbers or shock absorber mounting brackets. Reconnect loose parts and replace any damaged parts. Check the adjustment on the height control valve. |

**Problem—Air Spring Doesn't Fully Deflate When All Weight Is Removed from the Suspension**

| Problem—Air Spring Doesn't Fully Deflate When All Weight Is Removed from the Suspension | |
|---|---|
| **Possible Cause** | **Remedy** |
| Restricted air line between the height control valve and the air spring. | Disconnect the height control valve linkage, and push the control lever down. If the air spring remains inflated, check for a pinched or blocked line. Clean out any plugged line and replace any damaged line. |

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## Specifications

| Description | Size | Torque: lbf·ft (N·m) |
|---|---|---|
| Shock Absorber Mount Locknut | 3/4–16 | 110–150 (149–203) |
| Air Spring Upper Mounting Plate Locknut | 3/4–16 | 31–42 (42–57) |
| Air Spring Upper Mounting Plate Capscrew | 1/2–13 | 31–42 (42–57) |
| Air Spring Lower Mounting Plate Capscrew | 1/2–13 | 31–42 (42–57) |
| Transverse Beam Bushing Locknuts | 1-1/4–12 | 600–700 (814–950) |
| Equalizing Beam Center Bushing Locknut | 3/4–16 | 150–200 (203–271) |
| Equalizing Beam Front Bushing Locknut | 1-1/8–12 | 600–700 (814–950) |
| | 1-1/4–12 | |
| Control Rod Ball Stud Locknut | 1-1/8–12 | 550–650 (746–880) |
| Control and Torque Rod Mounting Locknuts | 5/8–18 | 110–150 (149–203) |

**Table 1, Suspension Torque Specifications (lubricated threads)**

See **Fig. 1** and **Table 2** for the bushing installation tool.

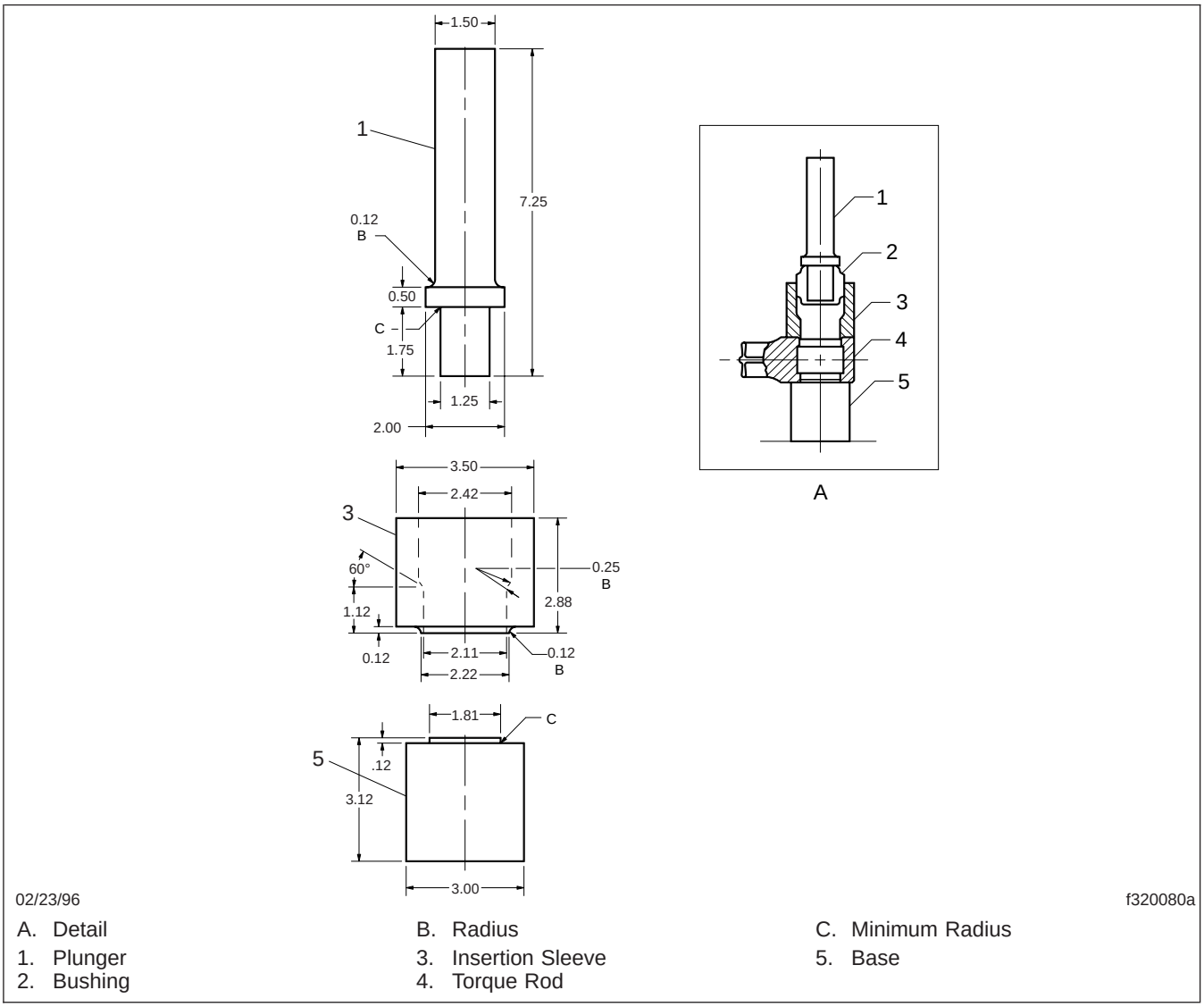
| Tool | Dimensions | Material |
|---|---|---|
| A | Bar, 2.00" Diameter (51 mm) | Mild Steel |
| B | Tube, 3.50" (89 mm) o.d. x 0.75" (19 mm) Wall | Mild Steel |
| C | Bar, 3.00" Diameter (76 mm) | Mild Steel |

**Table 2, Bushing Installation Tool Materials**

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## Specifications




A. Detail
1. Plunger
2. Bushing
B. Radius
3. Insertion Sleeve
4. Torque Rod
C. Minimum Radius
5. Base

**Fig. 1, Bushing Installation Tool**

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## General Information

The Chalmers 800 Series rear suspension is a walking beam-type tandem axle suspension that uses hollow rubber springs instead of leaf springs or air bags. Each hollow rubber spring is mounted between a frame-rail plate and the center (front-to-rear) of the steel walking beam. A sawhorse bracket assembly is attached to the frame and provides mounting points for the lower torque rods that tie the axles to the frame. The upper torque rods are fastened to brackets that bolt to the frame side rails and to tower assemblies that are welded to the top of the differential housings. See **Fig. 1**.

The 800 Series rear suspension allows a high degree of both parallel and diagonal articulation, while maintaining wheel load equalization to within 3 percent.

The Chalmers suspension design separates the rear suspension's responsibility for supporting/cushioning the load from that of locating/guiding the axles. The suspension is very light, relative to its load carrying capacity, but requires very little maintenance. In fact, there are no lubrication fittings since grease and oil are never needed.

The 800 Series rear suspension is available in three different maximum load capacities: 40,000 lb. (18 000 kg), 46,000 lb. (21 000 kg), and 50,000 lb. (23 000 kg). The 40,000 lb. version is easily distinguished from the other two versions since the upper torque rods do not cross over one another on the 40,000 lb. version.

The 800 Series is also available in three different axle spacings: 54-inch, 60-inch, and 72-inch axle-to-axle. The axle-to-axle spacing dimension is often included as part of the suspension name, e.g. "Chalmers 854 Rear Suspension" or "Chalmers 860 Suspension."

Shock absorbers are optional on all versions of the suspension, and available in two styles: beam-mounted and axle housing-mounted.

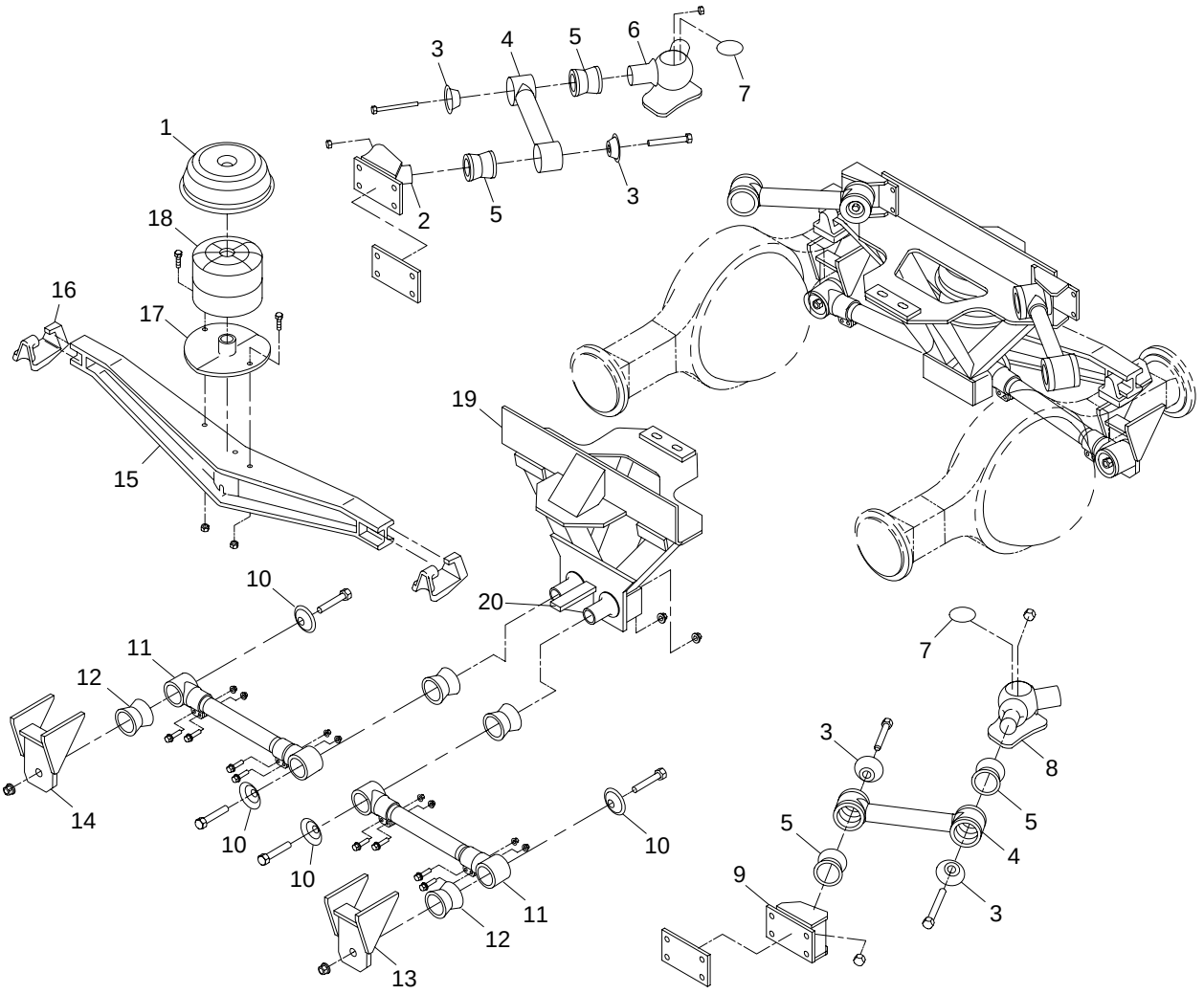
Other variations depend on whether the suspension is installed on a truck (high-mount) or a tractor (low-mount) and whether high center-of-gravity or low center-of-gravity is desired.

The rear suspension may be precision-aligned by adjusting the length of the lower torque rods. These rods have both left- and right-hand threads cut on the same tube so rotating the tube changes the effective length of the tube.

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## General Information




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1. Restrictor Can
2. Upper Torque Rod Frame Bracket (LH forward)
3. Spigot Cap (upper)
4. Upper Torque Rod
5. Torque Rod Bushing (upper)
6. Forward Rear Axle Tower
7. Rear Axle Tower Plug
8. Rearmost Rear Axle Tower
9. Upper Torque Rod Frame Bracket (LH rear)
10. Spigot Cap (lower)
11. Lower Torque Rod (adjustable)
12. Torque Rod Bushing (lower)
13. Lower Torque Rod Axle Housing Bracket (LH rear)
14. Lower Torque Rod Axle Housing Bracket (LH forward)
15. Beam
16. Axle Housing Beam Saddle Bracket
17. Beam Spring Plate
18. Hollow Rubber Spring
19. Sawhorse Bracket Assembly
20. Beam Stop

**Fig. 1, Chalmers 800 Series Tandem Axle Suspension (40,000-pound capacity without shock absorbers shown)**

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# Restrictor Can Removal, Inspection, and Installation

## Removal

1. If necessary, power wash the spring restrictor can area to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Raise the rear of the vehicle just enough to remove all weight from the rear axles, and place safety stands under the frame to support the vehicle in its raised position.
4. Remove the two bolts and nuts that secure the walking beam spring plate (**Fig. 1**) to the walking beam assembly. Discard the fasteners.

NOTE: On 54-inch spread suspensions, it may be necessary to remove either the front or rear tires to allow spring assembly removal.

5. Pull the lower spring plate, rubber spring, and restrictor can as one assembly outward, off the beam assembly. See **Fig. 1**.
6. Separate the restrictor can, spring, and spring plate.

## Inspection

1. Carefully inspect the restrictor can for cracks or severe corrosion. Pay special attention to the top surface of the can and the can rim. See **Fig. 2**.

NOTE: It is recommended that both restrictor cans be replaced at the same time to ensure evenness of ride and handling characteristics.

2. Replace a cracked or severely corroded restrictor can.

## Installation

1. Using a stiff wire brush or gasket scraper, clean rust and road dirt from the spring plate. Also, make sure that the center vent holes in the plate and in the walking beam are free of rust and debris. See **Fig. 3**.
2. Inspect the spring plate for cracks; replace it if any are present.

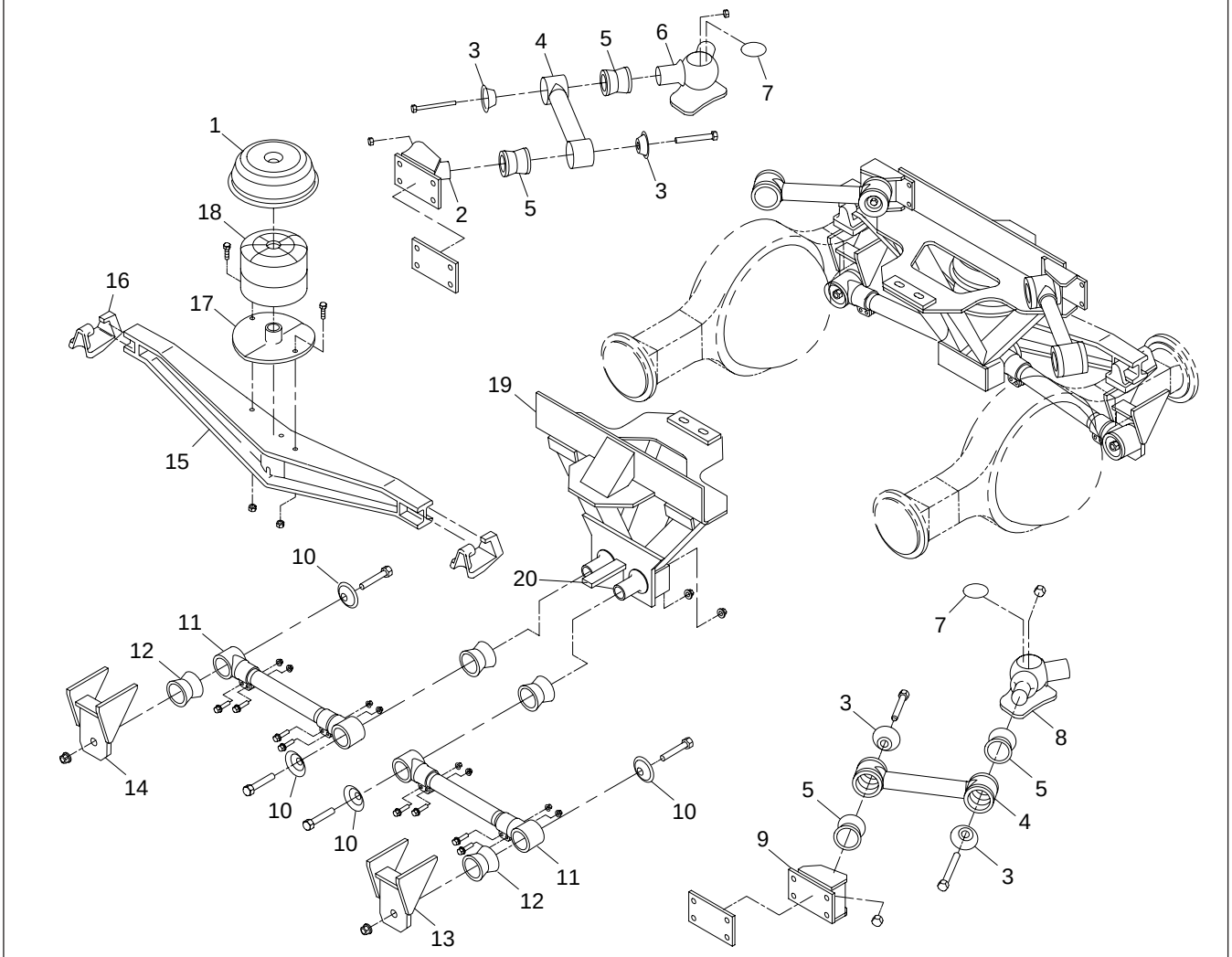
IMPORTANT: Never use any mineral based oils, greases, jellies, or solvent soaps to aid in the assembly of rubber suspension parts. Use only lubricants specifically designed for use with rubber compounds.

3. Position the rubber spring on the spring plate so it is upside down, relative to its original orientation. Make sure that the spring vent hole is centered on the spring plate tube. Place the new restrictor can over the spring; make sure the can is centered on the spring.
4. Slide, as one assembly, the spring plate, spring, and restrictor cap, into position on the walking beam.
5. Install and tighten the spring plate fasteners 35 lbf·ft (47 N·m).
6. Check the gap between the spring and the restrictor can to make sure it is even, all the way around the can. Rotate the spring and/or can as necessary to make the gap even.
7. Remove the safety stands from under the vehicle, then lower the vehicle.
8. Remove the chocks from the tires.

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## Restrictor Can Removal, Inspection, and Installation



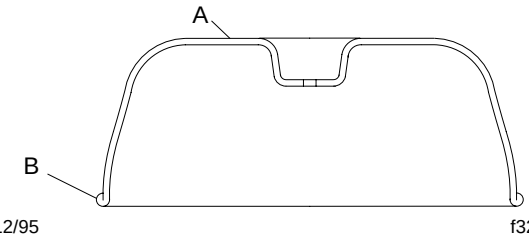

1. Restrictor Can
2. Upper Torque Rod Frame Bracket (LH forward)
3. Spigot Cap (upper)
4. Upper Torque Rod
5. Torque Rod Bushing (upper)
6. Forward Rear Axle Tower
7. Rear Axle Tower Plug
8. Rearmost Rear Axle Tower
9. Upper Torque Rod Frame Bracket (LH rear)
10. Spigot Cap (lower)
11. Lower Torque Rod (adjustable)
12. Torque Rod Bushing (lower)
13. Lower Torque Rod Axle Housing Bracket (LH rear)
14. Lower Torque Rod Axle Housing Bracket (LH forward)
15. Beam
16. Axle Housing Beam Saddle Bracket
17. Beam Spring Plate
18. Hollow Rubber Spring
19. Sawhorse Bracket Assembly
20. Beam Stop

**Fig. 1, Chalmers 800 Series Tandem Axle Suspension (40,000-pound capacity without shock absorbers shown)**

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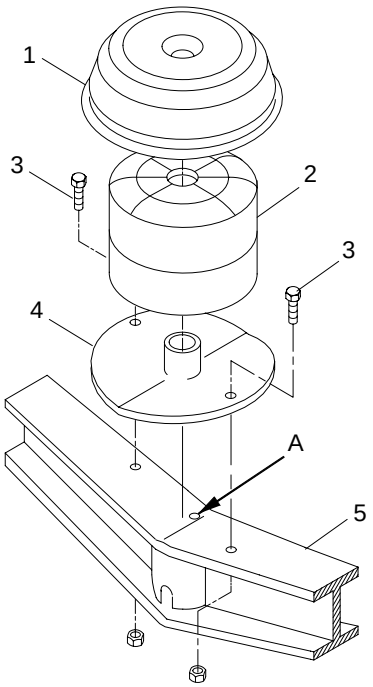


## Restrictor Can Removal, Inspection, and Installation




A. Inspect top surface for cracks or severe corrosion.
B. Carefully inspect can rim for cracks.

**Fig. 2, Restrictor Can Inspection Areas**




A. Make sure that the vent hole in the walking beam is free of rust and debris.

1. Spring Restrictor Can
2. Hollow Rubber Spring
3. Spring Plate Bolt
4. Spring Plate
5. Walking Beam

**Fig. 3, Spring Assembly Components**

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## Replacement

1. If necessary, power wash the spring restrictor can area to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Raise the rear of the vehicle just enough to remove all weight from the rear axles, and place safety stands under the frame to support the vehicle in its raised position.
4. Remove the two bolts and nuts that secure the walking beam spring plate (see **Fig. 1**) to the walking beam assembly. Discard the fasteners.

NOTE: On 54-inch spread suspensions, it may be necessary to remove either the front or rear tires to allow spring assembly removal.

5. Pull the lower spring plate, rubber spring, and restrictor can as one assembly outward, off the beam assembly. See **Fig. 1**.
6. Separate the restrictor can, spring, and spring plate; discard the spring.
7. Using a stiff wire brush or gasket scraper, clean rust and road dirt from the spring plate. Also, make sure that the center vent holes in the plate and in the walking beam are free of rust and debris. See **Fig. 2**.
8. Inspect the spring plate for cracks; replace it if any are present.

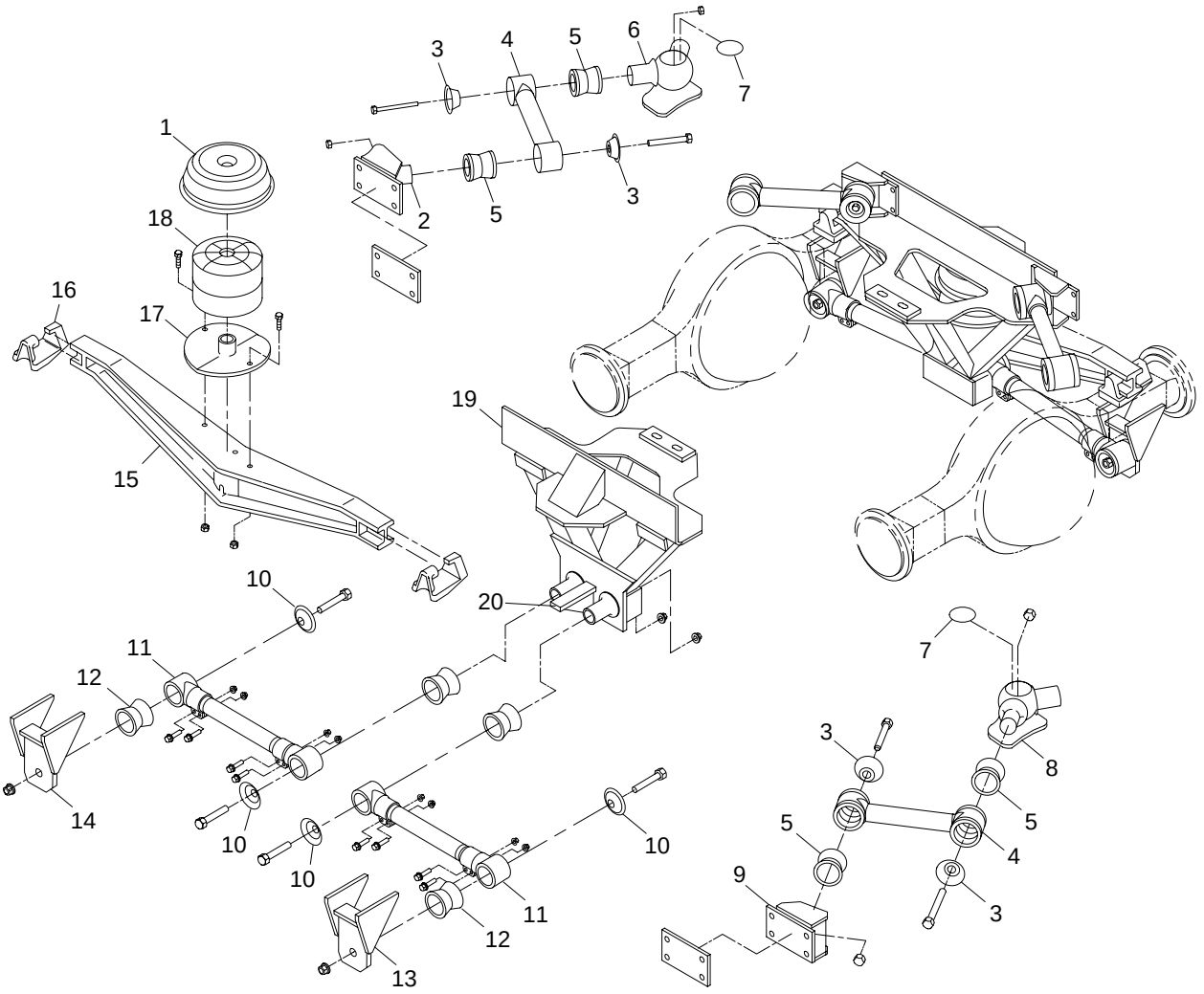
IMPORTANT: Never use any mineral based oils, greases, jellies, or solvent soaps to aid in the assembly of rubber suspension parts. Use only lubricants specifically designed for use with rubber compounds.

9. Position the new rubber spring on the spring plate, making sure that the vent hole is centered on the spring plate tube. Place the restrictor can over the spring; make sure the can is centered on the spring.
10. Slide, as one assembly, the spring plate, spring, and restrictor cap, into position on the walking beam.
11. Install and tighten the spring plate fasteners 35 lbf·ft (47 N·m).
12. Remove the safety stands from under the vehicle, then lower the vehicle.
13. Remove the chocks from the tires.

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## Rubber Spring Replacement



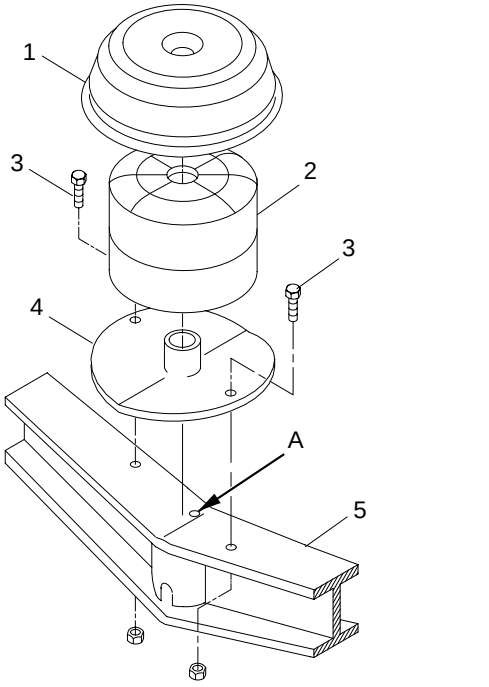

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1. Restrictor Can
2. Upper Torque Rod Frame Bracket (LH forward)
3. Spigot Cap (upper)
4. Upper Torque Rod
5. Torque Rod Bushing (upper)
6. Forward Rear Axle Tower
7. Rear Axle Tower Plug
8. Rearmost Rear Axle Tower
9. Upper Torque Rod Frame Bracket (LH rear)
10. Spigot Cap (lower)
11. Lower Torque Rod (adjustable)
12. Torque Rod Bushing (lower)
13. Lower Torque Rod Axle Housing Bracket (LH rear)
14. Lower Torque Rod Axle Housing Bracket (LH forward)
15. Beam
16. Axle Housing Beam Saddle Bracket
17. Beam Spring Plate
18. Hollow Rubber Spring
19. Sawhorse Bracket Assembly
20. Beam Stop

**Fig. 1, Chalmers 800 Series Tandem Axle Suspension (40,000-pound capacity without shock absorbers shown)**

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10/12/95 f320437

A. Make sure that the vent hole in the walking beam is free of rust and debris.

1. Spring Restrictor Can
2. Hollow Rubber Spring
3. Spring Plate Bolt
4. Spring Plate
5. Walking Beam

**Fig. 2, Spring Assembly Components**

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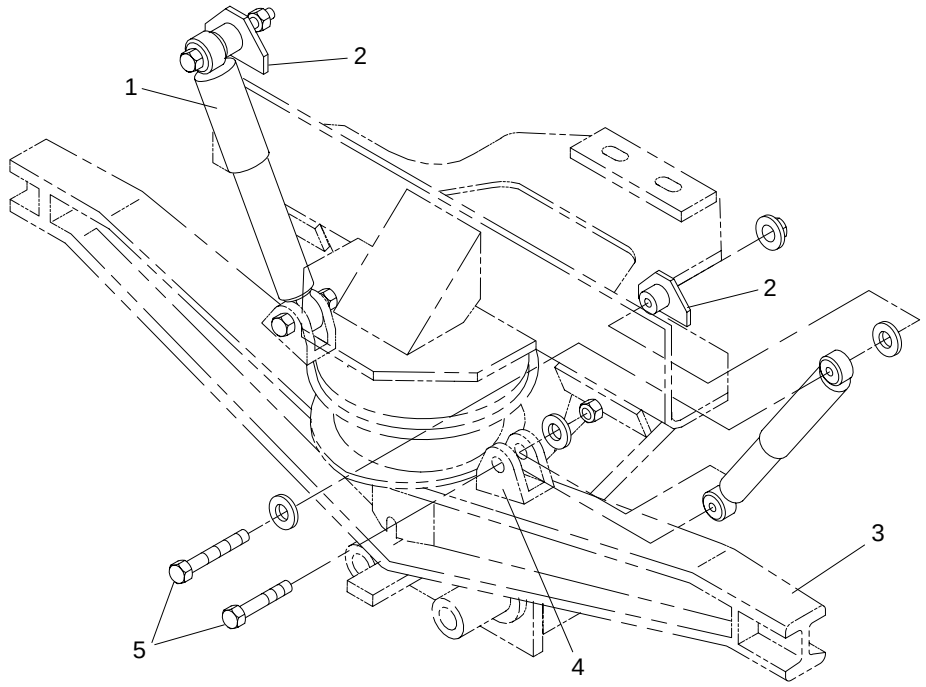


## Replacement

The Chalmers 800 Series Suspension may be fitted with either beam-mounted or axle-mounted shock absorbers. See **Fig. 1** and **Fig. 2**. The replacement procedure is essentially the same for both types of shock absorber.

1. If necessary, power wash the rear suspension to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Remove the shock absorber mounting fasteners.
   - 3.1 On beam-mounted shocks, remove the upper and lower bolts. See **Fig. 1**. Discard the fasteners.
   - 3.2 On axle-mounted shocks, remove the upper and lower locknuts and hardened washers. See **Fig. 2**. Discard the fasteners.
4. Remove and discard the shock absorber.
5. On axle-mounted shock absorber installations, the compression sleeve (see **Fig. 2**) may be rusted to the shock mounting pin and remain on the pin when the shock is removed. If this occurs, drive the sleeve off of the pin using a small, sharp chisel.
6. On axle-mounted shock absorber installations, clean the shock mounting pin threads using a stiff wire brush or, if necessary, a thread-chaser die.

   Lubricate the threads with a small amount of engine oil.
7. Install the new shock absorbers.
   - 7.1 On beam-mounted shock absorber installations, extend or compress the shock absorber as necessary to install the mounting bolts. Install the locknuts and tighten the fasteners 170 lbf·ft (230 N·m).




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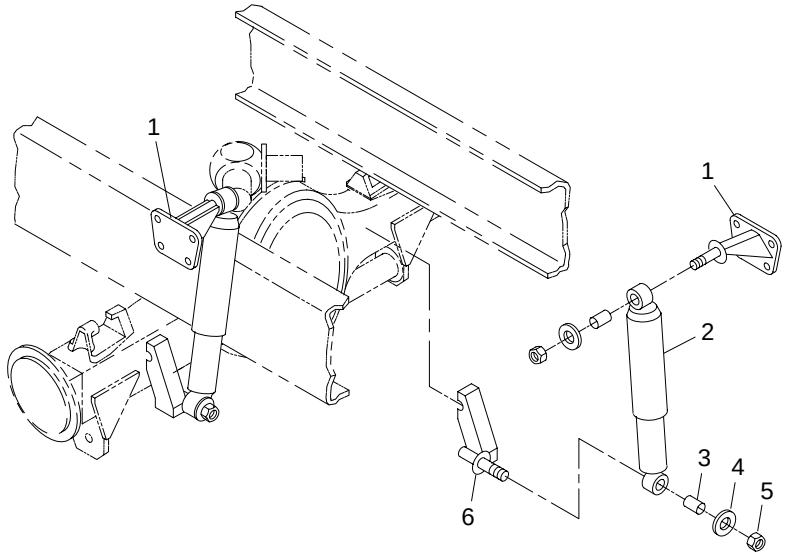
1. Shock Absorber
2. Frame-Mounted Bracket
3. Walking Beam
4. Beam-Mounted Bracket
5. 3/4" Mounting Bolts

**Fig. 1, Shock Absorbers, Beam-Mounted**

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## Shock Absorber Replacement




11/07/95 f320440

1. Frame-Mounted Bracket
2. Shock Absorber
3. Compression Sleeve
4. Hardened Washer
5. 7/8" Mounting Locknut
6. Axle-Mounted Bracket

**Fig. 2, Shock Absorbers, Axle-Mounted**

7.2 On axle-mounted shock absorber installations, extend or compress the shock absorber as necessary to fit it on the mounting pins. Install the locknuts and tighten them 270 lbf·ft (366 N·m).

8. Remove the chocks from the tires.

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# Walking Beam Removal, Inspection, and Installation

## Removal

1. If necessary, power wash the walking beams and axle housing ends to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Relieve all drive axle brake or wind-up loads by placing the transmission in neutral and releasing the spring or driveline brakes.
4. Raise the rear of the vehicle to remove all weight from the rear axles, and place safety stands under the frame to secure the vehicle in its raised position.
5. If equipped, disconnect beam-mounted shock absorbers from the walking beam being replaced. See **Subject 120**, if necessary.
6. Remove the two bolts and nuts that secure the walking beam spring plate (see **Fig. 1**) to the walking beam assembly. Discard the fasteners.

NOTE: On 54-inch spread suspensions, it may be necessary to remove the front or rear tires to allow spring assembly removal.

7. Pull the lower spring plate, rubber spring, and restrictor can as one assembly outward, off the beam assembly. See **Fig. 1**.

NOTE: Tag or otherwise mark each torque rod to ensure that it can be re-installed in the same position and orientation.

8. Disconnect the rearmost axle's upper torque rods from the rear axle tower and the lower torque rods from the rear axle housing brackets. See **Fig. 1**.
9. Roll the rear axle rearward just enough to disengage the axle saddles from the walking beam ends.
10. Lift up the free end of the walking beam and slide the beam rearward to disengage it from the front axle saddle; remove the walking beam.

## Inspection

1. Inspect the beam ends carefully, looking for cracks. Cracks along weld lines may be repairable, while cracks in or across the beam flanges require walking beam replacement. See **Fig. 2**.

NOTE: Take flange thickness measurements at least 1/2" (12 mm) from the flange edges. Measurements taken at the flange edges are not an accurate indication of beam wear and may lead to unnecessary beam repair/replacement.

2. Check for excessive wear on the beam flanges, where they contact the axle housing saddle brackets.

   If flange wear is significant, use a micrometer or vernier calipers to take measurements at both unworn and worn areas. The maximum allowable difference between unworn and worn areas is 0.062" (1.5 mm). See **Fig. 3**.
3. Beams showing excessive wear must be repaired or replaced. See **Subject 140** for beam repair information.

## Installation

1. Position the new or repaired walking beam over the rearmost rear axle, with the front end of the beam tilted downward.
2. Slide the beam forward and downward so the front end of the beam enters the axle housing saddle bracket. See **Fig. 4**. Let the middle of the beam rest on the sawhorse bracket beam stop.

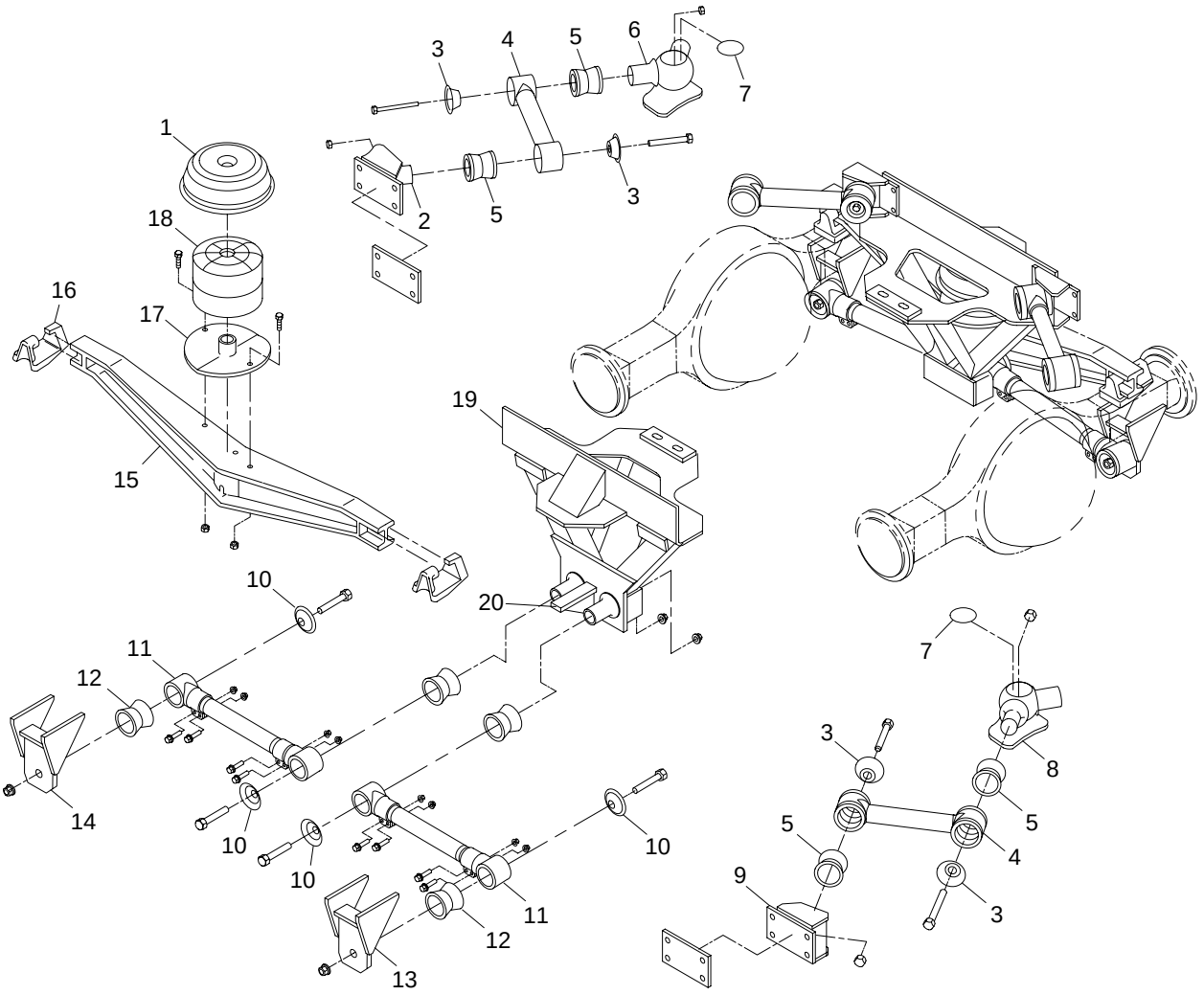
NOTE: On 54-inch spread suspensions, it may be necessary to install the spring assembly before the rearmost axle is rolled into place.

3. Carefully roll the rearmost rear axle forward, while lifting the rear end of the walking beam enough so the beam end enters the axle housing saddle bracket.
4. Connect the rearmost axle's upper and lower torque rods to the axle housing brackets. Install and tighten the torque rod bushing through-bolts 135 lbf·ft (183 N·m).
5. Slide, as one assembly, the spring plate, rubber spring, and restrictor cap, into position on the walking beam.
6. Install and tighten the spring plate fasteners 35 lbf·ft (47 N·m).

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## Walking Beam Removal, Inspection, and Installation




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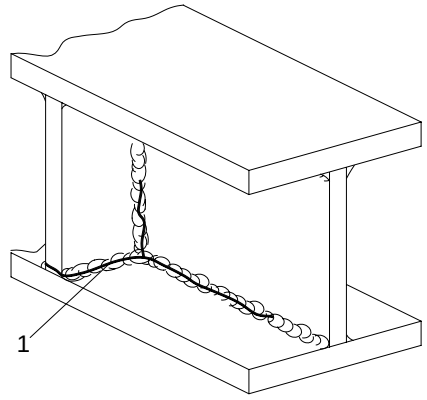
1. Restrictor Can
2. Upper Torque Rod Frame Bracket (LH forward)
3. Spigot Cap (upper)
4. Upper Torque Rod
5. Torque Rod Bushing (upper)
6. Forward Rear Axle Tower
7. Rear Axle Tower Plug
8. Rearmost Rear Axle Tower
9. Upper Torque Rod Frame Bracket (LH rear)
10. Spigot Cap (lower)
11. Lower Torque Rod (adjustable)
12. Torque Rod Bushing (lower)
13. Lower Torque Rod Axle Housing Bracket (LH rear)
14. Lower Torque Rod Axle Housing Bracket (LH forward)
15. Beam
16. Axle Housing Beam Saddle Bracket
17. Beam Spring Plate
18. Hollow Rubber Spring
19. Sawhorse Bracket Assembly
20. Beam Stop

**Fig. 1, Chalmers 800 Series Tandem Axle Suspension (40,000-pound capacity without shock absorbers shown)**

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## Walking Beam Removal, Inspection, and Installation

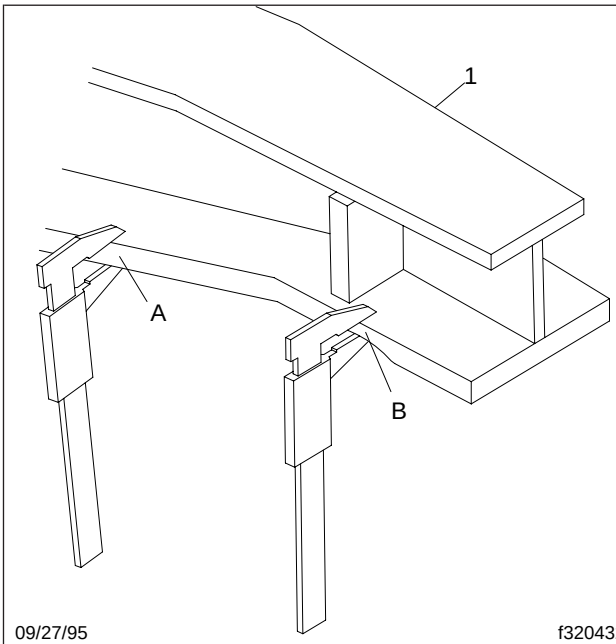



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A. Repairable Walking Beam
B. Non-repairable Walking Beam
1. Cracks

**Fig. 2, Repairable/Non-repairable Beam Cracks**

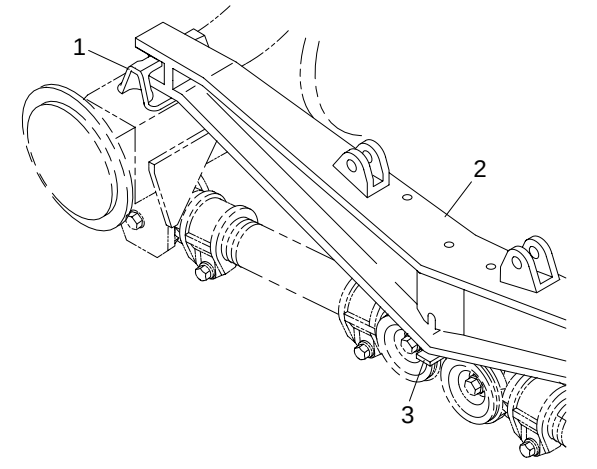
7. If so equipped, connect the beam-mounted shock absorbers to the beam brackets and tighten the fasteners 170 lbf·ft (230 N·m).
8. Remove the safety stands from under the vehicle, then lower the vehicle.
9. Remove the chocks from the tires.




09/27/95 f320432

A. Flange thickness measurement taken at unworn area for reference.
B. Flange thickness measurement taken at wear area to assess beam condition.
1. Walking Beam

**Fig. 3, Beam Wear Measurement**




01/11/96 f320442

1. Front Axle Housing, Beam Saddle Bracket
2. Walking Beam
3. Beam Stop

**Fig. 4, Beam/Saddle Bracket Alignment**

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## Repair

NOTE: This subject addresses only instances where excessive beam flange wear occurs, but cracks in the web or flange are not present.

Cracked webs and/or flanges require walking beam replacement.

Walking beams with excessive flange wear, however, can be repaired by welding a Chalmers Wear Plate over the worn areas as described below.

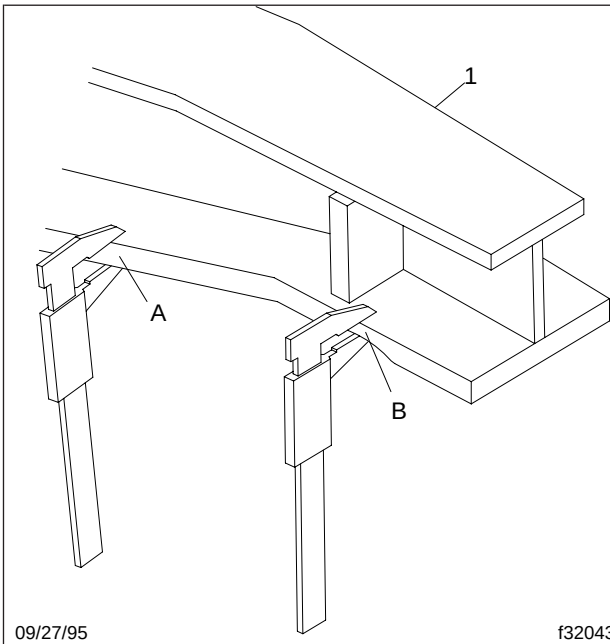
1. Remove the walking beam assembly. See **Subject 130** for information.

NOTE: Take flange thickness measurements at least 1/2" (12 mm) from the flange edges. Measurements taken at the flange edges are not an accurate indication of beam wear and may lead to unnecessary beam repair/replacement.

2. Confirm that flange wear is severe enough to warrant repairs. Use a micrometer or vernier calipers to take flange thickness measurements at both unworn and worn areas. The maximum allowable difference between unworn and worn areas is 0.062" (1.5 mm). See **Fig. 1**.
3. If repair is required, clean the worn area of the beam thoroughly. Make sure that any oil or grease is removed, as well as rust or road dirt accumulation. If necessary, slight grinding of the beam is allowed to smooth raised areas.
4. Clamp Chalmers Wear Plate #700313 to the bottom flange of the beam. Make sure the plate is centered and has good surface-to-surface contact with the beam. Slight grinding is allowable to obtain good plate-to-beam contact.
5. Tack weld the plate to the beam, welding on the sides of the plate only.

**CAUTION**

**Weld at the sides of the wear plate and beam only. Never weld at the ends of the wear plate. Welding the ends of the wear plate does not allow the wear plate to properly slightly expand nor contract, an action which, if the ends are welded, can cause cracks in the welds.**




A. Flange thickness measurement taken at unworn area for reference.
B. Flange thickness measurement taken at wear area to assess beam condition.
1. Walking Beam

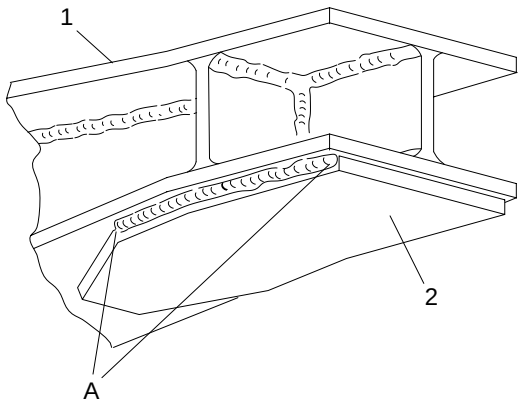
**Fig. 1, Beam Wear Measurement**

6. Remove the clamps and weld the plate to the beam, again, welding on the sides of the plate only. See **Fig. 2**.
7. Prime and paint the repaired area.
8. Install the repaired walking beam assembly. See **Subject 130** for information.

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## Walking Beam Repair




10/19/95 f320443

A. Limit weld to this area only.
1. Walking Beam 2. Wear Plate

**Fig. 2, Chalmers Wear Plate Welding**

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## Torque Rod Removal and Installation

The torque rods hold the rear axles in place, maintaining both axle alignment and pinion nose angle. When servicing the torque rods, it is good practice to remove and install them one at a time to avoid the possibility of mixing them up and affecting the alignment or pinion nose angle.

Several different styles of torque rods and bushing spigots exist. On the 40,000-pound version of the 800 Series suspension, the torque rods have tubular steel bodies and the upper rods do not cross over one another. On the 46,000- and 50,000-pound versions, the lower torque rods have tubular steel bodies, but the upper torque rods are made of "I-beam" shaped ductile iron. These upper torque rods do cross over one another. See **Fig. 1** and **Fig. 2**.

# Removal

NOTE: Inspect torque rod bushings for free play before removing the torque rods. See **Subject 160** for torque rod bushing inspection information.

1. If necessary, power wash the rear suspension to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Relieve all drive axle brake or wind-up loads by placing the transmission in neutral and releasing the spring or driveline brakes.
4. Raise the rear of the vehicle to remove all weight from the rear axles, and place safety stands under the frame to secure the vehicle in its raised position.
5. Working on one torque rod at a time, remove the torque rod bolts and spigot caps. Discard the bolts. Set the spigot caps aside for cleaning and inspection.

   Remove the torque rods by prying between the torque rod eye and the spigot base or frame bracket.

NOTE: At the axle housing towers, pry off the tower cap to access the torque rod fasteners.

6. Replace worn or damaged bushings following the instructions in **Subject 160**.
7. Inspect the spigots for damage, severe corrosion, or extensive wear. Replace damaged or severely corroded spigots. To determine whether or not a spigot is worn enough to warrant replacement, see **Fig. 3** and **Table 1**.

   The smaller of the two measurements should be used as the spigot diameter.

# Installation

1. Check the torque rod bushings to make sure they are properly installed. They must be centered within the torque rod eye. See **Fig. 4**.

IMPORTANT: Never use any mineral-based oils, greases, jellies, or solvent soaps to aid in the assembly of rubber suspension parts. Use only lubricants specifically designed for use with rubber compounds.

2. Lubricate the outside of the spigots and the inside of the rubber bushings with a generous amount of rubber lubricant such as Rimslip® or equivalent.
3. Push the torque rod into position on its spigots. After the torque rod is partially installed, use a heavy soft-faced mallet to drive the torque rod into position until the bushing contacts the spigot bottom face.

| Spigot Wear Limits | | | | |
|---|---|---|---|---|
| Spigot Size | Spigot Part Number | Usage | Minimum Spigot Diameter | |
| | | | Standard Bushing: inch (mm) | Oversize Bushing: inch (mm) |
| 1 | 800200 | 40,000 lb capacity—all | 2.350 (60) | 2.320 (59) |
| 2 | 800021 | 46,000 and 50,000 lb capacity—all | 2.530 (64) | 2.500 (63) |

**Table 1, Spigot Wear Limits**

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## Torque Rod Removal and Installation

NOTE: For easier installation, alternate mallet blows between ends of the torque rod to drive it onto the spigots evenly.

4. Install the spigot caps.
5. Install and tighten the torque rod bushing through-bolts 135 lbf·ft (183 N·m).
6. Remove the safety stands from under the vehicle, then lower the vehicle. Remove the chocks.

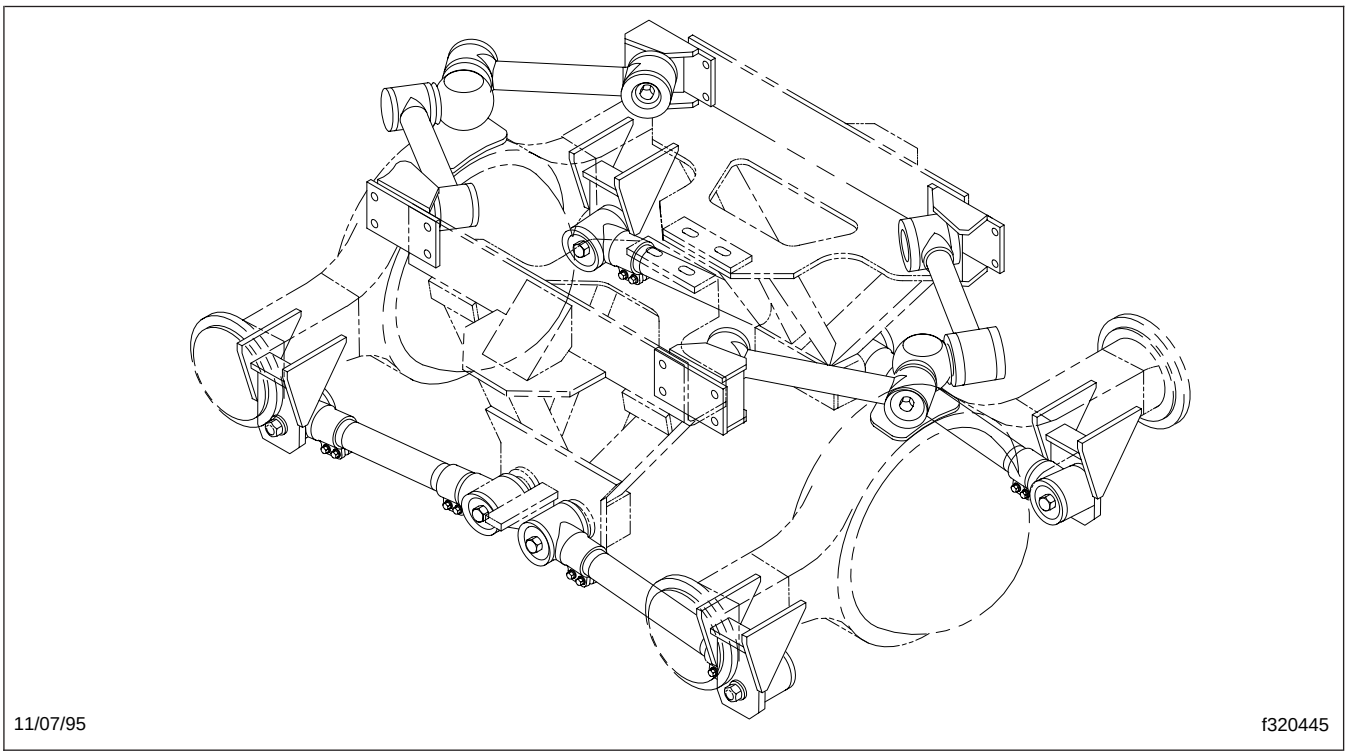
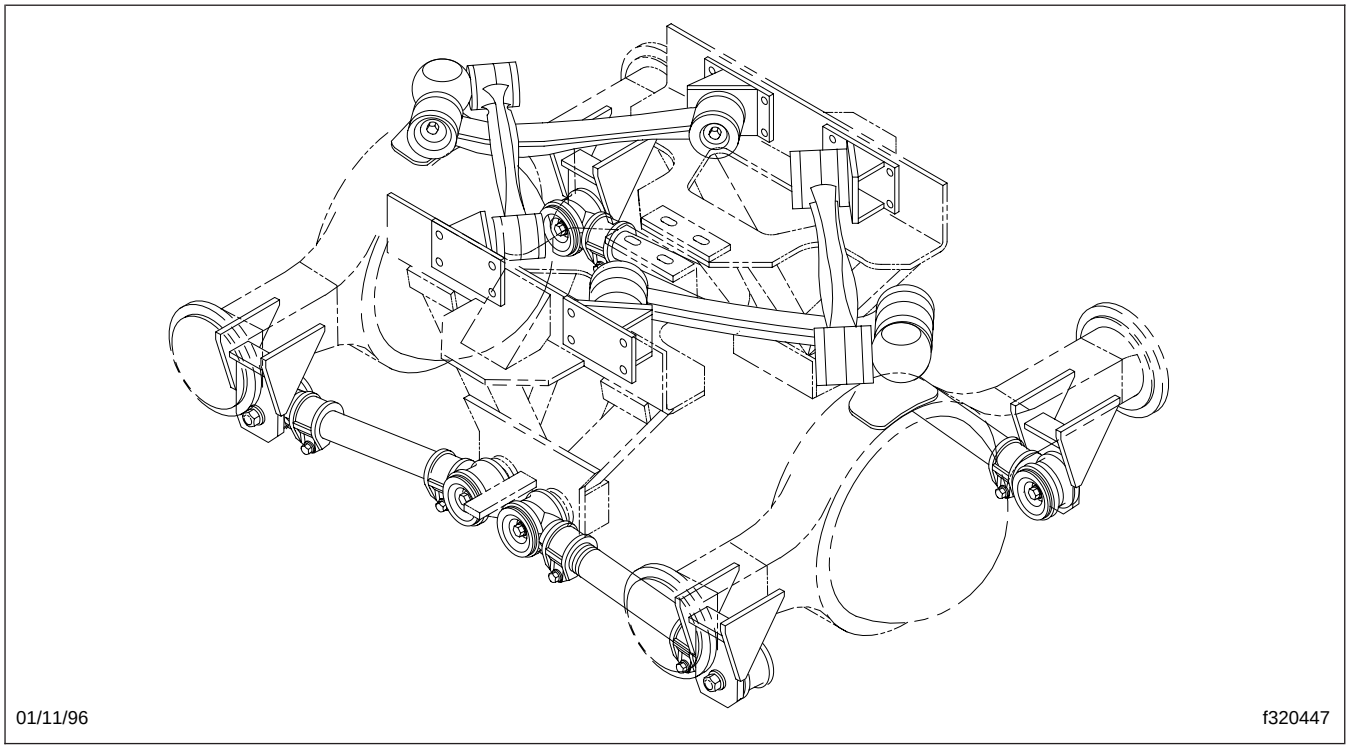



**Fig. 1, Torque Rod Arrangement, 40,000-Pound Capacity Suspension**

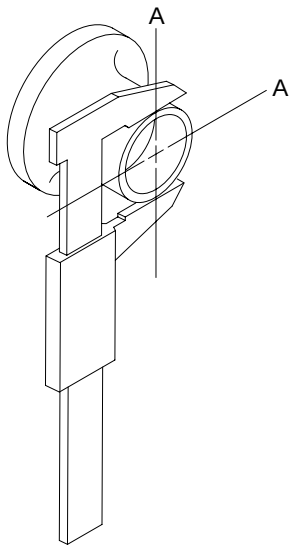
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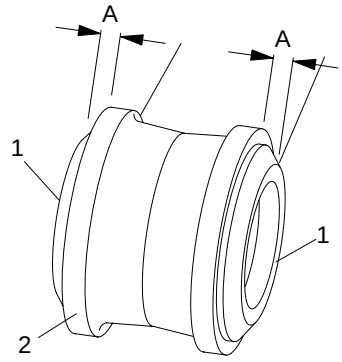
**Fig. 2, Torque Rod Arrangement, 46,000- and 50,000-Pound Capacity Suspensions**




10/24/95 f320446

A. Measure outside diameter at two locations, 90 degrees apart.

**Fig. 3, Spigot Measurement Points**




10/26/95 f320449

A. The amount of rubber protruding from each side of the torque rod eye must be equal.

1. Torque Rod Bushing 2. Torque Rod Eye

**Fig. 4, Torque Rod Bushing Protrusion**

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# Torque Rod Bushing Inspection and Replacement

## Inspection

1. If necessary, power wash the upper and lower torque rods to remove road dirt accumulation.
2. Chock the front tires to prevent vehicle movement.
3. Relieve all drive axle brake or wind-up loads by placing the transmission in neutral and releasing the spring or driveline brakes.
4. Using your hands only, attempt to move the torque rod ends, checking for free play. Some movement as the bushings "give" is normal, but only free play is cause for bushing replacement.

NOTE: Never use a lever or pry bar to check for torque rod bushing free play. To do so may result in unnecessary bushing replacement.

5. If free play is detected, replace the bushing as described below.

## Replacement

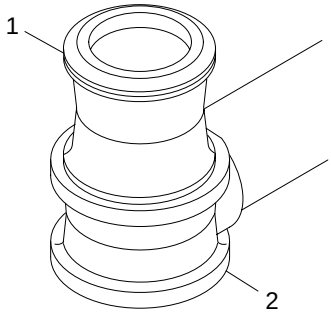
1. Remove the torque rod containing the worn out bushing. See **Subject 150**, if necessary.

NOTE: Remove only one torque rod at a time to avoid mixing-up torque rod positions.

2. Place the torque rod on the floor or a workbench with a bushing open end facing upward. Push the tip of a large screwdriver down between the torque rod eye and the bushing and pry out the bushing. Discard removed bushings.
3. Use a wire brush and/or scraper to clean the torque rod eyes, removing all rust, scale, and rubber accumulations.
4. Inspect the torque rod eyes looking for cracks, distortion, or severe corrosion. Replace torque rods with damaged bushing eyes.

IMPORTANT: Never use any mineral based oils, greases, jellies, or solvent soaps to aid in the assembly of rubber suspension parts. Use only lubricants specifically designed for use with rubber compounds.

5. Lubricate both the inside of the torque rod eye and the outside of the new bushing with a generous amount of rubber lubricant, such as Rimslip® or equivalent.
6. Place the torque rod on a solid level floor with an open end of the eye facing upward. Position a lubricated bushing on the eye, making sure that the tapered shoulder of the bushing is centered on the eye. See **Fig. 1**.




1. Torque Rod Bushing 2. Torque Rod Eye

**Fig. 1, Torque Rod Bushing Installation**

7. Using a heavy, soft-faced mallet, strike the bushing squarely to drive it into the torque rod eye. Then, flip the torque rod over 180 degrees and tap on the torque rod shaft with the mallet while the bushing rests on the floor.

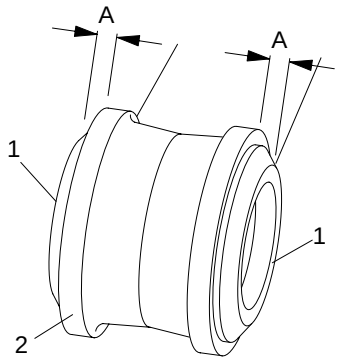
NOTE: If available, a small press may be used instead of a mallet for bushing installation.

8. The bushing is completely installed when it is centered within the torque rod eye. See **Fig. 2**.
9. Install the re-bushed torque rod. See **Subject 150**, if necessary.

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## Torque Rod Bushing Inspection and Replacement




10/26/95 f320449

A. The amount of rubber protruding from each side of the torque rod eye must be equal .

1. Torque Rod Bushing 2. Torque Rod Eye

**Fig. 2, Torque Rod Bushing Protrusion**

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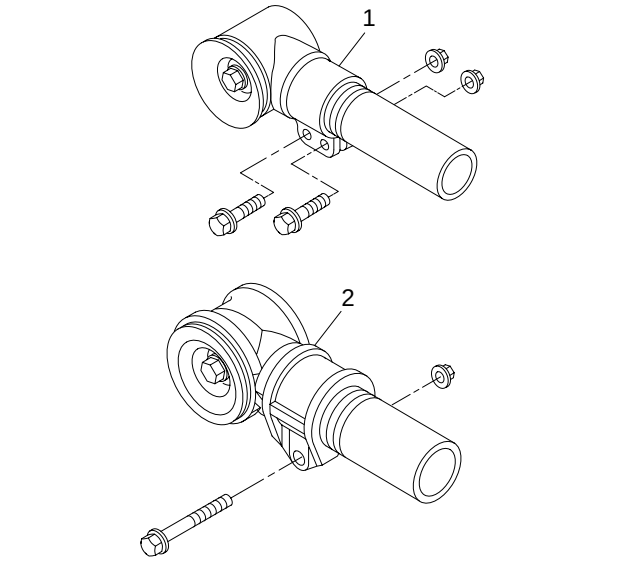


## Rear Axle Alignment Adjustment

On the Chalmers 800 Series Rear Suspension, the lower torque rods provide the only means for adjusting rear axle alignment. The upper torque rods play no part in the axle alignment process.

The lower torque rod bodies consist of steel tubes, with fine threads cut into the ends of the tube. Left-hand threads are cut into one end of the tube, right-hand threads into the other end. Therefore, by simply twisting the tube body while restraining the ends, the effective length of the tube is changed.

One type of torque rod end is used. A #1 size, two 1/2-inch clamp bolt secured the rod end to the tube. On the #2 size, a single 5/8-inch bolt is used. See **Fig. 1**.



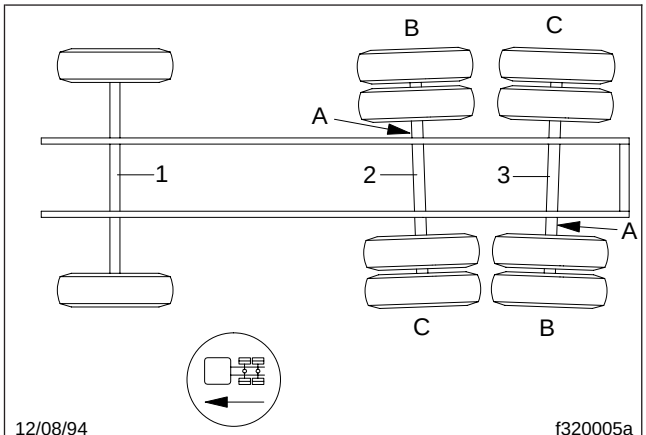

1. #1 Joint
2. #2 Joint

**Fig. 1, Adjustable Torque Rod Ends**

# Adjustment

1. Ensure that the torque rod bushings are in a fully relaxed, neutral state by slowly moving the vehicle back and forth a few times. Apply the service brakes, *not the parking brakes*.
2. Chock the front tires to prevent vehicle movement.
3. Relieve drive axle brake or wind-up loads by placing the transmission in neutral and releasing the brakes.
4. Using a straightedge and a tape measure, determine the amount of adjustment needed to align the forward-rear axle at right angles to the frame. For instructions, see **Group 35**. The difference in measurements between the sides of the vehicle is the approximate amount that the trailing end of the forward-rear axle will have to be brought forward, or the leading end will have to be moved back to align it at a right angle to the frame. See **Fig. 2**.

   If the forward-rear axle alignment is within specifications, go to the step that begins "Using a center-point bar, determine...".




A. Axle Out of Alignment
B. Leading End
C. Trailing End
1. Front Axle
2. Forward Rear Axle
3. Rearmost Axle

**Fig. 2, Tandem Axle, Shown Out of Alignment**

5. On the side of the vehicle that is to be adjusted forward or rearward, loosen the torque rod end pinch bolts at both ends of the torque rod.

NOTE: If the pinch bolts are badly corroded or otherwise damaged, remove and discard them. Install new Chalmers fasteners.

6. Attach a pipe wrench to the tube body (chain type preferred) and rotate the tube to shorten or

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## Rear Axle Alignment Adjustment

lengthen the torque rod. Continue to rotate the tube until the forward-rear axle is square to the frame.

NOTE: If the torque rod tube is difficult to rotate, apply penetrating oil to the tube threads. If this does not help, remove the pinch bolts and drive wedges between the eye lugs to relieve the clamping effect.

7. When the forward-rear axle is square with the frame, tighten the pinch bolts.
   - 7.1 Tighten 1/2-inch UNC bolts on #1 joints 65 lbf·ft (88 N·m).
   - 7.2 Tighten 5/8-inch UNC bolts on #2 joints 135 lbf·ft (183 N·m).
8. Using a center-point bar, determine the difference between the forward-rear and the rearmost axles' center-to-center measurements on each side of the vehicle. For instructions, see **Group 35**. This difference is the approximate distance that the leading end of the rearmost axle will have to be adjusted rearward, or that the trailing end will have to be adjusted forward, to align it at a right angle to the frame, and to align it parallel to the forward-rear axle. See **Fig. 2**.
9. On the side of the vehicle that is to be adjusted forward or rearward, loosen the torque rod end pinch bolts at both ends of the torque rod.

NOTE: If the pinch bolts are badly corroded or otherwise damaged, remove and discard them. Install new Chalmers fasteners.

10. Attach a pipe wrench to the tube body (chain type preferred) and rotate the tube to shorten or lengthen the torque rod. Continue to rotate the tube until the rearmost axle is square to the frame.

NOTE: If the torque rod tube is difficult to rotate, apply penetrating oil to the tube threads. If this does not help, remove the pinch bolts and drive wedges between the eye lugs to relieve the clamping effect.

11. When the rearmost axle is square with the frame, tighten the pinch bolts.
    - 11.1 Tighten 1/2-inch UNC bolts on #1 joints 65 lbf·ft (88 N·m).
    - 11.2 Tighten 5/8-inch UNC bolts on #2 joints 135 lbf·ft (183 N·m).
12. Remove the safety stands, and lower the vehicle. Remove the chocks from the front tires.
13. Using the center-point bar, check the rearmost axle alignment. If alignment is not within specifications, repeat the applicable steps above.

**⚠ CAUTION**

**Failure to periodically torque the suspension fasteners can result in abnormal tire wear, and damage to the suspension.**

IMPORTANT: All suspension fasteners require periodic torquing. For suspension component inspecting and fastener torque checking intervals and instructions, see **Group 32** of the *Western Star Maintenance Manual*.

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## Specifications

| Description | Bolt Size | IFI Grade | Torque: lbf·ft (N·m) |
|---|---|---|---|
| Beam Spring Plate Bolt | 3/8 UNC | 8 | 35 (47) |
| Torque Rod End Through Bolts | 5/8 UNC | 8 | 135 (183) |
| Shock Absorber (beam-mounted) Bolt | 3/4 | 8 | 170 (230) |
| Shock Absorber (axle-mounted) Nut | 7/8 | G | 270 (366) |
| #1 Torque Rod End Pinch Bolts | 1/2 UNC | 8 | 65 (88) |
| #2 Torque Rod End Pinch Bolts | 5/8 UNC | 8 | 135 (183) |

**Table 1, Fastener Torques, 800 Series Suspension**

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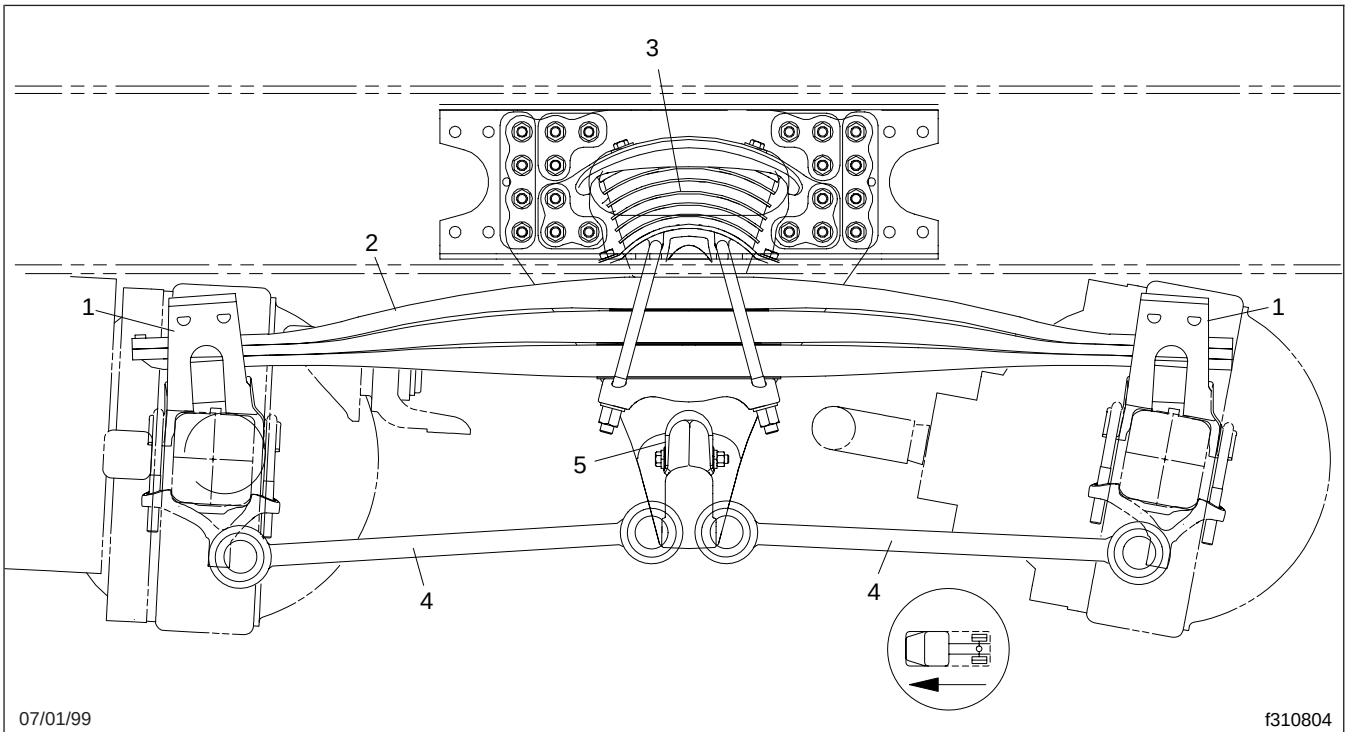
## General Description

The TufTrac Suspension (**Fig. 1**) is heavy-duty "six rod" tandem-axle suspension option for trucks built for severe on/off highway work. The TufTrac design allows a truck to maneuver over bumps, ridges and washboard roads that typically generate high rates of axle articulation, without bottoming out the suspension or losing traction.

The TufTrac suspension is available in three weight ratings: 40,000-, 46,000-, and 52,000-pound (18 144-, 20 865-, 23 586-kilogram) capacities. The 40,000-pound (18 144-kilogram) capacity suspension uses two taper leaf springs and has an axle spacing of 54 inches. The 46,000-pound (20 865-kilogram) capacity suspension has three leaf springs (shown in this section), while the 52,000-pound (23 586-kilogram) suspension features four leaf springs. Both the 46,000-pound (20 865-kilogram) and the 52,000-pound (23 586-kilogram) suspensions have a standard axle spacing of 56 inches.

## Principles of Operation

Six functional links in the TufTrac suspension maintain the positions of the axles. Side-to-side axle movement is controlled by two v-rods from the frame to the axles at the top of the suspension. Four bar links from the frame to the axles at the bottom control the forces of driving and braking as well as fore-and-aft road shocks. Vertical loads are carried by the rubber-isolated parabolic taper leaf spring packs.




1. Axle Clamps
2. Leaf Springs
3. Center Bearing
4. Lower Control Rods
5. Rebound Stop

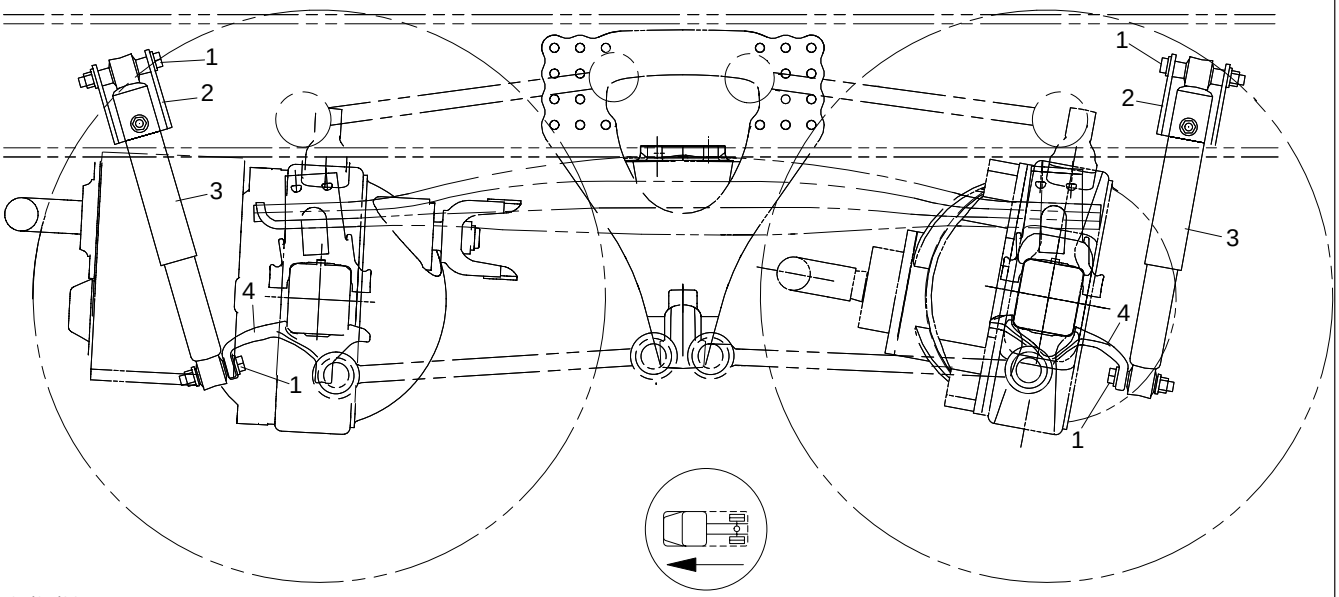
**Fig. 1, TufTrac Suspension (46,000-pound [20 865-kilogram] version shown)**

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## Replacement

1. Park the vehicle on a level surface, shut down the engine and apply the parking brakes. Chock the tires. See **Fig. 1**.
2. Remove the lower shock mounting nut and washer.
3. Remove the upper shock mounting nut and washer.
4. Remove the upper and lower mounting bolts and remove the shock absorber.
5. Position the new shock absorber in place and install the mounting bolts.
6. Loosely fasten the bolts with the nuts and washers removed from the old shock absorber.
7. Torque each mounting nut 241 lbf·ft (327 N·m).
8. Remove the chocks from the tires.




1. Mounting Bolt
2. Upper Mounting Bracket
3. Shock Absorber
4. Lower Mounting Bracket

**Fig. 1, Shock Absorber Replacement**

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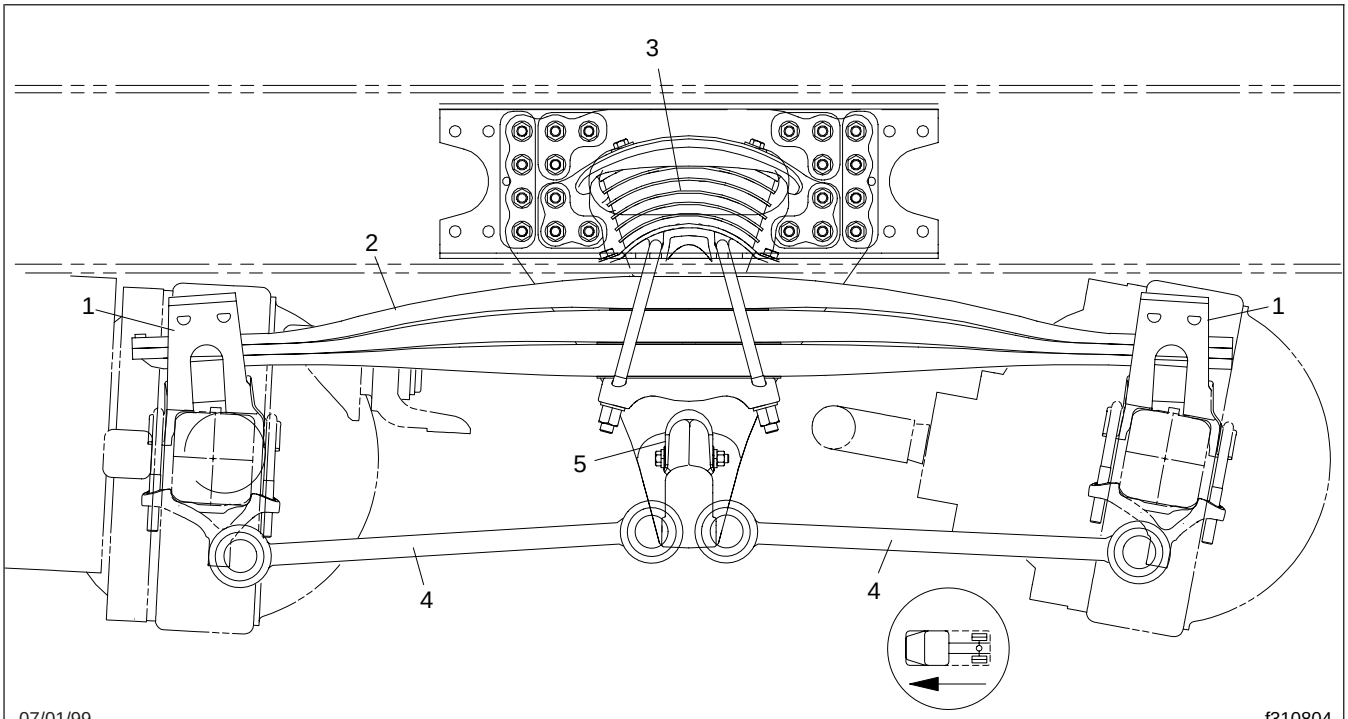


## Replacement

1. Park the vehicle on a level surface, shut down the engine and apply the parking brakes. Chock the tires.
2. Remove the rebound stop from the suspension. See **Fig. 1**.
   - 2.1 Remove the nut and bolt securing the rebound stop to the mounting bracket.
   - 2.2 Slide the rebound stop from the mounting bracket.
3. Remove the upper two fasteners on the center bearing.
4. Jack up the vehicle under the rear axle.
5. Support the rear frame rails with jack stands, then lower the jack. This will clear the center bearing from the top of the mounting bracket. See **Fig. 2**.
6. Remove the lower center bearing bolts attached to the spring assembly casting. Discard the bolts.
7. Remove the center bearing. See **Fig. 3**.
8. Position the new center bearing in the mounting bracket.
9. Install the upper mounting bolts and tighten 68 lbf·ft (92 N·m).
10. With the jack, raise the rear axle until bottom of the center bearing meets the mounting bracket on the leaf springs.

IMPORTANT: Be sure to use new bolts with loctite (p/n 23–12576–125) when attaching the center bearing to the leaf spring casting.

11. Install new lower mounting bracket bolts (p/n 23–12576–125). Tighten the bolts 155 lbf·ft (210 N·m).



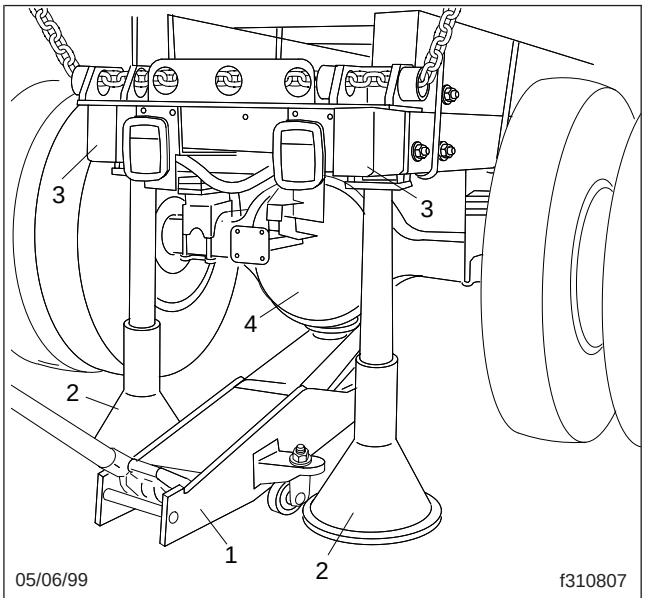

1. Axle Clamps
2. Leaf Springs
3. Center Bearing
4. Lower Control Rods
5. Rebound Stop

**Fig. 1, TufTrac Suspension (46,000-pound [20 865-kilogram] version shown)**

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## Center Bearing Replacement




1. Jack
2. Jack Stand
3. Frame Rail
4. Rear Axle

**Fig. 2, Jack and Jack Stand Placement**

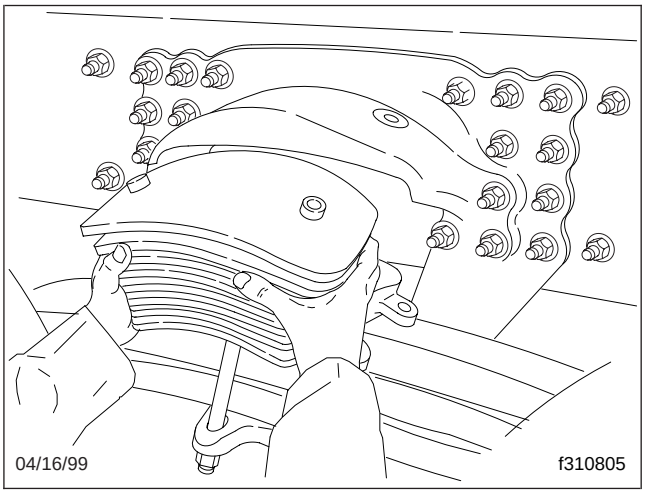



**Fig. 3, Center Bearing Removal**

12. Return the vehicle to its normal operating position.
13. Install the rebound stop.
14. Remove the chocks from the tires.

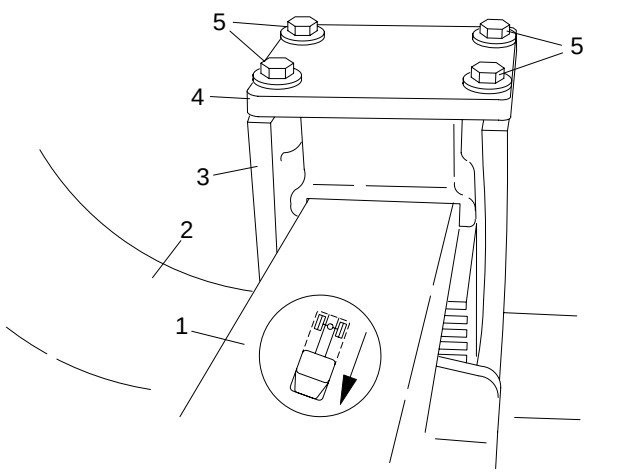
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IMPORTANT: The spring pack assembly is not available as an assembled unit in the aftermarket. If the spring pack assembly is to be replaced with a new assembly, the springs, center bearing seat and retainer bracket must be assembled before installation on the vehicle.

## Replacement

1. Park the vehicle on a level surface. Shut down the engine and apply the parking brakes. Chock the tires.
2. Remove the tip pad bolts above each axle on the axle clamp. There are four bolts on each pad. See **Fig. 1**.




1. Leaf Springs
2. Axle
3. Axle Pad
4. Tip Pad
5. Tip Pad Bolts

**Fig. 1, Tip Pad Installation**

3. Remove the center bearing. See **Subject 110**.
4. With the vehicle still raised, remove the wheels on both rear axles on the side the spring assembly will be replaced. For instructions, see **Group 40**.

**WARNING**

**Do not attempt to remove the spring assembly by hand. The assembly is very heavy and attempting to lift it could result in bodily injury.**

5. Using a lift (i.e. engine hoist), remove the leaf spring assembly from the vehicle. See **Fig. 2**.

IMPORTANT: Leaf springs in a spring pack assembly cannot be replaced individually. The entire spring pack assembly must be replaced.

6. Support both sides of the new spring pack assembly on jack stands. Make sure all the leaf springs are interlocking with the studs and dimples at the centers of the leaf springs.
7. If the assembly contains a spacer, place it on the center of the top leaf spring. Make sure the dimple in the spacer is aligned with the stud in the center of the top leaf spring.
8. Place the center bearing seat on the top of the spacer or leaf spring, as applicable. Make sure the dimple in the middle of the center bearing seat aligns with the stud in the middle of the leaf spring or the spacer.
9. Install the two 3/4-inch U-bolts over the center bearing seat. Make sure the U-bolts rest in the grooves of the center bearing seat.
10. At the bottom of the spring pack, install the U-bolt retainer bracket over the threaded ends of the U-bolts.
11. Holding the retainer bracket in place, install a hardened washer and hexnut over the threaded end of each U-bolt.
12. Tighten the U-bolts in a diagonal sequence as follows:
    - Stage 1: 60 lbf·ft (81 N·m)
    - Stage 2: 200 lbf·ft (271 N·m)
    - Stage 3: 300 lbf·ft (407 N·m)

**WARNING**

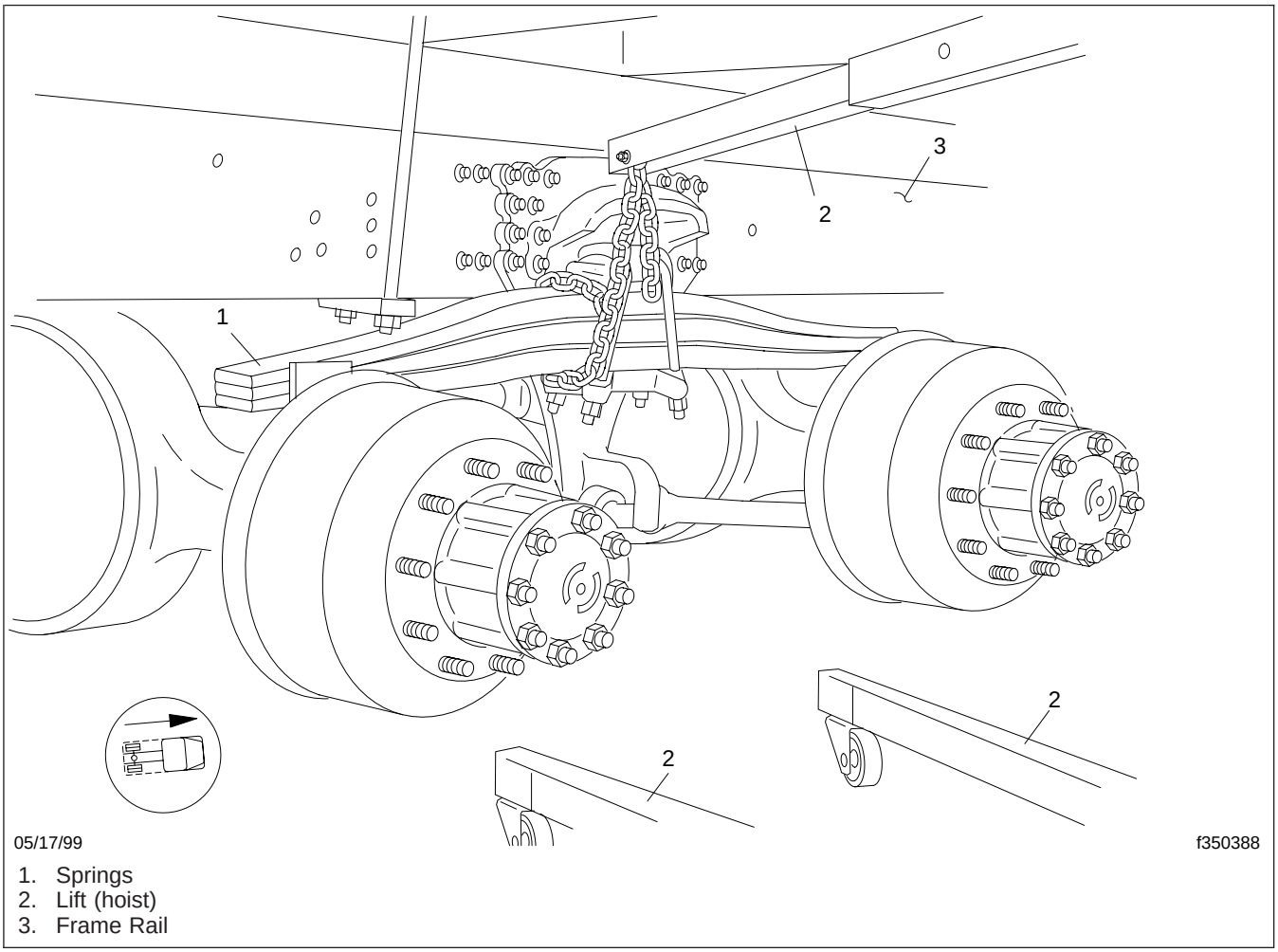
**Do not attempt to install the spring assembly by hand. The assembly is very heavy and attempting to lift it could result in bodily injury.**

13. Place the new spring assembly on the vehicle.

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## Spring Assembly Replacement




1. Springs
2. Lift (hoist)
3. Frame Rail

**Fig. 2, Leaf Spring Replacement**

13.1 Attach the new assembly to the lift.

13.2 Using the lift (hoist), lift the assembly into place on the axle clamps.

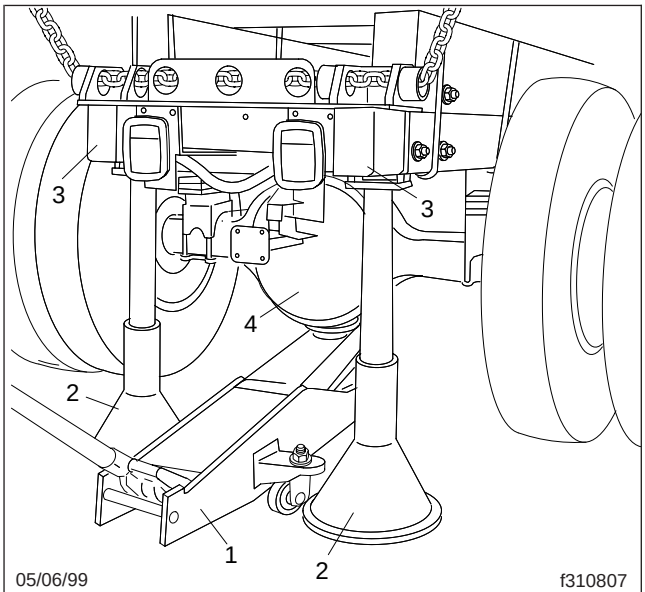
14. Install the center bearing. For instructions, see **Subject 110**.
15. Install the tip pad and bolts on each axle clamp. Tighten the bolts 37 lbf·ft (50 N·m). See **Fig. 1**.
16. If not already installed, install the rebound stop and mounting bolt. Tighten the nut 68 lbf·ft (92 N·m).
17. Install the wheels. For instructions, see **Group 40**.
18. Return the vehicle to its normal operating position.
19. Remove the chocks from the tires.

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## Lower Control Rod Replacement

1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the front tires.
2. Raise the rear axle and support the frame rails with jack stands.
3. Lower the jack under the axle. See **Fig. 1**.




1. Jack
2. Jack Stand
3. Frame Rail
4. Rear Axle

**Fig. 1, Jack and Jack Stand Placement**

4. Locate the lower control rods. See **Fig. 2**. Remove the bolts holding both rods between the rear axles, below the rebound stop. See **Fig. 3**.
5. Remove the nut and bolt from the axle clamp.
6. Remove the control rod from the vehicle.

IMPORTANT: When installing the rods make sure the labels on the rods are facing upward. Forward axle rods are marked "FDA" and rear axle rods "RDA."

7. Fasten the new control rod to the axle clamp. Tighten the nut 136 lbf·ft (184 N·m).
8. Fasten the other end of the rod to the bracket below the rebound stop. Tighten the nut 136 lbf·ft (184 N·m).
9. Return the vehicle to the normal operating position.

## V-Rod Replacement

1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the tires.
2. Raise the rear axle and support the frame rails with jack stands.
3. Lower the jack under the axle. See **Fig. 1**.
4. Locate the v-rods. See **Fig. 2**. Remove all six mounting bolts securing the v-rod to the chassis and axle. See **Fig. 4**.
5. Remove the v-rod from the chassis.

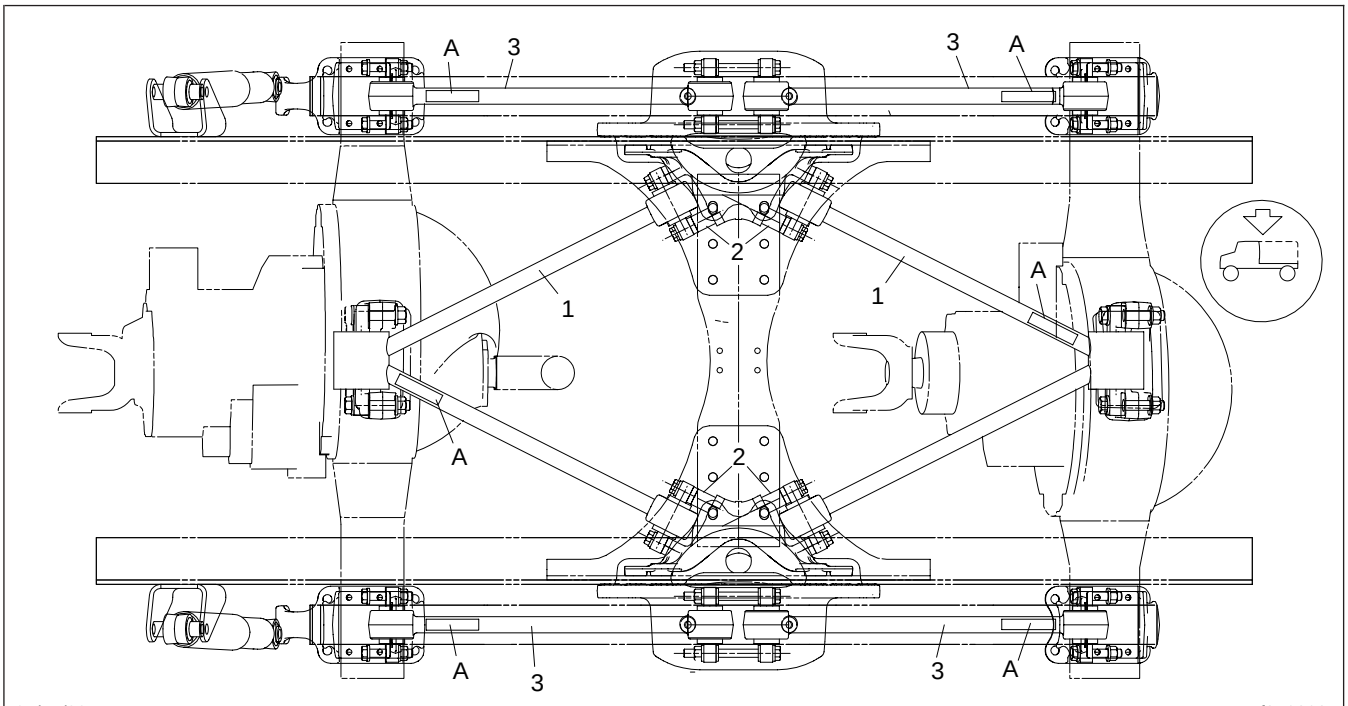
IMPORTANT: When installing the rods make sure the labels on the rods are facing upward. Forward axle rods are marked "FDA" and rear axle "RDA."

6. Install the v-rod.
   - 6.1 Place the new rod in position between the frame rails.
   - 6.2 Install the bolts and spacers and loosely tighten all connections.
   - 6.3 After all fasteners and spacers are installed, torque as follows:
     - Tighten the bolts at the frame bracket 136 lbf·ft (184 N·m).
     - Tighten the bolts at the axle bracket 427 lbf·ft (579 N·m).
7. Return the vehicle to normal operating position.
8. Remove the chocks from the tires.

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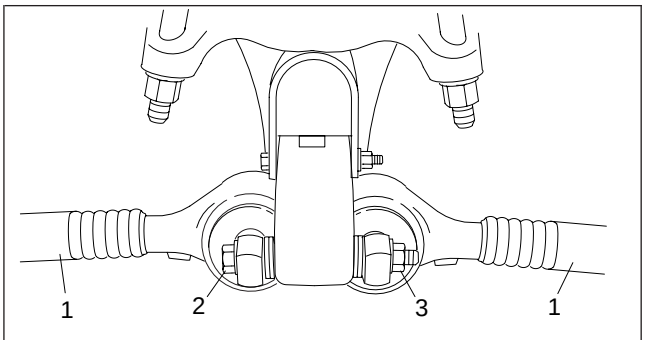


## Lower Control Rod and V-Rod Replacement



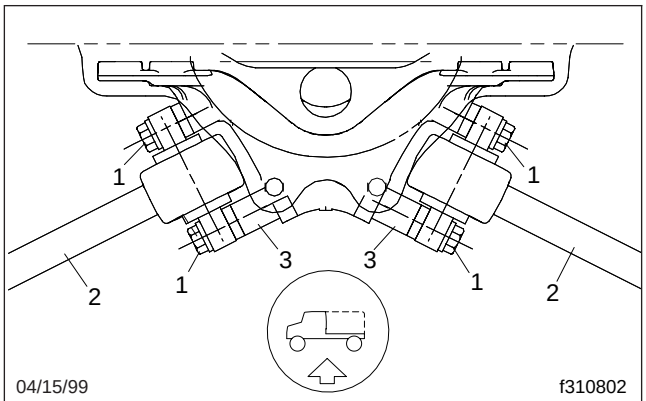

A. Label
1. V-Rod
2. Spacer
3. Lower Control Rod

**Fig. 2, Control and V-Rod Replacement**




1. Lower Control Rod
2. Mounting Bolt
3. Mounting Nut

**Fig. 3, Lower Control Rods**




1. Mounting Bolt
2. V-Rod
3. Spacer

**Fig. 4, V-Rod Replacement**

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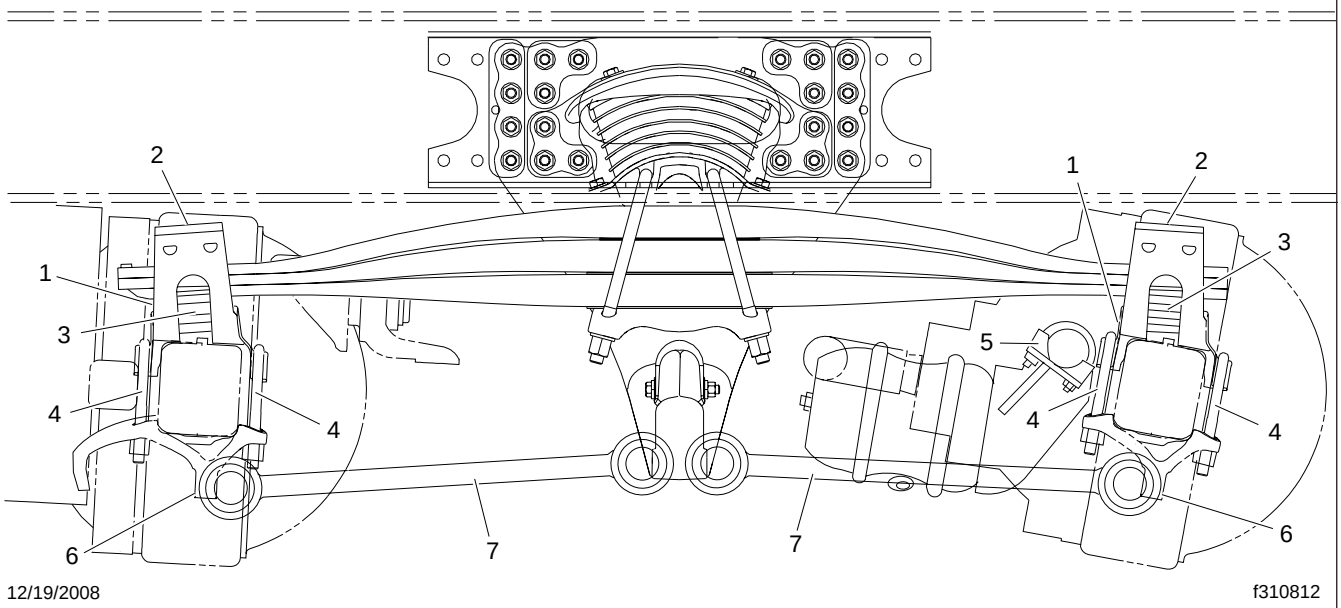
## Replacement

1. With the vehicle parked on a level surface, shut down the engine, and chock the tires.

NOTE: All of the following steps should be performed on the left side of the vehicle, first; then the right side of the vehicle.

2. Remove the two upper spring-tip pads and bolts from the suspension spring. See **Fig. 1**.
3. Disconnect the shock absorbers from the lower axle retainer on the suspension spring.
4. Disconnect the two lower torque-control rods from the lower axle retainers.
5. Remove and discard the U-bolt nuts and washers.
6. Remove the brake cam tube-support bracket.
7. Remove and discard the lower axle retainers.
8. Remove and discard the axle U-bolts from both rear axles.
9. Jack up the center of the suspension spring (at the center bearing, between the tandem) and support with jack stands at the frame. See **Fig. 2**. Make sure that all weight has been relieved from the axle clamp group and that there is sufficient clearance to remove the upper axle clamp.
10. Remove the lower spring-tip pads from both rear axles.
11. Remove and discard the upper axle clamps from both rear axles.
12. On both rear axles, install new upper axle clamps. Locate the dowel pin through the hole in the bottom of each axle clamp to confirm proper alignment.

NOTE: Confirm that you are installing the correct upper axle clamps before continuing. You can visually identify the new upper axle clamp because the step has been removed from the area directly above the U-bolt saddles. See **Fig. 3**.




1. Upper Axle Clamp
2. Upper Spring-Tip Pad
3. Lower Spring-Tip Pad
4. U-Bolt
5. Brake Cam Tube-Support Bracket
6. Lower Axle Retainer
7. Lower Torque-Control Rods

**Fig. 1, TufTrac Suspension (left-side view)**

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## Axle Clamp and Retainer Replacement

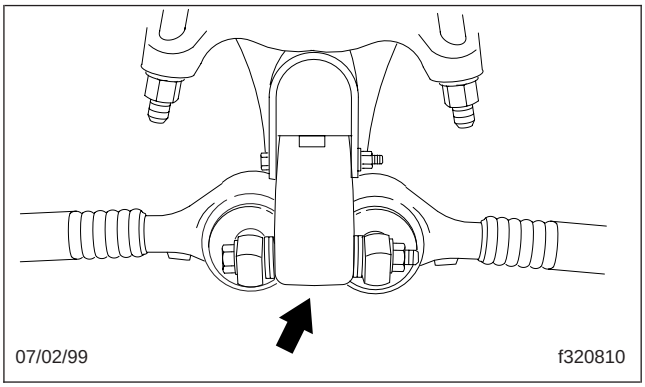



**Fig. 2, Vehicle Jacking Point**

13. Install the lower spring-tip pads into the front and rear axle clamps.
14. Jack up the left-side suspension spring, remove the jack stands, and lower the spring. While the spring is being lowered, ensure that it is seated correctly onto the lower spring-tip pads.
15. Install new lower axle retainers onto both rear axles.
16. Install the brake cam tube-support bracket onto the rear axle.
17. Install new U-bolts as follows.

IMPORTANT: Install two new washers for each U-bolt nut.

17.1 Install each U-bolt over the U-bolt saddle in the upper axle clamp and through the holes in the lower axle retainer.

17.2 Install the washers and finger-tighten the nuts in the order shown in **Fig. 4**.

Make sure all brackets are snug against the axle housing before proceeding.

IMPORTANT: U-bolt nuts must be tightened in the order shown in **Fig. 4**.

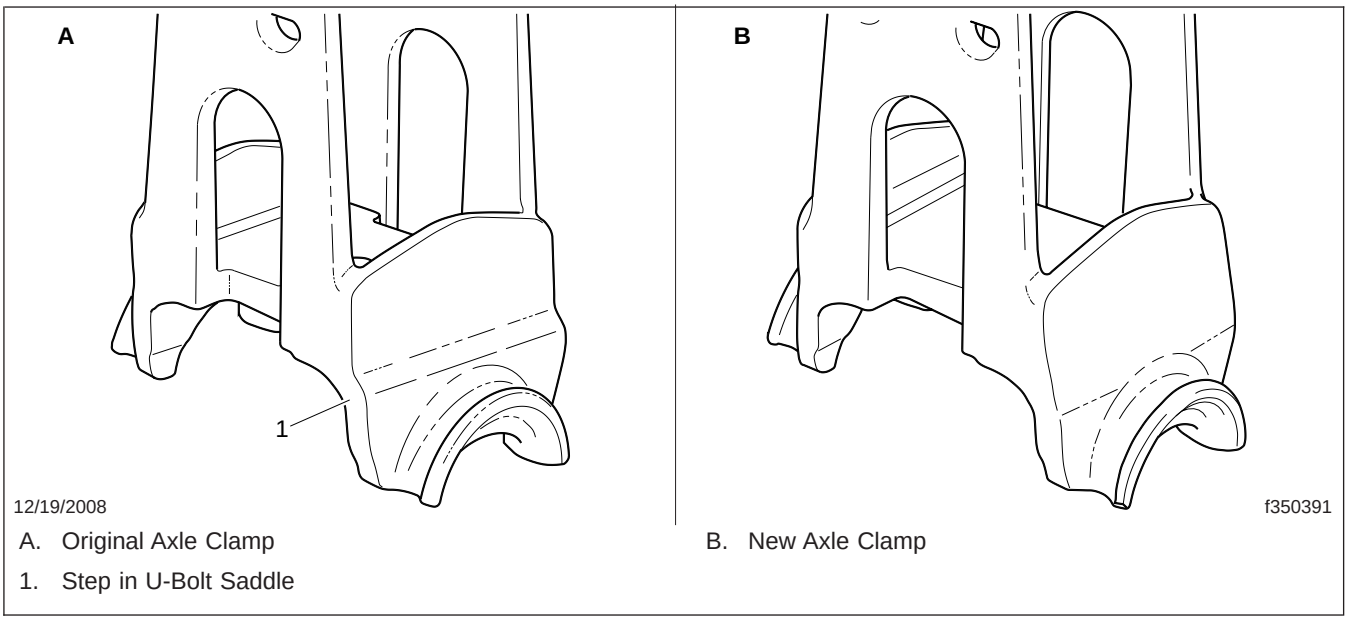
17.3 Tighten the nuts 60 lbf·ft (81 N·m), then 200 lbf·ft (271 N·m), in two separate rotations, following the order shown in **Fig. 4**.

18. Attach the lower torque-control rods to the lower axle retainers, then tighten 136 lbf·ft (184 N·m).
19. Install the shock absorbers as follows.

19.1 Install the lower shock mounting bolts.

19.2 Install the lower shock absorber mounting washers and nuts, then hand-tighten the nuts.

19.3 Tighten the nuts to 241 lbf·ft (327 N·m).

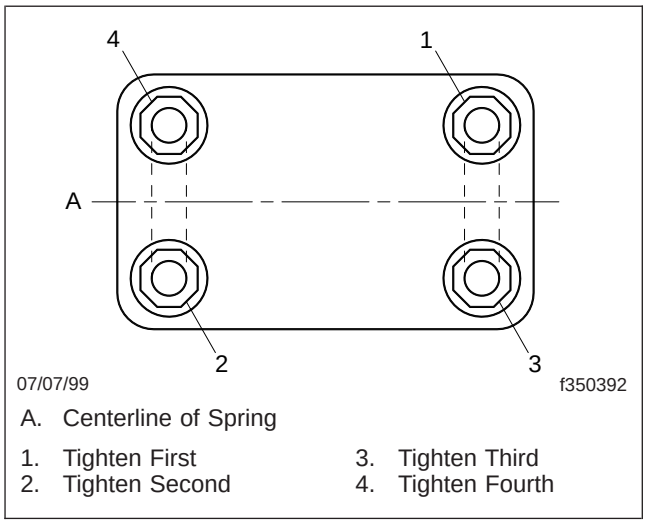



A. Original Axle Clamp
1. Step in U-Bolt Saddle
B. New Axle Clamp

**Fig. 3, Upper Axle Clamps**

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A. Centerline of Spring

1. Tighten First
2. Tighten Second
3. Tighten Third
4. Tighten Fourth

**Fig. 4, U-Bolt Nut Tightening Sequence**

20. Install the spring-tip pads on the suspension spring, then install the bolts, and tighten 37 lbf·ft (50 N·m).
21. Repeat the steps for the right-side spring.

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# Adjustments

Rear axle positioning and alignment on a vehicle equipped with the TufTrac suspension is determined by the length of the lower control rods and the V-rods. See **Fig. 1**. The length of the control rods and V-rods can be controlled by the addition or removal of shims at the mounting points of the control rods and/or V-rods. The addition of shim(s) between the control rod or V-rod and its mounting will effectively lengthen the rod moving the axle relative to the frame. Conversely, the removal of shim(s) will shorten the length of the rod, moving the axle in the opposite direction.

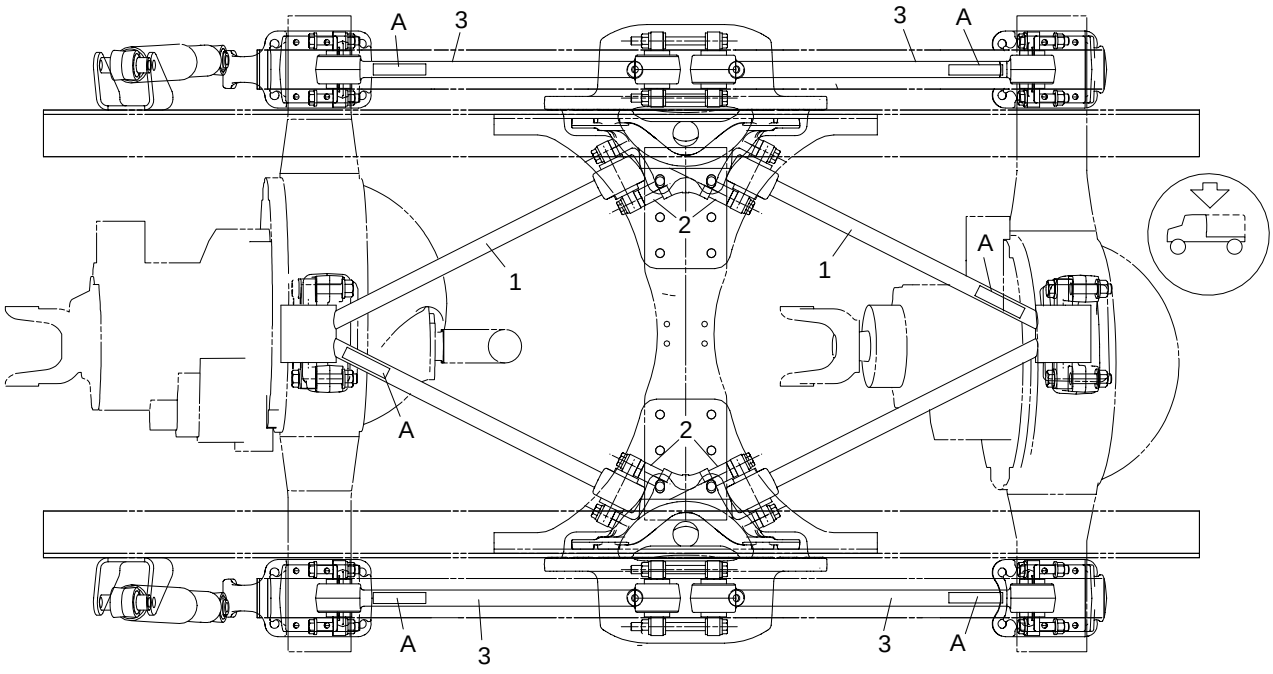
ment is to provide axle alignment and planing adjustment (angle of the axle from vertical in the side view).

Axle tracking (lateral axle positioning) is performed by inserting or removing hardened washers at the V-rod mounting at the frame end. See **Fig. 4**.

## Lower Control Rods

### Alignment Adjustments

NOTE: Alignment refers to the squareness of the axles to each other and the frame rails viewed from the top of the vehicle.




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A. Label
1. V-Rod
2. Spacer
3. Lower Control Rod

**Fig. 1, Control Rod and V-Rod Installation**

The lower control rods use a horse-shoe style of shim (**Fig. 2**) while the V-rods use hardened washers for shims.

Control rod shimming is performed at the center bracket. See **Fig. 3**. The purpose of this shim adjustment is to provide axle alignment and planing adjustment (angle of the axle from vertical in the side view).

Add or remove shims at the center bracket to achieve proper alignment. See **Fig. 3**. To minimize the effect on planing angles, if possible, add or remove shims from both sides of the vehicle.

When one 3mm thick shim is added and one removed (from the opposite side) the axle position is affected as follows:

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## Rear Axle Alignment Adjustments

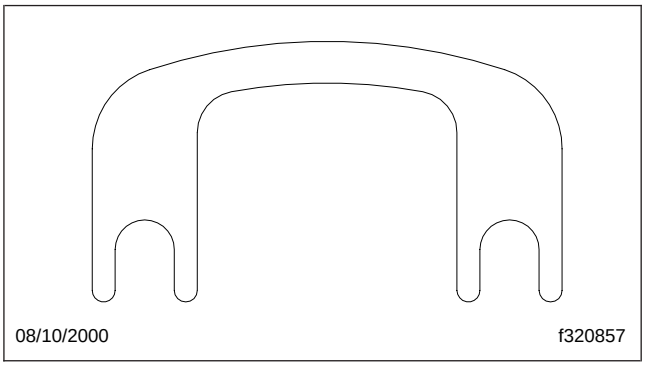
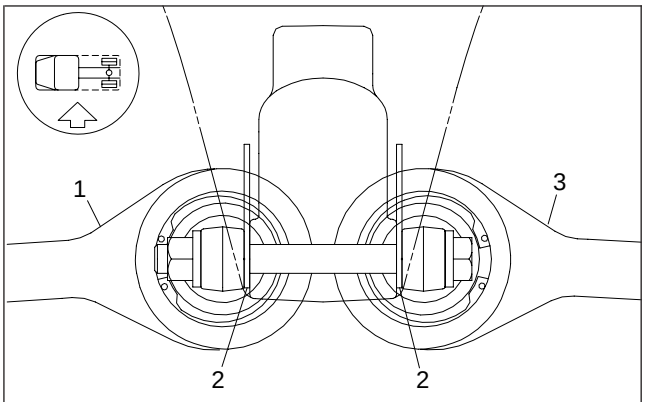



**Fig. 2, Lower Control Rod Shim**




1. Forward Lower Control Rod
2. Shims
3. Rear Lower Control Rod

**Fig. 3, Lower Control Rod Shim Installation**

- Angle of the axle in the plan view: 0.33 degrees
- Fore-aft movement of the wheel at the outside (assuming 97.6 in. (2480 mm) wheel to wheel distance): 0.283 in. (7.2 mm)

### Planing Adjustments

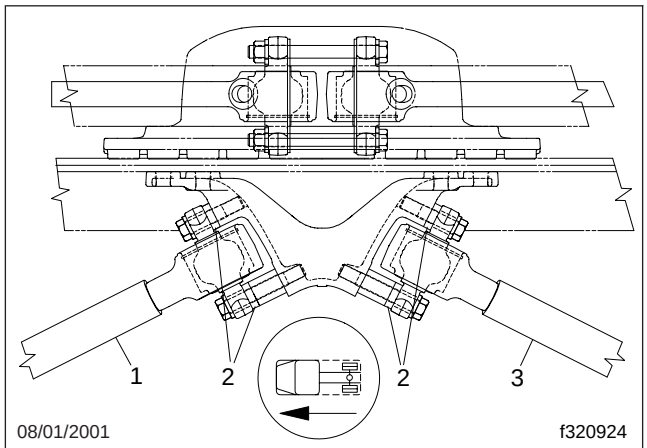
NOTE: planing refers to the angle of the axle from vertical in the side view.

Add or remove shims at the center bracket to change the planing angle. See **Fig. 3**. Unless alignment is required, an equal number of shims should be used left and right for a given axle; example, when adding one shim to the left forward rod add one shim to right forward rod. A shim 0.12 inch thick changes the planing angle 0.3 degrees.

## V-Rods

### Axle Tracking Adjustments

The tracking adjustment of the forward and rear axles is done by adding and/or removing hardened washers between the V-rod bar pin and the frame-mounted bracket. See **Fig. 4**.




1. Forward Rear Axle V-Rod
2. Hardened Washers
3. Rear Rear Axle V-Rod

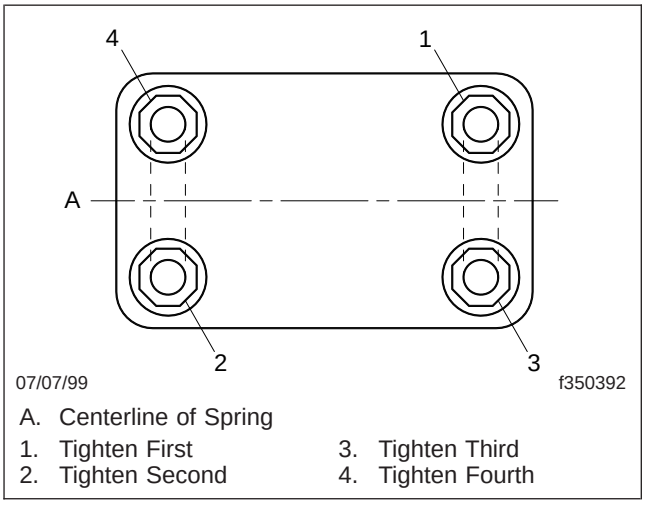
**Fig. 4, V-Rod Hardened Washer Installation**

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| Torque Specifications | |
|---|---|
| **Description** | **Torque Value lbf·ft (N·m)** |
| Shock Absorber Mounting Bolt | 241 (327) |
| Center Bearing Upper Mounting Bolts | 68 (92) |
| Center Bearing Lower Mounting Bolts | 155 (210) |
| Tip Pad Bolts | 37 (50) |
| Rebound Stop Mounting Bolt | 68 (92) |
| Lower Control Rod Mounting Bolts | 136 (184) |
| V-Rod Frame Bracket Mounting Bolts | 136 (184) |
| V-Rod Axle Bracket Mounting Bolts | 427 (579) |
| 5/8–18 Axle Clamp U-Bolt Nuts (tighten as shown in **Fig. 1**) | Stage 1: Hand-Tighten |
| | Stage 2: 60 (81) |
| | Stage 3: 200 (271) |
| 3/4-Inch Spring Pack U-Bolt Nuts | Stage 1: 60 (81) |
| | Stage 2: 200 (271) |
| | Stage 3: 300 (407) |

**Table 1, Torque Specifications**




A. Centerline of Spring
1. Tighten First
2. Tighten Second
3. Tighten Third
4. Tighten Fourth

**Fig. 1, U-Bolt Nut Tightening Sequence**

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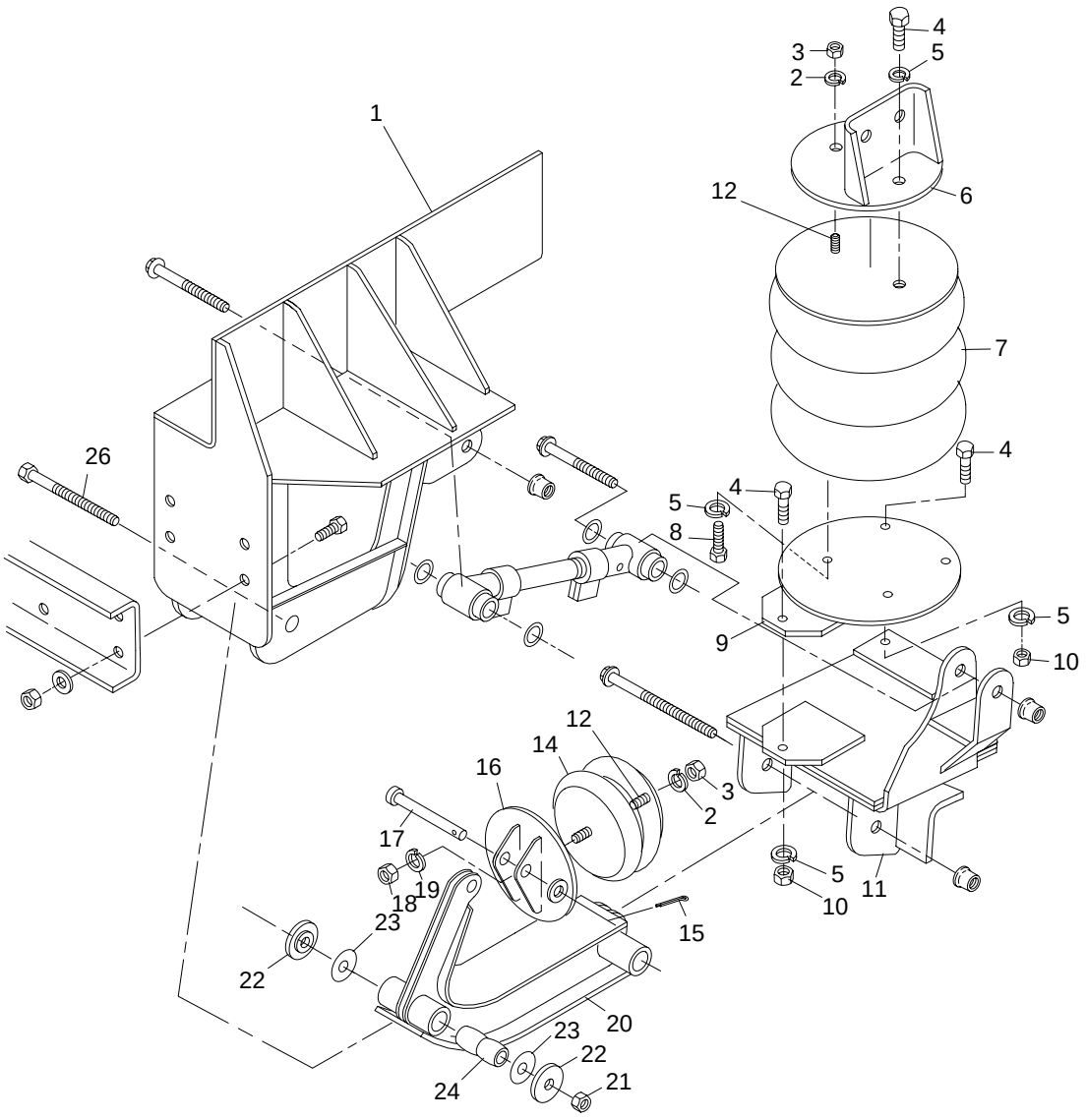
# General Information

The Watson and Chalin SL series steerable axle lift suspension (**Fig. 1**) uses a full-floating air spring design. Two air springs are attached to a trailing arm assembly. One air spring controls the suspension riding height, depending on load requirements, and the other air spring is used to lift the axle assembly when not in use. The trailing arm and air springs are attached to the frame rail with an upper torque rod, and a fastener that rides on a rubber bushing. Weld collars locate the suspension on the frame and hold the axle in alignment.

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## General Information




1. Side Rail Assembly
2. 3/4-Inch Lockwasher
3. 3/4-Inch UNF Hexnut
4. 3/8 x 1-1/8 Inch Capscrew
5. 3/8-Inch Lockwasher
6. Upper Air-Spring Plate
7. Load-Bearing Air Spring
8. 3/8-Inch UNC x 1-Inch Capscrew
9. Lower Air-Spring Plate
10. 3/8-Inch UNF Hexnut
11. Axle Pad Assembly
12. Air Fitting
13. Flatwasher
14. Axle Lift-Air Spring
15. Cotter Pin
16. Lift Plate
17. 3/4-Inch Clevis Pin
18. 1/2-Inch UNC Hexnut
19. 1/2-Inch Lockwasher
20. Trailing Arm
21. 1-1/8 Inch Locknut
22. Weld Collar
23. Washer
24. Bushing

**Fig. 1, Air Spring Replacement, Exploded View**

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# Upper Torque Rod Removal and Installation

## Removal

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. Completely drain all of the air from the air system. The air pressure gauge should read 0 psi (0 kPa).

**⚠ WARNING**

**Failure to drain the air system could result in personal injury, or property damage.**

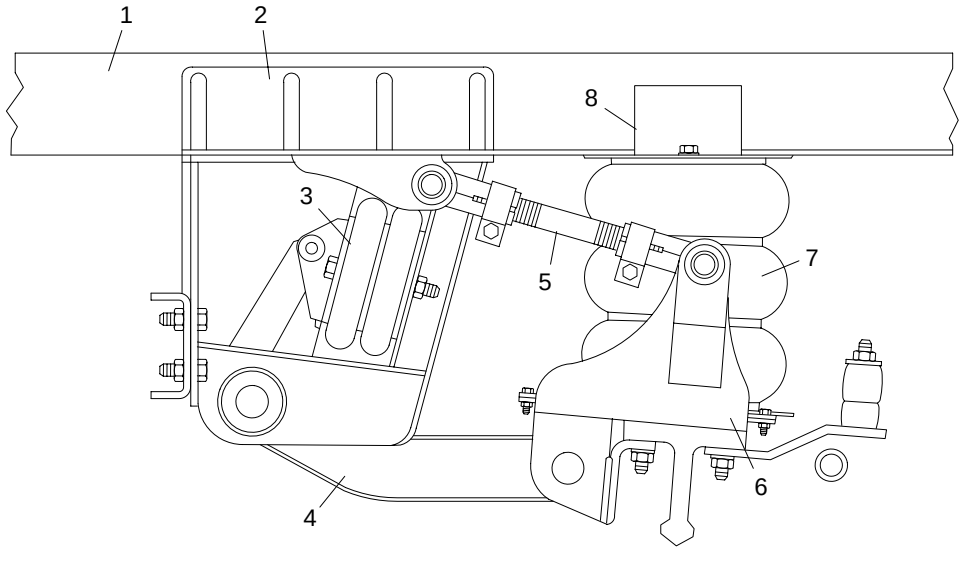
NOTE: If the upper torque rod has been previously serviced, remove the two mounting capscrews, two nuts, and four washers that attach the upper torque rod to the frame rail and axle assembly.

3. Remove the two huck bolts, two huck collars, and four washers that attach the upper torque rod to the frame rail and axle assembly. See **Fig. 1**.
4. Remove the upper torque rod from the vehicle.

## Installation

1. If you are replacing the upper torque rod, measure the length of the old upper torque rod.
2. Duplicate the measurement, as closely as possible, on the new upper torque rod.
3. Install the upper torque rod onto the frame rail and axle assembly using the two capscrews, four washers, and two locknuts. Do not tighten the upper torque rod clamps.

   Use a pipe wrench to align the upper torque rod to the frame hanger and the axle pad assembly.
4. Tighten the capscrew at the frame rail 600 lbf·ft (814 N·m).
5. Tighten the capscrew at the axle assembly 1000 lbf·ft (1356 N·m).
6. Connect a magnetic protractor to the steerable axle.
7. Position the protractor on the axle pad assembly, so it is even with the centerline of the axle and the axle spindle center. See **Fig. 2**.




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1. Frame Rail
2. Side Rail Assembly
3. Axle-Lift Air Spring
4. Trailing Arm
5. Torque Rod
6. Axle Pad Assembly
7. Load-Bearing Air Spring
8. Upper Air-Spring Mounting Plate

**Fig. 1, Watson and Chalin SL Series Steerable Axle Lift Suspension**

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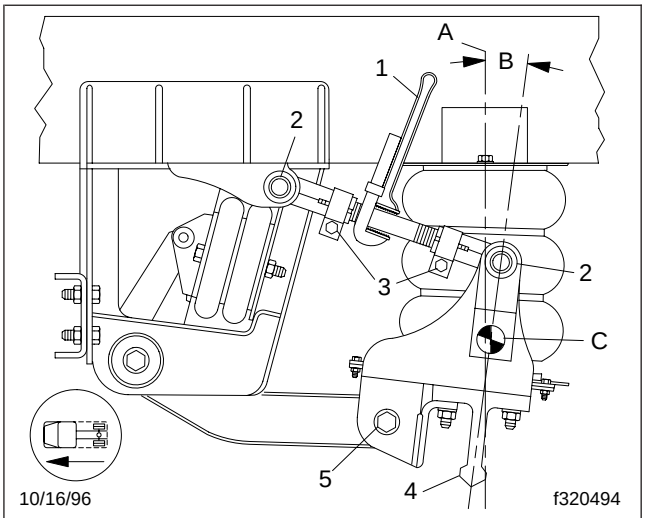
## Upper Torque Rod Removal and Installation

8. Move the protractor to position the centerline of the axle with the centerline of the upper torque rod capscrew. See **Fig. 2**.
9. Record the caster setting. See **Fig. 2**.

NOTE: Check both wheels for proper caster settings.

Caster should be set at 5 to 6 degrees positive. Caster cannot be less than 5 degrees positive.

10. If the caster setting is incorrect, adjust by turning the upper torque rod clockwise, or counterclockwise to achieve the proper caster setting. See **Fig. 2**.
11. Tighten the upper torque rod clamps 600 lbf·ft (814 N·m).
12. Check the toe-in of the axle, using instructions found in **Group 33**.




A. Centerline of Axle
B. Caster Setting
C. Axle Spindle Center
1. Pipe Wrench
2. Huck Collar
3. Upper Torque Rod Clamp
4. Steerable Axle
5. Axle Seat Capscrew

**Fig. 2, Watson and Chalin SL Series Suspension, Adjusting Caster**

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## Inspection

Check the air springs periodically to ensure that there is no dry rot, cracking, deformities, or other damage that could impede the performance of the vehicle.

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. Check the air bags for cracks, deformities, dry-rotting, or other damage. Replace the air bags as needed.
3. Check for obstructions that could cause a breach of the air bag integrity. Reposition any component that is making contact with the air spring.
4. Check that the air system is fully charged, then check the operation of the axle lift air spring. If the axle lift air springs do not operate properly, see **Subject 300** for troubleshooting information.
5. Check the air lines for cracks, deformities, or leaking. Replace the air lines as needed.

## Replacement

**WARNING**

**Before attempting to remove the air springs, be sure that all of the air has been drained from the air system. The air spring will expand suddenly, when removed from its mount, if the air system is not fully drained. This could result in personal injury or property damage.**

### Axle Lift Air Spring

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the wheels.
2. Completely drain all of the air from the air system. The air pressure gauges should read 0 psi (0 kPa).
3. Use a lifting device and elevate the steerable axle.
4. Place jack stands under the axle beam.
5. Remove the cotter pin, washer, and clevis pin from the lift plate. See **Fig. 1**.
6. Remove the air line and fitting from the axle lift air spring.
7. Remove the capscrew, two washers, two washers, and one locknut then lower the trailing arm.
8. Remove the 3/4-inch hexnut and washer; then remove the axle lift air spring.
9. Remove the 1/2-inch hexnut and lockwasher from the lift plate; then separate the axle-lift air spring.
10. Install the axle-lift air spring on the lift plate. Install the 1/2-inch hexnut and lockwasher on the lift plate. Tighten the hexnut 25 lbf·ft (34 N·m).
11. Install the new axle-lift air spring, lockwasher, and 3/4-inch hexnut on the frame hanger. Tighten the hexnut 200 lbf·ft (271 N·m).
12. Raise the trailing arm and insert the clevis pin through the lift plate; then insert and lock a new cotter pin into the clevis pin.
13. Start the capscrew through the frame hanger Position the washers between the frame hanger and the lower trailing arm and the trailing arm. Install the capscrew through the frame hanger and the trailing arm. Install the locknut and tighten it 1000 lbf·ft (1356 N·m).
14. Install the air fittings and the air lines.
15. Remove the jack stands.
16. Start the engine and build up air pressure.
17. Check for air leaks, and check axle lift operation.
18. Remove the chocks from the tires.

### Load Bearing Air Spring

**WARNING**

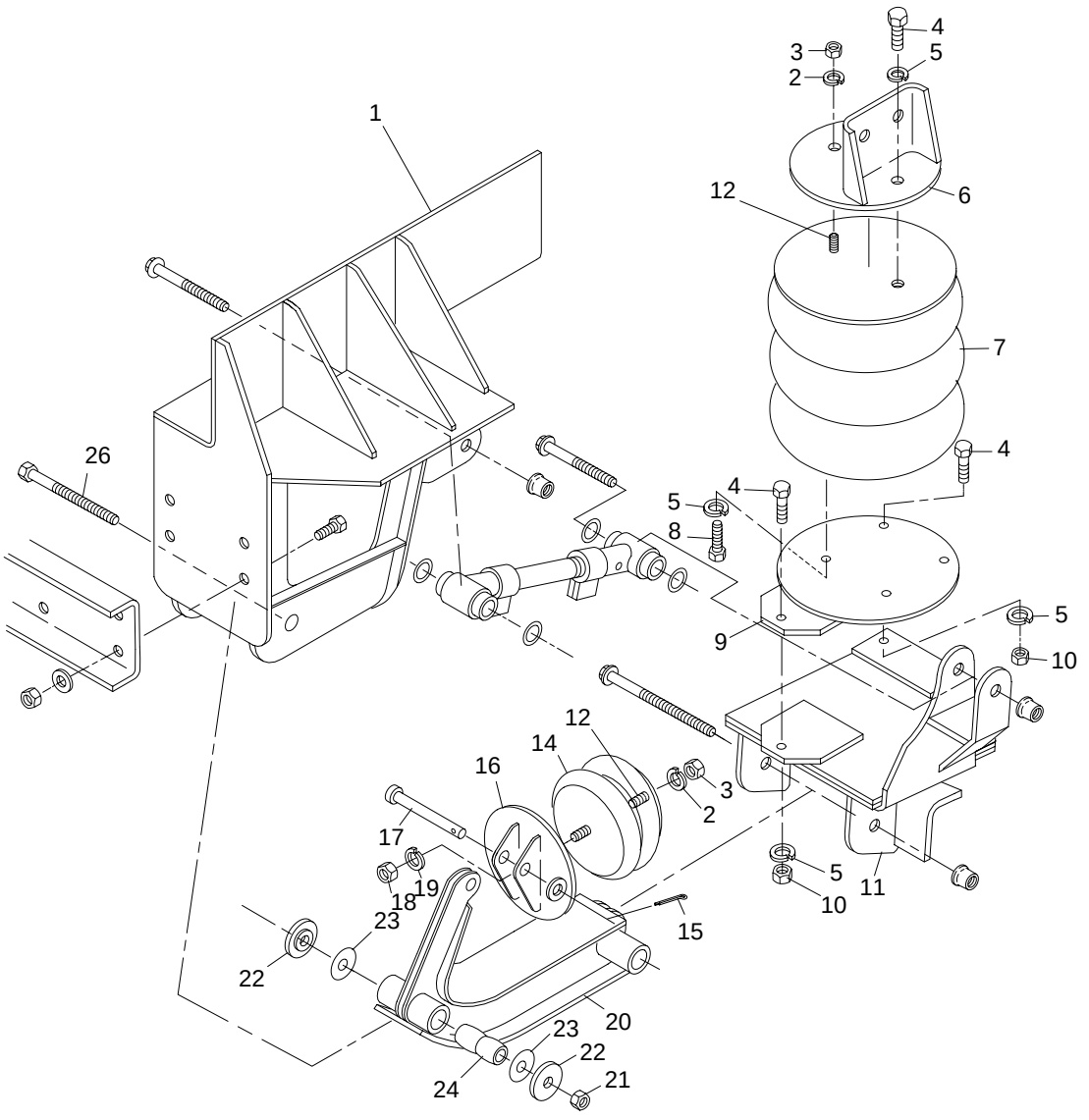
**Before attempting to remove the air springs, be sure that all of the air has been drained from the air system. The air spring will expand suddenly, when removed from its mount, if the air system is not fully drained. This could result in personal injury or property damage.**

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the tires.
2. Completely drain all of the air from the air system. The air pressure gauges should read 0 psi (0 kPa).
3. Remove the air line and fitting.

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## Air Spring Inspection and Replacement




1. Side Rail Assembly
2. 3/4-Inch Lockwasher
3. 3/4-Inch UNF Hexnut
4. 3/8 x 1-1/8 Inch Capscrew
5. 3/8-Inch Lockwasher
6. Upper Air-Spring Plate
7. Load-Bearing Air Spring
8. 3/8-Inch UNC x 1-Inch Capscrew
9. Lower Air-Spring Plate
10. 3/8-Inch UNF Hexnut
11. Axle Pad Assembly
12. Air Fitting
13. Flatwasher
14. Axle Lift-Air Spring
15. Cotter Pin
16. Lift Plate
17. 3/4-Inch Clevis Pin
18. 1/2-Inch UNC Hexnut
19. 1/2-Inch Lockwasher
20. Trailing Arm
21. 1-1/8 Inch Locknut
22. Weld Collar
23. Washer
24. Bushing

**Fig. 1, Air Spring Replacement, Exploded View**

4. Remove the 3/4-inch hexnut and lockwasher from the upper air-spring plate.
5. Remove the 3/8-inch capscrew and lockwasher from the upper air-spring plate.

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6. Remove three 3/8-inch capscrews, hexnuts, and three lockwashers from the rear of the axle pad assembly.
7. Place a pry tool between the upper air-spring plate and the load bearing air spring.
8. Pull down on the pry tool to separate the air spring from the mounting plate, and remove the air spring from the vehicle.
9. Remove two 3/8-inch capscrews and two lockwashers that secure the lower air-spring plate to the air spring. Separate the lower air-spring plate from the air spring.
10. Check the upper and lower air-spring plates for signs of corrosion, cracks, or other damage. Replace any air-spring plate that appears damaged, or excessively corroded.
11. Install the lower air-spring plate on the air spring.
12. Apply a light coating of Loctite® 242 to the threads of the capscrews. Install the capscrews on the air spring and tighten 15 lbf·ft (20 N·m).
13. Install the air spring on the upper air-spring plate and center the lower air-spring plate capscrew holes on the axle pad assembly.
14. Install the three 3/8-inch capscrews, three lockwashers, and three hexnuts on the lower air spring plate. Tighten the capscrews 15 lbf·ft (20 N·m).
15. Install the 3/8-inch x 1-1/8 inch capscrew and lockwasher on the upper air-spring plate. Tighten the capscrew 15 lbf·ft (20 N·m).
16. Install the 3/4-inch hexnut and lockwasher on the upper air-spring plate. Tighten the hexnut 200 lbf·ft (271 N·m).
17. Install the air fitting, then connect the air line to the air springs.
18. Start the engine and build up air pressure. Check for air leaks and repair as needed. See **Subject 300** for troubleshooting information.
19. Shut down the engine and remove the chocks from the tires.

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## Ride Height and Load Capacity Adjustment

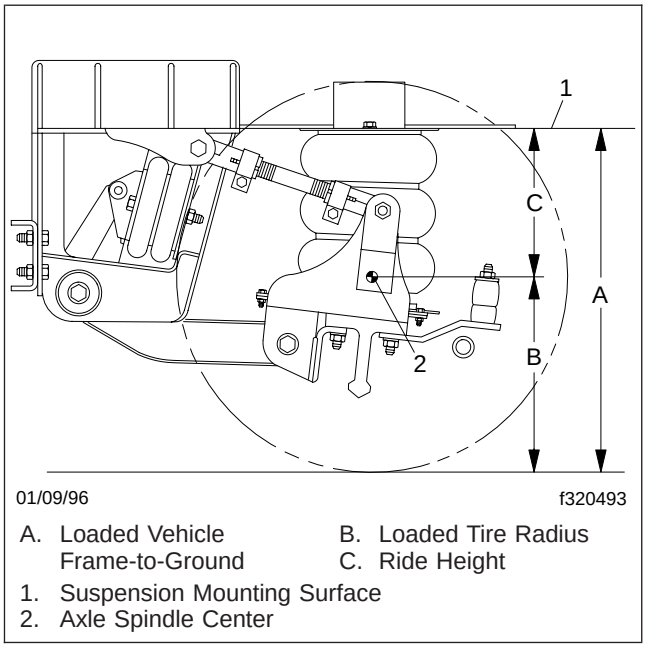
IMPORTANT: It is the responsibility of the vehicle operator to weigh the vehicle to get accurate axle load capacity for the vehicle for legal operation. The amount of air pressure supplied to the lift axle load air spring will vary depending on vehicle load.

## Ride Height

Suspension ride height is defined as the distance between the suspension mounting surface and the spindle center of the auxiliary liftable axle.Suspension ride height must be calculated with the vehicle in its loaded condition.

To check the ride height of the Watson & Chalin SL series suspension, use the following formula: A (loaded vehicle frame-to-ground) – B (loaded tire radius) = C (Ride Height). See **Fig. 1**.

1. Park the vehicle on a level surface. Apply the parking brakes and chock the front tires.
2. Run the engine until pressure in the air brake system exceeds 115 psi (792 kPa). Shut down the engine.
3. Measure the loaded frame-to-ground measurement; the distance from the bottom of the frame rail to the ground, with the vehicle in a loaded condition.
4. Measure the loaded tire radius; the distance from the axle spindle center to the ground, with the vehicle in a loaded condition.
5. Subtract the loaded tire radius from the loaded frame-to-ground measurement to determine ride height.



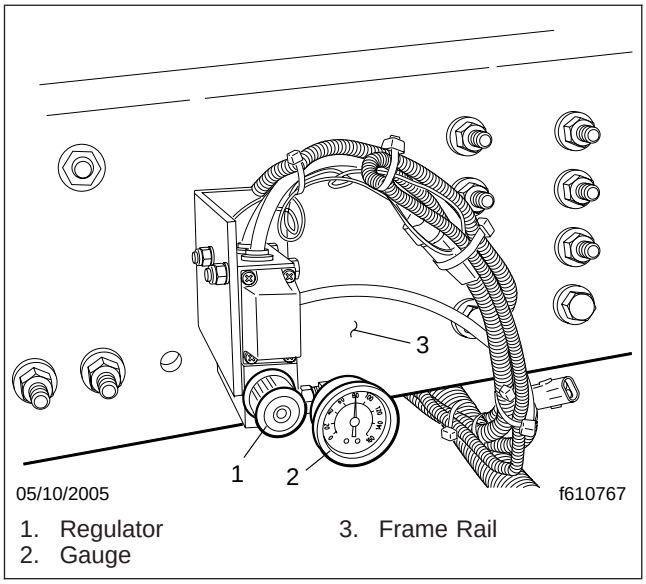

A. Loaded Vehicle Frame-to-Ground
B. Loaded Tire Radius
C. Ride Height
1. Suspension Mounting Surface
2. Axle Spindle Center

**Fig. 1, Watson & Chalin SL Series Suspension, Calculating Ride Height**

## Load Capacity Adjustment

Load capacity can be adjusted by increasing or decreasing the air pressure to the lift air springs. The amount of air pressure varies depending on vehicle load. See **Specifications 400**, for load-to-pressure specifications.

The air pressure to the lift air springs, which is indicated on the gauge located on the frame rail or in the cab, is set by the pressure regulator. See **Fig. 2**. Pressure is increased by turning the knob clockwise, and it is reduced by turning the knob counterclockwise.




1. Regulator
2. Gauge
3. Frame Rail

**Fig. 2, Pressure Regulator and Gauge**

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## Inspection

The Watson & Chalin SL series steerable-axle lift suspension is operated from a control panel consisting of an air pressure gauge, pressure regulator, and a double-pull, double-throw air valve. See **Fig. 1**.

The control panel is designed so the driver can regulate the load pressure in the air springs for the proper, or desired load on the auxiliary axle. It is also designed to lift the auxiliary axle to the UP position when the vehicle load is empty, or the auxiliary axle is not required.

Optionally, an automatic reverse lift can be installed to automatically lift the suspension when the vehicle is shifted into reverse. An automatic reverse lockout will automatically lock the steerable axle to prevent it from turning when the vehicle is shifted to reverse. See **Fig. 2**.

1. Park the vehicle on a level surface. Apply the parking brakes, and chock the front tires.
2. Start the engine and build up air pressure in excess of 80 psi (552 kPa).

**⚠ WARNING**

**Maintain air pressure of 80 psi (552 kPa). Failure to do so could result in brake failure if the suspension system suffered an air loss. This could result in personal injury or property damage.**

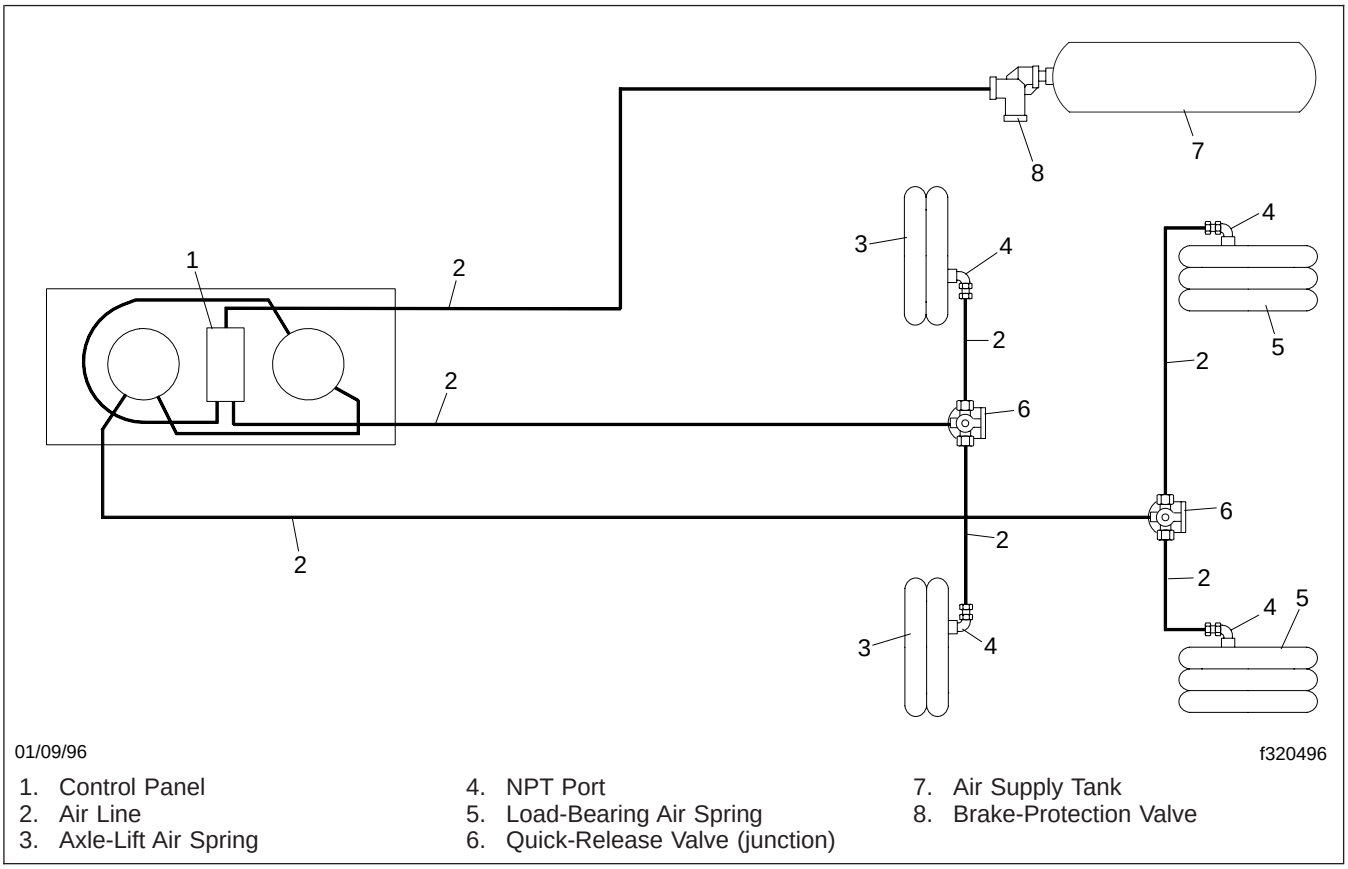
3. Shut down the engine.
4. With a mixture of soap and water, coat the air fitting on the load bearing air springs, axle lift air springs, and at each air line junction.
5. If an air leak exists, air bubbles will form around the area where the leak originated. Repair or replace any leaking air line, fitting, or junction as needed.
6. Inspect the air supply tank for excessive corrosion, dents, or other damage that could weaken the tank. Replace any air supply tank that's damaged.
7. On vehicles equipped with an automatic reverse lift, check the solenoids for proper operation.
   - 7.1 Start the engine and lower the auxiliary axle suspension.
   - 7.2 Shift the transmission to reverse and check the position of the auxiliary axle.

   NOTE: When the shifter is placed in reverse, the steering will lock in a straight-ahead position, and the axle will lift off the ground.
8. If the axle does not lift, shut down the engine and use the following instructions.
   - 8.1 Turn the ignition key ON, but do not start the engine.
   - 8.2 Disconnect the harness connector from the reverse lock-out solenoids.
   - 8.3 With a voltmeter, probe the harness side of the connector. There should be no voltage with the shifter in neutral or any forward gear.
   - 8.4 Do not start the engine. Move the shifter into reverse, and recheck for voltage. When the shifter is in reverse gear there should be 11 to 13 volts at the solenoid. If no voltage is found, trace and correct a short to ground in circuit 120B.
9. Check the air springs for cuts, dry-rotting, deformities, or other damage. Replace the air springs as needed. See **Subject 110**, for replacement instructions.

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## Air System Inspection

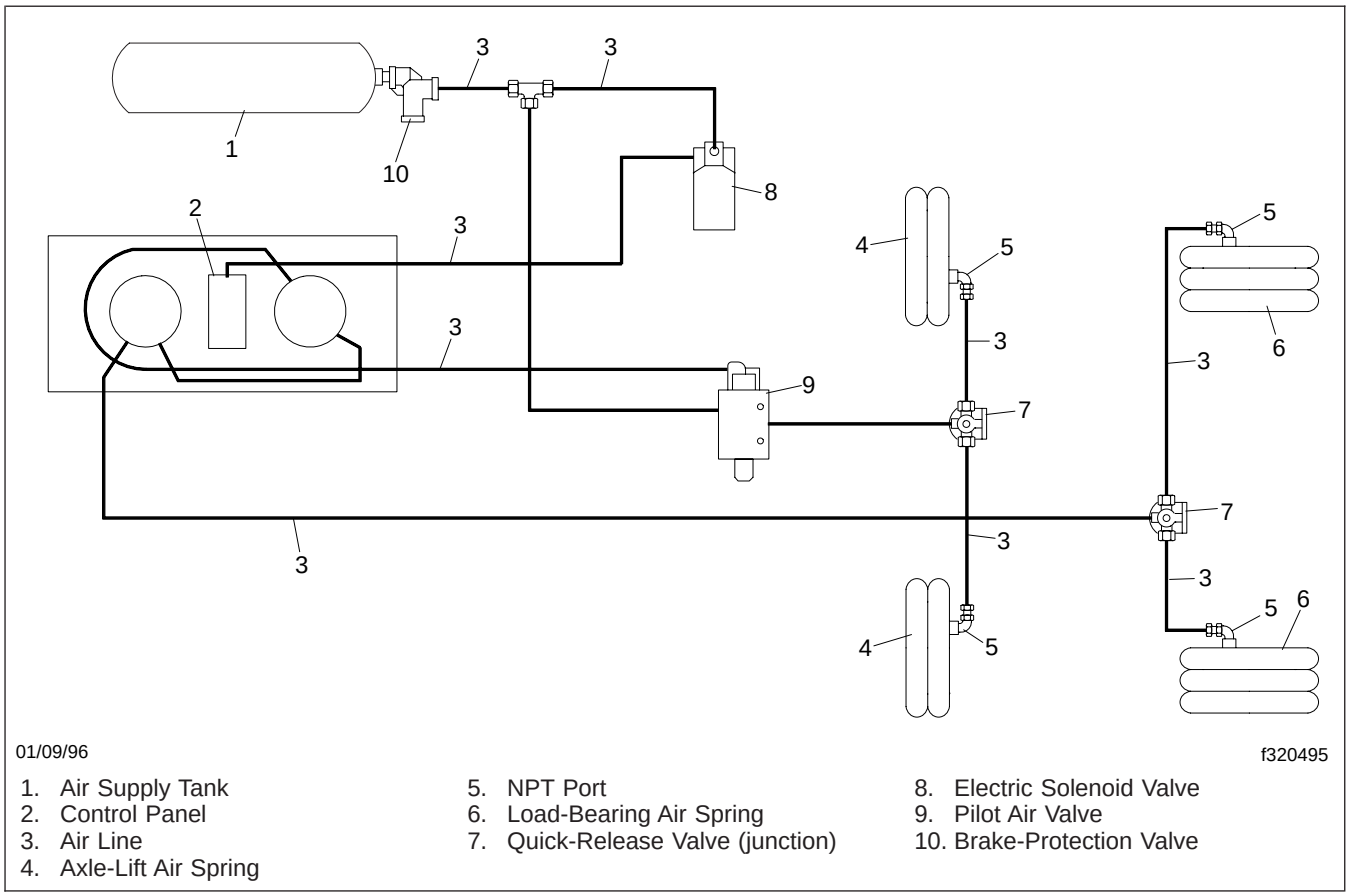



1. Control Panel
2. Air Line
3. Axle-Lift Air Spring
4. NPT Port
5. Load-Bearing Air Spring
6. Quick-Release Valve (junction)
7. Air Supply Tank
8. Brake-Protection Valve

**Fig. 1, Watson and Chalin Suspension with Standard Air Control**

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1. Air Supply Tank
2. Control Panel
3. Air Line
4. Axle-Lift Air Spring
5. NPT Port
6. Load-Bearing Air Spring
7. Quick-Release Valve (junction)
8. Electric Solenoid Valve
9. Pilot Air Valve
10. Brake-Protection Valve

**Fig. 2, Watson and Chalin Suspension with Automatic Reverse Lockout**

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# Troubleshooting Tables

**Problem–Not Getting the Desired Load on Steerable Axle**

| Problem–Not Getting the Desired Load on Steerable Axle | |
|---|---|
| **Possible Cause** | **Remedy** |
| Incorrect air pressure to load the air springs. | Increase or decrease air pressure at regulator valve. |
| Air control system not properly installed. | Check piping of air system. |
| Mounted too high. | Shim axle area. May require lower trailing arm replacement. |

**Problem–Insufficient Air Pressure to Steerable Axle System**

| Problem–Insufficient Air Pressure to Steerable Axle System | |
|---|---|
| **Possible Cause** | **Remedy** |
| Damaged brake protection valve or air compressor. | Replace brake protection valve and check air compressor. |

**Problem–Steerable Axle Not Getting the Correct Lift**

| Problem–Steerable Axle Not Getting the Correct Lift | |
|---|---|
| **Possible Cause** | **Remedy** |
| Axle lift air springs not getting proper air pressure. | Check system pressure, and check air system piping. |
| Interference with chassis, driveline, or other chassis components. | Check for interference, and correct as needed. |
| Unit not properly installed. | Check installation. |
| Lower trailing arm being restricted from full retraction. | Contact Watson and Chalin. |

**Problem–Steerable Axle is Steering in Opposite Direction from Truck**

| Problem–Steerable Axle is Steering in Opposite Direction from Truck | |
|---|---|
| **Possible Cause** | **Remedy** |
| Improper caster setting. | Adjust caster. |

**Problem–Steerable Axle has Vertical Hop**

| Problem–Steerable Axle has Vertical Hop | |
|---|---|
| **Possible Cause** | **Remedy** |
| Insufficient air pressure. | Increase air pressure. |
| Excessive road vibration. | Install vertical shock kit. |

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| Load at Ground lb (kg) | Run Height | | |
|---|---|---|---|
| | 10 Inches psi (kPa) | 11 Inches psi (kPa) | 12 Inches psi (kPa) |
| 5000 (2268) | 29 (200) | 31 (214) | 34 (234) |
| 6000 (2722) | 37 (255) | 39 (269) | 43 (297) |
| 7000 (3175) | 44 (303) | 47 (324) | 52 (360) |
| 8000 (3629) | 52 (360) | 56 (386) | 60 (414) |
| 9000 (4082) | 60 (414) | 64 (441) | 69 (476) |
| 10,000 (4536) | 67 (462) | 72 (496) | 78 (538) |
| 11,000 (4990) | 75 (517) | 80 (552) | 87 (600) |
| 12,000 (5443) | 82 (565) | 88 (607) | 96 (662) |
| 13,000 (5897) | 90 (621) | 97 (669) | 105 (724) |
| 14,000 (6350) | 98 (676) | 105 (724) | 114 (786) |

**Table 1, Load-to-Pressure Ratings for Watson and Chalin SL-1100-SR Suspension**

| Size inch | Torque Rating lbf·ft (N·m) |
|---|---|
| 1/4 | 5 (7) |
| 3/8 | 15 (20) |
| 1/2 | 25 (35) |
| 5/8 | 150 (205) |
| 3/4 | 200 (270) |
| 7/8 | 550 (745) |
| 1 | 600 (815) |
| 1-1/8 | 1000 (1355) |

**Table 2, Bolt Torque Specifications for Watson and Chalin SL-1100-SR suspension**

| Item | Minimum Setting | Variable |
|---|---|---|
| Caster | +5 Degrees | +1 Degrees |
| Toe-In | +1/32-Inch (+0.8 mm) | ±1/32-Inch (±0.8 mm) |

**Table 3, Wheel Caster and Toe-In Specifications**

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# General Information

The Front Airliner Suspension (also referred to as the Hendrickson AIRTEK suspension) is comprised of a front air suspension, and a welded steering axle (Hendrickson STEERTEK), that work together to form an integrated torsion system. See **Fig. 1**. See **Group 33** for Hendrickson STEERTEK front axle information.

## Axle Clamp Group

The clamp group provides four-sided clamping pressure. The clamp group consists of the following:

- top axle wrap
- bottom axle wrap
- top axle wrap liner
- bottom axle wrap liner
- top pad
- 3/4-inch bolts, washers, nylon locknuts

## Air Springs

The air springs are engineered to support 50 percent of the vertical load while providing very low spring rate. The "push-to-connect" air supply design also provides fast and easy installation and removal.

## Leaf Spring Assembly

The leaf springs share loads equally with the air springs. Front and rear bushings are greaseless, and only require periodic inspections.

## Shock Absorbers

The shock absorbers are tuned specifically for the AIRTEK system.

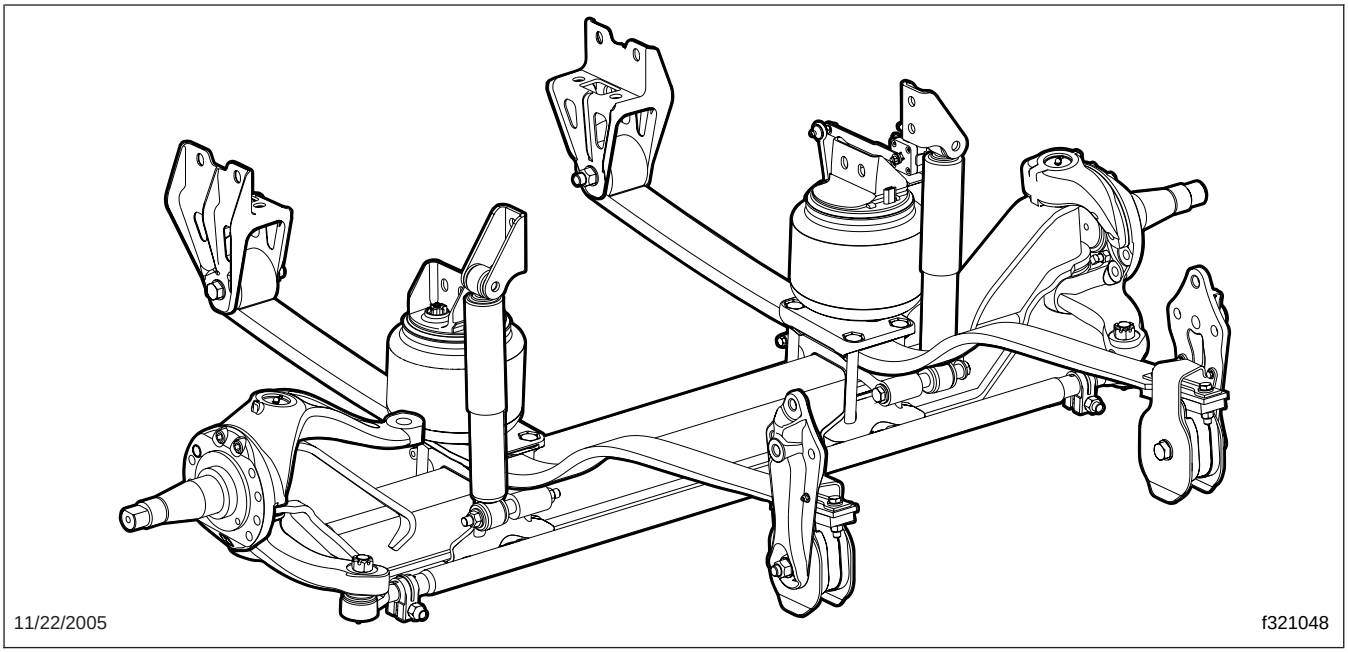



**Fig. 1, Front AirLiner (Hendrickson AIRTEK) Suspension**

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## Ride Height Adjustment

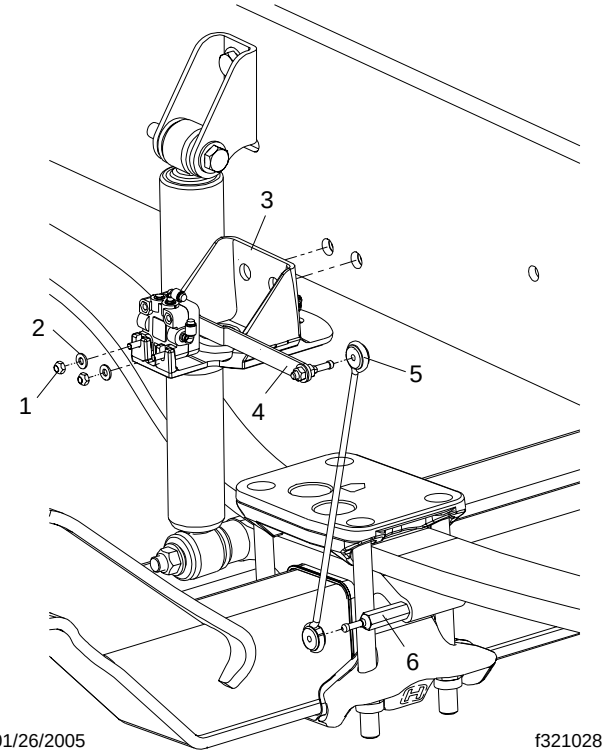
NOTE: As of August 2007, the Front AirLiner Suspension is equipped with dual height-control valves, one on each side of the vehicle. For vehicles with dual valves, inspect and adjust the ride height on both sides of the vehicle.

1. Use a work bay with a level floor. Drive the vehicle slowly, straight ahead. Try to slacken or loosen the suspension as the vehicle is positioned. End with all the wheels positioned straight ahead. Try to roll to a stop without the brakes being used.
2. Shut down the engine, then chock the tires. Do not set the parking brakes.
3. To ensure that the vehicle is level, check the tire pressure. The air pressure in both front tires should match.
4. Disconnect the vertical linkage from the stud on the horizontal control lever, and exhaust the suspension air by lowering the lever; see **Fig. 1**. If equipped with dual height-control valves, repeat for the other side of the vehicle.

NOTE: It is very important that the height-control valve be cycled completely before and after any ride height adjustments. This cycling of the height-control valve will help to make the adjustment as accurate as possible.

5. Attach the linkage to the stud on the horizontal control lever, and allow the suspension system to fill with air. If equipped with dual height-control valves, repeat for the other side of the vehicle. Wait until the airflow to the front air springs has stopped.
6. Measure the suspension ride height of the front axle. If equipped with dual height-control valves, measure the ride height on both sides of the vehicle.

   Using a Hendrickson AIRTEK height gauge, literature no. 45745-159, hold the gauge vertically and place it so the upper notch feature is between the height-control-valve mounting bolts, and sits flush against the bottom of the air-spring bracket; see **Fig. 2**. The piston-flange edge should contact the lower region marked "ACCEPTABLE."




1. 1/4-Inch Locknut
2. 1/4-Inch Washer
3. Air Spring Hanger
4. Horizontal Control Lever
5. Vertical Linkage
6. Link Mount

**Fig. 1, Height-Control Valve Linkage**

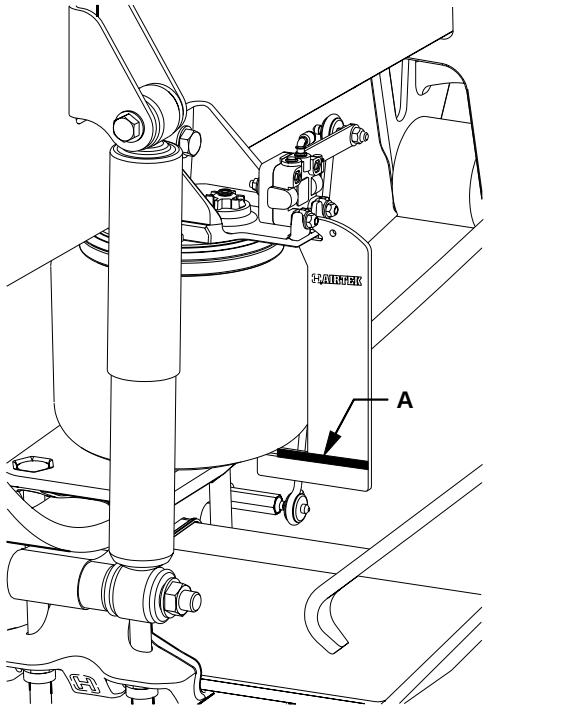
   If the flange edge contacts at the "BELOW SPEC" region, the ride height is set too low. If the flange contacts at the "ABOVE SPEC" region, the ride height is set too high.

   If a gauge is not available, measure the vertical distance from the bottom of the upper air-spring bracket to the bottom of the air-spring piston flange. This distance should be between 7-3/4 and 8 inches (197 and 203 mm).
7. If the suspension ride height is not within specification, disconnect the vertical linkage from the horizontal control lever, fill and exhaust the suspension system, then fill the system until the suspension is at the proper ride height.
8. Move the control lever to the neutral position, then hold it in position by inserting a 5/32-inch

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## Ride Height Adjustment




A. Acceptable Range

**Fig. 2, Using the Ride Height Gauge**

(4-mm) pin or drill bit into the holes in the control lever and valve body.

### NOTICE

**When loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.**

9. While holding the height-control valve mounting studs in place with an Allen wrench, loosen the valve mounting just enough to allow movement of the height-control valve.
10. Adjust the height-control valve by rotating the valve body until the rubber grommet at the upper end of the vertical linkage lines up with the stud on the horizontal control lever.
11. Make sure the height-control valve stays in position. If necessary, hold the height-control valve mounting studs in place with an Allen wrench, and tighten the nuts slightly. Do not tighten the locknuts to the specified torque until after the proper ride height is verified.
12. Remove the pin or drill bit from the holes in the control lever and valve body.
13. Detach the linkage from the stud on the horizontal control lever, and exhaust the suspension system air, then attach the linkage to the stud on the horizontal control lever, and fill the suspension system with air. Wait until the airflow to the front air springs has stopped.
14. Measure the suspension ride height again. If necessary, repeat 6 through 14.
15. Once the proper ride height is attained, tighten the valve mounting locknuts 95 lbf·in (1100 N·cm), while holding the height-control valve mounting studs in place with an Allen wrench. Do not overtighten.

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## Height-Control Valve Test

It is normal to hear air escaping from the height-control valve for as much as 10 minutes after getting out of the vehicle when it is in an unladen condition. This air "leaking" is just the height-control valve exhausting air from the suspension air springs in order to return to the neutral mode.

The height-control valves used on the Western Star are Barksdale valves. Two methods are available to check the operation of the Barksdale height-control valves. A leak in the valve may be discovered without using a test kit, but a test kit is necessary to determine if the valve has an unacceptable rate of leakage.

Some Barksdale height-control valves have been returned for warranty because the four bolts in the valve housing were overtightened, often, enough to crack the valve housing. These bolts should not be loose, and should not normally require tightening, as there are no serviceable parts in the valve.

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing if you detect leaks in the housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

### NOTICE

**When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.**

### Checking the Height-Control Valve Without Using a Test Kit

1. Apply the parking brakes and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa).
3. Shut off the engine and wait 5 to 10 minutes for the air suspension system to equalize.

NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal, and does not indicate a defective valve.

4. Disconnect the vertical linkage from the control lever; see **Fig. 1**.
5. Pull the control lever up about 45 degrees for 6 to 8 seconds. If air passes through the valve, that section of the valve is working.
6. Return the control lever to the neutral position. Air should stop flowing. If so, that section of the valve is working.
7. Push the control lever down about 45 degrees for 6 to 8 seconds. If air exhausts from the valve, that section of the valve is working.
8. Return the control lever to the neutral position. If the air stops again in the neutral position, the valve is working correctly.
9. If the valve works as stated in all of the above steps, then no further checking is necessary. Connect the vertical linkage to the control lever, then tighten the linkage nut.

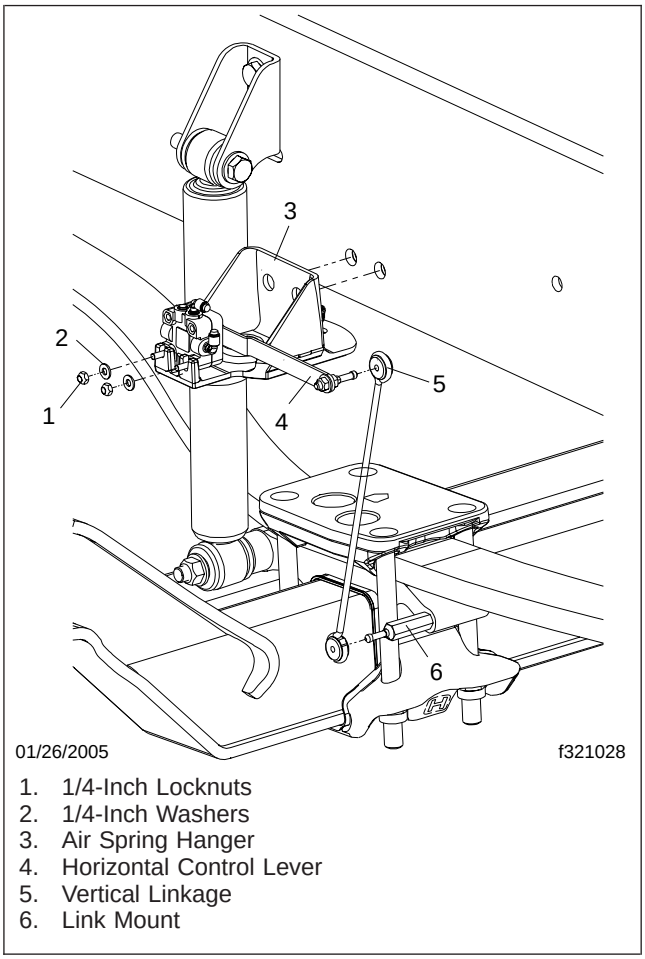
   If needed, adjust the ride height or replace the height-control valve. For adjustment of the ride height, see **Subject 100**. For replacement of the height-control valve, see "Height-Control Valve Replacement" below.

NOTE: If a leak is detected on a Barksdale height-control valve, go to "Checking a Barksdale Height-Control Valve Using a Test Kit". Barksdale valves have an acceptable leak rate of 3 cubic inches (50 cc) per minute. You can

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## Height-Control Valve Test and Replacement




1. 1/4-Inch Locknuts
2. 1/4-Inch Washers
3. Air Spring Hanger
4. Horizontal Control Lever
5. Vertical Linkage
6. Link Mount

**Fig. 1, Height-Control Valve Linkage**

determine if a leak is acceptable only by using the Barksdale test kit.

## Checking the Height-Control Valve Using a Test Kit

IMPORTANT: The procedure described below is for use on Barksdale height-control valves only.

NOTE: The Barksdale field test kit is designed to be used with the height-control valve installed on the vehicle. Refer to **Specifications 400** for information on ordering the Barksdale height-control valve test kit KD2264.

1. If not already done, park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa).
3. Shut off the engine and wait 5 to 10 minutes for the air suspension system to equalize.

NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal, and does not indicate a defective valve.

4. For valves without an integral dump port, go to the next step.

   For valves with an integral dump port, check the rubber exhaust flapper at the back of the valve housing for leaks; see **Fig. 2**. Use a soapy solution.

   If a leak is found, there may be contaminants blocking the piston. Cycle the height-control valve switch inside the cab for two-second bursts, four or five times, to clear away any contaminants.

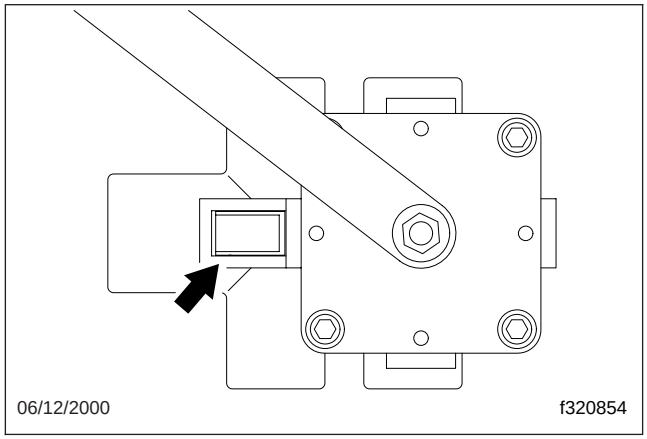



**Fig. 2, Exhaust Flap Location (height-control valve with integral dump port)**

5. Disconnect the vertical linkage from the horizontal control lever.
6. Rotate and hold the horizontal control lever down at about 45 degrees to exhaust air from the air springs.
7. *If equipped with an integral dump port,* turn on the quick dump switch on the dash. Leave the switch on until testing is complete.

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*If not equipped with an integral dump port,* disconnect the air lines from the air spring ports on the height-control valve. Leave the elbow fittings (if equipped) in place. Install a Parker plug into each air spring port (or elbow fitting); see **Fig. 3**.

8. If a flapper is present on the exhaust port of the height-control valve, remove it using needlenose pliers.
9. Clean the surface around the exhaust port, then install the test fitting into the exhaust port. The centering pin on the fitting must align with the slot on the exhaust port. Rotate the test fitting 45 degrees clockwise to lock it in place; see **Fig. 3**.

NOTE: It may be necessary to cut the tie straps that hold the chassis wiring running below the height-control valve, in order to access the exhaust port.

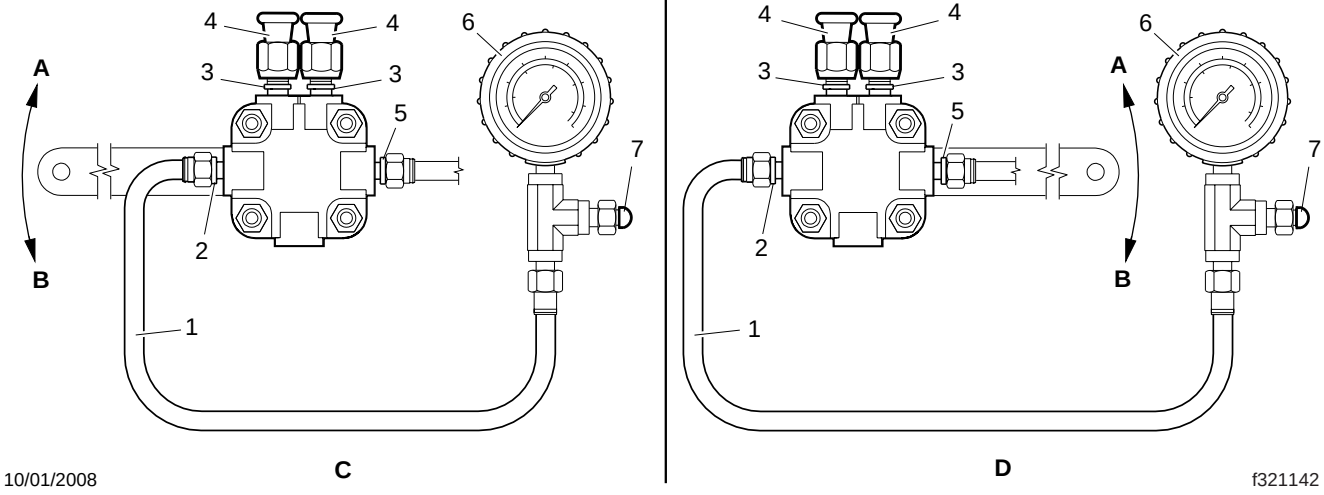
10. Connect one end of the air hose from the kit to the test connector on the exhaust port, and the other end to the test gauge.
11. Check the height-control valve in the fill mode, as follows.
    - 11.1 Rotate the valve control lever up 45 degrees from the horizontal to the fill position.
    - 11.2 Press the reset button on the test gauge.
    - 11.3 Observe the test gauge for 30 seconds. Refer to **Fig. 4** for the maximum allowable exhaust pressure change versus inlet pressure.

      The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

      If the gauge reads less than the maximum allowable pressure change in 30 seconds, the valve is okay.

NOTE: The test gauge will register the exhausting air. *This does not indicate a defective valve.*

12. Check the height-control valve in the exhaust mode, as follows.
    - 12.1 Rotate the valve control lever down 45 degrees from the horizontal to the exhaust position.




A. Fill
B. Exhaust
C. Left-Hand Valve
D. Right-Hand Valve
1. Air Line
2. Exhaust Port Test Fitting
3. Air Spring Port
4. Parker Plug
5. Air Intake Port
6. Test Gauge Assembly
7. Reset Button

**Fig. 3, Test Connections**

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## Height-Control Valve Test and Replacement

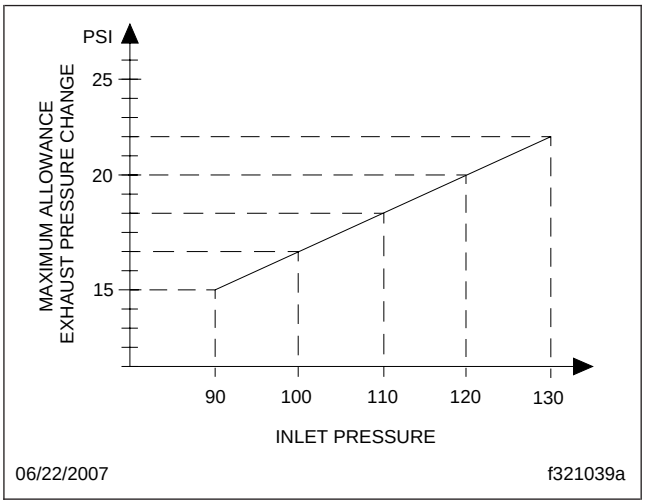



**Fig. 4, Inlet Pressure vs. Exhaust Pressure Change in 30 Seconds**

12.2 Press the reset button on the test gauge.

12.3 Observe the test gauge for 30 seconds. Refer to **Fig. 4** for the maximum allowable exhaust pressure change versus inlet pressure.

The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

If the gauge reads less than the maximum allowable pressure change in 30 seconds, the valve is okay.

NOTE: The test gauge will register the exhausting air. *This does not indicate a defective valve.*

13. Disconnect the test gauge and connector from the valve exhaust port.
14. If the height-control valve is defective, replace it; see "Height-Control Valve Replacement" below.
15. Install the flapper on the exhaust port by pressing it into place.
16. *For height-control valves with an integral dump port,* connect the vertical linkage to the height-control valve control lever. Turn off the quick dump switch on the dash. The ride height will automatically return to the correct position.

    *For height-control valves without an integral dump port,* remove the two Parker plugs from the air spring ports, and connect the air lines to the air spring ports (or elbow fittings). Connect the vertical linkage to the height-control valve control lever. The ride height will automatically return to the correct position.

## Height-Control Valve Replacement

1. Apply the parking brakes and chock the tires.

**WARNING**

**Keep your hands and all objects away from the area under and around the slack adjusters and suspension components when removing the pressure from the air system. These parts will move as the air is released and can cause personal injury or damage to any objects that are between the moving parts.**

2. Drain the air from the secondary air tank.

**WARNING**

**Air lines can whip dangerously if disconnected under pressure. Drain all air from the secondary air tank before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.**

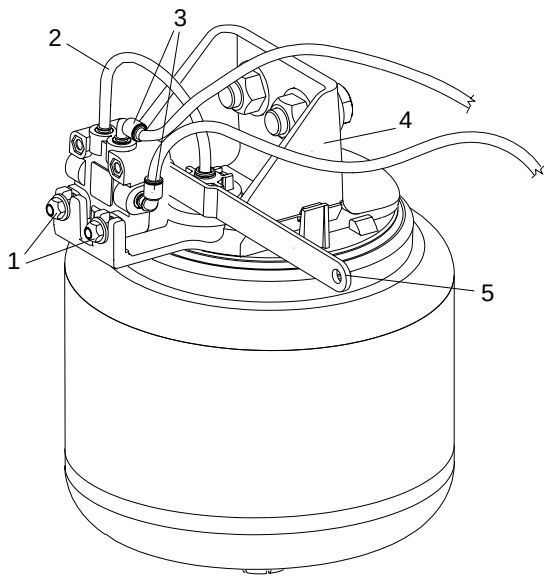
3. Disconnect the vertical linkage, then lower the control lever to exhaust the air.
4. Remove the air lines from the height-control valve; see **Fig. 5**. Push in on the air line to release the tension, then push down on the collar and pull out the air line.

**NOTICE**

**When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.**

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1. 1/4-Inch Locknuts
2. 1/4-Inch Nylon Air Line
3. Quick-Connect Fittings
4. Air-Spring Hanger Bracket
5. Horizontal Control Lever

**Fig. 5, Height-Control-Valve Components**

5. While holding the height-control valve mounting studs in place with an Allen wrench, remove the nuts and washers that attach the valve to the air-spring hanger bracket. Remove the height-control valve.
6. Position the new height-control valve on the hanger bracket, parallel to the flange. While holding the height-control mounting studs in place with an Allen wrench, install the nuts and washers. Do not tighten the locknuts to the specified torque until after the proper ride height is attained.

IMPORTANT: When replacing or installing nylon air lines on quick-connect fittings, it is critical that the end of the air line is cut square. An improper cut can cause the air line to seat improperly in the quick-connect fitting, allowing air leakage.

7. Install the air lines on the height-control valve.
8. Attach the vertical linkage to the horizontal control lever and the linkage mount.
9. Adjust the height-control valve to the proper specifications; see **Subject 100**.
10. While holding the height-control mounting studs in place with an Allen wrench, tighten the height-control valve mounting locknuts 95 lbf·in (1100 N·cm). Do not overtighten.

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## Shock Absorber Removal and Installation

# Removal

**CAUTION**

**Anytime the front axle on an AIRTEK suspension is suspended, it is mandatory that the shock absorbers remain connected. The shock absorbers are the rebound travel stops for the springs. Failure to do so could cause the air springs to exceed their maximum length, causing the air springs to separate from the piston, or reverse arch the steel leaf springs. This could result in premature steel leaf spring failure.**

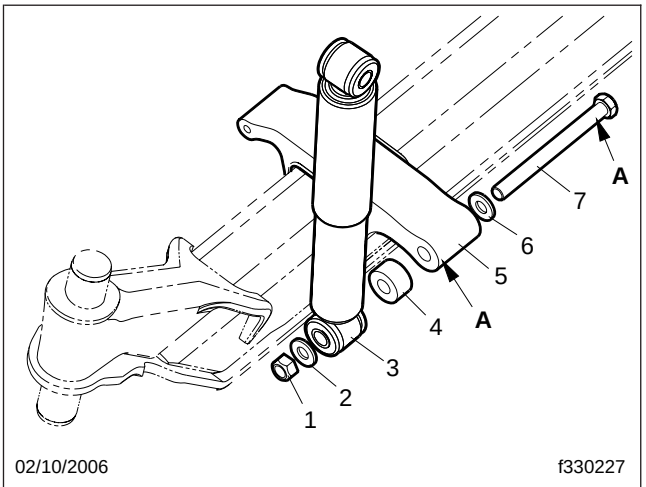
1. Set the parking brake, and shut down the engine. Chock the tires.

NOTE: It is not necessary to replace the shock absorbers in pairs if only one shock absorber requires replacement.

2. Remove the shock absorber lower mounting bolt, spacer, washers, and locknut.
3. Remove the shock absorber upper mounting bolt, washers, and locknut, then remove the shock absorber.
4. Inspect the shock absorber mounting brackets and hardware for damage or wear. Replace as necessary.

# Installation

1. Place the shock absorber into the upper mounting bracket.
2. Install the shock absorber upper mounting bolt, washers, and locknut.
3. Apply a thin coating of antiseize compound to the shank of the shock absorber lower mounting bolt, the mating surfaces of the axle wrap and spacer, and the inside bore of the aluminum axle wrap. This is necessary to help prevent the bolt from seizing to the aluminum axle wrap. See **Fig. 1**.
4. Install the lower bolt from the inboard side of the axle wrap to the outboard side, then install the spacer, washers, and locknut.
5. Tighten both of the shock absorber mounting locknuts 225 to 255 lbf·ft (305 to 345 N·m).




A, Apply a thin coating of antisieze compound to the shock absorber lower mounting bolt shank, the mating face of the axle wrap, the spacer, and to the inside bore of the aluminum top axle wrap.

1. 3/4-Inch Locknut
2. 3/4-Inch Washer
3. Shock Absorber
4. Spacer
5. Top Axle Wrap
6. 3/4-Inch Washer
7. 3/4–10 Bolt

**Fig. 1, Shock Absorber Installation**

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## Removal

1. Set the parking brake, and shut down the engine. Chock the tires.
2. Deflate the air springs by disconnecting the height-control-valve linkage and lowering the control arm to exhaust the air pressure. Disconnect the air lines at the air springs.

**⚠ WARNING**

**Failure to deflate and disconnect the air system prior to raising the front of the vehicle may result in sudden failure of the air spring, resulting in personal injury or property damage.**

3. Raise the vehicle and support the frame with stands.
4. Separate the air spring from the upper air-spring bracket by applying downward pressure on the air spring, pushing outward on the lock tabs outside the bracket, and inward on the inlet lock tabs to dislodge the air spring from the upper air-spring bracket. See **Fig. 1**. See **Fig. 2** for lock tab locations.

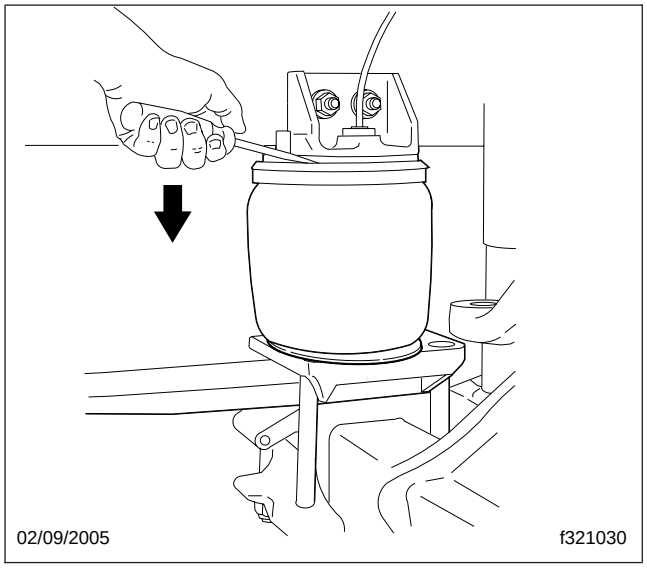
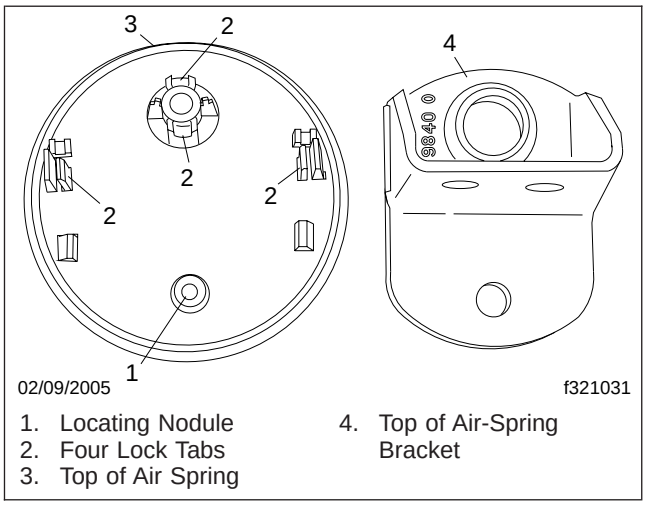



**Fig. 1, Upper Air Spring Bracket**

5. Apply upward pressure between the base of the air spring and the top-pad casting. This will dislodge the air spring from the top-pad casting. See **Fig. 3**.




1. Locating Nodule
2. Four Lock Tabs
3. Top of Air Spring
4. Top of Air-Spring Bracket

**Fig. 2, Air Spring Mounting**

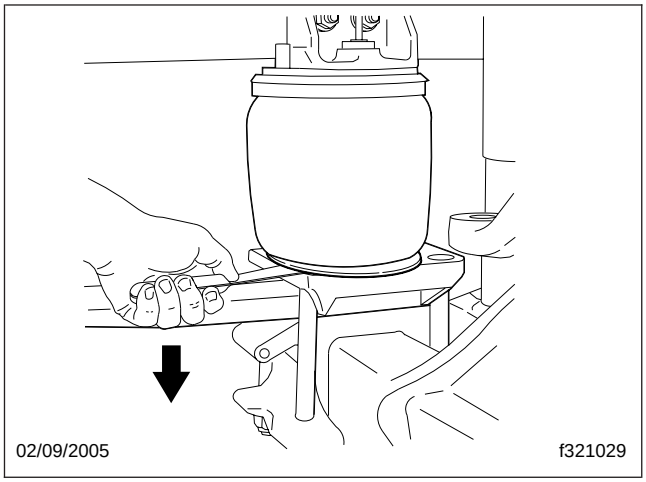



**Fig. 3, Base of the Air Spring**

6. Pull the air spring out from between the upper bracket and the top pad casting.

## Installation

**⚠ CAUTION**

**If the air spring will be re-installed, inspect the lock tabs for damage or cracks prior to installation. Damaged lock tabs may allow the air spring to become dislodged during operation, resulting in loss of vehicle control.**

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## Air Spring Removal and Installation

1. Insert the air spring into the top-pad casting. Make sure the lock tabs click in place.
2. Compress the air spring and slide it into position. Using the locating nodule, index the air spring position to the upper air-spring bracket.
3. Pull the air spring up into the upper air-spring bracket until the air spring snaps into place. Verify that all four lock tabs are engaged. See **Fig. 2**.

NOTE: When replacing or installing nylon air line tubing into quick-connect fittings, it is critical that the end of the air line is cut square. An improper cut can cause the air line to seat improperly in the quick-connect fitting, allowing air leakage.

4. Install the air lines on the air spring.
5. Inflate the air springs and check for leaks.
6. Lower the frame.
7. Charge the suspension system with air.

**⚠ WARNING**

**Before charging the suspension system with air, make certain the air-spring locator is indexed into the upper air-spring bracket, the lock tabs are snapped into place, and that the air spring is fully seated. Failure to follow these instructions could result in premature air-spring failure, which could result in personal injury or property damage.**

8. Check the ride height and adjust it if necessary. See **Subject 100** for instructions.
9. Remove the chocks.

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## Spring-Eye Bushing Replacement and Spring Eye Retorque

The spring-eye bushing for the front AirLiner suspension is designed for the life of the spring. If a premature failure occurs, careful consideration must be given to the contributing factor that made the bushing fail. This must be corrected in order to prevent the new bushing from failing in the same manner. It is recommended that in the event of a high-mileage bushing failure that the front leaf spring be replaced.

# Spring-Eye Bushing Replacement

Remove the front spring, following the procedure in **Subject 150**. Once the leaf spring is removed from the chassis, it will be necessary to use:

- A hydraulic press with an operating capacity of a minimum of 10,000 lb (4500 kg).
- A receiving tool.
- A removal and installation driver.

**⚠ WARNING**

**Do not use heat or a cutting torch to remove the bushing from the steel spring. The use of heat can adversely affect the strength of the spring. A component damaged in this manner can result in a loss of vehicle control, and possible personal injury or property damage.**

1. Support the spring, and center the spring-end hub on the receiving tool. The leaf spring must be level to distribute the vertical-pushing load equally on the bushing.
2. Place the center of the bushing driver on the spring-eye bushing. See **Fig. 1**.
3. Pushing directly on the driver, press out the spring-eye bushing until it clears the spring-eye bore.
4. Inspect the spring eye for any cracks or burrs. If cracks are present, install a new leaf spring.
5. Remove any nicks or burrs with an emery cloth or a rotary sander.
6. Lubricate the inner diameter of the spring bore, and the new rubber bushing, with a vegetable-based oil (cooking oil). Do not use petroleum- or soap-based lubricant. They can cause an adverse reaction with the spring-eye material.

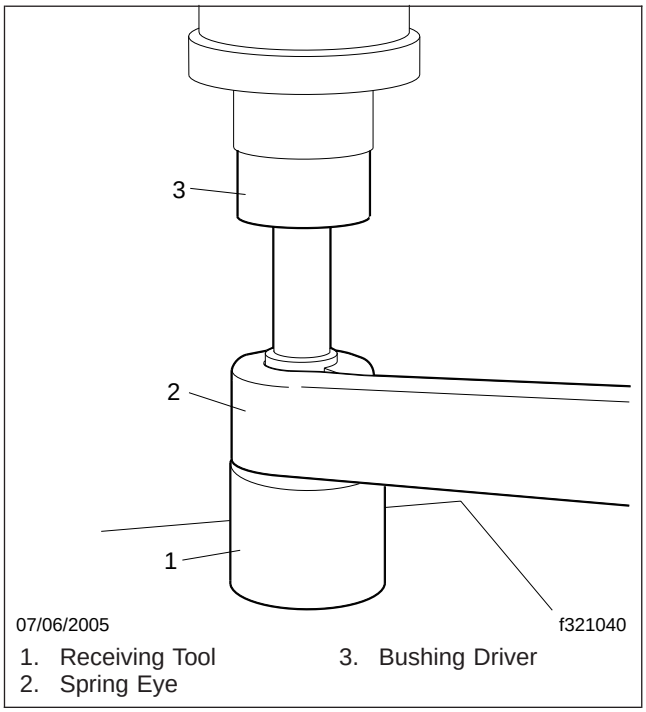



**Fig. 1, Removing the Spring-Eye Bushing**

7. Cut a strip of 3M Scotch® 890T black-fiber tape (duct tape or equivalent) 1-inch (25-mm) wide by 6-inches (150-mm) long.
8. Feed the tape into the spring eye, with the adhesive side facing the gap in the eye, to cover the sharp edge. Center the tape equally around each end.
9. Support the spring, and center it on the receiving tool.
10. Center the new bushing on the spring-eye bore, and line up the hydraulic press.
11. Press the bushing into the spring-eye bore, overshooting the desired final position by approximately 3/16 inch (5 mm). Press the bushing again from the opposite side, to center it in the spring-eye bore.
12. Once the bushing is installed, follow the instructions for the front leaf-spring installation in **Subject 150**.

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# Spring-Eye Bushing Replacement and Spring Eye Retorque

## Spring-Eye Retorque

NOTE: This procedure is also necessary when replacing the front or rear hanger brackets, or the steel leaf spring.

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the tires.
2. Deflate the air springs by disconnecting the height-control-valve linkage and lowering the control arm to exhaust the air pressure.

**⚠ WARNING**

**Failure to deflate and disconnect the air system prior to raising the front of the vehicle may result in sudden failure of the air spring, resulting in personal injury or property damage.**

IMPORTANT: Push-to-connect fittings are not serviceable. Clean dirt and debris away from the fittings to prevent foreign materials from entering the air system, or damaging the fittings. Clean the push-to-connect fittings using soapy water and a soft-bristled brush, then dry with compressed air.

3. Disconnect the air lines at the air springs.
4. Raise the vehicle and support the frame with stands.

**⚠ WARNING**

**The shock absorbers must remain connected when the front axle is suspended. The shock absorbers are the rebound travel stops for the springs. Disconnecting the shock absorbers could cause the air springs to exceed their maximum length, causing the air springs to separate from the piston, or reverse arch the steel leaf springs, which may result in premature steel leaf spring failure.**

5. Lower the front axle. Allow at least 3 inches (76 mm) of wheel clearance to the ground. The shock absorbers must be connected. DO NOT reverse arch the springs.
6. Loosen all four front and rear spring-eye bolts. See **Fig. 2**. The suspension may drop down slightly.

IMPORTANT: DO NOT remove the spring-eye bolts. The tires must not contact the ground.

7. Allow the suspension to settle.
8. Tighten the 3/4-inch locknuts on the front and rear spring-eye bolts 285 to 305 lbf·ft (385 to 415 N·m).
9. Raise the front axle and remove the frame stands.
10. Lower the vehicle.
11. Check the air springs to verify that they are seated properly, and install the air lines into the air springs.
12. Connect the height-control valve and charge the air system.
13. Affix a long straightedge to the bottom of the frame rails, in front of the air springs.
14. With the vehicle on a level surface, measure the distance from the top of the straightedge to the ground on both sides of the vehicle. Record the measurements.
15. Determine the difference from one side to the other. Remove the straightedge.
16. Perform a road test and repeat the previous three steps.
17. If the the difference in measurements is more than 3/8 inch (9.5 mm), contact Hendrickson Tech Services.

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## Spring-Eye Bushing Replacement and Spring Eye Retorque

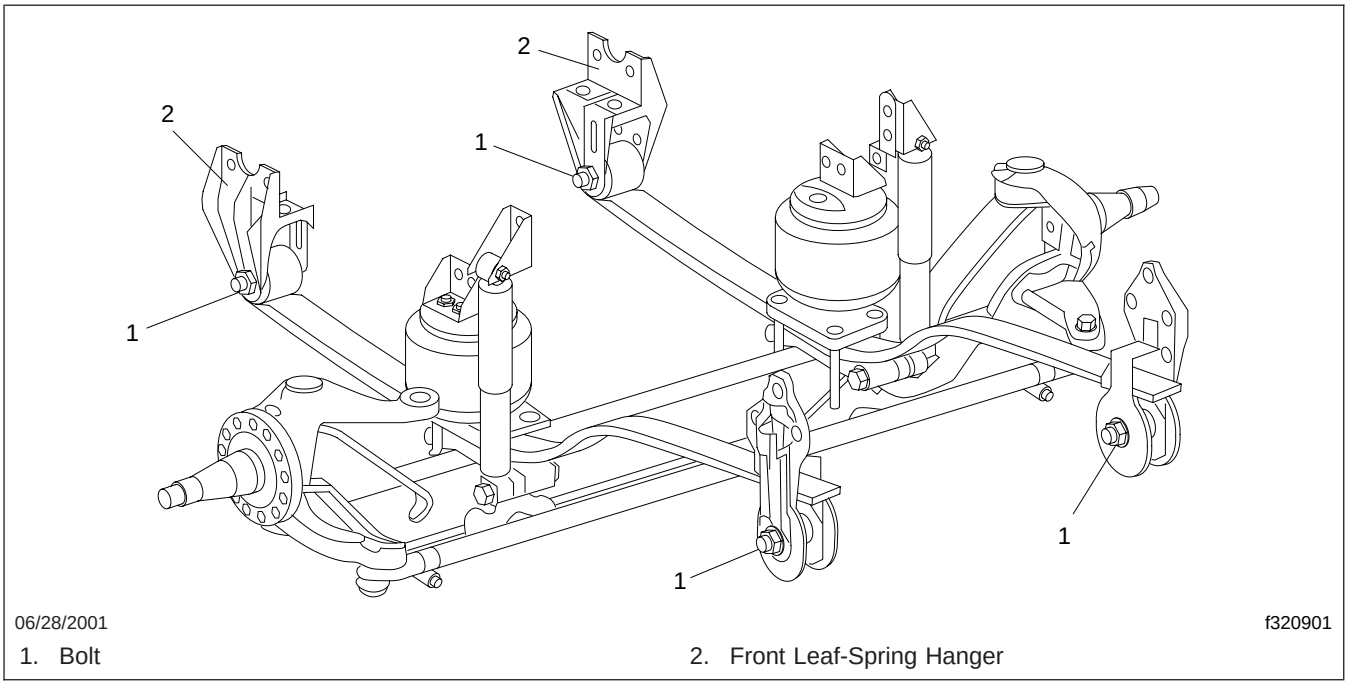



**Fig. 2, Front Spring Mounting**

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## Leaf Spring Removal and Installation

# Removal

NOTE: When replacing both steel springs, use springs with the same camber designation. The camber designation of the new spring is located at the front of the top leaf and will be defined with a (+), (0), or a (–).

1. Park the vehicle on a level surface and shut down the engine. Chock the tires.
2. Deflate the air springs by disconnecting the height-control-valve linkage and lowering the control arm to exhaust the air pressure.
3. Position a floor jack with a 4-inch lifting plate, below the axle, and raise the vehicle.
4. Remove the tires.
5. Position frame stands behind the rear spring mounts. It may be necessary to remove peripheral components for installation of the frame stands.
6. Lower the jack, allowing the axle to hang, but do not remove the jack from the axle.
7. Loosen both front spring-eye bolts, but do not remove the bolts.
8. Remove both rear spring-eye centerbolts.
9. Remove both lower shock absorber mounting bolts.

NOTE: To ease removal of the spring-eye bolts it may be necessary to raise or lower the axle.

10. Disconnect both air springs from the top pads of the clamp groups.
11. On the spring that is not being replaced, loosen the clamp group nylon locknuts.

**⚠ WARNING**

**Do not use a cutting torch to remove clamp group bolts or attaching fasteners. The use of heat on suspension components can decrease the strength of these parts. A component damaged in this manner can result in a loss of vehicle control and possible personal injury or property damage.**

12. Remove the 3/4-inch clamp group bolts, nuts, washers, top pad, galvanized liner, and the bottom axle wrap, from the spring that is going to be removed. See **Fig. 1**.
13. Lower the jack, allowing the suspension to pivot down and out of the rear hanger clamps.
14. Remove the front spring-eye bolt from the spring that is being removed, then remove the spring assembly.
15. Remove the thrustwashers from the rear spring-mount assembly. See **Fig. 1**.
16. Remove the 1/2-inch bolts, then remove the rear spring-mount assembly.
17. Inspect the thrustwashers, rear spring-mount bushing, rear-hanger clamp, top axle wrap, and the front and rear spring hangers. Replace them if worn, cracked, or damaged.

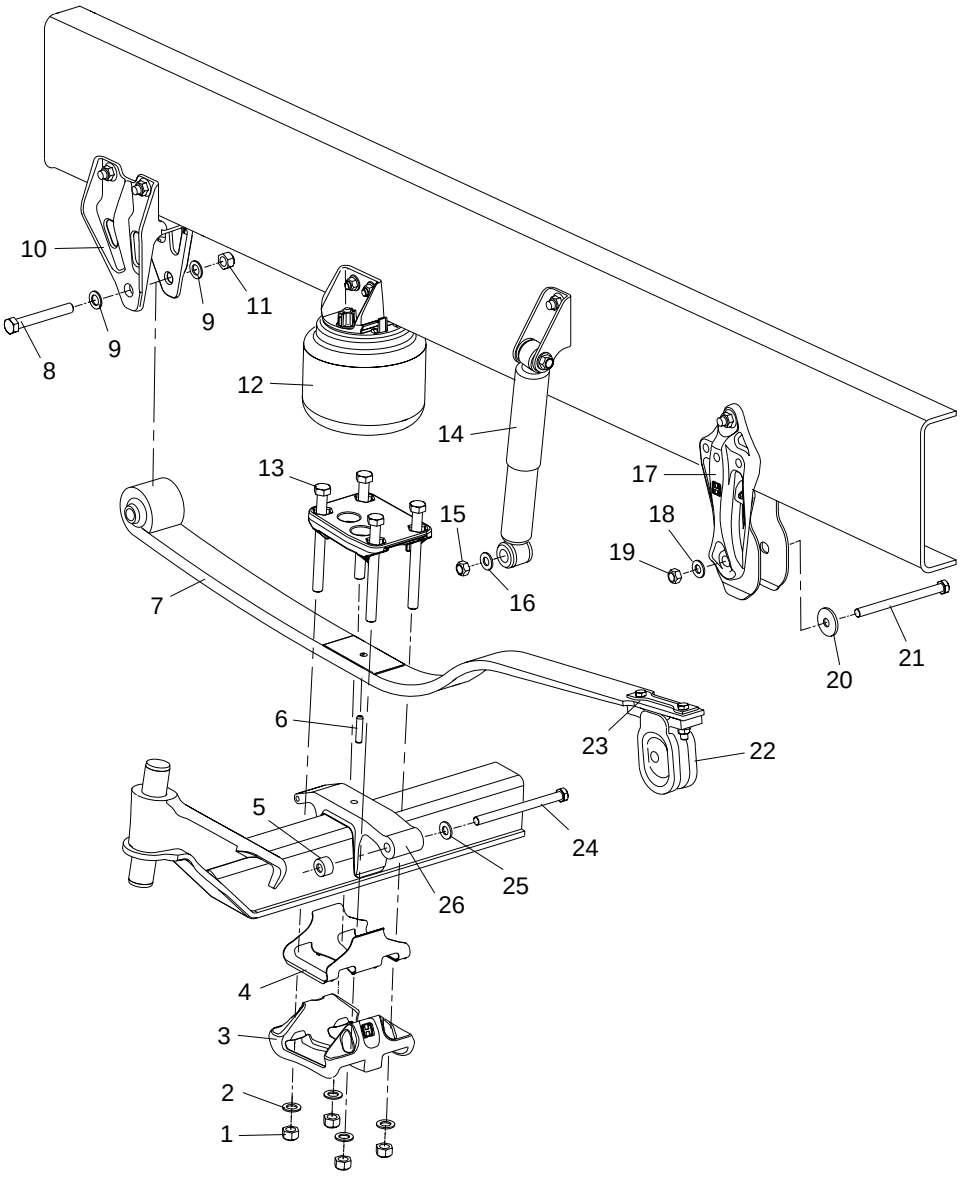
# Installation

1. Lubricate the front spring-eye bushing and the front hanger with a vegetable-based oil (cooking oil). **DO NOT** use petroleum- or soap-based lubricants; they can cause an adverse reaction with the spring-eye-bushing material.
2. Install the spring over the axle, and into the front spring hanger.
3. Install the 5 1/2-inch long front spring-eye bolt, washers, and nut, but do not tighten.
4. Using the dowel pin located on the top axle wrap, engage the spring to the axle. It may be necessary to loosen the other clamp group to allow the axle to pivot when installing the spring on the dowel pin.
5. Install the top pad on top of the spring.
6. Install a new bottom axle wrap liner in the bottom axle wrap.
7. Install the bottom axle wrap.
8. Install new clamp group bolts, washers, and new nylon locknuts.
9. Snug the clamp group, but DO NOT torque at this time.
10. Raise the axle and the rear spring assemblies into the rear spring hangers.
11. Install the 5-inch long centerbolts in the rear hangers. The bolt must be installed from the in-

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## Leaf Spring Removal and Installation




02/21/2006 f321057

1. 3/4–10 Nylon Locknut
2. 3/4-Inch Flatwasher
3. Bottom Axle Wrap
4. Bottom Axle Wrap Liner
5. Shock Spacer
6. Dowel Pin
7. Leaf Spring
8. 3/4–10 x 5-1/2 Hexbolt
9. 3/4-Inch Flatwasher
10. Front Hanger
11. 3/4–10 Locknut
12. Air Spring
13. 3/4–10 Hexbolt
14. Shock Absorber
15. 3/4–10 Locknut
16. 3/4-Inch Hardened Washer
17. Rear Hanger
18. 3/4-Inch Flatwasher
19. 3/4–10 Locknut
20. 3/4-Inch Wide Washer
21. 3/4–10 x 5 Hexbolt
22. Thrustwasher
23. Rear Spring Mount
24. 3/4–10 x 7 Lower Shock Bolt
25. 3/4-Inch Hardened Washer
26. Top Axle Wrap

**Fig. 1, Front AirLiner Spring Assembly**

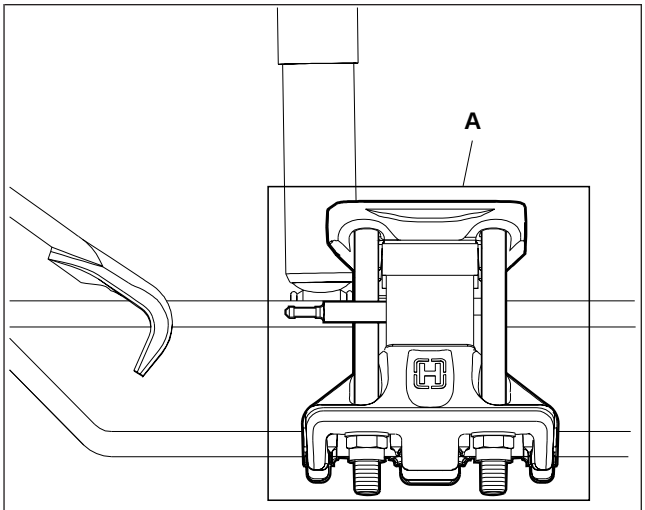
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board side, to the outboard side. The 2-inch o.d. washer should be against the aluminum wrap on the inboard side. See **Fig. 1**.

IMPORTANT: Only the weight of the axle should be on the spring at the time of the spring eye tightening torque.

12. Tighten the lower shock mounting bolts to 225 to 255 lbf·ft (305 to 345 N·m).
13. Tighten the front and rear spring-eye 3/4-inch locknuts to 285 to 305 lbf·ft (385 to 415 N·m).
14. Install the tires.
15. Install the air springs into the top pads. Make sure the piston is correctly seated in the top pad.
16. Remove the frame supports and load the front axle with the vehicle weight.
17. Ensure that the clamp group is properly aligned, and the bottom axle wrap is centered on the top axle wrap. See **Fig. 2**. Ensure that the hexbolts are seated in the top-pad casting. See **Fig. 3**.

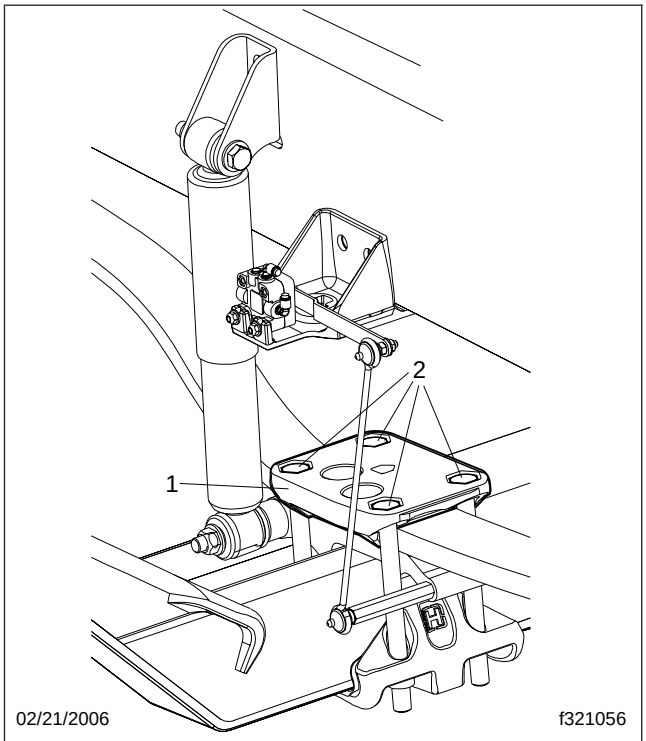



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A Ensure the axle clamp group is properly aligned as shown.

**Fig. 2, Axle Clamp Group**

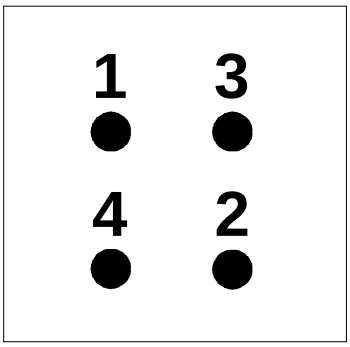
18. Tighten the clamp-group locknuts in sequence. See **Fig. 4**.
    - 18.1 Tighten the first diagonal to 100 lbf·ft (135 N·m).




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1. Top Pad
2. 3/4-Inch Bolts

**Fig. 3, Top Pad Installation**




02/16/2005 f310979

**Fig. 4, Clamp Group Locknut Tightening Sequence**

- 18.2 Tighten the second diagonal to 100 lbf·ft (135 N·m).
- 18.3 Tighten the first diagonal to 270 to 330 lbf·ft (365 to 445 N·m).
- 18.4 Tighten the second diagonal to 270 to 330 lbf·ft (365 to 445 N·m).

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## Leaf Spring Removal and Installation

19. Raise the frame and remove the frame stands.
20. Lower the vehicle.
21. Inflate the air springs, then follow the instructions for ride height adjustment in **Subject 100**.

**⚠ WARNING**

**Before charging the suspension system with air, make certain the air-spring locator is indexed into the upper air-spring bracket, the lock tabs are snapped into place, and that the air spring is fully seated. Failure to follow these instructions could result in premature air-spring failure, which could result in personal injury or property damage.**

22. Remove the chocks from the tires.

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## Front Spring Hanger Replacement

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the tires.

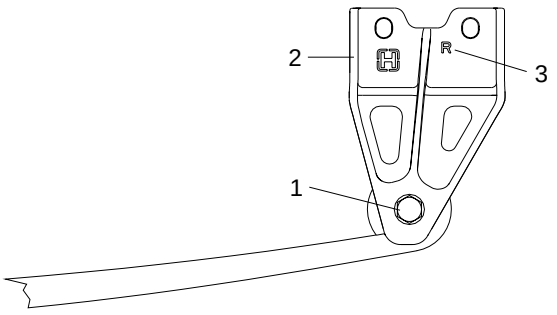
IMPORTANT: Push-to-connect fittings are not serviceable. Clean dirt and debris away from the fittings to prevent foreign materials from entering the air system, or damaging the fittings. Clean the push-to-connect fittings using soapy water and a soft-bristled brush, then dry with compressed air.

2. Deflate the air springs by disconnecting the height-control-valve linkage and lowering the control arm to exhaust the air pressure. Disconnect the air lines at the air springs.

**⚠ WARNING**

**Failure to deflate and disconnect the air system prior to raising the front of the vehicle may result in sudden failure of the air spring, resulting in personal injury or property damage.**

3. Raise the vehicle and support the frame with stands.
4. Suspend the front axle from the shock absorbers.
5. Remove the front spring-eye bolt. See **Fig. 1**.




02/16/2005 f310981

1. Spring-Eye Bolt
2. Front Spring Hanger
3. Right or Left Hanger Designation

**Fig. 1, Front Leaf Spring Hanger**

NOTE: A bottle jack may be required to raise the axle slightly in order to remove the mounting bolt, then lower it until the spring eye is clear of the hanger.

6. Remove the frame fasteners, then remove the spring hanger.
7. Inspect the mounting surfaces on the frame for cracks or fretting.
8. Inspect the spring-eye bushing for damage or excessive wear. If damaged or worn excessively, replaceme the bushing. See **Subject 140** for replacement instructions.
9. Install the new hanger, flush with the bottom of the frame. Left or right hanger designation is stamped on the outboard surface of the hanger. See **Fig. 1**.
10. Install the 3/4 x 5-1/2 spring-eye bolt. Tighten the locknut 285 to 305 lbf·ft (385 to 415 N·m).

NOTE: A bottle jack may be required to raise the axle slightly to facilitate installation of the front spring-eye bolt.

11. Raise the vehicle and remove the jack stands or frame support, then lower the vehicle.
12. Inflate the air springs, then follow the instructions for ride height adjustment in **Subject 100**.

**⚠ WARNING**

**Before charging the suspension system with air, make certain the air-spring locator is indexed into the upper air-spring bracket, the lock tabs are snapped into place, and that the air spring is fully seated. Failure to follow these instructions could result in premature air-spring failure, which could result in personal injury or property damage.**

13. Remove the chocks.

## Rear Spring Hanger Replacement

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the tires.

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## Front and Rear Spring-Hanger Replacement

IMPORTANT: Push-to-connect fittings are not serviceable. Clean dirt and debris away from the fittings to prevent foreign materials from entering the air system, or damaging the fittings. Clean the push-to-connect fittings using soapy water and a soft-bristled brush, then dry with compressed air.

2. Deflate the air springs by disconnecting the height-control-valve linkage and lowering the control arm to exhaust the air pressure. Disconnect the air lines at the air springs.

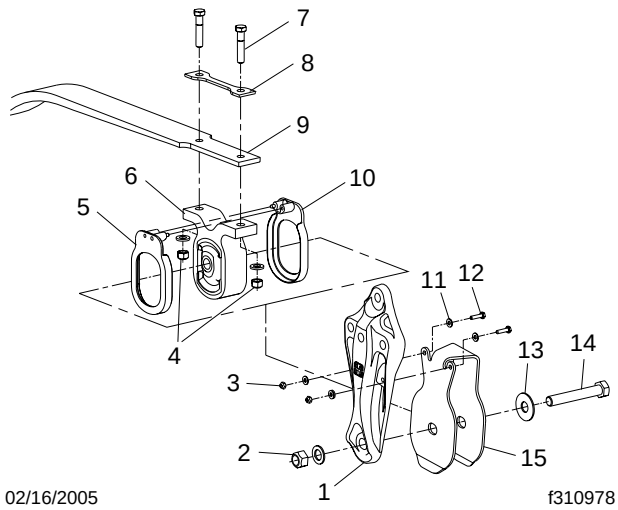
**⚠ WARNING**

**Failure to deflate and disconnect the air system prior to raising the front of the vehicle may result in sudden failure of the air spring, resulting in personal injury or property damage.**

3. Raise the vehicle and support the frame with stands.
4. Suspend the front axle from the shock absorbers.
5. Remove the rear hanger centerbolt.

NOTE: A bottle jack may be required to raise the axle slightly to facilitate removal of the rear hanger centerbolt.

6. Remove the two 1/4 x 1-1/4 hexbolts, washers, and the locknut, that attach the rear hanger to the hanger clamp.
7. Remove the frame fasteners, then remove the spring hanger. See **Fig. 2**.
8. Remove the clamp from the rear spring mount.
9. Remove the two thrustwashers.
10. Inspect the rear spring mount, rear hanger clamp, and both thrustwashers for excessive wear or damage. Replace if necessary.
11. Install the thrustwashers on the rear spring mount.
12. Slide the rear hanger clamp over the rear spring mount.
13. Using new fasteners, install the rear spring hanger on the frame.




1. Rear Spring Hanger
2. 3/4-Inch Locknut
3. 1/4-Inch Locknut
4. 1/2-Inch Locknut
5. Thrustwasher
6. Rear Spring Mount
7. 1/2-Inch Hexbolt
8. Spring End Plate
9. Leaf Spring Taper
10. Thrustwasher
11. 1/4-Inch Washer
12. 1/4-Inch Bolt
13. 2-Inch o.d. Washer
14. 3/4-Inch Hexbolt (installed from the inboard side)
15. Rear Hanger Clamp

**Fig. 2, Rear Spring Mount Assembly**

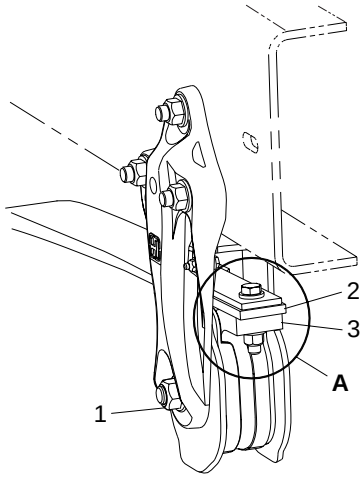
14. Install the two 1/4 x 1 1/4 bolts, washers, and nuts, through the rear hanger, and rear hanger clamp assembly. Tighten the locknuts 84 to 120 lbf·in (950 to 1350 N·cm).
15. Place the 2-inch o.d. washer against the inboard side of the rear hanger clamp. Install the 3/4 x 5 centerbolt, through the center of the spring hanger from the inboard side towards the outboard side.

NOTE: A bottle jack may be required to raise the axle slightly to facilitate installation of the rear hanger centerbolt.

16. Install the washer and locknut. Tighten the locknut to 285 to 305 lbf·ft (385 to 415 N·m). See **Fig. 3**.
17. Raise the vehicle and remove the jack stands or frame support.
18. Lower the vehicle.

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A. Verify that the rear spring mount is centered on the leaf spring taper.

1. 3/4-Inch Locknut
2. Leaf Spring Taper
3. Rear Spring Mount

**Fig. 3, Rear Spring Hanger Installation**

19. Inflate the air springs, then follow the instructions for ride height adjustment in **Subject 100**.

**⚠ WARNING**

**Before charging the suspension system with air, make certain the air-spring locator is indexed into the upper air-spring bracket, the lock tabs are snapped into place, and that the air spring is fully seated. Failure to follow these instructions could result in premature air-spring failure, which could result in personal injury or property damage.**

20. Remove the chocks.

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# Thrustwasher and Rear Hanger Clamp Removal and Installation

## Removal

1. Set the parking brake, and shut down the engine. Chock the tires.

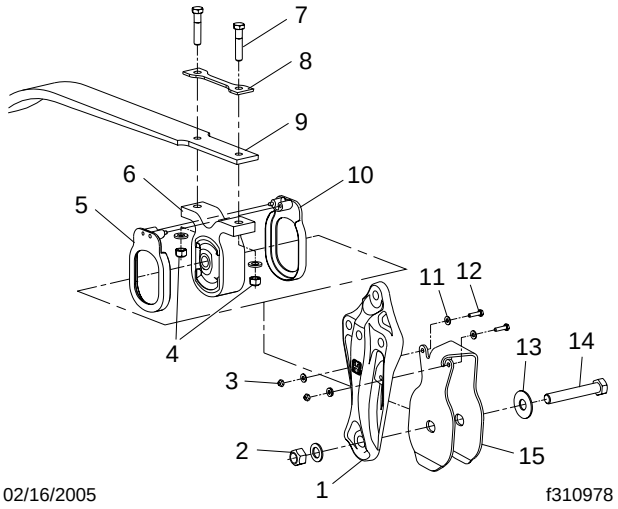
IMPORTANT: Push-to-connect fittings are not serviceable. Clean dirt and debris away from the fittings to prevent foreign materials from entering the air system, or damaging the fittings. Clean the push-to-connect fittings using soapy water and a soft-bristled brush, then dry with compressed air.

2. Deflate the air springs by disconnecting the height-control-valve linkage and lowering the control arm to exhaust the air pressure. Disconnect the air lines at the air springs.

**⚠ WARNING**

**Failure to deflate and disconnect the air system prior to raising the front of the vehicle may result in sudden failure of the air spring, resulting in personal injury or property damage.**

3. Raise the vehicle and support the frame with stands.
4. Suspend the front axle, ensuring there is enough clearance to allow the rear spring mount to clear the bottom of the spring hanger.
5. Loosen, but do not remove the front spring-eye bolt.
6. Support the axle with a floor jack.
7. Remove the rear hanger centerbolt.
8. Remove the lower shock bolt.
9. Lower the jack until the rear spring mount is below the spring hanger.
10. Remove the 1/4 x 1-1/4 rear hanger clamp bolt, and remove the rear hanger clamp.
11. Remove the two thrustwashers from the rear spring mount. See **Fig. 1**.
12. Inspect the spring mount for torn rubber, a worn metal sleeve, or a cracked housing. If any of these conditions exist, replaceme the spring mount.




1. Rear Spring Hanger
2. 3/4-Inch Locknut
3. 1/4-Inch Locknut
4. 1/2-Inch Locknut
5. Thrustwasher
6. Rear Spring Mount
7. 1/2-Inch Hexbolt
8. Spring-End Plate
9. Leaf-Spring Taper
10. Thrustwasher
11. 1/4-Inch Washer
12. 1/4-Inch Bolt
13. 2-Inch o.d. Washer
14. 3/4-Inch Hexbolt (Centerbolt installed from inboard side)
15. Rear-Hanger Clamp

**Fig. 1, Rear Spring Mount Assembly**

## Installation

1. Install the two 1/4 x 1 bolts, washers, and nuts, through the rear hanger, and rear hanger clamp assembly. Tighten the 1/4-inch locknuts 84 to 120 lbf·in (950 to 1350 N·cm).
2. Install two new thrustwashers onto the rear spring mount.
3. Raise the axle to install the rear spring mounts into the rear hanger clamps.
4. Install the 3/4 x 5 rear centerbolt, from the inboard side towards the outboard side. Place the 2-inch o.d. washer against the inboard side of the rear-hanger clamp.
5. Apply a thin coat of antiseize to the lower shock bolt.
6. Install the lower shock bolt, from the inboard side towards the outboard side. Tighten the shock bolt 225 to 255 lbf·ft (305 to 345 N·m).

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## Thrustwasher and Rear Hanger Clamp Removal and Installation

7. Remove the jack and let the suspension hang.
8. Tighten the front spring-eye bolt and rear center-bolt to 285 to 305 lbf·ft (385 to 415 N·m).
9. Raise the frame and remove the frame stands.
10. Lower the vehicle.
11. Inflate the air springs, then follow the instructions for ride height adjustment in **Subject 100**.

**⚠ WARNING**

**Before charging the suspension system with air, make certain the air-spring locator is indexed into the upper air-spring bracket, the lock tabs are snapped into place, and that the air spring is fully seated. Failure to follow these instructions could result in premature air-spring failure, which could result in personal injury or property damage.**

12. Remove the chocks from the tires.

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# Bottom Axle Wrap

## Removal

1. Park the vehicle and chock the tires.
2. Deflate the air springs by disconnecting the height-control-valve linkage and lowering the control arm to exhaust the air pressure.

**⚠ WARNING**

**Failure to deflate and disconnect the air system prior to raising the front of the vehicle may result in sudden failure of the air spring, resulting in personal injury or property damage.**

3. Raise the vehicle ad support the frame with frame stands.
4. Remove the air spring from the side that is being worked on. For instructions, see **Subject 130**.
5. Remove the 3/4-inch hexbolts and the nylon locknuts that fasten the axle wrap to the axle. See **Fig. 1**.

**⚠ WARNING**

**Do not use a cutting torch to remove clamp group bolts or attaching fasteners. The use of heat on suspension components can decrease the strength of these parts. A component damaged in this manner can result in a loss of vehicle control and possible personal injury or property damage.**

6. Remove the bottom axle wrap. It may be necessary to use a deadblow mallet to dislodge the axle wrap.
7. Inspect the axle wrap, and replace if necessary.
8. Discard the used bottom axle wrap liner.

## Installation

1. Install a new liner into the bottom axle wrap.
2. Using new 3/4-inch hexbolts and grade 8 nylon locknuts, install the bottom axle wrap on the axle. Ensure that the clamp group is aligned, the bottom axle wrap is centered on the top axle wrap, and the hexbolts are seated in the top-pad casting.
3. Tighten the clamp-group locknuts in sequence. See **Fig. 2**.
   - 3.1 Tighten the first diagonal to 100 lbf·ft (135 N·m).
   - 3.2 Tighten the second diagonal to 100 lbf·ft (135 N·m).
   - 3.3 Tighten the first diagonal to 270 to 330 lbf·ft (365 to 445 N·m).
   - 3.4 Tighten the second diagonal to 270 to 330 lbf·ft (365 to 445 N·m).
4. Following the instructions in **Subject 130**, install the air spring that was removed.

# Top Axle Wrap

## Removal

1. Park the vehicle and chock the tires.
2. Deflate the air springs by disconnecting the height-control-valve linkage and lowering the control arm to exhaust the air pressure. Disconnect the air lines at the air springs.

**⚠ WARNING**

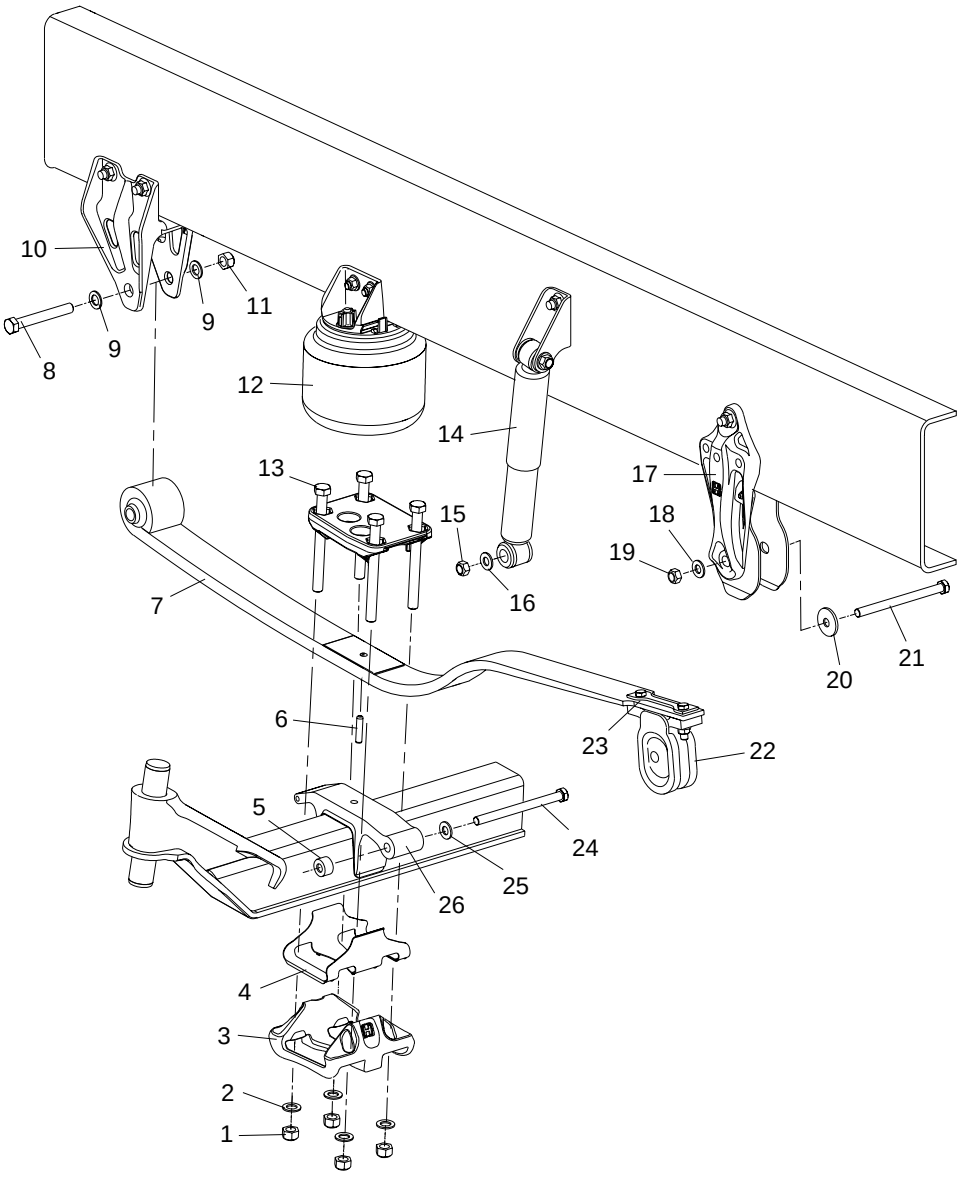
**Failure to deflate and disconnect the air system prior to raising the front of the vehicle may result in sudden failure of the air spring, resulting in personal injury or property damage.**

3. Raise the vehicle and support the frame with frame stands.
4. Remove the front tires.
5. Lower the floor jack and suspend the front axle to remove the load from the leaf springs.
6. Remove the air spring from the side that is being worked on. For instructions, see **Subject 130**.
7. Position a floor jack, that has a four-inch lifting plate, under the center of the axle.
8. Secure the axle on the jack to prevent the axle from rolling off the floor jack.
9. Remove the 3/4-inch hexbolts and the nylon locknuts that fasten the axle wrap to the axle.

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## Axle Wrap Removal and Installation




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1. 3/4–10 Nylon Locknut
2. 3/4-Inch Flatwasher
3. Bottom Axle Wrap
4. Bottom Axle Wrap Liner
5. Shock Spacer
6. Dowel Pin
7. Leaf Spring
8. 3/4–10 x 5-1/2 Hexbolt
9. 3/4-Inch Flatwasher
10. Front Hanger
11. 3/4–10 Locknut
12. Air Spring
13. 3/4–10 Hexbolt
14. Shock Absorber
15. 3/4–10 Locknut
16. 3/4-Inch Hardened Washer
17. Rear Hanger
18. 3/4-Inch Flatwasher
19. 3/4–10 Locknut
20. 3/4-Inch Wide Washer
21. 3/4–10 x 5 Hexbolt
22. Thrustwasher
23. Rear Spring Mount
24. 3/4–10 x 7 Lower Shock Bolt
25. 3/4-Inch Hardened Washer
26. Top Axle Wrap

**Fig. 1, Front AirLiner Spring Assembly**

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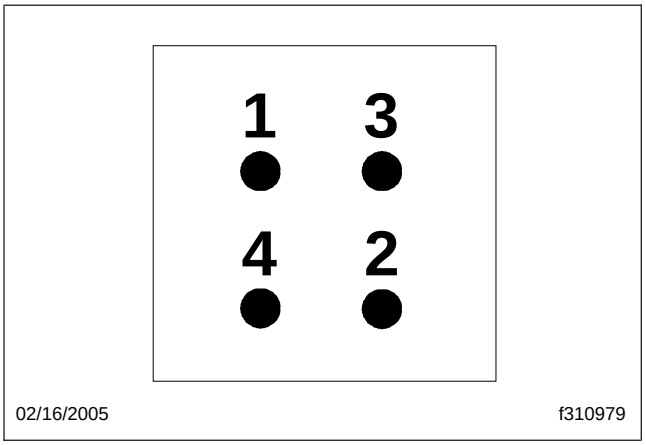



**Fig. 2, Clamp Group Locknut Tightening Sequence**

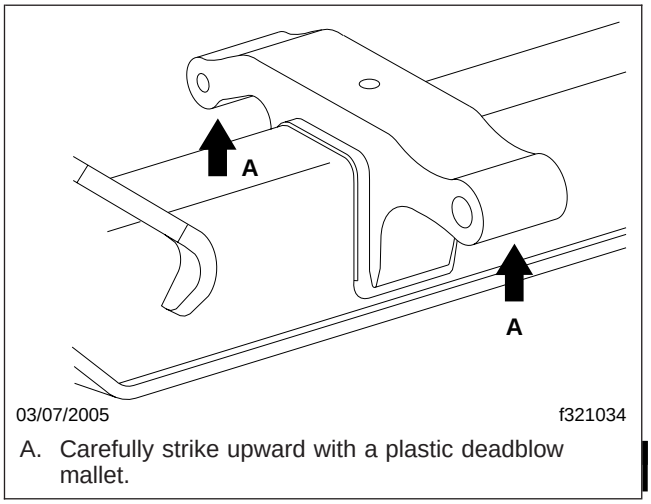
**WARNING**

**Do not use a cutting torch to remove clamp group bolts or attaching fasteners. The use of heat on suspension components can decrease the strength of these parts. A component damaged in this manner can result in a loss of vehicle control and possible personal injury or property damage.**

10. Remove the top spring pad casting, the bottom axle wrap, and the liner.
11. Remove the lower shock-mounting bolts.
12. Using the floor jack, lower the axle away from the leaf springs.
13. Remove the dowel pin, alignment shim, and spacer (if equipped).
14. Strike the axle wrap with a plastic deadblow mallet at the front and rear on the underside of the axle wrap, to dislodge it from the axle. See **Fig. 3**.
15. Clean the axle wrap and axle, then inspect for cracks or damage. Replace if cracks or damage are visible.

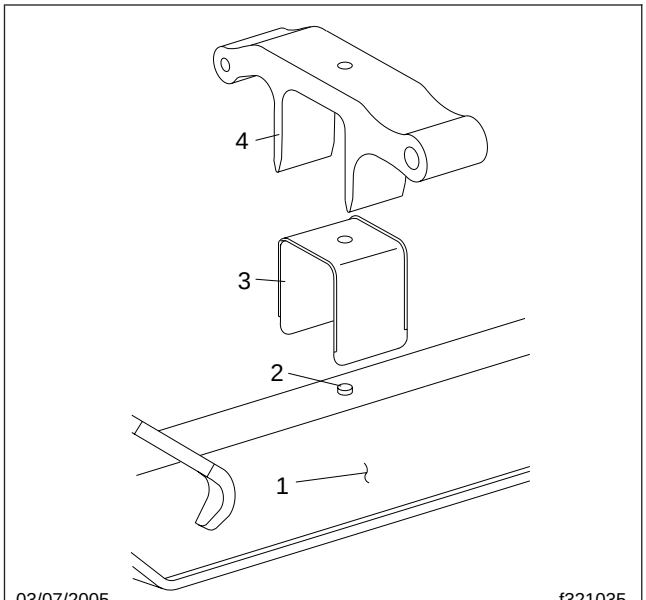
## Installation

1. Install a new axle wrap liner on the axle. See **Fig. 4**.
2. Spray the axle wrap liner and the axle wrap with a silicon lubricant.




A. Carefully strike upward with a plastic deadblow mallet.

**Fig. 3, Top Axle Wrap Removal**




1. Axle
2. Locating Bushing
3. Top Axle Wrap Liner
4. Top Axle Wrap

**Fig. 4, Top Axle Wrap Installation**

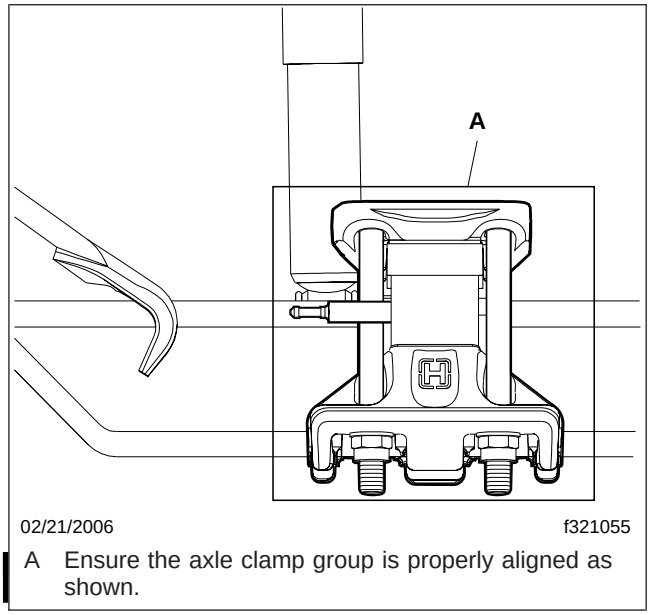
3. Position the axle wrap on the axle.
4. Protect the top surface of the axle wrap with a block of wood, cardboard, or shop towels.
5. Using a deadblow mallet, drive the axle wrap onto the axle, indexing the locating bushing until the axle wrap is firmly seated on the axle.

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## Axle Wrap Removal and Installation

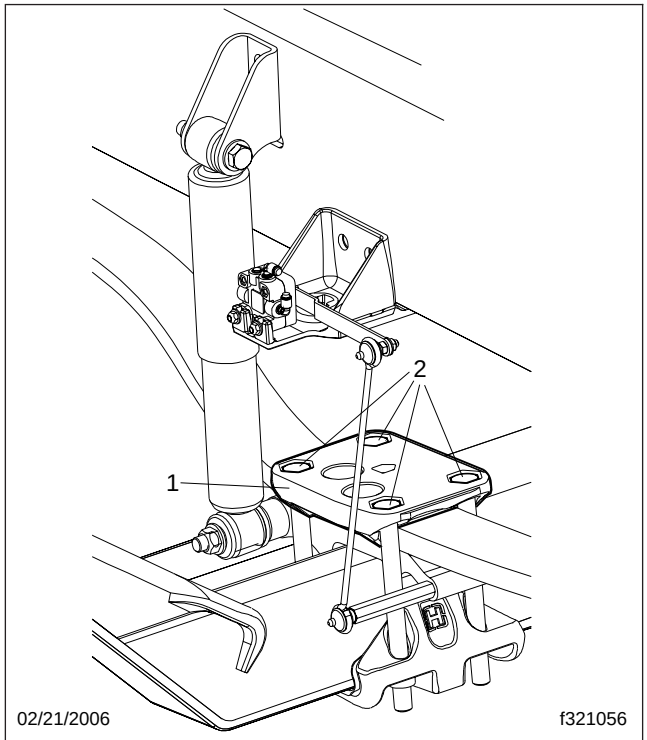
6. Install the dowel pin(s) into the axle wrap.
7. Install the alignment shims and spacer (if equipped).
8. Raise the axle assembly with a jack, and engage the dowel pins in the leaf spring bore.
9. Install the top pad with the arrows facing inboard on the leaf spring.
10. Install new clamp group hexbolts into the top pad.
11. Remove the old bottom axle-wrap liner, and install a new one.
12. Install the bottom axle wrap.
13. Install new clamp group washers and nylon locknuts (Grade 8).
14. Ensure that the clamp group is properly aligned and the hexbolts are seated in the top pad, and the bottom axle wrap is centered on the top axle wrap. See **Fig. 5** and **Fig. 6**.




A Ensure the axle clamp group is properly aligned as shown.

**Fig. 5, Axle Clamp Group**

15. Tighten the clamp-group locknuts in sequence. See **Fig. 2**.
    - 15.1 Tighten the first diagonal 100 lbf·ft (135 N·m).
    - 15.2 Tighten the second diagonal 100 lbf·ft (135 N·m).
    - 15.3 Tighten the first diagonal 270 to 330 lbf·ft (365 to 445 N·m).
    - 15.4 Tighten the second diagonal 270 to 330 lbf·ft (365 to 445 N·m).
16. Apply a thin coating of antiseize to the lower shock mounting bolt.
17. Install the lower shock bolt from the inboard side to the outboard side of the top axle wrap and attach the spacer, washer, and locknut.
18. Tighten the shock eye locknuts 225 to 255 lbf·ft (305 to 345 N·m).
19. Install the tires.
20. Install the air springs, following the instructions in **Subject 130**.




1. Top Pad
2. 3/4-Inch Bolts

**Fig. 6, Top Pad Installation**

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## Torque Specifications

For fastener torque values, see **Table 1**.

| Front AirLiner (AIRTEK) Suspension Fastener Torque Values | | |
|---|---|---|
| Fastener Application | Torque | |
| | lbf·ft (N·m) | lbf·in (N·cm) |
| Front Frame Hanger to Frame | 160–180 (215–245) | — |
| Front Spring Eye | 285–305 (385–415) | — |
| Rear Hanger to Rear Hanger Clamp | — | 84–120 (950–1350) |
| Rear Spring Hanger to Rear Spring Mount | 285–305 (385–415) | — |
| Rear Spring Mount to Leaf Spring | 80–110 (110–150) | — |
| Upper Air-Spring Bracket | 160–180 (215–245) | — |
| Height-Control Valve to Air-Spring Bracket Locknuts* | — | 95 (1100) |
| Barksdale Height-Control Valve Housing Capscrews* | — | 45 (500) |
| Clamp-Group Hardware | 285–305 (385–415) | — |
| Shock-Absorber Eye Bolt | 225–255 (305–345) | — |
| Shock Bracket to Frame | 160–180 (215–245) | — |

* See the cautionary statements below.

**Table 1, Front AirLiner (AIRTEK) Suspension Fastener Torque Values**

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

### NOTICE

**When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.**

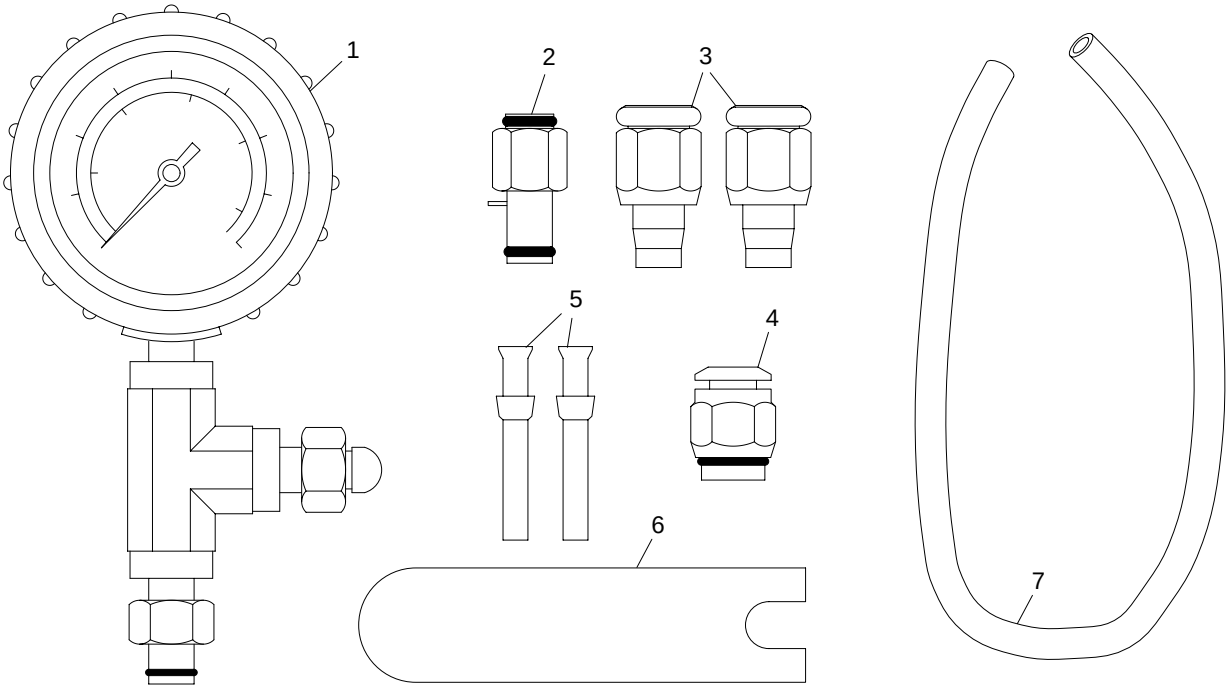
## Special Tools

Use the kit shown in **Fig. 1** to test a Barksdale height-control valve. Test kit BKS KD2264 is available via the Direct Ship program in Paragon.

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## Specifications




NOTE: Parts for cab suspension valve testing included.

1. Test Gauge Assembly with Reset Button
2. Exhaust Port Test Connector for Cab Suspension Valve (used for cab suspension valve testing)
3. Parker Plugs
4. Exhaust Port Test Connector for Chassis Suspension Valve
5. Test Plugs for Cab Suspension Valve (used for cab suspension valve testing)
6. Special Tool for Disconnecting Air Line
7. Air Line

**Fig. 1, Barksdale Height-Control Valve Test Kit BKS KD2264**

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# General Information

NOTE: For front axle troubleshooting procedures, refer to **Section 33.01**.

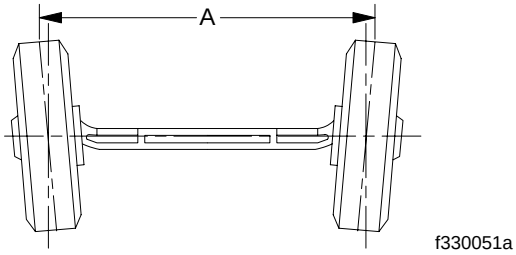
The front axle requires periodic servicing to maintain accurate wheel alignment. If the front axle is damaged enough to affect the camber angle it must be replaced. For axle removal and installation instructions, see **Subject 160**.

Correct front axle wheel alignment is needed to ensure long tire life, ease of handling, and steering stability.

Three factors are involved in wheel alignment: camber angle, caster angle, and wheel toe-in.

NOTE: For front axle troubleshooting procedures, refer to **Section 33.01**, Subject 300.

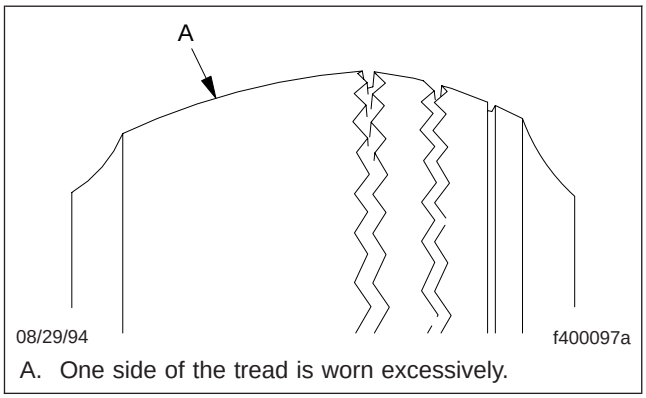
Camber angle (**Fig. 1**) is the vertical tilt of the wheel as viewed from the front of the vehicle. Camber angle is measured in degrees, and is not adjustable. Positive camber is the outward tilt of the wheel at the top. Excessive positive camber in one wheel causes the vehicle to pull in the opposite direction, rapidly wearing the outboard side of the tire tread. Negative camber is the inward tilt of the wheel at the top. Excessive negative camber in one wheel causes the vehicle to pull in the same direction that the negative-camber wheel is on, wearing the inboard side of the tire tread. If camber angles are not correct, the tires will wear smooth around the edge on one side. See **Fig. 2**.




A. Camber (Positive)

**Fig. 1, Camber Angle**

Caster angle (**Fig. 3**) is the tilt of the knuckle pin (or kingpin) as viewed from the side. Caster angle is measured in degrees and it is adjustable. A positive caster angle is the tilt of the top of the knuckle pin toward the rear of the vehicle. A negative caster angle is the tilt of the top of the knuckle pin toward the front of the vehicle. Caster angles are based on the design load of the vehicle. An incorrect caster angle does not cause tire wear. However, a positive caster angle that exceeds specifications could cause vehicle shimmy, road shock, and an increased steering effort. A negative caster angle that does not meet specifications could cause unstable steering. The vehicle may wander and weave, and extra steering effort may be necessary. After leaving a turn, the tendency to return to and maintain a straight-ahead position is reduced. Too much or too little caster in one wheel can cause erratic steering when the service brakes are applied to stop the vehicle.




A. One side of the tread is worn excessively.

**Fig. 2, Tire Damage Due to Excessive Camber**

Wheel toe-in (**Fig. 4**) is the distance in inches that the front of the wheels are closer together than the rear of the wheels, as viewed from the top. Wheel toe-in is adjustable. If it is not adjusted correctly, the vehicle could pull to one side while driving. Wheel shimmy and cupped tire treads (indentations on the road contact surface of the treads) could occur. Also, rapid or severe tire wear on the steering axle could occur, usually in a feather-edged pattern. See **Fig. 5**.

Advanced wear patterns can be seen, but less severe wear patterns are detected only by rubbing the palm of your hand flat across the tire tread.

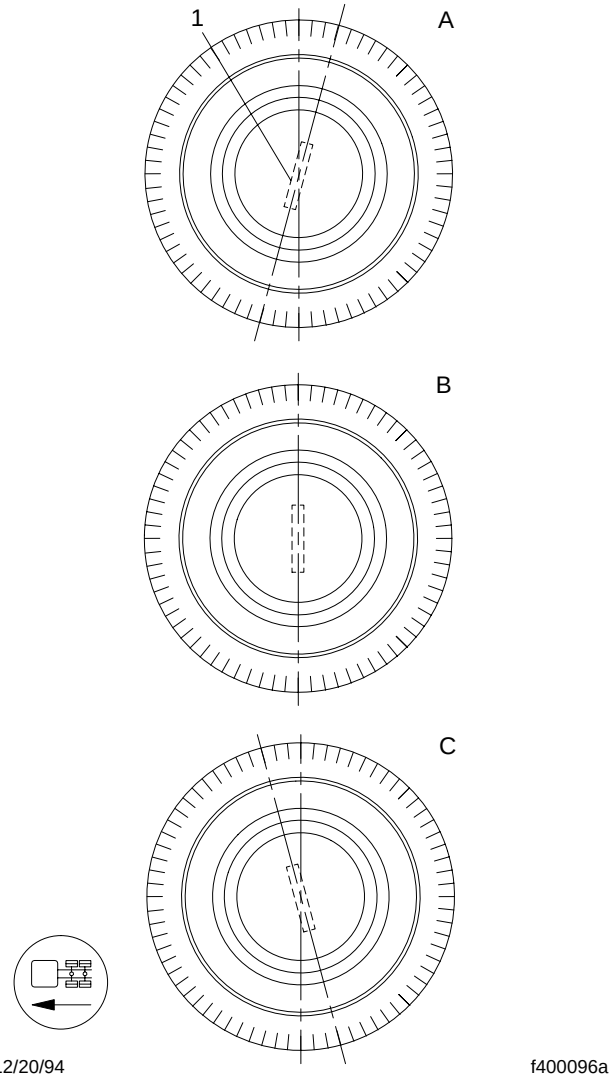
Feather-edging more often affects the front tire on the passenger's side of the vehicle, and is usually more apparent on the outside grooves of the tire.

If any of the conditions listed above occur, the vehicle could need a front end wheel alignment, and possibly, drive axle alignment. However, in some cases these conditions are not wheel alignment related. See **Section 33.01**, Subject 300 for other possible causes.

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## General Information

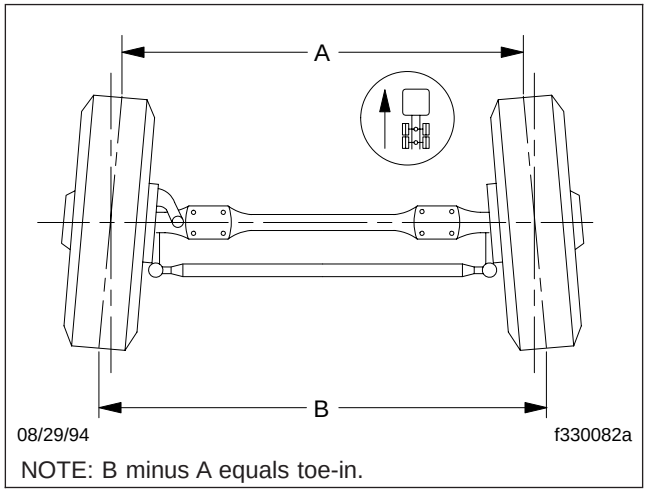



1. Knuckle Pin (King Pin)

A. Positive Caster
B. Zero Caster
C. Negative Caster

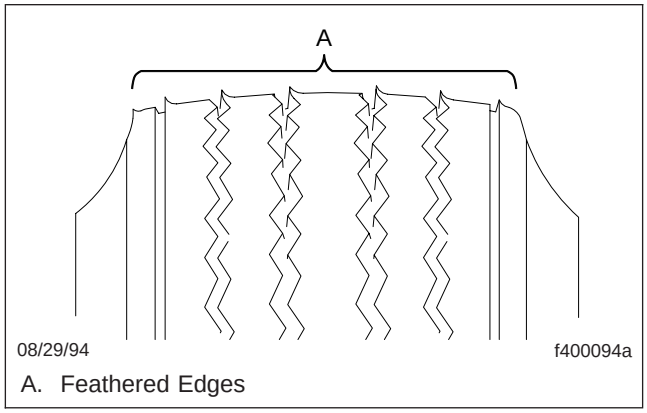
**Fig. 3, Caster Angle**

If excessive tire tread wear has resulted from incorrect wheel alignment, replace the damaged tires. For minimum tread wear specifications, see **Group 40** of the *Western Star Maintenance Manual*.




NOTE: B minus A equals toe-in.

**Fig. 4, Wheel Toe-In (overhead view)**




A. Feathered Edges

**Fig. 5, Tire Damage Due to Excessive Toe-In or Incorrect Drive Axle Alignment**

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## Preliminary Checks

1. Steering axle wheel assemblies should be balanced, especially for vehicles that travel at sustained speeds of more than 50 mph (80 km/h). Off-balance wheel assemblies cause vibrations that result in severely shortened life for tires, and steering suspension parts.
2. Do not mix tires of different size, type, or weight. Tire wear should be even and not worn to limits exceeding government specifications. See **Group 40** of this manual and **Group 40** of the *Western Star Maintenance Manual* for more information. Replace any tire that is excessively worn.
3. Check the inflation pressure of the tires. Refer to the wheels and tires section in this manual for recommended pressures. An underinflated tire causes tread wear completely around both tire shoulders. An overinflated tire causes tread wear in the center of the tire. See **Fig. 1**.

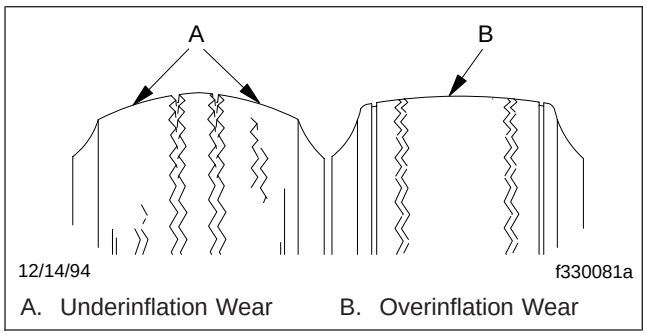



**Fig. 1, Tire Damage Due to Underinflated or Overinflated Tires**

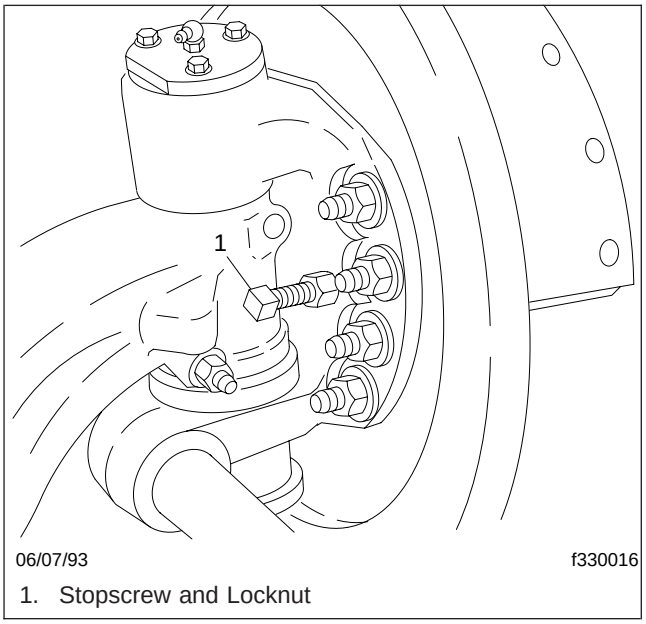
4. Check for out-of-round wheels, rims, or wheel stud holes. Replace the wheel if any of these conditions exist.
5. On each side of the vehicle, check the height of the chassis above the ground. Sagging, fatigued, or broken suspension springs create a lopsided vehicle appearance. This causes an unbalanced weight distribution. Anything that changes the ratio of weight on the springs affects the alignment angles and also the tire tread contact area. Replace damaged springs as instructed in **Group 32** of this manual.
6. Inspect the front axle beam (also called the axle center) for bends or twists. If the axle beam is bent or twisted over 1/2 degree, replace it before aligning the front axle wheels.
7. Check for damaged, worn, or bent steering gear or linkage parts. Make sure the steering gear is centered. Replace damaged components, and adjust the steering gear, using the instructions in **Group 46** of this manual.
8. Check the steering angle, and adjust the axle steering stops, as needed. For instructions, see **Subject 110**.

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## Checking and Adjusting

Steering (or turning) angle is the degree of front wheel movement from a straight-ahead position to either an extreme right or left position. Although front wheel movement can be limited by the amount of internal travel in the steering gear, it generally depends on how much clearance there is between chassis components and the tire and wheel assemblies. All axles have adjustable stopscrew-and locknut-type axle stops (**Fig. 1**), which are located on the rear side of each front axle spindle.




1. Stopscrew and Locknut

**Fig. 1, Axle Stop**

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Dealers must have proof of this calibration history.

1. Make sure the steering gear is in the center of travel when the wheels are in a straight-ahead position. Center the gear, using the instructions in the steering section in this manual. Bottoming of the steering gear must not occur when making an extreme right or left turn.
2. If using stationary turn-plates or turntables (**Fig. 2**), drive the vehicle on the plates; the tires must be exactly straight ahead. Apply the parking brakes.

   If using portable gauges, apply the parking brakes, chock the rear tires, and raise the front of the vehicle. Place a turn-plate or turntable under each tire. With the tires exactly straight ahead, lower the vehicle so that the tires rest on the center of the gauges.

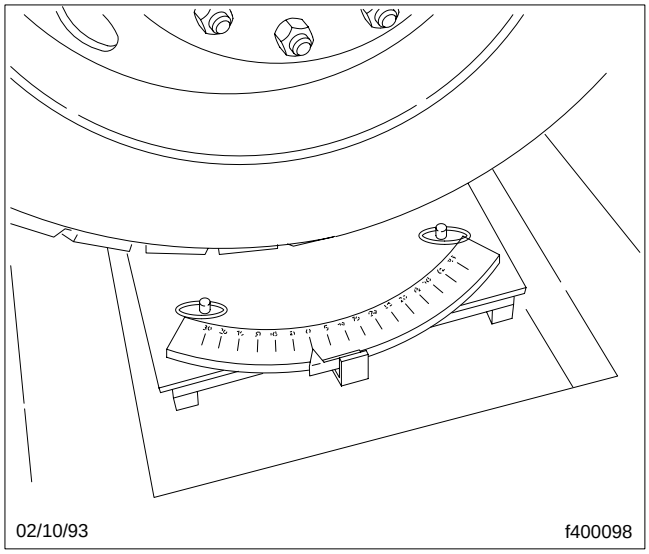



**Fig. 2, Turn-Plate (Turntable), Stationary Type**

3. Remove the lockpins from the gauges, and adjust the dials so that the pointers on both gauges read zero.
4. With the brakes fully applied, turn the steering wheel clockwise to the end of travel. Have someone check both sides of the vehicle for interference at the tires and wheels. There must be at least 0.50 inch (13 mm) clearance from any fixed object, and 0.75 inch (19 mm) from any moving object.

   If necessary, loosen the stopscrew locknut; adjust the stopscrew to contact the axle when the maximum turning angle of the wheels is determined.

   Tighten the locknut to the value in **Specifications, 400**.

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## Steering Angle Checking and Adjusting

5. Repeat the step above with the steering wheel turned counterclockwise. Adjust the axle stop, as needed.
6. If equipped with power steering, adjust the steering gear so that pressure is released ahead of the axle stop. This will prevent possible damage to the steering or axle components. For poppet valve adjustment instructions, see **Group 46**.
7. Drive the vehicle off the turn-plates or turntables, or remove them from under the tires and lower the vehicle.

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# Measuring and Adjusting Front Axle Wheel Alignment Angles

## Measuring and Adjusting

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Dealers must have proof of this calibration history.

Precision instruments and equipment are needed for accurately measuring and adjusting wheel alignment. Refer to the operating instructions provided by the wheel alignment equipment manufacturer.

Before checking or correcting wheel alignment, make sure the vehicle is at curb weight. Curb weight is the weight of the unloaded vehicle complete with accessories and full fuel tanks.

If a road test is necessary, the route should be one that allows full left and right turns and full stops. It should also include a length of straight, level road to check the steering wheel position during straight-ahead driving.

During the road test, note any steering effort and possible roughness. Check for looseness, too much wheel play, any tendency for the vehicle to lead in one direction, and for pull during stopping.

Note the position of the steering wheel while driving on a straight, level road. When the steering gear is centered, the steering wheel should be centered. See **Fig. 1**.

If there are any problems, see **Section 33.01**.

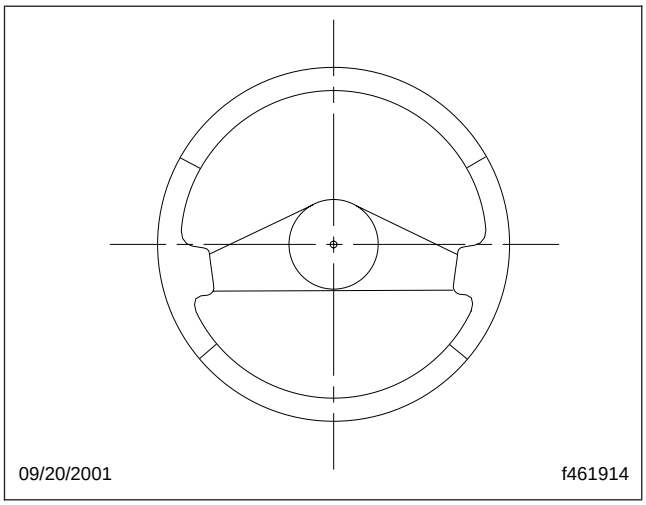



**Fig. 1, Steering Wheel Position**

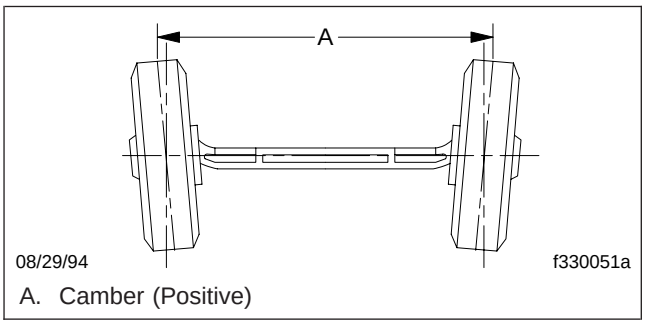
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## Checking

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Dealers must have proof of this calibration history.

1. Apply the parking brakes, and chock the rear tires.
2. Raise the front of the vehicle until the tires clear the ground. Place safety stands under the axle; make sure the stands will support the weight of the cab, frame, and front axle.
3. Before measuring camber (**Fig. 1**) check the front wheel bearings for wear and incorrect adjustment. Try moving the wheel on the axle spindle (steering knuckle) either by grasping the front tire on the top and bottom, or by using a bar for leverage. If movement between the brake drum and the backing plate or other axle-mounted reference point is 0.05 inch (1 mm) or more, the bearings may be worn or incorrectly adjusted. Inspect the wheel bearings for damage using the instructions in **Section 33.01**. If needed, replace or adjust the bearings.




A. Camber (Positive)

**Fig. 1, Camber Angle**

4. Remove the safety stands, and lower the vehicle to the ground.
5. Using the alignment equipment manufacturer's instructions, measure the front wheel camber.
6. Compare the camber angles with those shown in the appropriate table in **Specifications, 400**. Differences between the measurements taken in the step above and the angles in the table are caused by damaged (bent) axle components.

   Incorrect camber angles could be caused by damage in one or more of the following front axle components: the knuckle pin, the knuckle pin bushings, the axle spindle, or the axle beam. Replace twisted or otherwise damaged components. Don't try to straighten twisted or bent components; replace them with new components. If a bent or twisted front axle knuckle pin, axle spindle, or axle beam has been straightened, the axle warranty will be voided.

**⚠ WARNING**

**Do not attempt to straighten any twisted or bent front axle component. This could crack or weaken the component, possibly resulting in a collapsed front axle, loss of a wheel, and serious personal injury.**

7. Remove the chocks from the tires.

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## Checking and Adjusting

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Dealers must have proof of this calibration history.

Using the alignment equipment manufacturer's operating instructions, measure the front wheel caster. See **Fig. 1**.

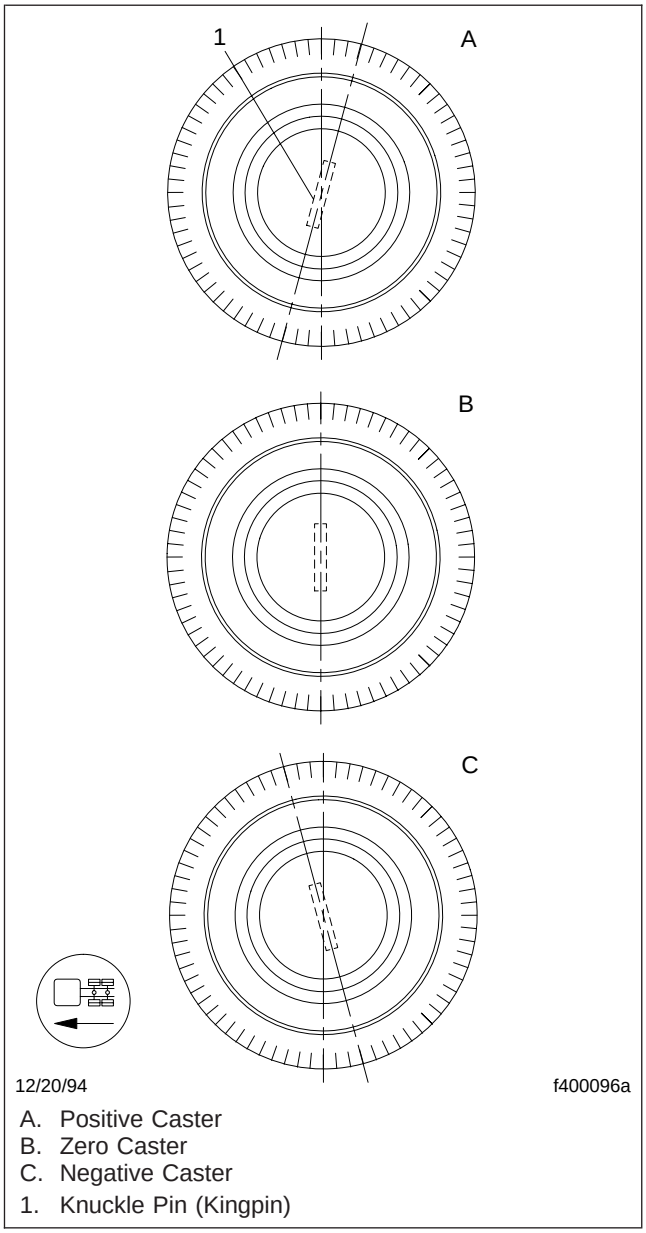
Compare the caster angles with those shown in **Specifications, 400**. If needed, adjust the caster angle by placing wedge-shaped shims between the axle spacer and the axle beam. See **Fig. 2**.

IMPORTANT: Extreme angle shims cannot be used to correct caster angles that vary by more than 2 degrees from the values in the table. Weak or broken leaf springs, or worn shackle bushings, can cause extreme deviations to caster angles. Replace damaged parts before doing caster adjustments.

1. Apply the parking brakes, and chock the front and rear tires.
2. Back off the U-bolt nuts from the U-bolts on one side of the front axle. See **Fig. 2**.
3. Raise the spring away from the axle enough to allow removal of the front caster shim.
4. Remove the shim, and install one that will provide the correct caster angle, as specified in **Specifications, 400**. Install the dowel pin and check penetration.

IMPORTANT: Place front caster shims between the axle beam and the axle spacer, or between the axle beam and the shock absorber bracket. See **Fig. 2**.

5. Lower the vehicle onto the axle.
6. Coat the threaded ends of the U-bolts with chassis lube or an antiseize compound, such as Loctite® 242. Tighten the U-bolt nuts to the value in the appropriate table in **Specifications, 400**.




A. Positive Caster
B. Zero Caster
C. Negative Caster
1. Knuckle Pin (Kingpin)

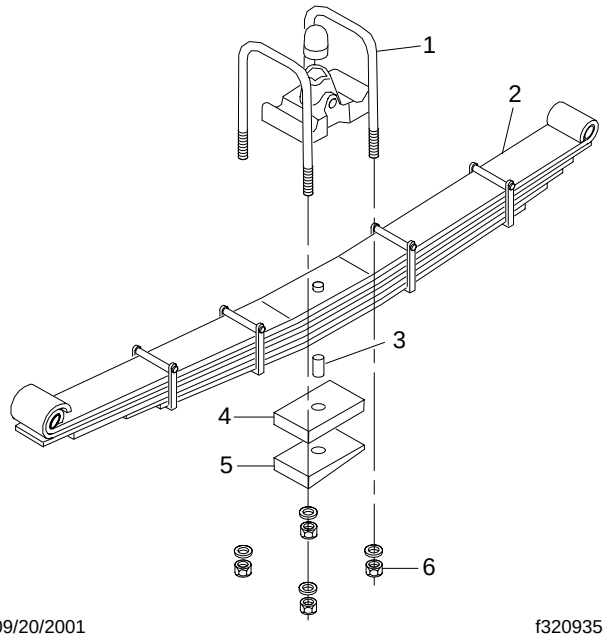
**Fig. 1, Caster Angle**

U-bolt nuts need periodic retightening. Refer to **Group 32** of the *Western Star Maintenance Manual* for recommended intervals.

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## Caster Angle Checking and Adjusting




1. Axle Spring U-Bolt
2. Leaf Spring Assembly
3. Spacer
4. Front Caster Shim
5. Dowel Pin
6. U-Bolt High Nut

**Fig. 2, Axle Spring Installation**

**⚠ CAUTION**

**Failure to periodically retighten the U-bolt nuts could result in spring breakage and abnormal tire wear.**

7. Using the steps above, replace the shim on the other side of the axle.
8. Remove the chocks from the tires. Do a final caster angle check.

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## Checking and Adjusting

Using the alignment equipment manufacturer's operating instructions, measure the wheel toe-in. See **Fig. 1**. Compare the measurement with that shown in **Specifications, 400**. If corrections are needed, go to the applicable (tie rod adjustment) step below.

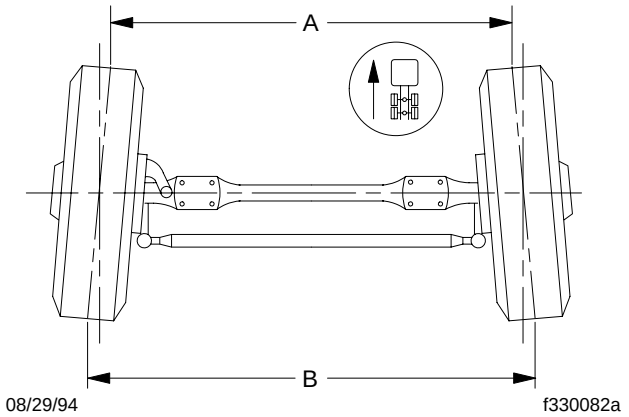



**Fig. 1, Wheel Toe-In (overhead view)**

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Dealers must have proof of this calibration history.

1. Apply the parking brakes, and chock the rear tires.
2. Raise the front of the vehicle until the tires clear the ground. Place safety stands under the axle. Make sure the stands will support the weight of the cab, axle, and frame.
3. Using spray paint or a piece of chalk, mark the entire center rib of each front tire.
4. Place a scribe or pointed instrument against the marked center rib of each tire, and turn the tires. The scribes must be held firmly in place so that a single straight line is scribed all the way around each tire.
5. Place a turn-plate or turntable under each tire. Remove the safety stands from under the axle, then lower the vehicle. Remove the lockpins from the gauges; make sure the tires are exactly straight ahead.

NOTE: If turn-plates or turntables are not available, lower the vehicle. Remove the chocks from the rear tires and release the parking brakes. Move the vehicle backward and then forward about six feet (2 meters).

6. Place the trammel bar at the rear of the front tires; locate the trammel pointers at spindle height, and adjust the pointers to line up with the scribe lines. Lock in place. Make sure that the scale is set on zero.
7. Place the trammel bar at the front of the tires as shown in **Fig. 2**. Adjust the scale end so that the pointers line up with the scribe lines. See **Fig. 3**.
8. Read the toe-in from the scale. Compare the toe-in with the value in **Specifications, 400**. If corrections are needed, go to the next step.
9. Loosen the tie rod (cross tube) clamp nuts, and turn the tie rod as needed.

   If the vehicle is not on turn-plates or turntables, move the vehicle backward and then forward about six feet (two meters). This is important when setting the toe-in on vehicles equipped with radial tires.

   Do a final wheel toe-in check to make sure that it is correct.

   Tighten the clamp nuts to the values in the appropriate table in **Specifications, 400**.
10. If not already done, remove the chocks from the rear tires. Road test the vehicle.

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## Wheel Toe-In Checking and Adjusting

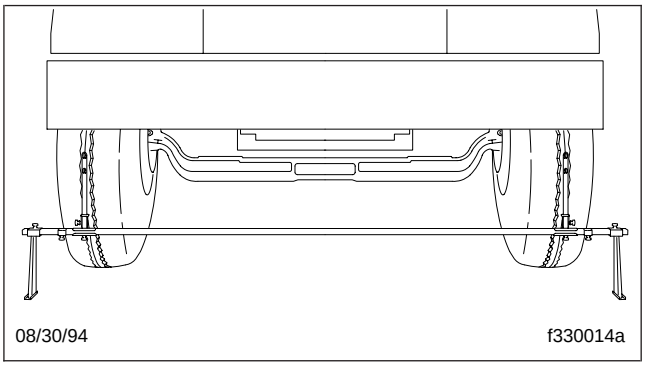



**Fig. 2, Trammel Bar Positioning**

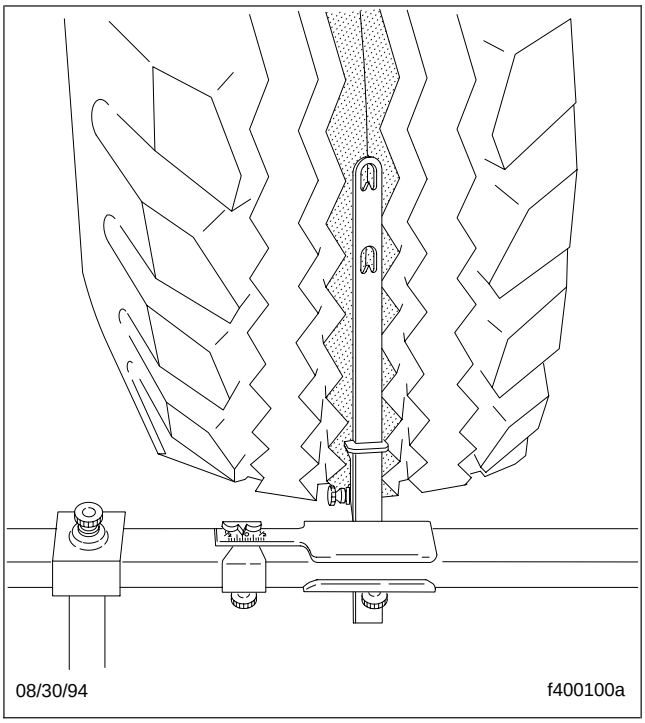



**Fig. 3, Calculating Wheel Toe-In**

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# Front Axle Removal and Installation

## Removal

NOTE: This procedure involves removing the axle from underneath the front of the vehicle. If you cannot support the vehicle high enough for the axle to clear the bumper, then you will need to remove the bumper.

1. Park the vehicle on a level surface, set the parking brakes, then chock the rear tires.
2. Tilt the hood.
3. Raise the vehicle, then support the frame rails with safety stands.
4. Remove the front tires.
5. If so equipped, disconnect the ABS sensors from the axle knuckles. Pull the sensors straight out.

**⚠ WARNING**

**When draining the air system, don't look into the air jets or direct them toward another person, as dirt or sludge particles may be in the airstream. Don't disconnect pressurized hoses because they may whip as air escapes from the line. Failure to take all necessary precautions while working on the air brake system can cause personal injury.**

6. Drain the air tanks.
7. Disconnect the air lines from the front brake chambers.
8. Remove the brake drums. See **Group 42** for instructions.
9. Remove the hubs. Refer to the applicable subject in **Section 33.01** for instructions.
10. Disconnect the steering drag link from the axle steering arm. See **Group 46** for instructions.
11. If needed, remove the front bumper.
12. Remove the U-bolts and nuts holding the axle to the leaf springs.
    - 12.1 Take the weight off the leaf springs by raising the axle.
    - 12.2 On one side of the axle, remove all the U-bolt nuts and washers, then remove the two U-bolts.
    - 12.3 Repeat the procedure on the other side of the axle.
13. Remove the axle stops from the top of the leaf springs.
14. Remove the axle spacers from the top of the axle beam.
15. Using a suitable axle jack, remove the axle by sliding it out from the front of the vehicle.
16. Remove the brake shoes, cam, and spider. See **Group 42** for instructions.

## Installation

1. From the front of the vehicle, and using a suitable axle jack, roll the axle into place under the leaf springs.
2. Install the axle spacers.
3. Slowly raise the axle up to the bottom of the leaf springs, making sure the dowels on top of the axle beam line up with the holes in the axle spacers.
4. Install the axle stops onto the tops of the leaf springs.
5. Install the U-bolts.
    - 5.1 Using a suitable clamp (such as a large C-clamp) compress one of the U-bolts, then install it on one side of the axle. Do the same for the second U-bolt.
    - 5.2 Install the U-bolt nuts and washers. Tighten the nuts finger-tight.
    - 5.3 Repeat the procedure on the other side of the axle.
6. Tighten the U-bolt nuts.

    *For 3/4–16 U-bolt nuts:* In a diagonal pattern, tighten the U-bolt nuts successively 80 lbf·ft (108 N·m), 200 lbf·ft (270 N·m), then 300 lbf·ft (406 N·m).

    *For 7/8–16 U-bolt nuts:* In a diagonal pattern, tighten the U-bolt nuts successively 60 lbf·ft (81 N·m), 200 lbf·ft (270 N·m), then 460 lbf·ft (624 N·m).
7. Install the brake spider, cam, and brake shoes. See **Group 42** for instructions.

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## Front Axle Removal and Installation

8. If so equipped, install the ABS sensors in the axle knuckles.
9. Connect the air lines to the brake chambers.
10. Connect the drag link to the steering arm. See **Group 46** for instructions.
11. Install the tires.
12. If it was removed, install the bumper.
13. Raise the vehicle, then remove the safety stands.
14. Lower the vehicle.
15. Lower the hood.
16. Remove the chocks from the rear tires.

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## Alignment Specifications

IMPORTANT: When aligning the front axle, it is essential that the rear axle(s) be checked for correct alignment at the same time. Alignment of the rear axle(s) has a direct impact on how the vehicle tracks. See **Section 35.00**, Specifications 400.

IMPORTANT: Caster settings for the left and right sides *must* be within ½ degree of each other. It is necessary for only one side to be within the specifications given in **Table 2** or **Table 5**.

NOTE: The alignment specifications below are for unloaded vehicles. These specifications will vary as weight is added to the vehicle and transferred to the front axle.

| Detroit Axles Camber | | |
|---|---|---|
| **Axle Model** | **Left Camber: degrees** | **Right Camber: degrees** |
| All | –1/4 ± 7/16 | –1/4 ± 7/16 |

**Table 1, Detroit Axles Camber**

| Detroit Axles Caster Target and Limits | | | | | |
|---|---|---|---|---|---|
| | **Hunter and Bee Line Equipment** | | **Hunter** | **Bee Line (Except LC4000)** | **Bee Line (LC4000 only)** |
| **Target: Degrees** | +3-1/2 | **Limits: Degrees** | +2 to +5 | +3 to +6-1/2 | +2-1/4 to +4-3/4 |

**Table 2, Detroit Axles Caster Target and Limits**

| Detroit Axles Toe-In Target and Limits | | | |
|---|---|---|---|
| **Hunter Equipment** | | **Bee Line Equipment** | |
| **Target: Degrees** | **Limits: Degrees** | **Target: Degrees** | **Limits: Degrees** |
| +0.09 | 0.00 to +0.18 | +1/16 (+1.6) | 0 to +1/8* (0 to +3.2) |

* If adjustment is required, set the toe-in as close as possible to +1/16 inch (+1.6 mm).

**Table 3, Detroit Axles Toe-In Target and Limits**

| Meritor and Dana Axles Camber and Toe-In, Left-Hand-Drive | | | | |
|---|---|---|---|---|
| **Axle Manufacturer** | **Axle Model** | **Left Camber*: degrees** | **Right Camber*: degrees** | **Toe-In: inch** |
| Meritor | FF–981, FF–961 | –0.20±0.50 | –0.20±0.50 | 0.3±0.3 |
| | FF–982 | –0.08±0.50 | –0.08±0.50 | 0.3±0.3 |
| | FG–941 | –0.00±0.50 | –0.00±0.50 | 0.3±0.3 |
| | FL–941 | –0.03±0.50 | –0.03±0.50 | 0.3±0.3 |
| Dana | E1200I, E1320I, E1460I | 0.19±0.50 | –0.06±0.50 | 0.3±0.3 |
| | EFA20F4 | 0.55±0.50 | –0.05±0.50 | 0.3±0.3 |
| | EFA13F5, EFA12F4 | 0.44±0.50 | –0.06±0.50 | 0.3±0.3 |

* Camber angle under axle rated load with axle installed in vehicle.

**Table 4, Meritor and Dana Axles Camber and Toe-In, Left-Hand-Drive**

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## Specifications

| Meritor and Dana Axles Caster, Left-Hand-Drive (Using Hunter Equipment) | | |
|---|---|---|
| **Axle Manufacturer** | **Without Slippered Springs: degrees** | **With Slippered Springs: degrees** |
| Meritor | 4±0.1 | 3.5±0.1 |
| Dana | 4±0.1 | 3.5±0.1 |

**Table 5, Meritor and Dana Axles Caster, Left-Hand-Drive (Using Hunter Equipment)**

# Torque Values

| Tie Rod Clamp Nut Torque Values | | | | |
|---|---|---|---|---|
| **Axle Manufacturer** | **Axle Model** | **Tie Rod Clamp Nut Size** | **Plain Nut Torque*: lbf·ft (N·m)** | **Locknut Torque*: lbf·ft (N·m)** |
| Detroit | All | 5/8–11 | 60–80 (81–108) | 60–80 (81–108) |
| Meritor | All | 5/8–11 | 40–60 (54–81) | 40–60 (54–81) |
| Dana Spicer | All | 5/8–18 | — | 45–60 (61–81) |

* All torque values in this table apply to parts lightly coated with rust-preventive type oil.

**Table 6, Tie Rod Clamp Nut Torque Values**

| Miscellaneous Torque Values | |
|---|---|
| **Description** | **Torque: lbf·ft (N·m)** |
| U-Bolt Nuts 7/8–14 | 400 (542) |
| Meritor Stopscrew Locknut | 50–65 (68–88) |
| Dana Spicer Stopscrew Locknut | 90–120 (122–163) |

**Table 7, Miscellaneous Torque Values**

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# General Information

A wheel end assembly consists of a wheel hub, wheel bearings, wheel studs, and brake drum or, for disc brakes, a rotor and caliper. See **Fig. 1** and **Fig. 2**. These vehicles are typically equipped with one of the following:

- A ConMet PreSet® hub and double spindle nut system.

  Many vehicles are equipped with PreSet hubs, which have the bearings and oil seal pre-installed. To install a new hub, mount it on the axle spindle, and secure it with a double spindle nut. For instructions, see **Subject 160**. A spacer between the inner and outer bearings adjusts the bearings to the correct end play and preload when the retaining nut is tightened.

- A ConMet PreSet hub and Axilok® spindle nut.

  Some ConMet PreSet hubs use an Axilok nut (see **Subject 170**). As with ConMet PreSet hubs that use the double spindle nut, the bearings and oil seal are pre-installed and a spacer between the inner and outer bearings adjusts the bearings to the correct end-play and preload when the retaining nut is tightened.

- The traditional hub and bearings, and a double spindle nut system.

  With traditional wheel ends, the bearings and oil seal must be assembled with the hub when the hub is installed on the axle spindle. First the oil seal is placed on the spindle (some brands of oil seal are installed in the hub bore), then the inner bearing and the hub are mounted on the axle spindle. Then, the outer bearing is mounted in the hub bore. A nut is installed on the axle spindle end and tightened and loosened to adjust the bearings. Finally, a locking device and jam nut are installed to secure the hub and bearings on the axle. For instructions, see **Subject 160**.

- The Meritor Easy Steer Plus® Axle, Model FF-981

  This axle has the hubs, bearings, and oil seals factory-installed on the axle spindles. The hubs can be removed and installed on the axle, and the studs can be replaced, but the wheel bearings and oil seal are not serviceable in the field. To install a new hub, mount it on the axle spindle, and secure it. For instructions, see **Subject 180**.

- The traditional hub and bearings, and a Pro-Torq® nut system.

  This system is the same as the above traditional hub and bearing system, but in place of the four-piece bearing-lock system, it has one adjusting nut and a lockring device. For instructions, see **Subject 190**.

## Tapered Wheel Bearings

A traditional tapered wheel bearing assembly consists of a cone, tapered rollers, a roller cage, and a separate cup that is press-fit in the hub. See **Fig. 3**. All components carry the load, with the exception of the cage, which spaces the rollers around the cone.

Each hub has a set of inner and outer tapered wheel bearing assemblies. On traditional hub and bearing assemblies, the bearing setting is locked in place on the axle spindle (steering knuckle) by an adjusting nut, a locking device such as a lockring or nut-lock, and a jam nut, or a Pro-Torq nut. See **Fig. 2**.

ConMet PreSet hubs have special bearing assemblies.

## Wheel Hub

The wheel and the brake drum are mounted on an aluminum or iron wheel hub. Both the inner and outer wheel bearing cups and the wheel studs are press-fit in the hub.

## Wheel Studs

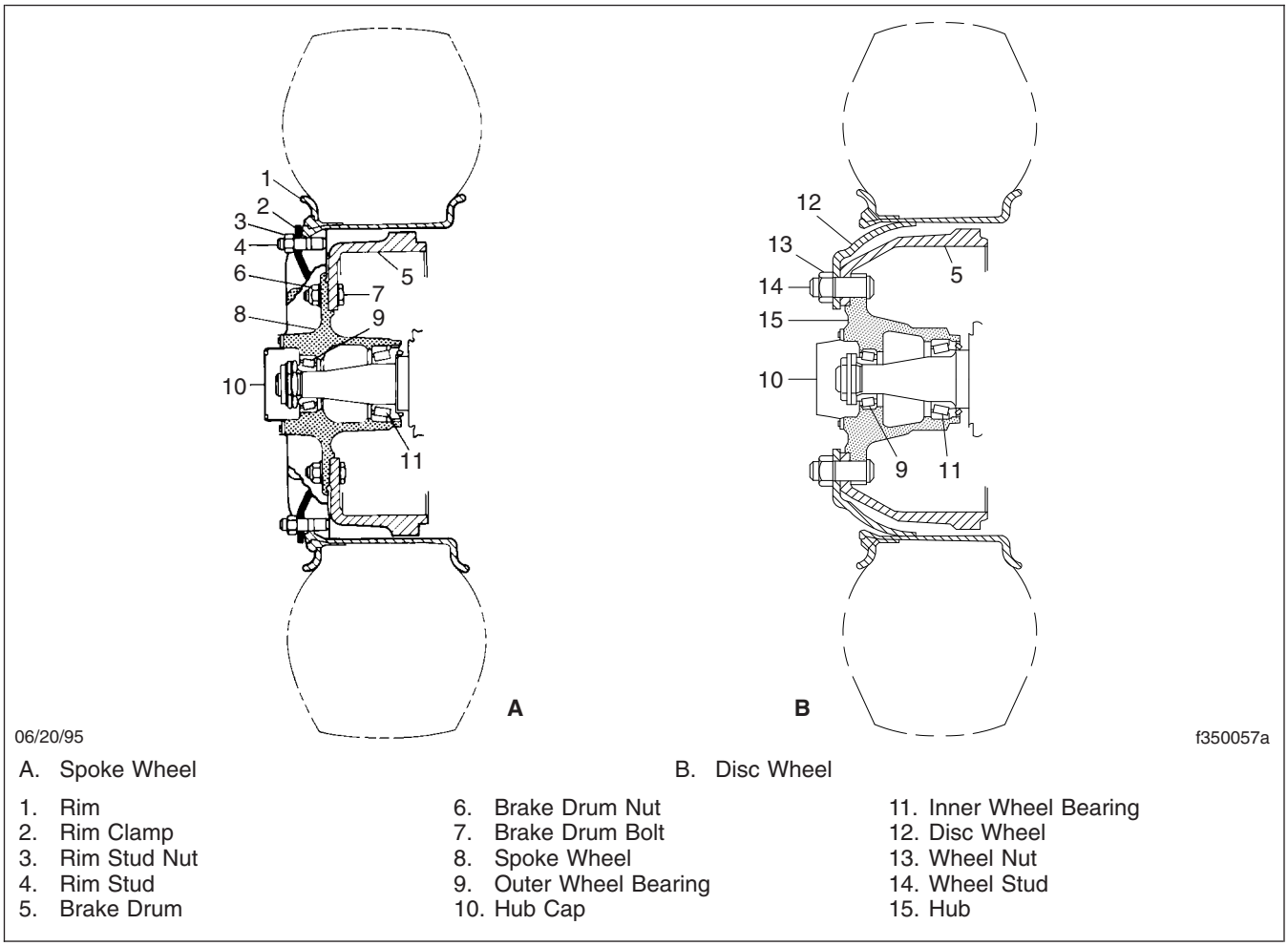
A headed wheel stud (**Fig. 4**) is used on front axle disc wheel hub assemblies and has either serrations on the stud body or a flat area on the stud's head to prevent the stud from turning in the wheel hub.

On vehicles equipped with ball-seat or stud-piloted wheels, the end of the stud that faces away from the vehicle is stamped with an "L" or "R," depending on which side of the vehicle the stud is installed. Studs stamped with an "L" are left-hand threaded and are installed on the left side of the vehicle. Studs stamped with an "R" are right-hand threaded and are installed on the right side of the vehicle.

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## General Information




A. Spoke Wheel

1. Rim
2. Rim Clamp
3. Rim Stud Nut
4. Rim Stud
5. Brake Drum

B. Disc Wheel

6. Brake Drum Nut
7. Brake Drum Bolt
8. Spoke Wheel
9. Outer Wheel Bearing
10. Hub Cap
11. Inner Wheel Bearing
12. Disc Wheel
13. Wheel Nut
14. Wheel Stud
15. Hub

**Fig. 1, Spoke and Disc Wheel Assemblies, Cutaway Views**

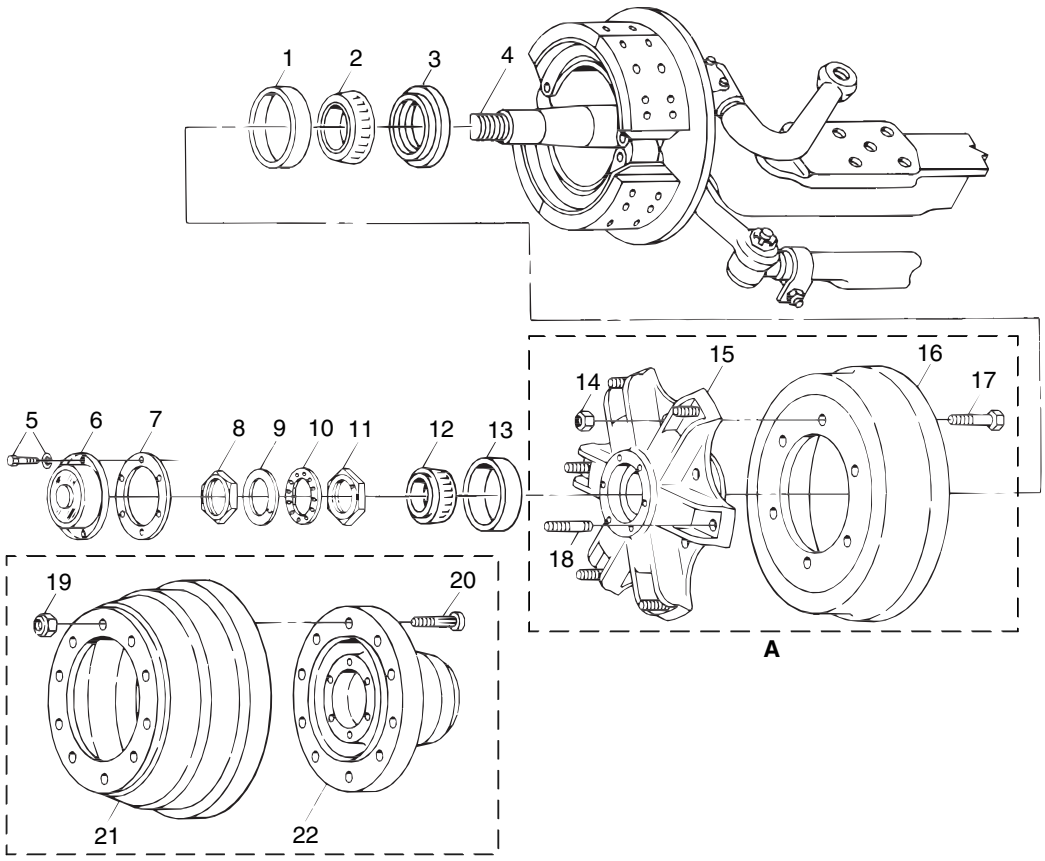
# Brake Drum

The brake drum and lining work together as a mated friction pair, with the drum responsible for both heat absorption and dissipation. Lining performance and life largely depend on the condition of the drum and whether it can adequately absorb and dissipate heat generated by braking action.

The brake drum is mounted on the outboard face of the hub and fits over the wheel studs. See **Fig. 2.**

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NOTE: On Meritor FF-981 Easy Steer Plus axles, the hub, wheel bearings, studs, and oil seal are assembled at Meritor and installed as an assembly.

A. Spoke Wheel and Inboard-Mounted Drum Assembly
B. Disc Wheel, Hub, and Outboard-Mounted Drum Assembly

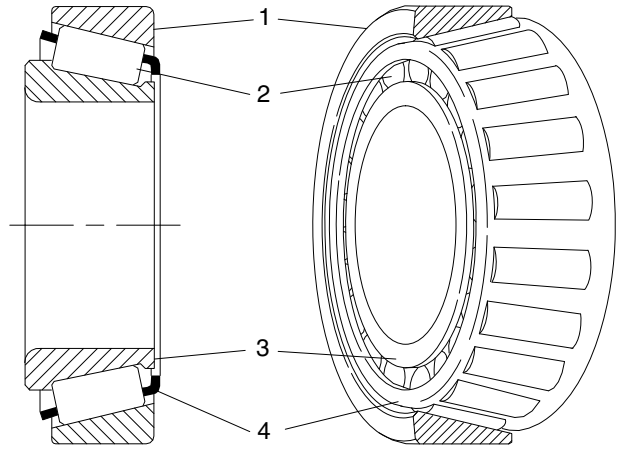
1. Inner Wheel Bearing Cup
2. Inner Wheel Bearing
3. Oil Seal
4. Axle Spindle (Steering Knuckle)
5. Hub Cap Capscrew and Washer
6. Hub Cap
7. Hub Cap Gasket
8. Jam Nut
9. Lockwasher
10. Lockring
11. Wheel Bearing Adjusting Nut
12. Outer Wheel Bearing
13. Outer Wheel Bearing Cup
14. Brake Drum Nut
15. Spoke Wheel
16. Brake Drum, Inboard-Mounted
17. Brake Drum Bolt
18. Rim Stud
19. Wheel Nut
20. Wheel Stud
21. Brake Drum, Outboard-Mounted
22. Wheel Hub

**Fig. 2, Typical Wheel and Axle Assembly**

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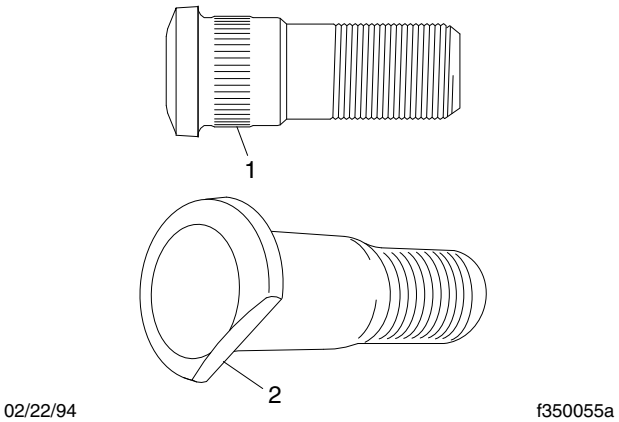
## General Information




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1. Cup
2. Tapered Roller
3. Cone
4. Roller Cage

**Fig. 3, Tapered Wheel Bearing Assembly**




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1. Serrations
2. Clipped Head

**Fig. 4, Typical Wheel Studs**

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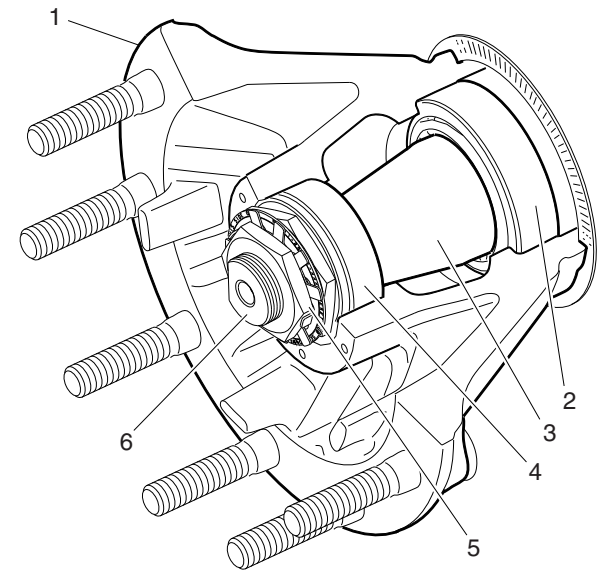


# Hub Assembly Removal and Installation

## General Information

ConMet PreSet® steer axle hubs are equipped with a special tubular spacer inside the hub, between the inner and outer bearings. See **Fig. 1**.

When installing a PreSet hub with the spacer and special PreSet bearings, the correct end play is set automatically and wheel bearing adjustment is unnecessary.




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1. Hub
2. Inner Bearing
3. Bearing Spacer
4. Outer Bearing
5. Retaining Nut (double spindle nut system)
6. Axle Spindle

**Fig. 1, ConMet PreSet Hub, Cut-Away View**

For vehicles equipped with ConMet PreSet hubs, it is highly recommended to **stay with the PreSet system** to optimize bearing and seal life. However, if you are replacing the bearings for a PreSet hub, and the special PreSet bearings are not available, standard wheel bearings can be used. In this case, the bearing spacer must be removed and the bearings adjusted manually. See the installation instructions for more information.

## Removal

For typical wheel end and axle assemblies, see **Fig. 2** and **Fig. 3**.

1. Chock the rear tires.
2. Raise the front of the vehicle until the tires clear the ground. Then place safety stands under the axle.
3. For drum brakes, back off the slack adjuster to release the front axle brake shoes.

**⚠ WARNING**

**Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.**

4. Remove the wheel and tire assembly. See **Group 40** for instructions.
5. For drum brakes, remove the brake drum. See **Subject 110** for instructions.

   For disc brakes, remove the brake caliper. See **Section 42.24** for instructions.

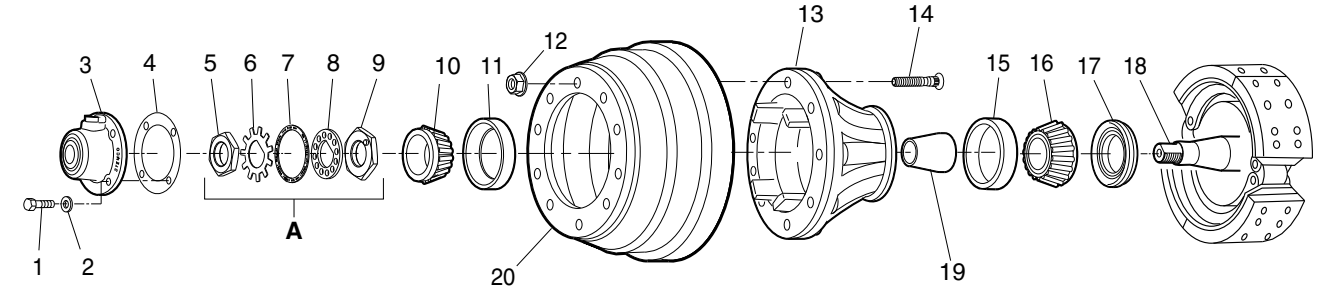
NOTE: Oil will spill as the hub cap and wheel hub are removed. Place a suitable container under the axle spindle to catch any spilled oil, and avoid contaminating the brake shoes with oil. Dispose of the oil properly.

6. Remove the capscrews, washers, and hub cap. Remove and discard the hub cap gasket.
7. Remove the wheel bearing locking device:
   - For an Axilok spindle nut, see **Subject 170**; then go to the next step.
   - For a Pro-Torq spindle nut, see **Subject 190**; then go to the next step.
   - If the axle is equipped with a double spindle nut system, see **Subject 160**; then go to the next step.

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## Hub Assembly Removal and Installation

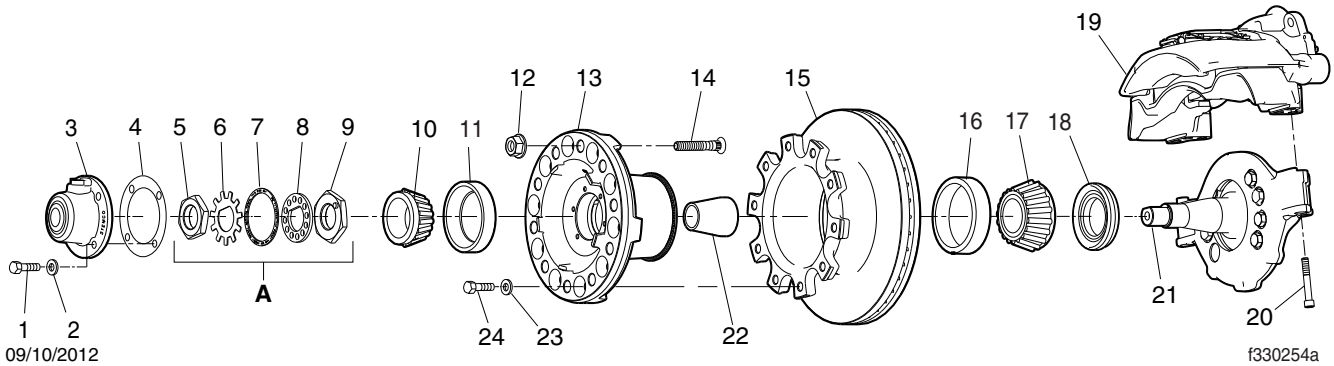



NOTE: An ID ring and bearing spacer are used with ConMet PreSet hubs only.

A. Double spindle nut set shown. Axilok or Pro-Torq spindle nuts could be used on some installations.

1. Hub Cap Capscrew
2. Washer
3. Hub Cap
4. Gasket
5. Jam Nut
6. Bend-Type Locking Washer
7. ID Ring
8. Lockring
9. Adjusting Nut
10. Outer Wheel Bearing
11. Outer Wheel Bearing Cup
12. Wheel Nut
13. Hub
14. Wheel Stud
15. Inner Wheel Bearing Cup
16. Inner Wheel Bearing
17. Oil Seal
18. Axle Spindle
19. Bearing Spacer
20. Brake Drum

**Fig. 2, Typical Wheel End Assembly, Front Axle with Drum Brakes**




NOTE: An ID ring and bearing spacer are used with ConMet PreSet hubs only.

A. Double spindle nut set shown. Axilok or Pro-Torq spindle nuts could be used on some installations.

1. Hub Cap Capscrew
2. Washer
3. Hub Cap
4. Gasket
5. Jam Nut
6. Bend-Type Locking Washer
7. ID Ring
8. Lockring
9. Adjusting Nut
10. Outer Wheel Bearing
11. Outer Wheel Bearing Cup
12. Wheel Nut
13. ConMet PreSet Hub
14. Wheel Stud
15. Brake Rotor
16. Inner Wheel Bearing Cup
17. Inner Wheel Bearing
18. Oil Seal
19. Brake Caliper
20. Caliper Mounting Capscrew
21. Axle Spindle
22. Bearing Spacer
23. Washer
24. Capscrew

**Fig. 3, Typical Wheel End Assembly, Front Axle with Disc Brakes**

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## NOTICE

**Be careful not to let the outer wheel bearing drop from the axle spindle. Dropping the bearing can warp the cage or damage the rollers, ruining the bearing. On vehicles equipped with WABCO ABS, use care when working with the hubs. To prevent damage to the tone wheel, do not drop the hub, or lay it down in a way that would damage the tone wheel.**

8. Move the hub about ½ inch (13 mm) to jar loose the outer wheel bearing (allow the hub-only assembly to rest on the axle spindle; be careful not to damage the axle spindle threads). Then, carefully remove the outer wheel bearing; handle the bearings with clean, dry hands. Wrap the bearings in either clean oil-proof paper or lint-free rags.

## NOTICE

**Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.**

9. Remove the hub from the axle spindle. Be careful not to damage the axle spindle threads as the assembly is removed.
10. Remove the inner wheel bearing; handle the bearings with clean, dry hands. Wrap the bearings in clean, oil-proof paper or lint-free rags. If the inner wheel bearing remains in the hub after the hub is removed, place a protective cushion where it will catch the bearings, and use a hardwood drift and a light hammer to gently tap the bearing (and seal, if necessary) out of the cup.
11. Remove the oil seal from the axle spindle, if not already removed. See **Section 33.02** for additional information.

NOTE: For vehicles equipped with disc brakes, instructions for removing the brake rotor are given in **Section 42.24**.

# Installation

For typical wheel end and axle assemblies, see **Fig. 2** and **Fig. 3**.

NOTE: For vehicles equipped with disc brakes, instructions for installing the brake rotor are given in **Section 42.24**.

1. Using cleaning solvent, remove the old oil from the axle spindle (steering knuckle) and the disassembled parts. Allow the parts to dry, or dry them with clean, absorbent, and lint-free cloth or paper. Wrap a protective layer of friction tape on the axle spindle threads.

   For PreSet hubs that are being reused, the bearing spacer must be replaced.

## NOTICE

**Make sure that both bearing assemblies are coated with fresh oil. Use only fresh oil on the bearing assemblies; old oil could be contaminated with dirt or water (both are corrosives) and could cause damage to both wheel bearing assemblies and the wheel hub.**

2. Coat both bearing assemblies with fresh oil. Install the inner wheel bearings and oil seal. Handle the bearings with clean, dry hands. See **Section 33.02** for oil seal installation instructions.
3. Wipe a film of axle oil on the axle spindle to prevent rust from forming behind the inner wheel bearing. Do not lubricate the seal journal.
4. If present, remove the temporary plastic bearing cover from the front of the hub.

## NOTICE

**Do not use the bearing spacer with standard wheel bearings. To do so may result in too much bearing end-play, which could damage the wheel bearings, oil seals, the axle spindle, and the hub.**

5. If using PreSet bearings, ensure the tubular spacer is in the PreSet hub.

   If replacing PreSet bearings with non-PreSet bearings, remove the tubular spacer from inside the hub. Save it for future use to convert the hub back to the PreSet system.

## NOTICE

**When installing a hub, remember the following:**

- **On vehicles equipped with WABCO ABS, use care when installing the hubs. To pre-**

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## Hub Assembly Removal and Installation

**vent damage to the tone wheel, do not drop the hub or lay it down in a way that would damage the tone wheel.**

- **Do not remove the outer wheel bearing once the hub is installed on the axle. Removing the outer bearing could cause the oil seal to become misaligned, which could cause damage to the wheel bearings, the hub, and the axle spindle.**

6. Mount the hub assembly on the axle spindle.
7. Remove the friction tape, then adjust (if needed) and secure the bearings:
   - For an Axilok spindle nut, see **Subject 170**; then go to the next step.
   - For a Pro-Torq spindle nut, see **Subject 190**; then go to the next step.
   - If the axle is equipped with a double spindle nut system, see **Subject 160**; then go to the next step.
8. Place the hub cap and a new gasket in position, then install the washers and capscrews. In a star pattern, tighten the capscrews 15 lbf·ft (20 N·m).
9. If applicable, add fresh oil to the wheel hub to the level indicated on the hub cap.

**⚠ WARNING**

**Failure to add oil to the wheel hub after the hub has been serviced will cause the wheel bearings to overheat and seize during vehicle operation. Seized bearing rollers can cause sudden damage to the tire or axle, possibly resulting in personal injury and property damage.**

10. Rotate the hub to distribute the oil, then check the level at the hub cap. Add lubricant as needed.
11. For drum brakes, install the brake drum on the wheel hub. See **Subject 110** for instructions.

    For disc brakes, install the brake caliper. See **Section 42.24** for instructions.
12. Install the wheel and tire assembly. See **Group 40** for instructions.

**⚠ WARNING**

**If the wheel nuts cannot be tightened to minimum torque values, the wheel studs have lost their locking action, and the wheel hub flange is probably damaged. In this case, replace it with a new wheel hub assembly. Failure to replace the wheel hub assembly when the conditions described above exist could result in the loss of a wheel or loss of vehicle control, and possible personal injury.**

13. Adjust the front axle brakes. For instructions, see **Group 42**.
14. Remove the safety stands from under the axle and lower the vehicle.

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# Outboard-Mounted Drum Removal and Installation

**⚠ WARNING**

**When replacing brake pads, shoes, rotors, or drums, always replace components as an axle set.**

- **Always reline both sets of brakes on an axle at the same time.**
- **Always replace both rotors/drums on an axle at the same time.**
- **Always install the same type of linings/pads or drums/rotors on both axle ends of a single axle, and all four axle ends of a tandem axle, at the same time. Do not mix component types.**

**Failure to do so could cause uneven braking and loss of vehicle control, resulting in property damage, personal injury, or death.**

## Removal

1. Chock the rear tires to prevent vehicle movement. Apply the parking brakes.
2. Raise the front of the vehicle until the tires clear the ground. Then place safety stands under the axle.
3. Back off the slack adjuster to release the front axle brake shoes. Refer to **Group 42** for instructions.

**⚠ WARNING**

**Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.**

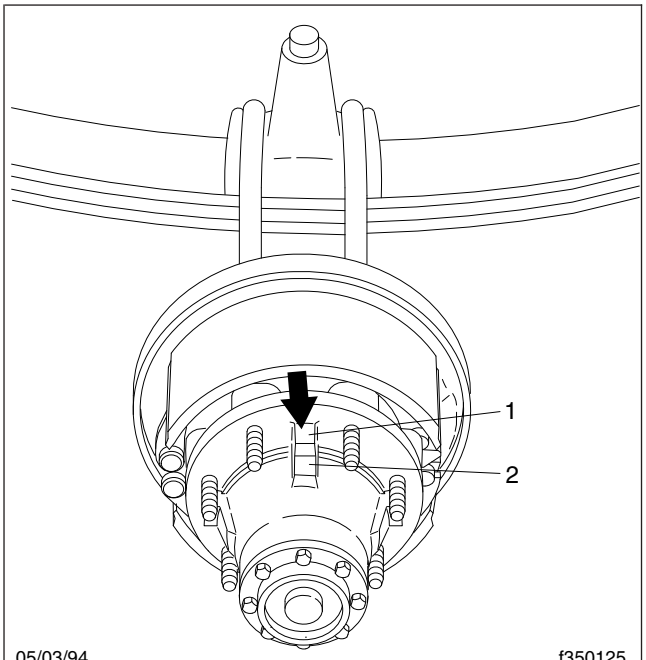
4. Remove the wheel and tire assembly. Refer to **Group 40** for instructions.

   To minimize the possibility of creating airborne brake lining dust, clean the dust from the brake drum, brake backing plate, and brake assembly, using an industrial-type vacuum cleaner equipped with a high-efficiency filter system. Then, using a rag soaked in water and wrung until nearly dry, remove any remaining dust. Don't use compressed air or dry brushing to clean the brake assembly.
5. Remove the brake drum.
6. Inspect the drum. See **Subject 120** for instructions.

## Installation

1. Install the brake drum on the wheel hub.

   1.1 On hub-piloted drums, position the brake drum on the top step of the pilot pad. One of the hub's pilot pads should be at the twelve o'clock (top center) position. See **Fig. 1**.




NOTE: Pilot pad at 12 o'clock position
1. Drum Pilot
2. Wheel Pilot

**Fig. 1, Hub Pilot Pads**

IMPORTANT: If the drum is not positioned correctly, the pilot pad could be damaged when the wheel nuts are torqued.

1.2 Make sure that the pilot pads securely center the drum (space between drum and hub is equal all around the hub).

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## Outboard-Mounted Drum Removal and Installation

IMPORTANT: If damage to the pads prevents the drum from centering, replace the hub. If necessary to hold the drum in position, adjust the brakes before installing the wheels.

2. Install the wheel and tire assembly. To ensure that the drum does not slip off the pilot pad, follow the proper nut tightening sequence. For instructions, see **Group 40**.

**⚠ WARNING**

**If the wheel nuts cannot be tightened to minimum torque values, the wheel studs have lost their locking ability, and the hub flange is probably damaged. In this case, replace it with a new wheel hub assembly. Failure to replace the wheel hub assembly when the conditions described above exist, could result in the loss of a wheel or loss of vehicle control, and possible personal injury.**

3. Adjust the front axle brakes. See **Group 42** of the *Western Star Maintenance Manual*.
4. Remove the safety stands from under the axle; lower the vehicle.
5. Remove the chocks from the rear tires.

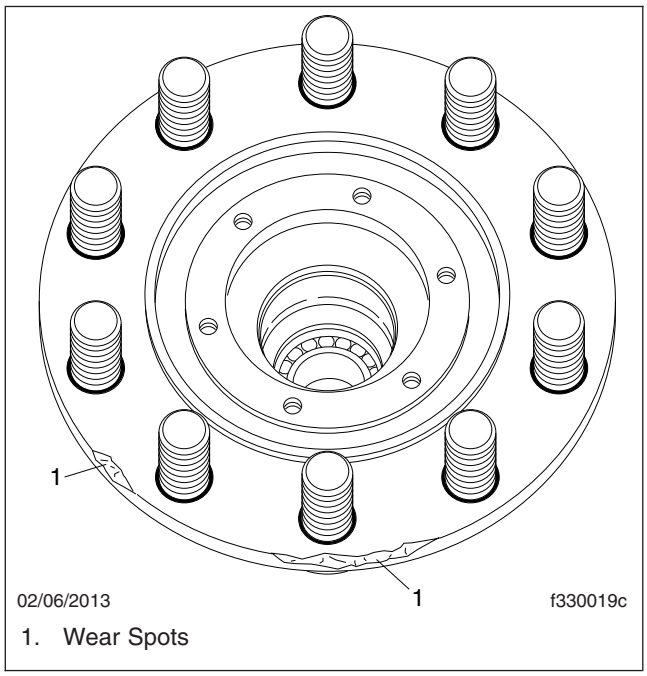
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## Wheel Hub Assembly Inspection

1. Inspect the wheel hub mounting flange. A loose wheel assembly will cause the flange to be worn, jagged, or warped. See **Fig. 1**. Replace the wheel hub if any of these conditions exist.

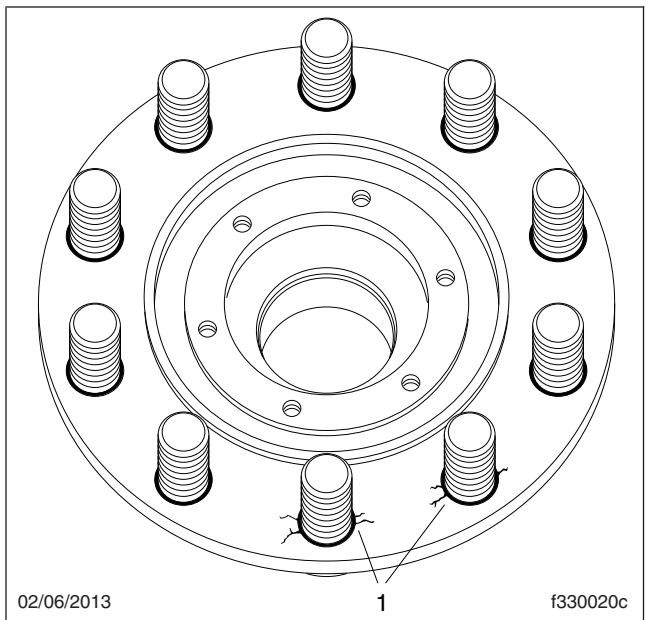
   Inspect the flange surface around the wheel studs. Improperly torqued wheel nuts will cause worn or cracked stud grooves on the hub. See **Fig. 2**. If wear spots or cracks appear anywhere on the hub, or if the hub is otherwise damaged, replace it with a new one.




1. Wear Spots

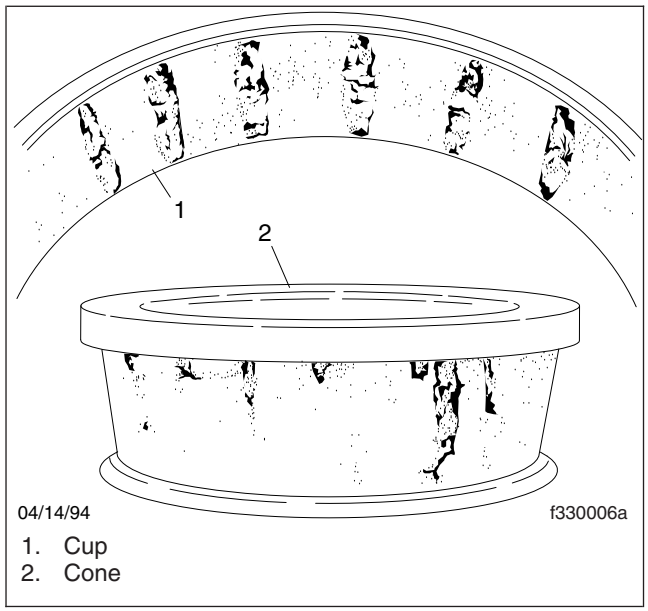
**Fig. 1, Damaged Front Axle Wheel Hub**

2. Remove all the old oil from the wheel hub cavity. Inspect the inner surface of the hub for cracks, dents, wear, or other damage. Replace the wheel hub if damage exists.
3. Remove all the old grease or oil from the surfaces of the wheel bearing cups. Inspect the wheel bearing cups for cracks, wear, spalling, or flaking. See **Fig. 3**. Replace the cups if damaged in any way. For instructions, see **Subject 130** or **Subject 140**.




1. Cracked Stud Grooves

**Fig. 2, Damaged Front Axle Wheel Hub**




1. Cup
2. Cone

**Fig. 3, Spalling (Flaking) of Wheel Bearing Assembly**

4. Inspect the wheel nuts on disc wheel installations, or the rim nuts on spoke-wheel installations. Damaged nuts (**Fig. 4**), usually caused by inadequate tightening, must be replaced with new ones.

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## Axle Components Cleaning and Inspection

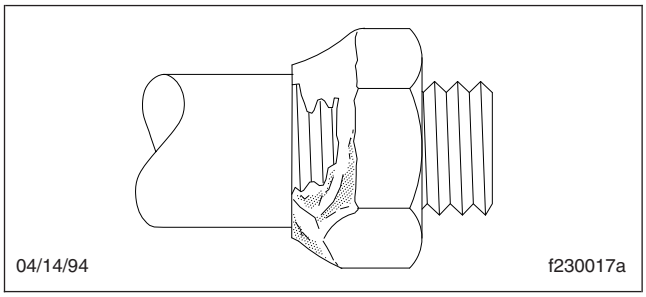



**Fig. 4, Damaged Wheel Stud Nut**

5. Inspect the wheel or rim studs. Replace studs that are stripped, broken, bent, or otherwise damaged. For instructions, see **Subject 150**.

# Wheel Bearing Inspection

Wheel bearings should be very closely inspected at the time of disassembly. Optimal inspection conditions are possible only after the bearings have been thoroughly cleaned using nonflammable solvent and a stiff brush. Before inspecting, clean the bearings.

1. Remove the wheel hub and bearing cones. For instructions, see **Subject 100**.
2. Using nonflammable solvent and a stiff brush, clean all the oil from the bearings and hub cavity. Do not use gasoline or heated solvent.
3. Allow the cleaned parts to dry, or dry them with a clean absorbent cloth or paper. Clean and dry your hands and all tools used in the maintenance operation. Oil will not stick to a surface which is wet with kerosene or diesel fuel, and the kerosene or diesel fuel may dilute the lubricant.

## NOTICE

**Do not spin the bearing rollers at any time. Dirt or grit can scratch the roller surface and cause premature wear of the bearing assembly. Treat a used bearing as carefully as a new one.**

4. After the bearings are cleaned, inspect the assemblies, which include the rollers, cones, cups, and cages. If any of the following conditions exist, replace the bearing assemblies:

    4.1 Large ends of rollers worn flush to the recess, or radii at the large ends of the rollers worn sharp. These are indications of advanced wear. See **Fig. 5**.

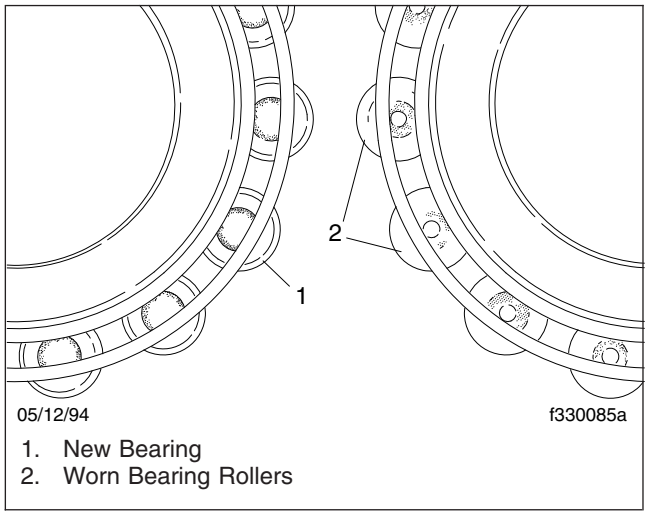



**Fig. 5, Wheel Bearing Roller Wear**

    4.2 Visible step wear, particularly at the small end of the roller track. Deep indentations, cracks, or breaks in the cone surfaces. See **Fig. 6**.

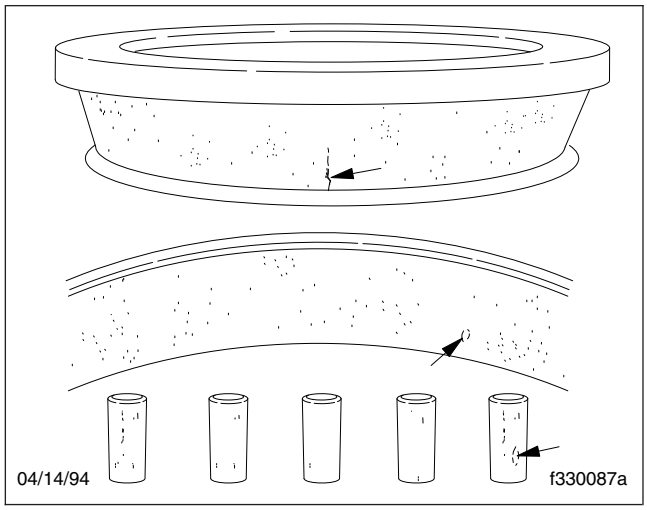



**Fig. 6, Indentations, Cracks, or Breaks in Bearing Surfaces**

    4.3 Bright rubbing marks on the dark phosphate surfaces of the bearing cage. See **Fig. 7**.

    4.4 Water etch on any bearing surface. Water etch appears as gray or black stains on the steel surface, and it greatly weakens

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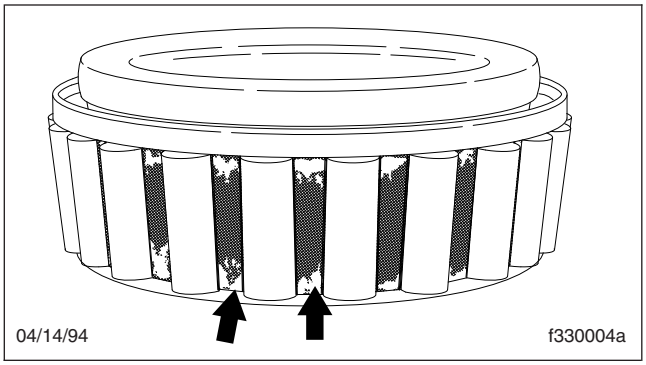



**Fig. 7, Rubbing Marks on Bearing Cage**

the affected area. If water etch is present, replace the bearing seals.

4.5 Etching or pitting on functioning surfaces. See **Fig. 8**.

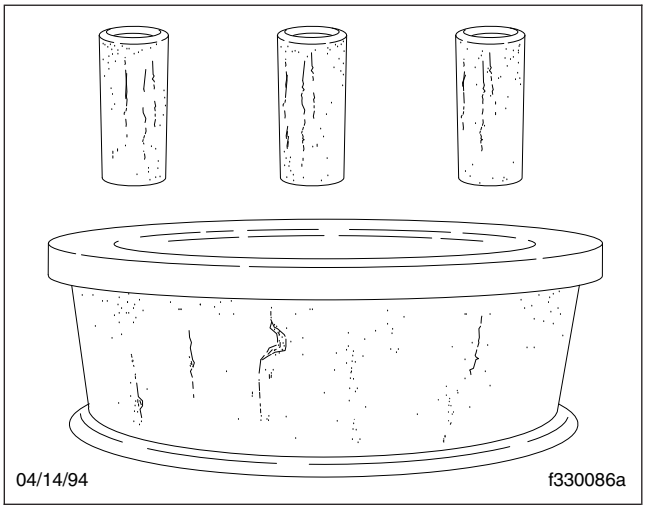



**Fig. 8, Etching (Pitting) on Bearing Surfaces**

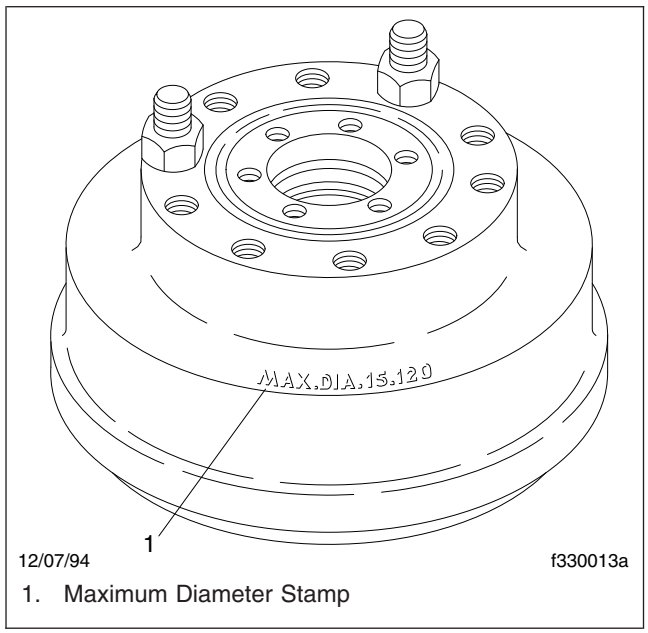
4.6 Spalling (flaking) of the bearing cup, roller, or cone surfaces. See **Fig. 3**.

After inspection, brush the bearings with fresh axle lubricant.

## Brake Drum Inspection

New brake drums are purposely undersized to allow for turning (remachining), since in mounting drums on the hub, there can be some eccentricity. If a new drum is installed, the protective coating on the inner friction surface must be removed with a solvent, prior to drum installation, then rinsed with a hot water wash. Use a clean rag to remove any oily residue or metal chips from the friction surface.

If a drum must be turned or replaced, the other same-axle drum must be similarly turned or replaced to provide the same braking power on both wheels. Turned drums should not exceed the maximum allowable diameter, which is stamped on the outside surface of the drum. See **Fig. 9** for a typical location of this stamp.




1. Maximum Diameter Stamp

**Fig. 9, Outboard Mounted Hub and Drum Assembly**

NOTE: Drums that have been turned should then be cleaned by using fine emery cloth followed with a hot water wash. Drums that have been renewed using emery cloth should also be followed with a hot water wash.

**NOTICE**

**Failure to replace drums when worn or turned to limits exceeding the maximum allowable diameter will result in drum weakness and reduced braking capacity, which can lead to distortion, higher drum temperatures, and ultimately, drum breakage.**

If the drums are turned or replaced, replace the brake linings. See **Group 42** for instructions.

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## Axle Components Cleaning and Inspection

1. Inspect the inner friction surface. If a veneered (highly glossed) or glazed surface exists, renew the drum by using 80-grit emery cloth or by turning the drums.
2. Inspect for heat checking, which is a form of buckling (cracking) resulting from a temperature differential in the drum wall between a relatively cool exterior and a hot friction surface. Heat checking is normal on all drums and may not impair performance and lining life if the network of fine hairline cracks remains small. Examine heat checks of drums frequently to be certain the checks have not widened into drum weakening cracks (substantial cracks extending to the open edge of the drum). Replace the same-axle drums if substantial cracks are present, or if widening of the fine hairline cracks occurs.

NOTE: If normal heat checking as described above is present, inspect the drums at least every 12,000 miles (19 300 km) thereafter. Inspect the drums (using a flashlight from the inboard side of the wheels) every 6000 miles (9700 km). Inspect more often under adverse operating conditions.

3. Check for a contaminated inner friction surface. If fluids are present, such as oil or grease, remove the contaminants. Locate and correct the source of the contamination. If the brake drums are contaminated with fluids, the brake linings will also be affected. Since oil or grease saturated linings cannot be salvaged, they must be replaced. For brake lining replacement procedures, see **Group 42**.

**⚠ WARNING**

**If the brake drums are contaminated with fluids, replace the brake linings. Failure to replace fluid contaminated brake linings could result in a partial loss of braking capacity, which could lead to personal injury or property damage.**

4. Measure the inside diameter of the drum. If the measured diameter is greater than the maximum allowable diameter, replace the same-axle drums and linings.
5. Ensure the roundness of the drum is within acceptable limits, as follows. Set the measuring tip of a dial indicator against the working surface of the drum between the brake shoes as far outboard as possible. Zero the gauge, then turn the drum one revolution and note the highest and lowest measurements.

   If the difference is 0.010 inch (0.25 mm) or less, proceed to the next step. If the difference is more than 0.010 inch (0.25 mm), mark the drum and hub to record their relative positions, and remove the drum. Clean the mating surfaces of the hub and drum, and re-install the drum rotated 90 degrees from its earlier position. Tighten four wheel nuts 50 lbf·ft (68 N·m), and repeat the measurement. If the difference is more than 0.010 inch (0.25 mm), the drum is out of round beyond acceptable limits and all drums on the axle must be re-machined or replaced.
6. Inspect the outside surface of the drum. Remove any accumulation of mud, dirt, or rust; foreign matter acts as an insulator, trapping heat within the drum.
7. Check for hard, slightly raised dark-colored spots on the inner friction surface or for a bluish cast on the brake parts, both of which are caused by high temperatures. If the drums' maximum allowable diameters have not been exceeded, remachine both same-axle drums. If the spots or discoloration cannot be removed, or if remachining is not possible, replace the drums. Also replace the brake shoe return springs.

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# Wheel Bearing Cup Removal and Installation, Aluminum Hubs

## Removal

To insure a tight fit, wheel bearing cups (**Fig. 1**) are purposely larger than the wheel hub bores they occupy. To remove the bearing cups, aluminum hub bores must be temporarily expanded by heating the hub in an oven (the bearing cups will also expand, but to a considerably lesser extent). If adequate heating facilities are not available, replace the hub, wheel stud, and bearing cup assembly.

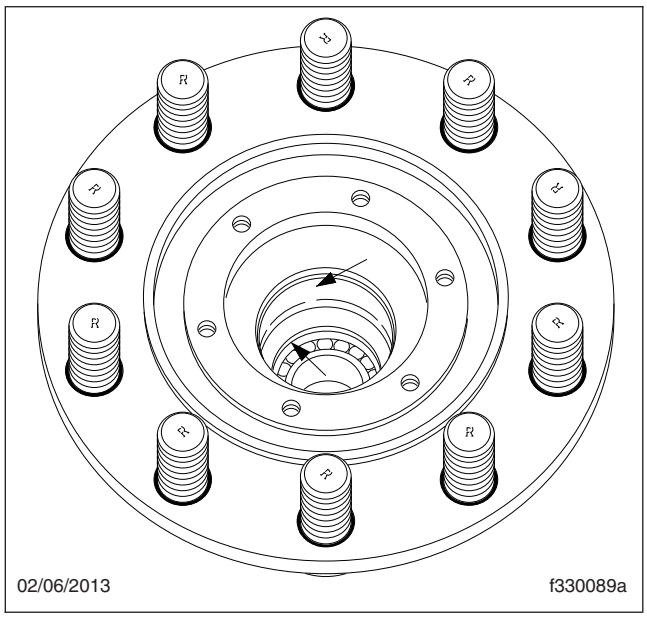



**Fig. 1, Wheel Bearing Cup Locations**

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly.
2. Oven-heat the hub to a temperature range of 240 to 280°F (116 to 138°C). Make sure the oven thermostat is accurately set; if unsure, use an oven thermometer to check the temperature of the oven before placing the hub inside.

   If adequate heating facilities are not available, replace the hub, wheel stud, and bearing cup assembly.

**⚠ WARNING**

**Do not use oxyacetylene equipment or similar equipment to heat the hub. Oxyacetylene equipment or similar equipment will cause cracks in the hub which could cause loss of a wheel and loss of vehicle control, leading to personal injury or property damage.**

3. Wearing heavy protective gloves, remove the hub from the oven. Place the hub on a suitable press so that the base is fully supported. Quickly press out the bearing cups.

## Installation

To install the bearing cups, aluminum hubs must again be temporarily expanded using oven heating. When the hub is properly heated, the bearing cup and hub can be press-fit together, using a suitable press.

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly, including the bearing cup bores.
2. Inspect the bearing cup bores of the hub for warpage or uneven surfaces. If a bearing cup bore is damaged, replace the wheel hub assembly.
3. Oven-heat the hub to a temperature range of 240 to 280°F (116 to 138°C). Make sure the oven thermostat is accurately set; if unsure, use an oven thermometer to check the temperature of the oven before placing the hub inside.

**⚠ WARNING**

**Do not use oxyacetylene equipment or similar equipment to heat the hub. Oxyacetylene equipment or similar equipment will cause cracks in the hub which could cause loss of a wheel and loss of vehicle control, leading to personal injury or property damage.**

4. Coat the replacement bearing cup hub contact surface with a film of grease.
5. Wearing heavy protective gloves, remove the hub from the oven.
6. Place the hub on a suitable press so that the base is fully supported. Quickly press-fit the bearing cup into the wheel hub until it is completely and evenly seated. Be careful not to shave the sides of the bearing cup bore as the bearing cup is seated. The accumulation of debris will prevent the cup from being seated and will also cause permanent damage to the wheel

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## Wheel Bearing Cup Removal and Installation, Aluminum Hubs

hub. If the sides of the bearing cup bore are damaged during installation, replace the wheel hub assembly.

7. Allow the wheel hub to cool before handling. Then, using a 0.0015-inch feeler gauge, check at several places for the seating of the bearing cup in the bearing cup bore. The gauge should not enter beneath the cup. If it does, there is probably dirt or debris preventing the cup from seating. Using the instructions above, remove the cup, then remove the foreign matter. Reinstall the cup.
8. Wipe off the accumulation of grease left after the bearing cup has been seated. Then, using a clean, lint-free cloth dampened with kerosene or diesel fuel oil, clean the inner surface of the bearing cup. Wipe the surface dry using a clean, absorbent, and lint-free cloth or paper.

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# Wheel Bearing Cup Removal and Installation, Ferrous Hubs

## Removal

Wheel bearing cups on ferrous hubs are removed and installed by driving them out and pressing them in without heating the hub.

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly.
2. Using a mild-steel rod through the opposite end of the hub, drive against the inner edge of the bearing cup. Alternately drive on opposite sides of the cup to avoid cocking the cup and damaging the inside of the hub.

## Installation

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly, including the bearing cup bores.
2. Inspect the bearing cup bores of the hub for warpage or uneven surfaces. If a bearing cup bore is damaged, replace the wheel hub assembly.
3. Coat the replacement bearing cup hub contact surface with a film of grease.
4. Position the cup in the hub and press it into place, using a suitable driving tool. Cups must seat against the shoulder in the hub.
5. Wipe off the accumulation of grease left after the bearing cup has been seated. Then, using a clean lint-free cloth dampened with kerosene or diesel fuel oil, clean the inner surface of the bearing cup. Wipe the surface dry using a clean, absorbent, and lint-free cloth or paper.

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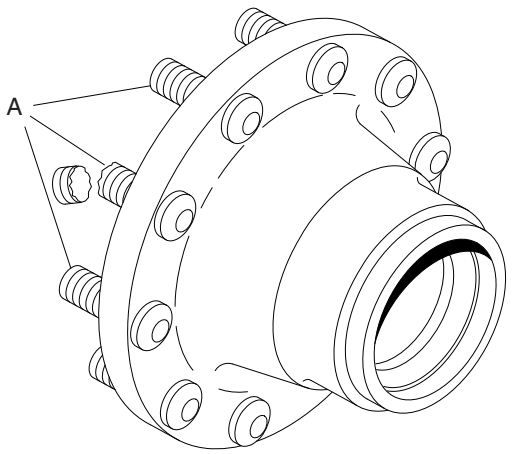


# Replacement

## Disc Wheels

**⚠ WARNING**

**If a wheel stud breaks, the remaining studs are subjected to undue strain and could fail due to fatigue. When a broken stud is replaced, replace the stud on each side of it. See Fig. 1. If more than one stud is broken, replace all of the studs. Failure to replace the studs could result in the loss of a wheel or loss of vehicle control, possibly resulting in personal injury.**




A. Replace

**Fig. 1, Wheel Stud Replacement**

1. Remove the wheel hub from the axle. For instructions, see **Subject 100**.
2. If a bent portion of a wheel stud will have to pass through the wheel stud bore, cut off the bent portion before removing the wheel stud.
3. Place the wheel hub on a suitable press; make sure the hub flange is supported evenly around and next to the stud being removed. With steady movement, press the damaged stud out of the hub.

**⚠ CAUTION**

**Do not use a drift and hammer or concentrated heat for removing and installing the wheel studs. Constant, smooth movement of the wheel stud is necessary to ensure the least amount of metal removal from the wheel stud bore. Concentrated heat will damage the hub. If the hub is damaged during wheel stud removal or installation, replace it.**

4. Apply a coating of clean axle grease to the entire shaft on headed studs.
5. With the hub on a suitable press, make sure the hub flange is supported evenly around and next to the stud being installed.
6. Position the stud in its hole. *Be sure the flat edge of the head flange on clipped studs is in line with the shoulder on the hub.*

**⚠ CAUTION**

**If headed studs with serrations are being installed, position the teeth of the serrated portion in the notches carved by the original wheel studs during factory installation. If additional metal is scraped from the wheel stud bores, the locking action provided by the serrations will be greatly weakened. Loss of locking action will prevent achieving final torque of the wheel nuts during wheel installation. If final wheel nut torques during wheel installation cannot be achieved, replace the wheel hub assembly.**

NOTE: If the left side of the vehicle is being serviced, the replacement wheel stud must be stamped with an "L" (left-hand threaded), and the nut's face must be stamped "Left". If the right side of the vehicle is being serviced, the replacement stud must be stamped with an "R" (right-hand threaded), and the nut's face must be stamped "Right" (**Fig. 2**).

7. With steady movement, press the new stud all the way into the hub.
8. Make sure the stud is fully seated and that its head (flange) is not embedded into the hub. If the head of the stud is embedded into the hub, replace the hub.

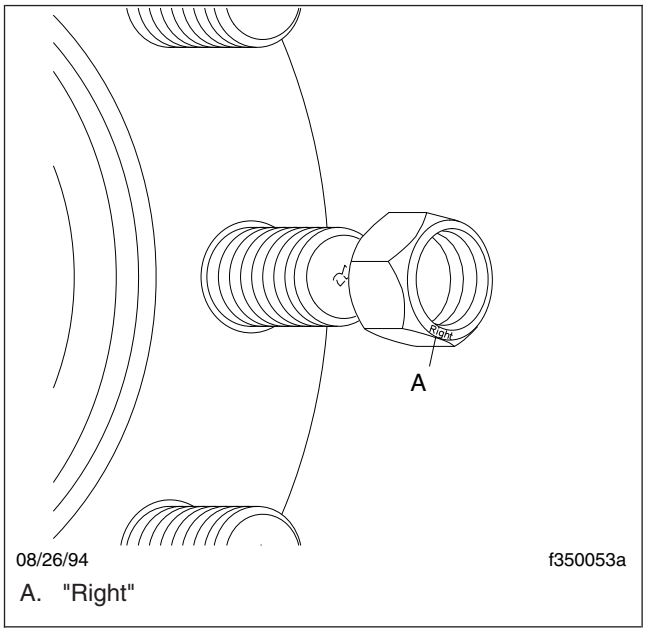
**⚠ WARNING**

**Don't embed the wheel stud heads in the wheel hub. Wheel studs with heads embedded in the wheel hub will weaken the wheel hub flange. Weakness in the wheel hub can result in the loss**

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## Wheel Stud Replacement




A. "Right"

**Fig. 2, Thread Stamp Location**

**of a wheel or loss of steering control, possibly resulting in personal injury.**

9. Wipe off any grease on the wheel studs and wheel hub. Install wheel nuts on dry wheel studs only.
10. Install the wheel hub on the axle. For instructions, see **Subject 100**.

# Spoke Wheels

1. Remove the rim and tire assembly from the spoked wheel. For instructions, refer to **Group 40**.
2. If enough threads remain on the damaged stud, remove it by double-nutting the stud. Turn the inner nut with a wrench in order to remove the stud. Then, proceed to the next step.

   If the rim stud is broken near the surface of the wheel, the stud should be center-drilled using a high-speed drill, and then removed with an easy-out tool. If needed, grind off a flat surface on the damaged stud, then centerpunch the surface as a starting point for drilling. Follow these recommendations:

   2.1 Determine the correct drill diameter by referring to the easy-out tool manufacturer's guidelines. At no time should it be large enough to penetrate the threads of the stud; if the stud threads in the wheel are damaged, replace the wheel.

   2.2 Do not drill more than 1.25 inches (32 mm) into the broken stud, as measured at the stud's entrance into the wheel. Drilling through the bottom of the rim stud could damage the wheel. If the wheel is drilled into, replace it.

   2.3 While drilling, keep the cutting surfaces of the drill well lubricated with oil, which acts as a coolant. Allow the drill and drill bit to cool frequently.
3. After the damaged stud is removed, tap out the rim stud hole in the wheel to rid the threads of old stud-locking compound. Use an appropriate sized tap, depending on the original rim stud installation size.
4. Be sure the threads of the new stud are clean and dry. Then, coat the insertion end of the rim stud with an anaerobic thread- lock compound.
5. Using double nuts on the fine thread portion of the stud, install the new stud. Seat the rim stud using the torque values in **Specifications, 400**.
6. Allow enough time for the thread-lock compound to set, as suggested by the manufacturer.
7. Install the rim and tire assembly. For instructions, refer to **Group 40**.

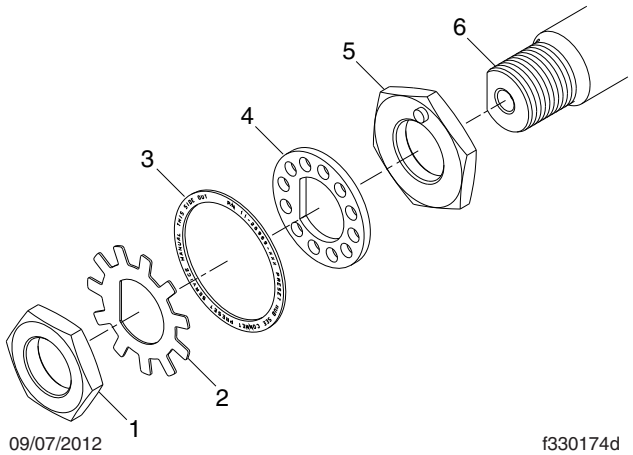
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# Double Spindle Nut Removal, Installation, and Adjustment

## General Information

ConMet PreSet hubs may use a double spindle nut system. See **Fig. 1**. A plastic ID ring between the adjusting nut and locking washer indicates that a ConMet Preset hub has been installed.




NOTE: ID ring used with ConMet PreSet hubs only.

1. Jam Nut
2. Bend-Type Locking Washer
3. ID Ring
4. Lockring
5. Adjusting Nut
6. Axle Spindle

**Fig. 1, Double Spindle Nut Set**

## Removal

Once a double spindle nut set is removed, discard the bend-type locking washer. Inspect the adjusting nut, lockring, and jam nut for visible damage prior to reuse.

## Installation

Instructions for installing a double spindle nut set for both PreSet and non-PreSet type bearings are provided in this subject. See the pertinent instructions for the type you are installing.

### Using PreSet Bearings

1. Install the adjusting nut onto the axle spindle, and tighten it 300 lbf·ft (407 N·m). See **Fig. 1**.

NOTE: The gaps between holes in the lockring are spaced unevenly, so to fit the tab on the adjusting nut into one of the holes with minimal turning of the adjusting nut, gauge the distance on one side of the lockring, then the other, and choose the side that requires the adjusting nut to be advanced the least. Do not back off the nut.

2. Install the lockring (as described in the note above), ID ring (for ConMet PreSet hubs only), and bend-type locking washer.
3. Install the jam nut, and tighten it 200 lbf·ft (271 N·m).
4. Bend the tabs on the locking washer at 6 o'clock and 12 o'clock to lock the jam nut in place. See **Fig. 2**.

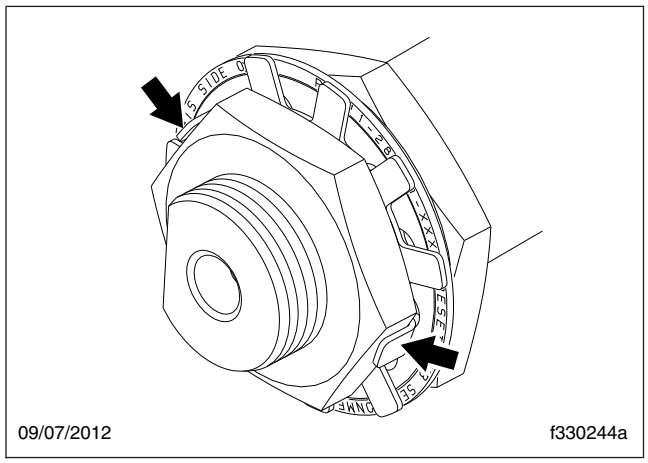



**Fig. 2, Tabs Bent to Lock the Jam Nut**

5. Rotate the hub in both directions. It should turn freely with no dragging or binding.

### Using Non-PreSet Bearings

For ConMet PreSet hubs, when there is no bearing spacer installed and non-PreSet type bearings are being used, proper wheel bearing adjustment is critical to the performance of the bearings, wheel seals, and other related wheel end components.

1. Install the adjusting nut, as follows. See **Fig. 1**.
   - 1.1 Install the adjusting nut on the spindle, and tighten it finger-tight.
   - 1.2 While rotating the wheel hub assembly, tighten the adjusting nut 200 lbf·ft (271 N·m).

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## Double Spindle Nut Removal, Installation, and Adjustment

1.3 Back off the adjusting nut one full turn.

1.4 Tighten the adjusting nut 50 lbf·ft (68 N·m) while rotating the wheel hub assembly.

1.5 Back off the adjusting nut one-quarter turn.

NOTE: The gaps between holes in the lockring are spaced unevenly, so to fit the tab on the adjusting nut into one of the holes with minimal turning of the adjusting nut, gauge the distance on one side of the lockring, then the other, and choose the side that requires the adjusting nut to be advanced the least. Do not back off the nut.

2. Install the lockring (as described in the note above) and bend-type locking washer.
3. Install the jam nut, and tighten it 200 to 300 lbf·ft (270 to 405 N·m).
4. Measure the end play; see **Subject 200** for instructions.

**⚠ WARNING**

**Correct wheel-bearing end play is crucial to the safe and sound operation of the vehicle. If the end play is not correct, the wheel bearings could fail and cause the loss of the wheel and hub assembly and result in an accident causing property damage, serious injury, or death. Use a dial indicator to measure the end play.**

5. **The end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm).** If the end play is not within this range, adjust the end play as follows.

   5.1 Remove the jam nut and locking device, and back off or tighten the inner adjusting nut.

   5.2 Install the locking device and jam nut as described earlier, and measure the end play. If the end play is not between 0.001 and 0.005 inch (0.03 and 0.13 mm), turn the adjusting nut again.

   5.3 Measure the end play.

   If the end play is not between 0.001 and 0.005 inch (0.03 and 0.13 mm), repeat the adjustment procedure until the correct end play is achieved.

   IMPORTANT: The correct end play **must** be achieved before completing the hub assembly installation procedure.

6. Once the end play is between 0.001 and 0.005 inch (0.03 and 0.13 mm), bend two tabs on the locking washer at 6 o'clock and 12 o'clock to lock the jam nut in place. See **Fig. 2**.
7. Rotate the hub in both directions. It should turn freely with no dragging or binding.

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# Axilok Spindle Nut Removal, Installation, and Adjustment

## General Information

Axilok® spindle nuts may be used on ConMet PreSet hubs. See **Fig. 1** and **Fig. 2**. These nuts can be damaged if they are not removed or installed correctly. Use the following guidelines when removing and installing Axilok retaining nuts.

- Use only the correct size, *six-point* socket to remove or install Axilok spindle nuts. Do not use a worn or loose-fitting socket. **Do not use a 12-point socket.**
- Do not use hammers, chisels, pliers, wrenches, or power tools to remove or install Axilok nuts.
- Do not use an Axilok nut if the locking clips are damaged or missing, or if the retainer cage tab or D-flat is damaged or missing.
- Never try to repair a damaged Axilok nut; always replace it with a new one.
- Always start an Axilok installation by hand. A good-fitting six-point socket will completely disengage the nut's locking clips, allowing it to spin freely by hand. See **Fig. 3**. Use an accurately calibrated torque wrench to tighten the nut to its final torque value.

## Installation

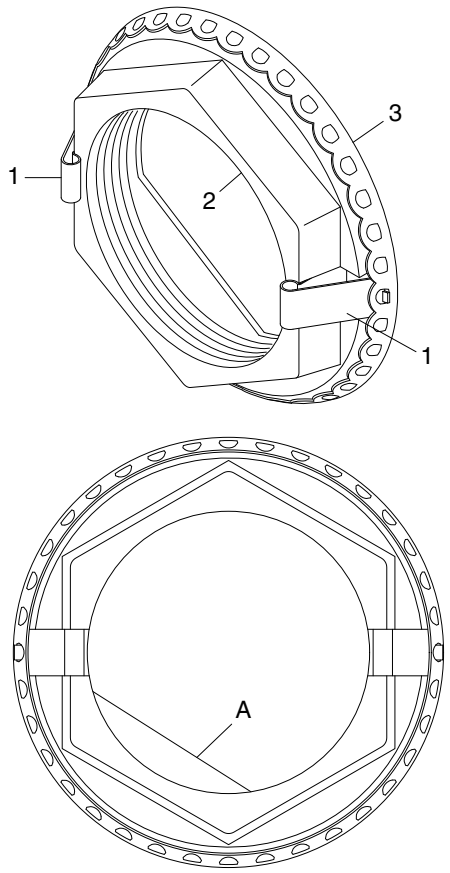
Instructions for installing an Axilok nut for both PreSet and non-PreSet type bearings are provided in this subject. See the pertinent instructions for the type you are installing.

### Using PreSet Bearings

**⚠ WARNING**

**Follow the guidelines at the beginning of this subject when installing an Axilok nut. Axilok retaining nuts secure the hub assemblies on the axle. If the Axilok nut is not correctly installed, the hub could separate from the axle, resulting in severe personal injury or death.**

1. Apply a few drops of oil through one of the holes in the Axilok retainer cage to reduce friction between the retainer cage and nut.
2. By hand, install the Axilok nut onto the axle spindle. See **Fig. 1** and **Fig. 2**.




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A. The flat side of the retainer must engage the flat side of the axle spindle.

1. Locking Clip
2. Nut
3. Retainer Cage

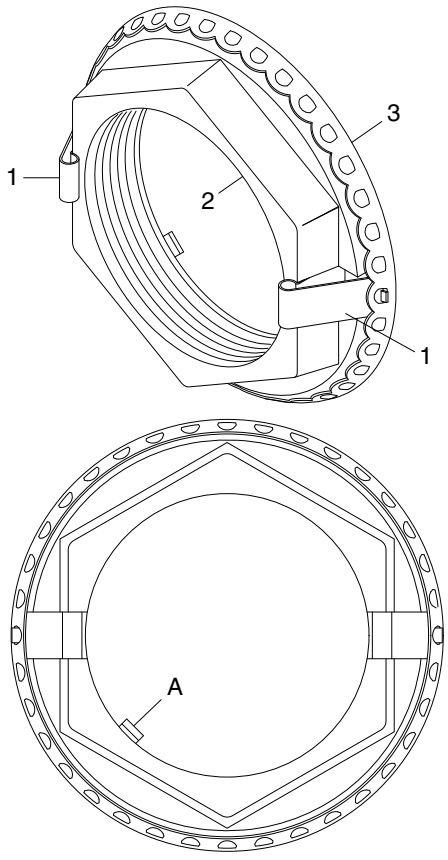
**Fig. 1, Axilok Retaining Nut, Meritor Front Axle**

3. Tighten the retaining nut 250 lbf·ft (339 N·m). The nut should lock in place when you remove the wrench. If it does not, advance the nut until it does. **Do not back it off**.
4. Ensure that both locking clips are present and engaged in the retainer cage. See **Fig. 3**. If the locking clips are not engaged, the nut is not locked in position and can rotate freely.

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## Axilok Spindle Nut Removal, Installation, and Adjustment




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A. This retainer tab must engage the keyway of the axle spindle.

1. Locking Clip
2. Nut
3. Retainer Cage

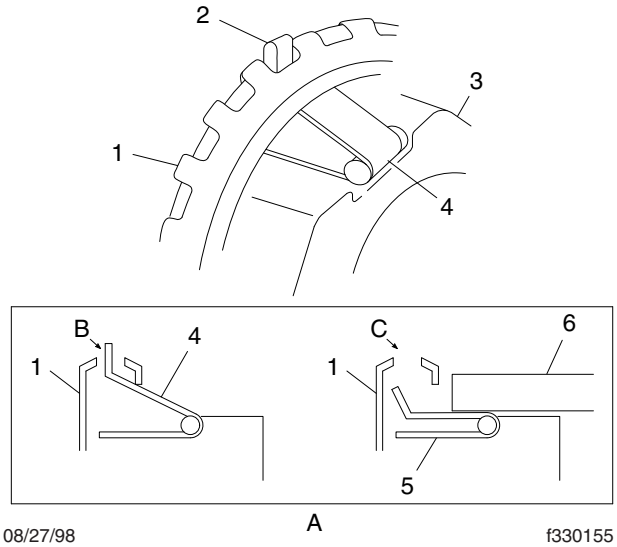
**Fig. 2, Axilok Retaining Nut, Eaton Front Axle**

## Using Non-PreSet Bearings

For ConMet PreSet hubs, when there is no bearing spacer installed and non-PreSet type bearings are being used, proper wheel bearing adjustment is critical to the performance of the bearings, wheel seals, and other related wheel end components.

**⚠ WARNING**

**Follow the guidelines at the beginning of this subject when installing an Axilok nut. Axilok retaining nuts secure the hub assemblies on the axle. If the Axilok nut is not correctly installed, the hub could separate from the axle, resulting in severe personal injury or death.**




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A. Cross-Section View
B. The tab is engaged.
C. The tab is disengaged.

1. Retainer Cage
2. Locking Clip Tab
3. Nut
4. Locking Clip
5. Locking Clip (compressed)
6. Six-Point Socket

**Fig. 3, Axilok Nut, Checking the Position of the Locking Clip**

1. Apply a few drops of oil through one of the holes in the Axilok retainer cage to reduce friction between the retainer cage and nut. See **Fig. 1** and **Fig. 2**.
2. Install the Axilok nut and adjust the wheel bearings, as follows.
   - 2.1 By hand, install the Axilok nut onto the axle spindle and turn it against the bearing while spinning the hub.
   - 2.2 Tighten the nut 90 to 110 lbf·ft (122 to 149 N·m) while spinning the hub in both directions.
   - 2.3 Loosen the nut to zero torque, and spin the hub a few turns.
   - 2.4 Tighten the nut 50 lbf·ft (68 N·m) while spinning the hub in both directions. Back off the nut one-eighth to one-sixth turn.

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2.5 Remove the wrench from the nut, and verify whether both locking clips are present and engaged in the retainer cage. See **Fig. 3**. If the locking clips are not engaged, advance the Axilok until they are.

3. Measure the end play; see **Subject 200** for instructions.

**⚠ WARNING**

**Correct wheel-bearing end play is crucial to the safe and sound operation of the vehicle. If the end play is not correct, the wheel bearings could fail and cause the loss of the wheel and hub assembly and result in an accident causing property damage, serious injury, or death. Use a dial indicator to measure the end play.**

4. **The end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm)**. If it is not within this range, remove the Axilok nut, and repeat the tightening sequence as described earlier in this procedure. Once the end play is correct, continue with your service procedure.

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# Meritor Easy Steer Plus Hub Installation and Adjustment

## Installation and Adjustment

1. With the hub mounted on the axle spindle, install the inner (adjusting) nut and tighten it 600 lbf·ft (813 N·m).
2. Install the locking device (nut-lock, lockwasher, or both).
3. Install the jam nut and tighten it 250 lbf·ft (339 N·m).
4. Bend two opposing tangs of the nut-lock as needed to lock the jam nut and adjusting nut.

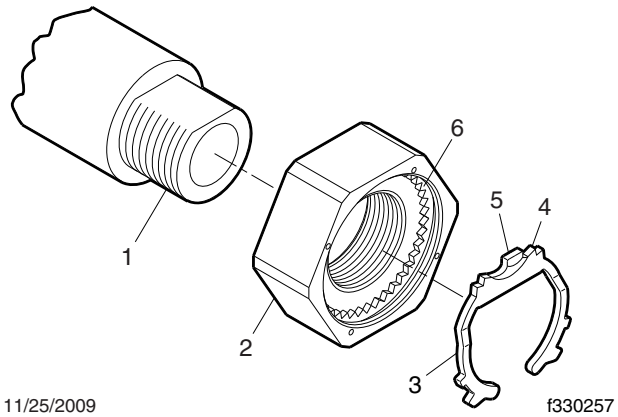
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# Pro-Torq Spindle Nut Removal, Installation, and Adjustment

## General Information

Pro-Torq® spindle nuts may be used on ConMet Pre-Set hubs. See **Fig. 1** and **Fig. 2**.




1. Axle Spindle
2. Pro-Torq Nut
3. Keeper Arm
4. Mating Teeth, Keeper
5. Keeper Tab
6. Mating Teeth, Nut

**Fig. 1, Pro-Torq Spindle Nut and Keeper**

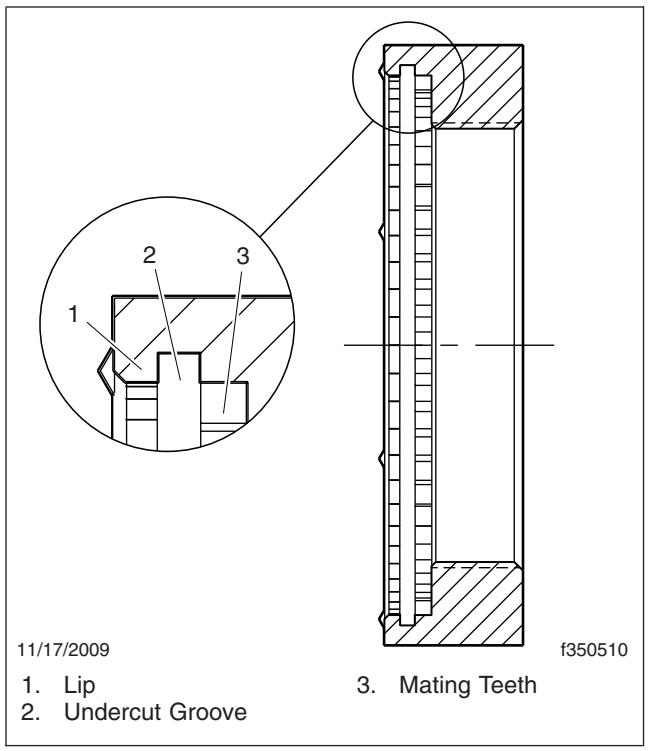
Each time the Pro-Torq nut assembly is removed for maintenance purposes, replacing the "keeper" is recommended.

## Removal

**⚠ WARNING**

**Do not place the nut on the spindle or tighten or loosen the nut on the spindle while the keeper is locked inside the nut. Doing so may damage the spindle threads and deform the keeper, and allow the nut to unthread during operation. Failure to follow this instruction could cause the hub to separate from the axle, resulting in severe personal injury or death.**

1. Insert the blade of a flathead screwdriver (or similar tool) in the slot of one of the keeper arms; see **Fig. 3**. Ensuring that the tool contacts the keeper and not the teeth of the nut, turn the tool slightly and carefully pry the arm from the undercut groove of the nut.




1. Lip
2. Undercut Groove
3. Mating Teeth

**Fig. 2, Pro-Torq Spindle Nut, Cross Section**

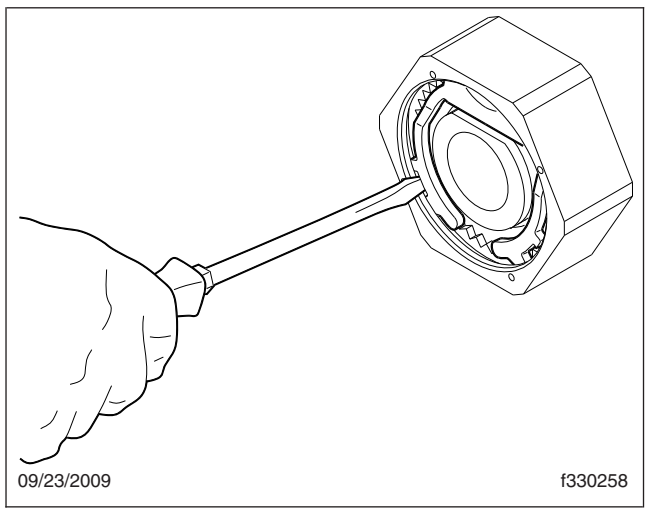



**Fig. 3, Removing the Keeper**

2. Repeat at the other arm, and remove the keeper from the nut.
3. Remove the Pro-Torq nut.

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## Pro-Torq Spindle Nut Removal, Installation, and Adjustment

# Installation

The following procedure applies to Pro-Torq steer axle nut 448-4836. The part number is stamped on the nut.

**⚠ WARNING**

**Do not place the nut on the spindle or tighten or loosen the nut on the spindle while the keeper is locked inside the nut. Doing so may damage the spindle threads and deform the keeper, and allow the nut to unthread during operation. Failure to follow this instruction could cause the hub to separate from the axle, resulting in severe personal injury or death.**

Instructions for installing a Pro-Torq spindle nut for both PreSet and non-PreSet type bearings are provided in this subject. See the instructions pertaining to the bearing type used with the hub you are securing.

## Using PreSet Bearings

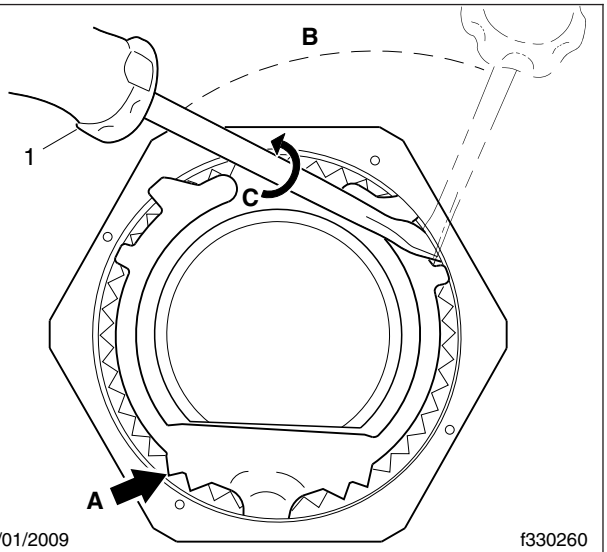
1. Ensure the keeper is removed from the nut.
2. Install the Pro-Torq spindle nut, and tighten it 250 lbf·ft (339 N·m). **Do not back it off**.
3. Install the keeper.
   - 3.1 With the correct side of the keeper facing out, insert the keeper tab in the undercut groove of the Pro-Torq nut, and engage the mating teeth.

   IMPORTANT: If the keeper cannot be engaged, advance the nut until it can be. Do not back off the nut.

   - 3.2 Use a flathead screwdriver to carefully compress and guide each arm past the lip and into the undercut groove of the nut as shown in **Fig. 4**. To secure the keeper it may be necessary to nudge the arms into the groove.

**⚠ WARNING**

**Failure to secure the keeper and lock the Pro-Torq nut could cause the wheel assembly to come off the vehicle, resulting in severe personal injury or death.**




A. Engage the mating teeth.
B. Compress the arm.
C. Turn the screwdriver to seat the keeper in the groove.

1. Flathead Screwdriver

**Fig. 4, Installing the Keeper**

4. Inspect the installation; ensure the keeper is locked in the undercut groove of the nut.

## Using Non-PreSet Bearings

For ConMet PreSet hubs, when there is no bearing spacer installed and non-PreSet type bearings are being used, proper wheel bearing adjustment is critical to the performance of the bearings, wheel seals, and other related wheel end components.

1. Ensure the keeper is removed from the nut.
2. Seat the bearings.
   - 2.1 Using a torque wrench, tighten the nut 200 lbf·ft (270 N·m). Spin the hub at least one full rotation.

   NOTE: Torque is lost when the hub is spun.

   - 2.2 Tighten the nut 200 lbf·ft (270 N·m). Spin the hub at least one full rotation.
   - 2.3 Tighten the nut 200 lbf·ft (270 N·m), but *do not spin the hub*.
3. Loosen the nut to zero torque. *Do not spin the hub*.

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4. Adjust the bearing.
   - 4.1 Using a torque wrench, tighten the nut 100 lbf·ft (136 N·m). Spin the hub at least one full rotation.

   NOTE: Torque is lost when the hub is spun.

   - 4.2 Tighten the nut 100 lbf·ft (136 N·m). Spin the hub at least one full rotation.
   - 4.3 Tighten the nut 100 lbf·ft (136 N·m).
   - 4.4 Back off the nut one-quarter turn.

IMPORTANT: If the keeper cannot be engaged, advance the nut until it can be. Do not back off the nut.

5. Install the keeper.
   - 5.1 With the correct side of the keeper facing out, insert the keeper tab in the undercut groove of the Pro-Torq nut, and engage the mating teeth.
   - 5.2 Use a flathead screwdriver to carefully compress and guide each arm past the lip and into the undercut groove of the nut as shown in **Fig. 4**. To secure the keeper it may be necessary to nudge the arms into the groove.

**⚠ WARNING**

**Failure to secure the keeper and lock the Pro-Torq nut could cause the wheel assembly to come off the vehicle, resulting in severe personal injury or death.**

6. Inspect the installation; ensure the keeper is locked in the undercut groove of the nut.
7. Measure the end play; see **Subject 200** for instructions.

**⚠ WARNING**

**Correct wheel-bearing end play is crucial to the safe and sound operation of the vehicle. If the end play is not correct, the wheel bearings could fail and cause the loss of the wheel and hub assembly and result in an accident causing property damage, serious injury, or death. Use a dial indicator to measure the end play.**

8. **The end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm)**. If it is not within this range, remove the Pro-Torq nut, and repeat the tightening sequence as described in previous steps. Once the end play is correct, continue your service procedure.

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## Wheel Bearing End Play Measurement

**⚠ WARNING**

**Correct wheel-bearing end play is crucial to the safe and sound operation of the vehicle. If the end play is not correct, the wheel bearings could fail and cause the loss of the wheel and hub assembly and result in an accident causing property damage, serious injury, or death. Use a dial indicator to measure the end play.**

IMPORTANT: Do not measure the wheel bearing end play with the wheel mounted on the hub; you cannot accurately measure or adjust bearing end play with the wheel mounted on the hub. Also, ensure that the brakes are not applied so that that drum and hub can move freely.

# Measurement

Using a dial indicator, measure the end play as follows.

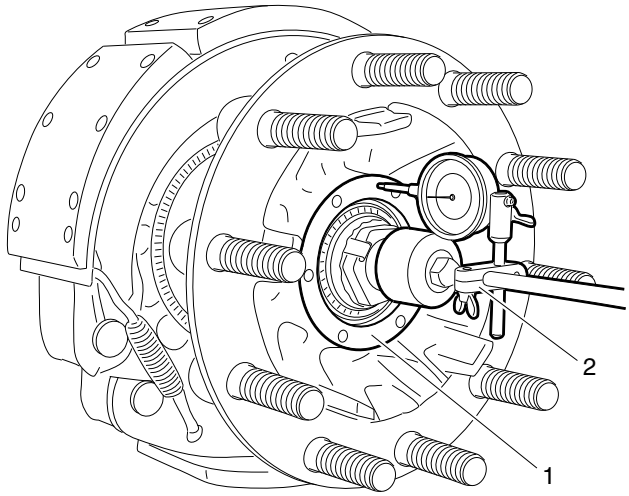
1. Attach the magnetic base of a dial indicator to the end of the spindle, and place the measuring end of the indicator against the hub cap mounting flange. See **Fig. 1**.

IMPORTANT: Maintain continual pressure on the hub until you have taken both the inboard and outboard measurements. If you release the hub, an accurate measurement is not possible.

2. To seat the bearings, grip the hub at the three o'clock and nine o'clock positions, and push inward while oscillating it approximately 45 degrees. Maintain pressure on the hub, note the inboard measurement, and then pull the hub outward while oscillating it as before. Maintain pressure on the hub, and note the outboard measurement. See **Fig. 2**.

   The end play is the difference between the two measurements.

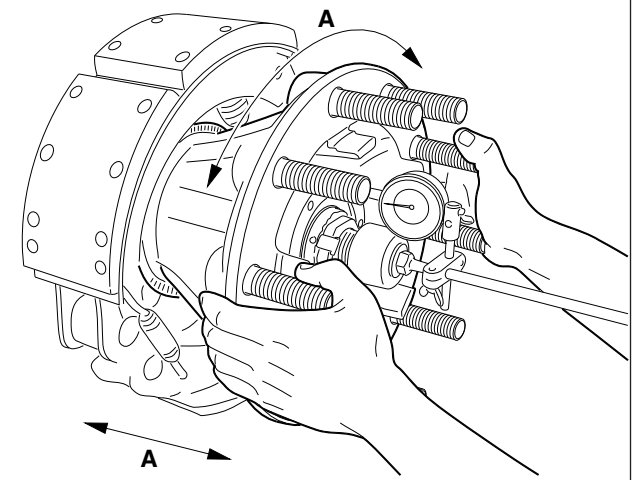
NOTE: If the end play exceeds the limit, the hub may need to be serviced. See **Subject 120** and manufacturer literature for procedures.




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1. Hub Cap Mounting Flange
2. Dial Indicator (with magnetic base)

**Fig. 1, Dial Indicator Setup**




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A. Pull and push the hub while oscillating it.

**Fig. 2, Measuring End Play**

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# Troubleshooting Tables

**Problem—Noisy Bearings or Excessive Bearing Replacement Intervals**

| Problem—Noisy Bearings or Excessive Bearing Replacement Intervals | |
|---|---|
| **Possible Cause** | **Remedy** |
| Not enough oil was used on the bearings, or the wrong type of oil was used. | Clean, then inspect the bearings for wear. Replace worn seals. Coat the bearing assemblies with fresh oil. |
| Foreign matter or corrosive agents entered the bearing assembly. Dirt or metallic debris from the bearings was not removed. | Clean, then inspect the bearings for wear. Replace worn seals. Also clean the wheel hub, the axle spindle, and any other component in contact with the bearing lubricant. |
| An incorrect adjustment of the wheel bearings is causing noise and wear. | Adjust the wheel bearings following the applicable instructions in this section. |
| Flat spots or dents on the roller surface were caused by skidding of the roller or improper handling of the wheel bearing during installation. | Clean, then inspect the bearing rollers. Replace the bearing if damaged. Coat the replacement bearings with fresh oil. For lubricant specifications, see **Specifications, 400**. |

**Problem—Broken Wheel or Rim Studs**

| Problem—Broken Wheel or Rim Studs | |
|---|---|
| **Possible Cause** | **Remedy** |
| The wheel or rim nuts were overtightened. | Replace the wheel or rim studs. See **Group 40** for the wheel or rim nut tightening sequence. |
| An incorrect nut tightening sequence was used. | |
| The wrong brake drums were installed. | Install new brake drums. |
| Wheels are mismatched (hub-piloted wheels are mixed with stud-piloted wheels). | Install properly matched wheels. |
| The vehicle is being overloaded. | Do not exceed the maximum load-carrying capacity of the vehicle. |

**Problem—Damaged Hub**

| Problem—Damaged Hub | |
|---|---|
| **Possible Cause** | **Remedy** |
| (Cracked hub) Local surface of an aluminum hub was heated higher than 350°F (177°C) during bearing cup removal. | Replace the hub assembly. When removing the bearing cup, oven-heat the hub. |
| (Bent flange) Incorrect installation of the wheel studs, such as using a hammer and drift, or the hub flange was not fully supported on the press during wheel stud replacement. | Replace the hub assembly; see **Subject 100**. Replace the wheel studs. |
| The wrong brake drums were installed. | Install new brake drums. |
| Insufficient tightening of the wheel nuts to the wheel hub. | Replace the hub assembly; see **Subject 100**. |

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## Troubleshooting

**Problem—Loss of Lubricant from the Wheel Hubs**

| Problem—Loss of Lubricant from the Wheel Hubs | |
|---|---|
| **Possible Cause** | **Remedy** |
| The seals or gaskets are worn or damaged. | Replace worn or damaged parts. |

**Problem—Vehicle Does Not Slow Down Quickly Enough When Brakes Are Applied**

| Problem—Vehicle Does Not Slow Down Quickly Enough When Brakes Are Applied | |
|---|---|
| **Possible Cause** | **Remedy** |
| Dirt or grease has built up on the brake linings (glazing), or the brake linings have worn excessively. | Install new brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums. |
| The brake drums are worn, heat-checked or cracked. | Install new brake drums. |

**Problem—Service Brakes Grab or Pull**

| Problem—Service Brakes Grab or Pull | |
|---|---|
| **Possible Cause** | **Remedy** |
| For detailed information, see **Group 42**. | |

**Problem—Poor Lining-to-Drum Contact**

| Problem—Poor Lining-to-Drum Contact | |
|---|---|
| **Possible Cause** | **Remedy** |
| The inside surface of the brake drum is scored or grooved. | Install new brake linings on both sets of axle brake shoes. Install new brake drums or turn the drums. |
| The brake shoes are stretched or bent. | Replace the brake shoes. |
| Undersized linings were installed. | Install new brake linings on both sets of axle brake shoes. |
| An incorrect grind was used on the brake linings. | |
| The wrong brake drums were installed. | Install new brake drums. |
| An incorrect adjustment of the wheel bearings is causing wheel instability. | Adjust the wheel bearings following the applicable instructions in this section. |

**Problem—Brake Linings Are Tapered Across the Width**

| Problem—Brake Linings Are Tapered Across the Width | |
|---|---|
| **Possible Cause** | **Remedy** |
| The inside surface of the brake drum is scored or grooved. | Install new brake linings on both sets of axle brake shoes. Turn or replace the drums. |
| The brake shoes are bent. | Replace the brake shoes. |
| An incorrect adjustment of the wheel bearings is causing wheel instability. | Adjust the wheel bearings following the applicable instructions in this section |

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## Troubleshooting

**Problem—Brake Shoes on the Same Brake Are Wearing Unequally**

| Problem—Brake Shoes on the Same Brake Are Wearing Unequally | |
|---|---|
| **Possible Cause** | **Remedy** |
| The brake linings are not a matched set. Different friction codes or different brands of brake linings are installed. | Install a new matched set of brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums. |
| The brake shoes are stretched. | Replace the brake shoes. |

**Problem—Shoes on Each Side of the Axle (Side-to-Side Brakes) Are Wearing Unequally**

| Problem—Shoes on Each Side of the Axle (Side-to-Side Brakes) Are Wearing Unequally | |
|---|---|
| **Possible Cause** | **Remedy** |
| The brake linings are not a matched set. Different friction codes or different brands of brake linings are installed. | Install a new matched set of brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums. |
| The inside surface of the brake drum is in poor condition. | Turn or replace the drums. |
| The wheel bearings are out of adjustment. | Adjust the wheel bearings following the applicable instructions in this section. |

**Problem—Edge of the Lining Is Showing Wear**

| Problem—Edge of the Lining Is Showing Wear | |
|---|---|
| **Possible Cause** | **Remedy** |
| The brake lining is too wide. | Install new brake linings on both sets of axle brake shoes. |
| The brake linings are misaligned because of incorrectly drilled brake lining holes. | |
| Undersized brake drums were installed. | Install new brake drums. |
| The wheel bearings are out of adjustment. | Adjust the wheel bearings following the applicable instructions in this section. |
| There is an incorrect fit of the wheel onto the spindle due to the wrong wheel bearings. | Install new wheel bearings and adjust them following the applicable instructions in this section. |
| The brake shoes are bent. | Replace the brake shoes. |

**Problem—Brake Linings Are Scored or Grooved**

| Problem—Brake Linings Are Scored or Grooved | |
|---|---|
| **Possible Cause** | **Remedy** |
| Worn or scored brake drums have been causing poor contact with the brake linings. | Install new brake linings on both sets of axle brake shoes. Turn or replace the brake drums. |
| There is abrasive material between the lining and the drum. | |

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## Troubleshooting

**Problem—Brake Linings Are Loose**

| Problem—Brake Linings Are Loose | |
|---|---|
| **Possible Cause** | **Remedy** |
| The rivet holes in the brake shoes are too large. | Replace the brake shoes. |
| Incorrectly crimped rivets are working loose and allowing the linings to move. | Replace the rivets. |
| Rust has built up on the shoe table. | Clean the brake shoe table of all rust, dirt, scale, and paint. |

**Problem—Brake Lining Is Cracked at the Rivet Holes or Bolt Holes**

| Problem—Brake Lining Is Cracked at the Rivet Holes or Bolt Holes | |
|---|---|
| **Possible Cause** | **Remedy** |
| Overtightening of the lining bolts is causing cracks. | Install new brake linings. Replace the rivets or bolts with the correct size. |
| The wrong size counter bore for the rivet holes was made. | |
| The wrong rivets or bolts were used. | Replace the rivets or bolts with the correct size. |
| Incorrectly crimped rivets are working loose and allowing the linings to move. | Replace the rivets. |
| Rust has built up on the shoe table. | Clean the brake shoe table of all rust, dirt, scale, and paint. |

**Problem—Out-of-Round Rivet Holes or Bolt Holes**

| Problem—Out-of-Round Rivet Holes or Bolt Holes | |
|---|---|
| **Possible Cause** | **Remedy** |
| The rivets or bolts are loose. | Replace the brake shoes or linings. |

**Problem—Brake Drums Are Heat-Checked**

| Problem—Brake Drums Are Heat-Checked | |
|---|---|
| **Possible Cause** | **Remedy** |
| The brake drums are out-of-round. | Turn or replace the brake drums. |
| The wrong brake drums were installed. | Install new brake drums. |
| The wheel bearings are out of adjustment. | Adjust the wheel bearings following the applicable instructions in this section. |
| The brake linings are glazed (dirt or grease build-up) or are worn unevenly. | Install new brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums. |
| The lining friction material for the operation of the vehicle is incorrect. | |
| There is a brake imbalance between the tractor and the trailer. | Do a brake balance test (tractor versus trailer). Contact the District Service Manager if help is needed. |

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**Problem—Brake Drums Are Heavily Scored**

| Problem—Brake Drums Are Heavily Scored | |
|---|---|
| **Possible Cause** | **Remedy** |
| The brake linings are damaged. | Install new brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums. |
| There is excessive wear on the linings. | |
| On the last brake reline, the drums were not turned. | Turn the brake drums. |

**Problem—Excessive Brake Lining Wear**

| Problem—Excessive Brake Lining Wear | |
|---|---|
| **Possible Cause** | **Remedy** |
| There is a brake imbalance between the tractor and the trailer. | Do a brake balance test (tractor versus trailer). Contact the District Service Manager if help is needed. |

**Problem—Hard Steering**

| Problem—Hard Steering | |
|---|---|
| **Possible Cause** | **Remedy** |
| Tire pressure is low in one or both front tires. | Inflate tires to the correct pressure. |
| Binding in the steering gear due to a lack of lubrication. | Test the steering system for binding with the front tires off the ground. For instructions, see **Group 46**. |
| Too much caster angle in the front wheels. | Check the caster angle and adjust as needed. |
| The front suspension is sagging due to a damaged spring. | Repair or replace the spring as needed. For instructions, see **Group 32**. |
| The axle spindle is bent. | Replace the spindle. |
| The frame is misaligned. | Check the frame alignment; correct, as needed. |

**Problem — Erratic Steering When the Brakes are Applied**

| Problem — Erratic Steering When the Brakes are Applied | |
|---|---|
| **Possible Cause** | **Remedy** |
| Tire pressure is low in one or both front tires. | Inflate the tires to the correct pressure. |
| One or more front axle spring U-bolt nuts are loose. | Check the U-bolt nuts for looseness. If loose, check the U-bolt for damage. Replace damaged parts; tighten loose nuts. |
| The brakes are not adjusted evenly. | Adjust the brakes on all axles. Also, check the operation of the slack adjusters. |
| Grease or oil contamination of the brake linings is reducing brake effectiveness. | Replace the brake linings and clean the drums. Find and correct the cause of grease or oil contamination. |
| The caster angle is wrong. | Check, and adjust as needed. |
| An axle spindle is bent. | Replace the axle spindle. |

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## Troubleshooting

| Problem — Erratic Steering When the Brakes are Applied | |
|---|---|
| **Possible Cause** | **Remedy** |
| The front axle wheel bearings are worn or were incorrectly adjusted. | Check the bearings for wear or damage; replace as needed. |

**Problem—Vehicle Pulls to One Side During Operation**

| Problem—Vehicle Pulls to One Side During Operation | |
|---|---|
| **Possible Cause** | **Remedy** |
| Tire pressure is low in one or both front tires. | Inflate the tires to the correct pressure. |
| One or more of the alignment measurements are incorrect. | Check all the alignment measurements. Correct as needed. |
| The wheels or tires are out-of-round. | Inspect the wheels and tires. Replace out-of-round parts. |
| The front axle wheel bearings are too tightly adjusted. | Check the bearings for wear or other damage. Replace the bearings if needed. |
| The front suspension is sagging due to a damaged spring. | Repair or replace the spring as needed. For instructions, see **Group 32**. |
| The axle spindle is bent. | Replace the spindle. |
| The frame is misaligned. | Check the frame alignment; correct as needed. |
| The rear axle(s) is out of alignment. | Check, and if needed, adjust the rear axle alignment. |

**Problem—Front Wheel Wander**

| Problem—Front Wheel Wander | |
|---|---|
| **Possible Cause** | **Remedy** |
| One or more wheels or brake drums are out-of-balance. | Balance the wheels. Check for out-of-round brake drums; correct as needed. |
| One of the front springs is weak or broken. | Repair or replace the spring as needed. For instructions, see **Group 32**. |

**Problem—Front Wheel Shimmy**

| Problem—Front Wheel Shimmy | |
|---|---|
| **Possible Cause** | **Remedy** |
| Tire pressure is low in one or both front tires. | Inflate the tires to the correct pressure. |
| One or more wheels or brake drums are out-of-balance. | Balance the wheels. Check for out-of-round brake drums, correct or replace as needed. |
| One or more tires are out-of-round or bulged. | Replace the tire. |
| The front axle wheel bearings are worn or were incorrectly adjusted. | Check the bearings for wear or other damage. Replace the bearings if needed. |
| Parts of the steering gear or linkage are worn. | Test for play in the steering gear and linkage with the front tires off the ground. Replace parts as needed. |

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| Problem—Front Wheel Shimmy | |
|---|---|
| **Possible Cause** | **Remedy** |
| The axle spindle is bent. | Replace the spindle. |
| One or more of the alignment measurements are incorrect. | Check all alignment measurements and correct as needed. |
| The knuckle pin is loose due to worn bushings. | Inspect the knuckle pin and bushings for damage. Replace worn or damaged parts as needed. |
| Shock absorbers are worn or damaged. | Check the shock absorbers and replace if needed. |

**Problem—Vehicle Wanders**

| Problem—Vehicle Wanders | |
|---|---|
| **Possible Cause** | **Remedy** |
| Tire pressure is low in one or both front tires. | Inflate the tires to the correct pressure. |
| One or more of the alignment measurements are incorrect. | Check all of the alignment measurements; correct as needed. |
| The rear axle(s) is out of alignment. | Check the rear axle alignment and adjust as needed. |
| Parts of the steering gear or linkage are worn. | Test for play in the steering gear and linkage with the front tires off the ground. Replace parts as needed. |
| A knuckle pin is loose due to worn bushings. | Inspect the knuckle pin and bushings for damage. Replace worn or damaged parts. |
| The axle spindle is bent. | Replace the spindle. |

**Problem—Cupped Tires**

| Problem—Cupped Tires | |
|---|---|
| **Possible Cause** | **Remedy** |
| Tire pressure is too low or too high in one or both front tires. | Inflate or deflate the tires to the correct pressure. |
| One or more wheels or brake drums are out-of-balance. | Balance the wheels. Check for eccentric brake drums; correct or replace as needed. |
| The wheel toe-in in not correct. | Adjust the wheel toe-in. |
| The brakes are not adjusted evenly. | Adjust the brakes on all axles. Also, check the operation of the slack adjusters. |
| The front axle wheel bearings are worn or were not adjusted correctly. | Check the bearings for wear or other damage; replace them if needed. |
| The camber angle is not within specifications. | Check the front wheel camber angle. If not correct, find and replace the damaged axle component. |

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## Troubleshooting

**Problem—Steering Wheel Spokes Do Not Point at the 4 and 8 O'clock Positions**

| Problem—Steering Wheel Spokes Do Not Point at the 4 and 8 O'clock Positions | |
|---|---|
| **Possible Cause** | **Remedy** |
| The steering gear is not centered. | Center the steering gear. |
| If adjustable, the drag link is out of adjustment. | Adjust the drag link. |
| The steering wheel was not installed (positioned) correctly on the steering column. | Reposition the steering wheel on the steering column. |
| The pitman arm is not correctly aligned with the timing mark on the steering gear output shaft. | Reposition the pitman arm on the steering gear output shaft. For instructions, see **Group 46**. |

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## Specifications

| Detroit Axle Recommended Lubricant* | |
|---|---|
| **Lubricant Type** | **SAE Viscosity Grade** |
| Hypoid Gear Oil API Service Classification GL–5 | 80W–90 |
| Synthetic Gear Oil | 75W–90 |

* The recommended lubricants listed in this table are for Detroit steer axles.

**Table 1, Detroit Axle Recommended Lubricant**

| Dana Spicer® Axle Recommended Lubricant | | |
|---|---|---|
| **Lubricant Type** | **Condition** | **SAE Viscosity Grade** |
| Eaton Roadranger® Synthetic Axle Lubricants, or Equivalent with Military Specification MIL–L–2105D | Over-the-Road Service | 75W–90 |
| | Off-Highway Equipment, or Under Extra Heavy Loads | 80W–140 |

**Table 2, Dana Spicer Axle Recommended Lubricant**

| Meritor Axle Recommended Lubricant | | | |
|---|---|---|---|
| **Lubricant Type** | **Ambient Temperature** | **SAE Viscosity Grade** | **Meritor Specification** |
| Hypoid Gear Oil API Service Classification GL–5 | +10°F (–12.2°C) and up* | 85W–140 | 0–76–A |
| | –15°F (–26.1°C) and up* | 80W–140 | 0–76–B |
| | –15°F (–26.1°C) and up* | 80W–90 | 0–76–D |
| | –40°F (–40°C) and up* | 75W–90 | 0–76–E |
| | –40°F (–40°C) to +35°F (+2°C) | 75W | 0–76–J |
| | –40°F (–40°C) and up* | 75W–140 | 0–76–L |
| Synthetic Gear Oil | –40°F (–40°C) and up* | 75W–90 | 0–76–N |
| | –40°F (–40°C) and up* | 75W–140 | 0–76–M |

* There is no upper limit on these ambient temperatures, but axle sump temperature must never exceed 250°F (121°C).

**Table 3, Meritor Axle Recommended Lubricant**

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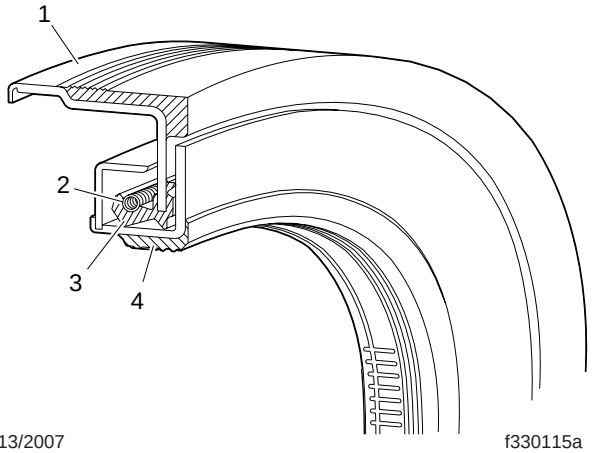


# General Information

Wheel oil seals (also called "oil bath seals" or "hub seals") work as a dam to keep oil in the hub cavity so that it constantly "bathes" the wheel bearings. The seals also protect the wheel bearings by keeping dirt, dust, and water out of the hub.

Most wheel oil seals consist of four basic parts (see **Fig. 1**):

- The outside edge (also called the outer "cup" or "case")
- The inside edge (also called the inner "cup" or "case")
- The sealing element
- The garter spring




1. Outside Edge
2. Garter Spring
3. Sealing Element
4. Inside Edge

**Fig. 1, Wheel Oil Seal Parts**

The oil seal fits between the hub bore and the axle spindle (**Fig. 2**), and the sealing element either turns with the wheel (*hub-mounted seals*) and seals against the axle spindle, or the sealing element stays stationary with the axle spindle (*spindle-mounted seals*) and seals against the turning hub.

The outside edge is usually metal coated with rubber or another sealing agent so that it grips the hub bore tightly enough to prevent oil escaping between the outer edge of the seal and the hub bore.

The inside edge is usually metal or rubber with a metal ring within it to prevent the sealing element from wearing a groove in the axle spindle.

The sealing element is usually molded rubber, leather, or a synthetic such as nitrile or silicone. The element is molded into lips which will seal against the axle spindle or against the outside or inside edge described above. The innermost lip, called the "primary lip," keeps the oil inside the hub cavity. The outermost lip, called the "secondary lip," keeps dirt out of the hub cavity.

The garter spring is a coiled wire spring with its ends connected to make a loop. On hub-mounted seals, the spring runs around the outside of the sealing element to press the element inwards against the sealing surface. On spindle-mounted seals, the spring runs around the inside of the sealing element to press the element outward against the sealing surface.

Western Star vehicles have been equipped with the following brands of axle oil seals:

- SKF (Scotseal® Classic and Scotseal Plus XL)
- Eaton (Outrunner™)
- Stemco (Guardian® and SS4®)

# SKF

## Scotseal Classic

The Scotseal Classic is a unitized, one-piece design consisting of a sealing element (packing) that is assembled between metal outer and inner cups. See **Fig. 2**. The sealing element consists of three sealing lips; a spring-loaded primary sealing lip that is factory pre-lubed and two dirt exclusion lips. The seal is press fit into the hub bore using Scotseal service installation tools. *Do not install the Scotseal directly onto the axle spindle.*

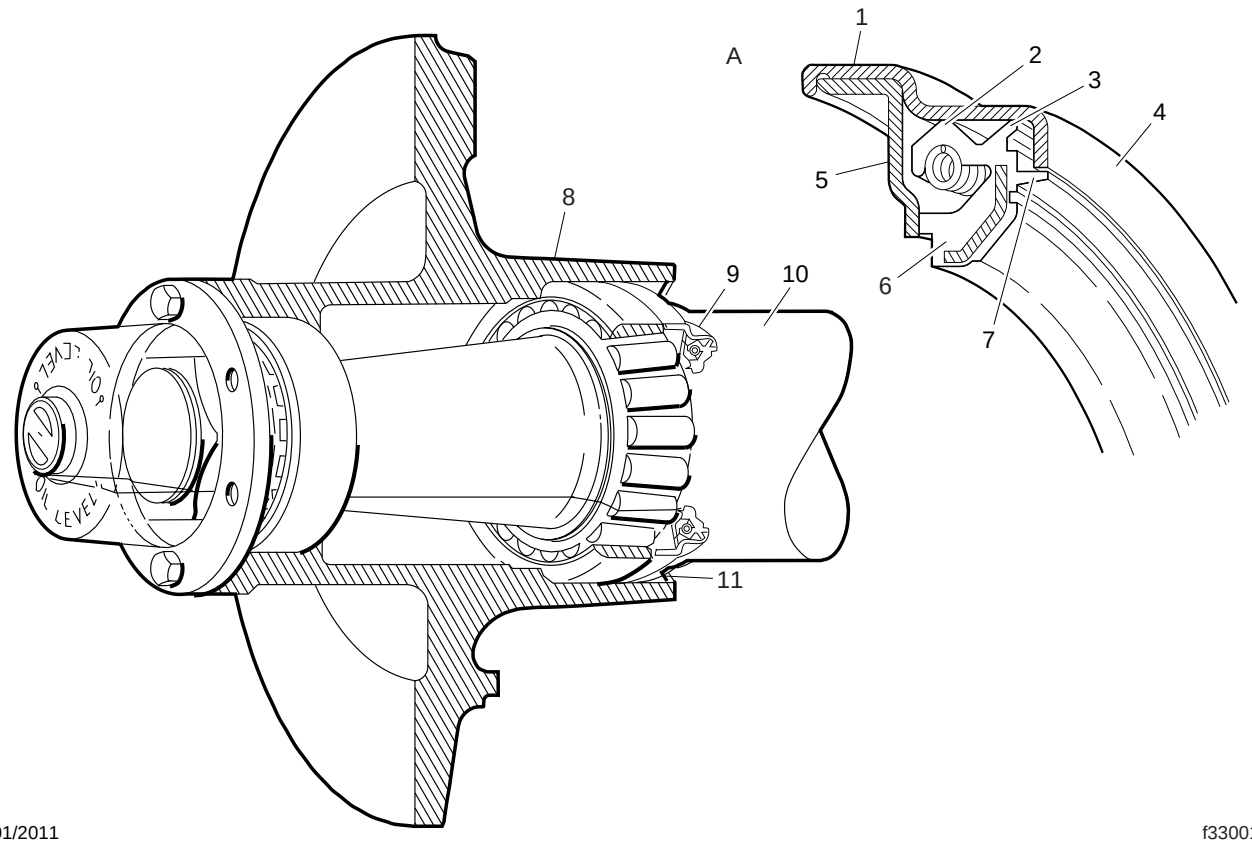
Although you install the Scotseal Classic into the hub bore, the seal's element grips the axle spindle tightly enough that the sealing element stays stationary with the spindle and seals against the outer cup which turns with the hub.

The Scotseal Classic maintains a metal-to-metal contact between the outer cup and the hub bore surface as well as a metal-to-metal contact between the sealing element inside edge and the axle spindle.

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## General Information




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A. Oil Seal, Detail

1. Bore-Tite® Coating
2 Primary Sealing Lip
3. Dirt Lip
4. Outer Cup
5. Inner Cup
6. Sealing Element (Packing)
7. Bumper Lip
8. Hub
9. Oil Seal
10. Axle Spindle
11. Hub Bore

**Fig. 2, Scotseal Classic, Installation and Detail**

## Scotseal Plus XL

The Scotseal Plus XL is a unitized, one-piece seal with one primary spring-loaded sealing lip and three secondary contacting sealing lips, which rotate with the housing. See **Fig. 3**. The outer diameter of the metallic case and the bore diameter of the seal counter face are coated with rubber. The seal is press fit into the hub bore using Scotseal service installation tools. *Do not install the Scotseal Plus XL directly onto the axle spindle.*

Although you install the Scotseal Plus XL into the hub bore, the seal's element grips the axle spindle tightly enough that the sealing element stays stationary with the spindle and seals against the outer cup, which turns with the hub.

## Eaton

The Eaton Outrunner has a rubber-coated outside edge and is installed in the hub bore using Eaton installation tools. See **Fig. 4**.

## Stemco

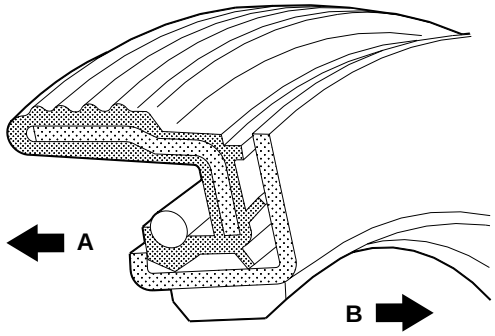
The Stemco wheel oil seals are spindle-mounted, with a rubber-coated outside edge that grips inside

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the hub bore and also holds the sealing element. See **Fig. 5**.

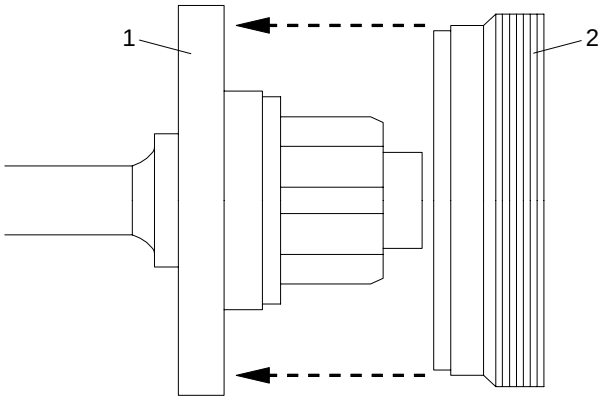
Although you install the Stemco seal onto the axle spindle, the outside edge grips the hub bore tight enough that the sealing element turns with the hub and seals against the inside edge which grips the axle spindle and acts as a wear sleeve.




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A. Oil and Bearing Side
B. Air Side

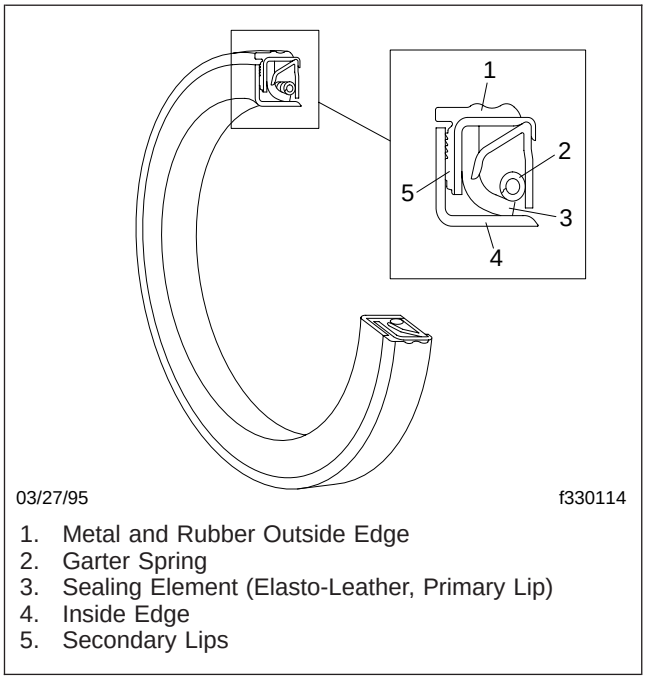
**Fig. 3, Scotseal Plus XL Oil Seal**




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1. Eaton Outrunner Installation Tool
2. Eaton Outrunner Seal

**Fig. 4, Eaton Outrunner Seal**




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1. Metal and Rubber Outside Edge
2. Garter Spring
3. Sealing Element (Elasto-Leather, Primary Lip)
4. Inside Edge
5. Secondary Lips

**Fig. 5, Stemco Oil Seal**

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## Seal Replacement, Scotseal Classic

## Replacement

1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 33.01**.
2. Remove the inner wheel bearing assembly from the axle. Handling the bearings with clean dry hands, wrap the bearings in clean oil-proof paper or lint-free cloths. Occasionally, the inner wheel bearing cone assembly will remain in the hub after the hub is removed from the axle. In those cases, place a protective cushion to catch the bearing assembly. Using a hardwood drift and a light hammer, gently tap the bearing and seal out of the inner wheel bearing cup.
3. Clean the spindle, spindle threads, seal bore, and the hub cavity. See **Fig. 1** and **Fig. 2**.
4. Remove all burrs from the shoulder and the seal bore with an emery cloth or a file. Clean any metal filings from the components.

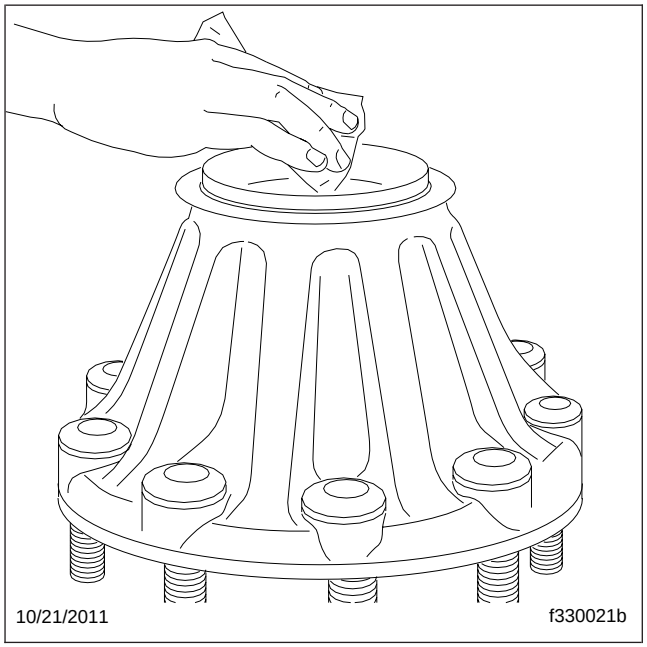



**Fig. 1, Cleaning the Hub**

### NOTICE

**Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.**

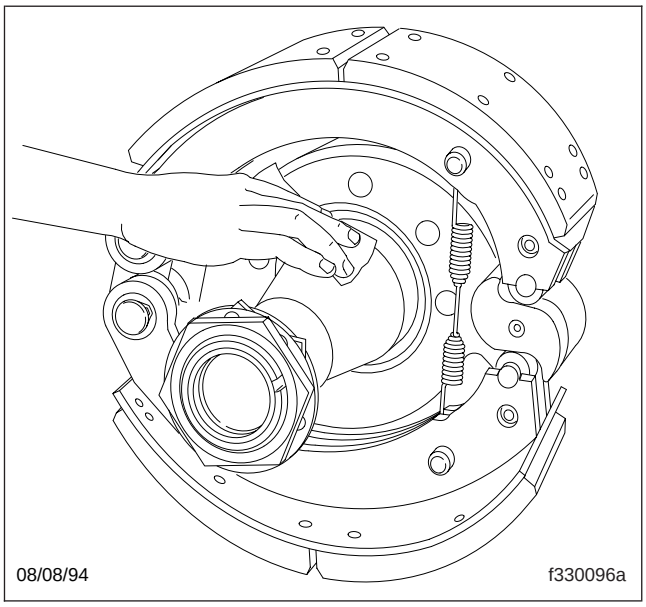



**Fig. 2, Cleaning the Spindle**

IMPORTANT: Use extreme care in cleaning the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause premature wear of the bearing assembly.

5. Inspect the bearings and hub components for wear or damage. Replace any worn or damaged components as necessary.
6. Coat the wheel bearing cones with oil.
7. Install the inner wheel bearing cone in the inner wheel bearing cup.
8. Seat the small outside edge of the seal in the recess of the tool adapter. See **Fig. 3**. The correct adapter is identified on the box.
9. Insert the centering plug of the tool in the bore of the inner bearing cone. See **Fig. 4**. The plug prevents cocking of the seal in the bore.
10. Hold the tool handle firmly, and strike it until the sound of the impact changes as the seal bottoms out. See **Fig. 5**. Hold the tool firmly to avoid bounce or unseating of the seal from the adapter.
11. After the seal is bottomed in the bore, check for freedom of movement by manually rotating the seal back and forth. A slight movement indicates a damage-free installation.

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## Seal Replacement, Scotseal Classic

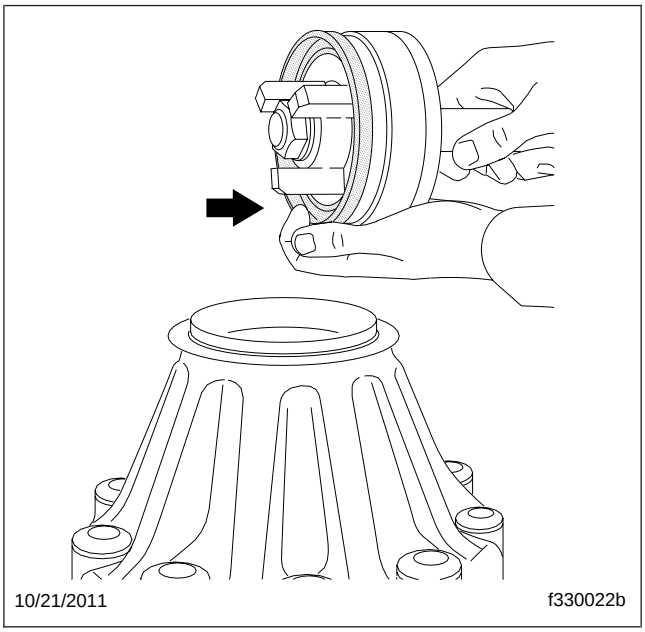



**Fig. 3, Placing the Seal on the Installation Tool**

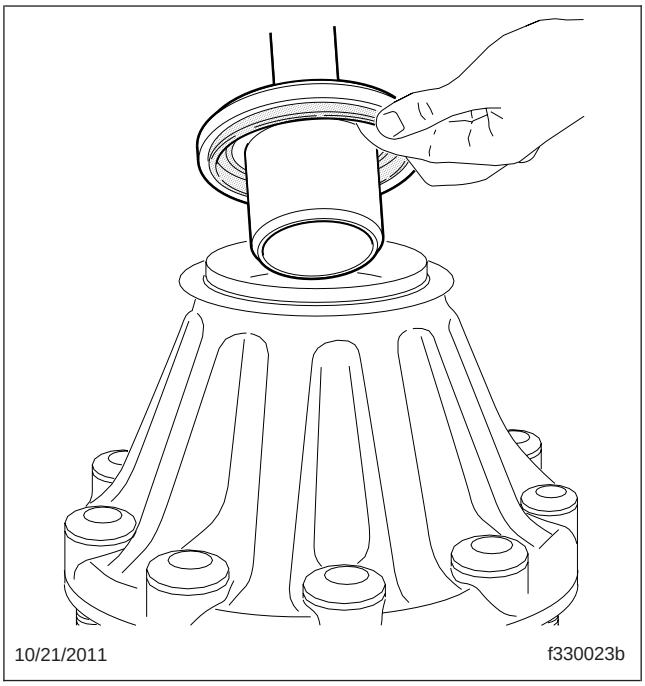



**Fig. 4, Inserting the Tool in the Hub Bore**

12. Install the wheel hub on the axle, and adjust the wheel bearings. For instructions, see **Section 33.01**.

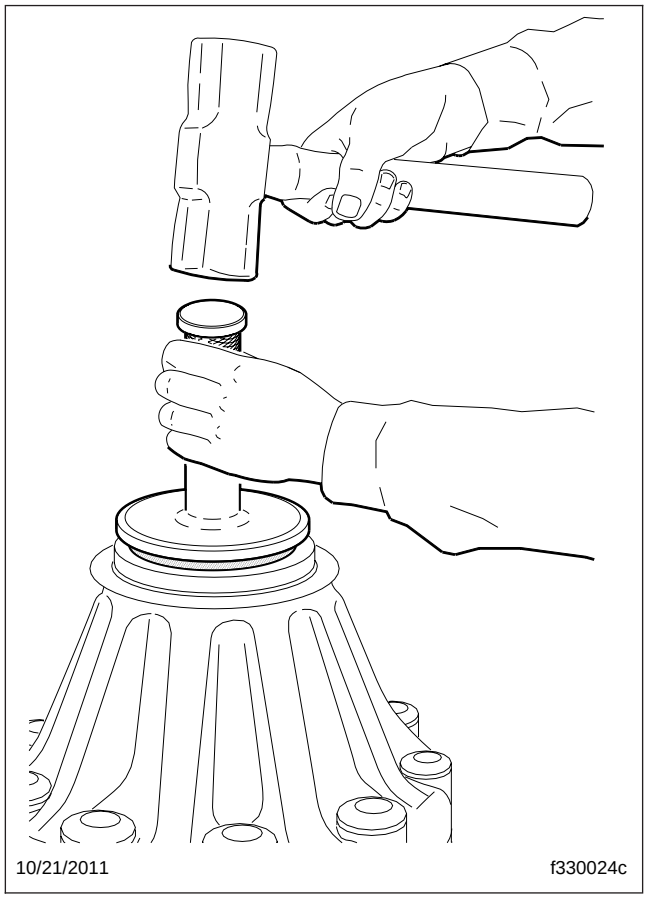



**Fig. 5, Striking the Tool**

IMPORTANT: When starting the wheel on the spindle, center the hub carefully to avoid seal damage from the leading edge of the spindle.

13. Place the hubcap and a new gasket in position. Install the capscrews. Tighten the capscrews 15 lbf·in (20 N·m).
14. Fill the hub with oil to the level shown on the hubcap. See **Fig. 6**. Do not overfill.
15. Spin the wheel and check the oil level.
16. Adjust the brake shoe-to-drum clearance. For instructions, see **Group 42**.

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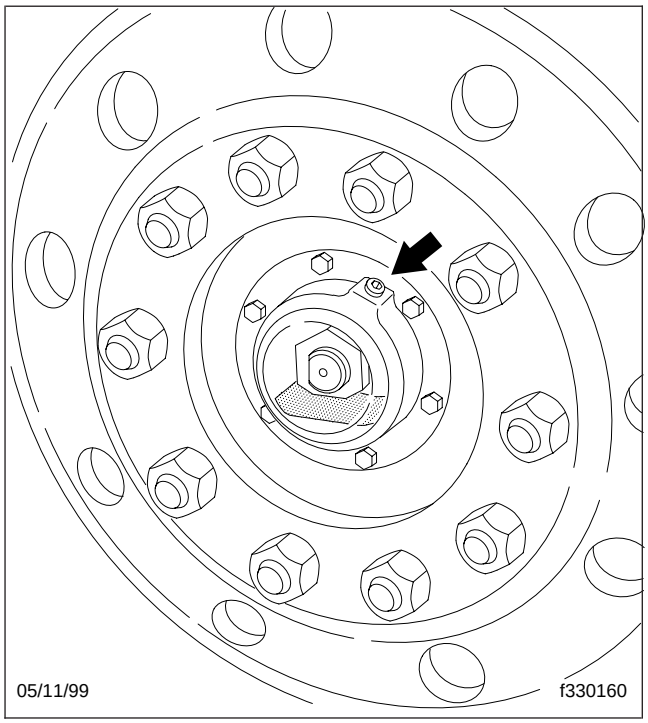



**Fig. 6, Hub Filler Plug**

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## Seal Replacement, Dana Spicer® Outrunner™

## Replacement

1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 33.01**.
2. Remove the inner wheel bearing assembly from the axle. Handling the bearings with clean dry hands, wrap the bearings in clean oil-proof paper or lint-free cloths. Occasionally, the inner wheel bearing cone assembly will remain in the hub after the hub is removed from the axle. In those cases, place a protective cushion to catch the bearing assembly. Using a hardwood drift and a light hammer, gently tap the bearing and seal out of the inner wheel bearing cup.

**⚠ CAUTION**

**Never use a sharp chisel to cut through an axle ring (wear sleeve). A sharp chisel could damage the spindle or shoulder.**

3. Remove the steel axle ring (wear sleeve) by striking the ring surface several times with a ball-peen hammer. See **Fig. 1**. Remove the stretched axle ring from the spindle.

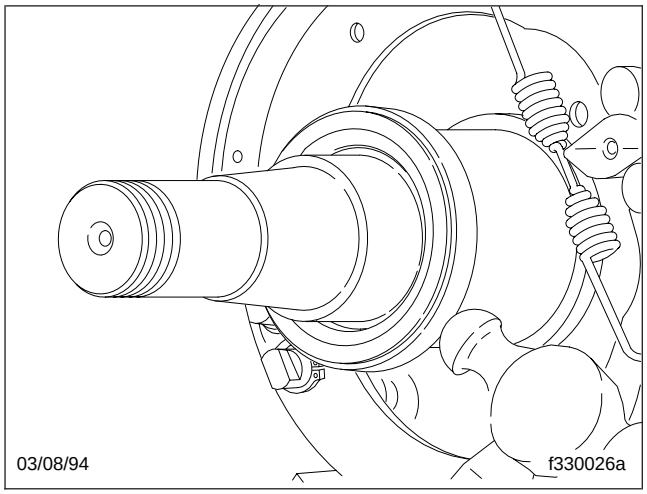



**Fig. 1, Removing the Axle Ring**

4. Clean and inspect the bearings, the spindle, spindle threads, seal bore, and the hub cavity.

   IMPORTANT: Use extreme care in cleaning the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause premature wear of the bearing assembly.

   4.1 Inspect the inner hub bore. Remove dirt and contaminants from all recesses and corners. Smooth any sharp edges with emery cloth, and fill in any grooves with filler. See **Fig. 2**.

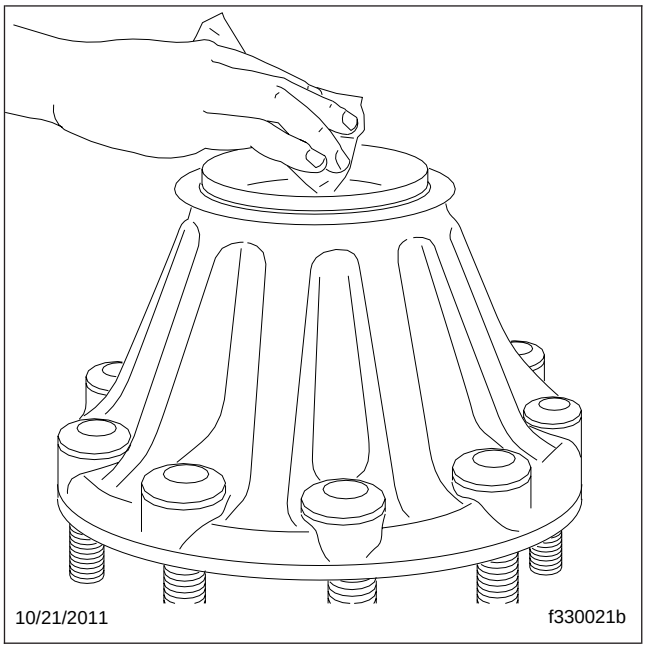



**Fig. 2, Clean and Inspect the Hub Bore**

   4.2 Wipe the hub area with a clean shop cloth.

   4.3 After removing the wear sleeve, inspect the spindle. Remove any sharp edges and burrs from the leading edges and the shoulder area. Repair deep gouges with filler and smooth with an emery cloth. See **Fig. 3**.

   4.4 Wipe the seal and shoulder area with a clean shop cloth.

**⚠ CAUTION**

**Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.**

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## Seal Replacement, Dana Spicer® Outrunner™

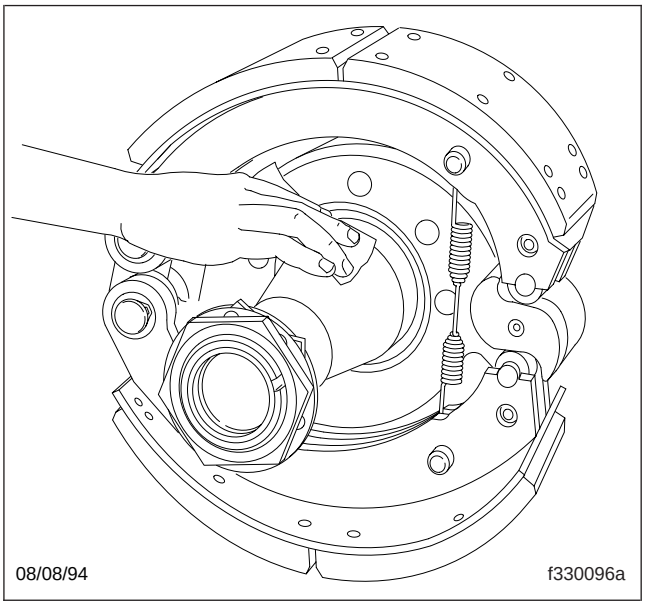



**Fig. 3, Clean and Inspect the Axle Spindle**

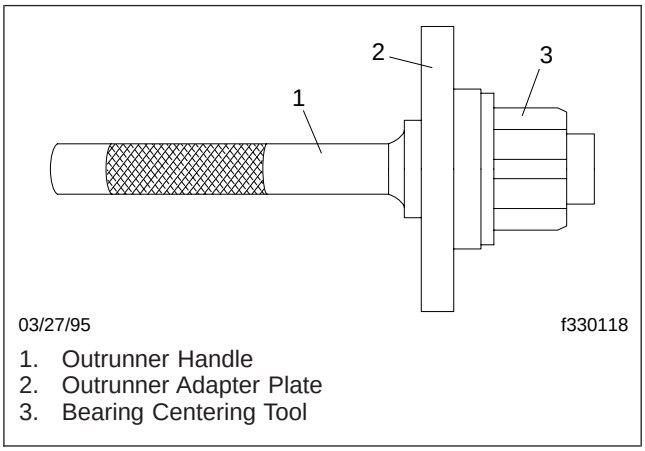
4.5 Inspect the bearings and hub components for wear or damage. Replace any worn or damaged components as necessary.

4.6 Coat the wheel bearing cones with oil.

5. Install the inner wheel bearing cone in the inner wheel bearing cup.

IMPORTANT: Use the Dana Spicer Outrunner installation tool *with the centering tool* when installing the seal. See **Fig. 4**.

6. Install the oil seal in the hub bore.




1. Outrunner Handle
2. Outrunner Adapter Plate
3. Bearing Centering Tool

**Fig. 4, Outrunner Installation Tool**

**⚠ CAUTION**

**Do not use any silicone or permatex type bore sealant with this seal. The Dana Spicer Corporation recommends a light coating of bearing oil on the outer circumference of the seal.**

**Do not mix lubricants of different grades. Do not mix mineral and synthetic lubricants. Do not pack the bearings with grease when using an oil bath system. Failure to follow these installation guidelines will result in less than desired performance of the Outrunner seal, and installation-related failures are not covered under warranty.**

6.1 Place the Outrunner seal tool with the words "air side" facing the adapter plate of the installation tool. See **Fig. 5**. Lubricate the seal outer circumference with wheel bearing oil.

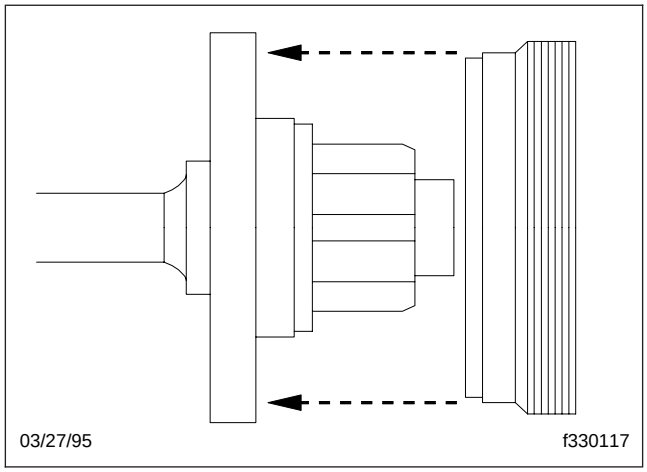



**Fig. 5, Seal Placement on Tool**

IMPORTANT: Install the seal in the hub bore with the hub lying flat. Do not install the seal with the hub in the vertical (upright) position.

6.2 With the hub and the wheel assembly lying flat on the floor, place the inner bearing cone in the cup.

6.3 Position the oil seal in the hub bore. Before striking the handle of the installation tool, tap the adapter plate around the outer edge to position the seal. See **Fig. 6**.

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## Seal Replacement, Dana Spicer® Outrunner™

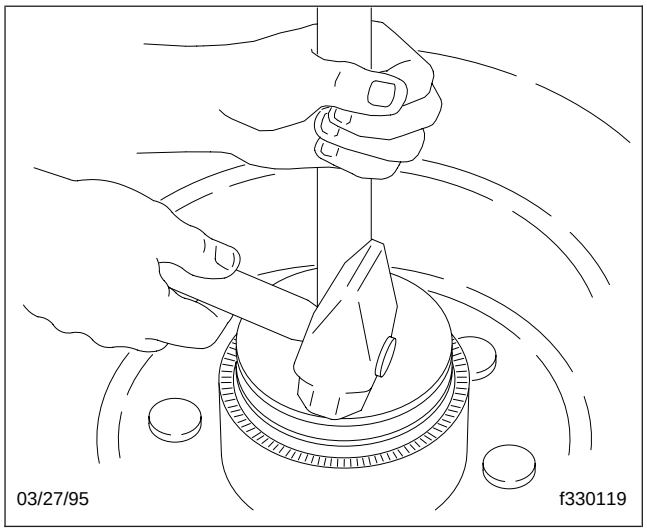



**Fig. 6, Position the Seal**

6.4 Hit the handle of the installation tool *gently*. See **Fig. 7**.

Because of the rubber outer circumference, the Outrunner seal is easier to install than seals with metal outer circumferences. When the adapter plate bottoms out on the hub surface, the seal is installed correctly. You will hear a metal-to-metal sound.

6.5 Check that the seal is not cocked, and that the unitized seal inner circumference and inner bearing turn freely.

6.6 Lubricate the inner circumference of the seal with a light film of clean bearing oil.

7. Install the wheel hub on the axle, and adjust the wheel bearings. For instructions, see **Section 33.01**.

IMPORTANT: When starting the wheel on the spindle, center the hub carefully to avoid seal damage from the leading edge of the spindle.

8. Place the hubcap and a new gasket in position. Install the capscrews. Tighten the capscrews 15 lbf·ft (20 N·m).
9. Fill the hub with oil to the level shown on the hubcap. See **Fig. 8**. Do not overfill.
10. Spin the wheel and check the oil level.
11. Adjust the brake shoe-to-drum clearance. For instructions, see **Group 42**.

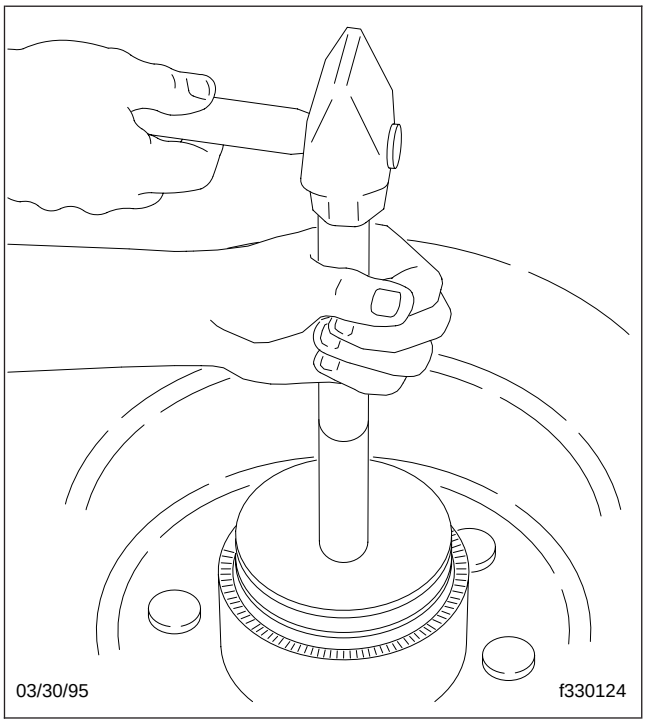



**Fig. 7, Install the Seal**

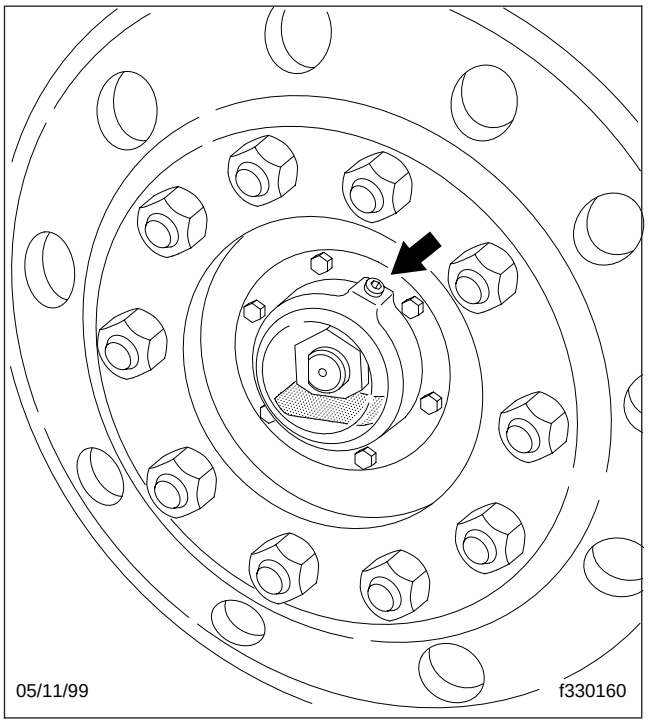



**Fig. 8, Hub Filler Plug**

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## Replacement

1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 33.01**.
2. Remove the old oil seal from the hub or spindle.
3. Clean the spindle, spindle threads, seal bore, and the hub cavity.

**⚠ CAUTION**

**Never use a sharp chisel to cut through an axle ring. A sharp chisel could damage the spindle or shoulder.**

4. Remove the steel axle ring by striking the ring surface several times with a ball-peen hammer. See **Fig. 1**. Remove the stretched axle ring from the spindle.

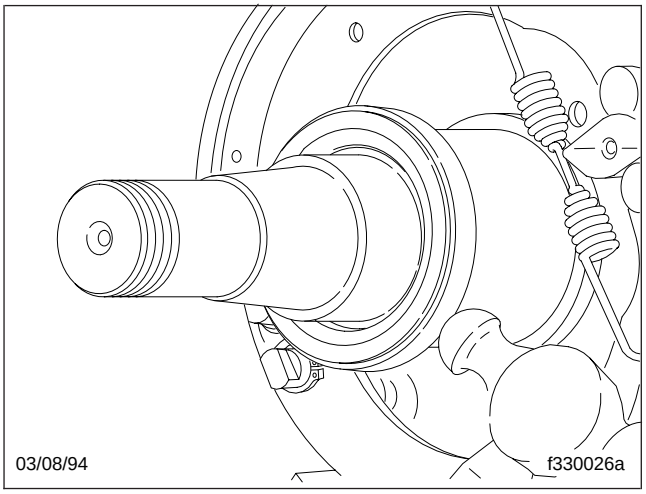



**Fig. 1, Remove the Axle Ring**

5. Using a wire brush, remove any old sealant and corrosion from the axle spindle and shoulder. Remove any burrs with an emery cloth. See **Fig. 2**. Wipe the spindle and shoulder clean with safety solvent.
6. Remove any burrs from the inside of the hub bore. See **Fig. 3**. The hub bore must be free of burrs that will scratch the outer surface of the seal and allow oil to escape from the hub. Remove any spacer rings or washers, if so equipped.

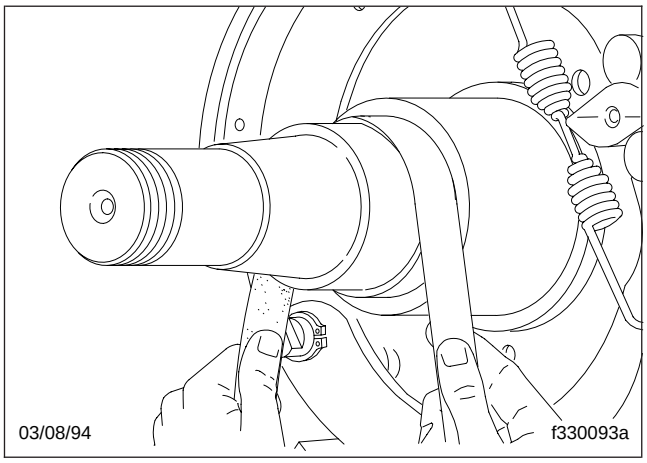
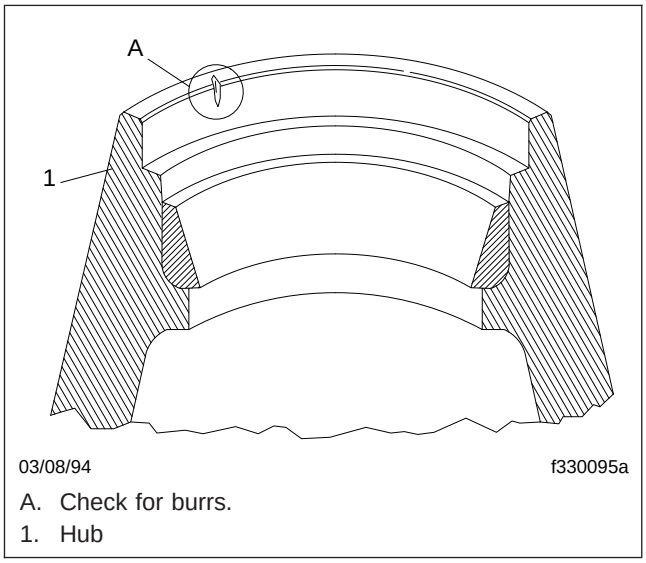



**Fig. 2, Clean the Axle Spindle**




A. Check for burrs.
1. Hub

**Fig. 3, Inspect the Hub Bore**

IMPORTANT: Clean the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause rapid wear of the bearing assembly.

7. Inspect the bearings and hub components for wear or damage. Replace any worn or damaged parts as necessary.

**⚠ CAUTION**

**Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause**

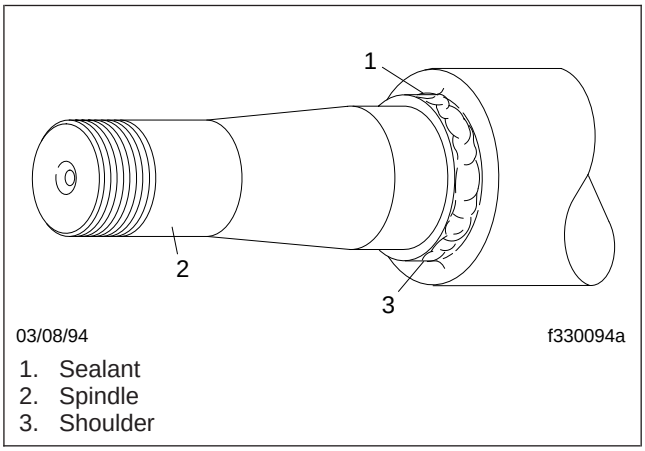
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## Seal Replacement, Stemco®

**rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.**

8. If burrs were removed from the spindle shoulder, apply a thin layer of non-hardening sealant to the spindle shoulder. See **Fig. 4**.




1. Sealant
2. Spindle
3. Shoulder

**Fig. 4, Apply Sealant to the Spindle Shoulder**

NOTE: Use a non-hardening sealant such as Permatex® Number-2 or Loctite® 515.

9. Place the oil seal on the spindle so the words "oil-bearing side" are exposed to the oil. A slight step on the inside circumference of the seal ring will allow it to be placed by hand about 1/8 inch (3 mm) onto the shoulder. See **Fig. 5**.

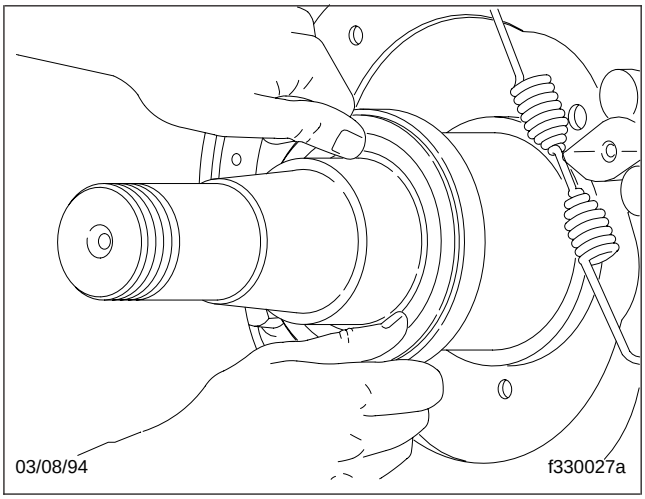



**Fig. 5, Place the Seal on the Spindle**

**⚠ CAUTION**

**Do not install the oil seal in the hub bore. Incorrect seal installation will damage the seal and lead to possible spindle, hub, and bearing damage.**

10. Position the Stemco installation tool over the spindle. See **Fig. 6**. Using a 3 to 5 lb (1 to 2 kg) hammer, drive the seal on the spindle until the tool bottoms against the shoulder. After the tool bottoms, turn it while applying several light taps with the hammer to ensure the seal ring is flush with the face of the shoulder. Wipe off all excess sealant.

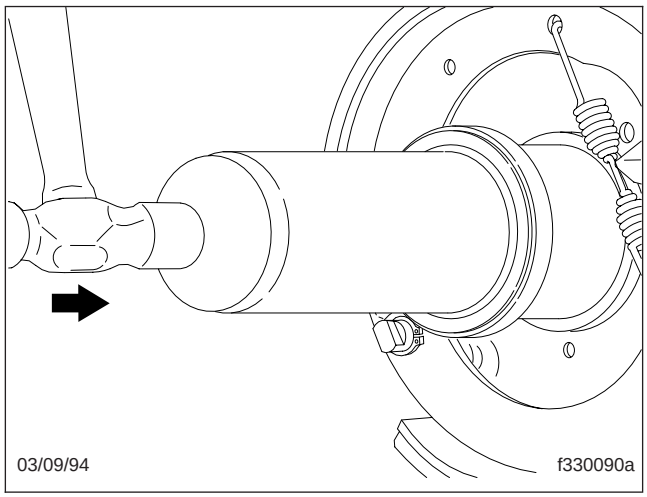



**Fig. 6, Drive the Seal onto the Spindle**

IMPORTANT: Use only the tool specified by Stemco for the vehicle's axle. In order for the Stemco warranty to apply, the product must be correctly installed using the correct tool made by Stemco or a tool approved by Stemco.

11. Make sure there are no gaps between the ring and shoulder. See **Fig. 7**.
12. Coat the inner wheel bearing with oil and install it on the spindle. See **Fig. 8**. No additional oil is needed on the outside of the seal. The seals are lubed at the factory.
13. Install the hub and wheel bearings. For instructions, see **Section 33.01**.

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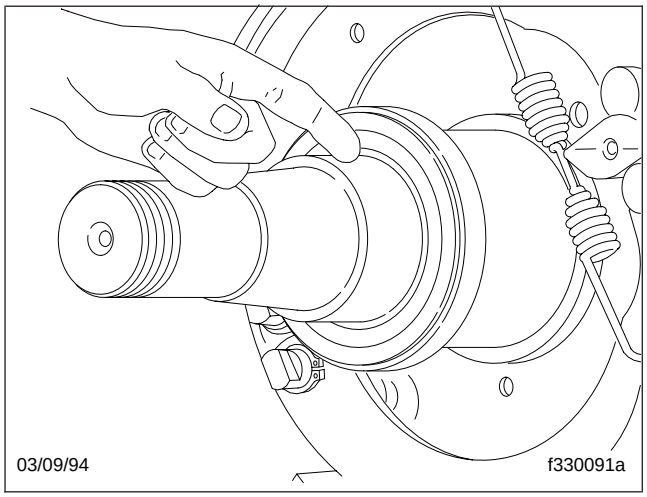



**Fig. 7, Check the Ring for Gaps**

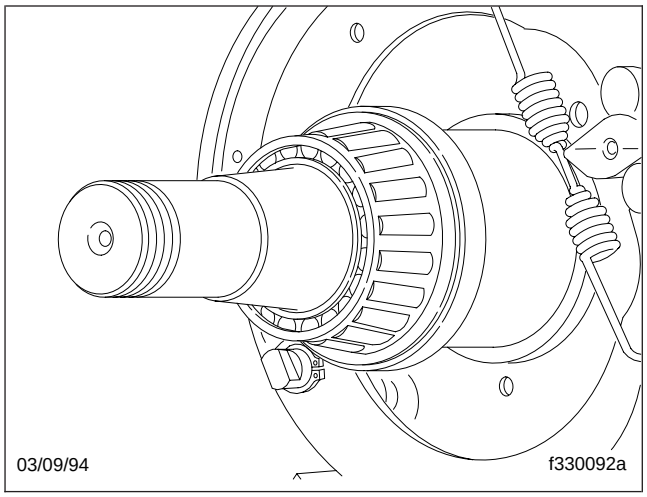



**Fig. 8, Install the Inner Bearings**

IMPORTANT: Do not force the wheel onto the seal. The wheel will seat on the seal when the adjustment nut is tightened.

14. Adjust the wheel bearings. For instructions, see **Section 33.01**.
15. Install the hub cap with a new gasket. Tighten the hub cap nuts 15 lbf·ft (20 N·m). Add oil to the level shown on the window. See **Fig. 9**. Turn the hub and allow the oil to settle. Recheck the hub and fill to a level between the oil line and about 1/4 inch (6 mm) above the oil line. Do not overfill the hub. Install the vent plug or threaded filler plug.

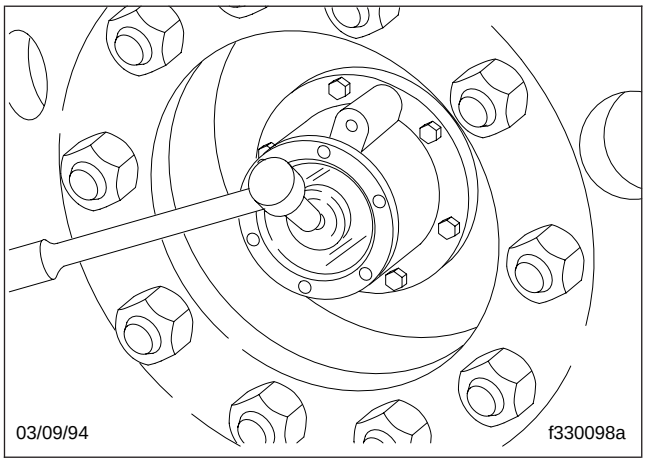



**Fig. 9, Fill the Hub with Oil**

16. Spin the wheel and check the oil level.
17. Adjust the brake shoe-to-drum clearance. For instructions, see **Group 42**.

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## Seal Replacement, Scotseal Plus XL

IMPORTANT: Make sure the required tools are available before beginning the service procedures described here. See **Table 1** for tool and seal numbers. See **Fig. 1** for a diagram of the installation tool.

## Replacement

1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 33.01**.
2. Remove the inner wheel bearing assembly from the axle. Handling the bearings with clean dry hands, wrap the bearings in clean oil-proof paper or lint-free cloths. Occasionally, the inner wheel bearing cone assembly will remain in the hub after the hub is removed from the axle. In those cases, place a protective cushion to catch the bearing assembly. Using a hardwood drift and a light hammer, gently tap the bearing and seal out of the inner wheel bearing cup. Discard the seal.
3. Clean the spindle, spindle threads, seal bore, and the hub cavity. See **Fig. 2** and **Fig. 3**.
4. Remove all burrs from the shoulder and the seal bore with an emery cloth or a file. Clean any metal filings from the components.

### NOTICE

**Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.**

IMPORTANT: Use extreme care in cleaning the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause premature wear of the bearing assembly.

5. Inspect the bearings and hub components for wear or damage. Replace any worn or damaged components as necessary.
6. Coat the wheel bearing cones with oil.
7. Install the inner wheel bearing cone in the inner wheel bearing cup.
8. Inspect a new seal for damage (such as cuts or being out of round) and contamination. If damage is evident, discard it and use a suitable seal.
9. Apply a thin layer of lubricant to the inside and outside diameters of the seal using the same lube used in the hub.
10. Seat the seal in the seal bore with the "air side" facing outward ("air side" is stamped on the sleeve flange of the seal), then press it down firmly with the flat side of the driver plate.
11. Insert the centering tool into the bore of the inner bearing cone. The plug prevents cocking of the seal in the bore.
12. Hold the tool handle firmly, and strike it until the seal bottoms out. See **Fig. 4**. Hold the tool firmly to avoid bounce or unseating of the seal from the adapter.
13. After the seal is bottomed in the bore, check for freedom of movement by manually rotating the seal back and forth. A slight movement indicates a damage-free installation. If any damage is visible, remove the seal and install a new one.
14. Install the wheel, drum, and hub on the axle, and adjust the wheel bearings. For instructions, see **Section 33.01**.

IMPORTANT: When starting the wheel on the spindle, center the hub carefully to avoid seal damage from the leading edge of the spindle.

15. Adjust the brake shoe-to-drum clearance. For instructions, see **Group 42**.

| Scotseal Plus XL Tool and Seal Numbers | | | |
|---|---|---|---|
| **Cone, Inner Bearing** | **Seal Stock Number** | **Centering Tool** | **Driver Plate** |
| SBN HM212049TRB | CHR 35058* | CHR 706 | CHR 436 |

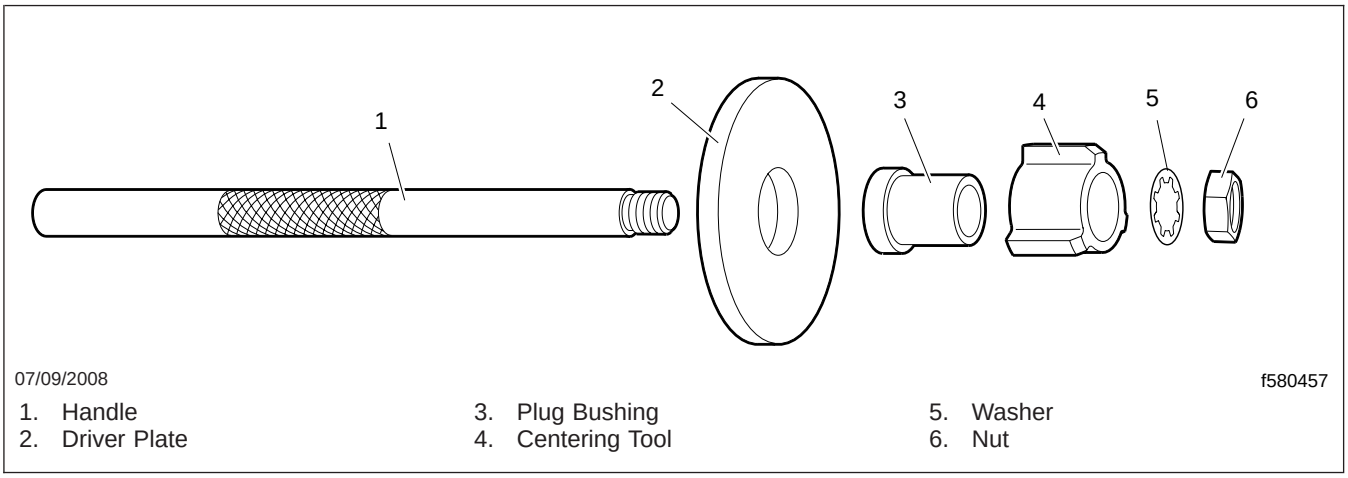
* The seal stock number is listed on the air-side flange of the seal.

**Table 1, Scotseal Plus XL Tool and Seal Numbers**

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## Seal Replacement, Scotseal Plus XL




1. Handle
2. Driver Plate
3. Plug Bushing
4. Centering Tool
5. Washer
6. Nut

**Fig. 1, Installation Tool**

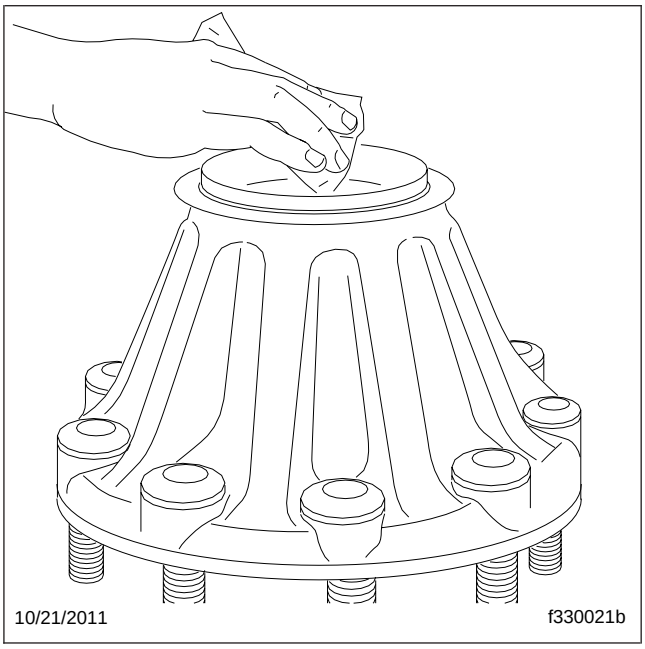



**Fig. 2, Cleaning the Hub**

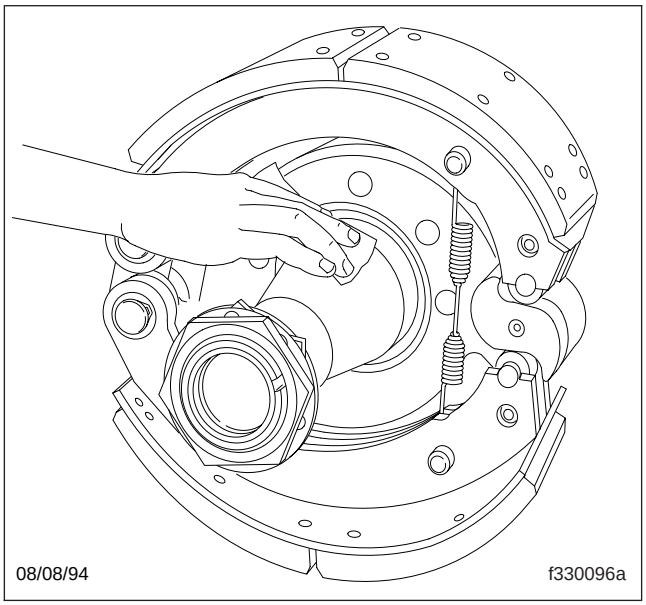



**Fig. 3, Cleaning the Spindle**

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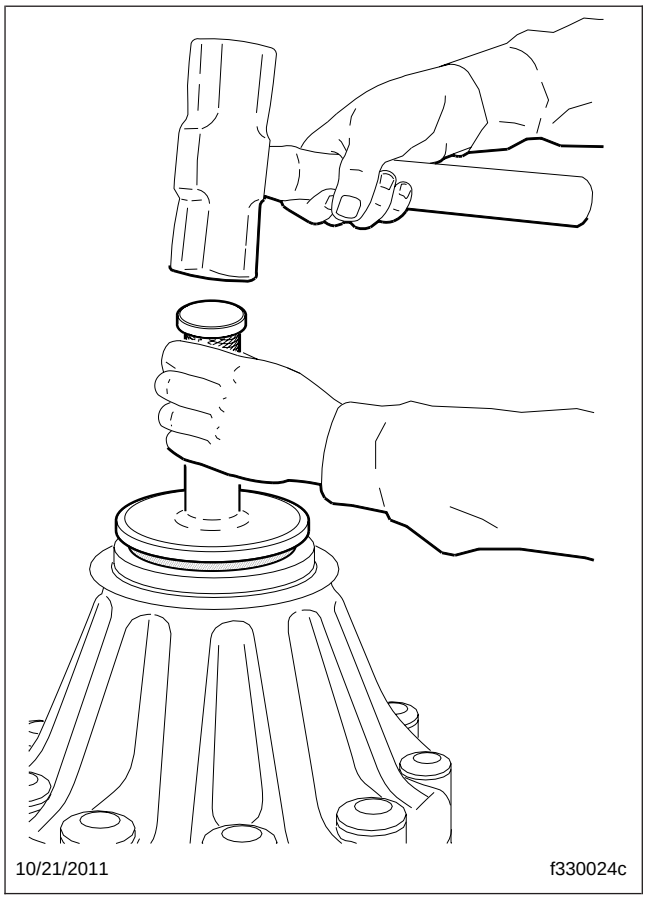



**Fig. 4, Striking the Tool**

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# General Information

Detroit™ front axles have a unique steering knuckle design that reduces vibration and wear. Low-friction, high-strength needle bearings roll on a large-diameter kingpin, replacing the conventional bushings. They are compatible with industry-standard brakes, hubs, and wheel bearings.

The following explains a typical model code found on a Detroit front axle identification tag. See **Fig. 1**.

Typical Model Code: AF-12-3.

- *AF* = front axle
- *12* = Weight Rating (times 1000 lb)
- *3* = Model Number

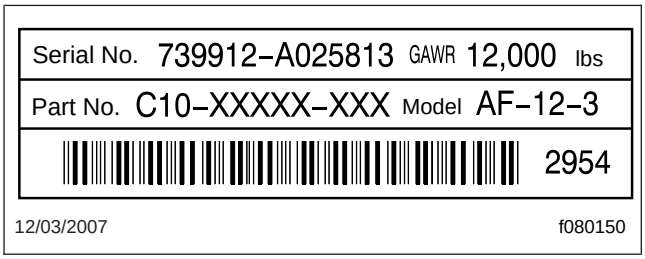



**Fig. 1, Front Axle ID Tag**

NOTE: Detroit axles are a proprietary product, though in some applications they may be referred to as "Axle Alliance axles" or "MB components."

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## Removal

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the rear tires. Put the transmission in neutral.
2. At both ends of the front axle, loosen all the wheel nuts.

**⚠ WARNING**

**Never work around or under a vehicle that is supported only by a jack. Always support the vehicle with safety stands. Jacks can slip, causing the vehicle to fall, which could result in serious injury or death.**

3. Raise the front of the vehicle and support it with safety stands.
4. Drain the air system.
5. Remove the front wheel and tire assemblies. For instructions, see **Group 40**.
6. Remove the brake drums. For instructions, see the applicable section in **Group 42**.
7. Remove the front hubs from the axle. For instructions, see **Section 33.01, Subject 100**.
8. Remove the brake shoes. For instructions, see the applicable section in **Group 42**.
9. Remove the ABS sensors and wiring from the brake anchor plates and secure them and their wiring out of the way.
10. Remove the brake air chambers and the slack adjusters. For instructions, see the applicable section in **Group 42**.
11. Remove the brake anchor plates from the axle ends.
12. Disconnect the drag link from the axle steering arm.
13. If so equipped, disconnect the sway bar from the axle brackets.
14. Using a suitable jack, support the front axle.
15. Remove the U-bolt nuts or remove the nuts holding the axle beam to the leaf springs and the air bag brackets, as applicable.
16. Remove the U-bolts, if applicable.
17. Remove the axle from the vehicle.
18. If you are replacing the steering knuckles, put the axle on a suitable stand and secure it to prevent it from moving.

## Installation

1. With the axle on a suitable jack, position it under the vehicle.
2. For vehicles with front air suspension, raise the axle so that the holes in the axle beam line up with the bolts holding the air bags to the leaf springs. Install the nuts and washers and tighten the nuts 220 lbf·ft (298 N·m).

   For vehicles with a leaf-spring front suspension, install the U-bolts and nuts. For instructions on tightening U-bolt nuts, see the applicable section in **Group 32**.
3. If so equipped, connect the sway bar to the axle brackets. Tighten the sway bar fasteners 100 lbf·ft (136 N·m).
4. Connect the drag link to the steering arm. For instructions, see the applicable section in **Group 46**.
5. Install the brake anchor plates to the axle ends. For instructions, see the applicable section in **Group 42**.
6. Install the brake air chambers and slack adjusters on the axle. For instructions, see the applicable section in **Group 42**.
7. Install the ABS sensors.
8. Install the brake shoes. For instructions, see the applicable section in **Group 42**.
9. Install the hubs and adjust the wheel bearings. For instructions, see **Section 33.01, Subject 100**.
10. Install the brake drums.
11. Adjust the slack adjusters. For instructions, see the applicable section in **Group 42**.
12. Install the tire and wheel assemblies. For instructions, see **Group 40**.
13. Raise the vehicle, remove the safety stands, and lower the vehicle.
14. Start the engine and build the air pressure.

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## Axle Removal and Installation

15. If equipped with a front air suspension, check that the suspension air bags are inflating correctly.
16. Remove the chocks from the rear tires.

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## Disassembly

NOTE: The following procedures can be done with the axle installed on the vehicle or with the axle removed from the vehicle.

1. If the axle has been removed, make sure it is securely mounted on a suitable stand. Go to the step for disconnecting the tie rod from the tie-rod arm.

   If the axle is on the vehicle, park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the rear tires. Drain the air system.

2. If the axle is on the vehicle, do the following substeps to gain access to the steering knuckle:

   2.1 Remove the wheel and tire assembly from the applicable side of the vehicle.

   2.2 Remove the hub and brake drum. For instructions, see **Section 33.01, Subject 100**.

   2.3 Remove the brake shoes. For instructions, see the applicable section in **Group 42**.

   2.4 If so equipped, remove the ABS sensor and wiring from the brake anchor plates and secure the sensor and the wiring out of the way.

   2.5 Disconnect the air line from the brake air chamber, then remove the air chamber and the slack adjusters. For instructions, see the applicable section in **Group 42**.

   2.6 Disconnect the drag link from the steering arm, if present.

   NOTE: On the driver's side of the vehicle, the steering arm connects to the steering knuckle. On the passenger's side, no steering arm is present.

3. If not already done, disconnect the tie rod from the tie-rod arm.

4. Remove the tie-rod arm from the steering knuckle. See **Fig. 1**.

5. If applicable, remove the steering arm. See **Fig. 1**.

6. Remove the steering knuckle and spindle assembly from the axle beam. See **Fig. 1**.

   6.1 Remove the upper and lower snap rings that hold the cover plates in place. See **Fig. 1**.

   6.2 Remove the upper and lower cover plates from the steering knuckle.

   6.3 Remove and discard the O-ring from the edges of each cover plate.

   6.4 Note the orientation of the draw keys and the kingpin, then remove the draw keys and nuts that hold the kingpin in place.

   6.5 Using a brass drift, remove the kingpin by driving it downward. Make a note of where the needle bearings were installed.

   6.6 Remove the spacer(s) and shim(s) from the upper surface of the axle beam bore.

   6.7 Push down on the steering knuckle and spindle assembly to clear the lip on the thrust friction bearing and remove the assembly from the axle beam bore.

NOTE: The steering knuckle on the passenger's side (side without a steering arm) has a thrust roller bearing instead of a thrust friction bearing. Unlike the thrust friction bearing, the thrust roller bearing has no protruding lip at the top. When removing the thrust roller bearing from the axle beam bore, it is not necessary to push down on the steering knuckle.

7. Remove the grease seal from the upper steering-knuckle bore.

8. Remove the thrust friction bearing (driver's side) or the thrust roller bearing (passenger's side) from the top of the lower steering knuckle bore.

NOTE: If removing the thrust friction bearing (driver's side), note the orientation of the bearing for future reference.

9. Using a brass drift, drive out the needle bearings from the steering knuckle bores.

10. If needed, repeat the entire procedure for the other side of the axle assembly.

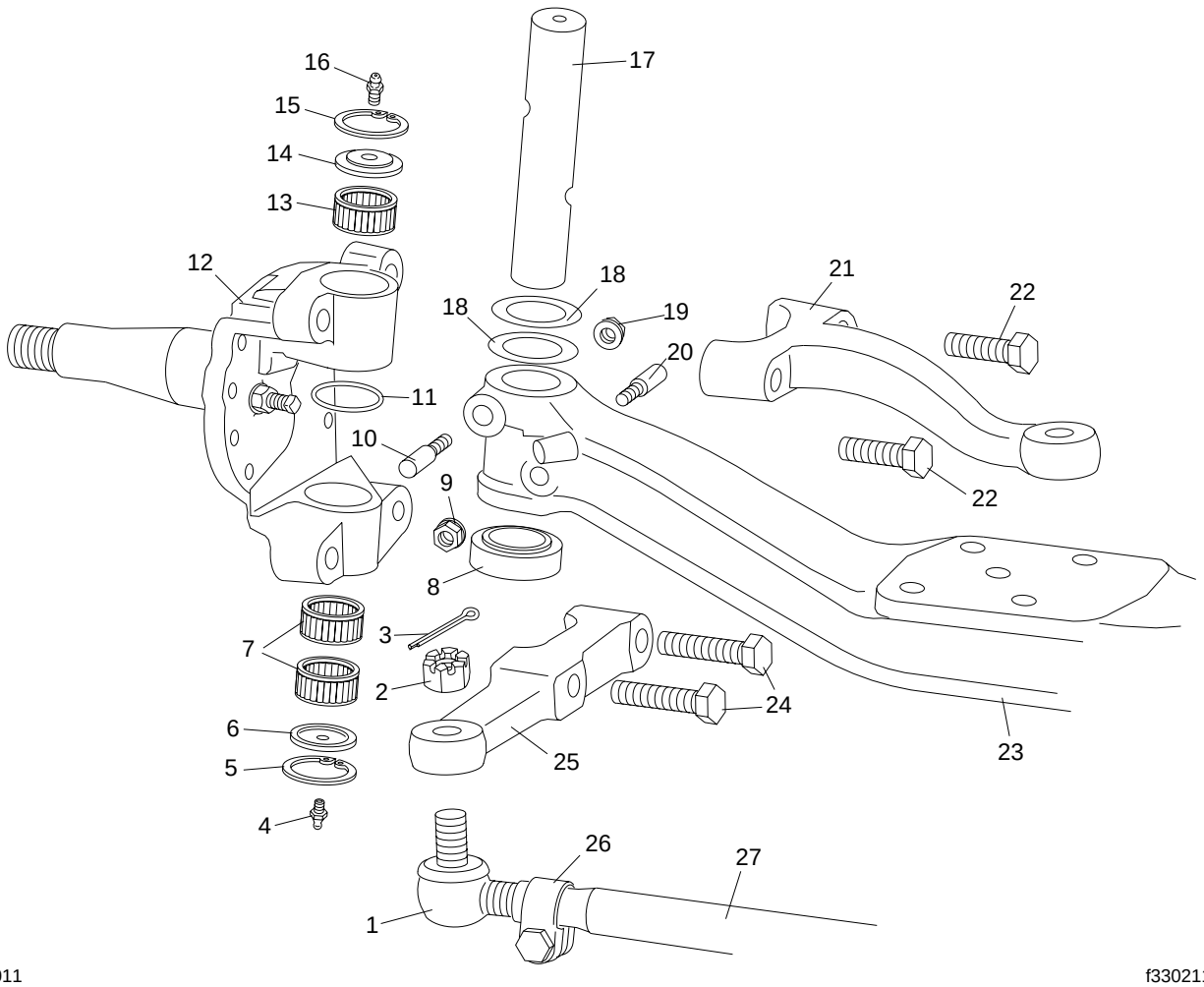
## Assembly

IMPORTANT: If replacing the kingpin, use a complete rebuild kit with all new components.

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## Steering Knuckle Disassembly and Assembly




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NOTE: The number of upper and lower needle bearing sets may vary, depending on the axle model.

1. Tie-Rod Ball Joint
2. Castle Nut
3. Cotter Pin
4. Lower Grease Fitting
5. Lower Snap Ring
6. Lower Cover Plate
7. Lower Needle Bearings (may be one or two sets)
8. Thrust Friction Bearing (thrust roller bearing on the passenger side)
9. Lower Draw Key Nut
10. Upper Draw Key
11. Grease Seal
12. Steering Knuckle
13. Upper Needle Bearing (may be one or two sets)
14. Upper Cover Plate
15. Upper Snap Ring
16. Upper Grease Fitting
17. Kingpin
18. Shim
19. Upper Draw Key Nut
20. Lower Draw Key
21. Steering Arm
22. Steering Arm Capscrew
23. Axle Beam
24. Tie-Rod Arm Capscrews
25. Tie-Rod Arm
26. Tie-Rod Clamp
27. Tie-Rod Tube

**Fig. 1, Front Axle Components (driver side shown)**

1. Clean the steering knuckle bores and the axle beam bores. Check for damage such as grooves, scratches, and pitting.

   If any bores show significant damage, replace the component.

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2. Install the grease seal — with the grooved side down (toward the road) — into the top of the upper steering knuckle bore. Carefully drive the seal down into the bore until the outer edge of the seal is flush with the bottom edge of the bore. Make sure the seal is not cocked.
3. Install new needle bearings into the bores of one of the steering knuckles. Install the same number of bearings as was removed.

NOTE: Install the needle bearings just far enough into the bores so that the cover plates can be installed.

4. Install a new thrust friction bearing (driver's side) or thrust roller bearing (passenger's side) into the top of the lower steering knuckle bore. Install the thrust friction bearing (or thrust roller bearing) with the sealed side up.

NOTE: The thrust friction bearing has a protruding lip at the top. The thrust roller bearing has no such protruding lip.

5. Partially install the steering knuckle on the axle beam.
   - 5.1 Making sure the flats on the kingpin are aligned with the draw-key holes in the axle beam, put the new kingpin into the top bore of the steering knuckle. Note that the top of the new kingpin is clearly marked. Push the kingpin through the axle beam bore until the upper end of the kingpin is flush with the upper surface of the axle beam bore.
   - 5.2 Align the steering knuckle with the axle beam, then check the clearance between the axle beam bore and the upper steering knuckle bore. Clearance is to be a maximum of 0.003 inch (0.08 mm).

   IMPORTANT: To correctly check the clearance, the thrust friction or thrust roller bearing must be installed correctly, and upward pressure must be applied to the steering knuckle.

   - 5.3 If needed, install sufficient spacers to reduce the clearance to 0.002 to 0.003 inch (0.05 to 0.08 mm).
6. Install the kingpin fully into the steering knuckle bores, making sure the flats on the kingpin are still aligned with the draw-key holes in the axle beam.
7. Install new upper and lower draw keys and nuts. See **Fig. 1**.
   - 7.1 Install the upper draw key from the back of the axle, and the lower one from the front of the axle.

   IMPORTANT: Make sure the new draw keys are the same length as those removed. On some axle models the lower draw key is longer than the upper one.

   - 7.2 Tighten the draw-key nuts 30 to 55 lbf·ft (40 to 75 N·m).
8. Install new grease fittings and cover plates.
   - 8.1 Install the new upper cover plate (with a new O-ring) and the snap ring. Install the new grease fitting into the cover plate.
   - 8.2 Install the new lower cover plate (with a new O-ring) and the snap ring. Install the new grease fitting into the cover plate.
9. Install the steering arm. Apply Loctite® 277 to the threads and tighten the steering arm capscrews: if M20 capscrews are used, tighten them 425 lbf·ft (575 N·m); if M24 capscrews are used, tighten them 664 lbf·ft (900 N·m).
10. Attach the tie-rod arm to the steering knuckle. Apply Loctite® 277 to the threads and tighten the tie-rod arm capscrews: if M20 capscrews are used, tighten them 425 lbf·ft (575 N·m); if M24 capscrews are used, tighten them 664 lbf·ft (900 N·m).
11. If applicable, repeat the entire procedure for the other side of the axle assembly.
12. Attach the tie-rod arm to the tie rod. Tighten the castle nut 120 to 170 lbf·ft (163 to 230 N·m) plus a maximum of one-sixth of a turn to align a slot in the castle nut with the cotter pin hole in the tie rod stud. Insert the cotter pin and bend the tangs to secure it.
13. If removed, install the axle.
14. If removed, connect the drag link to the steering arm.

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## Steering Knuckle Disassembly and Assembly

15. Install the brake anchor plates on the axle ends. For instructions, see the applicable section in **Group 42**.
16. Install the brake air chambers and slack adjusters onto the axle. For instructions, see the applicable section in **Group 42**.
17. Install the ABS sensor.
18. Install the brake shoes. For instructions, see the applicable section in **Group 42**.
19. Install the hub and adjust the wheel bearings. For instructions, see **Section 33.01**.
20. Install the brake drum.
21. Install the tire and wheel assembly. For instructions, see **Group 40**.
22. If necessary, repeat the entire procedure for the other side of the vehicle.
23. Raise the vehicle, remove the safety stand, then lower the vehicle.
24. Remove the chocks from the tires.

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## Specifications

| Torque Values | | | |
|---|---|---|---|
| **Application** | **Size** | **Class** | **Torque: lbf·ft (N·m)** |
| Air Bag-to-Leaf Spring Nuts | — | — | 220 (298) |
| Draw-Key Nuts | — | — | 30–55 (40–75) |
| Steering Arm Capscrews | M20 x 1.5 | 10.9 | 425 (575)* |
| | M24 x 1.5 | 10.9 | 664 (900)* |
| Sway Bar Fasteners | — | — | 100 (136) |
| Tie-Rod Arm Capscrews | M20 x 1.5 | 10.9 | 425 (575)* |
| | M24 x 1.5 | 10.9 | 664 (900)* |

* Apply Loctite® 277.

**Table 1, Torque Values**

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## General Information

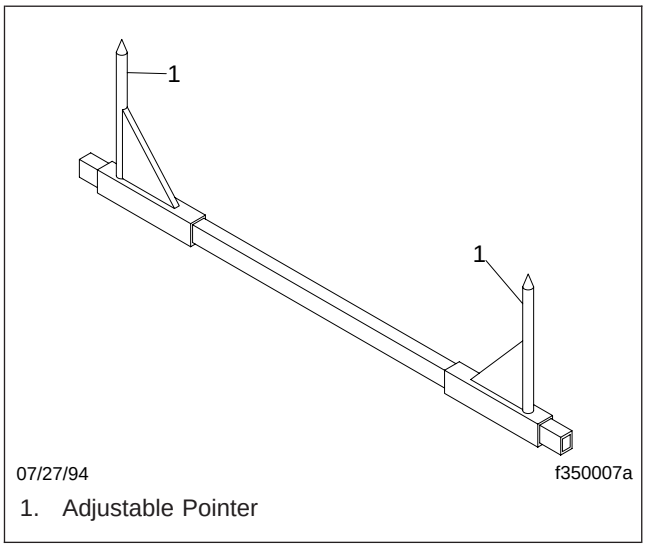
Rear axle alignment should be checked whenever rear axle or suspension components are replaced. It should also be checked when there is excessive front and rear tire wear, or hard or erratic steering.

Manufacturers of axle alignment equipment offer a variety of systems to precisely measure and correct rear axle alignment. If this type of equipment is not available, the basic tools needed for checking rear axle alignment on tandem or single axles are a straightedge (that is nonflexible and at least as long as the axle), steel tape rule, and trammel bar or center point bar.

The straightedge is used to see if a single axle, or a forward-rear axle of a tandem axle installation, is in alignment with the frame. The distance from the straightedge to the center of the wheel hub is measured on each side of the vehicle; any difference in the measurements means that the axle is out of alignment.

A center point bar (**Fig. 1**) is used to see if the forward-rear axle and rearmost axle of a tandem installation are aligned with each other (parallel). It has adjustable pointers at each end, which are inserted into the axle cap holes of each axle. By comparing the distance between the two axles on one side to the distance on the other side, it can be determined if the axles are parallel.

Instructions and a list of materials for making a center point bar are in **Subject 130**.




1. Adjustable Pointer

**Fig. 1, Center Point Bar**

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The following preliminary checks should be completed before checking any alignment measurements.

## Preliminary Checks

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. Relieve internal stresses in the suspension by driving the vehicle back and forth in a straight line.

1. Wheel assemblies should be balanced, especially for vehicles that travel at sustained speeds of more than 50 mph (80 km/h). Off-balance wheel assemblies cause vibrations that result in severely shortened life for tires and suspension parts.
2. Do not mix tires of different size, type, or weight. Tire wear should be even and not worn to limits exceeding government specifications. Refer to **Group 40** in this manual and **Group 40** in the *Western Star Maintenance Manual* for more information. Replace any tire that is excessively worn.
3. Check the inflation pressure of the tires. Refer to **Group 40** in this manual for recommended pressures. An underinflated tire causes tread wear completely around both tire shoulders. An overinflated tire causes tread wear in the center of the tire. See **Fig. 1.**

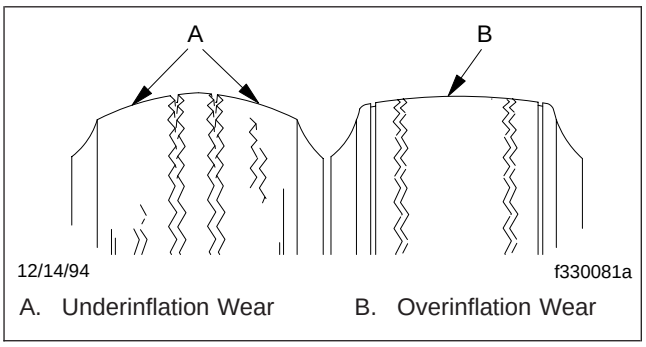



**Fig. 1, Tire Damage Due to Underinflated or Overinflated Tires**

4. Check for out-of-round wheels and wheel stud holes. Replace the wheel if any of these conditions exist.
5. On each side of the vehicle, check the height of the chassis above the ground; for instructions, see **Group 32** in this manual or the suspension manufacturer's service literature. Sagging, fatigued, or broken suspension springs create a lopsided vehicle appearance and an unbalanced weight distribution. Anything that changes the ratio of weight on the springs affects the alignment angles and also the tire tread contact area. Replace damaged springs as instructed in the applicable suspension section.
6. Check and, if necessary, correct frame rail alignment as instructed in **Group 31** in this manual.
7. Check and, if necessary, adjust rear axle tracking. For instructions, see **Group 32** in this manual or the suspension manufacturer's service literature.
8. Check the rear axle wheel bearings for wear and incorrect adjustment. Refer to **Section 35.01** for instructions.

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## Checking Using Computerized Alignment Systems

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Western Star dealers must have proof of this calibration history.

Follow the manufacturer's instructions for use of the alignment equipment, and use the alignment measurements given in **Fig. 1** and the applicable tables in **Specifications 400**.

## Checking Using the Manual Method

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction.

1. Park the vehicle on a level surface. Relieve internal stresses in the suspension by driving the vehicle back and forth in a straight line, or by jacking the axle up and letting it down.
2. Chock the front tires and place the transmission in neutral. Release the parking brakes.

### NOTICE

**Do not use scribe lines for marking on frame rails. Scribe lines, which cut or scratch the metal, can develop into starting points for structural damage to the frame.**

3. Select a point on the frame rail forward of the rear axle, and mark it using a pencil or soapstone. Then mark two other points, exactly 4 inches (102 mm) forward and to the rear of the original point. Make sure that all three marks are aligned and of equal distance from the outside edge of the frame rail. Using a center point or trammel bar, place one pointer on the forwardmost point, and make an arc with a pencil or soapstone on the opposite frame rail. Then place the pointer on the rearmost point and make an arc on the opposite frame rail intersecting the first arc. See **Fig. 2**. The point where the two arcs intersect and the original (or middle) point on the opposite frame rail have matching locations.
4. Line up the straightedge with the two matching points. Check that the straightedge extends out about the same distance on each side of the frame rail. Using C-clamps, clamp the straightedge to the frame; see **Fig. 3**. The straightedge must line up exactly with the points.
5. Measuring from the outside edge of each frame rail, mark the straightedge on both sides of the frame. The marks (**Fig. 3**, Ref. A) must be of equal distance from the frame and as far from the frame rail as the tires are at their farthest point from the frame.

IMPORTANT: The distance between the mark on the straightedge and the frame rail must be equal on both sides of the vehicle.

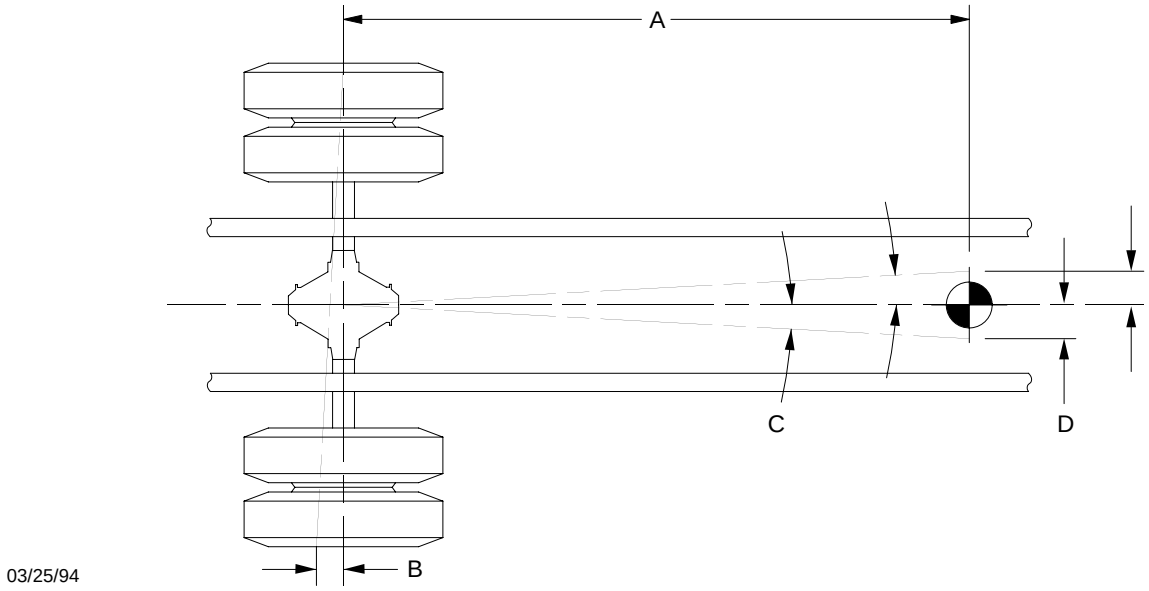
6. On each side of the vehicle, measure the distance from the mark on the straightedge to the center of the wheel hub. See **Fig. 3**.

   The difference between these measurements should be 1/4 inch (6 mm) or less. See **Fig. 1**. If the difference is more than 1/4 inch (6 mm), adjust the axle alignment. For instructions, see **Group 32** in this manual, or the suspension manufacturer's service literature.

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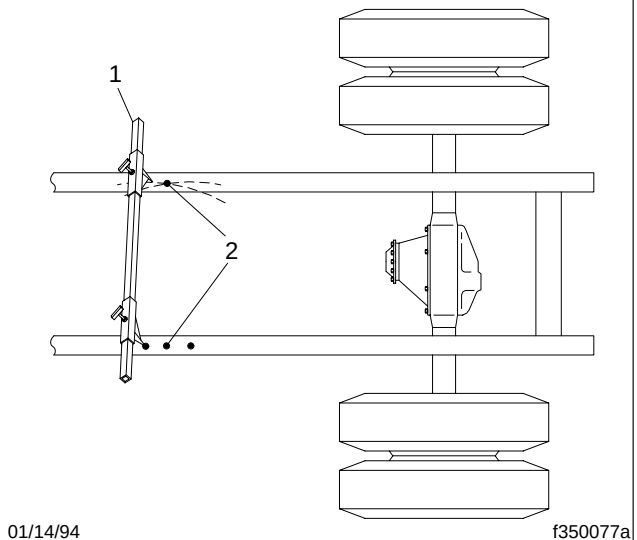
## Alignment Checking, Single Axle




For items A and D, see **Specifications 400**.

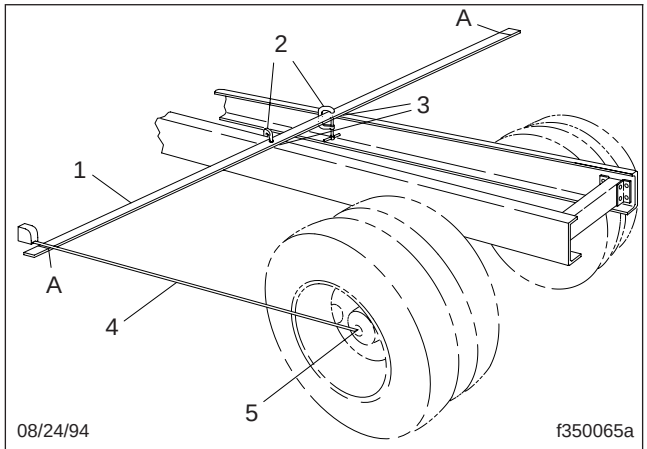
A. Distance from Rear Axle to Target (using Bee Line Alignment Tools)
B. Maximum Allowable Difference if Aligned Manually = ±1/4 inch (6 mm)
C. Maximum Allowable Tolerance if Aligned with Hunter Tools = ±0.18 degree
D. Maximum Allowable Tolerance if Aligned with Bee Line Tools

**Fig. 1, Alignment Measurements**




1. Center Point/Trammel Bar
2. Matching Points

**Fig. 2, Marking an Arc**




A. Marks

1. Straightedge
2. C-Clamps
3. Matching Points
4. Tape Measure
5. Wheel Hub

**Fig. 3, Straightedge to Wheel Hub Measurement**

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## Alignment Checking, Tandem Axle

To align a tandem axle, first, check and (if needed) align the rearmost axle; then, check and (if needed) align the forward-rear axle.

## Checking Using Computerized Alignment Systems

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction. The turn plates for the front wheels must rotate freely without friction, and the alignment equipment must be calibrated every three months by a qualified technician from the equipment manufacturer. Western Star dealers must have proof of this calibration history.

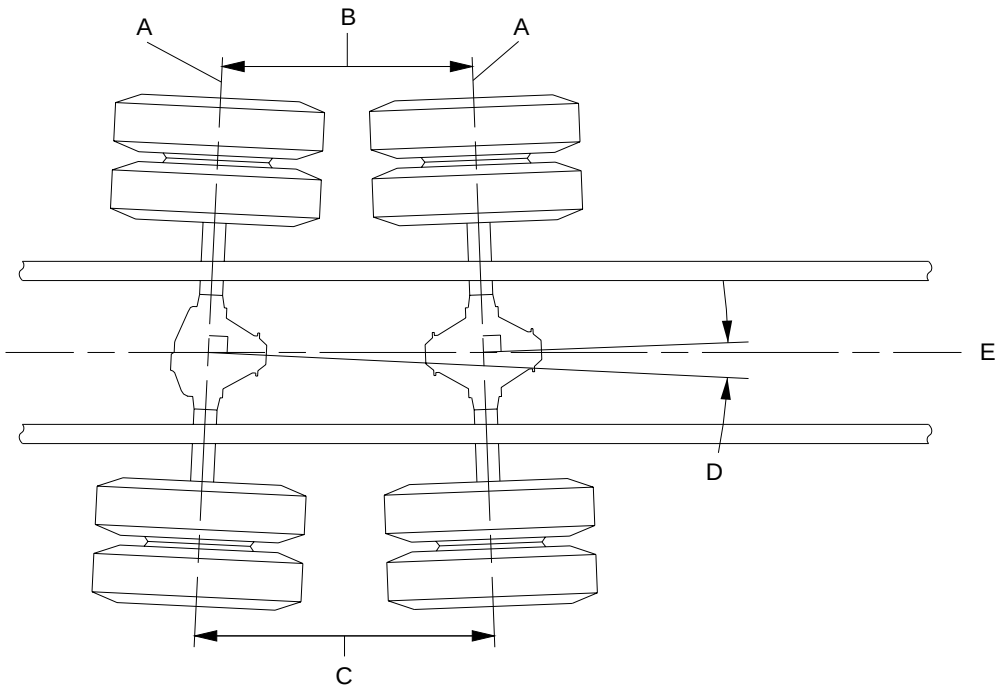
Follow the manufacturer's instructions for use of the alignment equipment, and use the alignment measurements given in **Fig. 1** and the applicable tables in **Specifications 400**.

## Checking Using the Manual Method

A straightedge and a center point bar are needed to manually align a tandem axle. For instructions for making a center point bar, see **Subject 130**.

IMPORTANT: For vehicle alignment to be accurate, the shop floor must be level in every direction.

1. Using the instructions in **Subject 110**, check and align the rearmost axle.
2. Using a center point bar, set the two points into the axle cap holes as shown in **Fig. 2**. Lock them in place by tightening the setscrews.
3. With the points still locked in place, move the center point bar to the other side of the vehicle, set the two points into the axle cap holes, and compare the axle spacing. If there is a difference




A. Axle Centerline
B. Left-Hand Axle End Spacing, Measured Manually or with Bee Line Alignment Tools
C. Right-Hand Axle End Spacing, Measured Manually or with Bee Line Alignment Tools
D. Maximum Tolerance as Measured with Hunter Alignment Tools = ±0.08 degree
E. Vehicle Centerline

**Fig. 1, Tandem Axle Measurements**

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## Alignment Checking, Tandem Axle

of 1/8 inch (3 mm) or less between the spacing on one side of the vehicle compared to the other, no further action is necessary. If the difference is more than 1/8 inch (3 mm), adjust the forward-rear axle alignment. See **Fig. 1**. For instructions, see **Group 32** in this manual, or the suspension manufacturer's service literature.

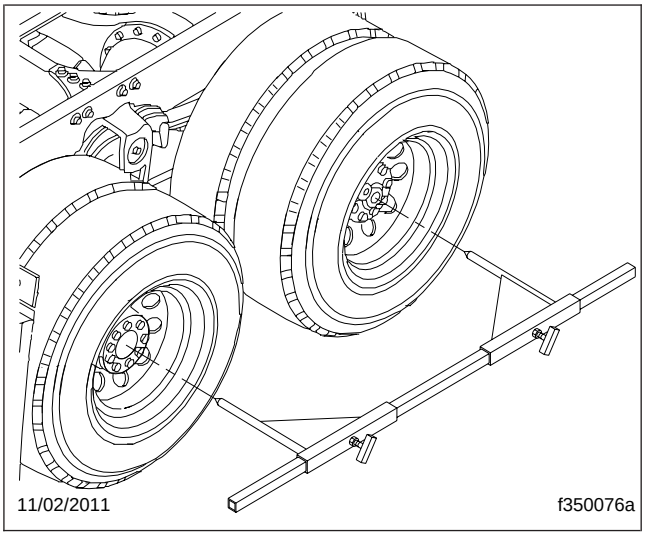



**Fig. 2, Center Point Bar Placement**

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## Center Point Bar Construction

## Materials Required

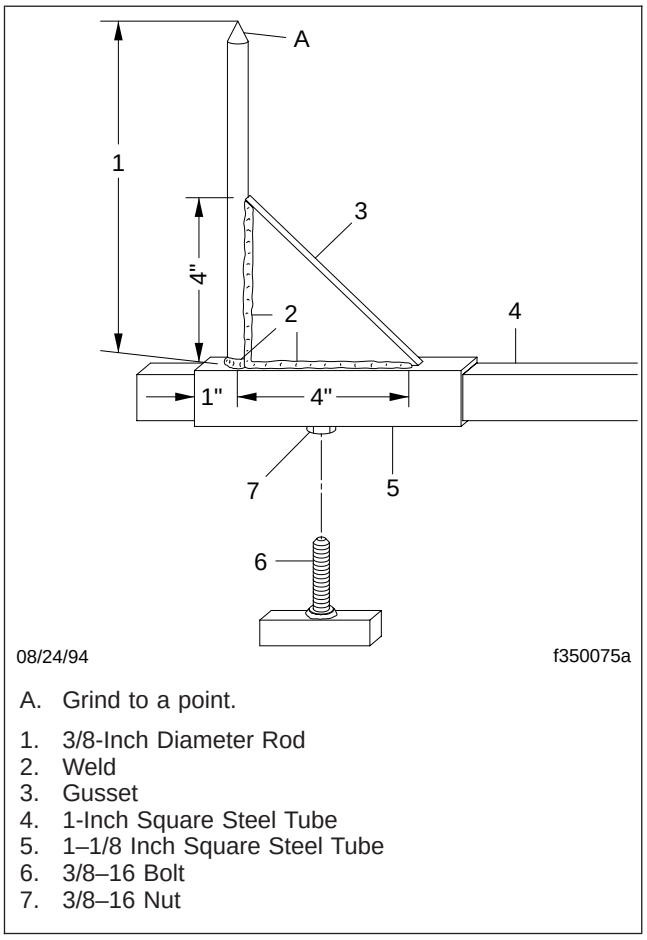
NOTE: To obtain metric conversions (millimeters), multiply the number of inches by 25.4.

The following materials are required:

- 62" of square steel tube (1" x 1", measured outside)
- 12" of square steel tube (1-1/8" x 1-1/8", measured inside)
- 20" of 3/8" steel rod
- two 1/2" x 3" pieces of steel square-bar stock
- one 4" x 4" steel plate, 1/8" thick
- two 3/8–16 capscrews (grade 5), 2" long
- two 3/8–16 hexnuts (equivalent to grade 5)

## Construction

1. Cut the 1-1/8 x 1-1/8 inch (inside measurement) square steel tube in half to obtain two pieces 6 inches long. These will be the sliding members (slides) of the center point bar.
2. Cut the 4-inch by 4-inch steel plate diagonally into two pieces (gussets). Weld one gusset to each slide, as shown in **Fig. 1**.
3. Cut the steel rod in half to obtain two 10-inch rods. Grind one end of each to form a point.
4. Weld the pointed steel rods to the slides and gussets, as shown in **Fig. 1**.
5. Drill a 1/2-inch hole in the center of each slide, on the side opposite where the pointer was welded. Drill through only one side of the tube.
6. Directly over each hole drilled in the step above, weld a 3/8–16 nut (equivalent to grade 5).
7. Weld a piece of steel stock, about 1/2-inch wide by 3-inches long, over the head of each of two 3/8–16 by 2-inch long capscrews.
8. Place a slide over each end of the 60-inch piece of steel tube, with the pointed rods to the outside. Screw the handscrews (made in the step above) into the slides until they are clamped tightly to the cross tube.




A. Grind to a point.

1. 3/8-Inch Diameter Rod
2. Weld
3. Gusset
4. 1-Inch Square Steel Tube
5. 1–1/8 Inch Square Steel Tube
6. 3/8–16 Bolt
7. 3/8–16 Nut

**Fig. 1, Center Point Bar Construction**

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## Specifications

| Maximum Tolerance from Perpendicular, Manual Method | |
|---|---|
| **Method** | **Maximum Tolerance ± from Perpendicular** |
| Manual | 1/4-inch (6 mm) |

**Table 1, Maximum Tolerance from Perpendicular, Manual Method**

| Maximum Tolerance from Perpendicular, Hunter Equipment | |
|---|---|
| **Method** | **Maximum Tolerance ± from Perpendicular** |
| Hunter* | 0.18 degree |

* To use Hunter alignment equipment, refer to the applicable Hunter service literature.

**Table 2, Maximum Tolerance from Perpendicular, Hunter Equipment**

| Maximum Tolerance from Perpendicular at Target, Bee Line Equipment | |
|---|---|
| **Distance from the Forward or Rear Drive Axle to Target: inches (mm)** | **Maximum Tolerance± from Perpendicular: inches (mm)** |
| 100 (2540) | 5/16 (8) |
| 120 (3048) | 3/8 (10) |
| 140 (3556) | 7/16 (11) |
| 160 (4064) | 1/2 (13) |
| 180 (4572) | 9/16 (14) |
| 200 (5080) | 5/8 (16) |
| 220 (5588) | 11/16 (17) |
| 240 (6096) | 3/4 (19) |
| 260 (6604) | 13/16 (21) |

**Table 3, Maximum Tolerance from Perpendicular at Target, Bee Line Equipment**

| Rear Axle Parallelism Specifications | |
|---|---|
| **Method** | **Maximum Tolerance** |
| Hunter | ±0.08 degree maximum axle-to-axle difference; reference "C" in **Fig. 1**. |

| Rear Axle Parallelism Specifications | |
|---|---|
| **Method** | **Maximum Tolerance** |
| Bee Line or Manual | ±1/8-inch max. difference in axle end-spacing; reference "B" minus "A" in **Fig. 1**. |

**Table 4, Rear Axle Parallelism Specifications**

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## Specifications

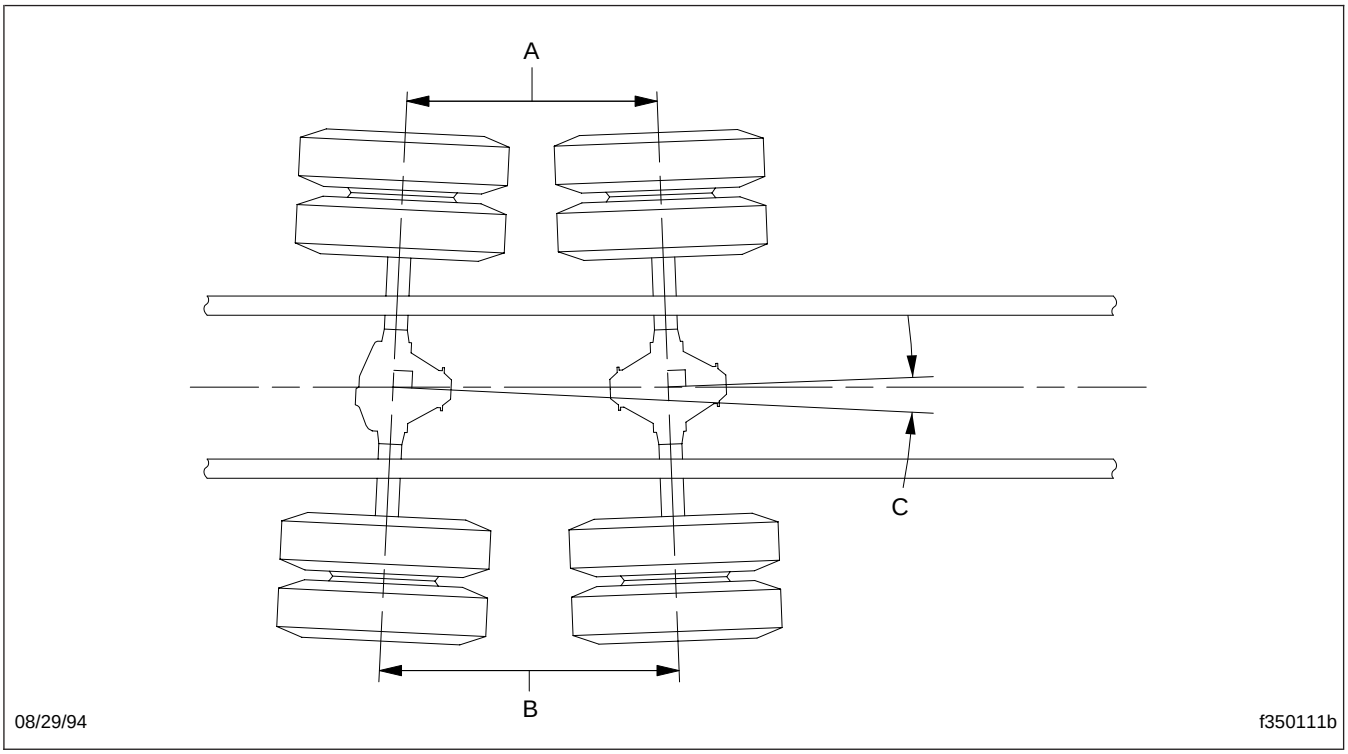



**Fig. 1, Tandem Axle Measurements**

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# General Information

A wheel end assembly consists of a wheel hub, wheel bearings, axle spindle, wheel studs, and brake drum or, for disc brakes, a rotor and caliper. See **Fig. 1** and **Fig. 2**. These vehicles are typically equipped with one of four different wheel end assemblies:

- A ConMet PreSet® hub and double spindle nut system.

  Vehicles equipped with PreSet hubs have the bearings and oil seal pre-installed. To install a new PreSet hub, mount it on the axle spindle, and secure it with a double spindle nut. For instructions, see **Subject 180**. A spacer between the inner and outer bearings adjusts the bearings to the correct end-play and preload when the retaining nut is tightened.

- A ConMet PreSet hub and Axilok® spindle nut.

  Some ConMet PreSet hubs use an Axilok nut (see **Subject 170**). As with ConMet PreSet hubs that use the double spindle nut, the bearings and oil seal are pre-installed and a spacer between the inner and outer bearings adjusts the bearings to the correct end-play and preload when the retaining nut is tightened.

- The traditional hub and bearings, and a double spindle nut system.

  With traditional wheel ends, the bearings and oil seal must be assembled with the hub when the hub is installed on the axle spindle. First the oil seal is placed on the spindle (some brands of oil seal are installed in the hub bore), then the inner bearing and the hub are mounted on the axle spindle. Then, the outer bearing is mounted in the hub bore. A nut is installed on the axle spindle end and tightened and loosened to adjust the bearings. Finally, locking device and jam nut are installed to secure the hub and bearings on the axle. For instructions, see **Subject 180**.

- The traditional hub and bearings, and a Pro-Torq® nut system.

  This system is the same as the above traditional hub and bearing system, but in place of the double spindle nut system, it has one adjusting nut and a lockring device. For instructions, see **Subject 190**.

## Tapered Wheel Bearings

A typical tapered wheel bearing assembly consists of a cone, tapered rollers, a roller cage, and a separate cup that is press-fit in the hub. See **Fig. 3**. All components carry the load, with the exception of the cage, which spaces the rollers around the cone.

Each hub has a set of inner and outer tapered wheel bearing assemblies. On traditional hub and bearing assemblies, the bearing setting is locked in place on the axle spindle (steering knuckle) by an adjusting nut, a locking device such as a lockring or nut-lock, and a jam nut, or a Pro-Torq nut. See **Fig. 2**.

## Drive Axle Spindle Assembly

The drive axle spindle assembly is made up of a drive axle flange and shaft, drive axle studs and stud nuts, a flange gasket, an axle spindle, an oil seal, and the locking assembly described above.

The surfaces of the spindle and the nut threads are machined. When these surfaces become damaged, repairs are necessary. There are standard methods for performing those repairs that preserve the proper alignment of the axle spindle assembly. Refer to the axle manufacturer for instructions.

**NOTICE**

**The National Highway Traffic Safety Administration (NHTSA) has warned against repairs that involve cutting off a portion of a damaged spindle and welding on a replacement part. The heat of welding can reduce the strength of spindles made with heat-treated materials and lead to spindle failure. After the cutting and welding operations, the replacement part may not be correctly aligned on the spindle. This can cause damage to the spindle nut.**

## Wheel Hub

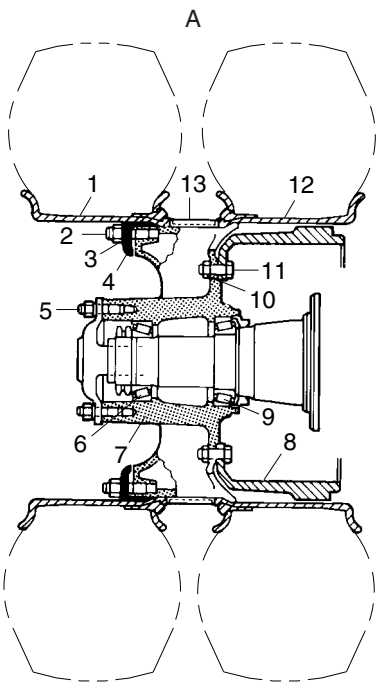
The inner disc wheel and/or brake drum is mounted on an aluminum or iron wheel hub (**Fig. 1**). Both the inner and outer bearing cups and certain types of wheel studs are press-fit in the hub. The hub is also the interconnecting point for the drive axle shaft and wheels.

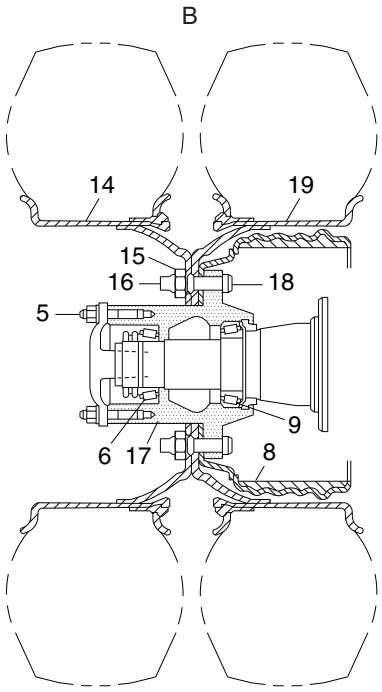
Each spoke wheel combines both wheel and hub into a single unit.

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## General Information




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A. Spoke Wheel and Brake Drum Assembly

B. Disc Wheel, Wheel Hub, and Brake Drum Assembly

1. Outer Rim
2. Rim Stud
3. Rim Stud Nut
4. Rim Clamp
5. Drive Axle Stud
6. Outer Wheel Bearing
7. Spoke Wheel
8. Brake Drum
9. Inner Wheel Bearing
10. Brake Drum Nut
11. Brake Drum Bolt
12. Inner Rim
13. Rim Spacer
14. Outer Wheel
15. Outer Wheel Nut
16. Inner Wheel Nut
17. Wheel Hub
18. Wheel Stud
19. Inner Wheel

**Fig. 1, Wheel Hub and Brake Drum Assembly**

# Brake Drum

The brake drum and lining work together as a mated friction pair, with the drum responsible for both heat absorption and dissipation. Lining performance and life largely depend on the condition of the drum and whether it can adequately absorb and dissipate heat generated by braking action.

The brake drum is mounted on the outboard face of the hub and fits over the wheel studs. See **Fig. 2**.

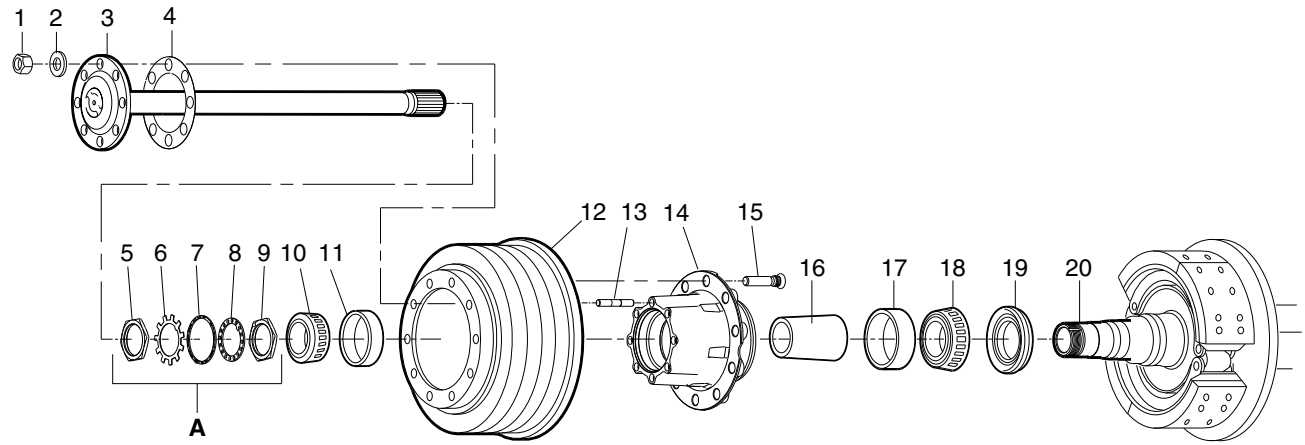
# Wheel Studs

A headed wheel stud (**Fig. 4**) is used on rear axle disc wheel hub assemblies and has either serrations on the stud body or a flat area on the stud's head to prevent the stud from turning in the wheel hub.

The end of the stud that faces away from the vehicle is stamped with an "L" or "R," depending on which side of the vehicle the stud is installed. Studs stamped with an "L" are left-hand threaded and are installed on the left side of the vehicle. Studs stamped with an "R" are right-hand threaded and are installed on the right side of the vehicle.

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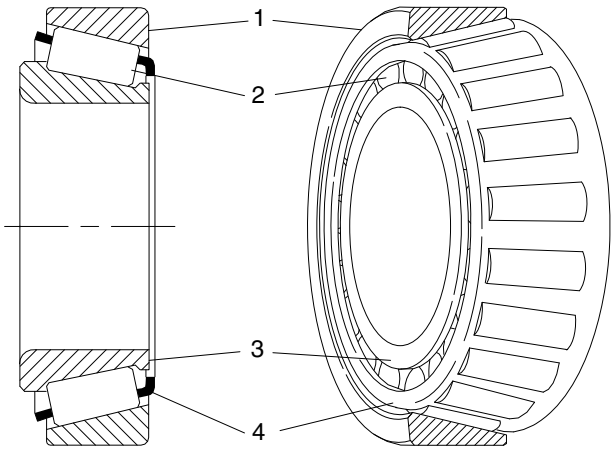

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NOTE: An ID ring and bearing spacer are used with ConMet PreSet hubs only.

A. Double spindle nut set shown; Axilok or Pro-Torq spindle nuts could be used on some installations.

1. Drive Axle Stud Nut
2. Washer
3. Drive Axle Shaft
4. Gasket
5. Jam Nut
6. Bend-Type Locking Washer
7. ID Ring
8. Lockring
9. Adjusting Nut
10. Outer Wheel Bearing
11. Outer Wheel Bearing Cup
12. Brake Drum
13. Drive Axle Stud
14. ConMet PreSet Hub
15. Wheel Stud
16. Bearing Spacer
17. Inner Wheel Bearing Cup
18. Inner Wheel Bearing
19. Oil Seal
20. Axle Spindle

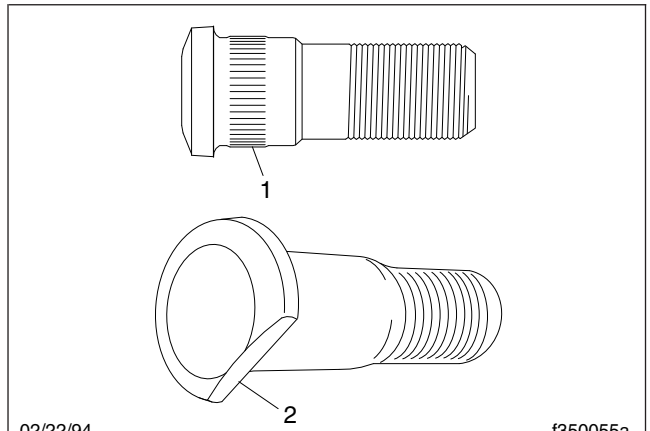
**Fig. 2, Typical Wheel End Assembly, Drive Axle with Drum Brakes**




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1. Cup
2. Tapered Roller
3. Cone
4. Roller Cage

**Fig. 3, Tapered Wheel Bearing Assembly**




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1. Serrations
2. Clipped Head

**Fig. 4, Typical Headed Wheel Studs**

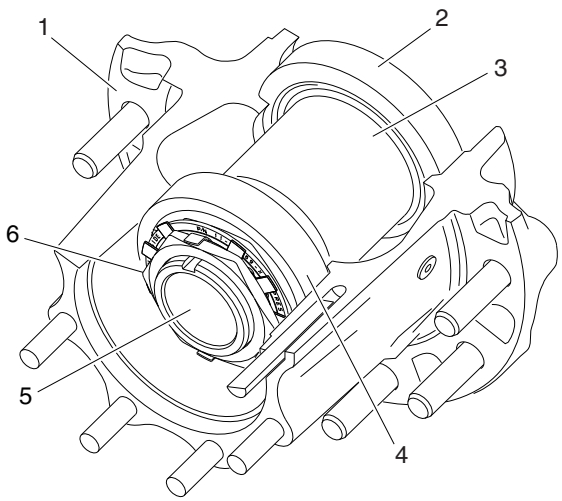
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## Hub Assembly Removal and Installation

# General Information

ConMet PreSet® hubs are equipped with a unique bearing spacer between special inner and outer bearings. See **Fig. 1.**




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1. Hub
2. Inner Bearing
3. Bearing Spacer
4. Outer Bearing
5. Axle Spindle
6. Retaining Nut (double spindle nut system)

**Fig. 1, ConMet PreSet Hub, Cut-Away View**

When installing a PreSet hub with the spacer and special PreSet bearings, the correct end play is set automatically and wheel bearing adjustment is unnecessary.

For vehicles equipped with ConMet PreSet hubs, it is highly recommended to **stay with the PreSet system** to optimize bearing and seal life. However, if you are replacing the bearings for a PreSet hub, and the special PreSet bearings are not available, standard wheel bearings can be used. In this case, the bearing spacer must be removed and the bearings adjusted manually. See the installation instructions for more information.

# Removal

For typical wheel end and axle assemblies, see **Fig. 2** and **Fig. 3**.

1. Shut down the engine and chock the front tires. Release the parking brakes.
2. Raise the rear of the vehicle until the tires clear the ground. Then place safety stands under the axle.
3. For drum brakes, back off the slack adjuster to release the rear axle brake shoes.

**⚠ WARNING**

**Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.**

4. Remove both wheel and tire assemblies. For instructions, see **Group 40**.
5. For drum brakes, remove the brake drum. See **Subject 110** for instructions.

   For disc brakes, remove the brake caliper. See **Section 42.24** for instructions.

NOTE: Oil will spill as the drive axle shaft (or hub cap) and the wheel hub are removed. Place a suitable container under the drive axle flange or hub cap to catch any spilled oil. Dispose of the oil properly.

6. Remove the drive axle stud nuts and washers. See **Fig. 4**.

**NOTICE**

**When tapping the drive axle flange, avoid striking the drive axle studs. If struck, the studs may bend or break, or the stud threads can be damaged. Replace damaged studs.**

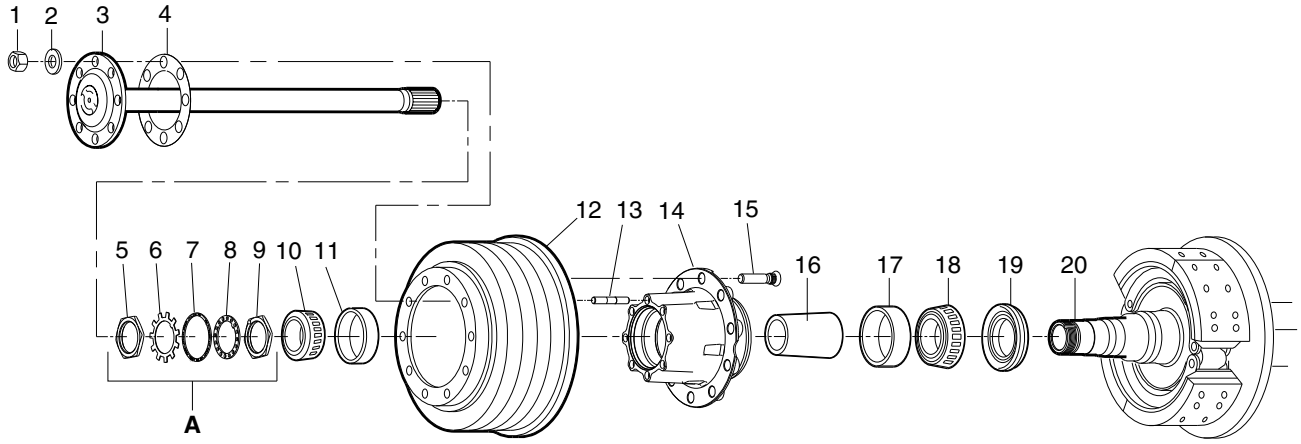
7. Using a hammer and a soft drift, such as one made of brass, sharply tap the center portion of the drive axle flange. The shaft will usually spring slightly outward after the seal has broken.

NOTE: Even if the drive axle shaft doesn't spring outward, the seal may have loosened enough to allow the shaft to be pulled from the axle housing. If the seal has not broken, repeat the step above.

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## Hub Assembly Removal and Installation




NOTE: An ID ring and bearing spacer are used with ConMet PreSet hubs only.

A. Double spindle nut set shown. Axilok or Pro-Torq spindle nuts could be used on some installations.

1. Drive Axle Stud Nut
2. Washer
3. Drive Axle Shaft
4. Gasket
5. Jam Nut
6. Bend-Type Locking Washer
7. ID Ring
8. Lockring
9. Adjusting Nut
10. Outer Wheel Bearing
11. Outer Wheel Bearing Cup
12. Brake Drum
13. Drive Axle Stud
14. ConMet PreSet Hub
15. Wheel Stud
16. Bearing Spacer
17. Inner Wheel Bearing Cup
18. Inner Wheel Bearing
19. Oil Seal
20. Axle Spindle

**Fig. 2, Typical Wheel End Assembly, Drive Axle with Drum Brakes**

8. If so equipped, remove the tapered dowels and washers from the drive axle flange.
9. Remove the drive axle shaft.
10. Remove and discard the gasket.
11. Remove the wheel bearing locking device:
    - For an Axilok spindle nut, see **Subject 170**; then go to the next step.
    - For a Pro-Torq spindle nut, see **Subject 190**; then go to the next step.
    - If the axle is equipped with a double spindle nut system, see **Subject 180**; then go to the next step.

### NOTICE

**Be careful not to let the outer wheel bearing drop from the axle spindle. Dropping the bearing can warp the cage or damage the rollers, ruining the bearing. On vehicles equipped with WABCO ABS, use care when working with the hubs. To prevent damage to the tone wheel, do not drop the hub, or lay it down in a way that would damage the tone wheel.**

12. Move the hub about ½ inch (13 mm) to jar loose the outer wheel bearing (allow the hub-only assembly to rest on the axle spindle; be careful not to damage the axle spindle threads).
13. Carefully remove the outer wheel bearing; handle the bearings with clean, dry hands. Wrap the bearings in either clean oil-proof paper or lint-free rags.

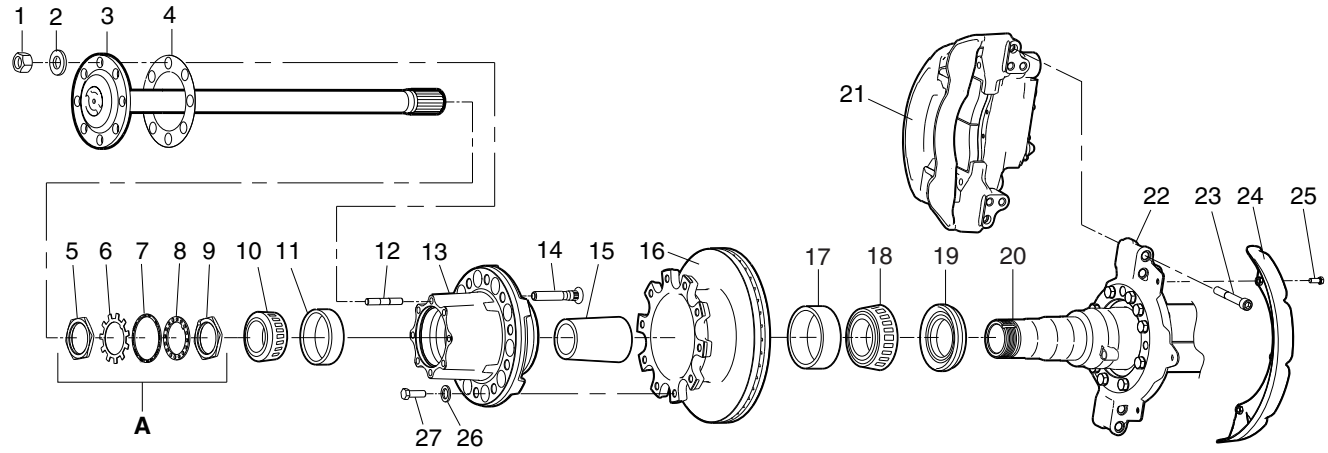
### NOTICE

**Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.**

14. Remove the hub. Be careful not to damage the axle spindle threads as the assembly is removed.
15. Remove the inner wheel bearing. Handle the bearings with clean, dry hands, then wrap the

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NOTE: An ID ring and bearing spacer are used with ConMet PreSet hubs only.

A. Double spindle nut set shown. Axilok or Pro-Torq spindle nuts could be used on some installations.

1. Drive Axle Stud Nut
2. Washer
3. Drive Axle Shaft
4. Gasket
5. Jam Nut
6. Bend-Type Locking Washer
7. ID Ring
8. Lockring
9. Adjusting Nut
10. Outer Wheel Bearing
11. Outer Wheel Bearing Cup
12. Drive Axle Stud
13. ConMet PreSet Hub
14. Wheel Stud
15. Bearing Spacer
16. Brake Rotor
17. Inner Wheel Bearing Cup
18. Inner Wheel Bearing
19. Oil Seal
20. Axle Spindle
21. Brake Caliper
22. Anchor Plate
23. Caliper Mounting Capscrew
24. Rotor Shield
25. Rotor Shield Capscrew
26. Washer
27. Capscrew

**Fig. 3, Typical Wheel End Assembly, Drive Axle with Disc Brakes**

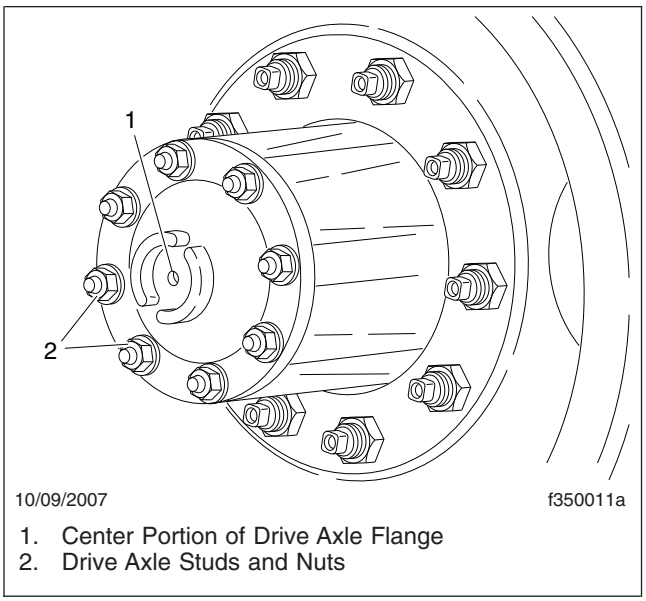
bearings in either clean oil-proof paper or lint-free rags. If the inner wheel bearing remains in the hub after the hub is removed from the axle, place a protective cushion where it will catch the bearings, then use a hardwood drift and a light hammer to gently tap the bearing (and seal, if necessary) out of the cup.

16. Remove the oil seal from the axle spindle, if not already removed. See **Section 35.02** for oil seal removal instructions.

NOTE: For vehicles equipped with disc brakes, instructions for removing the rotor from the hub are given in **Section 42.24**.

## Installation

For typical wheel end and axle assemblies, see **Fig. 2** and **Fig. 3**.




1. Center Portion of Drive Axle Flange
2. Drive Axle Studs and Nuts

**Fig. 4, Wheel Assembly and Hub**

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## Hub Assembly Removal and Installation

NOTE: For vehicles equipped with disc brakes, instructions for installing the rotor to the hub are given in **Section 42.24**.

1. Using cleaning solvent, remove the old oil from the axle spindle and the disassembled parts. Allow the parts to dry, or dry them with clean, absorbent, and lint-free cloth or paper. Wrap a protective layer of friction tape on the axle spindle threads.

   For PreSet hubs that are being reused, the bearing spacer must be replaced.

2. Coat both bearing assemblies with fresh oil. Then install the inner wheel bearing and oil seal. Handle the bearings with clean, dry hands. See **Section 35.02** for oil seal installation instructions.

### NOTICE

**Use only fresh oil on the bearing assemblies; old oil could be contaminated with dirt or water (both are corrosives) and could cause damage to both wheel bearing assemblies and the wheel hub.**

3. Wipe a film of axle oil on the axle spindle to prevent rust from forming behind the inner wheel bearing. Do not lubricate the seal journal.

### NOTICE

**Do not use the bearing spacer with standard wheel bearings. To do so may result in too much bearing end-play, which could damage the wheel bearings, oil seals, the axle spindle, and the hub.**

4. If using PreSet bearings, ensure the tubular spacer is in the PreSet hub.

   If replacing PreSet bearings with non-PreSet bearings, remove the tubular spacer from inside the hub. Save it for future use to convert the hub back to the PreSet system.

### NOTICE

**When installing a hub, remember the following:**

- **On vehicles equipped with WABCO ABS, use care when installing the hubs. To prevent damage to the tone wheel, do not drop the hub or lay it down in a way that would damage the tone wheel.**
- **Do not remove the outer wheel bearing once the hub is installed on the axle. Removing the outer bearing could cause the oil seal to become misaligned, which could cause damage to the wheel bearings, the hub, and the axle spindle.**

NOTE: A temporary plastic alignment sleeve may be installed in the center of a new hub. It will be pushed out when the hub is installed on the axle spindle. If it is present, remove and discard this sleeve.

5. Mount the bearings and hub on the spindle.
6. Remove the friction tape, then adjust and secure the bearings:
   - For an Axilok spindle nut, see **Subject 170**; then go to the next step.
   - For a Pro-Torq spindle nut, see **Subject 190**; then go to the next step.
   - If the axle is equipped with a double spindle nut system, see **Subject 180**; then go to the next step.
7. Install a new gasket, and the drive axle shaft or, on non-drive axles, the hub cap. The splined end of the axle shaft must seat before the drive axle flange will fit over the studs.
8. If equipped, install the dowels and washers on the drive axle studs. Install the drive axle stud nuts. Using the sequence shown in **Fig. 5**, tighten the nuts to the torque values given in the table in **Specifications, 400**.
9. For drum brakes, install the brake drum on the wheel hub. See **Subject 110** for instructions.

   For disc brakes, install the brake caliper. See **Section 42.24** for instructions.

### ⚠ WARNING

**If the wheel nuts cannot be tightened to minimum torque values, the wheel studs have lost their locking ability, and the hub flange is probably damaged. In this case, replace it with a new wheel hub assembly. Failure to replace the wheel hub assembly when the conditions described above exist, could result in the loss of a wheel or loss of vehicle control, and possible personal injury and property damage.**

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10. Install the inner and outer wheel and tire assemblies. For instructions, see **Group 40**.

**⚠ WARNING**

**Add oil to the axle housing bowl or the wheel hub after the drive axle shaft and wheel hub have been serviced. Failure to add oil will damage the wheel bearings and cause them to seize during vehicle operation. Seized bearing rollers can cause sudden damage to the tire or axle, possibly resulting in personal injury.**

11. Lubricate the wheel bearings, as follows.
    - For drive axles, see **Subject 210**.
    - For non-drive axles, add about 1 to 1-1/2 pints (0.5 to 0.7 liter) of oil to the level shown on the hub cap. Do not overfill. Install the vent plug or threaded filler plug.
12. Adjust the rear axle brakes. For instructions, see **Group 42**.
13. Remove the safety stands from under the axle, then lower the vehicle.

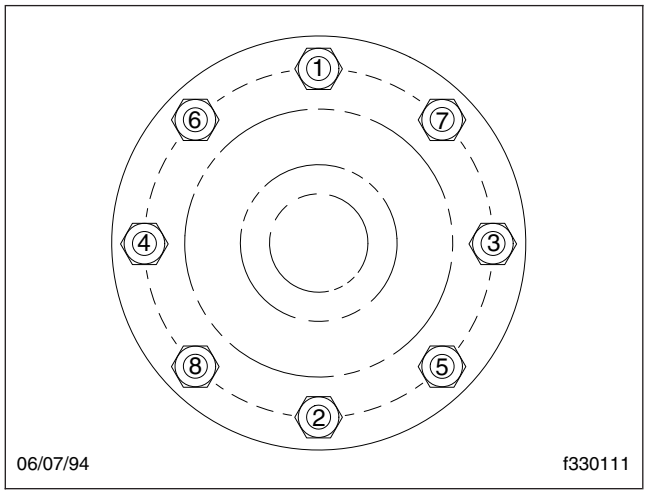



**Fig. 5, Tightening Sequence, Drive Axle Stud Nuts**

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# Outboard-Mounted Drum Removal and Installation

**⚠ WARNING**

**When replacing brake pads, shoes, rotors, or drums, always replace components as an axle set.**

- **Always reline both sets of brakes on an axle at the same time.**
- **Always replace both rotors/drums on an axle at the same time.**
- **Always install the same type of linings/pads or drums/rotors on both axle ends of a single axle, and all four axle ends of a tandem axle, at the same time. Do not mix component types.**

**Failure to do so could cause uneven braking and loss of vehicle control, resulting in property damage, personal injury, or death.**

## Removal

1. Park the vehicle, shut down the engine, apply the parking brakes and chock the front tires.
2. Raise the rear of the vehicle until the tires clear the ground. Then place safety stands under the axle.
3. Back off the slack adjuster to release the rear axle brake shoes.

**⚠ WARNING**

**Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH. Wear a respirator at all times when servicing the brakes, starting with removal of the wheels and continuing through assembly.**

4. Remove the wheel and tire assembly. See **Group 40** for instructions.

   To minimize the possibility of creating airborne brake lining dust, clean the dust from the brake drum, brake backing plate, and brake assembly, using an industrial-type vacuum cleaner equipped with a high-efficiency filter system. Then, using a rag soaked in water and wrung until nearly dry, remove any remaining dust.

   Don't use compressed air or dry brushing to clean the brake assembly.
5. Remove the brake drum.

## Installation

1. Install the brake drum on the wheel hub.

   1.1 On hub-piloted drums, position the brake drum on the top step of the pilot pad. One of the hub's pilot pads should be at the twelve o'clock (top center) position. See **Fig. 1**.

   IMPORTANT: If the drum is not positioned correctly, the pilot pad could be damaged when the wheel nuts are torqued.

   1.2 Make sure that the pilot pads securely center the drum (space between drum and hub is equal all around the hub).

   IMPORTANT: If damage to the pads prevents the drum from centering, replace the hub. If necessary to hold the drum in position, adjust the brakes before installing the wheels.
2. Install the wheel and tire assembly. To ensure that the drum does not slip off the pilot pad, follow the correct nut tightening sequence. For instructions, see **Group 40**.

**⚠ WARNING**

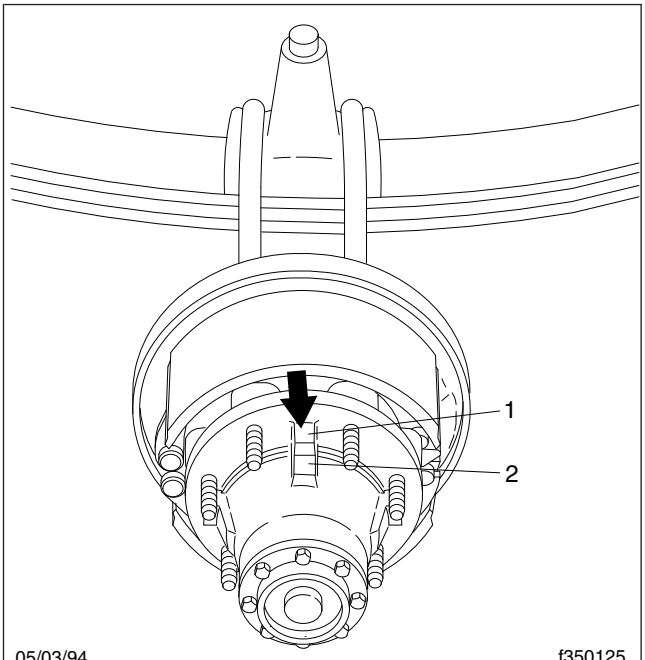
**If the wheel nuts cannot be tightened to minimum torque values, the wheel studs have lost their locking ability, and the hub flange is probably damaged. In this case, replace it with a new wheel hub assembly. Failure to replace the wheel hub assembly when the conditions described above exist, could result in the loss of a wheel or loss of vehicle control, and possible personal injury.**

3. Adjust the rear axle brakes. Refer to the brake section in the vehicle maintenance manual.
4. Remove the safety stands from under the axle; lower the vehicle.
5. Remove the chocks from the tires.

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## Outboard-Mounted Drum Removal and Installation




NOTE: Pilot pad at 12 o'clock position

1. Drum Pilot
2. Wheel Pilot

**Fig. 1, Hub Pilot Pads**

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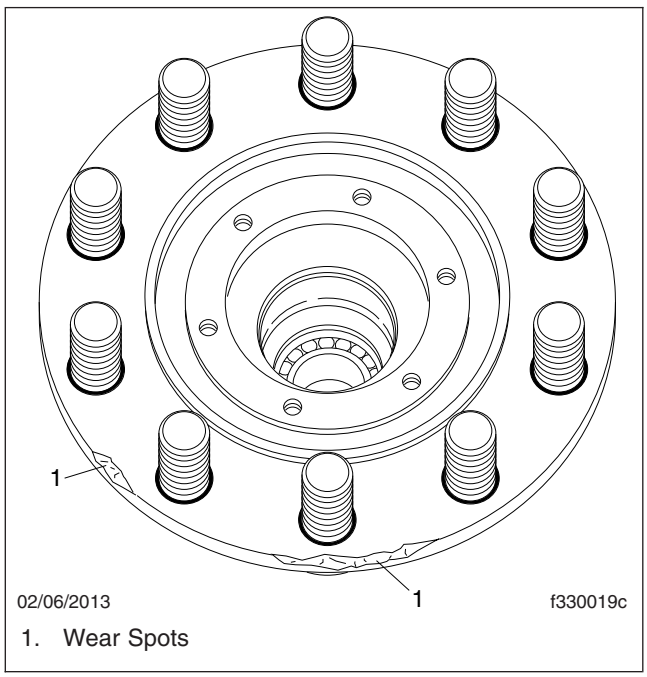
## Wheel Hub Assembly Inspection

1. Inspect the wheel hub mounting flange. A loose wheel assembly will cause the flange to be worn, jagged, or warped. See **Fig. 1**. Replace the wheel hub if any of these conditions exist.

   Inspect the flange surface around the wheel studs. Improperly torqued wheel nuts will cause worn or cracked stud grooves on the hub. See **Fig. 2**. If wear spots or cracks appear anywhere on the hub, or if the hub is otherwise damaged, replace it with a new one.

2. Remove all the old oil from the wheel hub cavity. Inspect the inner surface of the hub for cracks, dents, wear, or other damage. Replace the wheel hub if damage exists.

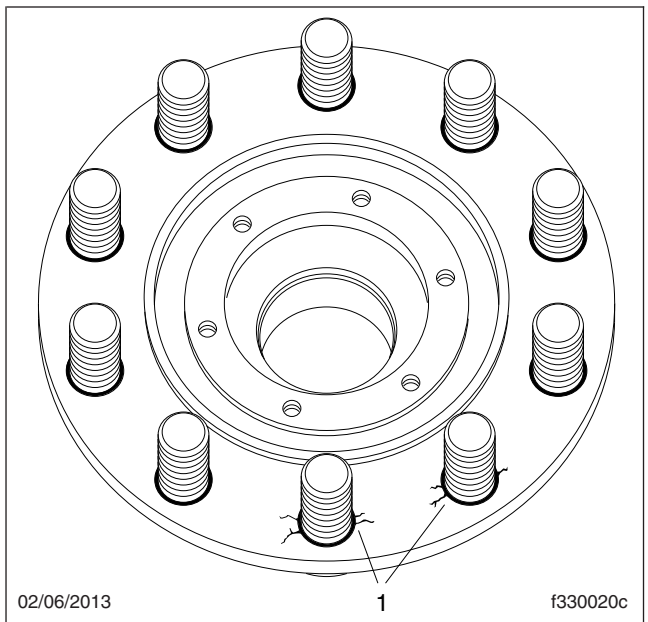
3. Remove all the old grease or oil from the surfaces of the wheel bearing cups. Inspect the wheel bearing cups for cracks, wear, spalling, or flaking. See **Fig. 3**. Replace the cups if damaged in any way. See **Subject 130** or **Subject 140**.




1. Wear Spots

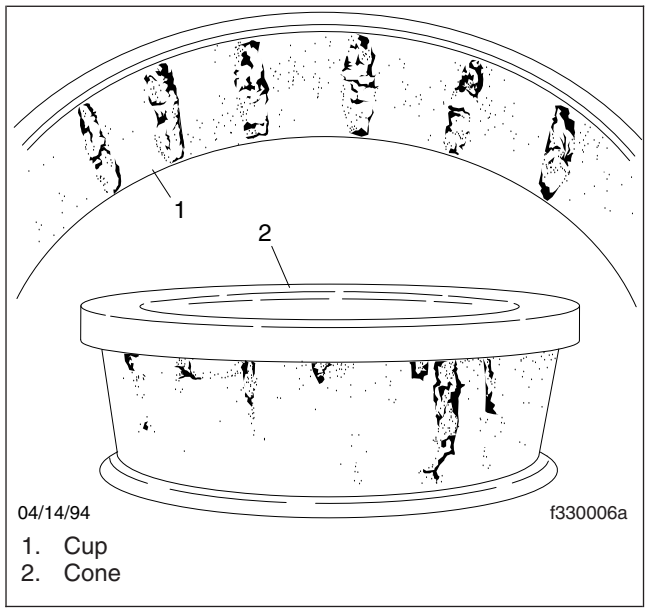
**Fig. 1, Damaged Front Axle Wheel Hub**

4. Inspect the wheel nuts on disc wheel installations, or the rim nuts on spoke-wheel installations. Damaged nuts (**Fig. 4**), usually caused by inadequate tightening, must be replaced with new ones.




1. Cracked Stud Grooves

**Fig. 2, Damaged Front Axle Wheel Hub**




1. Cup
2. Cone

**Fig. 3, Spalling (Flaking) of Wheel Bearing Assembly**

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## Axle Components Cleaning and Inspection

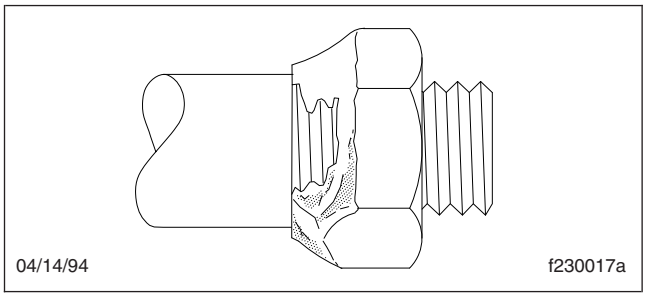



**Fig. 4, Damaged Wheel Stud Nut**

5. Inspect the wheel or rim studs. Replace studs that are stripped, broken, bent, or otherwise damaged. See **Subject 150** or **Subject 160**.

# Wheel Bearing Inspection

Wheel bearings should be very closely inspected at the time of disassembly. Optimal inspection conditions are possible only after the bearings have been thoroughly cleaned using nonflammable solvent and a stiff brush. Before inspecting, clean the bearings.

1. Remove the wheel hub and bearing cones. Refer to **Subject 100**.
2. Using nonflammable solvent and a stiff brush, clean all the oil from the bearings and hub cavity. Do not use gasoline or heated solvent.
3. Allow the cleaned parts to dry, or dry them with a clean absorbent cloth or paper. Clean and dry your hands and all tools used in the maintenance operation. Oil will not stick to a surface which is wet with kerosene or diesel fuel, and the kerosene or diesel fuel may dilute the lubricant.

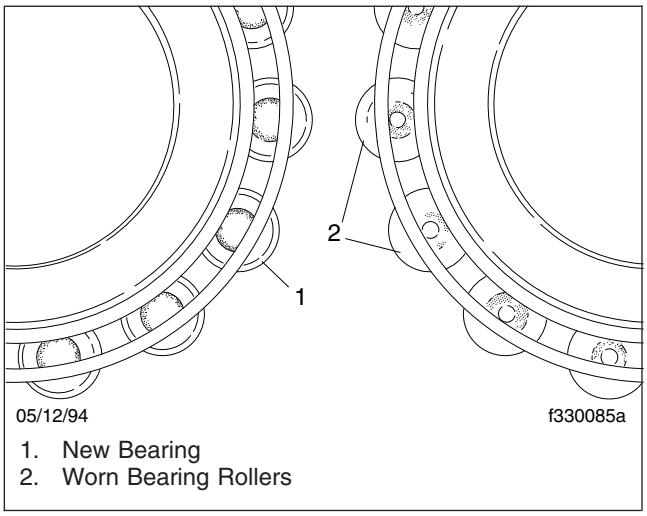
## NOTICE

**Do not spin the bearing rollers at any time. Dirt or grit can scratch the roller surface and cause premature wear of the bearing assembly. Treat a used bearing as carefully as a new one.**

4. After the bearings are cleaned, inspect the assemblies, which include the rollers, cones, cups, and cages. If any of the following conditions exist, replace the bearing assemblies:

   4.1 Large ends of rollers worn flush to the recess, or radii at the large ends of the rollers worn sharp. These are indications of advanced wear. See **Fig. 5**.

   4.2 Visible step wear, particularly at the small end of the roller track. Deep indentations, cracks, or breaks in the cone surfaces. See **Fig. 6**.




1. New Bearing
2. Worn Bearing Rollers

**Fig. 5, Wheel Bearing Roller Wear**

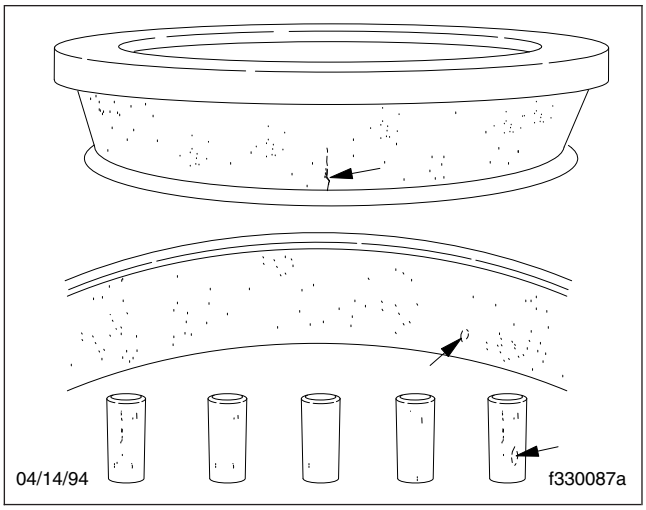



**Fig. 6, Indentations, Cracks, or Breaks in Bearing Surfaces**

   4.3 Bright rubbing marks on the dark phosphate surfaces of the bearing cage. See **Fig. 7**.

   4.4 Water etch on any bearing surface. Water etch appears as gray or black stains on the steel surface, and it greatly weakens

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the affected area. If water etch is present, replace the bearing seals.

4.5 Etching or pitting on functioning surfaces. See **Fig. 8**.

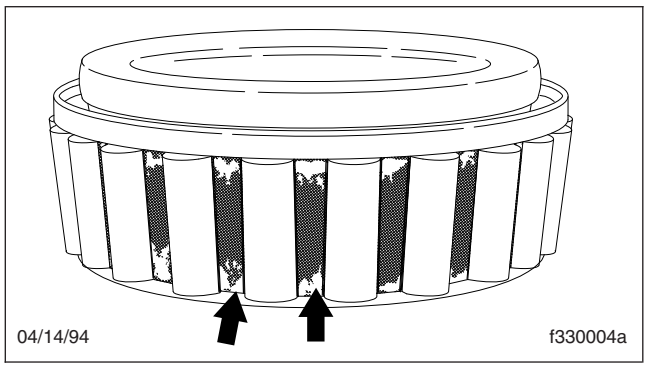



**Fig. 7, Rubbing Marks on Bearing Cage**

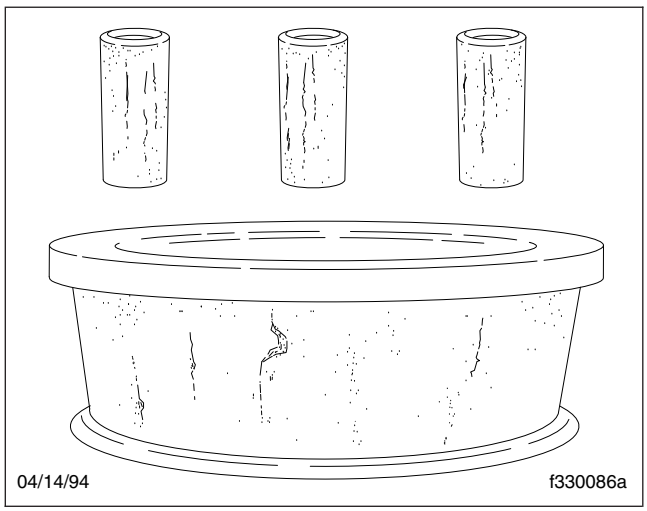



**Fig. 8, Etching (Pitting) on Bearing Surfaces**

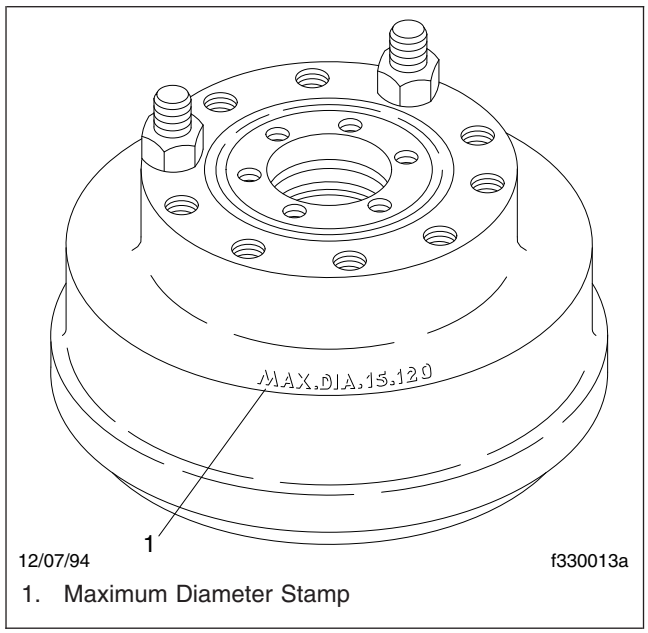
4.6 Spalling (flaking) of the bearing cup, roller, or cone surfaces. See **Fig. 3**.

After inspection, brush the bearings with fresh axle lubricant.

## Brake Drum Inspection

New brake drums are purposely undersized to allow for turning (remachining), since in mounting drums on the hub, there can be some eccentricity. If a new drum is installed, the protective coating on the inner friction surface must be removed with a solvent, prior to drum installation, then rinsed with a hot water wash. Use a clean rag to remove any oily residue or metal chips from the friction surface.

If a drum must be turned or replaced, the other same-axle drum must be similarly turned or replaced to provide the same braking power on both wheels. Turned drums should not exceed the maximum allowable diameter, which is stamped on the outside surface of the drum. See **Fig. 9** for a typical location of this stamp.




1. Maximum Diameter Stamp

**Fig. 9, Outboard Mounted Hub and Drum Assembly**

NOTE: Drums that have been turned should then be cleaned by using fine emery cloth followed with a hot water wash. Drums that have been renewed using emery cloth should also be followed with a hot water wash.

### NOTICE

**Failure to replace drums when worn or turned to limits exceeding the maximum allowable diameter will result in drum weakness and reduced braking capacity, which can lead to distortion, higher drum temperatures, and ultimately, drum breakage.**

If the drums are turned or replaced, replace the brake linings. See **Group 42** in this manual for instructions.

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## Axle Components Cleaning and Inspection

1. Inspect the inner friction surface. If a veneered (highly glossed) or glazed surface exists, renew the drum by using 80-grit emery cloth or by turning the drums.
2. Inspect for heat checking, which is a form of buckling (cracking) resulting from a temperature differential in the drum wall between a relatively cool exterior and a hot friction surface. Heat checking is normal on all drums and may not impair performance and lining life if the network of fine hairline cracks remains small. Examine heat checks of drums frequently to be certain the checks have not widened into drum weakening cracks (substantial cracks extending to the open edge of the drum). Replace the same-axle drums if substantial cracks are present, or if widening of the fine hairline cracks occurs.

NOTE: If normal heat checking as described above is present, inspect the drums at least every 12,000 miles (19 300 km) thereafter. Inspect the drums (using a flashlight from the inboard side of the wheels) every 6000 miles (9700 km). Inspect more often under adverse operating conditions.

3. Check for a contaminated inner friction surface. If fluids are present, such as oil or grease, remove the contaminants. Locate and correct the source of the contamination. If the brake drums are contaminated with fluids, the brake linings will also be affected. Since oil or grease saturated linings cannot be salvaged, they must be replaced. For brake lining replacement procedures, see **Group 42**.

**⚠ WARNING**

**If the brake drums are contaminated with fluids, replace the brake linings. Failure to replace fluid contaminated brake linings could result in a partial loss of braking capacity, which could lead to personal injury or property damage.**

4. Measure the inside diameter of the drum. If the measured diameter is greater than the maximum allowable diameter, replace the same-axle drums and linings.
5. Ensure the roundness of the drum is within acceptable limits, as follows. Set the measuring tip of a dial indicator against the working surface of the drum between the brake shoes as far outboard as possible. Zero the gauge, then turn the drum one revolution and note the highest and lowest measurements.

   If the difference is 0.010 inch (0.25 mm) or less, proceed to the next step. If the difference is more than 0.010 inch (0.25 mm), mark the drum and hub to record their relative positions, and remove the drum. Clean the mating surfaces of the hub and drum, and re-install the drum rotated 90 degrees from its earlier position. Tighten four wheel nuts 50 lbf·ft (68 N·m), and repeat the measurement. If the difference is more than 0.010 inch (0.25 mm), the drum is out of round beyond acceptable limits and all drums on the axle must be re-machined or replaced.
6. Inspect the outside surface of the drum. Remove any accumulation of mud, dirt, or rust; foreign matter acts as an insulator, trapping heat within the drum.
7. Check for hard, slightly raised dark-colored spots on the inner friction surface or for a bluish cast on the brake parts, both of which are caused by high temperatures. If the drums' maximum allowable diameters have not been exceeded, remachine both same-axle drums. If the spots or discoloration cannot be removed, or if remachining is not possible, replace the drums. Also replace the brake shoe return springs.

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# Wheel Bearing Cup Removal and Installation, Aluminum Hubs

## Removal

To insure a tight fit, wheel bearing cups are purposely larger than the wheel hub bores they occupy. To remove the bearing cups, aluminum hub bores must be temporarily expanded by heating the hub in an oven (the bearing cups will also expand, but to a considerably lesser extent). If adequate heating facilities are not available, replace the hub, wheel stud, and bearing cup assembly.

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly.
2. Oven-heat the hub to a temperature range of 240 to 280°F (116 to 138°C). Make sure the oven thermostat is accurately set; if unsure, use an oven thermometer to check the temperature of the oven before placing the hub inside.

   If adequate heating facilities are not available, replace the hub, wheel stud, and bearing cup assembly.

**⚠ WARNING**

**Do not use oxyacetylene equipment or similar equipment to heat the hub. Oxyacetylene equipment or similar equipment will cause cracks in the hub which could cause loss of a wheel and loss of vehicle control, leading to personal injury or property damage.**

3. Wearing heavy protective gloves, remove the hub from the oven. Place the hub on a suitable press so that the base is fully supported. Quickly press out the bearing cups.

## Installation

To install the bearing cups, aluminum hubs must again be temporarily expanded using oven heating. When the hub is properly heated, the bearing cup and hub can be press-fit together, using a suitable press.

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly, including the bearing cup bores.
2. Inspect the bearing cup bores of the hub for warpage or uneven surfaces. If a bearing cup bore is damaged, replace the wheel hub assembly.
3. Oven-heat the hub to a temperature range of 240 to 280°F (116 to 138°C). Make sure the oven thermostat is accurately set; if unsure, use an oven thermometer to check the temperature of the oven before placing the hub inside.

**⚠ WARNING**

**Do not use oxyacetylene equipment or similar equipment to heat the hub. Oxyacetylene equipment or similar equipment will cause cracks in the hub which could cause loss of a wheel and loss of vehicle control, leading to personal injury or property damage.**

4. Coat the replacement bearing cup hub contact surface with a film of grease.
5. Wearing heavy protective gloves, remove the hub from the oven.
6. Place the hub on a suitable press so that the base is fully supported. Quickly press-fit the bearing cup into the wheel hub until it is completely and evenly seated. Be careful not to shave the sides of the bearing cup bore as the bearing cup is seated. The accumulation of debris will prevent the cup from being seated and will also cause permanent damage to the wheel hub. If the sides of the bearing cup bore are damaged during installation, replace the wheel hub assembly.
7. Allow the wheel hub to cool before handling. Then, using a 0.0015-inch feeler gauge, check at several places for the seating of the bearing cup in the bearing cup bore. The gauge should not enter beneath the cup. If it does, there is probably dirt or debris preventing the cup from seating. Using the instructions above, remove the cup, then remove the foreign matter. Reinstall the cup.
8. Wipe off the accumulation of grease left after the bearing cup has been seated. Then, using a clean, lint-free cloth dampened with kerosene or diesel fuel oil, clean the inner surface of the bearing cup. Wipe the surface dry using a clean, absorbent, and lint-free cloth or paper.

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# Wheel Bearing Cup Removal and Installation, Ferrous Hubs

## Removal

Wheel bearing cups on ferrous hubs are removed and installed by driving them out and pressing them in without heating the hub.

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly.
2. Using a mild-steel rod through the opposite end of the hub, drive against the inner edge of the bearing cup. Alternately drive on opposite sides of the cup to avoid cocking the cup and damaging the inside of the hub.

## Installation

1. Using a solvent, completely remove all grease, oil, and other debris from the outer and inner surfaces of the wheel hub assembly, including the bearing cup bores.
2. Inspect the bearing cup bores of the hub for warpage or uneven surfaces. If a bearing cup bore is damaged, replace the wheel hub assembly.
3. Coat the replacement bearing cup hub contact surface with a film of grease.
4. Position the cup in the hub and press it into place, using a suitable driving tool. Cups must seat against the shoulder in the hub.
5. Wipe off the accumulation of grease left after the bearing cup has been seated. Then, using a clean lint-free cloth dampened with kerosene or diesel fuel oil, clean the inner surface of the bearing cup. Wipe the surface dry using a clean, absorbent, and lint-free cloth or paper.

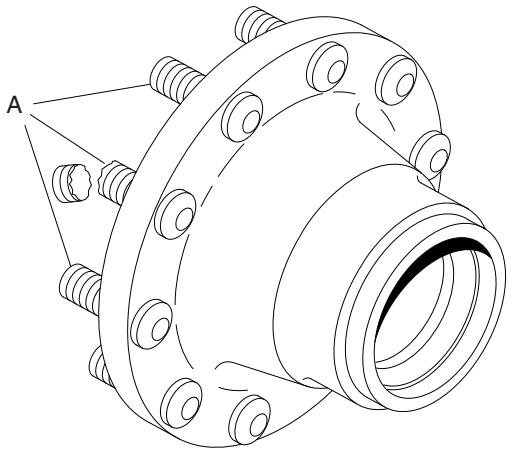
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## Replacement

**WARNING**

**If a wheel stud breaks, the remaining studs are subjected to undue strain and could fail due to fatigue. When a broken stud is replaced, replace the stud on each side of it. See Fig. 1. If more than one stud is broken, replace all of the studs. Failure to replace the studs could result in the loss of a wheel or loss of vehicle control, possibly resulting in personal injury.**




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NOTE: Front hub shown.

A. Replace

**Fig. 1, Wheel Stud Replacement**

1. Remove the wheel hub from the axle. For instructions, see **Subject 100**.
2. If a bent portion of a wheel stud will have to pass through the wheel stud bore, cut off the bent portion before removing the wheel stud.
3. Place the wheel hub on a suitable press; make sure the hub flange is supported evenly around and next to the stud being removed. With steady movement, press the damaged stud out of the hub.

**CAUTION**

**Do not use a drift and hammer or concentrated heat for removing and installing the wheel studs. Constant, smooth movement of the wheel stud is necessary to ensure the least amount of metal removal from the wheel stud bore. Concentrated heat will damage the hub. If the hub is damaged during wheel stud removal or installation, replace it.**

4. Apply a coating of clean axle grease to the entire shaft on headed studs.
5. With the hub on a suitable press, make sure the hub flange is supported evenly around and next to the stud being installed.
6. Position the stud in its hole. *Be sure the flat edge of the head flange on clipped studs is in line with the shoulder on the hub.*

**CAUTION**

**If headed studs with serrations are being installed, position the teeth of the serrated portion in the notches carved by the original wheel studs during factory installation. If additional metal is scraped from the wheel stud bores, the locking action provided by the serrations will be greatly weakened. Loss of locking action will prevent achieving final torque of the wheel nuts during wheel installation. If final wheel nut torques during wheel installation cannot be achieved, replace the wheel hub assembly.**

NOTE: If the left side of the vehicle is being serviced, the replacement wheel stud must be stamped with an "L" (left-hand threaded), and the nut's face must be stamped "Left". If the right side of the vehicle is being serviced, the replacement stud must be stamped with an "R" (right-hand threaded), and the nut's face must be stamped "Right", (see **Fig. 2**).

7. With steady movement, press the new stud all the way into the hub.
8. Make sure the stud is fully seated and that its head (flange) is not embedded into the hub. If the head of the stud is embedded into the hub, replace the hub.

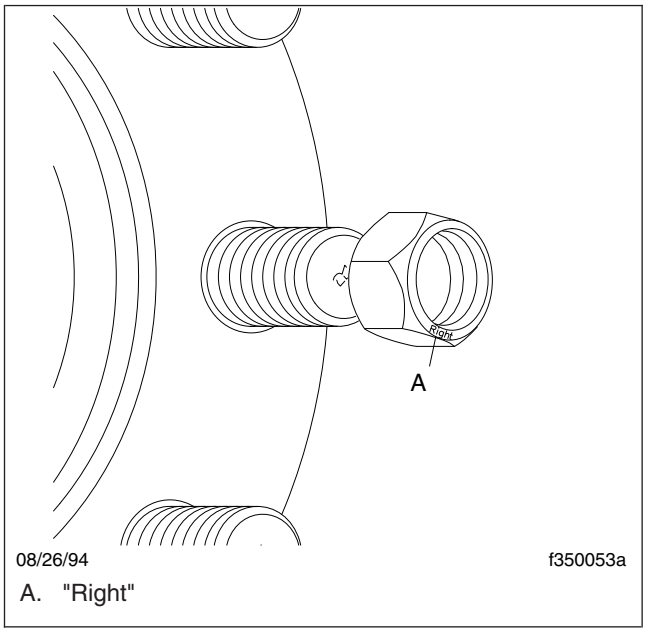
**WARNING**

**Don't embed the wheel stud heads in the wheel hub. Wheel studs with heads embedded in the wheel hub will weaken the wheel hub flange. Weakness in the wheel hub can result in the loss**

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## Wheel Stud Replacement




A. "Right"

**Fig. 2, Thread Stamp Location**

**of a wheel or loss of steering control, possibly resulting in personal injury.**

9. Wipe off any grease on the wheel studs and wheel hub. Install wheel nuts on dry wheel studs only.
10. Install the wheel hub on the axle. For instructions, see **Subject 100**.

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## Replacement

1. Remove the wheel hub from the axle. For instructions, see **Subject 100**.
2. If enough threads remain on the damaged stud, remove it by double-nutting the stud. Turn the inner nut with a wrench in order to remove the stud. Then, proceed to the next step.

   If the drive axle stud is broken near the surface of the hub, the stud should be center-drilled using a high-speed drill, and then removed with an easy-out tool. If needed, grind off a flat surface on the damaged stud, then center-punch the surface as a starting point for drilling. Follow these recommendations.

   2.1 Determine the correct drill diameter by referring to the easy-out tool manufacturer's guidelines. At no time should it be large enough to penetrate the threads of the stud; if the stud threads in the wheel hub are damaged, replace the hub.

   2.2 Do not drill more than 1.25 inches (32 mm) into the broken stud, as measured at the stud's entrance into the wheel hub. Drilling through the bottom of the drive axle stud could damage the hub. If the wheel hub is drilled into, replace it.

   2.3 While drilling, keep the cutting surfaces of the drill well lubricated with oil, which acts as a coolant. Allow the drill and drill bit to cool frequently.
3. After the damaged stud is removed, tap out the drive axle stud hole in the wheel to rid the threads of old stud-locking compound. Use an appropriate sized tap, depending on the original drive axle stud installation size.
4. Be sure the threads of the new stud are clean and dry. Then, coat the insertion end of the drive axle stud (the coarse threads) with an anaerobic thread-lock compound.
5. Using double nuts on the fine-thread portion of the stud, install the new stud. Seat the drive axle stud using the torque values in **Specifications, 400**.
6. Allow sufficient time for the thread-lock compound to set, as suggested by the manufacturer.
7. If the hub was removed from the axle, see **Subject 100** for installation instructions.

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# Axilok Spindle Nut Removal, Installation, and Adjustment

## General Information

Axilok® spindle nuts may be used on ConMet PreSet hubs. See **Fig. 1**. These nuts can be damaged if they are not removed or installed correctly. Use the following guidelines when removing and installing Axilok retaining nuts.

- Use only the correct size, *six-point* socket to remove or install Axilok spindle nuts. Do not use a worn or loose-fitting socket. **Do not use a 12-point socket.**
- Do not use hammers, chisels, pliers, wrenches, or power tools to remove or install Axilok nuts.
- Do not use an Axilok nut if the locking clips are damaged or missing, or if the retainer cage tab or D-flat is damaged or missing.
- Never try to repair a damaged Axilok nut; always replace it with a new one.
- Always start an Axilok installation by hand. A good-fitting six-point socket will completely disengage the nut's locking clips, allowing it to spin freely by hand. See **Fig. 2**. Use an accurately calibrated torque wrench to tighten the nut to its final torque value.

## Installation

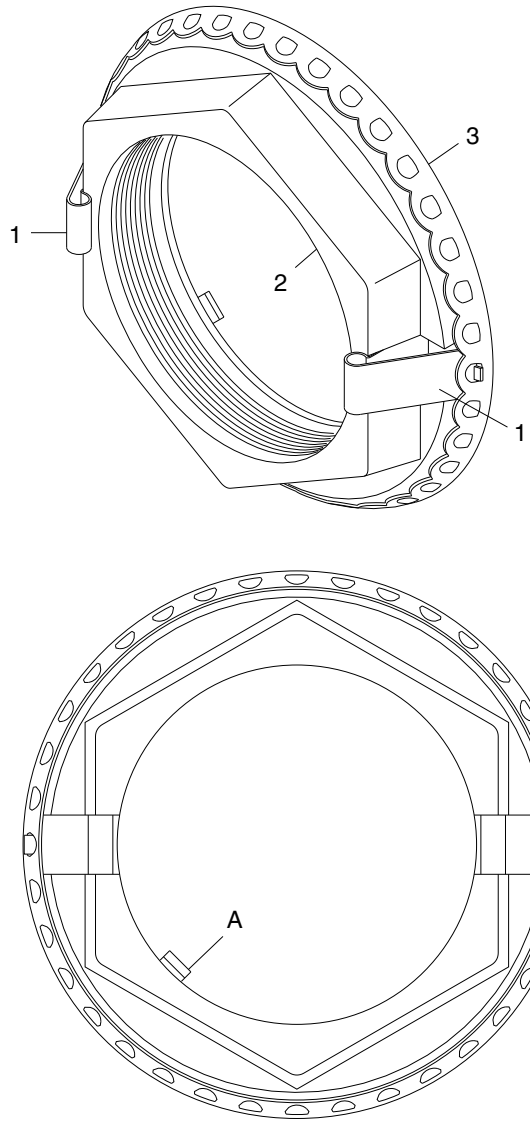
Instructions for installing an Axilok nut for both PreSet and non-PreSet type bearings are provided in this subject. See the pertinent instructions for the type you are installing.

### Using PreSet Bearings

**⚠ WARNING**

**Follow the guidelines at the beginning of this subject when installing an Axilok nut. Axilok retaining nuts secure the hub assemblies on the axle. If the Axilok nut is not correctly installed, the hub could separate from the axle, resulting in severe personal injury or death.**

1. Apply a few drops of oil through one of the holes in the Axilok retainer cage to reduce friction between the retainer cage and nut..
2. By hand, install the Axilok nut onto the axle spindle. See **Fig. 1**.




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A. The retainer tab must engage the keyway of the axle spindle.

1. Locking Clip
2. Nut
3. Retainer

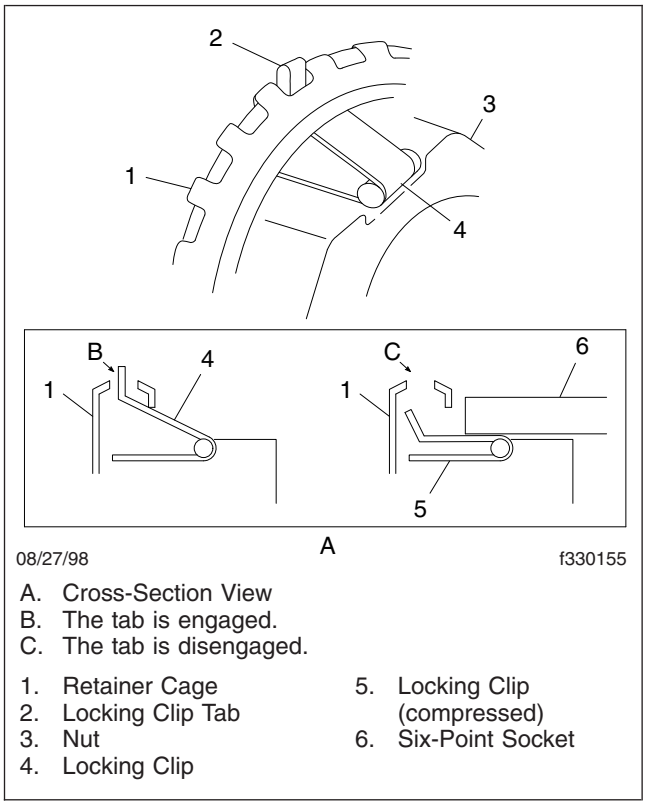
**Fig. 1, Rear Axle Axilok Nut**

3. Tighten the retaining nut 250 lbf·ft (339 N·m). The nut should lock in place when you remove the wrench. If it does not, advance the nut until it does. **Do not back it off**.

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## Axilok Spindle Nut Removal, Installation, and Adjustment




A. Cross-Section View
B. The tab is engaged.
C. The tab is disengaged.

1. Retainer Cage
2. Locking Clip Tab
3. Nut
4. Locking Clip
5. Locking Clip (compressed)
6. Six-Point Socket

**Fig. 2, Axilok Nut, Checking the Position of the Locking Clip**

4. Ensure that both locking clips are present and engaged in the retainer cage. See **Fig. 2**. If the locking clips are not engaged, the nut is not locked in position and can rotate freely.

## Using Non-PreSet Bearings

For ConMet PreSet hubs, when there is no bearing spacer installed and non-PreSet type bearings are being used, proper wheel bearing adjustment is critical to the performance of the bearings, wheel seals, and other related wheel end components.

**⚠ WARNING**

**Follow the guidelines at the beginning of this subject when installing an Axilok nut. Axilok retaining nuts secure the hub assemblies on the axle. If the Axilok nut is not correctly installed, the hub could separate from the axle, resulting in severe personal injury or death.**

1. Apply a few drops of oil through one of the holes in the Axilok retainer cage to reduce friction between the retainer cage and nut.
2. Install the Axilok nut and adjust the wheel bearings, as follows.
   - 2.1 By hand, install the Axilok nut onto the axle spindle. Then turn it against the bearing while spinning the hub. See **Fig. 1**.
   - 2.2 Tighten the nut 90 to 110 lbf·ft (122 to 149 N·m) while spinning the hub in both directions.
   - 2.3 Loosen the nut to zero torque, and spin the hub a few turns.
   - 2.4 Tighten the nut 50 lbf·ft (68 N·m) while spinning the hub in both directions. Back off the nut one-eighth to one-sixth turn.
   - 2.5 Remove the wrench from the nut, and verify whether both locking clips are present and engaged in the retainer cage. See **Fig. 2**. If the locking clips are not engaged, advance the Axilok until they are.
3. Measure the end play; see **Subject 200** for instructions.

**⚠ WARNING**

**Correct wheel-bearing end play is crucial to the safe and sound operation of the vehicle. If the end play is not correct, the wheel bearings could fail and cause the loss of the wheel and hub assembly and result in an accident causing property damage, serious injury, or death. Use a dial indicator to measure the end play.**

4. **The end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm)**. If it is not within this range, remove the Axilok nut, and repeat the tightening sequence as described earlier in this procedure. Once the end play is correct, continue with your service procedure.

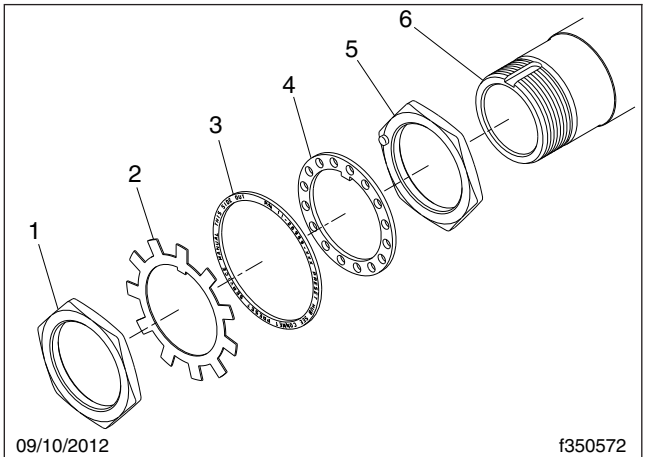
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# Double Spindle Nut Removal, Installation, and Adjustment

## General Information

ConMet PreSet hubs may use a double spindle nut system. See **Fig. 1**. A plastic ID ring between the adjusting nut and locking washer indicates that a ConMet Preset hub has been installed.




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NOTE: ID ring used with ConMet PreSet hubs only.

1. Jam Nut
2. Bend-Type Locking Washer
3. ID Ring
4. Lockring
5. Adjusting Nut
6. Axle Spindle

**Fig. 1, Double Spindle Nut Set**

## Removal

Once a double spindle nut set is removed, discard the bend-type locking washer. Inspect the adjusting nut, lockring, and jam nut for visible damage prior to reuse.

## Installation

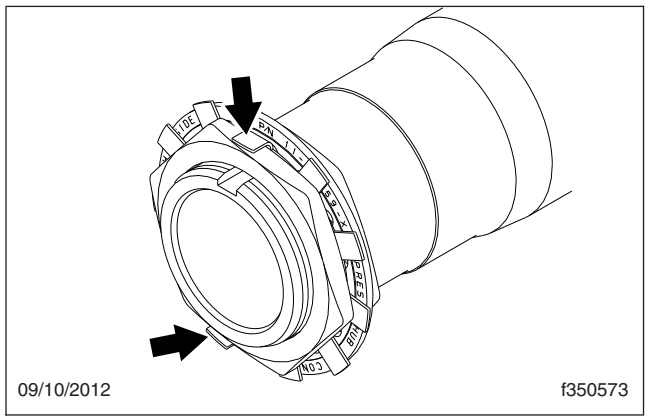
Instructions for installing a double spindle nut set for both PreSet and non-PreSet type bearings are provided in this subject. See the pertinent instructions for the type you are installing.

### Using PreSet Bearings

1. Install the adjusting nut onto the axle spindle, and tighten it 300 lbf·ft (410 N·m). See **Fig. 1**.

NOTE: The gaps between holes in the lockring are spaced unevenly, so to fit the tab on the adjusting nut into one of the holes with minimal turning of the adjusting nut, gauge the distance on one side of the lockring, then the other, and choose the side that requires the adjusting nut to be advanced the least. **Do not back off the nut**.

2. Install the lockring (as described in the note above), ID ring (for ConMet PreSet hubs only), and bend-type locking washer.
3. Install the jam nut, and tighten it 200 lbf·ft (271 N·m).
4. Bend the tabs on the locking washer at 6 o'clock and 12 o'clock to lock the jam nut in place. See **Fig. 2**.



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**Fig. 2, Tabs Bent to Lock the Jam Nut**

5. Rotate the hub in both directions. It should turn freely with no dragging or binding.

### Using Non-PreSet Bearings

For ConMet PreSet hubs, when there is no bearing spacer installed and non-PreSet type bearings are being used, proper wheel bearing adjustment is critical to the performance of the bearings, wheel seals, and other related wheel end components.

1. Install the adjusting nut, as follows. See **Fig. 1**.
   - 1.1 Install the adjusting nut on the spindle, and tighten it finger-tight.
   - 1.2 While rotating the wheel hub assembly, tighten the adjusting nut 200 lbf·ft (271 N·m).
   - 1.3 Back off the adjusting nut one full turn.

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## Double Spindle Nut Removal, Installation, and Adjustment

1.4 Tighten the adjusting nut 50 lbf·ft (68 N·m) while rotating the wheel hub assembly.

1.5 Back off the adjusting nut one-quarter turn.

NOTE: The gaps between holes in the lockring are spaced unevenly, so to fit the tab on the adjusting nut into one of the holes with minimal turning of the adjusting nut, gauge the distance on one side of the lockring, then the other, and choose the side that requires the adjusting nut to be turned the least.

2. Install the lockring (as described in the note above) and bend-type locking washer.
3. Install the jam nut, and tighten it 300 to 400 lbf·ft (410 to 540 N·m).
4. Measure the end play; see **Subject 200** for instructions.

**⚠ WARNING**

**Correct wheel-bearing end play is crucial to the safe and sound operation of the vehicle. If the end play is not correct, the wheel bearings could fail and cause the loss of the wheel and hub assembly and result in an accident causing property damage, serious injury, or death. Use a dial indicator to measure the end play.**

5. **The end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm).** If the end play is not within this range, adjust the end play as follows.

5.1 Remove the jam nut and locking device, and back off or tighten the inner adjusting nut.

5.2 Install the locking device and jam nut as described earlier, and measure the end play. If the end play is not between 0.001 and 0.005 inch (0.03 and 0.13 mm), turn the adjusting nut again.

5.3 Measure the end play.

If the end play is not between 0.001 and 0.005 inch (0.03 and 0.13 mm), repeat the adjustment procedure until the correct end play is achieved.

IMPORTANT: The correct end play **must** be achieved before completing the hub assembly installation procedure.

6. Once the end play is between 0.001 and 0.005 inch (0.03 and 0.13 mm), bend two tabs on the locking washer at 6 o'clock and 12 o'clock to lock the jam nut in place. See **Fig. 2**.
7. Rotate the hub in both directions. It should turn freely with no dragging or binding.

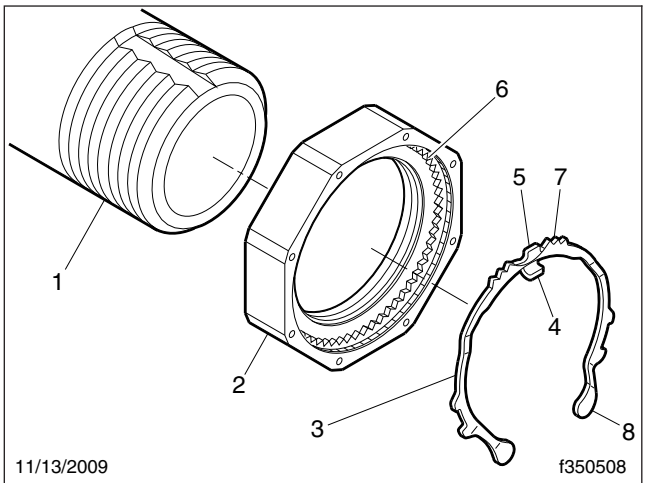
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# Pro-Torq Spindle Nut Removal, Installation, and Adjustment

## General Information

Pro-Torq® spindle nuts may be used on ConMet Pre-Set hubs. See **Fig. 1** and **Fig. 2**.




1. Axle Spindle
2. Pro-Torq Nut
3. Keeper Arm
4. Keyway Tab
5. Keeper Tab
6. Mating Teeth, Nut
7. Mating Teeth, Keeper
8. Keeper Protrusion

**Fig. 1, Pro-Torq Spindle Nut and Keeper**

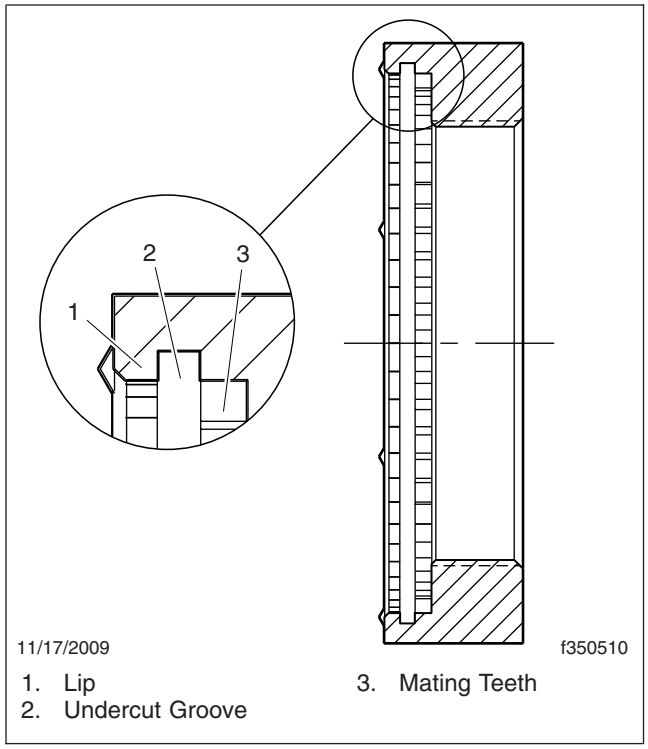
Each time the Pro-Torq nut assembly is removed for maintenance purposes, replacing the "keeper" is recommended.

## Removal

**⚠ WARNING**

**Do not place the nut on the spindle or tighten or loosen the nut on the spindle while the keeper is locked inside the nut. Doing so may damage the spindle threads and deform the keeper, and allow the nut to unthread during operation. Failure to follow this instruction could cause the hub to separate from the axle, resulting in severe personal injury or death.**

1. Insert the blade of a flathead screwdriver (or similar tool) in the slot of one of the keeper arms; see **Fig. 3**. Ensuring that the tool contacts the keeper and not the teeth of the nut, turn the tool slightly and carefully pry the arm from the undercut groove of the nut.




1. Lip
2. Undercut Groove
3. Mating Teeth

**Fig. 2, Pro-Torq Spindle Nut, Cross Section**

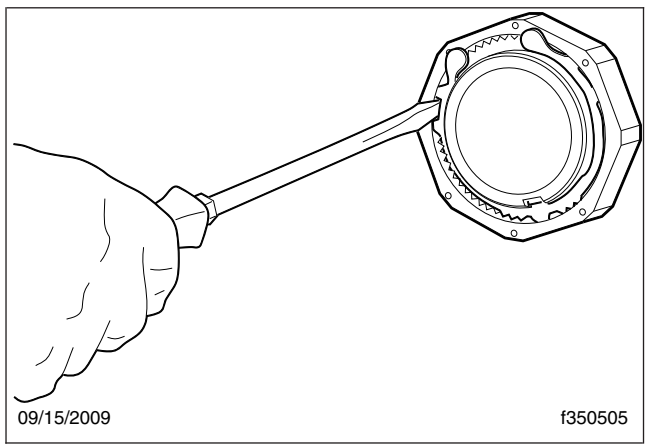



**Fig. 3, Removing the Keeper**

2. Repeat at the other arm, and remove the keeper from the nut.
3. Remove the Pro-Torq nut.

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## Pro-Torq Spindle Nut Removal, Installation, and Adjustment

# Installation

The following procedure applies to Pro-Torq drive axle nut 449-4973. The part number is stamped on the nut.

**⚠ WARNING**

**Do not place the nut on the spindle or tighten or loosen the nut on the spindle while the keeper is locked inside the nut. Doing so may damage the spindle threads and deform the keeper, and allow the nut to unthread during operation. Failure to follow this instruction could cause the hub to separate from the axle, resulting in severe personal injury or death.**

Instructions for installing a Pro-Torq spindle nut for both PreSet and non-PreSet type bearings are provided in this subject. See the instructions pertaining to the bearing type used with the hub you are securing.

## Using PreSet Bearings

1. Ensure the keeper is removed from the nut.
2. Install the Pro-Torq spindle nut, and tighten it 250 lbf·ft (339 N·m). **Do not back it off**.

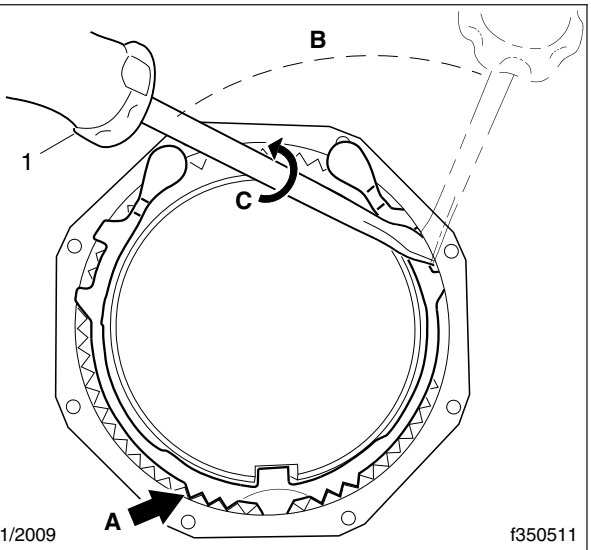
**⚠ WARNING**

**Do not bend or manipulate the keyway tab in any way. Doing so may cause it to break off in service, which could lead to the hub separating from the axle and result in severe personal injury or death.**

3. Install the keeper.
   - 3.1 With the protrusions facing outboard, insert the keeper tab in the undercut groove of the Pro-Torq nut and the keyway tab in the spindle keyway.

   IMPORTANT: If the keeper cannot be engaged, advance the nut until it can be. Do not back off the nut.

   - 3.2 Engage the mating teeth.
   - 3.3 Use a flathead screwdriver to carefully compress and guide each arm past the lip and into the undercut groove of the nut as shown in **Fig. 4**. To secure the keeper it may be necessary to nudge the arms into the groove.




A. Engage the mating teeth.
B. Compress the arm.
C. Turn the screwdriver to seat the keeper in the groove.

1. Flathead Screwdriver

**Fig. 4, Installing the Keeper**

**⚠ WARNING**

**Failure to secure the keeper and lock the Pro-Torq nut could cause the wheel assembly to come off the vehicle, resulting in severe personal injury or death.**

4. Inspect the installation; ensure the keeper is locked in the undercut groove and that the keyway tab does not contact the bottom of the keyway.

## Using Non-PreSet Bearings

For ConMet PreSet hubs, when there is no bearing spacer installed and non-PreSet type bearings are being used, proper wheel bearing adjustment is critical to the performance of the bearings, wheel seals, and other related wheel end components.

1. Ensure the keeper is removed from the nut.
2. Seat the bearings.

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## Pro-Torq Spindle Nut Removal, Installation, and Adjustment

2.1 Using a torque wrench, tighten the nut 200 lbf·ft (270 N·m). Spin the hub at least one full rotation.

NOTE: Torque is lost when the hub is spun.

2.2 Tighten the nut 200 lbf·ft (270 N·m). Spin the hub at least one full rotation.

2.3 Tighten the nut 200 lbf·ft (270 N·m), but *do not spin the hub*.

3. Loosen the nut to zero torque. *Do not spin the hub*.
4. Adjust the bearing.

4.1 Using a torque wrench, tighten the nut 100 lbf·ft (136 N·m). Spin the hub at least one full rotation.

NOTE: Torque is lost when the hub is spun.

4.2 Tighten the nut 100 lbf·ft (136 N·m). Spin the hub at least one full rotation.

4.3 Tighten the nut 100 lbf·ft (136 N·m).

4.4 Back off the nut one-eighth turn.

**WARNING**

**Do not bend or manipulate the keyway tab in any way. Doing so may cause it to break off in service, which could lead to the hub separating from the axle and result in severe personal injury or death.**

IMPORTANT: If the keeper cannot be engaged, advance the nut until it can be. Do not back off the nut.

5. Install the keeper.

5.1 With the protrusions facing outboard, insert the keeper tab in the undercut groove of the Pro-Torq nut and the keyway tab in the spindle keyway.

5.2 Engage the mating teeth.

5.3 Use a flathead screwdriver to carefully compress and guide each arm past the lip and into the undercut groove of the nut as shown in **Fig. 4**. To secure the keeper it may be necessary to nudge the arms into the groove.

**WARNING**

**Failure to secure the keeper and lock the Pro-Torq nut could cause the wheel assembly to come off the vehicle, resulting in severe personal injury or death.**

6. Inspect the installation; ensure the keeper is locked in the undercut groove and that the keyway tab does not contact the bottom of the keyway.
7. Measure the end play; see **Subject 200** for instructions.

**WARNING**

**Correct wheel-bearing end play is crucial to the safe and sound operation of the vehicle. If the end play is not correct, the wheel bearings could fail and cause the loss of the wheel and hub assembly and result in an accident causing property damage, serious injury, or death. Use a dial indicator to measure the end play.**

8. **The end play must be between 0.001 and 0.005 inch (0.03 and 0.13 mm)**. If it is not within this range, remove the Pro-Torq nut, and repeat the tightening sequence as described in previous steps. Once the end play is correct, continue your service procedure.

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## Wheel Bearing End Play Measurement

**⚠ WARNING**

**Correct wheel-bearing end play is crucial to the safe and sound operation of the vehicle. If the end play is not correct, the wheel bearings could fail and cause the loss of the wheel and hub assembly and result in an accident causing property damage, serious injury, or death. Use a dial indicator to measure the end play.**

IMPORTANT: Do not measure the wheel bearing end play with the wheel mounted on the hub; you cannot accurately measure or adjust bearing end play with the wheel mounted on the hub. Also, ensure that the brakes are not applied so that that drum and hub can move freely.

# Measurement

Using a dial indicator, measure the end play as follows.

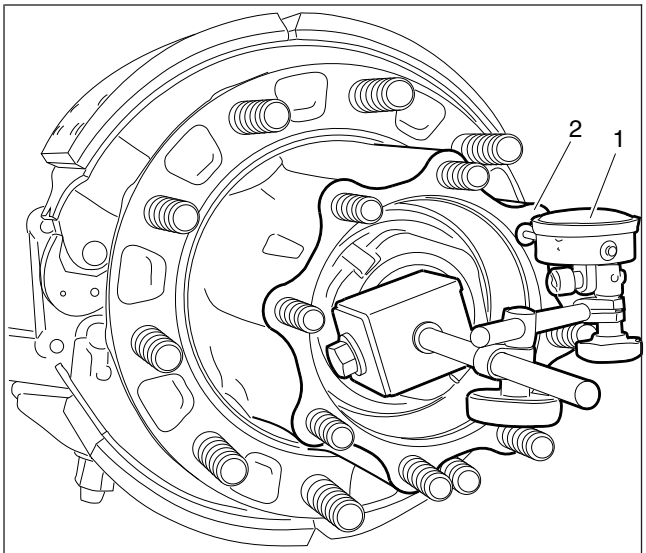
1. Attach the magnetic base of a dial indicator to the spindle, and place the measuring end of the indicator squarely against the flange as shown in **Fig. 1**.

IMPORTANT: Maintain continual pressure on the hub until you have taken both the inboard and outboard measurements. If you release the hub, an accurate measurement is not possible.

2. To seat the bearings, grip the hub at the three o'clock and nine o'clock positions, and push inward while oscillating it approximately 45 degrees. Maintain pressure on the hub, note the inboard measurement, and then pull the hub outward while oscillating it as before. Maintain pressure on the hub, and note the outboard measurement.

   The end play is the difference between the two measurements.

NOTE: If the end play exceeds the limit, the hub may need to be serviced. See **Subject 120** and manufacturer literature for procedures.




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1. Dial Indicator (with magnetic base)
2. Axle Shaft Mounting Flange

**Fig. 1, Dial Indicator Setup**

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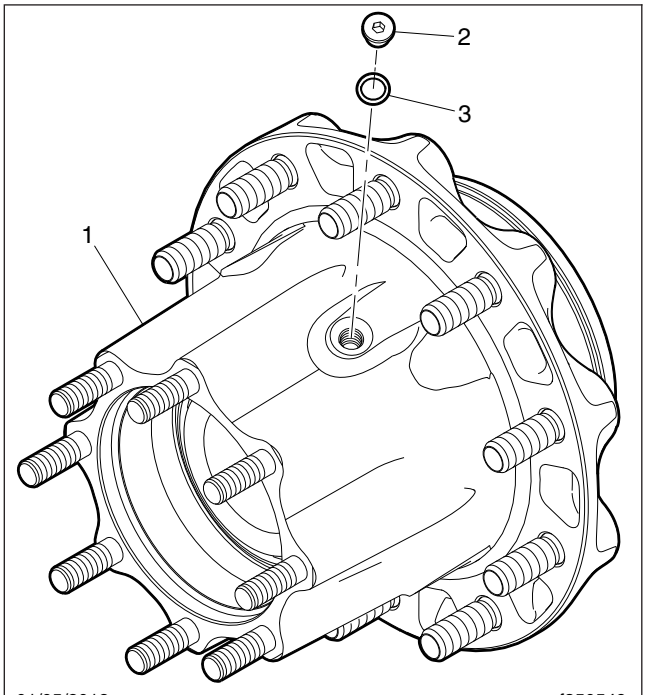
## General Information

Proper wheel bearing lubrication is critical to sound wheel end health and safe vehicle operation. Insufficient lubrication can lead to catastrophic consequences that can be avoided.

The procedure for lubricating wheel bearings depends on whether or not the hub has an oil fill port. This subject provides instructions for ConMet hubs with and without a fill port.

## ConMet Hub with an Oil Fill Port

For ConMet hubs with an oil fill port, lubricant is added through the fill port; see **Fig. 1** and use the following instructions.




1. Hub
2. Fill Port Plug
3. O-Ring

**Fig. 1, ConMet Hub with Oil Fill Port**

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.

IMPORTANT: When removing the fill port plug, make sure the rubber O-ring is attached to it and not stuck inside the fill port.

2. Clean the area surrounding the oil fill port plug, then remove the plug and O-ring.

NOTE: The fill port plug is magnetic. On drive axles, it is normal to find a small amount of very fine metallic particles from the carrier housing on the magnetic fill plug. These particles should be removed from the magnet anytime the plug is removed for inspection.

3. Inspect the plug for metallic particles picked up by the magnet. If very fine metallic particles are found, remove them from the magnet. If larger particles or chunks of metal are found, remove the hub from the spindle and inspect the bearings and other wheel end and axle components for signs of damage or excessive wear, and make the necessary repairs.

**⚠ WARNING**

**Failure to adequately lubricate wheel bearings can cause them to seize during vehicle operation. Seized wheel bearings can cause sudden, catastrophic damage to the wheel end and axle, possibly resulting in severe personal injury or death.**

4. Using a clean funnel, add 1.0 quart (0.95 liter) of the recommended drive axle lubricant through the oil fill port. For recommended lubricants, see the vehicle maintenance manual.
5. Install the fill port plug, and tighten it 20 to 25 lbf·ft (27 to 34 N·m).

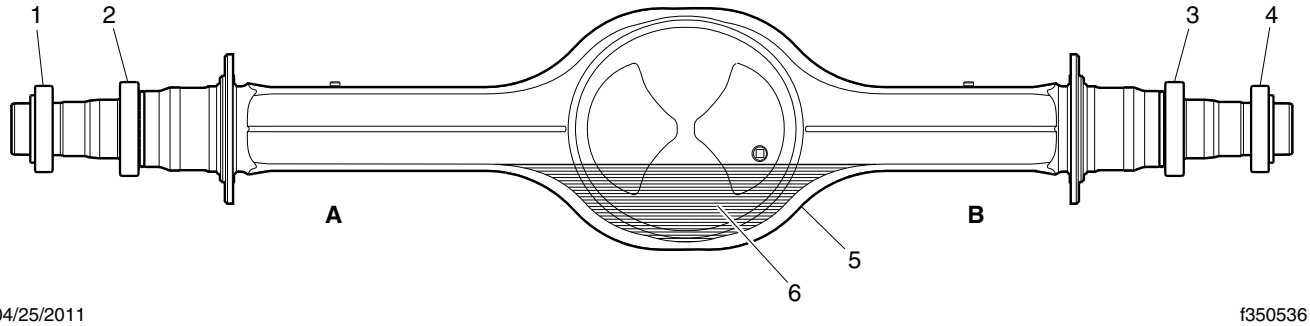
## ConMet Hub without an Oil Fill Port

For ConMet hubs without an oil fill port, lubricant must be transferred from the axle carrier housing to the hubs. To ensure each bearing is adequately lubricated, the axle must be filled with lubricant and tilted *three* times. See **Fig. 2** and use the following instructions to lubricate the wheel bearings on a rear drive axle.

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## Wheel Bearing Lubrication




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For an axle equipped with hubs without fill ports, when side A is raised first, bearing 4 is lubricated. Side B is raised next to lubricate bearings 3 and 1. Side A is raised again to lubricate bearing 2. The carrier housing must be refilled before and after each time the axle is lifted to ensure there is enough lubricant to reach the bearings.

A. Driver Side
B. Passenger Side

1. Outer Wheel Bearing, Driver Side
2. Inner Wheel Bearing, Driver Side
3. Inner Wheel Bearing, Passenger Side
4. Outer Wheel Bearing, Passenger Side
5. Carrier Housing
6. Lubricant (full)

**Fig. 2, Rear Drive Axle and Wheel Bearings**

1. Park the vehicle on level ground, apply the parking brakes, and chock the front wheels.

NOTE: Some Detroit and Meritor axles have a small tapped and plugged hole located below the housing oil fill hole. This smaller hole is for a lubricant temperature sensor only and must not be used as a fill hole.

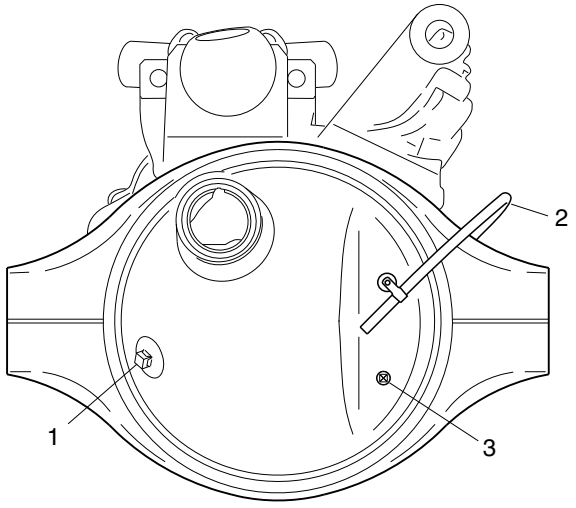
2. With the axle level and all wheels on the ground, clean the oil fill hole plug and the area surrounding it, then remove the fill plug. For Detroit axles, see **Fig. 3**; for Meritor axles, see **Fig. 4**; for Dana Spicer axles, see **Fig. 5**.

**⚠ WARNING**

**Failure to adequately lubricate wheel bearings can cause them to seize during vehicle operation. Seized wheel bearings can cause sudden, catastrophic damage to the wheel end and axle, possibly resulting in severe personal injury or death.**

IMPORTANT: A lubricant level close enough to be seen or touched is not sufficient; it must be level with the bottom of the fill hole. See **Fig. 6**.

3. Use a clean funnel to add lubricant until it reaches the fill hole, then install the fill plug. For recommended lubricants, see the vehicle maintenance manual. For fill plug torque values, see **Table 1**.




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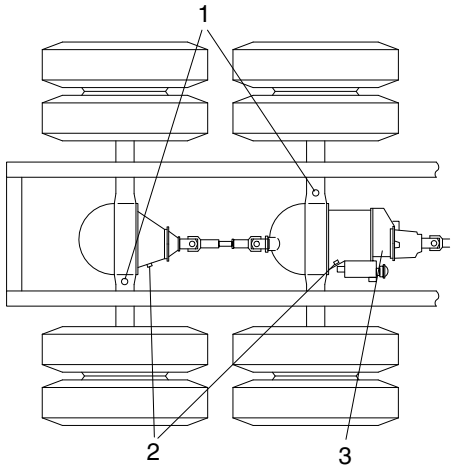
NOTE: Rear view of forward-rear axle shown.

1. Oil Fill Plug
2. Breather Hose
3. Temperature Sensor Port Plug

**Fig. 3, Fill Hole Plug Location, Detroit Tandem Axle**

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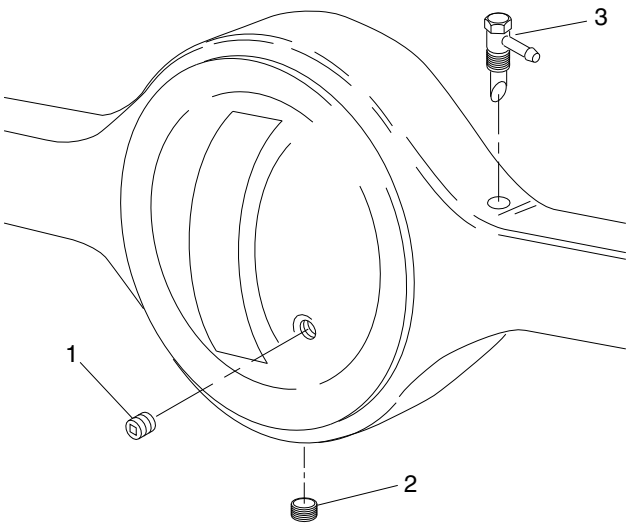





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1. Axle Housing Breathers
2. Carrier Oil Fill Plugs
3. Interaxle Differential

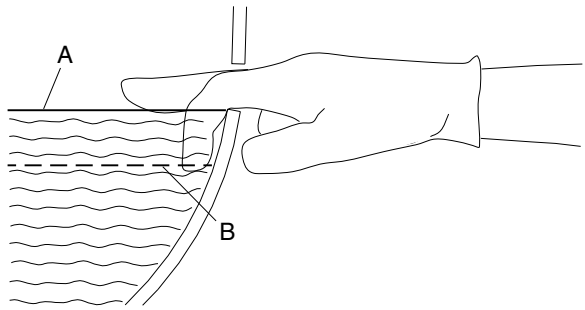
**Fig. 4, Fill Hole Plug Locations, Meritor Axles**




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1. Oil Fill Plug
2. Oil Drain Plug
3. Axle Breather

**Fig. 5, Fill Hole Plug Location, Dana Spicer Axles**




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A. Correct (lube level at bottom of fill hole)
B. Incorrect (lube level below fill hole)

**Fig. 6, Axle Lubricant Level Check**

| Oil Fill Plug Torque Values | |
|---|---|
| **Brand** | **Torque: lbf·ft (N·m)** |
| Detroit | 30 (41) |
| Meritor | 35 (47) |
| Dana Spicer | 40 to 60 (54 to 81) |

**Table 1, Oil Fill Plug Torque Values**

IMPORTANT: The axle must be tilted three times and the tilted position must be held for two minutes each time to allow enough lubricant to reach the hub and wheel bearings.

4. To tilt the axle, position a suitable jack at a leaf spring U-bolt, and raise it until the bottom of the outside part of the outside tire is 8 inches (20 cm) above the ground. See **Fig. 7** and **Fig. 8**.

   After two minutes, lower the axle, and add lubricant as described earlier in this procedure.

5. At a leaf spring U-bolt on the other end of the axle, tilt the axle as described earlier in this procedure.

   After two minutes, lower the axle, and add lubricant as described earlier in this procedure.

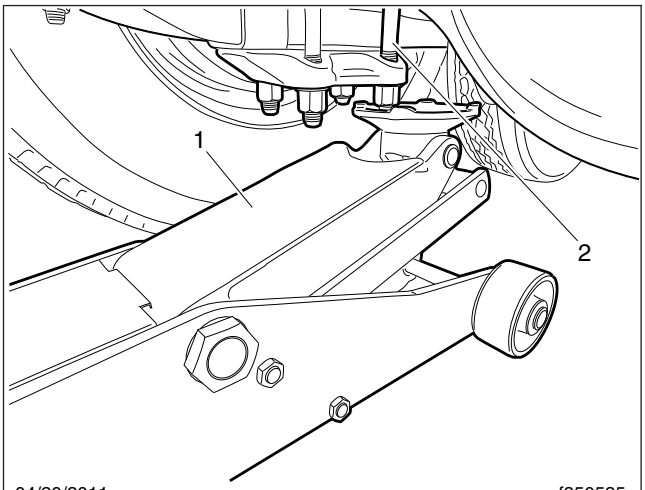
6. At the U-bolt where the axle was first lifted, tilt the axle as described earlier in this procedure.

   After two minutes, lower the axle, and add lubricant as described earlier in this procedure.

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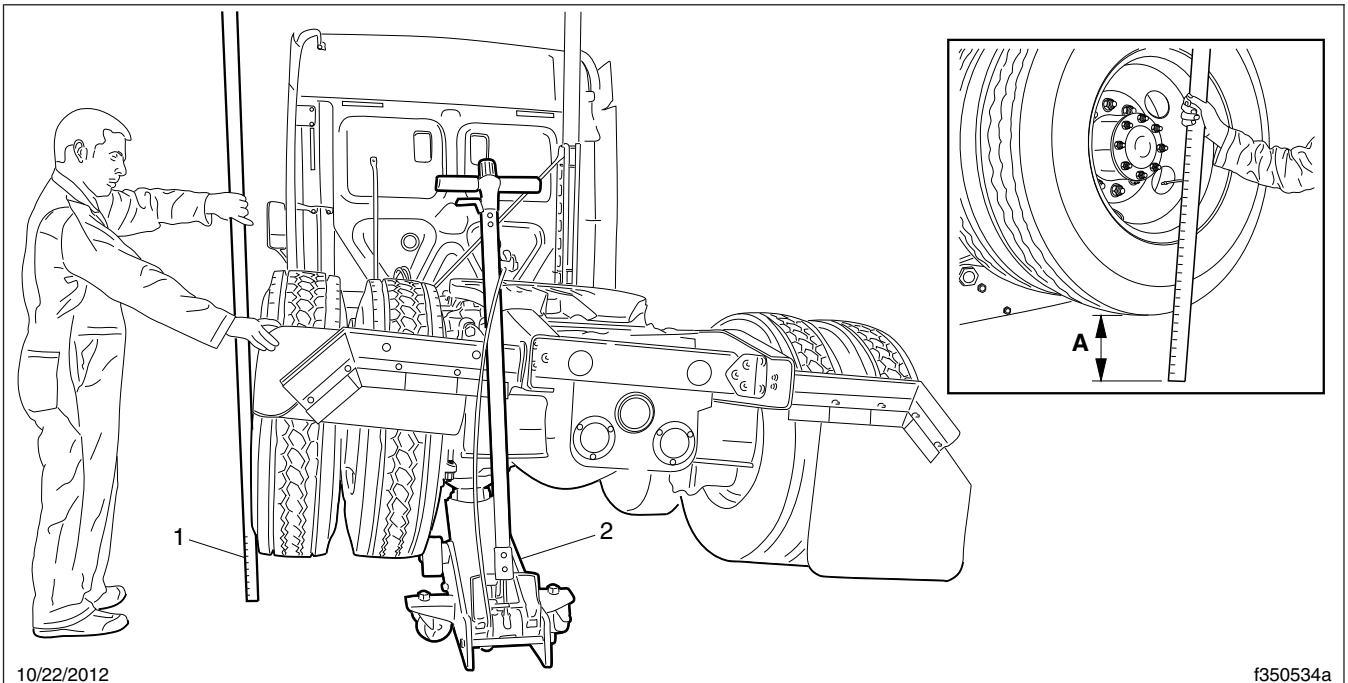


## Wheel Bearing Lubrication




1. Jack
2. U-bolt

**Fig. 7, Axle Lifted at Leaf Spring U-bolt**




Each time you lift a side of the axle to distribute lubricant, raise it until the bottom of the outside part of the outside tire is 8 inches (20 cm) above the ground.

A. 8 inches (20 cm)

1. Ruler
2. Jack

**Fig. 8, Distributing Lubricant from Carrier Housing to Wheel Bearings for ConMet Hubs without Oil Fill Ports**

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# Troubleshooting Tables

**Problem—Noisy Bearings or Excessive Bearing Replacement Intervals**

| Problem—Noisy Bearings or Excessive Bearing Replacement Intervals | |
|---|---|
| **Possible Cause** | **Remedy** |
| Not enough oil was used on the bearings, or the wrong type of oil was used. | Clean, then inspect the bearings for wear. Replace worn seals. Coat the bearing assemblies with fresh oil. For lubricant specifications, refer to **Group 35** of the *Western Star Maintenance Manual*. |
| Foreign matter or corrosive agents entered the bearing assembly. Dirt or metallic debris from the bearings was not removed. | Clean, then inspect the bearings for wear. Replace worn seals. Also clean the wheel hub, the axle spindle, and any other component in contact with the bearing lubricant. |
| An incorrect adjustment of the wheel bearings is causing noise and wear. | Adjust the wheel bearings following the applicable instructions in this section. |
| Flat spots or dents on the roller surface were caused by skidding of the roller or improper handling of the wheel bearing during installation. | Clean, then inspect the bearing rollers. Replace the bearing if damaged. Coat the replacement bearings with fresh oil. For lubricant specifications, see **Group 35** of the *Western Star Maintenance Manual*. |

**Problem—Broken Wheel or Rim Studs**

| Problem—Broken Wheel or Rim Studs | |
|---|---|
| **Possible Cause** | **Remedy** |
| The wheel or rim nuts were overtightened. | Replace the wheel or rim studs. See **Group 40** for the wheel or rim nut tightening sequence. |
| An incorrect nut tightening sequence was used. | |
| The wrong brake drums were installed. | Install new brake drums. |
| Wheels are mismatched (hub-piloted wheels are mixed with stud-piloted wheels). | Install properly matched wheels. |
| The vehicle is being overloaded. | Do not exceed the maximum load-carrying capacity of the vehicle. |

**Problem—Damaged Hub**

| Problem—Damaged Hub | |
|---|---|
| **Possible Cause** | **Remedy** |
| (Cracked hub) Local surface of an aluminum hub was heated higher than 350°F (177°C) during bearing cup removal. | Replace the hub assembly. When removing the bearing cup, oven-heat the hub. |
| (Bent flange) Incorrect installation of the wheel studs, such as using a hammer and drift, or the hub flange was not fully supported on the press during wheel stud replacement. | Replace the hub assembly. Replace the wheel studs as instructed under **Subject 150**. |
| The wrong brake drums were installed. | Install new brake drums. |
| Insufficient tightening of the wheel nuts to the wheel hub. | Replace the hub assembly; see **Subject 100**. |

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## Troubleshooting

**Problem—Loss of Lubricant From the Wheel Hubs**

| Problem—Loss of Lubricant From the Wheel Hubs | |
|---|---|
| **Possible Cause** | **Remedy** |
| The drive axle studs are loose. | Tighten the nuts to the torque values in the torque table in **Specifications, 400**. Add lubricant to the axle housing or to the wheel hub. |
| The seals or gaskets are worn or damaged. | Replace worn or damaged parts. |
| Minor burrs or rough spots are on the inboard portion of the drive axle flange. | Use fine-grit emery cloth to remove the burrs or rough spots. If they cannot be removed, replace the drive axle shaft. |

**Problem—Vehicle Does Not Slow Down Quickly Enough When Brakes Are Applied**

| Problem—Vehicle Does Not Slow Down Quickly Enough When Brakes Are Applied | |
|---|---|
| **Possible Cause** | **Remedy** |
| The brake linings are glazed (dirt or grease build-up) or are worn unevenly. | Install new brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums. |
| The brake drums are worn, heat-checked, or cracked. | Install new brake drums. |

**Problem—Service Brakes Grab or Pull**

| Problem—Service Brakes Grab or Pull | |
|---|---|
| **Possible Cause** | **Remedy** |
| The drum could be out of round if it was not correctly positioned on the drum pilot tabs before the wheel was installed. | Position one of the hub-piloted tabs in the top position before placing the drum on the hub. When doing so, be sure the drum is located flat against the hub and on the largest-diameter portion of the pilot tabs. After placing the wheel(s) on the studs, firmly hand-tighten the nut on the stud closest to the top position. Proceed with the other nuts. |
| Also refer to the air brake system troubleshooting section. | |

**Problem—Poor Lining-to-Drum Contact**

| Problem—Poor Lining-to-Drum Contact | |
|---|---|
| **Possible Cause** | **Remedy** |
| The inside surface of the brake drum is scored or grooved. | Install new brake linings on both sets of axle brake shoes. Turn or replace the brake drums. |
| The brake shoes are stretched or bent. | Replace the brake shoes. |
| Undersized linings were installed. | Install new brake linings on both sets of axle brake shoes. |
| An incorrect grind was used on the brake linings. | |
| The wrong brake drums were installed. | Install new brake drums. |
| An incorrect adjustment of the wheel bearings is causing wheel instability. | Adjust the wheel bearings following the applicable instructions in this section. |

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## Troubleshooting

**Problem—Brake Linings Are Tapered Across the Width**

| Problem—Brake Linings Are Tapered Across the Width | |
|---|---|
| **Possible Cause** | **Remedy** |
| The inside surface of the brake drum is scored or grooved. | Install new brake linings on both sets of axle brake shoes. Turn or replace the brake drums. |
| The brake shoes are bent. | Replace the brake shoes. |
| An incorrect adjustment of the wheel bearings is causing wheel instability. | Adjust the wheel bearings following the applicable instructions in this section. |

**Problem—Brake Shoes on the Same Brake Are Wearing Unequally**

| Problem—Brake Shoes on the Same Brake Are Wearing Unequally | |
|---|---|
| **Possible Cause** | **Remedy** |
| The brake linings are not a matched set. Different friction codes or different brands of brake linings are installed. | Install a new matched set of brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums. |
| The inside surface of the brake drum is in poor condition. | Turn or replace the brake drums. |
| The wheel bearings are out of adjustment. | Adjust the wheel bearings following the applicable instructions in this section. |

**Problem—Edge of the Lining Is Showing Wear**

| Problem—Edge of the Lining Is Showing Wear | |
|---|---|
| **Possible Cause** | **Remedy** |
| The brake lining is too wide. | Install new brake linings on both sets of axle brake shoes. |
| The brake linings are misaligned because their holes were incorrectly drilled. | |
| Undersized brake drums were installed. | Install new brake drums. |
| The wheel bearings are out of adjustment. | Adjust the wheel bearings following the applicable instructions in this section. |
| There is an improper fit of the wheel onto the spindle due to the wrong wheel bearings or cone. | Install and adjust the new wheel bearings and cone. |
| The brake shoes are bent. | Replace the brake shoes. |

**Problem—Brake Linings Are Scored or Grooved**

| Problem—Brake Linings Are Scored or Grooved | |
|---|---|
| **Possible Cause** | **Remedy** |
| Worn or scored brake drums have been causing poor contact with the brake linings. | Install new brake linings on both sets of axle brake shoes. Turn or replace the brake drums. |
| There is abrasive material between the lining and the drum. | |

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## Troubleshooting

**Problem—Brake Linings Are Loose**

| Problem—Brake Linings Are Loose | |
|---|---|
| **Possible Cause** | **Remedy** |
| The rivet holes in the brake shoes are too large. | Replace the brake shoes. |
| Improperly crimped rivets are working loose and allowing the linings to move. | Replace the rivets. |
| Rust has built up on the shoe table. | Clean the brake shoe table of all rust, dirt, scale, and paint. |

**Problem—Brake Lining is Cracked at the Rivet Holes or Bolt Holes**

| Problem—Brake Lining is Cracked at the Rivet Holes or Bolt Holes | |
|---|---|
| **Possible Cause** | **Remedy** |
| Overtightening of the lining bolts is causing cracks. | Replace the brake linings. Replace the rivets or bolts with the correct size. |
| The wrong size counter bore for the rivet holes was made. | |
| The wrong rivets or bolts were used. | Replace the rivets or bolts with the correct size. |
| Improperly crimped rivets are working loose and allowing the linings to move. | Replace the rivets. |
| Rust has built up on the shoe table. | Clean the brake shoe table of all rust, dirt, scale, and paint. |

**Problem—Out-of-Round Rivet Holes or Bolt Holes**

| Problem—Out-of-Round Rivet Holes or Bolt Holes | |
|---|---|
| **Possible Cause** | **Remedy** |
| The rivets or bolts are loose. | Replace the brake shoes or linings. |

**Problem—Brake Drums Are Heat-Checked**

| Problem—Brake Drums Are Heat-Checked | |
|---|---|
| **Possible Cause** | **Remedy** |
| The brake drums are out-of-round. | Turn or replace the brake drums. |
| The wrong brake drums were installed. | Install new brake drums. |
| The wheel bearings are out of adjustment. | Adjust the wheel bearings following the applicable instructions in this section. |
| The brake linings are glazed (dirt or grease build-up) or are worn unevenly. | Install new brake linings on both sets of axle brake shoes. Clean, turn, or replace the drums. |
| The lining friction material for the operation of the vehicle is incorrect. | |
| There is a brake imbalance between the tractor and the trailer. | Do a brake balance test (tractor versus trailer). Contact the District Service Manager if help is needed. |

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**Problem—Brake Drums Are Heavily Scored**

| Problem—Brake Drums Are Heavily Scored | |
|---|---|
| **Possible Cause** | **Remedy** |
| The brake linings are damaged. | Install new brake linings on both sets of axle brake shoes. Turn or replace the drums. |
| There is excessive wear on the linings. | |
| On the last brake reline, the drums were not turned. | Turn the brake drums. |

**Problem—Excessive Brake Lining Wear**

| Problem—Excessive Brake Lining Wear | |
|---|---|
| **Possible Cause** | **Remedy** |
| There is a brake imbalance between the tractor and the trailer. | Do a brake balance test (tractor versus trailer). Contact the District Service Manager if help is needed. |

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## Specifications

| Torque Values | | |
|---|---|---|
| **Description** | **Size (grade 8)** | **Torque: lbf·ft (N·m)** |
| Drive Axle Studs-to-Hub | 1/2–13 | 70 (95) |
| | 5/8–11 | 135 (185) |
| Drive Axle Stud Nuts | 1/2–20 | 75–115 (102–156) |
| | 5/8–18 | 150–170 (203–230) |
| Hub Cap Capscrews | 5/16–18 | 15 (20) |
| Oil Fill Plug (Detroit axles) | — | 30 (41) |
| Oil Filler Plug (Dana® Spicer® axles) | — | 40–60 (54–81) |
| Oil Filler Plug (Meritor axles) | — | 35 (47) |

**Table 1, Torque Values**

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# General Information

Wheel oil seals (also called "oil bath seals" or "hub seals") work as a dam to keep oil in the hub cavity so that it constantly "bathes" the wheel bearings. The seals also protect the wheel bearings by keeping dirt, dust, and water out of the hub. The oil seal is installed between the hub bore, which rotates, and the non-rotating axle spindle.

Most wheel oil seals consist of four basic parts (see **Fig. 1**):

- outside edge (also called outer "cup" or "case")
- inside edge (also called inner "cup" or "case")
- sealing element
- garter spring

The outside edge is usually metal that's coated with rubber or another sealing agent so that it grips the hub bore tightly enough to prevent oil from escaping between the outer edge of the seal and the hub bore.

The inside edge is usually metal or rubber with a metal ring within it to prevent the sealing element from wearing a groove in the axle spindle.

The sealing element is usually molded rubber, leather, or a synthetic such as nitrile or silicone. The element is molded into lips that seal against the axle spindle or against the outside or inside edge described above.

The garter spring is a loop of coiled wire spring that presses the sealing element against the sealing surface.

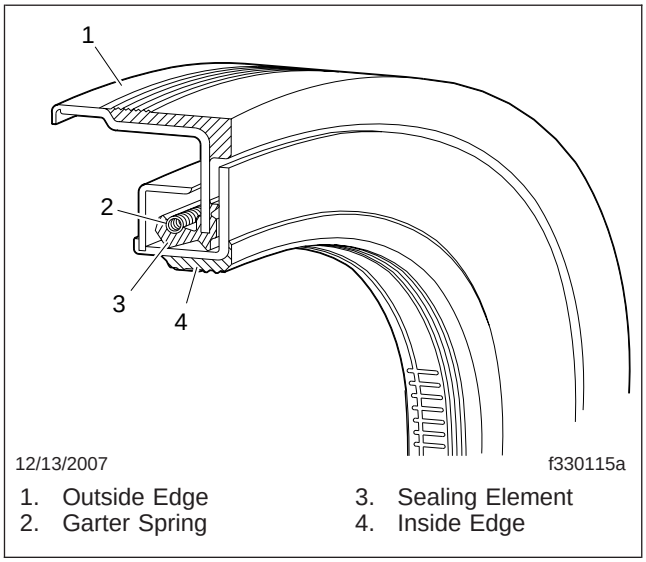



**Fig. 1, Wheel Oil Seal Parts**

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## Seal Replacement, Scotseal Classic

# Replacement

1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 35.01**.
2. Remove the inner wheel bearing assembly from the axle. Handling the bearings with clean dry hands, wrap the bearings in clean oil-proof paper or lint-free cloths. Occasionally, the inner wheel bearing cone assembly will remain in the hub after the hub is removed from the axle. In those cases, place a protective cushion to catch the bearing assembly. Using a hardwood drift and a light hammer, gently tap the bearing and seal out of the inner wheel bearing cup.
3. Clean the spindle, spindle threads, seal bore, and the hub cavity. See **Fig. 1** and **Fig. 2**.
4. Remove all burrs from the shoulder and the seal bore with an emery cloth or a file. Clean any metal filings from the components.

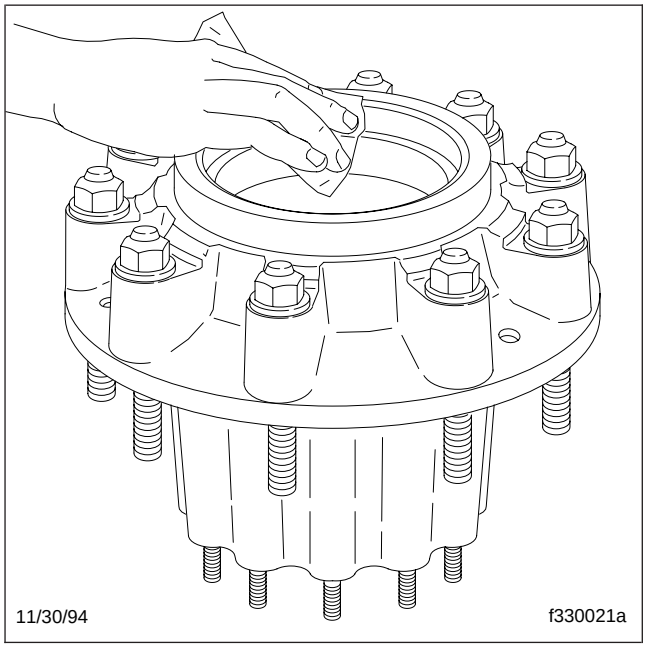
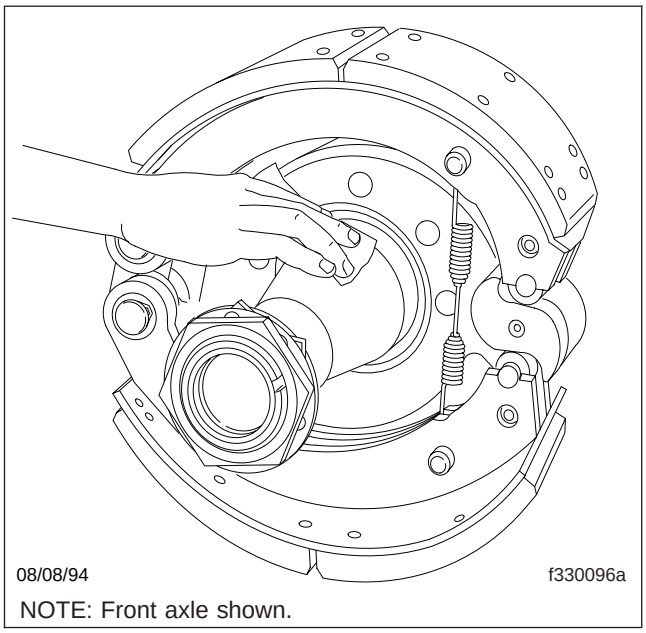



**Fig. 1, Cleaning the Hub**

## NOTICE

**Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.**




NOTE: Front axle shown.

**Fig. 2, Cleaning the Spindle**

IMPORTANT: Use extreme care in cleaning the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause premature wear of the bearing assembly.

5. Inspect the bearings and hub components for wear or damage. Replace any worn or damaged components as necessary.
6. Coat the wheel bearing cones with oil.
7. Install the inner wheel bearing cone in the inner wheel bearing cup.
8. Seat the small outside edge of the seal in the recess of the tool adapter. See **Fig. 3**. The correct adapter is identified on the box.
9. Insert the centering plug of the tool in the bore of the inner bearing cone. See **Fig. 4**. The plug prevents cocking of the seal in the bore.
10. Hold the tool handle firmly, and strike it until the sound of the impact changes as the seal bottoms out. See **Fig. 5**. Hold the tool firmly to avoid bounce or unseating of the seal from the adapter.
11. After the seal is bottomed in the bore, check for freedom of movement by manually rotating the

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## Seal Replacement, Scotseal Classic

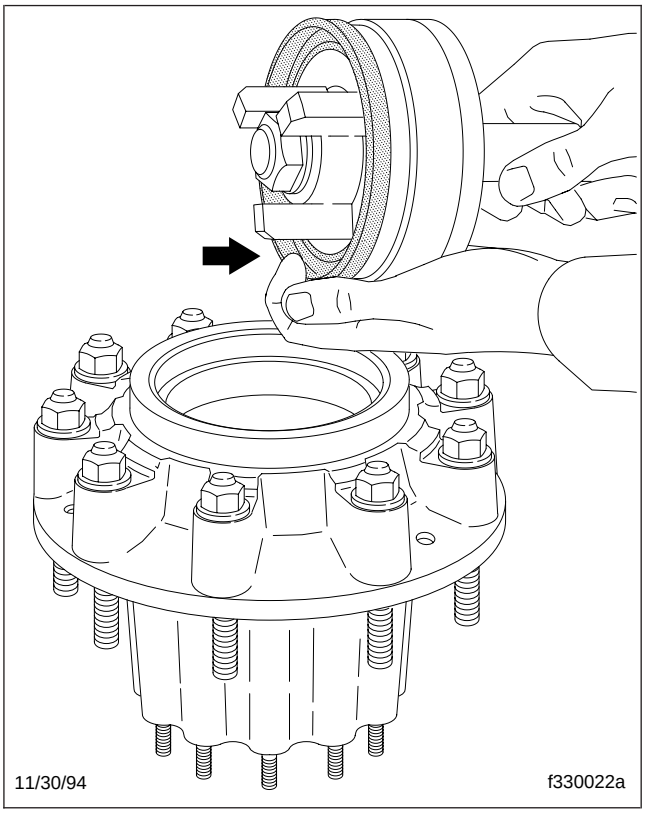



**Fig. 3, Placing the Seal on the Installation Tool**

seal back and forth. A slight movement indicates a damage-free installation.

12. Install the wheel, drum, and hub on the axle and adjust the wheel bearings. For instructions, see **Section 35.01**.

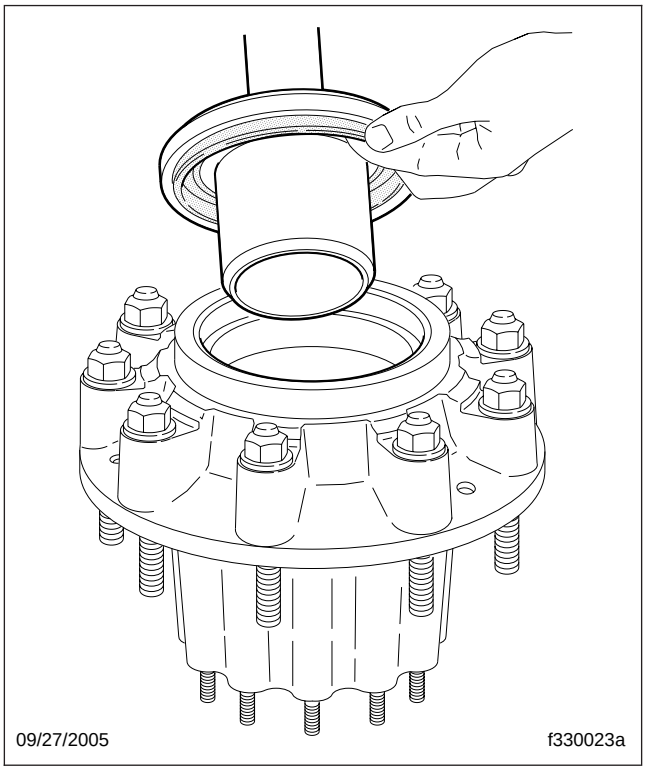



**Fig. 4, Inserting the Tool in the Hub Bore**

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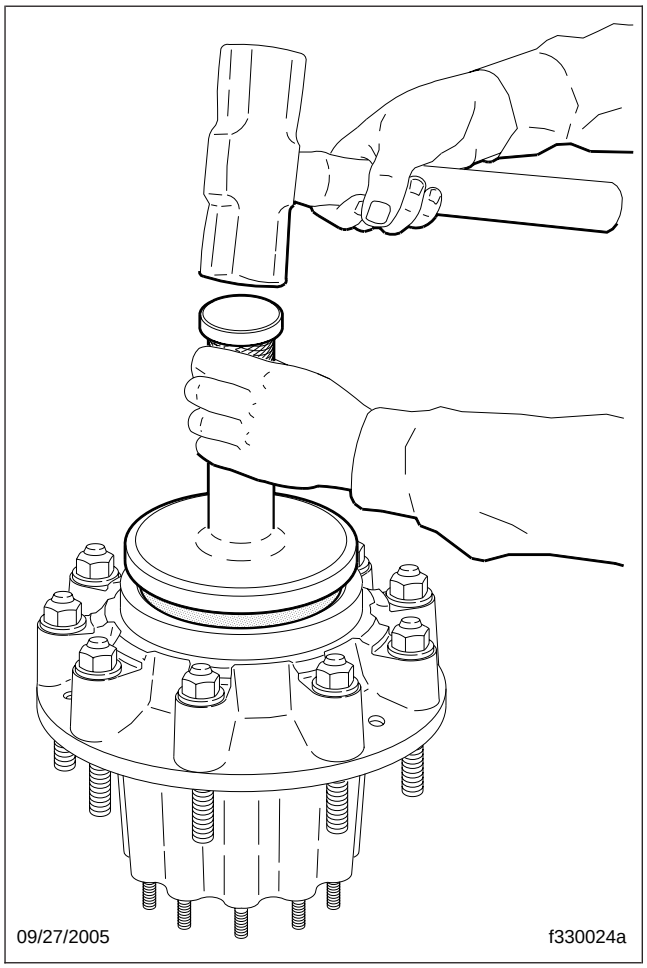



**Fig. 5, Striking the Tool**

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## Seal Replacement, Dana Spicer® Outrunner™

## Replacement

NOTE: This procedure applies to the Dana Spicer Outrunner seal.

1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 35.01**.
2. Remove the inner wheel bearing assembly from the axle. Handling the bearings with clean dry hands, wrap the bearings in clean oil-proof paper or lint-free cloths. Occasionally, the inner wheel bearing cone assembly will remain in the hub after the hub is removed from the axle. In those cases, place a protective cushion to catch the bearing assembly. Using a hardwood drift and a light hammer, gently tap the bearing and seal out of the inner wheel bearing cup.

**⚠ CAUTION**

**Never use a sharp chisel to cut through an axle ring (wear sleeve). A sharp chisel could damage the spindle or shoulder.**

3. Remove the steel axle ring (wear sleeve) by striking the ring surface several times with a ball-peen hammer. See **Fig. 1**. Remove the stretched axle ring from the spindle.

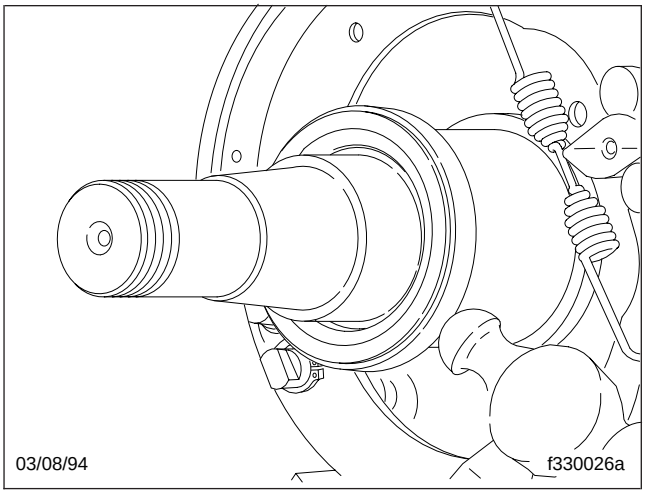



**Fig. 1, Removing the Axle Ring**

4. Clean and inspect the bearings, the spindle, spindle threads, seal bore, and the hub cavity.

   IMPORTANT: Use extreme care in cleaning the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause premature wear of the bearing assembly.

   4.1 Inspect the inner hub bore. Remove dirt and contaminants from all recesses and corners. Smooth any sharp edges with emery cloth, and fill in any grooves with filler. See **Fig. 2**.

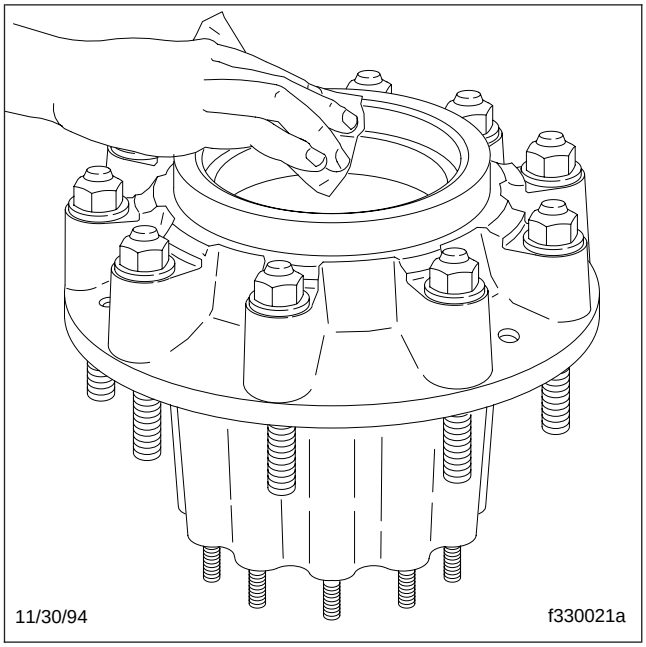



**Fig. 2, Clean and Inspect the Hub Bore**

   4.2 Wipe the hub area with a clean shop cloth.

   4.3 After removing the wear sleeve, inspect the spindle. Remove any sharp edges and burrs from the leading edges and the shoulder area. Repair deep gouges with filler and smooth with an emery cloth. See **Fig. 3**.

   4.4 Wipe the seal and shoulder area with a clean shop cloth.

**⚠ CAUTION**

**Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause**

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## Seal Replacement, Dana Spicer® Outrunner™

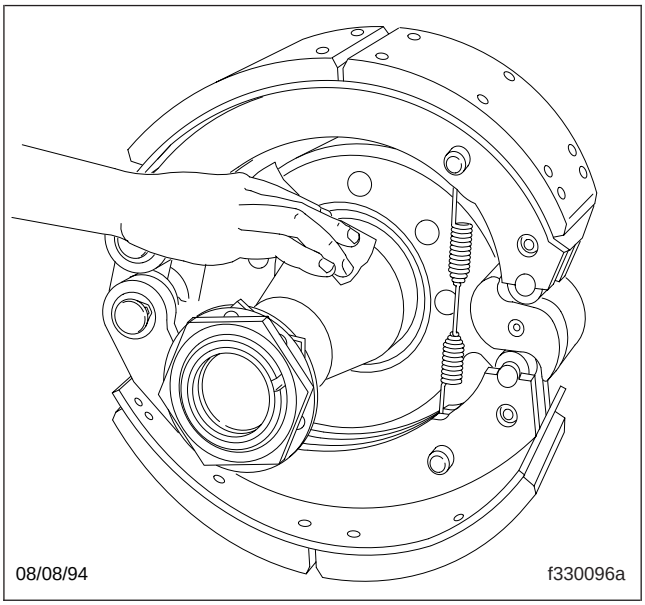



**Fig. 3, Clean and Inspect the Axle Spindle**

**rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.**

4.5 Inspect the bearings and hub components for wear or damage. Replace any worn or damaged components as necessary.

4.6 Coat the wheel bearing cones with oil.

5. Install the inner wheel bearing cone in the inner wheel bearing cup.

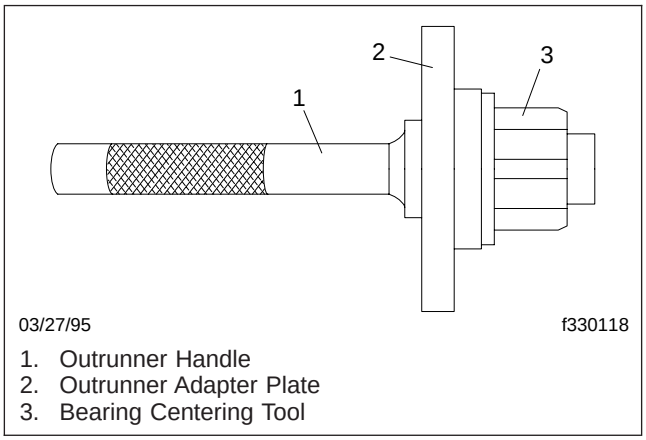
IMPORTANT: Use the Dana Spicer Outrunner installation tool *with the centering tool* when installing the seal. See **Fig. 4**.

6. Install the oil seal in the hub bore.

### ⚠ CAUTION

**Do not use any silicone or permatex type bore sealant with this seal. The Dana Spicer Corporation recommends a light coating of bearing oil on the outer circumference of the seal.**

**Do not mix lubricants of different grades. Do not mix mineral and synthetic lubricants. Do not pack the bearings with grease when using an oil bath system. Failure to follow these installation guidelines will result in less than desired performance of the Outrunner seal, and installation-related failures are not covered under warranty.**




1. Outrunner Handle
2. Outrunner Adapter Plate
3. Bearing Centering Tool

**Fig. 4, Outrunner Installation Tool**

6.1 Place the Outrunner seal tool with the words "air side" facing the adapter plate of the installation tool. See **Fig. 5**. Lubricate the seal outer circumference with wheel bearing oil.

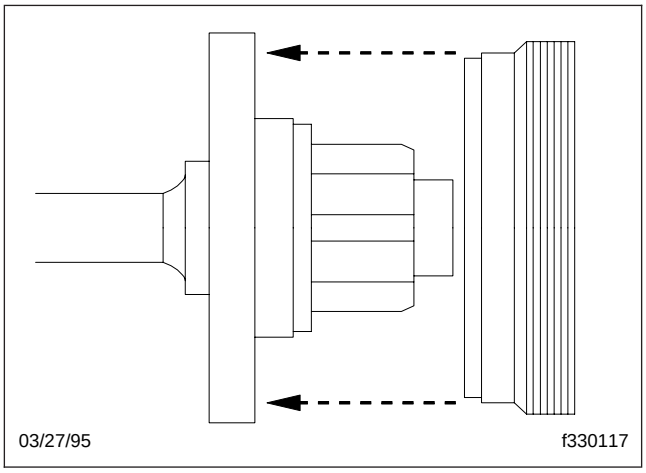



**Fig. 5, Seal Placement on Tool**

IMPORTANT: Install the seal in the hub bore with the hub lying flat. Do not install the seal with the hub in the vertical (upright) position.

6.2 With the hub and the wheel assembly lying flat on the floor, place the inner bearing cone in the cup.

6.3 Position the oil seal in the hub bore. Before striking the handle of the installation

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tool, tap the adapter plate around the outer edge to position the seal. See **Fig. 6**.

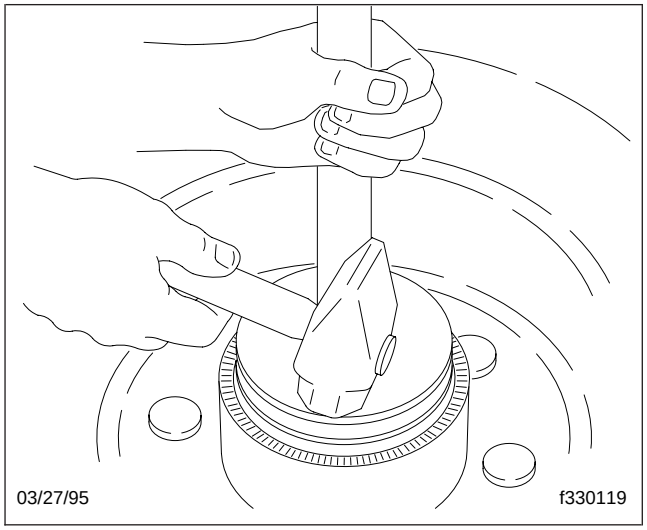



**Fig. 6, Position the Seal**

6.4 Hit the handle of the installation tool *gently*. See **Fig. 7**.

Because of the rubber outer circumference, the Outrunner seal is easier to install than seals with metal outer circumferences. When the adapter plate bottoms out on the hub surface, the seal is installed correctly. You will hear a metal-to-metal sound.

6.5 Check that the seal is not cocked, and that the unitized seal inner circumference and inner bearing turn freely.

6.6 Lubricate the inner circumference of the seal with a light film of clean bearing oil.

7. Install the wheel, drum, and hub on the axle and adjust the wheel bearings. For instructions, see **Section 35.01**.

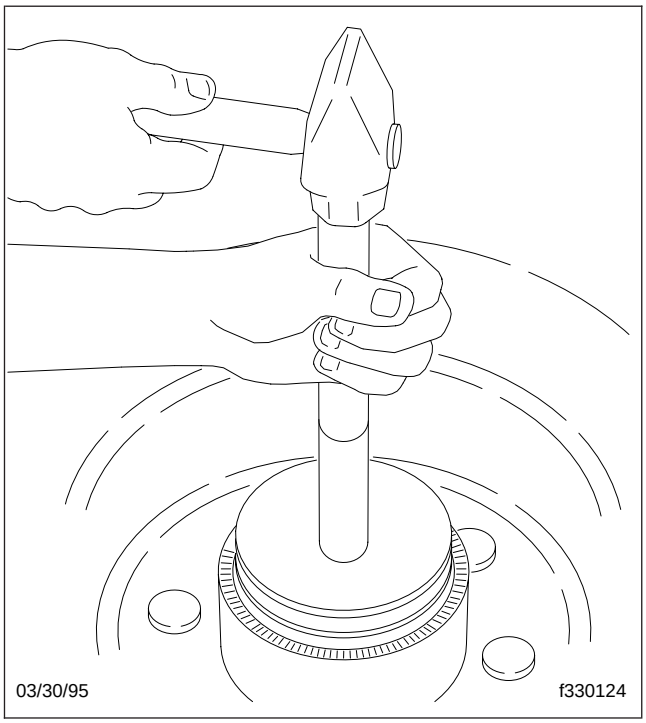



**Fig. 7, Install the Seal**

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## Replacement

1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 35.01**.
2. Remove the old oil seal from the hub or spindle.
3. Clean the spindle, spindle threads, seal bore, and the hub cavity.

**⚠ CAUTION**

**Never use a sharp chisel to cut through an axle ring. A sharp chisel could damage the spindle or shoulder.**

4. Remove the steel axle ring by striking the ring surface several times with a ball-peen hammer. See **Fig. 1**. Remove the stretched axle ring from the spindle.

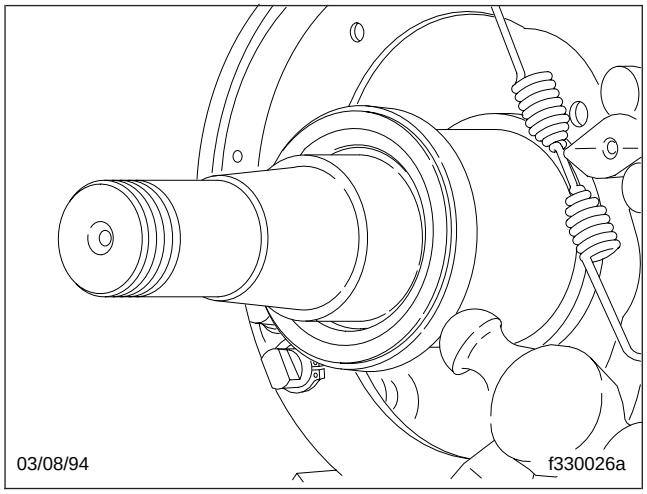



**Fig. 1, Remove the Axle Ring**

5. Using a wire brush, remove any old sealant and corrosion from the axle spindle and shoulder. Remove any burrs with an emery cloth. See **Fig. 2**. Wipe the spindle and shoulder clean with safety solvent.
6. Remove any burrs from the inside of the hub bore. See **Fig. 3**. The hub bore must be free of burrs that will scratch the outer surface of the seal and allow oil to escape from the hub. Remove any spacer rings or washers, if so equipped.

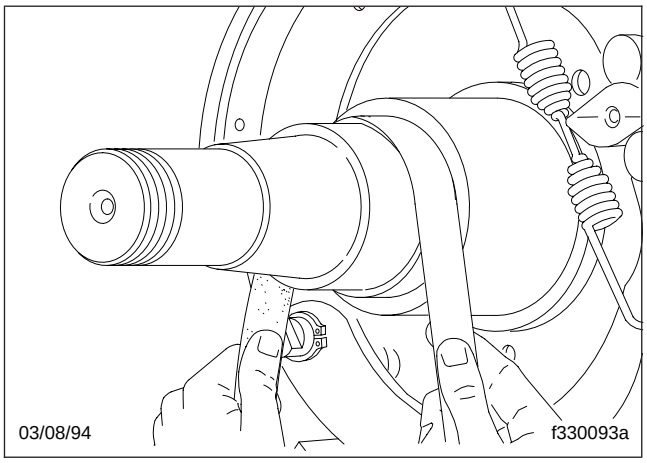
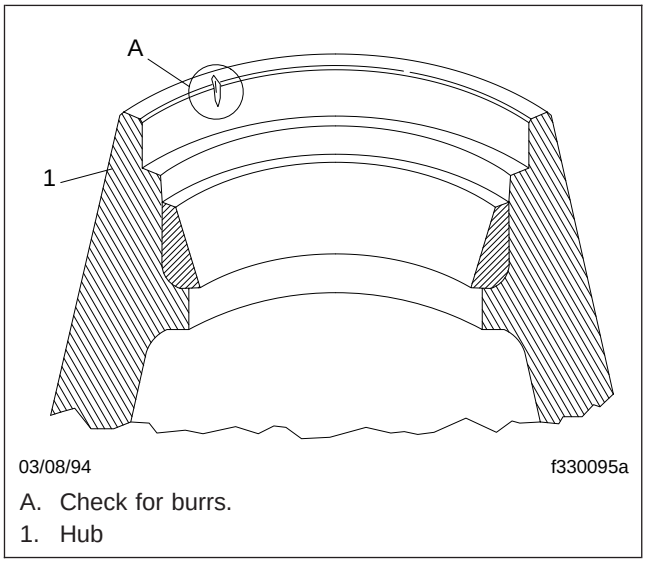



**Fig. 2, Clean the Axle Spindle**




A. Check for burrs.
1. Hub

**Fig. 3, Inspect the Hub Bore**

IMPORTANT: Clean the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause rapid wear of the bearing assembly.

7. Inspect the bearings and hub components for wear or damage. Replace any worn or damaged parts as necessary.

**⚠ CAUTION**

**Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause**

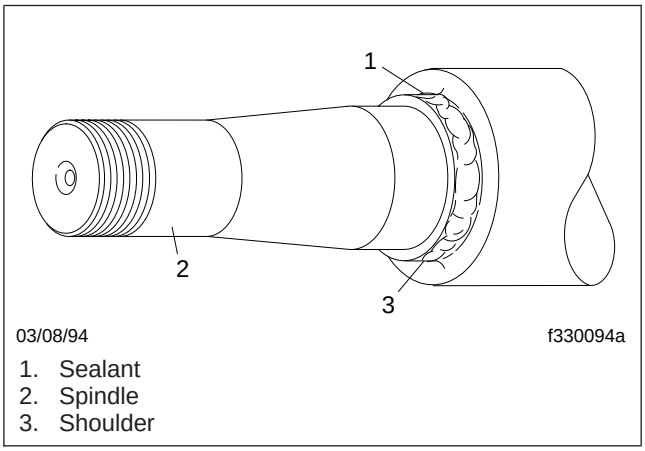
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## Seal Replacement, Stemco®

**rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.**

8. If burrs were removed from the spindle shoulder, apply a thin layer of non-hardening sealant to the spindle shoulder. See **Fig. 4**.




1. Sealant
2. Spindle
3. Shoulder

**Fig. 4, Apply Sealant to the Spindle Shoulder**

NOTE: Use a non-hardening sealant such as Permatex® Number-2 or Loctite® 515.

9. Place the oil seal on the spindle so the words "oil-bearing side" are exposed to the oil. A slight step on the inside circumference of the seal ring will allow it to be placed by hand about 1/8 inch (3 mm) onto the shoulder. See **Fig. 5**.

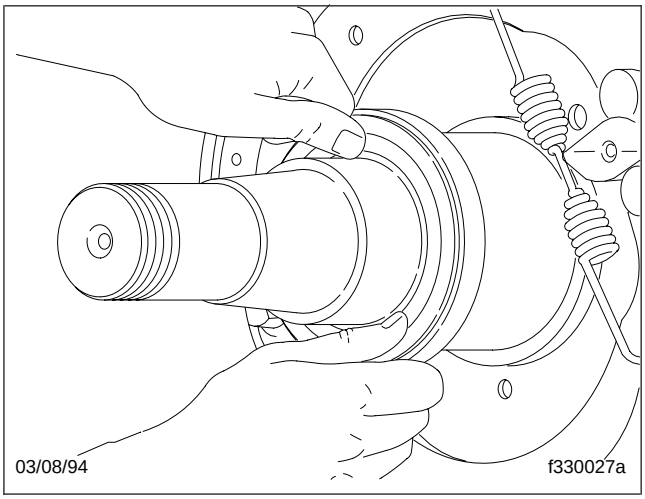



**Fig. 5, Place the Seal on the Spindle**

**CAUTION**

**Do not install the oil seal in the hub bore. Incorrect seal installation will damage the seal and lead to possible spindle, hub, and bearing damage.**

10. Position the Stemco installation tool over the spindle. See **Fig. 6**. Using a 3 to 5 lb (1 to 2 kg) hammer, drive the seal on the spindle until the tool bottoms against the shoulder. After the tool bottoms, turn it while applying several light taps with the hammer to ensure the seal ring is flush with the face of the shoulder. Wipe off all excess sealant.

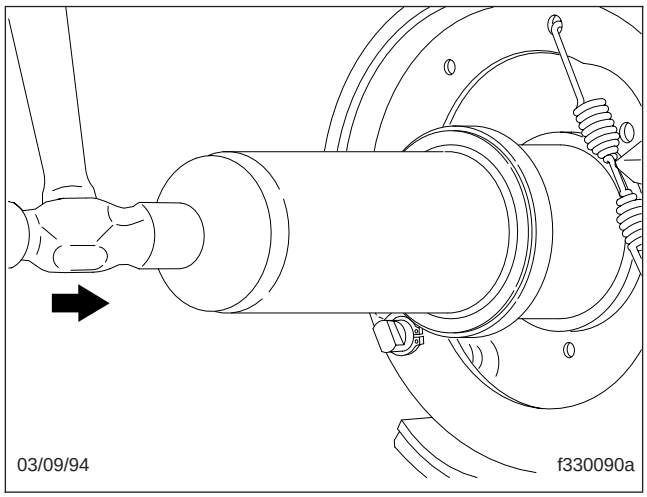



**Fig. 6, Drive the Seal onto the Spindle**

IMPORTANT: Use only the tool specified by Stemco for the vehicle's axle. In order for the Stemco warranty to apply, the product must be correctly installed using the correct tool made by Stemco or a tool approved by Stemco.

11. Make sure there are no gaps between the ring and shoulder. See **Fig. 7**.
12. Coat the inner wheel bearing with oil and install it on the spindle. See **Fig. 8**. No additional oil is needed on the outside of the seal. The seals are lubed at the factory.
13. Install the wheel, drum, and hub on the axle and adjust the wheel bearings. For instructions, see **Section 35.01**.

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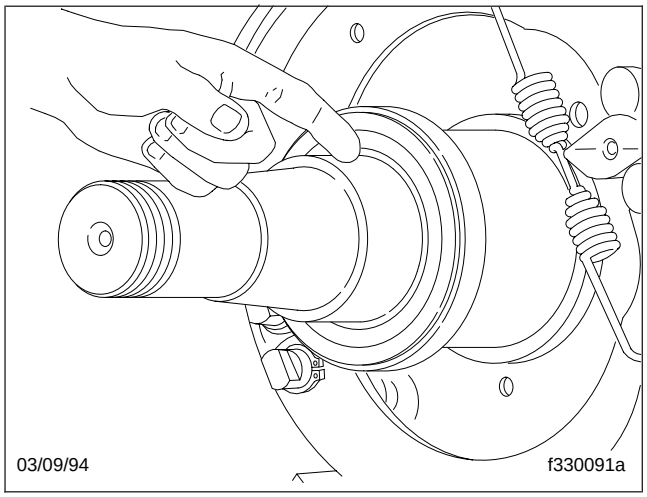



**Fig. 7, Check the Ring for Gaps**

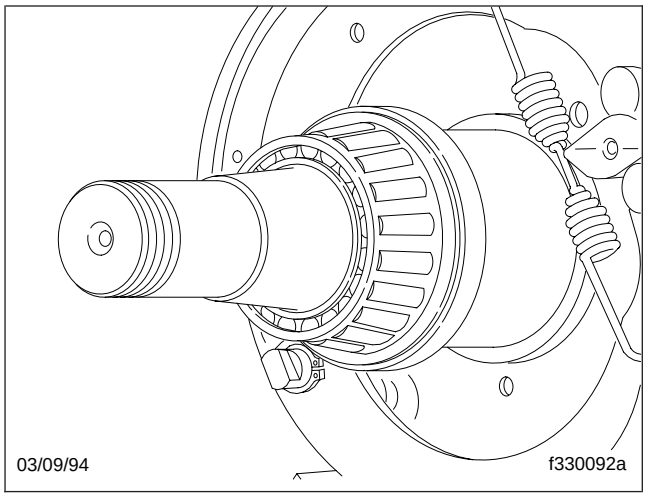



**Fig. 8, Install the Inner Bearings**

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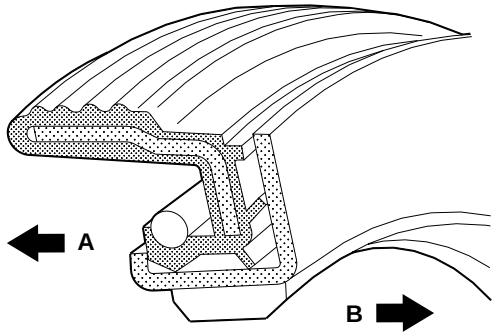
## Seal Replacement, Scotseal Plus XL

## General Information

The Scotseal Plus XL (see **Fig. 1**) is a unitized, one-piece seal. The outer diameter of the metallic case and the bore diameter of the seal counter face are coated with rubber. The seal is press-fit into the hub bore using Scotseal service installation tools. *Do not install the Scotseal Plus XL directly onto the axle spindle.*

Although you install the Scotseal Plus XL into the hub bore, the seal's element grips the axle spindle tightly enough that the sealing element stays stationary with the spindle, and seals against the outer cup, which turns with the hub.

IMPORTANT: Make sure the required tools are available before beginning the service procedures described here. See **Table 1** for tool and seal numbers. See **Fig. 2** for a diagram of the installation tool. Ensure that the **flat side** of the driver plate faces the seal.




A. Oil and Bearing Side
B. Air Side

**Fig. 1, Scotseal Plus XL**

| Scotseal Plus XL Seal and Tool Numbers | | | |
|---|---|---|---|
| **Bearing Cone** | **Seal Stock Number** | **Centering Tool Number** | **Driver Tool** |
| SBN 594ATRB | CHR 47691* | CHR 715 | CHR 435† |

* The seal stock number is listed on the air-side flange of the seal.

† The number 435 driver tool is the same one used for the Scotseal Classic.

**Table 1, Scotseal Plus XL Seal and Tool Numbers**

## Replacement

1. Remove the wheel, drum, and hub from the axle. For instructions, see **Section 35.01**.
2. Remove the inner wheel bearing assembly from the axle. Handle the bearings with clean dry hands, and wrap the bearings in clean oil-proof paper or lint-free cloths. Occasionally, the inner wheel bearing cone assembly will remain in the hub after the hub is removed from the axle. In those cases, place a protective cushion to catch the bearing assembly. Using a hardwood drift and a light hammer, gently tap the bearing and seal out of the inner wheel bearing cup. Discard the seal.
3. Clean the spindle, spindle threads, seal bore, and hub cavity. See **Fig. 3** and **Fig. 4**.
4. Remove all burrs from the shoulder and the seal bore with an emery cloth or a file. Clean any metal filings from the components.

### NOTICE

**Do not spin bearing rollers at any time. Dirt or grit can scratch the roller surface and cause rapid wear of the bearing assembly. Treat used bearings as carefully as new ones.**

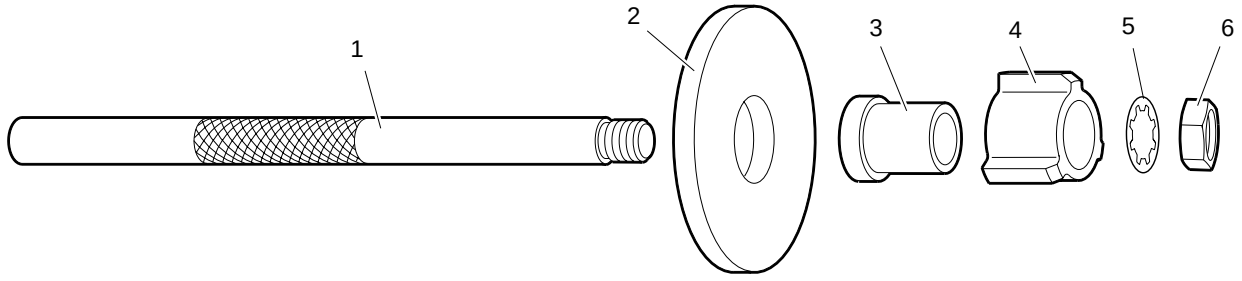
IMPORTANT: Use extreme care in cleaning the wheel hub cavity and axle spindle. Dirt, metal filings, or other contaminants can scratch the bearing roller surfaces, and cause premature wear of the bearing assembly.

5. Inspect the bearings and hub components for wear or damage. Replace any worn or damaged components as necessary.
6. Coat the wheel bearing cones with oil.

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## Seal Replacement, Scotseal Plus XL

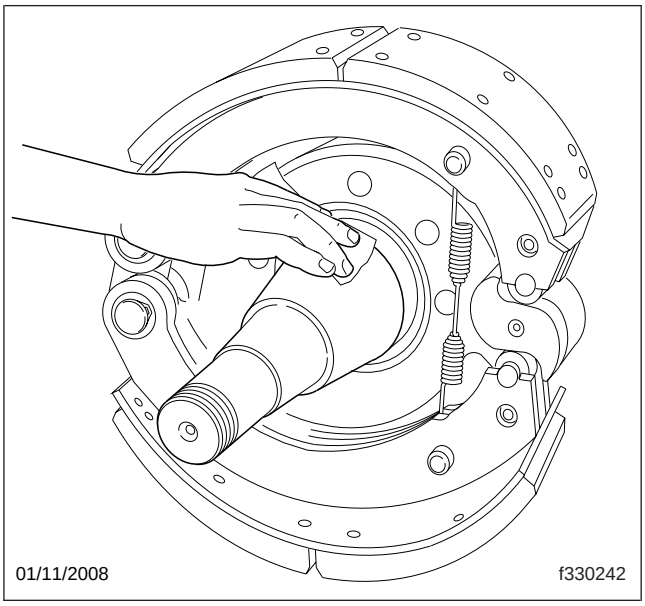



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NOTE: Ensure that the flat side of the driver plate faces the seal when installing a Scotseal Plus XL.

1. Handle
2. Driver Plate
3. Bushing
4. Centering Tool
5. Washer
6. Nut

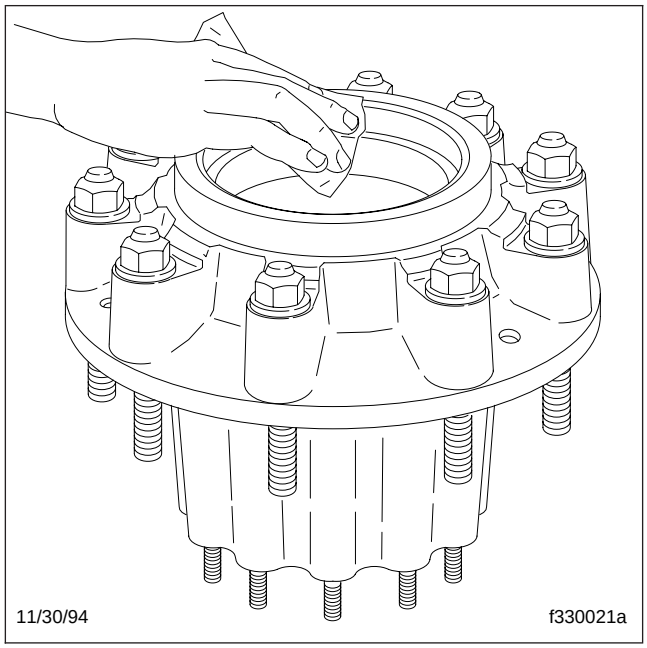
**Fig. 2, Installation Tool**



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**Fig. 3, Cleaning the Spindle**

7. Install the inner wheel bearing cone in the inner wheel bearing cup.
8. Inspect a new seal for damage (such as cuts or being out of round) and contamination. If damage is evident, discard it and use a suitable seal.
9. Apply a thin layer of lubricant to the inside and outside diameters of the seal using the same lube used in the hub.



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**Fig. 4, Cleaning the Hub**

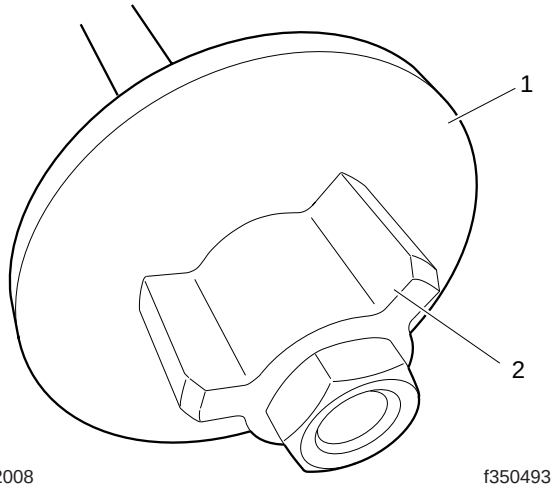
10. Using the appropriate driver plate and centering tool, assemble the installation tool so that the flat side of the plate is the seal installation surface. See **Fig. 5**.
11. Seat the seal in the seal bore with the "air side" facing outward ("air side" is stamped on the sleeve flange of the seal).

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## Seal Replacement, Scotseal Plus XL

12. Insert the centering tool into the bore of the inner bearing cone (to prevent cocking of the seal), and press the seal down firmly with the flat side of the driver plate. See **Fig. 6**.
13. To avoid bounce or unseating of the seal, hold the tool handle firmly, and strike it until the seal bottoms out. See **Fig. 7**.
14. After the seal is bottomed in the bore, check for freedom of movement by manually rotating the seal back and forth. A slight movement indicates a damage-free installation. If any damage is visible, remove the seal and install a new one.
15. Install the hub and drum on the axle, adjust the wheel bearings, then install the wheel. For instructions, see **Section 35.01**.




1. Driver Plate 2. Centering Tool

**Fig. 5, Installation Tool, Assembled**

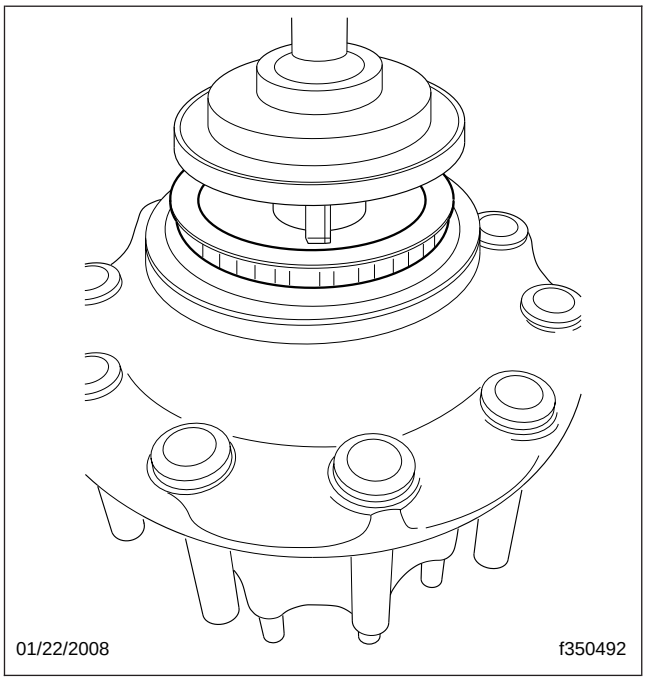



**Fig. 6, Inserting the Centering Tool into the Hub Bore**

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## Seal Replacement, Scotseal Plus XL

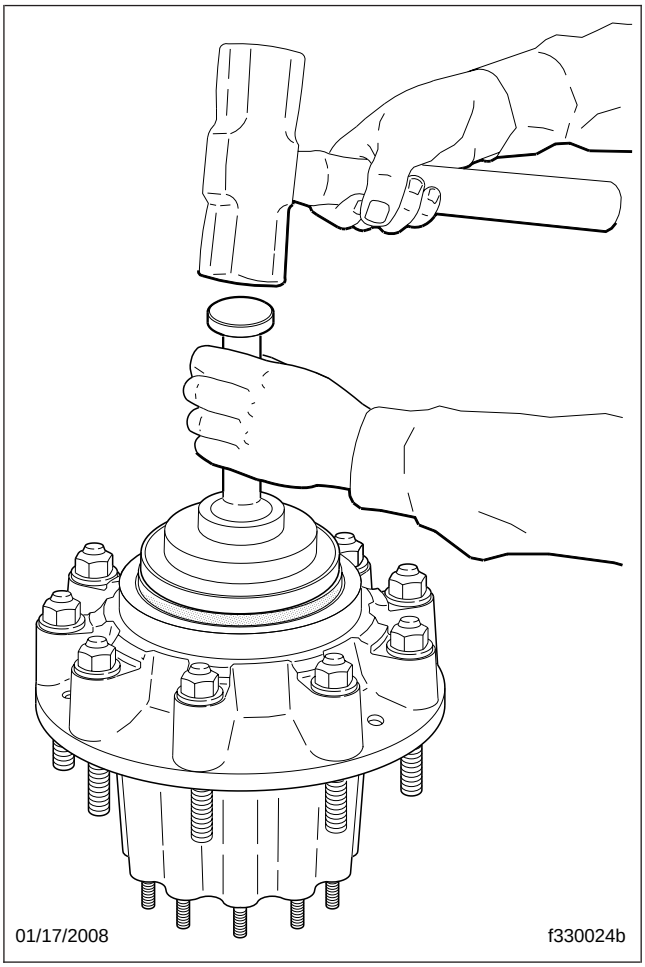



**Fig. 7, Striking the Tool**

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## General Information

Although Detroit axles are a proprietary product, in some applications they may be referred to as "Axle Alliance axles" or "M-B components."

Detroit rear axles are compatible with industry-standard brakes, hubs, and wheel bearings.

The following explains an example of the number found on a Detroit rear axle identification tag, which is located on the carrier. See **Fig. 1**.

Typical Model Number: ART-40.0-4

- *ART* = tandem rear axle
- *40.0* = weight rating (times 1000 lb)
- *4* = basic model number

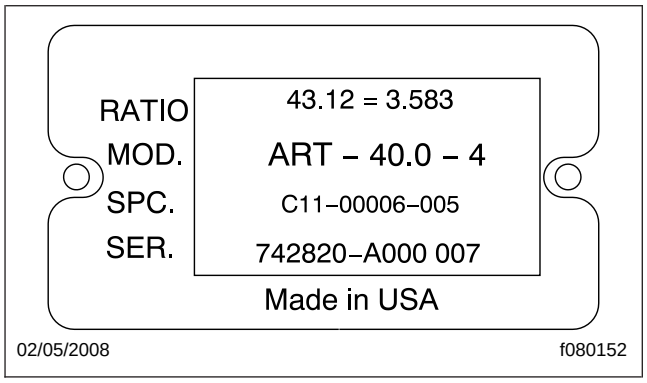



**Fig. 1, Rear Axle ID Tag**

Detroit rear axles may have a main differential lock, which is commonly known as the "DCDL" (Driver-Controlled Differential Lock). The DCDL is an optional feature that can lock the differential assembly to improve traction on icy road conditions. When the differential lock is engaged, the clutch collar completely locks the differential case, gearing, and axle shafts together to maximize traction of both wheels and protect against spinout. Each part of the DCDL is replaceable; see **Subject 180**.

On tandem axles there are three possible differential lock options: forward-rear carrier only, rear-rear carrier only, or both rear carriers.

## Warranty

To assist in the determination of warrantable and non-warrantable failures for these axles, warranty evaluation guides are available through WarrantyLit on **www.accessfreightliner.com**. These guides help determine whether or not pre-approval is needed for a repair. The following evaluation guides are available:

- **Warranty Evaluation Guide**
- **Submission Guidelines - Differential Cross Failure**
- **Submission Guidelines - Pinion Bearing Cage Damage**
- **Submission Guidelines - Pinion Nut Failure**
- **Submission Guidelines - Thrust Bearing Failure**
- **Submission Guidelines - Yoke (Pinion) End Play**

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# Single or Rearmost Axle Removal and Installation

## Removal

For rear axle components, see **Fig. 1**.

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires. Put the transmission in neutral.
2. Using a suitable jack, raise the vehicle enough to take the weight off the axles, but not enough to raise the tires off the ground.
3. At both ends of the axle, loosen all the wheel nuts.
4. Continue to raise the vehicle evenly until there is room to fit a stand underneath the axle housing.

**⚠ WARNING**

**Never work around or under a vehicle that is supported only by a jack. Always support the vehicle with safety stands. Jacks can slip, allowing the vehicle to fall, which could result in serious injury or death.**

5. Support the vehicle with safety stands.
6. Remove the tire and wheel assemblies.
7. Drain the oil from the differential housing. Install the drain plug.
8. Disconnect the driveshaft from the differential carrier. For instructions, see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
9. Release the parking brakes.
10. Cage the parking brake springs to prevent the parking brakes from engaging. For instructions, see **Group 42**.
11. If DCDL is installed on the vehicle, use the DCDL switch in the cab to engage the lock. An indicator light comes on when the differential lock is engaged. Turn the appropriate hubs to ensure the lock is fully engaged.
12. Drain the air system.
13. Place a basin under the axle shaft flanges to catch any oil, then remove the axle shafts. For instructions, see **Subject 120**.
14. Disconnect the DCDL air line from the carrier housing.
15. If necessary, back off the slack adjusters, then remove the brake drums.
16. Remove the hubs from the axle spindles. For instructions, see **Section 35.01, Subject 100**.
17. Remove the brake shoes. For instructions, see the applicable service brake section in **Group 42**.
18. If applicable, disconnect the leveling valve rod(s) from the suspension.
19. At the frame rail or crossmember, disconnect the wiring for the ABS sensors. Remove any tie straps that hold the wires to the frame rails.
20. Disconnect the air lines from the rear brake chambers.
21. Remove the brake air chambers and the slack adjusters from the axle housing. For instructions, see **Group 42**.
22. Remove the ABS sensors and wiring, and the fasteners that hold the brake spiders to the axle flanges. Remove the spiders from the axle.
23. Using a suitable jack, support the axle housing.
24. If applicable, remove the hexnuts that hold the bottom of each suspension air bag to its suspension bracket.
25. Remove the suspension components that attach the axle to the vehicle. If applicable, remove the U-bolt nuts from the U-bolts. Discard the U-bolt nuts and U-bolts.
26. Lower the axle enough to clear the suspension components.
27. Remove the axle from the vehicle.
28. If you are going to replace the differential carrier, place the axle on a secure axle stand.

## Installation

1. Position the axle underneath the vehicle.
2. Install the suspension components that attach the axle to the vehicle, as follows.

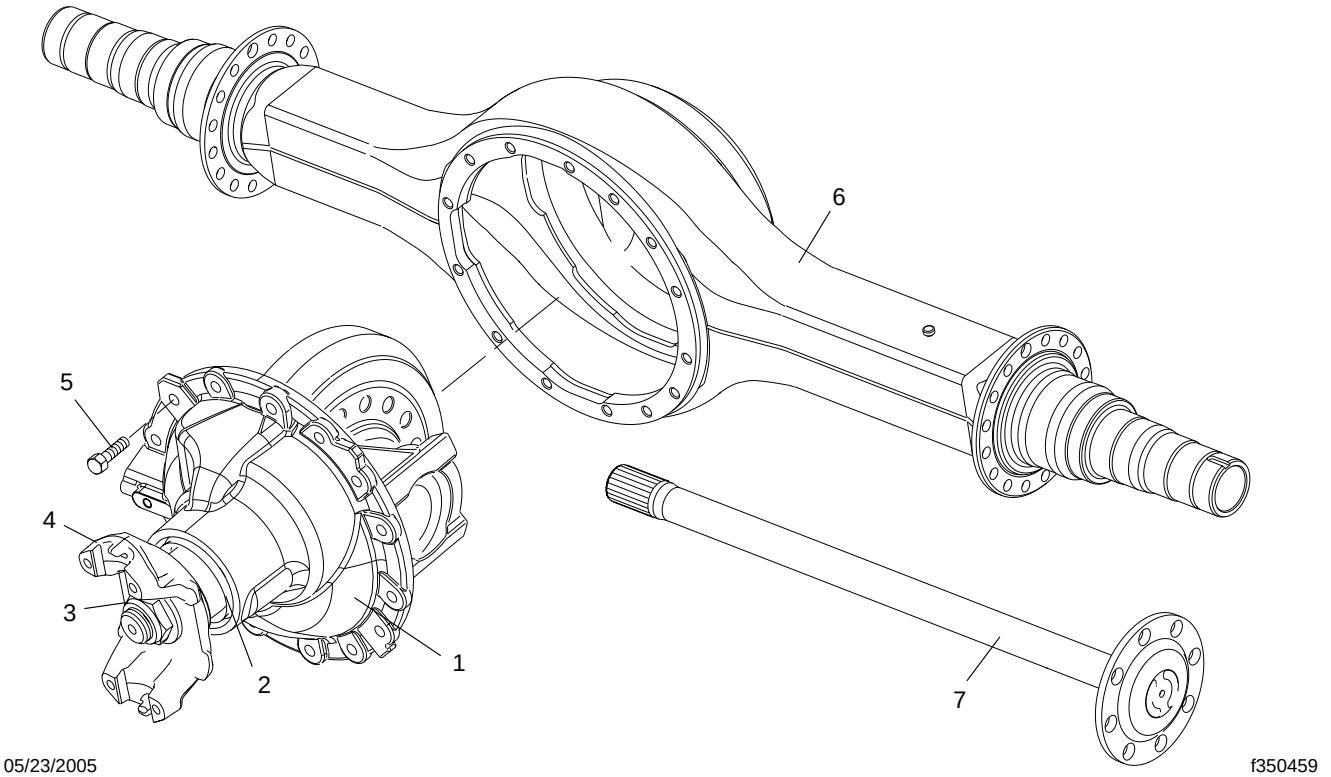
   NOTE: U-bolts and U-bolt nuts cannot be reused.

   2.1 On vehicles with conventional suspensions, install the upper U-bolt brackets,

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## Single or Rearmost Axle Removal and Installation




1. Differential Carrier
2. Radial Shaft Seal
3. Yoke Nut
4. Carrier Yoke
5. Carrier Capscrew
6. Rear Axle Housing
7. Axle Shaft

**Fig. 1, Single or Rearmost Axle Components**

new U-bolts, lower U-bolt brackets, and new U-bolt nuts.

On vehicles with air suspensions, in addition to the U-bolts, install the hexnuts that attach the air springs to the suspension brackets. For torque values, see **Group 32**.

On vehicles without U-bolts, install the walking beams.

2.2 If applicable, tighten the new U-bolt nuts in a diagonal pattern. For torque values, see **Group 32**.

3. Connect the driveshaft to the differential carrier yoke. For instructions, see **Section 41.00, Subject 120**.
4. Install the brake spiders on the axle flanges. For instructions, see the applicable service brake section in **Group 42**.
5. Install the ABS sensors and connect the wiring at the frame rail. Secure the wiring with tie straps as needed.
6. Install the brake air chambers and slack adjusters on the axle housing brackets. For instructions, see **Group 42**.
7. Connect the air lines to the brake air chambers.
8. Install the brake shoes, as removed. For instructions, see the applicable service brake section in **Group 42**.
9. Fill each hub with approved axle oil until you can see a little amount of oil trickling out of the back of the hub (use about 0.8 quart, or 0.75 liter). Install the hubs on the axle spindles, and adjust

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the wheel bearings. For instructions, see the applicable subject in **Section 35.01**.

NOTE: See **Table 1** for approved axle oils.

10. If DCDL is installed on the vehicle, connect the DCDL air line, fill the air system, and use the DCDL switch in the cab to engage the lock. An indicator light comes on when the differential lock is engaged.
11. Using new gaskets, install the axle shafts. For instructions, see **Subject 120**.
12. Install the brake drums on the hubs.
13. Install the wheels and tires. For instructions, see **Group 40**.
14. Adjust the brakes. For instructions, see the applicable service brake section in **Group 42**.
15. Uncage the parking brake springs.
16. Using approved axle oil, fill the axle housing to the bottom of the fill hole, or until filled to capacity as shown in **Table 1**.

| Single Rear Axle Oil Type and Capacity | | |
|---|---|---|
| Approved Oil Type | Capacity: quarts (liters) | |
| | Hubs Full | Hubs Dry |
| 80W-90 Gear Oil | 10.6 (10.0) | 12.2 (11.5) |
| 75W-90 Synthetic Gear Oil | | |

**Table 1, Single Rear Axle Oil Type and Capacity**

17. Raise one side of the vehicle about 8 inches (20 cm) to let the oil flow into the hub on the opposite side, then raise the other side in the same manner. On each side, hold the tilted position for three minutes to allow oil to run into the wheel end.

## NOTICE

**Make sure the hubs are filled. Driving with the hubs dry will cause bearing damage.**

18. Turn the wheels, wait one minute, and check the lubricant level.
19. Raise the vehicle, remove the safety stands, then lower the vehicle.
20. If applicable, connect the suspension leveling valve(s). Start the engine, build the air pressure, and make sure the suspension air bags inflate correctly. Make sure the ride height is correct. For instructions, see **Group 32**.
21. Check the oil level in the axle housing. The level should be up to the bottom of the fill hole. Add approved axle oil, if needed.
22. Set the parking brake.

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# Single or Rearmost Axle Differential Carrier Removal and Installation

## Removal

NOTE: The differential carrier can be removed either with the rear axle installed on the vehicle or with the rear axle removed from the vehicle.

### Axle Installed on Vehicle

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires. Put the transmission in neutral.
2. If applicable, release the suspension air pressure.
3. Using suitable jacks, raise the vehicle evenly until there is room to fit a jack underneath the axle housing.
4. Remove the tire and wheel assemblies. For instructions, see **Group 40**.
5. Drain the oil from the axle housing.
6. Disconnect the driveshaft from the carrier yoke. For instructions, see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
7. If DCDL is installed on the vehicle, use the DCDL switch in the cab to engage the lock. An indicator light comes on when the differential lock is engaged. Turn the appropriate hubs to ensure the lock is fully engaged.
8. Place a basin under the axle shaft flanges, then remove the axle shafts. For instructions, see **Subject 120**.
9. Do the steps under the heading, "Axle Removed from Vehicle."

### Axle Removed from Vehicle

1. Using a suitable jack, support the differential carrier. Chain the differential carrier to the jack.
2. If DCDL is installed on the vehicle, ensure the lock is engaged. Turn the appropriate wheels to verify it is fully engaged.

**⚠ WARNING**

**The differential carrier is heavy. Do not try to move it without a suitable support. To do so could result in the carrier falling, which could cause serious personal injury and component damage. Support the carrier with a suitable jack and chain it to the jack, or use a hoist if the axle has been removed from the vehicle.**

3. Remove the carrier capscrews that hold the differential carrier to the axle housing. See **Fig. 1**.
4. With the differential carrier securely supported, remove it from the axle housing.

## Installation

IMPORTANT: If you replace the yoke on the differential carrier, use a *new* nut when installing the new yoke.

NOTE: Use a cleaning solvent and clean rags to remove dirt. Blow dry the cleaned areas with air.

1. Remove any old sealant material from the mating surfaces of the axle housing. Clean the inside of the rear axle housing and the forward carrier mating surface.
2. Inspect the axle housing for damage. Repair or replace the axle housing as necessary.
3. Apply a thin bead of Loctite® 5900 sealant all the way around the mating surface of the axle housing, and around each bolt hole.

NOTE: Alignment dowels for installing the differential carrier can be made by sawing off the heads of two M16 x 1.5 x 100 mm bolts.

4. Install alignment dowels 180 degrees apart at the 3 o'clock and 9 o'clock positions on the axle housing flange.
5. If DCDL is installed on the vehicle, ensure it is engaged.

**NOTICE**

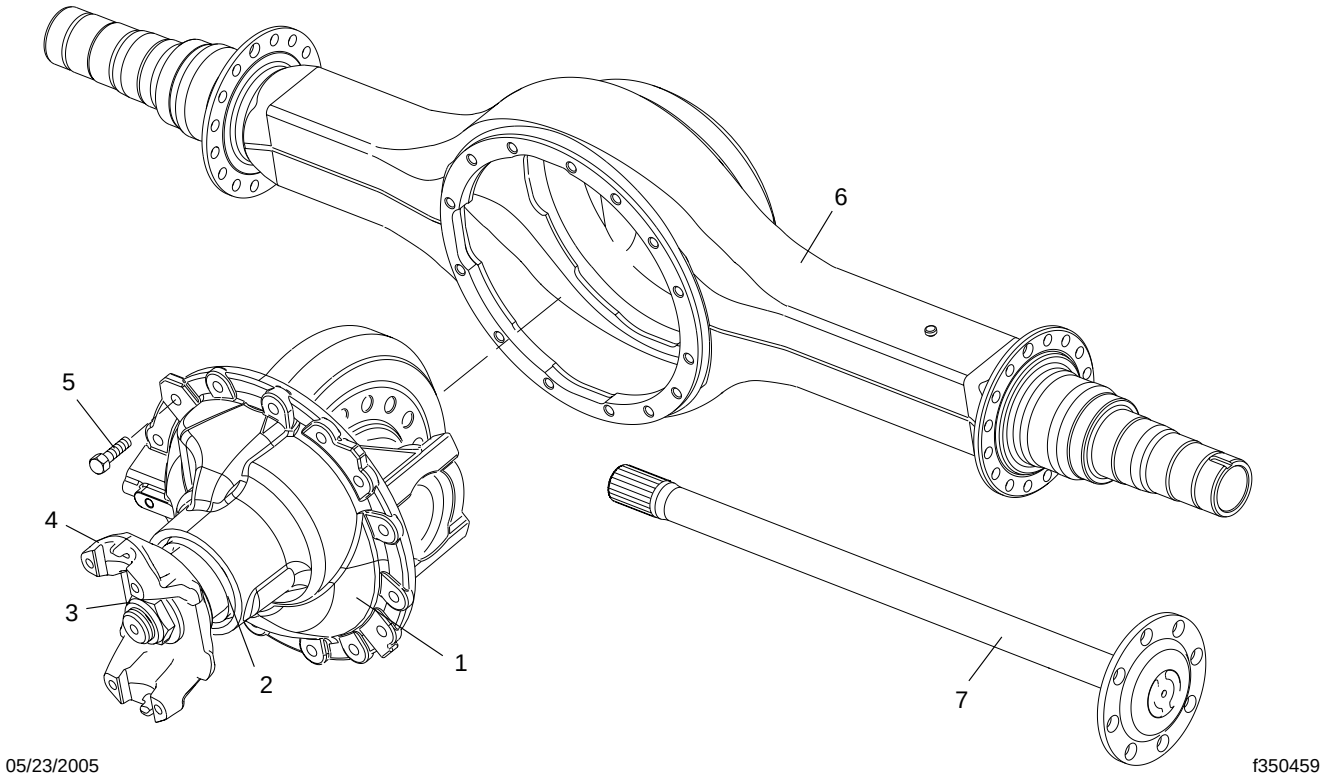
**Make sure the differential carrier is centered and straight on the axle housing before you install the mounting capscrews. Attempting to install the carrier when it is not centered or straight may cause damage to the carrier.**

6. Using a hoist (if the axle is removed from the vehicle) or a suitable transmission jack, install the differential carrier into the axle housing. Use the alignment dowels to center the carrier on the axle housing.

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## Single or Rearmost Axle Differential Carrier Removal and Installation




1. Differential Carrier
2. Radial Shaft Seal
3. Yoke Nut
4. Carrier Yoke
5. Carrier Capscrew
6. Rear Axle Housing
7. Axle Shaft

**Fig. 1, Single or Rearmost Axle Components**

7. Install the end caps on the sides of the carrier into the corresponding slots in the axle housing. See **Fig. 2**.
8. For the last 3/4 inch (19 mm) or so of travel, walk the carrier slowly into the housing.

IMPORTANT: The end caps fit tightly into the axle housing. Be very careful not to cock the carrier.

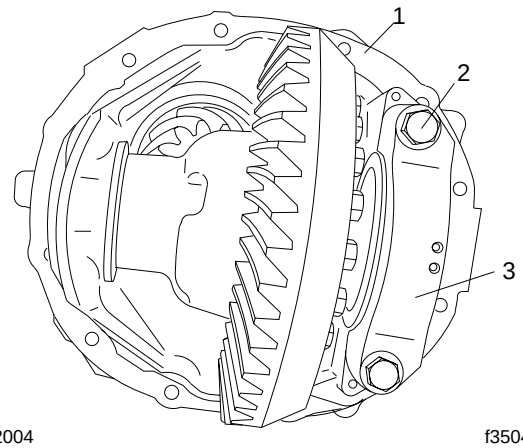
9. Install the carrier capscrews finger-tight. Make sure the carrier capscrews turn easily in the axle housing.
10. In a star pattern, gradually tighten the M16 carrier capscrews 200 lbf·ft (270 N·m).
11. If removed, install the axle on the vehicle. For instructions, see **Subject 100**.

    If the axle is already on the vehicle, go to the next step.
12. Connect the driveshaft to the carrier yoke. For instructions, see **Section 41.00, Subject 120**.
13. Using new gaskets, install the axle shafts. For instructions, see **Subject 120**.
14. Install the wheels and tires. For instructions, see **Group 40**.
15. Using approved axle oil, fill the axle housing to the bottom of the fill hole, or until filled to capacity as shown in **Table 1**.

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## Single or Rearmost Axle Differential Carrier Removal and Installation




1. Differential Carrier
2. End Cap Bolt
3. End Cap

**Fig. 2, Carrier End Caps**

| Axle Oil Capacities | | |
|---|---|---|
| Axle Model | Oil Capacity: quarts (liters) | |
| | Hubs Full | Hubs Dry |
| Model 4 | 10.6 (10.0) | 12.2 (11.5) |

**Table 1, Axle Oil Capacities**

16. Raise one side of the vehicle about 8 inches (20 cm) to let the oil flow into the hub on the opposite side, then raise the other side in the same manner. On each side, hold the tilted position for three minutes to allow oil to run into the wheel end.

## NOTICE

**Make sure the hubs are filled. Driving with the hubs dry will cause bearing damage.**

17. Turn the wheels, wait one minute, and check the lubricant level.
18. Raise the vehicle, remove the safety stands, then lower the vehicle.
19. Start the engine, build the air pressure, and check that the suspension air bags inflate evenly and correctly. Make sure the ride height is correct.
20. Check the oil level in the axle housing. The level should be up to the bottom of the fill hole. Add approved axle oil, if needed.

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## Removal

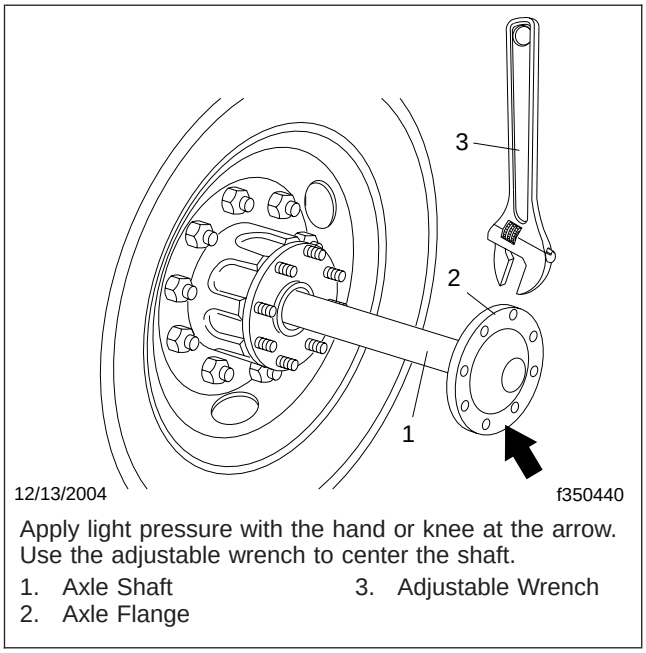
1. Chock the front tires.
2. Raise the rear of the vehicle with a suitable jack high enough to clear the axle. Support the axle with jack stands.
3. If DCDL is installed on the vehicle, use the DCDL switch in the cab to engage the lock. An indicator light comes on when the differential lock is engaged. Turn the appropriate wheels to ensure the lock is fully engaged.
4. Place a basin under the axle shaft flanges to catch any oil. Dispose of used oil properly.
5. If necessary, remove the tires. For procedures, see **Group 40**.

NOTE: This procedure can be done with the wheels and tires installed or with the wheels and tires removed.

6. Remove the drive axle stud nuts that attach the axle shaft to the wheel hub.
7. Tap the axle shaft flange if necessary to loosen it, then slide the axle shaft out of the axle. Remove and discard the gasket.

## Installation

1. Position a new gasket on the axle shaft flange.
2. If DCDL is installed on the vehicle, ensure it is engaged.
3. Install the axle shaft, as follows. See **Fig. 1**.
   - 3.1 Carefully raise the axle with a floor jack, and support the axle with jack stands. Slide the axle shaft into the axle.
   - 3.2 Apply light pressure with the hand or knee to the axle flange.
   - 3.3 Use an adjustable wrench to center the shaft. Turn the shaft with a slight rotating motion.
   - 3.4 Install the drive axle stud nuts and tighten them to the values given.
     - 1/2–20 nuts: 75 to 115 lbf·ft (102 to 156 N·m)
     - 5/8–18 nuts: 150 to 170 lbf·ft (203 to 230 N·m)




Apply light pressure with the hand or knee at the arrow. Use the adjustable wrench to center the shaft.

1. Axle Shaft
2. Axle Flange
3. Adjustable Wrench

**Fig. 1, Installing the Axle Shaft**

4. If removed, install the tires and tighten the wheel nuts according to the procedures in **Group 40**.
5. Remove the supports and lower the vehicle.
6. As needed, replace any oil that was drained from the hub when the axle shaft was removed.

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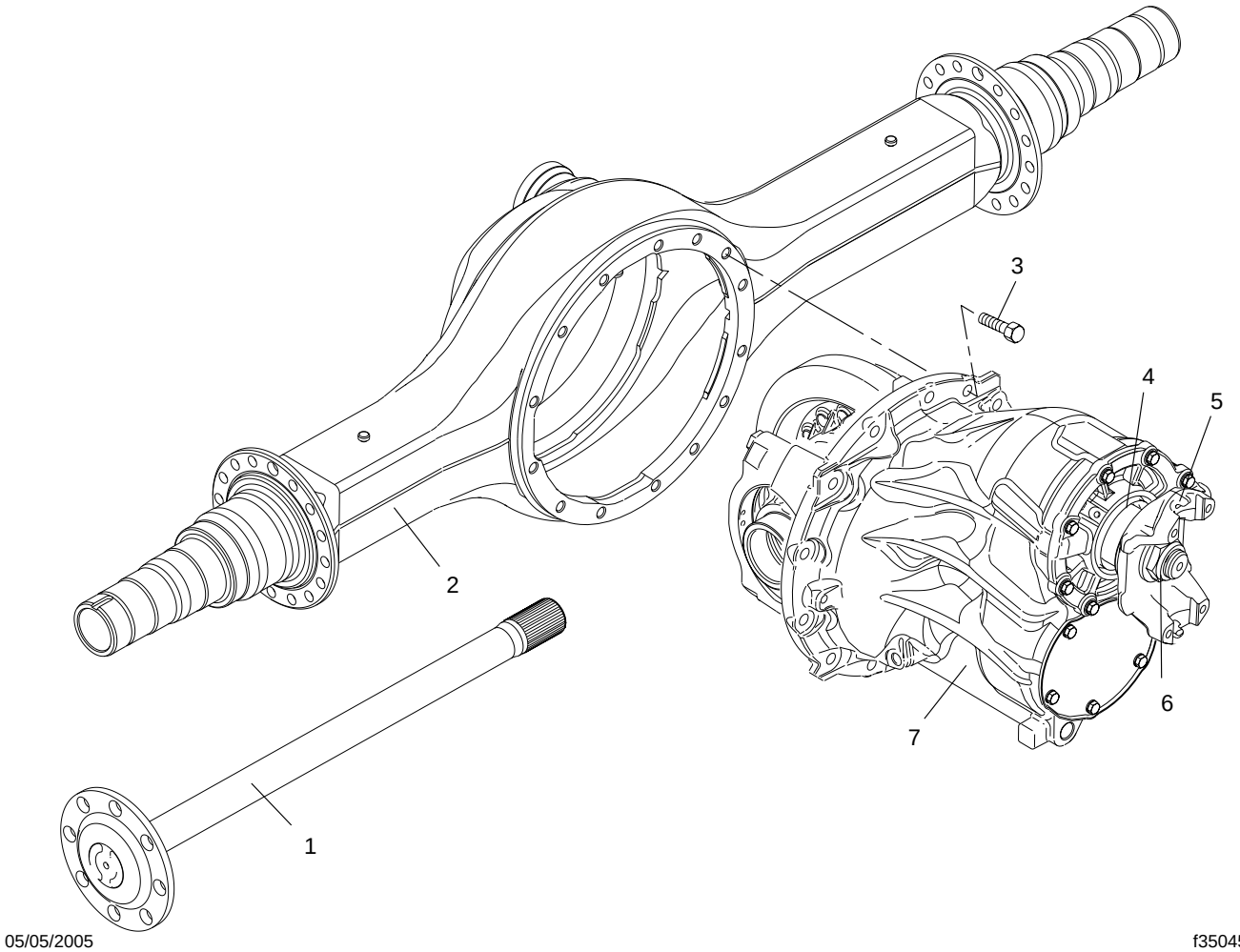


# Forward-Rear Tandem Axle Removal and Installation

## Removal

For forward-rear axle components of a tandem installation, see **Fig. 1**.

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the front tires. Put the transmission in neutral.
2. Using a suitable jack, raise the vehicle enough to take the weight off the axles, but not enough to raise the tires off the ground.
3. At both ends of the axle, loosen all the wheel nuts.
4. Using a suitable jack, continue to raise the vehicle evenly until there is room to fit a stand underneath the axle housing.




1. Axle Shaft
2. Forward-Rear Axle Housing
3. Carrier Capscrew
4. Input Seal
5. Carrier Yoke
6. Input Yoke Nut
7. Forward Differential Carrier

**Fig. 1, Forward-Rear Axle Components**

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# Forward-Rear Tandem Axle Removal and Installation

**WARNING**

**Never work around or under a vehicle that is supported only by a jack. Always support the vehicle with safety stands. Jacks can slip, allowing the vehicle to fall, which could result in serious injury or death.**

5. Support the vehicle with safety stands.
6. Remove the oil drain plug from the bottom of the axle housing and drain the oil from the axle housing. Install the drain plug after emptying.
7. Remove the wheels and tires. For instructions, see **Group 40**.
8. Release the parking brakes.
9. If necessary, back off the slack adjusters, then remove the brake drums.
10. If installed, make sure the optional DCDL (main differential lock) has been shifted into the engaged (locked) position.
11. Disconnect the air lines at the interaxle lock and (if installed) the wheel lock.
12. Disconnect the main driveshaft from the forward differential carrier. For instructions, see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
13. Disconnect the interaxle driveshaft from the output yoke of the forward tandem axle and the input yoke of the rear tandem axle. For instructions, see **Section 41.00, Subject 120**.
14. Cage the parking brake springs to prevent the parking brakes from engaging. For instructions, see **Group 42**.
15. Drain the air system.
16. Place a basin under the axle shaft flanges to catch any oil; then remove the axle shafts. For instructions, see **Subject 120**.
17. Remove the hubs from the axle spindles. For instructions, see **Section 35.01, Subject 100**.
18. Remove the brake shoes. For instructions, see the applicable service brake section in **Group 42**.
19. Remove the ABS sensors and wiring, and the fasteners that hold the brake spiders to the axle flanges. Remove the spiders from the axle.
20. If applicable, disconnect the leveling valve rod(s) from the suspension.
21. At the frame rail or crossmember, disconnect the wiring for the ABS sensors. Remove any tie straps that hold the wires to the frame rails.
22. Disconnect the air lines from the rear brake chambers.
23. Remove the brake air chambers and the slack adjusters from the axle housing. For instructions, see **Group 42**.
24. Using a suitable jack, support the axle housing.
25. If applicable, remove the hexnuts that hold the bottom of each suspension air bag to its suspension bracket.
26. Remove the suspension components that attach the axle to the vehicle. If applicable, remove the U-bolt nuts from the U-bolts. Discard the U-bolt nuts and U-bolts.
27. Lower the axle enough to clear the suspension components.
28. Remove the axle from the vehicle.
29. If you are going to replace the differential carrier, place the axle on a secure axle stand.

## Installation

1. Position the axle underneath the vehicle.
2. Install the suspension components that attach the axle to the vehicle, as follows.

   NOTE: U-bolts and U-bolt nuts cannot be reused.

   2.1 On vehicles with conventional suspensions, install the upper U-bolt brackets, new U-bolts, lower U-bolt brackets, and new U-bolt nuts.

   On vehicles with air suspensions, in addition to the U-bolts, install the hexnuts that attach the air springs to the suspension brackets. For torque values, see **Group 32**.

   On vehicles without U-bolts, install the walking beams.

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2.2 If applicable, tighten the new U-bolt nuts in a diagonal pattern. For torque values, see **Group 32**.

3. Connect the interaxle driveshaft to the output yoke of the forward carrier and the input yoke of the rear carrier. For instructions, see **Section 41.00, Subject 120**.
4. Install the brake spiders on the axle flanges. For instructions, see the applicable service brake section in **Group 42**.
5. Install the ABS sensors and connect the wiring at the frame rail. Secure the wiring with tie straps as needed.
6. Install the brake air chambers and slack adjusters on the axle housing brackets. Connect the air lines to the brake air chambers. For instructions, see **Group 42**.
7. Install the brake shoes, as removed. For instructions, see the applicable service brake section in **Group 42**.
8. If installed, disengage the DCDL (main differential lock).
9. Using new gaskets, install the axle shafts. For instructions, see **Subject 120**.
10. Connect the main driveshaft to the forward input yoke. For instructions, see **Section 41.00, Subject 120**.
11. Connect the air hoses to the air cylinder for the interaxle lock and (if installed) the wheel lock.
12. Connect the electrical connector of the sensor unit for axles equipped with a wheel lock.
13. Fill each hub with approved axle oil until you can see a little amount of oil trickling out of the back of the hub (use about 0.8 quart, or 0.75 liter). Install the hubs on the axle spindles, and adjust the wheel bearings. For instructions, see the applicable subject in **Section 35.01**. See **Table 1** for approved axle oils.
14. Install the brake drums on the hubs.
15. Install the wheels and tires. For instructions, see **Group 40**.
16. Adjust the brakes. For instructions, see the applicable service brake section in **Group 42**.
17. Uncage the parking brake springs.
18. Using approved axle oil, fill the forward-rear tandem axle housing to the bottom of the fill hole, or until filled to capacity as shown in **Table 1**.

| Forward-Rear Axle Oil Type and Capacity | | |
|---|---|---|
| **Approved Oil Type** | **Capacity: quarts (liters)** | |
| | **Hubs Full** | **Hubs Dry** |
| 80W-90 Gear Oil | 14.3 (13.5) | 15.9 (15.0) |
| 75W-90 Synthetic Gear Oil | | |

**Table 1, Forward-Rear Axle Oil Type and Capacity**

19. Raise one side of the vehicle about 8 inches (20 cm) to let the oil flow into the hub on the opposite side, then raise the other side in the same manner. On each side, hold the tilted position for three minutes to allow oil to run into the wheel end.

## NOTICE

**Make sure the hubs are filled. Driving with the hubs dry will cause bearing damage.**

20. Turn the wheels, wait one minute, and check the lubricant level.
21. Raise the vehicle, remove the safety stands, then lower the vehicle.
22. If applicable, connect the suspension leveling valve(s). Start the engine, build the air pressure, and make sure the suspension air bags inflate correctly. Make sure the ride height is correct. For instructions, see **Group 32**.
23. Check the operation of the wheel lock, if installed.
24. Check the oil level in the axle housing. The level should be up to the bottom of the fill hole. Add approved axle oil, if needed.
25. Set the parking brake.

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# Forward-Rear Tandem Axle Differential Carrier Removal and Installation

For forward-rear axle components of a tandem installation, see **Fig. 1**.

## Removal

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the front tires. Put the transmission in neutral.
2. If applicable, release the suspension air pressure.
3. Using suitable jacks, raise the vehicle evenly until there is room to fit a jack underneath the axle housing.
4. Remove the tires and wheels. For instructions, see **Group 40**.
5. Remove the oil drain plug from the bottom of the axle housing and drain the oil from the axle housing. Install the drain plug after emptying.
6. Disconnect the driveshaft from the carrier yoke. For instructions, see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
7. Place a basin under the axle shaft flanges to catch any oil; then remove the axle shafts. For instructions, see **Subject 120**.

**⚠ WARNING**

**The differential carrier is heavy. Do not try to move it without a suitable support. To do so could result in the carrier falling, which could cause serious personal injury and component damage. Support the carrier with a suitable jack and chain it to the jack, or use a hoist if the axle has been removed from the vehicle.**

8. Using a suitable jack, support the differential carrier. Chain the differential carrier to the jack.

**NOTICE**

**When using a pry bar, be careful not to damage the carrier or housing flange. Damage to these surfaces will cause oil leaks.**

9. Remove the differential carrier from the axle housing, as follows.

9.1 If equipped with a wheel lock, engage the lock with air. This will help separate the carrier assembly from the axle housing.

9.2 Remove all but the top two carrier capscrews.

9.3 Loosen and back off, but do not remove, the top two fasteners. The fasteners will hold the carrier in the housing.

9.4 Using a pry bar, separate the mating surfaces of the forward differential carrier and axle housing.

NOTE: Use a pry bar that has a round end to help separate the carrier from the housing.

9.5 When the surfaces are separated, finish removing the top two capscrews.

9.6 With the carrier on the jack, slide the carrier away from the rear axle housing.

9.7 Lift the carrier assembly onto a suitable stand.

## Installation

NOTE: Use a cleaning solvent and clean rags to remove dirt. Blow dry the cleaned areas with air.

1. Remove any old sealant material from the mating surfaces of the axle housing. Clean the inside of the axle housing and the carrier mating surface.
2. Inspect the axle housing for damage. Repair or replace the axle housing as necessary.
3. Apply a thin bead of Loctite® 5900 sealant all the way around the mating surface of the axle housing, and around each bolt hole.

NOTE: Alignment dowels for installing the differential carrier can be made by sawing off the heads of two M16 x 1.5 x 100 mm bolts.

4. Install alignment dowels 180 degrees apart at the 3 o'clock and 9 o'clock positions on the axle housing flange.

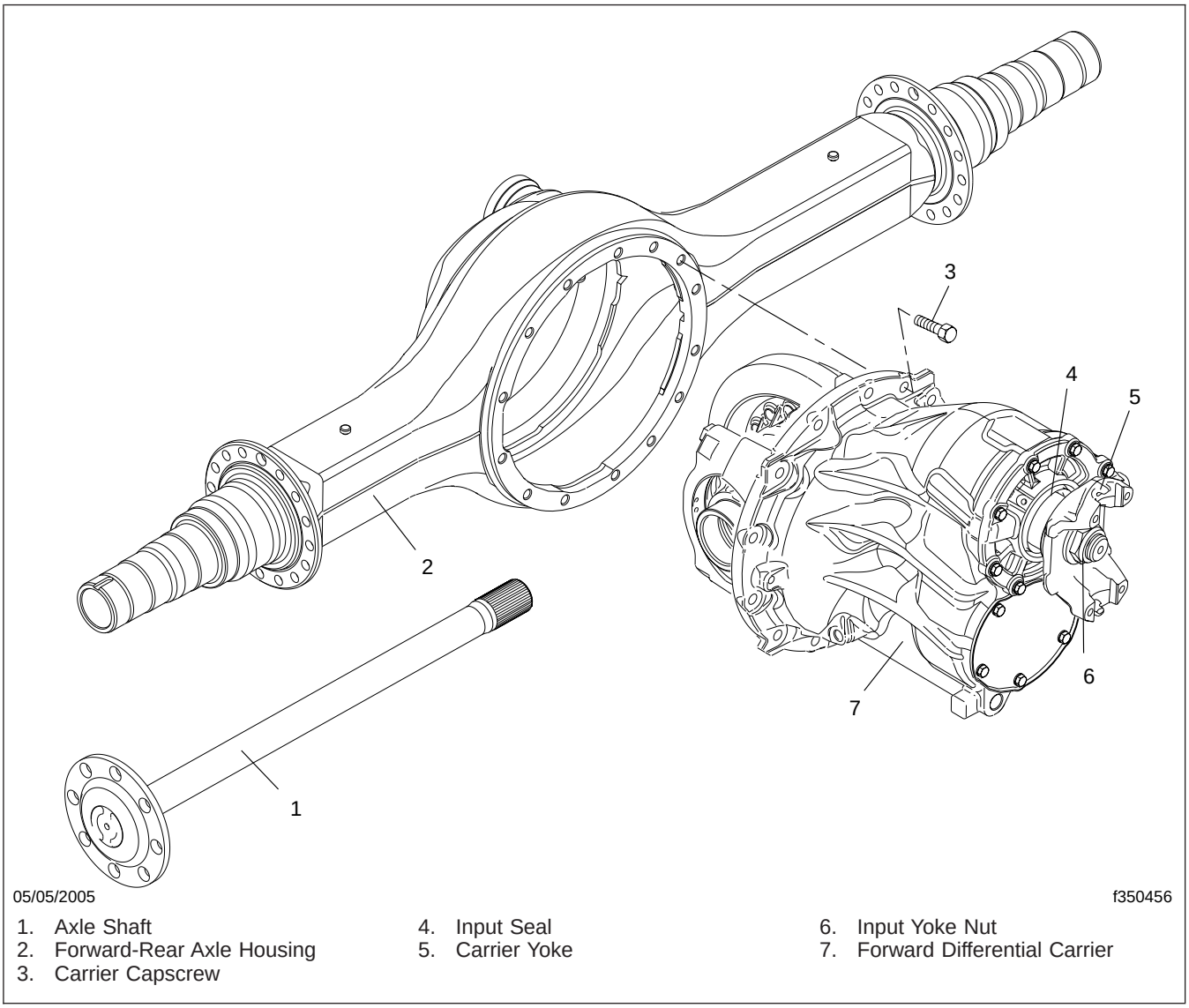
**⚠ WARNING**

**The differential carrier is heavy. Do not try to move it without a suitable support. To do so could result in the carrier falling, which could**

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## Forward-Rear Tandem Axle Differential Carrier Removal and Installation




1. Axle Shaft
2. Forward-Rear Axle Housing
3. Carrier Capscrew
4. Input Seal
5. Carrier Yoke
6. Input Yoke Nut
7. Forward Differential Carrier

**Fig. 1, Forward-Rear Tandem Axle Components**

**cause serious personal injury and component damage. Support the carrier with a suitable jack and chain it to the jack, or use a hoist if the axle has been removed from the vehicle.**

5. Position the forward differential carrier in front of the axle housing, using an axle jack or other suitable lifting tool.
6. If equipped with a wheel lock, engage the lock with air. This will help the carrier assembly join the axle housing.

### NOTICE

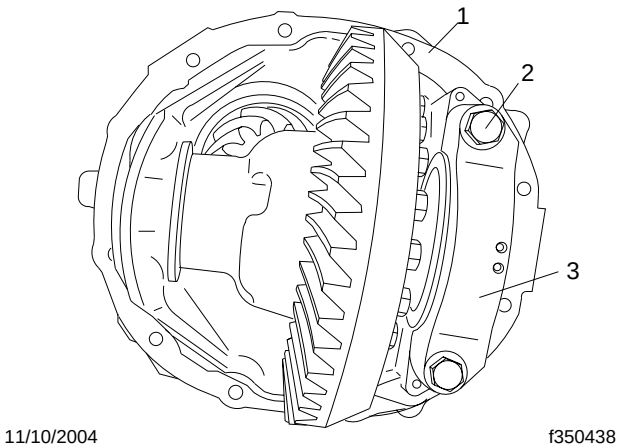
**Do not use a hammer or a mallet to install the differential carrier. A hammer or a mallet will damage the mounting flange of the carrier and cause oil leaks.**

7. Install the end caps on the sides of the forward differential carrier into the corresponding slots in the axle housing. See **Fig. 2**.

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## Forward-Rear Tandem Axle Differential Carrier Removal and Installation




1. Differential Carrier
2. End Cap Bolt
3. End Cap

**Fig. 2, Carrier End Caps**

8. For the last 3/4 inch (19 mm) or so of travel, walk the carrier slowly into the housing.

IMPORTANT: The end caps fit tightly into the axle housing. Be very careful not to cock the carrier.

9. Install the forward carrier capscrews finger-tight. Make sure the carrier capscrews turn easily in the axle housing.
10. In a star pattern, gradually tighten the M16 capscrews 200 lbf·ft (270 N·m).
11. Connect the driveshaft to the carrier yoke. For instructions, see **Section 41.00, Subject 120**.
12. Using new gaskets, install the axle shafts. For instructions, see **Subject 120**.
13. Install the wheels and tires. For instructions, see **Group 40**.
14. Using approved axle oil, fill the axle housing to the bottom of the fill hole, or until filled to capacity as shown in **Table 1**.

| Forward-Rear Axle Oil Type and Capacity | | |
|---|---|---|
| Approved Oil Type | Capacity: quarts (liters) | |
| | Hubs Full | Hubs Dry |
| 80W-90 Gear Oil | 14.3 (13.5) | 15.9 (15.0) |
| 75W-90 Synthetic Gear Oil | | |

**Table 1, Forward-Rear Axle Oil Type and Capacity**

15. If the hubs are dry, raise one side of the vehicle about 8 inches (20 cm) to let the oil flow into the hub on the opposite side, then raise the other side in the same manner. On each side, hold the tilted position for three minutes to allow oil to run into the wheel end.

### NOTICE

**Make sure the hubs are filled. Driving with the hubs dry will cause bearing damage.**

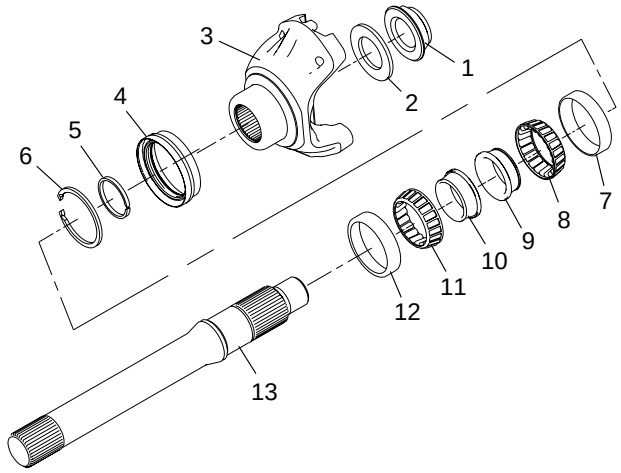
16. Turn the wheels, wait one minute, then check the lubricant level.
17. Raise the vehicle, remove the safety stands, then lower the vehicle.
18. Start the engine, build the air pressure, and check that the suspension air bags inflate evenly and correctly. Make sure the ride height is correct.
19. Check the oil level in the axle housing. The level should be up to the bottom of the fill hole. Add approved axle oil, if needed.

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## Repair

1. Remove the output yoke nut, washer, and output yoke. Then remove the output oil seal from the thru-shaft bore. See **Subject 170**.
2. Remove the snap ring and spacer from the thru-shaft. See **Fig. 1**.




05/04/2005 f350451

1. Output Yoke Nut
2. Washer
3. Output Yoke
4. Output Oil Seal
5. Spacer
6. Snap Ring
7. Outer Bearing Race
8. Outer Bearing
9. Outer Bearing Cup
10. Inner Bearing Cup
11. Inner Bearing
12. Inner Bearing Race
13. Thru-Shaft

**Fig. 1, Thru-Shaft Components**

3. Using a suitable shaft puller, draw the thru-shaft out of the bore.
4. Using a suitable bearing puller on the outer races, remove both the inner and outer bearings from the thru-shaft.
5. Inspect the bearings for wear and damage. Replace both bearings if any damage is found.
6. Install the inner bearing race in the thru-shaft bore.
7. Using an arbor press or other suitable pressing tool, press the bearings and bearing cups onto the thru-shaft.
8. Insert the thru-shaft into its bore.
9. Install the outer bearing race onto the thru-shaft and bore.
10. Install the snap ring and spacer. Use the next thicker snap ring from the snap ring pack supplied with the bearings.
11. Install a new output oil seal. See **Subject 170**.
12. Install the output yoke, and the new nut and washer. See **Subject 170**. Make sure the output yoke nut is firmly tightened, but do not tighten the nut to specifications at this time.
13. Attach a dial indicator to the flat surface of the output yoke.
14. Using a pry bar or other lever, apply force to the base of the output yoke. If the dial indicator shows a deflection of 0.0012 to 0.0024 inch (0.03 to 0.06 mm), the end play is correct.

    If the deflection is too large, use a thicker snap ring. If the deflection is too small, use a thinner snap ring.
15. Remove the yoke nut, and coat its threads with Loctite® 577. Install the nut, and tighten it 516 lbf·ft (700 N·m).

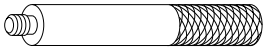
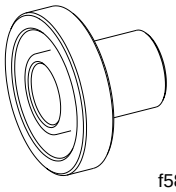
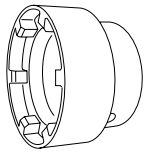
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# Single or Rearmost Axle Yoke and Seal Replacement

## Special Tools

Special tools are required for this procedure. See **Table 1**.

| Special Tools | | | |
|---|---|---|---|
| **Tool** | **Description** | **Manufacturer** | **Part Number** |
|  f580400 | Universal Handle* | Kent-Moore | J-8092 |
|  f580406 | Rear Pinion Seal Installer* | Kent-Moore | J-47354 |
|  f580450 | Yoke Nut Socket† | Daimler | MBA 742589020700 |

* To order Kent-Moore tools call 1-800-328-6657.

† The yoke nut socket is needed to remove the round, slotted yoke nut installed on some vehicles. It can be ordered through Paragon.

**Table 1, Special Tools**

## Replacement

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires.
2. Disconnect the driveshaft from the input yoke. For instructions, see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
3. Remove the yoke nut from the center of the carrier yoke. If the yoke nut is round and slotted, use the yoke nut socket shown in **Table 1**. See **Fig. 1**. Be careful not to damage the seal bore.

NOTE: Older models may not require the special socket for yoke nut removal.

4. Remove the carrier yoke from the input shaft. Be careful not to damage the seal bore.
5. Pry up the seal, using a prybar or large screwdriver. Clean any old sealant from the axle housing. Do not allow dirt or grease to contaminate the seal bore or shaft bearings. See **Fig. 2**.
6. Install a new rear pinion seal on the input shaft. See **Fig. 3**.
   - 6.1 Inspect the area around the seal for damage. Use emery paper to remove scratches, nicks, or burrs on the seal bore.
   - 6.2 Assemble the rear pinion seal installer onto the threaded end of the universal handle. See **Table 1**.

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## Single or Rearmost Axle Yoke and Seal Replacement

IMPORTANT: Be careful not to cock the seal during installation.

6.3 Using the rear pinion seal installer assembly, press the seal into the bore until the seal surface is flush with the bottom surface of the counterbore.

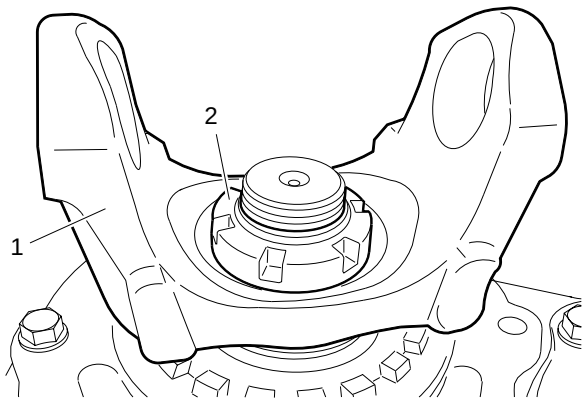
7. Install the carrier yoke on the input shaft. If the yoke is damaged or worn, install a new yoke.

NOTE: It is not necessary to replace the yoke when replacing the seal.

8. Install a new M45 x 1.5 pinion nut on the carrier yoke, and tighten the nut 627 lbf·ft (850 N·m).
9. Punch in the cylindrical area at the pinion groove to lock the nut in place.

IMPORTANT: The bent area has to reach the bottom of the pinion groove.

10. Connect the driveshaft. For instructions, see **Section 41.00, Subject 120**.

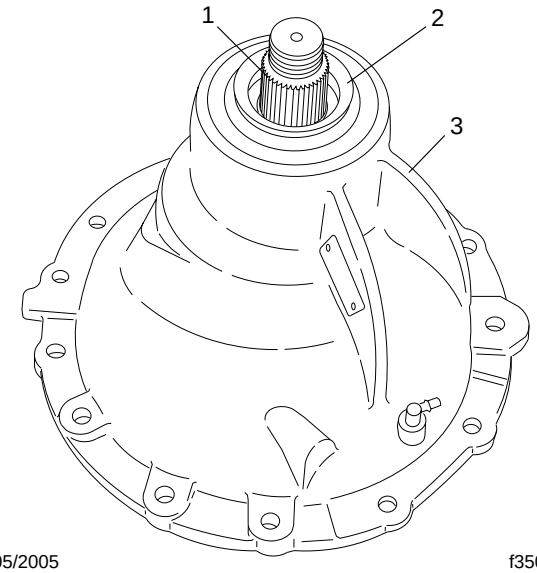



04/01/2008 f350496

NOTE: The yoke nut may be a hexnut rather than the round, slotted nut shown here.

1. Yoke
2. Yoke Nut

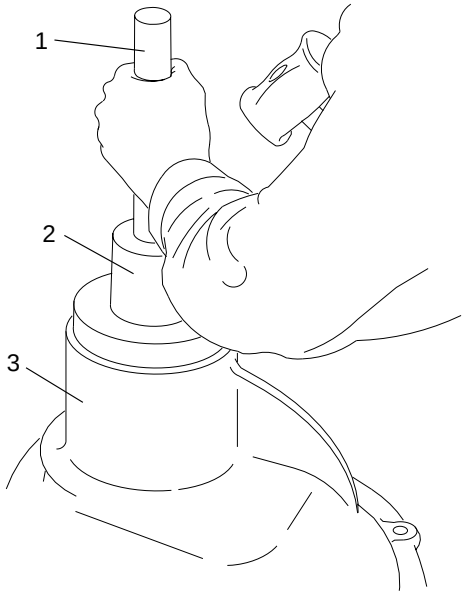
**Fig. 1, Yoke Nut on the Carrier**




05/05/2005 f350450

1. Input Shaft
2. Rear Pinion Seal
3. Carrier Housing

**Fig. 2, Rear Pinion Seal**




05/12/2005 f350448

1. Universal Handle
2. Rear Pinion Seal Installer
3. Carrier Housing

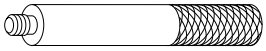
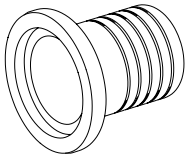
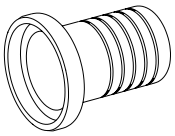
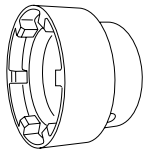
**Fig. 3, Installing the Rear Pinion Seal**

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## Special Tools

Special tools are required for this procedure. See **Table 1**.

| Special Tools for Forward-Rear Axle Yoke and Seal Replacement | | | |
|---|---|---|---|
| **Tool** | **Description** | **Manufacturer** | **Part Number** |
|  f580400 | Universal Handle* | Kent-Moore | J-8092 |
|  f580410 | Input Seal Installer* | Kent-Moore | J-47369 |
|  f580408 | Output Seal Installer* | Kent-Moore | J-47368 |
|  f580450 | Yoke Nut Socket† | Daimler | MBA 742589020700 |

* To order Kent-Moore tools call 1-800-328-6657.

† The yoke nut socket is needed to remove the round, slotted yoke nut installed on some vehicles. It can be ordered through Paragon.

**Table 1, Special Tools for Forward-Rear Axle Yoke and Seal Replacement**

## Replacement

### Forward Carrier Input Yoke and Seal

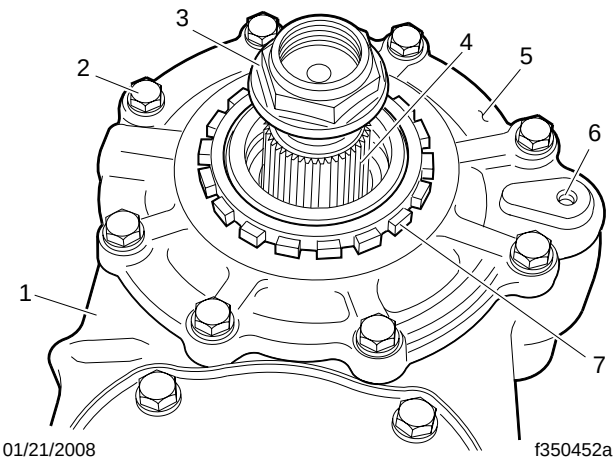
1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires.
2. Disconnect the main driveshaft from the forward carrier input yoke. For instructions, see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
3. Remove the input yoke nut and washer from the center of the forward carrier input yoke.
4. Remove the old forward carrier input yoke from the forward input shaft.

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## Forward-Rear Axle Yoke and Seal Replacement

5. If there is an oil leak at the threaded ring, repair it; for instructions, see **Subject 200**.
6. If there is a leak between the bearing cage and the axle housing, remove the bearing cage, as follows. See **Fig. 1**.




1. Forward Carrier Housing
2. Bearing Cage Mounting Capscrew
3. Input Yoke Nut
4. Input Shaft
5. Bearing Cage
6. Interaxle Lock Bore
7. Threaded Ring

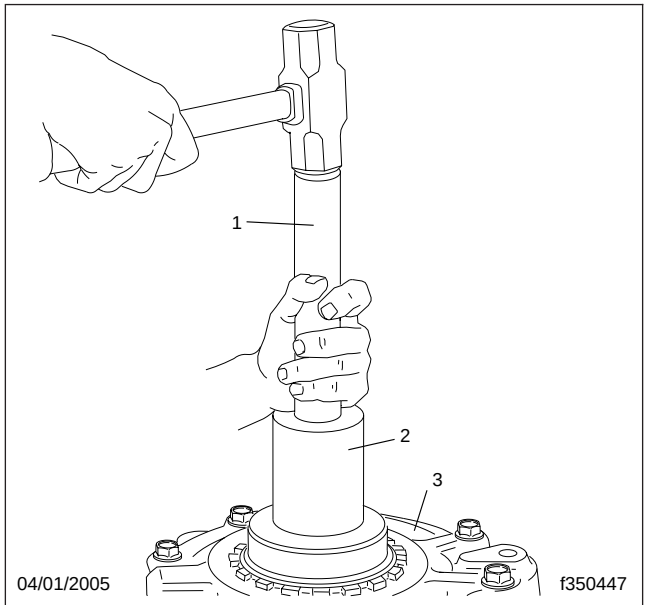
**Fig. 1, Bearing Cage**

6.1 Remove the bearing cage capscrews.

6.2 Pry the bearing cage from the forward carrier housing. Clean any remnants of sealant clinging to the mating surfaces of the carrier housing and the bearing cage.

7. Pry up the input seal, using a prybar or large screwdriver. Clean any old sealant from the axle housing. Do not allow dirt or grease to contaminate the seal bore or shaft bearings.
8. Install a new seal in the input shaft bore, as follows. See **Fig. 2**.

8.1 Inspect the area around the seal for damage. Use emery paper to remove scratches, nicks, or burrs on the seal bore.




1. Universal Handle
2. Input Seal Installer
3. Carrier Housing

**Fig. 2, Installing the Forward Carrier Input Seal**

8.2 Assemble the input shaft seal installer onto the threaded end of the universal handle. See **Table 1**.

8.3 Using the input shaft seal installer assembly, press the seal into the bore until the seal surface is flush with the threaded ring.

9. On the mating surface of the bearing cage, lay down a bead of Loctite® 5900 sealant, or equivalent. Go around all of the bolt holes and other openings in the inside cover of the bearing cage. See **Fig. 3**.

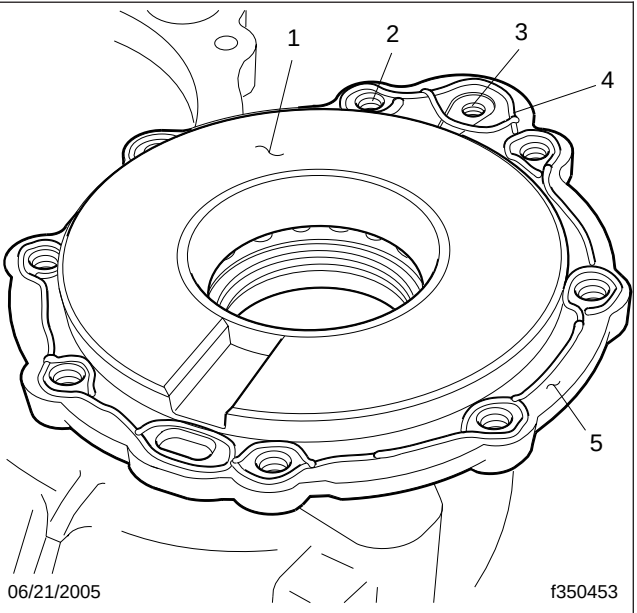
IMPORTANT: Do not allow sealant to get into the interaxle lock bore. See **Fig. 4**. Do not attempt to repair the interaxle lock (IAD). No repairs to this component are possible.

10. Install the bearing cage onto the forward carrier housing. Tighten the M12 bearing cage capscrews 107 lbf·ft (145 N·m).
11. Install the forward carrier input yoke on the forward input shaft. If the yoke is damaged or worn, install a new yoke.

NOTE: It is not necessary to replace the yoke when replacing the seal.

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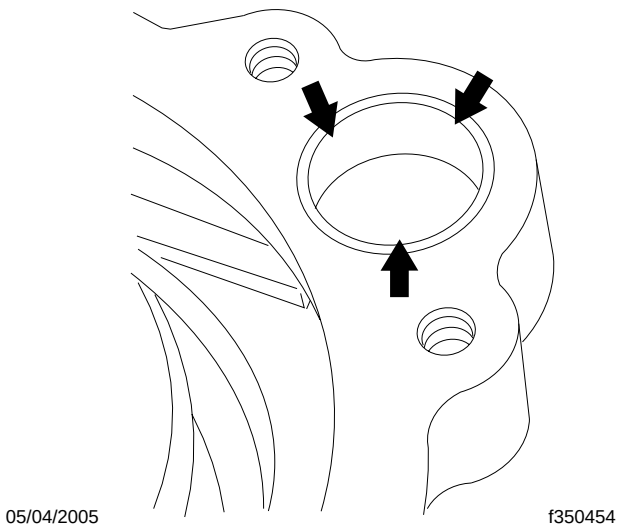





Apply a bead of sealant to the inner mating surface as shown.

1. Inside Cover
2. Mounting Capscrew Hole
3. Interaxle Lock Bore
4. Sealant
5. Mating Surface

**Fig. 3, Sealant Application**



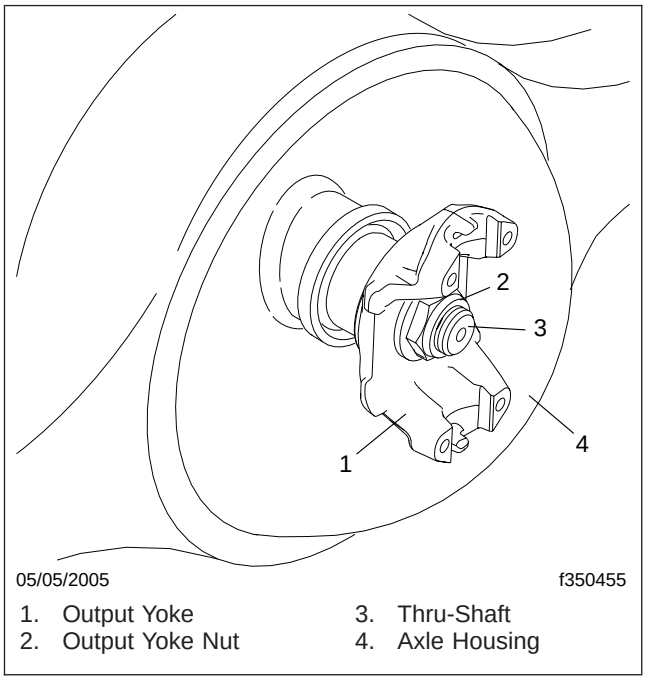

Keep sealant away from this bore.

**Fig. 4, Interaxle Lock Bore**

12. Coat the threads of a new M45 x 1.5 input yoke nut with Loctite® 277. Install the new washer and input yoke nut on the yoke. Tighten the nut 627 lbf·ft (850 N·m).
13. Connect the main driveshaft. For instructions, see **Section 41.00, Subject 120**.

## Output Yoke and Seal

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the tires.
2. Disconnect the interaxle driveshaft from the output yoke. For instructions, see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
3. Remove the output yoke nut and washer.
4. Remove the output yoke from the thru-shaft. See **Fig. 5**.




1. Output Yoke
2. Output Yoke Nut
3. Thru-Shaft
4. Axle Housing

**Fig. 5, Output Yoke**

5. Pry up the output oil seal, using a prybar or large screwdriver. Clean any old sealant from the axle housing. Do not allow dirt or grease to contaminate the seal bore or thru-shaft bearings.
6. Install a new seal on the thru-shaft, as follows.

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## Forward-Rear Axle Yoke and Seal Replacement

6.1 Inspect the area around the output oil seal for damage. Use emery paper to remove scratches, nicks, or burrs on the seal bore.

6.2 Assemble the output seal installer onto the threaded end of the universal handle. See **Table 1**.

6.3 Using the output seal installer assembly, press the seal into the bore until the seal surface is flush with the thru-shaft receptacle.

7. Install the output yoke on the thru-shaft. If the yoke is damaged or worn, install a new yoke.

NOTE: It is not necessary to replace the yoke when replacing the seal.

8. Coat the threads of a new M39 x 1.5 output yoke nut with Loctite® 577. Install the new washer and output yoke nut on the yoke. Tighten the nut 516 lbf·ft (700 N·m).
9. Connect the interaxle driveshaft. For instructions, see **Section 41.00, Subject 120**.

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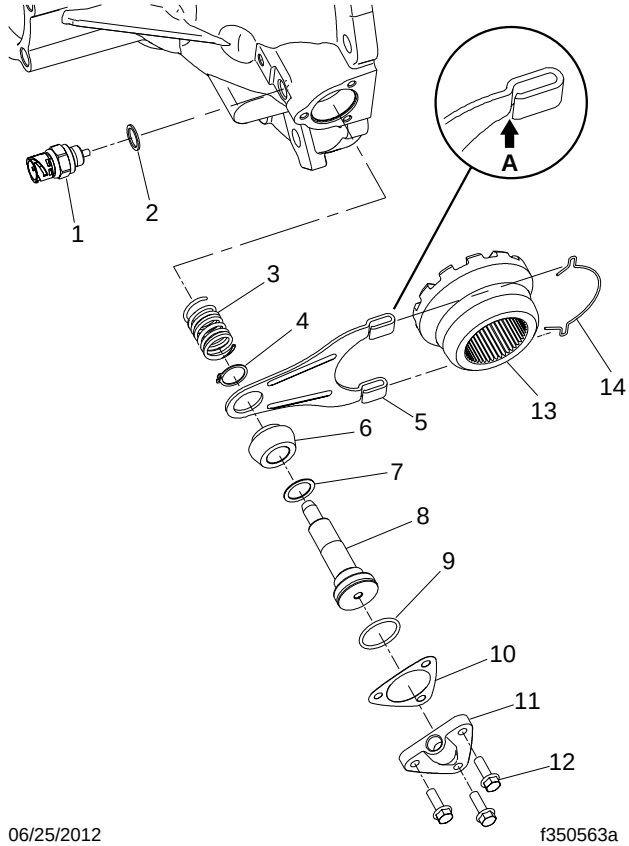


# Main Differential Lock Disassembly and Assembly

## General Information

Commonly known as DCDL (Driver-Controlled Differential Lock), a main differential lock is available on single and tandem rear axles. On tandem rear axles DCDL is available for the forward, rear, or both axles. The following procedures only apply to Model 4 rear axles with optional DCDL.

Each part of the main differential lock is replaceable. See **Fig. 1**.




A. Opening in fork loop faces away from the clutch collar as shown.

1. Sending Unit
2. Sending Unit Seal
3. Spring
4. Snap Ring
5. Shift Fork
6. Alignment Boss
7. Shim(s)
8. Shift Shaft Piston
9. O-Ring
10. Air Interface Gasket
11. Air Interface
12. Capscrew
13. Clutch Collar
14. Retaining Clip

**Fig. 1, DCDL Components**

## Disassembly

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the front tires.
2. Remove the differential carrier, and place it on a work stand.

   To remove a single or rearmost axle differential carrier, see **Subject 110**.

   To remove a forward-rear differential carrier, see **Subject 140**.
3. Unlatch the retaining clip, and remove it. See **Fig. 1**.
4. Remove the clutch collar.
5. Remove the DCDL sending unit from the carrier housing.
6. Remove the three bolts that attach the air interface to the carrier housing.
7. Remove the air interface and gasket.
8. Remove the shift shaft piston from the bore in the carrier housing, and note the number of shims found on the piston. There should be at least one shim, and a maximum of three.
9. Compress the spring and pull the shift fork from the carrier housing.
10. Remove the spring from the carrier housing.

## Assembly

1. Install the spring in the carrier housing, and compress it to install the shift fork in the housing. Ensure that the spring is centered in the bore.
2. Ensure the O-ring on the shift shaft piston is properly installed and lubricated. Then install the piston, being careful to properly align it in the bore. Do not force the piston into the bore.
3. Place the air interface and gasket over the air interface bore, and insert the three capscrews that attach the air interface to the carrier housing. Tighten the capscrews in a regular sequence that ensures it seats evenly. Tighten the capscrews 19 lbf·ft (25 N·m).
4. Install the clutch collar.
5. Install the retaining clip on the shift fork.

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## Main Differential Lock Disassembly and Assembly

6. Install the DCDL sending unit in the carrier housing, as removed.
7. Connect the DCDL air line, and engage the DCDL. Ensure the teeth of the lock fully engage the teeth of the gear inside the carrier housing.
8. The clearance between the clutch collar and ring gear must be between 0.4 and 1.4 mm. Engage the DCDL, and use a feeler gauge to measure the gap.

   If the gap between the clutch collar and ring gear measured between 0.4 and 1.4 mm, ensure the same number of shims are on the shift shaft piston (as when it was removed).

   If the gap between the clutch collar and ring gear was not between 0.4 and 1.4 mm, add or remove shims to vary the gap until it measures within the acceptable range. The acceptable maximum number of shims is three, and the minimum is one.
9. Install the differential carrier.

   For instructions on installing a single or rearmost axle differential carrier, see **Subject 110**.

   For instructions on installing a forward-rear axle differential carrier, see **Subject 140**.
10. Remove the chocks.

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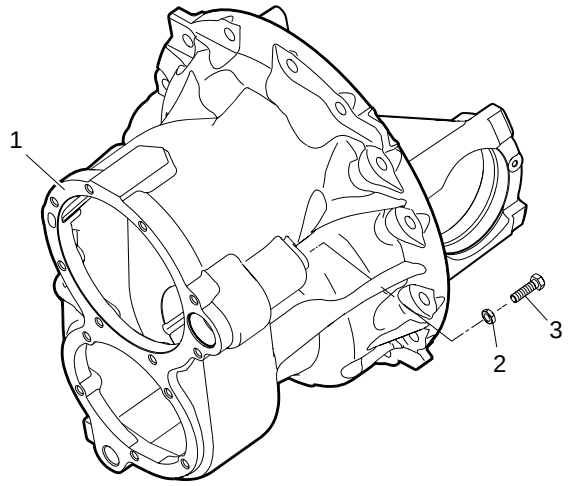


# Interaxle Differential Lock Adjustment

## Adjustment

The Interaxle Differential (IAD) has an adjustment screw that can become loose or even fall out, causing an oil leak, and malfunction of the IAD. To ensure the adjustment screw is properly tightened and secured, follow the steps below. The IAD is sometimes called the power divider. See **Fig. 1**.

1. Chock the front tires.
2. Use the IAD switch in the cab to engage the lock.
3. At the forward-rear axle, rotate one of the wheels to ensure the teeth of the lock fully engage the teeth of the gear inside the carrier housing.
4. Remove the adjustment screw, and using a suitable solvent (such as brake cleaner), clean the threads of the screw and bore. Dry the surfaces completely, making sure no cleaning solvent remains.
5. Coat the threads of the adjustment screw with Loctite® 577, install it, and hand-tighten it until it hits the shaft.
6. Disengage the IAD to relieve the air pressure exerted on the adjustment screw.
7. Hand-tighten the adjustment screw one quarter turn, then tighten the locknut 30 lbf·ft (41 N·m).
8. Remove the chocks.




1. Carrier Housing
2. Locknut
3. Adjustment Screw

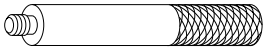
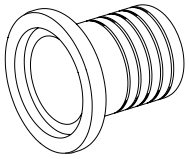
**Fig. 1, Interaxle Differential and Adjustment Screw**

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## Special Tools

Special tools are required for this procedure. See **Table 1**.

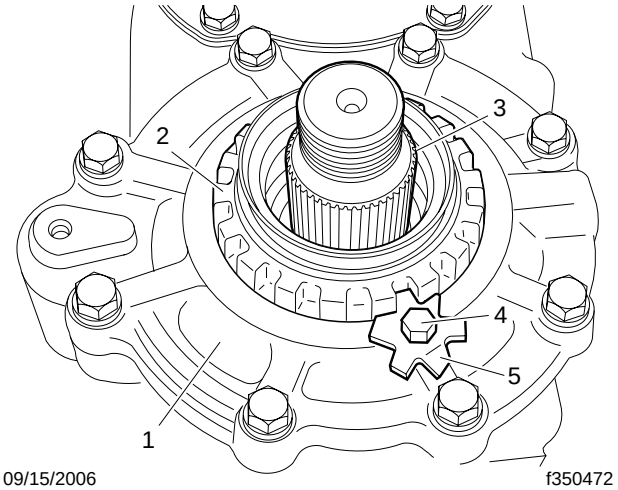
| Special Tools for Threaded Ring Repair | | | |
|---|---|---|---|
| **Tool** | **Description** | **Manufacturer** | **Part Number** |
|  f580400 | Universal Handle* | Kent-Moore | J-8092 |
|  f580410 | Input Seal Installer* | Kent-Moore | J-47369 |

* To order Kent-Moore tools call 1-800-328-6657.

**Table 1, Special Tools for Threaded Ring Repair**

## Repair

1. Apply the parking brakes, shut down the engine, and chock the tires.
2. Disconnect the main driveshaft from the forward carrier input yoke. For instructions, see **Section 41.00, Subject 120**. Using suitable straps, support the end of the driveshaft by attaching it to the frame rail.
3. Remove the yoke nut and washer from the input shaft of the forward differential carrier, then remove the yoke.
4. Remove the capscrew and the locking plate from the bearing cage on the front of the differential carrier. See **Fig. 1**.
5. Using a spanner wrench, remove the threaded ring to expose the bearing cavity. See **Fig. 2**.
6. Using a suitable solvent, such as brake cleaner, clean the surface of the bearing cavity. See **Fig. 2**. Dry the surface, making sure no cleaning solvent remains.
7. Coat the threads of the threaded ring with Loctite® 577 sealant. Apply a 1/8-inch (3-mm) diameter bead all the way around the bottom thread, then spread the sealant evenly over the threads, so that all threads are thoroughly covered with the sealant.




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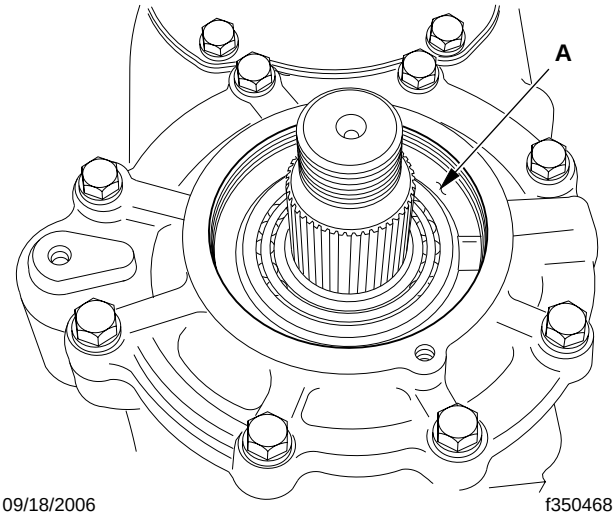
1. Bearing Cage
2. Threaded Ring
3. Input Shaft (yoke removed)
4. Capscrew
5. Locking Plate

**Fig. 1, Forward-Rear Axle Differential Housing**

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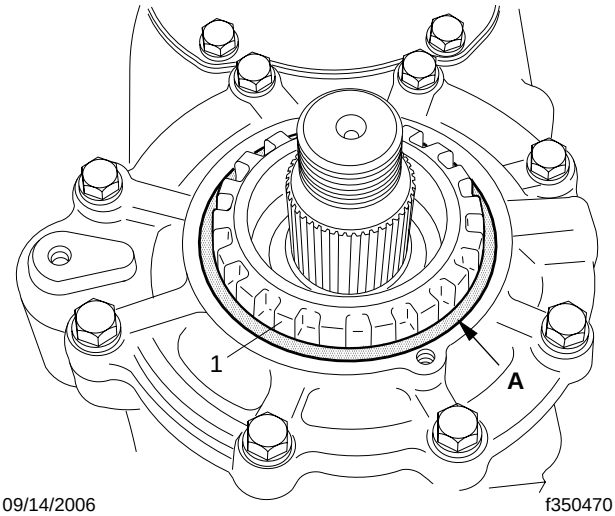
## Threaded Ring Repair




A. Clean and dry this entire surface.

**Fig. 2, Bearing Cavity Exposed**

8. Install the threaded ring (without the new input-shaft seal) and turn it clockwise (tighten it) enough to form a uniform bead of sealant all the way around the threaded ring. See **Fig. 3**.

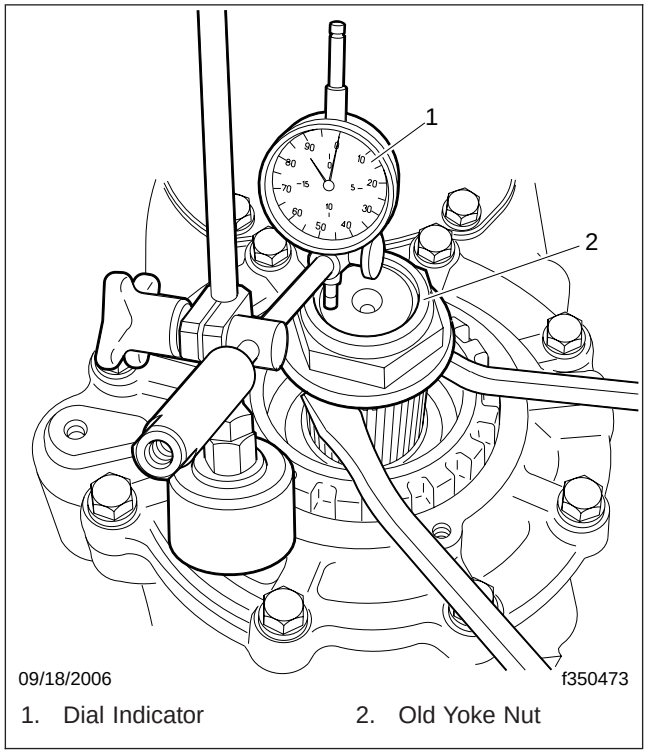



A. Loctite Bead from the Threads

1. Threaded Ring

**Fig. 3, Preliminary Installation of the New Threaded Ring**

9. Install the old yoke nut on the input shaft to protect the threads, then strike the nut sharply with a brass mallet to unseat the bearing.
10. Adjust the initial bearing preload to 0.002 inch (0.05 mm), as follows:
    10.1 Install a dial indicator on the bearing cage, and using two pry bars, pry up evenly on the yoke nut (and the input shaft) to determine the bearing preload. See **Fig. 4**.




1. Dial Indicator
2. Old Yoke Nut

**Fig. 4, Measuring Bearing Preload**

    10.2 Tighten the threaded ring until the dial indicator reads 0.002 inch (0.05 mm).
11. Using a suitable marker or paint, mark the center of one of the teeth on the threaded ring and the surface of the bearing cage. See **Fig. 5**.

IMPORTANT: The next step is critical. Tightening the threaded ring by advancing it one tooth will set the bearing preload to 0.00 to 0.0012 inch (0.00 to 0.03 mm). If you tighten the threaded ring beyond this tolerance, you cannot back it off; you will need to remove the threaded ring and repeat the entire installation procedure.

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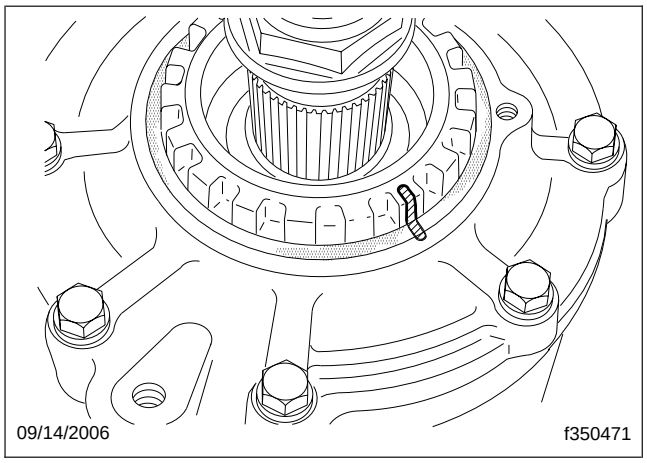



**Fig. 5, Marking the Tooth and Bearing Cage**

12. Very carefully advance the threaded ring one tooth while checking the paint mark. Stay close to a one-tooth advancement when making the final adjustment. Bear in mind that the new locking plate must fit into place once the correct tightness is achieved. The locking tab should fit in place either slightly before or slightly past a one-tooth advancement of the threaded ring. *You cannot back off the threaded ring once it is tightened.*

    Try fitting the new locking plate in place by turning and flipping it over as you slowly tighten the threaded ring. Tighten the threaded ring so the bearing preload is 0.00 to 0.0012 inch (0.00 to 0.03 mm). When the correct tolerance is reached, the mark on the surface of the bearing cage should line up with the center of the next tooth. See **Fig. 6**. Do not tighten the threaded ring any further.

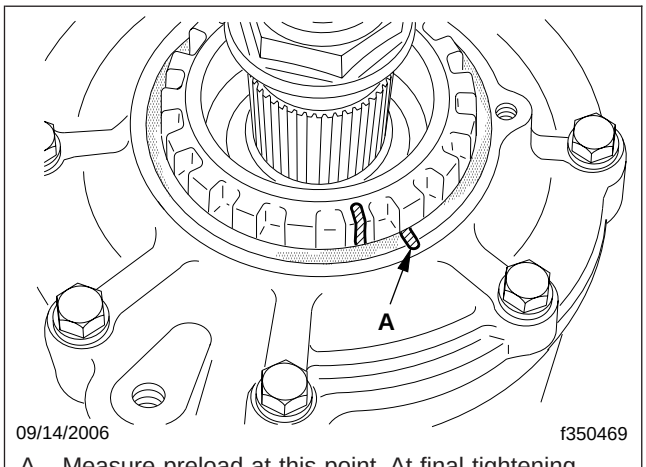
13. When the bearing preload is correct, install the new locking plate and capscrew. Tighten the capscrew 18 lbf·ft (24 N·m).

14. Install the new input-shaft seal as follows (see **Fig. 7**):

    14.1 Inspect the area around the seal for damage. Use emery paper to remove scratches, nicks, or burrs on the seal bore.

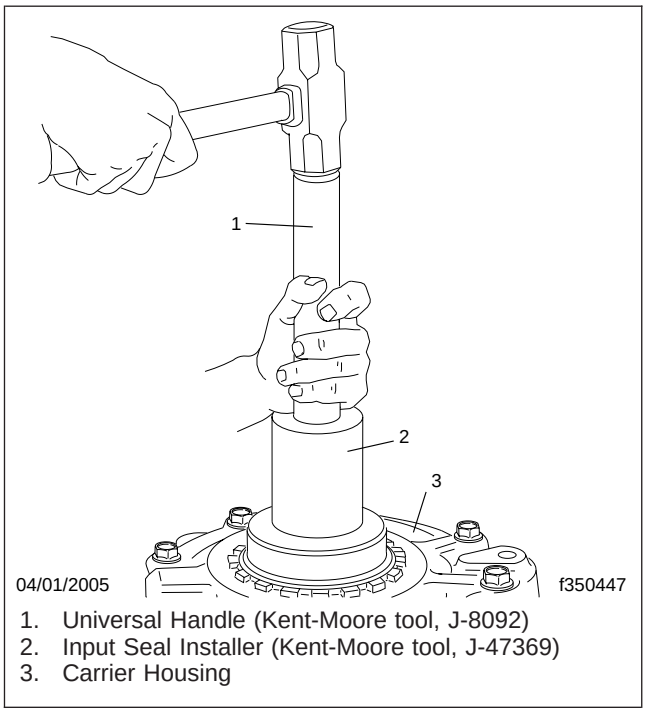
    14.2 Apply a light coating of axle oil to the seal bore.

    14.3 Coat the mating surfaces of the new seal with Loctite® 5900 sealant, or equivalent.




A. Measure preload at this point. At final tightening, this mark should be opposite the center of the next tooth, but no further.

**Fig. 6, Advancing the Threaded Ring**




1. Universal Handle (Kent-Moore tool, J-8092)
2. Input Seal Installer (Kent-Moore tool, J-47369)
3. Carrier Housing

**Fig. 7, Installing the Forward Carrier Input Seal**

14.4 Assemble the input shaft seal installer onto the threaded end of the universal handle. See **Fig. 7**.

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## Threaded Ring Repair

14.5 Using the input shaft seal installer assembly, press the seal into the bore until the seal surface is flush with the threaded ring.

15. Apply Loctite 242 to the threads of the new yoke nut, then using it and a new washer, install the existing yoke on the input shaft. Tighten the yoke nut 628 lbf·ft (850 N·m).
16. Connect the main driveshaft to the input shaft. For instructions, see **Section 41.00, Subject 120**.
17. Remove the chocks.

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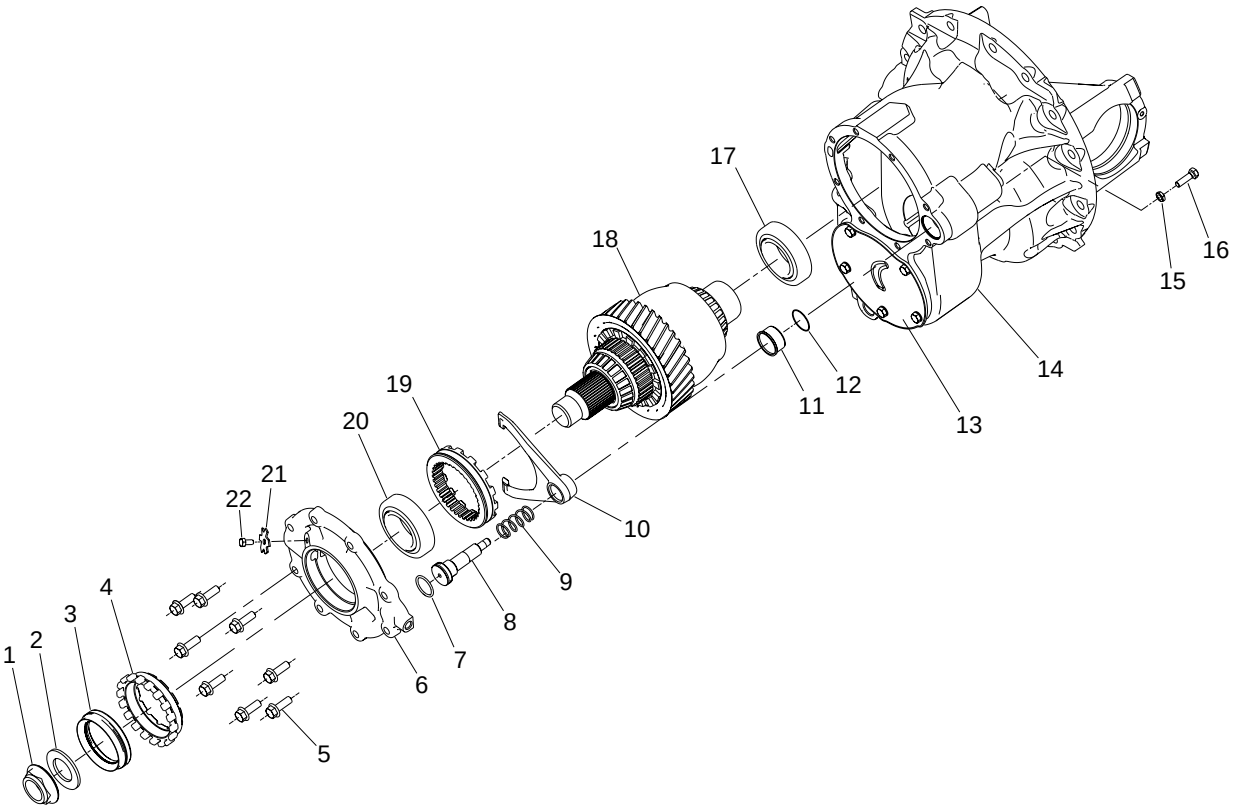


# Interaxle Differential Replacement

The following on-vehicle procedure replaces the interaxle differential (IAD) assembly and accomplishes a minor carrier rebuild by replacing the bearing races and, as needed, the shift shaft bushing. The front cover is resealed and the input shaft seal is replaced. See **Fig 1**.

## Special Tools

Special tools are required for this procedure. See **Table 1**.




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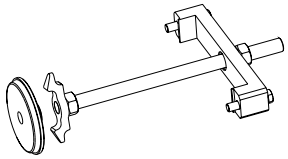
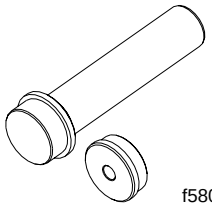
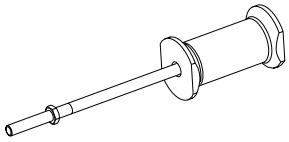
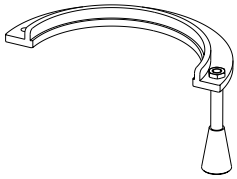
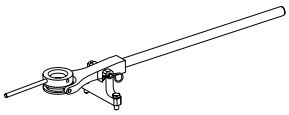
1. Yoke Nut
2. Washer
3. Input Shaft Seal
4. Threaded Ring
5. Bearing Cage Capscrews
6. Bearing Cage
7. Shift Shaft Piston O-ring
8. Shift Shaft Piston
9. Piston Spring
10. Shift Fork
11. Shift Shaft Bushing O-ring
12. Shift Shaft Bushing
13. Cover Plate
14. Carrier Housing
15. Locknut
16. IAD Adjustment Screw
17. Output Bearing Race
18. IAD Assembly
19. Clutch Collar
20. Input Bearing Race
21. Locking Plate
22. Locking Plate Capscrew

**Fig. 1, The Interaxle Differential and Carrier Housing Components**

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## Interaxle Differential Replacement

| Special Tools for Interaxle Differential Replacement | | | |
|---|---|---|---|
| **Tool** | **Description** | **Manufacturer** | **Part Number** |
|  f580478 | Output Bearing Remover and Installer | Daimler | MBA 420589003300 |
|  f580480 | Shift Shaft Bushing Remover and Installer | Daimler | MBA 420589013300 |
|  f580476 | Slide Hammer | Daimler | MBA 060589003300 |
|  f580479 | Half-Moon Device | Daimler | MBA 420589006300 |
|  f580477 | Push-Pull Device | Daimler | MBA 420589001600 |

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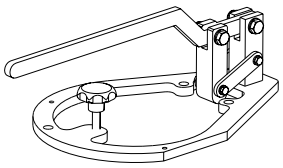
| Special Tools for Interaxle Differential Replacement | | | |
|---|---|---|---|
| **Tool** | **Description** | **Manufacturer** | **Part Number** |
|  f580481 | Shift Shaft Piston Installer | Daimler | MBA 420589023300 |

**Table 1, Special Tools for Interaxle Differential Replacement**

## Replacement

1. Park the vehicle on a level surface, shut down the engine, set the parking brake, and chock the front tires.
2. Ensure the interaxle differential is disengaged and the system is charged with air. The rear wheels will need to turn near the end of this procedure.
3. Place a suitable strap around the driveshaft and frame to hold the driveshaft out of the way after it is disconnected.
4. Disconnect the main driveshaft from the forward carrier input yoke (for instructions, see **Section 41.00, Subject 120**), and support it with the strap.
5. Clean the carrier housing and surrounding area as needed to remove any debris that could enter the housing.
6. Drain the oil from the carrier housing.
7. Disconnect the air line connected to the bearing cage.
8. Remove the yoke nut and washer from the input shaft of the forward differential carrier, then remove the yoke.
9. Remove the capscrew and the locking plate. See **Fig 1**.
10. Using a spanner wrench, remove the threaded ring by turning it counterclockwise.
11. Remove the bearing cage capscrews from the bearing cage, and pry the bearing cage from the carrier housing. It may help to tap the bearing cage loose with a chisel; see **Fig. 2**.

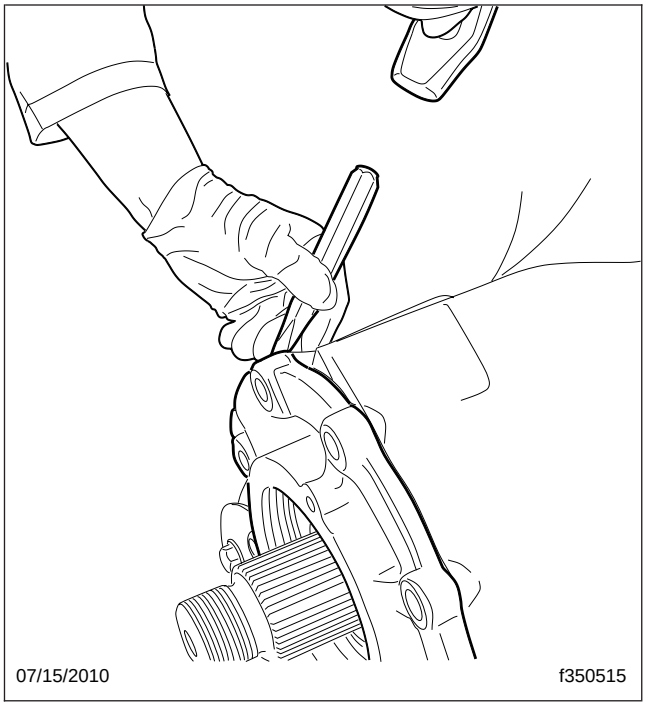



**Fig. 2, Tapping the Bearing Cage Loose**

12. Remove the IAD adjustment screw and locknut.

### NOTICE

**When unseating the shift shaft piston, multiple taps may be needed, but use moderate force only and be careful to hit the piston only (not the housing). Stop tapping it once it protrudes from the housing. The use of excessive force, or tapping it while it protrudes from the housing can damage the piston and the housing.**

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## Interaxle Differential Replacement

13. Using a brass or plastic mallet, squarely tap the shift shaft piston to unseat it, and then remove it from the carrier housing.
14. Remove the piston spring, clutch collar, and shift fork.

### NOTICE

**The IAD assembly is heavy. Use appropriate support while removing and transporting it to prevent dropping and damaging it. Do not allow it to rest on the oil slinger; see Fig. 3. Resting the IAD assembly on the oil slinger could damage the oil slinger.**

15. Remove the IAD assembly.
16. Align the output bearing remover (see **Table 1**) with the notches in the rear of the carrier housing, then attach it to the housing with bearing cage capscrews, and use it to remove the output bearing race. See **Fig. 4**.
17. If the brass shift shaft bushing is damaged or worn, assemble the slide hammer and shift shaft bushing remover (see **Table 1**), and slide the hammer handle to remove the bushing. See **Fig. 5**.
18. Using a suitable solvent (such as brake cleaner), clean any remaining sealant from the threaded ring and mating surfaces of the carrier housing and the bearing cage. Dry the surfaces with compressed air, ensuring no cleaning solvent remains.

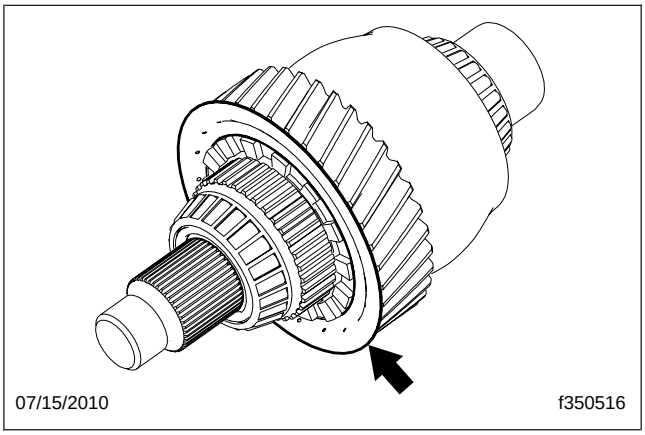



**Fig. 3, Oil Slinger**

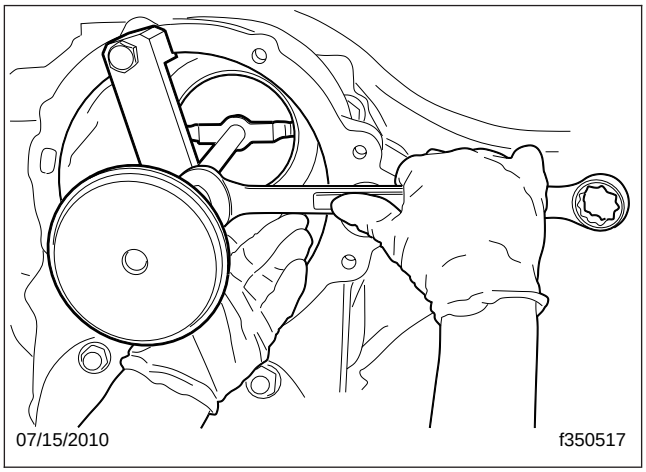
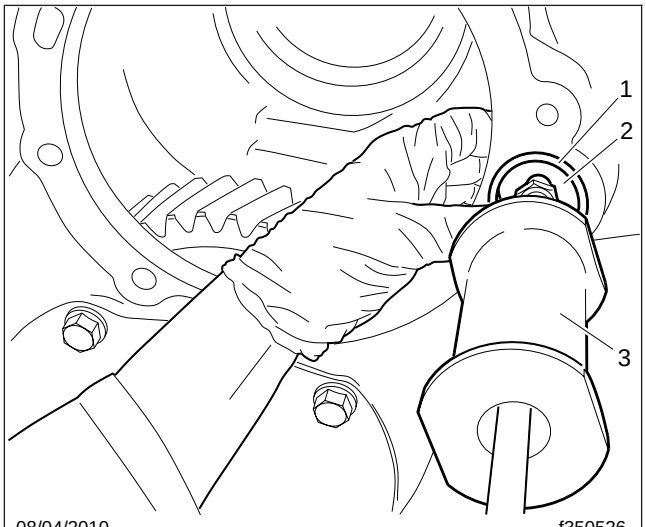



**Fig. 4, Removing the Output Bearing Race**




1. Shift Shaft Bushing
2. Shift Shaft Bushing Remover
3. Slide Hammer

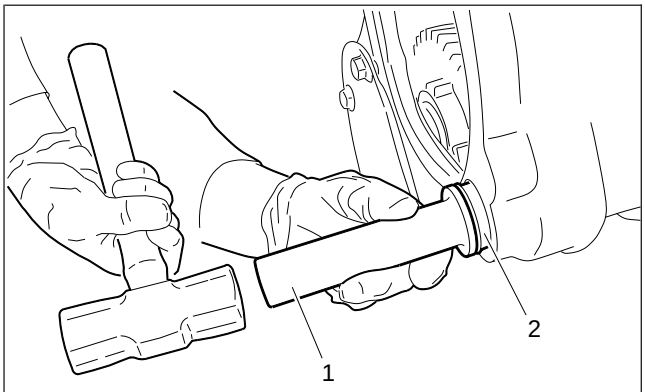
**Fig. 5, Installing the Bushing Remover**

19. As in the previous step, clean the groove at the piston bushing bore.
20. If the brass shift shaft bushing was removed, install a new one using a mallet and the Shift Shaft Bushing Installer. See **Fig. 6**.
21. A new output bearing race is included with the new IAD. Install it as follows.

    21.1 To get it started, lightly tap the race into place with a hammer handle or wood

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1. Shift Shaft Bushing Installer
2. Shift Shaft Bushing

**Fig. 6, Installing the Bushing**

block. The race must be square in the housing or damage will occur when it is pressed. See **Fig. 7**.

21.2 Fasten the output bearing installer to the carrier housing, and use it to press the race into the housing. As the race is installed, slight jerks can be felt and heard. See **Fig. 8**.

22. Lubricate the output gear and bearing of the new IAD assembly with white grease.
23. Install the IAD assembly and output gear. Do not allow the assembly to rest on the oil slinger.
24. Install the clutch collar and shift fork.
25. Apply a thin film of white grease to the shift shaft piston, and insert it with the piston spring into the housing until about 1 inch (2.5 cm) of the piston protrudes from the bore.
26. The half-moon device (see **Table 1**) helps align the shift fork and shift shaft piston. To install it, slide it between the oil slinger and the shift fork. See **Fig. 9**.
27. Install the shift shaft piston as follows.

    27.1 The shift shaft piston installer (see **Table 1**) is designed to install the piston without damaging it or the carrier housing. Use two bearing cage capscrews to mount it to the carrier housing. See **Fig. 10**.

    27.2 Adjust the hex screw until the shift fork is snug but not bound.

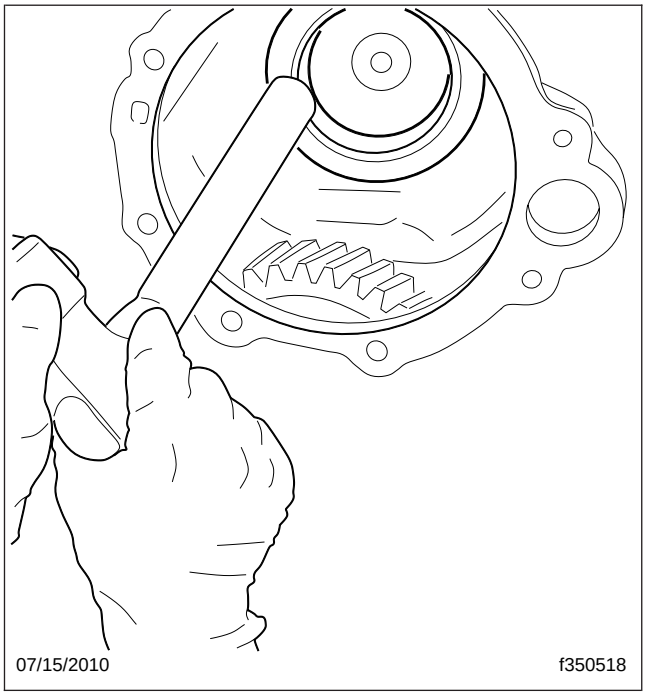



**Fig. 7, Setting the Race**

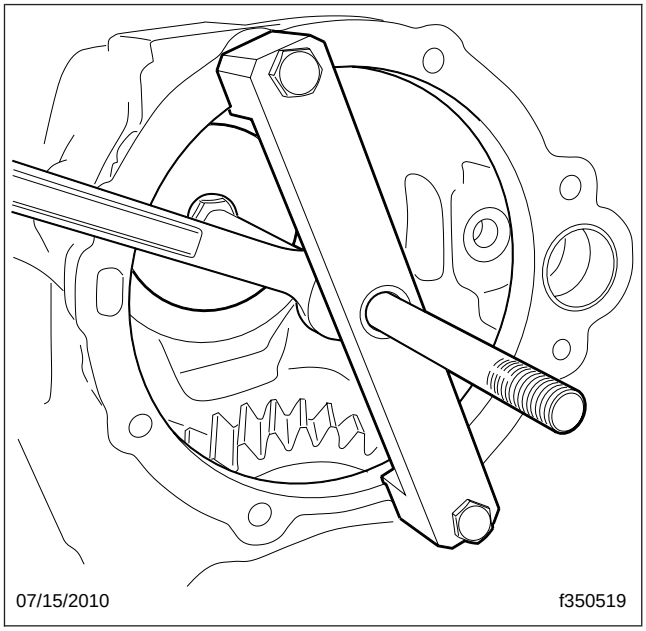



**Fig. 8, Pressing a New Race into the Housing**

27.3 In a single movement of moderate force, use the lever of the installer to press the piston into the bore until only about 1/8 to

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## Interaxle Differential Replacement

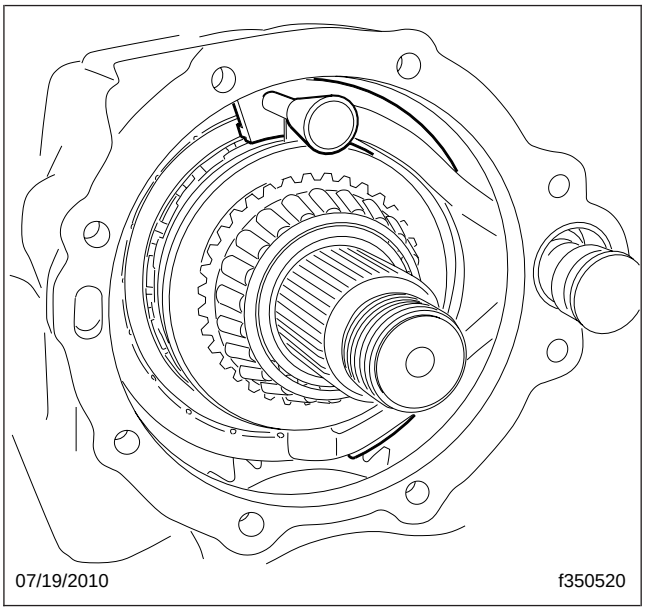



**Fig. 9, The Half-Moon Device, Installed**

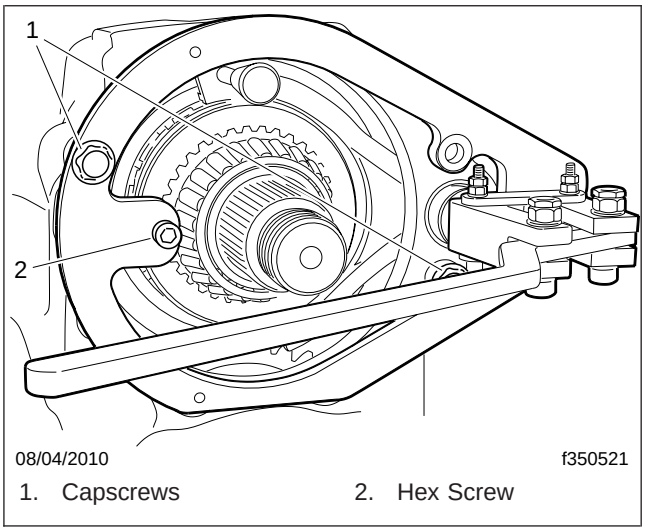



**Fig. 10, Shift Shaft Piston Installer, Mounted**

1/16 inch (2 to 3 mm) of the piston protrudes from the carrier housing. When the piston seats, a "click" sound may be audible. If the piston does not seat readily, adjust the hex screw, and try again.

27.4 Once the piston is seated, remove the shift shaft piston installer and the half-moon device.

28. Remove the input bearing race from the bearing cage. Place the new race into the cage so that it is more forward than in the final position. As the preload is adjusted, the race will seat to its final position.
29. Apply Loctite® 577 sealant to the threads of the threaded ring and tighten it until it is snug against the race.

IMPORTANT: Do not overapply sealant. Do not allow sealant to enter the oil return or touch the shift shaft piston.

30. Apply a small bead of Loctite 5900 to the carrier housing. See **Fig. 11**. To help ensure a good seal, spread it uniformly over the surface area.

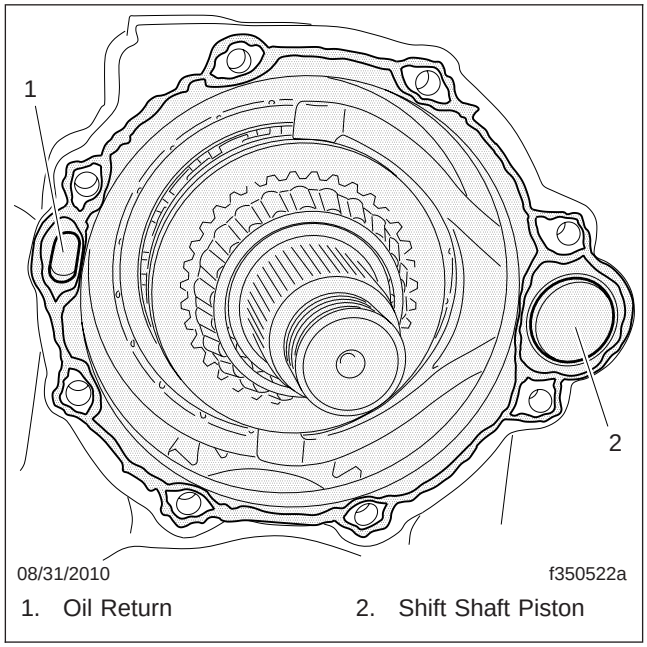



**Fig. 11, Sealant Applied to Carrier Housing**

31. Install the bearing cage, and using a star pattern tighten the capscrews to 103 lbf·ft (140 N·m).
32. The push-pull device (see **Table 1**) is used to set pre-load on the input bearing. Remove the two upper capscrews from the cover plate and install the device as shown in **Fig. 12**.
33. Set the correct end play as follows.

    33.1 Set up a dial indicator as shown in **Fig. 13**.

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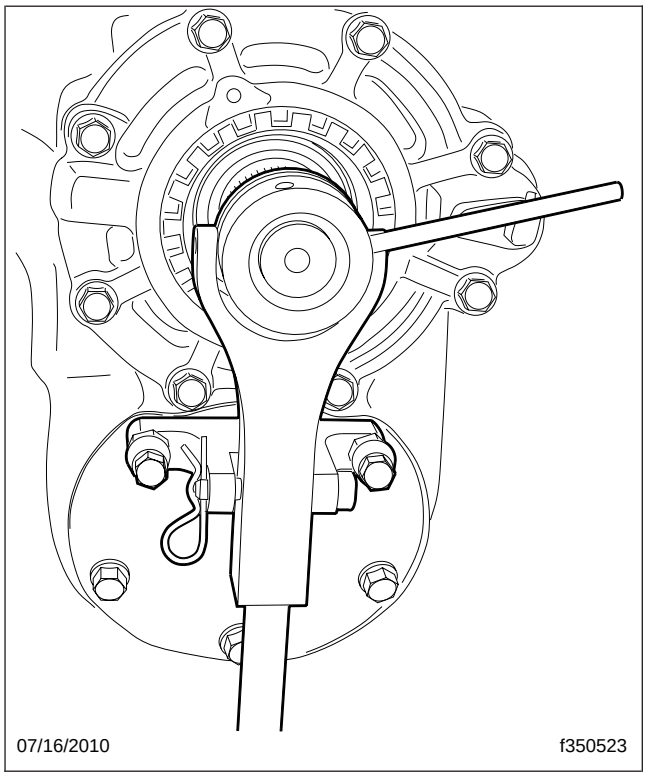



**Fig. 12, Push-Pull Device, Installed**

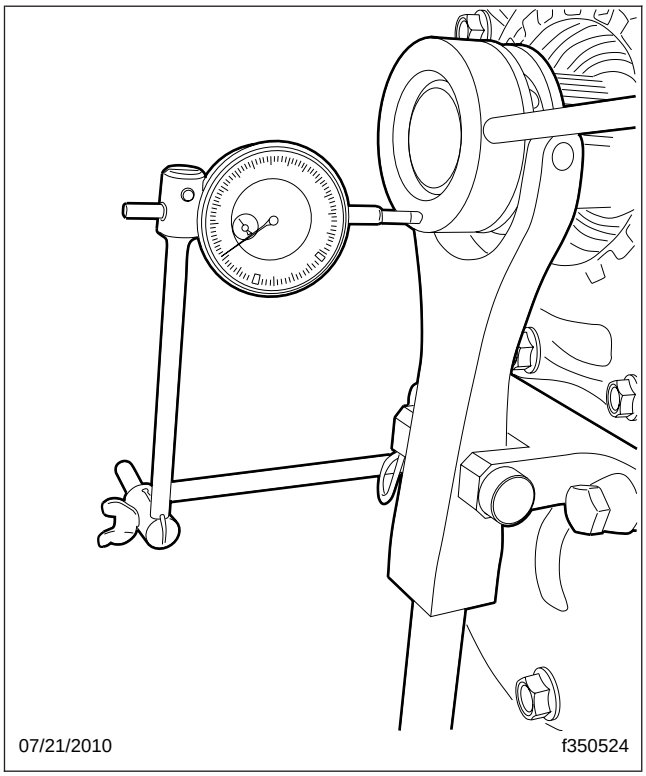



**Fig. 13, Dial Indicator and Push-Pull Device**

33.2 Turn the input shaft three revolutions and tighten the threaded ring until there is between 0.002 and 0.003 inch (0.05 and 0.08 mm) of end play. Turn the input shaft three more revolutions and verify the measurement.

33.3 When there is between 0.002 and 0.003 inch (0.05 and 0.08 mm) of end play, align a mark on the threaded ring with one on the bearing cage. See **Fig. 14**.

33.4 Tighten the threaded ring almost one notch.

IMPORTANT: Do not loosen the threaded ring. If the threaded ring is loosened, the bearing cage must be removed and the race re-installed.

33.5 The locking plate has six positions that can lock the threaded ring. Find the position that fits best, install it, and tighten the capscrew 18 lbf·ft (24 N·m).

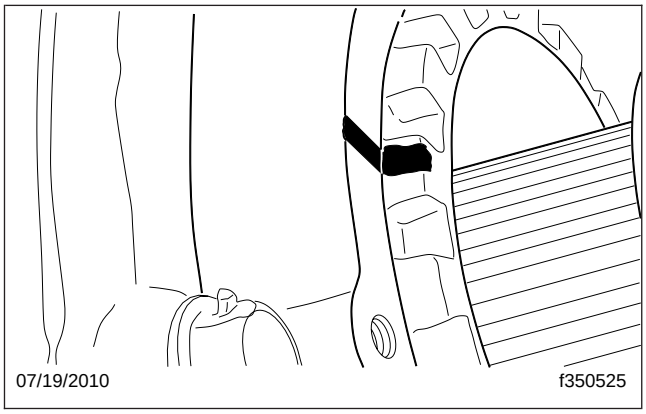



**Fig. 14, Threaded Ring and Bearing Cage, Marked**

33.6 Remove the push-pull device and dial indicator, and install the the two upper capscrews on the cover plate. Tighten the capscrews 63 lbf·ft (85 N·m).

34. Install a new input shaft seal and the yoke, nut, and washer; see **Subject 170** for instructions.

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## Interaxle Differential Replacement

35. Clean, install, and adjust the IAD adjustment screw and locknut as follows.
    - 35.1 Clean the IAD adjustment screw and locknut with a suitable solvent (such as brake cleaner). Dry the cleaned surfaces, ensuring no solvent remains.
    - 35.2 Connect an air line at the interaxle lock.
    - 35.3 Apply air, and by hand, turn the input shaft to ensure the gear cogs fully engage.
    - 35.4 Coat the threads of the adjustment screw with Loctite® 577.
    - 35.5 Install the adjustment screw, with the locknut, into the carrier housing, and handtighten the screw until it touches the engaged shift shaft piston.
    - 35.6 Disengage the IAD to relieve the air pressure exerted on the adjustment screw.
    - 35.7 Hand-tighten the adjustment screw one quarter turn, then tighten the locknut 30 lbf·ft (41 N·m).
36. Connect the main driveshaft; for instructions, see **Section 41.00, Subject 120**.
37. Using approved axle oil, fill the axle housing to the bottom of the fill hole, or until filled to capacity as shown in **Table 2**.

| Forward-Rear Axle Oil Type and Capacity | | |
|---|---|---|
| **Approved Oil Type** | **Capacity: quarts (liters)** | |
| | **Hubs Full** | **Hubs Dry** |
| 80W-90 Gear Oil | 14.3 (13.5) | 15.9 (15.0) |
| 75W-90 Synthetic Gear Oil | | |

**Table 2, Forward-Rear Axle Oil Type and Capacity**

38. To lubricate the wheel ends, tilt the axle to the left and right by jacking the opposite side 8 inches (20 cm). Hold the tilted position for two minutes on each side to allow oil to run into the wheel end. Return the axle to a level position, and add oil through the axle housing filler hole. About two more pints (1 liter) of lubricant will be needed to bring the oil level even with the base of the filler hole.

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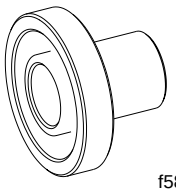


| Torque Values | | |
|---|---|---|
| **Application** | **Size** | **Torque: lbf·ft (N·m)** |
| *All Model 4 Axles* | | |
| Carrier Capscrews | M16 | 200 (270) |
| Drive Axle Stud Nuts | 1/2–20 | 75–115 (102–156) |
| | 5/8–18 | 150–170 (203–230) |
| Yoke Nut (model 4 axles) | M45 x 1.5 | 627 (850) |
| *Forward-Rear Axles* | | |
| Bearing Cage Capscrews | M12 | 107 (145) |
| Input Yoke Nut | M45 x 1.5 | 627 (850) |
| Output Yoke Nut | M39 x 1.5 | 516 (700) |

**Table 1, Torque Values**

| Rear Axle Lubricant Type and Capacity | | | |
|---|---|---|---|
| **Approved Lubricant Type** | **Axle** | **Oil Capacity: quarts (liters)** | |
| | | **Hubs Full** | **Hubs Dry** |
| 80W/90 Gear Oil | Forward-Rear | 14.3 (13.5) | 15.9 (15.0) |
| 75W/90 Synthetic Gear Oil | | | |
| 80W/90 Gear Oil | Single and Rearmost Tandem | 10.6 (10.0) | 12.2 (11.5) |
| 75W/90 Synthetic Gear Oil | | | |

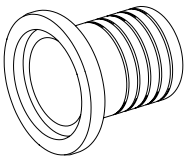
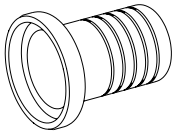
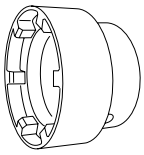
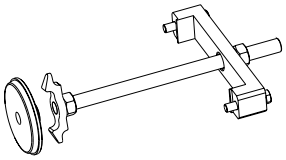
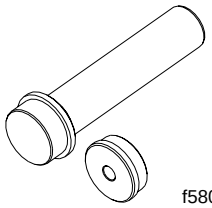
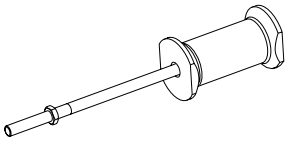
**Table 2, Rear Axle Lubricant Type and Capacity**

| Special Tools for Detroit Rear Axles | | | |
|---|---|---|---|
| **Tool** | **Description** | **Manufacturer** | **Part Number** |
|  f580400 | Universal Handle* | Kent-Moore | J-8092 |
|  f580406 | Rear Pinion Seal Installer* | Kent-Moore | J-47354 |

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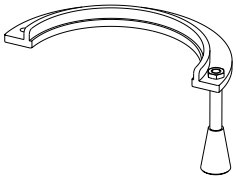
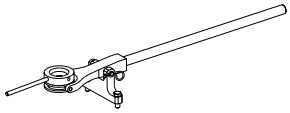
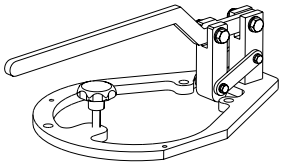


## Specifications

| Special Tools for Detroit Rear Axles | | | |
|---|---|---|---|
| **Tool** | **Description** | **Manufacturer** | **Part Number** |
|  f580410 | Input Seal Installer* | Kent-Moore | J-47369 |
|  f580408 | Output Seal Installer* | Kent-Moore | J-47368 |
|  f580450 | Yoke Nut Socket† | Daimler | MBA 742589020700 |
|  f580478 | Output Bearing Remover and Installer | Daimler | MBA 420589003300 |
|  f580480 | Shift Shaft Bushing Remover and Installer | Daimler | MBA 420589013300 |
|  f580476 | Slide Hammer | Daimler | MBA 060589003300 |

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| Special Tools for Detroit Rear Axles | | | |
|---|---|---|---|
| **Tool** | **Description** | **Manufacturer** | **Part Number** |
|  f580479 | Half-Moon Device | Daimler | MBA 420589006300 |
|  f580477 | Push-Pull Device | Daimler | MBA 420589001600 |
|  f580481 | Shift Shaft Piston Installer | Daimler | MBA 420589023300 |

* To order Kent-Moore tools call 1-800-328-6657.

† The yoke nut socket is needed to remove the round, slotted yoke nut installed on some vehicles. It can be ordered through Paragon.

**Table 3, Special Tools for Detroit Rear Axles**

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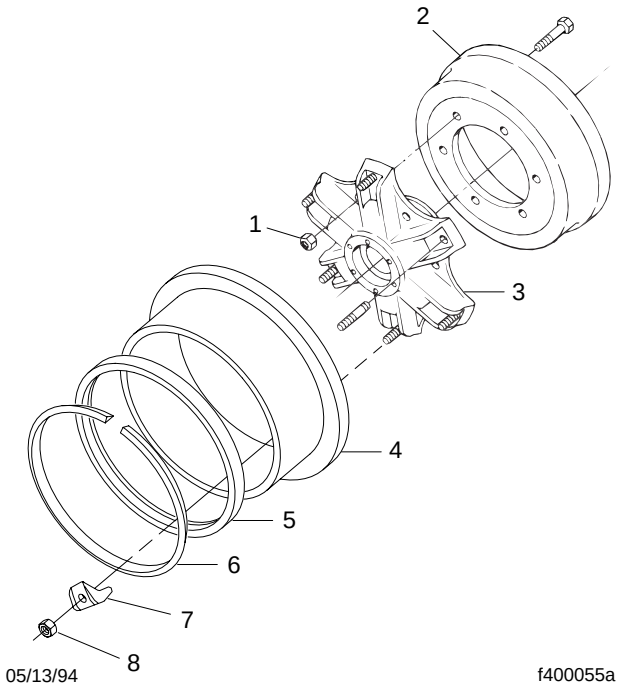
# General Information

## Wheels and Tires

The tires support the weight of the vehicle, and are integral parts of the transmission and braking systems. The wheels serve as load carrying members between the tires and the axle.

There are two types of wheels: spoke and disc.

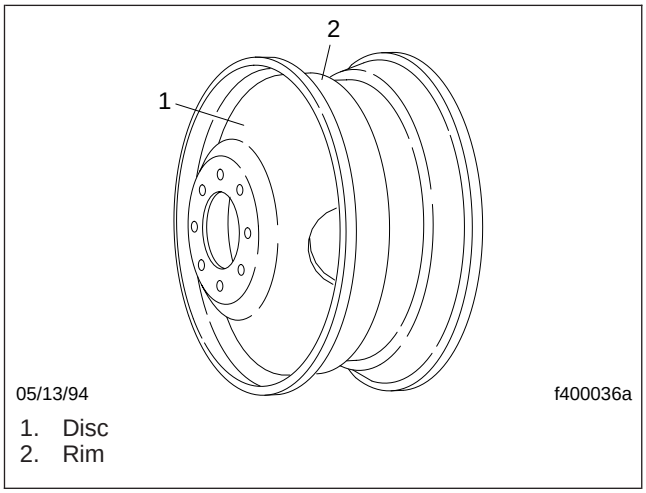
Spoke wheels consist of a wheel and brake drum assembly installed on the axle (**Fig. 1**), and a tire and rim assembly that mounts on the wheel. Rim clamps and rim nuts hold the tire and rim assembly in place.




1. Brake Drum Nut
2. Brake Drum
3. Spoke Wheel
4. Rim Base
5. Continuous Side Ring
6. Split Lockring
7. Rim Clamp
8. Rim Nut

**Fig. 1, Spoke Wheel and Brake Drum Assembly (Shown with Three-Piece Rim, for Tube-Type Tires)**

Disc wheels consist of a rim and disc. The rim, the portion of the wheel on which the tire is mounted and supported, is welded to the disc (**Fig. 2**). After the tire is mounted on the wheel, the assembly is held in place on the hub with wheel studs and nuts.




1. Disc
2. Rim

**Fig. 2, Disc wheel**

Standard ten-hole dual disc wheels are held in place on the hub by self-centering inner and outer wheel nuts. Eight-hole and optional ten-hole (single and dual) disc wheels are centered by pilot pads and are held in place on the hub with cone locknuts.

Tires are constructed of either radial or bias plies:

Radial tires have ply cords that run from bead to bead, and at a right angle to the belt plies and tire tread (**Fig. 3**). The belt plies constrict the radial ply cords and give rigidity to the tread.

Bias ply tires have body ply cords that run diagonally from bead to bead (**Fig. 4**). The tires may also have narrow plies under the tread, called breakers, with cords that lie in about the same direction as the body ply cords.

Tire body plies, breakers, and belts are made of polyester, rayon, nylon, fiberglass, steel, or aramids (fibrous reinforcements). In radial ply tires, these materials are used in various combinations, including steel body/steel belt, polyester body/fiberglass belt, or nylon body/steel belt.

Wheels and tires operate either with or without tubes. Tube-type tires require a tube and flap for correct assembly on a two-or three-piece rim (**Fig. 1**). Tubeless tires require only the tire, and a one-piece drop-center wheel or rim. See **Fig. 2**.

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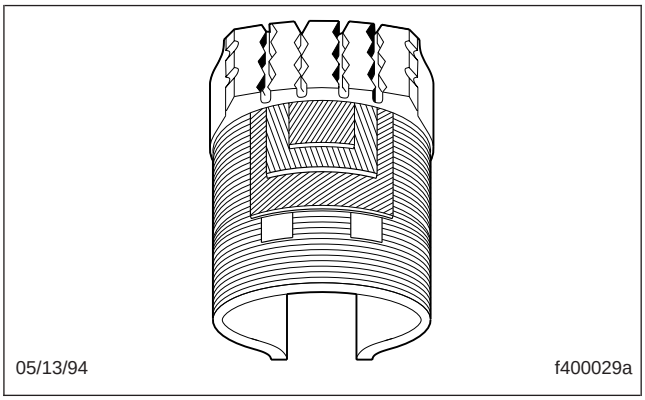



**Fig. 3, Radial Ply Tire Construction**

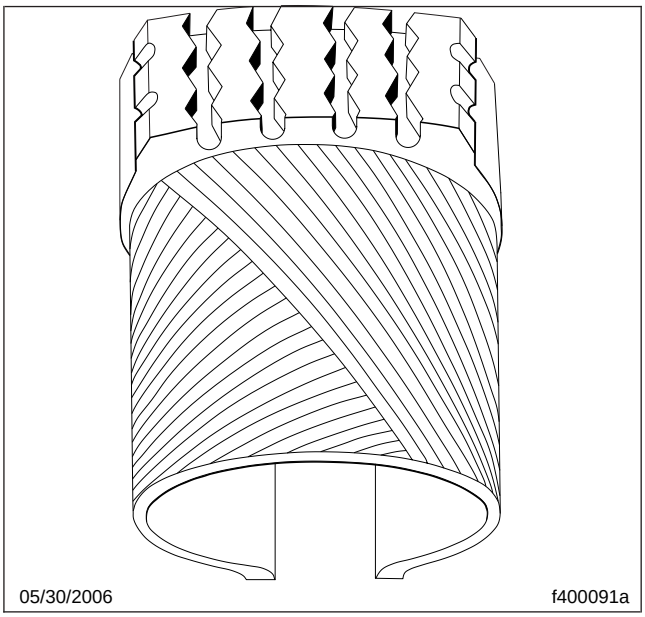
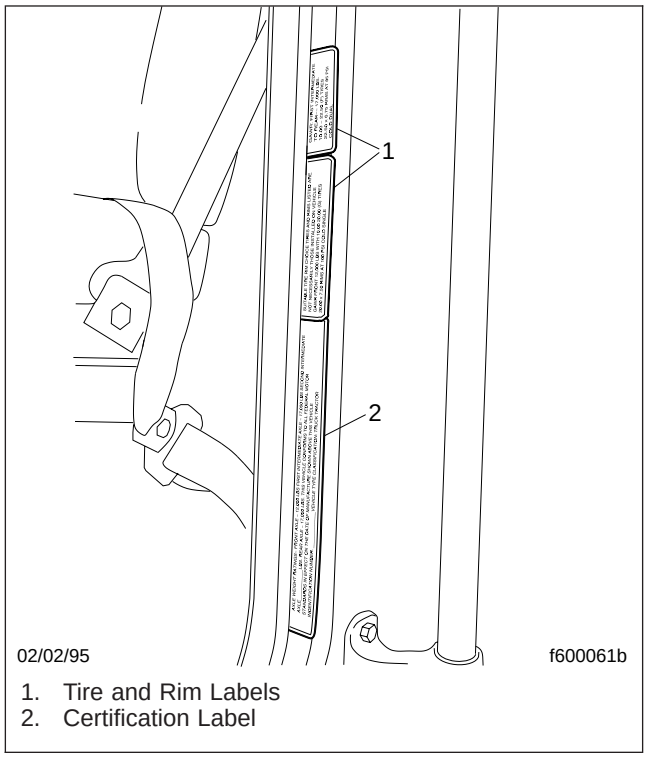



**Fig. 4, Bias Ply Tire Construction**

## Tire Matching and Mixing

IMPORTANT: Review and follow these requirements for matching and mixing tires, before installing any tire and wheel or rim assembly on a vehicle.

Before changing wheels and tires, consider the effect that the change may have on the Gross Vehicle Weight Rating (GVWR) of the vehicle. At the time of vehicle certification, the GVWR is calculated by adding the vehicle's Gross Axle Weight Ratings (GAWR). The GVWR and each of the GAWRs are shown on a certification label (U.S.-purchased tractors) or "Statement of Compliance" label (Canadian-purchased tractors) attached to the left rear door post. See **Fig. 5**.




1. Tire and Rim Labels
2. Certification Label

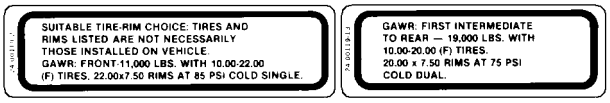
**Fig. 5, Certification Label, U.S.**

Tire and rim labels (**Fig. 5** and **Fig. 6**) certify the minimum tire and rim combinations that can be installed on the vehicle for the given GAWRs. Each GAWR is determined by considering each component of the axle system, including suspension, axle, wheels, and tires. The lowest component's capacity is the value used for the system. Therefore, the tires and rims installed on the vehicle at the time of vehicle manufacture may have a higher load capacity than that certified by the tire and rim label. Tires and rims of the minimum capacity can be installed without changing the load limitations. If tires and rims are installed that have a lower load capacity than that shown on the tire and rim label, then the tires and rims determine the load limitations (the GAWRs and GVWR will be lower).

When pairing tires in a dual assembly, the tire diameters must not differ by more than 1/4 inch (6.4 mm), or the tire circumference by more than 3/4 inch (19 mm). The total tire circumference of one driving rear

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NOTE: Examples only. Actual specifications may vary from vehicle to vehicle.

**Fig. 6, Tire and Rim Labels**

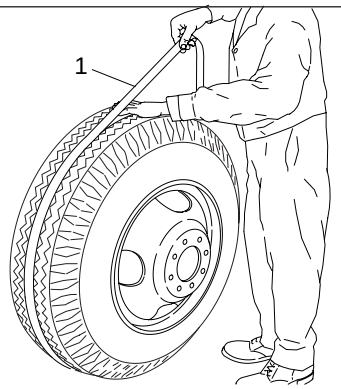
axle must match, as nearly as possible, the total tire circumference of the other driving rear axle.

## CAUTION

**Mismatching dual tires overloads the larger diameter tire, causing it to overdeflect and overheat. The smaller diameter tire, lacking proper road contact, wears faster and unevenly. Tread or ply separation, tire body breaks, and blowouts can occur from mismatched duals.**

With an endless pi tape (**Fig. 7**) or square (**Fig. 8**) measure the diameter of the tires 24 hours after inflation. A matching stick (**Fig. 9**), string gauge (**Fig. 10**), or tire straight edge (**Fig. 11**) can also be used to determine the difference in tire radius, which is then doubled to calculate the diameter difference.

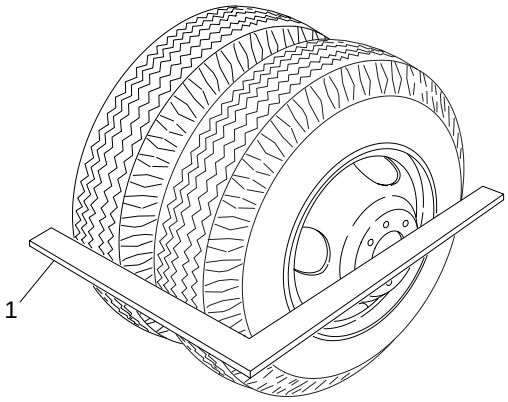
When pairing tires of unequal diameters (but within the above limits), mount the larger tire on the outside.




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1. Endless Pi Tape

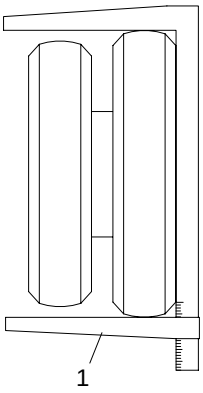
**Fig. 7, Endless Pi Tape**




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1. Square

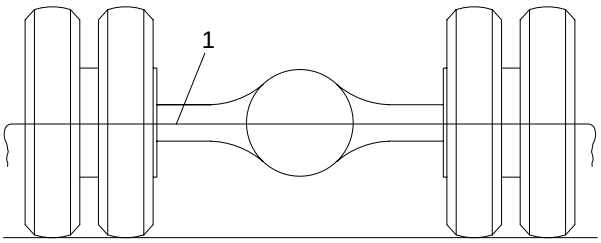
**Fig. 8, Square**




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1. Matching Stick

**Fig. 9, Matching Stick**




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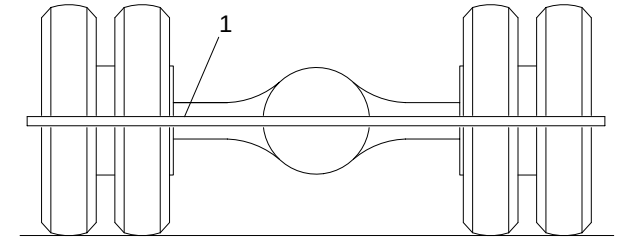
1. String Gauge

**Fig. 10, String Gauge**

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## General Information




1. Tire Straight Edge

**Fig. 11, Tire Straight Edge**

**CAUTION**

**Driving a vehicle on one tire of a dual assembly dangerously exceeds the carrying capacity of the single tire and wheel. Operating in this manner can cause damage to the wheel and tire.**

Inflate all tires on an axle, or on both axles of a tandem unit, to within 5 psi (35 kPa) of one another. For tire inflation specifications, see **Specifications, 400.**

There must be sufficient space between dual tires for air to flow and cool the tires, and to prevent them from rubbing against one another. Rims and wheels of the same size, but of different makes and types, can have different offsets, which would affect dual spacing. If there is sidewall contact between tires, or between the inside tire and the chassis, refer to the tire manufacturer's catalog to determine the minimum dual spacing. Refer to the rim or wheel manufacturer's catalog to determine the correct offset.

Federal Motor Carrier Safety regulations require the removal of all tires with less than 4/32-inch (3 mm) remaining groove depth on a front axle, and tires with less than 2/32-inch (1.5 mm) remaining groove depth on a rear axle. However, tires with the word "Regroovable" on the sidewall, may be regrooved.

Better tire and vehicle performance is usually obtained by using tires of the same size and construction. Using tires of different construction is permitted if the following rules are observed:

- Do not mix radial and bias ply tires on the same axle.
- If both radial and bias ply tires are used, better handling is usually obtained by using the bias ply tires on the front axle.
- Use either all radial or all bias ply tires on the non-driving rear axles of a vehicle. However, all radial or all bias ply tires must be used on vehicles with tandem drive-axles.

**CAUTION**

**Mixing radial and bias ply tires should be done as an emergency measure only. Some loss of steering control and premature tire wear could occur when driving under such conditions.**

If installing radial tires on a vehicle formerly equipped with bias ply tires, see **Specifications, 400** concerning the inflation needs and load limits of the bias ply tires being removed, and of the radial ply tires being installed. Radial ply tires permit greater loads per tire, but also require higher inflation. They can also cause higher stresses on rims and wheels than bias ply tires. Contact the rim or wheel manufacturer about the compatibility of the rim or wheel with radial ply tires. Also, see **Group 33** for information on the possible differences in toe-in setting between radial and bias ply tires.

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# 8-Hole Disc Wheel With Two-Piece Flange Nuts Removal and Installation

## Removal

**CAUTION**

**The wheel center hole and hub pilot have close tolerances. If the wheel is not kept square to the hub, it could bind during removal and damage the stud threads or hub-pilot pads. Keep the wheel square to the hub during removal.**

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock all tires that will not be serviced, to prevent vehicle movement.
2. Remove the wheels and tires from the front axle.
   - 2.1 Raise the front of the vehicle until the tires clear the floor. Place safety stands under the front axle.
   - 2.2 If the tire or wheel is damaged (or if there is suspected damage), deflate the tire being serviced by removing the valve core.
   - 2.3 Place a jack or wheel-and-tire dolly under the front wheel assembly being serviced. Turn the wheel until one hub-pilot pad is in the top-center position.
   - 2.4 Leaving the top nut until last, remove all eight two-piece flange nuts.

   IMPORTANT: On both sides of the vehicle, the two-piece flange nuts have right-hand threads.

   - 2.5 Remove the wheel. Do not let it drop on or drag across the stud threads.
3. Remove the wheels and tires from a rear axle.
   - 3.1 Raise the rear of the vehicle until the tires clear the floor. Place safety stands under the axle being serviced.
   - 3.2 If the tire or wheel is damaged (or if there is suspected damage), deflate both tires of the dual assembly being serviced by removing the valve cores.
   - 3.3 Place a jack or wheel-and-tire dolly under the dual wheel assembly being serviced. Turn the wheel until one hub pilot pad is in the top-center position.
   - 3.4 Leaving the top nut until last, remove all eight two-piece flange nuts.

   IMPORTANT: On both sides of the vehicle, the two-piece flange nuts have right-hand threads.

   - 3.5 Remove the wheel. Do not let it drop on or drag across the stud threads.

## Installation

NOTE: Before installing a wheel and tire assembly inspect it. See **Subject 190**. Also, follow the tire matching and mixing requirements. For instructions, see **Subject 050**.

1. Clean the hub and wheel mounting surfaces, and between the rims of dual wheels. Make sure the tire is correctly inflated. For instructions, see **Subject 210**.
2. Apply a few drops of light engine oil to the wheel studs and the area between the body and the flange of each two-piece flange nut. Wipe off any excess oil.

**CAUTION**

**The wheel center hole and hub pilot have close tolerances. If the wheel is not kept square to the hub, it could bind during installation and damage the stud threads or hub-pilot pads. Keep the wheel square to the hub during installation.**

IMPORTANT: Before installing the wheels, make sure the drum is positioned on the raised step of the pilot pad. One of the hub's pilot pads must be at the top location. To help keep the drum in place, it may be necessary to adjust the brakes before installing the wheels.

3. If installing a rear wheel assembly, go to the next step. Install the front wheel assembly.
   - 3.1 Locate one hub-pilot pad in the top-center position. Using a jack or wheel-and-tire dolly, position the wheel assembly on the hub. Make sure the wheel is square to the hub and that the threads or hub-pilot pads are not damaged by contact with the wheel during installation.

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## 8-Hole Disc Wheel With Two-Piece Flange Nuts Removal and Installation

3.2 Make sure the hub-pilot pad is still centered at the top.

IMPORTANT: Install the wheel assembly so that the balance weight(s) on the wheels are 180 degrees opposite the balance weight(s) on the brake drum.

4. Install the rear wheel assembly.

   4.1 Locate one hub-pilot pad in the top center position. Using a jack or wheel-and-tire dolly, position the inner wheel assembly on the hub. Make sure the wheel is square to the hub and that the threads or hub-pilot pads are not damaged by contact with the wheel during installation.

   4.2 Using the same procedure, mount the outer wheel against the inner wheel. Make sure the hub-pilot pad is still centered at the top.

IMPORTANT: Install the wheel assembly so that the balance weight(s) on the wheels are 180 degrees opposite the balance weight(s) on the brake drum. If this causes the valve stems to be in the same wheel hole, mount the outer wheel so that the outer wheel balance weight(s) are on the same side as the brake drum balance weight(s).

5. Install and hand-tighten a two-piece flange nut on the top and bottom studs.

**⚠ CAUTION**

**The two-piece flange nuts have right-hand metric threads. Do not try to install a similar size SAE nut on a stud, or the stud and nut will be damaged.**

6. Install and hand-tighten the remaining two-piece flange nuts. Tighten the two-piece flange nuts 50 to 100 lbf·ft (68 to 135 N·m) following the sequence in **Fig. 1**.
7. Check that the wheel is correctly seated against the hub and on the hub-pilot pads.
8. Following the sequence in **Fig. 1**, tighten the two-piece flange nuts 450 to 500 lbf·ft (610 to 678 N·m).

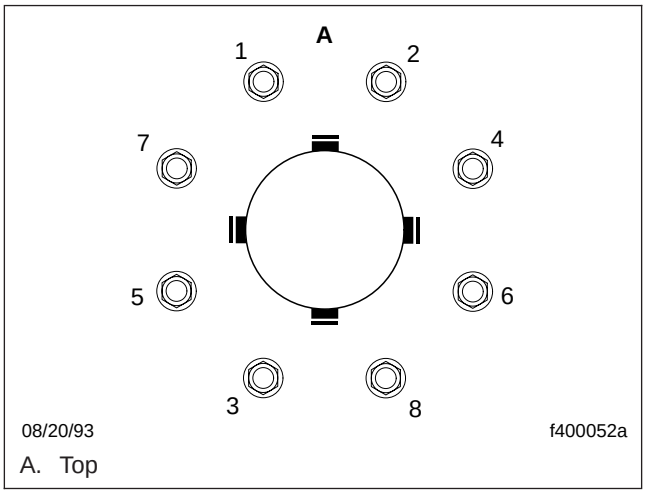



**Fig. 1, 8-Stud Disc Wheel Tightening Sequence**

**⚠ WARNING**

**Failure to replace damaged parts could result in the loss of a wheel or loss of vehicle control, causing personal injury or property damage. Always replace damaged parts with new parts.**

IMPORTANT: If the wheel nuts cannot be tightened to minimum torque values, the studs could be turning in the hub flange, having lost their locking ability. In this situation, the wheel hub assembly is damaged and must be replaced with a new assembly. Failure to reach minimum torque values could also be caused by stripped threads on the wheel studs or wheel nuts. Again, damaged parts must be replaced with new parts.

NOTE: Replace damaged parts following the instructions in **Group 33** or **Group 35**.

9. Remove the safety stands, lower the vehicle, and remove the chocks.
10. After operating the vehicle for 50 to 100 miles (80 to 160 km), retighten the wheel nuts 450 to 500 lbf·ft (610 to 678 N·m). Follow the sequence in **Fig. 1**.

**⚠ CAUTION**

**Too little wheel nut torque can cause wheel shimmy, wheel damage, stud breakage, and ex-**

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## 8-Hole Disc Wheel With Two-Piece Flange Nuts Removal and Installation

**treme tire tread wear. Too much wheel nut torque can break studs, damage threads, and crack discs in the stud hole area. Use the specified torque values, and follow the tightening sequence in Fig. 1.**

IMPORTANT: The two-piece flange nuts seat during vehicle operation. It is necessary to periodically tighten the wheel nuts to the specified torque. Tighten the two-piece flange nuts to the specified torque 50 to 100 miles (80 to 160 km) after service work, and check the torque every 50,000 miles (80 000 km) thereafter.

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# 10-Hole Disc Wheel With Two-Piece Flange Nuts Removal and Installation

## Removal

1. Park the vehicle on a level surface and apply the parking brakes. Shut down the engine. Chock all tires that will not be serviced, to prevent vehicle movement.
2. If working on the front axle wheels, raise the front of the vehicle until the tires clear the floor. Place safety stands under the front axle.

   If working on the rear axle wheels, raise the rear of the vehicle until the tires clear the floor. Place safety stands under the axle being serviced.
3. If the tire or wheel is damaged or if there is suspected damage, deflate the tire (or tires, on a dual assembly) being serviced by removing the valve core.
4. Turn the wheel until one hub-pilot pad is in the top-center position.
5. Leaving the top and bottom nuts until last, remove the other eight two-piece flange nuts.
6. Place a jack or wheel-and-tire dolly under the wheel assembly being serviced. Remove the top and bottom nuts.

**CAUTION**

**The wheel center hole and hub pilot have close tolerances. If the wheel is not kept square to the hub, it could bind during removal and damage the stud threads or hub-pilot pads. Keep the wheel square to the hub during removal.**

IMPORTANT: On both sides of the vehicle, the two-piece flange nuts have right-hand metric threads.

7. Remove the wheel. Do not let it drop on or drag across the stud threads.

## Installation

IMPORTANT: Before installing the wheels, it is recommended that an anti-seize compound be applied on the 360 degree wheel pilot hubs of Meritor FF-981 "Easy Steer Plus" front axles. After time in service, a small amount of rust or corrosion may make the wheel difficult to remove because of the extended wheel-to-hub contact. Applying an anti-seize compound on the wheel pilot of the hub will ensure easy wheel removal at a later date. Compounds such as the following may be used:

- Armite Led-Plate No. 250
- Loctite Anti-Seize No. 767
- Never-Seez
- Permabond Anti-Seize No. 82-9839

Compounds are available for purchase locally.

IMPORTANT: Freightliner "Turbo" wheel assemblies require directional mounting, as shown in **Fig. 1**.

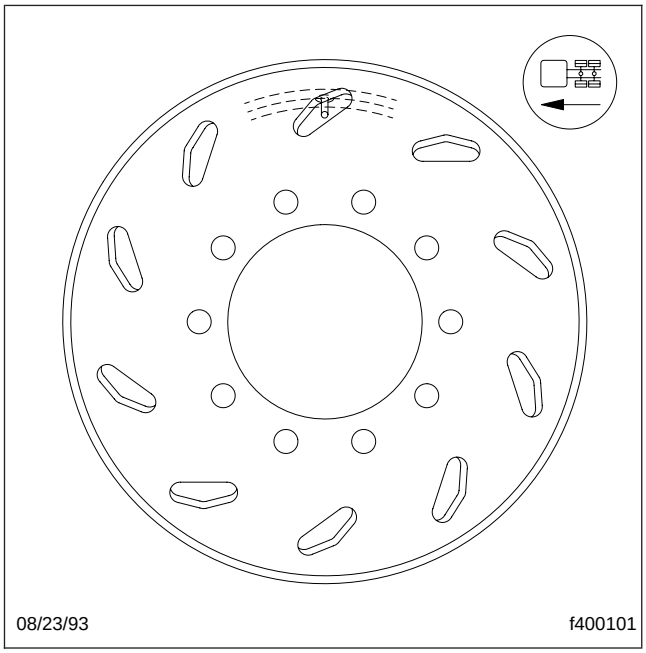



**Fig. 1, Side View**

NOTE: Before installing a wheel and tire assembly, inspect it using the instructions in **Subject 190**. Also, follow the tire matching and mixing requirements in **Subject 050**.

1. Clean the hub and wheel mounting surfaces, and all disc faces of dual wheels. Make sure the tire is correctly inflated. For instructions, see **Subject 210**.

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## 10-Hole Disc Wheel With Two-Piece Flange Nuts Removal and Installation

2. Apply a few drops of light engine oil to the wheel studs and the area between the body and the flange of each two-piece flange nut. Wipe off any excess oil.

**CAUTION**

**The wheel center hole and hub pilot have close tolerances. If the wheel is not kept square to the hub, it could bind during installation and damage the stud threads or hub-pilot pads. Keep the wheel square to the hub during installation.**

IMPORTANT: Before installing the wheels, make sure the drum is positioned on the raised step of the pilot pad. One of the hub's pilot pads must be at the top location. To help keep the drum in place, it may be necessary to adjust the brakes before installing the wheels.

3. If installing a rear wheel assembly, go to the next step. Install the front wheel assembly.
   - 3.1 Locate one hub-pilot pad in the top-center position. Using a jack or wheel-and-tire dolly, position the wheel assembly on the hub. Make sure the wheel is square to the hub so that the stud threads or hub-pilot pads are not damaged by contact with the wheel during installation.
   - 3.2 Make sure the hub-pilot pad is still centered at the top.

IMPORTANT: Install the wheel assembly so that the balance weight(s) on the wheels are 180 degrees opposite the balance weight(s) on the brake drum.

4. Install the rear wheel assembly:
   - 4.1 Locate one hub-pilot pad in the top-center position. Using a jack or wheel-and-tire dolly, position the inner wheel assembly on the hub. Make sure the wheel is square to the hub so that the stud threads or hub-pilot pads are not damaged by contact with the wheel during installation.
   - 4.2 Using the same procedure, mount the outer wheel against the inner wheel. Make sure the hub-pilot pad is still centered at the top.

IMPORTANT: Install the wheel assembly so that the balance weight(s) on the wheels are 180 degrees opposite the balance weight(s) on the brake drum. If this causes the valve stems to be in the same wheel hole on rear wheel assemblies, mount the outer wheel so that the outer wheel balance weight(s) is on the same side as the brake drum balance weight(s).

5. Install and hand-tighten a two-piece flange nut on the top and bottom studs.

**CAUTION**

**The two-piece flange nuts have right-hand metric threads. Do not try to install a similar size SAE nut on a stud, or the stud and nut will be damaged.**

6. Install and hand-tighten the remaining two-piece flange nuts. Tighten the nuts 50 lbf·ft (68 N·m) following the sequence in **Fig. 2**.

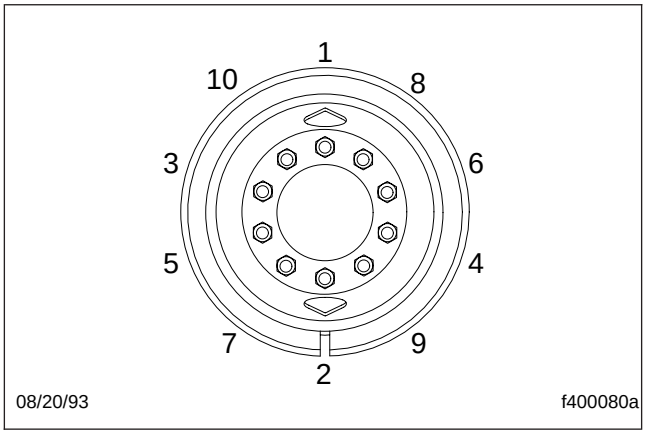



**Fig. 2, 10-Stud Disc Wheel Tightening Sequence**

7. Check that the wheel is correctly seated against the hub and on the hub-pilot pads.
8. Following the sequence in **Fig. 2**, tighten the two-piece flange nuts 450 to 500 lbf·ft (610 to 678 N·m).

**WARNING**

**Failure to replace damaged parts could result in the loss of a wheel or loss of vehicle control, causing personal injury or property damage. Always replace damaged parts with new parts.**

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IMPORTANT: If the wheel nuts cannot be tightened to minimum torque values, the studs could be turning in the hub flange, having lost their locking ability. In this situation, the wheel hub assembly is damaged and must be replaced with a new assembly. Failure to reach minimum torque values could also be caused by stripped threads on the wheel studs or wheel nuts. Again, damaged parts must be replaced with new parts.

9. Remove the safety stands, lower the vehicle, and remove the chocks.

**CAUTION**

**Too little wheel nut torque can cause wheel shimmy, wheel damage, stud breakage, and extreme tire tread wear. Too much wheel nut torque can break studs, damage threads, and crack discs in the stud hole area. Use the specified torque values, and follow the tightening sequence in Fig. 2.**

IMPORTANT: The two-piece flange nuts seat during vehicle operation. It is necessary to periodically tighten the wheel nuts to the specified torque. Tighten the two-piece flange nuts to the specified torque 50 to 100 miles (80 to 160 km) after service work, and check the torque every 10,000 miles (16 000 km) thereafter.

10. After operating the vehicle for 50 to 100 miles (80 to 160 km), retighten the wheel nuts 450 to 500 lbf·ft (610 to 678 N·m). Follow the sequence in Fig. 2.

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# 10-Hole Disc Wheel With Inner and Outer Nuts; Removal and Installation

## Removal

1. Chock all tires that will not be serviced, to prevent vehicle movement.
2. If removing wheels and tires from a rear axle, go to the next step. Remove the wheels and tires from the front axle.
   - 2.1 Apply the parking brakes.
   - 2.2 Raise the front of the vehicle until the tires clear the floor. Place safety stands under the front axle.
   - 2.3 Deflate the tire being serviced by removing the valve core.
   - 2.4 Place a jack or wheel-and-tire dolly under the front wheel assembly being serviced. Remove the wheel nuts, then raise and remove the wheel assembly. Be careful not to damage the threads of the wheel studs as the wheel is pulled away.
3. Remove the wheels and tires from a rear axle:
   - 3.1 Raise the rear of the vehicle until the tires clear the floor. Place safety stands under the axle being serviced.
   - 3.2 Deflate both tires of the dual assembly being serviced by removing the valve cores.
   - 3.3 Place a jack or wheel-and-tire dolly under the outer wheel assembly. Remove the outer wheel nuts, then raise and remove the outer wheel. Be careful not to damage the threads of the inner wheel nuts as the outer wheel is pulled away.
   - 3.4 Place a jack or wheel-and-tire dolly under the inner wheel assembly. Remove the inner wheel nuts, then raise and remove the inner wheel. Be careful not to damage the threads of the wheel studs as the inner wheel is pulled away.

## Installation

IMPORTANT: Before installing the wheels, it is recommended that an anti-seize compound be applied on the 360 degree wheel pilot hubs of Meritor FF–981 "Easy Steer Plus" front axles.

After time in service, a small amount of rust or corrosion may make the wheel difficult to remove because of the extended wheel-to-hub contact. Applying an anti-seize compound on the wheel pilot of the hub will ensure easy wheel removal at a later date. Compounds such as the following may be used:

- Armite Led-Plate No. 250
- Loctite Anti-Seize No. 767
- Never-Seez
- Permabond Anti-Seize No. 82–9839.

Compounds are available for purchase locally.

NOTE: Before installing a wheel and tire assembly, inspect it using the instructions in **Subject 190**. Also, follow the tire matching and mixing requirements in **Subject 050**.

1. Clean the hub and wheel mounting surfaces, and between the rims of dual wheels. Make sure the tire is inflated using the procedures in **Subject 210**.

**⚠ WARNING**

**Failure to replace damaged parts could result in the loss of a wheel or loss of vehicle control, causing personal injury or property damage. Always replace damaged parts with new parts.**

IMPORTANT: If the wheel nuts cannot be tightened to minimum torque values, the studs could be turning in the hub flange, having lost their locking ability. In this situation, the wheel hub assembly is damaged and must be replaced with a new assembly. Failure to reach minimum torque values could also be caused by stripped threads on the wheel studs or wheel nuts. Again, damaged parts must be replaced with new parts.

2. If installing a rear wheel assembly, go to the next step. Install the front wheel assembly.
   - 2.1 Use a jack or wheel-and-tire dolly to mount the wheel assembly on the wheel studs. Be careful not to damage the threads of the wheel studs when installing the wheel assembly.

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## 10-Hole Disc Wheel With Inner and Outer Nuts; Removal and Installation

2.2 Install a wheel nut on each wheel stud, and run them up until each nut is flush with the face or the chamfer of the wheel. Rotate the wheel a half turn to seat the parts.

2.3 Tighten the wheel nuts 50 lbf·ft (68 N·m), following the sequence in **Fig. 1**.

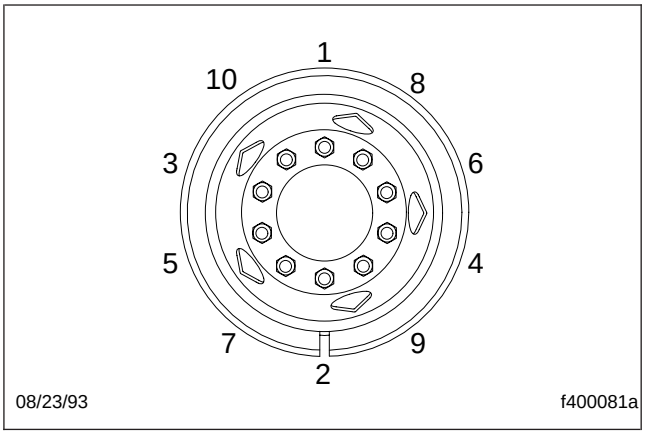



**Fig. 1, 10-Stud Disc Wheel Tightening Sequence**

2.4 Using the same sequence, tighten the wheel nuts again, to the torque in the disc-type wheel fastener torque table in **Specifications, 400**.

**⚠ WARNING**

**Failure to replace damaged parts could result in the loss of a wheel or loss of vehicle control, causing personal injury or property damage. Always replace damaged parts with new parts.**

IMPORTANT: If the wheel nuts cannot be tightened to minimum torque values, the studs could be turning in the hub flange, having lost their locking ability. In this situation, the wheel hub assembly is damaged and must be replaced with a new assembly. Failure to reach minimum torque values could also be caused by stripped threads on the wheel studs or wheel nuts. Again, damaged parts must be replaced with new parts.

3. Install a rear wheel assembly:

3.1 Use a jack or wheel-and-tire dolly to mount the inner wheel assembly on the wheel studs. Be careful not to damage the threads of the wheel studs when installing the wheel assembly.

IMPORTANT: Mount the wheel assembly so that the balance weight(s) on the wheels are 180 degrees opposite the balance weight(s) on the brake drum (**Fig. 2**).

If, on two-handhole wheels, this causes the valve stems to be in the same wheel hole, mount the outer wheel so that the outer wheel balance weight(s) are on the same side of the assembly as the brake drum balance weight(s). See **Fig. 3**.

If, on five-handhole or aluminum wheels, the valve stems are in the same handhole, separate the valve stems by one hole. If balancing the wheels, install the wheel weights evenly and as close to 180 degrees opposite the brake drum balance weight(s) as possible. See **Fig. 4**.

3.2 Install the inner wheel nuts on each wheel stud, and run them up until each nut is flush with the face or the chamfer of the wheel. Rotate the wheel a half turn to seat the parts.

3.3 Tighten the inner wheel nuts 50 lbf·ft (68 N·m), following the sequence in **Fig. 2**.

3.4 Using the same sequence, tighten the inner wheel nuts again, to the torque in the disc-type wheel fastener torque table in **Specifications, 400**.

3.5 Use a jack or wheel-and-tire dolly to mount the outer dual wheel on the inner wheel nuts. Be careful not to damage the threads of the inner wheel nuts when installing the wheel assembly.

3.6 Install the outer wheel nuts following the procedures above.

4. Remove the safety stands, lower the vehicle, and remove the chocks.

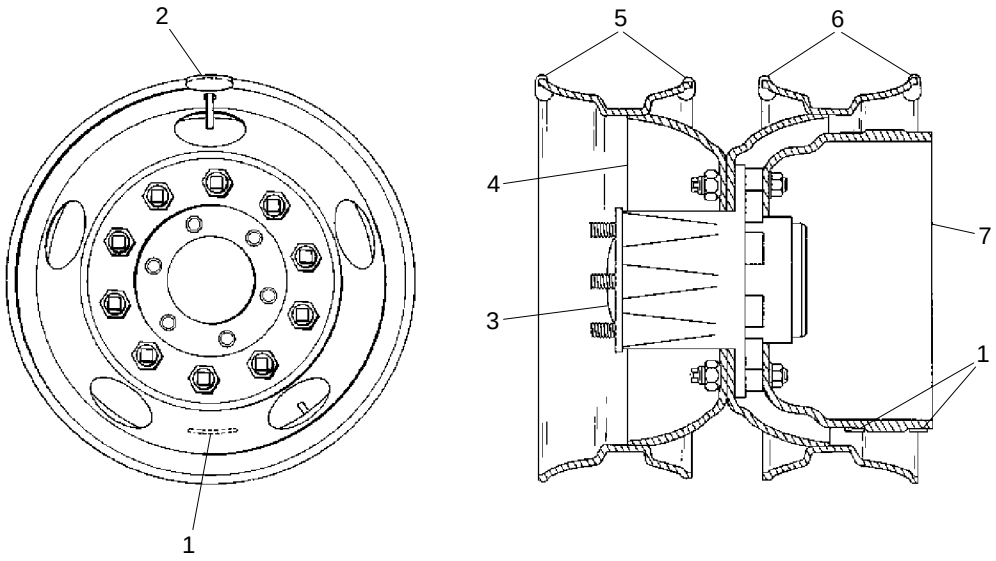
**⚠ CAUTION**

**Locknuts seat during vehicle operation. It is necessary to periodically tighten the wheel nuts to the specified torque. Not enough wheel nut**

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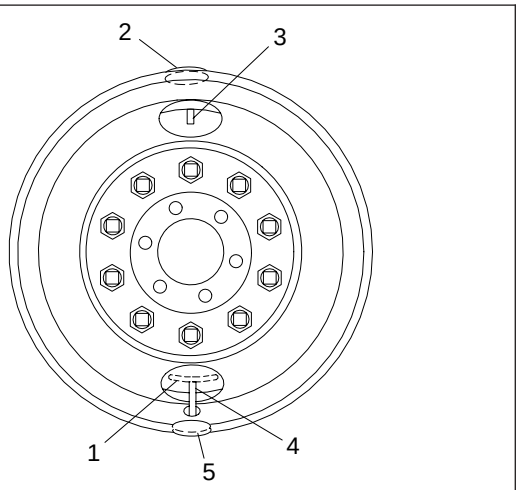
## 10-Hole Disc Wheel With Inner and Outer Nuts; Removal and Installation




07/14/93 f400035a

1. Brake Drum Balance Weight(s)
2. Inner and Outer Balance Weight(s)
3. Hub
4. Disc Wheel
5. Outer Wheel Balance Weight(s)
6. Inner Wheel Balance Weight(s)
7. Brake Drum

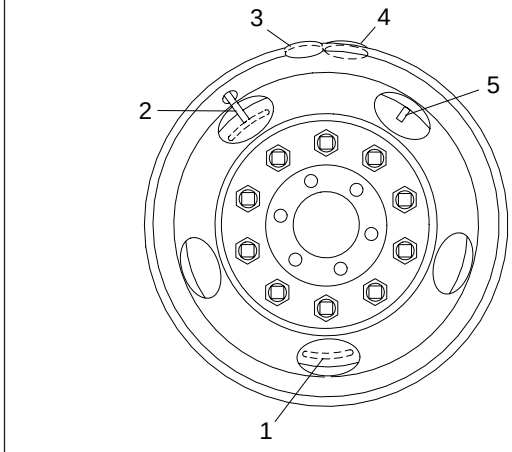
**Fig. 2, Recommended Location of Wheel and Brake Drum Balance Weights**




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1. Brake Drum Balance Weight(s)
2. Inner Wheel Balance Weight(s)
3. Inner Wheel Valve Stem
4. Outer Wheel Valve Stem
5. Outer Wheel Balance Weight(s)

**Fig. 3, Alternate Location of Wheel and Brake Drum Balance Weights, Two-Handhole Wheels**




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1. Brake Drum Balance Weight(s)
2. Outer Wheel Valve Stem
3. Outer Wheel Balance Weight(s)
4. Inner Wheel Balance Weight(s)
5. Inner Wheel Valve Stem

**Fig. 4, Alternate Location of Wheel and Brake Drum Balance Weights, Five-Handhole or Aluminum Wheels**

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## 10-Hole Disc Wheel With Inner and Outer Nuts; Removal and Installation

**torque can cause wheel shimmy, wheel damage, stud breakage, and extreme tire tread wear. Too much wheel nut torque can break studs, damage threads, and crack discs in the stud hole area. Use the specified torque values, and follow the tightening sequence in Fig. 1.**

5. After operating the vehicle for 50 to 100 miles (80 to 160 km), retighten the wheel nuts to the torque in the disc-type wheel fastener torque table in **Specifications, 400**. Follow the sequence in **Fig. 1**.

NOTE: When retightening the inner wheel nuts, loosen the outer wheel nuts several turns, retighten the inner wheel nuts, then the outer wheel nuts.

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# Spoke Wheel, Tire and Rim Assembly; Removal and Installation

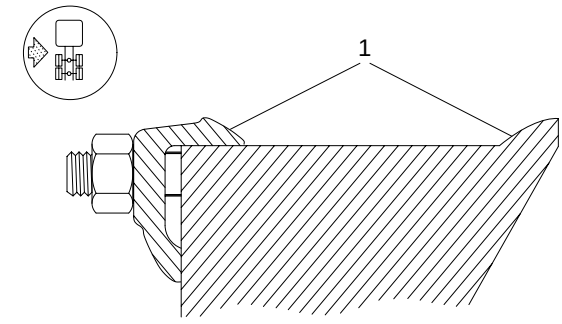
## Removal

1. Chock all tires that will not be serviced, to prevent vehicle movement.
2. If removing tire and rim assemblies from a rear axle, go to the next step. Remove the tire and rim assembly from the front axle.
   - 2.1 Apply the parking brakes.
   - 2.2 Raise the front of the vehicle until the tires clear the floor. Place safety stands under the front axle.
   - 2.3 Deflate the tire being serviced by removing the valve core.
   - 2.4 Place a jack or wheel-and-tire dolly under the front tire and rim assembly being serviced. Remove the rim nuts and rim clamps, then slide the tire and rim assembly off the wheel.
3. Remove a tire and rim assembly from a rear axle.
   - 3.1 Raise the rear of the vehicle until the tires clear the floor. Place safety stands under the axle being serviced.
   - 3.2 Deflate the tire(s) being serviced by removing the valve core(s).
   - 3.3 Place a jack or wheel-and-tire dolly under the outer tire and rim assembly being serviced. Remove the rim nuts and clamps; then slide the outer tire and rim off.
   - 3.4 Remove the rim spacer. Place a jack or wheel-and-tire dolly under the inner tire and rim assembly, and slide it off.

## Installation

NOTE: Before installing a wheel and tire assembly, inspect it using the instructions in **Subject 190**. Also, follow the tire matching and mixing requirements in **Subject 050**.

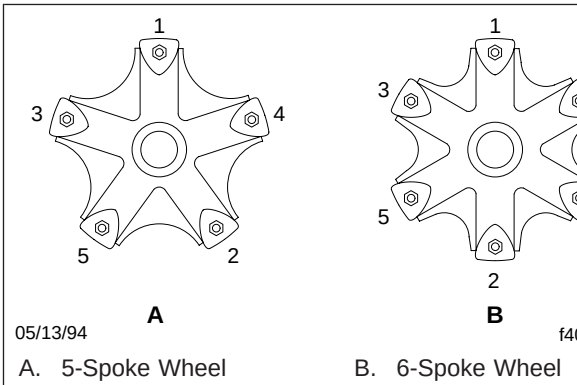
1. Clean the wheel, rim spacer, and rim mounting surfaces. The mounting surface of the wheel is the 28-degree taper on the inboard side of each spoke. See **Fig. 1**.
2. Make sure the tire and rim assembly is inflated using the procedures in **Subject 210**.




1. 28° Tapered Rim Mounting Surfaces

**Fig. 1, Spoke Wheel Tapered Mounting Surface**

3. If installing a rear tire and rim assembly, go to the next step. Install a front tire and rim assembly.
   - 3.1 Slide the assembly over the wheel and push it into place against the tapered mounting surface. It should fit snugly against all the tapers. Be sure that the valve stem faces out and is centered between two spokes.
   - 3.2 Install the rim clamps and nuts. Run the nuts up until the end of each wheel stud is flush with the face of its nut. Rotate the wheel a half turn to seat the parts.
   - 3.3 Tighten the rim nuts a quarter turn at a time, following the star pattern shown in **Fig. 2**. Continue until all the rim nuts are tightened to the torque in the applicable torque table in **Specifications, 400.**




A. 5-Spoke Wheel B. 6-Spoke Wheel

**Fig. 2, Spoke Wheel Tightening Sequence**

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## Spoke Wheel, Tire and Rim Assembly; Removal and Installation

**CAUTION**

**Failure to tighten the nuts in the sequence shown, and to the correct torque, could cause misalignment of the tire and chording of the rim (Fig. 3). This would result in excessive vehicle vibration and permanent damage to the rim and wheel.**

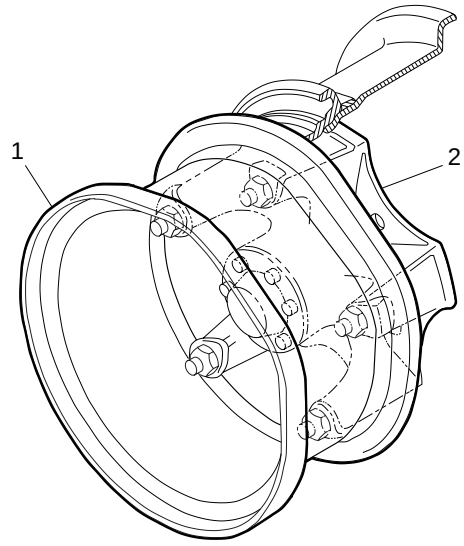
**WARNING**

**Failure to replace damaged parts could result in the loss of a wheel or loss of vehicle control, causing personal injury or property damage. Always replace damaged parts with new parts.**

IMPORTANT: If the wheel nuts cannot be tightened to minimum torque values, the studs could be turning in the hub flange, having lost their locking ability. In this situation, the wheel hub assembly is damaged and must be replaced with a new assembly. Failure to reach minimum torque values could also be caused by stripped threads on the wheel studs or wheel nuts. Again, damaged parts must be replaced with new parts.

NOTE: When replacing a spoke wheel, contact the wheel manufacturer for the correct torque value for the brake drum nuts attaching the spoke wheel to the brake drum.

4. Install a rear tire and rim assembly.
   - 4.1 Slide the inner tire and rim over the wheel hub. Push it into position against the tapered mounting surface. Make sure the valve stem faces out and is centered between two spokes.
   - 4.2 Slide the rim spacer over the wheel hub.
   - 4.3 Slide the outer tire and rim over the wheel hub. Make sure the valve stem faces inward, and is in the same position as the inner valve stem.
   - 4.4 Push the whole assembly in place, so that the inner rim fits snugly against the tapers all around, the spacer is seated against the inner rim, and the outer rim is seated against the spacer.




1. Rim
2. Spoke Wheel

**Fig. 3, Out-of-Round Rim (rim cording)**

   - 4.5 Install the rim clamps and nuts. Run the nuts up until the end of each stud is flush with the face of its nut. Rotate the wheel a half turn to allow the parts to seat.
   - 4.6 Tighten the rim nuts a quarter turn at a time, following the star pattern shown in **Fig. 2**. Continue until all the rim nuts are tightened to the torque in the applicable torque table in **Specifications, 400**.
   - 4.7 The clamps must not bottom out until at least 80 percent of the recommended torque is reached. If the clamps do bottom out, make sure the correct clamps and rim spacers are being used. Make sure the rim edges contact the spacer edges.

**CAUTION**

**Failure to tighten the nuts in the sequence shown, and to the correct torque, could cause misalignment of the tire and chording of the rim (Fig. 3). This would result in excessive vehicle vibration and permanent damage to the rim and wheel.**

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## Spoke Wheel, Tire and Rim Assembly; Removal and Installation

**WARNING**

**Failure to replace damaged parts could result in the loss of a wheel or loss of vehicle control, causing personal injury or property damage. Always replace damaged parts with new parts.**

IMPORTANT: If the wheel nuts cannot be tightened to minimum torque values, the studs could be turning in the hub flange, having lost their locking ability. In this situation, the wheel hub assembly is damaged and must be replaced with a new assembly. Failure to reach minimum torque values could also be caused by stripped threads on the wheel studs or wheel nuts. Again, damaged parts must be replaced with new parts.

NOTE: When replacing a spoke wheel, contact the wheel manufacturer for the correct torque value for the brake drum nuts attaching the spoke wheel to the brake drum.

5. Check the wheel alignment by placing a block of wood or any other point of reference on the floor next to the tire. Rotate the tire and note any variations in the space between the tire and the block. If the variation exceeds 1/16-inch (1.5 mm) for front rims, or 1/8-inch (3 mm) for rear duals, the rim is not correctly mounted.

   To correct any misalignment, loosen the rim nuts where the largest gap occurs, and tighten the nuts on the opposite side. Recheck and correct until the variation is corrected. Make sure the rim nuts are tightened to the correct torque in the applicable torque table in **Specifications, 400**.

6. Remove the safety stands, lower the vehicle, and remove the chocks.

7. After driving the vehicle for 50 to 100 miles (80 to 160 km), retighten the rim nuts to the torque specified in the applicable torque table in **Specifications, 400**. Follow the sequence shown in **Fig. 2**.

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# Tire Demounting and Mounting Service Precautions

## Service Precautions

**⚠ WARNING**

**Read the following information. Failure to follow the safety precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst causing personal injury and equipment damage.**

IMPORTANT: Don't mount or demount tires without proper training as required in Occupational Safety and Health Administration (OSHA) Rules and Regulations 1910.177, *Servicing Multi-Piece and Single Piece Rim Wheels*. Service information containing mounting and demounting instructions are available through your rim supplier. Charts detailing service procedures are available through OSHA area offices. The address and telephone number of the nearest OSHA area office can be obtained by looking in the local telephone directory under U.S. Government, Labor Department of Occupational Safety and Health Administration.

Use the information from the above sources with the following precautions before and during the demounting and mounting of tires:

- Examine all wheel and tire parts as explained in **Subject 190** and **Subject 200**. Replace damaged, rusted, or worn parts.
- Since wheels and rims are under stress, and are dangerous if improperly assembled, be sure all parts of an assembly match in size, manufacturer, and classification within a manufacturer's line. Before assembling the wheel or rim, check the catalog issued by the wheel or rim manufacturer for the correct part numbers and sizes of approved parts. Never use a part that does not bear clear, legible, and correct numbers and manufacturer's identification, even if that part appears to fit.
- Make sure that tires are stored indoors, or outdoors under cover, to prevent water collecting inside the tire.
- Use special tools, as recommended by tire suppliers, for mounting and demounting tires. These tools must be smooth, and used with care, to avoid gouging the rim.
- Loosening tire beads may be difficult, since considerable force may be needed. The use of a machine designed for loosening tire beads is recommended.
- Handle the wheels and rims on a wooden floor or rubber mat to prevent nicking or gouging the wheel or rim.
- Do not use a duck-bill hammer, or any steel hammer on wheel or rim parts. Use rubber, leather-faced, or plastic mallets to tap parts together, if necessary.
- Lubricate the tire with an approved tire-mounting lubricant. Never use antifreeze, silicones, petroleum-based lubricants, or any flammable material (ether/starting aid).
- When lubricating a tire prior to mounting, make sure excess lubricant does not run into the tire.
- Michelin Tire Corporation recommends applying lubricant to the valley of the tire, formed by the tire and rim, before using tools to break the bead.
- Michelin also recommends applying a sufficient but sparing amount of lubricant to the entire rim face when mounting a tire on a rim, to ensure correct bead seating and ease of mounting.
- Don't reinflate a tire that has been run flat or has been run at 80 per cent or less of its recommended operating pressure. Use your spare. Before removing the low tire from the vehicle, make sure it is completely deflated. Later, have the assembly taken apart and all the parts checked for damage, including the side or lockrings.
- The air pressure contained in a tire is dangerous. When servicing a tire, stay out of any potential path or route that a rim wheel component may travel during an explosive separation.

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# Demounting and Mounting Tubeless Tires on One-Piece Drop Center Wheels or Rims

## Five-Degree Full Drop Center

**WARNING**

**Read the information in Subject 140. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst, causing personal injury and equipment damage.**

To demount or mount tubeless tires on 5 degree full drop center rims, regular or safety type, follow the same procedures used to demount or mount tubeless automobile tires.

## Fifteen-Degree Tapered Drop Center

**WARNING**

**Read the information in Subject 140. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst, causing personal injury and equipment damage.**

### Demounting

1. Deflate the tire being serviced by removing the valve core. Check the valve stem by running a piece of wire through the stem to make sure it is not plugged.
2. Loosen both beads from the rim by driving the flat end of the tire tool between the tire bead and the rim flange. Holding the tool upright, hammer on the neck to free the tire bead from the rim (**Fig. 1**). Repeat at 8-inch (20 cm) intervals around the flanges, until both beads are free from the rim.
3. Place the wide side of the rim down. Lubricate the tire bead and the rim. Insert the curved end of two tire tools between the bead and the rim, and just to one side of the tire valve. Step on the side of the tire, opposite from the valve, to force the first bead into the rim well (**Fig. 2**). Hold one of the tools in place with your foot and pry with the second tool, forcing the bead over the rim flange. Continue to work the first bead off of the rim.

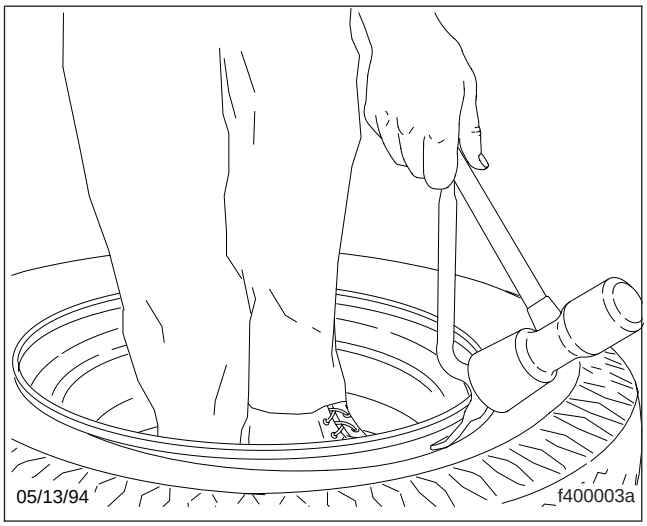



**Fig. 1, Loosening the Beads**

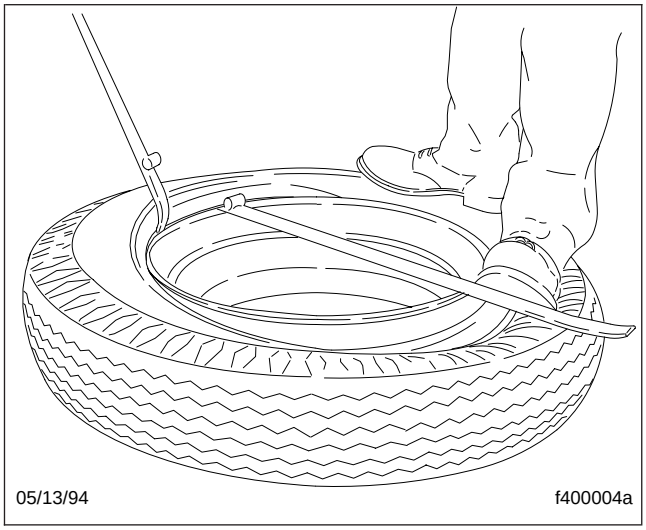



**Fig. 2, Forcing Bead into the Rim Well**

4. When the first bead is off the rim, and the second bead is in the rim well, stand the assembly upright with the valve stem near the top. Lubricate the second bead and rim. Insert the straight end of the tool between the tire bead and the back rim flange, hooking the tool over the second flange. Lean the tire assembly toward the tool and use a rocking or bouncing action to pry the rim out of the tire. See **Fig. 3**.

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## Demounting and Mounting Tubeless Tires on One-Piece Drop Center Wheels or Rims

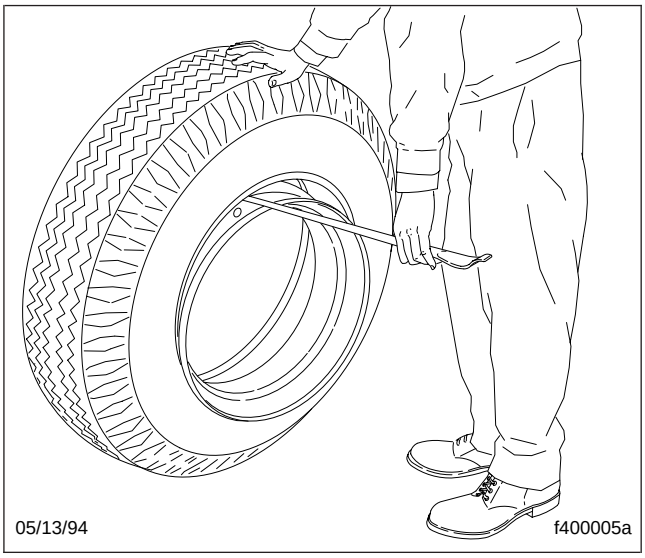



**Fig. 3, Prying the Rim Out of the Tire**

5. Clean and inspect all parts. See **Subject 190** and **Subject 200** for procedures.

## Mounting

1. Place the valve stem, with a rubber washer, through the valve hole from the tire side of the rim. Screw on the valve nut from the opposite side. Make sure the rubber bushing and metal collar or nut are centered and fit snugly in the valve hole (**Fig. 4**).Tighten the nut securely.

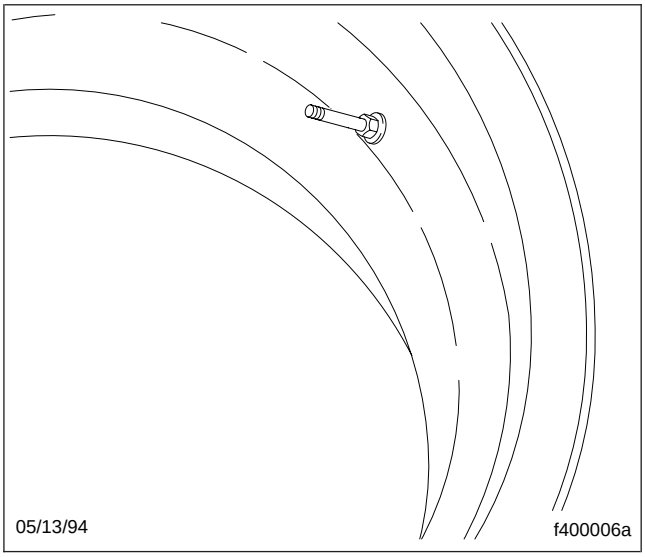



**Fig. 4, Valve Stem Installation**

2. Place the rim on the floor with the wide side down. Using a brush or swab, lubricate both bead seats (flanges) of the rim, and both tire beads, with an approved lubricant. Apply enough lubricant to enable correct bead seating, and to make mounting easier. Don't let excess lubricant run inside the tire.
3. Lay the tire on the rim. If there is a balance mark on the tire, line up this mark with the valve stem. Push the lower bead over the flange and into the rim well. Using the straight end of the tire tool (with the stop resting on the rim flange), take small bites to work the remaining section of the bead into the rim. See **Fig. 5**.

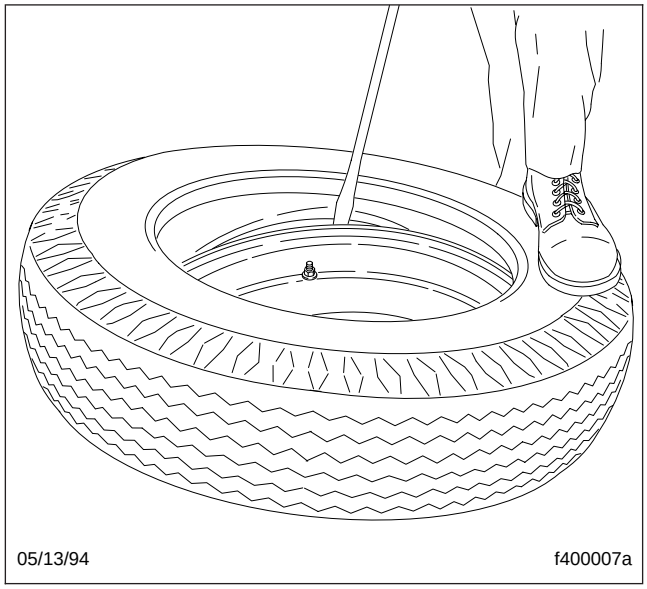



**Fig. 5, Working the Lower Bead into the Rim**

4. Start the upper bead over the rim flange and into the rim well by standing on the tire. If necessary, push a section of the bead into the rim well, and anchor it by attaching Vise-Grip® pliers to the rim flange (snub side toward the tire). Using the spoon end of the tire iron, with the stop toward the rim, work around the bead (**Fig. 6**). Use small bites until the bead slips over the flange and into the rim well. If necessary, insert a second tire iron and relubricate the last 8 inches (20 cm) of bead.
5. Inflate the tire. See **Subject 210** for procedures.

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## Demounting and Mounting Tubeless Tires on One-Piece Drop Center Wheels or Rims




**Fig. 6, Working the Upper Bead into the Rim**

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# Demounting and Mounting Tube-Type Tires on Two-Piece Flat Base Wheels or Rims

## Continuous Base, Split Side Ring

**WARNING**

**See Subject 140. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst, causing personal injury and equipment damage.**

### Demounting

1. Deflate the tire being serviced by removing the valve core. Check the valve stem by running a piece of wire through the stem to make sure it is not plugged.
2. Place the assembly on the floor, side ring up. Insert the hooked ends of the tire tools between the side ring and the sidewall of the tire. Pry the bead loose from the side ring using downward pressure on the tools (**Fig. 1**). Continue prying around the rim until the bead is loose.

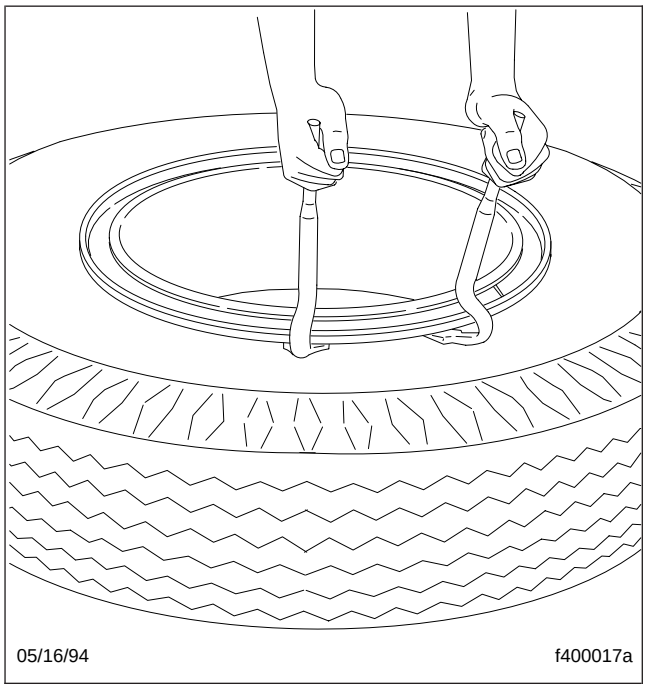



**Fig. 1, Prying the Bead Loose**

3. Insert the tapered end of the tool into the prying notch on the side ring (**Fig. 2**). Pry the side ring from its groove in the rim by prying around the tire until the ring is free.

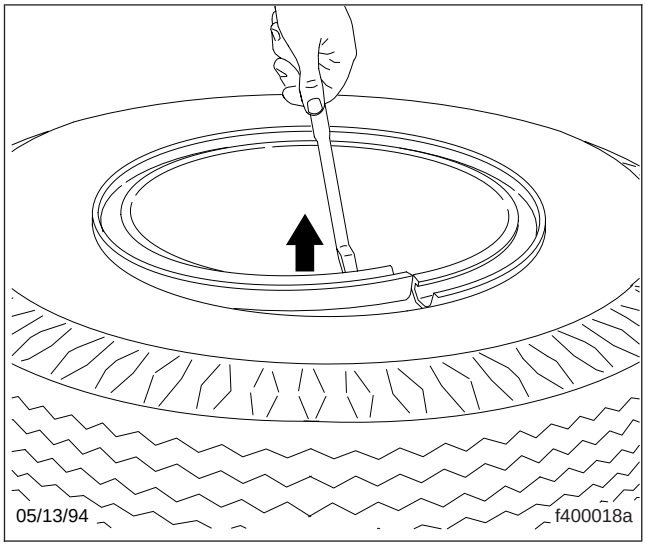



**Fig. 2, Prying the Side Ring from the Groove**

4. Turn the assembly over, and unseat the second tire bead from the rim. Lift the rim from the tire, and remove the tube and flap from the tire.
5. Clean and inspect all parts. See **Subject 190** and **Subject 200** for procedures.

### Mounting

1. Place the tube in the tire, then partially inflate it to round it out. Apply an approved tire lubricant to the inside and outside surfaces of both beads and to the portion of the tube that appears between the beads. Insert the flap, and lubricate the portion of the flap that faces the rim. Apply enough lubricant to enable correct bead seating, and to make mounting easier. Don't let excess lubricant run inside the tire.
2. Lay the rim flat on the floor with the valve slot up. Align the valve with the rim valve-slot. Place the tire on the rim, and insert the valve through the valve slot.
3. Place the side ring on the rim base so that the ring split is opposite the valve stem. Snap the leading end of the side ring into the rim groove

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## Demounting and Mounting Tube-Type Tires on Two-Piece Flat Base Wheels or Rims

(**Fig. 3**). Progressively "walk" the side ring into place. Check that the side ring is seated in the groove.

4. Inflate the tire. See **Subject 210** for procedures.

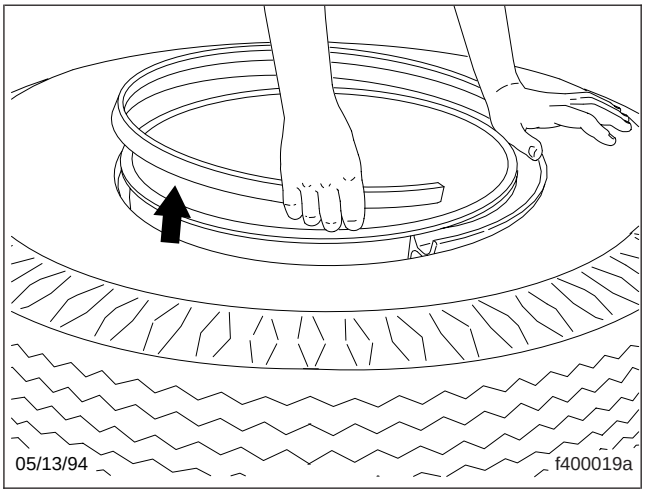



**Fig. 3, Seating the Side Ring**

# Split Base, Continuous Side Ring

**WARNING**

**Read the information in Subject 140. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst causing personal injury and equipment damage.**

## Demounting

1. Deflate the tire being serviced by removing the valve core. Check the valve stem by running a piece of wire through the stem to make sure it is not plugged.
2. Place the assembly on the floor, side ring up. Insert the hooked ends of the tools between the side ring and the sidewall of the tire. Pry the bead loose from the side ring using downward pressure on the tools (**Fig. 1**). Continue prying around the tire until the bead is loose.
3. Insert the tapered end of the tool into the breaking notch near the rim split, and push downward, partially offsetting the rim ends.
4. Insert the tapered end of the tool in the second rim notch, and push downward, prying the continuous side ring from the rim. See **Fig. 4**.

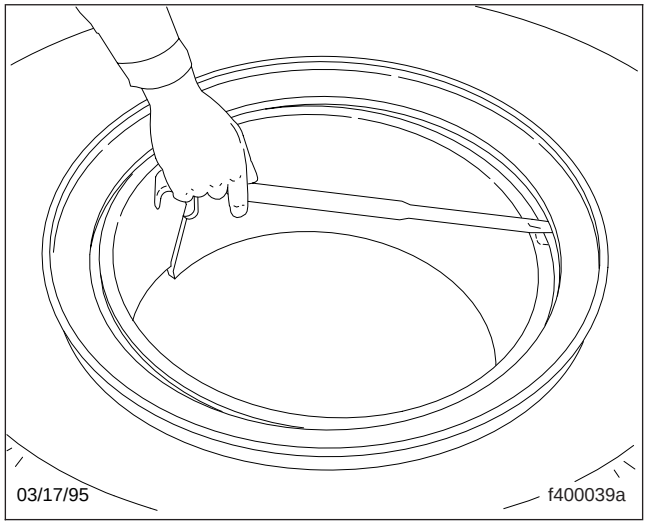



**Fig. 4, Continuous Side Ring Removal**

5. Turn the assembly over, and unseat the second tire bead from the rim. Lift the rim from the tire, and remove the tube and flap from the tire.
6. Clean and inspect all parts. See **Subject 190** and **Subject 200**.

## Mounting

1. Place the tube in the tire, then partially inflate it to round it out. Apply an approved tire lubricant to the inside and outside surfaces of both beads and to the portion of the tube that appears between the beads. Insert the flap, and lubricate the portion of the flap that faces the rim. Apply enough lubricant to enable correct bead seating, and to make mounting easier. Don't let excess lubricant run inside the tire.
2. Spread the rim base by placing a wooden block under the left side of the rim split (see **Fig. 5**). Place the tire, tube, and flap, over the rim base. Lay the rim flat on the floor with the valve slot up. Align the valve with the rim's valve slot. Place the tire on the rim, and insert the valve through the valve slot.

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## Demounting and Mounting Tube-Type Tires on Two-Piece Flat Base Wheels or Rims

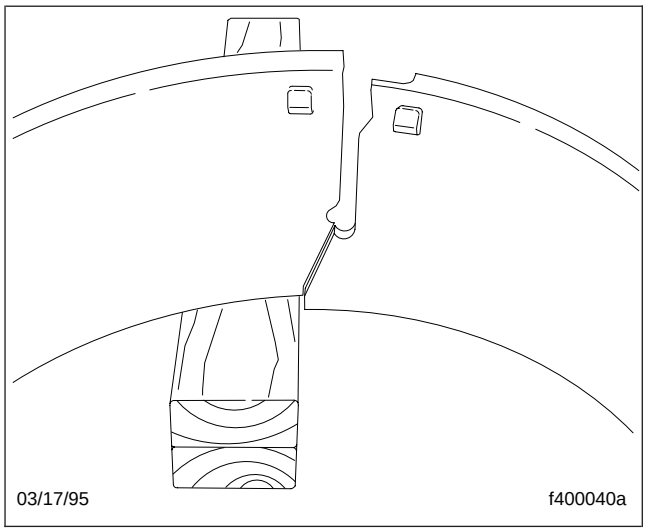



**Fig. 5, Spreading the Rim Base**

3. Install the side ring by starting at the left side of the split and "walking" the ring into place.
4. Turn the assembly over. With the fixed flange side up, place a wooden block under the right side of the split. Tap the rim base, as shown in **Fig. 6**, until the split is correctly aligned.
5. Inflate the tire. See **Subject 210** for procedures.

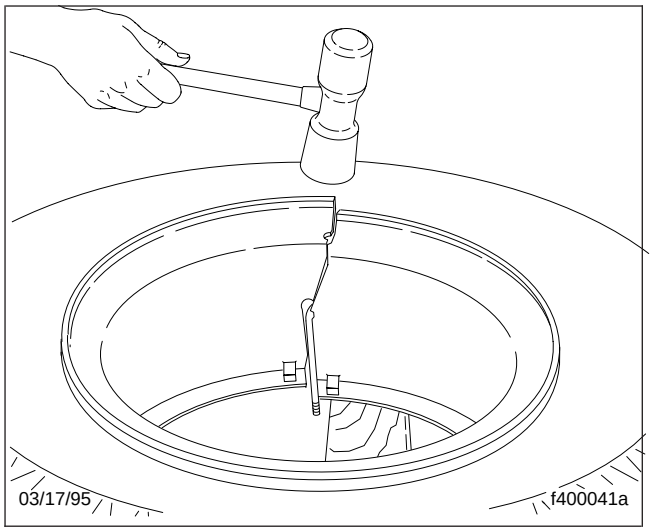



**Fig. 6, Aligning the Split**

## Continuous Base, Continuous Side Ring

**WARNING**

**See Subject 140. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst causing personal injury and equipment damage.**

### Demounting

1. Deflate the tire being serviced by removing the valve core. Check the valve stem by running a piece of wire through the stem to make sure it is not plugged.
2. Loosen the tire bead from the side ring by driving the curved end of a rim tool between the side ring and the bead (**Fig. 7**). Pry the bead loose from the side ring, using downward pressure on the tool. Continue prying around the tire until the bead is loose.

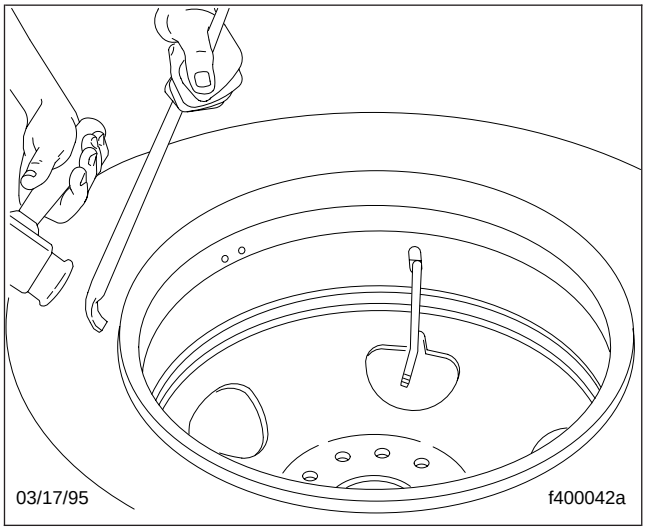



**Fig. 7, Loosening the Bead**

3. Insert the straight end of a rim tool into the notch (located between embossings) in the side ring. See **Fig. 8**. Push the ring downward at the point opposite the notch. At the same time, force the tool handle downward to disengage the ring from

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## Demounting and Mounting Tube-Type Tires on Two-Piece Flat Base Wheels or Rims

the rim gutter. Continue prying the side ring away from the rim gutter until it is loose.

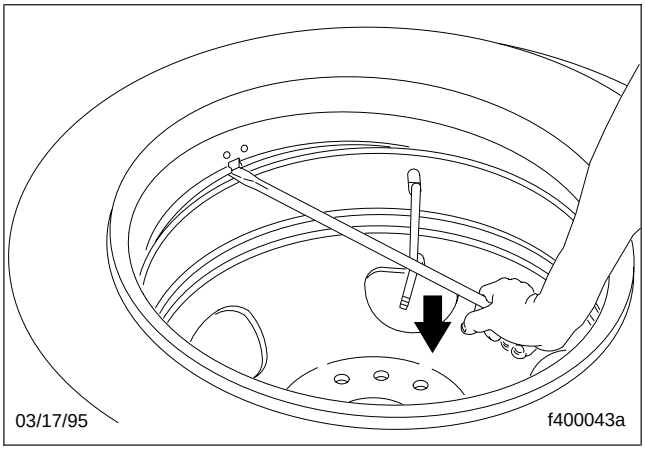



**Fig. 8, Prying the Side Ring Loose**

4. Turn the assembly over, and unseat the second tire bead the same way the first bead was loosened from the side ring in the step above. Stand the tire up, then remove the rim base. Remove the tube and flap from the tire.
5. Clean and inspect all parts. See **Subject 190** and **Subject 200** for procedures.

## Mounting

1. Place the tube in the tire, then partially inflate it to round it out. Apply an approved tire lubricant to the inside and outside surfaces of both beads and to the portion of the tube that appears between the beads. Insert the flap, and lubricate the portion of the flap that faces the rim. Apply enough lubricant to enable correct bead seating, and to make mounting easier. Don't let excess lubricant run inside the tire.
2. Place the disc portion of the wheel on the floor, with the rim gutter up. Position the tire, with the valve pointing in the desired direction, then insert the valve through the valve slot. Position the side ring by locating the operating notch between the two embossings, about 3 inches (8 cm) from the valve.
3. The two cutaway portions opposite each other in the inner diameter of the ring are placed so as to span the rim gutter. Opposite the valve, work half of the side ring into the gutter, as far as possible, using a mallet.
4. Insert the straight end of the rim tool into the notch. See **Fig. 9**. Maintaining pressure with the tool, strike the side ring downward with a mallet at the point between the tool slot and the cutaway portion, forcing the side ring over the rim gutter. Remove the tool, then strike additional blows, moving toward the other cutaway portion, until the entire toe of the side ring passes over the rim gutter. Be sure the side ring has cleared the gutter of the rim base and that the side ring can be depressed by hand.

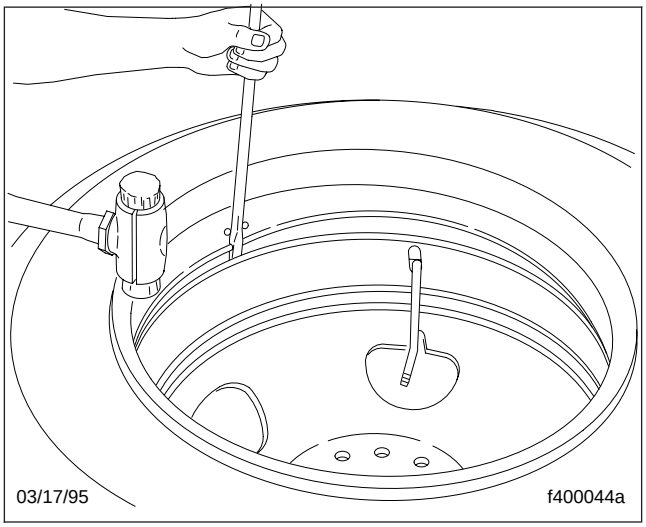



**Fig. 9, Installing the Side Ring**

5. Inflate the tire. See **Subject 210** for procedures.

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# Demounting and Mounting Tube-Type Tires on Three-Piece Flat Base Wheels or Rims

## Continuous Side Ring, Split Lockring

### Demounting

**⚠ WARNING**

**See Subject 140. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst, causing personal injury and equipment damage.**

1. Deflate the tire being serviced by removing the valve core. Check the valve stem by running a piece of wire through the stem to make sure it is not plugged.
2. Place the tire on the floor, side ring up. Insert the hooked ends of the tire tools between the side ring and the sidewall of the tire. Pry the bead loose from the side ring, using downward pressure on the tools (**Fig. 1**). Continue prying around the tire until the bead is loose.
3. With the side ring and tire bead pushed down, insert the tapered end of the tool into the notch near the split in the lockring.
4. Push downward to pry the lockring from the gutter groove of the rim base. See **Fig. 2**.
5. Using the hooked end of the tool, complete the removal of the lockring by working around the tire (**Fig. 3**). Lift off the side ring. Turn the assembly over and unseat the second tire bead from the rim. Lift the rim from the tire and remove the tube and flap from the tire.
6. Clean and inspect all parts. See **Subject 190** and **Subject 200** for procedures.

### Mounting

1. Place the tube in the tire, then partially inflate it to round it out. Apply an approved tire lubricant to the inside and outside surfaces of both beads, and to the portion of the tube that appears between the beads. Insert the flap, and lubricate the portion of the flap that faces the rim. Apply enough lubricant to enable correct bead seating, and to make mounting easier. Don't let excess lubricant run inside the tire.
2. Lay the rim flat on the floor, with the valve slot up. Align the valve with the rim valve slot. Place the tire on the rim and insert the valve through the slot.

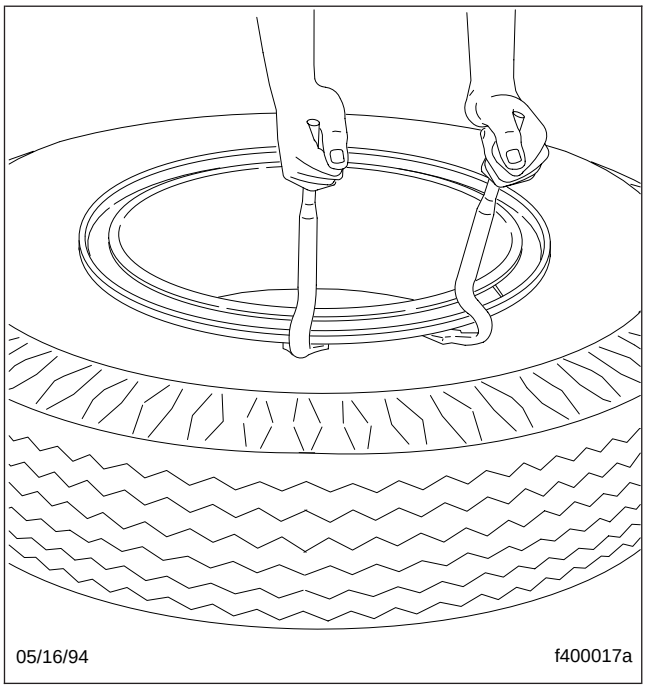



**Fig. 1, Prying the Bead Loose**

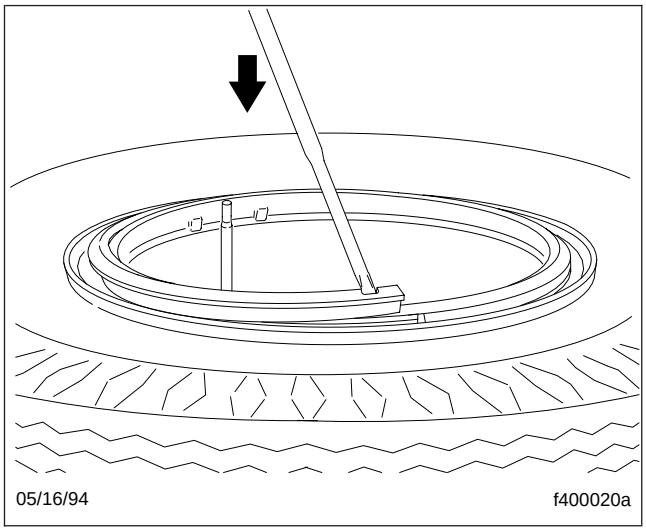



**Fig. 2, Prying the Lockring from the Gutter Groove**

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## Demounting and Mounting Tube-Type Tires on Three-Piece Flat Base Wheels or Rims

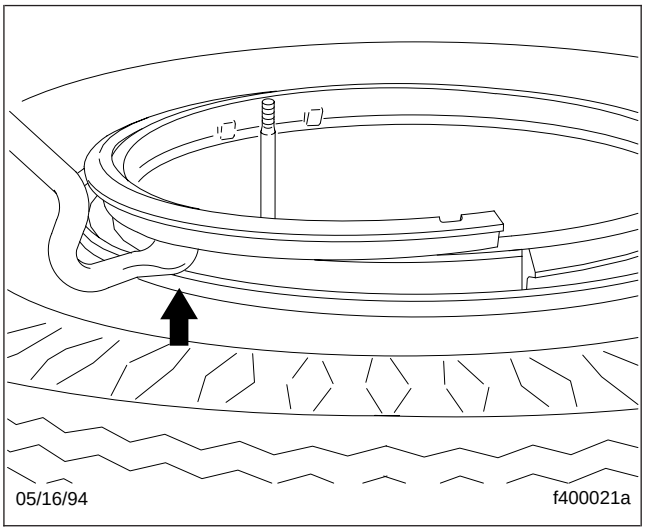



**Fig. 3, Lockring Removal**

3. Place the side ring on the rim base and stand on the ring to position it below the gutter grooves in the rim base.
4. Snap the leading end of the lockring into the gutter groove of the rim base, and "walk" the lockring into place (**Fig. 4**). Check that the lockring is seated in the gutter groove.
5. Inflate the tire. See **Subject 210** for procedures.

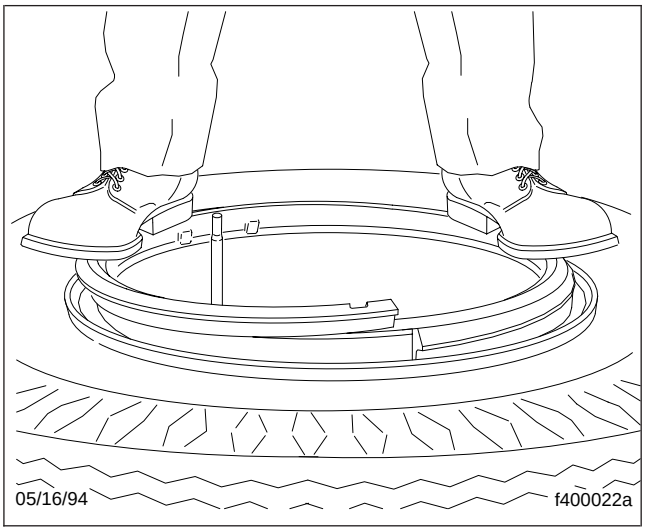



**Fig. 4, Installing the Lockring**

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# Demounting and Mounting Tube-Type Tires on Semi Drop-Center Wheels or Rims

## Continuous Base, Split Side Ring

See **Subject 160**, "Continuous Base, Split Side Ring," for tire demounting and mounting on a rim with a continuous base and a split side ring.

## Continuous Base, Continuous Side Ring

### Demounting

**⚠ WARNING**

**See Subject 140. Failure to follow the precautions, before and during tire demounting and mounting, could cause tire or rim damage while servicing or in use. An incorrectly mounted tire can burst causing personal injury and equipment damage.**

1. Deflate the tire being serviced by removing the valve core. Check the valve stem by running a piece of wire through the stem to make sure it is not plugged.
2. Place the tire and wheel on the floor with the side ring up. Loosen the first bead by driving the hooked end of the rim tool between the tire and rim flange, then press downward on the bead. Do this around the rim, using two tools (see **Fig. 1**).

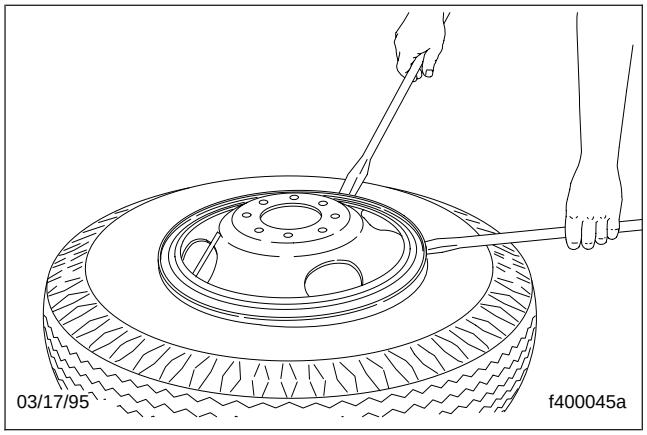



**Fig. 1, Loosening the Bead**

3. Insert the tool into the notch; then using foot pressure, force the side ring opposite the notch into the gutter (**Fig. 2**). Then, prying up and out on the side ring, carefully pry off the side ring. Don't bend the side ring.

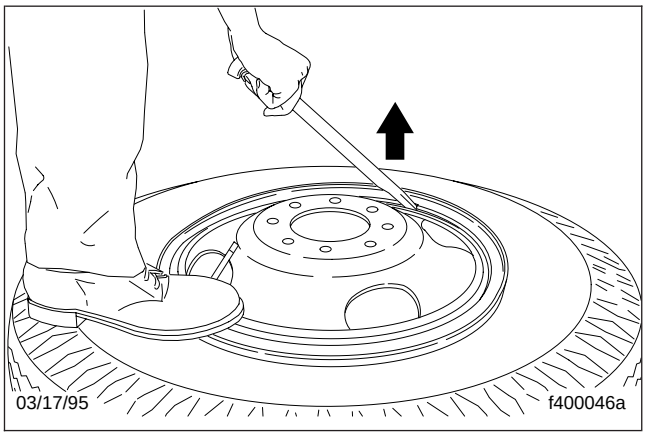



**Fig. 2, Forcing the Side Ring into the Gutter**

4. Force the upper tire bead into the well opposite the valve slot. With the tire tool, pry the opposite portion of the bead over the edge of the rim.
5. Turn the tire over. Using the tools, loosen the bead on the opposite bead seat. This can be done using foot pressure. Make sure one portion of the second bead is still in the rim well, then pry the opposite portion of the bead over the edge of the rim. This will free the tire from the rim (**Fig. 3**). Remove the tube and flap from the tire.

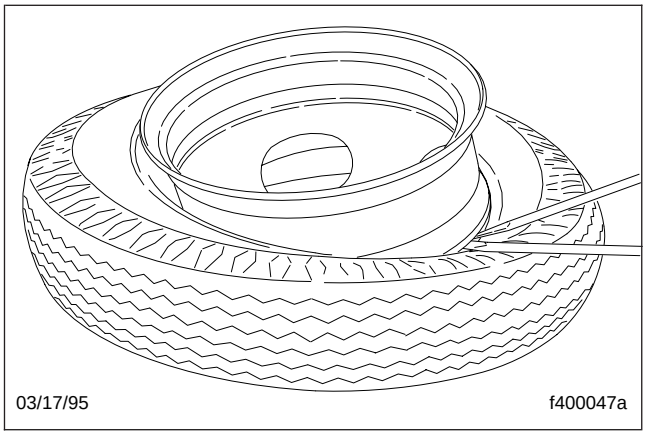



**Fig. 3, Prying the Bead Over the Edge of the Rim**

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# Demounting and Mounting Tube-Type Tires on Semi Drop-Center Wheels or Rims

6. Clean and inspect all parts. See **Subject 190** and **Subject 200** for procedures.

## Mounting

1. Place the tube in the tire and partially inflate it to round it out. Apply an approved tire lubricant to the inside and outside surfaces of both beads and to the portion of the tube that appears between the beads. Insert the flap, and lubricate the portion of the flap that faces the rim. Apply enough lubricant to enable correct bead seating, and to make mounting easier. Don't let excess lubricant run inside the tire.
2. Place the tire on the rim so that the valve lines up with the valve hole. Insert the valve through the valve hole. Using foot pressure, work the first bead into the rim well just to the side of the valve. Pry the first bead over the rim gutter with the rim tool, moving from each side of your foot, alternately, to a point just opposite your foot (**Fig. 4**). Then pry the last section over the rim gutter.
3. To mount the second bead, start at a point opposite the valve, and using foot pressure, press the bead toe over the rim gutter and into the rim well. Mount the remainder of the bead over the rim gutter, using a thin tire tool, and following the procedure in the step above. Be careful not to pinch the tube.
4. Place half of the side ring in the rim gutter with the cutaway portions in place (**Fig. 5**). Insert the thin end of a rim tool or heavy screwdriver, then pull the side ring outward toward the centered position. Work the side ring into the gutter by striking it with a mallet.
5. Inflate the tire. See **Subject 210** for procedures.

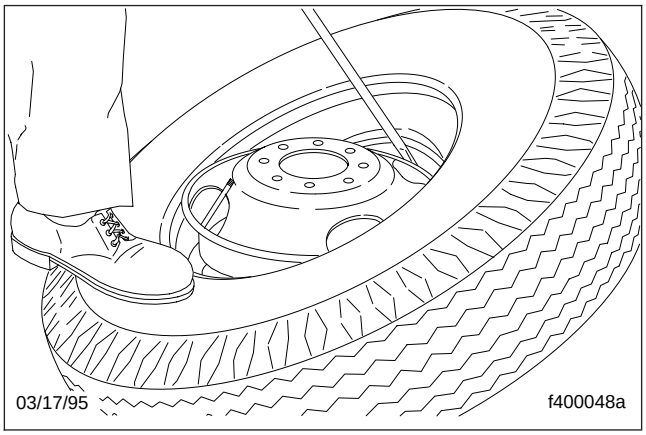



**Fig. 4, Prying the Bead Over the Rim Gutter**

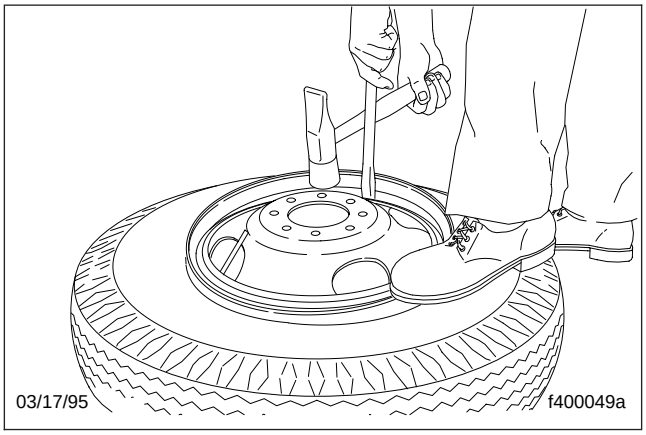



**Fig. 5, Placing Half of the Side Ring in the Rim Gutter**

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## Inspection

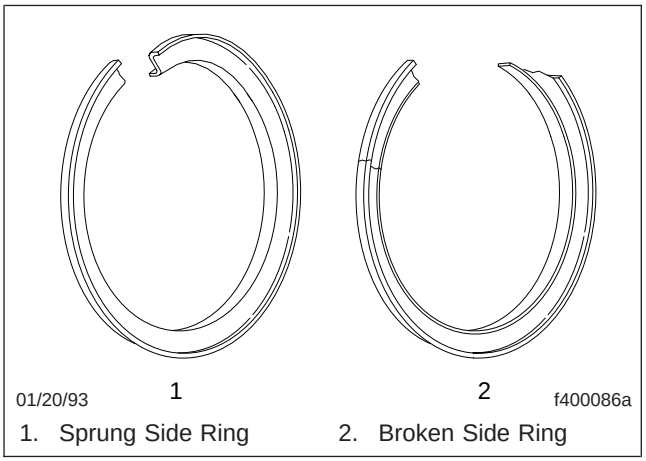
**⚠ WARNING**

**Inspect the tires and wheels, and correct any problems. Failure to do so could cause tire or rim damage while servicing or while in use. An incorrectly mounted tire can burst, causing equipment damage and personal injury.**

Examine the wheel or rim, and all parts. Remove any grease, dirt, or rust. Using a wire brush, remove any rubber from the bead seat. Use special care when cleaning the rim gutter. Rust or other foreign matter can prevent the correct fitting of side rings. Replace corroded parts. Paint the rim to prevent corrosion.

NOTE: Do not paint Alcoa aluminum disc wheels. If the wheels are corroded, contact the manufacturer for instructions.

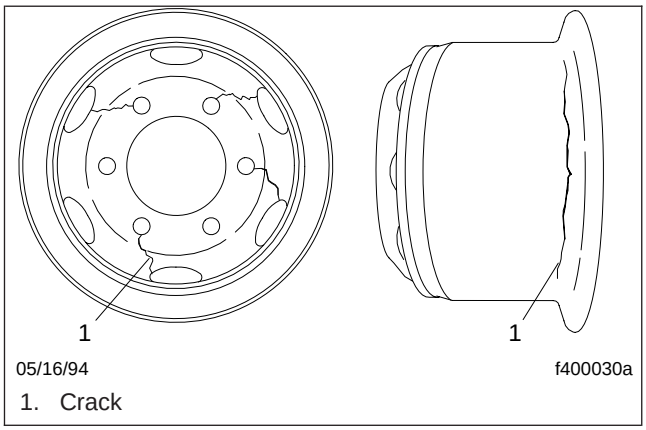
Sprung or broken rings (**Fig. 1**), a cracked rim, wheel (**Fig. 2**), or brake drum, damaged inner or outer wheel nuts (**Fig. 3**), or an out-of-round wheel or rim, require the replacement of the damaged part. Replace the wheel if it has out-of-round stud holes.




1. Sprung Side Ring
2. Broken Side Ring

**Fig. 1, Sprung and Broke Side Rings**

NOTE: See **Group 33** and **Group 35** for inspection and service procedures for the hub, wheel studs, wheel, and brake drum assemblies. When replacing the spoke wheel or the brake drum, contact the wheel manufacturer for the correct torque value for the brake drum nut that attaches the spoke wheel to the brake drum.




1. Crack

**Fig. 2, Cracked Wheel and Rim**

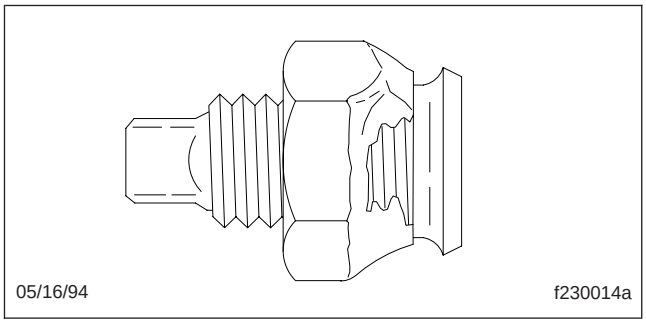



**Fig. 3, Damaged Outer Wheel Nut**

Inspect valve cores for cracks, bends, and air retention. Replace damaged or leaky cores.

The most critical area of a spoke wheel is the 28-degree tapered rim mounting surface (**Fig. 4**). Clean the surface and examine it for damage or excessive wear. Replace the wheel if the mounting surface is damaged or worn below the 28-degree taper.

Check the clamps, rim spacer, rim studs, and spoke-wheel nuts for damage or wear. The clamps must not be excessively worn. The end of the wedge portion must be at least 1/16-inch (1.5-mm) thick. See **Fig. 5**. The rim spacer must not be bent, distorted, or crushed. Replace all damaged or broken parts.

Do not attempt to rework, weld, heat, or braze any rim or wheel parts that are cracked, broken, or damaged. Use new parts or parts that are not cracked, broken, or otherwise damaged, and that are of the same size and type.

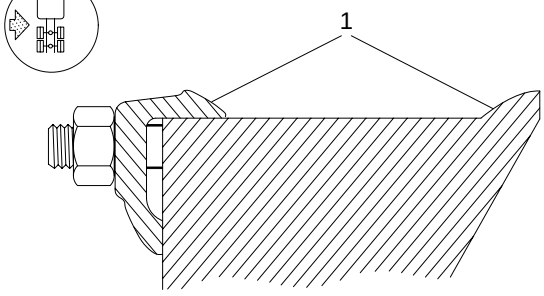
Remove all foreign matter, such as grease and dirt, from the wheel mounting surface. Smooth any pro-

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## Wheel and Components Inspection

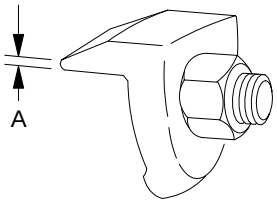
jections on the mounting surface to ensure even pressure when tightening the wheel nuts.




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1. 28 Degree Tapered Rim Mounting Surfaces

**Fig. 4, Spoke Wheel Tapered Mounting Surface**




05/16/94 f400078a

A. End of wedge must be at least 1/16" (1.5 mm) thick.

**Fig. 5, Rim Clamp**

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## Inspection

**⚠ WARNING**

**Inspect the tires and wheels, and correct any problems. Failure to do so could cause tire or rim damage while servicing or while in use. An incorrectly mounted tire can burst, causing equipment damage and personal injury.**

Inspect the inside and outside of the tire for out-of-roundness, loose cords, cuts, foreign objects, and other damage. Repair as needed. Contact the tire manufacturer for repair procedures.

Do not repair tires with the following problems:

- Cuts in the tread that are wire or breaker fiber deep.
- Tread worn to the wire or breaker fibers.
- Tread that is scalloped or otherwise worn unevenly.
- Visible, broken, deformed, or otherwise damaged bead wires.
- Deteriorated rubber.
- Rubber cracked to the wire or cord.
- Separations in the casing.
- Exposed cord (for example, due to weather checking or sidewall scuffing).

Inspect the tread for abnormal or excessive wear. See **Troubleshooting, 300** for possible causes of abnormal wear. If the tires are wearing irregularly, they should be rotated. If the front axle tires become irregularly worn, they should be moved to the drive axle(s) or trailer axles. The front-end alignment should be checked. In a dual assembly, if one tire wears faster than its mate, the position of the two tires should be reversed. Refer to the vehicle maintenance manual for tire rotation procedures.

Government regulations require the removal of any tire with less than 2/32-inch (1.5 mm) tread remaining. Retread the tire (if possible), regroove it (only if marked "Regroovable" on the sidewall), or discard it.

Clean and inspect the tube and flap of tube-type tires. Discard tubes or flaps that are buckled or creased. Do not use an old tube in a new tire, and always mount a used flap in the same size tire and on the same size rim as the one from which it was removed. Michelin Tire Corporation recommends using only new tubes, flaps, valve cores, caps, and O-rings in a new mounting.

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## Tire Inflation

1. Check all parts to make sure they are correctly seated prior to inflation.

NOTE: Inflate tires in a safety cage (**Fig. 1**) or an approved portable restraining device. Always use a clip-on chuck with an inline valve and gauge. Make sure the inflation hose is long enough to permit standing to the side of the tire during inflation. Never sit on or stand in front of an assembly that is being inflated.

**⚠ WARNING**

**During initial tire inflation, there is the possibility of an explosion of the assembly. Observe the following safety rules to reduce the possibility of serious physical injury in the event of an explosion.**

IMPORTANT: Inflate tires immediately after mounting, before the tire lubricant dries. Once the lubricant dries, bead positioning is not possible, even with increased inflation pressure.

Water in the tire can cause ply separation. During tire inflation, air tank reservoirs and lines must be dry. Use well-maintained air line moisture traps, and service them regularly.

2. After placing the tire in a safety cage, or an approved portable restraining device, inflate the tire to 10 psi (69 kPa). Check the parts for correct seating. If the seating is not correct, completely deflate the tire and correct the problem. Never attempt to seat rings or other parts by hammering on an inflated or partially inflated tire.

IMPORTANT: Due to the different flex characteristics of radial sidewalls, it may be necessary to use an inflation aid to help seat tubeless tire beads:

- Metal rings, which use a blast of compressed air to seat the beads.
- Rubber rings, which seal between the tire bead and rim, allowing the bead to move out and seat correctly. A well-lubricated, heavy-duty bicycle tube can be used to help seal between the tire bead and rim.

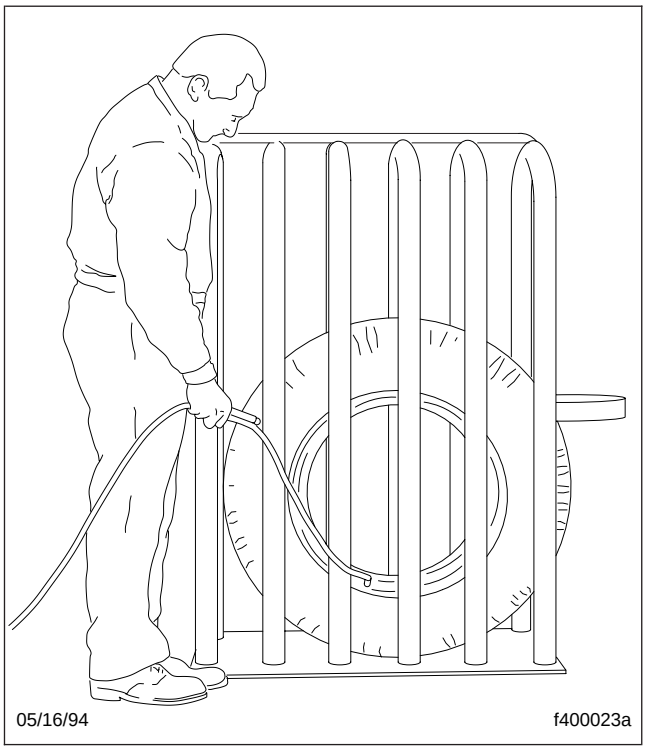



**Fig. 1, Safety Cage**

3. If there are no problems with the assembly at 10 psi (69 kPa), continue to inflate the tire to the recommended pressure. See **Specifications, 400** for correct cold inflation pressures. Michelin Tire Corporation recommends an initial inflation pressure of 90 to 100 psi (620 to 690 kPa) to correctly seat the tire beads.

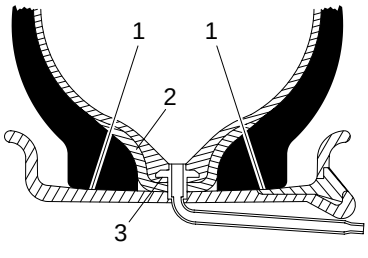
NOTE: The position of the beads, flap, and tube with 4 to 5 psi (28 to 35 kPa) pressure is shown in **Fig. 2**. The tube is fully rounded-out within the tire, but there isn't enough pressure to move the beads on wide-base rims. Depending on the tire size and rim condition, from 20 to 40 psi (140 to 275 kPa) pressure is needed to push the beads onto the bead seat. See **Fig. 3**.

4. After the initial inflation, completely deflate the tire by removing the valve core. This ensures correct bead seating, and prevents buckling or overstretching the tube in tube-type tires. Then inflate the tire to the recommended cold inflation pressure listed in **Specifications, 400**. Install valve caps and tighten them finger-tight.

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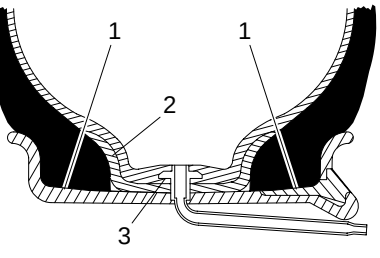


## Tire Inflation




1. Tapered Bead Seat
2. Flap
3. Valve Base

**Fig. 2, Position of Beads, Flap, and Tube at 4 to 5 psi (28 to 35 kPa)**




1. Tapered Bead Seat
2. Flap
3. Valve Base

**Fig. 3, Beads Pressured Onto the Bead Seat**

**⚠ CAUTION**

**Improperly inflating tube-type tires can crack or tear the edge or inside of the valve base. Once seated, the tube can stretch only in the rim area. Because resistance to stretch is greatest at the valve base, there is often enough tension to break the tube at the edge of the valve base or in the valve base.**

IMPORTANT: Use tires of the same size, type, and capacity to carry the load at the recommended cold pressure. Attempting to increase the load capacity of a tire by overinflation will damage the tire assembly.

NOTE: Inflate the tires to the recommended pressure. Driving on overinflated tires will weaken the cords by reducing their ability to absorb road shocks, and will increase the danger of cuts, snags, and punctures. Overinflation will overstress and damage the rims. Driving on underinflated tires will generate excessive heat. This weakens the tire body, and reduces tire strength.

**⚠ WARNING**

**Inflate tires to the specified pressure. Tire underinflation or overinflation will damage wheels and tires, and could result in a blowout, causing possible personal injury and property damage.**

5. Check the inflation pressure 24 hours after mounting new tires.

NOTE: When testing a vehicle on a dynamometer, severe tire damage can occur. Because the manufacturers differ in their recommendations for preventing tire damage, refer to the manufacturer's instructions for testing a vehicle on a dynamometer.

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# 12-Stud Rear Wheel Rim With Clamp and Nuts Removal and Installation

## Removal

**NOTICE**

**The wheel and hub have close tolerances. If the wheel is not kept square to the hub, it could bind during removal and damage the stud threads. Keep the wheel square to the hub during removal.**

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the front tires.
2. Remove the wheels and tires from a rear axle.
   - 2.1 Raise the rear of the vehicle until the tires clear the floor. Place safety stands under the axle being serviced.
   - 2.2 If the tire or wheel is damaged (or if there is suspected damage), deflate both tires of the dual assembly being serviced by removing the valve cores.
   - 2.3 Place a jack or wheel-and-tire dolly under the dual wheel assembly being serviced.
   - 2.4 Leaving the top nut until last, remove all twelve nuts and the clamps.
   - 2.5 Remove the wheel. Do not let it drop on or drag across the stud threads.

## Installation

IMPORTANT: These instructions apply to all repairs performed on rear wheels regardless of which wheel or tire position is being serviced. For consistent clamp integrity of wheel end components, the following procedure must be adhered to.

Before installing a wheel and tire assembly, inspect it. See **Subject 190**. Also, follow the tire matching and mixing requirements. For instructions, see **Subject 050**.

**NOTICE**

**The hubs must be free of corrosion and road grime to ensure that contaminants are not scraped on the mounting surfaces when sliding components over the hub. Failure to do this can shorten the life of wheel components.**

1. Clean all corrosion and road grime from the surface of the hubs, wheels, spacers, wedge bands, and clamps. If necessary, use a wire brush and/or pressure washing.

**NOTICE**

**The wheel and hub have close tolerances. If the wheel is not kept square to the hub, it could bind during installation and damage the stud threads. Keep the wheel square to the hub during installation.**

2. Slide the inner wheel over the hub, making certain that no contamination is scraped from the hub onto the mounting surfaces between the inner hub and wheel wedge.
3. Slide the spacer over the hub, making certain that no contamination is scraped onto the mounting surfaces between the wheel and spacer.
4. Slide the outer wheel against the spacer.
5. Install the wedge band with the open space at the valve stem.

NOTE: Inspect the spacer during installation of the outer wheel. The spacer must be aligned with the proper mounting surfaces.

6. Starting at the 12 o'clock position, hand-tighten the wheel nuts to take up any slack between the clamp, wedge band, inner wheel, outer wheel, and spacer.
7. Use the tightening sequence shown in **Fig. 1** for each of the three stages of tightening as follows:
   - 7.1 Tighten each nut 50 lbf·ft (68 N·m).
   - 7.2 Tighten each nut 100 lbf·ft (136 N·m).
   - 7.3 Tighten each nut 150 lbf·ft (203 N·m).
8. Remove the safety stands and lower the vehicle.
9. Drive the vehicle and make four complete figure eight turns, rotating the steering wheel to full-wheel lock in both directions.
10. Return to the service bay and raise the rear of the vehicle until the tires clear the floor.
11. Use the tightening sequence shown in **Fig. 1** and tighten the wheel nuts 150 lbf·ft (203 N·m).

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## 12-Stud Rear Wheel Rim With Clamp and Nuts Removal and Installation

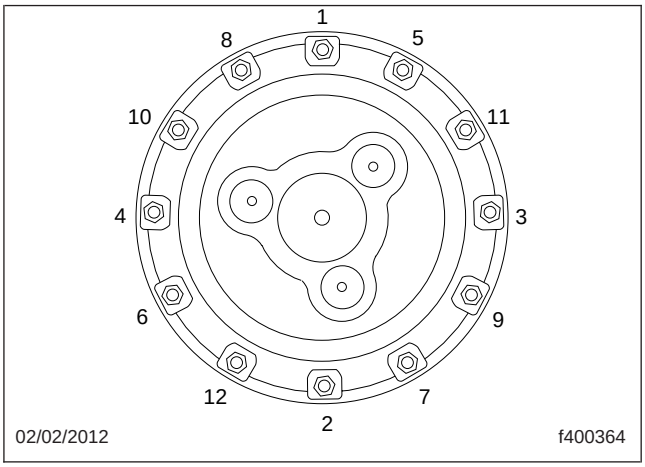



**Fig. 1, Tightening Sequence, 12-Stud Wheel Rim**

IMPORTANT: As components seat, loss of torque can occur. Therefore, additional torque checks must be performed.

After a 12-hole wheel has been installed, the wheel nut torque must be rechecked and tightened 150 lbf·ft (203 N·m) at the following intervals:

- after the first load;
- every four hours of operation for a minimum of five days;
- every 8 to 10 hours of operation.

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# Wheel and Tire Runout Measurements

## General Information

Runout is side-to-side (lateral) or up-and-down (radial) movement when the tire/wheel assembly is rotated. Runout can be measured with a dial indicator, a tire runout gauge, or another instrument capable of measuring small movements of the tire/wheel assembly.

Lateral runout, shown in **Fig. 1**, is side-to-side movement of the rotating tire/wheel assembly. This may cause a perceived "shimmy" or "wobble".

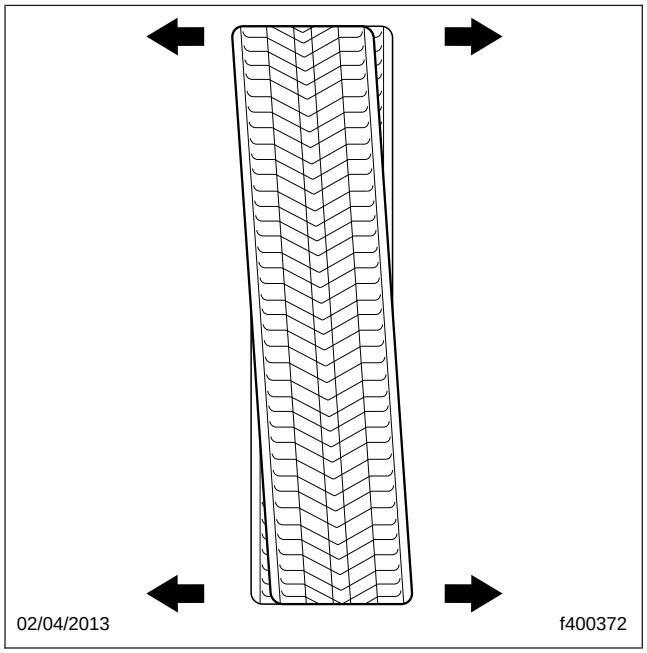



**Fig. 1, Lateral Runout**

Radial runout, shown in **Fig. 2**, is a changing radius of the rotating tire/wheel assembly. For a tire or wheel, its effect is to raise and lower the vehicle as it rolls along, giving the perception of a vertical "hop" or "bounce".

If a tire and wheel assembly shows visible up-and-down or side-to-side movement, it may have excessive runout. Use the inspection procedure that follows to measure runout.

## Inspection

IMPORTANT: Before checking wheel runout, check the tires for proper:

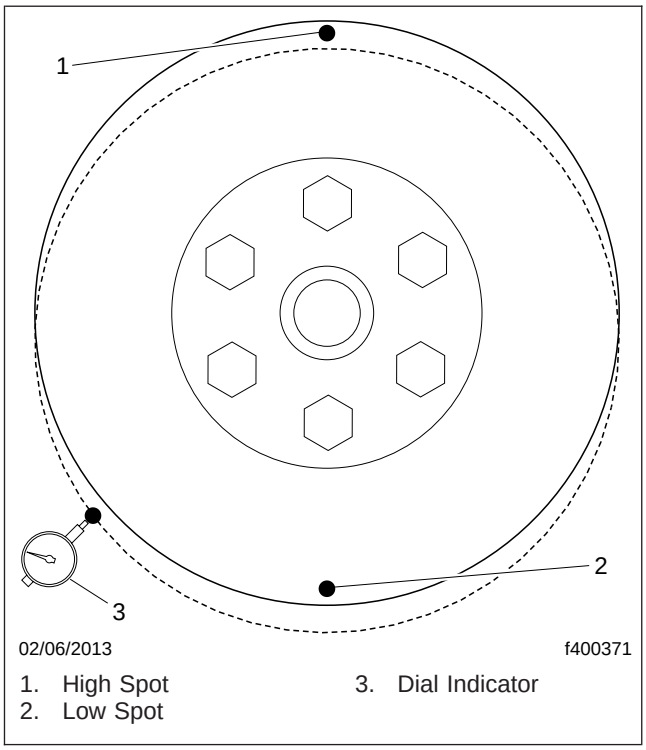



**Fig. 2, Radial Runout**

- inflation;
- wheel nut torque;
- bead seating on the rim.

Use a tire runout gauge, as shown in **Fig. 3**, to check lateral and radial runouts of the entire wheel end assembly.

Check radial runout on a smooth rib in the center of the tread. Check lateral runout on a smooth surface along the tire's mid-sidewall. If the wheel end assembly radial runout exceeds 0.060 inch (0.2 cm), or the lateral runout exceeds 0.150 inch (0.4 cm), the tire/wheel assembly should be removed to check the brake drum and hub runouts. Brake drum and hub runout tolerances are as follows:

- brake drum lateral runout—0.045 inch (0.11 cm)
- brake drum radial runout measured inside of the drum—0.020 inch (0.050 cm)
- hub lateral runout measured at the face of the hub—0.015 inch (0.38 cm)

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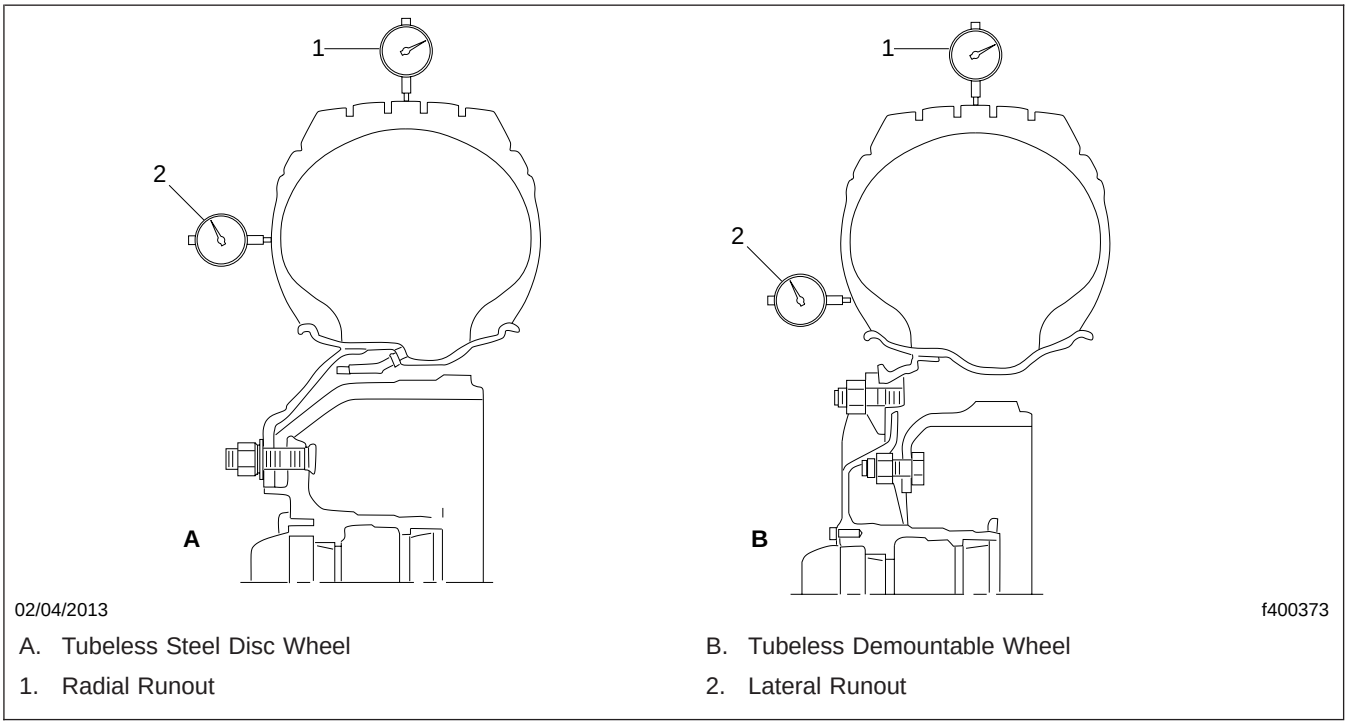
## Wheel and Tire Runout Measurements

- hub radial runout measured near the hub pilots—0.015 inch (0.38 cm)

If hub and brake drum runouts are within specification, then the wheel runout will need to be checked. Demount the tire from the wheel and check lateral and radial runouts for the wheel as shown in **Fig. 4**. For tire demounting instructions, see **Section 40.00**. Make certain the wheel is properly fixed in a wheel balancer or remounted on the hub. See **Table 1** for wheel runout specifications.

| Wheel Runout Specifications | | |
|---|---|---|
| **Wheel Type** | **Lateral Runout: inches (cm)** | **Radial Runout: inches (cm)** |
| Aluminum | 0.030 (0.08) | 0.030 (0.08) |
| Steel | 0.060 (0.15) | 0.060 (0.15) |

**Table 1, Wheel Runout Specifications**



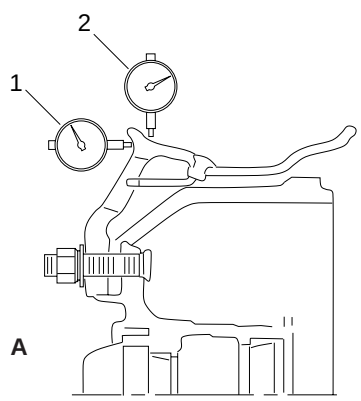

A. Tubeless Steel Disc Wheel
1. Radial Runout
B. Tubeless Demountable Wheel
2. Lateral Runout

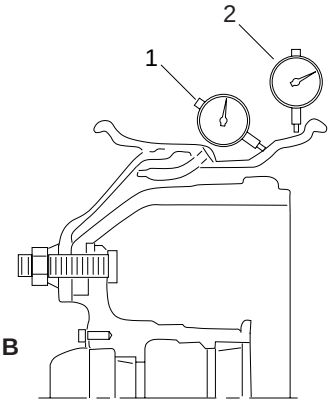
**Fig. 3, Runout Check for Tires**

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## Wheel and Tire Runout Measurements




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A. Tubeless Aluminum Disc Wheel
B. Tubeless Steel Disc Wheel
1. Lateral Runout
2. Radial Runout

**Fig. 4, Runout Check for Wheels**

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# Troubleshooting Tables

**Problem—Abnormal Tire Wear**

| Problem—Abnormal Tire Wear | |
|---|---|
| **Possible Cause** | **Remedy** |
| Tires are not inflated to the correct pressure | Operate the tires at the recommended inflation pressure and use the proper size tires, wheels, and rims for the load to be carried. See **Specifications, 400**. |
| Inflation pressures in a dual assembly are unequal. | Inflate all tires to a uniform pressure, within 5 psi (35 kPa). See **Specifications, 400** for the proper cold inflation pressures. |
| Dual tires are mismatched. | Examine all tires and match them according to **Specifications, 400**. |
| Vehicle is vibrating severely. | Follow the recommendations under "Vehicle Vibration" in this chart. |
| Brakes are grabbing. | Examine and adjust the brakes according to the instructions in **Group 42**. |
| Axles are improperly aligned. | Align the axles; see **Group 33** and **Group 35**. |
| Wheel bearings are loose or damaged, or bushings are excessively worn. | Examine, and repair or replace according to the instructions in **Group 33** and **Group 35**. |
| Wear is uneven among tire sets. | Rotate the tires according to the instructions in **Group 40** of the *Western Star Maintenance Manual*. |
| Driver is abusing equipment. | Caution the driver. |

**Problem—Vehicle Vibration**

| Problem—Vehicle Vibration | |
|---|---|
| **Possible Cause** | **Remedy** |
| Axles are improperly aligned. | Align the axles. See **Group 33** and **Group 35** for instructions. |
| Wheels, rims, or tires are out-of-round, bent, or distorted. | Replace damaged components. |
| Tires, wheels, rims, or brake drums are out-of-balance. | Determine the out of balance component and balance. |
| Tire beads are not properly seated. | Demount and mount the tire. Make certain adequate lubrication is used and, if necessary, use an inflation aid to help seat tubeless tire beads. |
| Tire and rim assembly is improperly installed on a spoke wheel. | Remove the tire and rim assembly and inspect it for out-of-round or rim chording. Replace the rim if it is damaged. Follow closely the tightening sequence and torque values listed. |
| Rim spacers are worn or distorted. | Replace the rim spacers. |
| Driveline, suspensions, or steering components are loose or worn. | Determine the location of the vibration, then repair or replace the loose or worn components. |

**Problem—Excessive On-the-Road Tire Failures**

| Problem—Excessive On-the-Road Tire Failures | |
|---|---|
| **Possible Cause** | **Remedy** |
| Tires are not inflated to the correct pressure. | Operate the tires at the recommended inflation pressure and use the proper size tires, wheels, and rims for the load to be carried. See **Specifications, 400**. |

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## Troubleshooting

| Problem—Excessive On-the-Road Tire Failures | |
|---|---|
| **Possible Cause** | **Remedy** |
| Dual tires are mismatched. | Examine all tires and match them according to **Specifications, 400**. |
| Water or foreign material is inside the casing. | Clean and dry the tires and tubes prior to mounting. Make sure excess lubricant does not flow down into the tire. Store unmounted tires indoors, or under cover, to prevent moisture from collecting inside. |
| Tires are contaminated with oil. | Clean the tires and inspect the engine seals, transmission seals, axle-end and drive axle seals, oil filters and oil lines for leakage. Make sure the lubricant used in mounting does not contain a petroleum derivative. |
| Vehicle is vibrating severely. | Follow the recommendations under "Vehicle Vibration" in this subject. |
| Wheel or rim components are mismatched. | Check the catalog issued by the applicable wheel or rim manufacturer for the proper part numbers and sizes of approved components. Make sure that all parts of an assembly match in size, manufacturer, and classifications within a manufacturer's line. Never use a component which does not bear clear, legible, and proper numbers and manufacturer's identification, even if it appears to fit. |
| Parts are corroded, worn, or otherwise damaged. | Clean or replace parts as necessary. |

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IMPORTANT: Tables 1 through 11 are for all tire makes except Michelin. Tables 1 through 10 list the maximum tire loads at inflation pressures for vehicles driven on paved highways at sustained speeds of 50 to 60 mph (80 to 97 km/h). Table 11 lists the variations in the load and inflation limits given in Table 1 through Table 10 needed to drive the vehicle at sustained speeds above 60 mph (97 km/h), or below 50 mph (80 km/h).

Tables 12 through 15 deal with Michelin tires only, and list the minimum cold inflation pressures for various tire sizes, types, and loads, when used in normal highway driving.

Do not reduce the pressure of a hot tire if it exceeds the specified pressure. In normal driving, tire temperature and inflation pressure increase. Increases of 10 to 15 psi (70 to 105 kPa) are common. Higher pressures may be signs of overloading, underinflation, excessive speed, improper tire size, or any combination of these factors, and must be checked when the tire is cool.

The load and cold inflation pressure must not exceed the rim or wheel manufacturer's recommendations, even though the tire may be approved for a higher load or inflation. Some rims and wheels are stamped with a maximum load and maximum cold inflation rating. Consult the rim or wheel manufacturer if they are not stamped. If the load exceeds the maximum rim or wheel capacity, the load must be adjusted or reduced.

For further data on rims and tires (other than Michelin), and for inflation and load limits not given here, see the "Tire and Rim Association Yearbook." Contact the Michelin Tire Corporation for further data on their tires.

NOTE: To obtain metric equivalents, use the following conversions:

- kg = lb x 0.454
- kPa = psi x 6.890

| Tire Load Limits, Bias Ply Tube-Type Tires, Front Axle (Maximum Speed of 60 mph [97 km/h]) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Size | Load Range | Ply Rating | Maximum Tire Loads (lb) at Various Cold Inflation Pressures | | | | | | | | | | | |
| | | | 55 psi | 60 psi | 65 psi | 70 psi | 75 psi | 80 psi | 85 psi | 90 psi | 95 psi | 100 psi | 105 psi | 110 psi | 115 psi |
| 9.00-20 | E | 10 | 3560 | 3770 | 4000 | 4210 | 4410 | 4610 | — | — | — | — | — | — | — |
| 9.00-20 | F | 12 | 3560 | 3770 | 4000 | 4210 | 4410 | 4610 | 4790 | 4970 | 5150 | — | — | — | — |
| 9.00-20 | G | 14 | 3560 | 3770 | 4000 | 4210 | 4410 | 4610 | 4790 | 4970 | 5150 | 5320 | 5490 | 5670 | — |
| 10.00-20 | F | 12 | — | 4290 | 4530 | 4770 | 4990 | 5220 | 5430 | — | — | — | — | — | — |
| 10.00-20 | G | 14 | — | 4290 | 4530 | 4770 | 4990 | 5220 | 5430 | 5640 | 5840 | 6040 | — | — | — |
| 10.00-20 | H | 16 | — | 4290 | 4530 | 4770 | 4990 | 5220 | 5430 | 5640 | 5840 | 6040 | 6240 | 6430 | 6610 |
| 10.00-22 | F | 12 | — | 4560 | 4820 | 5070 | 5310 | 5550 | 5780 | — | — | — | — | — | — |
| 10.00-22 | G | 14 | — | 4560 | 4820 | 5070 | 5310 | 5550 | 5780 | 6000 | 6210 | 6430 | — | — | — |
| 10.00-22 | H | 16 | — | 4560 | 4820 | 5070 | 5310 | 5550 | 5780 | 6000 | 6210 | 6430 | 6630 | 6840 | 7030 |
| 11.00-20 | F | 12 | — | 4670 | 4940 | 5200 | 5450 | 5690 | 5920 | — | — | — | — | — | — |
| 11.00-20 | G | 14 | — | 4670 | 4940 | 5200 | 5450 | 5690 | 5920 | 6140 | 6370 | 6590 | — | — | — |
| 11.00-20 | H | 16 | — | 4670 | 4940 | 5200 | 5450 | 5690 | 5920 | 6140 | 6370 | 6590 | 6790 | 7010 | 7200 |
| 11.00-22 | F | 12 | — | 4960 | 5240 | 5520 | 5790 | 6040 | 6290 | — | — | — | — | — | — |
| 11.00-22 | G | 14 | — | 4960 | 5240 | 5520 | 5790 | 6040 | 6290 | 6530 | 6770 | 7000 | — | — | — |
| 11.00-22 | H | 16 | — | 4960 | 5240 | 5520 | 5790 | 6040 | 6290 | 6530 | 6770 | 7000 | 7220 | 7440 | 7660 |

**Table 1, Tire Load Limits, Bias Ply Tube-Type Tires, Front Axle (Maximum Speed of 60 mph [97 km/h])**

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## Specifications

| Tire Load Limits, Bias Ply Tube-Type Tires, Rear Axle (Maximum Speed of 60 mph [97 km/h]) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Size | Load Range | Ply Rating | Maximum Tire Loads (lb) at Various Cold Inflation Pressures | | | | | | | | | | | |
| | | | 45 psi | 50 psi | 55 psi | 60 psi | 65 psi | 70 psi | 75 psi | 80 psi | 85 psi | 90 psi | 95 psi | 100 psi | 105 psi |
| 9.00-20 | E | 10 | 3120 | 3310 | 3510 | 3690 | 3870 | 4040 | — | — | — | — | — | — | — |
| 9.00-20 | F | 12 | 3120 | 3310 | 3510 | 3690 | 3870 | 4040 | 4200 | 4360 | 4520 | — | — | — | — |
| 9.00-20 | G | 14 | 3120 | 3310 | 3510 | 3690 | 3870 | 4040 | 4200 | 4360 | 4520 | 4670 | 4820 | 4970 | — |
| 10.00-20 | F | 12 | — | 3760 | 3970 | 4180 | 4380 | 4580 | 4760 | — | — | — | — | — | — |
| 10.00-20 | G | 14 | — | 3760 | 3970 | 4180 | 4380 | 4580 | 4760 | 4950 | 5120 | 5300 | — | — | — |
| 10.00-20 | H | 16 | — | 3760 | 3970 | 4180 | 4380 | 4580 | 4760 | 4950 | 5120 | 5300 | 5470 | 5630 | 5800 |
| 10.00-22 | F | 12 | — | 4000 | 4230 | 4450 | 4660 | 4870 | 5070 | — | — | — | — | — | — |
| 10.00-22 | G | 14 | — | 4000 | 4230 | 4450 | 4660 | 4870 | 5070 | 5260 | 5450 | 5640 | — | — | — |
| 10.00-22 | H | 16 | — | 4000 | 4230 | 4450 | 4660 | 4870 | 5070 | 5260 | 5450 | 5640 | 5820 | 6000 | 6170 |
| 11.00-20 | F | 12 | — | 4100 | 4330 | 4560 | 4780 | 4990 | 5190 | — | — | — | — | — | — |
| 11.00-20 | G | 14 | — | 4100 | 4330 | 4560 | 4780 | 4990 | 5190 | 5390 | 5590 | 5780 | — | — | — |
| 11.00-20 | H | 16 | — | 4100 | 4330 | 4560 | 4780 | 4990 | 5190 | 5390 | 5590 | 5780 | 5960 | 6150 | 6320 |
| 11.00-22 | F | 12 | — | 4350 | 4600 | 4840 | 5080 | 5300 | 5520 | — | — | — | — | — | — |
| 11.00-22 | G | 14 | — | 4350 | 4600 | 4840 | 5080 | 5300 | 5520 | 5730 | 5940 | 6140 | — | — | — |
| 11.00-22 | H | 16 | — | 4350 | 4600 | 4840 | 5080 | 5300 | 5520 | 5730 | 5940 | 6140 | 6330 | 6530 | 6720 |

**Table 2, Tire Load Limits, Bias Ply Tube-Type Tires, Rear Axle (Maximum Speed of 60 mph [97 km/h])**

| Tire Load Limits, Bias Ply Tubeless Tires, Front Axle (Maximum Speed of 60 mph [97 km/h]) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Size | Load Range | Ply Rating | Maximum Tire Loads (lb) at Various Cold Inflation Pressures | | | | | | | | | | | |
| | | | 55 psi | 60 psi | 65 psi | 70 psi | 75 psi | 80 psi | 85 psi | 90 psi | 95 psi | 100 psi | 105 psi | 110 psi | 115 psi |
| 10-22.5 | E | 10 | 3560 | 3770 | 4000 | 4210 | 4410 | 4610 | — | — | — | — | — | — | — |
| 10-22.5 | F | 12 | 3560 | 3770 | 4000 | 4210 | 4410 | 4610 | 4790 | 4970 | 5150 | — | — | — | — |
| 10-22.5 | G | 14 | 3560 | 3770 | 4000 | 4210 | 4410 | 4610 | 4790 | 4970 | 5150 | 5320 | 5490 | 5670 | — |
| 11-22.5 | F | 12 | — | 4290 | 4530 | 4770 | 4990 | 5220 | 5430 | — | — | — | — | — | — |
| 11-22.5 | G | 14 | — | 4290 | 4530 | 4770 | 4990 | 5220 | 5430 | 5640 | 5840 | 6040 | — | — | — |
| 11-22.5 | H | 16 | — | 4290 | 4530 | 4770 | 4990 | 5220 | 5430 | 5640 | 5840 | 6040 | 6240 | 6430 | 6610 |
| 11-24.5 | F | 12 | — | 4560 | 4820 | 5070 | 5310 | 5550 | 5780 | — | — | — | — | — | — |
| 11-24.5 | G | 14 | — | 4560 | 4820 | 5070 | 5310 | 5550 | 5780 | 6000 | 6210 | 6430 | — | — | — |
| 11-24.5 | H | 16 | — | 4560 | 4820 | 5070 | 5310 | 5550 | 5780 | 6000 | 6210 | 6430 | 6630 | 6840 | 7030 |

**Table 3, Tire Load Limits, Bias Ply Tubeless Tires, Front Axle (Maximum Speed of 60 mph [97 km/h])**

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| Tire Load Limits, Bias Ply Tubeless Tires, Rear Axle (Maximum Speed of 60 mph [97 km/h]) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Size | Load Range | Ply Rating | Maximum Tire Loads (lb) at Various Cold Inflation Pressures | | | | | | | | | | | |
| | | | 45 psi | 50 psi | 55 psi | 60 psi | 65 psi | 70 psi | 75 psi | 80 psi | 85 psi | 90 psi | 95 psi | 100 psi | 105 psi |
| 10-22.5 | E | 10 | 3120 | 3310 | 3510 | 3690 | 3870 | 4040 | — | — | — | — | — | — | — |
| 10-22.5 | F | 12 | 3120 | 3310 | 3510 | 3690 | 3870 | 4040 | 4200 | 4360 | 4520 | — | — | — | — |
| 10-22.5 | G | 14 | 3120 | 3310 | 3510 | 3690 | 3870 | 4040 | 4200 | 4360 | 4520 | 4670 | 4820 | 4970 | — |
| 11-22.5 | F | 12 | — | 3760 | 3970 | 4180 | 4380 | 4580 | 4760 | — | — | — | — | — | — |
| 11-22.5 | G | 14 | — | 3760 | 3970 | 4180 | 4380 | 4580 | 4760 | 4950 | 5120 | 5300 | — | — | — |
| 11-22.5 | H | 16 | — | 3760 | 3970 | 4180 | 4380 | 4580 | 4760 | 4950 | 5120 | 5300 | 5470 | 5630 | 5800 |
| 11-24.5 | F | 12 | — | 4000 | 4230 | 4450 | 4660 | 4870 | 5070 | — | — | — | — | — | — |
| 11-24.5 | G | 14 | — | 4000 | 4230 | 4450 | 4660 | 4870 | 5070 | 5260 | 5450 | 5640 | — | — | — |
| 11-24.5 | H | 16 | — | 4000 | 4230 | 4450 | 4660 | 4870 | 5070 | 5260 | 5450 | 5640 | 5820 | 6000 | 6170 |

**Table 4, Tire Load Limits, Bias Ply Tubeless Tires, Rear Axle (Maximum Speed of 60 mph [97 km/h])**

| Tire Load Limits, Bias Ply Wide Base Tires, Front Axle (Maximum Speed of 60 mph [97 km/h]) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Size | Load Range | Ply Rating | Maximum Tire Loads (lb) at Various Cold Inflation Pressures | | | | | | | | | | | |
| | | | 40 psi | 45 psi | 50 psi | 55 psi | 60 psi | 65 psi | 70 psi | 75 psi | 80 psi | 85 psi | 90 psi | 95 psi | 100 psi |
| 15-19.5 | D | 8 | 4090 | — | — | — | — | — | — | — | — | — | — | — | — |
| 15-19.5 | E | 10 | 4090 | 4470 | 4830 | 5180 | — | — | — | — | — | — | — | — | — |
| 15-19.5 | F | 12 | 4090 | 4470 | 4830 | 5180 | 5510 | 5820 | 6130 | — | — | — | — | — | — |
| 15-19.5 | G | 14 | 4090 | 4470 | 4830 | 5180 | 5510 | 5820 | 6130 | 6420 | 6710 | 6980 | — | — | — |
| 15-22.5 | E | 10 | — | — | — | 5680 | — | — | — | — | — | — | — | — | — |
| 15-22.5 | F | 12 | — | — | — | 5680 | 6040 | 6390 | 6720 | — | — | — | — | — | — |
| 15-22.5 | G | 14 | — | — | — | 5680 | 6040 | 6390 | 6720 | 7040 | 7360 | 7660 | — | — | — |
| 15-22.5 | H | 16 | — | — | — | 5680 | 6040 | 6390 | 6720 | 7040 | 7360 | 7660 | 7950 | 8240 | 8520 |
| 16.5-19.5 | H | 16 | — | — | — | 6030 | 6410 | 6780 | 7130 | 7480 | 7810 | 8130 | 8440 | — | — |
| 16.5-22.5 | H | 16 | — | — | — | 6590 | 7010 | 7410 | 7790 | 8170 | 8540 | 8890 | 9230 | — | — |
| 18-19.5 | G | 14 | — | — | — | 6700 | 7130 | 7540 | 7930 | — | — | — | — | — | — |
| 18-19.5 | H | 16 | — | — | — | 6700 | 7130 | 7540 | 7930 | 8310 | 8680 | 9040 | — | — | — |
| 18-19.5 | J | 18 | — | — | — | 6700 | 7130 | 7540 | 7930 | 8310 | 8680 | 9040 | 9390 | 9730 | 10060 |
| 18-22.5 | G | 14 | — | — | — | 7310 | 7780 | 8220 | 8650 | — | — | — | — | — | — |
| 18-22.5 | H | 16 | — | — | — | 7310 | 7780 | 8220 | 8650 | 9070 | 9470 | 9860 | — | — | — |
| 18-22.5 | J | 18 | — | — | — | 7310 | 7780 | 8220 | 8650 | 9070 | 9470 | 9860 | 10240 | 10610 | 10970 |

**Table 5, Tire Load Limits, Bias Ply Wide Base Tires, Front Axle (Maximum Speed of 60 mph [97 km/h])**

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## Specifications

| Tire Load Limits, Radial Ply Tube-Type Tires, Front Axle (Maximum Speed of 60 mph [97 km/h]) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Size | Load Range | Ply Rating | Maximum Tire Loads (lb) at Various Cold Inflation Pressures | | | | | | | | | | | |
| | | | 60 psi | 65 psi | 70 psi | 75 psi | 80 psi | 85 psi | 90 psi | 95 psi | 100 psi | 105 psi | 110 psi | 115 psi | 120 psi |
| 9.00R20 | E | 10 | 3560 | 3770 | 4000 | 4210 | 4410 | 4610 | — | — | — | — | — | — | — |
| 9.00R20 | F | 12 | 3560 | 3770 | 4000 | 4210 | 4410 | 4610 | 4790 | 4970 | 5150 | — | — | — | — |
| 9.00R20 | G | 14 | 3560 | 3770 | 4000 | 4210 | 4410 | 4610 | 4790 | 4970 | 5150 | 5320 | 5490 | 5670 | — |
| 10.00R20 | F | 12 | — | 4290 | 4530 | 4770 | 4990 | 5220 | 5430 | — | — | — | — | — | — |
| 10.00R20 | G | 14 | — | 4290 | 4530 | 4770 | 4990 | 5220 | 5430 | 5640 | 5840 | 6040 | — | — | — |
| 10.00R20 | H | 16 | — | 4290 | 4530 | 4770 | 4990 | 5220 | 5430 | 5640 | 5840 | 6040 | 6240 | 6430 | 6610 |
| 10.00R22 | F | 12 | — | 4560 | 4820 | 5070 | 5310 | 5550 | 5780 | — | — | — | — | — | — |
| 10.00R22 | G | 14 | — | 4560 | 4820 | 5070 | 5310 | 5550 | 5780 | 6000 | 6210 | 6430 | — | — | — |
| 10.00R22 | H | 16 | — | 4560 | 4820 | 5070 | 5310 | 5550 | 5780 | 6000 | 6210 | 6430 | 6630 | 6840 | 7030 |
| 11.00R20 | F | 12 | — | 4670 | 4940 | 5200 | 5450 | 5690 | 5920 | — | — | — | — | — | — |
| 11.00R20 | G | 14 | — | 4670 | 4940 | 5200 | 5450 | 5690 | 5920 | 6140 | 6370 | 6590 | — | — | — |
| 11.00R20 | H | 16 | — | 4670 | 4940 | 5200 | 5450 | 5690 | 5920 | 6140 | 6370 | 6590 | 6790 | 7010 | 7200 |
| 11.00R22 | F | 12 | — | 4960 | 5240 | 5520 | 5790 | 6040 | 6290 | — | — | — | — | — | — |
| 11.00R22 | G | 14 | — | 4960 | 5240 | 5520 | 5790 | 6040 | 6290 | 6530 | 6770 | 7000 | — | — | — |
| 11.00R22 | H | 16 | — | 4960 | 5240 | 5520 | 5790 | 6040 | 6290 | 6530 | 6770 | 7000 | 7220 | 7440 | 7660 |

**Table 6, Tire Load Limits, Radial Ply Tube-Type Tires, Front Axle (Maximum Speed of 60 mph [97 km/h])**

| Tire Load Limits, Radial Ply Tube-Type Tires, Rear Axle (Maximum Speed of 60 mph [97 km/h]) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Size | Load Range | Ply Rating | Maximum Tire Loads (lb) at Various Cold Inflation Pressures | | | | | | | | | | | |
| | | | 50 psi | 55 psi | 60 psi | 65 psi | 70 psi | 75 psi | 80 psi | 85 psi | 90 psi | 95 psi | 100 psi | 105 psi | 110 psi |
| 9.00R20 | E | 10 | 3120 | 3310 | 3510 | 3690 | 3870 | 4040 | — | — | — | — | — | — | — |
| 9.00R20 | F | 12 | 3120 | 3310 | 3510 | 3690 | 3870 | 4040 | 4200 | 4360 | 4520 | — | — | — | — |
| 9.00R20 | G | 14 | 3120 | 3310 | 3510 | 3690 | 3870 | 4040 | 4200 | 4360 | 4520 | 4670 | 4820 | 4970 | — |
| 10.00R20 | F | 12 | — | 3760 | 3970 | 4180 | 4380 | 4580 | 4760 | — | — | — | — | — | — |
| 10.00R20 | G | 14 | — | 3760 | 3970 | 4180 | 4380 | 4580 | 4760 | 4950 | 5120 | 5300 | — | — | — |
| 10.00R20 | H | 16 | — | 3760 | 3970 | 4180 | 4380 | 4580 | 4760 | 4950 | 5120 | 5300 | 5470 | 5630 | 5800 |
| 10.00R22 | F | 12 | — | 4000 | 4230 | 4450 | 4660 | 4870 | 5070 | — | — | — | — | — | — |
| 10.00R22 | G | 14 | — | 4000 | 4230 | 4450 | 4660 | 4870 | 5070 | 5260 | 5450 | 5640 | — | — | — |
| 10.00R22 | H | 16 | — | 4000 | 4230 | 4450 | 4660 | 4870 | 5070 | 5260 | 5450 | 5640 | 5820 | 6000 | 6170 |
| 11.00R20 | F | 12 | — | 4100 | 4330 | 4560 | 4780 | 4990 | 5190 | — | — | — | — | — | — |
| 11.00R20 | G | 14 | — | 4100 | 4330 | 4560 | 4780 | 4990 | 5190 | 5390 | 5590 | 5780 | — | — | — |
| 11.00R20 | H | 16 | — | 4100 | 4330 | 4560 | 4780 | 4990 | 5190 | 5390 | 5590 | 5780 | 5960 | 6150 | 6320 |
| 11.00R22 | F | 12 | — | 4350 | 4600 | 4840 | 5080 | 5300 | 5520 | — | — | — | — | — | — |
| 11.00R22 | G | 14 | — | 4350 | 4600 | 4840 | 5080 | 5300 | 5520 | 5730 | 5940 | 6140 | — | — | — |

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| Tire Load Limits, Radial Ply Tube-Type Tires, Rear Axle (Maximum Speed of 60 mph [97 km/h]) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Size | Load Range | Ply Rating | Maximum Tire Loads (lb) at Various Cold Inflation Pressures | | | | | | | | | | | |
| | | | 50 psi | 55 psi | 60 psi | 65 psi | 70 psi | 75 psi | 80 psi | 85 psi | 90 psi | 95 psi | 100 psi | 105 psi | 110 psi |
| 11.00R22 | H | 16 | — | 4350 | 4600 | 4840 | 5080 | 5300 | 5520 | 5730 | 5940 | 6140 | 6330 | 6530 | 6720 |

**Table 7, Tire Load Limits, Radial Ply Tube-Type Tires, Rear Axle (Maximum Speed of 60 mph [97 km/h])**

| Tire Load Limits, Radial Ply Tubeless Tires, Front Axle (Maximum Speed of 60 mph [97 km/h]) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Size | Load Range | Ply Rating | Maximum Tire Loads (lb) at Various Cold Inflation Pressures | | | | | | | | | | | |
| | | | 60 psi | 65 psi | 70 psi | 75 psi | 80 psi | 85 psi | 90 psi | 95 psi | 100 psi | 105 psi | 110 psi | 115 psi | 120 psi |
| 10R22.5 | E | 10 | 3560 | 3770 | 4000 | 4210 | 4410 | 4610 | — | — | — | — | — | — | — |
| 10R22.5 | F | 12 | 3560 | 3770 | 4000 | 4210 | 4410 | 4610 | 4790 | 4970 | 5150 | — | — | — | — |
| 10R22.5 | G | 14 | 3560 | 3770 | 4000 | 4210 | 4410 | 4610 | 4790 | 4970 | 5150 | 5320 | 5490 | 5670 | — |
| 11R22.5 | F | 12 | — | 4290 | 4530 | 4770 | 4990 | 5220 | 5430 | — | — | — | — | — | — |
| 11R22.5 | G | 14 | — | 4290 | 4530 | 4770 | 4990 | 5220 | 5430 | 5640 | 5840 | 6040 | — | — | — |
| 11R22.5 | H | 16 | — | 4290 | 4530 | 4770 | 4990 | 5220 | 5430 | 5640 | 5840 | 6040 | 6240 | 6430 | 6610 |
| 11R24.5 | F | 12 | — | 4560 | 4820 | 5070 | 5310 | 5550 | 5780 | — | — | — | — | — | — |
| 11R24.5 | G | 14 | — | 4560 | 4820 | 5070 | 5310 | 5550 | 5780 | 6000 | 6210 | 6430 | — | — | — |
| 11R24.5 | H | 16 | — | 4560 | 4820 | 5070 | 5310 | 5550 | 5780 | 6000 | 6210 | 6430 | 6630 | 6840 | 7030 |

**Table 8, Tire Load Limits, Radial Ply Tubeless Tires, Front Axle (Maximum Speed of 60 mph [97 km/h])**

| Tire Load Limits, Radial Ply Tubeless Tires, Rear Axle (Maximum Speed of 60 mph [97 km/h]) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Size | Load Range | Ply Rating | Maximum Tire Loads (lb) at Various Cold Inflation Pressures | | | | | | | | | | | |
| | | | 50 psi | 55 psi | 60 psi | 65 psi | 70 psi | 75 psi | 80 psi | 85 psi | 90 psi | 95 psi | 100 psi | 105 psi | 110 psi |
| 10R22.5 | E | 10 | 3120 | 3310 | 3510 | 3690 | 3870 | 4040 | — | — | — | — | — | — | — |
| 10R22.5 | F | 12 | 3120 | 3310 | 3510 | 3690 | 3870 | 4040 | 4200 | 4360 | 4520 | — | — | — | — |
| 10R22.5 | G | 14 | 3120 | 3310 | 3510 | 3690 | 3870 | 4040 | 4200 | 4360 | 4520 | 4670 | 4820 | 4970 | — |
| 11R22.5 | F | 12 | — | 3760 | 3970 | 4180 | 4380 | 4580 | 4760 | — | — | — | — | — | — |
| 11R22.5 | G | 14 | — | 3760 | 3970 | 4180 | 4380 | 4580 | 4760 | 4950 | 5120 | 5300 | — | — | — |
| 11R22.5 | H | 16 | — | 3760 | 3970 | 4180 | 4380 | 4580 | 4760 | 4950 | 5120 | 5300 | 5470 | 5630 | 5800 |
| 11R24.5 | F | 12 | — | 4000 | 4230 | 4450 | 4660 | 4870 | 5070 | — | — | — | — | — | — |
| 11R24.5 | G | 14 | — | 4000 | 4230 | 4450 | 4660 | 4870 | 5070 | 5260 | 5450 | 5640 | — | — | — |
| 11R24.5 | H | 16 | — | 4000 | 4230 | 4450 | 4660 | 4870 | 5070 | 5260 | 5450 | 5640 | 5820 | 6000 | 6170 |

**Table 9, Tire Load Limits, Radial Ply Tubeless Tires, Rear Axle (Maximum Speed of 60 mph [97 km/h])**

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## Specifications

| Tire Load Limits, Radial Ply Wide Base Tires, Front Axle (Maximum Speed of 60 mph [97 km/h]) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Size | Load Range | Ply Rating | Maximum Tire Loads (lb) at Various Cold Inflation Pressures | | | | | | | | | | | |
| | | | 45 psi | 50 psi | 55 psi | 60 psi | 65 psi | 70 psi | 75 psi | 80 psi | 85 psi | 90 psi | 95 psi | 100 psi | 105 psi |
| 15R19.5 | D | 8 | 4090 | — | — | — | — | — | — | — | — | — | — | — | — |
| 15R19.5 | E | 10 | 4090 | 4470 | 4830 | 5180 | — | — | — | — | — | — | — | — | — |
| 15R19.5 | F | 12 | 4090 | 4470 | 4830 | 5180 | 5510 | 5820 | 6130 | — | — | — | — | — | |
| 15R19.5 | G | 14 | 4090 | 4470 | 4830 | 5180 | 5510 | 5820 | 6130 | 6420 | 6710 | 6980 | — | — | — |
| 15R22.5 | E | 10 | — | — | — | 5680 | — | — | — | — | — | — | — | — | — |
| 15R22.5 | F | 12 | — | — | — | 5680 | 6040 | 6390 | 6720 | — | — | — | — | — | — |
| 15R22.5 | G | 14 | — | — | — | 5680 | 6040 | 6390 | 6720 | 7040 | 7360 | 7660 | — | — | — |
| 15R22.5 | H | 16 | — | — | — | 5680 | 6040 | 6390 | 6720 | 7040 | 7360 | 7660 | 7950 | 8240 | 8520 |
| 16.5R19.5 | H | 16 | — | — | — | 6030 | 6410 | 6780 | 7130 | 7480 | 7810 | 8130 | 8440 | — | — |
| 16.5R22.5 | H | 16 | — | — | — | 6590 | 7010 | 7410 | 7790 | 8170 | 8540 | 8890 | 9230 | — | — |
| 18R19.5 | G | 14 | — | — | — | 6700 | 7130 | 7540 | 7930 | — | — | — | — | — | — |
| 18R19.5 | H | 16 | — | — | — | 6700 | 7130 | 7540 | 7930 | 8310 | 8680 | 9040 | — | — | — |
| 18R19.5 | J | 18 | — | — | — | 6700 | 7130 | 7540 | 7930 | 8310 | 8680 | 9040 | 9390 | 9730 | 10060 |
| 18R22.5 | G | 14 | — | — | — | 7310 | 7780 | 8220 | 8650 | — | — | — | — | — | |
| 18R22.5 | H | 16 | — | — | — | 7310 | 7780 | 8220 | 8650 | 9070 | 9470 | 9860 | — | — | — |
| 18R22.5 | J | 18 | — | — | — | 7310 | 7780 | 8220 | 8650 | 9070 | 9470 | 9860 | 10240 | 10610 | 10970 |

**Table 10, Tire Load Limits, Radial Ply Wide Base Tires, Front Axle (Maximum Speed of 60 mph [97 km/h])**

| Variations in Load and Inflation Limits According to Speed | | | | |
|---|---|---|---|---|
| Speed Range: mph (km/h) | Inflation Pressure Increase | | Percent Increase/(Decrease) In Load | |
| | Bias Ply Tires: psi (kPa) | Radial Ply Tires: psi (kPa) | Regular Width Tires | Wide Base Tires |
| 71–75 (114–120) | 10 (69)* | 10 (69)* | (10) | (10) |
| 61–70 (98–112) | 10 (69)* | 10 (69)* | 0 | 0 |
| 51–60 (82–96) | 0 | 0 | 0 | 0 |
| 41–50 (66–80) | 0 | 0 | 9 | 7 |
| 31–40 (50–64) | 0 | 0 | 16 | 9 |
| 21–30 (34–48) | 0 | 10 (69)* | 24 | 12 |
| 11–20 (18–32) | 0 | 15 (103)* | 32 | 17 |

* Not to exceed the maximum rim or wheel capacity specified by the manufacturer of the rim or wheel.

**Table 11, Variations in Load and Inflation Limits According to Speed**

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| Tire Load Limits, Michelin Radial Ply Tires, Tube-Type and Tubeless, Front Axle | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Size | Load Range | Ply Rating | Maximum Tire Loads (lb) at Various Cold Inflation Pressures | | | | | | | | | | | | |
| | | | 55 psi | 60 psi | 65 psi | 70 psi | 75 psi | 80 psi | 85 psi | 90 psi | 95 psi | 100 psi | 105 psi | 110 psi | 115 psi | 120 psi |
| 8.25R20X | E | 10 | 2860 | 3090 | 3317 | 3502 | 3700 | 3912 | 4050 | — | — | — | — | — | — | — |
| 8.25R20X | F | 12 | 2860 | 3090 | 3317 | 3502 | 3700 | 3912 | 4050 | 4307 | 4500 | — | — | — | — | — |
| 9.00R20X | F | 12 | — | — | — | — | 4255 | 4490 | 4725 | 4963 | 5150 | — | — | — | — | — |
| 9.00R20X | G | 14 | — | — | — | — | 4255 | 4490 | 4725 | 4963 | 5150 | 5430 | 5510 | — | — | — |
| 9R22.5X | E | 10 | 2860 | 3090 | 3317 | 3502 | 3700 | 3912 | 4050 | — | — | — | — | — | — | — |
| 9R22.5X | F | 12 | 2860 | 3090 | 3317 | 3502 | 3700 | 3912 | 4050 | 4307 | 4500 | — | — | — | — | — |
| 10.00R20X | G | 14 | — | — | — | — | 4693 | 4950 | 5215 | 5470 | 5755 | 6040 | — | — | — | — |
| 10.00R20X | H | 16 | — | — | — | — | 4693 | 4950 | 5215 | 5470 | 5755 | 6040 | 6245 | 6428 | 6610 | — |
| 10.00R22X | F | 12 | — | — | — | — | 4960 | 5235 | 5513 | 5780 | — | — | — | — | — | — |
| 10.00R22X | G | 14 | — | — | — | — | 4960 | 5235 | 5513 | 5780 | 6105 | 6430 | — | — | — | — |
| 10R22.5X | F | 12 | — | — | — | — | 4255 | 4490 | 4725 | 4963 | 5150 | — | — | — | — | — |
| 10R22.5X | G | 14 | — | — | — | — | 4255 | 4490 | 4725 | 4963 | 5150 | 5430 | 5510 | — | — | — |
| 11.00R20X | G | 14 | — | — | — | — | 4958 | 5235 | 5513 | 5705 | 6055 | 6295 | 6590 | — | — | — |
| 11.00R20X | H | 16 | — | — | — | — | 4958 | 5235 | 5513 | 5705 | 6055 | 6295 | 6590 | 6835 | 7200 | — |
| 11.00R22X | G | 14 | — | — | — | — | 5265 | 5555 | 5845 | 6120 | 6435 | 6720 | — | — | — | — |
| 11.00R22X | H | 16 | — | — | — | — | 5265 | 5555 | 5845 | 6120 | 6435 | 6720 | 7000 | 7238 | 7400 | — |
| 11R22.5X | G | 14 | — | — | — | — | 4693 | 4950 | 5215 | 5470 | 5755 | 6040 | — | — | — | — |
| 11R22.5X | H | 16 | — | — | — | — | 4693 | 4950 | 5215 | 5470 | 5755 | 6040 | 6245 | 6428 | 6610 | — |
| 11.00R24X | H | 16 | — | — | — | — | 5638 | 5953 | 6268 | 6560 | 6890 | 7165 | 7500 | — | — | — |
| 11R24.5X | F | 12 | — | — | — | — | 4960 | 5235 | 5513 | 5780 | — | — | — | — | — | — |
| 11R24.5X | G | 14 | — | — | — | — | 4960 | 5235 | 5513 | 5780 | 6105 | 6430 | — | — | — | — |
| 12.00R20X | J | 18 | — | — | — | — | 5198 | 5513 | 5728 | 6118 | 6448 | 6725 | 7055 | 7330 | 7605 | 8100 |
| 12.00R22X | H | 16 | — | — | — | — | — | 5952 | 6267 | 6560 | 6890 | 7165 | 7550 | — | — | — |
| 12R22.5X | G | 14 | — | — | — | — | 4958 | 5235 | 5513 | 5705 | 6055 | 6295 | 6590 | — | — | — |
| 12R22.5X | H | 16 | — | — | — | — | 4958 | 5235 | 5513 | 5705 | 6055 | 6295 | 6590 | 6835 | 7200 | — |
| 12.00R24X | J | 18 | — | — | — | — | — | — | 7028 | 7370 | 7785 | 8130 | 8543 | 8840 | — | — |
| 13.00R20X | J | 18 | — | — | — | 6445 | 6805 | 7165 | 7557 | 7925 | 8337 | 8680 | 9055 | 9379 | — | — |
| 14.00R20X | J | 18 | — | — | — | 7510 | 7870 | 8265 | 8660 | 9025 | 9440 | 9920 | — | — | — | — |

**Table 12, Tire Load Limits, Michelin Radial Ply Tires, Tube-Type and Tubeless, Front Axle**

| Tire Load Limits, Michelin Radial Ply Tires, Tube-Type and Tubeless, Rear Axle | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Size | Load Range | Ply Rating | Maximum Tire Loads (lb) at Various Cold Inflation Pressures | | | | | | | | | | | | |
| | | | 55 psi | 60 psi | 65 psi | 70 psi | 75 psi | 80 psi | 85 psi | 90 psi | 95 psi | 100 psi | 105 psi | 110 psi | 115 psi | 120 psi |
| 8.25R20X | E | 10 | 2610 | 2840 | 3113 | 3261 | 3473 | 3671 | 3830 | — | — | — | — | — | — | — |

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## Specifications

| Tire Load Limits, Michelin Radial Ply Tires, Tube-Type and Tubeless, Rear Axle | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Size | Load Range | Ply Rating | Maximum Tire Loads (lb) at Various Cold Inflation Pressures | | | | | | | | | | | | |
| | | | 55 psi | 60 psi | 65 psi | 70 psi | 75 psi | 80 psi | 85 psi | 90 psi | 95 psi | 100 psi | 105 psi | 110 psi | 115 psi | 120 psi |
| 8.25R20X | F | 12 | 2610 | 2840 | 3113 | 3261 | 3473 | 3671 | 3830 | 4050 | 4220 | — | — | — | — | — |
| 9.00R20X | F | 12 | — | — | — | — | 3914 | 4130 | 4349 | 4566 | 4740 | — | — | — | — | — |
| 9.00R20X | G | 14 | — | — | — | — | 3914 | 4130 | 4349 | 4566 | 4740 | 4995 | 5080 | — | — | — |
| 9R22.5X | E | 10 | 2610 | 2840 | 3113 | 3261 | 3473 | 3671 | 3830 | — | — | — | — | — | — | — |
| 9R22.5X | F | 12 | 2610 | 2840 | 3113 | 3261 | 3473 | 3671 | 3830 | 4050 | 4220 | — | — | — | — | — |
| 10.00R20X | G | 14 | — | — | — | — | 4224 | 4550 | 4693 | 4923 | 5180 | 5440 | — | — | — | — |
| 10.00R20X | H | 16 | — | — | — | — | 4224 | 4550 | 4693 | 4923 | 5180 | 5440 | 5620 | 5880 | 5950 | — |
| 10.00R22X | F | 12 | — | — | — | — | 4534 | 4740 | 4976 | 5200 | — | — | — | — | — | — |
| 10.00R22X | G | 14 | — | — | — | — | 4534 | 4740 | 4976 | 5200 | 5495 | 5790 | — | — | — | — |
| 10R22.5X | F | 12 | — | — | — | — | 3914 | 4130 | 4349 | 4566 | 4740 | — | — | — | — | — |
| 10R22.5X | G | 14 | — | — | — | — | 3914 | 4130 | 4349 | 4566 | 4740 | 4995 | 5080 | — | — | — |
| 11.00R20X | G | 14 | — | — | — | — | 4390 | 4635 | 4880 | 5130 | 5361 | 5575 | 6000 | — | — | — |
| 11.00R20X | H | 16 | — | — | — | — | 4390 | 4635 | 4880 | 5130 | 5361 | 5575 | 6000 | 6055 | 6360 | — |
| 11.00R22X | G | 14 | — | — | — | — | 4788 | 5043 | 5303 | 5544 | 5806 | 6060 | — | — | — | — |
| 11.00R22X | H | 16 | — | — | — | — | 4788 | 5043 | 5303 | 5544 | 5806 | 6060 | 6300 | 6489 | 6650 | — |
| 11R22.5X | G | 14 | — | — | — | — | 4224 | 4550 | 4693 | 4923 | 5180 | 5440 | — | — | — | — |
| 11R22.5X | H | 16 | — | — | — | — | 4224 | 4550 | 4693 | 4923 | 5180 | 5440 | 5620 | 5880 | 5950 | — |
| 11.00R24X | H | 16 | — | — | — | — | 5075 | 5346 | 5623 | 5878 | 6166 | 6408 | 6750 | — | — | — |
| 11R24.5X | F | 12 | — | — | — | — | 4534 | 4740 | 4976 | 5200 | — | — | — | — | — | — |
| 11R24.5X | G | 14 | — | — | — | — | 4534 | 4740 | 4976 | 5200 | 5495 | 5790 | — | — | — | — |
| 12.00R20X | J | 18 | — | — | — | — | 4629 | 4905 | 5181 | 5435 | 5725 | 5966 | 6255 | 6500 | 6755 | 7160 |
| 12.00R22X | H | 16 | — | — | — | — | — | 5346 | 5642 | 5912 | 6221 | 6462 | 6800 | — | — | — |
| 12R22.5X | G | 14 | — | — | — | — | 4390 | 4635 | 4880 | 5130 | 5361 | 5575 | 6000 | — | — | — |
| 12R22.5X | H | 16 | — | — | — | — | 4390 | 4635 | 4880 | 5130 | 5361 | 5575 | 6000 | 6055 | 6360 | — |
| 12.00R24X | J | 18 | — | — | — | — | — | — | 6325 | 6635 | 7006 | 7316 | 7689 | 7950 | — | — |
| 13.00R20X | J | 18 | — | — | — | 5800 | 6125 | 6448 | 6802 | 7132 | 7503 | 7812 | 8150 | 8450 | — | — |
| 14.00R20X | J | 18 | — | — | — | 6757 | 7085 | 7440 | 7795 | 8122 | 8472 | 8900 | — | — | — | — |

**Table 13, Tire Load Limits, Michelin Radial Ply Tires, Tube-Type and Tubeless, Rear Axle**

| Tire Load Limits, Michelin Pilote X Radial Ply Tires, Tube-Type and Tubeless, Front Axle | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Size | Load Range | Ply Rating | Maximum Tire Loads (lb) at Various Cold Inflation Pressures | | | | | | | | | | | |
| | | | 60 psi | 65 psi | 70 psi | 75 psi | 80 psi | 85 psi | 90 psi | 95 psi | 100 psi | 105 psi | 110 psi | 115 psi | 120 psi |
| 255/70R22.5 | G | 14 | 3173 | 3385 | 3598 | 3810 | 4023 | 4235 | 4448 | 4653 | 4805 | 4940 | — | — | — |
| 275/80R22.5 | G | 14 | — | — | 4560 | 4825 | 5090 | 5365 | 5625 | 5920 | 6175 | — | — | — | — |

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| Tire Load Limits, Michelin Pilote X Radial Ply Tires, Tube-Type and Tubeless, Front Axle | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Size | Load Range | Ply Rating | Maximum Tire Loads (lb) at Various Cold Inflation Pressures | | | | | | | | | | | |
| | | | 60 psi | 65 psi | 70 psi | 75 psi | 80 psi | 85 psi | 90 psi | 95 psi | 100 psi | 105 psi | 110 psi | 115 psi | 120 psi |
| 275/80R24.5 | G | 14 | — | — | 4560 | 4825 | 5090 | 5365 | 5625 | 5920 | 6175 | — | — | — | — |
| 13/75R22.5 | J | 18 | — | — | — | — | — | 6043 | 6367 | 6682 | 6818 | 7308 | 7609 | 8000 | — |
| 13/80R20 | J | 18 | — | — | — | — | 5688 | 5995 | 6283 | 6610 | 6880 | 7210 | 7500 | 8000 | — |
| 14/80R20 | J | 18 | — | — | — | — | — | 6710 | 7020 | 7393 | 7700 | 8038 | 8393 | 8873 | 9040 |

**Table 14, Tire Load Limits, Michelin Pilote X Radial Ply Tires, Tube-Type and Tubeless, Front Axle**

| Tire Load Limits, Michelin Pilote X Radial Ply Tires, Tube-Type and Tubeless, Rear Axle | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Size | Load Range | Ply Rating | Maximum Tire Loads (lb) at Various Cold Inflation Pressures | | | | | | | | | | | |
| | | | 60 psi | 65 psi | 70 psi | 75 psi | 80 psi | 85 psi | 90 psi | 95 psi | 100 psi | 105 psi | 110 psi | 115 psi | 120 psi |
| 255/70R22.5 | G | 14 | 2943 | 3135 | 3329 | 3522 | 3713 | 3905 | 4096 | 4280 | 4420 | 4540 | — | — | — |
| 275/80R22.5 | G | 14 | — | — | 4113 | 4350 | 4588 | 4833 | 5070 | 5335 | 5675 | — | — | — | — |
| 275/80R24.5 | G | 14 | — | — | 4113 | 4350 | 4588 | 4833 | 5070 | 5335 | 5675 | — | — | — | — |
| 13/75R22.5 | J | 18 | — | — | — | — | — | 5417 | 5707 | 5990 | 6247 | 6552 | 6822 | 7160 | — |
| 13/80R20 | J | 18 | — | — | — | — | 5122 | 5512 | 5792 | 6075 | 6355 | 6625 | 6907 | 7160 | — |
| 14/80R20 | J | 18 | — | — | — | — | — | 6045 | 6325 | 6660 | 6937 | 7242 | 7562 | 7992 | 8140 |

**Table 15, Tire Load Limits, Michelin Pilote X Radial Ply Tires, Tube-Type and Tubeless, Rear Axle**

| Disc-Type Wheel Fastener Torques | | | |
|---|---|---|---|
| **Description** | **Nut Size** | **Wheel Manufacturer** | **Torque (dry threads): lbf·ft (N·m)** |
| *8-Hole Disc Wheel With Two-Piece Flange Nuts* | | | |
| Front and Rear Wheel Nut | M22 x 1.5 | All | 450–500 (610–678)* |
| *10-Hole Disc Wheel With Two-Piece Flange Nuts* | | | |
| Front and Rear Wheel Nut | M22 x 1.5 | All | 450–500 (610–678)* |
| *10-Hole Disc Wheel With Inner and Outer Nuts* | | | |
| Front Wheel Nut | 1-1/8–16 | Alcoa<br>Budd<br>Firestone and Motor Wheel | 400–500 (540–678)†<br>450–500 (610–678)‡<br>450–500 (610–678) |
| Rear Wheel Inner Nut | 3/4–16 | Alcoa<br>Budd, Firestone, and Motor Wheel | 400–500 (540–678)†<br>450–500 (610–678) |
| Rear Wheel Outer Nut | 1-1/8–16 | Alcoa<br>Budd, Firestone, and Motor Wheel | 400–500 (540–678)†<br>450–500 (610–678) |

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## Specifications

| Disc-Type Wheel Fastener Torques | | | |
|---|---|---|---|
| **Description** | **Nut Size** | **Wheel Manufacturer** | **Torque (dry threads): lbf·ft (N·m)** |
| Wheel Stud Retainer Nut | 3/4–16 | All | 175–200 (235–270) |

* Torque values are given for lubricated threads.

† Lubricated threads should be tightened 300 to 375 lbf·ft (405 to 510 N·m). Lubricate threads with a mixture of 25 percent colloidal graphite in cup grease or equivalent. Do not apply thread lubricant to ball seats of the nuts and wheels. Wipe it off if it is applied accidentally.

‡ On 1–1/8-16 size wheel studs with a head (**Fig. 1**), tighten the wheel nuts 650 to 750 lbf·ft (990 to 1020 N·m).

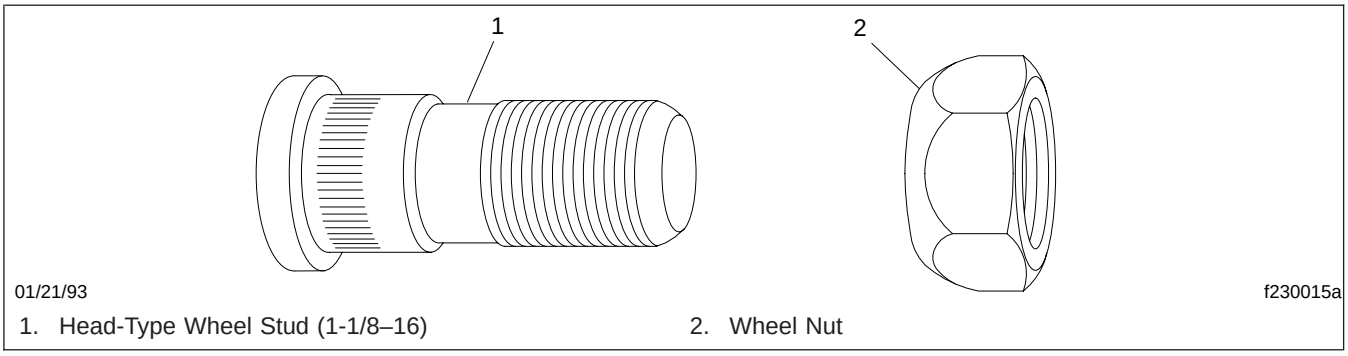
**Table 16, Disc-Type Wheel Fastener Torques**

| Spoke-Type Wheel Mounting Torque | | | |
|---|---|---|---|
| **Description** | **Nut Size** | **Manufacturer** | **Dry Threads: lbf·ft (N·m)** |
| Front Wheel Nut, 5 and 6 Spoke | 5/8–11 | Dayton and Gunite | 160–175 (215–235) |
| | | Webb | 150–175 (205–235) |
| | 3/4–10 | Dayton | 240–260 (325–355) |
| | | Gunite | 200–225 (270–305)* |
| | | Webb | 200–250 (270–340) |
| Rear Wheel Nut, 5 and 6 Spoke | 5/8–11 | Dayton and Gunite | 160–175 (215–235) |
| | | Webb | 150–175 (205–235) |
| | 3/4–10 | Dayton | 190–210 (260–285)† |
| | | Gunite | 200–225 (270–305) |
| | | Webb | 200–250 (270–340) |

* On front axles with over 12,000 lb (5448 kg) capacity, tighten nuts 240 to 265 lbf·ft (325 to 360 N·m). Gunite part number W-854 nut, with a phosphate and oil coating, must be used.

† 190 to 210 lbf·ft (260 to 285 N·m) recommended when using channel spacers (**Fig. 2**). 240 to 260 lbf·ft (325 to 355 N·m) permitted when using corrugated or corrugated-channel spacers. See **Fig. 3**.

**Table 17, Spoke-Type Wheel Mounting Torque**




1. Head-Type Wheel Stud (1-1/8–16)
2. Wheel Nut

**Fig. 1, Head-Type Wheel Stud**

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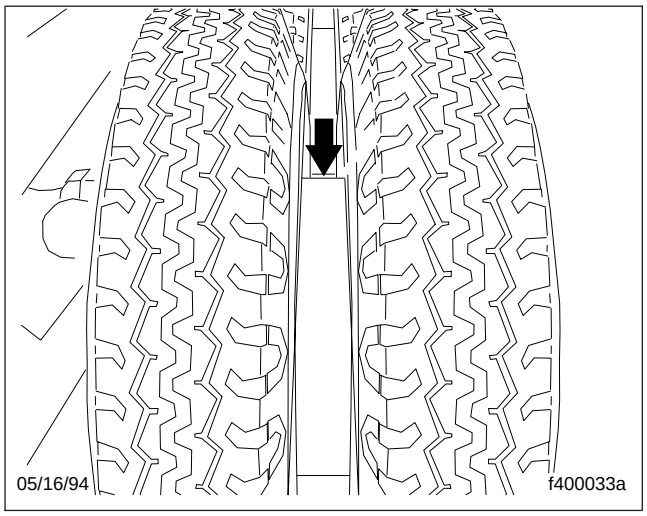
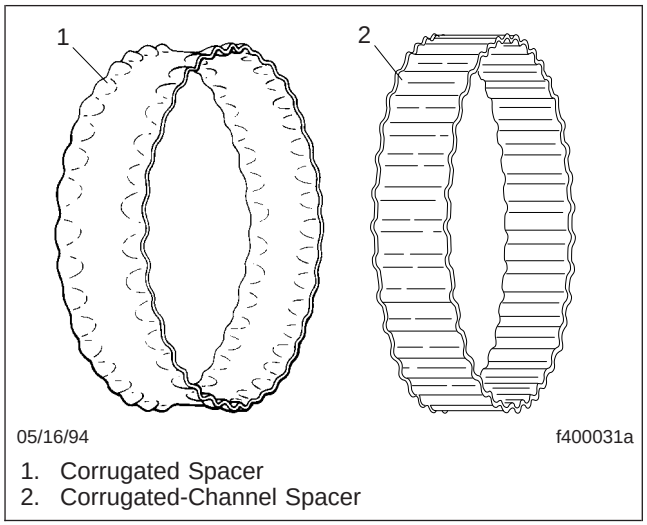



**Fig. 2, Channel Spacer**




1. Corrugated Spacer
2. Corrugated-Channel Spacer

**Fig. 3, Corrugated and Corrugated-Channel Spacers**

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# General Information

The simplest driveline consists of a transmission output-shaft end-yoke, an axle input-shaft end-yoke, and a single slip-jointed driveshaft connecting the two end-yokes. See **Fig. 1**. The driveshaft is made up of a universal joint (U-joint), a sleeve-yoke, a splined stub shaft, a driveshaft tube, a tube-yoke, and a second U-joint.

## Driveline Configurations

The specific type and number of drivelines used on each vehicle depends on its number of transmissions, its number of drive axles, and its wheelbase. See **Fig. 2**. A driveline is used between each driving and driven component. A driveline connecting a main transmission (or an auxiliary transmission) to a single drive axle or forward-rear axle of a dual-drive vehicle is always referred to as a No. 2 driveline. See **Fig. 2**, examples A, B, C, D, and E. An interaxle driveline of a dual-drive vehicle is always called a No. 3 driveline. See **Fig. 2**, examples B and C. A driveline connecting a main transmission to an auxiliary transmission is always referred to as a No. 1 driveline. See **Fig. 2**, example C.

A long driveshaft, supported only at its ends, will sag in the middle from its own weight. When turning at high rpm, it will flex, causing an out-of-balance vibration. Therefore, vehicles having a long wheelbase use a midship bearing, mounted on a frame crossmember, for additional support. See **Fig. 2**, example D. This allows the No. 2 driveline to be separated into two, shorter shafts (a coupling shaft and a No. 2 driveshaft), thus improving balance and stability.

Vehicles having an even longer wheelbase use two crossmember-mounted midship bearings, allowing the No. 2 driveline to be separated into three short shafts, joined by four U-joints. See **Fig. 2**, example E. The first shaft is the primary coupling shaft, the second is the intermediate coupling shaft, and the third is the No. 2 driveshaft.

## Slip-Joints, U-Joints, and Yokes

The basic function of the driveline is to send torque from the transmission to the axle in a smooth and continuous action. Because the vehicle axles are not attached directly to the frame, but are suspended by springs, they ride in an irregular, floating motion (when going over bumps or depressions), thus changing the distance between the transmission (or coupling shaft) and the rear axle, and the distance between the rear axles. The slip-joints of the No. 2 and No. 3 driveshafts, by expanding and contracting, allow for length changes between drivetrain components. Coupling shafts do not require a slip-joint.

Motion of the rear axle(s) also causes changes to the relative angles between drivetrain components. U-joints allow transfer of torque from an output shaft (or coupling shaft) to the driveshaft, and from the driveshaft to an input shaft, even though the angles between the shafts may be constantly changing.

Each U-joint consists of a cross with a close-tolerance ground cylindrical surface (trunnion) at the end of each of the four arms. Installed on each trunnion is a bearing cup lined with bearing needles. All bearing cups are sealed to retain lubricants, and to prevent entry of foreign material. See **Fig. 3**. In operation, the four bearing cups are held stationary in a pair of yokes, while the U-joint cross pivots on its trunnions.

Full-round yokes are installed at the front of coupling shafts and at both ends of the No. 2 and No. 3 driveshafts. All tube-yokes (yokes that are welded into driveshaft tubes) and all sleeve-yokes (yokes that are part of the internally splined half of slip-joints) are full-round yokes. See **Fig. 4**, items 4 and 9.

An end-yoke is an internally splined yoke, held on an externally splined shaft by a locknut. As standard equipment, all No. 2 driveline end-yokes are half-round, with full-round optional. And, as standard equipment, all No. 3 driveline end-yokes are full-round, with half-round optional. End-yokes are installed on the transmission output shaft, on each axle input and output shaft, and behind the midship bearing of most coupling shafts. See **Fig. 4**, items 2, 7, 12, and 14.

Meritor 17T and 18T U-joints are coupled to half-round end-yokes by capscrews inserted through semicircular bearing straps that hold the bearing cups in place under tabs in the yoke cross-holes. See **Fig. 5.**

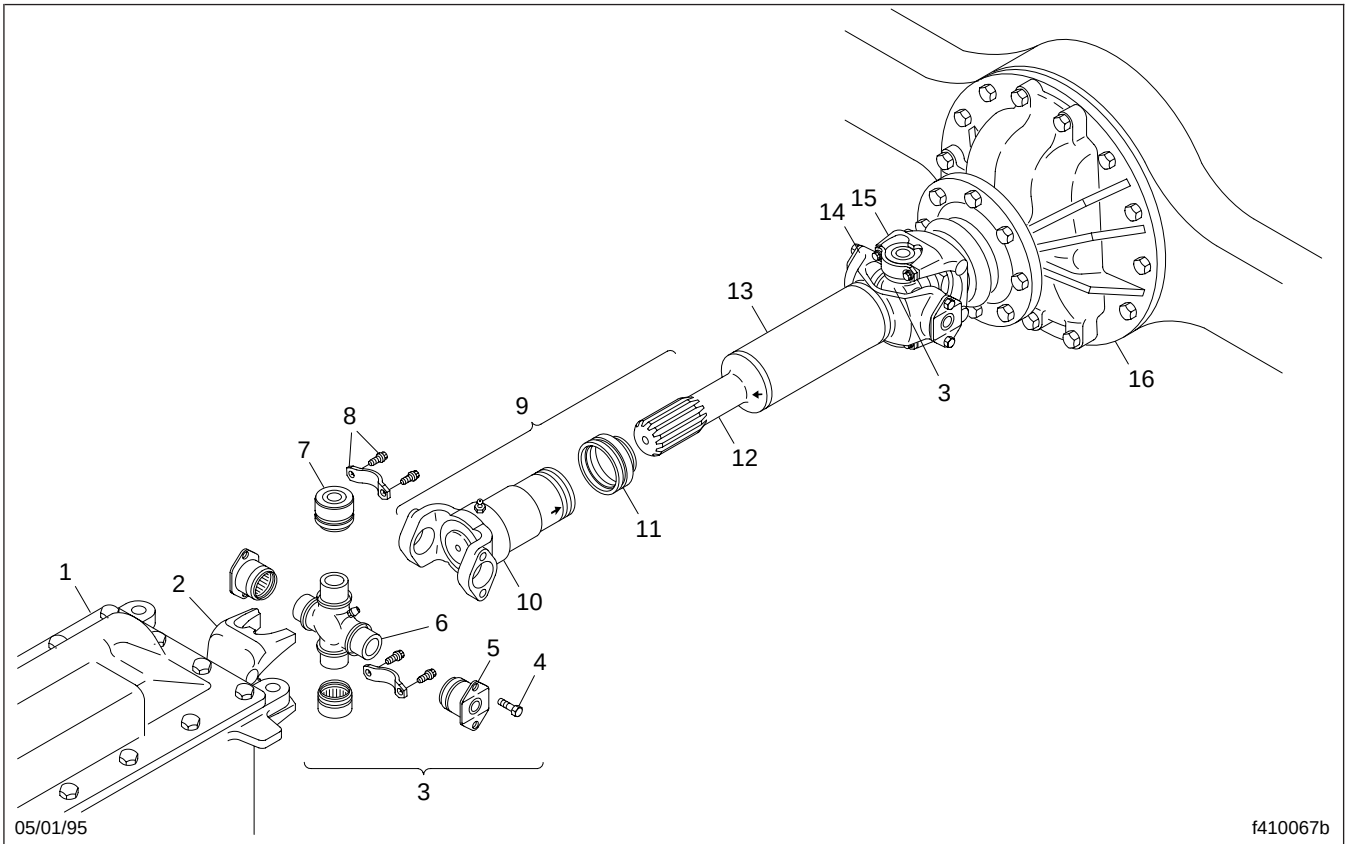
Meritor RPL Series U-joints are coupled to half-round end-yokes by capscrews inserted through the bearing cups. See **Fig. 6**.

U-joints are installed in full-round tube-yokes, sleeve-yokes, and end-yokes, by inserting the cross through from the inside of both yoke cross-holes, then installing the bearing cups into the outsides of the yoke

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## General Information




NOTE: Not all fasteners are shown.

1. Transmission
2. Transmission Output-Shaft End-Yoke (half-round)
3. U-Joint Assembly
4. Bearing Plate Self-Locking Capscrew
5. Bearing Cup (for full-round yoke)
6. U-Joint Cross
7. Bearing Cup (for half-round yoke)
8. Bearing Strap and Bearing-Strap Capscrew
9. Slip-Joint Assembly
10. Sleeve-Yoke (full-round)
11. Dust Cap
12. Splined Stub Shaft
13. Driveshaft Tube
14. Tube-Yoke (full-round)
15. Axle Input-Shaft End-Yoke (half-round)
16. Rear Axle

**Fig. 1, Components of a Basic Driveline**

and over the ends of the trunnions. Snap rings or self-locking capscrews are installed into the yoke to secure the cups. See **Fig. 7**.

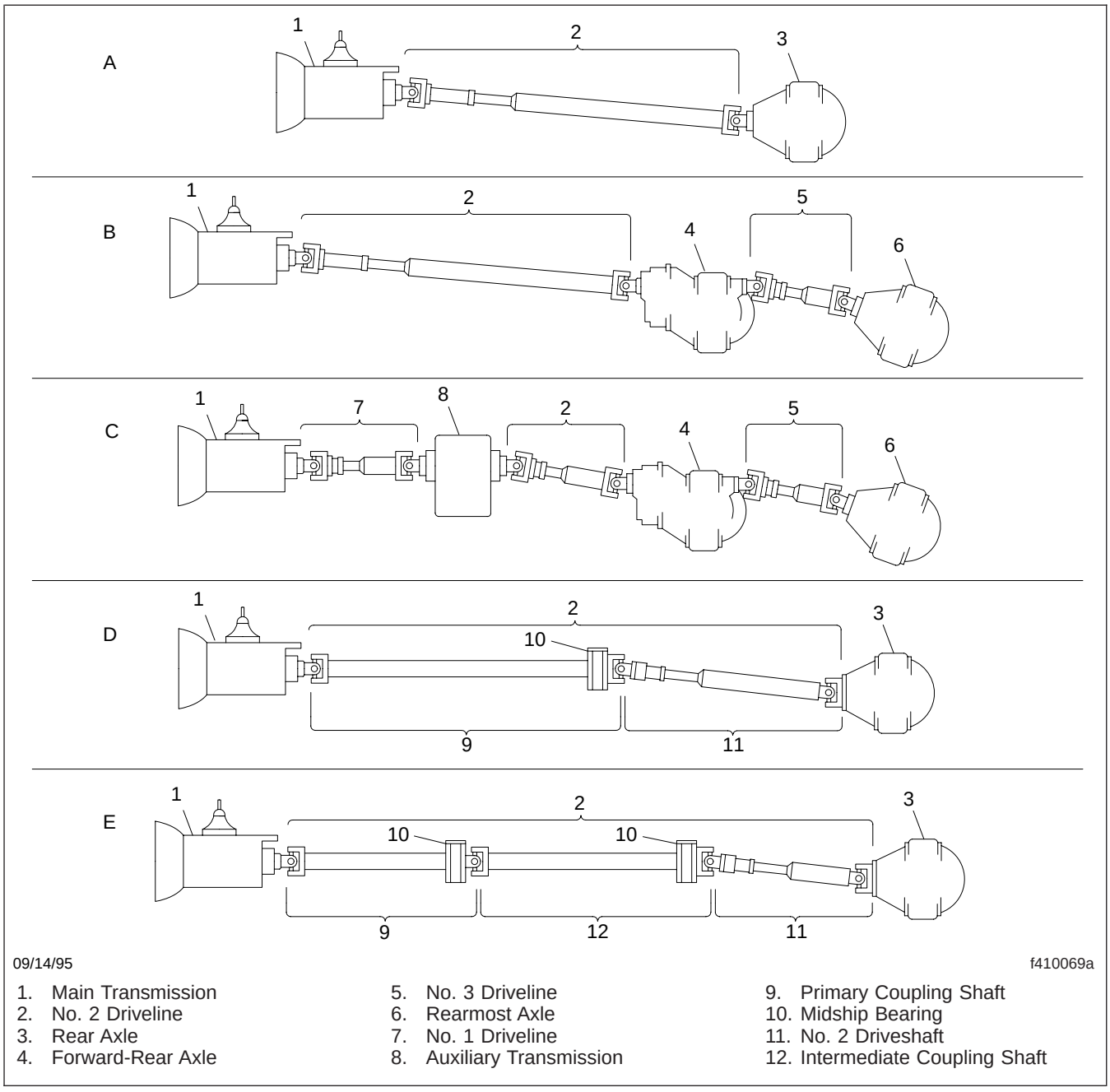
## U-Joint Angles, Phasing, and Driveline Balance

Correct U-joint working angles, U-joint phasing, and driveline balance are vital to maintaining a quiet-running drivetrain and long life of drivetrain components (including driveline components).

The U-joint working angle is the angle formed by the intersection of the driveshaft centerline and the extended centerline of the shaft of any component (or other driveshaft) to which the U-joint connects. See **Fig. 8**. Because the double oscillating motion of a U-joint that connects angled shafts causes a fluctuating speed difference between the shafts, the effect created by the U-joint at one end of the shaft must cancel the effect created by the U-joint at the other end. This is done by making U-joint working angles at both ends of the driveshaft approximately equal, with the U-joints in phase. If the yoke lugs at both ends of the shaft are lying in the same plane (a

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1. Main Transmission
2. No. 2 Driveline
3. Rear Axle
4. Forward-Rear Axle
5. No. 3 Driveline
6. Rearmost Axle
7. No. 1 Driveline
8. Auxiliary Transmission
9. Primary Coupling Shaft
10. Midship Bearing
11. No. 2 Driveshaft
12. Intermediate Coupling Shaft

**Fig. 2, Driveline Configurations**

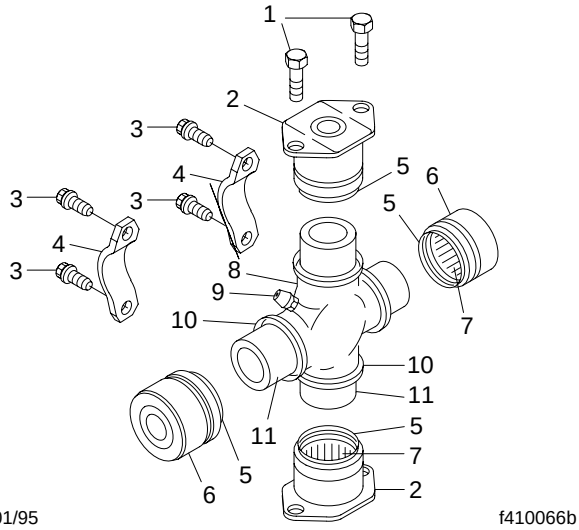
plane that bisects the shaft lengthwise) the U-joints will be in phase. See **Fig. 9**.

NOTE: Some driveshafts are designed and phased with their end yokes clocked 90 degrees from each other. This is referred to as cross phasing.

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## General Information




1. Bearing-Plate Capscrews
2. Bearing Cup (for full-round yoke)
3. Bearing-Strap Capscrew
4. Bearing Strap
5. Bearing-Cup Seal
6. Bearing Cup (for half-round yoke)
7. Bearing Needles
8. U-Joint Cross
9. Grease Fitting
10. U-Joint Cross Slinger
11. Trunnion

**Fig. 3, Typical U-Joint**

After manufacture, each driveline yoke is statically balanced. After assembly, each driveshaft and coupling shaft is checked for out-of-roundness, straightened as necessary, then dynamically balanced.

# Avoiding Driveline Problems

To ensure that U-joints turn in phase, sleeve-yokes, splined shafts, coupling shaft end-yokes, and coupling shafts, should be marked for assembly reference before disassembly. A misaligned slip-joint will seriously affect driveline balance (and U-joint phasing). Even if a slip-joint is assembled 180 degrees from its original position (which will keep the U-joints in phase), the dynamic balance of the driveshaft will be negatively affected.

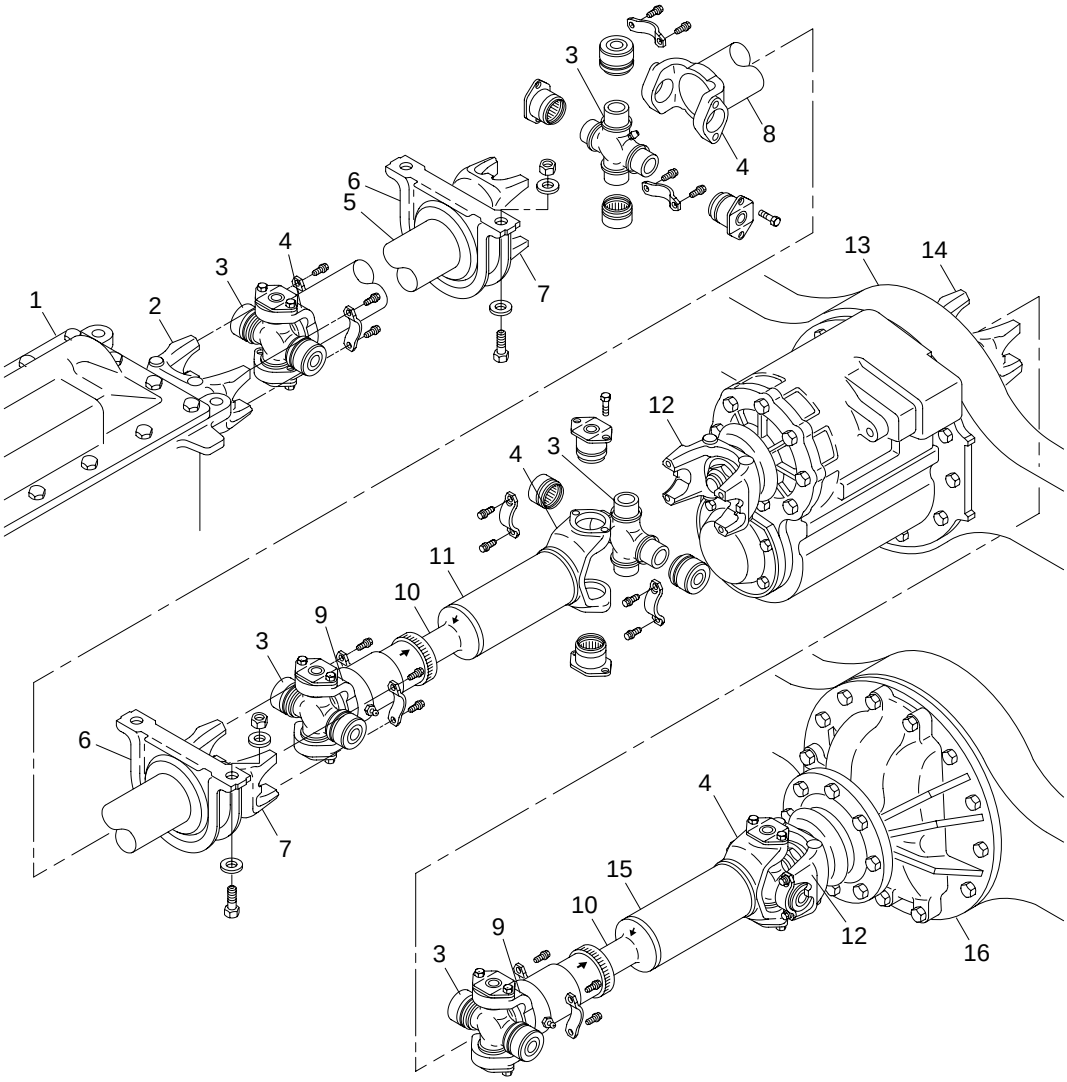
A driveline can become unbalanced or greatly weakened if a driveshaft has been dented, bent, twisted, or otherwise damaged. Operating a vehicle at speeds that exceed the speed of the driveshaft's design specifications will cause an out-of-balance vibration. Any condition that allows excessive movement of a driveshaft will cause driveline imbalance: loose end-yoke nuts, loose midship bearing mounts, loose U-joint bearing cup retaining capscrews, worn U-joint trunnions and bearings, and worn slip-joint splines.

Among the most common causes of U-joint and slip-joint damage is lack of lubrication.

To keep a vehicle operating smoothly and economically, the driveline must be carefully checked and lubricated at regular intervals. For inspection and lubrication intervals and procedures, see **Group 41** of the *Western Star Maintenance Manual*.

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NOTE: Not all fasteners are shown.

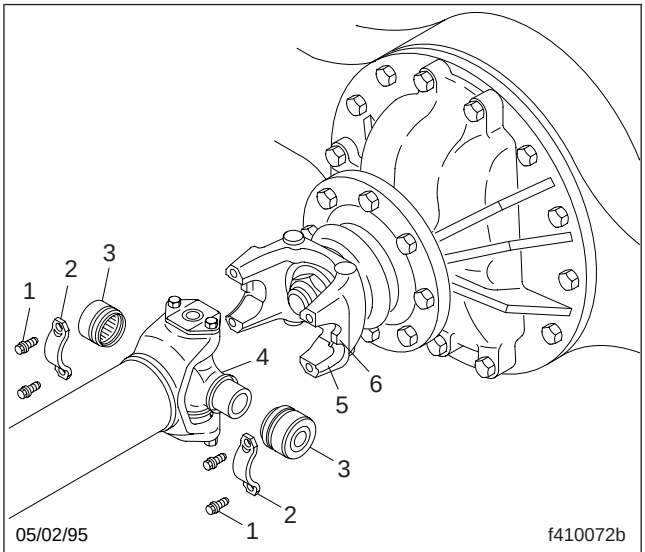
1. Transmission
2. Transmission Output-Shaft End-Yoke (half-round)
3. U-Joint Assembly
4. Full-Round Tube-Yoke
5. Primary Coupling Shaft Tube
6. Midship Bearing Assembly
7. Coupling Shaft End-Yoke (half-round)
8. Intermediate Coupling Shaft Tube
9. Sleeve-Yoke (full-round)
10. Slip-Joint Assembly
11. No. 2 Driveshaft Tube
12. Axle Input-Shaft End-Yoke (half-round)
13. Forward-Rear Axle
14. Axle Output-Shaft End-Yoke (half-round)
15. No. 3 Driveshaft Tube
16. Rearmost Axle

**Fig. 4, Dual-Drive Installation With Primary and Intermediate Coupling Shafts**

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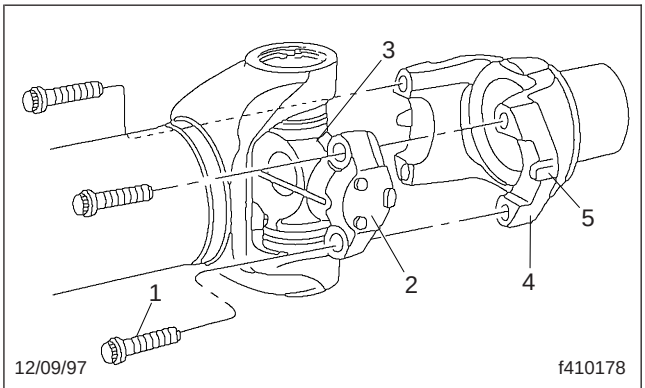


## General Information



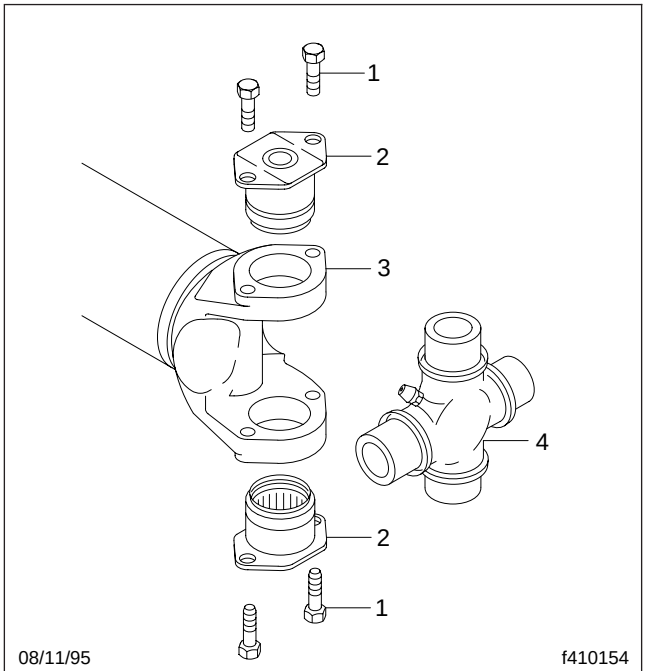

1. Bearing-Strap Capscrew
2. Bearing Strap
3. Bearing Cup
4. U-Joint Cross
5. Half-Round Yoke
6. Yoke Cross-Hole Tab

**Fig. 5, Coupling of a U-Joint With a Half-Round End-Yoke**




1. Capscrew
2. Bearing Cup
3. U-Joint Cross
4. Half-Round Yoke
5. Yoke Cross-Hole Tab

**Fig. 6, Coupling of a RPL Series U-Joint**

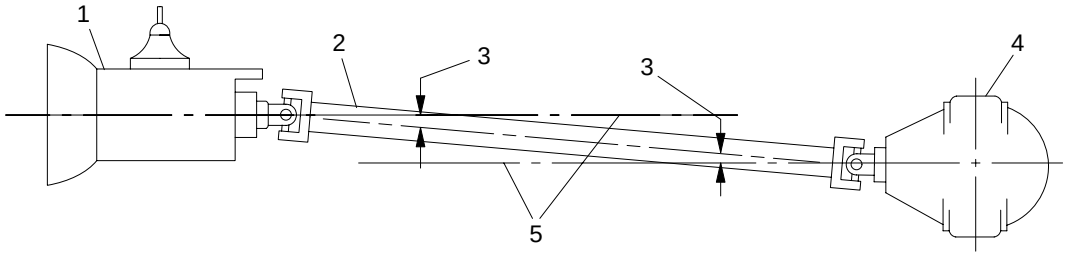



1. Bearing-Plate Self-Locking Capscrew
2. Bearing Cup (bearing-plate-type)
3. Full-Round Yoke
4. U-Joint Cross

**Fig. 7, Installation of a U-Joint in a Full-Round Yoke**

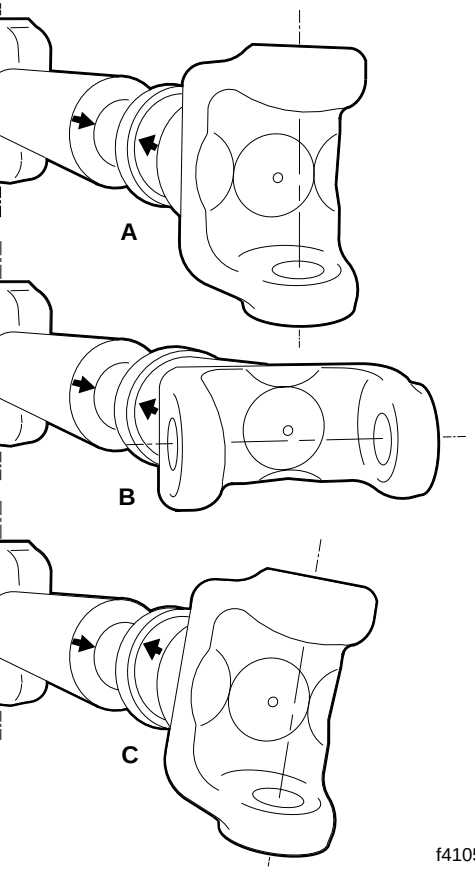
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1. Transmission
2. No. 2 Driveshaft
3. U-Joint Working Angles
4. Rear Axle
5. Extended Centerlines

**Fig. 8, U-Joint Working Angles**




A. In Phase (parallel phased)
B. In Phase (cross phased)
C. Out of Phase

**Fig. 9, U-Joint Phasing**

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# U-Joint Uncoupling and Coupling With a Half-Round End-Yoke

## U-Joint Uncoupling

NOTE: It is easier to check driveline parts, and to replace a U-joint or midship bearing assembly if the driveshaft is removed from the vehicle. If a driveshaft requires straightening or balancing, it must be removed, and installed on a lathe or a balance machine. Removal is required for replacement of slip-joint parts, a driveshaft tube, or a tube-yoke. To remove the driveshaft, see **Subject 120**.

NOTE: Many service operations do not require driveshaft removal from the vehicle: end-yoke nut tightening; drive component shaft seal or end-yoke replacement; changing U-joint phasing at the slip-yoke; and transmission or axle removal (for overhaul, repair, or replacement). To perform these operations, uncouple the U-joint at the applicable end of the appropriate driveshaft. See **Fig. 1** and **Fig. 2**.

1. Roll the vehicle forward or backward as needed to turn the rearmost end-yoke (of the driveline that is being uncoupled) until the centerline through its cross-holes is horizontal. See **Fig. 1**, Ref. A and Ref. B.
2. Apply the parking brakes, and chock the tires.
3. If the half-round bearing cups do not already have a retaining wire installed, install a bearing-cup retaining wire. See **Fig. 1**, Ref. C. Or, install safety wire from the retaining-wire groove of one half-round bearing cup to the other.
4. Support the driveshaft with a nylon support strap.

   When uncoupling a coupling shaft, install two or three support straps, as needed. Remove the fasteners that attach the midship bearing(s) to its bracket(s). See **Fig. 1** and **Fig. 2**.
5. Remove the capscrews that secure the bearing cups or straps to the half-round yoke. Remove the bearing straps, if equipped.
6. Compress the slip-joint to remove the U-joint from the yoke.

**CAUTION**

**Do not expose the U-joint trunnions or bearing-cup needles to dirt or grit. The smallest bits of dirt or grit can cause rapid wear and serious damage to the U-joint.**

## U-Joint Coupling

1. Check and clean the end-yoke.
   - 1.1 Check the torque on the end-yoke nut. See **Specifications, 400**.
   - 1.2 Check the end-yoke cross-holes for burrs or raised metal. Using a half-round file, remove burrs or raised metal. See **Fig. 3**.
   - 1.3 Using fine emery cloth, smooth and clean the entire surface of the yoke cross-holes and bearing straps. See **Fig. 4**.
   - 1.4 Turn the end-yoke until its cross-holes are horizontal. See **Fig. 1** and **Fig. 2**.
2. Check, clean, and lubricate the U-joint.
   - 2.1 Remove the bearing-cup retaining wire or safety wire. See **Fig. 1**, Ref. C.

**CAUTION**

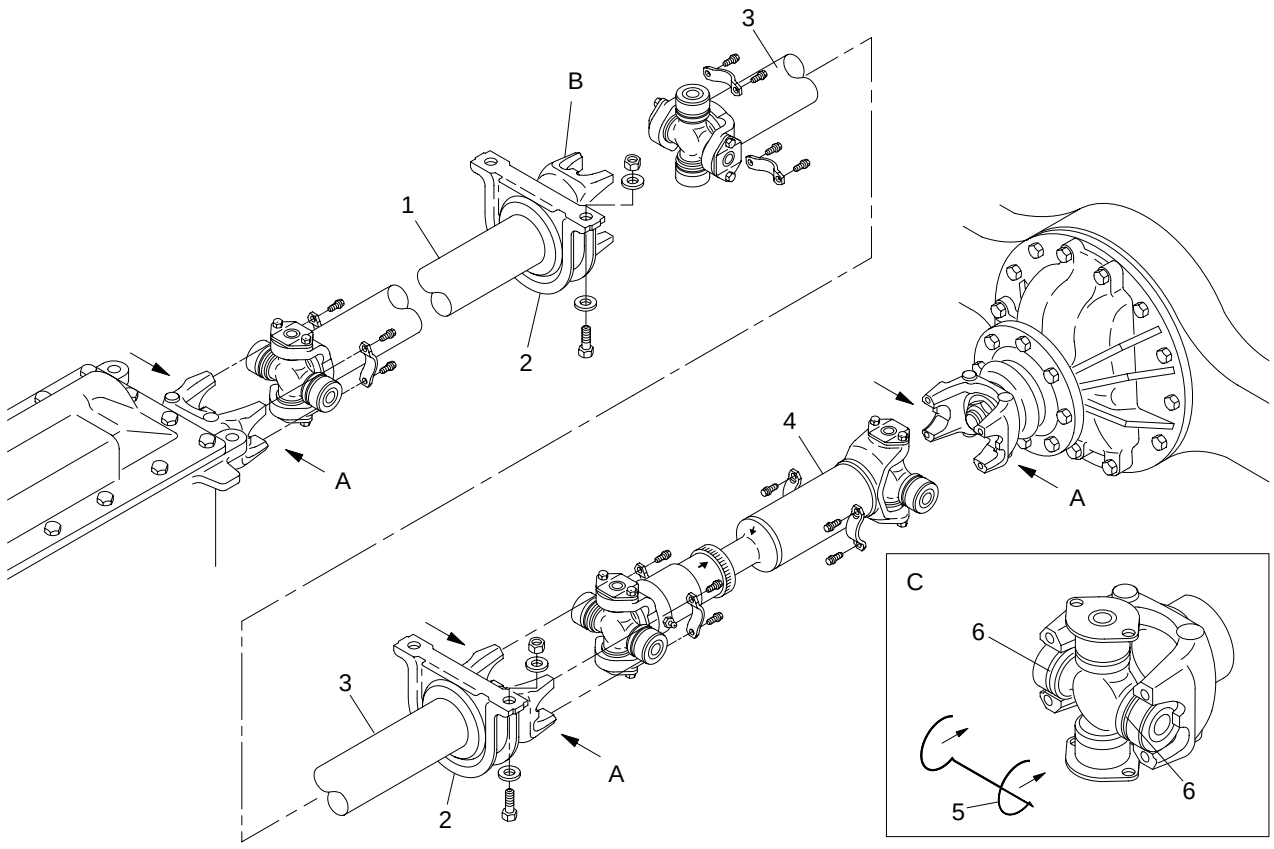
**Do not expose the U-joint trunnions or bearing-cup needles to dirt or grit. The smallest bits of dirt or grit can cause rapid wear and serious damage to the U-joint.**

   - 2.2 Using fine emery cloth, smooth and clean the outside surfaces of both bearing cups. See **Fig. 5**.
   - 2.3 Check the U-joint trunnions and bearing cups for minute particles of dirt or grit. Clean if necessary. See **Subject 140**.
   - 2.4 Using NLGI grade 2 grease with EP additives, wipe a small amount of grease on the needles in the bearing cups.
   - 2.5 Using a light-weight oil, lubricate the lips of the bearing-cup seals. See **Fig. 6**.
   - 2.6 Install the bearing cups on the cross.
   - 2.7 Install a bearing-cup retaining wire. See **Fig. 1**, Ref. C. Or, install safety wire from the retaining-wire groove of one half-round bearing cup to the other.
3. Extend the slip-joint, while pressing the cross and bearing cups into place in the yoke cross-

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## U-Joint Uncoupling and Coupling With a Half-Round End-Yoke




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NOTE: Not all fasteners are shown.

A. End-yoke cross-hole centerline is horizontal.
B. Before uncoupling/coupling the U-joint, turn the end-yoke until its cross-hole centerline is horizontal.
C. Install a half-round bearing-cup retaining wire (or safety wire) before removing the bearing straps.

1. Primary Coupling Shaft
2. Midship Bearing
3. Intermediate Coupling Shaft
4. No. 2 Driveshaft
5. Half-Round Bearing-Cup Retaining Wire
6. Retaining-Wire Groove

**Fig. 1, U-Joint Uncoupling/Coupling for Drivelines With Half-Round End-Yokes, Except RPL U-Joints**

holes. Using a rubber or plastic mallet, gently tap the bearing cups to seat them in the yoke. See **Fig. 7**.

**⚠ CAUTION**

**Do not use the capscrews and bearing straps (if equipped) to seat the bearing cups in the yoke. Seating the cross by tightening the bearing straps can deform the bearing straps, allowing the bearing cups to spin, which will cause rapid wear and serious damage to the U-joint.**

4. Place the bearing straps (if equipped) over the cups. Install the capscrews, finger-tight.

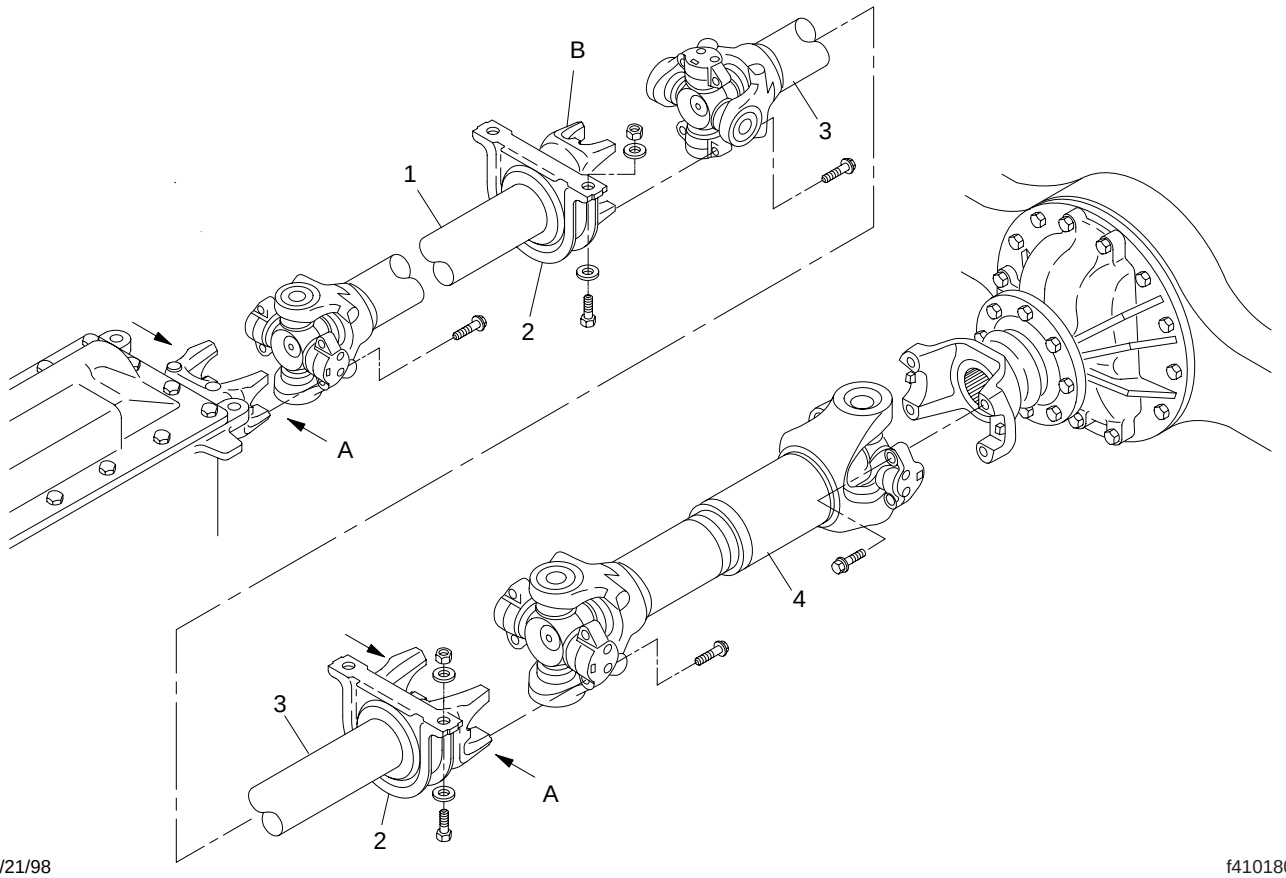
**⚠ WARNING**

**The self-locking capscrews must not be reused. Replace the capscrews with new ones. Also, do not undertighten or overtighten the capscrews. A loose or broken fastener at any point in the driveline weakens the driveline connection, which could cause serious vehicle damage, or could result in a driveshaft separating from the vehicle.**

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## U-Joint Uncoupling and Coupling With a Half-Round End-Yoke




NOTE: Not all fasteners are shown.

A. End-yoke cross-hole centerline is horizontal.
B. Before uncoupling/coupling the U-joint, turn the end-yoke until its cross-hole centerline is horizontal.

1. Primary Coupling Shaft
2. Midship Bearing
3. Intermediate Coupling Shaft
4. No. 2 Driveshaft

**Fig. 2, U-Joint Uncoupling/Coupling for Drivelines With Half-Round End-Yokes, RPL U-Joints**

**Driveline separation can cause loss of vehicle control that could result in serious personal injury or death.**

**Separation of the driveline can also cause damage to the driveline, driveline components, or other areas of the vehicle.**

5. Alternately tighten the capscrews in increments of 20 lbf·ft (27 N·m) to the applicable torque value in **Specifications, 400**.
6. If they were removed, install the fasteners that attach each midship bearing to its bracket; tighten the flanged locknuts 68 lbf·ft (92 N·m).
7. Lubricate the U-joint, following the procedure in **Group 41** of the *Western Star Maintenance Manual*.
8. Remove the nylon support straps, then remove the chocks.

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## U-Joint Uncoupling and Coupling With a Half-Round End-Yoke

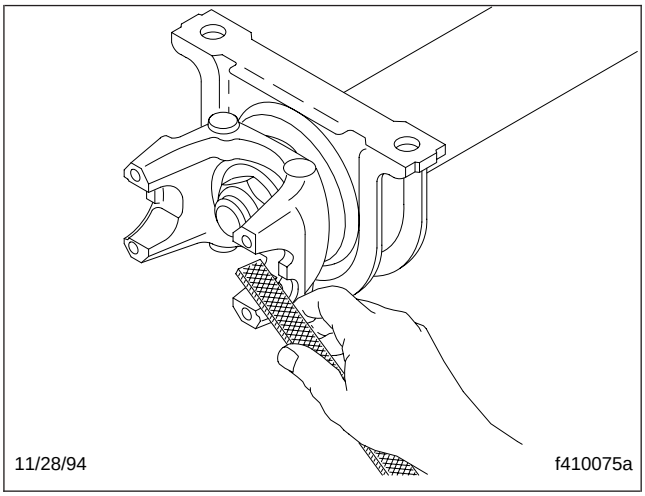
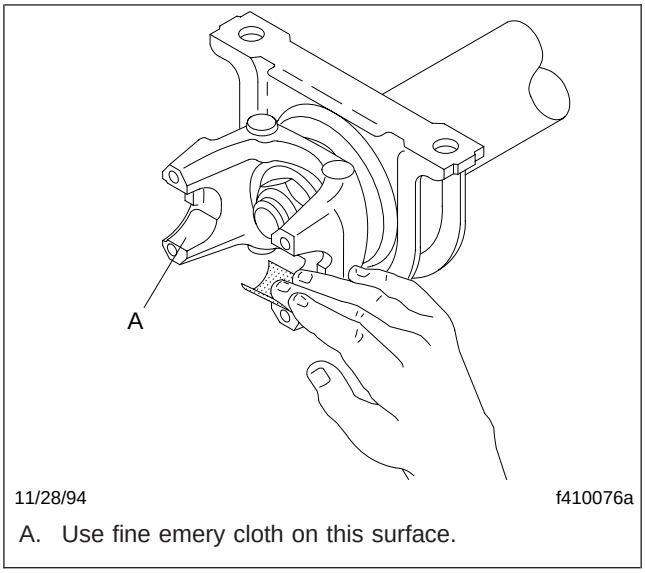
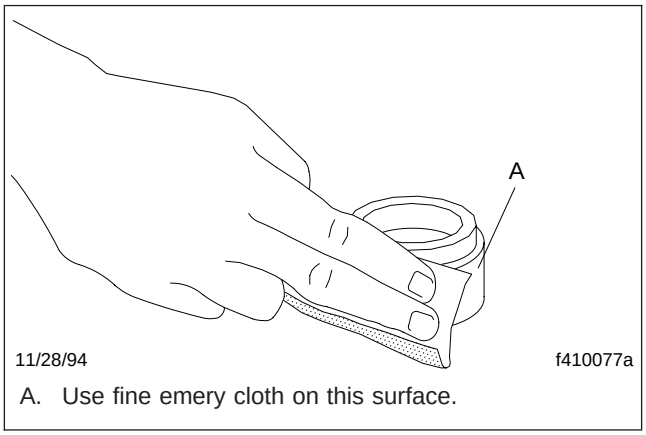



**Fig. 3, Remove Burrs from a Half-Round End-Yoke Cross-Hole**



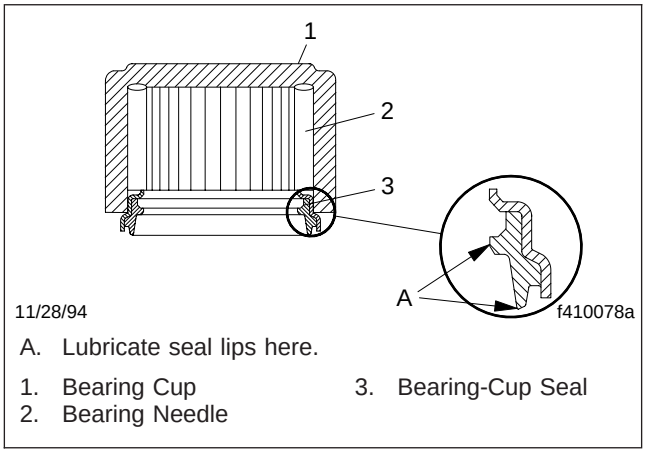

A. Use fine emery cloth on this surface.

**Fig. 4, Smooth a Half-Round End-Yoke Cross-Hole**




A. Use fine emery cloth on this surface.

**Fig. 5, Smooth a Half-Round End-Yoke U-Joint Bearing Cup**




A. Lubricate seal lips here.

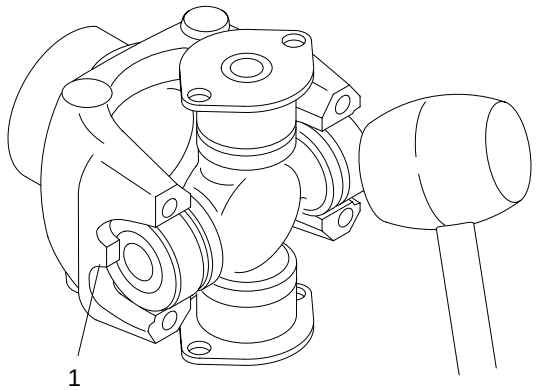
1. Bearing Cup
2. Bearing Needle
3. Bearing-Cup Seal

**Fig. 6, Sectional View of a Half-Round End-Yoke U-Joint Bearing Cup**

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## U-Joint Uncoupling and Coupling With a Half-Round End-Yoke




1. Retaining Tab

**Fig. 7, Seat a U-Joint in a Half-Round End-Yoke**

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# U-Joint Uncoupling and Coupling With a Full-Round End-Yoke

## U-Joint Uncoupling

NOTE: It is easier to check driveline parts, and to replace a U-joint or midship bearing assembly if the driveshaft is removed from the vehicle. If a driveshaft requires straightening or balancing, it must be removed, and installed on a lathe or a balance machine. Removal is required for replacement of slip-joint parts, a driveshaft tube, or a tube-yoke. To remove the driveshaft, see **Subject 120**.

Many service operations do not require driveshaft removal from the vehicle: end-yoke nut tightening; drive component shaft seal or end-yoke replacement; changing U-joint phasing at the slip-yoke; and transmission or axle removal (for overhaul, repair, or replacement). To perform these operations, uncouple the U-joint at the applicable end of the appropriate driveshaft. See **Fig. 1**.

1. Roll the vehicle forward or backward as needed to turn the end-yoke (of the driveline that is being uncoupled) until the centerline through its cross-holes is vertical. See **Fig. 1**.
2. Apply the parking brakes, and chock the tires.
3. Support the driveshaft with a nylon support strap.

   When uncoupling a coupling shaft, install two or three support straps, as needed. Remove the fasteners that attach the midship bearing(s) to its bracket(s).
4. Remove and discard all four bearing-cup-plate self-locking capscrews.
5. Using one of the U-joint pullers listed in **Specifications, 400**, remove both bearing assemblies from the end-yoke cross-holes. See **Fig. 2**.
6. Compress the slip-joint and pivot the end of the U-joint cross to remove it from the yoke. Install the bearing cups on the U-joint cross, and secure them with tape.

**CAUTION**

**Do not expose the U-joint trunnions or bearing-cup needles to dirt or grit. The smallest bits of dirt or grit can cause rapid wear and serious damage to the U-joint.**

## U-Joint Coupling

1. Check and clean the end-yoke.
   - 1.1 Check the torque on the end-yoke nut. See **Specifications, 400**.
   - 1.2 Check the end-yoke cross-holes for burrs or raised metal. Using a rat-tail or half-round file, remove burrs or raised metal. See **Fig. 3**.
   - 1.3 Using a mill file, and holding it flat against the machined surface of the yoke lug, remove any burrs or raised metal. See **Fig. 4**.
   - 1.4 Using fine emery cloth, smooth and clean the entire surface of the yoke cross-holes. See **Fig. 5**.
   - 1.5 Turn the end-yoke until the centerline through its cross-holes is vertical. See **Fig. 1**.
2. Check, clean, and lubricate the U-joint.
   - 2.1 Using fine emery cloth, smooth and clean the outside surfaces of both bearing cups. See **Fig. 6**.
   - 2.2 Check the U-joint trunnions and bearing cups for minute particles of dirt or grit. Clean if necessary; see **Subject 140**.

**CAUTION**

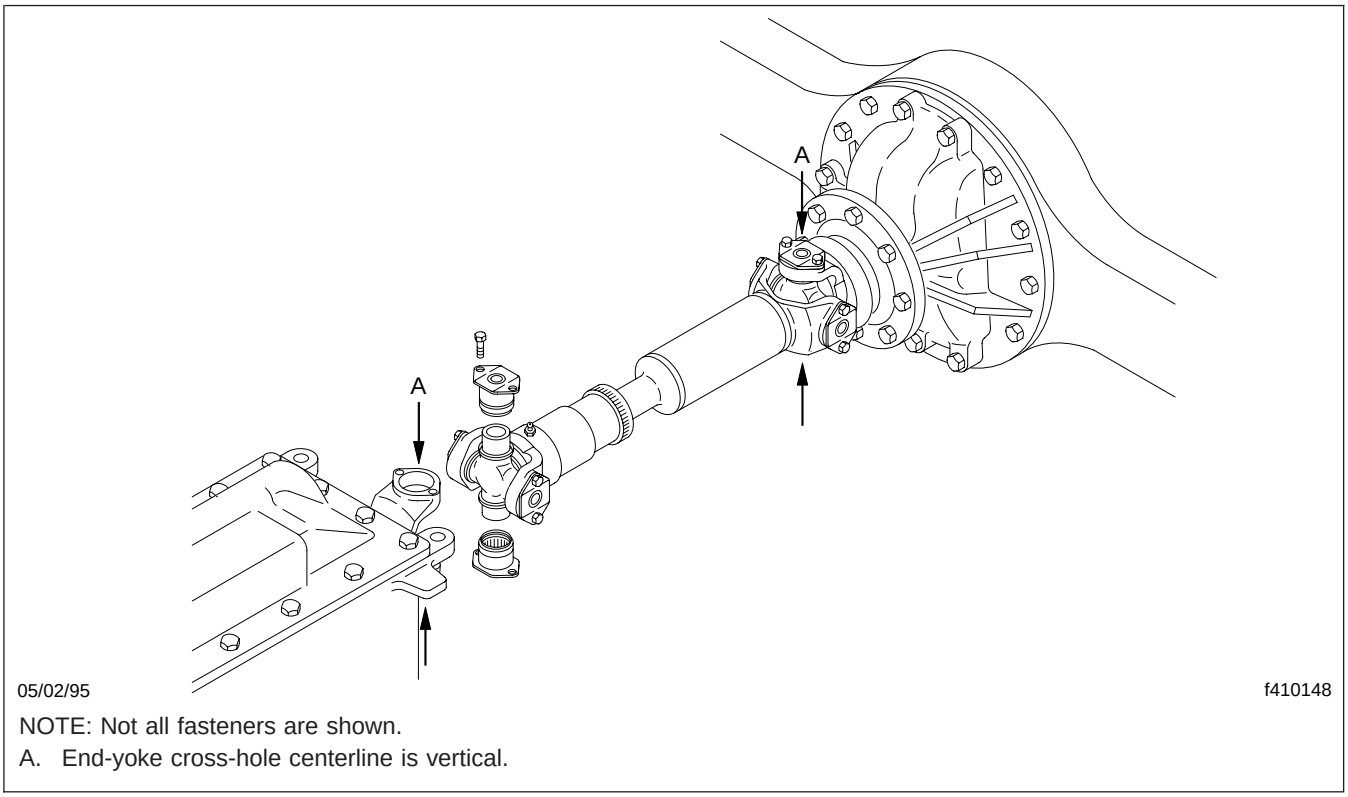
**Do not expose the U-joint trunnions or bearing-cup needles to dirt or grit. The smallest bits of dirt or grit can cause rapid wear and serious damage to the U-joint.**

   - 2.3 Using NLGI grade 2 grease with EP additives, wipe a small amount of grease on the needles in the bearing cups.
   - 2.4 Using a light-weight oil, lubricate the lips of the bearing-cup seals. See **Fig. 7**.
3. Couple the U-joint cross to the end-yoke.
   - 3.1 Extend the slip-joint, while pivoting the U-joint cross into place in the yoke cross-holes.
   - 3.2 Move one end of the cross until a trunnion projects through the cross-hole, beyond the outer machined face of the yoke lug.

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## U-Joint Uncoupling and Coupling With a Full-Round End-Yoke




NOTE: Not all fasteners are shown.
A. End-yoke cross-hole centerline is vertical.

**Fig. 1, U-Joint Uncoupling/Coupling of a Driveline With Full-Round End-Yokes**

Using a Spicer trunnion (journal) locator (see **Specifications, 400**), hold the trunnions in alignment with the cross-holes, while placing a bearing assembly over the projected trunnion, and aligning it with the cross-hole. See **Fig. 8**.

IMPORTANT: A Spicer trunnion (journal) locator should be used, to prevent damage to the U-joint trunnions and slingers.

3.3 By hand, press the bearing assembly flush with the face of the yoke. If the bearing assembly binds in the cross-hole, tap the *center* of the bearing plate with a rubber or rawhide mallet; do not tap the outer edges of the bearing plate. See **Fig. 9**.

3.4 Install *new* bearing-cup-plate self-locking capscrews (**Fig. 10**). Tighten the capscrews until all the parts are drawn down tight, with no gaps; do not tighten the capscrews to their final torque value.

**⚠ WARNING**

**Self-locking bearing-cup-plate capscrews must not be reused; replace the capscrews with new ones. Also, do not undertighten or overtighten any bearing-cup-plate capscrews. A loose or broken fastener at any point in the driveline weakens the driveline connection, which could cause serious vehicle damage, or could result in a driveshaft separating from the vehicle, possibly causing loss of vehicle control that could result in serious personal injury or death.**

3.5 Move the cross until it projects beyond the machined surface of the opposite yoke lug. Repeat applicable substeps to install the opposite bearing.

3.6 Alternately tighten the bearing-cup-plate capscrews in increments of 5 lbf·ft (7 N·m), to the torque value in **Specifications, 400**.

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## U-Joint Uncoupling and Coupling With a Full-Round End-Yoke

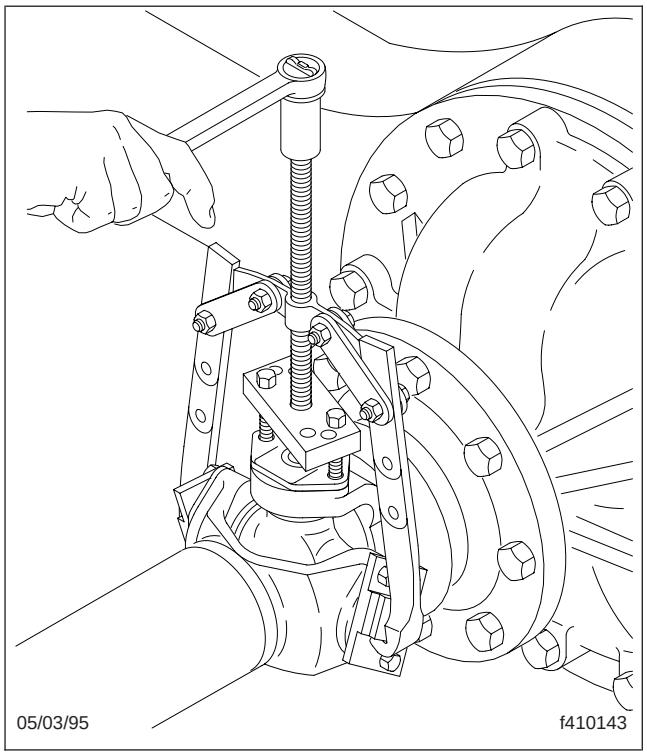



**Fig. 2, Remove a Bearing Cup from a Full-Round End-Yoke**

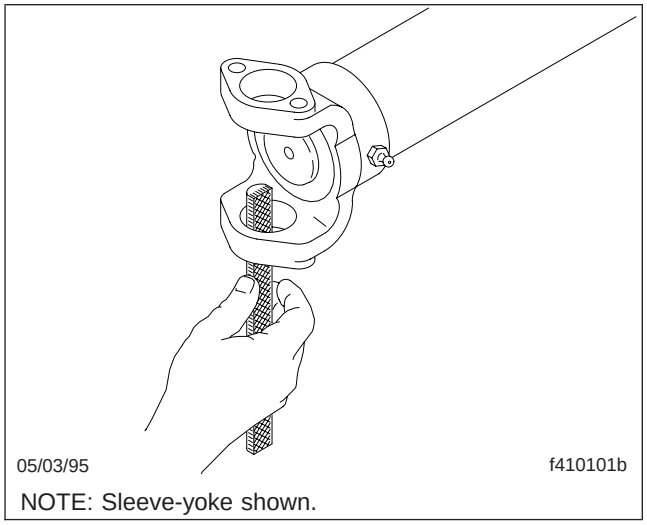



**Fig. 3, Remove Burrs from a Full-Round Yoke Cross-Hole**

4. If they were removed, install the fasteners that attach each midship bearing to its bracket; tighten the flanged locknuts 68 lbf·ft (92 N·m).

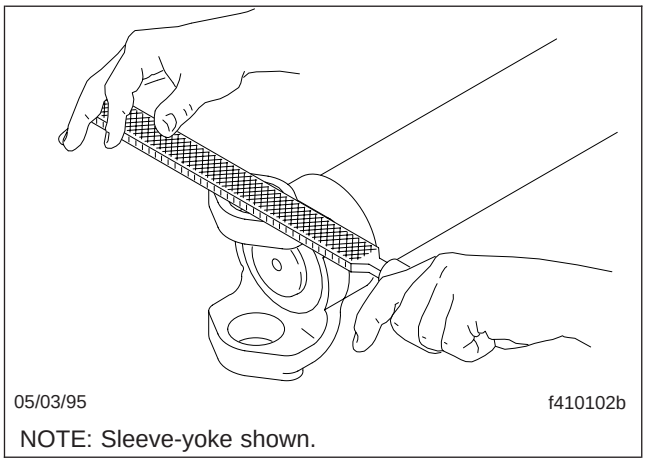



**Fig. 4, Remove Burrs from the Machined Surface of a Full-Round Yoke Lug**

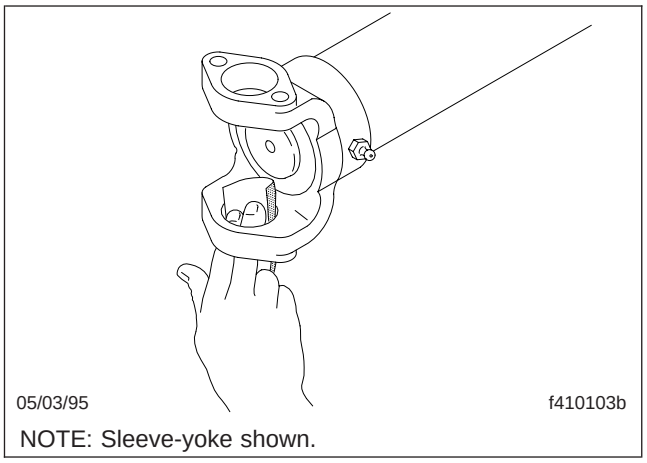



**Fig. 5, Smooth a Full-Round Yoke Cross-Hole**

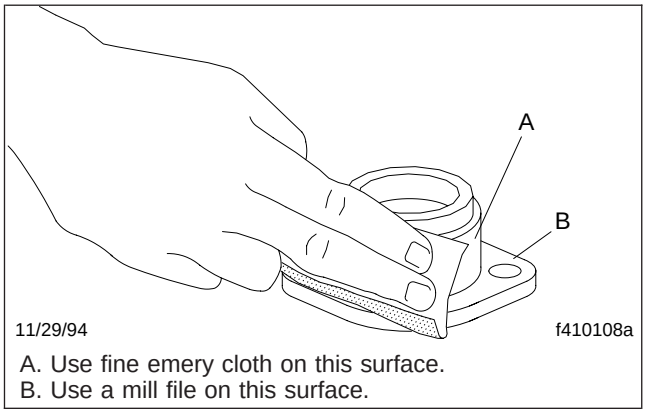
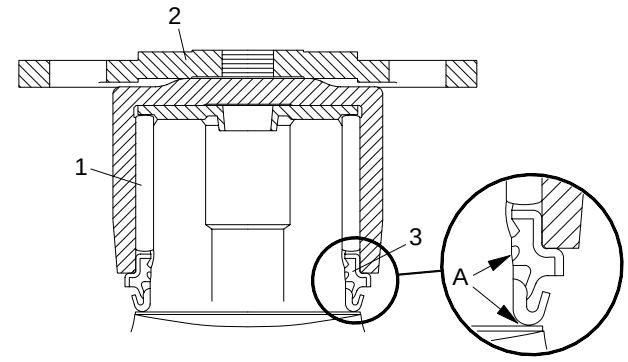



**Fig. 6, Smoothing a Full-Round Yoke U-Joint Bearing Cup**

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## U-Joint Uncoupling and Coupling With a Full-Round End-Yoke

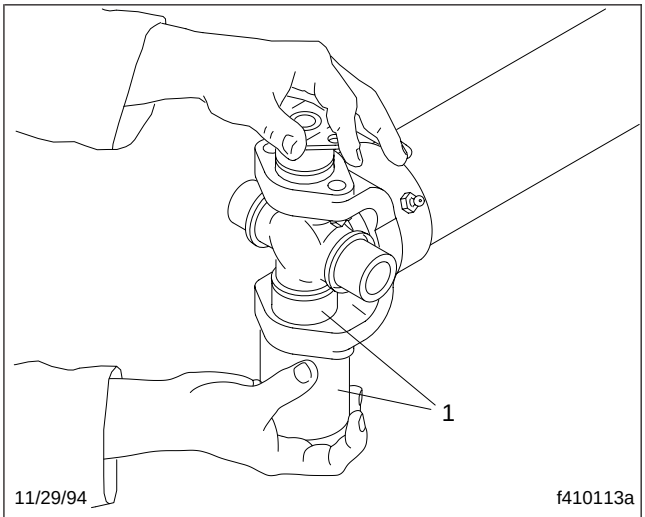



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A. Lubricate seal lips here.

1. Bearing Needle
2. Bearing-Cup Plate
3. Bearing-Cup Seal

**Fig. 7, Sectional View of a Full-Round Yoke U-Joint Bearing Cup**



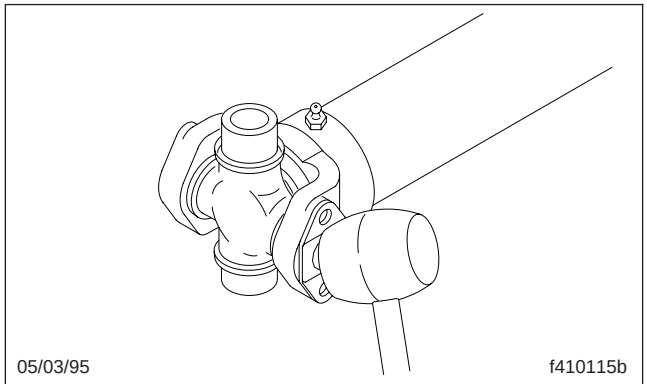

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NOTE: Sleeve-yoke shown.

1. Trunnion Locator

**Fig. 8, Use a U-Joint Trunnion Locator**

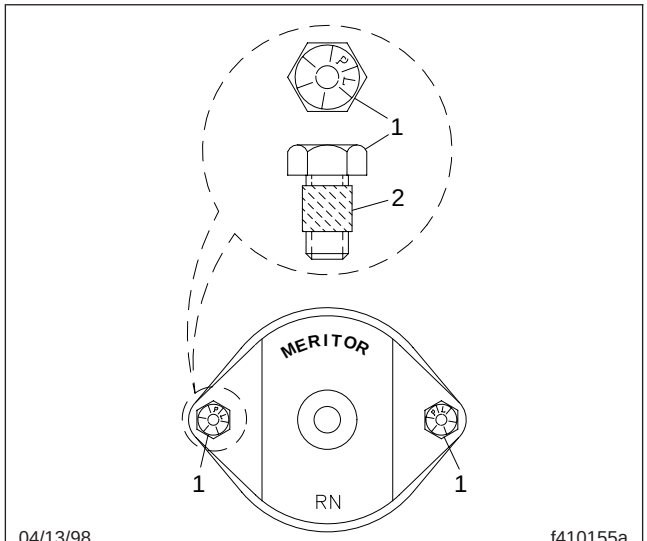
5. Lubricate the U-joint, following the procedure in **Group 41** of the *Western Star Maintenance Manual*.
6. Remove the nylon support straps, then remove the chocks.



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NOTE: Sleeve-yoke shown.

**Fig. 9, Seat a U-Joint Bearing Cup in a Full-Round Yoke**




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1. Self-Locking Capscrew
2. Adhesive Band

**Fig. 10, Meritor U-Joint Fasteners for Full-Round Yokes**

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## General Information

NOTE: Many service operations do not require driveshaft removal from the vehicle: end-yoke nut tightening; drive component shaft seal or end-yoke replacement; changing U-joint phasing at the slip-yoke; and transmission or axle removal (for overhaul, repair, or replacement). To perform these operations, uncouple the U-joint at the applicable end of the appropriate driveshaft. See **Subject 100** for uncoupling from a *half-round* end-yoke, or see **Subject 110** for uncoupling from a *full-round* end-yoke.

NOTE: It is easier to check driveline parts, and to replace a U-joint or midship bearing assembly if the driveshaft is removed from the vehicle. If a driveshaft requires straightening or balancing, it must be removed, and installed on a lathe or balance machine. Removal is required for replacement of slip-joint parts, a driveshaft tube, or a tube-yoke.

## No. 3 Driveshaft Removal

1. Uncouple the No. 3 driveshaft from the rearmost axle. See **Fig. 1** and **Fig. 2**. If the No. 3 driveshaft is coupled to *half-round* end-yokes, follow the uncoupling procedure in **Subject 100**. If the No. 3 driveshaft is coupled to *full-round* end-yokes, follow the uncoupling procedure in **Subject 110**.
2. Uncouple the No. 3 driveshaft from the forward-rear axle. If the No. 3 driveshaft is coupled to half-round end-yokes, follow the uncoupling procedure in **Subject 100**. If the No. 3 driveshaft is coupled to full-round end-yokes, follow the uncoupling procedure in **Subject 110**.
3. Lift the No. 3 driveshaft out of the chassis.

## No. 2 Driveshaft Removal

1. Uncouple the No. 2 driveshaft from the single or forward-rear axle. See **Fig. 3** and **Fig. 4**. If the No. 2 driveshaft is coupled to *half-round* end-yokes, follow the uncoupling procedure in **Subject 100**. If the No. 2 driveshaft is coupled to *full-round* end-yokes, follow the uncoupling procedure in **Subject 110**.
2. Uncouple the No. 2 driveshaft from the transmission or coupling shaft. If the No. 2 driveshaft is coupled to half-round end-yokes, follow the uncoupling procedure in **Subject 100**. If the No. 2 driveshaft is coupled to full-round end-yokes, follow the uncoupling procedure in **Subject 110**.
3. Lift the No. 2 driveshaft out of the chassis.

## Intermediate Coupling Shaft Removal

1. If the No. 2 driveshaft is also being removed, remove it first. See **Fig. 5** and **Fig. 6**.

   If the No. 2 driveshaft is not being removed, use a nylon support strap to support its forward end.
2. Uncouple the intermediate coupling shaft from the No. 2 driveshaft. If the intermediate coupling shaft has a *half-round* end-yoke, follow the uncoupling procedure in **Subject 100**. If the intermediate coupling shaft has a *full-round* end-yoke, follow the uncoupling procedure in **Subject 110**.
3. Uncouple the intermediate coupling shaft from the primary coupling shaft. See **Fig. 7** and **Fig. 8**. If the primary coupling shaft has a half-round end-yoke, follow the uncoupling procedure in **Subject 100**. If the primary coupling shaft has a full-round end-yoke, follow the uncoupling procedure in **Subject 110**.
4. Lift the intermediate coupling shaft out of the chassis.

## Primary Coupling Shaft Removal

1. *For a vehicle with one coupling shaft:*

   If the No. 2 driveshaft is also being removed, remove it first. See **Fig. 7** and **Fig. 8**.

   If the No. 2 driveshaft is not being removed, use a nylon support strap to support its forward end.

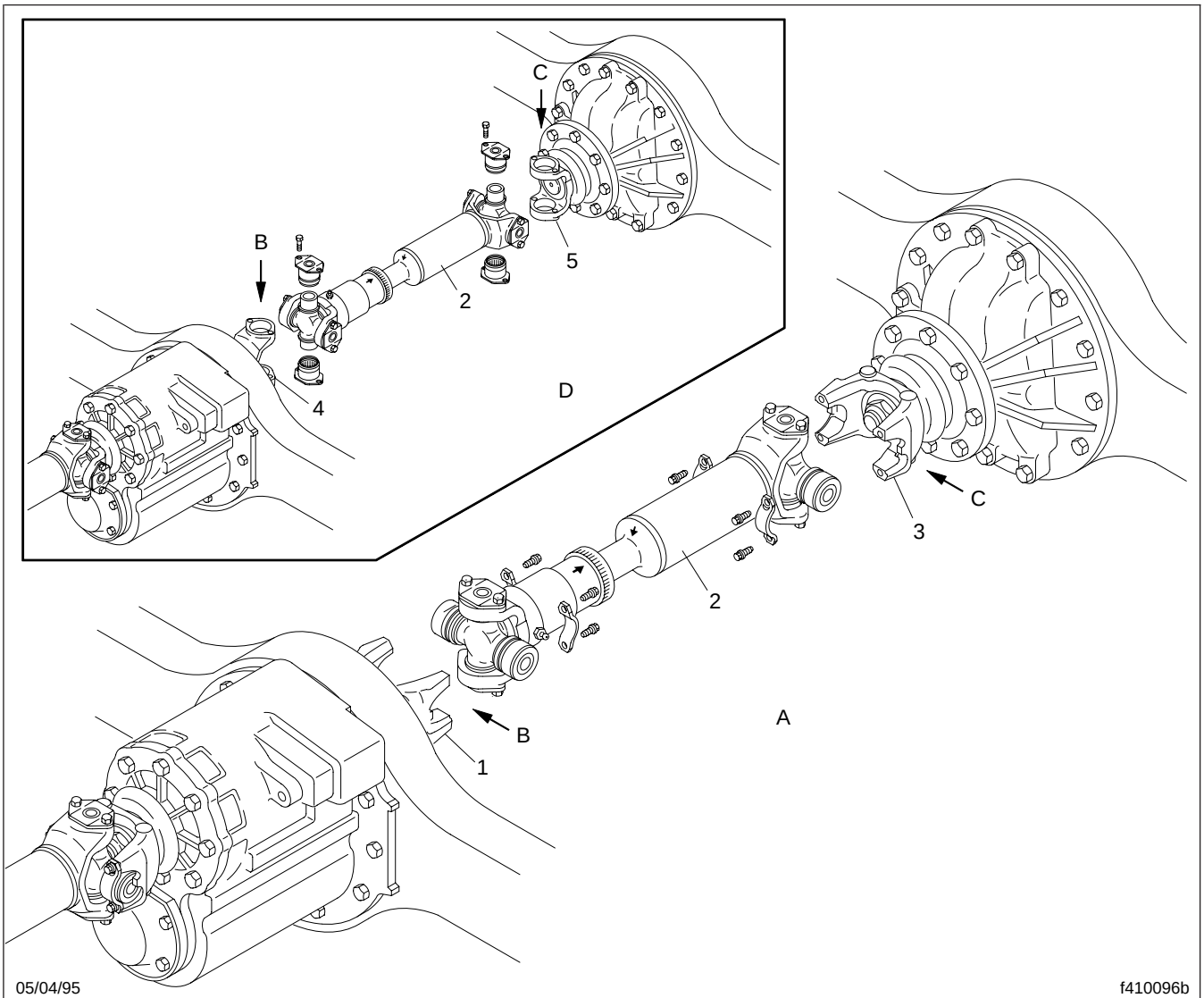
   *For a vehicle with two coupling shafts:*

   If the No. 2 driveshaft is also being removed, remove it first; then, remove the intermediate coupling shaft.

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## Driveshaft Removal and Installation




NOTE: Not all fasteners are shown.

A. No. 3 Driveshaft Coupled to Half-Round End-Yokes
B. Uncouple this end last; couple this end first.
C. Uncouple this end first; couple this end last.
D. No. 3 Driveshaft Coupled to Full-Round End-Yokes

1. Forward-Rear Axle Output-Shaft Half-Round End-Yoke
2. No. 3 Driveshaft
3. Rearmost Axle Input-Shaft Half-Round End-yoke
4. Forward-Rear Axle Output-Shaft Full-Round End-Yoke
5. Rearmost Axle Input-Shaft Full-Round End-yoke

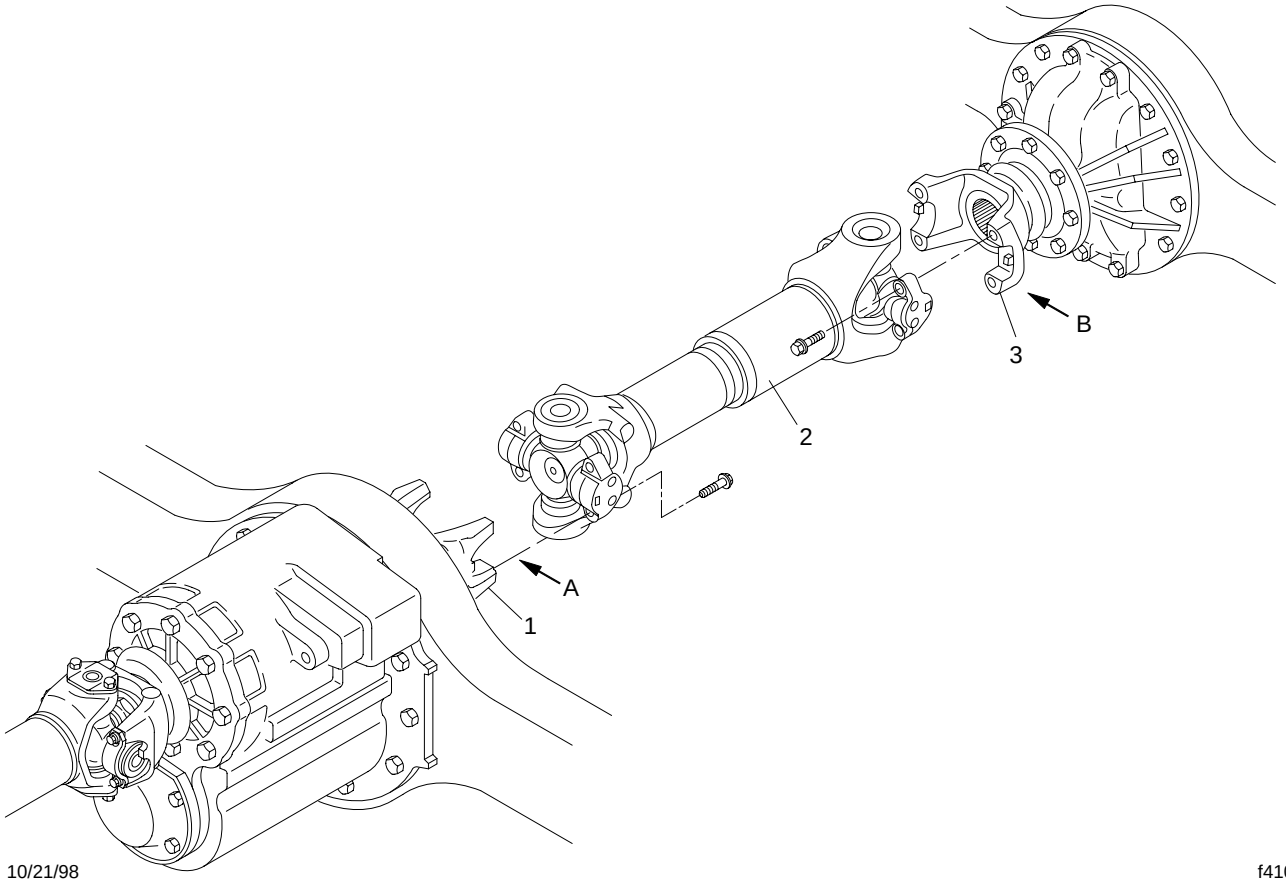
**Fig. 1, Removal/Installation of a No. 3 Driveshaft Without RPL U-Joints**

If the intermediate coupling shaft is also being removed (but not the No. 2 driveshaft), remove the intermediate coupling shaft first.

If only the primary coupling shaft is being removed, use nylon support straps to support the forward end of the No. 2 driveshaft and both ends of the intermediate coupling shaft. Then,

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NOTE: Not all fasteners are shown.

A. Uncouple this end last; couple this end first.
B. Uncouple this end first; couple this end last.
1. Forward-Rear Axle Output-Shaft Half-Round End-Yoke
2. No. 3 Driveshaft
3. Rearmost Axle Input-Shaft Half-Round End-Yoke

**Fig. 2, Removal/Installation of a No. 3 Driveshaft With RPL U-Joints**

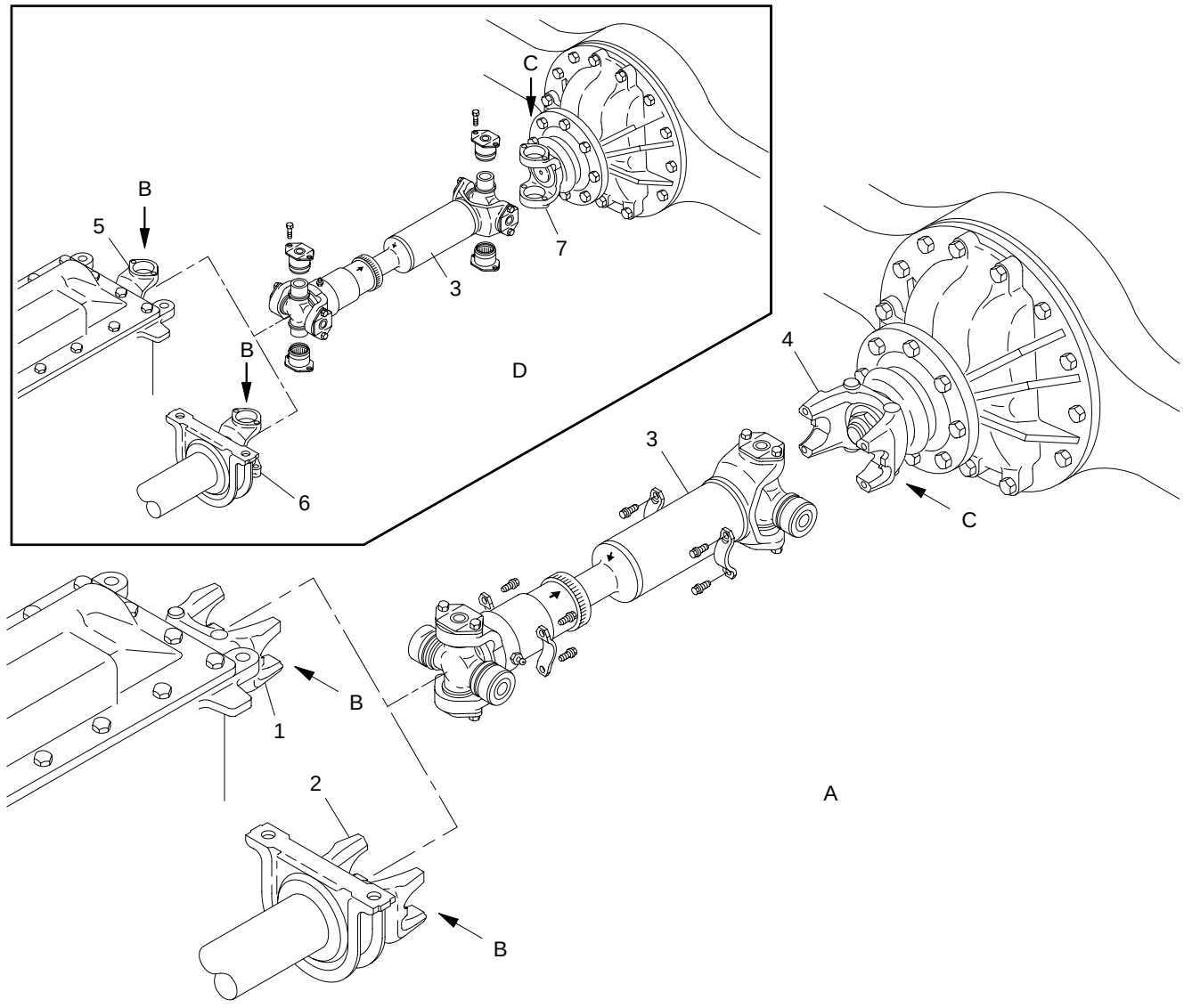
remove the fasteners that attach the intermediate coupling shaft midship bearing to its bracket. See **Fig. 7** and **Fig. 8**.

2. If not already done, uncouple the primary coupling shaft from the No. 2 driveshaft or intermediate coupling shaft. If the primary coupling shaft has a *half-round* end-yoke, follow the uncoupling procedure in **Subject 100**. If the primary coupling shaft has a *full-round* end-yoke, follow the uncoupling procedure in **Subject 110**.
3. Using two nylon support straps, support the primary coupling shaft. Then remove the fasteners that attach the primary coupling shaft midship bearing to its bracket. See **Fig. 7** and **Fig. 8**.
4. Uncouple the primary coupling shaft from the transmission. If the primary coupling shaft is coupled to a half-round end-yoke, follow the uncoupling procedure in **Subject 100**. If the primary coupling shaft is coupled to a full-round end-yoke, follow the uncoupling procedure in **Subject 110**.
5. Lift the primary coupling shaft out of the chassis.

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## Driveshaft Removal and Installation




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NOTE: Not all fasteners are shown.

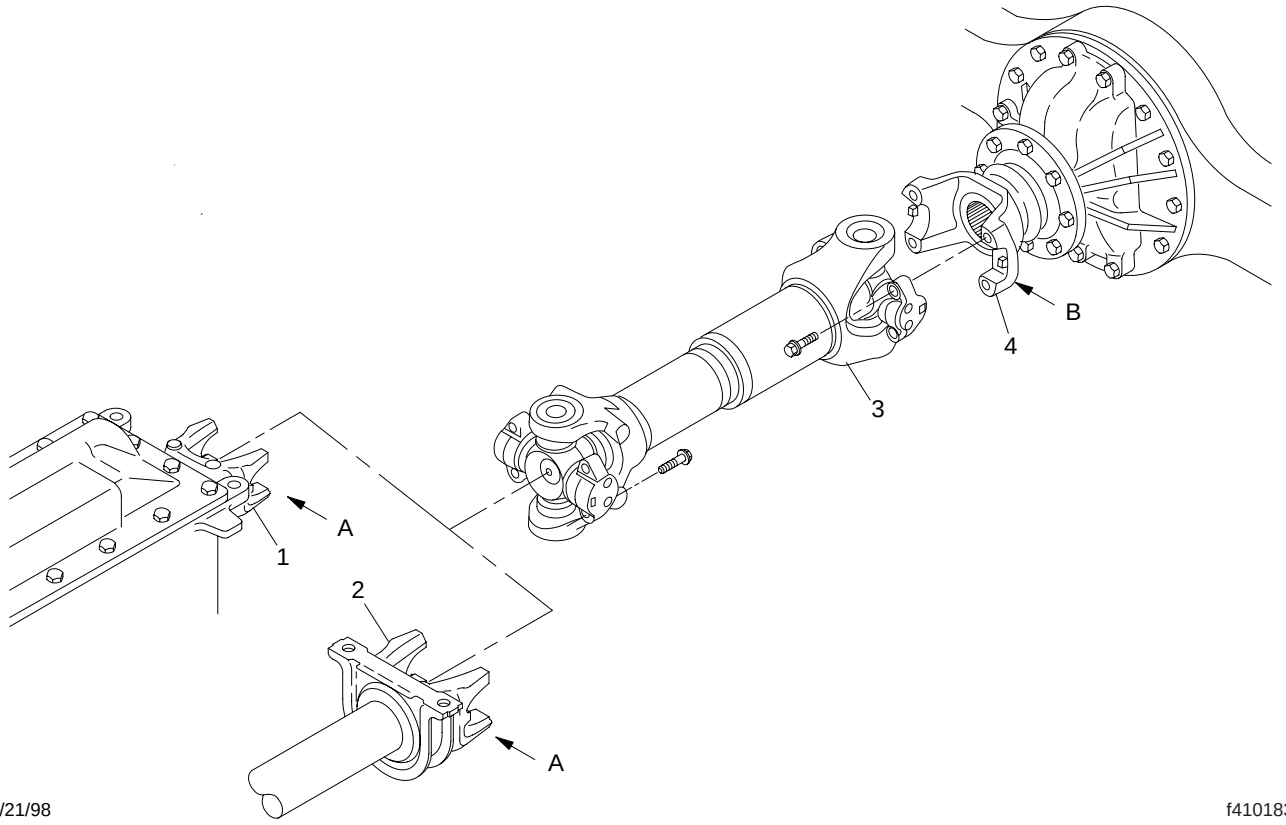
A. No. 2 Driveshaft Coupled to Half-Round End-Yokes
B. Uncouple this end last; couple this end first.
C. Uncouple this end first; couple this end last.
D. No. 2 Driveshaft Coupled to Full-Round End-Yokes

1. Transmission Output-Shaft Half-Round End-Yoke
2. Coupling Shaft Half-Round End-Yoke
3. No. 2 Driveshaft
4. Single Axle or Forward-Rear Axle Input-Shaft Half-Round End-Yoke
5. Transmission Output-Shaft Full-Round End-Yoke
6. Coupling Shaft Full-Round End-Yoke
7. Single Axle or Forward-Rear Axle Input-Shaft Full-Round End-Yoke

**Fig. 3, Removal/Installation of a No. 2 Driveshaft Without RPL U-Joints**

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NOTE: Not all fasteners are shown.

A. Uncouple this end last; couple this end first.

1. Transmission Output-Shaft Half-Round End-Yoke
2. Coupling Shaft Half-Round End-Yoke
3. No. 2 Driveshaft

B. Uncouple this end first; couple this end last.

4. Single Axle or Forward-Rear Axle Input-Shaft Half-Round End-Yoke

**Fig. 4, Removal/Installation of a No. 2 Driveshaft With RPL U-Joints**

## Primary Coupling Shaft Installation

IMPORTANT: Before installing a coupling shaft, make sure the yokes are aligned to keep the U-joints in phase. See **Fig. 9**.

1. Place the primary coupling shaft under the vehicle and support it with nylon support straps so it can be coupled to the transmission end-yoke.
2. Couple the shaft to the transmission end-yoke. See **Fig. 7** and **Fig. 8**. If the primary coupling shaft was coupled to a *half-round* end-yoke, follow the coupling procedure in **Subject 100**. If the primary coupling shaft was coupled to a *full-round* end-yoke, follow the coupling procedure in **Subject 110**.
3. *For a vehicle with one coupling shaft:*

   If the No. 2 driveshaft was also removed, install it, as instructed in this subject.

   If the No. 2 driveshaft was not removed, couple it to the primary coupling shaft end-yoke. If the primary coupling shaft has a half-round end-yoke, follow the coupling procedure in **Subject 100**. If the primary coupling shaft has a full-round end-yoke, follow the coupling procedure in **Subject 110**.

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## Driveshaft Removal and Installation

*For a vehicle with two coupling shafts:*

If the intermediate coupling shaft was also removed, install it, as instructed in this subject.

If only the primary coupling shaft was removed, couple the intermediate coupling shaft to the primary coupling shaft end-yoke. If the primary coupling shaft has a half-round end-yoke, follow the coupling procedure in **Subject 100**. If the primary coupling shaft has a full-round end-yoke, follow the coupling procedure in **Subject 110**.

## Intermediate Coupling Shaft Installation

IMPORTANT: Before installing a coupling shaft, make sure the yokes are aligned to keep the U-joints in phase. See **Fig. 9**.

1. If the primary coupling shaft was also removed, install it first, as instructed in this subject.
2. Place the intermediate coupling shaft under the vehicle and support it with nylon support straps so it can be coupled to the primary coupling shaft end-yoke.
3. Couple the intermediate coupling shaft to the primary coupling shaft end-yoke. See **Fig. 5** and **Fig. 6**. If the intermediate coupling shaft was coupled to a *half-round* end-yoke, follow the coupling procedure in **Subject 100**. If the intermediate coupling shaft was coupled to a *full-round* end-yoke, follow the coupling procedure in **Subject 110**.
4. If the No. 2 driveshaft was also removed, install it, as instructed in this subject.

   If the No. 2 driveshaft was not removed, couple it to the intermediate coupling shaft end-yoke. If the intermediate coupling shaft has a half-round end-yoke, follow the coupling procedure in **Subject 100**. If the intermediate coupling shaft has a full-round end-yoke, follow the coupling procedure in **Subject 110**.

## No. 2 Driveshaft Installation

IMPORTANT: Before installing a No. 2 driveshaft, make sure the alignment marks on the slip-joint assembly are aligned, to keep the U-joints in phase; see **Fig. 10**.

1. If a primary coupling shaft was also removed, install it first, as instructed in this subject. See **Fig. 3** and **Fig. 4**.
2. If an intermediate coupling shaft was also removed, install it before installing the No. 2 driveshaft.
3. Place the No. 2 driveshaft under the vehicle with its sleeve-yoke at the forward end, and support its rear end with a nylon support strap.
4. Couple the sleeve-yoke to the coupling shaft end-yoke or transmission output-shaft end-yoke, as applicable. If the No. 2 driveshaft was coupled to *half-round* end-yokes, follow the coupling procedure in **Subject 100**. If the No. 2 driveshaft was coupled to *full-round* end-yokes, follow the coupling procedure in **Subject 110**.
5. Couple the No. 2 driveshaft to the axle input-shaft end-yoke. If the No. 2 driveshaft was coupled to half-round end-yokes, follow the coupling procedure in **Subject 100**. If the No. 2 driveshaft was coupled to full-round end-yokes, follow the coupling procedure in **Subject 110**.

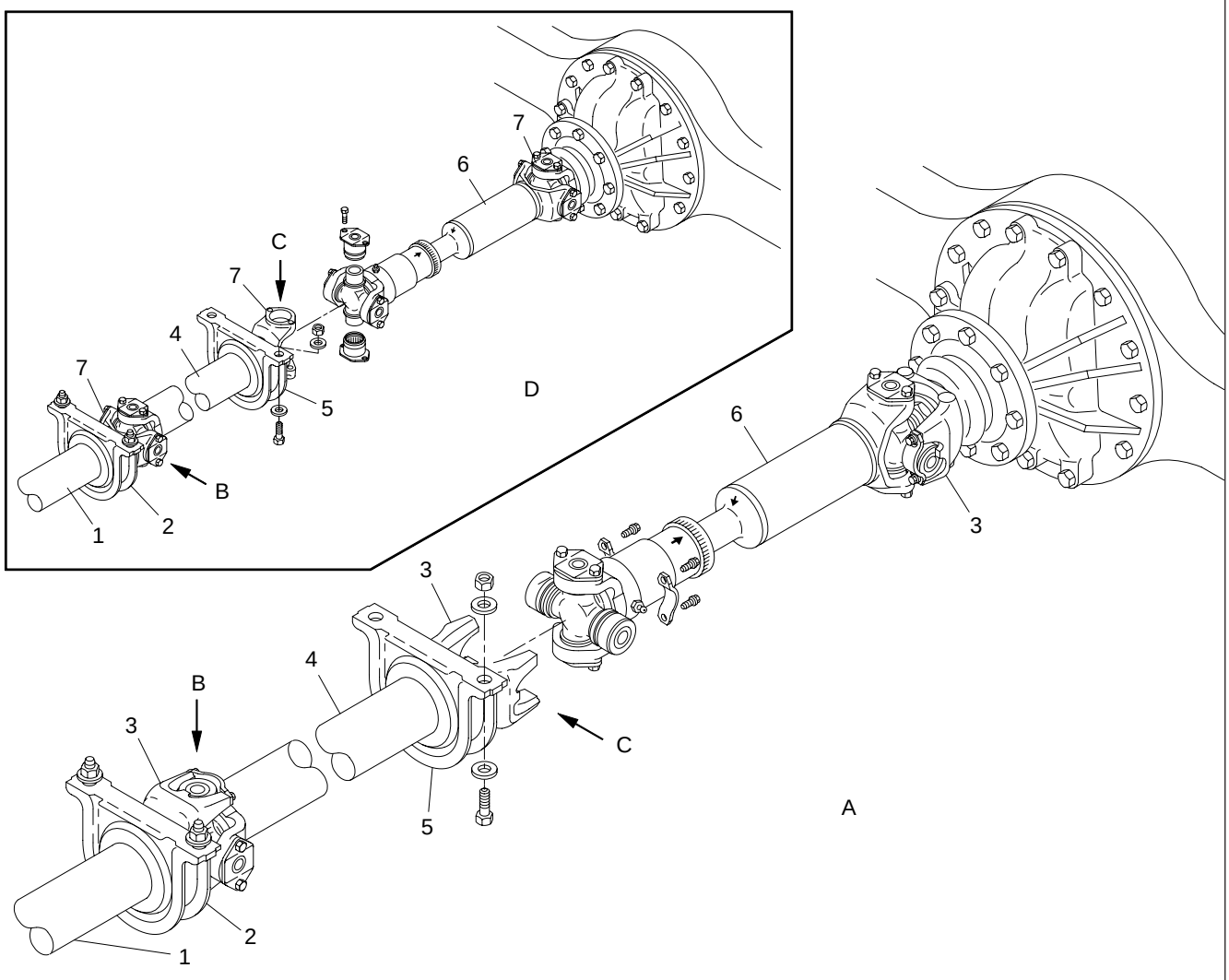
## No. 3 Driveshaft Installation

IMPORTANT: Before installing a No. 3 driveshaft, make sure the alignment marks on the slip-joint assembly are aligned, to keep the U-joints in phase; see **Fig. 10**.

1. Place the No. 3 driveshaft under the vehicle with its sleeve-yoke at the forward end, and support its rear end with a nylon support strap.
2. Couple the sleeve-yoke to the forward-rear axle output-shaft end-yoke. See **Fig. 1** and **Fig. 2**. If the No. 3 driveshaft was coupled to *half-round* end-yokes, follow the coupling procedure in **Subject 100**. If the No. 3 driveshaft was coupled to *full-round* end-yokes, follow the coupling procedure in **Subject 110**.
3. Couple the No. 3 driveshaft to the axle input-shaft end-yoke. If the No. 3 driveshaft was coupled to half-round end-yokes, follow the coupling procedure in **Subject 100**. If the No. 3 driveshaft was coupled to full-round end-yokes, follow the coupling procedure in **Subject 110**.

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NOTE: Not all fasteners are shown.

A. No. 2 Driveline With Half-Round End-Yokes
B. Uncouple this end last; couple this end first.
C. Uncouple this end first; couple this end last.
D. No. 2 Driveline With Full-Round End-Yokes

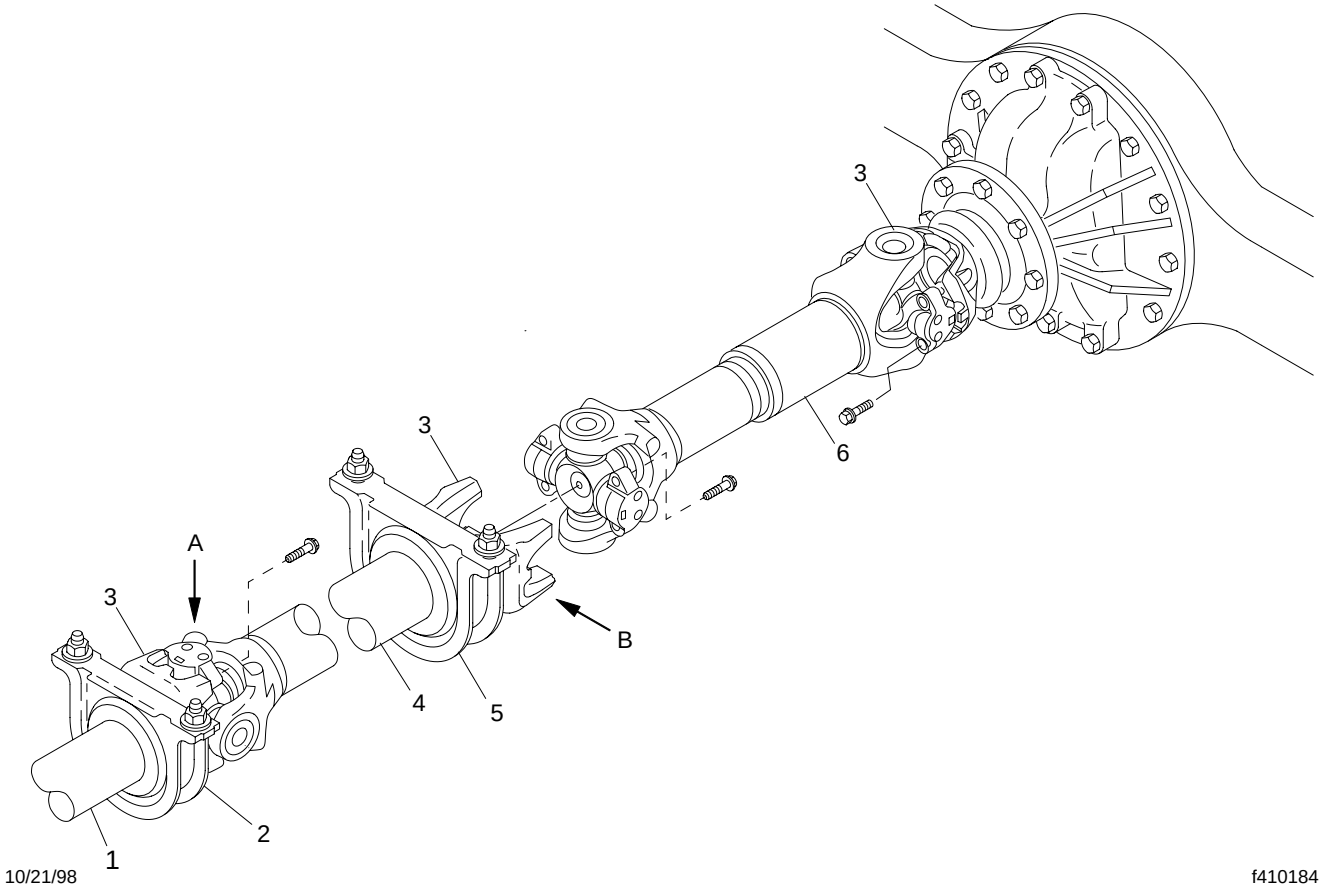
1. Primary Coupling Shaft
2. Primary Coupling Shaft Midship Bearing
3. Half-Round End-Yoke
4. Intermediate Coupling Shaft
5. Intermediate Coupling Shaft Midship Bearing
6. No. 2 Driveshaft
7. Full-Round End-Yoke

**Fig. 5, Removal/Installation of an Intermediate Coupling Shaft Without RPL U-Joints**

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## Driveshaft Removal and Installation




NOTE: Not all fasteners are shown.

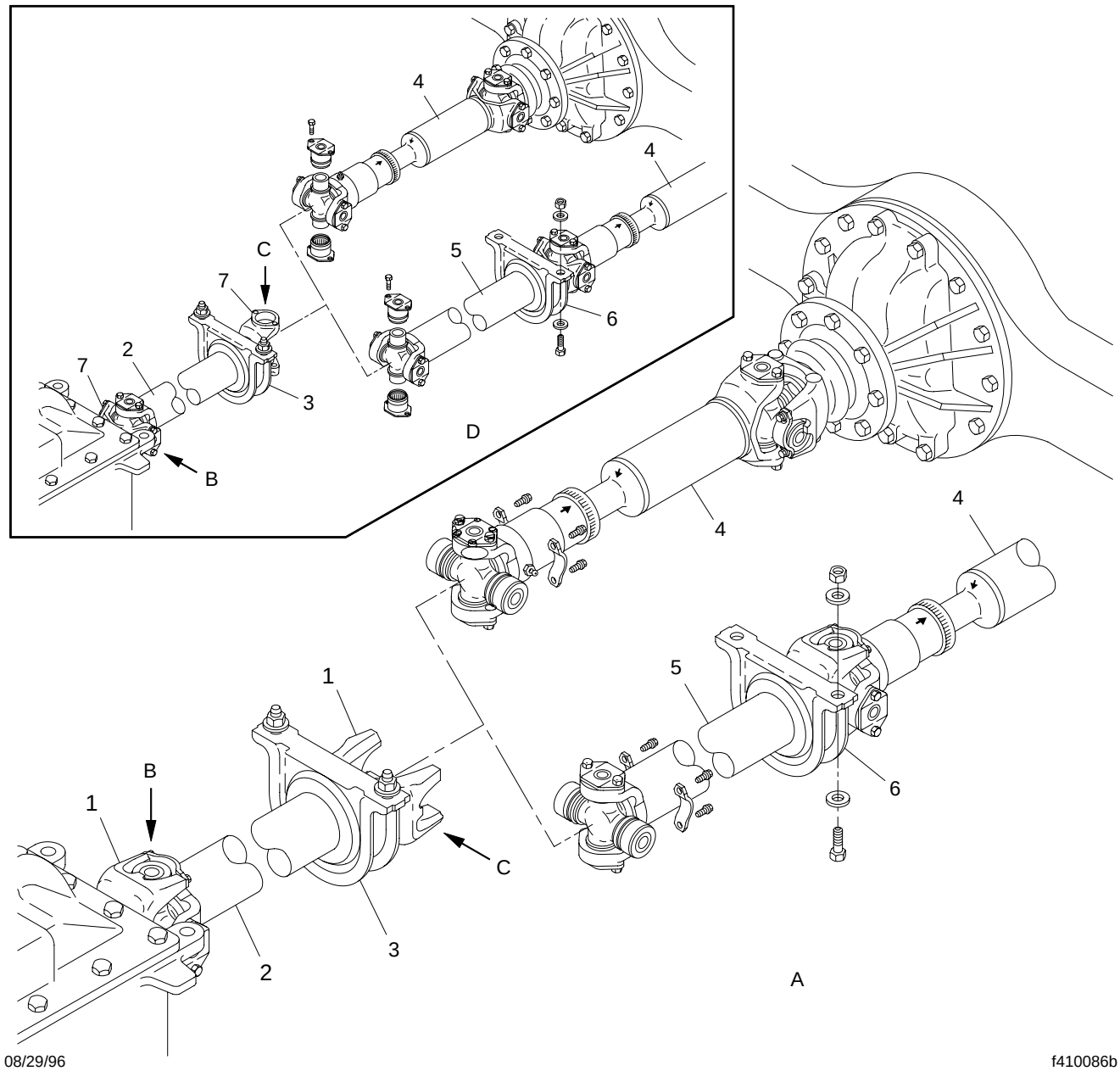
A. Uncouple this end last; couple this end first.
B. Uncouple this end first; couple this end last.

1. Primary Coupling Shaft
2. Primary Coupling Shaft Midship Bearing
3. Half-Round End-Yoke
4. Intermediate Coupling Shaft
5. Intermediate Coupling Shaft Midship Bearing
6. No. 2 Driveshaft

**Fig. 6, Removal/Installation of an Intermediate Coupling Shaft With RPL U-Joints**

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NOTE: Not all fasteners are shown.

A. No. 2 Driveline With Half-Round End-Yokes
B. Uncouple this end last; couple this end first.
C. Uncouple this end first; couple this end last.
D. No. 2 Driveline With Full-Round End-Yokes

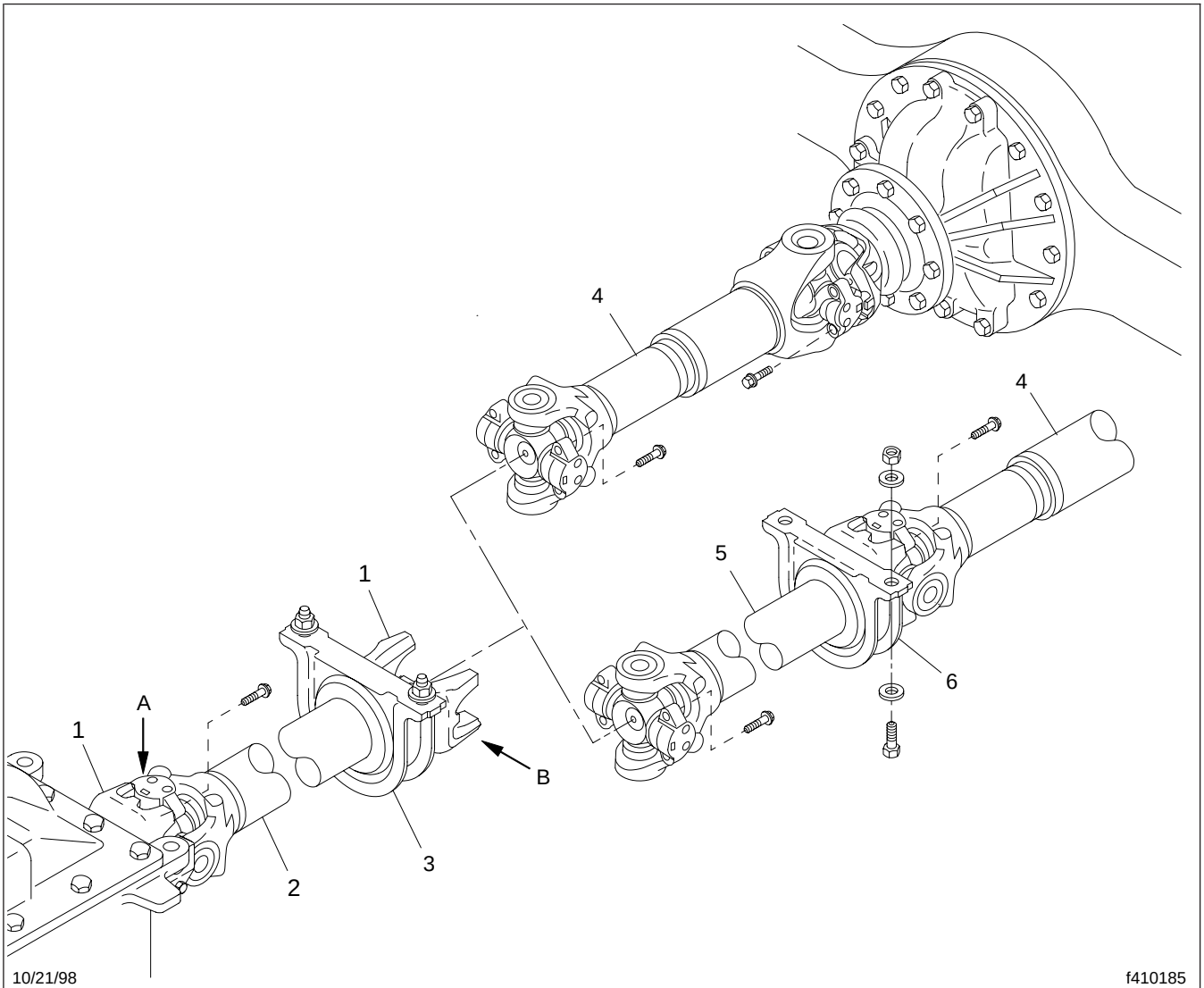
1. Half-Round End-Yoke
2. Primary Coupling Shaft
3. Primary Coupling Shaft Midship Bearing
4. No. 2 Driveshaft
5. Intermediate Coupling Shaft
6. Intermediate Coupling Shaft Midship Bearing
7. Full-Round End-Yoke

**Fig. 7, Removal/Installation of a Primary Coupling Shaft Without RPL U-Joints**

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## Driveshaft Removal and Installation




NOTE: Not all fasteners are shown.

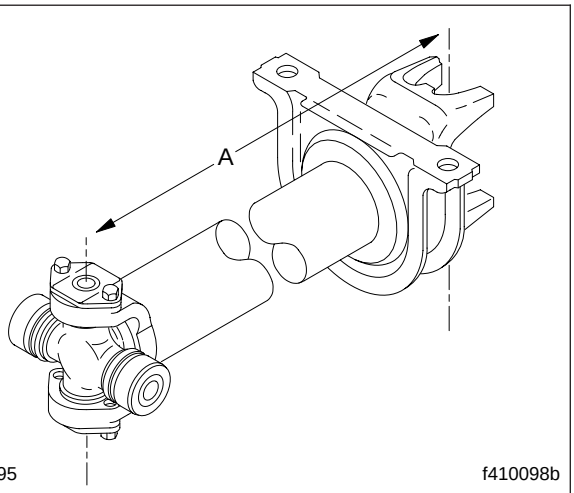
A. Uncouple this end last; couple this end first.
B. Uncouple this end first; couple this end last.

1. Half-Round End-Yoke
2. Primary Coupling Shaft
3. Primary Coupling Shaft Midship Bearing
4. No. 2 Driveshaft
5. Intermediate Coupling Shaft
6. Intermediate Coupling Shaft Midship Bearing

**Fig. 8, Removal/Installation of a Primary Coupling Shaft With RPL U-Joints**

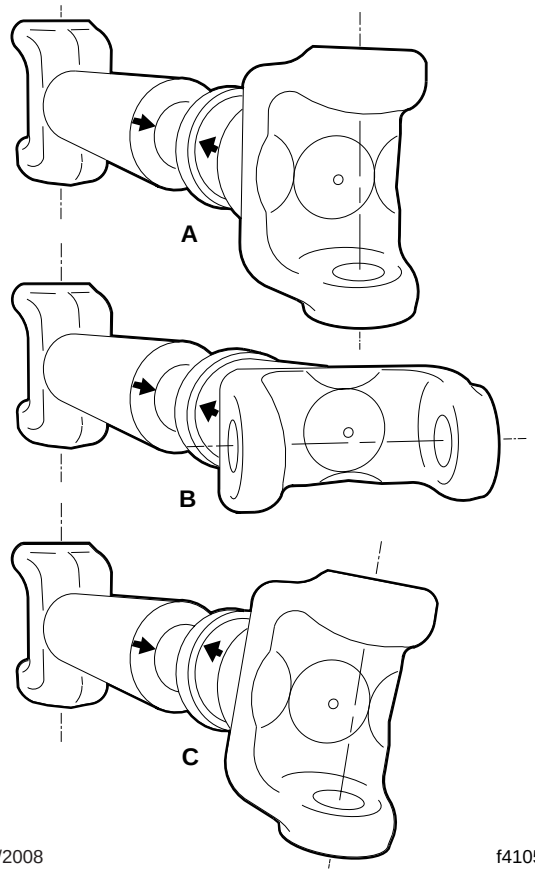
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A. Cross-hole centerlines of both yokes must be in alignment.

**Fig. 9, U-Joint Phasing of a Coupling Shaft**




A. In Phase (parallel phased)
B. In Phase (cross phased)
C. Out of Phase

**Fig. 10, U-Joint Phasing**

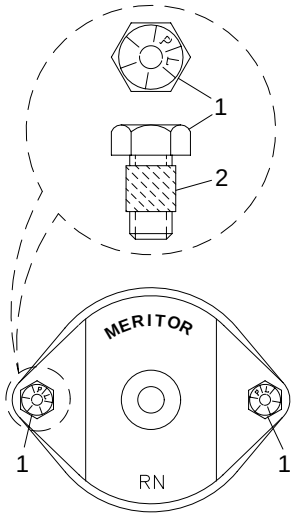
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# U-Joint Removal

## Full-Round Yokes

1. Remove the driveshaft from the vehicle. See **Subject 120**.
2. Place the driveshaft in V-blocks or a soft-jawed vise; do not distort the tube with excessive grip.
3. Remove and discard all four bearing-plate self-locking capscrews. See **Fig. 1**.




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1. Self-Locking Capscrew
2. Adhesive Band

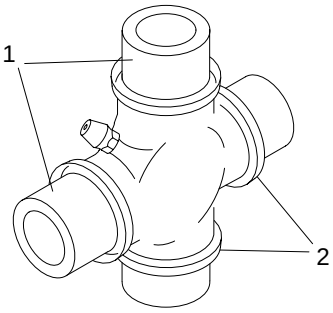
**Fig. 1, Meritor U-Joint Fasteners for Full-Round Yokes**

IMPORTANT: If the U-joint will be reinstalled, use care not to nick the cross trunnions or damage the slingers. See **Fig. 2**.

4. Using one of the U-joint pullers listed in **Specifications, 400**, remove both bearing cups from the yoke cross-holes. See **Fig. 3**. Remove the cross from the yoke.

## RPL Series U-Joint

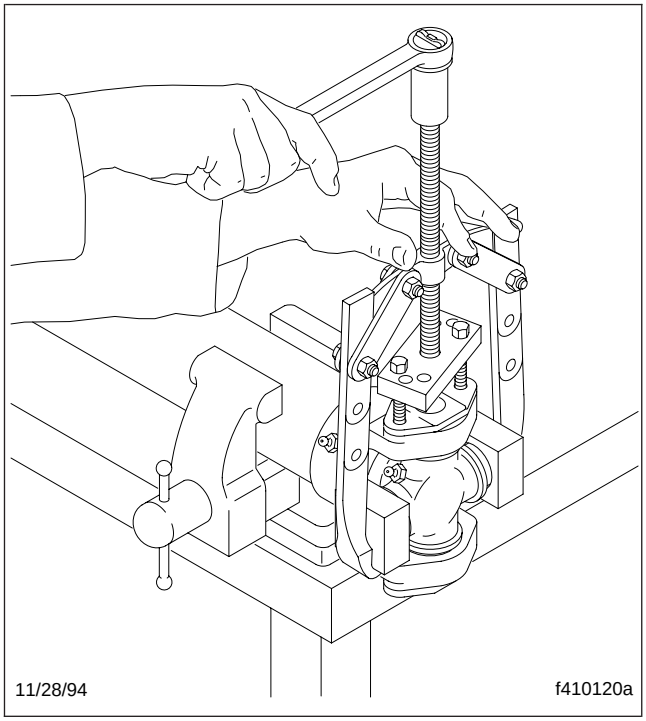
NOTE: Do not reuse RPL U-joints. Always replace an RPL U-joint with a new one after they have been disassembled and removed from a driveshaft.




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1. Trunnions 2. Slingers

**Fig. 2, U-Joint Cross**



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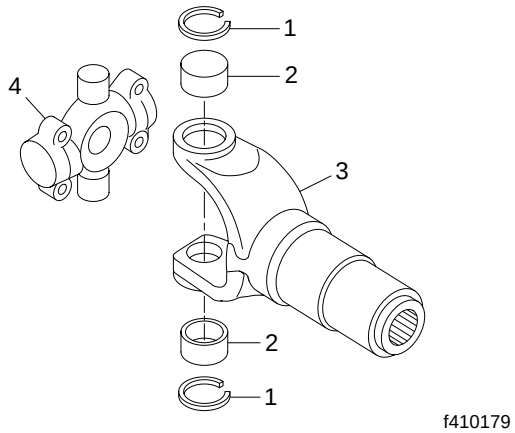
**Fig. 3, Removing a Bearing Cup from a Full-Round Yoke**

1. Remove the driveshaft from the vehicle. See **Subject 120**.
2. Place the driveshaft in V-blocks or a soft-jawed vise; do not distort the tube with excessive grip.
3. Remove and discard snap rings. See **Fig. 4**.
4. Cut the weld strap (**Fig. 5**) that retains the bearing cups, remove both bearing cups. See **Fig. 6**.

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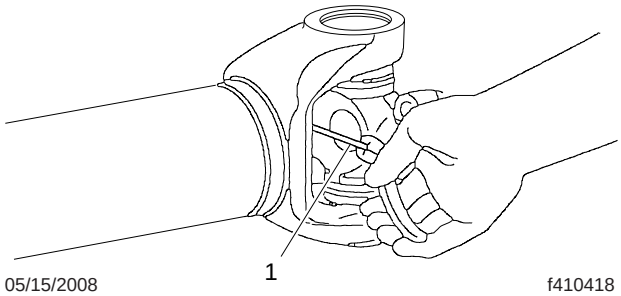


## Driveline Component Removal/Disassembly




1. Snap Ring
2. Bearing Cups
3. Full Round Yoke
4. Bearing Cups (RPL Joint)

**Fig. 4, RPL U-Joint Components**




1. Weld-Strap

**Fig. 5, Cutting the Weld-Strap**

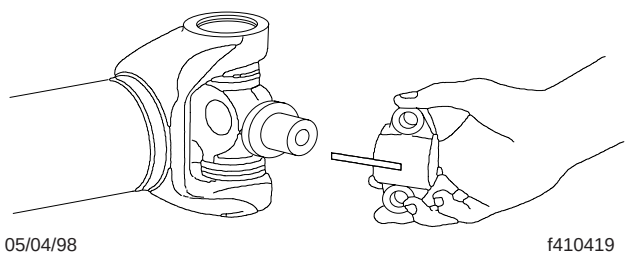
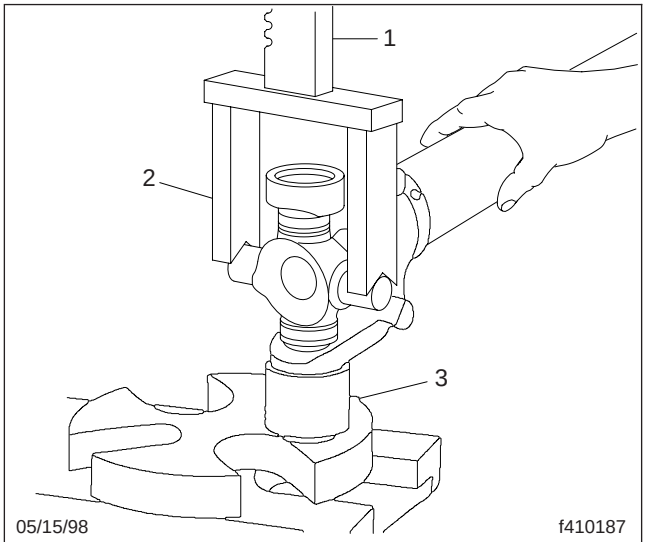



**Fig. 6, Remove the Bearing Cups**

5. Remove both bearing cups from the yoke cross-holes. See **Fig. 7**. Remove the cross from the yoke.




1. Press
2. Bridge
3. Bearing Cup Receiver

**Fig. 7, Remove Bearing Cups from an RPL U-Joint**

## Slip-Joint Disassembly

### Except RPL Drivelines

1. Check that the driveshaft yokes are aligned to hold the U-joints at either end in phase, as shown in **Fig. 8**. Using a marking stick or paint, mark the sleeve-yoke and splined shaft with alignment marks, as shown in **Fig. 9**. This will ensure proper alignment of the slip-joint components when the driveshaft is assembled.

IMPORTANT: Misaligned driveshaft yokes will cause the U-joints to be out of phase, which will cause vibration in the driveline.

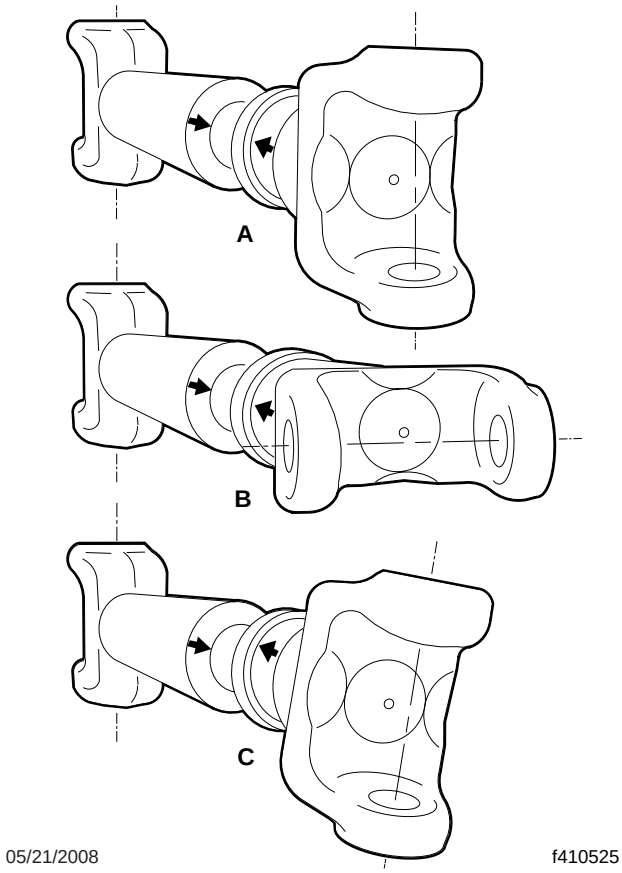
2. With the driveshaft uncoupled at one end, *or* removed from the vehicle, use a strap wrench to unscrew the slip-joint dust cap from the sleeve-yoke, then pull the sleeve-yoke off of the splined shaft. Remove the dust cap, and (if so equipped) the steel washer and cork seal. See **Fig. 10**.

### RPL Drivelines

1. Check that the driveshaft yokes are aligned to hold the U-joints at either end in phase, as shown in **Fig. 8**. Using a marking stick or paint, mark the sleeve-yoke and splined shaft with alignment marks, as shown in **Fig. 9**. This will

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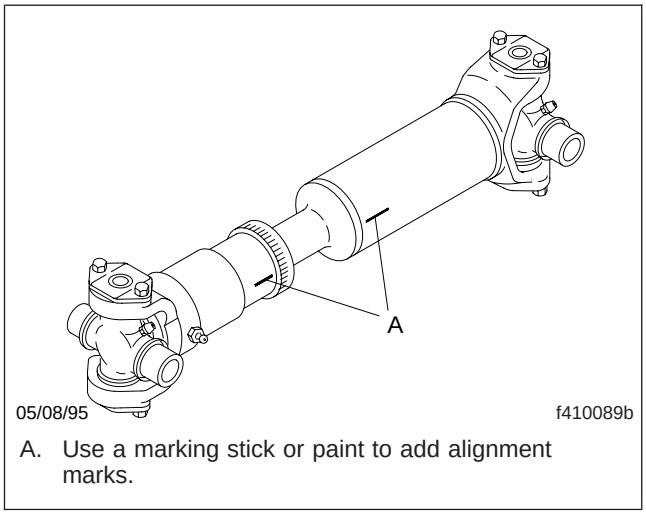

A. In Phase (parallel phased)
B. In Phase (cross phased)
C. Out of Phase

**Fig. 8, U-Joint Phasing**

ensure proper alignment of the slip-joint components when the driveshaft is assembled.

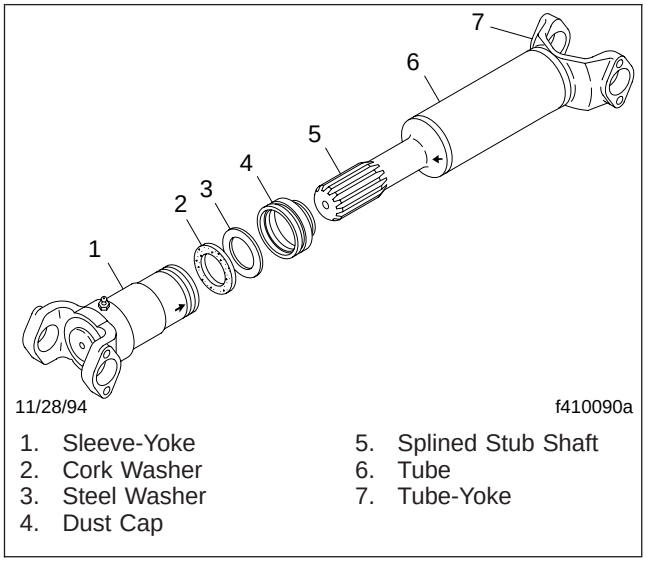
IMPORTANT: Misaligned driveshaft yokes will cause the U-joints to be out of phase, which will cause vibration in the driveline.

2. With the driveshaft uncoupled at one end, *or* removed from the vehicle, use a brass hammer and punch to tap the shroud off the slip seal. See **Fig. 11**.
3. Use a screwdriver to pry the seal out of the groove in the slip yoke, then pull the sleeve-yoke off of the splined shaft. Remove the shroud, and seal.




A. Use a marking stick or paint to add alignment marks.

**Fig. 9, Slip-Joint Alignment Marks**




1. Sleeve-Yoke
2. Cork Washer
3. Steel Washer
4. Dust Cap
5. Splined Stub Shaft
6. Tube
7. Tube-Yoke

**Fig. 10, Slip-Joint Components**

## Transmission/Axle End-Yoke Removal

IMPORTANT: Before removing a transmission output-shaft end-yoke or an axle shaft end-yoke, do the steps under "End-Yoke Cleaning and Inspection," in **Subject 140**.

1. Uncouple the driveshaft from the end-yoke (**Subject 100** for a half-round yoke or **Subject 110** for

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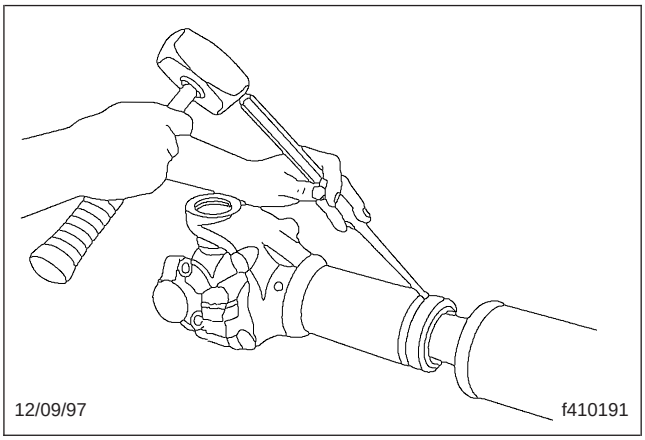



**Fig. 11, Shroud Removal**

a full-round yoke), or remove the driveshaft from the vehicle. See **Subject 120**.

2. Remove the end-yoke locknut. See **Fig. 12**.

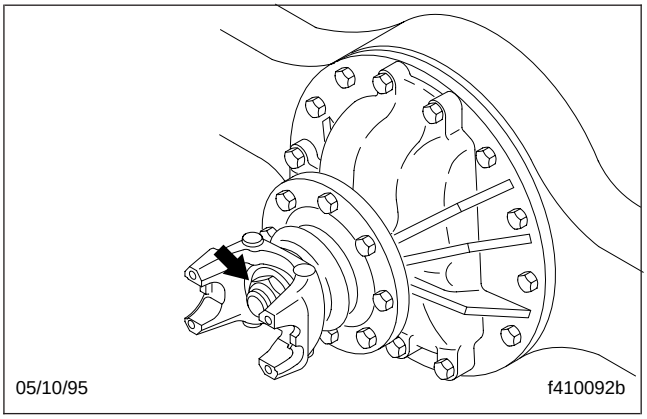
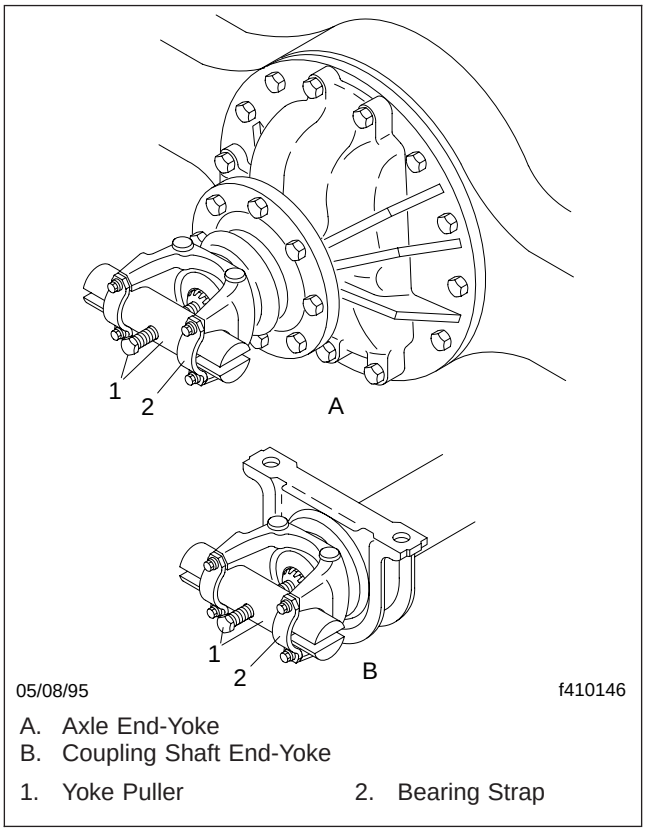



**Fig. 12, Axle End-Yoke Locknut**

3. Using a yoke puller, remove the end-yoke. See **Fig. 13** for a half-round end-yoke, or see **Fig. 14** for a full-round end-yoke.

## Coupling Shaft End-Yoke and Midship Bearing Removal

NOTE: Vehicles manufactured after January 18, 2002, were built with a newly designed Meritor midship hanger bearing assembly. Separate dust shields, or "slingers," common to the previous design, are no longer required.



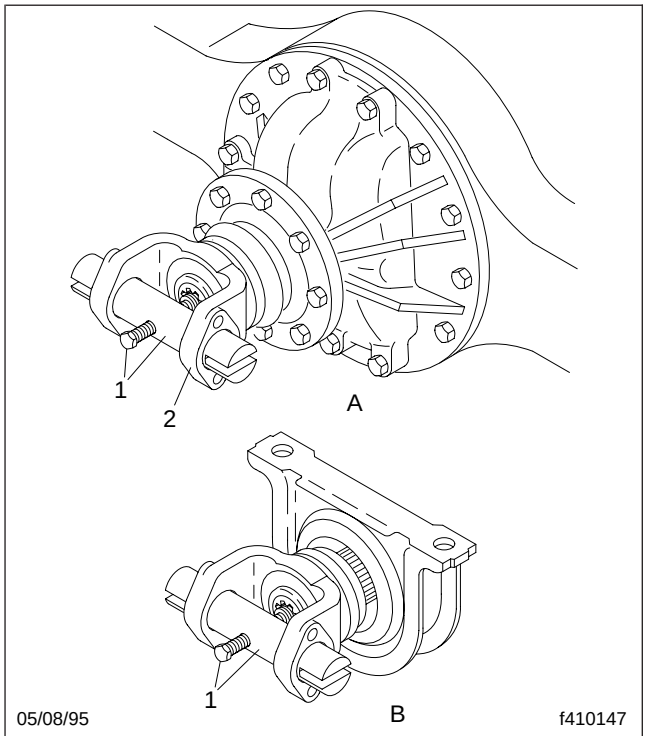

A. Axle End-Yoke
B. Coupling Shaft End-Yoke
1. Yoke Puller
2. Bearing Strap

**Fig. 13, Remove a Half-Round End-Yoke**

1. Remove the coupling shaft from the vehicle. See **Subject 120**.
2. Clamp the coupling shaft in a soft-jawed vise; do not distort the tube with excessive grip.
3. Remove the end-yoke; see **Fig. 13** for a half-round end-yoke, or see **Fig. 14** for a full-round end-yoke. Then, remove the midship bearing and slingers (if equipped). See **Fig. 15**.
   - 3.1 Use a marking stick or paint to mark the end-yoke and coupling shaft with alignment marks. See **Fig. 16**.
   - 3.2 Remove the coupling shaft end-yoke locknut.
   - 3.3 Using a yoke puller, remove the end-yoke. See **Fig. 13** for a half-round end-yoke, or see **Fig. 14** for a full-round end-yoke.
   - 3.4 Use a hammer and a brass drift to remove the midship bearing and slingers. See **Fig. 15**.

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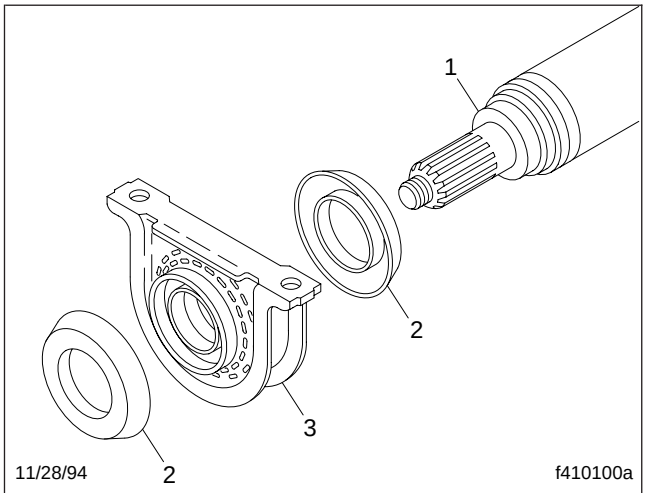





A. Axle End-Yoke
B. Coupling Shaft End-Yoke

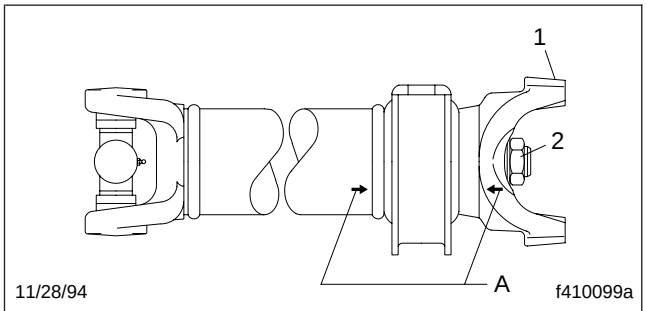
1. Yoke Puller
2. Full-Round End-Yoke

**Fig. 14, Removing a Full-Round End-Yoke**




1. Midship Bearing Shaft
2. Slinger
3. Midship Bearing

**Fig. 15, Midship Bearing and Slingers**




A. Use a marking stick or paint to mark the end-yoke and coupling shaft with alignment marks.

1. Half-Round End-Yoke
2. End-Yoke Locknut

**Fig. 16, Alignment Marks on a Coupling Shaft With an End-Yoke**

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## Driveshaft Tube, Slip-Joint, Sleeve-Yoke, and Tube-Yoke Cleaning and Inspection

1. With the driveshaft removed, scrape or soak away any foreign material.
2. Examine the driveshaft tube for dents, bends, twists, splitting weld-seams, and signs of missing balance weights.

   Replace the driveshaft tube if damaged; see "Driveshaft Tube, Stub Shaft (Slip-Joint), or Tube-Yoke Replacement," in **Subject 150**. If balance weights appear to be missing, have the driveshaft balanced to a maximum tolerance of one inch-ounce per ten pounds weight per end, at 3000 rpm.
3. Clean the slip-joint (male and female) splines, then check them for twisting and galling. See **Fig. 1**. Replace both the sleeve-yoke and the splined shaft if the slip-joint is damaged; see "Driveshaft Tube, Stub Shaft (Slip-Joint), or Tube-Yoke Replacement," in **Subject 150**. Remove any burrs or rough spots using fine emery cloth.

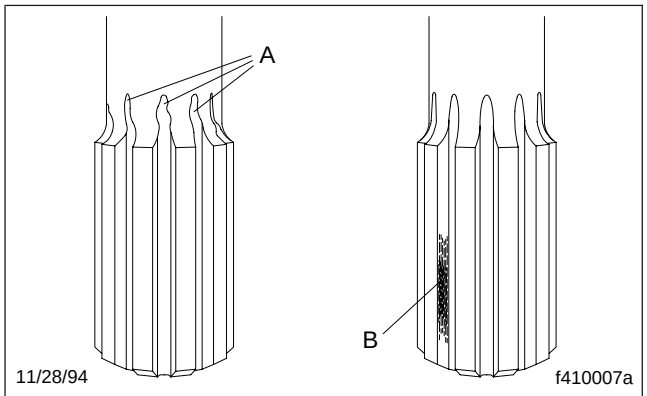



**Fig. 1, Damaged Slip-Joint Splines**

4. Check for a loose or missing sleeve-yoke plug. See **Fig. 2**. Repair or replace the plug as needed.
5. With the U-joint assemblies removed, check all driveshaft yoke cross-holes for raised metal. Using a rat-tail or half-round file, remove burrs or raised metal. See **Fig. 3**.

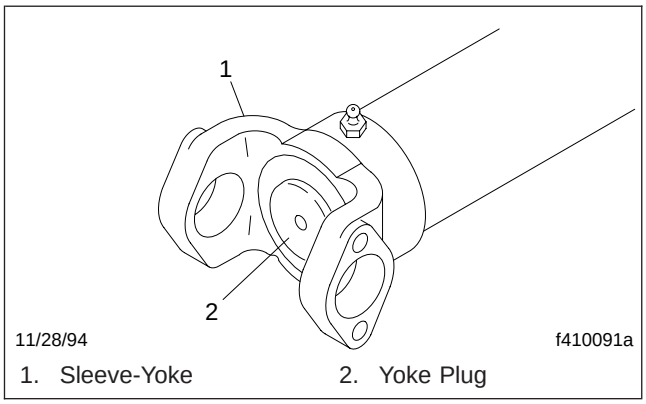



**Fig. 2, Sleeve-Yoke Plug**

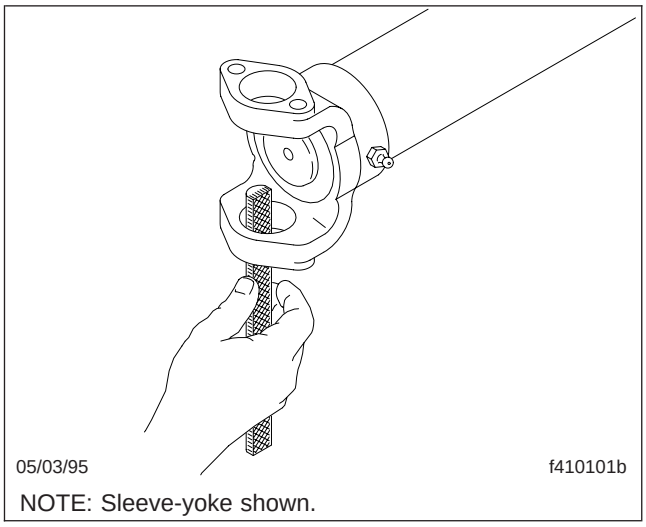



**Fig. 3, Removing Burrs From a Full-Round Yoke Cross-Hole**

6. Using a mill file, and holding it flat against the machined surface of the driveshaft yoke lug, file each yoke lug, to remove any burrs or raised metal. See **Fig. 4**.
7. Using fine emery cloth, smooth and clean the entire surface of all driveshaft yoke cross-holes. See **Fig. 5**.

## Midship Bearing Cleaning and Inspection

1. With the midship bearing removed from the coupling shaft, use clean rags or paper towels to

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## Driveline Component Cleaning and Inspection

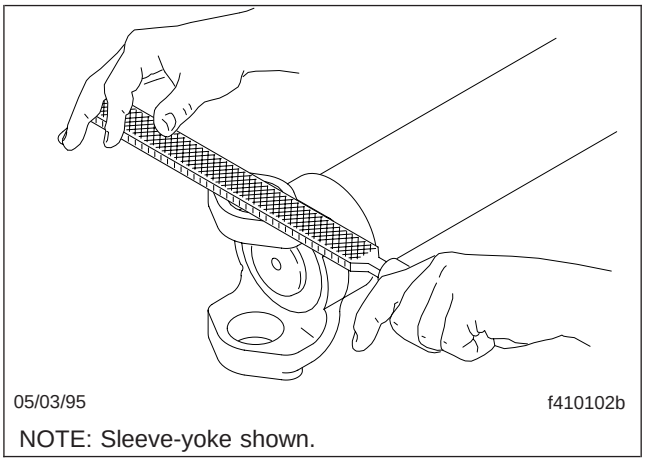



**Fig. 4, Removing Burrs From the Machined Surface of a Full-Round Yoke Lug**

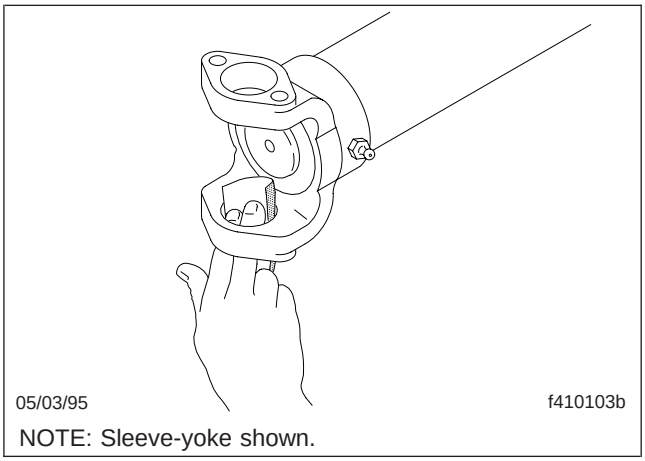



**Fig. 5, Smoothing a Full-Round Yoke Cross-Hole**

wipe off the outside of the midship bearing, rubber cushion, and slingers.

IMPORTANT: Do not immerse the midship bearing in cleaning solvent. The solvent will wash out the lubricant, requiring bearing-assembly replacement.

2. Check the midship bearing for roughness or rattles by holding the outside of the bearing while manually turning the inner bearing race. Replace the bearing assembly if there are any rough spots or rattles.
3. Check the rubber cushion for deterioration or oil-soaking, and replace the midship bearing assembly if needed.

## End-Yoke Cleaning and Inspection

1. With the transmission output-shaft and axle shaft end-yokes installed, check them for cracks and looseness.

   Replace cracked yokes. If the end-yoke can be moved in or out on its shaft, or can be rocked on its shaft, uncouple the driveshaft from the end-yoke. Check the drive component's shaft seal for leakage or other visible damage that may have been caused by the loose yoke. Replace the shaft seal if needed. Tighten the end-yoke nut to the torque value given in **Specifications, 400**. If the end-yoke is still loose after tightening the yoke nut, install a new yoke and yoke nut.

NOTE: If the end-yoke locknut is removed for any reason, install a new one.

2. With the U-joints uncoupled from the end-yokes, check all driveshaft and input/output shaft end-yoke cross-holes for raised metal. Using a rat-tail or half-round file, remove burrs or raised metal. See **Fig. 3** for full-round yokes, or see **Fig. 6** for half-round yokes.

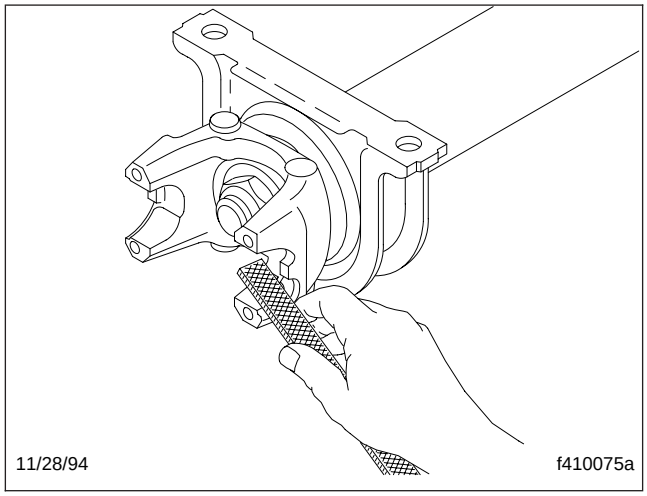


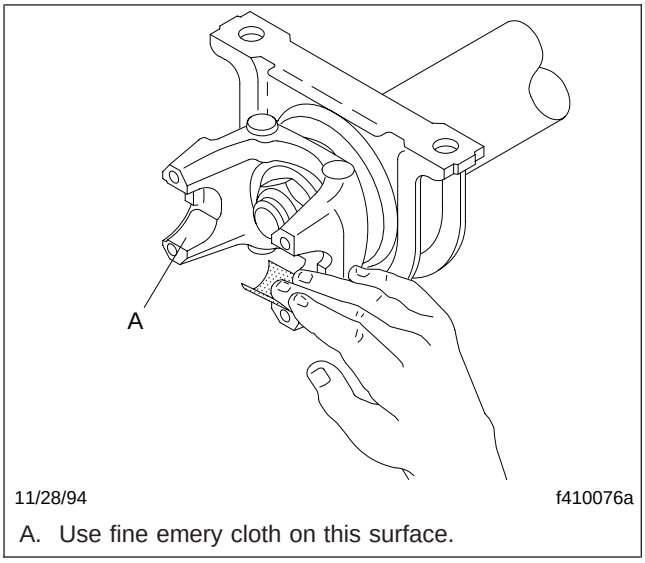

**Fig. 6, Removing Burrs From a Half-Round End-Yoke Cross-Hole**

3. Using a mill file, and holding it flat against the machined surface of the *full-round* end-yoke lug, file each yoke lug, to remove any burrs or raised metal. See **Fig. 4**.

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4. Smooth and clean the entire surface of all end-yoke cross-holes, using fine emery cloth. See **Fig. 5** for full-round yokes, or see **Fig. 7** for half-round yokes.




A. Use fine emery cloth on this surface.

**Fig. 7, Smoothing a Half-Round End-Yoke Cross-Hole**

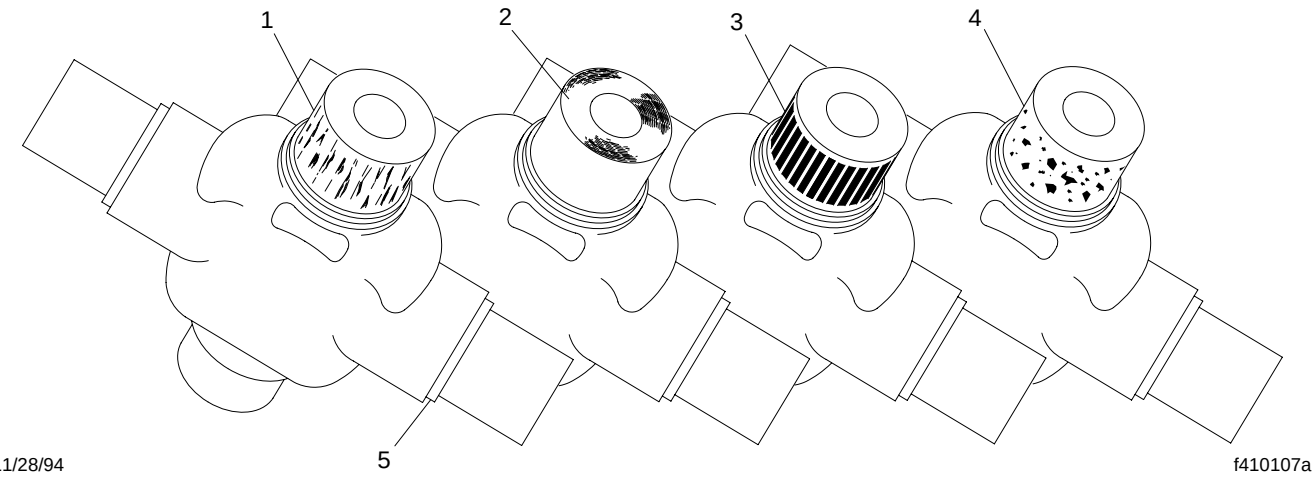
## U-Joint Cleaning and Inspection

1. With the U-joints removed from the yokes, and the bearing cups removed from the crosses, inspect the U-joint cross slingers for damage, then inspect the U-joint trunnions for spalling (flaking metal), end galling (displacement of metal), brinelling (grooves caused by bearing needles), and pitting (small craters caused by corrosion). See **Fig. 8**. If damaged, replace the U-joint assembly.
2. Using a hand-type grease gun, apply multipurpose chassis grease to the fitting on each U-joint cross until all old lubricant is forced out. See **Fig. 9**. Examine the old lubricant. If it appears rusty, gritty, or burnt, replace the U-joint assembly.
3. Soak the bearing cups in a non-flammable cleaner until particles of grease and foreign matter are loosened or dissolved. Do not disassemble the bearing cups; clean the bearing needles with a short, stiff brush, then blow them dry with compressed air. Check for minute particles of dirt or grit, and clean again if necessary.
4. Check each bearing cup for missing bearing needles. Check the bearing-cup seals for nicks. See **Fig. 10** for a half-round-yoke U-joint bearing cup, or see **Fig. 11** for a full-round-yoke U-joint bearing cup. Replace the U-joint assembly if any bearing needles are missing or any seals are damaged.
5. Apply a small quantity of multipurpose chassis grease to the bearing needles in each cup, then apply a small amount of light-weight oil to the lips of the bearing-cup seals. Rotate each bearing cup on the cross to check for wear. Replace the U-joint assembly if any bearing surfaces are worn.
6. Check the underside of each bearing-cup plate for burrs or raised metal. Use a mill file to remove any burrs or raised metal. See **Fig. 12**.
7. Using fine emery cloth, smooth and clean the outside surfaces of all bearing cups. See **Fig. 12** and **Fig. 13**.

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## Driveline Component Cleaning and Inspection




1. Spalling
2. End Galling
3. Brinelling
4. Pitting
5. Slinger

**Fig. 8, Damaged U-Joint Crosses**

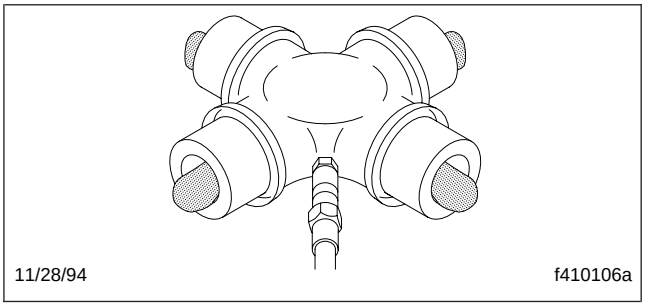
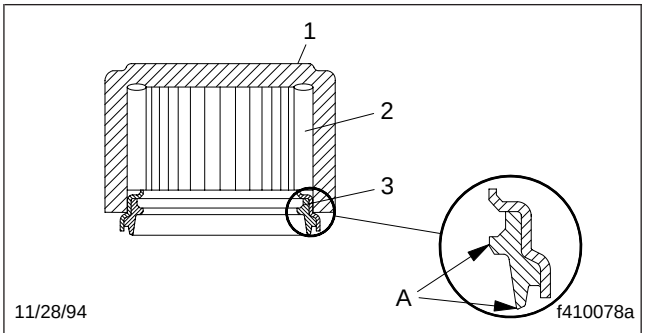
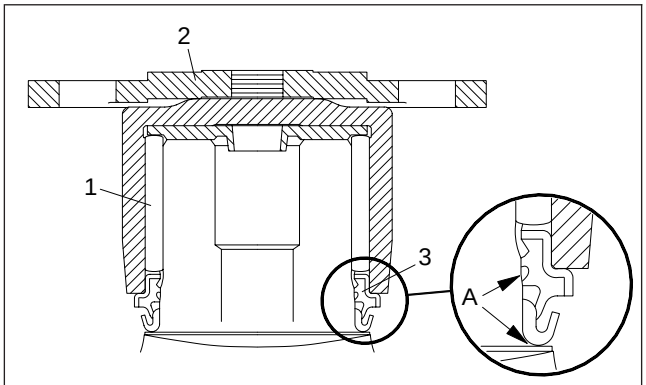



**Fig. 9, Forcing Out Old Lubricant From a U-Joint Cross**




A. Lubricate seal lips here.
1. Bearing Cup
2. Bearing Needle
3. Bearing-Cup Seal

**Fig. 10, Sectional View of a Half-Round End-Yoke U-Joint Bearing Cup**

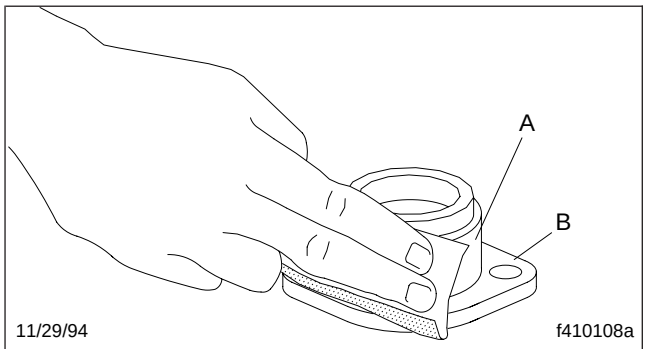



A. Lubricate seal lips here.
1. Bearing Needle
2. Bearing-Cup Plate
3. Bearing-Cup Seal

**Fig. 11, Sectional View of a Full-Round Yoke U-Joint Bearing Cup**

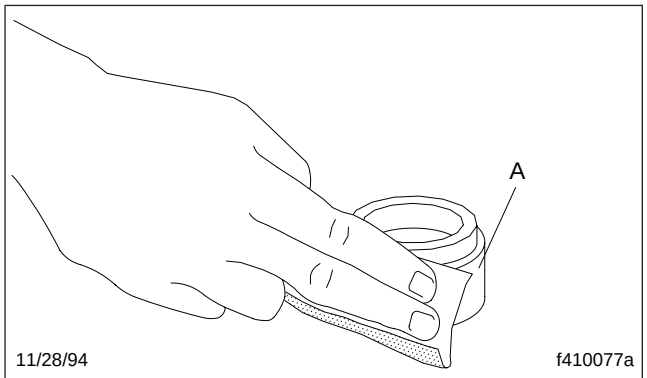
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A. Use fine emery cloth on this surface.
B. Use a mill file on this surface.

**Fig. 12, Smoothing a Full-Round Yoke U-Joint Bearing Cup**




A. Use fine emery cloth on this surface.

**Fig. 13, Smoothing a Half-Round Yoke U-Joint Bearing Cup**

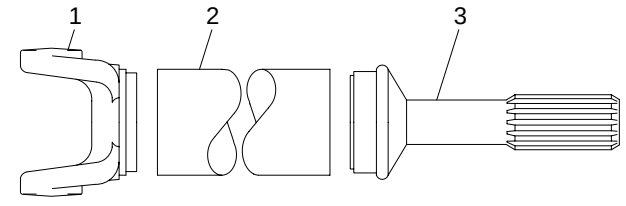
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## Driveshaft Tube, Stub Shaft (Slip-Joint), and Tube-Yoke Replacement

IMPORTANT: Parts for different series drivelines must not be intermixed. Incorrectly assembled or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

To replace a driveshaft tube, a tube-yoke, or a stub shaft (**Fig. 1**), the driveshaft must be chucked in a lathe, so the welds can be removed. Driveshaft rebuilding should be done by a machine shop that specializes in driveline repair.




1. Tube-Yoke
2. Driveshaft Tube
3. Stub Shaft

**Fig. 1, Driveshaft Tube, Stub Shaft, and Tube-Yoke**

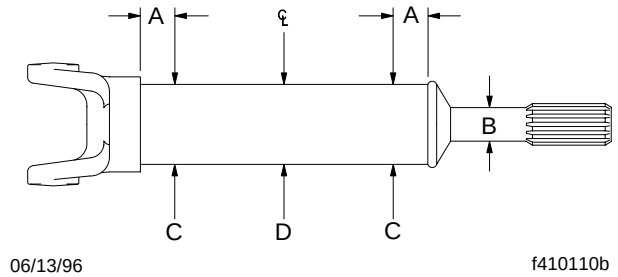
Runout limits for a new (rebuilt) driveshaft (**Fig. 2**) are:

- 0.005 inch (0.127 mm) T.I.R. (Total Indicator Reading) on the smooth portion of the stub shaft neck;
- 0.010 inch (0.254 mm) T.I.R. on the tube 3 inch (76 mm) from the front and rear welds;
- 0.015 inch (0.381 mm) T.I.R. at the center of the tube.

Balance the rebuilt driveshaft to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

## Slip-Joint Replacement or Assembly

IMPORTANT: Parts for different series drivelines must not be intermixed. Incorrectly assembled



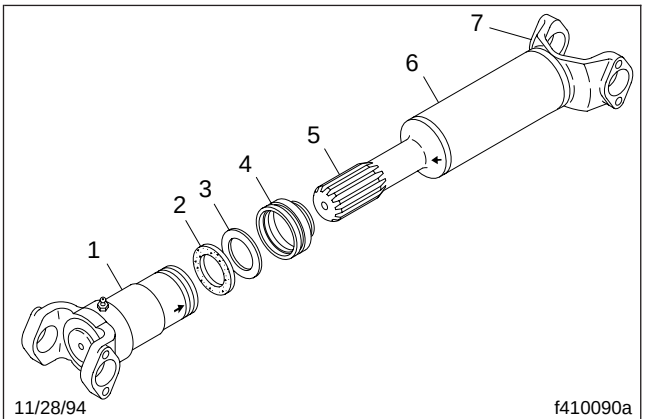

A. Measurement: 3 inches (76 mm)
B. Measurement: 0.005 inch (0.127 mm)
C. Measurement: 0.010 inch (0.2540 mm)
D. Measurement: 0.015 inch (0.381 mm)

**Fig. 2, Runout Specifications for a Rebuilt (or New) Driveshaft**

or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

### Except RPL Drivelines

1. Place the slip-joint dust cap, and (if so equipped) steel washer and cork seal, over the splined shaft. See **Fig. 3**.




1. Sleeve-Yoke
2. Cork Washer
3. Steel Washer
4. Dust Cap
5. Splined Stub Shaft
6. Tube
7. Tube-Yoke

**Fig. 3, Slip-Joint Components**

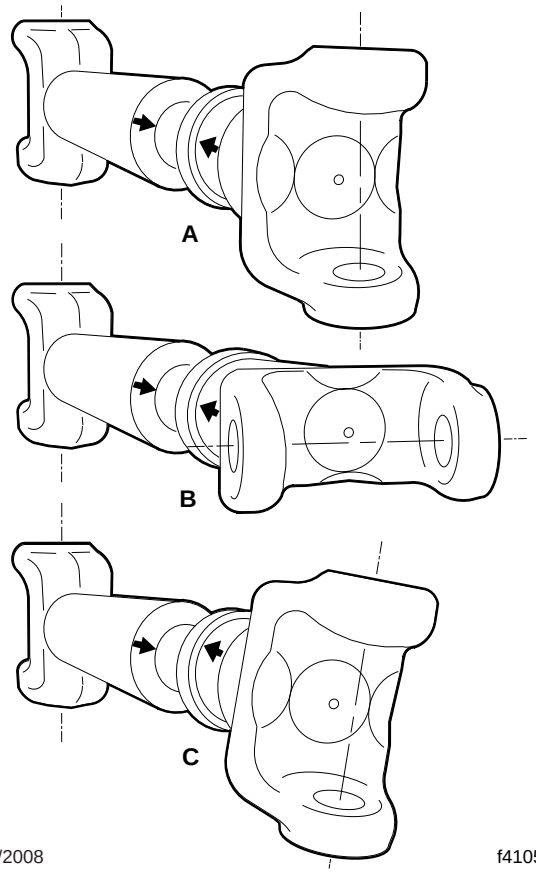
2. Coat the splines of the shaft with multipurpose chassis grease.

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## Driveline Component Replacement or Installation/ Assembly

3. Insert the splined shaft in the sleeve-yoke, so that the alignment marks are aligned, and the U-joints at each end of the driveshaft will be in phase. See **Fig. 4** and **Fig. 5**.

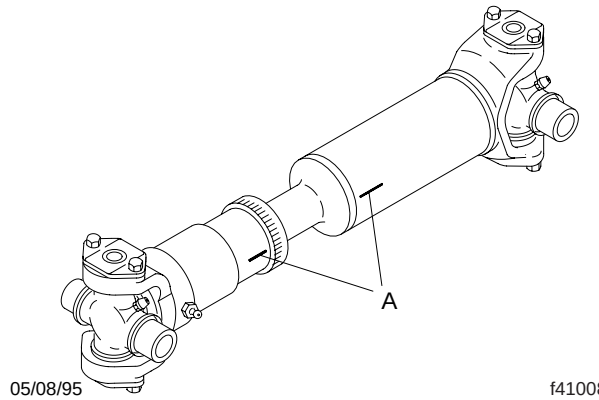



A. In Phase (parallel phased)
B. In Phase (cross phased)
C. Out of Phase

**Fig. 4, U-Joint Phasing**

IMPORTANT: If no alignment marks are visible, or new slip-joint components have been installed, align the yokes, assemble the slip-joint, then have the driveline balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

4. Install the slip-joint dust cap. Use only enough torque to seat the steel washer and cork seal (if so equipped) snug against the end of the sleeve-yoke; do not overtighten.




A. Use a marking stick or paint to add alignment marks.

**Fig. 5, Slip-Joint Alignment Marks**

NOTE: The splines should slide freely, with only a slight drag from the slip-joint dust cap.

## RPL Drivelines

1. Remove the grease plug from the sleeve-yoke.
2. Coat the splines of the sleeve-yoke with multipurpose chassis grease.
3. Install the shroud on the splined shaft.
4. Install the seal onto the shroud.
5. Insert the splined shaft in the sleeve-yoke so that the alignment marks are aligned, and the U-joints at each end of the driveshaft will be in phase. See **Fig. 4** and **Fig. 5**.

IMPORTANT: If no alignment marks are visible, or new slip-joint components have been installed, align the yokes, assemble the slip-joint, then have the driveline balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

6. Install the seal into the shaft groove.
7. Install the shroud. Use a brass hammer to tap the shroud over the seal.
8. Install the grease plug in the sleeve-yoke.

NOTE: The splines should slide freely, with only a slight drag from the slip-joint dust cap.

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## Midship Bearing and Coupling Shaft End-Yoke Replacement or Assembly

IMPORTANT: Parts for different series drivelines must not be intermixed. Incorrectly assembled or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

NOTE: Vehicles manufactured after January 18, 2002, were built with a newly designed Meritor midship hanger bearing assembly. Separate dust shields, or "slingers," common to the previous design, are no longer required.

1. Place the coupling shaft in a soft-jawed vise; do not distort the tube with excessive grip.
2. Fill the entire cavity around the midship bearing with a waterproof grease, to shield the bearing from water and contaminants. Use enough grease to fill the cavities to the extreme edge of the slingers that surround the front and rear of the bearing. See **Fig. 6**.

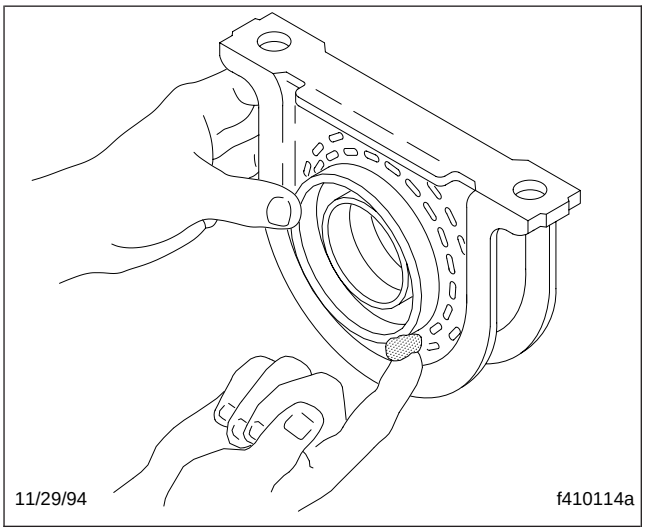
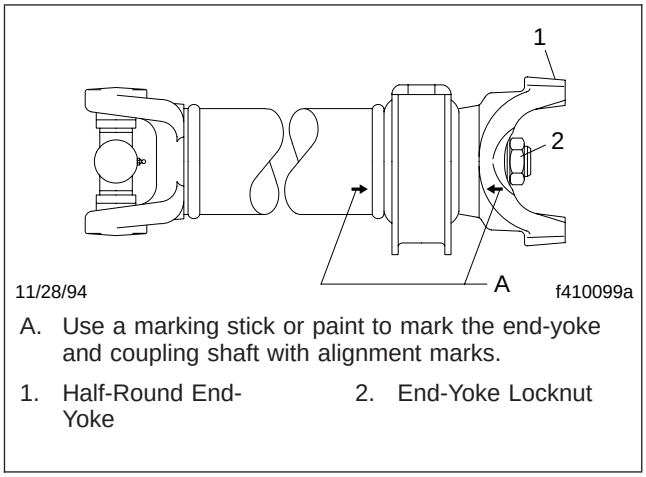



**Fig. 6, Greasing a Midship Bearing**

NOTE: Most midship bearings are permanently lubricated when manufactured; it is not necessary to pack these bearings with grease.

3. Install one of the slingers, the midship bearing, then the other slinger on the coupling shaft. Press the bearing and slingers on by hand, as far as they will go.
4. Install the end-yoke. See **Fig. 7**.




A. Use a marking stick or paint to mark the end-yoke and coupling shaft with alignment marks.

1. Half-Round End-Yoke
2. End-Yoke Locknut

**Fig. 7, Alignment Marks on a Coupling Shaft With an End-Yoke**

4.1 Apply Loctite® 242 to the shaft threads where the end-yoke locknut will be installed.

4.2 Align the marks added to the coupling shaft and end-yoke during removal, then place the end-yoke on the shaft so the yoke bores are aligned at both ends of the shaft. See **Fig. 7**.

4.3 Install the end-yoke nut, and tighten it 475 to 525 lbf·ft (645 to 710 N·m). Then back the nut off slightly, and tighten it to the same torque.

## U-Joint Replacement or Installation

IMPORTANT: Parts for different series drivelines must not be intermixed. Also, components of the various makes of U-joints may not be interchangeable, and must be assembled only with compatible products. Incorrectly assembled or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

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## Driveline Component Replacement or Installation/ Assembly

Worn bearing assemblies used with a new cross, or new bearing assemblies used with a worn cross will wear rapidly, making another replacement necessary in a short time. Always replace the cross and all four bearing assemblies at the same time.

If the slip-joint of a No. 2 or No. 3 driveshaft has been disassembled, assemble the slip-joint before installing the U-joints.

## Full-Round Yokes

1. Place the assembled driveshaft in V-blocks or a soft-jawed vise; do not distort the tube with excessive grip.
2. For a No. 2 or No. 3 driveshaft, check that the slip-joint alignment marks are aligned, so that the U-joints at each end of the driveshaft will be in phase. See **Fig. 4** and **Fig. 5**.

   For a coupling shaft, check that the end-yoke and tube-yoke are aligned, so that the U-joints at each end of the coupling shaft will be in phase. See **Fig. 7**.

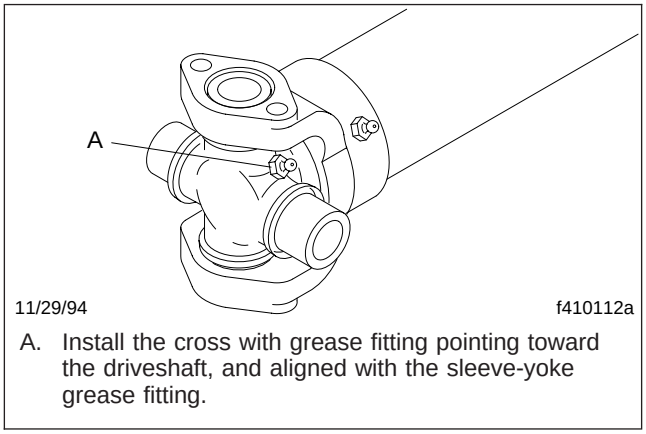
IMPORTANT: Misaligned driveshaft yokes will cause the U-joints to be out of phase, which will cause vibration in the driveline.

3. Inspect and lubricate the U-joint; see **Subject 140**.
4. Install the U-joint cross and bearing assemblies in the yoke.

   4.1 Position the U-joint cross in the driveshaft yoke so one grease fitting points toward the driveshaft, and aligns with the grease fitting on the sleeve-yoke (if so equipped). See **Fig. 8**.

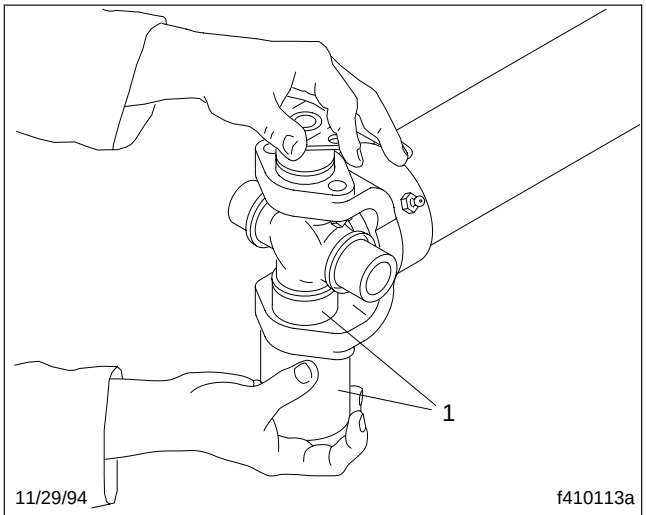
   4.2 Move one end of the cross until a trunnion projects through the cross-hole, beyond the outer machined face of the yoke lug. Using a Spicer trunnion (journal) locator (**Specifications, 400**), hold the trunnions in alignment with the cross-holes, while placing a bearing cup (plate-type) over the projected trunnion, and aligning it with the cross-hole. See **Fig. 9**.

   IMPORTANT: A Spicer trunnion (journal) locator should be used to prevent damage to the U-joint trunnions and slingers.




A. Install the cross with grease fitting pointing toward the driveshaft, and aligned with the sleeve-yoke grease fitting.

**Fig. 8, U-Joint Grease Fitting Positioning**




NOTE: Sleeve-yoke shown.
1. Trunnion Locator

**Fig. 9, Using a U-Joint Trunnion Locator**

   4.3 By hand, press the bearing-cup-plate flush with the face of the yoke. If the bearing cup binds in the cross-hole, tap the *center* of the bearing-cup plate with a leather or rubber mallet; do not tap the outer edges of the plate. See **Fig. 10**.

   4.4 Install *new* bearing-cup-plate self-locking capscrews. See **Fig. 11**. Tighten the capscrews until all the parts are drawn down tight, with no gaps; do not tighten the capscrews to their final torque value.

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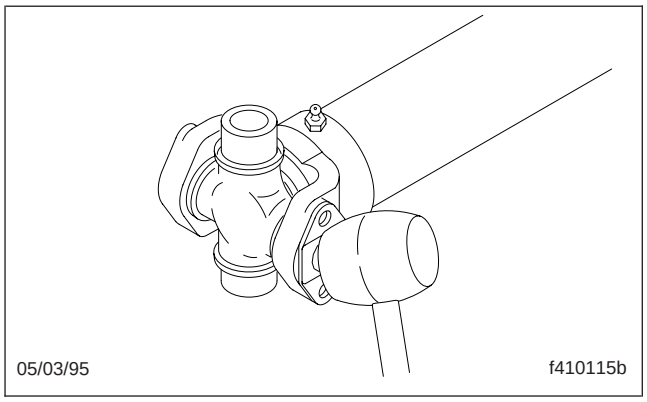
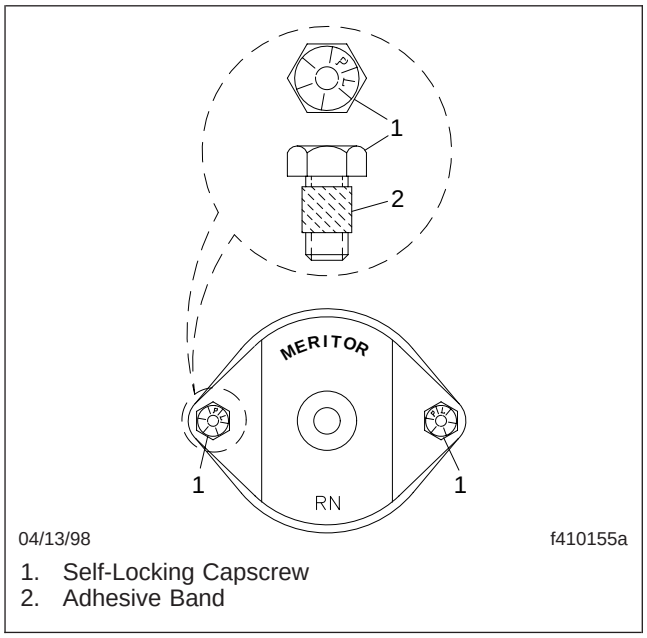



**Fig. 10, Seatting a U-Joint Bearing Cup In a Full-Round Yoke**




1. Self-Locking Capscrew
2. Adhesive Band

**Fig. 11, Meritor U-Joint Fasteners for Full-Round Yokes**

**⚠ WARNING**

**Self-locking bearing-cup-plate capscrews must not be reused; replace the capscrews with new ones. Also, do not undertighten or overtighten any bearing-cup-plate capscrews. A loose or broken fastener at any point in the driveline weakens the driveline connection, which could cause serious vehicle damage, or could result in a driveshaft separating from the vehicle, possibly causing loss of vehicle control that could result in serious personal injury or death.**

4.5 Move the cross until it projects beyond the machined surface of the opposite yoke lug. Using the above procedure, install the opposite bearing assembly and its fasteners.

4.6 Slightly back off all four capscrews, then alternately tighten them in increments of 5 lbf·ft (7 N·m), to the applicable torque value in **Specifications, 400**.

NOTE: The U-joint should flex, and be free of excessive bind. A slight drag is the most desirable condition for new U-joints. Excessive looseness is not desirable, and may result in an unbalanced driveshaft.

## RPL Series U-Joint

NOTE: Do not reuse RPL U-joints. Always replace an RPL U-joint with a new one after they have been disassembled and removed from a driveshaft.

1. Place the assembled driveshaft in V-blocks or a soft-jawed vise; do not distort the tube with excessive grip.
2. For a No. 2 or No. 3 driveshaft, check that the slip-joint alignment marks are aligned, so that the U-joints at each end of the driveshaft will be in phase. See **Fig. 4** and **Fig. 5**.

   For a coupling shaft, check that the end-yoke and tube-yoke are aligned, so that the U-joints at each end of the coupling shaft will be in phase. See **Fig. 7**.

IMPORTANT: Misaligned driveshaft yokes will cause the U-joints to be out of phase, which will cause vibration in the driveline.

3. Inspect the U-joint. See **Subject 140**.
4. Install the U-joint cross and bearing assemblies in the yoke.

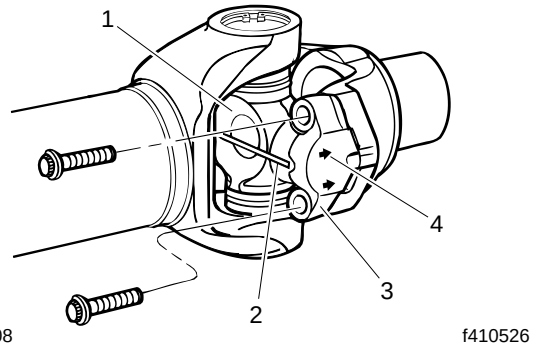
   4.1 Position the U-joint cross in the driveshaft yoke so that the wing bearing weld strap faces inboard, and the arrows point toward the end of the coupling yoke. See **Fig. 12**.

   4.2 Move one end of the cross until a trunnion projects through the cross-hole, beyond the outer machined face of the yoke lug.

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## Driveline Component Replacement or Installation/ Assembly




1. U-Joint Cross
2. Weld Strap
3. Wing Bushing
4. Arrows

**Fig. 12, Fitting the U-Joint**

Place a bearing cup over the projected trunnion, and align it with the cross-hole.

4.3 Press the bearing cup into the yoke slightly past the snap ring groove. See **Fig. 13**. Check that the bearing cup is aligned with the universal joint trunnion.

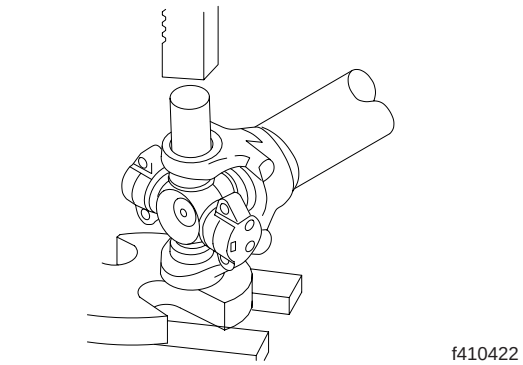


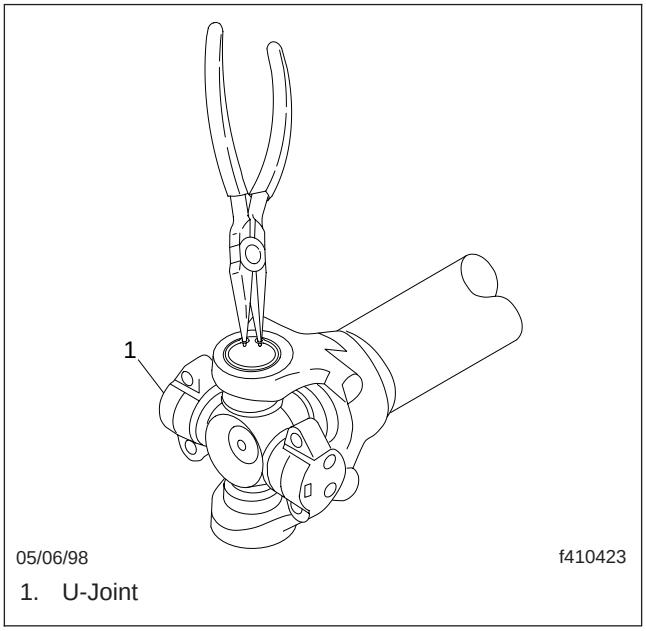

**Fig. 13, Installing Bearing Cups, RPL Series U-Joint**

4.4 Install the snap ring into the snap ring groove. See **Fig. 14**.

4.5 Use a snap ring installation gauge to check that the snap ring is fully seated in the snap ring groove. See **Fig. 15**.

4.6 Move the cross until it projects beyond the machined surface of the opposite yoke lug. Using the above procedure, install the opposite bearing cup assembly.

NOTE: The U-joint should flex, and be free of excessive bind. A slight drag is the most




1. U-Joint

**Fig. 14, Installing the Snap Rings**

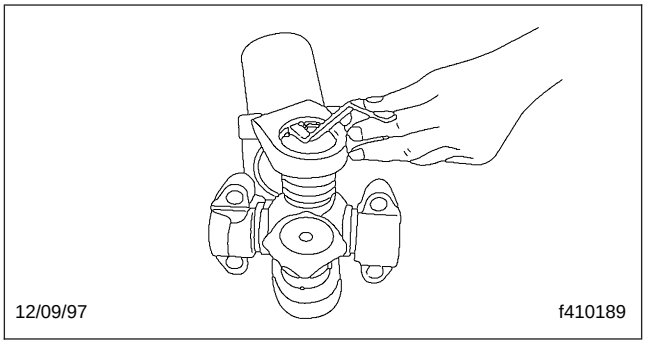



**Fig. 15, Checking Snap Ring Installation**

desirable condition for new U-joints. Excessive looseness is not desirable, and may result in an unbalanced driveshaft.

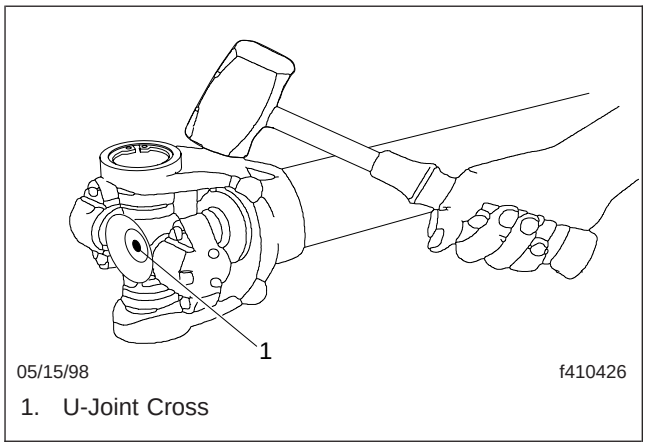
4.7 If the universal joint does not move freely, strike the yoke ear with a brass or copper hammer. See **Fig. 16**.

## Transmission/Axle End-Yoke Replacement or Installation

IMPORTANT: Parts for different series drivelines must not be intermixed. Incorrectly assembled

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1. U-Joint Cross

**Fig. 16, Striking the Yoke Ear**

or worn components can affect the entire driveline, resulting in too much vibration or driveline damage.

1. Apply Loctite® 242 to the input- or output-shaft threads where the end-yoke locknut will be installed. See **Fig. 17**.

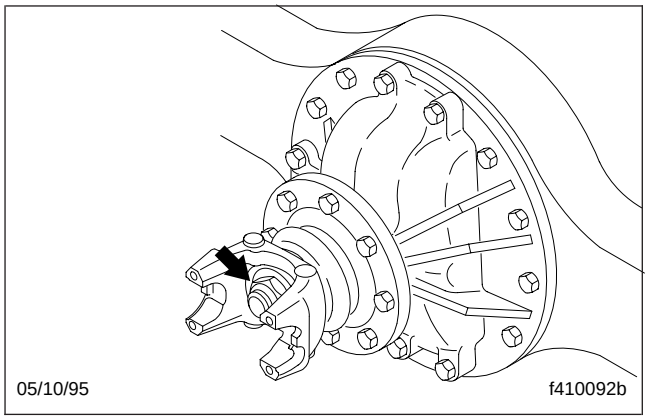



**Fig. 17, Axle End-Yoke Locknut**

2. By hand, install the end-yoke on the input or output shaft as far as it will go.
3. Install a new end-yoke locknut, and tighten it to the applicable torque value in **Specifications, 400**.

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## Troubleshooting

Noise or vibration associated with the driveline can be caused by non-driveline parts. To find the cause of noise or vibration, first road test the loaded vehicle. Drive in all gears and at all speed ranges for which the vehicle was designed, including those at which problems are reported.

NOTE: Operating a vehicle at speeds that exceed its drivetrain design specifications may cause an out-of-balance vibration.

The following is a troubleshooting elimination process; checks should be made in the order listed. At each step where a problem is found, correct the problem before proceeding to the next step, then test drive the vehicle to see if other problems still exist. If no other problems exist, the elimination process may be ended at that step.

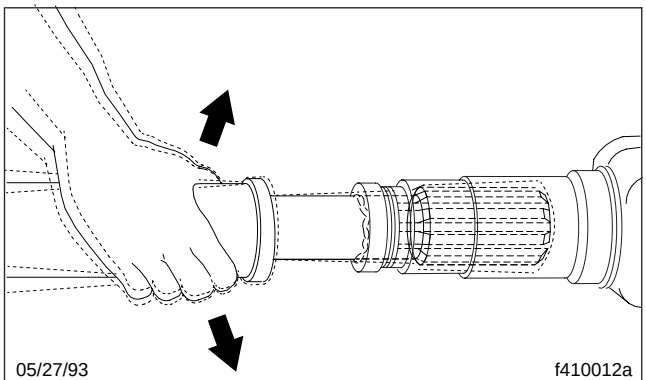
1. Check all tires for uneven wear and for out-of-roundness. Check for mismatched tires. Look for wheels and rims that are out of alignment. For instructions, see **Group 40**.
2. Check the rear suspension for loose or broken U-bolts; broken, shifted, or mismatched rear springs; or broken spring seats. If so equipped, check the air suspension for incorrect air spring height. Look for anything that could cause angular misalignment of the rear axle pinion(s). For instructions, see **Group 32**.
3. Check the frame rails and crossmembers for bends, twists, or breaks; for frame-alignment-checking and crossmember-replacement instructions, see **Group 31**.
4. Check the engine and transmission mounts; see **Group 01** (Engine) and **Group 26** (Transmission). Check the coupling shaft's midship bearing mounts. Replace mountings that are deteriorated or oil-soaked; tighten loose mounting bolts. Oil-soaked or deteriorated mountings, or loose mounting bolts, can cause driveline angular misalignment.
5. Check for loose U-joint bearing-cup-plate and bearing-strap capscrews. Tighten any loose fastener to the applicable torque value in **Specifications, 400**.

**⚠ CAUTION**

**Do not overtighten the bearing-cup-plate or bearing-strap capscrews. A loose or broken fastener at any point in the driveline weakens the driveline connection, which could result in serious vehicle damage.**

6. Check all U-joint assemblies, slip-joint splines, and midship bearings for wear.
   - 6.1 Try to move each driveshaft up and down, and from side to side. If movement is greater than 0.006 in (0.15 mm) of a U-joint cross in its bearings, replace the U-joint assembly.
   - 6.2 If the midship bearing rattles or is loose on its shaft, replace it.
   - 6.3 Try to bend the sleeve-yoke and splined shaft up and down, and from side to side. See **Fig. 1**. If looseness is greater than 0.007 in (0.18 mm), replace the sleeve-yoke and splined shaft.

     If driveline components must be replaced, see **Subject 150**.




Try to bend the sleeve-yoke and splined shaft up and down, and from side to side.

**Fig. 1, Checking for Slip-Joint Spline Wear**

7. Check each driveshaft for an indication of missing balance weights. If any weights appear to be missing, have the driveshaft balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.
8. Check each driveshaft for dents, bends, twists, or other damage.

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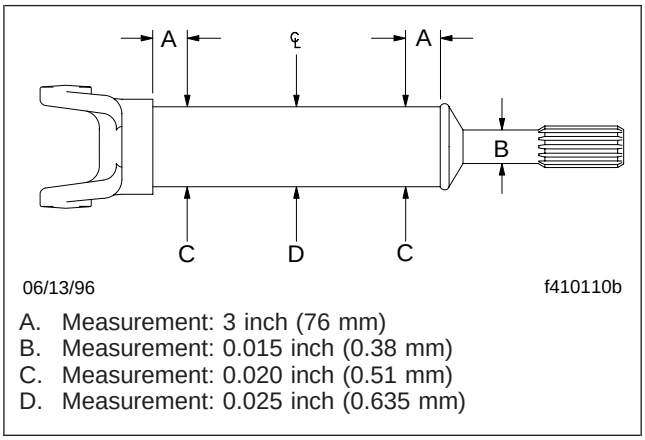


## Troubleshooting

If damaged, jack up the rear axle, support it on jackstands, place the transmission in neutral, and turn the driveshaft by hand to check runout.

The driveshaft must be straight within 0.015 inch (0.38 mm) on the slip-joint seal surface of the splined shaft, 0.020 inch (0.51 mm) on the tube 3 inch (76 mm) from the front and the rear welds, and 0.025 inch (0.635 mm) at the center of the tube. See **Fig. 2**.

If the driveshaft is not straight within specifications, replace the tube. See **Subject 150** for runout specifications for a *new* (or rebuilt) driveshaft.




A. Measurement: 3 inch (76 mm)
B. Measurement: 0.015 inch (0.38 mm)
C. Measurement: 0.020 inch (0.51 mm)
D. Measurement: 0.025 inch (0.635 mm)

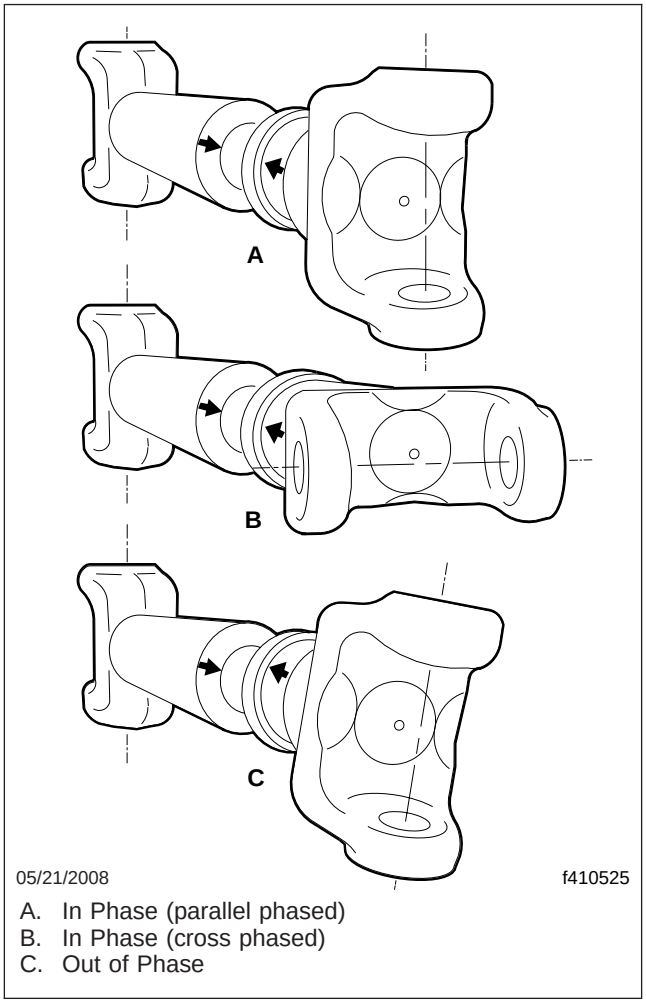
**Fig. 2, Runout Specifications for a Used Driveshaft**

NOTE: Some driveshafts are designed and phased with their end yokes clocked 90 degrees from each other. This is referred to as cross phasing.

9. Check each driveline for proper U-joint phasing. See **Fig. 3**.

   9.1 On No. 2 and No. 3 driveshafts, if the U-joints are out of phase, check the slip-joint for alignment marks. If necessary, disassemble the slip-joint, and align the marks.

   NOTE: To disassemble the slip-joint, uncouple the U-joint at one end of the driveshaft, unscrew the slip-joint seal from the sleeve-yoke, then pull the sleeve-yoke and splined shaft apart. Reverse the procedure to assemble the slip-joint.




A. In Phase (parallel phased)
B. In Phase (cross phased)
C. Out of Phase

**Fig. 3, U-Joint Phasing**

   9.2 If no alignment marks are present, disassemble the slip-joint, and reassemble it with the U-joints in one of the four in-phase positions (90 degrees apart).

   Test drive the vehicle, then assemble the slip-joint in the the next in-phase position. Test drive the vehicle again.

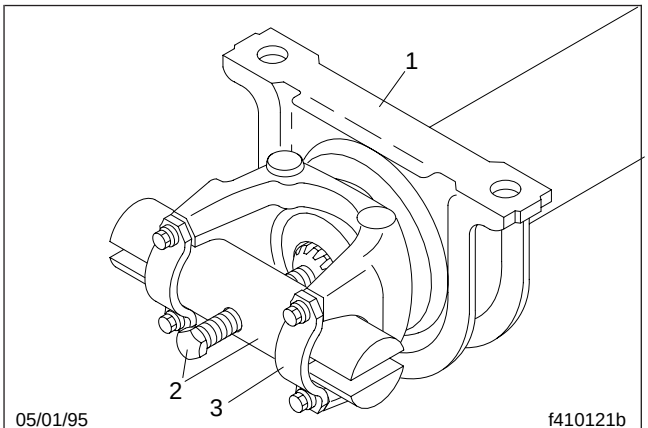
   Determine which in-phase position provides vibration-free operation. Assemble the slip-joint in the correct in-phase position, and mark the slip-joint with alignment marks.

   9.3 If the U-joints are out of phase on a coupling shaft, uncouple the U-joint from the

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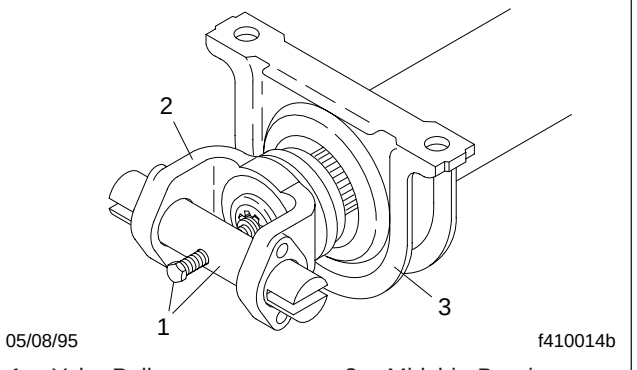


coupling shaft end-yoke, then remove the end-yoke nut. Remove the end-yoke, using a yoke puller. See **Fig. 4** for a half-round end-yoke, or see **Fig. 5** for a full-round end-yoke. Align the end-yoke, then install it by hand. Install the end-yoke nut, and tighten it 475 to 525 lbf·ft (645 to 710 N·m). Slightly back off the nut, and again tighten it to the same torque. Couple the coupling shaft to the driveshaft U-joint.




1. Midship Bearing
2. Yoke Puller
3. Bearing Strap

**Fig. 4, Removing a Half-Round End-Yoke from a Coupling Shaft**




1. Yoke Puller
2. Full-Round Yoke
3. Midship Bearing

**Fig. 5, Removing a Full-Round End-Yoke from a Coupling Shaft**

10. Check the torque on all of the end-yoke nuts in the drivetrain; see the applicable torque values in **Specifications, 400**.

    If any yoke nut was not at its specified torque, check the yoke for wear by trying to move it up and down, and back and forth. If the yoke can be rocked on its shaft, or moved in or out on its shaft, replace the yoke and yoke nut. See **Subject 150**.

    If the yoke is not worn, tighten the yoke nut to its torque value.

11. *On single-drive vehicles:*

    Have the No. 2 driveshaft balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

    *On dual-drive vehicles:*

    11.1 Remove the No. 3 driveline; then, with the interaxle differential locked, test drive the vehicle.

    11.2 If vibration still exists, install the No. 3 driveline, then have the No. 2 driveshaft balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

    If *no* vibration exists, check that both rear axle gear ratios are matched. If the gear ratios do not match, replace one of the gear sets with a gear set having the correct ratio, then install the No. 3 driveline.

    11.3 Have the No. 3 driveshaft balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

    11.4 Have the No. 2 driveshaft balanced to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

12. If so equipped, balance the coupling shaft(s) to a maximum tolerance of 1 inch-ounce per 10 pounds weight per end, at 3000 rpm.

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| Transmission Output-Shaft End-Yoke Nut Fastener Torques | | | |
|---|---|---|---|
| **Description** | | **Size** | **Torque: lbf·ft (N·m)** |
| Fuller | RT 8609 | 1-1/2–18 | 400–450 (542–610) |
| | T/X 14607<br>RT 8608 /7608LL<br>RTO 11909MLL /14909MLL /11908LL<br>RTX 16709 /15710 /16710<br>RT/X 11609 /11709 /12609 /12709 /13609 /13709 /14609 /14709 /11710 /12710 /13710 /14710<br>RTO/X 11708LL /14708LL<br>RT/O/X 14715 /15715<br>RTLO 12610 /13610 /14610 /15610 /16610 /12713 /14713 /16713 /14718 /16718 /18718 | 2–16 | 450–500 (610–678) |
| Meritor | RM/O/X 9–115, –125, –135, –145, –155<br>RM/X 10–115, –125, –135, –145, –155, –165<br>RMO 13–145 | 2–16 | 450–500 (610–678) |
| Allison | HD Series | 2–16 | 600–800 (813–1085) |

**Table 1, Transmission Output-Shaft End-Yoke Nut Fastener Torques**

| Midship Bearing Fastener Torques | | |
|---|---|---|
| **Location** | **Size** | **Torque: lbf·ft (N·m)** |
| Coupling Shaft | 1-1/4–18 | 475–525 (645–710) |
| Bracket to Crossmember Locknut | 1/2–13 | 68 (92) |
| Bearing Mount to Bracket Locknut | 1/2–13 | 68 (92) |

**Table 2, Midship Bearing Fastener Torques**

| Spicer U-Joint Capscrew Torque | | | |
|---|---|---|---|
| **Series** | **Thread Size** | **Style** | **Torque lbf·ft (N·m)** |
| 1710 HD<br>1760 HD<br>1810 HD | 1/2–20 | Half Round | 130–135 (176–183) |
| | 3/8–24 | Full Round | 38–48 (52–65) |
| SPL100 | 3/8–24 | Half Round | 45–60 (61–81) |
| SPL140/HD/XL<br>SPL170/XL<br>SPL250/HD/XL | M12–1.25 | Half Round | 115–135 (156–183) |

**Table 3, Spicer U-Joint Capscrew Torque**

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## Specifications

| Meritor U-Joint Capscrew Torque | | | |
|---|---|---|---|
| **Series** | **Thread Size** | **Style** | **Torque lbf·ft (N·m)** |
| 16T | 3/8–24 | Half Round | 45–60 (61–81) |
| 16N | 5/16–24 | Full Round | 26–35 (35–47) |
| 17T | 1/2–20 | Half Round | 115–135 (156–183) |
| 17N | 3/8–24 | Full Round | 38–48 (52–65) |
| 176T | 1/2–20 | Half Round | 115–135 (156–183) |
| 176N | 3/8–24 | Full Round | 38–48 (52–65) |
| 18T | 1/2–20 | Half Round | 115–135 (156–183) |
| 18N | 3/8–24 | Full Round | 38–48 (52–65) |
| RPL20 G2<br>RPL250HD G2 | 1/2–20 | Wing Yoke | 115–135 (156–183) |

**Table 4, Meritor U-Joint Capscrew Torque**

| Axle End-Yoke Fastener Torques | | | | |
|---|---|---|---|---|
| **Position** | **Brand** | **Model Number** | **Input Size** | **Torque: lbf·ft (N·m)** |
| Single Axle Input Shaft | Meritor | MS-21-14X | M39- 1.5 | 920-1130 (1250-1530) |
| | | RS-23-160, RS-23-161, RS-23-186, RS-25-160, RS-26-185, RS-30-185, | M45-1.5 | 1000-1230 (1355-1670) |
| | | RS-30-380, RS-38-380 | 1-1/2 -12 UNF | 800-1100 (1085-1490) |
| | Detroit | DA-RS-17.5-4, DA-RS-19.0-4, DA-RS-21.0-4, DA-RS-23.0-4 | M45-1.5 | 627-850 (850-1150) |
| First Carrier Input Shaft | Meritor | MT-40-143/4M, MT-40-14X, MT-40-14XGP, MT-40-14XP, MT-44-14X, MT-44-14XP | M 45-1.5 | 750-850 (1015-1150) |
| | | RT-40-145, RT-40-145A, RT-40-145GP, RT-40-145P, RT-44-145, RT-44-145P, RT-40-160, RT-40-160P, RT-46-160, RT-46-160GP, RT-46-160P, RT-46-164, RT-46-164P | | |
| | | RT-50-160, RT-50-160GP, RT-50-160P, RZ-166, RZ-166 R-SERIES | | |
| | | RT-52-185, RT-52-185G, RT-58-185, RT-52-380G, RT-70-380, RT-70-380P, RZ-186, RZ-188, RZ-188G | 1-3/4x12 UN | |
| | Detroit | DA-RT-40.0-4, DA-RT-40.0-4 HT, DA-RT-44.0-4, DA-RT-44.0-4 HT, DA-RT-46.0-4 HH | M45-1.5 | 627-850 (850-1150) |
| | Dana Spicer | DT463P, DD404, DD405, DD405P, DDH40, DDH40P, DS404, DS404P, DS405, DS405P, DSH40, DSH40P, DST40, DST41, DDH44P, DSH44P | M42 X 1.5 | 840-1020 (1140-1385) |
| | | S23-190, D46-170, D50-170P, D52-190P, D40-170, D40-170P, D46-170P | M48 X 1.5 | 800-1000 (1085-1355) |

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| Axle End-Yoke Fastener Torques | | | | |
|---|---|---|---|---|
| **Position** | **Brand** | **Model Number** | **Input Size** | **Torque: lbf·ft (N·m)** |
| First Carrier Output Shaft | Meritor | MT-40-143/4M, MT-40-14X, MT-40-14XGP, MT-40-14XP, MT-44-14X, MT-44-14XP | M 39 x 1.5 | 600-800 (815-1085) |
| | | RT-40-145, RT-40-145A, RT-40-145GP, RT-40-145P, RT-44-145, RT-44-145P, RT-40-160, RT-40-160P, RT-46-160, RT-46-160GP, RT-46-160P, RT-46-164, RT-46-164P | | |
| | | RT-50-160, RT-50-160GP, RT-50-160P, RZ-166, RZ-166 R-SERIES | | |
| | | RT-52-185, RT-52-185G, RT-58-185, RT-52-380G, RT-70-380, RT-70-380P, RZ-186, RZ-188, RZ-188G | 1-1/2x12 UNF | 450-650 (610-880) |
| | Detroit | DA-RT-40.0-4, DA-RT-40.0-4 HT, DA-RT-44.0-4, DA-RT-44.0-4 HT, DA-RT-46.0-4 HH | M39 x 1.5 | 520 - 700 (705-950) |
| | Dana Spicer | DT463P, DD404, DD405, DD405P, DDH40, DDH40P, DS404, DS404P, DS405, DS405P, DSH40, DSH40P, DST40, DST41, DDH44P, DSH44P | M39 X 1.5 | 680 - 832 (920-1130) |
| | | S23-190, D46-170, D50-170P, D52-190P, D40-170, D40-170P, D46-170P | M42 x 1.5 | 800-1000 (1085-1355) |
| Second Carrier Input Shaft | Meritor | MT-40-143/4M, MT-40-14X, MT-40-14XGP, MT-40-14XP, MT-44-14X, MT-44-14XP | M 39 x 1.5 | 920-1130 (1250-1530) |
| | | RT-40-145, RT-40-145A, RT-40-145GP, RT-40-145P, RT-44-145, RT-44-145P | | |
| | | RT-40-160, RT-40-160P, RT-46-160, RT-46-160GP, RT-46-160P, RT-46-164, RT-46-164P, RT-50-160, RT-50-160GP, RT-50-160P, RT-52-185, RT-52-185G, RT-58-185 | M45 x 1.5 | 1000-1230 (1355-1670) |
| | | RT-52-380G, RT-70-380, RT-70-380P | 1-1/2 - 12 UNF | 800-1100 (1085-1490) |
| | | RZ-166, RZ-166 R-SERIES, RZ-186 | M45 x 1.5 | 600-800 (815-1085) |
| | | RZ-188, RZ-188G | 1-3/4 - 12 UN | 600-800 (815-1085) |
| Second Carrier Output Shaft | Meritor | RZ-166, RZ-166 R-SERIES, RZ-186 | M39 x 1.5 | 450-650 (610-880) |
| | | RZ-188, RZ-188G | 1-1/2 -12 UNF | 450-650 (610-880) |
| Third Carrier Input Shaft | Meritor | RZ-166, RZ-166 R-SERIES, RZ-186, RZ-188, RZ-188G | M45 x 1.5 | 1000-1230 (1355-1670) |

**Table 5, Axle End-Yoke Fastener Torques**

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## Specifications

## Special Tools

### Journal Locator (for Installing U-Joints In Full-Round Yokes)

To order, contact your Dana Corporation Spicer Service Representative.

### U-Joint Removal Tool Kit (for Removing U-Joints From Full-Round Yokes)

To order Owatonna Tool Kit No. 7057, contact:

Owatonna Tool Company
Owatonna, Minnesota 55060

### End-Yoke Puller (for Removing End-Yokes From Transmission Output Shafts, Coupling Shafts, and Rear-Axle Input and Output Shafts)

To order End-Yoke Puller J 7804–01, contact:

Kent-Moore Tool Division
29784 Little Mack
Roseville, MI 48066–2298
Telephone: 1–800–328–6657 Telex: 244040 KMTR
UR FAX: (313) 774–9870

To order Yoke and Flange Remover SP–450, contact:

G & W Tool Company
907 South Dewey
Wagoner, OK 74467

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## Driveline Angularity

The most important consideration of driveline angularity is the U-joint working angle. A U-joint working angle is the angle formed by the intersection of the driveshaft centerline and the extended centerline of the shaft of any component to which the U-joint connects. See **Fig. 1**. Because the action of a U-joint causes a fluctuating speed difference between the shafts it connects, the effect created by the U-joint at the input-shaft end-yoke must cancel the effect created by the U-joint at the output-shaft end-yoke. This is done by making the U-joint working angles at both ends of the driveshaft approximately equal, with the U-joints in phase.

The U-joint working angles may be made approximately equal by either of two basic arrangements: a parallel arrangement (**Fig. 1**), or an intersecting arrangement (**Fig. 2**).

Driveline angularity may be adversely affected if rear suspension U-bolts are loose or broken; rear springs are broken, shifted, or mismatched; spring seats are broken; frame rails are bent, twisted, or broken; or transmission or engine mounts are loose or deteriorated.

## U-Joint Phasing

The fluctuating speed difference caused by the action of a U-joint connecting angled shafts can be cancelled only if the U-joint at the other end of the driveshaft is in phase with that U-joint (and the U-joint working angles are approximately equal). If the yoke lugs at both ends of the driveshaft are lying in the same plane (a plane that bisects the shaft lengthwise) the U-joints will be in phase. See **Fig. 3**.

NOTE: Some driveshafts are designed and phased with their end yokes clocked 90 degrees from each other. This is referred to as cross phasing.

To ensure that the U-joints turn in phase, the sleeve-yoke and splined shaft of driveshaft slip-joints, and the coupling shaft and midship bearing end-yoke, should be marked for assembly reference before disassembly.

## Driveline Balance

After manufacture, each driveline yoke is statically balanced. After assembly of the slip-joint, each driveshaft is checked for out-of-roundness, and straightened as necessary; then each shaft is dynamically balanced.

If the driveshaft slip-joint is disassembled for any reason, the sleeve-yoke and splined shaft should be marked for assembly alignment. Misaligned slip-joints will seriously affect the U-joint phasing and balance of the driveline. Even if the slip-joint is assembled 180 degrees from its original position (which will keep the U-joints in phase), the dynamic balance of the driveshaft will be negatively affected.

A driveline can become unbalanced or greatly weakened if a driveshaft has been dented, bent, twisted, or otherwise damaged. Operating a vehicle at speeds that exceed the speed of the driveshaft's design specifications will cause an out-of-balance vibration. Loose end-yoke nuts, loose midship bearing or auxiliary transmission mounts, loose bearing retainer capscrews, worn U-joint trunnions or bearings, and worn slip-joint splines can lead to excessive movement of the driveshaft and cause driveline imbalance.

## Midship Bearings

A long driveshaft, supported only at its ends, will sag in the middle from its own weight. When turning at high rpm, it will flex, causing an out-of-balance vibration. Therefore, most vehicles having a long wheelbase use a midship bearing, mounted on a crossmember in the frame, for additional driveline support. See **Fig. 4**. This allows the driveshaft to be separated into two shorter shafts, thus improving balance and stability.

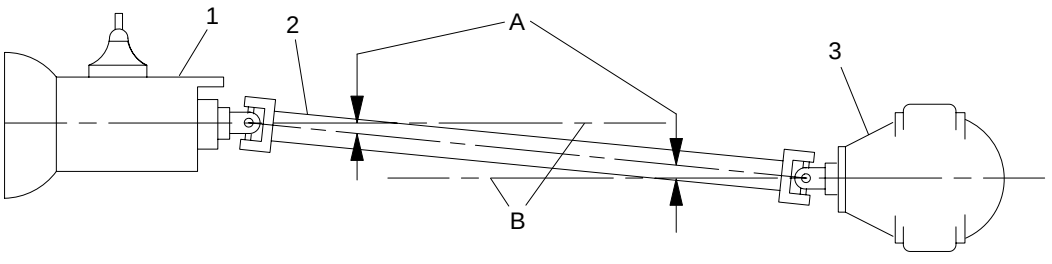
## Angularity Standards and Drivetrain Configuration

The U-joints require a minimum working angle of 1/2 degree to ensure needle-roller movement in the U-joint bearings. Without this movement, brinelling of the trunnion bearing-contact surfaces would occur. Suspension movement causes driveshaft angles to change (and therefore, needle-roller movement) in both of the U-joints attached to driveshafts that connect to the axles. However, no angle change occurs

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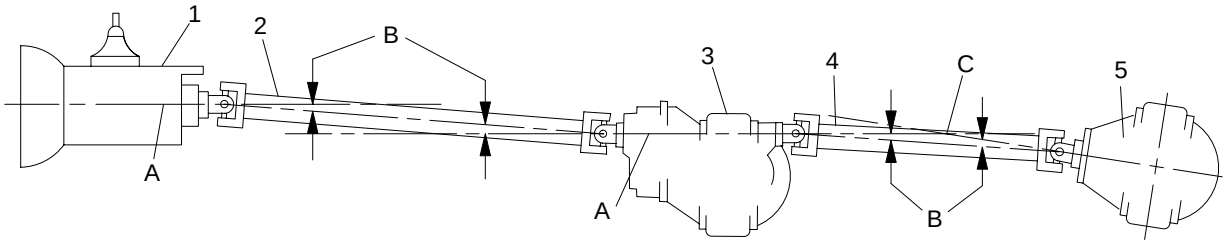
## General Information




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A. Equal U-Joint Working Angles
B. Parallel Centerlines
1. Transmission
2. No. 2 Driveshaft
3. Rear Axle

**Fig. 1, Parallel Arrangement for Single-Drive Vehicles**




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A. Parallel Centerlines
B. Equal U-Joint Working Angles
C. Intersecting Centerlines
1. Transmission
2. No. 2 Driveshaft
3. Forward-Rear Axle
4. No. 3 Driveshaft
5. Rearmost Axle

**Fig. 2, Intersecting Planing Arrangements for Dual-Drive Vehicles**

in the U-joints attached to a driveshaft that connects the main transmission to a midship bearing or auxiliary transmission. Their working angles must be established during installation.

When a midship bearing is included in the drivetrain, it is installed so that the centerline of the coupling shaft is in horizontal (side-to-side) alignment within 1/2 degree, and within 1/2 to 1 degree of vertical alignment, with the centerline of the main transmission output shaft. See **Fig. 4**.

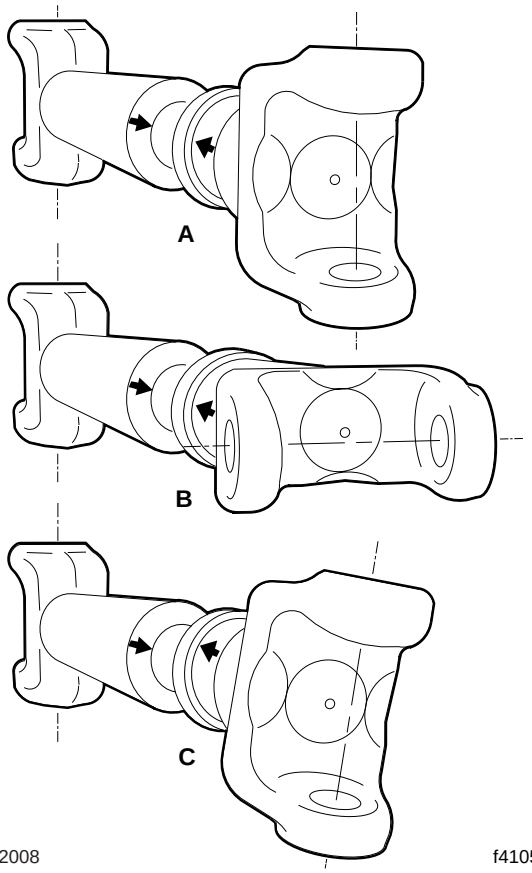
When an auxiliary transmission is included in the drivetrain, it is installed so that the centerline of the inter-transmission (no. 1) driveline is in exact horizontal (side-to-side) alignment (within 1/2 degree), and down 1/2 to 1 degree from vertical alignment, with the centerline of the main transmission output shaft. Further, the auxiliary transmission thru-shaft centerline must be parallel (horizontally and vertically) to the centerline of the main transmission output shaft, in order to achieve equal working angles. See **Fig. 5**.

Every U-joint has a maximum working angle, determined by the design and size of its cross assembly and yokes. Exceeding the maximum working angle can cause rapid U-joint wear, or in severe cases, destruction of the U-joint. For smooth operation and long drivetrain component life, the U-joint working angles must be kept small and approximately equal for each shaft.

The U-joint working angles may be made approximately equal by either of two basic arrangements: a parallel arrangement (**Fig. 1**) or an intersecting arrangement (**Fig. 2**). The parallel arrangement consists of installing the drivetrain components so that all of the input, output, and thru-shaft centerlines are approximately parallel. The intersecting arrangement (used only for some interaxle drivelines) consists of installing the drive components so that the rearmost axle pinion shaft's extended centerline intersects the

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A. In Phase (parallel phased)
B. In Phase (cross phased)
C. Out of Phase

**Fig. 3, Driveline U-Joint Phasing**

forward-rear axle thru-shaft's extended centerline approximately midway between the U-joints, when all of the other shafts (including the forward-rear axle thru-shaft) are approximately parallel.

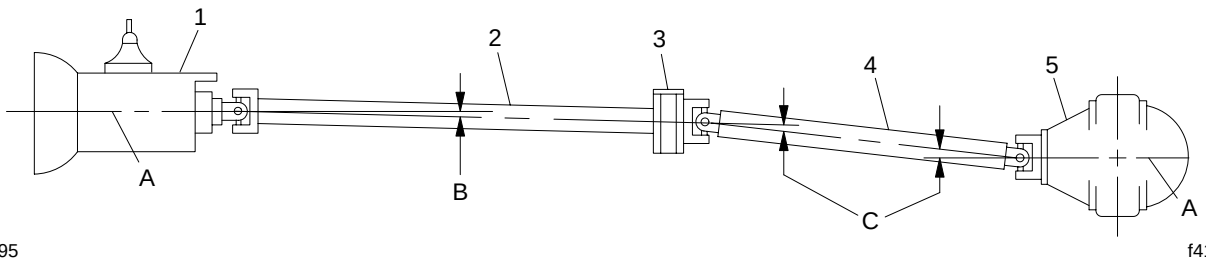
All single-drive vehicles, and the forward-rear axles of dual-drive vehicles, use the parallel arrangement. Rearmost axles of dual-drive vehicles may use the parallel arrangement or the intersecting arrangement, depending on the drivetrain configuration.

The specific drivetrain configuration of each vehicle consists of its wheelbase, number and type of axles, axle spacing, type of suspension, and number of transmissions. The specific drivetrain configuration determines the driveline arrangement and required installation angles of all the vehicle's drivetrain components.

The simplest drivetrain configuration consists of a single short driveline connecting a main transmission to a single-drive axle, in a parallel arrangement. This driveshaft is always referred to as the no. 2 driveshaft. The parallel arrangement always used on single-drive vehicles is shown in **Fig. 1**.

On dual-drive vehicles that have both axle input shafts of approximately the same height, a parallel arrangement is used. The driveshaft connecting the main (or auxiliary) transmission to the forward-rear axle is always referred to as the no. 2 driveshaft; and the interaxle driveshaft is always referred to as the no. 3 driveshaft. See **Fig. 6**, which shows a parallel arrangement when used on dual-drive vehicles.

Most dual-drive vehicles have a high thru-shaft on the forward-rear axle, and a low pinion on the rearmost axle. When the vehicle is on level ground, the




A. Parallel Centerlines
B. 1/2 to 1 Degree
C. Working Angles Unequal by 1/2 to 1 Degree

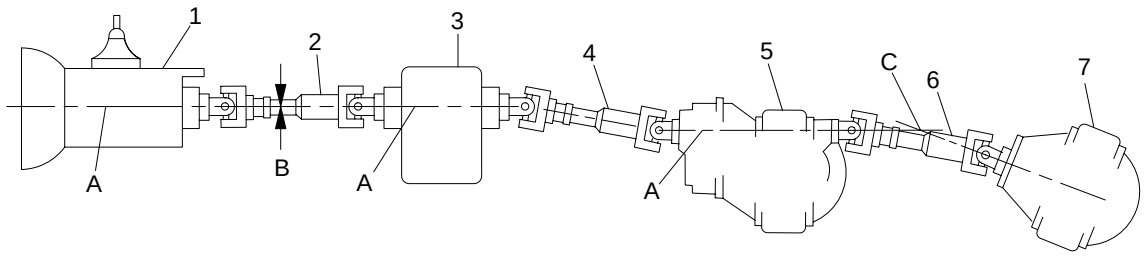
1. Main Transmission
2. Coupling Shaft
3. Midship Bearing
4. No. 2 Driveshaft
5. Rear Axle

**Fig. 4, Midship Bearing in a Single-Drive Vehicle**

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## General Information

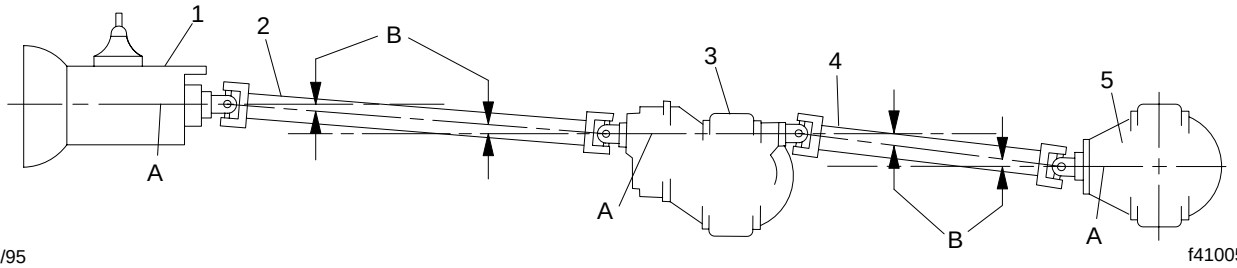



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A. Parallel Centerlines
B. 1/2 to 1 Degree
C. Intersecting Centerlines

1. Main Transmission
2. No. 1 Driveline
3. Auxiliary Transmission
4. No. 2 Driveshaft
5. Forward-Rear Axle
6. No. 3 Driveshaft
7. Rearmost Axle

**Fig. 5, Auxiliary Transmission in a Dual-Drive Vehicle**




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A. Parallel Centerlines
B. Equal U-Joint Working Angles

1. Transmission
2. No. 2 Driveshaft
3. Forward-Rear Axle
4. No. 3 Driveshaft
5. Rearmost Axle

**Fig. 6, Parallel Arrangement for Dual-Drive Vehicles**

interaxle (no. 3) driveshaft may create very sharp U-joint working angles with the input and output shafts when they are parallel. In normal driving, the U-joints could momentarily exceed their maximum working angle, and driveline or drivetrain damage could result. By using an intersecting arrangement at the no. 3 driveshaft, smaller U-joint working angles are created, promoting longer U-joint life and reduced driveline vibration. An intersecting arrangement used on dual-drive vehicles is shown in **Fig. 2**.

However, some axle spacings, axle models, and suspension designs allow additional axle movement or axle windup that requires additional clearances between the driveshaft and the frame or suspension components, or that creates other conditions that make the intersecting arrangement of the no. 3 driveshaft unsatisfactory. For those drivetrain configurations, it is necessary to use a modified parallel or modified-intersecting arrangement for the no. 3 driveshaft.

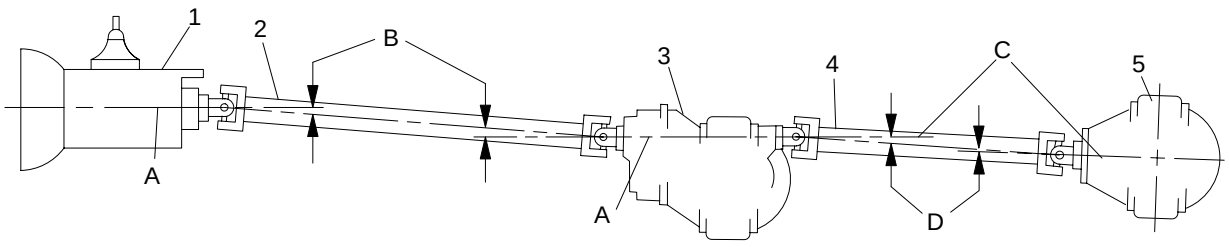
On drivetrain configurations that require a modified parallel arrangement, the rearmost-axle pinion shaft centerline is placed at an angle that is 2 degrees higher above horizontal than are the other input and output shafts. See **Fig. 7**.

On drivetrain configurations that require a modified-intersecting arrangement, the "proper" intersecting angle is determined, then the rearmost-axle pinion shaft centerline is placed at an angle that is 2 degrees closer to horizontal than the "proper" intersecting angle. See **Fig. 8**.

The axle pinion angles for all suspensions are factory-set for correct driveline angularity. On spring suspensions, tapered axle planing shims at the springs maintain the correct axle pinion angle. On

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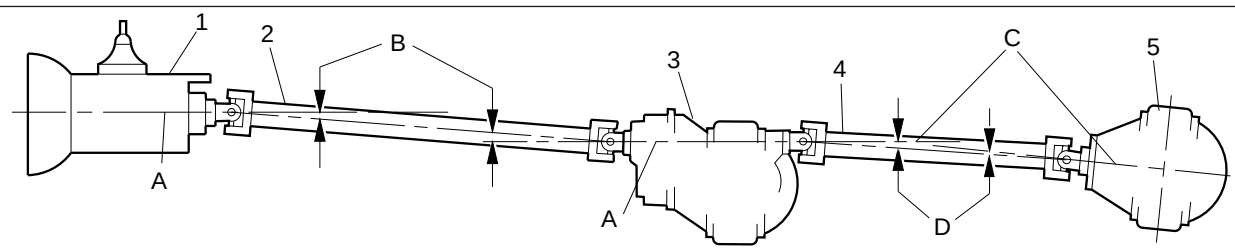





A. Parallel Centerlines
B. Equal U-Joint Working Angles
C. Modified-Parallel Centerlines
D. U-Joint Working Angles Not Equal by 2 Degrees

1. Transmission
2. No. 2 Driveshaft
3. Forward-Rear Axle
4. No. 3 Driveshaft
5. Rearmost Axle

**Fig. 7, Modified-Parallel Arrangement for Dual-Drive Vehicles**




A. Parallel Centerlines
B. Equal U-Joint Working Angles
C. Modified-Intersecting Centerlines
D. U-Joint Working Angles Not Equal by 2 Degrees

1. Transmission
2. No. 2 Driveshaft
3. Forward-Rear Axle
4. No. 3 Driveshaft
5. Rearmost Axle

**Fig. 8, Modified-Intersecting Arrangement for Dual-Drive Vehicles**

Hendrickson suspensions, spacers at the torque rods are used to maintain the correct axle pinion angles.

In the field, whenever axle or suspension components are changed, the axle pinion angles may also change. If this occurs, contact your district service manager for the correct axle pinion angle adjustment procedure.

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Use the procedure below for the type of tool being used. The Digital Angle Analyzer is the recommended tool.

## Digital Angle Analyzer

Before checking the pinion angles or engine angle, check that the engine and transmission mounts are tight and in good condition. Loose or deteriorated mounts will cause inaccurate readings.

IMPORTANT: When using a digital angle analyzer (DAA) or digital level, be sure to always take readings from the same side of the vehicle. Also, keep the same end of the DAA pointed toward the front of the truck.

Using a DAA (**Fig. 1**), measure the engine angle, driveshaft angles, and pinion angles. Read all angles to the nearest one-tenth of a degree.

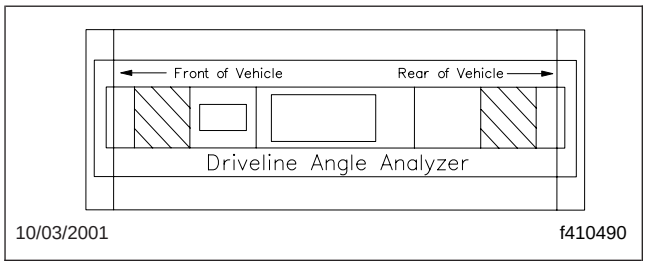
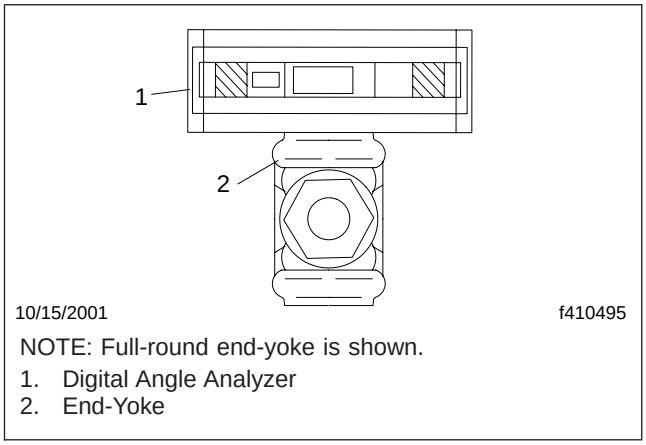



**Fig. 1, Digital Angle Analyzer**

After adjustment of any driveline angle, check the angle again. Also, verify ride height if the vehicle has an air suspension.

To measure the engine angle (transmission output-shaft angle) or axle pinion angles, do the following:

1. Inflate the vehicle tires to their normal operating pressure.
2. Park the unloaded vehicle on a level surface. Do not try to level the vehicle frame by jacking the front or rear axles. If the frame cannot be leveled from front to rear, determine and record the off-level inclination of the frame, and add or subtract that value from the measured values.
3. Chock the tires and place the transmission in neutral. Release the parking brakes.
4. The transmission output-shaft, coupling-shaft, and axle input- and output-yoke angles can be measured at either the top or bottom lug of the end-yoke being checked. For a full-round end-yoke, remove the bearing cup from the yoke lug. See **Section 41.00** for full-round end-yoke bearing cup removal.
5. Turn the end-yoke until the machined surface of the yoke lug is horizontal. See **Fig. 2**.




NOTE: Full-round end-yoke is shown.

1. Digital Angle Analyzer
2. End-Yoke

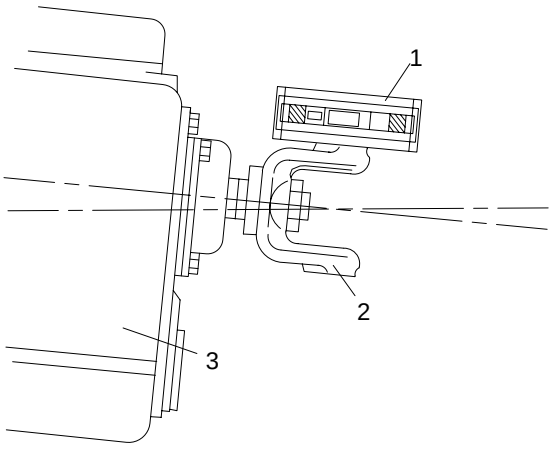
**Fig. 2, Horizontal Positioning of Yoke Lug Machined Surface**

6. To turn the driveshaft, raise one side of the rear (single-drive) or rearmost (dual-drive) axle until the tires are off the ground. Place a safety stand under the axle. With the transmission in neutral, and the interaxle differential (if equipped) unlocked, turn the tire to move the driveshaft.
7. Calibrate the digital level by placing it on the surface where the vehicle is parked at a 90-degree angle to the frame centerline. Zero the digital level.
8. Position the DAA alongside the U-joint trunnion, on the machined surface of the end-yoke, and at a 90-degree angle to the frame centerline. See **Fig. 2**. Then turn the end-yoke until the DAA reads 0 degrees. Remove the jack stand and lower the rear axle to the ground.
9. Calibrate the digital level by placing it on the surface where the vehicle is parked parallel to the frame centerline. Zero the digital level.
10. Without changing the position of the end-yoke, turn the DAA until it is parallel to the frame centerline. See **Fig. 3**. Record the measured angle of the pinion.

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## Engine and Pinion Angle Measurement




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NOTE: Full-round end-yoke is shown.

1. Digital Angle Analyzer
2. End-Yoke
3. Transmission

**Fig. 3, Measuring Pinion Angles**

11. For a full-round end-yoke, install the bearing cup. See **Section 41.00** for full-round end-yoke bearing cup installation.

# Spirit Level Protractor

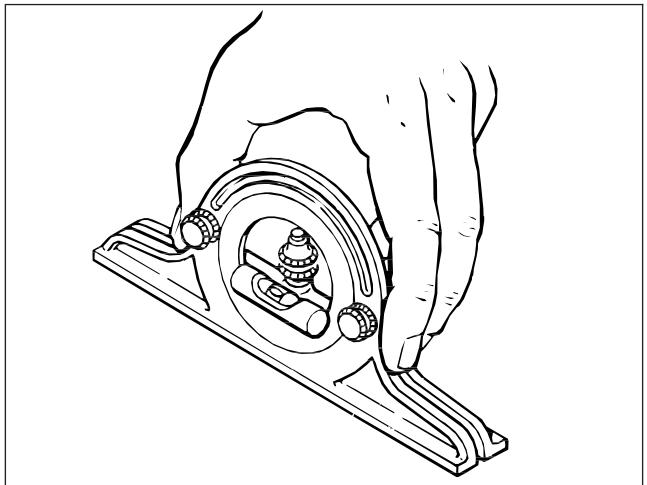
Before checking the pinion angles or engine angle, check that the engine and transmission mounts are tight and in good condition. Loose or deteriorated mounts will cause inaccurate readings.

Using a digital angle meter, spirit level protractor (see **Fig. 4**), or the head of a machinists's protractor, measure the engine angle, driveshaft angles, and pinion angles. Read all angles to the nearest one-tenth of a degree (6 minutes).

After adjustment of any driveline angle, check the angle again.

To measure the engine angle (transmission output-shaft angle) or axle pinion angles, do the following:

1. Inflate the vehicle tires to their normal operating pressure.
2. Park the unloaded vehicle on a level surface. Do not try to level the vehicle frame by jacking the front or rear axles. If the frame cannot be leveled from front to rear, determine and record the off-level inclination of the frame, and add or subtract that value from the measured values.



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**Fig. 4, Spirit Level Protractor**

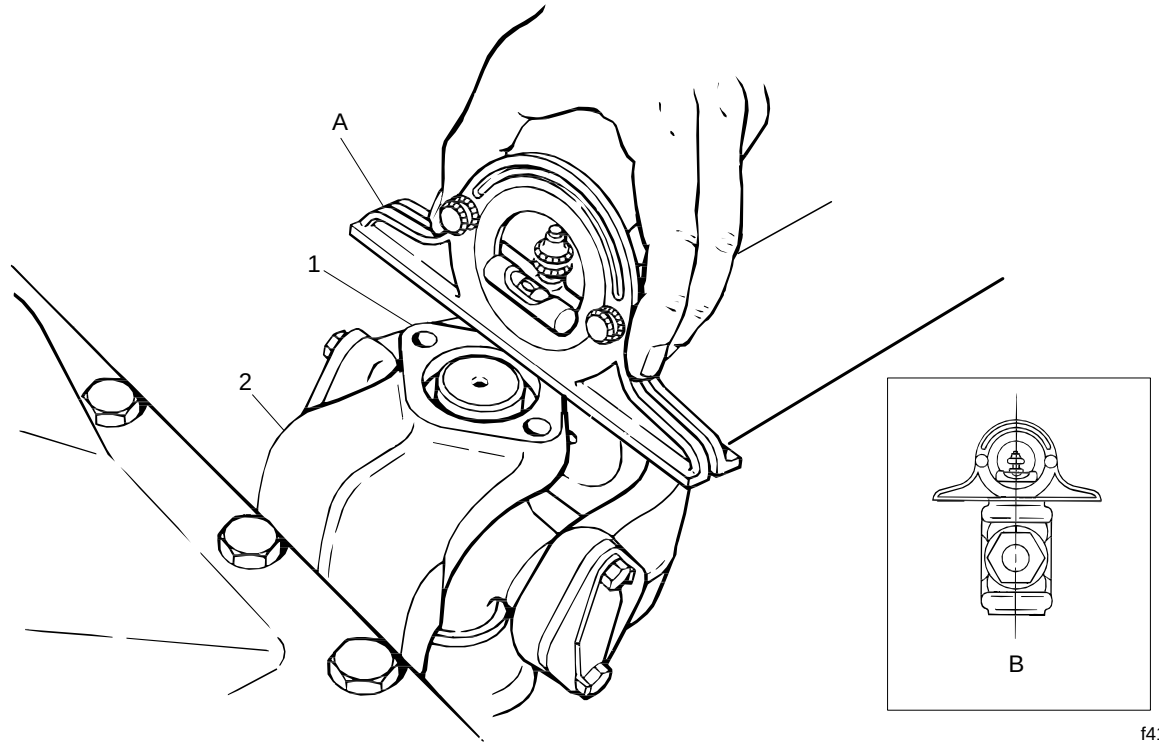
3. Chock the tires and place the transmission in neutral. Release the parking brakes.
4. The transmission output-shaft, coupling-shaft, and axle input- and output-yoke angles can be measured at either the top or bottom lug of the end-yoke being checked. For a full-round end-yoke, remove the bearing cup from the yoke lug. See **Section 41.00** for full-round end-yoke bearing cup removal.
5. Turn the end-yoke until the machined surface of the yoke lug is horizontal. See **Fig. 5**.

NOTE: To turn the driveshaft, raise one side of the rear (single-drive) or rearmost (dual-drive) axle until the tires are off the ground. Place a safety stand under the axle. With the transmission in neutral, and the interaxle differential (if equipped) unlocked, turn the tire to move the driveshaft.

6. Adjust the protractor scale to read 0 degrees. Position the protractor alongside the U-joint trunnion, on the machined surface of the end-yoke, and at a 90-degree angle to the frame centerline. See **Fig. 2**. Then turn the end-yoke until the bubble in the level vial is exactly between the two marks on the vial. Remove the jack stand and lower the rear axle to the ground.

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NOTE: Full-round end-yoke is shown.

A. Protractor held at right angle to vehicle frame centerline.
B. End view of end-yoke.

1. Machined Surface of Yoke Lug
2. End-Yoke

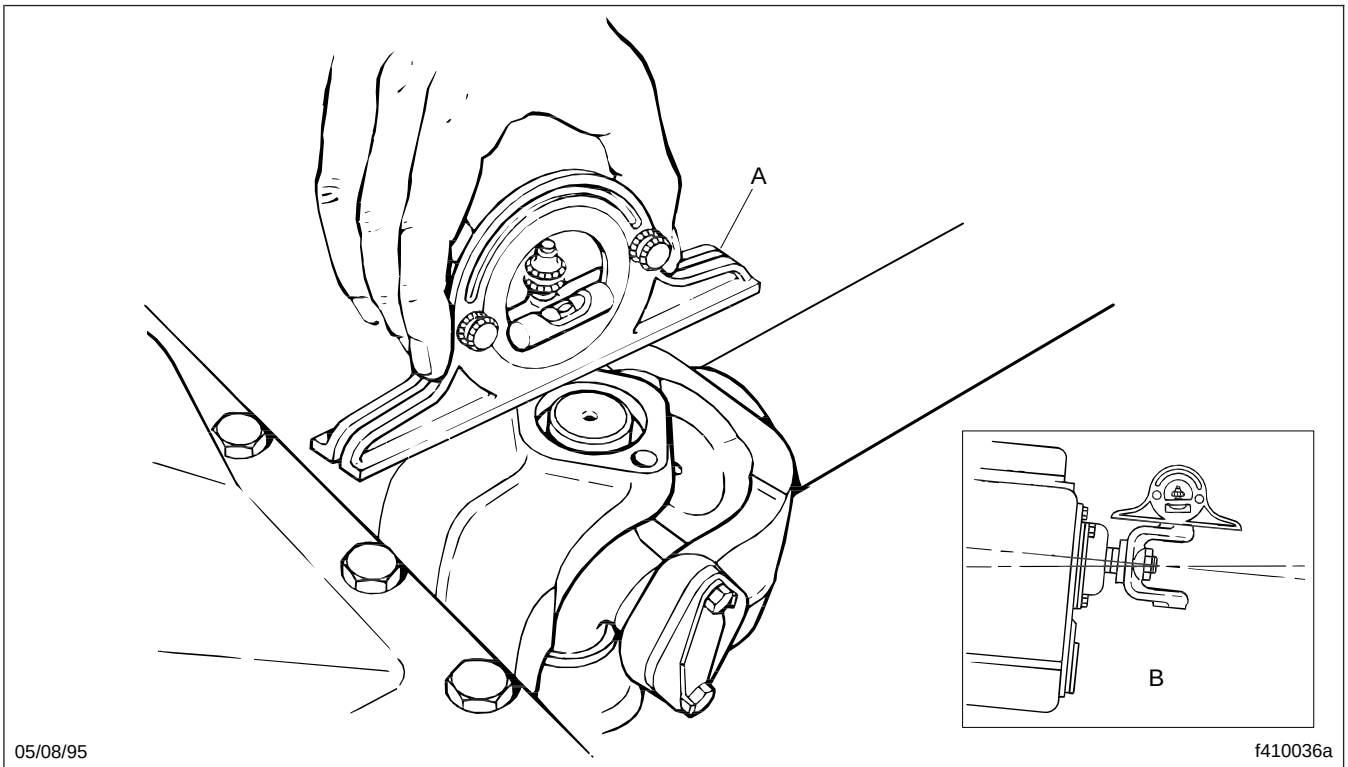
**Fig. 5, Horizontal Positioning of Yoke Lug Machined Surface**

7. Without changing the position of the end-yoke, turn the protractor until it is parallel to the frame centerline. See **Fig. 6**. Adjust the calibrated scale so the bubble is exactly between the two marks on the level vial. Record the calibrated scale reading opposite the "0" mark. Correct this value for any previously recorded off-level inclination.
8. For a full-round end-yoke, install the bearing cup. See **Section 41.00** for full-round end-yoke bearing cup installation.

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## Engine and Pinion Angle Measurement




NOTE: Full-round end-yoke is shown.

A. Protractor held parallel to vehicle frame centerline.
B. Side view of end-yoke.

**Fig. 6, Measuring Pinion Angles**

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## Driveline Angle Checking

Use the folowing procedure to check driveshaft angles for proper universal joint operating angles:

1. Inflate all tires to the pressure at which they are normally operated. Park the vehicle on a serface whis is as level as possible both from front-to-rear and from side-to-side. Do ot attempt to level the vehicle by jacking up the front or rear axles. Shift the transmission to neutral and block the front tires. Jack up a rear wheel.
2. Rotate the wheel by hand until the output yoke on the transmission is vertical, and lower the jack. This simplifies measurement later. Check driveshaft angles in the same loaded or unloaded condition as when the vibrations or noise occured
3. If using a protractor to measure angles, all angles should be read within 1/4 degree, and should be measured with the protractor held plumb on a clean flat surface. The electronic driveline inclinometer is automatically accurate to within 1/10 of 1 degree.

   Always measure the slope of the drivetrain going from front to rear. A component slopes downward if it is lower at the rear than the front. A component slopes upward when it is higher at the rear than it is in front.
4. Check and record the angle of the main transmission on the appropriate driveline angle chart. See **Fig. 1**, **Fig. 2**, **Fig. 3** or **Fig. 4**. This reading can be taken on the end yoke lug, with the bearing assembly removed or on a flat surface of the main transmission, parallel or perpendicular to the output yoke lug plane. Record your readings on the driveline angle chart as **Angle A**.
5. Next measure the driveshaft angle between the transmission and the steady bearing. On short tube length driveshafts, check the angle of the driveshaft on either the tube or slip yoke lug with the bearing assembly removed. On long tube length driveshafts, measure the angle on the tube at lease 3 inches (7.62 mm) away from the circle welds or at least 1 inch (2.5 mm) away from any balance weights. Be sure to remove any rust, scale or sound deadening compounds from the tube to obtain an accurate measurement. Record your readings on the driveline angle chart as **Angle B**.
6. Measure the angle of the driveshaft between the steady bearing and the forward rear axle, following the procedures in the previous step. Record your readings on the driveline angle chart as **Angle C**.
7. Check the forward axle input yoke angle by removing a bearing assembly and measuring the angle on the yoke lugs or on a flat surface of the angle housing, parallel or perpendicular to the input yoke lug plane. Record your readings on the driveline angle chart as **Angle D**.
8. Measure the angle of the tandem driveshaft between the forward axle and the rear axle. Record your readings on the driveline angle chart as **Angle E**.
9. Check the rear axle input yoke angle by removing the bearing assembly and measuring the angle on the yoke lugs or on a flat surface of the angle housing, parallel or perpendicular to the input yoke lug plene. Record your readings on the driveline angle chart as **Angle F**.

   All the angles on the chart should be filled in now.
10. To determine the universal joint operating angles, find the difference in the angles of the components.

    When the slopes are in the **same** direction on two connected components, **subtract** the smaller number from the larger to find the universal joint operating angle.

    When the slopes are in the **opposite** direction on two connected components, **add** the measurements to find the universal joint operating angle.

    The optimum operating angles on each end of the driveshaft should be equal to or within 1 degree of each other, have a 3 degree maximum operating angle, and have at least 1/2 of a degree continuous operating angle.

## Correcting Driveline Angle

The recommended method for correcting severe universal joint operating angles depends on the vehicle suspension or driveline design.

On vehicles with leaf spring suspensions, thin wedges called axle shims can be installed under the

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## Driveline Angle Checking

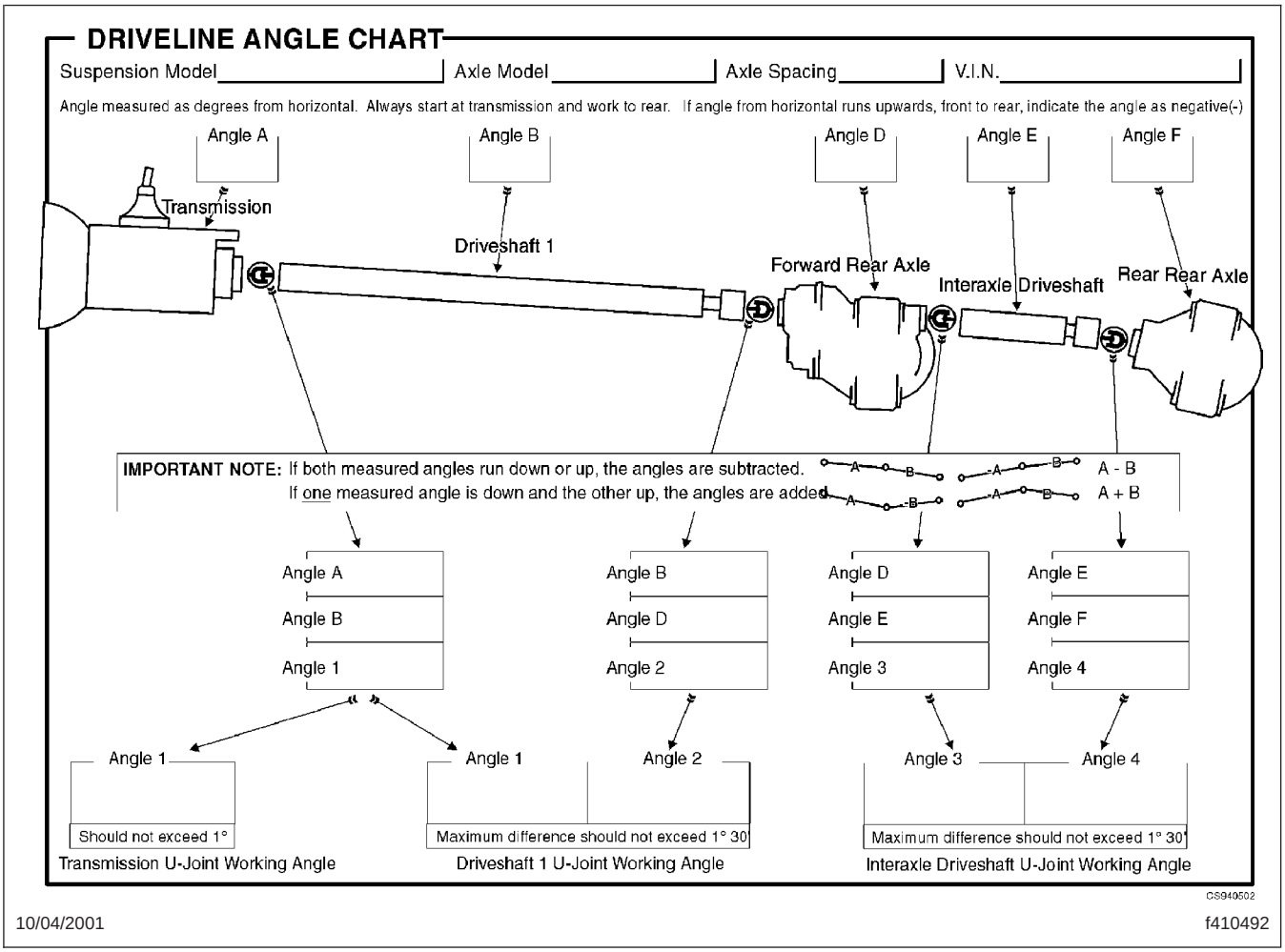



**Fig. 1, Driveline Angle Chart, Dual Driveshafts**

leaf spring of single axle vehicles to tilt the axle and correct universal joint operating angles. Wedges are available in a range of sizes to change pinion angles.

On vehicles with tandem axles, the torque rods can be shimmed. Torque rod shims rotate the axle pinion to change the universal joint operating angle. A longer or shorter torque rod may be available, if shimming is not practical.

As a general rule, the addition or removal of a 1/4-inch (6.35 mm) shim from the rear torque arm will change the axle angle approximately 3/4 of a degree. A 3/4 of a degree change in the pinion angle will change the universal joint operating angle about 1/4 of a degree.

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## Driveline Angle Checking

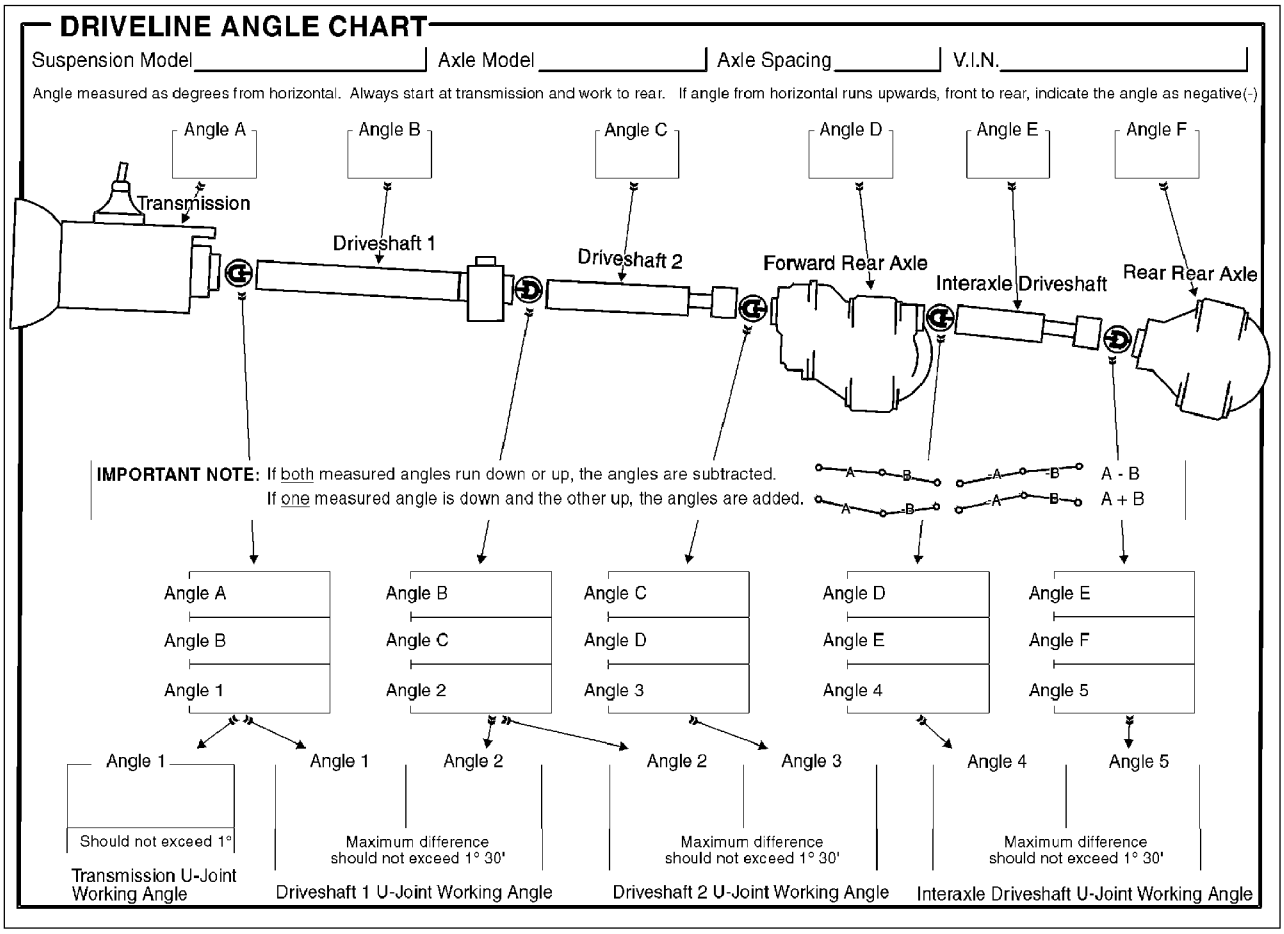



**Fig. 2, Driveline Angle Chart, Single Driveshaft**

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## Driveline Angle Checking

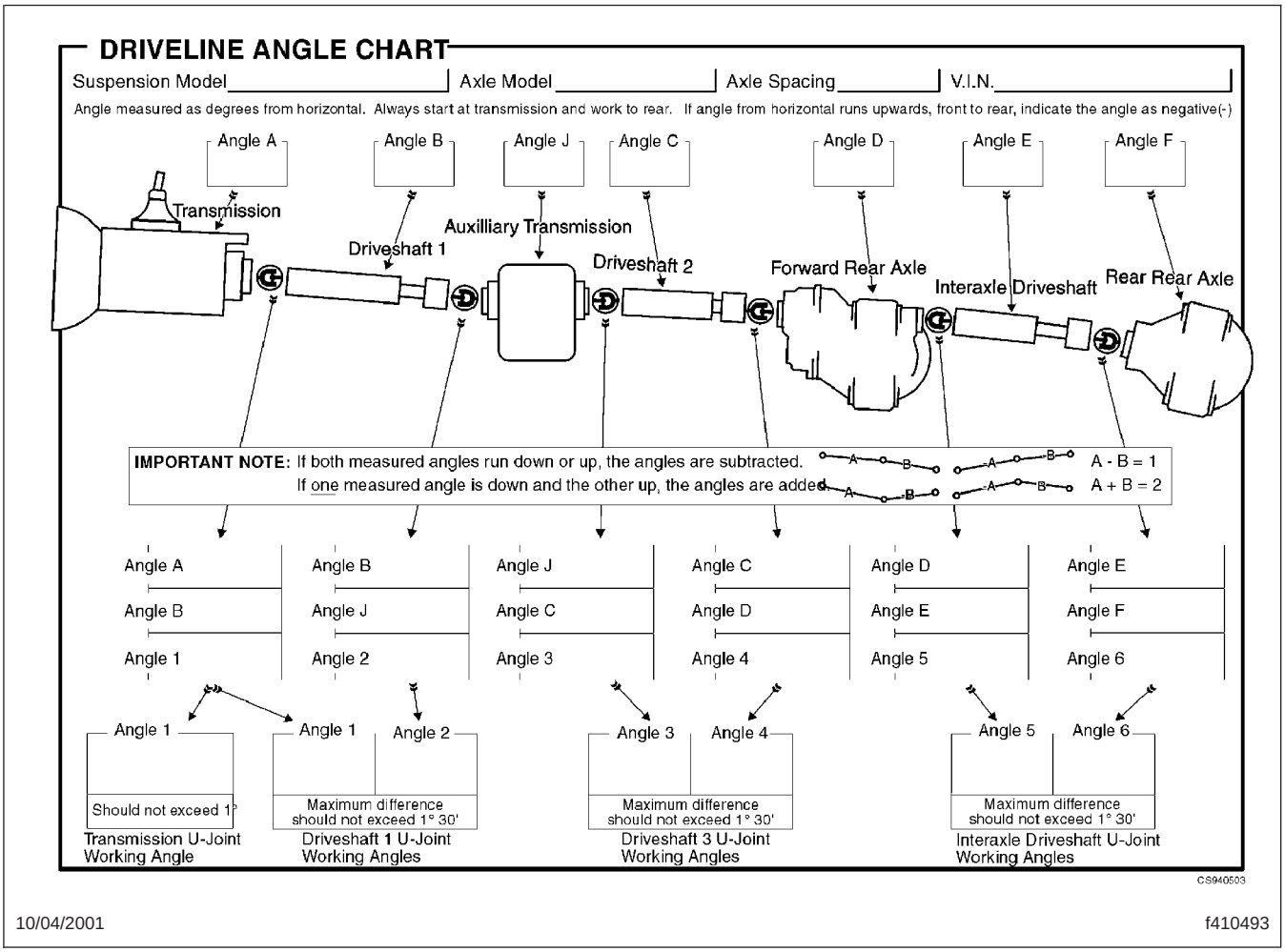



**Fig. 3, Driveline Angle Chart, Dual Driveshafts with Auxilliary Transmission**

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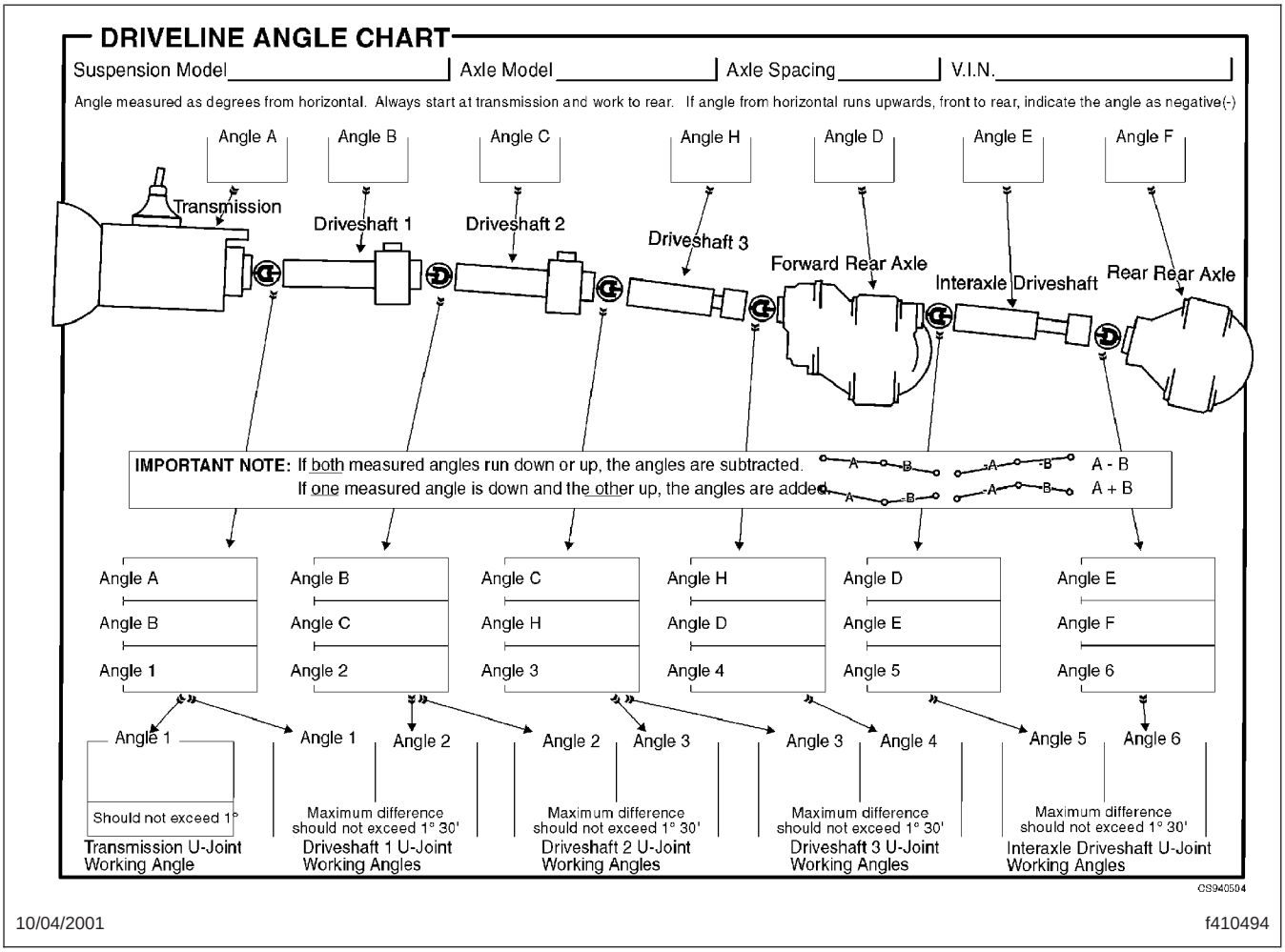



**Fig. 4, Driveline Angle Chart, Triple Driveshafts**

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## Specifications

| Application | lbf·ft | N·m |
|---|---|---|
| 1610 Series | 17–24 | 23–32 |
| 1880 Series | 50–60 | 68–81 |
| All Others | 32–42 | 42–56 |

**Table 1, Torque Specifications, Bearing Capscrews**

| Application | lbf·ft | N·m |
|---|---|---|
| 1610, 1710 Series | 40–48 | 54–65 |
| 1760, 1810 Series | 50–60 | 68–81 |
| 1880 Series | 194–232 | 263–314 |

**Table 2, Torque Specifications, Flange Bolts**

| Application | lbf·ft | N·m |
|---|---|---|
| Dana Spicer Axle | 780–960 | 1060–130 |
| Meritor Axle | 450–600 | 600–800 |
| Fuller Transmission | 450–500 | 600–675 |
| Spicer Transmission | 550–600 | 740–800 |

**Table 3, Torque Specifications, Yoke Nuts**

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## General Description

The Bendix PP-DC parking brake air valve is installed on non-towing trucks with air parking brakes, and is used to control the rear axle parking brakes. It is a push-pull type of valve, and is mounted on the right side of the dash.

## Principles of Operation

When the valve knob is pulled out, air is exhausted from the parking brake chambers, releasing the springs, and applying the parking brakes. When the knob is pushed in, air flows into the parking brake chambers from one of the reservoirs, and compresses the springs, releasing the parking brakes.

The PP-DC has a double check valve feature. If the pressure drops in either air system (primary or secondary), the valve will automatically use air pressure from the system with the higher pressure for the parking brakes. This prevents the parking brakes from applying automatically unless pressure is lost from both systems.

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## Safety Precautions

When working on or around air brake systems and components, observe the following precautions.

- Chock the tires and stop the engine before working under a vehicle. Keep hands away from brake chamber pushrods and slack adjusters; they may apply as air system pressure drops.
- Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
- Never exceed recommended air pressure, and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
- Never attempt to disassemble a component until you have read and understand the recommended procedures. Some components contain powerful springs and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to use of those tools.

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## Parking Brake Dash Valve Tests

**WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

Refer to **Fig. 1** for valve disassembly and assembly.

## Operating Test

1. Chock the tires.
2. Start the engine and build the air pressure to the normal operating level.
3. With the valve knob pulled out, supply either supply port with 120 psi (827 kPa) of pressure. Push the valve knob in. Air pressure should rise in the delivery line, and should equal supply line pressure.

   Pull the valve knob out. Delivery pressure should exhaust to zero.
4. Build air pressure to each supply source to 120 psi (827 kPa). Decrease supply pressure at the secondary service reservoir supply port at a rate of 10 psi (69 kPa) per second.

   Primary supply pressure and delivery pressure should not drop below 100 psi (690 kPa). Repeat this step for decreasing primary service reservoir pressure.
5. Build air pressure to each supply source to 120 psi (827 kPa). Then decrease both supply pressures to below 20 to 30 psi (138 to 207 kPa). The valve knob should automatically pop out when the pressure is within that range.
6. If the valve does not work as described, repair the valve or replace it, as instructed in **Subject 130**.

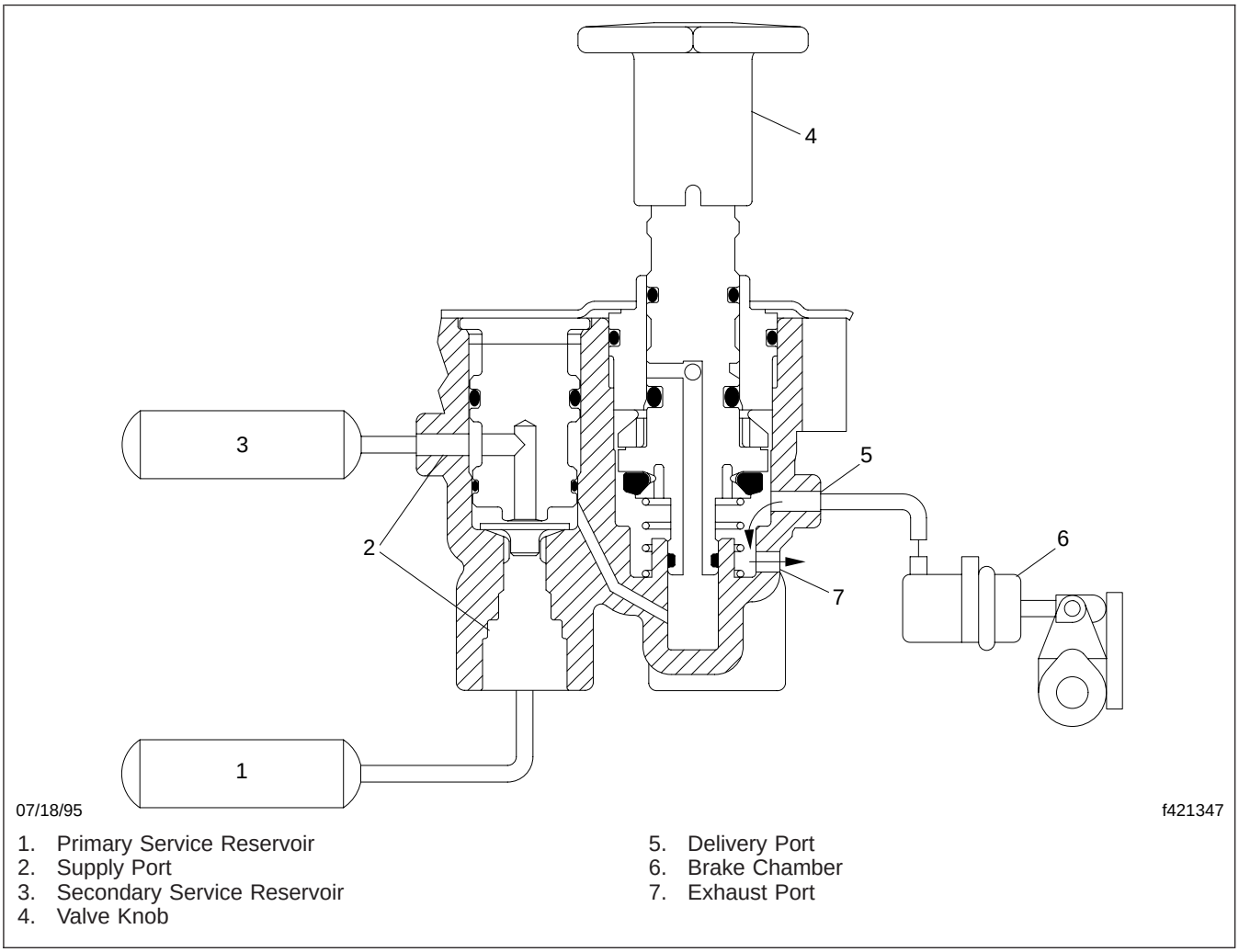
## Leak Testing

1. Chock the tires.
2. Supply the valve with 120 psi (827 kPa) from the primary reservoir supply port.
3. With the valve knob pulled out, coat the exhaust port and the plunger stem with a soapy solution. Leakage at either fitting should not exceed a 1-inch (2.5-cm) bubble every five seconds. There should be no leakage from the secondary reservoir supply port.
4. Supply the valve with 120 psi (827 kPa) from the secondary reservoir supply port. There should be no leakage from the primary reservoir supply port.
5. With the valve knob pushed in, coat the exhaust port and the plunger stem with a soapy solution. Leakage at the fittings should not exceed a 1-inch (2.5-cm) bubble every three seconds. If it does, replace or repair the valve, following instructions under **Subject 130**.

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## Parking Brake Dash Valve Tests




1. Primary Service Reservoir
2. Supply Port
3. Secondary Service Reservoir
4. Valve Knob
5. Delivery Port
6. Brake Chamber
7. Exhaust Port

**Fig. 1, Parking Brake Dash Valve (sectional view)**

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# Parking Brake Dash Valve Removal and Installation

## Removal

**WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

1. Park the vehicle on a level surface and apply the parking brakes. Chock the tires.
2. Drain the air tanks.
3. Remove the trim plate assembly from the radio and heater/air conditioner control panel. See Fig. 1.
4. Remove the screw from the right-hand trim cap. Remove the trim cap from the dash.
5. Remove the four screws that attach the auxiliary instrument panel in the dash. Pull the panel out to access the valve mounting screws.

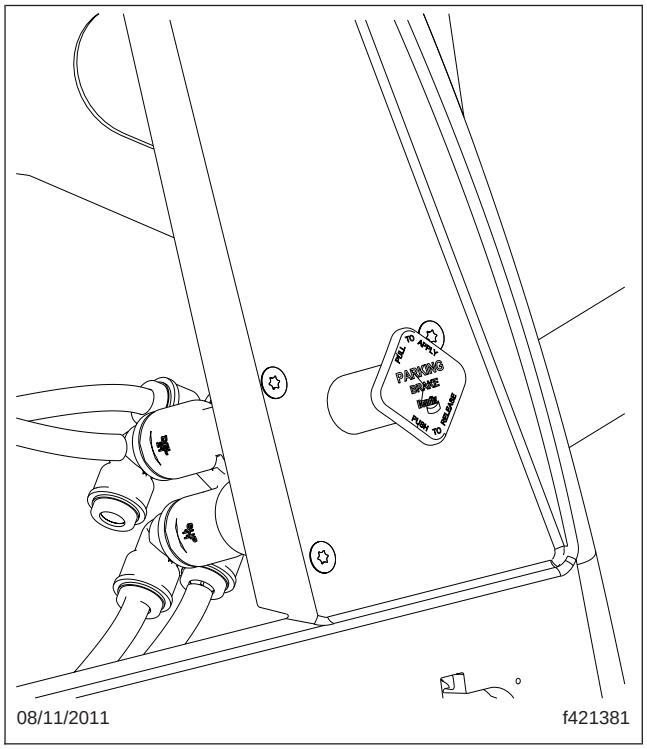



**Fig. 1, Parking Brake Hand Valve Mounting**

6. Turn the valve knob counterclockwise and remove it from the valve stem.
7. Mark the air lines for later reference, then disconnect them from the valve assembly.

NOTE: The primary supply line is green; the secondary supply line is red; the exhaust line is silver and 3/8 inch (10 mm) in diameter; the delivery line is black and 3/8 inch (10 mm) in diameter.

8. Remove the four screws that attach the valve to the auxiliary instrument panel. Remove the valve.

## Installation

1. Position the valve assembly in the auxiliary instrument panel. Install the four mounting screws.
2. Connect the air lines to the applicable fittings.
   - 2.1 Tighten the fitting hand tight.
   - 2.2 Using a wrench, tighten the fitting until the connection feels firm.
   - 2.3 Tighten the fitting an additional one-sixth turn.
3. Screw the valve knob onto the valve stem.
4. Leak test the fittings, following the instructions under Subject 110.
5. Install the auxiliary instrument panel, right-hand trim cap, and the radio and heater/air conditioner trim plate assembly.

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# Parking Brake Dash Valve Disassembly and Assembly

**⚠ WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

## Disassembly

1. Remove the valve assembly from the dash, following the instructions under **Subject 120**.
2. Put the valve assembly in a soft-jawed or padded vise.
3. Remove the screws that attach the cover to the body. Remove the cover. See **Fig. 1**.
4. Pull the plunger stem and remove the plunger and guide spool from the body.
5. Remove and discard the plunger spring.
6. Using a screwdriver (if needed), carefully remove the check valve seat from the body. Use care to not damage either the check valve seat or the valve body.
7. Remove and discard the check valve seat O-rings.
8. Turn the body upside down and gently tap it on a flat surface to remove the check valve. Discard the check valve.
9. Remove the guide spool from the plunger. Remove and discard the O-ring.
10. Remove and discard the O-rings from the plunger. Also, remove and discard the exhaust seal.

## Assembly

1. Clean and dry all the parts.
2. Check all the parts. Replace a part if any wear or damage is found.
3. Lightly grease all the parts, including the new parts from the maintenance kit, with Dow Corning 55 silicone pneumatic grease or equivalent.
4. Position the check valve in its seat in the body with the flat surface of the valve facing up. If needed, reach into the body to make sure that the valve is seated evenly in the bore. See **Fig. 1**.
5. Install the O-rings on the check valve seat and install the assembly into the body. Make sure that the check valve seat is even with the valve body surface.
6. Install the plunger spring into the body. Make sure that the spring is upright and seated properly in the body bore.

NOTE: The plunger spring should surround the protrusion or "lip" at the bottom of the body bore.

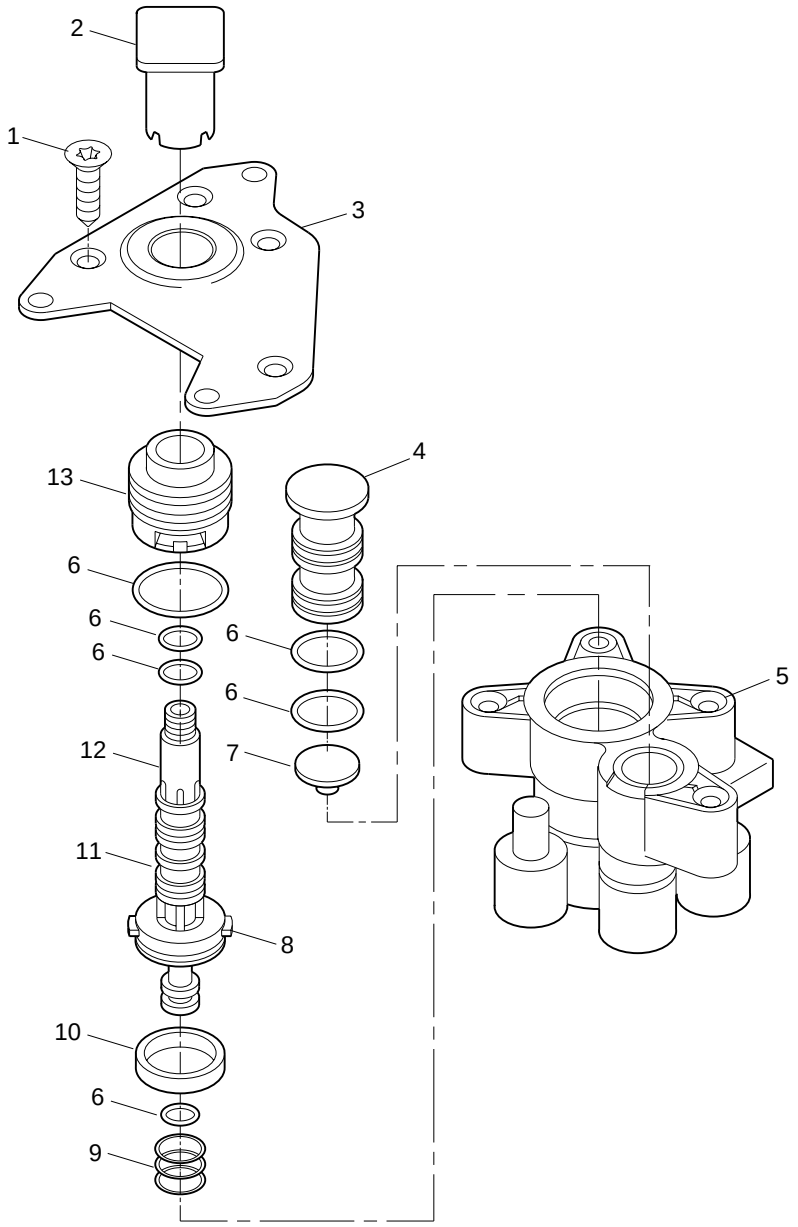
7. Install the O-rings onto the plunger, then install the plunger into the body.

   For ease of installation, line up the plunger's index tabs with the spaces in the body bore.
8. Install the O-ring on the guide spool. Install the spool over the plunger and into the body. Firmly press the guide spool into position.
9. Install the screws that attach the cover to the body. Tighten the screws 35 lbf·in (395 N·cm).
10. Install the valve in the dash, then leak test it. Follow the instructions under **Subject 120** for installation and **Subject 110** for leak testing.

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## Parking Brake Dash Valve Disassembly and Assembly




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1. Screw
2. Valve Knob
3. Cover
4. Check Valve Seat
5. Valve Body
6. O-Ring
7. Check Valve
8. Index Tab
9. Plunger Spring
10. Exhaust Seal
11. Plunger
12. Plunger Stem
13. Guide Spool

**Fig. 1, Exploded View**

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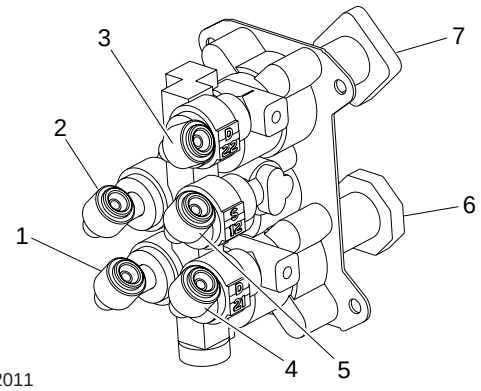


## General Description

The dash-mounted MV-3 control module is a two-button, push-pull control valve housed in a single body, which includes a dual circuit supply valve and a check valve.

The valve body, plungers, and spools are made out of a nonmetallic, noncorrosive material. All air connections are at the back of the valve. See **Fig. 1**.

The MV-3 module has several functions: tractor protection; trailer service air control; system park; trailer park only; trailer charge with tractor spring brakes applied (tractor park only); and supply reservoir selection.



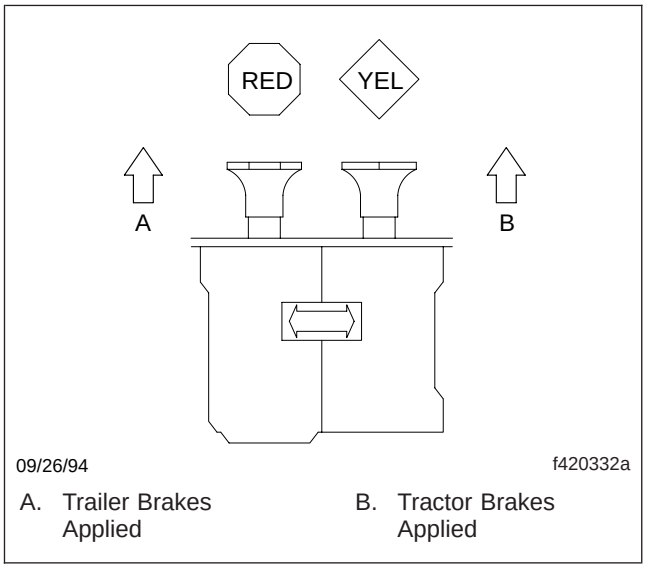

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1. Exhaust
2. Primary Reservoir Supply
3. Delivery–Tractor Spring Brakes
4. Delivery–Trailer Supply
5. Secondary Reservoir Supply
6. Trailer Air Supply Knob
7. Parking Brake Control Valve Knob

**Fig. 1, MV-3 Parking Brake Valve**

The MV-3 includes a spring-loaded, dual-circuit supply valve, which selects the primary air reservoir as the air source for both control valves, unless the pressure in the primary air reservoir falls below that of the secondary air reservoir. Then, the dual-circuit supply valve will shuttle and establish the secondary air reservoir as the air source.

The trailer air supply valve, actuated by the red knob and the yellow knob, delivers air to the trailer supply line. See **Fig. 2**. The parking brake valve, actuated by a yellow knob, controls the spring parking brakes on the tractor, and when exhausted, simultaneously causes the trailer supply valve to trip and exhaust, thus applying both the tractor and the trailer parking brakes as required by federal regulations. See **Fig. 2**. The trailer parking brakes may be independently released by pushing only the trailer air supply valve (red) knob in.




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A. Trailer Brakes Applied
B. Tractor Brakes Applied

**Fig. 2, Trailer and Tractor Delivery Air Discharged (control knobs out)**

## Principles of Operation

### Initial Charge

With both the primary and the secondary systems completely discharged, both knobs are out. See **Fig. 2**. When system pressure reaches 65 psi (448 kPa), the red knob (trailer air supply) may be pushed in, and should stay in, charging the trailer system and releasing the trailer parking brakes. See **Fig. 3**. The yellow knob (parking brake) may now be pushed in, which will supply air to the tractor parking brakes, releasing them.

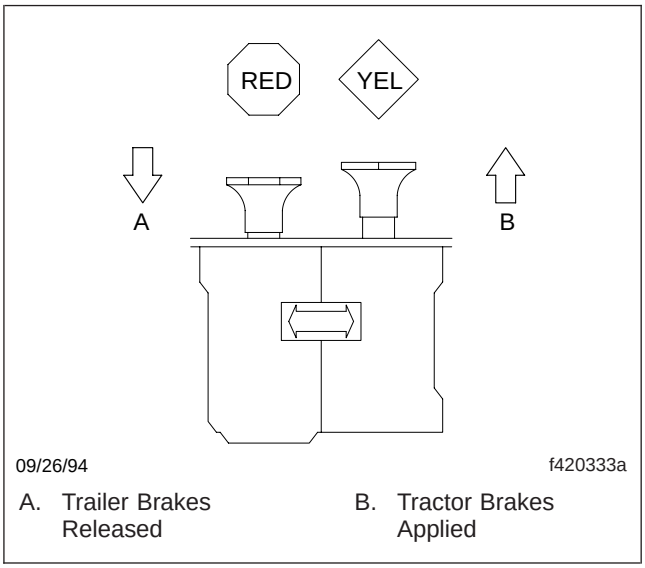
### Normal Operation Position

When both knobs are pushed in, air is supplied to the trailer and the tractor parking brakes; all parking brakes are released. See **Fig. 4**. This is the normal operating mode.

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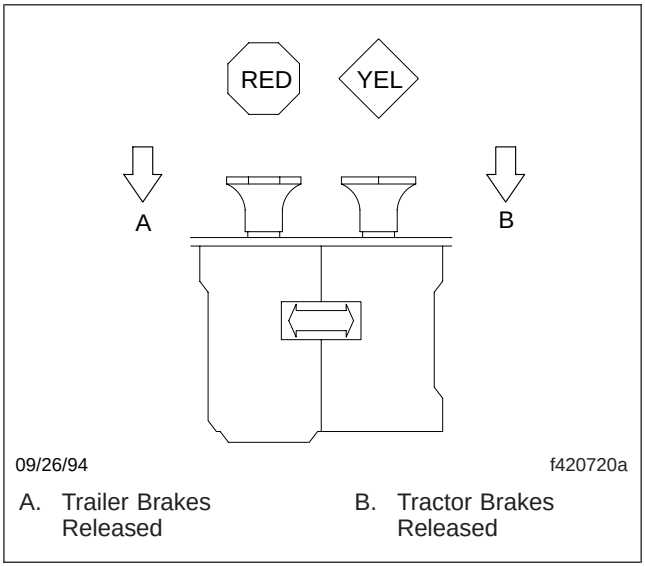


## General Information




A. Trailer Brakes Released
B. Tractor Brakes Applied

**Fig. 3, Trailer Parking Brakes Released (red control knob pushed in)**

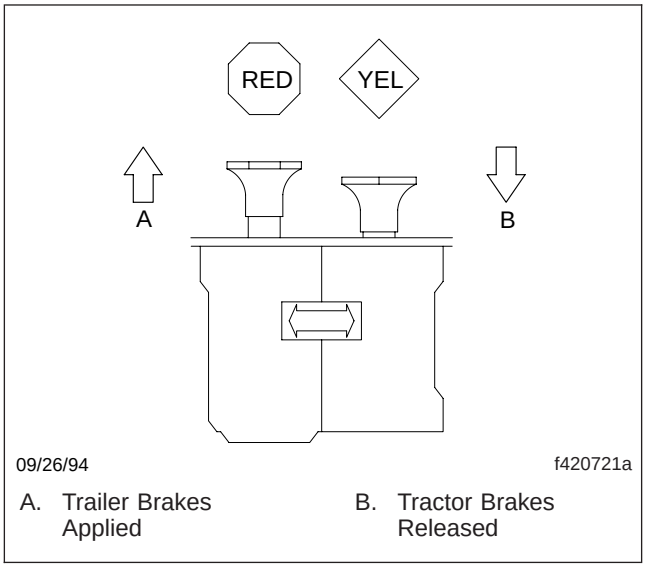



A. Trailer Brakes Released
B. Tractor Brakes Released

**Fig. 4, Trailer and Tractor Brakes Released (both control knobs pushed in)**

# Actuation of Trailer Park or Emergency Brakes

To actuate the trailer parking brakes only, the red knob is pulled out, exhausting the trailer supply line. The trailer parking brakes are now applied, either by emergency air or parking brakes, depending on the type of trailer system. This mode would be used to uncouple from the trailer, and during bobtail operation. See **Fig. 5**.




A. Trailer Brakes Applied
B. Tractor Brakes Released

**Fig. 5, Trailer Parking Brakes Applied (red control knob pulled out)**

# System Park

With both knobs pushed in, the parking brakes on both the tractor and the trailer may be actuated by pulling the yellow (parking brake) knob out. This exhausts the air from the tractor parking brakes and simultaneously causes the red (trailer air supply) knob to pop out, applying the trailer parking brakes (this complies with federal regulations that one control must apply all the parking brakes on the vehicle). See **Fig. 2**.

# Trailer Charge

If both valves are out, parking the combination vehicle, and it is desired to recharge the trailer (leaving only the tractor parking brakes applied), the red knob may be pushed in, repressurizing the trailer supply line. This mode might also be used to park a combination vehicle with air-actuated emergency brakes on the trailer to provide demonstrated parking capability with the tractor spring brakes only. See **Fig. 3**.

# Automatic Applications

If air pressure drops to 20 to 45 psi (138 to 310 kPa) in both the primary and the secondary systems, the

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red knob (trailer air supply valve) will automatically pop out, applying the emergency or parking brakes on the trailer. If the red knob is held in manually and the pressure decreases to 25 to 35 psi (172 to 241 kPa), a tripper piston within the MV-3 valve will move upward, exhausting the trailer supply, and applying the trailer parking brakes. If air pressure drops in both the primary and the secondary systems, the yellow (parking brake) knob will pop out at about 20 to 40 psi (138 to 276 kPa), applying the tractor parking brakes.

A warning buzzer and light are activated when pressure in either the primary or the secondary system drops below 64 to 76 psi (441 to 524 kPa).

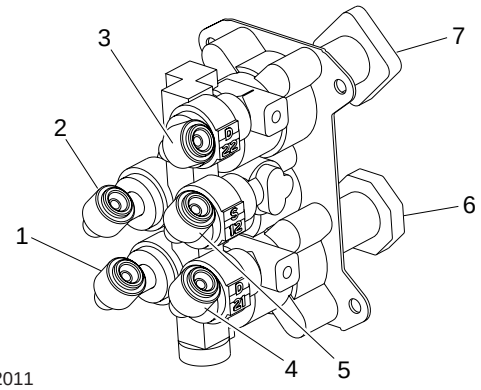
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## Tests

With the air brake system charged to 120 psi (827 kPa), check for leaks, using the following instructions. Repair or replace components as needed.

1. Apply a soap solution and check for leakage between the body and cover plate. Leakage at the exhaust port should produce less than a 1-inch (25-mm) bubble in five seconds.
2. With the trailer supply line sealed, push in the red knob. The knob must stay in. Leakage at the exhaust port must not exceed a 1-inch (25-mm) bubble in 5 seconds. See **Fig. 1**.




1. Exhaust
2. Primary Reservoir Supply
3. Delivery–Tractor Spring Brakes
4. Delivery–Trailer Supply
5. Secondary Reservoir Supply
6. Trailer Air Supply Knob
7. Parking Brake Control Valve Knob

**Fig. 1, MV–3 Parking Brake Valve**

3. Slowly reduce pressure in both service reservoirs. The red knob must pop out at 20 to 35 psi (138 to 310 kPa).

NOTE: Trip-on pressure is the pressure at which the valve automatically changes position or "pops out." It is advised to use an accurate pressure gauge other than those in the truck when performing tests.

4. Hold the red knob in and continue to reduce pressure in all service reservoirs. Air must start to escape from the exhaust port when the trailer line pressure reaches 20 to 35 psi (138 to 241 kPa).
5. Release the red knob and rebuild the supply pressure to 120 psi (827 kPa). Push in the yellow knob; the yellow knob must remain in. Leakage at the exhaust port should not exceed a 1-inch (25-mm) bubble in 5 seconds.
6. Pull the red knob out. Slowly reduce pressure in all service reservoirs. There is not a federal trip pressure requirement for the yellow knob, but it will pop out at 20 to 30 psi (138 to 207 kPa).
7. Charge the system to 120 psi (827 kPa), and push both knobs in. Pull the red knob out. The yellow knob must remain in. Push the red knob in and pull the yellow knob out. The red knob must pop out at once.
8. Install a gauge to monitor tractor spring brake delivery pressure. Build 120 psi (827 kPa) pressure in the primary and secondary air reservoirs. Push in the yellow knob. Delivery pressure should equal the pressure in the primary air reservoir. Reduce the pressure in the primary air reservoir. The dual-circuit supply valve shuttle should switch to the secondary air reservoir. After the primary air reservoir pressure is reduced to zero, there should not be audible leakage at the primary air reservoir opening. Stop the leak that was created in the primary air reservoir.
9. Leaving the yellow knob in, recharge the secondary air reservoir to 120 psi (827 kPa). The delivery pressure should also read 120 psi (827 kPa). Recharge the primary air reservoir to 100 psi (690 kPa). Slowly vent the secondary air reservoir. As the secondary air reservoir pressure and the delivery line pressure descend, pressure should stabilize at about 100 psi (690 kPa).
10. Close all leakage points and charge both reservoirs to 120 psi (827 kPa). Position the red knob out and the yellow knob in. Develop a leak in the spring brake delivery line and hold the yellow knob in. See **Fig. 1**. The air reservoir pressures will go to zero. The dual-circuit supply valve shuttle should cycle during the leak-down period.
11. If the MV-3 fails to operate as described, or leakage exceeds the limits stated, replace or repair it using genuine Bendix parts.

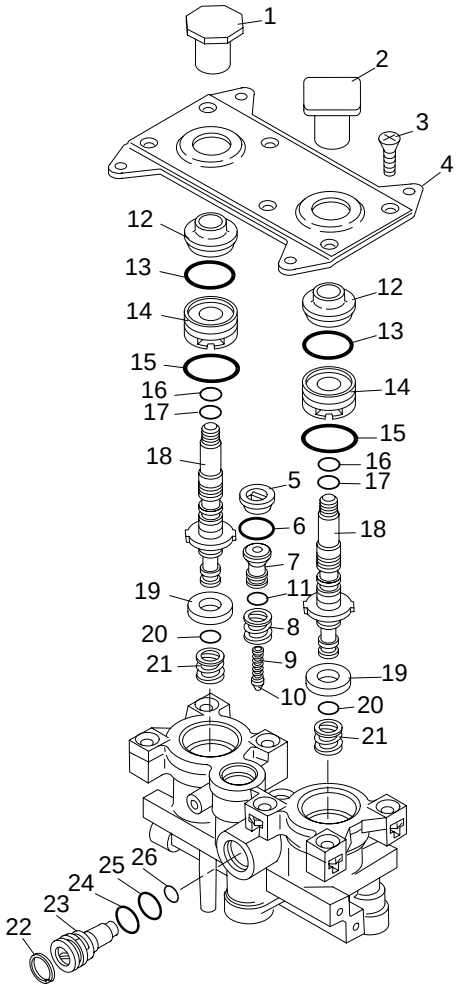
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## Control Module Disassembly, Cleaning and Inspection, and Assembly

# Disassembly

1. Remove the six screws from the cover plate and carefully remove the cover plate from the valve. See **Fig. 1**.
2. Remove the cap and O-ring from the bore of the tripper valve. Remove the tripper piston, large spring, small spring, and check valve. These parts will all fall out of the cavity of the MV–3 by




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1. Red Knob
2. Yellow Knob
3. Screw
4. Cover Plate
5. Cap
6. O-Ring
7. Tripper Piston
8. Spring, Large Diameter
9. Spring, Small Diameter
10. Check Valve
11. O-Ring
12. Guide Cap
13. O-Ring
14. Guide Spool
15. O-Ring
16. O-Ring
17. O-Ring
18. Plunger
19. Exhaust Seal, Beveled
20. O-Ring
21. Spring
22. Retaining Ring
23. Cap and Dual Circuit Valve Assembly
24. O-Ring
25. O-Ring
26. O-Ring

**Fig. 1, MV-3 Valve, Exploded View**

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## Control Module Disassembly, Cleaning and Inspection, and Assembly

tilting the body forward. Remove the O-ring from its groove on the piston.

3. Remove the two main spools from the body of the MV–3 valve by grasping the stem and pulling firmly. Remove the spring from the bottom of each spool cavity.
4. Pull the guide cap and guide spool over the threaded end of one of the plungers. Remove the O-ring from the guide cap and the O-ring from the guide spool. Remove the other O-rings and the exhaust seal from the plunger.
5. Repeat the previous step on the remaining spool assembly.
6. Remove the retaining ring from the cavity of the MV–3 body that contains the dual circuit supply valve.
7. Using a pair of needle nose pliers, grasp the bar in the center of the cap and dual circuit supply valve and remove the dual circuit valve assembly. Remove the three O-rings from the valve or from the cavity of the body, if some have remained there. Other than the three external O-rings, don't disassemble the piston assembly further.

NOTE: If during the removal of this assembly from the body the cap dislodges from the rest of the valve, the remaining parts can be removed using bent wire. The spring, piston and O-ring that are internal to the dual circuit valve assembly are nonserviceable.

# Cleaning and Inspection

The nonmetallic components making up most of the parts of the MV–3 *should not be immersed in any solvent type cleaner.* Old lubricant should be wiped out with a clean dry cloth.

If any visible damage to the body or the spools is found, replace the complete unit.

# Assembly

## Dual Circuit Supply Valve

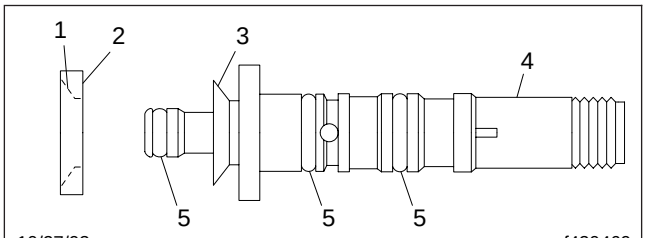
1. Lubricate all O-rings, bores, and sliding surfaces with silicone lubricant Bendix 291126, Dow Corning 55-M, or equivalent.
2. Install O-rings onto the cap and dual circuit supply valve. Then install the assembly, small diameter first, into its cavity in the body.
3. Install the retaining ring (Ref. 22) making sure it is fully seated in its groove.

## Spools

1. Install the O-rings and the exhaust seal onto the stem of the plunger.

IMPORTANT: The exhaust seal (Ref. 19) must be installed so that its beveled surface mates with the beveled surface of the plunger. See **Fig. 2**.

2. Install the O-ring onto the guide spool and the O-ring onto the guide cap. Place the guide cap on top of the guide spool, and install the entire assembly over the threaded end of the plunger; press down firmly until it snaps into place.




1. Inside Bevel
2. Exhaust Seal
3. Mating Exhaust Seal Bevel
4. Plunger
5. O-Rings

**Fig. 2, Plunger Assembly**

3. Install the spring over the boss in the bottom of the spool cavity in the body of the MV–3 valve. Place the spool assembly into the body, keeping the spool square to the body. Press and turn the stem until the spool is fully seated in its cavity. Note the assembly is keyed and can be installed one way only.
4. Repeat the previous steps for the opposite spool.

## Shuttle and Check Valve

1. Install the O-ring into its groove on the tripper piston; then install the O-ring onto the cap.
2. Install the large spring on the piston and the small spring on the boss of the check valve.

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3. Install the spring and check valve into their cavity in the body of the MV–3 valve (tapered end of the valve to enter cavity first). Make sure the spring is centered in the bore.
4. Install the piston assembly into the cavity, making sure the spring mates with the bore of the piston.
5. Install the cap with O-ring.
6. Attach the cover plate to the valve body using the six screws. Torque them 25 lbf·in (280 N·cm).
7. Check the operation of the valve using the instructions in **Subject 100**.

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## Removal

**⚠ WARNING**

**Wear eye protection when draining the air system or loosening an air line because dirt or sludge could fly out at high speeds. Do not direct the airstreams at anyone. Do not disconnect pressurized hoses, since they may whip as air escapes. Failure to take all necessary precautions could result in personal injury.**

1. Park the vehicle on a level surface, shut down the engine, apply the parking brakes, and chock the tires. Drain the air tanks.
2. Extend and lower the steering column as far as it will go.
3. Remove the retaining screws from the top corners of the auxiliary instrument panel.
4. Unscrew the red and yellow knobs from the stems of the spools on the MV-3 valve by turning them in a counterclockwise direction. Mark these knobs in relation to the valve for later reference.
5. Swing the panel down to access the control module mounting screws. You may need to hold the trailer brake lever down while lowering the panel.
6. Remove and save the four mounting screws and washers from the four corners of the cover plate.
7. Carefully push the valve assembly back through the holes in the dash and rotate it out from behind the panel. With the valve and cover plate assembly pulled out, note the positions of each of the numbered air lines, then remove the air lines from the back of the valve.

## Installation

1. Connect the numbered air lines to the proper ports as marked during removal.
2. Position the valve in the dash, being careful not to kink or damage any of the air lines.
3. Align the holes in the cover plate with the holes in the dash panel and install the four screws and washers into the corners of the cover plate.
4. Temporarily install the red and yellow knobs onto the threaded stems of the spools.
5. Leak test the fittings, following the instructions under **Subject 100.**
6. Remove the red and yellow knobs and close the auxiliary instrument panel. Install the retaining screws in the top corners of the auxiliary instrument panel.
7. Install the red and yellow knobs onto the threaded stems of the spools, making sure that they are oriented correctly as noted during removal.
8. Return the steering column to its original position.
9. Remove the chocks.

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## General Description

The function of the Bendix AD–9 air dryer (**Fig. 1**) is to collect and remove air system contaminants in solid, liquid, and vapor form before they enter the brake system.

The AD–9 air dryer consists of the desiccant cartridge and a die-cast aluminum end cover secured to a cylindrical steel outer shell with eight capscrews and nuts. The end cover contains a check valve assembly, a safety valve, three threaded air connections and the purge valve housing assembly. The removable purge valve housing assembly features a purge valve mechanism and a turbocharger cutoff that are designed to prevent loss of engine turbo boost pressure during the purge cycle of the air dryer.

To ease servicing, the desiccant cartridge and discharge check valve assembly are screw-in types. The purge valve housing assembly, which includes the heater and thermostat assembly, and the discharge check valve assembly, can be serviced without removing the air dryer from the vehicle. The screw-in desiccant cartridge requires removal of the air dryer assembly from the vehicle.

The AD–9 has three female pipe thread air connections; each is identified as follows (see **Table 1**):

| Female Pipe Thread Air Connections | |
|---|---|
| **Port I.D.** | **Function/Connection** |
| 4-CON | Control Port (purge valve control and turbo cutoff) |
| 11-SUP | Supply Port (air in) |
| 2-DEL | Delivery Port (air out) |

**Table 1, Female Pipe Thread Air Connections**

There are four versions of the AD–9 air dryer:

- Standard

  The standard air dryer (**Fig. 2**) uses a metal seat turbo cutoff valve. The function of the metal seat is to prevent turbocharger boost pressure loss through the air dryer during the purge (compressor unloaded) mode. Some low level turbo air leakage can occur in the unloaded mode.

- Discharge Line Unloader Style

  The discharge line unloader style air dryer (**Fig. 3**) is usually used on brake systems that have compressors equipped with a discharge unloader valve, but no integral unloading mechanisms. This air dryer is designed to bypass the turbo cutoff mechanism on the dryer, allowing air from the compressor to be vented out the bottom of the air dryer when the brake system is in a non-charging mode. An air governor is used on this system and replaces the discharge line unloader valve normally installed in the compressor's discharge line. This type of air dryer can be identified by the "U" stamped on the side of the purge valve housing.

- Soft Seat Air Dryer

  The soft seat style air dryer (**Fig. 4**) is usually used on vehicles equipped with Holset "E" and "QE" type air compressors. This air dryer eliminates the need for the Holset ECON valve (which is plumbed in the compressor discharge line). However, external plumbing of the make-up line and make-up line check valve is still required.

- Drop-In Air Dryer

  The drop-in style air dryer (**Fig. 5**) *can only be used* on vehicles equipped with Holset "E" and "QE" type air compressors. This air dryer eliminates any external plumbing requirements (such as the ECON valve, make-up line, and make-up line check valve). All of these components are an integral part of the air dryer.

## Principles of Operation

The AD–9 air dryer alternates between two operational modes or cycles during operation: the charge cycle and the purge cycle.

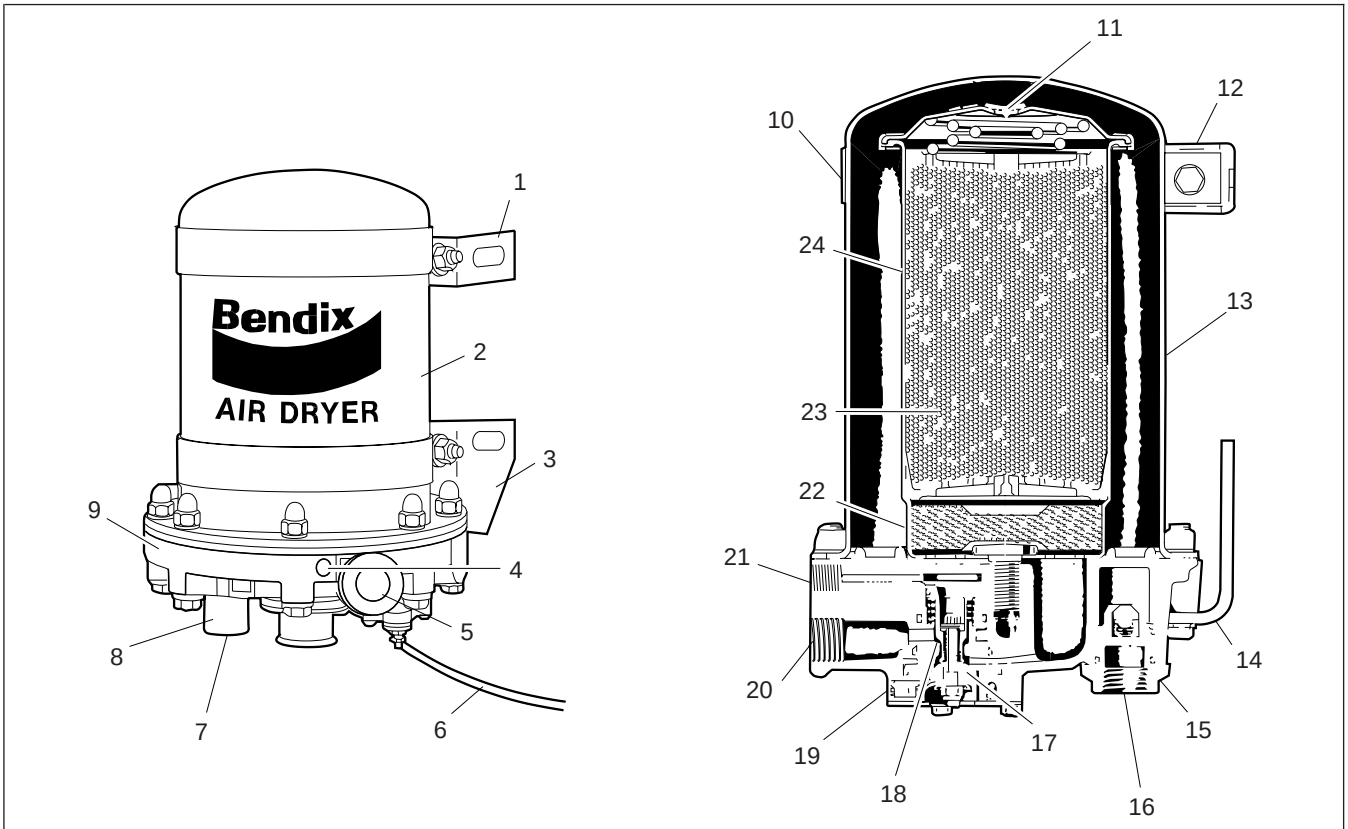
### Charge Cycle

When the compressor is loaded (compressing air), pressurized air, along with oil, oil vapor, water, and water vapor flow through the compressor discharge line to the supply port of the air dryer end cover. See **Fig. 6**. As air travels through the end-cover assembly, its direction of flow changes several times, reducing the temperature, causing contaminants to condense and drop to the bottom or sump of the air dryer end cover.

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## General Information




1. Upper Bracket
2. Outer Shell
3. Lower Bracket
4. Control Port
5. Supply Port
6. Wiring Harness
7. Delivery Port
8. Check Valve Assembly
9. End Cover
10. Upper Bracket Strap
11. Check Valve
12. Upper Bracket
13. Housing
14. Lower Bracket
15. Check Valve Assembly
16. Delivery Port
17. Purge Valve
18. Turbo Cutoff Piston
19. Purge Valve Housing Assembly
20. Supply Port
21. Control Port
22. Oil Separator
23. Desiccant Bed
24. Desiccant Cartridge

**Fig. 1, Bendix AD-9 Air Dryer and Cutaway View**

After exiting the end cover, air flows into the desiccant cartridge. Once in the cartridge, air first flows through an oil separator, which removes water, oil, oil vapor, and solid contaminants.

Air exits the oil separator and enters the desiccant drying bed. Air flowing through the column of desiccant becomes progressively drier as water vapor sticks to the desiccant material in a process known as adsorption. The desiccant cartridge, using the adsorption process typically removes 95 percent of the water vapor from the pressurized air.

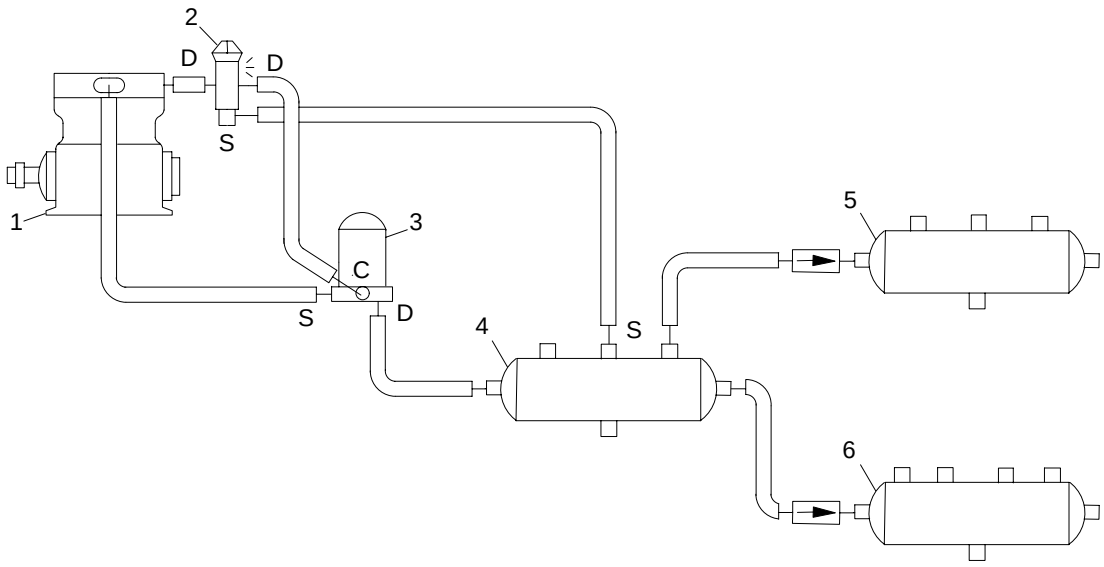
Most of the dry air exits the desiccant cartridge through its integral single check valve to fill the purge volume between the desiccant cartridge and outer shell. Some air also exits the desiccant cartridge through the purge orifice adjacent to the check valve.

Dry air flows out of the purge volume through the single check valve assembly and out the delivery port to the first (supply) reservoir of the air system.

The air dryer remains in the charge cycle until air brake system pressure builds to the governor cutout setting.

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C. Control
D. Delivery
S. Supply
1. Air Compressor
2. D–2 Governor
3. Air Dryer
4. Supply
5. Primary
6. Secondary

**Fig. 2, Standard Air Dryer Plumbing Diagram**

## Purge Cycle

When the brake system pressure reaches the governor cutout setting, the compressor unloads (air compression stopped), and the purge cycle of the air dryer begins. When the governor unloads the compressor, it pressurizes the unloader mechanism and line connecting the governor unloader port to the AD–9 end cover control port. See **Fig. 7**. The purge piston moves in response to air pressure causing the purge valve to open to atmosphere and partially close off the supply of air from the compressor. This is further discussed under "Turbo Cutoff Feature."

Contaminants in the end cover sump are expelled immediately when the purge valve opens. Also, air that was flowing through the desiccant cartridge changes direction and begins to flow toward the open purge valve. Oil and solid contaminants collected by the oil separator are removed by air flowing from the desiccant drying bed to the open purge valve.

The initial purge and desiccant cartridge decompression last only a few seconds and are signaled by an audible burst of air at the AD–9 exhaust. The actual reactivation of the desiccant drying bed begins as dry air flows from the purge volume through the desiccant cartridge purge orifice and into the desiccant drying bed. Pressurized air from the purge volume expands after passing through the purge orifice; its pressure is lowered and its volume increased. Dry air flowing through the drying bed reactivates the desiccant material by removing the water vapor sticking to it. Generally, it takes 15 to 30 seconds for the entire purge volume of a standard AD–9 to flow through the desiccant drying bed.

The end cover single check valve assembly prevents compressed air in the brake system from returning to the air dryer during the purge cycle. After the 30 second purge cycle is complete, the air dryer is ready for the next charge cycle to begin.

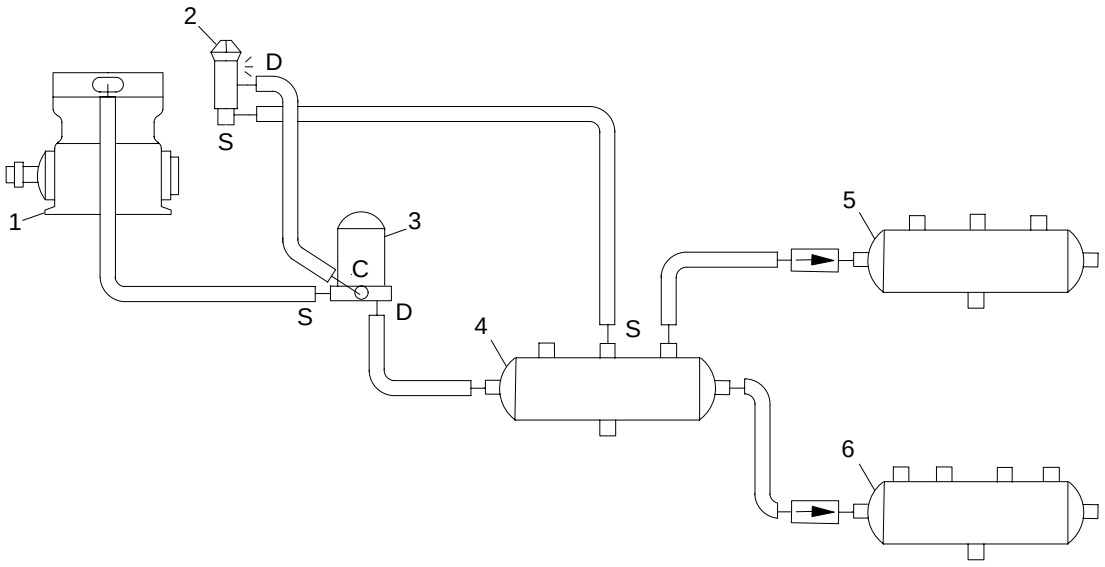
The purge valve will remain open after the purge cycle is complete, and will not close until air brake system pressure is reduced and the governor signals the compressor to charge.

NOTE: The air dryer should be periodically checked for operation and tested for leaks.

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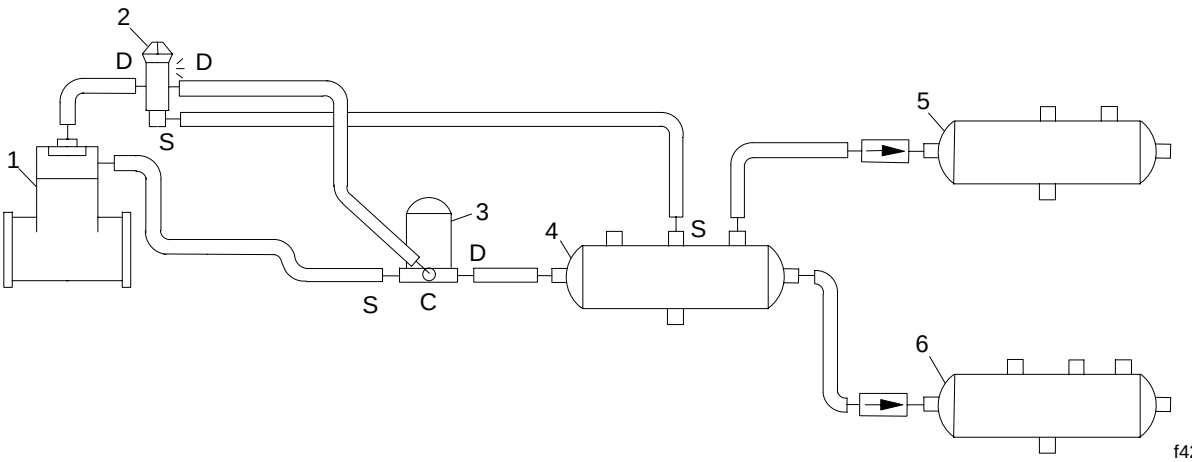


## General Information




C. Control
D. Delivery
S. Supply
1. Air Compressor
2. D–2 Governor
3. Air Dryer
4. Supply
5. Primary
6. Secondary

**Fig. 3, Discharge Line Unloader Style Air Dryer Plumbing Diagram**



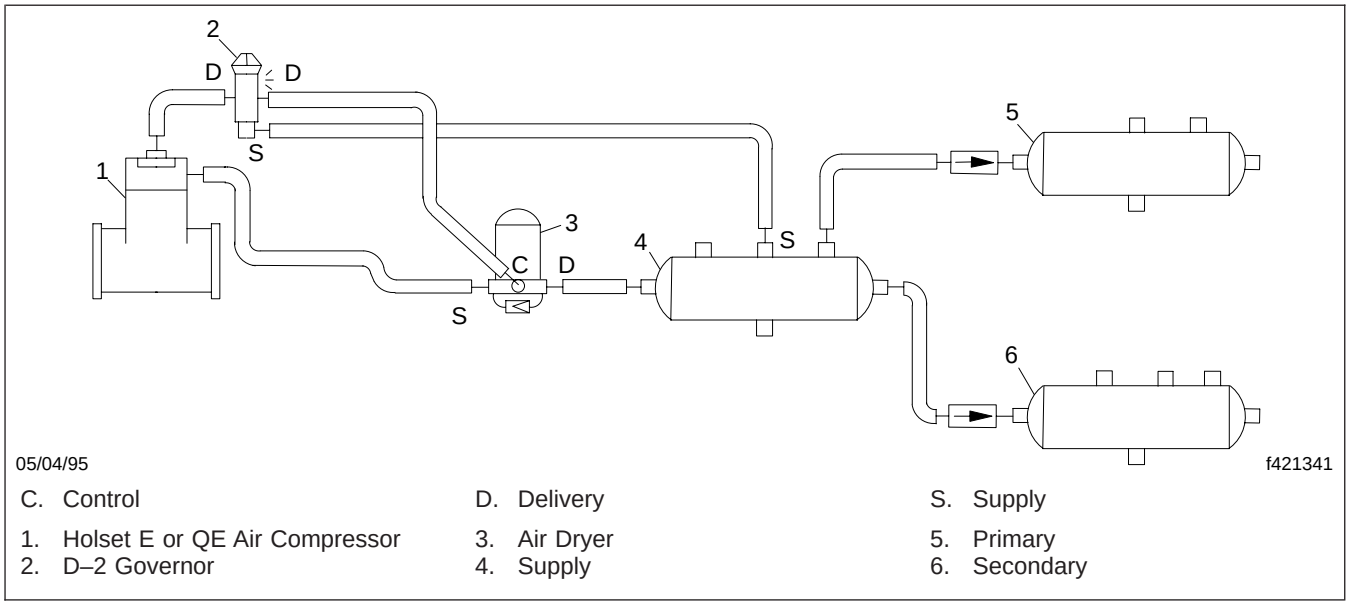

C. Control
D. Delivery
S. Supply
1. Holset E or QE Air Compressor
2. D–2 Governor
3. Air Dryer
4. Supply
5. Primary
6. Secondary

**Fig. 4, Soft Seat Air Dryer Plumbing Diagram**

Refer to the brake section in the vehicle maintenance manual for intervals and procedures.

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C. Control
D. Delivery
S. Supply
1. Holset E or QE Air Compressor
2. D–2 Governor
3. Air Dryer
4. Supply
5. Primary
6. Secondary

**Fig. 5, Drop-In Style Air Dryer Plumbing Diagram**

## Turbocharger Cutoff Feature

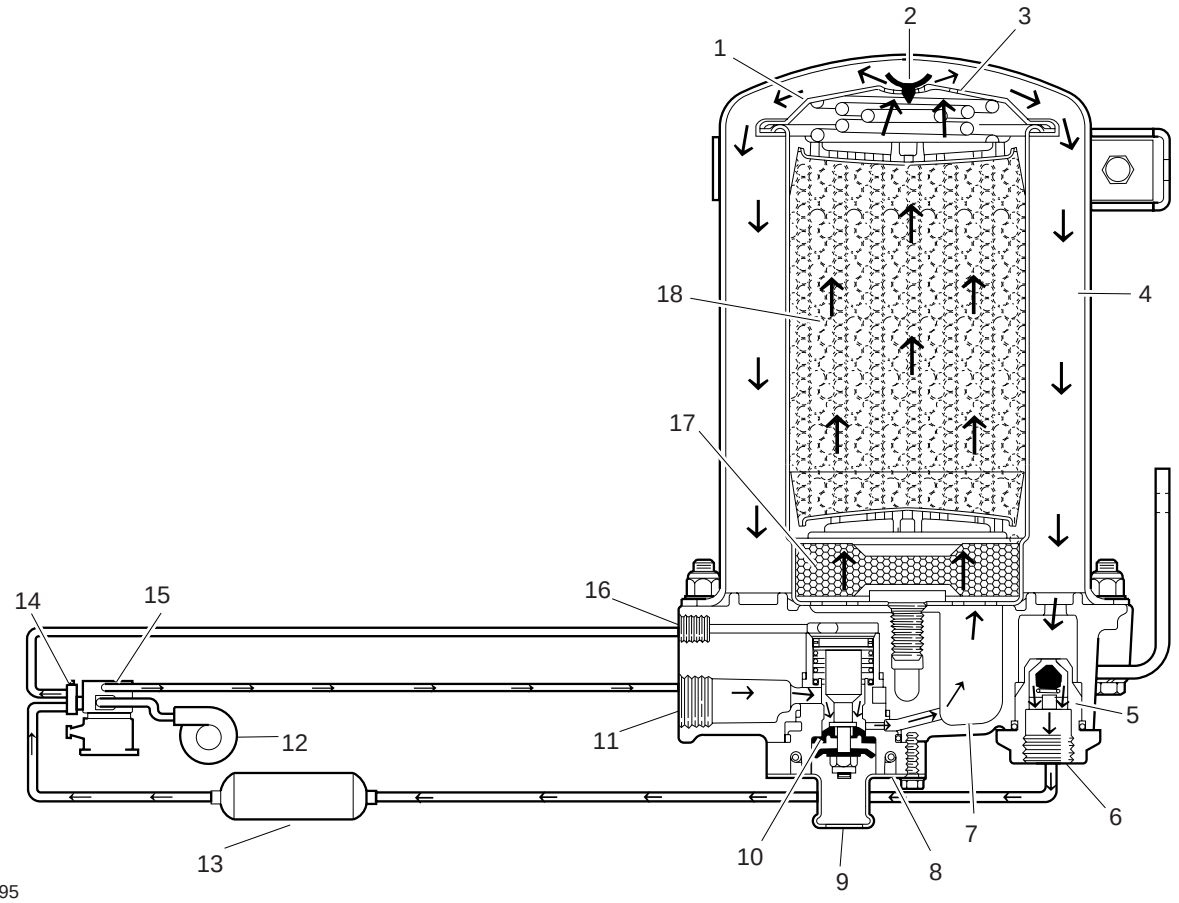
Primarily, the turbo cutoff valve (**Fig. 8**) prevents loss of engine turbocharger air pressure through the AD–9 in systems where the compressor intake is connected to the engine turbocharger. The turbo cutoff valve also reduces the puffing of air out the open exhaust when a naturally aspirated, single cylinder compressor equipped with an inlet check valve is in use.

At the beginning of the purge cycle, the downward travel of the purge piston is stopped when the turbo cutoff valve (tapered portion of the purge piston) contacts its mating metal seat in the purge valve housing. With the turbo cutoff valve seated (closed position), air in the discharge line and AD–9 supply port is restricted from entering the air dryer. While the turbo cutoff *effectively* prevents loss of turbocharger boost pressure to the engine, some seepage of air may be detected under certain conditions of compressor, engine, and turbocharger operation. Even so, there will be low pressure trapped in the discharge line.

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## General Information

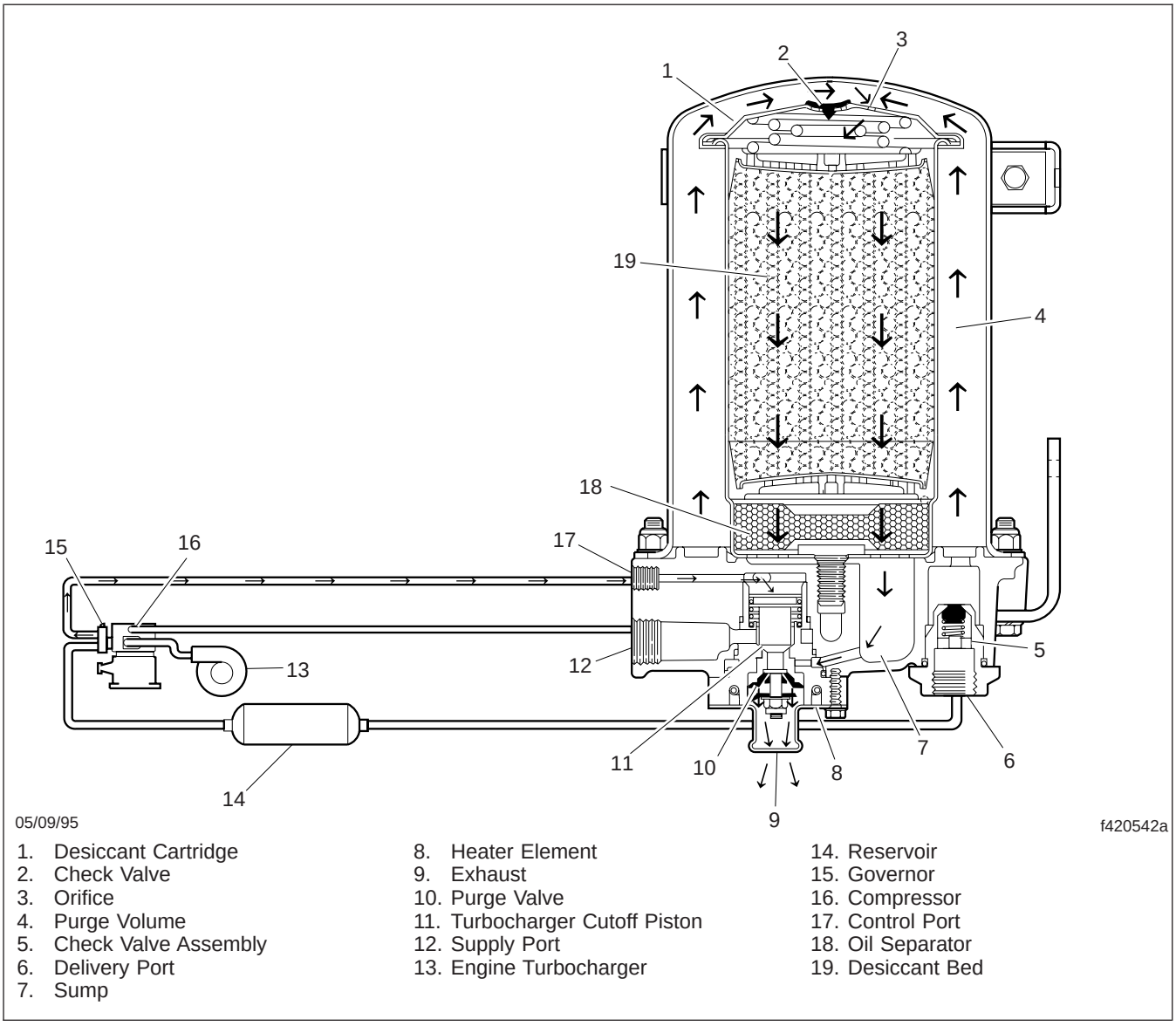



1. Desiccant Cartridge
2. Check Valve
3. Orifice
4. Purge Volume
5. Check Valve Assembly
6. Delivery Port
7. Sump
8. Heater Element
9. Exhaust
10. Purge Valve
11. Supply Port
12. Engine Turbocharger
13. Reservoir
14. Governor
15. Compressor
16. Control Port
17. Oil Separator
18. Desiccant Bed

**Fig. 6, AD-9 Charge Cycle**

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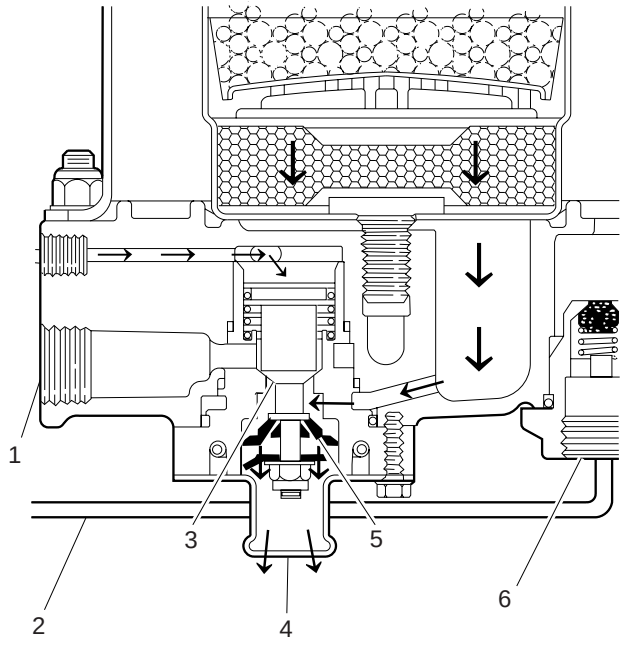

1. Desiccant Cartridge
2. Check Valve
3. Orifice
4. Purge Volume
5. Check Valve Assembly
6. Delivery Port
7. Sump
8. Heater Element
9. Exhaust
10. Purge Valve
11. Turbocharger Cutoff Piston
12. Supply Port
13. Engine Turbocharger
14. Reservoir
15. Governor
16. Compressor
17. Control Port
18. Oil Separator
19. Desiccant Bed

**Fig. 7, AD-9 Purge Cycle**

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## General Information




1. Supply Port
2. Discharge Line
3. Turbocharger Cutoff Piston
4. Exhaust
5. Purge Valve
6. Check Valve Assembly

**Fig. 8, AD-9 Turbo Cutoff**

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## Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

1. Chock the tires and stop the engine before working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters, which may apply as air pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure, and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Don’t disassemble a component until you have read and understood the service procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use the correct tools, and observe all precautions pertaining to use of those tools.
5. Replacement hardware, tubing, hose, fittings, etc. should be the equivalent size, type, length, and strength of the original equipment.

   Make sure that when replacing tubing or hose, all of the original supports, clamps, or suspending devices are installed or replaced.
6. Replace devices with stripped threads or damaged parts. Repairs requiring machining should not be attempted.

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# Air Dryer Removal and Installation

## Removal

**WARNING**

**Before working on or around air brake systems and components, read the safety precautions in Subject 100. Failure to do so could result in personal injury.**

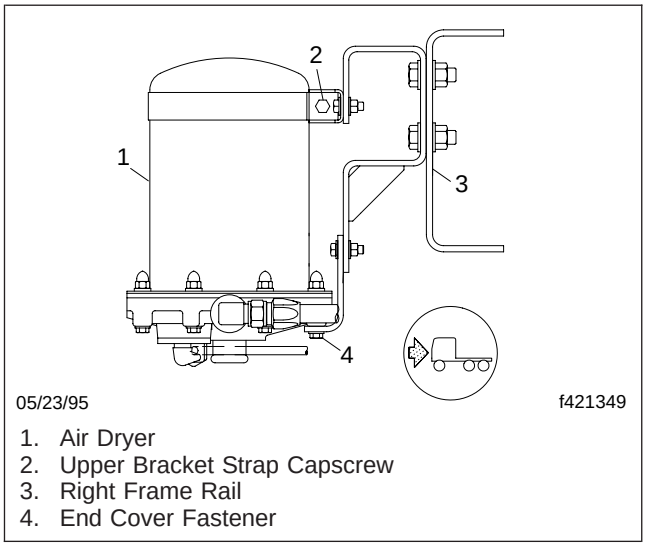
1. Park the vehicle on a level surface and chock the tires.
2. Completely drain all of the reservoirs.
3. Remove the air dryer. See **Fig. 1**.
   - 3.1 Mark and disconnect the three air lines from the end cover, and note the position of end cover ports relative to the vehicle.
   - 3.2 Unplug the vehicle wiring harness from the heater and thermostat assembly connector on the exhaust cover.
   - 3.3 Loosen the capscrew securing the upper bracket strap.
   - 3.4 Remove, save, and mark the two end cover capscrews, locknuts, and four special washers that retain the lower mounting bracket to the end cover. Also mark the two holes of the end cover (these receive the two longest capscrews.)
   - 3.5 Remove the air dryer from its mounting brackets.

## Installation

**WARNING**

**Before working on or around air brake systems and components, read the safety precautions in Subject 100. Failure to do so could result in personal injury.**

1. Install the assembled air dryer on the vehicle. See **Fig. 1**.
   - 1.1 Position the air dryer up into the upper mounting bracket and strap. Align the two unused holes in the end cover with the bottom mounting bracket so that the bottom bracket supports the air dryer. The end cover should rest on the bracket.
   - 1.2 Using the two longest capscrews, four special washers, and two locknuts, secure the air dryer to the lower bracket. Tighten the two remaining capscrews 270 to 385 lbf·in (3060 to 4340 N·cm).
   - 1.3 Tighten the capscrew and nut on the upper mounting bracket strap 80 to 120 lbf·in (900 to 1360 N·cm).
   - 1.4 As marked earlier in "Removal," connect the three air lines to the ports on the end cover.
   - 1.5 Connect the vehicle wiring harness to the air dryer heater and thermostat assembly connector by plugging it into the air dryer connector until its lock tab snaps in place.
2. Test the air dryer following instructions in **Group 42** of the *Western Star Maintenance Manual*.




1. Air Dryer
2. Upper Bracket Strap Capscrew
3. Right Frame Rail
4. End Cover Fastener

**Fig. 1, Air Dryer Mounting**

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# Air Dryer Disassembly, Cleaning and Inspection, and Assembly

As a convenience when rebuilding the air dryer, several replacement parts and maintenance kits are available that do not require full disassembly. Use the instructions provided with these parts or kits.

## Disassembly

**⚠ WARNING**

**Before working on or around air brake systems and components, read the safety precautions in Subject 100. Failure to do so could result in personal injury.**

**⚠ CAUTION**

**While servicing the air dryer, don't use a clamping device (vise, C-clamp, etc.) to hold any die cast aluminum part, as damage may result. To hold the end cover, install a pipe nipple in the supply port, and clamp the nipple in a vise.**

1. Remove the air dryer from the vehicle. See Fig. 1. For instructions, see Subject 110.
2. Remove the check valve assembly and O-ring. Remove the O-ring from the check valve assembly.
3. Remove the purge valve housing assembly.
   - 3.1 Remove the three self-tapping screws that secure the purge valve housing assembly to the end cover assembly.
   - 3.2 Pull the purge valve housing assembly out of the end cover assembly.
   - 3.3 Remove and discard the three O-rings from the exterior of the purge valve housing assembly.

   NOTE: These O-rings may lodge in and have to be removed from the end cover bores.
4. Remove the heater and thermostat assembly.
   - 4.1 Remove and discard the two screws that attach the heater and thermostat assembly to the purge valve housing.
   - 4.2 Gently rotate the electrical connector to the left until the thermostat clears the purge valve housing. Then, slide the heater element out, to the right and up. Discard the assembly.
5. Disassemble the purge valve housing assembly.
   - 5.1 If a flat non-extended exhaust cover is used, leave it intact while servicing the purge valve housing assembly.

     If an extended type exhaust cover is used for the attachment of an exhaust hose, *carefully* separate the exhaust cover from the purge valve housing. *Use a thin flat blade to pry the exhaust cover off, taking care not to damage the potting material (RTV sealant) under the cover.*
   - 5.2 Remove the bolt from the bottom of the purge valve housing assembly. Remove the diaphragm and the purge valve from the purge valve housing.
   - 5.3 Remove the purge piston, the return spring and two O-rings (one on the outside and the other in the inside of the purge piston).
6. Remove the remaining six capscrews (Ref. 24), locknuts (Ref. 7), and twelve special washers (Ref. 8) that secure the end cover to the housing (Ref. 6). Separate the end cover and desiccant cartridge (Ref. 9) from the housing (Ref. 6).
7. Remove the end-cover-to-outer-housing O-ring.
8. Don't remove the safety valve (Ref. 11) from the end cover unless it is known to be inoperative. If replacement is needed, apply thread sealant or Teflon® tape on the threads of the replacement valve and tighten 120 to 400 lbf·in (1360 to 4520 N·m). Make sure the drain hole (slot) is facing down.
9. Place a strap or chain wrench around the desiccant cartridge (Ref. 9) so that it is about 2 to 3 inches (5 to 8 cm) away from the end cover. Rotate the cartridge counterclockwise until it completely separates from the end cover.

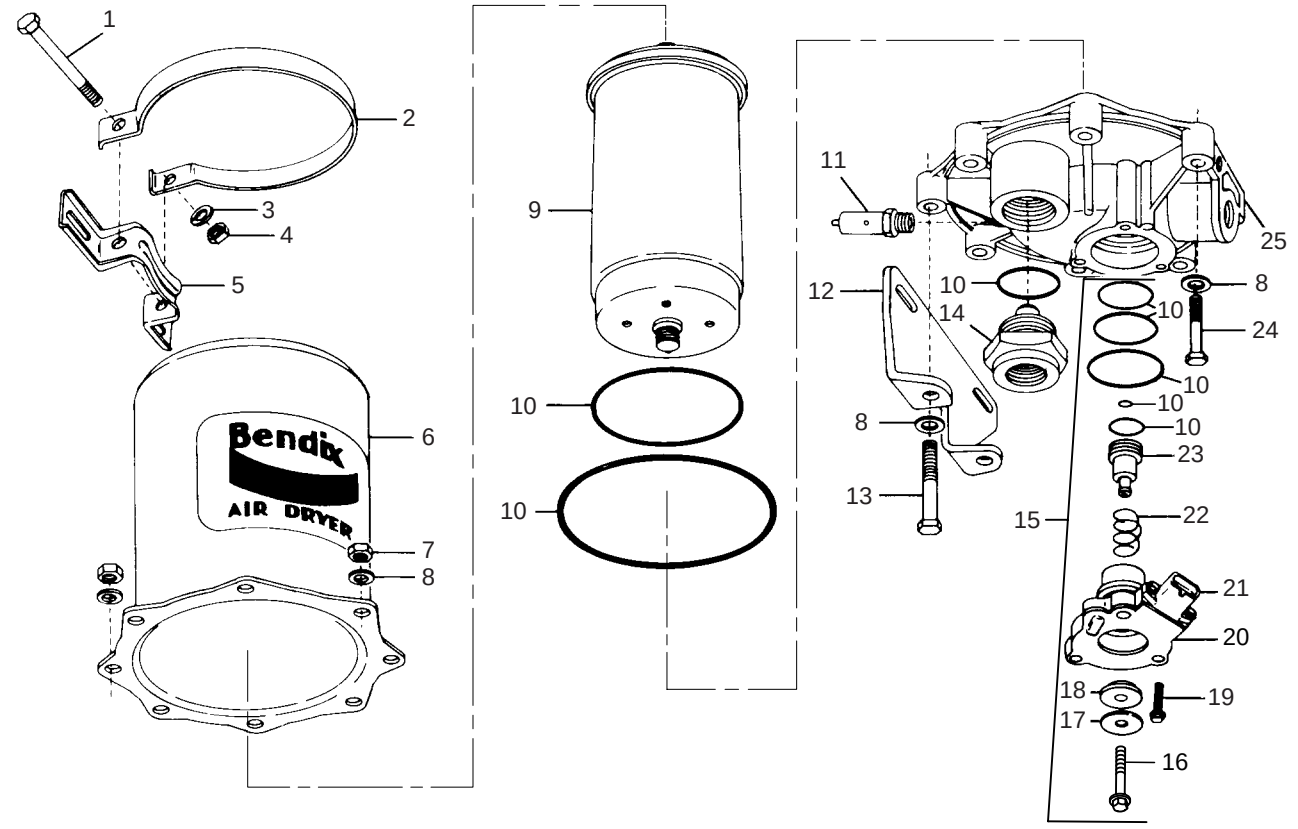
NOTE: Torque of up to 50 lbf·ft (68 N·m) may be needed to do this disassembly.

10. Remove the desiccant cartridge O-ring from the end cover.

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## Air Dryer Disassembly, Cleaning and Inspection, and Assembly




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1. 5/16-Inch x 4-1/2 Inch Upper Bracket Capscrew
2. Upper Bracket Strap
3. 5/16-Inch Lockwasher
4. 5/16-Inch Locknut
5. Upper Mounting Bracket
6. Housing
7. Locknut
8. 3/8-Inch Special Washer
9. Desiccant Cartridge
10. O-Ring
11. Safety Valve
12. Lower Mounting Bracket
13. 3/8-Inch Capscrew (Long)
14. Check Valve Assembly
15. Purge Valve Assembly
16. Purge Valve Bolt
17. Exhaust Diaphragm
18. Purge Valve
19. 1/4-Inch Tapping Screw
20. Purge Valve Housing
21. Heater and Thermostat Assembly
22. Return Spring
23. Purge Piston
24. 3/8-Inch Capscrew
25. End Cover

**Fig. 1, AD-9 Exploded View**

## Cleaning and Inspection

**⚠ WARNING**

**Before working on or around air brake systems and components, read the safety precautions in Subject 100. Failure to do so could result in personal injury.**

1. Wash all metal parts thoroughly, using a quality commercial solvent, such as mineral spirits.
2. Check for severe corrosion, pitting, and cracks on the inside and outside of all metal parts that will be reused. Superficial corrosion and pitting on the outside of the upper and lower body halves is acceptable.
3. Inspect the bores of both the end cover and the purge-valve housing for deep scuffing or gouges.

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4. Make sure that all purge-valve housing and end cover passages are open and free of blockages.
5. Inspect the pipe threads in the end cover. Make sure they are clean and free of thread sealant.
6. Inspect the purge-valve housing bore and seats for excessive wear and scuffing.
7. Inspect the purge valve piston seat for excessive wear.
8. Inspect all air line fittings for corrosion. Clean all old thread sealant from the pipe threads.
9. Replace all removed O-rings with new ones that are provided in the kits.

   Replace parts that show any of the conditions described in the previous steps.

## Assembly

**⚠ WARNING**

**Before working on or around air brake systems and components, read the safety precautions in Subject 100. Failure to do so could result in personal injury.**

1. Before assembly, coat all O-rings, O-ring grooves, and bores with a generous amount of barium-base lubricant. See **Fig. 1** during assembly unless otherwise advised.

IMPORTANT: When installing the heater and thermostat assembly, make sure that the seal ring under the electrical connector is not twisted.

2. Install the heater and thermostat assembly.
   - 2.1 Insert the heater element into the slot in the purge valve housing until the connector contacts the housing.
   - 2.2 Gently push the connector and the thermostat to the left until the thermostat clears the cavity in the housing. Then, turn the connector to the right while pushing the thermostat all the way down into the cavity.

     Make sure that the connector is seated evenly against the housing.
   - 2.3 Install the two mounting screws. Tighten the screws 10 to 20 lbf·in (113 to 226 N·cm).
3. Assemble the purge-valve housing.
   - 3.1 Install the O-ring on the purge piston. Place the return spring in the purge-valve housing. Place the O-ring in the bore of the purge piston. Insert the purge piston into the spring. Push the piston into the purge-valve housing until it bottoms.
   - 3.2 While holding the purge piston in, install the following parts: the purge valve with its rubber side first, followed by the diaphragm and the bolt. Torque the purge valve bolt 60 to 80 lbf·in (680 to 900 N·cm).
   - 3.3 Install the three O-rings in their correct locations on the purge-valve housing.
   - 3.4 If an extended type exhaust cover was removed, install it on the purge-valve housing assembly, making sure the "bubble" portion is positioned over the thermostat.
   - 3.5 Install the assembled purge-valve housing in the end cover; make sure you orient both parts so that the connector is about 10 degrees clockwise from the supply port. Also, make sure the purge-valve housing is fully seated against the end cover.
   - 3.6 Secure the purge-valve housing to the end cover using the three self-tapping screws. Start all three screws by hand, then torque them 85 to 125 lbf·in (960 to 1400 N·cm).
4. Install an O-ring on the check-valve assembly, then install the assembly in the end cover using a socket. Tighten it 200 to 250 lbf·in (2260 to 2820 N·cm).
5. Install the desiccant cartridge in the end cover.
   - 5.1 Install the smaller desiccant cartridge O-ring in its groove in the end cover. Using a light coat of barium grease, lubricate the bottom of the desiccant cartridge in the area that will contact the O-ring and end cover.

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## Air Dryer Disassembly, Cleaning and Inspection, and Assembly

5.2 Screw the desiccant cartridge into the end cover until the cartridge contacts the O-ring. Using a strap or chain wrench positioned 2 to 3 inches (5 to 8 cm) from the bottom of the cartridge, turn the desiccant cartridge clockwise 180 to 225 degrees beyond the position where initial contact was made with the O-ring. Torque should not exceed 50 lbf·ft (68 N·m).

6. Install the housing over the desiccant cartridge.

6.1 Install the large O-ring on the shoulder in the end cover. Place the housing over the desiccant cartridge and align the holes.

6.2 Install the six capscrews, locknuts, and the twelve special washers, making sure they are positioned as referenced earlier. The two longer capscrews will be used to secure the air dryer to its mounting bracket.

6.3 Tighten the six capscrews and nuts in a star pattern (depending on lower bracket location) 270 to 385 lbf·in (3060 to 4340 N·cm). See **Fig. 2**.

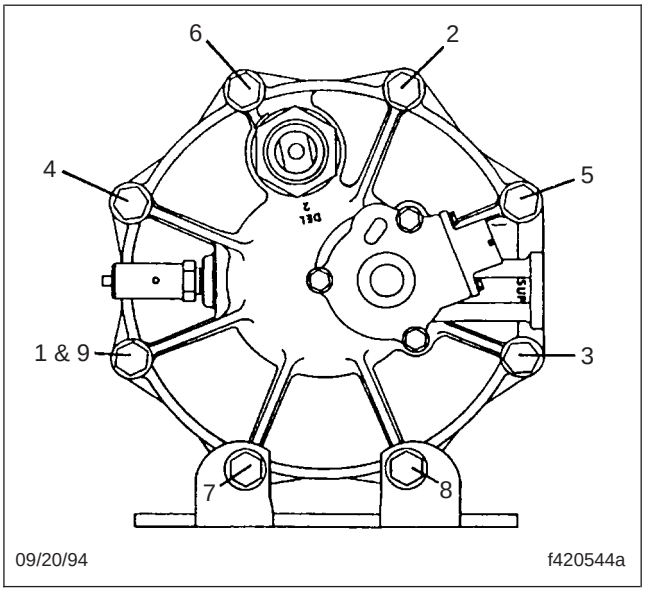



**Fig. 2, End Cover to Housing Torque Pattern**

NOTE: The two remaining bolt holes in the end cover and two 3/8-inch capscrews must be the ones marked during removal to ensure correct orientation of the ports and adequate length of the capscrews.

7. Connect the electrical connector to the heater and thermostat assembly.

8. Test the air dryer for proper operation. For instructions, see **Subject 130**.

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## Testing

During cold-weather operation, check the operation of the end cover heater and thermostat assembly.

1. With the ignition on, check for voltage to the heater and thermostat assembly. Unplug the electrical connector at the air dryer, and place the test leads on each of the pins of the male connector. If there is no voltage, look for a blown fuse, broken wires, or corrosion in the vehicle wiring harness. Check that a good ground path exists.
2. Check the thermostat and heater operation. Turn off the ignition switch and cool the end cover assembly to below 40°F (4°C). Using an ohmmeter, check the resistance between the electrical pins in the female connector. The resistance should be 1.5 to 3.0 ohms for the 12-volt heater assembly, and 6.8 to 9.0 ohms for the 24-volt heater assembly.

NOTE: Some early models of the AD–9 will have resistance readings of 1.0 to 2.5 ohms for the 12-volt heater assembly, and 4.8 to 7.2 ohms for the 24-volt heater assembly. If the resistance is higher than this, replace the purge-valve housing assembly, which includes the heater and thermostat assembly.

3. Warm the end cover assembly to over 90°F (32°C) and again check the resistance. It should exceed 1000 ohms. If it does, the thermostat and heater assembly is operating properly. If it doesn't, replace the purge-valve housing assembly, which includes the heater and thermostat assembly.

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# Troubleshooting Tables

**Problem—Air Dryer Is Constantly Cycling or Purging**

| Problem—Air Dryer Is Constantly Cycling or Purging | |
|---|---|
| **Possible Cause** | **Remedy** |
| Excessive system leakage. | Test for excessive leakage. Eliminate leaks, as needed. Allowable leakage is as follows:<br>• Single Vehicle—1 psi/min (7 kPa/min) per service reservoir<br>• Tractor/Trailer—3 psi/min (21 kPa/min) per service reservoir |
| There is excessive leakage in the fittings, hoses, and tubing connected to the compressor, air dryer, and wet tank. | Using a soap solution, test for leakage at the fittings, drain valve, and safety valve in the wet tank. Repair or replace as needed. |
| Check valve assembly in the air dryer end cover is not working. | Remove the check valve assembly from the end cover. Apply compressed air to the delivery side of the valve. Apply a soap solution at opposite end, and check for leakage. Permissible leakage is a 1-inch (2.5-cm) bubble in 5 seconds. If there is excessive leakage, replace the check valve assembly. |
| Governor is inoperative. | Test the governor for proper cut-in or cut-out pressures and excessive leakage in both positions. |
| Leaking purge-valve housing assembly or O-rings in the air dryer end cover. | With the supply port open to atmosphere, apply 120 psi (830 kPa) at the control port. Apply a soap solution to the supply port and exhaust port (purge valve seat area). Permissible leakage is a 1-inch (2.5-cm) bubble in 5 seconds. Repair or replace as needed. |
| Compressor unloader mechanism is leaking excessively. | Remove the air strainer or fitting from the compressor inlet cavity. With the compressor unloaded, check for unloader piston leakage. Slight leakage is allowed. |
| Holset "E" type compressor. | Test the air dryer system. For instructions, refer to Bendix Product Bulletin PRO-08-19 entitled "Troubleshooting the Holset "E" Compressor System with Bendix Air Dryer." |
| Lack of air at the governor RES port (rapid cycling of the governor). | Test the governor for proper pressure at the RES port. Pressure should not drop below cut-in pressure when the compressor begins the unloaded cycle. If the pressure does drop, check for kinks or restrictions in the line connected to the RES port. The line connected to the RES port on the governor must be the same diameter, or larger than the lines connected to the UNL ports on the governor. |

**Problem—Water in the Vehicle Reservoirs**

| Problem—Water in the Vehicle Reservoirs | |
|---|---|
| **Possible Cause** | **Remedy** |
| Desiccant cartridge assembly contains excessive contaminants. | Replace the desiccant cartridge. |
| Discharge line is of improper length or material. | Discharge line must consist of at least 6 ft. (1.8m) of wire braid Teflon hose, copper tubing, or a combination of both between the discharge port of the compressor and the air dryer supply port. Discharge line lengths and inside diameter requirements are dependent on the vehicle application. Contact your local Bendix representative for further information. |

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## Troubleshooting

| Problem—Water in the Vehicle Reservoirs | |
|---|---|
| **Possible Cause** | **Remedy** |
| Air system was charged from an outside air source that did not pass through an air dryer. | If the system must have an outside air fill provision, the outside air should pass through an air dryer. This practice should be minimized. |
| Air dryer is not purging. | Refer to "Problem—Air Dryer Does Not Purge or Exhaust Air." |
| Purge (air exhaust) is insufficient due to excessive system leakage. | Refer to "Problem—Air Dryer Is Constantly Cycling or Purging." |
| Air bypasses the desiccant cartridge assembly. | Replace the desiccant cartridge/end cover O-ring. Make sure the desiccant cartridge assembly is properly installed. |
| Purge (air exhaust) time is significantly less than the minimum allowable. | Replace the desiccant cartridge/end cover O-ring. Make sure the desiccant cartridge assembly is properly installed. Replace the desiccant cartridge assembly. |
| Excessive air usage—air dryer not compatible with vehicle air system. | Install an accessory bypass system. Consult your Bendix representative for additional information. |

**Problem—Safety Valve on Air Dryer Is Popping Off or Exhausting Air**

| Problem—Safety Valve on Air Dryer Is Popping Off or Exhausting Air | |
|---|---|
| **Possible Cause** | **Remedy** |
| Desiccant cartridge is plugged or saturated. | Check the compressor for excessive oil passing, or incorrect installation. Repair or replace as needed. |
| The check valve in the air dryer end cover is inoperative. | Test to determine if air is passing through the check valve. Repair or replace as needed. |
| There is a problem in the fittings, hose, or tubing between the air dryer and the wet tank. | See if air is reaching the first reservoir. Inspect for kinked tubing or hose. Check for undrilled or restricted hose or tubing fittings. |
| Safety valve setting is lower than the maximum system pressure. | Reduce the system pressure, or install a safety valve with a higher pressure setting. |

**Problem—Constant Exhaust of Air at the Air Dryer Purge Valve Exhaust; Unable to Build System Pressure**

| Problem—Constant Exhaust of Air at the Air Dryer Purge Valve Exhaust; Unable to Build System Pressure | |
|---|---|
| **Possible Cause** | **Remedy** |
| Air dryer purge valve is leaking excessively. | With the compressor loaded, apply a soap solution on the purge valve exhaust to test for excessive leakage. Repair the purge valve as needed. |
| The governor is inoperative. | Check the governor for proper cut-in and cut-out pressures, and excessive leakage in both positions. Repair or replace as needed. |
| Purge control line is connected to the reservoir or exhaust port of the governor. | Connect the purge control line to the unloader port of the governor. |
| Purge valve is frozen open due to an inoperative heater or thermostat, bad wiring, or a blown fuse. | Test the heater and thermostat, following instructions in this manual. |
| Inlet and outlet air connections are reversed—unable to build system pressure. | Reconnect the lines properly. |

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| Problem—Constant Exhaust of Air at the Air Dryer Purge Valve Exhaust; Unable to Build System Pressure | |
|---|---|
| **Possible Cause** | **Remedy** |
| Discharge line is kinked or blocked. | See if air passes through the discharge line. Check for kinks, bends, or excessive carbon deposits. |
| There are excessive bends in the discharge line. Water is collecting and freezing. | Discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible. |
| System is leaking excessively. | Test for excessive leakage. Eliminate leaks, as needed. Allowable leakage is as follows:<br>• Single Vehicle—1 psi/min (7 kPa/min) per service reservoir<br>• Tractor/Trailer—3 psi/min (21 kPa/min) per service reservoir |
| Purge valve stays open; supply air leaks to control side. | Replace the purge valve assembly O-rings. |

**Problem—Air Dryer Does Not Purge or Exhaust Air**

| Problem—Air Dryer Does Not Purge or Exhaust Air | |
|---|---|
| **Possible Cause** | **Remedy** |
| Purge control line is broken, kinked, frozen, plugged, or disconnected. | See if air flows through the purge control line when the compressor is unloaded. The purge control line must be connected to the unloader port of the governor. |
| Air dryer purge valve isn't working. | See if air reaches the purge valve. If it does, repair the purge valve. |
| The governor is inoperative. | Check the governor for proper cut-in and cut-out pressures, and excessive leakage in both positions. Repair or replace as needed. |
| Inlet and outlet air connections are reversed—unable to build system pressure. | Reconnect the lines properly. |
| Discharge line is kinked or blocked. | See if air passes through the discharge line. Check for kinks, bends, or excessive carbon deposits. |
| There are excessive bends in the discharge line. Water is collecting and freezing. | Discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible. |

**Problem—Desiccant Is Being Expelled from the Air Dryer Purge Valve Exhaust (May Look Like Whitish Liquid, Paste, or Small Beads); or, Unsatisfactory Desiccant Life**

| Problem—Desiccant Is Being Expelled from the Air Dryer Purge Valve Exhaust (May Look Like Whitish Liquid, Paste, or Small Beads); or, Unsatisfactory Desiccant Life | |
|---|---|
| **Possible Cause** | **Remedy** |
| This problem usually occurs with one or more of the previous problems. | Refer to the appropriate corrections listed previously. |
| Air dryer is not securely mounted; there is excessive vibration. | Vibration should be held to a minimum. Tighten the mounting fasteners. |
| Cloth-covered perforated plate in the air dryer desiccant cartridge is damaged, or the cartridge was rebuilt incorrectly. | Replace the plate or cartridge as needed. High operating temperatures may cause deterioration of filter cloth. Check the installation. |

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## Troubleshooting

| Problem—Desiccant Is Being Expelled from the Air Dryer Purge Valve Exhaust (May Look Like Whitish Liquid, Paste, or Small Beads); or, Unsatisfactory Desiccant Life | |
|---|---|
| **Possible Cause** | **Remedy** |
| Compressor is passing excessive oil. | Check for proper compressor installation; if symptoms persist, replace the compressor. |
| Heater and thermostat, wiring, or a fuse is at fault, and isn't allowing the air dryer to purge during cold weather. | Test the heater and thermostat, following instructions in this manual. |
| Desiccant cartridge not attached properly to the end cover. | Check the torque and tighten if necessary. Refer to **Subject 120** for instructions. |

**Problem—Pinging Noise Is Excessive During Compressor Loaded Cycle**

| Problem—Pinging Noise Is Excessive During Compressor Loaded Cycle | |
|---|---|
| **Possible Cause** | **Remedy** |
| Pinging noise is due to a single cylinder compressor with high pulse cycles. | A slight pinging sound may be heard during system build-up when a single cylinder compressor is used. If this sound is deemed objectionable, it can be reduced substantially by increasing the discharge line volume. This is done by adding a 90 $in^3$ (1475 $cm^3$) reservoir between the compressor and the air dryer. |

**Problem—Constant Air Seepage at the Purge Valve (Non-Charging Mode)**

| Problem—Constant Air Seepage at the Purge Valve (Non-Charging Mode) | |
|---|---|
| **Possible Cause** | **Remedy** |
| Air compressor inlet is pressurized by the engine turbocharger. | Some pressure leakage past the metal seat of the turbocharger cutoff feature of the AD-9 air dryer is normal, and may be heard. This slight loss of air will not affect the engine or turbocharger performance. |
| Check valve assembly in the air dryer end cover is not working. | Remove the check valve assembly from the end cover. Apply compressed air to the delivery side of the valve. Apply a soap solution at opposite end, and check for leakage. Permissible leakage is a 1-inch (2.5-cm) bubble in 5 seconds. If there is excessive leakage, replace the check valve assembly. |

**Problem—Air Dryer Purge Piston Cycles Rapidly in the Unloaded Mode**

| Problem—Air Dryer Purge Piston Cycles Rapidly in the Unloaded Mode | |
|---|---|
| **Possible Cause** | **Remedy** |
| Compressor does not "unload." | Check the governor installation: there is no air line from the governor to the compressor, or the line is restricted. Repair or replace as needed. |

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## General Description

Meritor Cam-Master® brakes are air actuated, cam operated, foundation brakes. The main components in each brake assembly (wheel end) consists of:

- a camshaft-and-chamber bracket;
- an "S" head camshaft;
- a brake spider;
- two brake shoe and lining assemblies;
- a return spring;
- and, two anchor pins.

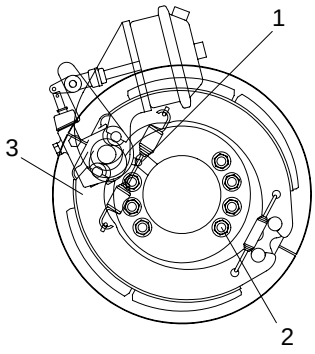
The "S" head camshaft is bushing mounted inside the camshaft-and-chamber bracket; and it transfers braking force from the slack adjuster to the brake shoe assemblies. Each brake shoe is mounted to the brake spider through an anchor pin; and it is controlled (moved) by either the outward braking force of the "S" head camshaft or the inward restoring force of the return spring. The brake spider is fastened to the axle flange and the camshaft-and-chamber bracket is mounted to the brake spider.

The steer axles are available with Q Plus brakes. See **Fig. 1**. Either 16-1/2 inch (419 mm) by 5 inch (127 mm) or 16-1/2 inch (419 mm) by 6 inch (152 mm) fabricated double web brake shoes are used with the Q Plus brakes.

The Q Plus brake shoes are designed with open anchor pin ends. Two retainer springs couple the brake shoes (anchor pin ends) to the anchor pins. Then, the anchor pins are coupled to the brake spider. This design makes "quick change" brake service possible.

Meritor steer axles have seven holes for attaching the spider to the axle flange. There is an eighth hole in the axle flange, which holds an ABS wheel speed sensor bushing, on both left and right sides of the steer axle. See **Fig. 2**. The seven holes used for attachment of the spider to the axle flange are 0.656 inch in diameter. The eighth hole is oversized at 0.687 inch in diameter. Depending on what side the axle flange is viewed from, the eighth hole is either in the 10 o'clock or 2 o'clock position.

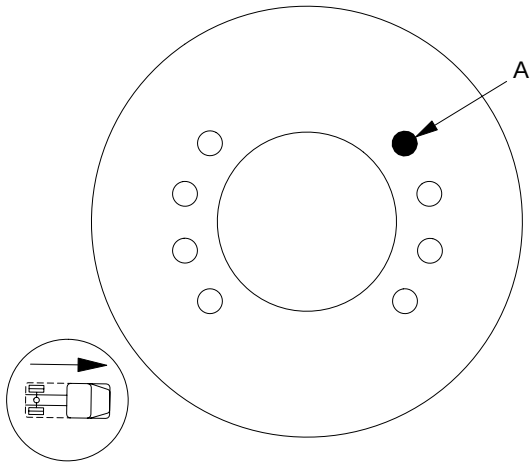
The rear axles are available with either Q Plus or P Series brakes. See **Fig. 3**. 16-1/2 inch (419 mm) by 7 inch (171 mm) heavy-duty fabricated double web brake shoes are used with the Q Plus brakes and




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1. ABS Sensor Bushing
2. Brake Spider Fastener
3. Brake Shoe Assembly

**Fig. 1, Front Axle Q Plus Brake**




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A. Open (10 o'clock or 2 o'clock)

**Fig. 2, Open Hole Location**

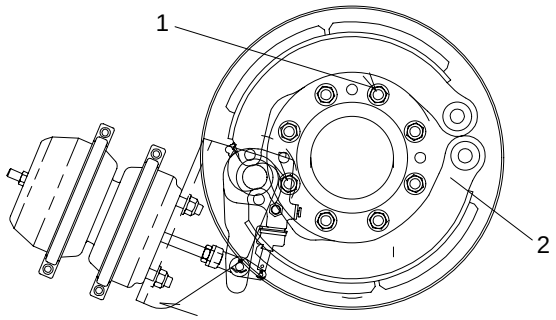
16-1/2 (419 mm) inch by 7 inch (171 mm) cast double web brake shoes are used with the P Series brakes.

Unlike the Q Plus brake shoes, the P Series brake shoes are designed with closed anchor pin ends. The anchor pins couple the brake shoes (the anchor pin ends) to the brake spider.

Q Plus LX500 and MX500 brakes are extended maintenance brakes. These brakes can be identified by an identification tag affixed to the brake shoe. An additional identification tag is affixed to the brake

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1. Brake Spider Fastener
2. Brake Shoe Assembly
3. Camshaft-and-Chamber Bracket

**Fig. 3, Rear Axle P Series Brake**

camshaft-and-chamber bracket (on top of the plugged grease hole).

# Principles of Operation

When the brake pedal is depressed, compressed air enters the brake chamber, causing the diaphragm to move a push rod assembly.

The push rod, which is connected to a slack adjuster, turns the slack adjuster and brake camshaft. As the camshaft turns, the S-type cam head, which is between the brake shoe rollers, forces the brake shoes against the brake drum, and braking occurs.

When the brakes are released and air is exhausted from the brake chamber, the actuator return spring (within the brake chamber) and the brake shoe return spring, return the camshaft, brake shoes, slack adjuster, and the push rod to their released positions.

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## General Safety Precautions

**⚠ WARNING**

**When replacing brake pads, shoes, rotors, or drums, always replace components as an axle set.**

- Always reline both sets of brakes on an axle at the same time.
- Always replace both rotors/drums on an axle at the same time.
- Always install the same type of linings/pads or drums/rotors on both axle ends of a single axle, and all four axle ends of a tandem axle, at the same time. Do not mix component types.

**Failure to do so could cause uneven braking and loss of vehicle control, resulting in property damage, personal injury, or death.**

When working on or around a vehicle, observe the following precautions:

- Park the vehicle on a level surface, shut down the engine, and apply the parking brake. Chock the tires.
- If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning any work on the vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters, which may apply as air pressure drops.
- Disconnect the batteries.
- Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
- Never exceed recommended air pressure. Always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
- Do not remove, disassemble, assemble, or install a component until you have read and understand the service procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use the correct tools and observe all precautions pertaining to use of those tools.
- Replacement hardware, tubing, hose, fittings, etc., should be the equivalent size, type, length, and strength of the original equipment.
- Make sure when replacing tubes or hoses that all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace devices that have stripped threads or damaged parts. Repairs requiring machining should not be attempted.
- Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

## Asbestos and Non-Asbestos Safety

**⚠ WARNING**

**Wear a respirator at all times when servicing the brakes, starting with the removal of the wheels and continuing through assembly. Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH.**

Because some brake linings contain asbestos, you should know the potential hazards of asbestos and the precautions to be taken. Exposure to airborne asbestos brake lining dust can cause serious and possibly fatal diseases such as asbestosis (a chronic lung disease) and cancer.

Because medical experts believe that long-term exposure to some *non-asbestos* fibers could also be a health hazard, the following precautions should also be observed if servicing non-asbestos brake linings.

Areas where brake work is done should be separate from other operations, if possible. As required by OHSA regulations, the entrance to the areas should have a sign displayed indicating the health hazard.

During brake servicing, an air purifying respirator with high-efficiency filters must be worn. The respirator and filter must be approved by MSHA or NIOSH, and worn during all procedures.

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## Safety Precautions

OSHA recommends that enclosed cylinders equipped with vacuums and high-efficiency particulate air (HEPA) filters be used during brake repairs. Under this system, the entire brake assembly is placed within the cylinder and the mechanic works on the brake through sleeves attached to the cylinder. Compressed air is blown into the cylinder to clean the assembly, and the dirty air is then removed from the cylinder by the vacuum.

If such an enclosed system is not available, the brake assembly must be cleaned in the open air. During disassembly, carefully place all parts on the floor to minimize creating airborne dust. Using an industrial vacuum cleaner with a HEPA filter system, remove dust from the brake drums, brake backing plates, and brake parts. After vacuuming, any remaining dust should be removed using a rag soaked in water and wrung until nearly dry. Do not use compressed air or dry brushing to clean the brake assembly.

If grinding or other machining of the brake linings is necessary, other precautions must be taken because exposure to asbestos dust is highest during such operations. In addition to the use of an approved respirator, there must be local exhaust ventilation such that worker exposure is kept as low as possible.

Work areas should be cleaned by industrial vacuums with HEPA filters or by wet wiping. Compressed air or dry sweeping should never be used for cleaning. Asbestos-containing waste, such as dirty rags, should be sealed, labeled, and disposed of as required by EPA and OSHA regulations. Respirators should be used when emptying vacuum cleaners and handling asbestos waste products.

Workers should wash before eating, drinking, or smoking, should shower after work, and should not wear work clothes home. Work clothes should be vacuumed after use and then laundered, without shaking, to prevent the release of asbestos fibers into the air.

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**WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

IMPORTANT: When replacing the brake linings, use a dial indicator to measure the cam-to-bushing radial free play (the up-and-down and side-to-side free play of the camshaft) and the camshaft axial end play (the in-and-out end play of the camshaft).

Replace the bushings if the cam-to-bushing radial free play exceeds:

- for all Cam-Master brakes except Q Plus (LX500 and MX500), 0.030 inch (0.8 mm) of movement;
- for Q Plus (LX500 and MX500), 0.020 inch (0.5 mm) of movement.

Remove the snap ring from the end of the slack adjuster and add shims between the slack adjuster and the snap ring if the axial end play exceeds:

- for all Cam-Master brakes except Q Plus (LX500 and MX500), 0.060 inch (1.5 mm) of movement;
- for Q Plus (LX500 and MX500), 0.005 to 0.030 inch (0.13 to 0.80 mm) of movement.

For more instructions, see **Subject 150**.

# P Series Brake Shoe Removal and Installation

## Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Raise the front or rear axle, then place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.

**WARNING**

**When work is being done on a spring chamber, carefully follow the service instructions of the chamber manufacturer. The sudden release of a compressed spring can cause serious personal injury.**

3. If the brakes have spring chambers, carefully cage and lock the springs so that the springs cannot actuate during disassembly.

**NOTICE**

**For a Meritor automatic slack adjuster, disengage the pull-pawl before turning the manual adjusting nut. Failure to do so could damage the pull-pawl teeth. The brake clearance will not automatically adjust if the pull-pawl is damaged.**

NOTE: For a Haldex or a Gunite automatic slack adjuster, there is an internal clutch that resists the manual adjusting nut from being turned in the counterclockwise direction (de-adjust direction). When turning the manual adjusting nut in the counterclockwise direction to back off the slack adjuster, a torque of approximately 30 lbf·ft (41 N·m) will need to be applied to overcome the resistance of the internal clutch.

4. For each wheel end, back off the automatic slack adjuster by turning its manual adjusting nut until the brake shoes retract and the drum will clear the linings.
5. Remove the wheels and brake drums. For instructions, see **Group 33** or **Group 35**.
6. Remove the brake shoes.

   6.1 Remove the anchor pin snap rings and washers from the anchor pins. See **Fig. 1**.

**WARNING**

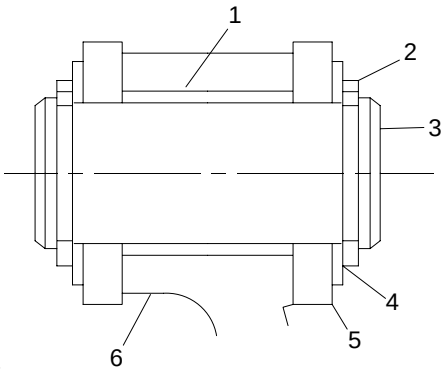
**Wear eye protection when using a drift. Do not hit steel parts with a steel hammer. To do so could cause steel pieces to break off and cause serious eye injury.**

   6.2 Remove the top anchor pin with a brass drift. See **Fig. 2**.

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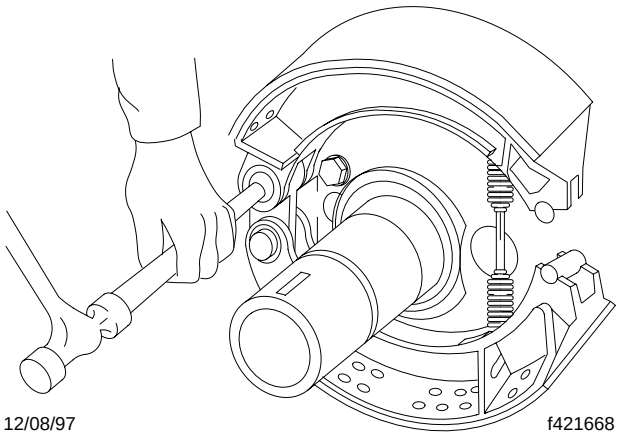
## Brake Shoe Removal and Installation




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1. Bushing
2. Snap Ring
3. Anchor Pin
4. Washer
5. Brake Shoe
6. Brake Spider

**Fig. 1, Anchor Pin Assembly**



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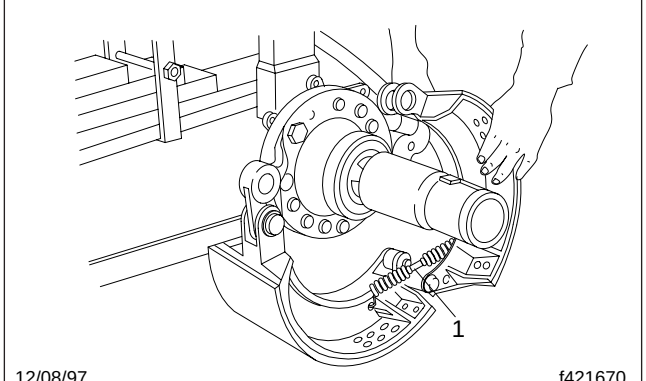
**Fig. 2, Removing/Installing the Anchor Pin**

6.3 Rotate the top brake shoe to release the tension on the return spring. Then, remove the brake shoe. See **Fig. 3**.

**⚠ WARNING**

**Wear eye protection when using a drift. Do not hit steel parts with a steel hammer. To do so could cause steel pieces to break off and cause serious eye injury.**

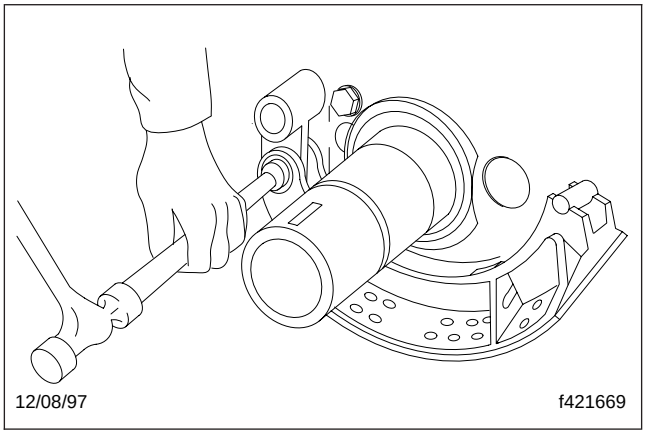
6.4 Remove the bottom anchor pin with a brass drift. See **Fig. 4**. Then, remove the bottom brake shoe.




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1. Brake Return Spring

**Fig. 3, Removing/Installing the Top Brake Shoe**



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**Fig. 4, Removing/Installing Lower Brake Shoe**

6.5 If necessary, remove the cam rollers from the brake shoes. See **Fig. 5**.

7. Inspect the brake shoes and linings for wear or damage. For instructions, see **Subject 120**.
8. Inspect the anchor pin bushings for wear. The inner surface must be smooth. Inspect the brake spider. For inspection instructions, see **Subject 150**.

**⚠ WARNING**

**Wear eye protection when using a drift. Do not hit steel parts with a steel hammer. To do so could cause steel pieces to break off and cause serious eye injury.**

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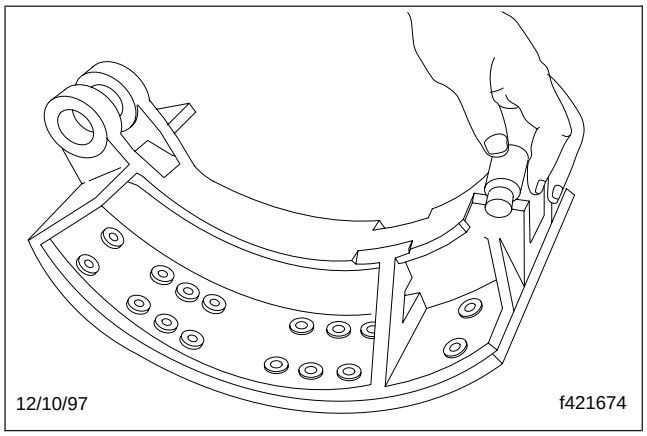



**Fig. 5, Removing the Cam Rollers**

9. If necessary and with an appropriate brass drift, remove the worn anchor pin bushings from the brake spider.

IMPORTANT: If the linings are being replaced, disassemble and inspect the camshaft-and-chamber bracket. For instructions, see **Subject 150**.

## Installation

**WARNING**

**Wear eye protection when using a drift. Do not hit steel parts with a steel hammer. To do so could cause steel pieces to break off and cause serious eye injury.**

1. If necessary and with an appropriate brass drift, install new anchor pin bushings. Align the holes in the bushings with the holes in the brake spider.
2. Install the brake shoes.

   NOTE: When lubricating the cam rollers, do not get grease on the part of the roller that touches the cam head.

   2.1 With an NLGI grade 1 or 2 multi-purpose chassis or temperature resistant grease (Meritor O-616A, O-617-A, O-617B, O-645, or O-692), lubricate the cam rollers where they touch the brake shoes. Then, attach the cam rollers to the brake shoes.

   2.2 With an NLGI grade 1 or 2 multi-purpose chassis or temperature resistant grease (Meritor O-616A, O-617-A, O-617B, O-645, or O-692), lubricate the anchor pins where they touch the brake shoes.

   2.3 Put the lower brake shoe in position on the brake spider.

**WARNING**

**Wear eye protection when using a drift. Do not hit steel parts with a steel hammer. To do so could cause steel pieces to break off and cause serious eye injury.**

   2.4 Using a brass drift, install the lower brake shoe anchor pin. If necessary, align the flat or groove on the anchor pin with the holes in the brake spider and bushing. See **Fig. 4**.

   2.5 Install the washer and snap ring on the lower brake shoe anchor pin. See **Fig. 1**.

   2.6 Install a new brake shoe return spring on the brake shoes. Then, move the upper brake shoe in position over the brake spider. See **Fig. 3**.

   2.7 Using a brass drift, install the upper brake shoe anchor pin. If necessary, align the flat or groove on the anchor pin with the holes in the brake spider and bushing. See **Fig. 2**.

   2.8 Install the washer and snap ring on the lower brake shoe anchor pin. See **Fig. 1**.

3. Install the brake drums and wheels. For instructions, see **Group 33** or **Group 35**.
4. Adjust the brakes at the slack adjusters. For instructions, see **Subject 130**.
5. Remove the safety stands and lower the vehicle.

**WARNING**

**When work is being done on a spring chamber, carefully follow the service instructions of the chamber manufacturer. The sudden release of a compressed spring can cause serious personal injury.**

6. If the brake has spring chambers, carefully release the springs.

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## Brake Shoe Removal and Installation

**DANGER**

**Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.**

7. Before you put the vehicle in service, in a safe area, check for proper brake operation.
   - 7.1 Apply and release the brakes several times to check for air leaks and proper operation of the slack adjusters.
   - 7.2 Do several low speed stops to ensure proper parts replacement and full vehicle control.
   - 7.3 Make ten 40 to 20 mph (64 to 32 km/h) snubs to seat the linings.
   - 7.4 Make ten stops from 20 mph (32 km/h) at 50 percent air pressure.
   - 7.5 Make a full-pressure stop from 20 mph (32 km/h).
   - 7.6 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than others show lack of braking effort on those wheels.

# Q Plus Brake Shoe Removal and Installation

## Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Raise the front or rear axle, then place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.

**WARNING**

**When work is being done on the spring chamber, carefully follow the service instructions of the chamber manufacturer. The sudden release of a compressed spring can cause serious personal injury.**

3. If the brake has spring chambers, carefully cage and lock the springs so that the springs cannot actuate during disassembly.

**NOTICE**

**For a Meritor automatic slack adjuster, disengage the pull-pawl before turning the manual adjusting nut. Failure to do so could damage the pull-pawl teeth. The brake clearance will not automatically adjust if the pull-pawl is damaged.**

NOTE: For a Haldex or a Gunite automatic slack adjuster, there is an internal clutch that resists the manual adjusting nut from being turned in the counterclockwise direction (de-adjust direction). When turning the manual adjusting nut in the counterclockwise direction to back off the slack adjuster, a torque of approximately 30 lbf·ft (41 N·m) will need to be applied to overcome the resistance of the internal clutch.

4. For each wheel end, back off the automatic slack adjuster by turning its manual adjusting nut until the brake shoes retract and the drum will clear the linings.
5. Remove the wheels and brake drums. For instructions, see **Group 33** or **Group 35**.
6. Remove the brake shoes.
   - 6.1 Push down on the bottom brake shoe, then pull on the roller retaining clip to remove the bottom cam roller. See **Fig. 6**.
   - 6.2 Lift the top brake shoe and pull on the roller retaining clip to remove the top cam roller.
   - 6.3 Lift the bottom shoe to release tension on the brake return spring. Remove the spring. See **Fig. 7** and **Fig. 8**.
   - 6.4 Rotate the bottom shoe to release tension on the two retaining springs. Remove the springs and brake shoes. See **Fig. 9**.
7. Inspect the brake shoes and linings for wear or damage. For instructions, see **Subject 120**.

IMPORTANT: If the linings are being replaced, disassemble and inspect the camshaft-and-chamber bracket. For instructions, see **Subject 150**.

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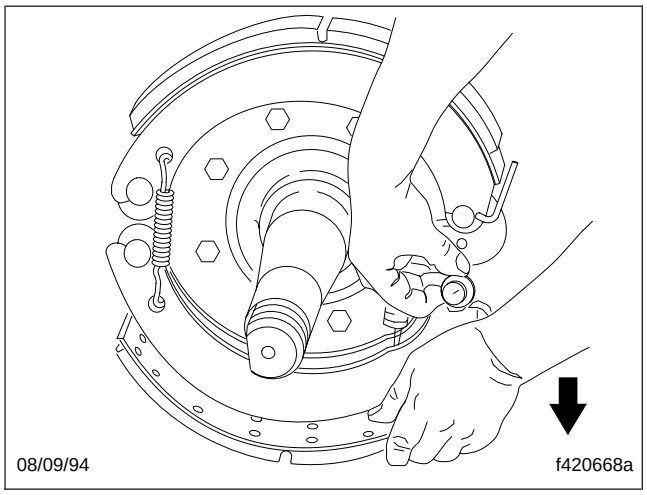
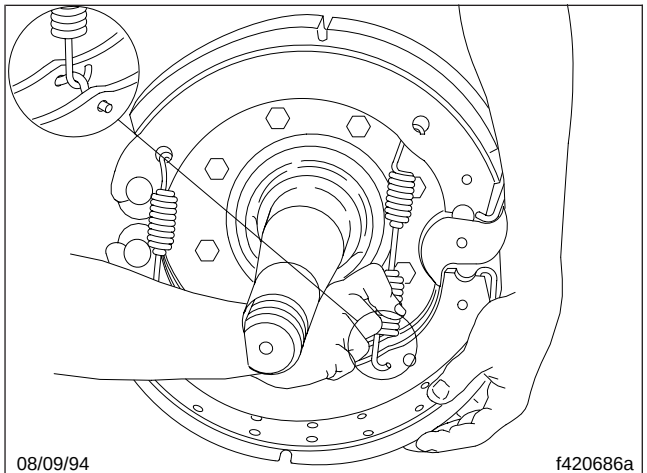
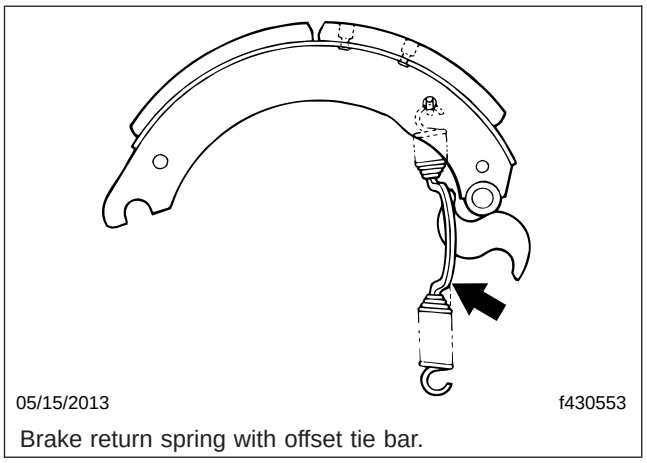



**Fig. 6, Removing the Bottom Cam Roller**




Brake return spring with conventional straight tie bar.

**Fig. 7, Return Spring Removal/Installation, Straight Tie Bar**




Brake return spring with offset tie bar.

**Fig. 8, Return Spring Removal/Installation, Offset Tie Bar**

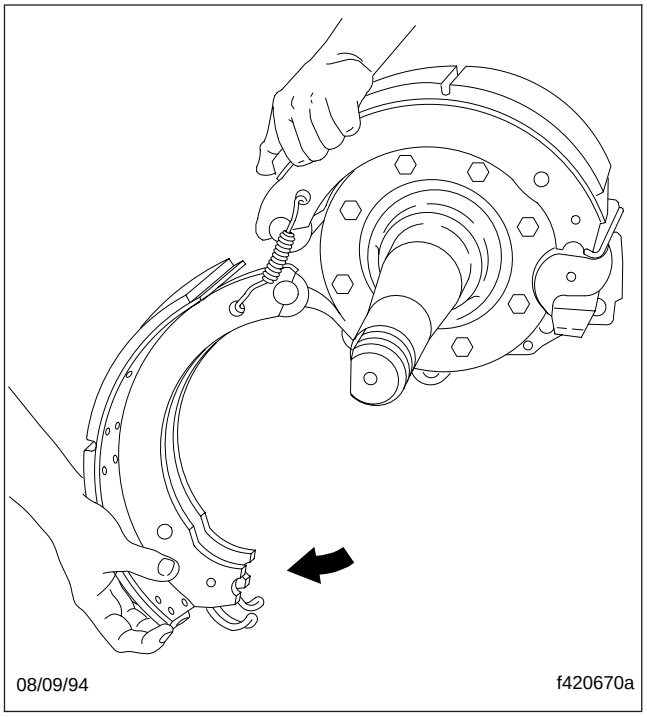



**Fig. 9, Removing the Brake Shoes**

## Installation

IMPORTANT: For best brake performance, don't mix Q Plus brakes with other brakes.

1. Install the brake shoes.

   NOTE: When lubricating the cam rollers, do not get grease on the part of the roller that touches the cam head.

   1.1 With an NLGI grade 1 or 2 multi-purpose chassis or temperature resistant grease (Meritor O-616A, O-617-A, O-617B, O-645, or O-692), lubricate the cam rollers where they touch the brake shoes.

   1.2 With an NLGI grade 1 or 2 multi-purpose chassis or temperature resistant grease (Meritor O-617-A, O-617B, O-645, or O-692), lubricate the anchor pins where they touch the brake shoes.

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## Brake Shoe Removal and Installation

1.3 Place the upper brake shoe in position on the top anchor pin. Hold the lower brake shoe on the bottom anchor pin and attach two new brake shoe retaining springs. See **Fig. 10**.

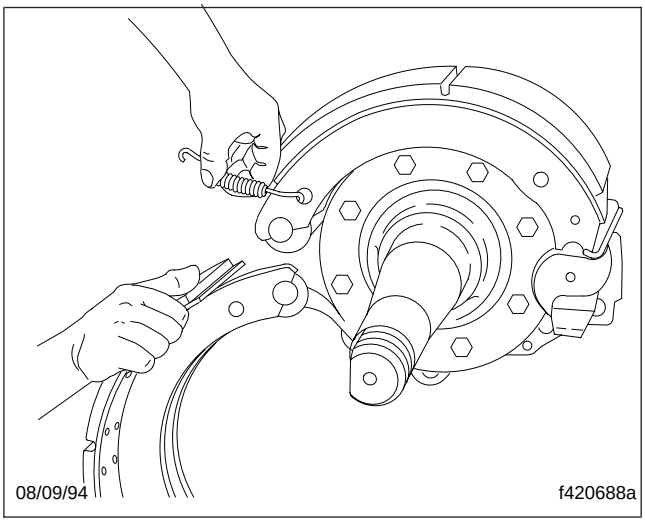



**Fig. 10, Attaching the Retaining Springs**

## NOTICE

**If the offset tie bar shoe return spring is reversed during installation, it will rub a groove in the barrel of the hub, requiring the hub to be replaced.**

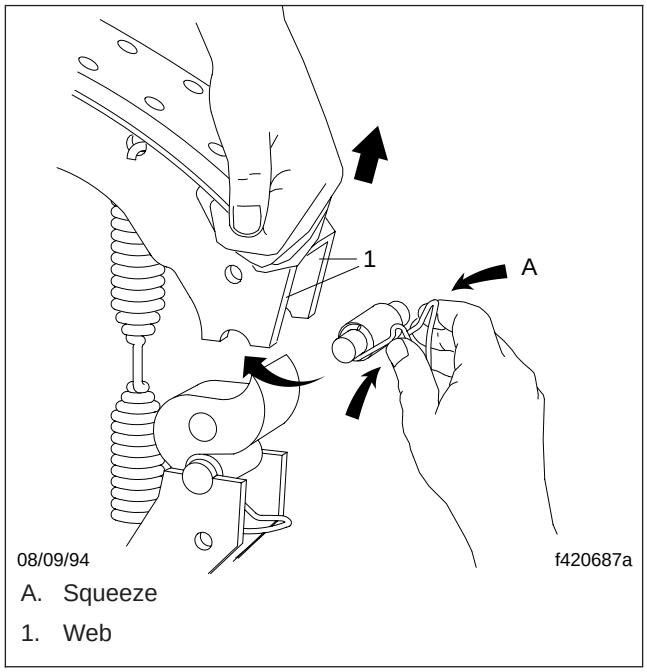
1.4 Turn the lower brake shoe forward and install a new brake shoe return spring. Install the open end of the spring hooks toward the camshaft. See **Fig. 7** and **Fig. 8**.

1.5 Pull each brake shoe away from the cam to allow enough space to install the cam rollers and retainers. Squeeze the ears of the retainer together to permit the retainer to fit between the brake shoe webs. See **Fig. 11**.

1.6 Push the retainer into the brake shoe until the ears lock in the holes in the shoe webs. See **Fig. 12**.

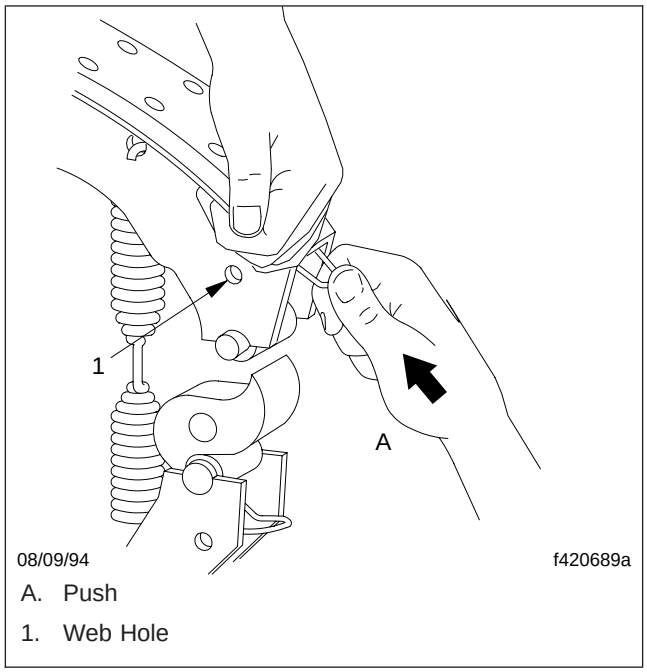
2. Install the wheels and brake drums. For instructions, see **Group 33** or **Group 35**.

3. Adjust the brakes at the slack adjusters. For instructions, see **Subject 130**.




A. Squeeze
1. Web

**Fig. 11, Squeezing the Retainer**




A. Push
1. Web Hole

**Fig. 12, Pushing the Retainer**

4. Remove the safety stands and lower the vehicle.

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**⚠ WARNING**

**When work is being done on a spring chamber, carefully follow the service instructions of the chamber manufacturer. The sudden release of a compressed spring can cause serious personal injury.**

5. If the brakes have spring chambers, carefully release the springs.

**⚠ DANGER**

**Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.**

6. Before you put the vehicle in service, in a safe area, check for proper brake operation.
   - 6.1 Apply and release the brakes several times to check for air leaks and proper operation of the slack adjusters.
   - 6.2 Do several low speed stops to ensure proper parts replacement and full vehicle control.
   - 6.3 Make ten 40 to 20 mph (64 to 32 km/h) snubs to seat the linings.
   - 6.4 Make ten stops from 20 mph (32 km/h) at 50 percent air pressure.
   - 6.5 Make a full-pressure stop from 20 mph (32 km/h).
   - 6.6 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than others shows a lack of braking effort on those wheels.

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**WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

## Inspection

1. Remove the brake shoes using the instructions in **Subject 110**.
2. Check the linings.

   2.1 If the linings are grease-or oil-soaked, cracked, or worn to less than 1/4-inch (6.4 mm) thickness at any point, replace them.

**NOTICE**

**Do not let the brake linings wear to the point were the rivets or bolts touch the drums. Damage to the drums will occur if the linings are allowed to wear to this point.**

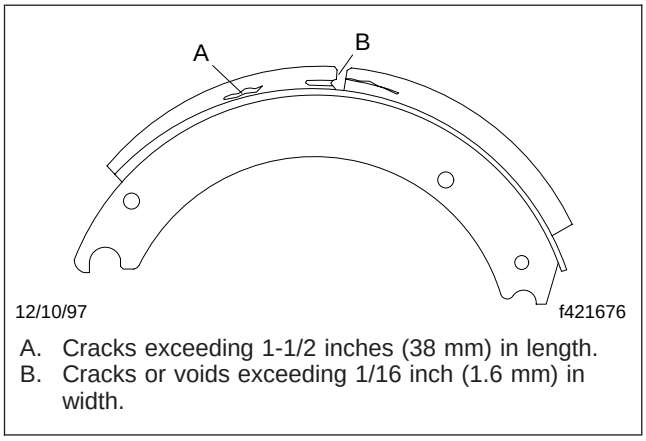
2.2 Replace the linings if the lining surface is closer than 1/32 inch (0.8 mm) to any rivet head.

If bolts are installed, the linings should not be allowed to wear to the point where rivets or bolts may contact the brake drums.

2.3 The lining is considered worn-out and the vehicle should not be driven if:

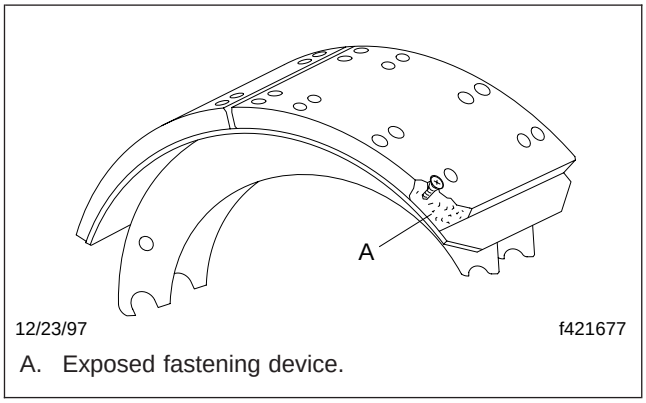
- Cracks on the lining surface exceed 1/16 inch (1.6 mm);
- The lining edge shows cracks or voids over 1/16 inch (1.6 mm) in width and 1-1/2 inches (38 mm) in length. See **Fig. 1**;
- Portions of the lining are missing exposing a rivet when viewed from the edge. See **Fig. 2**;
- Cracks extend across the lining face and through the lining edge, or the lining is loose on the shoe. See **Fig. 3**.

2.4 The vehicle is still operational but the linings should be replaced as soon as possible if:



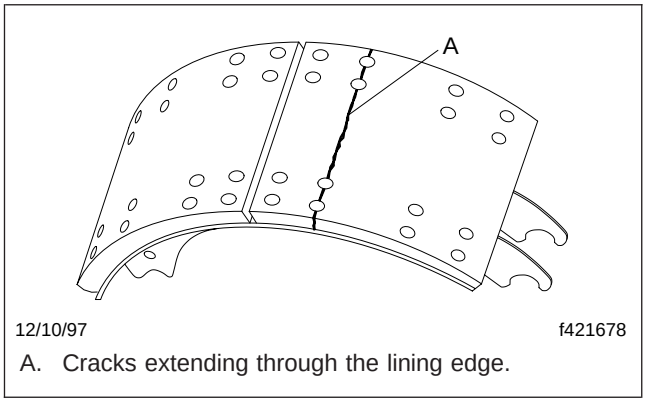

A. Cracks exceeding 1-1/2 inches (38 mm) in length.
B. Cracks or voids exceeding 1/16 inch (1.6 mm) in width.

**Fig. 1, Cracks and Voids**




A. Exposed fastening device.

**Fig. 2, Portions of Brake Lining Missing**




A. Cracks extending through the lining edge.

**Fig. 3, Cracks in the Brake Lining**

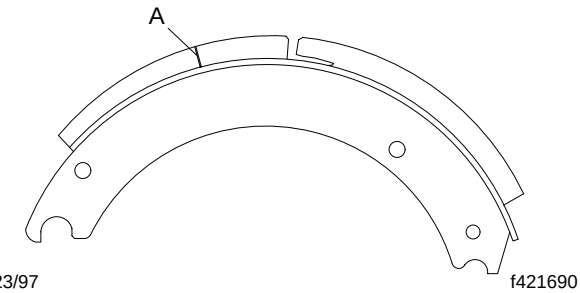
- Horizontal or vertical cracks in the lining edge exhibit no loss of material and do not exceed 1/16 inch

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## Brake Shoe and Lining Inspection

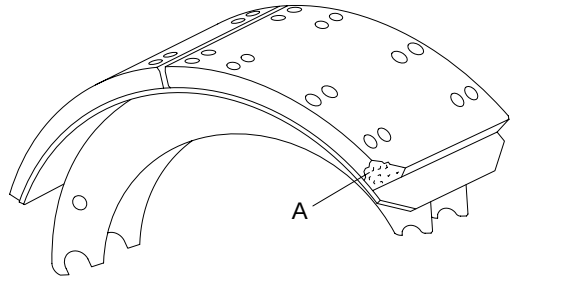
(1.6 mm) in width or 1-1/2 inches (38 mm) in length. See **Fig. 4**;




A. Cracks not exceeding 1-1/2 inches (38 mm) in length or 1/16 inch (1.6 mm) in width.

**Fig. 4, Cracks and Voids**

- Corner portions of the lining are missing with no fastener exposed. See **Fig. 5**;

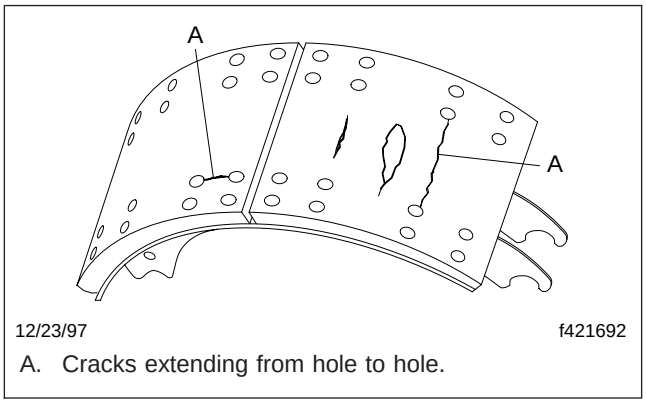



A. Corner segment missing with no fastener exposed.

**Fig. 5, Portions of the Brake Lining Missing**

- Surface cracks extend from hole to hole or if there is scoring and contamination from road debris. See **Fig. 6**.

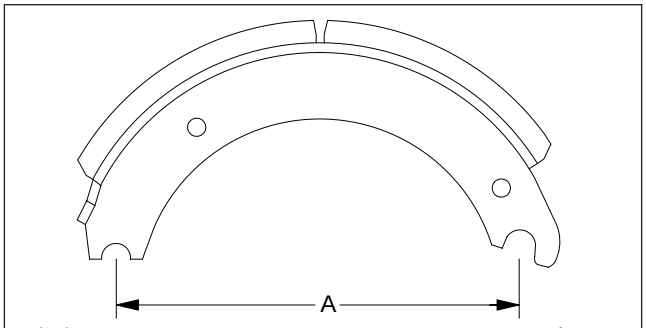
3. Check the brake shoes for bent or cracked webs or tables, rust, broken welds, expanded or out-of-round rivet or bolt holes, and correct alignment. Replace the shoes if any of these conditions exist.
4. Check the brake shoes for visible wear (looseness) at the anchor pin holes and the camshaft roller recesses. Replace the shoe if needed.




A. Cracks extending from hole to hole.

**Fig. 6, Crack in the Brake Lining**

5. Check the diameter of the anchor pin holes. The anchor pin holes must not exceed 1.009 inch (25.6 mm). Check the distance from the center of the anchor pin hole to the center of the cam roller hole (the shoe span). The shoe span must not exceed 12-7/8 inches (327 mm). Replace the shoe if needed. See **Fig. 7**.




A. 12-7/8 inches (327 mm)

**Fig. 7, Measuring the Shoe Span**

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## Pre-Adjustment Checks and General Adjustment Information

Before adjusting the brakes, check and adjust the following:

- Adjust the wheel bearings. For instructions, see **Group 33** or **Group 35**.
- Check the slack adjuster and the brake chamber for loose fasteners and tighten as necessary. For torque specifications, see **Specifications 400**. For slack adjuster installation instructions, see the appropriate section in this group.

Brakes with automatic slack adjusters should never have to be manually adjusted while in service. The only time automatic slack adjusters should be manually adjusted is during installation or after the brakes have been relined.

For cam brakes, there are two brake chamber stroke measurement specifications, applied chamber stroke and free-stroke.

The procedure for adjusting the brake chamber stroke (at the slack adjuster's manual adjusting nut) may vary between each slack adjuster manufacturer. But, there are three basic procedures in completing a manual brake chamber stroke adjustment as follows:

- Adjusting the approximate brake chamber stroke from the manual adjusting nut of the slack adjuster.
- Measuring and readjusting the free-stroke.
- Measuring and readjusting the applied chamber stroke.

The force used to move the slack adjuster from its released position to its applied position (where the brake linings contact the brake drum) distinguishes the free-stroke from the applied chamber stroke. The free-stroke is measured using a lever to move the slack adjuster (from the released to the applied positions). The applied chamber stroke is measured using an 80 to 90 psi (552 to 621 kPa) brake application to move the slack adjuster (from the released to applied positions). The stroke (free or applied chamber) is the distance that the large clevis pin moves when the brakes are applied.

With the engine off, 100 psi (690 kPa) of air tank pressure will apply the required (80 to 90 psi [552 to 621 kPa]) brake application for measuring the applied chamber stroke. The applied chamber stroke measurement can be used for diagnostic purposes. If the applied chamber stroke is too long or too short, this may indicate excessive wear in the cam, cam bushings, return springs, or air chamber. The applied chamber stroke should always be readjusted (minimized) to within the specified limit; but it should not be reduced to the point where the free stroke is too short and the brakes drag. To check for brake drag, spin the wheel end, tap the rim lightly with a hammer, and listen for a drag noise (a sharp ringing sound).

IMPORTANT: The U.S. Department of Transportation (DOT), Federal Highway Administration has issued the applied chamber stroke specifications for cam brakes. When the applied chamber stroke is checked and readjusted, it must not be greater than the DOT specification. See **Table 1**.

| Stroke Limits | | |
|---|---|---|
| **Chamber Size** | **Max. Applied Stroke*: in (mm)** | **Desired Free-Stroke: in (mm)** |
| 16 | 1-3/4 (44) | 5/8–3/4 (15.9–19.1) |
| 16 (long stroke)† | 2 (51) | 5/8–3/4 (15.9–19.1) |
| 20 | 1-3/4 (44) | 5/8–3/4 (15.9–19.1) |
| 20 (long stroke)† | 2 (51) | 5/8–3/4 (15.9–19.1) |
| 24 | 1-3/4 (44) | 5/8–3/4 (15.9–19.1) |
| 24 (long stroke)† | 2 (51) | 5/8–3/4 (15.9–19.1) |
| 30 | 2 (51) | 5/8–3/4 (15.9–19.1) |
| 30 (long stroke)† | 2-1/2 (64) | 5/8–3/4 (15.9–19.1) |
| 36 | 2-1/4 (57) | 5/8–3/4 (15.9–19.1) |

* These specifications are relative to a brake application with 80 to 90 psi (552 to 621 kPa) air pressure in the brake chambers.

† Long stroke design is indicated by a tag, or embossing, on the brake chamber.

**Table 1, Stroke Limits**

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# Adjustment

## Meritor Automatic Slack Adjuster

1. See the pre-adjustment checks and general adjustment information in this subject before adjusting the brakes.
2. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
3. Raise the front or rear axle. Then, place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
4. Fully release the brakes (the air chamber push rod must be fully retracted).
5. Check the condition of the boot on the slack adjuster. It should be held in the proper position with a retaining clip.

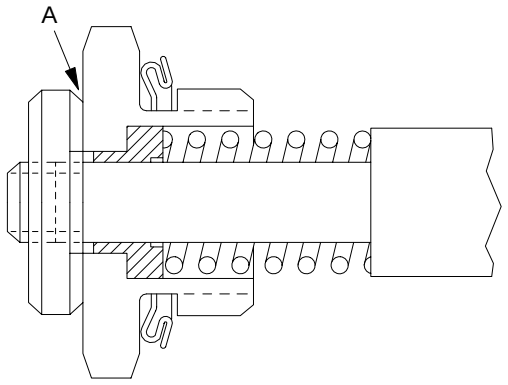
### NOTICE

**Before turning the manual adjusting nut of the slack adjuster, disengage the pull-pawl by raising it up about 1/32 inch (0.8 mm). Failure to do so could damage the pull-pawl teeth. A damaged pull-pawl will not allow the slack adjuster to automatically adjust the brake clearance.**

6. With a screwdriver, pry the pull-pawl up at least 1/32 inch (0.8 mm). This will disengage the pull-pawl teeth from the actuator of the slack adjuster. See **Fig. 1**. Wedge the screwdriver in place. The pull-pawl will need to be disengaged until the brake adjustment is complete.

NOTE: When the screwdriver is removed, the pull-pawl will re-engage automatically.

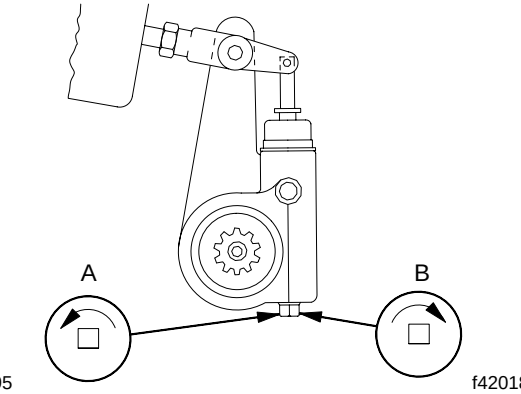
7. Adjust the approximate brake chamber stroke from the manual adjusting nut on the slack adjuster. See **Fig. 2**.
   - 7.1 Turn the adjusting nut counterclockwise until the brake linings touch the brake drum.
   - 7.2 Then, turn the adjusting nut one-half turn in the clockwise direction.
8. Measure and readjust the free-stroke.
   - 8.1 Measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 3**, Ref. A. Record this measurement as dimension A.
   - 8.2 Using a lever, move the slack adjuster until the brake linings contact the brake drum. Then, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 3**, Ref. B. Record this measurement as dimension B.
   - 8.3 Subtract dimension A from dimension B. The difference between these dimensions is the free-stroke.




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A. Insert screwdriver here.

**Fig. 1, Disengaging the Pull-Pawl**



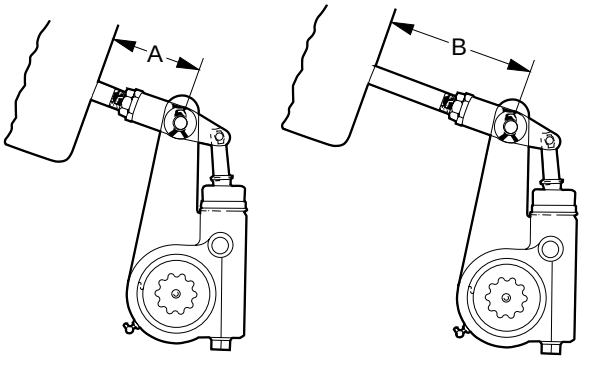

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A. Shorten stroke. B. Lengthen stroke.

**Fig. 2, Turning the Adjusting Nut**

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NOTE: For either free-stroke or applied chamber stroke, subtract measurement A from B.

A. Measurement with the brakes released.
B. Measurement with the brakes applied, by manual lever (free-stroke) or by pressurized brake application (applied chamber stroke).

**Fig. 3, Measuring the Stroke**

The free-stroke should be within the range specified in **Table 1**.

8.4 If the free-stroke is not within the range specified in **Table 1**, turn the adjusting nut one-eighth turn, as shown in **Fig. 2**. Then, measure the free-stroke again, and readjust until it is correct.

9. Measure and readjust the applied chamber stroke.

9.1 Build air pressure to 100 psi (690 kPa). Shut down the engine.

9.2 Fully apply the brakes. Then, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 3**, Ref. B. Record this measurement as dimension C.

9.3 Subtract dimension A (measured in the previous step [**Fig. 3**, Ref. A]) from dimension C. The difference between these dimensions is the applied chamber stroke.

9.4 The applied chamber stroke must be less than the measurements specified in **Table 1**.

**NOTICE**

**The readjusted applied chamber stroke should be as short as possible (allowable), but not so short that the free-stroke is too short and the linings drag. If the linings drag, the brakes could be damaged.**

9.5 If the applied chamber stroke is incorrect, turn the adjusting nut one-eighth turn, as shown in **Fig. 2**. Measure the applied chamber stroke again, and readjust until correct.

9.6 If the slack adjuster is not maintaining the correct applied chamber stroke, check the condition of the foundation brakes. See **Subject 150**. If necessary, replace the slack adjuster.

10. Remove the screwdriver from the pull-pawl assembly. This will engage the pull-pawl to the actuator.

11. Lower the vehicle, remove the safety stands, and remove the chocks from the tires.

**DANGER**

**Do not operate the vehicle until the brakes have been checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.**

12. Check for proper brake operation. For instructions, see **Subject 110**.

## Haldex Automatic Slack Adjuster

1. See the pre-adjustment checks and general adjustment information in this subject before adjusting the brakes.

2. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.

3. Raise the front or rear axle. Then, place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.

4. Fully release the brakes (the air chamber push rod must be fully retracted).

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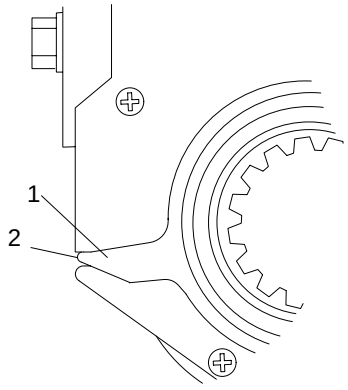


## Brake Adjustment

### NOTICE

**If the slack adjuster is equipped with an installation indicator, the indicator must be in the slotted area as shown in Fig. 4. If the installation indicator is not within the slotted area, the control arm is installed in the wrong position. This may result in tight brakes and excessive lining wear and possible brake damage.**

5. If the slack adjuster is equipped with an installation indicator, check that the installation indicator is within the slotted area. See **Fig. 4**. If the installation indicator is not within the slotted area, the control arm is not properly installed.




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1. Indicator Arrow 2. Slot

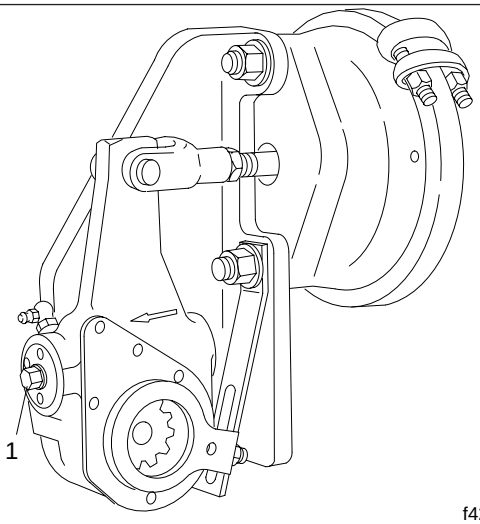
**Fig. 4, Installation Indicator**

6. Check the de-adjustment torque (the internal clutch slippage) of the slack adjuster.

   6.1 Place a torque wrench on the 7/16-inch adjusting hexnut. See **Fig. 5**.

   6.2 While turning the torque wrench in a counterclockwise direction, measure how much torque is required to overcome the resistance of the internal clutch. A normal ratcheting sound will occur while the adjusting hexnut is backed off in the counterclockwise direction. The minimum allowable de-adjustment torque is 13 lbf·ft (18 N·m).

   If the clutch slips with a torque less than 13 lbf·ft (18 N·m), the slack adjuster must be replaced.




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1. Adjusting Hexnut

**Fig. 5, Adjusting Hexnut**

7. Adjust the approximate brake chamber stroke from the manual adjusting nut on the slack adjuster.

   7.1 Turn the adjusting hexnut clockwise until the brake linings contact the brake drum.

   7.2 Then, turn the adjusting hexnut one-half turn in the opposite direction. A normal ratcheting sound will occur when the adjusting hexnut is backed off in the counterclockwise direction.

8. Measure and readjust the free-stroke.

   8.1 Measure the distance from the face of the brake chamber to the far side of the clevis pin. See **Fig. 6**, Ref. A. Record this measurement as dimension A.

   8.2 Using a lever, move the slack adjuster until the brake linings contact the brake drum. Then, measure the distance from the face of the brake chamber to the far side of the clevis pin. See **Fig. 6**, Ref. B. Record this measurement as dimension B.

   8.3 Subtract dimension A from dimension B. The difference between these dimensions is the free-stroke. The free-stroke should be within the range specified in **Table 1**.

   8.4 If the free-stroke is not within the range specified in **Table 1**, turn the adjusting nut

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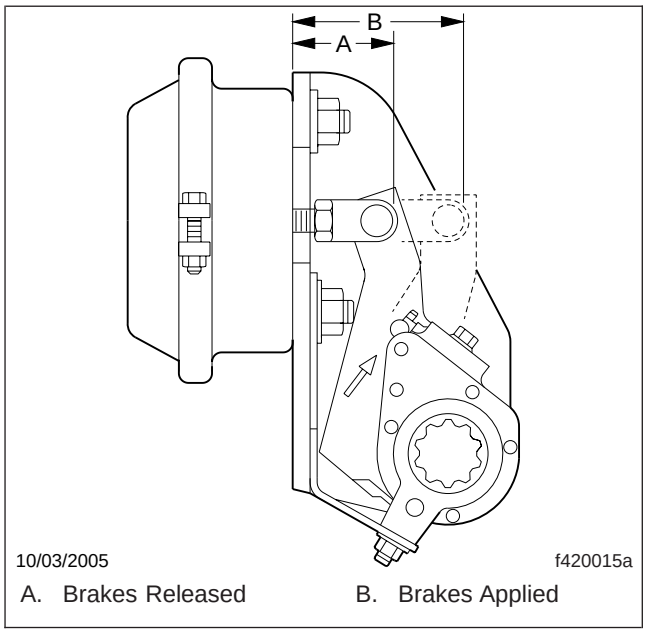



**Fig. 6, Measuring the Stroke**

in the direction required. Then, measure the free-stroke again, and readjust until it is correct.

9. Measure and readjust the applied chamber stroke.

   9.1 Build air pressure to 100 psi (690 kPa). Shut down the engine.

   9.2 Fully apply the brakes. Then, measure the distance from the face of the brake chamber to the far side of the clevis pin hole. See **Fig. 6**, Ref. B. Record this measurement as dimension C.

   9.3 Subtract dimension A (measured in the previous step [**Fig. 6**, Ref. A]) from dimension C. The difference between these dimensions is the applied chamber stroke. The applied chamber stroke must be less than the measurements shown in **Table 1**.

   9.4 If the applied chamber stroke is not correct, turn the adjusting nut in the direction required. Then, measure the applied chamber stroke again, and readjust until it is correct.

   9.5 If the slack adjuster is not maintaining the correct applied chamber stroke, check the condition of the foundation brakes (see **Subject 150**). If necessary, replace the slack adjuster.

10. Lower the vehicle, remove the safety stands, and remove the chocks from the tires.

**⚠ DANGER**

**Do not operate the vehicle until the brakes have been checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.**

11. Check for proper brake operation. For instructions, see **Subject 110**.

## Haldex Self-Setting Automatic Brake Adjusters (S-ABA)

IMPORTANT: Before adjusting the brakes, see the pre-adjustment checks and general adjustment information at the beginning of this subject.

NOTE: To ensure a proper fit and function, always replace both adjuster and mounting bracket as a set.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires on the axle that is not being repaired.
2. Make certain the system tank pressure is above 100 psi (690 kPa).
3. Raise the front or rear axle. Then, place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
4. Check to be sure the push rod is fully retracted. Apply air to release the spring brake. If air is not available, the spring brake must be manually caged.
5. Install the anchor bracket loosely as shown in **Fig. 7**.
6. Some strap brackets have two mounting holes. The proper mounting location is determined by the length of the adjuster arm. 5 inch and 5-1/2 inch adjuster arm lengths utilize the shorter hole location. 6 inch and 6-1/2 inch length adjusters utilize the longer hole locations.

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## Brake Adjustment

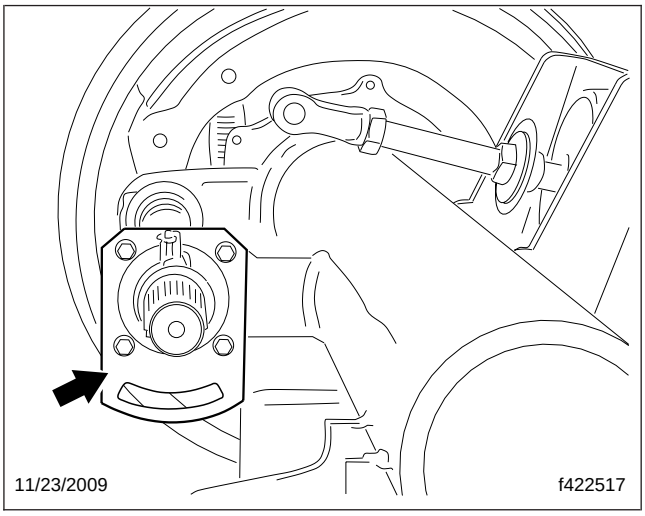



**Fig. 7, Anchor Bracket Installation**

7. Do not tighten the anchor bracket fasteners at this time. Apply antiseize lubricant to the camshaft splines.
8. Install the brake adjuster onto the camshaft *with the adjusting hex pointing away from the brake chamber.* See **Fig. 8**.

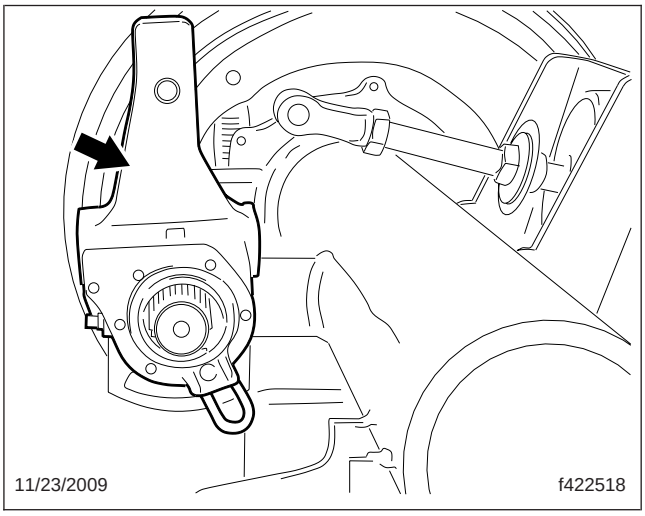



**Fig. 8, Installing the Brake Adjuster**

9. Secure the brake adjuster on the camshaft. Use at least one inner washer and enough outer washers to allow no more than 0.060 inch (1.52 mm) movement of the adjuster on the camshaft.

**NOTICE**

**Do not pull the push rod out to meet the brake adjuster. Doing so could damage the push rod.**

10. Rotate the 7/16 inch adjusting hexnut clockwise until the clevis hole lines up with the brake adjuster arm hole.
11. Apply antiseize to the clevis pin, then install and secure with the cotter pin.
12. The S-ABA control arm can be placed anywhere within the range of the bracket slot for automatic adjustment to take place. However, Haldex recommends rotating all control arms towards the axle until they come to a complete stop, as shown in **Fig. 9**, and then secure the arm in that position. This will create a 'common' position for all wheels.

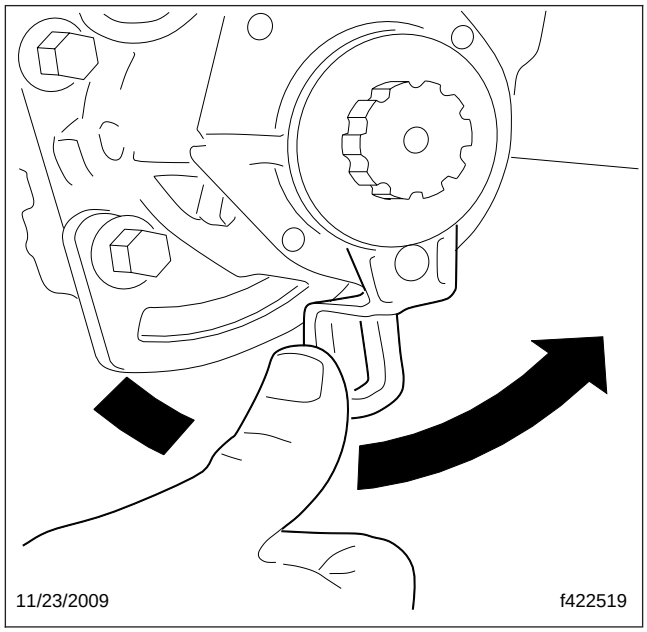



**Fig. 9, Positioning the Control Arm**

13. The adjuster must now be manually adjusted.
    - 13.1 Rotate the adjusting hexnut clockwise until the lining lightly contacts the drum.
    - 13.2 Back-off the adjuster by turning the adjusting hexnut 1/2-turn counterclockwise. See **Fig. 10**.

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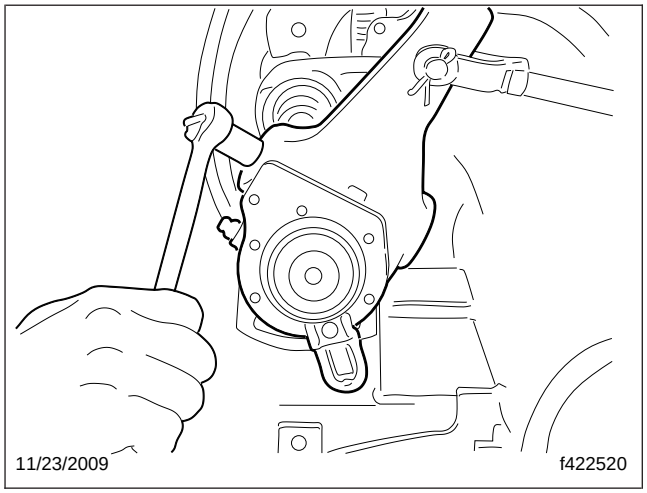



**Fig. 10, Backing Off the Adjuster**

## NOTICE

**Do not use an impact wrench or permanent internal damage will occur.**

13.3 A minimum of 13 lbf·ft (18 N·m) is needed to overcome the internal clutch; a ratcheting sound will be present.

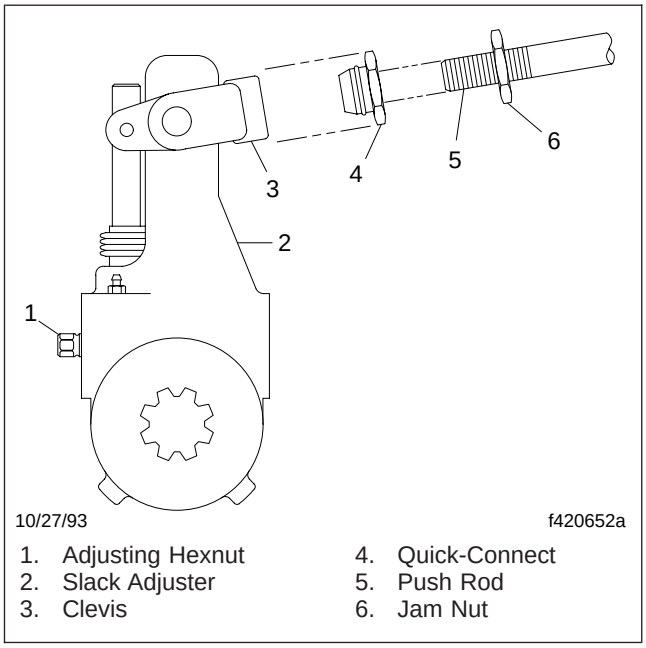
# Gunite Automatic Slack Adjuster

1. See the pre-adjustment checks and general adjustment information in this subject before adjusting the brakes.
2. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
3. Raise the front or rear axle. Then, place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
4. Fully release the brakes (the air chamber push rod must be fully retracted).
5. Check the de-adjustment torque (the internal clutch slippage) of the slack adjuster.

   5.1 Place a torque wrench on the adjusting hexnut. See **Fig. 11**.

   5.2 While turning the torque wrench in a counterclockwise direction, measure how much torque is required to overcome the resistance of the internal clutch. A normal ratcheting sound will occur while the adjusting hexnut is backed off in the counterclockwise direction. The de-adjustment torque must not be less than 15 lbf·ft (20 N·m).

   If the clutch slips with a torque less than 15 lbf·ft (20 N·m), the slack adjuster must be replaced.




1. Adjusting Hexnut
2. Slack Adjuster
3. Clevis
4. Quick-Connect
5. Push Rod
6. Jam Nut

**Fig. 11, Gunite Slack Adjuster**

6. Adjust the approximate brake chamber stroke from the manual adjusting nut on the slack adjuster.

   6.1 Turn the adjusting hexnut clockwise until the brake linings contact the brake drum.

   6.2 Turn the adjusting hexnut counterclockwise one-half turn. There should be about 30 lbf·ft (41 N·m) resistance, and a ratcheting sound will occur.

7. Measure and readjust the free-stroke.

   7.1 Measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 12**, Ref. A. Record this measurement as dimension A.

   7.2 Using a lever, move the slack adjuster until the brake linings contact the brake drum. Then, measure the distance from the bottom of the brake chamber to the

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## Brake Adjustment

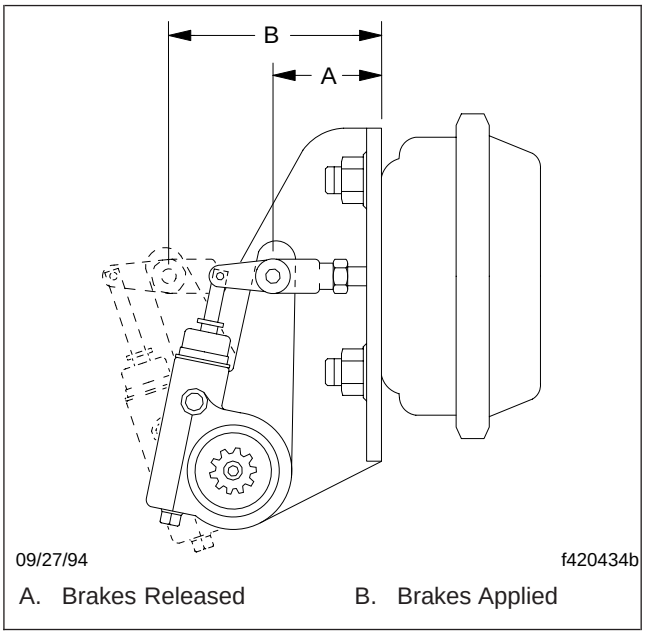



**Fig. 12, Measure the Stroke**

center of the large clevis pin. See **Fig. 12**, Ref. B. Record this measurement as dimension B.

7.3 Subtract dimension A from dimension B. The difference between these dimensions is the free-stroke. The free-stroke should be within the range specified in **Table 1**.

7.4 If the free-stroke is not within the range specified in **Table 1**, turn the adjusting nut in the direction required. Then, measure the free-stroke again, and readjust until it is correct.

8. Measure the applied chamber stroke.

8.1 Build air pressure to 100 psi (690 kPa). Shut down the engine.

8.2 Fully apply the brakes. Then, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 12**, Ref. B. Record this measurement as dimension C.

8.3 Subtract dimension A (measured in the previous step [**Fig. 12**, Ref. A]) from dimension C. The difference between these dimensions is the applied chamber stroke. The applied chamber stroke must be less than the measurements shown in **Table 1**.

8.4 If the applied chamber stroke is not correct, turn the adjusting nut in the direction required. Then, measure the free-stroke again, and readjust until it is correct.

8.5 If the slack adjuster is not maintaining the correct applied chamber stroke, check the condition of the foundation brakes. See **Subject 150**. If necessary, replace the slack adjuster.

9. Lower the vehicle, remove the safety stands, and remove the chocks from the tires.

**⚠ DANGER**

**Do not operate the vehicle until the brakes have been checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.**

10. Check for proper brake operation. For instructions, see **Subject 110**.

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**WARNING**

**Before starting the procedure below, read the safety precaution information in Subject 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.**

## Replacement

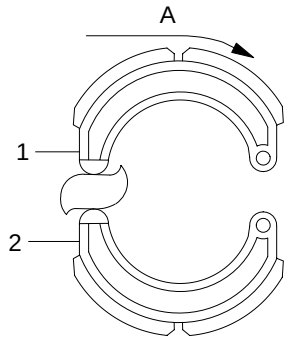
IMPORTANT: Vehicle brake systems require the correct lining material to perform as originally designed. The type of lining material that is specified for the vehicle is based on several technical considerations and DOT braking performance regulations. To ensure fewer relines and greater compatibility with the vehicles brake system, insist on the same quality OEM friction lining material.

Always reline both wheels of a single axle and all wheels of a tandem axle at the same time. Always install the same linings and drums on both wheels of a single axle and all four wheels of a tandem axle. It is not necessary that both axles (front and rear) have the same linings and drum.

Combination linings with different friction ratings for the primary and secondary shoes are sometimes used. When combination friction lining sets are used, the lining blocks must be installed in the correct locations on the brake shoes.

NOTE: Always follow the instructions supplied with the replacement combination lining sets for correct installation. The primary linings must be installed on the primary shoe. The first shoe past the cam in the direction of the wheel rotation is the primary shoe. The primary shoe can be either at the top or the bottom position, depending on the location of the cam. If the cam is behind the axle, then the top shoe is the primary shoe. If the cam is in front of the axle, then the bottom shoe is the primary shoe. See **Fig. 1** and **Fig. 2**.

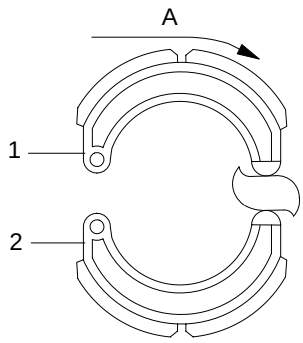
1. Remove the brake shoes. See **Subject 110** for instructions.




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A. Right wheel rotation
1. Primary Shoe 2. Secondary Shoe

**Fig. 1, Camshaft Behind the Axle**




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A. Right wheel rotation
1. Secondary Shoe 2. Primary Shoe

**Fig. 2, Camshaft Ahead of the Axle**

IMPORTANT: When replacing the brake linings, use a dial indicator to measure the cam-to-bushing radial free play (the up-and-down and side-to-side free play of the camshaft) and the camshaft axial end play (the in-and-out end play of the camshaft).

Replace the bushings if the cam-to-bushing radial free play exceeds:

- for all Cam-Master brakes except Q Plus (LX500 and MX500), 0.030 inch (0.8 mm) of movement;
- for Q Plus (LX500 and MX500), 0.020 inch (0.5 mm) of movement.

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## Brake Shoe Lining Replacement

Remove the snap ring from the end of the slack adjuster and add shims between the slack adjuster and the snap ring if the axial end play exceeds:

- for all Cam-Master brakes except Q Plus (LX500 and MX500), 0.060 inch (1.5 mm) of movement;
- for Q Plus (LX500 and MX500), 0.005 to 0.030 inch (0.13 to 0.80 mm) of movement.

For more instructions, see **Subject 150**.

2. Disassemble the lining blocks from the brake shoes.

   2.1 If the lining blocks are bolted, proceed to the next substep. Otherwise, if the lining blocks are riveted, using a suitable riveting mandrel, push out the old rivets.

### NOTICE

**Drilling out rivets or cutting off rivet heads with a chisel can cause the rivet hole to become out-of-round. This could damage the brake shoe.**

   2.2 If the lining blocks are bolted, remove the bolts, lockwashers, and nuts.

   2.3 Separate the lining blocks from the brake shoes.

3. Check the brake shoes for rust, expanded rivet or bolt holes, broken welds and correct alignment. Replace the shoe if any of these conditions exist.
4. If necessary, clean the brake shoe with solvent and wire brush the shoe table. Then, paint the brake shoe with rust inhibitive paint.
5. Assemble the lining blocks to the brake shoes.

   IMPORTANT: Use rivets that have the correct material, shank diameter, length, head size, and shape. Use tubular rivets that are 1/4-inch diameter by 9/16-inch long, SAE no. 10, made of plated steel or brass.

   5.1 If the lining blocks are bolted, proceed to the next substep. Otherwise, if the lining blocks are riveted, align the brake shoe rivet holes with the corresponding lining block holes. Using a C-clamp, clamp the lining block to the brake shoe.

   Insert the correct size rivets into all the holes and threads. Then, temporarily hold the rivets in place with masking tape.

   Fasten the rivets (from the lining block to the brake shoe) in the sequence shown in **Fig. 3**.

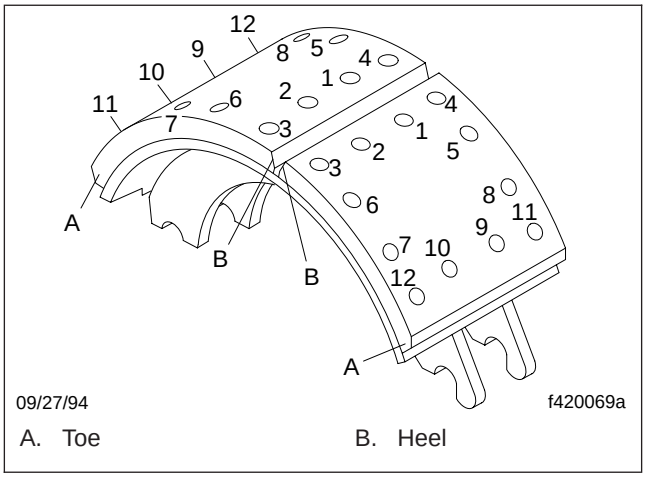



**Fig. 3, Fastening Sequence**

   5.2 If the lining blocks are bolted, align the brake shoe bolt holes with the corresponding lining block holes. Using a C-clamp, clamp the lining block to the brake shoe.

   Insert the correct size bolts, and new lockwashers into all the holes and threads. Loosely install the nuts.

   Tighten the nuts (in the sequence shown in **Fig. 3**):

   - 18 to 23 lbf·ft (24 to 31 N·m) for 3/8-inch brass bolts;
   - 80 to 100 lbf·in (904 to 1130 N·cm) for 1/4-inch brass bolts.

6. Check the lining installation by trying to insert a 0.010 inch (0.25 mm) feeler gauge between the linings and the shoe table along the edges. See **Fig. 4**, Ref. A. It should not be possible to insert the feeler gauge anywhere along the edge, except beyond the last row of rivets at each end. See **Fig. 5**, Ref. A. A larger clearance (up to 0.025 inch [0.64 mm]) may exist at the ends.

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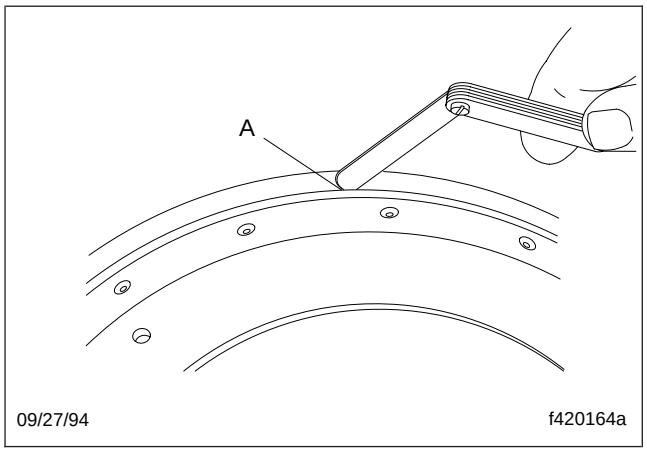



**Fig. 4, Checking Clearance Along the Edge**

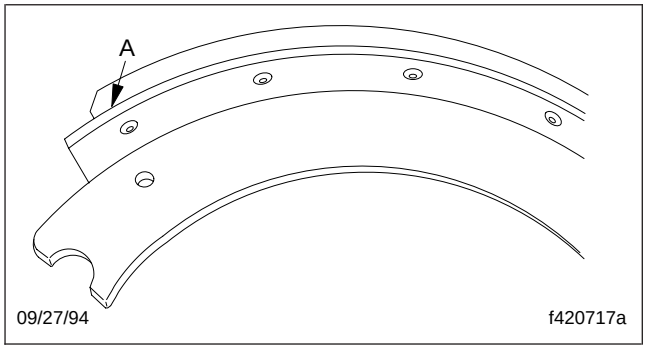



**Fig. 5, Checking Clearance at the Ends**

7. Circle grind the brake lining to obtain the correct lining-to-drum contact. With the cam in the full-release position, the new brake linings must be ground 0.070 inch (1.8 mm) less than the drum diameter. The cam must be adjusted and the lining ground until there is an 80 percent lining-to-drum contact, which must be continuous and in the center of the lining.
8. Install the brake shoes. See **Subject 110** for instructions.

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## Brake Components Disassembly and Inspection, Cleaning, and Assembly

# Disassembly and Inspection

**⚠ WARNING**

**Before starting the procedure below, read the safety precaution information in Subject 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.**

1. Remove the brake shoes, see **Subject 110** for instructions. See **Fig. 1**, **Fig. 2**, **Fig. 3**, or **Fig. 4**.

NOTE: Meritor recommends that the brake drum not be turned or rebored (resurfaced). Turning or reboring drums can decrease the strength and heat capacity of the drum.

2. Inspect the brake drum as shown in **Fig. 5**.
   - 2.1 Check the drum for cracks, severe heat-checking, heat spotting, scoring, pitting, distortion, and out-of-round.
   - 2.2 With a drum caliper, or other measuring device, measure the inside diameter of the drum in several locations. Replace the drum if it exceeds the maximum diameter stamped on it. Replace cracked drums. Some drums that are glazed, grooved, or out-of-round can be repaired. For detailed instructions, see **Group 33** or **Group 35**.
3. Remove the pushrod clevis pin and disconnect the slack adjuster from the pushrod clevis. See **Fig. 6**.
4. Check the camshaft radial free-play. See **Fig. 7**.
   - 4.1 Using a dial indicator, measure the up-and-down and side-to-side free-play of the camshaft.
   - 4.2 For all Cam-Master brakes except the Q Plus (LX500 and MX500) brakes, replace the camshaft bushings if there is more than 0.030 inch (0.8 mm) of free-play. For Q Plus (LX500 and MX500) brakes, replace the camshaft bushings if there is more than 0.020 inch (0.5 mm) of free-play.
5. Remove the slack adjuster.
   - 5.1 From the slack adjuster side of the camshaft-and-chamber bracket, remove any snap rings, washers, spacers, and the orange slack adjuster seal (Q Plus LX500 and MX500 only) from the camshaft.
   - 5.2 Remove the slack adjuster from the camshaft.
6. Inspect the slack adjuster for damage or binding.
   - 6.1 Check the slack adjuster clevis for cracks or bushing wear. Check the splines for chipped teeth and deformation. Replace as needed.

**NOTICE**

**For a Meritor automatic slack adjuster, before turning the manual adjusting nut, disengage the pull-pawl by raising it up about 1/32 inch (0.8 mm). Failure to do so could damage the pull-pawl teeth. A damaged pull-pawl will not allow the slack adjuster to automatically adjust the brake clearance.**

NOTE: For a Haldex or a Gunite automatic slack adjuster, there is an internal clutch that resists the manual adjusting nut from being turned in the counterclockwise direction (de-adjust direction). When checking these slack adjusters for binding, only rotate the manual adjusting nut in the clockwise direction.

- 6.2 Using a wrench, turn the manual adjusting nut so that the worm gear rotates a full 360 degrees. If there is binding, or if excessive force is needed to turn the slack adjuster, replace it. For instructions, see the appropriate slack adjuster section in this group.

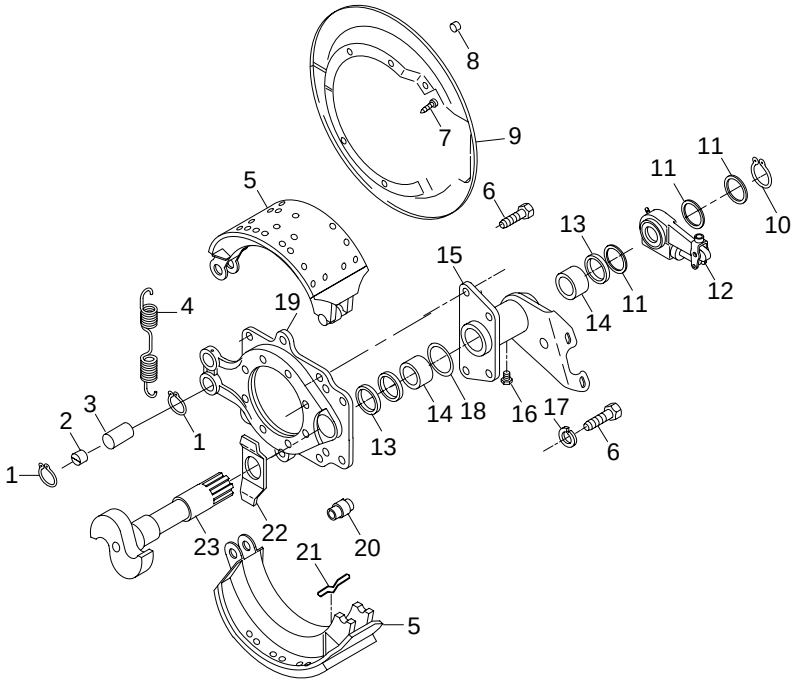
IMPORTANT: If any slack adjuster problem is found, repair or replace the unit, depending on the manufacturer's recommendations.

7. Remove the camshaft by grasping its head and pulling the camshaft outboard from the brake spider and camshaft-and-chamber bracket. See **Fig. 8**. Then, remove the thrust washer from the camshaft.
8. Check the camshaft spline end for cracks, corrosion, or worn or deformed splines. Replace the camshaft if damaged.
9. Check the camshaft bearing journals for wear or corrosion. Replace the camshaft if it is worn or if roughness is felt in the journal area.

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## Brake Components Disassembly and Inspection, Cleaning, and Assembly




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1. Anchor Pin Snap Ring
2. Anchor Pin Bushing
3. Brake Shoe Anchor Pin
4. Brake Shoe Return Spring
5. Brake Shoe and Lining Assembly
6. Camshaft Bracket Capscrew
7. Dust Shield Capscrew
8. Plug
9. Dust Shield
10. Camshaft Snap Ring
11. Spacing Washer
12. Automatic Slack Adjuster
13. Camshaft Grease Seal
14. Camshaft Bushing
15. Camshaft-and-Chamber Bracket
16. Grease Fitting
17. Bracket Capscrew Washer
18. Camshaft Bracket Seal
19. Brake Spider
20. Brake Shoe Roller
21. Return Spring Pin
22. Camhead Washer
23. "S" Head Camshaft

**Fig. 1, P Series Brake (exploded view)**

10. Inspect the camshaft head for brinelling, cracking, or flat spots. Replace the camshaft if a ridge can be felt between the worn area and the cam head surface.
11. From the brake spider and slack adjuster ends of the camshaft-and-chamber bracket, remove and inspect the camshaft grease seals. If a grease seal lip is nicked, cut or distorted, replace it.

**⚠ WARNING**

**When removing bushings with a driver, wear eye protection. Do not hit steel parts with a steel hammer. To do so could cause steel pieces to break off, which could cause serious eye injury.**

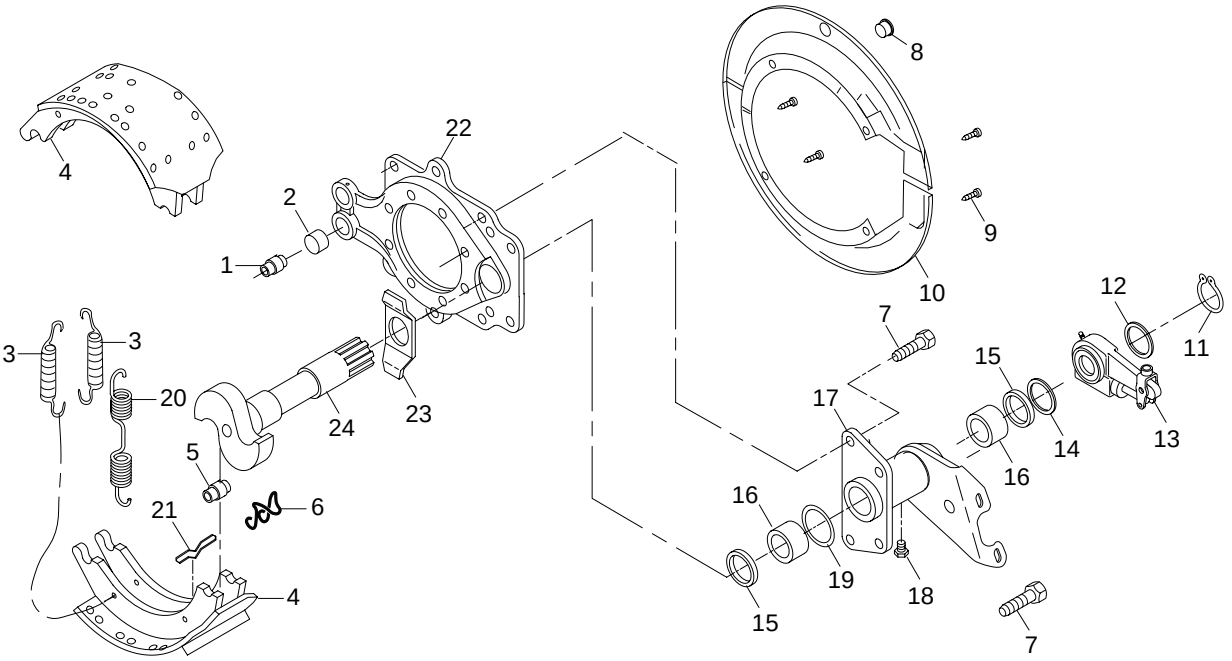
12. Using the correct size driver, remove the camshaft bushings from the camshaft-and-chamber bracket.
13. Check the camshaft bushings for wear. The inner surface must be smooth; if rough or abrasive, replace the bushings.
14. Remove the brake chamber stud nuts and lockwashers that attach the brake chamber to the camshaft-and-chamber bracket.

    Check the chamber for a cracked housing, bent pushrod, loose clamp ring, loose air fitting, air leaks, or clogged vent holes. Repair or replace brake chamber parts as needed.
15. Remove and inspect the camshaft-and-chamber bracket. Remove and discard its gasket.

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## Brake Components Disassembly and Inspection, Cleaning, and Assembly




1. Brake Shoe Anchor Pin
2. Anchor Pin Bushings
3. Shoe Retaining Spring
4. Brake Shoe and Lining Assembly
5. Brake Shoe Roller
6. Brake Shoe Roller Retainer
7. Chamber Bracket Capscrew
8. Plug
9. Dust Shield Capscrew
10. Dust Shield
11. Camshaft Snap Ring
12. Spacing Washer
13. Automatic Slack Adjuster
14. Thick Camshaft Washer
15. Camshaft Grease Seal
16. Camshaft Bushing
17. Camshaft-and-Chamber Bracket
18. Grease Fitting
19. Chamber Bracket Seal
20. Brake Shoe Return Spring
21. Brake Shoe Return Spring Pin
22. Brake Spider
23. Camhead Washer
24. "S" Head Camshaft

**Fig. 2, Q Plus Brake Without LX500 and MX500 ID Tag (exploded view)**

Check the bracket for a bent, broken or cracked arm, and cracked welds. Replace the bracket if any of these conditions exist.

16. Remove the brake spider-to-axle attaching nuts, hardened washers, and bolts. Remove the brake spider from the axle flange.
17. If equipped, remove the four capscrews that attach the dust shield to the brake spider; remove the dust shield.

NOTE: For P Series brakes, the anchor pins have already been removed (in the brake removal).

18. Inspect the brake spider and parts for damage; replace as needed.

18.1 Check the bolt holes, cam area, and anchor pin area for cracks and check for expanded anchor pin holes. Replace if damaged.

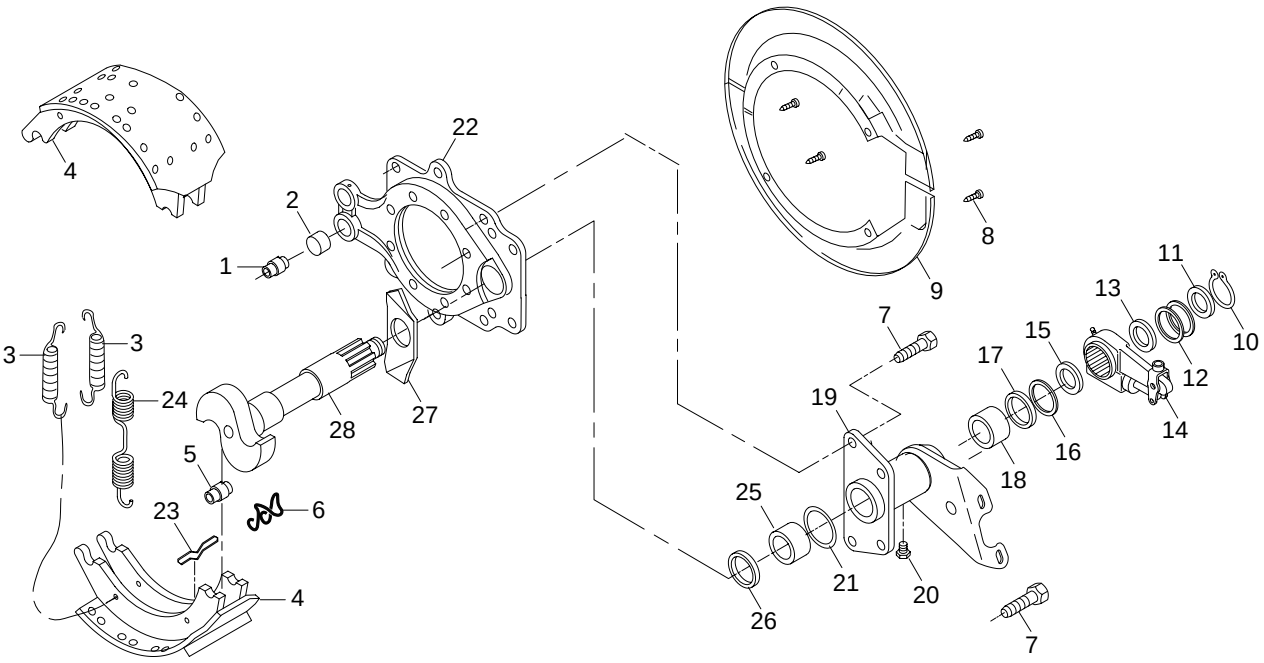
18.2 Check the anchor pins. If worn or loose, replace them.

18.3 Check the anchor pin bushings for wear. The inner surfaces must be smooth. If any surface is rough or abrasive, replace the part.

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## Brake Components Disassembly and Inspection, Cleaning, and Assembly




12/12/97 f421685

NOTE: 16-1/2 inch Q Plus (with LX500 and MX500 identification tags, and a cast brake spider) brake shown.

1. Brake Shoe Anchor Pin
2. Anchor Pin Bushing
3. Brake Shoe Retaining Spring
4. Brake Shoe and Lining Assembly
5. Brake Shoe Roller
6. Brake Shoe Roller Retainer
7. Chamber Bracket Capscrew
8. Dust Shield Capscrew
9. Dust Shield
10. Camshaft Snap Ring
11. Spacing Washer
12. Thin Spacing Washer
13. Orange Seal, Automatic Slack Adjuster
14. Automatic Slack Adjuster
15. Seal, Automatic Slack Adjuster
16. Thick Camshaft Washer
17. Camshaft Seal
18. Camshaft Bushing, 1.50" I.D.
19. Camshaft-and-Chamber Bracket
20. Pipe Plug
21. Chamber Bracket Seal
22. Brake Spider, Cast
23. Brake Shoe Return Spring Pin
24. Brake Shoe Return Spring
25. Camshaft Bushing, 1.625" I.D.
26. Orange Camshaft Seal
27. Camhead Washer
28. "S" Head Camshaft

**Fig. 3, Q Plus LX500 and MX500 Brake With Cast Spider (exploded view)**

## Cleaning

**⚠ WARNING**

**Before starting the procedure below, read the safety precaution information in Subject 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.**

**NOTICE**

**Do not clean ground or polished metal parts in a hot solution tank or with water, steam, or alkaline solutions. These solutions will cause parts to corrode.**

For corrosion protection, do not apply brake grease or corrosion-preventive materials to the brake linings or the brake drum.

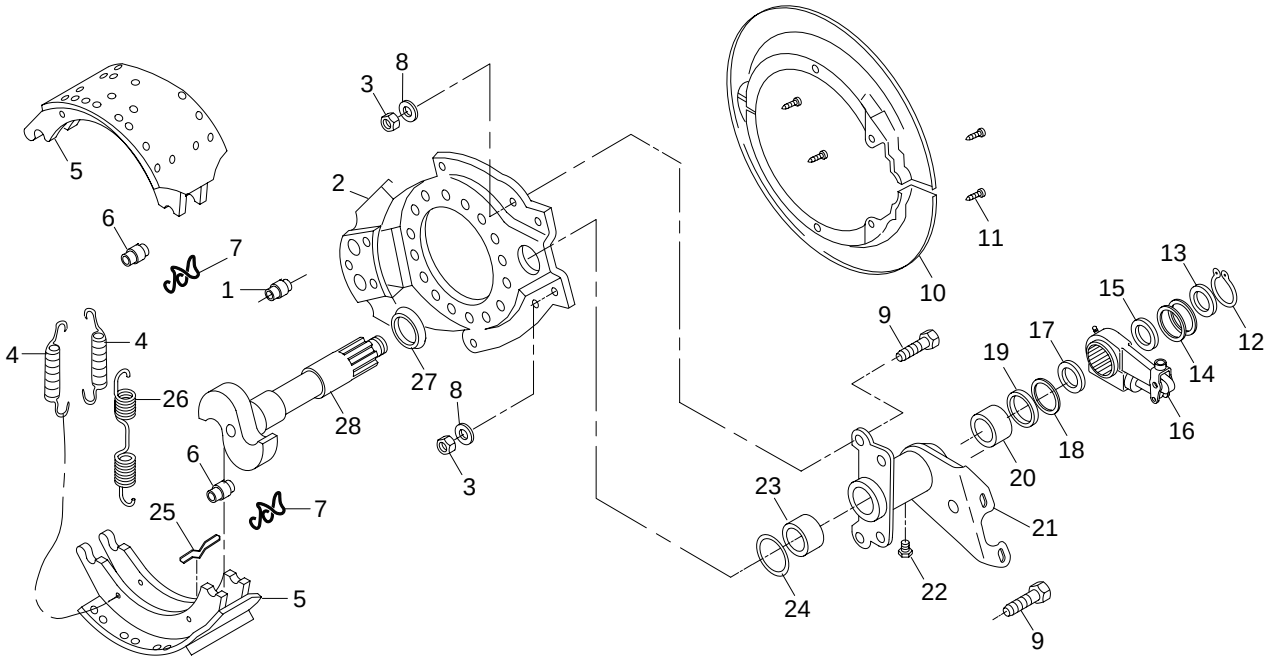
After removing the brake parts being serviced, do the following:

1. Clean the camshaft journals with an emery cloth.

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## Brake Components Disassembly and Inspection, Cleaning, and Assembly




NOTE: 16-1/2 inch drive axle Q Plus (with LX500 and MX500 identification tags, and a stamped brake spider) brake shown.

1. Brake Shoe Anchor Pin
2. Brake Spider, Stamped
3. Nut (4), Grade 8
4. Brake Shoe Retaining Spring
5. Brake Shoe and Lining Assembly
6. Brake Shoe Roller
7. Brake Shoe Retainer
8. Washers (4), Hard
9. Capscrew, Grade 8
10. Dust Shield
11. Dust Shield Capscrew
12. Camshaft Snap Ring
13. Spacing Washer
14. Thin Spacing Washer
15. Orange Seal, Automatic Slack Adjuster
16. Automatic Slack Adjuster
17. Seal, Automatic Slack Adjuster
18. Thick Camshaft Washer
19. Camshaft Seal
20. Camshaft Bushing, 1.50" I.D.
21. Camshaft-and-Chamber Bracket
22. Pipe Plug
23. Camshaft Bushing, 1.625" I.D.
24. Orange Camshaft Seal
25. Brake Shoe Return Spring Pin
26. Brake Shoe Return Spring
27. Camhead Washer
28. "S" Head Camshaft

**Fig. 4, Q Plus LX500 and MX500 Brake With Stamped Spider (exploded view)**

2. Wire brush all parts exposed to mud, road dirt, and salt, including the exterior of the drum, brake spider, camshaft-and-chamber bracket, and dust shields (if equipped). If relining the shoes, thoroughly wire-brush the shoe tables, and paint them with a rust inhibitive coating.

### NOTICE

**A thick layer of oxidation and dirt on the outside of a brake drum acts as an insulator and may hinder normal heat dissipation. Make sure oxidation and dirt are removed by wire brushing, or damage to brake components could occur.**

3. Using an industrial vacuum cleaner with a HEPA filter system, remove excessive dust accumulation from the brake parts.
4. Wipe the interior of the drums with a damp rag to remove brake lining dust.
5. Prepare the brake parts for assembly.

   5.1 Thoroughly, clean all the brake parts.

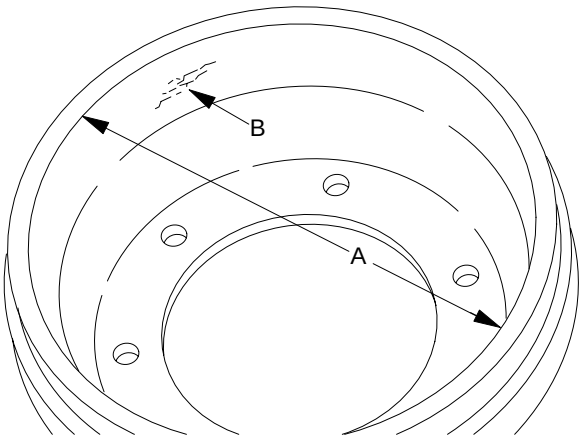
   For ground or polished metal parts, use a cleaning solvent to clean the parts and surfaces that are ground or polished.

   For rough metal parts, use a cleaning solvent, or a weak alkaline solution in a hot

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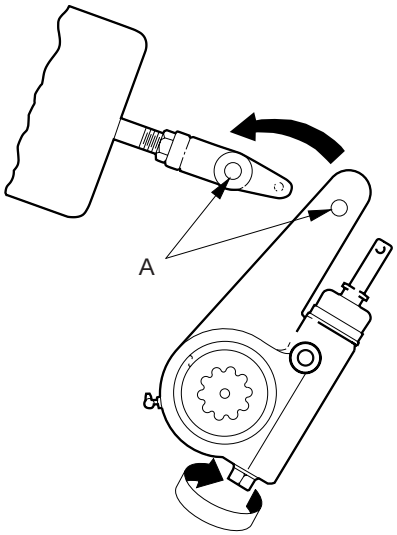
## Brake Components Disassembly and Inspection, Cleaning, and Assembly




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A. Check for diameter and for out-of-round.
B. Check for cracks, heat checks, glazing, and grooves.

**Fig. 5, Checking the Drum**

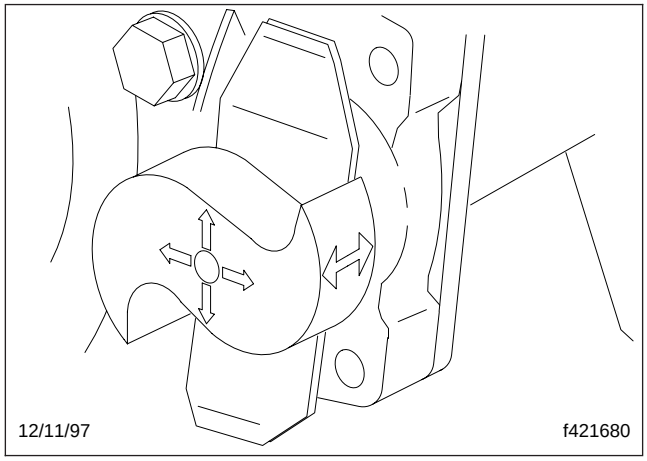



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A. Pushrod Clevis Hole

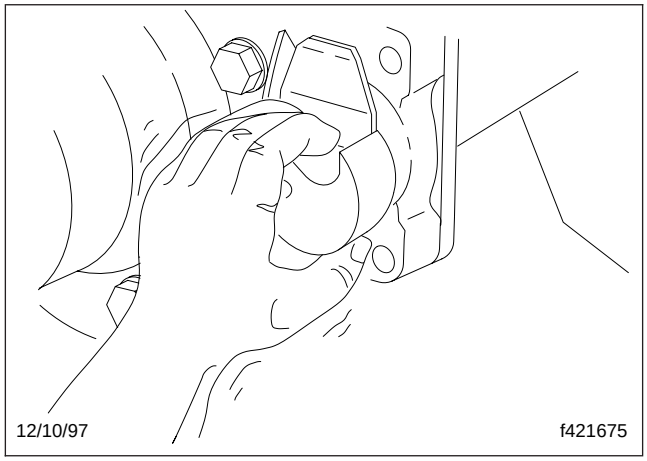
**Fig. 6, Disconnecting the Pushrod Clevis**

solution tank, to clean the parts. If a hot solution tank is used, leave the rough parts in the hot solution tank until they are completely cleaned and heated. Remove the rough parts from the hot solution tank



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**Fig. 7, Checking Free-Play**



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**Fig. 8, Removing the Camshaft**

and wash them with water until the alkaline solution is removed.

5.2 Thoroughly dry all the brake parts with either compressed air or a clean soft cloth (or paper) rag.

**⚠ WARNING**

**All worn or damaged brake parts must be replaced. If the brakes are assembled with worn or damaged brake parts, the brakes may not perform to their capacity and a brake failure may occur, which could cause personal injury and property damage.**

5.3 Thoroughly inspect all brake parts for wear or damage. It is very important that

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all the parts be carefully inspected before they are assembled. Repair or replace any worn or damaged parts.

5.4 To protect the parts from corrosion, apply a thin layer of brake grease to the parts which have been cleaned, dried, inspected, and will be assembled.

If the parts will be stored, apply a special material that prevents corrosion and rust on all surfaces. The parts should be stored in special paper (or other material) that prevents corrosion and rust.

## Assembly

**WARNING**

**Before starting the procedure below, read the safety precaution information in Subject 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.**

1. Install the dust shield, if equipped.

   Position the dust shield against the brake spider, and install the capscrews. Tighten the capscrews:

   - 5/16–18 Grade 5; 15 to 20 lbf·ft (20 to 27 N·m)
   - 3/8–16 Grade 5; 25 to 35 lbf·ft (34 to 47 N·m)
   - 3/8–16 Grade 8; 35 to 50 lbf·ft (47 to 68 N·m)

2. Install the brake spider.

   Place the brake spider on the axle flange. Using a hardened washer under the bolt head and the nut, install the mounting fasteners. Tighten the bolts, shown in **Fig. 9**, in a cross pattern:

   - 7/16–20; 60 to 75 lbf·ft (81 to 102 N·m)
   - 1/2–20; 85 to 115 lbf·ft (115 to 156 N·m)
   - 9/16–18; 135 to 165 lbf·ft (183 to 224 N·m)
   - 5/8–18; 180 to 230 lbf·ft (244 to 312 N·m)

3. Install the camshaft-and-chamber bracket and the brake chamber.

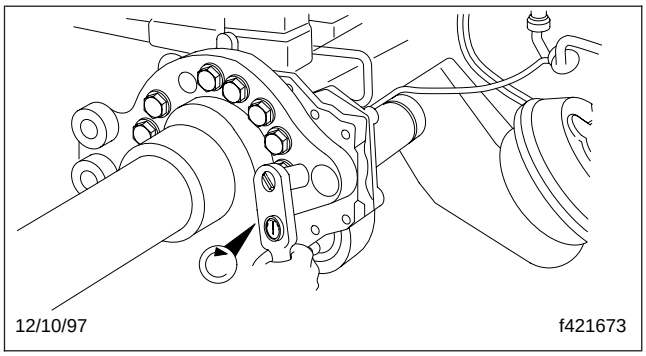



**Fig. 9, Tightening the Brake Spider Bolts**

3.1 Place the camshaft-and-chamber bracket and gasket against the brake spider, and install the lockwashers and capscrews. Tighten the capscrews:

- Without hexnuts, 1/2–13 Grade 5; 65 to 85 lbf·ft (88 to 115 N·m)
- Without hexnuts, 1/2–13 Grade 8; 70 to 100 lbf·ft (95 to 136 N·m)
- With locknuts, 5/8–18; 130 to 165 lbf·ft (176 to 224 N·m)
- With plain hexnuts, 5/8–18; 150 to 190 lbf·ft (203 to 258 N·m)

3.2 Place the brake chamber on the mounting flange (camshaft-and-chamber bracket) with the chamber mounting studs through the flange holes. Install the hardened flatwashers, lockwashers, and stud nuts. Tighten the brake chamber fasteners to the torque values listed in **Specifications 400**.

NOTE: If replacing a brake chamber, make sure that the new chamber is the same size and make as the brake chamber on the other side of the axle.

IMPORTANT: The grease seals are installed in both the brake spider and slack adjuster ends of the camshaft-and-chamber bracket, the grease seals must be installed with their lips toward the slack adjuster end of the camshaft-and-chamber bracket tube.

NOTE: To avoid shorter lining life, Meritor recommends replacing the springs, rollers, anchor pins, and camshaft bushings when the linings

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## Brake Components Disassembly and Inspection, Cleaning, and Assembly

are replaced. For brakes with the Q Plus LX500 and MX500 identification tags, if replacing the linings before the recommended service interval (3 years or 500,000 miles [800 000 km]), the camshaft bushings and the seals do not have to be replaced.

4. Using a seal driver, install the camshaft seals and the new camshaft bushings into the brake spider and slack adjuster ends of the camshaft-and-chamber bracket. See **Fig. 10**. Install the seals with their lips toward the slack adjuster. See **Fig. 11**.

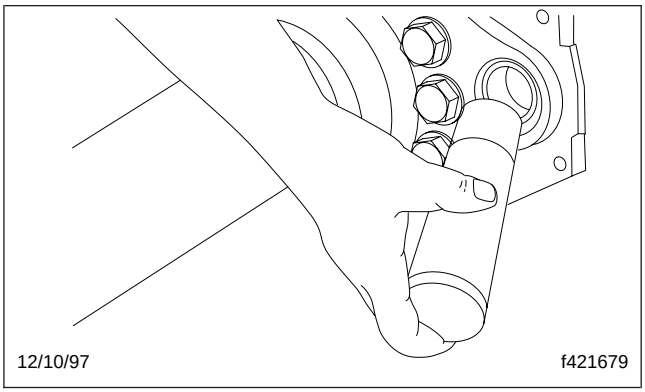
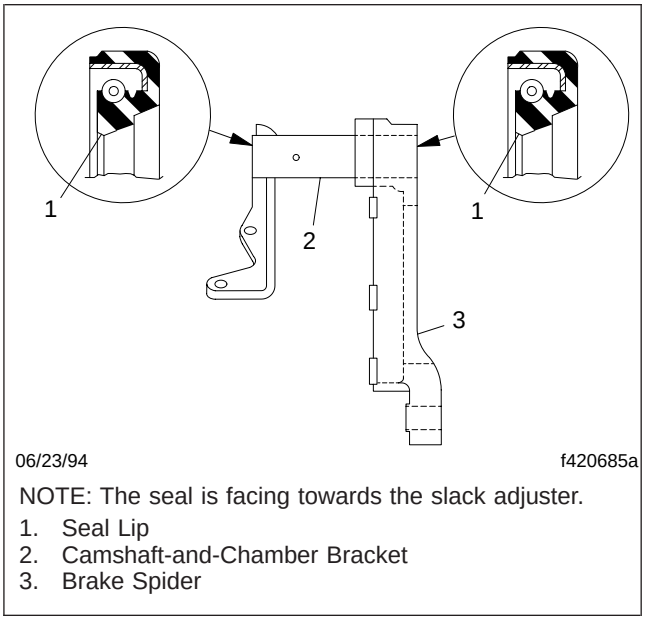



**Fig. 10, Installing the Seals and Bushings**




NOTE: The seal is facing towards the slack adjuster.

1. Seal Lip
2. Camshaft-and-Chamber Bracket
3. Brake Spider

**Fig. 11, Positioning the Seals**

5. Install the camshaft as shown in **Fig. 12**.

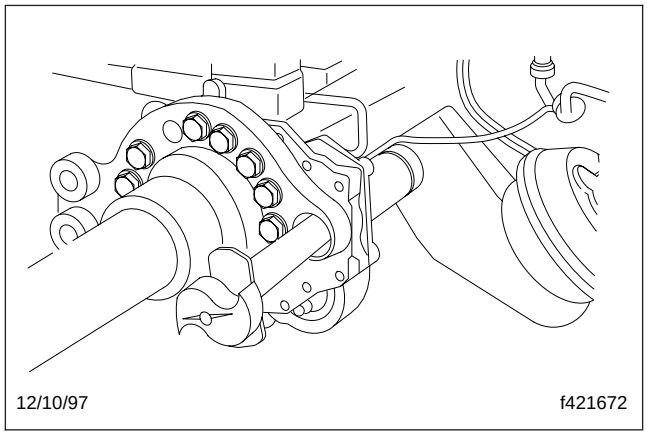



**Fig. 12, Installing the Camshaft**

5.1 Put the camhead thrust washer on the camshaft with the bent flaps toward the brake spider.

5.2 Apply a thin film of grease on the inside of the camshaft bushings and journals. See **Specifications 400** for the recommended grease specification. Don't grease the camshaft head area.

5.3 Apply a thin film of rust preventive grease on the camshaft splines. See **Specifications 400** for the recommended grease specification.

5.4 Carefully slip the camshaft into the brake spider and the camshaft-and-chamber bracket tube. The camshaft should turn freely by hand.

6. Install the slack adjuster.

6.1 Slide the spacing washer on the camshaft. Install the slack adjuster seal with the lip facing the brake spider (Q Plus LX500 and MX500 only).

6.2 Slide the slack adjuster on the camshaft, with the adjuster nut on the side opposite of the brake chamber.

6.3 Install the orange slack adjuster seal with the lip facing the snap ring (Q Plus LX500 and MX500 only), the outer washers, and snap ring.

6.4 Use a dial indicator to measure the in-and-out (axial) end-play of the camshaft.

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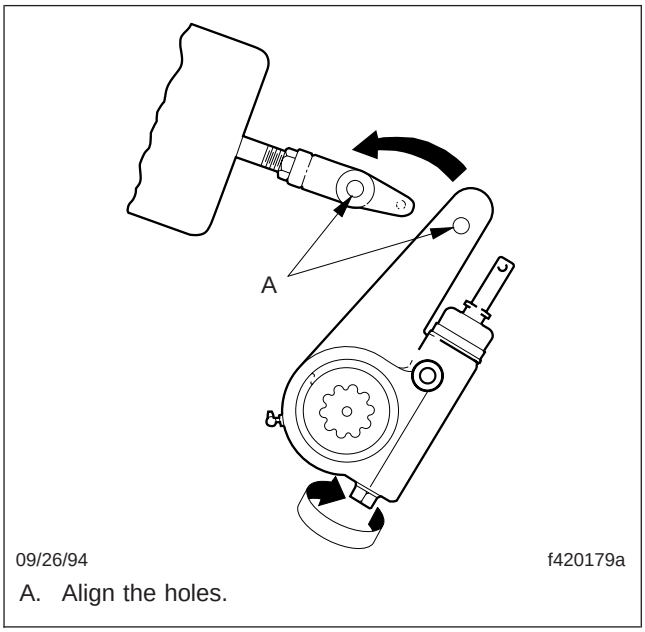
For all Cam-Master brakes, except the Q Plus brakes with a LX500 and MX500 identification tag, there should be no more than 0.060 inch (1.5 mm) movement. For the Q Plus brakes with a LX500 and MX500 identification tag, the axial end play should be within 0.005 to 0.030 inch (0.13 to 0.80 mm). See **Fig. 7**. If necessary, add the appropriate number of spacing shims to achieve the correct axial end play.

6.5 Apply anti-seize compound to the two clevis pins.

## NOTICE

**For Meritor automatic slack adjusters, before turning the manual adjusting nut, disengage the pull-pawl by raising it up about 1/32 inch (0.8 mm). Failure to do so could damage the pull-pawl teeth. A damaged pull-pawl will not allow the slack adjuster to automatically adjust the brake clearance.**

6.6 Using a wrench, turn the manual adjusting nut to align the large hole in the slack adjuster housing with the large hole in the clevis. See **Fig. 13**. Then, insert both the clevis pins and cotter pins.




A. Align the holes.

**Fig. 13, Attaching the Slack Adjuster to the Clevis**

7. For the Q Plus brakes with the LX500 and MX500 identification tag, proceed to the next step. Otherwise, pressure lube the camshaft-and-chamber bracket bushings.

7.1 Pump multipurpose chassis grease (NLGI grade 1 or 2) into the camshaft-and-chamber bracket until it appears at the slack adjuster end of the bracket. For recommended grease specification, see **Specifications 400**.

NOTE: The use of meter-type fittings, having a maximum 40 psi (276 kPa) pressure relief at shutoff, is recommended.

7.2 Use care that no grease enters the drum cavity. If grease leaks out under the cam head, the camshaft grease seal is worn or damaged, or is installed backwards.

For the Q Plus LX500 and MX500 brakes, if the brake linings are being replaced before the service interval (every 3 years or 500,000 miles [800 000 km], whichever comes first), then the camshaft-and-chamber bracket and the slack adjuster do not need lubrication.

8. For all Cam-Master brakes, except the Q Plus LX500 and MX500, proceed to the next step. Otherwise, when changing the brake linings for the Q Plus LX500 and MX500 brakes at the service interval (which is performed every 3 years or 500,000 miles [800 000 km], whichever comes first). Lubricate the camshaft-and-chamber bracket and the automatic slack adjuster.

8.1 Remove the identification tag from the camshaft-and-chamber bracket housing.

8.2 Remove the grease plugs from both the camshaft-and-chamber bracket and the automatic slack adjuster.

8.3 Install the grease fittings.

## WARNING

**When lubricating the camshaft-and-chamber bracket, if grease leaks out under the cam head, the camshaft grease seal is worn or damaged. See disassembly and inspection for grease seal replacement instructions. If the seal is not replaced, the brake linings could be contaminated by grease and the vehicles stopping distance**

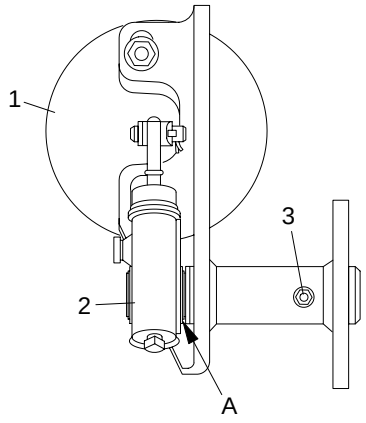
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## Brake Components Disassembly and Inspection, Cleaning, and Assembly

**could be reduced, which could result in personal injury or property damage.**

8.4 Using Meritor approved NLGI grade 2 synthetic polyurea grease (EVO-LUBE TEK-615), lubricate the brake assembly through the grease fitting in the bracket until new grease flows from the inboard seal. See **Fig. 14**, Ref. 3.




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A. Grease Exit

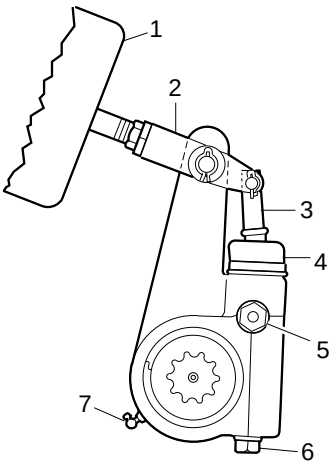
1. Brake Chamber
2. Slack Adjuster
3. Grease Fitting (or lube plug)

**Fig. 14, Camshaft-and-Chamber Bracket Lubrication**

8.5 Using Meritor approved NLGI grade 2 synthetic polyurea grease (EVO-LUBE TEK-615), lubricate the slack adjuster through the grease fitting until new grease flows out of the pull-pawl or camshaft seal. See **Fig. 15**, Ref. 7.

8.6 Replace the grease fittings with new grease plugs and cover the bracket plug with a new identification tag.

9. Install the brake shoes. For instructions, refer to **Subject 110**.




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1. Brake Chamber
2. Clevis
3. Actuator Rod
4. Boot
5. Pressure-Relief Capscrew, Gasket, Pawl Spring, and Pawl
6. Manual Adjusting Nut
7. Grease Fitting (or lube plug)

**Fig. 15, Slack Adjuster Lubrication**

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# Troubleshooting Tables

**Problem—No Adjustment or Adjusted Stroke is Too Long**

| Problem—No Adjustment or Adjusted Stroke is Too Long | |
|---|---|
| **Possible Cause** | **Remedy** |
| The wrong slack adjuster is installed. | Replace the slack adjuster with the correct one. |
| The clevis is not installed correctly. | Check the slack adjuster installation. For instructions, see the appropriate slack adjuster section in this group. |
| There is excessive wear between the clevis and collar. | Check the gap between the clevis and the collar. The maximum allowable gap is 0.060 inch (1.5 mm). Replace the threaded clevis as necessary. |
| The jam nut at the clevis is loose. | Tighten the jam nut to specifications. |
| The large clevis pin bushing in the slack adjuster arm is worn. | Measure the inside diameter of the large clevis pin bushing. The inside diameter must not be larger than 0.53 inch (13.46 mm). Replace the bushing as necessary. |
| The return spring in the air chamber is weak or broken. | Check the air spring force. At the first movement of the push rod, the spring force must be at least 32 lbf (142.3 N). Replace the return spring or air chamber as necessary. |
| The spring brake is not fully retracting. | Repair or replace the spring brake. |
| The pull-pawl or the actuator is worn (the teeth are stripped). | Replace the pull-pawl or the actuator in the slack adjuster. |
| The slack adjuster has internal damage. | Inspect the slack adjuster. Repair or replace the slack adjuster as necessary. For instructions, see the appropriate slack adjuster section in this group. |
| There is excessive play between the slack adjuster gear and the splines of the camshaft. | Replace the camshaft and/or the slack adjuster as necessary. |
| Foundation brake components are worn. | Replace the components. |

**Problem—Linings Dragging or Adjusted Stroke is Too Short**

| Problem—Linings Dragging or Adjusted Stroke is Too Short | |
|---|---|
| **Possible Cause** | **Remedy** |
| The incorrect brake linings are installed. | Install the correct Meritor approved brake linings. |
| The wrong slack adjuster is installed. | Replace the slack adjuster with the correct one. |
| The clevis is not installed correctly. | Check the slack adjuster installation. For instructions, see the appropriate slack adjuster section in this group. |
| The jam nut at the clevis is loose. | Tighten the jam nut to specifications. |
| The spring brake is not fully retracting. | Repair or replace the spring brake. |
| The manual (free-stroke) adjustment is incorrect. | Adjust the free-stroke and applied chamber stroke. For instructions, see **Subject 130**. |
| Poor contact between the linings and the drum, or the drum is out-of-round. | Repair or replace the drum or the linings. |
| There is a brake temperature imbalance. | Correct the brake balance. |

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| Brake Torque Specifications | | | | |
|---|---|---|---|---|
| **Description** | **Grade** | **Size** | **Torque: lbf·in (N·cm)** | **Torque: lbf·ft (N·m)** |
| Brake Shoe Lining Nuts | 5 | 3/8" | — | 18–23 (24–31) |
| Brake Shoe Lining Nuts | 5 | 1/4" | 80–100 (904–1130) | — |
| Dust Shield Capscrews | — | 5/16–18 | — | 12–20 (16–27) |
| Dust Shield Capscrews | 8 | 3/8–16 | — | 30–50 (41–68) |
| Dust Shield Capscrews | 5 | 3/8–16 | — | 25–35 (34–47) |
| Camshaft-and-Chamber Bracket Capscrews | 5 | 1/2–13 | — | 65–100 (88–136) |
| Camshaft-and-Chamber Bracket Capscrews | 8 | 1/2–13 | — | 90–120 (122–163) |
| Camshaft and Chamber With Locknuts | — | 5/8–18 | — | 130–165 (176–224) |
| Camshaft and Chamber With Plain Nuts | — | 5/8–18 | — | 150–190 (203–258) |
| Spider Capscrews | — | 7/16–20 | — | 60–75 (81–102) |
| Spider Capscrews | — | 1/2–20 | — | 85–115 (115–156) |
| Spider Capscrews | — | 9/16–18 | — | 130–165 (176–224) |
| Spider Capscrews | — | 5/8–18 | — | 180–230 (244–312) |

**Table 1, Brake Torque Specifications**

| Brake Chamber Torque Specifications | | | |
|---|---|---|---|
| **Chamber Size** | **Midland Chamber: lbf·ft (N·m)** | **MGM Chamber: lbf·ft (N·m)** | **Anchorlok Chamber: lbf·ft (N·m)** |
| 16 | 35–50 (47–68) | 35–40 (47–54) | Not Available |
| 20 | 70–100 (95–136) | 100–115 (136–156) | With hexnut, 110–115 (149–156)<br>With locknut, 85–95 (115–129) |
| 24 | 70–100 (95–136) | 100–115 (136–156) | With hexnut, 110–115 (149–156)<br>With locknut, 85–95 (115–129) |
| 30 | 70–100 (95–136) | 100–115 (136–156) | With hexnut, 110–115 (149–156)<br>With locknut, 85–95 (115–129) |
| 36 | 70–100 (95–136) | 100–115 (136–156) | With hexnut, 110–115 (149–156)<br>With locknut, 85–95 (115–129) |
| Spring Chamber | 70–100 (95–136) | 100–115 (136–156) | With hexnut, 110–115 (149–156)<br>With locknut, 85–95 (115–129) |

**Table 2, Brake Chamber Torque Specifications**

| Meritor Grease Specification | | | |
|---|---|---|---|
| **Specification Number** | **NLGI Grade** | **Grease Type** | **Outside Temperature: °F (°C)** |
| O–616–A | 1 | Clay-Base | Down to –40 (–40) |
| O–617–A or O–617–B | 1 and 2 | Lithium 12-Hydroxy Stearate or Lithium Complex | See Manufacturer's Specification |

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## Specifications

| Meritor Grease Specification | | | |
|---|---|---|---|
| **Specification Number** | **NLGI Grade** | **Grease Type** | **Outside Temperature: °F (°C)** |
| O–645 | 2 | Synthetic Oil, Clay-Base | Down to –65 (–54) |
| O–692 | 1 and 2 | Lithium-Base | Down to –40 (–40) |
| O–637 | 1 and 2 | Calcium-Base | See Manufacturer's Specification |
| O–641 | — | Anti-Seize | See Manufacturer's Specification |
| O–695 | 2 | Synthetic Polyurea | –40 (–40) |

**Table 3, Meritor Grease Specification**

| Component Lubrication | | | | | | |
|---|---|---|---|---|---|---|
| **Brake Type** | **Meritor Grease Specification Number** | | | | | |
| | **Clevis Pins** | **Camshaft Splines** | **Anchor Pins** | **Brake Shoe Rollers** | **Camshaft Bushings** | **Slack Adjuster** |
| All Cam-Master Brakes, Except Q Plus LX500 and MX500 Brakes | O–616–A, O–645, O–692, O–637, or O–641 | O–616–A, O–617–A, O–617–B, O–645, O–692, O–637, or O–641 | O–616–A, O–617–A, O–617–B, O–645, O–692 | O–616–A, O–617–A, O–617–B, O–645, O–692 | O–616–A, O–617–A, O–617–B, O–645, O–692 | O–616A, O–645, O–692 |
| Q Plus LX500 and MX500 Brakes Only | O–695 | O–695 | O–617–A, O–617–B, O–645, O–692 | O–617–A, O–617–B | O–616–A, O–617–A, O–617–B, O–645, O–692 | O–695 |

**Table 4, Component Lubrication**

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## General Description

The Meritor automatic slack adjuster has two main functions:

- As a lever, it converts the straight-line force of the brake chamber push rod to torque on the brake camshaft. Rotation of the camshaft forces the brake shoes against the brake drum.
- As an automatic adjuster, it automatically maintains brake chamber push rod stroke, which controls lining-to-drum clearance during operation.

With an automatic slack adjuster, brakes adjust automatically when needed. As long as the push-rod stroke doesn't exceed the desired length, no adjustment takes place. Adjustment is made on the return stroke, as air is released and the forces in the gearset are low. The force to make an adjustment comes directly from the brake shoe return spring and the brake chamber return spring.

## Principles of Operation

The externally splined end of the worm (**Fig. 1**, Ref. 21) fits the internal splines on the actuator (Ref. 16). Angled serrations on the spring-held pawl (Ref. 20) correspond with serrations on the actuator exterior. The serrations are formed to allow free upward movement of the actuator, and to lock in on the actuator serrations on a downward movement. As the brake is applied, the brake chamber push rod, connected to the end of the clevis, moves outward, forcing the slack adjuster arm to turn on the brake camshaft centerline. The actuator rod (Ref. 10) is connected to the clevis at one end, and to a small piston at the other end.

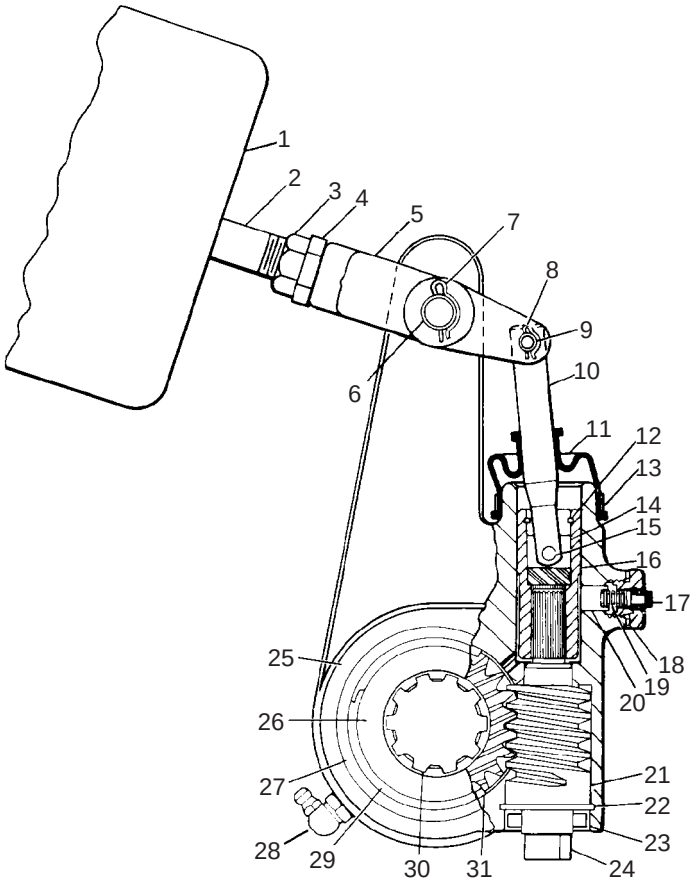
As the slack adjuster arm moves, the actuator rod is moved upward and outward, pulling the piston (Ref. 14) upward.

When lining wear becomes excessive, the brake chamber push-rod stroke goes beyond the desired length. The piston then makes contact with the retaining ring (Ref. 12) and pulls up the actuator. As the actuator moves upward and reaches a preset distance, it slides over one serration on the pawl. When the push rod moves back toward the brake chamber, the actuator is forced downward. Because the serrations in the pawl and actuator are now locked in, the actuator, following the curve of its serrations as it moves downward, turns slightly. This action causes the worm to turn, advancing the gear (Ref. 26) and the camshaft to automatically adjust the brake.

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## General Information




08/20/93 f420176a

1. Brake Air Chamber
2. Brake Chamber Push Rod
3. Clevis Jam Nut
4. Quick-Connect Collar (if equipped)
5. Clevis
6. Clevis Pin (large)
7. Cotter Pin (large)
8. Cotter Pin (small)
9. Clevis Pin (small)
10. Actuator Rod
11. Boot
12. Piston Retaining Ring
13. Boot Retaining Clamp
14. Actuator Piston
15. Roller (Pin)
16. Actuator (Adjusting Screw)
17. Pressure Relief Capscrew (shown 90 degrees out of position)
18. Gasket
19. Pawl Spring
20. Pawl Assembly
21. Worm
22. Worm Retaining Snap Ring
23. Worm Seal
24. Manual (Worm) Adjusting Nut End
25. Slack Adjuster
26. Gear
27. Gear Thrustwasher
28. Grease Fitting (if equipped)
29. Gear Retaining Ring
30. Camshaft Splines
31. Gear-to-Body Seal

**Fig. 1, Meritor Slack Adjuster**

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## Slack Adjuster Removal and Installation

## Removal

1. With the vehicle parked on a level surface, set the parking brakes, and shut down the engine. Chock the tires.

**⚠ WARNING**

**Manually cage each parking brake chamber power spring in the release (no application) position before continuing. Loss of brake chamber air pressure will cause sudden application of the parking brakes, which could result in personal injury.**

2. If the rear slack adjusters will be removed, release the parking brakes, then cage the power spring of the parking brake chamber.
3. Remove the retainer clips from the large and small clevis pins. Remove the clevis pins. See **Fig. 1**.

**⚠ CAUTION**

**Disengage the pull-pawl before turning the manual adjusting nut. Failure to do so could damage the pull-pawl teeth. The brake clearance will not automatically adjust if the pull-pawl is damaged.**

4. Using a screwdriver or an equivalent tool, pry the pawl button out about 1/32 inch (0.8 mm). See **Fig. 2**.

   Wedge the tool in place. Pull-pawls are spring-loaded; when the tool is removed, the pull-pawl will engage the teeth automatically.
5. Using a wrench, manually turn the square adjusting nut clockwise to move the slack adjuster away from the clevis. See **Fig. 3**.
6. Remove the snap ring, washer(s), and seal (if equipped) that secure the slack adjuster in place on the brake camshaft; save them for later installation.
7. Remove the slack adjuster from the camshaft.
8. Note the location and number of any remaining spacing washers on the camshaft. Remove the spacers and seal (LX500 and MX500 series only), and save them for later installation.

## Installation

NOTE: For brake chambers that have pushrods with threaded clevises, measure the pushrod length before installing the new slack adjuster. With the brakes fully released, and no air pressure to the chamber, check the dimension between the chamber face and the centerline of the 1/2 inch clevis pin hole. It should be 2.25 inches (57 mm) for long stroke chambers, and 2.75 inches (70 mm) for standard stroke chambers.

1. Inspect the parts and prepare the slack adjuster for installation.
2. Check the brake camshaft splines for wear or corrosion.

IMPORTANT: The following lubricants provide corrosion protection. Do not mix them with other types of lubricants.

3. Coat the camshaft splines and the splines of the slack adjuster gear with Meritor 0-637, Meritor 0-695 (LX500 and MX500 only), Southwest SA 8249496, or an equivalent.
4. Apply the service brake several times. Make sure the return spring retracts the pushrod quickly and completely. Replace the return spring or brake chamber, if needed.
5. Slide the spacing washer(s) on the camshaft.

   On LX500 and MX500, install the slack adjuster seal with the lip facing the brake spider.
6. If reinstalling the same slack adjuster:
   - 6.1 Slide the slack adjuster on the camshaft, with the actuator rod on the side opposite the brake chamber.
   - 6.2 On LX500 and MX500, install the orange slack adjuster seal on the camshaft. The lip on the seal must face the snap ring.
   - 6.3 Install the outer washer(s) and snap ring on the camshaft.

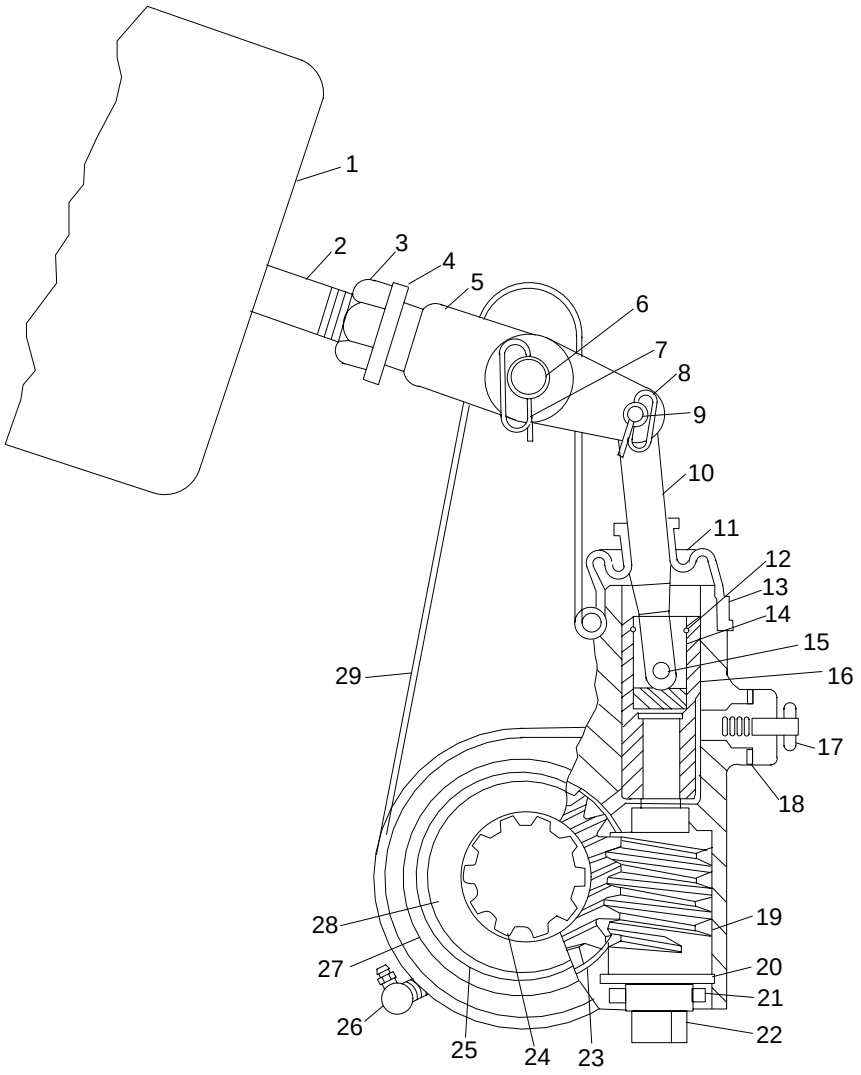
**⚠ CAUTION**

**Disengage the pull-pawl before turning the manual adjusting nut. Failure to do so could**

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## Slack Adjuster Removal and Installation



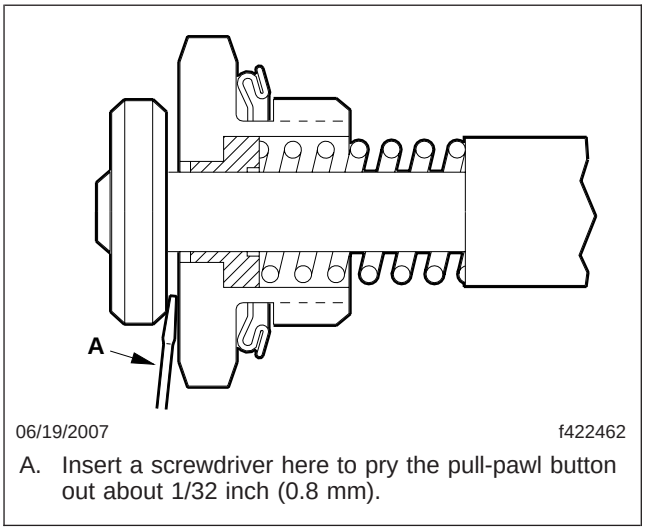

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1. Brake Air Chamber
2. Brake Chamber Pushrod
3. Clevis Jam Nut
4. Quick-Connect Collar (if equipped)
5. Clevis
6. Clevis Pin (large)
7. Retainer Clip (large)
8. Retainer Clip (small)
9. Clevis Pin (small)
10. Actuator Rod
11. Boot
12. Piston Retaining Ring
13. Boot Retaining Clamp
14. Actuator Piston
15. Roller (Pin)
16. Actuator (Adjusting Sleeve)
17. Pull-Pawl Assembly (shown 90 degrees out of position)
18. Gasket
19. Worm
20. Worm Retaining Snap Ring
21. Worm Seal
22. Manual Adjusting Nut
23. Gear-to-Body Seal
24. Camshaft Splines
25. Gear Retaining Ring
26. Grease Fitting (if equipped)
27. Gear Thrustwasher
28. Gear
29. Slack Adjuster Housing

**Fig. 1, Meritor Automatic Slack Adjuster**

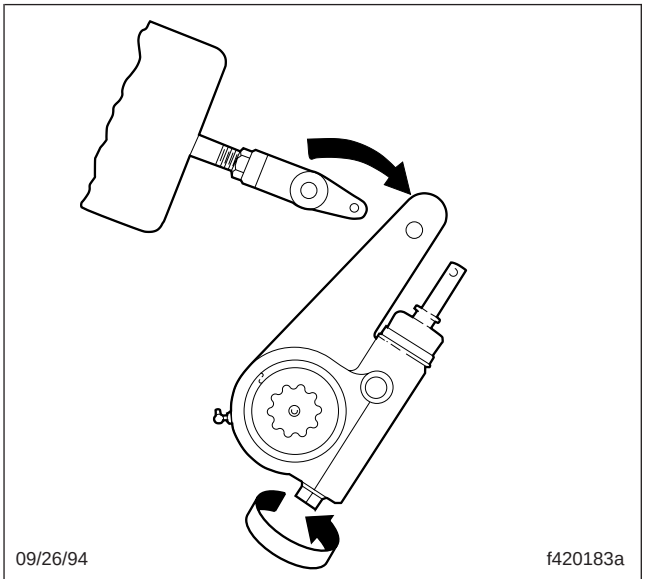
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A. Insert a screwdriver here to pry the pull-pawl button out about 1/32 inch (0.8 mm).

**Fig. 2, Pull-Pawl Assembly**




Turn the manual adjusting nut clockwise.

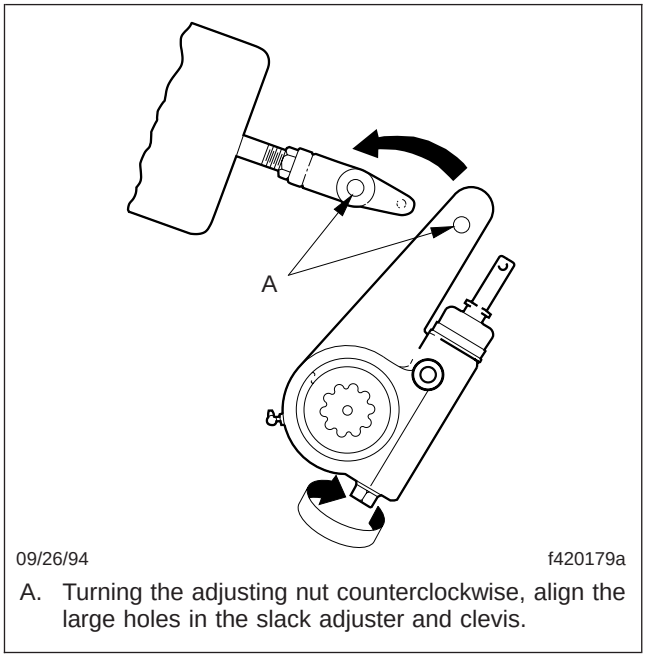
**Fig. 3, Slack Adjuster Removal**

**damage the pull-pawl teeth. The brake clearance will not automatically adjust if the pull-pawl is damaged.**

6.4 Using a screwdriver or an equivalent tool, pry the pawl button out at least 1/32 inch (0.8 mm). See **Fig. 2**. Wedge the tool in place.

IMPORTANT: Never pull the pushrod out to meet the slack adjuster or push the slack adjuster into position. Always turn the adjusting nut for positioning.

6.5 Using a wrench, turn the manual adjusting nut counterclockwise to align the hole in the slack adjuster housing with the large hole in the clevis. See **Fig. 4**.




A. Turning the adjusting nut counterclockwise, align the large holes in the slack adjuster and clevis.

**Fig. 4, Slack Adjuster Installation**

7. If installing a new slack adjuster:

7.1 Using an installation template, measure the old and new slack adjusters. Measure from the center of the large clevis-pin hole to the center of the camshaft opening. See **Fig. 5**.

Make sure the old and new slack adjusters are the same length.

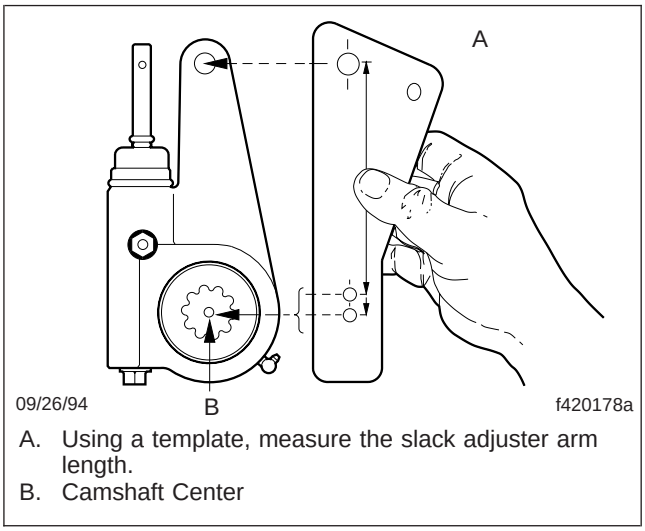
7.2 Slide the slack adjuster on the camshaft, with the actuator rod on the side opposite the brake chamber.

7.3 On LX500 and MX500 series, install the orange slack adjuster seal on the camshaft. The lip on the seal must face the snap ring.

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## Slack Adjuster Removal and Installation




A. Using a template, measure the slack adjuster arm length.
B. Camshaft Center

**Fig. 5, Slack Adjuster Measurement**

7.4 Install the outer washer(s) and snap ring on the camshaft.

7.5 Using a dial indicator, measure the in-and-out (axial) end play of the camshaft. If necessary, add the appropriate number of spacing washers to achieve the correct axial end play.

- For all Cam-Master brakes, except LX500 and MX500 series, there should be no more than 0.060 inch (1.52 mm) movement.
- For LX500 and MX500, the axial end play should be no more than 0.020 inch (0.51 mm).

**CAUTION**

**Disengage the pull-pawl before turning the manual adjusting nut. Failure to do so could damage the pull-pawl teeth. The brake clearance will not automatically adjust if the pull-pawl is damaged.**

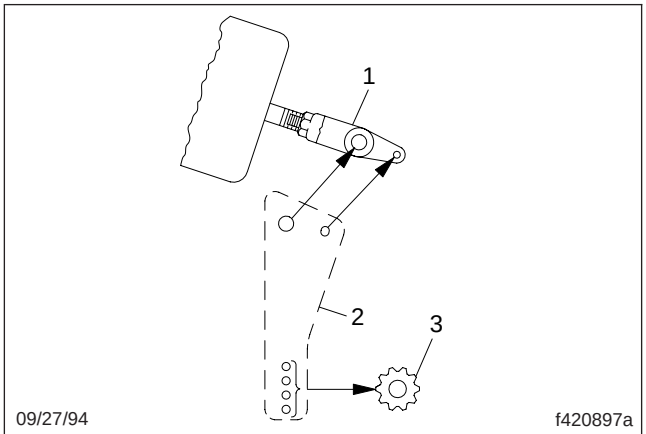
7.6 Using a screwdriver or an equivalent tool, pry the pawl button out about 1/32 inch (0.8 mm). See **Fig. 2**. Wedge the tool in place.

IMPORTANT: Never pull the pushrod out to meet the slack adjuster or push the slack adjuster into position. Always turn the adjusting nut for positioning.

7.7 Using a wrench, turn the manual adjusting nut counterclockwise to align the hole in the slack adjuster housing with the large hole in the clevis. See **Fig. 4**.

7.8 With the brakes fully released, place the installation template over the clevis and camshaft end. See **Fig. 6**.

7.9 Temporarily insert the large clevis pin through the large holes in the template and the clevis.




Place the template over the clevis and camshaft end.

1. Clevis
2. Template
3. Camshaft End

**Fig. 6, Template Placement**

7.10 Select the hole in the lower part of the template that matches the length of the slack adjuster. Hold the template in place on the center of the camshaft with a pencil.

7.11 Make sure the small hole in the clevis is completely visible through the 1/8-inch hole at the top of the template.

If it is not, loosen the clevis jam nut, and turn the clevis adjusting nut to adjust the position of the clevis on the pushrod until the small clevis hole is completely visible.

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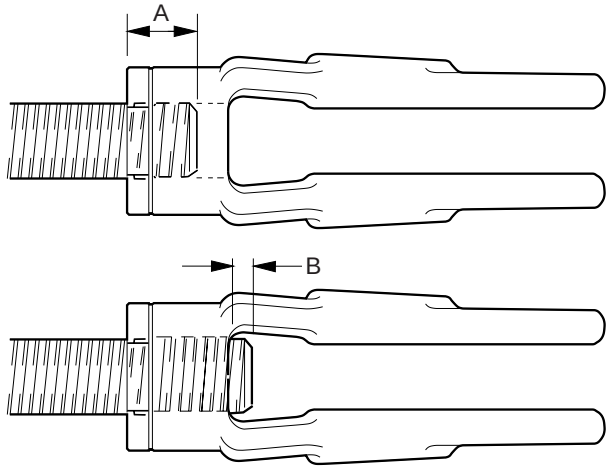


IMPORTANT: The pushrod must be installed in the clevis at least 1/2 inch (13 mm) and not extend beyond it more than 1/8-inch (3-mm).

7.12 Make sure there is at least 1/2 inch (13 mm) of thread engagement between the clevis and the pushrod. Also, check that the pushrod does not extend through the clevis more than 1/8-inch (3-mm). See **Fig. 7**.

If necessary, cut the pushrod, install a new pushrod, or install a new brake chamber.

7.13 Temporarily insert the small clevis pin through the template, clevis, and actuator rod to make sure the alignment is correct. Repeat the adjustment, if necessary. When the alignment is correct, remove both clevis pins and the template.




A. Minimum 1/2 inch (13 mm).
B. Maximum 1/8 inch (3 mm).

**Fig. 7, Check Pushrod Engagement**

8. Apply antiseize compound to the two clevis pins.
9. Insert both clevis pins with their pinheads on the inboard side of the slack adjuster. Be sure the small clevis pin is inserted through the hole in the actuator rod. Install new retaining clips to secure the clevis pins.
10. If it was loosened, tighten the clevis jam nut to the following values.
    - For 1/2–20 threads, tighten the clevis jam nut 20 to 30 lbf·ft (27 to 41 N·m).
    - For 5/8–18 threads, tighten the jam nut 25 to 50 lbf·ft (34 to 68 N·m).
11. Lube the slack adjuster through the grease fitting until the lubricant is forced out through the pawl slot or through the gear splines around the inboard snap ring.
12. Adjust the brakes. See "Brake Adjustment" below.

## Brake Adjustment

NOTE: A properly working self-adjusting slack adjuster does not require manual adjustment while in service.

**⚠ WARNING**

**Manually adjusting an automatic slack adjuster to bring the pushrod stroke within legal limits is likely masking a mechanical problem. Adjustment is not repairing. Before adjusting an automatic slack adjuster, troubleshoot the foundation brake system and inspect it for worn or damaged components. Improperly maintaining the vehicle braking system may lead to brake failure, resulting in property damage, personal injury, or death.**

1. If a rear axle slack adjuster was installed, manually uncage the parking brake.
2. Fully release the brakes (the air chamber pushrod must be fully retracted).

**⚠ CAUTION**

**Before turning the manual adjusting nut on the slack adjuster, disengage the pull-pawl. Failure to do so could damage the pull-pawl teeth. A damaged pull-pawl will not allow the slack adjuster to automatically adjust the brake clearance.**

3. Using a screwdriver, pry the pull-pawl button out at least 1/32 inch (0.8 mm) to disengage the pull-pawl teeth from the slack adjuster actuator. See **Fig. 2**. Wedge the screwdriver in place. The pull-pawl will need to be disengaged until the brake adjustment is complete.

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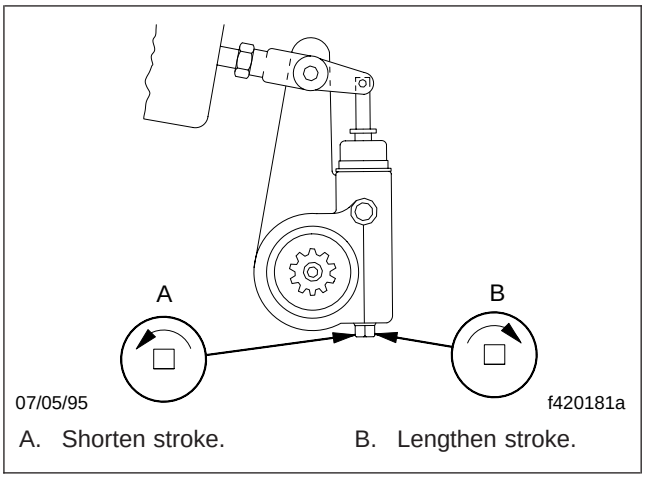


## Slack Adjuster Removal and Installation

NOTE: When the screwdriver is removed, the pull-pawl will engage automatically.

4. Using the manual adjusting nut on the slack adjuster, adjust the brake chamber stroke (coarse adjustment), as follows. See **Fig. 8**.

   4.1 Turn the adjusting nut counterclockwise until the brake linings touch the brake drum.




A. Shorten stroke. B. Lengthen stroke.

**Fig. 8, Adjusting the Stroke**

   4.2 Then, turn the adjusting nut clockwise 1/2 turn.

5. Measure and adjust the free-stroke, as follows.

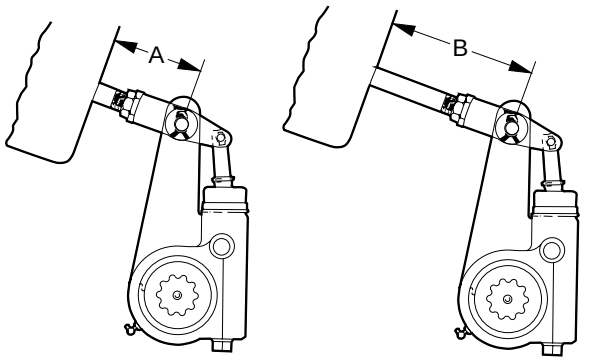
   5.1 With the brakes released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. Record this measurement as dimension A. See **Fig. 9**.

   5.2 Using a lever, move the slack adjuster until the brake linings contact the brake drum.

   Measure the distance from the bottom of the brake chamber to the center of the large clevis pin. Record this measurement as dimension B. See **Fig. 9**.

   5.3 Subtract dimension A from dimension B. The difference between these measurements is the free-stroke.

   5.4 The free-stroke for a new brake installation should be 5/8 to 3/4 inch (16 to 19 mm). For a brake that is in service, the free-stroke should be 1/2 to 5/8 inch (13 to 16 mm). If it is not, turn the adjusting nut 1/8 turn, as shown in **Fig. 8**. Then, measure the free-stroke again; readjust it until it is correct.




NOTE: For either free-stroke or applied chamber stroke, subtract measurement A from B.

A. Measurement with the brakes released.
B. Measurement with the brakes applied by manual lever (free-stroke) or pressurized brake application (applied chamber stroke).

**Fig. 9, Measuring the Stroke**

6. Measure and adjust the applied chamber stroke (fine adjustment), as follows.

   6.1 If system pressure is not already at 100 psi (689 kPa), start the engine and build air pressure, then shut down the engine.

   6.2 With the brakes released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. Record this measurement as dimension A. See **Fig. 9**.

   6.3 Fully apply the brakes. Then, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 9**, Ref. B. Record this measurement as dimension B.

   6.4 Subtract dimension A from dimension B. The difference between these measurements is the true applied chamber stroke.

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## Slack Adjuster Removal and Installation

**CAUTION**

**The adjusted applied chamber stroke should be as short as possible but not so short that the free-stroke is too short and the linings drag. If the linings drag, the brakes could be damaged.**

6.5 The applied chamber stroke must not exceed the maximum value specified in **Table 1**.

If the applied chamber stroke is incorrect, turn the adjusting nut 1/8-turn counterclockwise to shorten the stroke, or 1/8-turn clockwise to lengthen it. See **Fig. 8**. Measure the applied stroke again and readjust it until it is correct.

6.6 If the slack adjuster is not maintaining the correct applied chamber stroke, check the condition of the foundation brakes. See **Section 42.03, Subject 150**.

7. Remove the screwdriver from the pull-pawl assembly. This will engage the pull-pawl with the actuator.

**WARNING**

**Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.**

8. In a safe area, check for proper brake operation before you put the vehicle in service, as follows.

8.1 Apply and release the brakes several times to check for air leaks and proper operation of the slack adjusters.

8.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.

8.3 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than others show a lack of braking effort on those wheels.

| Brake Chamber Stroke Specifications | | | |
|---|---|---|---|
| Chamber Type (Size) | Maximum Applied Stroke*: inch (mm) | Free-Stroke: inch (mm) | |
| | | New Brake Installation | In-Service Brake |
| Long Stroke† | | | |
| 16 and 20 | 2-1/2 (64) | 5/8–3/4 (16–19) | 1/2–5/8 (13–16) |
| 24 and 30 | 3 (76) | | |

* Specifications are relative to a brake application with 80–90 psi (550–620 kPa) air pressure in the brake chambers.

† Long stroke design is indicated by a tag, or embossing, on the brake chamber.

**Table 1, Brake Chamber Stroke Specifications**

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## Specifications

| Slack Adjuster Arm Lengths | |
|---|---|
| **Slack Adjuster Arm Length: inches (mm)** | **Chamber Size** |
| 5 (127) | 9, 12, 16, 20, 24, 30 |
| 5-1/2 (140) | 9, 12, 16, 20, 24, 30, 36 |
| 6 (152) | 24, 30, 36 |
| 6-1/2 (165) | 30, 36 |

**Table 1, Slack Adjuster Arm Lengths**

| Lubricant Specifications | |
|---|---|
| **Lubricant Type** | **Temperature** |
| Meritor 0–616–A<br>Texaco Thermotex EP No. 1<br>Shell Darina No. 1<br>Texaco Hytherm EP No. 1<br>Aralub 3837<br>Tribolube 12, Grade 1<br>Meritor 0–692<br>Amoco Super Permalube No. 2<br>Citco Premium Lithium EP No. 2<br>Exxon Ronex MP No. 2<br>Kendall L–427 Super Blu No. 2<br>Mobilith AW No. 1<br>Sohio Factran EP No. 2 | Above –40°F (–40°C) |
| Meritor 0–645<br>Mobil 28 | Below –40°F (–40°C) |

**Table 2, Lubricant Specifications**

| Maximum Adjusted Brake Chamber Stroke | | |
|---|---|---|
| **Chamber Size** | **Maximum Stroke** | |
| | **Standard Stroke Chambers: in (mm)** | **Long Stroke Chambers: in (mm)** |
| 9 | Less than 1-3/8 (35) | — |
| 12 | Less than 1-3/8 (35) | — |
| 16 | Less than 1-3/4 (44) | Less than 2 (51) |
| 20 | Less than 1-3/4 (44) | Less than 2 (51) |
| 24 | Less than 1-3/4 (44) | Less than 2 (51): *2-1/2 inch rated stroke*<br>Less than 2-1/4 (63): *3-inch rated stroke* |
| 30 | Less than 2 (51) | Less than 2-1/2 (57) |

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## Specifications

| Maximum Adjusted Brake Chamber Stroke | | |
|---|---|---|
| Chamber Size | Maximum Stroke | |
| | Standard Stroke Chambers: in (mm) | Long Stroke Chambers: in (mm) |
| 36 | Less than 2-1/4 (57) | — |

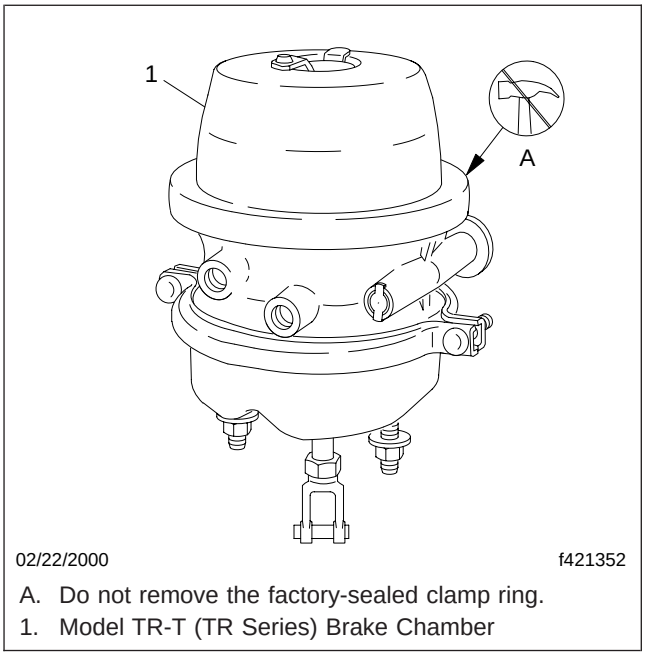
**Table 3, Maximum Adjusted Brake Chamber Stroke**

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**⚠ DANGER**

**Do not attempt to remove the factory-sealed clamp ring (Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from a sudden release of the power spring.**




A. Do not remove the factory-sealed clamp ring.
1. Model TR-T (TR Series) Brake Chamber

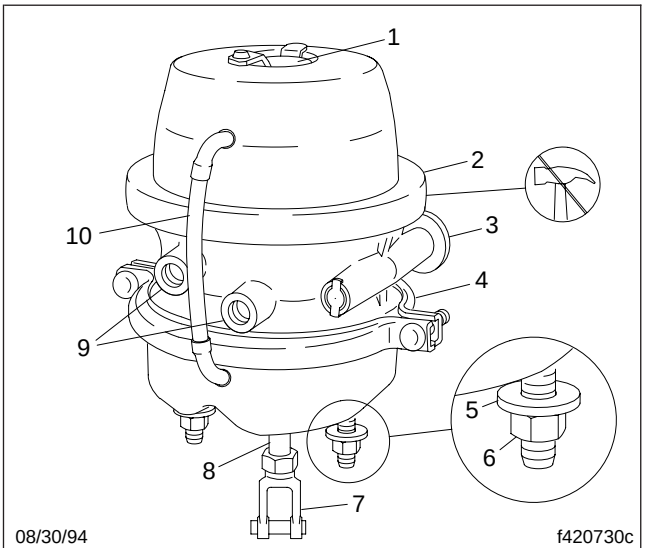
**Fig. 1, Brake Chamber**

IMPORTANT: On MGM "TR" Series chambers, the parking/emergency brake section is factory sealed (no clamp ring) and is a *non-serviceable* unit.

## General Information

MGM "TR" Series tandem cam brake chamber consists of a service brake section and a parking/emergency spring brake section. See **Fig. 2**. The service brake section is the smaller section near the clevis assembly.

In the service brake section, the flange case and non-pressure chamber contain a service return spring, piston rod assembly, and service brake diaphragm.




Do not remove the factory-sealed clamp ring.
1. End Cover Cap
2. Factory Sealed Parking Brake Clamp Ring
3. Release Bolt Storage Pocket
4. Service Brake Clamp Ring
5. Hardened Flatwasher
6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Air Inlet Ports
10. External Breather Tube

**Fig. 2, Model TR-T (TR Series) Brake Chamber**

In the parking/emergency brake section, the flange case and the head contain a return spring, a push rod assembly, a parking (spring) brake diaphragm, a piston, a power spring, and a detachable release bolt.

All MGM brake chambers are mounted to the frame using prevailing torque locknuts and hardened flatwashers.

MGM "TR" Series chambers may be equipped with an external breather tube that protects the parking brake chamber from contaminants. These chambers are called Model "TR-T" chambers. See **Fig. 2**.

Periodic maintenance of the brake chambers is required. Also, whenever the service brake chamber is disassembled (*do not attempt to disassemble the parking brake chamber*), the parts should be inspected for damage. For maintenance schedules and procedures, and for inspection of brake chamber parts, refer to the vehicle maintenance manual.

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## General Information

# Service Brakes, Principles of Operation

As the brake pedal is depressed, compressed air enters the service brake chamber through a port. Air pressure acts upon a diaphragm, which forces the piston rod toward the non-pressure chamber, applying a straight-line force to the slack adjuster, which converts it to a rotational force. This in turn rotates the camshaft and applies the brakes.

Then, when the brake pedal is released, air is exhausted from the service brake chamber, and the return spring allows the diaphragm, piston rod, and slack adjuster to return to their normal positions, releasing the brakes.

# Parking/Emergency Brakes, Principles of Operation

During parking brake release, compressed air enters the parking brake chamber and acts upon the diaphragm and piston, fully compressing the power spring. When the power spring is compressed, the parking brakes are released; the service brakes can then be operated at the brake pedal.

During parking brake application, air is exhausted from the parking brake chamber. The power spring releases, forcing the piston and parking brake diaphragm toward the flange case. The resulting motion on the push rod forces the service brake diaphragm and piston rod outward, applying the brakes.

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## General Safety Precautions

When working on or around a vehicle, observe the following precautions:

- Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
- If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning any work on the vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters, which may apply as air pressure drops.
- Disconnect the batteries.
- Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
- Never exceed recommended air pressure. Always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
- Do not remove, disassemble, assemble, or install a component until you have read and understand the service procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use the correct tools and observe all precautions pertaining to use of those tools.
- Replacement hardware, tubing, hose, fittings, etc., should be the equivalent size, type, length, and strength of the original equipment.
- Make sure when replacing tubes or hoses that all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace devices that have stripped threads or damaged parts. Repairs requiring machining should not be attempted.
- Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

## Asbestos and Non-Asbestos Safety

**⚠ WARNING**

**Wear a respirator at all times when servicing the brakes, starting with the removal of the wheels and continuing through assembly. Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. Occupational Safety and Health Administration (OSHA) has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by Mining Safety and Health Administration (MSHA) or National Institute for Occupational Safety and Health (NIOSH).**

Because some brake linings contain asbestos, you should know the potential hazards of asbestos and the precautions to be taken. Exposure to airborne asbestos brake lining dust can cause serious and possibly fatal diseases such as asbestosis (a chronic lung disease) and cancer.

Because medical experts believe that long-term exposure to some *non-asbestos* fibers could also be a health hazard, the following precautions should also be observed if servicing non-asbestos brake linings.

Areas where brake work is done should be separate from other operations, if possible. As required by OHSA regulations, the entrance to the areas should have a sign displayed indicating the health hazard.

During brake servicing, an air purifying respirator with high-efficiency filters must be worn. The respirator and filter must be approved by MSHA or NIOSH, and worn during all procedures.

OSHA recommends that enclosed cylinders equipped with vacuums and high-efficiency particulate air (HEPA) filters be used during brake repairs. Under this system, the entire brake assembly is placed within the cylinder and the mechanic works on the brake through sleeves attached to the cylinder. Compressed air is blown into the cylinder to clean the assembly, and the dirty air is then removed from the cylinder by the vacuum.

If such an enclosed system is not available, the brake assembly must be cleaned in the open air. During disassembly, carefully place all parts on the floor to minimize creating airborne dust. Using an industrial vacuum cleaner with a HEPA filter system,

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## Safety Precautions

remove dust from the brake drums, brake backing plates, and brake parts. After vacuuming, any remaining dust should be removed using a rag soaked in water and wrung until nearly dry. Do not use compressed air or dry brushing to clean the brake assembly.

If grinding or other machining of the brake linings is necessary, other precautions must be taken because exposure to asbestos dust is highest during such operations. In addition to the use of an approved respirator, there must be local exhaust ventilation such that worker exposure is kept as low as possible.

Work areas should be cleaned by industrial vacuums with HEPA filters or by wet wiping. Compressed air or dry sweeping should never be used for cleaning. Asbestos-containing waste, such as dirty rags, should be sealed, labeled, and disposed of as required by EPA and OSHA regulations. Respirators should be used when emptying vacuum cleaners and handling asbestos waste products.

Workers should wash before eating, drinking, or smoking, should shower after work, and should not wear work clothes home. Work clothes should be vacuumed after use and then laundered, without shaking, to prevent the release of asbestos fibers into the air.

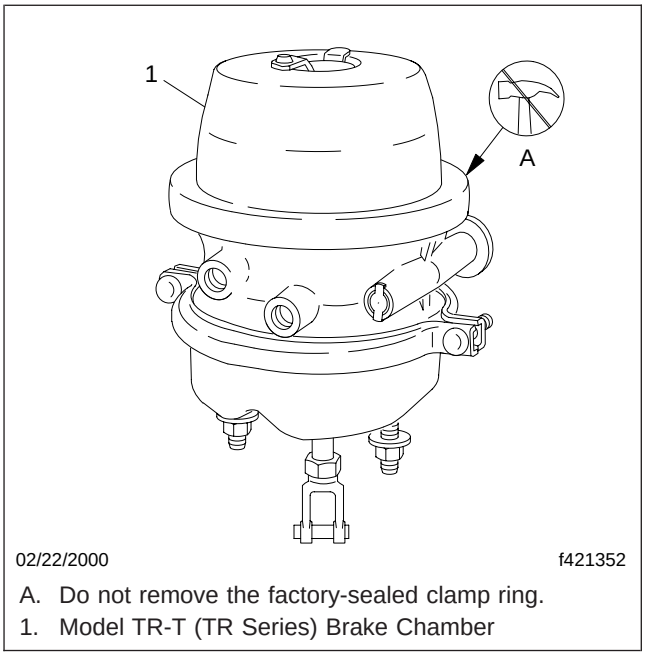
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## Power Spring Manual Compression and Reset

**⚠ DANGER**

**Do not attempt to remove the factory-sealed clamp ring (Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from a sudden release of the power spring.**




A. Do not remove the factory-sealed clamp ring.
1. Model TR-T (TR Series) Brake Chamber

**Fig. 1, Brake Chamber**

# Manual Compression (Parking Brake Release)

1. Chock the tires.
2. Remove the end cover cap from the center-hole in the head of the chamber. See **Fig. 2**.

**⚠ DANGER**

**Do not attempt to cage the power spring if the parking brake chamber is damaged severely enough to lose its structural integrity. If the power spring were to break loose, it could result in death, severe personal injury, or property damage.**

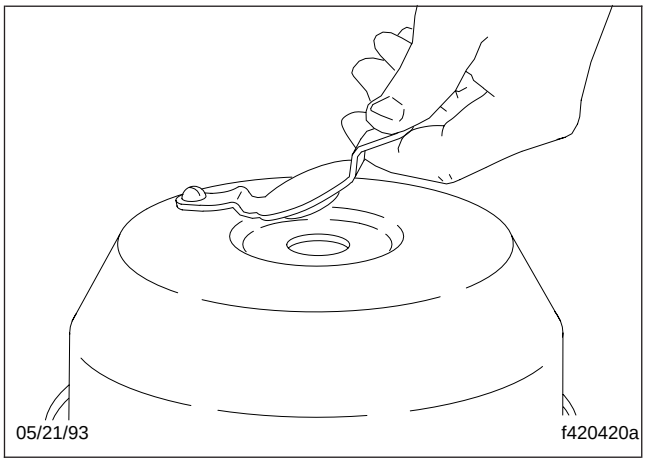



**Fig. 2, Remove the End-Cover Cap**

**A DAMAGED PARKING BRAKE CHAMBER IS EXTREMELY DANGEROUS! Only qualified service personnel should attempt to remove and disarm a damaged chamber. Using a torch, burn off the piston rod in the space between the clevis and the base of the service chamber.**

**Remove the chamber carefully from its bracket, and disarm it inside a suitable container. For disarming procedures, consult the MGM service manual.**

3. Manually release the parking brake (cage the power spring).

   3.1 Using a hand wrench (*don't use an impact wrench*), unscrew the release nut, and remove the nut, flatwasher, and release bolt from the storage pocket on the side of the chamber. See **Fig. 3**.

   IMPORTANT: If these parts are not stored on the chamber, they must be otherwise obtained or purchased; the parking brake cannot be manually released without them.

   3.2 Apply at least 90 psi (620 kPa) air pressure to the parking brake inlet port (set parking brake in the "release" position).

   3.3 Insert the release bolt into the center-hole in the chamber head. See **Fig. 4**. Insert the bolt until it bottoms out into the hole in the piston inside the chamber.

   IMPORTANT: If you are not absolutely sure that the formed end of the bolt has engaged

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## Power Spring Manual Compression and Reset

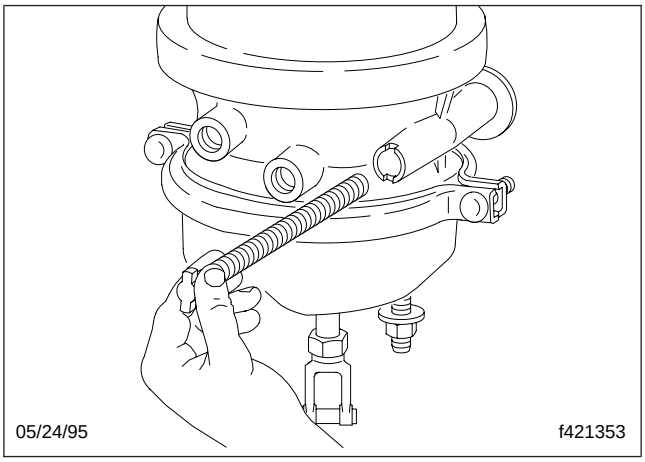



**Fig. 3, Remove the Release Bolt**

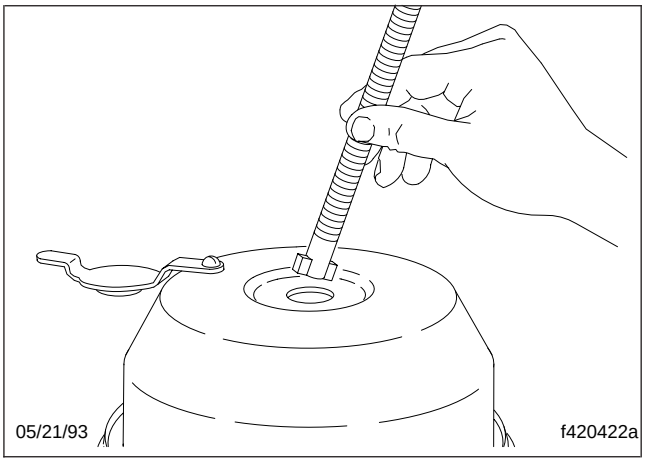



**Fig. 4, Insert the Release Bolt**

the piston correctly, repeat this step. Repeat it until you are absolutely sure.

3.4 Turn the release bolt one-quarter turn clockwise, and pull the bolt out to lock its formed end into the piston.

IMPORTANT: If the bolt doesn't lock into the piston in less than 1/2-inch (13-mm) outward movement, repeat these steps until you are sure it does lock.

3.5 Then, holding the bolt locked into the piston, install the flatwasher and release nut on the end of the release bolt, and turn down the nut against the flatwasher until it is finger-tight. See **Fig. 5**.

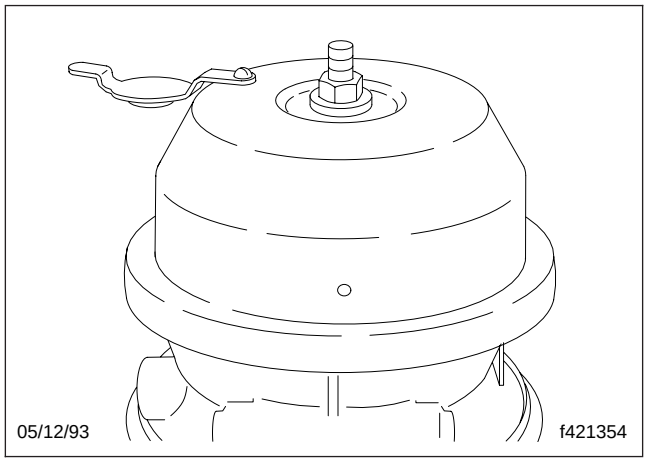
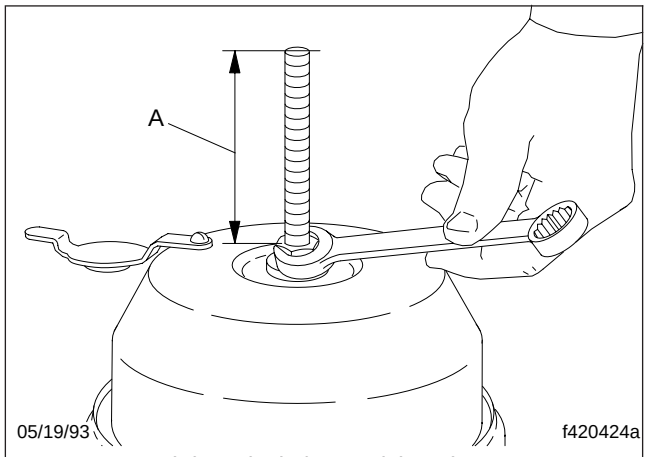



**Fig. 5, Flatwasher and Release Nut Installed**

**⚠ CAUTION**

**Do not exceed 50 lbf·ft (68 N·m) torque on the release nut; and don't use an impact wrench on this nut. Too much torque could distort the head of the chamber and prevent manual release of the parking brake.**

3.6 Using a hand wrench (*do not use an impact wrench*), turn the release nut clockwise until the bolt extends 3 inches (76 mm) above the nut. See **Fig. 6**.




Do not exceed the 3-inch (76-mm) length.
A. Measure this distance.

**Fig. 6, Turn the Release Nut**

IMPORTANT: Do not exceed the 3-inch (76-mm) length.

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4. Once the power spring has been caged, exhaust the compressed air from the parking brake.

## Manual Reset (Parking Brake Reset)

1. Uncage the power spring.
   1.1 Apply at least 90 psi (620 kPa) air pressure to the parking brake inlet port (set parking brake in the "release" position).

**⚠ CAUTION**

**Do not exceed 50 lbf·ft (68 N·m) torque on the release nut; and don't use an impact wrench on this nut. Too much torque could distort the head of the chamber and prevent manual release of the parking brake.**

   1.2 With air applied to the parking brake section (the parking brake control valve is in the "release" position), use a hand wrench to turn the release nut *counterclockwise* until the bolt bottoms out in the unit.

   1.3 Remove the nut and flatwasher.

   1.4 Push the release bolt into the piston and turn the release bolt one-quarter turn counterclockwise to unlock its formed end from the piston. Remove the release bolt from the center-hole of the chamber.

2. Using a hand wrench (*do not use an impact wrench*), install the release bolt, flatwasher, and release nut in the storage pocket. MGM recommends 10 lbf·ft (14 N·m) torque on the nut against the flatwasher. See **Fig. 7**.

3. Snap the end cover cap in place over the center-hole in the chamber head. See **Fig. 8**.

**⚠ CAUTION**

**If the external breather tube or end cover cap is missing or incorrectly installed, road dirt and debris can adversely affect the operation of the brake chamber. Once inside the chamber, dirt and debris cause the internal parts to deteriorate and shorten their lives. Operating the unit without the external breather tube or end cover cap in place voids the MGM warranty.**

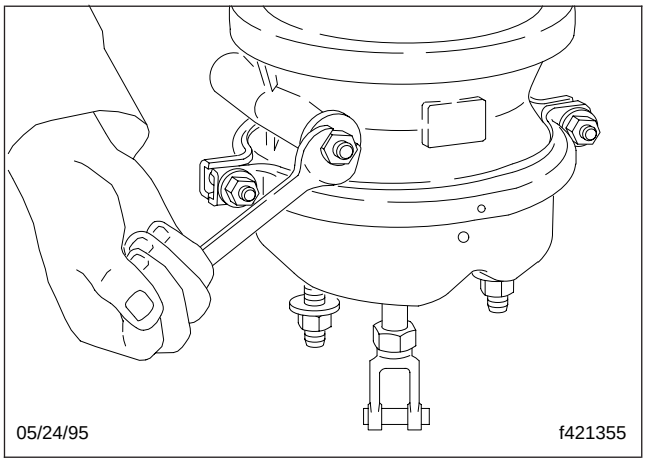



**Fig. 7, Tighten the Release Nut**

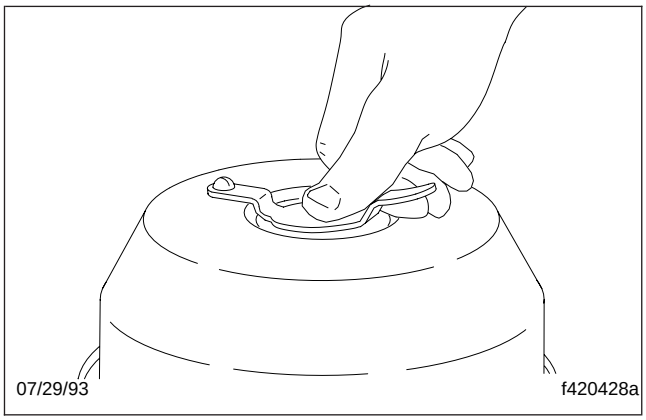



**Fig. 8, Snap the End Cover Cap in Place**

4. Check the plastic end cover cap periodically, and replace it with a new one at once if it is damaged or missing.

5. Remove the chocks from the tires.

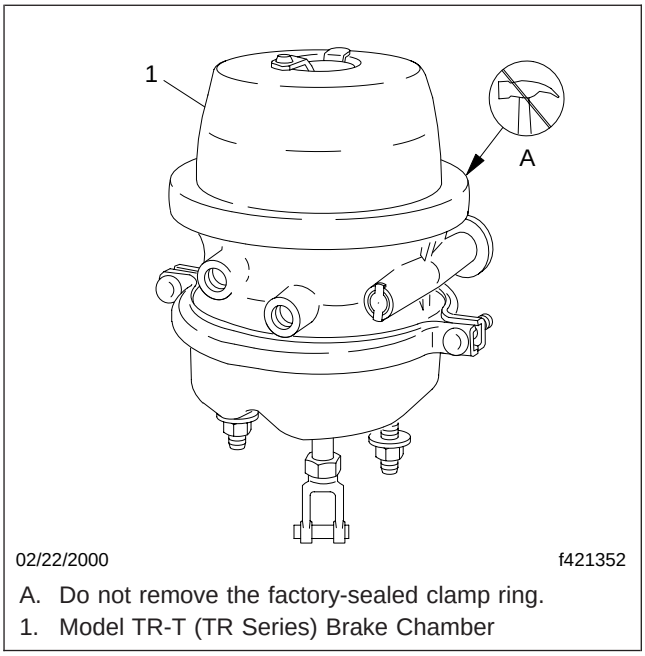
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## Service Brake Diaphragm Replacement

**DANGER**

**Do not attempt to remove the factory-sealed clamp ring (Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from a sudden release of the power spring.**




A. Do not remove the factory-sealed clamp ring.
1. Model TR-T (TR Series) Brake Chamber

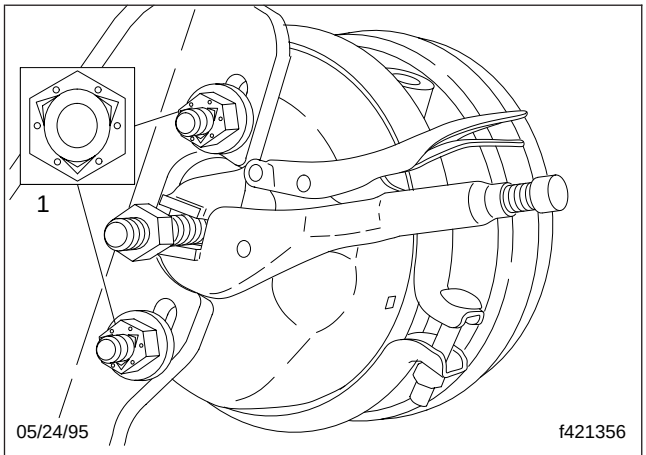
**Fig. 1, Brake Chamber**

# Removal

1. To make removal and installation of the parking brake section easier (without removing the service brake chamber), lock off the service chamber piston rod.

   1.1 Apply the service brakes by actuating the driver's foot brake treadle valve.

   1.2 With the brakes applied, clamp a pair of locking-jaw pliers on the piston rod to lock the rod in place when the air pressure is released. See **Fig. 2**.




1. Prevailing Torque Locknut

**Fig. 2, Lock the Piston Rod in Place**

**WARNING**

**Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in this section (see Subject 100). When the power spring is caged, the vehicle may be without brakes, allowing it to roll out of control, possibly resulting in personal injury or property damage.**

2. Manually release the parking brake (cage the power spring). For instructions, see **Subject 100**.

3. Mark the air lines for later reference. Then carefully disconnect them from the brake chamber.

   On chambers equipped with an external breather tube, disconnect the tube and elbow from the service brake chamber.

**DANGER**

**Do not attempt to remove the factory-sealed clamp ring (Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from a sudden release of the power spring.**

4. Remove the parking brake section from the service brake section.

   4.1 Using a hand wrench (*do not use an impact wrench*), remove the clamp nuts on

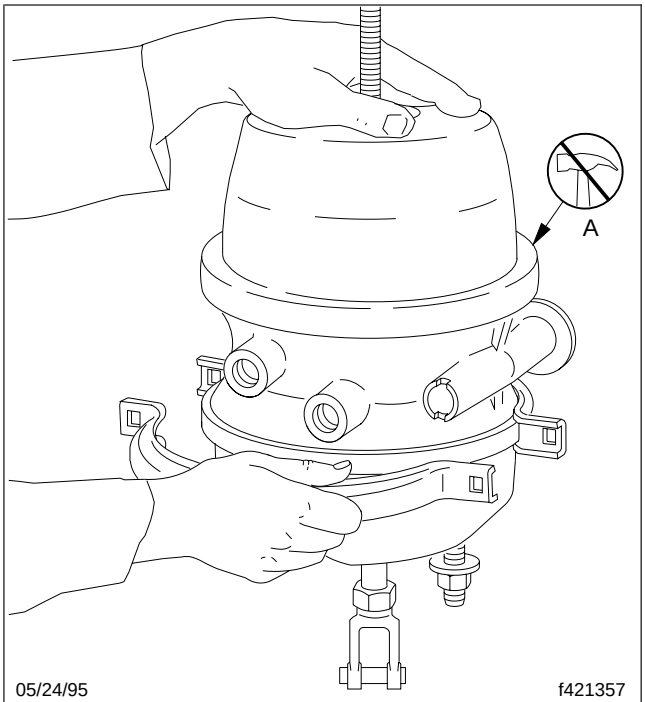
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## Service Brake Diaphragm Replacement

the *service* clamp ring (*do not disassemble the parking brake section*).

4.2 While holding the parking brake section securely in place, remove the service clamp ring. Then remove the parking brake section from the service brake non-pressure chamber. See **Fig. 3**.




A. Do not remove the factory-sealed clamp ring.

**Fig. 3, Remove the Service Clamp Ring**

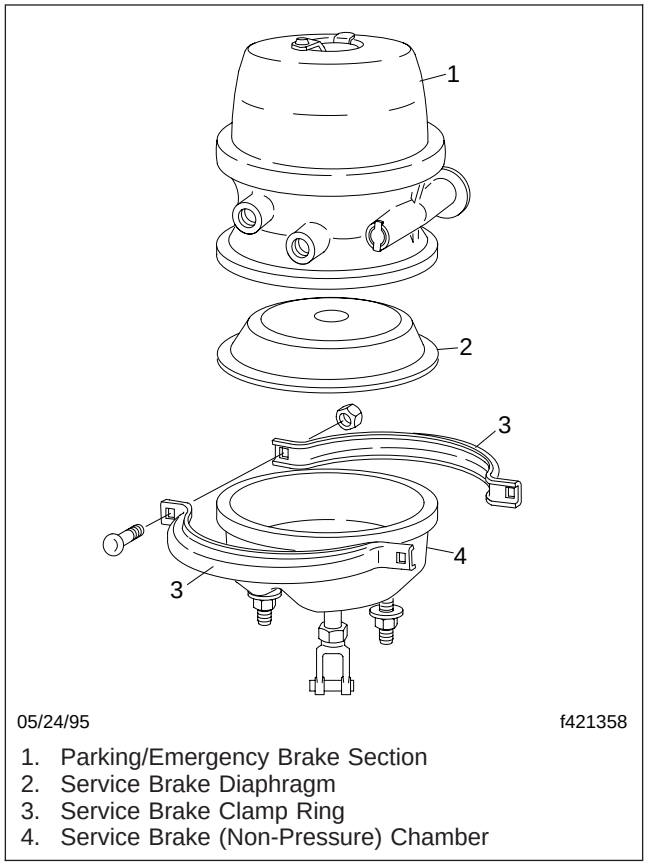
5. Remove the service brake diaphragm from the bottom of the parking brake section.

# Installation

IMPORTANT: At this time, take the opportunity to inspect the parking/emergency brake section, and replace it if it shows signs of damage, corrosion, or rust. Follow the detailed inspection instructions in the vehicle maintenance manual.

1. Inspect all parts in the service (non-pressure) chamber. Replace any damaged or worn parts with genuine MGM-engineered replacement parts.

2. Place the new service brake diaphragm in the bottom recess of the parking brake section. See **Fig. 4**.




1. Parking/Emergency Brake Section
2. Service Brake Diaphragm
3. Service Brake Clamp Ring
4. Service Brake (Non-Pressure) Chamber

**Fig. 4, Brake Chamber Parts**

3. Install the (new, if required) parking/emergency brake section.

   3.1 If installing a new parking brake section, be sure it is the same size and make as the old one.

   3.2 Check that the release bolt is fully extended outward. For instructions, see **Subject 100**.

   3.3 Install the parking brake section on the service chamber so that all mating parts are aligned straight and the air lines are positioned to mate with the vehicle air supply lines.

4. Install the service brake clamp ring.

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4.1 With the service brake clamp ring in place, install the clamp bolts and nuts.

4.2 Using a hand wrench (*do not use an impact wrench*), alternately tighten each clamp nut in increments of 60 to 120 lbf·in (680 to 1360 N·cm) while constantly rechecking the alignment of mating parts.

If realignment is needed, loosen the nuts again, and repeat this substep.

4.3 Firmly tap around the circumference of the service clamp ring with a rubber mallet to ensure full seating of the clamp. Tighten the nuts to a final torque of 25 to 30 lbf·ft (34 to 41 N·m).

5. Make sure the air hose fittings are free of grease, dirt, and other debris. Then, apply Loctite® 242 sealant, or an equivalent, to the fittings, and install, as referenced earlier. Using a hand wrench (*do not use an impact wrench*), tighten the fittings 25 lbf·ft (34 N·m).

6. Using the vehicle system air, charge the parking brake with full line pressure—at least 100 psi (690 kPa). Using only soapy water (*never use any type of oil,* which could deteriorate rubber parts), check for air leaks at the air lines and fittings. If bubbles or leaks appear, tighten the fittings slightly, but not over 25 lbf·ft (34 N·m).

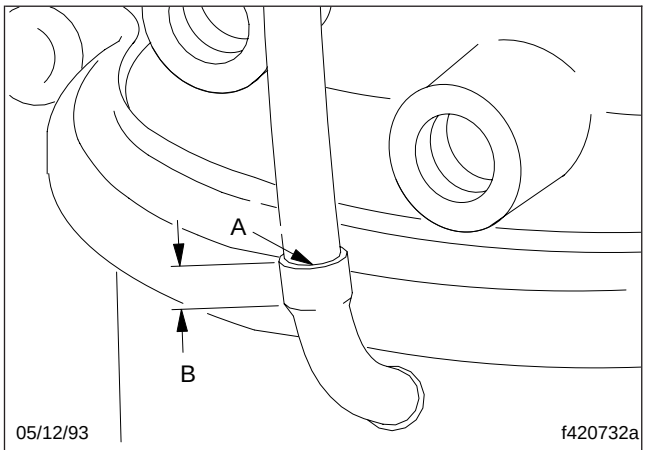
7. With the parking brake still charged with full line pressure, apply and hold the foot brake treadle valve down to charge the service brake chamber. Remove the locking-jaw pliers from the service piston rod so that the piston returns to a normal position in the chamber.

**⚠ DANGER**

**Do not attempt to remove the factory-sealed clamp ring (Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from a sudden release of the power spring.**

8. Test for air leaks around the circumference of the *service* brake clamp ring. If bubbles or leaks appear, firmly tap the circumference of the clamp ring with a rubber mallet, and retighten the clamp nuts until leaks cease (*do not touch the parking brake section*). MGM recommends 25 to 30 lbf·ft (34 to 41 N·m) torque on the clamp hexnuts.

9. On chambers equipped with an external breather tube, make sure that the open end of the tube is free of grease, dirt, and other debris. Then, apply a high-quality rubber cement to the tube and insert it into the elbow at least 1/2 inch (13 mm). See **Fig. 5**. Insert the tube into the service brake chamber.




A. Apply adhesive here.
B. Check for 1/2" (13 mm) minimum engagement.

**Fig. 5, Install the External Breather Tube**

10. With air pressure now exhausted from the service brake chamber, but held on the parking brake, reset the parking brakes by uncaging the power spring, and snap the end cover cap in place. For instructions, see **Subject 100**.

11. Adjust the brakes at the slack adjuster.

IMPORTANT: After replacing any brake chamber components, check the piston rod stroke and actuating alignment to ensure correct installation and foundation brake adjustment. No foundation brake adjustments, parking brake or service brake, can be made at the chamber and all "stroke" adjustments must be made at the slack adjuster. For instructions, see the applicable slack adjuster section in this group.

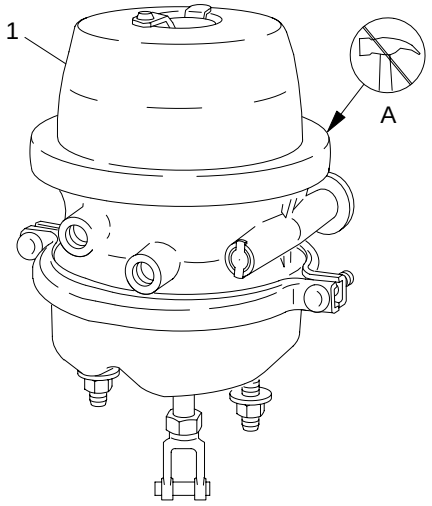
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## Replacement

**⚠ DANGER**

**Do not attempt to remove the factory-sealed clamp ring (Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from a sudden release of the power spring.**




02/22/2000 f421352

A. Do not remove the factory-sealed clamp ring.
1. Model TR-T (TR Series) Brake Chamber

**Fig. 1, Brake Chamber**

IMPORTANT: The parking/emergency brake section can be replaced as a unit. For instructions, see **Subject 110**.

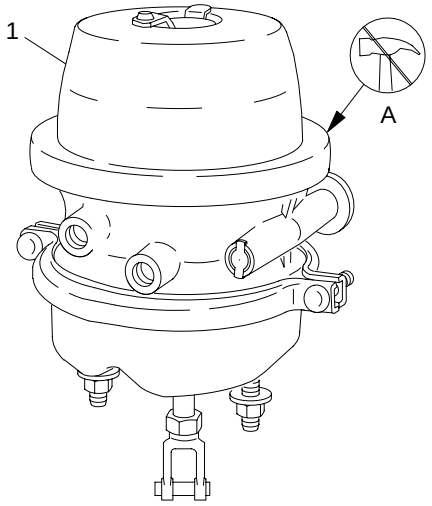
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# Combination Service and Parking Brake Chamber Removal and Installation

**⚠ DANGER**

**Do not attempt to remove the factory-sealed clamp ring (Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from a sudden release of the power spring.**




02/22/2000 f421352

A. Do not remove the factory-sealed clamp ring.
1. Model TR-T (TR Series) Brake Chamber

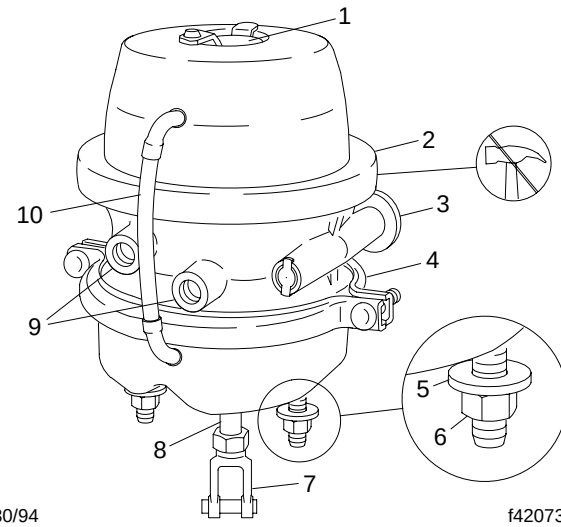
**Fig. 1, Brake Chamber**

## Removal

**⚠ WARNING**

**Before caging (compressing) the power spring, chock the vehicle tires and read the warnings and instructions in this section (see Subject 100). When the power spring is caged, the vehicle may be without brakes, allowing it to roll out of control, possibly resulting in personal injury or property damage.**

1. Manually release the parking brake (cage the power spring). For instructions, refer to **Subject 100**.
2. Mark the air lines for later reference. Then carefully disconnect them from the brake chambers.
3. Remove the brake chamber from the vehicle. See **Fig. 2**.




08/30/94 f420730c

Do not remove the factory-sealed clamp ring.
1. End Cover Cap
2. Factory Sealed Parking Brake Clamp Ring
3. Release Bolt Storage Pocket
4. Service Brake Clamp Ring
5. Hardened Flatwasher
6. Prevailing Torque Locknut
7. Clevis Assembly
8. Piston Rod
9. Air Inlet Ports
10. External Breather Tube

**Fig. 2, Model TR-T (TR Series) Brake Chamber**

3.1 Remove the cotter pin(s) from the clevis pin(s), then remove the clevis pin(s) from the clevis. Disconnect the clevis from the slack adjuster.

NOTE: Gunite and Meritor automatic slack adjusters have two clevis pins, one large and one small, each locked by a cotter pin.

3.2 Make sure the parking brake has been released manually (the power spring has been caged). For instructions, refer to **Subject 100**. Also, make sure that the service brake piston is fully retracted (in the brakes "OFF" position). Then, record both of the following dimensions in either mm or inches, measuring outward from the base of the service brake chamber (see **Fig. 3**):

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## Combination Service and Parking Brake Chamber Removal and Installation

X dimension: to end of threaded piston rod

Y dimension: to centerline of (large) clevis pin

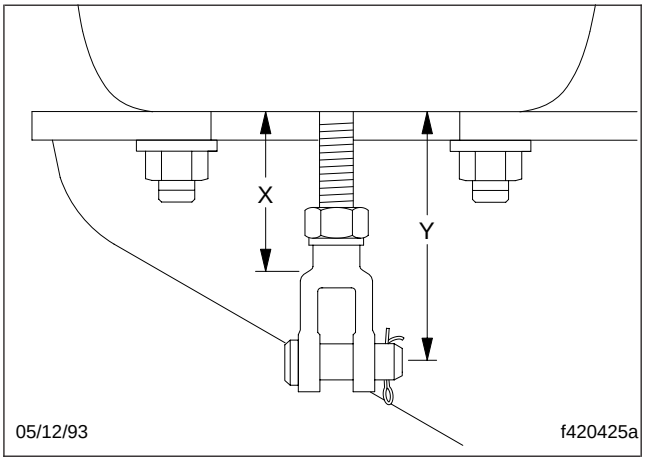



**Fig. 3, Measure X and Y**

IMPORTANT: If new chambers are to be attached to manual slack adjusters, the Y dimension is the most critical measurement. When installing the new assembly, its service piston rod must be cut (see **Fig. 4**) to exactly duplicate this "rod-plus-clevis" length *after* the clevis assembly is installed on the piston rod.

If new chambers are to be attached to automatic slack adjusters, the X dimension is the most critical measurement. When installing the new assembly, its service piston rod must be cut (see **Fig. 4**) to exactly duplicate the "rod only" length *before* the clevis assembly is installed on the piston rod.

3.3 From each mounting stud, remove any installed nuts and washers. Then, cautiously remove the brake chamber from the mounting bracket.

## Installation

1. If installing a new brake chamber unit, do the following steps:

   1.1 First, make sure the power spring is caged (release bolt fully extended outward). If not, go to **Subject 100** and do the applicable steps.

   1.2 Make sure that the piston rod is the same length as the rod on the old unit (measure the rods when *both* chambers are caged).

   1.3 Be sure the new chamber is the same size and make as the brake chamber installed on the other side of the axle.

   1.4 Remove the prevailing torque locknut and hardened flatwasher from each of the mounting studs on the chamber. See **Fig. 2**.

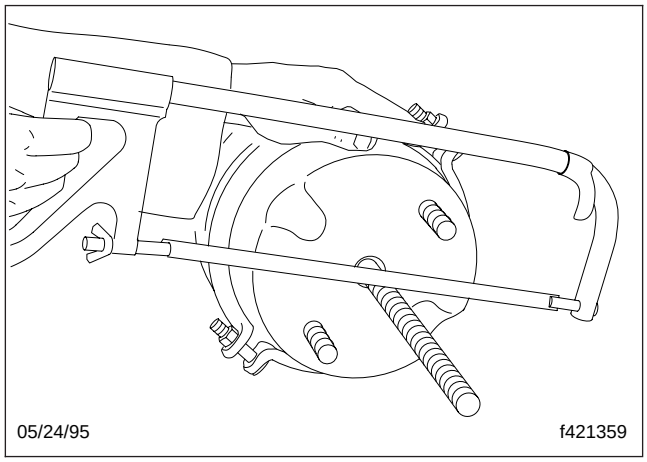



**Fig. 4, Cut the Service Piston Rod**

2. Clean the face of the mounting bracket, and install the chamber on the bracket, paying close attention to positioning the chamber air inlet ports for correct alignment to the vehicle air lines.

**⚠ WARNING**

**Tighten the mounting nuts with a hand wrench, not an impact wrench. An impact wrench could damage the mounting fasteners, reducing the force of the brakes. This could result in personal injury or property damage.**

3. Install one hardened flatwasher and prevailing torque locknut on each mounting stud. Using a hand wrench (*do not use an impact wrench*), tighten the nuts 100 to 115 lbf·ft (136 to 156 N·m). Make sure the flatwasher is installed between the locknut and the mounting bracket.

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## Combination Service and Parking Brake Chamber Removal and Installation

On chambers equipped with an external breather tube, make sure that the tube is installed in the side of the chamber that faces away from the road surface. An improperly installed breather tube voids the MGM warranty.

4. Check mating and alignment with the vehicle air lines.

**⚠ DANGER**

**Do not attempt to remove the factory-sealed clamp ring (Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from a sudden release of the power spring.**

4.1 Using a hand wrench (*do not use an impact wrench*), loosen the clamp nuts on the *service* clamp ring (*do not disassemble the parking brake section*).

4.2 Reposition the air inlet ports, as needed, to mate with vehicle air supply lines.

Alternately tighten each clamp nut in increments of 60 to 120 lbf·in (680 to 1360 N·cm) while constantly rechecking the alignment of mating parts.

If realignment is needed, loosen the nuts again, and repeat this substep.

4.3 Firmly tap around the circumference of the service clamp ring with a rubber mallet to ensure full seating of the clamp. Tighten the nuts to a final torque of 25 to 30 lbf·ft (34 to 41 N·m).

5. Install the slack adjuster. Refer to the applicable slack adjuster section in this group for installation instructions.

6. Inspect the piston rod to be sure it is working free, not binding, and is square with the chamber bottom within ±3° in any direction from zero to full stroke. If there is misalignment, make corrections by loosening the locknuts and repositioning the chamber on the mounting bracket, or by shimming the slack adjuster to the right or left on the camshaft.

7. Make sure the air hose fittings are free of grease, dirt, and other debris. Then, apply Loctite® 242 sealant, or an equivalent, to the fittings, and install, as referenced earlier. Using a hand wrench (*don't use an impact wrench*), tighten the fittings 25 lbf·ft (34 N·m).

8. Using the vehicle system air, charge the parking brake with full line pressure, at least 100 psi (690 kPa). Using only soapy water (*never any type of oil,* which could deteriorate rubber parts), check for air leaks at the air lines and fittings. If bubbles or leaks appear, tighten the fittings slightly, but not over 25 lbf·ft (34 N·m).

**⚠ DANGER**

**Do not attempt to remove the factory-sealed clamp ring (Fig. 1) for any purpose at any time. The parking/emergency brake section is not intended to be serviced. Serious injury or death may result from a sudden release of the power spring.**

IMPORTANT: If the service brake clamp ring was loosened to reposition the air inlet ports, apply air to the parking brake, and then apply and hold the foot brake treadle valve down to charge the service brake chamber. Now test for air leaks around the circumference of the *service* brake clamp ring. If bubbles or leaks appear, firmly tap the circumference of the clamp ring with a rubber mallet, and retighten the clamp nuts until leaks cease (*do not touch the parking brake section*). MGM recommends 25 to 30 lbf·ft (34 to 41 N·m) torque on the clamp hexnuts.

9. With air pressure now exhausted from the service brake chamber, but held on the parking brake, reset the parking brakes by uncaging the power spring, and snap the end cover cap in place. For instructions, refer to **Subject 100**.

10. Adjust the brakes at the slack adjuster. For instructions, refer to the applicable slack adjuster section in this group.

IMPORTANT: After replacing any brake chamber, check the piston rod stroke and actuating alignment to ensure correct installation and foundation brake adjustment. No foundation brake adjustments, parking brake or service brake, can be made at the chamber and all "stroke" adjustments must be made at the slack

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## Combination Service and Parking Brake Chamber Removal and Installation

adjuster. For instructions, refer to the applicable slack adjuster section in this group.

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## Specifications

| Description | Torque: lbf·ft (N·m) |
|---|---|
| Spring Brake Release Bolt Nut (in storage pocket) | 10 (14) |
| Service Brake Clamp Ring Nut | 25–30 (34–41) |
| Brake Chamber Mounting Stud Nut | 100–115 (136–156) |
| Air Hose Fitting-to-Chamber | 25 (34) |

**Table 1, Torque Values**

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# General Description

The Meritor WABCO Antilock Braking System (ABS) is an electronic wheel speed monitoring and control system that works with the standard air brake system. See **Fig. 1**. ABS passively monitors vehicle wheel speed at all times, and controls wheel speed during emergency stops. If equipped with Automatic Traction Control, wheel spin is controlled during reduced-traction starts. In normal braking applications, the standard air brake system is in effect.

ABS includes signal-generating tone wheels and sensors located in the wheel hubs of each sensed wheel. The sensors transmit vehicle wheel speed information to an electronic control unit. According to programmed specifications, the control unit signals the appropriate solenoid control valve to increase, reduce, or maintain air pressure supply in the brake chamber. This prevents front and rear wheel lockup, and enhances steering control during emergency braking situations. If equipped with Automatic Traction Control, an additional solenoid valve is installed. During reduced-traction starts, the system automatically applies the brakes on the wheel that is spinning, left or right side, to transfer power to the opposite-side wheel. If both the left and right wheels spin, then engine power is automatically reduced.

# Principles of Operation

The ABS electronic control unit (see **Fig. 2**) is a digital microcomputer that serves as the information processing and command center for the antilock braking system. The control unit receives and processes vehicle wheel speed information from the sensors. During emergency brake applications, the control unit regulates the braking force applied to each wheel by sending control signals to the solenoid control valves (see **Fig. 3**).

## ABS Major Components

### Wheel Speed Sensor

The wheel speed sensors use pulse feedback from tone wheels located in the front and rear axle wheel hubs. When the vehicle is moving, the teeth of the tone wheel cause interruptions in a magnetic field created by the sensor. The interruptions create electrical pulses that are sent by the sensor to the electronic control unit.

### Electronic Control Unit (ECU)

The electronic control unit (ECU), located on the underside of the cab floor forward of the drivers seat, contains microcomputers to monitor the front and rear control channels. The ECU receives speed sensor pulses and interprets these signals to calculate wheel speed and a vehicle reference speed. If the calculations indicate wheel slip or lockup, the appropriate control circuit signals the solenoid control valve(s) to increase or decrease braking pressure.

**⚠ CAUTION**

**Before performing any electric welding on a vehicle, disconnect the battery power and ground cables and the electrical harness connectors at the bottom of the ABS electronic control unit (ECU). See Fig. 2. Electric currents produced during electric welding can damage various electronic components on the vehicle.**

The ECU contains another microcomputer that provides a safety circuit to constantly monitor the wheel sensors, traction control valve (if equipped), solenoid control valves, and the electrical circuitry. After the ignition switch is turned on, the tractor warning light (TRAC ABS) and the wheel spin (WHL SPIN) indicator light come on for about three seconds. After about three seconds, the lights go out only if all of the tractor's ABS components are working.

A wheel spin (WHL SPIN) indicator light comes on if one of the drive wheels spins during acceleration. See the vehicle driver's manual for operating instructions.

IMPORTANT: If the TRAC ABS warning light and the WHL SPIN indicator light do not work as described above, repair the ABS/ATC system.

If the vehicle is equipped with an electronic engine, an automatic traction control (ATC) system may be installed. On these vehicles, the ATC system automatically reduces wheel spin during reduced-traction starts.

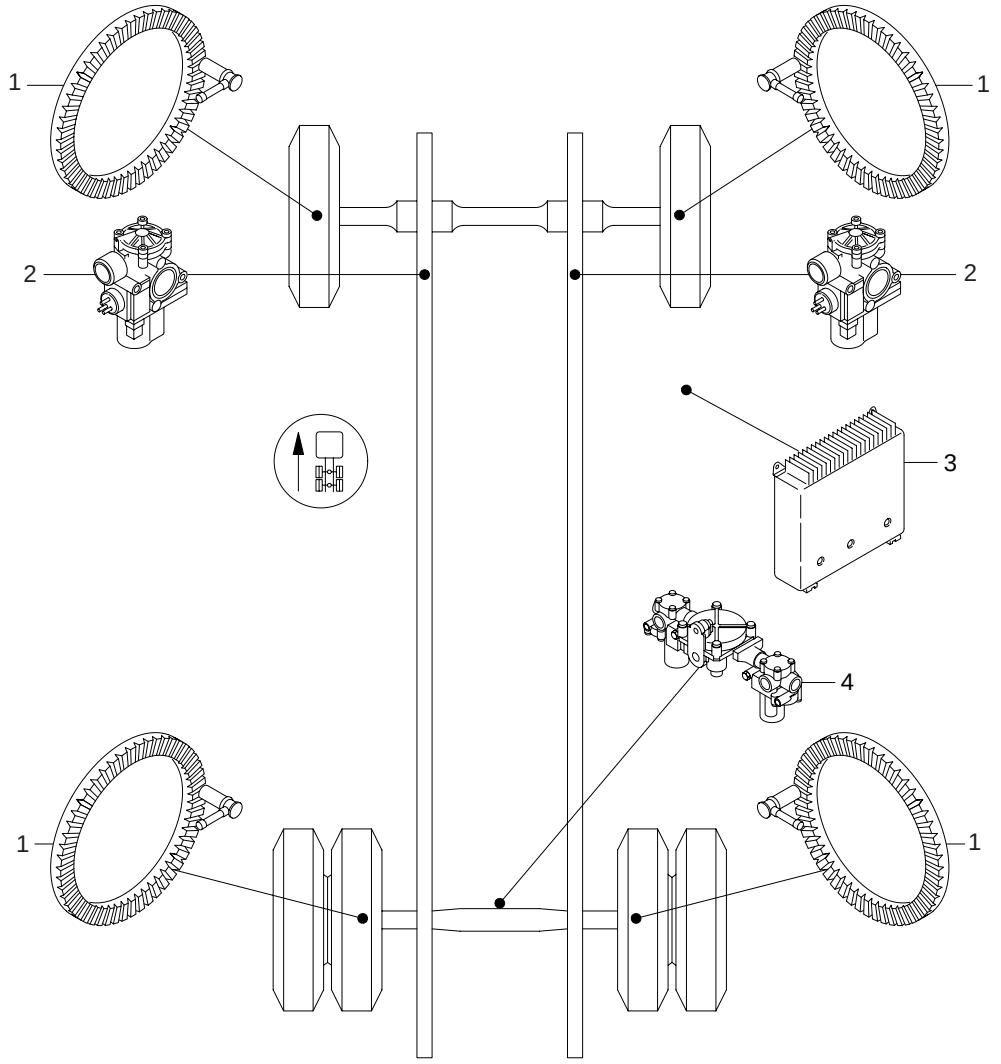
An "ATC Function" switch (if equipped), allows the driver to select from two levels of drive axle traction-control assistance:

- NORMAL/SPIN—which reduces drive axle wheel spin on icy, wet, or sand covered roads.

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## General Information




1. Tone Wheel and Sensor
2. Solenoid Control Valve
3. Electronic Control Unit
4. Combination Solenoid Control Valve

**Fig. 1, Location of ABS Components, Four-Channel System**

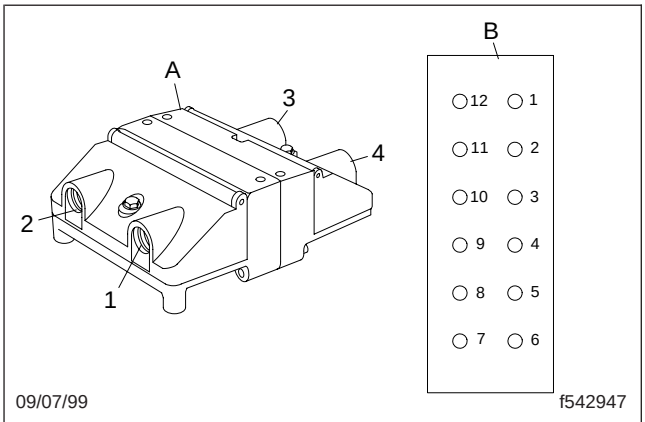
- ATC—which allows a higher threshold of drive axle wheel spin to help burn through a thin layer of ice, or to help throw off accumulated mud or snow.

The ATC mode is indicated by a flashing WHL SPIN light. To engage this mode, the ATC function switch (this is a momentary switch) must be pressed once the vehicle is started. The ECU indicates the activation by a constant flashing of the WHL SPIN lamp. This mode is disengaged by again pressing the ATC function switch. See the vehicle driver's manual for complete operating instructions.

If, during vehicle operation, the safety circuit senses a failure in any part of the ABS system (a sensor, solenoid control valve, wiring connection, short circuit, etc.), the tractor warning light (TRAC ABS)

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A. Frame-Mounted ECU
B. ECU Connector Pin Locations
1. X1 Connector (gray)
2. X2 Connector (black)
3. X3 Connector (green)
4. X4 Connector (brown—6S/4M, 6S/6M only)

**Fig. 2, Electronic Control Unit**

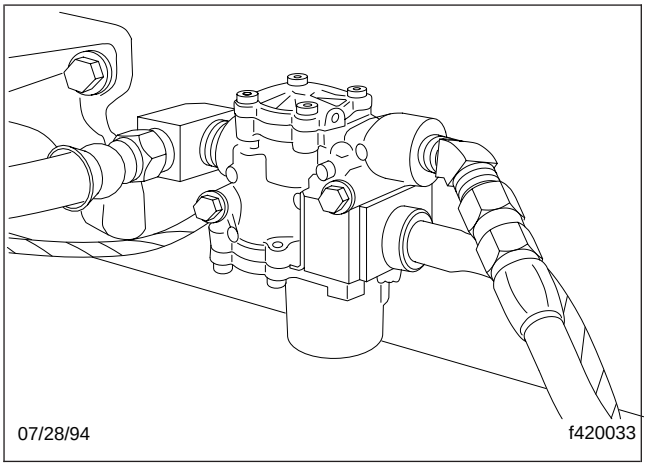


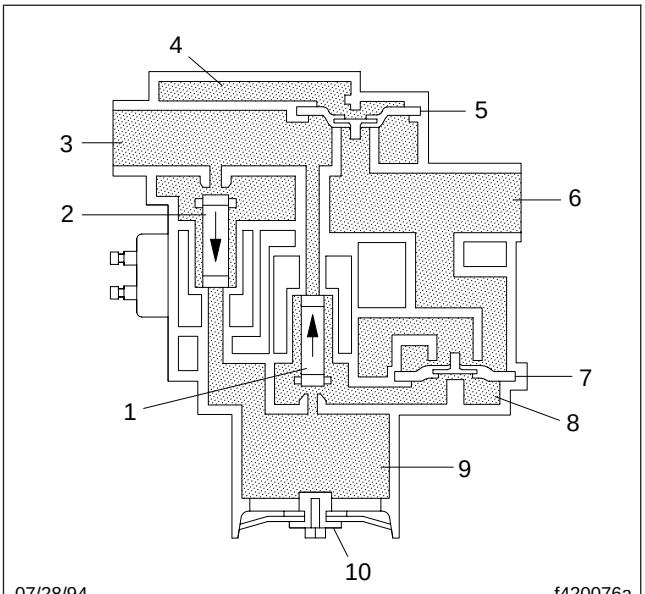

**Fig. 3, Solenoid Control Valve, Front Axle Mounting shown**

comes on, and the control circuit where the failure occurred is switched to normal braking action. The remaining control circuit will retain the ABS effect. Even if the ABS system is completely inoperative, normal braking is maintained. An exception would be if a solenoid control valve (or combination solenoid control valve) is damaged and inoperative. As these components are an integral part of the air brake system, normal braking may be impaired or inoperative.

## Solenoid Control Valve

The solenoid control valves for the front axle brakes are attached on each side of the vehicle (inboard of the forward fuel tank brackets). The combination solenoid control valves (which include a relay valve) for the rear axle brakes are attached to either the center or forward suspension crossmember near the brake chambers. Depending on the signal received from the electronic control unit, the control valve prevents wheel lockup by reducing, maintaining, or increasing brake chamber air pressure. During normal braking applications, compressed air flows freely to the brake chamber through the control valve.

If the electronic control unit signals indicate wheel lockup, air pressure is reduced in the brake chamber. Solenoid valve No. 1 opens allowing compressed air to enter the inlet chamber and pilot chamber No. 1. See **Fig. 4**.




1. Solenoid Valve No. 2
2. Solenoid Valve No. 1
3. Inlet Chamber
4. Pilot Chamber No. 1
5. Diaphragm Valve No. 1
6. Delivery Chamber
7. Diaphragm Valve No. 2
8. Pilot Chamber No. 2
9. Exhaust Chamber
10. Exhaust Port

**Fig. 4, Wheel Lockup Cycle**

At the same time, solenoid valve No. 1 closes off the exhaust chamber preventing the escape of air from the inlet chamber to atmosphere. Compressed air in

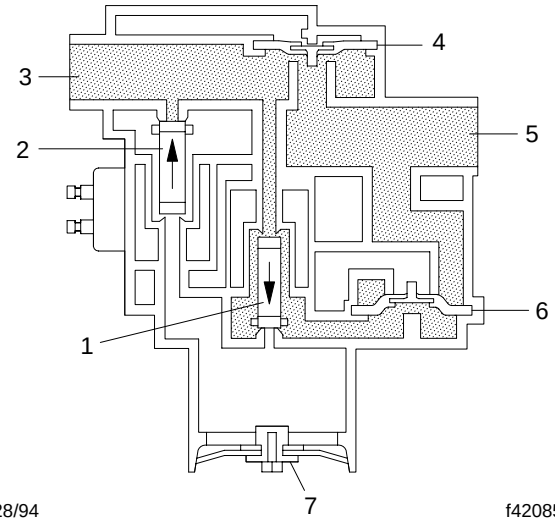
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the inlet chamber is forced into pilot chamber No.1, closing diaphragm valve No. 1; this prevents air passage to the delivery chamber. Solenoid valve No. 2 also opens, allowing air to vent from pilot chamber No. 2 through the exhaust port. Complete venting of all air in the delivery chamber occurs as diaphragm valve No. 2 opens.

As wheel speed increases, the control valve alternately increases, then maintains brake pressure until the proper wheel speed is obtained, or until wheel lockup occurs and the control cycle starts again.

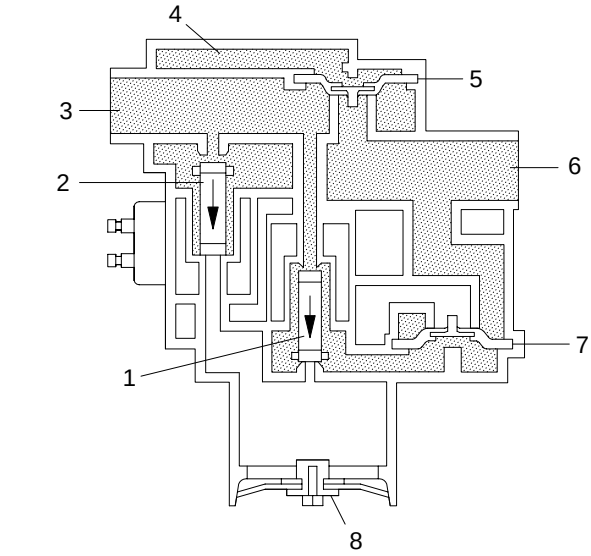
During the pressure increase cycle (see **Fig. 5**), both solenoid valves are closed. Compressed air entering through the inlet chamber forces diaphragm valve No. 1 open, allowing air to pass through the delivery chamber into the brake chamber. At the same time, pressure within the control valve keeps diaphragm valve No. 2 closed, preventing air from escaping through the exhaust port.




1. Solenoid Valve No. 2
2. Solenoid Valve No. 1
3. Inlet Chamber
4. Diaphragm Valve No. 1
5. Delivery Chamber
6. Diaphragm Valve No. 2
7. Exhaust Port

**Fig. 5, Pressure Increase Cycle**

If maintaining brake air pressure (see **Fig. 6**), solenoid valve No. 1 opens and compressed air passes from the inlet chamber into pilot chamber No. 1. Both of the diaphragm valves are forced closed, sealing the delivery chamber and maintaining brake air pressure.




1. Solenoid Valve No. 2
2. Solenoid Valve No. 1
3. Inlet Chamber
4. Pilot Chamber No. 1
5. Diaphragm Valve No. 1
6. Delivery Chamber
7. Diaphragm Valve No. 2
8. Exhaust Port

**Fig. 6, Maintaining Brake Air Pressure Cycle**

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# Wheel Speed Sensor Replacement

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. See **Group 54** (wiring) for information on special terminals and connectors, and on ordering tools for them.

## Front Axle

1. Chock the rear tires to prevent vehicle movement. Apply the parking brakes.
2. Twist and pull the sensor, to remove it from the steering knuckle. See **Fig. 1**.

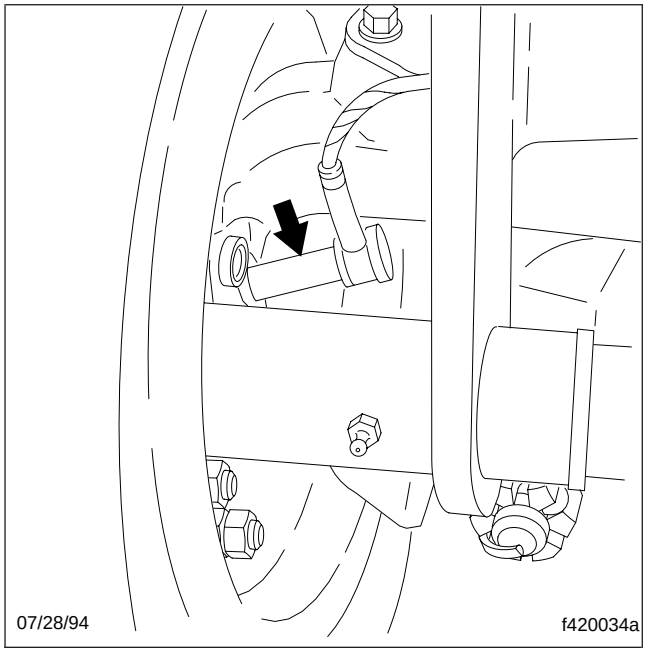



**Fig. 1, Remove the Wheel Speed Sensor**

3. Remove the sensor cable from the steering knuckle top cap.
4. Disconnect the sensor cable from the chassis harness.
5. Remove the clamping bushing from the steering knuckle.
6. Connect the sensor cable to the chassis harness.
7. Attach the sensor cable to the steering knuckle top cap.
8. Press the clamping bushing into the brake spider hole until it stops.
9. Coat the sensor with Mobil HP, Valvoline EP 633, Penzoil 707L, or an equivalent. Press the sensor into the clamping bushing until it is stopped by the tone wheel.
10. Remove the chocks from the rear tires.

## Rear Axle

1. Chock the front tires to prevent vehicle movement. Apply the parking brakes.
2. Raise the rear of the vehicle until the tires clear the ground. Place safety stands under the axle.
3. Back off the slack adjuster to release the rear axle brake shoes.
4. Remove the wheel and tire assembly from the rear axle. For instructions, see **Group 40**.
5. Remove the brake drum. For instructions, see **Group 35**.
6. Twist and pull the sensor, to remove it from the mounting block in the axle housing.
7. Remove the clamping bushing.
8. Remove the capscrew that attaches the sensor cable and the hose clamp to the axle tube.
9. Disconnect the sensor cable from the chassis harness.
10. Connect the sensor cable to the chassis harness.
11. Attach the hose clamp and sensor cable to the axle tube located between the backing plate and the spring plate.
12. Press the clamping bushing into the mounting block until it stops.
13. Coat the sensor with Mobil HP, Valvoline EP633, Penzoil 707L, or an equivalent. Using your hand, push the sensor into the clamping bushing until it is stopped by the tone wheel.
14. Install the brake drum on the wheel hub. For instructions, see **Group 35**.

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## Wheel Speed Sensor Replacement

15. Adjust the rear axle brakes. For instructions, see the applicable brake section in this manual.
16. Install the wheel and tire assembly and tighten the wheel nuts. Use the tightening sequence and torque values listed in **Group 40**.
17. Remove the safety stands, lower the vehicle, and remove the chocks from the front tires.

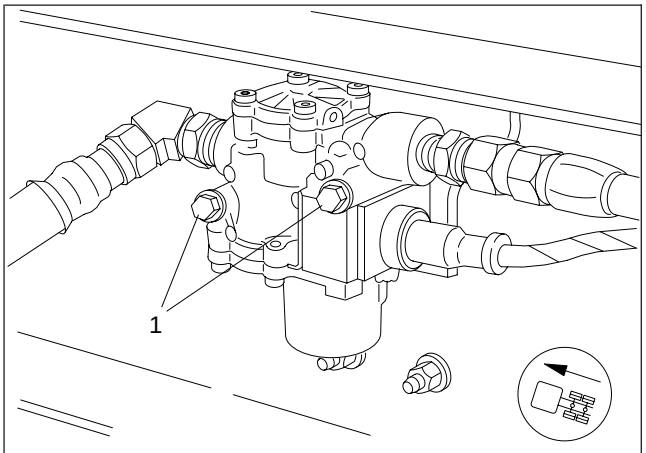
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## Replacement

NOTE: Wire repairs may require the use of special tools for certain connectors and terminals. See **Group 54** for information on special terminals and connectors, and on ordering tools for them.

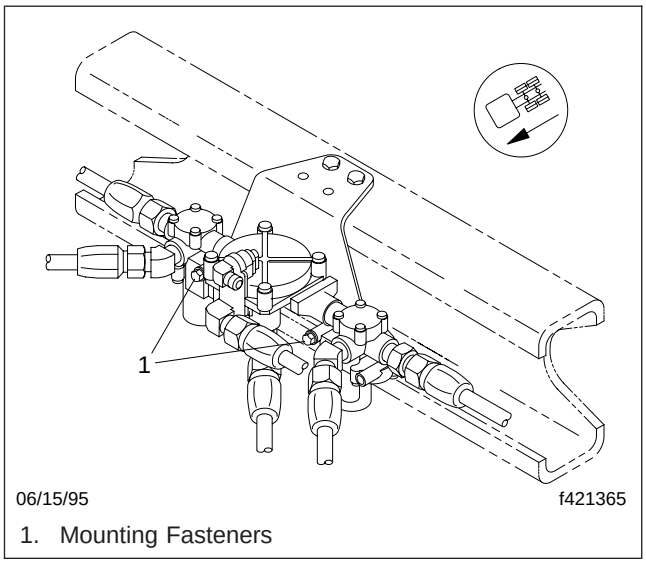
1. Chock the front and rear tires.
2. Release the pressure from the air reservoirs.
3. Disconnect the wiring from the solenoid control valve, or combination solenoid control valve(s).
4. Mark the air lines for ease of installation. Disconnect the air lines.
5. Remove the two mounting capscrews, washers, and nuts.
6. Remove the solenoid control valve. See **Fig. 1** or **Fig. 2**.




1. Mounting Fasteners

**Fig. 1, Solenoid Control Valve Mounting (inside right-hand rail mounting shown)**

NOTE: The combination solenoid control valve can be disassembled if replacement of the relay valve, automatic traction control valve, or one of the solenoid control valves is needed. For disassembly and assembly instructions, see **Subject 130**.




1. Mounting Fasteners

**Fig. 2, Combination Solenoid Control Valve Mounting (rear axle mounting shown)**

7. Install the solenoid valve using the above instructions in reverse order. Tighten the mounting nuts 18 lbf·ft (24 N·m).

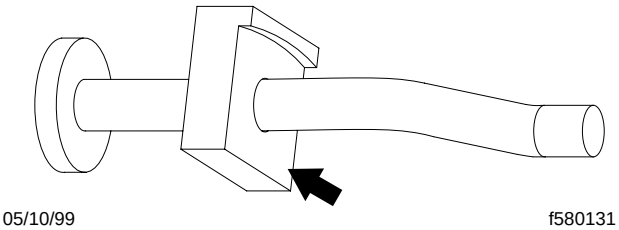
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## Adjustment

NOTE: The following adjustment procedure requires the use of special tool T11–17556–000. Use of this tool, available through the PDCs, eliminates the time-consuming task of removing the wheel and tire assembly, and the brake drum. See **Fig. 1**.

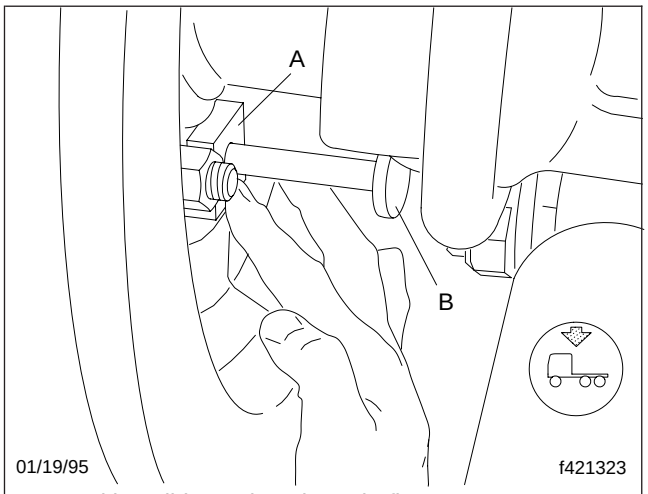
1. Park the vehicle on level ground, set the parking brake, and shut down the engine.




1. Slide

**Fig. 1, ABS Sensor Adjustment Tool**

2. Chock the front tires.
3. Find the sensor access hole in the rear axle flange.
   - 3.1 View the brake drum and axle from the rear. The ABS sensor wiring harness should be visible passing through a hole in the 12 o'clock position.
   - 3.2 Find the S cam at either the 3 o'clock or 9 o'clock position.
   - 3.3 Just opposite the S cam is the sensor access hole, approximately 3/4 inch (19 mm) diameter.
4. Insert the service tool T11–17556–000 into this hole.
5. Position the slide of the tool on the axle flange to align the tool. See **Fig. 2**.
6. Tap the tool lightly with the palm of your hand. This will ensure the sensor is touching the tone wheel.
7. Remove the tool from the wheel and repeat the procedure on the other rear axle speed sensor.
8. Remove the chocks from the tires.




A. Position slide against the axle flange.
B. Tap here with your hand.

**Fig. 2, Position the Tool**

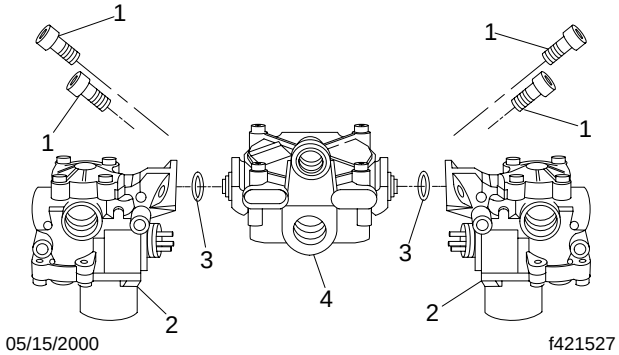
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# Combination Solenoid Control Valve Disassembly and Assembly

## Disassembly

1. Use a 6 mm allen-head wrench to loosen and remove the allen-head bolts. See **Fig. 1**.
2. Carefully separate the ABS control valve(s) from the relay valve.
3. Remove and discard the old O-rings.




1. Allen-Head Bolt
2. ABS Control Valve
3. O-Ring
4. Relay Valve

**Fig. 1, Combination Solenoid Control Valve**

## Assembly

1. Lubricate the replacement O-rings with the grease provided. See **Fig. 1**.
2. Plug any unused ports on the replacement valve(s).
3. Attach the ABS control valve(s) to the relay valve. Tighten the allen-head bolts 13 to 15 lbf·ft (18 to 20 N·m).

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## Installation

IMPORTANT: Some ABS service hubs do not have a tone ring installed on the hub. The tone ring must be ordered separately and installed on the hub before installation of the hub onto the axle. Tone rings are made of a special material and require a specific installation procedure for proper installation.

**⚠ WARNING**

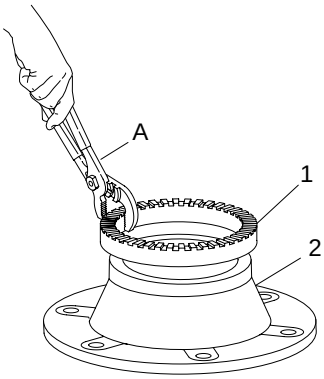
**When installing an ABS system, special ABS hubs must be ordered. Machining of older hubs to accommodate the installation of tone rings can cause problems due to insufficient hub bore wall thickness. Machining an older hub with insufficient hub bore wall thickness could result in cracking, causing bearing damage and wheel loss. This could cause an accident resulting in personal injury and property damage.**

1. Submerge the tone ring in boiling water or place it in an oven at 250°F (121°C) for approximately 15 minutes.

**⚠ CAUTION**

**Do not attempt to heat the tone ring with a torch as this can damage the ring.**

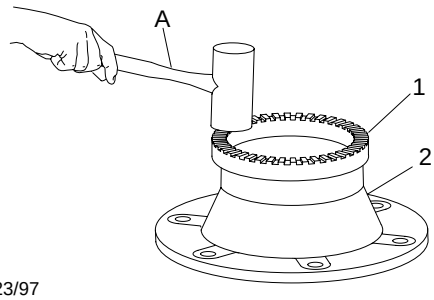
2. Using pliers, remove the tone ring from the boiling water or oven and center it on the machined area of the hub bore. See **Fig. 1**.
3. While the tone ring is still hot, make sure that it is properly centered on the machined surface. Using a rubber mallet, tap the tone ring until it bottoms out around the machined surface on the hub. See **Fig. 2**.
4. Install the hub on the axle. Position a dial indicator with a magnetic base so the dial indicator is against the tone ring teeth. See **Fig. 3**.
5. Rotate the hub and check the ring for runout. The runout should be less than 0.005 inch (0.13 mm). See **Fig. 4**.
6. Install the wheel. For instructions, see **Group 40**.




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A. Use pliers to apply the ring.
1. Tone Ring 2. Hub

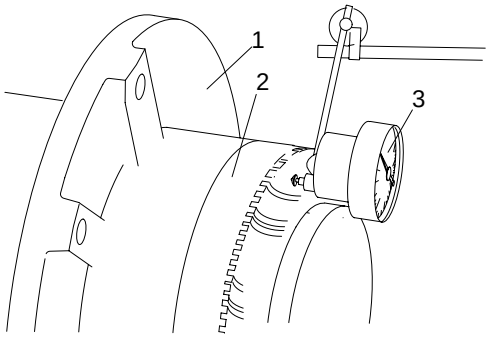
**Fig. 1, Install the Ring on the Hub**




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A. Use a rubber mallet.
1. Tone Ring 2. Hub

**Fig. 2, Tap the Tone Ring**




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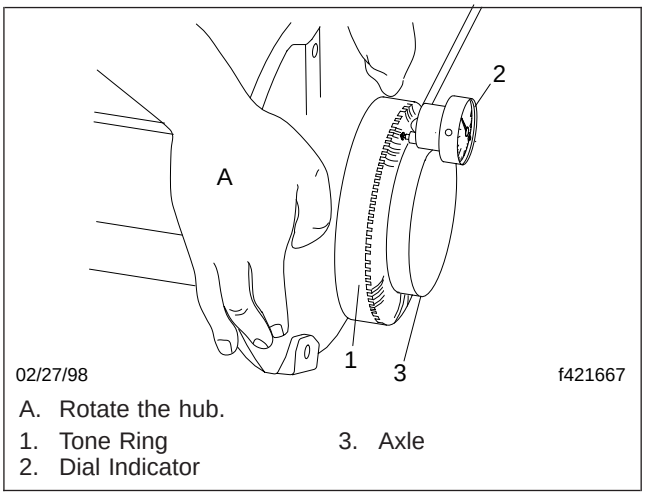
1. Hub 3. Dial Indicator
2. Tone Ring

**Fig. 3, Position the Dial Indicator**

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## ABS Tone Ring Installation on Service Hubs




A. Rotate the hub.
1. Tone Ring
2. Dial Indicator
3. Axle

**Fig. 4, Check Tone Ring Runout**

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# General Information

Air reservoirs serve two main purposes:

- They store compressed air used to apply the brakes and operate other air-powered devices, such as window lifts, windshield wipers, and seats.
- They provide a place where air, heated during compression, can cool and water vapor can condense into a liquid. Also, air reservoirs collect small amounts of oil passed by the compressor.

Each vehicle is equipped with three or four air reservoirs, depending on the number of rear axles. On all vehicles, each reservoir is identified as one of three types: supply, primary, and secondary.

A supply reservoir receives compressed air directly from the compressor. Also referred to as the wet tank, its functions are to collect most of the water and oil condensate from the air, and to supply air to the other reservoirs. At the outlet port of the supply reservoir (the port leading to the primary reservoir) is a safety valve, which protects the air system against excessive air pressure buildup. The supply reservoir is usually mounted on the right-hand frame rail.

Primary reservoirs are air sources for the brakes on the rear axles. One or two primary reservoirs are installed on a vehicle, depending on the number of rear axles and the air system configuration. Each primary reservoir is usually mounted behind the supply reservoir on the right-hand frame rail.

A secondary reservoir is the air source for the front axle brakes. It is usually mounted on the left-hand frame rail, and, like the primary reservoir, is equipped with an inline check valve.

The secondary reservoir supplies air to a pressure protection valve. This valve prevents complete loss of secondary air pressure if there is an air leak in any non-brake accessory.

All air reservoirs are equipped with drain valves to eject the water and oil emulsion from the tanks.

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## Safety Precautions

When working on or around air brake systems and components, observe the following precautions.

- Chock the tires and stop the engine before working under the vehicle. Releasing air from the system may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters; they will apply as air pressure drops.
- Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
- When working with compressed air, always wear safety glasses, and never exceed recommended air pressure.
- Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs, and injury can result if not correctly disassembled. Use only correct tools and observe all precautions regarding use of those tools.

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# Drain Valve Replacement and Leak Elimination

**⚠ WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

## Replacement and Leak Elimination

NOTE: If the vehicle is equipped with an automatic moisture-ejection valve, see **Section 42.12** for replacement instructions.

1. Apply the parking brakes, and chock the tires.
2. Drain the air system, using the instructions in the vehicle driver's manual.
3. Using two wrenches (hold the coupler in place with one of them), unscrew the drain valve from the coupler. Clean off the threads inside the coupler on the reservoir, removing all sludge and sealant build-up.

   Obtain a new drain valve if leaks occurred through the body of the valve.

   If leaks occurred at the joint of the drain valve and coupler, clean off the sludge and sealant from the threads of the valve. Check for damaged threads on the valve and inside the coupler. Replace damaged parts. If no damage exists, leakage was probably due to inadequate tightening of the drain valve in the coupler.
4. Apply Loctite®, or an equivalent sealant, to the end threads of the drain valve or coupler, as applicable, and install finger-tight. Tighten one and one-half additional turns (use two wrenches if installing the drain valve).
5. Perform a leak test after completing the installation. If leaks occur at the joint of the drain valve and coupler, tighten the valve up to one additional turn to stop the leaks.

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# Air Reservoir Replacement

**⚠ WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

## Replacement

1. Park the vehicle on a level surface, set the parking brake, and shut down the engine. Chock the rear tires.
2. Drain the air system.

NOTE: If access is limited, reverse the order of the next two steps and remove the air lines, couplers, and valves after removing the reservoir from its mount.

3. Mark or tag all reservoir air lines, couplers, and valves for later assembly, then disconnect the components. Cap the exposed ports tightly to keep out contaminants.
4. Remove the reservoir, as follows. See **Fig. 1** for a one-piece strap (under frame rail) mounting and **Fig. 2** for a frame rail mounting.

   4.1 Loosen the reaction joint clamp bolts.

   NOTE: If the reservoir is mounted on the fuel tank bracket, loosen the bottom strap fastener first.

   4.2 Remove the reservoir strap fasteners.

   4.3 Remove the reservoir.

NOTE: If access is limited, connect the air lines, couplers, and valves before installing the new reservoir.

5. If there is sufficient work space, place a new reservoir in the mount and install the strap fasteners.
   - Tighten the strap fasteners 64 lbf·ft (87 N·m).
   - Tighten the reaction joint clamp bolts 26 lbf·ft (35 N·m).
6. Connect all air lines, couplers, and valves to the new reservoir, removing the caps as each component is installed. Tighten the connections as instructed in **Section 42.10, Subject 100**.

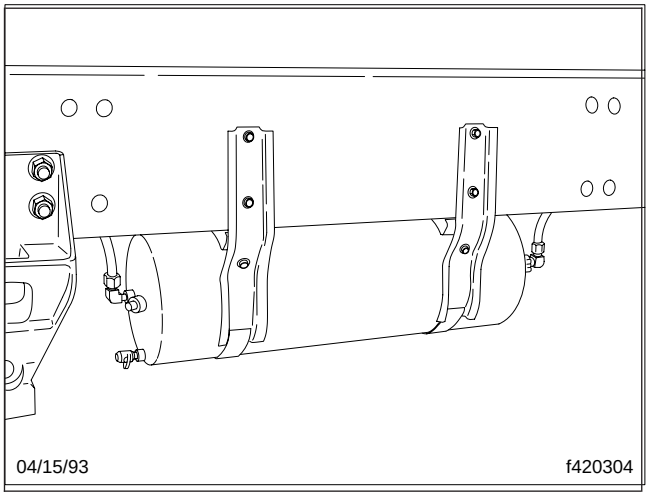



**Fig. 1, Air Reservoir, One-Piece Strap (Under Frame Rail) Mounting**

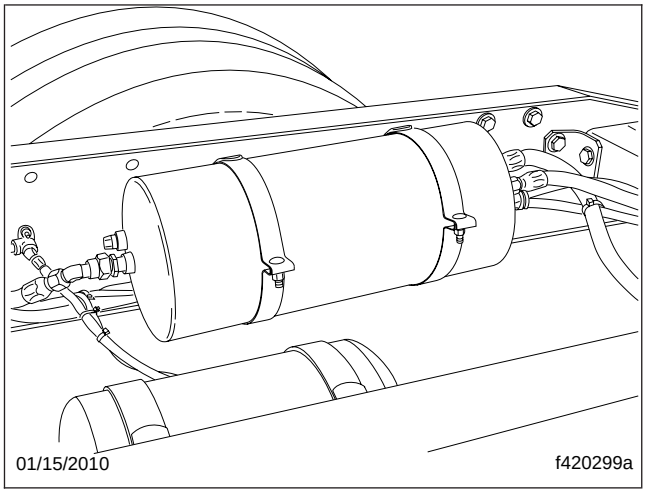



**Fig. 2, Air Reservoir, Frame Rail Mounting**

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**WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

# Internal Check Valve Replacement, Two-Chamber Air Reservoir

## General Information

Contamination in two-chamber, wet/secondary, reservoirs may cause the inline check valve to become clogged or stuck closed. This can result in insufficient air buildup. If insufficient air buildup is noted, replace the check valve. If the check valve can not be removed (due to corrosion), it is acceptable to install a bypass line.

There are two styles of check valves that may have been installed in the tank. An internal check valve is threaded into the internal wall that separates the wet side and secondary side of the reservoir. Or an external check valve is mounted in a port on the top surface of the reservoir.

## Internal Check Valve Replacement (located in the separator wall of the reservoir)

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Drain the air reservoir.
3. Disconnect the air lines, then remove the reservoir from the vehicle.
4. On the supply (wet) side of the reservoir, disconnect the pressure-protection valve, and the 90-degree elbow located on the end of the reservoir.
5. The check valve is located on the interior wall that separates the sides of the reservoir. To reach it, use a 1/4-inch drive, 1/2-inch deep-well socket with a 1/4- to 3/8-inch drive adapter, and necessary 3/8-inch extensions to reach the valve. Tape the socket and extensions, to ensure the valve will stay in the socket, and that the wrench assembly will stay together inside the tank. Insert the socket assembly through the end port of the reservoir, and remove the valve. See **Fig. 1** and **Fig. 2**.

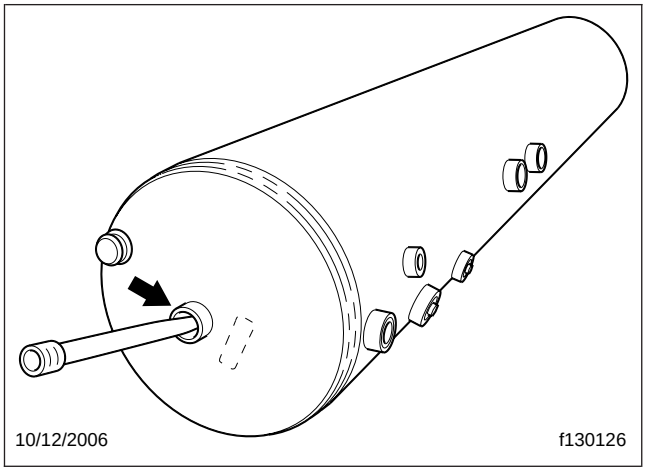
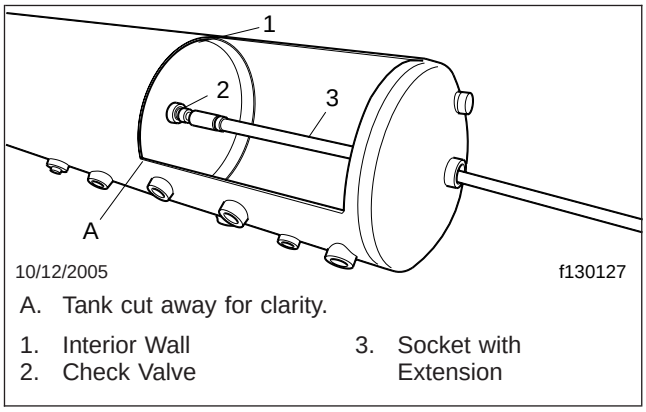



**Fig. 1, Accessing the Internal Check Valve**




A. Tank cut away for clarity.

1. Interior Wall
2. Check Valve
3. Socket with Extension

**Fig. 2, Cutaway View of Split Air Reservoir**

**NOTICE**

**Take care not to drop the check valve into the reservoir when removing or installing it. The reservoir can not be used if the check valve is lost in it. A loose check valve could scratch the teflon coating of the interior of the reservoir, causing it to corrode. If the check valve is not recoverable, replace the reservoir.**

6. Install a new check valve.
7. Attach the pressure-protection valve and the 90-degree elbow.

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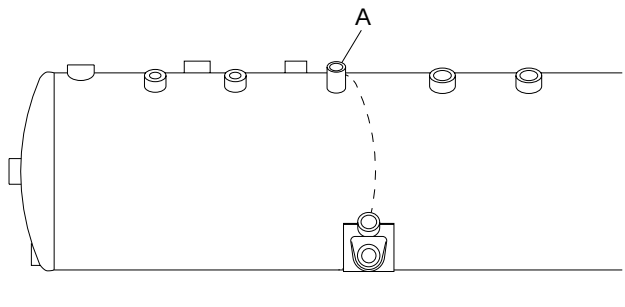


## Internal Check Valve Replacement

8. Install the reservoir on the vehicle and attach the air lines.
9. Charge the air system and inspect for leaks.
10. Remove the chocks from the tires.

# Internal Check Valve Replacement (located in the side port of the reservoir)

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Drain the air reservoir.
3. Remove the check valve assembly from the top port on the reservoir. See **Fig. 3** and **Fig. 4**.




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A. Check valve is located in this port.

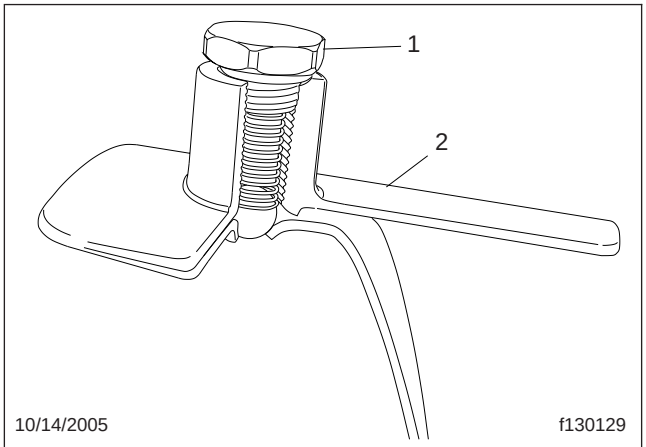
**Fig. 3, Check Valve Location**

4. Install a new check valve.
5. Charge the air system and inspect for leaks.
6. Remove the chocks from the tires.

# Bypass Line Installation

Check with the parts distribution center (PDC) for the appropriate bypass line kit for your vehicle.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Drain the air reservoir.
3. On the top port on both sides of the reservoir, disconnect the existing plumbing from the tank. Install a T-fitting, and connect the existing plumbing to the top port of the T-fitting. See **Fig. 5**.




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1. Check Valve
2. Tank Shell (cut away)

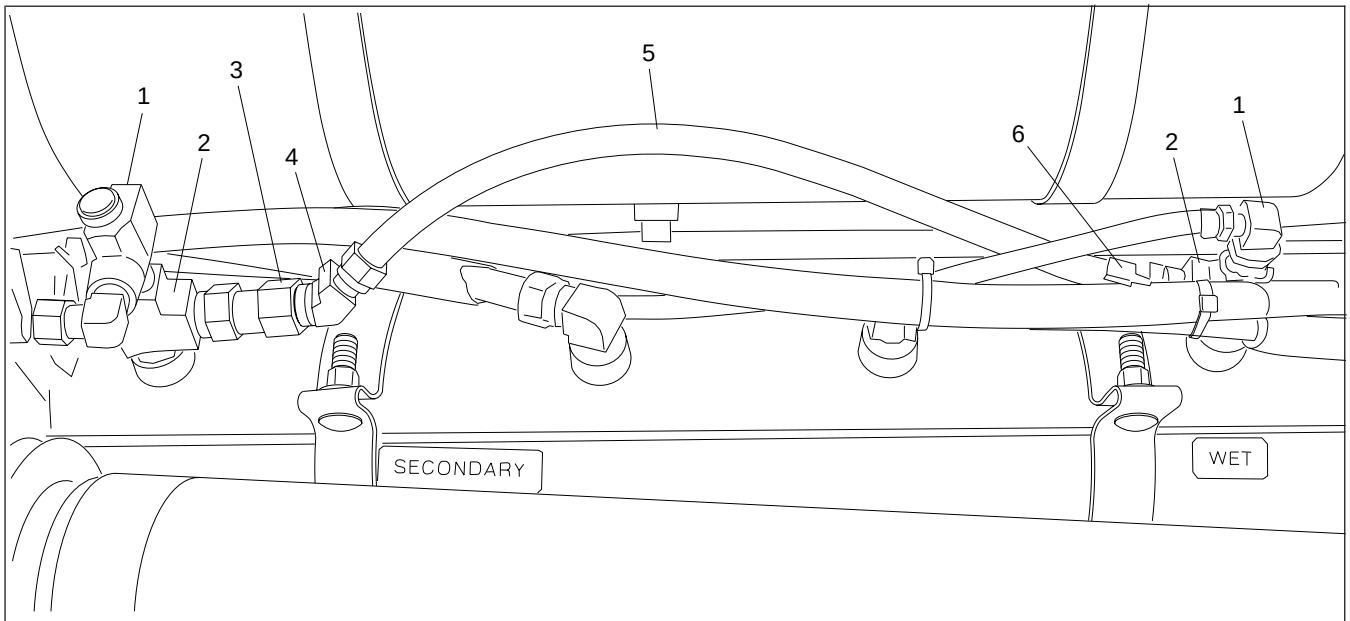
**Fig. 4, Cutaway View of the Check Valve Installation**

4. On the secondary (dry) side of the reservoir, on the side port of the T-fitting, install a check valve, then a 45-degree elbow.
5. On the supply (wet) side of the reservoir, on the side port of the T-fitting, install the straight brass fitting.
6. Install a 1/2-inch air line between the 45-degree elbow on the secondary (dry) side, and the brass fitting on the supply (wet) side.
7. Charge the air system and inspect for leaks.

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## Internal Check Valve Replacement




1. Existing Plumbing
2. T-Fitting
3. Check Valve
4. 45-Degree Elbow
5. 1/2-Inch Air Line
6. Brass Fitting

**Fig. 5, Check Valve Bypass**

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**WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

## Tests

Be sure the air system is fully charged. Using a soap solution or leak detector, check for leaks on the outside surfaces of the reservoirs and drain valves. No leakage is permitted.

If leaks exist at the drain valve, note if they occur at the joint of the valve and coupler, or through the valve body proceed to **Subject 110**.

If leaks occur on the surfaces of the air reservoir, replace the tank.

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# General Information

This troubleshooting guide is designed to help locate causes of problems originating in the air brake system. The corrective measures given are not intended to replace the detailed service information found in other sections of this manual or in the component manufacturer's service manuals. If the vehicle is equipped with ABS (antilock brake system), see the applicable section in this group for troubleshooting the ABS system.

Before attempting to isolate the causes of an air brake system problem, do the following.

1. Check the operation of the air compressor. See the engine manufacturer's service manual.

   Check the pressure levels of the air reservoirs. See the pretrip inspection and daily maintenance chapter in the *Western Star Driver's Manual*.

2. Be sure that all relay valves are operating. See **Group 42** of the *Western Star Maintenance Manual*.
3. Check the operation of the brake chambers as instructed in **Group 42** of the *Western Star Maintenance Manual*.
4. Examine all tubing for kinks, dents, and other damage. Replace damaged tubing.
5. Examine all hoses for cracks, drying out, overheating, and other damage. Replace damaged hoses.
6. Examine all air line fittings. Tighten loose connections; replace fittings that are damaged.
7. Examine leaking pipe connections for cracks or thread damage; replace as needed. If there is no damage, retighten the fitting.

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## Safety Precautions

**⚠ WARNING**

**Follow the manufacturer's procedures while working on any air device. Some parts are subject to mechanical (spring) or pneumatic propulsion and may cause personal injury or property damage when released. Failure to take all necessary precautions during servicing of the air brake system can result in personal injury or property damage.**

Compression and storage of air in the air brake system is comparable to the energy in a coiled spring: when released, it may present a hazard. Because of this, certain precautions are required.

1. Chock the tires. This will prevent accidental rolling of the vehicle when air is released from the brake system.
2. Do not disconnect pressurized hoses because they will whip as air escapes from the line. Drain the air system before disconnecting the air hoses.
3. When draining the air system, do not look into the air jets or direct them toward another person: dirt particles or sludge may be carried in the air stream.
4. As air pressure is drained and the parking/emergency brakes apply, keep your hands away from the brake chamber push rods and parking brake chambers, which will activate automatically with the loss of pressure.

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# Troubleshooting Tables

**Problem—Vehicle Does Not Slow Down Quickly Enough When Brakes Are Applied**

| Problem—Vehicle Does Not Slow Down Quickly Enough When Brakes Are Applied | |
|---|---|
| **Possible Cause** | **Remedy** |
| The vehicle is overloaded. | Observe the recommended maximum load limits. |
| There is low air pressure in the brake system, about 60 psi (413 kPa) or lower. | The drain cock on the air reservoir was left open; close the drain cock. |
| | Check the compressor output pressure; correct as necessary. |
| | Check the setting of the air governor with an accurate test gauge. Adjust the air governor to the recommended specification. |
| The application air lines are leaking excessively. | Check the application air lines, brake valve, and the service and parking brake chambers for air leaks. Repair or replace the damaged component(s). |
| Brake valve delivery pressure is below normal. | Lubricate the brake valve parts; overhaul the unit, if necessary. |
| Wear or glazing of the brake linings is present. | Install new brake linings on the brake shoes on both sides of the axle. |
| Adjustment or lubrication of the brakes is needed. | Adjust or lubricate the brakes. |
| The automatic slack adjusters are not operating. | Lubricate the automatic slack adjusters and check for binding, damaged, or inoperative slack adjuster parts. Replace damaged or inoperative parts, or eliminate the cause of the binding. |
| The cam has flipped over. | Replace the linings and the cam on each end of the axle. |
| Flat spots or dents on the roller surface were caused by skidding of the roller or improper handling of the wheel bearing during installation. | Clean, then inspect the bearing rollers. Replace the bearing if damaged. Ensure that the bearings to be installed are sufficiently lubricated as outlined in **Group 33** and **Group 35** of the *Western Star Maintenance Manual*. |
| One or more of the brake drums is broken or cracked. | Replace the brake drum(s). |
| Wrong size brake linings were installed. | Replace the brake linings with the recommended size. |
| Wrong size brake chambers were installed. | Replace the brake chambers with the recommended size. |
| A camshaft bracket or chamber mounting bracket is bent or broken. | Replace the camshaft bracket or chamber mounting bracket. |
| The brake chamber mounting stud nuts or brake chamber mounting bracket is loose. | Tighten the brake chamber to its mounting bracket or the mounting bracket to the foundation brake housing. |
| There is a ruptured diaphragm in the service brake. | Replace the diaphragm. |

**Problem—Service Brakes Release Too Slowly**

| Problem—Service Brakes Release Too Slowly | |
|---|---|
| **Possible Cause** | **Remedy** |
| The brake shoe anchor pins are frozen. | Inspect the anchor pins. If damaged, replace them; if not damaged, lubricate them. |

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## Troubleshooting

| Problem—Service Brakes Release Too Slowly | |
|---|---|
| **Possible Cause** | **Remedy** |
| Lubrication of the brake system components is inadequate. | Lubricate those components requiring periodic lubrication. |
| The brake foot valve is not returning to the fully released position. | Check for obstructions which might prevent the brake foot valve from returning to the fully released position. Remove any obstructions. |
| The exhaust port of the brake foot valve or quick-release valve is plugged. | Clear the exhaust port of obstructions. |
| The brake foot valve or quick-release valve is inoperative. | Overhaul or replace the inoperative valve, as needed. |
| The camshaft and bushings are binding. | Clean and lubricate the camshaft bushings. |
| The brake shoe return spring is weak or broken. | Replace the spring. |
| Flat spots or dents on the roller surface were caused by skidding of the roller or improper handling of the wheel bearing during installation. | Clean, then inspect the bearing rollers. Replace the bearing if damaged. Ensure that the bearings to be installed are sufficiently lubricated as outlined in **Group 33** and **Group 35** of the *Western Star Maintenance Manual*. |

**Problem—Service Brakes Do Not Apply or Apply Too Slowly**

| Problem—Service Brakes Do Not Apply or Apply Too Slowly | |
|---|---|
| **Possible Cause** | **Remedy** |
| Lubrication of the foundation brake assembly is needed. | Lubricate those components requiring periodic lubrication. |
| There is insufficient air pressure in the brake system. | Check all parts of the air pressure system for leaks or inoperative components. |
| The brake foot valve or relay valve is inoperative. | Repair or replace the brake foot valve or relay valve. |
| The camshaft bushings are binding. | Clean and lubricate the camshaft bushings. |

**Problem—Service Brakes Apply When the Parking Brakes Are Released With Air Pressure**

| Problem—Service Brakes Apply When the Parking Brakes Are Released With Air Pressure | |
|---|---|
| **Possible Cause** | **Remedy** |
| The air delivery lines to the brake chamber have been reversed. | Reverse the connections of the brake chamber air lines. |
| The braking mechanism is binding. | Lubricate the brake mechanism and make sure all parts are aligned with each other and are securely fastened. |
| | Check for obstructions; remove any obstructions. |

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**Problem—Service Brakes Do Not Release**

| Problem—Service Brakes Do Not Release | |
|---|---|
| **Possible Cause** | **Remedy** |
| The brake shoes are incorrectly adjusted. | Adjust the brakes. Also, make sure the slack adjuster is operating correctly. If not, overhaul or replace the slack adjuster. |
| The brake foot valve may not be in the fully released position. | Lubricate the brake foot valve if needed. |
| The brake foot valve is inoperative. | Overhaul or replace the brake foot valve. |
| There is restriction in the tubing, hose, or exhaust port of the brake foot valve or quick-release valve. | Check for bends or obstructions on the exhaust side of the service brakes. Remove any obstructions; plumb the air lines so that bends are minimal. |
| A broken power spring may be blocking the parking brake piston movement. | Replace the power spring or replace the parking brake assembly, whichever is recommended by the parking brake manufacturer. |

**Problem—Service Brakes Grab or Pull**

| Problem—Service Brakes Grab or Pull | |
|---|---|
| **Possible Cause** | **Remedy** |
| There is not enough weight on the vehicle (underloaded). | Add weight to the vehicle, reducing brake sensitivity. |
| Adjustment of the brakes on one axle is uneven. | Adjust the brakes. |
| Lubrication of the brake system components is inadequate. | Lubricate those components requiring periodic lubrication. |
| The brake mechanism is binding. | Lubricate the brake mechanism and make sure all parts are aligned with each other and are securely fastened. |
| The clevis pin or camshaft is binding at one or more wheels. | Clean and lubricate the camshaft bushings. |
| A brake spider is loose. | Tighten the mounting bolts or replace the brake spider. |
| A slack adjuster is damaged. | Replace the damaged component. |
| The air chamber push rods or slack adjusters are a different length. | Replace the components with the correct size and material. |
| The brake foot valve is inoperative. | Overhaul or replace the brake foot valve, as needed. |
| If equipped with cam brakes, there is a flat or dent on the S-head camshaft or on the cam roller(s). | Replace the damaged component(s). |
| Grease has saturated the brake linings or the linings are glazed. | Install a matched set of linings on both sets of brake shoes on that axle. Clean, turn, or replace both brake drums. For instructions on turning drums, the brake manufacturer's service manual. |
| The brake linings are loose or broken. | Install a matched set of linings on both sets of brake shoes on that axle. |
| The brake linings are not a matched set. Different friction codes or different brands of brake linings are installed. | Install a new, matched set of brake linings. Clean, turn, or replace both brake drums on that axle. For instructions on turning drums, the brake manufacturer's service manual. |
| A brake shoe is distorted or broken. | Replace the brake shoe. Install a new, matched set of linings on both sets of brake shoes on that axle. |

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## Troubleshooting

| Problem—Service Brakes Grab or Pull | |
|---|---|
| **Possible Cause** | **Remedy** |
| The pilot pads are damaged, allowing the brake drum to be installed out-of-round. | Replace the wheel hub. |
| A brake drum is out-of-round to unacceptable limits. | Turn both the brake drums on that axle. If the maximum allowable diameter of either drum has been exceeded, replace that drum. For instructions on turning drums, see the brake manufacturer's service manual. |
| One or more brake drums is scored or broken. | Replace both of the drums on that axle. |

**Problem—Uneven Service Brakes**

| Problem—Uneven Service Brakes | |
|---|---|
| **Possible Cause** | **Remedy** |
| The wrong brake linings were installed, or the linings were not replaced in pairs. | Replace the brake linings with the recommended size. Install new linings on both sets of axle brake shoes. |
| Grease has saturated the brake linings or the linings are glazed. | Install new linings on both axle brake shoes. Clean the brake drums. |
| The return spring for the brake shoe release or the service brake has broken. | Replace all broken springs. |
| The brake drum is out-of-round to unacceptable limits. | Turn both the brake drums on that axle. If the maximum allowable diameter of either drum has been exceeded, replace that drum. For instructions on turning drums, see the brake manufacturer's service manual. |
| A service brake chamber diaphragm is leaking. | Tighten the clamp ring. If leaks persist, replace the service brake diaphragm. |
| The wheel bearings are out of adjustment. | Adjust the wheel bearings, or replace them if damaged. For instructions, see **Group 33** or **Group 35** of this manual. |
| A brake spider is damaged. | Replace the brake spider. |
| The brake shoes are bent or stretched. | Replace the axle brake shoes on each wheel. |
| Grease, oil, or dirt is on the linings. | Replace the linings on each set of axle brake shoes. Clean the brake drums. |

**Problem—Dragging Service Brake**

| Problem—Dragging Service Brake | |
|---|---|
| **Possible Cause** | **Remedy** |
| The service brake return spring is broken. | Replace the service brake return spring. |
| The service-application air is not exhausting or not exhausting fast enough, due to blockage in the control valve, the quick-release valve, or the limiting and quick-release valve. | Test the air system valves for leakage and operation. |
| A brake shoe retracting spring is broken. | Replace the brake shoe retracting spring. |
| Binding is occurring in the camshaft linkage. | Lubricate the camshaft linkage. Replace bent or broken parts. |

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**Problem—Insufficient Parking Brake Application When Dash Control Valve Is Activated**

| Problem—Insufficient Parking Brake Application When Dash Control Valve Is Activated | |
|---|---|
| **Possible Cause** | **Remedy** |
| The parking brake is not set for full stroke. | Adjust the brakes. |
| There is a ruptured parking brake diaphragm or ineffective piston seal. | Replace the diaphragm or parking brake piston seal. |
| A power spring is broken. | Replace the parking/emergency brake section. |
| A power spring in a parking brake is manually caged. | Release the power spring by screwing in the release bolt. |

**Problem—Dragging Brakes Due to Parking Brake Mechanism**

| Problem—Dragging Brakes Due to Parking Brake Mechanism | |
|---|---|
| **Possible Cause** | **Remedy** |
| The system air pressure is insufficient to fully release the parking brake. | Be sure that all air lines are clear. Check that the air governor cutout settings meet recommended specifications. |
| A parking brake diaphragm is ruptured or a piston seal is ineffective. | Replace the diaphragm or parking brake piston seal. |
| There is a broken return spring in the parking brake (double-diaphragm type brake chambers only). | Replace the parking/emergency brake section. |

**Problem—Air Pressure Will Not Rise to Normal**

| Problem—Air Pressure Will Not Rise to Normal | |
|---|---|
| **Possible Cause** | **Remedy** |
| The air pressure gauge(s) on the dash is (are) registering inaccurately. | Check the dash gauge(s) with an accurate test gauge. Replace the dash gauge(s) as needed. |
| There is excessive leakage (not including the air compressor). | Check all valves, air lines, and connections for leakage. Repair or replace valves and lines until leakage is eliminated. |
| The compressor is inoperative (including excessive leakage of the compressor). | Rebuild or replace the compressor. |
| The air reservoir drain cock has been left open. | Close the drain cock. |
| The air governor cutout setting is not adjusted correctly. | Check the setting with an accurate test gauge, then adjust the air governor to the recommended specification. |
| There is inadequate clearance at the compressor unloading valve. | Repair or adjust the compressor at the unloading valve. |
| If so equipped, the compressor drive belt is slipping. | Adjust or replace the compressor drive belt. |
| Carbon is building up in the compressor cylinder head or discharge line. | Remove the carbon. If disassembly is not recommended by the compressor manufacturer, replace the air compressor with a factory rebuilt or a new unit. |

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## Troubleshooting

**Problem—Air Pressure Rises Above Normal**

| Problem—Air Pressure Rises Above Normal | |
|---|---|
| **Possible Cause** | **Remedy** |
| The air reservoir pressure dash gauge is inaccurate. | Check the dash gauge with an accurate test gauge. Replace the dash gauge as needed. |
| The compressor air governor is out of adjustment. | Check the setting with an accurate test gauge, then adjust the air governor to the recommended specification. |
| The air governor is not operating. | Repair or replace the air governor. |
| There is too much clearance at the air compressor unloading valve. | Repair or adjust the compressor at the unloading valve. |
| The air compressor unloading valve is stuck closed. | |
| The air compressor unloading valve cavities or the unloading valve passage is blocked with carbon. | |

**Problem— Air Pressure Drops Quickly With the Engine Stopped and the Brakes Released**

| Problem— Air Pressure Drops Quickly With the Engine Stopped and the Brakes Released | |
|---|---|
| **Possible Cause** | **Remedy** |
| The brake foot valve is leaking. | Repair or replace the brake foot valve. |
| The air compressor discharge valve is leaking. | Repair or replace the discharge valve. If disassembly is not recommended by the compressor manufacturer, replace the air compressor with a factory-rebuilt or a new unit. |
| The air governor is leaking. | Repair or replace the air governor. |

**Problem—Air Pressure Drops Quickly With the Engine Stopped and the Brakes Fully Applied**

| Problem—Air Pressure Drops Quickly With the Engine Stopped and the Brakes Fully Applied | |
|---|---|
| **Possible Cause** | **Remedy** |
| A service or parking brake chamber is leaking. | Tighten the clamp ring(s). If leaks persist, replace the diaphragm(s) or assembly. |
| The brake foot valve or relay valve is leaking. | Repair or replace the component(s) or assembly. |

**Problem—Compressor Knocks (Continuously or Intermittently)**

| Problem—Compressor Knocks (Continuously or Intermittently) | |
|---|---|
| **Possible Cause** | **Remedy** |
| There is a loose drive pulley, belt, coupling, or gear (as indicated). | Tighten or replace the component. If applicable, inspect the pulley shaft for damage. Replace the shaft, if damaged. |
| Backlash is in the compressor drive gears on the drive coupling. | Repair or replace the compressor drive gears or drive coupling. |
| The air compressor bearings are damaged or worn. | Replace the bearings. |

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| Problem—Compressor Knocks (Continuously or Intermittently) | |
|---|---|
| **Possible Cause** | **Remedy** |
| There are carbon deposits in the compressor cylinder head. | Remove the carbon deposits or replace the compressor. |

**Problem—Pressure Relief Valve Activates**

| Problem—Pressure Relief Valve Activates | |
|---|---|
| **Possible Cause** | **Remedy** |
| The pressure relief valve is out of adjustment. | Adjust the pressure relief valve, or install a new one. |
| There is excessive air pressure in the brake system. | See the problem "Air Pressure Rises Above Normal." |
| Draining of the air reservoirs needs to be performed more often. | Drain the air reservoirs daily. |

**Problem—Oil or Water in the Brake System**

| Problem—Oil or Water in the Brake System | |
|---|---|
| **Possible Cause** | **Remedy** |
| Excessive oil is passing through the air compressor. | Rebuild or replace the compressor. |
| If so equipped, the air compressor air strainer is dirty. | Clean the strainer or install a new one. |

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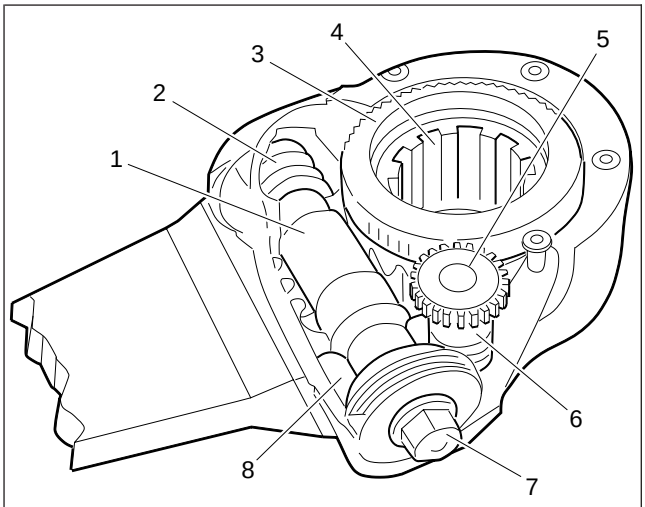
## General Description

The Haldex (S-ABA) automatic slack adjuster, shown in **Fig. 1**, serves two main functions:

- As a lever, it converts the straight-line force of the air brake chamber pushrod to torque on the brake camshaft. Rotation of the camshaft spreads the brake shoes out against the brake drum, applying the brakes.
- As an adjuster, it maintains cam brake chamber pushrod stroke and lining-to-drum clearance automatically during normal use.

## Principles of Operation

When the brakes are applied, the slack adjuster rotates and moves the shoes into contact with the drum. As the brake application continues, the rack moves upward and rotates the one-way clutch, which slips in this direction.




1. Wormshaft
2. Coil Spring
3. Control Disc
4. Worm Wheel
5. Regulator Gear
6. One-Way Clutch
7. Adjustment Hex
8. Clutch Wheel

**Fig. 1, Haldex Slack Adjuster**

As the brake torque increases, the coil-spring load is overcome and the wormshaft is displaced axially, releasing the cone clutch.

When the brake begins its return stroke, the coil spring load returns to normal and the cone clutch is again engaged. The rack is pulled back to its original position in the notch. Any additional travel brought about by brake lining wear causes the rack to turn the locked one-way clutch and rotates the wormshaft through the locked cone clutch. The wormshaft then rotates the worm wheel and camshaft, adjusting the brakes.

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## Safety Precautions

When working on or around a vehicle, observe the following precautions:

- Park the vehicle on a level surface, apply the parking brakes, and shut down the engine. Chock the tires.
- If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning any work on the vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters, which may apply as air pressure drops.
- Disconnect the batteries.
- Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
- Never exceed recommended air pressure. Always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
- Do not remove, disassemble, assemble, or install a component until you have read and understand the service procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use the correct tools and observe all precautions pertaining to use of those tools.
- Replacement hardware, tubing, hose, fittings, etc., should be the equivalent size, type, length, and strength of the original equipment.
- Make sure when replacing tubes or hoses that all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace devices that have stripped threads or damaged parts. Repairs requiring machining should not be attempted.
- Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

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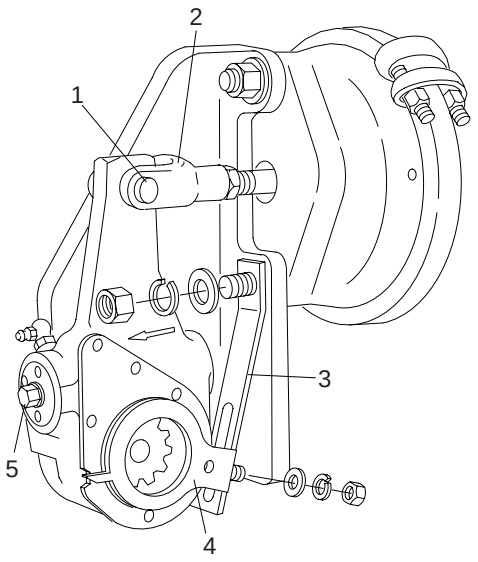
# Slack Adjuster Removal, Installation, and Brake Adjustment

**WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

## Removal

1. Park the vehicle on a level surface, set the parking brakes, and shut down the engine. Chock the front and rear tires.
2. If a rear-axle slack adjuster will be removed, release the parking brakes and cage the power spring of the parking brake chamber. For instructions, refer to the applicable brake chamber section in this group.
3. Remove the anchor bracket fasteners and the anchor bracket. See **Fig. 1**.




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1. Clevis Pin
2. Clevis
3. Anchor Bracket
4. Control Arm
5. Adjusting Hexnut

**Fig. 1, Anchor Bracket Removal/Installation**

4. Remove the cotter pin from the clevis pin. Remove the clevis pin.
5. Remove the snap ring that secures the slack adjuster on the camshaft.

**NOTICE**

**Do not use an impact wrench on the adjusting hexnut. To do so may damage the slack adjuster or camshaft.**

6. Using a 7/16-inch box wrench, turn the adjusting hexnut counterclockwise to move the adjuster arm out of the clevis. A minimum of 13 lbf·ft (18 N·m) is required to overcome the internal clutch. You will hear a ratcheting sound.
7. Remove the slack adjuster from the camshaft.

## Installation

NOTE: For brake chambers that have pushrods with threaded clevises, measure the pushrod length before installing a new slack adjuster. With the brakes fully released, and no air pressure to the chamber, check the dimension between the chamber face and the centerline of the 1/2 inch clevis pin hole. It should be 2.25 inches (57 mm) for long stroke chambers, and 2.75 inches (70 mm) for standard stroke chambers.

1. Check that the brake-chamber pushrod is fully retracted.
2. Apply antiseize compound to the camshaft splines.

IMPORTANT: When correctly installed, the brake-chamber pushrod pushes in the direction of the arrow on the slack adjuster housing.

3. Install the slack adjuster on the camshaft, with the adjusting hexnut pointing away from the brake chamber. See **Fig. 2**.
4. Using a snap ring, secure the slack adjuster on the camshaft. Use at least one inner washer and enough outer washers to allow no more than 0.060-inch (1.52-mm) movement on the shaft.

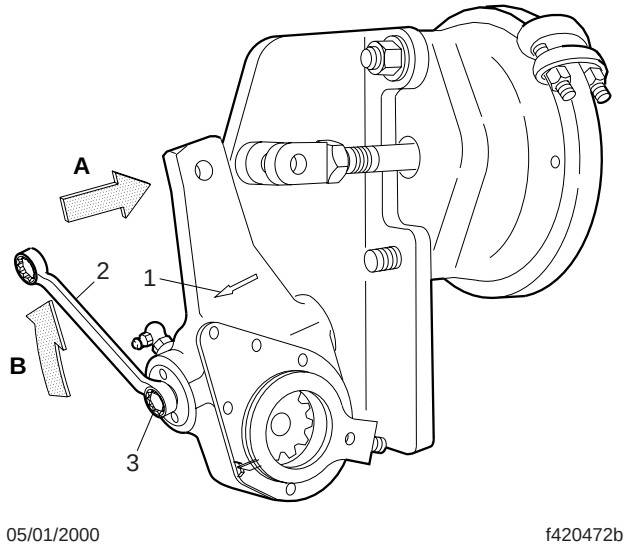
IMPORTANT: Never pull the pushrod out to meet the slack adjuster or push the slack adjuster into position. Always turn the adjusting hexnut for positioning.

5. Using a 7/16-inch box wrench, turn the adjusting hexnut clockwise until the slack adjuster hole is aligned with the pushrod clevis hole. See **Fig. 2**.

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## Slack Adjuster Removal, Installation, and Brake Adjustment




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A. Use only the adjusting hexnut to align the slack adjuster with the pushrod clevis.
B. Turn the adjusting hexnut clockwise.

1. Direction of Applied Stroke
2. Box Wrench, 7/16 in
3. Adjusting Hexnut

**Fig. 2, Slack Adjuster Installation**

6. Apply antiseize compound to the clevis pin, and insert the pin in the clevis hole. Do not install the cotter pin at this time.

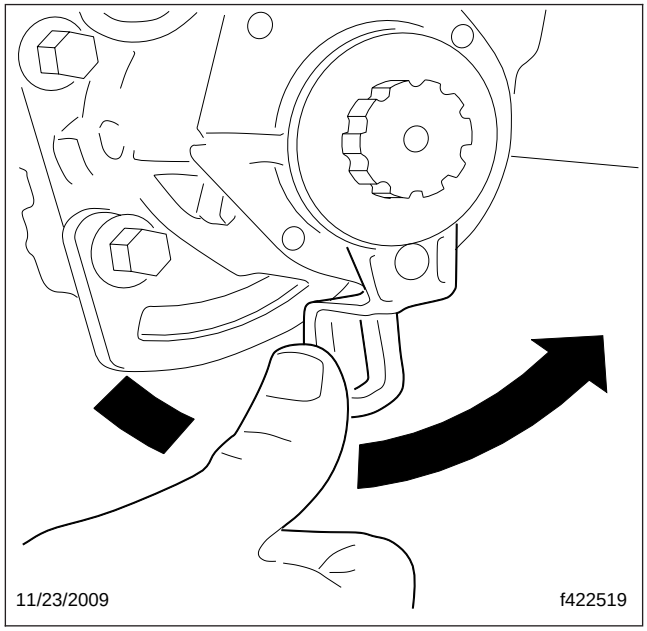
### NOTICE

**Never hammer the control arm. Hammering may damage the slack adjuster or camshaft splines.**

7. The S-ABA control arm can be placed anywhere within the range of the bracket slot for automatic adjustment to take place. However, Haldex recommends rotating all control arms towards the axle until they come to a complete stop, as shown in **Fig. 3**, and then secure the arm in that position. This will create a "common" position for all wheels.

NOTE: The anchor bracket and slack adjuster housing design will vary, depending on the axle. The anchor bracket mounting location is determined by the length of the control arm.

8. Install the control-arm anchor bracket, as follows. See **Fig. 1**.



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**Fig. 3, Positioning the Control Arm**

8.1 Tighten the anchor bracket fastener at the control arm 10 to 15 lbf·ft (14 to 20 N·m), making sure the control arm does not move from its position.

8.2 Tighten the fastener at the brake chamber mounting stud according to the brake chamber manufacturer's specifications.

9. Adjust the brakes. See "Brake Adjustment".

## Brake Adjustment

NOTE: A properly working self-adjusting slack adjuster does not require manual adjustment while in service.

### ⚠ WARNING

**Manually adjusting an automatic slack adjuster to bring the pushrod stroke within legal limits is likely masking a mechanical problem. Adjustment is not repairing. Before adjusting an automatic slack adjuster, troubleshoot the foundation brake system and inspect it for worn or damaged components. Improperly maintaining the vehicle braking system may lead to brake failure, resulting in property damage, personal injury, or death.**

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## Slack Adjuster Removal, Installation, and Brake Adjustment

1. Adjust the brake lining clearance by manually turning the adjusting hexnut clockwise until the brake lining contacts the brake drum, then back off the hexnut counterclockwise 1/2 turn. You will hear a ratcheting sound.

IMPORTANT: Incorrect installation can cause dragging brakes.

2. Make sure the brakes are still fully released. You should be able to remove the clevis pin without having the chamber clevis or slack arm move.

**⚠ WARNING**

**Install and lock a new cotter pin in the clevis pin. Failure to do so could allow the pushrod to disengage from the slack adjuster, causing a loss of braking ability that could result in personal injury and property damage.**

3. Install and lock a new cotter pin in the clevis pin.

IMPORTANT: Ensure that the air system has at least 100 psi prior to uncaging the brake chamber. This will aid in the uncaging of the parking brake since the parking brake should be fully released.

4. If a rear-axle slack adjuster was installed, manually uncage the parking brake. For instructions, refer to the applicable brake chamber section in this group.

**⚠ WARNING**

**Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.**

IMPORTANT: To check the brake adjustment, measure both the applied and free strokes.

NOTE: The location of the measurements is the same for both strokes but the applied stroke is measured with the brakes applied, while a lever is used to manually move the slack adjuster to measure the free stroke.

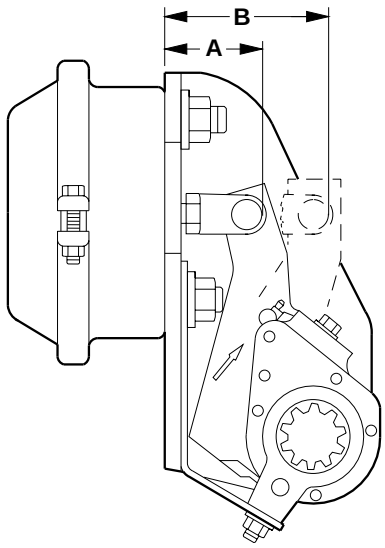
5. Measure the free stroke, as follows. The free stroke is the distance the slack adjuster has to travel to move the brake shoes against the drum.
   - 5.1 With the brakes released, measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. Record the exact distance as measurement A.
   - 5.2 Using a lever, move the slack adjuster until the brake shoes contact the drum. Measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. Record the exact distance as measurement B.
   - 5.3 Subtract measurement A from measurement B to determine the free stroke. For new brake installations, the free stroke should be 5/8 to 3/4 inch (16 to 19 mm). For in-service brakes, the free stroke should be 1/2 to 5/8 inch (13 to 16 mm).
6. Measure the applied stroke, as follows.
   - 6.1 With the brakes released (pushrod fully retracted), measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. See **Fig. 4**. Record the exact distance as measurement A.
   - 6.2 Apply and hold an 80 psi (552 kPa) brake application. Measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole. Record the exact distance as measurement B.
   - 6.3 Subtract measurement A from measurement B to determine the applied stroke. Compare this value to the value in **Table 1**.
7. Apply the parking brakes.
8. Remove the chocks from the tires.
9. In a safe area, check for proper brake operation, as follows.
   - 9.1 Apply and release the brakes several times to check for correct operation of the slack adjusters.
   - 9.2 Perform six low-speed stops to ensure correct parts replacement and full vehicle control.
   - 9.3 Immediately after doing the above stops, check the drum temperatures. Any drums

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## Slack Adjuster Removal, Installation, and Brake Adjustment

that are significantly cooler than the others show a lack of braking effort on those wheels.




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NOTE: Measurements are from the bottom of the brake chamber to the far side of the clevis-pin hole.

A. Measurement with brakes released.
B. Measurement with brakes applied at 80 psi (552 kPa).

**Fig. 4, Brake Applied Stroke Check**

| Brake Chamber Stroke Specifications | | | |
|---|---|---|---|
| Chamber Size | Maximum Applied Stroke: inch (mm) | Free Stroke: inch (mm) | |
| | | New Brake Installation | In-Service Brake Installation |
| 16 | 1-3/4 (44) | 5/8–3/4 (16–19) | 1/2–5/8 (13–16) |
| 20 | | | |
| 24 | 1-7/8 (48) | | |
| 30 | 2 (51) | | |

**Table 1, Brake Chamber Stroke Specifications**

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**Problem—Tight or Dragging Brakes**

| Problem—Tight or Dragging Brakes | |
|---|---|
| **Possible Cause** | **Remedy** |
| The control arm anchor bracket is not positioned properly. | See instructions in **Subject 110**. |
| System air pressure is too low to fully release the spring brake. | Check that the air governor cuts out at the recommended setting. |
| A spring brake diaphragm is ruptured or a piston seal is leaking. | Replace the diaphragm or spring brake piston seal. |
| A return spring in the brake chamber is broken. | Replace the spring brake return spring. |
| The pushrod binds on the chamber housing. | Check for correct alignment and correct chamber mounting bracket. Adjust or replace parts as needed. |
| The air supply does not exhaust completely. | Test the air system valves for leakage and correct operation. |
| The brake drums are out-of-round. | Turn the brake drums, if possible. If the maximum allowable diameter of any brake drum has been exceeded, replace the drum. Also, turn or replace the other drum on the axle. For turning the drums, refer to the brake manufacturer's service manual. |
| Extreme differences exist in lining-to-drum clearances between shoes on the same wheel. | Check for proper operation of the brake mechanism. Lubricate or overhaul as needed. |
| The wheel bearings are out of adjustment. | Adjust the wheel bearings, or replace them if damaged. For instructions, refer to **Group 33** and **Group 35**. |
| The brake shoe return spring is broken. | Replace the brake shoe return spring. |

**Problem—Brake Chamber Pushrod Travel Is Excessive**

| Problem—Brake Chamber Pushrod Travel Is Excessive | |
|---|---|
| **Possible Cause** | **Remedy** |
| The control arm anchor bracket is loose, broken, or bent. | Tighten or replace the anchor bracket as required. |
| There is excessive wear between the anchor bracket bolt and the control arm slot. | Replace the worn parts. |
| The control arm assembly is damaged or worn, resulting in lateral movement between the control arm and the cover plate. | Replace the slack adjuster. |
| The camshaft bushings are worn. | Replace the worn camshaft bushings. |
| The camshaft binds. | Lubricate the camshaft or overhaul the brake mechanism as needed. |
| The brake chamber mounting is loose. | Tighten the brake chamber mounting fasteners. |
| The slack adjuster is bound against the camshaft housing. There is no end play. | Check that the correct camshaft and camshaft tube have been used and that they are assembled correctly. Overhaul the brake mechanism as needed. |
| The slack adjuster clutch assembly is worn. | Replace the slack adjuster. |

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## Specifications

| Approved Lubricants | |
|---|---|
| **Lubricants Type** | **Lubricant Type** |
| Low Lube | Mobilgear SHC 460 Synthetic |
| Standard | Standard Chassis Grease |

**Table 1, Approved Lubricants**

| Brake Chamber Stroke Specifications | | | |
|---|---|---|---|
| **Chamber Size** | **Maximum Applied Stroke: inch (mm)** | **Free Stroke: inch (mm)** | |
| | | **New Brake Installation** | **In-Service Brake Installation** |
| 16 | 1-3/4 (44) | 5/8–3/4 (16–19) | 1/2–5/8 (13–16) |
| 20 | | | |
| 24 | 1-7/8 (48) | | |
| 30 | 2 (51) | | |

**Table 2, Brake Chamber Stroke Specifications**

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## Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

- Chock the tires and shut down the engine before working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters, which may apply as air pressure drops.
- Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
- Never exceed recommended air pressure.
- Always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
- Don't disassemble a component until you have read and understood the service procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use the correct tools, and observe all precautions pertaining to use of those tools.
- Replacement hardware, tubing, hose, fittings, etc., should be the equivalent size, type, length, and strength of the original equipment.

  Make sure that when replacing tubing or hose, all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace devices with stripped threads or damaged parts. Repairs requiring machining should not be attempted.

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**WARNING**

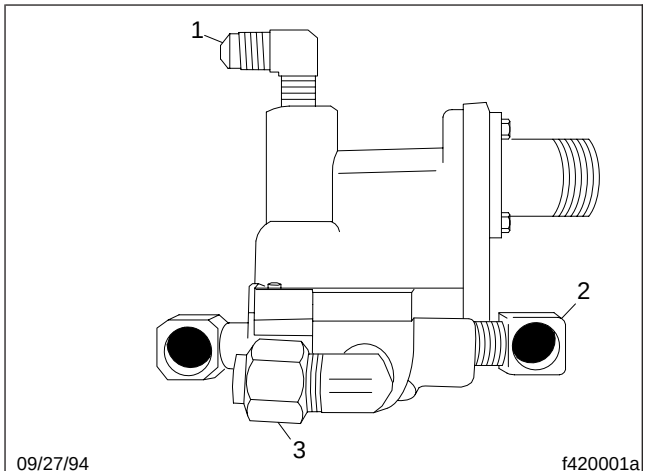
**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

# Installing Air Lines

## Nylon Tubes

When installing a nylon tube, be careful not to bend it past its minimum bend radius. For minimum bend radius values, refer to the appropriate table in **Specifications 400**.

**Figure 1** and **Fig. 2** show tubing and compression fittings used in the air system.



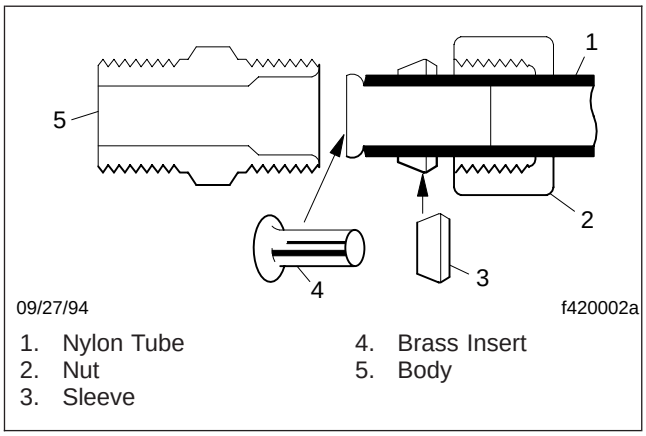

1. Wire Braid Hose Fitting
2. Pipe Fitting
3. Nylon Tube Fitting

**Fig. 1, Tube and Hose Fittings (for reference only)**

**NOTICE**

**If the tubing is bent to a radius smaller than the specified minimum bend radius, it may kink, and shut off normal airflow to the component.**

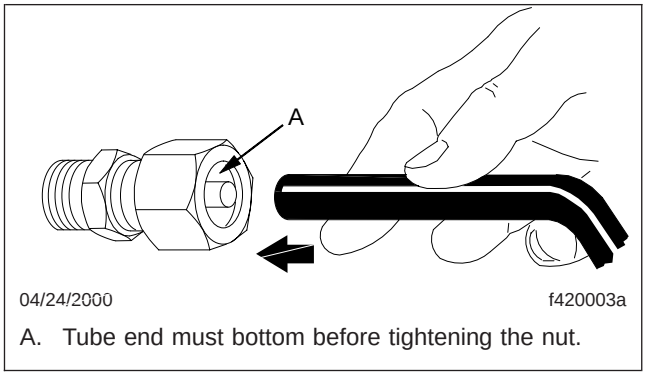
1. Cut the end of the tubing smooth and square.
2. Make sure the nylon tubing ends and fittings are free of grease and debris. If the tubing is crimped or otherwise damaged, replace it with new tubing.




1. Nylon Tube
2. Nut
3. Sleeve
4. Brass Insert
5. Body

**Fig. 2, Nylon Tube Fitting**

3. Slide the nut onto the tubing.
4. Install a new sleeve in the nut, and a new brass insert in the end of the tubing.
5. Insert the squared end of the tubing in the fitting, until it bottoms in the body of the fitting. See **Fig. 3**.




A. Tube end must bottom before tightening the nut.

**Fig. 3, Installing Nylon Tubing**

6. Tighten the nut finger-tight. Then, using two wrenches to prevent twisting of the tube, tighten the nut a minimum of two turns (refer to the appropriate table in **Specifications 400**) or until one thread shows on the fitting body.

## Wire Braid Hoses

When installing a wire braid hose, as shown in **Fig. 1**, be careful not to bend it past its minimum bend radius. For minimum bend radius values, refer to the appropriate tables in **Specifications 400**.

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## Installing Air Lines and Fittings

IMPORTANT: If the hose is bent to a radius smaller than the specified minimum bend radius, it may kink, and shut off normal airflow to the component.

Make sure the wire braid hose assembly is free of grease and dirt. Replace the assembly if the hose or fitting is crimped or otherwise damaged.

Install the hose and tighten the nut finger-tight. Then, using two wrenches to prevent twisting of the hose, tighten the nut until it seats solidly. Tighten the nut one-sixth turn more.

# Installing Fittings

## Brass and Steel Pipe Fittings

For brass pipe fittings, as shown in **Fig. 1**, both male and female parts, tighten as follows:

1. Make sure the fittings are free of grease, dirt, and old sealant. Apply liquid Loctite® Hydraulic Sealant (brown), or an equivalent, to the threads, then tighten securely, finger-tight.

NOTE: Always apply the sealant to the external thread, so that any excess will be scraped off externally rather than internally to the joint.

2. For fittings that must be positioned, tighten one additional turn from finger-tight using a wrench. Then, continue tightening until the fitting is correctly positioned.

   For fittings that do not require positioning, tighten 1-1/2 additional turns from finger-tight.

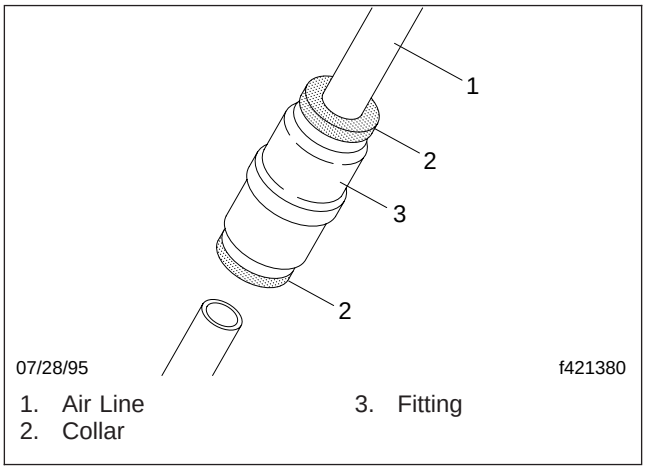
## Copper Tube Fittings

For copper tube fittings, tighten the nut finger-tight. Then, using two wrenches to prevent twisting of the tube, tighten the nut the number of turns shown in the table in **Specifications 400**.

## Quick-Connect Fittings

NOTE: If damaged, quick-connect fittings must be replaced as an assembly.

1. Push in on the fitting collar to release the air line and pull on the line while holding the fitting collar. See **Fig. 4**.
2. Push the air line all the way into the fitting. Pull the collar away from the fitting to secure the air line. Check and make sure that the air line is seated in the fitting.




1. Air Line
2. Collar
3. Fitting

**Fig. 4, Quick-Connect Fitting**

## Tube and Pipe Fittings on Plastic Components

For tightening specifications, refer to the table in **Specifications 400**.

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## Specifications

| Nylon Tube | | | |
|---|---|---|---|
| **Number** | **Inside Diameter: inch** | **Outside Diameter: inch** | **Minimum Bend Radius: inch (mm)** |
| 4 | 0.170 | 1/4 | 1.00 (25) |
| 6 | 0.251 | 3/8 | 1.50 (38) |
| 8 | 0.376 | 1/2 | 2.00 (51) |
| 10 | 0.439 | 5/8 | 2.50 (64) |
| 12 | 0.566 | 3/4 | 3.00 (76) |

**Table 1, Nylon Tube**

| Additional Turns from Hand-Tight (Nylon Tube) | |
|---|---|
| **Tube Size: inch** | **Additional Turns from Hand-Tight** |
| 1/4 | 3 |
| 3/8 or 1/2 | 4 |
| 5/8 or 3/4 | 3-1/2 |

**Table 2, Additional Turns from Hand-Tight (Nylon Tube)**

| 211 Wire Braid (Medium Pressure) Hose (211 hose is identified by dash number and size; for example, hose numbers 211-4, 211-5, and so on) | | | |
|---|---|---|---|
| **Dash Number** | **Inside Diameter: inch** | **Outside Diameter: inch** | **Minimum Bend Radius: inch (mm)** |
| 4 | 3/16 | 0.52 | 3.00 (76) |
| 5 | 1/4 | 0.58 | 3.38 (86) |
| 6 | 5/16 | 0.67 | 4.00 (102) |
| 8 | 13/32 | 0.77 | 4.63 (118) |
| 10 | 1/2 | 0.92 | 5.50 (140) |
| 12 | 5/8 | 1.08 | 6.50 (165) |
| 16 | 7/8 | 1.23 | 7.38 (187) |
| 20 | 1-1/8 | 1.50 | 9.00 (229) |

**Table 3, 211 Wire Braid (Medium Pressure) Hose (211 hose is identified by dash number and size; for example, hose numbers 211-4, 211-5, and so on)**

| 213 Wire Braid (Diesel) Hose (213 hose is identified by two green stripes 180 degrees apart, dash numbers, and size; for example, hose 213-4, 213-5, and so on) | | | |
|---|---|---|---|
| **Dash Number** | **Inside Diameter: inch** | **Outside Diameter: inch** | **Minimum Bend Radius: inch (mm)** |
| 4 | 3/16 | 0.49 | 0.75 (19) |
| 5 | 1/4 | 0.55 | 1.00 (25) |
| 6 | 5/16 | 0.62 | 1.25 (32) |
| 8 | 13/32 | 0.74 | 1.75 (44) |
| 10 | 1/2 | 0.83 | 2.25 (57) |
| 12 | 5/8 | 0.96 | 2.75 (70) |
| 16 | 7/8 | 1.21 | 3.50 (89) |
| 20 | 1-1/8 | 1.49 | 4.50 (114) |

**Table 4, 213 213 Wire Braid (Diesel) Hose (213 hose is identified by two green stripes 180 degrees apart, dash numbers, and size; for example, hose 213-4, 213-5, and so on)**

| 214 High Temperature Wire Braid (Diesel) Hose (214 hose is identified by two blue stripes 180 degrees apart, dash numbers, and size; for example, hose 214-10 and 214-16) | | | |
|---|---|---|---|
| **Dash Number** | **Inside Diameter: inch** | **Outside Diameter: inch** | **Minimum Bend Radius: inch (mm)** |
| 10 | 1/2 | 0.83 | 2.25 (57) |
| 16 | 7/8 | 1.21 | 3.50 (89) |

**Table 5, 214 High Temperature Wire Braid (Diesel) Hose (214 hose is identified by two blue stripes 180 degrees apart, dash numbers, and size; for example, hose 214-10 and 214-16)**

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## Specifications

| Copper Tube Fittings | | | |
|---|---|---|---|
| **Number** | **Outside Diameter: inch** | **Additional Turns from Hand-Tight** | |
| | | **Compression** | **Threaded Sleeve** |
| 2 | 1/8 | 1-1/4 | 1-1/2 |
| 3 | 3/16 | | |
| 4 | 1/4 | | |
| 5 | 5/16 | 1-3/4 | |
| 6 | 3/8 | 2-1/4 | |
| 8 | 1/2 | | |
| 10 | 5/8 | | |
| 12 | 3/4 | | |
| 16 | 1 | | |
| 20 | 1-1/4 | | |

**Table 6, Copper Tube Fittings**

| Tube and Pipe Fittings on Plastic Components | | | |
|---|---|---|---|
| **Description** | **Port Size: inch** | **Torque** | |
| | | **lbf·in (N·cm)** | **lbf·ft (N·m)** |
| Midland Quick Release Valve | 3/8 | 60–90 (678–1017)* | — |
| | 1/2 | — | 13–17 (18–23)* |
| Bendix MV-2/MV-3 Valve | 1/4 | — | 10 (14) |
| Pass-Through Manifold with Metal Thread Inserts | 1/8 NPT | 50–60 (565–678) | — |

* Tighten to the lower torque value. Then, if needed, turn the fittings to allow for the proper routing of the air lines.

**Table 7, Tube and Pipe Fittings on Plastic Components**

| Air System Nylon Tube Color Code | | | |
|---|---|---|---|
| **System** | **Color** | **Size: I.D.** | **Where Used** |
| Primary Air | Green | 3/4 inch | Air tank to rear service supply (6x4 vehicles only) |
| | | 5/8 inch | Primary air tank to foot valve |
| | | 1/2 inch | Air tank to rear service supply (4x2 vehicles only) |
| | | 3/8 inch | Foot valve to rear service control |
| | | | Wet tank to primary air tank |
| Secondary Air | Red | 5/8 inch | Secondary air tank to foot valve |
| | | 1/2 inch | Foot valve to front service brake |

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| Air System Nylon Tube Color Code | | | |
|---|---|---|---|
| **System** | **Color** | **Size: I.D.** | **Where Used** |
| Tractor Protection | Green | 1/2 inch | Foot valve primary delivery to tractor protection valve |
| | Black | 5/8 inch | Tractor protection valve to service anchor coupling |
| | | 1/2 inch | Foot valve secondary delivery to tractor protection valve |
| | Orange | 3/8 inch | Dash park valve to tractor protection valve |
| | | | Tractor protection valve to emergency anchor coupling |
| | | 1/4 inch | Tractor protection valve to stop light switch |
| Park Brake | Black | 3/8 inch | Dash valve to park quick release valve |
| | | | Rear relay to park quick release valve |
| Air Supply | Black | 1/2 inch | Air dryer to wet tank |
| | | 1/4 inch | Wet tank to air governor |
| | Silver | 1/4 inch | Air governor to air dryer purge valve |
| | Yellow | 3/8 inch | Pressure protection constant air |
| Non-Brake Applications | Blue | 3/8 inch | Chassis air suspension |
| | | 1/4 inch | Air suspension dump control |
| | Brown | 1/4 inch | Air suspension pressure gauge |
| | White | 1/4 inch | Interaxle lock control |
| | Red | 1/4 inch | Driver-controlled differential lock |
| | Green | 1/4 inch | Sliding fifth-wheel control |
| | Yellow | 1/4 inch | Fan air solenoid |

**Table 8, Air System Nylon Tube Color Code**

NOTE: In Tables 9 through 11, "BC Air only" refers to special installations used on some British Columbia log truck applications.

| Air Line Code Descriptions (air lines 1 through 32) | |
|---|---|
| **Code** | **Description** |
| 1 | Air compressor to wet tank (BC Air only) |
| 2 | Wet tank supply to dry tanks (BC Air only) |
| 3 | Wet tank drain to moisture ejector |
| 4 | Governor signal to moisture ejector |
| 5 | Dry tank C to governor |
| 6 | Dry air supply to relay valve |
| 7 | Cab manifold supply—wet air (BC Air only) |
| 8 | Dry tank supply to emergency tank |
| 9 | Transmission supply |
| 10 | Emergency tank supply to park valve |

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## Specifications

| Air Line Code Descriptions (air lines 1 through 32) | |
|---|---|
| **Code** | **Description** |
| 11 | Control forward rear axle relay valve (BC Air only) |
| 12 | Brake valve supply to front chamber (BC Air only) |
| 13 | Front axle quick release valve supply to frame (BC Air only) |
| 14 | Supply—deep reduction control |
| 15 | Trailer service |
| 16 | Trailer emergency |
| 17 | Forward rear axle tee supply to service chamber (BC Air only) |
| 18 | Relay valve supply to rear axle quick release valve or tee |
| 19 | Rear rear axle tee supply to service chamber (BC Air only) |
| 20 | Cab manifold to control valve—dry air (BC Air only) |
| 21 | Hand control valve to trailer service (BC Air only) |
| 22 | Tractor protection control supply to trailer emergency |
| 23 | Park control supply to frame tee (BC Air only) |
| 24 | Quick release valve to park brake chamber (BC Air only) |
| 25 | Differential lockout control supply to axle |
| 26 | Deep reduction control supply to transmission |
| 27 | Front brake limiting control to limiting valve |
| 28 | Supply to fifth wheel lock |
| 29 | Supply to air shift 2-speed axle |
| 30 | Supply to air seat |
| 31 | Supply to windshield wiper |
| 32 | Supply to air horn |

**Table 9, Air Line Code Descriptions (air lines 1 through 32)**

| Air Line Code Descriptions (air lines 33 through 67) | |
|---|---|
| **Code** | **Description** |
| 33 | Supply to reservoir pressure gauge |
| 34 | Supply to wig wag |
| 35 | Signal to stop lamp switch |
| 36 | (BC Air only) Rear axle wedge chamber to wedge chamber |
| 37 | Supply to front wheel limiting control |
| 38 | N/A |
| 39 | (BC Air only) Park brake drop lines |
| 40 | "C" supply to pusher/tag relay valve |
| 41 | "B" delivery to pusher/tag relay control |
| 42 | N/A |

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## Specifications

| Air Line Code Descriptions (air lines 33 through 67) | |
|---|---|
| **Code** | **Description** |
| 43 | N/A |
| 44 | N/A |
| 45 | N/A |
| 46 | N/A |
| 47 | (BC Air only) Low pressure governor supply |
| 48 | (BC Air only) Emergency dump valve to tractor protection valve |
| 49 | (BC Air only) Signal to trailer emergency pressure gauge |
| 50 | (BC Air only) Signal to trailer service gauge |
| 51 | (BC Air only) Rear brake application gauge supply |
| 52 | (BC Air only) Dump valve to low pressure governor |
| 53 | (BC Air only) Relay valve to axle tee service brake |
| 54 | (BC Air only) Supply—Dry air tank "C" to forward rear axle relay valve |
| 55 | (BC Air only) Supply—Dry air tank "B" to rear rear axle relay valve |
| 56 | (BC Air only) Control front brake relay valve |
| 57 | (BC Air only) Supply front brake relay valve |
| 58 | (BC Air only) Front brake relay valve to limit quick release valve |
| 59 | Differential lockout supply—Wet air |
| 60 | (BC Air only) Dry tank "C" supply to double check valve |
| 61 | Park brake control "D" to pressure holding valve |
| 62 | Park brake control "D" to tractor park brake control |
| 63 | Dry tank "B" supply to brake valve |
| 64 | Control rear rear axle relay (BC Air only) |
| 65 | Front axle drop lines to brake chambers (BC Air only) |
| 66 | Supply to reservoir gauge and wig wag (BC Air only) |
| 67 | Supply to front brake application gauge (BC Air only) |

**Table 10, Air Line Code Descriptions (air lines 33 through 67)**

| Air Line Code Descriptions (air lines 68 through 132) | |
|---|---|
| **Code** | **Description** |
| 68 | Pressure holding valve to tractor protection valve "S" (BC Air only) |
| 100 | Compressor discharge |
| 101 | Supply to service "A" |
| 102 | Supply to service "B" |
| 103 | Service "A" to brake valve supply |
| 104 | Service "B" to brake valve supply |
| 105 | Brake valve "A" control to rear relay valve |

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## Specifications

| Air Line Code Descriptions (air lines 68 through 132) | |
|---|---|
| **Code** | **Description** |
| 106 | Brake valve "B" control to front relay valve |
| 107 | Service "A" to forward rear relay valve |
| 108 | Service "A" to rear rear relay valve |
| 109 | Service "B" to front relay valve |
| 110 | Rear rear relay valve to service brake chambers |
| 111 | Front relay valve to service brake chambers |
| 112 | Wet supply reservoir to governor |
| 113 | Brake valve "B" supply to double check valve |
| 114 | Double check valve park brake control valve |
| 115 | Park brake control valve to control valve—Tractor trailer to tractor |
| 116 | Trailer park brake control valve to quick release valve |
| 117 | Quick release valve to frame tee |
| 118 | Drop line frame tee to axle tee |
| 119 | Drop line inversion valve to axle tee |
| 120 | Quick release valve/double check valve or axle tee to spring brake chambers |
| 121 | Park brake control valve to tractor protection control valve |
| 122 | Tractor protection control valve to tractor protection valve |
| 123 | Brake valve "A" to double check valve |
| 124 | Brake valve "B" to double check valve |
| 125 | Double check valve to tractor protection valve |
| 126 | Brake valve "A" to hand control valve |
| 127 | Hand control valve to double check valve |
| 128 | Hand control valve exhaust |
| 129 | Front axle ratio valve to inversion valve |
| 130 | Service "A" to inversion valve |
| 131 | Wedge brake chamber to wedge brake chamber |
| 132 | Tee to anti-skid power switch |

**Table 11, Air Line Code Descriptions (air lines 68 through 132)**

| Air Line Code Descriptions (air lines 133 through 165) | |
|---|---|
| **Code** | **Description** |
| 133 | Tee to double check valve "A" system |
| 134 | "B" system to double check valve |
| 135 | Tee to normally closed switch (Kelsey Hayes only) |
| 136 | Brake valve "B" to forward rear relay valve |

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| Air Line Code Descriptions (air lines 133 through 165) | |
|---|---|
| **Code** | **Description** |
| 137 | Rear axle relay valve to frame tee |
| 138 | Manifold supply—accessories |
| 139 | Park brake control to tractor protection control valve port |
| 140 | "B" supply to air gauge |
| 141 | "A" supply to air gauge |
| 142 | Quick release/double check valve to rear rear relay valve |
| 143 | Boost tank to tractor protection valve |
| 144 | Park brake valve relay supply |
| 145 | Forward rear relay valve to front brake valve |
| 146 | Brake valve "A" to forward rear relay valve |
| 147 | Brake valve "B" to rear rear relay valve |
| 148 | Brake valve "A" to park brake control valve |
| 149 | Brake valve "B" to park brake control valve |
| 150 | Bobtail ratio valve control |
| 151 | Transmission—stationary/mobile control valve feed (s) |
| 152 | Transmission—stationary/mobile control valve feed (m) |
| 153 | Transmission—neutral cylinder feed |
| 154 | Transmission—stationary/mobile control valve (s) delivery to splitter position sensing |
| 155 | Transmission—stationary/mobile control valve (s) delivery to sequence protection valve |
| 156 | Transmission—neutral cylinder to sequence protection valve |
| 157 | Transmission retarder—skinner solenoid valve to retarder |
| 158 | Transmission retarder—pressure switch to skinner valve |
| 159 | Transmission retarder—skinner valve to foot valve |
| 160 | Transmission retarder—control valve to supply |
| 161 | Auxiliary transmission—control valve port 2 to shift cylinder |
| 162 | Auxiliary transmission—control valve port 4 to shift cylinder |
| 163 | Rear rear pressure modulator valve to rear rear service chambers—ABS |
| 164 | Rear relay valve to rear rear pressure modulator valve double check valve—ABS |
| 165 | Anti-slip valve supply |

**Table 12, Air Line Code Descriptions (air lines 133 through 165)**

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## Specifications

| Air Line Code Descriptions (air lines 166 through 201) | |
|---|---|
| **Code** | **Description** |
| 166 | Anti-slip valve delivery to rear rear pressure modulator valve double check valve—ABS |
| 167 | Rear rear pressure modulator valve delivery to un-sensored axle relay valve control—ABS |
| 168 | Front pressure modulator valve to front service chambers |
| 169 | Front quick release valve to front pressure modulator valve |
| 170 | BrakeSaver—"A" supply to BrakeSaver pressure regulator valve inlet |
| 171 | BrakeSaver—regulating valve to hand control valve inlet |
| 172 | BrakeSaver—hand control valve delivery to double check valve |
| 173 | BrakeSaver—hand control valve exhaust |
| 174 | BrakeSaver—double check valve to BrakeSaver at engine |
| 175 | BrakeSaver—solenoid exhaust |
| 176 | BrakeSaver—double check valve to BrakeSaver application gauge |
| 177 | ATC/ASR relay valve delivery to un-sensored relay valve control—slaved |
| 178 | Rear rear relay valve delivery to ASR relay valve control—ASR/ATC |
| 179 | Tee 122 to proportioning bobtail valve |
| 180 | Cab air switch to dump (pilot) port on air suspension height control valve |
| 181 | Pressure protection valve on the air tank to supply port on the air suspension height control valve |
| 186 | Transfer case—supply from fail-safe side of pressure protection valve |
| 187 | Transfer case—2 speed shift dual shuttle valve to cylinder—A, B, C, D |
| 188 | Transfer case—front axle disengage |
| 189 | Transfer case—front axle engage |
| 190 | Bendix cruise control—supply tank to pressure protection valve |
| 191 | Bendix cruise control—pressure reducing valve to solenoid valve |
| 192 | Bendix cruise control—solenoid valve to inversion valve |
| 193 | Bendix cruise control—brake valve "A" delivery to inversion valve |
| 194 | Bendix cruise control—inversion valve to air cylinder |
| 195 | Transfer case control—control valve to transfer case |
| 196 | Transfer case control—2-speed shift—low |
| 197 | Transfer case control—2-speed shift—high |
| 198 | Transfer case control—neutral |
| 199 | Transfer case control—single shuttle to relay valve control |
| 200 | "B" side foot valve control line |
| 201 | Axle lift control line |

**Table 13, Air Line Code Descriptions (air lines 166 through 201)**

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## Specifications

| Air Line Code Descriptions (air lines 202 through 234) | |
|---|---|
| **Code** | **Description** |
| 202 | "B" or "C" supply to brake relay |
| 203 | Pusher load bag control—from pressure regulator |
| 204 | "B" or "C" supply to load bag relay valve |
| 205 | "B" or "C" supply to brake relay |
| 206 | Service brake lockout signal line |
| 207 | Steering lock signal line |
| 208 | Steering lock supply line |
| 209 | Steering stabilizer supply line |
| 210 | Pusher axle laden-side control valve supply—from pressure protection valve |
| 211 | Tee to unladen-side pressure regulator valve supply |
| 212 | Laden-side control valve to pressure regulator valve |
| 213 | Unladen-side pressure regulator valve to double check valve |
| 214 | Laden-side pressure regulator valve to quick release valve |
| 215 | Quick release valve to double check valve |
| 216 | Double check valve to load-bag relay valve control |
| 217 | Relay valve delivery to load-bags |
| 218 | Skinner solenoid valve to automatic transmission modulator cylinder |
| 219 | Load air shocks—front |
| 220 | Load air shocks—rear |
| 221 | Fuel selector valve—supply line |
| 222 | PTO control line—main transmission-mount PTO |
| 223 | PTO control line—auxiliary transmission or transfer case mount |
| 224 | Front drive axle—driver controlled differential lock |
| 225 | Air pressure gauge—rear suspension left hand or single valve |
| 226 | Air pressure gauge—rear suspension right hand valve |
| 227 | Air pressure gauge—single—accessory |
| 228 | Tractor protection valve to pilot relay valve |
| 229 | Brake valve "A" to anti-compound DCV |
| 230 | Boost tank to pilot relay valve (Australia) |
| 231 | TPCS—supply line |
| 232 | TPCS—PCU to front axle tee |
| 233 | TPCS—front axle tee to inlet tube |
| 234 | TPCS—PCU to rear axle frame tee |

**Table 14, Air Line Code Descriptions (air lines 202 through 234)**

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## Specifications

| Air Line Code Descriptions (air lines 235 through 268) | |
|---|---|
| **Code** | **Description** |
| 235 | TPCS—rear axle drop line |
| 236 | TPCS—drop line to rear axle inlet tube |
| 237 | TPCS—PCU to trailer connection |
| 238 | Transmission retarder—foot valve "B" delivery to retarder pressure switch manifold |
| 239 | Cab or combined cab/sleeper air ride supply |
| 240 | Sleeper air ride supply (when cab air ride is also used) |
| 241 | External "A" system service line—gladhands at front |
| 242 | External emergency and parkbrake control—gladhands at front |
| 243 | External supply—gladhands to supply tank |
| 244 | Supply air for remote parkbrake release—"B" tank to solenoid valve |
| 245 | Auxiliary air source outlets—pressure protected |
| 246 | Pintle hitch air supply |
| 247 | Dual connection to EOF—Service—hard plumbed |
| 248 | Dual connection to EOF—Emergency—hard plumbed |
| 249 | "B" reservoir pressure protection valve to under-cab accessory manifold |
| 250 | Rear relay delivery valve to inversion valve control port |
| 251 | Air supply to pressurized bell housing |
| 252 | Receiver tank to governor |
| 253 | Air dryer control to air dryer |
| 254 | Air dryer to purge tank |
| 255 | Air pressure gauge—trailer suspension |
| 256 | Pressure supply to outside lift axle controls |
| 257 | Air start pressure gauge (cab side) |
| 258 | Air start pressure gauge (chassis side) |
| 259 | Air start valve to starter, line #4 |
| 260 | Air starter to air start valve, line #4 |
| 261 | Air start valve to starter, line #20 |
| 262 | "B" air tank to air start valve, line #8 |
| 263 | Air start tank to air start valve, line #20 |
| 264 | Touch lock valve control port to tee |
| 265 | Touch valve delivery port to kingpin air cylinder |
| 266 | In cab air manifold to 5th wheel slide switch supply port |
| 267 | In cab air manifold to touch lock valve supply port |
| 268 | From COMBO ABS relay valve to remote mounted ABS modulators, Line #10 |

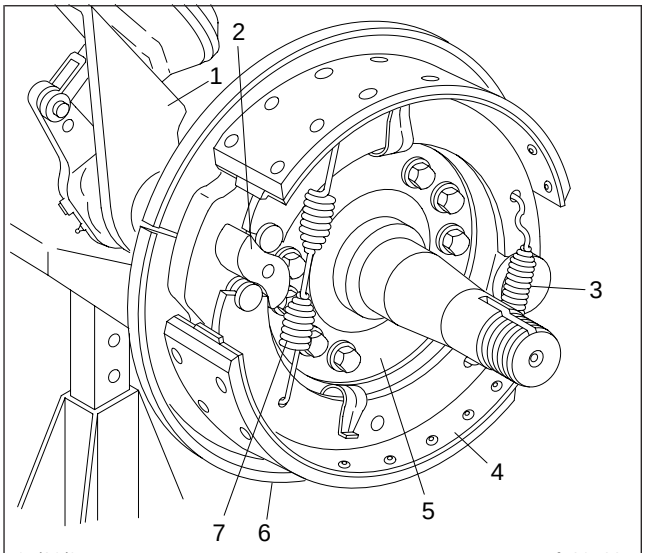
**Table 15, Air Line Code Descriptions (air lines 235 through 268)**

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# General Information

Eaton brakes (**Fig. 1**) are actuated by an S-type cam head, which is forged integrally with the camshaft and supported with nylon bushings. Cam pressure is applied through the cam rollers.




1. Air Chamber Bracket
2. Camshaft
3. Shoe Retaining Spring
4. Shoe Assembly
5. Spider
6. Dust Shield
7. Shoe Return Spring

**Fig. 1, Front Axle Brake**

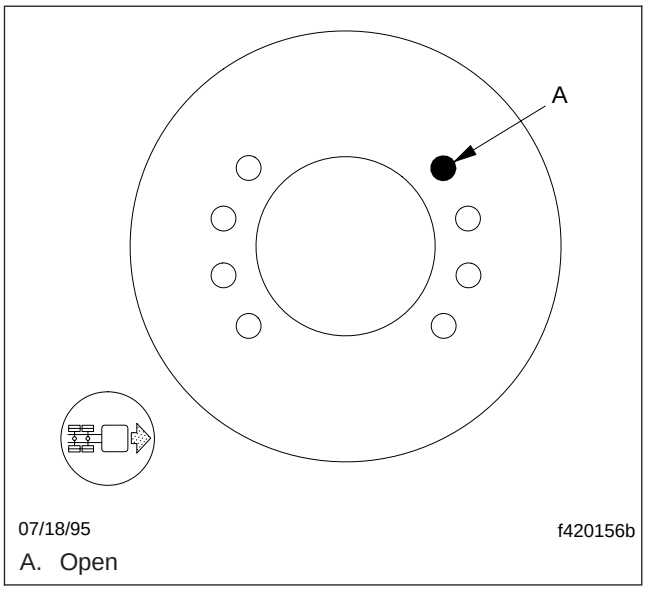
These brakes are used on both the front steer axle and rear axle.

Meritor steer axles have seven holes for attaching the spider to the axle flange. There is an eighth hole that is left open on the brake spider, on both left and right sides of the steer axle. See **Fig. 2**, Ref. A. The seven holes used for attachment of the spider to the axle flange are 0.656 inch in diameter. The eighth hole is oversized at 0.687 inch in diameter.

# Principles of Operation

When the brake pedal is depressed, compressed air enters the brake chamber, causing the diaphragm to move a pushrod assembly.

The pushrod, which is connected to a slack adjuster, turns the slack adjuster and brake camshaft. As the camshaft turns, the S-head, which is between the




A. Open

**Fig. 2, Open Hole Location**

brake shoe rollers, forces the brake shoes against the brake drum, and braking occurs.

When the brakes are released and air is exhausted from the brake chamber, the actuator return spring (within the brake chamber) and the brake shoe return spring, return the camshaft, brake shoes, slack adjuster, and pushrod to their released positions.

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## General Safety Precautions

**⚠ WARNING**

**When replacing brake pads, shoes, rotors, or drums, always replace components as an axle set.**

- Always reline both sets of brakes on an axle at the same time.
- Always replace both rotors/drums on an axle at the same time.
- Always install the same type of linings/pads or drums/rotors on both axle ends of a single axle, and all four axle ends of a tandem axle, at the same time. Do not mix component types.

**Failure to do so could cause uneven braking and loss of vehicle control, resulting in property damage, personal injury, or death.**

When working on or around a vehicle, observe the following precautions:

- Park the vehicle on a level surface and apply the parking brakes. Shut down the engine and chock the tires.
- If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning any work on the vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters, which may apply as air pressure drops.
- Disconnect the batteries.
- Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
- Never exceed recommended air pressure. Always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
- Do not remove, disassemble, assemble, or install a component until you have read and understand the service procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use the correct tools and observe all precautions pertaining to use of those tools.
- Replacement hardware, tubing, hose, fittings, etc. should be the equivalent size, type, length, and strength of the original equipment.
- Make sure when replacing tubes or hoses that all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace devices that have stripped threads or damaged parts. Repairs requiring machining should not be attempted.
- Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

## Asbestos and Non-Asbestos Safety

**⚠ WARNING**

**Wear a respirator at all times when servicing the brakes, starting with the removal of the wheels and continuing through assembly. Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH.**

Because some brake linings contain asbestos, you should know the potential hazards of asbestos and the precautions to be taken. Exposure to airborne asbestos brake lining dust can cause serious and possibly fatal diseases such as asbestosis (a chronic lung disease) and cancer.

Because medical experts believe that long-term exposure to some *non-asbestos* fibers could also be a health hazard, the following precautions should also be observed if servicing non-asbestos brake linings.

Areas where brake work is done should be separate from other operations, if possible. As required by OHSA regulations, the entrance to the areas should have a sign displayed indicating the health hazard.

During brake servicing, an air purifying respirator with high-efficiency filters must be worn. The respirator and filter must be approved by MSHA or NIOSH, and worn during all procedures.

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## Safety Precautions

OSHA recommends that enclosed cylinders equipped with vacuums and high-efficiency (HEPA) filters be used during brake repairs. Under this system, the entire brake assembly is placed within the cylinder and the mechanic works on the brake through sleeves attached to the cylinder. Compressed air is blown into the cylinder to clean the assembly, and the dirty air is then removed from the cylinder by the vacuum.

If such an enclosed system is not available, the brake assembly must be cleaned in the open air. During disassembly, carefully place all parts on the floor to minimize creating airborne dust. Using an industrial vacuum cleaner with a HEPA filter system, remove dust from the brake drums, brake backing plates, and brake parts. After vacuuming, any remaining dust should be removed using a rag soaked in water and wrung until nearly dry. Do not use compressed air or dry brushing to clean the brake assembly.

If grinding or other machining of the brake linings is necessary, other precautions must be taken because exposure to asbestos dust is highest during such operations. In addition to the use of an approved respirator, there must be local exhaust ventilation such that worker exposure is kept as low as possible.

Work areas should be cleaned by industrial vacuums with HEPA filters or by wet wiping. Compressed air or dry sweeping should never be used for cleaning. Asbestos-containing waste, such as dirty rags, should be sealed, labeled, and disposed of as required by EPA and OSHA regulations. Respirators should be used when emptying vacuum cleaners and handling asbestos waste products.

Workers should wash before eating, drinking, or smoking, should shower after work, and should not wear work clothes home. Work clothes should be vacuumed after use and then laundered, without shaking, to prevent the release of asbestos fibers into the air.

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## Removal

**⚠ WARNING**

**Before doing any of the work below, read the information under Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.**

1. Park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Raise the front or rear axle, then place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
3. Remove the wheels and brake drums. For instructions, see **Group 33** or **Group 35**.

**⚠ CAUTION**

**Before you back off automatic slack adjusters, see the applicable slack adjuster section in this manual, or to the manufacturer's service information for instructions. Failure to do so could damage the slack adjusters.**

4. Back off the slack adjusters. For instuctions, see the applicable slack adjuster section in this manual for instructions on backing off the slack adjuster.
5. If equipped with 16-1/2 inch series brakes, go to the next step.

   On 15-inch series brakes, remove the brake shoes.

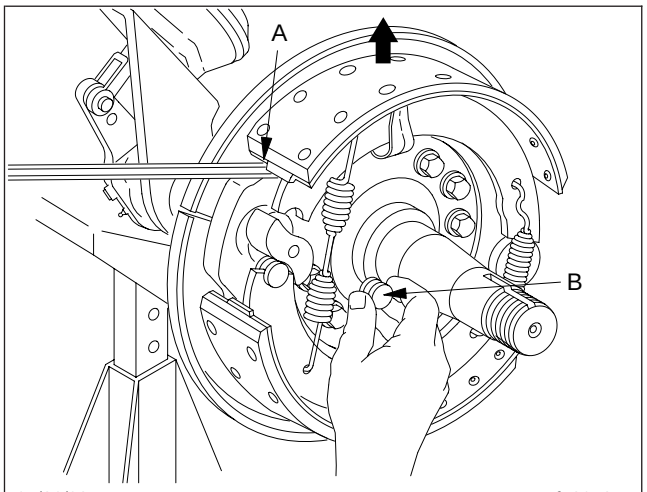
   5.1 Using a large screwdriver or lever, lift the upper shoe to stretch the return spring.

   Remove the upper cam roller. See **Fig. 1**. Repeat for the lower shoe and cam roller.

   5.2 Stretch the shoe return spring and unhook it from the upper shoe web. See **Fig. 2**.

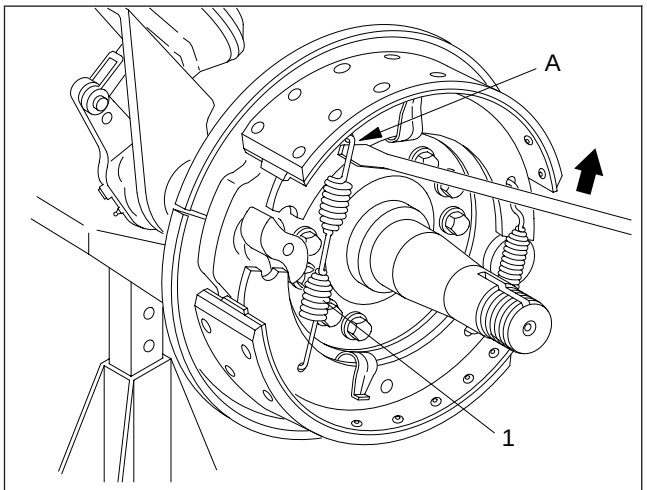
   5.3 Rotate the lower shoe downward and turn it to allow disengagement of the shoe retaining spring from the lower shoe web. See **Fig. 3**.

   5.4 Rotate the upper shoe upward and remove the shoe and shoe retaining spring.




A. Lift upper shoe to stretch spring.
B. Remove roller.

**Fig. 1, Remove the Upper Cam Roller**




A. Stretch spring to unhook from shoe web.
1. Shoe Return Spring

**Fig. 2, Stretch the Shoe Return Spring**

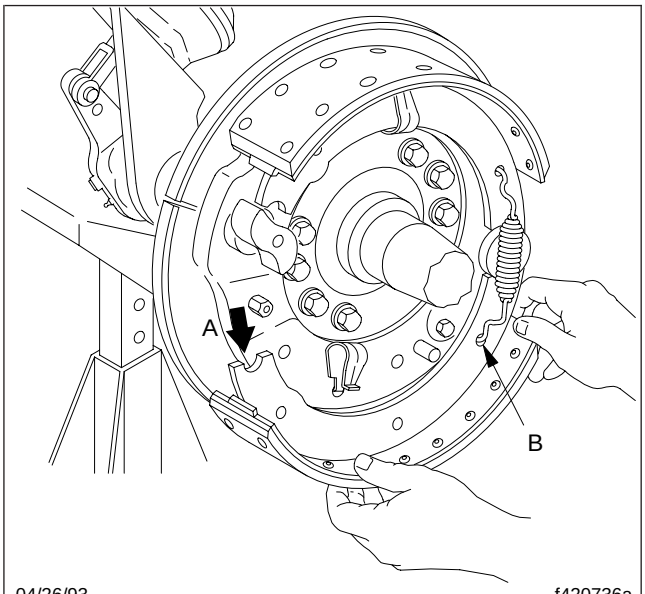
5.5 Discard the cam rollers, shoe return spring, and shoe retaining spring.

NOTE: If equipped with Extended Service brakes, pry the roller retainer loops out of both shoe web holes. See **Fig. 4**. Then, pivot the roller retainer to swing the loops clear of the shoe webs.

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## Brake Shoe Removal and Installation




A. Rotate down.
B. Unhook retaining spring.

**Fig. 3, Rotate the Lower Shoe Downward**

6. On 16-1/2 inch series brakes, remove the brake shoes.

   6.1 Using a large screwdriver or lever, lift the upper shoe to stretch the return spring. Remove the cam roller and the pin or retainer, as equipped. See **Fig. 5**.

   Repeat for the lower shoe.

   6.2 Push the cam end of both shoes toward the cam and unhook the shoe return spring.

   NOTE: If equipped with Extended Service brakes, position a suitable lever to engage the rod of the spring. See **Fig. 6**. Force the lever down to stretch the spring and allow removal of the upper spring hook.

   6.3 Rotate both shoes around the anchor pin, then remove the shoes. See **Fig. 7**.

   6.4 Discard the cam rollers and pins, and the shoe return spring (or shoe retainer springs on Extended Service brakes).

7. Inspect the brake shoes and linings for wear or damage. For instructions, see **Subject 120**.

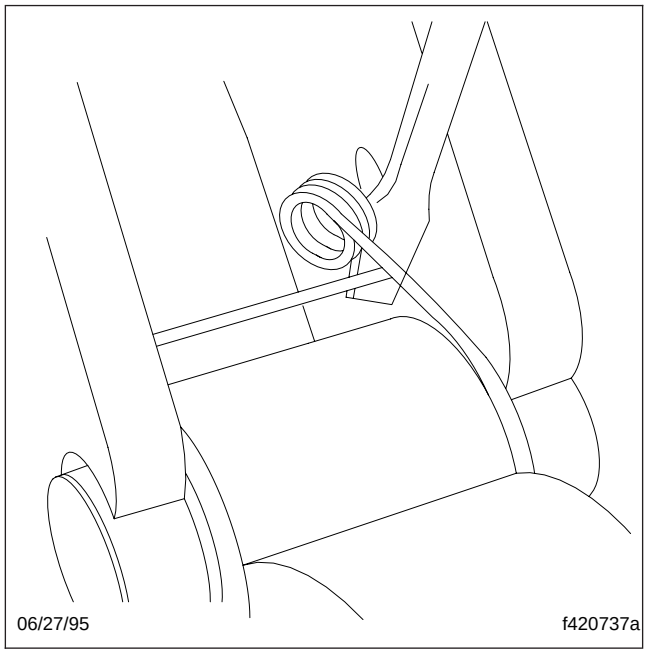
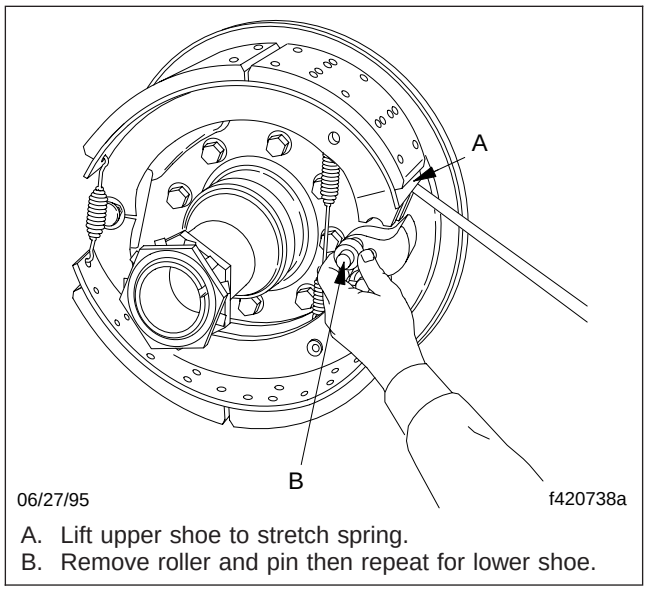



**Fig. 4, Pry out the Roller Retainer Loops**




A. Lift upper shoe to stretch spring.
B. Remove roller and pin then repeat for lower shoe.

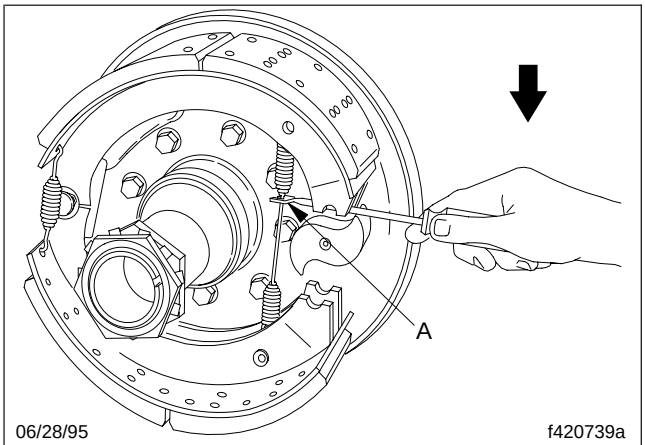
**Fig. 5, Removing the Cam Rollers**

## Installation

IMPORTANT: For best brake performance, don't mix Extended Service brakes with other Eaton

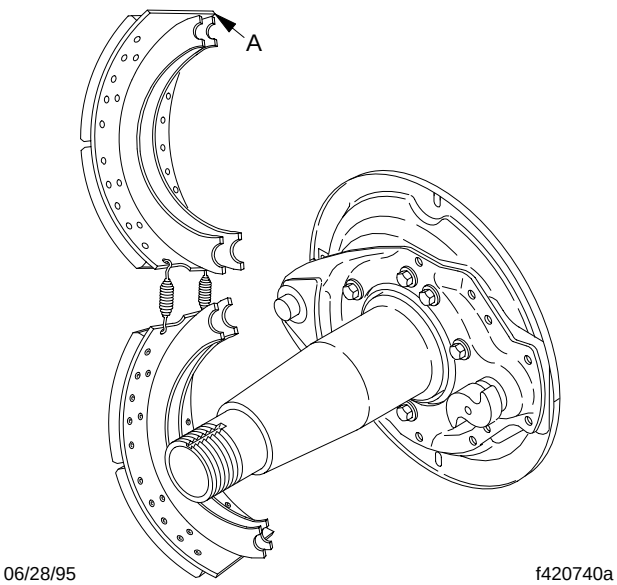
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A. Stretch spring using suitable tool positioned as shown.

**Fig. 6, Remove the Upper Spring Hook**




A. Rotate both shoes around anchor pin and lift off brake shoes.

**Fig. 7, Remove the Brake Shoes**

series brakes. Use the same brake series on the entire vehicle.

1. Apply a thin film of temperature resistant grease (Kendall M-621, or an equivalent) to the cam roller and, for all models except Extended Service brakes, the anchor pin recesses of each shoe web.
2. If equipped with 16-1/2 inch brakes, go to the next step.

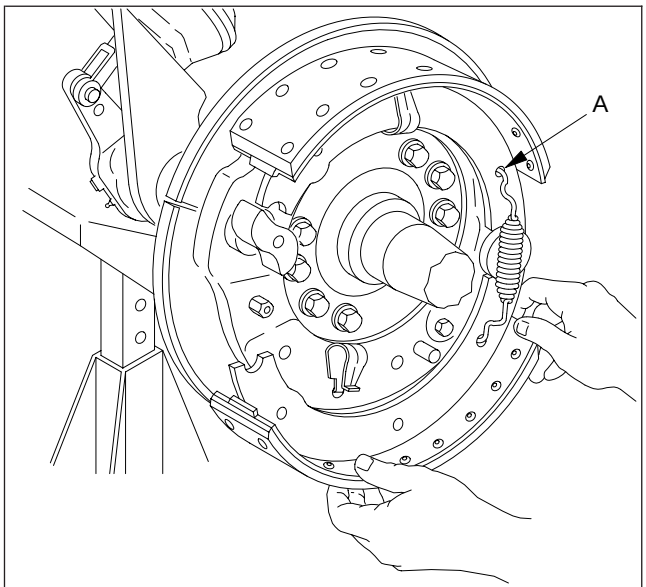
   On 15-inch series brakes, install the brake shoes.

   2.1 Place the upper brake shoe and lining web on the anchor pin and rotate down. Continue rotation until the shoe is held in place by the shoe hold-down spring.

   2.2 Hook one end of the new shoe retaining spring into the hole in the upper shoe web so that the coil lays across the anchor pin. See **Fig. 8**.

   Hook the opposite end of the spring into the hole on the lower shoe web.

   Stretch the spring to allow positioning of the lower shoe web against the anchor pin.




A. Hook spring into shoe web hole.

**Fig. 8, Attach the New Shoe Retaining Spring**

   2.3 Rotate the lower shoe into position so that the shoe web rests on the barrel nut (if equipped) or against the anchor pin.

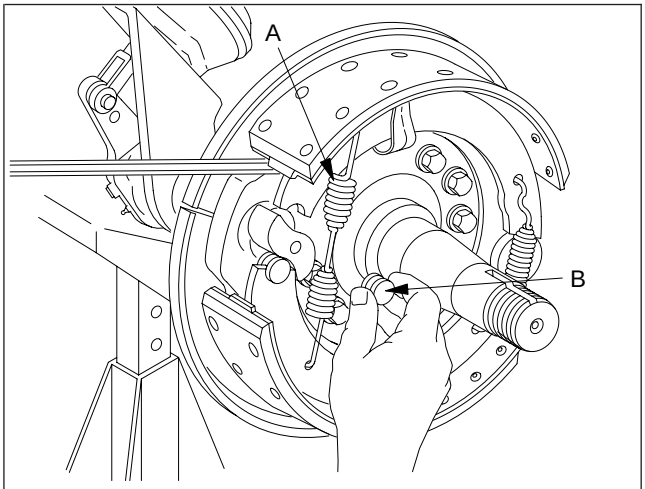
   2.4 Hook one end of the new shoe return spring in the lower shoe web hole. Using a screwdriver, stretch the shoe return spring hook in the upper shoe web hole.

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## Brake Shoe Removal and Installation

2.5 Using a large screwdriver or lever, stretch the shoe return spring to allow insertion of the new cam roller on the upper shoe web. See **Fig. 9**. Install the new cam roller on the lower shoe web.




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A. Install new return spring.
B. Install rollers.

**Fig. 9, Install the Cam Rollers**

3. If equipped with 16-1/2 inch series brakes, install the brake shoes.

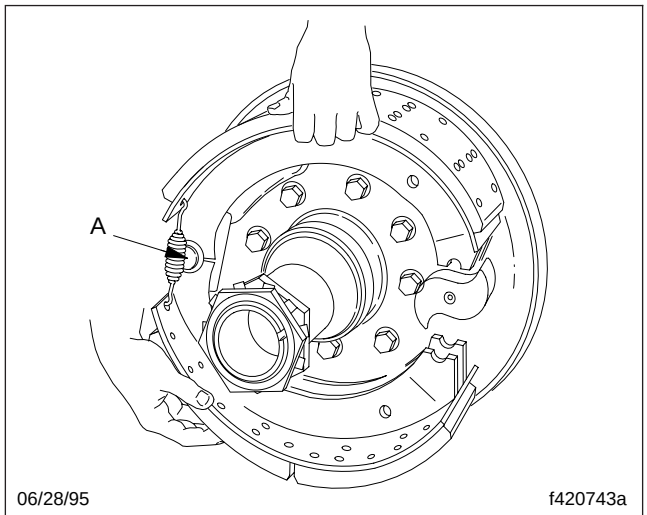
3.1 Hook the ends of the new retainer springs into the holes in both shoe tables. Make sure that the hooks are pointing out.

3.2 Position the upper and lower shoes around the anchor pin. See **Fig. 10**.

3.3 Install a new shoe return spring.

On Extended Service brakes, position a suitable lever to engage the rod of the spring. See **Fig. 6**. Force the lever down to stretch the spring and allow installation of the upper spring hook. Assemble the roller retainer on the ends of the roller. See **Fig. 11**.

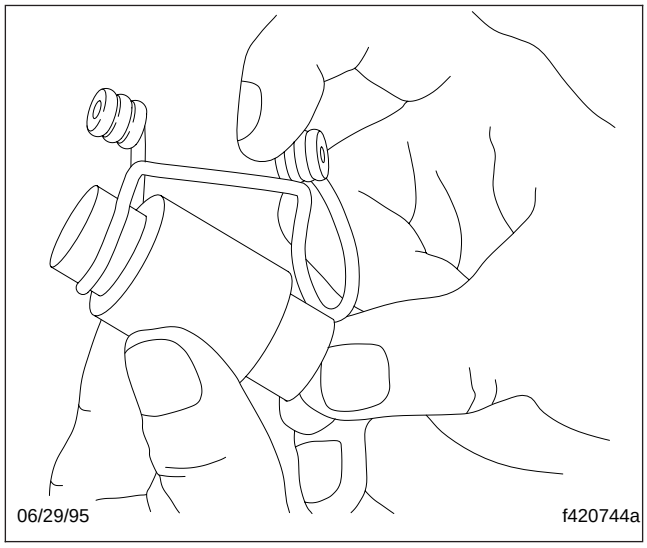
3.4 Using a lever or a large screwdriver, stretch the shoe return spring to allow insertion of the new pin and roller (or the new roller and retainer assembly on Extended Service brakes) on the lower shoe web. See **Fig. 12**.




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A. With retainer springs installed, position upper and lower shoes around anchor pin.

**Fig. 10, Position the Upper and Lower Shoes**



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**Fig. 11, Assemble the Roller Retainer**

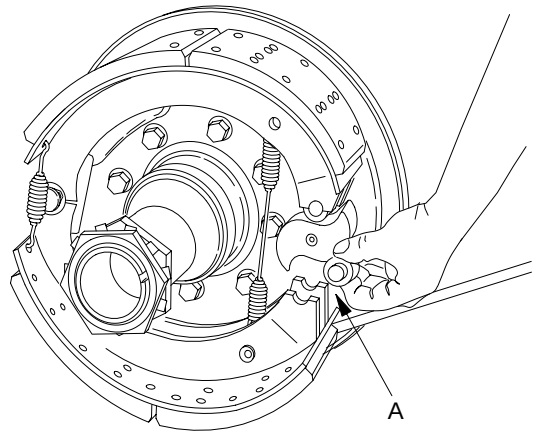
On Extended Service brakes, squeeze the loops and swing the retainer assembly into position (**Fig. 13**); then snap the loops into the web holes. Make sure that both retainer loops are engaged in the web holes.

Repeat on the upper shoe.

4. Install the wheels and brake drums. For instructions, see **Group 33** or **Group 35**.

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A. Using a lever, stretch return spring and install cam roller and pin.

**Fig. 12, Install the Cam Rollers**

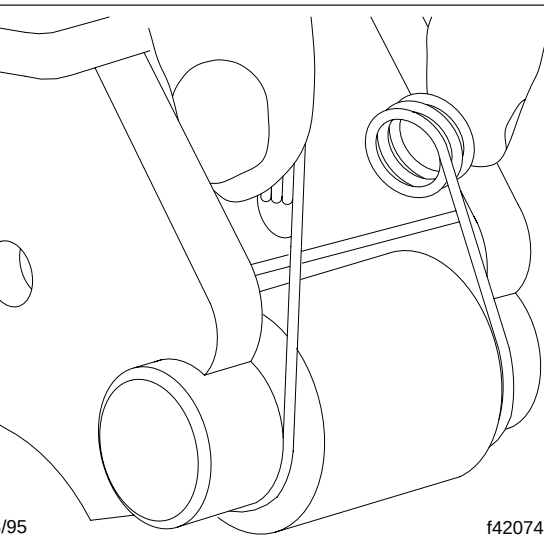



**Fig. 13, Position the Retainer Assembly**

If working on the rear axle, manually uncage the power spring of the parking brake chamber. For instructions, see the applicable brake chamber section in this manual.

5. Adjust the brakes at the slack adjusters. For instructions, see **Subject 130**.
6. Remove the safety stands, lower the vehicle, and remove the chocks from the tires.

**⚠ WARNING**

**Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.**

7. In a safe area, check for proper brake operation.
   - 7.1 Apply and release the brakes several times to check for air leaks and proper operation of the slack adjusters.
   - 7.2 Do several low speed stops to ensure proper parts replacement and full vehicle control.
   - 7.3 Make ten 40 to 20 mph (60 to 30 km/h) snubs to seat the linings.
   - 7.4 Make ten stops from 20 mph (30 km/h) at 50 percent air pressure.
   - 7.5 Make a full-pressure stop from 20 mph (30 km/h).
   - 7.6 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than the others shows a lack of braking effort on those wheels.

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## Inspection

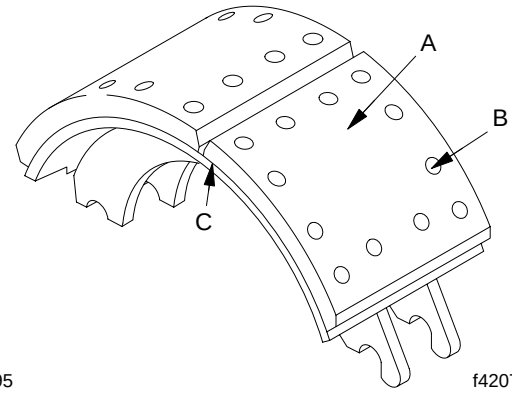
**WARNING**

**Before starting the procedure below, read the information under Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.**

1. Remove the brake shoes. See **Subject 110** for instructions.
2. Check the linings.

   On 15-inch series brakes, if the linings are grease or oil-soaked, cracked, or worn to less than 3/16-inch (4.5-mm) thickness at any point (the lining surface should be no closer than 1/16 inch [1.5 mm] to any rivet head), replace them. See **Fig. 1**.

   On 16-1/2 inch series brakes, if the linings are grease or oil-soaked, cracked, or worn to less than 1/4-inch (6.4-mm) thickness at any point, replace them.

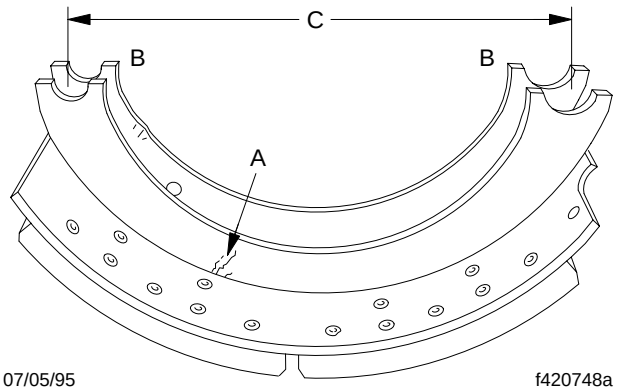



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A. Check for cracks or contamination.
B. No closer than 1/16" (1.5 mm) to any rivet head.
C. 3/16" (4.5 mm) minimum thickness.

**Fig. 1, Check the Brake Shoe (15-Inch Series shown)**

3. Check the shoes for bent or cracked webs or tables, broken welds, loose rivets, or out-of-round rivet holes. See **Fig. 2**. Replace the shoes if any of these conditions exist.




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A. Check table and web for cracks or bends.
B. Check both ends for wear and elongation.
C. Measure this distance.

**Fig. 2, Measuring the Shoe Span**

4. Check the anchor pin for looseness, and camshaft roller recesses in the shoe webs for visible wear. Replace the shoe if needed.
5. Check the shoe span. Measure the distances between the centerlines of the anchor pin and camshaft roller pin recesses in the shoe web. See **Fig. 2**. On 15-inch series brakes, if the measurement is more than 11-3/4 inches (298 mm), replace the shoe. On 16-1/2 inch series brakes, if the measurement is more than 12-9/16 inches (319 mm), replace the shoe.

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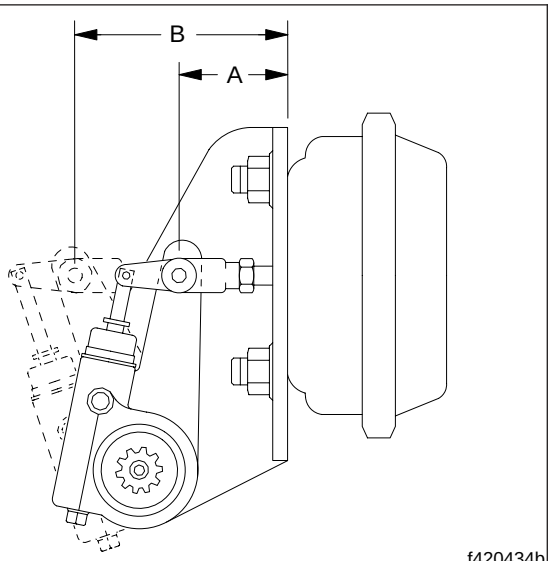


# Adjustment

## Meritor Automatic Slack Adjuster

1. Check the free-stroke.

    1.1 With the brakes fully released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 1**, Ref. A.




NOTE: Subtract measurement A from B.

A. Measurement With Brakes Released
B. Measurement With Brakes Applied

**Fig. 1, Measuring the Initial Free-Stroke**

    1.2 Use a pry bar to move the slack adjuster and apply the brakes. Again, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 1**, Ref. B.

    1.3 The difference between the two measurements is the initial free-stroke, and sets the clearance between the linings and the drum.

    1.4 The free-stroke must be 5/8 to 3/4 inch (16 to 19 mm).

    If the free-stroke is correct, go to the next step and check for correct brake chamber stroke.

    If the free-stroke is incorrect, remove the pressure relief capscrew (**Fig. 2**, Ref. 16), spring (Ref. 18), and pawl assembly (Ref. 19) from the slack adjuster housing. If equipped with a pull-pawl assembly (**Fig. 3**), carefully insert a screwdriver and raise the relief cap about 1/8 inch (3.2 mm).

**⚠ CAUTION**

**Before turning the adjusting nut, remove the pressure relief capscrew, spring, and pawl assembly. If equipped with a pull-pawl assembly, raise the relief cap about 1/8 inch (3.2 mm). Failure to do so could strip the teeth on the pawl.**

    1.5 Turn the adjusting nut 1/8 turn, as shown in **Fig. 4**. Measure the stroke again, and adjust until it is correct.

2. Check for correct brake chamber stroke.

    2.1 With the brakes fully released, measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 1**, Ref. A.

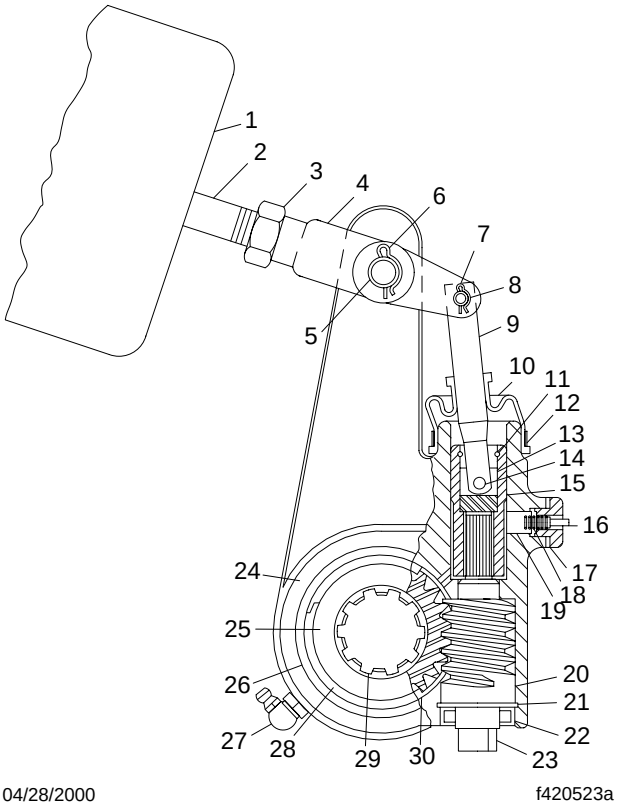
    2.2 Build air pressure to 100 psi (689 kPa). Shut down the engine. Fully apply the brakes, then measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 1**, Ref. B. The difference between the measurements is the brake chamber stroke.

    2.3 The brake chamber stroke must be less than the measurements shown in **Table 1**. If the brake chamber stroke is incorrect, remove the pressure relief capscrew (**Fig. 2**, Ref. 16), spring (Ref. 18), and pawl assembly (Ref. 19) from the slack adjuster housing. If equipped with a pull-pawl assembly (**Fig. 3**), carefully insert a screwdriver and raise the relief cap about 1/8 inch (3.2 mm).

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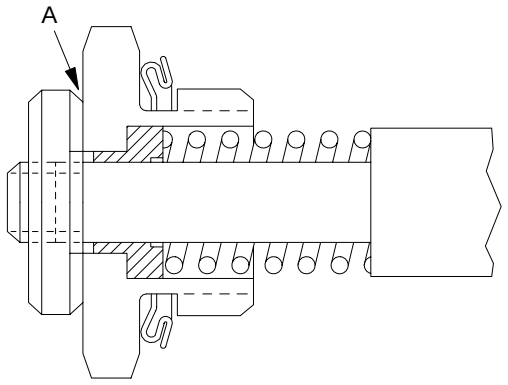
## Brake Adjustment




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1. Brake Air Chamber
2. Brake Chamber Push Rod
3. Clevis Jam Nut
4. Clevis
5. Clevis Pin (large)
6. Cotter Pin (large)
7. Cotter Pin (small)
8. Clevis Pin (small)
9. Actuator Rod
10. Boot
11. Piston Retaining Ring
12. Boot Retaining Clamp
13. Actuator Piston
14. Roller (Pin)
15. Actuator (Adjusting Screw)
16. Pressure Relief Capscrew (shown 90 degrees out of position)
17. Gasket
18. Pawl Spring
19. Pawl Assembly
20. Worm
21. Worm Retaining Snap Ring
22. Worm Seal
23. Manual (Worm) Adjusting Nut End
24. Slack Adjuster
25. Gear
26. Gear Thrustwasher
27. Grease Fitting
28. Gear Retaining Ring
29. Camshaft Splines
30. Gear-to-Body Seal

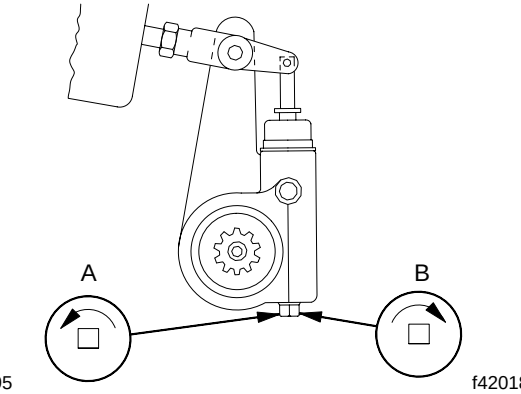
**Fig. 2, Meritor Automatic Slack Adjuster shown**




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A. Insert screwdriver here.

**Fig. 3, Pull-Pawl Assembly (sectional view)**




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A. Shorten stroke.
B. Lengthen stroke.

**Fig. 4, Turn the Adjusting Nut**

| Maximum Adjusted Brake Chamber Stroke With Automatic Slack Adjusters | |
|---|---|
| **Chamber Size** | **Stroke: inches (mm)** |
| 12 | Less than 1-3/8 (35) |
| 16, 20, 24 | Less than 1-3/4 (44) |
| 30 | Less than 2 (51) |

**Table 1, Maximum Adjusted Brake Chamber Stroke With Automatic Slack Adjusters**

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**CAUTION**

**Before turning the adjusting nut, remove the pressure relief capscrew, spring, and pawl assembly. If equipped with a pull-pawl assembly, raise the relief cap about 1/8 inch (3.2 mm). Failure to do so could strip the teeth on the pawl.**

2.4 Turn the adjusting nut 1/8 turn, as shown in **Fig. 4**. Measure the stroke again, and adjust until correct.

If the stroke varies or remains greater than the specified range, check brake components. For instructions, refer to **Subject 150.** If necessary, replace the slack adjuster. For instructions, see the applicable slack adjuster section in this group.

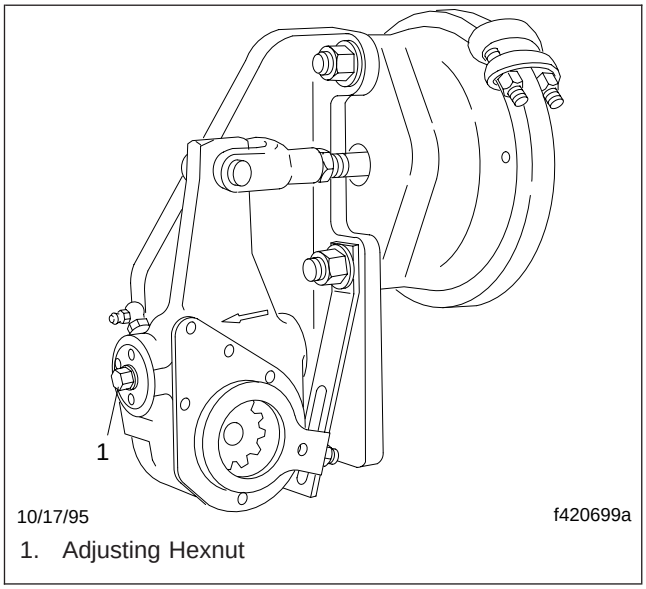
**CAUTION**

**Do not make the adjusted chamber stroke too short. The free-stroke must not be less than 5/8 to 3/4 inch (16 to 19 mm). If the chamber stroke is too short, the linings can drag and damage the brake.**

2.5 If removed, install the pawl assembly, spring, and the pressure relief capscrew. Tighten the capscrew 15 to 20 lbf·ft (20 to 27 N·m). Or, remove the screwdriver from the pull-pawl assembly (if equipped).

## Haldex Automatic Slack Adjuster

1. Turn the adjusting hexnut clockwise until the brake lining meets the brake drum, then back off counterclockwise 3/4 turn. See **Fig. 5**. There will be a ratcheting sound.
2. Measure the distance from the bottom of the air chamber to the far side of the clevis-pin hole (**Fig. 6**, Ref. A). Record the exact distance as measurement A. Apply and hold an 80 psi (551 kPa) brake application. Measure the distance from the bottom of the brake chamber to the far side of the clevis-pin hole (**Fig. 6**, Ref. B). Record the exact distance as measurement B. Subtract measurement A from measurement B to determine the applied stroke. Compare this value to the value in **Table 2**.




1. Adjusting Hexnut

**Fig. 5, Turn the Adjusting Hexnut**

If the stroke varies or remains greater than the specified range, check the brake components. For instructions, see **Subject 150.** If necessary, replace the slack adjuster. For instructions, refer to the applicable slack adjuster section in this group.

| Maximum Adjusted Brake Chamber Stroke With Haldex Automatic Slack Adjusters | |
|---|---|
| **Chamber Size** | **Stroke: inches (mm)** |
| 16 | 3/4 to 1-3/4 (19 to 44) |
| 20 | 1 to 1-/34 (25 to 44) |
| 24 | 1 to 1-7/8 (25 to 48) |
| 30 | 1-1/2 to 2 (38 to 51) |

**Table 2, Maximum Adjusted Brake Chamber Stroke With Haldex Automatic Slack Adjusters**

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## Brake Adjustment

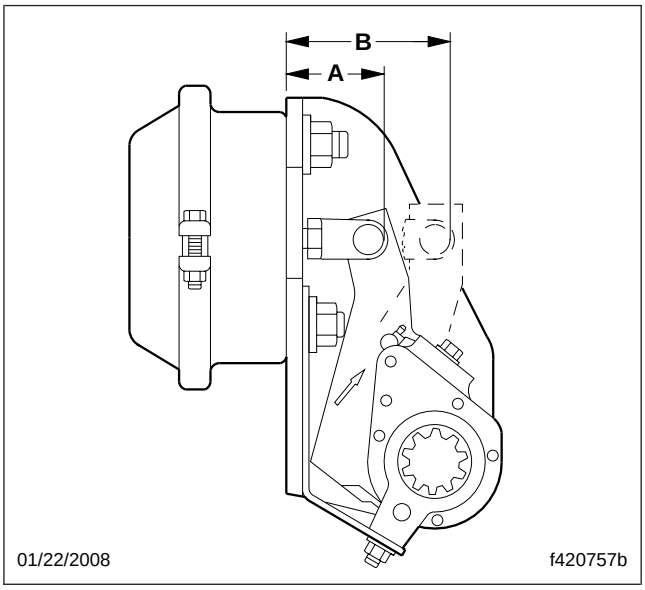



**Fig. 6, Brake Stroke Check, Haldex (SAB) Automatic Slack Adjuster**

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## Replacement

**⚠ WARNING**

**Before starting the procedure below, read the information under Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.**

IMPORTANT: For the best brake performance, don't mix brake linings between axles. When relining brake shoes, both wheel ends of each axle must have the same linings. On tandem axles, all four wheel ends must also have the same linings. However, it is not necessary for the steering axle brakes to have the same linings as the rear drive axle brakes. Also, when the minimum thickness is reached for any of the brake linings on an axle, reline both brakes on that axle at the same time.

NOTE: Replace the springs each time the brakes are relined. Eaton recommends replacement of the rollers and pins at each reline.

1. Remove the brake shoes. For instructions,see **Subject 110.**

**⚠ CAUTION**

**Drilling out rivets or cutting off rivet heads with a chisel can cause the rivet hole to become out-of-round. This could damage the brake shoe.**

2. Using a suitable riveting mandrel, push out (do not drill out) the old rivets.
3. Clean the shoe table. For instructions, see **Subject 150**.

**⚠ CAUTION**

**Make sure that the replacement lining material conforms to FMSI 1308. The FMSI number indicated is a standard for lining size and shape only. Use of an improper FMSI lining specification or friction material type may cause brake dragging, grabbing, or improper brake performance.**

4. Align the brake shoe and lining rivet holes. Using a C-clamp, clamp the lining to the brake shoe.
5. Insert the correct sized rivets into all holes in the new block, and temporarily hold them in place with masking tape.

IMPORTANT: Use rivets that have the correct material, shank diameter, length, head size, and shape. Use tubular rivets that are 1/4-inch (6-mm) diameter by 1/2-inch (13-mm) long, SAE no. 10-8, made of zinc- or brass-plated steel.

6. Begin riveting at the center of each edge of the shoe and lining, and work toward each end.
7. Check for a close fit between the lining and shoe table.

   Try to insert a 0.006-inch (0.15-mm) feeler gauge between the lining and shoe table along the edges. See **Fig. 1**, Ref. A. It should not be possible to insert the gauge anywhere along the edge, except at each end beyond the last row of rivets. A larger clearance may exist in these areas.

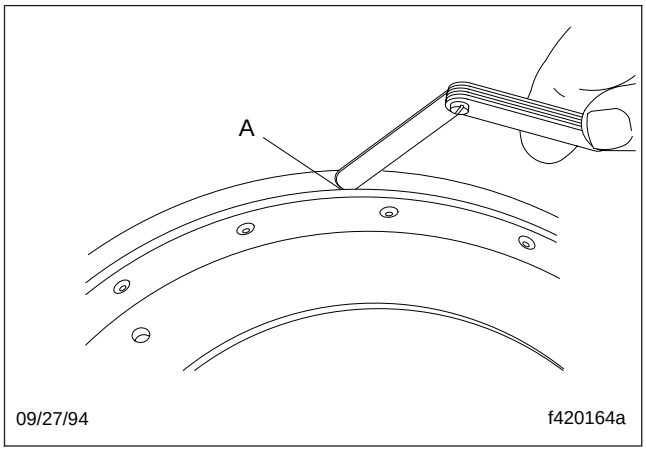



**Fig. 1, Insert the Feeler Gauge between the Lining and Shoe Table**

IMPORTANT: Always adjust the brakes at the slack adjusters after replacing the linings. For instructions, see **Subject 130**.

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# Brake Components Disassembly and Inspection, Cleaning, and Assembly

## Disassembly and Inspection

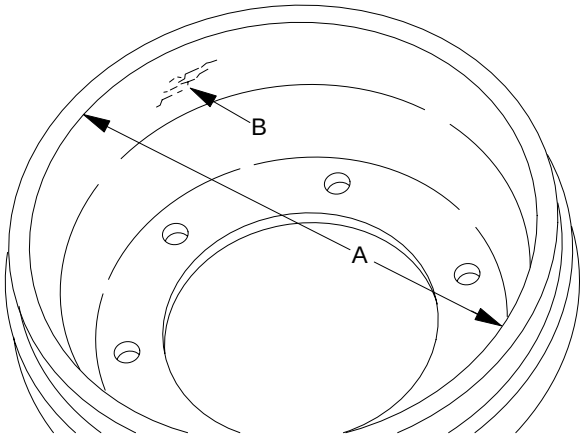
**⚠ WARNING**

**Before starting the procedure below, read the information in Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.**

1. Check the drum for cracks, heat checks, glazing, grooving, run-out, and out-of-round. See Fig. 1.

   Measure the drum diameter. Replace the drum if it exceeds the maximum diameter stamped on it. Replace cracked drums.

   Some drums that are glazed, grooved, or out-of-round can be repaired. For detailed instructions, see the front or rear axle section in this manual.




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A. Check for diameter and for out-of-round.
B. Check for cracks, heat checks, glazing, and grooves.

**Fig. 1, Check the Drum**

2. Disconnect the slack adjuster from the pushrod clevis. See Fig. 2 or Fig. 3. For instructions, refer elsewhere in this group, or to the manufacturer's service information for instructions.
3. With the brake shoes removed, use a dial indicator to measure the up-and-down and side-to-side end-play of the camshaft. Replace the bushings if there is more than 0.020 inch (0.5 mm) of movement.

**⚠ CAUTION**

**Do not hammer on the slack adjuster to remove it. Damage to the adjuster or camshaft spline may result.**

4. Remove the slack adjuster. For instructions, see the applicable slack adjuster section in this group, or to the manufacturer's service information for instructions.
5. Check the slack adjuster for damage and for binding.

   5.1 Check the slack adjuster clevis for cracks or bushing wear. Check the splines for chipped teeth and deformation. Replace as needed.

   5.2 Depress the locking sleeve, and turn the adjuster nut with a wrench at least one turn in each direction. If there is binding, or if excessive force is needed to turn the adjuster, replace it. For instructions, refer elsewhere in this group.

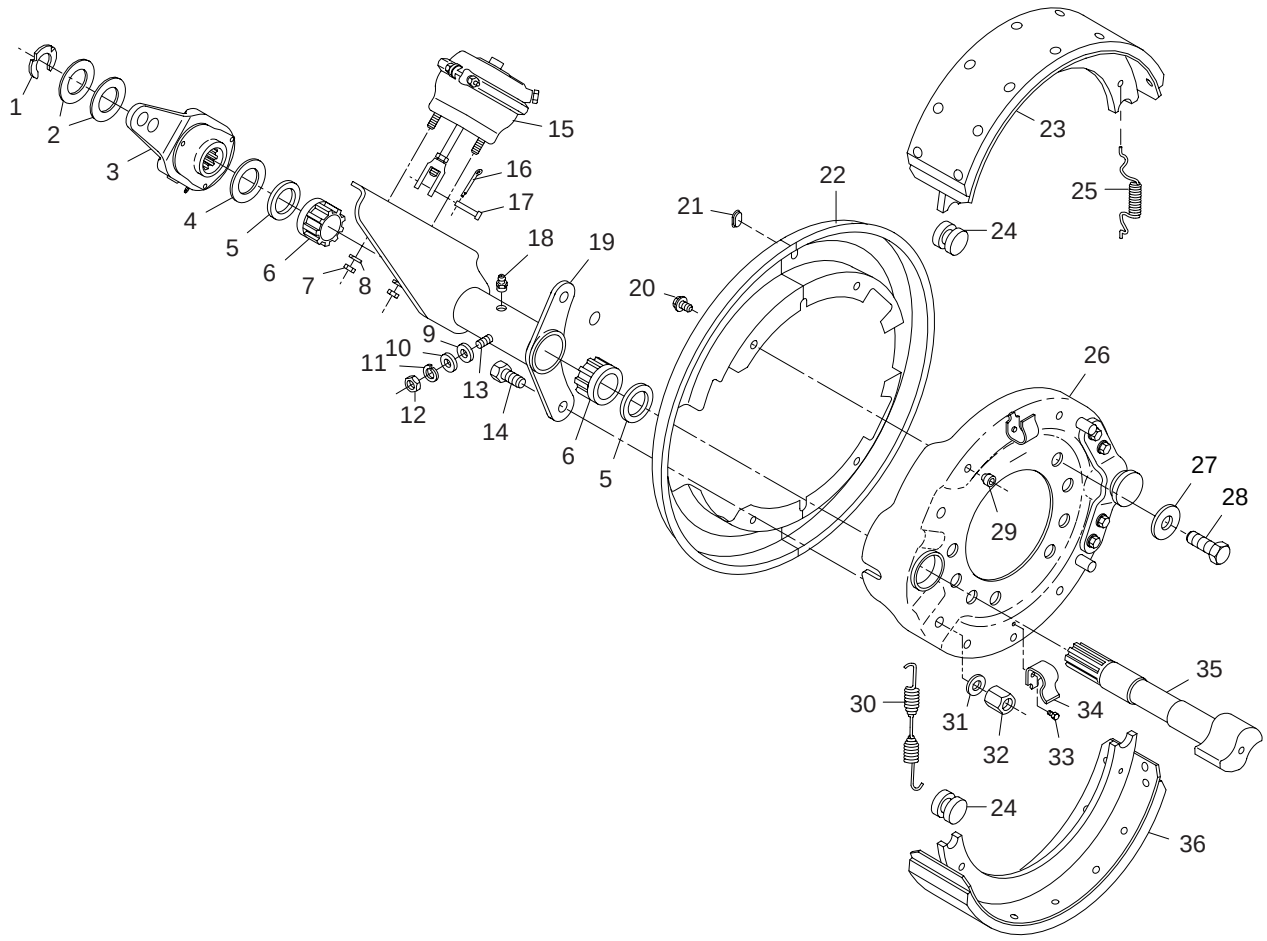
   IMPORTANT: If any slack adjuster problem is found, repair or replace the unit, depending on the manufacturer's recommendations.
6. Remove the camshaft by grasping its head and pulling the camshaft outboard.
7. Check the camshaft spline end for cracks, or worn or deformed splines. Replace the camshaft if damaged.
8. Check the camshaft bushing journals for wear or corrosion. Replace the camshaft if it is worn or if roughness is felt in the journal area.
9. Inspect the camshaft head for brinelling, cracking, or flat spots. Replace the camshaft if a ridge can be felt between the worn area and the cam head surface.
10. Remove the brake chamber stud nuts and lockwashers that attach the brake chamber to the camshaft support bracket. Check the chamber and parts for problems.

    Check the brake chamber for a cracked housing, bent pushrod, loose clamp ring, loose air fitting, air leaks, or clogged vent holes. Repair or replace parts as needed. For instructions, see elsewhere in this group.

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## Brake Components Disassembly and Inspection, Cleaning, and Assembly




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NOTE: Not all fasteners are shown.

1. Snap Ring
2. Camshaft Outer Washers
3. Slack Adjuster
4. Camshaft Inner Washer
5. Grease Seal
6. Camshaft Bushing
7. Stud Nut
8. Lockwasher
9. Spacer
10. Plain Washer
11. Lockwasher
12. Nut
13. Stabilizing Screw
14. Bracket Mounting Bolt
15. Brake Chamber
16. Cotter Key
17. Clevis Pin
18. Grease Fitting
19. Camshaft Support Bracket
20. Dust Shield Screw
21. Lining Inspection Plug
22. Dust Shield
23. Upper Brake Shoe and Lining
24. Cam Roller
25. Retaining Spring
26. Brake Spider and Anchor Pin Assembly
27. Hardened Washer
28. Spider Mounting Bolt
29. Nutsert
30. Return Spring
31. Lockwasher
32. Barrel Nut
33. Bolt
34. Shoe Hold-Down Spring
35. Camshaft
36. Lower Brake Shoe and Lining

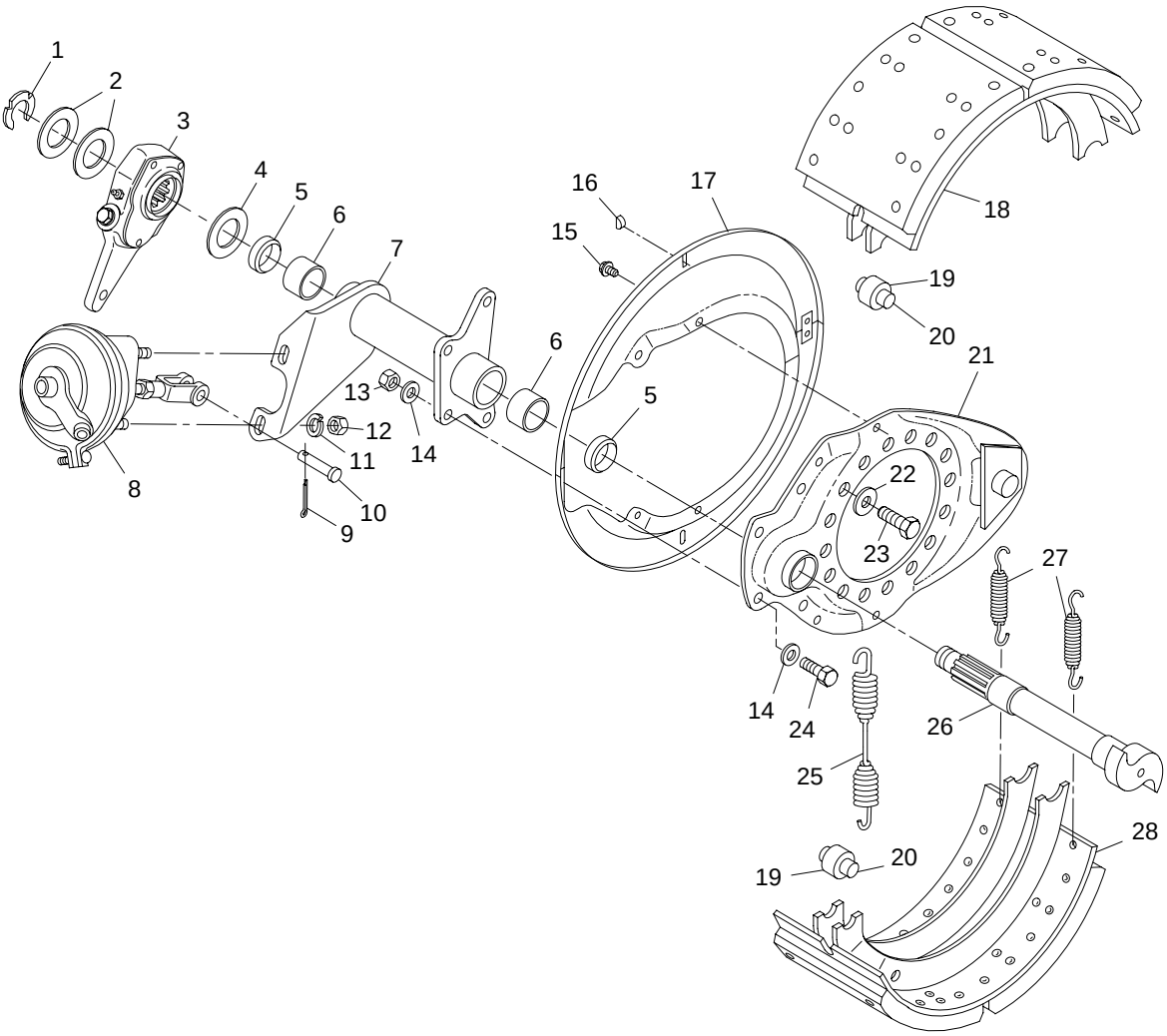
**Fig. 2, Front Axle Brake**

11. Remove and inspect the camshaft support bracket. Remove and discard its gasket. Check the bracket for a bent, broken, or cracked arm,

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## Brake Components Disassembly and Inspection, Cleaning, and Assembly




NOTE: Not all fasteners are shown.

1. Snap Ring
2. Camshaft Outer (Shim) Washers
3. Slack Adjuster
4. Camshaft Inner (Shim) Washer(s)
5. Spring-Loaded Lip Seal
6. Camshaft Bushing
7. Camshaft Mounting Bracket
8. Brake Chamber
9. Clevis Pin Cotter Pin
10. Brake Chamber Clevis Pin
11. Lockwasher
12. Stud Nut
13. Locknut
14. Washer
15. Dust Shield Capscrew
16. Dust Shield Plug
17. Dust Shield (Two-Piece)
18. Upper Brake Shoe and Lining
19. Cam Roller
20. Cam Roller Pin
21. Spider
22. Hardened Washer
23. Spider Mounting Bolt
24. Bracket Mounting Bolt
25. Return Spring
26. Camshaft
27. Retaining Springs
28. Lower Brake Shoe and Lining

**Fig. 3, Rear Axle Brake**

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## Brake Components Disassembly and Inspection, Cleaning, and Assembly

and for cracked welds. Replace the bracket if any of these conditions exist.

12. Remove and inspect the old bushing and the grease seal.

    12.1 Check the camshaft bushing for wear. The inner surface must be smooth; if rough or abrasive, replace the bushing.

    12.2 Inspect the seal. Replace it if the lip is nicked, cut, or distorted.

13. On 15-inch brakes, check the stabilizing screw for bends, looseness, or damaged threads.

**⚠ WARNING**

**Wear eye protection when driving the screw into the camshaft bracket tube with a pin punch and hammer. Failure to wear eye protection could result in personal injury due to flying metal debris.**

14. If necessary, replace the stabilizing screw.

    14.1 Remove the damaged screw by driving it into the camshaft bracket tube with a pin punch and hammer.

    14.2 Aligning the curvature of the screw head (**Fig. 4**) with the curvature of the bracket tube, install the new screw.

    14.3 Install the spacer, lockwasher, and nut. Tighten the nut 23 to 27 lbf·ft (31 to 37 N·m) to draw the screw serrations uniformly through the camshaft bracket tube wall.

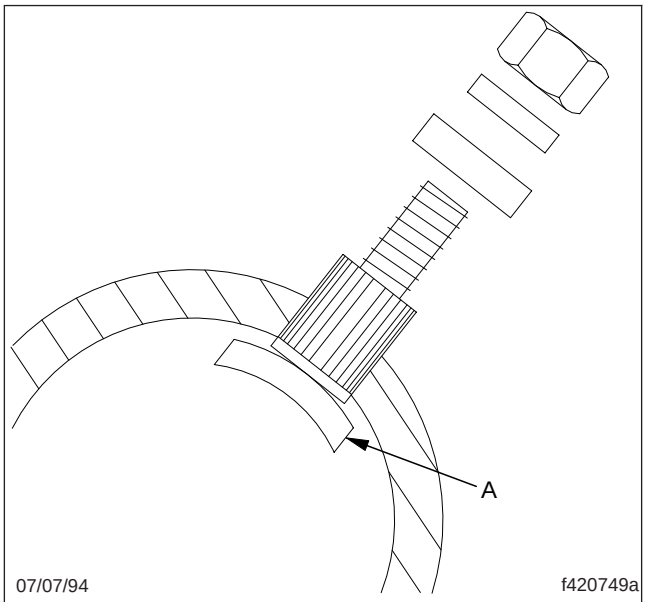
    14.4 Remove the nut and washer before assembling the bracket on the spider.

15. Using a suitable piloted driver, install the new bushing or seal.

    On 15-inch brakes, install the new bushing to a depth of 3/8 inch (9.5 mm) from each end of the bracket tube. See **Fig. 5**.

    On 16-1/2 inch brakes, install the new bushing to a depth of 22/32 inch (17.5 mm) at the slack adjuster end of the bracket tube and to a depth of 9/32 inch (7.1 mm) at the cam head end of the bracket tube.

    Install the grease seal flush with the end of the air chamber bracket tube.




A. Align curvature of the head with the curvature of the of the camshaft bracket tube.

**Fig. 4, Align the Screw Head**

IMPORTANT: Grease seals are installed in both the bracket and the brake spider so that the seal lip is facing toward the slack adjuster end of the bracket tube. See **Fig. 6**.

16. Remove the spider-to-axle attaching nuts, hardened washers, and bolts; remove the spider from the axle flange.

17. If equipped, remove the capscrews that attach the dust shield to the spider; remove the dust shield.

18. Inspect the spider and parts for damage; replace as needed.

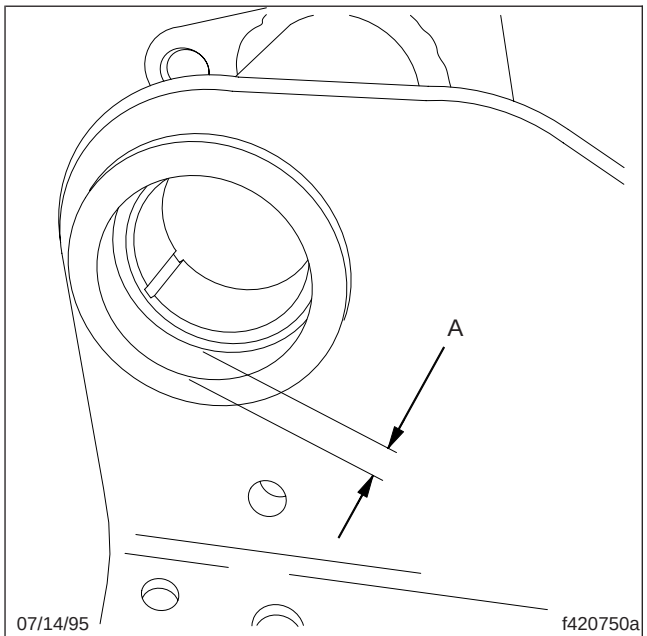
    18.1 Check for cracks at the bolt holes, cam area, and around the anchor pin. Replace if damaged.

    18.2 Check the anchor pin (**Fig. 7**). If the pin is loose, or grooved more than 0.03 inch (0.8 mm) below the original surface, replace the spider assembly.

    18.3 Check the anchor pin and brake spider bushings for deterioration. The inner surfaces must be smooth. If any surface is rough or abrasive, replace the part.

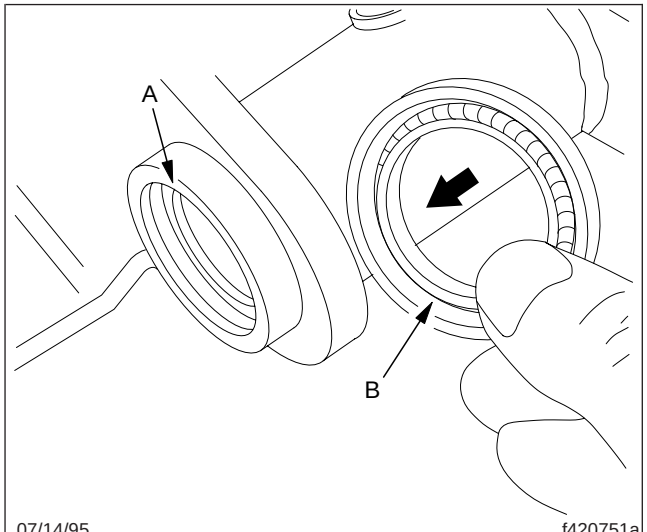
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A. Recess the bushing per specifications.

**Fig. 5, Install the New Bushing**

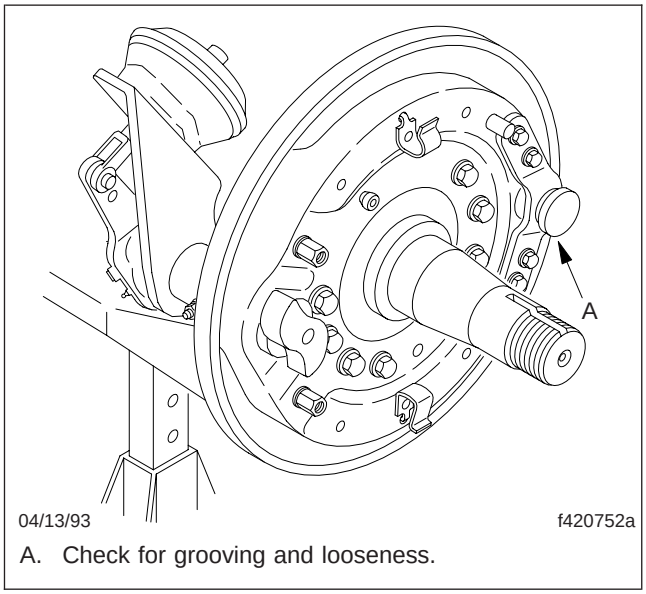



A. Install seals flush with end of tube.
B. Lip side of both seals must face toward slack adjuster end of bracket.

**Fig. 6, Install the Grease Seals**

18.4 On 15-inch brakes, check the anchor pin reinforcement plate attaching nuts (**Fig. 8**, Ref. A) for tightness. If needed, tighten the nuts 35 to 40 lbf·ft (47 to 54 N·m).

Check the anchor pin retaining nut (**Fig. 8**, Ref. B) for tightness. If needed, tighten the nut 475 to 525 lbf·ft (644 to 712 N·m).




A. Check for grooving and looseness.

**Fig. 7, Check the Anchor Pin**

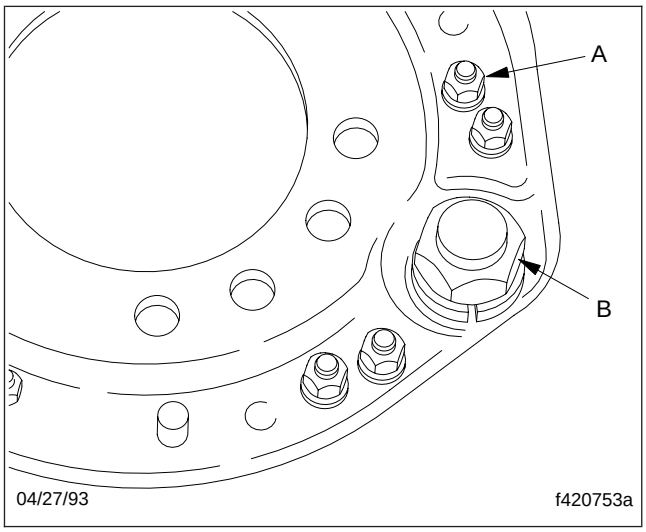



**Fig. 8, Check the Anchor Pin Reinforcement Plate**

IMPORTANT: If the anchor pin turns while checking the retaining nut torque, replace the spider assembly. Eaton recommends replace-

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ment of the complete spider and pin assembly. Do not try to repair the spider assembly.

## Cleaning

**WARNING**

**Before starting the procedure below, read the information in Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.**

1. Wire brush all removed parts that have been exposed to mud, road dirt, and salt, including the exterior of the drum, spider, brake chamber bracket, and dust shields. If relining the shoes, thoroughly wire-brush the shoe tables, and paint with a rust inhibitive coating.

**CAUTION**

**A thick layer of oxidation and dirt on the outside of a brake drum acts as an insulator and may hinder normal heat dissipation. Make sure oxidation and dirt are removed by wire brushing, or damage to brake parts could occur.**

2. Using an industrial vacuum cleaner with a HEPA filter system, pick up excessive dust. Wipe the inside of the drums with a greaseless solvent to remove lining dust.
3. Thoroughly clean all remaining brake parts with a suitable shop solvent. Wipe dry with a clean, lint-free cloth, or use low-pressure filtered and compressed air.

## Assembly

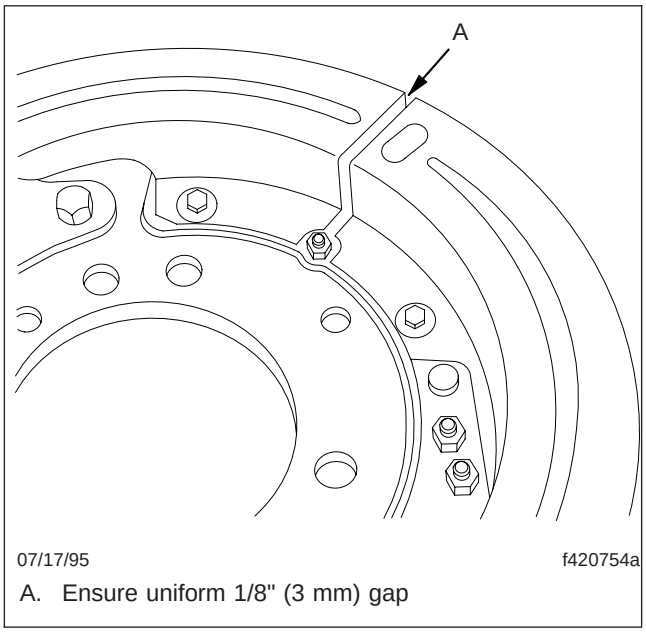
**WARNING**

**Before starting the procedure below, read the information in Safety Precautions, 100. Failure to be aware of the dangers of brake lining dust exposure could result in serious and permanent health damage.**

1. Install the dust shield (if equipped). See Fig. 2 or Fig. 3.

   If installing a one-piece dust shield, position it against the spider, and install the capscrews. Tighten the capscrews 11 to 16 lbf·ft (15 to 22 N·m).

   If installing a two-piece dust shield, position both halves against the spider. Tighten the attaching screws finger-tight. Reposition the dust shield halves to allow a uniform space of 1/8 inch (3 mm) along the mating edges. See Fig. 9. Tighten the screws 11 to 16 lbf·ft (15 to 22 N·m).




A. Ensure uniform 1/8" (3 mm) gap

**Fig. 9, Position both halves of the Dust Shield against the Spider**

NOTE: A designed interference fit at the upper dust shield-to-brake chamber bracket area (Fig. 10) may cause the need to slightly deform the upper dust shield by hand to allow the upper half to align properly with the lower half.

2. Install the spider.

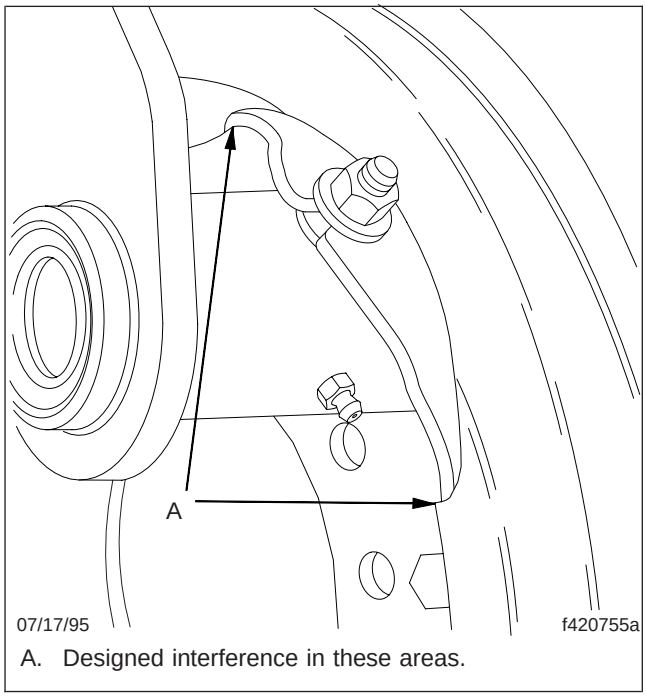
   Place the spider on the axle flange. Using a hardened washer under the bolt head and the nut, install the mounting fasteners. Tighten the bolts in a cross pattern:

   - 1/2–13; 60 to 80 lbf·ft (81 to 108 N·m)
   - 5/8–11 (flanged hexhead capscrew); 160 to 200 lbf·ft (217 to 271 N·m)

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- 5/8–11 (hexhead capscrew); 130 to 160 lbf·ft (176 to 217 N·m)

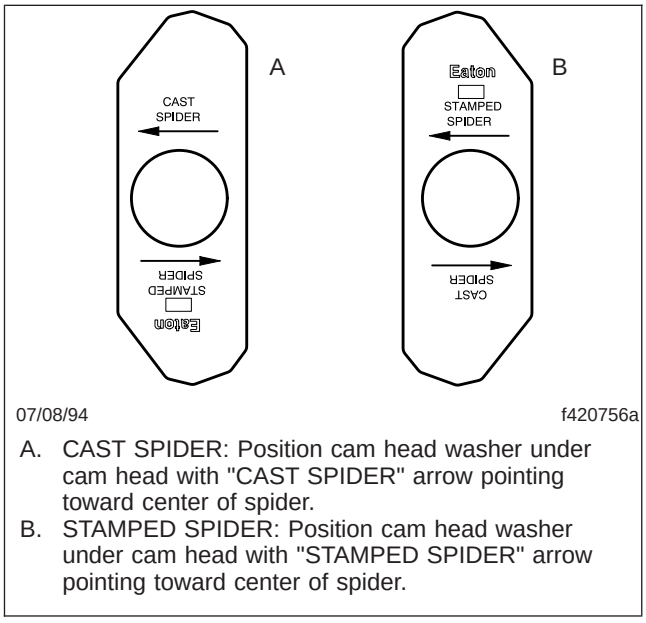



A. Designed interference in these areas.

**Fig. 10, Check the Fit at the Upper Dust Shield-to-Brake Chamber Bracket**

3. Install the brake chamber and bracket.
   - 3.1 Place the brake chamber on the mounting bracket with the chamber mounting studs through the bracket holes. Install the lockwashers and stud nuts. Tighten the nuts. See the brake chamber mounting torque table in **Specifications, 400.**
   - 3.2 Place the bracket against the spider, and install the lockwashers and barrel nuts. Tighten the nuts 55 to 65 lbf·ft (75 to 88 N·m).
   - 3.3 Install the washer, lockwasher, and nut on the stabilizing screw (if equipped). Tighten the nut 23 to 27 lbf·ft (31 to 37 N·m).
4. Install the camshaft and parts in the spider; install the slack adjuster.
   - 4.1 Apply a thin film of chassis grease on the inside of the camshaft bushings and journals. Don't grease the camshaft head area.
   - 4.2 Apply a thin film of rust preventive grease (Rockwell 0-637, or an equivalent) on the camshaft splines.
   - 4.3 Carefully slip the camshaft into the spider and the mounting bracket tube.

   IMPORTANT: If equipped with Extended Service brakes, a special washer is installed between the cam head and the spider. See **Fig. 11** for installation instructions.
   - 4.4 Install the thick camshaft washer on the camshaft.




A. CAST SPIDER: Position cam head washer under cam head with "CAST SPIDER" arrow pointing toward center of spider.
B. STAMPED SPIDER: Position cam head washer under cam head with "STAMPED SPIDER" arrow pointing toward center of spider.

**Fig. 11, Install the Special Washer**

   - 4.5 Install the slack adjuster on the camshaft, with the adjuster nut on the side opposite of the brake chamber.
   - 4.6 Install the thin outer washer(s) and snap ring.
5. Use a dial indicator to measure the end play of the camshaft. There should be no more than 0.005 to 0.045 inch (0.1 to 1.1 mm) movement. Add outer washers as needed to correct.
6. Pressure lube the camshaft bracket bushings.

   Pump multipurpose chassis grease (NLGI grade 1 or 2) into the chamber bracket until it appears at the slack adjuster end of the bracket. Use

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## Brake Components Disassembly and Inspection, Cleaning, and Assembly

care that no grease enters the drum cavity. If grease leaks out under the cam head, the camshaft grease seal is worn or damaged, or is installed backwards.

NOTE: The use of meter-type fittings, having a maximum 40 psi (276 kPa) pressure relief at shutoff, is recommended.

7. Adjust the brakes at the slack adjusters. For instructions, see **Subject 130**.
8. Install the brake shoes. For instructions, see **Subject 110**.

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## Specifications

| Description | Size | Torque: lbf·ft (N·m) |
|---|---|---|
| Camshaft Support Bracket Mounting Nuts | 1/2–13 | 55–65 (75–88) |
| Spider Mounting Flanged Nuts: | | |
| Front or Rear Axle | 1/2–13 | 60–80 (81–108) |
| Front or Rear Axle (Hexhead Capscrew) | 5/8–11 | 130–160 (176–217) |
| Front or Rear Axle (Flanged Hexhead Capscrew) | 5/8–11 | 160–200 (217–271) |
| Dust Shield Mounting Capscrews | — | 11–16 (15–22) |
| Anchor Pin Reinforcement | — | 35–40 (47–54) |
| Anchor Pin Retaining Nut | — | 475–525 (644–712) |

**Table 1, Torque Values**

| Manufacturer | Chamber Size (square inches) | Torque: lbf·ft (N·m) |
|---|---|---|
| Midland | 12, 16 | 30 (41) |
| | 20, 24, 30, 36 | 100 (136) |
| MGM | 24, 30, 36 | 100–115 (136–156) |

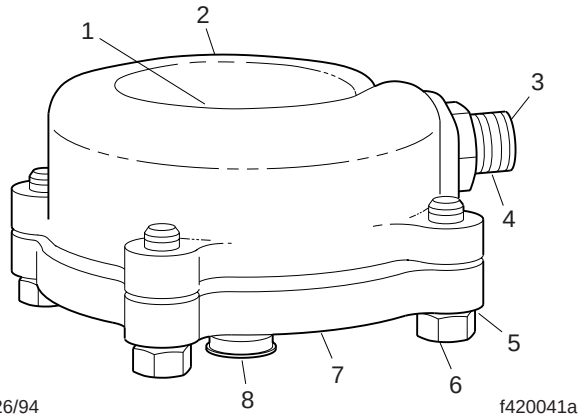
**Table 2, Brake Chamber Mounting Torques**

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## General Information

The DV-2 automatic reservoir drain valve, shown in **Fig. 1**, automatically removes contaminants and water from the wet-air tank each time the brakes are applied. The drain valve is screwed into the port at the lowest end of the tank, located on the bottom of either end of the wet-air tank. Since the brake application valve is protected by a check valve between the wet- and dry-air tanks, any leak or failure will not reduce the supply of air that is in the dry part of the system. If the leak is severe, it could prevent the continued resupply of air as it is used up when applying the brakes. A failed drain valve will allow moisture to build up in the wet tank, which in turn could reach the dry tank, and then travel into the air brake system where it could cause brake failure. A leaking drain valve allows wet tank leakdown, which in turn can cause premature wear on the air compressor during vehicle operation as the air compressor continues to run to maintain wet tank air pressure.




1. Top Reservoir Port
2. Valve Body
3. Hexhead Nipple
4. Side Reservoir Port
5. Lockwasher (4 qty.)
6. Capscrew (4 qty.)
7. Valve Cover
8. Exhaust Port

**Fig. 1, DV-2 Valve**

## Principles of Operation

With no pressure in the system, the drain valve's inlet and exhaust valves are closed. See **Fig. 2**. Upon charging the system, a slight pressure opens the inlet valve, which permits air and contaminants to collect in the sump. See **Fig. 3**. The inlet valve remains open when pressure is rising in the system until the air compressor cuts off, allowing the spring action of the valve guide in the sump cavity to close the inlet valve. The inlet valve and the exhaust valve are now both closed. See **Fig. 4**. When the wet tank pressure drops approximately 2 psi (14 kPa), the air pressure in the sump cavity opens the exhaust valve and allows moisture and contaminants to be ejected from the sump cavity until pressure in the sump cavity drops sufficiently to close the exhaust valve. See **Fig. 5**.

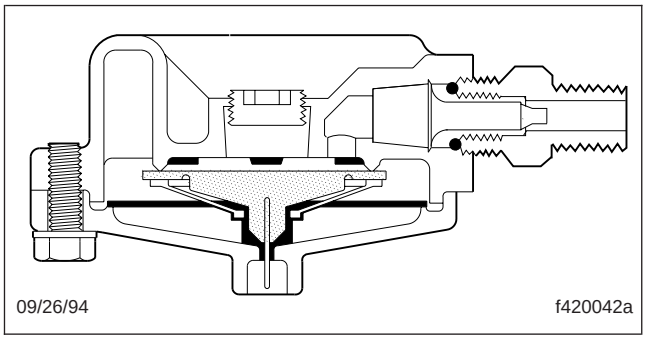



**Fig. 2, No System Pressure**

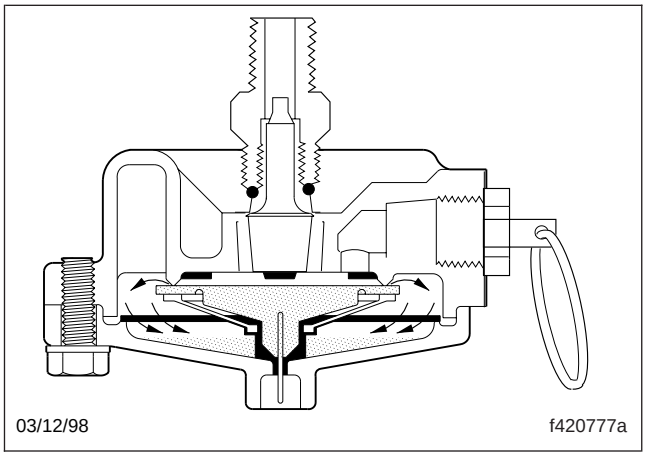



**Fig. 3, Start of System Pressure Charging**

The length of time the exhaust valve remains open and the amount of moisture and contaminants ejected depends upon the sump pressure and the wet tank pressure drop that occurs each time air is used from the system.

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## General Information

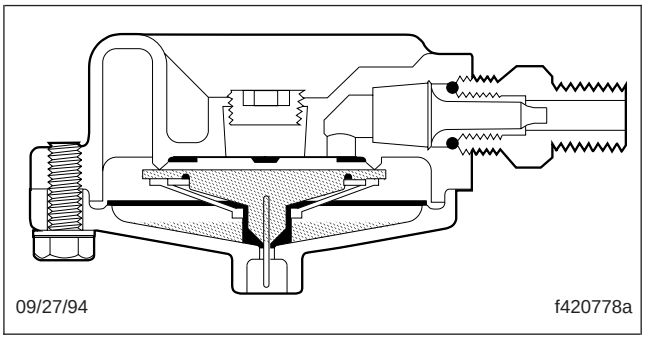



**Fig. 4, System Pressure Rising**

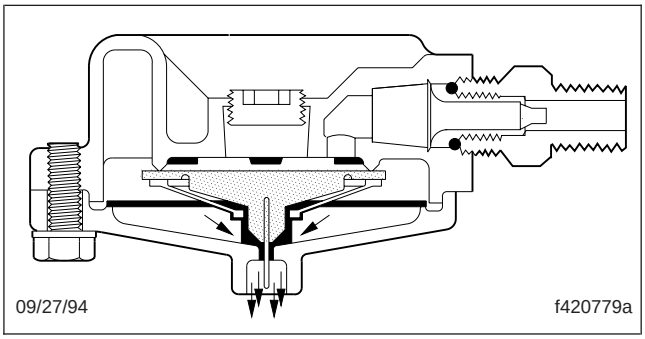



**Fig. 5, Exhaust Cycle**

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## Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

- Always chock the vehicle's wheels and shut down the engine when working under a vehicle. Depleting vehicle air system pressure may cause the vehicle to roll. Keep hands away from brake chamber push rods and slack adjusters; they may apply as air system pressure drops.
- Never connect or disconnect a hose or line containing air pressure. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been depleted.
- Never exceed recommended air pressure.
- Always wear safety glasses when working with air pressure. Never look into air jets or direct them at anyone.
- Never attempt to disassemble a component until you have read and understood the recommended procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to use of those tools.

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## Drain Valve Removal and Installation

**⚠ WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

## Removal

1. Chock the tires, and drain the air system.
2. Remove the drain valve assembly from the end of the wet tank air reservoir.

## Installation

1. Using a cleaning solvent, thoroughly flush and clean the wet tank reservoir to avoid early fouling at the drain valve. Aerate the wet tank thoroughly.
2. Install the drain valve assembly on the wet tank by tightening the hexagonal nipple until the drain valve is positioned so that the valve body is parallel to the bottom of the wet tank with the exhaust port facing straight down. Make sure that the exhaust port is clear of any air, electric, or fuel lines. Make sure the drain valve is attached tight enough to prevent leakage.
3. Close the drain cocks to the wet and dry air reservoirs. Start the vehicle engine to pressurize the air system.
4. Leak test the drain valve following the instructions in **Subject 130**.

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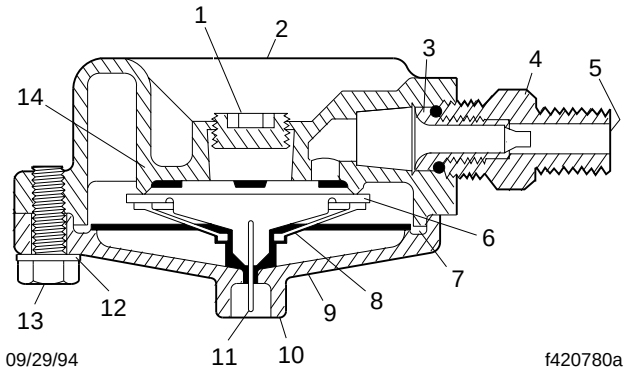
# Drain Valve Disassembly, Cleaning and Inspection, and Assembly

**WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

## Disassembly

Refer to **Fig. 1** during drain valve disassembly and assembly.




1. Top Reservoir Port
2. Valve Body
3. Filter Retainer
4. Hexhead Nipple
5. Side Reservoir Port
6. Inlet and Exhaust Valve
7. Valve Sealing Ring
8. Valve Guide
9. Valve Cover
10. Exhaust Port
11. Wire Stem
12. Lockwasher (4 qty.)
13. Capscrew (4 qty.)
14. Inlet Valve Seat

**Fig. 1, DV-2 Valve (cutaway view)**

1. Remove the drain valve, following the instructions in **Subject 110**.
2. Remove the four capscrews that hold the valve cover to the valve body.
3. Remove the valve cover and sealing ring.
4. Remove the valve guide, and the inlet and exhaust valve from the valve body.
5. Remove the hexhead nipple from the valve body.

## Cleaning and Inspection

**WARNING**

**Use eye protection when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.**

1. Wash all metal parts of the drain valve in an approved cleaning solvent. Dry the metal parts of the disassembled moisture ejection valve with compressed air.
2. Wipe all rubber parts clean with a clean cloth. Examine all rubber parts for wear, cracks, tears, or other deterioration. If any rubber parts are worn, cracked, torn, or otherwise deteriorated, replace them with new parts.
3. Examine all metal parts for wear, cracks, or other damage. If any metal parts are worn, cracked, or otherwise damaged, replace them with new parts.
4. Clean and examine the filter. If it will not clean completely, or is torn or damaged, replace it with a new filter.

**NOTICE**

**Do not reassemble the drain valve with a dirty filter; to do so could result in failure of the drain valve in service.**

## Assembly

Before assembling the drain valve, apply a light film of grease on the inlet valve seat.

IMPORTANT: Do not apply oil to the inlet and exhaust valve.

1. Install the valve sealing ring into its groove in the valve cover.
2. Install the valve guide over the inlet and exhaust valve.
3. Install the valve guide, and the inlet and exhaust valve as an assembly into the valve cover. The wire stem will project through the exhaust port.
4. Install the valve body on the valve cover, and install the lockwashers and capscrews. Tighten the capscrews 95 to 130 lbf·in (1073 to 1469 N·cm).

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## Drain Valve Disassembly, Cleaning and Inspection, and Assembly

5. Install the hexhead nipple onto the valve body, and tighten it 65 to 95 lbf·in (734 to 1073 N·cm).
6. Install the drain valve on the wet tank, following the instructions in **Subject 110**.

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**⚠ WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

## Operating Test

Perform the following test after repairing or replacing the DV-2 valve, to ensure that the valve is functioning properly.

With the system charged, apply the brakes several times. Each time the brakes are applied, an exhaust of air should occur from the exhaust port of the drain valve. If no air comes out, push the wire stem located inside the exhaust port. If no air comes out after pushing the wire stem, there may be a plugged filter in the adapter which should be replaced.

If the drain valve does not function properly, repair or replace it following the instructions in **Subject 110**.

## Leakage Test

Perform the following test after repairing or replacing the DV-2 valve, to ensure that the valve is functioning properly.

With the system charged and pressure stabilized in the system, there should be no leaks at the drain valve exhaust port. A constant slight exhaust of air at the drain valve exhaust port could be caused by excessive leakage in the air brake system.

If the drain valve is leaking excessively, repair or replace it following instructions in this section.

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## Specifications

| Torque Values | |
|---|---|
| **Description** | **Torque: lbf·in (N·cm)** |
| Valve Cover Capscrews | 95–130 (1073–1469) |
| Hexhead Nipple (to valve body) | 65–95 (734–1073) |

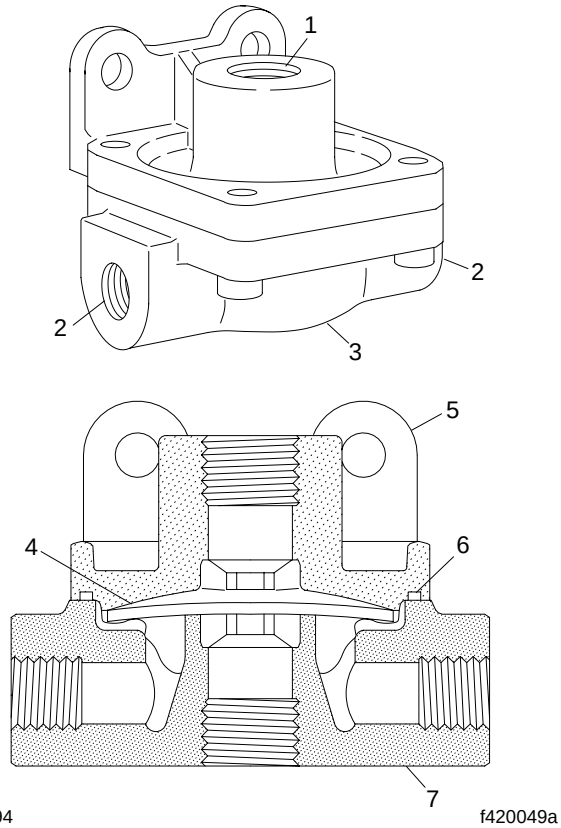
**Table 1, Torque Values**

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## General Information

The function of the QR–1 quick release valve (**Fig. 1**) is to speed up the release of air pressure from the brake chambers. If the front brake chambers are equipped with a QR–1 valve, and a foot brake application is released, the exhaust port of the quick release valve opens and the air from the front brake chambers is exhausted through the quick release valve. This accelerates the release of the front brakes.




1. Brake Valve Port
2. Brake Chamber Port
3. Exhaust Port
4. Diaphragm
5. Cover
6. O-Ring
7. Body

**Fig. 1, QR–1 Valve and Cross Section**

When the front brake chambers are equipped with a QR–1 valve, it is located on the forward face of the crossmember just aft of the transmission. A delivery line from the foot valve is connected to the port on top of the QR–1 quick release valve; the two side ports are for brake chamber connections, and the exhaust port is located at the bottom of the valve.

## Principles of Operation

When the foot brake control is applied, delivery air enters the brake valve port on the QR–1 quick release valve (**Fig. 1**); the diaphragm moves down, sealing the exhaust port. At the same time, air pressure forces the edges of the diaphragm down, allowing air to flow out the brake chamber ports, filling the chambers and applying the front axle brakes.

When the brake chamber air pressure (beneath the diaphragm) equals the air pressure being delivered by the foot valve (above the diaphragm), the outer edge of the diaphragm will seal against the valve body seat. The exhaust port is still sealed by the center portion of the diaphragm. When the foot brake is released, the air above the diaphragm is released back through the foot brake valve exhaust, while the air beneath the diaphragm forces the diaphragm to rise, opening the exhaust port, and allowing air in the brake chambers to exhaust.

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## Safety Precautions

When working on or around air brake systems and components, observe the following precautions.

1. Chock the tires and stop the engine before working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters; they may apply as air system pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to use of those tools.

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## Operating and Leakage Tests

The following tests should also be performed after repairing or replacing the QR–1 valve to ensure that it is functioning properly.

1. With the foot brake applied (pedal pushed in) perform the following checks.

    1.1 Coat the exhaust port with a soap solution; leakage of a one-inch bubble in three seconds is allowable.

    1.2 Coat the valve body and cover with a soap solution. No leakage is permitted between the valve body and cover.

2. If the valve does not function properly, or if leakage is excessive, repair or replace it following the instructions in this section.

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# QR–1 Quick Release Valve Disassembly, Cleaning and Inspection, and Assembly

## Disassembly

1. Remove the four screws holding the valve cover on the valve body.
2. If equipped, remove the spring and spring seat.
3. Remove the diaphragm.
4. Remove the cover O-ring.

## Cleaning and Inspection

1. Clean all metal parts in mineral spirits. Wipe all rubber parts clean.
2. It is recommended that all rubber parts and any other part showing signs of wear or deterioration be replaced with genuine Bendix parts.

## Assembly

1. If the quick release valve is not equipped with a spring, install the diaphragm into the valve body.

   If the quick release valve is equipped with a spring, position the spring in the valve body. Then, position the diaphragm over the spring seat.
2. Install the O-ring in the valve cover groove and install the valve cover. Tighten the screws 30 to 60 lbf·in (340 to 680 N·cm) evenly and securely.

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## General Information

The R–12 (**Fig. 1**) and R–14 (**Fig. 2**) relay valves are control relay stations in the air brake system to speed the application and release of the brakes. Mounted at the rear of the vehicle, they are operated by remote control and give about the same amount of air pressure to the brake chambers as they receive from the service brake foot valve or other source.

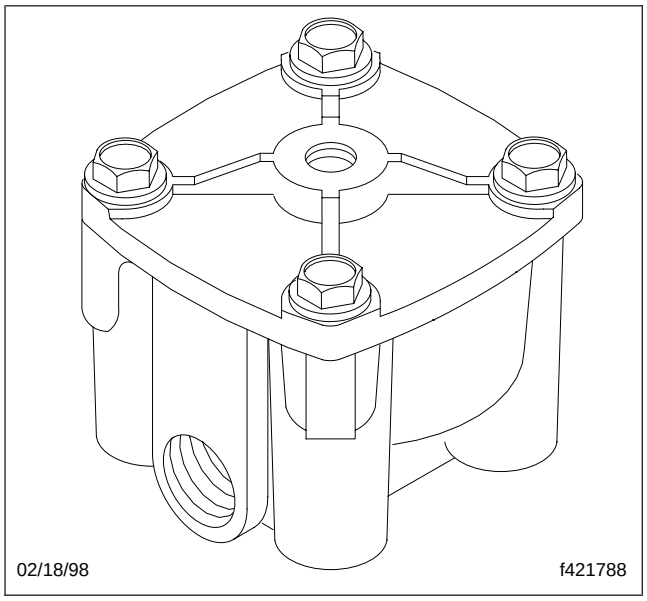



**Fig. 1, R-12 Relay Valve**

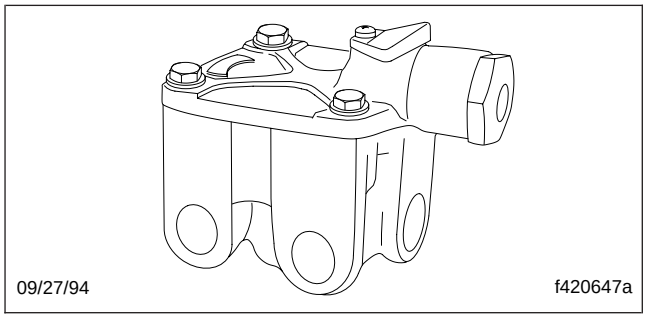


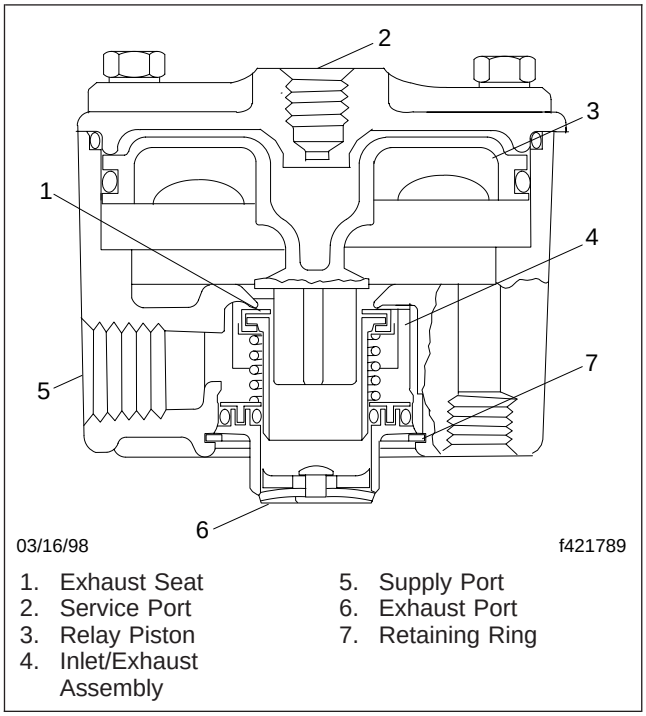

**Fig. 2, R-14 Relay Valve**

The valves are piston operated and have an insert-type inlet and exhaust valve that can be serviced.

## Principles of Operation

### Application

Air pressure delivered to the service port enters the small cavity above the piston and moves the piston down. See **Fig. 3** and **Fig. 4**. The exhaust seat moves down with the piston and seats on the inner or exhaust portion of the inlet/exhaust valve, sealing off the exhaust passage. At the same time, the outer or inlet portion of the inlet/exhaust valve moves off its seat, permitting supply air to flow from the reservoir, past the open inlet valve and into the brake chambers.




1. Exhaust Seat
2. Service Port
3. Relay Piston
4. Inlet/Exhaust Assembly
5. Supply Port
6. Exhaust Port
7. Retaining Ring

**Fig. 3, R-12 Relay Valve (sectional view)**

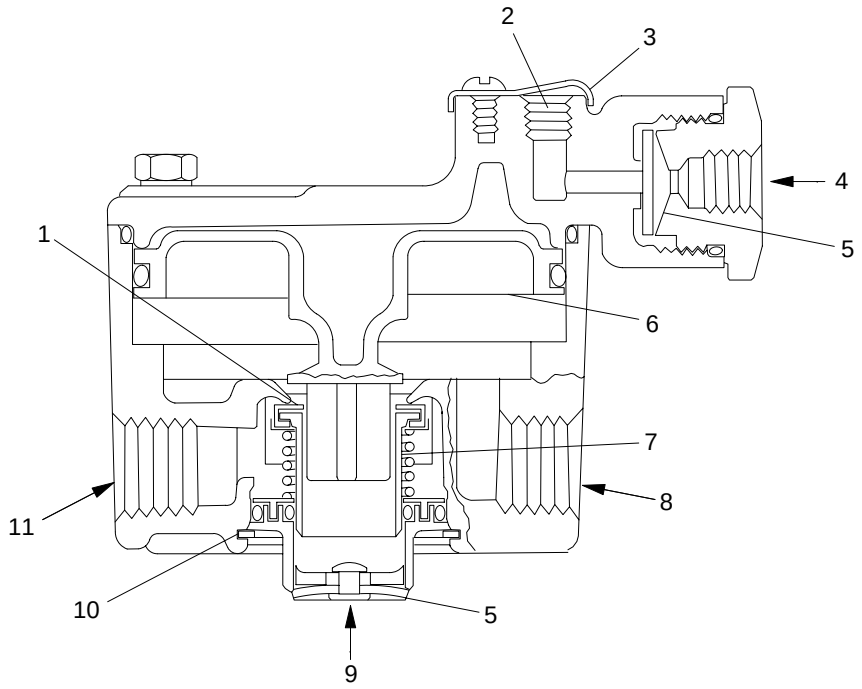
### Balance

The air pressure being delivered by the open inlet valve also is effective on the bottom area of the relay piston. When air pressure beneath the piston equals the service air pressure above, the piston lifts slightly and the inlet spring returns the inlet valve to its closed position. The exhaust remains closed as the service line pressure balances the delivery pressure.

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## General Information




1. Exhaust Seat
2. Balance/Quick Exhaust Port (Anti-Compound)
3. Exhaust Cover
4. Service Port
5. Double-Check Diaphragm
6. Relay Piston
7. Inlet/Exhaust Valve
8. Delivery Port
9. Retaining Ring
10. Exhaust Port
11. Supply Port

**Fig. 4, R-14 Relay Valve (sectional view)**

As delivered air pressure is changed, the valve reacts to the change, holding the brake application at the level.

## Exhaust or Release

When air pressure is released from the service port and air pressure in the cavity above the relay piston is exhausted, air pressure beneath piston lifts the relay piston and the exhaust seat moves away from the exhaust valve, opening the exhaust passage. With the exhaust passage open, the air pressure in the brake chambers is then permitted to exhaust through the exhaust port, releasing the brakes.

## Anti-Compounding (Simultaneous Service and Park Application), R–14 Valve

An "anti-compound" feature allows the R–14 valve to be used as either a service or spring brake relay valve. An exhaust cover is installed that protects the 1/8-inch balance port when the R–14 anti-compound feature is not in use. See **Fig. 4**.

In applications where the R–14 is used to control spring brake chambers, the anti-compound feature may be utilized. To utilize, the exhaust cover of the quick release portion of the R–14 is removed and a line is installed, which is connected to the delivery of the service brake valve or relay valve. With no air pressure at the service port of the R–14, the parking brakes apply. When a service brake application is made, air from the service brake valve enters the exhaust port of the quick release of the R–14 and

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moves the diaphragm, blocking the service port. Air then proceeds into the cavity above the relay piston, forces the piston down, closing the exhaust and opening the inlet to deliver air to the spring brake cavity.

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## Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

A. Chock the tires and stop the engine before working under the vehicle. Releasing air from the system may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters; they will apply as air pressure drops.

B. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.

C. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.

D. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs and injury can result if not correctly disassembled. Use only correct tools and observe all precautions regarding use of those tools.

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## Operation Test

IMPORTANT: Before working on or around air brake systems and components, see Safety Precautions, **Subject 100**.

1. Start the vehicle and build the brake system to cut-out pressure, about 130 psi (827 kPa).
2. Using a soap and water solution, check all air line fittings on the valve for leakage. If the fittings or air lines are leaking, replace the fittings. For instructions, see **Section 42.10**.
3. Make several service brake applications and check for prompt application and release of the brakes.
4. If brake response is slow, troubleshoot the brake system. For instructions, see **Section 42.08**. If the valve is malfunctioning, repair or replace it.

## Leakage Test

IMPORTANT: Before working on or around air brake systems and components, see Safety Precautions, **Subject 100**.

1. Start the vehicle and build the brake system to cut-out pressure,about 130 psi (827 kPa).
2. Using a soap and water solution, check for inlet valve and O-ring leakage.
   - 2.1 Make this check with the service brakes released when the R–12 or R–14 is used to control the service brakes.
   - 2.2 Make the check with the spring brakes (parking brakes) applied when the R–14 is used to control the spring brakes.
3. While holding a full service brake application, apply a soap solution to the exhaust port. Leakage at the exhaust port should not exceed a 1-inch (2.5-cm) bubble in three seconds.

NOTE: If the anti-compound feature is in use, the line attached to the balance port must be disconnected to perform this test.

4. Coat the outside of the valve where the cover joins the body to check for O-ring leakage; no leakage is permitted.
5. If the R–14 is used to control the spring brakes, release the parking brake, apply a soap solution to the balance port. Leakage at the balance port should not exceed a 1-inch (2.5-cm) bubble in three seconds.

IMPORTANT: If the valves do not function as described in the above test, or if leakage is excessive, replace it. For instructions, see **Subject 120**.

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## Removal

IMPORTANT: Before working on or around air brake systems and components, see Safety Precautions, **Subject 100**.

1. Chock the tires, and drain the air system.
2. Remove all air hoses from the valve. Cap the hoses and mark them for reassembly.
3. Remove the valve mounting bolts. Remove the valve.

## Installation

IMPORTANT: Before working on or around air brake systems and components, see Safety Precautions, **Subject 100**.

1. Attach the valve to the vehicle, using the bolts, washers, and nuts. Tighten the nuts 132 to 180 lbf·in (1500 to 2040 N·cm).
2. Remove the caps from the air lines, then depending on the type of air hose, do one of the following.

   *Nylon Tubing:* Connect the air line fittings to the valve ports, and tighten the nuts finger-tight. Using a wrench, tighten the nuts at least two turns, or until one thread shows on the fittings.

   *Wire Braid Hoses:* Connect the hose fittings to the valve ports, and hand-tighten the nuts. Using a wrench, tighten the nuts until resistance is felt. Tighten one-sixth turn more. Do not overtighten.
3. Close the air reservoir drain cocks. Start the vehicle engine to pressurize the air system.
4. Test the valve following the instructions in **Subject 110**.

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# Relay Valve Disassembly, Cleaning and Inspection, and Assembly

## Disassembly

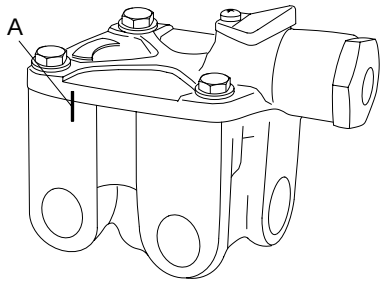
IMPORTANT: Before working on or around air brake systems and components, see Safety Precautions, **Subject 100**.

1. Remove the valve from the vehicle. For instructions, see **Subject 120**.

NOTE: Prior to disassembly, draw an alignment mark across the valve cover and body, for reassembly alignment. See **Fig. 1**.

2. Disassemble the valve.

   2.1 Referring to **Fig. 2**, remove the four cover capscrews and integral lockwashers.




A. Mark the valve housing for reassembly alignment.

**Fig. 1, Valve Marked for Reassembly (R-14 valve shown)**

   2.2 Remove the valve cover and O-ring.

   2.3 Remove the relay piston, and the O-ring.

   2.4 While depressing the exhaust cover, remove the retainer ring; slowly remove the exhaust cover and the valve spring. Remove the O-rings from the exhaust cover.

   2.5 Remove the inlet/exhaust valve. Remove the valve retainer from the inlet/exhaust valve.

3. On the R–14 valves, remove the Phillips head screw and the exhaust cover. Then, remove the service port cap nut, the O-ring, and the diaphragm located inside the service port.

## Cleaning and Inspection

**⚠ WARNING**

**Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.**

IMPORTANT: Before working on or around air brake systems and components, see Safety Precautions, **Subject 100**.

1. Wash all metal parts of the valve in cleaning solvent. Dry the metal parts of the disassembled valve with compressed air.
2. Wipe all rubber parts clean with a clean cloth. Examine all rubber parts for cracks, tears, or other deterioration. If any rubber parts are worn, cracked, torn or otherwise damaged, replace them with new parts.
3. Examine all metal parts for wear, cracks, or other damage. If any metal parts are worn, cracked or otherwise damaged, replace them with new parts.
4. Check the springs for distortion and corrosion. If the springs are distorted or corroded, replace them.
5. Inspect the exhaust seat of the quick release diaphragm in the R–14 cover and make sure all internal air passages in the area are open and clean and free of nicks and scratches.

## Assembly

IMPORTANT: Before working on or around air brake systems and components, see Safety Precautions, **Subject 100**.

1. Lubricate the O-rings and all sliding parts with Dow Corning 55-M pneumatic grease or equivalent. Assemble the valve (**Fig. 2**).

   1.1 Install the O-ring on the relay piston.

   1.2 Install the inner and outer O-rings on the exhaust cover.

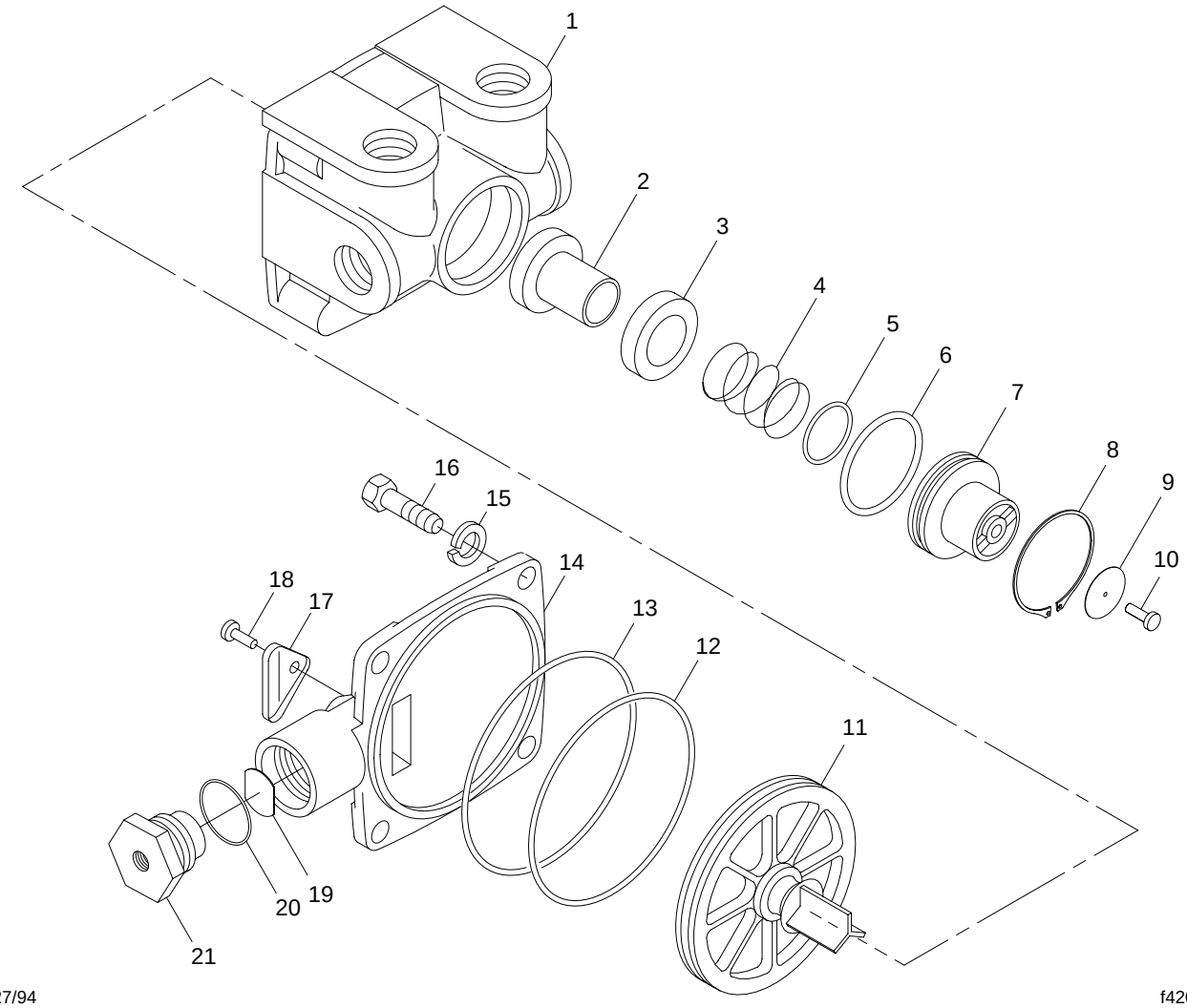
   1.3 Install the O-ring on the valve cover.

   1.4 Install the relay piston in the body, taking care not to damage the piston O-ring.

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## Relay Valve Disassembly, Cleaning and Inspection, and Assembly




1. Body
2. Inlet/Exhaust Valve
3. Valve Retainer
4. Valve Spring
5. O-Ring
6. O-Ring
7. Exhaust Cover
8. Retainer Ring
9. Diaphragm
10. Rivet
11. Relay Piston
12. O-Ring
13. O-Ring
14. Valve Cover
15. Lockwasher (4 qty)
16. Capscrew (4 qty)
17. Exhaust Cover
18. Screw, Phillips #10–24
19. Diaphragm
20. O-Ring
21. Cap Nut

**Fig. 2, R-14 Valve (R-12 similar)**

1.5 Noting the reference mark made during disassembly, secure the valve cover with four capscrews and lockwashers. Torque the capscrews 80 to 120 lbf·in (900 to 1360 N·cm).

1.6 Install the valve retainer and spring on the inlet/exhaust valve assembly. Install the inlet/exhaust valve assembly in the body.

1.7 Install the exhaust cover. While depressing the exhaust cover, install the retaining

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ring, making sure the retaining ring is completely seated in the groove.

1.8 On R–14 valves, place the diaphragm in the service port making sure it is positioned between the guide ribs. Install the service port cap nut and O-ring, then tighten to 150 lbf·in (1700 N·cm).

1.9 Position the exhaust cover, then install the Phillips head screw. Tighten the screw 25 lbf·in (280 N·cm).

2. Install the relay valve on the vehicle following the instructions in **Subject 120**.

3. Test the valve following the instructions in **Subject 110**.

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## Specifications

| Torque Values | |
|---|---|
| **Description** | **Torque: lbf·in (N·cm)** |
| Valve Cover Capscrews | 80–120 (900–1360) |
| Valve Mounting Capscrews | 132–180 (1500–2040) |
| Service Port Cap Nut | 150 (1700) |
| Phillips Screw, No. 10–24 | 25 (280) |

**Table 1, Torque Values**

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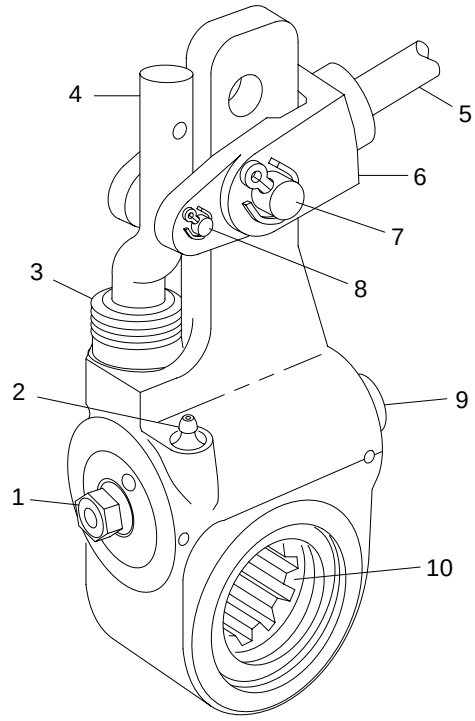
## General Information

The Gunite automatic slack adjuster has two main functions:

- As a lever it converts the straight-line force of the brake chamber push rod to torque on the brake camshaft. Rotation of the camshaft forces the brake shoes against the drum.
- As an automatic slack adjuster, it maintains the lining-to-drum clearance needed for proper brake chamber push rod stroke.

The slack adjuster is installed between the brake chamber push rod and the brake camshaft. A clevis connects the brake chamber push rod to the top of the slack adjuster. See **Fig. 1**. The bottom of the slack adjuster is splined to the brake camshaft. The splines hold the slack adjuster internal gear to the camshaft, so the camshaft turns when the slack adjuster moves. When the brakes are applied, the brake chamber push rod moves outward forcing the slack adjuster and camshaft to rotate. This movement forces the brake shoes against the drum.

The brakes are adjusted when the slack adjuster senses an increase in the lining-to-drum clearance. The slack adjuster's internal worm shaft and ratchet shorten excessive lining-to-drum clearance. This provides maximum leverage for the brake chamber push rod. The automatic slack adjuster adjusts the brakes at the beginning of the brake application.




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1. 7/16-Inch Adjusting Hexnut
2. Grease Fitting
3. Boot
4. Link
5. Brake Chamber Push Rod
6. Clevis
7. 1/2-Inch Clevis Pin
8. 1/4-Inch Clevis Pin
9. Grease Relief Opening
10. Slack Adjuster Spline

**Fig. 1, Gunite Slack Adjuster**

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## Safety Precautions

When working on or around a vehicle, observe the following precautions:

- Park the vehicle on a level surface, apply the parking brakes, and shut down the engine. Chock the tires.
- If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning any work on the vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters, which may apply as air pressure drops.
- Disconnect the batteries.
- Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
- Never exceed recommended air pressure.
- Always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
- Do not remove, disassemble, assemble, or install a component until you have read and understand the service procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use the correct tools and observe all precautions pertaining to use of those tools.
- Replacement hardware, tubing, hose, fittings, etc., should be the equivalent size, type, length, and strength of the original equipment.
- Make sure when replacing tubes or hoses that all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace devices with stripped threads or damaged parts. Repairs requiring machining should not be attempted.
- Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

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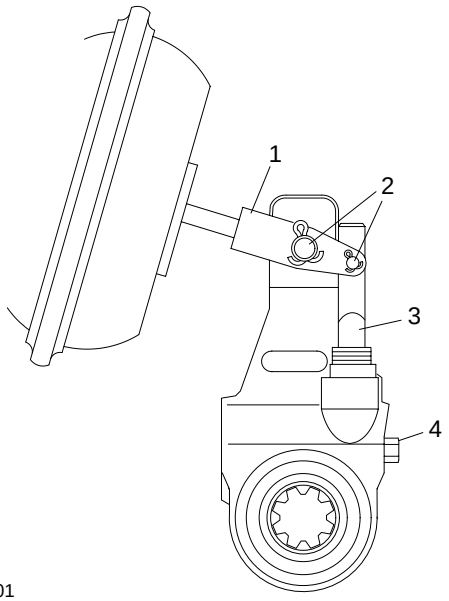
## Slack Adjuster Removal and Installation

**⚠ WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

IMPORTANT: This automatic slack adjuster cannot be rebuilt. If it is damaged or inoperative, replace the unit.

The factory installed brake chambers have welded clevises on the pushrod. See **Fig. 1**. On replacement brake chambers, the clevis is threaded onto the pushrod, and has a jam nut installed. See **Fig. 2**.



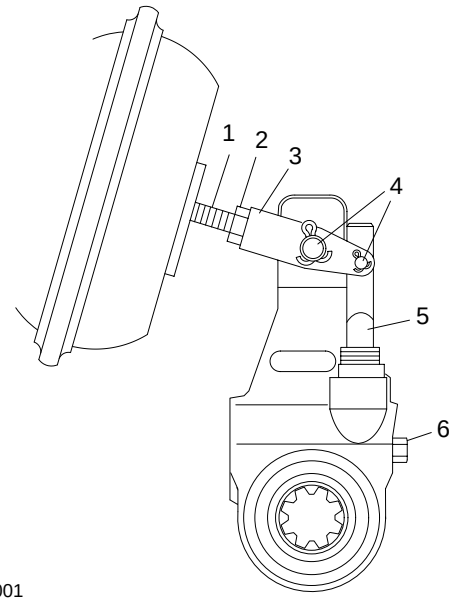

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1. Brake Chamber Pushrod and Clevis Assembly
2. Cotter Pins and Clevis Pins
3. Link
4. Adjusting Hexnut

**Fig. 1, Slack Adjuster (attached to welded clevis)**

## Removal

1. Park the vehicle on a level surface, and chock the tires. If you are removing a rear slack adjuster, cage the parking brake power spring. For instructions, refer to the applicable brake chamber section in this group.
2. Remove the cotter pins and clevis pins.




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1. Brake Chamber Pushrod (threaded)
2. Jam Nut
3. Threaded Clevis
4. Cotter Pins and Clevis Pins
5. Link
6. Adjusting Hexnut

**Fig. 2, Slack Adjuster (attached to threaded clevis)**

3. Rotate the adjusting hexnut counterclockwise until the slack adjuster clears the clevis.
4. Remove the snap ring from the brake camshaft, then slide the slack adjuster off the camshaft.

## Installation

IMPORTANT: For brake chambers that have pushrods with threaded clevises, measure the pushrod length before installing the new slack adjuster. With the brakes fully released, and no air pressure to the chamber, check the dimension between the chamber face and the centerline of the 1/2-inch clevis pin hole. It should be 2.25 inches (57 mm) for long stroke chambers, and 2.75 inches (70 mm) for standard stroke chambers.

There is a difference between the clevis pin spacing for Gunite slack adjusters used with standard stroke chambers and long stroke

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## Slack Adjuster Removal and Installation

chambers. These two slack adjusters are **not** interchangeable.

- The pin-to-pin dimension on standard stroke slack adjusters is 1.0 inch (2.54 cm).
- The pin-to-pin dimension on long stroke chambers is 1.3 inches (3.3 cm).

1. Coat the camshaft splines, and the splines of the slack adjuster gear with an anticorrosive grease.
2. Using the old snap ring, install the automatic slack adjuster on the brake camshaft.
3. Turn the adjusting hexnut clockwise to rotate the slack adjuster toward the brake chamber until the holes line up.
4. Install the clevis pins and cotter pins.

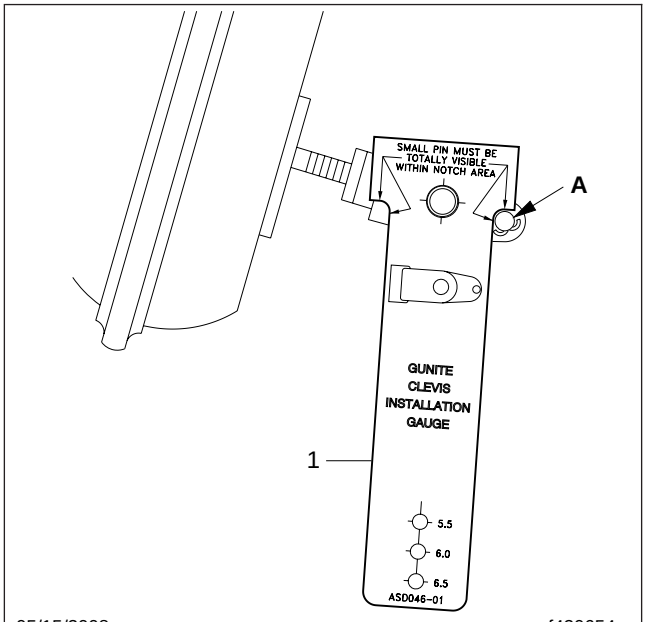
**⚠ WARNING**

**Manually adjusting an automatic slack adjuster to bring the pushrod stroke within legal limits is likely masking a mechanical problem. Adjustment is not repairing. Before adjusting an automatic slack adjuster, troubleshoot the foundation brake system and inspect it for worn or damaged components. Improperly maintaining the vehicle braking system may lead to brake failure, resulting in property damage, personal injury, or death.**

5. If the pushrod has a threaded clevis, use the gauge supplied with the new slack adjuster to check the adjustment of the clevis. See **Fig. 3**.
   - 5.1 Position the 1/2-inch hole in the gauge over the end of the 1/2-inch clevis pin.
   - 5.2 Align the applicable 1/4-inch hole in the bottom of the gauge over the center of the camshaft.
   - 5.3 Check that the 1/4-inch pin is visible in the notched area of the gauge. If the pin is not in the right location, back off the slack adjuster and readjust the pushrod length, then repeat this step.

NOTE: Make sure there is clearance between the slack adjuster and other vehicle components when the brakes are applied and the pushrod travels its maximum stroke.

6. Set the initial free-stroke.




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A. Adjust the clevis in or out to position the 1/4-inch clevis pin within the notched area of the gauge.

1. Installation Gauge

**Fig. 3, Checking the Clevis Adjustment**

   - 6.1 Turn the adjusting hexnut clockwise until the brake linings contact the drum.
   - 6.2 Turn the adjusting hexnut counterclockwise one-half turn. There should be about 30 lbf·ft (41 N·m) resistance, and a ratcheting sound will be heard.

7. Measure the brake chamber applied stroke.
   - 7.1 With the brakes fully released, use a ruler to measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 4**.
   - 7.2 Build air pressure to at least 85 psi (586 kPa). Apply the brakes, then measure the distance from the bottom of the brake chamber to the center of the large clevis pin. See **Fig. 4**. The difference between the measurements is the brake chamber stroke.
   - 7.3 The brake chamber stroke must be within the range shown in **Table 1**. If it is not, check the foundation brakes for problems such as worn cams, bushings, pins and

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rollers, or broken springs. Repair or replace as needed. For instructions, refer to the applicable brake section in this group. Then, repeat the two previous steps.

8. If a rear axle slack adjuster was installed, manually uncage the parking brake. Refer to the applicable brake chamber section in this group for instructions.
9. Apply the parking brakes.
10. Remove the chocks from the tires.
11. In a safe area, check for proper brake operation, as follows.
    - 11.1 Apply and release the brakes several times to check for correct operation of the slack adjusters.
    - 11.2 Perform six low-speed stops to ensure correct parts replacement and full vehicle control.
    - 11.3 Immediately after doing the above stops, check the drum temperatures. Any drums that are significantly cooler than the others show a lack of braking effort on those wheels.

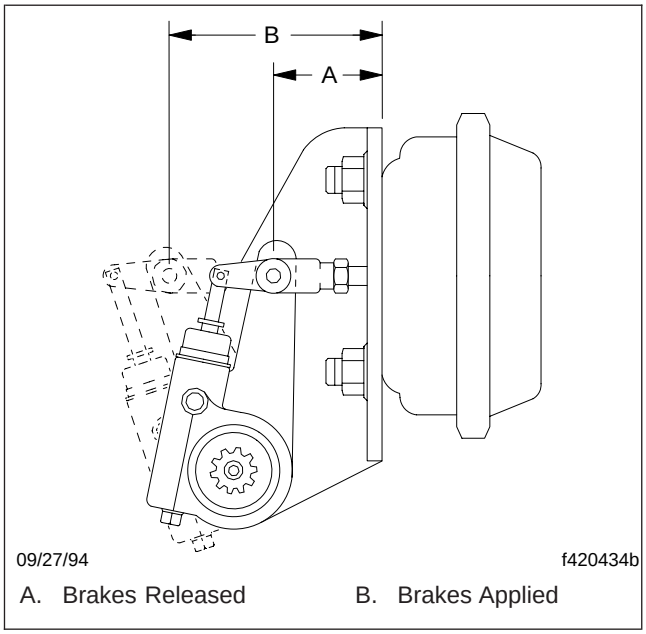



**Fig. 4, Make these Measurements**

| Brake Chamber Stroke Specifications | | | |
|---|---|---|---|
| Chamber Type (Size) | Maximum Applied Stroke*: inch (mm) | Free-Stroke: inch (mm) | |
| | | New Brake Installation | In-Service Brake |
| Standard Stroke | | 5/8 to 3/4 (16 to 19) | 1/2 to 5/8 (13 to 16) |
| 16 | 1-1/2 (38) | | |
| 20 and 24 | 1-3/4 (44) | | |
| 30 | 2 (51) | | |
| 36 | 2-1/2 (64) | | |

* Specifications are relative to a brake application with 80–90 psi (552–621 kPa) air pressure in the brake chambers.

**Table 1, Brake Chamber Stroke Specifications**

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## Specifications

| Approved Lubricants | |
|---|---|
| **Lubricant Type** | **Temperature** |
| Lubriplate Aero | Above –40°F (–40°C) |
| Texaco Multifak EP–2<br>Mobil Grease 77 | Above –20°F (–29°C) |

**Table 1, Approved Lubricants**

| Brake Chamber Stroke Specifications | | | |
|---|---|---|---|
| **Chamber Type (Size)** | **Maximum Applied Stroke*: inch (mm)** | **Free-Stroke: inch (mm)** | |
| | | **New Brake Installation** | **In-Service Brake** |
| Standard Stroke | | | |
| 16 | 1-1/2 (38) | | |
| 20 and 24 | 1-3/4 (44) | 5/8 to 3/4 (16 to 19) | 1/2 to 5/8 (13 to 16) |
| 30 | 2 (51) | | |
| 36 | 2-1/2 (64) | | |

* Specifications are relative to a brake application with 80–90 psi (552–621 kPa) air pressure in the brake chambers.

**Table 2, Brake Chamber Stroke Specifications**

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## General Information

Double check valves are used in the air brake system to direct a flow of air into a common line from either of two sources, whichever is at the higher pressure.

## Principles of Operation

As pressurized air enters either end of the double check valve inlet port, the moving shuttle responds to the greater pressure source and seals the opposite port. The air flow continues out the delivery port of the valve. The position of the shuttle will reverse if the pressure levels are reversed. Double check valves are designed so the shuttle cannot interfere with the backflow of air in the exhaust mode.

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## Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

1. Chock the tires and stop the engine before working under a vehicle. Dropping air system pressure may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters; they will apply as air pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs, and injury can result if they are not correctly disassembled. Use only the correct tools, and observe all precautions regarding use of those tools.

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## Operating Test

IMPORTANT: Before working on or around air brake systems and components, review Safety Precautions, **Subject 100**.

Perform the following test after repairing or replacing the DV–2 valve to ensure that the valve is functioning properly.

With the system charged, apply the brakes several times. Each time the brakes are applied, an exhaust of air should occur from the exhaust port of the drain valve. If no air comes out, push the wire stem located inside the exhaust port. If no air comes out after pushing the wire stem, there may be a plugged filter in the adapter, which should be replaced.

If the drain valve does not function properly, repair or replace it following instructions in this section.

## Leakage Test

Perform the following test after repairing or replacing the DV–2 valve to ensure that the valve is functioning properly.

With the system charged and pressure stabilized in the system, there should be no leaks at the drain valve exhaust port. A constant slight exhaust of air at the drain valve exhaust port could be caused by excessive leakage in the air brake system.

If the drain valve is leaking excessively, repair or replace it following instructions in this section.

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# Double Check Valve Disassembly, Cleaning and Inspection, and Assembly

## Disassembly

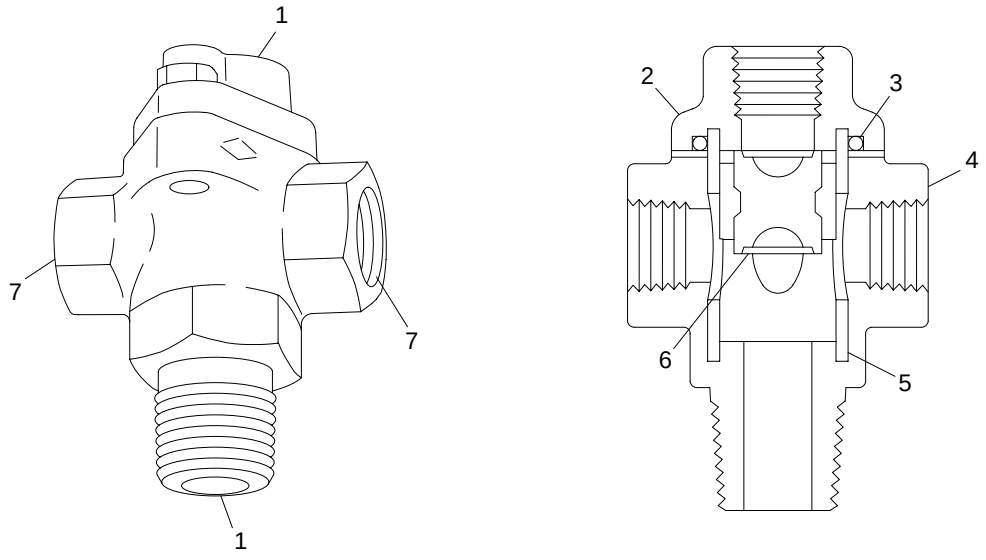
1. Remove the valve from the vehicle.
2. Remove the end cap from the valve. See **Fig. 1**.
3. Remove the O-ring.
4. Remove the shuttle valve and shuttle guide.

## Cleaning and Inspection

1. Clean all metal parts in a cleaning solvent.
2. Inspect all metal parts for signs of cracks, wear, or deterioration. Replace all parts not considered serviceable.
3. Replace all rubber parts.

## Assembly

1. Install the shuttle valve and shuttle guide in the valve body.
2. Coat the O-ring with BW 650M silicone lubricant (BW 291126). It is not necessary to lubricate the shuttle valve.
3. Install the O-ring.
4. Install the end cap on the valve body.
5. Install the valve on the vehicle.




1. Supply Port
2. End Cap
3. O-Ring
4. Valve Body
5. Shuttle Guide
6. Shuttle Valve
7. Delivery Port

**Fig. 1, Double Check Valve**

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See **Fig. 1** for a vehicle equipped with a single hand control valve. See **Fig. 2** for a vehicle without a TPV or hand control valve. See **Fig. 3** for a vehicle without a TPV, but equipped with a hand control valve. See **Fig. 4** for a vehicle equipped with a dual hand control valve.

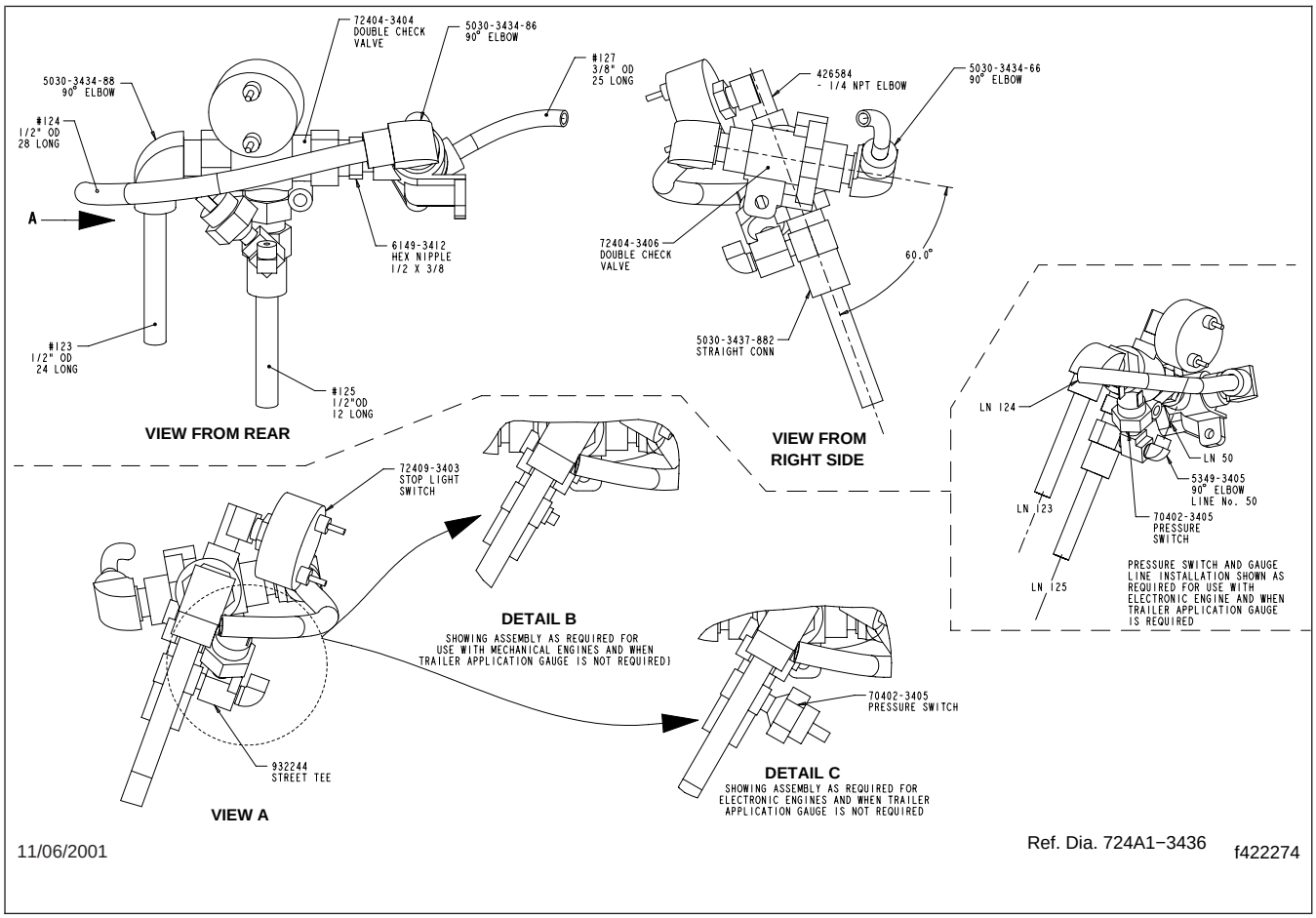



**Fig. 1, Tractor or Truck/Tractor Equipped with a Single Hand Control Valve**

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## Specifications

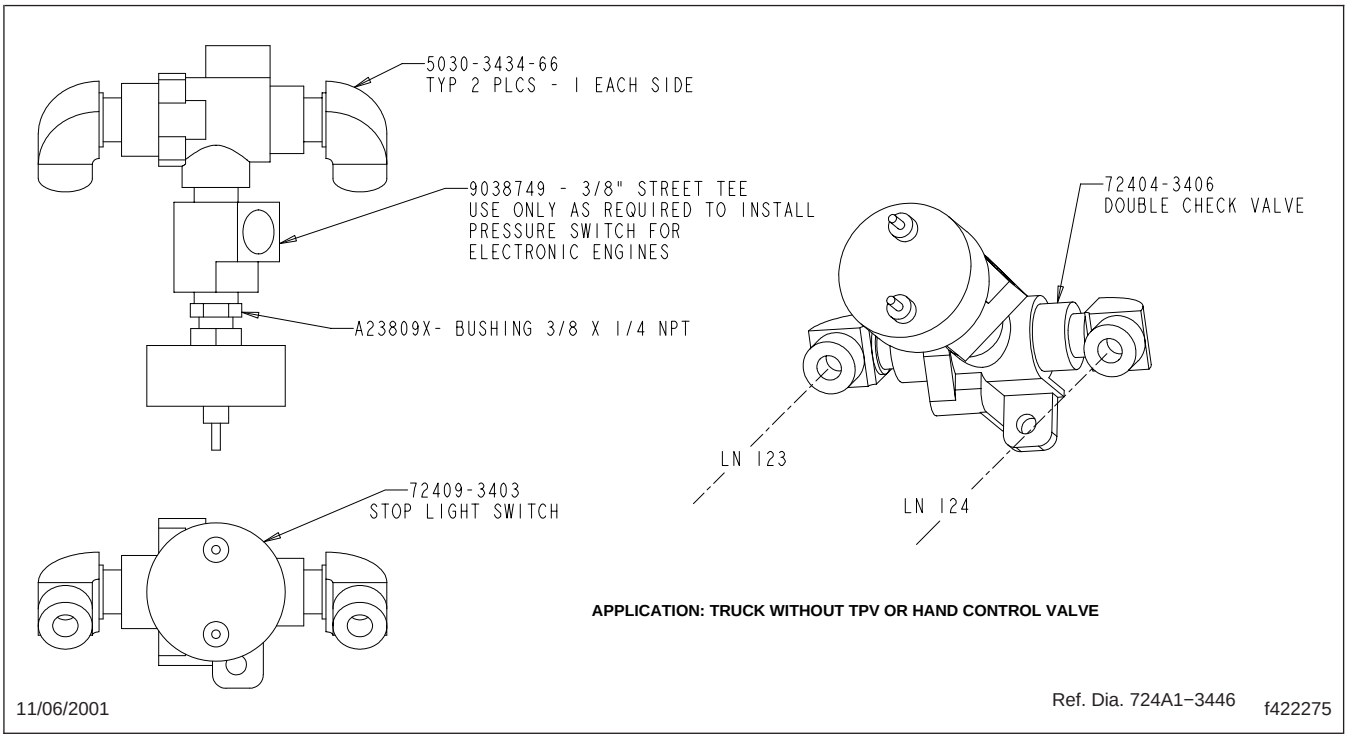



**Fig. 2, Truck Without TPV or Hand Control Valve**

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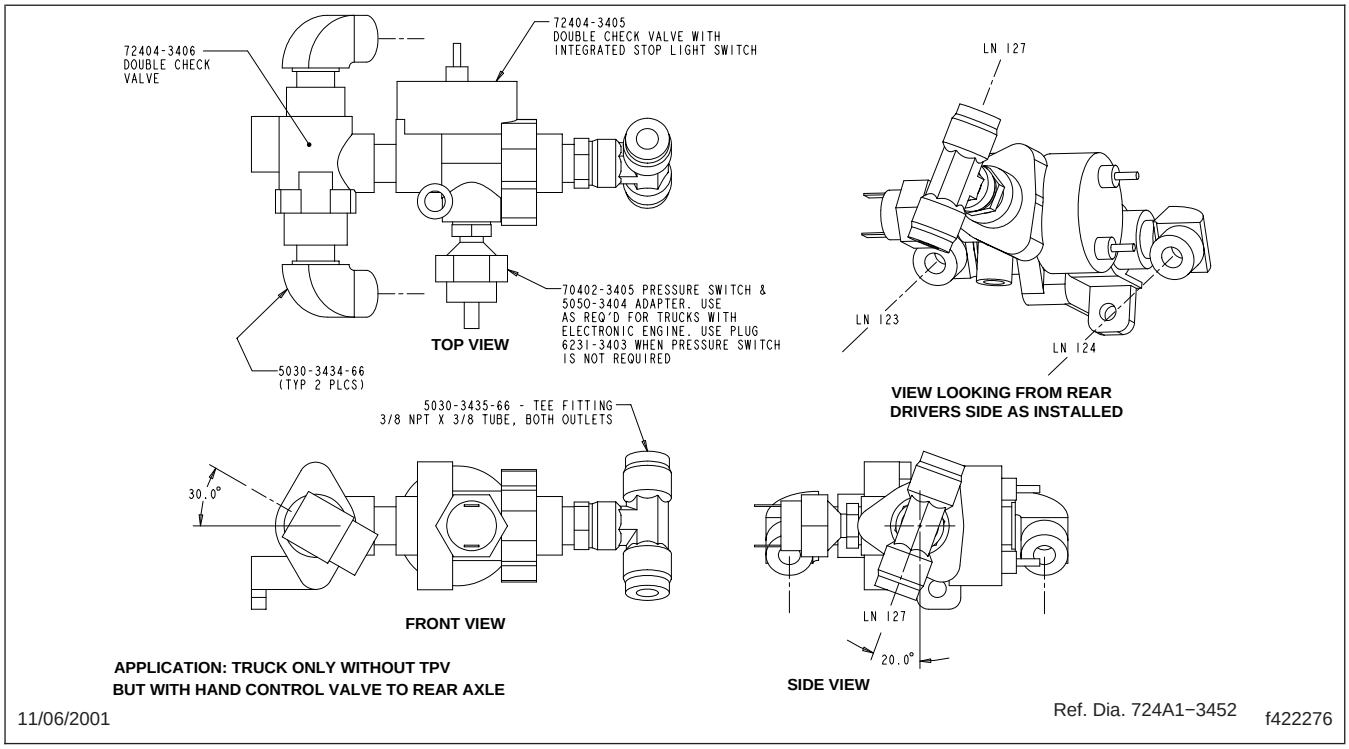



**Fig. 3, Truck Only Without TPV but with Hand Control Valve to Rear**

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## Specifications

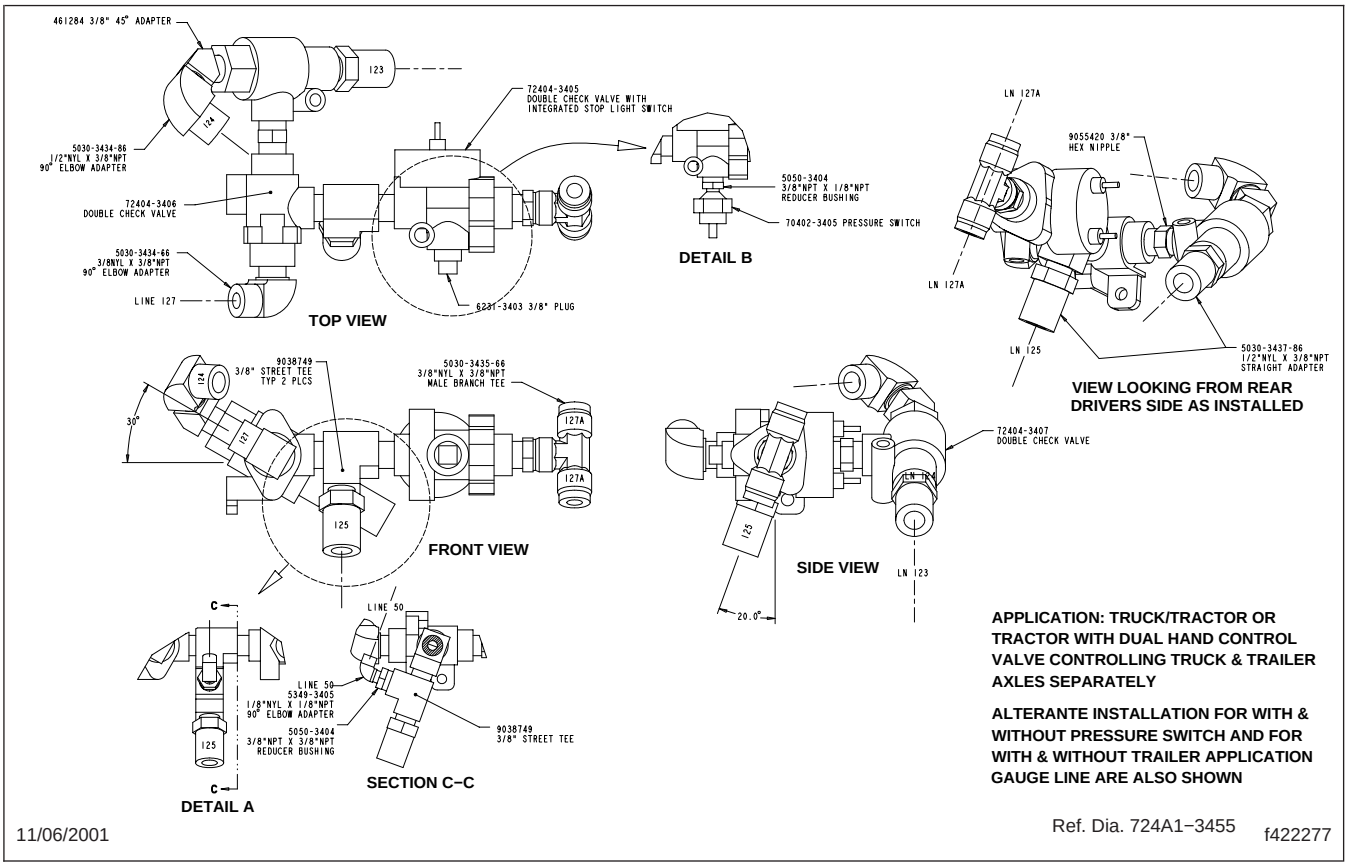


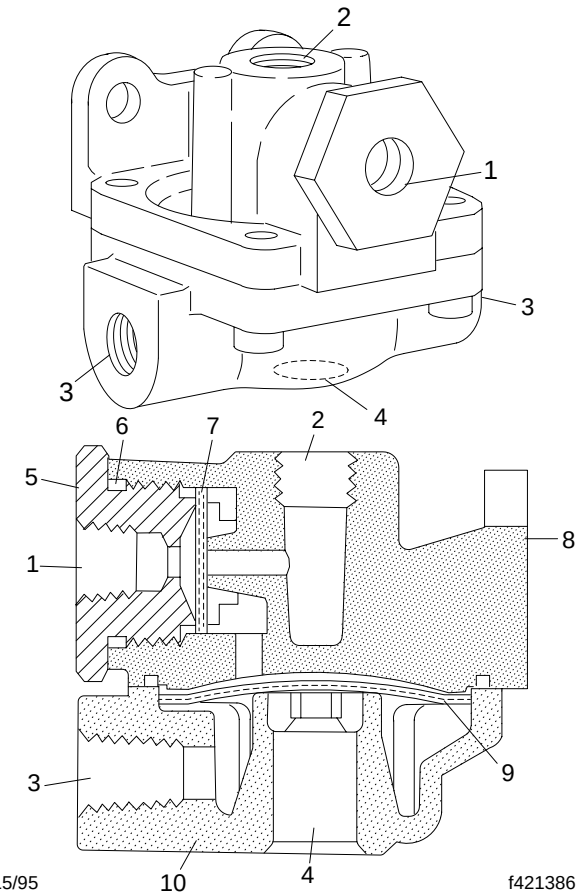

**Fig. 4, Truck/Tractor with Dual Hand Control Valve Controlling Truck and Trailer Separately**

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## General Information

The QR–1C quick release valve (**Fig. 1**) is a dual function valve. Its primary function is to speed up the release of air pressure from the service brake chambers. Additionally, the valve works as an anti-compound device. The double check valve feature prevents a service and parking brake application from occuring at the same time.




1. Supply Port
2. Balance Port
3. Delivery Port
4. Exhaust
5. Cap Nut
6. Sealing Ring
7. Double Check Diaphragm
8. Body
9. Quick Release Diaphragm
10. Cover

**Fig. 1, QR–1C Valve and Cross Section**

The QR–1C valve is generally mounted near the rear axle. A balance line from the relay valve delivery port (port 2 on the WABCO combination valve) is connected to the balance port on top of the QR–1C quick release valve; the two side ports are for brake chamber connections; the supply port is connected to the delivery port of the parking brake control valve, and the exhaust port is located at the bottom of the valve.

## Principles of Operation

### Parking Brakes Released

When the parking brakes are released, air from the parking brake control valve flows through the QR–1C valve. This forces the double check diaphragm and the quick release diaphragm to flex and seal the balance and exhaust ports. Air flows into the inlet ports of the parking brake chambers from the QR–1C valve delivery ports.

### Parking Brakes Applied

When the parking brakes are applied, supply line air pressure to the QR–1C valve is exhausted through the parking brake control valve. As air pressure is exhausted from one side of the double check diaphragm and the quick release diaphragm, both diaphragms flex in the opposite direction to open the balance and exhaust ports. Parking brake pressure is released at the exhaust port of the QR–1C valve while a small amount of air trapped between the two diaphragms is released through a relay valve or the foot valve exhaust port.

### Anti-Compounding

When a service brake application is made with the parking brakes applied, service air enters the balance port and flows through the QR–1C valve into the inlet ports of the parking brake chambers. This prevents application of the service and parking brakes at the same time. Service air passing through the QR–1C valve flexes the double check and quick release diaphragms, sealing the supply and exhaust ports. When the service brake application is released, air is exhausted from the parking brakes.

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## Safety Precautions

When working on or around air brake systems and components, observe the following precautions.

1. Chock the tires and stop the engine before working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters; they may apply as air system pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use only proper tools and observe all precautions pertaining to use of those tools.

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## QR–1C Quick Release Valve Operating and Leakage Tests

# Operating and Leakage Tests

**⚠ WARNING**

**Before working on or around air brake systems and components, review the safety precautions in Subject 100. Failure to do so could result in personal injury.**

The following tests should also be performed after repairing or replacing the QR–1C valve to ensure that it is functioning properly.

1. Chock the tires.
2. Drain the air system.
3. Release the parking brakes.
4. Remove the air line from the valve balance port. Build system air pressure to 120 psi (827 kPa). Coat the exhaust and balance ports with a soap solution; leakage of a one-inch bubble in five seconds at either port is allowable. Install the air line at the balance port.
5. Apply the parking brakes. Step on the foot brake; the QR–1C valve should exhaust air at the exhaust port.
6. Drain the air system.
7. Remove the air line from the valve supply port. Build system air pressure to 120 psi (827 kPa). With the foot valve depressed, coat the supply port and the seam between the body and cover with a soap solution; leakage of a one-inch bubble in 5 seconds at the supply port is allowable. No leakage between the body and cover is permitted. Install the air line at the supply port.
8. If the valve does not function properly, or if leakage is excessive, repair or replace it following the instructions in this section.

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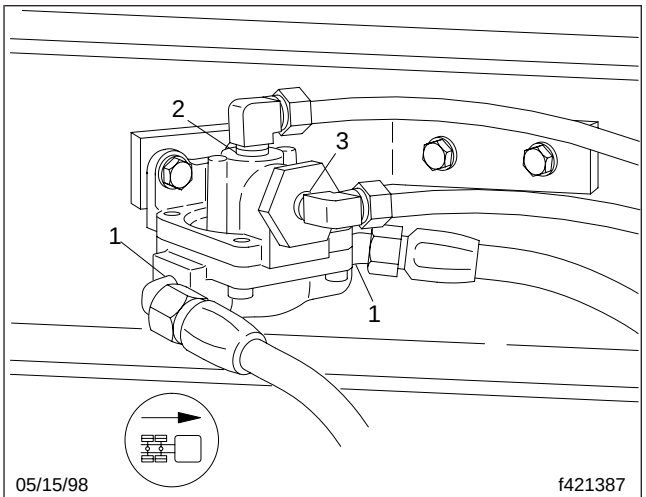
# QR–1C Quick Release Valve Removal and Installation

## Removal

**WARNING**

**Before working on or around air brake systems and components, review the safety precautions in Subject 100. Failure to do so could result in personal injury.**

1. Chock the tires or hold the vehicle by means other than air brakes.
2. Drain the air brake system.
3. Mark and disconnect the air lines from the quick release valve. See **Fig. 1**.
4. Remove the mounting bolts and the valve.




NOTE: Valve mounting inside the left frame rail shown. Plumbing and location will vary depending on vehicle configuration.

1. Delivery Port
2. Balance Port
3. Supply Port

**Fig. 1, QR–1C Valve Mounting**

## Installation

**WARNING**

**Before working on or around air brake systems and components, review the safety precautions in Subject 100. Failure to do so could result in personal injury.**

1. Install the quick release valve with the exhaust port facing down. See **Fig. 1**. Securely tighten the mounting bolts.
2. Connect the air lines to the quick release valve in the locations previously marked.
3. Perform the operating and leakage tests in **Subject 110**.

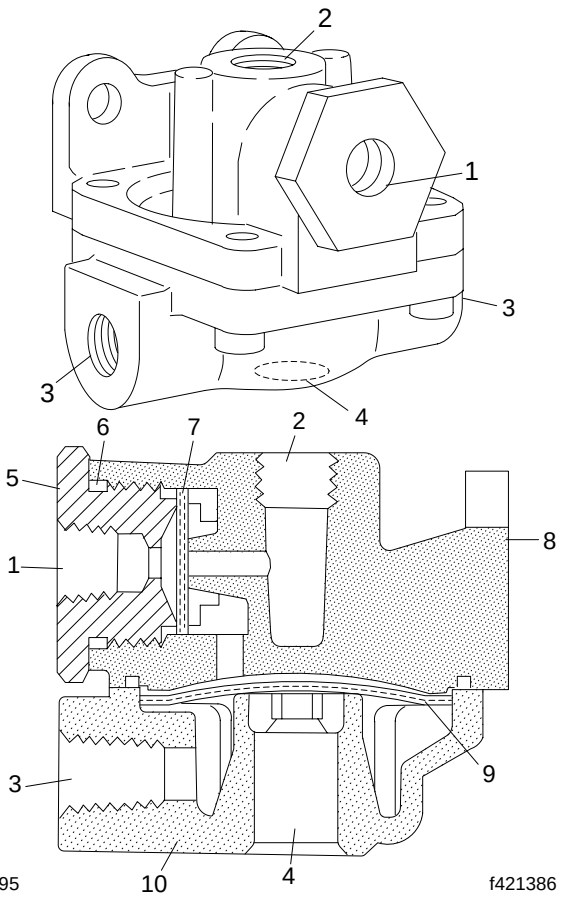
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# QR–1C Quick Release Valve Disassembly, Cleaning and Inspection, and Assembly

## Disassembly

1. Remove the quick release valve from the vehicle following the instructions in **Subject 120**.
2. Mark the valve body and cover for ease of installation.
3. Remove the cap nut at the supply port. See **Fig. 1**. Remove the sealing ring from the cap nut.




1. Supply Port
2. Balance Port
3. Delivery Port
4. Exhaust
5. Cap Nut
6. Sealing Ring
7. Double Check Diaphragm
8. Body
9. Quick Release Diaphragm
10. Cover

**Fig. 1, QR–1C Valve and Cross Section**

4. Remove the double check diaphragm.
5. Remove the four screws holding the valve cover on the valve body.
6. Separate the cover from the body and remove the sealing ring and the quick release diaphragm.

## Cleaning and Inspection

1. Clean all metal parts in mineral spirits. Wipe all rubber parts clean.
2. It is recommended that all rubber parts and any other part showing signs of wear or deterioration be replaced with genuine Bendix parts.

## Assembly

1. Install the sealing ring on the cap nut.
2. Install the double check diaphragm in the valve body.
3. Install the cap nut. Tighten the nut 150 to 400 lbf·in (1700 to 4520 N·cm).
4. Install the quick release diaphragm in the cover.
5. Install the valve cover on the body. Tighten the screws 30 to 60 lbf·in (340 to 680 N·cm) evenly and securely.
6. Install the quick release valve, following the instructions in **Subject 120**.
7. Do the operating and leakage test as instructed in **Subject 110**.

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## General Information

The following tables are legends for all air line diagrams in this section.

See **Table 1** for air line number descriptions. See **Table 2** for a line size legend. See **Table 3** for a valve port legend.

NOTE: Single lines in the plumbing diagrams denote fixed air lines (nylon, braided hose, copper). Double lines denote flexible drop lines.

| Air Line Reference Numbers Legend | |
|---|---|
| **No.** | **Description** |
| 1 | Compressor |
| 2 | Governor |
| 3 | Reservoir—Supply |
| 4A | Reservoir—"A" |
| 4B | Reservoir—"B" |
| 4C | Reservoir—"C" |
| 4D | Reservoir—"D" |
| 5 | Reservoir—"EXTRA" |
| 6 | Brake Valve |
| 7 | Chamber, Service, Wedge |
| 8 | Chamber, Service, Park, Cam |
| 9 | — |
| 10 | Relay Valve Dual Supply (5.5 psi Crack) |
| 11 | Relay Valve Single Supply (4.0 psi Crack) |
| 12 | Single Check Valve |
| 13 | Double Check Valve |
| 14 | Quick Release Valve |
| 15 | Frame Tee |
| 16 | Tee |
| 16A | Axle Tee |
| 17 | Park Control Valve-System |
| 18 | Tractor Protection Valve Control—Trailer Air Supply |
| 19 | Tractor Protection Valve |
| 20 | Hand Control Valve |
| 21 | Spring Brake/Inversion Valve |
| 22 | ABS Pressure Modulator Valve (PMV) |
| 23 | ABS Anti-spin Valve (ATC) |
| 24 | Air Pressure Gauge, Dual |
| 24A | Air Pressure Gauge, Single |

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## General Information

| Air Line Reference Numbers Legend | |
|---|---|
| **No.** | **Description** |
| 25 | Drain Valve (Spitter Valve) |
| 26 | Drain Cock |
| 27 | Stop Lamp Switch |
| 28 | Air Dryer |
| 29 | Quick Release / Double Check Valve (QR-1C) |
| 30 | Low Pressure Switch |
| 31 | Glad Hand |
| 32 | Cab to Chassis Manifold |
| 33 | Bulkhead Fitting |
| 34 | Front Limiting Valve |
| 35 | — |
| 36 | Pressure Relief Valve |
| 37 | Pressure Protection Valve |
| 38 | Adjustable Pressure Regulator |
| 39 | Preset Pressure Regulator |
| 40 | Control Valve |
| 41 | Bobtail Valve (BP-R1) |
| 42 | Double Check Valve (DC-4) |
| 43 | Double Check Valve (DS-2) |

**Table 1, Air Line Reference Numbers Legend**

| Line Size Legend | | |
|---|---|---|
| **Symbol** | **Nylon** | **Hose** |
|  f422316 | 1/4 | #4 |
|  f422317 | 3/8 | #6 |
|  f422318 | 1/2 | #8 |

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| Line Size Legend | | |
|---|---|---|
| **Symbol** | **Nylon** | **Hose** |
|  f422319 | 5/8 | #10 |
|  f422320 | 3/4 | #12 |
|  f422321 | 3/4 Copper | |
|  f422322 | 1/8 | — |

**Table 2, Line Size Legend**

| Port Legend | |
|---|---|
| **Symbol** | **Description** |
| S | Supply |
| D | Delivery |
| C | Control |
| E | Exhaust |
| R | Reservoir |
| A | Accessory |

**Table 3, Port Legend**

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# Cab Air Line Schematics, Tractor or Truck/Tractor With Dual Hand Controls

The air line schematics in this subject apply to tractors or truck/tractors with dual hand controls.

See **Fig. 1** for the cab air line schematic for tractors or truck/tractors with three valve park brake, and with anti-compounding valve.

See **Fig. 2** for the cab air line schematic for tractors or truck/tractors with three valve park brake, and without anti-compounding valve.

See **Fig. 3** for the cab air line schematic for tractors or truck/tractors with dual valve park brake, and with anti-compounding valve.

See **Fig. 4** for the cab air line schematic for tractors or truck/tractors with dual valve park brake, and without anti-compounding valve.

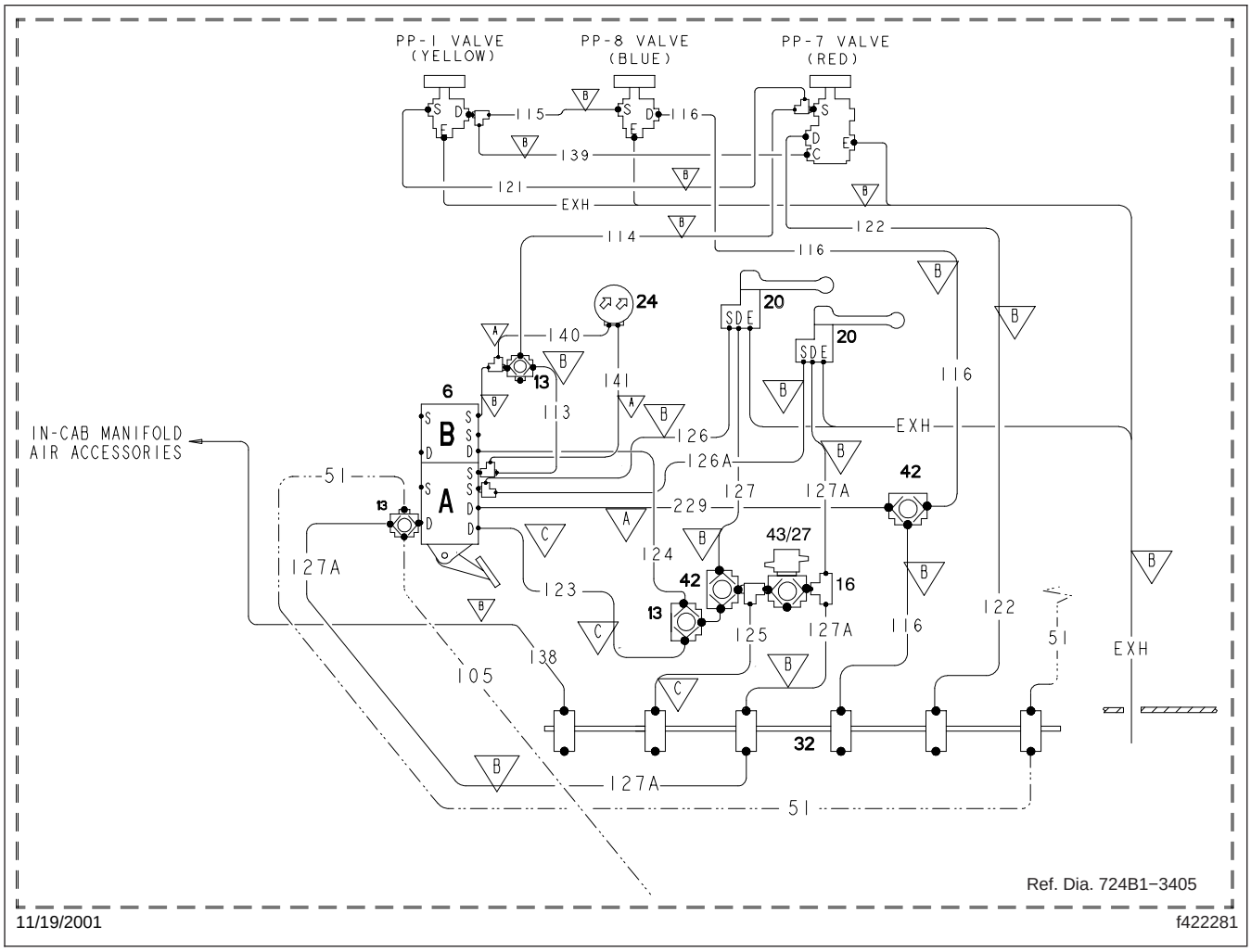



**Fig. 1, Cab Air Line Schematic, Tractor or Truck/Tractor With Three Valve Park Brake, With Anti-Compounding**

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## Cab Air Line Schematics, Tractor or Truck/Tractor With Dual Hand Controls

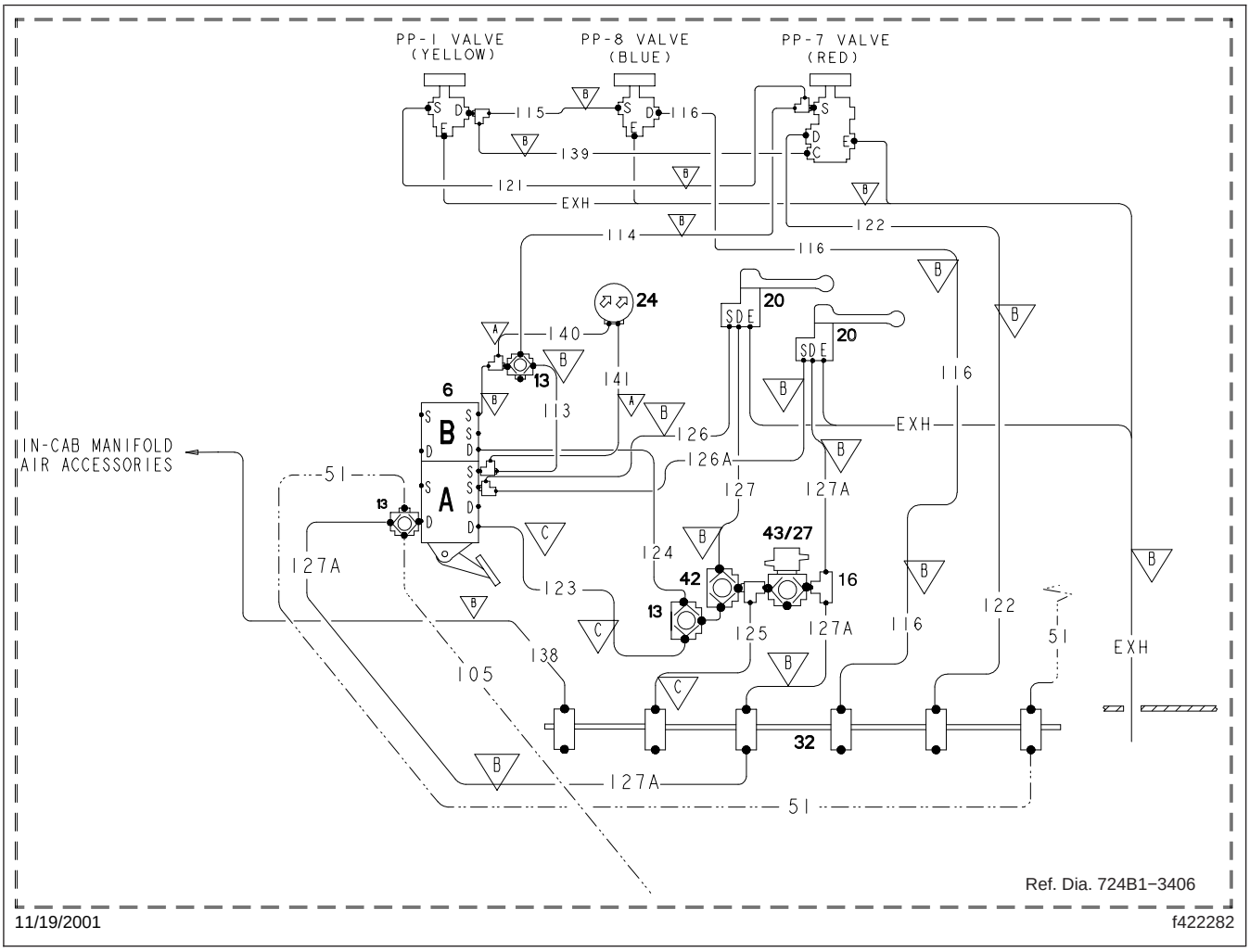



**Fig. 2, Cab Air Line Schematic, Tractor or Truck/Tractor With Three Valve Park Brake, Without Anti-Compounding**

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## Cab Air Line Schematics, Tractor or Truck/Tractor With Dual Hand Controls

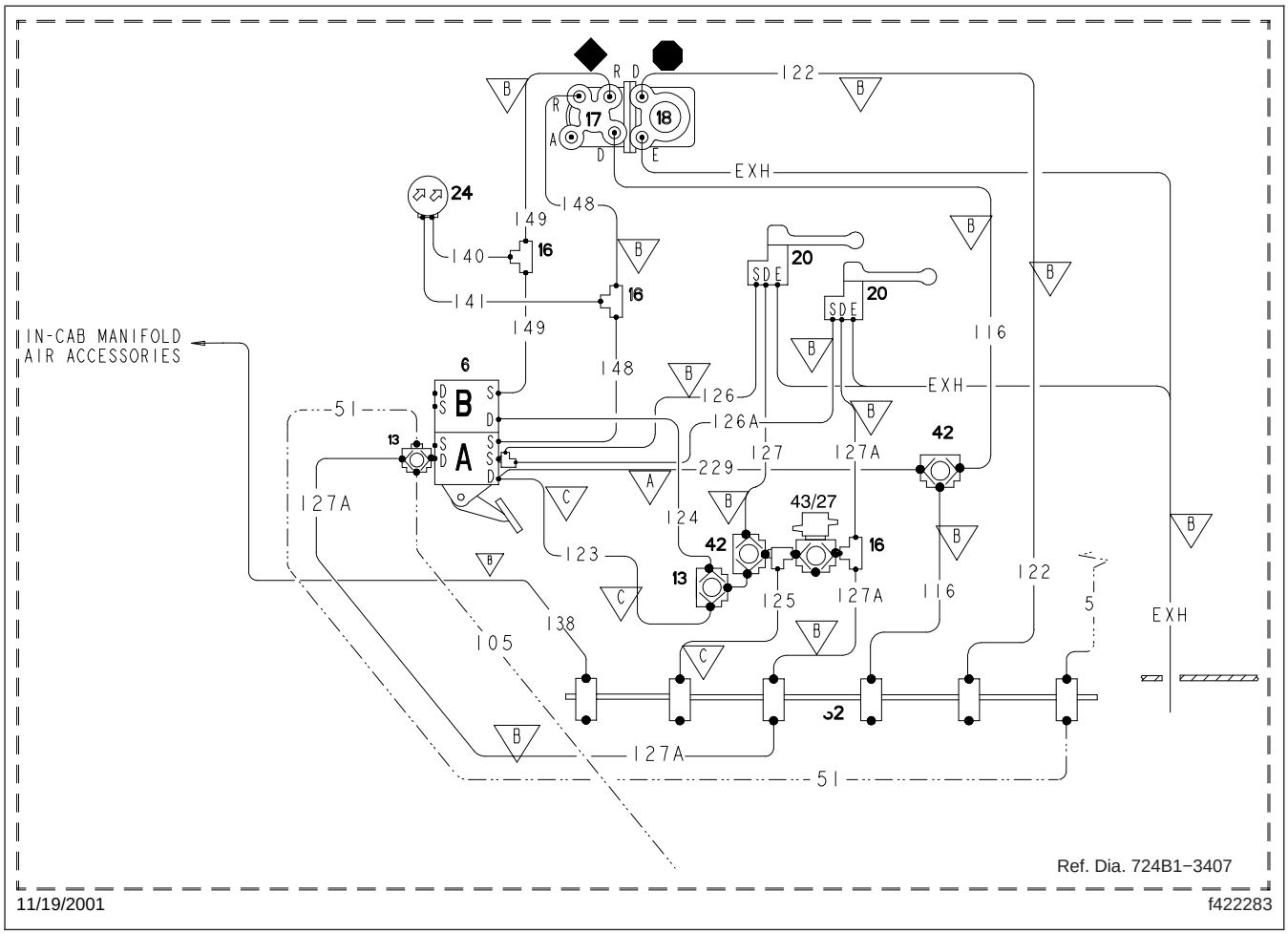



**Fig. 3, Cab Air Line Schematic, Tractor or Truck/Tractor With Dual Valve Park Brake, Without Anti-Compounding**

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## Cab Air Line Schematics, Tractor or Truck/Tractor With Dual Hand Controls

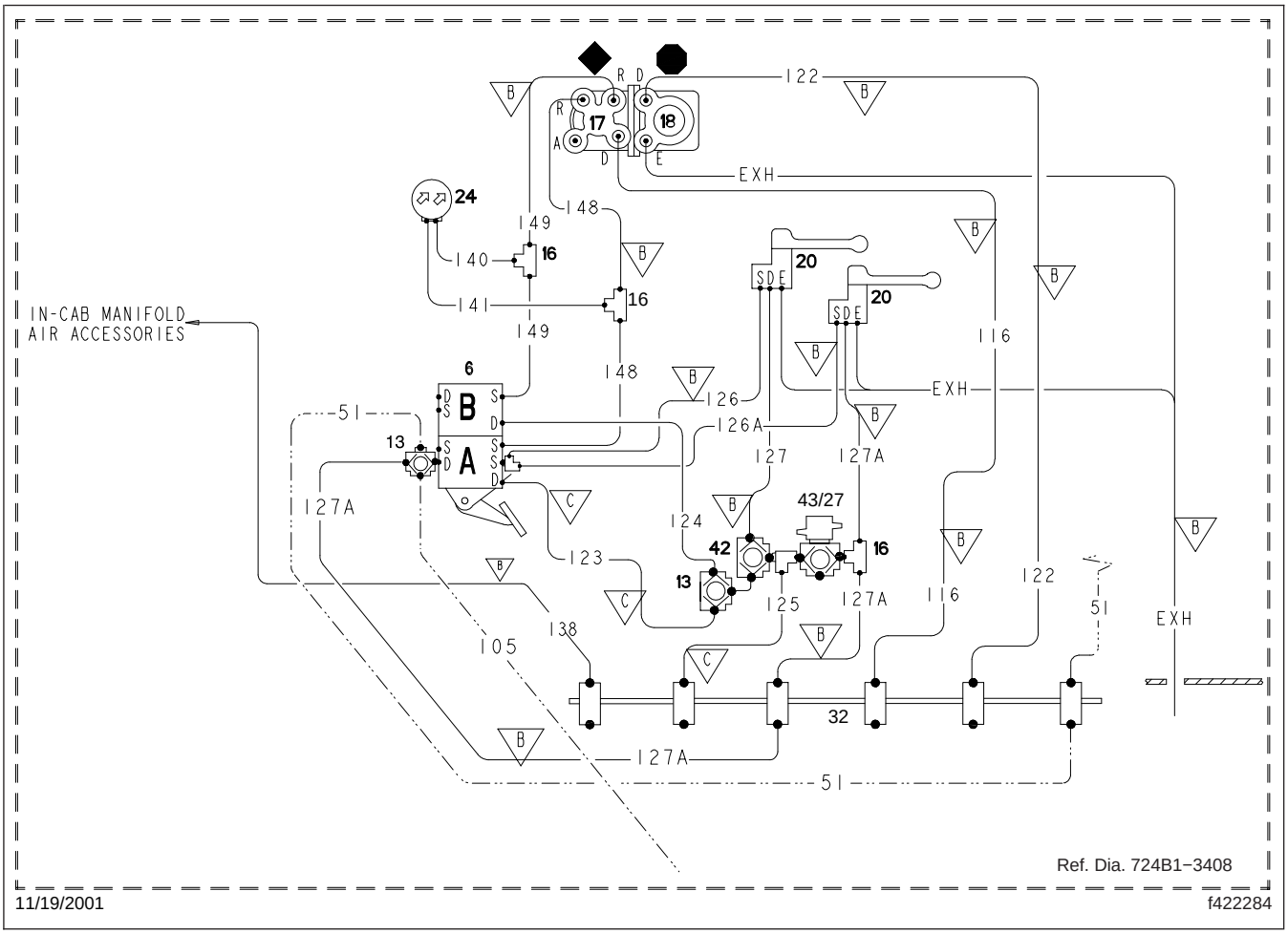



**Fig. 4, Cab Air Line Schematic, Tractor or Truck/Tractor With Dual Valve Park Brake, Without Anti-Compounding**

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# Cab Air Line Schematics, Tractor or Truck/Tractor With Single Hand Controls

The air line schematics in this subject apply to tractors or truck/tractors with single hand controls.

See **Fig. 1** for the air line schematic for tractors or truck/tractors with three valve park brake, and with anti-compounding valve.

See **Fig. 2** for the air line schematic for tractors or truck/tractors with three valve park brake, and without anti-compounding valve.

See **Fig. 3** for the air line schematic for tractors or truck/tractors with dual valve park brake, and with anti-compounding valve.

See **Fig. 4** for the air line schematic for tractors or truck/tractors with dual valve park brake, and without anti-compounding valve.

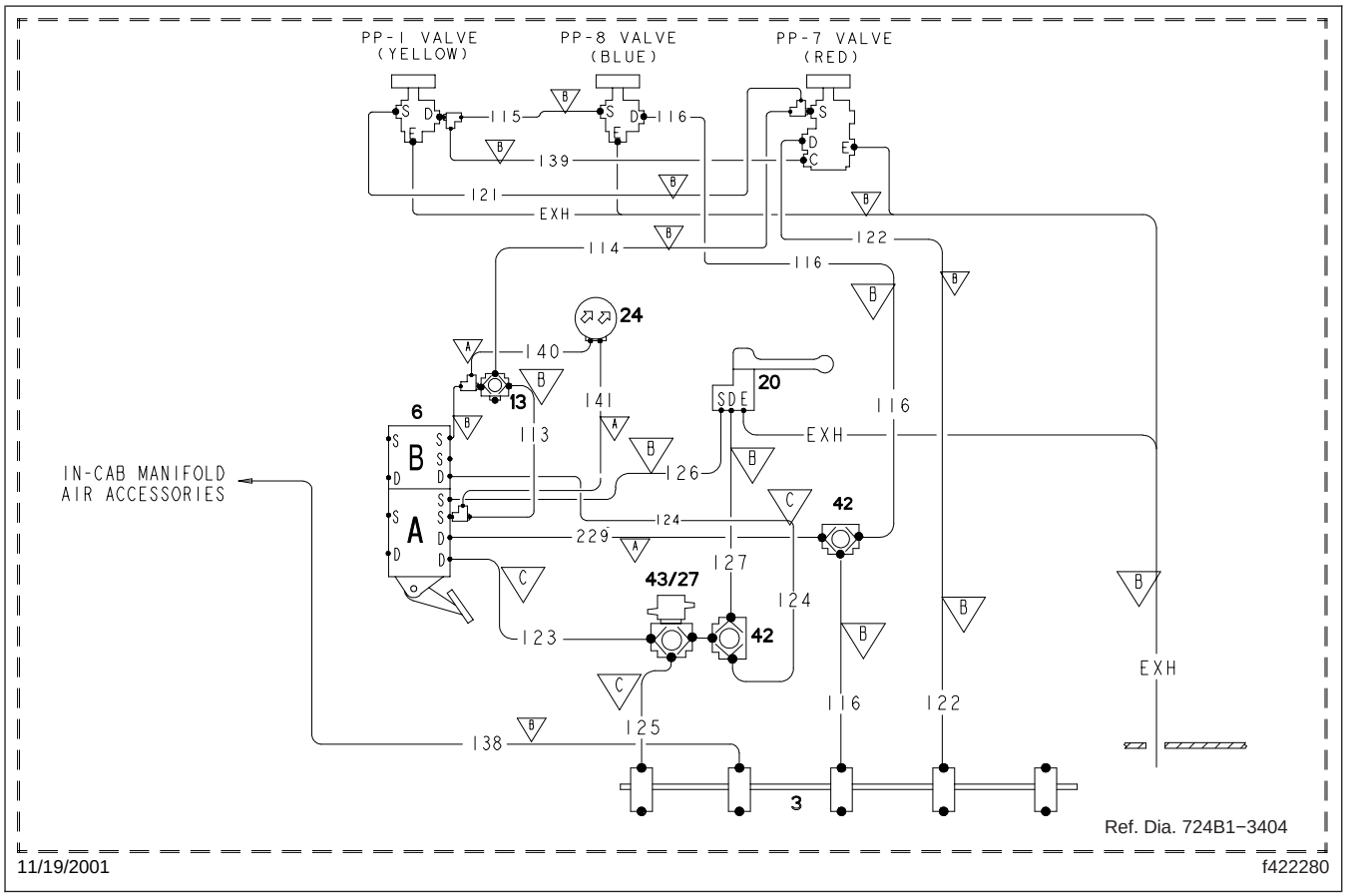



**Fig. 1, Air Line Schematic, Tractor or Truck/Tractor With Three Valve Park Brake, With Anti-Compounding**

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## Cab Air Line Schematics, Tractor or Truck/Tractor With Single Hand Controls

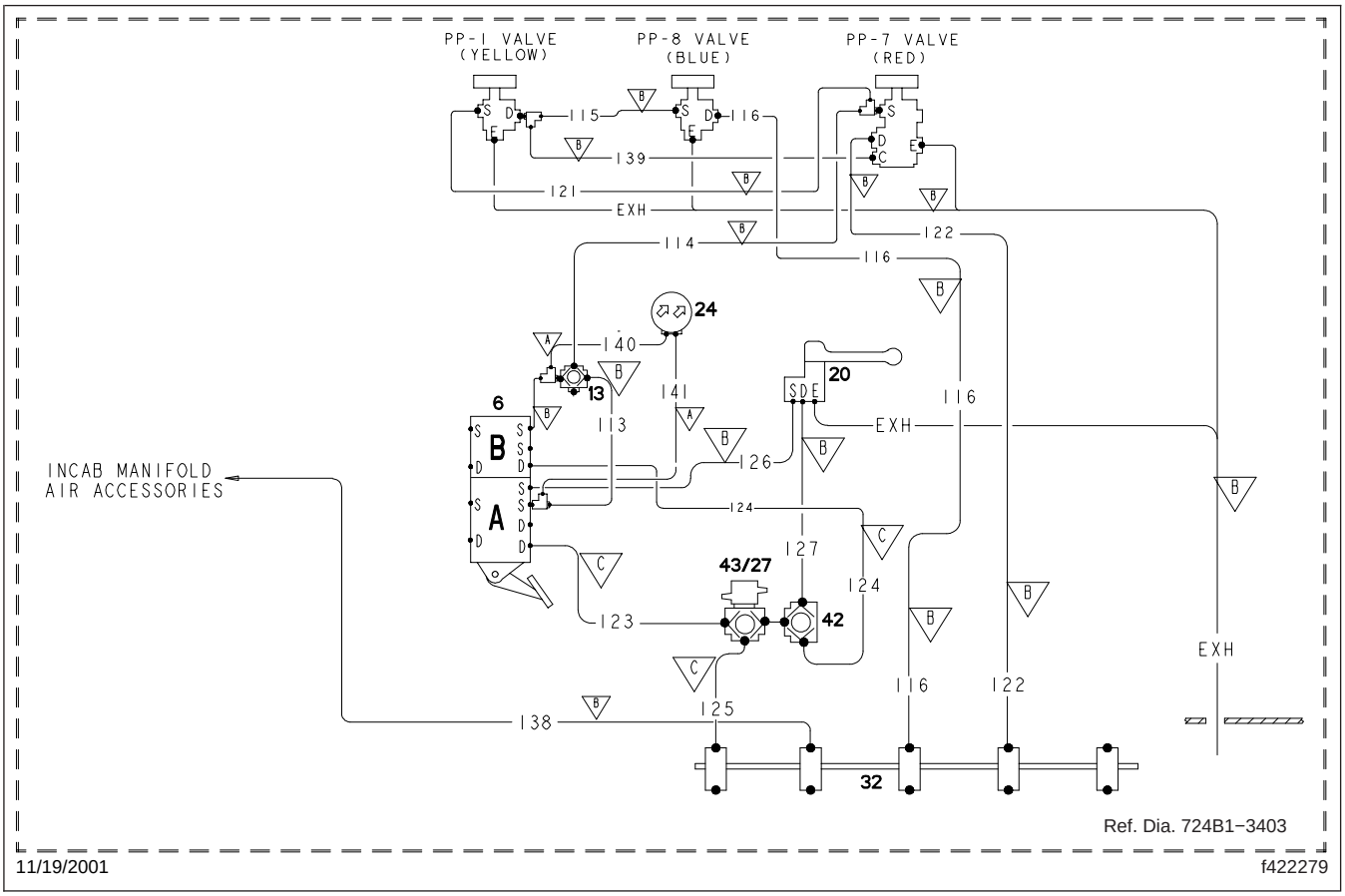



**Fig. 2, Air Line Schematic, Tractor or Truck/Tractor With Three Valve Park Brake, Without Anti-Compounding**

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## Cab Air Line Schematics, Tractor or Truck/Tractor With Single Hand Controls

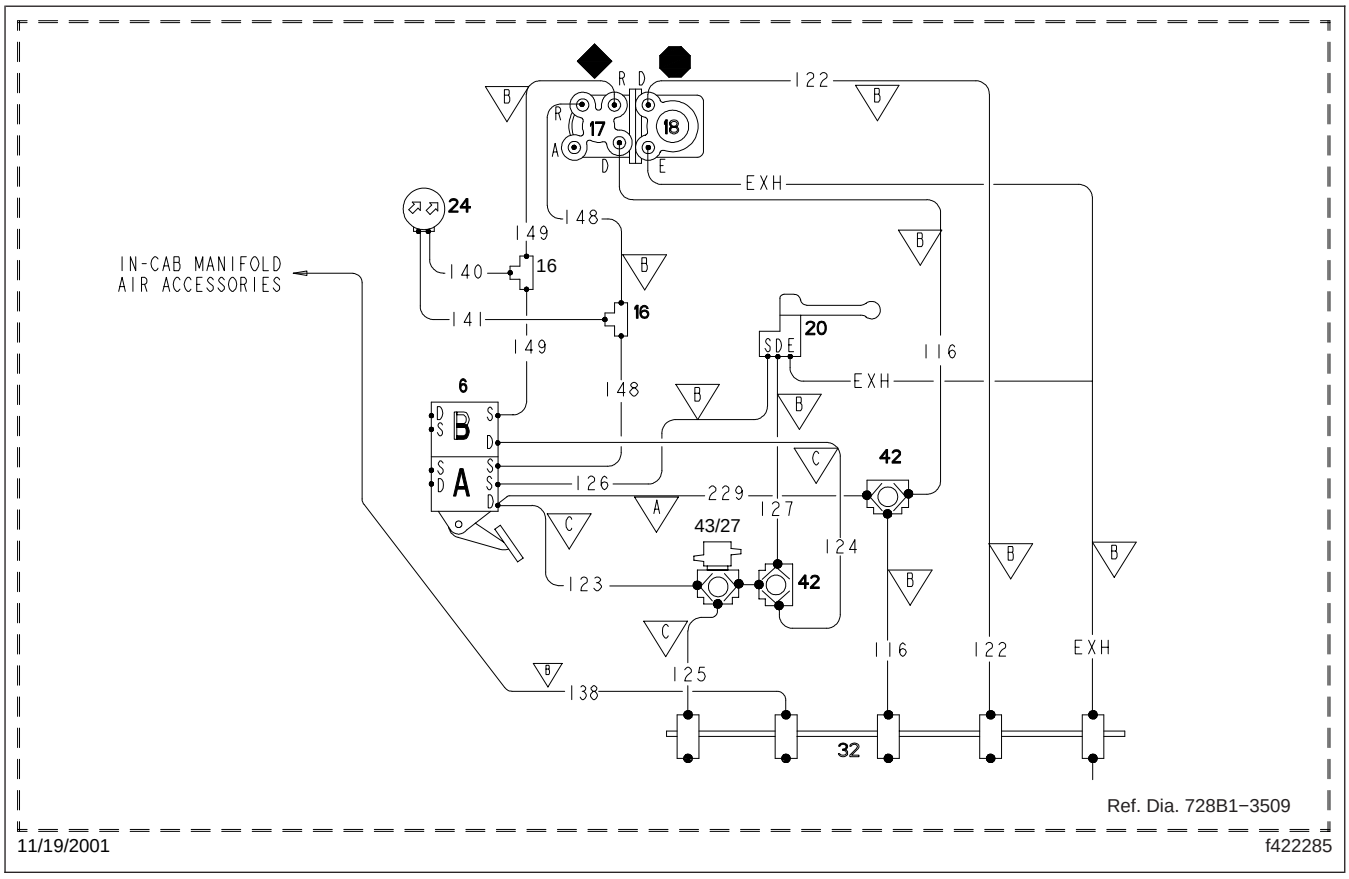



**Fig. 3, Air Line Schematic, Tractor or Truck/Tractor With Dual Valve Park Brake, With Anti-Compounding**

https://truckmanualshub.com/



## Cab Air Line Schematics, Tractor or Truck/Tractor With Single Hand Controls

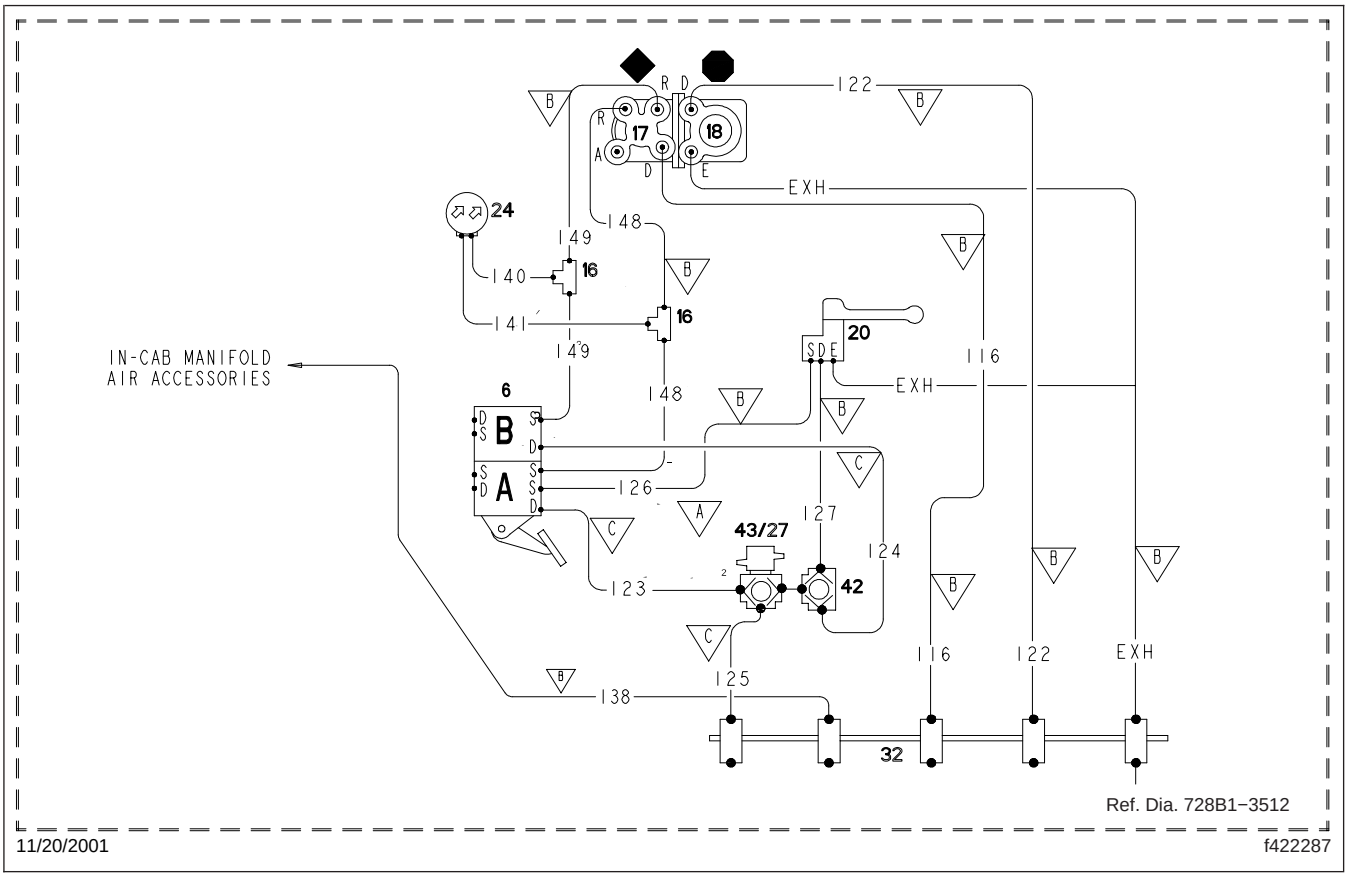



**Fig. 4, Air Line Schematic, Tractor or Truck/Tractor With Dual Valve Park Brake, Without Anti-Compounding**

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# Cab Air Line Schematics, Truck With Single Hand Control to Rear, With Single Park Brake

The air line schematics in this subject apply to trucks with single hand control to rear, and with single park brake.

See **Fig. 1** for the air line schematic for trucks with an anti-compounding valve.

See **Fig. 2** for the air line schematic for trucks without an anti-compounding valve.

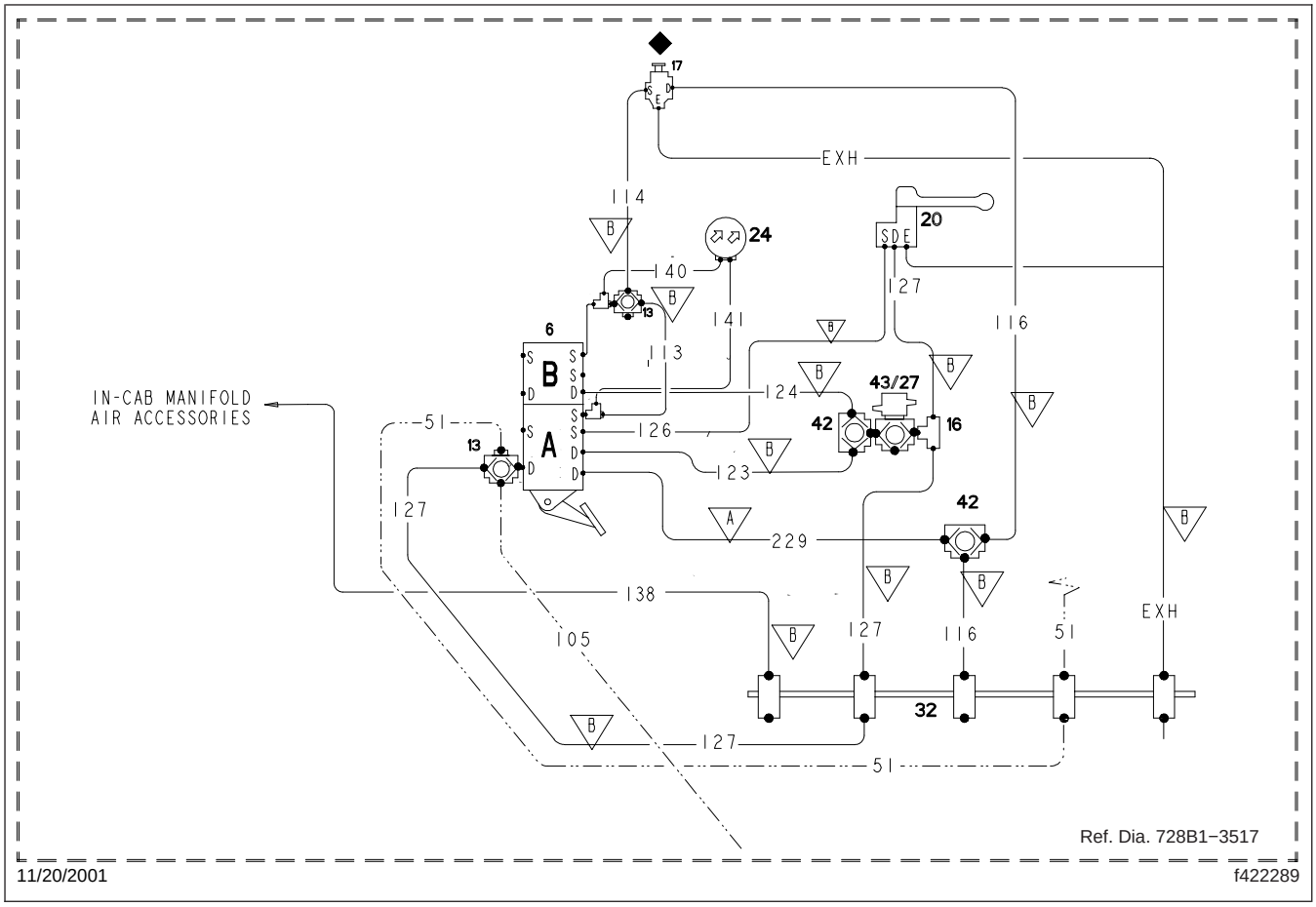



**Fig. 1, Cab Air Line Schematic, Truck With Single Hand Control to Rear, Single Valve Park Brake, With Anti-Compounding**

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## Cab Air Line Schematics, Truck With Single Hand Control to Rear, With Single Park Brake

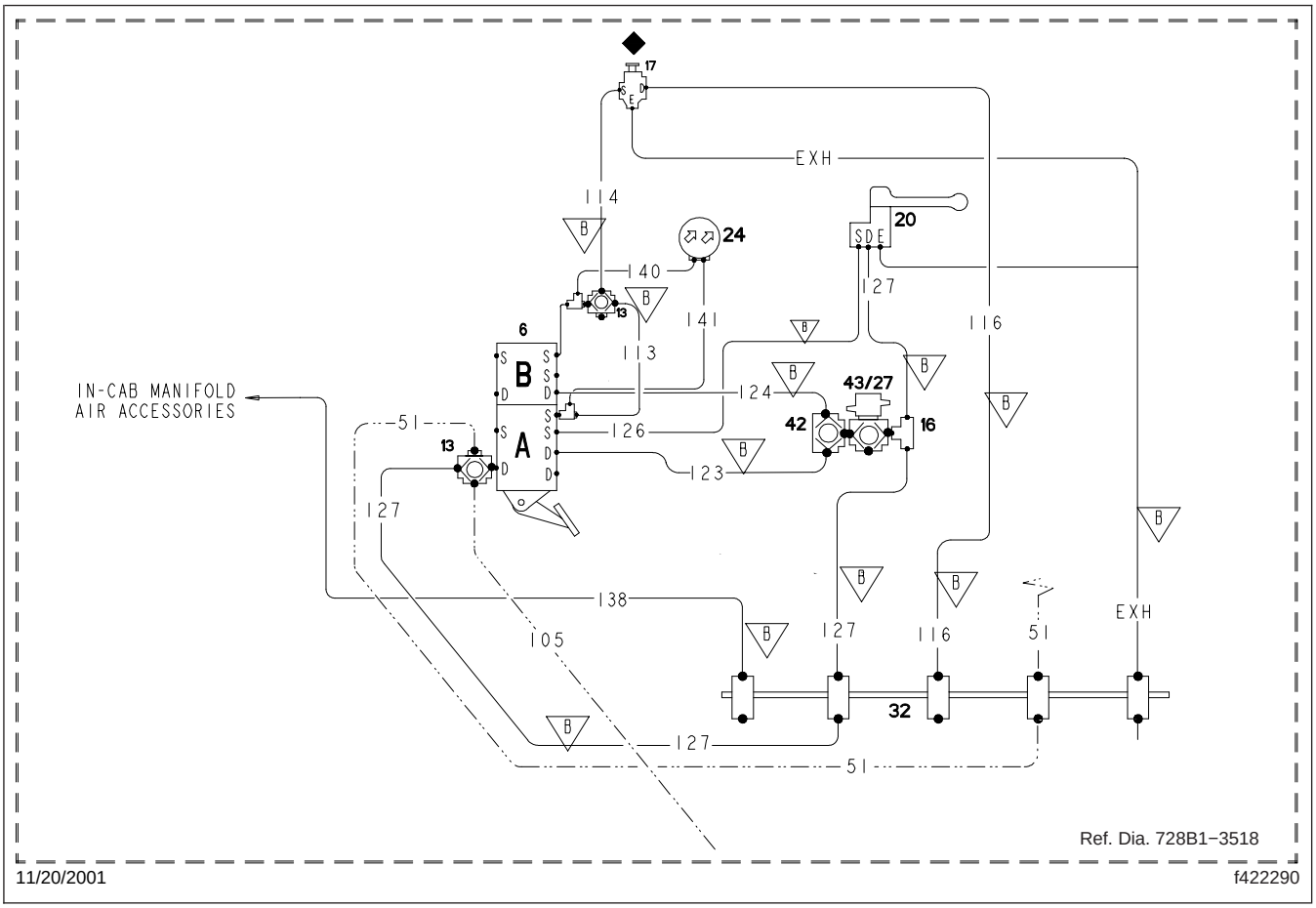



**Fig. 2, Cab Air Line Schematic, Truck With Single Hand Control to Rear, Single Valve Park Brake, Without Anti-Compounding**

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# Cab Air Line Schematics, Truck Without Hand Control, With Single Park Brake

The air line schematics in this subject apply to trucks without hand control, and with single park brake.

See **Fig. 1** for the air line schematic for trucks with an anti-compounding valve.

See **Fig. 2** for the air line schematic for trucks without an anti-compounding valve.

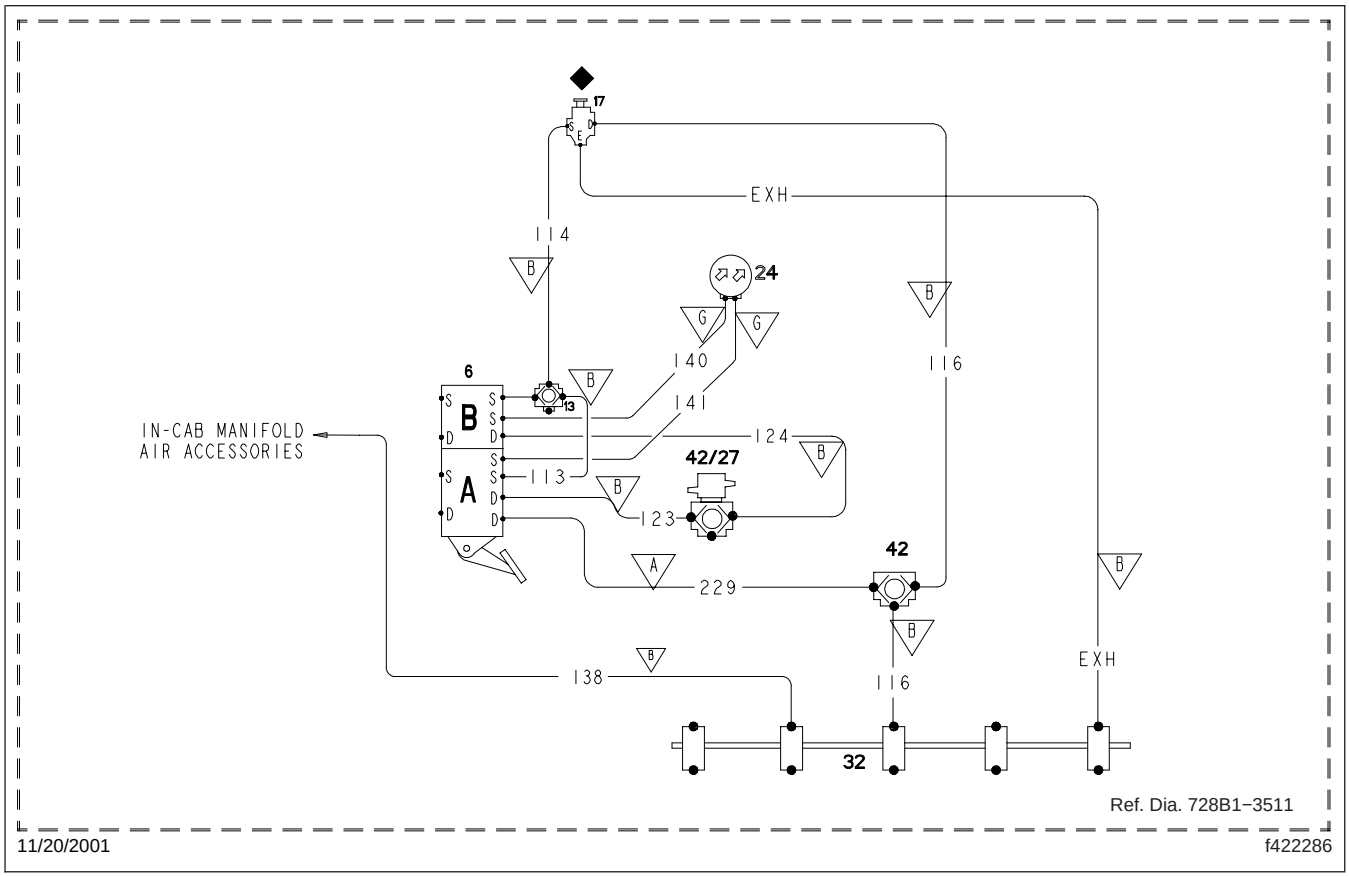



**Fig. 1, Cab Air Line Schematic, Truck With Single Hand Control to Rear, Single Valve Park Brake, With Anti-Compounding**

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## Cab Air Line Schematics, Truck Without Hand Control, With Single Park Brake

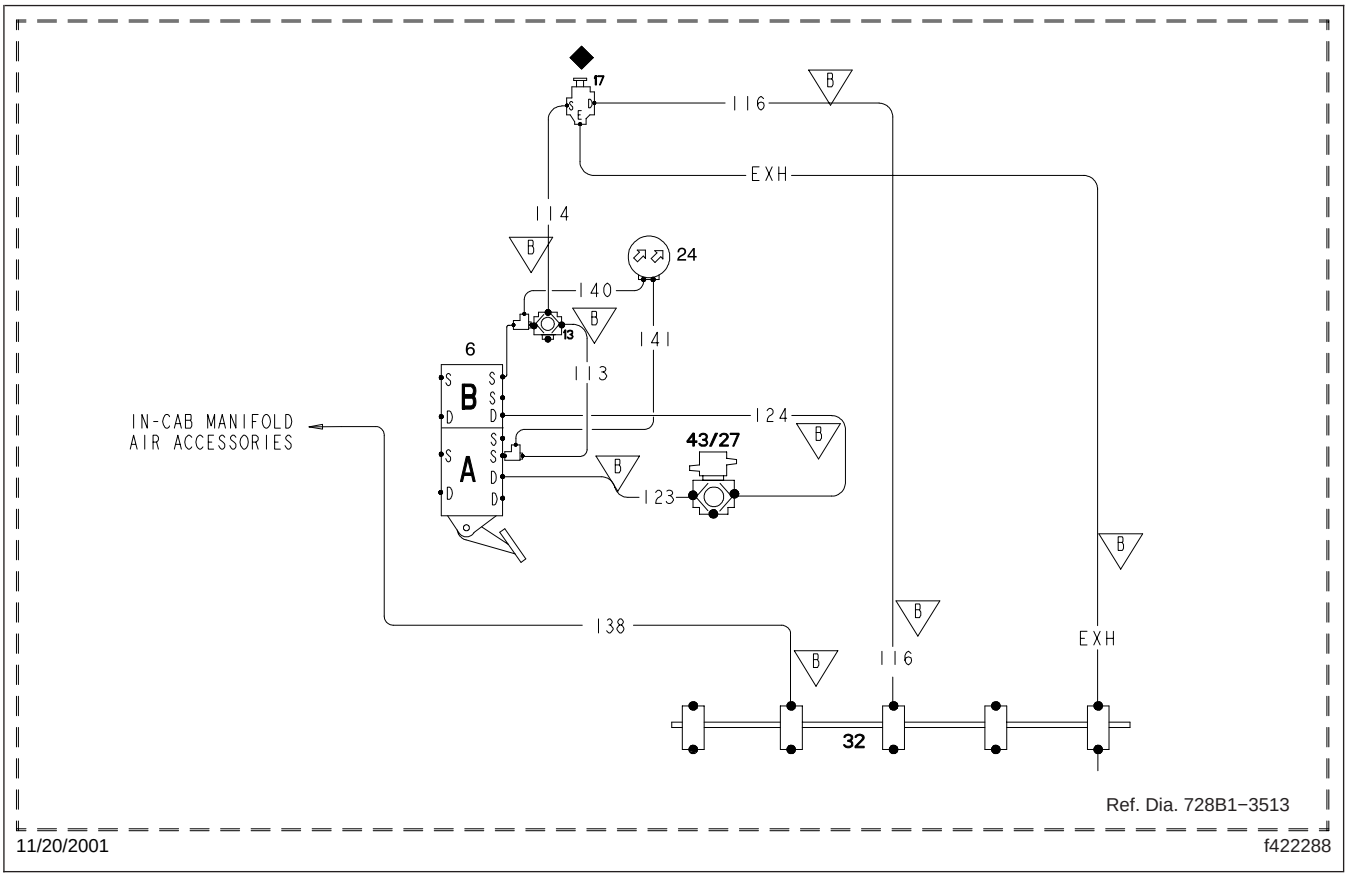



**Fig. 2, Cab Air Line Schematic, Truck With Single Hand Control to Rear, Single Valve Park Brake, Without Anti-Compounding**

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## Chassis Air Line Schematic, Tractor With Bobtail Proportioning Valve

See **Fig. 1** for a full view of the chassis air line schematic for tractors with a bobtail proportioning valve. See **Fig. 2** and **Fig. 3** for partial views of **Fig. 1**.

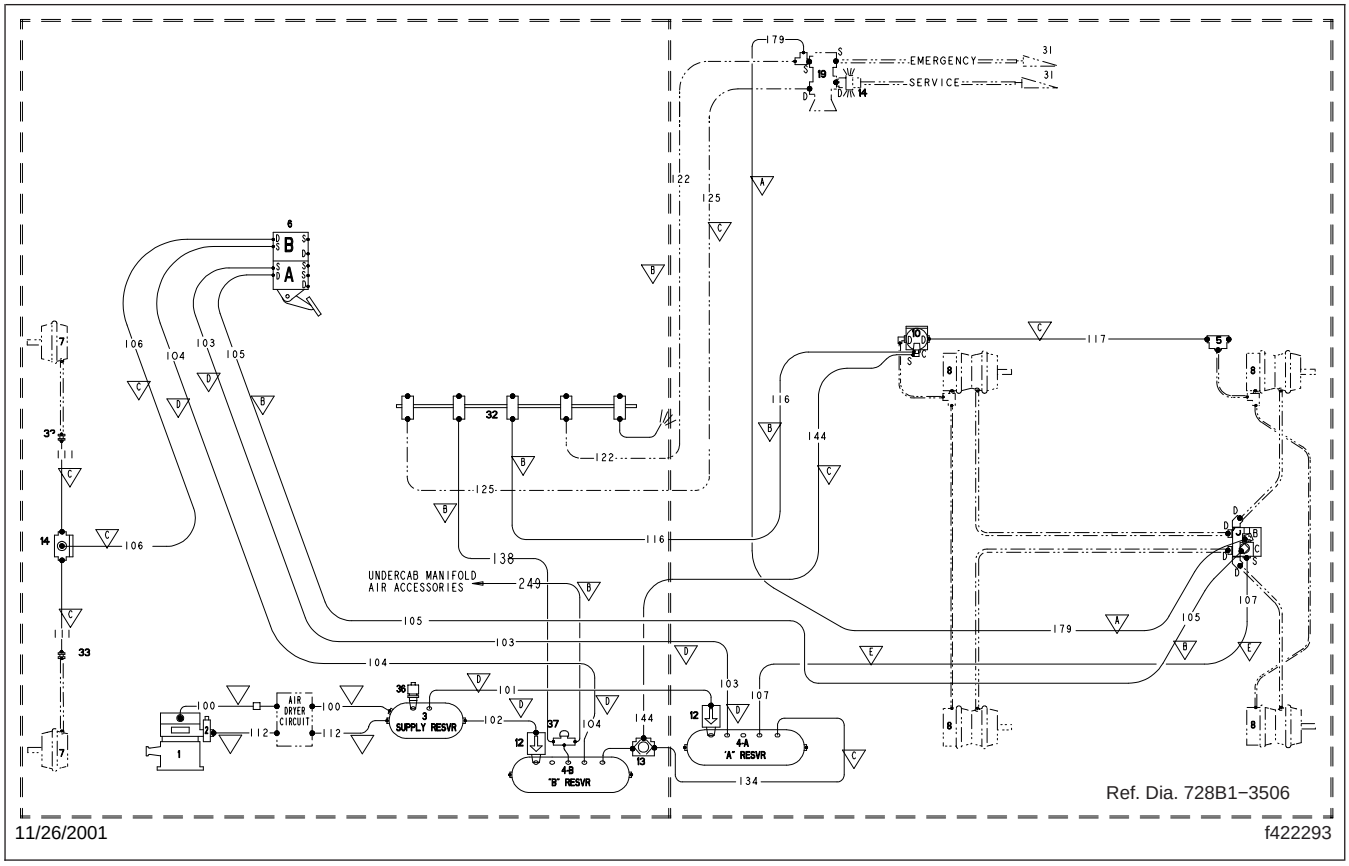



**Fig. 1, Chassis Air Line Schematic, Tractor With Bobtail Proportioning Valve (full view)**

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## Chassis Air Line Schematic, Tractor With Bobtail Proportioning Valve

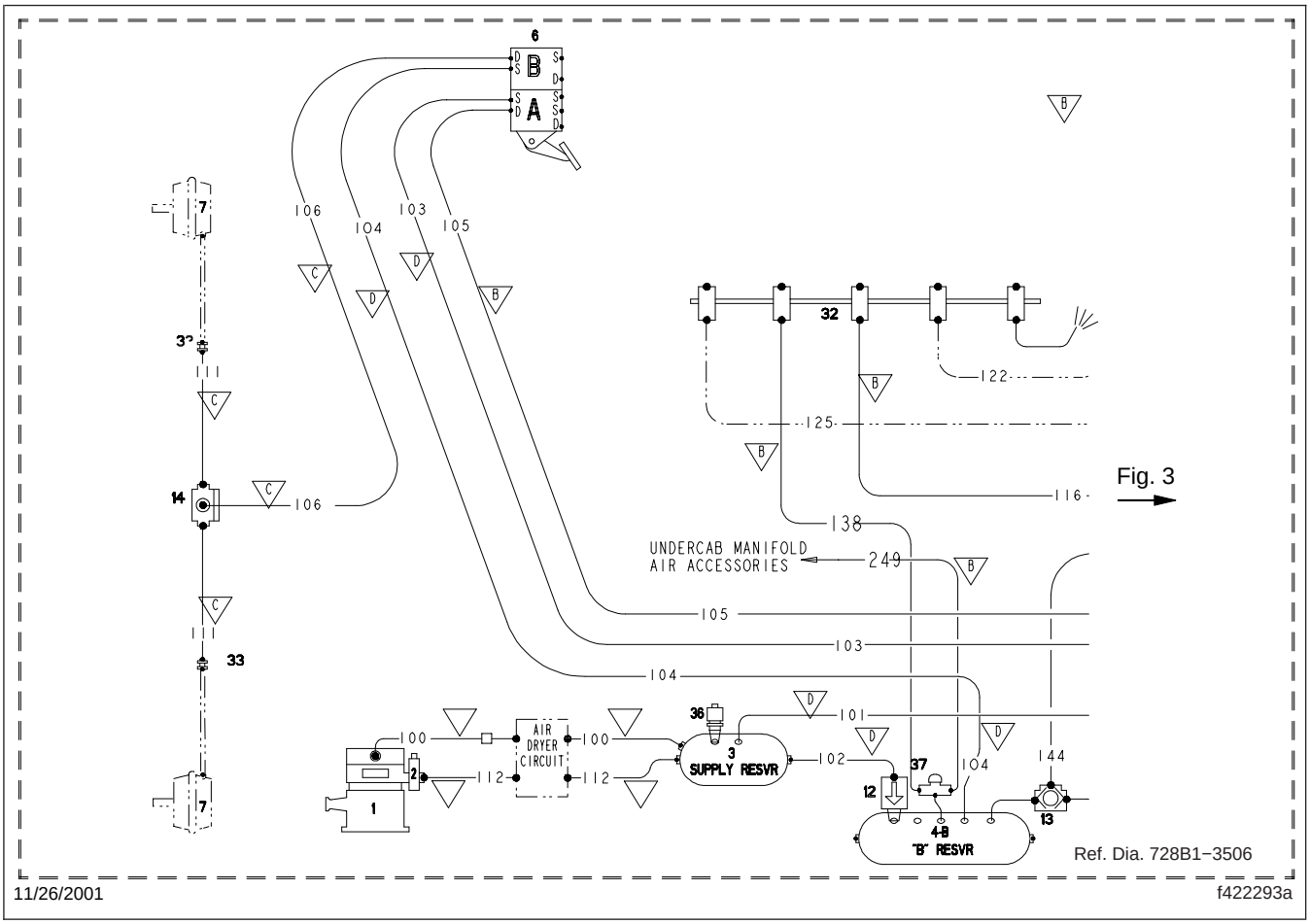



**Fig. 2, Chassis Air Line Schematic, Tractor With Bobtail Proportioning Valve (partial view)**

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## Chassis Air Line Schematic, Tractor With Bobtail Proportioning Valve

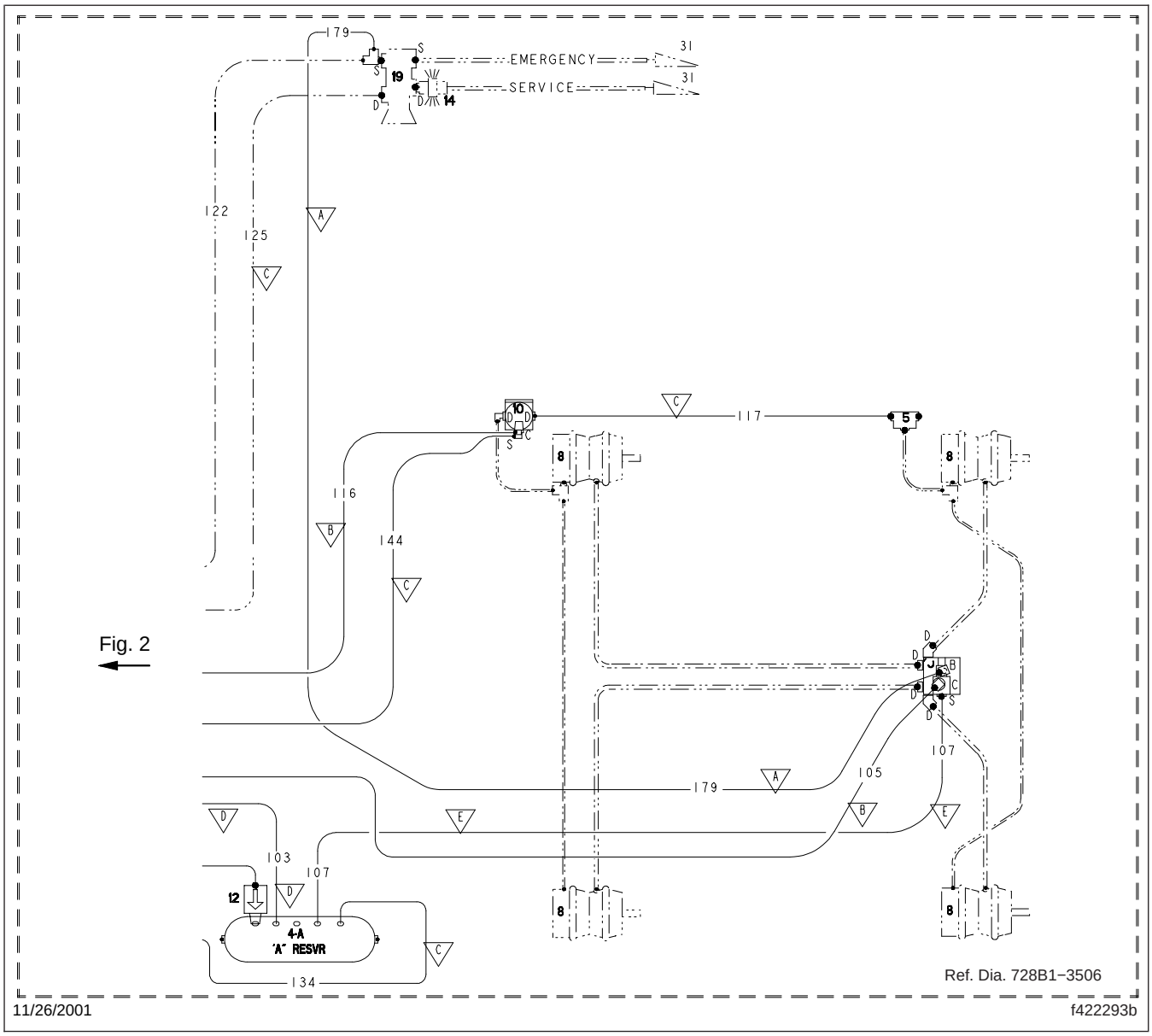



**Fig. 3, Chassis Air Line Schematic, Tractor With Bobtail Proportioning Valve (partial view)**

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# Chassis Air Line Schematic, Tractor With Inversion Valve

See **Fig. 1** for a full view of the chassis air line schematic for tractors with an inversion valve. See **Fig. 2** and **Fig. 3** for partial views of **Fig. 1**.

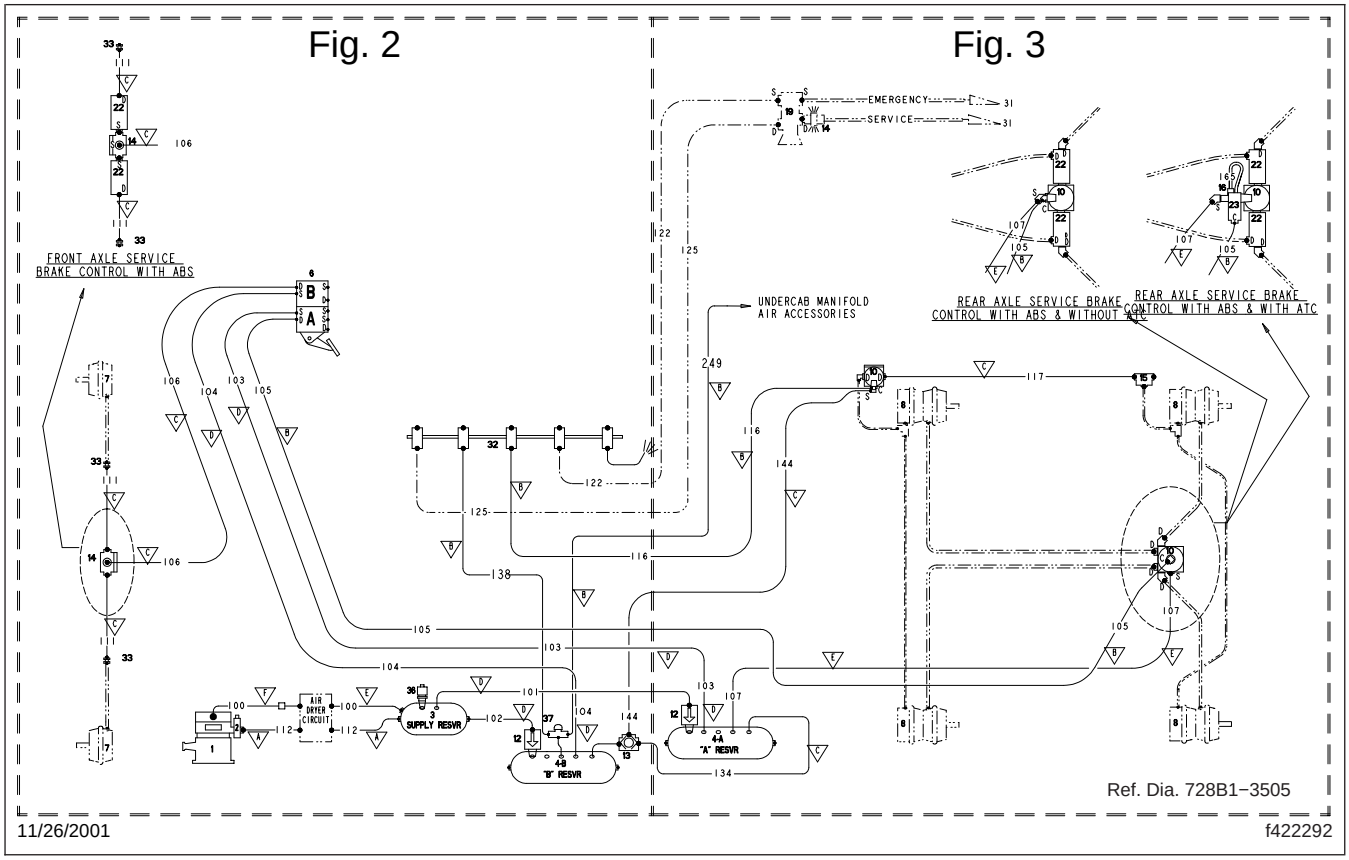



**Fig. 1, Chassis Air Line Schematic, Tractor With Inversion Valve (full view)**

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## Chassis Air Line Schematic, Tractor With Inversion Valve

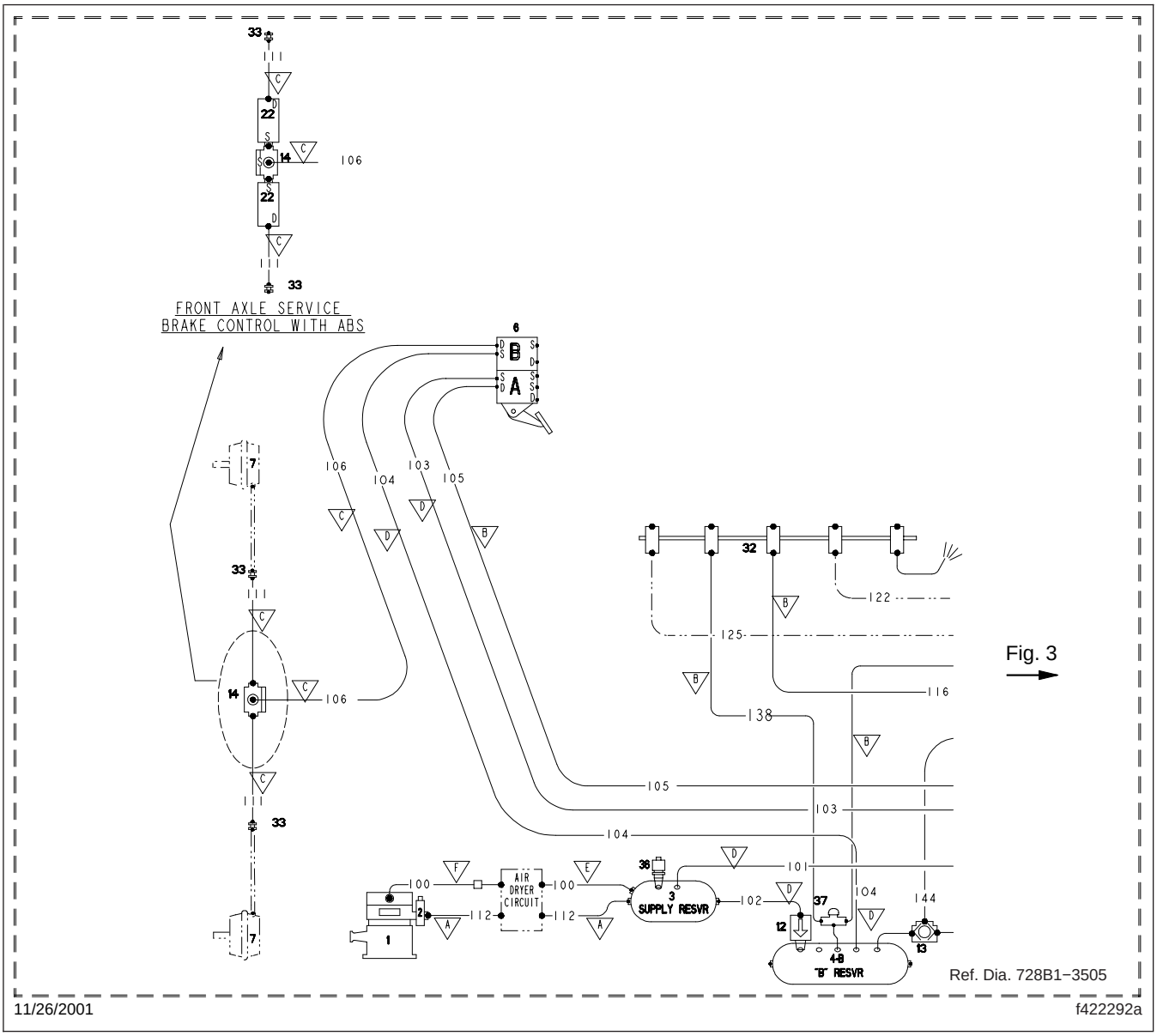



**Fig. 2, Chassis Air Line Schematic, Tractor With Inversion Valve (partial view)**

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## Chassis Air Line Schematic, Tractor With Inversion Valve

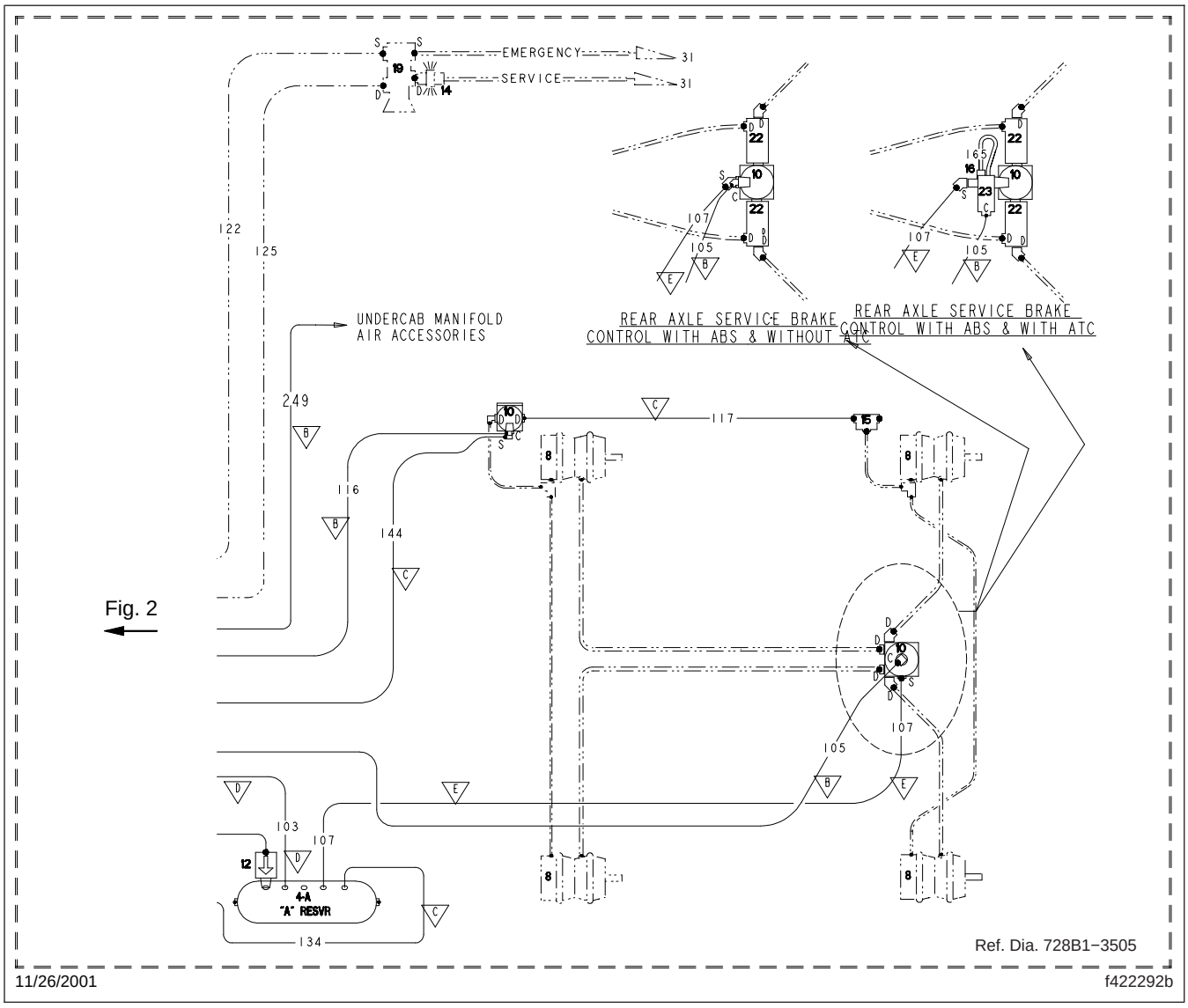



**Fig. 3, Chassis Air Line Schematic, Tractor With Inversion Valve (partial view)**

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## Chassis Air Line Schematic, Tractor With ABS

See **Fig. 1** or a full view of the chassis air line schematic for tractors with ABS. See **Fig. 2** and **Fig. 3** for partial views of **Fig. 1**.

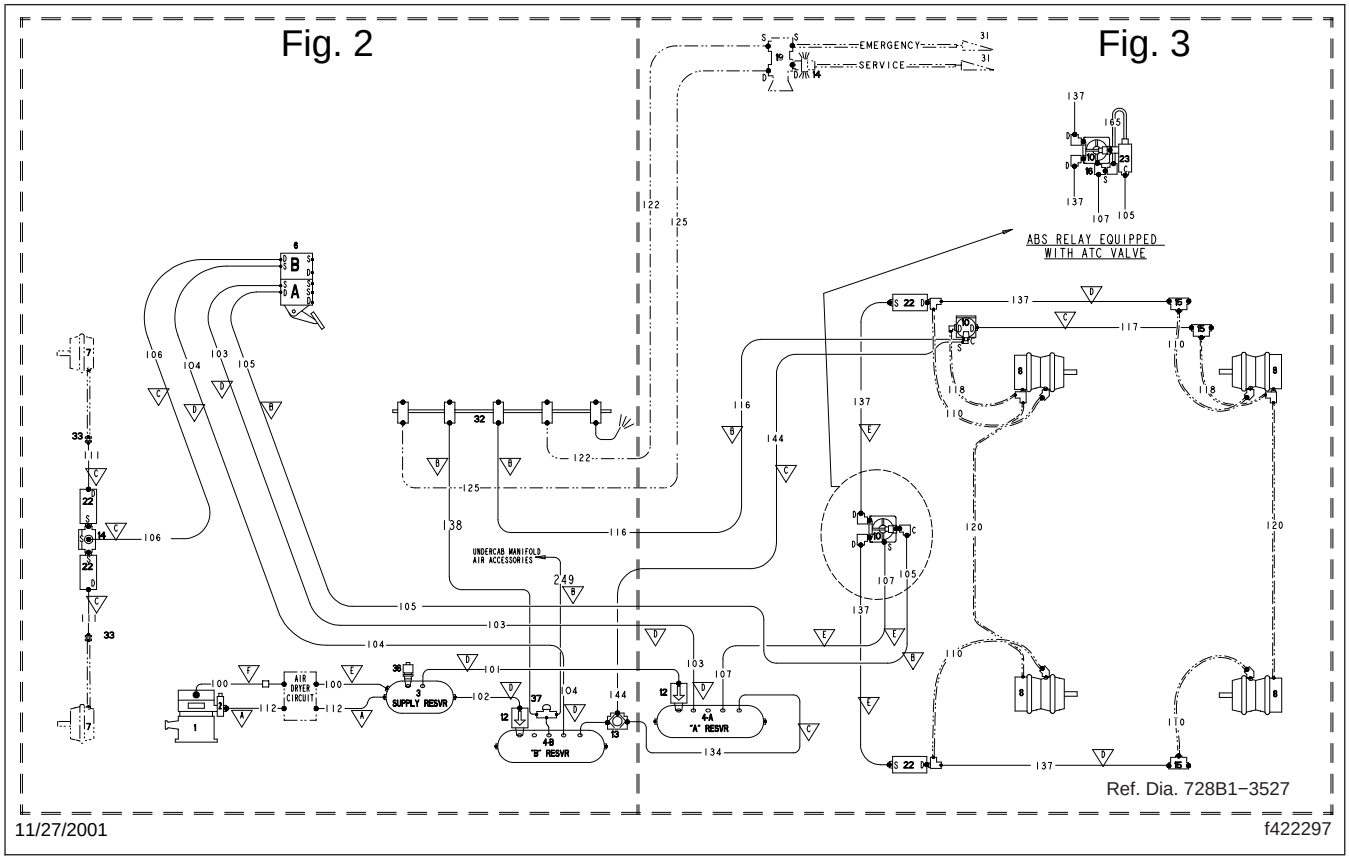



**Fig. 1, Chassis Air Line Schematic, Tractor With ABS (full view)**

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## Chassis Air Line Schematic, Tractor With ABS

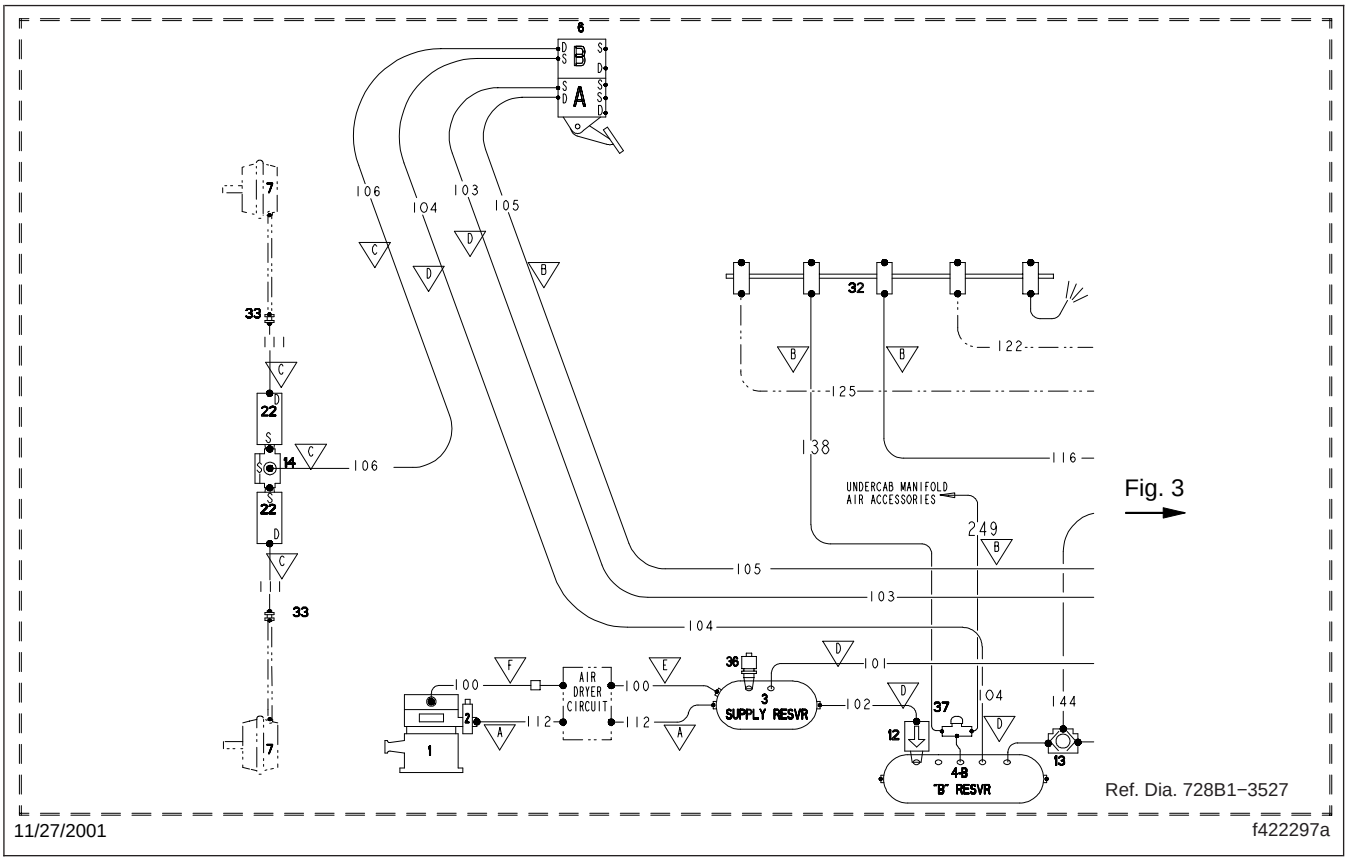



**Fig. 2, Chassis Air Line Schematic, Tractor With ABS (partial view)**

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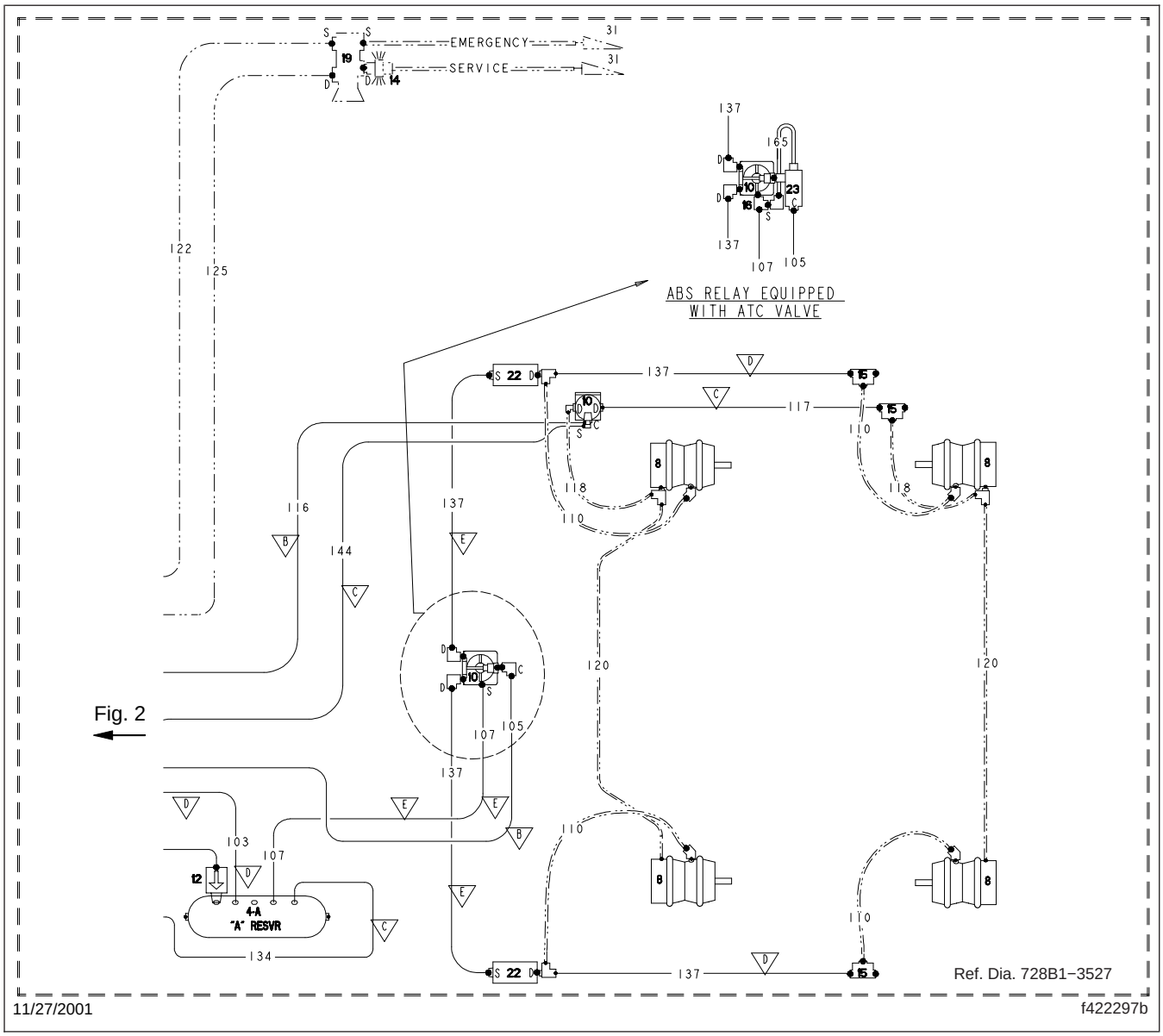



**Fig. 3, Chassis Air Line Schematic, Tractor With ABS (partial view)**

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## Chassis Air Line Schematic, Tractor Without ABS

See **Fig. 1** or a full view of the chassis air line schematic for tractors without ABS. See **Fig. 2** and **Fig. 3** for partial views of **Fig. 1**.

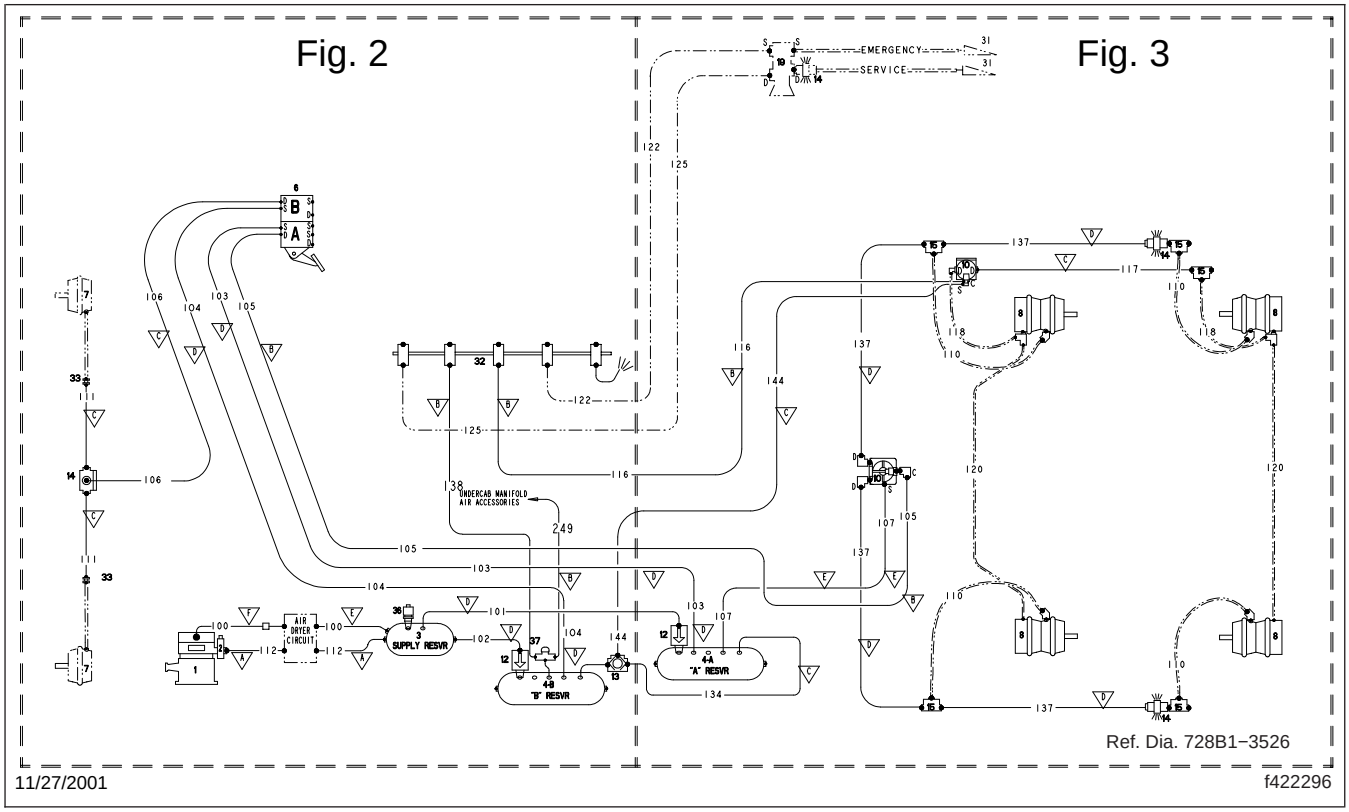



**Fig. 1, Chassis Air Line Schematic, Tractor Without ABS (full view)**

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## Chassis Air Line Schematic, Tractor Without ABS

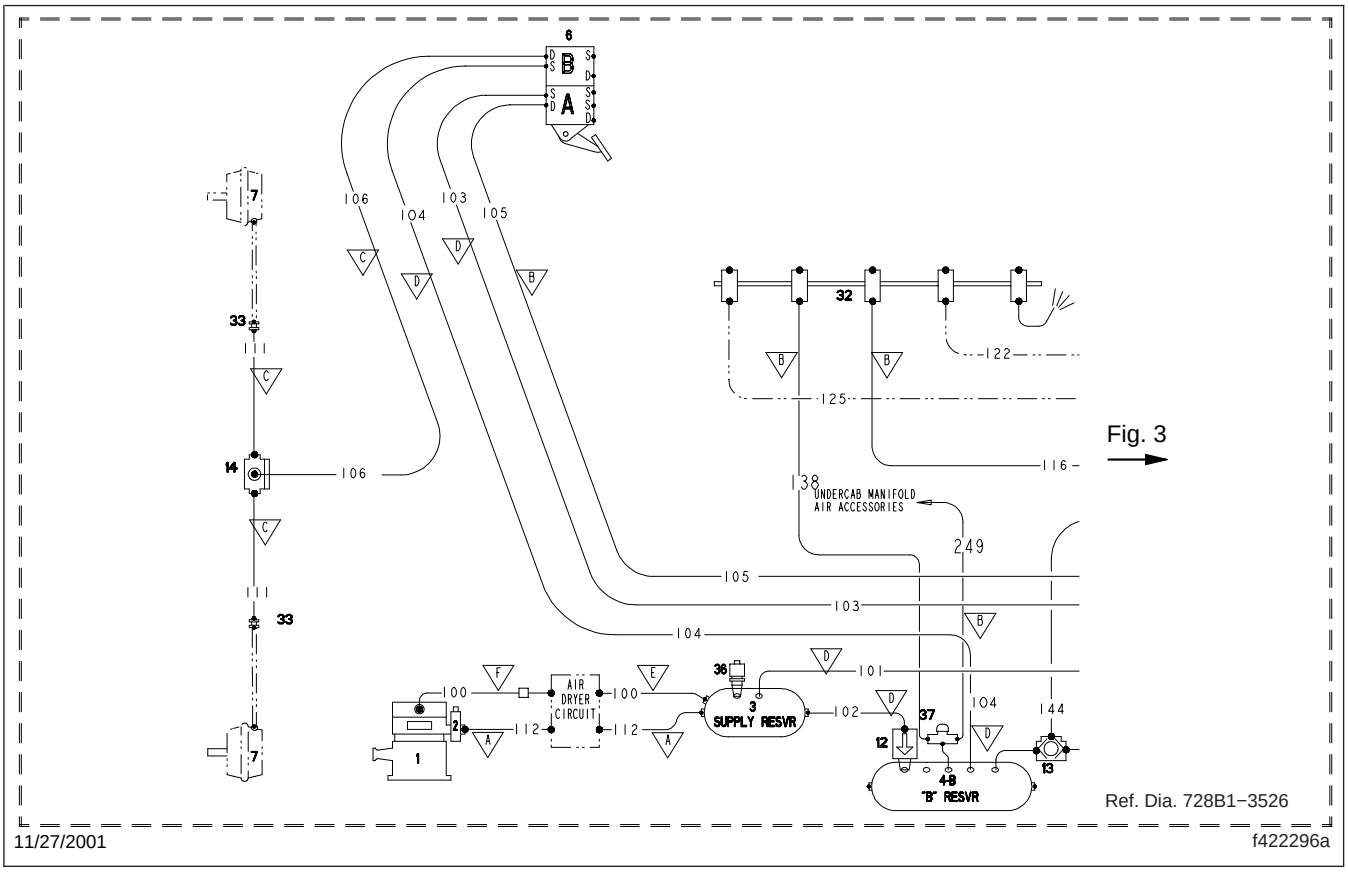



**Fig. 2, Chassis Air Line Schematic, Tractor Without ABS (partial view)**

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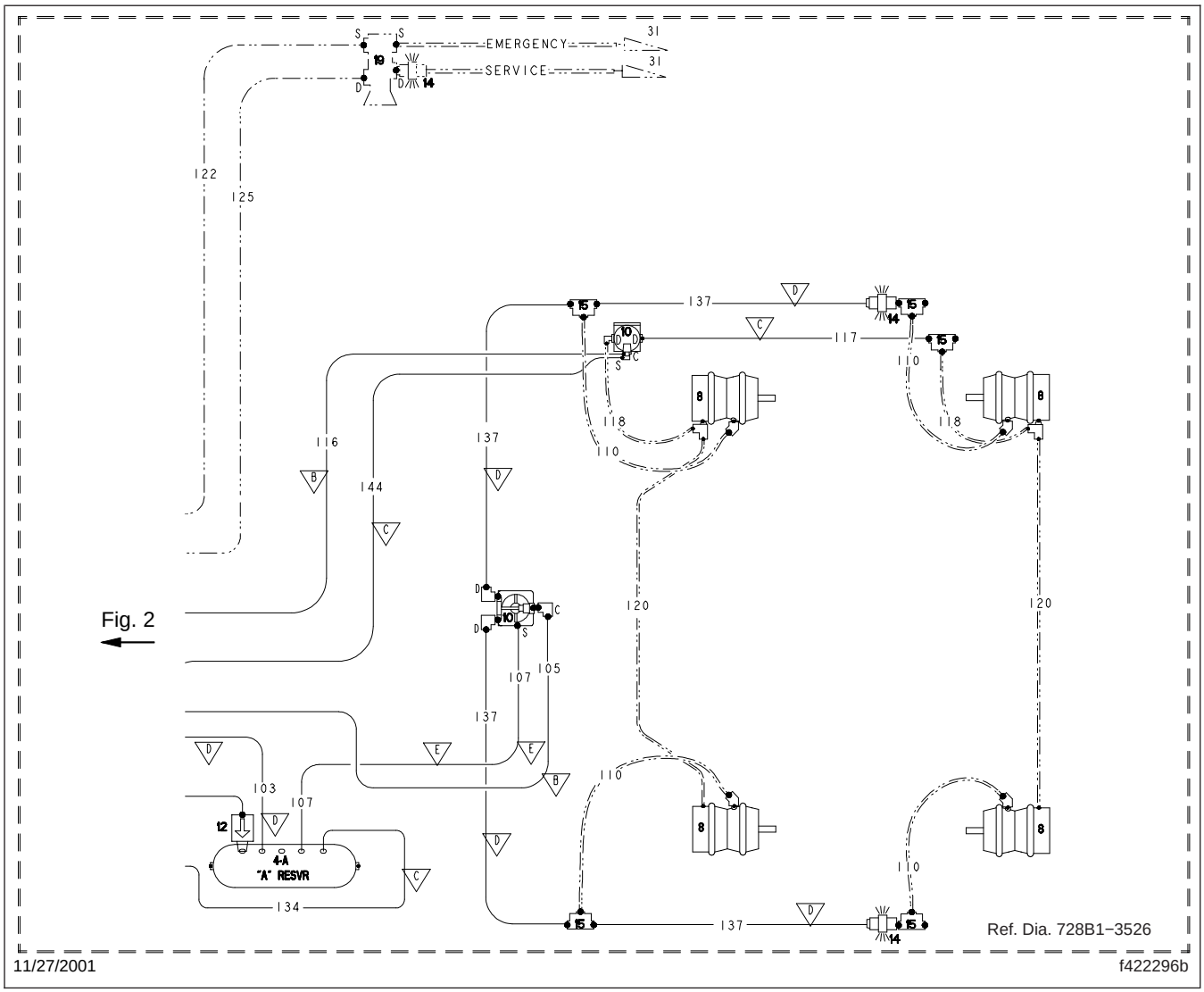



**Fig. 3, Chassis Air Line Schematic, Tractor Without ABS (partial view)**

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## Chassis Air Line Schematic, Truck With ABS

See **Fig. 1** or a full view of the chassis air line schematic for trucks with ABS. See **Fig. 2** and **Fig. 3** for partial views of **Fig. 1**. See **Fig. 4** for a partial view showing the ATC option.

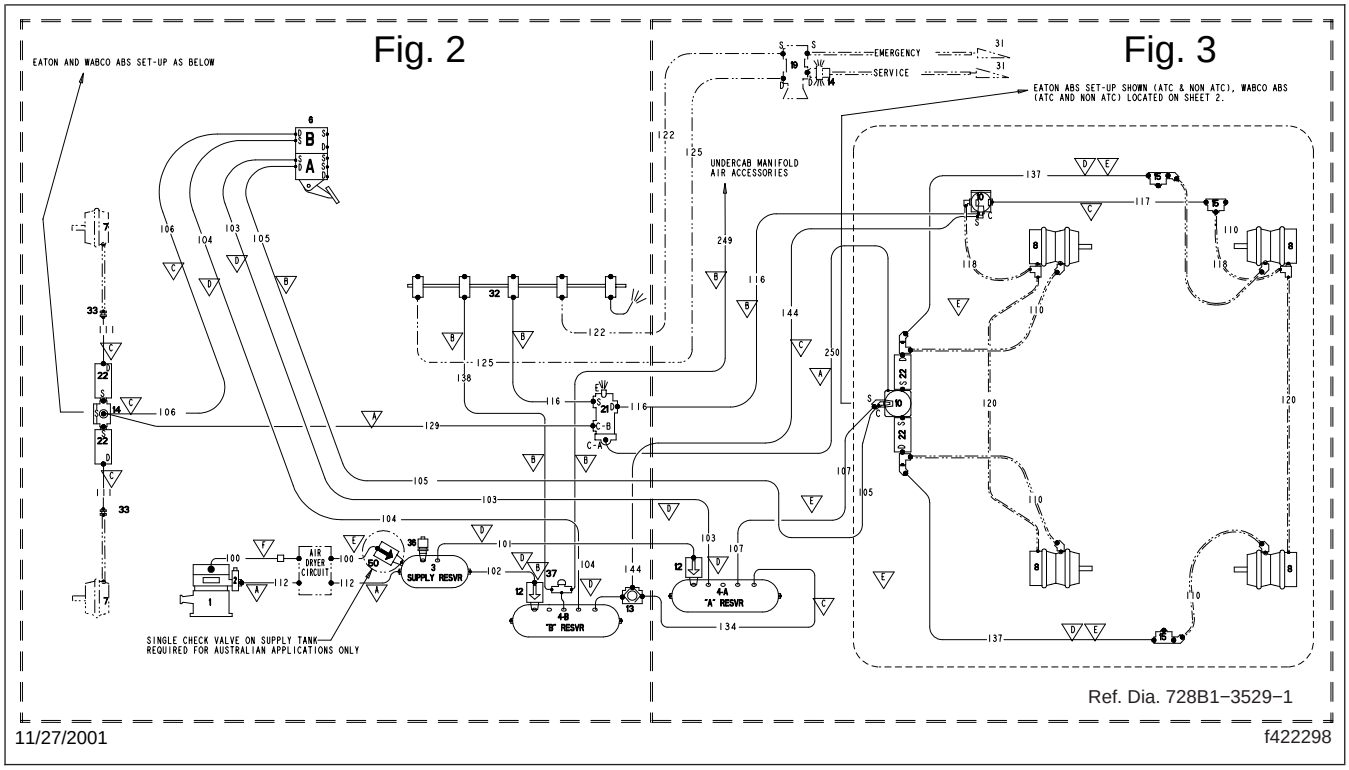



**Fig. 1, Chassis Air Line Schematic, Truck With ABS (full view)**

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## Chassis Air Line Schematic, Truck With ABS

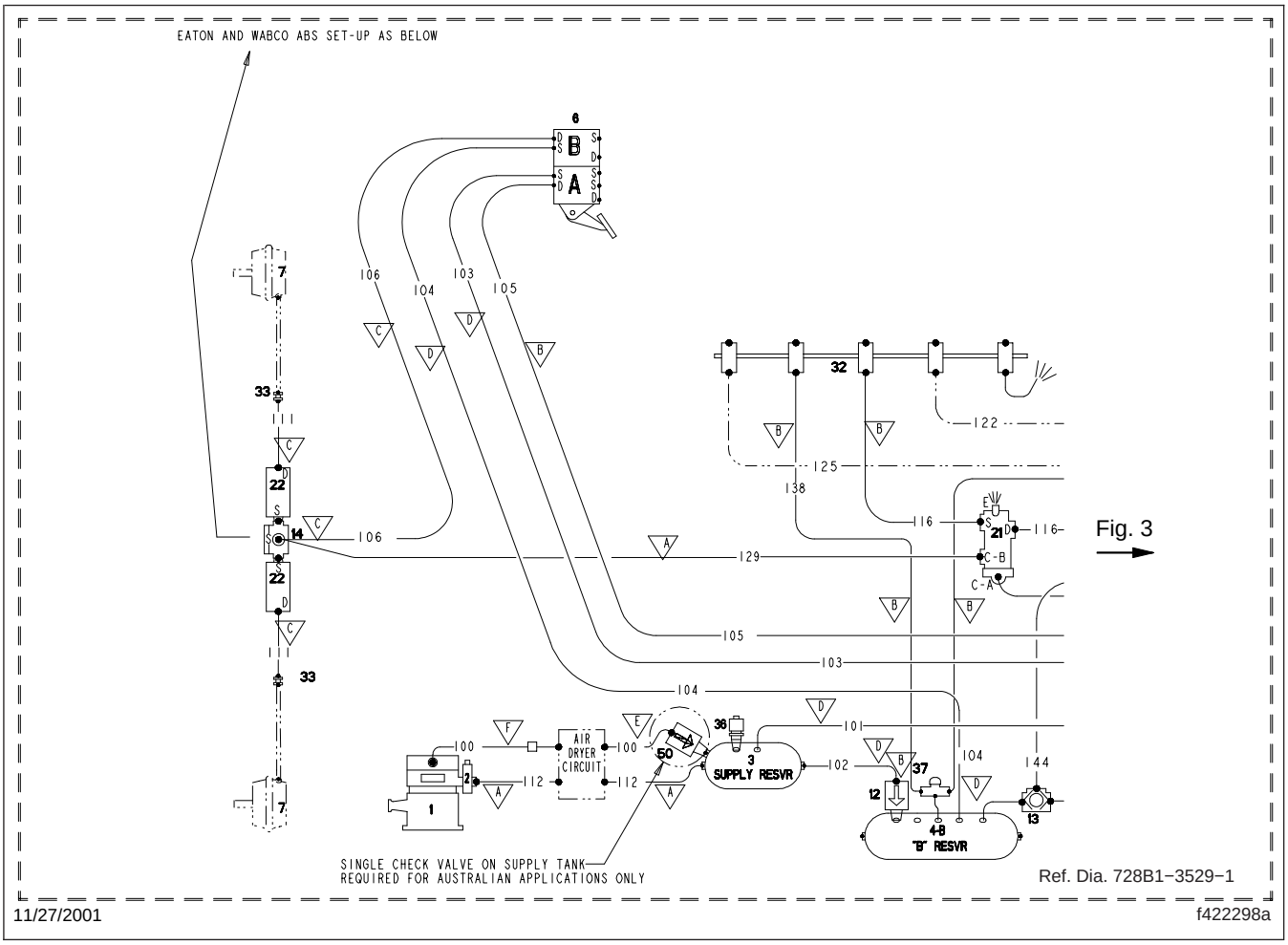



**Fig. 2, Chassis Air Line Schematic, Truck With ABS (partial view)**

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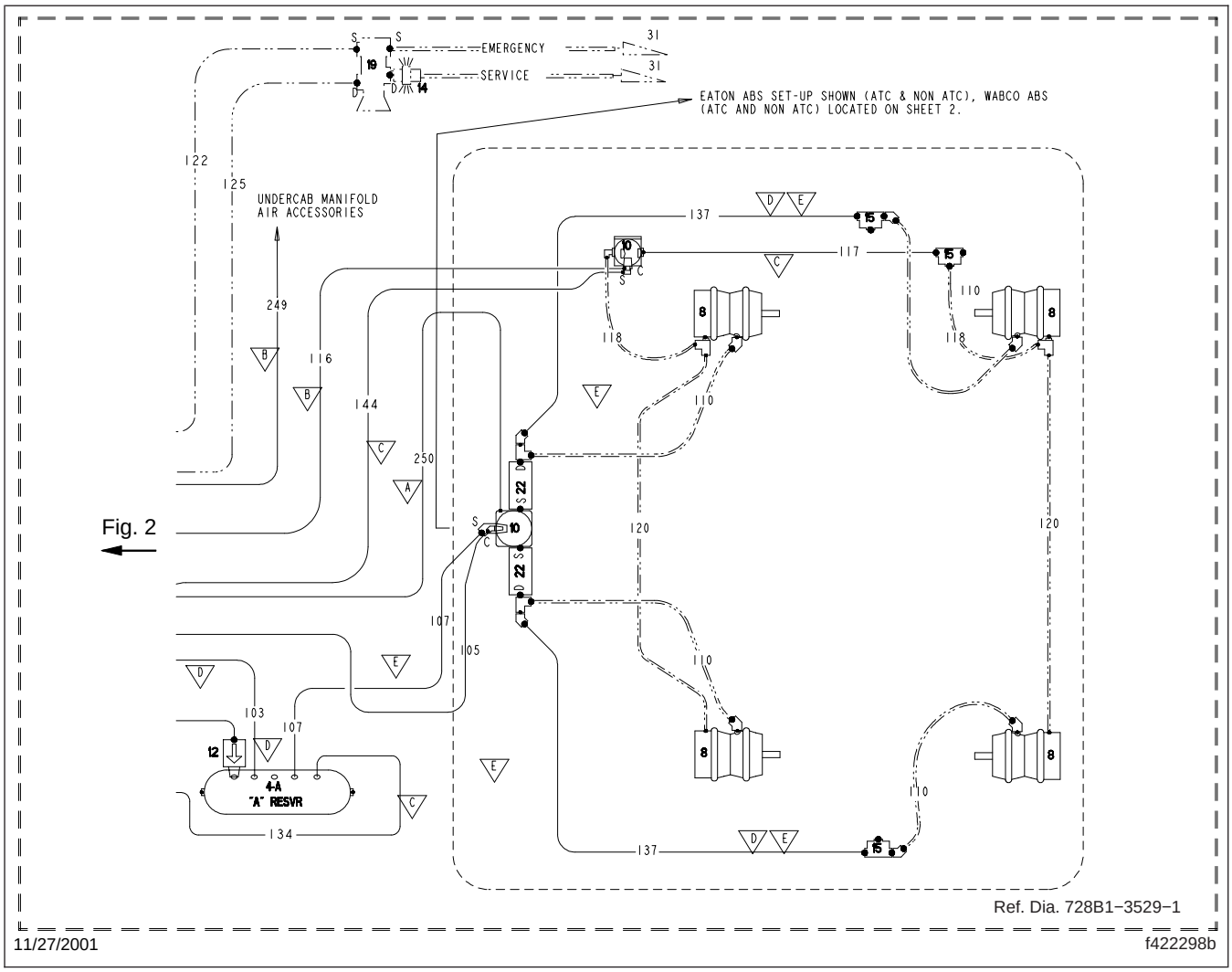



**Fig. 3, Chassis Air Line Schematic, Truck With ABS (partial view)**

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## Chassis Air Line Schematic, Truck With ABS

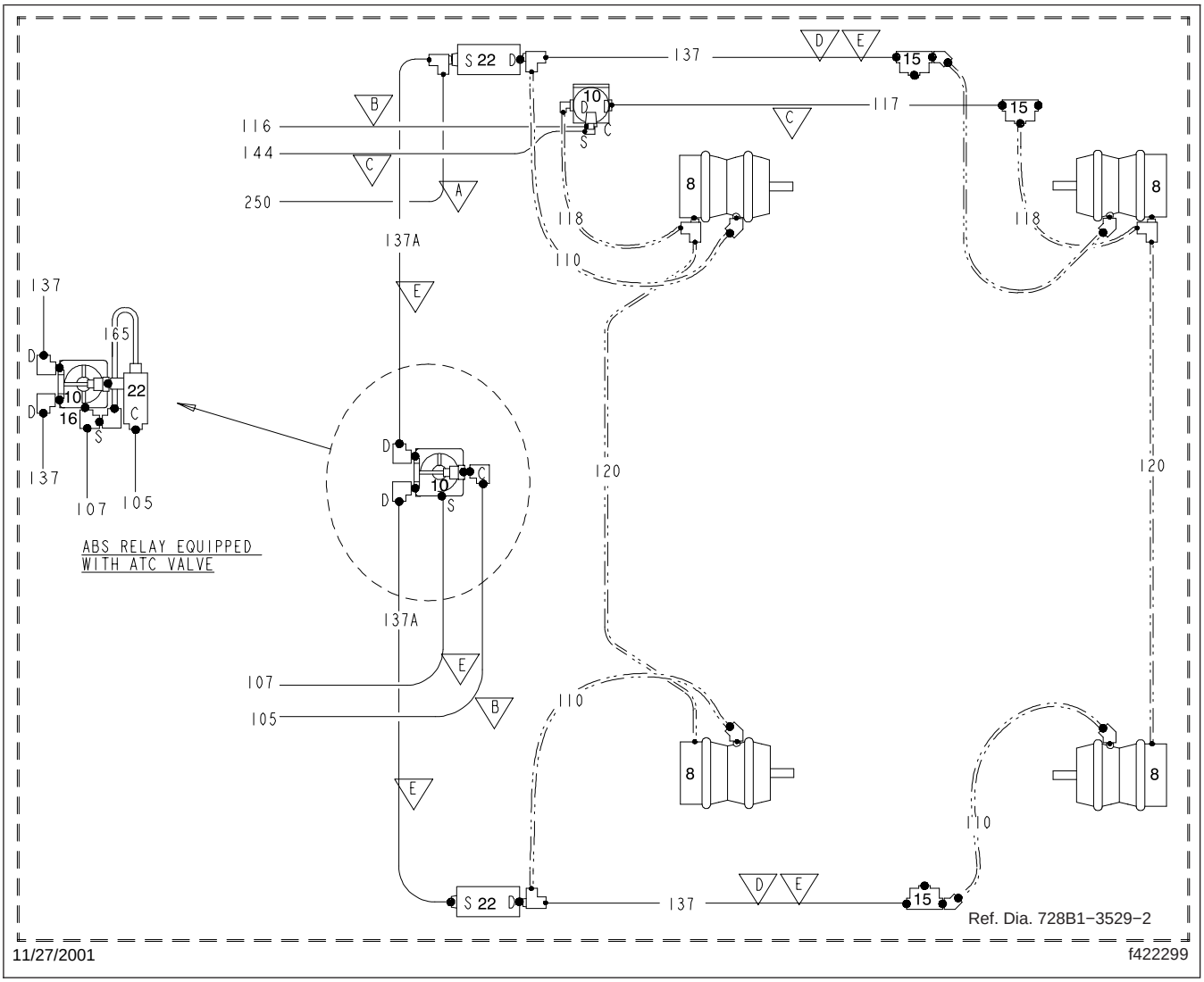



**Fig. 4, Chassis Air Line Schematic, Truck With ABS and ATC (partial view)**

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## Chassis Air Line Schematic, Vehicle With Single Axle

See **Fig. 1** or a full view of the chassis air line schematic for vehicles with single axles. See **Fig. 2** and **Fig. 3** for partial views of **Fig. 1**.

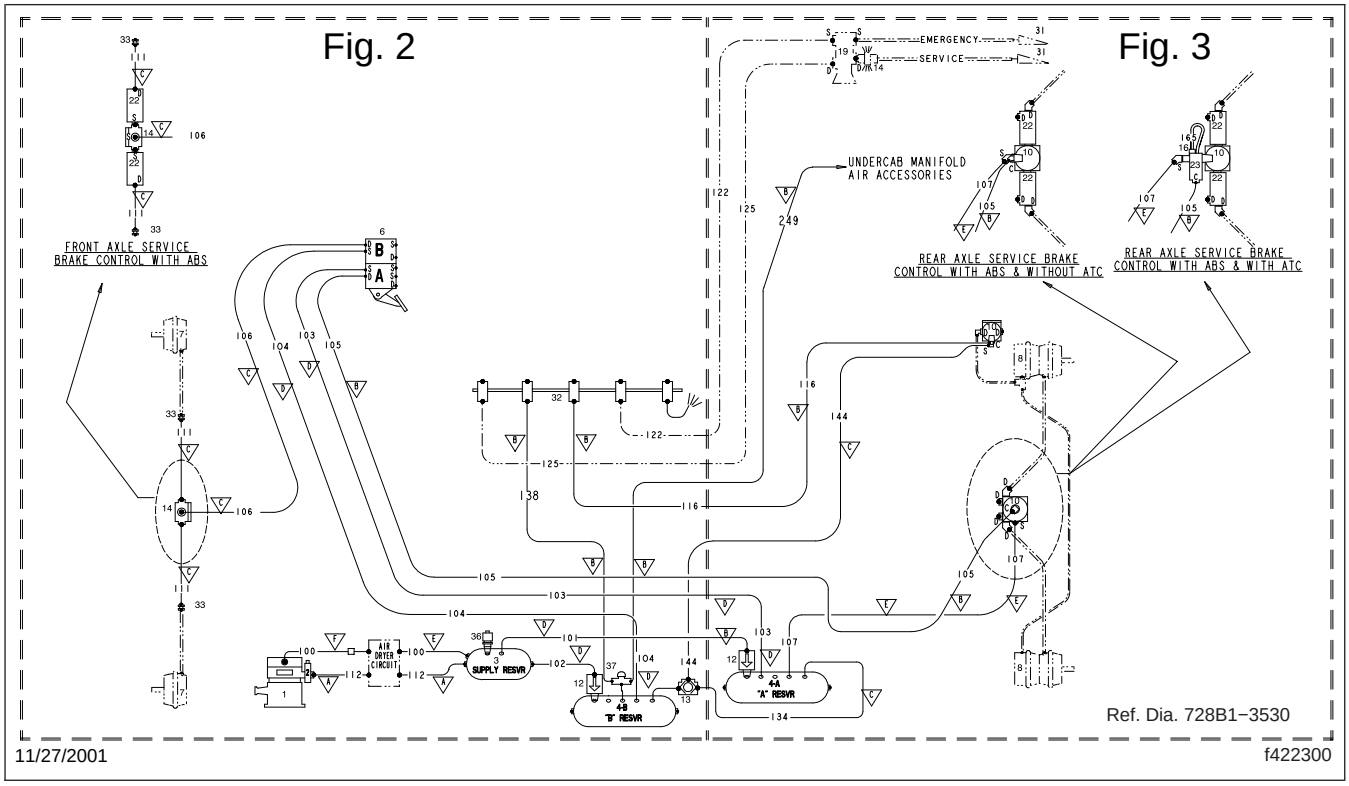



**Fig. 1, Chassis Air Line Schematic, Vehicle With Single Axle (full view)**

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## Chassis Air Line Schematic, Vehicle With Single Axle

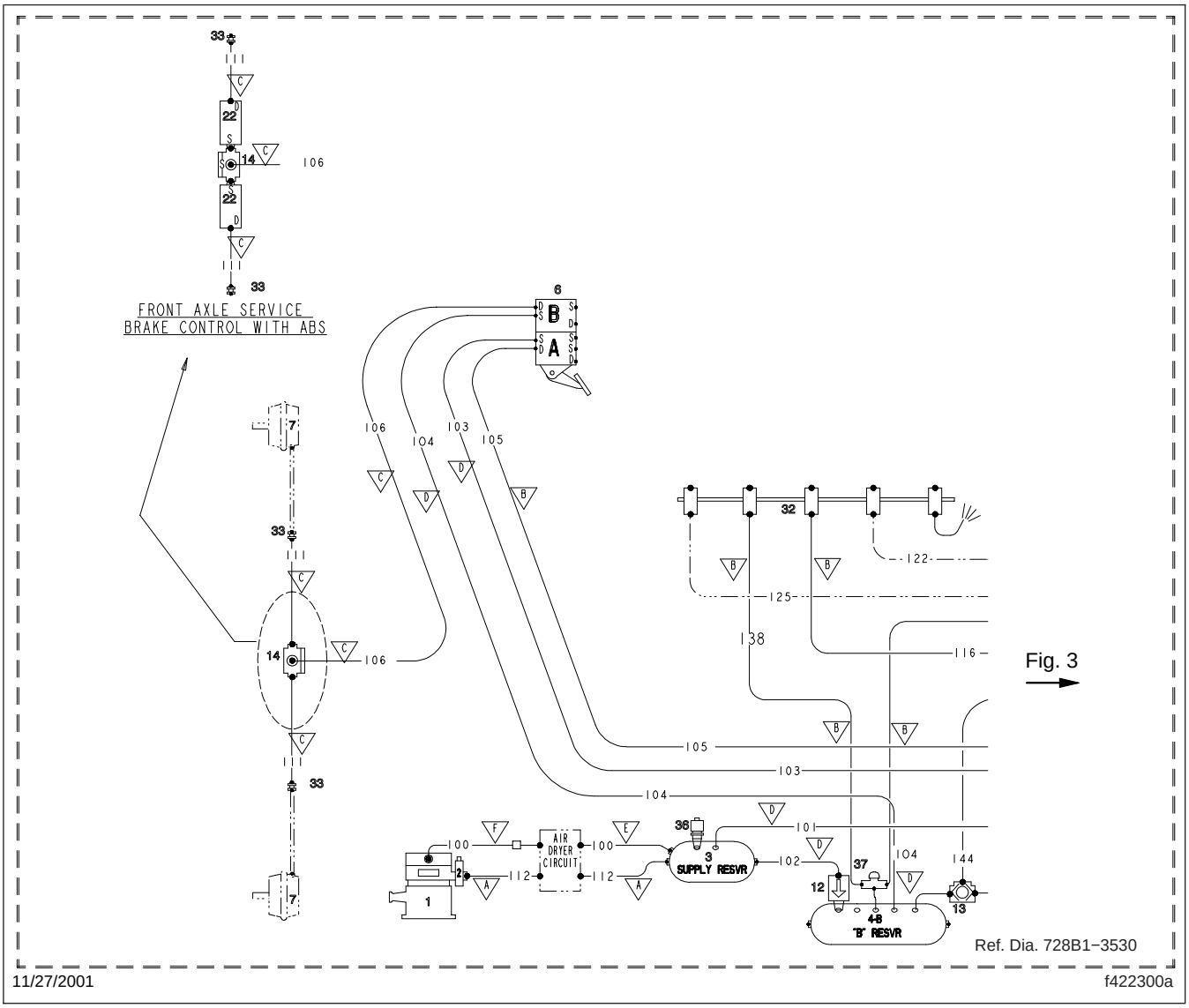



**Fig. 2, Chassis Air Line Schematic, Vehicle With Single Axle (partial view)**

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## Chassis Air Line Schematic, Vehicle With Single Axle

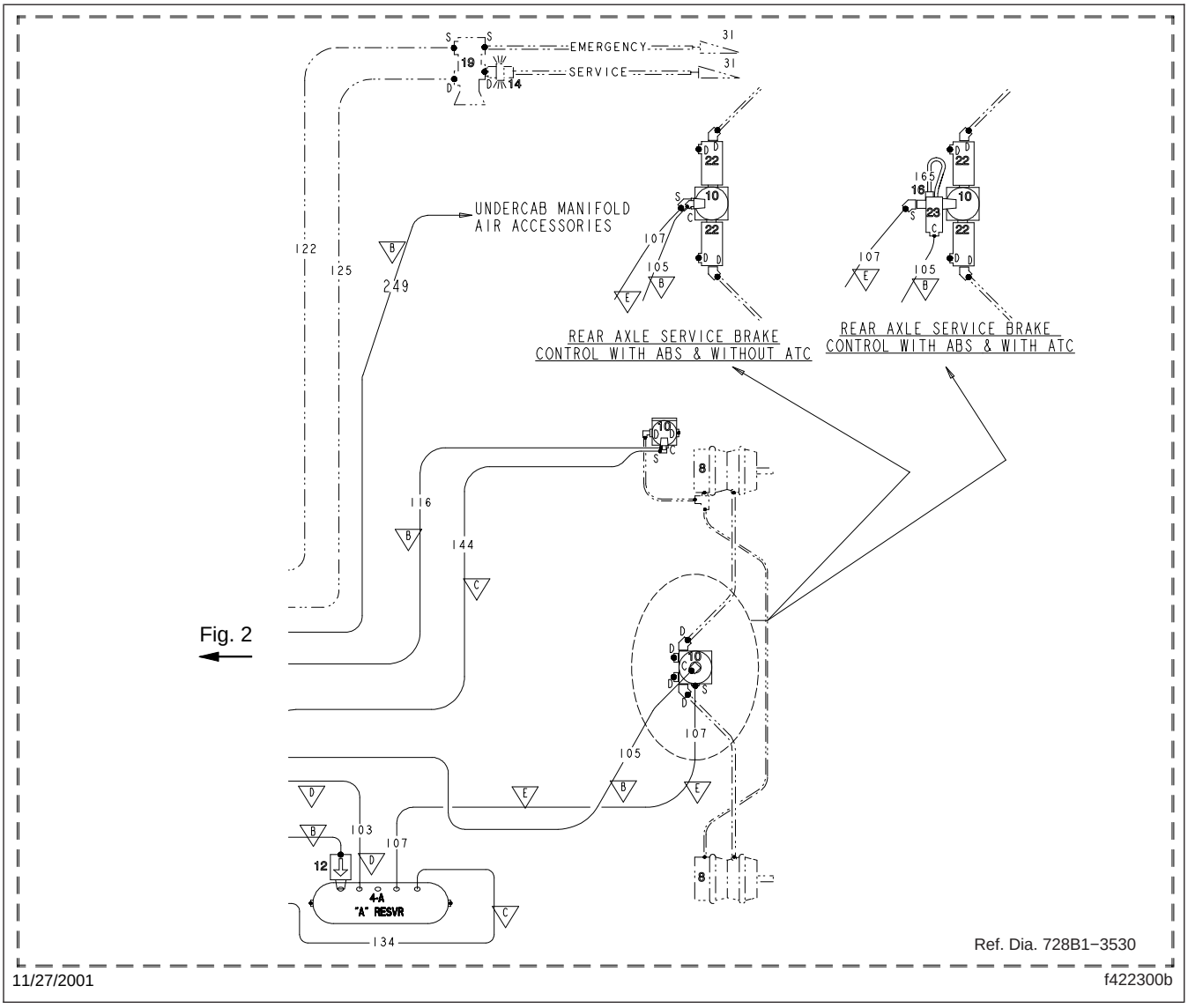



**Fig. 3, Chassis Air Line Schematic, Vehicle With Single Axle (partial view)**

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## Chassis Air Line Schematic, Vehicle With Tri-Drive Axles

See **Fig. 1** or a full view of the chassis air line schematic for vehicles with tri-drive axles. See **Fig. 2** and **Fig. 3** for partial views of **Fig. 1**.

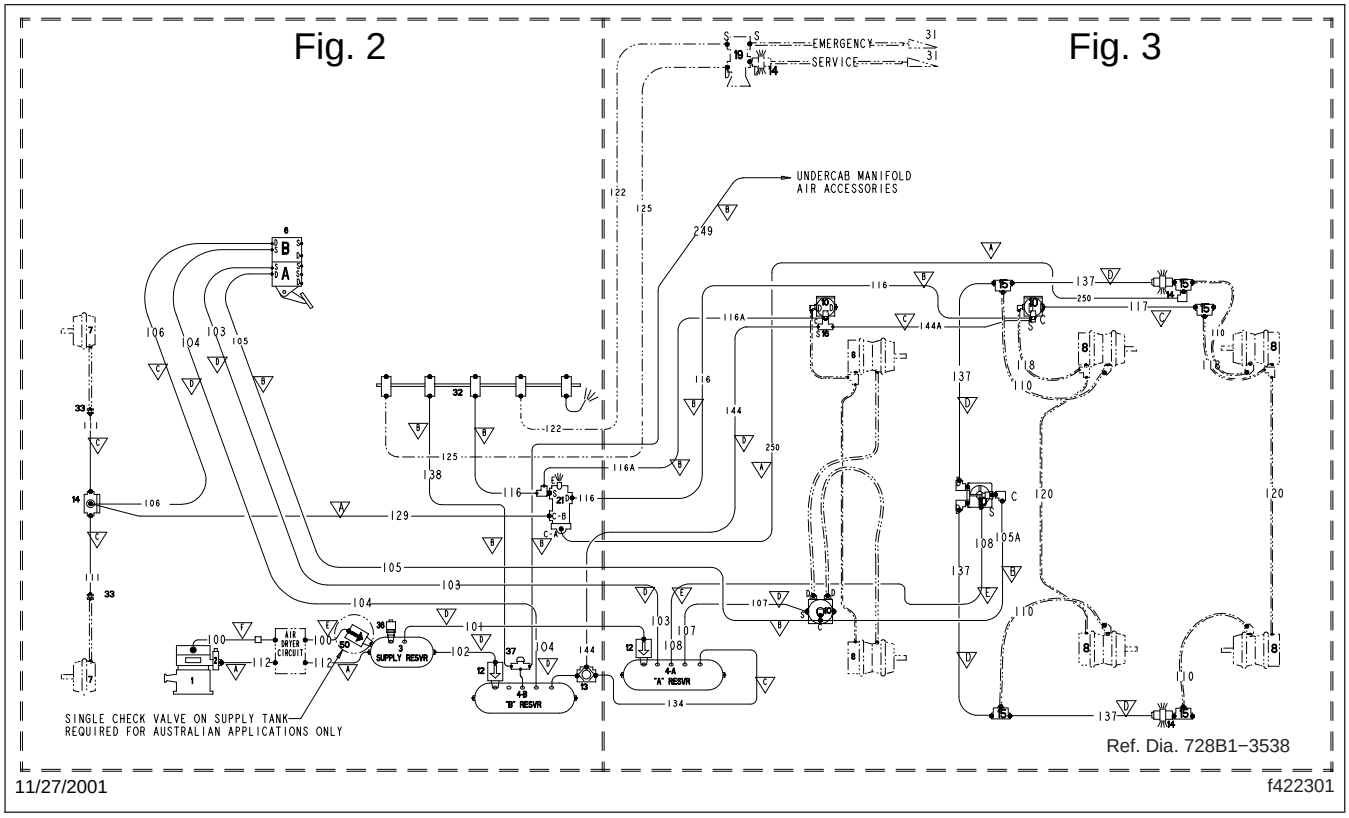



**Fig. 1, Chassis Air Line Schematic, Vehicle With Tri-Drive Axles (full view)**

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## Chassis Air Line Schematic, Vehicle With Tri-Drive Axles

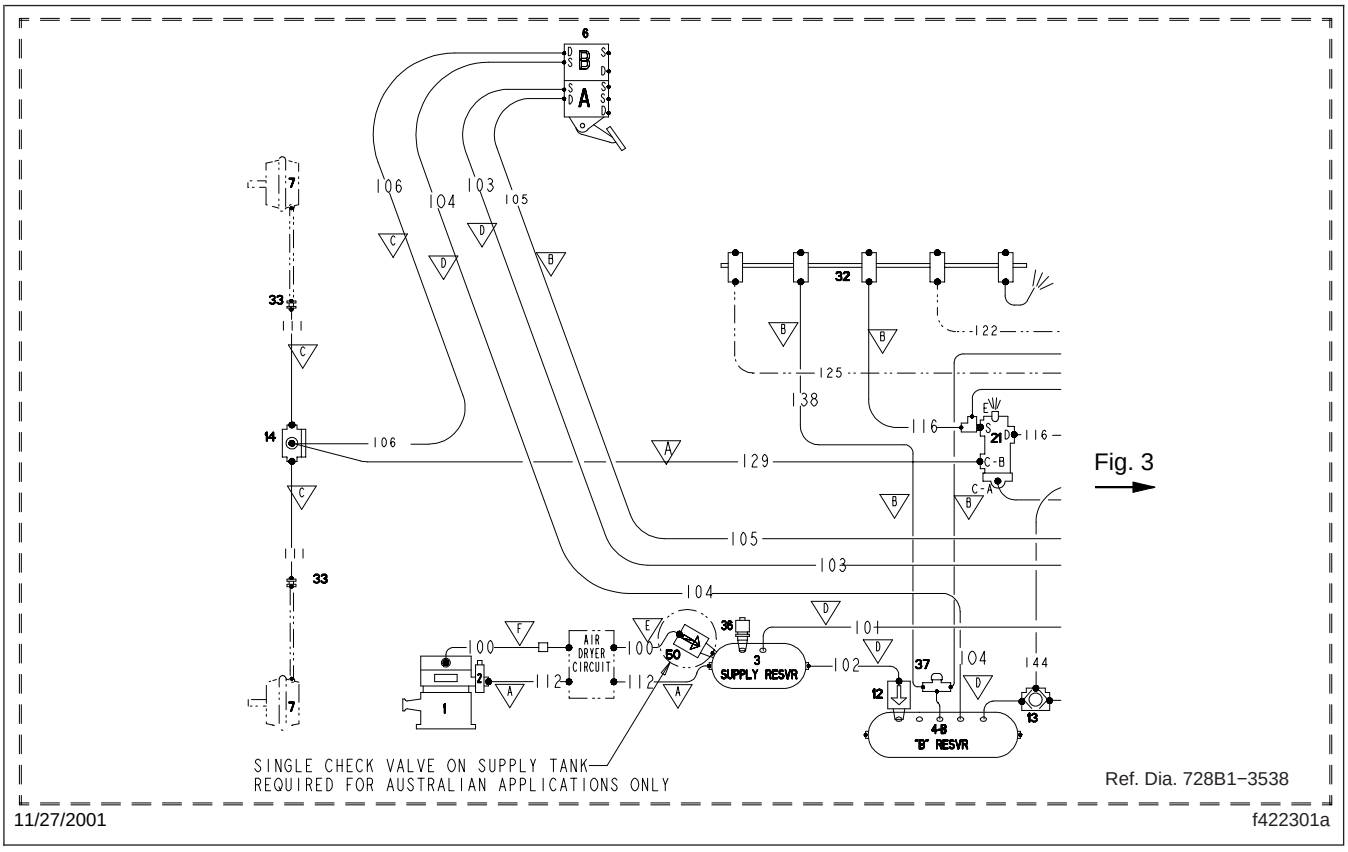



Fig. 3 →

**Fig. 2, Chassis Air Line Schematic, Vehicle With Tri-Drive Axles (partial view)**

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## Chassis Air Line Schematic, Vehicle With Tri-Drive Axles

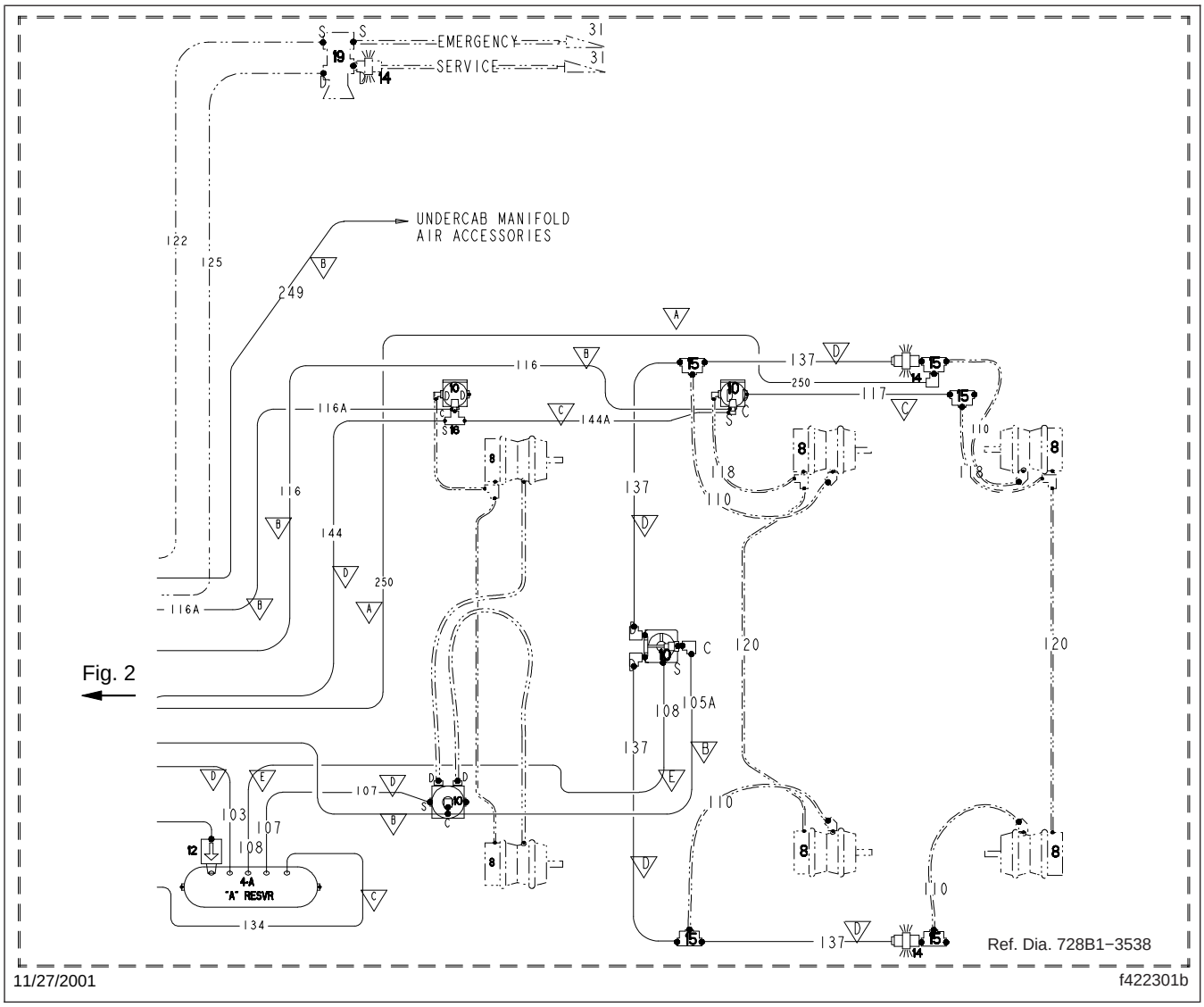



**Fig. 3, Chassis Air Line Schematic, Vehicle With Tri-Drive Axles (partial view)**

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## General Information

The Bendix TP–3 tractor protection valve is usually mounted in the frame rail channel, as shown in **Fig. 1**.

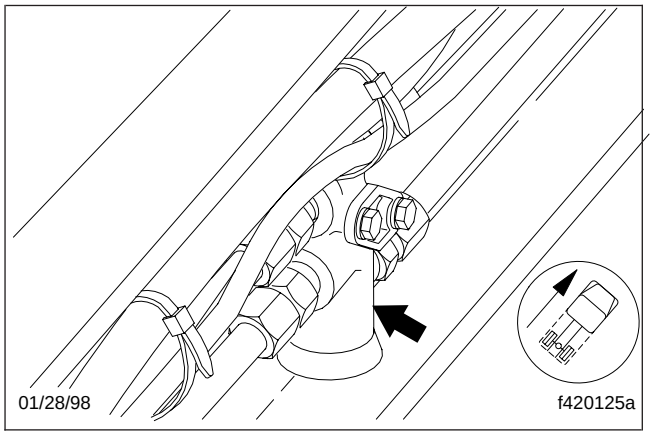


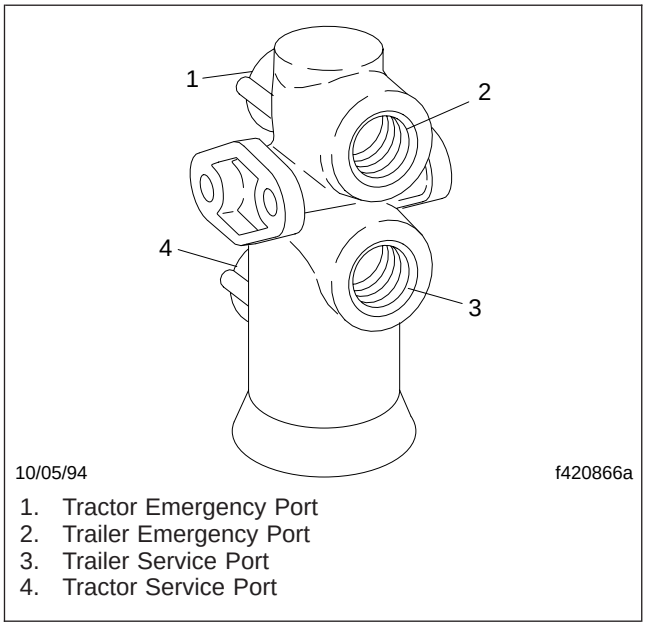

**Fig. 1, TP-3 Valve in Frame Rail**

An air hose from the dash-mounted trailer air supply valve connects to the TP–3 valve tractor emergency port. See **Fig. 2**. An air hose from the foot and hand brake valves connects to the TP–3 valve tractor service port. The tractor-to-trailer air brake hoses are connected to the TP–3 valve trailer emergency port and trailer service port.

## Principles of Operation

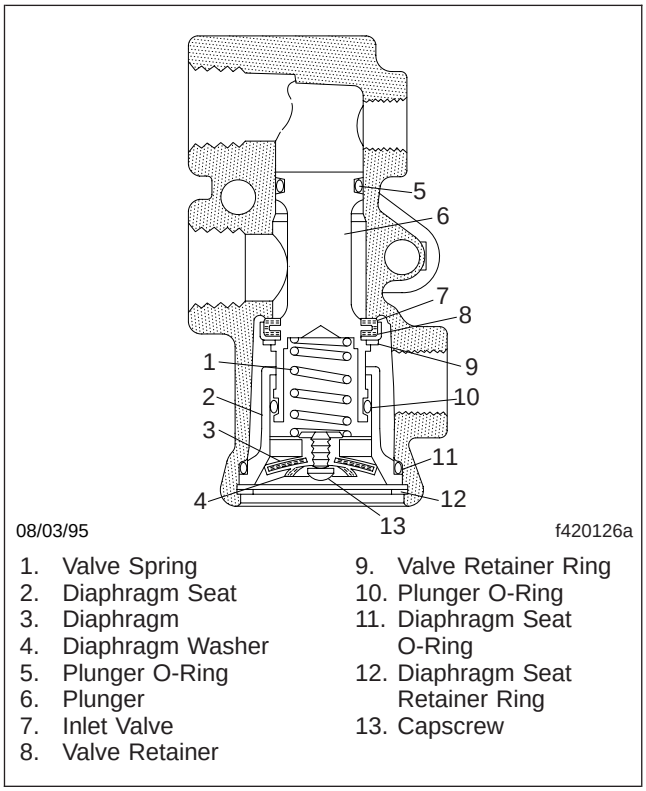
When the trailer air supply valve is open, air flows through the TP–3 valve emergency ports to the trailer air brake system, and releases the trailer parking brakes. See **Fig. 2**. The air within the TP–3 valve exerts pressure on a plunger, which unseats an inlet valve, and opens the service ports. See **Fig. 3**. This allows service application of the trailer air brakes.

At least 45 psi (310 kPa) pressure on the plunger is required to open the inlet valve. Whenever the air supply is shut off (at the trailer air supply valve), or the pressure drops below the minimum 45 psi (310 kPa), the plunger rises, seating the inlet valve and closing the service ports to protect the tractor brake system pressure.




1. Tractor Emergency Port
2. Trailer Emergency Port
3. Trailer Service Port
4. Tractor Service Port

**Fig. 2, TP-3 Valve Ports**




1. Valve Spring
2. Diaphragm Seat
3. Diaphragm
4. Diaphragm Washer
5. Plunger O-Ring
6. Plunger
7. Inlet Valve
8. Valve Retainer
9. Valve Retainer Ring
10. Plunger O-Ring
11. Diaphragm Seat O-Ring
12. Diaphragm Seat Retainer Ring
13. Capscrew

**Fig. 3, TP-3 Valve Cross Section**

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## Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

- Chock the tires and shut down the engine before working under the vehicle. Releasing air from the system may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters; they will apply as air pressure drops.
- Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
- Never exceed recommended air pressure.
- Always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
- Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs, and injury can result if not correctly disassembled. Use only correct tools and observe all precautions regarding use of those tools.

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**⚠ WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

## Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Open the air reservoir drain cocks to bleed the air from the system.
3. Remove the trailer hose assemblies from the TP–3 valve. Disconnect the tractor service and supply lines. Mark the lines for later assembly reference. Cap the air lines tightly to keep out contaminants.
4. Remove the fasteners attaching the TP–3 valve to the vehicle, and remove the valve.

## Installation

1. Place the TP–3 valve on the vehicle, and attach it with bolts, washers, and nuts. Tighten the nuts 11 to 15 lbf·ft (15 to 20 N·m).
2. The delivery line from the trailer air supply valve is connected to the tractor emergency port of the TP–3 valve. See **Fig. 1**. The delivery line from the brake valve (double check valve) is connected to the tractor service port of the TP–3 valve. Trailer hose assemblies are installed in the trailer emergency and trailer service ports of the TP–3 valve.

   Remove the caps from the air lines, and depending on the type of air hose, use the following instructions to connect the air hoses to the TP–3 valve.

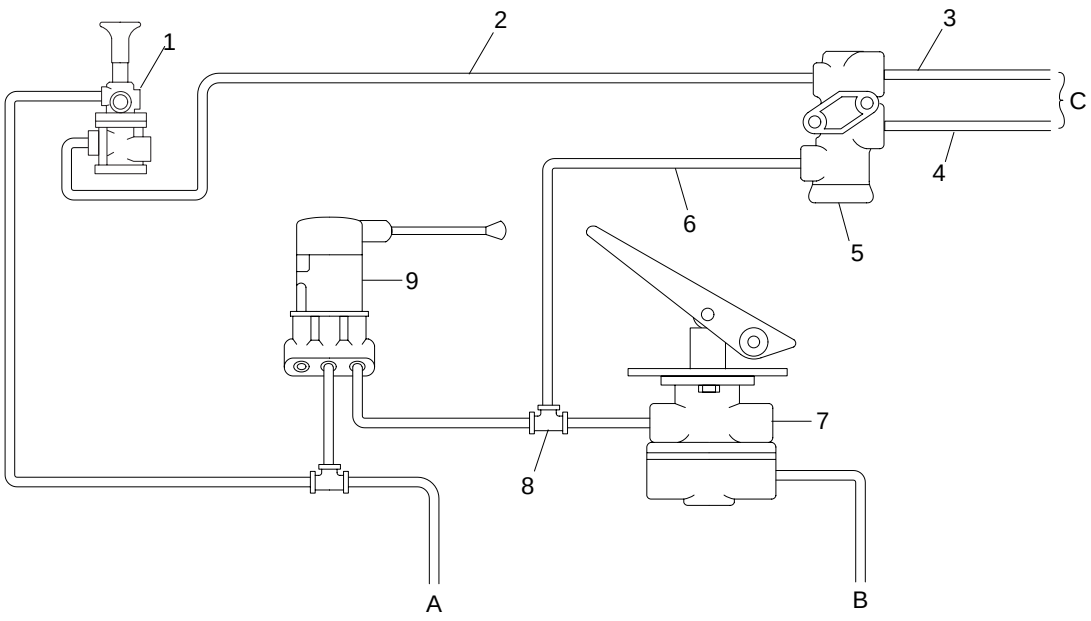
   If equipped with nylon tube air hoses, connect the hose fittings to the valve ports, and tighten the nuts finger-tight. Then, using a wrench, tighten the nuts at least two turns, or until no threads show on the fitting.

   If equipped with wire braid hoses, connect the hose fittings to the valve ports, and hand-tighten the nuts. Using a wrench, tighten the nuts until there is resistance. Tighten one-sixth turn more. Do not overtighten.
3. Close the drain cocks to the air reservoirs. Start the vehicle engine to pressurize the air system.
4. Leak test the TP–3 valve following the instructions in **Subject 130**.

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## Valve Removal and Installation




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A. To air reservoirs.
B. To air reservoirs.
C. To trailer hose connections.

1. Trailer Supply Valve
2. Trailer Supply Line
3. Trailer Emergency Line
4. Trailer Service Line
5. TP–3 Valve
6. Tractor Service Line
7. Foot Brake Valve
8. Double Check Valve
9. Hand Brake Valve

**Fig. 1, TP-3 Valve Plumbing**

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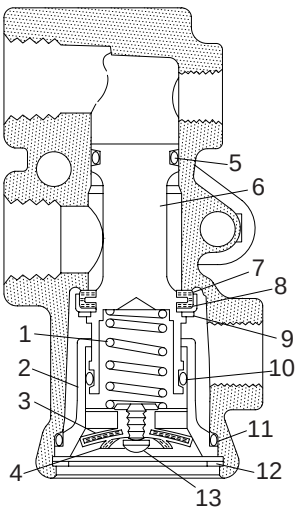
# Valve Disassembly, Cleaning and Inspection, and Assembly

**WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

## Disassembly

1. Remove the valve from the vehicle. For instructions, see **Subject 110**.
2. Holding the diaphragm seat in the body, remove the diaphragm seat retainer ring. See **Fig. 1**.




1. Valve Spring
2. Diaphragm Seat
3. Diaphragm
4. Diaphragm Washer
5. Plunger O-Ring
6. Plunger
7. Inlet Valve
8. Valve Retainer
9. Valve Retainer Ring
10. Plunger O-Ring
11. Diaphragm Seat O-Ring
12. Diaphragm Seat Retainer Ring
13. Capscrew

**Fig. 1, TP-3 Valve Cross Section**

3. Allow the valve spring to expand until the valve diaphragm seat assembly, valve spring, and plunger assembly can be removed.
4. Remove the diaphragm seat O-ring from the valve housing.
5. Remove the capscrew and diaphragm washer from the diaphragm seat assembly.
6. Remove the valve retainer ring, valve retainer, inlet valve, and O-rings from the plunger.

## Cleaning and Inspection

**WARNING**

**Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.**

1. Wash all metal parts of the TP–3 valve in cleaning solvent. Dry the metal parts of the disassembled valve with compressed air.
2. Wipe all rubber parts clean with a clean cloth. Examine all rubber parts for cracks, tears, or other deterioration. If any of these conditions are found on a part, replace the part with a new one.
3. Examine all metal parts for wear, cracks, or other damage. If any of these conditions are found on a part, replace the part with a new one.
4. Check the spring for distortion and corrosion. If the spring is distorted or corroded, replace it.

## Assembly

1. Lubricate the O-rings and all sliding parts with Dow Corning 55-M pneumatic grease or equivalent.
2. Install the inlet valve on the plunger. See **Fig. 1**.
3. Install the valve retainer over the inlet valve.
4. Install the valve retainer ring beneath the inlet valve retainer.
5. Install both plunger O-rings in the proper grooves.
6. Place the plunger and valve assembly in the valve body.
7. Install the capscrew, diaphragm washer (concave side down), and diaphragm into the diaphragm seat.
8. Place the inlet valve spring into the plunger.
9. Install the diaphragm seat O-ring in the body.
10. Install the diaphragm seat assembly over the spring and plunger assembly, and force them into the valve body.

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## Valve Disassembly, Cleaning and Inspection, and Assembly

11. Install the diaphragm seat retainer ring, making sure the retainer ring snaps fully into the groove.
12. Install the TP–3 valve on the vehicle following the instructions in **Subject 110**.

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**WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

## Leakage Test

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Place the trailer air supply valve in the emergency position, and disconnect the trailer air lines from the trailer supply and service couplings. Apply a soap-water solution to the couplings.
3. With tractor reservoirs charged to at least 100 psi (690 kPa) make and hold a full service brake application. Leakage at either tractor hose coupling should not exceed a 1-inch (2.5-cm) bubble in five seconds.
4. Connect the trailer supply line hose coupling, and place the trailer supply valve in the "run" position. Leakage at the service coupling should not exceed a 1-inch (2.5-cm) bubble in five seconds.
5. Connect the service brake coupling, and make and hold a full service brake application. Leakage at the diaphragm end of the TP–3 valve should not exceed a 1-inch (2.5-cm) bubble in three seconds.

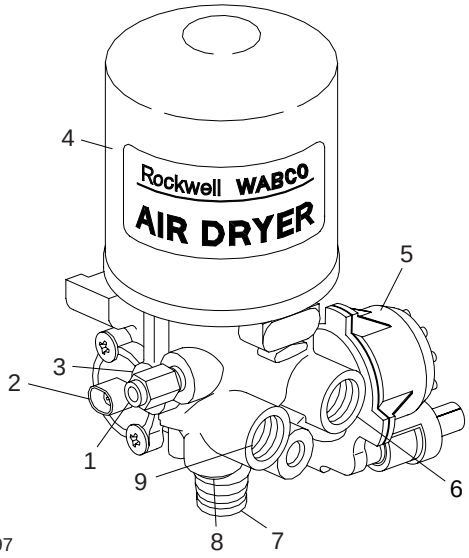
IMPORTANT: If leakage is excessive, replace the valve.

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## General Information

The System Saver 1200 air dryer (**Fig. 1**) is a desiccant air dryer, mounted vertically between the air compressor and the supply reservoir. The air dryer receives hot compressed air, which it cools and filters before sending it to the supply reservoir, reducing the build-up of dirt and moisture in the vehicle air system.




1. Pressure Relief Valve
2. Heater/Thermostat Assembly
3. Governor Port (to air governor)
4. Desiccant Canister
5. Regeneration Valve Assembly
6. Outlet Port (to air supply reservoir)
7. Exhaust Port (Purge Valve Assembly)
8. Turbocharger Cutoff Valve
9. Inlet Port (from air compressor)

**Fig. 1, WABCO System Saver 1200**

The air dryer consists of a light weight aluminum and steel body. The desiccant cartridge is contained in a spinoff canister at the top of the air dryer.

The bottom half of the air dryer houses the following components.

- Pressure Relief Valve–this valve protects the air dryer from over pressurization. The valve is attached directly to the air dryer.
- Desiccant Canister–a cylindrical steel housing that contains the filter elements and the desiccant needed to filter and dry the air that passes through it.
- Heater/Thermostat Assembly–located in the air dryer base, this assembly is designed to prevent the collected moisture from freezing.
- Outlet Check Valve–this valve prevents air in the system from flowing back through the air dryer and escaping out the purge valve during the compressor unload cycle.
- Pressure-Controlled Check Valve–this valve is separate from the air dryer and is installed on the system air tank. The valve allows air to back flow from the system tank to the supply tank as long as air system pressure remains between the normal cut in and cut out range of the air governor.
- Purge Valve–this valve allows the collected moisture and contaminants to be expelled from the air dryer during the purge cycle.
- Regeneration Valve–this valve allows air from the supply and system tanks to bypass the outlet check valve and flow into the regeneration valve. Air then flows through an orifice where the air expands and back flushes moisture off of the desiccant. The air is then exhausted through the purge valve.
- Silencer (Muffler)–an optional component that is attached to the purge valve and used to eliminate most of the noise during the air dryer purge cycle.
- Turbocharger Cut-Off Valve–this valve closes the path between the air compressor and the air dryer purge valve to help maintain boost pressure for maximum engine horsepower during the compressor unload cycle.

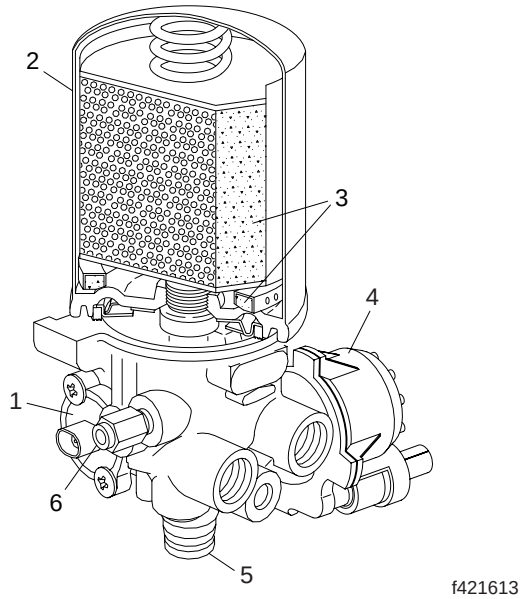
## Principles of Operation

Hot, compressed air enters the air dryer through the inlet port. As the hot air is forced into the desiccant cartridge, the temperature of the compressed air falls to nearly ambient. Oil and water vapor condense and initially settle into the base of the dryer. The moisture-laden air also passes through the desiccant bed, where any remaining moisture is retained by the desiccant. The clean air then passes through the air dryer outlet port to the supply reservoir. See **Fig. 2**.

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## General Information




1. Heater/Thermostat Assembly
2. Desiccant Canister
3. Filter
4. Regeneration Valve Assembly
5. Exhaust Port (Purge Valve Assembly)
6. Pressure Relief Valve

**Fig. 2, WABCO System Saver 1200 Air Dryer Sectional View**

When the compressor reaches 125 psi (862 kPa), the purge valve opens allowing the initial decompression of the dryer and expels the water and contaminants collected in the base of the dryer. The regeneration valve, along with the pressure-controlled check valve, allows the system air to flow back through the dryer. This back flow dries the desiccant for the next cycle.

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## Safety Precautions

**⚠ WARNING**

**When draining the air system, don't look into the air jets or direct them toward another person, as dirt or sludge particles may be in the airstream. Don't disconnect pressurized hoses because they may whip as air escapes from the line. Failure to take all necessary precautions during service operations of the air brake system can cause personal injury.**

When working on or around air brake systems and components, observe the following precautions.

1. Apply the parking brake, chock the tires, and stop the engine when working under the vehicle. Draining the air system may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters, which may apply as air system pressure drops.
2. Wear safety goggles.
3. Never connect or disconnect a hose or line containing air under pressure; it may whip as air escapes. Never remove a component or pipe plug unless you are sure all system pressure has been depleted.
4. Don't disassemble a component before reading and understanding recommended procedures. Use only the correct tools and follow basic tool safety.
5. Replacement hardware, tubing, hose, fittings, etc. should be the same size, type, length, and strength as the original equipment. When replacing tubing or hose, be sure that all of the original supports, clamps, or suspending devices are installed or replaced.
6. Replace any components that have stripped threads or damaged parts. Don't attempt to repair parts by machining.
7. Never exceed recommended air pressure.

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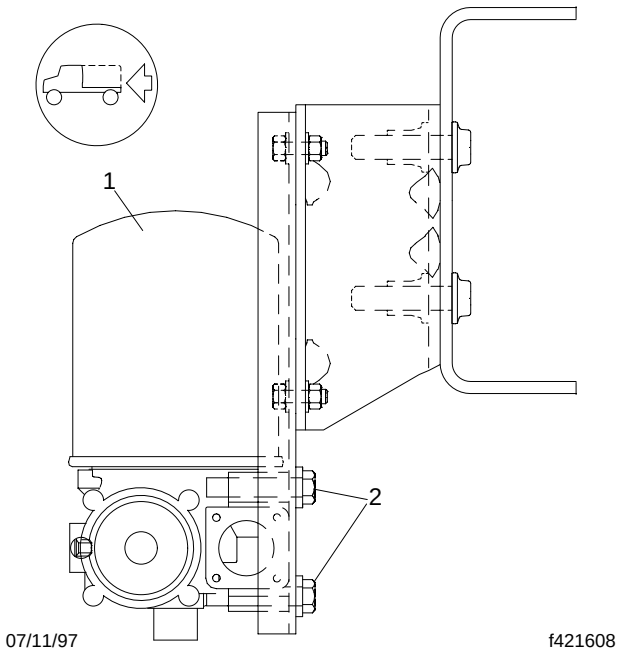


**⚠ WARNING**

**Before starting the procedures below, read the information in Safety Precautions, Subject 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.**

## Removal

1. Drain the air system.
2. Disconnect the wiring harness from the air dryer.
3. Mark the air lines for later reference; then, disconnect them from the air dryer.
4. Remove the capscrews, washers, and spacers that attach the air dryer to the mounting bracket. See **Fig. 1**.




1. Desiccant Canister
2. 1/2" Capscrew, Washer, and Spacer

**Fig. 1, Air Dryer Installation (outboard rail mounting shown)**

5. Remove the air dryer.

## Installation

1. Position the air dryer on the mounting bracket. See **Fig. 1**. Install the spacers, washers, and capscrews. Tighten them 22 to 30 lbf·ft (30 to 41 N·m).
2. Make sure the air lines are clean. Replace any line or fitting that is crimped or damaged.
3. Connect the remaining air lines to the air dryer as previously marked. Tighten the nut on each fitting finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut until there is firm resistance.
4. Connect the air dryer wiring harness.

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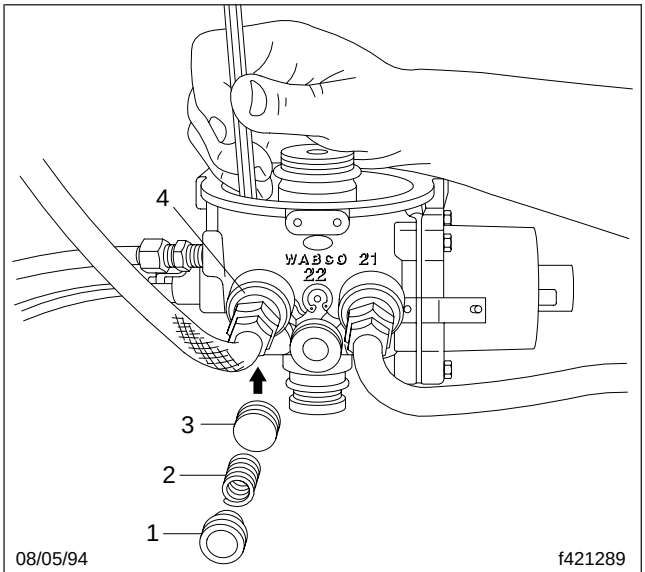


## Replacement

**⚠ WARNING**

**Before starting the procedures below, read the information in Safety Precautions, Subject 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.**

1. Drain the air system.
2. Remove the snap ring at the bottom of the valve assembly. The valve cover and spring may fall out of the cavity when the snap ring is removed. See Fig. 1.




1. Cover
2. Spring
3. Piston
4. Inlet Port

**Fig. 1, Push the Piston, Spring, and Cover out of the Valve Cavity**

3. Using a strap wrench, turn the desiccant cartridge counterclockwise and remove it.
4. Using a wooden stick, push the piston, spring, and the cover out of the valve cavity.
5. Clean the valve cavity with a commercial cleaning solvent.
6. Install new O-rings on the piston and the cover.
7. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-rings and the valve cavity.
8. Install the new piston with its hollow side facing out.

IMPORTANT: If the valve cavity is damaged, preventing a tight seal, replace the air dryer.

9. Install the new spring, cover, and snap ring to hold the components in place.
10. Thread the desiccant cartridge onto the dryer base (turn clockwise). When the seal contacts the base, tighten the cartridge one complete turn more. Do not over tighten.

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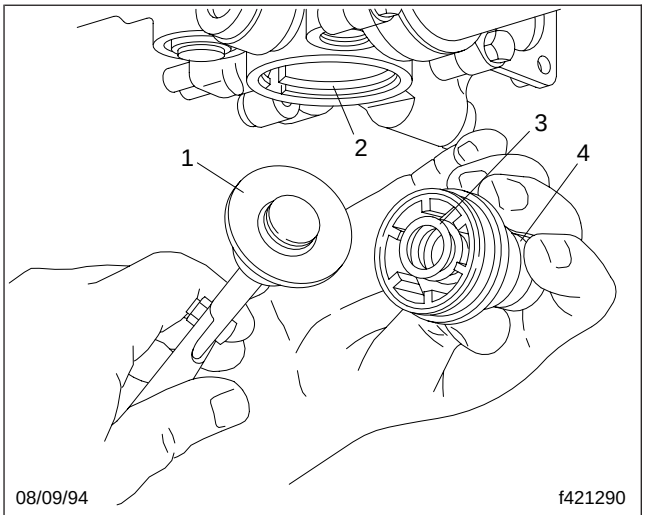


## Replacement

**⚠ WARNING**

**Before starting the procedures below, read the information in Safety Precautions, Subject 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.**

1. Drain the air system.
2. Remove the snap ring, valve head, and the spring from the exhaust port. See **Fig. 1**.




1. Valve Assembly
2. Exhaust Port
3. Spring
4. Valve Head

**Fig. 1, Remove the Valve Assembly**

3. Pull the valve assembly out of the exhaust port.
4. Remove the O-ring from the base of the exhaust port.
5. Clean the purge valve cavity area with a commercial cleaning solvent.
6. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the valve cavity and to all of the new O-rings. Install the O-rings in the base of the exhaust port and on the valve head.
7. Position the new valve assembly in the valve cavity.

IMPORTANT: If the valve cavity is damaged, preventing a tight seal, replace the air dryer.

8. Install the spring in the valve head, and position them in the valve cavity.
9. Install the snap ring to secure the valve head in position.

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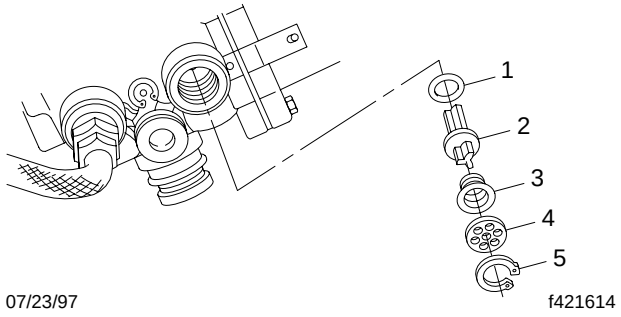


## Replacement

**WARNING**

**Before starting the procedures below, read the information in Safety Precautions, Subject 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.**

1. Drain the air system.
2. Disconnect the air line from the outlet port.
3. Remove the snap ring, washer, valve body, and the O-ring. See **Fig. 1**.




1. O-Ring
2. Valve Body
3. Spring
4. Washer
5. Snap Ring

**Fig. 1, Outlet Check Valve Assembly**

4. Clean the cavity area with a commercial cleaning solvent.
5. Install a new O-ring on the valve body.
6. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-ring and the valve cavity.
7. Install the new valve body. Make sure that the long end of the body is inserted first into the valve cavity.
8. Install the new spring with its small end around the "Y" shaped fins on the valve body.

IMPORTANT: If the valve cavity is damaged, preventing a tight seal, replace the air dryer.

9. Install a new washer and snap ring to secure the assembly in the valve cavity.
10. Connect the air line to the outlet port. Tighten the nut on the fitting finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut until there is firm resistance. Tighten the nut one-sixth turn more.

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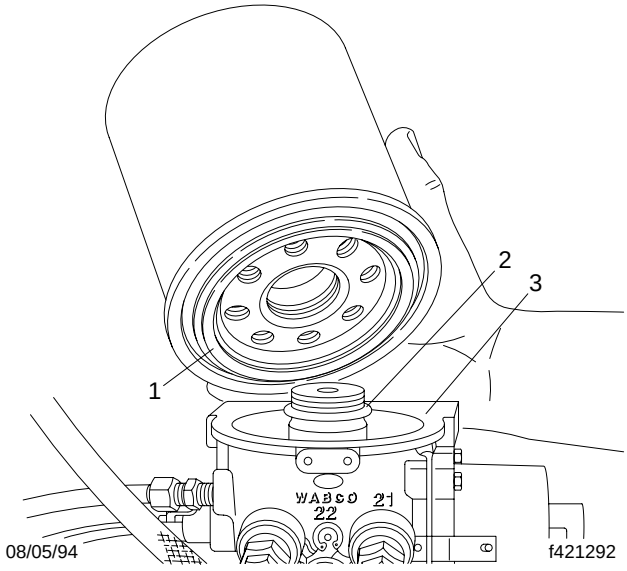


## Replacement

**⚠ WARNING**

**Before starting the procedures below, read the information in Safety Precautions, Subject 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.**

1. Drain the air system.
2. Using a strap wrench, turn the desiccant cartridge counterclockwise and remove it. See **Fig. 1**.




1. Seal
2. O-Ring
3. Air Dryer Base

**Fig. 1, Desicant Cartridge Replacement**

3. Remove and discard the O-ring.
4. Clean the top surface of the dryer base with a commercial cleaning solvent.
5. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-ring and the dryer base. Install the O-ring.
6. Thread the desiccant cartridge onto the dryer base (turn clockwise). When the seal contacts the base, tighten the cartridge one complete turn more. Do not over tighten.

IMPORTANT: If the air dryer base is damaged, preventing a tight seal, replace the air dryer.

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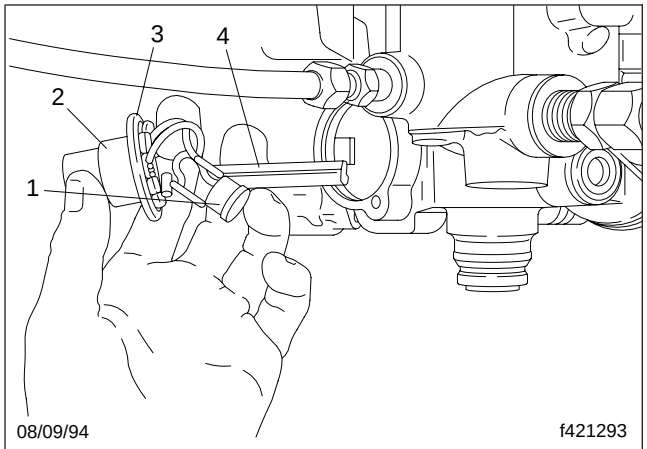


## Replacement

**⚠ WARNING**

**Before starting the procedures below, read the information in Safety Precautions, Subject 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.**

1. Drain the air system.
2. Disconnect the wiring harness. See **Fig. 1**.




1. Thermostat
2. Receptacle
3. O-Ring
4. Element

**Fig. 1, Heater/Thermostat Replacement**

3. Remove the screws that attach the heater/thermostat receptacle. Remove the receptacle and the O-ring.
4. Remove the retaining screw that holds the assembly in place. Remove and discard the heater/thermostat assembly.
5. Clean the heater/thermostat assembly area with a commercial cleaning solvent.
6. Position the new heater/thermostat assembly in the cavity. Install the retaining screw.
7. Position the new receptacle and O-ring, and install the screws. Tighten the screws securely.
8. Connect the wiring harness.

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## Replacement

**⚠ WARNING**

**Before starting the procedures below, read the information in Safety Precautions, Subject 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.**

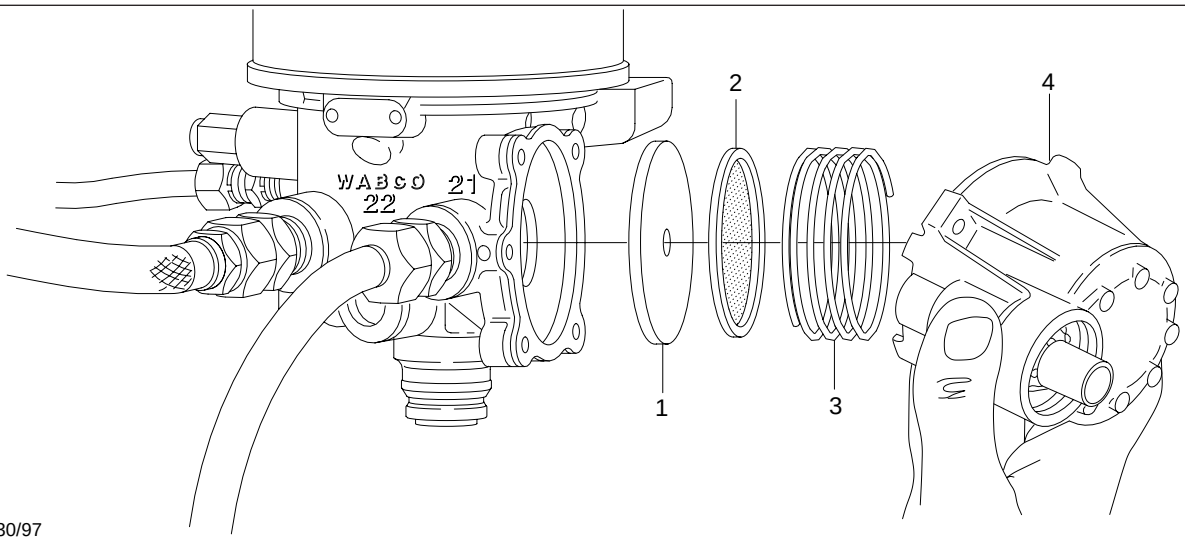
1. Drain the air system.

NOTE: When the valve housing is removed, the spring and the retainer will fall out of the housing.

2. Remove the four mounting bolts and remove the valve housing assembly. See **Fig. 1**.
3. Remove the rubber diaphragm.
4. Clean the groove where the diaphragm lip fits with a commercial cleaning solvent.
5. Install a new diaphragm with its lip in the groove.

IMPORTANT: If the groove is damaged, preventing a tight seal, replace the air dryer.

6. Install the new spring and retainer (with the retainer lip facing out).
7. Position the valve housing on the air dryer. Install the bolts and tighten them to 53 lbf·in (600 N·cm).




1. Diaphragm
2. Retainer
3. Spring
4. Valve Housing Assembly

**Fig. 1, Regeneration Valve Assembly**

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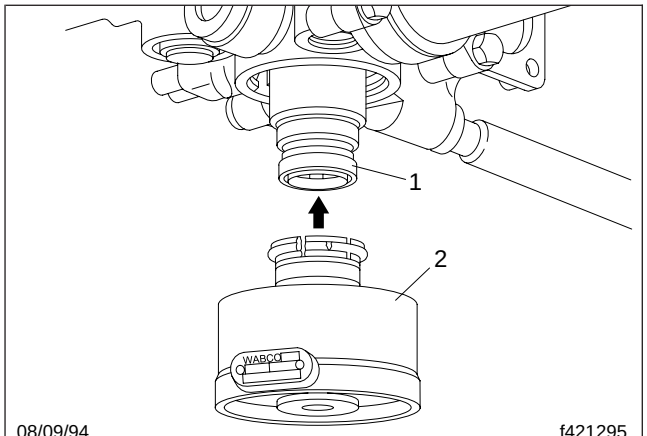


## Replacement

**WARNING**

**Before starting the procedures below, read the information in Safety Precautions, Subject 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.**

1. Using snap ring pliers, expand the snap ring and pull the silencer off of the purge valve head. See **Fig. 1**.




1. Purge Valve Head
2. Silencer

**Fig. 1, Silencer Replacement**

2. Push the new silencer onto the purge valve head until the silencer snaps into place.

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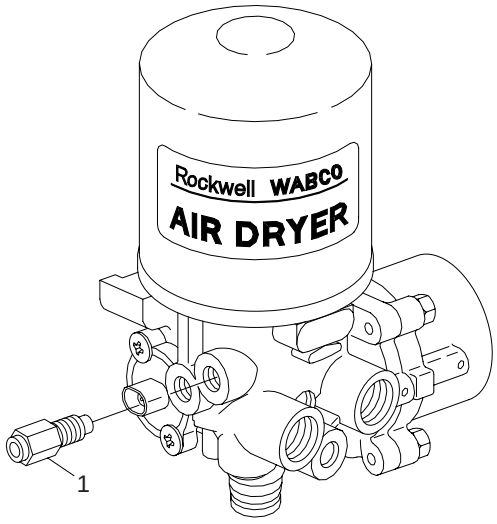


## Replacement

**⚠ WARNING**

**Before starting the procedures below, read the information in Safety Precautions, Subject 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.**

1. Drain the air system.
2. Unscrew and remove the old valve from the dryer. See **Fig. 1**.




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1. Pressure Relief Valve

**Fig. 1, Pressure Relief Valve Replacement**

3. Screw the replacement valve into the dryer base. Do not exceed a torque of 30 lbf·ft (41 N·m) for a 3/8 inch thread, or 65 lbf·ft (88 N·m) for 1/2 inch thread.

NOTE: The threads on the replacement pressure relief valve provided by Meritor WABCO are coated with sealant. They do not require any additional sealant.

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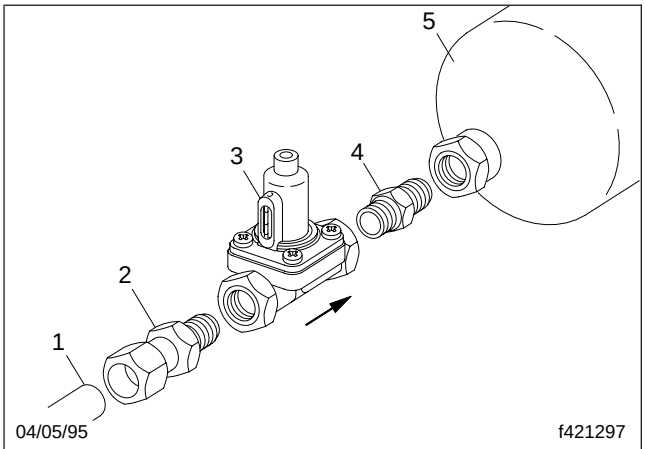


## Replacement

**⚠ WARNING**

**Before starting the procedures below, read the information in Safety Precautions, Subject 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.**

1. Drain the air system.
2. Disconnect the air line from the pressure-controlled check valve. See **Fig. 1**.




1. Air Line
2. Nylon Tube Connector
3. Pressure-Controlled Check Valve
4. Hex Nipple Pipe Fitting
5. Air Tank

**Fig. 1, Check Valve Assembly Replacement**

3. Remove the valve and the hex nipple fitting from the air tank
4. Install the pipe fitting on the new valve.
5. Install the new valve on the air tank with the arrow on the valve pointing towards the tank.
6. Apply liquid Loctite® Hydraulic Sealant (brown), or an equivalent, to the air line threads. Connect the air line to the valve. Tighten the air line securely.

NOTE: Always apply sealant to the external threads so that any excess will be scraped off externally rather that internally to the joint.

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# Operating Tests

**⚠ WARNING**

**Before starting the procedures below, read the information in Safety Precautions, Subject 100. Failure to follow the safety precautions during service operations on the air brake system can cause personal injury.**

## Air Dryer Operating Check

1. Drain the air system.
2. Start the engine and build the air pressure to as close to cutout pressure as possible (about 125 psi [162 kPa]).
3. When the compressor reaches the unload cycle, the air dryer purges, beginning regeneration of the air dryer.
4. During the purge cycle, which lasts about 10 to 15 seconds, the wet tank and system tank sith pressure-controlled check valve will drop about 10 psi (69 kPa). Check the system air gauge in the cab dash panel.
5. If the gauge needle does not show a pressure drop of about 10 psi (69 kPa), one of the following problems may exist.
   - A pressure-controlled check valve is not installed.
   - The pressure-controlled check valve is installed in the wrong air tank.
   - The pressure-controlled check valve is installed on a one-way check valve, instead of in place of a one-way check valve.
   - There is an extra check valve located somewhere between the air dryer and the secondary air tank (usually at the wet tank).
   - The system air gauge is not plumbed to the correct air system.
6. If system air pressure drops 15 psi (103 kPa) or more during the purge cycle, and there are no other air-operated components in use, then there are air leaks or other system problems. See Troubleshooting, **Subject 300** for other possible causes.

## Pressure-Control Check Valve Operating Check

IMPORTANT: Install a calibrated air gauge (accurate to within 1 psi [7 kPa]) in the system air tank with the pressure-controlled check valve to check the valve. Do not use the cab air gauges.

1. Start the engine and build the air pressure to as close to cutout pressure as possible (about 125 psi [862 kPa]).
2. Stop the engine after the air compressor has unloaded.
3. Drain the opposite system air tank(s) down to about 80 psi (552 kPa).
4. Check the calibrated air gauge. It should read 95 ±5 psi (655 ±34 kPa).

   If the gauge reading is less that 85 psi (586 kPa), either the pressure-control check valve is installed backwards, it is damaged, or there are air leaks in the system tank air system.

   If the gauge reading does not change, or the reading does not fall below 105 psi (724 kPa), make the checks under "Air Dryer Operating Check." If none of those problems exist, replace the control valve.

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# Troubleshooting Tables

**Problem—Purge Cycle is too Long (more than 30 seconds)**

| Problem—Purge Cycle is too Long (more than 30 seconds) | |
|---|---|
| **Possible Cause** | **Remedy** |
| The air dryer outlet check valve is stuck open. | Replace the check valve assembly. |
| The turbocharger cutoff valve is leaking. | Replace the turbocharger cutoff valve. |
| The regeneration valve is not working correctly. | Replace the regeneration valve. |

**Problem—Purge Cycle is too Short (less than 8 seconds)**

| Problem—Purge Cycle is too Short (less than 8 seconds) | |
|---|---|
| **Possible Cause** | **Remedy** |
| The air governor is not working. | Replace the air governor. |
| The pressure-control check valve is not working correctly. | Replace the pressure-control check valve. |
| The regeneration valve is not working correctly. | Replace the regeneration valve. |

**Problem—System Air Pressure Drops Rapidly**

| Problem—System Air Pressure Drops Rapidly | |
|---|---|
| **Possible Cause** | **Remedy** |
| Fittings are loose or damaged. | Tighten or replace loose or damaged fittings. |
| Air reservoir, tubing, or hoses are damaged. | Repair or replace damaged items. |
| The air dryer outlet check valve is stuck open. | Clean or replace the outlet check valve assembly. |

**Problem—Excessive Cycling of the Air Dryer**

| Problem—Excessive Cycling of the Air Dryer | |
|---|---|
| **Possible Cause** | **Remedy** |
| Fittings are loose or damaged. | Tighten or replace loose or damaged fittings. |
| Air reservoir, tubing, or hoses are damaged. | Repair or replace damaged items. |
| The air dryer outlet check valve is leaking or stuck open. | Replace the outlet check valve assembly. |
| High air usage or demand for a particular system. | Increase air system capacity or reduce air demand. |
| The governor is not working properly. | Replace the air governor. |

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## Troubleshooting

| Problem—Excessive Cycling of the Air Dryer | |
|---|---|
| **Possible Cause** | **Remedy** |
| The air compressor needs to be serviced or replaced. | Rebuild or replace the air compressor. |

**Problem—Water and/or Oil in the Vehicle Air Reservoirs**

| Problem—Water and/or Oil in the Vehicle Air Reservoirs | |
|---|---|
| **Possible Cause** | **Remedy** |
| The desiccant cartridge contains excessive contaminants. | Replace the desiccant cartridge. |
| Purge cycle is too short. | Refer to "Problem—Purge Cycle is too Short (less than 8 seconds)." |
| The pressure relief valve is leaking. | Replace the pressure relief valve. |
| Too much oil is pumped from the air compressor. | Rebuild or replace the air compressor. |
| The regeneration valve is not working correctly. | Replace the regeneration valve. |
| The air dryer is mounted too close to a heat source. | Locate the air dryer away from heat sources and where air can flow around it. |
| Discharge line is of improper length or material. | Discharge line must consist of at least 6 ft. (1.8 m) of wire braid Teflon hose, copper tubing, or a combination of both between the discharge port of the compressor and the air dryer supply port. Discharge line lengths and inside diameter requirements are dependent on the vehicle application. Contact your local Meritor WABCO representative for further information. |

**Problem—The Air Compressor Runs Continuously (System Pressure Will Not Build Up)**

| Problem—The Air Compressor Runs Continuously (System Pressure Will Not Build Up) | |
|---|---|
| **Possible Cause** | **Remedy** |
| Fittings are loose or damaged. | Tighten or replace loose or damaged fittings. |
| Air reservoir, tubing, or hoses are damaged. | Repair or replace damaged items. |
| The air compressor needs to be serviced or replaced. | Rebuild or replace the air compressor. |
| The purge valve is stuck open. | Replace the purge valve. |
| The line between the air compressor and the air dryer is blocked, leaks, or is plumbed incorrectly. | Repair or replace the line as needed. |
| The governor is not working properly. | Replace the air governor. |
| The turbocharger cutoff valve or the outlet check valve is stuck in the closed position. | Replace the turbocharger cutoff valve or the outlet check valve. |
| The desiccant cartridge or cartridge seal is leaking. | Tighten or replace the desiccant cartridge. |
| The wrong air line is connected to port 4 on the air dryer. | Correct the air line plumbing. |

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| Problem—The Air Compressor Runs Continuously (System Pressure Will Not Build Up) | |
|---|---|
| **Possible Cause** | **Remedy** |
| The air dryer outlet port is plumbed incorrectly. | Connect the outlet port line to the supply air tank. |
| The air dryer base is cracked. | Replace the air dryer. |

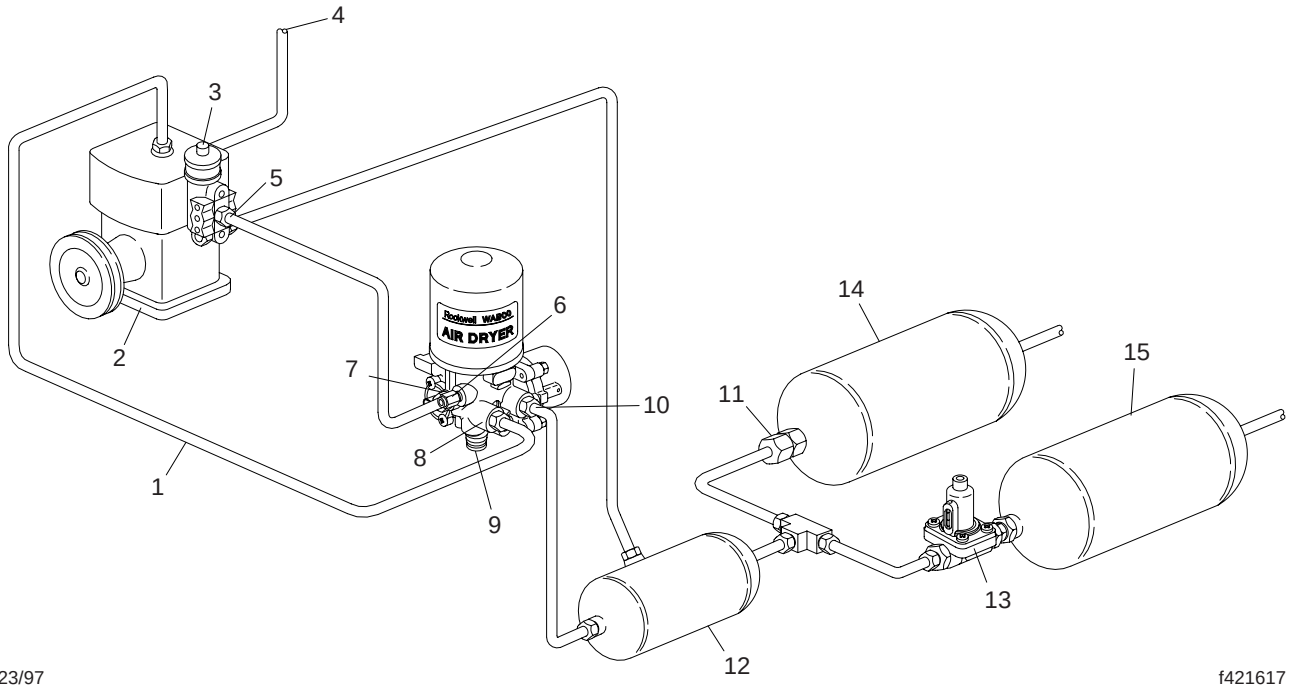
**Problem—The Air Dryer Does Not Unload When the Air Compressor Goes Into Standby Mode**

| Problem—The Air Dryer Does Not Unload When the Air Compressor Goes Into Standby Mode | |
|---|---|
| **Possible Cause** | **Remedy** |
| The line between the air governor and the air dryer purge port is missing, loose, or damaged. | Install or replace the air line, or tighten the fittings. |
| The heater/thermostat assembly is not working. | Replace the heater/thermostat assembly or check the electrical connections. |

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See **Fig. 1** for the plumbing diagram.




1. Compressor Discharge Line
2. Air Compressor
3. Air Governor
4. Compressor Intake Line
5. Unloader Port
6. Pressure Relief Valve
7. Air Governor Port
8. Air Dryer Inlet
9. Purge Valve
10. Air Dryer Outlet
11. Check Valve
12. Supply Tank
13. Pressure-Control Check Valve
14. System Reservoir
15. System Reservoir

**Fig. 1, Air Dryer Plumbing Diagram**

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## General Description

The Eaton Antilock Braking System (ABS) is an electronic wheel speed monitoring and control system that works with the standard air brake system. See **Fig. 1**. Its advanced electronic technology prevents wheel lock-ups by maintaining precise control of vehicle brake pressure. This ensures optimum vehicle stability while minimizing the stopping distance. During vehicle operation, the ABS Electronic Control Unit (ECU) continuously monitors all the wheel speed sensors. This wheel speed data allows the ECU to: detect an impending wheel lock; maintain an optimum wheel slip; and maximize the overall braking effectiveness.

The ABS system monitors and controls the brake pressure as follows:

- Each wheel speed sensor monitors and communicates wheel rotation information (speed signal pulses) to the ECU;
- The signals from the wheel speed sensors are then received and interpreted by the ECU. The ECU constantly calculates the relationship of wheel speed, acceleration and deceleration;
- Then, based on this wheel speed information, the ECU operates the ABS pressure modulator valves to regulate the air pressure in the brake chambers;
- During normal braking, air flows freely through the modulator valves to the brake chambers;
- During an emergency braking situation, the ECU signals the pressure modulator valves to increase, reduce, or maintain air pressure supply in the brake chamber.

The ABS indicator lamp reveals the condition of the ABS system. Under normal conditions, whenever the ignition is turned on, the ABS indicator lamp lights steadily for a two-second bulb check. If there are no problems, the ABS indicator lamp goes out. If it remains on, or lights during vehicle operation, then the ABS system requires service.

NOTE: In the case of a speed sensor failure which has been corrected, the ABS indicator lamp will remain on until the speed sensor output has been verified by the ECU. In this case it is necessary to operate the vehicle above a speed of five miles per hour before the indicator light goes out.

The Automatic Traction Control (ATC) System is an option on all ABS applications. The ATC system helps improve traction on slippery or unstable driving surfaces by reducing drive wheel overspin. This system consists of two control circuits; the brake control circuit and the engine throttle control circuit. If only one drive wheel slips, the ATC brake control circuit is activated, and then braking force is applied to the slipping wheel which adds torque to the traction wheel. Brake pressure is increased until the speed of the slipping is the same as the non slipping wheel. To prevent overheating of the brakes, the ATC system automatically deactivates after being applied for an extended amount of time. Then, after allowing sufficient time to cool the brakes, the ATC system will automatically reactivate. As an added safety feature, the brake controller is deactivated at speeds above 19 mph (30 km/h). If both driving wheels slip equally, the engine controller is activated, and then the engine torque is reduced to minimize the drive wheel spin. This option requires the addition of an ATC valve and an SAE J1922 engine interface. The ECU configures itself for traction control when it detects the presence of the ATC valve.

There are three ATC modes of operation:

- During the high-speed mode (highway speed operation), the engine is throttled back to control spin out;
- During the low-speed mode (low speed operation), both the engine controls and the brake controls are used to enhance vehicle traction;
- During the mud and snow mode (optional), a dash switch allows the driver to select more engine power and wheel spin if needed.

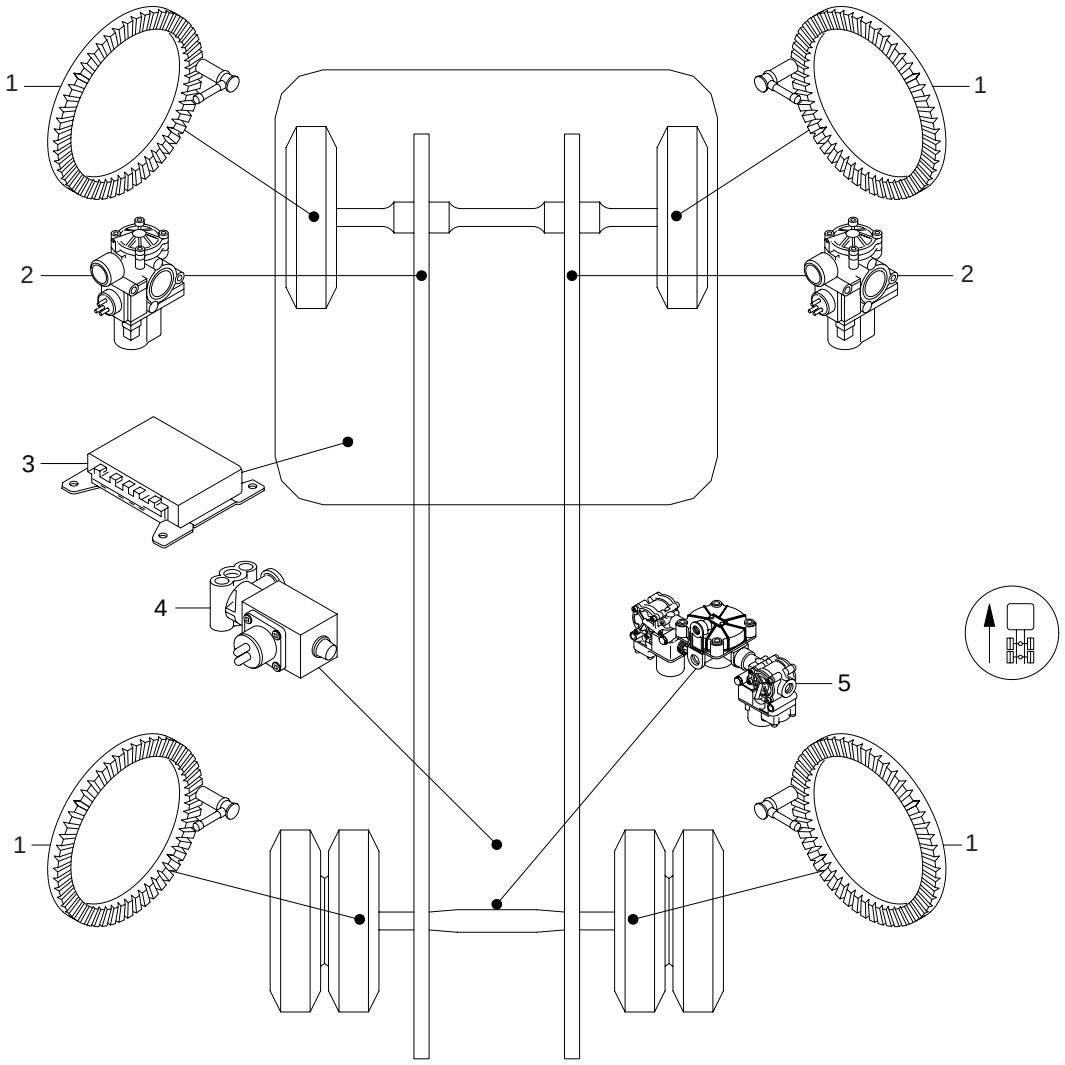
The ATC system can not increase traction to a particular wheel, it can only utilize the available traction.

The ATC (Wheel Spin) indicator lamp reveals the condition of the ATC system. The indicator lamp lights when the ignition is switched on and remains lit until the driver applies the brake pedal. The light flashes rapidly in the ATC mode, and it flashes slowly when the "mud and snow" mode is selected.

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## General Information




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1. Wheel End Sensor and Tone Wheel
2. Front (Steer) Pressure Modulator Valve
3. Automatic Traction Control (ATC) Valve
4. Combination (Rear Axle Module) Pressure Modulator Valve Assembly
5. Electronic Control Unit (ECU)

**Fig. 1, Location of ABS/ATC Components**

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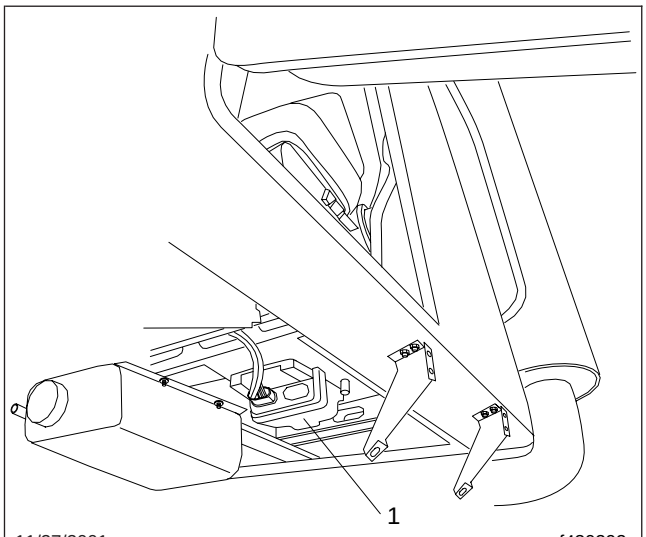


# Principles of Operation

## ABS and ATC Major Components

### Electronic Control Unit (ECU)

The ECU monitors and controls the ABS/ATC system. It receives and evaluates wheel speed information from four speed sensors, and if necessary, transmits control signals to the modulator valves. If the ECU detects no impending wheel lockups, the standard braking system is in effect. The ECU operates actively through the ABS release and hold modes of operation during emergency braking situations. The ABS release and hold modes are activated by the ECU as it signals the appropriate modulator valve to reduce braking force at that halting wheel until the threat of a skid is eliminated. With automatic traction control (ATC), the ECU also sends control signals to the ATC valve and engine control interface. If a drive wheel slips, the ECU signals the ATC valve to release supply air to the brake chamber of the slipping wheel. This adds braking force to the slipping wheel, which results in the transfer of torque from the wheel with less traction to the wheel with more traction. If both drive wheels slip, the ECU signals the engine controller to reduce engine torque, which will reduce the drive wheel slip. Also, the ECU monitors the ABS/ATC system for malfunctions and stores fault codes into memory. The ECU is mounted under the cab on the left hand side. See **Fig. 2**.



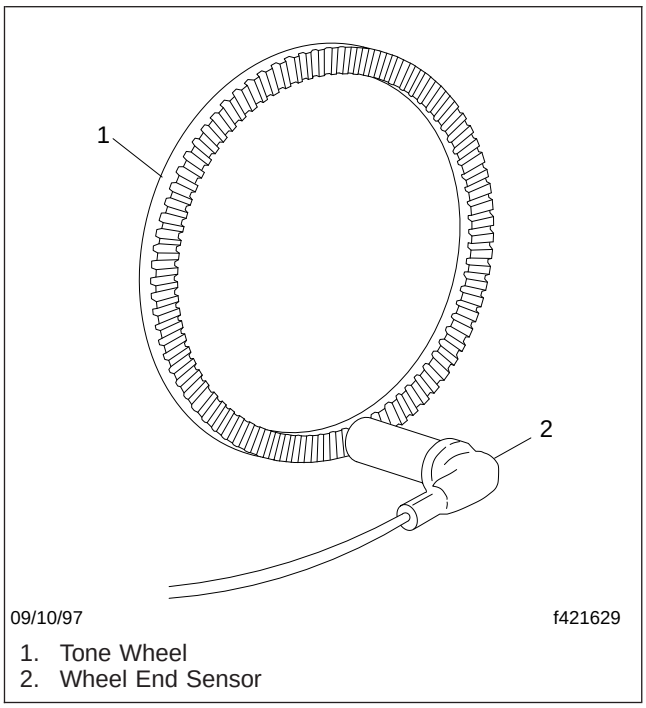

1. Electronic Control Unit

**Fig. 2, Electronic Control Unit (ECU) Located Under Cab**

### Speed Sensors

Each wheel of an axle under ABS control is monitored by a speed sensor. Speed sensors for drive axles and steer axles are mounted at the wheel ends.

The Eaton ABS uses standard wheel end sensors (**Fig. 3**). The sensors generate an alternating current signal in response to the movement of the teeth on the tone wheel. Either front sensor is accessible on the inboard side of the steering knuckle. Either rear drive axle sensor is accessible by removing the wheel and drum assembly.




1. Tone Wheel
2. Wheel End Sensor

**Fig. 3, Wheel End Sensor Assembly**

### Modulator Valves

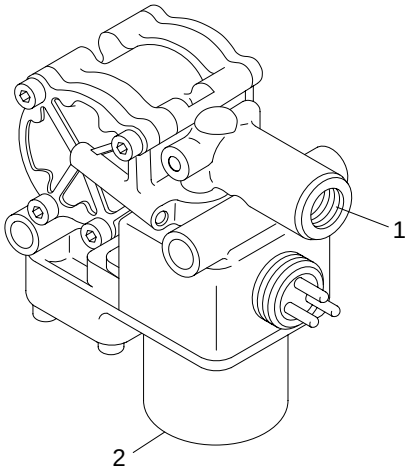
The ABS air modulator valves control air pressure to the individual brake assemblies. The system utilizes four modulator valves. The steer axle uses separate modulator valves (**Fig. 4**) and the drive axles incorporate two modulator valves into a combination (rear axle module) valve (**Fig. 5**).

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## General Information

The pressure modulator valves regulate air pressure to the brake chambers. A pressure modulator valve is located near each brake chamber or pair of brake chambers on any ABS equipped axle. Each modulator valve contains two solenoids for air control. The hold solenoid maintains air pressure; the release solenoid removes (vents) pressure from the brake chamber. The ECU signals each modulator valve to hold or release air by activating the appropriate solenoid. Each modulator valve carries a three pin terminal connection that connects with the ECU harness. See **Fig. 4**.




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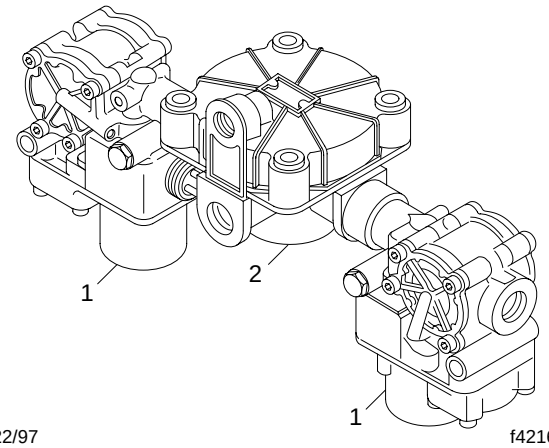
1. Supply
2. Exhaust Port

**Fig. 4, Pressure Modulator Valve**

The combination (rear axle module) valve (**Fig. 5**) is an assembly of two pressure modulator valves and a standard relay valve. These assemblies have four solenoids which are controlled in the same manner as the solenoids housed in the front axle pressure modulator valves. These valves are available with a crack pressure setting between 4.0 and 5.0 psi (27.5 and 34.5 kPa). The crack pressure is the ascending input pressure flow required to initiate output pressure flow. Pressure is identified on a stamped washer mounted on the relay valve.

The modulator valves have four modes of operation: the normal and ABS apply mode; the normal release mode; the ABS hold mode; and the ABS release mode.

The normal apply and ABS apply mode operates as follows (see **Fig. 6**):




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1. Modulator Valve
2. Relay Valve

**Fig. 5, Combination (rear axle module) Valve**

- Neither solenoid is activated;
- The supply air enters the inlet port;
- Inlet air is routed through solenoid #2 which then forces the release diaphragm to block the exhaust port;
- At the same time, the hold diaphragm is vented through solenoid #1, which allows supply air to flow to the outlet;
- Supply air flows from the inlet port to the outlet port.

The normal release mode operates as follows (see **Fig. 7**):

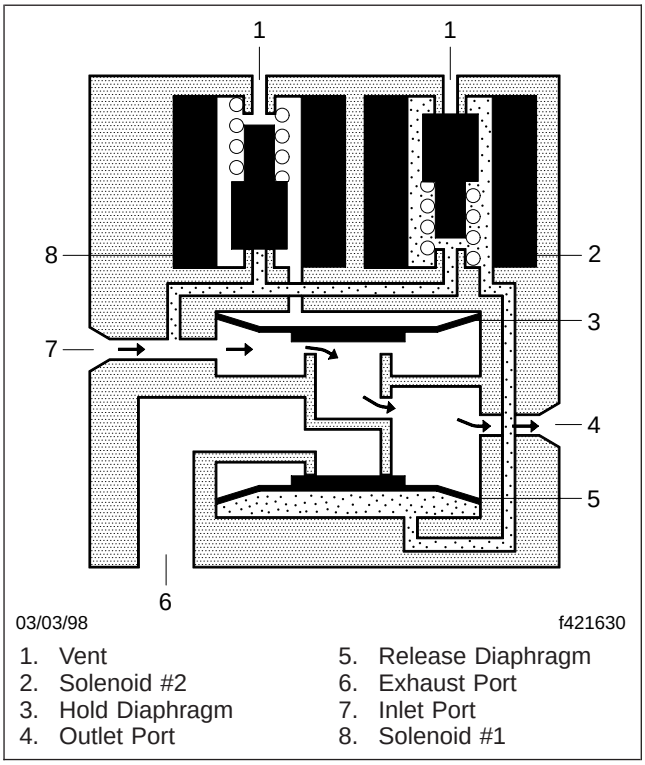
- Neither solenoid is activated;
- The hold diaphragm is vented through solenoid #1 and there is no pressure at the inlet port;
- The release diaphragm is not pressurized and the outlet pressure forces the exhaust port open;
- Pressurized air flows from the outlet port to the inlet port and also from the outlet port to the exhaust port.

The ABS hold mode operates as follows (see **Fig. 8**):

- Solenoid #1 is activated;
- Supply air enters the inlet port;
- Inlet air routes through both the #1 and #2 solenoids;

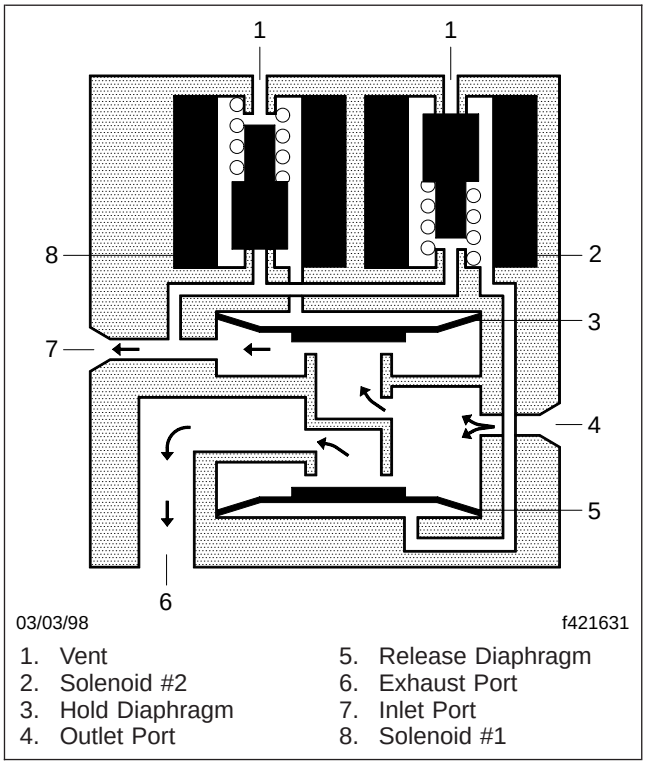
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1. Vent
2. Solenoid #2
3. Hold Diaphragm
4. Outlet Port
5. Release Diaphragm
6. Exhaust Port
7. Inlet Port
8. Solenoid #1

**Fig. 6, Normal Apply and ABS Apply Mode**




1. Vent
2. Solenoid #2
3. Hold Diaphragm
4. Outlet Port
5. Release Diaphragm
6. Exhaust Port
7. Inlet Port
8. Solenoid #1

**Fig. 7, Normal Release Mode**

- Both the hold and release diaphragm cavities become pressurized;
- The hold diaphragm closes off the air passage between the inlet and outlet port and the release diaphragm closes off the exhaust port;
- No air flows through the valve.

The ABS release mode operates as follows (see **Fig. 9**):

- Both solenoids are activated;
- Supply air enters the inlet port;
- Inlet air routes through solenoid #1;
- The hold diaphragm cavity becomes pressurized;
- The hold diaphragm closes off the air passage between the inlet and outlet port;
- The release diaphragm is vented through solenoid #2, which allows the outlet air pressure to force open the exhaust port;
- Pressurized air flows from the outlet port to the exhaust port.

## Automatic Traction Control (ATC) Valve

When in the traction control mode of operation, the ATC valve (**Fig. 10**) applies full system pressure to the relay valve to provide differential (side to side) braking. The valve is located near the rear axle.

## ABS and ATC (Wheel Spin) Indicator Lamps

The amber ABS indicator lamp is located on the driver's instrument panel. The indicator lamp warns the driver of any ABS malfunctions. It is also capable of blinking diagnostic fault codes when the ECU is in the diagnostic mode.

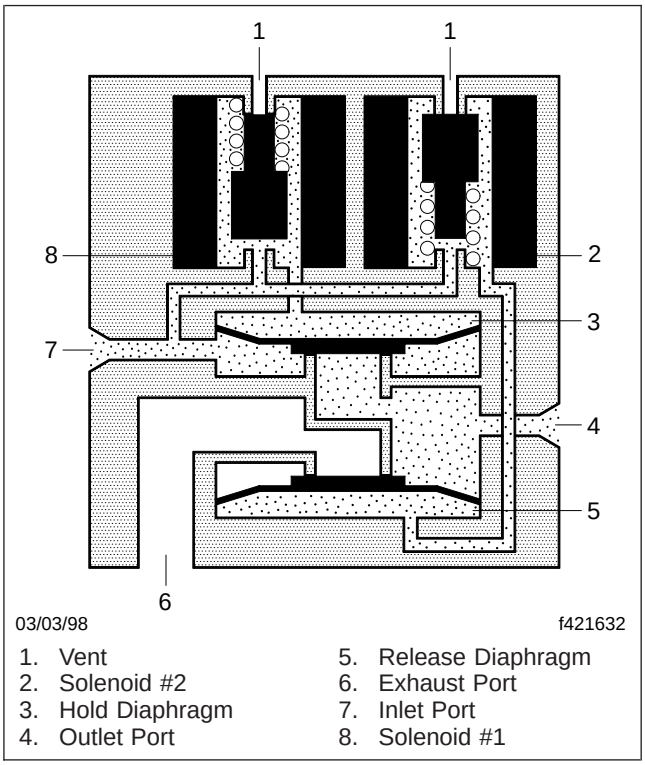
The ATC (Wheel Spin) indicator lamp is located on the driver's instrument panel. This indicator lights when a loss of traction condition exists and the ATC system is activated.

NOTE: In some cases, vehicles without ATC are equipped with an ATC (Wheel Spin) indicator

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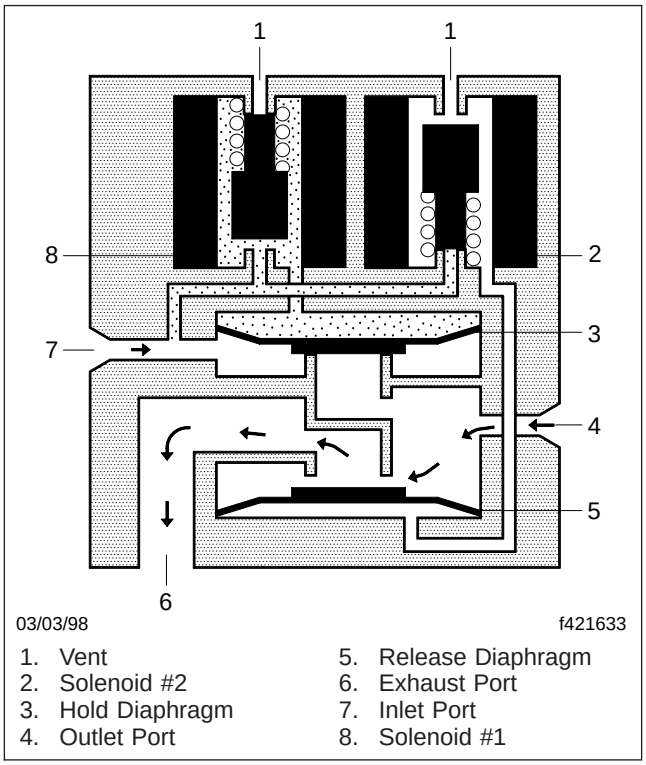


## General Information




1. Vent
2. Solenoid #2
3. Hold Diaphragm
4. Outlet Port
5. Release Diaphragm
6. Exhaust Port
7. Inlet Port
8. Solenoid #1

**Fig. 8, ABS Hold Mode**




1. Vent
2. Solenoid #2
3. Hold Diaphragm
4. Outlet Port
5. Release Diaphragm
6. Exhaust Port
7. Inlet Port
8. Solenoid #1

**Fig. 9, ABS Release Mode**

lamp. In these cases, the lamp indicates a slip condition but no control action is taken.

## Diagnostic Port Connector

The diagnostic port connector is an industry standard connector, which is used to provide a connector to the J1587 diagnostic link. This connector also provides power and ground to the diagnostic test equipment.

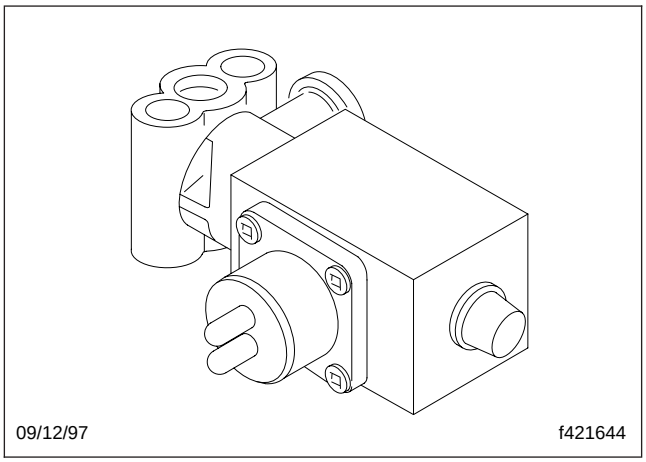



**Fig. 10, ATC Valve**

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## Front Axle Speed Sensor Replacement

1. Apply the parking brakes. Chock the rear tires to prevent vehicle movement.
2. Disconnect the sensor cable from the harness.

NOTE: While conducting the next step, avoid pulling on the cable.

3. Using a twisting and pulling motion, remove the speed sensor from the bushing in the steering knuckle (**Fig. 1**).

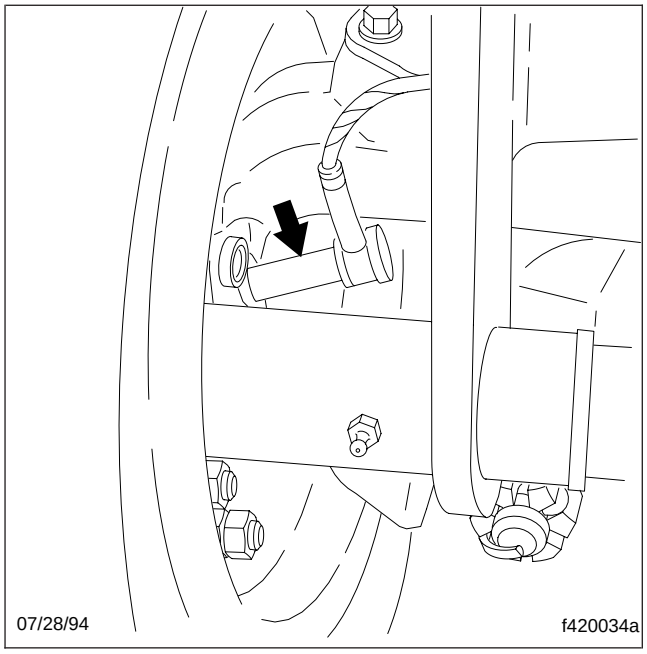
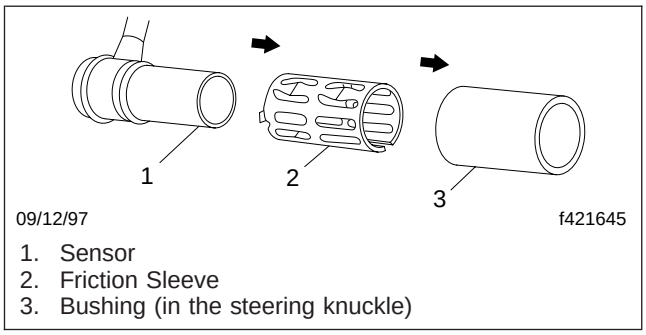



**Fig. 1, Remove the Wheel Speed Sensor**

4. Remove the speed sensor friction sleeve from the bushing in the steering knuckle (**Fig. 2**).
5. Install the speed sensor friction sleeve into the bushing (in the steering knuckle) with the flange stops toward the inboard side of the vehicle.

**⚠ CAUTION**

**The speed sensor must slide freely in and out of the mounting sleeve bore. Operating the vehicle with seized components will damage the speed sensor and the tone wheel.**




1. Sensor
2. Friction Sleeve
3. Bushing (in the steering knuckle)

**Fig. 2, Front Wheel Speed Sensor Components**

6. Lubricate the body of the speed sensor with Penzoil 707L, Valvoline LP, or Mobil HP.
7. By hand, push the speed sensor completely into the bushing (in the steering knuckle) until the speed sensor stops against the tone wheel.

   The speed sensor is properly installed and adjusted when it is touching the tone wheel.
8. Connect the sensor cable to the harness.
9. Remove the chocks from the rear tires.

## Rear Axle Speed Sensor Replacement

1. Chock the front tires to prevent vehicle movement. Release the parking brakes.
2. Raise the rear of the vehicle until the tires clear the ground. Place safety stands under the axle.
3. Back off the slack adjuster to release the rear axle brake shoes.
4. Remove the wheel and tire assembly from the rear axle. For instructions, see **Group 40**.
5. Remove the brake drum. For instructions, see **Group 35**.

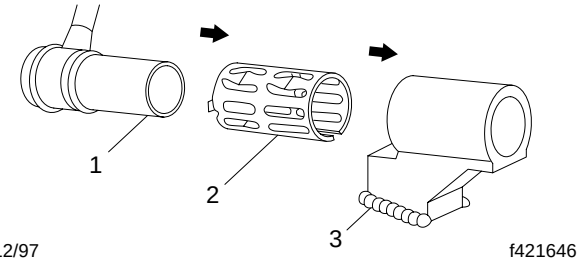
NOTE: While conducting the next step, avoid pulling on the cable.

6. Using a twisting and pulling motion, remove the speed sensor from the mounting block on the axle housing.
7. Remove the friction sleeve from the mounting block on the axle housing (**Fig. 3**).

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## Wheel Speed Sensor Replacement




1. Sensor
2. Friction Sleeve
3. Mounting Block (on axle housing)

**Fig. 3, Rear Wheel Speed Sensor Components**

8. Disconnect any fasteners that attach the speed sensor cable to other components and disconnect the speed sensor from the harness.
9. Install the friction sleeve on the mounting block (on the axle housing) with the flange stops toward the inboard side of the vehicle.

**⚠ CAUTION**

**The speed sensor must slide freely in and out of the mounting sleeve bore. Operating the vehicle with seized components will damage the speed sensor and the tone wheel.**

10. Lubricate the body of the speed sensor with Penzoil 707L, Valvoline LP, or Mobil HP.
11. By hand, push the speed sensor completely into the bushing (on the axle housing) until the speed sensor stops against the tone wheel.

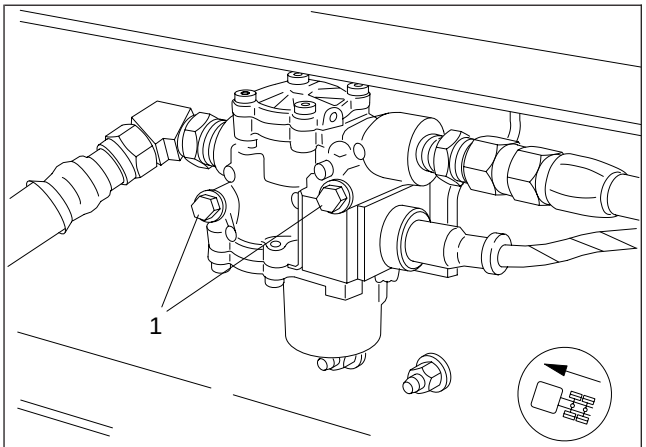
    The speed sensor is properly installed and adjusted when it is touching the tone wheel.
12. Route the cable to the frame.
13. Connect sensor cable to harness and install fasteners to hold sensor cables in position.
14. Install the brake drum on the wheel hub. For instructions, see **Group 35**.
15. Adjust the rear axle brakes. For instructions, see **Group 42**.
16. Install the wheel and tire assembly to the rear axle and tighten the wheel nuts. For instructions, see **Group 40**.
17. Remove the safety stands, lower the vehicle, set the parking brake, and remove the chocks from the tires.

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## Replacement

1. Turn the ignition switch to the off position.
2. Apply the parking brakes. Chock the front and rear tires to prevent vehicle movement.
3. Release the pressure from the air reservoirs.
4. Disconnect the wiring from the pressure modulator valve or the combination (rear axle module) valve.
5. Mark the air lines for ease of installation. Disconnect the air lines.
6. Remove the two mounting capscrews, washers, and nuts.
7. Remove the pressure modulator valve or combination (rear axle module) valve. See **Fig. 1** and **Fig. 2**.

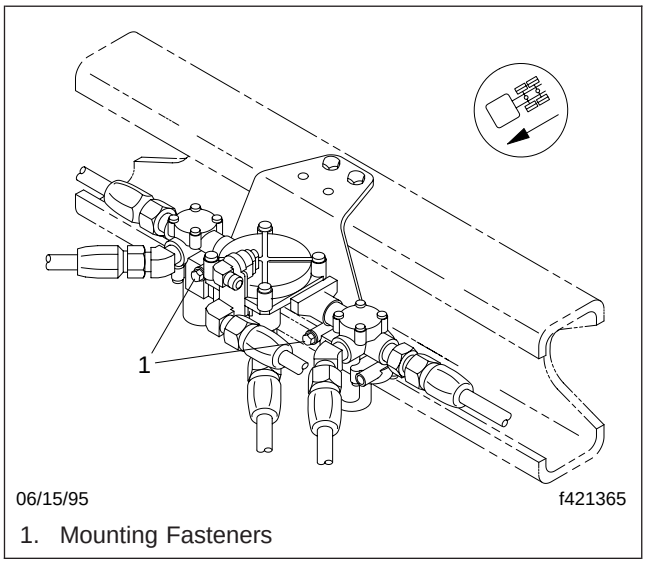



1. Mounting Fasteners

**Fig. 1, Front Pressure Modulator Valve Mounting (inside right-hand rail mounting shown)**

NOTE: The combination (rear axle module) valve can be disassembled, if the relay valve or one of the pressure modulator valves need replacing. For disassembly and assembly instructions, see **Subject 120**.

8. Install the pressure modulator valve or the combination valve using the above instructions in reverse order. Tighten the mounting nuts 18 lbf·ft (24 N·m).




1. Mounting Fasteners

**Fig. 2, Combination (rear axle module) Valve Mounting**

9. Test the pressure modulator valve.
   - 9.1 Check the pressure modulator valve for leaks by applying and holding the brakes. No audible air leaks are permitted.
   - 9.2 Using a MPSI Pro-Link 9000® hand-held tester, go to component test (#4) menu screen (on the hand-held tester) and select the valve routines option. This will verify the operation and the proper location of the pressure modulator valve. For more information on the use of the hand-held tester, see Troubleshooting, **Subject 300**.

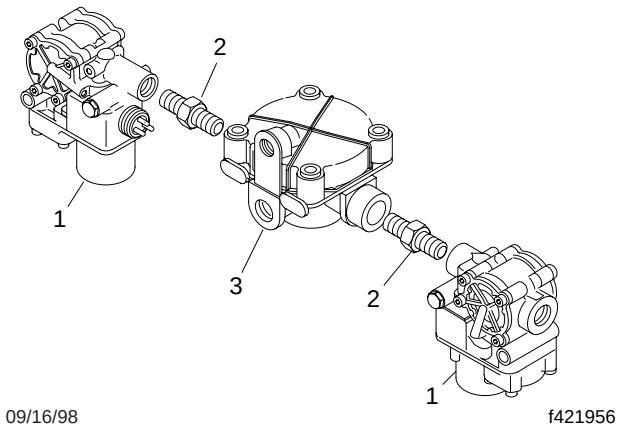
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# Combination (Rear Axle Module) Valve Disassembly and Assembly

## Disassembly

1. Remove the combination valve. For instructions, see **Subject 110**.
2. Carefully separate the pressure modulator valves from the relay valve. See **Fig. 1**.




1. Modulator Valve
2. Pipe Nipple
3. Relay Valve

**Fig. 1, Combination (rear axle module) Valve**

## Assembly

1. Plug any unused ports on the replacement valve(s).

IMPORTANT: Before installing the pipe nipples into the valves, apply a small quantity of Loctite® Pipe Sealant (with Teflon® 59241), or an equivalent sealant, to the male threads of each side of the pipe nipples.

2. Using the pipe nipples, attach the ABS control valve(s) to the relay valve. See **Fig. 1**.
3. Install the combination valve. For instructions, see **Subject 110**.
4. Test the relay valve assembly.

   4.1 With the front and rear wheels chocked, fully charge the air system (governor cut out point). Then, release the parking brake.

   4.2 With the engine off, apply the service brake several times, then hold and check all the wheels for prompt application and release. If a sluggish response is noted at all of the wheels, inspect for a kinked or obstructed air line leading to or from the valve.

   4.3 Check for air leaks.

   Apply and hold the brakes. Coat the outside of the relay valve (where the cover joins the body and where the pressure modulator valves meet the body) with a soap solution. No air leakage is permitted.

   Increase the system air pressure to the governor cut-off. Turn the engine off. With the brakes released, coat the exhaust port of the relay valve with a soap solution. Leakage of a 1-inch (2.5-cm) bubble in five seconds is permissible.

   4.4 Depress the foot valve. Coat the exhaust port with a soap solution. Leakage of a 1-inch (2.5-cm) bubble in three seconds is permissible. Release the foot valve.

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## Replacement

**⚠ WARNING**

**Do not start and engage the transmission with one wheel raised from the floor. For vehicles equipped with ATC, if the transmission is engaged with one of the drive axles raised, all the driving torque from the transmission will go to the wheel on the floor (the drive axle not raised). This could cause the vehicle to move on its own and result in personal injury or property damage.**

1. Apply the parking brakes. Chock the front and rear tires to prevent vehicle movement.
2. Release the pressure from the air reservoirs.
3. Disconnect the wiring from the ATC valve. See **Fig. 1**.

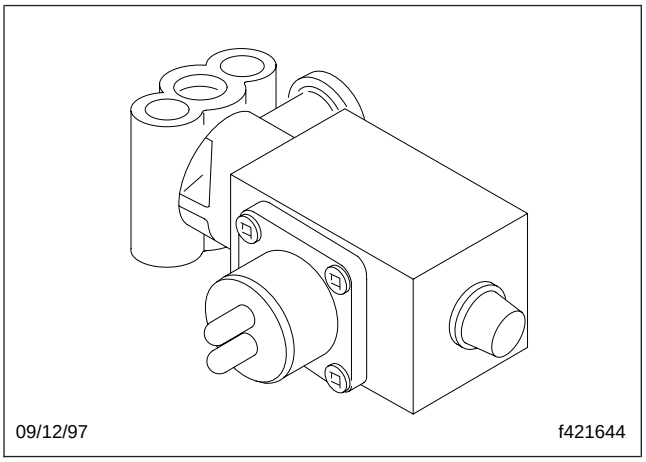



**Fig. 1, ATC Valve**

4. Mark the air lines for ease of installation. Disconnect the air lines.
5. Remove the two mounting capscrews, washers, and nuts.
6. Remove the ATC valve.
7. Install the ATC valve using the above instructions in reverse order. Tighten the mounting nuts 18 lbf·ft (24 N·m).
8. Test the ATC valve.

8.1 Check ATC valve for leaks by applying and holding the brakes. No audible air leaks are permitted.

8.2 Using a MPSI Pro-Link 9000® hand-held tester, go to test (#4) menu screen (on the hand-held tester) and select the TCV option. This will verify the operation of the ATC (wheel spin) indicator light and the operation of the ATC valve.

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See **Fig. 1** for a full view of the electrical schematic for vehicles equipped with Eaton or Wabco ABS. See **Fig. 2** and **Fig. 3** for partial (detailed) views of **Fig. 1**.

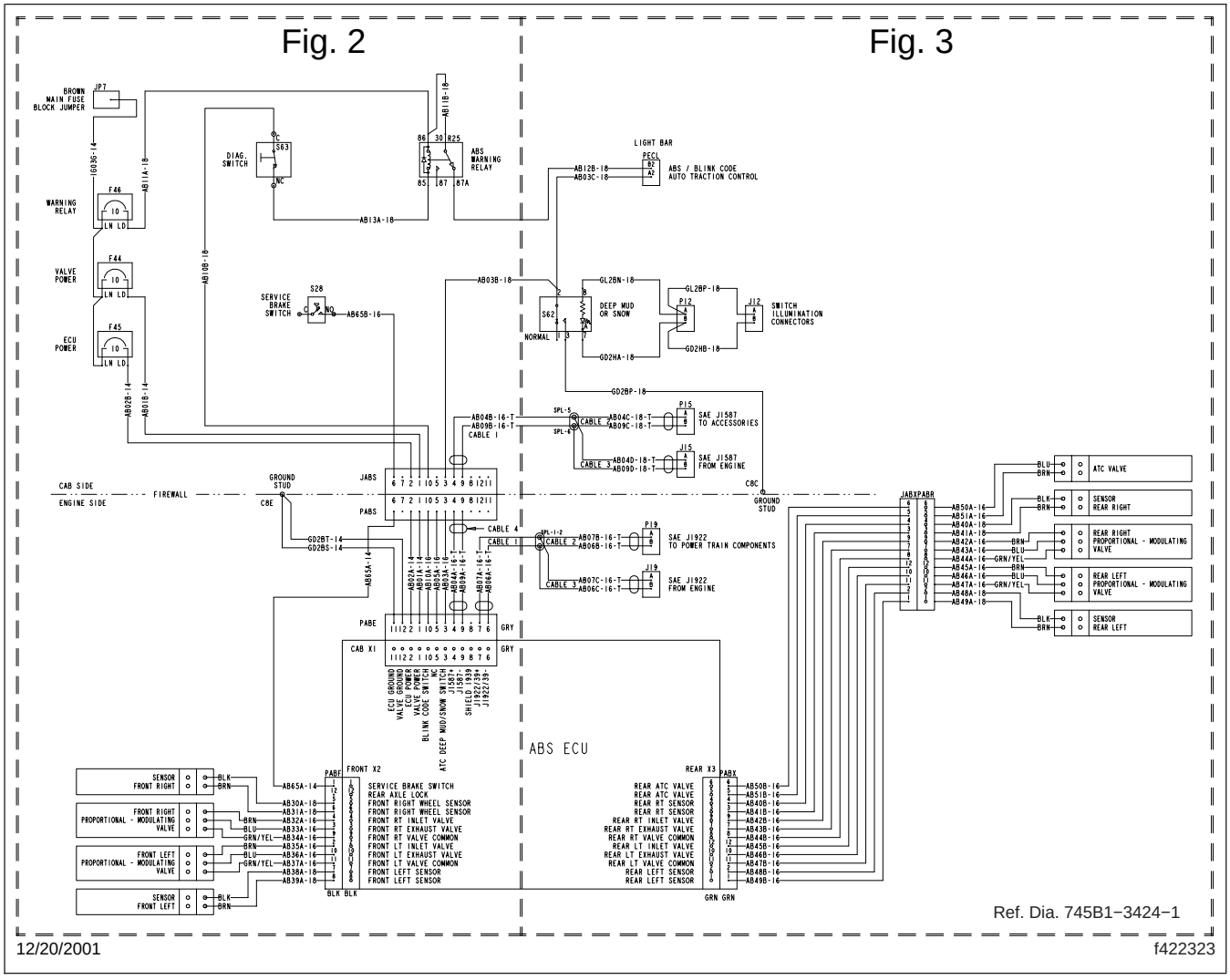



**Fig. 1, Tractor ABS, Eaton or WABCO ABS System Wiring Diagram**

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## Specifications

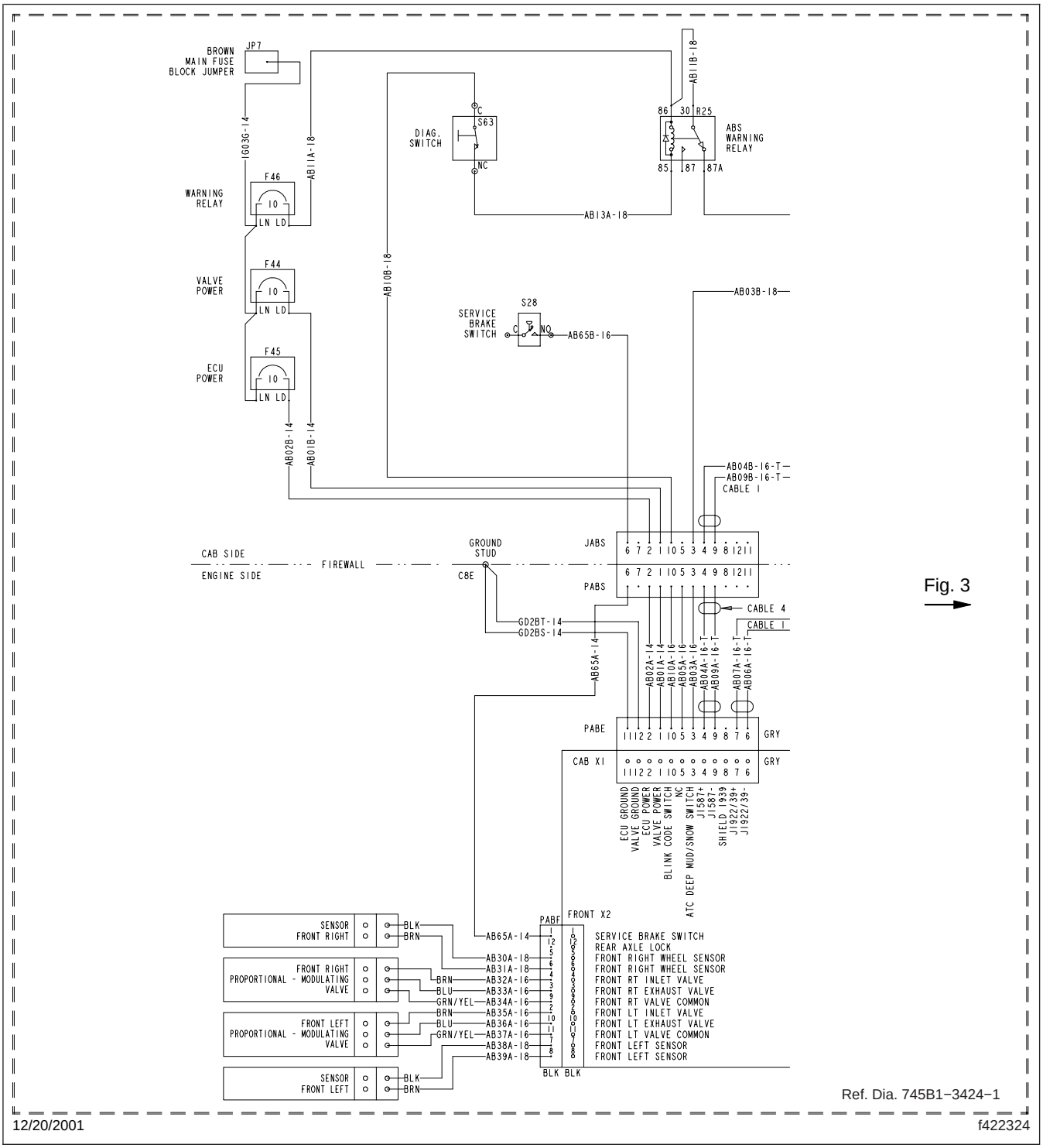



Fig. 3

**Fig. 2, Tractor ABS, Eaton or WABCO ABS System Wiring Diagram (partial view)**

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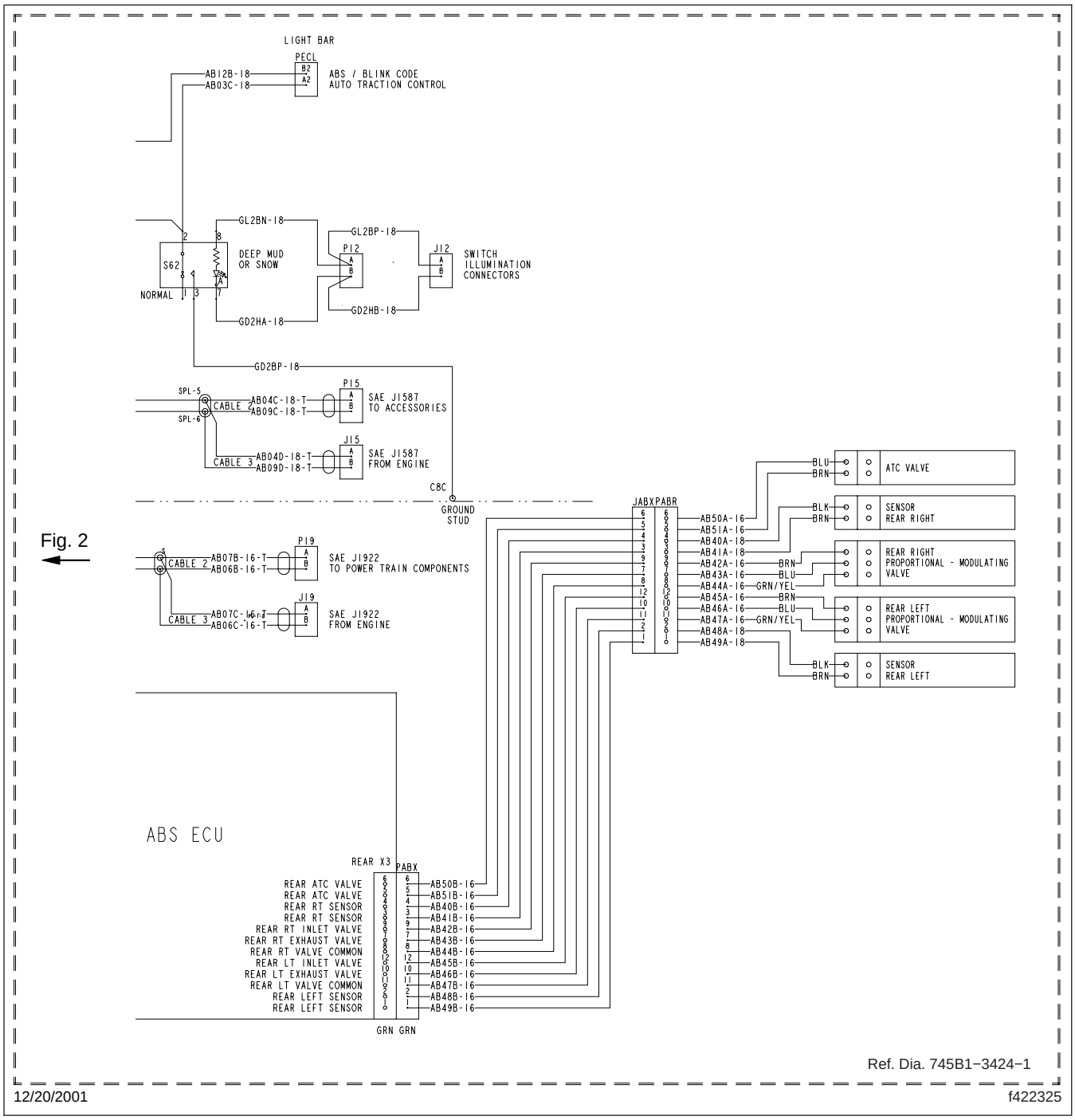



Fig. 2

**Fig. 3, Tractor ABS, Eaton or WABCO ABS System Wiring Diagram (partial view)**

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## General Information

The PP–1 and PP–8 valves are push-pull manually operable on-off air control valves.

The PP–1 valve is used to control parking and emergency brakes.

The PP–8 valve is used to control the tractor spring brakes independently of the trailer. It is not automatic and will remain in the applied (button in) position regardless of delivery supply pressure.

## Principles of Operation

When the valve knob is pulled out, air is exhausted from the parking brake chambers, releasing the springs, and applying the parking brakes. When the knob is pushed in, air flows into the parking brake chambers from one of the reservoirs and compresses the springs, releasing the parking brakes.

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## Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

1. Chock the tires and stop the engine before working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters, which may apply as air pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure, and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Don't disassemble a component until you have read and understood the service procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use the correct tools, and observe all precautions pertaining to use of those tools.
5. Replacement hardware, tubing, hose, fittings, etc. should be the equivalent size, type, length, and strength of the original equipment.

   Make sure that when replacing tubing or hose, all of the original supports, clamps, or suspending devices are installed or replaced.
6. Replace devices with stripped threads or damaged parts. Repairs requiring machining should not be attempted.

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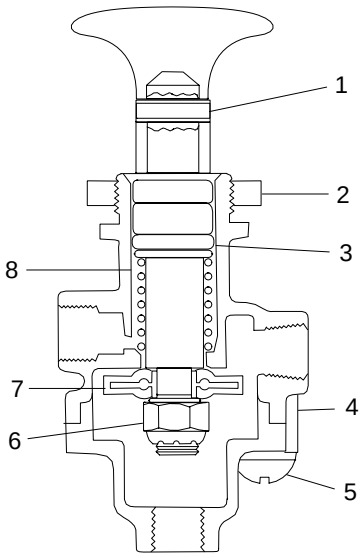


## Removal

**WARNING**

**Review the precautions under Safety Precautions, 100 before doing any work on the parking brake valve. Failure to do so could result in personal injury.**

1. Park the vehicle on a level surface, apply the parking brakes, chock the tires, and drain the air tanks.
2. Using a punch, drive out the button roll pin (Fig. 1). Remove the button.




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| | | | |
|---|---|---|---|
| 1 | Button Roll-Pin | 5 | Capscrews |
| 2 | Panel Mounting Nut | 6 | Locknut |
| 3 | O-Ring | 7 | Inlet-Exhaust Valve |
| 4 | Sealing Ring | 8 | Spring |

**Fig. 1, Valve Cross-Section (PP-1 shown)**

3. Disconnect the air connections, remove the panel mounting nut, then remove the valve.

## Installation

1. Install the valve in the panel, securing it with the panel mounting nut.
2. Connect the air lines to the applicable fittings.
   - 2.1 Tighten the fittings hand tight.
   - 2.2 Using a wrench, tighten the fittings until the connections feel firm.
   - 2.3 Tighten the fittings an additional one-sixth turn.
3. Install the operating button. Secure the operating button by installing the roll pin.

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## Disassembly

1. Remove the valve assembly from the dash, following the instructions in **Subject 110**.
2. Put the valve assembly in a soft-jawed or padded vise.
3. Remove the two capscrews which retain the lower cover then remove the cover. Remove the sealing ring.
4. Insert a small punch through the roll pin hole in the stem and remove the locknut with a 7/16-inch wrench.
5. Remove the inlet-exhaust valve and spring (if any).
6. Remove the O-ring from the plunger.

## Assembly

1. Clean and dry all the parts.
2. Check all the parts. Replace a part if any wear or damage is found.
3. Lightly grease all the parts, including the new parts from the maintenance kit, with Dow Corning 55 silicone pneumatic grease or equivalent.
4. Install the O-rings onto the plunger, then install the plunger into the body. Make sure that the plunger spring is upright and seated properly in the body bore.
5. Install the inlet/exhaust valve.
6. Install the screws that attach the cover to the body. Tighten the screws 35 lbf·in (400 N·cm).
7. Install the valve in the dash, then leak test it. Follow the instructions in **Subject 110** for installation, and **Subject 130** for leak testing.

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IMPORTANT: To do the following tests, connect two separate 120 psi (827 kPa) air sources to the PP–1 or PP–8 supply ports. Tee an accurate test gauge into the supply lines, and provide for a means to control supply line pressure. Connect a small volume air source with a gauge to the delivery port.

## Operating Tests

1. Chock the tires.
2. Start the engine and build up the air pressure to the normal operating level.
3. With the valve knob pulled out, supply either supply port with 120 psi (827 kPa) of pressure. Push the valve knob in. Air pressure should rise in the delivery line and equal supply line pressure.

   Pull the valve knob out. Delivery pressure should exhaust to zero.
4. Build air pressure to each supply source to 120 psi (827 kPa). Decrease supply pressure at the secondary service reservoir supply port at a rate of 10 psi (69 kPa) per second.

   Primary supply pressure and delivery pressure should not drop below 100 psi (689 kPa). Repeat this step for decreasing primary service reservoir pressure.
5. If the valve does not work as described, repair the valve following instructions under **Subject 120** or replace it following instructions in **Subject 110**.

### PP–1 Valve Automatic Pop Out Test

1. Build air pressure to each supply source to 120 psi (827 kPa). Then, decrease both supply pressures to below 20 to 30 psi (138 to 207 kPa). The valve knob should automatically pop out when the pressure is within that range.
2. If the valve does not work as described, repair the valve following instructions under **Subject 120** or replace it following instructions in **Subject 110**.

## Leak Testing

1. Chock the tires.
2. Supply the valve with 120 psi (827 kPa) from the primary reservoir supply port.
3. With the valve knob pulled out, coat the exhaust port and the plunger stem with a soapy solution. Leakage at either fitting should not exceed a 1-inch (2.5-cm) bubble every five seconds.There should be no leakage from the secondary reservoir supply port.
4. Supply the valve with 120 psi (827 kPa) from the secondary reservoir supply port. There should be no leakage from the primary reservoir supply port.
5. With the valve knob pushed in, coat the exhaust port and the plunger stem with a soapy solution. Leakage at the fittings should not exceed a 1-inch (2.5-cm) bubble every three seconds. If it does, replace or repair the valve, following instructions under **Subject 120** or replace it following instructions in **Subject 110**.

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## General Description

The PP–7 trailer supply valve provides in-cab control for the tractor protection system and functions in conjunction with the tractor-trailer parking brake control valve. It is responsible for synchronizing the tractor and trailer parking and emergency brakes.

It is essentially a combination of two non-modulating, on-off control valves in a single package.

Each of the four pipe-tapped ports of the PP–7 are identified with cast-in, raised letters. The supply and control ports have 1/8-inch NPTF dry seal pipe threads while the delivery and exhaust ports have 1/4-inch NPTF dry seal pipe threads.

## Principles of Operation

The PP–7 trailer supply valve is a panel mounted, push-pull operated control valve. The button of the PP–7 valve must be manually pushed in to charge the trailer with air, but will automatically pop out and exhaust if supply air is below 40 psi (276 kPa).50 psi (345 kPa) or greater supply air pressure is required for the button to remain in after it is pushed in, and it will remain in until the supply air pressure falls below 40 psi (276 kPa), or until the valve is manually actuated.

With less than 50 psi (345 kPa) system air pressure, the button of the PP–7 valve will be out and the tractor-trailer parking brake control valve will not deliver air to the control port of the PP–7 valve. In this condition, supply air cannot flow past the closed plunger inlet, and the plunger exhaust valve is off its seat. With no air pressure on the control port, the control inlet is seated and the exhaust passage through the control piston is open.

If the driver holds the button of the PP–7 valve in after supply air pressure has dropped below the 40 psi (276 kPa) automatic pop-out pressure, the control piston will move into the exhaust position when control port pressure falls below 20 psi (138 kPa).

When system air pressure is greater than 50 psi (345 kPa), the button of the PP–7 valve can be pushed in and it will stay in. If the vehicle is in the running condition (parking brake released), the tractor-trailer parking brake control valve will be delivering system air pressure to the control port of the PP–7 valve.

With the button of the PP–7 valve pushed in, the plunger inlet will be open and the exhaust valve will be seated, sealing the exhaust vent. Supply air is permitted to flow through the body to the control inlet and exhaust valve. With the tractor-trailer parking brake control valve delivering full system pressure to the control port of the PP–7 valve, the control piston moves into contact with the control valve, closing the exhaust passage through the piston and opening the inlet. Opening the control inlet permits supply air to flow out the delivery port of the PP–7 valve.

NOTE: If the vehicle parking brakes are applied and system air pressure is above 50 psi (345 kPa), the tractor-trailer parking control valve will not be delivering air to the PP–7 control port and the control inlet valve will be closed. In this case, no air will be flowing from the delivery port of the PP–7 valve.

Prior to disconnecting the trailer from the tractor, the button of the PP–7 valve is pulled out by the operator. This will shut off the air supply to the trailer without bleeding down the tractor air system. Pulling the button closes the plunger inlet and unseats the exhaust valve. Air that was flowing out the delivery port returns to the PP–7 valve and is exhausted from the vent in the midsection of the PP–7 valve.

NOTE: If the parking brakes were applied prior to pulling the PP–7 button, no delivery air would be present to exhaust. Delivery air would have been exhausted when the parking brakes were applied.

In the event of trailer breakaway or a sudden complete failure of the trailer supply line, the button of the PP–7 will pop out. In this situation the air pressure retained in the tractor air system should be within approximately 10 psi (69 kPa) of the registered air pressure just prior to the breakaway or failure. The reason for this reaction is that air escaping from the failed supply line cannot be replaced through the supply port of the PP–7 valve as fast as it is being lost. The rapid loss of air pressure within the PP–7 valve results in a momentary reduction below the 40 psi (276 kPa) pop out pressure of the PP–7 plunger.

If a leak develops that is not as severe as a broken line, the PP–7 button will pop out when air pressure in the supply line falls below 40 psi (276 kPa).

During a parking brake application, the tractor-trailer parking brake control valve removes air pressure

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## General Information

from the control port of the PP–7, which cuts off the air supply to the trailer. The button of the PP–7 valve remains in.

With air pressure removed from the control port of the PP–7 valve, the control piston moves away from the control inlet and exhaust valve. The inlet valve seats and the exhaust passage through the control piston is open. Air at the delivery port of the PP–7 valve is exhausted at the exhaust port of the PP–7 valve.

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## Safety Precautions

When working on or around air brake systems and components, observe the following precautions:

1. Chock the tires and stop the engine before working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters, which may apply as air pressure drops.
2. Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
3. Never exceed recommended air pressure, and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
4. Don’t disassemble a component until you have read and understood the service procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use the correct tools, and observe all precautions pertaining to use of those tools.
5. Replacement hardware, tubing, hose, fittings, etc. should be the equivalent size, type, length, and strength of the original equipment.

   Make sure that when replacing tubing or hose, all of the original supports, clamps, or suspending devices are installed or replaced.
6. Replace devices with stripped threads or damaged parts. Repairs requiring machining should not be attempted.

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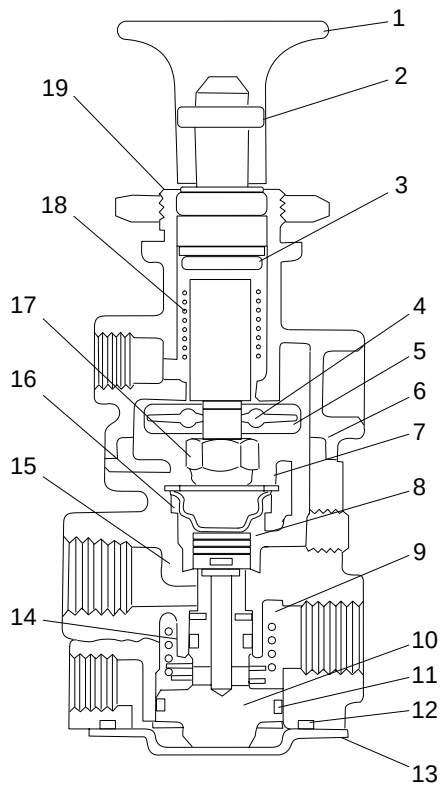


## Removal

1. Apply the parking brakes, and chock the tires. Completely drain the air system.
2. Remove the screws attaching the push-pull air brake valves panel to the dash control panel. Lift the panel to a serviceable level.
3. Disconnect all of the air lines leading to and from the PP–-7 valve, and mark them for later assembly reference. Cap the air lines tightly to keep out contaminants.
4. Using a drift pin punch, remove the spirol pin (**Fig. 1**) which secures the button to the plunger. Remove the button.
5. Using a 1-5/16 inch wrench, remove the special thin nut which secures the PP–-7 valve to the panel, and remove the valve.

## Installation

1. Place the PP–-7 valve in the panel mounting hole. Install and tighten the special thin nut.
2. Install the button on the valve, and attach it with the button spirol pin.
3. Remove the caps from the air lines. Connect the air lines to the PP–-7 valve, as previously marked. Connect the nylon tube hose fittings to the elbow fittings in the valve ports, and tighten the nuts finger-tight. Then, using a wrench, tighten the nuts a minimum of two turns, or until no thread shows on the fittings.
4. Place the push-pull air brake valves panel on the dash control panel. Install and tighten the attaching screws.




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1. Button
2. Spirol Pin
3. O-Ring
4. Inlet and Exhaust Valve
5. Retaining Ring
6. Sealing Ring
7. O-Ring Retainer
8. Inlet and Exhaust Valve Spring
9. Spring
10. Piston
11. O-Ring
12. O-Ring
13. End Plate
14. O-Ring
15. Inlet and Exhaust Valve
16. O-Ring
17. Nut
18. Plunger Return Spring
19. Plunger

**Fig. 1, Bendix PP-7 Valve Cross Section**

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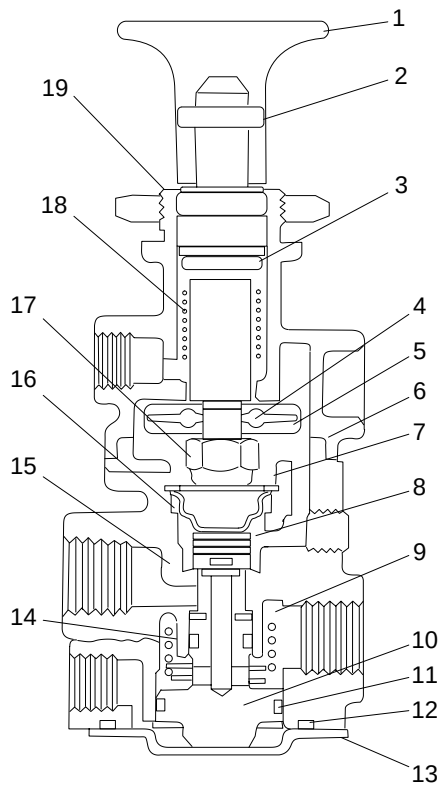
## Disassembly, Cleaning and Inspection, and Assembly

## Disassembly

1. Block and/or hold the vehicle by a means other than air brakes, and drain all reservoirs.
2. Remove the PP–-7 valve from the vehicle. For instructions, see **Subject 110**.
3. Mark the upper and lower body halves to show their relationship to each other.
4. Remove the two 1/4–20 capscrews that secure the lower valve body to the upper valve body, using a 7/16-inch wrench. See **Fig. 1**. Separate the two body halves.
5. Remove and discard the square cut sealing ring between the upper and lower body halves.
6. Remove the end plate and O-ring from the lower body and discard the O-ring.
7. Remove the control piston and piston return spring.
8. Remove the large and small diameter O-rings from the piston and discard them.
9. Remove the internal tru arc retaining ring from the lower body.
10. Remove the O-ring retainer, then remove and discard the O-ring.
11. Remove the inlet and exhaust valve, and the return spring.
12. Using a 7/16-inch wrench, remove the special (ESNA) hexnut from the plunger inlet exhaust valve and washer.
13. Remove the plunger inlet and exhaust valve, and washer.
14. Remove the plunger and the plunger return spring from the body.
15. Remove and discard the plunger O-ring.

## Cleaning Inspection

1. Clean all metal parts in a good commercial solvent making sure all ports, passages, and bores are clean and open.
2. Dry the parts thoroughly, and inspect the plunger and piston bores for scratches and nicks.




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1. Button
2. Spirol Pin
3. O-Ring
4. Inlet and Exhaust Valve
5. Retaining Ring
6. Sealing Ring
7. O-Ring Retainer
8. Inlet and Exhaust Valve Spring
9. Spring
10. Piston
11. O-Ring
12. O-Ring
13. End Plate
14. O-Ring
15. Inlet and Exhaust Valve
16. O-Ring
17. Nut
18. Plunger Return Spring
19. Plunger

**Fig. 1, Bendix PP-7 Valve Cross Section**

3. It is recommended that all non-metallic parts and springs be replaced, using only genuine Bendix replacements.

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## Disassembly, Cleaning and Inspection, and Assembly

# Assembly

Prior to assembly, all internal bores and all non-metallic parts should be coated with a film of silicone lubricant, Bendix part number 291126, or equivalent.

1. Install the inlet and exhaust valve and the return spring in the lower body.
2. Install the O-ring in the body, then the O-ring retainer and the tru arc retaining ring.
3. Install the end plate O-ring in the oval groove in the lower body.
4. Install the plunger O-ring, and place the plunger return spring and plunger in the upper body.
5. Depress the plunger until the threaded portion extends sufficiently to install the plunger inlet and exhaust valve, the valve washer, and special hexnut. Tighten the special hexnut 30 to 40 lbf·in (340 to 460 N·cm).
6. Install the square cut seal ring in the upper body.
7. Install the large and small diameter O-rings on the control piston.
8. Place the upper and lower bodies together taking care to align the marks made during disassembly.
9. Install the piston return spring and the control piston in the lower body.
10. Install the end plate on the lower body, and secure it with the two 1/4-20 capscrews.
11. Tighten the capscrews 30 to 40 lbf·in (340 to 460 N·cm).
12. Install the PP–-7 valve in the control panel. For instructions, see **Subject 110**.
13. Test the rebuilt unit. For instructions, see **Subject 130**.

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IMPORTANT: To do the following tests, connect two separate 120 psi (827 kPa) air sources to the PP–7 supply ports. Tee an accurate test gauge into the supply lines, and provide for a means to control supply line pressure. Connect a small volume air source with a gauge to the delivery port.

## Operating Checks

1. Chock the tires.
2. Place the tractor parking control valve in the "brakes released" position and observe an immediate rise in the pressure on the test gauge. The pressure registered on the test gauge should equal dash gauge or system pressure.
3. With the tractor air system at governor cut-out pressure, shut off the engine. Quickly disconnect the test gauge and hose coupling from the tractor-trailer supply line coupling. Leakage from the tractor-trailer supply line should cease immediately and the button of the PP–7 should be out.
4. Reconnect the test gauge to the tractor-trailer supply line and depress the button of the PP–7. Open the drain cocks of the service reservoirs slightly. Note at what pressure the button of the PP–7 pops out and exhausts the tractor-trailer supply line. This should occur between 20 to 45 psi (137 to 310 kPa) air system pressure.

   If the PP–7 trailer supply valve fails to function as described, follow instructions under **Subject 110** for replacement or **Subject 120** for repair.

## Leakage Checks

1. Chock the tires.
2. With the PP–7 valve knob pulled out, and the parking control valve in the applied position, build the air system pressure to governor cut-out.
3. Coat the exhaust port and the plunger stem with a soapy solution. Leakage at either fitting should not exceed a 1-inch (2.5-cm) bubble every five seconds. There should be no leakage from the secondary reservoir supply port.

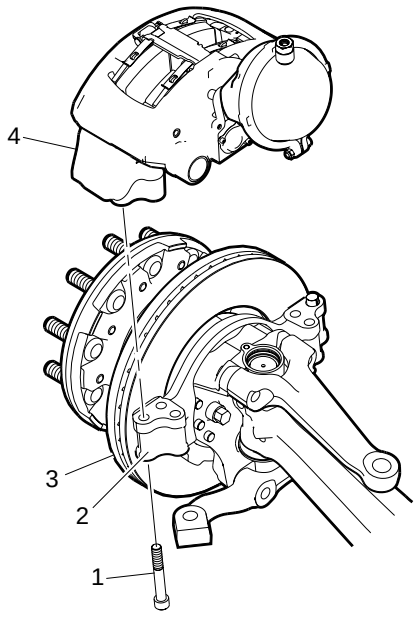
If the PP–7 trailer supply valve leaks excessively, follow instructions under **Subject 110** for replacement or **Subject 120** for repair.

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# Description

Bendix air disc brakes use a floating caliper design to provide foundation braking on all axles. They are fitted with a standard brake chamber or a combination spring brake chamber, depending on the vehicle specification, and the position on the vehicle. The caliper-carrier and anchor plate are a proprietary design available only on Daimler vehicles. This design allows for easy removal and installation of the caliper/carrier assembly on all axles, without removing other major components. See **Fig. 1**.




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1. Capscrew
2. Anchor Plate
3. Rotor
4. Caliper/Carrier

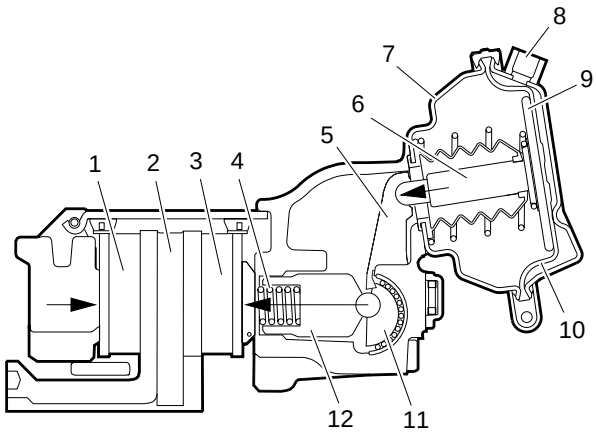
**Fig. 1, Caliper/Carrier Installation**

# Operation

Bendix air disc brakes convert air pressure into braking force. See **Fig. 2**.

## Brake Application

When the vehicle brakes are applied, air enters the service brake chamber through the supply port, applying pressure within the diaphragm. The pressure expands the diaphragm, applying force to the pressure plate and pushrod, and moving them forward.




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1. Outer Brake Pad
2. Rotor
3. Inner Brake Pad
4. Return Spring
5. Lever
6. Pushrod
7. Brake Chamber
8. Supply Port
9. Pressure Plate
10. Diaphragm
11. Eccentric Bearing
12. Bridge

**Fig. 2, Brake Operation**

The pushrod presses against a cup in the internal lever, which pivots on an eccentric bearing, moving the bridge. Moving against a return spring, the bridge transfers the motion to two threaded tubes and tappets, which move the inner brake pad. The inner brake pad (from its normal position of having a running clearance between it and the rotor) moves into contact with the brake rotor. Further movement of the bridge forces the caliper, sliding on two stationary guide pins, away from the rotor, which pulls the outer brake pad into the rotor. The clamping action of the brake pads on the rotor applies braking force to the wheel.

## Brake Release and Adjustment

When the vehicle brakes are released, the air pressure in the service brake chamber is exhausted, and the return springs in the chamber and the bridge return the caliper to a neutral, non-braked position. To maintain the running clearance gap between the rotor and the brake pads over time, the non-braked position is mechanically adjusted by a mechanism in the caliper. The adjustment mechanism operates automatically whenever the brakes are activated, to compensate for rotor and brake pad wear and to keep the running clearance constant. During pad or

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## General Information

rotor maintenance, the technician manually sets the system's initial non-braked position. The total running clearance (sum of clearances on both sides of the rotor) should be between 0.024 to 0.043 in. (0.6 and 1.1 mm).

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## General Safety Precautions

**⚠ WARNING**

**When replacing brake pads, shoes, rotors, or drums, always replace components as an axle set.**

- Always reline both sets of brakes on an axle at the same time.
- Always replace both rotors/drums on an axle at the same time.
- Always install the same type of linings/pads or drums/rotors on both axle ends of a single axle, and all four axle ends of a tandem axle, at the same time. Do not mix component types.

**Failure to do so could cause uneven braking and loss of vehicle control, resulting in property damage, personal injury, or death.**

When working on or around a vehicle, observe the following precautions:

- Park the vehicle on a level surface and apply the parking brakes. Shut down the engine and chock the tires.
- If the vehicle is equipped with air brakes, make certain to drain the air pressure from all reservoirs before beginning any work on the vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake calipers, which may apply as air pressure drops.
- Disconnect the batteries.
- Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
- Never exceed recommended air pressure. Always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
- Do not remove, disassemble, assemble, or install a component until you have read and understand the service procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use the correct tools and observe all precautions pertaining to use of those tools.
- Replacement hardware, tubing, hose, fittings, etc., should be the equivalent size, type, length, and strength of the original equipment.
- Make sure when replacing tubes or hoses that all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace devices that have stripped threads or damaged parts. Repairs requiring machining should not be attempted.
- Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

## Asbestos and Non-Asbestos Safety

**⚠ WARNING**

**Wear a respirator at all times when servicing the brakes, starting with the removal of the wheels and continuing through assembly. Breathing brake lining dust (asbestos or non-asbestos) could cause lung cancer or lung disease. OSHA has set maximum levels of exposure and requires workers to wear an air purifying respirator approved by MSHA or NIOSH.**

Because some brake linings contain asbestos, you should know the potential hazards of asbestos and the precautions to be taken. Exposure to airborne asbestos brake lining dust can cause serious and possibly fatal diseases such as asbestosis (a chronic lung disease) and cancer.

Because medical experts believe that long-term exposure to some *non-asbestos* fibers could also be a health hazard, the following precautions should also be observed if servicing non-asbestos brake linings.

Areas where brake work is done should be separate from other operations, if possible. As required by OHSA regulations, the entrance to the areas should have a sign displayed indicating the health hazard.

During brake servicing, an air purifying respirator with high-efficiency filters must be worn. The respirator and filter must be approved by MSHA or NIOSH, and worn during all procedures.

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## Safety Precautions

OSHA recommends that enclosed cylinders equipped with vacuums and high-efficiency particulate air (HEPA) filters be used during brake repairs. Under this system, the entire brake assembly is placed within the cylinder and the mechanic works on the brake through sleeves attached to the cylinder. Compressed air is blown into the cylinder to clean the assembly, and the dirty air is then removed from the cylinder by the vacuum.

If such an enclosed system is not available, the brake assembly must be cleaned in the open air. During disassembly, carefully place all parts on the floor to minimize creating airborne dust. Using an industrial vacuum cleaner with a HEPA filter system, remove dust from the brake drums, brake backing plates, and brake parts. After vacuuming, any remaining dust should be removed using a rag soaked in water and wrung until nearly dry. Do not use compressed air or dry brushing to clean the brake assembly.

If grinding or other machining of the brake linings is necessary, other precautions must be taken because exposure to asbestos dust is highest during such operations. In addition to the use of an approved respirator, there must be local exhaust ventilation such that worker exposure is kept as low as possible.

Work areas should be cleaned by industrial vacuums with HEPA filters or by wet wiping. Compressed air or dry sweeping should never be used for cleaning. Asbestos-containing waste, such as dirty rags, should be sealed, labeled, and disposed of as required by EPA and OSHA regulations. Respirators should be used when emptying vacuum cleaners and handling asbestos waste products.

Workers should wash before eating, drinking, or smoking, should shower after work, and should not wear work clothes home. Work clothes should be vacuumed after use and then laundered, without shaking, to prevent the release of asbestos fibers into the air.

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## Brake Pad Removal, Inspection, and Installation

**WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

**WARNING**

**When replacing brake pads, shoes, rotors, or drums, always replace components as an axle set.**

- Always reline both sets of brakes on an axle at the same time.
- Always replace both rotors/drums on an axle at the same time.
- Always install the same type of linings/pads or drums/rotors on both axle ends of a single axle, and all four axle ends of a tandem axle, at the same time. Do not mix component types.

**Failure to do so could cause uneven braking and loss of vehicle control, resulting in property damage, personal injury, or death.**

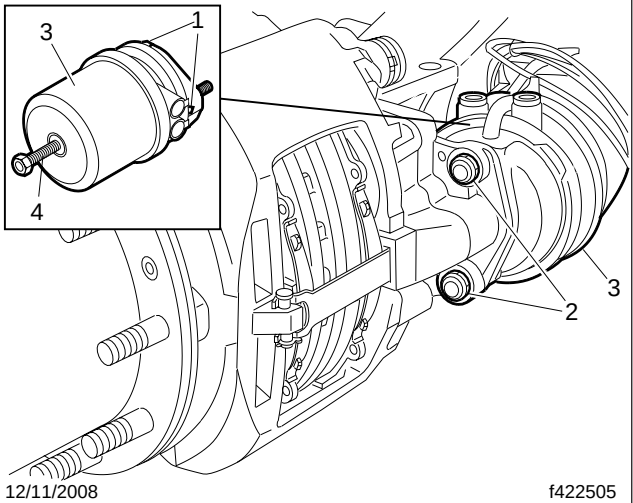
# Removal

1. Shut down the engine. Chock the tires on the axle that is not being serviced.
2. If working on the drive axle, carefully cage and lock the spring brakes so that the springs cannot actuate during disassembly.

   Back out the release bolt using a maximum torque of 26 lbf·ft (35 N·m) to release spring force on the pushrod. See **Fig. 1**.
3. Drain the air from the air system.
4. Raise the front or rear axle and place safety stands under the frame or axle. Be sure the stands will support the weight of the vehicle.
5. Remove the wheel(s). See **Group 40**.

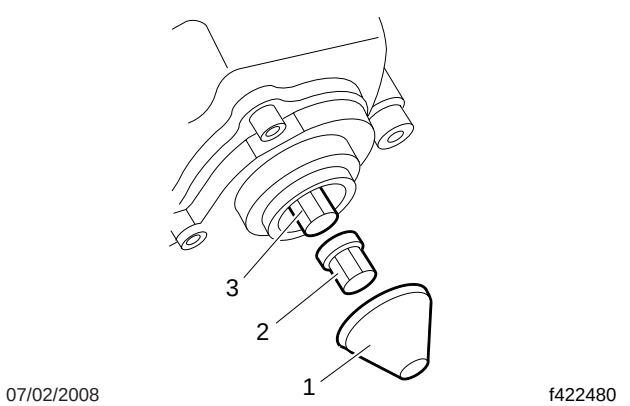
IMPORTANT: Before removing the brake pads, check the adjuster mechanism for proper operation.

6. Using the tab, pull off the adjuster cap, being sure to keep the shear adaptor in position on the adjuster. See **Fig. 2**.




1. Drain Plugs
2. Brake Chamber Nuts
3. Brake Chamber
4. Release Bolt

**Fig. 1, Spring Brake Chamber Installation**




1. Adjuster Cap
2. Shear Adaptor
3. Adjuster

**Fig. 2, Shear Adaptor in Position**

**NOTICE**

**Do not use an open-ended wrench, as this may damage the adaptor.**

IMPORTANT: Never turn the adjuster without the shear adaptor installed. The shear adaptor is a safety feature and is designed to prevent an excess of torque being applied to the adjuster. The shear adaptor will come loose if too much

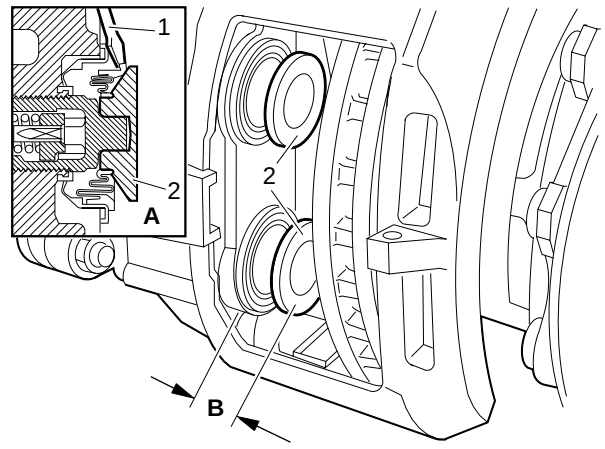
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## Brake Pad Removal, Inspection, and Installation

torque is applied. If the shear adaptor fails, try again with a new adaptor. A second failure confirms that either the brake is applied or the adjustment mechanism is seized and the caliper/carrier assembly must be replaced.

7. Using a box-end wrench or socket, fully retract the tappet and boot assemblies by rotating the shear adaptor counterclockwise. See **Fig. 3**.




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A. Boot Location Ring
B. Extend less than 1.18 in (30 mm)

1. Boot Location Ring
2. Tappet and Boot Assembly

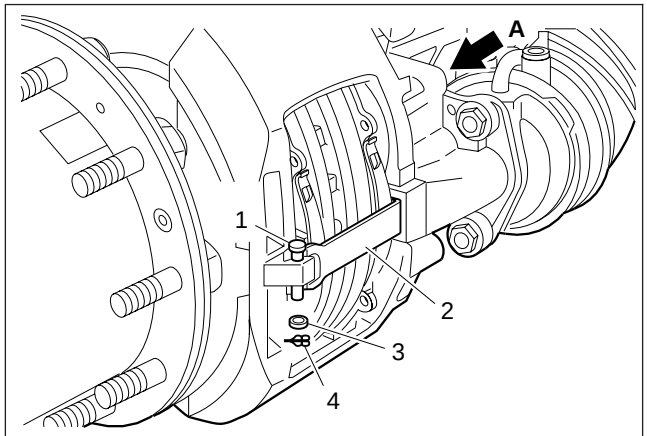
**Fig. 3, Tappet and Boot Assembly**

8. Remove the pad retainer clip and washer. See **Fig. 4**. Depress the pad retainer and remove the pad retainer pin. Discard all components that have been removed.
9. Slide the caliper to the outboard position. Remove the outer pad. See **Fig. 5**.
10. Slide the caliper to the inboard position. Remove the inner pad.

# Inspection

## Brake Pads

1. Measure the thickness of the friction material on the brake pad.

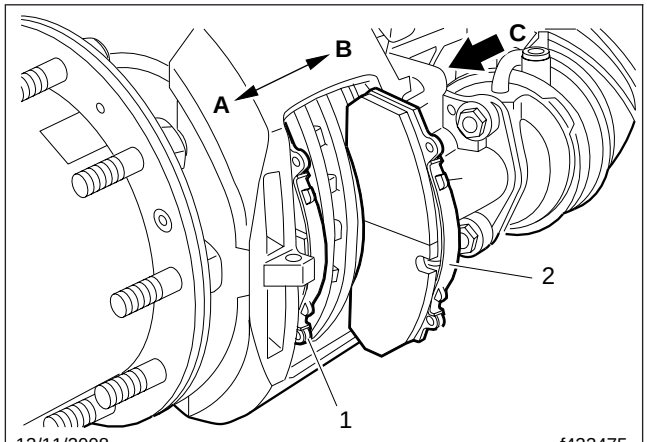



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A. Shear Adjuster Location

1. Pad Retainer Pin
2. Pad Retainer
3. Washer
4. Clip

**Fig. 4, Caliper Assembly**




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A. Outboard
B. Inboard
C. Area of Shear Adaptor

1. Outboard Brake Pad
2. Inboard Brake Pad

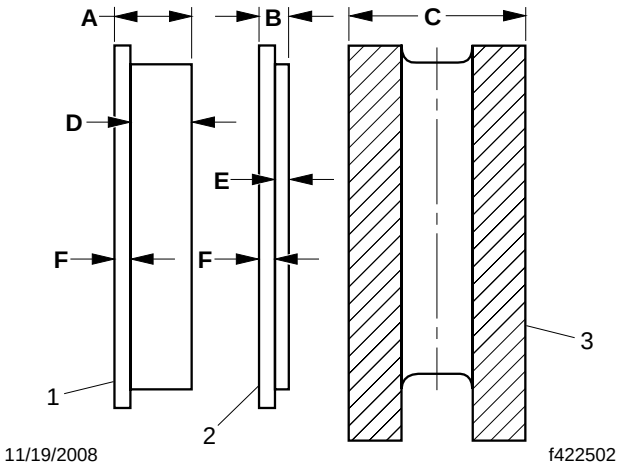
**Fig. 5, Brake Pad Removal**

If the thickness of the friction material is less than 0.079 in (2 mm) the pads must be replaced. See **Fig. 6**, Ref. E.

Most Bendix air disc brakes use 0.35 in (9 mm) backing plates. On a used brake pad, the combined pad and backing plate thickness should be no less than 0.43 in (11 mm).

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1. New Pad
2. Used Pad
3. Rotor

A. New Pad Thickness 1.18 inch (30 mm)
B. Used Pad Thickness 0.43 inch (11 mm)
C. Rotor Thickness 1.77 to 1.46 inches (45 to 37 mm)
D. New Pad Friction Material Thickness
E. Used Pad Friction Material Thickness 0.079 inch (2 mm) minimum
F. Backing Plate Thickness 0.35 to 0.43 inch (9 mm to 11 mm)

**Fig. 6, Brake Pad Inspection**

2. If the pad thickness is within the acceptable range, inspect the pad surface.

   Minor damage (small amount of brake material chipped) at the edges is permitted, but replace the pads if major damage (section damaged or missing) is found on the surface.

## Rotors

1. Examine the rotor and measure the thickness at the thinnest point. Avoid measuring near the edge of the rotor as minor burrs may be present. Replace the rotors when the minimum thickness is 1.46 in (37 mm), or when **one side** is greater than 0.15 inch (4 mm).

NOTE: It is recommended to replace the rotor with the same type that was originally installed on the vehicle and to replace the brake pads at the same time.

2. Inspect the rotor for grooves and cracks.

   Conventional rotors may be turned when changing pads, but is not normally necessary. In the case of severe grooving of the entire friction surface, then turning could be useful and may increase the load-bearing surface of the pads. To meet Bendix recommendations, the minimum rotor thickness after turning must be greater than 1.53 in (39 mm).

IMPORTANT: Always maintain air disc brake pads and rotors within specifications. Excessive pad or rotor wear will degrade optimum performance. When replacing rotors, be sure to adhere to Daimler Trucks North America (DTNA) recommended bolt tightening torques and sequence. See **Subject 130** for rotor replacement.

## Installation

NOTE: When replacing brake pads, replace them as an axle set. Only use pads that have the same backing plate thickness as originally specified.

1. Install the outboard brake pad by sliding the caliper to the outboard position (be sure the brake lining material is facing the rotor).
2. Install the inboard pad by sliding the caliper to the inboard position.
3. Using a box-end wrench or socket, turn the shear adaptor clockwise until the pads come into contact with the rotor. Then turn the shear adaptor counterclockwise two clicks to set the initial running clearance.
4. Install the new pad retainer into the groove of the caliper. Depress the pad retainer, and install the new pad retainer pin so that it is pointing downward.
5. Install the new washer and spring clip to secure the pad retainer pin. See **Fig. 1**.

NOTE: The adjustment mechanism operates automatically whenever the brakes are activated, to compensate for rotor and brake pad wear and to keep the running clearance constant. During pad or rotor maintenance the technician is to manually set the systems' initial non-braked position.

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## Brake Pad Removal, Inspection, and Installation

6. Set the total running clearance (sum of clearances on both sides of the rotor), between 0.024 to 0.043 in (0.6 to 1.1 mm). See **Fig. 7**.

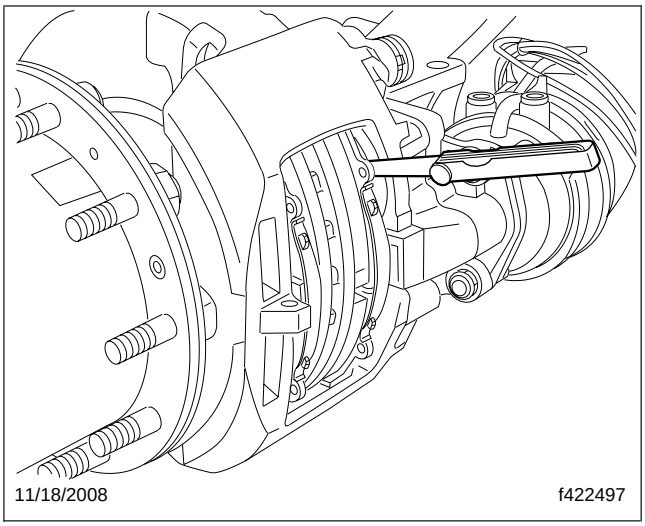



**Fig. 7, Checking Brake Pad Running Clearance**

7. Uncage the spring brake.
8. Apply and release the brake, then check that the hub turns easily by hand.
9. Using white lithium-based grease, lightly grease and install the adjuster cap.
10. Install the wheel(s). See **Group 40**.
11. Remove the safety stands and lower the vehicle.

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# Brake Caliper/Carrier Assembly Removal and Installation

**⚠ WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

NOTE: Replacement bolts are not supplied with the caliper, use only bolts of a grade and type specified by Daimler Trucks North America (DTNA).

Replacement caliper/carrier assemblies may be delivered with a plastic cap, adhesive tape, or a breakthrough diaphragm in the area where the actuator is mounted. Remove the cap or tape only after installing the replacement caliper. If the replacement caliper has the breakthrough diaphragm, it should be left in place. Refer to **Fig. 1** for front caliper/carrier removal and installation.

## Front Caliper/Carrier Assembly Removal

1. Apply the brakes and chock the tires.
2. Drain the air from the air system.
3. Raise the axle being serviced, and support it on a jackstand.
4. Remove the wheel. See **Group 40**.
5. Cut the zip ties holding the ABS harness to the brake hose as needed.

NOTE: If you are not replacing the caliper, it is not necessary to disconnect the air hose, if it can be safely supported out of the way while doing other work.

6. If replacing the caliper, disconnect the brake hose at the swivel connection at the frame rail, then remove the brake chamber from the caliper. See **Subject 150**.
7. With the caliper/carrier assembly securely supported, remove and discard the six bolts attaching the carrier to the anchor plate. Remove the caliper/carrier assembly.
8. Clean and inspect the anchor plate contact area. If damage is found, replace the anchor plate. See **Subject 140**.

## Front Caliper/Carrier Assembly Installation

1. Position the carrier/caliper assembly, and attach it to the anchor plate with new bolts. Tighten 170 to 200 lbf·ft (230 to 271 N·m).
2. Install the brake pads, and brake pad shield, if equipped. See **Subject 110**.
3. Using new nuts, attach the brake chamber to the caliper/carrier assembly. Tighten 127 to 137 lbf·ft (172 to 186 N·m). See **Subject 150**.
4. Connect the brake hose.
5. Position the ABS harness, and install new zip ties to hold the harness to the brake hose. Leave room for movement.
6. Install the wheel. See **Group 40**.
7. Remove the jackstand, and lower the vehicle.

**⚠ WARNING**

**Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.**

8. In a safe area, check for proper brake operation, as follows, before you put the vehicle in service.
   - 8.1 Apply and release the brakes several times to check for air leaks and proper operation.
   - 8.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.
   - 8.3 Immediately after doing the above stops, check the rotor temperatures. Any rotors that are significantly cooler than others show a lack of braking effort on those wheels.

## Rear Caliper/Carrier Assembly Removal

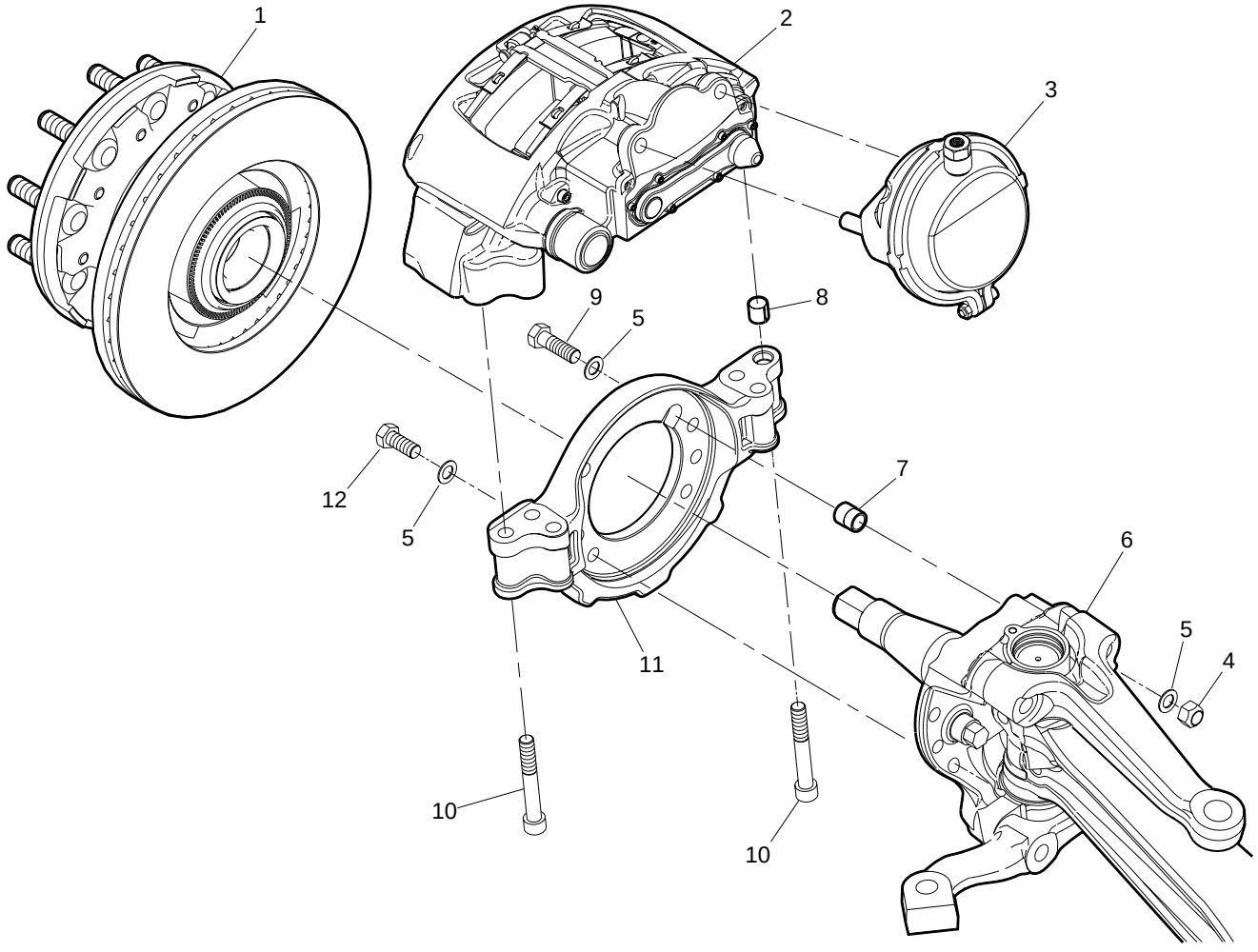
Refer to **Fig. 2** for rear caliper/carrier removal and installation.

1. Apply the brakes and chock the tires.

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## Brake Caliper/Carrier Assembly Removal and Installation




1. Hub and Disc Assembly
2. Caliper/Carrier Assembly
3. Brake Chamber
4. Nut
5. Washer
6. Spindle Assembly
7. ABS Sensor Bushing
8. Carrier Guide Bushing
9. Anchor Plate Bolt
10. Caliper Mounting Capscrew
11. Anchor Plate
12. Anchor Plate Capscrew

**Fig. 1, Front Caliper and Carrier Assembly Installation**

2. Raise the axle being serviced, and support it with an appropriate jackstand.
3. Remove the wheels. See **Group 40**.

**⚠ WARNING**

**When work is being done on the spring chamber, carefully follow the service instructions of the chamber manufacturer. The sudden release of a compressed spring can cause serious personal injury or death.**

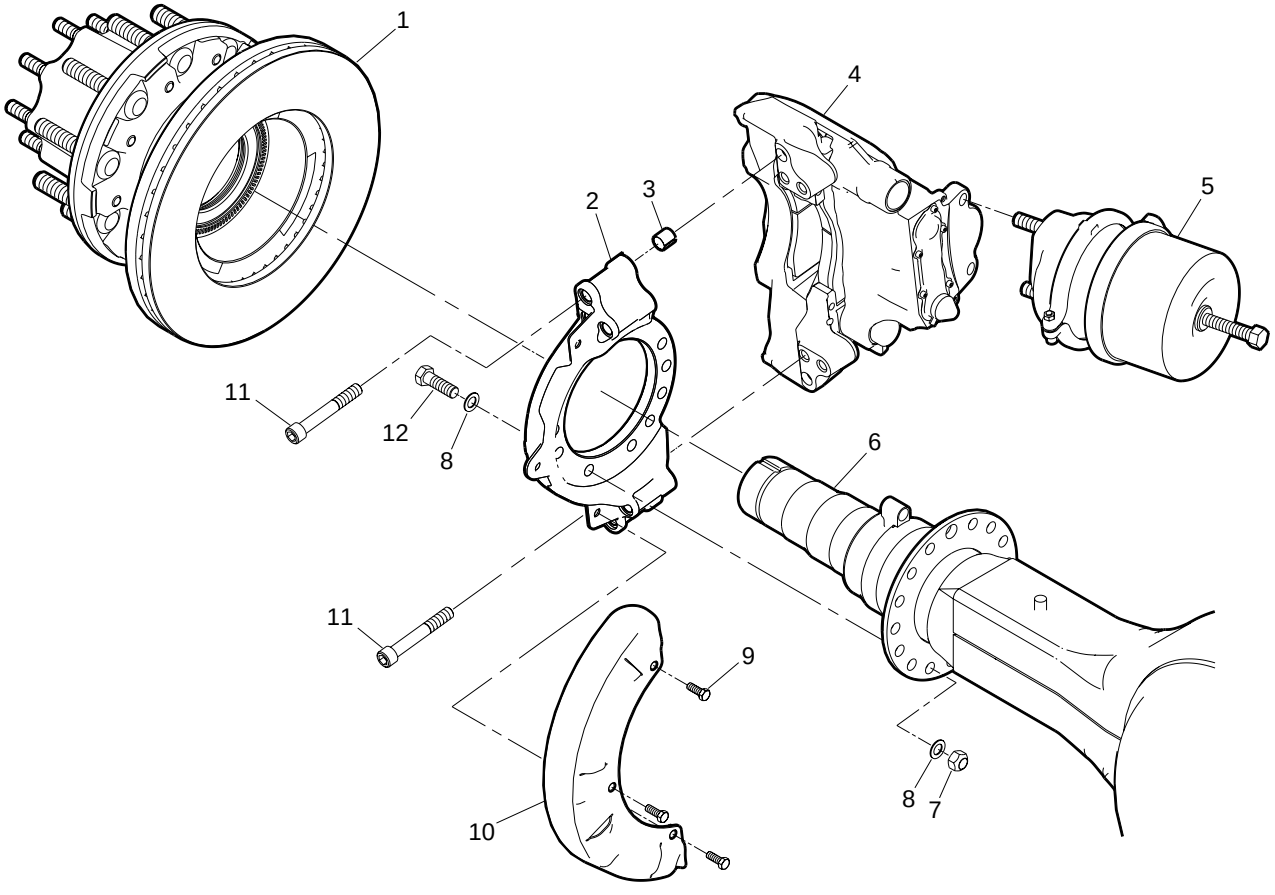
4. Carefully cage and lock the spring brakes so that the springs cannot actuate during disassembly.

   Back out the release bolt using a maximum torque of 26 lbf·ft. (35 N·m) to release spring force on the pushrod. See **Fig. 3**.
5. Drain the air from the air system.

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## Brake Caliper/Carrier Assembly Removal and Installation




1. Hub and Rotor Assembly
2. Anchor Plate
3. Carrier Guide Bushing
4. Caliper/Carrier Assembly
5. Spring Brake Chamber
6. Axle End
7. Nut
8. Washer
9. Rotor Shield Capscrew
10. Rotor Shield
11. Caliper Mounting Capscrew
12. Bolt

**Fig. 2, Rear Caliper and Carrier Assembly Installation**

6. Cut the zip ties holding the ABS harness to the brake hose as needed.
7. Remove the brake chamber from the caliper. See **Subject 150**.
8. Remove the rotor shield, if equipped.
9. With the caliper/carrier assembly securely supported, remove and discard the six bolts attaching the carrier to the anchor plate. Remove the caliper/carrier assembly.
10. Clean and inspect the anchor plate contact area. If damage is found, replace the anchor plate. See **Subject 140**.

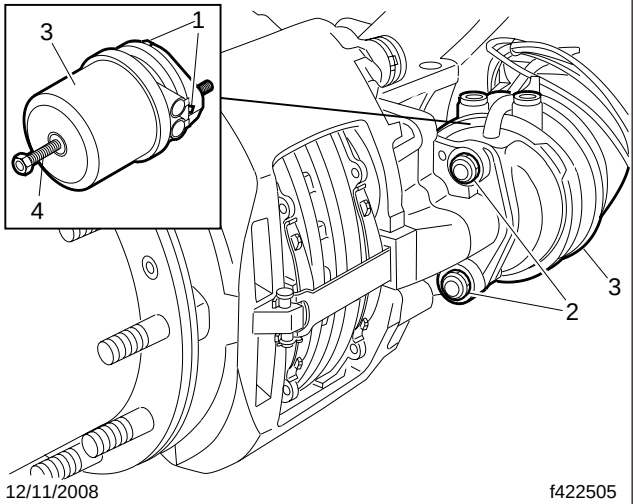
## Rear Caliper/Carrier Assembly Installation

1. Position the new carrier/caliper assembly, and attach it to the anchor plate with new bolts. Tighten 170 to 200 lbf·ft (230 to 271 N·m).

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## Brake Caliper/Carrier Assembly Removal and Installation




1. Drain Plugs
2. Brake Chamber Nuts
3. Brake Chamber
4. Release Bolt

**Fig. 3, Spring Brake Chamber Installation**

2. Install the brake pads, and brake pad shield, if equipped. See **Subject 110**.
3. Using new nuts, attach the brake chamber to the caliper/carrier assembly. Tighten 127 to 137 lbf·ft (172 to 186 N·m). See **Subject 150**.
4. Install the rotor shield, if equipped.
5. Uncage the spring brake chamber.
6. Install the wheels. See **Group 40**.
7. Remove the jackstand, and lower the vehicle.

**⚠ WARNING**

**Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.**

8. In a safe area, check for proper brake operation, as follows, before you put the vehicle in service.
   - 8.1 Apply and release the brakes several times to check for air leaks and proper operation.
   - 8.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.
   - 8.3 Immediately after doing the above stops, check the rotor temperatures. Any rotors that are significantly cooler than others show a lack of braking effort on those wheels.

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**WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

**WARNING**

**When replacing brake pads, shoes, rotors, or drums, always replace components as an axle set.**

- Always reline both sets of brakes on an axle at the same time.
- Always replace both rotors/drums on an axle at the same time.
- Always install the same type of linings/pads or drums/rotors on both axle ends of a single axle, and all four axle ends of a tandem axle, at the same time. Do not mix component types.

**Failure to do so could cause uneven braking and loss of vehicle control, resulting in property damage, personal injury, or death.**

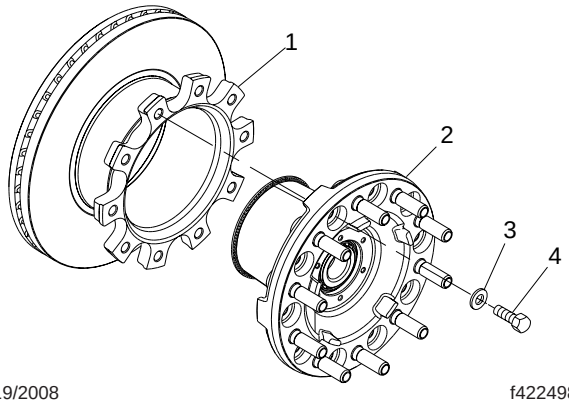
## Brake Rotor Removal

1. Chock the wheels on an axle that is not being serviced.
2. Raise the axle end to be serviced, and secure it on a jackstand.
3. Remove the wheel(s). See **Group 40**.
4. Remove the brake caliper/carrier assembly. See **Subject 120**.
5. Remove the hub and rotor assembly. See **Group 33** for the front axle, or **Group 35** for the rear axle.

   If replacing the rotor, remove the capscrews from the hub, and remove the brake rotor. See **Fig. 1** for front axles, or **Fig. 2** for rear axles.

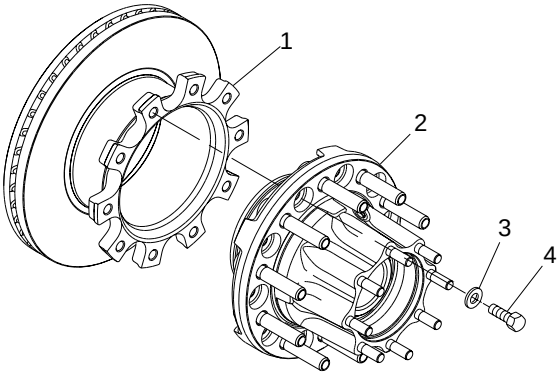
## Brake Rotor Installation

1. If the rotor was removed from the hub, clean the mating surface of the hub and brake rotor as needed.




1. Rotor
2. Hub
3. Washer
4. Capscrew

**Fig. 1, Front Rotor Installation**




1. Rotor
2. Hub
3. Washer
4. Capscrew

**Fig. 2, Rear Rotor Installation**

NOTE: It may be necessary to install the hub prior to tightening the hub-to-rotor capscrews to their final torque setting.

2. If replacing the rotor, position the new rotor on the hub, and install the capscrews. See **Fig. 1** for front axles, or **Fig. 2** for rear axles. Tighten 190 to 210 lbf·ft (258 to 285 N·m) using the sequence shown in **Fig. 3**.
3. Install the hub and rotor assembly. See **Group 33** for the front axle, or **Group 35** for the rear axle.

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## Brake Rotor Removal and Installation

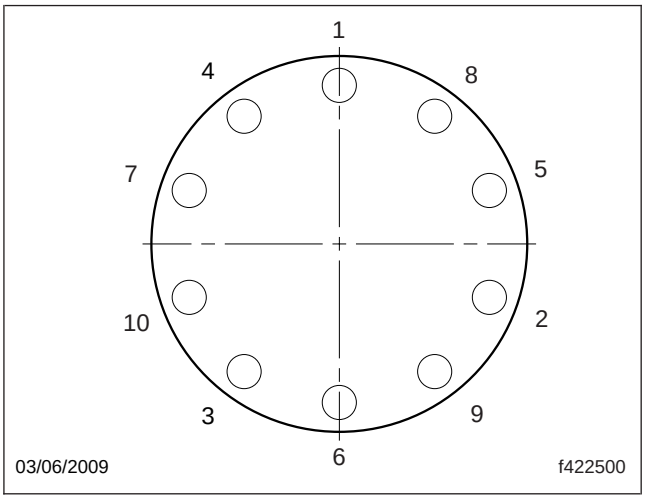



**Fig. 3, Tightening Sequence**

4. Install the brake caliper/carrier assembly. See **Subject 120**.
5. Install the wheel(s). See **Group 40**.
6. Remove the jackstand, and lower the vehicle.

**⚠ WARNING**

**Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.**

7. In a safe area, check for proper brake operation, as follows, before you put the vehicle in service.
   - 7.1 Apply and release the brakes several times to check for air leaks and proper operation.
   - 7.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.
   - 7.3 Immediately after doing the above stops, check the rotor temperatures. Any rotors that are significantly cooler than others show a lack of braking effort on those wheels.

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# Anchor Plate Disassembly, Inspection, Cleaning, and Assembly

**⚠ WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

## Front Anchor Plate Removal

1. Apply the brakes and chock the tires.
2. Drain the air from the air system.
3. Raise the axle being serviced, and support it on a jackstand.
4. Remove the wheel. See **Group 40**.
5. Remove the caliper/carrier assembly. See **Subject 120**.
6. Remove the hub and disc assembly. See **Subject 130**.
7. Pull the ABS sensor from its hole in the axle flange, and secure it in a safe place.
8. Remove the fasteners and remove the anchor plate. See **Fig. 1**.

## Rear Anchor Plate Removal

1. Apply the brakes and chock the tires.
2. Drain the air from the air system.
3. Raise the axle being serviced, and support it on a jackstand.
4. Remove the wheels. See **Group 40**.
5. Remove the rotor shield, if equipped. See **Fig. 2**.
6. Remove the caliper/carrier assembly. See **Subject 120**.
7. Remove the hub and disc assembly. See **Subject 130**.
8. Cut the zip ties holding the ABS sensor harness in place.
9. Disconnect the ABS sensor harness at its connection to the chassis harness, then feed it through the hole in the anchor plate and secure it in a safe manner.
10. Remove the fasteners and remove the anchor plate.

## Anchor Plate Cleaning and Inspection

If replacing the anchor plate, it is not necessary to clean and inspect it. If the anchor plate will be reused, clean and inspect it as follows.

1. Clean the anchor plate with a brush and solvent.
2. Inspect the anchor plate for cracks or other damage. If damage is found, replace the anchor plate.
3. Inspect the carrier and axle flange mounting surface of the anchor plate. All surfaces must be clean and free of any rust or corrosion. Use a hand-held wire brush to clean these surfaces, if needed.
4. Check that the carrier bolt hole threads are clean and free of foreign matter, and that the carrier guide bushing is secure and properly seated.

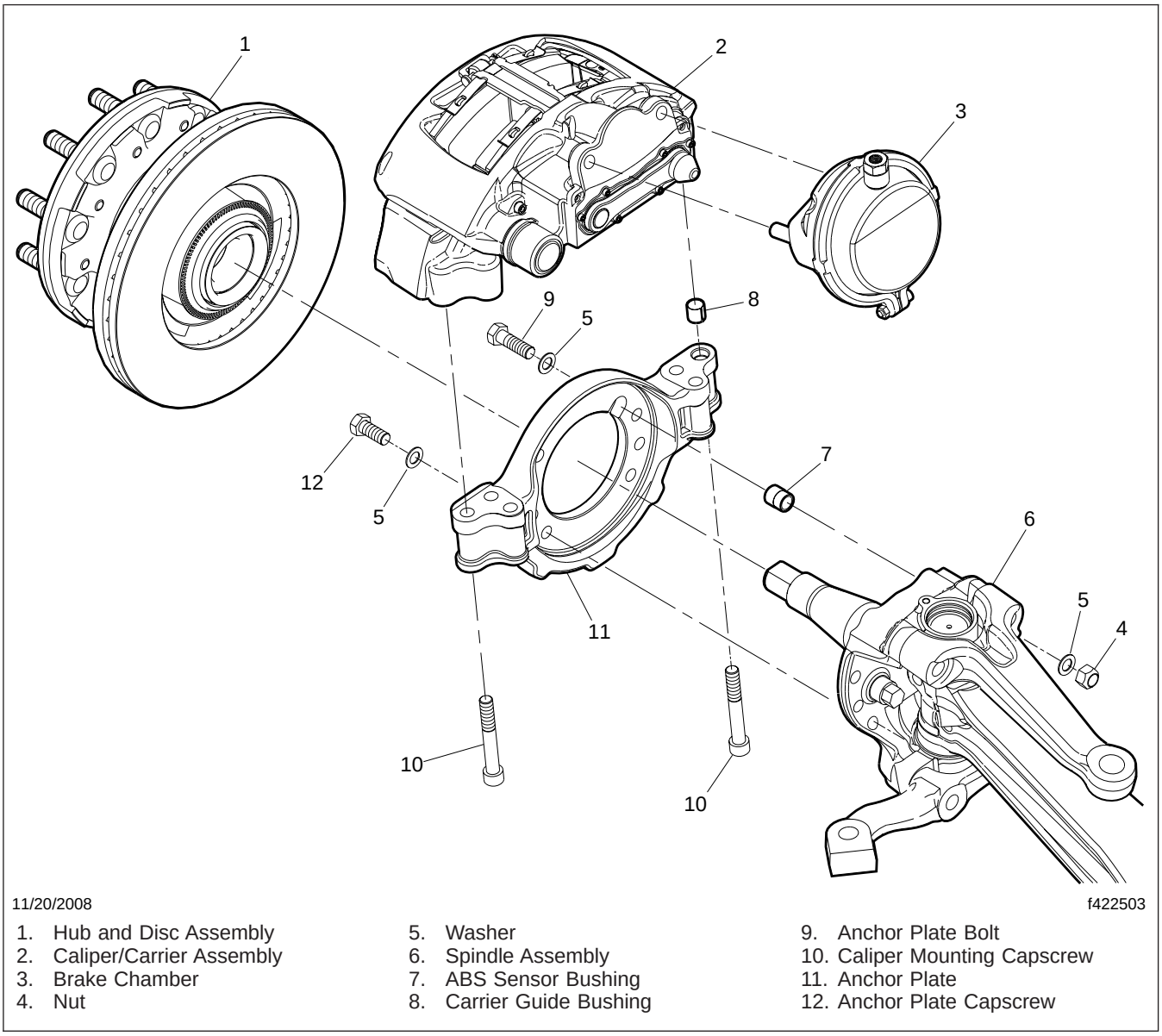
## Front Anchor Plate Installation

1. Position the anchor plate on the spindle flange with the caliper mounting bosses facing up, and the ABS sensor hole (larger) aligned with the uppermost forward hole on the axle flange.
2. Install the capscrews, washers, and nuts, as shown in **Fig. 1**.
   - 2.1 Install the 2-inch capscrew, washers, and nut, in the hole next to the ABS sensor hole.
   - 2.2 Then install the 1-1/2-inch capscrews that thread into the steering knuckle.
   - 2.3 Tighten the 2-inch capscrew 144 to 164 lbf·ft (195 to 222 N·m), and the 1-1/2-inch capscrews 168 to 188 lbf·ft (228 to 255 N·m) using the sequence shown in **Fig. 3**.
3. Install the hub and disc assembly. See **Subject 130**.
4. Install the ABS sensor. Push it in by hand, as far as it will go.
5. Install the caliper/carrier assembly. See **Subject 120**.
6. Install the wheel. See **Group 40**.
7. Remove the jackstand, and lower the vehicle.

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## Anchor Plate Disassembly, Inspection, Cleaning, and Assembly




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1. Hub and Disc Assembly
2. Caliper/Carrier Assembly
3. Brake Chamber
4. Nut
5. Washer
6. Spindle Assembly
7. ABS Sensor Bushing
8. Carrier Guide Bushing
9. Anchor Plate Bolt
10. Caliper Mounting Capscrew
11. Anchor Plate
12. Anchor Plate Capscrew

**Fig. 1, Front Axle Anchor Plate Installation**

**⚠ WARNING**

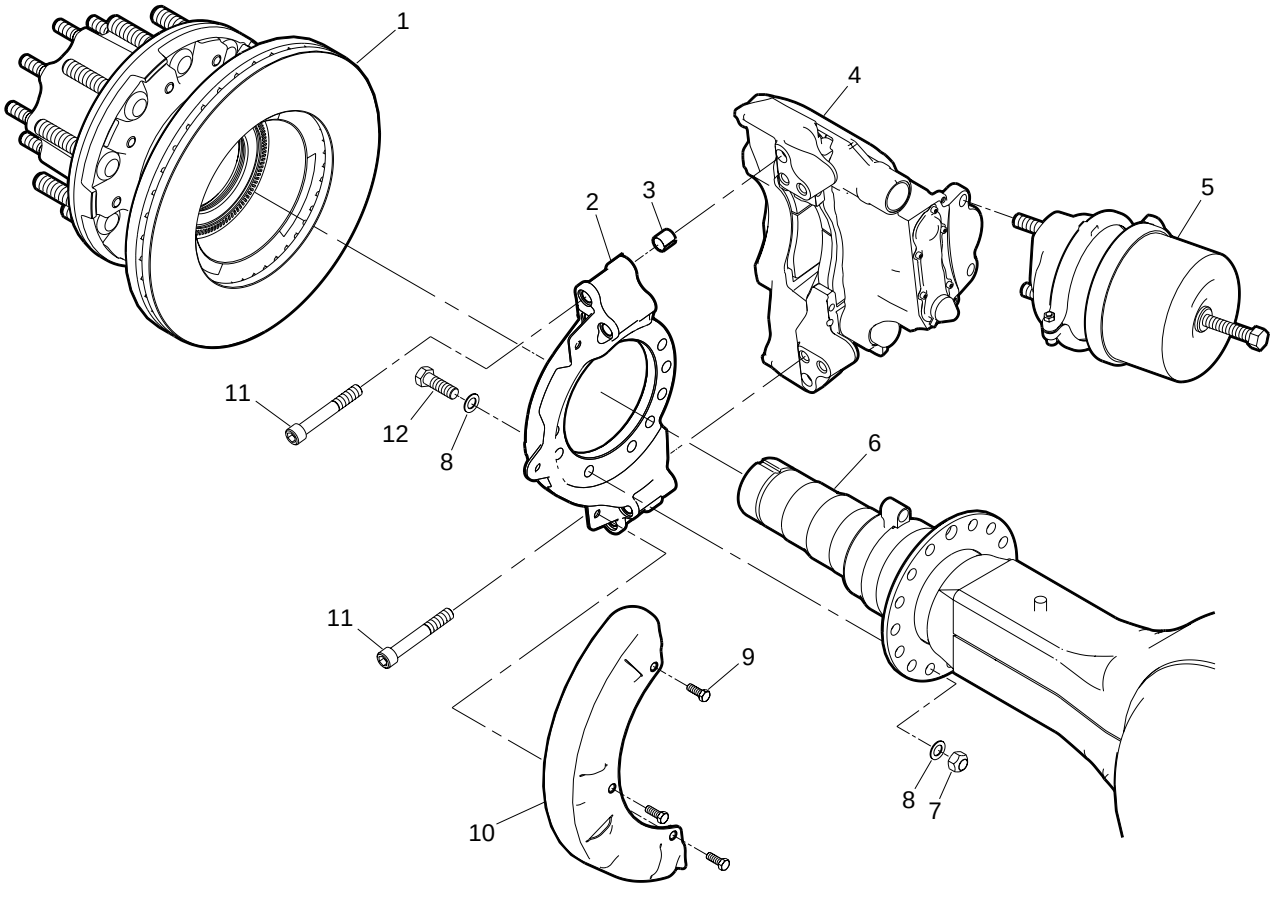
**Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.**

8. In a safe area, check for proper brake operation, as follows, before you put the vehicle in service.
   - 8.1 Apply and release the brakes several times to check for air leaks and proper operation.
   - 8.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.

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## Anchor Plate Disassembly, Inspection, Cleaning, and Assembly




1. Hub and Rotor Assembly
2. Anchor Plate
3. Carrier Guide Bushing
4. Caliper/Carrier Assembly
5. Spring Brake Chamber
6. Axle End
7. Nut
8. Washer
9. Rotor Shield Capscrew
10. Rotor Shield
11. Caliper Mounting Capscrew
12. Bolt

**Fig. 2, Rear Axle Anchor Plate Installation**

8.3 Immediately after doing the above stops, check the rotor temperatures. Any rotors that are significantly cooler than others show a lack of braking effort on those wheels.

## Rear Anchor Plate Installation

1. Position the anchor plate on the axle flange with the ABS sensor hole at the 12 o'clock position on the axle flange. Install the ten capscrews, washers, and nuts, leaving the holes at 12, 3, and 9 o'clock positions empty. Tighten 144 to 164 lbf·ft (195 to 222 N·m), using the sequence shown in **Fig. 3**.
2. Feed the ABS sensor harness through the hole in the anchor plate, and connect it at the chassis harness. Secure it with zip ties as needed.
3. Install the hub and disc assembly. See **Subject 130**.
4. Install the caliper/carrier assembly. See **Subject 120**.
5. Install the rotor shield, if equipped.

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## Anchor Plate Disassembly, Inspection, Cleaning, and Assembly

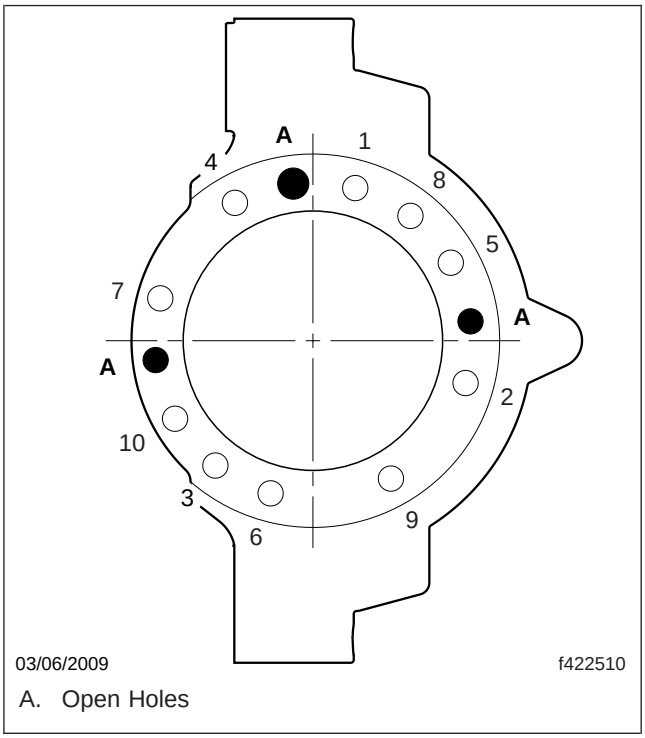



**Fig. 3, Tightening Sequence**

6. Install the wheels. See **Group 40**.
7. Remove the jackstand, and lower the vehicle.

**WARNING**

**Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.**

8. In a safe area, check for proper brake operation, as follows, before you put the vehicle in service.
   - 8.1 Apply and release the brakes several times to check for air leaks and proper operation.
   - 8.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.
   - 8.3 Immediately after doing the above stops, check the rotor temperatures. Any rotors that are significantly cooler than others show a lack of braking effort on those wheels.

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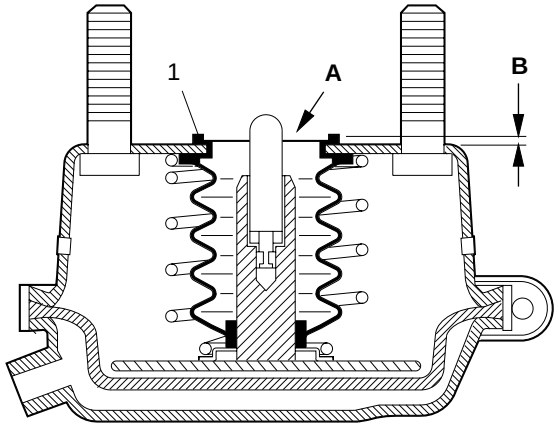
# Brake Chamber, or Spring Brake Chamber, Removal and Installation

**WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

IMPORTANT: Replace the brake chamber, or spring-brake chamber, only with units that are the same as originally installed on the vehicle. Replacement with alternate equipment could compromise brake performance and the vehicle warranty. Do not use brake chambers with seals with a thickness less than 0.12 in. (3 mm). See Fig. 1. Use only brake chambers which are recommended by Daimler Trucks North America (DTNA).

NOTE: New brake chambers have drain hole plugs installed in all positions. After installation, remove whichever plug is at the lowest position. Be sure that all other drain holes remain plugged.




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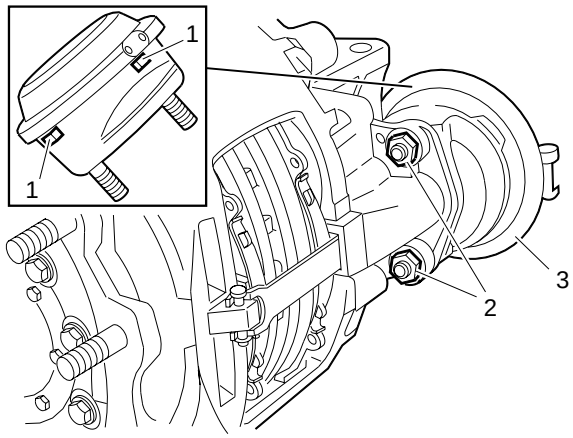
A. Pushrod Area
B. Do Not Use if Thickness is Less than 0.12 in (3 mm)

1. Seal

**Fig. 1, Pushrod Area**

## Front Brake Chamber Removal

1. Apply the brakes and chock the tires.
2. Remove the wheels.
3. Drain the air from the air system.
4. Cut the zip ties holding the ABS wire to the air hose.
5. Disconnect the air hose at the frame rail connection.
6. Remove and discard the brake chamber mounting nuts. See Fig. 2.




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1. Drain Plugs
2. Brake Chamber Mounting Nuts
3. Brake Chamber

**Fig. 2, Brake Chamber Installation**

7. Remove the brake chamber.
8. If replacing the brake chamber, remove the air hose to use on the new one.

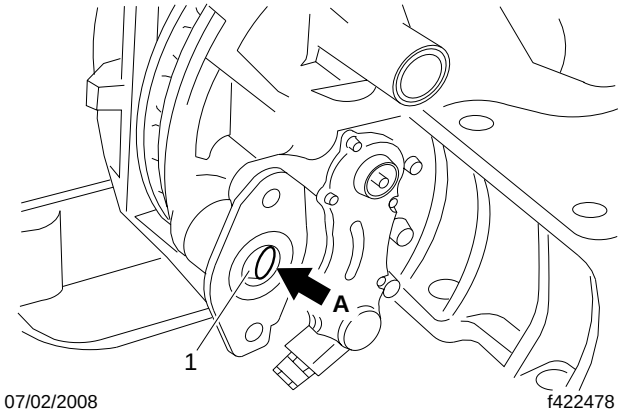
## Front Brake Chamber Installation

1. If replacing the brake chamber, install the air hose from the old chamber.
2. Before installing the new brake chamber, clean and inspect the brake chamber flange for damage. See Fig. 3. The seal, as well as the pushrod area must be clean and dry. See Fig. 1.
3. Lubricate the spherical cup in the lever with white grease. Do not use grease containing molybdenum disulfate.

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## Brake Chamber, or Spring Brake Chamber, Removal and Installation




A. Actuator Flange
1. Spherical Cup in Lever

**Fig. 3, Actuator Flange**

4. Install the brake chamber using new self-locking nuts. Alternately tighten both nuts in increments to a final torque of 126 to 140 lbf·ft (170 to 190 N·m).
5. Connect the air hose. Be sure that the hose is not twisted, or in contact with moving vehicle components. The air hose routing must allow for full caliper travel.
6. Secure the ABS wire to the brake hose. Be sure to leave flex room.
7. Install the wheels.
8. Lower the vehicle.

**WARNING**

**Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.**

9. In a safe area, check for proper brake operation, as follows, before you put the vehicle in service.
   - 9.1 Apply and release the brakes several times to check for air leaks and proper operation.
   - 9.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.
   - 9.3 Immediately after doing the above stops, check the rotor temperatures. Any rotors that are significantly cooler than others show a lack of braking effort on those wheels.

## Spring Brake Chamber Removal

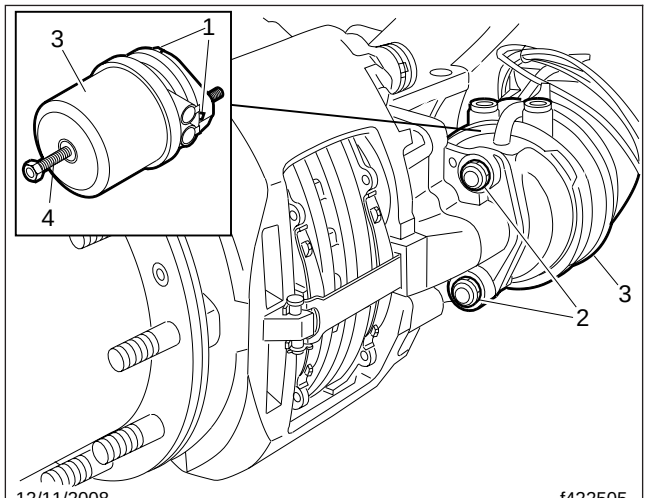
1. Set the brakes and chock the tires.
2. Remove the wheels.

**WARNING**

**When work is being done on the spring chamber, carefully follow the service instructions of the chamber manufacturer. The sudden release of a compressed spring can cause serious personal injury or death.**

3. Carefully cage and lock the spring brakes so that the springs cannot actuate during disassembly.

   Back out the release bolt using a maximum torque of 26 lbf·ft. (35 N·m) to release spring force on the pushrod. See **Fig. 4**.




1. Drain Plugs
2. Brake Chamber Nuts
3. Brake Chamber
4. Release Bolt

**Fig. 4, Spring Brake Chamber Installation**

4. Drain all the air pressure from the air brake system.

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5. Cut the zip ties holding the ABS wire to the air hose.
6. Disconnect the air hose at the frame rail connection.
7. While supporting the spring brake chamber in position, remove and discard brake chamber mounting nuts. Remove the brake chamber.
8. If replacing the brake chamber, remove the air hose to use on the new one.

## Spring Brake Chamber Installation

IMPORTANT: Replace the brake chamber, or spring-brake chamber, only with units that are the same as originally installed on the vehicle. Replacement with alternate equipment could compromise brake performance and the vehicle warranty. Do not use brake chambers with seals with a thickness less than 0.12 in. (3 mm). See **Fig. 1**. Use only brake chambers which are recommended by DTNA.

NOTE: New brake chambers have drain hole plugs installed in all positions. After installation, remove whichever plug is at the lowest position. Be sure that all other drain holes remain plugged.

1. If replacing the brake chamber, install the air hose from the old chamber.
2. Before installing the new brake chamber, clean and inspect the brake chamber flange for damage. The seal, as well as the pushrod area must be clean and dry. See **Fig. 3**.
3. Lubricate the spherical cup in the lever with white grease. Do not use grease containing molybdenum disulfate. See **Fig. 3**.
4. Install the brake chamber using new self-locking nuts. Alternately tighten both nuts in increments to a final torque of 126 to 140 lbf·ft (170 to 190 N·m).
5. Connect the air hose. Be sure that the hose is not twisted, or in contact with moving vehicle components. The air hose routing must allow for full caliper travel.
6. Secure the ABS wire to the brake hose. Be sure to leave flex room.
7. Uncage the spring brake.
8. Install the wheels.
9. Lower the vehicle.

**⚠ WARNING**

**Do not operate the vehicle until the brakes have been adjusted and checked for proper operation. To do so could result in inadequate or no braking ability, which could cause personal injury or death, and property damage.**

10. In a safe area, check for proper brake operation, as follows, before you put the vehicle in service.
    - 10.1 Apply and release the brakes several times to check for air leaks and proper operation.
    - 10.2 Perform six low-speed stops to ensure proper parts replacement and full vehicle control.
    - 10.3 Immediately after doing the above stops, check the rotor temperatures. Any rotors that are significantly cooler than others show a lack of braking effort on those wheels.

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## Specifications

| Bendix Air Disc Brake Fastener Torque Specifications | |
|---|---|
| **Installation** | **Torque: lbf·ft (N·m)** |
| Hub to Rotor | 190–210 (258–285) |
| Anchor Plate to Axle Flange: 2-inch (front) | 144–164 (195–222) |
| Anchor Plate to Axle Flange: 1.5-inch (front) | 168–188 (228–255) |
| Anchor Plate to Axle Flange (rear) | 144–164 (195–222) |
| Caliper to Anchor Plate | 170–200 (230–271) |
| Brake Chamber to Caliper | 126–140 (170–190) |
| Rotor Shield to Anchor Plate | 25–35 (34–47) |

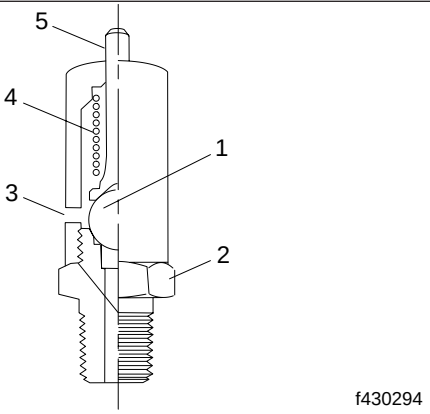
**Table 1, Bendix Air Disc Brake Fastener Torque Specifications**

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## General Information

The pressure relief valve (**Fig. 1**) protects the air brake system against excessive air pressure build-up. The valve has a spring-loaded cap and O-ring assembly which will exhaust air from the reservoir, if pressure rises above the valve's pressure setting. This setting is determined by the force of the spring.




1. Ball Valve
2. Body
3. Exhaust Port
4. Spring
5. Release Pin

**Fig. 1, Bendix ST-3 Valve**

## Principles of Operation

To illustrate the operation of the pressure relief valve, note that the governor cut-out pressure on all vehicles is set at a maximum 125 psi (862 kPa). A pressure relief valve with a setting of 150 psi (1034 kPa) is then used. Should system pressure rise to approximately 150 psi (1034 kPa), air pressure will force the cap and O-ring assembly off its seat, and allow the reservoir pressure to vent to the atmosphere.

When the reservoir pressure decreases sufficiently, the spring force will seat the cap and O-ring assembly, sealing off reservoir pressure. This will occur at approximately 135 psi (931 kPa) for the 150 psi (1034 kPa) valve. Note that the desired pressure setting of the pressure relief valve is determined by the governor cut-out pressure. The opening and closing pressures of the pressure relief valve should always be in excess of the governor cut-out pressure setting.

Normally, the pressure relief valve remains inoperative and only functions if, for any reason, the reservoir pressure rises above the setting of the valve. Constant exhausting of the pressure relief valve can be caused by a faulty pressure relief valve, faulty governor, faulty compressor unloading mechanism, or a combination of any of the preceding.

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## Operating Check

With air pressure built up in the system, proceed as follows:

**⚠ WARNING**

**Wear safety goggles when exhausting the air system because debris could fly out at high speed. Failure to take all necessary precautions could result in personal injury.**

1. Using pliers, pull the release pin of the valve, removing the spring load from the O-ring. See **Fig. 1**. Air should exhaust from the valve.

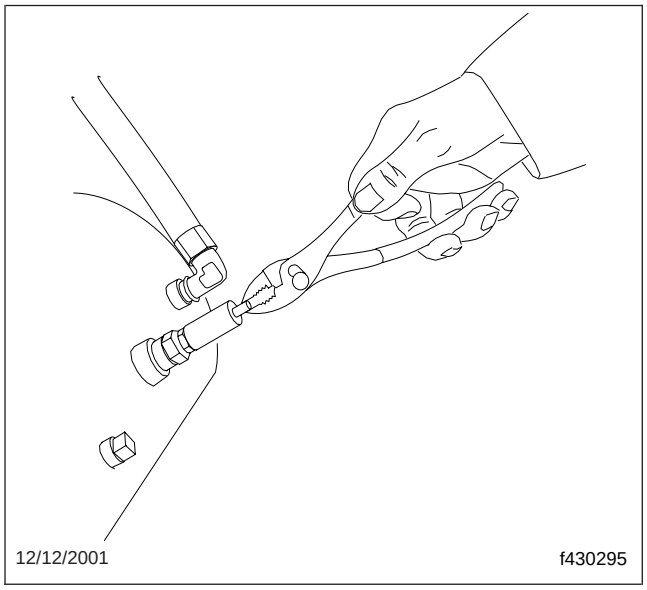



**Fig. 1, Valve Operating Check (ST-3 valve shown)**

2. Release the cap; the air flow should stop.

   Failure of a valve to pass the operating test indicates the valve should be replaced, using the instructions in **Subject 110**.

## Leakage Check

Coat the exhaust port with a soap solution. Leakage resulting in a 1-inch (2.5-cm) bubble in 5 seconds is permitted. Excessive leakage indicates dirt in the valve or a faulty O-ring or seat. The valve should be replaced, using the instructions in **Subject 110**.

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## Replacement

1. Chock the tires, and drain the air reservoirs.
2. Using a wrench, unscrew the valve from the reservoir.
3. Apply a small quantity of Loctite®242, or an equivalent sealant, to the threads of the new valve.

**⚠ WARNING**

**Make sure that excess sealant does not get inside either the male or female fittings. This would allow loose foreign material inside the plumbing, and may clog a valve. This could result in an unexpected loss of brake control, which could cause personal injury or property damage.**

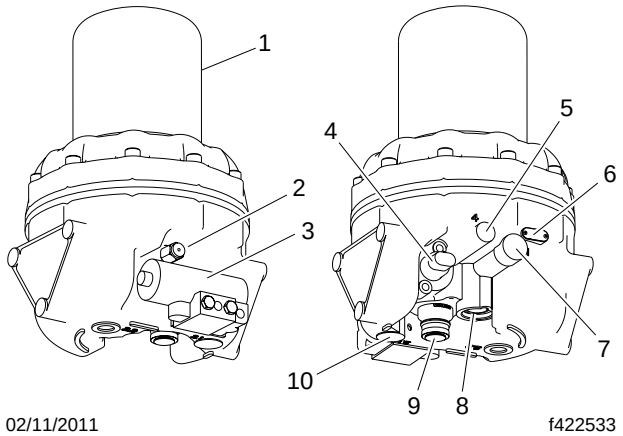
4. Install the valve and tighten it finger-tight. With a wrench, tighten it 1-1/2 additional turns past finger-tight.
5. Perform the operating and leakage checks on the valve and the valve fitting. For instructions, see **Subject 100**.

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## General Information

The System Saver 1200 Plus air dryer, shown in **Fig. 1**, is a desiccant air dryer, mounted vertically between the air compressor and the supply reservoir. The air dryer receives hot compressed air, which it cools and filters before sending it to the supply reservoir, reducing the buildup of dirt and moisture in the vehicle air system.




1. Desiccant Canister
2. Pressure Relief Valve
3. Governor
4. Heater/Thermostat Assembly
5. Control Port (to the air compressor unloader port)
6. Date Code Information (for the air dryer)
7. Air Dryer Inlet (from the air compressor discharge)
8. Turbocharger Cutoff Valve
9. Exhaust Port (Purge Valve Assembly)
10. Delivery/Outlet Port (to the air supply reservoir)

**Fig. 1, WABCO System Saver 1200 Plus**

The air dryer consists of a light weight aluminum and steel body. The desiccant cartridge is contained in a spinoff canister at the top of the air dryer.

The bottom half of the air dryer houses the following components.

- Pressure Relief Valve—this valve protects the air dryer from over pressurization. The valve is attached directly to the air dryer.
- Desiccant Canister—a cylindrical steel housing that contains the filter elements and the desiccant needed to filter and dry the air that passes through it.
- Heater/Thermostat Assembly—located in the air dryer base, this assembly is designed to prevent the collected moisture from freezing.
- Outlet Check Valve—this valve prevents air in the system from flowing back through the air dryer and escaping out the purge valve during the compressor unload cycle.
- Purge Valve—this valve allows the collected moisture and contaminants to be expelled from the air dryer during the purge cycle.
- Silencer (Muffler)—an optional component that is attached to the purge valve and used to eliminate most of the noise during the air dryer purge cycle.
- Turbocharger Cutoff Valve—this optional valve closes the path between the air compressor and the air dryer purge valve to help maintain boost pressure for maximum engine horsepower during the compressor unload cycle. A turbocharger cutoff valve is required with air compressors that use a turbocharged air intake.

NOTE: If the air compressor is naturally aspirated, the air passes from the vehicle air filter directly to the air compressor intake and **does not** require a turbocharger cutoff valve.

## Principles of Operation

Hot, compressed air enters the air dryer through the inlet port. As the hot air is forced into the desiccant cartridge, the temperature of the compressed air falls to nearly ambient. Oil and water vapor condense and initially settle into the base of the dryer. The moisture-laden air also passes through the desiccant bed, where any remaining moisture is retained by the desiccant. The clean air then passes through the air dryer outlet port to the supply reservoir.

When the compressor reaches 125 psi (862 kPa), the purge valve opens, allowing the initial decompression of the dryer, and expelling the water and contaminants collected in the base of the dryer.

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## Safety Precautions

**⚠ WARNING**

**When draining the air system, do not look into the air jets or direct them toward another person, as dirt or sludge particles may be in the air-stream. Do not disconnect pressurized hoses because they may whip as air escapes from the line. Failure to take all necessary precautions during service operations of the air brake system can cause personal injury.**

When working on or around air brake systems and components, observe the following precautions.

- Apply the parking brake, chock the tires, and stop the engine when working under the vehicle. Draining the air system may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters, which may apply as air system pressure drops.
- Wear safety goggles.
- Never connect or disconnect a hose or line containing air under pressure; it may whip as air escapes. Never remove a component or pipe plug unless you are sure all system pressure has been depleted.
- Do not disassemble a component before reading and understanding recommended procedures. Use only the correct tools and follow basic tool safety.
- Replacement hardware, tubing, hose, fittings, etc., should be the same size, type, length, and strength as the original equipment. When replacing tubing or hose, be sure that all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace any components that have stripped threads or damaged parts. Do not attempt to repair parts by machining.
- Never exceed recommended air pressure.

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**WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

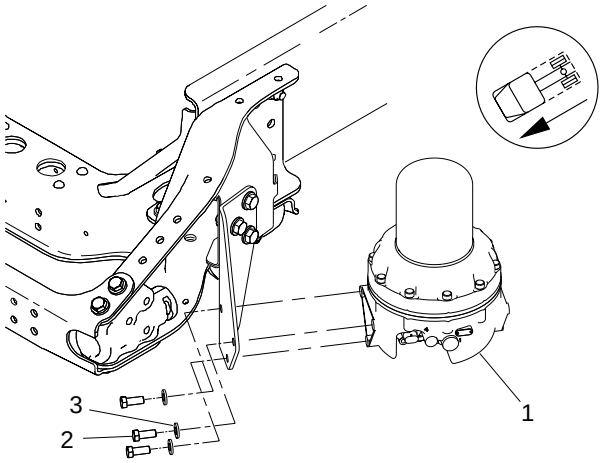
Refer to **Fig. 1** for removal and installation of the air dryer.

## Removal

1. Drain the air system.
2. Disconnect the wiring harness from the air dryer.
3. Mark the air lines for later reference; then, disconnect them from the air dryer.
4. Remove the mounting screws and washers that attach the air dryer to the mounting bracket.
5. Remove the air dryer.

## Installation

1. Position the air dryer on the mounting bracket. Install the washers and capscrews. Tighten them 52±4 lbf·ft (71±4 N·m).
2. Make sure the air lines are clean. Replace any line or fitting that is crimped or damaged.
3. Connect the remaining air lines to the air dryer as previously marked. Tighten the nut on each fitting finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut until there is firm resistance.
4. Connect the air dryer wiring harness.




1. Air Dryer
2. Mounting Screw
3. Washer

**Fig. 1, Air Dryer Installation (left-hand forward frame mounting shown)**

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## Turbocharger Cutoff Valve Replacement

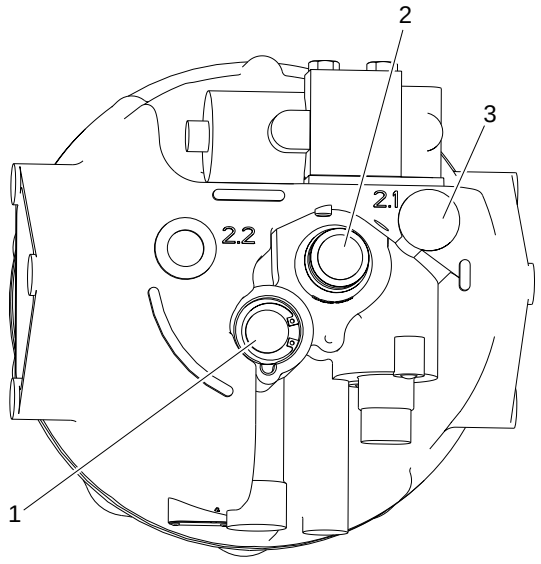
**⚠ WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

IMPORTANT: The turbocharger cutoff valve is optional on the WABCO System Saver 1200 Plus air dryer.

## Replacement

1. Drain the air system.
2. Remove the snap ring at the bottom of the valve assembly. See **Fig. 1** for the location of the turbocharger cutoff valve and **Fig. 2** for an example of the turbocharger cutoff valve assembly.




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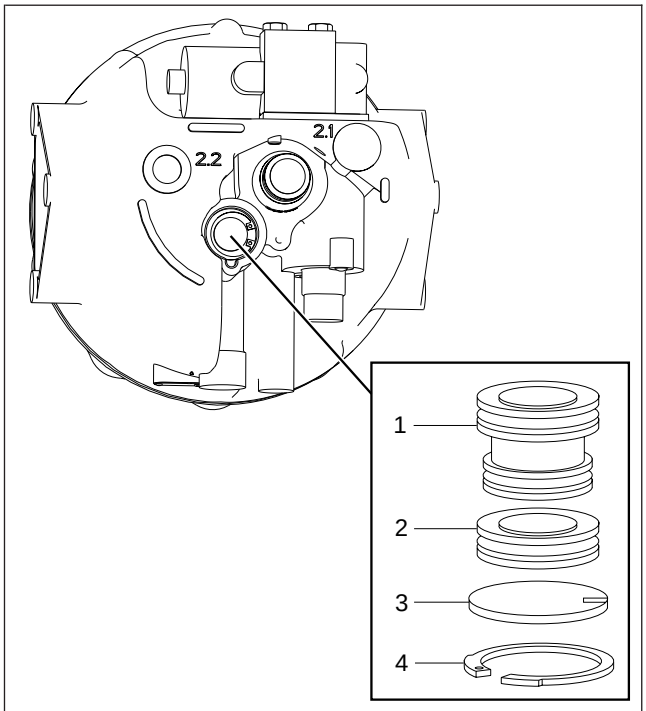
1. Turbocharger Cutoff Valve (has an orange cover)
2. Exhaust Port (Purge Valve Assembly)
3. Delivery/Outlet Port (to the air supply reservoir)

**Fig. 1, Turbocharger Cutoff Valve**

3. Clean the valve cavity with a commercial cleaning solvent.

IMPORTANT: If the valve cavity is damaged, preventing a tight seal, replace the air dryer. See **Subject 110** for instructions.

4. Install new O-rings on the piston and the sleeve.




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1. Piston
2. Sleeve
3. Cover
4. Snap Ring

**Fig. 2, Turbocharger Piston and Sleeve Assembly**

5. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-rings and the valve cavity.
6. Press the piston into the sleeve.
7. Press the new piston and sleeve assembly into the air dryer.
8. Install the cover and snap ring to hold the components in place.

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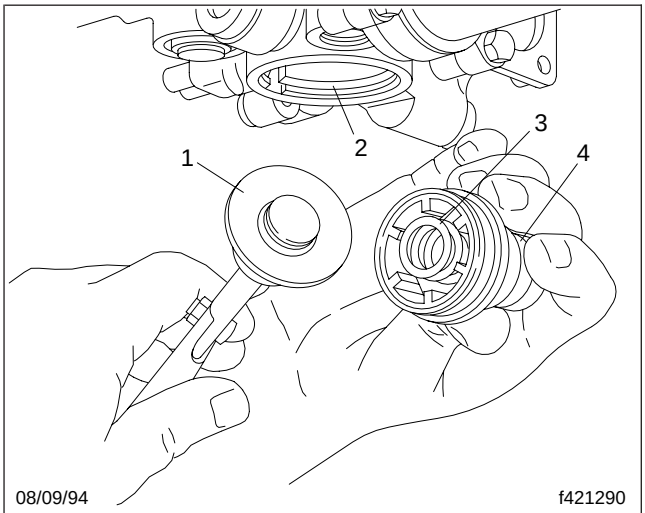


**⚠ WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

## Replacement

Refer to **Fig. 1** for purge valve replacement.




1. Valve Assembly
2. Exhaust Port
3. Spring
4. Valve Head

**Fig. 1, Removing the Valve Assembly**

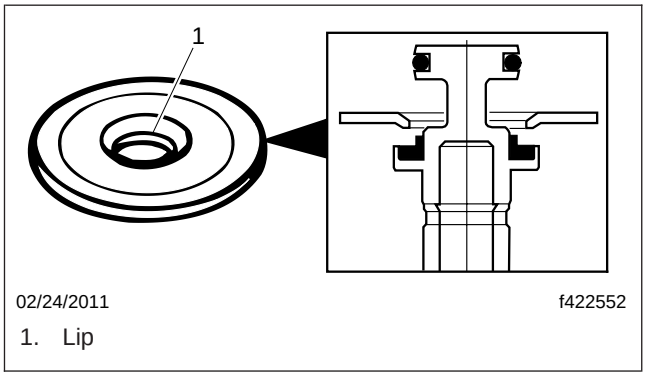
1. Drain the air system.
2. Remove the snap ring, valve head, and the spring from the exhaust port.
3. Pull the valve assembly out of the exhaust port.
4. Remove the O-ring from the base of the exhaust port.
5. Clean the purge valve cavity area with a commercial cleaning solvent.

IMPORTANT: If the valve cavity is damaged, preventing a tight seal, replace the air dryer.

6. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the valve cavity and all of the new O-rings. Install the O-rings in the base of the exhaust port and on the valve head.
7. Install the new washer and O-ring in the dryer base and on the valve head.

NOTE: The lip on the washer must face the piston seat as shown in **Fig. 2**.

8. Assemble the piston assembly.
   - 8.1 Install the O-ring in the groove on the piston head.
   - 8.2 Install the piston seat in the groove on the piston base.
   - 8.3 Install the washer on the piston.
9. Position the new valve assembly in the valve cavity.




1. Lip

**Fig. 2, Washer Lip Facing Piston Seat**

10. Install the spring in the valve head, and position them in the valve cavity.
11. Install the snap ring to secure the valve head in position.

NOTE: Make certain the snap ring is fully seated or the assembly will leak from the purge valve.

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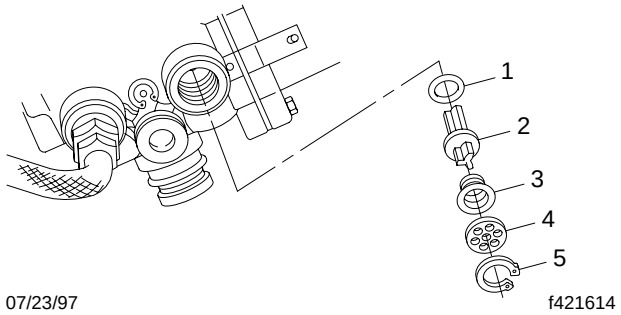


**⚠ WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

## Replacement

Refer to **Fig. 1** for valve replacement.




1. O-Ring
2. Valve Body
3. Spring
4. Washer
5. Snap Ring

**Fig. 1, Outlet Check Valve Assembly**

1. Drain the air system.
2. Disconnect the air line from the outlet port.
3. Remove the snap ring, washer, valve body, and the O-ring.
4. Clean the cavity area with a commercial cleaning solvent.
5. Install a new O-ring on the valve body.
6. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-ring and the valve cavity.
7. Install the new valve body. Make sure that the long end of the body is inserted first into the valve cavity.
8. Install the new spring with its small end around the Y-shaped fins on the valve body.

IMPORTANT: If the valve cavity is damaged, preventing a tight seal, replace the air dryer.

9. Install a new washer and snap ring to secure the assembly in the valve cavity.
10. Connect the air line to the outlet port. Tighten the nut on the fitting finger-tight. Then, using two wrenches to prevent twisting the hose, further tighten the nut until there is firm resistance. Tighten the nut one-sixth turn more.

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**⚠ WARNING**

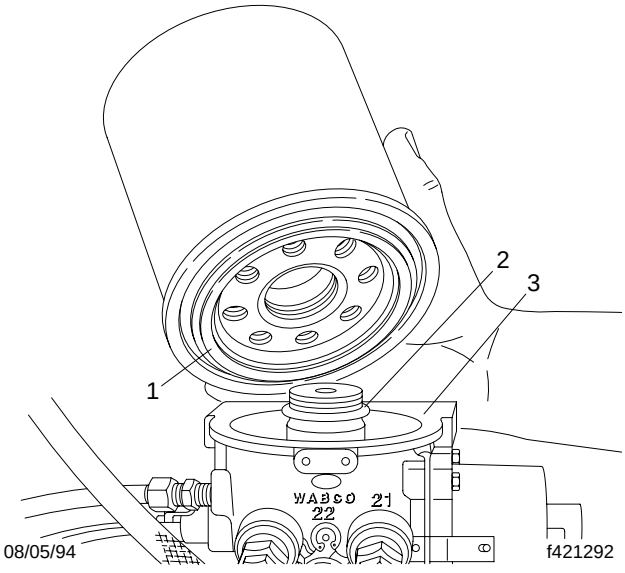
**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

**NOTICE**

**The WABCO System Saver 1200 Plus air dryer can use either a standard or oil coalescing desiccant cartridge. When replacing the desiccant cartridge, it is very important to use the same type of cartridge that was originally installed on the dryer. Oil coalescing cartridges can be used in any application, but require more frequent service intervals (every 1 to 2 years instead of every 2 to 3 years for a standard cartridge). Do not replace an oil coalescing cartridge with a standard cartridge, as this may result in contamination and malfunctioning of downstream air system components.**

## Replacement

Refer to **Fig. 1** for cartridge replacement.




1. Seal
2. O-Ring
3. Air Dryer Base

**Fig. 1, Desiccant Cartridge Replacement**

1. Drain the air system.
2. Using a strap wrench, turn the desiccant cartridge counterclockwise and remove it.
3. Remove and discard the O-ring.
4. Clean the top surface of the dryer base with a commercial cleaning solvent.

IMPORTANT: If the air dryer base is damaged, preventing a tight seal, replace the air dryer.

5. Using a multipurpose, high-temperature grease that resists water, steam, and alkali, lightly coat the surfaces of the new O-ring and the dryer base. Install the O-ring.
6. Thread the desiccant cartridge onto the dryer base (turn clockwise). When the seal contacts the base, tighten the cartridge one complete turn more. Do not overtighten.

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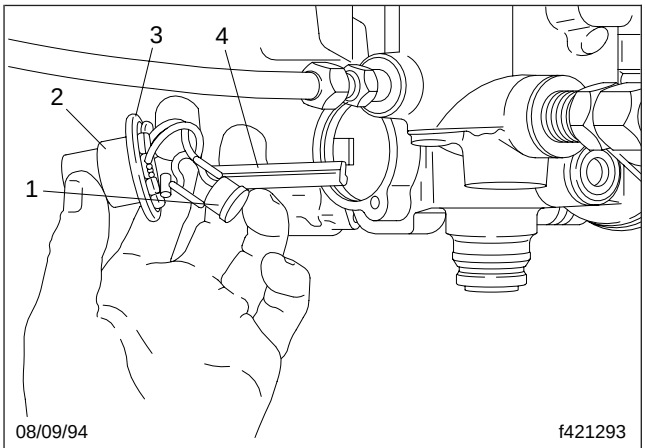


**⚠ WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

## Replacement

Refer to **Fig. 1** for heater/thermostat assembly replacement.




1. Thermostat
2. Receptacle
3. O-Ring
4. Element

**Fig. 1, Heater/Thermostat Replacement**

1. Drain the air system.
2. Disconnect the wiring harness.
3. Remove the screws that attach the heater/thermostat receptacle. Remove the receptacle and the O-ring.
4. Remove the retaining screw that holds the assembly in place. Remove and discard the heater/thermostat assembly.
5. Clean the heater/thermostat assembly area with a commercial cleaning solvent.
6. Position the new heater/thermostat assembly in the cavity. Install the retaining screw.
7. Position the new receptacle and O-ring, and install the screws. Tighten the screws securely.
8. Connect the wiring harness.

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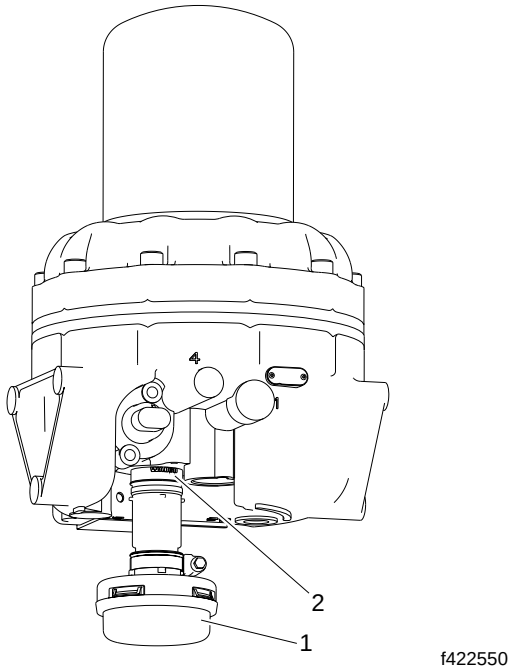


**⚠ WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

## Replacement

Refer to **Fig. 1** for silencer replacement.




1. Silencer
2. Purge Valve Head

**Fig. 1, Silencer Replacement**

1. Using snap ring pliers, expand the snap ring and pull the silencer off of the purge valve head.
2. Push the new silencer onto the purge valve head until the silencer snaps into place.

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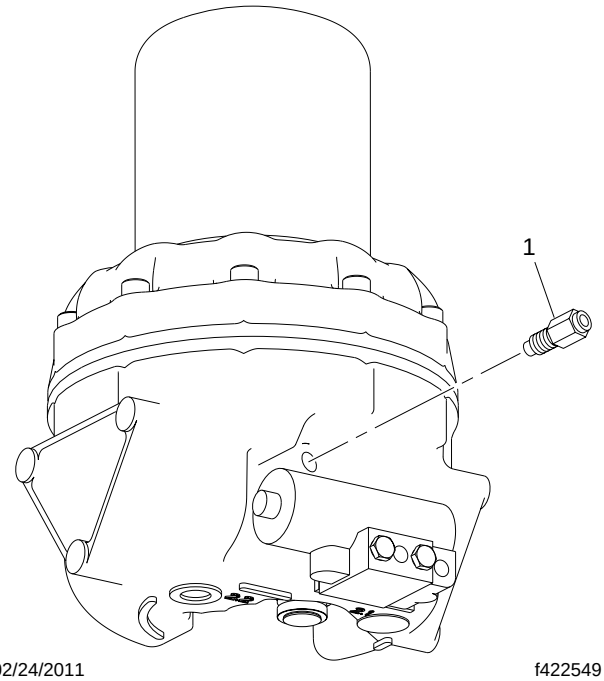


**⚠ WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

## Replacement

Refer to **Fig. 1** for valve replacement.




1. Pressure Relief Valve

**Fig. 1, Pressure Relief Valve Replacement**

1. Drain the air system.
2. Unscrew and remove the old valve from the dryer.
3. Screw the replacement valve into the dryer base. Do not exceed a torque of 30 lbf·ft (41 N·m) for a 3/8-inch thread, or 65 lbf·ft (88 N·m) for a 1/2-inch thread.

NOTE: The threads on the replacement pressure relief valve provided by WABCO are coated with sealant. They do not require any additional sealant.

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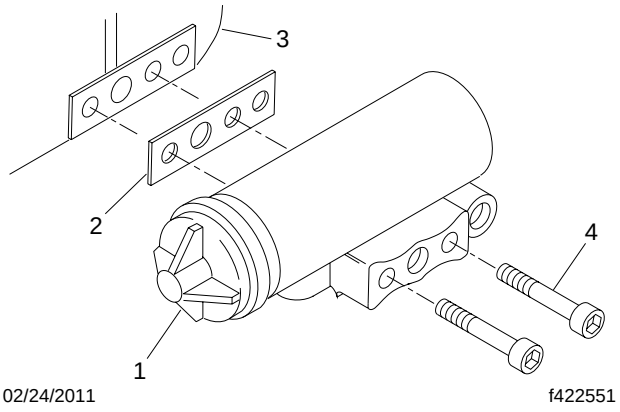
**WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

IMPORTANT: When replacing the governor, use only the Meritor WABCO governor specified for use with the System Saver 1200 Plus air dryer.

## Replacement

1. Remove the mounting bolts, governor and gasket as shown in **Fig. 1**. Discard the gasket.




1. Governor
2. Gasket
3. Air Dryer
4. Mounting Bolt

**Fig. 1, Replacing the Governor**

2. Place the new governor and gasket into position on the air dryer.
3. Using the mounting bolts, install the governor. Tighten the bolts 15 lbf·ft (20 N·m).

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**WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

## Air Dryer Operating Tests

1. Drain the air system.
2. Start the engine and build the air pressure to as close to cutout pressure as possible (about 125 psi [862 kPa]).
3. When the compressor reaches the unload cycle, the air dryer purges, beginning regeneration of the air dryer.
4. There should be no visible pressure drop on the vehicle dash gauges during regeneration. If there is a visible pressure drop, and there are no other air-operated components in use, then there are air leaks or other system problems. Refer to **Troubleshooting 300** for other possible causes.

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**Problem—Air Dryer Purges Too Often and Is Accompanied by Excessive Cycling of the Compressor**

| Problem—Air Dryer Purges Too Often and Is Accompanied by Excessive Cycling of the Compressor | |
|---|---|
| **Possible Cause** | **Remedy** |
| There is a leak in the line between the unloader port of the air compressor and dryer port 4. | Repair the air line. |
| There is a leak in the line between the supply tank and the delivery/outlet port. | Repair the air line. |
| Excessive air system leaks. | Repair all leaks. |
| Excessive air system demands. | Increase the air system capacity or reduce air demand. |
| The outlet check valve does not seal. | Inspect and replace the outlet check valve as needed. |
| There is a leak at the air governor gasket. | Replace the gasket. |
| The air governor has less than 16 psi (110 kPa) range. | Replace the air governor. |
| The air compressor's unloader(s) is leaking. | Inspect the air compressor and repair or replace it according to the manufacturer's instructions. |

**Problem—The Air Dryer Does not Purge When the Compressor Unloads (No Blast of Air from the Purge Valve)**

| Problem—The Air Dryer Does not Purge When the Compressor Unloads (No Blast of Air from the Purge Valve) | |
|---|---|
| **Possible Cause** | **Remedy** |
| The air line between the unloader port of the air compressor and air dryer port 4 is kinked or plugged. | Repair the air line. |
| The purge valve is stuck closed. | Replace the purge valve. |
| The air governor is not working properly. | Inspect the air governor and repair or replace it according to the manufacturer's instructions. |
| Cut-out pressure is never achieved by the air compressor. | Check for air leaks in the system and repair as needed. If no leaks are found, check the compressor output. Repair or replace the compressor according to the manufacturer's instructions. |

**Problem—There Is Rapid "Spitting" of Air from the Purge Valve in Small Amounts; Frequency Varies With Engine Speed**

| Problem—There Is Rapid "Spitting" of Air from the Purge Valve in Small Amounts; Frequency Varies With Engine Speed | |
|---|---|
| **Possible Cause** | **Remedy** |
| A Holset E-type compressor is being used, but a non-1200E air dryer is installed. | Replace the air dryer with an SS1200E air dryer. |
| The compressor does not completely unload when cut-out pressure is reached. | Inspect the compressor and repair or replace it according to the manufacturer's instructions. |
| This is normal for air dryers that are not equipped with an optional turbocharger cutoff valve. | Not applicable. |

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## Troubleshooting

**Problem—Air Leaks at the Turbo Cutoff Valve Vent; There Is a Hole Burned in the Piston**

| Problem—Air Leaks at the Turbo Cutoff Valve Vent; There Is a Hole Burned in the Piston | |
|---|---|
| **Possible Cause** | **Remedy** |
| The temperature of the air coming into the dryer is too high, and there is not enough cooling taking place before the air gets to the air dryer inlet. | Move the dryer farther from the compressor. Add additional compressor discharge line before the air dryer. Add a cooling coil or heat exchanger before the air dryer.<br>NOTE: The inlet air temperature must not exceed 175°F (79°C). |
| The valve bore is worn excessively. | Inspect the valve bore for wear. If a new turbo cut-off valve does not seal in a clean, lubricated bore, replace the air dryer. |
| The piston is broken. | Replace the turbocharger cutoff valve. See **Subject 120**. |

**Problem—The Air Dryer Is Frozen (Water Collected in the Base of the Air Dryer Freezes)**

| Problem—The Air Dryer Is Frozen (Water Collected in the Base of the Air Dryer Freezes) | |
|---|---|
| **Possible Cause** | **Remedy** |
| There is no power to the heater connector. | Check for a blown fuse. Repair the heater circuit.<br>NOTE: There must be power to the heater connector the entire time the vehicle's ignition is activated. |
| Low voltage to the heater connector. | Repair the cause of low voltage—poor electrical ground, bad connections, corroded wire splices, etc. |
| The heater assembly is not working. | Replace the heater assembly. |
| An incorrect voltage air dryer is being used (for example a 12V air dryer in a 24V system). | Replace with the correct voltage air dryer. |

**Problem—Air Pressure Will Not Build-Up in the System**

| Problem—Air Pressure Will Not Build-Up in the System | |
|---|---|
| **Possible Cause** | **Remedy** |
| The air dryer is not plumbed correctly. | Make certain the compressor discharge line is plumbed to air dryer port 1, and air dryer port 21 is connected to the vehicle's supply tank. |
| The wrong air line is connected to air dryer port 4. | Verify that the air dryer port 4 line is connected to the "UNL" port of the unloader port of the air compressor. |
| The air governor is not working properly. | Inspect the air governor and repair or replace it according to the manufacturer's instructions. |
| Air system components, such as the compressor discharge line, air dryer reservoirs, brake valves, or suspension valves leak. | Locate the leak(s) and repair as needed. |
| The air dryer leaks at the purge valve. | See *Air dryer purges too often and is accompanied by excessive cycling of the compressor* and *The air dryer leaks from the purge valve during a compressor loaded cycle (the leak may cause excessive compressor cycling or prevent the system from building air pressure).* |

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**Problem—Water, Oil, or Sludge Is in the Air System Tanks**

| Problem—Water, Oil, or Sludge Is in the Air System Tanks | |
|---|---|
| **Possible Cause** | **Remedy** |
| Desiccant is contaminated with oil. | Replace desiccant. Inspect the compressor according to the manufacturer's instructions. |

**Problem—Water Is in the Air System Tanks**

| Problem—Water Is in the Air System Tanks | |
|---|---|
| **Possible Cause** | **Remedy** |
| The air dryer is not suitable for the vehicle. | Review the vehicle guidelines. Call the Meritor Customer Support Center for assistance at 1-800-535-5560. |

**Problem—The air dryer leaks from the purge valve during a compressor loaded cycle (the leak may cause excessive compressor cycling or prevent the system from building air pressure)**

| Problem—The air dryer leaks from the purge valve during a compressor loaded cycle. The leak may cause excessive compressor cycling or prevent the system from building air pressure. | |
|---|---|
| **Possible Cause** | **Remedy** |
| The purge valve is frozen open. | Check the heater, and repair or replace it if necessary. Make sure the air line between the unloader port of the air compressor and dryer port 4 is free of water and oil. Remove and inspect the purge valve, and clean any water or oil from the top of the piston. |
| Debris is under the purge valve seat. | Remove the purge valve and clean it. See **Subject 130** for instructions to remove the purge valve. Remove the desiccant cartridge and clean the dryer sump area. See **Subject 150** for instructions. |
| The purge valve washer is installed upside down. | Make certain the lip on the washer faces down, away from the air dryer. |
| The wrong air line is connected to air dryer port 4. | Verify that the dryer port 4 line is connected to the "UNL" port of the air compressor. |
| The purge valve snap ring is not fully seated in the groove. | Seat the snap ring fully into the groove. |

**Problem—The regeneration cycle is too long (more than 30 seconds), accompanied by loss of pressure in the supply tank**

| Problem—The regeneration cycle is too long (more than 30 seconds), accompanied by loss of pressure in the supply tank | |
|---|---|
| **Possible Cause** | **Remedy** |
| The outlet check valve is not seating. | Inspect the outlet check valve. Replace the valve if needed. |

**Problem—The regeneration cycle is too short (less than 20 seconds)**

| Problem—The regeneration cycle is too short (less than 20 seconds) | |
|---|---|
| **Possible Cause** | **Remedy** |
| There are high air system demands during a compressor unloaded cycle. | Increase the air system capacity or reduce air demands. |

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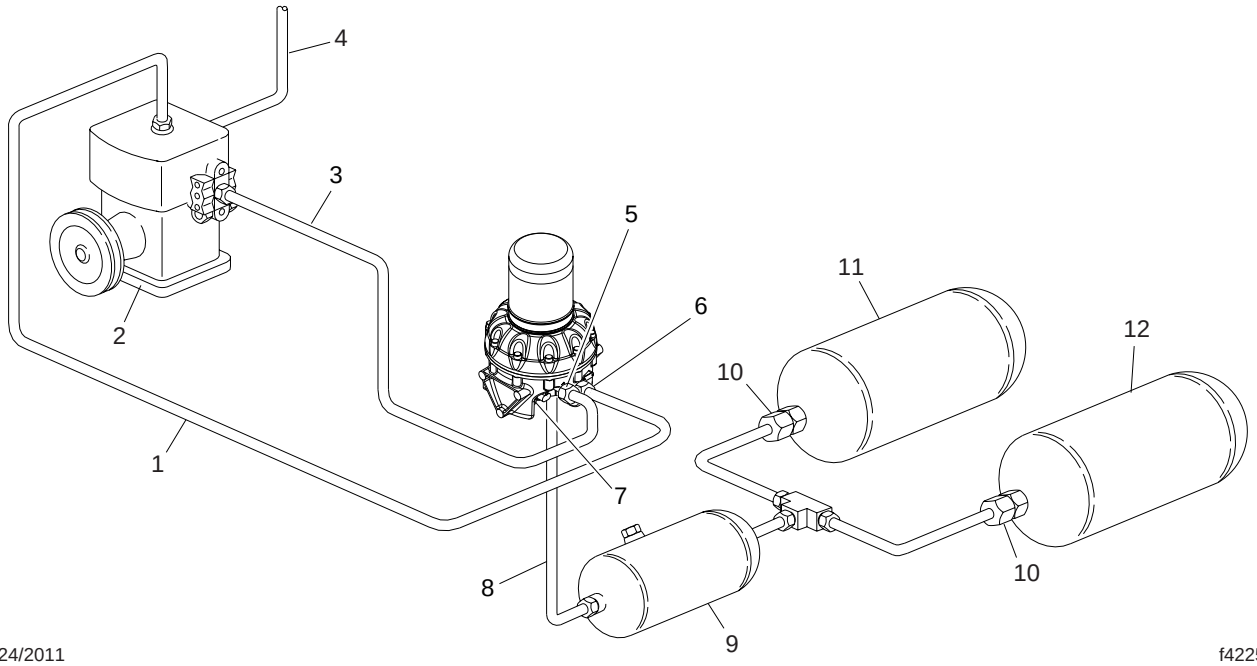
## Troubleshooting

| Problem—The regeneration cycle is too short (less than 20 seconds) | |
|---|---|
| **Possible Cause** | **Remedy** |
| The air governor is not working correctly. | Inspect the air governor and repair or replace it according to the manufacturer's instructions. |

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See **Fig. 1** for the plumbing diagram.




1. Compressor Discharge Line
2. Compressor
3. Signal Line
4. Compressor Intake Line (naturally aspirated or turbocharged)
5. Air Dryer Control Port
6. Air Dryer Inlet
7. Exhaust Port (Purge Valve Assembly)
8. Delivery Line (from the delivery/outlet port)
9. Supply Tank
10. Check Valve
11. System Reservoir
12. System Reservoir

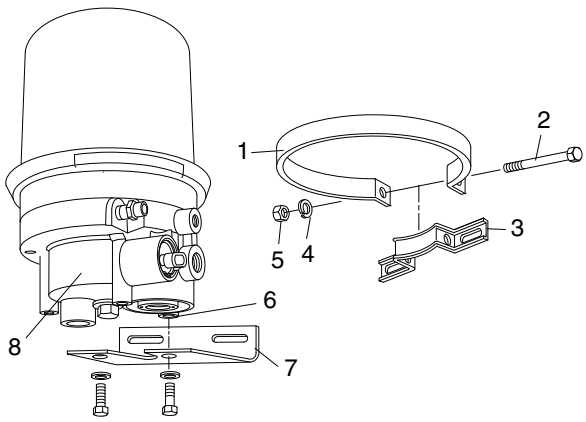
**Fig. 1, Air Dryer Plumbing Diagram**

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# General Information

The function of the AD-IP Integral Purge Air Dryer, shown in **Fig. 1**, is to collect and remove air system contaminants in solid, liquid, and vapor form before they enter the brake system. It provides clean, dry air to the components of the brake system, which increases the life of the system and reduces maintenance costs.




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1. Mounting Strap
2. 5/16-Inch Bolt
3. Saddle Bracket
4. Lockwasher
5. Nut
6. End Cover Mounting Holes
7. Lower Mounting Bracket
8. Air Dryer

**Fig. 1, Bendix AD-IP Air Dryer**

The AD-IP air dryer consists of a desiccant cartridge secured to a die-cast aluminum end cover with a single, central bolt. The end cover contains a check valve assembly, safety valve, heater and thermostat assembly, three pipe thread air connections, and the purge valve assembly. The removable purge valve assembly incorporates the purge valve mechanism and a turbocharger cutoff feature that is designed to prevent loss of engine turbocharger boost pressure during the purge cycle of the AD-IP air dryer. For ease of serviceability, all replaceable assemblies can be replaced without removal of the air dryer from its mounting on the vehicle.

To ease servicing, the desiccant cartridge and discharge check valve assembly are screw-in types.

The purge valve housing assembly, which includes the heater and thermostat assembly, and the discharge check valve assembly, can be serviced **without** removing the air dryer from the vehicle. The screw-in desiccant cartridge requires removal of the air dryer assembly from the vehicle.

The AD-IP has three female pipe thread air connections identified in **Table 1**.

| Air Dryer Port Identification | |
|---|---|
| **Port I.D.** | **Function/Connection** |
| CON 4 | Control Port (purge valve control and turbo cutoff) |
| SUP 11 | Supply Port (air in) |
| DEL 2 | Delivery Port (air out) |

**Table 1, Air Dryer Port Identification**

# Principles of Operation

The AD-IP air dryer alternates between two operational modes or cycles during operation: the charge cycle, shown in **Fig. 2**, and the purge cycle, shown in **Fig. 3**.

## Charge Cycle

When the compressor is loaded (compressing air), compressed air, along with oil, oil vapor, water, and water vapor flows through the compressor discharge line to the supply port of the air dryer body.

As air travels through the end cover assembly, its direction of flow changes several times, reducing the temperature, causing contaminants to condense, and to drop to the bottom or sump of the air dryer end cover.

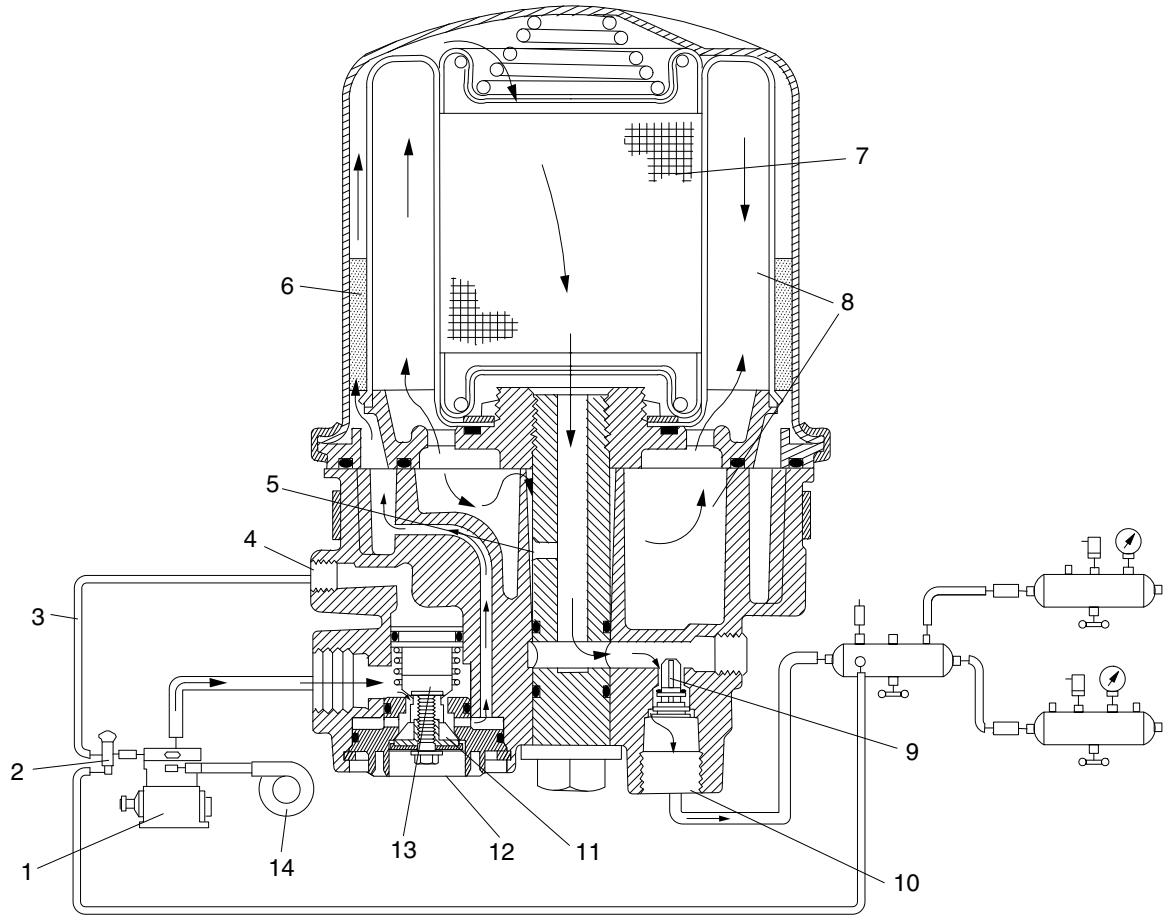
After exiting the end cover, the air flows into the desiccant cartridge. Once in the desiccant cartridge, air first flows through an oil separator located between the outer and inner shells of the cartridge. The separator removes water in liquid form as well as oil and solid contaminants.

Air, along with the remaining water vapor, is further cooled as it exits the oil separator and continues to flow upward between the outer and inner shells. Upon reaching the top of the cartridge the air reverses its direction of flow and enters the desiccant drying bed. Air flowing down through the column of desiccant becomes progressively dryer as water

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## General Information




1. Compressor
2. Governor
3. Purge Control Line
4. Control Port
5. Purge Orifice
6. Oil Separator
7. Desiccant Bed
8. Purge Volume
9. Delivery Check Valve
10. Discharge Port
11. Purge Valve
12. Exhaust
13. Turbo Cutoff Valve
14. Engine Turbocharger

**Fig. 2, AD-IP Charge Cycle**

vapor adheres to the desiccant material in a process known as adsorption. The desiccant cartridge, using the adsorption process, typically removes most of the water vapor from the pressurized air.

Dry air exits the bottom of the desiccant cartridge and flows through the center of the bolt used to secure the cartridge to the end cover. Air flows down the center of the desiccant cartridge bolt, through a cross-drilled passage and exits the air dryer delivery port through the delivery check valve.

Dry air flowing through the center of the desiccant cartridge bolt also flows out the cross-drilled purge orifice and into the purge volume.

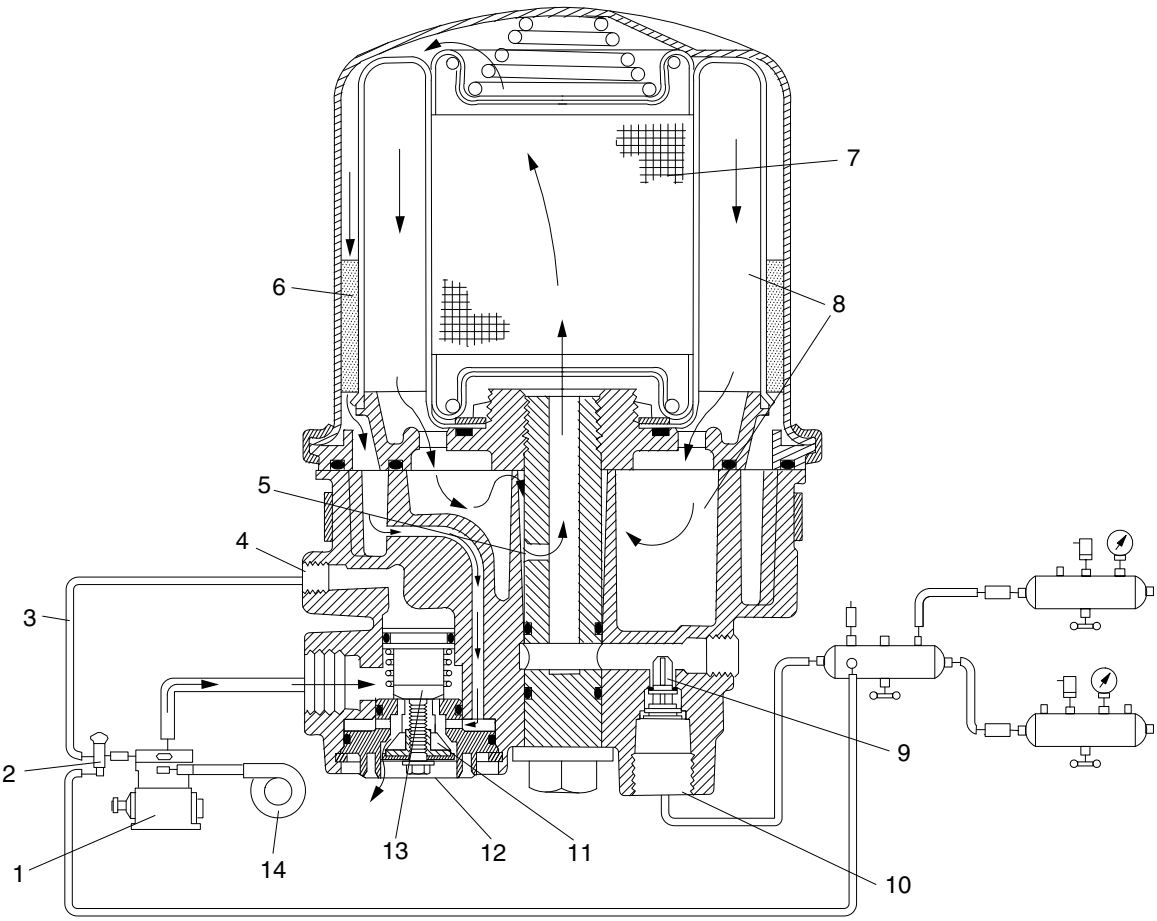
The air dryer will remain in the charge cycle until the air brake system pressure builds to the governor cutout setting.

## Purge Cycle

As air brake system pressure reaches the cutout setting of the governor, the governor unloads the compressor (air compressor stops compressing air) and

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1. Compressor
2. Governor
3. Purge Control Line
4. Control Port
5. Purge Orifice
6. Oil Separator
7. Desiccant Bed
8. Purge Volume
9. Delivery Check Valve
10. Discharge Port
11. Purge Valve
12. Exhaust
13. Turbo Cutoff Valve
14. Engine Turbo

**Fig. 3, AD-IP Purge Cycle**

the purge cycle of the air dryer begins. When the governor unloads the compressor, it pressurizes the compressor unloader mechanism and the line connecting the governor unloader port to the AD-IP end cover control port. The purge piston moves in response to air pressure, causing the purge valve to open to the atmosphere and the turbo cutoff valve to close off the supply of air from the compressor (this will be further discussed under the *Turbocharger Cutoff Feature* heading). Water and contaminants in the end cover sump are expelled immediately when the purge valve opens. Also, air which was flowing through the desiccant cartridge changes direction and begins to flow toward the open purge valve. Oil and solid contaminants collected by the oil separator are removed by air flowing from the purge volume through the desiccant drying bed to the open purge valve.

The initial purge and desiccant cartridge decompression lasts only a few seconds and is evidenced by an audible burst of air at the AD-IP exhaust.

The actual reactivation of the desiccant drying bed begins as dry air flows from the purge volume

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through the purge orifice in the desiccant cartridge bolt, then through the center of the bolt and into the desiccant bed. Pressurized air from the purge volume expands after passing through the purge orifice; its pressure is lowered and its volume increased. The flow of dry air through the drying bed reactivates the desiccant material by removing the water vapor adhering to it. Generally 30 seconds are required for the entire purge volume of a standard AD-IP to flow through the desiccant drying bed.

The delivery check valve assembly prevents air pressure in the brake system from returning to the air dryer during the purge cycle. After the 30-second purge cycle is complete, the desiccant has been reactivated or dried. The air dryer is ready for the next charge cycle to begin. However, the purge valve will remain open and will not close until air brake system pressure is reduced and the governor signals the compressor to charge the system.

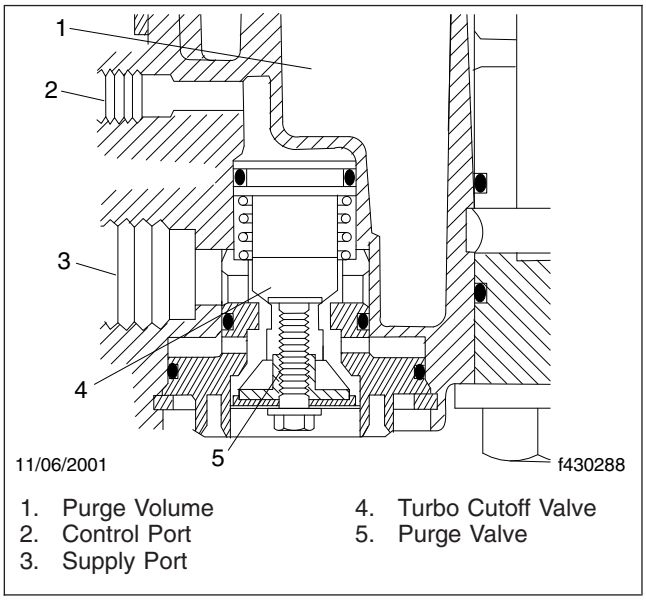
NOTE: The air dryer should be periodically checked for operation and tested for leaks. Refer to **Group 42** of the vehicle maintenance manual for intervals and procedures.

## Turbocharger Cutoff Feature

NOTE: The air compressor is naturally aspirated; the air passes from the vehicle air filter directly to the air compressor intake.

The primary function of the turbo cutoff valve is to prevent loss of engine turbocharger air pressure through the AD-IP in systems where the compressor intake is connected to the engine turbocharger. The turbo cutoff valve also removes the "puffing" of air out of the open purge exhaust, when a naturally aspirated, single-cylinder compressor, equipped with an inlet check valve, is in use. See **Fig. 4**.

At the beginning of the purge cycle, the downward travel of the purge piston is stopped when the turbo cutoff valve (tapered portion of purge piston) contacts its mating metal seat in the purge valve housing. With the turbo cutoff valve seated (closed position), air in the compressor discharge line and AD-IP inlet port cannot enter the air dryer. In this manner, the turbo cutoff effectively maintains turbocharger boost pressure to the engine.




1. Purge Volume
2. Control Port
3. Supply Port
4. Turbo Cutoff Valve
5. Purge Valve

**Fig. 4, AD-IP Turbo Cutoff**

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# Safety Precautions

When working on or around air brake systems and components, observe the following precautions.

- Chock the tires and shut down the engine before working under a vehicle. Depleting air system pressure may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters, which may apply as air pressure drops.
- Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
- Never exceed recommended air pressure, and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
- Do not disassemble a component until you have read and understood the service procedures. Some components contain powerful springs, and injury can result if not properly disassembled. Use the correct tools, and observe all precautions pertaining to use of those tools.
- Replacement hardware, tubing, hose, fittings, etc., should be the equivalent size, type, length, and strength of the original equipment.

  Make sure that when replacing tubing or hose, all of the original supports, clamps, or suspending devices are installed or replaced.
- Replace devices that have stripped threads or damaged parts. Repairs requiring machining should not be attempted.

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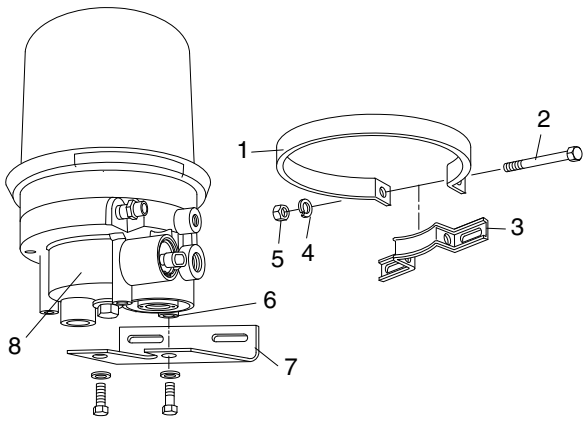


**WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

## Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Completely drain all of the reservoirs.
3. Mark and disconnect the three air lines from the end cover, and note the position of end cover ports relative to the vehicle.
4. Unplug the vehicle wiring harness from the heater and thermostat assembly connector on the purge valve assembly.
5. Remove the four bolts that secure both the upper and lower mounting brackets to the vehicle, and remove the air dryer from the vehicle. See Fig. 1.




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1. Mounting Strap
2. 5/16-Inch Bolt
3. Saddle Bracket
4. Lockwasher
5. Nut
6. End Cover Mounting Holes
7. Lower Mounting Bracket
8. Air Dryer

**Fig. 1, Bendix AD-IP Air Dryer**

6. Mark the relationship of the saddle bracket to the end cover assembly. Remove the 5/16-inch bolt, washer, and nut that secures the upper mounting strap to the saddle bracket. Remove the upper mounting strap from the end cover assembly.
7. Mark the relationship of the lower bracket to the end cover assembly. Remove the two 3/8-inch end cover capscrews and two washers that retain the lower mounting bracket to the end cover.
8. Remove the air dryer from its mounting brackets.

## Installation

1. Install the lower mounting bracket on the end cover and secure it using the two 3/8-inch capscrews and washers. Tighten the capscrews 25 to 30 lbf·ft (34 to 41 N·m). See Fig. 1.
2. Install the saddle bracket and mounting strap on the end cover, and using the 5/16-inch bolt, washer, and nut secure the strap to the saddle bracket. Tighten the 5/16-inch nut on the upper mounting bracket 60 to 100 lbf·in (678 to 1130 N·cm).
3. Install the AD-IP on the vehicle using the four bolts that secure both the upper and lower mounting brackets.
4. As marked earlier in "Removal," connect the three air lines to the ports on the end cover.
5. Connect the vehicle wiring harness to the air dryer heater and thermostat assembly connector by plugging it into the air dryer connector until its lock tab snaps in place.
6. Test the air dryer, following instructions in **Group 42** of the vehicle maintenance manual.

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# Air Dryer Disassembly, Cleaning and Inspection, and Assembly

**⚠ WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

NOTE: As a convenience when rebuilding the air dryer, several replacement parts and maintenance kits are available that do not require full disassembly. Use the instructions provided with these parts or kits.

## Disassembly

NOTE: Refer to **Fig. 1** during disassembly.

**NOTICE**

**While servicing the air dryer, do not use a clamping device (vise, C-clamp, etc.) to hold any die cast aluminum part, as damage may result. To hold the end cover, install a pipe nipple in the supply port, and clamp the nipple in a vise.**

1. Remove the air dryer from the vehicle. See **Subject 110**.
2. Loosen the desiccant cartridge bolt, then separate the desiccant cartridge from the end cover. Pull the desiccant cartridge bolt out of the end cover. See **Fig. 1**.

**⚠ CAUTION**

**Disassembly of the desiccant cartridge assembly should not be attempted! Detail parts for the cartridge are not available and the cartridge contains a 150 lb spring which can not be mechanically caged. Releasing the spring could cause serious personal injury.**

3. Remove both O-rings from the desiccant cartridge bolt.
4. Remove the retaining ring that secures the purge valve assembly in the end cover.
5. Remove the 1/4-inch shoulder bolt from the bottom of the purge valve housing assembly, using a 3/8-inch socket wrench and a large blade screwdriver, inserted in the slot on top of the purge piston. Remove the exhaust diaphragm, and the purge valve from the purge valve housing.
6. Remove the O-rings from the purge valve housing.
7. Remove the purge piston and the return spring. Remove the O-ring from the purge piston.
8. Remove the retaining ring that secures the delivery check valve assembly in the end cover. Remove and separate the perforated plate, spring, check valve body, and O-ring.
9. Remove the retaining ring that secures the heater and thermostat assembly in the end cover. Gently pull the heater and thermostat out of the end cover and remove the O-ring.
10. Using a 9/16-inch wrench, remove the safety valve assembly from the end cover.

## Cleaning and Inspection

1. Wash all metal parts thoroughly, using a quality commercial solvent, such as mineral spirits.

NOTE: Do not clean the desiccant cartridge.

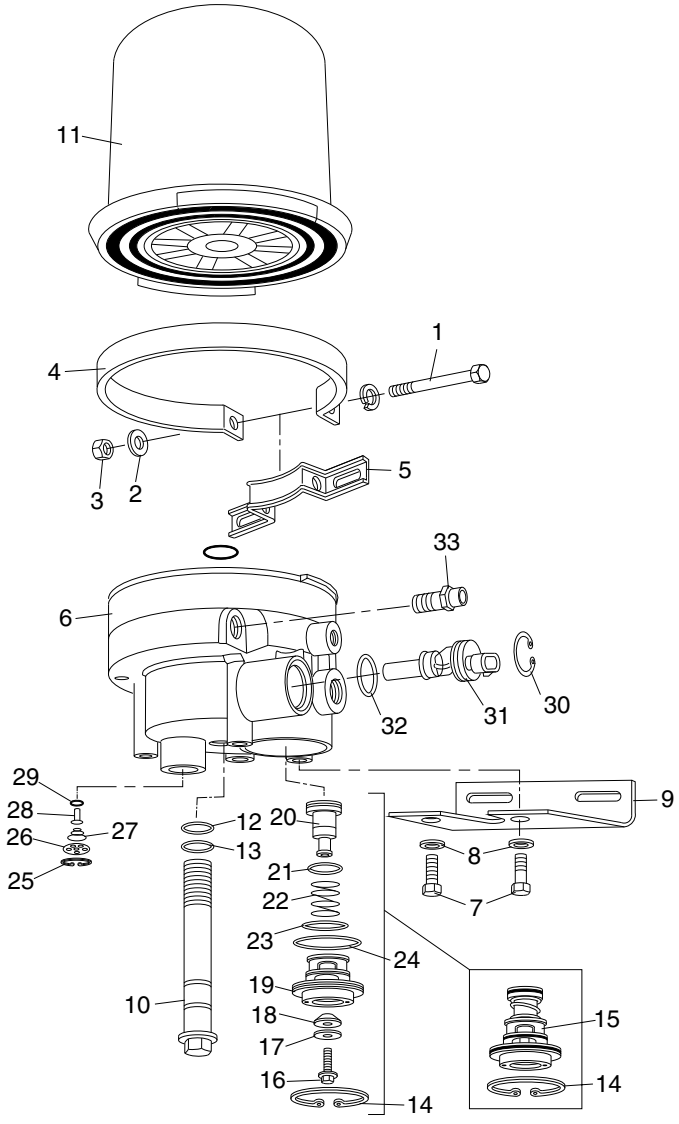
2. Check for severe corrosion, pitting, and cracks on the inside and outside of all metal parts that will be reused. Superficial corrosion and pitting on the outside of the upper and lower body halves is acceptable.
3. Inspect the bores of both the end cover and the purge-valve housing for deep scuffing or gouges.
4. Make sure that all purge-valve housing and end cover passages are open and free of blockages.
5. Inspect the pipe threads in the end cover. Make sure they are clean and free of thread sealant.
6. Inspect the purge-valve housing bore and seats for excessive wear and scuffing.
7. Inspect the purge valve piston seat for excessive wear.
8. Make certain that the purge orifice in the cartridge bolt is open and free of obstructions.
9. Inspect all air line fittings for corrosion. Clean all old thread sealant from the pipe threads.
10. Replace all removed O-rings with new ones that are provided in the kits.

    Replace parts that show any of the conditions described in the previous steps.

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## Air Dryer Disassembly, Cleaning and Inspection, and Assembly




1. 5/16-Inch Bolt
2. 5/16-Inch Lockwasher
3. 5/16-Inch Locknut
4. Upper Bracket Strap
5. Saddle Bracket
6. End Cover
7. 3/8-Inch Capscrew
8. 3/8-Inch Lockwasher
9. Lower Mounting Bracket
10. Cartridge Bolt
11. Desiccant Cartridge
12. O-Ring
13. O-Ring
14. Retaining Ring
15. Purge Valve Cartridge Assembly
16. Shoulder Bolt
17. Exhaust Diaphragm
18. Purge Valve
19. Purge Valve Housing
20 Purge Valve Piston
21 O-Ring
22. Piston Return Spring
23. O-Ring
24. O-Ring
25. Retaining Ring
26. Perforated Plate
27. Check Ring Spring
28. Check Valve
29. O-Ring
30. Retaining Ring
31. Heater/Thermostat Assembly
32. O-Ring
33. Safety Valve Assembly

**Fig. 1, AD-IP (exploded view)**

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## Assembly

1. Before assembly, coat all O-rings, O-ring grooves, and bores with a generous amount of barium-base lubricant. See **Fig. 1** during assembly unless otherwise advised.
2. Install and center the exhaust diaphragm over the shoulder bolt, making certain that the diaphragm ID is over the bolt shoulder. Then install the purge valve on the shoulder bolt, making certain its metal support side is against the diaphragm.
3. Push the purge piston into the housing until it bottoms, and insert a large blade screwdriver in the piston's slotted head. While depressing the purge piston with the screwdriver, install the shoulder bolt with exhaust diaphragm and purge valve in the piston. Tighten the shoulder bolt 60 to 80 lbf·in (678 to 904 N·cm).
4. Install the two O-rings on the purge valve housing, placing each in its appropriate location. Install the assembled purge valve housing in the end cover while making certain the purge valve housing is fully seated against the end cover. Secure the purge valve housing in the end cover, using the retaining ring. Make certain the retaining ring is fully seated in its groove in the end cover.
5. Using a 9/16-inch wrench, install the safety valve assembly into the end cover.
6. Install the O-ring on the check valve body, and push the O-ring down, over the three guide lands until it is in the O-ring groove of the check valve body. Install the check valve spring on the check valve body so that the small coils of the spring slip over the check valve body. Install the assembled check valve body, O-ring, and spring in the end cover so that the O-ring rests on its seat in the end cover, and the spring is visible.
7. Install the O-ring on the heater and thermostat assembly. After making certain the sponge-rubber cushion is positioned between the connector body and thermostat, gently push the heater and thermostat assembly into the end cover, making certain the heating element enters the small diameter bore in the larger heater and thermostat bore in the end cover. Secure the heater and thermostat assembly in the body, using the retaining ring. Make certain the retaining ring is fully seated in its groove in the end cover.
8. Install both O-rings on the desiccant cartridge bolt, and using a twisting motion, insert the assembled desiccant cartridge bolt in the end cover.
9. Install the desiccant cartridge on the end cover, making certain the cartridge is properly seated and flush on the end cover.

NOTE: It may be necessary to rotate the cartridge slightly until the anti-rotation lugs are properly aligned and they allow the cartridge to rest flush against the end cover.

10. Tighten the desiccant cartridge bolt 50 lbf·ft (68 N·m), to secure the desiccant cartridge to the end cover.
11. Install the air dryer. For instructions, see **Subject 110**.

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## Testing

During cold-weather operation, check the operation of the end cover heater and thermostat assembly.

1. With the ignition on, check for voltage to the heater and thermostat assembly. Unplug the electrical connector at the air dryer, and place the test leads on each of the pins of the male connector. If there is no voltage, look for a blown fuse, broken wires, or corrosion in the vehicle wiring harness. Check that a good ground path exists.
2. Check the thermostat and heater operation. Turn off the ignition switch and cool the end cover assembly to below 40°F (4°C). Using an ohmmeter, check the resistance between the electrical pins in the female connector. The resistance should be 1.5 to 3.0 ohms for the 12-volt heater assembly, and 6.8 to 9.0 ohms for the 24-volt heater assembly.
3. Warm the end cover assembly to over 90°F (32°C) and again check the resistance. It should exceed 1000 ohms. If it does, the thermostat and heater assembly is operating properly. If it doesn't, replace the purge-valve housing assembly, which includes the heater and thermostat assembly.

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**Problem—Air Dryer Is Constantly Cycling or Purging**

| Problem—Air Dryer Is Constantly Cycling or Purging | |
|---|---|
| **Possible Cause** | **Remedy** |
| Excessive system leakage. | Test for excessive leakage. Eliminate leaks, as needed. Allowable leakage is 1 psi/min (7 kPa/min) per service reservoir |
| There is excessive leakage in the fittings, hoses, and tubing connected to the compressor, air dryer, and wet tank. | Using a soap solution, test for leakage at the fittings, drain valve, and safety valve in the wet tank. Repair or replace as needed. |
| Check valve assembly in the air dryer end cover is not working. | Remove the check valve assembly from the end cover. Apply compressed air to the delivery side of the valve. Apply a soap solution at opposite end, and check for leakage. Permissible leakage is a 1-inch (2.5-cm) bubble in 5 seconds. If there is excessive leakage, replace the check valve assembly. |
| Governor is inoperative. | Test the governor for proper cut-in or cut-out pressures and excessive leakage in both positions. |
| Leaking purge-valve housing assembly or O-rings in the air dryer end cover. | With the supply port open to atmosphere, apply 120 psi (830 kPa) at the control port. Apply a soap solution to the supply port and exhaust port (purge valve seat area). Permissible leakage is a 1-inch (2.5-cm) bubble in 5 seconds. Repair or replace as needed. |
| Compressor unloader mechanism is leaking excessively. | Remove the air strainer or fitting from the compressor inlet cavity. With the compressor unloaded, check for unloader piston leakage. Slight leakage is allowed. |
| Lack of air at the governor RES port (rapid cycling of the governor). | Test the governor for proper pressure at the RES port. Pressure should not drop below cut-in pressure when the compressor begins the unloaded cycle. If the pressure does drop, check for kinks or restrictions in the line connected to the RES port. The line connected to the RES port on the governor must be the same diameter, or larger than the lines connected to the UNL ports on the governor. |

**Problem—Water in the Vehicle Reservoirs**

| Problem—Water in the Vehicle Reservoirs | |
|---|---|
| **Possible Cause** | **Remedy** |
| Desiccant cartridge assembly contains excessive contaminants. | Replace the desiccant cartridge. |
| Discharge line is of improper length or material. | Discharge line must consist of at least 6 ft. (1.8 m) of wire braid Teflon hose, copper tubing, or a combination of both between the discharge port of the compressor and the air dryer supply port. Discharge line lengths and inside diameter requirements are dependent on the vehicle application. Contact your local Bendix representative for further information. |
| Air system was charged from an outside air source that did not pass through an air dryer. | If the system must have an outside air fill provision, the outside air should pass through an air dryer. This practice should be minimized. |
| Air dryer is not purging. | Refer to "Problem—Air Dryer Does Not Purge or Exhaust Air." |
| Purge (air exhaust) is insufficient due to excessive system leakage. | Refer to "Problem—Air Dryer Is Constantly Cycling or Purging." |
| Air bypasses the desiccant cartridge assembly. | Replace the desiccant cartridge/end cover O-ring. Make sure the desiccant cartridge assembly is properly installed. |

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## Troubleshooting

| Problem—Water in the Vehicle Reservoirs | |
|---|---|
| **Possible Cause** | **Remedy** |
| Purge (air exhaust) time is significantly less than the minimum allowable. | Replace the desiccant cartridge/end cover O-ring. Make sure the desiccant cartridge assembly is properly installed. Replace the desiccant cartridge assembly. |
| Excessive air usage—air dryer not compatible with vehicle air system. | Install an accessory bypass system. Consult your Bendix representative for additional information. |

**Problem—Safety Valve on Air Dryer Is Popping Off or Exhausting Air**

| Problem—Safety Valve on Air Dryer Is Popping Off or Exhausting Air | |
|---|---|
| **Possible Cause** | **Remedy** |
| Desiccant cartridge is plugged or saturated. | Check the compressor for excessive oil passing, or incorrect installation. Repair or replace as needed. |
| The check valve in the air dryer end cover is inoperative. | Test to determine if air is passing through the check valve. Repair or replace as needed. |
| There is a problem in the fittings, hose, or tubing between the air dryer and the wet tank. | See if air is reaching the first reservoir. Inspect for kinked tubing or hose. Check for undrilled or restricted hose or tubing fittings. |
| Safety valve setting is lower than the maximum system pressure. | Reduce the system pressure, or install a safety valve with a higher pressure setting. |

**Problem—Constant Exhaust of Air at the Air Dryer Purge Valve Exhaust; Unable to Build System Pressure**

| Problem—Constant Exhaust of Air at the Air Dryer Purge Valve Exhaust; Unable to Build System Pressure | |
|---|---|
| **Possible Cause** | **Remedy** |
| Air dryer purge valve is leaking excessively. | With the compressor loaded, apply a soap solution on the purge valve exhaust to test for excessive leakage. Repair the purge valve as needed. |
| The governor is inoperative. | Check the governor for proper cut-in and cut-out pressures, and excessive leakage in both positions. Repair or replace as needed. |
| Purge control line is connected to the reservoir or exhaust port of the governor. | Connect the purge control line to the unloader port of the governor. |
| Purge valve is frozen open due to an inoperative heater or thermostat, bad wiring, or a blown fuse. | Test the heater and thermostat, following instructions in this manual. |
| Inlet and outlet air connections are reversed—unable to build system pressure. | Reconnect the lines properly. |
| Discharge line is kinked or blocked. | See if air passes through the discharge line. Check for kinks, bends, or excessive carbon deposits. |
| There are excessive bends in the discharge line. Water is collecting and freezing. | Discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible. |
| System is leaking excessively. | Test for excessive leakage. Eliminate leaks, as needed. Allowable leakage is 1 psi/min (7 kPa/min) per service reservoir. |
| Purge valve stays open; supply air leaks to control side. | Replace the purge valve assembly O-rings. |

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**Problem—Air Dryer Does Not Purge or Exhaust Air**

| Problem—Air Dryer Does Not Purge or Exhaust Air | |
|---|---|
| **Possible Cause** | **Remedy** |
| Purge control line is broken, kinked, frozen, plugged, or disconnected. | See if air flows through the purge control line when the compressor is unloaded. The purge control line must be connected to the unloader port of the governor. |
| Air dryer purge valve isn't working. | See if air reaches the purge valve. If it does, repair the purge valve. |
| The governor is inoperative. | Check the governor for proper cut-in and cut-out pressures, and excessive leakage in both positions. Repair or replace as needed. |
| Inlet and outlet air connections are reversed—unable to build system pressure. | Reconnect the lines properly. |
| Discharge line is kinked or blocked. | See if air passes through the discharge line. Check for kinks, bends, or excessive carbon deposits. |
| There are excessive bends in the discharge line. Water is collecting and freezing. | Discharge line should be constantly sloping from the compressor to the air dryer with as few bends as possible. |

**Problem—Desiccant Is Being Expelled from the Air Dryer Purge Valve Exhaust (May Look Like Whitish Liquid, Paste, or Small Beads); or, Unsatisfactory Desiccant Life**

| Problem—Desiccant Is Being Expelled from the Air Dryer Purge Valve Exhaust (may look like whitish liquid, paste, or small beads) or Unsatisfactory Desiccant Life | |
|---|---|
| **Possible Cause** | **Remedy** |
| This problem usually occurs with one or more of the previous problems. | Refer to the appropriate corrections listed previously. |
| Air dryer is not securely mounted; there is excessive vibration. | Vibration should be held to a minimum. Tighten the mounting fasteners. |
| Cloth-covered perforated plate in the air dryer desiccant cartridge is damaged, or the cartridge was rebuilt incorrectly. | Replace the plate or cartridge as needed. High operating temperatures may cause deterioration of filter cloth. Check the installation. |
| Compressor is passing excessive oil. | Check for proper compressor installation; if symptoms persist, replace the compressor. |
| Heater and thermostat, wiring, or a fuse is at fault, and isn't allowing the air dryer to purge during cold weather. | Test the heater and thermostat. See **Group 83** in this manual. |
| Desiccant cartridge not attached properly to the end cover. | Check the torque and tighten if necessary. Refer to **Subject 120** for instructions. |

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## Troubleshooting

**Problem—Pinging Noise Is Excessive During Compressor Loaded Cycle**

| Problem—Pinging Noise Is Excessive During Compressor Loaded Cycle | |
|---|---|
| **Possible Cause** | **Remedy** |
| Pinging noise is due to a single cylinder compressor with high pulse cycles. | A slight pinging sound may be heard during system build-up when a single cylinder compressor is used. If this sound is deemed objectionable, it can be reduced substantially by increasing the discharge line volume. This is done by adding a 90 $in^3$ (1475 $cm^3$) reservoir between the compressor and the air dryer. |

**Problem—Constant Air Seepage at the Purge Valve (Non-Charging Mode)**

| Problem—Constant Air Seepage at the Purge Valve (Non-Charging Mode) | |
|---|---|
| **Possible Cause** | **Remedy** |
| Air compressor inlet is pressurized by the engine turbocharger. | Some pressure leakage past the metal seat of the turbocharger cutoff feature of the AD-9 air dryer is normal, and may be heard. This slight loss of air will not affect the engine or turbocharger performance. |
| Check valve assembly in the air dryer end cover is not working. | Remove the check valve assembly from the end cover. Apply compressed air to the delivery side of the valve. Apply a soap solution at opposite end, and check for leakage. Permissible leakage is a 1-inch (2.5-cm) bubble in 5 seconds. If there is excessive leakage, replace the check valve assembly. |

**Problem—Air Dryer Purge Piston Cycles Rapidly in the Unloaded Mode**

| Problem—Air Dryer Purge Piston Cycles Rapidly in the Unloaded Mode | |
|---|---|
| **Possible Cause** | **Remedy** |
| Compressor does not "unload." | Check the governor installation: there is no air line from the governor to the compressor, or the line is restricted. Repair or replace as needed. |

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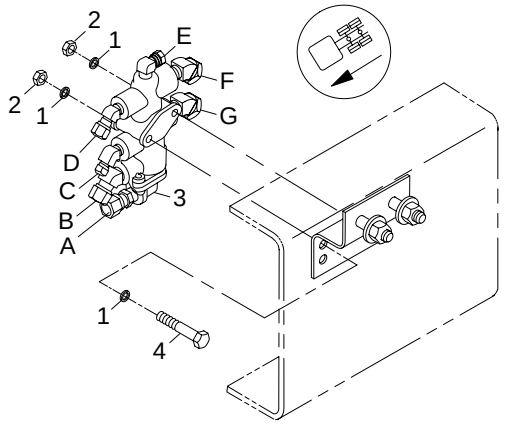


## General Description

The Bendix TP–3DC is a tractor protection valve that includes an integral double check valve. The TP–3DC serves two purposes. First, as required by Federal law, the valve protects the tractor brakes in the event of trailer breakaway or a severe air system leak. Second, when used with a dash-mounted trailer supply control valve, the TP–3DC valve can be used to shut off the trailer control line before the trailer is disconnected.

The TP–3DC also includes an integral single check valve that prevents air from getting trapped in the trailer control line. Trapped air in this line could cause service/spring brake compounding and, if the trailer is parked with air applied, a trailer roll-away situation.

There are several different mounting locations for the TP–3DC tractor protection valve. A common mounting location is in the frame rail channel. See **Fig. 1**.



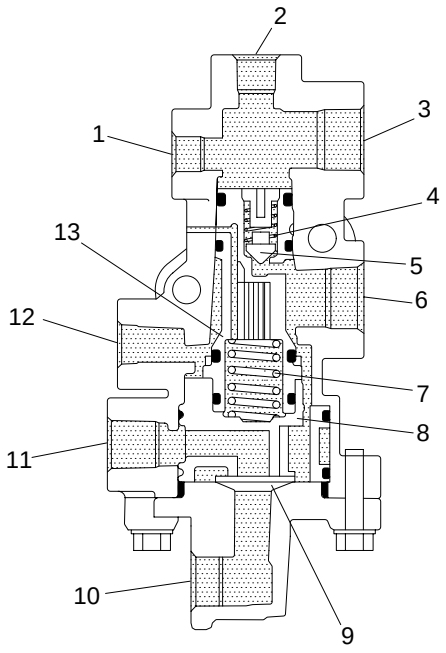

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A. From service brake foot valve, primary circuit.
B. From service brake foot valve, secondary circuit.
C. To air manifold (stop lamp switch).
D. From trailer supply valve.
E. To proportioning relay (if installed).
F. To trailer emergency port.
G. To trailer service port.

1. 1/4" Flatwasher
2. 1/4–20 Locknut
3. TP–3DC Tractor Protection Valve
4. 1/4–20 Capscrew

**Fig. 1, TP-3DC Mounting Location and Connections**

TP–3DC valve port designations and internal components are shown in **Fig. 2**.




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1. Tractor Supply Port
2. Auxiliary Supply Port
3. Trailer Supply Port
4. Check Valve Spring
5. Check Valve
6. Trailer Control Port
7. Valve Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control Port (Primary)
11. Tractor Control Port (Secondary)
12. Stop Lamp Switch Port
13. Plunger

**Fig. 2, TP-3DC, Sectional View**

## Principles of Operation

### Initial Charge

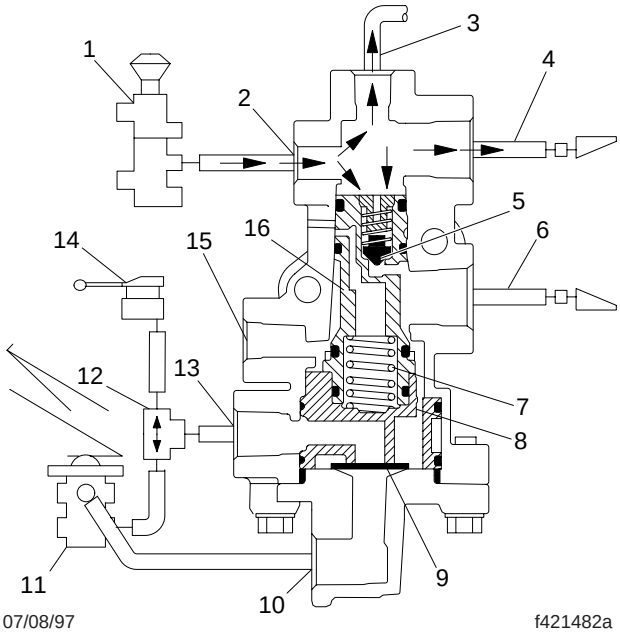
Pushing in the red trailer air supply knob on the instrument panel causes air to flow into the TP–3DC valve at the tractor supply port. See **Fig. 3**. Air flows through the valve housing, exiting via the auxiliary supply port (if used) and the trailer supply port, to pressurize the trailer brake system and release the trailer parking brakes.

As air pressure builds in the trailer supply circuit, the single check valve seats, and the valve plunger be-

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## General Information




1. Trailer Air Supply Valve
2. Tractor Supply Port
3. Auxiliary Supply Port
4. Trailer Supply Port
5. Single Check Valve
6. Trailer Control Port
7. Spring
8. Guide
9. Diaphragm (Double Check Valve)
10. Tractor Control Port (Primary)
11. Foot Valve
12. Double Check Valve
13. Tractor Control Port (Secondary)
14. Hand Valve
15. Stop Lamp Switch Port
16. Plunger

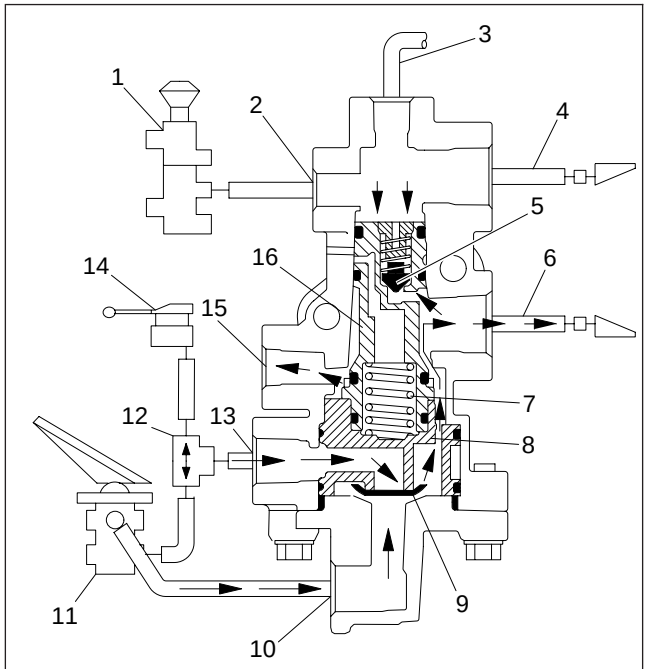
**Fig. 3, Initial Charge**

gins to move (against spring pressure) toward the guide. When pressure reaches about 45 psi (310 kPa), the inlet valve opens.

The TP–3DC valve is in the "run" mode, and ready to receive and deliver a service brake application from either the foot valve or the hand valve.

## Service Brake Application

When the foot pedal is pressed, air flows to the TP–3DC valve tractor control primary and secondary ports. See **Fig. 4**. If the trailer control valve is also used, the external double check delivers the higher pressure (trailer control or foot valve secondary) to the TP–3DC Tractor Control secondary port.




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10. Tractor Control Port (Primary)
11. Foot Valve
12. Double Check Valve
13. Tractor Control Port (Secondary)
14. Hand Valve
15. Stop Lamp Switch Port
16. Plunger

**Fig. 4, Service Brake Application**

Inside the TP–3DC valve, the higher pressure (primary or secondary) moves the diaphragm to seal off the port at the lower pressure.

With the plunger bottomed against the guide and the inlet valve open (as described earlier), the higher pressure air flows through the valve to the trailer control port and the stop lamp switch, applying the brakes and activating the stop lamps.

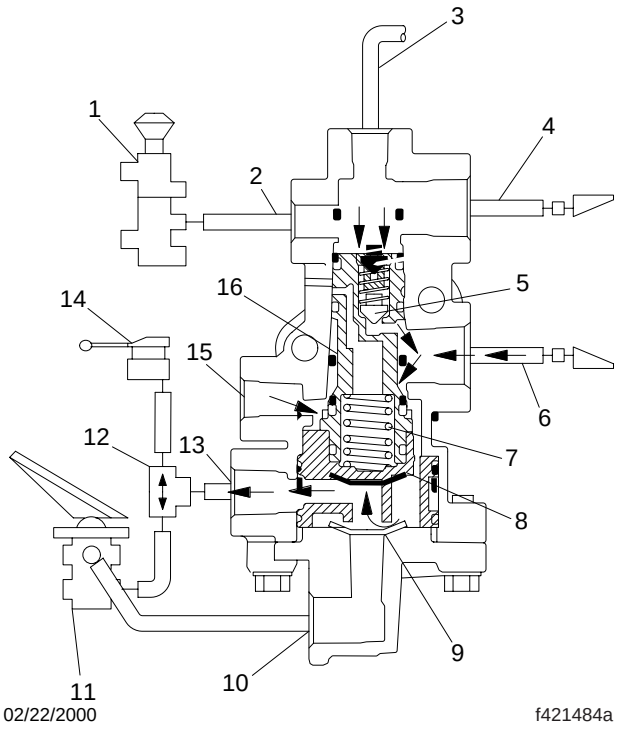
NOTE: While air pressure also reaches the TP–3DC single check valve, the valve stays closed because supply pressure is acting on the other side.

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## Service Brake Release

When the foot pedal is released, air stops flowing into the TP–3DC valve at the tractor control primary or secondary port. See **Fig. 5**. At the same time, air in the trailer control line returns to the valve, flowing back through the open inlet valve.




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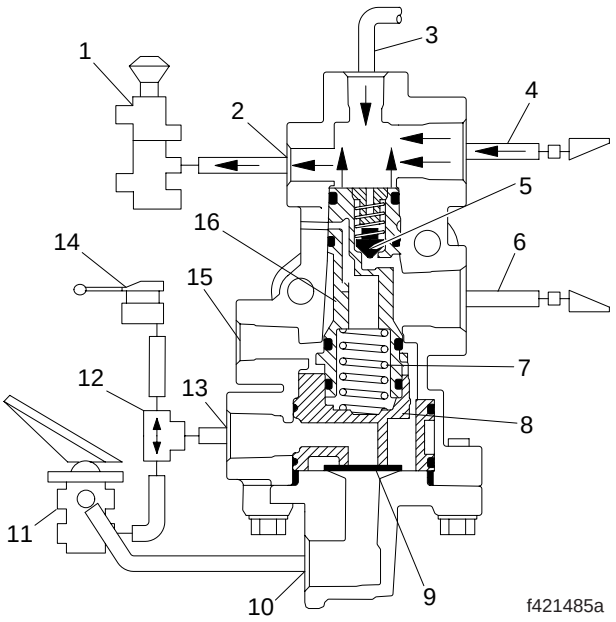
**Fig. 5, Service Brake Release**

Once the exhausting air has reached a sufficient flow level, a quick release valve located in-line between the trailer control line and the TP3-DC service brake port allows rapid exhausting.

The air forces the diaphragm to seat, sealing off the tractor control primary port. The air then exits the valve at the tractor control (secondary) port and flows to the foot valve or hand valve where it is exhausted.

## Tractor Protection

If the red trailer air supply knob on the instrument panel is pulled out (or if a large leak develops in the trailer supply circuit), pressure in the trailer supply circuit (and the auxiliary supply circuit, if used) is vented. See **Fig. 6**. When pressure drops to about 20 to 30 psi (138 to 207 kPa), the pressure can no longer overcome the spring force inside the TP–3DC valve and the inlet valve closes.




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15. Stop Lamp Switch Port
16. Plunger

**Fig. 6, Tractor Protection**

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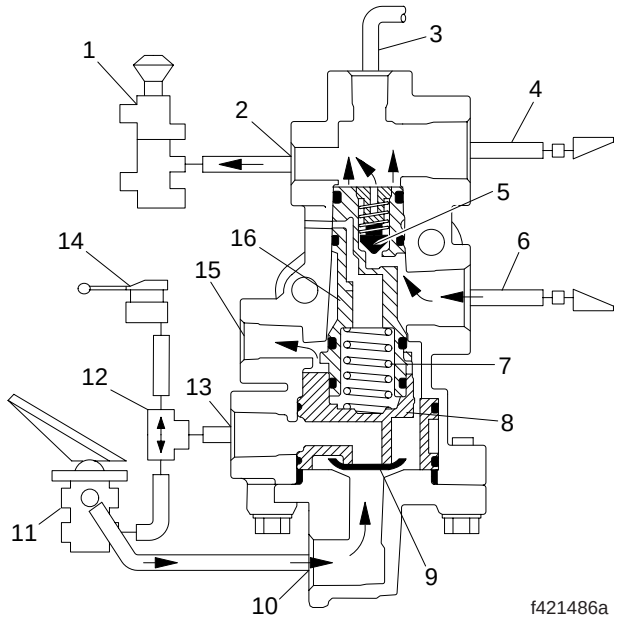


## General Information

With the inlet valve closed, air pressure from the brake foot or hand control valves will not reach the trailer control circuit when the brakes are applied.

## Anti-Compounding

If the red trailer air supply knob on the instrument panel is pulled out while the service brakes are applied, the single check valve in the TP–3DC prevents simultaneous spring and service brake application. See **Fig. 7**. As pressure in the trailer supply circuit drops, the spring in the TP–3DC valve forces the inlet valve closed (as described above in "Tractor Protection".) Any pressure in the trailer control circuit is relieved by passing first through the single check valve and then exhausting at the trailer supply valve.




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15. Stop Lamp Switch Port
16. Plunger

**Fig. 7, Anti-Compounding**

If the service brakes (hand or foot) are released and applied again, the closed inlet valve prevents air pressure from reaching the trailer control circuit.

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## Safety Precautions

When working on or around air brake systems and components, observe the following precautions.

- Chock the tires and shut down the engine before working under the vehicle. Releasing air from the system may cause the vehicle to roll. Keep hands away from brake chamber pushrods and slack adjusters; they will apply as air pressure drops.
- Never connect or disconnect a hose or line containing compressed air. It may whip as air escapes. Never remove a component or pipe plug unless you are certain all system pressure has been released.
- Never exceed recommended air pressure, and always wear safety glasses when working with compressed air. Never look into air jets or direct them at anyone.
- Never attempt to disassemble a component until you have read and understood recommended procedures. Some components contain powerful springs, and injury can result if not correctly disassembled. Use only correct tools and observe all precautions regarding use of those tools.

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## Removal

**WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

1. Chock the tires.
2. Open the air reservoir drain cocks to bleed the air from the system.
3. Remove the trailer hose assemblies from the TP–3DC valve. Disconnect the tractor service and supply lines. Mark the lines for later assembly reference. Cap the air lines tightly to keep out contaminants.
4. Remove the fasteners that attach the TP–3DC valve to the vehicle, and remove the valve.

## Installation

1. Place the TP–3DC valve on the vehicle, and attach it with bolts, washers, and nuts. Tighten the nuts 11 to 15 lbf·ft (15 to 20 N·m).

NOTE: The delivery line from the trailer air supply valve is connected to the tractor emergency port of the TP–3DC valve. See **Fig. 1**. The delivery line from the brake valve (double check valve) is connected to the tractor service port of the TP–3DC valve. Trailer hose assemblies are installed in the trailer emergency and trailer service ports of the TP–3DC valve.

2. Remove the caps from the air lines, and, depending on the type of air hose, use the following instructions to connect the air hoses to the TP–3DC valve:

   If equipped with nylon tube air hoses, connect the hose fittings to the valve ports, and tighten the nuts finger-tight. Then, using a wrench, tighten the nuts at least two turns, or until no threads show on the fitting.

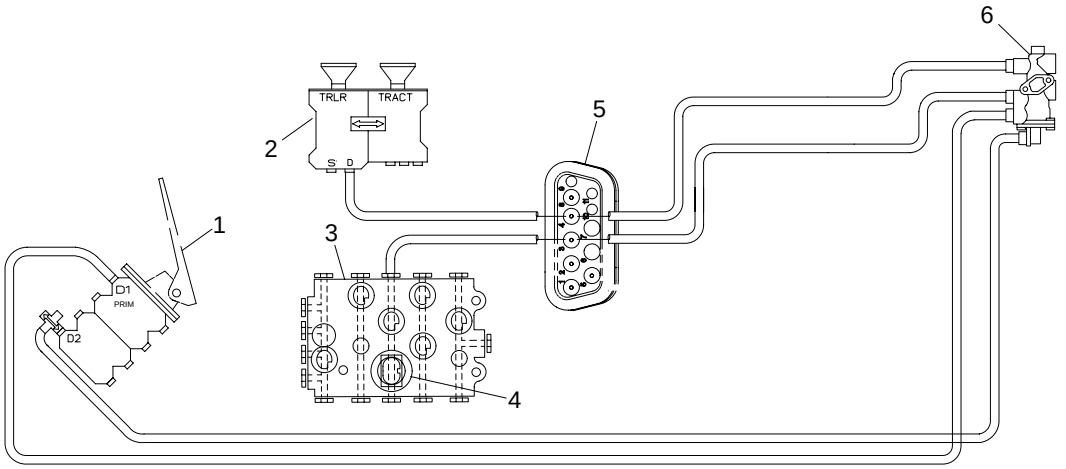
   If equipped with wire braid hoses, connect the hose fittings to the valve ports, and hand-tighten the nuts. Using a wrench, tighten the nuts until there is resistance. Tighten one-sixth turn more. Do not overtighten.

3. Close the drain cocks to the air reservoirs. Start the vehicle engine to pressurize the air system.
4. Leak test the TP–3DC valve following the instructions in **Subject 130**.

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## Valve Removal and Installation




1. Foot Valve
2. Dash Valves
3. Air Manifold and Pressure Switch
4. Stop Lamp Switch
5. Pass-Thru Grommet
6. TP–3DC Valve

**Fig. 1, TP-3DC Plumbing Diagram**

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# Valve Disassembly, Cleaning and Inspection, and Assembly

**WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

## Disassembly

See **Fig. 1** for an exploded view of the TP-3DC valve.

1. Remove the valve from the vehicle, retaining the mounting hardware. For instructions, see **Subject 110**.
2. Scribe a line across the valve cover and valve body to ensure proper alignment during assembly.
3. Remove the two 1/4-inch screws that secure the valve cover to the valve body, and allow the valve spring to expand until the valve cover can be removed.
4. Remove the cover O-ring and discard it.
5. Remove the diaphragm, from the valve body, and discard it.
6. Remove the guide from the valve body.
7. Remove the O-rings from the guide and discard them.
8. Remove the valve spring from the plunger, then the plunger from the valve body.
9. Remove the O-rings from the plunger and discard them.
10. Remove the collar and the O-ring from the plunger. Discard the O-ring, but keep the collar.

## Cleaning and Inspection

**WARNING**

**Wear goggles when using compressed air to clean or dry parts, as permanent harm to eyes could result from flying debris.**

1. Wash all metal parts of the TP–3DC valve in cleaning solvent, then dry them using compressed air.
2. Examine the cover, body, guide, and plunger for corrosion, excessive wear, cracks, or other damage. If any of these conditions are found on a part, replace the part with a new one.
3. Check the spring for distortion and corrosion. If the spring is distorted or corroded, replace it.
4. Check the valve body bores for deep scratches or gouging.

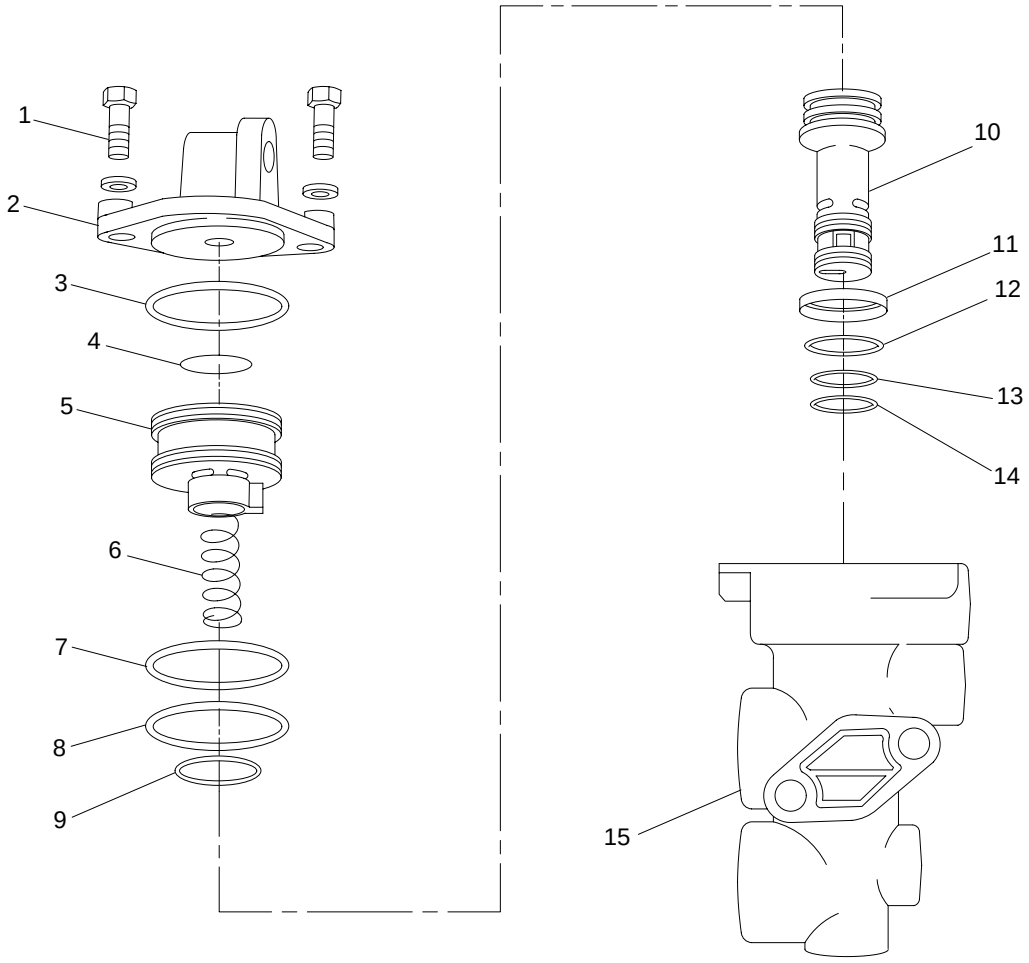
## Assembly

1. Lubricate the O-rings, O-ring grooves, body bores, and all sliding parts with the lubricant provided in the overhaul kit (Bendix silicone lubricant #291126 or equivalent).
2. Install the O-rings on the plunger.
3. Install the O-ring on the plunger and then the collar over the O-ring. Make sure that the collar is fully seated and firmly in place over the O-ring.
4. Install the plunger into the valve body and the spring into the plunger.
5. Install the O-rings in their grooves on the guide.
6. Align the indexing tab on the guide with the notch in the valve body and install the guide in the valve body.
7. Place the diaphragm in its recess on the guide.
8. Place the O-ring on the cover.
9. Place the cover on the guide and press them down, against spring pressure, until the cover is seated against the valve body.
10. Install the two 1/4-inch screws and tighten them 30 to 60 lbf·in (338 to 678 N·cm).
11. Install the TP–3DC valve on the vehicle following the instructions in **Subject 110**.

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## Valve Disassembly, Cleaning and Inspection, and Assembly




06/10/96 f421479

1. 1/4" Hex/Torx Screw
2. Valve Cover
3. O-Ring
4. Diaphragm
5. Guide
6. Valve Spring
7. O-Ring
8. O-Ring
9. O-Ring
10. Plunger
11. Collar
12. O-Ring
13. O-Ring
14. O-Ring
15. Valve Body

**Fig. 1, Exploded View of TP-3DC Valve**

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**⚠ WARNING**

**Before working on or around air brake systems and components, see Safety Precautions 100. Failure to do so may result in personal injury.**

## Operation and Leakage Test

1. Chock the tires.
2. Start the engine, and run it until the air system is fully charged.
3. Shut down the engine and place the trailer air supply valve in the emergency position (red knob pulled out).
4. Disconnect the trailer control line hose coupling. Then make a service application with either the foot valve or trailer control valve and check for leakage at the hose coupling with a soap-and-water solution. Leakage should not exceed a 1-inch (2.5-cm) bubble in 5 seconds.
5. Release the service brake application and place the trailer supply valve in the "run" position (red knob pushed in). Connect the trailer control valve to a test gauge.
6. Make a service brake application and note that service air pressure is present at the trailer control line hose coupling.
7. With the ignition on, make and hold a service brake application and note that the stop lights function.
8. Disconnect the air line at the TP–3DC tractor control port (primary) and plug the line. Using a soap-and-water solution, make a service brake application and check for leakage at the open tractor control port. Leakage should not exceed a 1-inch (2.5-cm) bubble in 5 seconds.
9. Reconnect the air line to the tractor control port (primary) and disconnect the air line at the tractor control port (secondary). Then, plug the disconnected line. Make a service brake application, and check for leakage at the open tractor control port using a soap-and-water solution. Leakage should not exceed a 1-inch (2.5-cm) bubble in 5 seconds.

IMPORTANT: If the valve does not function as described, or if leakage is excessive, repair or replace the valve.

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# General Information

The LuK Automotive Hydraulics (formerly Vickers) LF 73 power steering pump supplies power steering fluid for the operation of the power steering gear.

The pump is mounted on the left side of the engine, at the rear of the gear case, or the air compressor. See **Fig. 1**. It is powered by an adaptor gear in the engine.

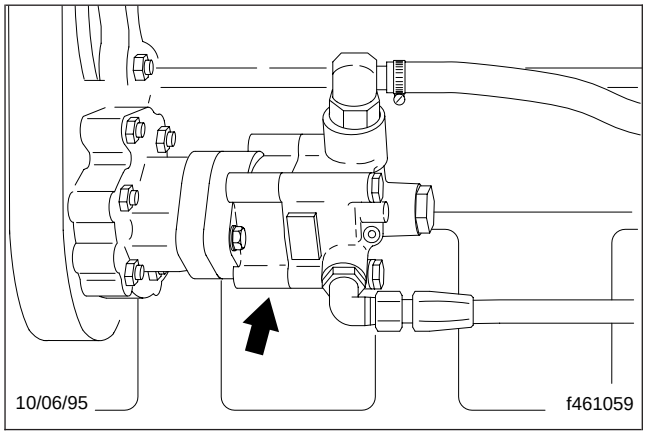


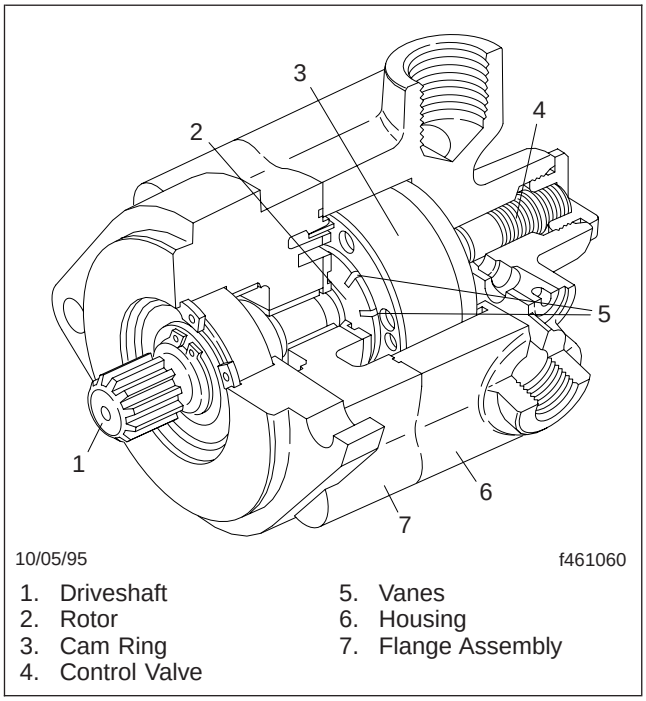

**Fig. 1, Pump Mounting (at the rear of the gear case)**

The main parts of the power steering pump are the housing, driveshaft, cam ring, rotor, vanes, and control valve. See **Fig. 2**.

# Principles of Operation

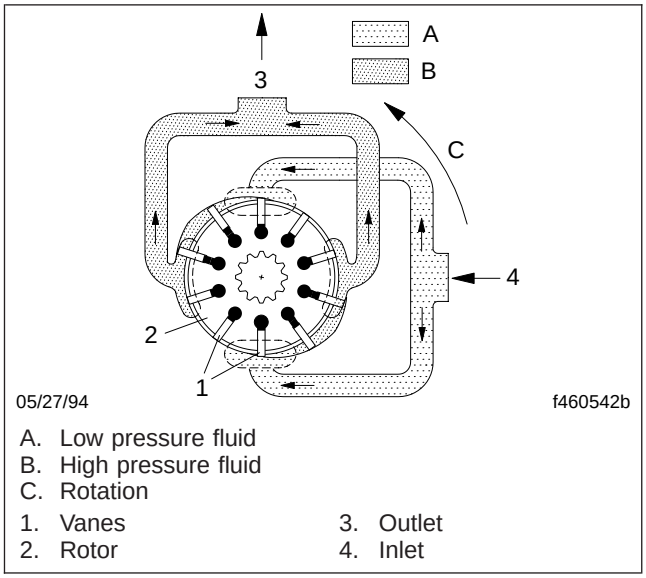
The driveshaft, powered by the adaptor gear in the engine gear case, turns the rotor, which is inside the cam ring. As the rotor turns, centrifugal force pushes the vanes out toward the surface of the cam ring. As fluid enters the cam ring through the inlet port, the rotor vanes force it out through the outlet port, and into the system. See **Fig. 3**. The fluid operates the steering gear. Eventually the fluid returns to the power steering reservoir, and then back to the power steering pump.

If the system pressure gets too high, a poppet inside the control valve is forced off its seat, shunting fluid into a relief passage connected to the inlet port. The fluid then recirculates inside the pump instead of going to the outlet port. When the system pressure drops to the correct level, the poppet seats, closing off the relief passage to the inlet port. The fluid flow returns to normal, flowing from the inlet port to the outlet port and then into the power steering system.




1. Driveshaft
2. Rotor
3. Cam Ring
4. Control Valve
5. Vanes
6. Housing
7. Flange Assembly

**Fig. 2, Pump Components**




A. Low pressure fluid
B. High pressure fluid
C. Rotation

1. Vanes
2. Rotor
3. Outlet
4. Inlet

**Fig. 3, Pump Fluid Flow Diagram**

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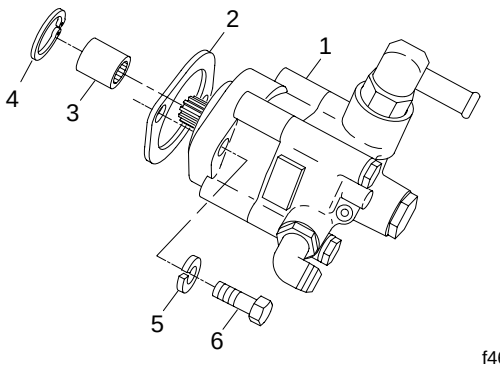
## Steering Pump Removal and Installation

# Removal

1. Park the vehicle on a level surface.
2. Shut down the engine, set the parking brake, and chock the tires.
3. Open the hood.
4. Clean all dirt from around the fittings and hose connections.
5. Put a container under the inlet port of the pump, then disconnect the fitting. Plug the hose to keep out dirt and to prevent fluid from leaking.

   Repeat this step at the pump outlet port.
6. On Cummins and Caterpillar engines, remove the mounting bolts that attach the pump to the engine accessory drive mounting flange. See **Fig. 1**. Slide the pump out of the shaft coupling or sleeve, and remove the pump from the engine.

   On Detroit Diesel Series 60 engines, remove the two pump-mounting bolts that attach the pump to the adaptor flange. See **Fig. 2**. Slide the pump out of the coupling. Remove the sprocket from the shaft if necessary. Check around the adaptor flange for oil leaks. If there are leaks, remove the adaptor flange from the engine. Remove all old gasket material.




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1. Pump
2. Gasket
3. Coupling
4. Coupling Clip
5. Lock Washer
6. Mounting Bolt

**Fig. 1, Cummins and Caterpillar Pump Mounting**

# Installation

1. Using engine oil, lightly lubricate a new gasket and the pump shaft.
2. On Cummins and Caterpillar engines, install the new gasket on the pump mounting flange, then place the pump on the engine's accessory drive mounting. See **Fig. 1**. Turn the pump or shaft as needed to mesh the shaft with the shaft coupling or sleeve. Seat the pilot of the pump mounting flange in the accessory drive mounting, without applying unnecessary force. Install the lock washers and mounting bolts. Tighten the bolts 32 to 37 lbf·ft (43 to 50 N·m).

   On Detroit Diesel Series 60 engines, make sure that the clip is installed in the sprocket, and that the coupling and sprocket are installed in the engine's accessory drive. See **Fig. 2**. If the adaptor flange was removed, use engine oil to lightly lubricate a new O-ring. Install the O-ring on the flange, and install the flange on the engine. Cross tighten the six mounting bolts 22 to 25 lbf·ft (30 to 34 N·m). Install the new gasket on the pump mounting flange, then position the pump on the adaptor flange. Turn the pump or shaft as needed to mesh the shaft with the sprocket. Seat the pump mounting flange pilot in the adaptor flange without applying unnecessary force. Apply Loctite® 242, or an equivalent sealant, to the pump mounting bolts. Install the pump mounting washers and bolts. Tighten the bolts 30 to 50 lbf·ft (41 to 68 N·m).
3. Connect the hoses to the pump inlet and outlet ports.
4. Check the fluid level of the power steering reservoir and add fluid if necessary. Start the engine and let it idle for two minutes. Do not turn the steering wheel; doing so can cause air to enter the system.

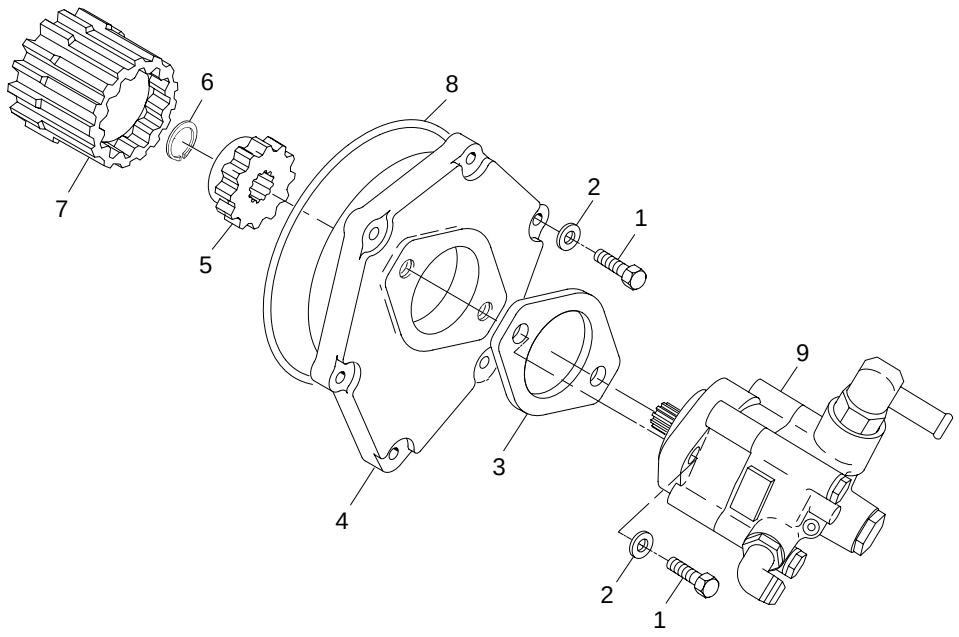
   Turn off the engine, and check the fluid level in the reservoir.
5. Start the engine again. To remove air from the system, steer the vehicle from full-left to full-right several times.

   Add fluid as necessary to the full line on the reservoir dipstick.
6. If the steering gear doesn't have a manual bleed screw, turn the steering wheel from full lock to

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## Steering Pump Removal and Installation




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1. Mounting Bolt
2. Washer
3. Gasket
4. Adaptor Flange
5. Sprocket
6. Clip
7. Coupling
8. O-Ring
9. Pump

**Fig. 2, Detroit Diesel Pump Mounting**

full lock two or three times with the engine running at idle. Repeat this step, and add fluid as necessary until there are no bubbles in the reservoir.

If the steering gear is equipped with a manual bleed screw, turn the steering wheel from full lock to full lock two or three times with the engine running at idle. Then, loosen the manual bleed screw about one turn and look for clear fluid or fluid mixed with bubbles at the threaded area of the bleed screw. Repeat this step and add fluid as necessary until only clear fluid shows. Tighten the manual bleed screw 27 to 33 lbf·in (300 to 360 N·cm). Refill the reservoir if necessary to the full line on the dipstick.

7. Lower the hood.
8. Remove the chocks from the tires.
9. Test drive the vehicle and ensure that the steering pump and the steering system operate properly.

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## Steering Pump Shaft Seal Replacment

**⚠ CAUTION**

**Be careful when working on the pump housing; it is aluminum, and can be easily damaged. When putting it in a vise, pad the vise jaws; tighten the vise just enough to hold the pump.**

## Replacement

**⚠ WARNING**

**Wear safety goggles or glasses when disassembling the power steering pump. Some of the parts are held in place by springs or snap rings, which can release with considerable force, possibly causing injury. See Fig. 1.**

NOTE: The shaft seal kit contains a replacement seal for LF and VT series pumps. The seal for the LF-series pump is smaller.

1. Remove the power steering pump from the engine, following the instructions under **Subject 100**.
2. Carefully remove the end plug (there is a spring underneath it) from the pump body. Remove the spring, then, slide out the control valve, as shown in **Fig. 2**. Be careful not to scratch the control valve.
3. Remove and discard the O-ring from the plug.
4. Put the pump housing in a padded vise, then remove the four screws holding the housing and the flange assembly together. See **Fig. 3**.
5. Remove and discard the combination O-rings/back-up rings from the pump housing. See **Fig. 4**.
6. Remove the pressure plate, guide pins, cam ring, rotor, vanes, and wear plate as a unit and set aside.
7. Remove and discard the small and large O-rings from the flange assembly. See **Fig. 5**.
8. Remove the snap ring holding the shaft seal in place. Discard the snap ring. See **Fig. 6**.
9. Put the flange assembly in a vise with the inner end of the shaft pointing up. Carefully tap out the driveshaft. See **Fig. 7**.
10. Remove and discard the shaft seal.
11. Clean all the parts, using a solvent compatible with the power steering fluid. Then, using filtered compressed air, dry all the parts.
12. Coat all the parts with clean power steering fluid. See the power steering fluid table in **Specifications, 400**.
13. Place the spacer over the outer (drive) end of the shaft with the cupped side of the spacer facing the inner end of the shaft.
14. Using power steering fluid, lubricate the new shaft seal. Carefully place the seal over the outer (drive) end of the shaft, up against the spacer. The lettered side of the seal should be visible.

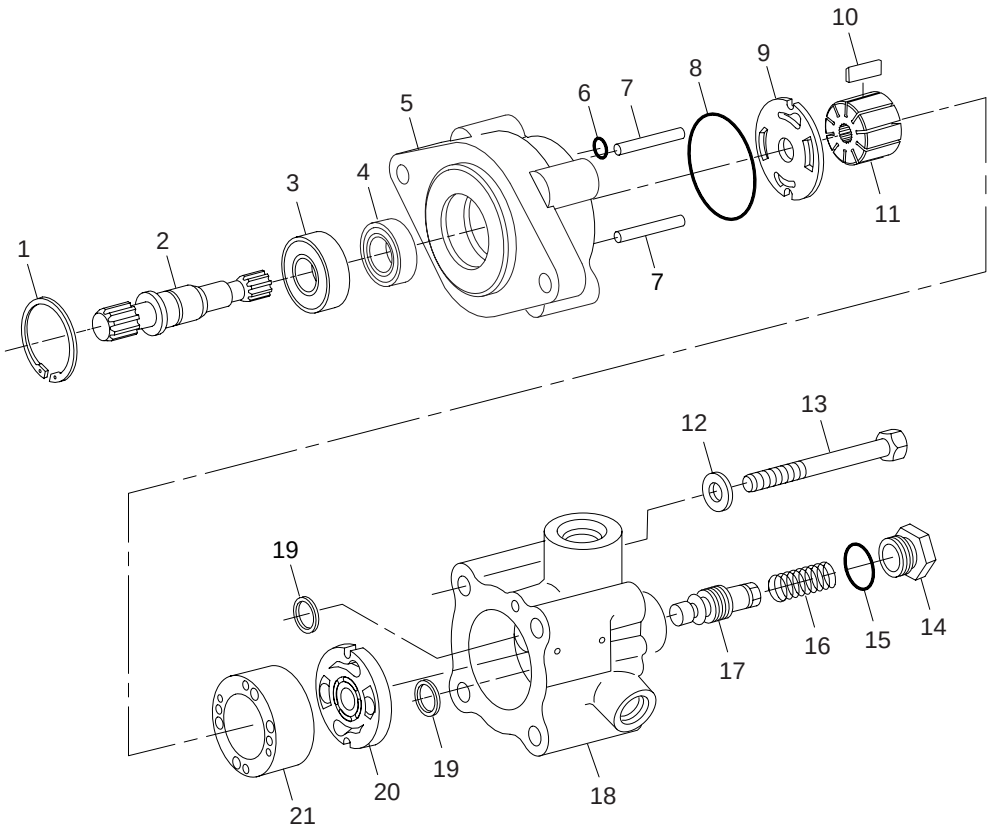
NOTE: To correctly install the driveshaft seal, it is necessary to make a suitable driver from tubular stock. See **Fig. 8** for the applicable dimensions.

15. Using a suitable driver, install the shaft seal into the bore in the flange assembly. Make sure the spring side of the seal faces the flange. See **Fig. 9**. Seat the seal firmly against the shoulder in the bore.
16. Install the small snap ring in its groove on the driveshaft, with the sharp edge facing toward the bushing.
17. Put the flange assembly in a padded vise with the drive end of the shaft pointing up. Install a new large O-ring in the flange assembly.
18. Install a new small O-ring in the flange assembly.
19. Install the pressure plate, guide pins, cam ring, rotor, vanes, and wear plate as a unit. Make sure that the two guide pins are seated in the flange assembly.
20. Using power steering fluid, lubricate the new combination O-ring/back-up rings. Install the rings in the pump housing with the black side facing the housing, and the white-plastic side exposed.
21. Install the pump housing over the flange assembly, lining up the mounting holes.
22. Install the four hexbolts and washers in the pump housing. Tighten them in a cross pattern 29 to 37 lbf·ft (40 to 50 N·m).

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## Steering Pump Shaft Seal Replacment




10/16/95 f461063

1. Snap Ring
2. Driveshaft
3. Driveshaft Bushing
4. Shaft Seal
5. Flange Assembly
6. Small O-Ring
7. Guide Pin
8. Large O-Ring
9. Wear Plate
10. Vane
11. Rotor
12. Washer (4 qty.)
13. Hexbolt (4 qty.)
14. End Plug
15. End Plug O-Ring
16. Spring
17. Control Valve
18. Pump Housing
19. Combination O-Ring/Back-up Ring
20. Pressure Plate
21. Cam Ring

**Fig. 1, Steering Pump Assembly**

23. Install the control valve in the pump housing.

**⚠ CAUTION**

**Make sure you install the control valve correctly in its bore. If it's installed backwards, the power steering pump won't work, and will quickly overheat, which could cause severe damage to the pump.**

23.1 Lubricate the control valve with power steering fluid (see the power steering fluid table in **Specifications, 400**), then install it—with the hex-plug end up—into the bore in the pump housing. See **Fig. 10**.

23.2 Install the spring over the hex-plug end of the control valve.

23.3 Install a new O-ring on the end plug, then install the end plug. Tighten it 33 to 40 lbf·ft (45 to 55 N·m).

24. Turn the shaft by hand; it should turn smoothly and without binding.

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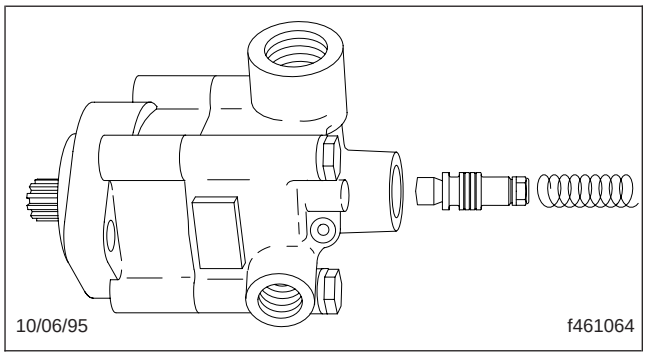



**Fig. 2, Slide Out the Control Valve**

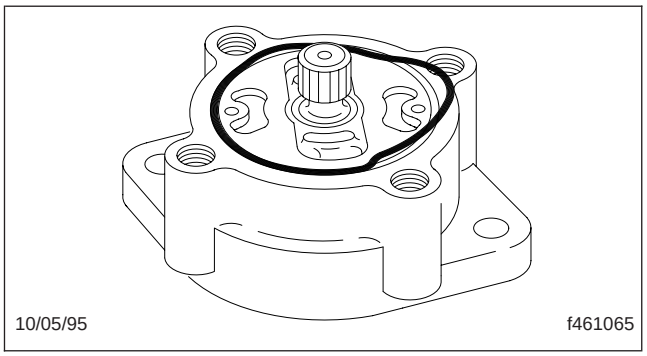



**Fig. 5, Remove the Large O-Ring**

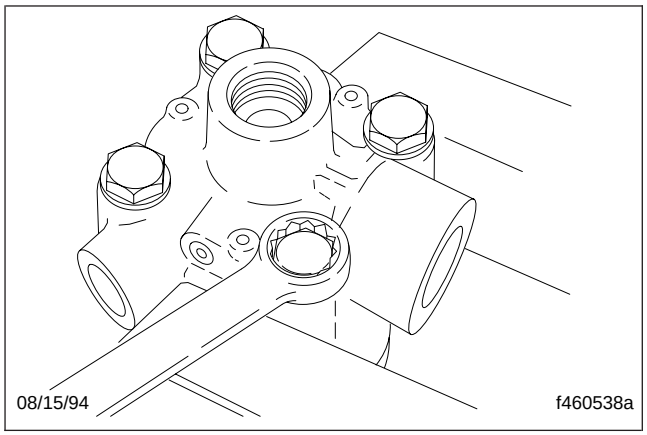



**Fig. 3, Remove the Screws**

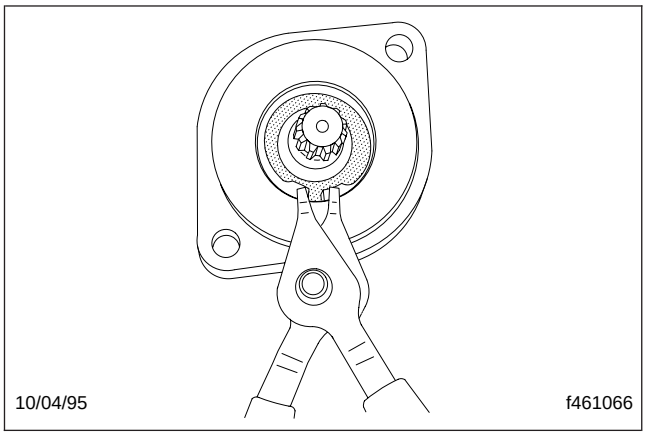



**Fig. 6, Remove the Snap Ring**

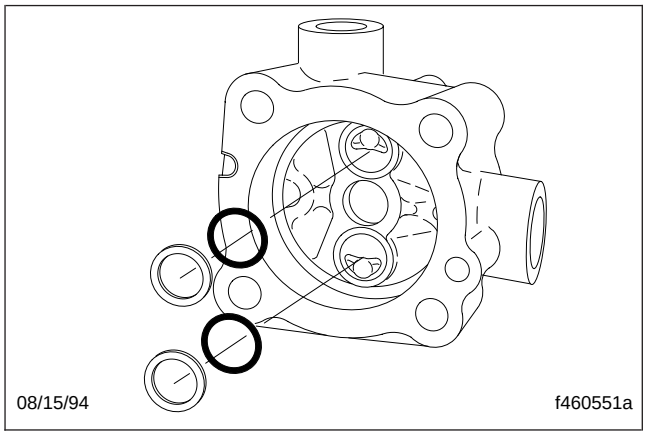



**Fig. 4, Remove the Two Combination O-Ring/Back-Up Rings**

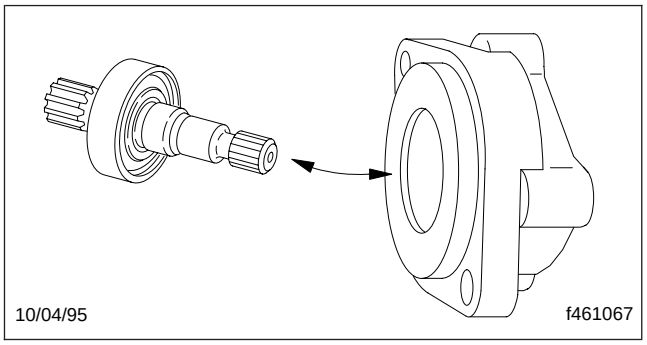


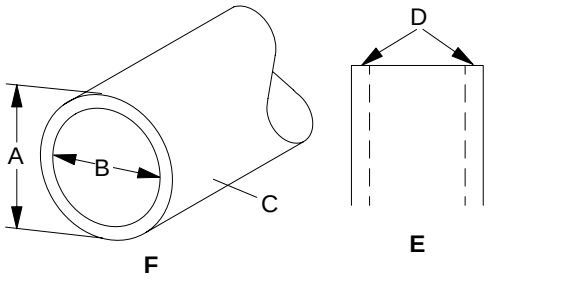

**Fig. 7, Tap Out the Driveshaft**

25. Install the power steering pump on the engine. For instructions, see **Subject 100.**

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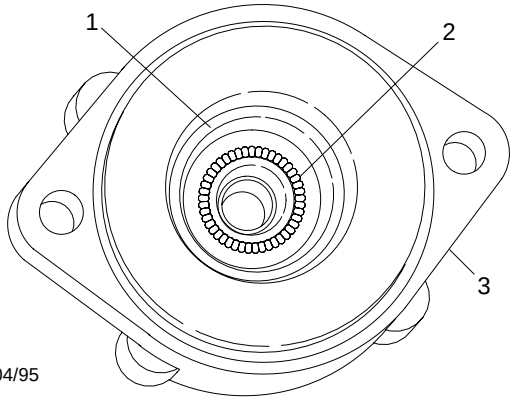
## Steering Pump Shaft Seal Replacment




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A. Slightly smaller than the o.d. of the shaft seal.
B. Slightly larger than the o.d. of the driveshaft.
C. To be made of tubular stock.
D. The ends must be square.
E. Side View
F. Front View

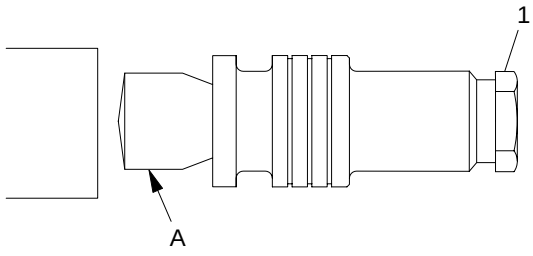
**Fig. 8, Shaft Seal Installation Tool**




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1. Shaft Seal
2. Garter Spring
3. Flange

**Fig. 9, Install the Shaft Seal**




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A. Insert this end first.
1. Hex Plug

**Fig. 10, Install the Control Valve**

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| Model Code Description* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| LF73V | 21 | 16 | 163 | L | P | U | D | 02 | 11 | GE11 |
| Flange Type | Displacement (cubic cm/ rev) | Control Flow (Lpm) | Pressure Limit (bar) | Direction of Rotation | Inlet Port Connection | Pressure Port Connection | Pressure Port View from Cover End | Shaft | Design Number | With Gear and Locknut |

* Model codes contain specifications in metric units.

**Table 1, Model Code Description**

| Pump Specifications | | | |
|---|---|---|---|
| **LuK Model Code** | **Pump Displacement: cubic inch/rev (cubic cm/rev)** | **Control Flow: gpm (Lpm)** | **Maximum Pressure: psi (bar)** |
| LF73V-21-16-163-L-P-U-D-02-11-GE11 | 1.28 (21) | 4.2 (16) | 2396 (163) |

**Table 2, Pump Specifications**

| Pump Port Specifications | | | |
|---|---|---|---|
| **Code** | **Size** | **Shaft Minor Diameter: inches (mm)** | **O-Ring Chamfer** |
| **Inlet Port** | | | |
| M | M26 x 1.5 | 0.63 (16) | — |
| P | 1-1/16–12 UN-2B | 0.79 (20) | SAE J514 |
| U | 1-5/16–12 UN -2B | | |
| **Outlet Port** | | | |
| M | M16 x 1.5 | 0.55 (14) | — |
| N | M18 x 1.5 | | — |
| U | 3/4–16 UNF-2B | | SAE J514 |

**Table 3, Pump Port Specifications**

| Fastener Torques | |
|---|---|
| **Description** | **Torque: lbf·ft (N·m)** |
| Pump Mounting Bolts | Cummins Engines: 32–37 (43–50) |
| | Caterpillar Engines: 32–37 (43–50) |
| | Detroit Diesel Engines: 30–50 (41–68) |
| Pump Housing-to-Flange Assembly Hexbolts | 29–37 (40–50) |
| Pump End-Plug | 33–40 (45–55) |
| Pump Inlet Connection | 26 (35) |

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## Specifications

| Fastener Torques | |
|---|---|
| **Description** | **Torque: lbf·ft (N·m)** |
| Pump Outlet Connection | 22 (30) |

**Table 4, Fastener Torques**

| Power Steering Fluid | |
|---|---|
| **Steering Gear and Lubricant Type** | **Recommended Lubricant** |
| Power Steering Gears With Automatic Transmission Fluid Installed* | Dexron® III |
| Power Steering Gears With Heavy-Duty Engine Oil Installed* | 15W–40 |

* Do not mix engine oil with automatic transmission fluid (ATF). Use the same lubricant for parts as is in the power steering system.

**Table 5, Power Steering Fluid**

| Pressure Settings | |
|---|---|
| **Code** | **Pressure in psi (kPa)** |
| 80 | 1116.5–1261.5 (7700–8700) |
| 100 | 1406.5–1551.5 (9700–10 700) |
| 110 | 1551.5–1696.5 (10 700–11 700) |
| 115 | 1624–1769 (11 200–12 200) |
| 120 | 1696.5–1841.5 (11 700–12 700) |
| 130 | 1841.5–1986.5 (12 700–13 700) |
| 135 | 1914–2059 (13 200–14 200) |
| 140 | 1986.5–2131.5 (13 700–14 700) |
| 145 | 2059–2204 (14 200–15 200) |
| 150 | 2131.5–2276.5 (14 700–15 700) |
| 155 | 2204–2349 (15 200–16 200) |
| 163 | 2320–2465 (16 000–17 000) |
| 000 | — |

**Table 6, Pressure Settings**

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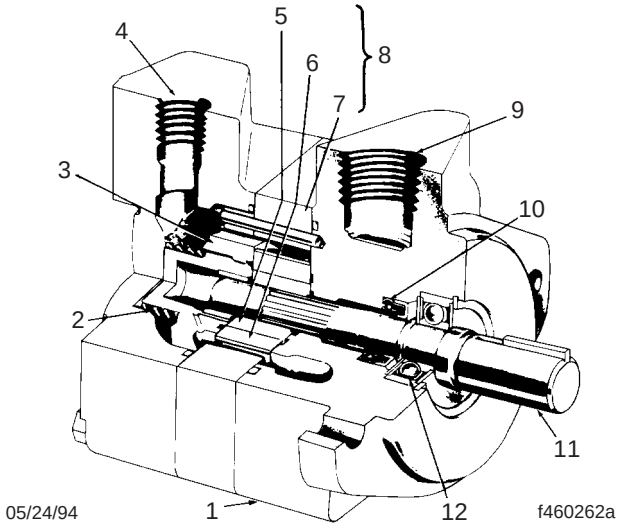


## General Information

The Vickers V20F power steering pump, used with Caterpillar C10/C12 engines, supplies the hydraulic fluid needed to operate the power steering system. See **Fig. 1**.

Primary parts of the pump include a ported body, a cover, and a pumping cartridge. Fluid from the power steering reservoir enters the pumping cartridge through the inlet port in the body. A rotor inside the pumping cartridge is driven by the pump's driveshaft and the engine's accessory drive. When the rotor turns, vanes move along the surface of a cam ring. Hydraulic fluid is circulated under pressure and forced between the vanes creating sealed chambers that carry and discharge the fluid through a pressure plate to the outlet port in the pump cover.

The cover's integral flow control and relief valve limits the fluid flow and the system pressure to preset values. Fluid that is not used to operate the system is recirculated to the power steering reservoir.




1. Body
2. Spring
3. Pressure Plate
4. Outlet Port
5. Rotor
6. Vane
7. Cam Ring
8. Pumping Cartridge
9. Inlet Port
10. Shaft Seal
11. Driveshaft
12. Bearing

**Fig. 1, Vickers V20F Series Power Steering Pump**

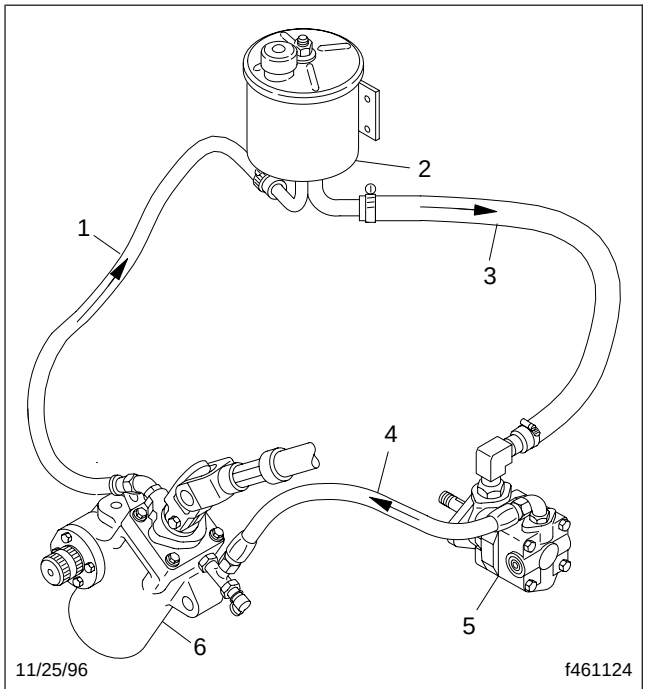
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## Steering Pump Removal and Installation

## Removal

1. Clean all outside dirt from around the fittings and hose connections. See **Fig. 1**.



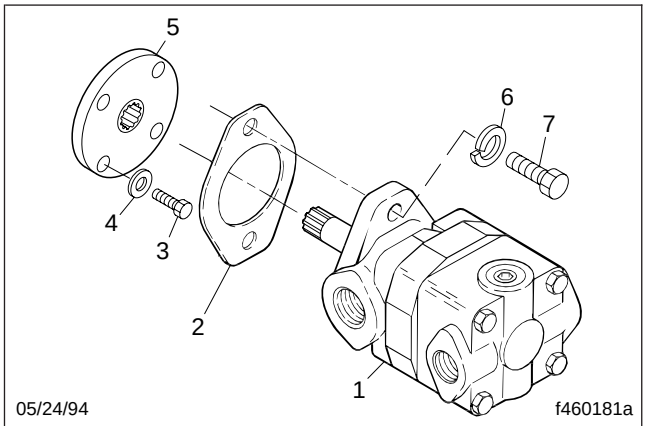

1. Return Line
2. Reservoir
3. Supply Line
4. Pressure Line
5. V20F Power Steering Pump
6. Steering Gear

**Fig. 1, Steering Pump Fittings and Hose Connections (two-line pump shown)**

2. Disconnect the hydraulic pressure line (between the power steering gear and the pump) from the elbow fitting on the pump. Plug the line, and cap the fitting. If the pump is being replaced, remove the elbow and plug the port in the pump.
3. At the power steering pump, disconnect the reservoir supply line from the pump. Drain the power steering fluid from the line. Plug the supply line and cap the fitting on the pump. If the pump is being replaced, remove the elbow and plug the port in the pump.
4. Remove the mounting bolts that attach the pump to the engine accessory drive mounting flange. See **Fig. 2**. Slide the pump out of the sleeve, and remove the pump from the engine.

## Installation

1. Using engine oil, lightly lubricate a new gasket and the pump shaft.
2. Install the new gasket on the pump mounting flange, then place the pump on the engine's accessory drive mounting. See **Fig. 2**. Turn the pump or shaft as needed to mesh the shaft with the sleeve. Seat the pilot of the pump mounting flange in the accessory drive mounting, without applying unnecessary force. Install the lockwashers and mounting bolts, and tighten them 32 lbf·ft (43 N·m).
3. Connect the hydraulic pressure and pump supply lines. See **Fig. 1**.




1. Pump
2. Gasket
3. Bolt
4. Washer
5. Sleeve
6. Lockwasher
7. Mounting Bolt

**Fig. 2, Caterpillar N10 and N12 Pump Mounting**

3.1 Connect the pressure line to the elbow fitting at the pump's pressure line port. If a new pump is installed, first install the elbow fitting.

3.2 Connect the supply line to the elbow fitting at the pump's supply line port. If a new pump is installed, first install the elbow fitting.

3.3 Tighten the elbow fitting nuts finger-tight. Use a wrench to tighten the nuts until there is resistance; then tighten them one-sixth turn more.

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## Steering Pump Removal and Installation

4. Check the fluid level of the power steering reservoir and add fluid if necessary. Start the engine and let it idle for two minutes. Do not turn the steering wheel; doing so can cause air to enter the system.

   Turn off the engine, and check the fluid level in the reservoir.

5. Start the engine again. To remove air from the system, steer the vehicle from full-left to full-right, several times. Adjust the steering gear poppet or pressure-relief valves. For instructions, see the appropriate section in this manual.

   Add fluid, as necessary, to the full line on the reservoir dipstick.

6. If the steering gear doesn't have a manual bleed screw, turn the steering wheel from full lock to full lock two or three times with the engine running at idle. Repeat this step, and add fluid as necessary until there are no bubbles in the reservoir.

   If the steering gear is equipped with a manual bleed screw, turn the steering wheel from full lock to full lock two or three times with the engine running at idle. Then loosen the manual bleed screw about one turn and look for clear fluid or fluid mixed with bubbles at the threaded area of the bleed screw. Repeat this step and add fluid, as necessary, until only clear fluid discharges. Tighten the manual bleed screw 27 to 33 lbf·in (300 to 360 N·cm). Refill the reservoir, if necessary, to the full line on the reservoir dipstick.

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# Steering Pump Disassembly, Inspection, and Assembly

## Disassembly

1. Remove the power steering pump. See **Subject 100**.
2. Clamp the pump body in a vise with the cover facing up.

**⚠ CAUTION**

**Don't use excessive pressure to clamp the pump body. Applying excessive pressure could damage the pump body.**

3. Remove the four capscrews from the cover, and remove the cover and O-ring. See **Fig. 1**.
4. Remove the relief valve plugs from the pump cover.
5. Insert a suitable tool through the snap ring end of the cover and carefully push out the relief valve and spring.

**⚠ CAUTION**

**Do not disassemble the relief valve. Valve specifications are set by the manufacturer. The valve may not work properly if disassembled, and damage to the pump could occur.**

6. Remove the pressure plate and spring.
7. Note the position of the cam ring, then remove the guide pins and cam ring.
8. Remove the vanes from the rotor, then remove the rotor from the shaft.
9. Turn the pump body over. If applicable, remove the shaft key and the snap ring that holds the bearing in place.
10. Using a soft hammer, tap on the splined end of the shaft to remove the shaft from the pump body.
11. Remove the snap ring from the shaft.
12. Support the bearing inner race on a press, and press the shaft out of the bearing.
13. Using a suitable hooked tool, pull the shaft seal out of the pump body.

## Inspection

1. Clean all parts in an approved cleaning solvent.
2. Check the body, pressure plate, cam ring, and rotor for scoring or wear. Replace parts if necessary.
3. Check the vanes for burrs. Check the rotor slots for wear. Replace parts if necessary.
4. Check the bearings for wear and looseness. Applying pressure, turn the bearings and check for pitted or cracked bearing races. Replace the bearings if necessary.
5. Check the oil seal sealing surface on the shaft for wear. If wear marks on the shaft can't be removed by light polishing, replace the shaft.
6. Check that the relief valve moves easily within the cover bore. If the cover bore is worn or pitted, replace the cover.
7. Check the relief valve for burrs. Remove burrs by polishing, but take care not to round off the corners of the valve ends.

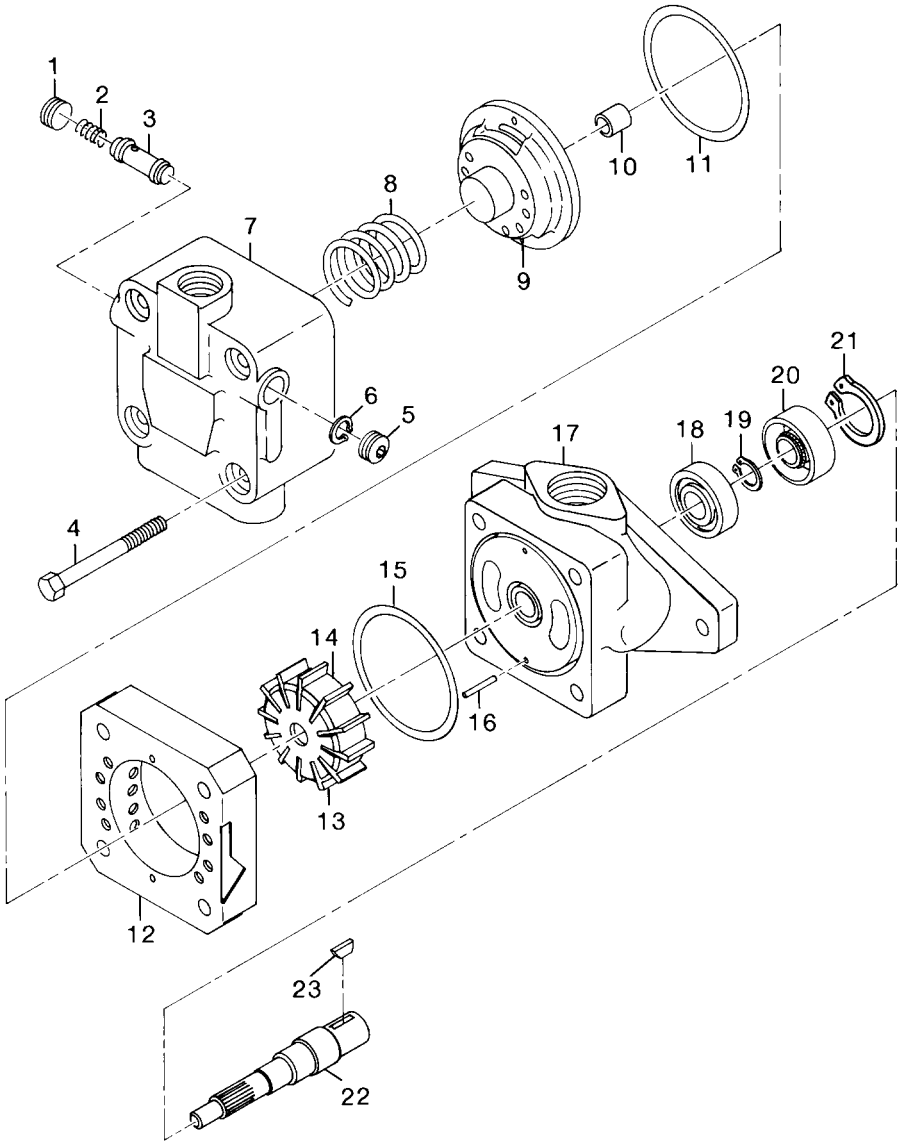
## Assembly

1. Coat all parts with hydraulic fluid. If using a new assembly part, remove any burrs from the sharp edges of the part.
2. Insert the small end of the relief valve in the bore of the pump cover. On one side of the cover, install the spring and relief valve plug. Install the snap ring and the other relief valve plug on the opposite side.
3. Support the bearing inner race, and press the shaft through the bearing. Install the small snap ring on the shaft.
4. Lubricate the sealing lip of the shaft seal with chassis grease. Check that the shaft seal garter spring is facing toward the cover end of the pump. See **Fig. 2**. Press the seal in place.
5. Slide the driveshaft into the pump body until the bearing is seated. If necessary, use a soft hammer and lightly tap the end of the shaft.
6. Install new O-rings in the pump body and cover.
7. Insert the cam ring guide pins in the pump body. Make sure that the arrow on the perimeter of the

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## Steering Pump Disassembly, Inspection, and Assembly




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1. Relief Valve Plug
2. Spring
3. Relief Valve
4. Capscrew
5. Relief Valve Plug
6. Snap Ring
7. Cover
8. Spring
9. Pressure Plate
10. Bushing
11. O-ring
12. Cam Ring
13. Roll Vane
14. Rotor
15. O-ring
16. Guide Pin
17. Body
18. Shaft Seal
19. Snap Ring
20. Bearing
21. Snap Ring
22. Driveshaft
23. Key (if applicable)

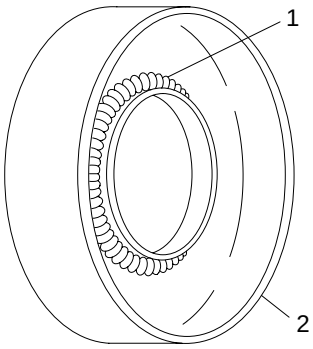
**Fig. 1, Hydraulic Power Steering Pump Assembly**

ring points in the direction of rotation, then install the cam ring. See **Fig. 3**.

8. Install the rotor on the driveshaft. Insert the vanes in the rotor slots. Make sure that the ra-

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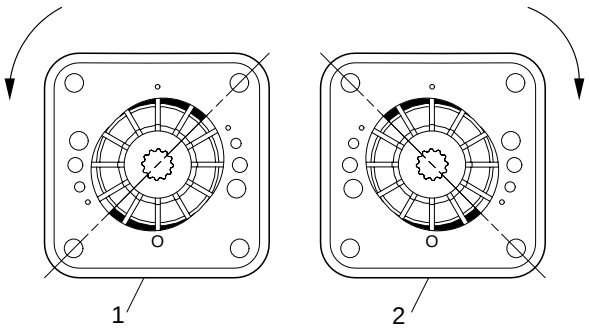

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NOTE: Assemble with spring toward cover end of pump.

1. Garter Spring 2. Shaft Seal

**Fig. 2, Shaft Seal**

dius edges of the vanes are positioned toward the cam ring.




10/31/96 f460190a

1. Right-Hand Rotation 2. Left-Hand Rotation

**Fig. 3, Cam Ring Positions (view from cover end)**

9. Place the pressure plate on the guide pins.
10. Position the spring on the pressure plate, then install the pump cover. Tighten the capscrews 80 lbf·ft (108 N·m).
11. Turn the driveshaft to ensure that there is no internal binding.

**WARNING**

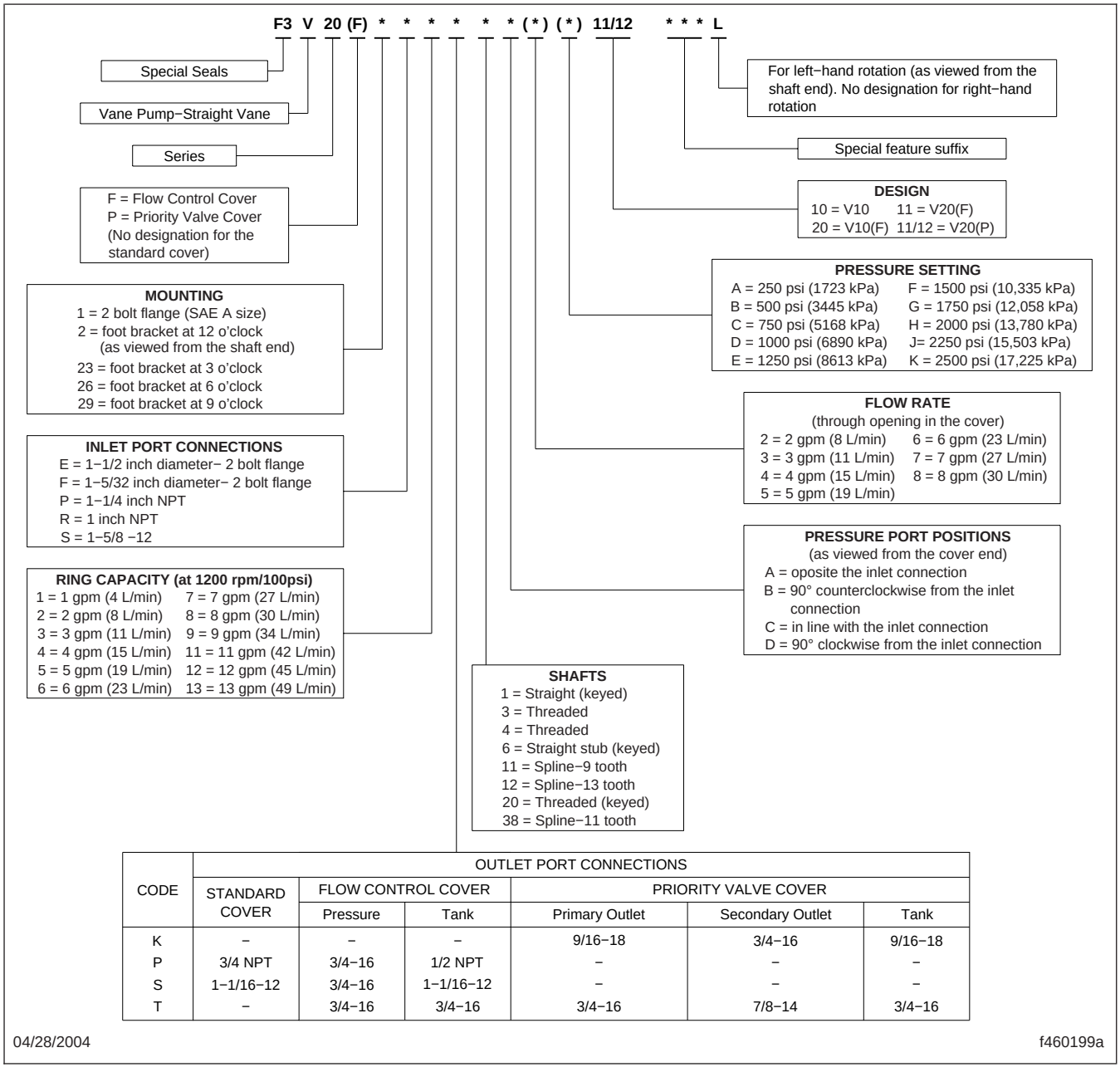
**Be sure to correct any binding of the steering pump. This could cause damage to the pump, an unexpected loss of power steering assist, and possible personal injury or property damage.**

12. Install the shaft key (if applicable).
13. Install the pump; see **Subject 100**.

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See **Fig. 1** for model number breakdown.




| CODE | OUTLET PORT CONNECTIONS | | | | | |
|---|---|---|---|---|---|---|
| | STANDARD COVER | FLOW CONTROL COVER | | PRIORITY VALVE COVER | | |
| | | Pressure | Tank | Primary Outlet | Secondary Outlet | Tank |
| K | – | – | – | 9/16−18 | 3/4−16 | 9/16−18 |
| P | 3/4 NPT | 3/4−16 | 1/2 NPT | – | – | – |
| S | 1−1/16−12 | 3/4−16 | 1−1/16−12 | – | – | – |
| T | – | 3/4−16 | 3/4−16 | 3/4−16 | 7/8−14 | 3/4−16 |

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**Fig. 1, Model Number Breakdown**

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## General Description

NOTE: Procedures in this section have been slightly modified from the original component manufacturer's service manual. See the manufacturer's service literature (**trucksteering.trw-.com**) for additional information.

TRW TAS power steering gears are integral hydraulic power steering gears that contain a manual steering mechanism, a hydraulic control valve, and a hydraulic power cylinder.

The pressure required for the steering gear to overcome resistance at the steered wheels is provided by the power steering pump. The rotary control valve directs the flow of hydraulic fluid to the appropriate cylinder cavity in the steering gear (and in the auxiliary cylinder in a dual steering gear system) at the proper flow rate and pressure. As the steering wheel is turned faster or slower, more or less fluid is required by the gear.

## Principles of Operation

When the driver turns the steering wheel, that force travels from the steering wheel to the steering gear input shaft. A torsion bar, pinned at one end to the input shaft and at the other end to the worm shaft, turns with the input shaft and exerts a rotational force on the worm shaft. In response to the force exerted by the torsion bar, the worm shaft moves the rack piston forward or backward in the gear housing by means of a series of recirculating balls in the spiral channels of the worm shaft. As the rack piston slides back and forth, it turns the sector shaft. The sector shaft swings the pitman arm, which pulls or pushes the drag link. The drag link moves the axle steering arm, steering the vehicle.

The rack piston's axial movement is resisted by its engagement to the sector shaft, which is linked to the steered wheels. Because of this resistance, the torsion bar activates the control valve, which directs pressurized fluid to the upper or lower cylinder cavity (depending on the direction of turn). The pressurized fluid assists in moving the rack piston up or down in the cylinder bore.

Most TAS steering gears are equipped with two poppet (unloading) valves, one at each end of the rack piston. As the front wheels reach the axle stop—the farthest the wheels can turn in either direction—one poppet or the other, depending on the direction of the turn, will trip to prevent steering system damage. The tripped poppet reduces pressure in the gear, heat generated by the power steering pump, and outside forces acting on the steering linkage.

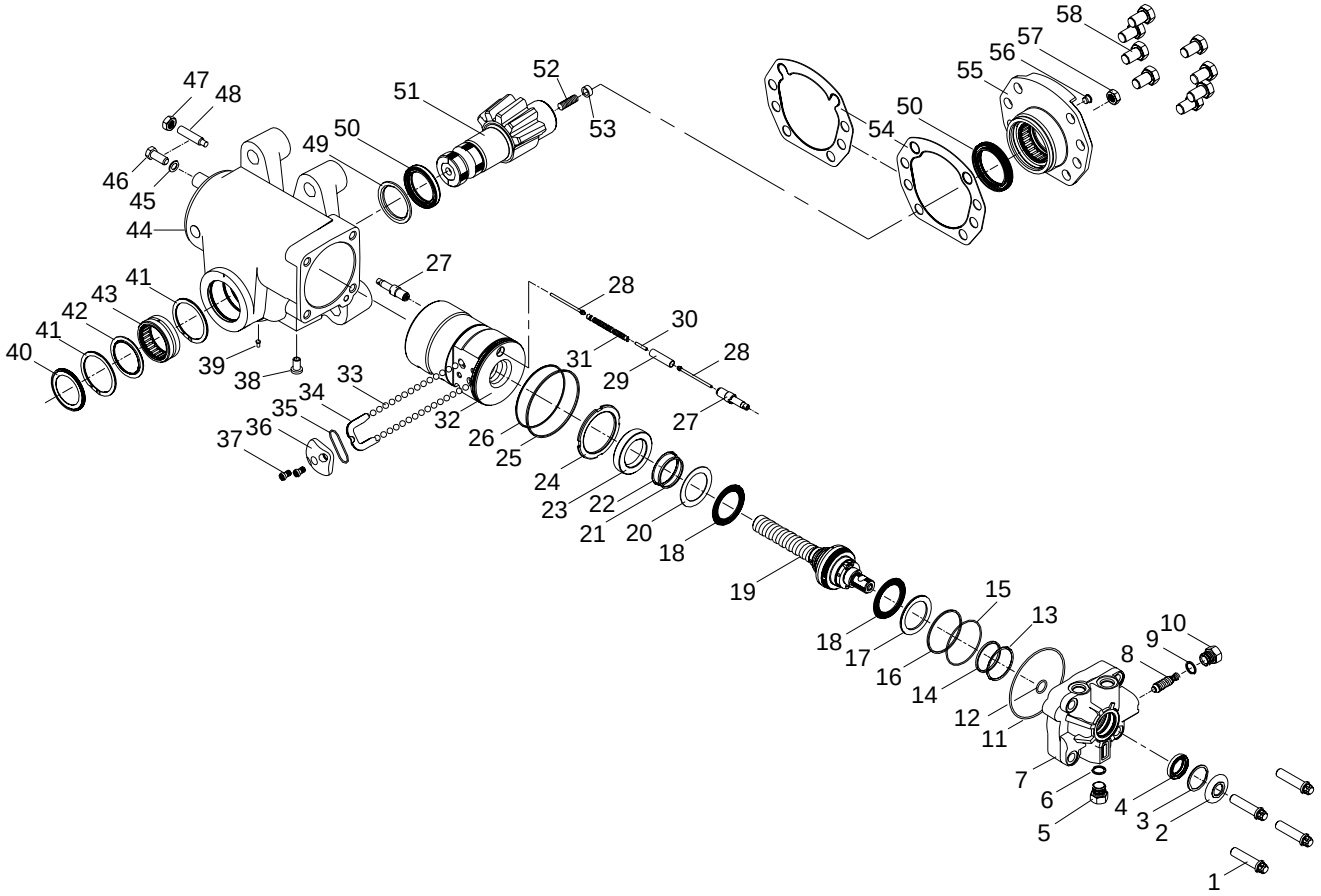
Some TAS steering gears are also supplied with an internal pressure relief valve (PRV). The PRV limits maximum supply pressure to protect the power steering gear, but it does not reduce pressure as the steered wheels approach the axle stops.

See **Fig. 1** for an exploded diagram of a TRW TAS power steering gear.

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## General Information




1. Bolts, Valve Housing
2. Dirt and Water Seal
3. Retaining Ring
4. Input Shaft Seal
5. Auxiliary Port Plug
6. O-Ring, Auxiliary Port Plug
7. Valve Housing
8. Relief Valve
9. O-Ring, Relief Valve
10. Relief Valve Cap
11. Seal Ring, Large
12. Seal Ring, Small
13. Seal Ring
14. O-Ring
15. Seal Ring
16. O-Ring, Valve Housing
17. Thrust Washer, Thick
18. Roller Thrust Bearing
19. Input Shaft/Valve/Worm Assembly
20. Thrust Washer, Thin
21. Seal Ring
22. O-Ring
23. Bearing Adjuster
24. Adjuster Locknut
25. Seal Ring, Rack Piston
26. O-Ring, Backup
27. Poppet Adjuster Seat and Sleeve Assembly
28. Poppet
29. Push Tube
30. Spacer Rod
31. Poppet Spring
32. Rack Piston
33. Steel Balls
34. Ball Return Guide Halves
35. Seal, Ball Return Guide Cap
36. Ball Return Guide Cap
37. Torx® Screws
38. Plug, Auto-Bleed
39. Grease Fitting
40. Dirt and Water Seal, Trunnion
41. Retaining Ring
42. Dirt Seal
43. Roller Bearing
44. Gear Housing
45. Washer, Stopscrew
46. Fixed Stop Screw, Poppet
47. Service Sealing Jam Nut
48. Service Poppet Adjusting Screw
49. Washer, Spacer
50. Output Seal
51. Sector Shaft
52. Adjusting Screw, Shaft
53. Retainer, Adjusting Screw
54. Gasket, Side Cover
55. Side Cover and Bushing/Bearing Assembly
56. Vent Plug, Side Cover
57. Jam Nut
58. Special Bolts, Side Cover

**Fig. 1, TRW TAS85 Power Steering Gear Components**

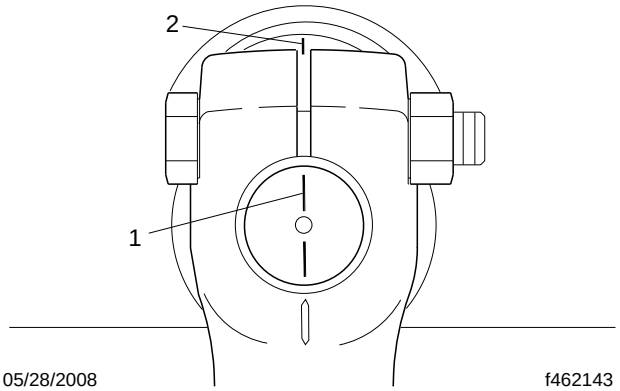
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## Sector Shaft Adjustment

NOTE: If the steering gear is installed on the frame rail, sector shaft adjustment can only be completed if the adjusting screw jam nut (located on the side cover) is accessible.

1. Apply the parking brakes and chock the rear tires.
2. With the engine on, turn the steering wheel until the timing mark on the sector shaft lines up with the timing mark on the housing. The sector shaft is now at its center of travel. See **Fig. 1**. Shut down the engine.




1. Housing Timing Mark
2. Sector Shaft Alignment Mark

**Fig. 1, Timing Mark Placement**

3. Remove the cotter pin and castle nut that attach the drag link to the pitman arm. Disconnect the drag link from the pitman arm.

IMPORTANT: To avoid resetting the poppets, do not turn the input shaft more than 1-1/2 turns from the center-of-travel position while the drag link is disconnected.

4. From the center-of-travel position, grasp the pitman arm at the lower end of the arm and gently try to move the arm back and forth. See **Fig. 2**. If the pitman arm is loose or lash (free play) is detected, the sector shaft is out of adjustment.
5. Loosen the adjusting screw jam nut.
6. If no lash was detected in step 4, use a screwdriver to turn the sector shaft adjusting screw

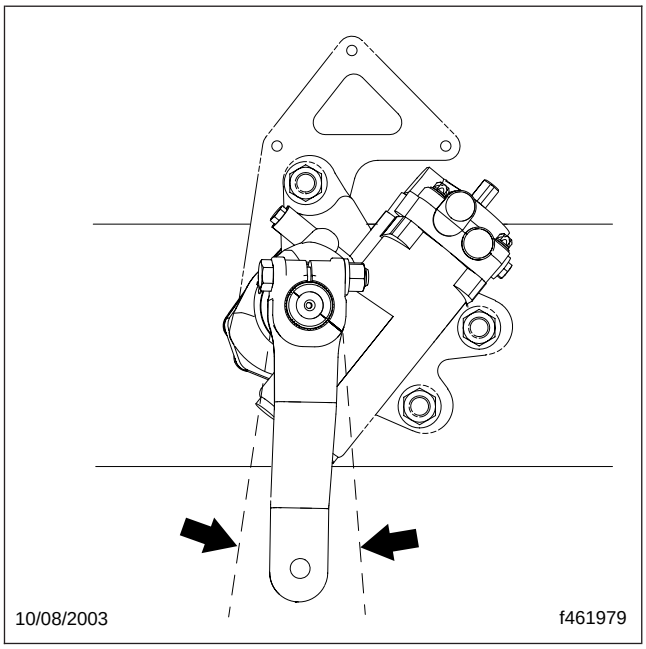



**Fig. 2, Lash Check**

counterclockwise until you feel lash at the sector shaft. See **Fig. 3**.

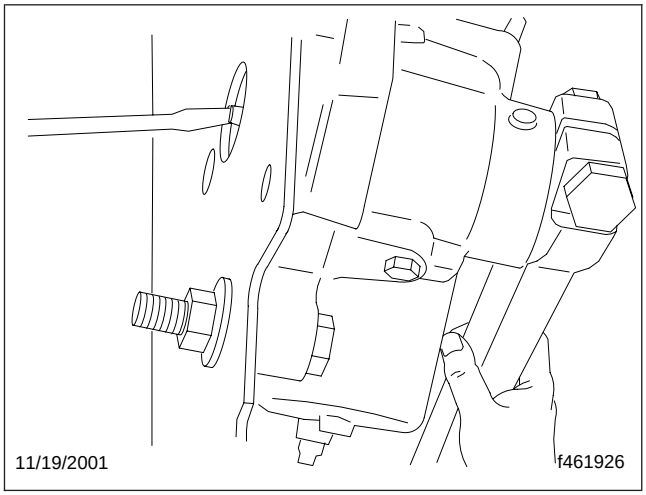



**Fig. 3, Adjusting the Sector Shaft**

IMPORTANT: Do not use more than 10 lbf·ft (14 N·m) of force when tightening the adjusting screw.

7. Slowly turn the adjusting screw clockwise until no lash is felt at the pitman arm. From this position, turn the adjusting screw clockwise 1/8 to 3/16 of

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a turn more. Hold the adjusting screw in place and tighten the jam nut 43 lbf·ft (58 N·m).

8. Turn the steering wheel 1/4 of a turn to each side of center and recheck the pitman arm for lash. If lash is detected, adjust the sector shaft again.
9. Using a castle nut, attach the drag link to the pitman arm. Tighten the castle nut using the appropriate torque value.
    - 3/4–16: 90 to 170 lbf·ft (122 to 230 N·m)
    - 7/8–14: 160 to 300 lbf·ft (217 to 407 N·m)

**WARNING**

**Failure to install and lock a new cotter pin in the ball stud and nut could result in disengagement of the parts and loss of steering control, which could result in personal injury or property damage.**

10. Continue to tighten the castle nut until a slot on the nut aligns with the hole in the ball stud. Do **not** reverse the tightening direction of the nut when locating the cotter pin hole. Install a new cotter pin in the ball stud and nut, then lock the cotter pin in place.

**NOTICE**

**Do not use a power grease gun to add grease to the sector shaft bearing. Doing so could damage the high-pressure seal and contaminate the hydraulic fluid.**

11. Using only a hand-operated grease gun, add grease to the sector shaft bearing through the grease fitting in the housing until grease begins to extrude past the dirt and water seal.

## Resetting the Poppet Valves

IMPORTANT: The axle stops must be set so that there are at least 1-3/4 steering wheel turns from a straight-ahead position to both a full-left and a full-right turn; otherwise the poppet valves will not work.

1. Verify that the axle stops are adjusted properly. See **Group 33** for instructions.
2. Start the engine and allow the vehicle to idle for 5 to 10 minutes to warm the hydraulic fluid.
3. Shut down the engine, apply the parking brakes, and chock the rear tires.
4. Hold the poppet screw with a wrench and turn the sealing nut back toward the wrench until the nut is flush with the base of the hex area of the poppet screw.
5. Make sure that the engine is off and the wheels are in the straight-ahead position.

**NOTICE**

**Make sure the drive end of the adjusting screw is not below the face of the nut. If the drive end of the adjusting screw is below the face of the nut, the poppet seat flange will break when the upper poppet is prepared for setting.**

6. Using a 7/32-inch Allen wrench, turn the adjusting screw and nut assembly (without turning the nut on the screw) into the housing until the nut is firmly against the housing. Tighten the nut against the housing. See **Fig. 4**.

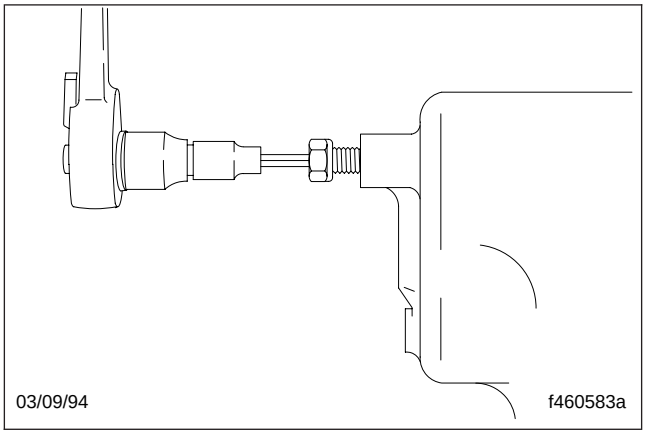



**Fig. 4, Adjusting Screw and Nut Assembly**

**WARNING**

**Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.**

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7. Fill the power steering reservoir nearly full with automatic transmission fluid. Do not turn the steering wheel.
8. Place a jack under the center of the front axle and jack up the front of the vehicle so the steer axle tires are off the ground.
9. Push the upper poppet out to prepare it for setting.
   - 9.1 Start the engine and let it idle.
   - 9.2 Note which sector shaft timing mark is nearest the housing piston bore.

## NOTICE

**Do not hold the steering wheel at full turn for more than 10 seconds at a time. The heat buildup at pump relief pressure may damage components.**

   - 9.3 Turn the steering wheel in the direction that makes this timing mark move toward the adjusting screw just installed. Turn the wheel in this direction until axle stop contact is made.
   - 9.4 Pull hard on the steering wheel. Put up to 40 lbf (178 N) pull on a 20-inch diameter steering wheel.
10. Set the upper poppet.
   - 10.1 Turn the steering wheel in the opposite direction (the timing mark will move away from the adjusting screw) until the other axle stop is contacted.
   - 10.2 Pull hard on the steering wheel. Put up to 40 lbf (178 N) pull on a 20-inch diameter steering wheel.
   - 10.3 Release the steering wheel and shut off the engine.
11. Loosen the sealing nut and back out the adjusting screw until the adjusting screw is 1 inch (2.5 cm) past the nut. See **Fig. 5**. Tighten the nut against the housing.
12. Set the lower poppet.
   - 12.1 Start the engine and let it idle.

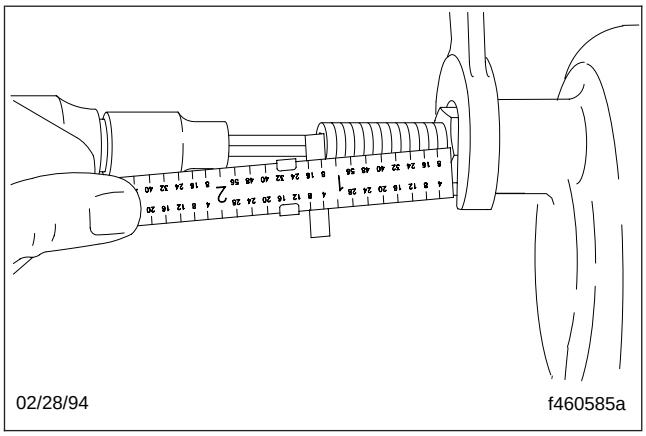



**Fig. 5, Adjusting Screw Position**

   - 12.2 Turn the steering wheel in the original direction (the timing mark will move toward the adjusting screw) until axle stop contact is made.
   - 12.3 Hold the steering wheel in this position with up to 40 lbf (178 N) pull on a 20-inch diameter steering wheel for 10 seconds, then release. Repeat this hold-and-release process as many times as necessary while completing the next step.
13. Position the adjusting screw.
   - 13.1 With the steering wheel held tightly at full turn, loosen the nut and hold it in place with a wrench.

IMPORTANT: Do not attempt to turn the adjusting screw in any farther. Pause the turning-in process each time the driver releases the steering wheel. Continue turning only while the steering wheel is held at full turn.

   - 13.2 Using an Allen wrench and finger pressure only, turn the adjusting screw clockwise until the Allen wrench stops.

## WARNING

**If the adjusting screw protrudes more than 1-1/16 inches (27 mm) from the sealing nut, the screw could fall out of the steering gear, resulting in loss of power steering. This could cause an accident resulting in personal injury or property damage.**

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## Steering Gear Adjustments

13.3 Back off the adjusting screw 3-1/4 turns and tighten the nut 35 lbf·ft (47 N·m).

**⚠ WARNING**

**Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.**

14. The poppets have now been completely reset. Check the power steering reservoir. If needed, add fluid.
15. Lower the vehicle.

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## Steering Gear Removal and Installation

# Removal

1. Verify correct axle stop adjustment. Ensuring correct axle stop adjustment now will eliminate the need to reset the steering gear poppet valves after the gear is installed. For instructions, refer to **Group 33**.
2. Place the front tires in the straight-ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping where the work is to be done.
3. Shut down the engine, apply the parking brakes, and chock the tires.
4. Clean all fittings and hose connections on the steering gear until they are free of dirt.
5. Drain the fluid from the power steering system. Disconnect all hydraulic lines from the gear, marking the lines for later reference. Seal the lines and the fittings to keep out dirt.
6. Disconnect the pitman arm from the steering gear sector shaft.
   - 6.1 Remove and discard the pinch bolt, washer, and nut from the pitman arm.
   - 6.2 Remove the pitman arm using a suitable puller, then swing the pitman arm and drag link out of the way.
7. Disconnect the steering driveline from the steering gear input shaft.
   - 7.1 Remove and discard the pinch bolt and nut from the steering driveline lower end yoke.

**NOTICE**

**Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.**

   - 7.2 Remove the lower end yoke from the input shaft.

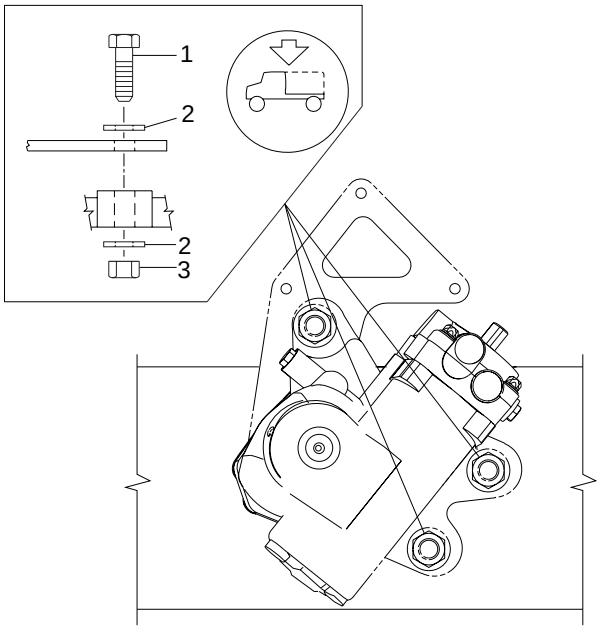
**WARNING**

**The steering gear is heavy. Use caution when removing, lifting, or carrying the steering gear. Failure to do so could cause personal injury.**

8. Remove the fasteners that attach the steering gear to the frame rail. Remove the steering gear.

# Installation

1. Install the steering gear and fasteners as shown in **Fig. 1**. Tighten the fasteners 427 lbf·ft (579 N·m).




05/28/2008 f462142

1. Bolt
2. Washer
3. Nut

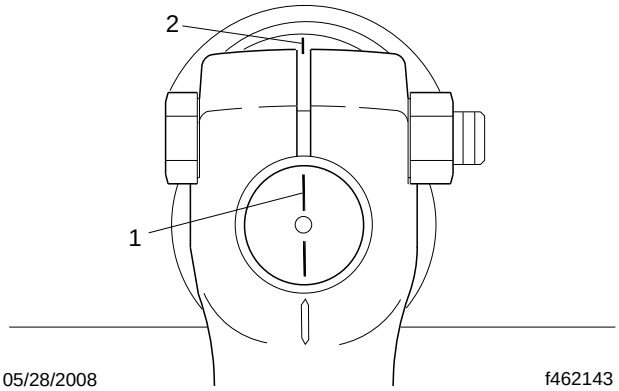
**Fig. 1, Steering Gear Installation**

2. Center the steering gear so that the timing mark on the sector shaft is aligned with the timing mark on the steering gear housing. See **Fig. 2**. Keep the steering gear centered as the installation continues.
3. Connect the steering driveline to the steering gear input shaft.
   - 3.1 Clean the steering gear input shaft and the inside of the driveline yoke.
   - 3.2 Apply a thin film of grease to the yoke spline.

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## Steering Gear Removal and Installation




1. Housing Timing Mark
2. Sector Shaft Alignment Mark

**Fig. 2, Timing Mark Placement**

3.3 Slide the yoke on the input shaft and install a new pinch bolt and nut. Tighten the nut 30 to 35 lbf·ft (41 to 47 N·m).

3.4 Apply torque seal, OGP F900WHITE, to the exposed bolt threads and the nut to indicate the fasteners have been properly tightened.

**⚠ WARNING**

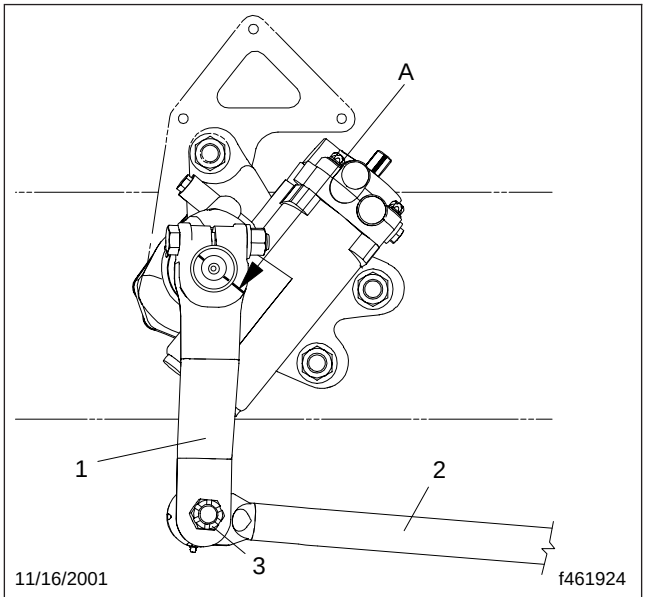
**Never leave a chisel wedged in the pitman arm slot. When using a chisel to spread the slot in the pitman arm, maintain a firm grip on the chisel at all times. Otherwise the chisel may fly loose, which could cause an injury.**

NOTE: The pitman arm may not fit over the splines on the sector shaft without spreading the slot in the arm. Use a ball-peen hammer to drive a chisel into the slot. Hold the chisel in place. Install the pitman arm on the sector shaft. Remove the chisel from the slot.

4. Install the pitman arm.

4.1 Position the pitman arm on the steering gear, aligning the timing mark as shown in **Fig. 3**.

4.2 Using a new pinch bolt, nut, and washer (if applicable), attach the pitman arm to the steering gear sector shaft.




A. The timing mark on the pitman arm must line up with the timing mark on the sector shaft.

1. Pitman Arm
2. Drag Link
3. Castle Nut

**Fig. 3, Pitman Arm**

Tighten the nut 200 to 230 lbf·ft (272 to 313 N·m).

4.3 Apply torque seal, OGP F900WHITE, to the exposed bolt threads and the nut to indicate the fasteners have been properly tightened.

5. If they were removed, attach the hydraulic line fittings to the steering gear. Tighten the fittings 38 lbf·ft (52 N·m). Tighten the pressure line fitting jam nut 41 lbf·ft (56 N·m).
6. Remove the plugs from the hydraulic lines. Connect the lines to the steering gear as previously marked. Tighten the nut on each fitting finger tight. Then, use a wrench to tighten the nut until there is firm resistance. Tighten 1/6 of a turn more.
7. Connect the batteries.
8. Fill and bleed the steering system.

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**WARNING**

**Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.**

8.1 Fill the power steering reservoir nearly full with automatic transmission fluid. Do not turn the steering wheel.

8.2 Start the engine and let it idle for ten seconds, then shut it off. Check and fill the reservoir. Repeat this step at least three times, checking the fluid level in the reservoir each time.

IMPORTANT: Do not let the fluid level drop significantly or allow the reservoir to empty. Doing so may introduce air into the system.

8.3 Start the engine and let it idle for two minutes. Do not turn the steering wheel. Shut off the engine and check the fluid level in the reservoir. If needed, add more fluid.

8.4 Start the engine again. Steer the vehicle from full left to full right several times. Check and, if necessary, refill the reservoir.

Automatic bleed systems should now be free of trapped air. Skip to the last step in this procedure.

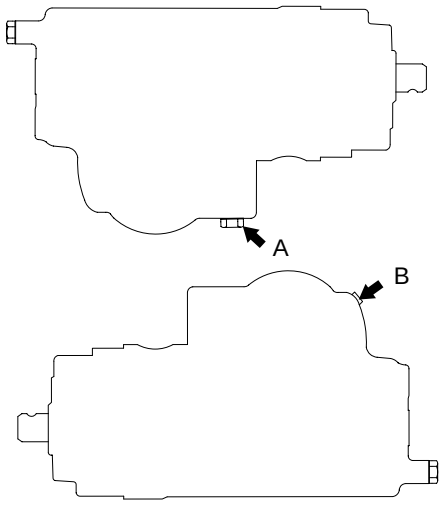
If the vehicle has a manual bleed system (**Fig. 4**), proceed to the next step.

IMPORTANT: Do not turn the steering wheel while the bleed screw is loosened.

8.5 With the wheels in the straight-ahead position, loosen the manual bleed screw two to three turns. Allow air and aerated fluid to bleed out until only clear fluid is seen. Close the bleed screw and add fluid to the reservoir if needed.

Repeat this step until all air is out of the system.

Tighten the bleed screw 45 lbf·in (509 N·cm).




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A. Steering gear with automatic bleed plug. Do not remove the bleed plug.
B. Steering gear with manual bleed plug.

**Fig. 4, Steering Gear Bleed Systems**

9. Close the hood and perform the post-service checks in **Subject 130**.

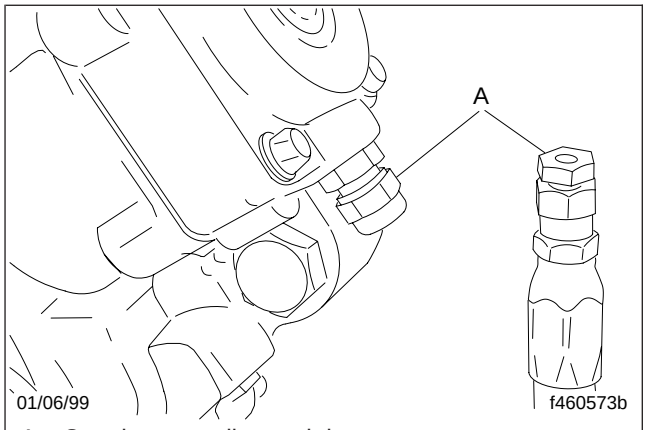
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## Replacement

NOTE: The power steering pump is used in this procedure to force out the input shaft seal. To use this procedure, the power steering pump should have a minimum of 1500 psi (10 342 kPa) available.

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Disconnect the return line from the steering gear and plug the line. See **Fig. 1**. Cap the return port of the gear with a high-pressure fitting.




A. Cap the return line and the return port.

**Fig. 1, Disconnected Return Line**

### NOTICE

**Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.**

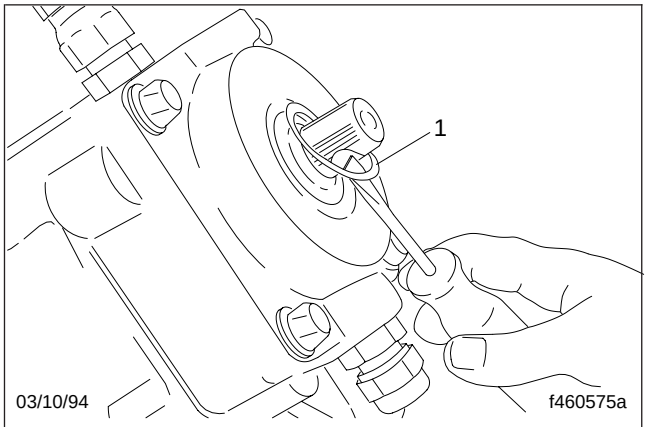
3. Disconnect the steering driveline from the steering gear input shaft.

   3.1 Remove and discard the pinch bolt and nut from the steering driveline lower end yoke.

   IMPORTANT: Do not turn the steering gear input shaft when removing the lower end yoke.

   3.2 Remove the lower end yoke from the input shaft. Push the driveline shaft into the driveline tube as you remove the lower end yoke.

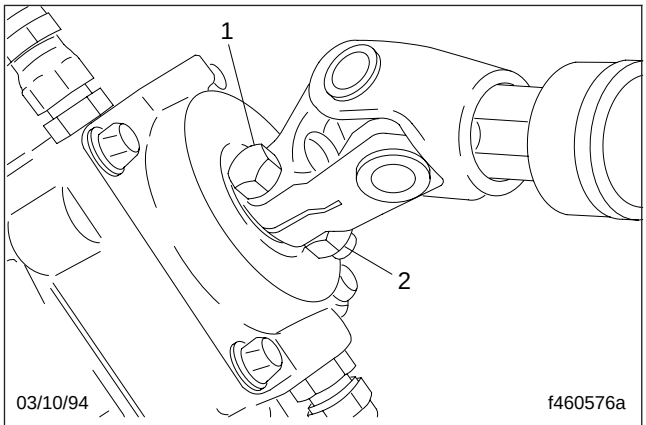
4. Remove the dirt and water seal from the steering gear. Save this seal to determine the correct size of the new seal.
5. Using a clean cloth, remove all grease from around the input shaft.
6. Using a screwdriver inserted into the notch formed in the end of the retaining ring, remove the retaining ring. See **Fig. 2**. Be careful not to scratch the bore with the screwdriver.




1. Retaining Ring

**Fig. 2, Retaining Ring Removal**

7. Slip the driveline lower end yoke back on the input shaft, then insert but do not tighten the pinch bolt. See **Fig. 3**.




1. Pinch Bolt 2. Pinch Bolt Nut

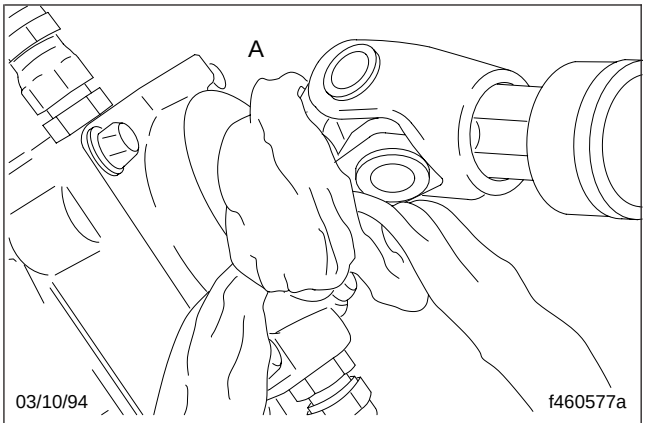
**Fig. 3, Pinch Bolt Installation**

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## Input Shaft Seal Replacement

8. Tie or wrap a shop towel around the input shaft area and place a drip pan under the vehicle to catch the oil. See **Fig. 4**.



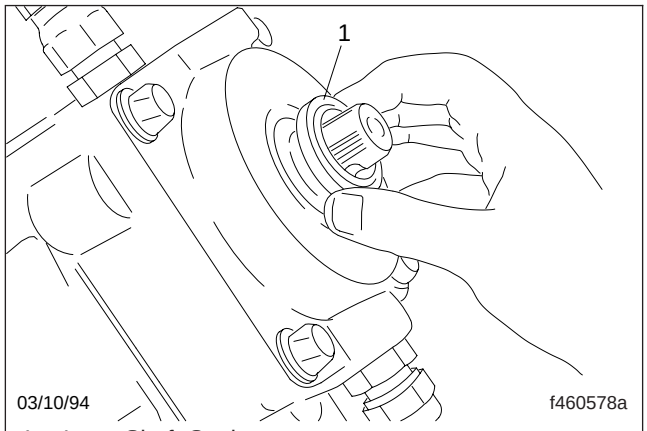

A. Cover the input shaft area.

**Fig. 4, Shop Towel Covering the Input Shaft**

**WARNING**

**Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.**

9. If needed, fill the power steering reservoir with automatic transmission fluid.
10. With the vehicle in neutral, momentarily turn the starter. If the engine starts, quickly turn it off. This should force out the input shaft seal.
11. Remove the shop towel, pinch bolt, and input yoke. Remove the input shaft seal. See **Fig. 5**.
12. Inspect the seal area of the valve housing for seal fragments. Remove any seal fragments.
13. Check the seal for heat damage. If the seal is stiff and brittle, and not pliable like the new seal, it is probably heat damaged. Determine and fix the cause of any excessive heat in the vehicle. Discard the old seal.




1. Input Shaft Seal

**Fig. 5, Input Shaft Seal Removal**

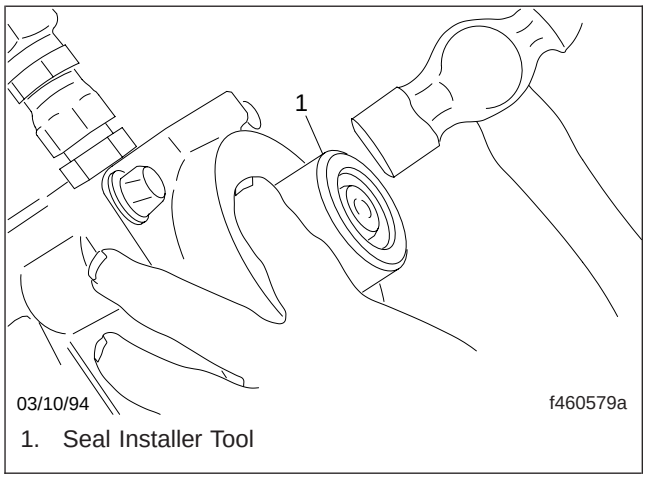
**WARNING**

**Do not use a socket to install the input shaft seal. You will not be able to control the seal installation depth with a socket and this could lead to leaks. Leaks could result in loss of steering assist and spillage on the roadway, which could result in personal injury or property damage.**

14. Install a new input shaft seal.
    - 14.1 Using Exxon Polyrex® EP2 grease (045422), lubricate the inside diameter of the new input shaft seal and install it on the input shaft.
    - 14.2 Using a hammer and seal driver (J37073), tap the driver until the shoulder of the driver is square against the valve housing. See **Fig. 6**. Remove any seal material that may have sheared off in the seal bore or retaining ring groove.
15. Install a new retaining ring in the groove.
16. Using Exxon Polyrex EP2 grease, pack the end of the valve housing bore and around the input shaft with clean grease.
17. Install a new dirt and water seal.
    - 17.1 Choose the correct size dirt and water seal by comparing the replacement seals to the old seal.
    - 17.2 Apply Exxon Polyrex EP2 grease to the new dirt and water seal and install it on the input shaft. See **Fig. 7**. Seat it in the

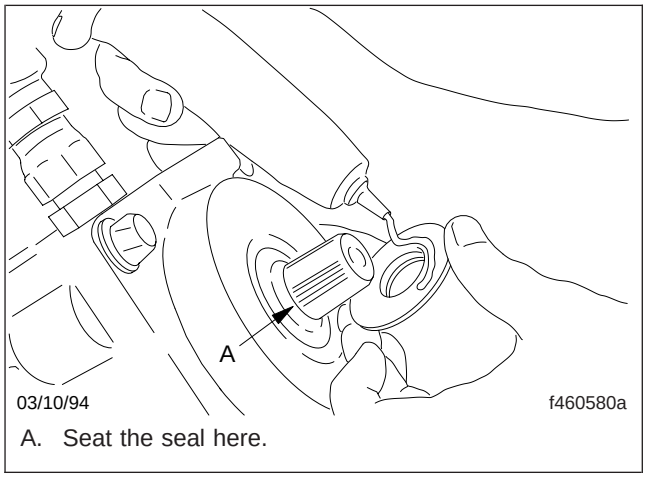
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1. Seal Installer Tool

**Fig. 6, Seal Installer Tool Position**




A. Seat the seal here.

**Fig. 7, Dirt and Water Seal Installation**

groove behind the serrations and against the valve housing.

Wipe any excess grease from the valve housing bore and input shaft once the seal has been installed.

18. Connect the steering driveline to the steering gear input shaft.

    18.1 Clean the input shaft and the inside of the driveline yoke.

    18.2 Apply a thin film of grease to the yoke splines.

    18.3 Slide the yoke on the input shaft and install a new pinch bolt and nut. Tighten the nut 30 to 35 lbf·ft (41 to 47 N·m).

    18.4 Apply torque seal, OGP F900WHITE, to the exposed bolt threads and the nut to indicate the fasteners have been properly tightened.

19. Connect the return line to the steering gear return port.

20. Fill and bleed the steering system.

**⚠ WARNING**

**Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.**

    20.1 Fill the power steering reservoir nearly full with automatic transmission fluid. Do not turn the steering wheel.

    20.2 Start the engine and let it idle for ten seconds, then shut it off. Check and fill the reservoir. Repeat this step at least three times, checking the fluid level in the reservoir each time.

IMPORTANT: Do not let the fluid level drop significantly or allow the reservoir to empty. Doing so may introduce air into the system.

    20.3 Start the engine and let it idle for two minutes. Do not turn the steering wheel. Shut off the engine and check the fluid level in the reservoir. If needed, add more fluid.

    20.4 Start the engine again. Steer the vehicle from full left to full right several times. Check and, if necessary, refill the reservoir.

    Automatic bleed systems should now be free from trapped air.

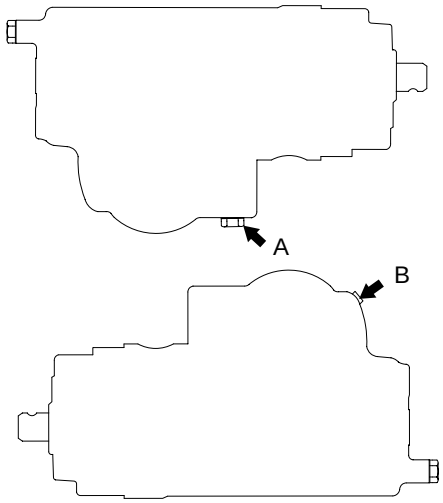
    If the vehicle has a manual bleed system (**Fig. 8**), proceed to the next step.

IMPORTANT: Do not turn the steering wheel while the bleed screw is loosened.

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## Input Shaft Seal Replacement




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A. Steering gear with automatic bleed plug. Do not remove the bleed plug.
B. Steering gear with manual bleed plug.

**Fig. 8, Steering Gear Bleed Systems**

20.5 With the wheels in the straight-ahead position, loosen the manual bleed screw two to three turns. Allow air and aerated fluid to bleed out until only clear fluid is seen. Close the bleed screw and add fluid to the reservoir if needed.

Repeat this step until all air is out of the system.

Tighten the bleed screw 45 lbf·in (509 N·cm).

21. Perform the post-service checks in **Subject 130**.

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## Post-Service Checks

After power steering components have been worked on and before the vehicle is placed into service, the following items must be checked.

**⚠ WARNING**

**Failure to check the following items could result in damage to the power steering system. This could cause loss of steering assist and spillage on the roadway, which could cause personal injury or property damage.**

1. Operate the engine at low idle while turning the steering wheel through several full-left and full-right turns. With the engine running and the power steering system at operating temperature, turn the steering wheel slowly from stop to stop while checking the power steering reservoir for frothing or a change in the fluid level (signs that air is trapped in the system).

   If air is present, inspect the system for leaking hoses or loose fittings. Replace the hoses or tighten the fittings as necessary. Bleed the air from the system.
2. With the engine turned off and warm, check the power steering reservoir fluid level. If needed, add power steering fluid.
3. At full-left and full-right wheel cuts, be sure the axle stops (on the rear-side of the spindle) are set so there is at least 1/2-inch (13-mm) clearance between the tires and any fixed components that are attached to the vehicle. Clearance between moving components should be 3/4 of an inch (19 mm). If clearance is less than this, reset the axle stops.
4. Check that the poppets are set correctly. If necessary, adjust them. For instructions, see **Subject 100**.
5. If there are still problems with the power steering system, perform the troubleshooting procedures in **Section 46.06**. Otherwise, go to the next step.
6. Test drive the vehicle and check the steering wheel spoke position. With the front tires pointing straight ahead, check the position of the steering wheel spokes. They must be pointing within ±10 degrees of the 9 o'clock and 3 o'clock positions on a four-spoke steering wheel. If not, remove the steering wheel and install it in the correct position. See **Fig. 1**.

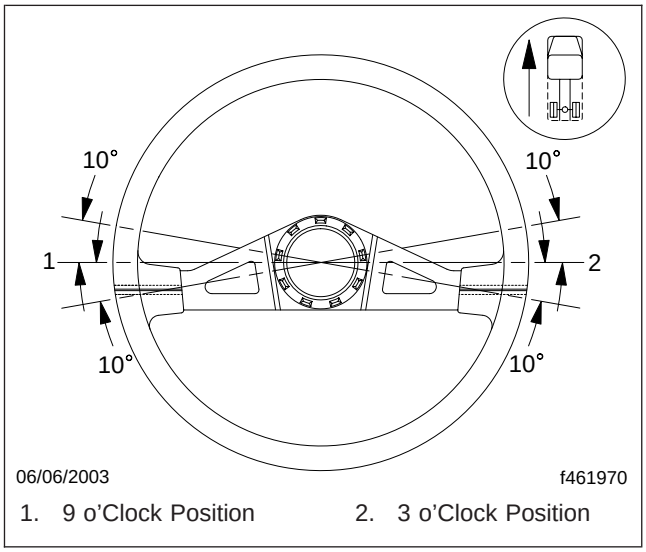



**Fig. 1, Steering Wheel Centered**

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## Specifications

**⚠ WARNING**

**Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.**

TRW TAS power steering gears use automatic transmission fluid that meets Dexron II, Dexron III, Mercon, or ATF +4™ specifications.

Exxon Polyrex® EP2 Grease (045422) is approved for use on steering gear components.

Special tools can be ordered from:

SPX Kent-Moore
28635 Mount Road
Warren, Michigan 48092-3499
1-800-328-6657

| SPX Kent-Moore Tools | | |
|---|---|---|
| Kent-Moore Part Number | | Tool |
| TAS65 | TAS85 | |
| J37070 | J37070 | Adjuster Tool |
| J37464 | J37464 | Adjuster Locknut Tool |
| J37071 | J38779 | Bearing and Seal Tool |
| J37073 | J37073 | Seal Installer Tool |
| J38713 | J38713 | Poppet Adjuster Seat Tool, Heavy-Duty (preferred) |
| J36452 | J36452 | Poppet Adjuster Seat Tool |
| J37130 | J37130 | Relief Valve Plug |
| J8092 | J8092 | Tool Handle |

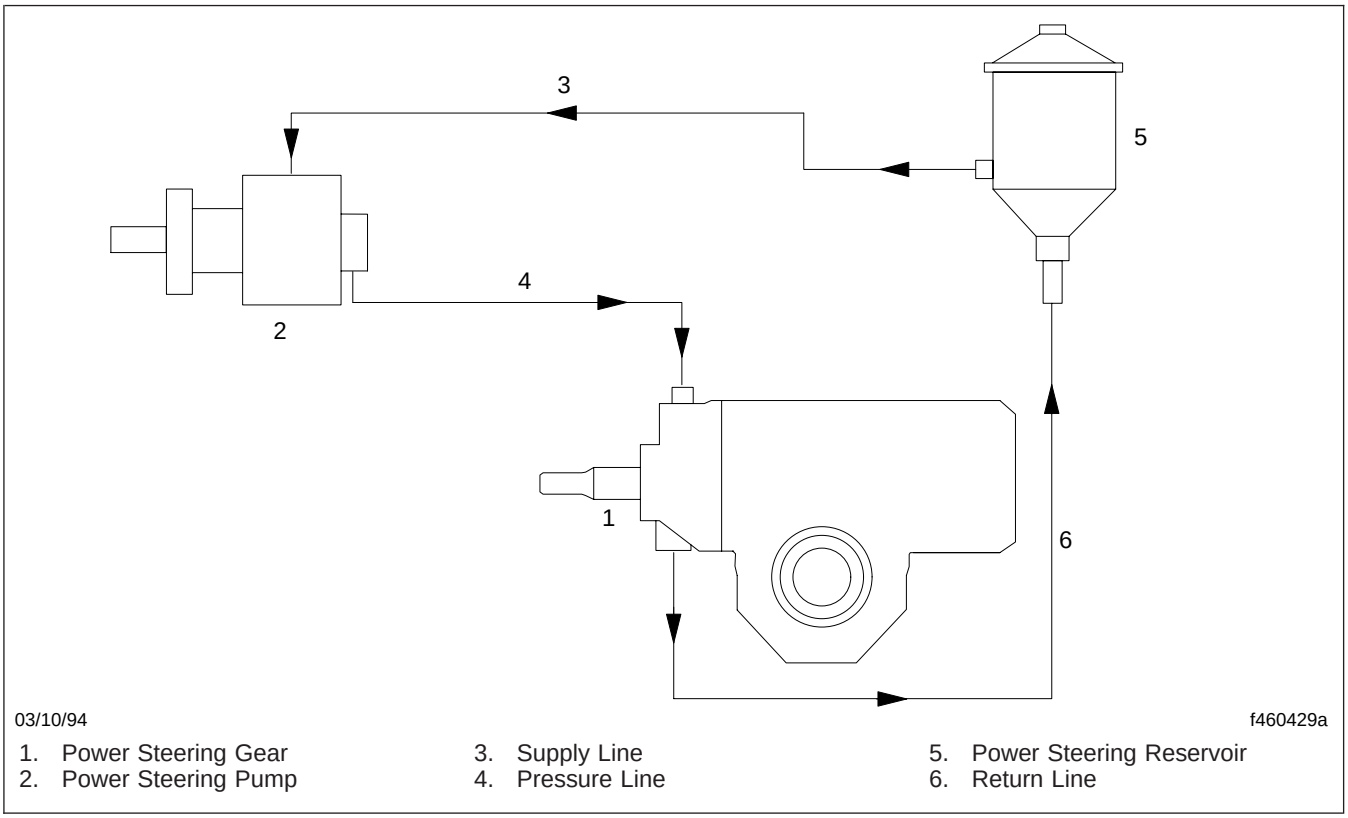
**Table 1, SPX Kent-Moore Tools**

See **Fig. 1** for the steering system plumbing diagram.
See **Fig. 2** for the steering gear mounting diagram.

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## Specifications

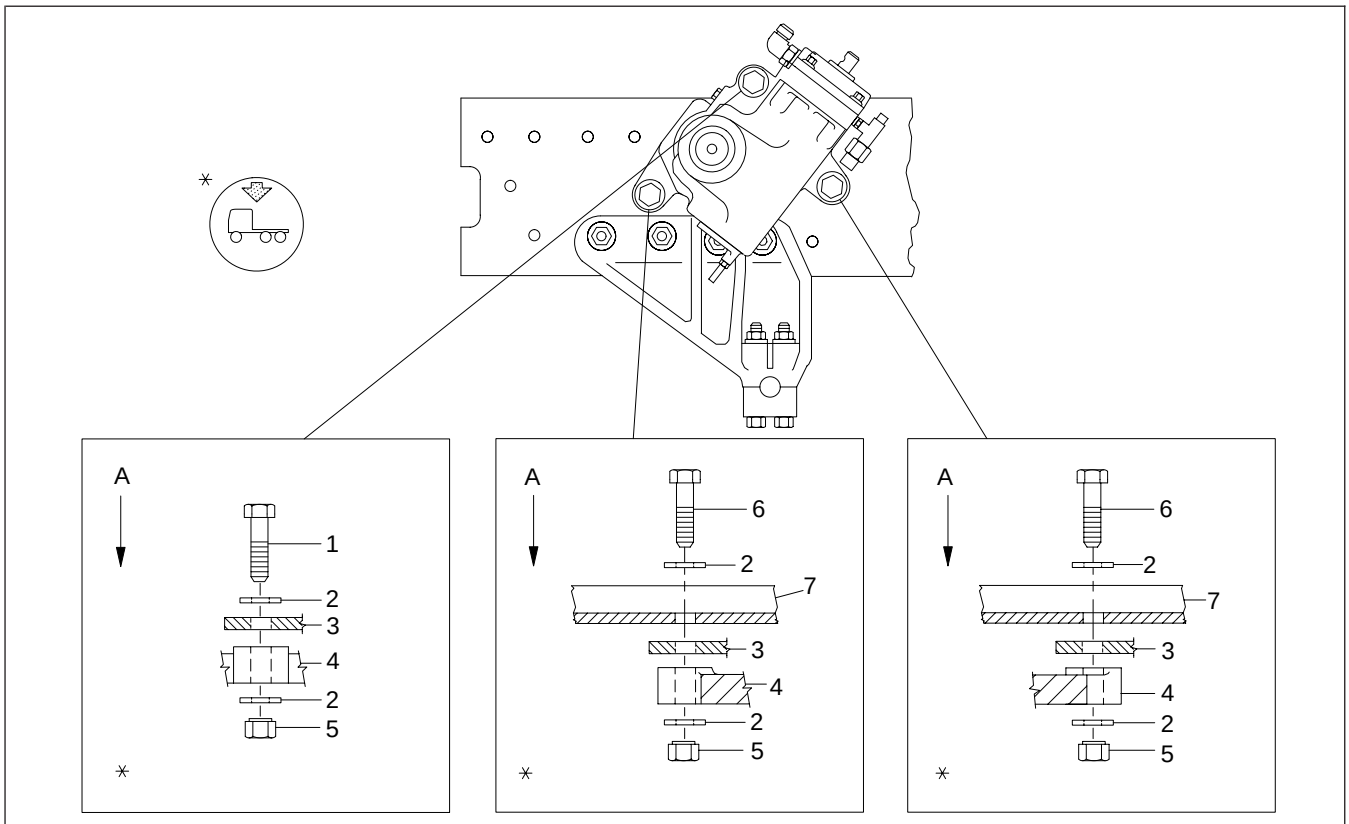



1. Power Steering Gear
2. Power Steering Pump
3. Supply Line
4. Pressure Line
5. Power Steering Reservoir
6. Return Line

**Fig. 1, Plumbing Diagram**

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A. Outboard

1. 7/8–14 x 4-1/2 Bolt
2. Washer
3. Gear Mounting Bracket
4. Steering Gear
5. 7/8–14 Nut
6. 7/8–14 x 5-1/2 Bolt
7. Frame Rail

**Fig. 2, Steering Gear Mounting**

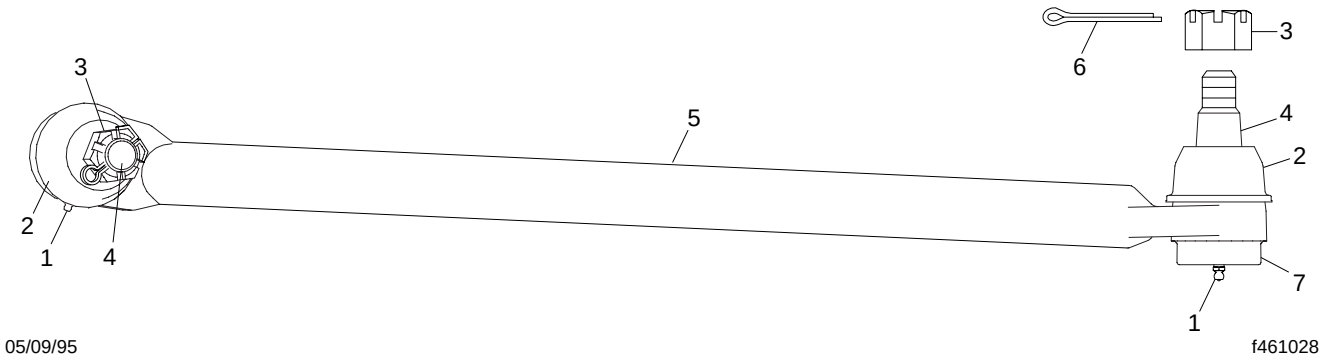
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## General Information

A fixed-length drag link assembly (**Fig. 1**) connects the steering gear pitman arm to the axle steering arm. The ball stud and socket assemblies at each end of the drag link prevent binding when the relative angles of the pitman arm and steering arm change, which happens when the vehicle is steered or the front axle moves up or down.

Both ball-stud sockets of a fixed-length drag link assembly are an integral part of the drag link; they cannot be moved to change its length. See **Fig. 1**. The ball studs and sockets are a dual-seat design.




1. Grease Fitting
2. Ball Stud Cover
3. Castle Nut
4. Tapered Ball Stud
5. Drag Link
6. Cotter Pin
7. Dust Cap

**Fig. 1, Fixed-Length Drag Link Assembly**

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# Drag Link Removal and Installation

## Removal

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where service work will be done. *Do not move the tires from the straight-ahead position during removal or at any time while the drag link is removed.*
2. Apply the parking brakes and chock the rear tires.
3. Tilt the hood.
4. At both ends of the drag link, remove the cotter pins and castle nuts from the ball studs. See **Fig. 1**.
5. Using a ball stud removal tool, remove the ball studs from the pitman arm and the axle steering arm.
6. Check the ball stud cover for damage. If needed, replace the cover using the instructions in **Subject 120**.

## Installation

1. Insert the axle-end ball stud up through the bottom of the axle steering arm, then install the castle nut, finger-tight.
2. Turn the steering wheel as needed to align the hole in the lower end of the pitman arm with the forward ball stud. Insert the ball stud in the pitman arm from the inboard side. Install the castle nut. See **Fig. 1**.
3. Tighten both of the castle nuts:
   - 3/4–16; 90 to 170 lbf·ft (122 to 230 N·m)
   - 7/8–14; 160 to 300 lbf·ft (217 to 407 N·m)

   If needed, continue tightening each nut until a slot on the nut aligns with the hole in the ball stud. *Do not back off the nut to align it with the cotter pin hole.*
4. Install and lock a new cotter pin in each of the ball studs and nuts.

**⚠ WARNING**

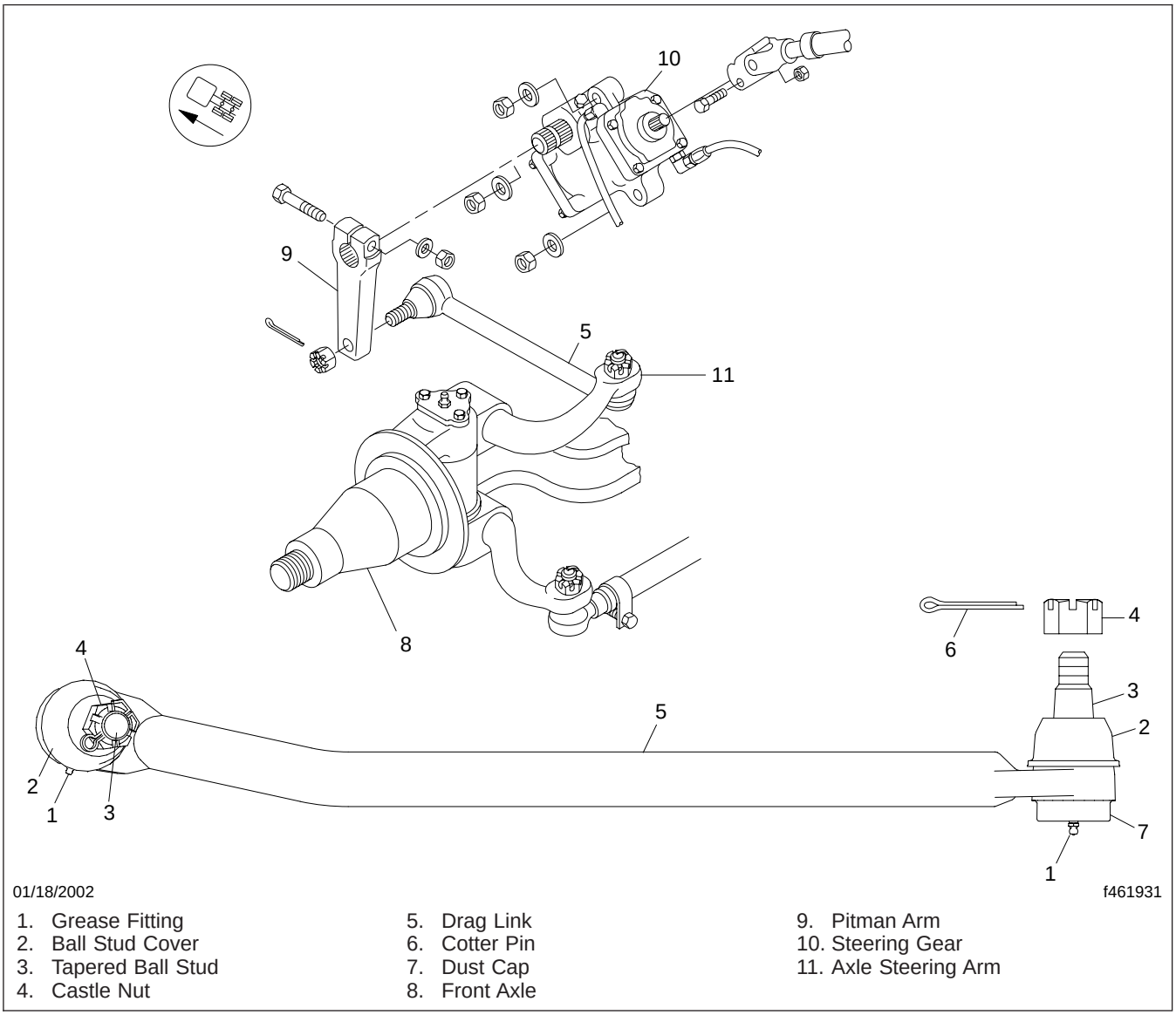
**Install and lock new cotter pins in the ball studs and nuts. Failure to do so could result in disengagement of the components, causing loss of steering control, which could result in personal injury and property damage.**

5. Check the vehicle maintenance manual to determine if lubrication of the drag link is required. If so, follow the instructions in the maintenance manual.
6. Check the axle stop settings, and adjust them if needed. For instructions, refer to **Group 33**.
7. Check the settings of the steering gear poppet valves (TRW) or relief valve plungers (Sheppard). Adjust them if needed. For instructions on checking and adjusting, refer to the applicable steering gear section elsewhere in this group.
8. With the front tires straight ahead, and no load on the vehicle, the steering wheel spokes should be centered as shown in **Fig. 2**. If not, remove the steering wheel and install it in the correct position.
9. Return the hood or cab to the operating position. For cab lowering instructions, see **Group 60**.

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## Drag Link Removal and Installation




1. Grease Fitting
2. Ball Stud Cover
3. Tapered Ball Stud
4. Castle Nut
5. Drag Link
6. Cotter Pin
7. Dust Cap
8. Front Axle
9. Pitman Arm
10. Steering Gear
11. Axle Steering Arm

**Fig. 1, Drag Link Installation**

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## Drag Link Removal and Installation

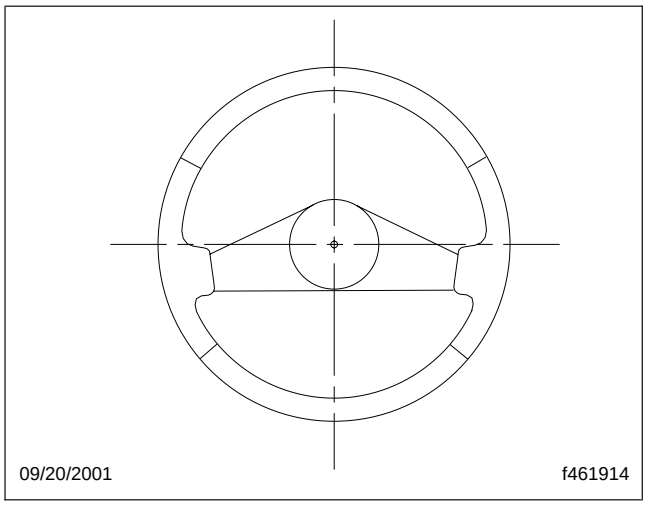



**Fig. 2, Steering Wheel Centered**

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## Testing

**WARNING**

**All steering mechanisms are essential to the safe operation of the vehicle. Follow the instructions in this subject exactly. Failure to do so may result in loss of steering, which could cause personal injury or property damage.**

Have someone gently turn the steering wheel back and forth; check for looseness between the ball stud end, and both the pitman arm and steering arm. Also check for looseness of the ball stud nut.

If the ball stud *end* is loose, replace the drag link. If the ball stud *nut* is loose, replace the nut and cotter key. Tighten the ball stud nut as follows (see **Table 1**):

| Size | Torque: lbf·ft (N·m) |
|---|---|
| 3/4–16 | 90–170 (122–230) |
| 7/8–14 | 160–300 (217–407) |

**Table 1, Torque Values**

Grasp the drag link near the pitman arm end, push and pull laterally to check for axial looseness in the ball stud end. If there is looseness, replace the drag link. For instructions, refer to **Subject 100**. If there is 1/8-inch (3-mm) looseness or more, do not drive the vehicle until the drag link is replaced.

Grasp the drag link near the steering arm end. Push and pull vertically to check for axial looseness in the ball stud end. If there is looseness, replace the drag link. For instructions, refer to **Subject 100**. If there is 1/8-inch (3-mm) looseness or more, do not drive the vehicle until the drag link is replaced.

Grease the drag link until the old grease is purged.

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## Replacement

1. Remove the drag link. For instructions, see **Subject 100**.

**CAUTION**

**Use care when removing the ball stud cover with a screwdriver. Damage to the sealing surface of the socket forging could occur.**

2. Using a screwdriver, press or tap on the flanged portion of the cover and remove it from the ball stud socket assembly. See **Fig. 1**.
3. Using a clean rag, wipe off all grease and dirt from around the ball stud and socket throat.
4. Grease the socket throat and ball stud with a multipurpose chassis grease NLGI Grade 2 (8% 12-hydroxy lithium stearate grease) or NLGI Grade 1 (6% 12-hydroxy lithium stearate grease); Grade 2 is preferred. Using the same grease, fill the new ball stud cover three-quarters full.
5. Position the socket assembly in a large vise, or on a press so that the ball stud is perpendicular to the socket stem.

**CAUTION**

**Do not use a screwdriver, chisel, or punch (or any other sharp-pointed tool) to install the ball stud cover. Using these types of tools could cut and damage the cover.**

IMPORTANT: To install the stud cover, use a section of tubing that has an inside diameter as close as possible to the outside diameter of the stud cover. Also, make sure that the inside edge of the tube is chamfered (angled) to avoid cutting the rubber stud cover.

6. Using a section of tubing, press on the new stud cover. The cover is in place when the flanged portion of the cover is seated on the machined section (sealing face) of the socket forging.

**CAUTION**

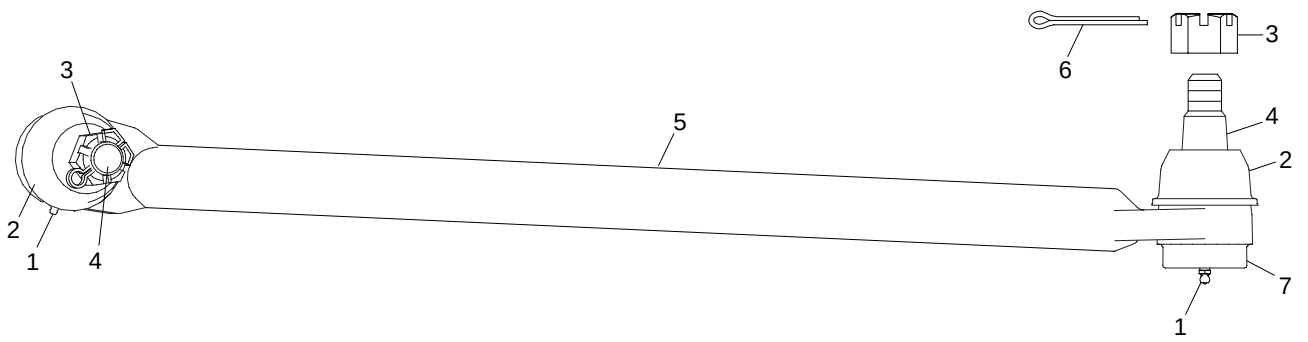
**Do not apply excessive pressure when pressing on the seal. Too much pressure during installation could deform the cover and result in incorrect sealing.**

7. Install the drag link. For instructions, see **Subject 100**.

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## Ball Stud Cover Replacement




1. Grease Fitting
2. Ball Stud Cover
3. Castle Nut
4. Tapered Ball Stud
5. Drag Link
6. Cotter Pin
7. Dust Cap

**Fig. 1, Drag Link Assembly**

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# General Information

The Douglas telescoping/tilt steering column is equipped with an emergency warning flasher control, a combination turn signal switch and dimmer switch, and a tilt control lever. See **Fig. 1**.

To change position of your tilt steering wheel, pull the tilt lever toward you and move the steering wheel to the desired position, then release the lever. This permits individual selections of the most comfortable positions for all driving conditions. To telescope the steering wheel, push the lever and extend or retract the steering wheel as desired.

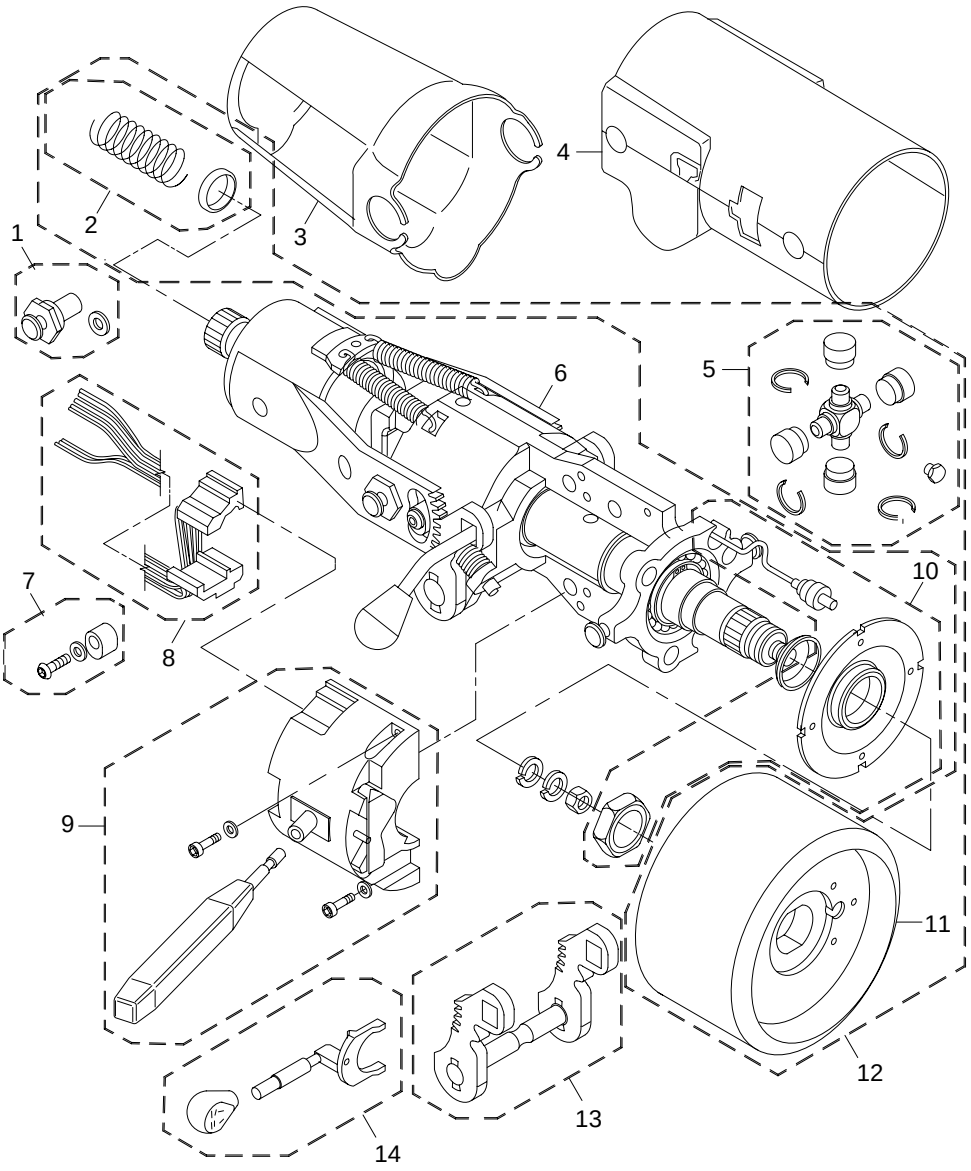
For instructions on using the turn signal switch, the hazard light switch or the dimmer switch, see the *Western Star Driver's Manual*.

The steering wheel and the horn button are supplied separately. See **Fig. 2**.

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## General Information




1. Tilt Bolt
2. Anti-Rattle Spring
3. Trough Cover
4. Upper/Lower Cover
5. U-Joint
6. Column Core
7. Tilt Stop
8. Wire Harness
9. Turn Signal
10. Horn Brush
11. Gap Hider
12. Anti-Noise Cover
13. Rod and Pawl
14. Tilt Lever

**Fig. 1, Tilt Steering Column Assembly**

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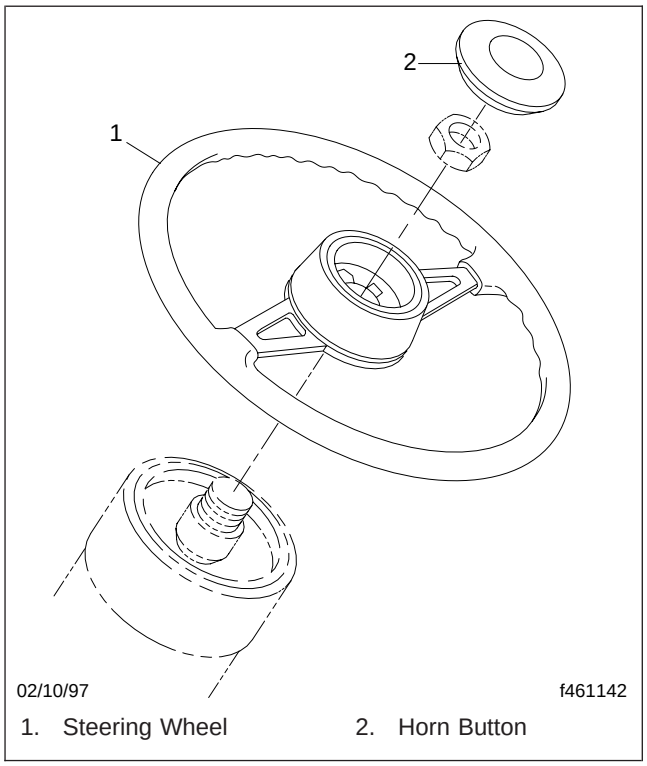



**Fig. 2, Steering Wheel and Horn Button Installation**

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## Steering Wheel Removal and Installation

# Removal

IMPORTANT: Don't turn the steering wheel at any time during the removal procedure.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Disconnect the batteries at the negative terminal.
3. Using a small screwdriver, carefully pry out the horn button. See **Fig. 1**.

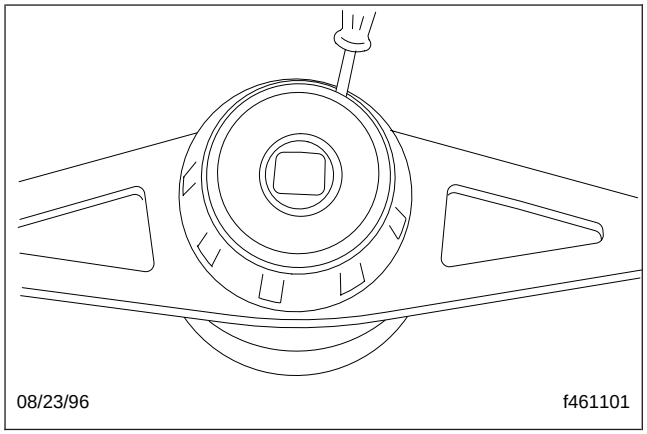
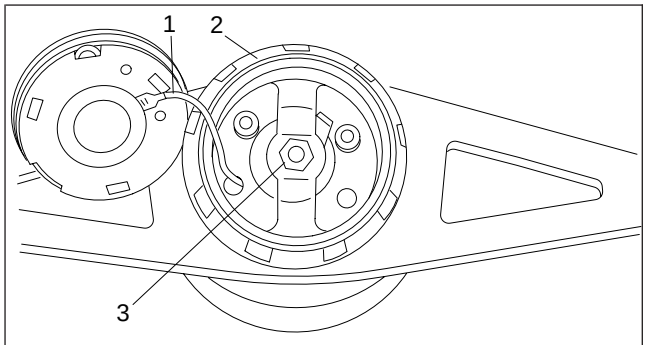



**Fig. 1, Pry out the Horn Button**

4. Unhook the wire connector and remove the horn button. See **Fig. 2**. Remove the nut, lockwasher, and the locking knob.

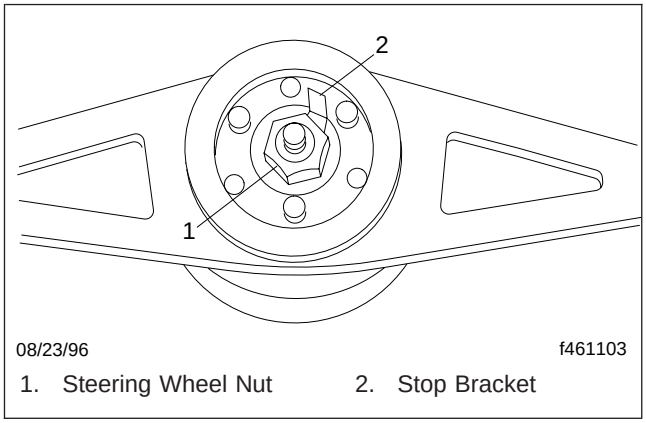



1. Wire Connector
2. Locking Knob
3. Nut

**Fig. 2, Unhook the Wire Connector**

NOTE: There is another lockwasher under the locking knob. Remove this lockwasher.

5. Using a deep socket, remove the steering wheel nut and stop bracket. See **Fig. 3**.




1. Steering Wheel Nut
2. Stop Bracket

**Fig. 3, Remove the Steering Wheel Nut**

IMPORTANT: Mark the steering wheel-to-shaft alignment to ensure proper installation.

6. Using a steering wheel puller, remove the steering wheel from the steering column.

# Installation

1. Make sure the front tires are pointed straight ahead and the steering gear is centered.
2. Put the steering wheel on the steering column so that the spokes are within 10 degrees of the 3 o'clock and 9 o'clock positions. See **Fig. 4**.
3. Thread the horn wire through the steering wheel. Using the alignment marks made during removal, position the wheel on the shaft.
4. Install the stop bracket and a new steering wheel nut. Tighten the nut 30 lbf·ft (41 N·m).
5. Install the lockwashers (one is installed under the locking knob), locking knob, and nut. Turn the locking knob until it rests against the stop bracket. Tighten the nut 10 lbf·ft (13 N·m).
6. Connect the horn wire and install the horn button in the steering wheel hub.

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## Steering Wheel Removal and Installation

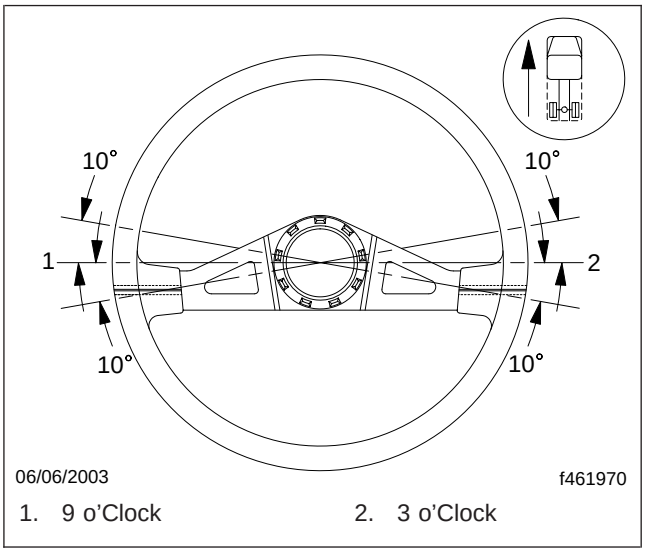



**Fig. 4, Centered Steering Wheel**

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# Steering Column Assembly Removal and Installation

## Removal

1. Park the vehicle on a level surface. Make sure the front tires are pointing forward. Apply the parking brakes. Shut down the engine. Chock the tires.

IMPORTANT: Once the vehicle is parked, do not turn the steering wheel at any time during the following procedures.

2. Disconnect the batteries.
3. Remove the steering wheel. For instructions, see **Subject 100**.
4. Remove the pinch-bolt nut and pinch bolt from the upper end yoke. Discard the nut and the bolt.
5. Disconnect the wiring harness connectors.
6. Remove the capscrews, washers, and nuts that attach the mounting brackets to the support column. See **Fig. 1**.
7. Remove the steering column assembly from the vehicle.

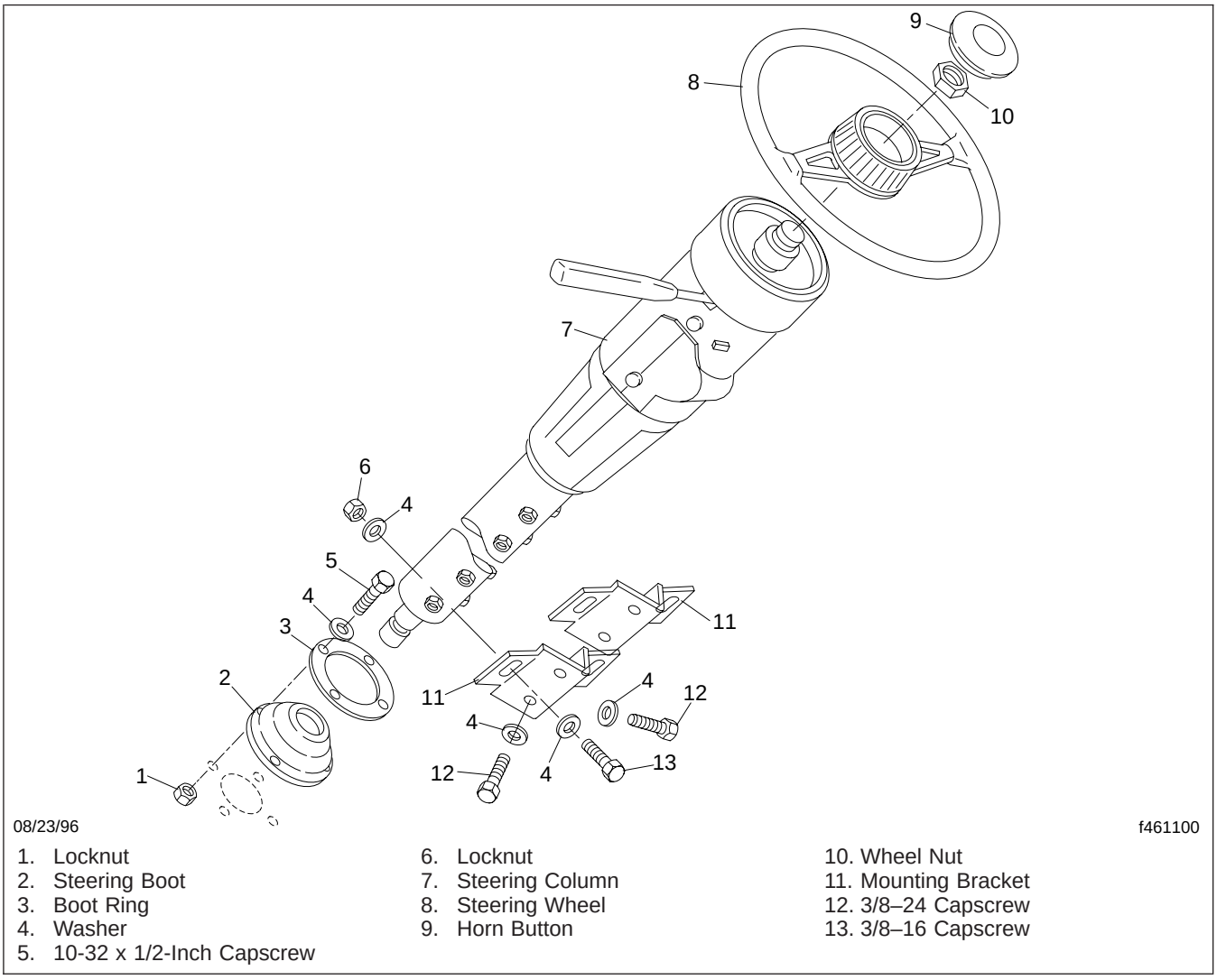
## Installation

1. Position the steering column in the vehicle, inserting the column through the floor opening. Tighten the nuts 26 lbf·ft (35 N·m).
2. Position the mounting brackets and loosely install the mounting fasteners.
3. Wipe the end of the column shaft with a clean, dry cloth.
4. Slide the upper end yoke onto the column shaft. Install a new end yoke pinch bolt. Before installing the pinch-bolt nut, make sure the pinch bolt is centered in the steering column shaft notch. The pinch bolt is centered if it can slip in and out of the end yoke with ease. Install and tighten a new pinch-bolt nut. For the proper torque, see **Specifications, 400**.
5. Apply torque seal OGP F900WHITE to the exposed pinch-bolt threads and to the locknut.
6. Tighten the mounting bracket capscrews 17 lbf·ft (23 N·m).
7. Connect the wiring harness connectors.
8. Install the steering wheel. For instructions, see **Subject 100**.
9. Connect the batteries.
10. Remove the chocks from the tires.
11. Test drive the vehicle and make sure the steering column assembly operates smoothly. If it does not operate smoothly, repeat the service operations.

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## Steering Column Assembly Removal and Installation




1. Locknut
2. Steering Boot
3. Boot Ring
4. Washer
5. 10-32 x 1/2-Inch Capscrew
6. Locknut
7. Steering Column
8. Steering Wheel
9. Horn Button
10. Wheel Nut
11. Mounting Bracket
12. 3/8–24 Capscrew
13. 3/8–16 Capscrew

**Fig. 1, Steering Column Assembly Installation**

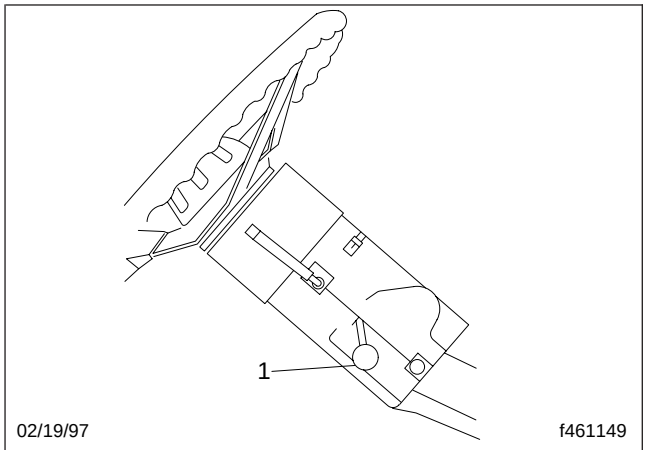
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## Replacement

If any of the steering column components require service beyond what is listed in this subject, complete replacement is required.

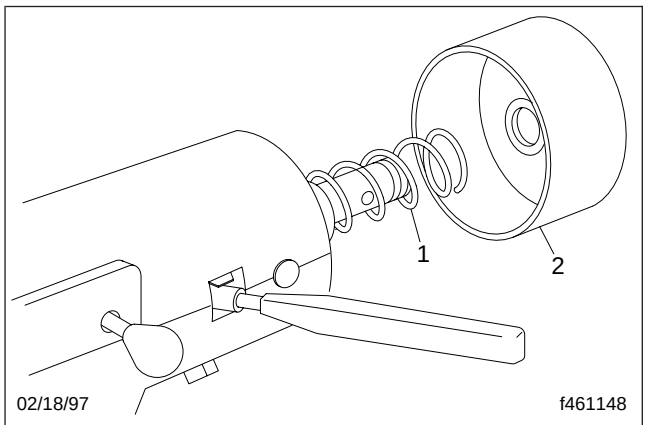
1. If the tilt control lever knob requires replacement, unscrew it from the lever. See **Fig. 1**.




1. Knob

**Fig. 1, Tilt Control Lever**

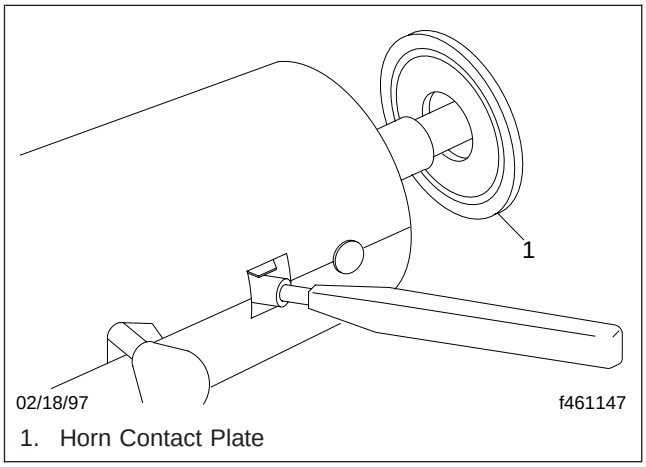
2. Remove the steering wheel. For instructions, refer to **Subject 100**.
3. Remove the cover assembly. **Fig. 2**.




1. Telescoping Spring
2. Cover Assembly

**Fig. 2, Steering Column, Cover Removed**

4. Remove the telescoping spring.
5. Remove the horn contact plate assembly. See **Fig. 3**.




1. Horn Contact Plate

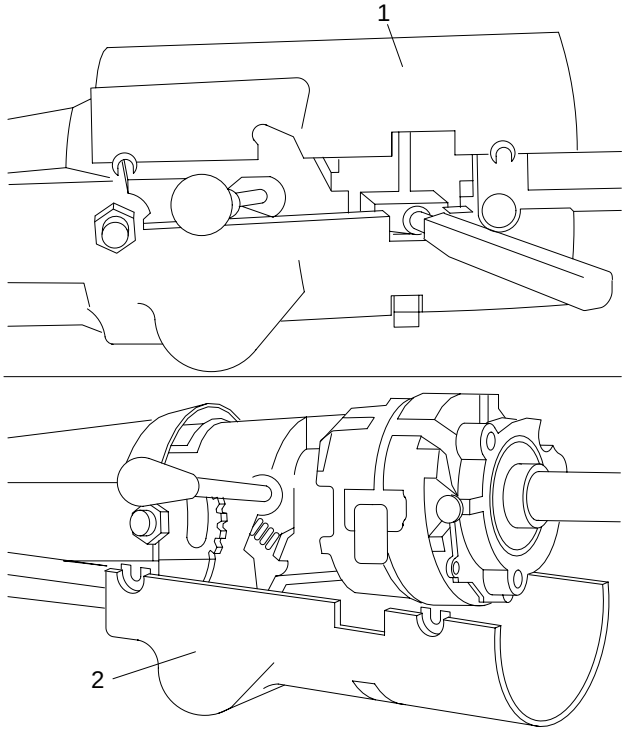
**Fig. 3, Steering Column, Horn Contact Plate Removed**

6. Carefully remove the upper and lower covers from the column. See **Fig. 4**.
7. If necessary to remove, tap the horn plunger assembly upward from the housing. Install the new plunger assembly by tapping it carefully into place. See **Fig. 5**.
8. Remove two screws and remove the turn signal switch assembly. See **Fig. 6**.
9. If the bottom of the cover assembly requires replacement, you must remove the steering column from the vehicle. See **Fig. 7**. For instructions, refer to **Subject 110**.
10. Install the necessary components and assemble the steering column in the reverse order.

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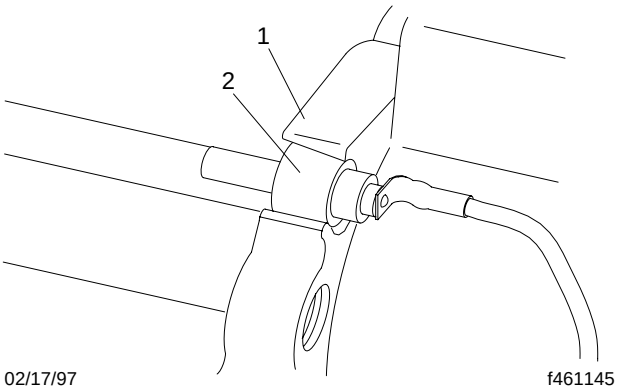


## Steering Column Component Replacement



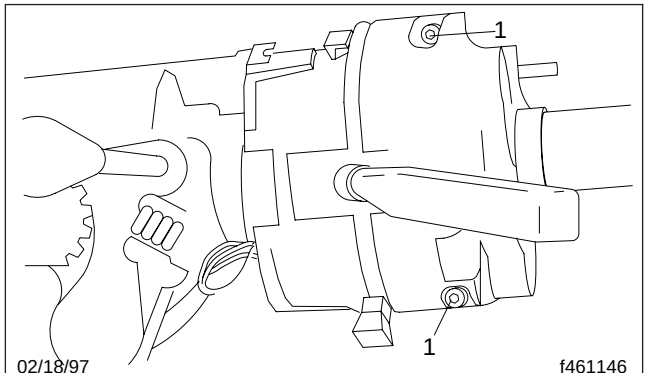

1. Upper Cover
2. Lower Cover

**Fig. 4, Steering Column, Covers Removed**



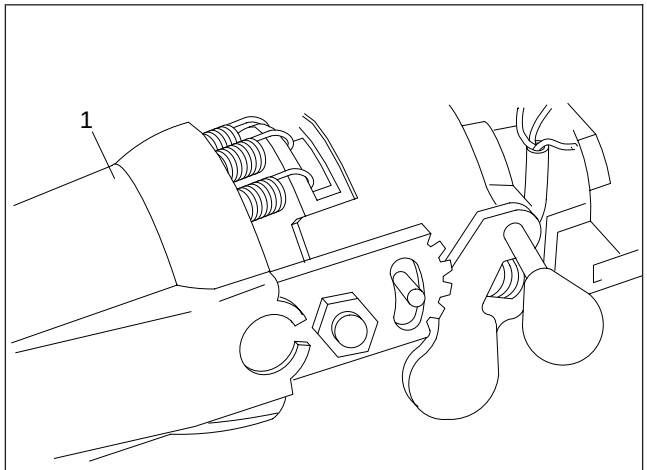

1. Housing
2. Horn Plunger

**Fig. 5, Steering Column, Horn Plunger Assembly**




1. Screw

**Fig. 6, Steering Column, Turn Signal Switch Mounting**




1. Bottom Cover Assembly

**Fig. 7, Lower Steering Column**

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## Specifications

| Torque Values | | |
|---|---|---|
| **Description** | **Size** | **Torque: lbf·ft (N·m)** |
| Steering Wheel Retaining Nut | — | 30 (41) |
| Steering Wheel Locking Knob Nut | — | 10 (13) |
| Steering Column Mounting Bracket Nuts | — | 26 (35) |
| Steering Column Mounting Bracket Capscrews | 3/8–16<br>3/8–24 | 17 (23) |
| Steering Driveline Upper End Yoke Pinch Bolt | 3/18–16 | 37 (50) |
| | 3/18–24 | 44 (60) |
| | 7/16–20 | 55 (75) |

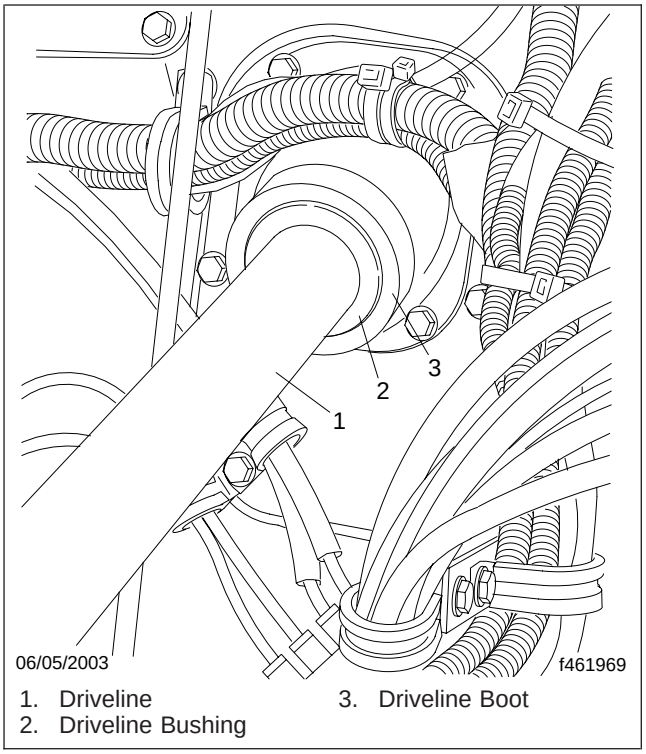
**Table 1, Torque Values**

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## Replacement

1. Position the front tires straight ahead. If possible, drive the vehicle in a straight line for a short distance, stopping at the spot where the work will be done.
2. Shut down the engine, apply the parking brakes, chock the rear tires, and open the hood.
3. Loosen the clamp around the driveline boot and slide the driveline bushing down the driveline. See **Fig. 1**.




1. Driveline
2. Driveline Bushing
3. Driveline Boot

**Fig. 1, Steering Driveline**

**CAUTION**

**Be careful when disconnecting the steering driveline from the steering column. Excessive force could damage the steering gear input valve attached to the opposite end of the steering shaft.**

4. From inside the cab, disconnect the upper end yoke.
   - 4.1 Remove and discard the pinch bolt and nut from the upper end yoke. Do not reuse the bolt or nut.
   - 4.2 Remove the upper end yoke from the steering column shaft.

**CAUTION**

**Do not use a torch to break the threads loose when removing the lower end yoke. Heat will damage the seals in the power steering gear.**

5. Disconnect the lower end yoke.
   - 5.1 Remove and discard the pinch bolt and nut from the lower end yoke. Do not reuse the bolt or nut.
   - 5.2 Remove the yoke from the steering gear input shaft. Don't turn the steering gear input shaft when removing the lower end yoke.
6. Pull the steering driveline forward through the driveline boot and out of the engine compartment.
7. Remove the driveline bushing from the driveline and set it aside.

IMPORTANT: When installing the replacement steering driveline, be sure to connect the yoke shaft (inner tube) to the steering column and connect the slip yoke (outer tube) to the steering gear.

8. If necessary, clean the end yokes, the steering driveline, and the steering gear input shaft with a clean, dry cloth.
9. Apply a thin film of grease to the yoke splines. Use lithium-based grease, NLGI grade 2.
10. Install the driveline bushing on the driveline.
11. Insert the driveline end of the new steering driveline through the driveline boot and partially into the cab.
12. Install the lower end yoke on the steering gear input shaft with a new pinch bolt centered on the input shaft notch. The driveline is properly installed on the input shaft if the pinch bolt can slip in and out of the end yoke easily. Install a new nut on the pinch bolt and tighten the pinch bolt and nut 55 to 65 lbf·ft (75 to 88 N·m).

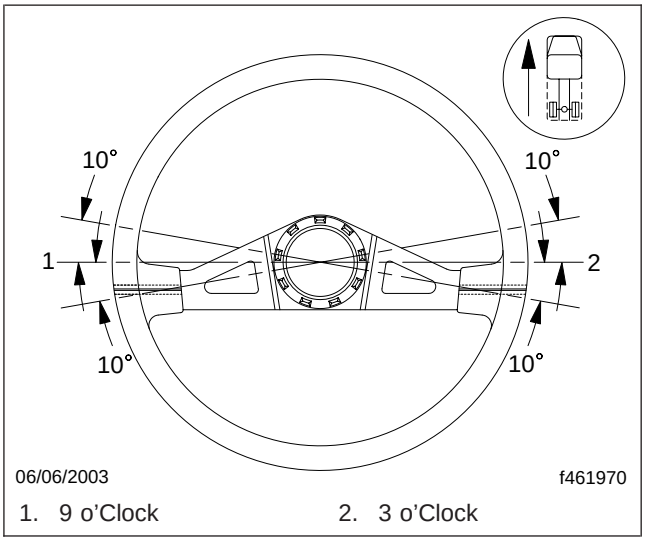
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## Steering Driveline Replacement

13. Apply torque seal, OGP F900WHITE, to the exposed pinch bolt threads and to the nut.
14. Before attaching the upper end yoke to the steering column, make sure that the front tires are pointing straight ahead and that the steering gear is centered.
15. Attach the upper end yoke to the steering column shaft, then install a new pinch bolt. Before installing the nut, make sure that the pinch bolt is in the steering column shaft groove. Install a new nut and tighten the pinch bolt and nut 55 to 65 lbf·ft (75 to 88 N·m).
16. Apply torque seal, OGP F900WHITE, to the exposed pinch bolt threads and to the nut.
17. Install the driveline bushing on the driveline. Tighten the clamp around the driveline boot and bushing.
18. With the front tires pointing straight ahead, the steering wheel should be within ±10 degrees of center as shown in **Fig. 2**.

    If not, remove the steering wheel and install it in the correct position. For instructions, see **Section 46.02**, Subject 100.




1. 9 o'Clock 2. 3 o'Clock

**Fig. 2, Steering Wheel Centered**

19. Close the hood.
20. Leave the parking brakes applied and the chocks at the rear tires.

**WARNING**

**Driving a vehicle with hard steering or binding in the steering system could result in partial or complete loss of steering control during vehicle operation, possibly causing personal injury and property damage.**

21. Start the vehicle and turn the steering wheel from side to side to check for hard steering or binding. If there is difficulty, check the assembly and installation of the driveline. If the cause is not the driveline, see the applicable steering gear section in this group.
22. Remove the chocks from the rear tires.

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## General Information

A *Checklist for Troubleshooting Power Steering Problems*, form STI-492, has been developed to accompany the procedures below. Form STI-492 can be downloaded or printed **here** after logging into **www.AccessFreightliner.com**.

Each step and substep in these troubleshooting procedures corresponds to a step or substep on form STI-492. Use **Table 1** to determine which steps should be completed, based on the customer's complaint. It is very important that the information provided by the driver is communicated accurately to prevent wasting of diagnostic time. For example, if complaints include "Pulling to one side" and "Noisy steering," steps 1, 3, 4, 5, and 6 will be the tests for the most likely failure modes.

Start with the lowest test number and work up to the highest. For example, when completing steps 1, 3, and 6 to determine the cause of a vehicle pulling to one side, start with step 1 and finish with step 6.

## Troubleshooting Steps

NOTE: Some of these inspections and procedures can be found in the Pretrip and Post-Trip Inspections and Maintenance chapter in the vehicle driver's/operator's manual.

Steps 1 through 4 may have been performed by the customer. Verify the vehicle service history with the customer to prevent redundant testing.

All measurements and readings must be recorded on STI-492.

Refer to the applicable section in this manual to repair or replace steering system components.

1. Check the tire pressure and load.

   1.1 Check the tires for damage.

   1.2 Check that the front tires are inflated to the correct pressure, and the tire pressure is equal on both sides. Correct the pressure if needed.

   Low pressure causes increased steering effort due to friction with the road surface. Unequal tire pressure causes unequal friction between the tire and the road. This can cause pulling to one side.

| Steering Complaint and Troubleshooting Steps Checklist | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LH | RH | Both | Complaint | Troubleshooting Steps | | | | | | | | |
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| | | | Hard or heavy steering | • | • | | • | • | • | • | • | • |
| | | | Low assist | | | | | | | | | |
| | | | Binding | | | | | | | | | |
| | | | Locking | | | | | | | | | |
| | | | Occasional loss of assist | | | | | | | | | |
| | | | Reduced wheel cut | | | | | | | | • | |
| | | | Pulling to one side* | • | | • | | | • | | | |
| | | | Darting/oversteering | • | • | • | • | | • | | | |
| | | | Wandering | | | | | | | | | |
| | | | Noisy steering | | | | • | • | • | | | |
| | | | External seals leaking | | | | | • | • | | | • |
| | | | Excessive heat | | | | | | | | | |

* If there is consistent pull to one side, a braking issue could feel like a steering assist problem. Refer to **Group 42** in this manual to ensure the brake system is functioning properly.

**Table 1, Steering Complaint and Troubleshooting Steps Checklist**

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## Troubleshooting Procedures

1.3 Check that the rear tires are inflated to the correct pressure, and the tire pressure is equal on both sides. Correct the pressure if needed.

1.4 Check that the tire sizes are correctly matched, and whether duplex or oversized tires (that were not originally specified for the vehicle) have been installed.

Extra tire width causes increased steering effort due to extra friction with the road surface. If the axle stops were turned out to reduce wheel cut due to a change in tires, the power steering gear poppets may need to be adjusted.

1.5 Communicate with the driver or operator to determine whether the vehicle is operated at or over the rated load.

Increased load causes greater steering effort. Make sure the vehicle is being operated within rated capacities.

2. Check fifth wheel lubrication and condition.

A dry fifth wheel plate makes it difficult to change direction. Check the plate surface for burrs, gouges, and irregularities.

3. Check vehicle alignment and wheel bearing adjustment.

3.1 Check the vehicle service history for the last known alignment, and inspect tire wear for indications that an alignment needs to be completed.

3.2 Check front axle caster and camber measurements.

3.3 Ensure wheel bearings and rear axle are in good condition, and that toe is set correctly.

3.4 Ensure the rear axle is properly aligned.

4. Check for loose and binding components. Check whether any steering components need maintenance or adjustment.

4.1 Check for proper lubrication of the drag link, tie rods, and knuckle pins. Apply lubrication as needed.

4.2 Check the COE steering column, if equipped. Chock the rearmost tires. With the engine shut down, turn the steering wheel and check for looseness or binding. Make sure all components are free to move, but are not excessively loose.

4.3 Check the steering driveline U-joints for looseness or binding. Lubricate them if needed.

4.4 Check the sector shaft adjustment.

- With the vehicle on the ground, the engine idling, and the front tires pointed straight ahead, turn the steering wheel until slight motion is observed at the front wheels.
- Align a reference mark on the steering wheel to a rule, then, with the engine running, slowly turn the steering wheel in the opposite direction until motion is again detected at the wheels.
- Measure the lash (free play) at the rim of the steering wheel.

Excessive lash exists if steering wheel movement exceeds 2-1/2 inches (64 mm) with a 20-inch (508-mm) steering wheel, or 2-1/4 inches (57 mm) with an 18-inch (457-mm) steering wheel.

4.5 Check that the front wheels self-return without binding.

- With the engine off, chock the rearmost tires and place the front tires on radius plates (turntables).
- Disconnect the drag link from the steering arm.
- By hand, pull one tire to the axle stop and release. The tire should self-return to almost straight ahead.
- Repeat with the opposite tire.

If a tire does not return to near straight ahead, check for binding or lack of lubrication in the steering axle kingpin bushings or tie rod linkage.

- Connect the drag link and tighten the castle nut, then install a new cotter pin.

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4.6 Inspect all suspension fasteners and components for wear or looseness.

5. Check the steering system for leaks and restrictions, and test the system back pressure.

5.1 Inspect hoses, fittings, and seals for damage or leaks.

- With the engine idling, inspect for kinked or collapsed hoses. Repair or replace any collapsed or kinked hoses. If collapsed hoses are found, ensure the steering system is filled with the correct automatic transmission fluid.
- Inspect fittings for leaks. Repair leaking fittings; replace parts as needed.
- Inspect all external seals. Replace leaking seals.

  Inspect the seal bores and sealing surfaces for scrapes or burrs. Make sure the seals are installed correctly using the recommended tools.
- If you replaced the steering gear input shaft seal and found it to be excessively hard, test the system operating temperature in step 6.

5.2 Inspect the steering gear for external leakage.

- Clean the area around the input shaft and inspect the input shaft for signs of leakage after operating the vehicle under normal conditions through steering maneuvers.
- Inspect the sector shaft for signs of leakage. A well greased or heavily used steering gear may weep oil from the grease seal, but a confirmed leak will be evidenced by fluid collecting while the vehicle is being operated under normal conditions.
- Inspect the vent plug in the trunnion housing for signs of leakage. Any fluid in or around the rubber vent plug indicates leakage from an internal steering gear seal.

**NOTICE**

**Do not turn the steering wheel or allow system pressure to exceed the rating of the gauge during the following test. Damage to the gauge could occur.**

5.3 Check total steering system back pressure.

- Install a low pressure gauge—300 psi (2068 kPa) maximum—between the steering pump and the steering gear.
- Check for correct fluid level. If necessary, add fluid. If bubbles or foam appear in the reservoir, check hose fittings for looseness or leaks.
- With the engine idling, read the total system back pressure on the pressure gauge.
- If the total system back pressure is greater than 100 psi (689 kPa), or 140 psi (965 kPa) for a vehicle with hydraulic brakes, replace the steering fluid filter and re-test the system. If the system back pressure is still excessive, go to the next substep.

  If the total system back pressure is less than 100 psi (689 kPa), or 140 psi (965 kPa) for a vehicle with hydraulic brakes, restriction is not a problem—go to step 6.

5.4 Leave the low pressure gauge in place and check individual steering system components for excessive restriction. See **Fig. 1** for a plumbing diagram.

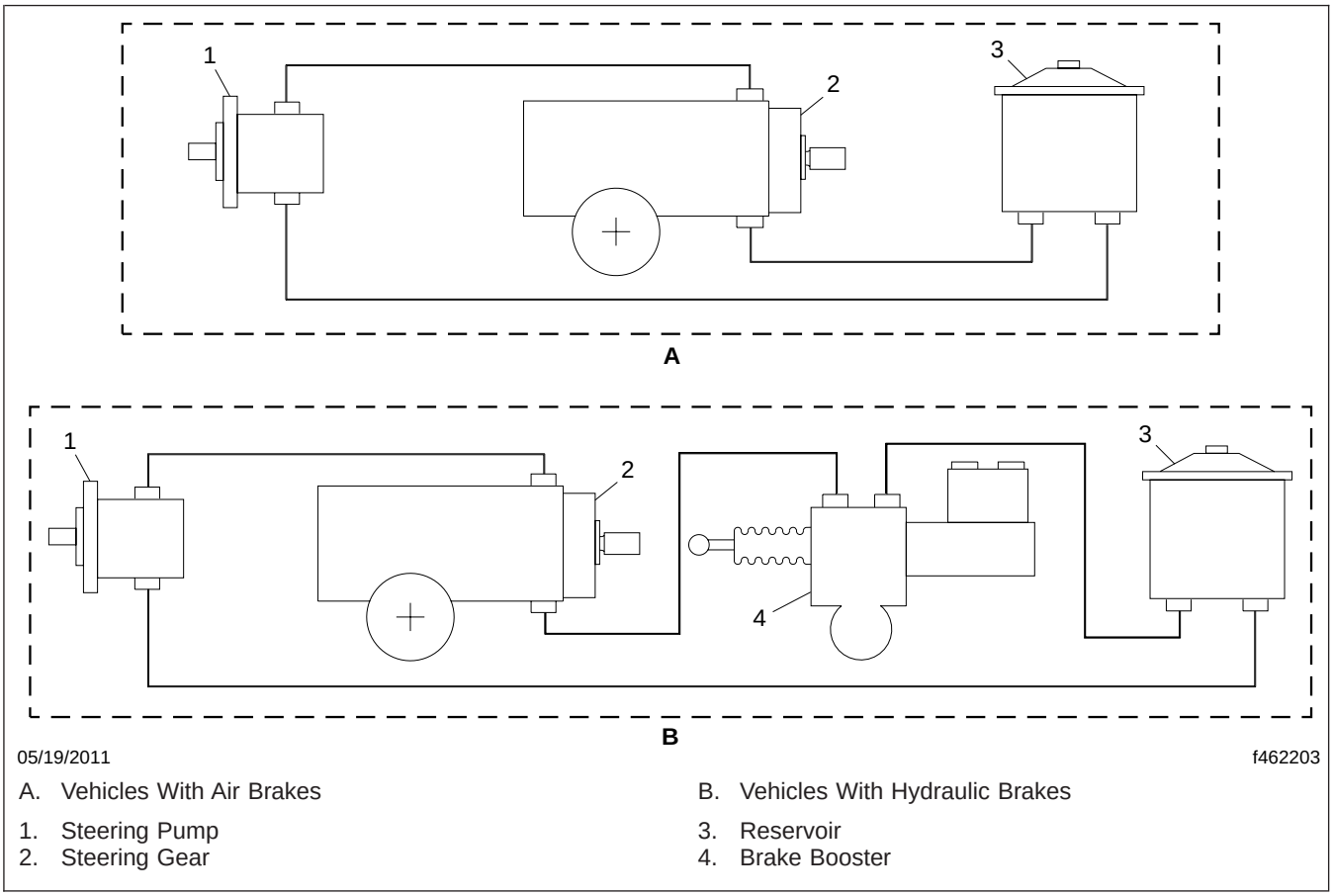
- Bypass the steering gear by disconnecting the steering gear input and output lines from the gear and coupling them together. See **Fig. 2** for an example.

  If the drop in system pressure from the value found in substep 5.3 is greater than 55 psi (379 kPa), the steering gear has excessive restriction. If the drop in pressure is less than 55 psi (379 kPa), reconnect the

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## Troubleshooting Procedures




A. Vehicles With Air Brakes
1. Steering Pump
2. Steering Gear

B. Vehicles With Hydraulic Brakes
3. Reservoir
4. Brake Booster

**Fig. 1, Plumbing Diagrams**

gear input and output lines to the gear and continue with this substep.

- If the vehicle is equipped with hydraulic brakes, bypass the brake booster by disconnecting the booster input and output lines and coupling them together.

  If the drop in system pressure from the value found in substep 5.3 is greater than 40 psi (276 kPa), the brake booster has excessive restriction. If the drop in pressure is less than 40 psi (276 kPa), reconnect the booster input and output lines and continue with this substep.

- Test each hydraulic line in the power steering system individually by bypassing them one at a time, as was done with the steering gear and brake booster, if equipped.

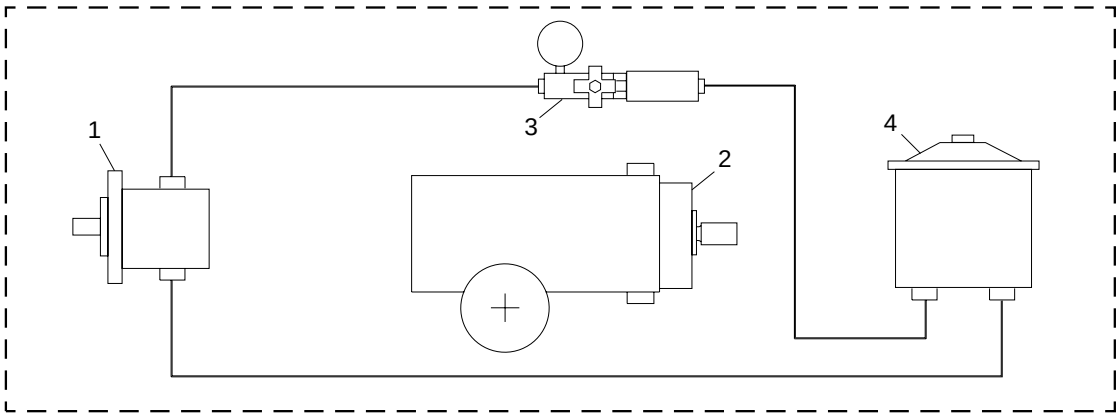
  If the drop in system pressure from the value found in substep 5.3 is greater than 12 psi (83 kPa) for any one line, replace the line and test total system back pressure again.

6. Check steering pump performance. Power steering fluid temperature should be approximately 180°F (82°C) to best replicate fluid temperatures under normal driving conditions.

   If the system fails the tests in the following substeps, replace the pressure relief valve (PRV) and complete the tests in the substeps below again. If the system fails again, replace the pump.

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1. Steering Pump
2. Steering Gear
3. Low Pressure Gauge
4. Reservoir

**Fig. 2, Testing Steering Gear Restriction**

Install the PSSA between the steering pump and the gear for the following substeps. See the following heading, **Power Steering System Analyzer Setup**, for instructions on PSSA installation.

## NOTICE

**Do not leave the load valve closed for longer than five seconds during the following test. Doing so could damage the power steering system.**

6.1 Check for erratic pump response.

- Slowly close the load valve and watch the pressure and flow readings as the valve closes, then open the valve immediately.
- If the pressure rises rapidly or appears uncontrolled, open the load valve immediately.
- If the response was erratic, replace the PRV or pump, as required. If the response was smooth and controlled, go to the next substep.

6.2 Check the pump relief pressure.

- Slowly close the load valve. When the valve is completely closed, read the pressure gauge, then open the valve.
- If the pump relief pressure does not exceed the relief pressure in **Table 2** or **Table 3**, refer to the pump manufacturer's service literature to verify the exact relief pressure for the pump.
- If the pump relief pressure does not exceed the relief pressure in **Table 2**, **Table 3**, or the pump manufacturer's specifications, replace the PRV or pump, as required.
- If the pump relief pressure exceeds the relief pressure in **Table 2** or **Table 3**, it is acceptable. Go to the next substep.

6.3 Test the pump relief valve reaction at idle.

- Run the engine at idle and note the flow rate with the load valve open.

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## Troubleshooting Procedures

| Minimum Measured Pump Flow and Relief Pressure at Engine Idle | | | | |
|---|---|---|---|---|
| **Power Steering Gear** | **Flow at 1500 rpm, No Load: gpm (L/min)** | **Flow at 1000 psi (6900 kPa): gpm (L/min)** | **Flow at 1800 psi (12 400 kPa): gpm (L/min)** | **Typical Relief Pressure: psi (kPa)** |
| Sheppard M100 | 3.7 (14.0) | 2.8 (10.6) | 2.3 (8.7) | 2175 ± 100 (15 000 ± 700)* |
| TRW TAS40 | 3.7 (14.0) | 2.1 (7.9)† | 1.6 (6.1) | |
| TRW TAS55 | | 2.4 (9.1)† | 1.9 (7.2) | |
| TRW TAS65 | | 2.8 (10.6)† | 2.3 (8.7) | |
| TRW TAS85 | | 3.3 (12.5) | 2.8 (10.6) | |
| TRW TAS65 With C28 or C32 Linear Cylinder | 5.8 (22.0) | 4.9 (18.5) | 4.4 (16.7) | |
| TRW TAS65 With RCS65 | | | | |
| TRW TAS85 With C28 or C32 Linear Cylinder | | 5.4 (20.4)† | 4.9 (18.5) | |
| TRW TAS85 With RCS65 | | | | |
| ThyssenKrupp LZS5 Rack and Pinion | 3.7 (14.0) | 3.3 (12.5) | 2.8 (10.6) | 2300 ± 116 (15 500 ± 800) |

* On vehicles with TRW TAS steering gears and hydraulic brakes, typical relief pressure is 2375 ± 100 psi (16 375 ± 690 kPa).

† Approximate value based on flow at 1800 psi (12 400 kPa).

**Table 2, Minimum Measured Pump Flow and Relief Pressure at Engine Idle**

| Minimum Measured Pump Flow and Relief Pressure for High-Pressure Gears at Engine Idle | | | | |
|---|---|---|---|---|
| **Power Steering Gear** | **Flow at 1500 rpm, No Load: gpm (L/min)** | **Flow at 1000 psi (6900 kPa): gpm (L/min)** | **Flow at 2300 psi (15 860 kPa): gpm (L/min)** | **Typical Relief Pressure: psi (kPa)** |
| Sheppard HD94 | 3.7 (14.0) | 2.6 (9.8) | 1.8 (6.8) | 2683 ± 100 (18 500 ± 700) |
| TRW THP45 | | 2.2 (8.3) | 1.4 (5.3) | |
| TRW THP60 or PCF60 | | 2.6 (9.8) | 1.8 (6.8) | |
| TRW THP60 With Linear Cylinder | 5.8 (22.0) | 4.1 (15.5) | 3.3 (12.5) | |
| TRW THP60 With RCH45 | | | | |

**Table 3, Minimum Measured Pump Flow and Relief Pressure for High-Pressure Gears at Engine Idle**

- Close the load valve until the pump relief pressure is reached. Smoothly and quickly open the load valve and note the flow rate. Repeat this action three times. The flow rate should return to the flow rate first noted with the load valve open.
- If the flow rate does not return smoothly and quickly, the pump relief valve is not working correctly. Replace the replace the PRV or pump, as required.
- If the flow rate returns smoothly and quickly, the pump relief valve is acceptable. Go to the next substep.

6.4 Test the pump relief valve reaction at 1500 rpm.

- Run the engine at 1500 rpm and note the flow rate with the load valve open.
- Close the load valve until the pump relief pressure is reached. Smoothly and quickly open the load valve and note the flow rate. Repeat this ac-

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tion three times. The flow rate should return to the flow rate first noted with the load valve open.

- If the flow rate does not return smoothly and quickly, replace the PRV or pump, as required.
- If the flow rate returns smoothly and quickly, the pump relief valve is acceptable. Go to the next substep.

6.5 Test the flow of the pump at idle with a load applied.

For vehicles with low-pressure steering gears, run the engine at idle and slowly close the load valve until the pressure gauge reads 1000 psi (6900 kPa). Read the flow rate on the gauge, then set the pressure to 1800 psi (12 400 kPa). Read the flow gauge, then open the load valve. Compare the values to those in **Table 2**.

For vehicles with high-pressure steering gears, use 1000 psi (6900 kPa) and 2300 psi (15 860 kPa) as the test load pressures. See **Table 3** for minimum flow rate.

6.6 Test the maximum flow of the pump with no load applied.

- Run the engine at 1500 rpm, make sure the load valve is completely open, and read the flow gauge.
- If the flow rate is below the minimum indicated in **Table 2** or **Table 3**, replace the PRV or pump, as required.
- If the flow rate is above 5.5 gpm (20.8 L/min) on a vehicle with a single steering gear, or 7.7 gpm (28.8 L/min) on a vehicle with an assist cylinder installed, replace the pump.

7. Test the steering gear internal leakage.

Select TRW integral steering gears and all ThyssenKrupp rack and pinion steering gears are equipped with an internal PRV that significantly limits maximum supply pressure to protect the steering gear. These gears, unlike gears on vehicles fitted with hydraulic brake boosters, cannot be tested for internal leakage by plugging the internal PRV in the gear. The pump output must be limited to prevent excessive pressure from damaging the gear, and the internal PRV passage must be blocked to direct oil flow through the gear.

Use PartsPro® for the specific VIN to determine if the steering gear is equipped with an internal PRV, which will be listed as a serviceable part under module 536.

If a TRW steering gear has an internal PRV but no hydraulic brake booster, see the following heading, **Internal Leakage Test Setup, TRW Steering Gears With an Internal PRV**, for instructions on setting up the necessary test components before proceeding with the following substeps.

ThyssenKrupp rack and pinion steering gears are also equipped with an internal PRV, but cannot be tested for internal leakage.

IMPORTANT: Make sure the fluid temperature is approximately 180°F (82°C) and the vehicle is stationary with the front wheels pointing forward.

7.1 Run the engine at idle with the load valve open.

**WARNING**

**Keep fingers clear of the stop bolt and spacer block during the following test. Make sure that the spacer block contacts the axle stop squarely. Contact that is not square could break the stop bolts or eject the spacer block, which could cause serious personal injury.**

7.2 Place an unhardened steel spacer, 1-inch (25-mm) thick, between the axle and the stop bolt on one side of the axle.

The spacer should have an extension or handle long enough to keep fingers clear of the axle stop area. A brazing rod or welding rod works well for this purpose.

**NOTICE**

**While running the following test, do not hold the steering wheel in the full-turn position for more than five seconds. Doing so could damage the pump.**

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## Troubleshooting Procedures

7.3 Have someone turn the steering wheel, applying enough force to completely close the rotary valve.

Complete closure of the rotary valve requires approximately 20 lbf (27 N) pull on the steering wheel, and will be indicated by a pressure reading nearly equal to the system relief pressure (tested in substep 6.2).

7.4 Hold the steering wheel in the full-turn position. Note the steering gear internal leakage on the PSSA.

7.5 Repeat the previous substeps for the opposite turn.

The maximum permissible internal leakage for a single gear is 1.0 gpm (3.8 L/min). If leakage is greater in either turning direction, replace the steering gear components as needed.

For systems with two or more steering gears and/or linear cylinders, the total acceptable internal leakage is 1.0 gpm (3.8 L/min) for each steering gear/ram in the system. Maximum internal leakage on a dual-gear system is 2.0 gpm (7.6 L/min). If the leakage is more than 2.0 gpm (7.6 L/min) on a dual-gear system, isolate the auxiliary cylinder from the system using the substeps that follow.

7.6 Disconnect the auxiliary cylinder hydraulic lines at the main gear auxiliary ports.

7.7 Plug the main steering gear ports with suitable steel or high-pressure plugs or caps.

7.8 Repeat the internal leakage test.

If the internal leakage is less than 1 gpm (3.8 L/min), repair or replace the auxiliary gear or linear cylinder. If the internal leakage is greater than 1 gpm (3.8 L/min), repair or replace the main gear.

8. Check the steering gear poppet relief valve and stop bolt adjustment.

NOTE: Poppets limit the steering assist when the front wheels approach the stop bolts. Improper adjustment can apply excessive force to the steering linkage, or cause loss of assist, as the steering wheel approaches either full-left or full-right turn.

8.1 Check the steering system for stop bolt adjustment.

Make sure the stop bolt settings limit the steering travel so there is ½-inch (13-mm) clearance from all stationary components, and 3/4-inch (19-mm) clearance from all moving components.

8.2 Make sure the pitman arm is situated on the steering gear sector shaft correctly. Check that the pitman arm and sector shaft timing marks are aligned.

### NOTICE

**If power steering pump relief pressure is reached while the steering wheel is at full lock, release the steering wheel from this position. Do not allow the pump relief pressure to be maintained for longer than five seconds or damage to the pump may result.**

8.3 Check the poppet relief pressure.

- Install the PSSA between the steering pump and the steering gear. See the following heading, **Power Steering System Analyzer Setup**, for instructions on PSSA installation.
- Run the engine at idle with the load valve open. Turn the steering wheel to either full-lock position. Note the pressure gauge reading, then repeat for the opposite turn.
- The pressure should drop slightly before the stop bolts are contacted. If the pressure increases (from contact with the stop bolts), the poppets must be manually reset.

  If the pressure is relieved and assist is lost when the wheel is too far from the axle stop bolts, refer to the applicable section in this manual for gear-specific information.
- After poppet replacement or adjustment, test again for correct poppet relief function and record the new pressure.

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8.4 Check for normal hissing sound at full turn.

NOTE: Noise from the power steering system does not necessarily mean there is a problem. Some noises are normal and are the result of proper operation.

See **Table 4** for possible causes and remedies for common noises associated with the power steering system and power steering pump.

8.5 Check for abnormal power steering noise.

Listen for a hissing sound at less than full turn. If a hissing sound is heard, check the steering gear poppet and the axle stop adjustment.

## NOTICE

**If the temperature exceeds 250°F (121°C), damage to hoses, seals, and other components may result if the vehicle continues to operate at excessive steering system temperatures. If this temperature is exceeded, stop the test and record the last noted temperature on STI-492.**

9. Test the system operating temperature.

- Run the engine at governed speed.
- Observe the power steering fluid temperature until it stabilizes.
- Record the power steering fluid temperature in 10-minute intervals until 40 minutes have passed.
- If the temperature does not exceed 250°F (121°C) during the test, excessive heat due to system components is probably not the cause of the complaint. The system may still experience overheating due to driving and load conditions.

  If the temperature exceeds 250°F (121°C), excessive steering system back pressure or excessive pump flow may be the cause of the high temperature problem. If system back pressure or restriction values found in substeps 5.3 and 5.4 above were close to the maximum allowable, complete step 5 again. If steering pump flow and relief pressures found in step 6 above were close to the maximum allowable, complete step 6 again.
- If excessive heat continues to be a problem, a cooler may need to be added to the system.

| Power Steering System Noise | |
|---|---|
| **Noise** | **Remedy** |
| Growling or other abnormal steering noise | Check the fluid level. Check for air bubbles and foam. Check for hose and fitting leaks. If there is air in the fluid, check for inlet tube and hose leaks. Correct all leaks. |
| A change from the usual pump sound | Check the steering fluid reservoir for air bubbles and foam. If there is air in the fluid, check for inlet tube and hose leaks. Correct all leaks. |
| Clicking noise during a turn | Check for loose steering components. Tighten any loose steering components. Check the front suspension for insufficient spring pin shims. Add front spring pin shims if needed. |
| Hissing when the steering wheel is at or near full turn | This is normal; no action is needed. |
| Steering Pump intake line is plugged | Drain the system. Clear the intake line if needed. Fill the system. |
| Air leak at the pump or reservoir connections, fittings, or shaft seal | Check all the connections by pouring power steering fluid over them, and listening for a reduction in sound. Tighten all connections as needed. |
| Pump input shaft is misaligned | Replace the pump. |

**Table 4, Power Steering System Noise**

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## Troubleshooting Procedures

# Power Steering System Analyzer Setup

The hydraulic power steering system is tested with a Power Steering System Analyzer (PSSA), and with the hydraulic fluid at operating temperature. The PSSA and adaptor kit are available from SPX Kent-Moore.

A PSSA is a combination of a flow meter, a shutoff valve, and a high-pressure gauge. See **Fig. 3**. The PSSA will allow you to measure flow and pressure, and provide a load on the pump in the hydraulic lines of the steering system.

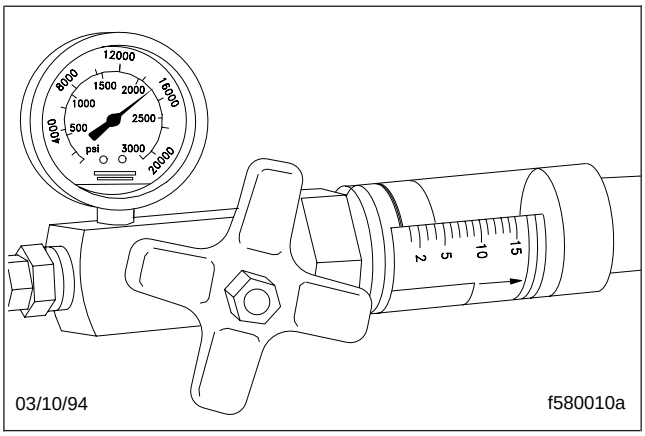



**Fig. 3, Power Steering System Analyzer**

1. Install a PSSA between the pump high-pressure line and the steering gear.
2. Fill and bleed the steering system as needed.

## NOTICE

**Do not leave the load valve fully closed for longer than five seconds. Doing so could damage the power steering system.**

3. Run the engine at idle.
4. Partially close the load valve on the PSSA until the pressure gauge reads 1000 psi (6895 kPa).
5. Open the valve when the fluid temperature reaches about 180°F (82°C).

# Internal Leakage Test Setup, TRW Steering Gears With an Internal PRV

Select TRW steering gears are equipped with an internal PRV that limits maximum supply pressure to protect the steering gear. These gears cannot be tested for internal leakage using the standard procedure. The pump output must be limited to prevent excessive pressure from damaging the gear, and the internal PRV passage must be blocked to direct oil flow through the gear.

Use PartsPro® to determine if a specific TRW steering gear is equipped with an internal PRV, which will be listed as a serviceable part under module 536.

If your TRW steering gear has an internal PRV, complete the following steps to set up the necessary internal leakage test components. See **Table 5** for a list of required leakage test components. The plumbing fittings and hose part numbers are recommended, but may be replaced with identical parts from other suppliers, if necessary.

The ThyssenKrupp rack and pinion steering gear is also equipped with an internal PRV, but cannot currently be tested for internal leakage.

IMPORTANT: The front wheels must be raised or on turnplates during this procedure.

1. Turn the engine off. Remove the relief valve cap, O-ring, and relief valve from the steering gear. See **Fig. 4**.
2. Install the relief valve plug, J-37130, in the internal PRV hole. Install the relief valve cap and O-ring over the plug.
3. Assemble the relief valve cartridge body, relief valve, and tee fittings as shown in **Fig. 4**.
4. Install the PSSA and other test components as shown in **Fig. 4**.
5. Open the external relief valve (**Fig. 4**, Item 15) on the relief valve cartridge. Ensure the PSSA shutoff valve is fully open.
6. Raise the front wheels off the ground and turn the steering wheel to the right and left full-lock positions five times to bleed air from the system.
7. Start the engine and bleed the remaining air out of the system by continuing to turn the wheel from side to side.

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## NOTICE

**Do not leave the PSSA shutoff valve fully closed for longer than five seconds. Doing so could damage the power steering system.**

8. With the engine on, close the shutoff valve on the PSSA.
9. Set the system relief pressure by closing the external relief valve (**Fig. 4**, Item 15) until the gauge on the PSSA reaches 2,000 psi (13 790 kPa), then fully open the shutoff valve on the PSSA.
10. Continue with the steering gear internal leakage test (step 9 of the **Troubleshooting Steps** heading above).

| Internal Leakage Test Components | | | |
|---|---|---|---|
| **Part** | **Available From** | **Part Number (Vendor P/N)** | **Item #, Fig. 4** |
| Power Steering System Analyzer (PSSA) | SPX Kent-Moore | J-26487 | 5 |
| PSSA Adaptor Kit | SPX Kent-Moore | J-28593 | — |
| Relief Valve Plug | SPX Kent-Moore | J-37130 | — |
| Connector, Straight Thread with O-Ring | Daimler Trucks PDC | 23-11470-088 | 6 |
| Power Steering Hose, 42" | Daimler Trucks PDC | 14-12694-042 | 8 |
| Connector, 3/8" Male NPT to 5/8" Beaded Hose Barb | Daimler Trucks PDC | 23-11321-001 | 9 |
| Pipe Coupling, 3/8" NPT | Parker Hannifin | PH 3/8 GG S (3/8 GG-S) | 10 |
| Tee, Male JIC with Male NPT Branch* | Parker Hannifin | PH 8STXS (8 STX-S) | 11 |
| Swivel Adaptor, 3/8" Male NPT to Female 37 degree JIC (qty 2) | Weatherhead | WH 9100X8X6 (9100x8x6) | 12 |
| Swivel Nut Run Tee | Parker Hannifin | PH 8 R6X S (8 R6X-S) | 13 |
| 3/8" Female NPT Aluminum Relief Valve Threaded Cartridge Body | Parker Hannifin | B10-2-A6P (PH B102A6P) | 14 |
| Aluminum Hydraulic Threaded Cartridge Relief Valve with Knob | Parker Hannifin | PH RAH101K30 (RAH101K30) | 15 |

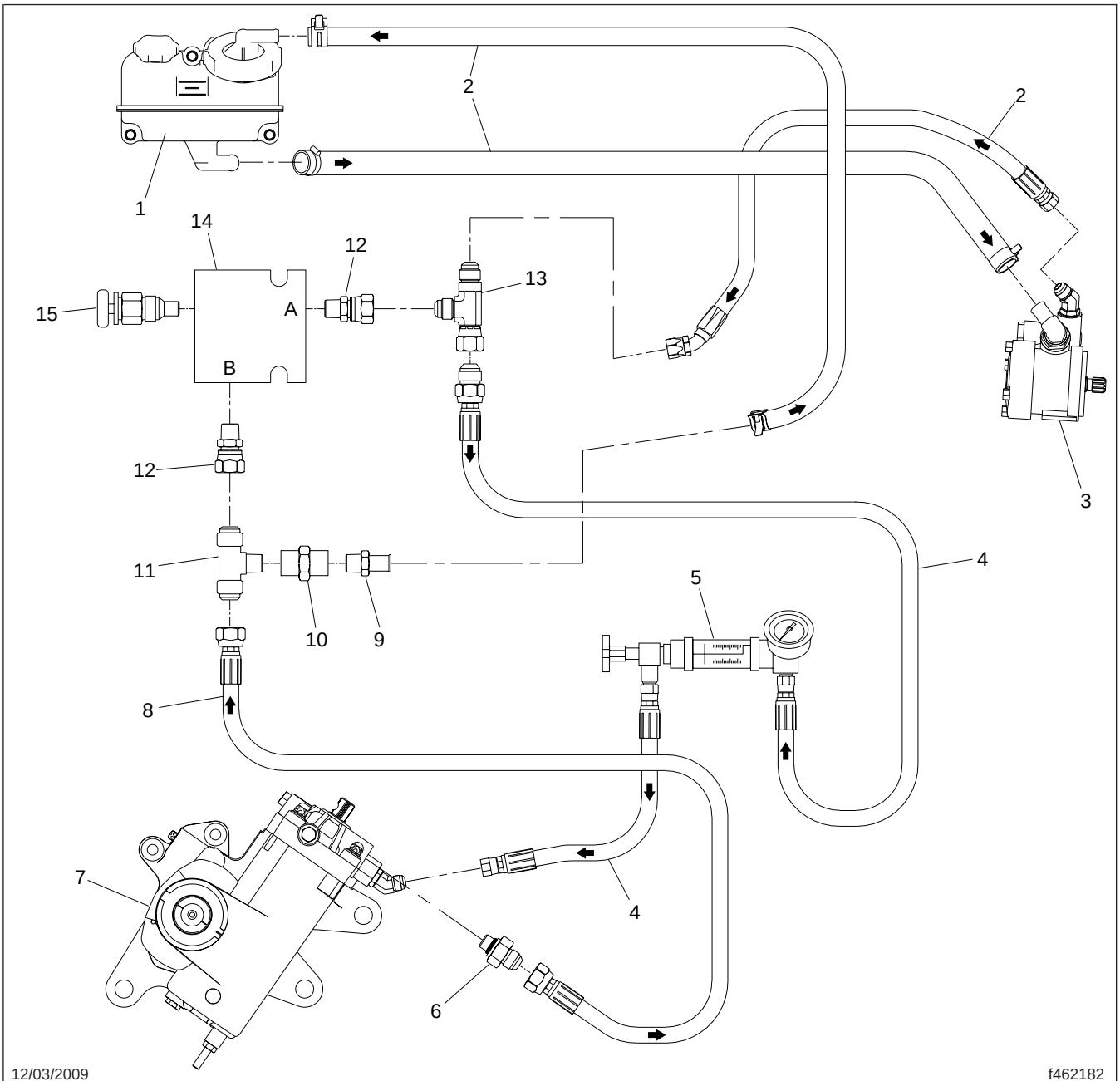
* Use steel 37 degree JIC fittings only.

**Table 5, Internal Leakage Test Components**

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## Troubleshooting Procedures




A. High-Pressure Input Port
B. Low-Pressure Output Port

1. Power Steering Fluid Reservoir
2. Existing Power Steering Fluid Lines (Qty 3)
3. Power Steering Pump
4. PSSA Fluid Lines (Qty 2)
5. PSSA
6. Connector, Straight Thread with O-Ring
7. Power Steering Gear (TAS85 shown)
8. Power Steering Hose, 42"
9. Connector, Male NPT to Beaded Hose Barb
10. Pipe Coupling
11. Tee, Male JIC with Male NPT Branch
12. Swivel Adaptor (Qty 2)
13. Swivel Nut Run Tee
14. Relief Valve Threaded Cartridge Body
15. External Relief Valve, Threaded Cartridge Type

**Fig. 4, Internal Leakage Test Component Installation**

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## General Description

The TRW EV Series power steering pump supplies power steering fluid for the operation of the power steering gear. The EV Series power steering pump is a balanced, positive displacement, sliding-vane, two-line pump with an internal pilot-operated flow control and relief valve.

## Principles of Operation

As the input shaft turns the rotor inside the cam ring, the centrifugal force pushes the vanes out toward the surface of the cam ring. The pumping element has two pumping pockets opposed 180 degrees from each other that balance the internal forces using the pressure generated by the pumping action. Fluid entering via the inlet port is forced by the vanes through the pumping pockets in the cam ring, and out through the outlet port, to the steering gear. Once through the steering gear, the fluid returns to the power steering reservoir, then back to the power steering pump.

The pump outputs a fixed volume for each revolution of the input shaft. This volume is determined by the internal contour of the cam ring.

The pump has a pilot-operated valve built into the pump housing that controls the amount of fluid that is output to the steering gear. This allows the output flow to remain within specification for almost any input speed variation.

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## Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake.
2. Chock the tires and open the hood.
3. Clean all dirt from around the fittings and hose connections.
4. Place a container under the pump, then disconnect the hoses from the fittings on the pump. Plug the hoses and cap the fittings to keep out dirt and to prevent fluid leakage.
5. Remove and discard the capscrews and washers that attach the pump to the engine accessory drive mounting flange. Support the pump as you remove the second mounting bolt.
6. Pull the pump straight out from the engine. Keep it level to avoid spilling fluid.
7. Turn the pump upside down over the container and let the fluid drain out.
8. Discard the gasket from the pump mounting flange.

## Installation

1. Install a new gasket on the pump mounting flange, then place the pump on the engine accessory drive mounting.
2. Install new mounting fasteners and tighten them 27 to 32 lbf·ft (37 to 43 N·m).
3. Connect the inlet hose from the power steering reservoir to the inlet port adaptor. Tighten the adaptor 38 lbf·ft (52 N·m).
4. Connect the outlet hose from the power steering gear to the outlet port. Tighten the adaptor 47 lbf·ft (64 N·m).
5. Bleed the power steering system.
   - 5.1 Check the fluid level in the power steering reservoir. If necessary, fill the reservoir with automatic transmission fluid that meets Dexron III or TES-389 specifications.
   - 5.2 Start the engine and let it idle for several minutes.
   - 5.3 Turn the wheels fully left and right five times.
   - 5.4 Check the fluid level in the power steering reservoir. The power steering fluid level should be between the MIN COLD mark and the middle mark just above it. If needed, fill the reservoir with automatic transmission fluid that meets Dexron III or TES-389 specifications.
   - 5.5 Shut down the engine.

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## Specifications

TRW EV Series pumps use ATF fluid that meets TES-389 or Dexron III specifications.

The TRW part number is located as shown in **Fig. 1**.

Pump specifications by TRW part number are listed in **Table 1**.

| Specification Codes for Fourteen-Character TRW Part Number | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Character Position** | **1, 2** | **3, 4** | **5, 6** | **7, 8** | **9** | **10** | **11, 12** | **13, 14** |
| **Typical TRW Part Number** | **EV** | **22** | **16** | **18** | **L** | **1** | **01** | **01** |
| **Code Description** | | | | | | | | |
| Family Designation<br>EV = EV Series Pump | | | | | | | | |
| Displacement per Revolution<br>18 = 18 cc (1.10 cir)<br>22 = 22 cc (1.34 cir)<br>25 = 25 cc (1.53 cir)<br>28 = 28 cc (1.71 cir) | | | | | | | | |
| Flow Control<br>12 = 12 lpm (3.17 gpm)<br>14 = 14 lpm (3.70 gpm)<br>16 = 16 lpm (4.23 gpm) | | | | | | | | |
| Relief Setting<br>09 = 90 bar (1305 psi)<br>15 = 150 bar (2175 psi)<br>16 = 160 bar (2320 psi)<br>17 = 170 bar (2465 psi)<br>18 = 185 bar (2683 psi) | | | | | | | | |
| Direction of Rotation<br>R = clockwise rotation<br>L = counterclockwise rotation | | | | | | | | |
| Shaft Type<br>1 = 11 tooth 16/32 spline | | | | | | | | |
| Housing<br>01 = SAE A Flange - JIC ports<br>02 = SAE A Flange - Metric ports | | | | | | | | |
| Customer Version<br>01 = Freightliner | | | | | | | | |

**Table 1, Specification Codes for Fourteen-Character TRW Part Number**

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## Specifications

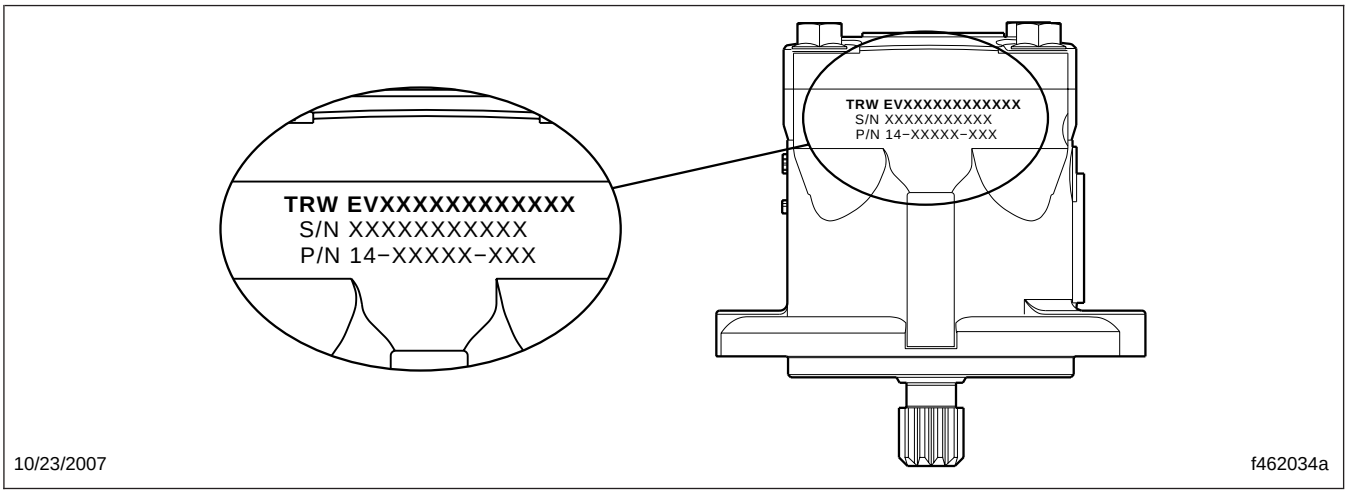



**Fig. 1, Power Steering Pump Identification Numbers**

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## General Description

NOTE: Procedures in this section are slightly modified from the original component manufacturer's service literature. Consult the manufacturer's service literature for additional information.

The THP60 power steering gears are integral hydraulic power steering gears that contain a manual steering mechanism, a hydraulic control valve, and a hydraulic power cylinder.

The pressure required for the steering gear to overcome resistance at the steered wheels is provided by the power steering pump. The rotary control valve directs the flow of hydraulic fluid to the appropriate cylinder cavity in the steering gear (and in the auxiliary cylinder in a dual steering gear system) at the proper flow rate and pressure. As the steering wheel is turned faster or slower, more or less fluid will be required by the gear.

If the rotary control valve is controlling an auxiliary cylinder, increased minimum flow is required (generally at least 75 percent) based on the size of the auxiliary cylinder and the steering geometry of the vehicle.

## Principles of Operation

When the driver turns the steering wheel, that force travels from the steering wheel to the steering gear input shaft. A torsion bar, pinned at one end to the input shaft and at the other end to the worm shaft, turns with the input shaft and exerts a rotational force on the worm shaft. In response to the force exerted by the torsion bar, the worm shaft moves the rack piston forward or backward in the gear housing by means of a series of recirculating balls in the spiral channels of the worm shaft. Grooves in the rack piston mesh with teeth in the sector shaft and, as the piston slides back and forth, it turns the sector shaft. The sector shaft swings the pitman arm. The pitman arm pulls or pushes the drag link, and the drag link moves the axle steering arm, steering the vehicle.

The rack piston's axial movement is resisted by its engagement to the sector shaft, which is linked to the steered wheels. Because of this resistance, the torsion bar activates the control valve, which directs pressurized fluid to the upper or lower cylinder cavity (depending on the direction of turn). The pressurized fluid assists in moving the rack piston up or down in the cylinder bore by providing the extra force needed to overcome the resistance from the front wheels and allows the worm shaft to slide the rack piston in the cylinder bore.

If the steered wheels receive a shock load, the shock forces are transmitted through the sector shaft to the rack piston and on to the worm shaft. The internal construction of the steering gear causes the control valve to send pressurized fluid to the correct cylinder cavity to resist the shock forces. By absorbing the shock forces hydraulically, the steering gear prevents kickback at the steering wheel.

Most THP60 steering gears are equipped with two poppet (unloading) valves, one at each end of the rack piston. As the front wheels reach the axle stop—the farthest the wheels can turn in either direction—one poppet or the other, depending on the direction of the turn, will trip to prevent steering gear damage. The tripped poppet reduces pressure in the gear, heat generated by the power steering pump, and outside forces acting on the steering linkage.

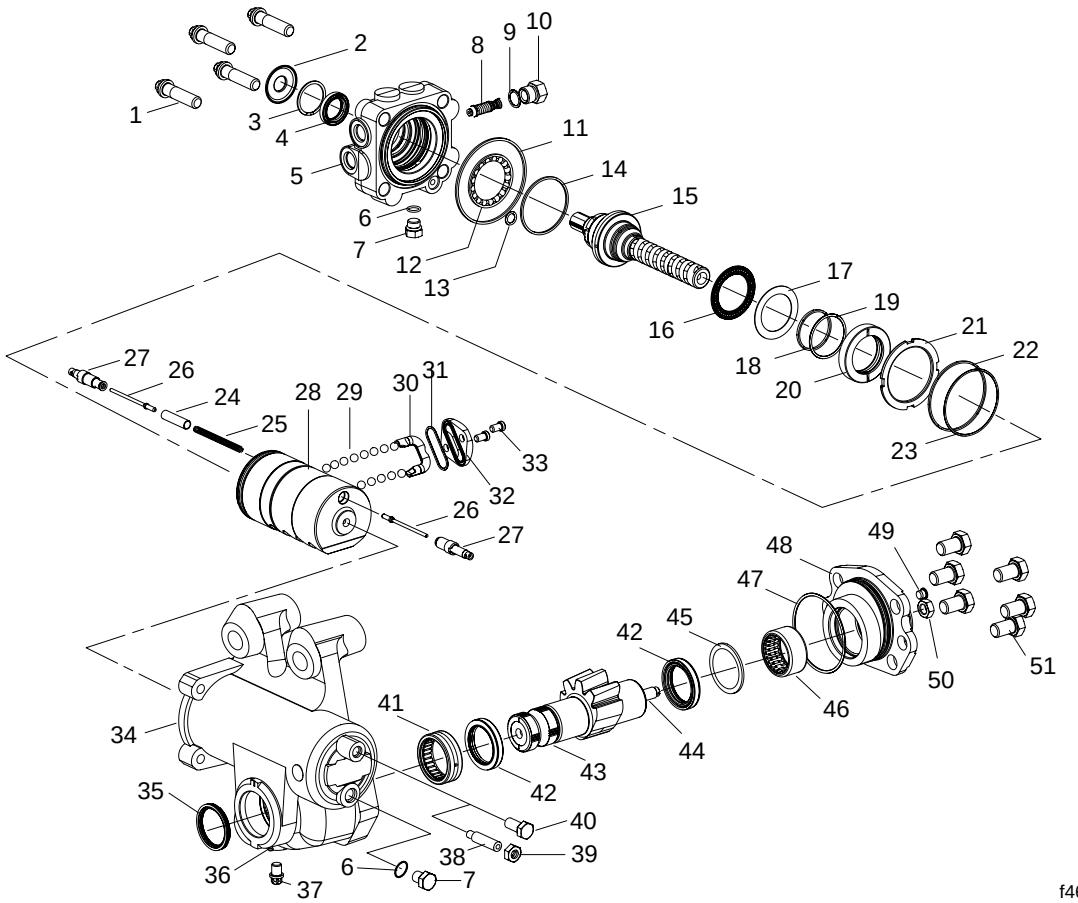
Some THP60 steering gears are also supplied with a relief valve. The relief valve limits maximum supply pressure to protect the power steering gear, but it does not reduce pressure as the steered wheels approach the axle stops.

See **Fig. 1** for an exploded view of the steering gear.

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## General Information




10/21/2003 f461925

1. Valve Housing Capscrew
2. Dirt and Water Seal
3. Retaining Ring
4. Input Shaft Seal
5. Valve Housing
6. Auxiliary Port O-Ring (2)
7. Auxiliary Port Plug (2)
8. Relief Valve
9. O-Ring
10. Relief Valve Cap
11. Valve Housing O-Ring
12. Bearing Assembly
13. O-Ring
14. Seal Ring
15. Input Shaft Assembly
16. Thrust Bearing
17. Thrust Washer
18. Seal Ring
19. O-Ring
20. Bearing Adjuster
21. Adjuster Locknut
22. O-Ring
23. Seal Ring
24. Push Tube
25. Poppet Spring
26. Poppet
27. Poppet Seat and Sleeve Assembly
28. Rack Piston
29. Ball
30. Ball Return Guide
31. Cap Seal
32. Ball Return Guide Cap
33. Torx® Capscrew
34. Gear Housing
35. Dirt and Water Seal
36. Grease Fitting
37. Automatic Bleed Plug
38. Poppet Adjusting Screw
39. Poppet Adjusting Screw Nut
40. Poppet Fixed Stop Screw
41. Roller Bearing
42. Output Seal
43. Sector Shaft Assembly
44. Sector Shaft Adjusting Screw
45. Washer
46. Roller Bearing
47. Side Cover O-Ring
48. Side Cover Assembly
49. Vent Plug, Side Cover
50. Adjusting Screw Jam Nut
51. Capscrew

**Fig. 1, TRW THP Steering Gear**

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## Removal

1. Verify that the axle stops are adjusted correctly. Ensuring correct axle stop adjustment will eliminate the possibility of resetting steering gear poppet valves after the gear is installed. See **Group 33** for instructions.
2. Place the front tires in the straight-ahead position. If possible, drive the vehicle in a straight line for a short distance, stopping where the work is to be done.
3. Turn off the engine, apply the parking brakes, and chock the tires.
4. Disconnect the batteries and open the hood.
5. Remove all dirt from all fittings and hose connections on the steering gear.
6. Drain the fluid from the power steering system. Disconnect the hydraulic lines from the steering gear, marking the lines for later reference. Plug the lines and fittings to keep out dirt and debris.
7. Remove the pitman arm.
   - 7.1 Remove and discard the pinch bolt, nut, and washer (if equipped) that attach the pitman arm to the steering gear sector shaft.
   - 7.2 Using a two-jaw puller, remove the pitman arm from the steering gear sector shaft. See **Fig. 1**.
8. Disconnect the steering driveline from the steering gear input shaft.
   - 8.1 Remove and discard the pinch bolt and nut from the steering driveline lower end yoke.

**NOTICE**

**Do not pound the U-joint or lower end yoke on or off the input shaft. Internal damage to the steering gear can result.**

   - 8.2 Remove the end yoke from the input shaft.

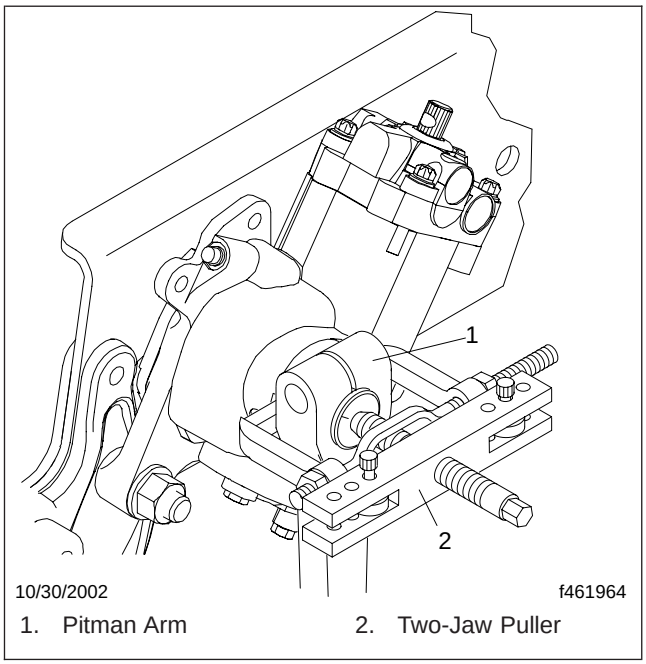



**Fig. 1, Pitman Arm Removal**

**WARNING**

**The steering gear is heavy. Use caution when removing, lifting, or carrying the steering gear. Failure to do so could cause personal injury.**

9. Remove the fasteners that secure the steering gear to the frame rail. Remove the steering gear.

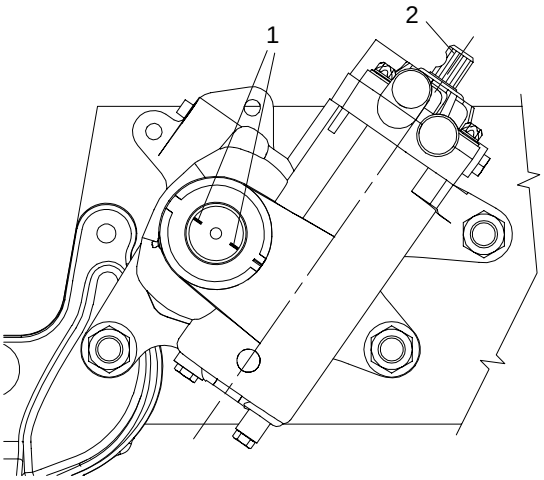
## Installation

1. Mount the steering gear on the frame rail and install the mounting fasteners. Tighten the fasteners 342 to 434 lbf·ft (464 to 588 N·m).
2. Center the steering gear so that the sector shaft alignment mark is at a 90-degree angle to the steering gear input shaft centerline. Make sure that the timing mark on the sector shaft is aligned with the timing mark on the steering gear, and that the steering gear remains centered as the installation continues. See **Fig. 2**.
3. Connect the steering driveline to the steering gear input shaft.
   - 3.1 Align the hole in the steering driveline lower end yoke with the indentation on the input shaft.

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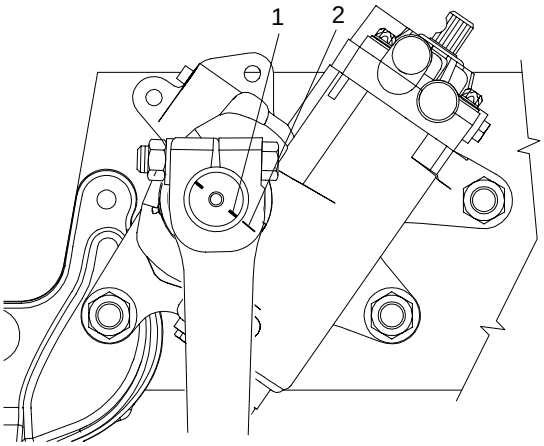
## Removal and Installation




10/30/2002 f461965

1. Sector Shaft Alignment Mark
2. Input Shaft

**Fig. 2, Sector Shaft Aligned With Input Shaft Centerline**




11/04/2002 f461966

1. Sector Shaft Timing Mark
2. Pitman Arm Timing Mark

**Fig. 3, Timing Mark Alignment**

3.2 Using a new pinch bolt and nut, attach the driveline lower end yoke to the input shaft. Tighten the nut 30 to 35 lbf·ft (41 to 47 N·m).

3.3 Apply torque seal, OGP F900WHITE, to the pinch bolt and nut.

4. Install the pitman arm.

4.1 Make sure that the timing mark on the pitman arm is aligned with the timing mark on the sector shaft. See **Fig. 3**.

**⚠ WARNING**

**Never leave a chisel wedged in the pitman arm slot. When using a chisel to spread the slot in the pitman arm, wear safety glasses and maintain a firm grip on the chisel at all times. Otherwise, the chisel may fly loose, which could cause an injury.**

NOTE: The pitman arm may not fit over the splines on the sector shaft without spreading the slot in the arm. To wedge the slot open, drive a chisel into the slot using a ball-peen hammer. Hold the chisel in place and install the pitman arm on the sector shaft. Remove the chisel from the slot.

4.2 Using a new pinch bolt, nut, and washer (if applicable), attach the pitman arm to the steering gear sector shaft.

4.3 Tighten the nut 230 lbf·ft (312 N·m).

5. If the hydraulic line fittings were removed, attach them to the steering gear. Tighten the fittings 37 lbf·ft (50 N·m). Tighten the jam nut on the pressure line fitting to a maximum 41 lbf·ft (56 N·m).
6. Remove the plugs from the hydraulic lines. Connect the hydraulic lines to the steering gear. Tighten the nut on each fitting finger tight. Then use a wrench to tighten the nut until there is firm resistance. Tighten one-sixth turn more.
7. Connect the batteries.
8. Fill and bleed the steering system. For instructions, refer to **Subject 110**.
9. Close the hood and perform the post-service checks in **Subject 150**.

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## Air Bleeding the System

IMPORTANT: Make sure the poppets are set correctly before beginning this procedure. If the poppets are not set correctly, see **Subject 140** for instructions.

**⚠ WARNING**

**Do not mix hydraulic fluid types or use unapproved fluids. Doing so could cause seal deterioration, leaks, loss of steering assist, and spillage on the roadway, which could result in serious personal injury or death.**

1. Fill the power steering reservoir nearly full with automatic transmission fluid that meets Dexron III or TES-389 specifications. Do not turn the steering wheel.
2. Start the engine and let it idle for ten seconds, then shut it off. Check and fill the reservoir. Repeat this step at least three times, checking the fluid level in the reservoir each time.

IMPORTANT: Do not let the fluid level drop significantly or allow the reservoir to empty. Doing so may introduce air into the system.

3. Start the engine and let it idle for two minutes. Do not turn the steering wheel. Shut off the engine and check the fluid level in the reservoir. The power steering fluid level should be between the MIN COLD mark and the middle mark just above it. If needed, add more fluid.
4. Start the engine again. Turn the steering wheel from full left to full right several times. If needed, add more fluid to the reservoir.

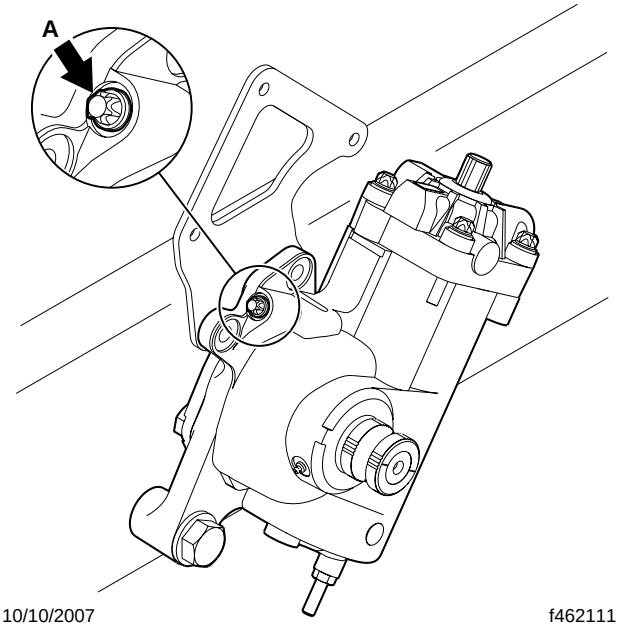
   Automatic bleed systems should now be free of trapped air. See **Fig. 1**

   If the vehicle has a manual bleed system (**Fig. 2**), proceed to the next step.

IMPORTANT: Do not turn the steering wheel while the bleed screw is loosened.

5. With the wheels in the straight-ahead position, loosen the manual bleed screw two to three turns. Allow air and aerated fluid to bleed out until only clear fluid is seen. Close the bleed screw and add fluid to the reservoir if needed.

   Repeat this step until all air is out of the system. Tighten the bleed screw 40 to 50 lbf·in (452 to 565 N·cm).



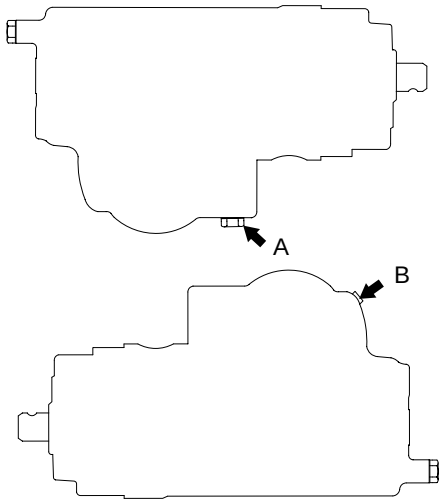

A. Location of automatic bleed plug.

**Fig. 1, Steering Gear with Automatic Bleed Plug**

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## Air Bleeding the System




12/07/2001 f461929

A. Steering gear with automatic bleed plug. Do not remove the bleed plug.
B. Steering gear with manual bleed plug.

**Fig. 2, Steering Gears With Bleed Systems**

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## Replacement

NOTE: The power steering pump is used in this procedure to force out the input shaft seal. To use this procedure, the power steering pump should have a minimum of 1500 psi (10 342 kPa) available.

1. Turn off the engine, apply the parking brake, and chock the tires.
2. Disconnect the return line from the steering gear and plug the line. Cap the return port of the steering gear with a high pressure fitting.
3. Remove the steering driveline from the steering gear input shaft.
4. Remove the dirt and water seal (**Fig. 1**, Item 2) from the steering gear. Save this seal to determine the correct size of the new seal.
5. Using a clean cloth, remove all grease from around the input shaft.
6. Using a screwdriver inserted into the notch formed in the end of the retaining ring (**Fig. 1**, Item 3), remove the retaining ring. Be careful not to scratch the bore with the screwdriver.
7. Using a pinch bolt and nut, attach the steering driveline to the input shaft but do not tighten the nut.
8. Tie or wrap a shop towel around the input shaft and place a drain pan under the steering gear to catch the oil.

**WARNING**

**Do not mix hydraulic fluid types or use unapproved fluids. Doing so could cause seal deterioration, leaks, loss of steering assist, and spillage on the roadway, which could result in serious personal injury or death.**

9. If needed, fill the power steering reservoir with automatic transmission fluid that meets Dexron III or TES-389 specifications.
10. With the vehicle in neutral, momentarily turn the starter. If the engine starts, quickly turn it off. This should force out the input shaft seal.
11. Remove the shop towel. Disconnect the steering driveline from the steering gear and remove the input shaft seal (**Fig. 1**, Item 4).
12. Inspect the seal area of the valve housing for seal fragments. Remove all seal fragments.
13. Check the input shaft seal for heat damage. If the seal is stiff and brittle, it is probably heat damaged. Determine and fix the cause of excessive heat in the vehicle.

**WARNING**

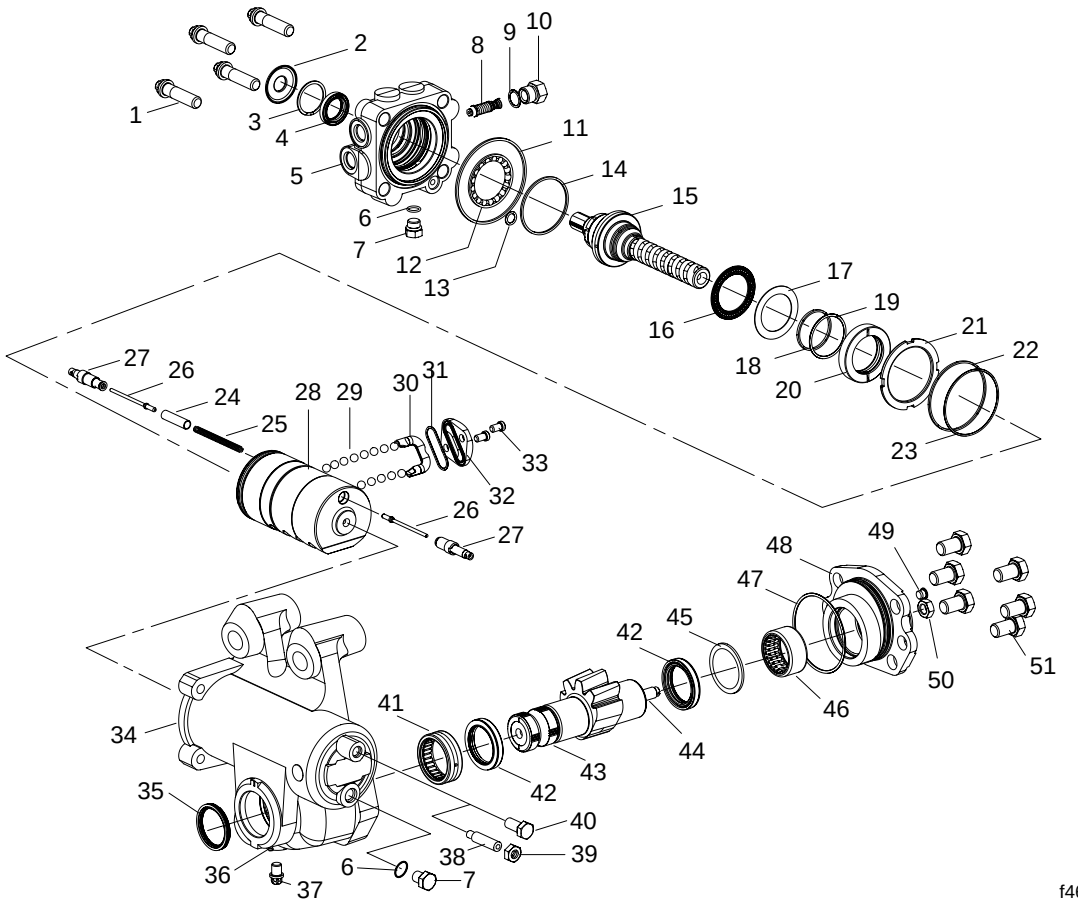
**Do not use a socket to install the input shaft seal. You will not be able to control the seal installation depth with a socket and this could lead to leaks. Leaks could result in loss of steering assist and spillage on the roadway, which could result in personal injury or property damage.**

14. Install a new input shaft seal.
    - 14.1 Using Exxon Polyrex® EP2 grease (045422), lubricate the inside diameter of the new input shaft seal and install it on the input shaft.
    - 14.2 Using a hammer and seal driver (J37073), tap the driver until the shoulder of the driver is square against the valve housing. Remove any seal material that may have sheared off in the seal bore or retaining ring groove.
15. Install a new retaining ring in the groove.
16. Using Exxon Polyrex EP2 grease, pack the end of the valve housing bore.
17. Install a new dirt and water seal.
    - 17.1 Compare the replacement seals to the old seal to determine the correct size, or measure the major diameter of the input shaft serrations. See **Table 1** for the major serration diameter and the corresponding seal part number.
    - 17.2 Apply Exxon Polyrex EP2 grease to the new dirt and water seal and install it on the input shaft. Seat it in the groove behind the serrations and against the valve housing.
18. Using a new pinch bolt and nut, attach the steering driveline to the input shaft. Tighten the nut 30 to 35 lbf·ft (41 to 47 N·m).
19. Attach the return line to the steering gear return port.

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## Input Shaft Seal Replacement




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1. Valve Housing Capscrew
2. Dirt and Water Seal
3. Retaining Ring
4. Input Shaft Seal
5. Valve Housing
6. Auxiliary Port O-Ring (2)
7. Auxiliary Port Plug (2)
8. Relief Valve
9. O-Ring
10. Relief Valve Cap
11. Valve Housing O-Ring
12. Bearing Assembly
13. O-Ring
14. Seal Ring
15. Input Shaft Assembly
16. Thrust Bearing
17. Thrust Washer
18. Seal Ring
19. O-Ring
20. Bearing Adjuster
21. Adjuster Locknut
22. O-Ring
23. Seal Ring
24. Push Tube
25. Poppet Spring
26. Poppet
27. Poppet Seat and Sleeve Assembly
28. Rack Piston
29. Ball
30. Ball Return Guide
31. Cap Seal
32. Ball Return Guide Cap
33. Torx® Capscrew
34. Gear Housing
35. Dirt and Water Seal
36. Grease Fitting
37. Automatic Bleed Plug
38. Poppet Adjusting Screw
39. Poppet Adjusting Screw Nut
40. Poppet Fixed Stop Screw
41. Roller Bearing
42. Output Seal
43. Sector Shaft
44. Sector Shaft Adjusting Screw
45. Washer
46. Roller Bearing
47. Side Cover O-Ring
48. Side Cover
49. Vent Plug, Side Cover
50. Adjusting Screw Jam Nut
51. Capscrew

**Fig. 1, TRW Steering Gear**

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20. Bleed the air from the system. For instructions, see **Subject 110**.

| Major Serration Diameters and Corresponding Seal Part Numbers | | |
|---|---|---|
| **Major Serration Diameter: inch (mm)** | **Serration Size** | **Part Number** |
| 0.807/0.799 (20) | 13/16 in (21 mm) x 36 | 478044 |
| 0.866/0.857 (22) | 7/8 in (22 mm) x 36 | 478060 |
| 0.987/0.977 (25) | 1 in (25 mm) x 36 | 478050 |
| 1.008/1.000 (25) | 1 in (25 mm) x 79 | 478050 |

**Table 1, Major Serration Diameters and Corresponding Seal Part Numbers**

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## Adjustment

NOTE: The jam nut is located on the side cover.

If the steering gear is installed on the frame rail, sector shaft adjustment can only be completed if the adjusting screw jam nut is accessible. If the adjusting screw jam nut is not accessible, the steering gear must be removed. For instructions, see **Subject 100**.

1. Apply the parking brakes and chock the rear tires.
2. With the engine on, turn the steering wheel until the timing mark on the sector shaft lines up with the timing mark on the housing. The line on the sector shaft should be at a 90-degree angle to the input shaft. The sector shaft is now on its center of travel. Turn the engine off.
3. Remove the cotter pin and castle nut that attach the drag link to the pitman arm. Remove the drag link from the pitman arm.

IMPORTANT: To avoid resetting the poppets, do not turn the input shaft more than 1-1/2 turns from the center-of-travel position while the drag link is disconnected.

4. From the center-of-travel position, grasp the pitman arm at the lower end of the arm and gently try to move the arm back and forth. If the pitman arm is loose or lash (free play) is detected, the sector shaft is out of adjustment.
5. Loosen the adjusting screw jam nut.
6. Slowly turn the shaft adjusting screw clockwise until you feel no lash at the sector shaft without using more than 10 lbf·ft (14 N·m) of torque. See **Fig. 1**. From this position, turn the screw clockwise 1/8 to 3/16 of a turn more. Hold the adjusting screw in place and tighten the jam nut 43 lbf·ft (58 N·m).
7. Turn the steering wheel 1/4 turn each side of center then back to center and check the pitman arm for lash. There should be no lash. If lash is detected, loosen the jam nut and repeat the previous step as well as this step.
8. If the steering gear was removed from the frame rail, install the steering gear. For instructions, see **Subject 100**.

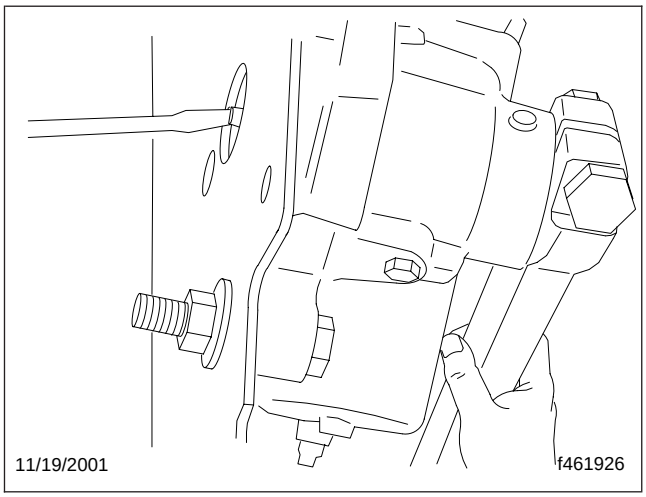



**Fig. 1, Adjusting the Sector Shaft**

9. Using a castle nut, attach the drag link to the pitman arm. Tighten the castle nut using the appropriate torque value.
   - 3/4–16: 90 to 170 lbf·ft (122 to 230 N·m)
   - 7/8–14: 160 to 300 lbf·ft (217 to 407 N·m)

**WARNING**

**Failure to install and lock a new cotter pin in the ball stud and nut could result in disengagement of the parts and loss of steering control, which could result in personal injury or property damage.**

10. Continue to tighten the castle nut until a slot on the nut aligns with the hole in the ball stud. Do **not** reverse the tightening direction of the nut when locating the cotter pin hole. Install a new cotter pin in the ball stud and nut, then lock the cotter pin in place.

**NOTICE**

**Do not use a power grease gun to add grease to the sector shaft bearing. Doing so could damage the high-pressure seal and contaminate the hydraulic fluid.**

11. Using only a hand-operated grease gun, add grease to the sector shaft bearing through the grease fitting in the housing until grease begins to extrude past the dirt and water seal.

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## Poppet Adjustment

The poppet adjustment will work in most cases with at least 1-3/4 turns of the steering wheel from each side of center.

If a large reduction in wheel cut is being made and this procedure does not work, you may have to replace or reset the poppets.

1. Check that the axle stops are adjusted appropriately. See **Group 33** for instructions.
2. Start the engine and allow the vehicle to idle for 5 to 10 minutes to warm the hydraulic fluid.
3. Shut down the engine, apply the parking brakes, and chock the rear tires.
4. If a new poppet adjusting screw and nut (**Fig. 1**, Items 38 and 39) are being used, turn the screw into the non-sealing end of the nut until the drive end of the screw is flush with the nut.

NOTE: The steering gear will have either a poppet fixed stop screw or a poppet adjusting screw. See **Fig. 1**. If the adjusting screw is already part of the steering gear, back the nut off of the adjusting screw until it is flush with the end of the adjusting screw.

5. Make sure that the engine is off and the wheels are in the straight-ahead position.

### NOTICE

**Make sure the drive end of the adjusting screw is not below the face of the nut. If the drive end of the adjusting screw is below the face of the nut, the poppet seat flange will break when the upper poppet is prepared for setting.**

6. Using a 7/32-inch Allen wrench, turn the adjusting screw and nut assembly (without turning the nut on the screw) into the housing until the nut is firmly against the housing. Tighten the nut against the housing.
7. Place a jack under the center of the front axle and jack up the front of the vehicle so the steer axle tires are off the ground.
8. Push the upper poppet out to prepare it for setting.
   - 8.1 Start the engine and let it run at idle speed.
   - 8.2 Note which sector shaft timing mark is nearest the housing piston bore.

### NOTICE

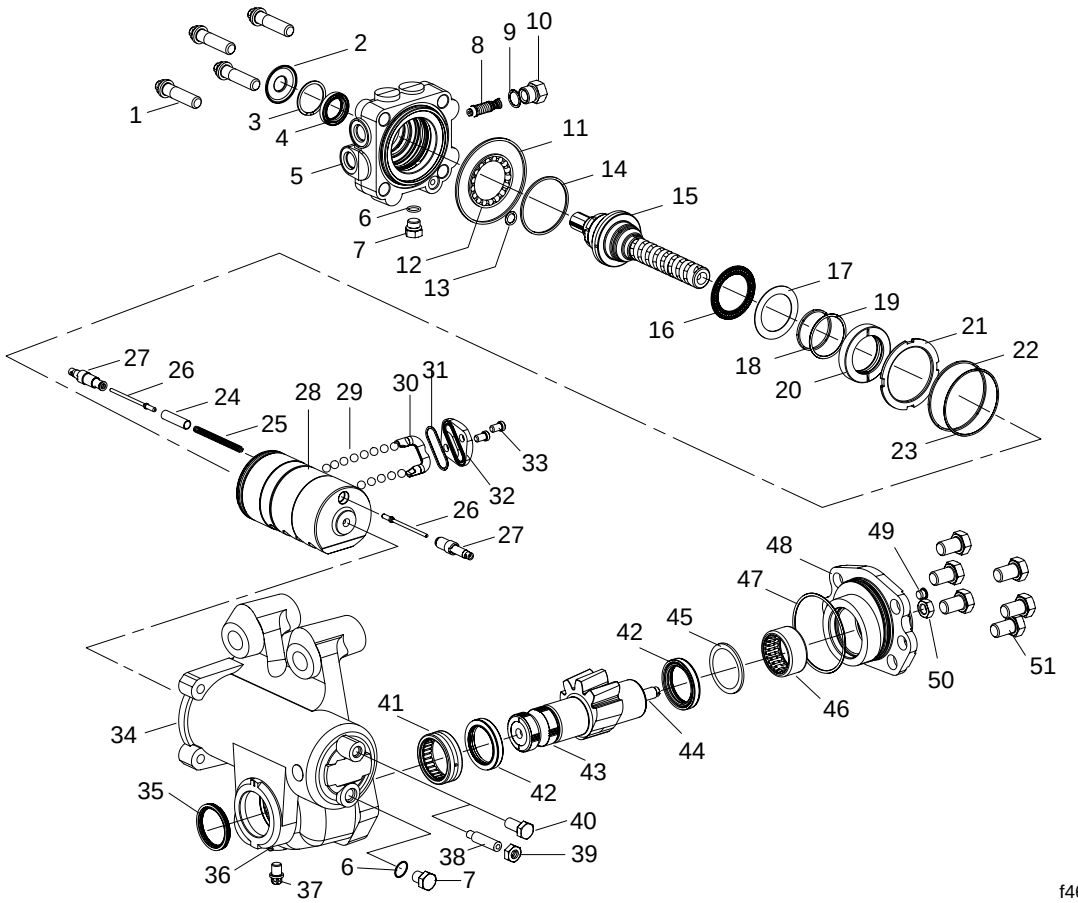
**Do not hold the steering wheel at full turn for more than 10 seconds at a time. The heat buildup at pump relief pressure may damage components.**

   - 8.3 Turn the steering wheel in the direction that makes this timing mark move toward the adjusting screw just installed. Turn the steering wheel in this direction until axle stop contact is made.
   - 8.4 Pull hard on the steering wheel. Put up to 30 lb (133 N) of pull on a 18-inch diameter steering wheel after the axle stop is contacted.
9. Set the upper poppet.
   - 9.1 Turn the steering wheel in the opposite direction (the end of the timing mark away from the adjusting screw) until the other axle stop is contacted.
   - 9.2 Pull hard on the steering wheel. Put up to 30 lb (133 N) of pull on a 18-inch diameter steering wheel.
   - 9.3 Release the steering wheel and shut off the engine.
10. Loosen the nut and back out the adjusting screw until the adjusting screw is one inch (2.5 cm) past the nut. Tighten the nut against the housing.
11. Set the lower poppet.
   - 11.1 Start the engine and let it idle.
   - 11.2 Turn the steering wheel in the original direction (the end of the timing mark is toward the adjusting screw) until axle stop contact is made.
   - 11.3 Hold the steering wheel in this position with up to 30 lb (133 N) of pull for 10 seconds, then release. Repeat this hold-and-release process as many times as necessary while completing the next step.
12. Position the adjusting screw.

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## Poppet Adjustment on a Single Gear




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1. Valve Housing Capscrew
2. Dirt and Water Seal
3. Retaining Ring
4. Input Shaft Seal
5. Valve Housing
6. Auxiliary Port O-Ring (2)
7. Auxiliary Port Plug (2)
8. Relief Valve
9. O-Ring
10. Relief Valve Cap
11. Valve Housing O-Ring
12. Bearing Assembly
13. O-Ring
14. Seal Ring
15. Input Shaft Assembly
16. Thrust Bearing
17. Thrust Washer
18. Seal Ring
19. O-Ring
20. Bearing Adjuster
21. Adjuster Locknut
22. O-Ring
23. Seal Ring
24. Push Tube
25. Poppet Spring
26. Poppet
27. Poppet Seat and Sleeve Assembly
28. Rack Piston
29. Ball
30. Ball Return Guide
31. Cap Seal
32. Ball Return Guide Cap
33. Torx® Capscrew
34. Gear Housing
35. Dirt and Water Seal
36. Grease Fitting
37. Automatic Bleed Plug
38. Poppet Adjusting Screw
39. Poppet Adjusting Screw Nut
40. Poppet Fixed Stop Screw
41. Roller Bearing
42. Output Seal
43. Sector Shaft Assembly
44. Sector Shaft Adjusting Screw
45. Washer
46. Roller Bearing
47. Side Cover O-Ring
48. Side Cover Assembly
49. Vent Plug, Side Cover
50. Adjusting Screw Jam Nut
51. Capscrew

**Fig. 1, THP/PCF Steering Gear**

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12.1 With the steering wheel held tightly at full turn, loosen the nut and hold it in place with a wrench.

12.2 Using an Allen wrench and finger pressure only, turn the adjusting screw clockwise until the Allen wrench stops. Do not attempt to turn the adjusting screw in any farther. Pause the turning-in process each time the driver releases the steering wheel. Continue turning only while the steering wheel is held at full turn.

12.3 Back off the adjusting screw 3-1/4 turns and tighten the nut 35 lbf·ft (47 N·m).

**⚠ WARNING**

**If the adjusting screw protrudes more than 1-1/16 inches (27 mm) from the sealing nut, the screw could fall out of the steering gear, resulting in loss of power steering. This could cause an accident resulting in personal injury or property damage.**

IMPORTANT: Once the poppet adjusting screw and sealing nut are in place, and the poppet valves have been manually adjusted, the adjustment procedure must be repeated if steering travel is increased or decreased in the future.

13. The poppets have now been completely reset. Check the power steering reservoir. The power steering fluid level should be between the MIN COLD mark and the middle mark just above it. If needed, add fluid that meets Dexron III or TES-389 specifications.
14. Lower the vehicle.

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## Post-Service Checks

After power steering components have been worked on and before the vehicle is placed into service, the following items must be checked.

**⚠ WARNING**

**Failure to check the following items could result in damage to the power steering system. This could cause loss of steering assist and spillage on the roadway, which could cause personal injury or property damage.**

1. Operate the engine at low idle while turning the steering wheel through several full-left and full-right turns. With the engine running and the power steering system at operating temperature, turn the steering wheel slowly from stop to stop while checking the power steering reservoir for frothing or a change in the fluid level (signs that air is trapped in the system).

   If air is present, inspect the system for leaking hoses or loose fittings. Replace the hoses or tighten the fittings as necessary. Bleed the air from the system.

2. With the engine turned off and warm, check the power steering reservoir fluid level. The power steering fluid level should be between the MIN COLD mark and the middle mark just above it. If needed, add fluid that meets Dexron III or TES-389 specifications.

3. At full-left and full-right wheel cuts, be sure the axle stops on the rear side of the spindle are set so there is at least 1/2-inch (13-mm) of clearance between the tires and any fixed components that are attached to the vehicle. Clearance between moving components should be at least 3/4-inch (19-mm). If clearance is less, reset the axle stops.

4. Check that the poppets are set correctly. If needed, adjust them. For instructions, refer to **Subject 140**.

5. Test drive the vehicle. Check the steering wheel spoke position. If, during straight-ahead driving on a level road, the steering wheel spokes are not within ±10 degrees of the 9 o'clock and 3 o'clock positions, remove the steering wheel and reposition it. See **Fig. 1**.

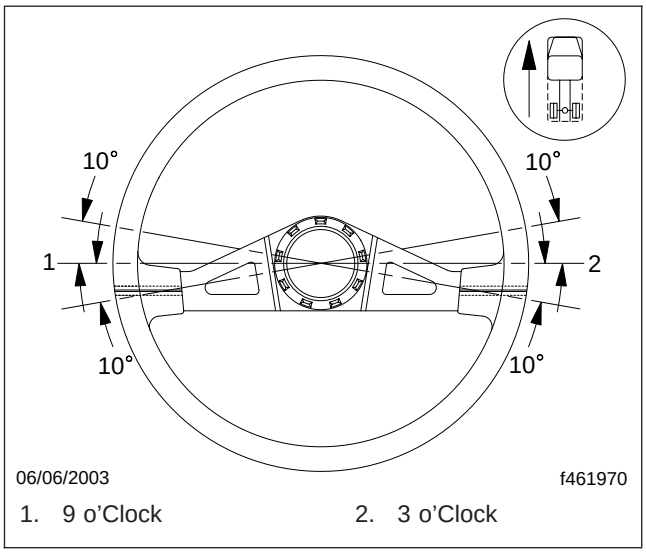



**Fig. 1, Centered Steering Wheel**

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**⚠ WARNING**

**Fill the power steering system with only approved, clean hydraulic fluid. Mixing hydraulic fluids and using unapproved hydraulic fluid could lead to seal deterioration and leaks. Leaks could result in loss of power steering assist and spillage on the roadway, which could cause personal injury or property damage.**

TRW power steering gears use ATF fluid that meets Dexron III or TES-389 specifications.

Exxon Polyrex® EP2 Grease (045422) is approved for use on steering gear components.

Special tools can be ordered from:

SPX Kent-Moore
28635 Mound Road
Warren, Michigan 48092-3499
1-800-328-6657

| SPX Kent-Moore Tools | |
|---|---|
| **Tool Name** | **Part Number** |
| Bearing and Seal Tool | J37071 and J37071–A |
| Special Tool | J36452–A |
| Bearing Adjuster Tool | J37070 |
| Seal Driver Tool | J37073 |
| Adjuster Locknut Tool | J37464 |

**Table 1, SPX Kent-Moore Tools**

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## General Description

The vehicle fuel system delivers fuel to the engine and consists of fuel tanks, tank mounting components, fuel lines, and shutoff valves.

NOTE: Fuel filters, injectors, transfer pumps, and governors are considered parts of the **engine fuel system**, which is considered separate from the **vehicle fuel system**. For service and maintenance information on the engine fuel system, refer to the engine manufacturer's manual.

The fuel tanks are held in place by metal bands and brackets that transfer the load to the vehicle frame. A cab access step assembly or a tank fairing may be attached to the fuel tank bands.

Flexible, high-temperature nylon fuel lines carry fuel from the tank(s) to the engine, and return any surplus fuel back to the tank(s). On dual-tank installations, the fuel lines are routed inboard of the frame rails to the shutoff valves, which are located on the transmission. Fuel is drawn from and returned to each tank in such a way that the tank levels remain equal. The return fuel line directs fuel to the bottom of the tank to ensure thorough mixing of the fuel and vapor dispersal before the fuel is drawn up by the supply line.

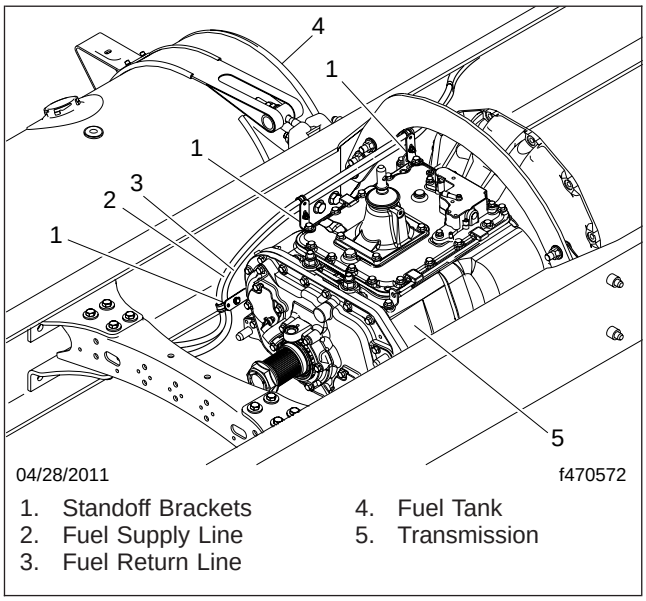
A fuel level sensor (in the primary tank on a dual-tank system) feeds an electronic fuel level gauge in the cab instrument cluster.

## EquiFlo® Fuel System (Vehicles Built Since November 1, 2004)

The EquiFlo fuel system (see **Fig. 1** and **Fig. 2**) is standard on all vehicles manufactured since November 1, 2004. This system maintains similar fuel levels in both fuel tanks, without the need of a low crossover line and includes the following components:

- supply and return lines;
- tank vent and line located on the top of the tank;
- quarter-turn, non-vented fuel cap.

If fuel levels in the tanks are equal, the engine will draw equally from each tank. If fuel levels are unequal, the engine will draw more from the full tank in order to equalize the levels. If the tanks are different sizes, the larger tank will hold a slightly higher fuel level, causing more fuel to flow from it to the engine.




1. Standoff Brackets
2. Fuel Supply Line
3. Fuel Return Line
4. Fuel Tank
5. Transmission

**Fig. 1, EquiFlo Fuel Line Routing (single-tank installation)**

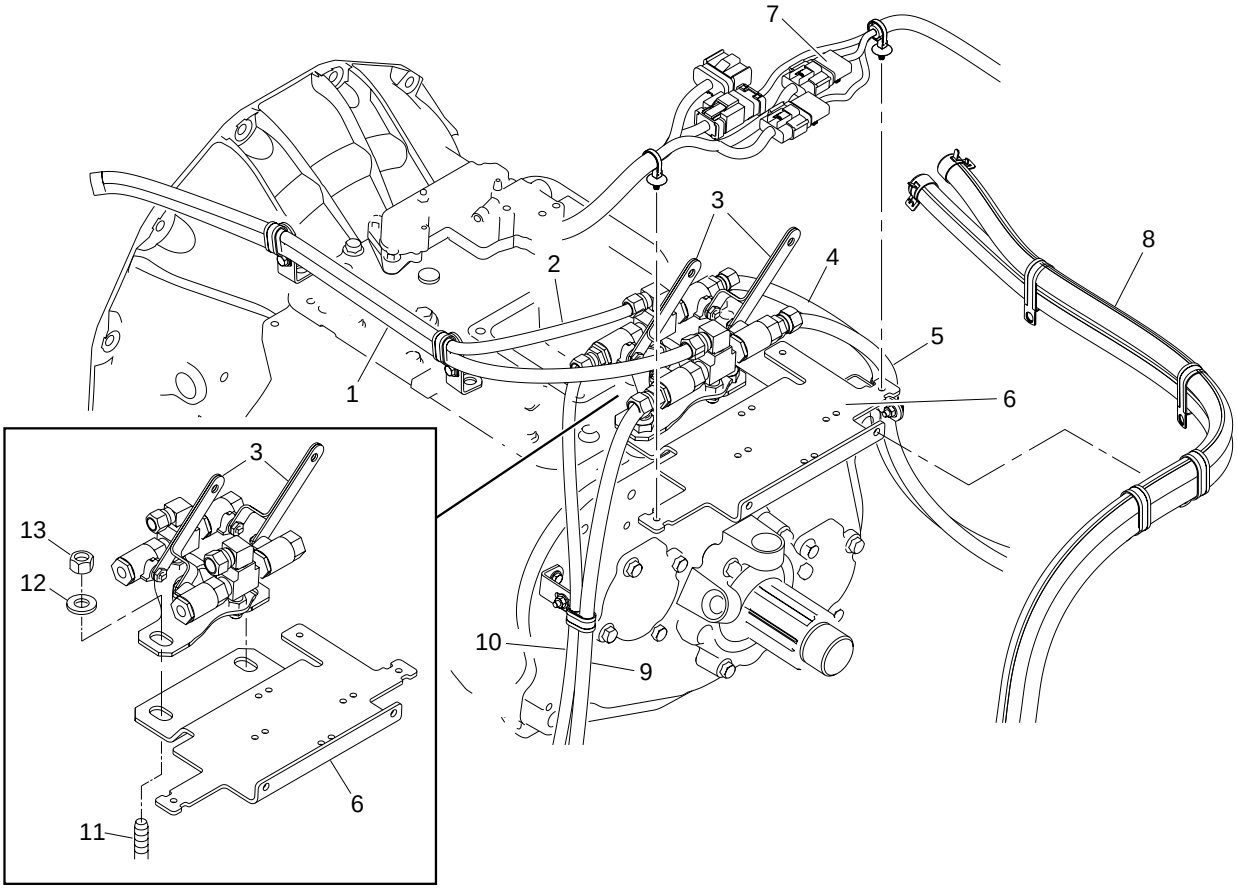
## Splitter Fuel System (Vehicles Built Before November 1, 2004)

The splitter fuel system was standard on all vehicles manufactured before November 1, 2004. Vehicles with dual tanks have splitter valves to regulate fuel flow to and from the fuel tanks. See **Fig. 3**. The splitter valves proportion flow to and from each fuel tank by maintaining constant back pressure, so that each fuel tank supplies and receives equal amounts of fuel. This keeps the fuel load balanced and hot fuel evenly distributed.

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## General Information



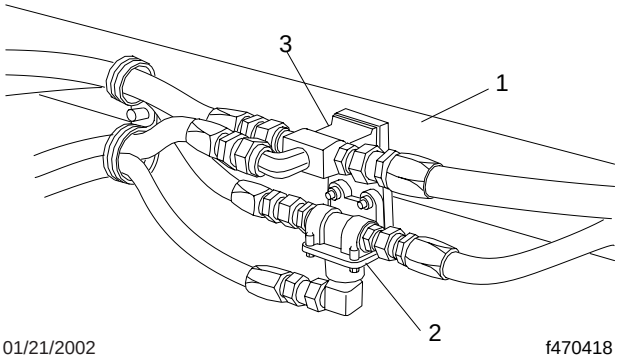

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1. Fuel Supply Line to Engine
2. Fuel Return Line from Engine
3. Fuel Shutoff Valves (qty 2)
4. Fuel Return Line to Right-Hand Fuel Tank
5. Fuel Supply Line from Right-Hand Tank
6. EquiFlo Bracket
7. ATD Wiring Harnesses
8. Coolant Lines (to and from DEF tank)
9. Fuel Supply Line from Left-Hand Tank
10. Fuel Return Line to Left-Hand Tank
11. EquiFlo Bracket Stud (qty 2)
12. Washer (qty 2)
13. Jam Nut (qty 2)

**Fig. 2, EquiFlo Line Routing (dual-tank installation)**

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1. Front Cab Crossmember
2. Fuel Return Splitter Valve
3. Fuel Supply Splitter Valve

**Fig. 3, Splitter Valves**

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## Fuel Line Replacement

**⚠ WARNING**

**Never bundle fuel lines with air conditioning lines.**

**Never route fuel lines with electrical wiring, including electrical harnesses, battery cables, or jumper cables. Doing so creates a fire hazard, and may result in property damage or personal injury.**

If fuel lines are worn, damaged, or deteriorated, replace them. Use the following guidelines for installing and routing fuel lines.

- Fuel lines must be free of droops, sharp bends, and kinks in the lines.
- Fuel lines must not extend below the fuel tank, unless they are completely enclosed in a protective housing.
- Fuel lines must be routed in a continuous upward slope from the fuel tanks, to prevent high and low spots in the hoses.
- Wire braid fuel line requires a 4-inch (102 mm) minimum clearance from exhaust pipes, but does not require additional heat insulation.
- Nylon fuel lines routed within 5 inches (127 mm) of exhaust system pipes must be protected with an approved exhaust shield or foam insulation.
- Fuel lines must be routed to allow routinely serviced components, such as dipsticks, filters, and fuel/water separators, to be easily reached without the need to disconnect the fuel lines.
- Fuel lines must be secured to prevent chafing, kinking, or other damage.
- Fuel lines routed along the inside of the frame rail should be fastened with rubber clamps and standoff brackets, and clipped separately from the battery cables at all times, to avoid fire hazards.
- Space between clamps, whether inside or outside the frame rails, should be no more than 16 inches (405 mm). Ties should be used between clamps, at a maximum distance of 12 inches (305 mm) apart.
- Fuel lines should have a minimum of 1/2-inch (13 mm) of clearance from stationary parts.
- Fuel lines should have a minimum of 1-inch (25 mm) of clearance from any moving parts, and should be well secured near moving parts.
- Fuel lines must be long enough to follow full movement of the parts to which they are attached.
- Coat all tapered pipe threads with Loctite® 592, or an equivalent high-temperature thread sealant.
- Finger-tighten pipe fittings; then tighten 1-1/2 additional turns. Tighten more, if necessary, to seal.
- Fuel lines and fittings must be free of leaks. Fuel loss or entry of air into the fuel line can cause loss of prime in the engine fuel system.
- Drains or other bottom fittings must not extend more than 3/4-inch (19 mm) below the lowest part of the fuel tank or sump.

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## Fuel Tank Replacement, 4900/6900 Models

# Replacement

IMPORTANT: U.S. Federal Motor Carrier Safety Regulation 393.67 establishes standards relating to fuel tank strength, leakage, and venting. Replacement fuel tanks must meet these same standards.

**WARNING**

**Do not expose the fuel to open fire. Do not work with the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.**

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.

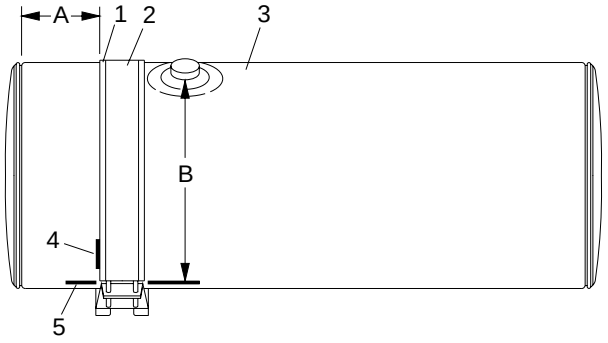
IMPORTANT: On vehicles with dual-tank installations, close the fuel shutoff valves before draining the tank.

2. Drain the fuel from the tank.
   - 2.1 Remove the drain plug from the fuel tank that is to be replaced.
   - 2.2 Drain the fuel into a suitable container, big enough to hold the amount of fuel in the tank.
   - 2.3 If the fuel is to be re-used, store it in a clean container and keep it covered, clean, and free from contaminants.
3. If a lightbar is fitted over the fuel tank, disconnect the wiring harness and remove the lightbar.
4. Disconnect the fuel lines from the tank, then cap the lines.
5. Remove the fuel level sending unit.
6. Remove and clean all of the pipe plugs, then save them for installation on the new tank.
7. Before removing the fuel tank bands, measure and record the distance from the forward edge of the fuel tank to the edge of the forwardmost band isolator.

   Measure and record the distance from the fuel filler cap to the end of the J-bracket. See **Fig. 1**.
8. To prevent the fuel tank from rolling during and after removal, nail 2-by-4 or 4-by-4 wooden blocks to the top of a pallet about 18 inches (460 mm) apart, then place the pallet on the forks of a forklift. See **Fig. 2**.

   Move the forklift and pallet into place to support the fuel tank.
9. Remove the fasteners that secure the lower ends of the tank bands to the J-brackets. See **Fig. 3**.
10. Remove the fasteners that secure the upper ends of the tank bands to the J-brackets.
11. Remove the tank bands with their rubber insulators.
12. Using the forklift and pallet, remove the fuel tank from the J-brackets.

NOTE: The tank may stick to the rubber isolator on the J-bracket, but it will come loose. Lift carefully, and take care to keep it evenly balanced.




A. Measure and record the distance from the forward edge of the fuel tank to the edge of the forwardmost band isolator.
B. Measure and record the distance from the fuel filler cap to the end of the J-bracket.

1. Tank Band Isolator
2. Tank Band
3. Fuel Tank

**Fig. 1, Fuel Tank Orientation**

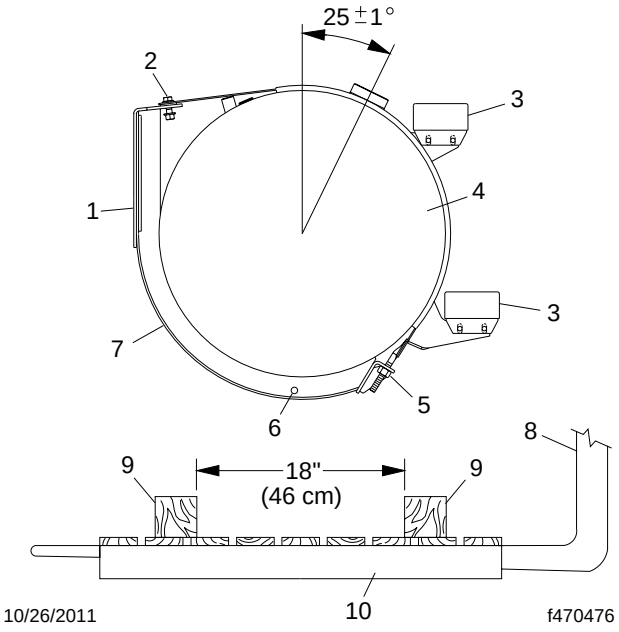
**WARNING**

**Failure to replace worn or damaged parts could result in loss of a fuel tank and spilling of fuel, which could cause property damage or personal injury.**

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## Fuel Tank Replacement, 4900/6900 Models

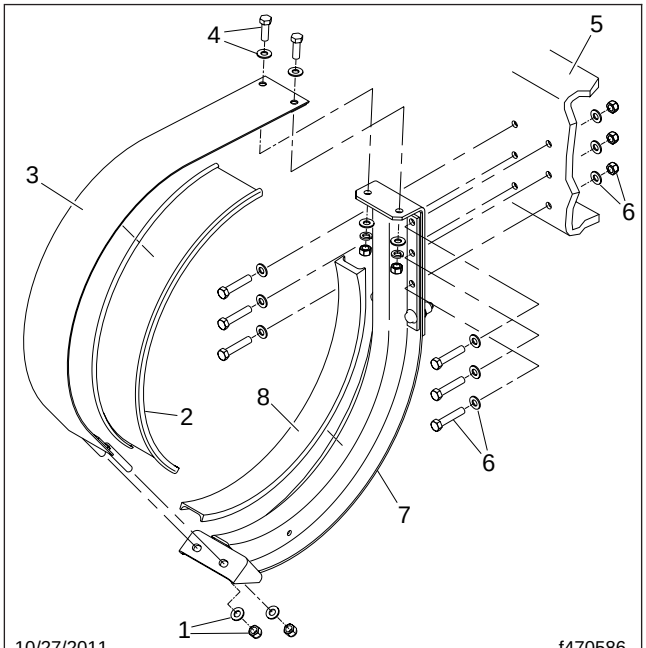



NOTE: Fuel filler neck is positioned 25±1º outboard of vertical.

1. J-Bracket Mount
2. Upper Tank Band Fasteners
3. Steps
4. Fuel Tank
5. Lower Tank Band Fasteners
6. Compression Brace Mounting Hole
7. J-Bracket
8. Forklift
9. Wood Blocks Fastened to Pallet
10. Wood Pallet

**Fig. 2, Forklift Anti-Roll Pallet Assembly**

13. After removing the tank, inspect the tank bands, isolators, and brackets for damage. Replace worn or damaged parts with new parts. Refer to **Subject 120** for band and bracket replacement procedures.
14. Using the forklift and pallet, put the new fuel tank in its approximate installed position on the J-brackets. Ensure the tank is rotated so the vent is located on top of the tank. Position the filler neck 25±1 degrees outboard from vertical. See **Fig. 2**.




1. Lower Band Mounting Fasteners (2 sets)
2. Tank Band Isolator
3. Tank Band
4. Upper Band Mounting Fasteners (2 sets)
5. Frame Rail
6. J-Bracket Mounting Fasteners (6 sets)
7. J-Bracket
8. J-Bracket Isolator

**Fig. 3, Fuel Tank Mounting Assembly**

## NOTICE

**Fuel tanks can be damaged by direct isolator pressure on the tank weld seam, and by over-tightening the fuel tank bands. Be sure the weld seam aligns with reliefs in the isolators and that the bands are tightened to specification.**

NOTE: On vehicles equipped with side fairings, the fuel tank filler neck need not be exactly centered in the fill door opening. The centerline of the fuel filler cap can be anywhere within one inch (25 mm) of the centerline of the fill door opening.

15. Place the tank bands, with their isolators, on the fuel tank.
16. Adjust the tank position until the distance between the forward edge of the tank and the for-

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wardmost band isolator is equal to the distance measured in **Fig. 1**.

17. Insert the lower tank band studs in the J-brackets, and loosely install the washers and nuts.
18. Install the fasteners that secure the upper ends of the tank bands to the J-brackets. Tighten the nuts 30 to 35 lbf·ft (41 to 47 N·m).
19. Tighten the lower band fasteners alternately in stages 16 to 20 lbf·ft (22 to 27 N·m).
20. Ensure the fuel lines are clean, then install them on the fuel tank fittings.
21. Install the fuel level sender, if equipped.
22. Coat the pipe plug threads with Loctite® 592, or an equivalent. Install pipe plugs in any remaining open threaded holes.
23. Install the lightbar, if equipped.
24. Fill the fuel tank with clean fuel. Prime the engine fuel pump. See the engine manufacturer's operation and maintenance manual for instructions.
25. On vehicles with dual-tank installations, open the fuel shutoff valves.

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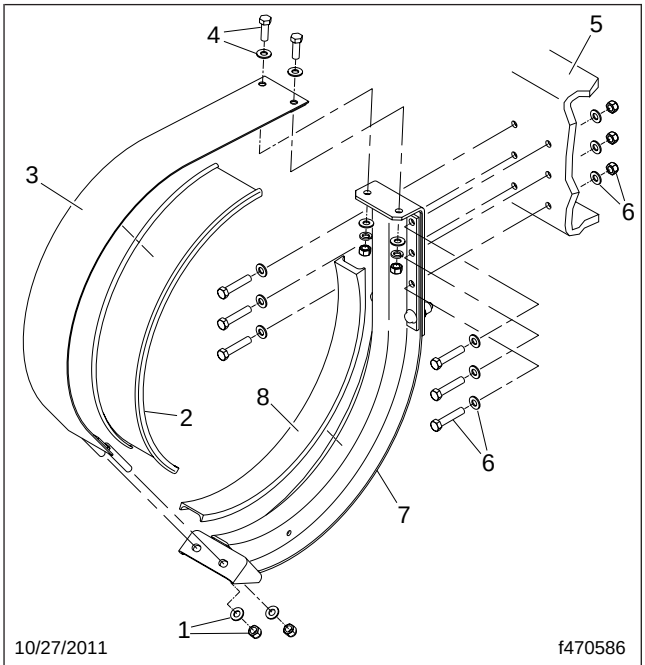
# Tank Band and Bracket Replacement, 4900/6900 Models

## Band Replacement

**WARNING**

**Do not expose the fuel to open fire. Do not work with the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.**

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Using a floor jack or forklift and protective padding, support the fuel tank.
3. Remove the nuts and washers that secure the lower end of the tank band to the J-bracket. See **Fig. 1**.




1. Lower Band Mounting Fasteners (2 sets)
2. Tank Band Isolator
3. Tank Band
4. Upper Band Mounting Fasteners (2 sets)
5. Frame Rail
6. J-Bracket Mounting Fasteners (6 sets)
7. J-Bracket
8. J-Bracket Isolator

**Fig. 1, Fuel Tank Mounting Assembly**

4. Remove the fasteners that secure the upper end of the tank band to the J-bracket.
5. Remove the tank band and rubber isolator.

**NOTICE**

**Fuel tanks can be damaged by direct isolator pressure on the tank weld seam, and by overtightening the fuel tank bands. Be sure the weld seam aligns with reliefs in the isolators and that the bands are tightened to specification.**

6. Position the new tank band, with the band isolator, around the tank. Insert the isolator under the band so that the relief in the isolator aligns with the tank longitudinal weld seam.

**NOTICE**

**Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other could lead to corrosion of the metals, resulting in damage to the components.**

7. Apply Alumilastic®, or an equivalent, to the J-bracket where it contacts the band.
8. Insert the lower tank band studs in the J-bracket, and loosely install the washers and nuts.
9. Install the fasteners that secure the upper end of the tank band to the J-bracket. Tighten the nuts 30 to 35 lbf·ft (41 to 47 N·m).
10. Tighten the band lower fasteners alternately in stages to 16 to 20 lbf·ft (22 to 27 N·m).

## Bracket Replacement

**WARNING**

**Do not expose the fuel to open fire. Do not work with the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.**

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.

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## Tank Band and Bracket Replacement, 4900/6900 Models

2. Support the tank and remove the fuel tank band from the bracket that is being replaced. See the heading above, **Band Replacement**, for instructions.

NOTE: It is not necessary to disconnect the fuel lines and vent hose to change only the J-bracket or its fittings. The fuel lines should allow sufficient careful movement of the tank to replace the brackets, though some fuel line P-clamps may need to be removed to allow tank movement without damaging the fuel lines.

3. Move the fuel tank enough to gain access to the J-bracket.
4. Remove the fasteners from the compression brace, if equipped.
5. Remove the fasteners that attach the J-bracket to the frame rail and remove the J-bracket. See **Fig. 1**.

### NOTICE

**Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the components.**

6. Apply Alumilastic® compound, or equivalent, between the new J-bracket and the frame rail.
7. Loosely install the new J-bracket and compression brace, if equipped, on the frame rail.
8. Tighten the J-bracket mounting fasteners 160 lbf·ft (217 N·m).
9. Install the fuel tank band. See the heading above, **Band Replacement**, for instructions.

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# Fuel Shutoff Valve Replacement, EPA10 Engines

## Replacement

NOTE: Fuel shutoff valves are only installed on vehicles with dual tanks.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Put the transmission into high gear and open the hood.

**⚠ WARNING**

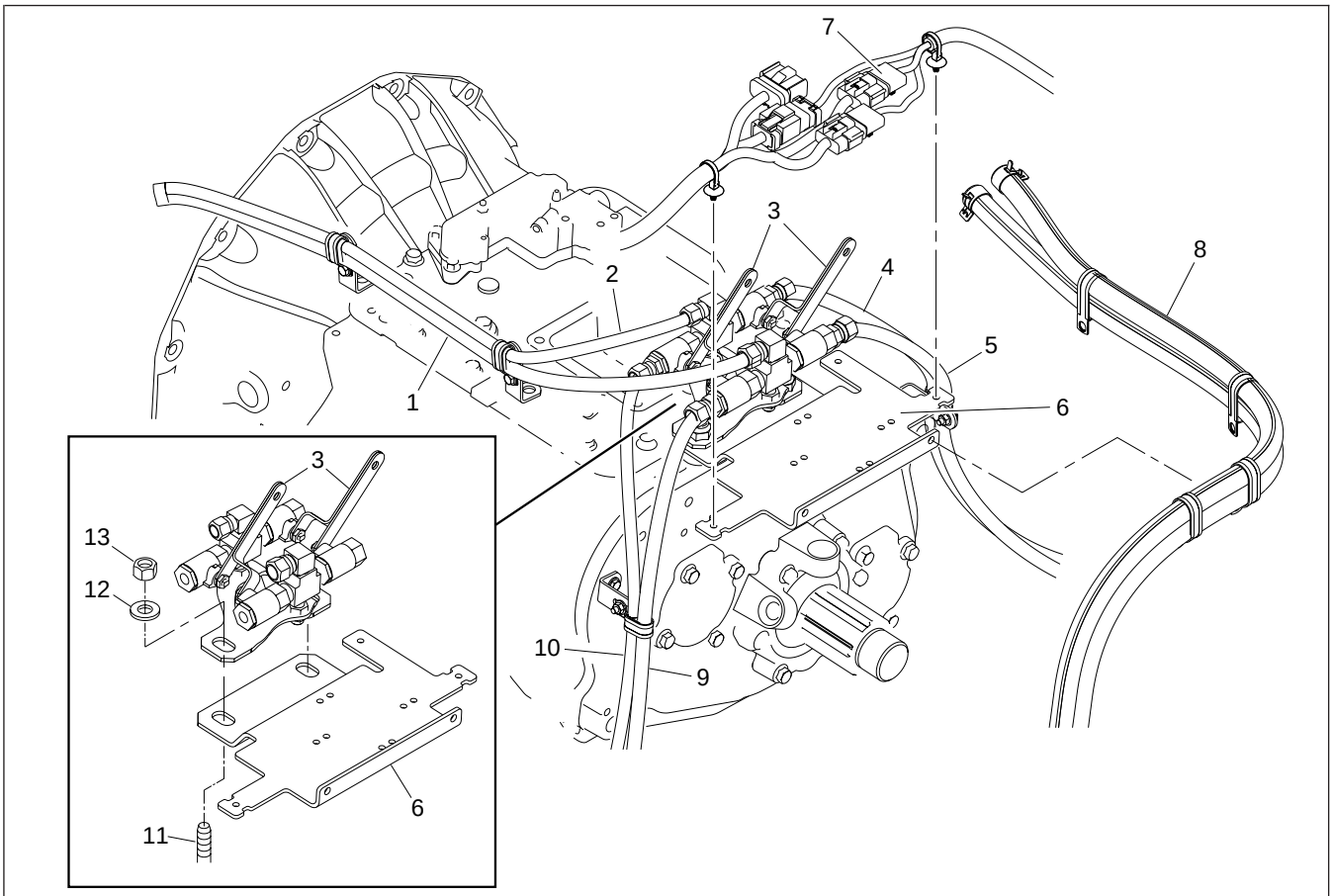
**Aftertreatment device (ATD) internal temperatures can remain hot enough to cause personal injury or ignite combustible materials for hours after the engine is shut down, causing potentially serious burns or material damage. Wear appropriate protective gear when working around the ATD. Do not to let diesel from the fuel lines come into contact with the ATD.**

3. Disconnect the driveline from the transmission output yoke. For instructions, see **Section 41.00, Subject 100** for uncoupling from a *half-round* end-yoke, or **Section 41.00, Subject 110** for uncoupling from a *full-round* end-yoke.
4. Disconnect the driveline midship bearing from the midship bearing bracket, and set the driveline out of the way.
5. Disconnect the ATD wiring harnesses located on the EquiFlo bracket.
6. Disconnect the diesel exhaust fluid (DEF) coolant lines, located on the EquiFlo bracket.
7. Disconnect the fuel lines from the tee fittings, then cap the lines.
8. In order to gain access to the fuel shutoff valves, it may be necessary to remove the standoff brackets that secure the DEF lines to the EquiFlo bracket and move the lines aside. See **Fig. 1**.
9. Remove any remaining cables and brackets as needed to access the fuel shutoff valves.
10. Loosen the two jam nuts that secure the fuel shutoff valves and tee fittings to the EquiFlo bracket. Remove the tee fittings and valves as an assembly.
11. Remove the shutoff valves from the tee fittings, then install new shutoff valves.
12. Using two jam nuts, install the tee fitting and shutoff valve assembly on the EquiFlo bracket.
13. Install the fuel lines on the tee fittings and tighten the fittings.
14. If any ATD wiring harness standoff brackets were previously removed, install them on the EquiFlo bracket, then connect the wiring harnesses.
15. If any DEF line standoff brackets were previously removed, install them on the EquiFlo bracket.
16. Connect the DEF coolant lines.
17. Install any remaining cables and brackets that were previously removed.
18. Connect the driveline to the transmission output yoke. For instructions, see **Section 41.00, Subject 100** for coupling to a *half-round* end-yoke, or **Section 41.00, Subject 110** for coupling to a *full-round* end-yoke.
19. Connect the midship bearing to the midship bearing bracket.
20. Start the engine and check for leaks.

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## Fuel Shutoff Valve Replacement, EPA10 Engines




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1. Fuel Supply Line to Engine
2. Fuel Return Line from Engine
3. Fuel Shutoff Valves (qty 2)
4. Fuel Return Line to Right-Hand Fuel Tank
5. Fuel Supply Line from Right-Hand Tank
6. EquiFlo Bracket
7. ATD Wiring Harnesses
8. Coolant Lines (to and from DEF tank)
9. Fuel Supply Line from Left-Hand Tank
10. Fuel Return Line to Left-Hand Tank
11. EquiFlo Bracket Stud (qty 2)
12. Washer (qty 2)
13. Jam Nut (qty 2)

**Fig. 1, Fuel Shutoff Valve Assembly, Dual-Tank Vehicle**

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## Fuel Tank Replacement, 4700 Models

# Removal

IMPORTANT: U.S. Federal Motor Carrier Safety Regulation 393.67 establishes standards relating to fuel tank strength, leakage, and venting. Replacement fuel tanks must meet these same standards.

**⚠ WARNING**

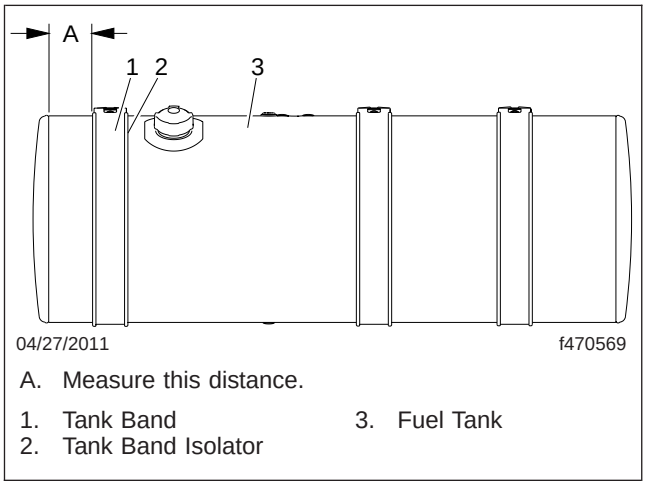
**Do not expose the fuel to open fire. Do not work with the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.**

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.

IMPORTANT: On vehicles with dual-tank installations, close the fuel shutoff valves before draining the tank.

2. Drain the fuel from the tank.
   - 2.1 Remove the drain plug from the fuel tank that is to be replaced.
   - 2.2 Drain the fuel into a suitable container, big enough to hold the amount of fuel in the tank.
   - 2.3 If the fuel is to be re-used, store it in a clean container and keep it covered, clean, and free from contaminants.
3. Disconnect the fuel lines from the tank, then cap the lines.
4. Remove the fuel level sending unit.
5. Remove and clean all of the pipe plugs, then save them for installation on the new tank.
6. Before removing the fuel tank bands, measure and record the distance from the forward edge of the fuel tank to the edge of the forwardmost band isolator. See **Fig. 1**.
7. To prevent the fuel tank from rolling during and after removal, nail 2-by-4 or 4-by-4 wooden blocks to the top of a pallet about 18 inches (460 mm) apart, then place the pallet on the forks of a forklift. See **Fig. 2**.

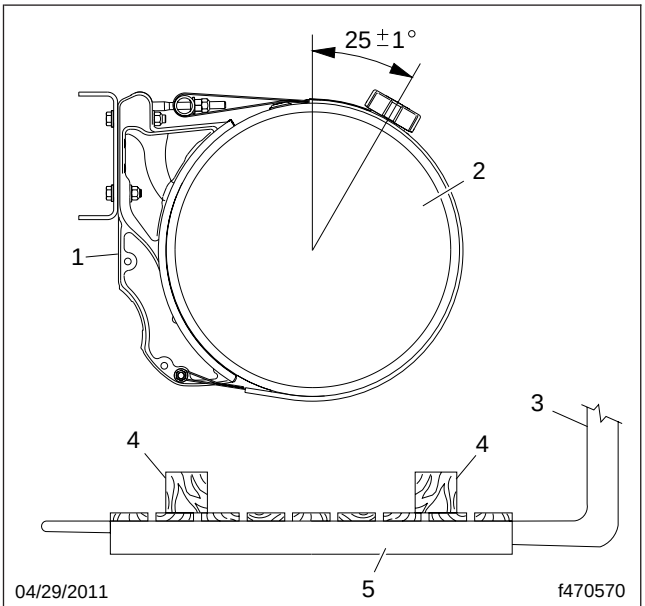
Move the forklift and pallet into place to support the fuel tank.




A. Measure this distance.

1. Tank Band
2. Tank Band Isolator
3. Fuel Tank

**Fig. 1, Distance From Forward Edge of Fuel Tank to Isolator**




NOTE: The fuel filler neck should be rotated 25º outboard of the vertical on standard tanks.

1. Fuel Tank Bracket
2. Fuel Tank
3. Forklift
4. Wooden Blocks
5. Wooden Pallet

**Fig. 2, Fuel Tank Orientation and Support**

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## Fuel Tank Replacement, 4700 Models

8. Loosen the jam nut on each tank band eye bolt. Remove the jam nut, inner hexnut, and washer. See **Fig. 3**.

   Drop the tank bands and isolators. Leave the tensioner lug inside the band.

9. Remove the fuel tank.
10. After removing the tank, inspect the tank bands, isolators, and brackets for damage. Replace worn or damaged parts with new parts. Refer to **Subject 150** for tank band and bracket replacement instructions.
11. Using the forklift and pallet, put the new fuel tank in its approximate installed position. Ensure the tank is rotated so the vent is located on top of the tank. See **Fig. 2**.

    Install the forward tank band and band isolator loosely.

    11.1 Holding the tank on the forklift, attach the band and isolator to the eye bolt.

    11.2 Install a hardened flatwasher and the inner 5/8–11 hexnut, but do not tighten it yet.

12. Adjust the tank position until the distance between the forward edge of the tank and the band isolator is equal to the distance measured in **Fig. 1**.

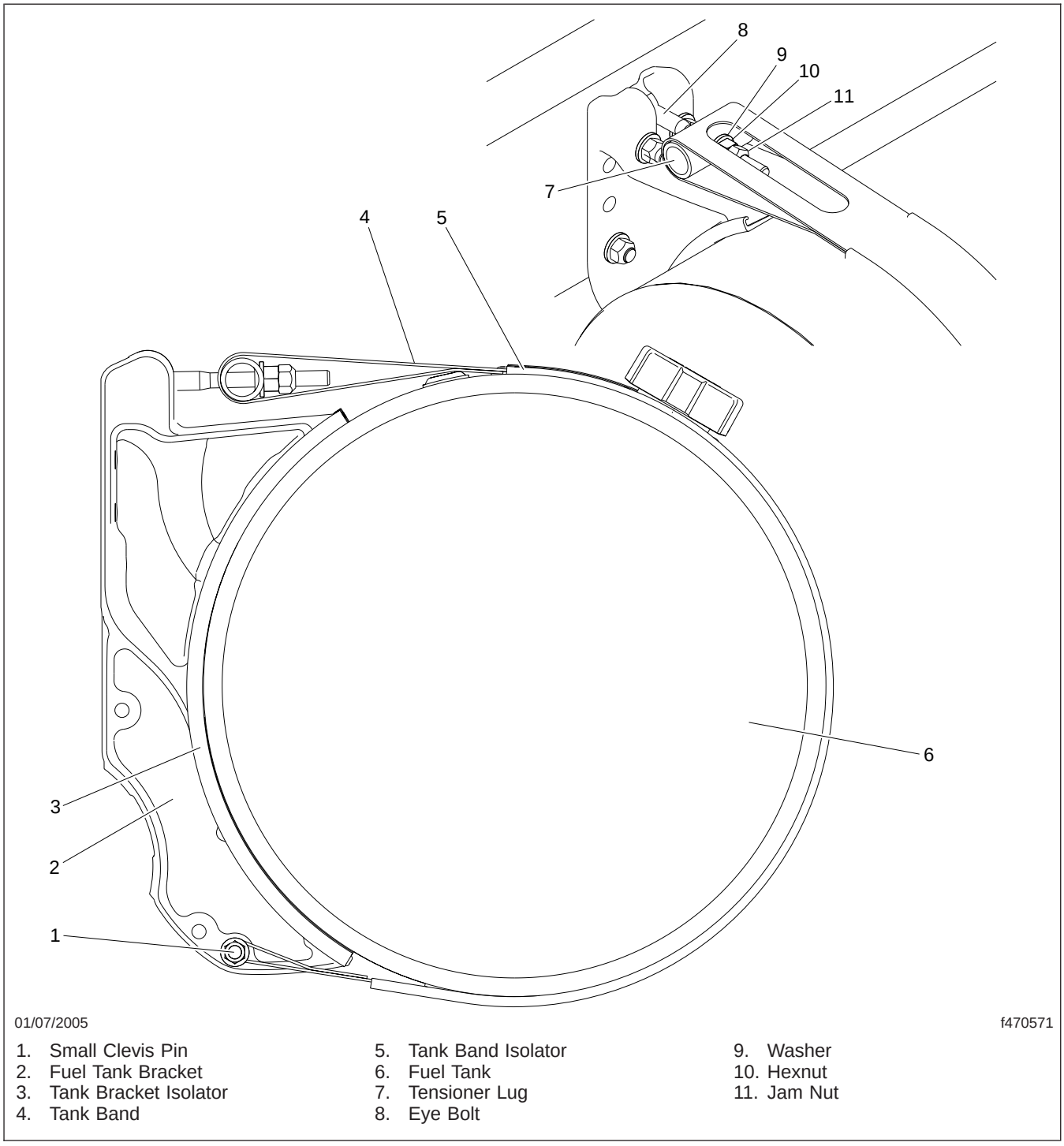
### NOTICE

**Fuel tanks can be damaged by direct isolator pressure on the tank weld seam, and by overtightening the fuel tank bands. Be sure the weld seam aligns with reliefs in the isolators and that the bands are tightened to specification.**

13. Install the other tank band around the tank. Insert the isolators under the bands so that the relief in each isolator aligns with the tank longitudinal weld seam.
14. Tighten the inner hexnuts alternately in stages, until each is tightened 32 lbf·ft (43 N·m).
15. Install a jam nut on each hexnut, then tighten each jam nut 32 lbf·ft (43 N·m).
16. Make certain the fuel lines are clean, then install them on the fuel tank fittings.
17. Coat the pipe plug threads with Loctite® 592, or an equivalent. Install pipe plugs in any remaining open threaded holes.
18. Fill the fuel tank with clean fuel. Prime the engine fuel pump. See the engine manufacturer's operation and maintenance manual for instructions.
19. On vehicles with dual-tank installations, open the fuel shutoff valves.

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1. Small Clevis Pin
2. Fuel Tank Bracket
3. Tank Bracket Isolator
4. Tank Band
5. Tank Band Isolator
6. Fuel Tank
7. Tensioner Lug
8. Eye Bolt
9. Washer
10. Hexnut
11. Jam Nut

**Fig. 3, Fuel Tank Band Assembly**

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# Tank Band and Bracket Replacement, 4700 Models

## Band Replacement

**WARNING**

**Do not expose the fuel to open fire. Do not work with the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.**

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Using a floor jack or forklift and protective padding, support the fuel tank.
3. Remove the nuts and washers from the tank band eye bolt, at the outboard end of the tank bracket. See **Fig. 1**.
4. Drop the tank band. Inspect both the band and bracket isolators for wear or damage, and replace if needed.
5. Remove the small clevis pin from the bottom end of the fuel tank bracket, freeing the band.
6. Remove the band from the fuel tank.
7. Install the new band.
   - 7.1 Position the small end of the new band on the bottom edge of the fuel tank bracket.
   - 7.2 Install the small clevis pin with two hardened flatwashers onto the fuel tank bracket and band, and fasten it in place with a cotter pin.

**NOTICE**

**Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other could lead to corrosion of the metals, resulting in damage to the components.**

8. Apply Alumilastic®, or an equivalent, to the bracket where it contacts the band.

**NOTICE**

**Fuel tanks can be damaged by direct isolator pressure on the tank weld seam, and by overtightening the fuel tank bands. Be sure the weld seam aligns with reliefs in the isolators and that the bands are tightened to specification.**

9. Position the new tank band and band isolator around the tank. Insert the band isolator so that the relief in the isolator aligns with the tank longitudinal weld seam.
10. Attach the upper end of the band and tighten the band nuts.
    - 10.1 Position the large end of the band, with tensioner lug in place, on the end of the eye bolt.
    - 10.2 Install a hardened flatwasher and the inner hexnut. Tighten the inner hexnut 32 lbf·ft (43 N·m).
    - 10.3 Install a jam nut on the hexnut and tighten the jam nut 32 lbf·ft (43 N·m).
11. Repeat this procedure to replace the other bands, as needed. When the bands have been replaced, check the inner hexnuts and jam nuts for tightness.

## Bracket Replacement

1. Support the tank and remove the fuel tank band from the bracket that is being replaced. See the heading above, **Band Replacement**, for instructions.
2. Remove the fasteners that attach the bracket to the frame rail and remove the bracket. See **Fig. 2**.
3. Install the new tank bracket.

**NOTICE**

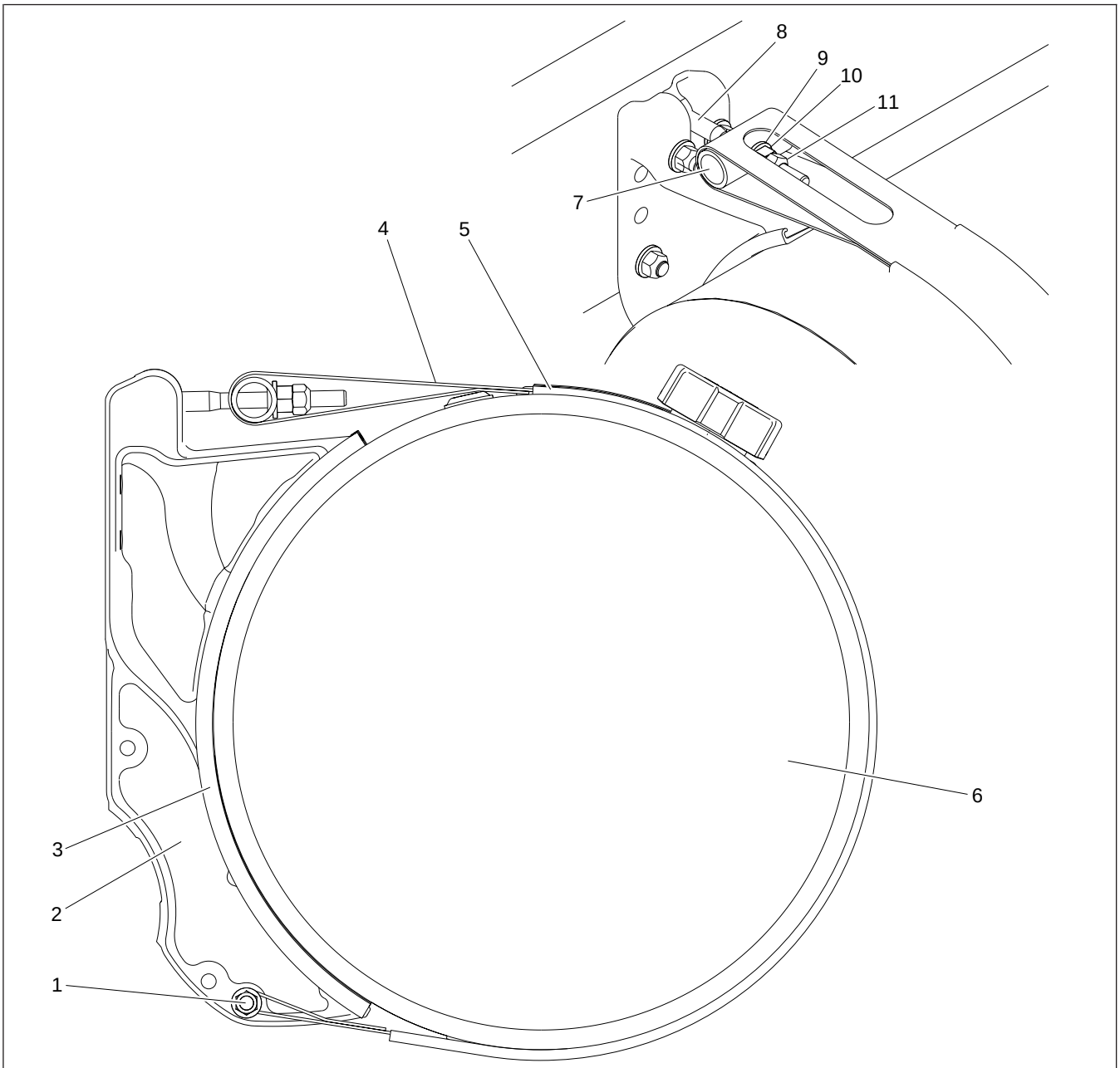
**Failure to apply Alumilastic compound, or an equivalent, to areas where aluminum and steel parts contact each other, could lead to corrosion of the metals, resulting in damage to the components.**

- 3.1 Apply Alumilastic® compound, or equivalent, between the fuel tank bracket and the frame rail.
- 3.2 Position the new tank bracket against the outside of the frame rail. See **Fig. 2**.

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## Tank Band and Bracket Replacement, 4700 Models




1. Small Clevis Pin
2. Fuel Tank Bracket
3. Tank Bracket Isolator
4. Tank Band
5. Tank Band Isolator
6. Fuel Tank
7. Tensioner Lug
8. Eye Bolt
9. Washer
10. Hexnut
11. Jam Nut

**Fig. 1, Fuel Tank Band Assembly**

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## Tank Band and Bracket Replacement, 4700 Models

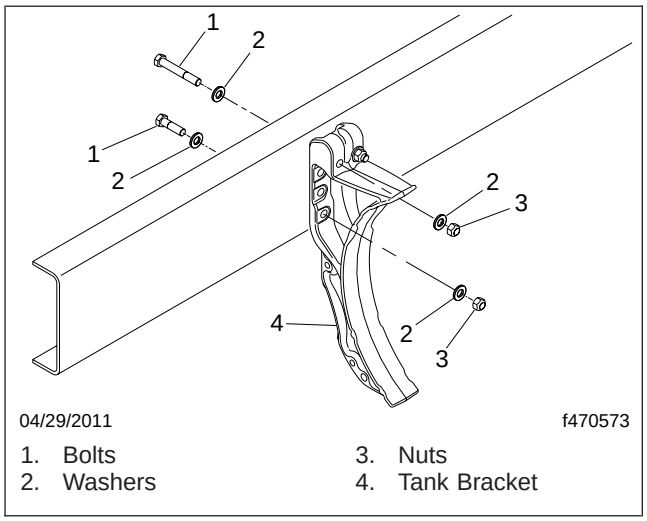



**Fig. 2, Fuel Tank Bracket Installation**

3.3 Insert two 5/8–11 x 4-inch bolts with washers through the top holes in the frame rail and bracket.

3.4 Insert two 5/8–11 x 2-1/4 inch bolts with washers through the bottom holes in the frame rail and bracket.

3.5 Install hardened washers and hexnuts on all four bolts. Tighten the hexnuts 136 lbf·ft (184 N·m).

3.6 Install the fuel tank band. See the heading above, **Band Replacement**, for instructions.

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## Flushing

In the event of a catastrophic failure of the high-pressure fuel pump, it is necessary to clean the fuel tanks and all other system components between the tanks and the engine. For information about cleaning the engine components after a failure, refer to the engine manufacturer's service literature.

IMPORTANT: Always follow EPA and local regulations when disposing of contaminated fuel.

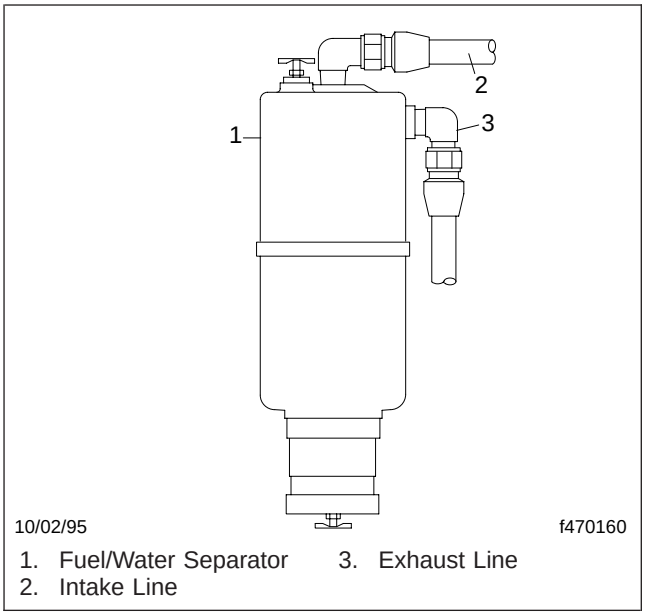
1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Drain all of the fuel from the tank(s) into a suitable container. Dispose of the contaminated fuel in an appropriate manner.
3. Remove the tank(s) from the vehicle. For instructions, refer to **Subject 100**.
4. Thoroughly steam clean the inside of the tank until all water leaving the drain hole looks clean.
5. Install the drain plug and cap any other open outlets.
6. Put two gallons of diesel fuel in the tank, and install the cap. Slosh the diesel around in the tank making sure it reaches all interior surfaces. This should collect most of any remaining contaminants in the tank.
7. Drain this fuel from the tank into a suitable container. Dispose of the contaminated fuel in an appropriate manner.
8. If equipped, remove the fuel/water separator(s) from the system. For instructions, refer to **Group 47**.
9. Remove and discard the filter element. Then thoroughly clean the unit.
10. Install a new filter element.
11. Remove all of the fuel lines from the system and replace them with new lines.
12. Install the fuel/water separator. For instructions, refer to **Group 47**.
13. Install the fuel tank(s) on the vehicle. For instructions, refer to **Subject 100**.

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## General Description

The Con Met fuel/water separator (see **Fig. 1**) removes water and solid contaminants from diesel fuel. Installed on the left frame rail between the fuel tank and the fuel transfer pump, the separator has no moving parts and contains no filters.




1. Fuel/Water Separator
2. Intake Line
3. Exhaust Line

**Fig. 1, Con Met Fuel/Water Separator, Basic Model**

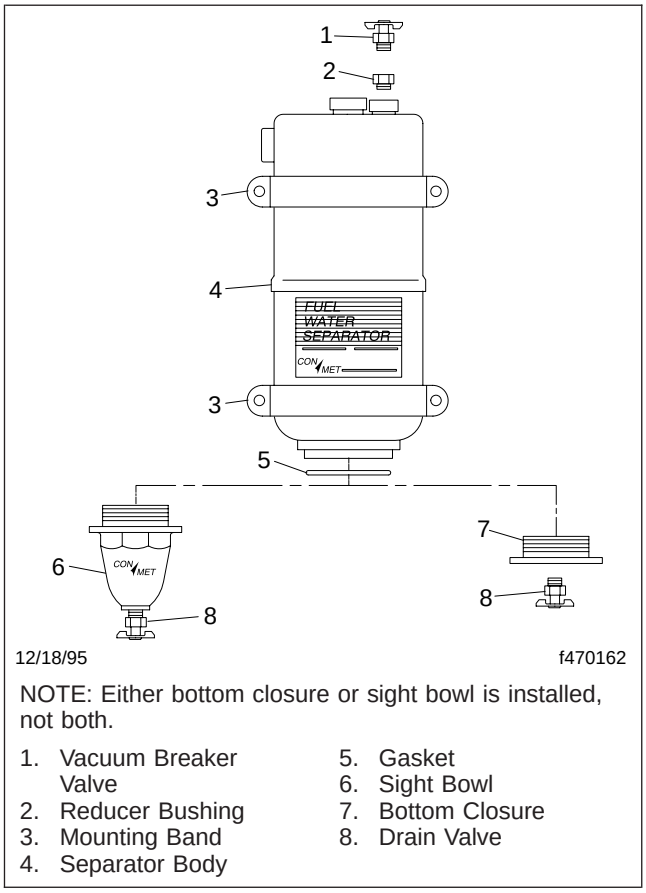
It is available in a basic model, or with a sight bowl, and/or a heater activated by a mechanical thermostat. All fuel and coolant line fittings are 1/2-inch NPT.

## Principles of Operation

Diesel fuel enters at the top of the separator (see **Fig. 2**) and flows down through a specially-designed baffle, causing the water in the fuel to coalesce in large droplets which then accumulate in the bottom of the unit and can be drained by opening a valve.

The heater, if installed (see **Fig. 3**), routes engine coolant through a tube to heat the fuel as it trickles down through the baffle. If a sight bowl is also installed, a heater rod warms the water in the sight bowl.

Fuel passing through the thermostat activates a valve that controls coolant flow and regulates fuel temperature. To prevent mixing, fuel and coolant are completely separated.




NOTE: Either bottom closure or sight bowl is installed, not both.

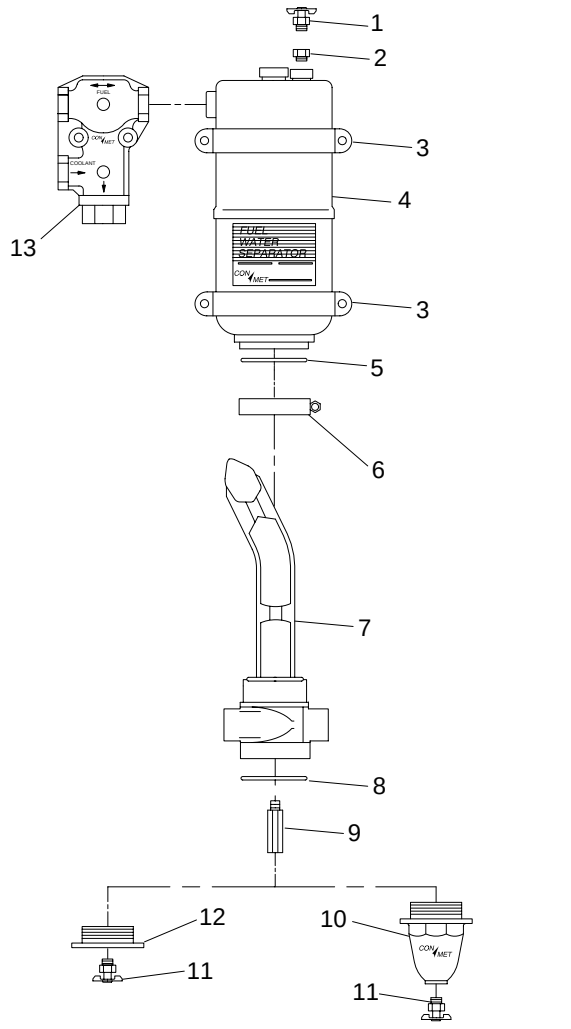
1. Vacuum Breaker Valve
2. Reducer Bushing
3. Mounting Band
4. Separator Body
5. Gasket
6. Sight Bowl
7. Bottom Closure
8. Drain Valve

**Fig. 2, Separator Model with Sight Bowl Option**

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## General Information




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NOTE: Either bottom closure or sight bowl is installed, not both.

1. Vacuum Breaker Valve
2. Reducer Bushing
3. Mounting Band
4. Separator Body
5. O-Ring
6. V-Clamp
7. Heater Tube
8. Gasket
9. Sight Bowl Heater Rod
10. Sight Bowl
11. Drain Valve
12. Bottom Closure
13. Thermostat

**Fig. 3, Separator Model with Heater Option**

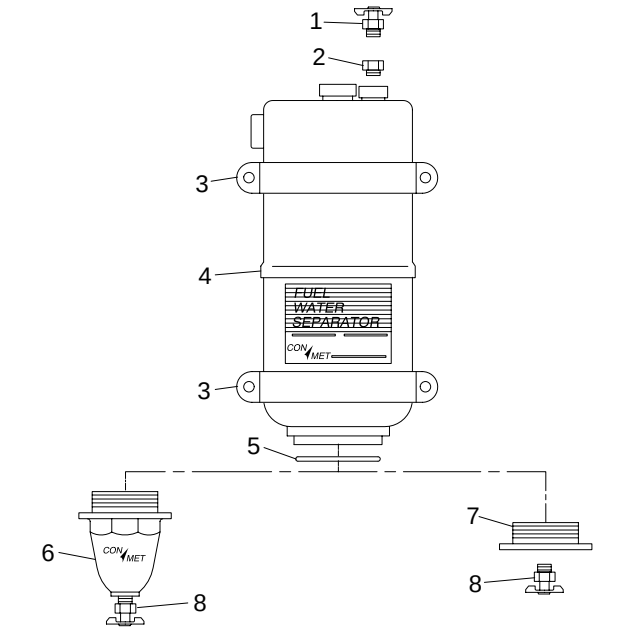
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# ConMet Fuel/Water Separator Removal and Installation

## Removal

1. Apply the parking brakes, shut down the engine, chock the tires, and tilt the hood.
2. Drain the fuel/water separator. See **Fig. 1**.




NOTE: Either bottom closure or sight bowl is installed, not both.

1. Vacuum Breaker Valve
2. Reducer Bushing
3. Mounting Band
4. Separator Body
5. Gasket
6. Sight Bowl
7. Bottom Closure
8. Drain Valve

**Fig. 1, ConMet Fuel/Water Separator**

2.1 Place a suitable container under the separator body.

2.2 With the engine shut down, open the drain valve on the bottom of the separator body.

2.3 If the accumulated water does not drain immediately, open the vacuum breaker valve on the top of the separator body.

2.4 When the unit is completely drained, close the drain valve.

2.5 If opened, close the vacuum breaker valve.

**WARNING**

**Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.**

3. If a heater is installed, drain the coolant. See **Section 20.01**, Subject 100, for instructions.
4. Disconnect the 1/2-inch NPT fuel line fittings to the intake and exhaust lines on the separator body.

   If a heater is installed, disconnect the 1/2-inch NPT coolant line fittings to the heater body. Also, disconnect the 1/2-inch NPT fuel line and coolant line fittings to the thermostat.

NOTE: If installed, remove the thermostat. For instructions, see **Subject 110**.

5. Remove the mounting capscrews, lockwashers and hexnuts that secure the mounting bands to the mounting bracket. See **Fig. 2**. Remove the fuel/water separator from the vehicle.
6. If installed, remove the sight bowl and clean it. See **Fig. 3**.

   6.1 Unscrew the sight bowl from the separator body.

   6.2 Wipe the sight bowl clean using a soft cloth.

   6.3 Inspect the gasket for damage and install a new one if necessary. Lubricate the gasket with a thin film of engine oil and install it on the sight bowl.

   6.4 Lubricate the threads on the sight bowl with a thin film of engine oil.

   6.5 Hand tighten the sight bowl until the gasket has fully contacted the separator body, and then tighten 1/4 to 1/3 turn more.

   6.6 Make sure the drain valve is tightened and closed.

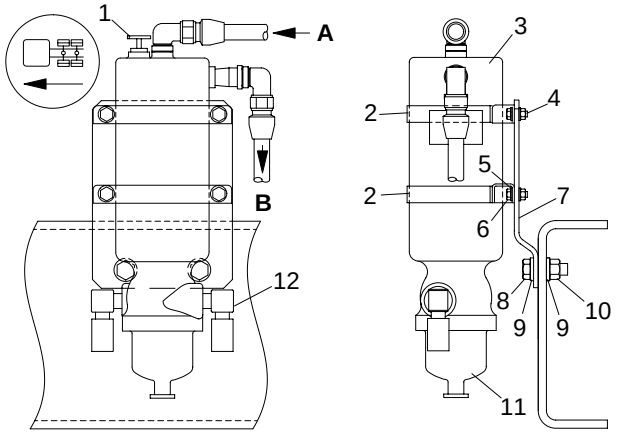
## Installation

1. Check the mounting bracket locknuts for tightness. If necessary, tighten the locknuts 113 lbf·ft (153 N·m).

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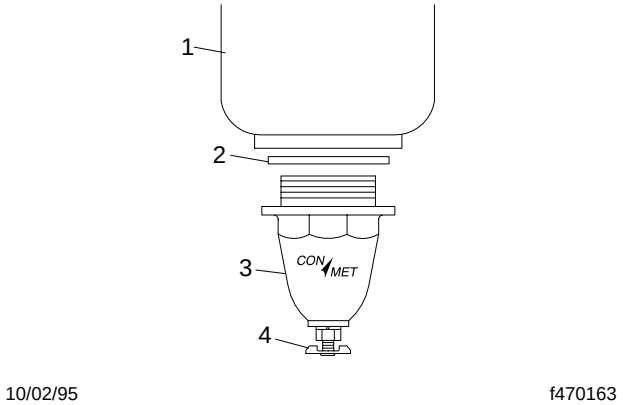
## ConMet Fuel/Water Separator Removal and Installation




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A. From Fuel Tanks
B. To Engine
1. Vacuum Breaker Valve
2. Mounting Band
3. Separator Body
4. 5/16–18 Mounting Band Capscrew
5. Lockwasher
6. 5/16–18 Hexnut
7. Mounting Bracket
8. 5/8–11 Mounting Bracket Capscrew
9. Hardened Flatwasher
10. 5/8–11 Locknut
11. Sight Bowl (if installed)
12. Coolant Line (if installed)

**Fig. 2, ConMet Fuel/Water Separator Mounting**




10/02/95 f470163

1. Separator Body
2. Gasket
3. Sight Bowl
4. Drain Valve

**Fig. 3, Sight Bowl**

2. Mount the new fuel/water separator vertically on the mounting bracket. Install the mounting bands, and secure them with the 5/16–18 mounting capscrews, lockwashers, and hexnuts. Tighten the hexnuts 15 lbf·ft (20 N·m). See **Fig. 2**.
3. Attach the 1/2-inch NPT fuel line fittings to the inlet and outlet ports on the separator body.

   If removed, attach the 1/2-inch NPT coolant line fittings to the heater body. Also, attach the 1/2-inch NPT fuel and coolant line fittings to the thermostat.
4. Apply Loctite® 271 (or equivalent) to all fitting threads. Tighten all fittings until they are airtight.
5. Prime the fuel/water separator with clean diesel fuel.

   5.1 Open the vacuum breaker valve.

   5.2 Fill the unit with clean diesel fuel.

   5.3 Close the vacuum breaker valve and be sure it is airtight.

IMPORTANT: To prevent fuel leaks, be sure the vacuum breaker valve is closed airtight.

6. Start the engine and check for leakage. With the engine shut down, repair any leaks.
7. Lower the hood, and remove the chocks from the tires.

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# Con Met Fuel/Water Separator Heater and Thermostat Replacement

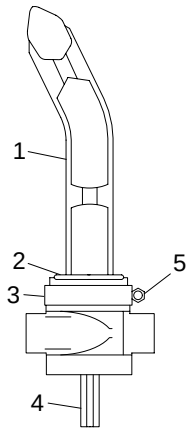
## Heater Replacement

1. Apply the parking brakes, shut down the engine, chock the tires, and tilt the hood.
2. Drain the fuel/water separator. For detailed instructions, see **Subject 100**.

**⚠ WARNING**

**Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.**

3. Drain the coolant. See **Section 20.01**, Subject 100, for instructions.
4. Disconnect the 1/2-inch NPT coolant line fittings from the heater tube body.
5. Loosen the clamp nut and slowly, then carefully lower the heater tube out of the separator body. See **Fig. 1**. Remove the V-clamp and O-ring with the heater.




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1. Heater Tube
2. O-Ring
3. V-Clamp
4. Sight Bowl Heater
5. Clamp Nut

**Fig. 1, Fuel Heater Assembly**

6. Attach the 1/2-inch NPT coolant line fittings to the new heater. Apply Loctite® 271 (or equivalent) to all fitting threads. Tighten all fittings until they are airtight.

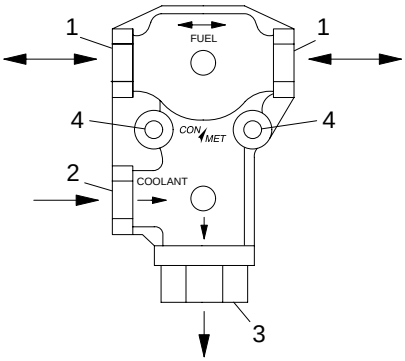
**⚠ CAUTION**

**To prevent fuel leaks, rotate the heater so that it does not contact any internal components of the separator body.**

7. With the V-clamp and O-ring already in place, carefully insert the new heater tube into the separator body.
8. When the O-ring is firmly seated, tighten the clamp nut 30 to 40 lbf·in (340 to 460 N·cm).
9. Lower the hood, and remove the chocks from the tires.

## Thermostat Replacement

1. Apply the parking brakes, chock the tires, and tilt the hood.
2. Disconnect the 1/2-inch NPT fuel line fittings from the thermostat.
3. Mark and disconnect the 1/2-inch NPT coolant line fittings from the thermostat.
4. Remove the thermostat mounting bolts. See **Fig. 2**. Remove the thermostat from the vehicle.




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1. Fuel In/Out
2. Engine Coolant In
3. Engine Coolant Out
4. Mounting Bolts

**Fig. 2, Thermostat**

5. Install the 5/16-inch thermostat mounting bolts. See **Fig. 2**. Install the new thermostat on the vehicle.
6. Attach the 1/2-inch NPT fuel line fittings to the new thermostat. Apply Loctite® 271 (or equiva-

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## Con Met Fuel/Water Separator Heater and Thermostat Replacement

lent) to all fitting threads. Tighten all fittings until they are airtight.

7. Attach the 1/2-inch NPT coolant line fittings to the new thermostat as marked. Apply Loctite® 271 (or equivalent) to all fitting threads. Tighten all fittings until they are airtight.
8. Lower the hood, and remove the chocks from the tires.

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# Troubleshooting Tables

**Problem—Leaking Air in the Fuel System**

| Problem—Leaking Air in the Fuel System | |
|---|---|
| **Possible Cause** | **Remedy** |
| The vacuum breaker valve is loose. | Tighten the vacuum breaker valve. Make sure it is airtight. |
| There are loose or broken fuel fittings, valves, or filters. | Tighten or repair the fuel fittings, valves, or filters as needed. |

**Problem—Leaking Fuel**

| Problem—Leaking Fuel | |
|---|---|
| **Possible Cause** | **Remedy** |
| The sight bowl is loose. | Tighten the sight bowl. For instructions, see **Subject 100**. |
| The sight bowl is cracked or broken. | Replace the sight bowl. For instructions, see **Subject 100**. |
| The fuel heater is loose. | Tighten the fuel heater V-clamp. For instructions, see **Subject 110**. |
| The fuel heater is incorrectly installed. | Install the fuel heater correctly, so that it is not touching any components in the separator body. For instructions, see **Subject 110**. |
| There are loose or broken fittings somewhere within the fuel system, including in the return lines. | Tighten or repair the fuel fittings as needed. |

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## Specifications

| Fastener Torques | | | |
|---|---|---|---|
| **Description** | **Size** | **Torque** | |
| | | **lbf·ft (N·m)** | **lbf·in (N·cm)** |
| Mounting Band Hexnuts | 5/16–18 | 15 (20) | — |
| Mounting Bracket Locknuts | 5/8–11 | 113 (153) | — |
| Heater Element V-Clamp | — | — | 30–40 (340–460) |

**Table 1, Fastener Torques**

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## General Description

The fuel/water separator is mounted on the frame rail, between the fuel tank and the fuel pump. Fuel drawn to the engine travels through the fuel/water separator, which removes water and solid contaminants. The fuel/water separator includes a spin-on filter element and a sight bowl. See **Fig. 1**. The fuel/water separator may also be equipped with the following optional components:

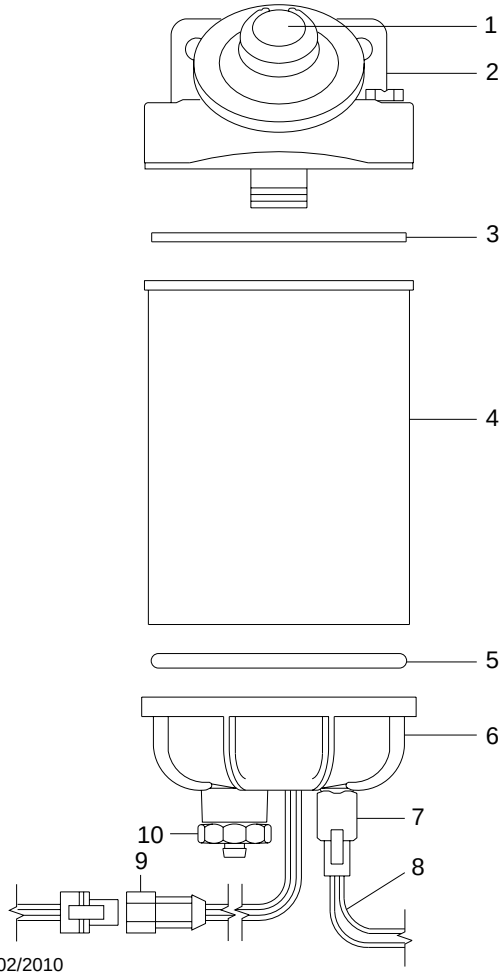
- Ignition-controlled heater to melt ice and wax in the fuel
- Water sensor probe to alert the operator to drain the sight bowl
- Manual priming pump to easily prime the fuel/water separator

## Principles of Operation

Diesel fuel enters at the top of the separator and flows down past the heater element, if equipped, to the top of the filter element. As the fuel flows down the sides of the element, the heavier contaminants fall directly to the collection bowl. The filter element itself contains a resin that repels water and forces it to bead and fall to the collection bowl.

Filtered fuel is drawn out through the top of the separator, and the water and solid contaminants remain in the collection bowl. As water collects, it completes the circuit between the two prongs of the water sensor probe, if equipped, and a warning light on the dash alerts the operator to drain the bowl.

The heater is operated by turning on the ignition switch for 5 minutes before starting the engine.




1. Priming Pump
2. Mounting Head
3. Gasket
4. Filter Element
5. O-Ring
6. Sight Bowl
7. Water Sensor Probe
8. Water Sensor Probe Wiring Harness
9. Heater Wiring Harness
10. Drain Plug

**Fig. 1, Fuel/Water Separator Assembly**

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## Removal

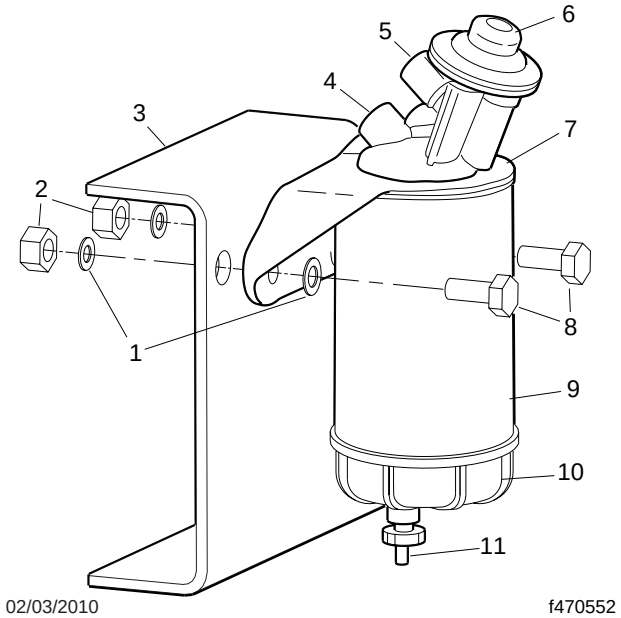
1. Shut down the engine, apply the parking brake, and chock the tires.

   Open the hood.

2. Place a suitable container under the fuel/water separator.

IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many states now issue fines for draining fuel/water separators onto the ground.

3. Turn the drain plug counterclockwise to open it. If equipped, operate the priming pump. See **Fig. 1**.




1. Washers (qty 2)
2. Nuts (qty 2)
3. Frame Rail
4. Fuel Outlet Port
5. Fuel Inlet Port
6. Priming Pump
7. Mounting Head
8. Mounting Bolts (qty 2)
9. Filter Element
10. Sight Bowl
11. Drain Plug

**Fig. 1, Fuel/Water Separator Assembly and Installation**

4. When the fuel/water separator is completely drained, turn the drain plug clockwise to close it.

**⚠ WARNING**

**Do not expose the fuel to open fire. Do not work with the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.**

5. Disconnect the fuel lines from the fuel/water separator.
6. If equipped, disconnect the wiring harnesses from the water sensor probe and the heater element.
7. Remove the fuel/water separator mounting bolts, and remove the fuel/water separator from its mounting bracket.

## Installation

1. Mount the fuel/water separator on the frame rail mounting bracket, and install the mounting bolts. Tighten the bolts 40 lbf·ft (55 N·m).
2. Remove the sight bowl and the filter element as a unit from the new fuel/water separator.
3. Using clean motor oil or diesel fuel, lubricate the gasket in the top of the filter element.
4. Make sure the drain in the sight bowl is closed, then fill the filter element and bowl assembly with clean fuel.
5. Install the element and bowl assembly on the mounting head and hand-tighten it until snug.
6. If equipped, connect the wiring harnesses to the water sensor probe and the heater.
7. Connect the fuel lines to the fuel/water separator. Tighten all fittings finger-tight plus 1/4 turn.
8. Prime the fuel/water separator.

   If equipped with a priming pump, loosen the drain plug and operate the priming pump until fuel comes out at the drain.

   If not equipped with a priming pump, fill the filter element and sight bowl with clean fuel and crank the engine until it starts.
9. Start the engine and check for leaks.
10. Shut down the engine and repair any leaks.

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## Replacement

1. Shut down the engine, apply the parking brakes, and chock the tires.

   Open the hood.

2. Place a suitable container under the fuel/water separator.

IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many states now issue fines for draining fuel/water separators onto the ground.

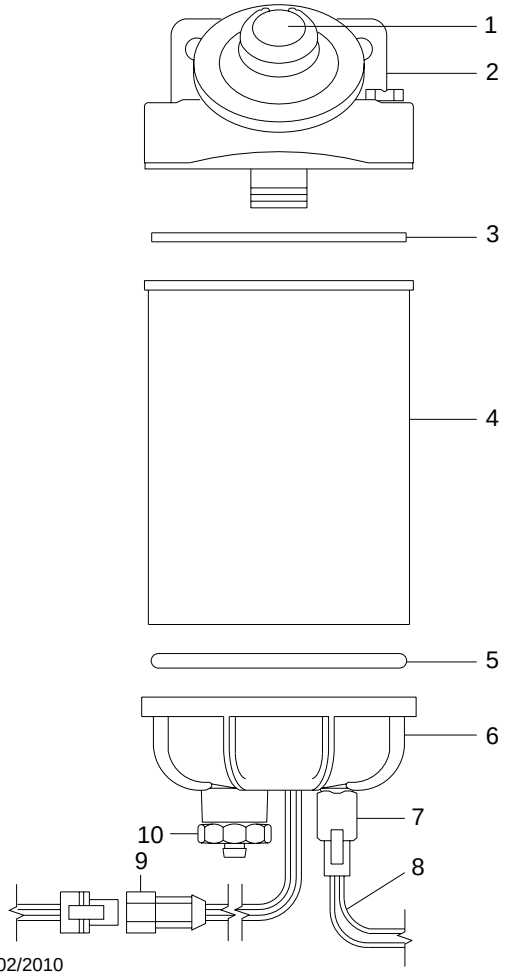
3. Turn the drain plug counterclockwise to open it. If equipped, operate the pump.
4. When the fuel/water separator is completely drained, turn the drain plug clockwise to close it.

**⚠ WARNING**

**Do not expose the fuel to open fire. Do not work with the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.**

5. If equipped, disconnect the wiring harnesses from the water sensor probe and the heater. See **Fig. 1**.
6. Spin off the sight bowl and the filter element as a unit. Remove the gasket from the top of the filter element.
7. Remove the sight bowl from the filter element. Clean the O-ring seating surface.
8. Apply a thin coating of clean diesel fuel or engine oil to the O-ring and the new gasket.
9. Spin the sight bowl onto the new filter element and then fill the filter element and sight bowl assembly with clean diesel fuel.
10. Spin the entire assembly onto the mounting head and tighten by hand until snug.
11. Connect the heater and water sensor wiring harnesses, if equipped.
12. Prime the fuel/water separator.

    If equipped with a priming pump, loosen the drain plug and operate the priming pump until fuel comes out at the drain.




1. Priming Pump
2. Mounting Head
3. Gasket
4. Filter Element
5. O-Ring
6. Sight Bowl
7. Water Sensor Probe
8. Water Sensor Probe Wiring Harness
9. Heater Wiring Harness
10. Drain Plug

**Fig. 1, Fuel/Water Separator Assembly**

   If not equipped with a priming pump, fill the filter element and sight bowl with clean fuel and crank the engine until it starts.

13. Start the engine and check for leaks.
14. Shut down the engine and repair any leaks.

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## Replacement

1. Shut down the engine, apply the parking brake, and chock the tires.

   Open the hood.

2. Place a suitable container under the fuel/water separator.

IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many states now issue fines for draining fuel/water separators onto the ground.

3. Turn the drain plug counterclockwise to open it. If equipped, operate the priming pump.
4. When the fuel/water separator is completely drained, turn the drain plug clockwise to close it.

**⚠ WARNING**

**Do not expose the fuel to open fire. Do not work with the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.**

5. If equipped, disconnect the wiring harness from the water sensor probe. See **Fig. 1**.

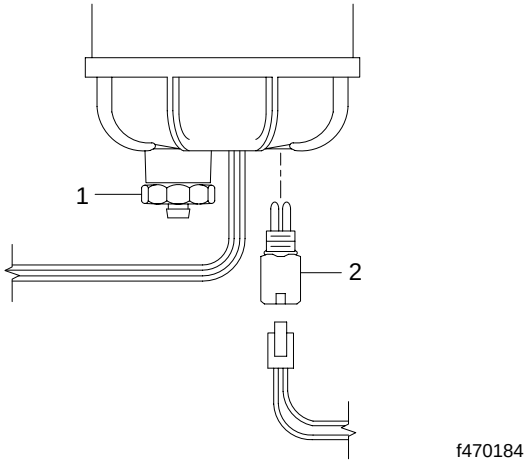



**Fig. 1, Water Sensor Probe**

6. Disconnect the heater wiring harness. See **Fig. 2**.

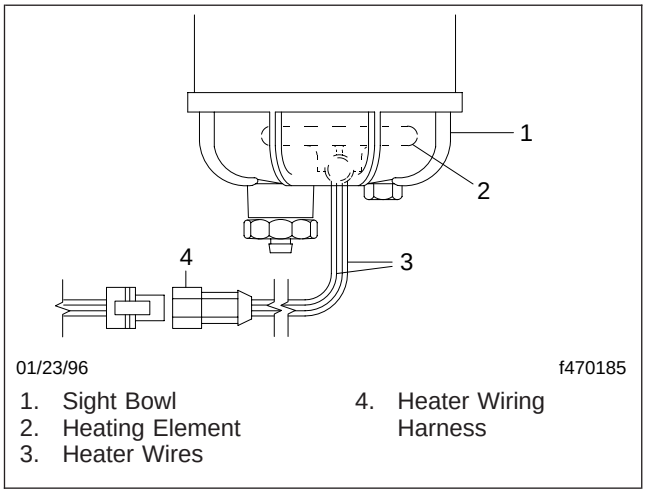



**Fig. 2, In-Bowl Heater**

7. Spin off the sight bowl and the filter element as a unit.
8. Remove the sight bowl from the filter element.
9. Remove the O-ring from the lip of the new sight bowl. Lubricate the O-ring with a thin film of clean engine oil or diesel fuel and put it back in the sight bowl.
10. Install the sight bowl on the bottom of the filter element and hand-tighten until it is snug.
11. Make sure the drain in the sight bowl is closed, then fill the filter element and bowl assembly with clean fuel.
12. Install the element and bowl assembly on the mounting head and hand-tighten it until snug.
13. Connect the heater wiring harness.

    If equipped, connect the water sensor wiring harness to the water sensor probe.

14. Prime the fuel/water separator.

    If equipped with a priming pump, loosen the drain plug and operate the priming pump until fuel comes out at the drain.

    If not equipped with a priming pump, fill the filter element and sight bowl with clean fuel and crank the engine until it starts.

15. Start the engine and check for leaks.
16. Shut down the engine and repair any leaks.

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## Replacement

1. Apply the parking brakes, shut down the engine, and chock the tires.

   Open the hood.

2. Place a suitable container under the fuel/water separator.

IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many states now issue fines for draining fuel/water separators onto the ground.

3. Turn the drain plug counterclockwise to open it. If equipped, operate the priming pump.
4. When the fuel/water separator is completely drained, turn the drain plug clockwise to close it.

**⚠ WARNING**

**Do not expose the fuel to open fire. Do not work with the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.**

5. Disconnect the water sensor wiring harness from the water sensor probe. See **Fig. 1**.

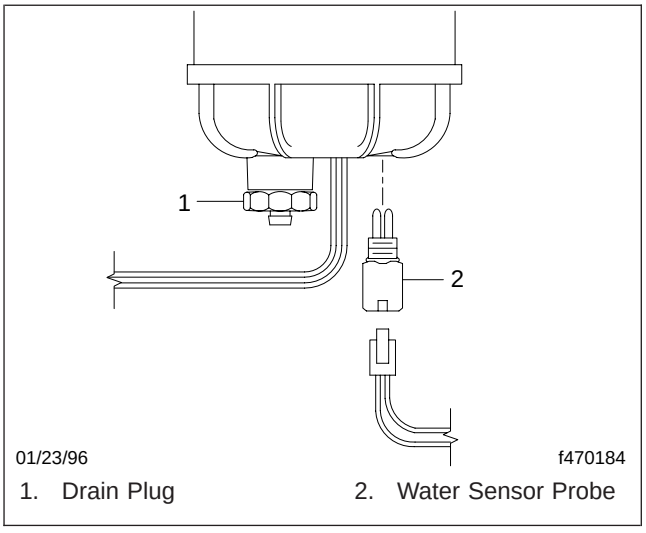



**Fig. 1, Water Sensor Probe**

6. Spin off the sight bowl and filter element as a unit.
7. Unscrew the water sensor probe from the base of the sight bowl.
8. Install a new water sensor probe in the base of the sight bowl.
9. Make sure the drain plug in the base of the sight bowl is closed snugly.
10. Fill the filter element and sight bowl assembly with clean diesel fuel.
11. Install the element and bowl assembly on the mounting head and hand-tighten it until snug.
12. Connect the water sensor wiring harness to the water sensor probe.
13. Prime the fuel/water separator.

    If equipped with a priming pump, loosen the drain plug and operate the priming pump until fuel comes out at the drain.

    If not equipped with a priming pump, fill the filter element and sight bowl with clean fuel and crank the engine until it starts.

14. Start the engine and check for leaks.
15. Shut down the engine and repair any leaks..

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# Troubleshooting

**Problem—Air Leaking into the Fuel System**

| Problem—Air Leaking into the Fuel System | |
|---|---|
| **Possible Cause** | **Remedy** |
| The drain is not closed. | Tighten the drain valve. |
| The sight bowl or filter element is loose. | Hand-tighten the sight bowl or filter element until snug. |
| There are loose, broken, or clogged fuel fittings, valves, or filters. | Tighten, clean, or repair the fuel fittings, valves, or filters as needed. |

**Problem—High Water Light Does Not Illuminate For 2 to 5 Seconds When Ignition is Turned to ACCESSORY**

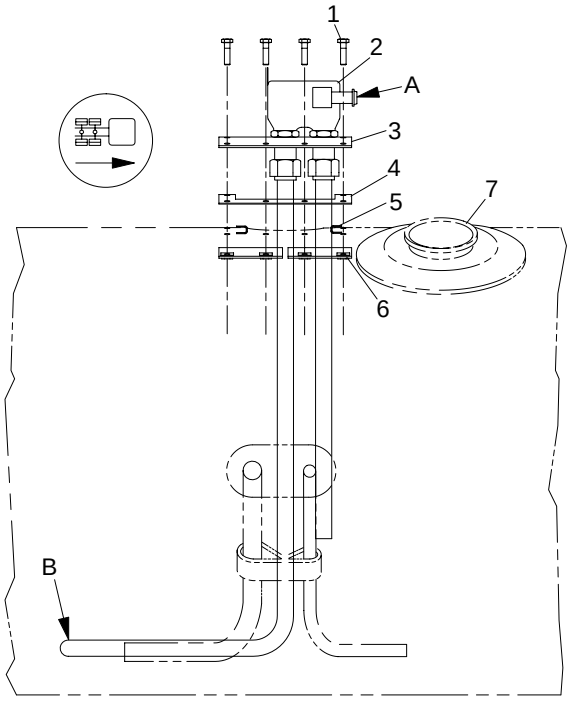
| Problem—High Water Light Does Not Illuminate For 2 to 5 Seconds When Ignition is Turned to ACCESSORY | |
|---|---|
| **Possible Cause** | **Remedy** |
| Wiring connections are loose. | Tighten connections as needed. |
| Fuel/water separator is not grounded. | Check that power is on, and the fuel/water separator is grounded. |
| Wiring is damaged. | Check for damaged wiring and replace as needed. See EZWiring for a diagram of the sensor circuit. |
| Water sensor probe is damaged. | Replace the water sensor probe. See **Subject 130** for instructions. |

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## General Description

The Arctic Fox fuel heater Model C406 (see **Fig. 1**) is installed in the fuel tank facing the fuel filler neck. It comes in two different lengths to accomodate 22- and 26-inch cylindrical tanks.




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NOTE: Right-hand tank shown

A. Orient coolant fittings toward the fuel filler neck.
B. Install fuel heater with lower loop pointing aft.

1. Mounting Capscrew
2. Fuel Heater
3. Mounting Flange
4. Gasket
5. Mounting Clip
6. Backing Plate
7. Fuel Filler Neck

**Fig. 1, Arctic Fox Fuel Heater**

Twelve 1/4-inch capscrews bolt the heater to the tank, attaching to a mounting flange that is an integral part of the heater head. A heating coil, consisting of a coolant tube in the form of a closed loop, extends down into the tank.

To prevent overheating, the unit is equipped with a temperature probe that monitors fuel temperature. It is connected to a bypass thermostat that controls an automatic coolant shut-off valve.

## Principles of Operation

Hot engine coolant is routed through the heating coil, warming the fuel as it passes. A bypass thermostat shuts off the coolant flow when the fuel in the tank reaches a temperature of approximately 80°F (27°C).

The hot coolant is then directed through a bypass circuit within the thermostat head, which sends it straight back to the engine. For this reason, the head of the fuel heater stays hot even when the heating circuit has been bypassed.

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## Arctic Fox Fuel Heater Replacement

# Replacement

IMPORTANT: When installed in the fuel tank, the clearance between the bottom of the fuel heater and the inside of the tank wall must be at least 1 inch (25 mm) and no more than 2 inches (51 mm).

1. Apply the parking brakes, shut down the engine, and chock the tires.

**⚠ WARNING**

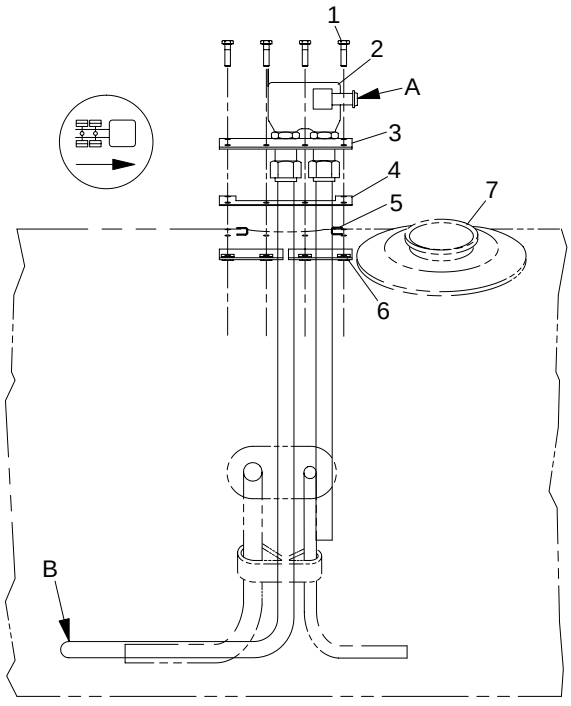
**Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.**

2. Drain the coolant. See **Section 20.01**, Subject 100, for instructions.
3. Mark the coolant fittings and lines. Disconnect the coolant lines from the fittings on the fuel heater.

**⚠ WARNING**

**Do not expose the fuel to, or work with the fuel system near, open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.**

4. Remove the twelve 1/4-inch capscrews attaching the fuel heater mounting flange to the fuel tank. See **Fig. 1**.
5. Remove the fuel heater from the fuel tank.
   - 5.1 Carefully work the fuel heater coil out of the fuel tank around the backing plate.
   - 5.2 Remove the fuel heater gasket.
6. Install the new fuel heater in the fuel tank.
   - 6.1 Position a new gasket on the hole in the fuel tank. Align the holes in the gasket with those in the tank.
   - 6.2 Insert the heater coil into the tank, making sure that it does not contact anything inside the tank, such as the tank wall, the fuel gauge, the standpipe, or tank baffles.




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NOTE: Right-hand tank shown

A. Orient coolant fittings toward the fuel filler neck.
B. Install fuel heater with lower loop pointing aft.

1. Mounting Capscrew
2. Fuel Heater
3. Mounting Flange
4. Gasket
5. Mounting Clip
6. Backing Plate
7. Fuel Filler Neck

**Fig. 1, Arctic Fox Fuel Heater Installation**

   - 6.3 Line up the heater mounting flange with the gasket and the holes in the tank, and insert the twelve 1/4-inch mounting capscrews. Tighten the capscrews 40 to 60 lbf·in (460 to 680 N·cm).

   NOTE: Be sure the heads of the capscrews are snug to the top of the mounting flange.

   - 6.4 Now tighten each capscrew 78 to 95 lbf·in (880 to 1080 N·cm).
7. Using the sequence shown in **Fig. 2**, recheck each capscrew for 78 to 95 lbf·in (880 to 1080 N·cm).

IMPORTANT: To ensure that the gasket seals properly, follow the tightening sequence exactly.

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## Arctic Fox Fuel Heater Replacement

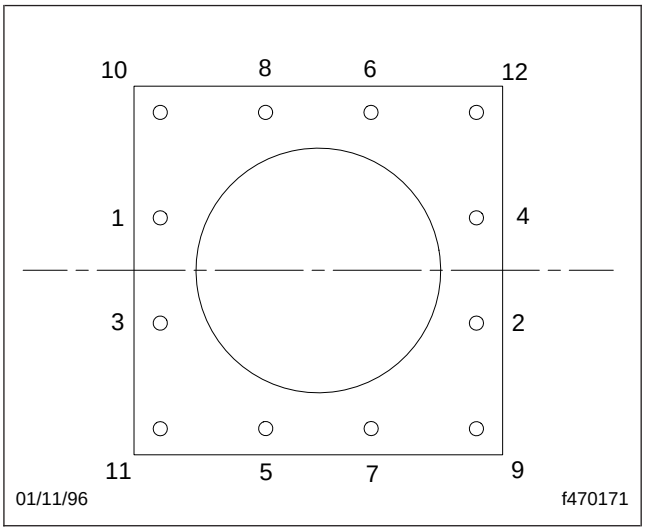



**Fig. 2, Fastener Tightening Order**

8. Connect the coolant lines to the heater, as marked. Apply Loctite® 271 (or equivalent) to all fitting threads. Tighten all fittings until they are airtight.

IMPORTANT: Keep all lines as straight and short as possible.

9. Fill the cooling system with clean coolant. See **Section 20.01**, Subject 100, for instructions.
10. Start the engine and check for coolant leaks. With the engine shut down, repair any leaks.
11. Lower the hood, and remove the chocks from the tires.

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## General Information

The Hayden fuel cooler (see **Fig. 1**) consists of a heat exchanger, fuel tubing, and a rubber mounting block.

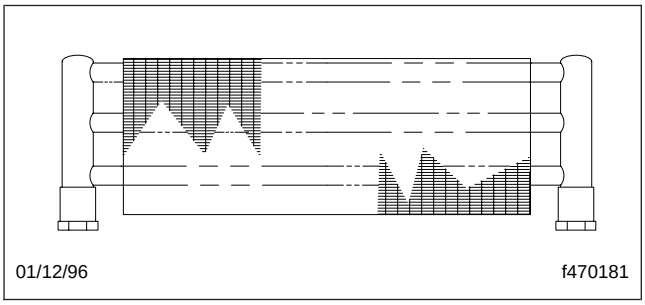



**Fig. 1, Hayden Fuel Cooler**

The heat exchanger bolts to a mounting bracket which attaches to the radiator. A retaining plate and biscuits protect the exposed side of the installation.

Fuel in the return line flows through the cooler and exchanges heat with the air flowing past while the vehicle is moving. The cooled fuel then returns to the fuel tanks.

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# Hayden Fuel Cooler Removal and Installation

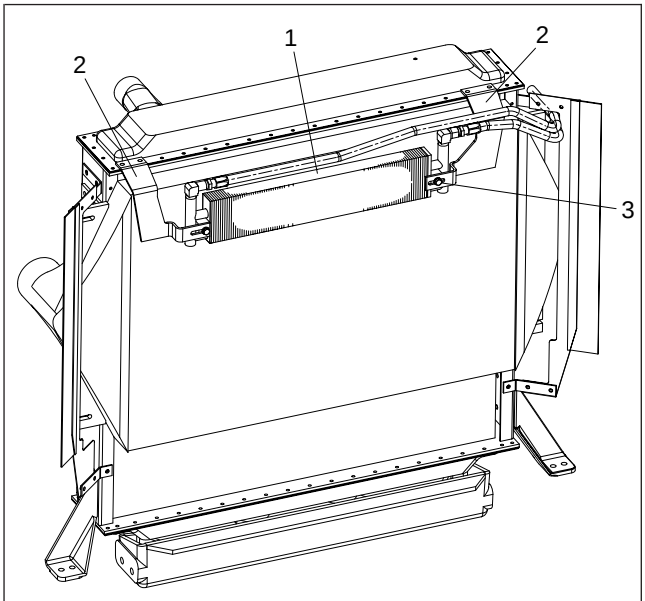
## Removal

1. Apply the parking brakes, shut down the engine, and chock the tires.

**⚠ WARNING**

**Do not expose the fuel to, or work with the fuel system near, open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.**

2. Mark the fuel fittings and lines. Disconnect the fuel lines from the fittings on the fuel cooler. Have a basin ready to catch the fuel that comes out of the lines. Tie up the fuel lines to prevent dripping.
3. Remove the fuel cooler from its mounting bracket. See **Fig. 1**.




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1. Hayden Fuel Cooler
2. Mounting Bracket
3. 5/16–18 Mounting Capscrew

**Fig. 1, Fuel Cooler Mounted on Radiator**

3.1 Remove the two 5/16–18 locknuts and rear washers from the mounting bracket.

3.2 Remove the capscrews, front washers, biscuits, and retaining plates.

3.3 Drain the fuel in the fuel cooler into a basin.

## Installation

1. Install the fuel cooler on its mounting bracket.
   1.1 Position the retaining plates, biscuits, front washers, and 5/16–18 capscrews on the fuel cooler and mounting bracket.
   1.2 Install the 5/16–18 locknut and rear washer. Tighten the locknuts 25–30 lbf·in (280–340 N·cm).
2. Connect the fuel lines to the fuel cooler.
   2.1 Apply Loctite® 271 (or equivalent) to all fitting threads.

**⚠ CAUTION**

**To avoid damaging the connections, use a back-up wrench on the heat exchanger fittings when tightening the fuel line fittings.**

   2.2 Connect the fuel lines and tighten the fittings 15 lbf·ft (20 N·m).

3. Prime the engine fuel pump; refer to the engine manufacturer's operation and maintenance manual.
4. Start the engine and check for fuel leaks. With the engine shut down, repair any leaks.
5. Lower the hood, and remove the chocks from the tires.

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# Troubleshooting Tables

**Problem—The Heat Exchanger Is Not Cooling the Fuel**

| Problem—The Heat Exchanger Is Not Cooling the Fuel | |
|---|---|
| **Possible Cause** | **Remedy** |
| The cooling fins are dirty. | Wearing eye protection, clean the heat exchanger fins carefully. If necessary, use water flowing at low pressure to remove debris lodged in the fins.<br>**CAUTION**<br>**Do not direct a high-pressure stream of water at the fuel cooler. This will damage the fins.** |
| The cooling fins are bent. | Using a 12 fin/inch fin comb, straighten any bent fins. |
| The heat exchanger is clogged with contaminated fuel. | Using a compatible fuel system fluid, flush out the heat exchanger in both directions (through both fittings). |
| There are hairline cracks in the heat exchanger. | Replace the fuel cooler. |
| The heat exchanger's fuel tubing is dented badly enough to restrict fuel flow past the heat exchanger. | Replace the fuel cooler. |

**Problem—The Fuel Cooler Is Leaking**

| Problem—The Fuel Cooler Is Leaking | |
|---|---|
| **Possible Cause** | **Remedy** |
| The fuel line connections are loose. | Tighten the connections until the leaks disappear. Do not tighten more than 15 lbf·ft (20 N·m) and use a back-up wrench on the heat exchanger fitting. Start the engine and make sure there are no more leaks. |
| The sealant on the fittings is not adequate. | Remove the fittings, clean off any dried or cracked sealant, and apply Loctite® 271 (or equivalent) to all fitting threads. |
| The fitting(s) are cracked or stripped. | Replace the fitting(s). |

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## Specifications

| Fastener Torque Values | | | |
|---|---|---|---|
| **Fastener Description** | **Size** | **Torque Value** | |
| | | **lbf·ft (N·m)** | **lbf·in (N·cm)** |
| Mounting Locknuts | 5/16–18 | — | 25–30 (280–340) |
| Fuel Line Fittings | — | 15 (20) | — |

**Table 1, Fastener Torque Values**

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## General Information

Fuel/water separators are mounted between the fuel tank and the fuel pump. Fuel drawn to the engine travels through the fuel/water separator, which removes water and solid contaminants. See **Fig. 1**, **Fig. 2**, or **Fig. 3** for DAVCO fuel/water separator configurations.

Heavier contaminants and water separate from the fuel in the lower housing of the fuel/water separator, and collect in the bottom to be drained out when the drain valve is opened. From the lower housing, the fuel level rises into the clear cover, which contains the replaceable filter element. The fuel passes through the filter element into the center of the filter, and on to the outlet port.

When the filter is new, fuel is able to pass through the lower part of the filter element. As the element's lower portion clogs, the fuel level rises in the clear cover in order to pass through the filter. This process continues until the filter element is clogged all the way to the top.

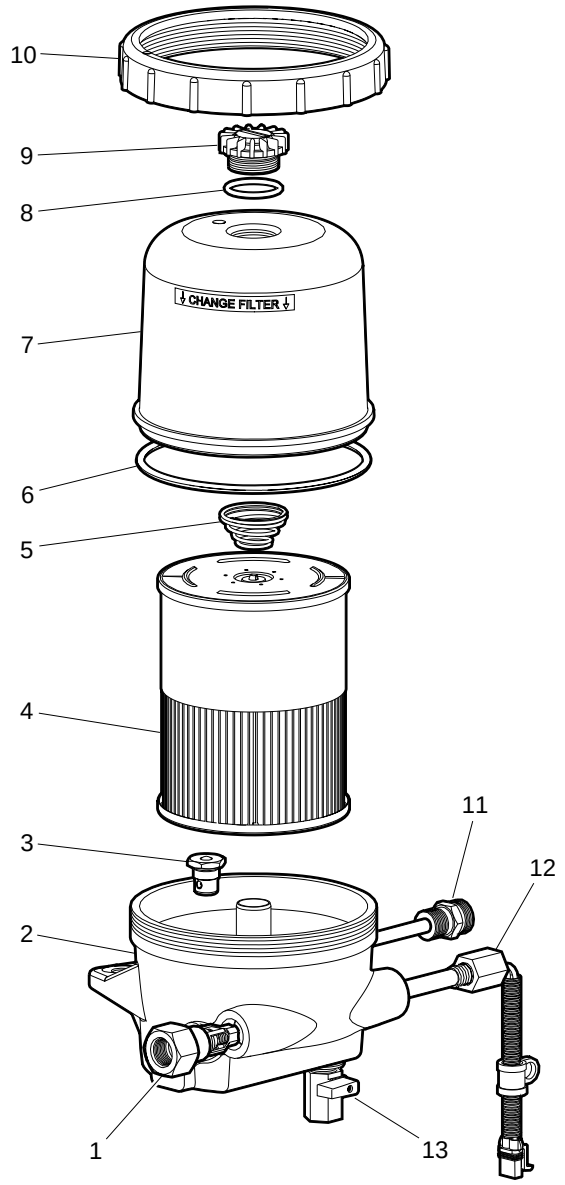
For efficiency, the filter should only be changed when the fuel level has reached the top of the filter element. There is no significant restriction to fuel flow until the element is completely clogged.

DAVCO fuel/water separators come in a number of different configurations. There may be an electric heating element installed in the lower housing (**Fig. 1**, items 11 and 12) or there may be a fluid heat exchanger in the lower housing (**Fig. 2**, item 3). If there is fluid heat, the warming fluid may be fuel returning from the engine or engine coolant. **Fig. 4** shows the patterns that fuel and heating fluids follow in fluid-heated units.

NOTE: The Daimler Trucks North America Learning Center (accessible through **www.AccessFreightliner.com**) and DAVCO (**www.DavcoTec.com**) offer excellent online resources for understanding, testing, and diagnosing fuel/water separator problems.

**⚠ WARNING**

**Fluid circulated through the fuel/water separator may be diesel fuel returned from the engine, or engine coolant. Drain the fuel/water separator only when the engine and fluids have cooled.**




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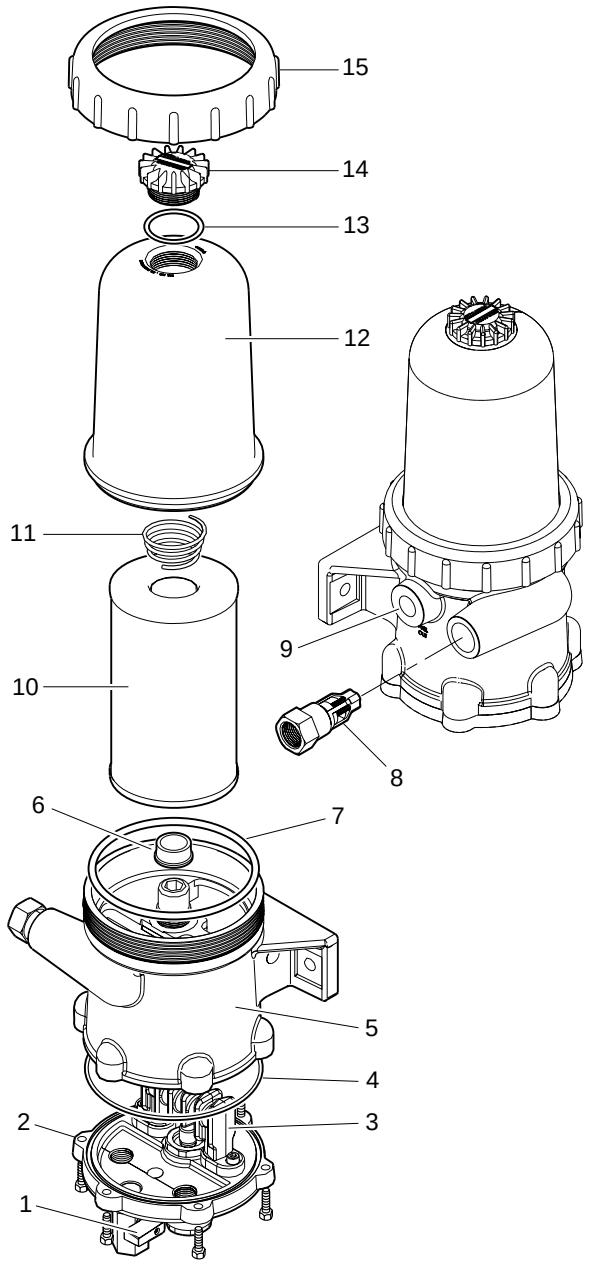
1. Inlet Port/Check Valve
2. Lower Housing
3. Bypass Valve
4. Filter Element
5. Spring
6. Cover O-Ring
7. Clear Cover
8. Vent Cap O-Ring
9. Vent Cap
10. Collar
11. 120VAC Pre-Heater
12. 12VDC Pre-Heater
13. Drain Valve

**Fig. 1, DAVCO Fuel Pro 482**

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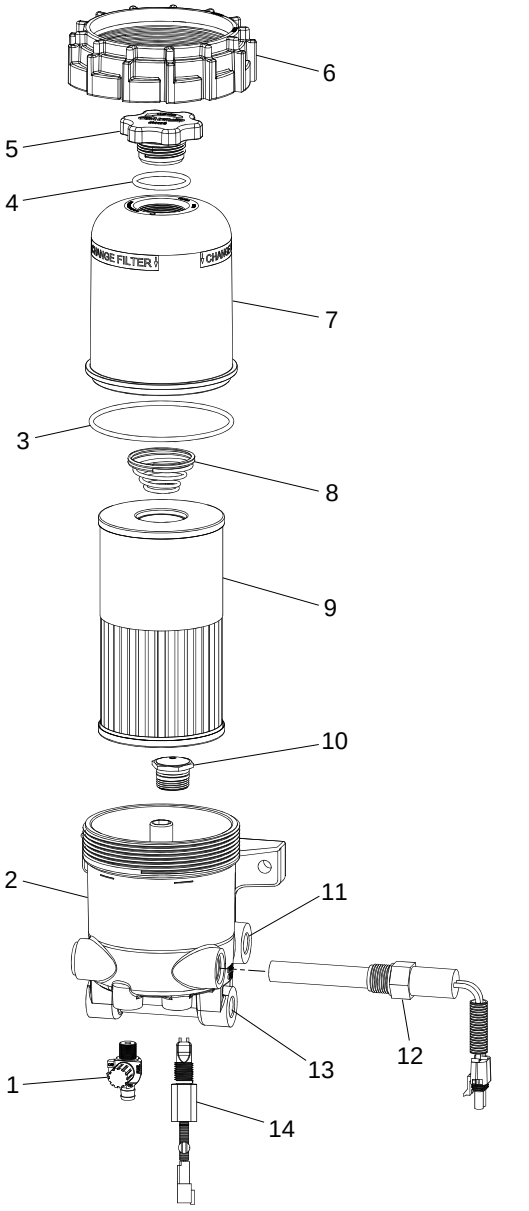
## General Information




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1. Drain Valve
2. Bottom Plate
3. Heat Exchanger
4. Bottom Plate O-Ring
5. Lower Housing
6. Grommet
7. Cover O-Ring
8. Inlet Port/Check Valve
9. Fuel Outlet Port
10. Filter Element
11. Spring
12. Clear Cover
13. Vent Cap O-Ring
14. Vent Cap
15. Collar

**Fig. 2, DAVCO Fuel Pro 382**



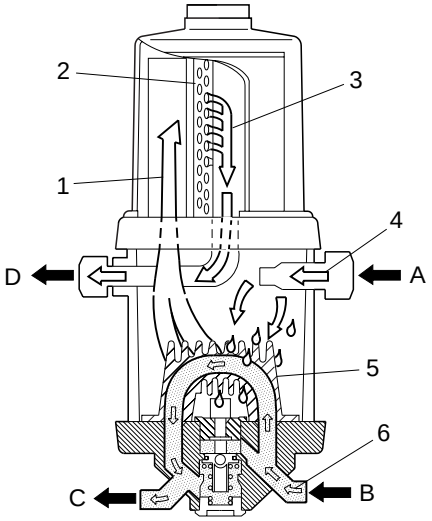

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1. Drain Valve
2. Lower Housing
3. Cover O-Ring
4. Vent Cap O-Ring
5. Vent Cap
6. Collar
7. Clear Cover
8. Spring
9. Filter Element
10. Check Valve Assembly
11. Fuel Inlet Port
12. Pre-Heater
13. Fuel Outlet Port
14. Water-In-Fuel Sensor

**Fig. 3, DAVCO Diesel Pro 243**

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A. Fuel Inlet Flow
B. Heating Fluid Inlet Flow
C. Heating Fluid Outlet Flow
D. Fuel Outlet Flow

1. Unfiltered, Heated Fuel
2. Filter Element
3. Filtered Fuel
4. Fuel From Fuel Tank
5. Heat Exchanger
6. Heating Fluid From Engine

**Fig. 4, Fluid Circulation, Fluid-Heated Units**

**Draining it when the engine is hot could cause severe personal injury due to scalding.**

**If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. Do not expose the fuel to, or work with, the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.**

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## Removal

**WARNING**

**Fluid circulated through the fuel/water separator may be diesel fuel returned from the engine, or engine coolant. Drain the fuel/water separator only when the engine and fluids have cooled. Draining it when the engine is hot could cause severe personal injury due to scalding.**

**If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. Do not expose the fuel to, or work with, the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.**

Most service procedures are done with the fuel/water separator in place, but some procedures, such as pressure testing, require that the fuel/water separator be removed from the vehicle.

1. Shut down the engine, set the parking brake, and chock the tires.

IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many jurisdictions now issue fines for draining fuel/water separators onto the ground.

2. Put a clean receptacle under the fuel/water separator, then attach a piece of hose to the drain valve to direct fuel into the receptacle.

NOTE: Use a hose with a ½-inch pipe thread to fit the drain valve on a Fuel Pro 382.

3. Remove the vent cap (**Fig. 1**, Item 14) and open the drain valve (**Fig. 1**, Item 1). Drain the fuel to just below the collar level, then close the drain valve.
4. Unplug the electric heating element, if equipped, or disconnect the heating fluid lines.
5. Disconnect the fuel outlet line.
6. Disconnect the fuel inlet line. If the inlet line is difficult to reach, loosen the connection, then fully disconnect it after the fuel/water separator is removed from the frame rail.
7. Remove the fuel/water separator mounting fasteners and remove the fuel/water separator from the frame rail. If the fuel inlet line was not completely disconnected in the previous step, disconnect it.

## Installation

IMPORTANT: All fittings must be very clean as they are installed. A piece of grit or a damaged surface on a sealing face or in threads can cause air leaks.

Use paste sealer to ensure that the tapered thread fuel line fittings will not leak. Do not use sealer on compression fittings and do not seal the fittings with tape, which will eventually leak.

1. If the inlet fuel line is inaccessible when the fuel/water separator is mounted on the vehicle, loosely connect the line before mounting the fuel/water separator on the frame rail.

   To minimize restrictions, keep fuel line routing as smooth as possible, with no low-hanging loops that could trap water. If the fuel line is being made to length on the job, be sure that the inner liner of the hose is not cut by the fitting. Be certain the interior of all fuel lines is clean and free of debris before connecting them, and confirm that all fittings are clean.
2. Mount the fuel/water separator on the frame rail and install the mounting fasteners.

**NOTICE**

**The lower housings on DAVCO fuel/water separators are made of aluminum. To avoid damaging threads, be careful not to overtighten fasteners or fittings on the fuel/water separator.**

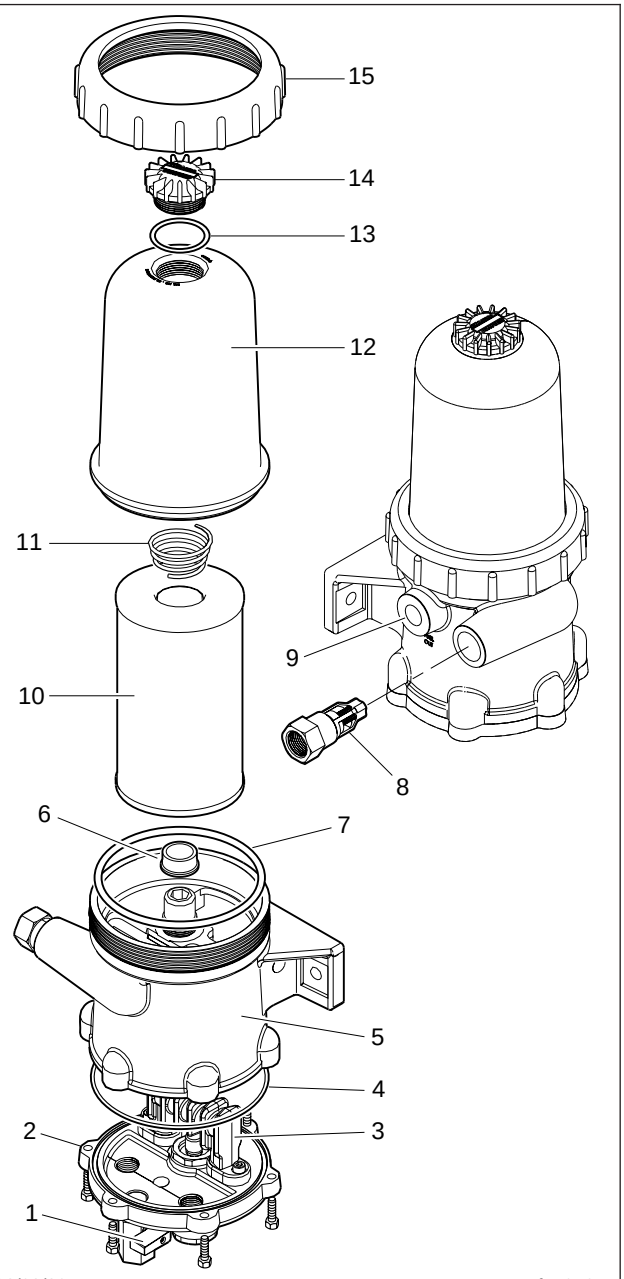
3. If the fuel inlet line was loosely connected previously, tighten it. If it was not connected, connect and tighten it.
4. Connect and tighten the fuel outlet line.
5. Install the electric heating element, if equipped, and connect the wiring harness, or connect the fluid heater lines. It does not matter which direction the heating fluid flows through the housing; the lines can be reversed.
6. Prime the system

   6.1 Ensure that the drain valve is closed.

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## Removal and Installation




1. Drain Valve
2. Bottom Plate
3. Heat Exchanger
4. Bottom Plate O-Ring
5. Lower Housing
6. Grommet
7. Cover O-Ring
8. Inlet Port/Check Valve
9. Fuel Outlet Port
10. Filter Element
11. Spring
12. Clear Cover
13. Vent Cap O-Ring
14. Vent Cap
15. Collar

**Fig. 1, Fuel/Water Separator (Fuel Pro 382 shown)**

6.2 Remove the vent cap from the cover, and fill the housing to the top with clean diesel fuel.

6.3 Install and hand-tighten the vent cap.

6.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.

6.5 With the engine running and air purged from the system, loosen the vent cap. When the fuel level falls to just above the collar, hand-tighten the vent cap.

6.6 Check for leaks and shut down the engine.

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# Filter Element and Check Valve Replacement

**⚠ WARNING**

**Fluid circulated through the fuel/water separator may be diesel fuel returned from the engine, or engine coolant. Drain the fuel/water separator only when the engine and fluids have cooled. Draining it when the engine is hot could cause severe personal injury due to scalding.**

**If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. Do not expose the fuel to, or work with, the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.**

## Filter Element Replacement

1. Shut down the engine, set the parking brake, and chock the tires.

IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many jurisdictions now issue fines for draining fuel/water separators onto the ground.

2. Put a clean receptacle under the fuel/water separator, then attach a piece of hose to the drain valve to direct fuel into the receptacle.

NOTE: Use a hose with a ½-inch pipe thread to fit the drain valve on a Fuel Pro 382.

3. Remove the vent cap (**Fig. 1**, Item 14) and open the drain valve (**Fig. 1**, Item 1). Drain the fuel to just below the collar level, then close the drain valve.
4. Using a DAVCO collar wrench (**Fig. 2**), remove the clear cover and collar.

NOTE: Broken vent cap and collar warranty claims will not be accepted if any tool other than a DAVCO collar wrench, p/n 380134, 382002, or 232007, is used for removal. During installation, the vent cap and collar are to be **hand-tightened only**, not tightened with a wrench.

5. Remove the filter and O-rings. Dispose of the filter and O-rings in an environmentally acceptable manner.
6. Remove the filter grommet from the filter stud, if equipped.
7. Clean all threads and sealing surfaces very thoroughly. Even a small amount of dirt will prevent the fuel/water separator from sealing, and an air leak will result.
8. Install the grommet on the bottom of the new filter, if equipped.
9. Install the new filter and cover O-ring on the housing.
10. Install the clear cover and the collar. Hand-tighten the collar.
11. Prime the system.
    - 11.1 Ensure that the drain valve is closed.
    - 11.2 Fill the housing to the top with clean diesel fuel.
    - 11.3 Install the O-ring in the vent cap. Install and hand-tighten the vent cap on the fuel/water separator.
    - 11.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.
    - 11.5 With the engine running and air purged from the system, loosen the vent cap. When the fuel level falls to just above the collar, hand-tighten the vent cap.
    - 11.6 Check for leaks and shut down the engine.

## Emergency Temporary Filter Replacement

1. Shut down the engine, set the parking brake, and chock the tires.

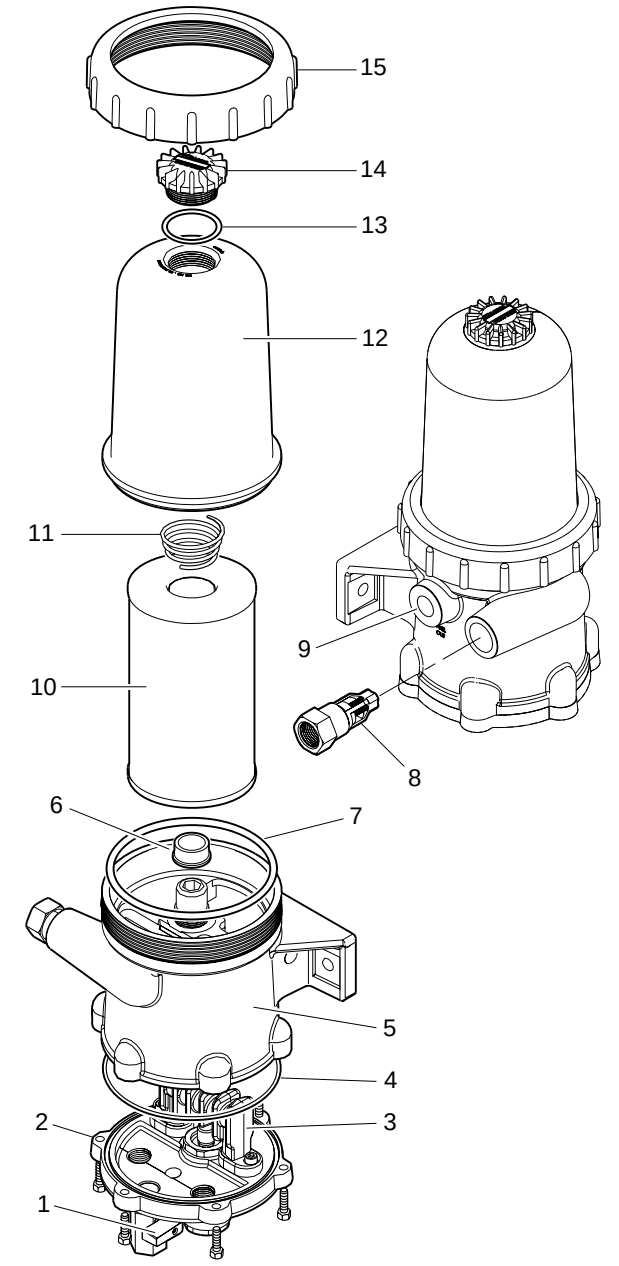
IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many jurisdictions now issue fines for draining fuel/water separators onto the ground.

2. Put a clean receptacle under the fuel/water separator, then attach a piece of hose to the drain valve to direct fuel into the receptacle.

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## Filter Element and Check Valve Replacement




1. Drain Valve
2. Bottom Plate
3. Heat Exchanger
4. Bottom Plate O-Ring
5. Lower Housing
6. Grommet
7. Cover O-Ring
8. Inlet Port/Check Valve
9. Fuel Outlet Port
10. Filter Element
11. Spring
12. Clear Cover
13. Vent Cap O-Ring
14. Vent Cap
15. Collar

**Fig. 1, Fuel/Water Separator (Fuel Pro 382 shown)**

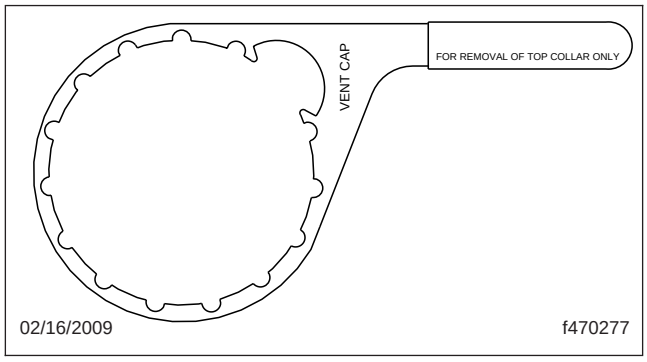



**Fig. 2, DAVCO Collar Wrench**

NOTE: Use a hose with a ½-inch pipe thread to fit the drain valve on a Fuel Pro 382.

3. Remove the vent cap (**Fig. 1**, Item 14) and open the drain valve (**Fig. 1**, Item 1). Drain the fuel to just below the collar level, then close the drain valve.
4. Using a DAVCO collar wrench (**Fig. 2**), remove the clear cover and collar.

NOTE: Broken vent cap and collar warranty claims will not be accepted if any tool other than a DAVCO collar wrench, p/n 380134, 382002, or 232007, is used for removal. During installation, the vent cap and collar are to be **hand-tightened only**, not tightened with a wrench.

5. Remove the filter and dispose of it in an environmentally acceptable manner.
6. Clean all threads and sealing surfaces very thoroughly. Even a small amount of dirt will prevent the fuel/water separator from sealing, and an air leak will result.
7. Ensure that the drain valve is closed.
8. Remove the filter grommet from the filter stud, if equipped.
9. Fill the housing to the top with clean diesel fuel.
10. Install a standard engine spin-on filter (part number FF105 or equivalent) on the filter stud.
11. Install the cover O-ring, clear cover, and the collar. Hand-tighten the collar.
12. Install the O-ring in the vent cap, then install and hand-tighten the vent cap on the fuel/water separator.

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13. Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.
14. Check for leaks and shut down the engine.

## Check Valve Replacement, Fuel Pro Models

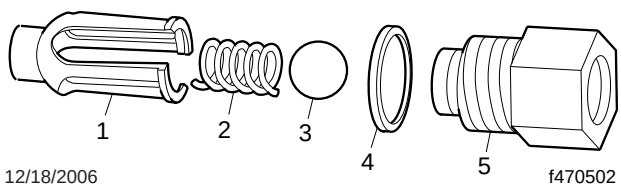
1. Shut down the engine, set the parking brake, and chock the tires.

IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many jurisdictions now issue fines for draining fuel/water separators onto the ground.

2. Put a clean receptacle under the fuel/water separator, then attach a piece of hose to the drain valve to direct fuel into the receptacle.

NOTE: Use a hose with a ½-inch pipe thread to fit the drain valve on a Fuel Pro 382.

3. Remove the vent cap (**Fig. 1**, Item 14) and open the drain valve (**Fig. 1**, Item 1). Drain the fuel to just below the collar level, then close the drain valve.
4. Place a shop towel under the fuel inlet fitting. Hold the check valve body in place with an open-end wrench and, using a flare-nut wrench, carefully remove the fuel inlet fitting. Drain any residual fuel into the container.
5. Remove the check valve assembly from the fuel/water separator housing.
6. Remove and discard the check ball, spring, and plastic retainer. See **Fig. 3**.




1. Plastic Spring Retainer
2. Retaining Spring
3. Check Ball
4. Seal
5. Check Valve Body

**Fig. 3, Check Valve Assembly**

7. Carefully clean the threads on the check valve body. Install the new check ball, spring, and plastic retainer on the check valve body.
8. Clean the threads on the fuel inlet fitting and fuel/water separator housing. Apply a soft-set pipe thread sealant to the check valve body threads.
9. Install the check valve body in the fuel/water separator housing and tighten per the specifications in **Table 1**. Do not use tape to seal the fuel fittings; it will eventually leak.

| Check Valve Assembly Torque Values | |
|---|---|
| **Fuel/Water Separator** | **Torque Value: lbf·ft (N·m)** |
| Fuel Pro 382 | 44–60 (60–81) |
| Fuel Pro 482 | 45 (61) |

**Table 1, Check Valve Assembly Torque Values**

10. Prime the system.
    - 10.1 Ensure that the drain valve is closed.
    - 10.2 Remove the vent cap from the clear cover, and fill the housing to the top with clean diesel fuel.
    - 10.3 Install and hand-tighten the vent cap.
    - 10.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.
    - 10.5 With the engine running and air purged from the system, loosen the vent cap. When the fuel level falls to just above the collar, hand-tighten the vent cap.
    - 10.6 Check for leaks and shut down the engine.

## Check Valve Replacement, Diesel Pro 243

1. Shut down the engine, set the parking brake, and chock the tires.

IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropri-

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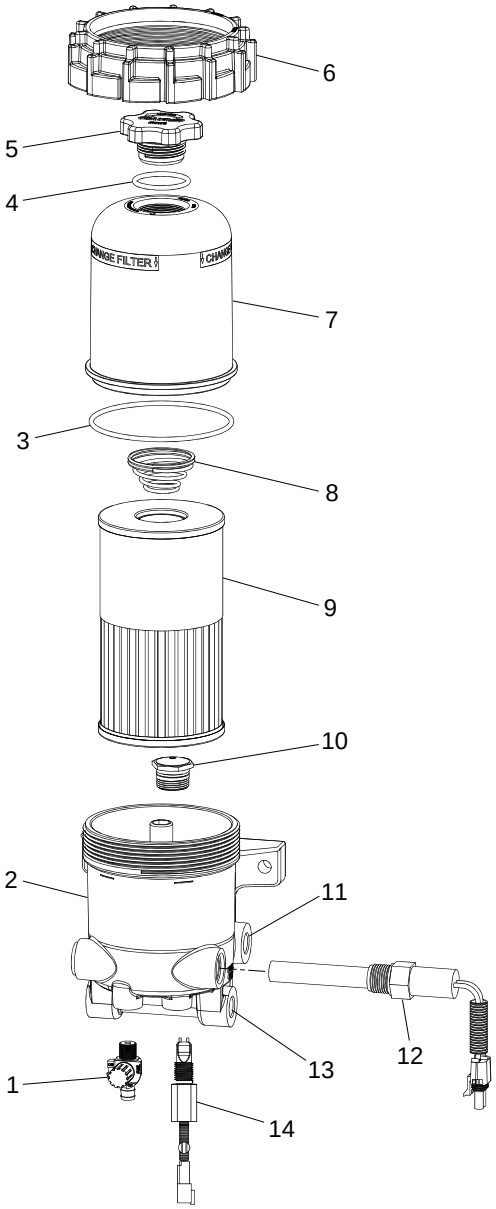
## Filter Element and Check Valve Replacement

ate container, and dispose of it properly. Many jurisdictions now issue fines for draining fuel/water separators onto the ground.

2. Put a clean receptacle under the fuel/water separator, then attach a piece of hose to the drain valve to direct fuel into the receptacle.
3. Remove the vent cap (**Fig. 4**, Item 5) and open the drain valve (**Fig. 4**, Item 1). Drain the fuel to just below the collar level, then close the drain valve.
4. Using a DAVCO collar wrench (**Fig. 2**), remove the clear cover and collar.

NOTE: Broken vent cap and collar warranty claims will not be accepted if any tool other than a DAVCO collar wrench, p/n 380134, 382002, or 232007, is used for removal. During installation, the vent cap and collar are to be **hand-tightened only**, not tightened with a wrench.

5. Remove the filter and O-rings. Dispose of the filter and O-rings in an environmentally acceptable manner.
6. Remove the check valve from the lower housing.
7. Clean all threads and sealing surfaces very thoroughly. Even a small amount of dirt will prevent the fuel/water separator from sealing, and an air leak will result.
8. Install the new check valve body in the lower housing. Tighten the check valve 12 to 14 lbf·ft (16 to 19N·m).
9. Install the new filter and cover O-ring on the housing.
10. Install the clear cover and the collar. Hand-tighten the collar.
11. Prime the system.
    - 11.1 Ensure that the drain valve is closed.
    - 11.2 Fill the housing to the top with clean diesel fuel.
    - 11.3 Install and hand-tighten the vent cap O-ring and vent cap.
    - 11.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.




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1. Drain Valve
2. Lower Housing
3. Cover O-Ring
4. Vent Cap O-Ring
5. Vent Cap
6. Collar
7. Clear Cover
8. Spring
9. Filter Element
10. Check Valve
11. Fuel Inlet Port
12. Pre-Heater
13. Fuel Outlet Port
14. Water-In-Fuel Sensor

**Fig. 4, DAVCO Diesel Pro 243**

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11.5 With the engine running and air purged from the system, loosen the vent cap. When the fuel level falls to just above the collar, hand-tighten the vent cap.

11.6 Check for leaks and shut down the engine.

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# Electric Heater, Thermoswitch, and Fluid Heat Exchanger Tests

**⚠ WARNING**

**Fluid circulated through the fuel/water separator may be diesel fuel returned from the engine, or engine coolant. Drain the fuel/water separator only when the engine and fluids have cooled. Draining it when the engine is hot could cause severe personal injury due to scalding.**

**If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. Do not expose the fuel to, or work with, the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.**

Any one of several types of heaters and thermoswitches may be fitted to DAVCO fuel/water separators. They include 12 VDC heaters, 120 VAC heaters, combination heater thermoswitches, and fluid heaters. The voltage and wattage ratings are stamped on the hex or the sheath of each component.

Test procedures under these headings apply to the following heater types, as specified:

- Electric Heater
- 12 VDC Thermoswitch
- Combination Heater Thermoswitch
- Fluid Heat

The following equipment is recommended to test DAVCO heaters and thermoswitches:

- A precision low-resistance ohmmeter capable of measuring 0.1 ohm or less
- A clamp-on DC current-flow meter
- A means of chilling a thermoswitch, such as ice, dry ice, or compressed carbon dioxide
- A flameless source of heat, such as an infrared heat lamp
- A vortex tube to heat and cool a thermoswitch

## Electric Heater

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Disconnect the heater from the wiring harness.
3. Connect the ohmmeter leads to the pins of the heater (for heaters with one pin, connect to the pin and the bushing).
4. Read the resistance and use **Table 1** to determine whether the heater is within the acceptable resistance range.
5. Connect the heater wiring harness.

| Electric Heater Test Parameters | | |
|---|---|---|
| **Electric Heater** | **Watts** | **Resistance Range: Ohms** |
| 12 VDC (two pin) | 250 | 0.6–0.8 |
| 12 VDC (single pin) | 250 | 0.4–0.5 |
| 12 VDC (single pin) | 150 | 0.8–1.1 |
| 120 VAC | 75 | 173–203 |
| 120 VAC | 37 | 369–411 |

**Table 1, Electric Heater Test Parameters**

## 12 VDC Thermoswitch

1. Shut down the engine, apply the parking brake, and chock the tires.

IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many jurisdictions now issue fines for draining fuel/water separators onto the ground.

2. Put a clean receptacle under the fuel/water separator, then attach a piece of hose to the drain valve to direct fuel into the receptacle.

NOTE: Use a hose with a ½-inch pipe thread to fit the drain valve on a Fuel Pro 382.

3. Remove the vent cap and open the drain valve. Drain the fuel to just below the collar level, then close the drain valve.
4. Disconnect the thermoswitch wiring harness, see **Fig. 1**. Remove the thermoswitch from the fuel/water separator.
5. Connect the ohmmeter leads to the pins of the thermoswitch.
6. Lower the thermoswitch temperature to below 40°F (4.4°C). The resistance shown on the ohmmeter should be less than 0.1 ohm.

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## Electric Heater, Thermoswitch, and Fluid Heat Exchanger Tests

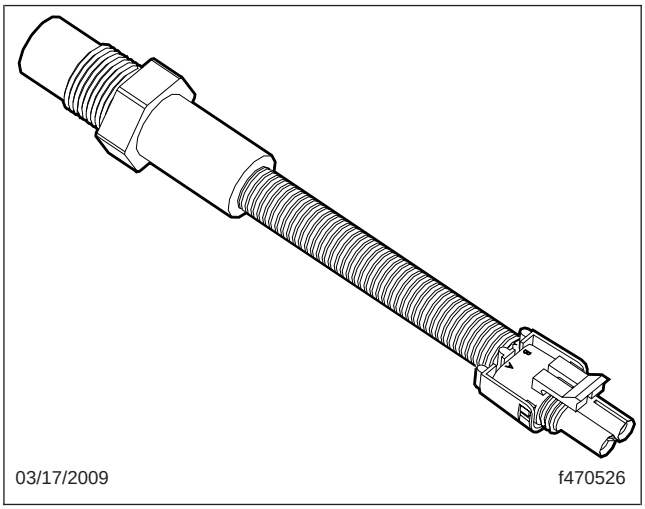



**Fig. 1, 12 VDC Thermoswitch**

7. Raise the thermoswitch temperature to above 60°F (15.5°C). The resistance should be more than 10 megohms.
8. Install the thermoswitch in the fuel/water separator. Connect the thermoswitch wiring harness.
9. Prime the system
   - 9.1 Ensure that the drain valve is closed.
   - 9.2 Remove the vent cap from the clear cover, and fill the housing to the top with clean diesel fuel.
   - 9.3 Install and hand-tighten the vent cap.
   - 9.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.
   - 9.5 With the engine running and air purged from the system, loosen the vent cap. When the fuel level falls to just above the collar, hand-tighten the vent cap.
   - 9.6 Check for leaks and shut down the engine.

## Combination Heater Thermoswitch

1. Shut down the engine, apply the parking brake, and chock the tires.

IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many jurisdictions now issue fines for draining fuel/water separators onto the ground.

2. Put a clean receptacle under the fuel/water separator, then attach a piece of hose to the drain valve to direct fuel into the receptacle.

NOTE: Use a hose with a ½-inch pipe thread to fit the drain valve on a Fuel Pro 382.

3. Remove the vent cap and open the drain valve to drain the fuel to just below the collar level, then close the drain valve.
4. Disconnect the heater/thermoswitch unit from the wiring harness, see **Fig. 2**.

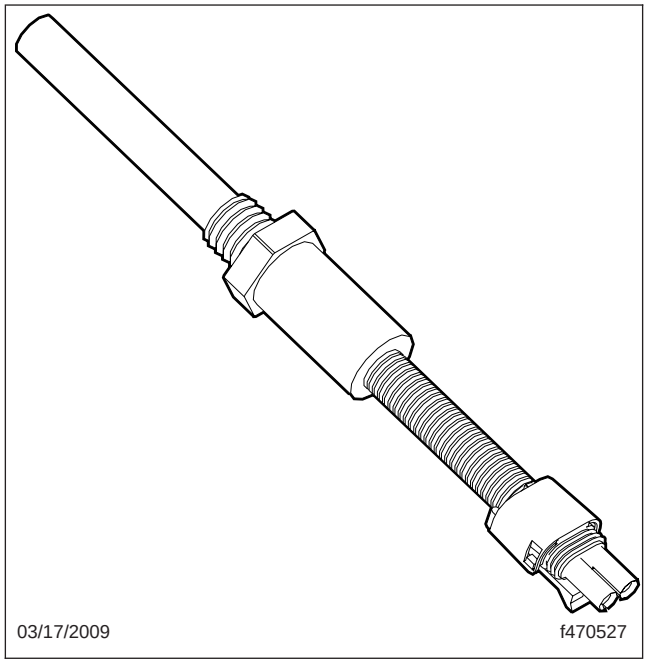



**Fig. 2, Combination Heater Thermoswitch**

5. Connect the ohmmeter leads to the heater/thermoswitch pins.
6. Lower the heater/thermoswitch unit temperature to below 40°F (4.4°C).

   The resistance shown on the ohmmeter should be:

   - 0.8 to 1.1 ohms for a 12 VDC 150 W unit
   - 0.2 to 2.5 ohms for a 24 VDC 250 W unit

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7. Raise the heater/thermoswitch unit temperature to above 70°F (21°C). The heater/thermoswitch unit should show an open circuit.
8. Install the heater/thermoswitch in the fuel/water separator. Connect the heater/thermoswitch wiring harness.
9. Prime the system
   - 9.1 Ensure that the drain valve is closed.
   - 9.2 Remove the vent cap from the clear cover, and fill the housing to the top with clean diesel fuel.
   - 9.3 Install and hand-tighten the vent cap.
   - 9.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.
   - 9.5 With the engine running and air purged from the system, loosen the vent cap. When the fuel level falls to just above the collar, hand-tighten the vent cap.
   - 9.6 Check for leaks and shut down the engine.

## Fluid Heat Exchanger

1. Shut down the engine, apply the parking brake, and chock the tires.

IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many jurisdictions now issue fines for draining fuel/water separators onto the ground.

2. Put a clean receptacle under the fuel/water separator, then attach a piece of hose to the drain valve to direct fuel into the receptacle.

NOTE: Use a hose with a ½-inch pipe thread to fit the drain valve on a Fuel Pro 382.

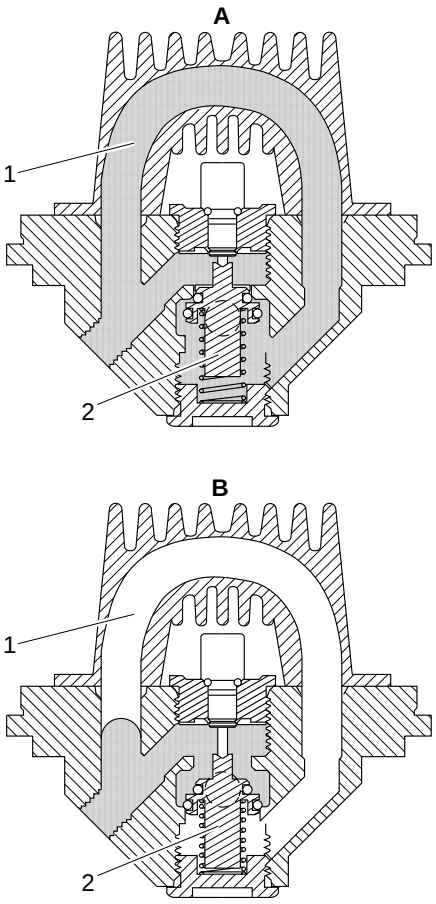
3. Remove the vent cap and open the drain valve to drain the fuel to just below the collar level, then close the drain valve.
4. Disconnect the heating fluid lines from the bottom plate. These will be either engine coolant lines or return fuel lines. Plug engine coolant lines after removing them from the bottom plate of the housing.
5. Remove the bottom plate and lower housing O-ring.
6. When the fuel entering the fuel/water separator is cold, the thermovalve moves up, allowing warming fluid to enter the heater loop in the heat exchanger. When the fuel is warm, the thermovalve moves down, causing the warming fluid to bypass the heater loop and return directly to the tank. See **Fig. 3**.

   While looking into the fluid port of the bottom plate (**Fig. 4**), flow cold water over the thermovalve for 30 seconds, then run hot water over the thermovalve to determine whether the thermovalve spool is opening and closing.
7. Replace the lower housing O-ring, and install the bottom plate on the fuel/water separator. Install the screws on the bottom plate and tighten them 8 to 10 lbf·ft (11 to 14 N·m).
8. Connect the heating fluid lines.
9. Prime the system
   - 9.1 Ensure that the drain valve is closed.
   - 9.2 Remove the vent cap from the clear cover, and fill the housing to the top with clean diesel fuel.
   - 9.3 Install and hand-tighten the vent cap.
   - 9.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.
   - 9.5 With the engine running and air purged from the system, loosen the vent cap. When the fuel level falls to just above the collar, hand-tighten the vent cap.
   - 9.6 Check for leaks and shut down the engine.

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## Electric Heater, Thermoswitch, and Fluid Heat Exchanger Tests

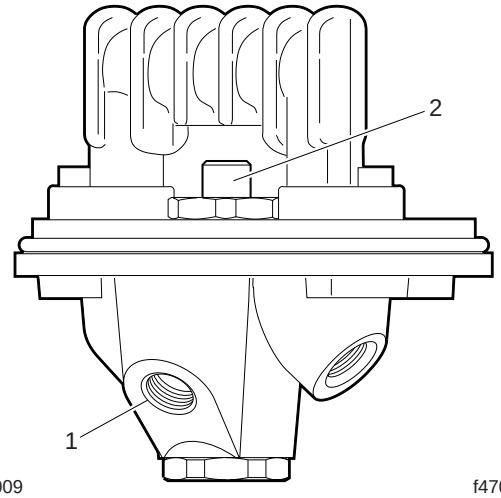



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A. Fuel is Cold, Thermovalve Is Up
B. Fuel is Warm, Thermovalve is Down

1. Heater Loop
2. Thermovalve

**Fig. 3, Heat Exchanger Fluid Flow**




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1. Fluid Port
2. Top of Thermovalve Spool

**Fig. 4, Fluid Heater Thermovalve Test**

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The Daimler Trucks North America Learning Center (accessible through **www.AccessFreightliner.com**) and DAVCO ( **www.DavcoTec.com**) offer excellent online resources for understanding, testing, and diagnosing fuel/water separator problems.

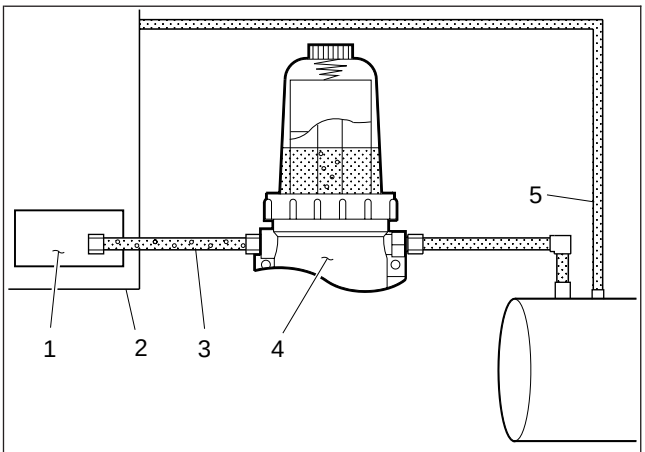
## Identifying Bubble Types

### Vapor Bubbles

Vapor bubbles are harmless and are present in all diesel fuel systems. Vapor bubbles are often mistaken for air bubbles, but *do not affect engine performance.*

Vapor bubbles (see **Fig. 1**) may be visible in a diagnostic sight tube installed between the fuel/water separator and the fuel pump. They consist of harmless fuel vapor and trapped air, may vary from champagne-size to 1/4-inch (6-mm) diameter, and may increase in volume or size as the engine rpm increases. The lower pressure inside a fuel/water separator filter, caused by the suction of the fuel pump pulling fuel through the fuel/water separator, creates vapor bubbles. These vapor bubbles are normal and harmless to engine operation. In the fuel pump, the fuel is pressurized and the vapor bubbles dissolve. Vapor bubbles do not appear on the fuel return side of the system.

There is no troubleshooting or repair procedure required for vapor bubbles. Vapor bubbles do not cause performance issues and will not be present downstream of the fuel pump.




1. Fuel Pump
2. Engine
3. Fuel Outlet Line, Vapor Bubbles Visible
4. Fuel/Water Separator, Vapor Bubbles Visible *Inside* Filter, *No* Bubbles Visible in Clear Cover
5. Fuel Return Line (no bubbles)

**Fig. 1, Harmless Vapor Bubbles**

### Air and Gas Bubbles

Air or gas bubbles indicate harmful leaks, and can cause hard starting and impaired engine performance. All diesel fuel holds some trapped air, caused by the natural splashing that occurs in the fuel tank. But excessive air bubbles, severe enough to degrade engine performance, indicate an air leak on the suction side of the fuel system, from the fuel tank into the fuel pump.

Air bubbles visible in the clear cover of a DAVCO fuel/water separator may indicate an air leak in the fuel system upstream of the bubbles, or in the fuel/water separator; see **Fig. 2**. If there are no bubbles visible in the clear cover but the engine runs rough, there may be an air leak at or between the fuel/water separator outlet port and the fuel pump inlet. These bubbles will be visible in a diagnostic sight tube installed between the fuel pump and the fuel/water separator, and in a diagnostic sight tube installed in the fuel return hose.

Exhaust gas bubbles may also be visible in the clear filter cover. They are the result of leaking fuel injector seals, which can allow combustion gases to enter the fuel system, pass through the fuel return line into the fuel tank, and be drawn into the fuel/water separator. They may be visible in a diagnostic sight tube installed in the fuel return line. To test for combustion gas in the fuel, disconnect the return line at the tank, submerge the end in a bucket of fuel, run the engine, and watch for bubbles. As they pop, these bubbles may smell like exhaust fumes.

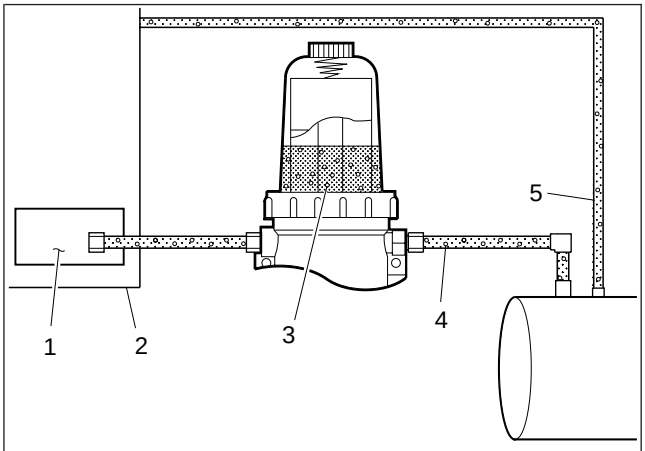
In extreme cases, these combustion gas bubbles cause enough aeration in the fuel tank to create visible bubbles in the clear cover of the fuel/water separator and impair engine performance. See the engine manufacturer's documentation for diagnosis and repair of injector seal leakage.

Use the following procedures to determine which bubbles are present in the fuel system, and whether repair is necessary.

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## Troubleshooting




1. Fuel Pump
2. Engine
3. Fuel/Water Separator, Bubbles Visible in Clear Cover
4. Fuel Inlet Line, Bubbles Visible
5. Fuel Return Line, Bubbles Visible

**Fig. 2, Air Bubbles Indicating a Leak**

# Initial Diagnostic Procedure

1. Apply the parking brake, chock the tires, and turn on the engine.
2. Check for air bubbles in the fuel/water separator clear cover.
3. If no bubbles are visible in the clear cover, but the engine continues to run rough, lopes, or has loss of power, there may be an air leak between the fuel/water separator outlet and the fuel pump inlet.

   If so, bubbles should be visible in a diagnostic sight tube installed at the fuel pump inlet. Air bubbles may also be visible in a diagnostic sight tube installed in the fuel return line to the fuel tank.
4. Replace fuel lines and tighten fittings as needed.

# Testing Procedures

## Air Leak in the Fuel System

Air leaks are sometimes caused by:

- loose fittings;
- a faulty inlet check valve;
- faulty O-rings;
- leakage elsewhere in the fuel system;
- or dirt on threads and sealing surfaces.

Air leaks originating between the fuel tank and the fuel/water separator cause air bubbles visible in the clear cover, as shown in **Fig. 2**.

If there are symptoms of sucking air and there are no bubbles in the clear cover, look for the air leak at:

- the outlet fitting;
- the fuel pump inlet connection;
- the fuel hose connections;
- or at the vent cap O-ring.

1. Shut down the engine, apply the parking brake, and chock the tires.

**⚠ WARNING**

**Fluid circulated through the fuel/water separator may be diesel fuel returned from the engine, or engine coolant. Drain the fuel/water separator only when the engine and fluids have cooled. Draining it when the engine is hot could cause severe personal injury due to scalding.**

**If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. Do not expose the fuel to, or work with, the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.**

2. Remove the fuel hose from the fuel pump inlet port.
3. Install a jumper hose from the inlet port into the fuel tank through the fill cap, or into a container of fuel.
4. Start the engine and look for bubbles in the clear filter cover. If the air bubbles are eliminated, the air source (and the leak) is at either the fuel tank fittings, or the hose connections.

   If air bubbles persist after the tank fittings and hose connections are secured, the leak may be in the fuel/water separator.
5. If the leak is suspected to be in the fuel/water separator, disconnect all fuel connections, coat

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the threads with liquid or paste sealer, and reconnect the fuel connections and tighten them securely.

## Air Pressure Testing

1. Shut down the engine, apply the parking brake, and chock the tires.

IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many jurisdictions now issue fines for draining fuel/water separators onto the ground.

2. Put a clean receptacle under the fuel/water separator, then attach a piece of hose to the drain valve to direct fuel into the receptacle.

NOTE: Use a hose with a ½-inch pipe thread to fit the drain valve on a Fuel Pro 382.

3. Remove the vent cap and open the drain valve. Drain the fuel to just below the collar level, then close the drain valve.
4. Remove the fuel/water separator from the chassis. For instructions, see **Subject 100**.

**⚠ WARNING**

**Wear goggles and skin protection when pressure-testing a fuel/water separator, and be careful not to perform this test near a source of possible ignition, such as an open flame. Never exceed the maximum pressure stipulated for the test, and do not perform this test if the clear cover appears to be damaged.**

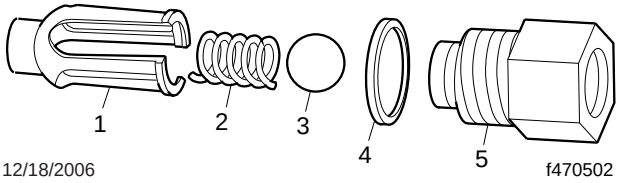
5. Plug the fuel outlet port. Do not remove the filter, filter cover, collar, vent cap, drain valve, or check valve. Do not remove the electric heating element (if equipped), and do not plug the fluid heat ports (if equipped).
6. Apply 15 psi (207 kPa) air pressure at the fuel inlet. Immerse the unit in a tank of water and look for air bubbles.
7. If no bubbles appear, the air leak is not in the fuel/water separator.
8. Install the fuel/water separator onto the chassis frame rail. For instructions, see **Subject 100**.
9. Prime the system
   - 9.1 Ensure that the drain valve is closed.
   - 9.2 Remove the vent cap from the cover, and fill the housing to the top with clean diesel fuel.
   - 9.3 Install and hand-tighten the vent cap.
   - 9.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.
   - 9.5 With the engine running and air purged from the system, loosen the vent cap. When the fuel level falls to just above the collar, hand-tighten the vent cap.

## Filter Element Restriction Check

A properly assembled DAVCO fuel/water separator does not restrict fuel flow until the fuel level has risen to the top of the filter. If the fuel level has risen to the top of the filter, replace the filter.

## Check Valve Operation Test, Fuel Pro Models

When air is introduced into the fuel system, (e.g. when draining fluid or when replacing the fuel filter), the check valve (**Fig. 3**) works to keep the fuel system primed from the fuel tank to the fuel/water separator.




1. Plastic Spring Retainer
2. Retaining Spring
3. Check Ball
4. Seal
5. Check Valve Body

**Fig. 3, Check Valve Assembly, Fuel Pro Configurations**

To test for proper check valve operation, remove the fuel inlet line, then open the vent cap. Fuel should not flow out of the check valve, although a slight seepage of fuel is normal. If fuel drains back out of the check valve, complete the following procedure.

1. Shut down the engine, apply the parking brake, and chock the tires.

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## Troubleshooting

**⚠ WARNING**

**Fluid circulated through the fuel/water separator may be diesel fuel returned from the engine, or engine coolant. Drain the fuel/water separator only when the engine and fluids have cooled. Draining it when the engine is hot could cause severe personal injury due to scalding.**

**If returning fuel is released into the atmosphere, its vapors can ignite in the presence of any ignition source. Do not expose the fuel to, or work with, the fuel system near open flame or intense heat. To do so could cause fire, possibly resulting in serious personal injury or property damage.**

IMPORTANT: When draining fluid from a fuel/water separator, drain the fluid into an appropriate container, and dispose of it properly. Many jurisdictions now issue fines for draining fuel/water separators onto the ground.

2. Put a clean receptacle under the fuel/water separator, then attach a piece of hose to the drain valve to direct fuel into the receptacle.

NOTE: Use a hose with a ½-inch pipe thread to fit the drain valve on a Fuel Pro 382.

3. Remove the vent cap and open the drain valve to drain the fuel to just below the collar level, then close the drain valve.
4. Place a shop towel under the fuel inlet fitting. Hold the check valve body in place with an open-end wrench and, using a flare-nut wrench, carefully remove the fuel inlet fitting. Drain any residual fuel into the container.
5. Remove the check valve assembly from the fuel/water separator housing, see **Fig. 3**.
6. Clean and inspect the check valve body. If the valve body is damaged, or if the ball seat is not smooth, replace the valve. For instructions, see **Subject 110**.
7. If the valve body and ball seat are not damaged, clean the threads on the check valve body, fuel inlet fitting, and the lower housing.
8. Apply a soft-set pipe thread sealant to the check valve body threads. Install the check valve body in the fuel/water separator housing. Do not use tape to seal the fuel fittings; it will eventually leak.

   Tighten the check valve body 44 to 60 lbf·ft (60 to 81 N·m) on a Fuel Pro fuel/water separator, or 25 to 40 lbf·ft (34 to 54 N·m) on a Diesel Pro fuel/water separator
9. Prime the system
   - 9.1 Ensure that the drain valve is closed.
   - 9.2 Remove the vent cap from the clear cover, and fill the housing to the top with clean diesel fuel.
   - 9.3 Install and hand-tighten the vent cap O-ring and vent cap.
   - 9.4 Start the engine. When the lubricating oil reaches its normal operating pressure, increase engine speed to high idle for one to two minutes to purge air from the system.
   - 9.5 With the engine running and air purged from the system, loosen the vent cap. When the fuel level falls to just above the collar, hand-tighten the vent cap.
   - 9.6 Check for leaks and shut down the engine.

## Other Conditions Visible Inside the Cover

The clear filter covers fitted to DAVCO fuel/water separators provide the opportunity to monitor several aspects of fuel condition and engine status, as described in **Table 1**.

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| Conditions Visible Inside DAVCO Clear Filter Covers | | |
|---|---|---|
| **If You See:** | **What to Do:** | **Comments:** |
| Amber-colored fuel below the top of the filter element | Nothing, the filter is doing its job | Do not change the filter. |
| Amber-colored fuel with dark patches in places on the filter element | Dark patches indicate bacteria or algae may be present. Use Fleetguard Monitor Kit CC2650 to test for microbiological activity. | It may be necessary to use a microbicide, and suggest vehicle operator carry extra filters. |
| Extremely dark or cloudy fuel with thick black film or sludge collecting on the filter element | Black film or sludge on the filter media indicates the presence of asphaltenes. It may be necessary to use an asphaltene conditioner. | Do not assume this is oil from the engine. Monitor the vehicle for oil consumption. Refer to engine manufacturer's service literature for more information. |
| Bubbles inside the clear cover | Check for air leaks anywhere in the fuel system. Any leak in any fitting will cause bubbles to appear in the clear cover. | This problem will lead to power complaints; it must be remedied. |
| No bubbles in the cover, but the engine is running rough | Check for air leaks between the fuel/water separator outlet port and the fuel pump inlet. Check and tighten all fuel fittings in the area of the leak. | Do not replace the fuel/water separator. |
| Coolant in the fluid drained from the fuel/water separator | Check for leaks in the engine, where fuel and coolant are near each other. The most common problem place is the injector cup. | Do not allow the equipment to be operated until the problem is found and repaired. |
| Anything not listed here | Call DAVCO at 1-800-328-2611, or email: customerservice@DavcoTec.com. | — |

**Table 1, Conditions Visible Inside DAVCO Clear Filter Covers**

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## Specifications

| Torque Values | | | | | |
|---|---|---|---|---|---|
| Component | Fuel Pro 482 | Fuel Pro 382 | | Diesel Pro 243 | |
| | lbf·ft (N·m) | lbf·ft (N·m) | lbf·in (N·cm) | lbf·ft (N·m) | lbf·in (N·cm) |
| Inlet Port/Check Valve | 45 (61) | 44–60 (60–81 ) | — | 12–14 (16–19)* | — |
| Water in Fuel Sensor | — | — | 20–24 (226–271) | — | 20–24 (226–271) |
| Electric Heating Element | 15–30 (20–41) | 15–30 (20–41) | — | 25–40 (34–54) | — |

* Check valve assembly not connected to inlet port on Diesel Pro 243 configurations.

**Table 1, Torque Values**

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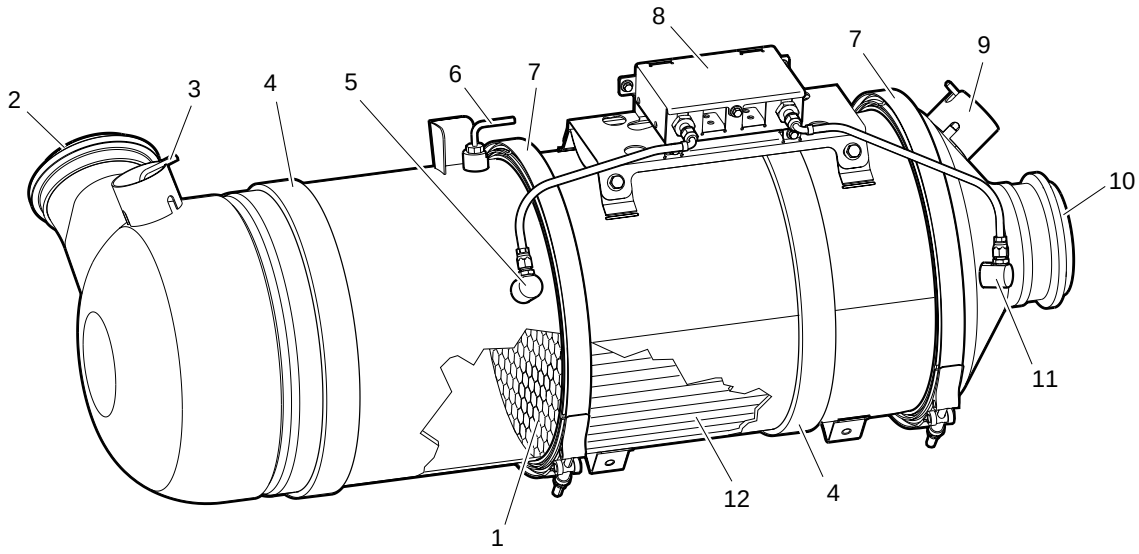
## General Information

The EPA07 aftertreatment **system** (ATS), introduced to meet the requirements of the EPA07 emission control regulations, includes all the piping and equipment between the turbocharger outlet and the tip of the exhaust pipe. It resembles the exhaust system on earlier vehicles, but includes an aftertreatment **device** (ATD) instead of a muffler (see **Fig. 1**), and other equipment. An electronic control module (ECM) controls the operation of the ATS.

(DPF), which traps solid particles. Particulates trapped in the DPF are almost completely vaporized in a process called regeneration.

Soot trapped in the DPF cannot be vaporized, but it is burned to ash and held in the DPF. When the ash buildup is heavy enough to begin clogging the DPF, it must be removed from the vehicle and physically cleaned in special processes specified by the engine manufacturers.

Low-ash oil extends the DPF cleaning intervals, and




1. Diesel Particulate Filter (DPF) Ceramic Honeycomb Substrate Openings
2. Marmon Fitting at Inlet from Turbocharger
3. Diesel Oxidation Catalyst (DOC) Intake Temperature Sensor
4. ATD Mounting Band
5. DPF Intake Pressure Sensor
6. DOC Outlet Temperature Sensor (connection to sensor housing not shown)
7. DPF V-Band Mounting Clamps
8. Sensor Housing
9. DPF Outlet Temperature Sensor (connection to sensor housing not shown)
10. Exhaust Outlet Marmon Fitting
11. DPF Outlet Pressure Sensor
12. DPF Substrate Tubes

**Fig. 1, ATD Components (typical)**

Engine manufacturers use different methods and equipment to reduce emissions from their engines, but an ATD is used on all of them. All ATDs are chassis-mounted, but they can be mounted either horizontally or vertically. All ATS exhaust piping is stainless steel.

Inside the ATD, the exhaust passes first through the diesel oxydation catalyst (DOC) where it is chemically treated, then through the diesel particulate filter gives it longer life. **Only low-ash oil should be used in EPA07 engines**.

EPA07 emissions regulations limit NOx to just over 1 gram per brake horsepower hour (g/bhp-hr) and particulate matter cannot exceed 0.01 g/bhp-hr. **EPA07 engines require ultralow sulphur diesel (ULSD) fuel, for low emissions and long life of the ATD.**

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## General Information

**Running an EPA07 engine on non-ULSD fuel will cause expensive damage, not covered under warranty.**

NOTE: Western Star documentation deals only with removal and installation of the ATD and other parts of the ATS. Refer to the engine manufacturers' service literature for all testing, disassembly, cleaning, and repair of the ATD and other components.

IMPORTANT: The ATS is part of an interrelated engine and emissions management system, controlled by the ECM. Follow the engine manufacturer's procedures, and use the correct equipment when diagnosing or working on any part of the ATS.

In Mercedes-Benz, Detroit Diesel, and Cummins engines, there is a diesel oxidation catalyst (DOC) inside the intake side of the ATD. The DOC chemically treats the exhaust, to reduce gas emissions before the exhaust reaches the DPF.

At the rear of the ATD, the DPF honeycomb tubes are closed at alternate ends, forcing the exhaust to move through its walls where it traps the soot.

There are two modes of regeneration; **passive and active**.

**Passive** regeneration is ongoing, whenever vehicle operation creates an ATD temperature of 572°F (300°C) or higher. This happens during normal vehicle operation, and exhaust gas temperature is no higher than normal. Under load and at highway speeds, passive regeneration may be all that is necessary to keep the DPF clear. But operating under light loads or at low speeds does not generate enough heat in the ATD for passive regen, and particulate matter builds up in the DPF.

As particulate matter builds up in the DPF, it blocks exhaust gas from passing through the honeycomb tube walls. Pressure sensors on the intake and exhaust sides of the DPF sense the increase in back pressure, and signal the ECM. The ECM also keeps track of other measurements such as engine hours and mileage, to calculate when active regeneration is necessary.

During **active** regen, extra fuel is injected into the ATD to raise its interior temperature very high and turn the trapped soot to harmless ash. Exhaust gas temperature reaches over 1112°F (600°C). **There are two types of active regeneration; at-speed and parked.**

- **At-speed** regeneration is automatically begun by the ECM. The exact conditions to trigger regeneration vary, according to the engine manufacturer's design. Generally, it can begin only when the vehicle is travelling at least 7.5 mph, and active regeneration stops when the vehicle slows to 5 mph or below.
- **Parked** regeneration is initiated by the driver when the vehicle is safely parked with the exhaust outlet well away from any flammable substance, a specific sequence of procedures is followed, and the driver pushes the regeneration button on the dashboard. The parked regeneration sequence varies with vehicle configuration, but it must be exactly followed or regeneration cannot happen. Follow the exact sequence from the engine manufacturer's literature.

IMPORTANT: The ATS is an integrated system, and every component must be operating in place for the ATS to work correctly.

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## Removal

These instructions are generalized, because vehicle configurations vary widely. The basic procedures apply to all aftertreatment devices (ATDs). For service and repair beyond removal and installation, refer to the engine manufacturer's service literature.

NOTE: For specific instructions on servicing any components of the aftertreatment system (ATS) including the ATD, consult the engine manufacturer's service literature.

NOTE: It may be necessary to raise the vehicle, or remove heat shields or body panels, to service the ATD.

**⚠ CAUTION**

**The ATD assembly weighs from 125 to 150 pounds (57 to 68 kg) and must be protected from impact or sharp jolts. Dropping the ATD, or subjecting it to jarring impact can crack the diesel particulate filter (DPF) inside, which is built on a ceramic substrate. If that happens, the DPF is ruined and must be replaced.**

**A secure support is necessary to remove and install the ATD safely. The ATD must be held securely to protect it from falling, or hitting hard against something else.**

**The horizontal ATD lifting device (TLZ00785) is designed to handle a horizontal ATD. Vertical ATDs require a shop hoist secured to the lifting ears on top.**

The ATD is designed so that its exterior operating temperature is comparable to that of a standard muffler, but during active regeneration, its interior (see **Fig. 1**) and the outlet become hot enough to melt or ignite many common materials.

**⚠ DANGER**

**Aftertreatment Device (ATD) internal temperatures can remain hot enough to cause personal injury, or ignite combustible materials, for hours after the engine is shut down.**

**To avoid potentially serious burns or material damage:**

- Let the ATD cool before handling it; be especially careful when opening it to expose the DPF.
- Wear appropriate protective gear.
- Be careful not to place the ATD where flammable gases or other combustible materials may come into contact with hot interior parts.

1. Set the parking brake, and chock the tires.

NOTE: Never attempt to start the vehicle with the ATD removed or with the ATD sensors disconnected, unless the engine manufacturer's documentation allows it for a diagnostic procedure.

2. Disconnect the connections at the sensor box (see **Fig. 1**) and the diesel oxidation catalyst (DOC) inlet temperature sensor.
3. Mark the Marmon fitting joints and mounting bracket orientation to the ATD, so that the ATD can be installed exactly as it was removed. See **Fig. 2**.

NOTE: There are guide pins (see **Fig. 3**) to position the ATD during vehicle manufacture, but they are designed to break off if they are stressed, to avoid damage to the expensive ATD. If the guide pins are gone, the locating marks serve the same purpose.

4. If the ATD is horizontally mounted, move the ATD handling device into place against it, so that it is in position to support the ATD securely and the ATD can not roll, tip, or fall. If the ATD is vertically mounted, attach a shop crane or similar device to the lifting ears and take up the slack, so that the lifting device is beginning to support the weight of the ATD.
5. The exhaust pipe may require support, such as a rope sling, to support it during ATD removal. If such support is required, install it now.

**⚠ CAUTION**

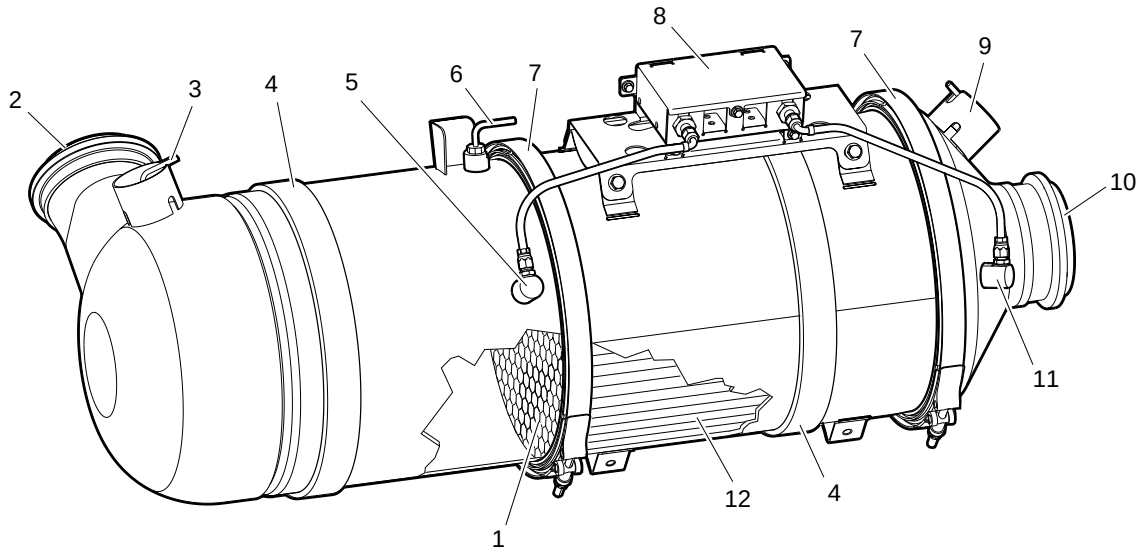
**Be careful not to stress or twist the bellows as the ATD is manipulated. The bellows is not designed to support weight or withstand undue stress and can easily be damaged, requiring expensive replacement.**

6. Remove the clamps from the Marmon fittings at the inlet and outlet of the ATD.

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## Aftertreatment Device Removal and Installation




1. Diesel Particulate Filter (DPF) Front End Honeycomb
2. Marmon Fitting at Inlet from Turbocharger
3. Diesel Oxidation Catalyst (DOC) Intake Temperature Sensor
4. ATD Mounting Band
5. DPF Intake Pressure Sensor
6. DOC Outlet Temperature Sensor (connection to sensor housing not shown)
7. DPF V-Band Mounting Clamp
8. Sensor Housing
9. DPF Outlet Temperature Sensor (connection to sensor housing not shown)
10. Exhaust Outlet Marmon Fitting
11. DPF Outlet Pressure Sensor
12. DPF Ceramic Substrate

**Fig. 1, Typical ATD**

7. Remove the two mounting bands that hold the ATD to its frame brackets, so that the ATD is held by the ATD handling device.
8. Move the ATD handling device slightly, so that the ATD positioning pin (see **Fig. 4**) clears its hole in the mounting bracket. Carefully remove the ATD from the vehicle.

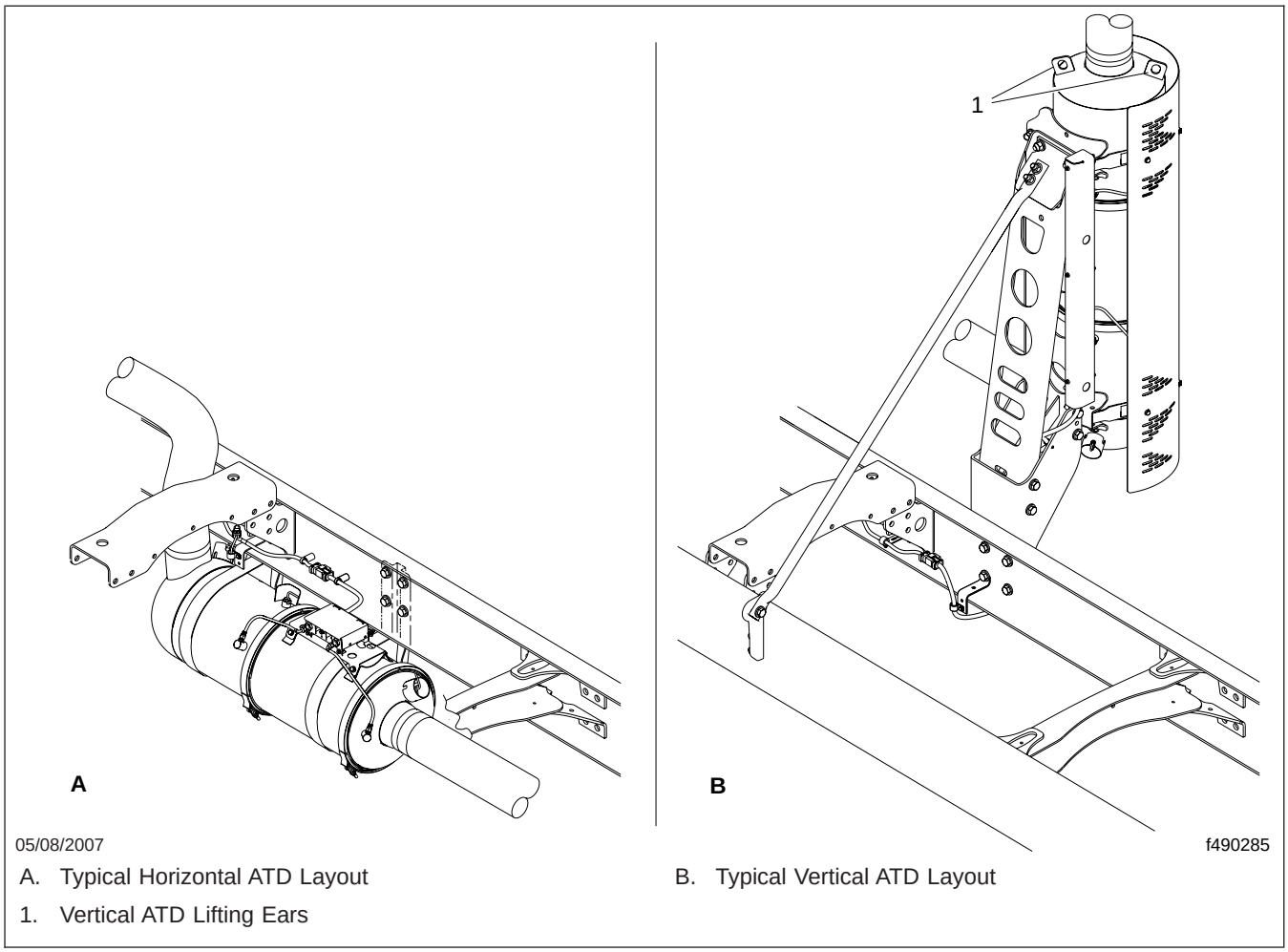
NOTE: ATD component service procedures, such as cleaning the DPF or servicing the sensors, are documented in the engine manufacturer's service literature.

# Installation

1. Use the ATD handling device to move the ATD into position, so the inlet and exhaust align with the inlet and exhaust piping. Be sure the ATD positioning pin engages its hole in the ATD mounting bracket, or that the positioning marks align.
2. Install the ATD mounting bands, but do not tighten them yet.
3. Position the V-band clamps on the Marmon fittings and tighten them to the torque value shown in **Table 1**.
4. Tighten the ATD mounting bands to the torque value shown in **Table 1**. Do not overtighten or the ATD could deform, damaging and ruining the DPF.
5. Connect the harness to the sensor housing and the front temperature sensor.
6. Remove the ATD handling device.
7. If a support was fastened around the exhaust pipe, remove it.
8. Remove the chocks from the tires.
9. Operate the vehicle and check for leaks.

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A. Typical Horizontal ATD Layout

B. Typical Vertical ATD Layout

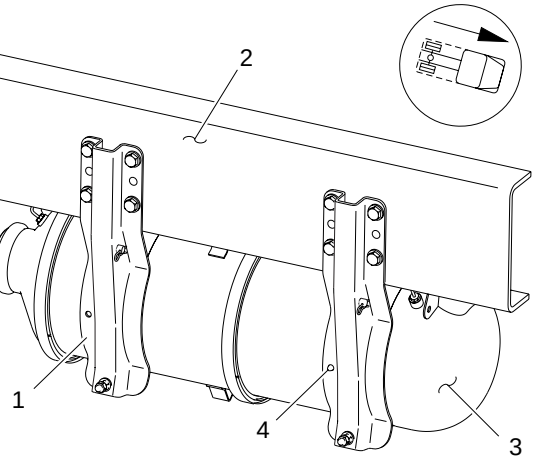
1. Vertical ATD Lifting Ears

**Fig. 2, ATD Mounting Options**

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## Aftertreatment Device Removal and Installation



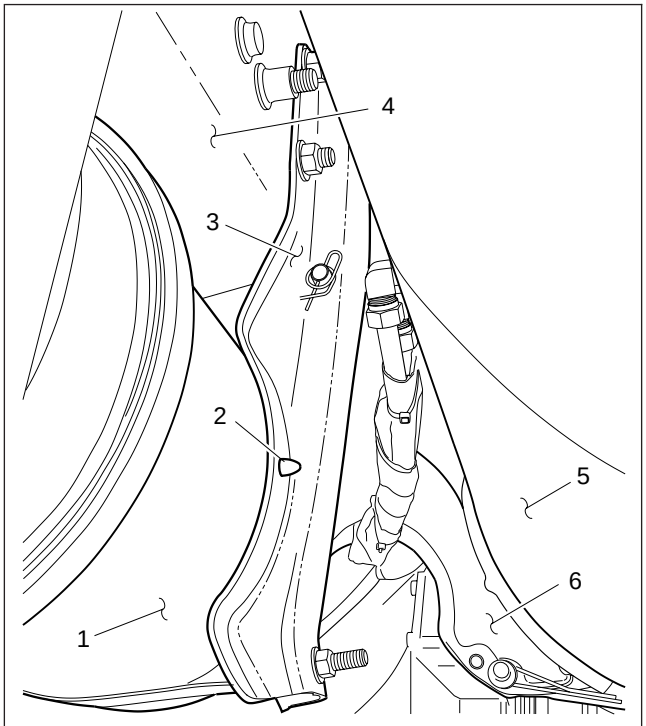

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1. ATD Mounting Bracket
2. Chassis Frame Rail
3. ATD Inlet End
4. ATD Locating Pin

**Fig. 3, ATD Mounting on Frame Rail**

| ATD Torque Values | |
|---|---|
| **Fitting** | **Torque: lbf·ft (N·m)** |
| Mounting Bands | Initial: 15 (20)<br>Final: 30 (41) |
| Temperature Sensor Nuts | 26–29 (35–39) |
| Pressure Line Tube Nuts | 11–13 (15–17) |
| Pressure Sensor Jam Nuts | 15–18 (20–25) |
| Marmon V-Band Clamps | 12–13 (16–17) |
| Compression Fittings | 15–18 (20–25) |
| Bellows Torco Clamps | Target: 41 (56)<br>Range: 35–48 (48–64) |

**Table 1, ATD Torque Values**




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1. ATD
2. ATD Locating Pin
3. ATD Mounting Bracket
4. Chassis Frame Rail
5. Fuel Tank
6. Fuel Tank Mounting Bracket

**Fig. 4, ATD Mounting Bracket**

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NOTE: The bellows is very difficult to remove without serious damage to it, and will almost certainly have to be replaced with a new one if it is removed.

Check the bellows for damage. If the bellows is damaged or leaking, replace it. Minor dents are not a problem, as long as there are no leaks.

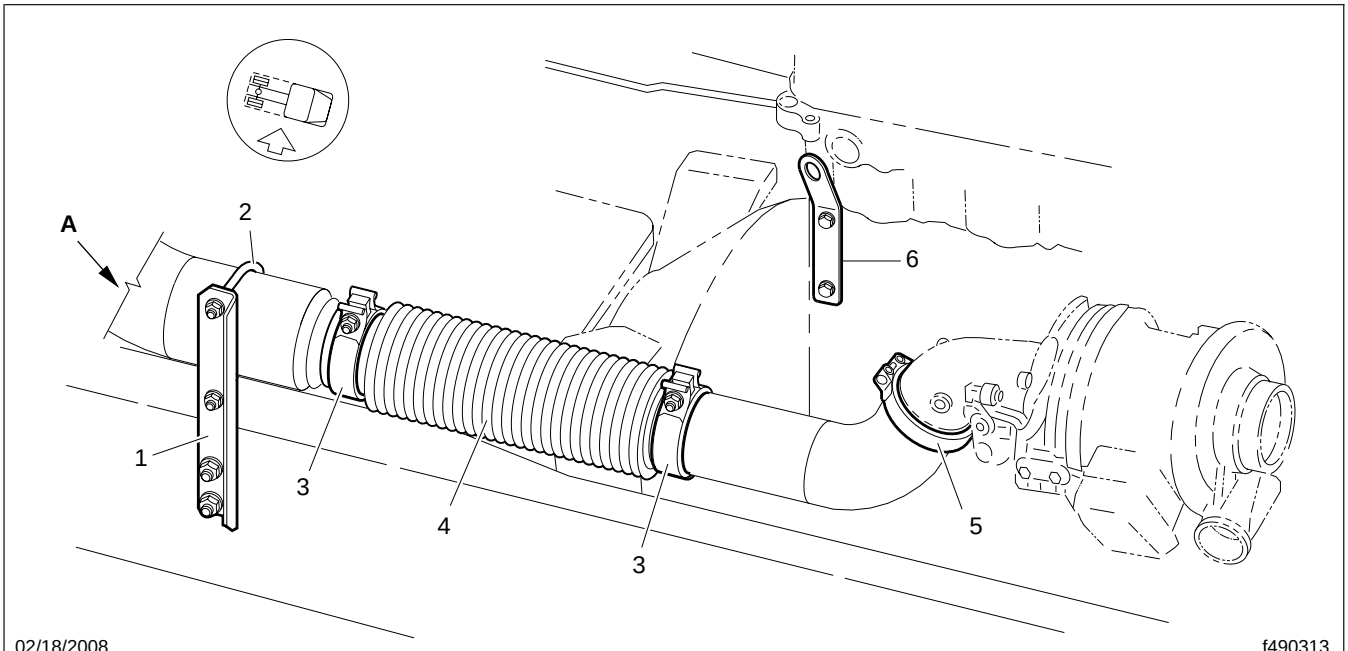
## Replacement

1. Open the hood.
2. Open the tool box under the passenger-side door, and remove the cover.
3. Remove the right quarter fender and mud flap. For instructions, see **Group 88**.
4. Remove the V-clamp (**Fig. 1**, Item 5) that holds the turbo outlet pipe to the turbocharger.
5. Remove the U-clamp that holds the aftertreatment device (ATD) inlet pipe to the support bracket on the frame rail (**Fig. 1**, Item 2).
6. Remove the clamp that holds the exhaust pipe to the front of the ATD, then disconnect the exhaust pipe from the ATD.
7. Remove the bellows and exhaust pipes as a unit from under the vehicle. If the vehicle is equipped with side fairings, remove the parts from the rear of the vehicle.
8. Place the assembly on a work bench. Loosen and spread the seal clamps on the ends of the bellows. Pry the ends of the bellows off the exhaust pipes, being careful not to damage the exhaust pipe ends. If it is not possible to remove the bellows this way, proceed as follows:

**⚠ WARNING**

**Always wear a face shield and other appropriate protection when using a cutting wheel.**

**The cut edges of the bellows are extremely sharp, and can cause serious injury. Wear appropriate protective gear, including heavy gloves**




02/18/2008 f490313

A. To the Aftertreatment Device (ATD)

1. Frame-rail Support Bracket
2. U-Clamp
3. Seal Clamp
4. Bellows
5. V-Clamp
6. Bellows Support Bracket

**Fig. 1, Bellows Installation**

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## Bellows Replacement

**and a face shield, when removing the bellows from the exhaust pipes.**

9. If you cannot remove the bellows by prying, use a cutoff wheel to cut through each end of the bellows between the exhaust pipe ends. Be careful not to cut the exhaust pipes. Discard the center section of the bellows when it is cut loose.
10. Carefully remove the bellows ends and clamps from the exhaust pipes, either by prying them off, or by driving them off with a soft drift. Be careful not to damage the exhaust pipes.

IMPORTANT: Take the following measurements *before* installing the bellows.

The main section of the ATD inlet pipe is larger diameter than the turbo outlet pipe. Make sure you measure at the **end** of the pipe, where it inserts into the bellows. The two measurements should be identical. If they are not, loosen the U-clamp nuts that hold the ATD inlet pipe to the frame-rail support bracket, and move the pipe up or down as needed.

**CAUTION**

**The ends of the ATD inlet pipe and the turbo outlet pipe must be in exact vertical and horizontal alignment before installing the new bellows. If they are not aligned the bellows will be twisted, and will fail after a short time.**

11. Attach the turbo outlet pipe to the turbocharger, then to the bellows support bracket. Tighten the clamps enough to hold the pipe in place.
12. Attach the ATD inlet pipe to the ATD and the frame-rail support bracket. Tighten the clamps enough to hold the pipes in place.
13. Using a ruler or tape measure, measure the vertical distance between the end of the ATD inlet pipe and the frame rail. See **Fig. 2**. Do the same for the end of the turbo outlet pipe. The two measurements must be the same. If the measurements are different, loosen the U-clamp nuts on the frame-rail support bracket, and raise or lower the ATD inlet pipe as needed. Tighten the U-clamp nuts enough to hold the pipe in place.
14. Using a ruler (or a T-square) and a tape measure, measure the distance between each pipe end and the frame rail. See **Fig. 3**. If these two measurements are different, do one or more of the following adjustments (see **Fig. 4**):
    - Check that the U-clamp on the bellows support bracket is installed correctly, and is not crooked.
    - Rotate the turbo outlet pipe at the turbocharger.
    - Support the ATD with a suitable jack, then loosen the ATD straps and rotate the ATD.
    - Rotate the ATD inlet pipe at the Marmon flange on the ATD.
15. With the two pipe ends in horizontal and vertical alignment and the bellows not installed, measure the distance between them. See **Fig. 5**.

    The distance between the pipe ends is to be at least 14 inches (35.5 cm), but not more than 14-3/8 inches (36.5 cm).

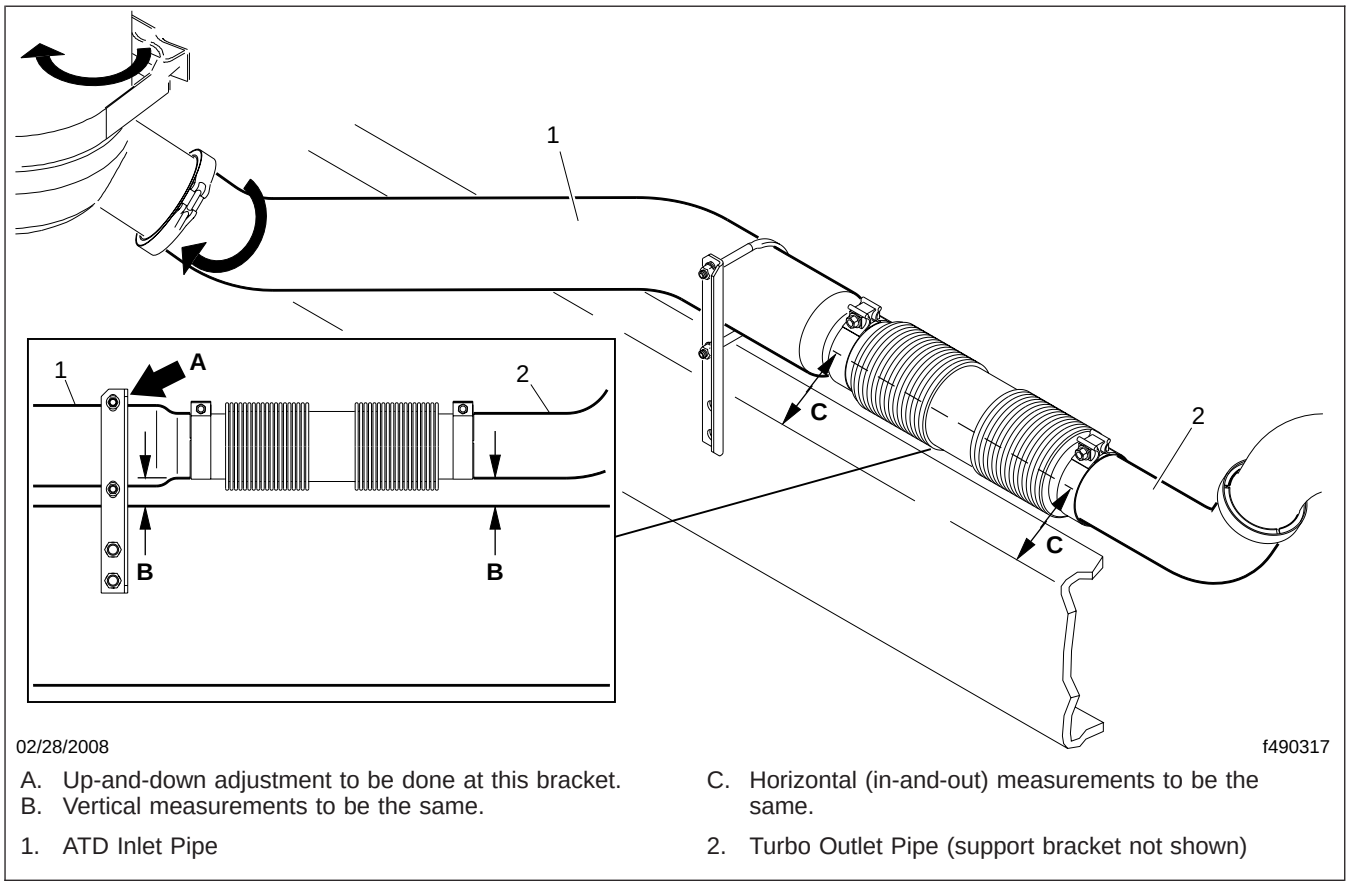
    If the distance is less than the above, remove the turbo outlet pipe and the ATD inlet pipe, and cut off an equal amount from each pipe end, as needed; otherwise, go to the next step. Make sure you remove all burrs from the cut ends of the pipes.

IMPORTANT: If they were loosened, do not tighten the ATD mounting straps until the U-clamp nuts on the frame-rail support bracket are tightened to their final torque. To do otherwise will affect the alignment of the exhaust pipes.

16. When the horizontal and vertical alignment is the same for both exhaust pipes and the distances between the pipe ends is correct, tighten the U-clamp nuts on the frame-rail support bracket that holds the ATD inlet pipe in place. See **Subject 100** for torque values.
17. Tighten the V-clamp that holds the inlet pipe to the ATD; see **Subject 100** for torque values.
18. If applicable, tighten the mounting straps on the ATD, then remove the jack.
19. Remove the turbo outlet pipe from the turbocharger.
20. Remove any dirt or soot from the outer surface of the exhaust pipe ends to ease the installation of the new bellows.

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A. Up-and-down adjustment to be done at this bracket.
B. Vertical measurements to be the same.
C. Horizontal (in-and-out) measurements to be the same.
1. ATD Inlet Pipe
2. Turbo Outlet Pipe (support bracket not shown)

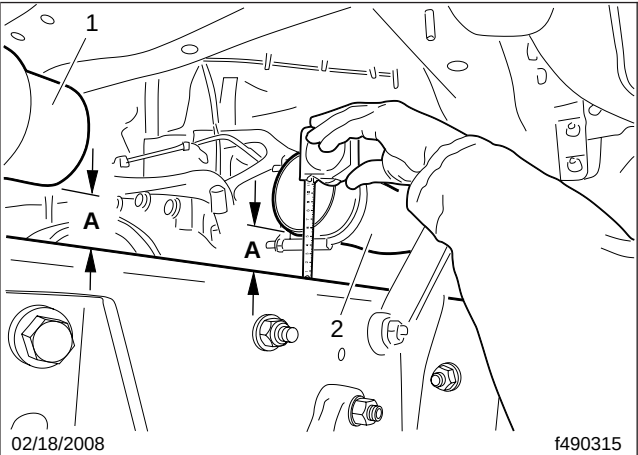
**Fig. 2, Rotation and Adjustment Areas for Exhaust Pipe alignment (vertical ATD installation shown)**

21. Install the new bellows on the ATD inlet pipe, with the clamp nuts on top and facing outboard (**Fig. 2**).
22. Insert the end of the turbo outlet pipe into the bellows, then connect the pipe to the turbocharger and to the new bellows support bracket. See **Subject 100** for torque values.
23. Tighten the bellows seal clamps; see **Subject 100** for torque values.
24. Close the hood.
25. Start the engine and check for leaks. Shut down the engine, and tighten any clamps as needed.

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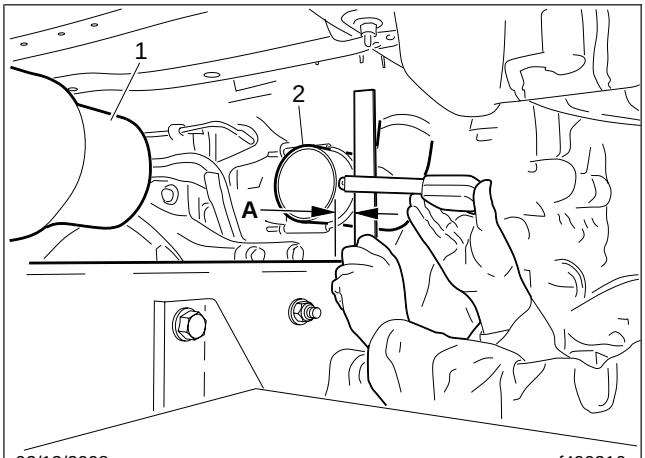
## Bellows Replacement




A. This distance must be the same at both exhaust-pipe ends.

1. ATD Inlet Pipe
2. Turbo Outlet Pipe

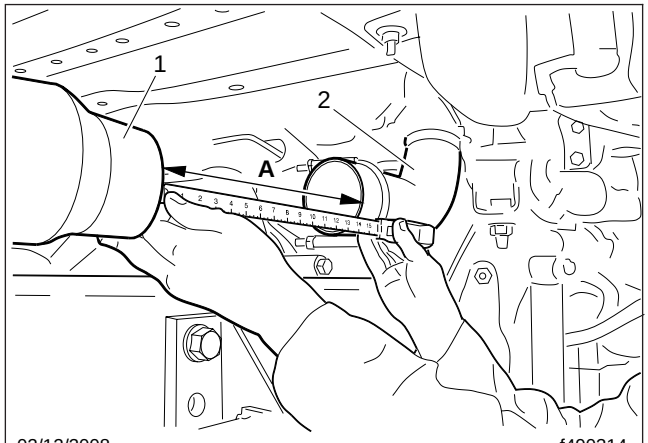
**Fig. 3, Measuring the Vertical Distance**




A. This distance must be the same at both exhaust-pipe ends.

1. ATD Inlet Pipe
2. Turbo Outlet Pipe

**Fig. 4, Measuring the Horizontal Distance**




A. This distance should be a minimum of 14 inches (35.5 cm) and a maximum of 14-3/8 inches (36.5 cm).

1. ATD Inlet Pipe
2. Turbo Outlet Pipe

**Fig. 5, Measuring the Distance Between Pipe Ends**

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# General Information

The Environmental Protection Agency (EPA) mandated that all engines built after December 31, 2009 must reduce the level of emissions exhausted by the engine to 0.2 grams per brake horsepower hour (g/bhp-hr) of nitrogen oxides (NOx).

To meet the EPA10 requirements, Daimler Trucks North America is using technology known as Selective Catalytic Reduction (SCR) in the exhaust aftertreatment system (ATS). The SCR process requires the introduction of diesel exhaust fluid (DEF) into the exhaust stream. DEF is colorless, non-toxic, and biodegradable.

IMPORTANT: The ATS is part of an integrated engine and emissions management system, controlled by the aftertreatment control module (ACM). Follow the engine manufacturer's procedures, and use the correct equipment when diagnosing or working on any part of the ATS.

The ATS is always chassis-mounted, but there are several different installation options available to fit any needed vehicle configuration. ATS exhaust piping is stainless steel. The EPA10 aftertreatment system (ATS) includes all the piping and equipment between the turbocharger outlet and the tip of the exhaust pipe. It includes an aftertreatment device (ATD), an SCR catalyst, a DEF tank, tank header unit, pump, metering unit, DEF, aftertreatment control module (ACM), coolant, and air lines that run between each component. See **Fig. 1** for system components and function. Monitoring and operation of the ATS is controlled by an electronic control module (ACM).

EPA10 engines require ultralow sulphur diesel (ULSD) fuel, for low emissions and long life of the diesel particulate filter (DPF), a honeycomb soot filter inside the ATD. Inside the ATD, the exhaust first passes through the diesel oxidation catalyst (DOC) where combustion gasses are chemically broken down to water and carbon dioxide, then through the DPF, where solid particles are trapped. The soot is reduced to ash during regeneration, and the ash is collected in the DPF until the DPF is full, at which time the DPF must be removed and cleaned. The DPF needs to be removed and cleaned of ash at specific cleaning intervals. For DPF maintenance and repair information, see the specific engine manufacturer's service literature.

If the exhaust temperature is high enough, the trapped soot is reduced to ash in a process called passive regen, which occurs as the vehicle is driven normally. Passive regen, however, cannot always keep the DPF clean, so the ATD must also periodically undergo active regen. During active regen, extra fuel is injected into the exhaust stream to superheat and reduce the soot trapped in the DPF to ash. Active regen happens only when the vehicle is moving above a certain speed, as determined by the engine manufacturer.

Both active and passive regen happen automatically, without driver input. When operating conditions do not allow for active or passive regen, the vehicle may require a driver-activated parked regen which takes 20 to 60 minutes, depending on ambient conditions.

After exhaust gases leave the ATD, a controlled quantity of diesel exhaust fluid (DEF) is injected into the exhaust stream. DEF is colorless, non-toxic, and biodegradable. In the presence of heat, DEF is converted to ammonia gas, which reacts with NOx in the SCR chamber to yield nitrogen and water vapor, which exit through the tailpipe.

EPA10 compliant DTNA vehicles are equipped with an additional tank to carry the DEF necessary for the SCR process. The DEF tank will require filling a minimum of every second diesel refuel, dependant on the DEF tank capacity. DEF consumption will vary depending on ambient conditions and vehicle application.

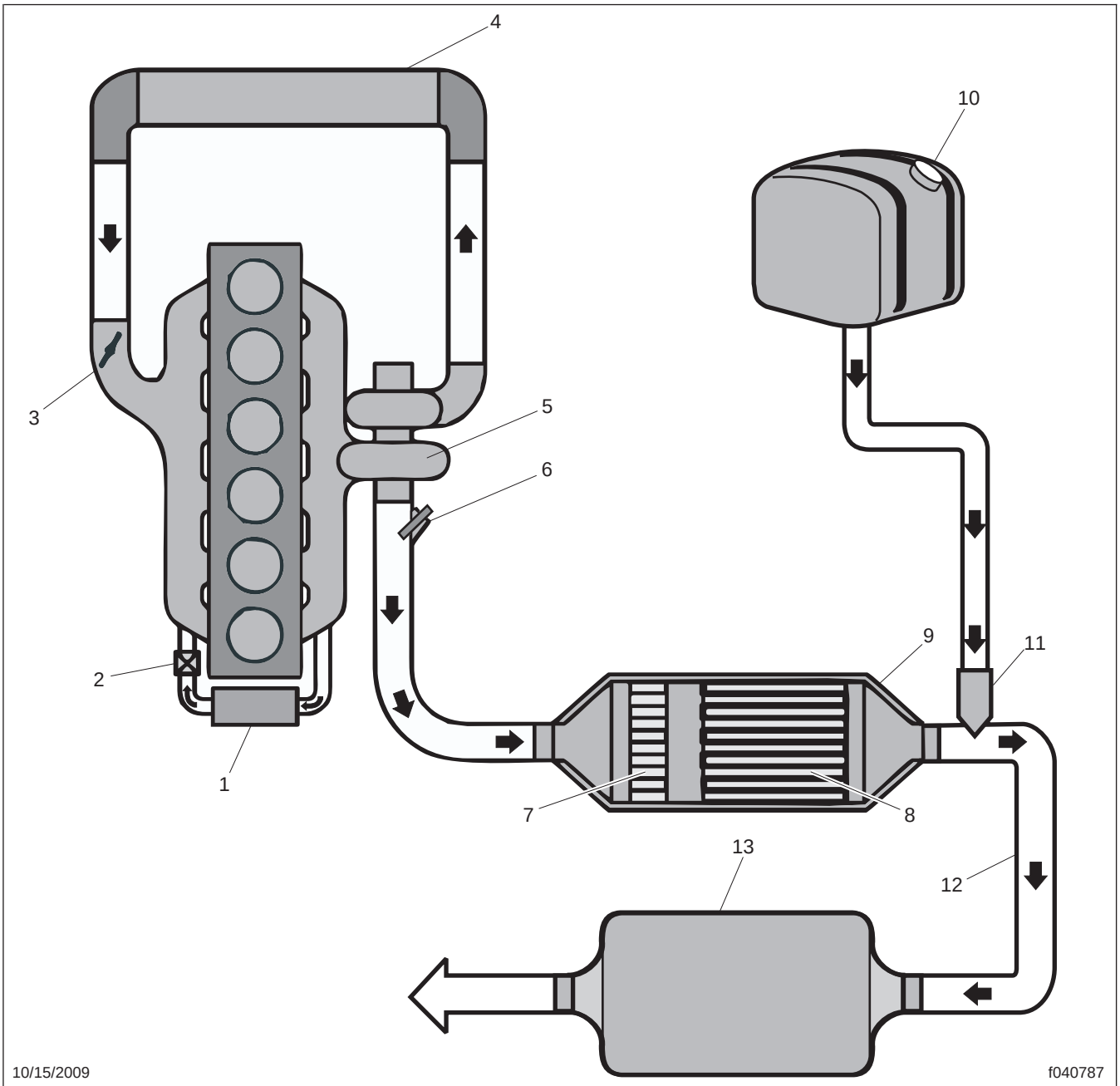
IMPORTANT: All EPA10 compliant DTNA vehicles require the use of ULSD fuel with a maximum sulfur content of 15 parts per million (PPM). In addition, DTNA vehicles require the use of CJ-4 engine oils with less than 1% ash. See the specific engine manufacturer's literature for additional information.

NOTE: Freightliner documentation deals only with removal and installation of the components of the ATS. Refer to the engine manufacturer's service literature for all testing, disassembly, cleaning, and repair of the ATS components.

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## General Information




1. Exhaust Gas Recirculation (EGR) Cooler
2. EGR Valve
3. Intake Throttle Valve
4. Charge Air Cooler (CAC)
5. Turbocharger
6. Hydrocarbon Doser
7. Diesel Oxidation Catalyst (DOC)
8. Diesel Particulate Filter (DPF)
9. Aftertreatment Device (ATD)
10. Diesel Exhaust Fluid Tank
11. DEF Injector
12. Mixing Tube
13. SCR Catalyst Chamber

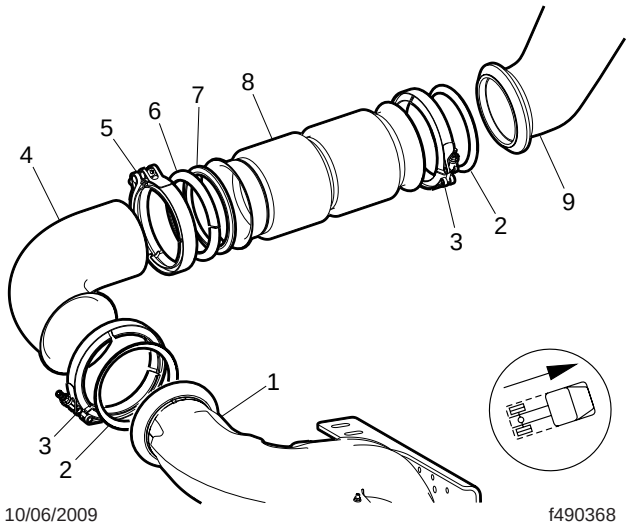
**Fig. 1, Aftertreatment System (typical)**

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## Replacement

Refer to **Fig. 1** for bellows replacement.




1. ATD
2. Spherical Clamp Gasket
3. Spherical Clamp
4. ATD Inlet Pipe
5. Slip-Joint Clamp
6. Compression Gasket
7. Conical Gasket
8. Bellows
9. Turbocharger Outlet Pipe

**Fig. 1, Exhaust Bellows Installation (typical, DD15 shown)**

NOTE: Always use new exhaust pipe clamps and gaskets when installing exhaust system components.

1. Shut down the engine and chock the tires.

**⚠ WARNING**

**Aftertreatment Device (ATD) internal temperatures can remain hot enough to cause personal injury, or ignite combustible materials, for hours after the engine is shut down.**

**To avoid potentially serious burns or material damage:**

- Let the ATD cool before handling it; be especially careful when opening it to expose the DPF.
- Wear appropriate protective gear.
- Be careful not to place the ATD where flammable gases or other combustible materials may come into contact with hot interior parts.

2. Allow the exhaust system to cool before working on it.
3. Remove the inner fender/splash shield.
4. Remove the spherical clamp at the turbocharger outlet pipe. Discard the clamp and gasket.
5. Remove the spherical clamp at the ATD inlet. Discard the clamp and gasket.
6. On DD13 engines only, remove the turbocharger-outlet-pipe support bracket clamp, if equipped. Save the clamp for reuse.
7. On DD13 engines only, remove the ATD-inlet-pipe support bracket clamp, if equipped. Save the clamp for reuse.
8. On DD13 engines only, if needed to make clearance, remove the ATD-inlet-pipe support bracket form the frame rail.
9. Remove the bellows and ATD inlet pipe as an assembly.
10. On the workbench, replace the bellows as follows.
    - 10.1 Remove the bellows-to-ATD inlet-pipe slip-joint clamp and gaskets. Discard the clamp and gaskets.
    - 10.2 Slide the new slip-joint clamp, then the two new gaskets onto the ATD inlet pipe in the order shown in **Fig. 1**.
    - 10.3 Slide the new bellows onto the ATD inlet pipe.
    - 10.4 Position the slip-joint clamp over the gaskets. Do not tighten at this time.
11. Position the bellows and ATD inlet pipe assembly on the vehicle.
12. Slide the ATD inlet pipe in or out of the bellows to align it with the ATD inlet.
13. Install the new spherical clamp and gasket at the ATD inlet. Do not tighten at this time.
14. Install the new spherical clamp and gasket at the bellows-to-turbocharger outlet-pipe connection. Do not tighten at this time.

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## Bellows Replacement

15. On DD13 engines only, install the new spherical clamp and gasket at the turbocharger-outlet-pipe to turbocharger connection. Do not tighten at this time.
16. On DD13 engines only, if removed, install the ATD-inlet-pipe support bracket on the frame rail.
17. On DD13 engines only, install the turbocharger-outlet-pipe support bracket clamp. Do not tighten at this time.
18. On DD13 engines only, install ATD-inlet-pipe support bracket clamp. Do not tighten at this time.
19. Using a straight edge, align the bellows, the ATD inlet pipe, and the turbocharger outlet pipe. Check from at least two positions about 90 degrees apart. All three components should form a straight line through the connections.
20. Tighten the spherical clamp at the turbocharger outlet pipe connection 126 to 138 lbf·in (1425 to 1560 N·cm).
21. Tighten the spherical clamp at the ATD inlet connection 126 to 138 lbf·in (1425 to 1560 N·cm).
22. On DD13 engines only, tighten the turbocharger-outlet-pipe support bracket clamp 126 to 138 lbf·in (1425 to 1560 N·cm).
23. On DD13 engines only, tighten the turbocharger-outlet-pipe support bracket clamp 24 lbf·ft (30 N·m).
24. On DD13 engines only, tighten the ATD-inlet-pipe support bracket clamp 24 lbf·ft (30 N·m).
25. Tighten the slip-joint clamp at the ATD inlet to bellows connection 13 lbf·ft (18 N·m).
26. Start the engine and check for leaks. Further tighten the clamps on any leaking connections as needed.
27. Install the inner fender/splash shield.

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# DDC Understep 1-Box ATD and SCR Catalyst Removal and Installation

## Removal

**NOTICE**

**Under normal circumstances, the two top, and the forward ATD mounting brackets, should not be removed during one-box understep ATD removal. If the brackets must be removed for any reason, mark their exact location with spray paint or with some other method before removing the brackets. Improper alignment of the ATD during installation can lead to unnecessary component failure. Warranty does not cover parts that are damaged due to improper installation.**

1. Shut down the engine, set the parking brakes, and chock the tires.

**WARNING**

**Aftertreatment Device (ATD) internal temperatures can remain hot enough to cause personal injury, or ignite combustible materials, for hours after the engine is shut down.**

**To avoid potentially serious burns or material damage:**

- Let the ATD cool before handling it; be especially careful when opening it to expose the DPF.
- Wear appropriate protective gear.
- Be careful not to place the ATD where flammable gases or other combustible materials may come into contact with hot interior parts.

2. Allow the exhaust system to completely cool before working on the aftertreatment system.
3. Remove the eight bolts that mount the steps to the mounting brackets on the ATD housing, and remove the steps.
4. Remove the inner splash shield.

NOTE: The exhaust piping from the turbocharger outlet to the ATD inlet will vary depending on vehicle configuration and engine installation.

5. Remove the clamp at the ATD inlet. See **Fig. 1** for DD13 engines, and **Fig. 2** for DD15/16 engines.
6. Remove the cover from the DEF metering unit. Disconnect the DEF supply and return lines, and the control wiring connectors, from the metering unit. See **Fig. 3**.
7. Disconnect the wiring harness from the sensor box.

NOTE: Exhaust piping downstream from the ATD will vary depending on vehicle configuration.

8. Disconnect the exhaust pipe from the SCR catalyst outlet pipe as needed.
9. Position the ATD jack, with the one-box understep attachment, under the ATD and strap the ATD to the jack. **Figure 4** shows the jack and attachment.
10. Remove the four nuts and bolts that attach the ATD to the upper mounting brackets. See **Fig. 5**.
11. On the forward ATD mounting bracket, remove the four bolts that fasten the ATD to the frame rail mounting bracket. Leave the mounting bracket attached to the frame rail. See **Fig. 6**.
12. On the rear ATD mounting bracket remove the three bolts that fasten the ATD mounting bracket to the frame rail. See **Fig. 7**.
13. Move the ATD away from the frame rail a few inches, then lower it to the floor.

## Installation

**NOTICE**

**Be careful not to bump the probe on the back side of the ATD when positioning the ATD on the frame rail. The probe could be damaged.**

1. Using the ATD jack, lift the ATD and position it on top of the upper ATD mounting brackets.
2. Install the four bolts into the forward frame rail mounting bracket and tighten the bolts 10 lbf·ft (14 N·m).
3. Install the four bolts (two on each bracket) into the upper ATD mounting brackets and tighten the bolts 10 lbf·ft (14 N·m).
4. Align the rear frame rail mounting bracket to the frame rail, install the three bolts and tighten the bolts 10 lbf·ft (14 N·m).

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## DDC Understep 1-Box ATD and SCR Catalyst Removal and Installation

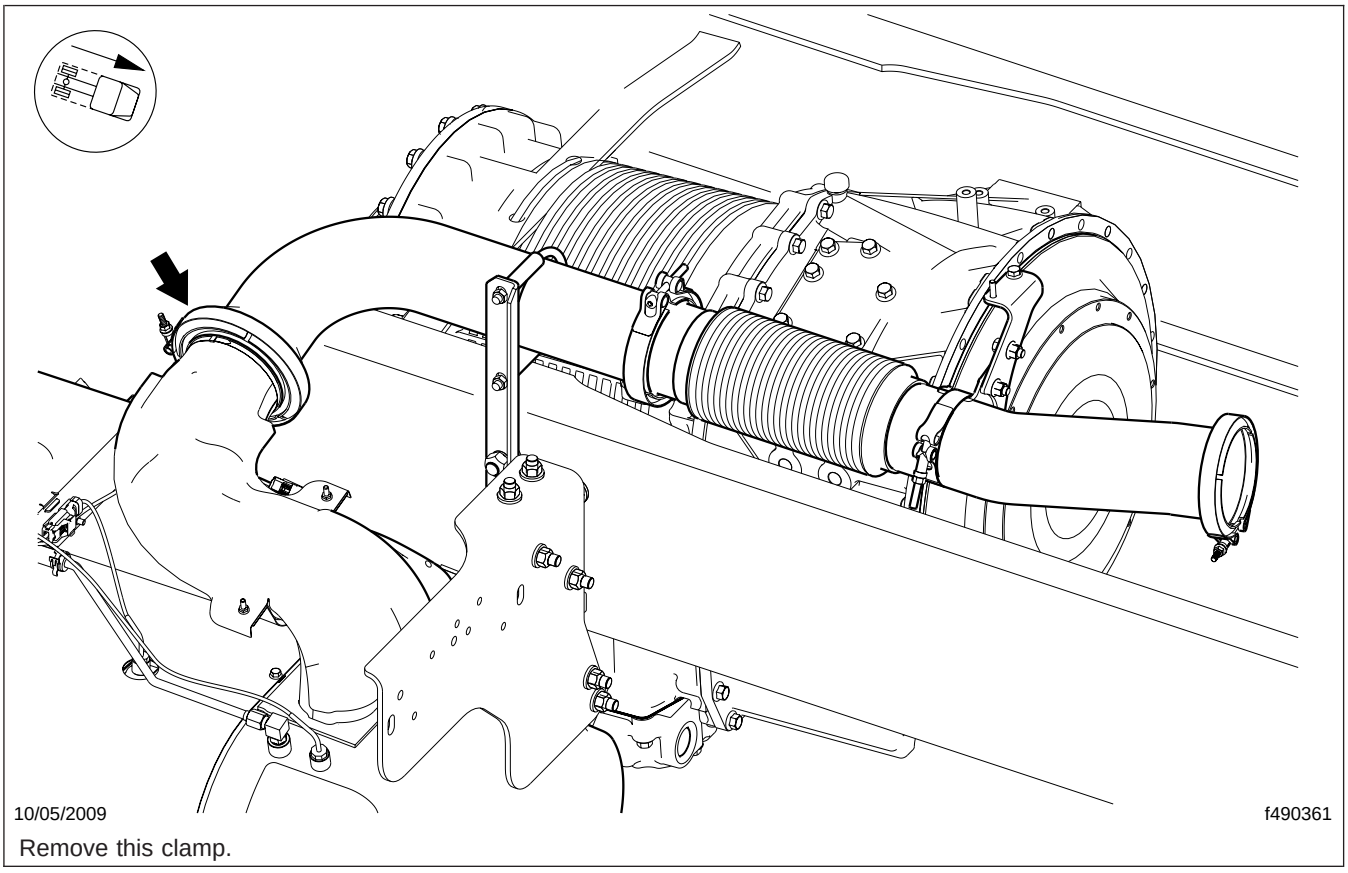



**Fig. 1, Disconnecting the ATD from the Exhaust Piping, DD13**

5. Loosen the four bolts on the rear ATD mounting bracket.

### NOTICE

**Follow the tightening sequence shown in Fig. 8 for the following steps. Improper tightening will put potentially damaging stresses on the installation.**

6. Tighten the four bolts on the forward ATD mounting bracket 50 lbf·ft (68 N·m).
7. Tighten the four bolts (two on each bracket) on the upper ATD mounting brackets 50 lbf·ft (68 N·m).
8. Tighten the four bolts on the rear ATD mounting bracket 50 lbf·ft (68 N·m).
9. Tighten the three bolts on the rear frame rail mounting bracket 50 lbf·ft (68 N·m).
10. Remove the ATD jack.
11. Connect the wiring harness to the sensor box.
12. Connect the DEF supply and return lines, and the control wiring connectors, to the metering unit. Install the cover.
13. Install the spherical clamp and gasket at the ATD inlet. See **Fig. 1** and **Fig. 2**. Tighten 126 to 138 lbf·in (1425 to 1560 N·cm).
14. If disconnected, connect the exhaust pipe to the SCR catalyst outlet pipe. Tighten 45 to 60 lbf·ft (60 to 80 N·m).
15. Start the engine and check for leaks. Further tighten the clamps on any leaking connections as needed.
16. Install the inner splash shield.
17. Install the steps.

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## DDC Understep 1-Box ATD and SCR Catalyst Removal and Installation

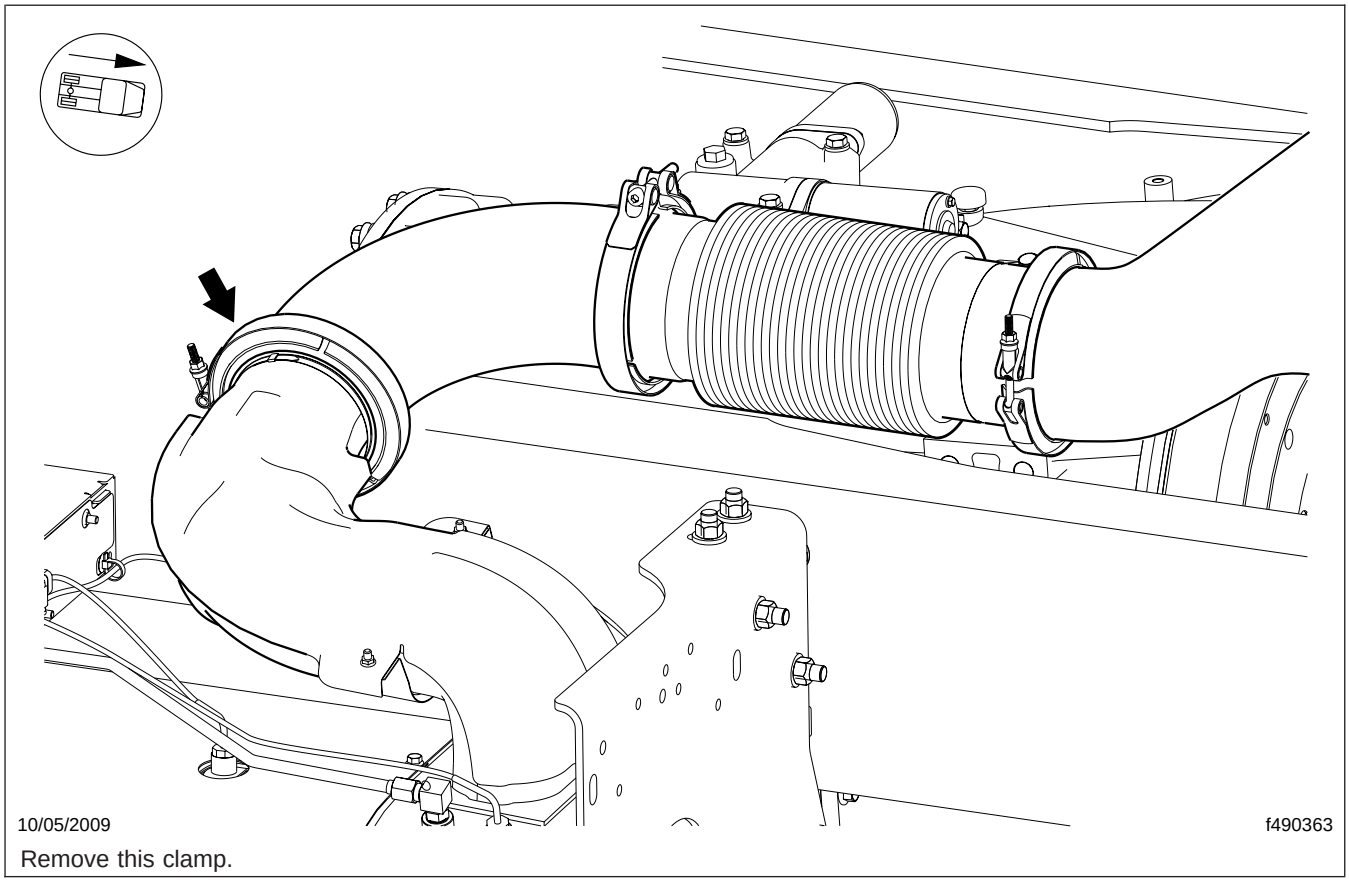
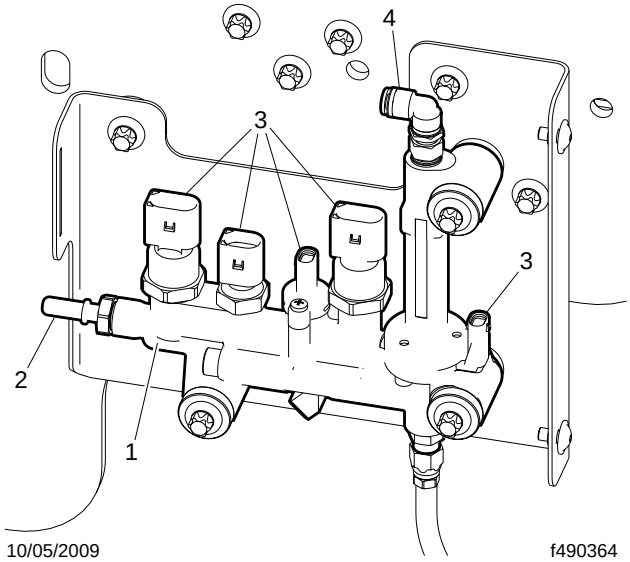



**Fig. 2, Disconnecting the ATD from the Exhaust Piping, DD15/16**

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## DDC Understep 1-Box ATD and SCR Catalyst Removal and Installation




1. Metering Unit
2. Metering Unit Air Line
3. Wiring (controls, sensors, and heaters)
4. Metering Unit DEF Supply Line

**Fig. 3, DEF Metering Unit Installation (cover removed for clarity)**

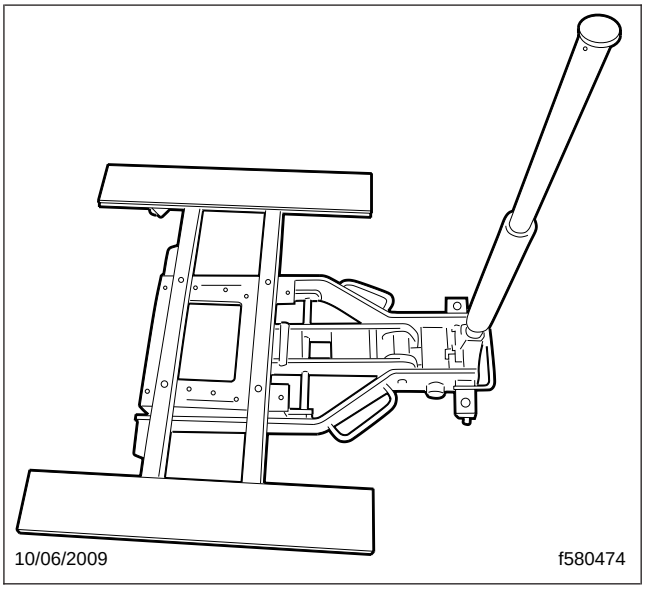



**Fig. 4, ATD Jack (with "one-box" attachment)**

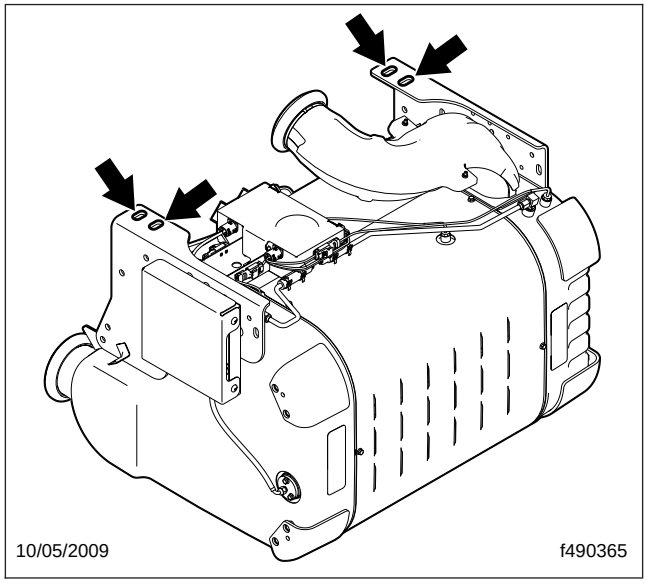



**Fig. 5, Upper ATD Mounting Brackets**

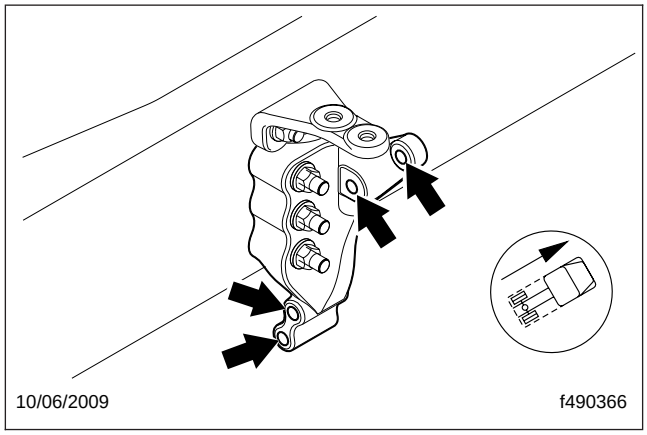



**Fig. 6, Forward ATD Mounting Bracket**

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## DDC Understep 1-Box ATD and SCR Catalyst Removal and Installation

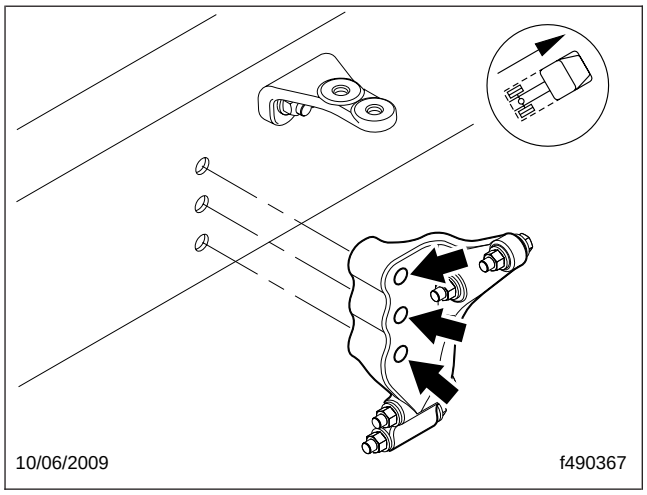



**Fig. 7, Rear ATD Mounting Bracket**

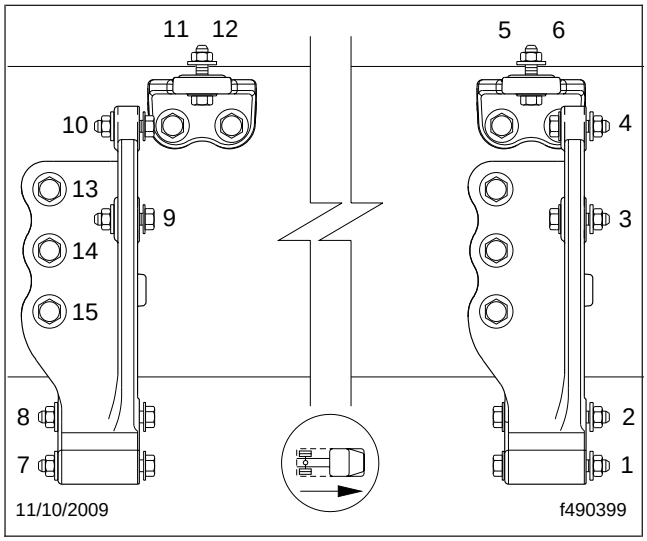



**Fig. 8, Mounting Bolt Tightening Sequence**

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# DDC 2V2 ATD and SCR Catalyst Removal and Installation

## General Information

Removing the DDC 2V2 ATD and SCR catalyst as a unit is the quickest, and easiest, way to remove it from the vehicle. The ATD or the SCR catalyst can be removed separately. When removing the components separately, mark all parts to assist in proper assembly. Daimler Trucks North America LLC does not recommend disassembling the ATD on the vehicle. Remove the component following the instructions below, and then disassemble it on a workbench following the instructions in the engine manufacturer's service literature.

**⚠ WARNING**

**Aftertreatment Device (ATD) internal temperatures can remain hot enough to cause personal injury, or ignite combustible materials, for hours after the engine is shut down.**

**To avoid potentially serious burns or material damage:**

- Let the ATD cool before handling it; be especially careful when opening it to expose the DPF.
- Wear appropriate protective gear.
- Be careful not to place the ATD where flammable gases or other combustible materials may come into contact with hot interior parts.

## ATD and SCR Catalyst Removal and Installation

### Removal

Refer to **Fig. 1** for the following procedure.

1. Shut down the engine and chock the tries.
2. Allow the ATS time to cool.
3. Remove the heat shield.
4. Remove the exhaust stack from the SCR catalyst.
5. Disconnect the two 14-pin connectors at the sensor box.
6. Disconnect the wiring connectors from the metering unit.
7. Disconnect the air lines from the metering unit.
8. Disconnect and cap/plug the DEF lines from the metering unit.
9. Remove the metering unit mounting plate with the metering unit attached.
10. Loosen the lower fasteners on the diagonal support brace. Disconnect the diagonal support brace from the lifting bracket that attaches to the vertical stanchion and swing it out of the way. Secure it as needed.
11. Disconnect the exhaust pipe at the intake to the ATD. Support it as needed so there is no stress on the bellows.
12. Position the overhead lifting device over the vertical stanchion and connect the hooks at the lifting points. Apply enough pressure to the lift points to prevent the unit from dropping when loosened.
13. Remove the four mounting fasteners that attach the vertical stanchion to the frame rail.
14. Lower the unit away from the vehicle.

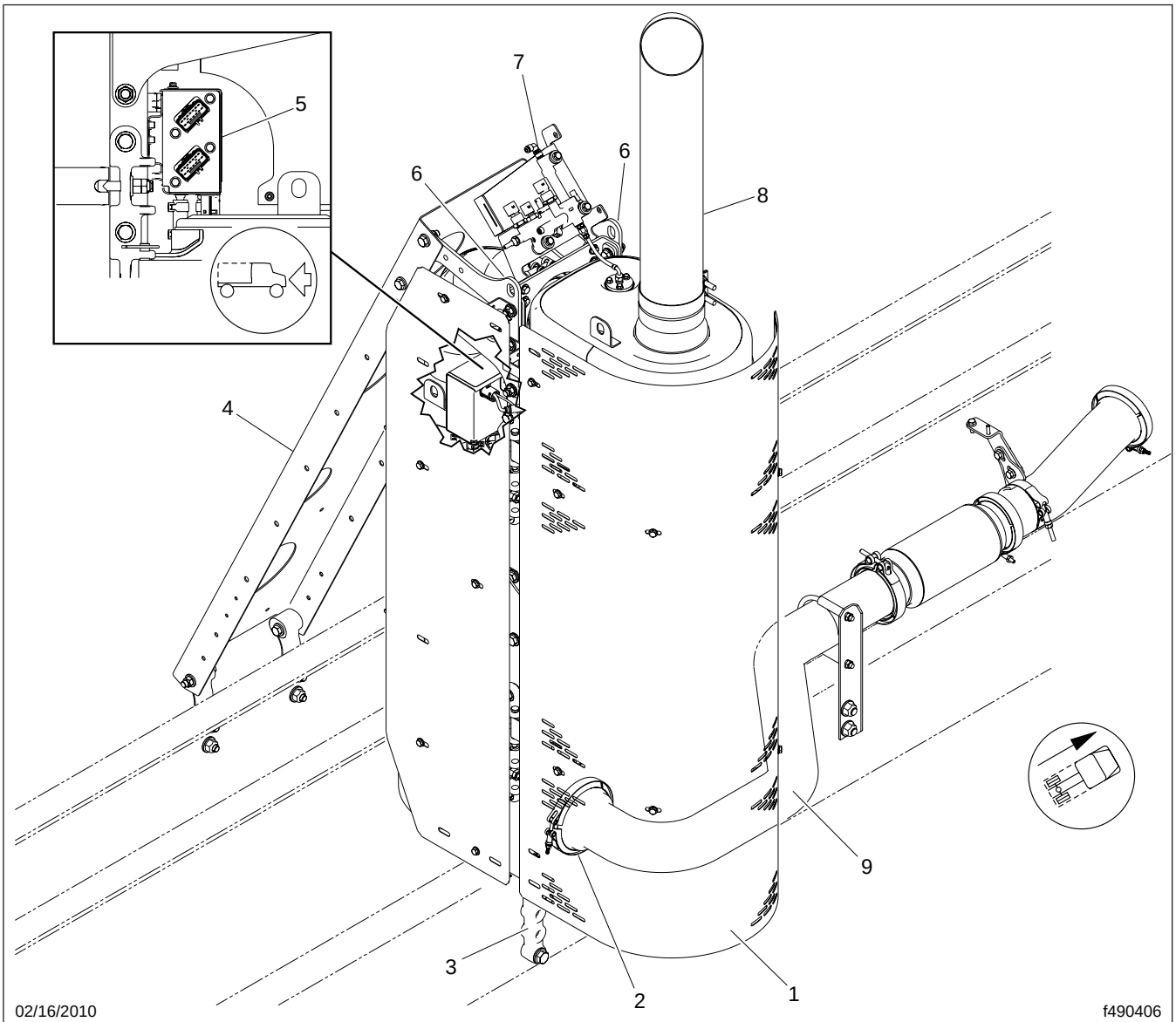
### Installation

1. Using the overhead lifting device, position the unit at the frame rail, and install the mounting fasteners. Tighten 159 to 201 lbf·ft (212 to 268 N·m).
2. Position the diagonal support brace and install the mounting fasteners. Tighten the upper and lower fasteners 49 to 63 lbf·ft (66 to 86 N·m).
3. Connect the two 14-pin connectors at the sensor box.
4. Install the metering unit and mounting plate.
5. Connect the wiring connectors to the metering unit.
6. Connect the air lines to the metering unit.
7. Connect the DEF lines to the metering unit.
8. Using a new seal, connect the exhaust pipe to the ATD. See **Fig. 2** for proper installation. Tighten the clamp 114 to 126 lbf·in (1290 to 1425 N·cm).
9. Install the exhaust stack. Tighten the clamp 27 to 37 lbf·ft (37 to 50 N·m).
10. Install the heat shield. Tighten 13 to 17 lbf·ft (18 to 22 N·m).

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## DDC 2V2 ATD and SCR Catalyst Removal and Installation




1. Heat Shield
2. Inlet Clamp
3. Vertical Stanchion
4. Diagonal Support Brace
5. Sensor Box
6. Lifting Points
7. Metering Unit and Mounting Plate
8. Exhaust Stack
9. Exhaust Pipe

**Fig. 1, 2V2 ATD and SCR Catalyst Installation**

11. Start the engine and check for leaks. Tighten any connections as needed.

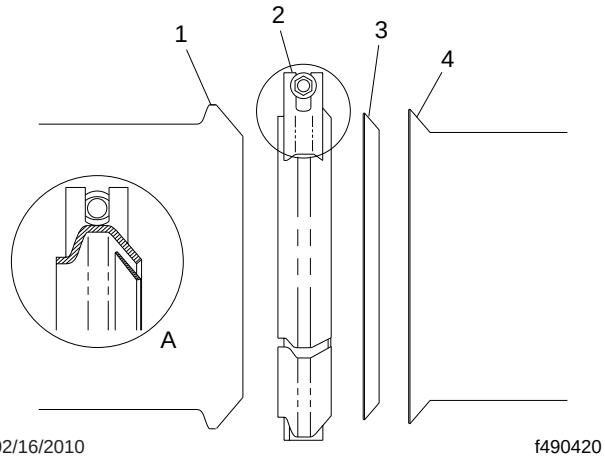
## ATD Removal and Installation

Refer to **Fig. 3** for the following procedure.

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# DDC 2V2 ATD and SCR Catalyst Removal and Installation




NOTE: Clamp and seal are directional.

A. Correct Clamp and Seal Installation

1. ATD
2. Clamp
3. Gasket
4. Exhaust Pipe

**Fig. 2, Spherical Clamp Installation**

## NOTICE

**Alignment is essential. Mark every component's position prior to disassembling it on the truck. Improper assembly may result in leaks or damage to the ATS.**

## Removal

1. Shut down the engine and chock the tries.
2. Allow the ATS time to cool.
3. Remove the heat shield.
4. Disconnect the two pressure tubes at the connection to the ATD.
5. Disconnect the three temperature sensors on the ATD.
6. Disconnect the two 14-pin connectors at the sensor box.
7. Disconnect the wiring connectors from the metering unit.
8. Disconnect the air lines from the metering unit.
9. Disconnect and cap/plug the DEF lines from the metering unit.
10. Remove the metering unit mounting plate with the metering unit attached.
11. Loosen the lower fasteners on the diagonal support brace. Disconnect the diagonal support brace from the vertical stanchion, and swing it out of the way. Secure it as needed.
12. Remove the intake and outlet clamps from the ATD. Support the turbo outlet pipe as needed so there is no stress on the bellows.
13. Position the overhead lifting device over the ATD and connect the hooks at the lifting points. Apply enough pressure to the lift points to prevent the unit from dropping when loosened.
14. Remove the mounting clamps.
15. Lift the ATD away from the vehicle.

## Installation

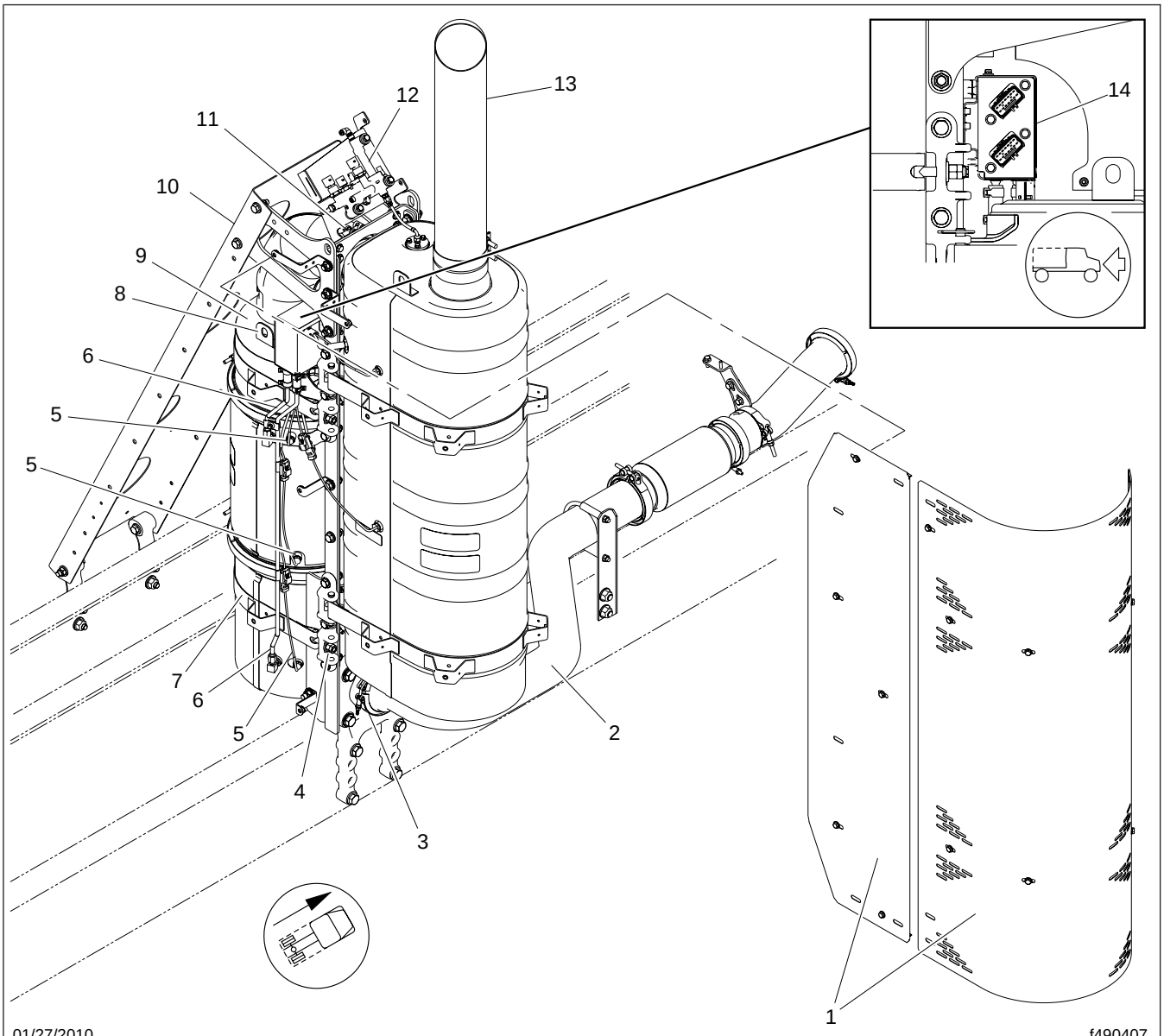
1. Using the overhead lifting device, position the ATD on the vertical stanchion, and secure it in position with the mounting clamps. Do not tighten the straps at this time.
2. Align the connection with the SCR catalyst, and using a new seal, install the clamp. See **Fig. 2** for proper installation. Tighten the clamp 114 to 126 lbf·in (1290 to 1425 N·cm).
3. Align the connection with the exhaust pipe from the turbocharger, and, using a new seal, install the clamp. See **Fig. 2** for proper installation. Tighten the clamp 114 to 126 lbf·in (1290 to 1425 N·cm).
4. Check all alignment marks, and tighten the clamping strap nuts incrementally, first 15 lbf·ft (20 N·m), then 30 lbf·ft (40 N·m).

   Install the jam nuts. Using a back-up wrench, tighten 30 lbf·ft (40 N·m).
5. Connect the two pressure tubes.
6. Connect the three temperature sensors.
7. Position the diagonal support brace and install the mounting fasteners. Tighten the upper and lower fasteners 49 to 63 lbf·ft (66 to 86 N·m).
8. Connect the two 14-pin connectors at the sensor box.
9. Install the metering unit and mounting plate.
10. Connect the wiring connectors to the metering unit.

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## DDC 2V2 ATD and SCR Catalyst Removal and Installation




1. Heat Shield
2. Exhaust Pipe
3. Intake Clamp
4. Clamping Strap Nuts
5. Temperature Sensor
6. Pressure Tube
7. Clamping Strap
8. Lifting Points
9. ATD
10. Diagonal Support Brace
11. Outlet Clamp
12. Metering Unit and Mounting Plate
13. Exhaust Stack
14. Sensor Box

**Fig. 3, 2V2 ATD Installation**

11. Connect the air lines to the metering unit.
12. Connect the DEF lines to the metering unit.
13. Install the heat shield.
14. Start the engine and check for leaks. Tighten any connections as needed.

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# DDC 2V2 ATD and SCR Catalyst Removal and Installation

## SCR Catalyst Removal and Installation

Refer to **Fig. 4** for the following procedure.

### Removal

1. Shut down the engine and chock the tries.
2. Allow the ATS time to cool.
3. Remove the heat shield.
4. Remove the exhaust stack from the SCR catalyst.
5. Remove the SCR catalyst inlet clamp.
6. Disconnect the two temperature sensors and the NOx sensor.
7. Disconnect the DEF nozzle.
8. Position the overhead lifting device over the SCR catalyst and connect the hooks at the lifting points. Apply enough pressure to the lift points to prevent the unit from dropping when loosened.
9. Remove the clamping strap nuts.
10. Lift the SCR catalyst away from the vehicle.

### Installation

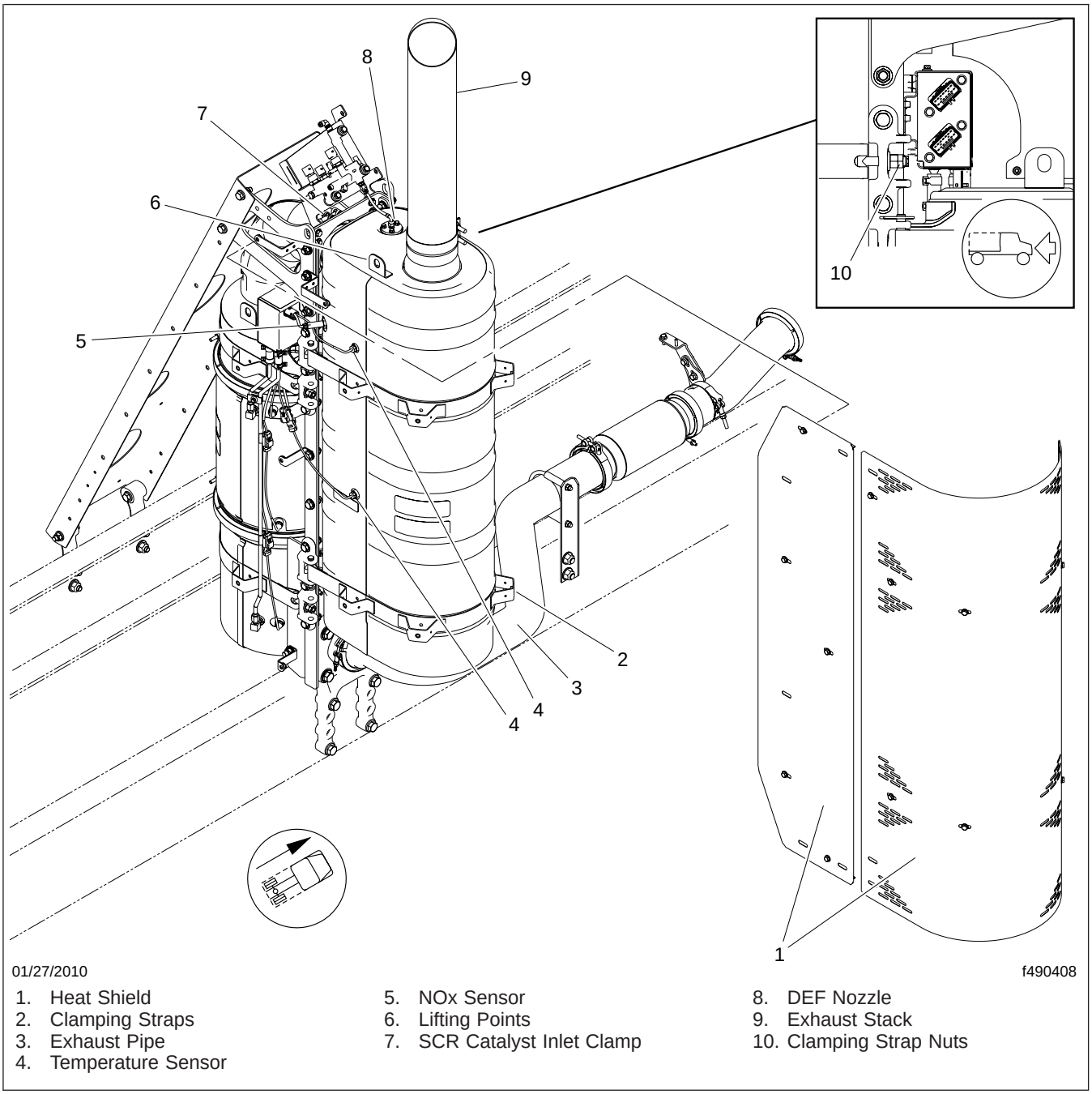
1. Using the overhead lifting device, position the SCR catalyst on the vertical stanchion, and secure it in position with the mounting clamps. Do not tighten the straps at this time.
2. Align the connection with the ATD, and using a new seal, install the clamp. See **Fig. 2** for proper installation. Tighten the clamp 114 to 126 lbf·in (1290 to 1425 N·cm).
3. Check all alignment marks, and tighten the clamping strap nuts incrementally, first 15 lbf·ft (20 N·m), then 30 lbf·ft (40 N·m).

   Install the jam nuts. Using a back-up wrench, tighten 30 lbf·ft (40 N·m).
4. Connect the two temperature sensors and the NOx sensor.
5. Connect the DEF nozzle.
6. Install the exhaust stack. Tighten the clamp 27 to 37 lbf·ft (37 to 50 N·m).
7. Install the heat shield. Tighten 13 to 17 lbf·ft (18 to 22 N·m).
8. Start the engine and check for leaks. Tighten any connections as needed.

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## DDC 2V2 ATD and SCR Catalyst Removal and Installation




1. Heat Shield
2. Clamping Straps
3. Exhaust Pipe
4. Temperature Sensor
5. NOx Sensor
6. Lifting Points
7. SCR Catalyst Inlet Clamp
8. DEF Nozzle
9. Exhaust Stack
10. Clamping Strap Nuts

**Fig. 4, 2V2 SCR Catalyst Installation**

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# Cummins Understep Switchback ATD and SCR Catalyst Removal and Installation

**⚠ WARNING**

**Aftertreatment Device (ATD) internal temperatures can remain hot enough to cause personal injury, or ignite combustible materials, for hours after the engine is shut down.**

**To avoid potentially serious burns or material damage:**

- Let the ATD cool before handling it; be especially careful when opening it to expose the DPF.
- Wear appropriate protective gear.
- Be careful not to place the ATD where flammable gases or other combustible materials may come into contact with hot interior parts.

**NOTICE**

**Alignment is essential. Using a paint pen, mark every component's position prior to disassembling it on the truck. Improper assembly may result in leaks or damage to the ATS.**

## ATD and SCR Catalyst Assembly Removal and Installation

Daimler Trucks North America LLC does not recommend disassembling the ATD on the vehicle. Remove the component following the instructions below, and then disassemble it on a workbench following the instructions in the engine manufacturer's service literature.

### Removal

Refer to **Fig. 1** for this procedure.

1. Shut down the engine, set the parking brakes, and chock the tires.
2. Allow the ATS time to cool.
3. Raise the hood.
4. Remove the right side steps and fairing.
5. Remove the step mounting bracket, brace, and step rails. See **Fig. 2**.
6. Remove the spherical clamp connecting the ATD inlet pipe to the ATD.
7. Disconnect the SCR catalyst outlet pipe from the SCR catalyst.
8. Disconnect the wiring harnesses from the ATD sensor box.
9. Mark the clocking of the mixer tube to both elbows in several places. Disconnect the mixer tube from the elbows at both ends of the mixer tube, and secure the mixer tube on top of the frame rail.
10. Disconnect the wiring harness from the NOx sensor module.
11. Disconnect the wiring harness from the temperature sensor module.
12. Cut any zip ties as necessary, and free the harness from the ATS.
13. Remove the NOx sensor module from the mounting bracket on the frame rail, and secure it to the ATS.
14. Position an ATD jack, with a "one box" attachment, under the ATS and secure it to the jack with a strap. See **Fig. 3**.
15. Remove the eight bolts and nuts that attach the ATS mounting frame to the mounting brackets on the frame rail.
16. Lower the ATS from the vehicle.

### Installation

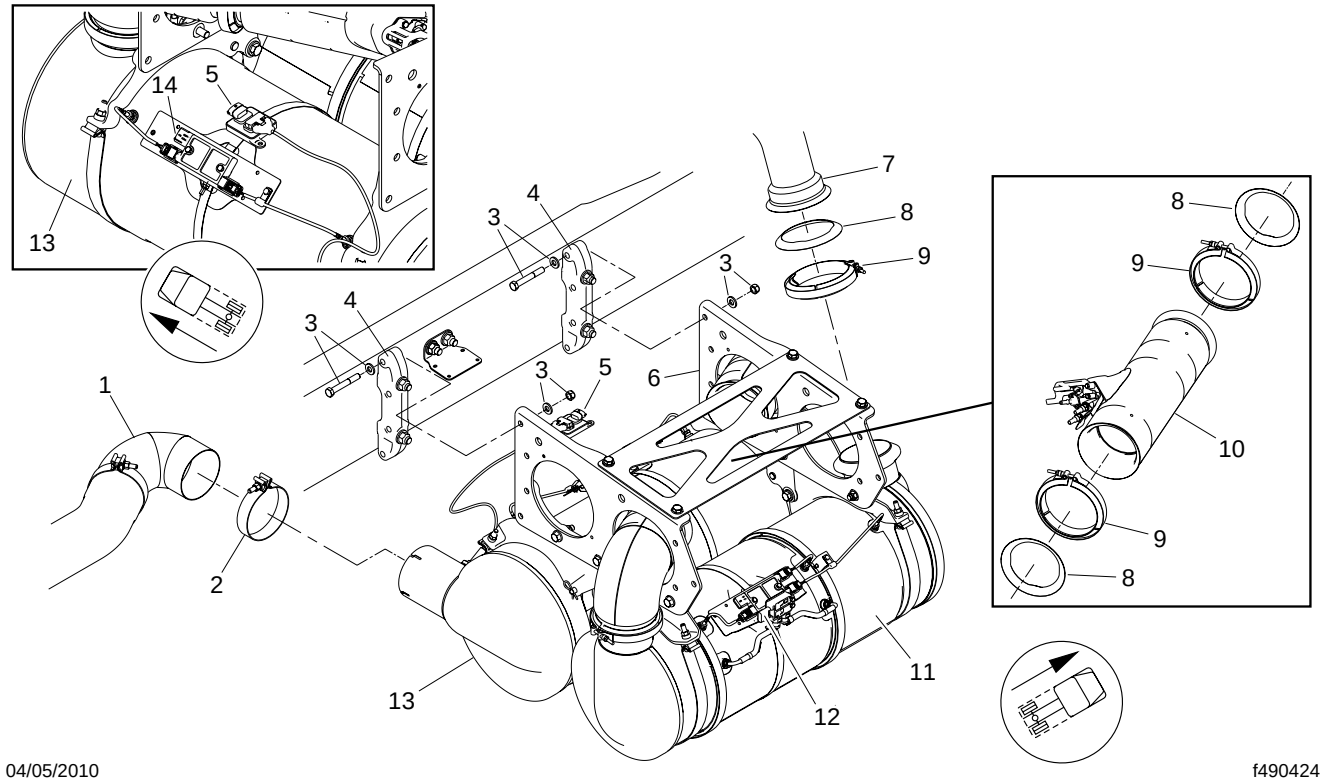
NOTE: The ATD mounting frame attaches to the forward face of the mounting brackets.

1. Using the jack, raise the ATS into position.
2. Install the eight bolts and nuts that attach the ATS mounting frame to the mounting brackets on the frame rail. Tighten the nuts 50 lbf·ft (68 N·m).
3. Position the wiring harness on the ATS. Install new zip ties as needed.
4. Install the NOx sensor module on the mounting bracket on the frame rail. Connect the wiring harness.
5. Connect the wiring harnesses to the ATD sensor box.
6. Connect the wiring harness to the temperature sensor module.

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## Cummins Understep Switchback ATD and SCR Catalyst Removal and Installation




1. SCR Catalyst Outlet Pipe
2. Narrow Band Clamp
3. ATS Frame Fasteners (8)
4. ATS Mounting Brackets
5. NOx Sensor Module
6. ATS Mounting Frame
7. ATD Inlet Pipe
8. Gasket
9. Spherical Clamp
10. Mixer Tube
11. ATD
12. ATD Sensor Box
13. SCR Catalyst
14. Temperature Sensor Module

**Fig. 1, ATS Installation**

7. Connect the SCR catalyst outlet pipe to the SCR catalyst. Tighten the clamp 37 to 45 lbf·ft (50 to 60 N·m).
8. Using a new gasket, install the spherical clamp connecting the ATD inlet pipe to the ATD. Tighten the clamp 114 to 126 lbf·in (1290 to 1425 N·cm).
9. Position the mixer tube, and using a new gaskets install the spherical clamps that connect the mixer tube to the ATD outlet elbow and the SCR inlet elbow. Align the mixing tube using the paint pen marks applied during disassembly, then tighten the clamps 114 to 126 lbf·in (1290 to 1425 N·cm).
10. Start the engine and check for leaks. Tighten any connections as needed.
11. Install the step mounting bracket, brace, and step rails.
12. Install the steps and fairing.

## ATD Removal and Installation

Daimler Trucks North America LLC does not recommend disassembling the ATD on the vehicle. Remove the component following the instructions below, and then disassemble it on a workbench following the instructions in the engine manufacturer's service literature.

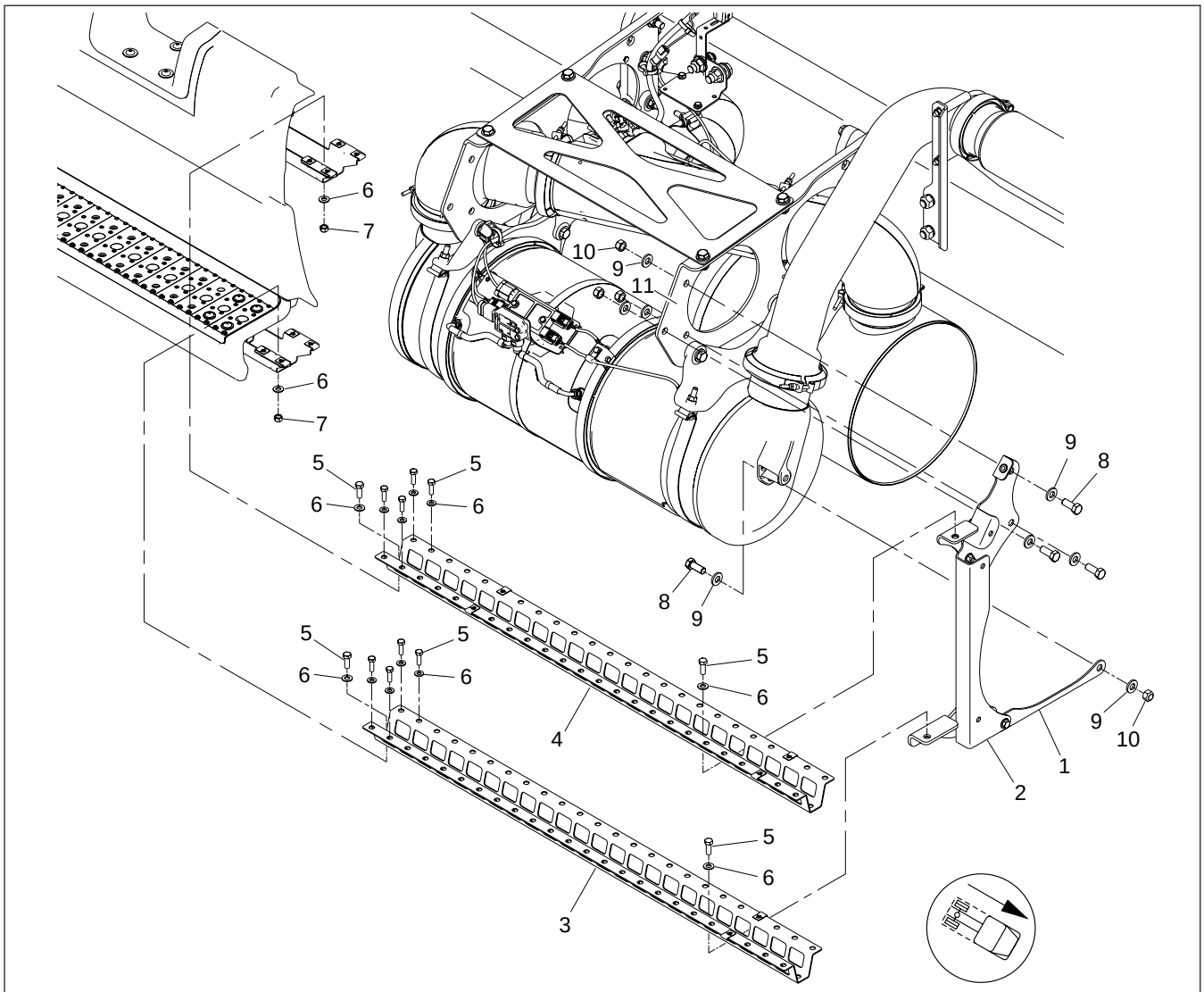
### Removal

Refer to **Fig. 4** for this procedure.

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## Cummins Understep Switchback ATD and SCR Catalyst Removal and Installation




04/05/2010 f490427

1. Step Mounting Bracket
2. Step Mounting Bracket Brace
3. Lower Step Rail
4. Upper Step Rail
5. Bolt
6. Washer
7. Nut
8. Bolt
9. Washer
10. Nut
11. ATS Mounting Frame

**Fig. 2, Step Mounting Bracket and Step Rail Installation**

1. Shut down the engine, set the parking brakes, and chock the tires.
2. Allow the ATS time to cool.
3. Raise the hood.
4. Remove the right side steps and fairing.
5. Remove the step mounting bracket, brace, and step rails. See **Fig. 2**.
6. Remove the spherical clamp connecting the ATD inlet pipe to the ATD.
7. Remove the spherical clamp connecting the ATD inlet pipe to the mixer tube elbow.

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## Cummins Understep Switchback ATD and SCR Catalyst Removal and Installation

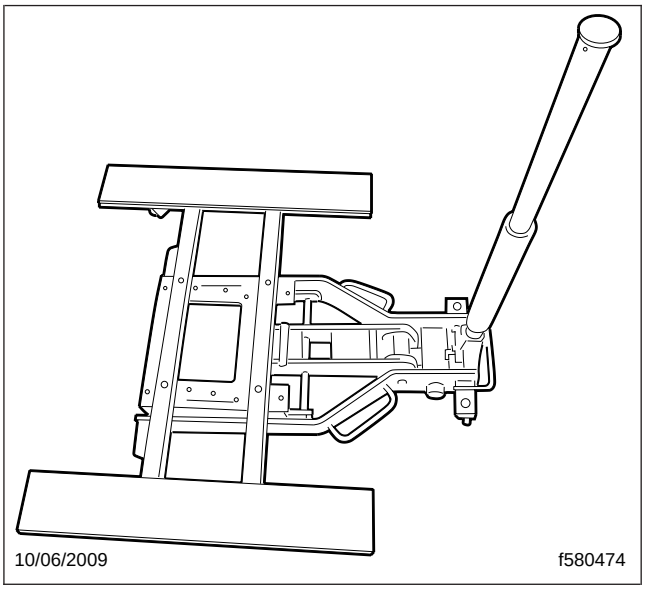



**Fig. 3, ATD Jack (with "one-box" attachment)**

8. Disconnect the wiring harnesses from the ATD sensor box.
9. Cut any zip ties as necessary to free the harness from the ATD.
10. Mark the clocking of the ATD on both mounting frames in several places for later installation.
11. Position an ATD jack, with single unit cradles, under the ATD and secure it to the jack with a strap.
12. Remove the nuts from the ATD clamping straps. Remove the straps, and discard the straps and hardware.
13. Lower the ATD from the truck.

### Installation

IMPORTANT: Always use new gaskets when installing exhaust system components.

1. Using the ATD jack, raise the ATS into position.

**NOTICE**

**The ATD may rotate while tightening the clamps. It is important that this is prevented. Check the alignment during and after the clamping procedure and make adjustments as needed. Improper installation may lead to component failure.**

2. Install new clamping straps. Do not tighten at this time. Allow room to align the ATD in the mounting frame and with the inlet and mixer tubes.
3. Align the ATD in the mounting frame using the paint pen marks applied during disassembly.
4. Align the mixer tube elbow with the ATD outlet, then using a new gasket install the spherical clamp. Do not tighten at this time.
5. Align the ATD inlet pipe to the ATD, then using a new gasket, install the spherical clamp. Do not tighten at this time.
6. Check all alignment marks on the ATD, then tighten the clamping strap nuts incrementally, first 15 lbf·ft (20 N·m), then 30 lbf·ft (40 N·m).
7. Tighten the spherical clamps at the ATD inlet and the mixer tube elbow 114 to 126 lbf·in (1290 to 1425 N·cm).
8. Connect the wiring harnesses to the ATD sensor box.
9. Start the engine and check for leaks. Tighten any connections as needed.
10. Install the step mounting bracket, brace, and step rails.
11. Install the steps and fairing.

## SCR Catalyst Removal and Installation

### Removal

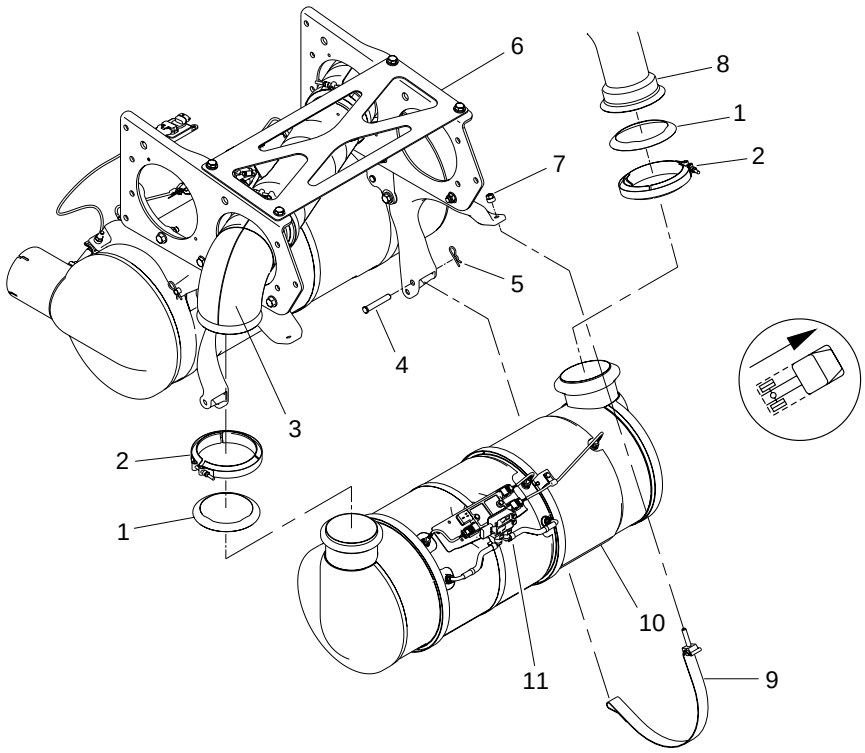
Refer to **Fig. 5** for this procedure.

1. Shut down the engine, set the parking brakes, and chock the tires.
2. Allow the ATS time to cool.
3. Raise the hood.
4. Remove the right side splash shield.
5. Remove the right side steps and fairing.
6. Remove the step mounting bracket, brace, and step rails. **Fig. 2**.
7. Mark the clocking of the SCR catalyst on both mounting frames in several places for later installation.
8. Remove the marmon clamp connecting the SCR catalyst inlet to the mixer tube elbow.

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## Cummins Understep Switchback ATD and SCR Catalyst Removal and Installation




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1. Gasket
2. Spherical Clamp
3. ATD to Mixer Tube Elbow
4. Clamping Strap Pin
5. Retaining Pin
6. ATS Mounting Frame
7. Clamping Strap Nut
8. ATD Inlet Pipe
9. Clamping Strap
10. ATD
11. Sensor Box

**Fig. 4, ATD Installation**

9. Remove the narrow band clamp connecting the SCR catalyst outlet pipe to the SCR catalyst.
10. Disconnect the wiring harness from the NOx sensor module.
11. Disconnect the wiring harness from the temperature sensor module.
12. Cut any zip ties as necessary, and free the harness from the SCR catalyst.
13. Remove the NOx sensor module from the mounting bracket on the frame rail, and secure it to the SCR catalyst.
14. Position an ATD jack, with single unit cradles, under the SCR catalyst and secure it to the jack with a strap.
15. Remove the nuts from the SCR catalyst clamping straps. Remove the straps, and discard the straps and hardware.
16. Lower the SCR catalyst from the truck.

# Installation

IMPORTANT: Always use new gaskets when installing exhaust system components.

1. Using the jack, raise the SCR catalyst into position.

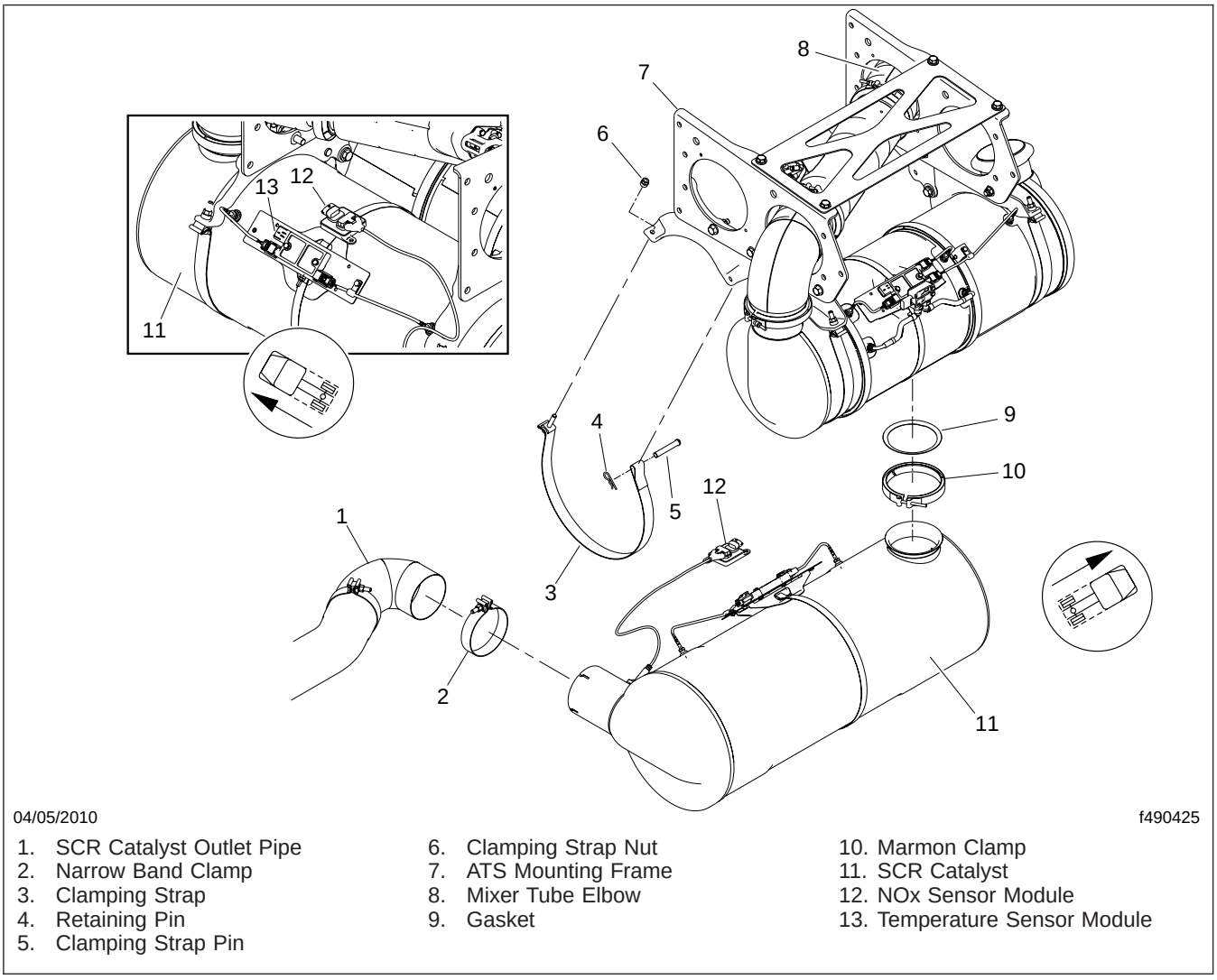
**NOTICE**

**The SCR catalyst may rotate while tightening the clamps. It is important that this is prevented. Check the alignment during and after the clamp-**

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## Cummins Understep Switchback ATD and SCR Catalyst Removal and Installation




1. SCR Catalyst Outlet Pipe
2. Narrow Band Clamp
3. Clamping Strap
4. Retaining Pin
5. Clamping Strap Pin
6. Clamping Strap Nut
7. ATS Mounting Frame
8. Mixer Tube Elbow
9. Gasket
10. Marmon Clamp
11. SCR Catalyst
12. NOx Sensor Module
13. Temperature Sensor Module

**Fig. 5, SCR Catalyst Installation (typical)**

**ing procedure and make adjustments as needed. Improper installation may lead to component failure.**

2. Install new clamping straps. Do not tighten at this time. Allow room to align the SCR catalyst in the mounting frame and mixer tube and outlet pipe.
3. Align the SCR catalyst in the mounting frame using the paint pen marks applied during disassembly.
4. Align the mixer tube elbow to the SCR catalyst inlet, then using a new gaskets, install the marmon clamp. Do not tighten at this time.
5. Align the SCR catalyst outlet pipe to the SCR catalyst, then install the clamp. Do not tighten at this time.
6. Check all alignment marks on the SCR catalyst, and tighten the clamping strap nuts incrementally, first 15 lbf·ft (20 N·m), then 30 lbf·ft (40 N·m).
7. Check the alignment on the mixer tube, then tighten the clamp 12 to 13 lbf·ft (16 to 17 N·m).
8. Tighten the SCR catalyst outlet pipe clamp 37 to 45 lbf·ft (50 to 60 N·m).

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## Cummins Understep Switchback ATD and SCR Catalyst Removal and Installation

9. Position the wiring harness on the ATS. Install new zip ties as needed.
10. Install the NOx sensor module on the mounting bracket on the frame rail. Connect the wiring harness.
11. Connect the wiring harness to the temperature sensor module.
12. Start the engine and check for leaks. Tighten any connections as needed.
13. Install the step mounting bracket, brace, and step rails.
14. Install the steps and fairing.
15. Install the splash shield.

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# Cummins 2HH ATD and SCR Catalyst Removal and Installation

**⚠ WARNING**

**Aftertreatment Device (ATD) internal temperatures can remain hot enough to cause personal injury, or ignite combustible materials, for hours after the engine is shut down.**

**To avoid potentially serious burns or material damage:**

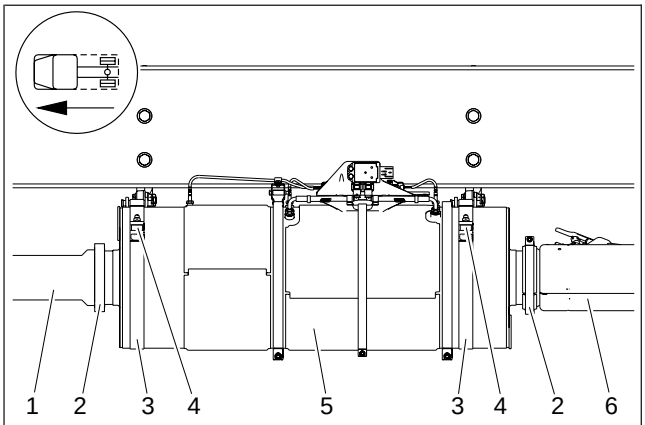
- Let the ATD cool before handling it; be especially careful when opening it to expose the DPF.
- Wear appropriate protective gear.
- Be careful not to place the ATD where flammable gases or other combustible materials may come into contact with hot interior parts.

**NOTICE**

**Alignment is essential. Using a paint pen, mark every component's position prior to disassembling it on the truck. Improper assembly may result in leaks or damage to the ATS.**

## ATD Removal and Installation

Refer to **Fig. 1** for removal and installation of the ATS components.




1. ATD Inlet Pipe
2. Spherical Clamp
3. Clamping Strap
4. Clamping-Strap Bolt and Nut
5. Aftertreatmment Device (ATD)
6. Mixer Tube

**Fig. 1, ATD Installation**

### Removal

1. Shut down the engine and chock the tires.
2. Allow the ATS to cool before working on it.

**NOTICE**

**Component alignment is critical to proper installation of ATS components. Before removing any components, put alignment marks (use both clocking and longitudinal marks where applicable) on all ATS components. This will aid in faster and more accurate alignment during assembly. Failure to accurately align all of the components of the ATS may result in component damage.**

3. Make alignment marks on all of the components to be removed.
4. Disconnect the wire harness to the control module on the ATD.
5. Remove the spherical clamp and gasket that connects the ATD inlet pipe to the ATD. Discard the clamp and gasket.
6. Remove the spherical clamp and gasket that connects the ATD to the mix-tube. Discard the clamp and gasket.
7. Position the jack and cradle under the assembly and secure it with straps.
8. Remove the clamping bolts and nuts from the clamping straps.
9. Lower the unit.
10. Remove and discard the clamping straps and hardware.

### Installation

1. Position the assembly in the jack cradle and secure it with straps.
2. Slide the unit under the vehicle and raise it into position.
3. Install the new clamping straps.
4. Position the assembly in the clamping straps, then install the clamping bolts and nuts. Do not tighten at this time.

IMPORTANT: Always use new gaskets when installing exhaust system components.

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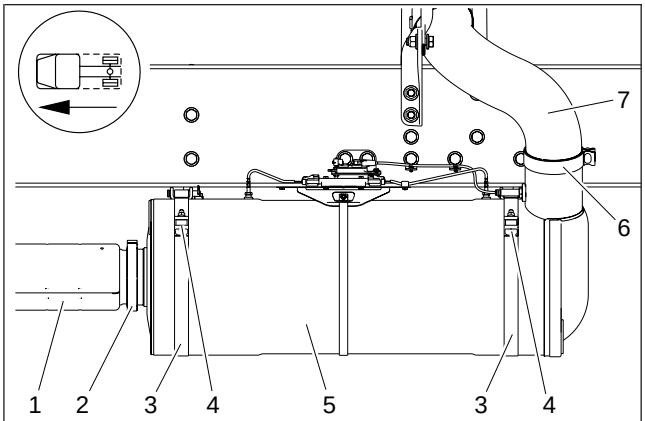


## Cummins 2HH ATD and SCR Catalyst Removal and Installation

5. Connect the ATD to the ATD inlet pipe and install the new spherical clamp and gasket. Do not tighten at this time.
6. Connect the ATD outlet to the mix tube and install the new spherical clamp and gasket. Do not tighten at this time.
7. Recheck the alignment of all components. Make adjustments to the clamping straps as needed, then incrementally tighten the bolts 15 lbf·ft (20 N·m), them 30 lbf·ft (41 N·m).
8. Tighten the spherical clamps at the connections to the ATD inlet pipe and the mix tube 126 to 138 lbf·in (1425 to 1560 N·cm).
9. Connect the wiring harnesses to the control module on the ATD.
10. Remove the jack and cradle.
11. Start the engine and check for leaks. Further tighten the clamps on any leaking connections as needed.

# SCR Catalyst Removal and Installation

Refer to **Fig. 2** for removal and installation of the ATS components.




1. Mixer Tube
2. Marmon Clamp
3. Clamping Strap
4. Clamping-Strap Bolt and Nut
5. SCR Catalyst
6. Wide-Band Clamp
7. Exhaust Pipe

**Fig. 2, SCR Catalyst Installation**

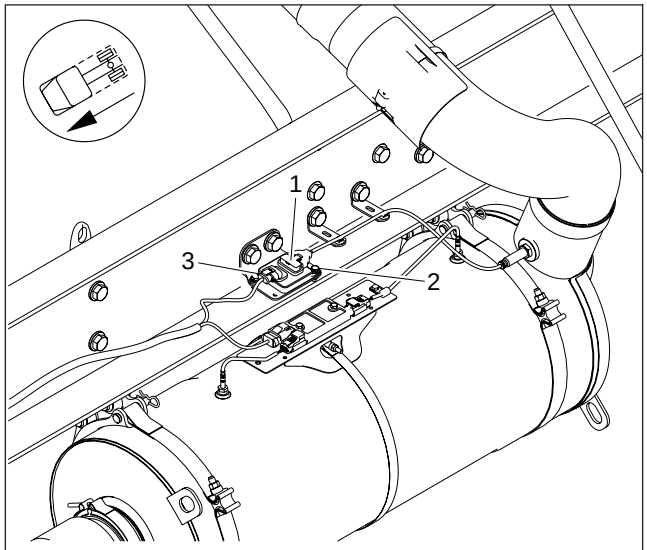
## Removal

1. Shut down the engine and chock the tires.
2. Allow the ATS to completely cool before working on it.

**NOTICE**

**Component alignment is critical to proper installation of ATS components. Before removing any components, put alignment marks (use both clocking and longitudinal marks where applicable) on all ATS components. This will aid in faster and more accurate alignment during assembly. Failure to accurately align all of the components of the ATS may result in component damage.**

3. Make alignment marks on all components to be removed.
4. Disconnect the wire harness to the NOx sensor.
5. Remove the NOx sensor module from the frame rail bracket and secure it to the SCR catalyst. See **Fig. 3**.




1. NOx Sensor Module
2. Mounting Bolts and Nuts
3. Chassis Harness Connector

**Fig. 3, NOx Sensor Module Installation**

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6. Disconnect the wire harness to the control module on the SCR catalyst.
7. Remove the marmon clamp that connects the SCR catalyst to the mixer tube. Discard the clamp.
8. Remove the wide-band clamp that connects the SCR catalyst to the exhaust pipe. Discard the clamp.
9. Position the jack and cradle under the assembly and secure it with straps.
10. Remove the bolts and nuts from the four clamping straps.
11. Remove and discard the clamping straps and hardware.
12. Lower the unit.

## Installation

1. Position the assembly in the jack cradle and secure it with straps.
2. Install the new clamp straps.
3. Slide the unit under the vehicle and raise it into position.
4. Position the assembly in the clamping straps, and install the clamping bolts and nuts. Do not tighten at this time.

IMPORTANT: Always use new gaskets when installing exhaust system components.

5. Connect the SCR catalyst to the mixer tube and install the new marmon clamp and gasket. Do not tighten at this time.
6. Connect the SCR catalyst to the exhaust outlet pipe and install the new wide-band clamp. Do not tighten at this time.
7. Recheck the alignment of all components. Make adjustments to the clamping straps as needed then tighten the bolts 15 lbf·ft (20 N·m), then 30 lbf·ft (41 N·m).
8. Tighten the marmon clamp at the connection of the SCR catalyst and the mixer tube 12 to 13 lbf·ft (16 to 17 N·m).
9. Install the NOx sensor module on the bracket on the frame rail, then connect it to the chassis harness.
10. Connect the wiring harness to the control box on the SCR catalyst.
11. Remove the jack and cradle.
12. Start the engine and check for leaks. Further tighten the clamps on any leaking connections as needed.

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## General Description

The Environmental Protection Agency (EPA) mandated that all engines built after December 31, 2009 must reduce the level of emissions exhausted by the engine to 0.2 grams per brake horsepower hour (g/bhp-hr) of nitrogen oxides (NOx).

To meet the EPA10 requirements, Daimler Trucks North America is using technology known as Selective Catalytic Reduction (SCR) in the exhaust aftertreatment system (ATS). See **Fig. 1**.

The SCR process requires the introduction of diesel exhaust fluid (DEF) into the exhaust stream. DEF is colorless, non-toxic, and biodegradable. In the ATS, the exhaust gases pass through the ATD, then are treated with precisely-controlled quantities of DEF, and then pass into the SCR catalyst. DEF consumption is dependent on ambient conditions and vehicle operation.

DEF is drawn from the tank by the DEF pump. The DEF is then filtered and, from the pump, transported through the DEF lines to the metering unit. The metering unit measures the correct amount of DEF, which is then injected into the hot exhaust flow after exhaust gases have passed through the ATD. In the presence of heat, DEF is converted to ammonia gas, which reacts with NOx in the selective catalyst chamber to yield harmless nitrogen and water vapor, which exit out the tailpipe.

DEF causes mild discoloration to aluminum, but will not affect its strength or structure. White crystals may be noticeable around components that come into contact with DEF. The crystals can be easily removed using water.

DEF freezes to a slush consistency at 12°F (-11°C). Because DEF can freeze, the DEF lines and metering unit are designed to purge whenever the engine is shut down to prevent damage. Complete purging of the DEF lines requires approximately five minutes after the engine is shut down.

DEF in the tank is allowed to freeze while the vehicle is non-operational. The DEF temperature sensor detects when the temperature of the DEF in the tank is approaching its freezing point. After the engine has been started and the engine coolant reaches a certain temperature, the coolant valve opens, allowing the coolant to flow through the coolant lines inside the DEF tank. The lines transfer heat, causing any frozen DEF in the tank to thaw and preventing liquid DEF from freezing during operation in cold weather. After flowing through the tank, the coolant is redirected back to the engine.

DEF will degrade over an extended period of time; shelf life is between twelve and eighteen months in standard operating conditions and temperatures. As DEF begins to degrade, it is usable but may be consumed at a slightly higher rate than normal.

A minor engine derate (approximately 25%) will occur when the DEF level registers below 5% on vehicles with Detroit Diesel engines, or 2.5% on vehicles with Cummins engines. If the DEF tank is empty, a major engine derate (vehicle speed is limited to 5 mph) will occur after an engine shut down and restart if the diesel tank has been refueled and the DEF tank is not refilled.

There are also safety controls that derate the engine if a contaminant has been introduced into the DEF tank. When a contaminant is detected, a minor engine derate will occur. When the vehicle has operated for 20 hours or 1000 miles with a contaminated tank, the vehicle will experience a major engine derate once the system determines that the vehicle is in a safe situation. Once the DEF tank has been filled with clean DEF, engine performance will return to normal.

DTNA-covered components of the DEF system include the DEF tank, tank header unit, pump, and coolant, DEF, and air lines between these components. See the engine manufacturer's service literature for information regarding other DEF system components such as the metering unit and injector, and DEF system maintenance instructions and intervals.

For additional operating information, see the *Western Star Driver's Manual*.

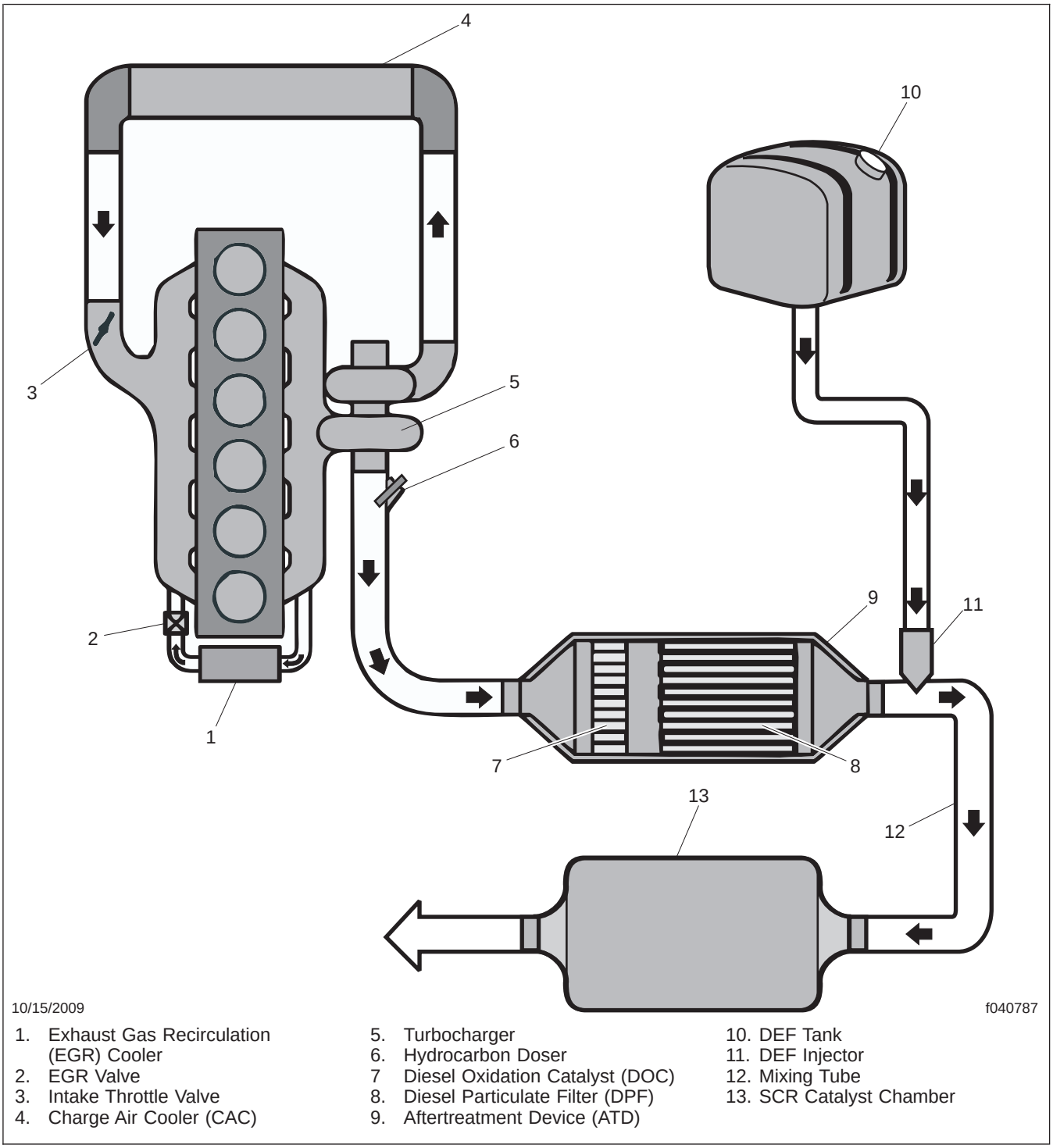
For additional information on and definitions for EPA10-compliant systems and components, see **Section 01.00**, EPA07/EPA10 Engine Information.

For additional information on the ATS, see **Section 49.01**, Aftertreatment System, EPA10.

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## General Information




1. Exhaust Gas Recirculation (EGR) Cooler
2. EGR Valve
3. Intake Throttle Valve
4. Charge Air Cooler (CAC)
5. Turbocharger
6. Hydrocarbon Doser
7 Diesel Oxidation Catalyst (DOC)
8. Diesel Particulate Filter (DPF)
9. Aftertreatment Device (ATD)
10. DEF Tank
11. DEF Injector
12. Mixing Tube
13. SCR Catalyst Chamber

**Fig. 1, EPA10 Aftertreatment System**

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Daimler Trucks North America vehicles carry diesel exhaust fluid (DEF) tanks in three sizes: 6 gallons, 13 gallons, or 23 gallons.

NOTE: DEF creeps, causing white crystals to form around the line fittings. The presence of crystals does not mean the system has a leak. Replacing fittings or components is not necessary unless there is a system failure or a fault code.

## 6-Gallon Tank

### Removal

IMPORTANT: Discard contaminated DEF or coolant in accordance with EPA regulations.

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Open the hood.
3. Drain the coolant from the cooling system. For instructions, see **Group 20**.
4. Place a clean drain pan underneath the tank to catch draining DEF. Uncontaminated DEF may be reused.

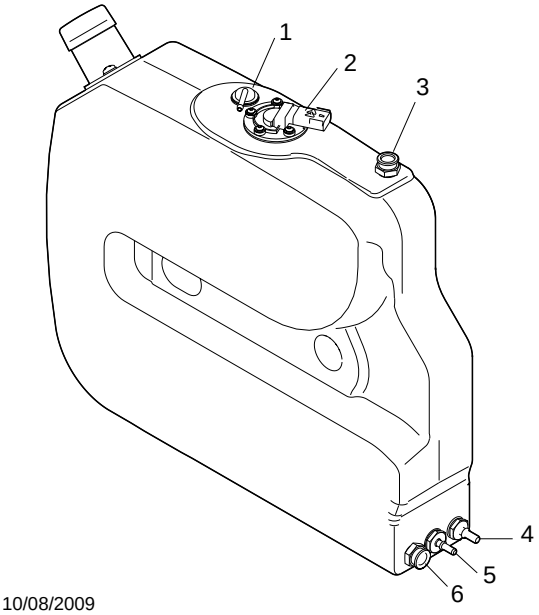
IMPORTANT: Wait at least five minutes after shutting down the engine to disconnect the DEF lines. Complete purging of the DEF lines requires approximately five minutes after the engine is shut down.

5. Disconnect the DEF line heater wiring harnesses from the DEF lines at the tank.

**NOTICE**

**To disconnect a DEF line, push the line coupling in towards the male connector to move the holding clip to the unlocked position, then compress the prongs of the holding clip and pull the line off of the male connector. Failure to properly remove a DEF line can result in damage to a line coupling or DEF fitting.**

6. Disconnect the DEF lines from the supply and return ports and let the DEF drain into the drain pan. See **Fig. 1** or **Fig. 2**.
7. Disconnect the wiring harness from the tank header unit.




1. Vent
2. DEF Level and Temperature Sensor Wiring Harness
3. Coolant Inlet
4. DEF Outlet
5. DEF Inlet
6. Coolant Outlet

**Fig. 1, 6-Gallon Tank Ports (Detroit Diesel shown)**

8. Disconnect the coolant lines from the supply and return ports.
9. Disconnect the vent line.
10. If another chassis-mounted component is located directly aft of the DEF tank, check to see if the component is mounted close enough to prevent the tank from sliding off the mounting studs. If so, remove the nuts, bolts, and washers that secure the tank assembly to the frame casting, and remove the assembly from the frame casting.
11. Remove the two capscrews that secure the tank and retaining washers on the mounting studs. See **Fig. 3**.
12. Remove the two tank retaining washers from the tank mounting studs.
13. Slide the tank off of the mounting studs.

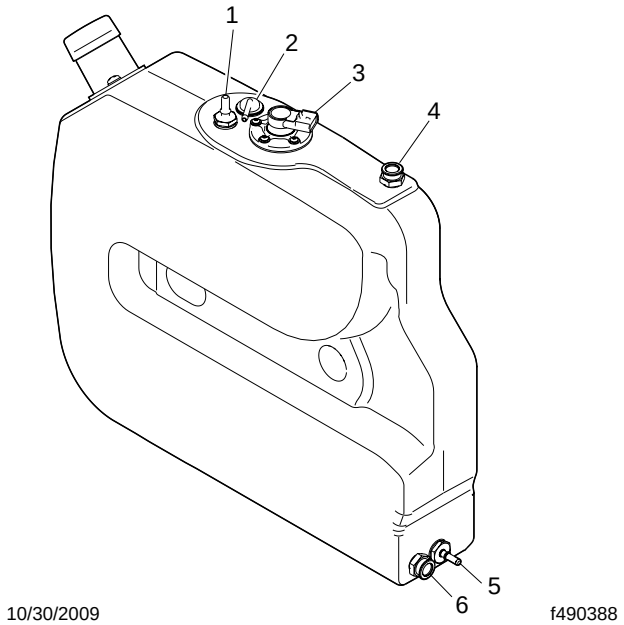
### Installation

1. Slide the tank onto the mounting studs.

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## Tank Removal and Installation

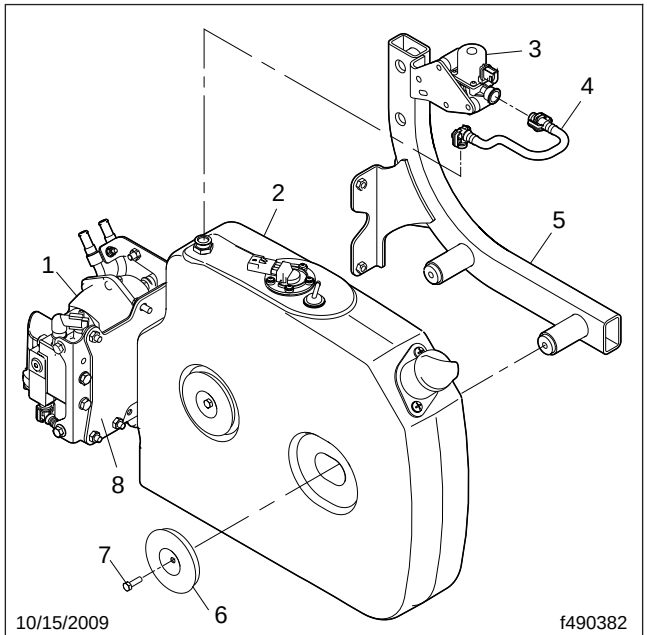



1. DEF Inlet
2. Vent
3. DEF Level and Temperature Sensor Wiring Harness
4. Coolant Inlet
5. DEF Outlet
6. Coolant Outlet

**Fig. 2, 6-Gallon Tank Ports (Cummins shown)**

2. Install two tank retaining washers on the tank mounting studs.
3. Install two capscrews onto the mounting studs, securing the tank and retaining washers on the tank mounting studs. Tighten the capscrews 11 to 18 lbf·ft (15 to 25 N·m).
4. If the tank assembly was previously removed from the frame casting, install the tank assembly on the frame casting. Tighten the four tank assembly mounting bolts 112 lbf·ft (152 N·m).
5. Connect the vent line.
6. Connect the coolant supply and return lines to the coolant ports on the tank.
7. Remove any white DEF crystals from the DEF ports on the tank and the DEF line couplings.

IMPORTANT: To connect a DEF line, push the line coupling onto the DEF port male connector, then pull back gently on the coupling to engage the holding clip in the locked position.




1. DEF Pump
2. DEF Tank
3. Coolant Valve
4. Coolant Supply Line
5. Tank Mounting Bracket
6. Tank Retaining Washer (Qty 2)
7. Capscrew (Qty 2)
8. Pump Mounting Bracket

**Fig. 3, 6-Gallon Tank Mounting Assembly**

8. Connect the DEF supply and return lines to the DEF ports on the back of the tank.
9. Connect the DEF line heater wiring harnesses to the DEF lines at the tank.
10. Connect the wiring harness to the tank header unit.
11. Fill the DEF tank.
12. Fill the cooling system and check for leaks. For instructions, see **Group 20**.
13. Close the hood.

## 13- or 23-Gallon Tank

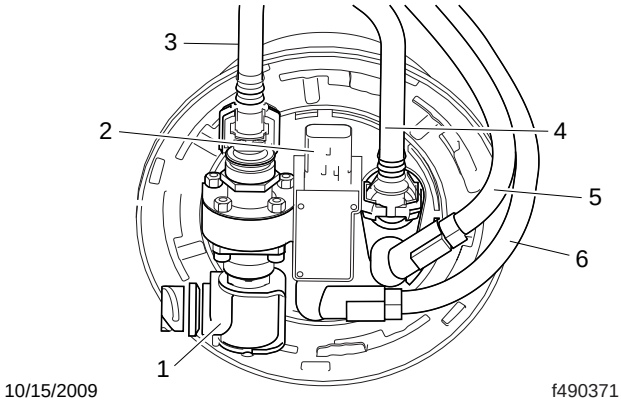
### Removal

IMPORTANT: Discard contaminated DEF or coolant in accordance with EPA regulations.

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1. Shut down the engine, apply the parking brake, and chock the tires.
2. Open the hood.
3. Drain the coolant from the cooling system. For instructions, see **Group 20**.
4. Remove the beauty cover, if equipped.
5. Using a siphon, empty the DEF from the tank into a clean container. Uncontaminated DEF may be reused.
6. Place a drain pan underneath the tank to catch any remaining DEF or coolant that drains out.
7. Disconnect the coolant valve and DEF level and temperature sensor wiring harnesses from the tank header unit. See **Fig. 4**.




1. Coolant Valve Wiring Harness
2. DEF Level and Temperature Sensor Wiring Harness
3. Coolant Return Line
4. Coolant Supply Line
5. DEF Return Line
6. DEF Supply Line

**Fig. 4, DEF Tank Header Unit (Detroit Diesel shown)**

8. Disconnect the coolant lines from the tank header unit.

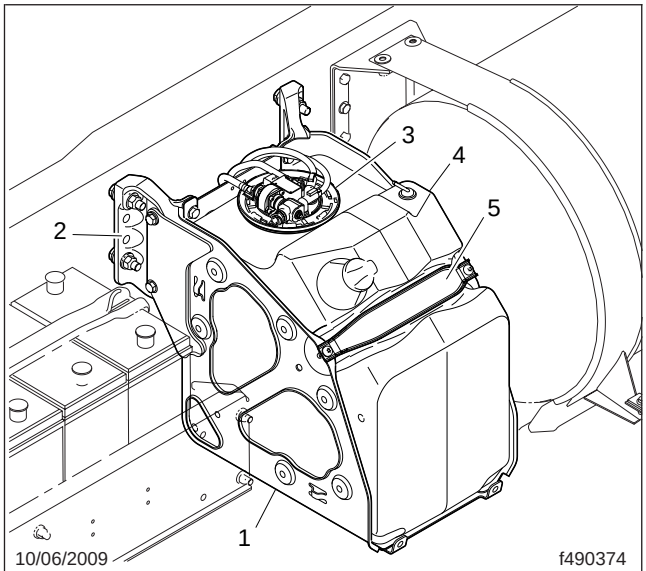
IMPORTANT: Wait at least five minutes after shutting down the engine to disconnect the DEF lines. Complete purging of the DEF lines requires approximately five minutes after the engine is shut down.

9. Disconnect the DEF line heater wiring harnesses from the DEF lines at the tank.

## NOTICE

**To disconnect a DEF line, push the line coupling in towards the male connector to move the holding clip to the unlocked position, then compress the prongs of the holding clip and pull the line off of the male connector. Failure to properly remove a DEF line can result in damage to a line coupling or DEF fitting.**

10. Disconnect the DEF lines from the tank header unit.
11. Disconnect the vent line.
12. Remove the two nuts that secure the tank retaining bracket to the tank mounting cage and remove the retaining bracket. See **Fig. 5**.




1. Mounting Cage
2. Mounting Support Bracket
3. Tank Header Unit
4. Tank
5. Tank Retaining Bracket

**Fig. 5, 13- or 23-Gallon DEF Tank Mounting Assembly**

13. Remove the tank from the mounting cage.

# Installation

1. Install the tank into the mounting cage.

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## Tank Removal and Installation

2. Install the tank retaining bracket on the tank mounting cage studs. Install two nuts on the tank retaining bracket and tighten the nuts 12 lbf·ft (16 N·m).
3. Connect the vent line.
4. Remove any white DEF crystals from the DEF ports on the header unit and the DEF line couplings.

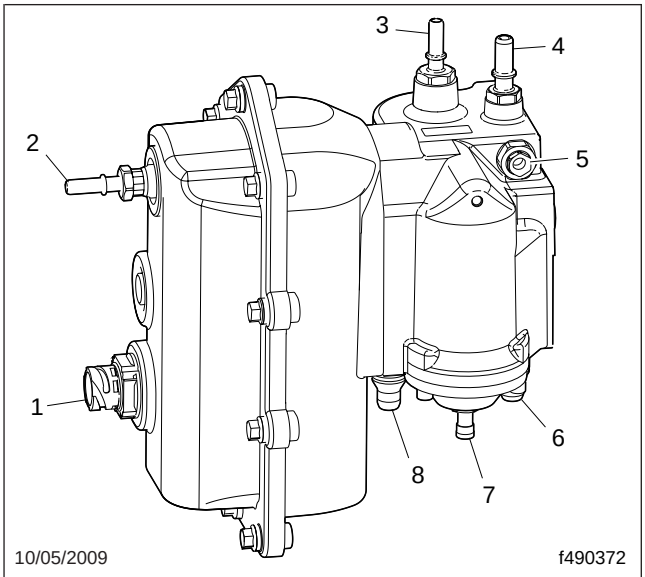
IMPORTANT: To connect a DEF line, push the line coupling onto the DEF port male connector, then pull back gently on the coupling to engage the holding clip in the locked position.

5. Connect the DEF supply and return lines to the tank header unit.
6. Connect the DEF line heater wiring harnesses to the DEF lines at the tank.
7. Connect the coolant lines to the tank header unit.
8. Connect the coolant valve and DEF level and temperature sensor wiring harnesses to the tank header unit.
9. Fill the DEF tank.
10. Install the beauty cover, if equipped.
11. Fill the cooling system and check for leaks. For instructions, see **Group 20**.
12. Close the hood.

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EPA10-compliant vehicles have a diesel exhaust fluid (DEF) pump module (**Fig. 1**) mounted in a protective box to the back of the DEF tank.




1. Wiring Harness Connector
2. DEF Inlet Port
3. DEF Outlet Port (to metering unit)
4. DEF Outlet Port (to tank)
5. Compressed Air Port
6. Coolant Outlet Port
7. Air Bladder Fill Valve
8. Coolant Inlet Port

**Fig. 1, DEF Pump (Detroit Diesel shown)**

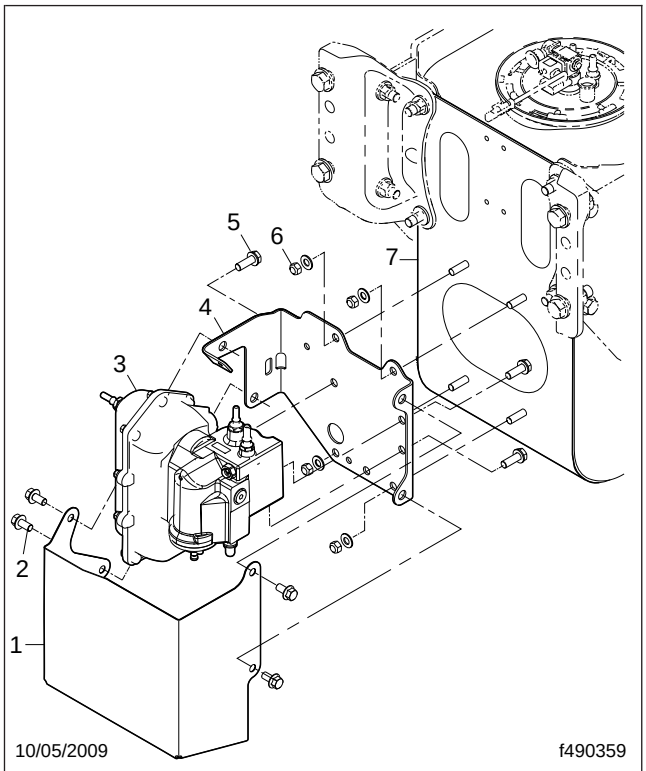
The DEF pump module filters and supplies DEF to the metering unit. The only serviceable components of the pump module are the air bladder and the filter. See the engine manufacturer's service literature for maintenance instructions and intervals.

NOTE: DEF creeps, causing white crystals to form around the line fittings. The presence of crystals does not mean the system has a leak. Replacing fittings or components is not necessary unless there is a system failure or a fault code.

## Removal

IMPORTANT: Discard contaminated DEF or coolant in accordance with EPA regulations.

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Open the hood.
3. Drain the air system.
4. On a vehicle equipped with a Detroit Diesel engine, drain the coolant from the cooling system. For instructions, see **Group 20**.
5. Place a drain pan underneath the pump to catch any DEF or remaining coolant that drains out.
6. Remove the four mounting bolts that secure the protective cover over the pump. Remove the cover. See **Fig. 2**.




1. Protective Cover
2. Protective Cover Mounting Fasteners
3. DEF Pump
4. Pump Mounting Bracket
5. Pump Mounting Fasteners
6. Mounting Bracket Fasteners
7. DEF Tank Mounting Cage

**Fig. 2, DEF Pump Removal and Installation**

7. Disconnect the wiring harness from the pump.

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## Pump Removal and Installation

8. Disconnect the coolant lines and air line, if equipped, from the pump.

IMPORTANT: Wait at least five minutes after shutting down the engine to disconnect the DEF lines. Complete purging of the DEF lines requires approximately five minutes after the engine is shut down.

9. Disconnect the DEF line heater wiring harnesses from the DEF lines at the pump.

**NOTICE**

**To disconnect a DEF line, push the line coupling in towards the male connector to move the holding clip to the unlocked position, then compress the prongs of the holding clip and pull the line off of the male connector. Failure to properly remove a DEF line can result in damage to a line coupling or DEF fitting.**

10. Disconnect the DEF lines from the pump.
11. Loosen and remove the four nuts that secure the pump mounting bracket to the tank mounting cage.
12. Remove the DEF pump and mounting bracket.
13. Remove the three fasteners that secure the pump to the mounting bracket, and remove the pump from the bracket.

## Installation

1. Using the three pump mounting fasteners, secure the pump to the pump mounting bracket. Tighten the fasteners 26 lbf·ft (35 N·m).
2. Install the four nuts that secure the pump mounting bracket to the DEF tank mounting bracket. Tighten the nuts 23 lbf·ft (31 N·m).
3. Remove any white DEF crystals from the DEF ports on the pump and the DEF line couplings.

IMPORTANT: To connect a DEF line, push the line coupling onto the DEF port male connector, then pull back gently on the coupling to engage the holding clip in the locked position.

4. Connect the DEF supply and return lines to the three DEF ports on the pump.
5. Connect the DEF line heater wiring harnesses to the DEF lines at the pump.
6. Connect the air line and coolant lines, if equipped, to the pump.
7. Connect the wiring harness to the pump.
8. Place the protective cover over the pump and install the four mounting bolts that secure the protective cover to the pump mounting bracket. Tighten the bolts 37 lbf·ft (50 N·m).
9. On a vehicle equipped with a Detroit Diesel engine, fill the cooling system and check for leaks. For instructions, see **Group 20**.
10. Fill the air system.
11. Close the hood.

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NOTE: Diesel exhaust fluid (DEF) creeps, causing white crystals to form around the line fittings. The presence of crystals does not mean the system has a leak. Replacing fittings or components is not necessary unless there is a system failure or a fault code.

## Replacement

IMPORTANT: Discard contaminated DEF or coolant in accordance with EPA regulations.

1. Shut down the engine, apply the parking brake, and chock the tires.

IMPORTANT: Wait at least five minutes after shutting down the engine to disconnect the battery ground cable. Disconnecting the battery ground cable too soon will prevent purging of the DEF lines after the engine is shut down.

2. Disconnect the batteries.
3. Place drain pans underneath the DEF pump and the DEF metering unit to catch any draining DEF.
4. Disconnect the DEF line heater wiring harnesses from the DEF lines at the tank, pump, and metering unit.

### NOTICE

**To disconnect a DEF line, push the line coupling in towards the male connector to move the holding clip to the unlocked position, then compress the prongs of the holding clip and pull the line off of the male connector. Failure to properly remove a DEF line can result in damage to a line coupling or DEF fitting.**

5. Disconnect the DEF lines between the DEF pump and the tank. See **Fig. 1**.
6. Disconnect the DEF lines between the pump and the metering unit.
7. Discard the lines.
8. Ensure the new DEF lines are undamaged and free of dirt or debris.
9. Remove any white DEF crystals from the DEF ports on the tank, pump, and metering unit.

IMPORTANT: To connect a DEF line, push the line coupling onto the DEF port male connector, then pull back gently on the coupling to engage the holding clip in the locked position.

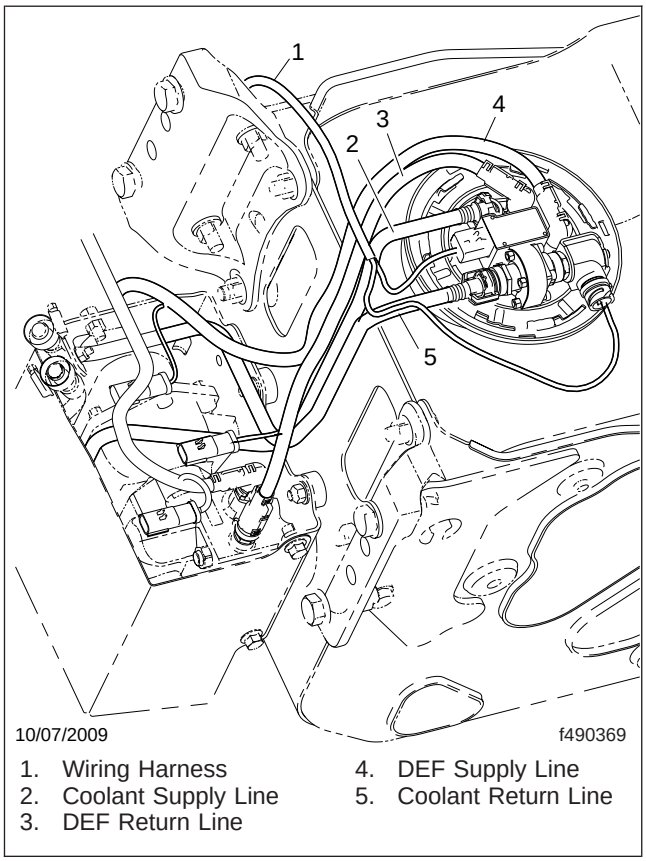



**Fig. 1, DEF Pump Line Connections**

10. Install new DEF lines between the DEF pump and the tank.
11. Install new DEF lines between the DEF pump and the metering unit.
12. Connect the DEF line heater wiring harnesses to the DEF lines at the tank, pump, and metering unit.
13. Connect the batteries.

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NOTE: DEF creeps, causing white crystals to form around the line fittings. The presence of crystals does not mean the system has a leak. Replacing fittings or components is not necessary unless there is a system failure or a fault code.

## Replacement, 6-Gallon Tank

The DEF header unit on vehicles with a 6-gallon DEF tank is secured to the top of the tank, and contains the DEF level sensor and the DEF temperature sensor.

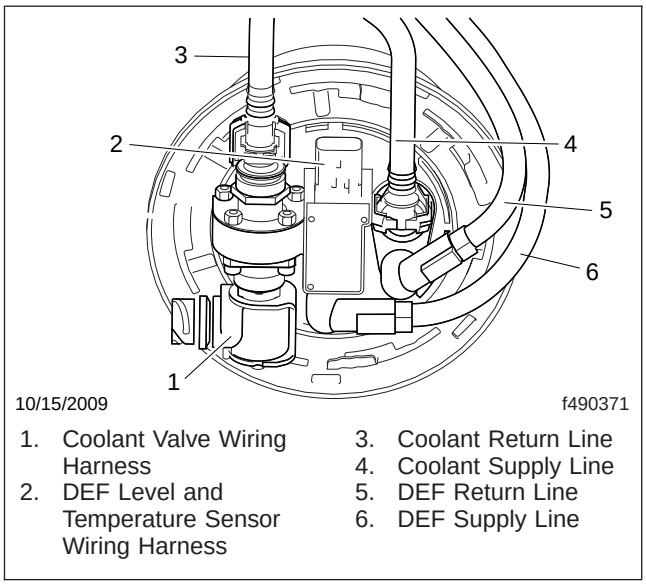
IMPORTANT: Discard contaminated DEF or coolant in accordance with EPA regulations.

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Remove the tank from the vehicle. See **Subject 100** for instructions.
3. Remove the header unit mounting capscrews and washers that secure the header to the tank.
4. Remove the header unit from the tank.
5. Install a new header unit into the tank.
6. Ensure that the header unit is situated securely on the raised lip of the tank, and is not tilted to the side.
7. Install the mounting capscrews and washers to secure the header unit to the tank. Tighten the capscrews 5 lbf·ft (7 N·m).
8. Connect the DEF level and temperature sensor wiring harness.
9. Install the DEF tank on the vehicle. See **Subject 100** for instructions.

## Replacement, 13- or 23-Gallon Tank

The DEF header unit on vehicles with a 13- or 23-gallon DEF tank is secured to the top of the tank, and contains the engine coolant lines that run through the tank, the coolant valve, the DEF level sensor, and the DEF temperature sensor. See **Fig. 1**.

IMPORTANT: Discard contaminated DEF or coolant in accordance with EPA regulations.




1. Coolant Valve Wiring Harness
2. DEF Level and Temperature Sensor Wiring Harness
3. Coolant Return Line
4. Coolant Supply Line
5. DEF Return Line
6. DEF Supply Line

**Fig. 1, DEF Tank Header Unit (Detroit Diesel shown)**

1. Shut down the engine, apply the parking brake, and chock the tires.
2. Remove the tank from the vehicle. See **Subject 100** for instructions.
3. Rotate the header lockring counter-clockwise to loosen it, then remove the lockring.
4. Remove the header unit from the tank by pulling the assembly straight up, then tilting it to pull the horizontal end clear of the tank; see **Fig. 2**.
5. Install a new header unit by tilting it to insert the horizontal end into the tank. Once the horizontal segment is inside the tank, tilt the header unit back to vertical to settle the bracket on top of the tank.
6. Ensure that the header unit is situated securely on the raised lip of the tank, and is not tilted to the side.
7. Install the header lockring and rotate it clockwise to secure it to the tank.
8. Remove any white DEF crystals from the DEF ports on the header unit and the DEF line couplings.
9. Install the DEF tank on the vehicle. See **Subject 100** for instructions.

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## Tank Header Unit Replacement

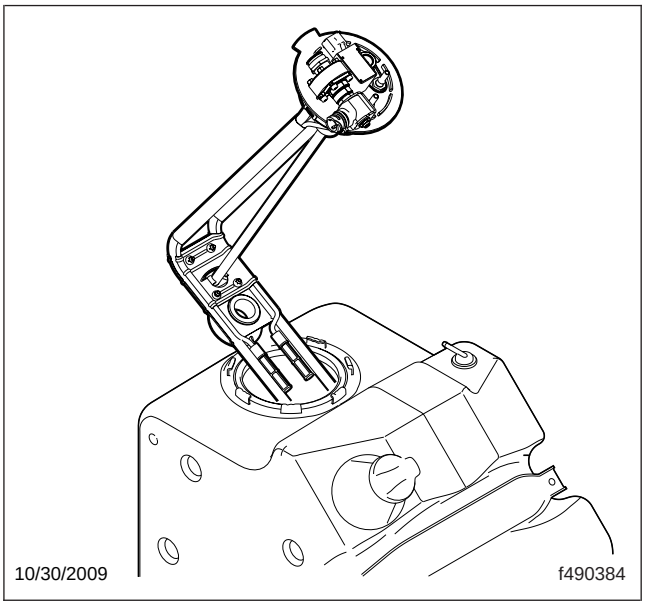



**Fig. 2, Header Unit Tilt**

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NOTE: Diesel exhaust fluid (DEF) creeps, causing white crystals to form around the line fittings. The presence of crystals does not mean the system has a leak. Replacing fittings or components is not necessary unless there is a system failure or a fault code.

Periodic maintenance of the DEF pump filter is required. For instructions and intervals, see the engine manufacturer's service literature.

# Replacement

## Detroit Diesel

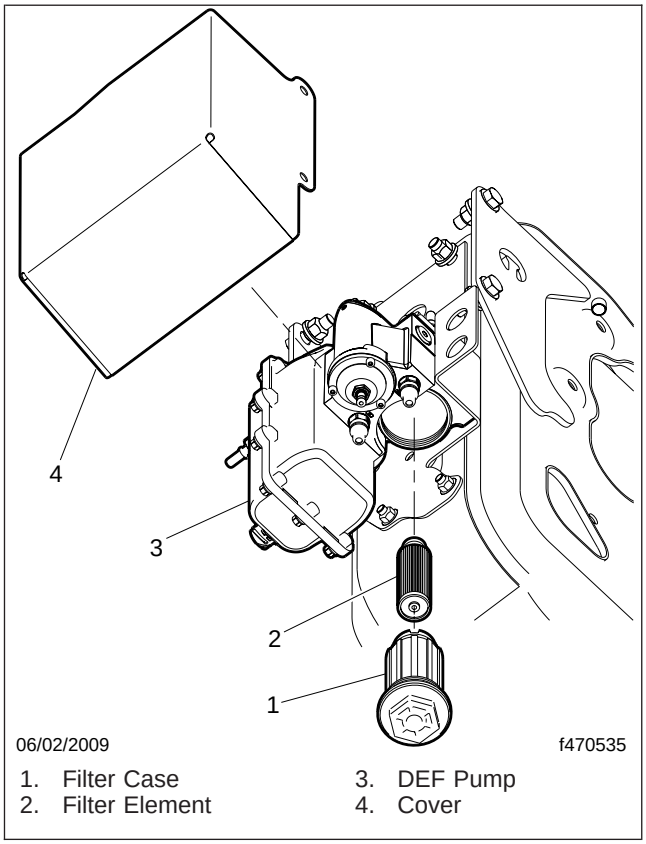
IMPORTANT: Discard contaminated DEF in accordance with EPA regulations.

1. Shut down the engine, apply the parking brake, and chock the tires.

IMPORTANT: Wait at least five minutes after shutting down the engine to disconnect the battery ground cable. Disconnecting the battery ground cable too soon will prevent purging of the DEF lines after the engine is shut down.

2. Disconnect the batteries.
3. Remove the four mounting bolts that secure the protective cover over the pump. Remove the cover. The pump is located next to, or inboard of, the DEF tank.
4. Unscrew the filter cartridge; see **Fig. 1**. The cartridge includes both the filter case and the filter element, which are replaced as a unit. Verify that the filter element was removed with the case. If the filter element was not removed, use a suitable tool to remove it from the pump.

   Discard the filter element and case.
5. Lubricate the O-rings with clean DEF.
6. Check the new filter cartridge to ensure that the O-ring end of the filter element is facing out of the cartridge. Install the cartridge into the DEF pump. Tighten the filter cartridge 22 to 25 lbf·ft (30 to 34 N·m).
7. Place the protective cover over the pump and install the four mounting bolts that secure the protective cover to the pump mounting bracket. Tighten the bolts 37 lbf·ft (50 N·m).




1. Filter Case
2. Filter Element
3. DEF Pump
4. Cover

**Fig. 1, DEF Filter Replacement, Detroit Diesel Engine**

8. Connect the batteries.

## Cummins

IMPORTANT: Discard contaminated DEF in accordance with EPA regulations.

1. Shut down the engine, apply the parking brake, and chock the tires.

IMPORTANT: Wait at least five minutes after shutting down the engine to disconnect the battery ground cable. Disconnecting the battery ground cable too soon will prevent purging of the DEF lines after the engine is shut down.

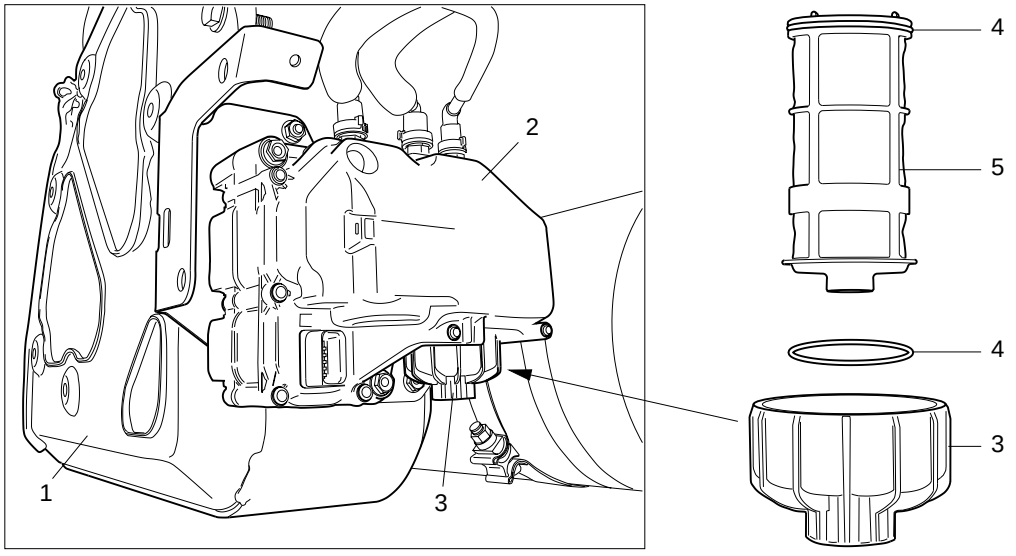
2. Disconnect the batteries.
3. Remove the four mounting bolts that secure the protective cover over the pump. Remove the cover. The pump is located inboard of the DEF tank.

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## Pump Filter Replacement

4. Unscrew the filter cap, then remove and discard the filter element. See **Fig. 2**.
5. Install the new filter element into the DEF pump with the O-ring end facing into the pump.
6. Install the filter cap. Tighten the cap 15 to 18 lbf·ft (20 to 25 N·m).
7. Place the protective cover over the pump and install the four mounting bolts that secure the protective cover to the pump mounting bracket. Tighten the bolts 37 lbf·ft (50 N·m).
8. Connect the batteries.




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1. DEF Tank
2. DEF Pump
3. Filter Cap
4. O-Ring
5. Filter Element

**Fig. 2, DEF Filter Replacement, Cummins Engine**

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If a contaminant has been introduced into the diesel exhaust fluid (DEF) system and the engine has been started, the following DEF components must be replaced:

- Tank
- Pump
- Header unit
- Metering unit
- Injector

See the other subjects in this section for tank, pump, and header unit replacement.

See the engine manufacturer's service literature for other component replacement instructions.

## Flushing

If a contaminant has been introduced to the DEF tank, but the engine has not been started, complete the following steps.

1. Apply the parking brake and chock the tires.
2. Place a suitable container underneath the DEF tank to catch any draining DEF.

IMPORTANT: Discard contaminated DEF or coolant in accordance with EPA regulations.

3. Remove the DEF and contaminant from the tank.

   On vehicles with a 6-gallon DEF tank, disconnect the DEF line from the DEF outlet port and let the DEF drain into the drain pan.

   On vehicles with a 13- or 23-gallon DEF tank, use a siphon to empty the DEF from the tank.
4. Remove the DEF tank. See **Subject 100** for instructions.
5. Thoroughly flush the tank with water until the tank is free of all contaminants.
6. Install the DEF tank. See **Subject 100** for instructions.

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## Definitions

See the following list for definitions of common electrical terms.

**Alternating Current** (AC) Alternating current is a type of electrical energy. It is an electrical current whose polarity is constantly changing from positive to negative and back again.

**Alternator** The alternator is a power supplier. It is a type of generator used in vehicles to produce electrical current. It creates AC current which it changes to DC current.

**Ammeter** The ammeter is an appliance. It is an instrument that measures and displays current flow.

**Amperage** (Amp) This is a component of electrical energy. The strength of an electrical current is measured in amperes, which is the quantity of electrons moving along a complete circuit (path).

**Amperage Draw** The quantity of amperes required for an appliance under normal operating conditions.

**Ampere** (Amp) An ampere is a component of electrical energy.

**Armature** The armature is part of a directional controller. It is a movable device with contacts, found in a switch or relay. Also the rotating part of an electric motor.

**Battery** The battery is a power supplier. It is a device that converts chemical energy into electrical energy.

**Breakout** A breakout is part of the circuit where a wire(s) exits or enters a wiring harness.

**Brush** A brush is part of an appliance. It is an electrical conductive material, usually carbon, which slides over contact points to complete a circuit.

**Bus Bar** This is a part of the directional controller, it is a conductive metal strip that connects several circuits to a single source.

**Capacitor** The capacitor is a power supplier. It is also called a condenser. It is a device for storing an electrical charge.

**Cavity** A cavity is the chamber in a connector that holds a wire terminal.

**Cell** A cell is a part of a battery. It is a single set of positive and negative plates that with electrolyte produces electrical energy.

**Charge** An electrical energy value and characteristic, as in a negative charge, or a positive charge. To restore the active materials in a battery cell by electrically reversing the chemical action, thus restoring the electrical potential of the battery.

**Circuit** The circuit consists of a power supply, power controllers, directional controllers, and an appliance. It is the complete path provided for the electrical current flow. Electrons stored on a battery plate need a pathway. The vehicle's electrical system uses wires, terminals, the cab structure, the frame, engine block and component cases or housings, fasteners (screws, bolts and washers) as circuit pathways.

**Circuit Breaker** The circuit breaker is a power controller. A breaker is a switch that opens when an amperage overload occurs. An internal bimetallic strip expands as heat builds during the overload and opens the contacts of the breaker stopping the electrical flow.

**Closed** This is the condition of a power controller or of a directional controller. Contacts have been made to touch, completing the path for the current to follow.

**Commutator** The commutator is a component of an appliance. It is a series of contact points on a motor armature.

**Conductive** The ability of a material to allow current to flow.

**Conductivity** How well a material will allow current to move along it. Conductivity is measured by the materials resistance to current flow and is measured in Ohms.

**Conductor** A wire or material which allows current to flow along it.

**Contact** A Contact is a component used in power controllers, directional controllers, and appliances. The parts of a device that come together to open or close a circuit.

**Connector** An insulating device that holds terminals isolated from one another and aligns them for joining with a mating connector and its terminals.

**Continuity** A continuous path with no breaks or opens; a continuous circuit, or portion of a circuit.

**Current** The flow of electrons along a complete circuit expressed as amperage.

**Data** Information used as a basis for mechanical or electronic computations.

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## General Information

**Data Bus** A common electrical circuit through which processors transmit data.

**Data Processing** The handling of information in a sequence of reasonable operations.

**Device** Any component found in the electrical system.

**Dielectric** Non-conductive; an insulator. Dielectric materials are used to protect surfaces from corrosion, rust and accidental electrical contact.

**Diode** The diode is a directional controller; a semiconductor which permits current to flow in one direction only.

**Dip Switch** The dual In-line package dip switch is a set of switches used with integrated circuits to provide a path to one or two possible circuits.

**Direct Current** (DC) An electrical current that flows in one direction only.

**Electric** A word used to describe anything having to do with electricity in any form. Used interchangeably with electrical.

**Electricity** The movement of electrons from one body of matter to another.

**Electrolyte** An acid solution of sulphuric acid and water used to activate the chemical process that results in an electrical current.

**Electromagnet** A soft-iron core which is magnetized when an electric current is passed through a coil of wire around it.

**Female Terminal** The socket wire terminal in which the mating male terminal fits into.

**Filament** A conductor in a light bulb with sufficient resistance to glow when adequate current is sent through it.

**Fuse** The fuse is a power controller. A device placed into a circuit, which has a soft metal bridge that melts and opens the circuit when it is overloaded.

**Gauge** The size of wire. The larger the number, the thinner the wire core.

**Ground** The return path for electrons after going through a device to get back to negative post on the battery.

**Insulation** A component of very high resistance used to keep electrons on their intended path.

**Male Terminal** The plug wire terminal that fits into the mating female terminal.

**Motor** A motor is a appliance. It is an electromagnetic device used to convert electrical energy to mechanical energy.

**Multimeter** Tool used for checking voltage, resistance, continuity and amperage.

**Normally Closed** (N.C.) This is an unpowered condition of a directional controller. Refers to a switch or relay with the contacts touching, completing the circuit.

**Normally Open** (N.O.) This is an unpowered condition of a directional controller. Refers to a switch or relay without the contacts touching, an incomplete circuit.

**Ohm** The unit of measure for electrical resistance.

**Open** This is the condition of a power controller or of a directional controller. Contacts have been made to separate, making the conductor path incomplete.

**Parallel** A circuit where all devices are connected together with negative-to-negative and positive-to-positive. The current flows equally to all the devices.

**Pin** A male terminal attached to the end of a wire that can be connected to a female terminal by pushing it into the mating terminal.

**Pick-up** A device in which an induced voltage and amperage are generated. Also called a sensor. This device is used to broadcast an event or to report on the quantity of an event at a given time.

**Polarity** The positive and negative sides of a circuit.

**Pole** The number of conductor armatures in a switch.

**Relay** The relay is a directional controller. An electromagnetic device using low current to open or close high-current circuits, or to interrupt an electrical current.

**Resistance** The measure (Ohms) of a material's ability to transfer electrons. Good conductors have low resistance while poor conductors have high resistance. Insulators have infinite resistance. Each part in a circuit acts like an obstacle that the electrons must pass through, losing energy (voltage drop) as they pass through it.

**Resistor** The resistor is a power controller. A device used in an electrical circuit to produce work or to lower voltage in a circuit.

**Series** A circuit where the units are connected together with negative to positive and positive to nega-

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tive. The current flows through each of the units; one after the other.

**Socket** A female terminal attached to the end of a wire that can be connected to a male terminal (pin) and removed.

**Solenoid** A coil containing a movable core which moves when the coil is energized. Used to operate switches, valves or engage/disengage a mechanical device.

**Switch** The switch is a directional controller. A device used for opening, closing or changing the connections of a electrical circuit.

**Terminal** A mechanism attached to a wire or device that can be connected to another wire or device.

**Throw** The number of contacts that the armature of a switch can be moved.

**Voltage** (Volt or V) A unit of measure of electrical pressure in a circuit.

**Watt** The measure of electrical energy or *work*.

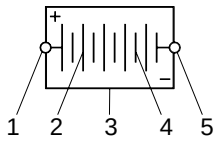
**Wire** Wire is a directional controller. Electrons follow the path of least resistance and wires made of strands of copper provide this path. Insulated wires contain the electron flow and direct it to the appliance with the least amount electron loss.

# Electrical System Basics

The flow of electrons (current) is used to control, operate or monitor the vehicle's systems. The vehicle electrical system can be divided into four basic groups; power suppliers, power controllers, directional controllers, and appliances. Every system has these four parts, in one form or another.

## Power Suppliers

The battery is a source of electrical power in the vehicles. A (wet cell) battery is an electrochemical device consisting of metal plates and an acid-water solution. The battery has both positive and negative plates. The plates are grouped alternating together, like a stack of cards, but not allowed to touch each other. The action of the acid on the plates inside the battery results in an electron build up on one set of plates and a shortage of electrons on the other set of plates. The electrons will follow any available path to get from one set of plates to the other. See **Fig. 1** for the battery symbol found on the electrical schematics.

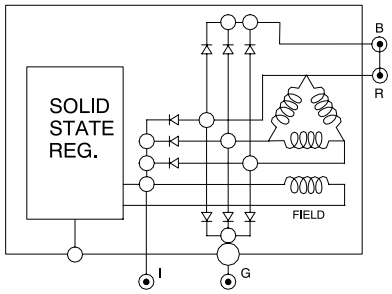



11/27/2001 f543972

1. Positive Post
2. Positive Plate
3. Case
4. Negative Plate
5. Negative Post

**Fig. 1, Battery Symbol**

The alternator converts mechanical energy supplied by the engine to electrical energy. The alternator produces electrical power to operate lights, motors, etc., and keep the batteries charged. See **Fig. 2** for the alternator symbol found on the electrical schematics.




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**Fig. 2, Alternator Symbol**

There are other *power suppliers* but they are devices that use electrical power and modify it for use in an electronic subsystem (like engine control or ABS).

## Power Controllers

Fuses, circuit breakers and fuseable links are power controllers. They are *safety valves* in the electrical system. If too many electrons are flowing through a fuse it gets hot and the *bridge* melts interrupting the flow of electrons before other parts of the circuit are damaged. A breaker is a switch that opens when an amperage overload occurs, either stopping or restricting the current flow protecting the circuits or devices from overheating and becoming damaged. See **Fig. 3** for fuse symbols and **Fig. 4** for breaker symbols found on the electrical schematics.

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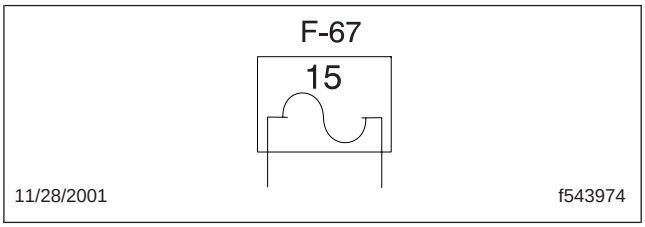



**Fig. 3, Fuse Symbol**

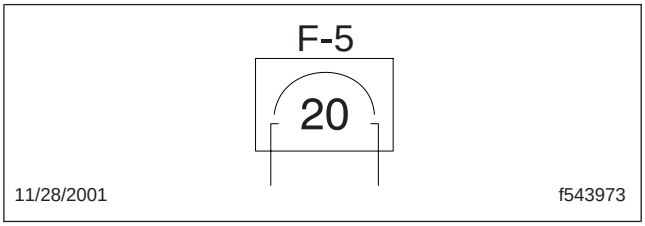



**Fig. 4, Breaker Symbol**

The variable resistor is a device that reduces or restricts electron flow (current) in a circuit. Examples are sensors such as fuel level, pressure or temperature sensors. The amount that they restrict the current is used to indicate fuel level, pressure or temperature on the gauges in the dash. The throttle position sensor is also a variable resistor. See **Fig. 5** for variable resistor symbols found on the electrical schematics.

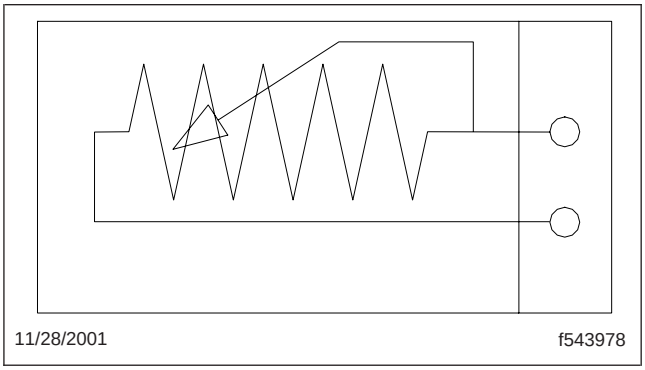



**Fig. 5, Resistive Sensor Symbol**

## Directional Controllers

Directional controllers are devices that are used to determine which circuits will be energized and from where the power comes. Switches and relays are directional controllers.

Switches are used to open and close circuits or to change the current flow from one circuit to another circuit. Switches are generally found in low power circuits.

Relays are used to open and close circuits or to change the current flow from one circuit to another circuit. Relays are generally found in high power circuits.

Switches use low amperage to activate a relay which opens or closes the high amperage circuit. See **Fig. 6** for switch symbols and **Fig. 7** for relay symbols found on the electrical schematics.

## Appliances

Appliances are the devices that convert electrons into a function required such as fans, illumination, heating, sound, system status monitoring (gauges). Examples are: motors, lamps (bulbs), heating elements (air dryer), solid-state items (computerized modules) and gauges. See **Fig. 8** for appliance symbols.

# Basic Operation

All the wiring circuits are protected from overloading by fuses and circuit breakers. The circuit breakers, fuses and relays are in electrical panels located inboard of the passenger side glove box. Access to the panel is achieved by removing the four screws located in each corner of the panel. See **Fig. 9**.

The opening next to the glove box is the main panel and the opening closer to the driver is the option panel. See **Fig. 10**. The main panel consists of most of the standard fuses, beakers and relays that are usually found on every Western Star vehicle. The option panel fuses, breakers and relays are used for customer ordered options.

The option panel is made up of fuse/breaker blocks each can contain four fuses/breakers. The power feeds for the fuse/breakers in the option panels come from the jumpers at the bottom of the main panel. Relay sockets are installed as required.

A decal, showing the layout of the fuses, breakers and relays, is on the back of the fuse/breaker/relay panel cover. See **Fig. 11**.

The main panel holds 30 bayonet style fuses or circuit breakers. Along the sides of the panel are 14 relays; seven to a side. The top relays on each side

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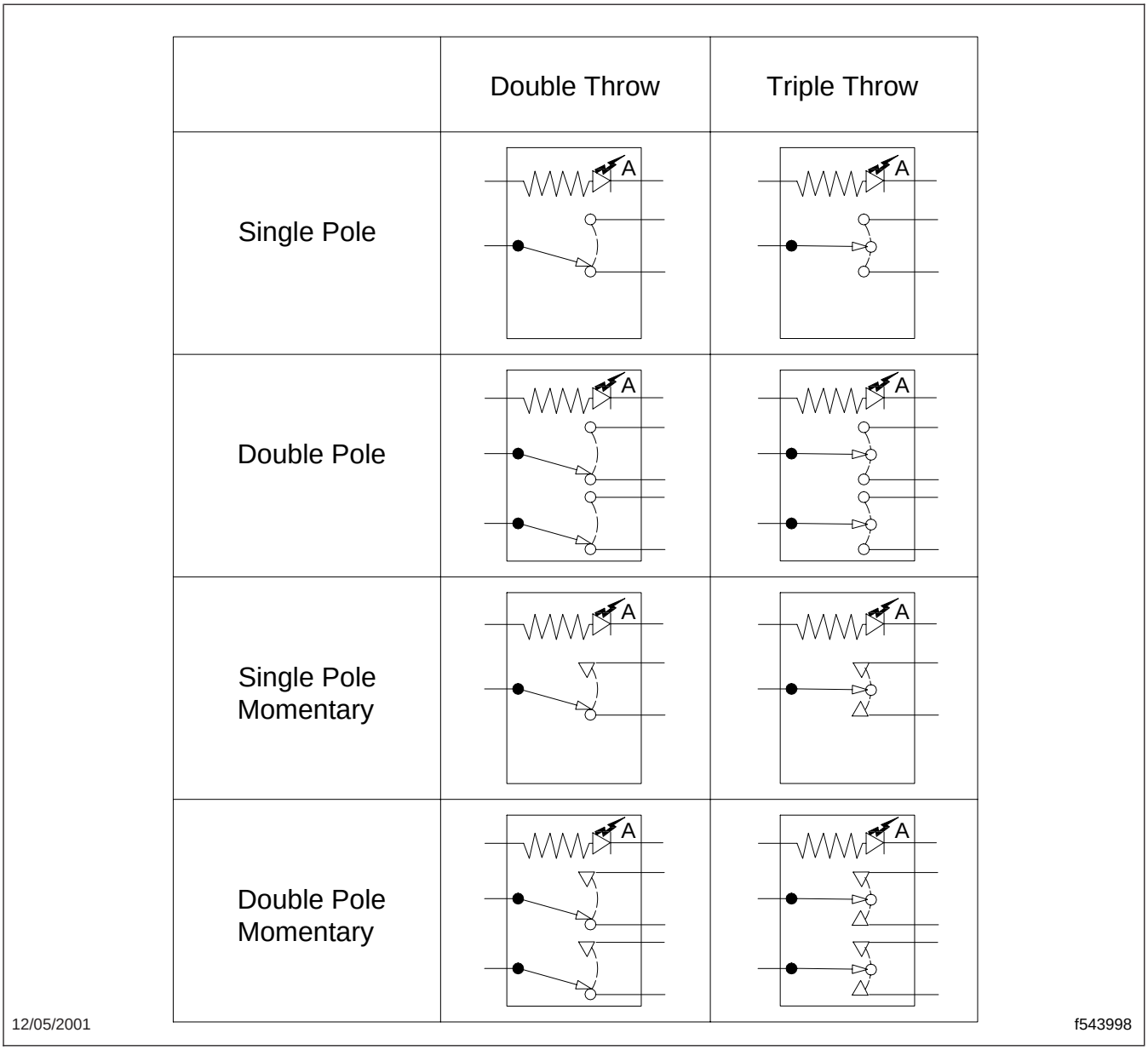



**Fig. 6, Switch Symbols**

are for *Accessory Power* and the other for *Ignition Power*. The rest of the relays are for circuits. There are 18 jumper connections in three rows across the bottom for optional equipment power sources. Each column uses a colored and indexed connector specific to the jumper column. See **Table 1**.

Battery power means that the circuit can be powered at all times with the ignition key removed. This has the potential to accidentally drain the batteries if left *ON*.

Ignition power means that the circuit can only be powered when the vehicle is running.

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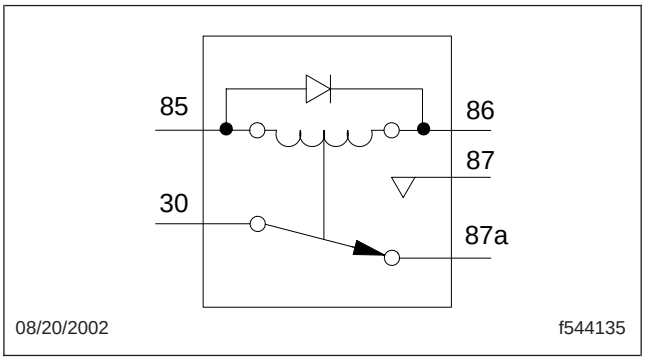
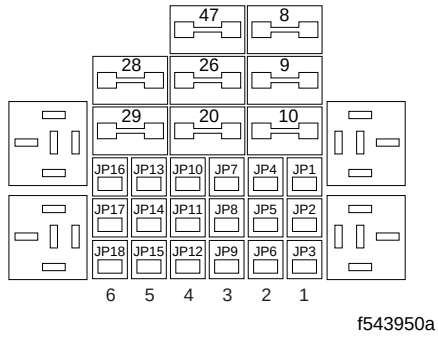



**Fig. 7, Relay Symbol**

Accessory power means that the circuit can be powered when the vehicle is running or turned *OFF* but the ignition key is turned to accessory.

**Jumper Power Locations and Sources**




| Column Number Right-to-Left | Color | Power Source |
|---|---|---|
| 1 | Green | Battery |
| 2 | Blue | Battery |
| 3 | Brown | Ignition |
| 4 | Black | Ignition |
| 5 | Orange | Accessory |
| 6 | Grey | Accessory |

**Table 1, Jumper Power Locations and Sources**

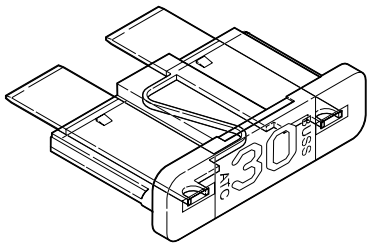
## Fuses

The fuses in the dash panels and some in-line fuses are bayonet style. See **Table 2**.

A few vendor-supplied harnesses contain glass tube style fuses in an in-line twist type holder. The fuse amperage is engraved on the top of the fuse. See **Fig. 12**.

The frontwall panel has a mega fuse installed in the engine compartment. See **Fig. 13**.

Bayonet Style Fuses




| Amperage | Color |
|---|---|
| 3 | Violet |
| 5 | Tan |
| 7.5 | Brown |
| 10 | Red |
| 15 | Blue |
| 20 | Yellow |
| 25 | White |
| 30 | Green |

**Table 2, Bayonet Style Fuses**

## Circuit Breakers

The circuit breakers in the dash panels are bayonet style. There are three types of breakers.

- Type I–These are self-resetting. When an overload occurs, heat build-up in the breaker causes the breaker contacts to snap open, preventing circuit meltdown. When the open contacts cool, the contacts snap back closed allowing the current to flow again. If the circuit is still in overload the points will open again. This will occur again and again until the overload condition is corrected. See **Fig. 14**.

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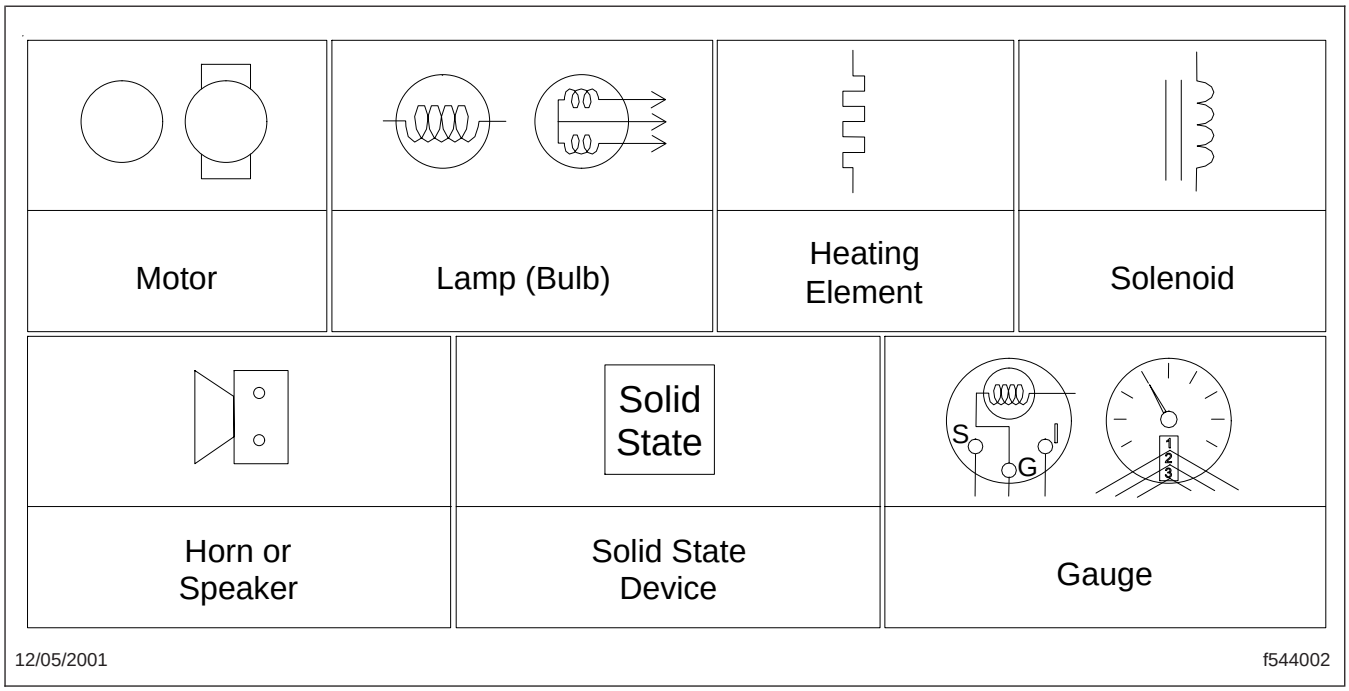
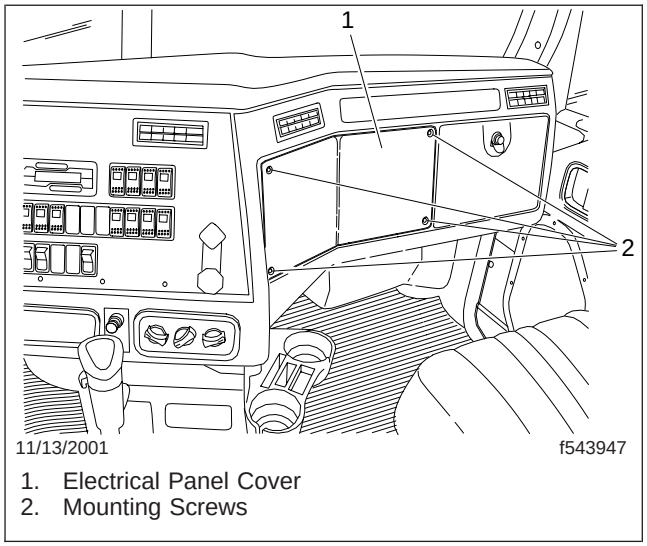
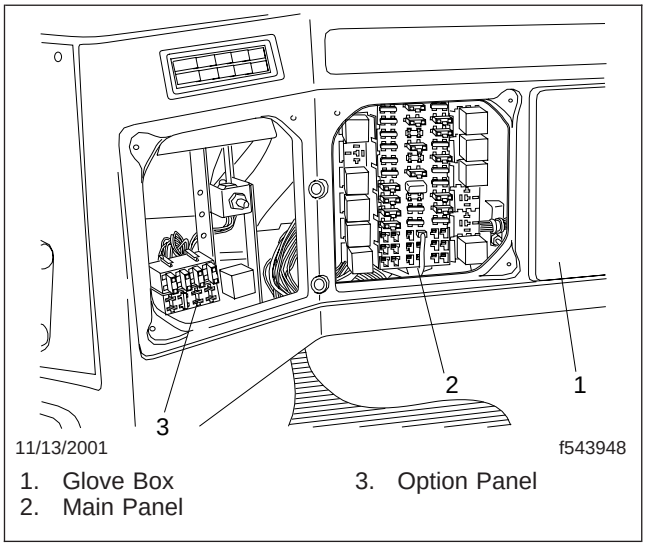



**Fig. 8, Appliance Symbols**




1. Electrical Panel Cover
2. Mounting Screws

**Fig. 9, Dash Panel**



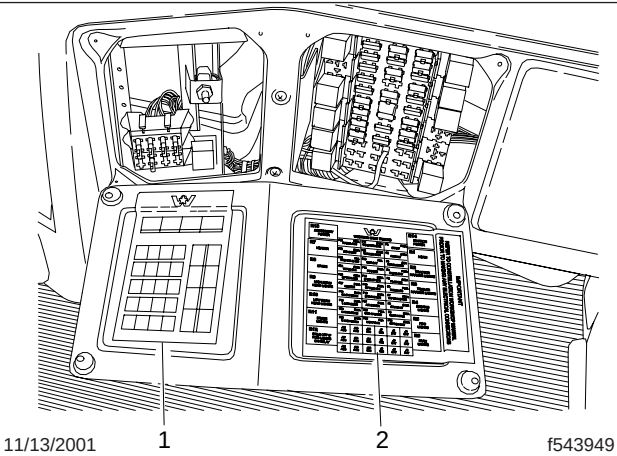

1. Glove Box
2. Main Panel
3. Option Panel

**Fig. 10, Open Electrical Panel**

- Type II—These are also self resetting. When an overload occurs heat build-up in the breaker causes the breaker contacts to snap open preventing circuit meltdown. The design of this breaker allows a reduced current flow through an internal resistor to keep the breaker hot as long as the overloaded circuit is turned on. Once the circuit is turned off the armature cools and the contracts snap together, closing the circuit and allowing full current to flow again. If the overload condition still exists, the contacts will again snap open and remain open

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1. Decal Option Panel 2. Decal Main Panel

**Fig. 11, Electrical Panel Decals**

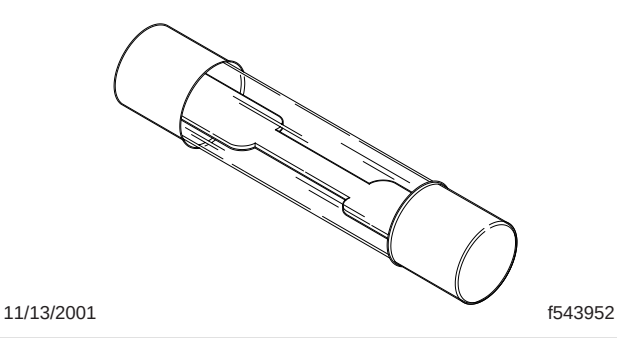



**Fig. 12, Glass Tube Style Fuse**

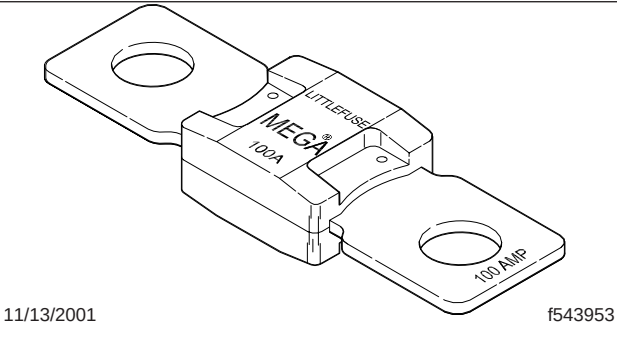



**Fig. 13, 100A Mega Fuse**

until the circuit is turned off and/or repaired. See **Fig. 14**.

- Type III—These are manual resetting. When an overload occurs heat build-up causes the breaker contacts to snap open, stopping the current flow, and preventing circuit meltdown. A small button pops up and after the circuit is repaired the button can be pressed down to reset the breaker's armature allowing the current to flow again. See **Fig. 15**.

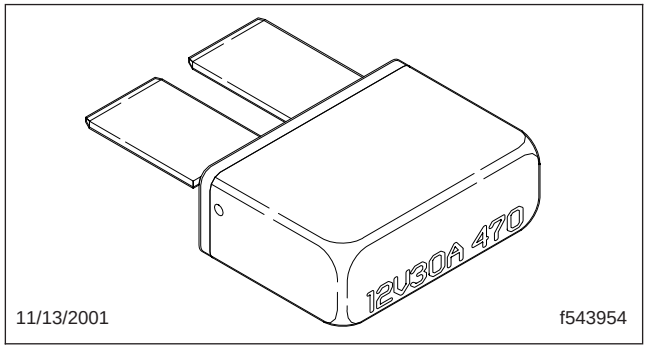



**Fig. 14, Type I and II Circuit Breaker, 30A**

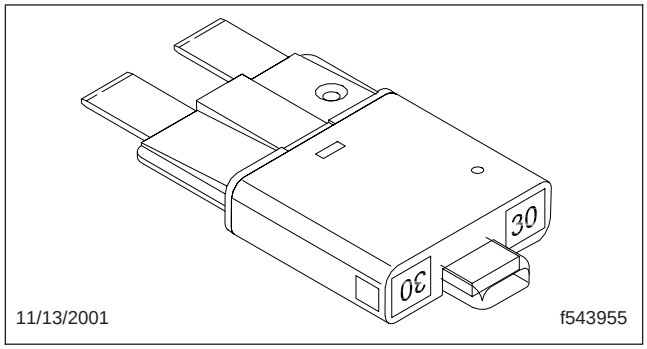



**Fig. 15, Type III Circuit Breaker, 8A, 10A, 15A, 20A, or 25A**

## Relays

Relays protect the switches by intercepting the electrical demand of the circuit before the switch. Relays use a magnetic coil to move the armature to either open a circuit or to close it. When a switch is closed low amperage power flows to the relay. The energized coil can then close the circuit allowing a separate high amperage power source to energize the intended circuit. The contacts of the switch are saved from the heat and damaging arcing, which occurs as the contacts come together or are pulled apart. See **Fig. 16** and **Fig. 17**.

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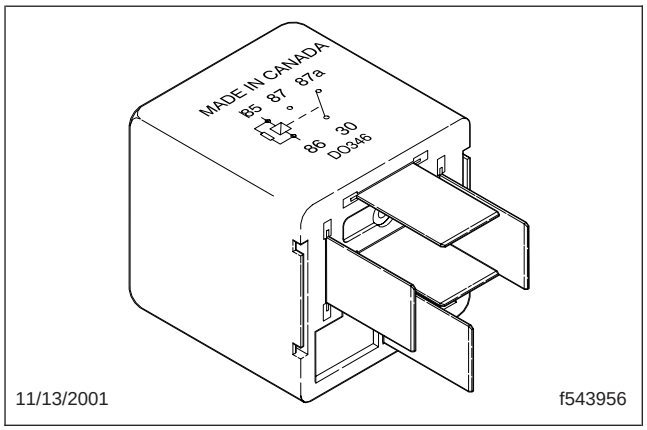



**Fig. 16, 40A-30A Relay**

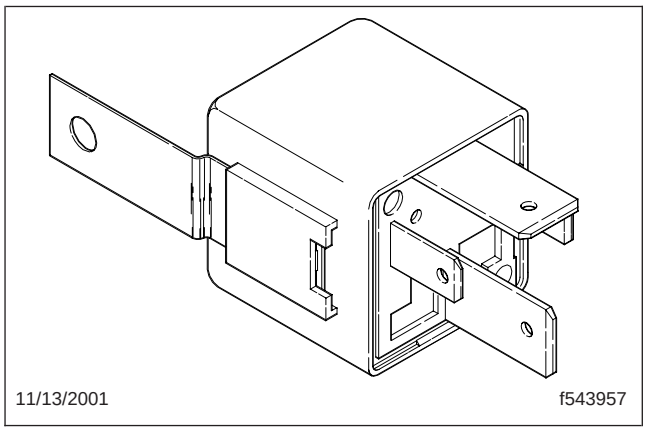



**Fig. 17, 70A Relay**

## Wiring

When replacing wiring, make sure to use the same size or a larger gauge wire. Western Star uses SXL copper stranded insulated wire for outside the cab circuits and GXL copper stranded insulated wire for inside the cab circuits. SXL wire has heavier insulation than GXL. Wire terminals come in various sizes to match the wire size. Western Star uses 20, 18, 16, 14, 12, 10, 8, 6, 4, and 00 gauge wires on its vehicles.

## Custom Added Circuits

When adding new circuits first find the total amperage required for each item in the new circuit. If there are several bulbs the amperage of all the bulbs must be added together to get the total amperage required. If the total amperage is close to the maximum that a specific wire gauge can safely handle always choose the next larger size, as the initial amperage draw will be higher than the normal draw. Find the total amperage in the table under amperes and find the distance the wire must run at the top of the columns at the left. Where the amperage row and the length column intersect, the wire gauge size is given. See **Table 3**.

Choose the power requirements for the added circuit. It is not recommended to place circuits on battery power unless it is required to have the circuit powered with the ignition *OFF*. Most circuits should be connected to ignition power. Use the jumper locations at the bottom of the main fuse panel. Run the power from the jumper location to an empty fuse location in the optional panel.

NOTE: Most extra switches installed at the factory are wired to a fuse block and only require the power and a fuse to be installed to power up the switch circuit. The wiring from the extra switch to the device it is intended to operate is not supplied and must be added, as previously shown.

| Amperes | Length of Circuit | | | | | | |
|---|---|---|---|---|---|---|---|
| | 3 ft (91 cm) | 5 ft (152 cm) | 7 ft (213 cm) | 10 ft (304 cm) | 15 ft (457 cm) | 20 ft (609 cm) | 25 ft (762 cm) |
| 0 to 5 | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| 6 to 7 | 18 | 18 | 18 | 18 | 18 | 18 | 16 |
| 8 | 18 | 18 | 18 | 18 | 18 | 16 | 16 |
| 10 | 18 | 18 | 18 | 18 | 16 | 16 | 16 |
| 11 to 12 | 18 | 18 | 18 | 18 | 16 | 16 | 14 |
| 15 | 18 | 18 | 18 | 16 | 14 | 14 | 12 |

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| Amperes | Length of Circuit | | | | | | |
|---|---|---|---|---|---|---|---|
| | 3 ft (91 cm) | 5 ft (152 cm) | 7 ft (213 cm) | 10 ft (304 cm) | 15 ft (457 cm) | 20 ft (609 cm) | 25 ft (762 cm) |
| 18 | 18 | 18 | 16 | 16 | 14 | 14 | 12 |
| 20 | 18 | 18 | 16 | 16 | 14 | 12 | 10 |
| 22 to 24 | 18 | 18 | 16 | 14 | 12 | 12 | 10 |
| 30 | 18 | 16 | 14 | 12 | 10 | 10 | 10 |
| 40 | 18 | 16 | 14 | 12 | 10 | 10 | 8 |
| 50 | 16 | 14 | 12 | 12 | 8 | 8 | 8 |
| 100 | 12 | 12 | 10 | 10 | 6 | 6 | 4 |
| 150 | 10 | 10 | 8 | 8 | 4 | 4 | 2 |
| 200 | 10 | 8 | 8 | 6 | 4 | 4 | 2 |

**Table 3, Amperage Over Distance Wire Gauge Table**

## Wiring Terminals

All wiring terminals should be corrosion-resistant. They should be a non-corrosive material such as brass, bronze, copper or coated with a non-corrosive material; such as cadmium, zinc, nickel or chrome. There are two types of wiring terminals; permanent and quick disconnect.

Permanent terminals are ring terminals used on studs or bolts. See **Fig. 18**.

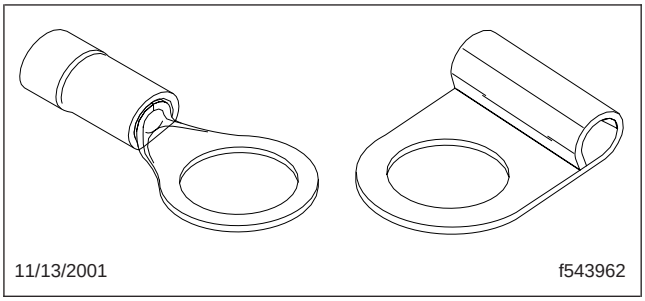



**Fig. 18, Ring Terminals**

Quick disconnect terminals are usually housed in a connector body. Two terminals are required, a male pin (**Fig. 19**) and a female socket (**Fig. 20**), or a male blade (**Fig. 21**) and a female slot (**Fig. 22**). The male terminal is pressed into the female terminal to complete the circuit.

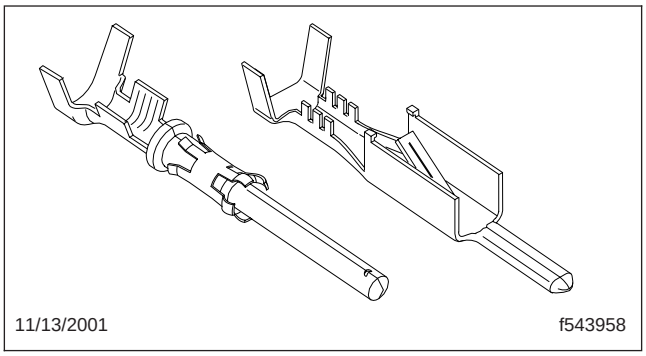



**Fig. 19, Male Pin Terminal**

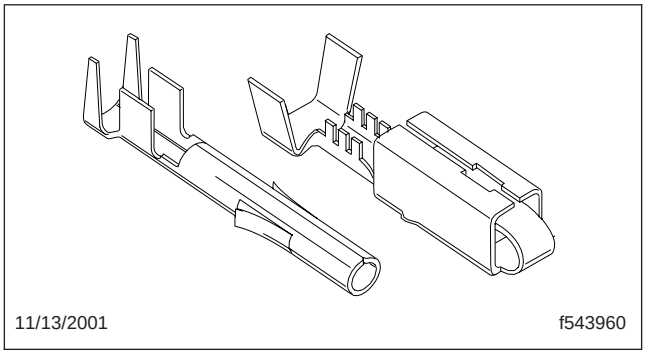



**Fig. 20, Female Socket Terminal**

NOTE: All exposed terminals should be sprayed with a dielectric sealant. Terminals housed in connectors should have a coating of dielectric grease.

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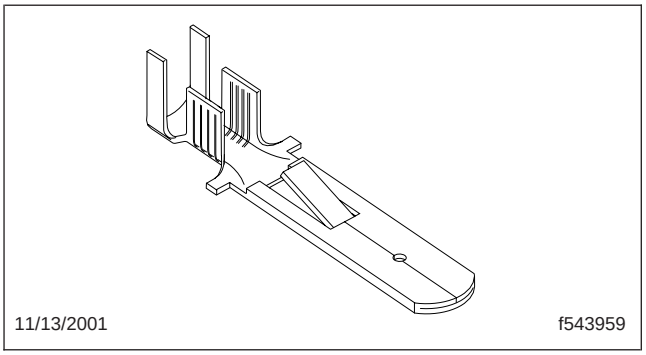



**Fig. 21, Male Blade Terminal**

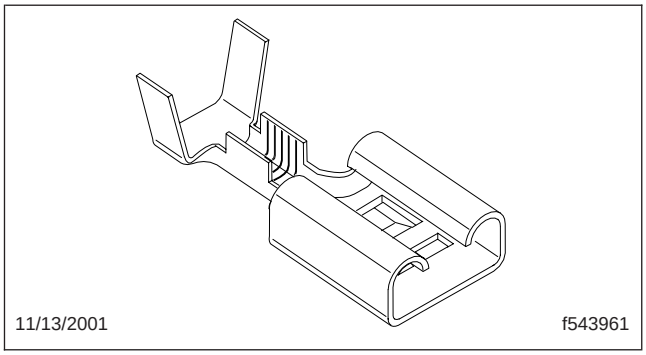



**Fig. 22, Female Slot Terminal**

Several terminals may be bundled together in a housing (connector). The housings are also made to connect one into another. These connectors are refered to as *plugs* (male, usually attached to the wiring harness) and *jacks* (female, part of an appliance or attached to objects). Some connectors are fitted with weatherproof seals, depending on where they are located (inside the cab or outside). Male connectors usually have female terminals and female connectors usually house the male terminals.

Connectors used outside the cab should be weatherproof type such as Weather Pack® connectors.

## Studs

Threaded studs are usually used as ground points, but there are also battery power studs on the frontwall. Western Star uses wires with ring or flag terminals where the connection is a stud. The contact area where the ring terminal will contact should be clean of corrosion and paint. Once the nut has been tightened on the ring terminal, spray the connection with dielectric red enamel. See **Table 4** for the recommended protectant type for various electrical connections.

| Electrical Component Protection Locations | |
|---|---|
| **Protection** | **Component** |
| Dielectric Red Enamel | Alternator |
| | Battery Cut-Off Switch Connections |
| | Bolt and Stud Ground Connections (outside cab) |
| | Exposed Battery Cable Connections (located outside of battery box) |
| | Magnetic Switch |
| | MEGA Fuses (when located outside of battery box) |
| | Starter—All Exposed Connections |
| Dielectric Grease Petroleum | Battery Interconnect Cable Connections |
| | Battery Terminals |
| | Engine Heater Receptacle Boot |
| | MEGA Fuses (if located in battery box) |
| | Tail Lamp Bulb Sockets (non LED) |
| Dielectric Grease Synthetic | 7-Way Receptacles |
| | MCM Connector on DDC and M-B Engines |
| | Rear Chassis-Mounted PDM Connectors |

**Table 4, Electrical Component Protection Locations**

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## Component Locations

See **Fig. 23** for the locations of electrical components on the frontwall engine side.

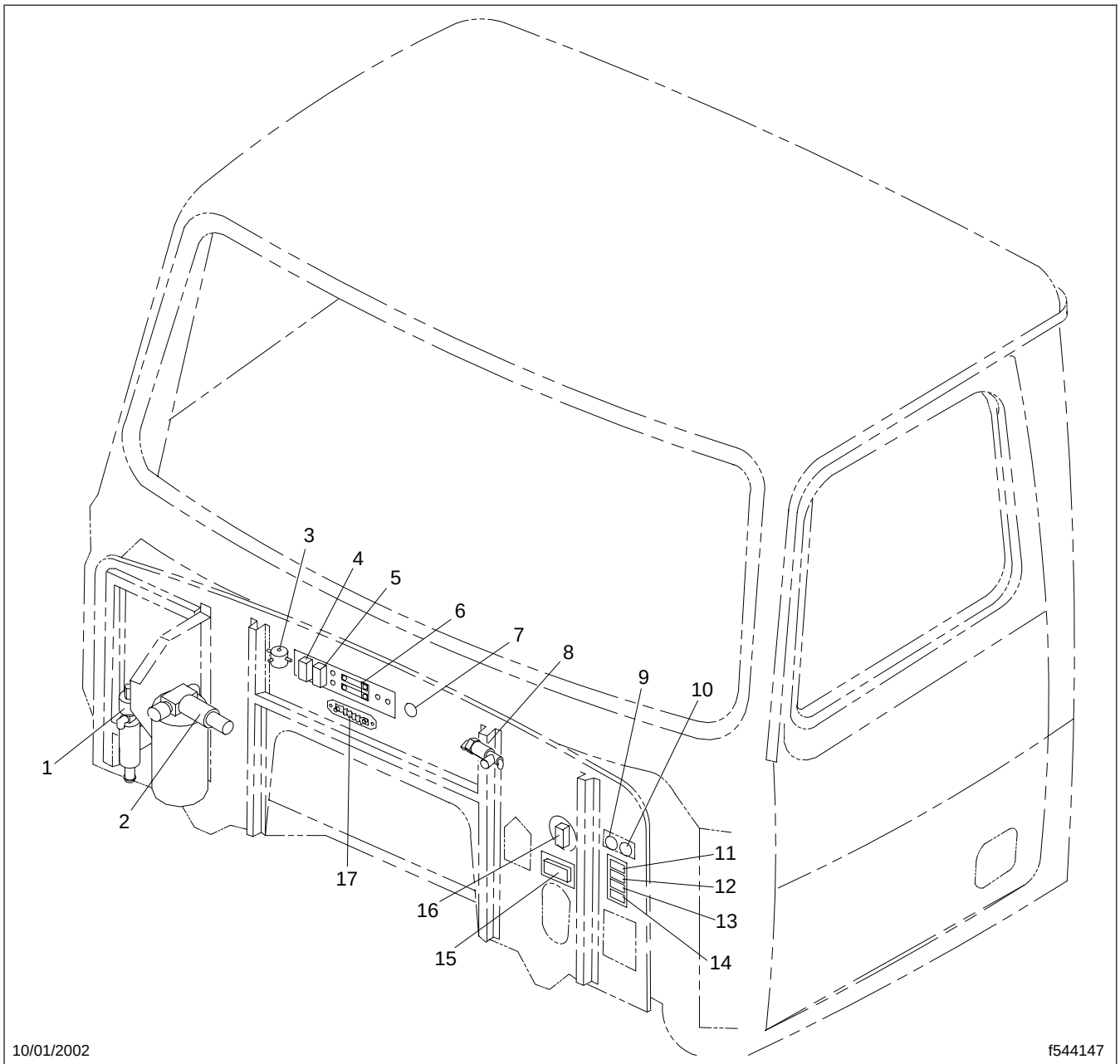
See **Fig. 24** for a detailed engine-side view of the frontwall bus bar connectors.

See **Fig. 25** for the location of the cab interior electrical components.

See **Fig. 26** for the location of dash electrical connnectors.

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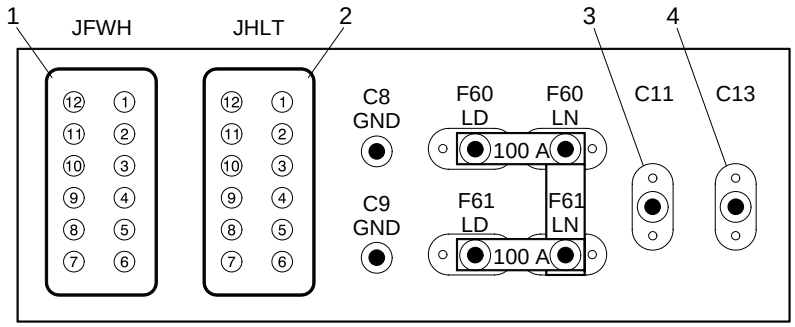

1. Water Valve Solenoid
2. Trinary Switch
3. Starter Relay
4. JFWH Black Connector
5. JHLT Grey Connector
6. Two 100-Amp Megs
7. Wabasto Connector
8. Fan Control Relay
9. JABT Connector
10. JTLR Connector
11. JSST Brown Connector
12. JSPR Green Connector
13. JABS Black Connector
14. JTLT Grey Connector
15. JE Connector
16. CEEMAT Connector
17. Shunt

**Fig. 23, Frontwall Electrical Components, Engine Side**

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## General Information



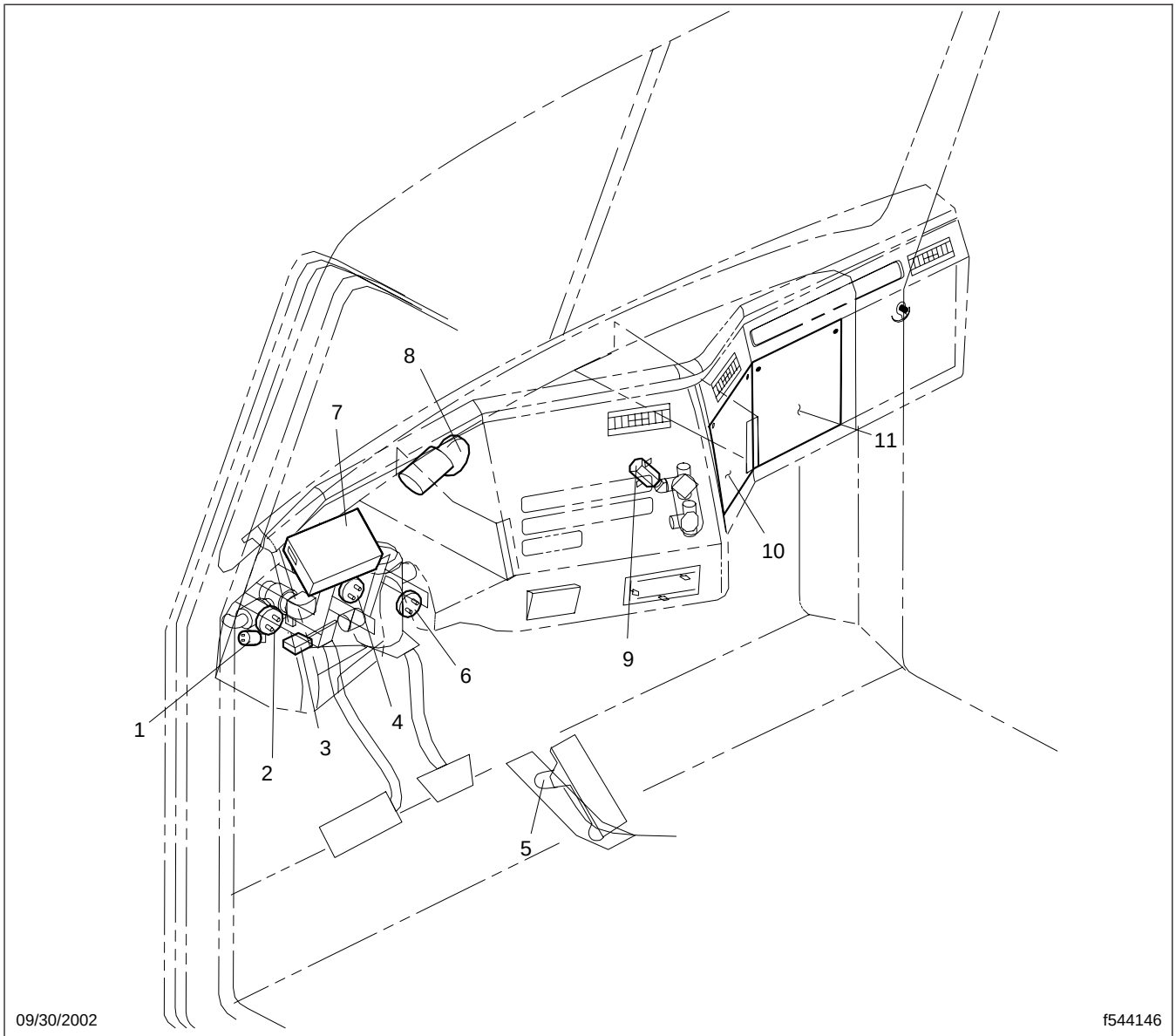

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1. JFWH Black Connector
2. JHLT Grey Connector
3. Engine Power Stud
4. Engine Ground Stud

**Fig. 24, Frontwall Bus Bar Connectors, Engine Side**

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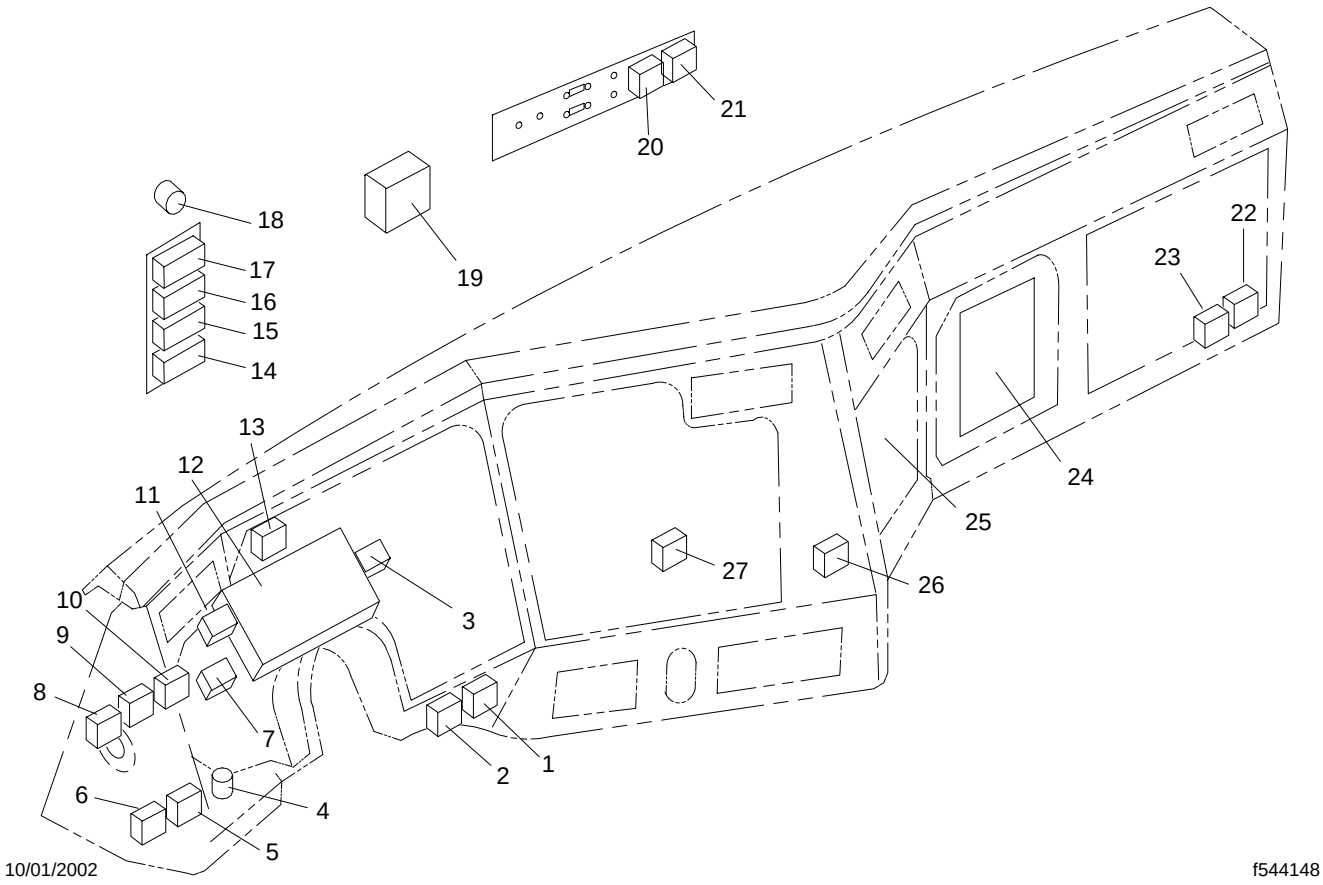

1. Brake Application Sensing Switches
2. Stop Lamp Switch
3. Clutch Switch
4. *B* Side Low Air Switch
5. Throttle Position Switch
6. *A* Side Low Air Switch
7. Electronic Control Center (ECC)
8. Wiper Motor
9. Park Brake Switch
10. Optional Fuses, Relays and Diagnostic Switches
11. Standard Fuses and Relays

**Fig. 25, Cab Interior Electrical Component Locations**

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## General Information




1. PTSS
2. PBSS
3. PECE
4. JDIA
5. PLPM
6. PLHD
7. PECP
8. POHC
9. JSSP
10. JSSS
11. PECV
12. ECC
13. PECL
14. JTLT Grey
15. JABS Black
16. JSPR Green
17. JSST Brown
18. JTLR
19. JE
20. JHLT Grey
21. JFWH Black
22. PRHD
23. PRPM
24. Relay, Breaker and Fuse Area
25. Optional Breaker and Fuse Area
26. PHTR
27. PWM

**Fig. 26, Dash Electrical Connectors**

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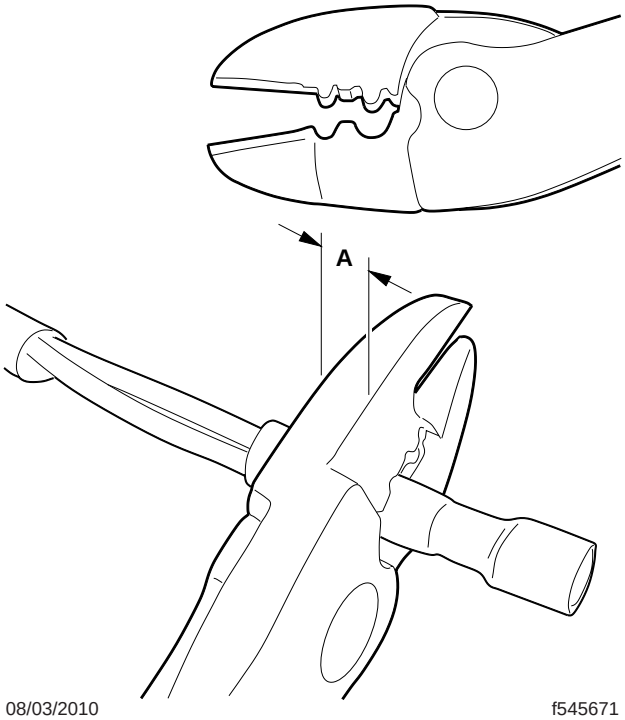
# Wiring Repair Using Phillips STA-DRY® Solderless Connectors

## Parts and Tools

Parts are available through the Parts Distribution Centers (PDCs) in packages of 25 connectors. Use the connectors and adhesive lined shrinkable tubing shown in **Table 1** when making a wiring splice.

Tools needed for wiring repair using solderless connectors include the following.

- A dimple-type crimp tool with a minimum 3/16-inch (7.6-cm) width. See **Fig. 1** for an example of a proper crimp tool. A typical manufacturer for this tool is Thomas & Betts.
- A heat gun rated at 1000°F (538°C).




A. Minimum 3/16-inch (8-cm) width.

**Fig. 1, Dimple-Type Crimp Tool**

## Procedure

1. Dress the wires to be spliced by stripping the insulation to expose 1/4 inch (2.5 cm) of copper. Slide a 3-inch (7.6-cm) section of adhesive coated shrink tubing onto one of the wires.
2. Crimp the splice connector onto the wires. Use the type of crimp tool that makes a dimple in the connector. The dimple must be at least 3/16-inch (7.6-cm) wide or there will be too much space inside the connector and the solder will not flow into the wire. This crimp provides the mechanical retention needed. See **Fig. 2**.

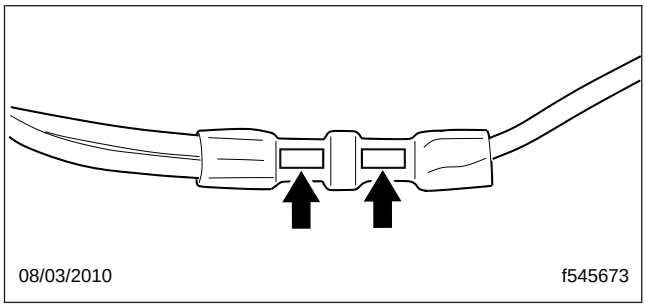



**Fig. 2, Properly Crimped Splice**

3. Pull test the wires by hand to ensure the crimp is mechanically solid.

IMPORTANT: A crimp tool that is too narrow will leave excessive air gaps in the crimp. The connection will not have the required amount of mechanical strength and the solder will not bond the wire to the connector. **Figure 3** shows an example of a bad crimp when the wrong tool is used.

4. Heat the properly crimped splice connector with the heat gun while slowly rotating the wire. The solder will take longer to flow than it will for the shrinkable insulation to contract. Heat until the solder band has completely melted into the connector. If the shrinkable insulation ruptures and a small amount of solder bubbles out, gently shake the splice to remove the solder. See **Fig. 4**.
5. When the connector has cooled, center the shrinkable tubing over the splice and heat the tubing until it has completely sealed the splice and a small fillet of adhesive is visible at the ends of the shrink tube. See **Fig. 4**.
6. A three-wire tap splice can be made following the same procedure. Use a connector that is large enough to fit all the strands of the wires. See **Fig. 5** for an example of the completed splice.

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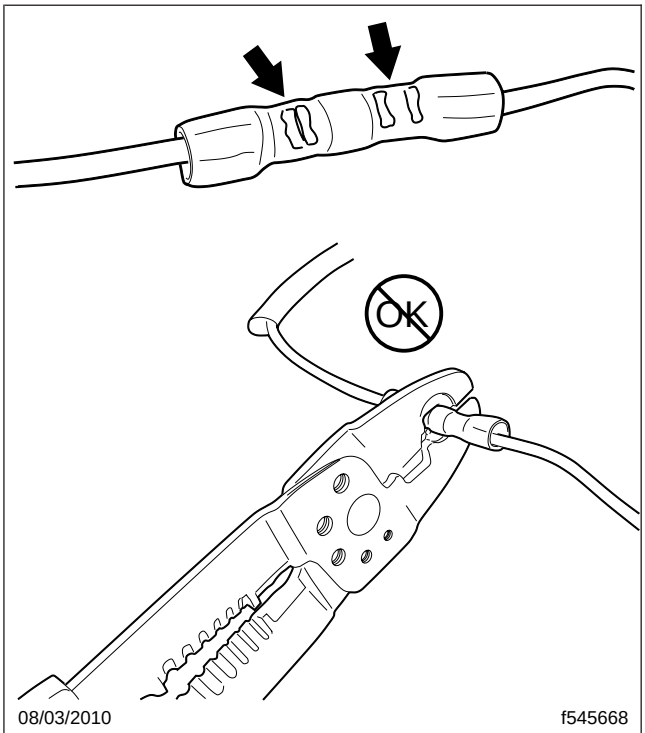


# Wiring Repair Using Phillips STA-DRY® Solderless Connectors

| Solderless Connector Parts | | |
|---|---|---|
| **Wire Size: gauge (mm)** | **Connector Part Number*** | **Shrinkable Tubing (Daimler Part Number)** |
| 20 to 18 (0.5 to 0.8) | PHM 1 1863 | 1/4 inch (2.5 cm) with internal adhesive coating (48-02461-025) |
| 16 10 14 (1 to 2) | PHM 1 1862 | 1/4 inch (2.5 cm) with internal adhesive coating (48-02461-025) |
| 12 to 10 (3 to 5) | PHM 1 1861 | 3/8 inch (7.6 cm) with internal adhesive coating–4 foot length (48-02461-038) |
| 8 or larger (5 or larger) | Replace the terminal or the entire cable | Use adhesive lined red for positive cables and black for negative cables. |

* Twenty-five connectors per pack.

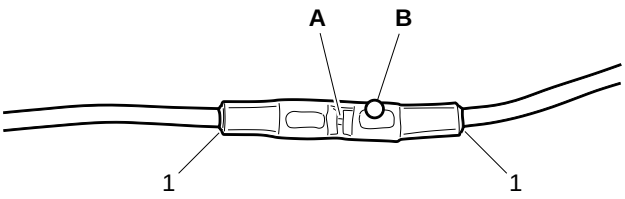
**Table 1, Solderless Connector Parts**




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NOTE: Even with two crimps, there is too much air gap; the solder will not bond.

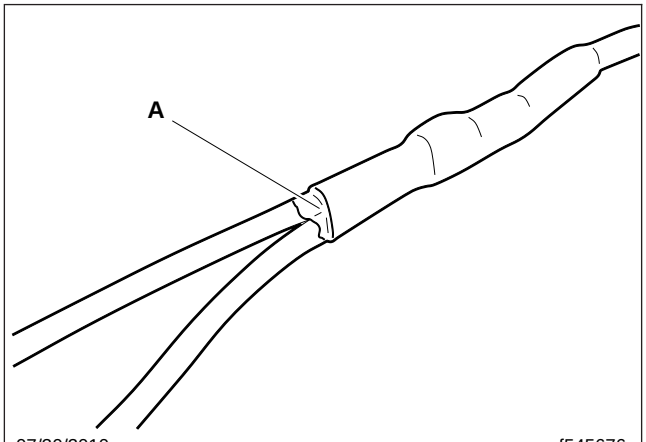
**Fig. 3, Wrong Tool Being Used and a Crimp That Will Fail**




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A. The solder band is completely melted.
B. Insulation rupture; gently shake off the solder bead.
1. Adhesive Fillet

**Fig. 4, Solder Bead Rupture**




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A. The fillet of adhesive at the ends of the shrink tube indicate a complete seal.

**Fig. 5, Completed Three-Wire Tap Splice**

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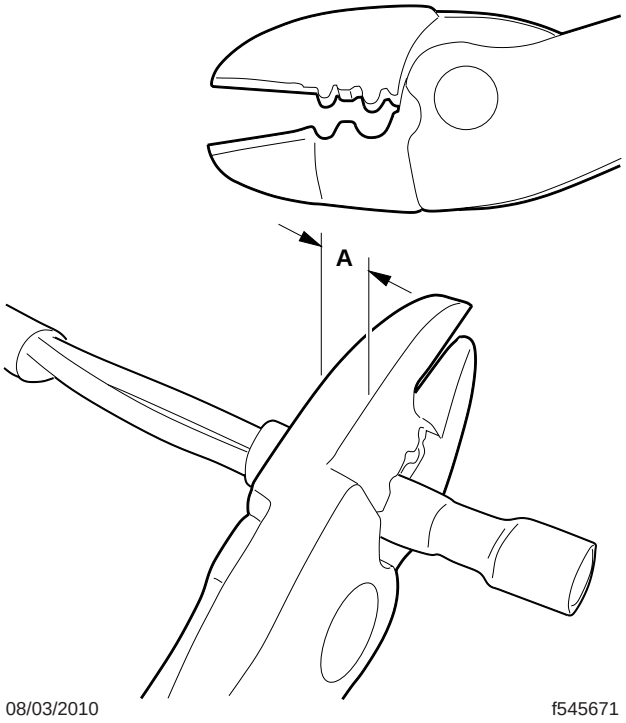
# Wiring Repair Using Daimler Trucks North America (DTNA) Kit ESY ES66 404

## Parts and Tools

Parts are available through the Parts Distribution Centers (PDCs) in kits with material for 50 splices. This kit may be used on 16 to 14 gauge (1 to 2 mm) wire.

Tools needed for wiring repair using solderless connectors include the following.

- A dimple-type crimp tool with a minimum 3/16-inch (7.6-cm) width. See **Fig. 1** for an example of a proper crimp tool. A typical manufacturer for this tool is Thomas & Betts.
- A heat gun rated at 250°F (121°C).




A. Minimum 3/16 inch (7.6 cm) width.

**Fig. 1, Dimple-Type Crimp Tool**

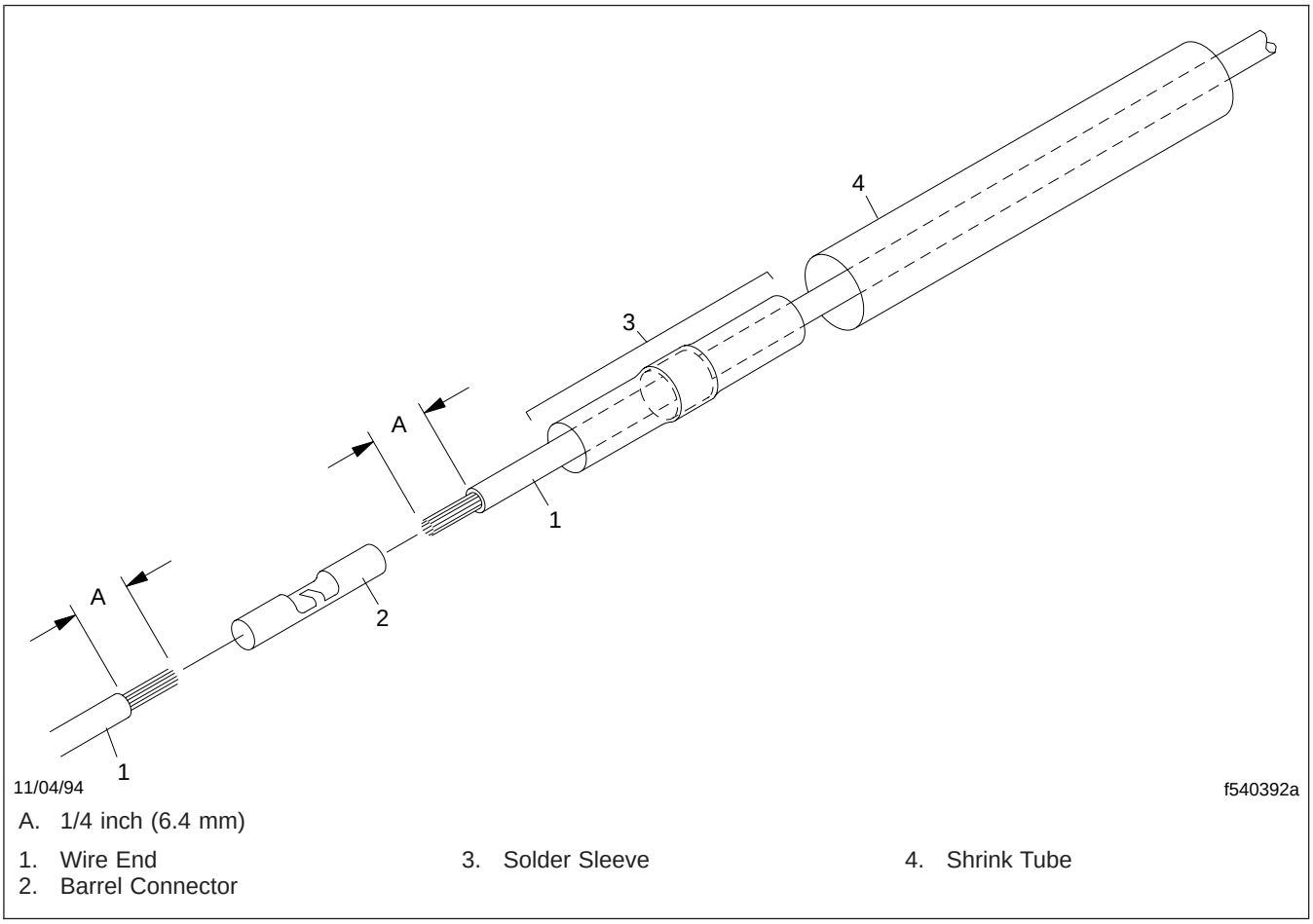
## Procedure

1. Dress the wires to be spliced by stripping the insulation to expose 1/4 inch (2.5 cm) of copper. Slide a piece of the shrink tubing from the kit onto one of the wires.
2. Slide a shrinkable solder sleeve from the kit onto one of the wires.
3. Place the wires that will be spliced into each end of the barrel connector. See **Fig. 2** for an example of the splice.
4. Crimp each end of the barrel using a dimple-type crimp tool to secure the wires. See **Fig. 1** for an example of a proper crimp tool.
5. Pull test the wires by hand to ensure the crimp is mechanically solid.
6. Slide the shrinkable solder sleeve onto the barrel connector so the solder band is at the center of the barrel connector.
7. Heat the splice using a heat gun rated at 250°F (121°C) until the sleeve has completely shrunk against the wire and the solder flows into the barrel connector. A small fillet of adhesive may be visible at the ends of the connector. See **Fig. 3**.
8. Slide the shrinkable tubing over the splice and apply heat with a heat gun rated at 250°F (121°C) until it has completely shrunk against the wire insulation. A small fillet of adhesive should be visible at the ends of the shrinkable tubing.

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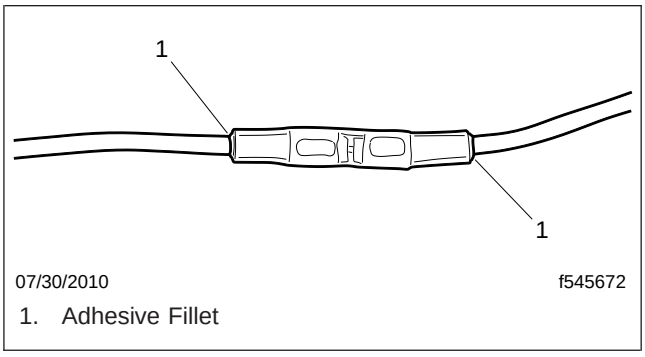
# Wiring Repair Using Daimler Trucks North America (DTNA) Kit ESY ES66 404




A. 1/4 inch (6.4 mm)

1. Wire End
2. Barrel Connector
3. Solder Sleeve
4. Shrink Tube

**Fig. 2, Splice Prepared with Parts in Kit ESY ES66 404**




1. Adhesive Fillet

**Fig. 3, Heated Solder Sleeve with Solder Band Melted into the Splice**

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## Single Wire Codes

Western Star utilizes a coding system to create the part number for single wire cable assemblies. Using the part number, a complete description of the cable assembly can be determined, using the following example in **Table 1**.

Use the following tables in this section to break down the components in any single cable assembly.

| Example: W14BF-BM066ST12 Single Cable Assembly Codes | | |
|---|---|---|
| **Symbol** | **Description** | **Instructions** |
| W | Insulation Color Code | See **Table 2**, Color Codes |
| 14 | Wire Gauge Symbols | See **Table 3**, Wire Gauges |
| BF | Terminal Symbols | See the following Single Wire Code Tables |
| — | Unprotected cable assembly (an X in place of the dash indicates loom required). | See **Table 4**, Protective Loom |
| BM | Terminal Symbol | See the following Single Wire Code Tables |
| 066 | Length in Inches (66 inches) | N/A |
| ST12 | Circuit Number | N/A |

**Table 1, Example: Single Cable Assembly Codes**

| Code | Color |
|---|---|
| A | Orange |
| B | Blue |
| G | Green |
| N | Black |
| R | Red |
| T | Tan |
| U | Brown |
| W | White |
| Y | Yellow |

**Table 2, Standard Wiring Color Codes**

| Wire Gauge Symbol | Wire Gauge Size |
|---|---|
| 18 | 18 |
| 16 | 16 |
| 14 | 14 |
| 12 | 12 |
| 10 | 10 |
| 8 | 8 |
| 6 | 6 |
| 4 | 4 |
| 2/0 | 00 |
| 3/0 | 000 |

**Table 3, Wire Gauges**

| Fits Wire Gauge | Nominal Size |
|---|---|
| 12–16 | 3/16 |
| 8–10 | 1/4 |
| 4–6 | 5/16 |

**Table 4, Protective Loom**

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## Single Wire Codes

**Single Wire Codes—A**

| Single Wire Codes—A | | | |
|---|---|---|---|
| **Terminal Symbol** | **Terminal Description** | **Wire Size** | **Stud Size** |
| AA | Cut end only | — | All |
| AB | Flag, uninsulated | 6 | #10 |
| AC | Flag, uninsulated | 6 | 1/4 |
| AD | Flag, uninsulated | 6 | 5/16 |
| AE | Flag, uninsulated | 6 | 3/8 |
| AF | Ring, uninsulated | 6 | #10 |
| AG | Ring, uninsulated | 6 | 1/4 |
| AH | Ring, uninsulated | 6 | 5/16 |
| AJ | Ring, uninsulated | 6 | 3/8 |
| AK | Ring, uninsulated | 6 | 1/2 |
| AL | Flag, uninsulated | 8 | #10 |
| AM | Flag, uninsulated | 8 | 1/4 |
| AN | Flag, uninsulated | 8 | 5/16 |
| AP | Flag, uninsulated | 8 | 3/8 |
| AQ | Ring, uninsulated | 8 | #10 |
| AR | Ring, uninsulated | 8 | 1/4 |
| AS | Ring, uninsulated | 8 | 5/16 |
| AT | Ring, uninsulated | 8 | 3/8 |
| AU | Ring, uninsulated | 8 | 1/2 |
| AV | Ring, uninsulated | 8 | 5/8 |
| AW | Flag, uninsulated | 10–12 | #10 |
| AY | Flag, uninsulated | 10–12 | 1/4 |

**Single Wire Codes—C**

| Single Wire Codes—C | | | |
|---|---|---|---|
| **Terminal Symbol** | **Terminal Description** | **Wire Size** | **Stud Size** |
| CA | Ring, battery terminal, uninsulated | 2/0 | 3/8 |
| CB | Ring, battery terminal, uninsulated | 2/0 | 1/2 |
| CC | Flag, battery terminal, uninsulated | 2/0 | 3/8 |
| CD | Battery, negative | 2/0 | — |
| CE | Battery, positive | 2/0 | — |

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| Single Wire Codes—C | | | |
|---|---|---|---|
| **Terminal Symbol** | **Terminal Description** | **Wire Size** | **Stud Size** |
| CF | Ring, battery terminal, uninsulated | 3/0 | 3/8 |
| CG | Ring, battery terminal, uninsulated | 3/0 | 1/2 |
| CH | Flag, battery terminal, uninsulated | 3/0 | 3/8 |
| CJ | Battery, negative | 3/0 | — |
| CK | Battery, positive | 3/0 | — |
| CL | Ring, battery terminal, uninsulated | 2/0 | 5/16 |
| CM | Ring, battery terminal, uninsulated | 3/0 | 5/16 |
| CN | Ring, battery terminal, uninsulated | 6 | 3/8 |
| CP | Ring terminal, uninsulated | 4 | 3/8 |
| CQ | Ring terminal, uninsulated | 4 | #10 |
| CR | Ring terminal, uninsulated | 4 | 5/16 |
| CS | Ring terminal, uninsulated | 4 | 3/8 |
| CT | Ring terminal, uninsulated | 4 | 1/2 |
| CU | Ring terminal, insulated | 8 | 1/4 |
| CV | Ring terminal, insulated | 18–22 | #6 |
| CW | Ring terminal, insulated | 18–22 | #8 |
| CY | Ring terminal, insulated | 18–22 | #10 |
| CZ | Ring terminal, insulated | 18–22 | 1/4 |

**Single Wire Codes—D**

| Single Wire Codes—D | | | |
|---|---|---|---|
| **Terminal Symbol** | **Terminal Description** | **Wire Size** | **Stud Size** |
| DA | Tab, male push-on, thin blade | 14–18 | — |
| DB | Strip 1/4-inch insulation | All | — |
| DC | Tab, male push-on | 14–16 | — |
| DD | Tab, female push-on | 14–16 | — |
| DE | Butt splice, insulated | 14–16 | — |
| DF | Button, indicator lamp socket | 16–20 | — |
| DG | Butt splice | 14–16 | — |
| DH | Male pin—Packard 12010085 | 14–16 | — |

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## Single Wire Codes

| Single Wire Codes—D | | | |
|---|---|---|---|
| **Terminal Symbol** | **Terminal Description** | **Wire Size** | **Stud Size** |
| DJ | Female sleeve—Packard 12010182 | 14–16 | — |
| DK | Deutsch pin | 16–18 | — |
| DL | Deutsch socket | 16–18 | — |
| DM | Deutsch pin | 14–16 | — |
| DN | Deutsch socket | 14–16 | — |
| DP | Male pin—Packard 12033674 | 18–20 | — |
| DQ | Female pin—Packard 12034051 | 18–20 | — |
| DR | Female push-on straight (non-locking) | 14–16 | — |
| DS | Amp socket | 14–20 | — |
| DT | Terminal PED 56 series female | 12–16 | — |
| DU | Terminal PED 56 series female | 18–20 | — |
| DV | Micropack socket terminal | 16–18 | — |
| DW | Deutsch pin | 16–18 | — |
| DY | Deutsch socket | 16–18 | — |

**Single Wire Codes—G and H**

| Single Wire Codes—G and H | | | |
|---|---|---|---|
| **Terminal Symbol** | **Terminal Description** | **Wire Size** | **Stud Size** |
| GA | Terminal, Shur plug receptical (lighter) | 16–20 | — |
| GB | Terminal, female push-on with male tab | 14–16 | — |
| HB | Heavy-duty ring, uninsulated | 10–12 | — |
| HC | Heavy-duty ring, uninsulated | 10–12 | — |
| HD | Heavy-duty ring, uninsulated | 12–16 | — |

**Single Wire Codes—J**

| Single Wire Codes—J | | | |
|---|---|---|---|
| **Terminal Symbol** | **Terminal Description** | **Wire Size** | **Stud Size** |
| JA | Option terminal | 18–20 | — |
| JB | Option terminal | 18–20 | — |

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| Single Wire Codes—J | | | |
|---|---|---|---|
| **Terminal Symbol** | **Terminal Description** | **Wire Size** | **Stud Size** |
| JC | Option terminal | 18–20 | — |
| JD | Option terminal | 18–20 | — |
| JE | Option terminal | 18–20 | — |
| JF | Option terminal | 18–20 | — |
| JG | Option terminal | 14–16 | — |
| JH | Option terminal | 14–16 | — |
| JJ | Option terminal | 14–16 | — |
| JK | Option terminal | 14–16 | — |
| JL | Option terminal | 14–16 | — |
| JM | Option terminal | 14–16 | — |
| JN | Option terminal | 10–12 | — |
| JP | Option terminal | 10–12 | — |
| JQ | Option terminal | 10–12 | — |
| JR | Option terminal | 10–12 | — |
| JS | Option terminal | 10–12 | — |
| JT | Option terminal | 10–12 | — |

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# Component Codes

Connectors are listed in alphabetical order by the electrical schematic code and description. This code can then be used to look up the connector loading plans in **Subject 420**.

**A—Alarms**

| A—Alarms | | | |
|---|---|---|---|
| **Code** | **Location** | **Type** | **Function** |
| A1 | Optimized Idle | 77Db continuous tone | Optimized idle engine start warning alarm |

**AMP—Amplifier**

| AMP—Amplifier | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| AMP1 | Sleeper | Sub-woofer amplifier |

**AT—Actuators**

| AT—Actuators | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| AT1 | Door locks | Power door lock actuator left-hand side |
| AT2 | Door locks | Power door lock actuator right-hand side |

**CB—CB Radio**

| CB—CB Radio | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| CB1 | CB harness | CB radio |

**CL—Clock**

| CL—Clock | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| CL1 | Sound system harness | Clock |
| CL2 | Sleeper harness sleeper | Clock |

**CP—Crossover Speakers**

| CP—Crossover Speakers | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| CP1 | Overhead console | Crossover right front speaker |
| CP2 | Overhead console | Crossover right front optional tweeter |
| CP3 | Overhead console | Crossover left front speaker |

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## Component Codes

| CP—Crossover Speakers | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| CP4 | Overhead console | Crossover left front optional tweeter |
| CP5 | Overhead console | Crossover optional sub-woofer (right channel) |
| CP6 | Overhead console | Crossover optional sub-woofer (left channel) |

**D—Diodes**

| D—Diodes | | | |
|---|---|---|---|
| **Code** | **Location** | **Type** | **Function** |
| D1 | Engine harness | Three Amp | Fan control solenoid flyback |
| D2 | Power harness | Three Amp | AC compressor solenoid flyback |
| D4 | Mechanical engine harness | Three Amp | Engine brake solenoid flyback |
| D5 | Mechanical engine harness | Three Amp | Engine brake solenoid flyback |
| D6 | Mechanical engine harness | Three Amp | Fuel solenoid flyback |
| D7 | Power harness | Three Amp | Alternator field current |
| D8 | C8.3 engine harness | Three Amp | Fuel solenoid pull in flyback |
| D9 | 42-inch and 66-inch sleeper harness | Three Amp | Right luggage light control |
| D10 | 42-inch and 66-inch sleeper harness | Three Amp | Right luggage light control |
| D11 | SuperPac (3406C) | Three Amp | SuperPac warm-up solenoid flyback |
| D12 | SuperPac (3406C) | Three Amp | SuperPac exhaust brake solenoid flyback |
| D13 | Tandem differential lock | Three Amp | Front signal to buzzer |
| D14 | Tandem differential lock | Three Amp | Rear signal to buzzer |
| D15 | Auto Select transmission | Three Amp | Start enable relay latch |
| D16 | Sleeper start | Three Amp | Ignition switch to water temperature gauge |
| D17 | Bogaard timer | Six Amp | Ignition keep alive circuit isolation |

**FSE—FlameStart Electronic Control Unit**

| FSE—FlameStart Electronic Control Unit | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| FSE | FlameStart ECU | Cat 3406C |

**F—Fuses and Circuit Breakers F01 through F50**

| F—Fuses and Circuit Breakers F01 through F50 | | | | |
|---|---|---|---|---|
| **Code** | **Location** | **Function** | **Type** | **Size** |
| F01 | Main fuse block | Start switch | Breaker | 8 |
| F02 | Main fuse block | Park lamps | Breaker | 15 |

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| F—Fuses and Circuit Breakers F01 through F50 | | | | |
|---|---|---|---|---|
| **Code** | **Location** | **Function** | **Type** | **Size** |
| F03 | Main fuse block | Headlamp switch | Breaker | 8 |
| F04 | Main fuse block | Sound system battery source | Breaker | 8 |
| F05 | Main fuse block | ECC flasher power | Breaker | 20 |
| F06 | Main fuse block | Cab interior lamps | Breaker | 8 |
| F07 | Main fuse block | Not used | Breaker | 8 |
| F08 | Main fuse block | Brake lamps | Breaker | 15 |
| F09 | Main fuse block | Electric horn | Breaker | 10 |
| F10 | Main fuse block | Option harness battery | Fuse | 30 |
| F11 | Main fuse block | Tractor marker lamps | Breaker | 15 |
| F12 | Main fuse block | Trailer marker lamps | Breaker | 20 |
| F13 | Main fuse block | Driving lamps | Breaker | 15 |
| F14 | Main fuse block | Fog lamps | Breaker | 15 |
| F15 | Main fuse block | Back-up lamps | Breaker | 20 |
| F16 | Main fuse block | Option harness ignition | Breaker | 30 |
| F17 | Main fuse block | Wiper motor power | Breaker | 25 |
| F18 | Main fuse block | Right-hand side low beam headlight | Breaker | 10 |
| F19 | Main fuse block | Left-hand side low beam headlight | Breaker | 10 |
| F20 | Main fuse block | ECC/light bar ignition power | Fuse | 5 |
| F21 | Main fuse block | Sound system accessory source | Breaker | 21 |
| F22 | Main fuse block | Cigar lighter and rotating beacons | Breaker | 20 |
| F23 | Main fuse block | Heated mirrors | Breaker | 15 |
| F24 | Main fuse block | Wiper switch power | Fuse | 5 |
| F25 | Main fuse block | Option harness accessories | Breaker | 30 |
| F26 | Main fuse block | ECC gauge power | Fuse | 5 |
| F27 | Main fuse block | Cab heater | Breaker | 30 |
| F28 | Main fuse block | Right-hand side high beam headlamp | Breaker | 15 |
| F29 | Main fuse block | Left-hand side high beam headlamp | Breaker | 15 |
| F30 | Main fuse block | ECC battery power | Fuse | 5 |
| F31 | Option fuse block | Engine battery power (3406E/3176B) | Breaker | 15 |
| | Option fuse block | Engine ignition power (DDEC111) | Fuse | 5 |
| F32 | Option fuse block | Engine battery power (3406E/3176B) | Breaker | 15 |
| | Option fuse block | Diagnostics jumper (Celect) | Fuse | 1 |
| | Option fuse block | Prodriver (battery) (DDEC111) | Fuse | 3 |
| F33 | Option fuse block | Fan clutch override (3306/3406C/DDEC111/ C8.3/L10) | Breaker | 8 |
| F33 | Option fuse block | Fan clutch override (3176B/3406E/C10/C12) | Breaker | 8 |

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## Component Codes

| F—Fuses and Circuit Breakers F01 through F50 | | | | |
|---|---|---|---|---|
| **Code** | **Location** | **Function** | **Type** | **Size** |
| F33 | Option fuse block | Fan clutch override (Celect) | Fuse | 5 |
| F34 | Option fuse block | Prodriver (ignition) (DDEC111) | Fuse | 5 |
| | Option fuse block | Speed control (3306/3406C/C8.3/L10) | Fuse | 8 |
| F35 | Option fuse block | Speedo-tachograph (ignition) | — | — |
| F36 | Option fuse block | Speedo-tachograph (battery) | — | — |
| F37 | Option fuse block | Additional switches one, four, seven and ten | Breaker | 15 |
| F38 | Option fuse block | Additional switches two, five, eight and eleven | Breaker | 15 |
| F39 | Option fuse block | Additional switches three, six, nine and twelve | Breaker | 15 |
| F40 | Option fuse block | Power windows | Breaker | 20 |
| F41 | Option fuse block | VHF radio preparation | Breaker | 1 |
| F42 | Option fuse block | Cellular phone preparation | Breaker | 1 |
| F43 | Option fuse block | Moto-mirror | Breaker | 10 |
| F44 | Option fuse block | ABS valves power | Breaker | 10 |
| F45 | Option fuse block | ABS ECU power | Breaker | 10 |
| F46 | Option fuse block | ABS cab | Breaker | 10 |
| F47 | Option fuse block | Air dryer | Breaker | 20 |
| | Option fuse block | Air dryer (AD-9/Turbo 2000/Anchorlock) | Breaker | 10 |
| F48 | Option fuse block | Trailer accessory | Breaker | 15 |
| F49 | Option fuse block | Customer supplied back-up lamp | — | — |
| F50 | Option fuse block | Ether start | — | — |

**F—Fuses and Circuit Breakers F51 through F100**

| F—Fuses and Circuit Breakers F51 through F100 | | | | |
|---|---|---|---|---|
| **Code** | **Location** | **Function** | **Type** | **Size** |
| F51 | Engine harness | Battery power (DDECIII) | Fuse | 15 |
| F52 | Option fuse block | Spot lamp power | Fuse | 20 |
| F54 | Engine harness | Battery power (Celect) | Fuse | 15 |
| F55 | Engine harness | Battery power (Celect) | Fuse | 15 |
| F56 | Option fuse block | Argo 1318-4 (battery) | Fuse | 5 |
| | Option fuse block | Argo 1310-7 (battery) | Fuse | 7.5 |
| F57 | Option fuse block | Argo 1318-4 (ignition) | Fuse | 5 |
| | Option fuse block | Argo 1310-7 (ignition) | Fuse | 7.5 |
| F58 | In-line | C8.3 FlameStart glow plugs | Fuse | 80 |
| F59 | S60 | Ether start | Fuse | 15 |
| F60 | Frontwall | Main ignition/accessory power | Fuse | 100 |

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| F—Fuses and Circuit Breakers F51 through F100 | | | | |
|---|---|---|---|---|
| **Code** | **Location** | **Function** | **Type** | **Size** |
| F61 | Frontwall | Main ignition/accessory power | Fuse | 100 |
| F62 | Option fuse block | Rooftop condenser separate power | Breaker | 15 |
| F63 | Option fuse block | FlameStart ignition | Breaker | 8 |
| F64 | In-line | FlameStart flame plug power | Fuse | 50 |
| F65 | In-line | FlameStart fuse on Cat engine harness (AGC-10) | Fuse | 10 |
| F66 | Option fuse block | CEEMAT battery power | Breaker | 15 |
| F67 | Option fuse block | CEEMAT ignition power | Breaker | 15 |
| F70 | Sleeper | Sleeper interior lamps | Breaker | 15 |
| F71 | Sleeper | Heating and AC power | Breaker | 25 |
| F72 | Sleeper | Utility outlet | Breaker | 15 |
| F73 | Sleeper | TV/VCR outlet | Breaker | 15 |
| F74 | Sleeper | Refrigerator | Breaker | 30 |
| F75 | Sleeper | Clock battery power | Breaker | 8 |
| F76 | Sleeper | Desk lamp | Breaker | 8 |
| F77 | Sleeper | Two-speed fans or sub-woofer amplifier | Breaker | 8 |
| F78 | Option fuse block | ABS trailer power (battery) | Breaker | 20 |
| F79 | Option fuse block | ABS trailer power (ignition) | Breaker | 10 |
| F80 | Option fuse block | Fuel separate power (ignition) | Breaker | 20 |
| F81 | Option fuse block | P.T.O./remote throttle power (ignition) | Fuse | 15 |
| F82 | Option fuse block | Racor fuel heater (ignition) | Breaker | 10 |
| F83 | In-line | Racor fuel heater | Fuse | 50 |
| F84 | Option fuse block | Additional switch four, seven and ten | — | — |
| F85 | Option fuse block | Additional switch five, eight and eleven | — | — |
| F86 | Option fuse block | Additional switch six, nine and twelve | — | — |
| F87 | Option fuse block | Convenience lamp switch | Breaker | 15 |
| F88 | Option fuse block | Allison transmission ignition power | Breaker | 10 |
| F89 | Option fuse block | TPCS ECU power (battery) | Breaker | 20 |
| F90 | Option fuse block | TCPS ECU power (ignition) | Breaker | 5 |
| F91 | Option fuse block | Top 2 transmission solenoid battery power | Fuse | 10 |
| F92 | Option fuse block | AutoSelect/shift transmission power (ignition) | Breaker | 10 |
| F93 | In-line | FlameStart for 3406C | Fuse | 10 |
| F94 | Option fuse block | ABS trailer power | Breaker | 15 |
| F95 | In-line | CEEMAT battery power | Fuse | 20 |
| F96 | Option fuse block | Frame-mounted convenience/work light switch | Breaker | 15 |
| F97 | Option fuse block | Trailer turn signal power | Breaker | 15 |

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## Component Codes

| F—Fuses and Circuit Breakers F51 through F100 | | | | |
|---|---|---|---|---|
| **Code** | **Location** | **Function** | **Type** | **Size** |
| F98 | Option fuse block | Flasher power | Breaker | 15 |
| F99 | Option fuse block | ABS second trailer power (ignition) | Fuse | 5 |
| F100 | Option fuse block | Bullet light power | Fuse | 20 |

**F—Fuses and Circuit Breakers F101 through F122**

| F—Fuses and Circuit Breakers F101 through F122 | | | | |
|---|---|---|---|---|
| **Code** | **Location** | **Function** | **Type** | **Size** |
| F101 | Option fuse block | P.T.O.,170 Ignition power fuse | Fuse | 5 |
| F102 | Option fuse block | Refrigerator | Fuse | 10 |
| F103 | Driver-controlled traction differential | Latch circuit | Breaker | 10 |
| F104 | Option fuse block | Additional switch seven and ten | — | — |
| F105 | Option fuse block | Additional switch eight and eleven | — | — |
| F106 | Option fuse block | Additional switch nine and twelve | — | — |
| F107 | Option fuse block | Additional switch ten | — | — |
| F108 | Option fuse block | Additional switch eleven | — | — |
| F109 | Option fuse block | Additional switch twelve | — | — |
| F110 | In-line fuse | Sleeper sub-woofer | Fuse | 15 |
| F111 | Option fuse block | Allison transmission modulator relay | Fuse | 5 |
| F112 | Option fuse block | Allison transmission modulator | Fuse | 3 |
| F113 | Option fuse block | Frame-mounted convenience/work light switch (second set) | — | — |
| F114 | Option fuse block | Additional headlamp high beam | Fuse | 15 |
| F115 | Option fuse block | Additional headlamp low beam | Fuse | 10 |
| F116 | ADH, engine harness | ADH Cummins, priming pump | — | — |
| F117 | Option fuse block | Power door-lock relay | — | — |
| F118 | Option fuse block | Remote starter main power | Fuse | — |
| F119 | Option fuse block | Remote starter secondary power | Fuse | — |
| F120 | Option fuse block | Vorad CPU power fuse | Fuse | — |
| F121 | Option fuse block | Frame-mounted convenience/work light switch (third set) | — | — |
| F122 | Option fuse block | Frame-mounted convenience/work light switch (fourth set) | — | — |

**GA—Gauges**

| GA—Gauges | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| GA1 | Main cab | Voltmeter |

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| GA—Gauges | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| GA2 | Engine and cab | Transmission oil temperature stand and Ceemat |
| GA3 | Engine | Fuel pressure |
| GA4 | Engine | Lube oil temperature |
| GA5 | Engine | Lube oil pressure |
| GA6 | Engine | Tachometer |
| GA7 | Engine | Speedometer |
| GA8 | Engine | Engine water temperature |
| GA9 | Engine | Exhaust gas pyrometer |
| GA10 | Main cab | Ammeter |
| GA11 | Option | Forward drive axle oil temperature |
| GA12 | Option | Rear drive axle oil temperature |
| GA13 | Cab and engine | Fuel level |
| GA14 | Sleeper start | Sleeper engine coolant temperature |
| GA15 | Option | Argo 1318-4 speedograph |
| GA16 | Option | Brakesaver temperature |
| GA17 | Engine | Remote tachometer |
| GA18 | Engine | Remote engine water temperature |
| GA19 | Engine | Remote lube oil pressure |
| GA20 | Option | Rear rear drive axle oil temperature |
| GA21 | Option | Auxiliary transmission oil temperature gauge |

**JC—Junctions**

| JC—Junctions | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| JC1 | Option | Taillight junction box |

**JP—Jumpers**

| JP—Jumpers | | | |
|---|---|---|---|
| **Code** | **Use** | **Type** | **Function** |
| JP1 | GRN | Battery | Argo, Ceemat |
| JP2 | GRN | Battery | ABS trailer |
| JP3 | GRN | Battery | — |
| JP4 | BLU | Battery | Spot light, prodriver |
| JP5 | BLU | Battery | — |
| JP6 | BLU | Battery | — |

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## Component Codes

| JP—Jumpers | | | |
|---|---|---|---|
| **Code** | **Use** | **Type** | **Function** |
| JP7 | BRN | Ignition | ABS, engine, air dryer |
| JP8 | BRN | Ignition | Ether start, ABS trailer |
| JP9 | BRN | Ignition | — |
| JP10 | BLK | Ignition | Fuel separator, Argo, roof-top condensor, FlameStart, Ceemat, Allison |
| JP11 | BLK | Ignition | Fuel heater |
| JP12 | BLK | Ignition | Convenience light |
| JP13 | ORG | Accessory | — |
| JP14 | ORG | Accessory | Power windows |
| JP15 | ORG | Accessory | Motorized mirror |
| JP16 | GRY | Accessory | — |
| JP17 | GRY | Accessory | — |
| JP18 | GRY | Accessory | — |
| JP19 | GRN | Battery | ADH Cummins, priming pump |

**L—Lamps L1 through L50**

| L—Lamps L1 through L50 | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| L1 | Main | Under-dash light |
| L2 | Overhead console | Dome light |
| L3 | Overhead console | Right-hand door reading light |
| L4 | Option | Right-hand visor vanity light |
| L5 | Overhead console | Overhead console reading light |
| L6 | Option | Left-hand visor vanity light |
| L7 | Overhead console | Left-hand door top reading light |
| L8 | Main | Heater control back light |
| L9 | Sleeper | Left-hand back-up/convenience light |
| L10 | Sleeper | Right-hand backup/convenience light |
| L11 | Headlights | Right-hand headlight |
| L12 | Headlights | Left-hand headlight |
| L13 | Headlights | Right-hand high beam |
| L14 | Headlights | Left-hand high beam |
| L15 | Driving/fog lights | Right-hand fog light |
| L16 | Driving/fog lights | Left-hand fog light |
| L17 | Driving/fog lights | Right-hand driving light |
| L18 | Driving/foglights | Left-hand driving light |
| L19 | Headlights | Right-hand turn signal |

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| L—Lamps L1 through L50 | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| L20 | Headlights | Left-hand turn signal |
| L21 | Headlights | Right-hand side-marker turn signal |
| L22 | Headlights | Left-hand side-marker turn signal |
| L23 | Taillights | Left-hand taillight |
| L24 | Taillights | Right-hand taillight |
| L25 | Sleeper | Left-hand back-up light (back-of-sleeper or side shield mount) |
| L26 | Sleeper | Right-hand back-up light (back-of-sleeper or side shield mount) |
| L27 | Taillights | License plate light |
| L28 | Sleeper | Sleeper dome light |
| L29 | Sleeper | Floor light |
| L31 | Sleeper | Lower bunk sleeper reading light |
| L32 | Sleeper | Upper bunk sleeper reading light |
| L33 | Sleeper | Writing table sleeper reading light |
| L34 | Sleeper | Left-hand sleeper luggage compartment light |
| L35 | Sleeper | Right-hand sleeper luggage compartment light |
| L36 | Overhead console | Right-hand rotating beacon |
| L37 | Overhead console | Left-hand rotating beacon |
| L38 | Overhead console | Right-hand back-of-cab back-up lights |
| L39 | Overhead console | Left-hand back-of-cab back-up lights |
| L40 | Overhead console | Right outboard cab top marker light |
| L41 | Overhead console | Right inboard cab top marker light |
| L42 | Overhead console | Center cab top marker light |
| L43 | Overhead console | Left inboard cab top marker light |
| L44 | Overhead console | Left outboard cab top marker light |
| L45 | Sleeper start | Stop engine light |
| L46 | Sleeper start | Check engine light |
| L47 | Sleeper start | Ignition light |
| L48 | Right-hand door | Right-hand courtesy lamp |
| L49 | Left-hand door | Left door courtesy lamp |
| L50 | Option | Left-hand spot light |

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## Component Codes

**L—Lamps L51 through L82**

| L—Lamps L51 through L82 | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| L51 | Option | Right-hand spot light |
| L52 | Option | Right-hand door back-up lamp |
| L53 | Option | Left-hand door back-up lamp |
| L54 | Option | Right-hand door marker lamp |
| L55 | Option | Left-hand door marker lamp |
| L56 | Sleeper | Back-of-sleeper outboard marker light |
| L57 | Sleeper | Back-of-sleeper inboard marker light |
| L58 | Sleeper | Back-of-sleeper center marker light |
| L59 | Sleeper | Back-of-sleeper left inboard marker light |
| L60 | Sleeper | Back-of-sleeper left outboard marker light |
| L61 | Sleeper | Desk lamp |
| L62 | Sleeper | Low roof sleeper right dome light |
| L63 | Sleeper | Low roof sleeper left dome light |
| L64 | Sleeper | 42-inch and 66-inch sleeper right floor light |
| L65 | Sleeper | 42-inch and 66-inch sleeper left floor light |
| L66 | Sleeper | 42-inch and 66-inch sleeper right luggage light |
| L67 | Sleeper | 42-inch and 66-inch sleeper left luggage light |
| L68 | Sleeper | Right-hand rotating beacon |
| L69 | Sleeper | Left-hand rotating beacon |
| L70 | Sleeper | Right-hand back-of-sleeper convenience light (flush mount) |
| L71 | Sleeper | Left-hand back-of-sleeper convenience light (flush mount) |
| L72 | Option | Left-hand mirror-mounted signal lamp |
| L73 | Option | Right-hand mirror-mounted signal lamp |
| L74 | Option | Left-hand taillight |
| L75 | Option | Right-hand taillight |
| L76 | Option | Left-hand end outline marker lamp |
| L77 | Option | Right-hand end outline marker lamp |
| L78 | Australia taillight | Left-hand taillight end outline marker lamp |

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| L—Lamps L51 through L82 | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| L79 | Australia taillight | Right-hand taillight end outline marker lamp |
| L80 | Australia bullet light | Left-hand bullet light |
| L81 | Australia bullet light | Right-hand bullet light |
| L82 | Option | Five-inch auxiliary/work lamp |

**LL—Crossover Speakers**

| LL—Crossover Speakers | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| LL1 | Overhead console | Crossover right speakers |
| LL2 | Overhead console | Crossover left speakers |

**M—Motors**

| M—Motors | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| M1 | Starter | Starter motor |
| M2 | AC compressor | AC compressor motor |
| M3 | Windshield wipers | Windshield wiper motor |
| M4 | Roof-mounted condenser | Roof-mounted condenser motor |
| M5 | Power windows | Power window motor left-hand side |
| M6 | Power windows | Power window motor right-hand side |

**RA—Radio**

| RA—Radio | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| RA1 | Sound system harness | Radio/tapedeck |

**R—Relays**

| R—Relays | | | |
|---|---|---|---|
| **Code** | **Location** | **Size** | **Function** |
| R1 | Main block | 40/30 | Horn |
| R2 | Main block | 40/30 | Tractor marker lights |
| R3 | Main block | 40/30 | Trailer marker lights |
| R4 | Main block | 40/30 | Driving lights |
| R5 | Main block | 40/30 | Fog lights |
| R6 | Main block | 40/30 | Taillights |

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## Component Codes

| R—Relays | | | |
|---|---|---|---|
| **Code** | **Location** | **Size** | **Function** |
| R7 | Main block | 40/30 | Air conditioning compressor |
| R8 | Main block | 40/30 | Not defined |
| R9 | Main block | 40/30 | High beams |
| R10 | Main block | 40/30 | Low beams |
| R11 | Main block | 40/30 | Trailer brake lights |
| R12 | Main block | 40/30 | Not defined |
| R14 | Main block | 70 | Ignition circuit power |
| R15 | Main block | 70 | Battery circuit power |
| R16 | Option | 40/30 | ECM ignition power (DDECIII, 3406E, 3176B) |
| R17 | Frontwall | — | Starter magnetic switch |
| R18 | Sleeper | 40/30 | Heater relay |
| R19 | Cat | 40/30 | Cat fan control relay |
| R20 | sleeper | 40/30 | Sleeper fridge power |
| R21 | Roof-top air conditioning | 40/30 | Roof-top condenser fan motor relay |
| R22 | ABS | 40/30 | ABS engine brake |
| R23 | C8.3 | — | C8.3 FlameStart glow plugs |
| R24 | Option | 40/30 | Brakesaver enable |
| R25 | ABS | 40/30 | ABS warning light |
| R26 | Option | 40/30 | Five-minute idle shutdown |
| R27 | Option | 40/30 | P.T.O. park brake interlock |
| R28 | Option | 40/30 | Remote starter park brake interlock |
| R29 | Option | 75 | Racor fuel heater |
| R30 | Option | 40/30 | Webasto control of heater water valve |
| R31 | Option | 40/30 | Webasto control of 42-inch and 66-inch sleeper control valve |
| R32 | Option | 40/30 | FlameStart 3306 indicator inverter |
| R33 | Option | 40/30 | Back-up light relay |
| R34 | Option | 40/30 | Ceemat start enable relay |
| R35 | Option | 40/30 | Ceemat engine brake relay |
| R36 | Option | 40/30 | Allison brake light relay (when retarder supplied) |
| R37 | Option | 40/30 | Allison ABS active relay (when ABS supplied) |
| R38 | Option | 40/30 | Tire pressure control system |
| R39 | Option | 40/30 | Shutdown relay (optimized idle) |
| R40 | Option | 40/30 | Starter control relay (optimized idle) |
| R41 | Option | 40/30 | Park brake applied relay (optimized idle) |
| R42 | Option | 40/30 | Starter interrupt relay (optimized idle) |

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| R—Relays | | | |
|---|---|---|---|
| **Code** | **Location** | **Size** | **Function** |
| R43 | Option | 40/30 | Autoselect/shift transmission start enable relay |
| R44 | Option | 40/30 | Autoselect transmission engine brake relay |
| R45 | Option | 40/30 | Five-minute idle shutdown latch relay (Cat elec) |
| R46 | Option | 40/30 | Top-two transmission relay (Cat Elec) |
| R47 | Option | 40/30 | Ceemat light bar relay |
| R48 | Aus | 30/10 | Flasher relay left turn signal |
| R49 | Aus | 30/10 | Flasher relay right turn signal |
| R50 | Aus | — | Flasher thermal relay |
| R51 | ABS | — | Infomodule ABS for first trailer |
| R52 | ABS | — | Infomodule ABS for second trailer |
| R53 | Aus | 40/30 | Bullet lights |
| R54 | Driver-controlled traction differential | 40/30 | Cutout (forward-rear or single) |
| R55 | Driver-controlled traction differential | 40/30 | Latching (forward-rear or single) |
| R56 | Driver-controlled traction differential | 40/30 | Cutout (rearmost) |
| R57 | Driver-controlled traction differential | 40/30 | Latching (rear most) |
| R58 | WTECIII | 40/30 | Engine compression relay |
| R59 | Transmission | 40/30 | Allison transmission modulator relay |
| R60 | Aus | 40/30 | Australian brake failure test relay |
| R61 | Headlamps | 40/30 | Additional headlamp high beam relay |
| R62 | Headlamps | 40/30 | Additional headlamp low beam relay |
| R63 | Power locks | 40/30 | Door unlock relay |
| R64 | Power locks | 40/30 | Door lock relay |
| R65 | Remote starter | 40/30 | Starter kill/enable relay |
| R66 | Remote starter | 40/30 | Dome lamp control relay |

**RE—Resistors**

| RE—Resistors | | | | |
|---|---|---|---|---|
| **Code** | **Location** | **Function** | **Type** | **Size** |
| RE1 | Overhead console | Speaker attenuation overhead console right | 2R0 | 5W |
| RE2 | Overhead console | Speaker attenuation overhead console left | 2R0 | 5W |
| RE3 | Power | Provide field current at low RPM to Delco 21SI alternators | 24R9 | 10W |
| RE4 | Optimized idle | Starter interrupt relay | 10K | 5W |

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## Component Codes

| RE—Resistors | | | | |
|---|---|---|---|---|
| **Code** | **Location** | **Function** | **Type** | **Size** |
| RE5 | On engine | Engine brake prep | 24R | 10W |
| RE6 | On engine | Engine brake prep | 24R | 10W |
| RE7 | Overhead console | Speaker crossover overhead console right | 3R0 | 5W |
| RE8 | Overhead console | Speaker crossover overhead console left | 3R0 | 5W |
| RE9 | Sleeper | Sub-woofer crossover sleeper left positive | 2R2K | 1/2W |
| RE10 | Sleeper | Sub-woofer crossover sleeper right positive | 2R2K | 1/2W |
| RE11 | Sleeper | Sub-woofer crossover sleeper left negative | 4R7K | 1/2W |
| RE12 | Sleeper | Sub-woofer crossover sleeper right negative | 4R7K | 1/2W |
| RE13 | Sleeper | Sub-woofer crossover component | 22R | 1/2W |
| FRE14 | Sleeper | Sub-woofer crossover component | 470R | 1/2W |
| RE15 | Sleeper | Sub-woofer crossover component | 470R | 1/2W |
| RE16 | Sleeper | Sub-woofer crossover component | 470R | 1/2W |
| RE17 | Sleeper | Sub-woofer crossover component | 470R | 1/2W |
| RE18 | Sleeper | Sub-woofer crossover component | 22R | 1/2W |
| RE19 | Sleeper | Sub-woofer crossover component | 470R | 1/2W |
| RE20 | Sleeper | Sub-woofer crossover component | 470R | 1/2W |
| RE21 | Sleeper | Sub-woofer crossover component | 470R | 1/2W |
| RE22 | Sleeper | Cigar lighter and rotating beacons | 470R | 20 |
| RE23 | P.T.O.-170 | P.T.O. speed signal resistor | 2R2K | 15 |

**RR—Engine Displays**

| RR—Engine Displays | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| RR1 | Road Relay harness | Celect Road Relay |

**S—Switches S1 through S50**

| S—Switches S1 through S50 | | | |
|---|---|---|---|
| **Code** | **Location** | **Size** | **Function** |
| S1 | CMCD | Rocker | Engine brake on/off |
| S2 | CMCD | Rocker | Engine brake selector |
| S3 | CMCD | Rocker | Cruise control set/resume |
| S4 | CMCD | Rocker | Cruise control on/off |
| S5 | Sleeper start | Rocker | Sleeper start enable |
| S6 | CMCD | Rocker | Fan clutch override |
| S7 | Main | Rocker | Tractor marker lights |
| S8 | Main | Rocker | Trailer marker lights |
| S9 | Main | Rocker | Driving lights |

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| S—Switches S1 through S50 | | | |
|---|---|---|---|
| **Code** | **Location** | **Size** | **Function** |
| S10 | Main | Rocker | Fog lights |
| S11 | Main | Rocker | Headlights and park lights |
| S12 | Main | Rocker | Instrument dimming |
| S13 | Main | Rocker | Back-up (mirror) lights |
| S14 | Main | Rocker | Windshield wiper low/high |
| S15 | CMCD | Rocker | Odometer reset |
| S16 | Main | Push/momentary | Steering column horn |
| S17 | Main | Push/momentary | Steering column turn signal |
| S18 | Main | Rocker | Back-up (back-of-cab/back-of-sleeper) lights |
| S19 | Option | Slide | Transmission-shifter-mounted cruise control switches |
| S20 | Main | Rocker | Heated mirrors |
| S21 | Main | Rocker | Rotating beacon |
| S22 | Option | Push/momentary | Ether start |
| S23 | CMCD | Limit/Microswitch | Clutch switch |
| S24 | Main | Limit/plunger | Right-hand door switch |
| S25 | Main | Limit/plunger | Left-hand door switch |
| S26 | CMCD | Trinary pressure switch | Air conditioning freon pressure |
| S27 | CMCD | Pressure | Brakes applied |
| S28 | Main | Pressure | Brakes applied |
| S29 | Main | Pressure | Park brake applied |
| S30 | Main | Pressure | ’A’ system brake pressure low |
| S31 | Main | Pressure | ’B’ system brake pressure low |
| S32 | Main | Air | Interaxle differential lock |
| S33 | Differential | Air | Forward rear differential lock |
| S34 | Differential | air | Rear rear axle or single rear axle differential lock |
| S35 | CMCD | Limit/microswitch | Transmission reverse switch |
| S36 | Main | Key | Ignition switch |
| S37 | Sleeper start | Key | Ignition switch |
| S38 | Option | Limit/microswitch | Transmission neutral switch |
| S39 | Mech | Limit | Minimum fuel switch |
| S40 | Mech | Level | Coolant level low |
| S41 | Mech | Pressure | Oil pressure low switch |
| S42 | Option | Pressure | Low-speed axle switch |
| S43 | Option | Pressure | Clutch switch |
| S44 | Option | Limit/microswitch | Neutral start switch |

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## Component Codes

| S—Switches S1 through S50 | | | |
|---|---|---|---|
| **Code** | **Location** | **Size** | **Function** |
| S45 | CMCD | Limit/microswitch | Reverse switch |
| S46 | Sleeper start | Limit/plunger | Left-hand sleeper luggage door switch |
| S47 | Sleeper start | Limit/plunger | Right-hand sleeper luggage door switch |
| S48 | Sleeper | Limit/plunger | Sleeper door switch |
| S49 | Sleeper | Rocker | Sleeper light on/off from sleeper |
| S50 | Sleeper | Rocker | Sleeper light on/off from cab |

**S—Switches S52 through S100**

| S—Switches S52 through S100 | | | |
|---|---|---|---|
| **Code** | **Location** | **Size** | **Function** |
| S52 | CEL | Foot treadle | Throttle switch (Celect) |
| S53 | DDEC | Rocker | Diagnostic test switch (DDECIII/Celect) |
| S54 | CEL | Rocker | Idle/diagnostics switch (Celect) |
| S55 | Sleeper | Limit/plunger | Bunk lifted switch |
| S56 | Differential | Limit | Forward /single drive axle differential lock |
| S57 | Differential | Limit | Rear drive axle differential lock |
| S58 | Main | Rocker | Windshield washer |
| S59 | Main | Rocker | Windshield wiper intermittant/off/on |
| S60 | Sleeper | Potentiometer | Sleeper volume control |
| S61 | Option | Rocker | Racor fuel heater |
| S62 | ABS | Rocker | ATC deep snow and mud |
| S63 | ABS | Push on/off | ABS blink code and diagnostics with J1922 |
| S64 | Option | Rocker | Additional switch one |
| S65 | Option | Rocker | Additional switch two |
| S66 | Option | Rocker | Additional switch three |
| S67 | Option | Rocker | Additional switch four |
| S68 | Option | Rocker | Additional switch five |
| S69 | Option | Rocker | Additional switch six |
| S70 | Sleeper | Rocker | Storage lamp below sleeper bunk |
| S27 | DFUEL | Rocker | Two fuel tanks no cross over |
| S72 | Option | Rocker | Trailer accessory switch |
| S73 | Option | Rocker | Customer supplied back-up lights |
| S74 | Option | Rocker | Right-hand spot light on/off |
| S75 | Option | DPST toggle | Isolation switch |
| S76 | Option | Rocker | Mirror rotation (right-hand side) |
| S77 | Option | Rocker | Mirror rotation (left-hand side) |

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| S—Switches S52 through S100 | | | |
|---|---|---|---|
| **Code** | **Location** | **Size** | **Function** |
| S78 | Option | SPST toggle | Isolation switch |
| S79 | Option | Rocker | Power window (left-hand side) |
| S80 | Option | Rocker | Power window (right-hand side) |
| S81 | Option | AIR rocker | Fifth wheel lock |
| S82 | Option | Air rocker | Suspension height |
| S83 | Option | Air rocker | Lift axle |
| S84 | C8.3 | Pressure | Oil pressure switch for engine run detection |
| S85 | Ether | Temperature | Engine mounted thermostat |
| S86 | Option | Pressure | Brakesaver pressure switch |
| S87 | Option | Limit | Transmission range sensor (neutral start switch) |
| S88 | Option | Rocker | Trailer marker light interrupt switch |
| S89 | Option | Push button | Remote starter switch |
| S90 | Option | Rocker | Dash P.T.O. switch |
| S91 | Option | Rocker | Convenience light switch |
| S92 | Differential | Limit | Rear rear axle differential lock |
| S93 | Webasto | Rocker | Webasto on/off control |
| S94 | Option | Rocker | Engine warm-up switch |
| S95 | Ceemat | Limit | P.T.O. switch (Ceemat) |
| S96 | Ceemat | Pressure | Service brake applied (in cab for Ceemat) |
| S97 | Traction differential | Pressure | First axle differential lock switch for traction differential, mounted in cab |
| S98 | Traction differential | Pressure | Second axle differential lock switch for traction differential, mounted in cab |
| S99 | Traction differential | Pressure | Third axle differential lock switch for traction differential, mounted in cab |
| S100 | Allison | Rocker | Retarder enable |

**S—Switches S101 through S139**

| S—Switches S101 through S139 | | | |
|---|---|---|---|
| **Code** | **Location** | **Size** | **Function** |
| S101 | Allison | Pressure | Service brake is on |
| S102 | Option | Rocker | Five-minute idle shutdown override |
| S103 | Tire Pressure | Pressure | Air pressure switch, wet tank |
| S104 | Argo 1 event | Pressure | Deep reduction transmission |
| S105 | Optimized Idle | Mercury | Hood open switch |
| S106 | Allison retarder | Pressure | Allison retarder pressure switch number one |

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## Component Codes

| S—Switches S101 through S139 | | | |
|---|---|---|---|
| **Code** | **Location** | **Size** | **Function** |
| S107 | Main | Rocker | Tridem rear axle differential lock |
| S108 | Brakesaver | Rocker | Brakesaver on/off |
| S109 | Extarder throttle | Limit | Extarder throttle switch |
| S110 | Australia | Special | Australian dash mount hazard switch |
| S111 | Differential | Air | Forward and rear differential lock |
| S112 | ABS | Pressure | Trailer connected switch for infomodule |
| S113 | Australia | Rocker | Bullet lights |
| S114 | P.T.O.,170 | Air | P.T.O.,170 engage switch |
| S115 | P.T.O.,170 | Air | Rear axle disengage switch |
| S116 | Cab fridge | Rocker | Cab fridge on/off |
| S117 | Driver-controlled traction differential | Air | Transmission low-range sensor |
| S118 | Driver-controlled traction differential | Rocker | Front-rear or single axle |
| S119 | Driver-controlled traction differential | Rocker | Rear-rear axle |
| S120 | Suspension | Air | Suspension pressure |
| S121 | Australia sleeper | Limit | Left door switch |
| S122 | Australia sleeper | Limit | Rear luggage door switch |
| S123 | Australia sleeper | Limit | Right luggage door switch |
| S124 | Two-speed fan | Rocker | Sleeper fan number one |
| S125 | Two-speed fan | Rocker | Sleeper fan number two |
| S126 | Additional headlamp | Rocker | Headlamp selector switch (snowplow) |
| S127 | Transmission | Pressure | Allison HT/MT transmission back-up lamp switch |
| S128 | Transmission | Limit | Allison HT/MT neutral start switch (in shift tower) |
| S129 | Power locks | Rocker | Power door lock/unlock switch |
| S130 | Remote start | Toggle | Remote start on/off, valet switch |
| S131 | Remote start | Pressure | Remote start park brake (normally open) switch |
| S132 | Remote start | Pin | Remote start hood switch |
| S133 | ABS | Push on/off | ABS blink code and diagnostics with J1939 |
| S134 | Option | Rocker | Work/auxiliary lamp switch |
| S135 | Option | Rocker | Headlight interrupter switch |
| S136 | Two-speed axle | Pressure | Two-speed axle (low) pressure switch |
| S137 | Option | Temperature | P.T.O. overheat temperature switch |
| S138 | Trailer pressure | Pressure | Trailer pressure failure |

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| S—Switches S101 through S139 | | | |
|---|---|---|---|
| **Code** | **Location** | **Size** | **Function** |
| S139 | Trailer pressure | Pressure | Trailer pressure high |

**SP—Speakers**

| SP—Speakers | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| SP1 | Main | Woofer right-hand door |
| SP2 | Main | Woofer left-hand door |
| SP3 | Sleeper | Standard right rear |
| SP4 | Sleeper | Standard left rear |
| SP5 | Sleeper | Standard right front |
| SP6 | Sleeper | Standard left front |
| SP7 | Overhead console | Tweeter right rear |
| SP8 | Overhead console | Tweeter left rear |
| SP9 | Overhead console | Standard right front |
| SP10 | Overhead console | Standard left front |
| SP11 | CB | CB speaker in overhead console |
| SP12 | Sleeper | Sub-woofer in box in sleeper |

**SV—Solenoids**

| SV—Solenoids | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| SV1 | CMCD | Fan control |
| SV2 | Option | Radiator shutter control |
| SV3 | Frontwall | Heater coolant flow control |
| SV4 | Mech | Front engine brake solenoid (3406C) |
| SV5 | Mech | Rear engine brake solenoid (3406C) |
| SV6 | Mech | Fuel solenoid (3406C) |
| SV7 | Mech | Engine brake solenoid (L10) |
| SV8 | Air start | Air start control valve on frontwall |
| SV9 | C8.3 | Fuel shutoff solenoid |
| SV10 | C8.3 | Glow plug number one |
| SV11 | C8l3 | Glow plug number two |
| SV12 | Option | Brakesaver plenum solenoid |
| SV13 | Option | Brakesaver cutout solenoid |
| SV14 | 3306 | FlameStart fuel solenoid |
| SV15 | Mech | SuperPac warmup solenoid (3406C) |

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## Component Codes

| SV—Solenoids | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| SV16 | Mech | SuperPac exhaust brake solenoid (3406C) |
| SV17 | Ceemat | De-fuel solenoid (mechanical engine only) |
| SV18 | Extarder | Extarder enable solenoid |
| SV19 | Driver controlled traction differential | Air shift cylinder |

**TR—Sub-woofer Crossovers**

| TR—Sub-woofer Crossovers | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| TR1 | Isolation | Sub-woofer crossover component (left) |
| TR2 | Isolation | Sub-woofer crossover component (right) |

**TX—Senders**

| TX—Senders | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| TX1 | Temperature | Transmission oil |
| TX2 | Pressure | Fuel |
| TX3 | Position | Throttle |
| TX4 | T/C Type K | Thermocouple, exhaust gas temperature |
| TX5 | Pick up | Vehicle speed sensor |
| TX6 | Pick up | Engine speed sensor |
| TX7 | Level | Engine water |
| TX8 | Temperature | Forward/single drive axle |
| TX9 | Temperature | Rear drive axle |
| TX10 | Current | Ammeter shunt |
| TX11 | Temperature | Engine oil |
| TX12 | Pressure | Engine oil |
| TX13 | Level | Fuel left-hand side |
| TX14 | Pressure | Turbo |
| TX15 | Level | Fuel right-hand side |
| TX16 | Temperature | Engine water |
| TX17 | Temperature | Engine water (C8.3 FlameStart) |
| TX18 | Temperature | Brakesaver sensor |

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| TX—Senders | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| TX19 | Position | Remote throttle |
| TX20 | Temperature | Engine water |
| TX21 | Pressure | Engine oil |
| TX22 | Temperature | Rearmost axle |
| TX23 | Position | Transmission retarder brake pedal transmission |
| TX24 | Temperature | Auxiliary transmission oil temperature sender |
| TX25 | Temperature | Remote starter ambient temperature sensor |

**UT—Utility Outlets**

| UT—Utility Outlets | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| UT1 | Sleeper | Utility outlet |
| UT2 | Sleeper | TV/VCR utility outlet |
| UT3 | Sleeper | Fridge utility outlet |

**WB—Webasto Heater**

| WB—Webasto Heater | | |
|---|---|---|
| **Code** | **Location** | **Function** |
| WB1 | Overhead console | Webasto seven-day timer |

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# Connector Loading Codes

The first letter of the connector code is either a "J" for jack, or a "P" for plug. These letters are not considered when listing the connectors in alphabetical order so that the jack and the mating plug are together in the list. The wire code for each cavity of the connector is listed beside the cavity designator.

**J15**

| J15—J1587 Receive on Component Side | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Cavity** | **Prodriver** | **Cat DISP** | **Road Relay** | **Argo** | **ABS** | **Ceemat** | **WTECII** | **WTECIII** | **TPCS** |
| A (+) | 900G | B783F | B27 | IN58B | AB04D | TW04C | TR66C | 142B | NCXXX |
| B (-) | 901G | B792F | B08 | IN59B | AB09D | TW03C | TR67C | 151B | NCXXX |

**P15**

| P15—J1587 Transmit on Engine Side | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cavity** | **Celect** | **ProDr** | **3406E** | **Cat DIS** | **DDECIII** | **Road Relay** | **Argo** | **ABS** | **Ceemat** | **WTECII** | **WTECIII** |
| A (+) | B27F | 900F | B793D | B793G | 900D | B27 | IN58A | AB04C | TW04D | TR66D | 142C |
| B (-) | B08F | 901F | B792G | B792D | 901D | B08 | IN59A | AB09C | TW03D | TR67D | 151C |

**J19**

| J19—J1922 Receive on Component Side | | |
|---|---|---|
| **Cavity** | **ABS** | **Ceemat** |
| A (+) | AB07C | TW17B |
| B (-) | AB06C | TW18B |

**P19**

| P19—J1922 Transmit on Engine Side | | | | | |
|---|---|---|---|---|---|
| **Cavity** | **3406E 3176B** | **Celect** | **DDECIII** | **ABS** | **Ceemat** |
| A (+) | E721A | B27C | 800A | AB07B | TW17C |
| B (-) | E720A | B08C | 801A | AB06B | TW18C |

**J1939**

| J1939—J1939 on Allison Harness from ECU | |
|---|---|
| A | 182S |
| B | 184N |
| C | 183P |

**P1939**

| P1939—Mating Connector for J1939 | |
|---|---|
| A | Plug |

| P1939—Mating Connector for J1939 | |
|---|---|
| B | Plug |
| C | Plug |

**JL28**

| JL28—Sleeper Incandescent Lamp Splitter | |
|---|---|
| A | LS02E/F |
| B | GD7AG/AH |

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## Connector Loading Codes

### JABC

| JABC—Antilock Brake System, Coil Cable to Trailer Receptacle | |
|---|---|
| 1 | AB54B |
| 2 | AB55B |
| 3 | NC |
| 4 | NC |
| 5 | AB56B |
| 6 | NC |

### PABE

| PABE—Antilock Brake System, ECU Connector | |
|---|---|
| 1 | AB01A |
| 2 | AB02A |
| 3 | AB03A |
| 4 | AB04A |
| 5 | AB05A |
| 6 | AB06A |
| 7 | AB07A |
| 8 | – |
| 9 | AB09A |
| 10 | AB10A |
| 11 | GD2BS |
| 12 | GD2BT |

### PABF

| PABF—Antilock Brake System, ECU to Forward Valves Connecor | |
|---|---|
| 1 | NC |
| 2 | AB35A |
| 3 | AB33A |
| 4 | AB32A |
| 5 | AB30A |
| 6 | AB31A |
| 7 | AB38A |
| 8 | AB39A |
| 9 | AB34A |
| 10 | AB36A |
| 11 | AB37A |

| PABF—Antilock Brake System, ECU to Forward Valves Connecor | |
|---|---|
| 12 | NC |

### PABR

| PABR—Antilock Brake System, ECU to Extension Cable | |
|---|---|
| 1 | AB49B |
| 2 | AB48B |
| 3 | AB41B |
| 4 | AB40B |
| 5 | AB51B |
| 6 | AB50B |
| 7 | AB43B |
| 8 | AB44B |
| 9 | AB42B |
| 10 | AB46B |
| 11 | AB47B |
| 12 | AB45B |

### JABS

| JABS—Antilock Brake System, Cab Side of Frontwall | |
|---|---|
| 1 | AB01B |
| 2 | AB02B |
| 3 | AB03B |
| 4 | AB04B |
| 5 | AB05B |
| 6 | NC |
| 7 | Yellow (Argo tach pulse divider) |
| 8 | Blue (Argo tach pulse divider) |
| 9 | AB09B |
| 10 | AB10B |
| 11 | Yellow (Argo speedo pulse divider) |
| 12 | Blue (Argo speedo pulse divider) |

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## Connector Loading Codes

**PABS**

| JABS—Antilock Brake System, Cab Side of Frontwall | |
|---|---|
| 1 | AB01A |
| 2 | AB02A |
| 3 | AB03A |
| 4 | AB04A |
| 5 | AB05A |
| 6 | NC |
| 7 | IN64A (Argo 1310-7) |
| 8 | IN65A (Argo 1310-7) |
| 9 | AB09A |
| 10 | AB10A |
| 11 | IN66A (Argo 1310-7) |
| 12 | IN67A (Argo 1310-7) |

**JABT**

| JABT—Antilock Brake System, Trailer, Frontwall Connector to Cab | |
|---|---|
| 1 | AB54A |
| 2 | AB55A |
| 3 | NC |
| 4 | NC |
| 5 | AB56A |
| 6 | NC |

**PABT**

| PABT—Antilock Brake System, Trailer Receptacle to Frontwall | |
|---|---|
| 1 | AB54B |
| 2 | AB55B |
| 3 | NC |
| 4 | NC |
| 5 | AB56B |
| 6 | NC |

**JABX**

| JABX—Antilock Brake System, Extension Cable to Rear Valves | |
|---|---|
| 1 | AB49B |

| JABX—Antilock Brake System, Extension Cable to Rear Valves | |
|---|---|
| 2 | AB48B |
| 3 | AB41B |
| 4 | AB40B |
| 5 | AB51B |
| 6 | AB50B |
| 7 | AB43B |
| 8 | AB44B |
| 9 | AB42B |
| 10 | AB46B |
| 11 | AB47B |
| 12 | AB45B |

**PABX**

| PABX—Antilock Brake System, Rear Sensors to Extension Cable | |
|---|---|
| 1 | AB49A |
| 2 | AB48A |
| 3 | AB41A |
| 4 | AB40A |
| 5 | AB51A |
| 6 | AB50A |
| 7 | AB43A |
| 8 | AB44A |
| 9 | AB42A |
| 10 | AB46A |
| 11 | AB47A |
| 12 | AB45A |

**PAHD**

| PAHD—Signature 600 ADH Fifty Pin Engine Connector | |
|---|---|
| 1 | BA13A |
| 2 | B04C |
| 3 | B06A |
| 4 | Plug |
| 5 | B01A |
| 6 | B16A |

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## Connector Loading Codes

| PAHD—Signature 600 ADH Fifty Pin Engine Connector | |
|---|---|
| 7 | ADH10A |
| 8 | ADH11A |
| 9 | B10A |
| 10 | B10D |
| 11 | Plug |
| 12 | Plug |
| 13 | B09A |
| 14 | B22R |
| 15 | A19A |
| 16 | B25A |
| 17 | ADH12A |
| 18 | ADH14A |
| 19 | Plug |
| 20 | Plug |
| 21 | Plug |
| 22 | ADH06A |
| 23 | B02D |
| 24 | B12A |
| 25 | Plug |
| 26 | B27C |
| 27 | B08C |
| 28 | ADH15A |
| 29 | ADH17A |
| 30 | ADH18A |
| 31 | ADH07A |
| 32 | ADH05A |
| 33 | Plug |
| 34 | Plug |
| 35 | C24A |
| 36 | S1939F-SLD |
| 37 | N1939F-Black |
| 38 | C26A |
| 39 | ADH19A |
| 40 | ADH21A |
| 41 | Plug |
| 42 | Plug |

| PAHD—Signature 600 ADH Fifty Pin Engine Connector | |
|---|---|
| 43 | Plug |
| 44 | A16A |
| 45 | Plug |
| 46 | S1939F-white |
| 47 | B11A |
| 48 | B18A |
| 49 | B19A |
| 50 | ADH22A |

**PAHO**

| PAHO—Signature 600 ADH Thirty-One Pin Engine Connector | |
|---|---|
| 1 | Plug |
| 2 | Plug |
| 3 | Plug |
| 4 | Plug |
| 5 | A18A |
| 6 | A09A |
| 7 | A22A |
| 8 | Plug |
| 9 | Plug |
| 10 | Plug |
| 11 | Plug |
| 12 | AHD01A |
| 13 | ADH02A |
| 14 | Plug |
| 15 | Plug |
| 16 | Plug |
| 17 | A08A |
| 18 | B10B |
| 19 | A13A |
| 20 | Plug |
| 21 | B03A |
| 22 | B07A |
| 23 | Plug |
| 24 | Plug |
| 25 | Plug |

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| PAHO—Signature 600 ADH Thirty-One Pin Engine Connector | |
|---|---|
| 26 | Plug |
| 27 | Plug |
| 28 | Plug |
| 29 | Plug |
| 30 | Plug |
| 31 | Plug |

**JARG**

| JARG—Argo Speedograph, Speedo Harness Side | |
|---|---|
| A | Orange/Brown |
| B | Grey |
| C | Red/Black |
| D | Brown/Black |
| E | Purple |
| F | Blue |
| G | Yellow |
| H | Green |

**PARG**

| PARG—Argo Speedograph, Dash Harness Side | |
|---|---|
| A | IN61A |
| B | GL1T |
| C | IN63A |
| D | GD5AT |
| E | NC |
| F | NC |
| G | IN58A/B |
| H | IN59A/B |

**PATC**

| PATC—Automatic Transmission, Ceemat | | |
|---|---|---|
| **Cavity** | **Dash Mount** | **Floor Mount** |
| A | TW17A-T | TW17A-T |
| B | TW13A | TW13A |
| C | TW14A | TW14A |
| D | TW05B | TW05B |

| PATC—Automatic Transmission, Ceemat | | |
|---|---|---|
| **Cavity** | **Dash Mount** | **Floor Mount** |
| E | TW06A | TW06A |
| F | TW07A | TW07A |
| G | TW16A | TW16A |
| H | TW09A | TW09A |
| J | TW12A | TW12A |
| K | TW01C | TW01C |
| L | TW02C | TW02E |
| M | TW03A-T | TW03A-T |
| N | TW04A-T | TW04A-T |
| P | TW18A-T | TW18A-T |
| R | TW15A | TW15A |
| S | NC | NC |
| T | TW11A | TW11A |
| U | TW10A | TW10A |
| V | NC | NC |

**JATL**

| JATL—Additional Taillamp Preperation, to Taillamp Connections | |
|---|---|
| 1 | TL12A |
| 2 | TL14A |
| 3 | TL16A |
| 4 | TL18A |
| 5 | NC |
| 6 | NC |
| 7 | NC |
| 8 | NC |
| 9 | NC |
| 10 | NC |
| 11 | NC |
| 12 | NC |

**PATL**

| PATL—Additional Taillamp Preperation, Jumper from Taillamps on Frontwall | |
|---|---|
| 1 | TL12A |
| 2 | TL13A |

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## Connector Loading Codes

| PATL—Additional Taillamp Preperation, Jumper from Taillamps on Frontwall | |
|---|---|
| 3 | TL15A |
| 4 | TL17A |
| 5 | NC |
| 6 | NC |
| 7 | NC |
| 8 | NC |
| 9 | NC |
| 10 | NC |
| 11 | NC |
| 12 | NC |

**JBGT**

| JBGT—Bogaard Timer Connector, Harness Side | |
|---|---|
| 1 | IG10A/Diode D17(-) |
| 2 | ST01C |
| 3 | NC |
| 4 | GD2HU |
| 5 | AC01P |
| 6 | IG01T/Diode D17(+) |

**PBGT**

| PBGT—Bogaard Timer Connector, Bogaard Side | |
|---|---|
| 1 | Blue/Diode (+) |
| 2 | Red |
| 3 | NCC |
| 4 | Black |
| 5 | Diode (-) |
| 6 | White |

**PBSA**

| PBSA—Hi/Low Beam Switch, Australia | |
|---|---|
| A | HL04B |
| B | HL03B |
| C | HL02B |

**JBSS**

| JBSS—Hi/Low Beam Switch | |
|---|---|
| A | HL04B |
| B | HL03B |
| C | HL02B |

**PBSS**

| PBSS—Hi/Low Beam Switch | |
|---|---|
| A | HL04A/DL04A |
| B | HL03A |
| C | HL02A |

**PCAC**

| PCAC—Compressor for Air Conditioning | |
|---|---|
| A | HT02B |

**JCBP**

| JCBP—CB Power CB Radio Side | |
|---|---|
| A | Red/Black |
| B | NC |
| C | Black |

**PCBP**

| PCBP—CB Power on CB Harness to CB Radio | |
|---|---|
| A | RA01E |
| B | NC |
| C | GD2BM |

**PCBS**

| PCBS—CB Power on CB Harness to CB Radio | |
|---|---|
| In | RA18A |
| Out | RA19A |

**PCFG**

| PCFG—Tire Pressure Control Configurator | |
|---|---|
| A | GD2EW |
| B | TP24A |
| C | TP02E |

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# Connector Loading Codes

**PCK**

| PCK—Clock Connector | |
|---|---|
| A | RA01B |
| B | RA02B |
| C | GD2BB |

**PCKS**

| PCKS—Clock Connector, Sleeper | |
|---|---|
| A | AC01F |
| B | RA13A |
| C | GD7M |

**JCMT**

| JCMT—Ceemat Transmission at Frontwall, Cab Side | | |
|---|---|---|
| **Cavity** | **Dash Mount** | **Floor Mount** |
| 1 | NC | TR10B |
| 2 | TW18E-T | TR11B |
| 3 | TW17E-T | TR07B |
| 4 | TW02B | TW02B |
| 5 | NC | GL1W |
| 6 | TW07B | TW07B |
| 7 | TW06B | TW06B |
| 8 | TW04B-T | TW04B-T |
| 9 | TW03BT | TW03BT |
| 10 | TW16B | TW16B |
| 11 | TW01A | TW01A |

| JCMT—Ceemat Transmission at Frontwall, Cab Side | | |
|---|---|---|
| **Cavity** | **Dash Mount** | **Floor Mount** |
| 12 | TW05D | TW05D |

**PCMT**

| PCMT—Ceemat Transmission at Frontwall, Engine Side | | |
|---|---|---|
| **Cavity** | **Dash Mount** | **Floor Mount** |
| 1 | NC | TR10C |
| 2 | TW18D-T | TR11C |
| 3 | TW17D-T | TR07C |
| 4 | TW02C | TW02D |
| 5 | TW15A | GL1X |
| 6 | TW07A | TW07A |
| 7 | TW06A | TW06A |
| 8 | TW04A-T | TW04A-T |
| 9 | TW03A-T | TW03A-T |
| 10 | TW16A | TW16A |
| 11 | TW01B | TW01B |
| 12 | TW05C | TW05C |

**PCOM**

| PCOM—Serial Communication Interface, Overhead Console Side | |
|---|---|
| A | 142P |
| B | 151N |

**JDIA**

| JDIA—Diagnostics Connector for Engine, Ceemat | | | | |
|---|---|---|---|---|
| **Cavity** | **3406E 3176B** | **Celect** | **DDECIII** | **Ceemat** |
| A (+) | B793E | B27G | 900E | TW04E-T |
| B (-) | B792E | B08G | 901E | TW03E-T |
| C (BA) | C987C | C31E | 439B | TW01G |
| D | NC | NC | NC | NC |
| E(GD) | C993E | C25E | 953H | GD2EF |
| F | NC | NC | NC | NC |

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# Connector Loading Codes

**PDIA**

| PDIA—Mates to J15 Diagnostics Connector for Transmission, Ceemat | |
|---|---|
| A (+) | TW01E-T |
| B (-) | TW03E-T |

**PDIS**

| PDIS—Caterpillar DIS Display Connector | |
|---|---|
| 1 | B793H-T |
| 2 | B792H-T |
| 3 | IN52 |
| 4 | GD2BN |
| 5 | GL2V |
| 6 | Plug |

**PDRY**

| PDRY—Air Dryer | |
|---|---|
| A | AD2B |
| B | GD1X |

**JDTG**

| JDTG—Digital Clock | |
|---|---|
| A | RA26A |
| B | RA27A |
| C | GD2DU |

**JE**

| JE—Engine Connector, at Frontwall Cab Side | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Cavity | 3406E and 3176B | 3306 | Celect | C8.3 | DDECIII | 3406C | ADH | L10 |
| 1 | IN73A | IN73A | IN73A | IN73A | IN73A | IN73A | Plug | IN73A |
| 2 | ES03A | ES03A | ES03A | ES03A | ES03A | ES03A | Plug | ES03A |
| 3 | L901A | EB05A | B27D | EB05A | 900B | EB05A | B27D | EB05A |
| 4 | D745B | EB04B | B08D | EB04B | 901B | EB04B | B08D | EB04A |
| 5 | C987A | CC02B CRUZ | C26B | CC02B CRUZ | 439C | CC02B CRUZ | C26B | CC02B CRUZ |
| 6 | C992B | CC03B CRUZ | B13B | CC03B CRUZ | 543B | CC03B CRUZ | B13B | CC03B CRUZ |
| 7 | E717B | CC04B CRUZ | B05B | CC04B CRUZ | 979B | CC04B CRUZ | B28D | CC04B CRUZ |
| 8 | E716B | CC05B CRUZ | B28B | CC05B CRUZ | 583B | CC05B CRUZ | B05B | CC05B CRUZ |
| 9 | C979B | CC06B CRUZ | B22B | CC06B CRUZ | 545B | CC06B CRUZ | B22B | CC06B CRUZ |
| 10 | C978B | IN34A | B12B | IN34A | 541B | IN34A | B12B | IN34A |
| 11 | C975B | IN33A | B02B | IN33A | 544B | IN33A | B02B | IN33A |
| 12 | B793B | IN32A | A16B | IN32A | 528B | IN32A | A16B | IN32A |
| 13 | B792B | IN47A | NC | IN47A | 524B/ID07B | IN47A | Plug | IN47A |
| 14 | IN14A | IN14A | IN14A | IN14A | IN14A | IN14A | IN14A | IN14A |
| 15 | IN12A | IN12A | IN12A | IN12A | IN12A | IN12A | IN12A | IN12A |
| 16 | C993D | IN53A | B10D | IN53A | NC | IN53A | B10J | IN53A |

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## Connector Loading Codes

| JE—Engine Connector, at Frontwall Cab Side | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Cavity** | **3406E and 3176B** | **3306** | **Celect** | **C8.3** | **DDECIII** | **3406C** | **ADH** | **L10** |
| 17 | IN26A<br>TR20A | IN26A<br>TR20A | IN26A<br>TR20A | IN26A<br>TR20A | IN26A<br>TR20A | IN26A<br>TR20A | IN26A<br>TR20A | IN26A<br>TR20A |
| 18 | IN27A | IN27A | B06B | NC | IN27A | IN27A | B06B | IN27A |
| 19 | E715B | IN35A | B09B | IN35A | NC | IN35A | B09B | IN35A |
| 20 | 659B | IN36A | B16B | IN36A | 509B | IN36A | B16B | IN36A |
| 21 | D799B | IN30B | B25B | IN30B | 419B | IN30B | B25B | IN30B |
| 22 | IN13A | IN54B | B01B | IN54B | 988B | IN54B | B01B | IN54B |
| 23 | K999A | IN31B | C21E | IN31B | NC | IN31B | C21E | IN31B |
| 24 | TC02B | IN54D | C23C-Rdrly | IN54D | NC | IN54D | Plug | IN54D |
| 25 | C977B | FS03D | B04B | FS03A | 531B | FS03F | B04B | NC |
| 26 | ST08A | FS09A | C24B | NC | NC | FS09C | Plug | NC |
| 27 | SD01B | NC | B14B | NC | SD01B | NC | B10Q | NC |
| 28 | C985 | EB02A | B18B | EB02A | 916B | EB02A | B18B | EB02A |
| 29 | C986 | EB03A | B11B | EB03A | 417B | EB03A | B11B | EB03A |
| 30 | E718 | FC04A | B19B | FC04A | 952B | FC04A | B19B | FC04A |
| 31 | EB07A | NC | NC | NC | ID11B | EB12A | Plug | NC |
| 32 | EB08A | NC | NC | NC | ID12A | NC | Plug | NC |
| 33 | EB06A | NC | NC | NC | ID05A | NC | Plug | NC |
| 34 | EB11A | NC | NC | NC | ID13A | NC | Plug | NC |
| 35 | K998A | NC | NC | NC | ID06A | NA | Plug | NC |
| 36 | TH01D | NC | NC | NC | NC | NC | Plug | NC |
| 37 | PT12B | PT12B | PT12B | PT12B | PT12B | PT12B | Plug | PT12B |
| 38 | PT01C | PT01C | PT01C | PT01C | PT01C | PT01C | Plug | PT01C |
| 39 | FC05A | FC03C | B23B | FC03C | NC | FC03C | Plug | FC03C |
| 40 | FC02A | FC02A | A19B | FC02A | FC02A | FC02A | A19B | FC02A |

**PE**

| PE—Engine Connector, at Frontwall Engine Side | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Cavity** | **3406E and 3176B** | **3306** | **Celect** | **C8.3** | **DDECIII** | **3406C** | **ADH** | **L10** |
| 1 | IN73B | IN73B | IN73B | IN73B | IN73B | IN73B | Plug | IN73B |
| 2 | ES03B | NC | ES03B | NC | ES03B | ES03B | Plug | NC |
| 3 | L901B | EB05B | B27B | NC | 900A | EB05B/<br>EB15A | B27C | EB05D |
| 4 | D745A | EB04C | B08B | EB04H | 901A | EB04C/<br>EB14A | B08C | EB04G |

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## Connector Loading Codes

| PE—Engine Connector, at Frontwall Engine Side | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Cavity** | **3406E and 3176B** | **3306** | **Celect** | **C8.3** | **DDECIII** | **3406C** | **ADH** | **L10** |
| 5 | C987B | CC02A CRUZ | C26A | CC02A CRUZ | NC | NC | C26A | CC02A CRUZ |
| 6 | NC | CC03A CRUZ | NC | CC03A CRUZ | 543A | CC03A CRUZ | B13A | CC03A CRUZ |
| 7 | E717A | CC04A CRUZ | B05A | CC04A CRUZ | 979A | CC04A CRUZ | B28C | CC04A CRUZ |
| 8 | E716A | CC05A CRUZ | B28A | CC05A CRUZ | 583A | CC05A CRUZ | B05A | CC05A CRUZ |
| 9 | C979A | CC06A CRUZ | B22A | CC06A CRUZ | NC | NC | B22C | CC06A CRUZ |
| 10 | NC | IN34B | NC | IN34B | 541A | IN34B | B12C | IN34B |
| 11 | C975A | IN33B | B02A | IN33B | NC | NC | B02C | IN33B |
| 12 | NC | IN32B | NC | IN32B | 528A | IN32B | A16A | IN32B |
| 13 | B792A | IN47B | C25C | IN47B | 524A/ID07C | IN47B | Plug | IN47B |
| 14 | Yellow | Yellow | Yellow | Yellow | Yellow | Yellow | Plug | Yellow |
| 15 | Red | Red | Red | Red | Red | Red | Plug | Red |
| 16 | C993C | IN53B | B10C | IN53B | 953B | IN53B | B10D | IN53B |
| 17 | IN26B | IN26B | IN26B | IN26B | IN26B | IN26B | IN26B | IN26B |
| 18 | IN27B | IN27B | B06A | NC | IN27B | IN27B | B06A | IN27B |
| 19 | E715A | IN35B | B09A | IN35B | NC | IN35B | B09A | IN35B |
| 20 | 659A | IN36B | B16A | IN36B | 509A | IN36B | B16A | IN36B |
| 21 | D799A | IN30A | B25A | IN30A | 419A | IN30A | B25A | IN30A |
| 22 | IN13B | IN54A | B01A | IN54A | 988A | IN54A | B01A | IN54A |
| 23 | K999B | IN31A | C21B | IN31A | NC | IN31A | C21B | IN31A |
| 24 | TC02A | IN54C | C23B | IN54C | NC | IN54C | C23B | IN54C |
| 25 | C977A | FS03C | B04A | FS03B | 531A | FS03E | B04D | NC |
| 26 | ST08B | FS09B | C24A | NC | NC | FS09D | C24A | NC |
| 27 | SD01A | NC | B14A | NC | 499A | NC | B10C | NC |
| 28 | C985A | EB02B | B18A | EB02D | 916A | EB02B | B18A | EB02C |
| 29 | C986A | EB03A | B11A | EB03D | 417A | EB03A | B11A | EB03C |
| 30 | E718A | FC04B | B19A | FC04B | 952A | FC04B | B19A | FC04B |
| 31 | EB07B | NC | NC | NC | ID11C | NC | Plug | NC |
| 32 | EB08B | NC | NC | NC | ID12B | NC | Plug | NC |
| 33 | EB06B | NC | NC | NC | ID05B | NC | Plug | NC |
| 34 | EB11A | NC | NC | NC | ID13A | NC | Plug | NC |
| 35 | K998B | NC | NC | NC | ID06B | NC | Plug | NC |
| 36 | TH01E | NC | NC | NC | NC | NC | Plug | NC |

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## Connector Loading Codes

| PE—Engine Connector, at Frontwall Engine Side | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Cavity | 3406E and 3176B | 3306 | Celect | C8.3 | DDECIII | 3406C | ADH | L10 |
| 37 | PT12A | PT12A | PT12A | PT12A | PT12A | PT12A | Plug | PT12A |
| 38 | PT01B | PT01B | PT01B | PT01B | PT01B | PT01B | PT01B | PT01B |
| 39 | FC05B | FC03A | B23A | FC03A | NC | FC03A | Plug | FC03A |
| 40 | FC02B | FC02B | A19A | FC02B | FC02B | FC02B | A19A | FC02B |

**JEB**

| JEB—Engine Brake, on Engine | |
|---|---|
| A | EB16A |
| B | EB17A |

| PEB—Engine Brake, on Engine, L10 | |
|---|---|
| B | EB04G |
| C | EB02C |
| D | EB03C |

**PEB**

| PEB—Engine Brake, on Engine, L10 | |
|---|---|
| A | EB05D |

**PECE**

| PECE—Engine Control Center (ECC) | | | | | | |
|---|---|---|---|---|---|---|
| Pin | 3406E and 3176B | Celect | DDECIII | 3406C and C8.3 | Pin | ADH |
| 1 | IN06A | IN06A | IN06A | IN06A | E01 | IN06A |
| 2 | IN10A | IN10A | IN10A | IN10A | E02 | IN10A |
| 3 | IN48A | IN48A | IN48A | IN48A | E03 | NC |
| 4 | B792C | B08E | 901C | IN34A | E04 | B08E |
| 5 | B793C | B27E | 900C | NC | E05 | B27E |
| 6 | NC | NC | NC | FC04A | E06 | NC |
| 7 | IN12A | IN12A | IN12A | IN12A | E07 | IN12A |
| 8 | IN14A | IN14A | IN14A | IN14A | E08 | IN14A |
| 9 | 659B | B16B | 509B | NC | E09 | B16B |
| 10 | C993J | B10E | 953G | NC | E10 | B10E |
| 11 | IN43A | IN43A | IN43A | IN43A | E11 | IN43A |
| 12 | NC | NC | NC | IN54B/D | E12 | NC |
| 13 | IN29A | IN29A | IN29A | IN29A | E13 | NC |
| 14 | NC | NC | NC | IN32A | E14 | NC |
| 15 | NC | B01B | 988B | NC | E15 | B01B |
| 16 | NC | NC | NC | IN31B | E16 | NC |
| 17 | NC | NC | NC | IN30B | F01 | IN08A |
| 18 | NC | NC | NC | FC03C | F02 | IN07A |

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## Connector Loading Codes

| PECE—Engine Control Center (ECC) | | | | | | |
|---|---|---|---|---|---|---|
| Pin | 3406E and 3176B | Celect | DDECIII | 3406C and C8.3 | Pin | ADH |
| 19 | IN16A | IN16A | IN16A | IN16A | F03 | IN05A |
| 20 | IN04A | IN04A | IN04A | IN04A | F04 | IN11A |
| 21 | D799B | B25B | 419B | IN36A | F05 | IN09A |
| 22 | IN28A | IN28A | IN28A | IN28J | F06 | IN13A |
| 23 | NC | NC | 524B | IN33A | F07 | IN15A |
| 24 | GL1L | GL1A | GL1J | GL1N | F08 | NC |
| 25 | NC | NC | NC | NC | F09 | GL1AC |
| 26 | IN15A | IN15A | IN15A | NC | F10 | NC |
| 27 | NC | IN13A | IN13A | NC | F11 | IN28A |
| 28 | IN09A | IN09A | IN09A | NC | F12 | B25B |
| 29 | IN11A | IN11A | IN11A | IN11A | F13 | IN04A |
| 30 | IN05A | IN05A | IN05A | IN05A | F14 | IN16A |
| 31 | IN07A | IN07A | IN07A | IN07A | F15 | NC |
| 32 | IN08A | IN08A | IN08A | IN08A | F16 | NC |

**PECL**

| PECL—Engine Control Center, Light Bar | |
|---|---|
| A1 | AB56A |
| A2 | AB03/TR52B/115A (ABS/Allison WTECII/ Allison WTECIII) |
| A3 | IN18A |
| A4 | TL07D |
| A5 | TR02A/TR60B/105A (Range Sensor/ Allison WTECII/Allison WTECIII) |
| A6 | LB09A |
| A7 | EB06A/FS03A/FS11A/FS03F (Engine Brake/FlameStart C8.3/FlameStart 3306/ 3406C |
| A8 | TL04D |
| A9 | LB05A |
| A10 | AB03C/ID06A (ATC/Optimized Idle) |
| A11 | IG04B |
| A12 | LB01B |
| B1 | IN17A |
| B2 | AB12B (ABS) |
| B3 | IN21A |
| B4 | LB08A |

| PECL—Engine Control Center, Light Bar | |
|---|---|
| B5 | LB04A |
| B6 | GD5U |
| B7 | NC |
| B8 | IN68A |
| B9 | LB03A |
| B10 | LB07A |
| B11 | LB02B |
| B12 | LB06A |

**PECP**

| PECP—Engine Control Center Power | |
|---|---|
| A | WW11B |
| B | GD5T/U |
| C | HL08B |
| D | TL03A |
| E | WW09A |
| F | WW08A |
| G | WW10A |
| H | TL11A |

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# Connector Loading Codes

**PECT**

| PECT—Electronic Control Transmission, Ceemat | |
|---|---|
| 1 | Pink |
| 2 | Green |
| 3 | White |
| 4 | Black |
| 5 | Brown |
| 6 | NC |

**JECT**

| JECT—Electronic Control Transmission, Ceemat | |
|---|---|
| 1 | IN52L |
| 2 | TR19A |
| 3 | TR18A |
| 4 | GD5AX |
| 5 | TR20A |
| 6 | NC |

**PECV**

| Electronic Control Center (ECC) | |
|---|---|
| C1 | IG04A |
| C2 | TR02B/TR19A |
| C3 | NC |
| C4 | LB03A |
| C5 | NC |
| C6 | NC |
| C7 | NC |
| C8 | WW03A |
| C9 | WW04A |
| C10 | IN22A |
| C11 | IN23A |
| C12 | WW01A |
| C13 | LB01A |
| C14 | LB09A |
| C15 | HL10A |
| C16 | IN19A |
| D1 | LB07A |
| D2 | LB04A |
| D3 | BA06A |
| D4 | IN03E |
| D5 | IN03D |
| D6 | LB02A |
| D7 | LB06A |
| D8 | WW05A |
| D9 | GL2K |
| D10 | GL2L |
| D11 | LB05A |
| D12 | IN52A |
| D13 | IN20A |
| D14 | WW06A |
| D15 | NC |
| D16 | LB08A |

**PEFS**

| PEFS—Engine Fuel Solenoid, C8.3 | |
|---|---|
| A | IN32A |
| B | ST04C |
| C | GD2DF |

**PENG**

| PENG—Engine Connector, at Engine, 3406E/3176B | |
|---|---|
| 1 | B792A |
| 2 | C983A |
| 3 | E720A |
| 4 | E715A |
| 5 | C998A |
| 6 | C987B |
| 7 | B793A |
| 8 | K999B |
| 9 | E721A |
| 10 | NC |
| 11 | 450A |
| 12 | D785A |
| 13 | E717A |
| 14 | C922A |

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## Connector Loading Codes

| PENG—Engine Connector, at Engine, 3406E/3176B | |
|---|---|
| 15 | C979A |
| 16 | NC |
| 17 | 451A |
| 18 | D784A |
| 19 | E716A |
| 20 | C975A |
| 21 | K998B |
| 22 | D799A |
| 23 | C984A |
| 24 | C977A |
| 25 | C978A |
| 26 | NC |
| 27 | 659A |
| 28 | D745A |
| 29 | C993A |
| 30 | L901C |
| 31 | K982A |
| 32 | NC |
| 33 | NC |
| 34 | NC |
| 35 | C985A |
| 36 | C997A |
| 37 | C986A |
| 38 | E971A |
| 39 | NC |
| 40 | E718A |

**PENG**

| PENG—Engine Connector, at Engine, Celect | |
|---|---|
| B01 | B01A |
| B02 | B02A |
| B03 | B03A |
| B04 | B04A |
| B05 | B05A |
| B06 | B06A |
| B07 | B07A |
| B08 | B08A |

| PENG—Engine Connector, at Engine, Celect | |
|---|---|
| B09 | B09A |
| B10 | B10A |
| B11 | B11A |
| B12 | B12A |
| B13 | B13A |
| B14 | B14A |
| B15 | NC |
| B16 | B16A |
| B17 | NC |
| B18 | B18A |
| B19 | B19A |
| B20 | NC |
| B21 | NC |
| B22 | B22A |
| B23 | B23A |
| B24 | NC |
| B25 | B25A |
| B26 | NC |
| B27 | B27A |
| B28 | B28A |
| K2 | 583A |
| K3 | 979A |

**PENG**

| PENG—Engine Connector, at Engine, DDECIII | |
|---|---|
| A1 | 988A |
| A2 | 555A |
| A3 | 916A |
| B1 | 419A |
| B2 | 509A |
| B3 | 439D |
| C1 | 901A |
| C2 | 900A |
| C3 | 952A |
| D1 | NC |
| D2 | 417A |
| D3 | NC |

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## Connector Loading Codes

| PENG—Engine Connector, at Engine, DDECIII | |
|---|---|
| E1 | NC |
| E2 | 556A |
| E3 | 557A |
| F1 | 542A |
| F2 | 544A |
| F3 | 499A/ID13A |
| G1 | 528A |
| G2 | 543A |
| G3 | 545A |
| H1 | NC |
| H2 | 524A/ID07E |
| H3 | 115A |
| J1 | 541A |
| J2 | 531A |
| J3 | NC |
| K1 | NC |

**PENG2**

| PENG2—Celect ECM A/C | |
|---|---|
| A | C26A |
| B | NC |
| C | C07A |
| D | NC |
| E | NC |
| F | NC |

| PENG2—Celect ECM A/C | |
|---|---|
| G | NC |
| H | NC |
| J | A22A |
| K | A13A |
| L | A18A |
| M | A09A |
| N | NC |
| P | NC |
| R | NC |
| S | NC |
| T | A08A |
| U | A19A |
| V | A16A |
| W | NC |
| X | NC |

**PENGD**

| PENGD—Data Connector, at Engine | |
|---|---|
| A (+) | 800A |
| B (-) | 801A |
| C | NC |
| D | NC |
| E | NC |
| F | NC |

**PENGP**

| PENGP—Power Connector, at Engine | | |
|---|---|---|
| **Cavity** | **Celect** | **DDECIII** |
| A | C21A | 240A |
| B | C25A | 151A |
| C | C23A | 241A |
| D | NA | 150A |
| E | NA | 150B |

**PESA**

| PESA—Engine Speed Sensor, Argo | |
|---|---|
| A | IN64A |

| PESA—Engine Speed Sensor, Argo | |
|---|---|
| B | IN65A |

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# Connector Loading Codes

**PESP**

| PESP—Engine Speed Sensor, 3406C, C8.3 | |
|---|---|
| A | IN31A |
| B | IN54C |

**PESM**

| PESM—Ether Start Module, S60 Engines | |
|---|---|
| A | ES06A |
| B | GD2DK |
| C | ES07A |

| PESM—Ether Start Module, S60 Engines | |
|---|---|
| D | ES09A |
| E | ES08A |

**JESV**

| JESV—Ether Start Valve, S60 Engines | |
|---|---|
| A | ES08A |
| B | ES09A |

**JESD**

| JESD—Ether Start Data, S60 Engines | | |
|---|---|---|
| **Cavity** | **Ether Start** | **Optimum Idle** |
| A | NC | ID06B |
| B | NC | NC |
| C | ES07A | NC |

**JFWH**

| JFWH—HVAC Start, Miscelanious Cab Side | |
|---|---|
| 1 | ST02C/TR12A/TR54B |
| 2 | NC |
| 3 | NC |
| 4 | HT03A |
| 5 | HT02A |
| 6 | HT03A |
| 7 | AD02A |
| 8 | IN40A |
| 9 | IN50A |
| 10 | FH01B |
| 11 | TR01B/AX01B/TC11B |
| 12 | FH02A/AX02B |

**PFWH**

| PFWH—HVAC, Start, Miscelanious Cab Side | |
|---|---|
| 1 | ST02D |
| 2 | NC |
| 3 | NC |
| 4 | Black/White to Trinary Switch |

| PFWH—HVAC, Start, Miscelanious Cab Side | |
|---|---|
| 5 | HT02B |
| 6 | Black to Trinary Switch |
| 7 | AD02B |
| 8 | IN40B |
| 9 | IN50A |
| 10 | FH01A/FH6A |
| 11 | TR01A/AX01C/TC11A |
| 12 | FH02B/AX02A |

**PFS4**

| PFS4—3306 FlameStart Module, Four-Way | |
|---|---|
| 1 | FS08A |
| 2 | FS06A |
| 3 | NC |
| 4 | GD1AB |
| 5 | FS05A |

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## Connector Loading Codes

**PFS6**

| PFS6—3306 FlameStart Module, Six-Way | |
|---|---|
| 1 | NC |
| 2 | FS09B |
| 3 | ST04D |
| 4 | FS03C |
| 5 | FS04A |
| 6 | FS07A |

**JFSC**

| JFSC—3406c FlameStart, at Engine Harness | |
|---|---|
| 1 | Caterpillar 0375 |
| 2 | Caterpillar 0995 |
| 3 | Caterpillar 0944 |
| 4 | Caterpillar B444 |
| 5 | GD2FN |
| 6 | — |

**JFSE**

| JFSE—3406C FlameStart Electronic Control Unit | |
|---|---|
| A | Caterpillar 0944 |
| B | — |
| C | — |
| D | GD2FP |
| E | — |
| F | — |
| G | FS09D |
| H | FS03E |
| J | Caterpillar 0375 |
| K | ST02H |
| L | — |
| M | Caterpillar 0995 |
| N | Caterpillar A571A |
| O | — |
| P | Caterpillar A571B |
| R | — |

**JFSP**

| JFSP—3306 FlameStart, at Pressure Switch | |
|---|---|
| 1 | FS08B |
| 2 | NC |

**PFSV**

| PFSV—3306 FlameStart, Valve | |
|---|---|
| 1 | NC |
| 2 | NC |
| 3 | GD1AB |
| 4 | FS04A |
| 5 | FS05A |
| 6 | FS06A |
| 7 | FS07A |

**JGA17**

| JGA17—Remote Tachometer, 3406E/3176B | |
|---|---|
| 1 | 450A |
| 2 | TH01J |
| 3 | GD |
| 4 | TH01H/TH01J |
| 5 | 451A |
| 6 | NC |

**PHLT**

| PHLT—Headlamps | |
|---|---|
| 1 | TL07C |
| 2 | HL07A |
| 3 | HL09B |
| 4 | DL02A |
| 5 | FL02A |
| 6 | HL10B |
| 7 | HL08A |
| 8 | TL08A |
| 9 | TL04C |
| 10 | WW01A |
| 11 | HN03A |
| 12 | NC |

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## Connector Loading Codes

**JHLT**

| JHLT—Headlamps | | |
|---|---|---|
| **Cavity** | **Standard** | **Extension From Frontwall** |
| 1 | TL07E | TL07 |
| 2 | HL07C | HL07 |
| 3 | HL09C | HL09 |
| 4 | DL02B | DL02 |
| 5 | FL02B | FL02 |
| 6 | HL10C | HL10 |
| 7 | HL08C | HL08 |
| 8 | TL08E | TL08 |
| 9 | TL04E | TL04 |
| 10 | WW01B | WW01 |
| 11 | HN03B | HN03 |
| 12 | NC | NC |

**PHTO**

| PHTO—Heater Control Jumper, Optimized Idle | |
|---|---|
| A | HT07C |
| B | HT03G |
| C | ID02A |
| D | GD2EZ |
| E | HT04G |
| F | NC |

**JHTO**

| JHTO—Heater Control Jumper, Optimized Idle | |
|---|---|
| A | HT07C |
| B | HT03G |
| C | ID02A |
| D | GD2EZ |
| E | HT04G |
| F | NC |

**PHTR**

| PHTR—Heater, Truck Side | |
|---|---|
| A | HT07A |
| B | HT03A |

| PHTR—Heater, Truck Side | |
|---|---|
| C | HT01B |
| D | GD2B |
| E | HT04A |
| F | NC |

**JHTR**

| JHTR—Heater, Heater Side | |
|---|---|
| A | Brown |
| B | White |
| C | Red |
| D | Black |
| E | Blue |
| F | NC |

**JIA**

| JIA—Illumination Jack, Auxiliary Panel | |
|---|---|
| A | GL2AY |
| B | GD2GG |

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## Connector Loading Codes

**JI0**

| JI0—Illumination Jack, Air Switch Row | |
|---|---|
| A | GL2Y/GL2AZ |
| B | GD2BV/GH |

**JI1**

| JI1—Illumination Jack, Headlamp Row | |
|---|---|
| A | GL2BA/BB |
| B | GD2GJ/GK |

**JI2**

| JI2—Illumination Jack, Dash Display Row | |
|---|---|
| A | GL2BB/BC |
| B | GD2GK/GL |

**JI3**

| JI3—Illumination Jack, Top Row | |
|---|---|
| A | GL2BC |
| B | GD2GG/GL |

**JLDF**

| JLDF—Left Drive and Fog Lamps, Main Harness Side | |
|---|---|
| A | DL02D |
| B | GD1N |
| C | FL02D |

**PLDF**

| PLDF—Left Drive and Fog Lamps, Light Side | |
|---|---|
| A | DL02E |
| B | GD1J |
| C | FL02E |

**PLHD**

| PLHD—Left Hand Door, Cab Side | |
|---|---|
| A | ML03C |
| B | BL03C |
| C | GD2AA/CJ |
| D | GD2AA/GD2AP |

| PLHD—Left Hand Door, Cab Side | |
|---|---|
| E | HM02A |
| F | LC02C |
| G | GD2CJ |
| H | NC |

**JLHD**

| JLHD—Left Hand Door, Door Side | |
|---|---|
| A | Black, Marker Light, Hot |
| B | Backup Light, Hot |
| C | Backup Light Ground/Mirror Ground |
| D | Courtesy Light Ground |
| E | Heated Mirror, Hot |
| F | Courtesy Light, Hot |

**JLHL**

| JLHL—Left Headlight, Harness Side | |
|---|---|
| A | HL08C |
| B | GD1B |
| C | HL10C |
| D | TL04E |
| E | GD1F |
| F | TL08G |

**PLHL**

| PLHL—Left Headlight, Conventional Hood, Light Side | |
|---|---|
| A | HL08D |
| B | GD1C |
| C | HL10D |
| D | NC |
| E | NC |
| F | NC |

**PLHL**

| PLHL—Left Headlight, Australia Hood, Light Side | |
|---|---|
| A | HL11A |
| B | GD1AK |
| C | HL12A |

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## Connector Loading Codes

| PLHL—Left Headlight, Australia Hood, Light Side | |
|---|---|
| D | TL28A |
| E | GD1AG |
| F | TL08Z |

**PLHL**

| PLHL—Left Headlight, Aero Hood, Light Side | |
|---|---|
| A | HL08D |
| B | GD1C |
| C | HL10D |
| D | TL04F |
| E | GD1V |
| F | TL08K |

**PLPM**

| PLPM—Left-Hand Power Mirror, Cab Side | |
|---|---|
| A | PM03B |
| B | PM02B |
| C | RA06D |
| D | RA07E |
| E | PW03B |
| F | PW02B |

**JLPM**

| JLPM—Left-Hand Power Mirror, Door Side | |
|---|---|
| A | Green, Moto-Mirror |
| B | White, Moto-Mirror |
| C | RA6E |
| D | RA07F |
| E | PW03C |
| F | PW02C |

**PLPW**

| PLPW—Left-Hand Power Window | |
|---|---|
| A | PW03C |
| B | PW02C |

**JLTL**

| JLTL—Left Taillamp | |
|---|---|
| A | TL08AG |
| B | TL05D |
| C | TL02J |
| D | BL01T |
| E | NC |
| F | GD4T |

**PLTL**

| PLTL—Left Taillamp | |
|---|---|
| A | TL08AF |
| B | TL05C |
| C | TL02H |
| D | BL01S |
| E | BL01R |
| F | GD4S |

**JOHC**

| JOHC—Overhead Console, Overhead Console Side | |
|---|---|
| A | LC02H |
| B | BL11B |
| C | RB02B/RB02C |
| D | BL03E/BL03F |
| E | ML03E |
| F | LC01F/LC01G |

**JOCH**

| JOCH—Overcrank Harness, Overcrank Harness Side | |
|---|---|
| A | ST02F |
| B | NC |

**POCP**

| POCP—Tire Pressure Control Operator Panel | |
|---|---|
| 1 | TP02P |
| 2 | GD2BU |
| 3 | NC |
| 4 | TP10D |

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## Connector Loading Codes

| POCP—Tire Pressure Control Operator Panel | |
|---|---|
| 5 | TP17B |
| 6 | TP16B |

**POCS**

| POCS—Overcrank Connector on Starter | |
|---|---|
| A | ST07A |
| B | ST02F |

**POHC**

| POHC—Overhead Console, Cab Side | |
|---|---|
| A | LC02G |
| B | BL11A |
| C | RB02A |
| D | BL03D |
| E | ML03D |
| F | LC01C |

**JOP2**

| Grey Webasto Frontwall Connector, Cab Side | | | | | | |
|---|---|---|---|---|---|---|
| **Cavity** | **7-Day Timer** | **Switch** | **7-Day Timer** | **Switch** | **7-Day Timer** | **Switch** |
| 1 | WB01A | WB01A | WB01A | WB01A | WB01A | WB01A |
| 2 | WB02E | WB02D | WB02E | WB02D | WB02E | WB02D |
| 3 | NC | NC | NC | NC | NC | NC |
| 4 | WB04A | WB04A | NC | NC | WB04B | WB04B |
| 5 | WB05B | WB05D | WB05B | WB05D | WB05B | WB05D |
| 6 | — | — | — | — | — | — |
| 7 | — | — | — | — | — | — |
| 8 | — | — | — | — | — | — |
| 9 | — | — | — | — | — | — |
| 10 | — | — | — | — | — | — |
| 11 | DL08A | DL08A | DL08A | DL08A | DL08A | DL08A |
| 12 | DL08C | DL08C | DL08C | DL08C | DL08C | DL08C |

**POP2**

| POP2—Webasto Frontwall Connector, Grey, Engine Side | |
|---|---|
| 1 | Red |
| 2 | Black |
| 3 | Brown |
| 4 | Blue |
| 5 | Green |
| 6 | NC |

| POP2—Webasto Frontwall Connector, Grey, Engine Side | |
|---|---|
| 7 | NC |
| 8 | NC |
| 9 | NC |
| 10 | NC |
| 11 | DL08B |
| 12 | DL08D |

**JOP4**

| JOP4—Frontwall Option Connector,Transmission at Frontwall, Ceemat, Black, Cab Side | | |
|---|---|---|
| **Cavity** | **Dash Mount** | **Floor Mount** |
| 1 | NC | TR10B |

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## Connector Loading Codes

| JOP4—Frontwall Option Connector,Transmission at Frontwall, Ceemat, Black, Cab Side | | |
|---|---|---|
| **Cavity** | **Dash Mount** | **Floor Mount** |
| 2 | TW18E-T | TR11B |
| 3 | TW17E-T | TR07B |
| 4 | TW02B | TW02B |
| 5 | NC | GL1W |
| 6 | TW07B | TW07B |
| 7 | TW06B | TW06B |
| 8 | TW04B-T | TW04B-T |
| 9 | TW03B-T | TW03B-T |
| 10 | TW16B | TW16B |
| 11 | TW01A | TW01A |
| 12 | TW05D | TW05D |

**POP4**

| POP4—Frontwall Option Connector,Transmission at Frontwall, Ceemat, Black, Engine Side | | |
|---|---|---|
| **Cavity** | **Dash Mount** | **Floor Mount** |
| 1 | NC | TR10C |
| 2 | TW18D-T | TR11C |
| 3 | TW17D-T | TR07C |
| 4 | TW02C | TW02D |
| 5 | TW15A | GL1X |
| 6 | TW07A | TW07A |
| 7 | TW06A | TW06A |
| 8 | TW04A-T | TW04A-T |
| 9 | TW03A-T | TW03A-T |
| 10 | TW16A | TW16A |
| 11 | TW01B | TW01B |
| 12 | TW05C | TW05C |

**JOPT**

| JOPT—Sleeper Thermostat | |
|---|---|
| 1 | Orange |
| 2 | NC |
| 3 | Brown |
| 4 | ID11A |
| 5 | ID10A |

| JOPT—Sleeper Thermostat | |
|---|---|
| 6 | ID09A |

**JPD**

| JPD—Pro-Driver Connector | |
|---|---|
| 1 | 888A |
| 2 | 900H |

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## Connector Loading Codes

| JPD—Pro-Driver Connector | |
|---|---|
| 3 | 901H |
| 4 | 251B |
| 5 | 439E |
| 6 | ID09A |
| 7 | 150C |

**PPCL**

| PPCL—Tire Pressure Control Pneumatic Controller | |
|---|---|
| A | TP05D |
| B | TP15A |
| C | TP21A |
| D | TP22A |
| E | TP20A |
| F | TP05E |
| G | TP23A |
| H | TP05C |
| J | NC |
| K | TP14A |

**PPCS**

| PPCS—Tire Pressure Control Pressure Transducer | |
|---|---|
| A | TP13A |
| B | TP12A |
| C | TP11A |

**PRAS**

| PRAS—Radio Speakers, at Radio | |
|---|---|
| A | RA03A |
| B | RA05G |
| C | RA06A |
| D | RA07G |
| E | RA09A |
| F | RA10A |
| G | RA11A |
| H | RA12A |

**JRDF**

| JRDF—Right Drive and Fog Lamps, Main Harness Side | |
|---|---|
| A | DL02C |
| B | GD1L |
| C | FL02C |

**PRDF**

| PRDF—Right Drive and Fog Lamps, Light Side | |
|---|---|
| A | DL02E |
| B | GD1L |
| C | FL02E |

**PRFG**

| PRFG—Refridgerator Plug | |
|---|---|
| A | FR02A |
| B | GD7T |

**PRDH**

| PRDH—Right Hand Door | |
|---|---|
| A | ML03B |
| B | BL03A |
| C | GD2Z/AN |
| D | GD2Z/CH |
| E | HM02B |
| F | LC02B |
| G | GD2CH |
| H | NC |

**JRDH**

| JRDH—Right Hand Door | |
|---|---|
| A | Black, Marker Light, Hot |
| B | Backup Light, Hot |
| C | Backup Light Ground/Mirror Ground |
| D | Courtesy Light Ground |
| E | Heated Mirror, Hot |
| F | Courtesy Light, Hot |

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## Connector Loading Codes

**PRHL**

| PRHL—Right Headlight, Light Side, Conventional Hood | |
|---|---|
| A | HL07D |
| B | GD1R |
| C | HL09D |
| D | NC |
| E | NC |
| F | NC |

**PRHL**

| PRHL—Right Headlight, Light Side, Aero Hood | |
|---|---|
| A | HL07D |
| B | GD1R |
| C | HL09D |
| D | TL07F |
| E | GD1T |
| F | TL08H |

**PRP**

| PRP—Radio Power on Overhead Console Harness | |
|---|---|
| A | RA01C |
| B | RA02C |
| C | GD2BC |

**JRPC**

| JRPC—Radio Power on CB Radio Harness, to Overhead Console Harness | |
|---|---|
| A | RA01D/E |
| B | RA02D |
| C | GD2BL/M |

**PRPC**

| PRPC—Radio Power on CB Radio Harness, to Radio | |
|---|---|
| A | RA01D |
| B | RA02D |
| C | GD2BL |

**JRPM**

| JRPM—Right Hand Power Mirror | |
|---|---|
| A | White, Moto-Mirror |
| B | Green, Moto-Mirror |
| C | RA3E |
| D | RA5F |
| E | PW05C |
| F | PW04C |

**PRPM**

| PRPM—Right Hand Power Mirror | |
|---|---|
| A | PM05B |
| B | PM04B |
| C | RA03D |
| D | RA05E |
| E | PW05B |
| F | PW04B |

**PRPW**

| PRPW—Left Hand Power Mirror | |
|---|---|
| A | PW05C |
| B | BW04C |

**JRS**

| JRS—Reverse Switch, Engine Harness Side | |
|---|---|
| A | BL01E |
| B | BL01F |

**PRS**

| PRS—Reverse Switch, Taillamp Harness Side | |
|---|---|
| A | BL01D |
| B | BL01G |

**JRST**

| JRST—Remote Start, Harness Side | |
|---|---|
| 1 | ST09C |
| 2 | NC |

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## Connector Loading Codes

**PRST**

| PRST—Remote Start, Engine Harness Side | |
|---|---|
| 1 | ST02E |
| 2 | NC |

**PRTC**

| PRTC—Rooftop Condenser | |
|---|---|
| A | Black |
| B | Green |
| C | White |

**JRTH**

| JRTH—Rooftop Heater | |
|---|---|
| A | HT07B |
| B | HT03E |
| C | HT01C |
| D | GD2BG |
| E | HT04B |
| F | NC |

**PRTH**

| PRTH—Rooftop Heater | |
|---|---|
| A | HT07B |
| B | HT03E |
| C | HT01C |
| D | GD2BG |
| E | HT04B |
| F | NC |

**JRTL**

| JRTL—Right Taillamp | |
|---|---|
| A | TL08B |
| B | TL06D |
| C | TL02F |
| D | BL01P |
| E | NC |
| F | GD4N |

**PRTL**

| PRTL—Right Taillamp | |
|---|---|
| A | TL08AC |
| B | TL06E |
| C | TL02G |
| D | BL01Q |
| E | NC |
| F | GD4P |

**JSAC**

| JSAC—Speed Control Actuator Control | |
|---|---|
| A | CC05B |
| B | CC06B |

**PSAM**

| PSAM—Speed Control Actuator Motor | |
|---|---|
| A | CC03B |
| B | CC04B |

**PSCI**

| PSCI—Serial Communication Interface | |
|---|---|
| A | 142A |
| B | 151A |

**JSCI**

| JSCI—Serial Communication Interface | |
|---|---|
| A | 142B |
| B | 151N |

**JSC**

| JSC—Speed Control | |
|---|---|
| 1 | IN31C |
| 2 | GD2CA |
| 3 | NC |
| 4 | CC10A |
| 5 | PLUGGED |
| 6 | CC13A |
| 7 | CC12A |

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## Connector Loading Codes

| JSC—Speed Control | |
|---|---|
| 8 | CC01B/C |
| 9 | CC08A |
| 10 | CC06A |
| 11 | CC03A |
| 12 | CC04A |
| 13 | CC05A |
| 14 | IN30C |
| 15 | CC01A/B |
| 16 | GD2CA |
| 17 | CC11A |

**PSH**

| PSH—Sleeper Heater | |
|---|---|
| A | HT10A |
| B | HT12A |
| C | HT14A |
| D | HT13A |
| E | NC |
| F | HT08A |
| G | GD7R |
| H | HT11A |

**PSHP**

| PSHP—Sleeper to Heater Control Panel | |
|---|---|
| A | HT10A |
| B | HT12A |
| C | HT14A |
| D | HT13A |
| E | NC |
| F | HT08A/B |
| G | GD7Q/R |
| H | HT11A |

**JSJC**

| JSJC—Sleeper Jumper Cable, Frontwall to Back-of-Cab | |
|---|---|
| 1 | RA10E |

| JSJC—Sleeper Jumper Cable, Frontwall to Back-of-Cab | |
|---|---|
| 2 | RA09D |
| 3 | RA11D |
| 4 | RA12E |
| 5 | ML03S |
| 6 | BL03L |
| 7 | HT04D |
| 8 | LS01L |
| 9 | LS05C |
| 10 | LS04C |
| 11 | AC01H |
| 12 | SP01A |

**PSJC**

| PSJC—Sleeper Jumper Cable, Back-of-Cab to Sleeper | |
|---|---|
| 1 | RA10F |
| 2 | RA09E |
| 3 | RA11E |
| 4 | RA12F |
| 5 | ML03T |
| 6 | BL03M |
| 7 | HT04E |
| 8 | LS01M |
| 9 | LS05D |
| 10 | LS04D |
| 11 | AC01J |
| 12 | SP01B |

**JSJS**

| JSJS—Sleeper Start Jumper Cable, Back-of-Cab to Sleeper | |
|---|---|
| 1 | ST10C |
| 2 | IG01L |
| 3 | ST05D |
| 4 | AC01L |
| 5 | GD5AS |
| 6 | IN28P |

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| JSJS—Sleeper Start Jumper Cable, Back-of-Cab to Sleeper | |
|---|---|
| 7 | IN48D |
| 8 | LB01F |
| 9 | LB02F |
| 10 | SP02B |
| 11 | SP03B |
| 12 | SP04B |

**PSJS**

| PSJS—Sleeper Start Jumper Cable, Frontwall to Back-of-Cab | |
|---|---|
| 1 | ST10B |
| 2 | IG01K |
| 3 | ST05C |
| 4 | AC01K |
| 5 | GD5AR |
| 6 | IN28N |
| 7 | IN48C |
| 8 | LB01E |
| 9 | LB02E |
| 10 | SP02A |
| 11 | SP03A |
| 12 | SP04A |

**JSPR**

| JSPR—Sleeper, Cab Side | |
|---|---|
| 1 | RA10B |
| 2 | RA09B |
| 3 | RA12B |
| 4 | RA11B |
| 5 | ML03K |
| 6 | BL03G |
| 7 | HT04A |
| 8 | LS01C |
| 9 | LS05A |
| 10 | LS04A |
| 11 | AC01D |
| 12 | BL08A |

**PSPR**

| PSPR—Sleeper, Engine Side | |
|---|---|
| 1 | RA10C |
| 2 | RA09C |
| 3 | RA11C |
| 4 | RA12C |
| 5 | ML03C |
| 6 | BL03H |
| 7 | HT04C |
| 8 | LS01B |
| 9 | LS05B |
| 10 | LS04B |
| 11 | AC01E |
| 12 | SP01B |

**PSPT**

| PSPT—Air Dryer | |
|---|---|
| A | AD03C |
| B | GD1AA |

**PSPT**

| PSPT—Second Air Dryer | |
|---|---|
| A | AD03C |
| B | GD1AT |

**JSSA**

| JSSA—Argo Special Event, Sleeper Start Jack | |
|---|---|
| 1 | ST10D |
| 2 | IG01N |
| 3 | ST05A |
| 4 | AC01M |
| 5 | GD5BA |
| 6 | IN28Q |
| 7 | IN48E |
| 8 | LB01G |
| 9 | LB02G |
| 10 | NC |
| 11 | NC |

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## Connector Loading Codes

| JSSA—Argo Special Event, Sleeper Start Jack | |
|---|---|
| 12 | NC |

**PSSA**

| PSSA—Argo Special Event, Sleeper Start Plug | |
|---|---|
| 1 | ST10D |
| 2 | IG01M |
| 3 | ST05B |
| 4 | AC01M |
| 5 | GD5BA |
| 6 | IN28Q |
| 7 | IN48E |
| 8 | LB01G |
| 9 | LB02G |
| 10 | IN71A |
| 11 | NC |
| 12 | NC |

**JSSP**

| JSSP—Sound System Power, Cab Side | |
|---|---|
| A | RA01A |
| B | RA02A |
| C | GB2BA |

**PSSP**

| PSSP—Sound System Power, Overhead Console Side | |
|---|---|
| A | RA01B/C |
| B | RA02B/C |
| C | GB2BB/BC |

**JSSS**

| JSSS—Sound System Power, Speakers Signal, Cab Side | |
|---|---|
| A | RA03D |

| JSSS—Sound System Power, Speakers Signal, Cab Side | |
|---|---|
| B | RA05E |
| C | RA06D |
| D | RA07E |
| E | RA09B |
| F | RA10B |
| G | RA11B |
| H | RA12B |

**PSSS**

| PSSS—Sound System Power, Speakers Signal, Overhead Console Side | |
|---|---|
| A | RA03E |
| B | RA05F |
| C | RA06E |
| D | RA07F |
| E | RA09A |
| F | RA10A |
| G | RA11A |
| H | RA12A |

**JSSS**

| JSSS—Sound System Power, Speakers Signal, Cab Side | |
|---|---|
| A | RA03D |
| B | RA05E |
| C | RA06D |
| D | RA07E |
| E | RA09B |
| F | RA10B |
| G | RA11B |
| H | RA12B |

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## Connector Loading Codes

**JSST**

| JSST Sleeper Start, Cab Side | | | | |
|---|---|---|---|---|
| **Cavity** | **Old Style Steel Sleepers** | **Aluminum Sleepers or New Steel Sleepers** | **Optmized Idle** | **Australia** |
| 1 | ST02B | ST10A | ID09B | ST10A |
| 2 | IG01A | IG01A | ID10B | IG01A |
| 3 | ST05A | ST05A | ID11B | ST05A |
| 4 | AC01B | AC01B | NC | AC01B |
| 5 | GD5AA | GD5AA | NC | GD5AA |
| 6 | IN28L | IN28L | NC | IN28L |
| 7 | IN48A | IN48A | NC | IN48A |
| 8 | LB01C | LB01C | NC | LB01C |
| 9 | LB02C | LB02C | NC | LB02C |
| 10 | White (Argo) | White (Argo) | NC | White (Argo) |
| 11 | NC | NC | NC | HT25A |
| 12 | NC | NC | NC | HT26A |

**PSST**

| PSST Sleeper Start, Engine Side | | | | |
|---|---|---|---|---|
| **Cavity** | **Old Style Steel Sleepers** | **Aluminum Sleepers or New Steel Sleepers** | **Optmized Idle** | **Australia** |
| 1 | ST02B | ST10E | ID09A | ST10E |
| 2 | IG01B | IG01Q | ID10A | IG01Q |
| 3 | ST05B | ST05F | ID11A | ST05F |
| 4 | AC01C | AC01N | NC | AN01N |
| 5 | GD5AB | GD5BB | NC | GD5BB |
| 6 | IN28M | IN28F | NC | IN28F |
| 7 | IN48B | IN48E | NC | IN48E |
| 8 | LB01D | LB01H | NC | LB01H |
| 9 | LB02D | LB02H | NC | LB02H |
| 10 | NC | SP02C | NC | SP02C |
| 11 | NC | SP03C | NC | SP03C |
| 12 | NC | SP04C | NC | SP04C |

**JT3**

| JT3—Traction Differential Harness in Cab, Third Axle, Main Cab Harness Side | |
|---|---|
| A | IN68A |

**PT3**

| PT3—Traction Differential Harness in Cab, Third Axle, Switch Side | |
|---|---|
| A | IN68C |

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## Connector Loading Codes

**JT12**

| JT12—Traction Differential Harness in Cab, First and Second Axle, Main Cab Harness Side | |
|---|---|
| A | IN17A |
| B | IN18A |

**PT12**

| PT12—Traction Differential Harness in Cab, First and Second Axle, Switch Side | |
|---|---|
| A | IN17C |
| B | IN18C |

**JTCC**

| JTCC—Eaton Transmission Mounted Cruise Control Switches | |
|---|---|
| 1 | CC14C |
| 2 | CC15A |
| 3 | CC14A |
| 4 | NC |
| 5 | CC16A |
| 6 | CC17A |
| 7 | NC |
| 8 | NC |
| 9 | NC |
| 10 | NC |
| 11 | NC |
| 12 | NC |

**PTCC**

| PTCC—Eaton Transmission Mounted Cruise Control Switches | |
|---|---|
| 1 | CC14D |
| 2 | Cruise on Line to Engine |
| 3 | Switch Common from Engine |
| 4 | NC |
| 5 | Cruise Reset Line to Engine |
| 6 | Cruise Set Line to Engine |
| 7 | NC |
| 8 | NC |

| PTCC—Eaton Transmission Mounted Cruise Control Switches | |
|---|---|
| 9 | NC |
| 10 | NC |
| 11 | NC |
| 12 | NC |

**JTPC**

| JTPC—Tire Pressure Control Cab Floor | |
|---|---|
| 1 | TP07A |
| 2 | TP08A |
| 3 | TO09A |
| 4 | GD2EV |
| 5 | NC |
| 6 | NC |
| 7 | NC |
| 8 | NC |
| 9 | NC |
| 10 | NC |
| 11 | NC |
| 12 | NC |

**PTPC**

| PTPC—Tire Pressure Control Cab Floor | |
|---|---|
| 1 | TP07B |
| 2 | TP08B |
| 3 | TO09B |
| 4 | GD2EU |
| 5 | NC |
| 6 | NC |
| 7 | NC |
| 8 | NC |
| 9 | NC |
| 10 | NC |
| 11 | NC |
| 12 | NC |

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## Connector Loading Codes

**JTPI**

| JTPI—Tire Pressure Control Cab Interface, Right Pillar | |
|---|---|
| A | TP16A |
| B | TP17A |
| C | TO18A |
| D | GD19A |
| E | TO02D |
| F | NC |

**PTPI**

| PTPI—Tire Pressure Control Cab Interface, Right Pillar | |
|---|---|
| A | TP16B |
| B | TP17B |
| C | TO18B |
| D | GD19B |
| E | TO02C |
| F | NC |

**PTPP**

| PTPP—Tire Pressure Control Cab Power Interface, Right Pillar | |
|---|---|
| A | GD2ET |
| B | TP05B |
| C | TO06B |
| D | TP10C |
| E | NC |
| F | NC |

**PTPL**

| PTPL—Tire Pressure Control ECU 30 Pin | |
|---|---|
| A1 | NC |
| A2 | NC |
| A3 | GD2EY |
| B1 | NC |
| B2 | NC |
| B3 | GD2EX |
| C1 | TP22A |

| PTPL—Tire Pressure Control ECU 30 Pin | |
|---|---|
| C2 | TP23A |
| C3 | TP16A |
| D1 | NC |
| D2 | NC |
| D3 | TP18A |
| E1 | TP05G |
| E2 | TPA |
| E3 | TP19A |
| F1 | NC |
| F2 | NC |
| F3 | TP21A |
| G1 | TP02F |
| G2 | TP17A |
| G3 | NC |
| H1 | NC |
| H2 | TP05F |
| H3 | NC |
| J1 | NC |
| J2 | TP24A |
| J3 | TP08B |
| K1 | NC |
| K2 | NC |
| K3 | TP07B |

**PTPS**

| PTPS—Tire Pressure Control ECU 18 Pin | |
|---|---|
| A1 | NC |
| A2 | NC |
| A3 | NC |
| B1 | TP14A |
| B2 | NC |
| B3 | NC |
| C1 | TP13A |
| C2 | NC |
| C3 | TP11A |
| D1 | TP12A |
| D2 | NC |

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## Connector Loading Codes

| PTPS—Tire Pressure Control ECU 18 Pin | |
|---|---|
| D3 | TP10B |
| E1 | TP15A |
| E2 | NC |
| E3 | NC |
| F1 | NC |
| F2 | NC |
| F3 | TP09B |

**JTRC**

| JTRC—Meritor Transmission Mounted Cruise Control Switches | |
|---|---|
| 1 | CC18A |
| 2 | CC19A |
| 3 | NC |
| 4 | CC20B |
| 5 | CC20D |
| 6 | CC21B |
| 7 | CC21D |
| 8 | CC22B |
| 9 | CC22D |

| JTRC—Meritor Transmission Mounted Cruise Control Switches | |
|---|---|
| 10 | NC |
| 11 | NC |
| 12 | NC |

**PTRC**

| PTRC—Meritor Transmission Mounted Cruise Control Switches | |
|---|---|
| 1 | CC18A |
| 2 | From Engine Harness |
| 3 | NC |
| 4 | CC20A |
| 5 | From Engine Harness |
| 6 | CC21A |
| 7 | From Engine Harness |
| 8 | CC22A |
| 9 | From Engine Harness |
| 10 | NC |
| 11 | NC |
| 12 | NC |

**JTLF**

| JTLF—Taillamps on Frame, Taillamp Side | | |
|---|---|---|
| A | White | GD4D |
| B | Blue | BL01M |
| C | Green | TL06E |
| D | Brown | TL08Q |
| E | Yellow | TL05D |
| F | BL1G | NC |

**PTLF**

| PTLF—Taillamps on Frame, Cab Side | | |
|---|---|---|
| A | White | GD4C |
| B | – | BL01K |
| C | Green | TL06D |
| D | Brown | TL08P |
| E | Yellow | TL05C |
| F | – | BL01L |

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## Connector Loading Codes

**JTLR**

| JTLR—Trailer, Cab Side | | | |
|---|---|---|---|
| **Cavity** | **No Trailer Option** | **ABS no ABT** | **Third Axle Lift** |
| A | NC | AC10 | AB57 |
| B | TL10A | — | — |
| C | TL07A | — | — |
| D | TL08C | — | — |
| E | ML06A | — | — |
| F | TL04A | — | — |

**PTLR**

| PTLR—Trailer, Trailer Side | |
|---|---|
| A | Blue |
| B | Red |
| C | Green |
| D | Brown |
| E | Black |
| F | Yellow |

**JTLT**

| JTLT—Taillamps on Frontwall, Cab Side | |
|---|---|
| 1 | BL02B/TR09A/TR59B |
| 2 | TL08D |

| JTLT—Taillamps on Frontwall, Cab Side | |
|---|---|
| 3 | TL05A |
| 4 | TL06A |
| 5 | IN18A |
| 6 | IN17A |
| 7 | IN38A |
| 8 | IN39A |
| 9 | TL02D |
| 10 | IN70A |
| 11 | IN68A |
| 12 | IN57A |

**PTLT**

| PTLT—Taillamps on Frontwall, Engine Side | | | |
|---|---|---|---|
| **Cavity** | **Unsealed** | **Sealed** | **Australia** |
| 1 | BL01D-Black | BL01D-Black | BL01D-Black |
| 2 | TL08M-Brown | TL08P-Brown | TL08AA-Brown |
| 3 | TL05B-Yellow | TL05C-Yellow | TL05C-Yellow |
| 4 | TL06B-Green | TL06D-Green | TL06D-Green |
| 5 | IN18B | IN18B | — |
| 6 | IN17B | IN17B | — |
| 7 | IN38B | IN38B | — |
| 8 | IN39B | IN39B | — |
| 9 | NC | TL02E-Red | — |
| 10 | Brown | Brown Interaxle Differential Lock Switch | — |
| 11 | IN68B | IN68B | — |

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## Connector Loading Codes

| PTLT—Taillamps on Frontwall, Engine Side | | | |
|---|---|---|---|
| **Cavity** | **Unsealed** | **Sealed** | **Australia** |
| 12 | IN57B | IN57B | — |

**PTRR**

| PTRR—Trinary Switch, Roof Top Air | |
|---|---|
| A | FC04D |

| PTRR—Trinary Switch, Roof Top Air | |
|---|---|
| B | GD2BF |

**PTRS**

| PTRS—Trinary Switch | | | | |
|---|---|---|---|---|
| **Cavity** | **3406E/3176B** | **Celect** | **DDECIII** | **3406C, C8.3** |
| A | E791A | A08A | 542A | FC04B |
| B | C988B | B10B | 953D | GD5J |

**PTSD**

| PTSD—Transmission Shifter, Dash Mount | |
|---|---|
| A1 | TR11A |
| A2 | TR12B |
| A3 | NC |
| A4 | NC |
| A5 | TW02A |
| A6 | NC |
| A7 | TW01F |
| A8 | NC |
| A9 | TW18E-T |
| A10 | TW17E-T |
| A11 | NC |
| A12 | NC |
| B1 | GD2EG |
| B2 | TR10A |
| B3 | TR15A |
| B4 | GL1V |
| B5 | TR07A |
| B6 | TR06A |
| B7 | NC |
| B8 | NC |
| B9 | TR15A |
| B10 | NC |
| B11 | NC |

| PTSD—Transmission Shifter, Dash Mount | |
|---|---|
| B12 | GD2EE |

**PTSF**

| PTSF—Transmission Shifter, Floor Mount | |
|---|---|
| A1 | TR11C |
| A2 | TR13B |
| A3 | NC |
| A4 | NC |
| A5 | TW02F |
| A6 | NC |
| A7 | TW01H |
| A8 | NC |
| A9 | TW18F-T |
| A10 | TW17F-T |
| A11 | NC |
| A12 | NC |
| B1 | TW13D |
| B2 | TR10C |
| B3 | TR15A |
| B4 | GL1X |
| B5 | TR07C |
| B6 | NC |
| B7 | NC |
| B8 | NC |

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| PTSF—Transmission Shifter, Floor Mount | |
|---|---|
| B9 | TR15A |
| B10 | NC |
| B11 | NC |
| B12 | TW13E |

**JTSA**

| JTSA—Turn Signal Switch, Australia | |
|---|---|
| A | TL07U |
| B | TL04U |
| C | TL26A |

**JTSS**

| JTSS—Turn Signal Switch, Australia, Harness Side | |
|---|---|
| A | TL04Q |
| B | TL07Q |
| C | TL04R |
| D | TL07R |
| E | TL03B |
| F | TL02D |
| G | TL04P |
| H | TL07O |

**PTSS**

| PTSS—Turn Signal Switch, Cab Side | |
|---|---|
| A | TL06A |
| B | TL05A |

| PTSS—Turn Signal Switch, Cab Side | |
|---|---|
| C | TL07B |
| D | TL04B |
| E | TL03A |
| F | TL02A |
| G | TL04A |
| H | TL07A |

**JTVH**

| JTVH—Transmission Vehicle Harness Connector, Allison | |
|---|---|
| 1 | TR60A |
| 2 | NC |
| 3 | TR61A |
| 4 | NC |
| 5 | TR64A |
| 6 | TR66A |
| 7 | TR67A |
| 8 | NC |
| 9 | NC |
| 10 | NC |
| 11 | NC |
| 12 | TR65A |
| 13 | TR63A |
| 14 | TR62A |
| 15 | NC |
| 16 | NC |

**JTV1**

| JTV1—Transmission Vehicle Signal Connector, Overhead Console Side | | |
|---|---|---|
| **Cavity** | **WTECII** | **WTECIII** |
| A | TR66B | 154A |
| B | TR67B | 137A |
| C | TR65B | 161A |
| D | TR64B | 118A |
| E | TR63B | 105A |
| F | TR62B | NC |
| G | TR61B | NC |

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## Connector Loading Codes

| JTV1—Transmission Vehicle Signal Connector, Overhead Console Side | | |
|---|---|---|
| **Cavity** | **WTECII** | **WTECIII** |
| H | TR60B | NC |

**PTV1**

| PTV1—Transmission Vehicle Signal Connector, Dash Side | | |
|---|---|---|
| **Cavity** | **WTECII** | **WTECIII** |
| A | TR66A | 154 |
| B | TR67A | 137 |
| C | TR65A | 161 |
| D | TR64A | 118 |
| E | TR63A | 105 |
| F | TR62A | NC |
| G | TR61A | NC |
| H | TR60A | NC |

**PTVK**

| PTVK—Transmission Vehicle SIGN Connector, Overhead Console Side, WTECIII | |
|---|---|
| A | NC |
| B | NC |
| C | NC |
| D | 115 |
| E | NC |
| F | 166 |
| G | 186 |
| H | 163 |

**JTVK**

| JTVK—Transmission Vehicle SIGN Connector, Overhead Console Side, WTECIII | |
|---|---|
| A | NC |
| B | NC |
| C | NC |
| D | 115A |
| E | NC |
| F | 166A |
| G | 186A |
| H | 163A |

**PVIM**

| PVIM—Vehicle Interface Module, to Module Under Seat | | |
|---|---|---|
| **Cavity** | **WTECII** | **WTECIII** |
| A1 | TR58A | 313NO |
| A2 | NC | NC |
| A3 | NC | NC |
| B1 | TR59A | 313CM |
| B2 | NC | NC |
| B3 | NC | NC |
| C1 | TR51E | 346 |
| C2 | NC | NC |

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| PVIM—Vehicle Interface Module, to Module Under Seat | | |
|---|---|---|
| **Cavity** | **WTECII** | **WTECIII** |
| C3 | NC | NC |
| D1 | TR53A | 325NC |
| D2 | TR57A | 332CM |
| D3 | NC | NC |
| E1 | GD2EM | 325CM |
| E2 | TR56A | 332NC |
| E3 | NC | NC |
| F1 | TR54A | 323NO |
| F2 | NC | NC |
| F3 | NC | NC |
| G1 | TR55A | 323CM |
| G2 | NC | NC |
| G3 | NC | NC |
| H1 | NC | NC |
| H2 | NC | NC |
| H3 | NC | NC |
| J1 | BA03X | 336A |
| J2 | BA03Y | 336C |
| J3 | TRGL1AA | NC |
| K1 | GD2EK | 343A |
| K2 | GD2EL | 343C |
| K3 | TR52A | — |

**JVMP**

| JVMP—Vehicle Interface Module Power, Overhead Console side | | |
|---|---|---|
| **Cavity** | **WTECII** | **WTECIII** |
| A | TR52A | NC |
| B | NC | NC |
| C | BA03W | 336B |
| D | GD2EJ | 3343B |
| E | NC | NC |
| F | GL1AA | NC |

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## Connector Loading Codes

**PVMP**

| PVMP—Vehicle Interface Module Power, Dash Side | | |
|---|---|---|
| **Cavity** | **WTECII** | **WTECIII** |
| A | TR52B | NC |
| B | NC | NC |
| C | BA03V | 336D |
| D | GD2EH | 343D |
| E | NC | NC |
| F | GL1Z | NC |

**JVMS**

| JVMS—Vehicle Interface Module Signals, Dash Side | | |
|---|---|---|
| **Cavity** | **WTECII** | **WTECIII** |
| A | TR59B | 313CM |
| B | TR58B | 313NO |
| C | TR57B | 332CM |
| D | TR56B | 332NC |
| E | TR55B | 323CM |
| F | TR54B | 323NO |
| G | TR53B | 325NC |
| H | TR51B | 325CM |

**PVMS**

| PVMS—Vehicle Interface Module Signals, Overhead Console Side | | |
|---|---|---|
| **Cavity** | **WTECII** | **WTECIII** |
| A | TR59B | 313CM |
| B | TR58B | 313NO |
| C | TR57B | 332CM |
| D | TR56B | 332NC |
| E | TR55B | 323CM |
| F | TR54B | 323NO |
| G | TR53B | 325NC |
| H | TR51B | 325CM |

**PVSA**

| PVSA—Vehicle Speed Sensor, Argo | |
|---|---|
| A | IN66A |
| B | IN67A |

**JVSP**

| JVSP—Vehicle Speed Sensor | |
|---|---|
| A | IN30C |
| B | IN54D |

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# Connector Loading Codes

**PVSP**

| PVSP—Vehicle Speed Sensor | | | | |
|---|---|---|---|---|
| **Cavity** | **3406E/3176B** | **Celect** | **DDECIII** | **3406C, C8.3** |
| A | D784A | B03A | 556A | IN30A |
| B | D785B | B07A | 557A | IN54A |

**PVST**

| PVST—Vehicle Speed Sensor | |
|---|---|
| A | TP07A |
| B | TP08A |

**JWBH**

| JWBH—Webasto Heater Connector | |
|---|---|
| A | WB07A |
| B | HT03F |
| C | HT01H |
| D | GD2DW |
| E | HT04F |
| F | NC |

**PWBH**

| PWBH—Webasto Heater Connector | |
|---|---|
| A | WB06A |
| B | HT03F |
| C | HT01H |
| D | GD2DW |
| E | HT04F |
| F | NC |

**PWM**

| PWM—Wiper Motor | |
|---|---|
| A | WW08A |
| B | WW09A |
| C | WW11A |
| D | WW10A |

**JWT1**

| JWT1—Webasto Timer | |
|---|---|
| A | WB01C |
| B | WB02B |
| C | WB03A |

**PWT1**

| PWT1—Webasto Timer | |
|---|---|
| A | WB01D |
| B | WB02C |
| C | WB03B |

**Binding Posts**

| Binding Posts | | | |
|---|---|---|---|
| **Cavity** | **Location** | **Type** | **Function** |
| BP1 | VHF Preparation Harness | Red | Positive |
| BP2 | VHF Preperation Harness | Black | Negative |
| BP3 | Cell Preparation Harness | Red | Positive |
| BP4 | Cell Preparation Harness | Black | Negative |

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## Connector Loading Codes

**JL72**

| JL72—Left-Hand Mirror Mounted Turn Signal | |
|---|---|
| A | GD2FU |
| B | TL04L |

**PL72**

| PL72—Left-Hand Mirror Mounted Turn Signal | |
|---|---|
| A | GD2FT |
| B | TL04K |

**JL73**

| JL73—Left-Hand Mirror Mounted Turn Signal | |
|---|---|
| A | GD2FV |
| B | TL07L |

**PL73**

| PL73—Left-Hand Mirror Mounted Turn Signal | |
|---|---|
| A | GD2FV |
| B | TL07L |

**JLTM**

| JLTM—Mirror Mounted Turn Signal, Frontwall Side | |
|---|---|
| A | TL04C |
| B | TL07C |

**PLTM**

| PLTM—Mirror Mounted Turn Signal, Frontwall Side | |
|---|---|
| A | TL04H |
| B | TL07H |

**JVC2**

| JVC2—Subwoofer Jumper, at Sleeper Dash Panel | |
|---|---|
| A | RA22B |
| B | RA23B |
| C | NC |
| D | NC |
| E | RA25B |
| F | RA24B |

**PVC2**

| PVC2—Subwoofer Jumper, at Sleeper Dash Panel | |
|---|---|
| A | RA22B/RA22C |
| B | RA23B/RA23C |
| C | NC |
| D | NC |
| E | RA25B/RA25C |
| F | RA24B/RA24C |

**JCKC**

| JCKC—Subwoofer Jumper, at Sleeper Dash Panel | |
|---|---|
| A | RA201F/RA01E |
| B | RA02E/RARA23C |
| C | GD2GD/GD2BM |

**PCKC**

| PCKC—Subwoofer Jumper, at Clock | |
|---|---|
| A | RA01F |
| B | RA02E |
| C | GD2GD |

**PTRS**

| PTRS—A/C Trinary Switch, at Frontwall | | | |
|---|---|---|---|
| **Cavity** | **3406E/C12/C10** | **S60** | **N14/M11** |
| A | E971A | 542A | A08A |
| B | C988 | 953D | B10B |

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## Connector Loading Codes

**PTX7**

| PTX7—Coolant Level, at Frontwall | | | |
|---|---|---|---|
| **Cavity** | **3406E/C12/C10** | **S60** | **N14/M11** |
| A | C964A | 115A | A09A |
| B | C933B | 953C | A13A |
| C | C997A | — | A22A |
| D | C983A | — | A18A |

**PTX7**

| PTX7—Engine Oil Temperature, 3406E/C12/C10 | |
|---|---|
| A | IN13B |
| B | GD5F |

**PTX1**

| PTX1—Transmission Oil Temperature | |
|---|---|
| A | IN26B |
| B | GD5A |

**PTX5**

| PTX5—Vehicle Speed | | | |
|---|---|---|---|
| **Cavity** | **3406E/C12/C10** | **S60** | **N14/M11** |
| A | D784A | 556A | B03A |
| B | D785A | 557A | B07A |

**PTX3**

| PTX3—Vehicle Speed | | | |
|---|---|---|---|
| **Cavity** | **3406E/C12/C10** | **S60** | **N14/M11** |
| A | C985B | 925B | B19B |
| B | C993F | 417B | B11B |
| C | C986B | 916B | B18B |

**VIW–S**

| VIW–S—Vehicle Interface Module Signals, Overhead Console Side | |
|---|---|
| A | 159S |
| B | 115 |
| C | 126P |
| D | NC |
| E | 166 |
| F | NC |
| G | NC |
| H | NC |
| J | NC |
| K | NC |

| VIW–S—Vehicle Interface Module Signals, Overhead Console Side | |
|---|---|
| L | NC |
| M | NC |
| N | NC |
| P | 143N |
| Q | NC |
| R | 163 |
| S | NC |
| T | 186 |
| U | NC |
| V | NC |

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## Connector Loading Codes

**VIW–V**

| VIW–V—Vehicle Interface Module Signals, Overhead Console Side | |
|---|---|
| A | NC |
| B | NC |
| C | 118 |
| D | 154 |
| E | 105 |
| F | NC |
| G | NC |
| H | NC |
| J | NC |
| K | NC |
| L | 161 |
| M | NC |
| N | NC |
| P | NC |
| Q | NC |
| R | NC |
| S | NC |
| T | NC |
| U | 137 |
| V | NC |

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# Circuit Codes A through F

All wires have three to five character alphanumeric codes printed on them every four to six inches. The first two characters are a letter code that denotes the circuit type in which the wire is used. The next one or two numbers denote the specific circuit, and last letter denotes the branch in the circuit. Use the following circuit code tables to look up the circuit code that is printed on a wire and determine its function.

See **Table 1** for an explanation of location abbreviations used in the circuit code tables.

| Abbreviation | Location |
|---|---|
| CAB | Cab |
| CHA | Chassis |
| ENG | Engine Compartment |
| FW | Frontwall |
| LHD | Left-Hand Door |
| OHC | Overhead Console |
| RHD | Right-Hand Door |
| SLPR | Sleeper |

**Table 1, Location Code Abbreviations**

**AB—Antilock Brakes Circuits AB01 through AB39**

| AB—Antilock Brakes Circuits AB01 through AB39 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| AB01A | Antilock brakes | Fused ignition power for valves; ECU to firewall | CHA |
| AB01B | Antilock brakes | Fused ignition power for valves; frontwall to fuse | CAB |
| AB02A | Antilock brakes | Fused ignition power for ECU; ECU to frontwall | CHA |
| AB02B | Antilock brakes | Fused ignition power for ECU; ECU to fuse | CAB |
| AB03A | Antilock brakes | Deep mud/snow switch; ECU to frontwall | CHA |
| AB03B | Antilock brakes | Deep mud/snow switch; frontwall to switch | CAB |
| AB03C | Antilock brakes | Deep mud/snow switch; switch to lightbar | CAB |
| AB04A | Antilock brakes | J1587+; ECU to frontwall | CHA |
| AB04B | Antilock brakes | J1587+; frontwall to splice | CAB |
| AB04C | Antilock brakes | J1587+; switch to splice to P15 | CAB |
| AB04D | Antilock brakes | J1587+; switch to splice to J15 | CAB |
| AB05A | Antilock brakes | Retarder signal; ECU to frontwall | CHA |
| AB05B | Antilock brakes | Retarder signal; frontwall to retarder control relay | CAB |
| AB05C | Allison | Retarder signal; AB05B via P44 to Allison ABS active relay | CAB |
| AB05D | Allison | Retarder signal; Allison ABS active relay to frontwall | CAB |
| AB06A | Antilock brakes | J1922-; ECU to splice | CHA |
| AB06B | Antilock brakes | J1922-; splice to P19 | CHA |
| AB06C | Antilock brakes | J1922-; splice to J19 | CHA |
| AB07A | Antilock brakes | J1922+; ECU to splice | CHA |
| AB07B | Antilock brakes | J1922+; splice to P19 | CHA |
| AB07C | Antilock brakes | J1922; splice to J19 | CHA |
| AB09A | Antilock brakes | J1587-; ECU to frontwall | CHA |
| AB09B | Antilock brakes | J1587-; frontwall to splice | CAB |

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## Circuit Codes A through F

| AB—Antilock Brakes Circuits AB01 through AB39 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| AB09C | Antilock brakes | J1587-; switch to splice to P15 | CAB |
| AB09D | Antilock brakes | J1587-; switch to splice to J15 | CAB |
| AB10A | Antilock brakes | Blink code switch; ECU to frontwall | CHA |
| AB10B | Antilock brakes | Blink code switch; frontwall to blink code switch | CAB |
| AB11A | Antilock brakes | Fused ignition power; fuse to ABS warning relay | CAB |
| AB11B | Antilock brakes | Fused ignition power; ABS warning relay to ABS warning relay | CAB |
| AB12A | Antilock brakes | Blink code signal; warning relay to light in blink code switch | CAB |
| AB12B | Antilock brakes | Blink code signal; warning relay to lightbar | CAB |
| AB13A | Antilock brakes | Warning relay control; warning relay to blink code switch | CAB |
| AB14A | Antilock brakes | Engine brake control; engine brake relay to engine brake switch in dash | CAB |
| AB15A | Antilock brakes | Engine brake control; engine brake relay to EB04A line with one way connector | CAB |
| AB16A | Antilock brakes | Engine brake control; warning relay to engine brake relay | CAB |
| AB30A | Antilock brakes | Front right wheel sensor black; sensor to ECU | CHA |
| AB31A | Antilock brakes | Front right wheel sensor brown; sensor to ECU | CHA |
| AB32A | Antilock brakes | Front right PMV valve inlet brown; valve to ECU | CHA |
| AB33A | Antilock brakes | Front right PMV valve exhaust blue; valve to ECU | CHA |
| AB34A | Antilock brakes | Front right PMV valve common green/yellow; valve to ECU | CHA |
| AB35A | Antilock brakes | Front left PMV valve inlet brown; valve to ECU | CHA |
| AB36A | Antilock brakes | Front left PMV valve exhaust blue; valve to ECU | CHA |
| AB37A | Antilock brakes | Front left PMV valve common green/yellow; valve to ECU | CHA |
| AB38A | Antilock brakes | Front left wheel sensor black; sensor to ECU | CHA |
| AB39A | Antilock brakes | Front left wheel sensor brown; sensor to ECU | CHA |

**AB—Antilock Brakes Circuits AB40 through AB64**

| AB—Antilock Brakes Circuits AB40 through AB64 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| AB40A | Antilock brakes | Rear right wheel sensor black; sensor to extension cable | CHA |
| AB40B | Antilock brakes | Rear right wheel sensor black; ECU to extension cable | CHA |
| AB41A | Antilock brakes | Rear right wheel sensor brown; sensor to extension cable | CHA |
| AB41B | Antilock brakes | Rear right wheel sensor brown; ECU to extension cable | CHA |
| AB42A | Antilock brakes | Rear right PMV valve inlet brown; valve to extension cable | CHA |
| AB42B | Antilock brakes | Rear right PMV valve inlet brown; ECU to extension cable | CHA |
| AB43A | Antilock brakes | Rear right PMV valve exhaust blue; valve to extension cable | CHA |
| AB43B | Antilock brakes | Rear right PMV valve exhaust blue; ECU to extension cable | CHA |

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| AB—Antilock Brakes Circuits AB40 through AB64 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| AB44A | Antilock brakes | Rear right PMV valve common green/yellow; valve to extension cable | CHA |
| AB44B | Antilock brakes | Rear right PMV valve common green/yellow; ECU to extension cable | CHA |
| AB45A | Antilock brakes | Rear left PMV valve inlet brown; valve to extension cable | CHA |
| AB45B | Antilock brakes | Rear left PMV valve inlet brown; ECU to extension cable | CHA |
| AB46A | Antilock brakes | Rear left PMV valve exhaust blue; valve to extension cable | CHA |
| AB46B | Antilock brakes | Rear left PMV valve exhaust blue; ECU to extension cable | CHA |
| AB47A | Antilock brakes | Rear left PMV valve common green/yellow; valve to extension cable | CHA |
| AB47B | Antilock brakes | Rear left PMV valve common green/yellow; ECU to extension cable | CHA |
| AB48A | Antilock brakes | Rear left wheel sensor black; sensor to extension cable | CHA |
| AB48B | Antilock brakes | Rear left wheel sensor black; ECU to extension cable | CHA |
| AB49A | Antilock brakes | Rear left wheel sensor brown; sensor to extension cable | CHA |
| AB49B | Antilock brakes | Rear left wheel sensor brown; ECU to extension cable | CHA |
| AB50A | Antilock brakes | Rear ATC valve blue; valve to extension cable | CHA |
| AB50B | Antilock brakes | Rear ATC valve blue; ECU to extension cable | CHA |
| AB51A | Antilock brakes | Rear ATC valve brown; valve to extension cable | CHA |
| AB51B | Antilock brakes | Rear ATC valve brown; ECU to extension cable | CHA |
| AB52A | Antilock brakes | Main fuse block bat jumper to ABS harness F78 | CAB |
| AB53A | Antilock brakes | Main fuse block ignition jumper to ABS harness F79 | CAB |
| AB53B | Antilock brakes | Option fuse block ignition jumper F79 to F99 | CAB |
| AB54A | Antilock brakes | Fused battery power for trailer receptacle; frontwall to fuse | CAB |
| AB55A | Antilock brakes | Fused ignition power for trailer receptacle; frontwall to fuse | CAB |
| AB56A | Antilock brakes | Trailer warning signal; frontwall to lightbar | CAB |
| AB57A | Antilock brakes | Trailer ABS power; fuse to JTLR | CAB |
| AB57B | Antilock brakes | Trailer ABS power; main fuse block to ABS option fuse block | CAB |
| AB58A | Antilock brakes | Trailer ABS power; F79 to ABS infomodule R51 | CAB |
| AB58B | Antilock brakes | Trailer ABS power; infomodule R51 jumper | CAB |
| AB59A | Antilock brakes | Trailer ABS power; ABS infomodule to JABT | CAB |
| AB59B | Antilock brakes | Trailer ABS power; PABT to JABC | CAB |
| AB59C | Antilock brakes | Trailer ABS power; F79 to splice | CAB |
| AB59D | Antilock brakes | Trailer ABS power; splice to ABS infomodule R51-S2 | CAB |
| AB59E | Antilock brakes | Trailer ABS power; splice to ABS infomodule R51-UES | CAB |
| AB60A | Antilock brakes | Trailer ABS power, F99 to ABS infomodule R52 | CAB |
| AB60B | Antilock brakes | Trailer ABS power; infomodule R52 jumper | CAB |

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## Circuit Codes A through F

| AB—Antilock Brakes Circuits AB40 through AB64 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| AB60C | Antilock brakes | Trailer ABS power; F99 to splice | CAB |
| AB60D | Antilock brakes | Trailer ABS power; splice to ABS infomodule R52-S2 | CAB |
| AB60E | Antilock brakes | Trailer ABS power; splice to ABS infomodule R52-UES | CAB |
| AB61A | Antilock brakes | Trailer ABS power; ABS infomodule to JABT | CAB |
| AB61B | Antilock brakes | Trailer ABS power; JABT to JABC | CAB |
| AB62A | Antilock brakes | Trailer ABS power; JABT to ABS infomodule R52 | CAB |
| AB62B | Antilock brakes | Trailer ABS power; PABT to JABC | CAB |
| AB63A | Antilock brakes | Trailer ABS power; ABS infomodule R51 to PECL | CAB |
| AB63B | Antilock brakes | Trailer ABS power; ABS infomodule R51 to ABS infomodule R52 | CAB |
| AB64A | Antilock brakes | Trailer ABS power; ABS infomodule R51 to Air switch S112 (Trailer present) | CAB |

**AC—Accessories Circuits AC01 through AC15**

| AC—Accessories Circuits AC01 through AC15 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| AC01A | Main | Key in accessory position; key switch to accessory relay coil | CAB |
| AC01B | Sleeper start | Key in accessory position; key switch to sleeper start connector | CAB |
| AC01C | Sleeper start | Key in accessory position; sleeper start connector to sleeper key switch | CHA |
| AC01D | Sleeper | Key in accessory position; key switch to sleeper connector | CAB |
| AC01E | Sleeper | Key in accessory position; sleeper connector to sleeper stud | SLPR |
| AC01F | Sleeper | Key in accessory position; sleeper stud to sleeper clock connector | SLPR |
| AC01G | Fridge | Key in accessory position; sleeper stud to fridge relay coil | SLPR |
| AC01H | Sleeper | Key in accessory position; sleeper connector to sleeper jumper connector | SLPR |
| AC01J | Sleeper | Key in accessory position; sleeper jumper connector to sleeper stud | SLPR |
| AC01K | Sleeper start | Key in accessory position; sleeper connector to back-of-cab | CHA |
| AC01L | Sleeper start | Key in accessory position.; back-of-cab to sleeper ignition switch | CHA |
| AC01M | Argo special event | Key in accessory position; PSSA to back-of-cab; JSSA | CHA |
| AC01N | Sleeper start | Key in accessory position.; sleeper connector to sleeper key switch | CHA |
| AC01P | Bogaard timer | Key in accessory position; key switch to Bogaard timer | CAB |
| AC2-BB | Main | Main accessory power; bus bar between fuse line terminals | ALL |
| AC02A | Main | Main fused accessory power; relay to F21-LN | CAB |
| AC02B | Main | Main fused accessory power F24-LN to F25-LN | CAB |

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| AC—Accessories Circuits AC01 through AC15 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| AC02C | Main | Main fused accessory power; F23-LN to jumpers JP-13 | CAB |
| AC02D | Main | Main fused accessory power; F22-LN to F27-LN | CAB |
| AC03A | Power | Main fuse block JP14 to F40-LN | CAB |
| AC04A | Extra switch | Main fuse block JP13 to F37-LN (extra switches) | CAB |
| AC05A | Extra switch | Fused accessory power to extra switch one | CAB |
| AC05B | Extra switch | Fused accessory power; extra switch one to extra switch four | CAB |
| AC06A | Extra switch | Fused accessory power to extra switch two | CAB |
| AC06B | Extra switch | Fused accessory power; extra switch two to extra switch five | CAB |
| AC07A | Extra switch | Fused accessory power to extra switch three | CAB |
| AC07B | Extra switch | Fused accessory power; extra switch three to extra switch six | CAB |
| AC08A | Option | Main fuse block JP13 to F48-LN (trailer accessory switch) | CAB |
| AC09A | Option | Fused accessory power; trailer accessory switch | CAB |
| AC10A | Option | Trailer accessory signal; switch to trailer connector | CAB |
| AC11A | Power mirror | Main fuse block JP15 to F43-LN | CAB |
| AC12A | Main | Fused accessory power to accessory option harnesses JP16-JP18 | CAB |
| AC12B | Main | Fused accessory power; JP13-JP15 to JP16-JP18 | CAB |
| AC12C | Main | Fused sleeper accessory power; JP17 to JSPR-11 | CAB |
| AC13A | Cab fridge | Main fused accessory power JP16 to fuse | CAB |
| AC14A | Cab fridge | Fused accessory power; fuse to cab fridge on-off switch | CAB |
| AC15A | Cab fridge | Cab fridge on-off; switch to lower left of dash | CAB |
| AC15B | Cab fridge | Cab fridge on-off; lower left of dash to cab fridge | OHC |

**AD—Accessories Circuits AD01 through AD04**

| AD—Accessories Circuits AD01 through AD04 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| AD01A | Air dryer | Main fused air dryer power: JP7 to air dryer fuse | CAB |
| AD02A | Air dryer | Fused air dryer power; air dryer fuse to frontwall connector | CAB |
| AD02B | Air dryer | Fused air dryer power; frontwall connector to air dryer | CHA |
| AD03A | Air dryer | Fused air dryer power: frontwall to spitter valve splice | CHA |
| AD03B | Air dryer | Fused air dryer power; spitter valve splice to spitter valve | CHA |
| AD03C | Air dryer | Fused air dryer power; spitter valve splice to air dryer | CHA |
| AD03D | Air dryer | Fused air dryer power; solenoid splice to solinoid | CHA |
| AD03E | Air dryer | Fused air dryer power; splice to splice | CHA |
| AD03F | Air dryer | Fused air dryer power; splice to second air dryer | CHA |
| AD04A | Air dryer | Fused power; spitter valve splice to spitter valve splice | CHA |

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## Circuit Codes A through F

### AS—Accessories Switches Circuits AS01 through AS06

| AS—Accessories Switches Circuits AS01 through AS06 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| AS01A | Extra switch | Fused acc power; extra switch to sleeper connector; frontwall (one switch) | CAB |
| AS01B | Extra switch | Fused acc power; sleeper connector to 6-ft. back-of-cab (one switch) | CHA |
| AS02A | Extra switch | Fused acc power; extra switch to sleeper connector; frontwall (two switches) | CAB |
| AS02B | Extra switch | Fused acc power; sleeper connector to 6-ft. back-of-cab (two switches) | CHA |
| AS03A | Extra switch | Fused acc power; extra switch to sleeper connector; frontwall (three switches) | CAB |
| AS03B | Extra switch | Fused acc power; sleeper connector to 6-ft. back-of-cab (three switches) | CHA |
| AS04A | Extra switch | Fused acc power; extra switch to sleeper connector; frontwall (four switches) | CAB |
| AS04B | Extra switch | Fused acc power; sleeper connector to 6-ft. back-of-cab (four switches) | CHA |
| AS05A | Extra switch | Fused acc power; extra switch to sleeper connector; frontwall (five switches) | CAB |
| AS05B | Extra switch | Fused acc power; sleeper connector to 6-ft. back-of-cab (five switches) | CHA |
| AS06A | Extra switch | Fused acc power; extra switch to sleeper connector; frontwall (six switches) | CAB |
| AS06B | Extra switch | Fused acc power; sleeper connector to 6-ft. back-of-cab (six switches) | CHA |

### AX—Axle Circuits AX01 through AX11

| AX—Axle Circuits AX01 through AX11 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| AX01A | DCTD interlock | Main breaker F108 to Ignition JP11 | CAB |
| AX01B | DCTD interlock | Main breaker F108 to frontwall connector JFWH | CAB |
| AX01C | DCTD interlock | Pressure switch; frontwall connector JFWH to sensor switch S117 | ENG |
| AX02A | DCTD interlock | Pressure switch; sensor switch to frontwall connector JFWH | ENG |
| AX02B | DCTD interlock | Frontwall connector JFWH to relay R54 | CAB |
| AX02C | DCTD interlock | Relay R54 to dash switch DCTD (front-rear or single) S118 | CAB |
| AX02D | DCTD interlock | Relay R54 to Relay 56 | CAB |
| AX02E | DCTD interlock | Relay 56 to DCTD (rearmost) S119 | CAB |
| AX03A | DCTD interlock | Switch DCTD (rearmost) S119 to Relay DCTD R54 | CAB |
| AX04A | DCTD interlock | Switch DCTD (rear-rear) S119 to latching relay DCTD R55 | CAB |

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| AX—Axle Circuits AX01 through AX11 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| AX04B | DCTD interlock | Jumper from pin 87 to 86 of latching relay R55 | CAB |
| AX04C | DCTD interlock | From latching relay R55 to solenoid SV19 | CAB |
| AX05A | DCTD interlock | DCTD relay R54 to DCTD latching relay R55 | CAB |
| AX06A | DCTD interlock | DCTD relay R54 to DCTD latching relay R55 | CAB |
| AX07A | DCTD interlock | DCTD relay 56 to DCTD (rear-rear) S119 | CAB |
| AX08A | DCTD interlock | DCTD (rear-rear) S119 to DCTD latching relay R57 | CAB |
| AX08B | DCTD interlock | Jumper from pin 87 to 86 of latching relay R57 | CAB |
| AX08C | DCTD interlock | From latching relay R57 to solenoid SV20 | CAB |
| AX09A | DCTD interlock | DCTD relay R56 to DCTD latching relay R57 | CAB |
| AX10A | DCTD interlock | DCTD relay R56 to DCTD latching relay R57 | CAB |
| AX11A | 2-speed axle | Ignition power; ignition switch to 2-speed axle air switch | CAB |
| AX11B | 2-speed axle | Ignition power; 2-speed axle air switch to Argo SDL control signal input; PARG | CAB |

**BA—Battery Power Curcuits BA01 through BA15**

| BA—Battery Power Circuits BA01 through BA15 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| BA01A | Engine | Engine power; battery positive to frontwall engine power stud | CHA |
| BA01C | CAT engine | Engine power; frontwall engine power stud to CAT ignition power relay fuse | CAB |
| BA01D | Option | Engine power; battery positive to isolation switch | CHA |
| BA01E | Option | Engine power; isolation switch to frontwall engine power stud | CHA |
| BA2FL | Power | Cab power; fuse link; battery stud to BA20B | CHA |
| BA02B | Power | Cab power; fuse link to frontwall stud | CHA |
| BA02C | Power | Cab power; main power fuses to ammeter shunt | ENG |
| BA02D | Power | Cab power; main power fuses to alternator | ENG |
| BA02E | Option | Cab power; frontwall stud to night switch | CAB |
| BA02F | Option | Cab power; night switch to ammeter shunt | CAB |
| BA02G | Option | Cab power, ammeter shunt to main fuses | CAB |
| BA02H | Option | Cab power; frontwall stud to main fuses (used when no switch and no shunt) | CAB |
| BA02J | Option | Cab power; frontwall stud to ammeter shunt (used when no night switch) | CAB |
| BA02K | Option | Cab power; night switch to main fuses (used when no ammeter shunt) | CAB |
| BA3-BB | Main | Main battery fused cab power; bus bar between fuse line terminals | CAB |

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## Circuit Codes A through F

| BA—Battery Power Circuits BA01 through BA15 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| BA03A | Power | Main battery fused cab power; main battery fuse to magnetic start switch | ENG |
| BA03B | Main | Main battery fused cab power; FW to man cab harness fuse block | CAB |
| BA03C | Main | Main ignition fused cab power; FW to main cab harness ignition relay | CAB |
| BA03D | Main | Main acc fused cab power; FW to man cab harness acc relay | CAB |
| BA03E | Main | Main battery fused cab power; bus bar to high beam relay | CAB |
| BA03F | Main | Main battery fused cab power; bus bar to low beam relay | CAB |
| BA03G | Main | Main battery fused cab power; FW to main cab harness jumper block JP6 | CAB |
| BA03H | Main | Main battery fused cab power; jumper block JP5 to F11-LN | CAB |
| BA03J | Main | Main battery fused cab power; jumper block JP4 to F10-LN | CAB |
| BA03K | Main | Main battery fused cab power; F6-LN to F17-LN | CAB |
| BA03L | Main | Main battery fused cab power; F7-LN to F30-LN | CAB |
| BA03M | Main | Main battery fused cab power; F8-LN to F9-LN | CAB |
| BA03N | Main | Main battery fused cab power; F4-LN to F5LN | CAB |
| BA03P | Option | ISO switch jumper (ECM by-pass) engine power; battery side to engine power; frontwall side | CHA |
| BA03Q | Spot lamp | Main battery fused cab power; main fuse block jumper to spot light harness | CAB |
| BA03R | VHF radio | Main battery fused cab power; main fuse block jumper to VHF radio prep | CAB |
| BA03S | Cell phone | Main battery fused cab power; main fuse block jumper to cell phone prep | CAB |
| BA03T | Main | Main battery fused cab power; F60-LDC to F11-LN | CAB |
| BA03U | Main | Main battery fused cab power; F12-LN to F10-LN | CAB |
| BA03V | Main | Main battery fused cab power; F60-LDC to Allison VIM power connector | CAB |
| BA03W | Main | Main battery fused cab power; Allison VIM power connector to splice | CAB |
| BA03X | Main | Main battery fused cab power; splice to Allison VIM | CAB |
| BA03Y | Main | Main battery fused cab power; splice to Allison VIM | CAB |
| BA04A | 12/24 | 24-volt unfused power; alternator to starter positive | CHA |
| BA05A | 12/24 | 12-volt cab power for 24-volt start; battery pos to iso switch | CHA |
| BA06A | Main | Fused battery power to ECC controller | CAB |
| BA7FL | Sleeper | Main battery power; fuselink; frontwall fuse line side to BA07B | CHA |
| BA07B | Sleeper | Main battery power; fuselink to sleeper power stud | SLPR |
| BA07C | Sleeper | Main battery power; sleeper power stud to fuse block | SLPR |

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| BA—Battery Power Circuits BA01 through BA15 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| BA07D | Sleeper | Main battery power; sleeper power stud to fuse block | SLPR |
| BA07E | Sleeper | Main battery power; between fuse blocks | SLPR |
| BA07FL | Sleeper | Main battery power; fuselink to sleeper jumper cable | SLPR |
| BA07G | Sleeper | Main battery power; sleeper jumper cable to sleeper power stud | SLPR |
| BA11A | CAT Engine | Fused battery power; fuse to engine ignition relay | CAB |
| BA12A | Main | Fused battery power to battery option harnesses JP4-JP6 | CAB |
| BA12B | Main | Fused battery power; JP4-JP6 to JP1-JP3 | CAB |
| BA13A | Option | Cab power; battery positive to isolation switch | CHA |
| BA14A | Option | Fused battery power; additional headlamp selector switch | CAB |
| BA15A | AHD, Cummins | Battery power; priming pump; fuse F116 to PAHO connector | ENG |

**BL—Back-up Lamps Circuits BL01**

| BL—Back-up Lamps Circuits BL01 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| BL01A | Main | Fused ignition power to mirror back-up light switch | CAB |
| BL01B | Main | Fused ignition power; mirror back-up light switch to boc/bos switch | CAB |
| BL01C | Main | Fused Ignition power; boc/bos back-up switch to taillight connector | CAB |
| BL01D | Taillights | Back-up light; FW to transmission connector | CHA |
| BL01E | Engine | Back-up light; transmission connector to transmission switch | ENG |
| BL01F | Engine | Back-up light; transmission switch to transmission connector | ENG |
| BL01G | Taillights | Back-up light; transmission connector to left taillight | CHA |
| BL01H | Taillights | Back-up light; left taillight to right taillight (unsealed) | CHA |
| BL01J | Seal | Back-up light; transmission connector to splice | CHA |
| BL01K | Seal | Back-up light; splice to end of frame connector | CHA |
| BL01L | Seal | Back-up light; splice to end of frame connector | CHA |
| BL01M | Seal | Back-up light; end of frame connector to splice | CHA |
| BL01N | Seal | Back-up light; splice to left back-up light | CHA |
| BL01N | Seal | Back-up light; splice to right back-up light | CHA |
| BL01P | AUS | Back-up light; splice to right back-up light connector | CHA |
| BL01Q | AUS | Back-up light; right back-up light connector to right back-up light | CHA |
| BL01R | AUS | Back-up light; splice to left back-up light connector | CHA |
| BL01S | AUS | Back-up light; splice to left back-up light connector | CHA |
| BL01T | AUS | Back-up light; left back-up light connector to left back-up light | CHA |
| BL01U | AUS | Back-up light; transmission connector to transmission connector | CHA |
| BL01V | AUS | Back-up light; transmission connector to splice | CHA |

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## Circuit Codes A through F

| BL—Back-up Lamps Circuits BL01 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| BL01W | AUS | Back-up light; splice to transmission connector | CHA |
| BL01X | AUS | Back-up light; splice to trailer connector | CHA |
| BL01Y | AUS | Back-up light; transmission connector to splice | CHA |
| BL01Z | AUS | Back-up light; splice to transmission connector | CHA |
| BL01AA | AUS | Back-up light; transmission connector to transmission connector | CHA |
| BL01AB | AUS | Back-up light; splice to trailer connector dual receptacle splice | CHA |
| BL01AC | AUS | Back-up light; splice to trailer connector dual receptacle plug | CHA |
| BL01AD | AUS | Back-up light; splice to trailer connector dual receptacle jack | CHA |
| BL01AE | Tag/Pusher | — | CHA |
| BL01AF | Tag/Pusher | — | CHA |
| BL01AG | Tag/Pusher | — | CHA |
| BL01AH | Tag/Pusher | — | CHA |
| BL01AJ | Tag/Pusher | — | CHA |
| BL01AK | Trans | Back-up light; transmission connector to transmission switch (Allison HT/MT) | CHA |
| BL01AL | Trans | Back-up light; transmission switch to transmission connector (Allison HT/MT) | CHA |

**BL—Back-up Lamps Circuits BL02 through BL11**

| BL—Back-up Lamps Circuits BL02 through BL11 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| BL02A | Main | Switched mirror back-up light signal; switch to left connector | CAB |
| BL02B | Main | Switched mirror back-up light signal; switch to right connector | CAB |
| BL03A | Main | Switched back-of-cab/back-of-sleeper back-up light signal; switch to splice | CAB |
| BL03D | Main | Switched back-up light power; splice to overhead console connector | CAB |
| BL03E | Overhead console | Switched back-up light power; splice to right back-up light | OHC |
| BL03F | Overhead console | Switched back-up light power; splice to right back-up light | OHC |
| BL03G | Main | Switched back-up light power; splice to sleeper connector | CAB |
| BL03H | Sleeper | Switched back-up light power; cab connector to sleeper control panel connector | SLPR |
| BL03J | Sleeper | Switched back-up light power; sleeper control panel connector to left back-up light | SLPR |
| BL03K | Sleeper | Switched back-up light power; sleeper control panel connector to right back-up light | SLPR |
| BL03L | Sleeper | Switched back-up light power; cab connector to sleeper jumper connector | SLPR |

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| BL—Back-up Lamps Circuits BL02 through BL11 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| BL03M | Sleeper | Switched back-up light power; sleeper jumper connector to sleeper stud | SLPR |
| BL03N | Sleeper | Switched back-up light power; sleeper stud to left back-up light | SLPR |
| BL03P | Sleeper | Switched back-up light power; sleeper stud to right back-up light | SLPR |
| BL03Q | Sleeper | Switched back-up light power; main sleeper harness to convenience light | SLPR |
| BL03R | Main | Switched back-up light power; cab connector to splice | OHC |
| BL03S | Convenience light | Switched back-up light power; over head console to jumper | CAB |
| BL03T | Remote start | Switched back-up light power; cab connector to OHC connector | CAB |
| BL05A | Spot lamp | Fused battery power to right spot light on/off switch | CAB |
| BL05B | Spot lamp | Fused battery power to A-pillar | CAB |
| BL05C | Spot lamp | Fused battery power to up A-pillar and to left spot light | OHC |
| BL06A | Spot lamp | Switched right spot light power; right spot light switch to A-pillar | CAB |
| BL06B | Spot lamp | Switched right spot light power; up A-pillar and to right spot light | OHC |
| BL07A | Back-up lamp | Fused ignition power to convenience back-up light switch | CAB |
| BL08A | Back-up lamp | Switched convenience light signal; switch to sleeper convenience lights; frontwall | CAB |
| BL08B | Sleeper | Switched convenience light power; cab connector to sleeper control panel connection | SLPR |
| BL08C | Sleeper | Switched convenience light power; sleeper control panel connection to BL08D left convenience light | SLPR |
| BL08D | Sleeper | Switched convenience light power; sleeper control panel connection to right convenience light | SLPR |
| BL09A | Back-up lamp | Main fuse block ignition jumper to work lamp harness F87 | CAB |
| BL10A | Back-up lamp | Fused ignition power to work lamp switch | CAB |
| BL11A | Work lamp | Switched work light signal; switch to work lights; overhead console | CAB |
| BL11B | Work lamp | Switched work light signal; overhead console to work lights splice | OHC |
| BL11C | Work lamp | Switched work light signal; work lights splice to left work light | OHC |
| BL11D | Work lamp | Switched worklight signal; worklights splice to right work light | OHC |

**CA—Collision Avoidance Circuits CA01 through CA16**

| CA—Collision Avoidance Circuits 01 through 16 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| CA01A | Vorad | Main fuse block ignition jumper to Vorad CPU ignition power fuse F120-LN | CAB |
| CA02A | Vorad | Fused ignition power; F120-LD to Vorad CPU | CAB |

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## Circuit Codes A through F

| CA—Collision Avoidance Circuits 01 through 16 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| CA03A | Vorad | VBUS neg. signal; Vorad CPU to driver dash unit, overhead console | CAB |
| CA03B | Vorad | VBUS neg. signal; Vorad CPU; overhead console to driver dash unit | OHC |
| CA04A | Vorad | VBUS pos. signal; Vorad CPU to driver dash unit; overhead console | CAB |
| CA04B | Vorad | VBUS pos. signal; Vorad CPU; overhead console to driver dash unit | OHC |
| CA05A | Vorad | DC return; Vorad CPU to driver dash unit; overhead console | CAB |
| CA05B | Vorad | DC return; Vorad CPU; overhead console to driver dash unit | OHC |
| CA06A | Vorad | DDU power; Vorad CPU to driver dash unit; overhead console | CAB |
| CA06B | Vorad | DDU power; Vorad CPU; overhead console to driver dash unit | OHC |
| CA07A | Vorad | J1587+; Vorad CPU to splice | CAB |
| CA07C | Vorad | J1587+; splice to J15 | CAB |
| CA07D | Vorad | J1587+; splice to P15 | CAB |
| CA08A | Vorad | J1587-; Vorad CPU to splice | CAB |
| CA08B | Vorad | J1587-; splice to J15 | CAB |
| CA08C | Vorad | J1587-; splice to P15 | CAB |
| CA09A | Vorad | SSD signal; CPU to side sensor display; overhead console | CAB |
| CA09B | Vorad | SSD signal; overhead console to side sensor display | OHC |
| CA10A | Vorad | Side sensor ground; CPU ot side sensor display splice | CAB |
| CA10B | Vorad | Side sensor ground; splice to side sensor display; overhead console | CAB |
| CA10C | Vorad | Side sensor ground; overhead console to side sensor display | OHC |
| CA10D | Vorad | Side sensor ground; splice to side sensor; frontwall | ENG |
| CA10E | Vorad | Side sensor; frontwall to side sensor | CHA |
| CA11A | Vorad | SS signal; CPU to side sensor; frontwall | ENG |
| CA11B | Vorad | Side sensor; frontwall to side sensor | CHA |
| CA12A | Vorad | Side sensor power; CPU to side sensor display splice | CAB |
| CA12B | Vorad | Side sensor power; splice to side sensor display; overhead console | CAB |
| CA12C | Vorad | Side sensor power; overhead console to side sensor display | OHC |
| CA12D | Vorad | Side sensor power; splice to side sensor; frontwall | ENG |
| CA12E | Vorad | Side sensor power; frontwall to side sensor | CHA |
| CA13A | Vorad | VBUS neg.; CPU to antenna; frontwall | ENG |
| CA13B | Vorad | VBUS neg.; frontwall to antenna | CHA |
| CA14A | Vorad | VBUS pos.; CPU to antenna; frontwall | ENG |
| CA14B | Vorad | VBUS pos.; frontwall to antenna | OHC |

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| CA—Collision Avoidance Circuits 01 through 16 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| CA15A | Vorad | VDC return; CPU to antenna; frontwall | ENG |
| CA15B | Vorad | DC return; frontwall to antenna | CHA |
| CA16A | Vorad | Antenna power; CPU to antenna; frontwall | ENG |
| CA16B | Vorad | Antenna power; frontwall to antenna | CHA |

**CC—Cruise Control Circuits CC01 through CC25**

| CC—Cruise Control Circuits CC01 through CC25 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| CC01A | Cruise control | Fused ignition power to cruise control | CAB |
| CC01B | Cruise control | Fused ignition power to cruise control | CAB |
| CC01C | Cruise control | Fused ignition power; cruise control to brake switch | CAB |
| CC02A | Cruise control | Neutral switch line; cruise control to frontwall | CAB |
| CC02B | Cruise control | Neutral switch line; frontwall to neutral switch | ENG |
| CC03A | Cruise control | Speed actuator motor+; cruise control to frontwall | CAB |
| CC03B | Cruise control | Speed actuator motor+; frontwall to actuator | ENG |
| CC04A | Cruise control | Speed actuator motor-; cruise control to frontwall | CAB |
| CC04B | Cruise control | Speed actuator motor; frontwall to actuator | ENG |
| CC05A | Cruise control | Speed actuator clutch+; cruise control to frontwall | CAB |
| CC05B | Cruise control | Speed actuator clutch+; frontwall to actuator | ENG |
| CC06A | Cruise control | Speed actuator clutch-; cruise control to frontwall | CAB |
| CC06B | Cruise control | Speed actuator clutch-; frontwall to actuator | ENG |
| CC08A | Cruise control | Speed control enable; cruise control to clutch switch | CAB |
| CC09A | Cruise control | Speed control enable; clutch switch to brake switch | CAB |
| CC10A | Cruise control | Cruise control switch common; cruise control to on/off switch | CAB |
| CC10B | Cruise control | Cruise control switch common; on/off switch to set/resume switch | CAB |
| CC11A | Cruise control | Cruise control on; cruise control to on/off switch | CAB |
| CC12A | Cruise control | Cruise control set; cruise control to set/resume switch | CAB |
| CC13A | Cruise control | Cruise control resume; cruise control to set/resume switch | CAB |
| CC14A | Option | Engine switch common; transmission harness connector to splice | CHA |
| CC14B | Option | Engine switch common; splice to transmission cruise switch harness | CHA |
| CC14C | Option | Engine switch common; splice to transmission harness connector | CHA |
| CC14D | Option | Engine switch common; transmission harness connector ot frontwall engine connector | CHA |

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## Circuit Codes A through F

| CC—Cruise Control Circuits CC01 through CC25 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| CC15A | Option | Cruise on; transmission harness connector to transmission harness connector | CHA |
| CC16A | Option | Cruise resume; transmission harness connector to transmission harness connector | CHA |
| CC17A | Option | Cruise set; transmission harness connector to transmission harness connector | CHA |
| CC18A | Option | Clutch signal; cab connector at frontwall to transmission harness connector | CHA |
| CC18B | Option | Clutch signal; transmission harness connector to transmission connector | CHA |
| CC19A | Option | Clutch signal; transmission connector to transmission harness connector | CHA |
| CC20A | Option | Common; cab connector at frontwall to transmission harness connector | CHA |
| CC20B | Option | Common; transmission harness connector to splice | CHA |
| CC20C | Option | Common; splice to transmission connector | CHA |
| CC20D | Option | Common; transmission harness connector to splice | CHA |
| CC21A | Option | Resume; cab connector at frontwall to transmission harness connector | CHA |
| CC21B | Option | Resume; transmission harness connector to splice | CHA |
| CC21C | Option | Resume; splice to transmission connector | CHA |
| CC21D | Option | Resume; transmission harness connector to splice | CHA |
| CC22A | Option | Set; cab connector at frontwall to transmission harness connector | CHA |
| CC22B | Option | Set; transmission harness connector to splice | CHA |
| CC22C | Option | Set; splice to transmission connector | CHA |
| CC22D | Option | Set; transmission harness connector to splice | CHA |
| CC23A | Option | Common; cab connector at frontwall to remote idle connector | CHA |
| CC23B | Option | Common; remote idle connector to splice | CHA |
| CC23C | Option | Common; splice to remote idle | CHA |
| CC24A | Option | Resume; cab connector at frontwall to remote idle connector | CHA |
| CC24B | Option | Resume; remote idle connector to splice | CHA |
| CC24C | Option | Resume; splice to remote idle | CHA |
| CC25A | Option | Set; cab connector at frontwall to remote idle connector | CHA |
| CC25B | Option | Set; remote idle connector to splice | CHA |
| CC25C | Option | Set; splice to remote idle | CHA |

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**CG—Cigar Lighter**

| CG—Cigar Lighter | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| CG01A | Main | Fused accessory power to cigar lighter | CAB |

**DL—Driving Lamps Circuits DL01 through DL08**

| DL—Driving Lamps Circuits DL01 through DL08 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| DL01A | Main | Fused ignition power to drive light relay contact | CAB |
| DL02 | Drive/fog lamp | Switched drive light power; extension cord | ENG |
| DL02A | Main | Switched drive light power; relay contact to frontwall connector | CAB |
| DL02B | Headlamps | Switched drive light power; frontwall headlight connector to splice | ENG |
| DL02C | Headlamps | Switched drive light power; splice to right radiator connector | ENG |
| DL02D | Headlamps | Switched drive light power; splice to left radiator connector | ENG |
| DL02E | Drive/fog lamp | Switched drive light power; radiator connector to drive light | ENG |
| DL03A | Main | Switched drive light power; switch to relay coil | CAB |
| DL04A | Main | High beams on; high beam switch to drive light switch | CAB |
| DL05A | Bullet lights | Main fused ignition power to bullet light fuse | CAB |
| DL06A | Bullet lights | Fused bullet light power to bullet light dash switch | CAB |
| DL06B | Bullet lights | Fused bullet light power to bullet light relay | CAB |
| DL07A | Bullet lights | Bullet lights on; bullet light switch to bullet light relay | CAB |
| DL08A | Bullet lights | Right bullet light power on; bullet light relay to frontwall connector | CAB |
| DL08B | Bullet lights | Right bullet light power on; frontwall connector to right bullet light | ENG |
| DL08C | Bullet lights | Left bullet light power on; bullet light relay to frontwall connector | CAB |
| DL08D | Bullet lights | Left bullet light power on; frontwall connector to left bullet light | ENG |

**EB—Engine Brake Circuits EB01 through EB18**

| EB—Engine Brake Circuits EB01 through EB18 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| EB01A | Engine | Fused ignition power to clutch switch | CAB |
| EB02A | Engine | Clutch in; clutch switch to frontwall | CAB |
| EB02B | Engine | Clutch in; frontwall to minimum fuel switch | ENG |
| EB02C | Engine | Clutch in; frontwall to engine brake plug on engine | ENG |
| EB02D | Engine | Clutch in; frontwall to extarder throttle switch | ENG |
| EB03A | Engine | Clutch in and fuel applied; minimum fuel switch to frontwall | ENG |

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## Circuit Codes A through F

| EB—Engine Brake Circuits EB01 through EB18 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| EB03B | Engine | Clutch in and fuel applied; frontwall to engine brake on/off switch | CAB |
| EB03C | Engine | Clutch in and fuel applied; frontwall to engine brake plug on engine | CAB |
| EB03D | Extarder | Clutch in and fuel applied; frontwall to extarder throttle switch | ENG |
| EB04A | Engine | Engine brake enabled; enable switch to engine brake power select switch | CAB |
| EB04B | Engine | Engine brake enabled; power switch to frontwall | CAB |
| EB04C | Engine | Engine brake enabled; frontwall to brake solenoid | ENG |
| EB04E | Engine | Engine brake enabled; brake solenoid to flyback diode | ENG |
| EB04F | Engine | Required for M11 engines cut for N14; allows engine brake to work | ENG |
| EB04G | Engine | Engine brake enabled; frontwall to engine brake plug on engine | ENG |
| EB04H | Extarder | Engine brake enabled; frontwall to extarder enable solenoid | ENG |
| EB05A | Engine | Engine brake enabled and high power; power switch to frontwall | CAB |
| EB05B | Engine | Engine brake enabled and high power; frontwall to brake solenoid | ENG |
| EB05C | Engine | Engine brake enabled and high power; brake solenoid to flyback diode | ENG |
| EB05D | Engine | Engine brake enabled; frontwall to engine brake plug on engine | ENG |
| EB06A | BrakeSaver | BrakeSaver pressure switch; frontwall to brakesaver indicator lamp | ENG |
| EB06B | BrakeSaver | BrakeSaver pressure switch to brakesaver indicator lamp; frontwall | ENG |
| EB07A | BrakeSaver | BrakeSaver solenoid; frontwall to brakesaver enable relay | CAB |
| EB08A | BrakeSaver | BrakeSaver cutout solenoid, frontwall to engine brake on/off switch | CAB |
| EB08B | BrakeSaver | BrakeSaver cutout solenoid to engine brake on/off switch; frontwall | ENG |
| EB09A | BrakeSaver | BrakeSaver enable relay to engine brake on/off switch | CAB |
| EB10A | BrakeSaver | BrakeSaver enable; frontwall to brakesaver enable relay (86) | CAB |
| EB11A | BrakeSaver | BrakeSaver sender; frontwall to brakesaver temperature gauge | CAB |
| EB11B | BrakeSaver | BrakeSaver temperature gage; frontwall to brakesaver sender | ENG |
| EB12A | Engine | SuperPac warm-up switch to frontwall | CAB |
| EB12B | Engine | SuperPac warm-up switch; frontwall to warm-up solenoid block diode | ENG |
| EB12C | Engine | Warm-up solenoid block diode to warm-up solenoid | ENG |
| EB13A | Engine | Fused ignition power; clutch switch to SuperPac warm-up switch | CAB |

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| EB—Engine Brake Circuits EB01 through EB18 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| EB14A | Engine | Engine brake enabled power; frontwall to exhaust brake solenoid diode | ENG |
| EB14B | Engine | Exhaust brake solenoid diode to exhaust brake solenoid | ENG |
| EB15A | Engine | Engine brake enabled and high/low power; frontwall to brake front and rear banks diode | ENG |
| EB15B | Engine | Engine brake front and rear banks diode to engine brake front bank | ENG |
| EB15C | Engine | Engine brake front and rear banks diode to engine brake rear bank | ENG |
| EB16A | Engine | Engine brake connector on supplied with engine harness to resistor | ENG |
| EB17A | Engine | Engine brake connector on supplied with engine harness to resistor | ENG |
| EB18A | BrakeSaver | Ignition power feed; fan switch to brakesaver on/off switch | CAB |
| EB18B | BrakeSaver | Ignition power feed to fan switch to fan switch | CAB |

**ES—Ether Start Circuits ES01 through ES09**

| ES—Ether Start Circuits ES01 through ES09 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| ES01A | Option | F50 breaker (LN) to main fuse block jumper | CAB |
| ES02A | Option | F50 breaker (LD) to S22 (com) ether start switch | CAB |
| ES03A | Option | Ether on signal; ether start switch to frontwall | CAB |
| ES03B | Option | Ether on signal; frontwall to ether solenoid | ENG |
| ES04A | Option | Ether start solenoid to ether start thermostat | ENG |
| ES05A | Option | Start signal; ignition switch to ether start switch | ENG |
| ES06A | Option | Ether start S60; fuse to control module | ENG |
| ES07A | Option | Ether start S60; control module to data output from on engine harness | ENG |
| ES08A | Option | Ether start S60; fuse to control module to valve power | ENG |
| ES09A | Option | Ether start S60; fuse to control module to valve return | ENG |

**FC—Fan Control Circuits FC01 through FC06**

| FC—Fan Control Circuits FC01 through FC06 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| FC01A | Engine | Fused ignition power to engine brake on/off switch | CAB |
| FC01B | Engine | Fused ignition power; engine brake on/off switch to fan control override switch | CAB |
| FC01C | Engine | Fused ignition power; fan control override switch to fan control override switch | CAB |

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## Circuit Codes A through F

| FC—Fan Control Circuits FC01 through FC06 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| FC02A | Engine | Fan control solenoid powered; control override switch to frontwall | CAB |
| FC02B | Engine | Fan control solenoid powered; frontwall to solenoid | ENG |
| FC02C | Engine | Fan control solenoid powered; solenoid to diode | ENG |
| FC02D | Engine | Fan control solenoid powered; ECC to diode | ENG |
| FC02C | Engine | Fan control solenoid jumper powered; JSV1 to diode | CAB |
| FC02D | Engine | Fan control solenoid jumper powered; diode to solenoid | CAB |
| FC03A | Engine | Fan control solenoid on/off; solenoid to frontwall | ENG |
| FC03B | Engine | Fan control solenoid on/off; solenoid to diode | ENG |
| FC03C | Engine | Fan control solenoid on/off; frontwall to ECC | CAB |
| FC03D | Engine | Fan control solenoid jumper on/off; JSV1 to diode | CAB |
| FC03E | Engine | Fan control solenoid jumper on/off; diode to solenoid | CAB |
| FC04A | Engine | Condenser hi-pressure; ECC to frontwall | CAB |
| FC04B | Engine | Condenser hi-pressure; frontwall to trinary switch | ENG |
| FC04C | Option | Condenser hi-pressure; frontwall to relay (roof top condenser) | CAB |
| FC04D | Option | Condenser hi-pressure; trinary switch to frontwall (roof top condenser) | ENG |
| FC05A | Engine | Fan off signal; relay to frontwall | CAB |
| FC05B | Engine | Fan off signal; frontwall to solenoid valve | ENG |
| FC05C | Engine | Fan off signal; solenoid valve to diode | ENG |
| FC06A | Engine | Fan off signal; fan control override switch to frontwall | CAB |
| FC06B | Engine | Fan off signal; fan control override switch to fan control override switch | CAB |
| FC06C | Engine | Fan off signal; frontwall to two-way Packard plug | ENG |

**FH—Fuel Heater Circuits FH01 through FH07**

| FH—Fuel Heater Circuits 01 through 07 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| FH01A | Option | Fused ignition power to fuel heater switch | CAB |
| FH01B | Option | Main fuse block ignition jumper to fuel heater harness F82 | CAB |
| FH02A | Option | Fuel heater switch to fuel heater 75A relay; frontwall | CAB |
| FH02B | Option | Fuel heater switch; frontwall to fuel heater 75A relay | ENG |
| FH03A | Option | Fuel heater power feed to fuel heater 75A relay | ENG |
| FH04A | Option | Fuel heater 75A relay to fuel heater 50A battery fuse | ENG |
| FH05A | Option | Fuel heater 50A battery fuse to starter battery positive | ENG |
| FH06A | Option | Fused ignition power; frontwall to DAVCO fuel heater | ENG |
| FH07A | Option | Fuel heater 50A battery fuse to C51 | ENG |

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**FL—Fog Lamps Circuits FL01 through FL04**

| FL—Fog Lamps Circuits FL01 through FL04 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| FL01A | Main | Fused battery power to fog light relay | CAB |
| FL02 | Drive/fog lamp | Switched fog light power; extension cord | ENG |
| FL02A | Main | Switched fog light power; relay contact to frontwall headlight connector | CAB |
| FL02B | Headlamps | Switched fog light power; frontwall headlight connector to splice | ENG |
| FL02C | Headlamps | Switched fog light power; splice to right radiator connector | ENG |
| FL02D | Headlamps | Switched fog light power; splice to left radiator connector | ENG |
| FL02E | Drive/fog lamp | Switched fog light power; radiator connector to fog light | ENG |
| FL03A | Main | Switched fog light power; switch to relay coil | CAB |
| FL04A | Main | Park lights on; instrument dimmer switch to fog light switch | CAB |

**FR—Fridge Circuits FR01 through FR02**

| FR—Fridge Circuits FR01 through FR02 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| FR01A | Sleeper | Fused fridge power to relay | SLPR |
| FR02A | Sleeper | Accessory controlled fridge power; relay to fridge | SLPR |

**FS—Flame Start Circuits FS01 through FS11**

| FS—Flame Start Circuits 01 through 11 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| FS1FL | C8.3 FlameStart | Battery power at starter to FS01A (this is a fuse link) | ENG |
| FS01A | C8.3 FlameStart | Battery power at starter to glow plug relay | ENG |
| FS01B | 3306 FlameStart | Battery power at starter to main fuse | ENG |
| FS03A | C8.3 FlameStart | Wait lamp signal; wait lamp (in lightbar) to engine connector | CAB |
| FS03B | C8.3 FlameStart | Wait lamp signal; engine connector to Cummins supplied option harness | ENG |
| FS03C | 3306 FlameStart | Wait lamp signal; module to frontwall | ENG |
| FS03D | 3306 FlameStart | Wait lamp signal; frontwall to inverter relay | CAB |
| FS03E | 3406C FlameStart | Wait lamp signal; flame start ECU to frontwall | ENG |
| FS03F | 3406C FlameStart | Wait lamp signal; frontwall to lightbar | CAB |
| FS04A | 3306 FlameStart | Run signal; engine main connector to module | ENG |
| FS05A | 3306 FlameStart | Temperature signal; engine main connector to module | ENG |
| FS06A | 3306 FlameStart | Flame plug control; module to engine main connector | ENG |
| FS07A | 3306 FlameStart | Fuel solenoid control; module to engine main connector | ENG |
| FS08A | 3306 FlameStart | Fused battery power; fuse to module | ENG |

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## Circuit Codes A through F

| FS—Flame Start Circuits 01 through 11 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| FS08B | 3306 FlameStart | Fused battery power; fuse to oil pressure switch power connector | ENG |
| FS09A | 3306 FlameStart | Fused ignition power; fuse to frontwall | CAB |
| FS09B | 3306 FlameStart | Fused ignition power; frontwall to module | CAB |
| FS09C | 3406C FlameStart | Fused ignition power; ignition switch to frontwall | CAB |
| FS09D | 3406C FlameStart | Fused ignition power; frontwall to flame start ECU | ENG |
| FS10A | 3306 FlameStart | Main fused ignition power; main fuse block to option fuse block | CAB |
| FS11A | 3306 FlameStart | Light bar icon on; inverter relay to lightbar | CAB |

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# Circuit Codes G through H

All wires have three to five character alphanumeric codes printed on them every four to six inches. The first two characters are a letter code that denotes the circuit type in which the wire is used. The next one or two numbers denote the specific circuit, and last letter denotes the branch in the circuit. Use the following circuit code tables to look up the circuit code that is printed on a wire and determine its function.

See **Subject 430** for an explanation of location abbreviations used in the circuit code tables.

**GD1—Miscellaneous Ground**

| GD1—Miscellaneous Ground | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD1A | Headlight | Left frame-rail to left radiator ground | ENG |
| GD1B | Headlight | Headlight ground; left radiator ground to left headlight connector | ENG |
| GD1C | Headlight | Left headlight connector to left high/low beam | ENG |
| GD1D | Headlight | Left high/low beam to left high beam | ENG |
| GD1E | Headlight | Left park light ground; left radiator ground to splice | ENG |
| GD1F | Headlight | Left park light ground; splice to left headlight connector | ENG |
| GD1G | Headlight | Left park light ground; splice to horn | ENG |
| GD1H | Headlight | Left drive and fog light ground; left radiator ground to left drive and fog light connectors | ENG |
| GD1J | Drive/fog lamp | Drive and fog ground; radiator connector to driving light | ENG |
| GD1K | Drive/fog lamp | Drive and fog light ground; drive light to fog light | ENG |
| GD1L | Headlight | Right drive and fog light ground; right radiator ground to right drive and fog light connectors | ENG |
| GD1M | Headlight | Right park light ground; right radiator ground to right headlight connector | ENG |
| GD1N | Headlight | Right park light ground; splice to right headlight connector | ENG |
| GD1P | Headlight | Right park light ground; right radiator ground to windshield washer pump | ENG |
| GD1Q | Headlight | Right headlight ground; right radiator ground to right headlight connector | ENG |
| GD1R | Headlight | Right headlight connector to right high/low beam | ENG |
| GD1S | Headlight | Right high/low beam to right high beam | ENG |
| GD1T | Headlight | Right headlight connector to right side light | ENG |
| GD1U | Headlight | Right side light to right aero turn signal | ENG |
| GD1V | Headlight | Left headlight connector to left side light | ENG |
| GD1W | Headlight | Left side light to left aero turn signal | ENG |
| GD1X | Air dryer | Air dryer ground; air dryer to taillight frontwall ground stud | CHA |
| GD1Y | C8.3 Flamestart | Ground; Flamestart relay case to coil negative | ENG |
| GD1Z | Option | Ether start thermostat to ground on engine block | ENG |
| GD1AA | Air Dryer | Air dryer ground; solenoid splice to air dryer with spitter valve | ENG |

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## Circuit Codes G through H

| GD1—Miscellaneous Ground | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD1AB | 3306 Flamestart | Flamestart ground; module to main Flamestart connector | ENG |
| GD1AC | Air dryer | Air dryer ground; taillight ground stud to solenoid splice | CHA |
| GD1AD | Air dryer | Air dryer ground; solenoid splice to solenoid | CHA |
| GD1AE | Air dryer | Air dryer ground; frontwall to air dryer with spitter valve | CHA |
| GD1AF | Headlight | Left frame-rail to right radiator ground | ENG |
| GD1AG | Headlight | Radiator connector to splice | ENG |
| GD1AH | Headlight | Splice ot front turn signal connector | ENG |
| GD1AJ | Headlight | Splice to side turn signal connector | ENG |
| GD1AK | Headlight | Radiator connector to splice | ENG |
| GD1AL | Headlight | Splice to park light on high/low/park light | ENG |
| GD1AM | Headlight | Splice to high/low beam light on high/low/park light | ENG |
| GD1AN | Headlight | Splice to high beam light connector | ENG |
| GD1AP | Headlight | High beam light connector to high beam light | ENG |
| GD1AQ | Bullet lights | Left bullet light to radio connector | ENG |
| GD1AR | Bullet lights | Right bullet light to radio connector | ENG |
| GD1AS | Air Dryer | Air dryer ground; splice to splice | CHA |
| GD1AT | Air Dryer | Air dryer ground; splice to second air dryer | ENG |

**GD2—Cab Ground Circuits GD2A through GD2Z**

| GD2—Cab Ground Circuits GD2A through GD2Z | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD2A | Engine | Frontwall stud plate to fan control over ride switch | CAB |
| GD2B | Engine | Fan control over ride switch to engine brake on/off switch | CAB |
| GD2C | Engine | Engine brake on/off switch to engine brake low/med/hi switch | CAB |
| GD2D | Engine | Engine brake low/med/hi switch to cruise resume/set switch | CAB |
| GD2E | Engine | Cruise resume set switch to cruise on/off switch | CAB |
| GD2F | Engine | Cruise on/off switch to diagnostics switch | CAB |
| GD2G | Engine | Cruise on/off switch to shutdown or diagnostics switch | CAB |
| GD2H | Engine | Frontwall stud to fan control relay coil | CAB |
| GD2J | Engine | Fan control relay coil to fan control relay contact | CAB |
| GD2K | Engine | Fan control relay contact to ignition relay coil | CAB |
| GD2L | Engine | Frontwall stud plate to fuel solenoid bypass diode | ENG |
| GD2M | Engine | Frontwall stud plate to engine brake solenoid bypass diode | ENG |
| GD2N | Engine | Between engine brake solenoid bypass diodes | ENG |
| GD2P | Power | Starter to frontwall | ENG |
| GD2Q | Power | Starter to alternator | ENG |

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| GD2—Cab Ground Circuits GD2A through GD2Z | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD2R | Main | Frontwall to main ignition relay coil | CAB |
| GD2S | Main | Main ignition relay coil to main accessories relay coil | CAB |
| GD2T | Main | Back-up switch (mirror) to fog light switch | CAB |
| GD2U | Main | Fog light switch to drive light switch | CAB |
| GD2V | Main | Drive light switch to trailer marker light switch | CAB |
| GD2W | Main | Trailer marker light switch to tractor marker light switch | CAB |
| GD2X | Main | Tractor marker light switch to dash dimmer switch | CAB |
| GD2Y | Main | Dash dimmer switch to headlight switch | CAB |
| GD2Z | Main | Between two pins on RHD connector | CAB |

**GD2—Cab Ground Circuits GD2AA through GD2AZ**

| GD2—Cab Ground Circuits GD2AA through GD2AZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD2AA | Main | Between two pins on LHD connector | CAB |
| GD2AB | Main | Frontwall ground stud to brake relay coil | CAB |
| GD2AC | Main | Brake relay coil to low beam relay coil | CAB |
| GD2AD | Main | Low beam relay coil to high beam relay coil | CAB |
| GD2AE | Main | High beam relay coil to park light relay coil | CAB |
| GD2AF | Main | Park light relay coil to tractor marker relay coil | CAB |
| GD2AG | Main | Tractor marker relay coil to trailer marker relay coil | CAB |
| GD2AH | Main | Trailer marker relay coil to drive light relay coil | CAB |
| GD2AJ | Main | Drive light relay coil to fog light relay coil | CAB |
| GD2AK | Main | Back-up light (back-of-cab/back-of-sleeper) switch to back-up light (mirror) switch | CAB |
| GD2AL | Main | Fog light relay coil to heater relay coil | CAB |
| GD2AM | Main | Headlight switch to frontwall ground stud | CAB |
| GD2AN | Main | Right hand door connector to frontwall ground stud | CAB |
| GD2AP | Main | Left-hand door connector to frontwall ground stud | CAB |
| GD2AQ | Main | Frontwall ground stud to cigar lighter | CAB |
| GD2AR | Main | Cigar lighter to under dash light | CAB |
| GD2AS | Main | Back-up light switch (boc/bos) to heated mirrors switch | CAB |
| GD2AT | Main | Heated mirrors switch to rotating beacons switch | CAB |
| GD2AU | Main | Door courtesy light ground | RHD |
| GD2AV | Main | Ground from battery to engine ground stud | CHA |
| GD2AW | Main | Wiper motor to frontwall | CAB |
| GD2AX | Main | Rotating beacon switch to washer switch | CAB |

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## Circuit Codes G through H

| GD2—Cab Ground Circuits GD2AA through GD2AZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD2AY | Option | Washer switch to wiper int/off/on switch | CAB |
| GD2AZ | Main | Wiper int/off/on switch to wiper high/slow switch | CAB |

**GD2—Cab Ground Circuits GD2BA through GD2BZ**

| GD2—Cab Ground Circuits GD2BA through GD2BZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD2BA | Main | Sound system connector to frontwall stud | CAB |
| GD2BB | Overhead console | Sound system connector to clock | OHC |
| GD2BC | Overhead console | Sound system connector to radio | OHC |
| GD2BD | Main | Heater to main ground stud on frontwall | CAB |
| GD2BE | Main | Heater control panel lamp to under dash lamp | CAB |
| GD2BF | Option | Roof top trinary switch connector to frontwall stud | ENG |
| GD2BG | Option | Heater connector in to heater connector out | CAB |
| GD2BH | Sleeper start | Sleeper start enable switch to splice to any GD2 | CAB |
| GD2BJ | Sleeper | Sleeper light switch ground | CAB |
| GD2BK | Option | Two fuel tanks selector switch ground | CAB |
| GD2BL | CB Radio | Overhead console connector to radio connector | OHC |
| GD2BM | CB Radio | Overhead console connector to CB radio connector | OHC |
| GD2BN | CAT DIS | Frontwall ground stud to driver information system connector | CAB |
| GD2BP | Antilock brakes | Frontwall ground stud to deep mud snow switch | CAB |
| GD2BQ | Antilock brakes | Deep mud snow switch to deep mud snow switch | CAB |
| GD2BR | Antilock brakes | Frontwall ground stud to blink code light in blink code switch | CAB |
| GD2BS | Antilock brakes | Frontwall ground stud to ECU for ECU ground | CAB |
| GD2BT | Antilock brakes | Frontwall ground stud to ECU for valve ground | CAB |
| GD2BU | Tire pressure control | Frontwall ground to operator control panel (Eaton TPCS) | CAB |
| GD2BV | Main | Wiper high/low switch to interaxle differential lock switch | CHA |
| GD2BW | Spot lamp | Right spot light switch common to splice to any GD2 line | CAB |
| GD2BX | Cruise control | Transmission in neutral switch to frontwall | ENG |
| GD2BY | Cruise control | Frontwall to cruise resume/set switch | CAB |
| GD2BZ | Cruise control | Cruise resume/set switch to cruise off/on switch | CAB |

**GD2—Cab Ground Circuits GD2CA through GD2CZ**

| GD2—Cab Ground Circuits 2CA through 2CZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD2CA | Cruise control | Frontwall to cruise control box | CAB |

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| GD2—Cab Ground Circuits 2CA through 2CZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD2CB | Power window | Right-hand power window switch to left-hand power window switch | CAB |
| GD2CC | Power window | Jumper for left-hand power window switch; | CAB |
| GD2CD | Power window | Cab ground to right-hand power window switch | CAB |
| GD2CE | Power window | Jumper for right-hand power window switch | CAB |
| GD2CF | VHF radio | Frontwall ground to binding post (VHF neg.) | CAB |
| GD2CG | Cell phone | Frontwall ground to binding post (VHF neg.) | CAB |
| GD2CH | Main | Ground for courtesy lights right-hand door | CAB |
| GD2CJ | Main | Ground for courtesy lights left-hand door | CAB |
| GD2CK | Option | Any rear axle differential lock air switch ground | CAB |
| GD2CL | Option | Any miscellaneous air switch ground | CAB |
| GD2CM | Extra switch | Frontwall ground to extra switch one | CAB |
| GD2CN | Extra switch | Extra switch one to extra switch four | CAB |
| GD2CP | Extra switch | Frontwall ground to extra switch two | CAB |
| GD2CQ | Extra switch | Extra switch two to extra switch five | CAB |
| GD2CR | Extra switch | Frontwall ground to extra switch three | CAB |
| GD2CS | Extra switch | Extra switch three to extra switch six | CAB |
| GD2CT | Option | Frontwall ground to trailer accessory switch | CAB |
| GD2CU | Power mirror | CGND to right-hand power mirror switch | CAB |
| GD2CV | Power mirror | Right hand power mirror switch to left-hand power mirror switch | CAB |
| GD2CW | Power mirror | Jumper for right-hand power mirror switch; 5–7 | CAB |
| GD2CX | Power mirror | Jumper for left-hand power mirror switch; 5–7 | CAB |
| GD2CY | Main | C8 ground stud to option fuse bracket ground | CAB |
| GD2CZ | Extra switch | Extra switch one to extra switch two | CAB |

**GD2—Cab Ground Circuits GD2DA through GD2DZ**

| GD2—Cab Ground Circuits GD2DA through GD2DZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD2DA | Extra switch | Extra switch two to extra switch three | CAB |
| GD2DB | Extra switch | Extra switch three to extra switch four | CAB |
| GD2DC | Extra switch | Extra switch four to extra switch five | CAB |
| GD2DD | Extra switch | Extra switch five to extra switch six | CAB |
| GD2DE | C8.3 engine | Hold fuel solenoid flyback diode to pull in fuel solenoid flyback diode | ENG |
| GD2DF | C8.3 engine | Pull in fuel solenoid flyback diode to fuel solenoid connector | ENG |
| GD2DG | Antilock brakes | ABS frontwall ground connector (ignition) to trailer ground stud | CAB |
| GD2DJ | Antilock brakes | ABS frontwall ground (battery) to trailer ground stud | CAB |

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## Circuit Codes G through H

| GD2—Cab Ground Circuits GD2DA through GD2DZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD2DK | Option | S60 ether control module ground | ENG |
| GD2DL | Option | Fuel heater frontwall ground to fuel separator | ENG |
| GD2DM | BrakeSaver | BrakeSaver pressure switch to cab ground stud | ENG |
| GD2DP | BrakeSaver | BrakeSaver cutout solenoid to cab ground stud | ENG |
| GD2DQ | Option | Remote throttle station switch led common | CAB |
| GD2DR | Option | Frontwall ground to convenience light switch | CAB |
| GD2DS | Option | Frontwall ground to fuel heater switch | CAB |
| GD2DT | Option | Frontwall ground to fuel heater 75A relay | ENG |
| GD2DU | Option | Ground from clock plug to clock ground; temperature gauge connection | OHC |
| GD2DV | Option | Webasto off/on control switch LED ground | CAB |
| GD2DW | Option | Webasto jumper ground between heater and main cab harness | CAB |
| GD2DX | 3306 FlameStart | FlameStart signal inverter relay ground; coil to contact | CAB |
| GD2DY | 3306 FlameStart | FlameStart signal inverter relay ground; contact to option block ground stud | CAB |
| GD2DZ | Option | SuperPac warm-up switch to engine brake low/med/hi switch | CAB |

**GD2—Cab Ground Circuits GD2EA through GD2EZ**

| GD2—Cab Ground Circuits GD2EA through GD2EZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD2EA | Option | Frontwall stud plate to engine brake solenoid bypass diode (SuperPac) | ENG |
| GD2EB | Option | Frontwall stud plate to warm-up solenoid bypass diode (SuperPac) | ENG |
| GD2EC | Option | Warm-up solenoid diode to exhaust brake solenoid diode (SuperPac) | ENG |
| GD2ED | CEEMAT | Frontwall stud plate to engine brake relay | CAB |
| GD2EE | CEEMAT | Engine brake relay to dash shifter light ground | CAB |
| GD2EF | CEEMAT | Frontwall stud plate to diagnostic connector (mechanical only) | CAB |
| GD2EG | CEEMAT | Frontwall stud plate to dash shifter ground | CAB |
| GD2EH | Allison | Frontwall stud plate to Allison VIM power connector (dash side) | CAB |
| GD2EJ | Allison | VIM power connector (overhead console side) to splice | CAB |
| GD2EK | Allison | Splice to VIM | CAB |
| GD2EL | Allison | Splice to VIM | CAB |
| GD2EM | Allison | Splice to VIM retarder on relay | CAB |
| GD2EN | Option | Splice any GD2 to five minute idle shutdown override switch | CAB |
| GD2EP | Sleeper | Sleeper light switch to cruise resume/set switch | SLPR |

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| GD2—Cab Ground Circuits GD2EA through GD2EZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD2EQ | Option | Heated convex mirror (door connection) to convex mirror connection | CAB |
| GD2ER | Option | Heated convex mirror (mirror connection) to standard mirror interface connection | CAB |
| GD2ES | Tire pressure control | Frontwall ground stud to under seat ground splice; right door pillar | CAB |
| GD2ET | Tire pressure control | Under-seat ground splice; right door pillar to under seat ground splice | CAB |
| GD2EU | Tire pressure control | Under-seat ground splice to wet tank pressure switch; cab floor | CAB |
| GD2EV | Tire pressure control | Under-seat ground splice; cab floor to wet tank pressure switch | CAB |
| GD2EW | Tire pressure control | Under-seat ground splice to TPCS configurator ground | CAB |
| GD2EX | Tire pressure control | Under-seat ground splice to TPCS ECU ground | CAB |
| GD2EY | Tire pressure control | Under-seat ground splice to TPCS ECU ground | CAB |
| GD2EZ | Optimized Idle | Heater connector in to heater connector out | CAB |

**GD2—Cab Ground Circuits GD2FA through GD2FZ**

| GD2—Cab Ground Circuits GD2FA through GD2FZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD2FA | Webasto | Seven day timer ground; seven day timer to overhead console ground stud | OHC |
| GD2FB | Sisu interaxle | Sisu interaxle connector to frontwall ground stud | CHA |
| GD2FC | AutoSelect | Frontwall ground stud to engine brake relay (85) | CHA |
| GD2FD | AutoSelect | Engine brake relay (85) to start enable relay (85) | CAB |
| GD2FE | Five minute idle shut down | Shutdown relay ground; idle shutdown relay (85) to shutdown latch relay (85) | CAB |
| GD2FF | Traction differential | Forward axle traction differential air switch | CAB |
| GD2FG | Traction differential | Rear axle traction differential air switch | CAB |
| GD2FH | Traction differential | Rear rear traction differential air switch | CAB |
| GD2FJ | Power windows | Right-hand power window switch to right-hand power window switch | CAB |
| GD2FK | Power windows | Right-hand power window switch to right-hand power window switch | CAB |
| GD2FL | Power windows | Left-hand power window switch to left-hand power window switch | CAB |
| GD2FM | Power windows | Left-hand power window switch to left-hand power window switch | CAB |
| GD2FN | 3406C FlameStart | Frontwall stud to CAT engine harness ground | CAB |
| GD2FP | 3406C FlameStart | Frontwall stud to CAT FlameStart ECU | CAB |
| GD2FQ | Engine ground | Engine ground stud to resistors for engine brake prep | CAB |

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## Circuit Codes G through H

| GD2—Cab Ground Circuits GD2FA through GD2FZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD2FR | Engine ground | Engine ground stud to resistors for engine brake prep | CAB |
| GD2FS | Turn signal ground | Right-hand mirror mounted turn signal ground, frontwall stud to connector | CAB |
| GD2FT | Turn signal ground | Left-hand mirror mounted turn signal ground, frontwall stud to connector | CAB |
| GD2FU | Turn signal ground | Right-hand mirror mounted turn signal ground, connector to lamp | CAB |
| GD2FV | Turn signal ground | Left-hand mirror mounted turn signal ground, connector to lamp | CAB |
| GD2FW | Celect | Idle diagnostic switch to diagnostic off/on switch | CAB |
| GD2FX | Ceemat | Ground wire, relay (35) to splice | CAB |
| GD2FY | Ceemat | Ground wire, relay (47) to splice | CAB |
| GD2FZ | Ceemat | Ground wire, relay (47) to splice | CAB |

**GD2—Cab Ground Circuits GD2GA through GD2GZ**

| GD2—Cab Ground Circuits GD2GA through GD2GZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD2GA | Ceemat | Ground wire, splice to frontwall ground stud | CAB |
| GD2GB | Engine | Fan control switch to frontwall ground stud | CAB |
| GD2GC | Extarder | Extarder enable solenoid to frontwall ground stud | ENG |
| GD2GD | CB radio | OHC harness to clock connector | OHC |
| GD2GE | Main | Frontwall ground stud to splice | CAB |
| GD2GF | Main | Splice to headlight switch | CAB |
| GD2GG | Main | Splice to auxiliary panel illumination plug | CAB |
| GD2GH | Main | Splice to air switch row illumination plug | CAB |
| GD2GJ | Main | Splice to lighting row illumination plug | CAB |
| GD2GK | Main | Lighting row illumination plug to dash display row illumination plug | CAB |
| GD2GL | Main | Dash display row illumination plug; top row illumination plug | CAB |
| GD2GM | Aus | Flasher relay ground | CAB |
| GD2GN | Aus | Flasher relay ground | CAB |
| GD2GP | Aus | Hazard switch ground | CAB |
| GD2GQ | Sleeper in cab | Sleeper in cab harness; illumination in to illumination out | CAB |
| GD2GR | Traction differential | Forward and rear axle traction differential air switch | CAB |
| GD2GS | ABS | Frontwall ground stud to ABS infomodule switch S112 | CAB |
| GD2GT | ABS | Infomodule switch S112 to R51 infomodule | CAB |
| GD2GU | ABS | R51 infomodule to R52 infomodule | CAB |
| GD2GV | ABS | R51 infomodule to frontwall stud plate | CAB |

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| GD2—Cab Ground Circuits GD2GA through GD2GZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD2GW | BrakeSaver | Splice any GD2 to brakesaver on/off switch | CAB |
| GD2GX | Bullet Lights | Bullet light relay to bullet light switch | CAB |
| GD2GY | Bullet Lights | Bullet light switch to lighting in connector | CAB |
| GD2GZ | Bullet Lights | Lighting in connector to lighting out connector | CAB |

**GD2—Cab Ground Circuits GD2HA through GD2HZ**

| GD2—Cab Ground Circuits GD2HA through GD2HZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD2HA | ABS | ATC switch to lighting in connector | CAB |
| GD2HB | ABS | Lighting in connector to lighting out connector | CAB |
| GD2HC | Power mirrors | Lighting in connector to lighting out connector | CAB |
| GD2HD | Fuel switch | Lighting in connector to lighting out connector | CAB |
| GD2HE | CAT DIS | CAT DIS to lighting in connector | CAB |
| GD2HF | CAT DIS | Lighting in connector to lighting out connector | CAB |
| GD2HG | Power window | Lighting connector to right-hand power window switch | CAB |
| GD2HH | Power window | Lighting in connector to lighting out connector | CAB |
| GD2HJ | Trailer accessories | Third axle lift switch to lighting in connector | CAB |
| GD2HK | Trailer accessories | Lighting in connector to lighting out connector | CAB |
| GD2HL | Aus | Trailer receptacle to frontwall ground | ENG |
| GD2HM | Option | Five minute idle shutdown override switch to lighting in connector | CAB |
| GD2HN | Option | Lighting in connector to lighting out connector | CAB |
| GD2HP | Option | Fuel heater switch to lighting in connector | CAB |
| GD2HQ | Option | Lighting in connector to lighting out connector | CAB |
| GD2HR | BrakeSaver | BrakeSaver off/on switch to lighting in connector | CAB |
| GD2HS | BrakeSaver | Lighting in connector to lighting out connector | CAB |
| GD2HT | Aus | Frontwall ground to dual receptacle ground stud | ENG |
| GD2HU | Bogaard timer | Timer to frontwall ground | CAB |
| GD2HV | Traction differential | Forward axle traction differential air switch to illumination in | CAB |
| GD2HW | Traction differential | Rear axle traction differential air switch to illumination in | CAB |
| GD2HX | Traction differential | Rear rear traction differential air switch to illumination in | CAB |
| GD2HY | Traction differential | Forward axle traction differential air switch; illumination in to illumination out | CAB |
| GD2HZ | Traction differential | Rear axle traction differential air switch; illumination in to illumination out | CAB |

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## Circuit Codes G through H

**GD2—Cab Ground Circuits GD2JA through GD2JZ**

| GD2—Cab Ground Circuits GD2JA through GD2JZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD2JA | Traction differential | Rear rear traction differential air switch; illumination in to illumination out | CAB |
| GD2JB | Extra switches | Illumination ground; switch to illumination out | CAB |
| GD2JC | Cab fridge | Illumination ground; switch to illumination out | CAB |
| GD2JD | Cab fridge | Illumination ground; illumination in to illumination out | CAB |
| GD2JE | Option | Air switch to lighting in connector | CAB |
| GD2JF | Option | Air switch; lighting in connector to lighting out connector | CAB |
| GD2JG | Axle interlock | Solenoid from driver controlled traction differential air shift cylinder to ground | CAB |
| GD2JH | Axle interlock | Driver-controlled traction differential latching relay to ground | CAB |
| GD2JJ | Axle interlock | Driver-controlled traction differential latching relay to ground | CAB |
| GD2JK | Axle interlock | Solenoid from driver controlled traction differential air shift cylinder to ground | CAB |
| GD2JL | Axle interlock | Driver-controlled traction differential latching relay to ground | CAB |
| GD2JM | Axle interlock | Driver-controlled traction differential latching relay to ground | CAB |
| GD2JN | Driver controlled traction differential interlock | Driver-controlled traction differential switch to ground | CAB |
| GD2JO | Driver-controlled traction differential interlock | Driver-controlled traction differential switch to ground | CAB |
| GD2JP | Option | Frontwall ground to dual receptacle ground stud | ENG |
| GD2JQ | Overhead console | Sound system connector to jumper | OHC |
| GD2JR | Sleeper start | Illumination ground; in to out | SLPR |
| GD2JS | sleeper start | Illumination ground; in to out | SLPR |
| GD2JT | Sleeper start | Illumination ground; in to out | SLPR |
| GD2JU | Transmission module | Transmission solenoid to cab ground | CAB |
| GD2JV | Aus signal lights | Right turn signal relay to brake light test relay | CAB |
| GD2JW | Aus signal lights | Brake light test relay to brake light test relay | CAB |
| GD2JX | Option | Cab ground stud to additional high beam relay coil | CAB |
| GD2JY | Option | Additional high beam relay to additional low beam relay coil | CAB |
| GD2JZ | Option | Splice any GD2 to additional headlamp switch | CAB |

**GD2—Cab Ground Circuits GD2KA through GD2KZ**

| GD2—Cab Ground Circuits GD2KA through GD2KZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD2KA | Option | Door lock relay ground; cab ground stud to door lock relay (87A) | CAB |

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| GD2—Cab Ground Circuits GD2KA through GD2KZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD2KB | Option | Door lock relay ground; door lock relay (87A) to door lock relay (85) | CAB |
| GD2KC | Option | Door lock relay ground; door lock relay (85) to door unlock relay (87A) | CAB |
| GD2KD | Option | Door lock relay ground; door unlock relay (87A) to door lock relay (85) | CAB |
| GD2KE | Option | Splice any GD2 to power door lock switch | CAB |
| GD2KF | Option | Ungo remote start ground; cab ground stud to Ungo remote start main unit | CAB |
| GD2KG | Option | Ungo on/off switch ground; cab ground stud to on/off switch | CAB |
| GD2KH | Option | Ungo hood pin switch ground; cab ground stud to hood pin switch | CAB |
| GD2KJ | Option | Dome lamp relay ground; cab ground stud to dome lamp relay (85) | CAB |
| GD2KK | Antilock brakes | Trailer ABS power; blink code switch S133 to snow or mud switch S62 | CAB |
| GD2KL | Option | Splice any GD2 to work lamp switch | CAB |
| GD2KM | Option | Auxilliary/work lamp ground; overhead console ground stud to left work lamp | OHC |
| GD2KN | Option | Auxilliary/work lamp ground; overhead console ground stud to right work lamp | OHC |
| GD2KP | Voradiator | CPU case ground to cab ground stud | CAB |
| GD2KQ | ADR | Trailer fail warn S139 to frontwall ground stud | CAB |

**GD3—Frame Rail/Engine Block Ground Circuits GD3A through GD3F**

| GD3—Frame Rail/Engine Block Ground Circuits GD3A through GD3F | | |
|---|---|---|
| **Circuit** | **Function** | **Location** |
| GD3A | Left-hand frame-rail ground to engine block ground | ENG |
| GD3B | M2, condenser to ground | ENG |
| GD3C | M2, condenser to ground | ENG |
| GD3D | left-hand frame-rail ground to splice | ENG |
| GD3E | Splice to engine block ground | ENG |
| GD3F | Frontwall stud place C8 to cab structure | CAB |

**GD4—Chassis Ground for Taillights Circuits GD4A through GD4AA**

| GD4—Chassis Ground for Taillights Circuits GD4A through GD4AA | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD4A | Taillight | Frontwall to left taillight | CHA |
| GD4B | Taillight | Left taillight to right taillight | CHA |

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## Circuit Codes G through H

| GD4—Chassis Ground for Taillights Circuits GD4A through GD4AA | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD4C | Taillight | Frontwall to end of frame connector | CHA |
| GD4D | Taillight | End of frame connector to splice | CHA |
| GD4E | Taillight | Splice to left side splice | CHA |
| GD4F | Taillight | Left side splice to left back-up light | CHA |
| GD4G | Taillight | Left side splice to left turn signal | CHA |
| GD4H | Taillight | Splice to right side splice | CHA |
| GD4J | Taillight | Right side splice to right back-up light | CHA |
| GD4K | Taillight | Right side splice to right turn signal | CHA |
| GD4L | Taillight | Splice to license plate light | CHA |
| GD4M | Air Dryer | Frame rail ground to air dryer heater | CHA |
| GD4N | Aus taillights | Splice to right taillight connector | CHA |
| GD4P | Aus taillights | Right taillight connector to right taillight | CHA |
| GD4Q | Aus taillights | Right taillight to tail end outline marker | CHA |
| GD4R | Aus taillights | Splice to license plate connector | CHA |
| GD4S | Aus taillights | Splice to left taillight connector | CHA |
| GD4T | Aus taillights | Left taillight connector to left taillight | CHA |
| GD4U | Aus taillights | Left taillight to tail end outline marker | CHA |
| GD4V | Aus taillights | Right taillight ground jumper | CHA |
| GD4W | Aus taillights | Right taillight ground jumper | CHA |
| GD4X | Aus taillights | Left taillight ground jumper | CHA |
| GD4Y | Aus taillights | Left taillight ground jumper | CHA |
| GD4Z | Tag/pusher axle | Reverse signal ground; frontwall to tag/pusher | CHA |
| GD4AA | Back-up alarm | Back-up alarm to frame ground | CHA |

**GD5—Instrument Ground Circuits GD5A through GD5Z**

| GD5—Instrument Ground Circuits GD5A through GD5Z | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD5A | Engine | Frontwall to transmission oil temperature sender | ENG |
| GD5B | Engine | Frontwall stud plate to speedometer | CAB |
| GD5C | Engine | Speedometer to tachometer | CAB |
| GD5D | Engine | Tachometer to oil pressure gauge | CAB |
| GD5E | Option | Low speed axle to frontwall stud | CAB |
| GD5F | Engine | Frontwall stud to engine oil temperature sender | ENG |
| GD5G | Engine | Tachometer to pyrometer | ENG |
| GD5H | Engine | Frontwall stud to engine water temperature sender | ENG |
| GD5J | Engine | Frontwall stud to trinary switch | ENG |

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| GD5—Instrument Ground Circuits GD5A through GD5Z | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD5K | Option | Rear differential lock switch to splice | CHA |
| GD5L | Option | Front differential lock switch to splice | CHA |
| GD5M | Option | Differential lock switch common; splice to frontwall | CHA |
| GD5N | Main | Interaxle differential lock switch to main GD5 splice | CAB |
| GD5P | Main | Main GD5 splice to frontwall stud | CAB |
| GD5Q | Main | Main GD5 splice to park brake switch | CAB |
| GD5R | Main | Park brake switch to A system air pressure low switch | CAB |
| GD5S | Main | A system air pressure low switch to B system air pressure low switch | CAB |
| GD5T | Main | Main GD5 splice to ECC | CAB |
| GD5U | Main | ECC to lightbar | CAB |
| GD5V | Main | Main GD5 splice to fuel level gauge | CAB |
| GD5W | Option | Rear axle temperature transducer to splice | CHA |
| GD5X | Option | Forward axle temperature transducer to splice | CHA |
| GD5Y | Option | Axle temperature transducer splice to frontwall | CHA |
| GD5Z | Option | Fuel level transducer to frontwall | CHA |

**GD5—Instrument Ground Circuits GD5AA through GD5AZ**

| GD5—Instrument Ground Circuits 5AA through 5AZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD5AA | Sleeper start | Engine water temperature gauge to sleeper start connector | CAB |
| GD5AB | Sleeper start | Sleeper start connector ot sleeper water temperature gauge | SLPR |
| GD5AC | Sleeper start | Sleeper water temperature gauge to ignition on light | SLPR |
| GD5AD | Option | Right fuel tank level transducer to frontwall | CHA |
| GD5AE | Option | Differential lock switch harness; frontwall to splice | CHA |
| GD5AF | Option | Differential lock switch harness; splice to forward rear axle switch | CHA |
| GD5AG | Option | Differential lock switch harness; splice to rear rear axle switch | CHA |
| GD5AH | Option | Axle temperature sender harness; frontwall to splice | CHA |
| GD5AJ | Option | Axle temperature sender harness; splice to forward rear axle | CHA |
| GD5AK | Option | Axle temperature sender harness; splice to rear rear axle | CHA |
| GD5AL | Option | Differential lock switch harness; frontwall to single rear axle switch | CHA |
| GD5AM | Engine | Coolant level sensor to frontwall stud plate | ENG |
| GD5AP | Option | Transmission range sensor to cab ground stud | ENG |
| GD5AQ | Main | Trailer marker light interrupt switch pigtail | ENG |
| GD5AR | Sleeper start | Frontwall to back-of-cab | CHA |

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## Circuit Codes G through H

| GD5—Instrument Ground Circuits 5AA through 5AZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD5AS | Sleeper start | Back-of-cab to sleeper ignition switch | SLPR |
| GD5AT | Option | Argo ground | CAB |
| GD5AU | Option | Axle temperature sender harness; frontwall to splice | CHA |
| GD5AV | Option | Axle temperature sender harness; splice to rear rear axle (tridem) | CHA |
| GD5AW | Option | Axle traction differential lock to rear rear axle (tridem) | CHA |
| GD5AX | Ceemat | Oil temperature gauge to insight temperature module | CAB |
| GD5AY | BrakeSaver | BrakeSaver enable relay (85) to ground stud of brakesaver temperature gauge | CAB |
| GD5AZ | Option | W wire from traction differential switches mounted in cab to engine oil pressure gauge | CAB |

**GD5—Instrument Ground Cirucits GD5BA through GD5BM**

| GD5—Instrument Ground Circuits GD5BA through GD5BZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD5BA | Argo special event | Engine water temperature ground; PSSA to BPC; JSSA | CHA |
| GD5BB | Sleeper start | Frontwall to sleeper ignition switch | SLPR |
| GD5BC | Option | Auxiliary transmission temperature gauge ground; frontwall to sender | ENG |
| GD5BD | Main | Gauge ground; splice to right side gauges | CAB |
| GD5BE | Main | Gauge ground; right side gauges to left side gauges | CAB |
| GD5BF | BrakeSaver | BrakeSaver enable relay (85) to frontwall ground stud | CAB |
| GD5BG | Option | Rear suspension pressure switch to frontwall stud plate | CAB |
| GD5BH | Option | Trailer marker light to lighting in connector | CAB |
| GD5BJ | Option | Trailer marker light to lighting out connector | CAB |
| GD5BK | Option | Argo to lighting in connector | CAB |
| GD5BL | Option | Argo lighting in connector to lighting out connector | CAB |
| GD5BM | Vorad | Instrument ground to CPU ground pin | CAB |

**GD6—Overhead Console Ground Circuits GD6A through GD6W**

| GD6—Overhead Console Ground Circuits GD6A through GD6W | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD6A | Overhead console | Left-hand back-up light to overhead console ground stud | OHC |
| GD6B | Overhead console | Right-hand back-up light to overhead console ground stud | OHC |
| GD6C | Overhead console | Overhead console ground stud to left-hand outboard marker | OHC |
| GD6D | Overhead console | Left-hand outboard marker to left-hand inboard marker | OHC |
| GD6E | Overhead console | Left-hand inboard marker to middle marker | OHC |

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| GD6—Overhead Console Ground Circuits GD6A through GD6W | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD6F | Overhead console | Middle marker to right-hand inboard marker | OHC |
| GD6G | Overhead console | Right hand inboard marker to right-hand outboard marker | OHC |
| GD6H | Overhead console | Overhead console ground stud to right-hand back-up light | OHC |
| GD6J | Overhead console | Overhead console ground stud to left-hand back-up light | OHC |
| GD6K | Overhead console | Overhead console ground stud to left-hand reading light | OHC |
| GD6L | Overhead console | Left-hand reading light to dome light | OHC |
| GD6M | Overhead console | Overhead console ground stud to center reading light | OHC |
| GD6N | Overhead console | Center reading light to right-hand reading light | OHC |
| GD6P | Option | Left-hand vanity light ground to spliced into GD6M | OHC |
| GD6Q | Option | Right-hand vanity light ground to spliced into GD6N | OHC |
| GD6R | Option | Roof top condenser motor to overhead console ground stud | OHC |
| GD6S | Option | Center reading light ground on overhead console harness to center reading light | OHC |
| GD6T | Option | Center reading light ground on overhead console harness to left vanity light | OHC |
| GD6U | Option | Center reading light ground to right vanity light | OHC |
| GD6V | Cab fridge | Overhead console ground stud C49/C50 to frontwall stud plate | OHC |
| GD6W | Convenience lights | Overhead console ground stud C48/C50 to cab fridge | OHC |

**GD7—Sleeper Ground Circuits GD7A through GD7Z**

| GD7—Sleeper Ground CircuitsGD 7A through GD7Z | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD7A | Sleeper | Main cab frontwall stud to sleeper control panel stud | SLPR |
| GD7B | Sleeper | Sleeper stud to control panel light switch | SLPR |
| GD7C | Sleeper | Control panel light switch to dome light | SLPR |
| GD7D | Sleeper | Sleeper stud to lower bunk reading light | SLPR |
| GD7E | Sleeper | Lower bunk reading light to upper bunk reading light | SLPR |
| GD7F | Sleeper | Sleeper stud to right luggage compartment light | SLPR |
| GD7G | Sleeper | Sleeper stud to left luggage compartment light | SLPR |
| GD7H | Sleeper | Sleeper stud to utility outlet | SLPR |
| GD7J | Sleeper | Utility outlet to floor light | SLPR |
| GD7L | Sleeper | Sleeper stud to heater relay coil | SLPR |
| GD7M | Sleeper | Heater relay coil to sleeper clock connector | SLPR |
| GD7P | Fridge | Sleeper stud to fridge relay coil | SLPR |
| GD7Q | Sleeper | Sleeper stud to heater control panel plug | SLPR |
| GD7R | Sleeper | Heater control panel plug to heater plug | SLPR |
| GD7S | TV/VCR | Sleeper stud to TV/VCR outlet | SLPR |

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## Circuit Codes G through H

| GD7—Sleeper Ground CircuitsGD 7A through GD7Z | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD7T | Fridge | Sleeper stud to fridge | SLPR |
| GD7U | Option | Sleeper stud to desk lamp | SLPR |
| GD7V | Option | Sleeper stud to left back-up lamp | SLPR |
| GD7W | Option | Sleeper stud to right back-up lamp | SLPR |
| GD7X | Option | Sleeper stud to left outboard marker light | SLPR |
| GD7Y | Option | Left outboard marker light to left inboard marker light | SLPR |
| GD7Z | Option | Left inboard marker light to right inboard marker light | SLPR |

**GD7—Sleeper Ground Circuits GD7AA through GD7BD**

| GD7—Sleeper Ground Circuits GD7AA through GD7BD | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD7AA | Option | Center marker light to right inboard marker light | SLPR |
| GD7AB | Option | Right inboard marker light to right outboard marker light | SLPR |
| GD7AC | Sleeper | Ground line jumper on ground stud connector | SLPR |
| GD7AD | Sleeper | Ground line jumper on ground stud connector | SLPR |
| GD7AE | Sleeper | Ground line jumper on ground stud connector | SLPR |
| GD7AF | Sleeper | Ground line jumper on ground stud connector | SLPR |
| GD7AG | Sleeper | Ground line from right dome light to dome power plug | SLPR |
| GD7AH | Sleeper | Ground line form right dome light to dome power plug | SLPR |
| GD7AJ | Sleeper | Ground line from tv/vcr to tv/vcr | SLPR |
| GD7AK | Sleeper | Frontwall stud plate to sleeper jumper connector | SLPR |
| GD7AL | Sleeper | Sleeper jumper connector to sleeper stud plate | SLPR |
| GD7AM | Sleeper | Sleeper stud to floor light (aluminum sleepers) | SLPR |
| GD7AN | Sleeper | Sleeper stud to sleeper structure in control panel | SLPR |
| GD7AP | Option | Sleeper stud to left convenience light | SLPR |
| GD7AQ | Option | Sleeper stud to right convenience light | SLPR |
| GD7AR | Option | Sleeper stud to right rotating sleeper beacon | SLPR |
| GD7AS | Option | Sleeper stud to left rotating sleeper beacon | SLPR |
| GD7AT | Option | Sleeper stud to upper bunk reading light | SLPR |
| GD7AU | Sleeper | Main sleeper harness ground to convenience light | SLPR |
| GD7AV | Sleeper | Main sleeper harness ground to subwoofer amplifier | SLPR |
| GD7AW | Sleeper | Sleeper stud to two speed fan switch 1 | SLPR |
| GD7AX | Sleeper | Two-speed fan switch 1 to two speed fan switch 2 | SLPR |
| GD7AY | Sleeper | Sleeper stud to two-speed fan one | SLPR |
| GD7AZ | Sleeper | Sleeper stud to two-speed fan two | SLPR |
| GD7BA | Star Light Sleeper | Sleeper ground to dome light | SLPR |

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| GD7—Sleeper Ground Circuits GD7AA through GD7BD | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD7BB | Star Light Sleeper Start | Sleeper ground to sleeper start ignition light | SLPR |
| GD7BC | Sleeper | Gauge ground; cruise switch in sleeper to sleeper light switch | SLPR |
| GD7BD | Sleeper | Gauge ground; sleeper light switch to gauge ground in (wires to light switch) | SLPR |

**GD8—Electronic Engine Ground Circuit GD8A**

| GD8—Electronic Engne Ground Circuit GD8A | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD8A | Power | Electronic engine ground; battery to frontwall | ENG |

**GD9—Allison Transmission Ground Circuit GD9A**

| GD9—Allison Transmission Ground Circuit GD9A | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GD9A | Transmission | Transmission modulator ground; modulator to frontwall | ENG |

**GL—Gauge Lamps Circuits GL1 through GL1AD**

| GL—Gauge Lamps GL1 through GL1AD | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GL1 | Jumper | Pulse width modulated gauge lighting power; engine cab harness | ALL |
| GL1# | Jumper | Pulse width modulated gauge lighting power; jumper between gauges | ALL |
| GL1A | Engine | ECC to diagnostics switch | CAB |
| GL1B | Engine | Diagnostics switch to cruise on/off switch | CAB |
| GL1C | Engine | Cruise on/off switch to cruise resume/set switch | CAB |
| GL1D | Engine | Cruise resume/set switch to engine brake low/med/high switch | CAB |
| GL1E | Engine | Engine brake low/med/hi switch to engine brake on/off switch | CAB |
| GL1F | Engine | Engine brake on/off switch to fan control override switch | CAB |
| GL1G | Engine | Fan control override switch to speedometer | CAB |
| GL1H | Engine | Speedometer to tachometer | CAB |
| GL1J | Engine | ECC to shutdown or diagnostics switch | CAB |
| GL1K | Engine | Shutdown override diagnostics switch to cruise on/off switch | CAB |
| GL1L | Engine | ECC to cruise on/off switch | CAB |
| GL1M | Engine | Tachometer to engine oil pressure gauge | CAB |
| GL1N | Engine | ECC to engine brake low/high selector switch | CAB |
| GL1P | Sleeper start | Sleeper start enable switch to splice to any GL1 wire | CAB |
| GL1R | Cruise Control | Splice into any GL1 line to cruise resume/set switch | CAB |

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## Circuit Codes G through H

| GL—Gauge Lamps GL1 through GL1AD | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GL1S | Cruise Control | Cruise resume/set switch to cruise off/on switch | CAB |
| GL1T | Option | Argo illumination | CAB |
| GL1U | Engine Brake | SuperPac warm-up switch to engine brake low/med/hi switch | CAB |
| GL1V | Ceemat | Ceemat illumination; any GL1 line to dash shifter | CAB |
| GL1W | Ceemat | Ceemat illumination; any GL1 line to frontwall | CAB |
| GL1X | Ceemat | Ceemat illumination; any GL1 line to floor shifter | CAB |
| GL1Y | Allison | Illumination; any GL1 line to retarder on/off switch | CAB |
| GL1Z | Allison | Illumination; retarder on/off switch to VIM power connector (dash side) | CAB |
| GL1AA | Allison | Illumination; VIM power connector (overhead console side) to VIM | CAB |
| GL1AB | Engine | Sleeper light switch to cruise resume/set switch | SLPR |
| GL1AC | Engine | ECC to diagnostics on/off switch | CAB |
| GL1AD | Engine | Idle diagnostics switch to diagnostics off/on switch | CAB |

**GL—Gauge Lamps Circuits GL2 through GL2Z**

| GL—Gauge Lamps Circuits GL2 through GL2Z | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GL2 | Main | Pulse width modulated gauge lighting power; main cab harness | ALL |
| GL2# | Jumper | Pulse width modulated gauge lighting power; jumper between gauges | ALL |
| GL2A | Main | Headlight switch to splice (see GL2K and GL2M) | CAB |
| GL2B | Main | Back-up (mirrors) light switch to fog light switch | CAB |
| GL2C | Main | Fog light switch to drive light switch | CAB |
| GL2D | Main | Drive light switch to trailer marker switch | CAB |
| GL2E | Main | Trailer marker switch to tractor marker switch | CAB |
| GL2F | Main | Tractor marker switch to instrument dimmer switch | CAB |
| GL2G | Main | Instrument dimmer switch to headlight switch | CAB |
| GL2H | Main | Back-up light (back-of-cab/back-of-sleeper) switch to heated mirrors switch | CAB |
| GL2J | Main | Heated mirrors switch to rotating beacons switch | CAB |
| GL2K | Main | Splice to ECC | CAB |
| GL2L | Main | Splice to ECC | CAB |
| GL2M | Main | Rotating beacon switch to washer off/on switch | CAB |
| GL2N | Main | Washer off/on switch to wiper int/off/on switch | CAB |
| GL2P | Main | Wiper int/off/on switch to wiper high/low switch | CAB |
| GL2Q | Main | Wiper high/low switch to heater control lamp | CAB |

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| GL—Gauge Lamps Circuits GL2 through GL2Z | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GL2R | Man | Splice to fuel gauge | CAB |
| GL2S | Main | Back-up light (boc/bos) switch to back-up light (mirror) switch | CAB |
| GL2T | Sleeper | Sleeper lights on/off switch to splice to any GL2 wire | CAB |
| GL2U | Option | Two fuel tanks selector switch internal illumination | CAB |
| GL2V | CAT DIS | Illumination for CAT driver information system | CAB |
| GL2W | Antilock brakes | Splice to deep mud/snow switch | CAB |
| GL2X | Option | Splice any GL2 to convenience light switch | CAB |
| GL2Y | Main | Wiper low/high switch to interaxle differential lock switch | CAB |
| GL2Z | Spot light | Splice any GL2 to spot light switch | CAB |

**GL—Gauge Lamps Circuits GL2AA through GL2AZ**

| GL—Gauge Lamps Circuits GL2AA through GL2AZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GL2AA | Power window | Splice any GL2 to power window switch | CAB |
| GL2AB | Power window | Right-hand power window switch to left-hand power window switch | CAB |
| GL2AC | Option | Any rear axle differential switch | CAB |
| GL2AD | Option | Any miscellaneous air switch illumination | CAB |
| GL2AE | Extra Switch | Splice any GL2 to extra switch one | CAB |
| GL2AF | Extra Switch | Extra switch one to extra switch two | CAB |
| GL2AG | Extra Switch | Extra switch two to extra switch three | CAB |
| GL2AH | Extra Switch | Extra switch three to extra switch four | CAB |
| GL2AJ | Extra Switch | Extra switch four to extra switch five | CAB |
| GL2AK | Extra Switch | Extra switch five to extra switch six | CAB |
| GL2AL | Option | Splice any GL2 to trailer accessory switch | CAB |
| GL2AM | Power Window | Splice any GL2 to power mirror switch (right-hand side) S76 | CAB |
| GL2AN | Power mirror | Right-hand power mirror switch to left-hand power mirror switch | CAB |
| GL2AP | Option | Remote throttle station switch led illumination power | CAB |
| GL2AQ | Option | Splice any GL2 to fuel heater switch | CAB |
| GL2AR | Option | Splice any GL2 to Webasto on/off switch | CAB |
| GL2AS | Option | Splice any GL2 to five minute idle shutdown override switch | CAB |
| GL2AT | Traction differential | Forward axle air switch to splice any GL2 | CAB |
| GL2AU | Traction differential | Rear axle air switch to splice any GL2 | CAB |
| GL2AV | Traction differential | Rear rear axle air switch to splice any GL2 | CAB |
| GL2AW | Main | Splice (near ECC) to splice (near switch panel) | CAB |
| GL2AX | Main | Splice to headlight switch | CAB |

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## Circuit Codes G through H

| GL—Gauge Lamps Circuits GL2AA through GL2AZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GL2AY | Main | Splice to auxiliary panel illumination plug | CAB |
| GL2AZ | Main | Splice to air switch row illumination plug | CAB |

**GL—Gauge Lamps Circuits GL2BA through GL2BZ**

| GL—Gauge Lamps Circuits GL2BA through GL2BZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GL2BA | Main | Splice to lighting row illumination plug | CAB |
| GL2BB | Main | Lighting row illumination plug to dash display row illumination plug | CAB |
| GL2BC | Main | Dash display row illumination plug; top row illumination plug | CAB |
| GL2BD | Main | Splice (near ECC) to right side air gauge connector | CAB |
| GL2BE | Main | Right side gauges to left side gauges | CAB |
| GL2BF | Sleeper in cab | Sleeper in cab harness; illumination in to illumination out | CAB |
| GL2BG | Main | Right side air gauges connector to right side gauges | CAB |
| GL2BH | Main | Left side gauges to left side air gauges connector | CAB |
| GL2BJ | Traction differential | Forward and rear axle air switch to splice any GL2 | CAB |
| GL2BK | BrakeSaver | Splice any GL2 to brakesaver on/off switch | CAB |
| GL2BL | Bullet lights | Bullet light switch to lighting in connector | CAB |
| GL2BM | Bullet lights | Lighting in connector to lighting out connector | CAB |
| GL2BN | ABS | ATC switch to lighting in connector | CAB |
| GL2BP | ABS | Lighting in connector to lighting out connector | CAB |
| GL2BQ | Power mirrors | Lighting in connector to lighting out connector | CAB |
| GL2BR | Power mirrors | Lighting in connector to dash switch | CAB |
| GL2BS | Fuel switch | Lighting in connector to lighting out connector | CAB |
| GL2BT | CAT DIS | Lighting in connector to lighting out connector | CAB |
| GL2BU | Power windows | Right power window switch to lighting in connector | CAB |
| GL2BV | Power windows | Lighting in connector to lighting out connector | CAB |
| GL2BW | Trailer Accessory | Third-axle lift switch to lighting in connector | CAB |
| GL2BX | Trailer Accessory | Lighting in connector to lighting out connector | CAB |
| GL2BY | Option | Five-minute idle shutdown override switch to lighting in connector | CAB |
| GL2BZ | Option | Lighting in connector to lighting out connector | CAB |

**GL—Gauge Lamps Circuits GL2CA through GL2CZ**

| GL—Gauge Lamps Circuits GL2CA through GL2CZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GL2CA | Option | Racor fuel heater switch to lighting in connector | CAB |

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| GL—Gauge Lamps Circuits GL2CA through GL2CZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GL2CB | Option | Lighting in connector to lighting out connector | CAB |
| GL2CC | BrakeSaver | BrakeSaver off/on switch to lighting in connector | CAB |
| GL2CD | BrakeSaver | Lighting in connector to lighting out connector | CAB |
| GL2CE | Traction differential | Forward axle air switch to illumination in | CAB |
| GL2CF | Traction differential | Rear axle air switch to illumination in | CAB |
| GL2CG | Traction differential | Rear rear axle air switch to illumination in | CAB |
| GL2CH | Traction differential | Forward axle air switch; illumination in to illumination out | CAB |
| GL2CJ | Traction differential | Rear axle air switch; illumination in to illumination out | CAB |
| GL2CK | Traction differential | Rear rear axle air switch; illumination in to illumination out | CAB |
| GL2CL | Extra switches | Switch illumination; illumination in to illumination out | CAB |
| GL2CM | Cab fridge | Switch illumination; cab fridge switch to illumination in | CAB |
| GL2CN | Cab fridge | Switch illumination; illumination in to illumination out | CAB |
| GL2CP | Option | Air switch to lighting in connector | CAB |
| GL2CQ | Option | Air switch lighting in connector to lighting out connector | CAB |
| GL2CR | Driver-controlled traction differential | Interlock switch Driver controlled traction differential rear interlock | CAB |
| GL2CS | Driver-controlled traction differential | Interlock switch Driver controlled traction differential forward interlock | CAB |
| GL2CT | Option | Trailer marker light to lighting in connector | CAB |
| GL2CU | Option | Trailer marker light to lighting out connector | CAB |
| GL2CV | Option | Argo to lighting in connector | CAB |
| GL2CW | Option | Argo lighting in connector to lighting out connector | CAB |
| GL2CX | Sleeper start | Switch illumination; sleeper start switch to illumination in | CAB |
| GL2CY | Sleeper start | Switch illumination; illumination in to illumination out | CAB |
| GL2CZ | Sleeper back-up lights | Switch illumination; illumination in to illumination out | CAB |

**GL—Gauge Lamps Circuits GL2DA through GL2DH**

| GL—Gauge Lamps Circuits GL2DA through GL2DZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GL2DA | Sleeper back-up lights | Switch illumination; back-up light switch to illumination in | CAB |
| GL2DB | Heritage sleeper start | Switch illumination; illumination in to illumination out | CAB |
| GL2DC | Heritage sleeper start | Switch illumination; sleeper start enable switch to illumination in | CAB |
| GL2DD | Option | Splice any GL2 to additional headlight switch | CAB |
| GL2DE | Option | Splice any GL2 to power door lock switch | CAB |
| GL2DF | Option | Splice any GL2 to work lamp switch | CAB |
| GL2DG | Option | Gauge power, cruise switch in sleeper to sleeper light switch | SLPR |

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## Circuit Codes G through H

| GL—Gauge Lamps Circuits GL2DA through GL2DZ | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| GL2DH | Option | Gauge power; sleeper light switch to gauge power in (wires to light switch) | SLPR |

**HL—Headlights HL01 through HL18**

| HL—Headlights Circuits HL01 through HL18 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| HL01A | Main | Fused battery power to head/park lights switch | CAB |
| HL02A | Main | Headlights on signal; on/off switch to beam selector switch | CAB |
| HL02B | Aus | Headlights on signal; main cab harness to Aus beam selector switch | CAB |
| HL02C | Option | Headlights on signal; headlamp select switch to beam selector switch | CAB |
| HL03A | Main | Low beams on control signal; beam selector switch to relay coil | CAB |
| HL03B | Aus | Low beams on control signal; main cab harness to Aus beam selector switch | CAB |
| HL03C | Option | Low beams on control signal to additional headlamp selector switch | CAB |
| HL03D | Option | Low beams on signal; additional headlamp selector switch to beam selector switch | CAB |
| HL04A | Main | High beams on control signal; beam selector switch to relay coil | CAB |
| HL04B | Aus | High beams on control signal; main cab harness to Australia beam selector switch | CAB |
| HL04C | Option | High beams on control signal to additional headlamp selector switch | CAB |
| HL04D | Option | High beams on signal; additional headlamp selector switch to beam selector switch | CAB |
| HL05A | Main | Switched unfused high beam power; relay to fuses | CAB |
| HL06A | Main | Switched unfused low beam power; relay to fuses | CAB |
| HL07 | Option | Fused right low beam power; extension cord | ENG |
| HL07A | Main | Fused right low beam power to frontwall headlight connector | CAB |
| HL07C | Headlight | Right low beam; frontwall to right headlight connector | ENG |
| HL07D | Headlight | Right low beam to right headlight connector | ENG |
| HL08 | Option | Fused left low beam power; extension cord | ENG |
| HL08A | Main | Fused left low beam power to frontwall headlight connector | CAB |
| HL08B | Main | Switched unfused low beam power; fuses to ECC for DRL | CAB |
| HL08C | Headlight | Left low beam; frontwall to left headlight connector | ENG |
| HL08D | Headlight | Left low beam to left headlight connector | ENG |
| HL09 | Option | Fused right high beam power; extension cord | ENG |
| HL09B | Main | Fused right beam power to frontwall headlight connector | CAB |

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| HL—Headlights Circuits HL01 through HL18 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| HL09C | Headlight | Right high beam; frontwall to right headlight connector | ENG |
| HL09D | Headlight | Right high beam; right headlight connector to high/low beam light | ENG |
| HL09E | Headlight | Right high beam; high/low beam to high beam | ENG |
| HL10 | Option | Fused left high beam power; extension cord | ENG |
| HL10A | Main | Fused left high beam power to ECC | CAB |
| HL10B | Main | Fused left high beam power to frontwall headlight connector | CAB |
| HL10C | Headlight | Left high beam; frontwall to left headlight connector | ENG |
| HL10D | Headlight | Left high beam; left radiator connection to high/low beam light | ENG |
| HL10E | Headlight | Left high beam; high/low beam light to high beam light | ENG |
| HL11A | Headlight | Low beam; radiator to high/low/park light low beam | ENG |
| HL12A | Headlight | High beam; radiator to splice | ENG |
| HL12B | Headlight | High beam; Splice to high/low/part light high beam | ENG |
| HL12C | Headlight | High beam; splice to high beam light connector | ENG |
| HL12D | Headlight | High beam; high beam light connector to high beam light | ENG |
| HL13A | Option | High beams on signal; selector switch to additional high beam relay | CAB |
| HL14A | Option | Low beams on signal; selector switch to additional high beam relay | CAB |
| HL15A | Option | Fused high beam power to additional high beam relay | CAB |
| HL16A | Option | Fused high beam power to additional high beam relay | CAB |
| HL17A | Option | Fused high beam power to frontwall sleeper start connector | CAB |
| HL18A | Option | Fused low beam power to frontwall sleeper start connector | CAB |

**HM—Heated Mirror Circuits HM01 through HM03**

| HM—Heated Mirror Circuits HM01 through HM03 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| HM01A | Main | Fused accessory power to heated window control switch | CAB |
| HM02A | Main | Heated window control switch to left door connector | CAB |
| HM02B | Main | Heated window control switch to right door connector | CAB |
| HM03A | Option | Heated convex mirror (door connection) to convex mirror connection | CAB |
| HM03B | Option | Heated convex mirror (mirror connection) to standard mirror interface connection | CAB |

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## Circuit Codes G through H

### HN—Horn Circuits HN01 through HN03

| HN—Horn Circuits HN01 through HN03 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| HN01A | Main | Fused battery power to horn relay contact | CAB |
| HN01B | Main | Fused battery power; horn relay contact to horn relay coil | CAB |
| HN02A | Main | Horn on signal; horn switch connector to horn relay coil | CAB |
| HN03A | Main | Horn control power; horn relay contact to frontwall headlight connector | CAB |
| HN03B | Headlight | Horn control power; frontwall headlight connector to horn | ENG |

### HT—Heater/Air Conditioning Circuits HT01 through HT32

| HT—Heater/Air Conditioning Circuits HT01 through HT32 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| HT01A | Main | Fused accessory power to compressor relay contact | CAB |
| HT01B | Main | Fused accessory power to heater connector | CAB |
| HT01C | Roof Top Condenser | Fused accessory power; heater connector in to splice | CAB |
| HT01D | Roof Top Condenser | Fused accessory power; splice to heater connector out | CAB |
| HT01E | Roof Top Condenser | Fused accessory power; splice to condenser blower relay contact | CAB |
| HT01F | Roof Top Condenser | Fused accessory power; condenser blower relay contact to coil | CAB |
| HT01G | Main | Fused accessory power to splice | CAB |
| HT01H | Webasto | Fused accessory power; heater connector in to heater connector out | CAB |
| HT01J | Main | Fused accessory power; heater connector | CAB |
| HT01K | Optimized Idle | Fused accessory power; heater connector in to heater connector out | CAB |
| HT02A | Main | Compressor relay contact to frontwall | CAB |
| HT02B | Power | Frontwall to flyback diode | ENG |
| HT02C | Power | Compressor to diode | ENG |
| HT02D | Power | Compressor to PCAC connector | ENG |
| HT03A | Main | Fan on; heater to frontwall | CAB |
| HT03D | Main | Fan on; compressor relay coil to frontwall | CAB |
| HT03E | Roof Top Condenser | Fan on; heater connector in to heater connector out | CAB |
| HT03F | Webasto | Fan on; heater connector in to heater connector out | CAB |
| HT03G | Optimized Idle | Fan on; heater connector in to heater connector out | CAB |
| HT04A | Main | Sleeper heater control; heater to sleeper connector at frontwall | CAB |
| HT04B | Roof Top Condenser | Sleeper heater control; heater connector in to heater connector out | CAB |
| HT04C | Sleeper | Sleeper heater control; cab connector to sleeper relay | SLPR |

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| HT—Heater/Air Conditioning Circuits HT01 through HT32 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| HT04D | Sleeper | Sleeper heater control; cab connector to sleeper jumper connector | SLPR |
| HT04E | Sleeper | Sleeper heater control; sleeper jumper connector to sleeper relay | SLPR |
| HT04F | Webasto | Sleeper heater control; heater connector in to heater connector out | CAB |
| HT04G | Optimized Idle | Sleeper heater control; heater connector in to heater connector out | CAB |
| HT07A | Main | Coolant flow control; heater to frontwall | CAB |
| HT07B | Roof Top Condenser | Coolant flow control; heater connector in to heater connector out | CAB |
| HT07C | Optimized Idle | Coolant flow control; heater connector in to heater connector out | CAB |
| HT08A | Sleeper | Red Dot red; sleeper heater to sleeper heater control | SLPR |
| HT08B | Sleeper | Red Dot red; sleeper heater control to power relay contact | SLPR |
| HT10A | Sleeper | Red Dot yellow; sleeper heater to sleeper heater control | SLPR |
| HT11A | Sleeper | Red Dot black/white; sleeper heater to sleeper heater control | SLPR |
| HT12A | Sleeper | Red Dot orange; sleeper heater to sleeper heater control | SLPR |
| HT13A | Sleeper | Red Dot brown; sleeper heater to sleeper heater control | SLPR |
| HT14A | Sleeper | Red Dot purple; sleeper heater to sleeper heater control | SLPR |
| HT15A | Sleeper | Fused battery power ot sleeper heater control relay | SLPR |
| HT16A | Roof Top Condenser | Roof top condenser fan relay to over head console connector | CAB |
| HT16B | Roof Top Condenser | Roof top condenser to cab connector | OHC |
| HT17A | Sleeper | Switched power; heater relay to heater control panel | SLPR |
| HT18A | Sleeper | Low-speed fan; heater control panel to heater | SLPR |
| HT19A | Sleeper | Medium-speed fan; heater control panel to heater | SLPR |
| HT20A | Sleeper | High-speed fan; heater control panel to heater | SLPR |
| HT21A | Sleeper | Heat valve control signal; heater control panel to heater | SLPR |
| HT21B | Sleeper | Heat valve control signal; heater control panel to Webasto relay, 42-inch and 66-inch sleeper | SLPR |
| HT21C | Sleeper | Cool valve control signal; heater to heater control panel | SLPR |
| HT22A | Sleeper | Cool valve control signal; heater control panel to heater | CAB |
| HT23A | Roof Top Condenser | Main fused ignition power; main fuse block to option fuse block | CAB |
| HT24A | Roof Top Condenser | Fused condenser power; option fuse block to over head console connector | CAB |
| HT24B | Roof Top Condenser | Fused condenser power; option fuse block to relay | CAB |
| HT24C | Roof Top Condenser | Fused condenser power; option relay to relay | CAB |
| HT25A | In cab sleeper | Bunk switch pressed | CAB |
| HT25B | In cab sleeper | Bunk switch pressed, jumper | CAB |

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## Circuit Codes G through H

| HT—Heater/Air Conditioning Circuits HT01 through HT32 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| HT26A | In cab sleeper | AC switch pressed | CAB |
| HT26B | In cab sleeper | AC switch pressed, jumper | CAB |
| HT27A | Sleeper | Fused battery power for two-speed fans; fuse to fan switch one | SLPR |
| HT27B | Sleeper | Fused battery power for two-speed fans; fan switch one to fan switch two | SLPR |
| HT28A | Sleeper | Fan one fast; fan one switch to fan one | SLPR |
| HT29A | Sleeper | Fan one slow; fan one switch to fan two | SLPR |
| HT30A | Sleeper | Fan two fast; fan two switch to fan two | SLPR |
| HT31A | Sleeper | Fan two slow; fan two switch to fan two | SLPR |
| HT32A | Sleeper | Accessory power for two-speed fans; accessory terminal to fan switch two | SLPR |
| HT32B | Sleeper | Accessory power for two-speed fans; fan switch two to fan switch one | SLPR |

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# Circuit Codes I through R

All wires have three to five character alphanumeric codes printed on them every four to six inches. The first two characters are a letter code that denotes the circuit type in which the wire is used. The next one or two numbers denote the specific circuit, and last letter denotes the branch in the circuit. Use the following circuit code tables to look up the circuit code that is printed on a wire and determine its function.

See **Subject 430** for an explanation of location abbreviations used in the circuit code tables.

**ID—Optimized Idle Circuits ID01 through ID18**

| ID—Optimized Idle Circuits ID01 through ID18 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| ID01A | Optimized Idle | Blower/shutdown relay (87) to heater jumper jack | CAB |
| ID01B | Optimized Idle | Heater jumper plug to blower/shutdown relay (30) | CAB |
| ID02A | Optimized Idle | Ignition power; ignition switch to shutdown relay (86) | CAB |
| ID02B | Optimized Idle | Ignition power; shutdown relay (86) to park brake applied relay (86) | CAB |
| ID03A | Optimized Idle | Start power; ignition switch to starter control relay (30) | CAB |
| ID04A | Optimized Idle | Battery power; ignition switch to starter control relay (87) | CAB |
| ID05A | Optimized Idle | Starter signal; frontwall to starter control relay (85) | CAB |
| ID05B | Optimized Idle | Starter signal; ECM interface to frontwall | ENG |
| ID06A | Optimized Idle | System active light signal; frontwall to lightbar (A10) | CAB |
| ID06B | Optimized Idle | System active light signal; ECM sensor to frontwall | ENG |
| ID07A | Optimized Idle | Park brake interlock ground signal; engine ground to park brake applied relay (30) | CAB |
| ID07B | Optimized Idle | Park brake interlock ground; park brake applied relay (87) to transmission neutral switch; frontwall | CAB |
| ID07C | Optimized Idle | Park brake interlock ground; frontwall to transmission neutral switch | ENG |
| ID07D | Optimized Idle | Park brake interlock ground; transmission neutral switch to hood open switch | ENG |
| ID07E | Optimized Idle | Hood open switch to park brake interlock ground signal; ECM | ENG |
| ID08A | Optimized Idle | Park brake signal to park brake applied relay (85) | CAB |
| ID09A | Optimized Idle | Vehicle ground; sleeper thermostat to frontwall | SLPR |
| ID09B | Optimized Idle | Vehicle ground; frontwall to engine ground stud (C13) | CAB |
| ID10A | Optimized Idle | Ignition power; sleeper thermostat to frontwall | SLPR |
| ID10B | Optimized Idle | Ignition power; park brake applied relay (87) to thermostat ignition power; frontwall | CAB |
| ID11A | Optimized Idle | ECM analog input; sleeper thermostat to frontwall (sleeper start) | SLPR |
| ID11B | Optimized Idle | ECM analog input; frontwall (sleeper start) to frontwall | CAB |
| ID11C | Optimized Idle | ECM analog input; frontwall to ECM interface connector | ENG |
| ID12A | Optimized Idle | Engine battery power to engine start alarm; frontwall | CAB |

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## Circuit Codes I through R

| ID—Optimized Idle Circuits ID01 through ID18 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| ID12B | Optimized Idle | Engine battery power; frontwall to engine start alarm | ENG |
| ID12C | Optimized Idle | Alarm signal; ECM interface connector to engine start alarm | ENG |
| ID13A | Optimized Idle | Vehicle power shutdown signal; ECM to frontwall | ENG |
| ID13B | Optimized Idle | Vehicle power shutdown signal; frontwall to shutdown relay (85) | CAB |
| ID14A | Optimized Idle | Interlocks closed signal; hood switch to starter interrupt relay; frontwall | ENG |
| ID14B | Optimized Idle | Interlocks closed signal; frontwall to starter interrupt relay (86) | CAB |
| ID15A | Optimized Idle | Ignition power; ignition switch to starter interrupt relay; splice to resistor | CAB |
| ID15B | Optimized Idle | Ignition power; splice to resistor to starter interrupt relay (30) | CAB |
| ID16A | Optimized Idle | Ignition power; starter interrupt relay (30) to starter interrupt relay (85) | CAB |
| ID17A | Optimized Idle | Ignition signal; starter control relay to starter interrupt relay; splice to resistor | CAB |
| ID17B | Optimized Idle | Ignition signal; splice to resistor to starter interrupt relay (87) | CAB |
| ID 18A | Optimized Idle | Interlocks closed signal from hood switch to ECM and interrupt relay | ENG |

**IG—Ignition Circuits IG01 through IG10**

| IG—Ignition Circuits IG01 through IG10 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| IG01A | Sleeper start | Key in ignition position; cab key switch to sleeper start connector | CAB |
| OG01B | Sleeper start | Key in ignition position; sleeper start connector to sleeper key switch | CHA |
| IG01C | Sleeper start | Key in ignition position; sleeper key switch to engine water temperature gauge | SLPR |
| IG01D | Sleeper start | Key in ignition position; engine water temperature gauge to check engine light | SLPR |
| IG01E | Sleeper start | Key in ignition position; check engine light to stop engine light | SLPR |
| IG01F | Sleeper start | Key in ignition position; stop engine light to ignition light | SLPR |
| IG01G | Main | Key in ignition position; key switch to power relay coil | CAB |
| IG01J | Main | Key in ignition position; power relay coil to field power resistor | CAB |
| IG01K | Sleeper start | Key in ignition position; frontwall to back-of-cab | CHA |
| IG01L | Sleeper start | Key in ignition position; back-of-cab to sleeper ignition switch | SLPR |
| IG01M | Argo special event | Key in ignition position; PSSA to Argo feed splice | CHA |
| IG01N | Argo special event | Key in ignition position; Argo feed splice to back-of-cab; JSSA | CHA |
| IG01P | Argo special event | Pressure switch ignition feed; Argo feed splice to pressure switch | CHA |

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| IG—Ignition Circuits IG01 through IG10 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| IG01Q | Sleeper start | Key in ignition position; frontwall to sleeper ignition switch | SLPR |
| IG01R | Sleeper start | Key in ignition position; sleeper key switch to diode | SLPR |
| IG01S | Sleeper start | Key in ignition position; diode to engine water temperature gauge | SLPR |
| IG01T | Bogaard timer | Key in ignition position; key switch to Bogaard timer | CAB |
| IG01U | Argo special event | Key in ignition position; grey frontwall connector to pressure switch | CHA |
| IG01V | Argo special event | Key in ignition position; grey frontwall connector to ignition switch | CAB |
| IG3-BB | Main | Main ignition power; bus bar between fuse terminals | CAB |
| IG03A | Engine | Main fuse block ignition jumper to engine harness F33 | CAB |
| IG03C | Engine | Engine harness F31 to engine harness F32 | CAB |
| IG03D | Main | Ignition power; F14-LN to F20-LN | CAB |
| IG03E | Main | Ignition power; F15-LN to F26-LN | CAB |
| IG03F | Main | Ignition power; F16-LN to JP7 | CAB |
| IG03G | Anti-lock brakes | Main fuse block ignition jumper to ABS harness F46 | CAB |
| IG04A | Main | Fused ignition power to ECC | CAB |
| IG04B | Main | Fused ignition power to lightbar | CAB |
| IG05A | Main | Alternator field; field power diode to splice | CAB |
| IG05B | Main | Alternator field; splice to frontwall | CAB |
| IG05C | Main | Alternator field; splice to lightbar | CAB |
| IG05D | Power | Alternator field; frontwall to alternator I terminal | ENG |
| IG06A | Engine | Fused ignition power; ignition relay to fuse | CAB |
| IG07A | Engine | Fused ignition signal; F31 to ignition control relay | CAB |
| IG08A | Main | Fused ignition power to ignition option harnesses JP10-J12 | CAB |
| IG08B | Main | Fused ignition power, JP10-JP12 to JP7-JP9 | CAB |
| IG09A | Main | Main fuse block ignition jumper to convenience harness F87 | CAB |
| IG010A | Bogaard timer | Ignition keep alive; Bogaard timer to main ignition relay | CAB |

**IN—Instruments Circuits IN03 through IN06**

| IN—Instruments Circuits IN03 through IN26 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| IN03A | Main | Park lights on; park light switch to park light relay coil | CAB |
| IN03B | Main | Park lights on; park light switch to instrument dimmer switch | CAB |
| IN03C | Main | Park lights on; park light relay coil to splice | CAB |
| IN03D | Main | Park lights on; splice to ECC | CAB |
| IN03E | Main | Park lights on; splice to ECC | CAB |

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## Circuit Codes I through R

| IN—Instruments Circuits IN03 through IN26 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| IN03F | Aus | Park lights on; splice to main cab harness connector | CAB |
| IN03G | Aus | Park lights on; splice to headlight switch | CAB |
| IN03H | Aus | Park lights on; splice to left mirror connector | CAB |
| IN03J | Aus | Park lights on; splice to right mirror connector | CAB |
| IN03K | Aus | Park lights on; splice to marker light switch wires | CAB |
| IN04A | Engine | Odometer signal; ECC to speedometer | CAB |
| IN05A | Engine | Cosine pointer signal; ECC to speedometer | CAB |
| IN06A | Engine | Sine pointer signal; ECC to speedometer | CAB |
| IN07A | Engine | Sine pointer signal; ECC to tachometer | CAB |
| IN08A | Engine | Cosine pointer signal; ECC to tachometer | CAB |
| IN09A | Engine | Pointer signal; ECC to engine oil pressure gauge | SLPR |
| IN10A | Engine | Pointer signal; ECC to pyrometer | CAB |
| IN11A | Engine | Pointer signal; ECC to engine water temperature gauge | CHA |
| IN12A | Engine | Yellow thermocouple wire; ECC to frontwall | CAB |
| IN13A | S60/N14/M11 | Pointer signal; ECC to lube oil temperature gauge | CAB |
| IN13A | 3406E | Pointer signal; ECC to frontwall connector | CAB |
| IN13B | 3406E | Pointer signal; frontwall connector to sender | ENG |
| IN14A | Engine | Red thermocouple wire; ECC to frontwall | CAB |
| IN15A | Engine | Pointer signal; ECC to turbo pressure gauge | CAB |
| IN16A | Engine | Hourmeter signal; ECC to tachometer | CAB |
| IN17A | Main | Front drive axle differential lock; lightbar to taillight connector or two-way | CAB |
| IN17B | Option | Front drive axle differential lock; taillight connector to switch | CHA |
| IN17C | Option | "W" wire from first traction differential switch mounted in the cab to two-way connector | CAB |
| IN17D | Option | Traction differential engaged (forward) air switch to lightbar | CAB |
| IN18A | Main | Rear drive axle differential lock; lightbar to taillight connector or two-way | CAB |
| IN18B | Option | Rear drive axle differential lock; taillight connector to switch | CHA |
| IN18C | Option | "W" wire from second traction differential switch mounted in cab to two-way connector | CAB |
| IN18D | Option | Traction differential engaged (rear); air switch to lightbar | CAB |
| IN19A | Main | air brake system low air pressure;"A" pressure switch to ECC | CAB |
| IN19B | Main | Air brake system low air pressure; "A" pressure switch to "B" pressure switch | CAB |
| IN19C | Aus signal lights | Ignition switch start contact to air brake system low air pressure "B" pressure switch | CAB |

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| IN—Instruments Circuits IN03 through IN26 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| IN19D | Aus signal lights | Trailer pressure fail switch to air brake system low air pressure "A" pressure switch | CAB |
| IN20A | Main | Park brake engaged; pressure switch to ECC | CAB |
| IN20A | Main | Park brake engaged; pressure switch to ECC | CAB |
| IN20B | Option | Park brake engaged; pressure switch to R27 P.T.O. interlock relay | CAB |
| IN20C | Option | Park brake engaged; pressure switch to R28 remote start interlock relay | CAB |
| IN21A | Main | Interaxle differential lock; lightbar to switch | CAB |
| IN22A | Main | Illumination brighter; illumination control switch to ECC | CAB |
| IN23A | Main | Illumination dimmer; illumination control switch to ECC | CAB |
| IN26A | Engine | Pointer signal; transmission oil temperature gauge to frontwall | CAB |
| IN26B | Engine | Pointer signal; frontwall to transmission oil temperature sender | ENG |

**IN—Instruments Circuits IN27 through IN51**

| IN—Instruments Circuits IN27 through IN51 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| IN27A | Engine | Pointer signal; fuel pressure gauge to frontwall | CAB |
| IN27B | Engine | Pointer signal; frontwall to fuel pressure sender | ENG |
| IN28 | Engine | ECC gauge five volt reference to all sine-cosine gauges | CAB |
| IN28A | Engine | ECC to turbo pressure gauge | CAB |
| IN28B | Engine | Turbo pressure gauge to engine oil temperature gauge | CAB |
| IN28C | Engine | Engine oil temperature gauge to pyrometer | CAB |
| IN28D | Engine | Pyrometer to water temperature gauge | CAB |
| IN28E | Engine | Water temperature gauge to engine oil pressure gauge | CAB |
| IN28F | Engine | Engine oil pressure gauge to tachometer | CAB |
| IN28G | Engine | Tachometer to speedometer | CAB |
| IN28H | Engine | Turbo pressure gauge to pyrometer | CAB |
| IN28J | Engine | ECC to engine water temperature | CAB |
| IN28K | Engine | Pyrometer to tachometer | CAB |
| IN28L | Sleeper start | Engine water temperature gauge to sleeper start connector | CAB |
| IN28M | Sleeper start | Sleeper start connector to engine water temperature gauge | CHA |
| IN28N | Sleeper start | Frontwall to back-of-cab | CHA |
| IN28P | Sleeper start | Back-of-cab to sleeper water temperature gauge | SLPR |
| IN28Q | Argo special event | Engine water temperature gauge; PSSA to back-of-cab; JSSA | CHA |
| IN28R | Sleeper start | Frontwall to sleeper water temperature gauge | SLPR |
| IN29A | Engine | Axle high/low speed signal; pressure switch to ECC | CAB |

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## Circuit Codes I through R

| IN—Instruments Circuits IN27 through IN51 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| IN30A | Engine | Vehicle speed signal; sender to frontwall | ENG |
| IN30B | Engine | Vehicle speed signal; frontwall to ECC | CAB |
| IN30C | Auxiliary Transmission | Vehicle speed signal; auxiliary transmission to engine harness | ENG |
| IN31A | Engine | Tachometer signal; sender to frontwall | ENG |
| IN31B | Engine | Tachometer signal; frontwall to ECC | CAB |
| IN32A | Engine | Fuel solenoid power; ECC to frontwall | CAB |
| IN32B | Engine | Fuel solenoid power; frontwall to solenoid | ENG |
| IN32C | Engine | Fuel solenoid power; solenoid to flyback diode | ENG |
| IN33A | Engine | Engine oil pressure low switch; frontwall to ECC | CAB |
| IN33B | Engine | Engine oil pressure low switch; frontwall to switch | ENG |
| IN34A | Engine | Engine coolant level low switch; frontwall to ECC | CAB |
| IN34B | Engine | Engine coolant level low switch; frontwall to switch | CAB |
| IN35A | Engine | Pointer signal; engine oil temperature gauge to frontwall | CAB |
| IN35B | Engine | Pointer signal; frontwall to engine oil temperature sender | ENG |
| IN36A | Engine | Engine water temperature signal; ECC to frontwall | CAB |
| IN36B | Engine | Pointer signal; frontwall to engine water temperature sender | ENG |
| IN38A | Main | Pointer signal; forward axle oil temperature gauge to taillight connector | CAB |
| IN38B | Axle temperature | Pointer signal; taillight connector to splice | CHA |
| IN38C | Axle temperature | Pointer signal; splice to forward axle oil temperature sender | CHA |
| IN39A | Main | Pointer signal; rear axle oil temperature gauge to taillight connector | CAB |
| IN39B | Axle temperature | Pointer signal; taillight connector to splice | CHA |
| IN39C | Axle temperature | Pointer signal; splice to rear axle oil temperature sender | CHA |
| IN40A | Main | Pointer signal; fuel level gauge to frontwall | CAB |
| IN40B | Fuel level | Pointer signal; frontwall to fuel level sender | CHA |
| IN40C | Fuel level | Pointer signal; frontwall to tank selector switch | CAB |
| IN41A | Main | Ammeter shunt signal; gauge ignition terminal to engine connector | CAB |
| IN41B | Power | Ammeter shunt signal; cab connector to fuse link | ENG |
| IN41FL | Power | Ammeter shunt signal (fuselink); alternator side to IN41B | ENG |
| IN42A | Main | Ammeter shunt signal; gauge signal terminal to engine connector | CAB |
| IN42B | Power | Ammeter shunt signal; cab connector to fuse link | ENG |
| IN42FL | Power | Ammeter shunt signal (fuse link); battery side to IN42B | ENG |
| IN43A | Power | Miles/kilometers; speedometer to ECC | CAB |
| IN47A | Engine | Pointer signal; engine oil pressure gauge to frontwall | CAB |

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| IN—Instruments Circuits IN27 through IN51 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| IN47B | Engine | Pointer signal; engine oil pressure sender to frontwall | ENG |
| IN48A | Sleeper start | Pointer signal; ECC to sleeper start connector | CAB |
| IN48B | Sleeper start | Pointer signal; sleeper start connector to engine water temp gauge | CHA |
| IN48C | Sleeper start | Pointer signal; Frontwall to back-of-cab | CHA |
| IN48D | Sleeper start | Pointer signal; back-of-cab to sleeper water temperature gauge | SLPR |
| IN48E | Sleeper start | Pointer signal; frontwall to sleeper water temperature gauge | SLPR |
| IN49A | Engine | Power for Celect road relay | CAB |
| IN50A | Fuel level | Pointer signal; tank selector switch to frontwall | CAB |
| IN50B | Fuel level | Pointer signal; frontwall ot RH tank fuel level sender | CHA |
| IN51A | Fuel level | Pointer signal; fuel level gauge to tank selector switch | CAB |

**IN—Instruments Circuits IN52 through IN70**

| IN—Instruments Circuits IN52 through IN70 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| IN52A | Main | Fused ignition power for gauges to ECC | CAB |
| IN52B | Main | Fused ignition power for gauges to fuel gauge | CAB |
| IN52C | Main | Fused ignition power for gauges; fuel gauge to voltmeter | CAB |
| IN52D | Main | Fused ignition power for gauges; voltmeter to transmission oil temperature gauge | CAB |
| IN52E | Engine | Fused ignition power for gauges; fuel gauge to speedometer | CAB |
| IN52F | Cat DIS | Power for Caterpillar driver information system | CAB |
| IN52G | Celect Road Relay | Power for Celect Road Relay | CAB |
| IN52H | Engine | Fused ignition power for gauges; speedometer to tachometer | CAB |
| IN52J | Option | Any miscellaneous air switch power in | CAB |
| IN252K | Option | Any miscellaneous air switch power in to power out | CAB |
| IN52L | CEMAT | Fused ignition power; oil temperature gauge to insight module | CAB |
| IN52M | Main | Fused ignition power for gauges to left side gauges | CAB |
| IN52N | Main | Fused ignition power for gauges; left side gauges to right side gauges | CAB |
| IN52P | Main | Fused ignition power for gauges; right side gauges to air switch row | CAB |
| IN52Q | Cat DIS | Power "Y" for Caterpillar driver information system | CAB |
| IN52R | Celect Road Relay | Power "Y" for Celect Road Relay system | CAB |
| IN53A | Engine | Pointer signal; turbo pressure gauge to frontwall | CAB |
| IN53B | Engine | Pointer signal; frontwall to turbo pressure sender | ENG |
| IN54A | Engine | Return signal for vehicle speed pickup; pickup to frontwall | ENG |

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## Circuit Codes I through R

| IN—Instruments Circuits IN52 through IN70 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| IN54B | Engine | Return signal for vehicle speed pickup; frontwall to ECC | CAB |
| IN54C | Engine | Return signal for engine speed pickup; pickup to frontwall | ENG |
| IN54D | Engine | Return signal for engine speed pickup; frontwall to ECC | CAB |
| IN55A | Option | Water temperature signal; customer furnished water temperature sender to temperature gauge | CHA |
| IN56A | Option | Water temperature signal; customer furnished oil pressure sender to oil pressure gauge | CHA |
| IN57A | Main | Pointer signal; rearmost axle oil temperature gauge to taillight connector | CAB |
| IN57B | Axle temperature | Pointer signal; taillight connector to splice | CHA |
| IN57C | Axle temperature | Pointer signal; splice to rear rear axle oil temperature sender | CHA |
| IN58A | ARGO | J1587 (+) ARGO to J1587 plug | CAB |
| IN58B | ARGO | J1587 (+) ARGO to J1587 jack | CAB |
| IN59A | ARGO | J1587 (–) ARGO to J1587 plug | CAB |
| IN59B | ARGO | J1587 (–) ARGO to J1587 jack | CAB |
| IN60A | ARGO | Battery power; main fuse block to option fuse block | CAB |
| IN61A | ARGO | Battery power; option fuse block to ARGO harness connector | CAB |
| IN62A | ARGO | Ignition power; main fuse block to option fuse block | CAB |
| IN63A | ARGO | Ignition power; option fuse block to ARGO harness connector | CAB |
| IN64A | ARGO | Engine speed signal; pickup to frontwall | ENG |
| IN65A | ARGO | Engine speed ground; pickup to frontwall | ENG |
| IN66A | ARGO | Vehicle speed signal; pickup to frontwall | ENG |
| IN67A | ARGO | Vehicle speed ground; pickup to frontwall | ENG |
| IN68A | Option | Tridem axle differential lock; lightbar to taillight connector | CAB |
| IN68B | Option | Tridem axle differential lock; taillight connector to switch | CHA |
| IN68C | Option | "W" wire form third traction differential switch mounted in cab to two-way connector | CAB |
| IN68D | Option | Traction differential engaged (rear rear); air switch to lightbar | CAB |
| IN69A | Option | Rear rear differential lock signal; splice to (–) buzzer input diode (D14) | CAB |
| IN69B | Option | Forward rear differential lock signal; splice to (–) buzzer input diode (D13) | CAB |
| IN69C | Option | Forward rear differential lock signal; diode (D13) to rear rear differential lock signal; diode (D14) | CAB |
| IN69D | Option | Rear rear differential lock signal; diode to (–) buzzer input; PECV | CAB |
| IN70A | Option | Interaxle differential lock switch in cab wire; frontwall to lightbar | CAB |
| IN70B | Option | Interaxle differential lock switch chassis wire; frontwall to axle | CHA |
| IN71A | Argo special event | Pressure switch feed to ARGO; frontwall | CHA |

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| IN—Instruments Circuits IN52 through IN70 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| IN72A | Engine | Vehicle speed signal; Allison VIM to overhead console | ENG |
| IN72B | Engine | Vehicle speed signal; overhead console to ECC | ENG |
| IN73A | Option | Auxiliary transmission temperature gauge signal; gauge to frontwall | CAB |
| IN73B | Option | Auxiliary transmission temperature gauge signal; frontwall to sender | ENG |
| IN74A | Option | Traction differential engaged; air switch to lightbar splice | CAB |
| IN74B | Option | Traction differential engaged; splice to lightbar (forward) | CAB |
| IN74C | Option | Traction differential engaged; splice to lightbar (rear) | CAB |
| IN75A | Option | Rear rear differential lock signal; splice to (–) buzzer input diode (D14) | CAB |
| IN75B | Option | Rear rear differential lock signal; splice to taillight connector | CAB |
| IN76A | Option | Rear rear differential lock signal; splice to (–) buzzer input diode (D13) | CAB |
| IN76B | Option | Rear rear differential lock signal; splice to lightbar | CAB |
| IN77A | Aus turn signal | Trailer brake pressure low switch to not in bobtail mode pressure switch | CAB |

**J1939—Data Link Backbone, Base Numbers**

| J1939—Data Link Backbone, Base Numbers | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| N1939 | Option | J1939 negative (low) | CHA |
| P1939 | Option | J1939 positive (high) | CHA |
| S1939 | Option | J1939 shield | CHA |
| D1939 | Option | J1939 drain | — |
| D1939A | Autoshift | J1939 drain; T-receptacle number two to drain splice | CHA |
| D1939B | Autoshift | J1939 drain; drain splice to starter negative | CHA |
| N1939A | Autoshift | J1939 negative; shift tower to T-receptacle number one | CHA |
| P1939A | Autoshift | J1939 positive; shift tower to T-receptacle number one | CHA |
| S1939A | Autoshift | J1939 shield; shift tower to T-receptacle number one | CHA |
| N1939B | Autoshift | J1939 negative; T-receptacle number one to terminator number one | CHA |
| P1939B | Autoshift | J1939 positive; T-receptacle number one to terminator number one | CHA |
| S1939B | Autoshift | J1939 shield; T-receptacle number one to terminator number one | CHA |
| N1939C | Autoshift | J1939 negative; T-receptacle number one to T-receptacle number two | CHA |

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## Circuit Codes I through R

| J1939—Data Link Backbone, Base Numbers | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| P1939C | Autoshift | J1939 positive; T-receptacle number one to T-receptacle number two | CHA |
| S1939C | Autoshift | J1939 shield; T-receptacle number one to T-receptacle number two | CHA |
| N1939D | Autoshift | J1939 negative; T-receptacle number two to engine ECM | CHA |
| P1939D | Autoshift | J1939 positive; T-receptacle number two to engine ECM | CHA |
| S1939D | Autoshift | J1939 shield; T-receptacle number two to engine ECM | CHA |
| N1939E | Autoshift | J1939 negative; T-receptacle number two to terminator number two | CHA |
| P1939E | Autoshift | J1939 negative; T-receptacle number two to terminator number two | CHA |
| S1939E | Autoshift | J1939 negative; T-receptacle number two to terminator number two | CHA |
| N1939F | Cummins AHD | J1939 negative; engine ECM to engine data link connector | CHA |
| P1939F | Cummins AHD | J1939 positive; engine ECM to engine data link connector | CHA |
| S1939F | Cummins AHD | J1939 shield; engine ECM to engine data link connector | CHA |
| N1939G | ABS | J1939 negative; engine data link connector to ABS ECU | CHA |
| P1939G | ABS | J1939 positive; engine data link connector to ABS ECU | CHA |
| S1939G | ABS | J1939 shield; engine data link connector to ABS ECU | CHA |
| N1939H | Vorad | J1939 negative; Vorad CPU to T-receptacle number one | ENG |
| P1939H | Vorad | J1939 positive; Vorad CPU to T-receptacle number one | ENG |
| S1939H | Vorad | J1939 shield; Vorad CPU to T-receptacle number one | ENG |
| N1939J | ADAM111 | J1939 negative; Engine ECM to engine data link connector | CHA |
| P1939J | ADAM111 | J1939 positive; Engine ECM to engine data link connector | CHA |
| S1939J | ADAM111 | J1939 shield; engine ECM to engine data link connector | CHA |

**LB—Light Bar Circuits LB01 through LB09**

| LB—Light Bar Circuits LB01 through LB09 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| LB01A | Main | Stop engine lamp; ECC to splice | CAB |
| LB01B | Main | Stop engine lamp; splice to lightbar | CAB |
| LB01C | Main | Stop engine lamp; splice to sleeper start connector | CAB |
| LB01D | Sleeper start | Stop engine lamp; sleeper start connector to stop engine lamp | CHA |
| LB01E | Sleeper start | Stop engine lamp; frontwall to back-of-cab | CHA |
| LB01F | Sleeper start | Stop engine lamp; back-of-cab to sleeper stop engine light | SLPR |
| LB01G | Argo special event | Stop engine lamp; PSSA to back-of-cab; JSSA | CHA |
| LB01H | Sleeper start | Stop engine lamp; frontwall to sleeper stop engine light | SLPR |
| LB02A | Main | Check engine lamp; ECC to splice | CAB |

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| LB—Light Bar Circuits LB01 through LB09 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| LB02B | Main | Check engine lamp; splice to lightbar | CAB |
| LB02C | Main | Check engine lamp; splice to sleeper start connector | CAB |
| LB02D | Sleeper start | Check engine lamp; sleeper start connector to check engine lamp | CHA |
| LB02F | Sleeper start | Check engine lamp; back-of-cab to sleeper check engine light | SLPR |
| LB02G | Argo special event | Check engine lamp; PSSA to back-of-cab; JSSA | CHA |
| LB02H | Sleeper start | Check engine lamp; frontwall to sleeper check engine light | SLPR |
| LB03A | Main | Park brake indicator; ECC to lightbar | CAB |
| LB04A | Main | High beam indicator; ECC to lightbar | CAB |
| LB05A | Main | Data error; ECC to lightbar | CAB |
| LB06A | Main | Engine low coolant indicator; ECC to lightbar | CAB |
| LB087A | Main | Low air pressure indicator; ECC to lightbar | CAB |
| LB08A | Main | Daytime running light indicator; ECC to lightbar | CAB |
| LB09A | Main | Buzzer; ECC to lightbar | CAB |

**LC—Lighting Cab Circuits LC01 through LC02**

| LC—Lighting Cab Circuits LC01 through LC02 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| LC01A | Main | Fused battery power to right door switch | CAB |
| LC01B | Main | Fused battery power to left door switch | CAB |
| LC01C | Main | Fused battery power; left door switch to OHC connector | CAB |
| LC01F | Overhead console | Fused battery power; cab connector to center reading light | OHC |
| LC01G | Overhead console | Fused battery power; cab connector to left reading light | OHC |
| LC01H | Overhead console | Fused battery power; center reading light to right reading light | OHC |
| LC01J | Option | Fused battery power; left vanity light spliced into LC01F | OHC |
| LC01K | Overhead Console | Fused battery power; left reading light to dome light | OHC |
| LC01L | Option | Fused battery power; right-hand vanity light spliced to LC01H | OHC |
| LC01M | Vanity mirror | Fused battery power; overhead console reading light power to center reading light | OHC |
| LC01N | Vanity mirror | Fused battery power, overhead console reading light to left vanity light | OHC |
| LC01P | Vanity mirror | Fused battery power; overhead console center reading light to right vanity light | OHC |
| LC01Q | Main | Fused battery power; fuse to splice | CAB |
| LC01R | Remote start | Fused battery power; cab connector to dome control relay splice | CAB |
| LC01S | Remote start | Fused battery power; dome control relay splice to center reading light | CAB |

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## Circuit Codes I through R

| LC—Lighting Cab Circuits LC01 through LC02 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| LC02A | Option | Door open or dome on; cab to door light | RHD |
| LC02B | Main | Door open or dome on; right-hand switch to right-hand door connector | CAB |
| LC02C | Main | Door open or dome on; left-hand switch to left-hand door connector | CAB |
| LC02D | Main | Door open or dome on; left-hand switch to splice | CAB |
| LC02E | Main | Door open or dome on; right-hand switch to splice | CAB |
| LC02F | Main | Door open or dome on; splice to under dash light | CAB |
| LC02G | Main | Door open or dome on; splice to overhead console connector | CAB |
| LC02H | Overhead console | Door open or dome on; cab connector to dome light | OHC |
| LC02J | Remote start | Door open or dome on; cab connector to dome control relay splice | CAB |
| LC02K | Remote start | Door open or dome on; dome control relay splice to dome light | CAB |

**LS—Lighting Sleeper Circuits LS01 through LS06**

| LS—Lighting Sleeper Circuits LS01 through LS06 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| LS01A | Sleeper | Fused battery power to control center connector J21 | SLPR |
| LS01B | Sleeper | Fused battery power; cab frontwall plug to sleeper light switch in cab | CHA |
| LS01C | Sleeper | Fused battery power; left door switch to OHC connector | CAB |
| LS01D | Sleeper | Fused battery power; control center connector J21 to sleeper door switch | SLPR |
| LS01E | Sleeper | Fused battery power to lower bunk reading light | SLPR |
| LS01F | Sleeper | Fused battery power; lower bunk reading light to upper bunk reading light | SLPR |
| LS01G | Sleeper | Fused battery power; sleeper door switch to left luggage door switch | SLPR |
| LS01H | Sleeper | Fused battery power; sleeper door switch to right luggage door switch | SLPR |
| LS01J | Sleeper | Fused battery power; right luggage door switch to bunk lifted switch | SLPR |
| LS01K | Sleeper | Fused battery power; control center connector P21 to sleeper light switch | SLPR |
| LS01L | Sleeper | Fused battery power, frontwall plug to sleeper jumper connector | SLPR |
| LS01M | Sleeper | Fused battery power; sleeper jumper connector to sleeper stud | SLPR |
| LS01N | Sleeper | Fused battery power; sleeper stud to sleeper door switch | SLPR |
| LS01P | Sleeper | Fused battery power to sleeper stud | SLPR |
| LS01Q | Sleeper | Fused battery power; sleeper stud to right luggage door switch | SLPR |

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| LS—Lighting Sleeper Circuits LS01 through LS06 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| LS01R | Sleeper | Fused battery power; JSPR jumper used on low roof standard lighting | SLPR |
| LS01S | Sleeper | Fused battery power; breaker to splice | SLPR |
| LS01T | Sleeper | Fused battery power; splice to upper bunk reading light | SLPR |
| LS01U | Sleeper | Fused battery power; splice to lower bunk reading light | SLPR |
| LS01V | Aus sleeper | Fused battery power; left luggage door switch to rear luggage door switch | SLPR |
| LS01W | Aus sleeper | Fused battery power; rear luggage door switch to right luggage door switch | SLPR |
| LS01X | Aus sleeper | Fused battery power; right door switch to left door switch | SLPR |
| LS01Y | Sleeper | Fused battery power; control center C24 to upper reading light | SLPR |
| LS01Z | Sleeper | Fused battery power; control center C24 to lower reading light | SLPR |
| LS01AC | Sleeper | Fused battery power; left luggage door switch to bunk open switch | SLPR |
| LS02A | Sleeper | Sleeper lights on; sleeper door switch to sleeper light on/off switch | SLPR |
| LS02B | Sleeper | Sleeper lights on; sleeper light on/off switch to itself | SLPR |
| LS02C | Sleeper | Sleeper lights on; sleeper light on/off switch to dome light | SLPR |
| LS02D | Sleeper | Sleeper lights on; sleeper door switch to floor light | SLPR |
| LS02E | Sleeper | Sleeper lights on; dome power plug to right dome light bulb | SLPR |
| LS02F | Sleeper | Sleeper lights on; dome power plug to left dome light bulb | SLPR |
| LS02G | Sleeper | Sleeper lights on; sleeper light switch to left floor light | SLPR |
| LS02H | Sleeper | Sleeper lights on; sleeper door switch to diode pair | SLPR |
| LS02J | Sleeper | Sleeper lights on; splice to floor light | SLPR |
| LS02K | Sleeper | Sleeper lights on; splice to door switch | SLPR |
| LS02L | Sleeper | Sleeper lights on; splice to control panel light switch | SLPR |
| LS02M | Sleeper | Sleeper lights on; splice to control panel light switch | SLPR |
| LS02N | Sleeper | Sleeper lights on; splice to dome light | SLPR |
| LS02P | Sleeper | Sleeper lights on; right door switch to left door switch | SLPR |
| LS02Q | Sleeper | Sleeper lights on; sleeper switch to dome light | SLPR |
| LS02R | Sleeper | Sleeper lights on; sleeper switch to floor light | SLPR |
| LS03A | Sleeper | Luggage door open; left luggage door switch to bunk switch | SLPR |
| LS03B | Sleeper | Luggage door open; left luggage door switch to left luggage light | SLPR |
| LS03C | Sleeper | Luggage door open; right luggage door switch to right luggage light | SLPR |
| LS03D | Sleeper | Luggage door open; right luggage door switch to bunk switch | SLPR |
| LS03E | Sleeper | Luggage door open; bunk switch to right luggage light | SLPR |

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## Circuit Codes I through R

| LS—Lighting Sleeper Circuits LS01 through LS06 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| LS03F | Sleeper | Luggage door open; diode pair to right luggage light | SLPR |
| LS03G | Sleeper | Luggage door open; right switch to left switch | SLPR |
| LS03H | Sleeper | Luggage door open; right light to left light | SLPR |
| LS03J | Aus sleeper | Luggage door open; left luggage door switch to rear luggage door switch | SLPR |
| LS03K | Sleeper | Luggage door open; rear luggage door switch to right luggage door switch | SLPR |
| LS04A | Sleeper | Sleeper light switch three-way control line; cab switch to frontwall connector | CAB |
| LS04B | Sleeper | Sleeper light switch three-way control line; frontwall connector to sleeper switch | CHA |
| LS04C | Sleeper | Sleeper light switch three-way control line; frontwall connector to sleeper jumper connector | SLPR |
| LS04D | Sleeper | Sleeper light switch three-way control line; sleeper jumper connector to sleeper switch | SLPR |
| LS05A | Sleeper | Sleeper light switch three-way control line; cab switch to frontwall connector | CAB |
| LS05B | Sleeper | Sleeper light switch three-way control line; frontwall connector to sleeper switch | CHA |
| LS05C | Sleeper | Sleeper light switch three-way control line; frontwall connector to sleeper jumper connector | SLPR |
| LS05D | Sleeper | Sleeper light switch three-way control line; sleeper jumper connector to sleeper switch | SLPR |
| LS06A | Sleeper | Sleeper interior lights on; sleeper light switch to sleeper light switch | SLPR |
| LS06B | Sleeper | Sleeper interior lights on; sleeper light switch to dome light | SLPR |
| LS06C | Sleeper | Sleeper interior lights on; sleeper light switch to right floor light | SLPR |
| LS06D | Sleeper | Sleeper interior lights on; sleeper light switch to left floor light | SLPR |
| LS06E | Sleeper | Sleeper interior lights on; sleeper light switch to diode pair | SLPR |
| LS06F | Sleeper | Sleeper interior lights on; diode pair to right floor light | SLPR |

**ML—Marker Lamps Circuits ML01 through ML10**

| ML—Marker Lamps Circuits ML01 through ML10 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| ML01A | Main | Fused battery power to tractor marker switch | CAB |
| ML01B | Main | Fused battery power; tractor marker switch to trailer marker switch | CAB |
| ML01C | Main | Fused battery power; to tractor marker relay contact | CAB |
| ML02A | Main | Switched tractor marker signal; switch to relay coil | CAB |
| ML02B | Main | Switched tractor marker signal; tractor switch to trailer switch | CAB |

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| ML—Marker Lamps Circuits ML01 through ML10 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| ML03A | Main | Switched tractor marker power; relay to splice | CAB |
| ML03B | Main | Switched tractor marker power; relay to right-hand door connector | CAB |
| ML03C | Main | Switched tractor marker power; splice to left-hand door connector | CAB |
| ML03D | Main | Switched tractor marker power; splice to overhead console connector | CAB |
| ML03E | Overhead console | Switched tractor marker power; cab connector to left-hand outboard marker | OHC |
| ML03F | Overhead console | Switched tractor marker power; right-hand outboard marker to right-hand inboard marker | OHC |
| ML03G | Overhead console | Switched tractor marker power; right-hand inboard marker to middle marker | OHC |
| ML03H | Overhead console | Switched tractor marker power; middle marker to left-hand inboard marker | OHC |
| ML03J | Sleeper | Switched tractor marker power; left-hand inboard marker to left-hand outboard marker | OHC |
| ML03K | Main | Switched tractor marker power; splice to sleeper connector | CAB |
| ML03L | Sleeper | Switched tractor marker power; sleeper connector to sleeper control panel connector | SLPR |
| ML03M | Sleeper | Switched tractor marker power; sleeper control panel connector to left-hand outboard marker | SLPR |
| ML03N | Sleeper | Switched tractor marker power; left-hand outboard marker to left-hand inboard marker | SLPR |
| ML03P | Sleeper | Switched tractor marker power; left-hand inboard marker to center marker | SLPR |
| ML03Q | Sleeper | Switched tractor marker power; center marker to right-hand inboard marker | SLPR |
| ML03R | Sleeper | Switched tractor marker power; right-hand inboard marker to right-hand outboard marker | SLPR |
| ML03S | sleeper | Switched tractor marker power; frontwall to sleeper jumper connector | SLPR |
| ML03T | Sleeper | Switched tractor marker power; sleeper jumper connector to sleeper stud | SLPR |
| ML03U | Sleeper | Switched tractor marker power; sleeper stud to left outboard marker | SLPR |
| ML03V | Inside/outside temperature gauge | Switched tractor marker power; marker light to overhead console harness | OHC |
| ML03W | Remote start | Switched tractor marker power; to overhead console connector | CAB |
| ML04A | Main | Fused battery power to trailer marker relay contact | CAB |
| ML05A | Main | Switched trailer marker signal; switch to relay coil | CAB |

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## Circuit Codes I through R

| ML—Marker Lamps Circuits ML01 through ML10 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| ML06A | Main | Switched trailer marker power; relay control to frontwall trailer connector | CAB |
| ML06B | Option | Switched trailer marker power; T-connection for dual trailer (frontwall to splice) | ENG |
| ML06C | Option | Switched trailer marker power; T-connection for dual trailer (splice to main) | ENG |
| ML06D | Option | Switched trailer marker power; T-connection for dual trailer (splice to additional) | ENG |
| ML06E | Aus | Switched trailer marker power; frontwall connector to trailer receptacle | ENG |
| ML06F | Aus | Switched trailer marker power; frontwall connector to dual trailer receptacle splice | ENG |
| ML06G | Aus | Switched trailer marker power; dual trailer receptacle splice to main trailer jack | ENG |
| ML06H | Aus | Switched trailer marker power; dual trailer receptacle splice to additional trailer jack | ENG |
| ML06J | Option | Marker lights; trailer frontwall connector to splice | CHA |
| ML06K | Option | Marker lights; splice to JTLRM | CHA |
| ML06L | Option | Marker lights, splice to JTLRA | CHA |
| ML07A | Main | Switched trailer marker signal; S8 to S88 | CAB |
| ML08A | Overhead console | Switched tractor marker power; cab connector to left-hand outboard marker; temperature gauge connector | OHC |
| ML09A | Sleeper | Switched tractor marker power; marker connector to marker lights | SLPR |
| ML10A | Option | Switched tractor marker power; marker connector to marker lights | CAB |

**OP—Option Jumper Feeds Circuits OP01 through OP13**

| OP—Option Jumper Feeds Circuits OP01 through OP13 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| OP01A | Main | Fused battery power to jumper terminal one | CAB |
| OP07A | Main | Fused ignition power to jumper terminal two | CAB |
| OP13A | Main | Fused accessirt power to jumper terminal three | CAB |

**PM—Power Mirrors Circuits PM01 through PM06**

| PM—Power Mirrors Circuits PM01 through PM06 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| PM01A | Power Windows | Fused accessory power; to right-hand power mirror switch | CAB |
| PM01B | Power Windows | Fused accessory power; left-hand power mirror switch to right-hand power mirror switch | CAB |

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| PM—Power Mirrors Circuits PM01 through PM06 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| PM02A | Power Windows | Jumper; left-hand power mirror switch one to six | CAB |
| PM02B | Power Windows | Motor power; left-hand switch to door connector | CAB |
| PM03A | Power Windows | Jumper; left-hand power mirror switch three to four | CAB |
| PM03B | Power Windows | Motor power; left-hand switch to door connector | CAB |
| PM04A | Power Windows | Jumper; right-hand power mirror switch one to six | CAB |
| PM04B | Power Windows | Motor power; right-hand switch to door connector | CAB |
| PM05A | Power Windows | Jumper; right-hand power mirror switch three to four | CAB |
| PM05B | Power Windows | Motor power; right-hand switch to door connector | CAB |
| PM06A | Power Windows | Fused accessory power to F43-in | CAB |

**PT—Power Take Off (P.T.O.) Circuits PT01 through PT12**

| PT—Power Take Off (P.T.O.) Circuits PT01 through PT12 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| PT01A | Option | Ground signal; frontwall stud to P.T.O. | CHA |
| PT01B | Option | Ground signal; P.T.O. to speed signal relay; frontwall | CHA |
| PT01C | Option | Ground signal; speed signal relay; frontwall to speedometer cutout relay (85) | CAB |
| PT01D | Option | Ground signal speed signal relay (85) to indicator relay (85) | CAB |
| PT02A | Option | Negative speedometer signal; frontwall to load resistor | CAB |
| PT02B | Option | Negative speedometer signal from transmission; speed pickup to load resistor | CAB |
| PT03A | Option | Positive speedometer signal; frontwall to speed signal relay (87) | CAB |
| PT03B | Option | Positive speedometer signal; speed pickup to speed signal relay (87) | CAB |
| PT04A | Option | Positive speedometer signal; speed signal relay (30) to engine ECM; frontwall | CAB |
| PT05A | Option | Negative speedometer signal; speed signal relay (87A) to load resistor | CAB |
| PT05B | Option | Negative speedometer signal; load resistor to engine ECM; frontwall | CAB |
| PT05C | Option | Negative speedometer signal; frontwall to engine ECM | CAB |
| PT06A | Option | Ignition power; option block to P.T.O. fuse | CAB |
| PT06B | Option | Ignition power; P.T.O. fuse to speed signal relay (86) | CAB |
| PT06C | Option | Ignition power; P.T.O. fuse to indicator light relay (30) | CAB |
| PT06D | Option | Ignition power; indicator light relay (86) to indicator light relay (30) | CAB |
| PT06E | Option | Ignition power; P.T.O. fuse to P.T.O. switch | CAB |
| PT07A | Option | Switch light ground; splice to P.T.O. switch | CAB |

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## Circuit Codes I through R

| PT—Power Take Off (P.T.O.) Circuits PT01 through PT12 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| PT08A | Option | Switch light power; splice to P.T.O. switch | CAB |
| PT09A | Option | Switch light ground; splice to rear axle switch | CAB |
| PT10A | Option | Switch light power; splice to rear axle switch | CAB |
| PT11A | Option | Ignition power; indicator light relay (87A) to rear axle switch | CAB |
| PT12A | Option | P.T.O. overheat ground signal; P.T.O. to lightbar; frontwall | CHA |
| PT12B | Option | P.T.O. overheat ground signal; frontwall to lightbar | CAB |

**PW—Power Windows Circuits PW01 through PW06**

| PW—Power Windows Circuits PW01 through PW06 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| PW01A | Power windows | Fused accessory power; to right-hand power window switch | CAB |
| PW01B | Power windows | Fused accessory power; left-hand power window switch to right-hand power window switch | CAB |
| PW01C | Power windows | Fused accessory power; right-hand power window switch to right-hand power window switch | CAB |
| PW01D | Power windows | Fused accessory power; left-hand power window switch to left-hand power window switch | CAB |
| PW02A | Power windows | Jumper; left-hand power window switch one to six | CAB |
| PW02B | Power windows | Motor power; left-hand switch to door connector | CAB |
| PW02C | Power windows | Motor power; door connector to left-hand motor connector | CAB |
| PW03A | Power windows | Jumper; left-hand power window switch three to four | CAB |
| PW03B | Power windows | Motor power; left-hand switch to door connector | CAB |
| PW03C | Power windows | Motor power; door connector to left-hand motor connector | CAB |
| PW04A | Power windows | Jumper, right-hand power window switch one to six | CAB |
| PW04B | Power windows | Motor power; right-hand switch to door connector | CAB |
| PW04C | Power windows | Motor power; door connector to right-hand motor connector | CAB |
| PW05A | Power windows | Jumper; right-hand power window switch three to four | CAB |
| PW05B | Power windows | Motor power; right-hand switch to door connector | CAB |
| PW05C | Power windows | Motor power; door connector to right-hand motor connector | CAB |
| PW06A | Power windows | Fused accessory power to F40-in | CAB |

**RA—Radio and Stereo Circuits RA01 through RA09**

| RA—Radio and Stereo Circuits RA01 through RA09 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| RA01A | Main | Fused accessory power for clock/radio to radio harness connector | CAB |
| RA01B | Overhead console | Fused accessory power for clock | OHC |

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| RA—Radio and Stereo Circuits RA01 through RA09 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| RA01C | Overhead console | Fused accessory power for radio | OHC |
| RA01D | CB radio | Fused accessory power; overhead console to radio connector | OHC |
| RA01E | CB radio | Fused accessory power; overhead console to CB radio connector | OHC |
| RA01F | CB radio | Fused accessory power; overhead console to clock connector | OHC |
| RA01G | Overhead console | Fused accessory power for radio; jumper | OHC |
| RA01H | Inside/outside temperature gauge | Fused accessory power; overhead console harness to clock | OHC |
| RA02A | Main | Fused battery power for clock/radio to radio harness connector | CAB |
| RA02B | Overhead console | Fused battery power for clock | OHC |
| RA02C | Overhead console | Fused battery power for radio | OHC |
| RA02D | CB radio | Fused battery power; overhead console to radio connector | OHC |
| RA02E | CB radio | Fused battery power; overhead console to clock connector | OHC |
| RA02F | Overhead console | Fused battery power for radio; jumper | OHC |
| RA02G | Inside/outside temperature gauge | Fused battery power; overhead console harness to clock | OHC |
| RA03A | Overhead console | Right front speaker positive; radio to splice | OHC |
| RA03B | Overhead console | Right front positive; splice to left rear tweeter | OHC |
| RA03C | Overhead console | Right front positive; splice to cab connector | OHC |
| RA03D | Main | Right front positive; cab connector to right door woofer | CAB |
| RA03E | Door speakers | Right door speaker positive; speaker to door connector | CAB |
| RA03F | Overhead console | Right front speaker; positive; resistor to right front speaker | OHC |
| RA03G | Overhead console | Right front speaker; positive; coil to right front optional tweeter connector | OHC |
| RA03H | Tweeter | Right front speaker; positive, tweeter connector to capacitor | OHC |
| RA03J | Tweeter | Right front speaker; positive; tweeter capacitor to optional tweeter | OHC |
| RA03K | Overhead console | Right front speaker positive; coil to cab connector | OHC |
| RA04A | Overhead console | Right front negative; radio to right front speaker ballast resistor | OHC |
| RA04B | Overhead console | Right front negative; right front speaker ballast resistor to speaker | OHC |
| RA05A | Overhead console | Between series speakers; right front speaker to ballast resistor | OHC |
| RA05B | Overhead console | Between series speakers; ballast resistor to splice | OHC |
| RA05C | Overhead console | Between series speakers; splice to rear left tweeter | OHC |
| RA05D | Overhead console | Between series speakers; splice to cab connector | OHC |
| RA05E | Main | Between series speakers; cab connector to right door woofer | CAB |
| RA05F | Door speakers | Right door speaker negative; speaker to door connector | OHC |
| RA05G | Overhead console | Right front speaker negative; radio to splice | OHC |

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## Circuit Codes I through R

| RA—Radio and Stereo Circuits RA01 through RA09 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| RA05H | Overhead console | Right front negative speaker; splice to right front speaker | OHC |
| RA05J | Overhead console | Right front negative speaker; left front speaker to right optional tweeter | OHC |
| RA05K | Overhead console | Right front speaker negative splice to cab connector | OHC |
| RA05L | Overhead console | Right front speaker negative; jumper | OHC |
| RA06A | Overhead console | Left front speaker positive; radio to splice | OHC |
| RA06B | Overhead console | Left front positive; splice to right rear tweeter | OHC |
| RA06C | Overhead console | Left front positive; splice to cab connector | OHC |
| RA06D | Main | Left front positive; cab connector to left door woofer | CAB |
| RA06E | Door speakers | Left door speaker positive; speaker to door connector | CAB |
| RA06F | Overhead console | Left front speaker; resistor to left front speaker | OHC |
| RA06G | Overhead console | Left front speaker; positive; coil to left front optional tweeter connector | OHC |
| RA06H | Tweeter | Left front speaker; positive; tweeter connector to capacitor | OHC |
| RA06J | Tweeter | Left front speaker; positive; tweeter capacitor to optional tweeter | OHC |
| RA06K | Overhead console | Left front speaker; positive; coil to cab connector | OHC |
| RA07A | Overhead console | Between series speakers; left front speaker to ballast resistor | OHC |
| RA07B | Overhead console | Between series speakers; ballast resistor to splice | OHC |
| RA07C | Overhead console | Between series speakers; splice to right rear tweeter | OHC |
| RA07D | Overhead console | Between series speakers; splice to cab connector | OHC |
| RA07E | Overhead console | Between series speakers; cab connector to left door woofer | CAB |
| RA07F | Overhead console | Left door speaker negative; speaker to door connector | CAB |
| RA07G | Overhead console | Left front speaker negative; splice to radio connector | OHC |
| RA07H | Overhead console | Left front speaker negative; splice to left front speaker | OHC |
| RA07J | Overhead console | Left front speaker negative; left front speaker to left optional tweeter | OHC |
| RA07K | Overhead console | Left front speaker negative; splice to cab connector | OHC |
| RA07L | Overhead console | Left front speaker negative; jumper | OHC |
| RA08A | Overhead console | Left front negative; radio to left front speaker ballast resistor | OHC |
| RA08B | Overhead console | Left front negative; ballast resistor to left front speaker | OHC |
| RA09A | Overhead console | Right rear positive; radio to cab connector | OHC |
| RA09B | Main | Right rear positive; cab connector to sleeper connector | CAB |
| RA09C | Sleeper | Right rear positive; sleeper connector to volume control | SLPR |
| RA09D | Sleeper | Right rear positive; sleeper connector to sleeper jumper connector | SLPR |
| RA09E | Sleeper | Right rear positive; sleeper jumper connector to volume control | SLPR |
| RA09F | Overhead console | Right rear positive speaker; jumper | OHC |

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**RA—Radio and Stereo Circuits RA10 through RA37**

| RA—Radio and Stereo Circuits RA10 through RA37 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| RA10A | Overhead console | Right rear negative; radio to cab connector | OHC |
| RA10B | Main | Right rear negative; cab connector to sleeper connector | CAB |
| RA10C | Sleeper | Right rear negative; sleeper connector to volume control | SLPR |
| RA10D | Sleeper | Right rear negative; volume control to right rear speaker | SLPR |
| RA10E | Sleeper | Right rear negative; sleeper connector to sleeper jumper connector | SLPR |
| RA10F | Sleeper | Right rear negative; sleeper jumper connector to volume control | SLPR |
| RA10G | Overhead console | Right rear negative speaker; jumper | OHC |
| RA11A | Overhead console | Left rear positive; radio to cab connector | OHC |
| RA11B | Main | Left rear positive; cab connector to sleeper connector | CAB |
| RA11C | Sleeper | Left rear positive; sleeper connector to volume control | SLPR |
| RA11D | Sleeper | Left rear positive; sleeper connector to sleeper jumper connector | SLPR |
| RA11E | Sleeper | Left rear positive; sleeper jumper connector to volume control | SLPR |
| RA11F | Overhead console | Left rear positive speaker; jumper | OHC |
| RA12A | Overhead console | Left rear negative; radio to cab connector | OHC |
| RA12B | Main | Left rear negative; cab connector to sleeper connector | CAB |
| RA12C | Sleeper | Left rear negative; sleeper connector to volume control | SLPR |
| RA12D | Overhead console | Left rear negative; volume controlto left rear speaker | SLPR |
| RA12E | Sleeper | Left rear negative; sleeper connector to sleeper jumper connector | SLPR |
| RA12F | Sleeper | Left rear negative; sleeper jumper connector to volume control | SLPR |
| RA12G | Overhead console | Left rear negative speaker; jumper | OHC |
| RA13A | Sleeper | Sleeper clock power; fuse to sleeper clock connector | SLPR |
| RA13B | Fridge | Sleeper clock power; extension; jack to plug | SLPR |
| RA14A | Sleeper | Right rear level; volume control to right front speaker | SLPR |
| RA14B | Sleeper | Right level; volume control to right speaker | SLPR |
| RA15A | Sleeper | Right rear; right front speaker to right rear speaker | SLPR |
| RA16A | Sleeper | Left rear level; volume control to left front speaker | SLPR |
| RA16B | Sleeper | Left rear level; volume control to left speaker | SLPR |
| RA17A | Sleeper | Left rear; left front speaker to left rear speaker | SLPR |
| RA18A | CB radio | CB radio speaker wire; hot | OHC |
| RA19A | CB radio | CB radio speaker wire; common | OHC |
| RA20A | VHF radio | Fused battery power to red binding post | CAB |
| RA21A | Cell phone | Fused battery power to red binding post | CAB |
| RA22A | Sleeper | Right positive; volume control to right speaker | SLPR |

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## Circuit Codes I through R

| RA—Radio and Stereo Circuits RA10 through RA37 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| RA22B | Sleeper | Right positive; volume control to sub-woofer jumper harness | SLPR |
| RA22C | Sleeper | Right positive; volume control to sub-woofer crossover | SLPR |
| RA23A | Sleeper | Right negative; volume control to right speaker | SLPR |
| RA23B | Sleeper | Right negative; volume control to sub-woofer jumper harness | SLPR |
| RA023C | Sleeper | Right negative; volume control to sub-woofer crossover | SLPR |
| RA024A | Sleeper | Left positive; volume control to left speaker | SLPR |
| RA24B | Sleeper | Left positive; volume control to sub-woofer jumper harness | SLPR |
| RA25A | Sleeper | Left negative; volume control to left speaker | SLPR |
| RA25B | Sleeper | Right negative; volume control to sub-woofer jumper harness | SLPR |
| RA25C | Sleeper | Right negative; volume control to sub-woofer crossover | SLPR |
| RA26A | Overhead console | Accessory power for clock; overhead console clock plug to clock; temperature gauge connector | OHC |
| RA27A | Overhead console | Battery power for clock; overhead console clock plug to clock; temperature gauge connector | OHC |
| RA28A | Overhead console | Stereo speaker; right front, radio plug to coil | OHC |
| RA28B | Overhead console | Stereo speaker; right front, Re7 resistor to right front speaker | OHC |
| RA28C | Overhead console | Stereo speaker; right front, Re7 resistor to right front tweeter | OHC |
| RA28D | Overhead console | Stereo speaker; right front, jumper | OHC |
| RA29A | Overhead console | Stereo speaker, left front, radio plug to coil | OHC |
| RA29B | Overhead console | Stereo speaker; left front, Re7 resistor to left front speaker | OHC |
| RA29C | Overhead console | Stereo speaker; left front, Re7 resistor to left front speaker | OHC |
| RA29D | Overhead console | Left front positive speaker; jumper | OHC |
| RA30A | Sleeper | Right positive; sub-woofer crossover to sub-woofer amplifier | SLPR |
| RA31A | Sleeper | Right negative; sub-woofer crossover to sub-woofer amplifier (shielding) | SLPR |
| RA32A | Sleeper | Left positive; sub-woofer crossover to sub-woofer amplifier | SLPR |
| RA33A | Sleeper | Left negative; sub-woofer crossover to sub-woofer amplifier (shielding) | SLPR |
| RA34A | Sleeper | Positive; sub-woofer amplifier to sub-woofer speaker | SLPR |
| RA35A | Sleeper | Negative; sub-woofer amplifier to sub-woofer speaker | SLPR |
| RA36A | Sleeper | Power for sub-woofer amplifier; fuse to amp | SLPR |
| RA37A | Option | Sleeper control panel to sub-woofer amplifier | SLPR |
| RA37B | Option | Stereo overhead console to under dash | OHC |
| RA37C | Option | Under dash to frontwall | CAB |
| RA37D | Cable | Sub-woofer control; sleeper start connector to sleeper | SLPR |

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**RB—Rotating Beacon Circuits RB01 through RB05**

| RB—Rotating Beacon Circuits RB01 through RB05 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| RB01A | Main | Fused accessory power to rotating beacon on/off switch | CAB |
| RB02A | Main | Rotating beacon on/off switch to overhead console | CAB |
| RB02B | Overhead console | Right rotating beacon to splice | OHC |
| RB02C | Overhead console | Left rotating beacon to splice | OHC |
| RB02D | Overhead console | Cab connector to splice | OHC |
| RB02E | Remote start | Rotating beacon on/off switch to overhead console | CAB |
| RB03A | Option | Rotating beacon on/off switch to sleeper connector | CAB |
| RB03B | Option | Sleeper connector to left rotating beacon | SLPR |
| RB03C | Option | Left rotating beacon to sleeper control panel spare line | SLPR |
| RB03D | Option | Left rotating beacon to right rotating beacon | SLPR |
| RB03E | Option | Sleeper connector to sleeper control panel spare line | SLPR |
| RB04A | Option | Left rotating beacon to right rotating beacon | SLPR |
| RB05A | Option | Sleeper connector to back-of-cab | CHA |

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# Circuit Codes S through W

All wires have three to five character alphanumeric codes printed on them every four to six inches. The first two characters are a letter code that denotes the circuit type in which the wire is used. The next one or two numbers denote the specific circuit, and last letter denotes the branch in the circuit. Use the following circuit code tables to look up the circuit code that is printed on a wire and determine its function.

See **Subject 430** for an explanation of location abbreviations used in the circuit code tables.

**SD—Shutdown Circuits SD01 through SD02**

| SD—Shutdown Circuits SD01 through SD02 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| SD01A | Option | Five-minute shutdown signal; ECM to engine connector; frontwall | ENG |
| SD01B | Option | Five-minute shutdown signal; engine connector to idle shutdown relay (30) | CAB |
| SD02A | Option | Five-minute idle shutdown override switch to idle shutdown relay (30) | CAB |
| SD02B | Option | Ignition switch (IG) to five-minute idle shutdown override switch | CAB |
| SD02C | Option | Five-minute idle shutdown relay (87) to ignition power; ignition switch (BA) | CAB |
| SD02D | Option (DDEC) | Battery power (idle shutdown relay 87) to five-minute idle shutdown relay (86) | CAB |
| SD02E | Option (CAT E) | Five-minute idle shutdown over-ride switch to idle shutdown relay (86) | CAB |
| SD02F | Option (CAT E) | Five-minute shutdown latch relay (87a) to idle shutdown relay (30) | CAB |

**SL—Suspension Pressure Lamps Circuits SL01 through SL02**

| SL—Suspension Pressure Lamps Circuits SL01 through SL02 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| SL01A | Option | Pressure switch to lightbar | CAB |
| SL02A | Option | Pressure switch to cab ground | CAB |

**SP—Spare Circuits SP01 through SP05**

| SP—Spare Circuits SP01 through SP05 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| SP01A | Option | Frontwall to back-of-cab | SLPR |
| SP01B | Option | Back-of-cab to sleeper control panel | SLPR |
| SP02A | Option | Frontwall to back-of-cab | SLPR |
| SP02B | Option | Back-of-cab to sleeper control panel | SLPR |
| SP02C | Option | Frontwall to sleeper control panel | SLPR |
| SP02C | Option | Sleeper control panel to sub-woofer amplifier | SLPR |

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## Circuit Codes S through W

| SP—Spare Circuits SP01 through SP05 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| SP02E | Option | Stereo; overhead console to under dash | OHC |
| SP02F | Option | Under dash to frontwall | CAB |
| SP03A | Option | Frontwall to back-of-cab | SLPR |
| SP03B | Option | Back-of-cab to sleeper control panel | SLPR |
| SP03C | Option | Frontwall to sleeper control panel | SLPR |
| SP04A | Option | Frontwall to back-of-cab | SLPR |
| SP04B | Option | Back of cab to sleeper control panel | SLPR |
| SP04C | Option | Frontwall to sleeper control panel | SLPR |
| SP05A | Remote start | Overhead console (cab side) to overhead console (console side) | CAB |

**ST—Start Circuits ST01 through ST10**

| ST—Start Circuits ST01 through ST10 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| ST01A | Main | Fused start power to cab key switch | CAB |
| ST01B | Sleeper start | Fused start power; cab key switch to sleeper start enable switch | CAB |
| ST01C | Bogaard timer | Fused start power; cab key switch to Bogaard timer | CAB |
| ST02A | Sleeper start | Magnetic switch control signal; ignition switch to sleeper start connector | CAB |
| ST02B | Sleeper start | Magnetic switch control signal; sleeper start connector to key switch | CHA |
| ST02C | Main | Magnetic switch control signal; ignition switch to frontwall | CAB |
| ST02D | Main | Magnetic switch control signal; frontwall to magnetic switch | ENG |
| ST02E | Option | Magnetic switch control signal; frontwall to neutral start switch | ENG |
| ST02F | Option | Magnetic switch control signal; neutral start switch harness to overcrank switch | ENG |
| ST02G | Sleeper start | Magnetic switch control signal; sleeper start enable switch to cab ignition switch | CAB |
| ST02H | 3406C FlameStart | Magnetic switch control signal; magnetic switch to FlameStart ECU | ENG |
| ST02J | Aus signal lights | Magnetic switch control signal; ignition switch to brake fail indicator test relay | CAB |
| ST02K | Option | Magnetic switch control signal; frontwall to neutral start switch (Allison HT/MT) | CHA |
| ST03A | Option | Magnetic switch control signal; neutral start switch to magnetic switch | ENG |
| ST03B | Option | Magnetic switch control signal; neutral start switch to magnetic switch (Allison HT/MT) | CHA |

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| ST—Start Circuits ST01 through ST10 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| ST04A | Option | Magnetic switch control signal; magnetic switch to starter control | ENG |
| ST04B | Engine C8.3 | Magnetic switch control signal; magnetic switch to fuel solenoid flyback diode | ENG |
| ST04C | Engine C8.3 | Fuel solenoid flyback diode to fuel solenoid connector | ENG |
| ST04D | Engine 3306 | Magnetic switch control signal; magnetic switch to FlameStart module | ENG |
| ST05A | Sleeper start | Sleeper start enabled; sleeper start enable switch to SST connector | CAB |
| ST05B | Sleeper start | Sleeper start enabled; sleeper start connector to sleeper key switch | CHA |
| ST05C | Sleeper start | Sleeper start enabled; frontwall to back-of-cab | CHA |
| ST05D | Sleeper start | Sleeper start enabled; back-of-cab to sleeper ignition switch | SLPR |
| ST05E | Argo special event | Sleeper start enabled; PSSA to back-of-cab; JSSA | CHA |
| ST05F | Sleeper start | Sleeper start enabled; frontwall to sleeper ignition switch | SLPR |
| ST6FL | 12/24 | Fuse link; starter positive post to ST6A | ENG |
| ST6A | 12/24 | Magnetic switch power; fuse link to magnetic starter switch contact | ENG |
| ST07A | Option | Magnetic switch control signal; frontwall to overcrank switch | ENG |
| ST08A | Option | Remote starter signal; R28 relay to frontwall connector | CAB |
| ST08B | Option | Remote starter signal; frontwall connector to remote starter switch | ENG |
| ST09A | Option | Remote starter signal; remote starter switch to splice | ENG |
| ST09B | Option | Remote starter signal; splice to frontwall connector PFWH | ENG |
| ST09C | Option | Remote starter signal; splice to connector JRST | ENG |
| ST10A | Sleeper start | Sleeper initiated start request signal; cab enable switch to frontwall | CHA |
| ST10B | Sleeper start | Sleeper initiated start request signal; frontwall to back-of-cab | CHA |
| ST10C | Sleeper start | Sleeper initiated start request signal; back-of-cab to sleeper ignition switch | SLPR |
| ST10D | Argo special event | Sleeper initiated start request signal; PSSA to back-of-cab; JSSA | CHA |
| ST10E | Sleeper start | Sleeper initiated start request signal; frontwall to sleeper ignition switch | SLPR |

**TC—Transmission Circuits TC01 through TC11**

| TC—Transmission Circuits TC01 through TC11 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TC01A | Top two CAT | Ground; engine ground stud to transmission solenoid block | ENG |

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## Circuit Codes S through W

| TC—Transmission Circuits TC01 through TC11 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TC02A | Top two CAT | Ground signal; ECU multi-function number one to top two power relay; frontwall | ENG |
| TC02B | Top two CAT | Ground signal; frontwall to top two power relay (86) | CAB |
| TC03A | Top two CAT | Fused battery power; power splice to top two power relay (85) | CAB |
| TC03B | Top two CAT | Fused battery power; relay (85) to top two power relay (30) | CAB |
| TC04A | Top two CAT | Fused battery power; relay (87) to ECU battery positive; output splice | CAB |
| TC05A | Allison | Fused ignition power; fuse block to translator module | CAB |
| TC06A | Allison | Fused ignition power; fuse block to relay (R59-85) | CAB |
| TC06B | Allison | Fused ignition power; relay (R59-85) to relay (R59-30) | CAB |
| TC07A | Allison | Fused ignition power; relay (R59-86) to translator module | CAB |
| TC08A | Allison | Fused ignition power; relay (R59-87) to solenoid valve pigtail | CAB |
| TC09A | Allison | J1587 (+); plug to splice | CAB |
| TC09B | Allison | J1587 (+); splice to translator module | CAB |
| TC09C | Allison | J1587 (+); splice to jack | CAB |
| TC10A | Allison | J1587 (–); plug to splice | CAB |
| TC10B | Allison | J1587 (–); splice to translator module | CAB |
| TC10C | Allison | J1587 (–); splice to jack | CAB |
| TC11A | Transmission | Shift tower lighting; shift tower to gauge light circuit; frontwall (Allison HT/MT) | CHA |
| TC11B | Transmission | Shift tower lighting; frontwall to any GL2 circuit (Allison HT/MT) | CAB |

**TH—Throttle Circuits TH01 through TH03**

| TH—Throttle Circuits TH01 through TH03 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TH01A | Option | F-81 fuse (ignition) to R27 P.T.O. park brake interlock relay | CAB |
| TH01B | Option | Ignition power; R27 P.T.O park brake interlock relay to remote start brake interlock relay coil | CAB |
| TH01C | Option | Ignition power; remote start brake interlock relay coil to remote start brake interlock relay 87 terminal | CAB |
| TH01D | Option | Ignition power; F-81 fuse (ignition) to engine frontwall connector | CAB |
| TH01E | Option | Ignition power; engine frontwall connector to remote engine throttle control | ENG |
| TH01F | Option | Ignition power; remote engine throttle control to remote water temperature gauge | ENG |
| TH01G | Option | Ignition power; remote water temperature gauge to remote oil pressure gauge | ENG |
| TH01H | Option | Ignition power; remote oil pressure gauge to remote tachometer | ENG |

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| TH—Throttle Circuits TH01 through TH03 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TH01J | Option | Ignition power; remote tachometer pin two to remote tachometer pin four | ENG |
| TH02A | Option | P.T.O. switch signal; S90 dash switch to R27 park brake interlock relay | CAB |
| TH03A | Option | Ignition power; JP to fuse | CAB |

**TLA—Trailer Accessories Circuits TLA01 through TLA04**

| TLA—Trailer Accessories CircuitsTLA 01 through TLA04 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TLA01A | Trailer accessory | Main fuse block jumper to trailer accessory fuse | CAB |
| TLA01B | Trailer accessory | Trailer accessory fuse to third axle lift switch | CAB |
| TLA01C | Trailer accessory | Third axle lift switch to trailer frontwall connector | CAB |
| TLA01D | Trailer accessory | Frontwall connector to trailer receptacle | CHA |
| TLA01E | Trailer accessory | Frontwall connector to dual trailer receptacle splice | CHA |
| TLA01F | Trailer accessory | Dual trailer receptacle splice to main trailer receptacle jack | CHA |
| TLA01G | Trailer accessory | Dual trailer receptacle splice to additional trailer receptacle jack | CHA |
| TLA02A | Trailer accessory | Taillights; trailer frontwall connector to splice | CHA |
| TLA02B | Option | Taillights; splice to JTLRM | CHA |
| TLA02C | Option | Taillights; splice to JTLRA | CHA |
| TLA03A | Trailer accessory | Trailer accessory fuse to third axle lift switch | CAB |
| TLA04A | Trailer accessory | Third axle lift switch to trailer frontwall connector | CAB |

**TL—Taillights Circuits TL01 through TL06**

| TL—Taillights Circuits TL01 through TL06 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TL01A | Main | Fused brake light power to brakes applied pressure switch | CAB |
| TL01B | Main | Fused brake light power to trailer relay coil | CAB |
| TL01C | Allison | Brakes applied pressure switch to retarder active relay | CAB |
| TL01D | Main | Fused brake light power to splice to pressure switch | CAB |
| TL01E | Main | Fused brake light power to fuse to splice | CAB |
| TL01F | Main | Fused brake light power to splice to trailer relay | CAB |
| TL02A | Main | Brakes applied; pressure switch to hazard switch | CAB |
| TL02B | Main | Brakes applied; pressure switch to trailer relay coil | CAB |
| TL02C | Allison | Brakes applied pressure switch to retarder active relay | CAB |
| TL02D | Aus | Brakes applied; main cab harness to frontwall taillight connector | CAB |
| TL02E | Aus | Brakes applied; frontwall taillight connector to splice | CHA |
| TL02F | Aus | Brakes applied; splice to right taillight connector | CHA |

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## Circuit Codes S through W

| TL—Taillights Circuits TL01 through TL06 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TL02G | Aus | Brakes applied; right taillight connector to right taillight | CHA |
| TL02H | Aus | Brakes applied; splice to left taillight connector | CHA |
| TL02J | Aus | Brakes applied; left taillight connector to left taillight | CHA |
| TL02K | Vorad | Brakes applied; pressure switch to Vorad CPU | CAB |
| TL03A | Main | Turn signal flasher signal; ECC to turn signal switch | CAB |
| TL03B | Aus | Turn signal flasher signal; main cab harness to hazard switch | CAB |
| TL04 | Option | Left turn; extension cable | ENG |
| TL04A | Main | Left turn; switch to trailer connector | CAB |
| TL04B | Main | Left turn; switch to splice | CAB |
| TL04C | Main | Left turn; splice to headlight connector | CAB |
| TL04D | Main | Left turn; splice to lightbar | CAB |
| TL04E | Head lamps | Left turn; frontwall headlight connector to left headlight connector | ENG |
| TL04F | Head lamps | Left turn; left headlight connector to left sidelight | ENG |
| TL04G | Head lamps | Left turn; left sidelight to aero turn signal | ENG |
| TL04H | Option | Left turn; three-way Deutsch plug to splice | CAB |
| TL04J | Option | Left turn; splice to twelve-way Deutsch connector | CAB |
| TL04K | Option | Left turn; splice to three-way metripac plug | CAB |
| TL04L | Option | Left turn; T-connector for dual trailer (frontwall to splice) | ENG |
| TL04M | Option | Left turn; T-connector for dual trailer (splice to main) | ENG |
| TL04N | Option | Left turn; T-connector for dual trailer (splice to additional) | ENG |
| TL04P | Aus | Left turn; main cab harness to flasher relay contact | CAB |
| TL04Q | Aus | Left turn; main cab harness to splice | CAB |
| TL04R | Aus | Left turn; main cab harness to splice | CAB |
| TL04S | Aus | Left turn; splice to left flasher relay coil | CAB |
| TL04T | Aus | Left turn; splice to hazard switch left contact | CAB |
| TL04U | Aus | Left turn; splice to turn signal switch left contact | CAB |
| TL04V | Aus | Left turn; frontwall connector to trailer receptacle | CAB |
| TL04W | Aus | Left turn; frontwall connector to dual trailer receptacle splice | CAB |
| TL04X | Aus | Left turn; dual trailer receptacle splice to main trailer jack | CAB |
| TL04Y | Aus | Left turn; dual trailer receptacle splice to additional trailer jack | CAB |
| TL04Z | Option | Taillights; trailer frontwall connector to splice | CHA |
| TL04AA | Option | Taillights; splice to JTLRM | CHA |
| TL04AB | Option | Taillights; splice to JTLRA | CHA |
| TL05A | Main | Left turn; switch to taillight connector | CAB |
| TL05B | Taillights | Left turn; frontwall to left taillight (unsealed lights) | CHA |

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| TL—Taillights Circuits TL01 through TL06 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TL05C | Taillights | Left turn; frontwall to end of frame connector | CHA |
| TL05D | Taillights | Left turn; left taillight connector to left tail lamp | CHA |
| TL06A | Main | Right turn; switch to taillight connector | CAB |
| TL06B | Taillight | Right turn; frontwall to left taillight (unsealed lights) | CHA |
| TL06C | Taillight | Right turn; left taillight to right taillight (unsealed lights) | CHA |
| TL06D | Taillight | Right turn; frontwall to end of frame connector | CHA |
| TL06E | Taillight | Right turn; end of frame connector to right turn light | CHA |

**TL—Taillights Circuits TL07 through TL08**

| TL—Taillights Circuits TL07 through TL08 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TL07 | Option | Right turn; extension cable | ENG |
| TL07A | Main | Right turn; switch to trailer connector | CAB |
| TL07B | Main | Right turn; switch to splice | CAB |
| TL07C | Main | Right turn; splice to headlight connector | CAB |
| TL07D | Main | Right turn; splice to lightbar | CAB |
| TL07E | Headlights | Right turn; frontwall headlight connector to right headlight connector | ENG |
| TL07F | Headlights | Right turn; headlight connector to right sidelight | ENG |
| TL07G | Headlights | Right turn; right sidelight to aero turn signal | ENG |
| TL07H | Headlights | Right turn; three-way Deutsch plug to splice | CAB |
| TL07J | Option | Right turn; splice to twelve-way Deutsch connector | CAB |
| TL07K | Option | Right turn; splice to three-way Metripac plug | CAB |
| TL07L | Option | Right turn; T-connector for dual trailer (frontwall to splice) | ENG |
| TL07M | Option | Right turn; T-connector for dual trailer (splice to main) | ENG |
| TL07N | Option | Right turn; T-connector for dual trailer (splice to additional) | ENG |
| TL07P | Aus | Right turn; main cab harness to flasher relay contact | CAB |
| TL07Q | Aus | Right turn; main cab harness to splice | CAB |
| TL07R | Aus | Right turn; main cab harness to splice | CAB |
| TL07S | Aus | Right turn; splice to right flasher relay coil | CAB |
| TL07T | Aus | Right turn; splice to hazard switch right contact | CAB |
| TL07U | Aus | Right turn; splice to turn signal switch right contact | CAB |
| TL07V | Aus | Right turn; frontwall connector to trailer receptacle | CAB |
| TL07W | Aus | Frontwall connector to dual receptacle splice | CAB |
| TL07X | Aus | Right turn; dual receptacle splice to main trailer jack | CAB |
| TL07Y | Aus | Right turn; dual receptacle splice to additional trailer jack | CAB |

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## Circuit Codes S through W

| TL—Taillights Circuits TL07 through TL08 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TL07Z | Option | Taillights; trailer frontwall connector to splice | CHA |
| TL07AA | Option | Taillights; splice to JTLRM | CHA |
| TL07AB | Option | Taillights; splice to JTLRA | CHA |
| TL07AC | Vorad | Right turn; splice to Vorad CPU | CAB |
| TL08 | Option | Park lights; extension cable | ENG |
| TL08A | Main | Park lights; relay contact to frontwall headlight connector | CAB |
| TL08B | Main | Park lights; relay contact to splice | CAB |
| TL08C | Main | Park lights; splice to trailer connector | CAB |
| TL08D | Main | Park lights; splice to taillight connector | CAB |
| TL08E | Main | Park lights; frontwall headlight connector to splice | ENG |
| TL08F | Headlights | Park lights; splice to right headlight connector | ENG |
| TL08G | Headlights | Park lights; splice to left headlight connector | ENG |
| TL08H | Headlights | Park lights; right headlight connector to right sidelight | ENG |
| TL08J | Headlights | Park lights; right sidelight to right aero turn signal | ENG |
| TL08K | Headlights | Park lights; left headlight connector to left sidelight | ENG |
| TL08L | Headlights | Park lights; left sidelight to left aero turn signal | ENG |
| TL08M | Taillights | Taillights; frontwall to left taillight | CHA |
| TL08N | Taillights | Taillights; left taillight to right taillight | CHA |
| TL08P | Taillights | Taillights; frontwall to end of frame connector | CHA |
| TL08Q | Taillights | Taillights; end of frame connector to splice | CHA |
| TL08R | Taillights | Taillights; splice to left taillight | CHA |
| TL08S | Taillights | Taillights; splice to right taillight | CHA |
| TL08T | Taillights | Taillights; splice to licence plate light | CHA |
| TL08U | Option | Mirror-mounted turn signals; three-way Deutsch plug to splice | CAB |
| TL08V | Option | Mirror-mounted turn signals; splice to twelve-way Deutsch connector | CAB |
| TL08W | Option | Mirror-mounted turn signals; splice to splice | CAB |
| TL08X | Option | Mirror-mounted turn signals; splice to three-way Metripak plug | CAB |
| TL08Y | Option | Mirror-mounted turn signals; splice to three-way Metripak plug | CAB |
| TL08Z | Headlights | Park light; radiator to high/low/park light | ENG |
| TL08AA | Aus | Taillights; frontwall to splice | CHA |
| TL08AB | Aus | Taillights; splice to right taillight connector | CHA |
| TL08AC | Aus | Taillights; right taillight connector to right taillight | CHA |
| TL08AD | Aus | Taillights; right taillight to tail end outline marker | CHA |
| TL08AE | Aus | Taillights; splice to license plate connector | CHA |
| TL08AF | Aus | Taillights; splice to left taillight connector | CHA |

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| TL—Taillights Circuits TL07 through TL08 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TL08AG | Aus | Taillights; left taillight connector to left taillight | CHA |
| TL08AH | Aus | Taillights; left taillight to tail end outline marker | CHA |
| TL08AJ | Option | Taillights; trailer frontwall connector to splice | CHA |
| TL08AK | Option | Taillights; splice to JTLRM | CHA |
| TL08AL | Option | Taillights; splice to JTLRA | CHA |

**TL—Tail Lamps Circuits TL09 through TL28**

| TL—Tail Lamps Circuits TL09 through TL28 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TL09A | Main | Fused battery power to park/taillight relay contact | CAB |
| TL09B | Main | Fused battery power to park/taillight switch | CAB |
| TL10A | Main | Brakes applied; trailer relay contact to frontwall connector | CAB |
| TL10B | Main | Brakes applied; T-connector for dual trailer (frontwall to splice) | ENG |
| TL10C | Option | Brakes applied; T-connector for dual trailer (splice to main) | ENG |
| TL10D | Option | Brakes applied; T-connector for dual trailer (splice to additional) | ENG |
| TL10E | Aus | Brakes applied; frontwall connector to trailer receptacle | CHA |
| TL10F | Aus | Brakes applied; frontwall connector to dual receptacle splice | CHA |
| TL10G | Aus | Brakes applied; dual receptacle splice to main trailer jack | CHA |
| TL10H | Aus | Brakes applied; dual receptacle splice to additional trailer jack | CHA |
| TL10J | Option | Taillights; trailer frontwall connector to splice | CHA |
| TL10K | Option | Taillights; splice to JTLRM | CHA |
| TL10L | Option | Taillights; splice to JTLRA | CHA |
| TL11A | Main | Fused battery power to ECC for flasher | CAB |
| TL12A | Option | Pin one jumper from PATL to JATL | ENG |
| TL13A | Option | Pin two jumper from PATL to splice to additional light and JATL | ENG |
| TL14A | Option | Pin two jumper from JATL to splice to additional taillight and PATL | ENG |
| TL15A | Option | Pin three jumper from PATL to splice to additional left turn and JATL | ENG |
| TL16A | Option | Pin three jumper from JATL to splice to additional left turn and PATL | ENG |
| TL17A | Option | Pin four jumper from PATL to splice to additional right turn and JATL | ENG |
| TL18A | Option | Pin three jumper from JATL to splice to additional right turn and PATL | ENG |
| TL19A | Option | Brakes applied; pressure switch to junction box; frontwall | CAB |
| TL19B | Option | Brakes applied; frontwall to junction box | CHA |
| TL20A | Option | Taillights; T-connector for dual trailer (frontwall to splice) | ENG |

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## Circuit Codes S through W

| TL—Tail Lamps Circuits TL09 through TL28 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TL20B | Option | Taillights; T-connector for dual trailer (splice to main) | ENG |
| TL20C | Option | Taillights; T-connector for dual trailer (splice to additional) | ENG |
| TL21A | Option | Trailer accessory; T-connector for dual trailer (frontwall to splice) | ENG |
| TL21B | Option | Trailer accessory; T-connector for dual trailer splice to main) | ENG |
| TL21C | Option | Trailer accessory; T-connector for dual trailer (splice to additional) | ENG |
| TL22A | Aus | Turn signal circuit power; main fuse block jumper to option fuse block | CAB |
| TL23A | Aus | Fused trailer turn signal power; fuse to splice | CAB |
| TL23B | Aus | Splice to right flasher relay | CAB |
| TL23C | Aus | Splice to left flasher relay | CAB |
| TL24A | Aus | Fused turn signal flasher power; fuse to flasher | CAB |
| TL25A | Aus | Flashing power; flasher to hazard switch (bypass contact) | CAB |
| TL26A | Aus | Flashing power; (off when hazard); hazard switch to turn signal switch | CAB |
| TL27A | Aus | Hazard switch jumper; terminals 30 to 49a | CAB |
| TL28A | Headlights Aus | Turn signal; radiator to splice | ENG |
| TL28B | Headlights Aus | Turn signal; splice to front turn signal | ENG |
| TL28C | Headlights Aus | Turn signal; splice to side turn signal | ENG |

**TP—Central Tire Inflation Circuits TP01 through TP24**

| TP—Central Tire Inflation Circuits TP01 through TP24 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TP01A | Tire pressure control | Main fused ignition power; main fuse block to option fuse block | CAB |
| TP02A | Tire pressure control | Fused ignition power to ignition splice; dash | CAB |
| TP02B | Tire pressure control | Fused ignition power; dash ignition splice to operator control panel | CAB |
| TP02C | Tire pressure control | Fused ignition power; dash ignition splice to seat ignition splice; right door pillar | CAB |
| TP02D | Tire pressure control | Fused ignition power; right door pillar to seat ignition splice | CAB |
| TP02E | Tire pressure control | Fused ignition power; seat ignition splice to TPCS configurator | CAB |
| TP02F | Tire pressure control | Fused ignition power; seat ignition splice to TPCS ECU | CAB |
| TP03A | Tire pressure control | Main fused battery power; main fuse block to option fuse block | CAB |
| TP04A | Tire pressure control | Fused battery power to TPCS relay (86) | CAB |
| TP04B | Tire pressure control | Fused battery power; TPCS relay (86) to TPCS relay (87) | CAB |
| TP05A | Tire pressure control | Fused battery power; TPCS relay (30) to seat battery splice; right door pillar | CAB |

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| TP—Central Tire Inflation Circuits TP01 through TP24 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TP05B | Tire pressure control | Fused battery power; right door pillar to seat battery splice | CAB |
| TP05C | Tire pressure control | Fused battery power; seat battery splice to pneumatic controller | CAB |
| TP05D | Tire pressure control | Fused battery power; seat battery splice to pneumatic controller | CAB |
| TP05E | Tire pressure control | Fused battery power; seat battery splice to pneumatic controller | CAB |
| TP06A | Tire pressure control | ECU signal to TPCS relay; right door pillar | CAB |
| TP06B | Tire pressure control | ECU signal; right door pillar to TPCS relay (85) | CAB |
| TP07A | Tire pressure control | Speed signal (+) to TPCS ECU; cab floor | CHA |
| TP07B | Tire pressure control | Speed signal (+) cab floor to TPCS ECU | CAB |
| TP08A | Tire pressure control | Speed signal (–) to TPCS ECU; cab floor | CHA |
| TP08B | Tire pressure control | Speed signal (–); cab floor to TPCS ECU | CAB |
| TP09A | Tire pressure control | Pressure tank signal to TPCS ECU; cab floor | CHA |
| TP09B | Tire pressure control | Pressure tank signal; cab floor to TPCS ECU | CHA |
| TP10A | Tire pressure control | Lamp feed; right outboard marker feed to right outboard marker | CAB |
| TP10B | Tire pressure control | Lamp feed; right outboard marker feed to TPCS ECU | CAB |
| TP10C | Tire pressure control | Lamp feed; right outboard marker feed to OCP; right door pillar | CAB |
| TP10D | Tire pressure control | Lamp feed; right door pillar to operator control panel | CAB |
| TP11A | Tire pressure control | Pressure transducer signal to TPCS ECU | CAB |
| TP12A | Tire pressure control | Pressure transducer reference to TPCS ECU | CAB |
| TP13A | Tire pressure control | Pressure transducer ground to TPCS ECU | CAB |
| TP14A | Tire pressure control | Trailer solenoid signal; ECU to pneumatic controller | CAB |
| TP15A | Tire pressure control | Deflate solenoid signal; ECU to pneumatic controller | CAB |
| TP16A | Tire pressure control | J1922 (–) feed to operator control panel; right door pillar | CAB |
| TP16B | Tire pressure control | J1922 (–) feed; right door pillar to operator control panel | CAB |
| TP17A | Tire pressure control | J1922 (+) feed to operator control panel; right door pillar | CAB |
| TP17B | Tire pressure control | J1922 (+) feed; right door pillar to operator control panel | CAB |
| TP18A | Tire pressure control | ATA (+) feed to SAE J1587 diagnostics; right door pillar | CAB |
| TP18B | Tire pressure control | ATA (+) feed; right door pillar to SAE J1587 diagnostics splice | CAB |
| TP18C | Tire pressure control | ATA (+) feed; diagnostics splice to SAE J1587 diagnostics (to accessories) | CAB |
| TP18D | Tire pressure control | ATA (+) feed; diagnostics splice to SAE J1587 diagnostics (from engine) | CAB |
| TP19A | Tire pressure control | ATA (–) feed to SAE J1587 diagnostics; right door pillar | CAB |
| TP19B | Tire pressure control | ATA (–) feed; right door pillar to SAE J1587 diagnostics splice | CAB |
| TP19C | Tire pressure control | ATA (–) feed; diagnostics splice to SAE J1587 diagnostics (to accessories) | CAB |
| TP19D | Tire pressure control | ATA (–) feed; diagnostics splice to SAE J1587 diagnostics (from engine) | CAB |

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## Circuit Codes S through W

| TP—Central Tire Inflation Circuits TP01 through TP24 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TP20A | Tire pressure control | Drive solenoid signal; ECU to pneumatic controller | CAB |
| TP21A | Tire pressure control | Supply solenoid signal; ECU to pneumatic controller | CAB |
| TP22A | Tire pressure control | Control solenoid signal; ECU to pneumatic controller | CAB |
| TP23A | Tire pressure control | Steer solenoid signal; ECU to pneumatic controller | CAB |
| TP24A | Tire pressure control | Configurator signal to TPCS ECU | CAB |

**TR—Transmission Circuits TR01 through TR59**

| TR—Transmission Circuits TR01 through TR59 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TR01A | Option | Transmission range sensor neutral start switch to frontwall | ENG |
| TR01B | Option | Transmission range neutral start switch; frontwall to lightbar and ECC buzzer splice | CAB |
| TR01C | Option | Light bar and ECC buzzer splice to lightbar | CAB |
| TR01D | Option | Light bar and ECC buzzer splice to ECC buzzer | CAB |
| TR04A | CEEMAT | Main fused battery power; main fuse block to option fuse block | CAB |
| TR05A | CEEMAT | Fused ignition power; main fuse block to option fuse block | CAB |
| TR06A | CEEMAT | Reverse relay power; dash shifter to relay | CAB |
| TR07A | CEEMAT | Reverse relay control; dash shifter to relay | CAB |
| TR07B | CEEMAT | Reverse relay control; relay to frontwall | CAB |
| TR07C | CEEMAT | Reverse relay control; frontwall to floor shifter | ENG |
| TR08A | CEEMAT | Backup light power; BL01B line to reverse relay | CAB |
| TR09A | CEEMAT | Backup light signal; reverse relay to frontwall connector | CAB |
| TR10A | CEEMAT | Start enable relay common; dash shifter to relay | CAB |
| TR10B | CEEMAT | Start enable relay common; relay to frontwall | CAB |
| TR10C | CEEMAT | Start enable relay common; frontwall to floor shifter | ENG |
| TR11A | CEEMAT | Start enable relay control; dash shifter to relay | CAB |
| TR11B | CEEMAT | Start enable relay control; relay to frontwall | CAB |
| TR11C | CEEMAT | Start enable relay control; frontwall to floor shifter | ENG |
| TR12A | CEEMAT | Engine cranking signal; start enable relay to frontwall | CAB |
| TR12B | CEEMAT | Engine cranking signal; start enable relay to dash shifter | CHA |
| TR13A | CEEMAT | Engine cranking signal; floor shifter to coil of start solenoid | ENG |
| TR14A | CEEMAT | Key in start position; ST02C to start enable relay | CHA |
| TR15A | CEEMAT | Station in command jumper; shifter to shifter | CAB |
| TR16A | CEEMAT | Engine brake on; engine brake off/on switch to emergency brake control relay | CAB |
| TR17A | CEEMAT | Engine brake is on and enabled; emergency brake control relay to wire EB04A | CAB |

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| TR—Transmission Circuits TR01 through TR59 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TR18A | CEEMAT | Oil temperature signal; insight module to temperature gauge | CAB |
| TR19A | CEEMAT | Alarm signal (ground); insight module to ECC vehicle connector | CAB |
| TR20A | CEEMAT | Oil temperature sender signal; insight module to frontwall | CAB |
| TR21A | CEEMAT | Reverse switch bypass jumper | ENG |
| TR50A | Allison | Ignition power; main fuse panel ignition option jack to optional fuse panel | CAB |
| TR51A | Allison | Fused ignition power; optional fuse panel to brake light relay | CAB |
| TR51B | Allison | Fused ignition power; optional fuse panel to retarder on/off switch | CAB |
| TR51C | Allison | Fused ignition power; retarder on/off switch to ABS detect relay | CAB |
| TR51D | Allison | Fused ignition power; brake light relay to VIM signal connector (dash) | CAB |
| TR51E | Allison | Fused ignition power; VIM signal connector (overhead console) to VIM | CAB |
| TR52A | Allison | Do not shift signal; VIM to VIM power connector (overhead console) | CAB |
| TR52B | Allison | Do not shift signal; VIM power connector (dash) to lightbar | CAB |
| TR53A | Allison | Retarder on signal; VIM signal connector (overhead console) | CAB |
| TR53B | Allison | Retarder on signal; VIM signal connector (dash) to brake light relay | CAB |
| TR54A | Allison | Neutral contact; VIM to VIM signal connector (overhead console) | CAB |
| TR54B | Allison | Neutral contact; VIM signal connector (dash) to ST02C (one-way connector) | CAB |
| TR55A | Allison | Neutral contact; VIM to VIM signal connector (overhead console) | CAB |
| TR55B | Allison | Neutral contact; VIM signal connector (dash) to frontwall heater connector | CAB |
| TR56A | Allison | Engine brake enable; VIM to VIM signal connector (overhead console) | CAB |
| TR56B | Allison | Engine brake enable: VIM signal connector (dash) to EB04A (one way connector) | CAB |
| TR57A | Allison | Engine brake enable; VIM to VIM signal connector (overhead console) | CAB |
| TR57B | Allison | Engine brake enable; VIM signal connector (dash) to engine brake on/off switch | CAB |
| TR58A | Allison | Reverse light on; VIM to VIM signal connector (overhead console) | CAB |
| TR58B | Allison | Reverse lights on; VIM signal connector (dash) to BL01C (one-way connector) | CAB |
| TR59A | Allison | Reverse lights on; VIM signal connector (overhead console) | CAB |

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## Circuit Codes S through W

| TR—Transmission Circuits TR01 through TR59 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TR59B | Allison | Reverse lights on; VIM signal connector (dash) to frontwall taillight connect | CAB |

**TR—Transmission Circuits TR60 through TR99**

| TR—Transmission Circuits TR60 through TR99 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TR60A | Allison | Overtemp signal output; transmission harness to vehicle connector (overhead console) | CAB |
| TR60B | Allison | Overtemp signal output; vehicle connector (overhead console) to lightbar | CAB |
| TR61A | Allison | Engine brake requested; transmission harness to vehicle connector (overhead console) | CAB |
| TR61B | Allison | Engine brake requested; vehicle connector (dash) to engine brake switch | CAB |
| TR62A | Allison | Retarder requested; transmission harness to vehicle connector (overhead console) | CAB |
| TR62B | Allison | Retarder requested; vehicle connector (dash) to retarder enable switch | CAB |
| TR63A | Allison | Signal common; transmission harness to vehicle connector (overhead console) | CAB |
| TR63B | Allison | Signal common; vehicle connector (dash) to ABS relay | CAB |
| TR63C | Allison | Signal common; ABS relay to retarder request switch | CAB |
| TR63D | Allison | Signal common; retarder request switch to retarder request switch | CAB |
| TR63E | Allison | Signal common; retarder request switch to service brake switch | CAB |
| TR64A | Allison | Service brake on; transmission harness to vehicle connector (overhead console) | CAB |
| TR64B | Allison | Service brake on; vehicle connector (dash) to service brake switch | CAB |
| TR65A | Allison | ABS active; transmission harness to vehicle connector (overhead console) | CAB |
| TR65B | Allison | ABS active; vehicle connector (dash) to ABS relay | CAB |
| TR66A | Allison | J1587 (+); transmission harness to vehicle connector (overhead console) | CAB |
| TR66B | Allison | J1587 (+); vehicle connector (dash) to splice | CAB |
| TR66C | Allison | J1587 (+); splice to J15 | CAB |
| TR66D | Allison | J1587 (+); splice to P15 | CAB |
| TR67A | Allison | J1587 (–); transmission harness to vehicle connector (overhead console) | CAB |
| TR67B | Allison | J1587 (–); vehicle connector (dash) to splice | CAB |
| TR67C | Allison | J1587 (–); to J15 | CAB |

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| TR—Transmission Circuits TR60 through TR99 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TR67D | Allison | J1587 (–); splice to P15 | CAB |
| TR68W | Allison | Retarder extension cable; white wire | CAB |
| TR69B | Allison | Retarder extension cable; black wire | CAB |
| TR70W | Allison | Retarder extension cable; red wire | CAB |
| TR71A | Top 2 S60, CAT | Lockout solenoid signal; ECM connector to lockout solenoid; transmission | ENG |
| TR72A | Top 2 S60 | Fused battery power; starter to transmission solenoid block | ENG |
| TR73A | Top 2 S60, CAT | Shift solenoid signal; ECM connector to shift solenoid; transmission | ENG |
| TR74A | Allison | Retarder extension cable (pressure switch); A-cavity | CAB |
| TR75A | Allison | Retarder extension cable (pressure switch); B-cavity | CAB |
| TR76A | AutoSelect | J1939 red cable; transmission interface | CHA |
| TR77A | AutoSelect | J1939 black cable; transmission interface | CHA |
| TR78A | AutoSelect | J1939 shield cable; transmission interface | CHA |
| TR79A | AutoSelect | Battery power lead number two; transmission interface | CHA |
| TR80A | AutoSelect | Ground lead number two; transmission interface | CHA |
| TR81A | AutoSelect | Battery power lead number two; transmission interface | CHA |
| TR82A | AutoSelect | Battery power lead number one; transmission interface | CHA |
| TR83A | AutoSelect | Ground lead number one; transmission interface | CHA |
| TR84A | AutoSelect | Battery power lead number one; transmission interface | CHA |
| TR85A | AutoSelect | Clock signal; vehicle interface to dash display; frontwall | CHA |
| TR85B | AutoSelect | Clock signal; frontwall to dash display | CHA |
| TR86A | AutoSelect | Data signal; vehicle interface to dash display; frontwall | CHA |
| TR87A | AutoSelect | Positive power; vehicle interface to dash display; frontwall | CAB |
| TR87B | AutoSelect | Positive power; frontwall to dash display | CAB |
| TR88A | AutoSelect | Negative power; vehicle interface to dash display; frontwall | CAB |
| TR88B | AutoSelect | Negative power; frontwall to dash display | CAB |
| TR89A | AutoSelect | J1587 (+); vehicle interface to J1587 splice; frontwall | CAB |
| TR89B | AutoSelect | J1587 (+); frontwall to J1587 splice | CAB |
| TR89C | AutoSelect | J1587 (+); splice to P15 | CAB |
| TR89D | AutoSelect | J1587 (+); splice to J15 | CAB |
| TR90A | AutoSelect | J1587 (–); vehicle interface to J1587 splice; frontwall | CAB |
| TR90B | AutoSelect | J1587 (–); frontwall to J1587 splice | CAB |
| TR90C | AutoSelect | J1587 (–); splice to P15 | CAB |
| TR90D | AutoSelect | J1587 (–); splice to J15 | CAB |
| TR91A | AutoSelect | Start enable signal; vehicle interface to start enable relay; frontwall | CHA |

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## Circuit Codes S through W

| TR—Transmission Circuits TR60 through TR99 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TR91B | AutoSelect | Start enable signal; frontwall to start enable relay (86) | CAB |
| TR92A | AutoSelect | Engine brake signal; vehicle interface to engine brake relay; frontwall | CHA |
| TR92B | AutoSelect | Engine brake signal; frontwall to engine brake relay (86) | CAB |
| TR93A | AutoSelect | Fused ignition power; vehicle interface to ignition fuse F92; frontwall | CAB |
| TR93B | AutoSelect | Fused ignition power; frontwall to ignition fuse F92 | CAB |
| TR93C | AutoSelect | Ignition jumper to ignition fuse F92 | CAB |
| TR94A | AutoSelect | Dash light signal; vehicle interface to marker light splice; frontwall | CHA |
| TR94B | AutoSelect | Dash light signal; marker light to splice; ML03A line | CAB |
| TR95A | AutoSelect | Starter signal; ignition switch to start enable relay (30) | CAB |
| TR96A | AutoSelect | Relay latch power; start enable relay (87) to diode D15 | CAB |
| TR96B | AutoSelect | Relay latch power; diode D15 to start enable relay (86) | CAB |
| TR97A | AutoSelect | Starter signal; start enable relay (87) to starter magnetic switch; frontwall | CAB |
| TR98A | AutoSelect | Engine brake power; engine brake relay (87a) to S2 emergency engine brake low/med/hi | CAB |
| TR99A | AutoSelect | Engine brake power; engine brake relay (30) to S1 engine brake on/off | CAB |

**TW—CEEMAT Transmission Circuits TW01 through TW18**

| TW—CEEMAT Transmission CircuitsTW 01 through TW18 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TW01A | CEEMAT | Fused ignition power; fuse to frontwall | CAB |
| TW01B | CEEMAT | Fused ignition power; frontwall to splice | ENG |
| TW01C | CEEMAT | Fused ignition power; splice to transmission | ENG |
| TW01D | CEEMAT | Fused ignition power; splice to P.T.O. switch | ENG |
| TW01E | CEEMAT | Fused ignition power; fuse to service brake switch | CAB |
| TW01F | CEEMAT | Fused ignition power; service brake switch to dash shifter | CAB |
| TW01G | CEEMAT | Fused ignition power; service brake switch to diagnostic connector mechanical | CAB |
| TW01H | CEEMAT | Fused ignition power; splice to floor shifter | ENG |
| TW01J | CEEMAT | Fused ignition power; service brake switch to reverse relay light | CAB |
| TW02A | CEEMAT | Fused battery power; fuse to dash shifter | CAB |
| TW02B | CEEMAT | Fused battery power; fuse to frontwall | CAB |
| TW02C | CEEMAT | Fused battery power; frontwall to transmission | ENG |
| TW02D | CEEMAT | Fused battery power; frontwall to splice | ENG |

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| TW—CEEMAT Transmission CircuitsTW 01 through TW18 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TW02E | CEEMAT | Fused battery power; splice to transmission | ENG |
| TW02F | CEEMAT | Fused battery power; splice to floor shifter | ENG |
| TW02G | CEEMAT | Power from starter terminal fuse (95) to splice | ENG |
| TW02H | CEEMAT | Fuse (95) to splice | ENG |
| TW02J | CEEMAT | Splice to transmission connector PATC | ENG |
| TW02K | CEEMAT | Fused battery power; splice to connector PCMT | ENG |
| TW02L | CEEMAT | Fused battery power; connector JCMT to floor shifter | ENG |
| TW03A | CEEMAT | J1587 data bus (–); transmission to frontwall | ENG |
| TW0B | CEEMAT | J1587 data bus (–); frontwall to splice | CAB |
| TW03C | CEEMAT | J1587 data bus (–); splice to jack | CAB |
| TW03D | CEEMAT | J1587 data bus (–); splice to plug | CAB |
| TW03E | CEEMAT | J1587 data bus (–); diagnostic connector to two-way plug | CAB |
| TW04A | CEEMAT | J1587 data bus (+); transmission to frontwall | ENG |
| TW04B | CEEMAT | J1587 data bus (+); frontwall to splice | CAB |
| TW04C | CEEMAT | J1587 data bus (+); splice to jack | CAB |
| TW04D | CEEMAT | J1587 data bus (+); splice to plug | CAB |
| TW04E | CEEMAT | J1587 data bus (+); diagnostic connector to two-way plug | CAB |
| TW04F | CEEMAT | Connector JCMT to relay (47) | CAB |
| TW04G | CEEMAT | Relay (47) to lightbar | CAB |
| TW05A | CEEMAT | Power-take-off signal; power take-off switch to splice | ENG |
| TW05B | CEEMAT | Power-take-off signal; splice to transmission | ENG |
| TW05C | CEEMAT | Power-take-off signal; splice to frontwall | ENG |
| TW05D | CEEMAT | Power-take-off signal; frontwall to lightbar | CAB |
| TW06A | CEEMAT | Service brake applied; transmission to frontwall | ENG |
| TW06B | CEEMAT | Service brake applied; frontwall to brake switch | CAB |
| TW07A | CEEMAT | Engine brake disable; transmission to frontwall | ENG |
| TW07B | CEEMAT | Engine brake disable; frontwall to engine brake relay | CAB |
| TW09A | CEEMAT | De-fuel control; transmission to de-fuel solenoid | ENG |
| TW10A | CEEMAT | Throttle position sensor return; transmission to throttle position sensor | ENG |
| TW11A | CEEMAT | Throttle position sensor signal; transmission to throttle position sensor | ENG |
| TW12A | CEEMAT | Throttle position sensor power; transmission to throttle position sensor | ENG |
| TW13A | CEEMAT | Ground; transmission to splice | ENG |
| TW13B | CEEMAT | Ground; splice to frontwall stud plate | ENG |
| TW13C | CEEMAT | Ground; frontwall to de-fuel solenoid | ENG |

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## Circuit Codes S through W

| TW—CEEMAT Transmission CircuitsTW 01 through TW18 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| TW13D | CEEMAT | Ground; splice to floor shifter | ENG |
| TW13E | CEEMAT | Ground; splice to floor shifter (lighting) | ENG |
| TW13F | CEEMAT | Ground; transmission to frontwall | ENG |
| TW13G | CEEMAT | Ground; transmission to starter ground stud | ENG |
| TW13H | CEEMAT | Ground; starter ground stud to de-fuel solenoid | ENG |
| TW14A | CEEMAT | Ground; transmission to frontwall stud plate | ENG |
| TW14B | CEEMAT | Ground; transmission to starter ground stud | ENG |
| TW15A | CEEMAT | Spare input; transmission to frontwall | ENG |
| TW16A | CEEMAT | Service light; transmission to frontwall | ENG |
| TW16B | CEEMAT | Service light; frontwall to lightbar | CAB |
| TW17A | CEEMAT | J1922 data bus (+); transmission to splice | ENG |
| TW17B | CEEMAT | J1922 data bus (+); splice to jack | ENG |
| TW17C | CEEMAT | J1922 data bus (+); splice to plug | ENG |
| TW17D | CEEMAT | J1922 data bus (+); splice to frontwall | ENG |
| TW17E | CEEMAT | J1922 data bus (+); frontwall to dash shifter | CAB |
| TW17F | CEEMAT | J1922 data bus (+); splice to floor shifter | ENG |
| TW18B | CEEMAT | J1922 data bus (–); splice to jack | ENG |
| TW18C | CEEMAT | J1922 data bus (–); splice to plug | ENG |
| TW18D | CEEMAT | J1922 data bus (–); splice to frontwall | ENG |
| TW18E | CEEMAT | J1922 data bus (–); frontwall to dash shifter | CAB |
| TW18F | CEEMAT | J1922 data bus (–); splice to floor shifter | ENG |

**WB—Webasto Heater Circuits WB01 through WB09**

| WB—Webasto Heater Circuits WB01 through WB09 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| WB01A | Webasto | Webasto fused battery power; frontwall option connector to dash junction plug | CAB |
| WB01B | Webasto | Webasto fused battery power; dash junction plug to heater valve control relay | CAB |
| WB01C | Webasto | Webasto fused battery power; dash junction plug to timer overhead console connector | CAB |
| WB01D | Webasto | Webasto fused battery power; timer overhead console connector to timer | OHC |
| WB01E | Webasto | Webasto fused battery power; dash junction plug to Webasto on/off switch | CAB |
| WB01F | Webasto | Webasto fused battery power; dash junction plug to seven-day timer overhead console connector | CAB |

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| WB—Webasto Heater Circuits WB01 through WB09 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| WB01G | Webasto | Webasto fused battery power; seven-day timer overhead console connector to splice | OHC |
| WB01H | Webasto | Webasto fused battery power; splice to seven-day timer | OHC |
| WB01J | Webasto | Webasto fused battery power; splice to seven-day timer | OHC |
| WB01K | Webasto | Webasto fused battery power; splice to seven-day timer | OHC |
| WB02A | Webasto | Webasto on/off control line; frontwall connector to black and yellow Webasto wires | ENG |
| WB02b | Webasto | Webasto on/off control line; frontwall connector to overhead console timer connector | CAB |
| WB02C | Webasto | Webasto on/off control line; overhead console timer connector to timer | OHC |
| WB02D | Webasto | Webasto on/off control line; frontwall connector to on/off switch | CAB |
| WB02E | Webasto | Webasto on/off control line; frontwall connector to overhead console seven-day timer connector | CAB |
| WB02F | Webasto | Webasto on/off control line; seven-day timer connector to seven-day timer | OHC |
| WB03A | Webasto | Webasto common; frontwall connector to overhead console timer connector | CAB |
| WB03B | Webasto | Webasto common; overhead console timer connector to timer | OHC |
| WB04A | Webasto | Webasto heater control line; frontwall connector to heater control relay coil | CAB |
| WB04B | Webasto | Webasto heater control line; frontwall connector to sleeper start connector | CAB |
| WB04C | Webasto | Webasto heater control line; Webasto sleeper relay to spare two line in sleeper start harness | SLPR |
| WB05A | Webasto | Webasto operating indicator; frontwall connector to lightbar | CAB |
| WB05B | Webasto | Webasto operating indicator; frontwall connector to seven-day timer overhead console connector | CAB |
| WB05C | Webasto | Webasto operating indicator; seven-day timer overhead console connector to seven-day timer | OHC |
| WB05D | Webasto | Webasto operating indicator; frontwall connector to switch | CAB |
| WB06A | Webasto | Webasto heater control; heater control relay to cab heater | CAB |
| WB07A | Webasto | Webasto heater control; heater control relay to coolant flow valve | CAB |
| WB08A | Webasto | Battery power for Webasto relay; terminal strip to relay | SLPR |
| WB08B | Webasto | Battery power for Webasto relay; relay coil to relay contact | SLPR |
| WB09A | Webasto | Seven-day timer illumination; timer to left outboard marker light power | OHC |
| WB09B | Webasto | Seven-day timer illumination; left outboard marker light power to marker light | OHC |

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## Circuit Codes S through W

**WW—Windshield Wiper/Washer Circuits WW01 through WW11**

| WW—Windshield Wiper/Washer Circuits WW01 through WW11 | | | |
|---|---|---|---|
| **Circuit** | **Harness** | **Function** | **Location** |
| WW01 | Option | Washer motor control; extension cable | ENG |
| WW01A | Main | Washer motor control; frontwall to ECC | CAB |
| WW01B | Headlights | Washer motor control; motor to frontwall | ENG |
| WW02A | Main | Fused power to intermittent/off/on switch | CAB |
| WW02B | Main | Fused power; intermittent/off/on switch to washer off/on switch | CAB |
| WW03A | Main | High speed to ECC | CAB |
| WW04A | Main | Slow speed to ECC | CAB |
| WW05A | Main | Intermittent (delay) speed to ECC | CAB |
| WW06A | Main | Washer on to ECC | CAB |
| WW07A | Main | Wipers on switch to high/slow speed switch | CAB |
| WW08A | Main | Fast; ECC to motor | CAB |
| WW09A | Main | Slow; ECC to motor | CAB |
| WW10A | Main | Park; ECC to motor | CAB |
| WW11A | Main | Wiper power to motor | CAB |
| WW11B | Main | Wiper power to ECC | CAB |

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# General Information

## Lead-Acid Batteries

Batteries are electrochemical devices that store chemical energy. When the battery is connected to an external load, such as a starter, the chemical energy is converted into electrical energy and current flows through the circuit.

The battery has three functions:

- To supply power to start the engine.
- To stabilize the voltage in the electrical system. The battery filters high voltage transients and protects electronic components in the vehicle.
- To supply power when the vehicle's electrical load requirements go beyond what the charging system can supply or when the engine is not running.

All lead-acid batteries use plates made of two unlike metals held apart by separators. One of the metals becomes the positive plate, the other the negative plate. These plates are then grouped in pairs, alternating negative and positive. The groups are connected in series, and each plate group (cell) produces about two volts. Thus, a battery with six cells is a 12-volt battery.

In conventional liquid-electrolyte batteries (wet cells), each battery contains a group of plates immersed in a solution of electrolyte (dilute sulfuric acid).

Batteries may produce hydrogen gas when being charged. The vents allow the escape of gases produced in the battery.

NOTE: Liquid-electrolyte batteries must be kept in an upright position to prevent electrolyte leakage. Tipping a wet cell beyond a 45-degree angle in any direction can allow a small amount of electrolyte to leak out the vent holes.

## Absorbed Glass Mat (AGM) Batteries

Absorbed Glass Mat (AGM) batteries are lead-acid batteries in which the electrolyte is contained in a fiberglass mat. AGM batteries are physically similar to standard batteries. Carefully check the label on every battery to be certain it is AGM, and **never install AGM batteries in the same circuit with other types of batteries.**

AGM batteries are designed for high cranking amps and repeated cycle service to accommodate many of the auxiliary loads on vehicle electrical systems. They offer good protection against damage due to vibration, and are leak- and spill-proof, even if cracked or broken. Also, they self-discharge more slowly, and generate less heat when charging or discharging.

IMPORTANT: AGM batteries may be damaged or ruined by equipment designed for other types of batteries. AGM battery chargers must be regulated to a charge voltage less than 15.4 DCV; many chargers provide excessive voltage. To get full service from AGM batteries, carefully follow the battery manufacturer's instructions regarding charging rates and procedures.

## Parasitic Battery Drain

Batteries are replenished each time the vehicle is driven with normal vehicle use. In long-term parking situations, however, parasitic drains may discharge the batteries enough that the starter will not be able to crank the engine.

A parasitic drain is an electrical load that draws current from the batteries when the ignition remains off.

A typical parasitic drain falls into the 25 to 325 mA (0.025 to 0.325 amps) range. Multiply the drain (in amps) by the time (in hours) the batteries sit without being recharged. The result is the amount of ampere-hours consumed by the parasitic drain. The actual drain may be small, but over time the batteries grow steadily weaker.

At warm temperature of 77°F (25°C), using approximately 40 percent of the total available ampere-hours will bring fully charged batteries to a no-start condition. In colder temperatures, the batteries will reach a no-start condition sooner.

A vehicle with a 325 mA drain and a fully charged 70 RC battery will last between five and six days. But if the batteries are at only 65 percent of full-charge, they are going to last only two days before causing a no-start condition.

IMPORTANT: If the batteries begin storage at 90 percent of full charge, reduce the available ampere-hours accordingly.

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## General Information

# Capacity

There are two types of capacity measurements for a battery, cold cranking amps (CCA) and reserve capacity (RC).

- **Cold Cranking Amps** is a measure of the ability of the battery to produce high current for short periods of time. High current loads for short periods of time such as starter motors rely heavily on the battery's CCA.
- **Reserve Capacity** is a measure of the ability of the battery to produce low current for a long period of time. Hotel loads such as parked HVAC and interior lighting rely heavily on the battery's reserve capacity.

There is no direct relationship between CCA and RC. A new battery may have high CCA and high RC. As the battery ages, it could have high CCA and low RC. Though not always the case, if a battery has low CCA it will also typically have low RC.

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## General Safety Precautions

**WARNING**

**Keep sparks, flames, burning cigarettes, etc. away from batteries. Batteries generate explosive gases, which could cause a battery to explode, causing serious personal injury, including blindness.**

When charging the batteries, gas forms in each cell and escapes through the vent holes. In poorly ventilated areas, the gas lingers around the battery several hours after it has been charged. The gas is explosive around sparks, flame, or other intense heat; if ignited, it could cause the battery to explode. Follow these precautions when charging the batteries.

- Wear safety glasses or a face shield when working with batteries. When many batteries are handled, wear rubber gloves and an apron to protect clothing.
- Make sure that the area is well ventilated.
- Do not install any lead-acid battery in a sealed container or enclosure. Allow hydrogen gas caused by overcharging to escape. Exploding hydrogen gas can cause blindness or other bodily injury.
- Make sure that the charger cable leads are clean and making good connections. A poor connection could cause an electrical arc which could ignite the gas mixture and explode the battery.
- Do not break live circuits at the terminals because a spark usually occurs at the point where a live circuit is broken. Use care when connecting or disconnecting booster leads or cable clamps on chargers.
- Do not smoke near batteries that are being charged or have recently been charged. Keep the batteries away from open flames or sparks.
- If the battery is frozen, let it reach room temperature and completely thaw before trying to charge it. Check for leaks and cracks before charging the battery. Replace the battery if leaks or cracks are seen.
- Take care that tools or metal objects do not fall across the battery terminals.

**WARNING**

**Do not install any lead-acid battery in a sealed container or enclosure. Allow hydrogen gas caused by overcharging to escape. Exploding hydrogen gas can cause blindness or other bodily injury.**

**CAUTION**

**If a metal object connects an ungrounded battery terminal to a nearby metal part of the vehicle which is grounded, it could short out the batteries, causing sparks and possible property damage.**

## Battery Electrolyte Safety Precautions

**WARNING**

**Protect skin and eyes from battery electrolyte (acid). Electrolyte is corrosive and could result in serious personal injury if splashed on your skin or in your eyes.**

If electrolyte is splashed on your skin or in your eye, force the eye open, rinse it with cool, clean water for about five minutes and call a doctor immediately. Do not add eye drops or other medication unless advised by the doctor.

If electrolyte is swallowed, drink several large glasses of milk or water. Follow with milk of magnesia, a beaten raw egg, or vegetable oil. Call a doctor immediately.

Use extreme care to avoid spilling or splashing electrolyte. Electrolyte spilled or splashed on your body or clothing should be neutralized with baking soda or household ammonia, then rinsed with clean water.

Electrolyte can also damage painted or unpainted metal vehicle parts. If electrolyte is spilled or splashed on any metal surface, neutralize and rinse it with clean water.

To prevent possible skin burns, do not wear watches, rings, or other jewelry while performing maintenance work on the batteries.

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## Safety Precautions

**⚠ WARNING**

**Do not apply pressure to the end walls of a plastic-case battery. This could cause electrolyte to squirt from the vents, possibly resulting in serious injury to skin or eyes.**

When handling plastic-case batteries, use a battery carrier. If one is not available, lift these batteries with your hands placed at opposite corners of the battery.

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# Emergency Starting Using Booster Cables

**WARNING**

**Before jump-starting a vehicle, read the instructions in Subject 100. Failure to follow the safety precautions could result in personal injury.**

**WARNING**

**Batteries release explosive gas. Do not smoke when working around batteries. Put out all flames and remove all sources of sparks or intense heat in the vicinity of the battery. Do not allow the vehicles to touch each other. Do not lean over the batteries when making connections, and keep all other persons away from the batteries. Failure to follow these precautions could lead to severe personal injury as a result of an explosion or acid burns.**

**NOTICE**

**Make sure both electrical systems are the same voltage. Electronic devices on both vehicles can be damaged when connected to a vehicle with a different operating voltage.**

1. Apply the parking brakes and turn off all lights and other electrical devices. Ensure that the vehicles are not touching and both ignition switches are turned to the OFF position.

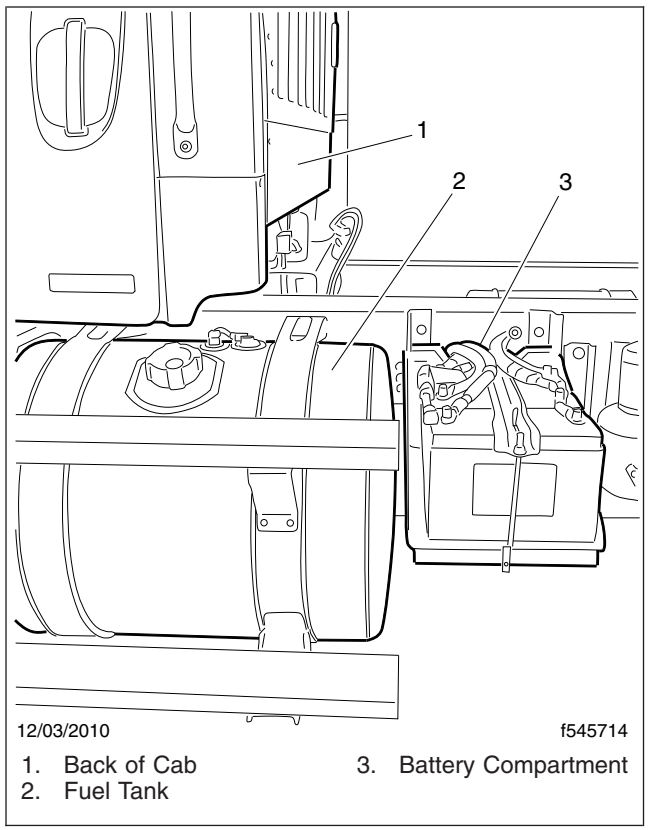
IMPORTANT: Do not attempt to jump start a damaged battery.

2. Remove the battery box cover. See **Fig. 1** for the standard battery compartment location.

**NOTICE**

**Always connect the batteries and jumper cables correctly (positive-to-positive and negative-to-negative). Connecting a charging device backwards (positive-to-negative) can severely damage the vehicle electrical content and cause non-warrantable failures.**

IMPORTANT: On vehicles equipped with optional jump start posts, connect to these posts instead of the battery terminals. Jump start




1. Back of Cab
2. Fuel Tank
3. Battery Compartment

**Fig. 1, Standard Battery Compartment Location**

posts may be installed in various locations on the vehicle. See **Fig. 2**.

3. Connect the positive (+) jumper cable to the positive terminal or jump start post on the discharged battery. See **Fig. 3**.
4. Connect the other end of the positive jumper cable to the positive terminal or jump start post on the booster battery providing the charge.

**WARNING**

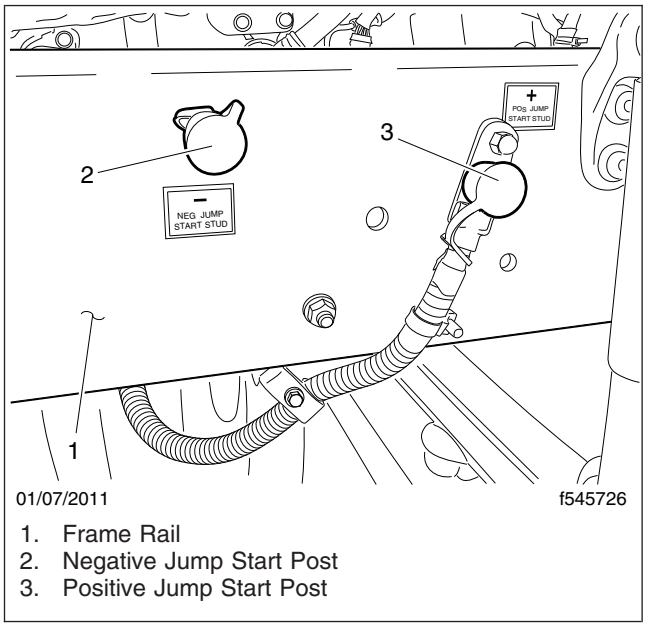
**Do the next step exactly as instructed and do not allow the clamps of one cable to touch the clamps of the other cable. Otherwise, a spark could occur near a battery, possibly resulting in severe personal injury from explosion and acid burns.**

5. Connect the negative (-) jumper cable to the negative terminal or jump start post on the booster battery.

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## Emergency Starting Using Booster Cables




1. Frame Rail
2. Negative Jump Start Post
3. Positive Jump Start Post

**Fig. 2, Possible Jump Start Post Location (passenger-side engine compartment)**

6. Connect the other end of the negative jumper cable to the negative ground stud on the vehicle requiring the jump start.
7. Start the engine of the vehicle providing the jump start and let the engine run a few minutes to charge the batteries of the other vehicle.
8. Attempt to start the engine of the vehicle receiving the jump. Do not operate the starter longer than 30 seconds, and wait at least two minutes between starting attempts to allow the starter to cool.
9. When the engine starts, let it idle a few minutes.

**⚠ WARNING**

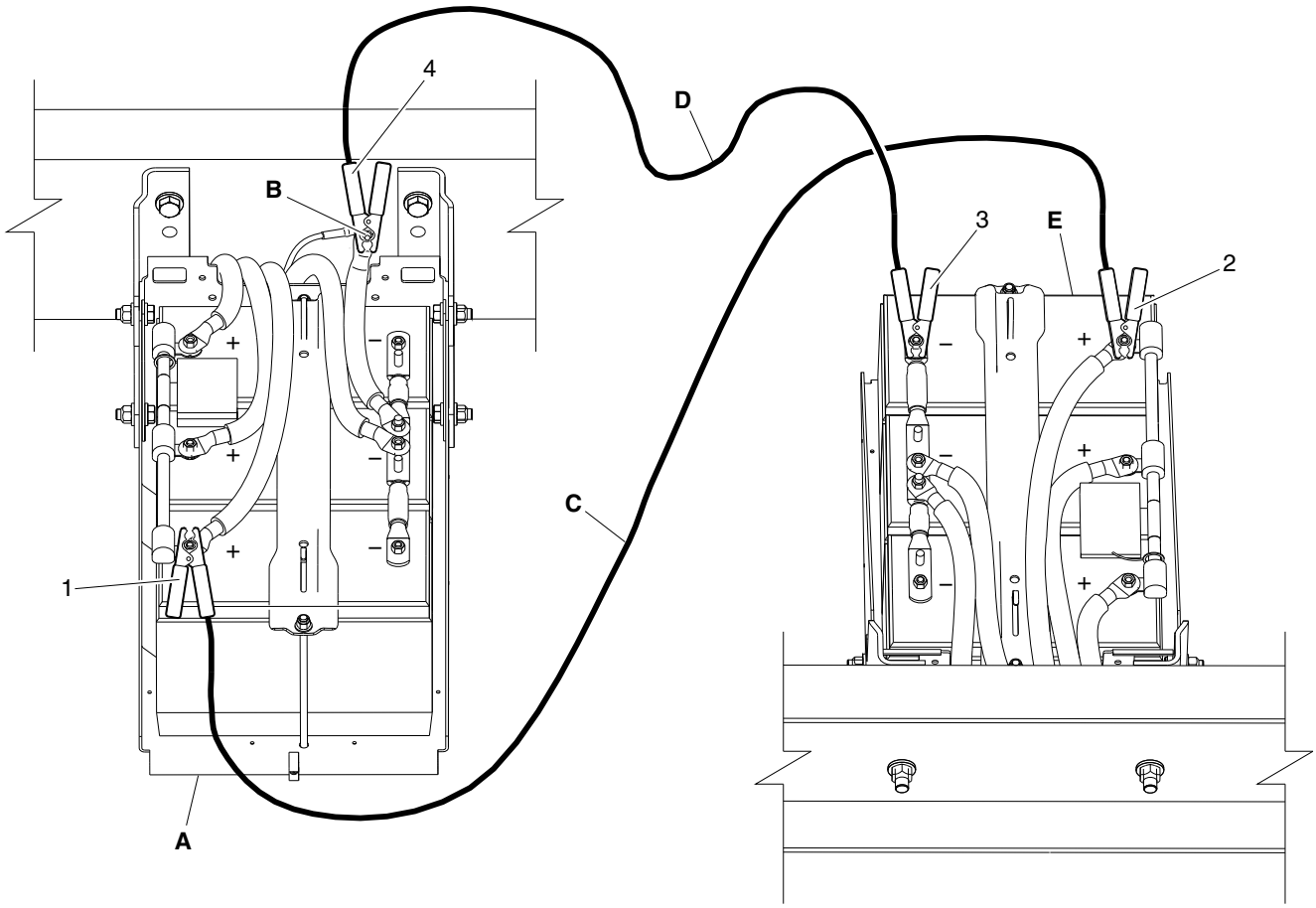
**Do the next step exactly as instructed and do not allow the clamps of one cable to touch the clamps of the other cable. Otherwise, a spark could occur near a battery, possibly resulting in severe personal injury from explosion and acid burns.**

10. Disconnect the negative jumper cable from the negative cable stud on the jump-started vehicle.
11. Disconnect the negative jumper cable from the booster battery.
12. Disconnect the positive cable from the booster battery.
13. Disconnect the other end of the positive jumper cable from the jump-started vehicle.
14. Install the battery box cover; be sure it is positioned properly before fastening the latch.

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## Emergency Starting Using Booster Cables




01/07/2011 f545725

Disconnect jumper cables in the REVERSE order that they were connected.

A. Discharged Battery
B. Negative Ground Stud
C. Positive Jumper Cable
D. Negative Jumper Cable
E. Booster Battery

1. 1st Connection: Positive Jumper Cable to Discharged Battery
2. 2nd Connection: Positive Jumper Cable to Booster Battery
3. 3rd Connection: Negative Jumper Cable to Booster Battery
4. 4th Connection: Negative Jumper Cable to Negative Ground Stud (discharged battery)

**Fig. 3, Jumper Connections**

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# Battery Charging

**⚠ WARNING**

**Before charging a battery, read the instructions in Subject 100. Failure to follow the safety precautions could result in personal injury.**

**When charging batteries, always wear eye protection. During charging, batteries give off explosive hydrogen gas. Exploding gas can cause blindness or other bodily injury.**

**NOTICE**

**To prevent sparking, or damage caused by improperly installed leads, many charger leads remain inactive unless the charger detects a minimum voltage. The minimum voltage limit varies between charger models from just under 1 volt to as high as 8 volts. If the voltage is too low, the charger will not turn on and the battery will not be charged. The charger expects current acceptance to fall to a low value as the battery approaches a full state of charge. An overly discharged battery may have very low initial current acceptance. This can result in the charger incorrectly reading the battery voltage as "full", which reduces the charging voltage to an ineffective level. In order to charge an overly discharged battery, place the battery in parallel with a second, slightly discharged battery, and charge the pair together. By doing so the severely discharged battery is given a moderate amount of current allowing the battery to be charged.**

**NOTICE**

**AGM batteries may be damaged or ruined by equipment designed for other types of batteries. AGM battery chargers must be regulated to a charge voltage less than 15.4 DCV. To get full service from AGM batteries, carefully follow the battery manufacturer's instructions on charging rates and procedures.**

Many common battery chargers are not compatible with AGM batteries. Generally, these include large "wheeled" chargers that are common in many shops. While these chargers may not cause significant damage if used once or twice over the lifetime of the battery, severe battery damage can occur in only a few hours of use. Use only chargers that are approved for use with AGM batteries. See the DTNA approved tools list for specific changers. When using approved chargers, make sure that the charge voltage does not exceed 15.4 DCV. If the maximum voltage of the charger is not known, check voltage a few minutes after charging begins and periodically during charging. As the battery charges, the current will fall and the voltage may rise. If the charger does not exceed 15.4 volts as the current falls to a low charge rate of 5 amps or less, the charger does not need to be monitored.

See **Table 1** for voltage to approximate battery state-of-charge for flooded batteries.

| Voltage to Approximate Battery State-of-Charge | | |
|---|---|---|
| Voltage | | State of Charge |
| Flooded | AGM | |
| 12.6 | 12.8 | 100% |
| 12.4 | 12.6 | 75% |
| 12.2 | 12.3 | 50% |
| 12.0 | 12.0 | 25% |
| 11.8 | 11.8 | 0% |

**Table 1, Voltage to Approximate Battery State-of-Charge**

1. If the batteries are not installed in the vehicle, install the lead adapters on the battery positive and negative posts.
2. Connect the charger to the battery following the manufacturer's instructions. Slightly rock the charger's clamps to insure a complete connection.

**⚠ WARNING**

**Always turn the charger off before disconnecting it. Touching a charger lead when the circuit is live could create a spark and cause an explosion, resulting in personal injury.**

IMPORTANT: If the battery feels hotter than 125°F (52°C) or if rapid gassing or spewing of electrolyte occurs, lower the charging rate or stop charging the battery and allow it to cool.

3. When finished, turn the charger off.

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# Battery Removal, Cleaning and Inspection, and Installation

**⚠ WARNING**

**Before doing any of the following procedures, read the instructions in Subject 100. Failure to follow the safety precautions could result in personal injury.**

## Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Before working on the battery, make sure all electrical loads such as lights, ignition, and accessories, are turned off.
3. Remove the battery box cover.
4. Disconnect the negative battery cable leads.
5. Disconnect the positive battery cable leads.
6. Disconnect the battery interconnect cables.
7. Remove the battery holddowns. Then remove the batteries from the carrier.

## Cleaning and Inspection

1. Inspect all battery cables and interconnectors for wear, and replace them if necessary. Remove corrosion from cables, terminals, and battery posts with a wire brush and a solution of baking soda and water. Rinse thoroughly with clean water, and dry.
2. Clean and tighten the battery ground cable at the weld stud on the frame rail. Inspect and ensure that the nut is self-locking and that a flat washer is used. Do not use a split-lock washer or star washer. Torque the nut 15 to 18 lbf·ft (20 to 24 N·m). Seal the area with red dielectric enamel.
3. Inspect the retainer assembly and battery box. Replace worn or damaged parts. Remove any corrosion with a wire brush and wash with a weak solution of baking soda and water. Rinse with clean water and dry. To prevent rusting, paint the retainer assembly if needed.
4. Be sure foreign objects, such as stones, bolts, and nuts, are removed from the battery box.

## Installation

1. Be sure that the replacement battery has a sufficient capacity to cover the electrical needs of the vehicle.

**NOTICE**

**Using an under-capacity battery will result in poor performance and premature battery failure, resulting in damage or reduced life of the starter.**

2. Be sure the battery is at full charge when installed. If the battery has been in storage for some time, or if the installation is being made in subfreezing temperatures, give the battery a top-off charge before installing it. For instructions, see Subject 110.
3. Place the batteries in the carrier with the terminals in the proper position as referenced earlier. The batteries must rest level in the carrier.
4. Install the battery holddown and tighten it to 12 lb·ft (8 N·m). See Fig. 1.

**NOTICE**

**Do not overtighten the battery holddown. Overtightening could damage the batteries.**

IMPORTANT: Many electrical components are located outside of the cab in areas subjected to harsh weather and road spray. Some components also have exposed metal electrical terminals, which, when subjected to harsh conditions, may suffer corrosion at the electrical connection.

5. To provide corrosion protection, apply lithium dielectric grease liberally to the terminal pads, then install the interconnectors.
6. Connect the battery interconnecting cables to the batteries and check for correct polarity with respect to the vehicle. Connect the ground cables last.

**NOTICE**

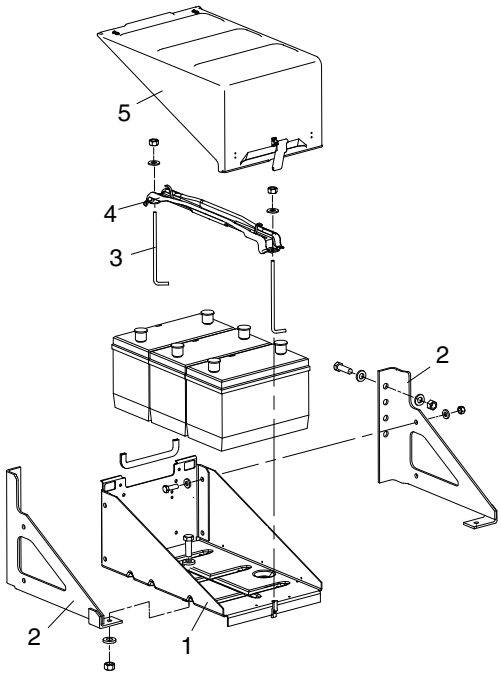
**Reversed polarity may cause serious damage to the electrical system.**

7. Tighten all battery connections to the torque specifications listed on the battery. Generally

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## Battery Removal, Cleaning and Inspection, and Installation




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1. Battery Box
2. Bracket, Battery Box
3. Holddown Bolt
4. Holddown
5. Battery Box Cover
6. Batteries

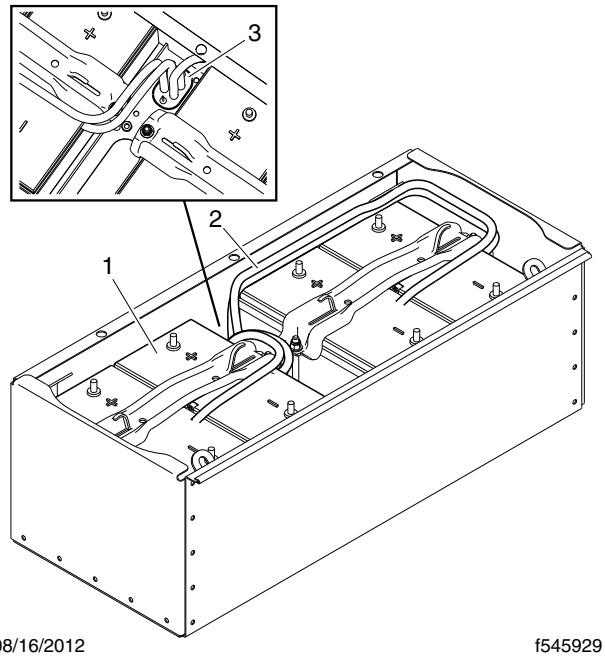
**Fig. 1, Frame-Mounted Battery Box, Battery, and Battery Holddown**

those are 10 to 15 lbf·ft (14 to 20 N·m). Proper torque is important for electrical system operation.

8. On in-cab battery installations, attach the vent tubing to all battery vent ports. See **Fig. 2**.
9. Start the engine and check the operation of the charging system. If needed, repair the charging system to obtain the correct charging output. For instructions, see the appropriate section in **Group 15**.

### NOTICE

**Make sure all battery posts are covered with dielectric grease to protect against corrosion.**




08/16/2012 f545929

1. Battery
2. Vent Tube
3. Vent Tube Passthrough

**Fig. 2, Battery Vent Tubing Installation**

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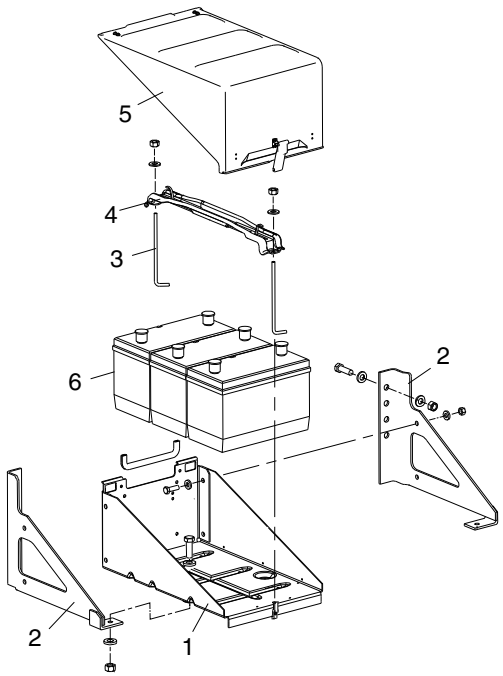
# Battery Box Removal and Installation

**WARNING**

**Before doing any of the following procedures, read the instructions in Subject 100. Failure to follow the safety precautions could result in personal injury.**

## Frame-Mounted Battery Box

Refer to **Fig. 1**, **Fig. 2**, **Fig. 3**, and **Fig. 4**, for different frame rail battery box installations.



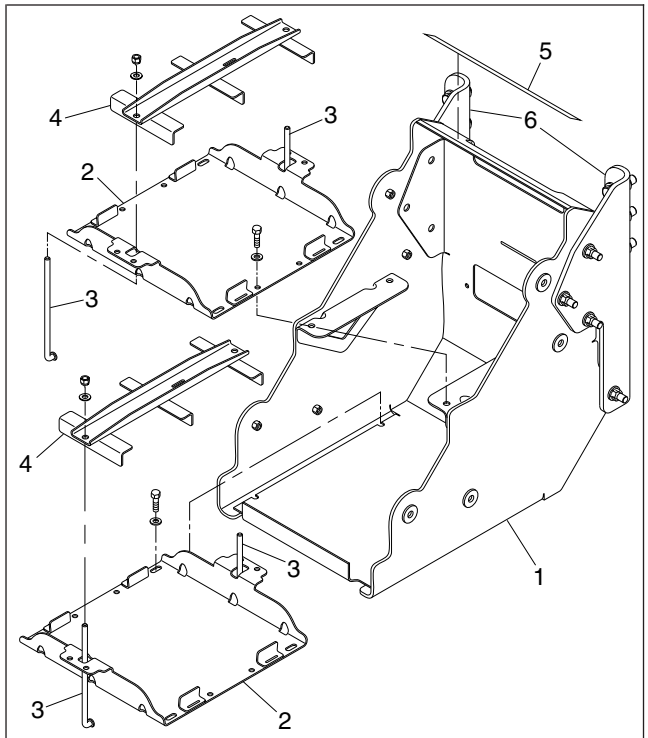

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1. Battery Box
2. Bracket, Battery Box to Frame Rail
3. Holddown Bolt
4. Battery Holddown
5. Cover
6. Batteries

**Fig. 1, Frame-Mounted Battery Box**

## Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Before working on the battery box, make sure all electrical loads such as lights, ignition, and accessories, are turned off.




08/20/2012 f545932

1. Battery Box
2. Battery Tray
3. Holddown Bolt
4. Holddown
5. Frame Rail
6. Bracket, Battery Box to Frame Rail

**Fig. 2, Frame-Mounted Battery Box, Stacked**

3. Remove the batteries. For instructions, see **Subject 130**.
4. Remove the fasteners that hold the battery box to the brackets.
5. Remove the battery box.

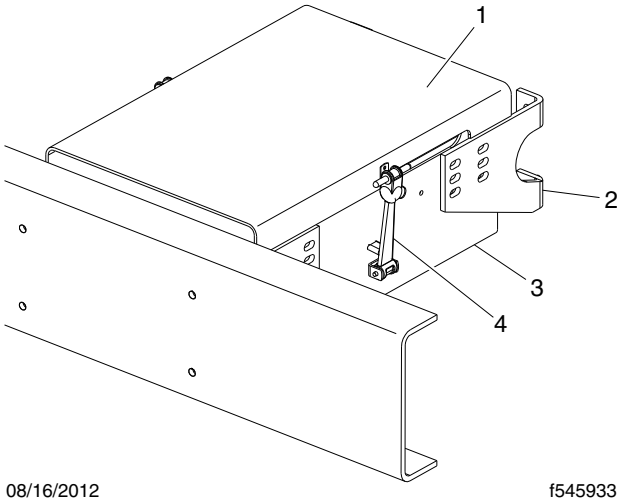
## Installation

1. Line up the holes in the battery box with the holes in each mounting bracket.
2. Install the fasteners that attach the battery box to the mounting brackets. Tighten the fasteners 18 lbf·ft (24 N·m).
3. Install the batteries. For instructions, see **Subject 130**.

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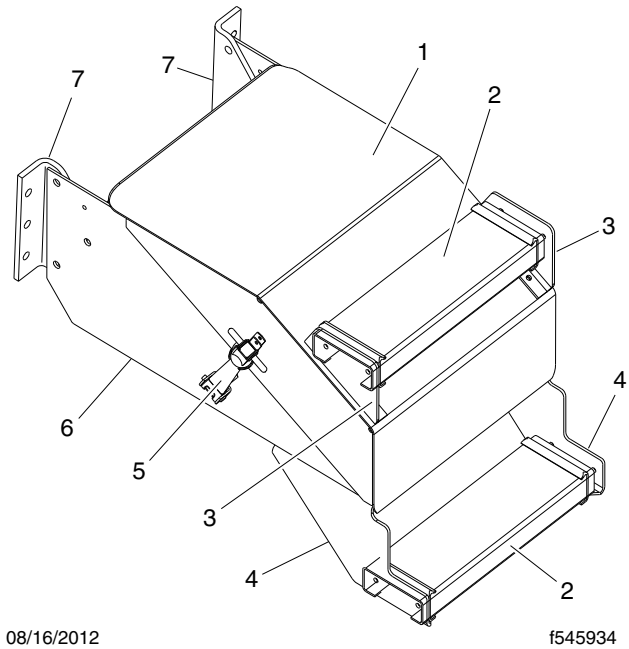
## Battery Box Removal and Installation




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1. Battery Box Cover
2. Bracket, Battery Box to Frame Rail
3. Battery Box
4. Holddown, Battery Box Cover

**Fig. 3, Frame-Mounted Battery Box, Between Frame Rails**




08/16/2012 f545934

1. Battery Box Cover
2. Step
3. Upper Step Bracket
4. Lower Step Bracket
5. Holddown
6. Battery Box
7. Bracket, Battery Box to Frame

**Fig. 4, Frame-Mounted Battery Box, Under Cab**

**NOTICE**

**Do not overtighten the battery holddowns. Overtightening could damage the batteries.**

4. Install the battery holddowns. Tighten each nut 12 lbf·ft (9 N·m).
5. Place the battery box cover over the battery box and fasten the latch.

## In Cab Battery Box

### Removal

In cab battery installations may be either under the bunk or under the passenger seat.

1. Remove the battery box cover.
2. Remove the battery holddowns.
3. Disconnect the batteries.
4. Disconnect the battery vent tubes from the batteries, and the vent tube passthrough if needed. See **Fig. 5**
5. Remove the batteries.
6. Remove the mounting fasteners and remove the battery box sides.

### Installation

1. Position the battery box sides and install the fasteners.
2. Install the batteries.
3. Install the battery hold downs.

**WARNING**

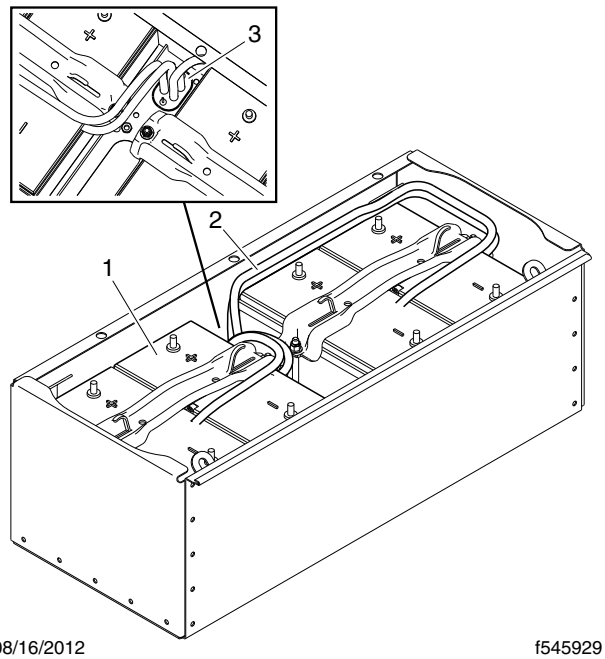
**When installing or servicing batteries located in the cab, always make sure that the vent tubes are attached to each battery and to the vent port in the cab floor. Battery vapor in the cab could cause a fire or explosion leading to property damage and personal injury.**

4. Connect the vent tubes in the batteries, and make sure the vent tubes are properly attached to the passthrough in the cab floor.
5. Connect the batteries.
6. Install the battery box cover.

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## Battery Box Removal and Installation




1. Battery
2. Vent Tube
3. Vent Tube Passthrough (to outside of cab)

**Fig. 5, Battery Vent Tube Installation (typical)**

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## Troubleshooting

If the batteries pass testing, check for the following causes:

1. Accessories were left on overnight.
2. A slipping alternator belt, high resistance in the wiring, or a defective alternator is causing the batteries to discharge.
3. The electrical loads are exceeding the charging system capacity.
4. Wires in the electrical system are shorted or pinched.
5. There are loose or damaged battery cable-to-terminal connections.
6. The batteries are still connected in a vehicle that has been out of service. Small current drains of accessories that are connected all the time can discharge the batteries in a few days. Batteries left in a discharged condition are subject to freezing.

## Electrical Drain and Parasitic Load

Batteries are replenished each time the vehicle is driven with normal vehicle use. In long-term parking situations, however, parasitic drains may discharge the batteries enough to cause a no-start condition.

A parasitic drain is an electrical load that draws current from the batteries when the ignition remains off. Some devices, such as the electronic control unit (ECU), the bulkhead module (BHM), the chassis module (CHM), the antilock braking system (ABS), and radio memory are intended to draw a very small current continuously. These draws are measured in milliamps (mA). Current draw should be less than 325 milliamps with no circuits active and the ECU, BHM, CHM, and ABS turned off.

**Problem—The Batteries Are Undercharged**

| Problem—The Batteries Are Undercharged | |
|---|---|
| **Possible Cause** | **Remedy** |
| The drive belt is loose. | Check the drive belt and tensioner. Refer to the drive belt subject in the appropriate engine section in **Group 01** for instructions. If necessary, tighten to the manufacturer's specifications.<br>Start the engine and check the alternator voltage and output. Refer to the troubleshooting subject in the alternator section in **Group 15** for instructions. |
| The drive belt is damaged or missing. | Check the drive pulleys for locked bearings. Repair or replace any damaged components. Replace the drive belt and start the engine.<br>Check the alternator voltage and output. Refer to the troubleshooting subject in the alternator section in **Group 15** for instructions. |
| The batteries are undercharged. | Perform a battery test. Charge or replace batteries as needed.<br>If the batteries were discharged, start the engine and check the alternator voltage and output. Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions. |
| The alternator or battery cables are undersized. | Perform a cable load drop test. |
| The alternator is malfunctioning. | Refer to the troubleshooting subject in the appropriate alternator section in **Group 15** for instructions. |
| The isolator relay is not operating correctly (optional battery isolator system only). | Refer to **Group 82, Subject 300** in this manual for instructions. |

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## Battery Troubleshooting

1. **Check battery pack voltage to determine state of charge**.

   If equipped, set Load Disconnect Switch to "Off." With the DMM probes on the positive and negative posts of the battery pack, record the voltage. Due to differences in their design and operation, flooded cell and AGM batteries have different voltages at the same state of charge.

   Batteries should be fully charged before further testing. If batteries are not fully charged, they will draw current to recharge during testing, invalidating the troubleshooting test results. Fully charged batteries ensure reliable diagnosis.

   See **Table 1** for voltage as an approximate indicator of state of charge for AGM and flooded batteries.

   If the battery pack will not charge to 100% state of charge, there may be a shorted cell. Break the pack into individual batteries and test individually using an approved tester. Go to **Check 3, Individual Battery Testing**. After batteries have been tested individually, verify pack voltage once again.

| Flooded | AGM | SoC |
|---|---|---|
| 12.6 | 12.8 | 100% |
| 12.4 | 12.6 | 80% |
| 12.3 | 12.4 | 60% |
| 12.1 | 12.2 | 40% |
| 12 | 12 | 20% |
| 11.8 | 11.8 | 0% |

**Table 1, Voltage to Approximate State of Charge (SoC)**

2. **Remove surface charge: HVAC blower, lights on, 5 min.**

   Surface charge refers to a higher initial charge (volts), when discharging, in recently-charged batteries. This charge is a "shallow" charge, meaning that the charging-induced chemical reaction has mostly occurred at the surface of the lead plates, and has not equalized throughout the lead. Drawing current from the batteries before testing removes the surface charge, allowing for a better assessment of the "deep charge" state of the lead plates.

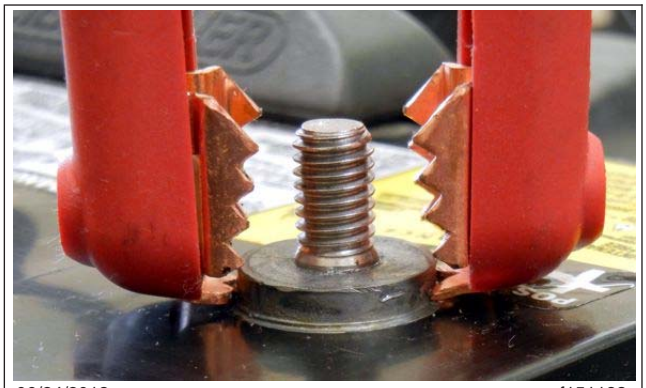
   After the surface charge is removed, the batteries need to be at least 80% SoC for further testing. See **Table 1** for voltage as an approximate indicator of state of charge.

3. **Test Individual Batteries**.

   IMPORTANT: Batteries should only be tested individually.

   3.1 Remove the negative cables of the batteries first, and secure the leads out of the way before touching the positive cables. Remove the battery cables and clean the terminal pads with a wire brush. The adapters will not make sufficient contact with dirty or corroded contact pads.

   3.2 Connect the battery tester's positive and negative clamps to the lead base terminal pads at the positive and negative studs. See **Fig. 1**.



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**Fig. 1, Tester Clamps Attached to the Post**

The threaded portion of the battery posts are *not* the right place to clip: the steel threads won't make a good connection. The base of the post, on the lead, is the best place to clip. Taking a few extra seconds to make sure the tester, DMM, and carbon pile clips are well-connected can be the difference between a useful and a useless test.

NOTE: If the lead base is too small to clamp to, only lead stud adapters should be used, never nuts. The lead stud adapters must be screwed down tight against the cleaned lead base using a

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hand tool. Lead adapters are available at most tool vendors.

Refer to the battery tester instruction manual for complete testing instructions.

If the battery tester requires the CCA rating of the battery, it should be on the battery label. See **Fig. 2**.

3.3 If the battery fails, enter the battery serial number and print out the result. The sensor windows on the tester and printer must be aligned to transmit the test results to the printer.




**Fig. 2, Battery Label**

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## Specifications

See **Table 1** for recharge times. Refer to the commercial batteries page at **www.dekabatteries.com** for more information.

| Recharge Time Using a Typical Charger (hours) | | | | | | |
|---|---|---|---|---|---|---|
| Open Circuit Voltage | | State of Charge | Charger Maximum Rate | | | |
| Flooded | AGM | | 50 Amps | 30 Amps | 20 Amps | 10 Amps |
| 12.6V | 12.8V | 100% | Ready to Use | | | |
| 12.4V | 12.6V | 75% | 0.6 | 0.9 | 1.3 | 2.5 |
| 12.2V | 12.3V | 50% | 1.2 | 1.9 | 2.7 | 5.1 |
| 12.0V | 12.0V | 25% | 1.8 | 2.9 | 4.3 | 10.7 |
| 11.8V | 11.8V | 0% | 2.5 | 4.0 | 5.7 | 10.7 |

**Table 1, Recharge Time Using a Typical Charger**

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# Electrical Systems Troubleshooting

This section covers troubleshooting for the electrical and electronics systems shown in **Table 1**.

NOTE: See **Subject 370** in this section for information on ECC managed systems, installed on vehicles built before January, 2001.

| Table of Contents | |
|---|---|
| **System** | **Subject Number** |
| Gauges and Driver Displays | **300** |
| Fuel and DEF Level Gauges | **310** |
| Coolant Level Sensing | **320** |
| Windshield Wipers and Washer | **330** |
| Turn Signals, 4-Way Flashers, and Brake Lights | **340** |
| Headlights, Tail Lights, DRLs, Dash Backlighting, and Marker Lamps | **350** |
| Power Windows and Door Locks | **360** |
| ECC Managed Systems (Vehicles Built Before January, 2001) | **370** |

**Table 1, Table of Contents**

The Western Star electrical system distributes power to the cab and chassis through the main PDM. This PDM is accessed by removing the panel on the passenger-side dashboard.

The instruments in the dashboard and driver display receive data over the vehicle serial data bus.

The Electronic Control Center (ECC) manages some of the vehicle electronic systems. The ECC does not use serial data communications and is not part of any multiplexed system.

## Electronic Control Center (ECC), 2001 and Newer Vehicles

In January 2001, a revised ECC was introduced. This ECC manages the systems listed below:

- windshield wipers and washers
- turn signals and 4-way flashers
- daytime Running Lamps (DRLs)
- backlighting dimming control
- in-dash warning alarm
- light bar indicators: DRL, High beam, Low air, Park brake, and, unless hardwired; Stop engine, Check engine, Service engine (MIL).

NOTE: All other lightbar indicators are hardwired and not managed by the ECC.

These systems are described in detail in this subject.

**Figure 1** demonstrates the systems with ECC managed inputs and outputs on vehicles manufactured since January, 2001.

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## General Information

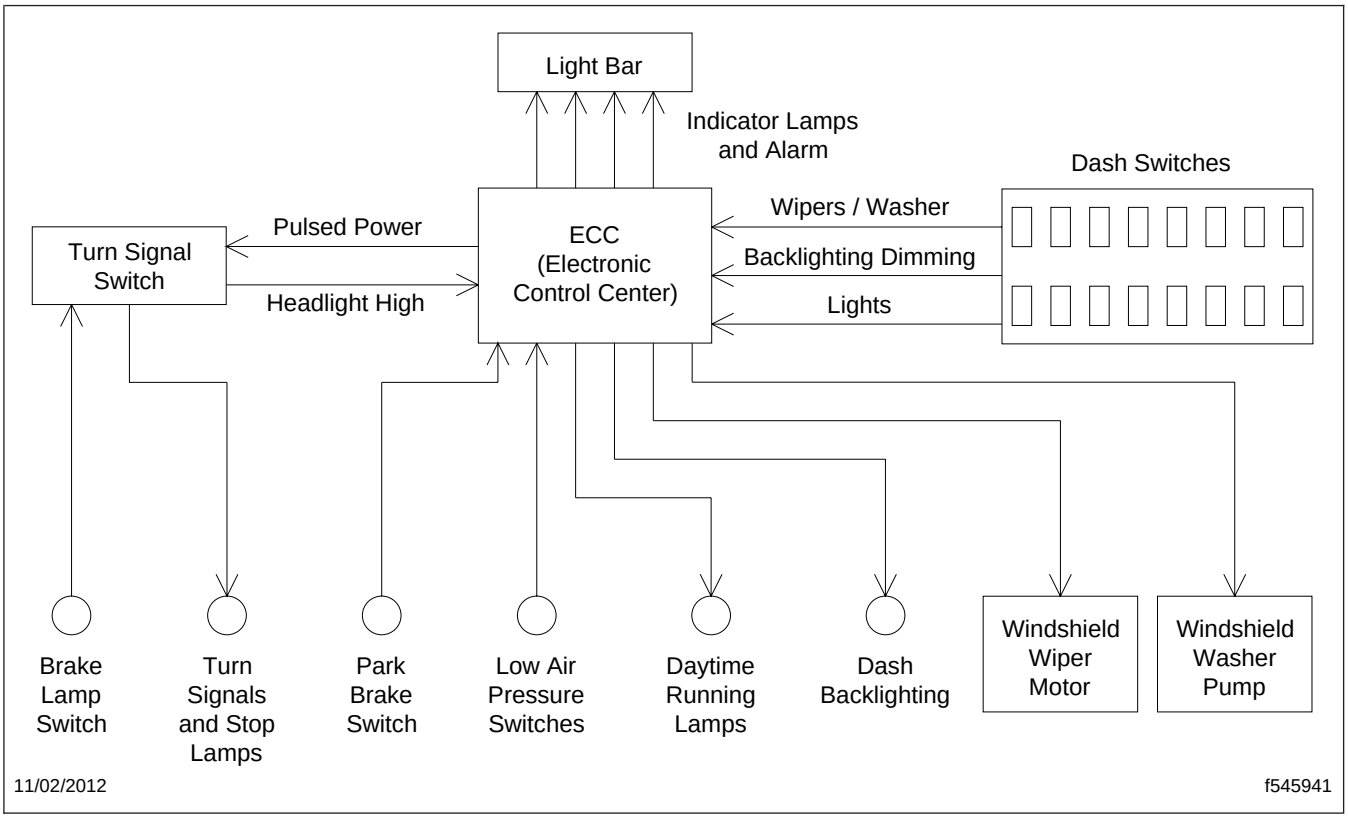



**Fig. 1, ECC Managed Systems**

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## Gauges and Driver Displays

Beginning in January, 2001, the gauges in the instrument panel began using a technology called Star Gauges. The Star Gauges receive data over a single databus that is sourced at the speedometer. The speedometer is a data translator that takes J1587 data input and converts it to Star Gauge data. The figures below show the evolution of instrumentation data routing with the Star Gauge system.

The RX module and the PX module convert voltages, air pressures, and resistances into J1587 serial data for the speedometer and the Datastar.

The indicators in the light bar are all hardwire circuits. **Table 1** shows the lightbar circuit and pin numbers for the standard light bar lamps.

**Table 2** shows ECC functions, and the corresponding pins and circuits.

See **Fig. 1** for a block diagram of the instrumentation topology for vehicles built before April 4, 2005.

See **Fig. 2** for a block diagram of the instrumentation topology for vehicles built after April 4, 2005.

See **Fig. 3** for a block diagram of the instrumentation topology for EPA10 vehicles.

| Light Bar Circuits | | | | |
|---|---|---|---|---|
| **PECA Pin** | **Function** | **Circuit** | **Active** | **Controlled By** |
| 1 | Left Turn Signal | TL04D | High | Turn signal switch |
| 2 | Optional – Top 2 (Water In Fuel) | — | Low | Hardwire input |
| 3 | Optional – Top 3 | — | Low | Hardwire input |
| 4 | Optional – Top 4 | — | Low | Hardwire input |
| 5 | Park Brake | LB03A | Low | ECC connector PECV pin B9 |
| 6 | Tractor ABS - High Input | — | — | Typically not used |
| 7 | Stop Engine | LB01B | Low | Engine ECU and ECC PECV B4 |
| 8 | Trailer ABS | AB68B | Low | Tractor ABS controller |
| 9 | Check Engine | LB02B | Low | Engine ECU and ECC PECV B5 |
| 10 | Malfunction Illumination Lamp (MIL) | EN10A | Low | Engine ECU |
| **PECB Pin** | **Function** | **Circuit** | **Active** | **Controlled By** |
| 1 | High Beam | LB04A | High | ECC connector PECB pin B11 |
| 2 | Daytime Running Lamps | LB08A | Low | ECC connector PECV pin A10 |
| 3 | Ignition Power In | IG04B | — | Hardwire input |
| 4 | Optional – Top 8 | — | Low | Hardwire input |
| 5 | Optional – Top 9 | — | Low | Hardwire input |
| 6 | Right Turn Signal Indicator | TL07D | High | Turn signal switch |
| 7 | Regen | EN02A | Low | Engine ECU |
| 8 | Optional – Top 7 | — | Low | Hardwire input |
| 9 | Wait to Start | — | Low | Engine ECU |
| 10 | High Exhaust Temperature | EN03A | Low | Engine ECU |
| 11 | Ground | GD5U | — | Hardwire input |
| 12 | Tractor ABS – Low Input | AB12B | Low | Tractor ABS controller |
| 13 | Low Air Pressure | LB07A | Low | ECC connector PECV pin B8 |

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## Gauges and Driver Displays

| Light Bar Circuits | | | | |
|---|---|---|---|---|
| **PECA Pin** | **Function** | **Circuit** | **Active** | **Controlled By** |
| 14 | Buzzer | LB09A | High | ECC connector PECV pin B1 |

**Table 1, Light Bar Circuits**

| ECC Connector Pinout | | |
|---|---|---|
| **PECV** | **Function** | **Circuit** |
| A1 | Signal Ground | BA06A |
| A2 | ECC Power In | WW06A |
| A3 | Windshield Washer Switch | IN22A |
| A4 | Backlighting Brighter Switch | WW03A |
| A5 | Wipers High Speed Switch | WW04A |
| A6 | Wipers Low Speed Switch | WW05A |
| A7 | Wipers Intermittent Switch | IN19A |
| A8 | Low Air Pressure Switch In | IG04A |
| A9 | Ignition Power In | LB08A |
| A10 | DRL Indicator to Light Bar | HL04C |
| A11 | High Beam Headlights In | GL2AW |
| A12 | Backlighting PWM Output | LB09A |
| B1 | Buzzer Output | LB09A |
| B2 | Windshield Washer Pump Out | WW10A |
| B3 | Wiper Park Switch In | WW10A |
| B4 | Stop Engine Indicator Out | LB01A |
| B5 | Check Engine Indicator Out | LB02A |
| B6 | Backlighting Dimmer Switch | IN23A |
| B7 | Engine Malfunction Indicator Lamp | — |
| B8 | Low Air Pressure Indicator Out | LB07A |
| B9 | Park Brake Switch Out | LB03A |
| B10 | Park Brake Switch In | IN20A* |
| B11 | High Beam Indicator Out | LB04A |
| B12 | Running Lamps Signal In | IN03D |
| **PECP** | **Function** | **Circuit** |
| A | Turn Signal Pulse Out | TL03A † |
| B | Ground - From Vehicle | GD5T |
| C | Windshield Wiper Low Speed Out | WW09A‡ |
| D | Windshield Wiper High Speed Out | WW08A |
| E | Windshield Wipers Power In | WW11B |
| F | DRL / Backlighting Power In | HL08J |

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| ECC Connector Pinout | | |
|---|---|---|
| G | DRL Output | HL05B |
| H | Turn Signal Power In | TL11A |
| **PECE** | **Function** | **Circuit** |
| A | Engine Malfunction Indicator Lamp | — |
| B | Check Engine Indicator In | MBE34A or 440A |
| C | Stop Engine Indicator In | MBE33A or 440S |
| D | Spare Alarm – | — |
| E | Spare Alarm + | — |
| F | Spare Alarm + | — |
| G | Park Brake - Low Side Out | MBE31A or 440X |
| H | Ground - From Vehicle | MBE09R or 440G |

* Ground when brake is applied.

† 90 pulses per minute when load is applied.

‡ 6-second intervals in intermittent mode; changes when interrupted less than 1 second, or 1 to 25 second.

**Table 2, ECC Connector Pinout**

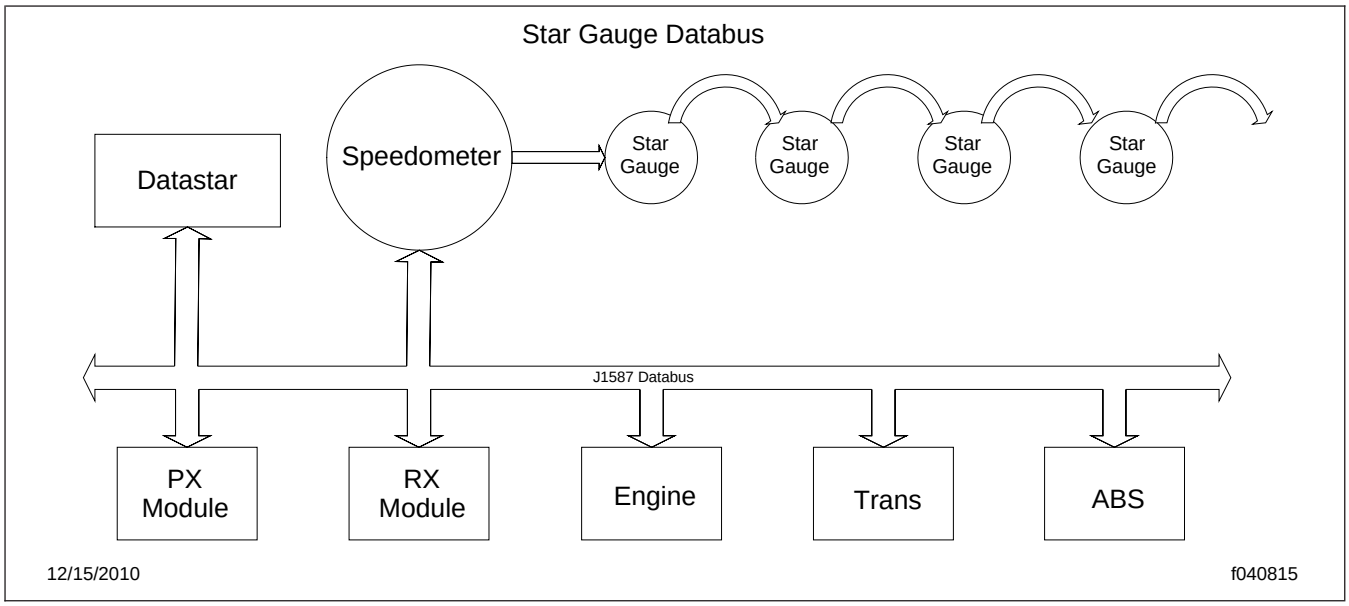



**Fig. 1, Instrumentation Topology (Pre-April 4, 2005)**

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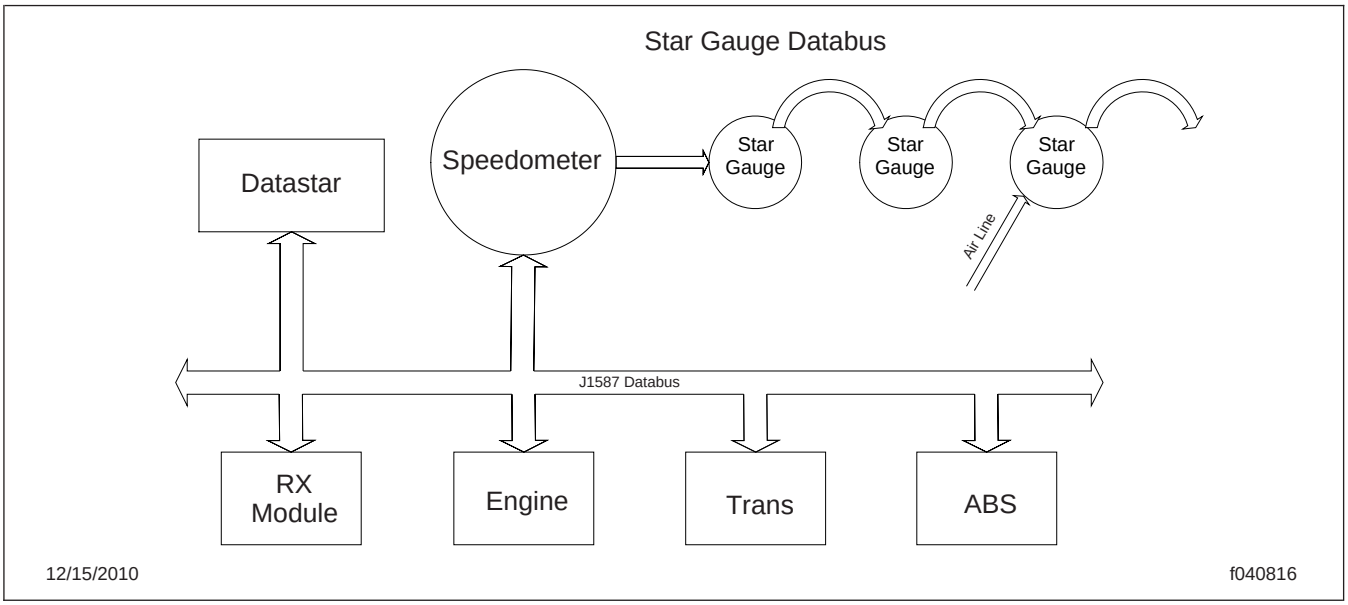



**Fig. 2, Instrumentation Topology (April 4, 2005 through December 2009)**

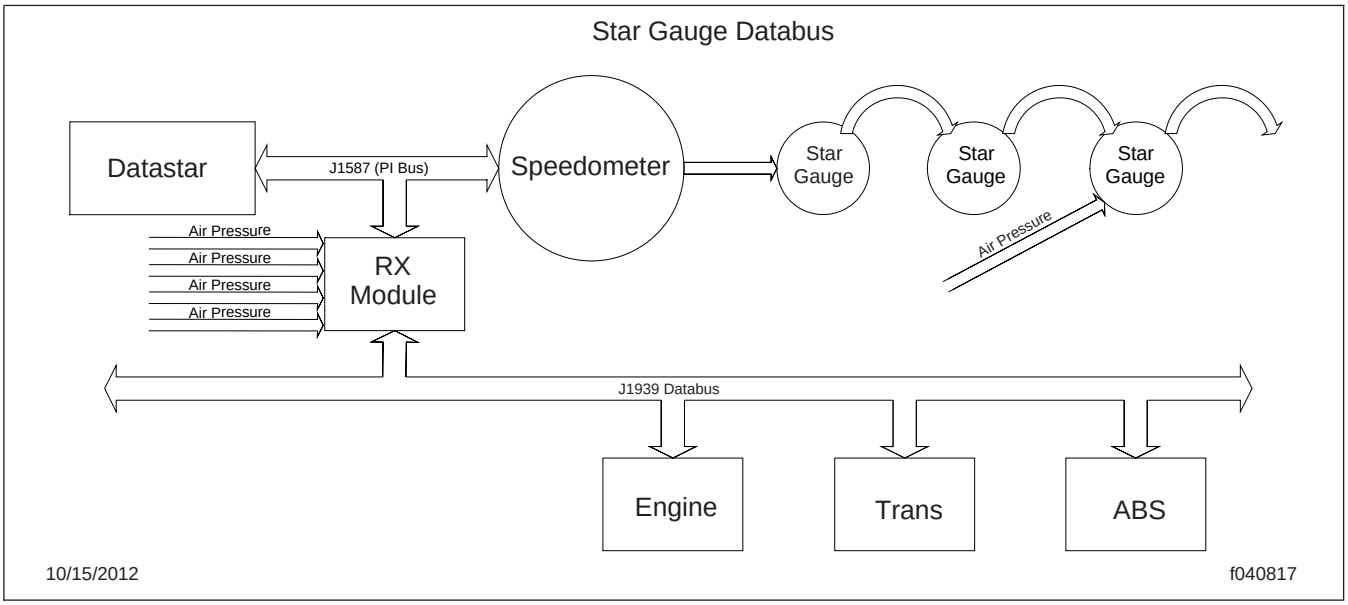



**Fig. 3, Instrumentation Topology (EPA10)**

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## Fuel and DEF Level Gauges

Refer to **Section 54.03** in this manual for additional fuel and DEF level troubleshooting information and for all the other Star Gauges.

The fuel level gauge is driven by data over the Star Gauge databus. The speedometer converts J1587 data into Star Gauge data. The RX module converts the variable resistance from the fuel level sender into J1587 data. See **Fig. 1** for a diagram of this data exchange.

Beginning with the EPA10 models, the RX module broadcasts its data over a private databus called the PI bus to the speedometer and the datastar. This databus operates like J1587 but is not connected to the vehicle diagnostic connector. EPA10 vehicles also use the RX module to translate DEF level data received from the engine/ACM on the J1939 databus into PI bus data.

See **Table 1** for fuel and DEF level circuit connections.

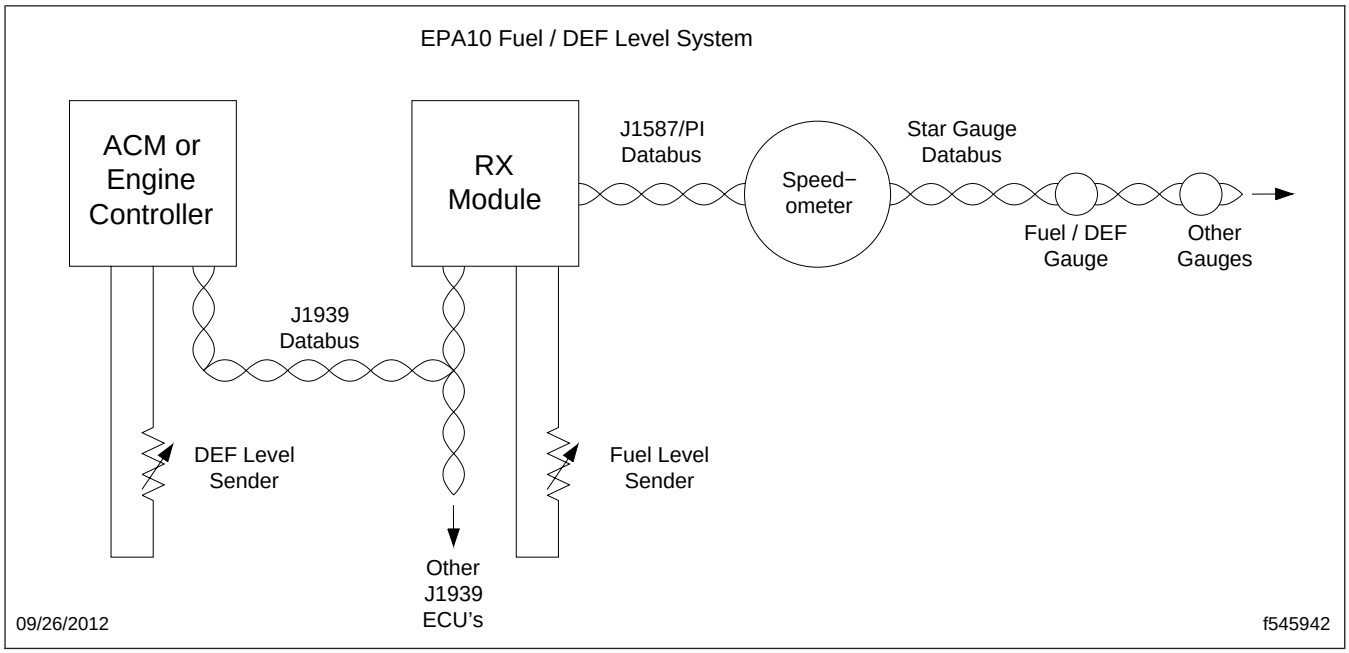



**Fig. 1, Fuel and DEF level sensing and display**

| Fuel and DEF Level Circuit Connections | | |
|---|---|---|
| **Function** | **EPA07 and Earlier Conn/Pin** | **EPA10 Conn/Pin** |
| Fuel Level Signal | RX module pin 15 | RX Module conn 2, pin G |
| Fuel Level Ground | Cab Ground | RX Module conn 2, pin H |
| DEF Level Signal | Not applicable | Use specific vehicle schematic |

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## Fuel and DEF Level Gauges

| Fuel and DEF Level Circuit Connections | | |
|---|---|---|
| **Function** | **EPA07 and Earlier Conn/Pin** | **EPA10 Conn/Pin** |
| DEF Level Ground | Not applicable | Use specific vehicle schematic |
| J1939 High | Not applicable | RX Module conn 1, pin F |
| J1939 Low | Not applicable | RX Module conn 1, pin E |
| J1587 + | RX module pin 3 | RX Module conn 1, pin H |
| J1587 – | RX module pin 6 | RX Module conn 1, pin G |
| J1587 + | Speedometer 6-wire connector, pin 5 | Speedometer 6-wire connector, pin 5 |
| J1587 – | Speedometer 6-wire connector, pin 6 | Speedometer 6-wire connector, pin 6 |
| Star Gauge Data | 3-wire conn, pin 2 | 3-wire connector, pin 2 |
| Star Gauge + (IGN voltage) | 3-wire conn, pin 1 | 3-wire connector, pin 1 |
| Star Gauge – | 3-wire conn, pin 3 | 3-wire connector, pin 3 |

**Table 1, Fuel and DEF Level Circuit Connections**

# Fuel Level System Troubleshooting

Disconnect the fuel level sender connector at the fuel tank and place a 100Ω resistor across the two circuits in the harness connector. Turn the ignition to the ON position without starting the engine. If the fuel gauge points close to the 1/2-tank mark, the wiring, RX module, J1587 data, and all dash components are working properly. When these tests all pass, focus on troubleshooting the fuel level sending unit.

When the RX module reads a resistance that is out of range high or out of range low from the fuel level sender, it broadcasts a data message to the speedometer that will position the fuel gauge at empty. The EPA10 RX module also broadcasts fuel level position over the J1939 data bus. The fuel level position can be seen using the instrumentation template in ServiceLink. If the EPA10 RX module fuel level sender resistance is out of range low or high, it stops broadcasting fuel level position over the J1939 data bus. The ServiceLink template will show a yellow triangle over the fuel gauge display in this instance.

See **Section 54.03** in this manual for additional information on fuel level and gauge troubleshooting.

# DEF Level System Troubleshooting

If the vehicle has been parked for an extended period, it is possible that DEF has crystallized in the sending unit and on the float, and is causing it to stick. Remove the DEF tank and then the float header assembly from the DEF tank. If the failure is a stuck float due to DEF crystallization, the float header assembly and DEF tank can be cleaned and reinstalled. Use warm water to wash the tank, float, and sensor shaft, then use fresh DEF to refill the tank.

After cleaning, use an ohm meter to test the resistance of the DEF level sensor at the top of travel, midpoint, and bottom of travel. See **Table 2** for measuring the DEF level sender resistance.

| DEF Level Sensor Resistance Measurement | | |
|---|---|---|
| **Function** | **Vehicles with a Detroit Engine** | **Vehicles with a Cummins Engine** |
| Measure at sensor pins | Pins 1 and 2 | Pins 1 and 4 |
| Resistance with float at top of travel | ~19800Ω | ~ 70Ω |
| Resistance with float at center of travel | ~2000Ω | ~700Ω |

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| DEF Level Sensor Resistance Measurement | | |
|---|---|---|
| **Function** | **Vehicles with a Detroit Engine** | **Vehicles with a Cummins Engine** |
| Resistance with float at bottom of travel | ~240Ω | ~4810Ω |

**Table 2, DEF Level Sensor Resistance Measurement**

Both Cummins and Detroit engine systems log fault codes for low DEF level and for DEF level circuitry errors. If the fault code is for low DEF level, turn the ignition OFF and refill the DEF tank. It may take several minutes before the new DEF level will be indicated on the gauge. The DEF level sensing circuitry is heavily buffered to prevent excessive gauge movement. See **Table 3** for DEF level fault codes from SA 0 or SA 61.

| DEF Level Faults from SA 0 or SA 61 | | | | |
|---|---|---|---|---|
| **SPN** | **FMI** | **Description** | **Behavior** | **Action** |
| 1761 | 1<br>17<br>18<br>31 | DEF Level Low | The DEF level is low. MIL, CEL, STOP engine lamp, and engine derate may be active. | The DEF tank has run too low. Fill the DEF tank so that it is at least 25% full and idle the engine for 5 minutes. If the DEF tank was not empty or low, use the troubleshooting procedure described above. Also see gauge troubleshooting in **Section 53.03** of this manual. |
| 1761 | 3 | DEF Level Circuit Out of Range High | The voltage on circuit 532F is greater than expected or the circuit is open. | Troubleshoot circuit 532F and 532F– between the ACM/Engine ECU and the DEF level sensor for a wiring fault and also test for an open level sensor unit. |
| 1761 | 4 | DEF Level Circuit Out of Range Low | The voltage on circuit 532F is close to 0 volts. | Troubleshoot circuit 532F from the DEF level sensor for a wiring fault and also test for a shorted level sensor unit. |

**Table 3, DEF Level Faults from SA 0 or SA 61**

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# Coolant Level Sensing

## Float Type Sensor in Cowl-Mounted Surge Tank

**CAUTION**

**Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.**

The coolant level sensor float operates a switch in the sensor body. When the float is up the switch is closed and the resistance across the sensor will measure approximately 130Ω. When the float is down, the switch is open and sensor resistance will measure approximately 1200Ω. See **Fig. 1**.

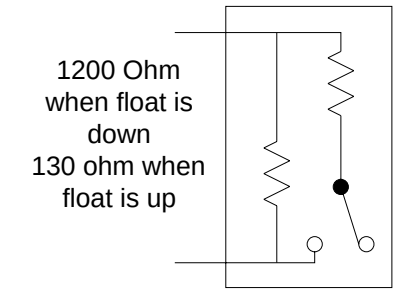
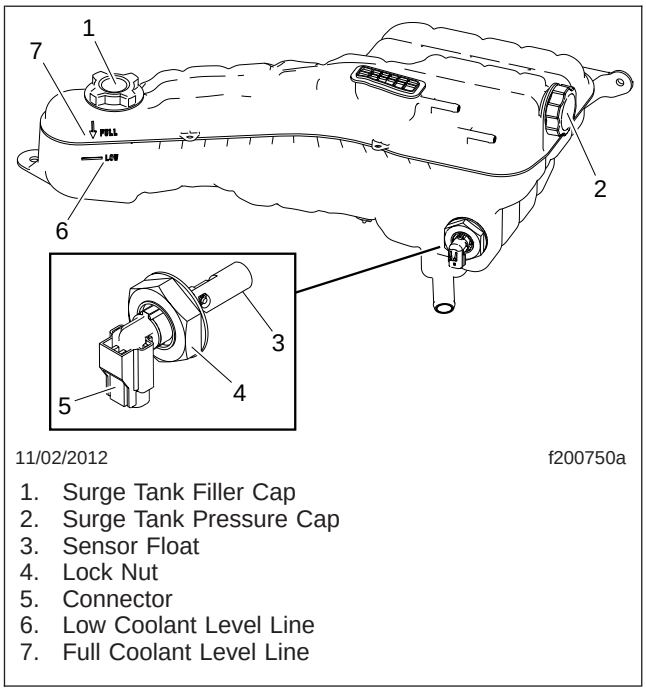



**Fig. 1, Low Coolant Level Sensor Resistance Measurement**

Many vehicles will indicate low coolant level if the coolant is not filled to the full line on the surge tank. Even if the coolant level is above the low line, the amount of coolant is too low unless it is filled to full. See **Fig. 2**.

Sensor operation may also be measured by back-probing circuit 440L with a volt meter. Turn the ignition to ON but do not start the engine. When the float is up, the circuit will measure 1.25 +/- 0.5 volts and when the float is down, 3.75 +/- 0.5 volts.




1. Surge Tank Filler Cap
2. Surge Tank Pressure Cap
3. Sensor Float
4. Lock Nut
5. Connector
6. Low Coolant Level Line
7. Full Coolant Level Line

**Fig. 2, Low Coolant Level Sensor Installation**

If voltage or resistance measurements are not as stated above, check the sensor for the following failure modes:

- The float axle is worn, causing the magnet to be too far from the sensor body.
- The float is sticking to the axle, preventing it to properly track coolant level.
- The alignment tabs on the sensor are damaged, causing the sensor to be improperly aligned in the tank.

Refer to **Table 1** for coolant level sensor fault codes.

| Coolant Level Sensor Fault Codes | | | |
|---|---|---|---|
| **SPN** | **FMI** | **Description** | **Troubleshooting** |
| 111 | 1 | Coolant level is low, or engine ECU may need software update | Use the engine manufacturers diagnostic software program to determine if software or calibration updates are necessary. Check for coolant leaks. Inspect the coolant level in the reservoir and add if it is below the full line. When it is safe to start the engine, inspect the coolant level in the reservoir. |

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## Coolant Level Sensing

| Coolant Level Sensor Fault Codes | | | |
|---|---|---|---|
| **SPN** | **FMI** | **Description** | **Troubleshooting** |
| 111 | 3 | Coolant level sensor circuit voltage out of range high | Troubleshoot circuit 440L and circuit 440G for a wiring fault between the sensor and the engine ECU. This code indicates the circuit is shorted to a voltage source or that the circuit is high resistance or open. |
| 111 | 4 | Coolant level sensor circuit voltage out of range low | Troubleshoot circuit 440L for a wiring fault. This code indicates the circuit is shorted to ground. |
| 111 | 17 | Coolant level is low | Check for coolant leaks. Inspect the coolant level in the reservoir and add if it is below the full line. When it is safe to start the engine, inspect the coolant level in the reservoir. |
| 111 | 18 | Coolant level is low | Check for coolant leaks. Inspect the coolant level in the reservoir and add if it is below the full line. When it is safe to start the engine, inspect the coolant level in the reservoir. |
| 111 | 19 | Coolant level may be low | Check for coolant leaks. Inspect the coolant level in the reservoir and add if it is below the full line. When it is safe to start the engine, inspect the coolant level in the reservoir. |

**Table 1, Coolant Level Sensor Fault Codes**

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# Windshield Wiper and Washer System

The windshield wiper switches receive ignition power through fuse F24. The wiper and washer motors receive battery power through fuse F17. The motor power is input to the ECC on connector PECP pin E. The ECC manages wiper delay timing based on the amount of time the intermittent switch is interrupted.

- Place the intermittent switch in the intermittent position, and the wipers will swipe once every 6 seconds.
- Place the intermittent switch in the off position for less than 1 second before returning it to the intermittent position, and the wipers will swipe every 1 second.
- Place the intermittent switch in the off position for any time period between 1 second and 25 seconds, and the wipers will swipe at the interval that the switch was in the off position.
- Place the intermittent switch in the off position for any time period between 25 seconds and 50 seconds, and the wipers will swipe once every 25 seconds.

See **Fig. 1** for a windshield wiper and washer system schematic.

The park circuit is switched to ground by the wiper motor when the wipers are at the bottom of travel. The circuit floats to battery voltage during the wiper sweep. Wiper motor high speed power is connected to the motor at pin A. Low speed power is connected at pin B.

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## Windshield Wiper and Washer System

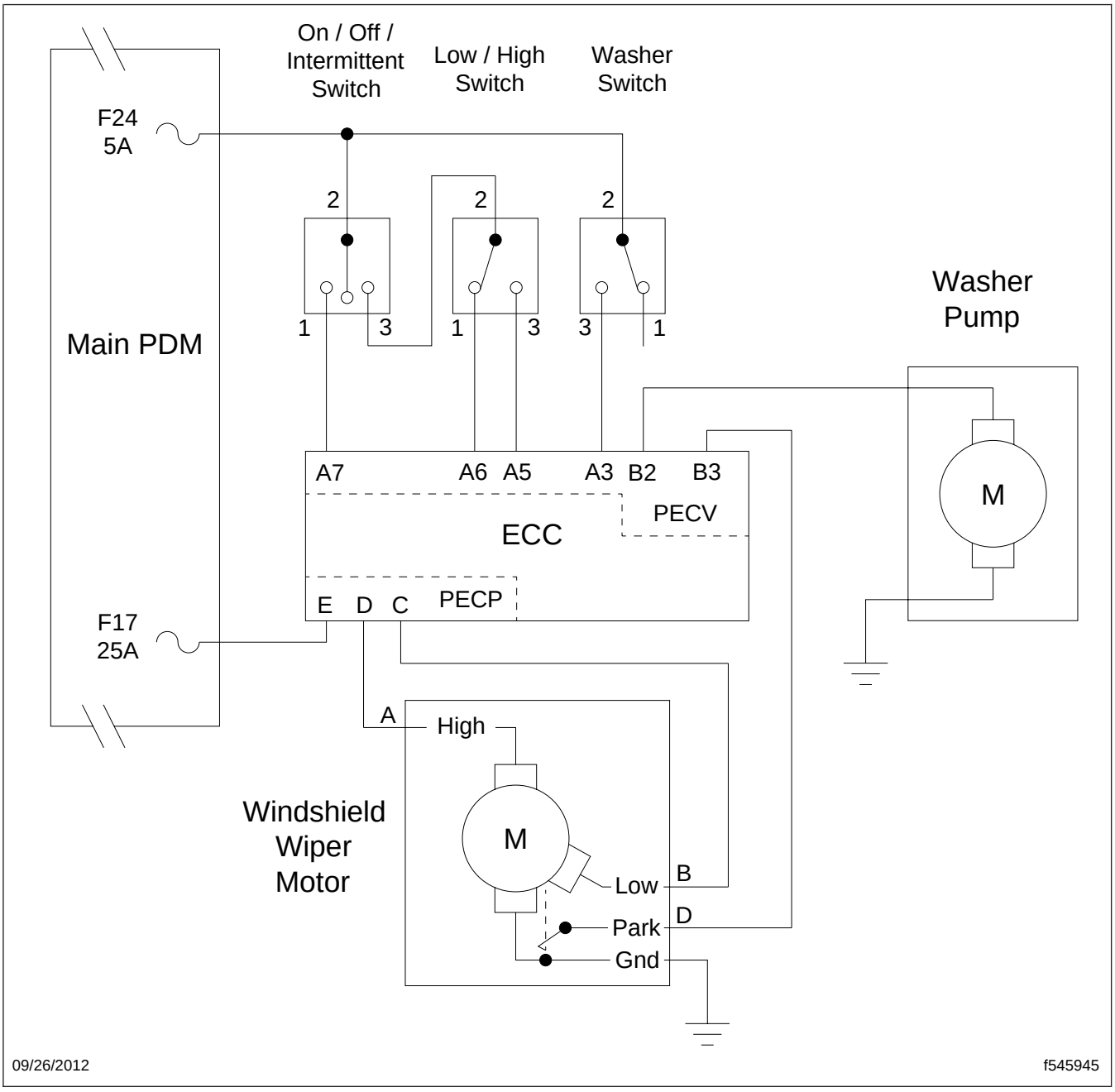



**Fig. 1, Windshield Wiper and Washer System Schematic**

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# Turn Signals, 4-Way Flashers, and Brake Lights

The turn signals and 4-way flashers operate through a combination of the ECC and the turn signal switch. The brake lights are powered through a relay that is controlled by the brake light switch. Brake lights are routed through the turn signal switch. On vehicles with combination rear stop/turn lamps, the tractor brake light signal is interrupted by the turn signal switch when the switch is active. Trailer turn signals are not combined with brake lamps. The turn signal indicators in the dash display are powered from the front turn signal circuits.

The power for turn signals and 4-way flashers is sourced through the ECC. When the turn signals or 4-way flashers are switched on, the ECC generates a 90 pulse per minute signal to power the lights.

See **Fig. 1** for a system schematic.

Western Star has designed and wired the 4-way emergency flashers so that the brake lights will override the flashers. In some vocations, customers prefer that the 4-way flashers remain flashing during use of the service brakes. In order to accomplish this, the red jumper wire used to activate this circuit is cut and the ends taped. See **Fig. 2**. Both methods of wiring comply fully with Canada and USA regulations.

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## Turn Signals, 4-Way Flashers, and Brake Lights

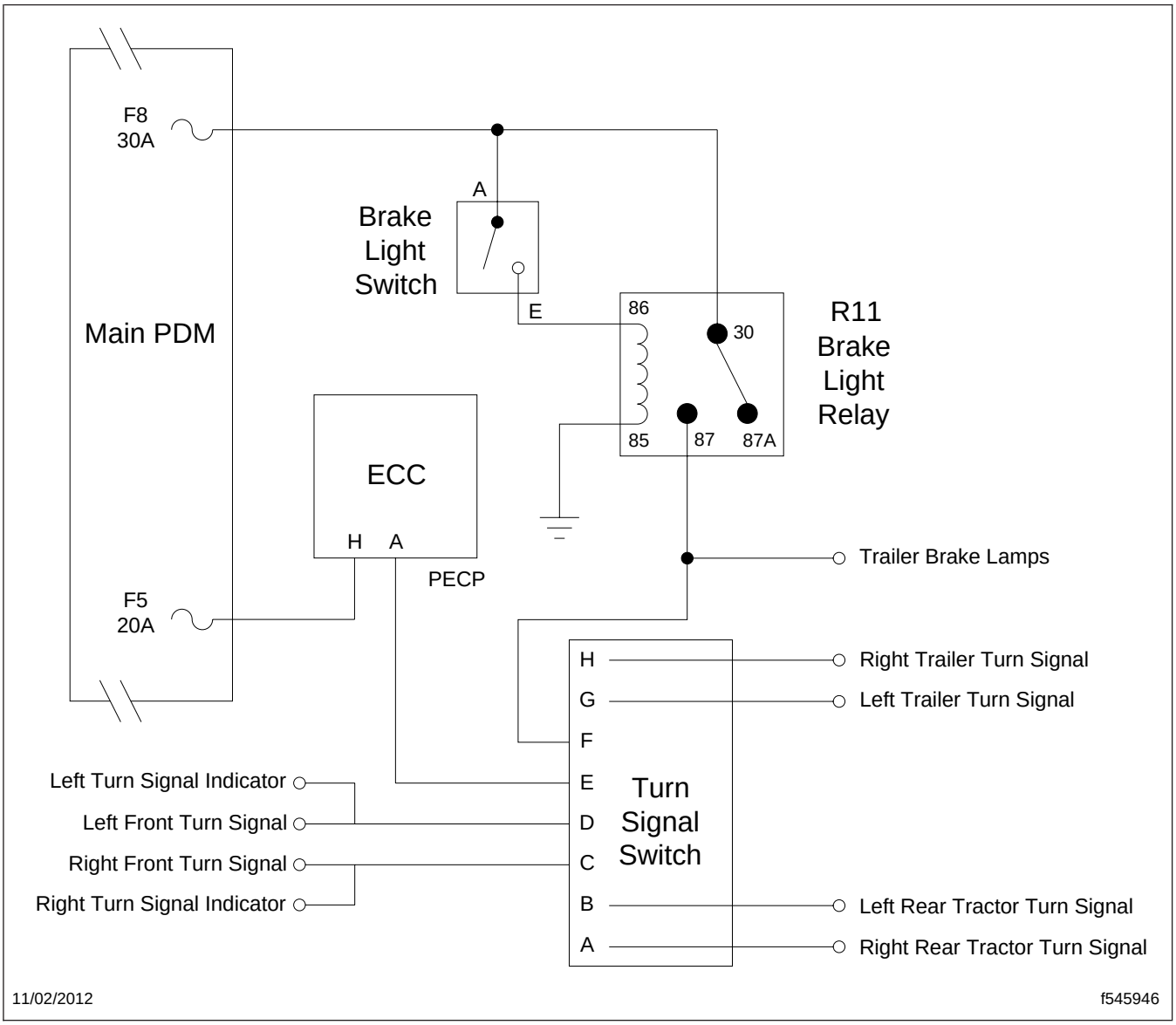
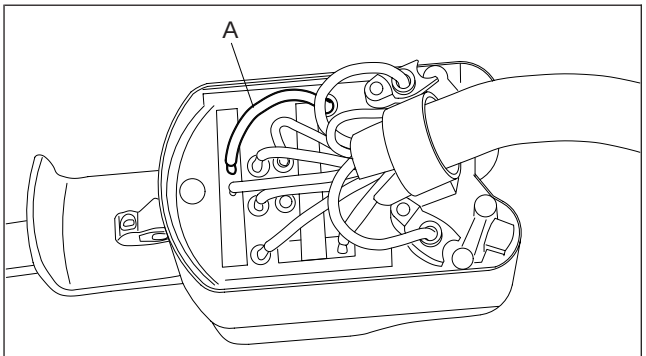



**Fig. 1, Turn Signal, 4-Way Flashers, and Brake Lights System Schematic**

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A. The red jumper wire is cut and taped for the stop lights to remain flashing when the hazard flashers are on and the service brakes are applied

**Fig. 2, Turn Signal Switch**

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# Headlights, Tail Lights, Marker Lights, DRLs, and Backlighting

The daytime running lamps (DRLs) are activated when the headlights are off and the park brake is not applied. The ECC monitors these inputs and activates the DRLs. The DRL output from the ECC is connected directly to the low beam circuit after the low beam relay.

See **Fig. 1** for a system schematic.

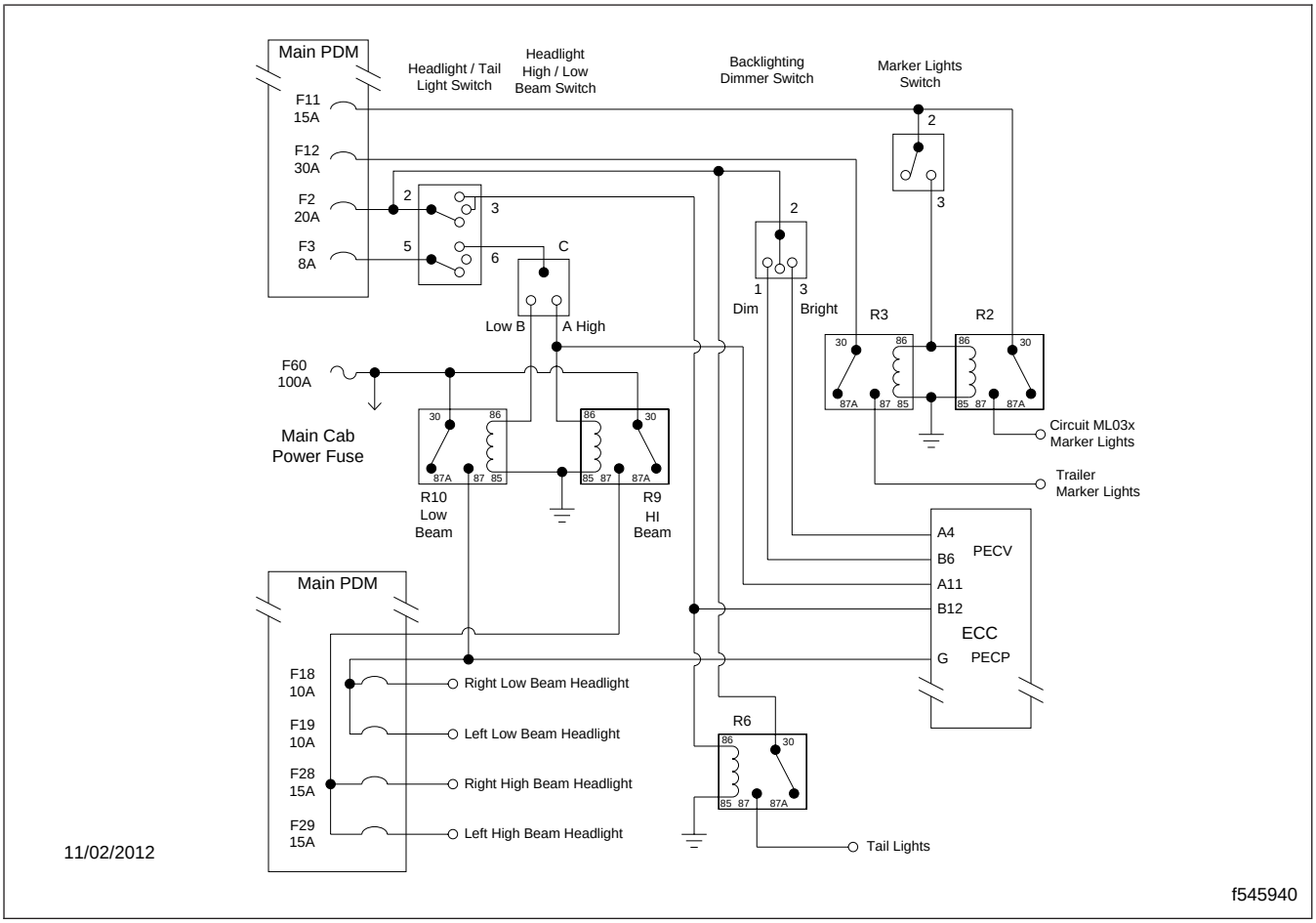



**Fig. 1, Headlights, DRLs, Tail and Marker Lamp Schematic**

The exterior lighting circuits are protected with self resetting circuit breakers located in the main PDM.

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# Power Windows and Door Locks

The polarity of the power to the window motors is reversed when operating the window up versus down. Power door locks operate similarly, with polarity reversed to lock versus unlock. The remote keyless entry lock system is described in detail, including key fob programming instructions, in **Section 54.10** in this manual.

See **Fig. 1** for a power window schematic for vehicles with the power window switches in the dash. See **Fig. 2** for a power window schematic for vehicles with the switches in the doors.

When the power door lock switches are in the neutral position, pins 5 and 7 are internally connected. Pins 4 and 6 are also connected when the switch is in the neutral position. This wiring method prevents damage if one switch is activated in the lock direction while the other switch is activated in the unlock direction.

See **Fig. 3** for power door locks without keyless entry, and **Fig. 4** for door locks with keyless entry.

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## Power Windows and Door Locks

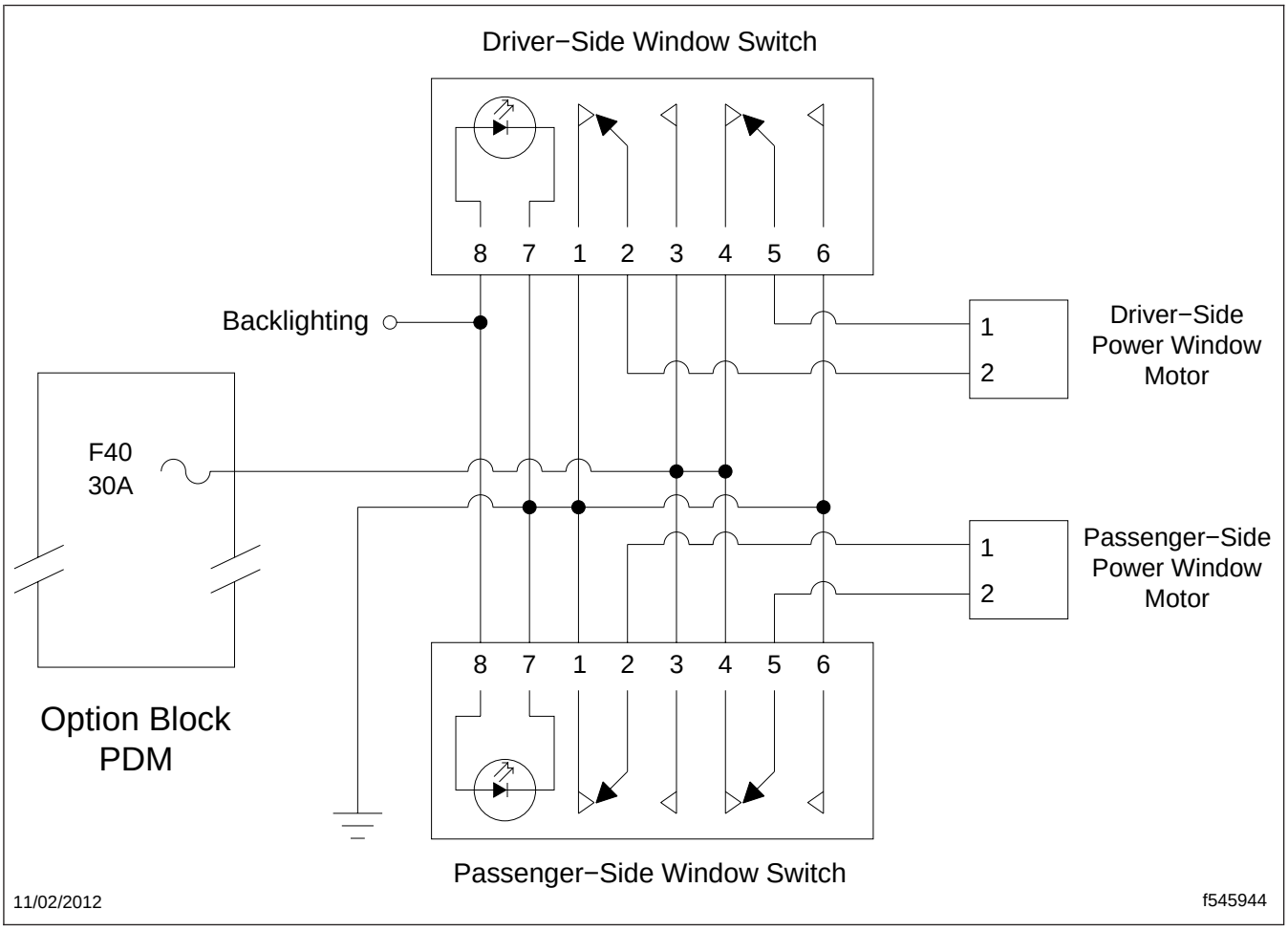



**Fig. 1, Power Windows With Switches on the Dash**

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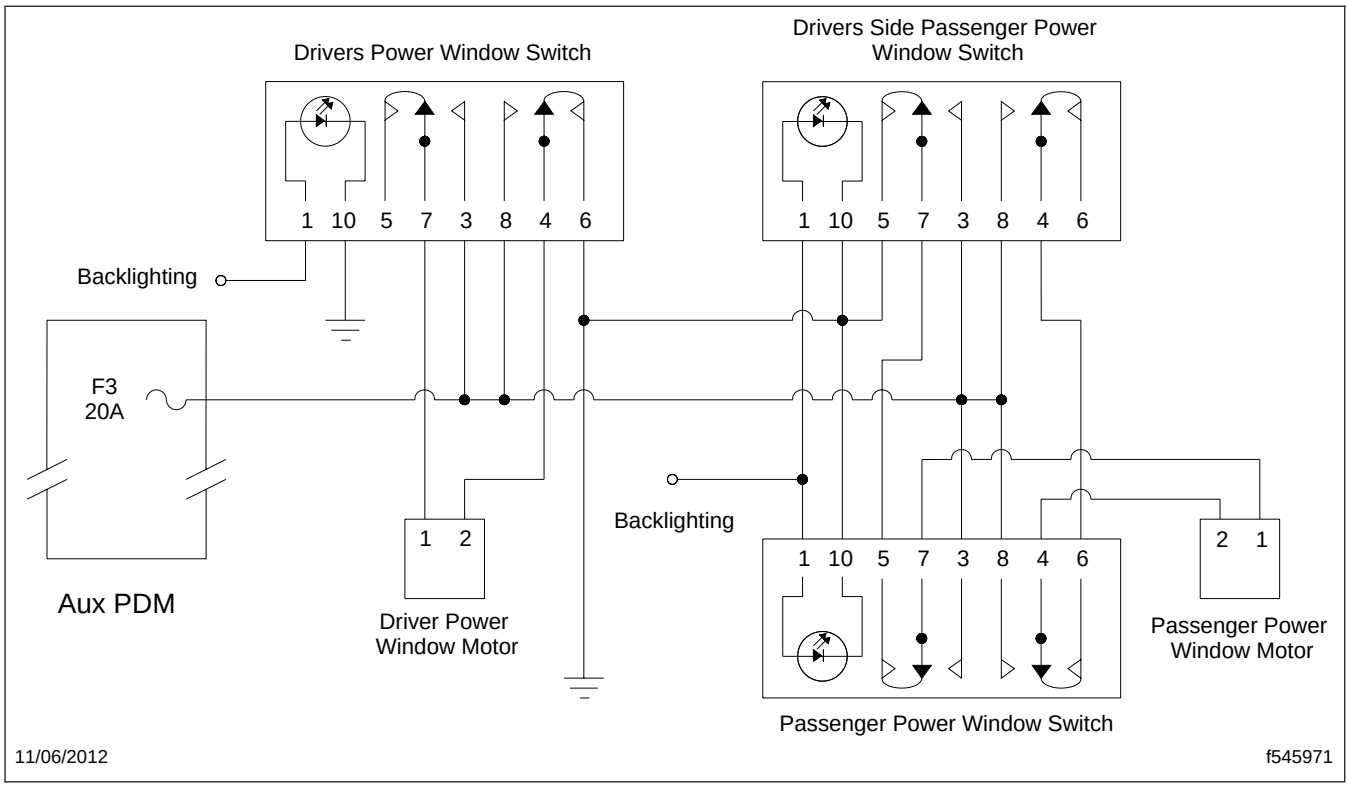



**Fig. 2, Power Windows with Switches in the Doors**

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## Power Windows and Door Locks

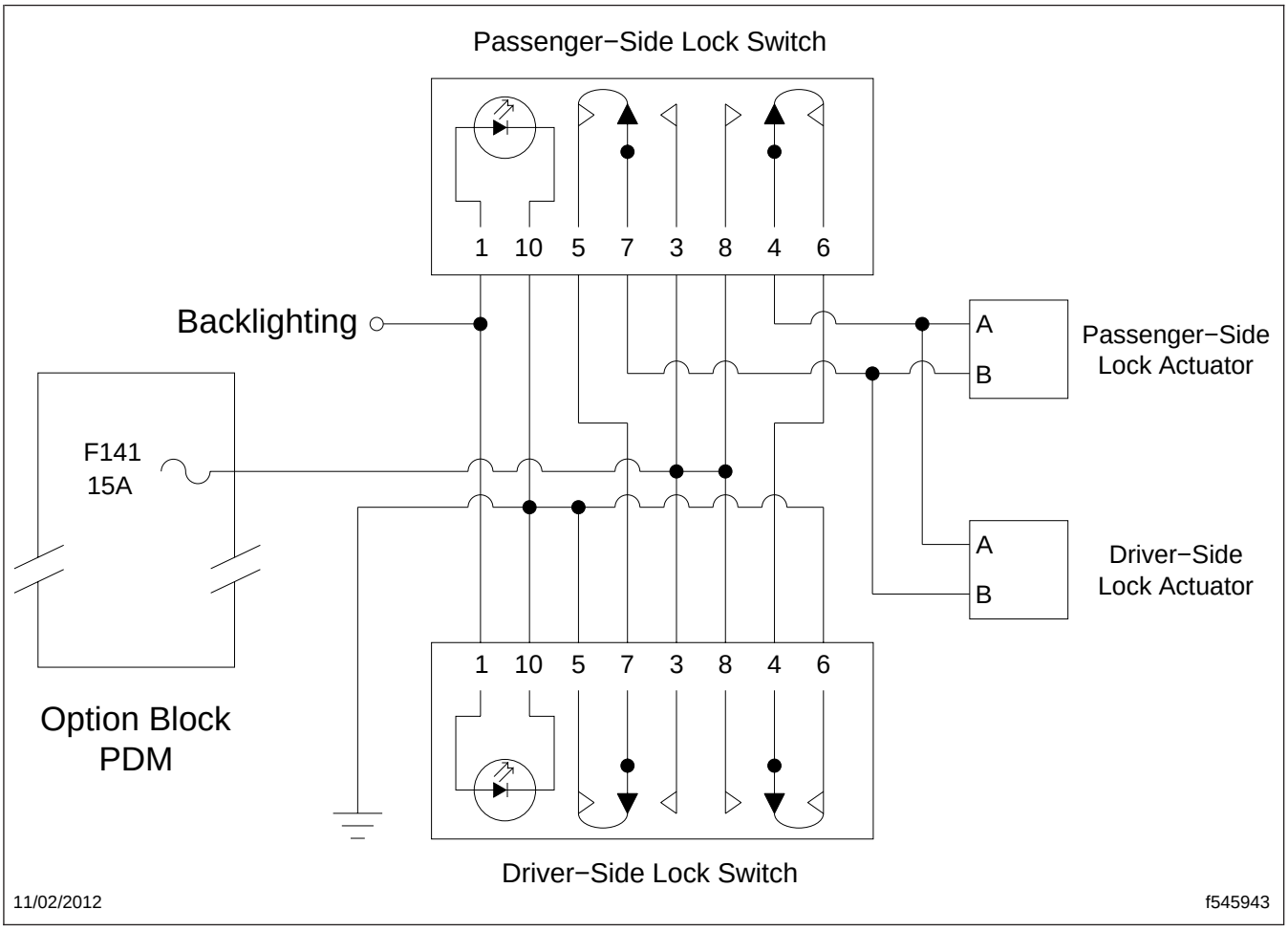



**Fig. 3, Power Door Locks without Keyless Entry**

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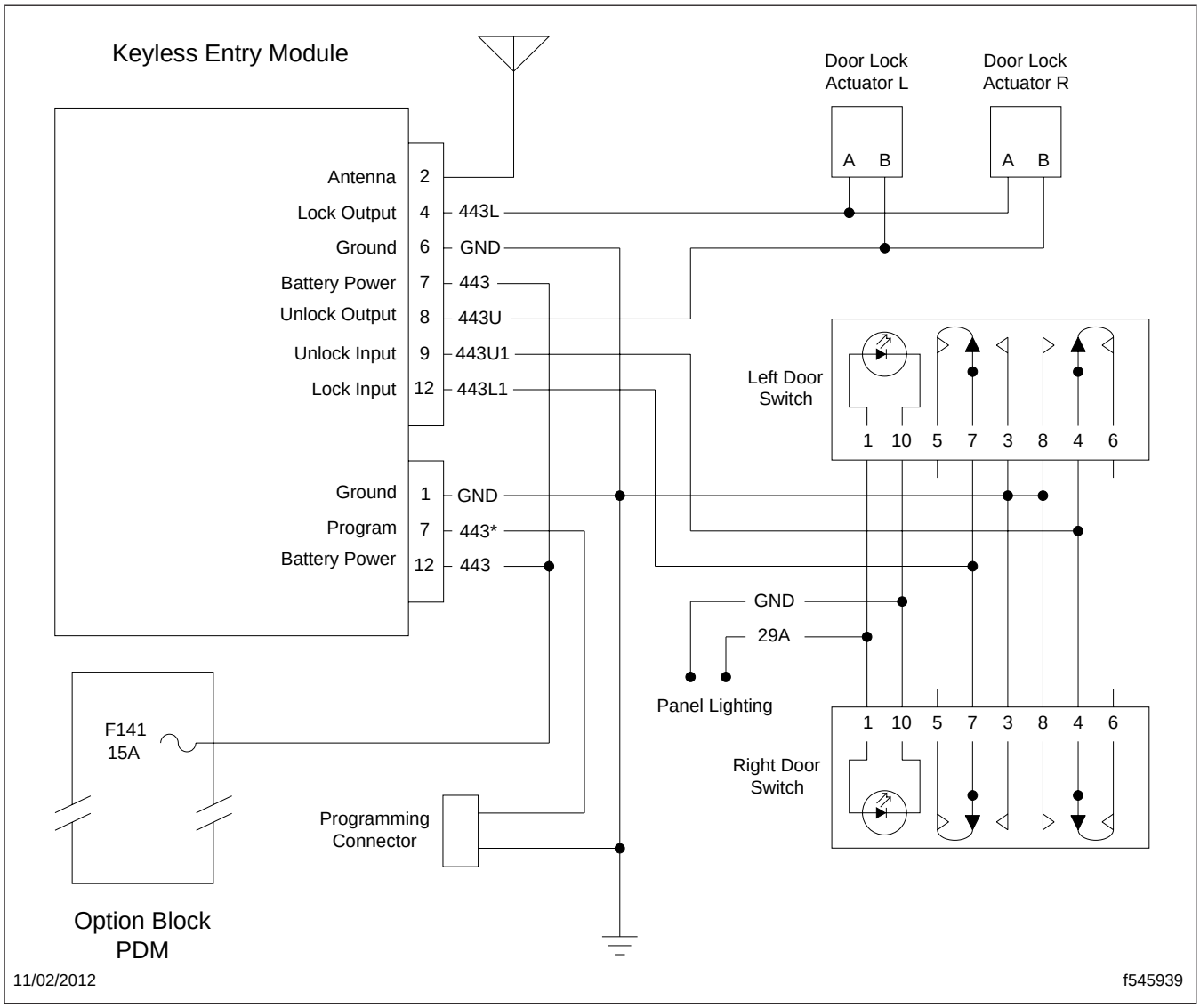



**Fig. 4, Power Door Locks with Keyless Entry**

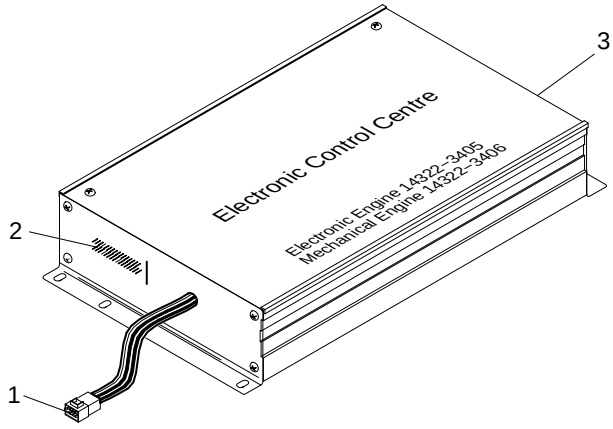
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# ECC Managed Systems (Vehicles Built Before January, 2001)

## Non-Star Gauge ECCs

ECCs (electronic control centers) used before January 2001 or with non-Star Gauge gauges (Teleflex gauges), control the dash gauges and the warning/indicator display center. See **Fig. 1**. There are two different types of non-Star Gauge ECCs; one for mechanical engines, and one for electronic engines. They are located behind the main dash panel, behind the speedometer and tachometer.




10/22/2002 f544156

1. JECP Black
2. JECV Blue
3. JECE Yellow (Electronic Engine) or Green (Mechanical Engine)

**Fig. 1, Non-Star Gauge ECCs**

The non-Star Gauge ECCs control the following:

- gauges
- windshield wipers/washer
- dash illumination
- daytime running lamps
- engine shutdown
- engine warning/indicator display center
- park brake output and indicator
- low air pressure alarm

## Non-Star Gauge ECC Tests

These tests only apply to ECCs that were used with the non-Star Gauge instrumentation system (Teleflex gauges). This ECC tester only works on the non-Star Gauge ECCs.

The ECC tests are meant to determine if the ECC is functioning correctly. The tester sends and receives signals from the ECC, identifying if the ECC is functioning properly. These tests can determine if an electrical issue is caused by wiring or the ECC.

The ECC tester ( **Fig. 2**) is designed to simulate the engine signal inputs and outputs of the Western Star trucks to verify the proper operation of the ECC.

The tester can also check the operation of the LED lightbar indicators and alarms. Connecting the black connector on the 24-wire harness of the tester to the lightbar should activate the alarms and every indicator at the same time.

To test an ECC, first determine if the ECC has come from a truck with an electronic or a mechanical engine. An electronic engine ECC has a yellow JECE connector. A mechanical engine ECC has a green JECE. See **Fig. 3**.

Some tests may require access inside the ECC to temporarily change jumper or DIP switch settings, or to view the status of the red input and green output LED indicators. Access can be gained by removing the four screws from the end plate attached to the sliding cover plate. This cover should be removed before the yellow or green harness connector on the tester is attached to the ECC. Also note that the LED indicators are identified on the inside of the cover plate. See **Fig. 4** for an LED map of an electronic engine ECC for vehicles built from November 8, 1995, through October 6, 1996. See **Fig. 5** for an LED map of a mechanical engine ECC. See **Fig. 6** for an LED map of an electronic engine ECC for vehicles built after October 6, 1996.

### Connecting the Tester to the ECC

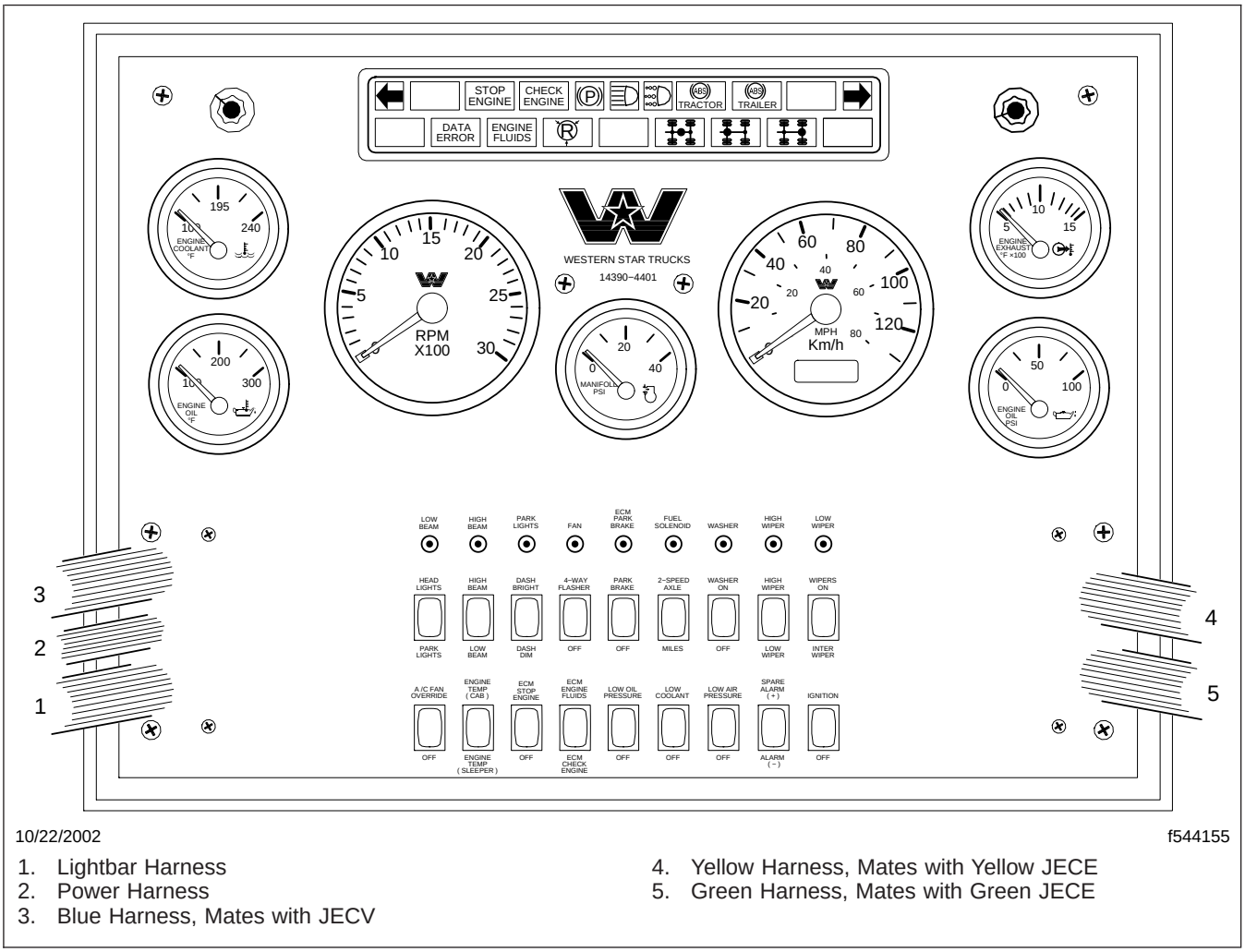
Disconnect the ECC from the truck by unplugging the black eight-way harness first, then the two large harnesses.

Connect the female blue PECV tester harness ( **Fig. 7**) to the mating male blue JECV connector of the ECC ( **Fig. 8**).

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## ECC Managed Systems (Vehicles Built Before January, 2001)




10/22/2002 f544155

1. Lightbar Harness
2. Power Harness
3. Blue Harness, Mates with JECV
4. Yellow Harness, Mates with Yellow JECE
5. Green Harness, Mates with Green JECE

**Fig. 2, ECC Tester**

If the ECC is from an electronic engine, connect the female yellow PECE tester harness ( **Fig. 9**) to the mating male yellow JECE connector of the ECC ( **Fig. 10**).

If the ECC is from a mechanical engine, connect the female green PECE tester harness ( **Fig. 11**) to the mating male green JECE connector of the ECC ( **Fig. 12**).

Plug the tester female black PECP connector ( **Fig. 13**) into the ECC short black JECP pigtail ( **Fig. 14**).

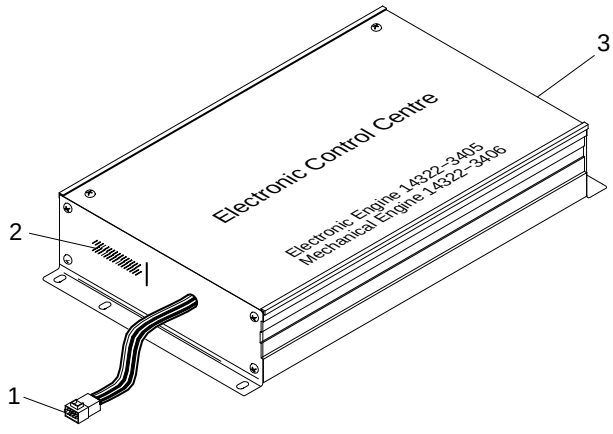
Supply battery power from the truck to the tester by plugging the two wire black connector of the tester into the eight way female black connector on the truck that was disconnected previously.

For bench testing, a two-wire harness should be made to supply 12 volts to the ECC tester. See **Fig. 15**. A switch is placed in the harness to ensure that a full uninterrupted 12 volts is supplied to the ECC tester.

NOTE: Do not use alligator clips to power the ECC tester. Connecting the power could cause a low voltage error to the ECC.

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1. JECP Black
2. JECV Blue
3. JECE Yellow (Electronic Engine) or Green (Mechanical Engine)

**Fig. 3, Engine ECC**

To check the operation of the speedometer and tachometer on a mechanical engine ECC, the DIP switches must be set before the ignition is switched on.

NOTE: Record the original DIP switch settings before setting them.

All the dip switches should be set to off, except for DS2-1 and DS2-2. The ECC reads these switches when the ignition is first turned on. See **Fig. 16**.

The ECC also has features that can be enabled or disabled by jumpers, and must be enabled to fully test. The ends of the jumpers are coded ENA for enable, and DIS for disable. See **Fig. 17**. The jumpers consist of three pins and a cap. The cap is placed over two pins. To enable or disable a jumper function, slide the cap off and place it over the other two pins.

# Tests for Both Electronic and Mechanical Engines

The diagrams in the following subject show the connections required for a specific ECC function. The inputs and outputs are shown on opposite sides regardless of the connector involved.

There must be power supplied to the ECC from fuse F30 via BA06A. See **Fig. 18**.

## Headlights/Park Lights On Alarm

When the headlights or the park lights are on, the ECC receives power from wires IN03E and IN03D. See **Fig. 19**. If the ECC is receiving park light power, and not receiving ignition power from IG04A, an alarm is activated by sending a signal out LB09A to the lightbar buzzer.

With the ECC tester ignition switch off, turning on the headlights switch should activate a short double beep. The park lights switch will turn on only the ECC tester park lights LED, and the headlights switch will turn on the park lights LED plus either the high beams or low beams LED, depending on the high beam/low beam switch setting on the tester. Turning the ignition off cuts the power from IG04A. The buzzer of the tester indicates that the ECC is sending a signal out LB09A to the lightbar buzzer. These indicators determine if the ECC is responding correctly.

## High Beam Indicator

When the headlights are turned on, the ECC receives high beam power from HL10A, then sends power to the high beam indicator in the lightbar via wire LB04A. See **Fig. 20**.

With the tester headlights switch on, the park lights LED and either the high beam or low beam LED should illuminate, depending on the high beam/low beam switch setting on the tester. When the high beams are selected, the ECC should activate the high beam blue indicator light on the tester lightbar.

## Daytime Running Lights (DRL)

The ECC activates the daytime running lights system by modulating power from WW11B and sending it to the low beam headlights via HL08B, and grounds wire LB07A to activate the DRL indicator in the lightbar. Power is supplied to the lightbar by F20 through wire IG04B. See **Fig. 21**.

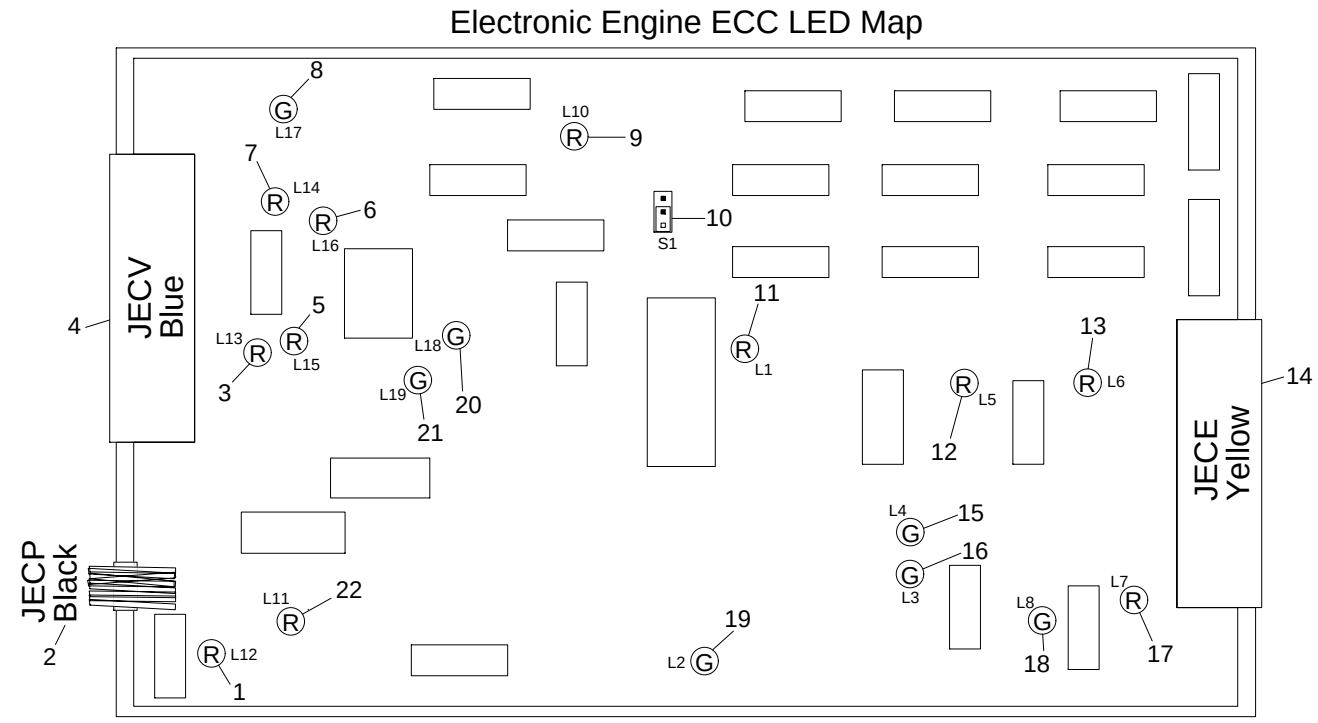
To activate the daytime running lights the following conditions must occur:

- The ignition is on. The ECC is receiving power from IG04A.
- The park brake is released. Wire IN20A is open from ground.

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## ECC Managed Systems (Vehicles Built Before January, 2001)




NOTE: G (Green) LED is output.R (Red) LED is input.

1. Windshield Wiper Intermittent Switch Input (JECV-D9)
2. JECP Black
3. Windshield Wiper High Switch Input (JECV-C8)
4. JECV Blue
5. Dash Lights Dimmer Switch Input (JECV-C11)
6. Dash Lights Brighter Switch Input (JECV-C10)
7. Windshield Wiper Low Switch Input (JECV-C9)
8. Windshield Washer Pump Output (JECV-C12)
9. Low Air Pressure Input (JECV-C16)
10. ECM Warning Jumper
11. Two-Speed Axle Input (JECE-E13)
12. Odometer Miles/Km Input (JECE-E11)
13. A/C Fan Overide Input (JECE-E6)
14. JECE Yellow
15. Hourmeter Output (JECE-F14)
16. Odometer Pulse Output (JECE-F13)
17. ECM Fan Signal Input (JECE-F16)
18. Fan Solenoid Output (JECE-F15)
19. Five Volt Gauge Reference Output (JECE-F11)
20. Windshield Wiper High Output (JECP-F)
21. Windshield Wiper Low Output (JECP-E)
22. Windshield Washer Switch Input (JECV-D3)

**Fig. 4, Electronic Engine ECC LED Map, Built From November 8, 1995 Through October 6, 1996**

- The headlights are off. No power is sent to the ECC from wires HL08B low beam or HL10A high beam.

With the ECC tester park brake and the headlights/park lights switch off, and the ignition switch on, the low beam LED and the DRL indicator in the lightbar should activate. The DRL outputs should be disabled by either turning on the park brake, turning off the ignition, or by turning on the low or high beam headlights.

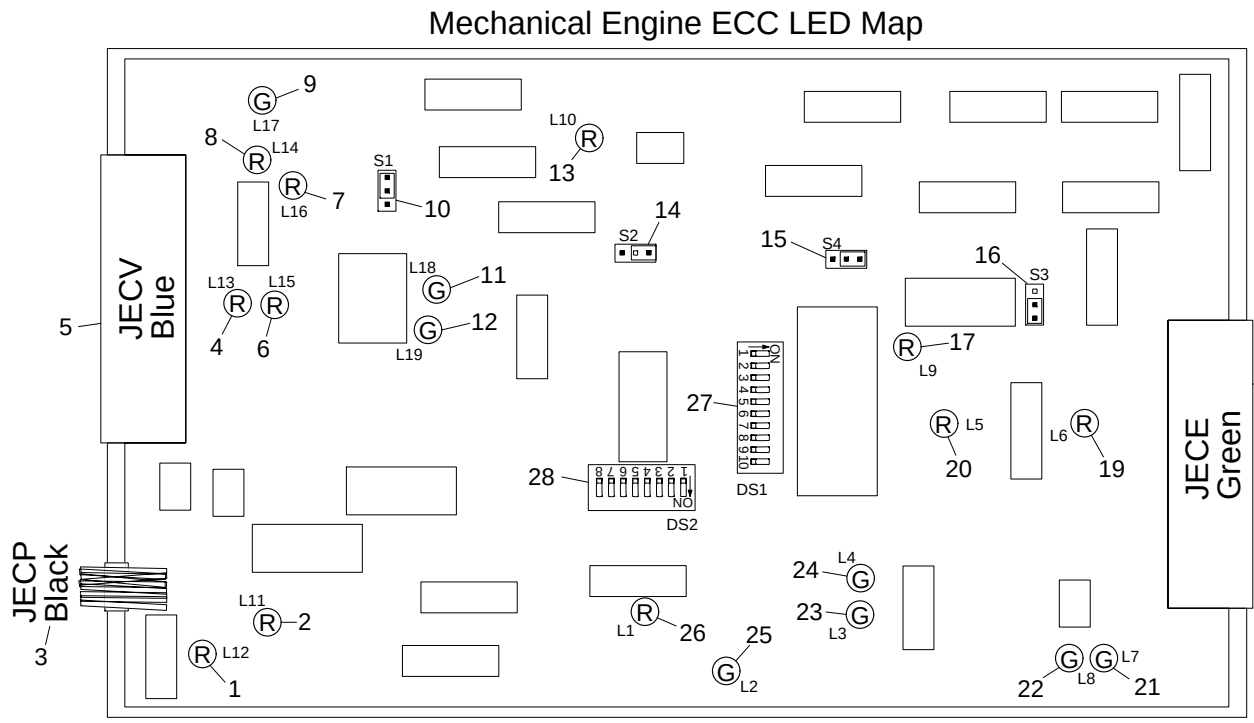
## Dash Light Brightening/Dimming

When the headlights or park lights are on, the ECC receives power from wires IN03E and IN03D. Pressing the dash bright/dim switch to bright sends power out wire IN22A to the ECC. See **Fig. 22** and **Fig. 23**. The ECC sends increasing power out wires GL2K, GL2L and GL1A, or GL1J, GL1L, and GL1N to the gauges and switches, brightening the illumination.

Pressing the dash bright/dim switch to dim sends power out wire IN23A to the ECC. See **Fig. 24** and

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NOTE: G (Green) LED is output.R (Red) LED is input.

1. Windshield Wiper Intermittent Switch Input (JECV-D9)
2. Windshield Washer Switch Input (JECV-D3)
3. JECP Black
4. Windshield Wiper High Switch Input (JECV-C8)
5. JECV Blue
6. Dash Light Dimmer Switch Input (JECV-C11)
7. Dash Lights Brighter Switch Input (JECV-C10)
8. Windshield Wiper Low Switch Input (JECV-C9)
9. Windshield Washer Pump Output (JECV-C12)
10. Low Coolant Warning Jumper
11. Windshield Wiper High Output (JECP-F)
12. Windshield Wiper Low Output (JECP-E)
13. Low Air Pressure Input (JECV-C16)
14. Park Brake Shutdown Jumper
15. Low Coolant Shutdown Jumper
16. Low Oil Pressure Shutdown Jumper
17. Two-Speed Axle Input (JECE-C13)
18. JECE Green
19. A/C Fan Override Input (JECE-C6)
20. Odometer Miles/Km Input (JECE-C11)
21. Fuel Solenoid Output (JECE-C14)
22. Fan Solenoid Output (JECE-D15)
23. Odometer Pulse Output (JECE-D13)
24. Hourmeter Output (JECE-D15)
25. Fan Solenoid Output (JECE-D15)
26. Low Oil Pressure Input (JECE-D10)
27. Speedometer DIP Switches
28. Tachometer DIP Switches

**Fig. 5, Mechanical Engine ECC LED Map**

**Fig. 25**. The ECC sends decreasing power out wires GL2K, GL2L, and GL1A, or GL1J, GL1L, and GL1N to the gauges and switches, dimming the illumination.

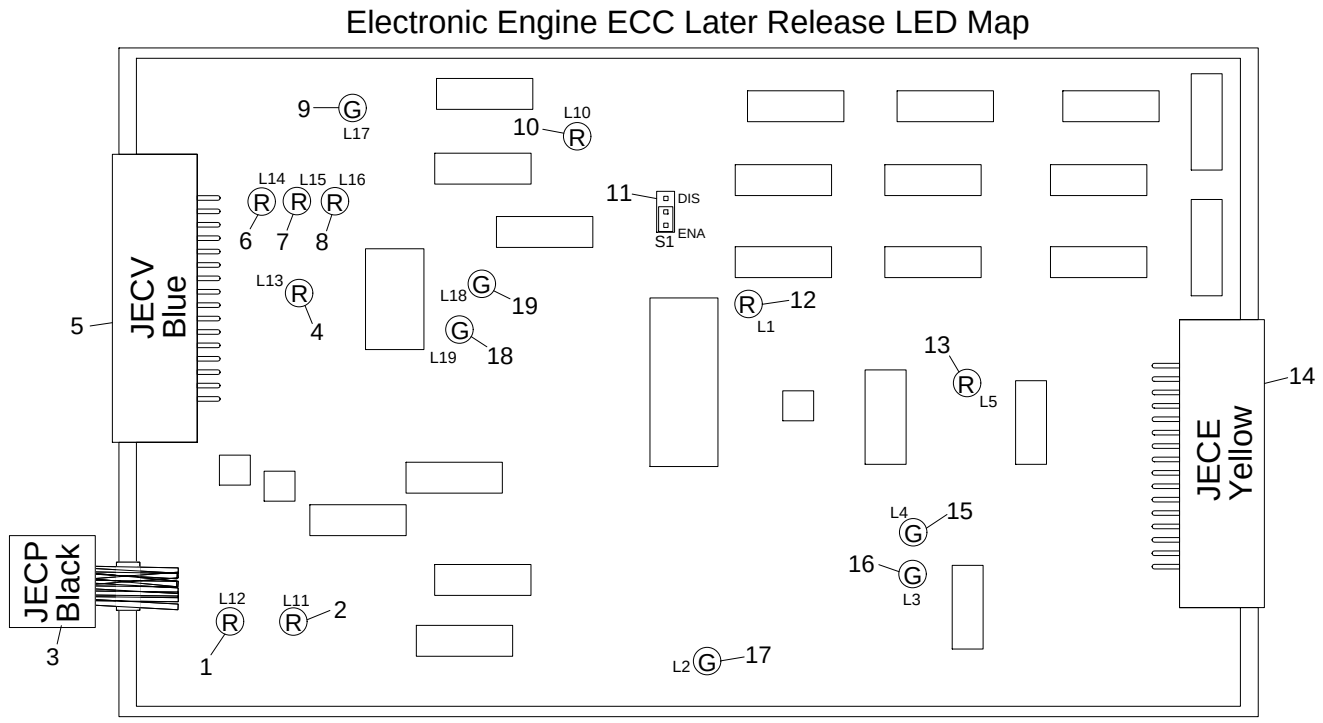
Remove the cover from the ECC and connect the tester. When the tester dash brighter switch on the tester is pressed, the dash light brighter input red LED on the ECC should light, and when dash dim is pressed, the dash lights dimmer input red LED should light. See **Fig. 26**.

Running this test with the ECC connected to the vehicle will point out if a fault is before or after the ECC. The pair of wires GL2K and GL2L are required to carry the current. GL1A, GL1J, or GL1L carry the current to the engine gauges and switches for elec-

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## ECC Managed Systems (Vehicles Built Before January, 2001)




NOTE: G (Green) LED is output.R (Red) LED is input.

1. Windshield Wiper Intermittent Switch Input (JECV-D9)
2. Windshield Washer Switch Input (JECV-D3)
3. JECP Black
4. Windshield Wiper High Switch Input (JECV-C8)
5. JECV Blue
6. Windshield Wiper Low Switch Input
7. Dash Lights Dimmer Switch Input (JECV-C11)
8. Dash Lights Brighter Switch Input (JECV-C16)
9. Windshield Washer Pump Output (JECV-C12)
10. Low Air Pressure Input (JECV-C16)
11. ECM Alarm Jumper
12. Two-Speed Axle Input (JECE-E13)
13. Odometer Miles/Km Input (JECE-F14)
14. JECE Yellow
15. Hourmeter Output (JECE-F14)
16. Odometer Pulse Output (JECE-F13)
17. Five Volt Gauge Reference Output (JECE-F11)
18. Windshield Wiper Low Output (JECP-E)
19. Windshield Wiper High Output (JECP-F)

**Fig. 6, LED Map, Electronic Engine ECC Built After October 6, 1996**

tronic engines. GL1N carries the power to the engine gauges and switches for mechanical engines.

## Signal/Four Way Flashers

The ECC receives power from TL11A then sends the flashed power out wire TL03A at 90 flashes per minute. See **Fig. 27**. The turn signal switch distributes the flash power to the turn signal lights and to the lightbar.

Turning on the ECC tester four way flasher switch should flash the left and right turn signal indicators on the lightbar at 90 flashes per minute.

## Park Brake

The ECC monitors IN20A from the park brake switch. When the park brake is set, the switch closes to ground and the ECC activates the lightbar park brake indicator by closing LB03A to ground. The lightbar park brake indicator receives power from wire IG04B. See **Fig. 28**.

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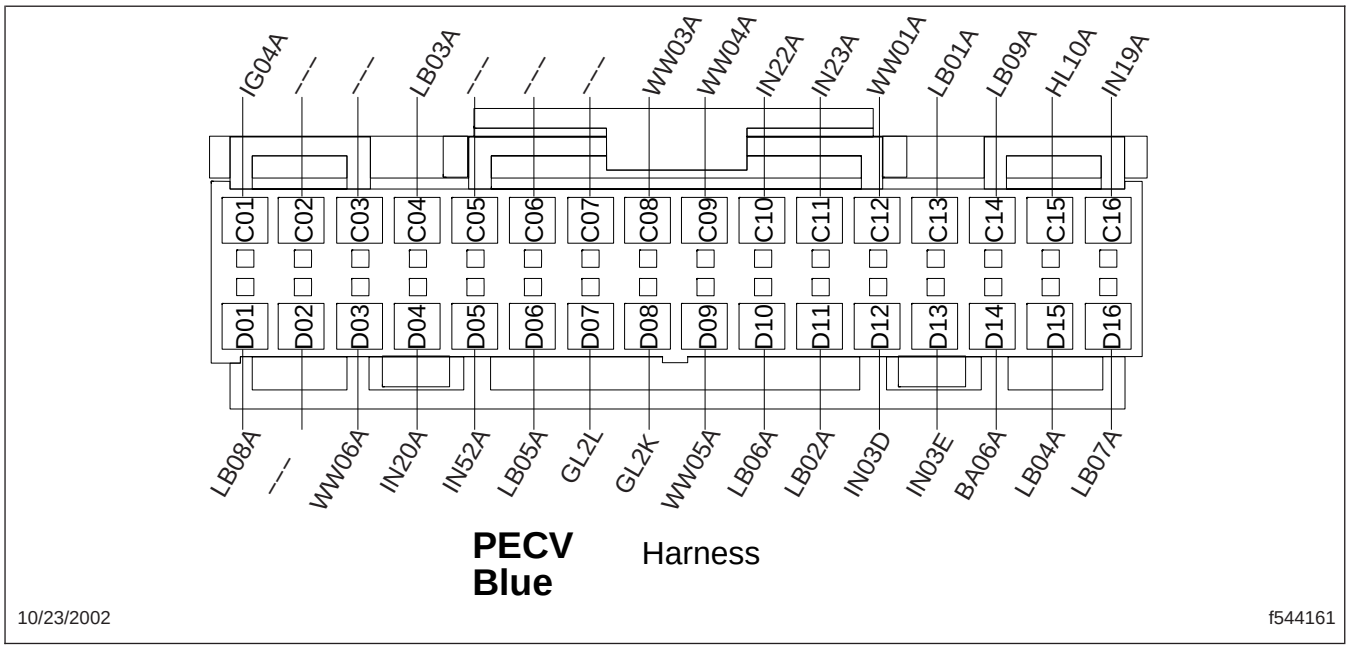



**Fig. 7, PECV Blue, Tester**

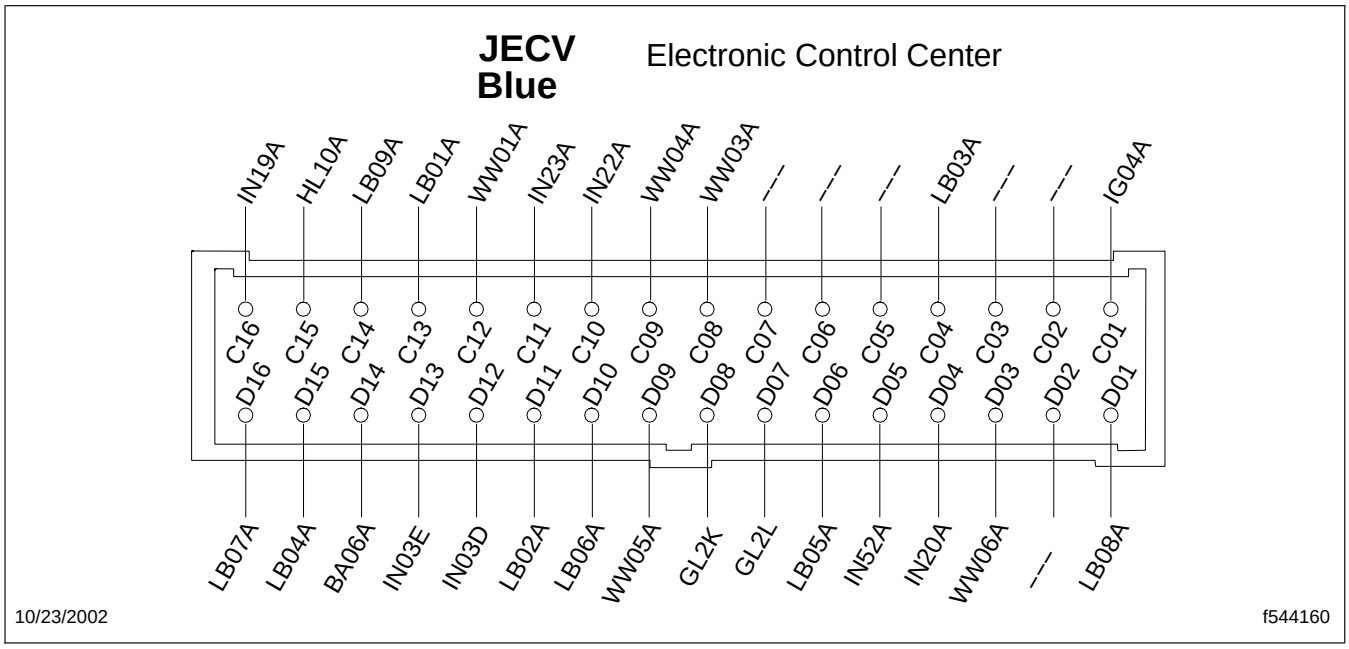



**Fig. 8, JECV Blue, ECC**

On DDEC engines the ECC grounds 524B to the sensor common 953G to signal the electronic engine ECM.

Turning on the ECC tester park brake switch, and the tester ignition switch should activate the tester park brake indicator on the lightbar. The tester ECM

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## ECC Managed Systems (Vehicles Built Before January, 2001)

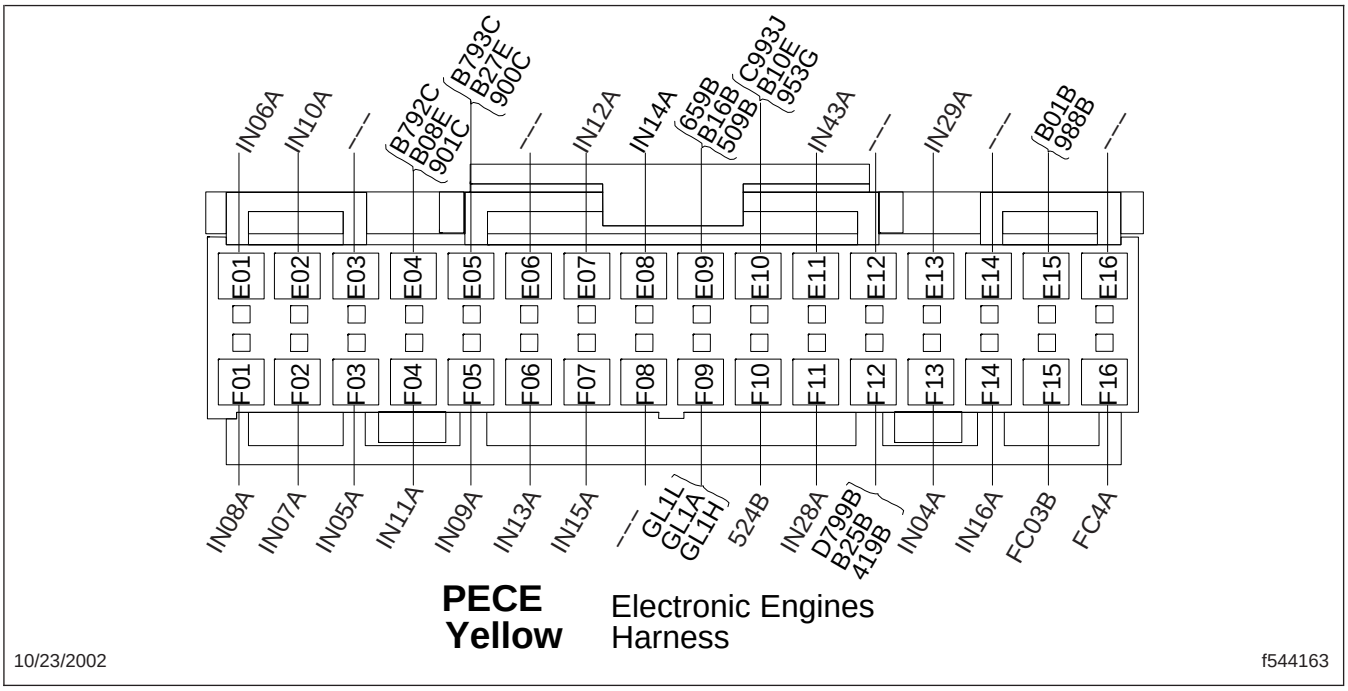



**Fig. 9, PECE Yellow, Tester**

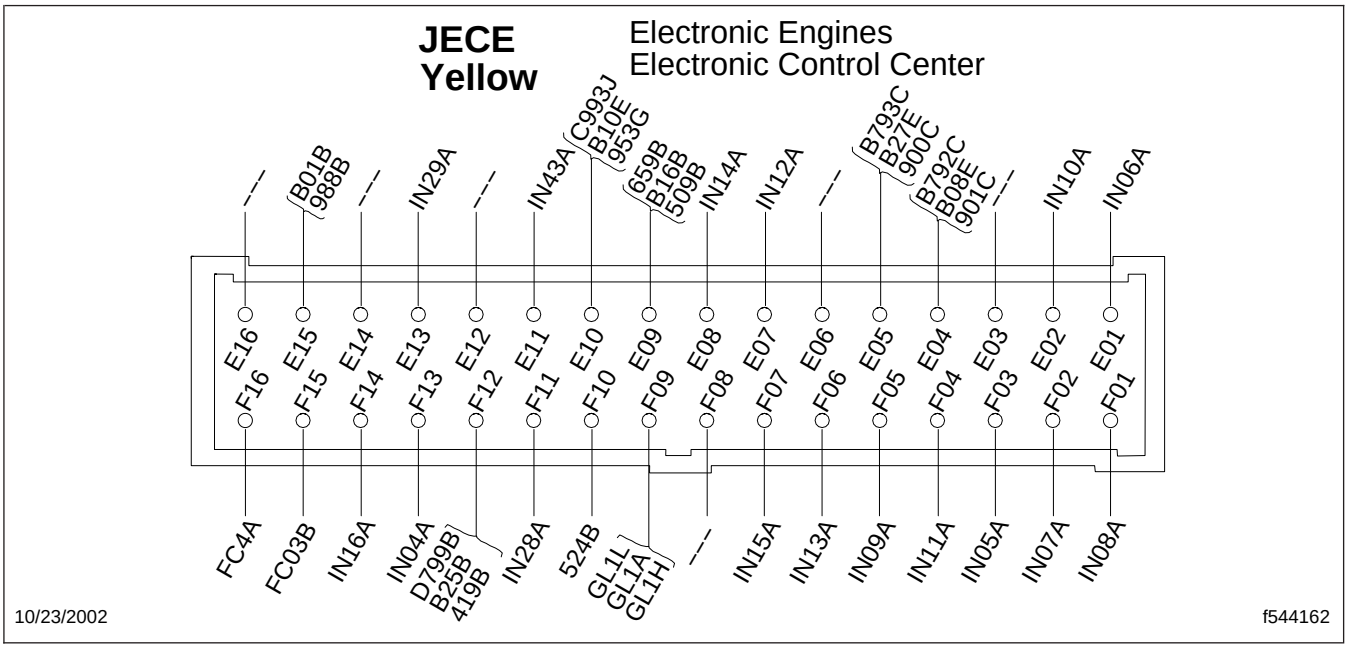



**Fig. 10, JECE Yellow, ECC, Electronic Engine**

park brake LED should also activate, indicating the signal to the electronic engine.

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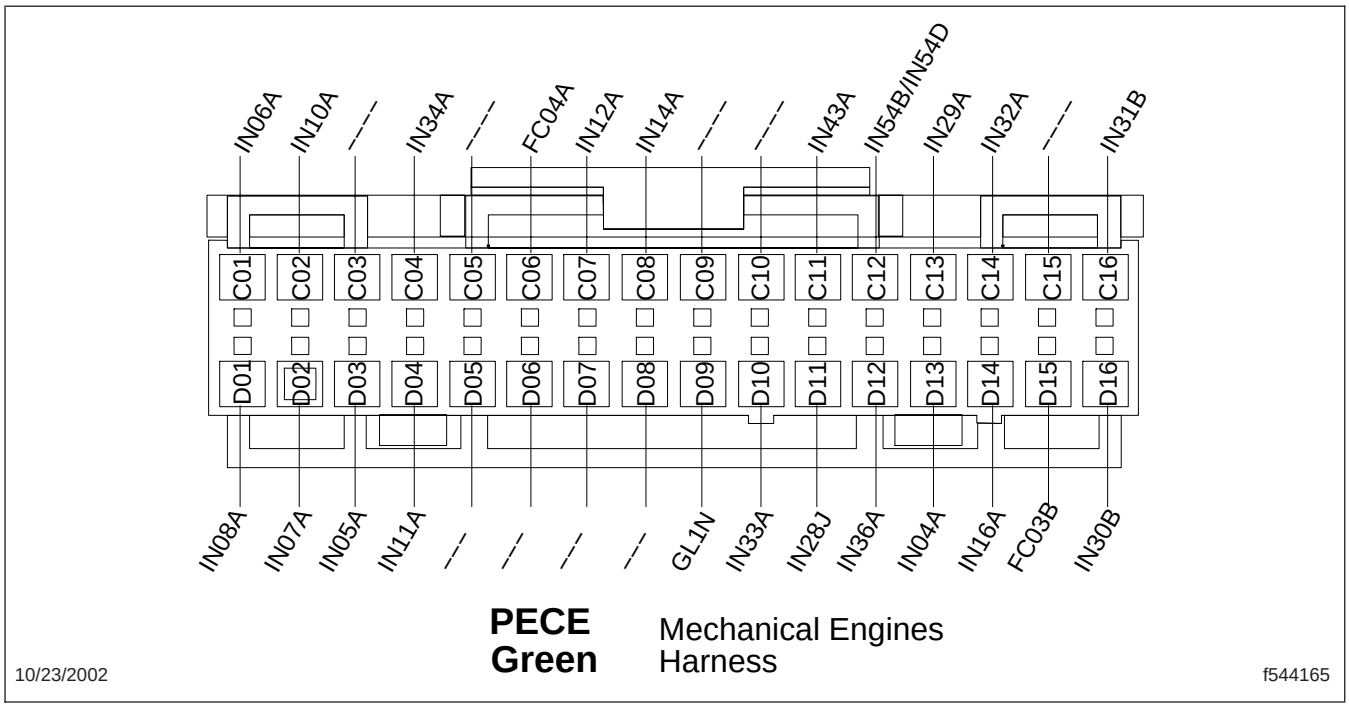



**Fig. 11, PECE Green, Tester**

## Windshield Wipers Low

When the windshield wiper switch is turned on, 12 volts from fuse F24 via wire WW02A is sent to the windshield wiper speed selection switch via wire WW07A. When the wiper speed is set to low, 12 volts is sent out WW04A to the ECC. See **Fig. 29**. The ECC windshield wiper low input red LED should light, and the windshield wiper low output green LED should light, indicating that the power from WW11B is being sent out wire WW09A to the wiper motor. See **Fig. 30**.

When the wipers are turned off, the ECC monitors the current in wire WW10A. When ground is detected from the wiper motor the ECC turns the power off to WW09A . After 18 milliseconds a ground is applied to WW09A, reversing the wiper motor and stopping it in the park position. The ECC windshield wiper low output green LED should turn on momentarily.

Turning the ECC tester ignition switch on and turning on the low wiper speed should activate the low wiper red LED. This indicates that the ECC has received the signal from the wiper speed switch via wire WW04A and sent the power from WW11B out to the wiper motor by wire WW09A. When the wipers are turned off the low wiper LED should turn on momentarily, sending the WW11B power out wire WW09A to park the wiper motor.

## Windshield Wipers High

When the windshield wiper switch is turned on, 12 volts from fuse F24 via wire WW02A is sent to the windshield wiper speed selection switch via wire WW07A. When wiper high speed is selected, the 12 volts are sent to the ECC from wire WW03A. See **Fig. 31**. The ECC internal windshield wiper high switch input red LED should light, and the windshield wiper high output green LED should light, indicating that power from WW11B is being sent out wire WW08A to the wiper motor. See **Fig. 32**.

When the wipers are turned off, the ECC monitors WW10A. When ground is detected from the wiper motor the ECC turns the power off to WW09A. After 18 milliseconds a ground is applied to WW09A, reversing the wiper motor and stopping it in the park position.

Turning the ECC tester ignition switch on, turning on the wiper switch, and setting the wiper speed to high on the tester should turn on the high wiper red LED. This indicates that the ECC has received the wiper

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## ECC Managed Systems (Vehicles Built Before January, 2001)

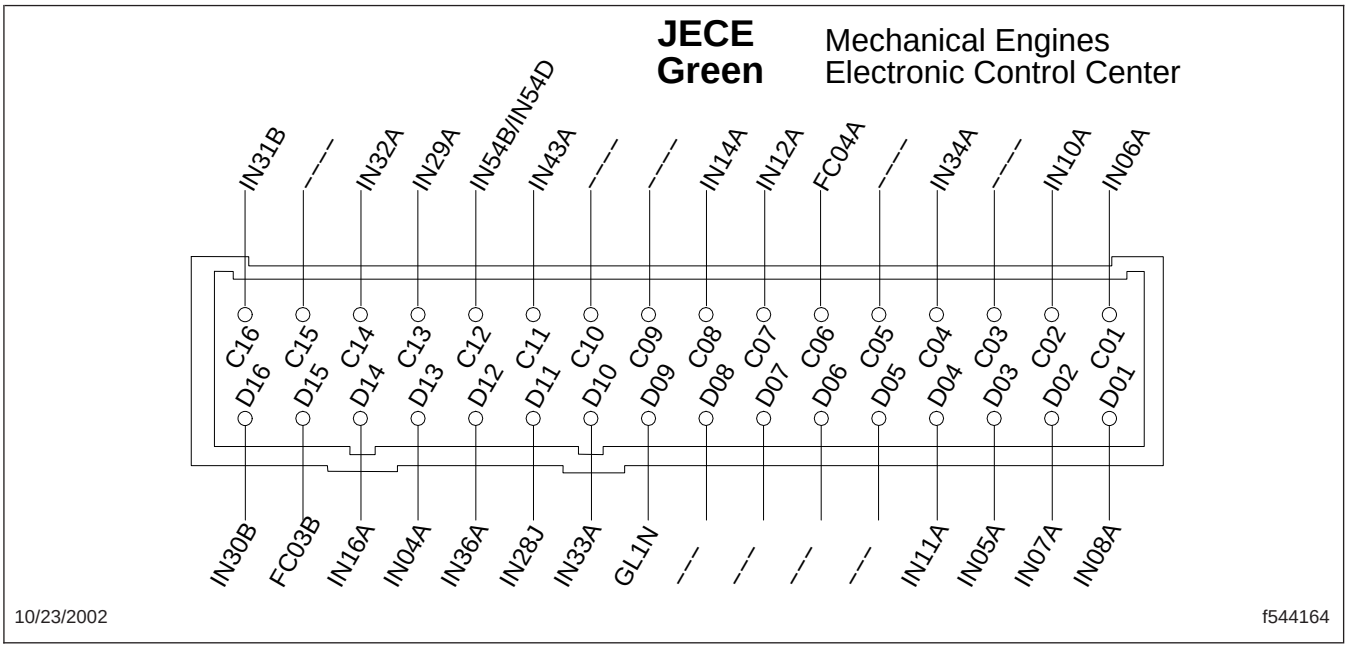



**Fig. 12, JECE Green, ECC, Mechanical Engine**

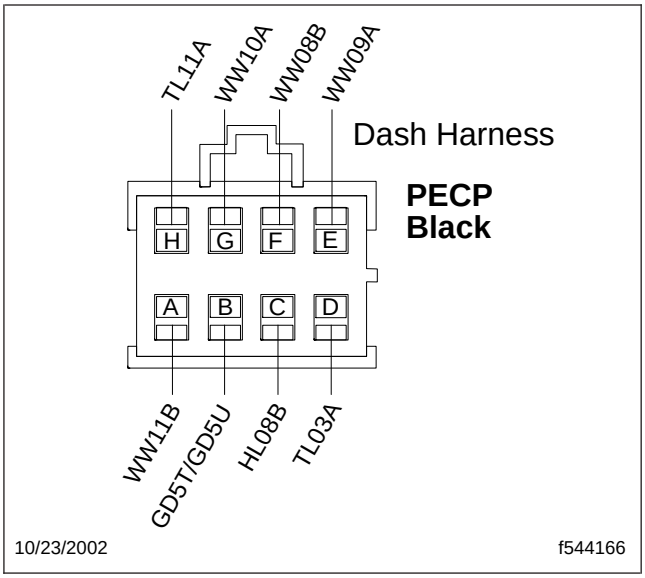



**Fig. 13, PECP Black, Tester**

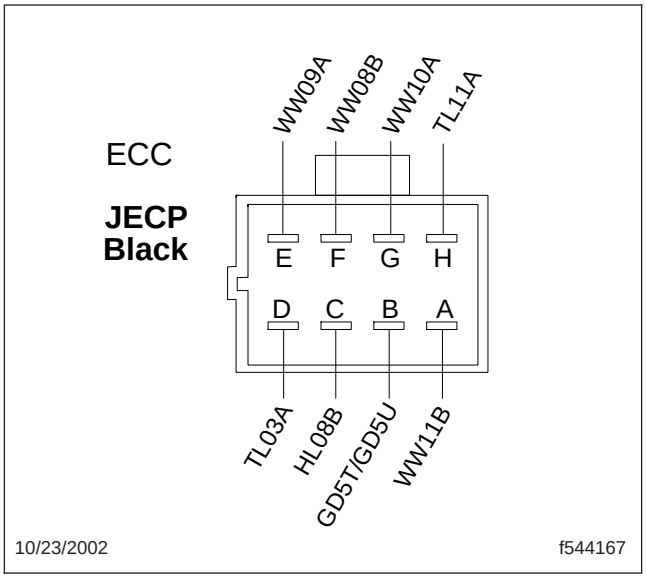



**Fig. 14, JECP Black, ECC**

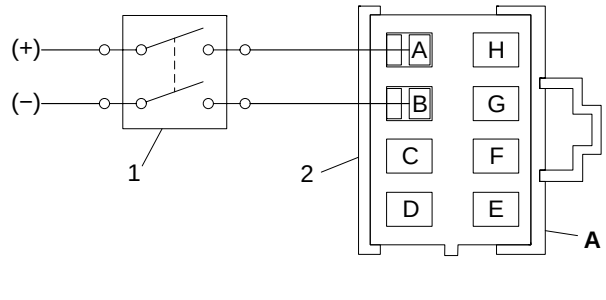
speed signal through wire WW03A and sent the power from WW11B out wire WW08A to the wiper motor. When the wiper switch is turned off the high wiper LED should turn off and the low wiper LED should turn on momentarily.

## Windshield Wipers Intermittent

When the intermittent switch on the dash is first selected, power is sent via wire WW05A to the ECC. See **Fig. 33**. The ECC windshield wiper intermittent switch input red LED should stay on. The windshield wiper low output green LED should come on for one

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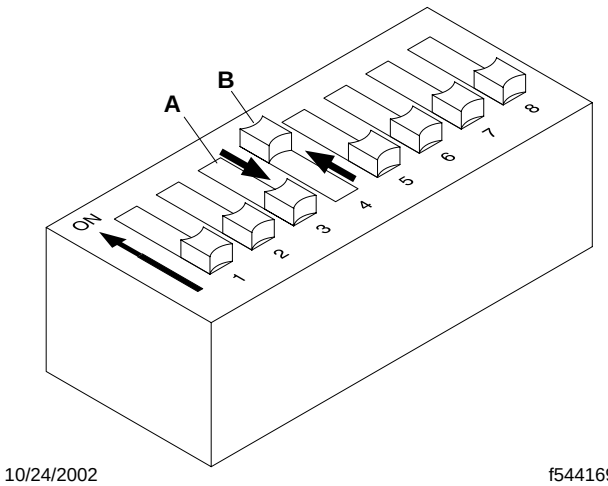





A. Connects to ECC Tester 8-Way Black plug

1. DSPT Toggle Switch
2. Connector Body

**Fig. 15, Tester Power Harness**




A. Off
B. On

**Fig. 16, Dip Switches in Mechanical Engine ECC**

second as power from WW11B is being sent out wire WW09A. See **Fig. 34**.

When the wipers are turned off, the ECC monitors WW10A. When ground is detected from the wiper motor the ECC turns the power off to WW09A. After 18 milliseconds a ground is applied to WW09A, reversing the wiper motor and stopping it in the park position. The wipers should make one sweep every 6 seconds.

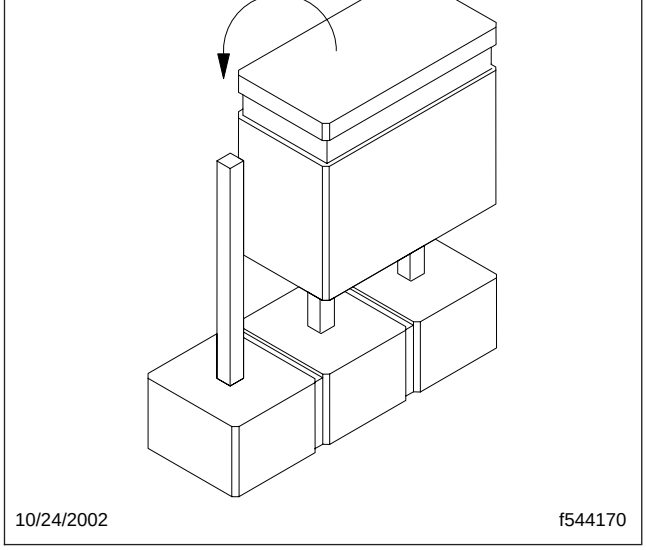



**Fig. 17, Jumper**

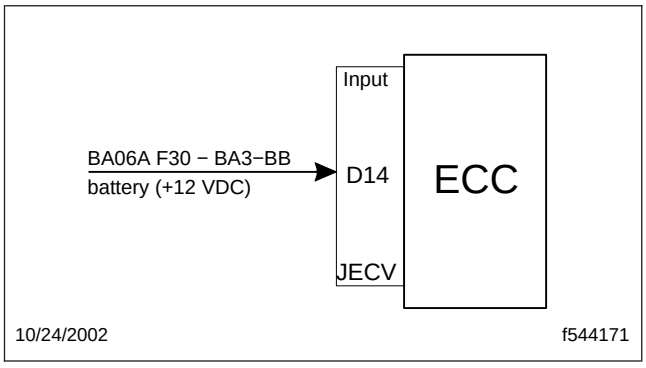



**Fig. 18, ECC Power Circuit**

Turning the intermittent switch off and back on resets the sweep interval. The time between the last sweep and turning the intermittent switch back on will be the interval between sweeps.

When the intermittent switch on the ECC tester is first selected the low wiper LED should come on briefly. This indicates that the signal from the intermittent wiper switch is being received from wire WW05A and the power from WW11B is sent out wire WW09A.

## Windshield Washer

Pressing and releasing the windshield washer switch sends power out wire WW06A to the ECC. See **Fig. 35**. The ECC windshield washer input red LED

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## ECC Managed Systems (Vehicles Built Before January, 2001)

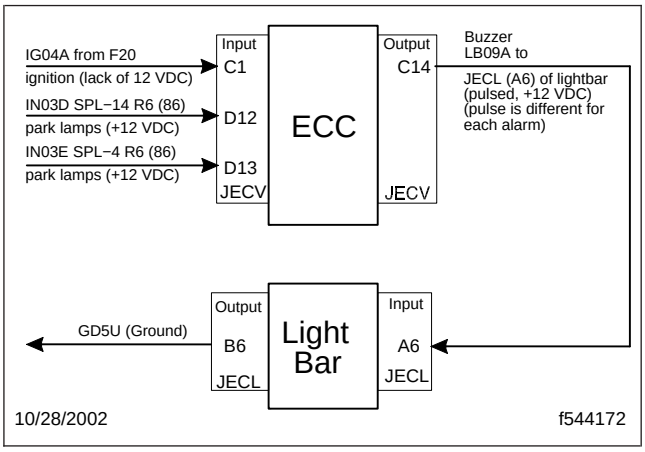



**Fig. 19, Headlights/Park Lights On Alarm Circuit**

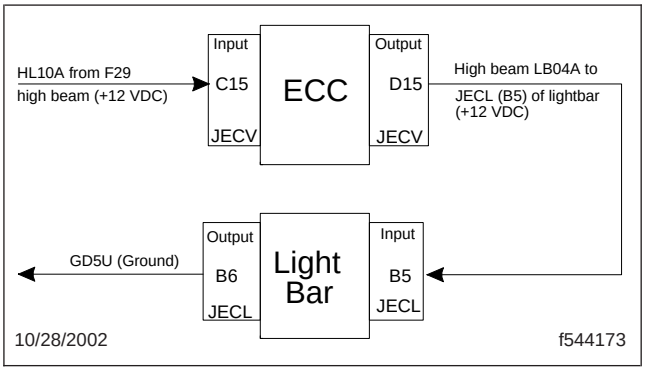



**Fig. 20, High Beam Indicator Circuit**

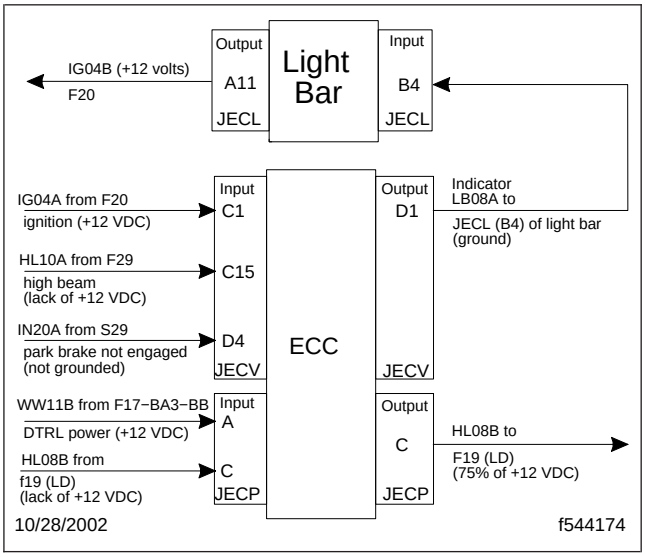



**Fig. 21, Daytime Running Lights Circuit**

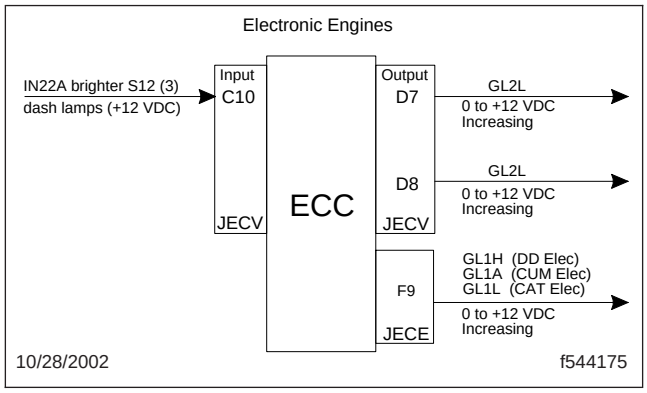



**Fig. 22, Dash Lights Brighten, Electronic Engine Circuit**

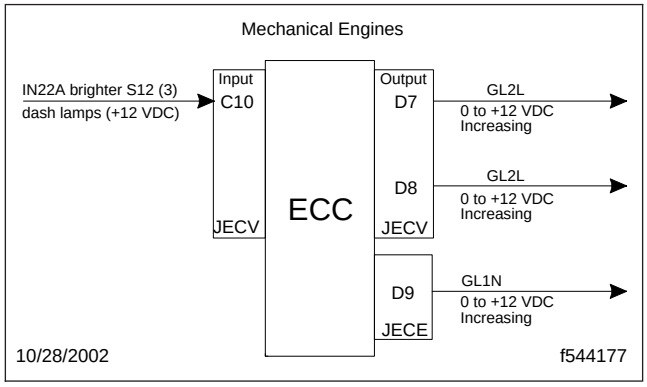



**Fig. 23, Dash Lights Brighten, Mechanical Engine Circuit**

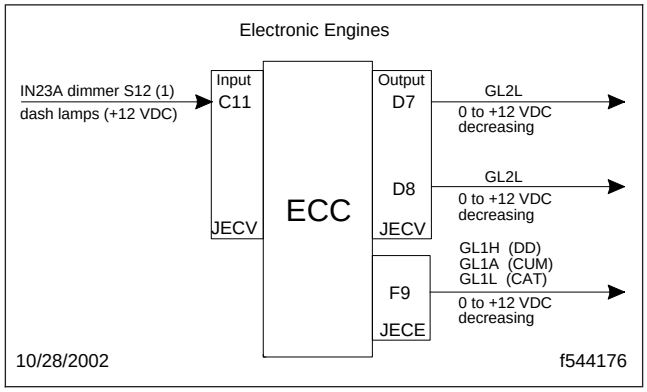



**Fig. 24, Dash Lights Dim, Electronic Engines Circuit**

should be on when the washer switch is pressed. The windshield washer pump green LED activates, indicating that power from WW11B is being sent to the washer motor by wire WW01A. The windshield wiper low output green LED activates, indicating that

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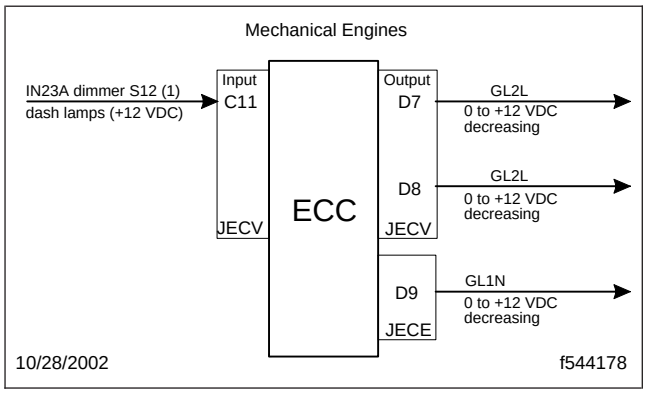
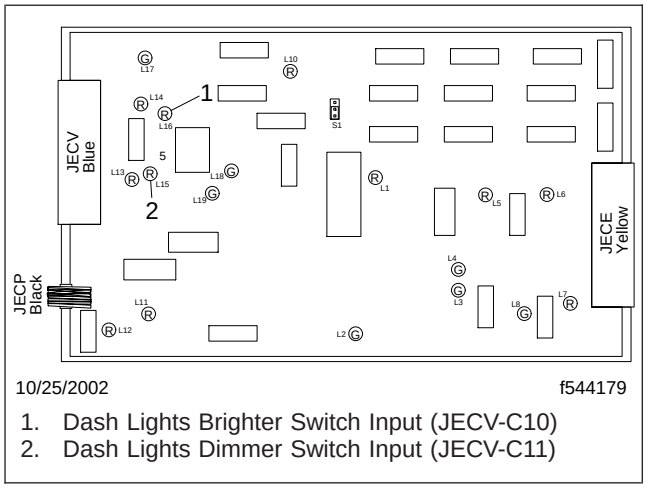



**Fig. 25, Dash Lights Dim, Mechanical Engines Circuit**




1. Dash Lights Brighter Switch Input (JECV-C10)
2. Dash Lights Dimmer Switch Input (JECV-C11)

**Fig. 26, Dash Lights Brighten/Dim LEDs**

power from WW11B is being sent out wire WW09A to the wiper motor during each sweep. See **Fig. 36**.

The ECC counts the number of sweeps by the ground signals received from WW10A. Pressing and releasing the windshield washer switch turns on the windshield washer for two sweeps and turns on the windshield wipers for five sweeps. Holding the windshield washer on for more than 3 seconds runs the windshield washer until the switch is released. The wipers continue to run for three sweeps after the washer stops.

At the end of the cycle the ECC monitors wire WW10A. When ground is detected from the wiper motor, the ECC turns the power to WW09A off. After 18 milliseconds a ground is applied to WW09A, reversing the wiper motor, and stopping it in the park position.

With the ECC tester connected, after briefly pressing and releasing the washer on switch, the washer LED on the tester should be activated for about 3 seconds, while the low wiper LED should be on for about 6 seconds. If the washer switch is held on, the washer and low speed wiper LEDs should stay on. If the washer switch is held on for more than 3 seconds, the washer LED should turn off at the same time as the switch is released, while the low speed wiper LED should turn off 3 seconds later.

## Low Air Pressure Alarm and Indicator

The ECC monitors wire IN19A from the low air pressure sensor. See **Fig. 37**. If the air pressure drops, the sensor closes IN19A to ground, and the ECC low air pressure input red LED should light. See **Fig. 38**. The ECC provides a ground for LB07A and turns on the red low air pressure indicator in the dash lightbar. Power is supplied to the lightbar by F20 through wire IG04B. The alarm is activated by the ECC sending a signal out LB09A to the lightbar buzzer.

Turning on the ECC tester low air pressure switch should activate the beeping alarm and turn on the red air pressure indicator on the lightbar. The tester applies ground to wire IN19A simulating the air pressure low switches. The ECC then grounds LB07A to the lightbar to activate the indicator.

## Spare Alarm

With the ECC tester ignition switch on, turning on either the spare alarm (+) or spare alarm (-) switch should activate a slow beeping alarm. See **Fig. 39**.

# Tests for Electronic Engines Only

## Engine Computer Data

NOTE: The data for the gauges is received by the ECC from the engine ECM through the twisted pair of wires connected to terminals E4 and E5 of the yellow PECE plug. The wire codes change for each engine manufacturer.

When the ECC tester ignition switch is turned on, the tester will generate data like an electronic engine ECM (electronic control module). The electronic engine ECC under test should read this data, which is set up to position the needles of the engine coolant temperature

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## ECC Managed Systems (Vehicles Built Before January, 2001)

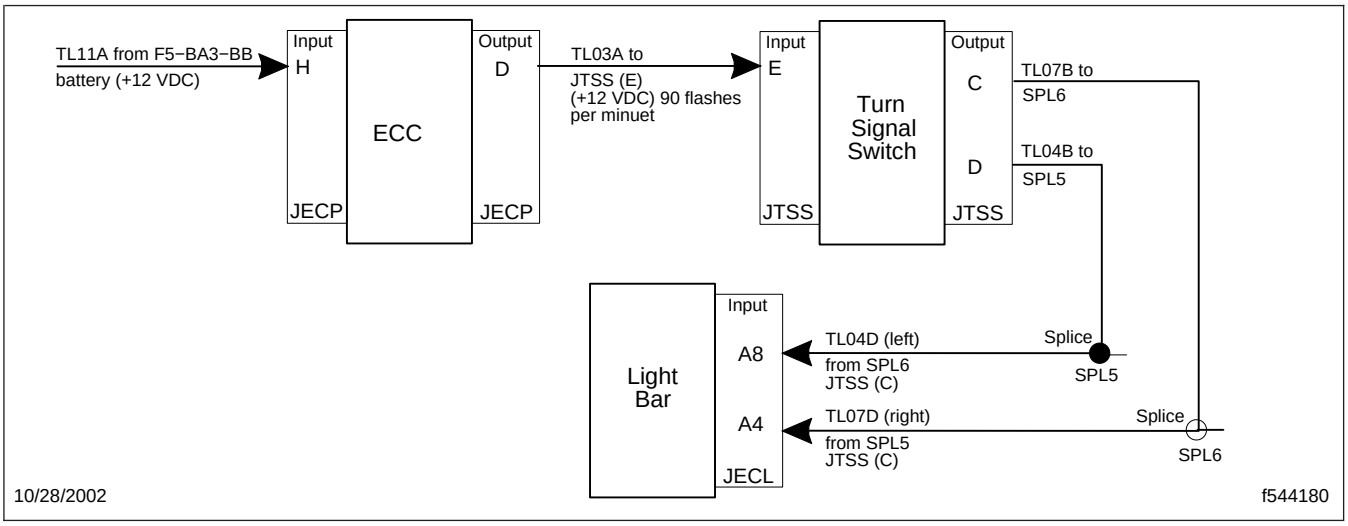



**Fig. 27, Signal/Four Way Flashers Circuit**

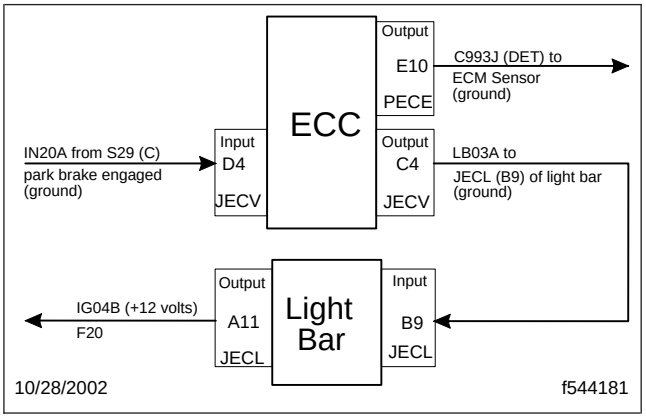



**Fig. 28, Park Brake Circuit**

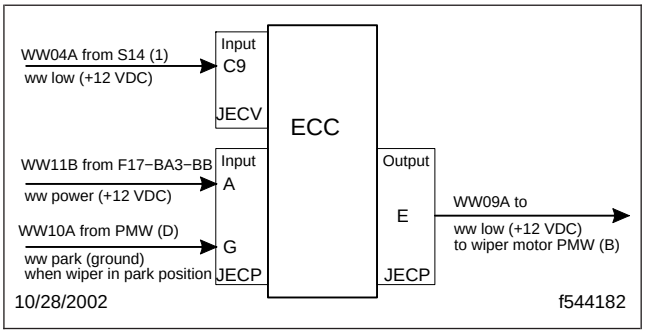
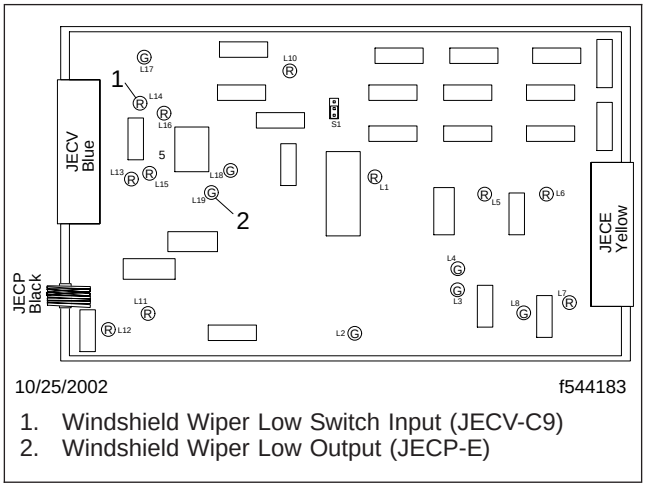



**Fig. 29, Windshield Wipers Low Circuit**

gauge, the engine oil temperature gauge, the tachometer, the manifold pressure gauge, the speedometer, the engine oil pressure gauge,




1. Windshield Wiper Low Switch Input (JECV-C9)
2. Windshield Wiper Low Output (JECP-E)

**Fig. 30, Windshield Wipers Low LEDs**

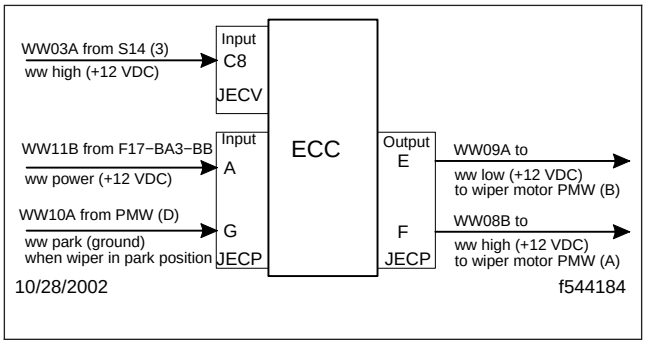
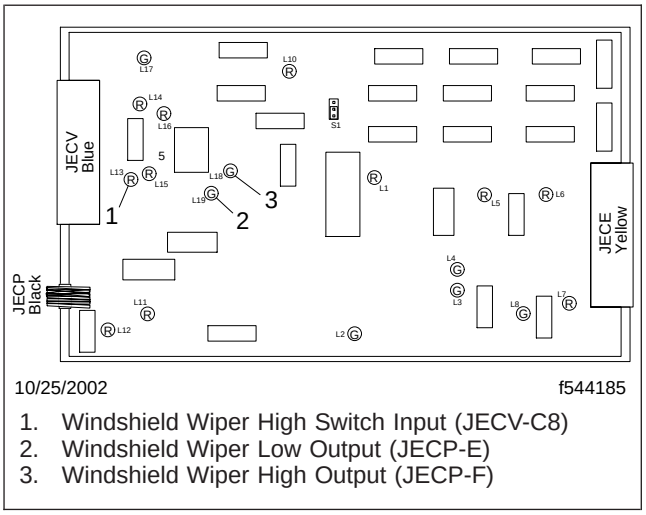



**Fig. 31, Windshield Wipers High Circuit**

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1. Windshield Wiper High Switch Input (JECV-C8)
2. Windshield Wiper Low Output (JECP-E)
3. Windshield Wiper High Output (JECP-F)

**Fig. 32, Windshield Wipers High LEDs**

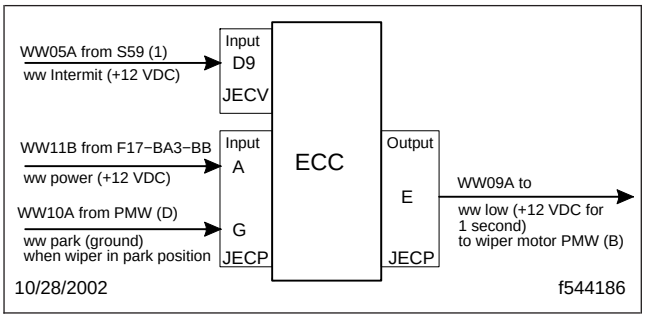
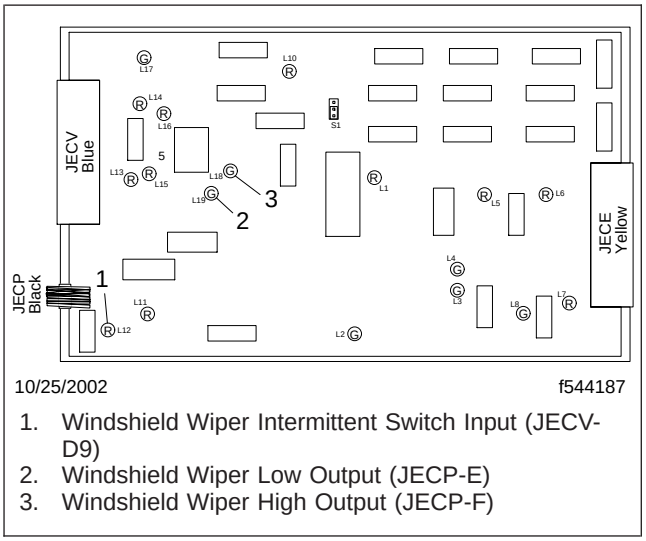



**Fig. 33, Windshield Wipers Intermittent Circuit**




1. Windshield Wiper Intermittent Switch Input (JECV-D9)
2. Windshield Wiper Low Output (JECP-E)
3. Windshield Wiper High Output (JECP-F)

**Fig. 34, Windshield Wipers Intermittent LEDs**

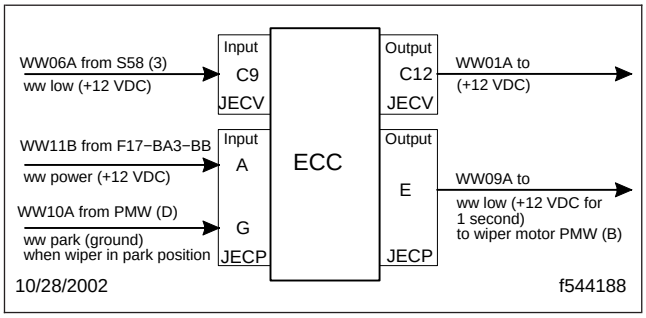
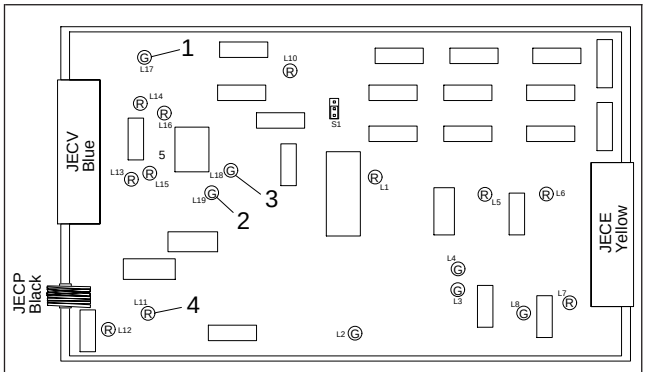



**Fig. 35, Windshield Washer Circuit**




1. Windshield Washer Pump Output (JECV-C12)
2. Windshield Wiper Low Output (JECP-E)
3. Windshield Wiper High Output (JECP-F)
4. Windshield Washer Switch Input (JECV-D)

**Fig. 36, Windshield Washer LEDs**

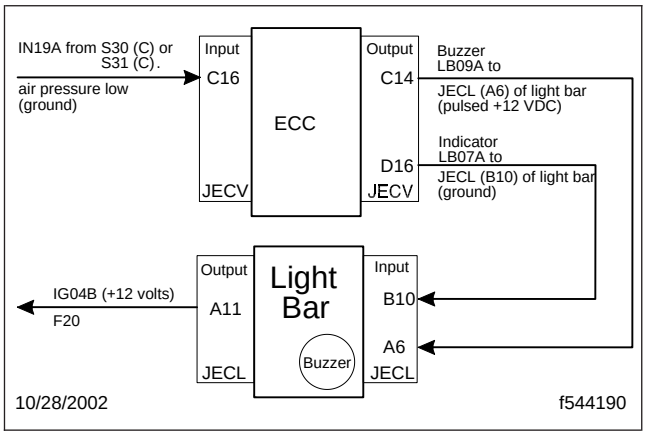


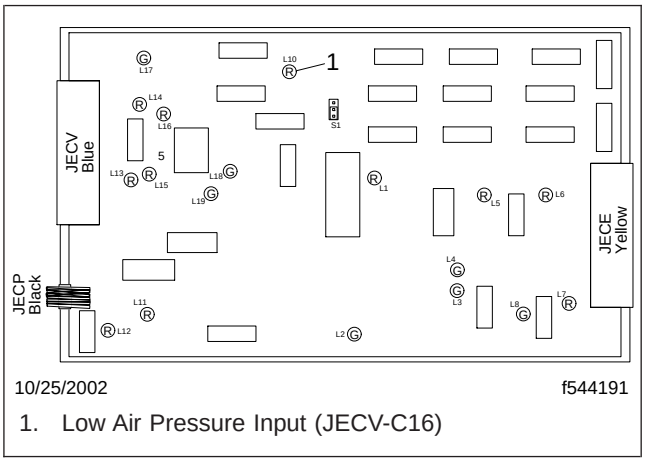

**Fig. 37, Low Air Pressure Alarm and Indicator Circuit**

and a spare engine coolant temperature gauge for a sleeper, simultaneously stopping at the

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## ECC Managed Systems (Vehicles Built Before January, 2001)




1. Low Air Pressure Input (JECV-C16)

**Fig. 38, Low air Pressure Alarm and Indicator LEDs**

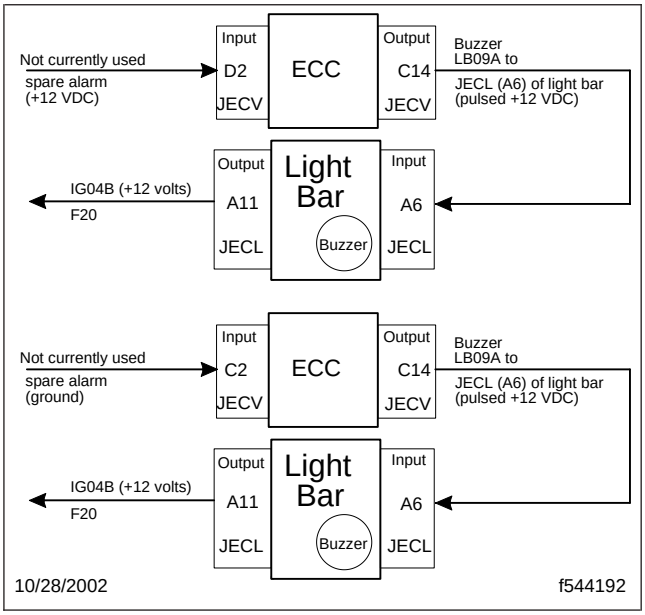



**Fig. 39, Spare Alarm Circuit**

bottom, middle and top of each gauge. Although a second engine temperature gauge has not been included in the tester, the two internal engine temperature outputs of the ECC can be checked by directing either output into the engine coolant temperature gauge with the engine temperature cab, or the engine temperature sleeper switch.

## Gauge Reference

The ECC supplies a 5 volt reference voltage to the engine gauges through IN28A or IN28J, with power coming from gauge fuse F26 via wire IN52A. See **Fig. 40**. When the ignition is on, the 5 volt gauge reference output green LED should be on. See **Fig. 41**.

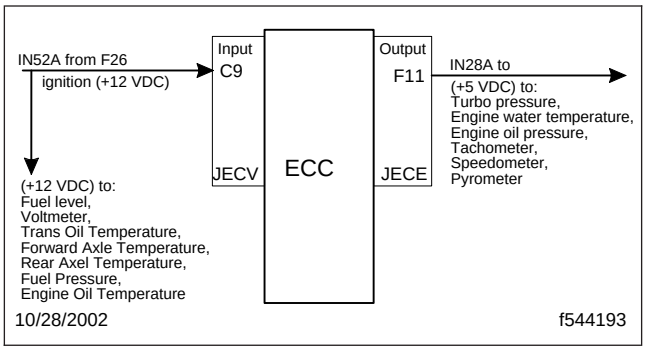
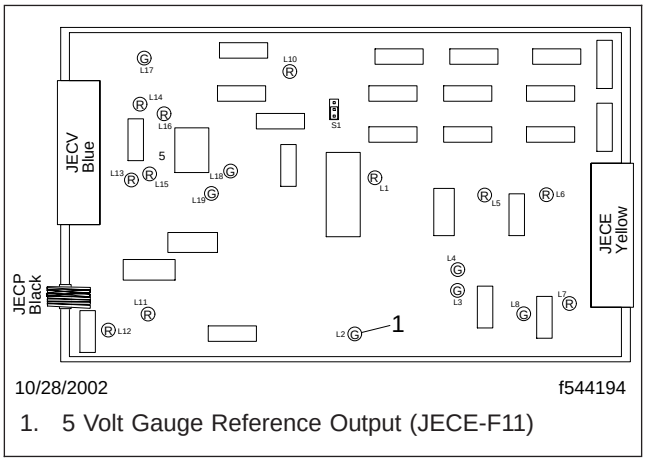



**Fig. 40, Gauge Reference Circuit**




1. 5 Volt Gauge Reference Output (JECE-F11)

**Fig. 41, Gauge Reference LEDs**

Non-engine gauges are supplied twelve volts power direct from F26 through wire IN52B.

## Speedometer and Odometer

The speedometer data is supplied to the ECM by the ECC via the twisted pair of wires to terminal E4 and E5 of the yellow PECE plug. The ECC sends a SIN function signal to the speedometer through wire IN06A and a COS function signal through wire IN05A. See **Fig. 42**. A 5 volt reference is sent out IN28A. The gauge uses the three signals to display the correct reading.

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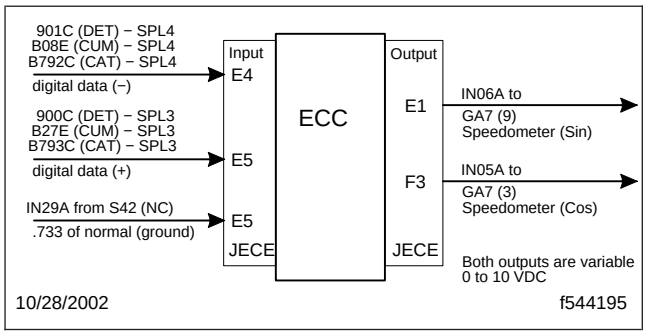



**Fig. 42, Speedometer and Odometer Circuit (Kilometers)**

The ECC tester simulates the speedometer data sent to the ECC. Data from the tester makes the gauge fluctuate from 0 to 50 percent, then to 100 percent and back. Set the tester switch to miles for setting the odometer to miles. If the speedometer on the tester is moving from 0 to 50 percent, then to 100 percent speed and back, the ECC is functioning correctly.

When wire IN43A is grounded the ECC converts the speed calculation to miles. See **Fig. 43**. When set to miles, the odometer miles/km input red LED should be illuminated, and the odometer output green LED should turn on every 528 feet (161 meters). See **Fig. 44**. If set to kilometers, the LED should flash faster, every 328 feet (100 meters). The ECC internal odometer pulse output green LED should be flashing when the speedometer is above zero, indicating pulses being sent out by wire IN04A. The rate of flashing will also be affected by the position of the miles switch and the two-speed axle switch.

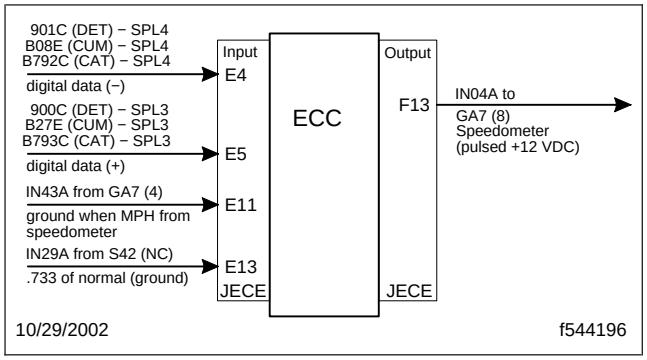



**Fig. 43, Speedometer and Odometer Circuit (Miles)**

When the two-speed axle switch is activated it grounds the signal from wire IN29A. The internal two-speed axle red LED in the ECC should be off

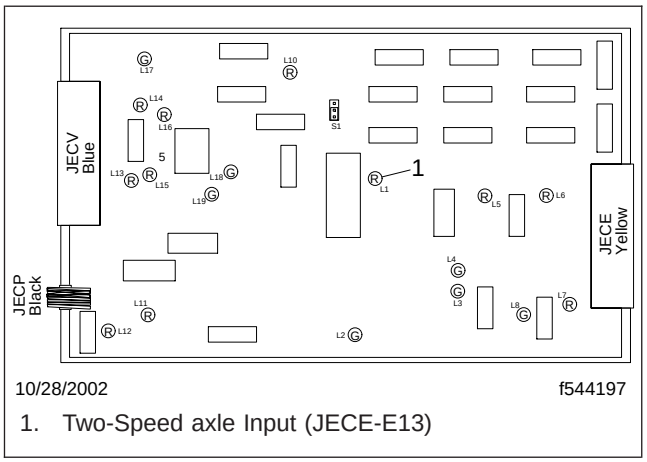



**Fig. 44, Speedometer and Odometer LEDs**

and the speedometer needle should be positioned at 73.3 percent of the normal reading, which means the odometer output should also flash less frequently.

## Tachometer

The ECC sends a SIN function signal to the tachometer via IN07A and a COS function signal via IN08A. A 5 volt reference is sent through wire IN28A. See **Fig. 45**. The gauge uses the three signals to display the correct reading.

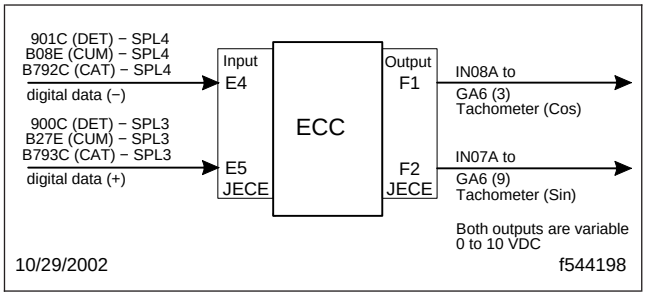



**Fig. 45, Tachometer Circuit**

The ECC tester simulates the tachometer data sent to the ECC. The signal from the tester makes the gauge fluctuate from 0 to 50 percent, then to 100 percent. If the tachometer on the tester is moving from 0 to 50 percent, then to 100 percent speed and back, the ECC is functioning correctly.

## Hourmeter

The signal for the hourmeter is sent via wire IN16A. See **Fig. 46**.

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## ECC Managed Systems (Vehicles Built Before January, 2001)

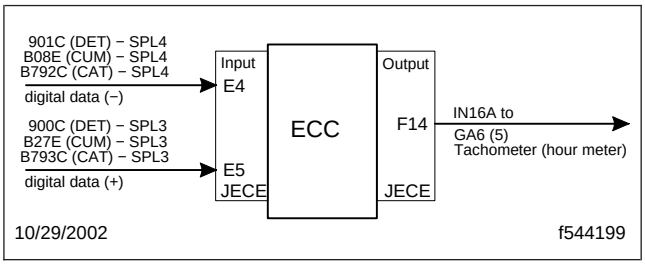
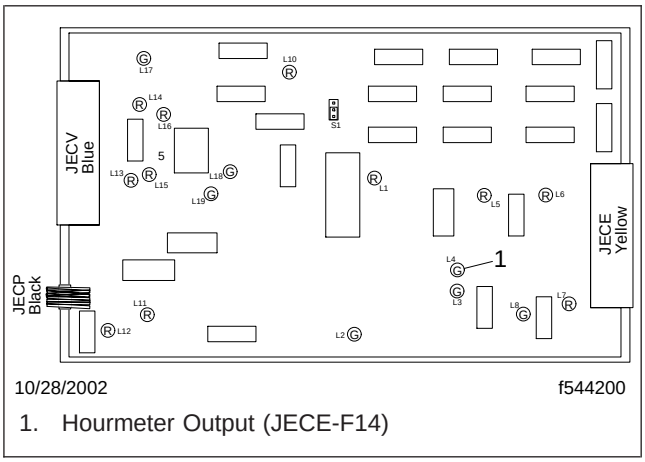



**Fig. 46, Hourmeter Circuit**

The hourmeter output green LED inside the ECC should be illuminated when the engine speed is above 250 rpm. See **Fig. 47**. If the tachometer has a built-in hourmeter it should be operating whenever the green LED is on.




1. Hourmeter Output (JECE-F14)

**Fig. 47, Hourmeter LEDs**

## Engine Exhaust Temperature Gauge

With the ECC tester ignition switch on, the ECC should position the engine exhaust temperature gauge needle in response to a thermocouple voltage that is simulated by adjusting the potentiometer in the upper right hand corner of the tester. IN12A (yellow) is positive from the thermocouple, IN14A (red) is negative from the thermocouple, and IN15A is output to the gauge. See **Fig. 48**.

## Turbo Pressure Gauge

The ECC sends a signal to the turbo pressure gauge through wire IN15A. The 5 volt reference is sent out wire IN28A. See **Fig. 49**. The gauge uses the two signals to display the correct reading.

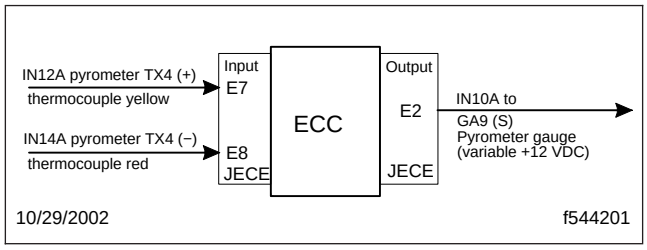



**Fig. 48, Engine Exhaust Temperature Gauge Circuit**

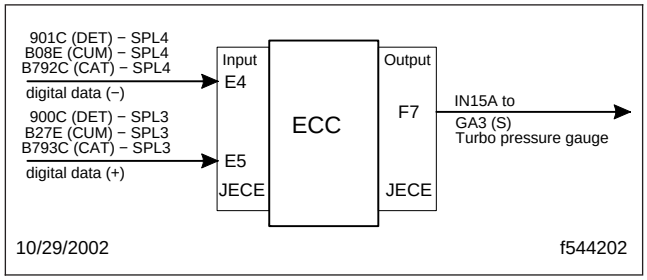



**Fig. 49, Turbo Pressure Gauge Circuit**

When the ECC tester ignition switch is on, the ECC tester simulates the turbo pressure signals sent to the ECC. The tester signal makes the gauge fluctuate from 0 to 50 percent, then to 100 percent. If the turbo pressure gauge on the tester is moving from 0 to 50 percent, then to 100 percent and back the ECC is functioning correctly.

## Engine Coolant Temperature Gauge (Cab)

The ECC sends a signal to the engine coolant temperature gauge via IN11A. A 5 volt reference is sent via wire IN28A. See **Fig. 50**. The gauge uses the two signals to display the correct reading.

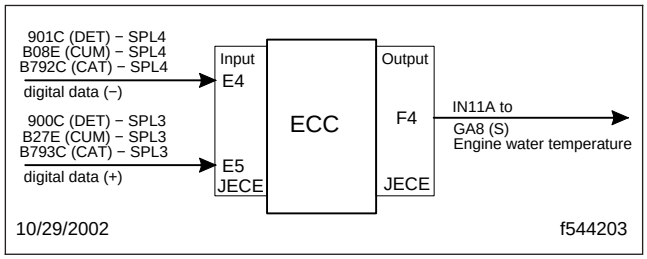



**Fig. 50, Engine Coolant Temperature Gauge Circuit (Cab)**

With the ECC tester ignition switch on, select the engine temperature (cab) switch. The ECC tester simulates the engine coolant temperature signals sent to

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the ECC. The tester signal makes the gauge fluctuate from 0 to 50 percent, then to 100 percent. If the engine coolant temperature gauge on the tester is moving from 0 to 50 percent, then to 100 percent and back the ECC is functioning correctly.

## Engine Coolant Temperature Gauge (Sleeper)

The ECC sends a signal to the engine coolant temperature gauge via plug JECE, pin E3. A 5 volt reference is sent out via IN48A. See **Fig. 51**. The gauge uses the two signals to display the correct reading.

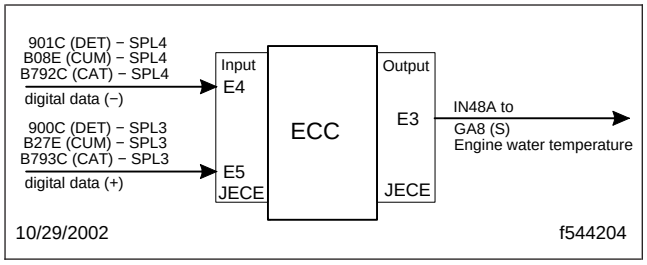



**Fig. 51, Engine Coolant Temperature Gauge Circuit (Sleeper)**

With the ECC tester ignition switch on, select the engine temperature (sleeper) switch. The ECC tester simulates the engine coolant temperature signals sent to the ECC. The tester signal makes the gauge fluctuate from 0 to 50 percent, then to 100 percent. If the engine coolant temperature gauge on the tester is moving from 0 to 50 percent, then to 100 percent and back, the ECC is functioning correctly.

## Engine Oil Temperature Gauge

The ECC sends a signal to the engine oil temperature gauge through wire IN13A . A 5 volt reference is sent out wire IN28A. See **Fig. 52**. The gauge uses the two signals to display the correct reading.

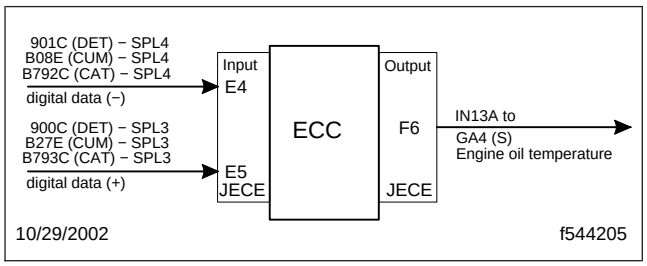



**Fig. 52, Engine Oil Temperature Gauge Circuit**

With the ECC tester ignition switch on, the ECC tester simulates the engine oil temperature signals sent to the ECC. The tester signal makes the gauge fluctuate from 0 to 50 percent, then to 100 percent. If the engine oil temperature gauge on the tester is moving from 0 to 50 percent, then to 100 percent and back, the ECC is functioning correctly.

## Oil Pressure Gauge

The ECC sends a signal to the engine oil pressure gauge through wire IN09A. A 5 volt reference is sent out wire IN28A. See **Fig. 53**. The gauge uses the two signals to display the correct reading.

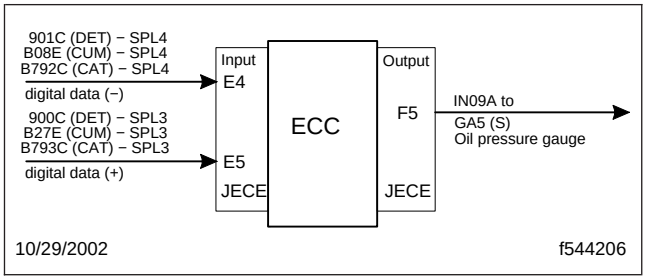



**Fig. 53, Oil Pressure Gauge Circuit**

With the ECC tester ignition switch on, select the engine oil pressure switch. The ECC tester simulates the engine oil pressure signals sent to the ECC. The tester signal makes the gauge fluctuate from 0 to 50 percent, then to 100 percent. If the engine oil pressure gauge on the tester is moving from 0 to 50 percent, then to 100 percent and back, the ECC is functioning correctly.

## ECM Stop Engine

The ECC monitors the data from the ECM via the JECE, pin E9. When the ECM sends a warning lamp signal, the ECC sends power out wire LB09A and activates the alarm. Jumper S1 is enabled and the ECC grounds wire LB01A to turn on the red stop engine indicator on the lightbar. Power is supplied to the lightbar by F20 through IG04B. See **Fig. 54**. Turning on the tester ECM stop engine switch will turn on the red stop engine indicator on the lightbar.

With the ECC tester ignition switch on, when the ECM stop engine switch is pressed the ECC tester should light the red stop engine indicator on the lightbar and activate the alarm.

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## ECM Engine Fluids

The ECC monitors the data from the ECM via wire B01B or 988B. See **Fig. 55**. When the ECM sends an engine fluid lamp signal, the ECC grounds wire LB06A to illuminate the lightbar engine fluids red indicator. Power is supplied to the lightbar by F20 through wire IG04B.

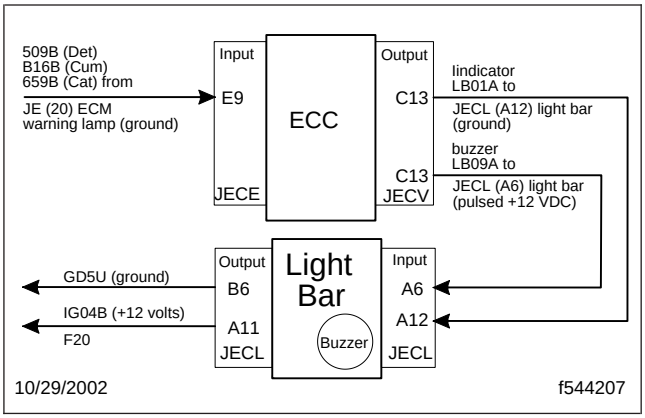



**Fig. 54, ECM Stop Engine Circuit**

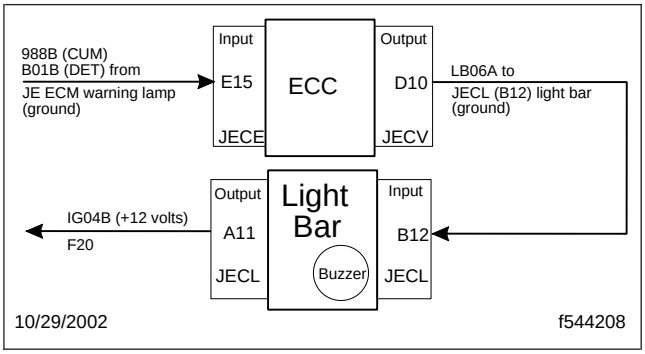



**Fig. 55, ECM Engine Fluids Circuit**

When the ECC tester ignition switch is on, and the ECM engine fluids switch is set, the ECC tester should illuminate the lightbar engine fluids red indicator.

## ECM Check Engine

The ECC monitors the data from the ECM via plug JECE, pin F112. See **Fig. 56**. When the ECM sends a diagnostic lamp signal, the ECC grounds wire LB02A, turning on the lightbar yellow check engine indicator. Power is supplied to the lightbar by F20 through wire IG04B.

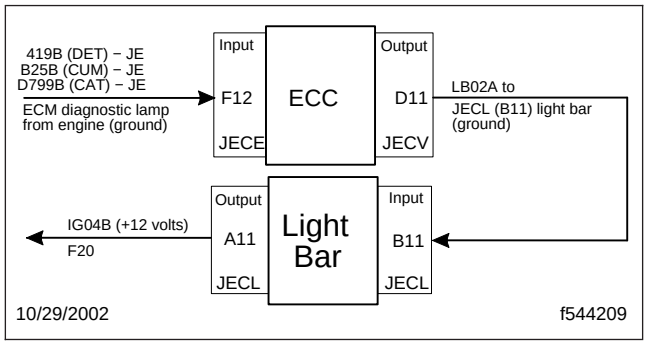



**Fig. 56, ECM Check Engine Circuit**

When the ECC tester ignition switch is on, and the ECM check engine switch is selected, the ECC tester should illuminate the lightbar yellow check engine indicator.

## Data Error Indication

If the ECC detects a break in data on JECE, E4 or E5 wires, it will supply a ground to wire LB05A and illuminate the lightbar data error indicator. See **Fig. 57**. The indicator will stay on for a minimum of 2 seconds.

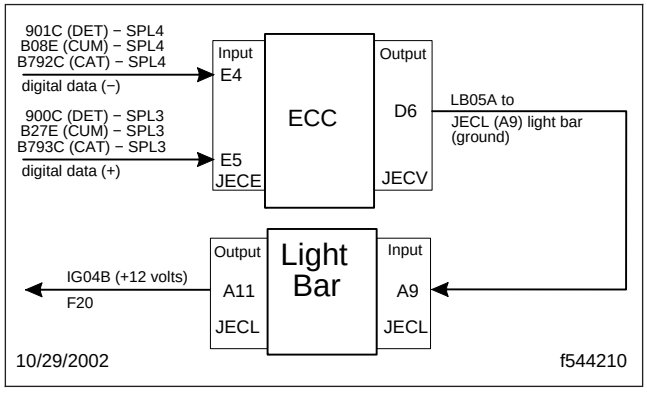



**Fig. 57, Data Error Indication Circuit**

Power is supplied to the lightbar by F20 through wire IG04B.

# Tests for Mechanical Engines Only

## Magnetic Speedometer and Tachometer Sensors

When the tester ignition switch is turned on the tester will generate signals to simulate the magnetic sen-

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sors for road speed and engine speed. Record the ECC internal DIP switch positions, as they must be temporarily reset. Switch the ECC DIP switches number one and two to the on position, and the rest of the DIP switches to the off position. The simulated sensor signals will position the tachometer needle at 1500 and 3000 rpm, and the speedometer needle at zero, midway, and 80 mph (130 kmh).

## Gauge Reference

The ECC supplies a 5 volt reference voltage to the engine gauges through IN28A or IN28J, with power coming from fuse F26 through wire IN52A. See **Fig. 58**.

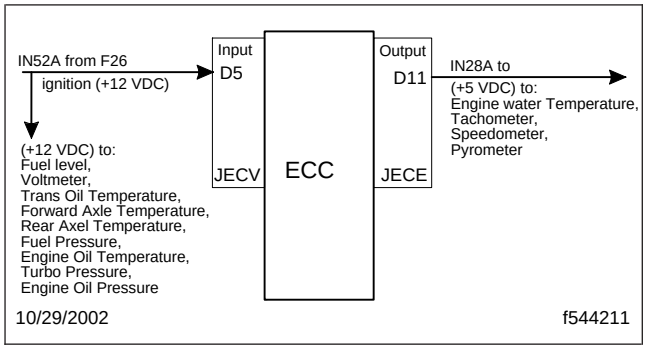
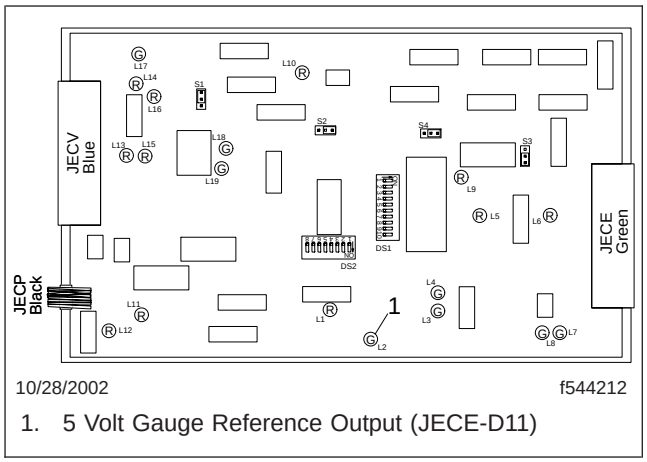



**Fig. 58, Gauge Reference Circuit**

When the ignition is on the 5 volt gauge reference output green LED should be on. See **Fig. 59**. Non-engine gauges are supplied 12 volts power direct from F26 via IN52B.




1. 5 Volt Gauge Reference Output (JECE-D11)

**Fig. 59, Gauge Reference LEDs**

## Speedometer and Odometer

The speedometer signal is received from the pickup by the ECC via the twisted pair of wires IN30B and IN54B. The ECC sends a SIN function signal to the speedometer through wire IN06A and a COS function signal through wire IN05A. See **Fig. 60**. A 5 volt reference is sent out the IN28J circuit. The gauge uses the three signals to display the correct reading.

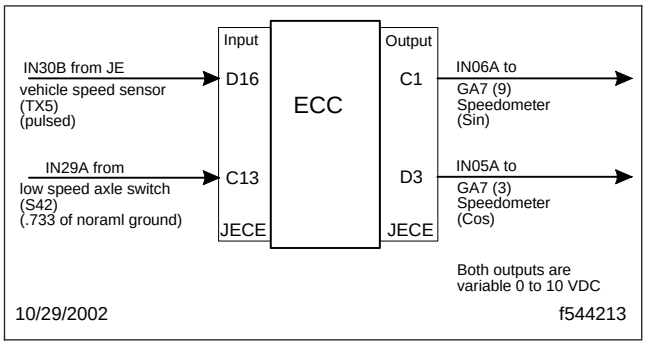



**Fig. 60, Speedometer and Odometer Circuit (Kilometers)**

With the ECC tester switch on, the ECC tester simulates the speedometer signals sent to the ECC. The tester signal makes the gauge fluctuate from 0 to 50 percent, then to 100 percent and back. Set the tester switch to miles for setting the odometer to miles. If the speedometer on the tester is reading from 0 to 50 percent, then to 100 percent speed and back the ECC is functioning correctly.

The ECC monitors wire IN43A for a ground indicating miles, or an open circuit for kilometers. When wire IN43A is grounded the ECC converts the speed calculation to miles. See **Fig. 61**.

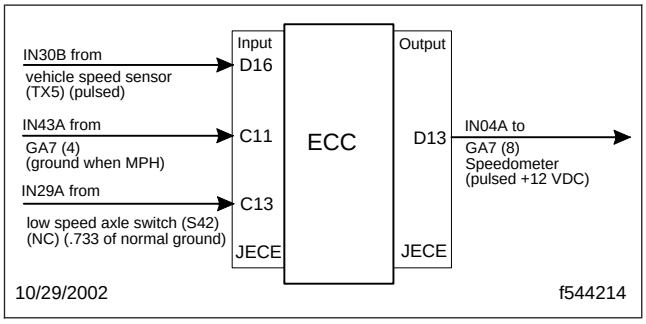



**Fig. 61, Speedometer and Odometer Circuit (Miles)**

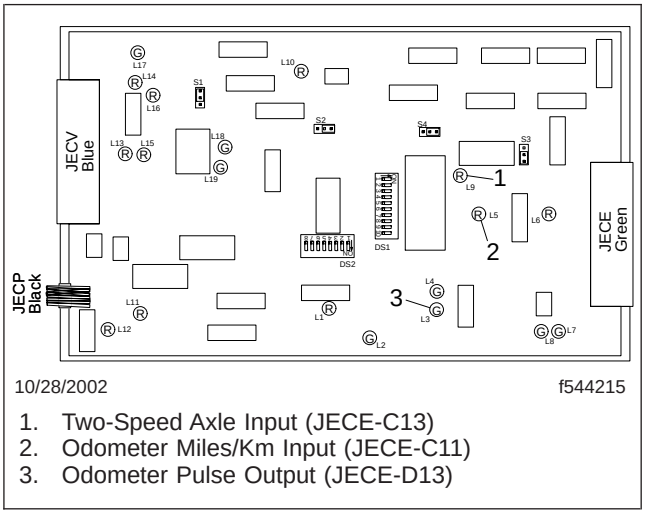
When set to miles the odometer miles/km input red LED should be illuminated inside the ECC, and the

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odometer output green LED should illuminate every 528 feet (161 meters). See **Fig. 62**. If set to kilometers, the LED should flash faster, every 328 feet (100 meters). The ECC internal odometer pulse output green LED should be flashing when the speedometer is above zero, indicating a pulse is being sent out wire IN04A. The rate of flashing will also be affected by the position of the miles switch and the two-speed axle switch.




1. Two-Speed Axle Input (JECE-C13)
2. Odometer Miles/Km Input (JECE-C11)
3. Odometer Pulse Output (JECE-D13)

**Fig. 62, Speedometer and Odometer LEDs**

When the two-speed axle switch is selected, it grounds the signal wire IN29A. The ECC internal two-speed axle red LED should be off, and the speedometer needle should be positioned at 73.3 percent of the normal reading, which means the odometer output should also flash less frequently.

## Tachometer

The tachometer data is received from the pickup by the ECC via the twisted pair of wires IN31B and IN54D. See **Fig. 63**. The ECC sends a SIN function signal to the tachometer through wire IN07A and a COS function signal through wire IN08A. A 5 volt reference is sent out IN28J. The gauge uses the three signals to display the correct reading.

With the ECC tester ignition switch on, the ECC tester simulates the tachometer signals sent to the ECC. The tester signal makes the gauge fluctuate from 50 percent to 100 percent. If the tachometer on the tester is moving from 50 percent to 100 percent and back the ECC is functioning correctly.

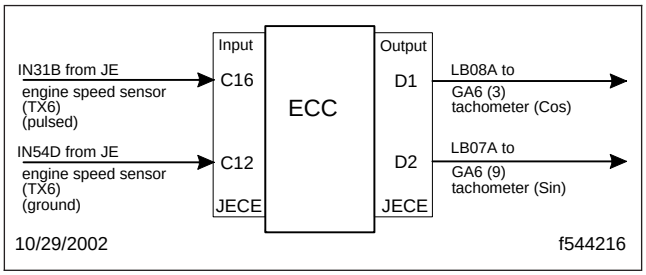



**Fig. 63, Tachometer Circuit**

## Hourmeter

The ECC monitors the data from the ECM via the twisted pair of wires IN31B and IN54D. The signal for the hourmeter is sent by wire IN16A. See **Fig. 64**.

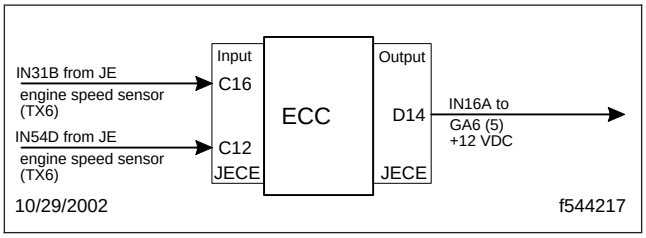
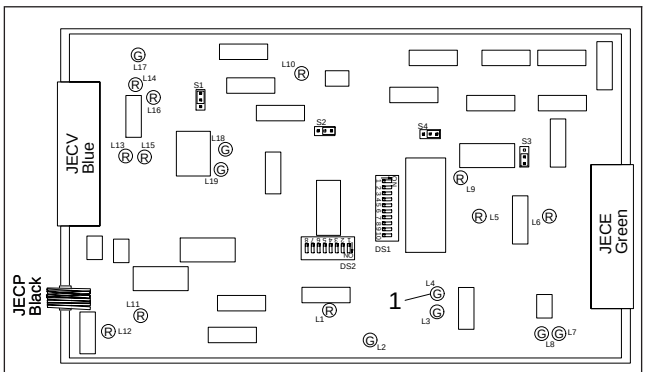



**Fig. 64, Hourmeter Circuit**

The hourmeter output green LED inside the ECC should be illuminated when the engine speed is above 250 rpm. If the tachometer has a built-in hourmeter, it should be operating whenever this green LED is illuminated. See **Fig. 65**.




1. Hourmeter Output (JECE-D14)

**Fig. 65, Hourmeter LED**

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## Engine Exhaust Temperature Gauge

With the ECC tester ignition switch on, the ECC should position the engine exhaust temperature gauge needle in response to the thermocouple voltage (that is simulated by adjusting the tester potentiometer). IN12A (yellow) is positive from the thermocouple, IN14A (red) is negative from the thermocouple. IN10A is output to gauge. See **Fig. 66**.

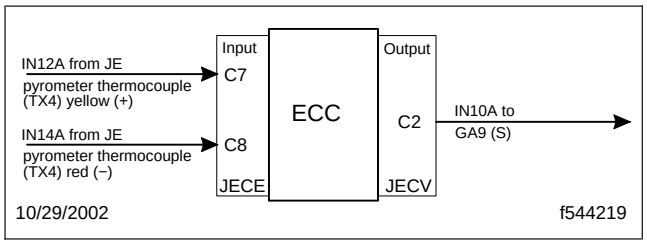



**Fig. 66, Engine Exhaust Temperature Gauge Circuit**

## Engine Coolant Temperature Gauge (Cab)

The ECC measures the signal being sent out wire IN36A from the water temperature sensor. See **Fig. 67**.

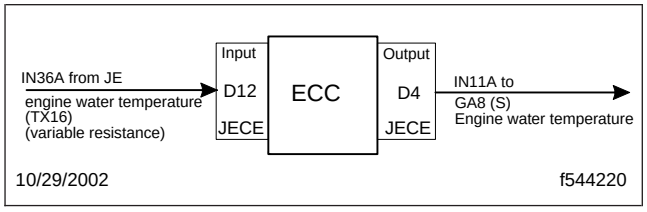



**Fig. 67, Engine Coolant Temperature Gauge (Cab) Circuit**

When the engine coolant temperature reaches 215° F (101° C) wire LB01A grounds, the lightbar water temperature red indicator should light, and an alarm should sound. Power is supplied to the lightbar by F20 through wire IG04B. A signal is sent out LB09A to the alarm.

The tester has a potentiometer on the upper left that will simulate an engine temperature sensor. Adjusting it clockwise should make the gauge display higher temperatures. If the gauge functions on the tester the ECC is functioning correctly. When the tester water temperature potentiometer is turned up until the temperature reads above 215° F (101° C) the tester stop engine red indicator will light in the lightbar and an alarm will sound.

## Engine Coolant Temperature Gauge (Sleeper)

The ECC measures the signal being sent out IN36A from the water temperature sensor. The data received from the sensor is sent out connector JECE to pin C3 to the water temperature gauge. See **Fig. 68**.

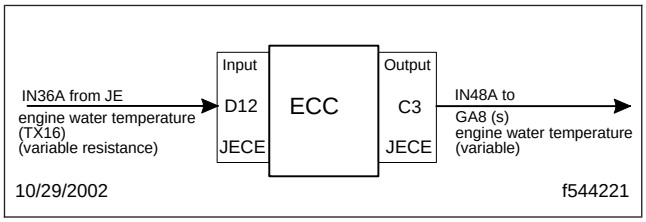



**Fig. 68, Engine Coolant Temperature Gauge (Sleeper) Circuit**

When the engine coolant temperature reaches 215° F (101° C), wire LB01A grounds, the lightbar water temperature red indicator should light, and an alarm should sound. Power is supplied to the lightbar by F20 through wire IG04B. A signal is sent out LB09A to the alarm.

The tester has a potentiometer on the upper left that will simulate an engine temperature sensor. Adjusting it clockwise should make the gauge display higher temperatures. If the gauge functions on the tester the ECC is functioning correctly. When the tester' water temperature potentiometer is turned up until the temperature reads above 215° F (101° C) the tester stop engine red indicator will light in the lightbar and alarm will sound.

## Fan Control

When the engine coolant temperature is below 195° F (90° C) the ECC sends a ground to FC03C from the fan solenoid (see **Fig. 69**) which energizes the solenoid and disengages the fan. The ECC fan solenoid output green LED is illuminated. See **Fig. 70**. The ECC opens the ground to FC03C when the engine temperature is above 203° F (95° C) which de-energizes the solenoid, engaging the fan. The ECC fan solenoid output green LED should be off.

When the ECC senses a ground at wire FC04A from the trinary switch, the ECC opens a ground to FC03C. The ECC A/C fan override input red LED

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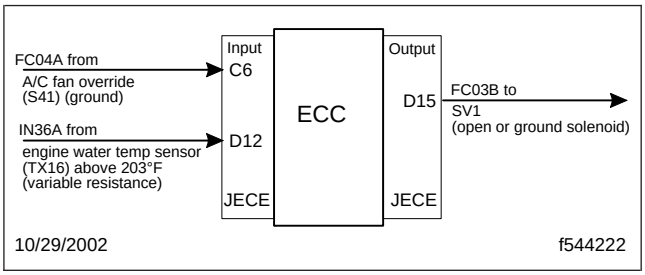
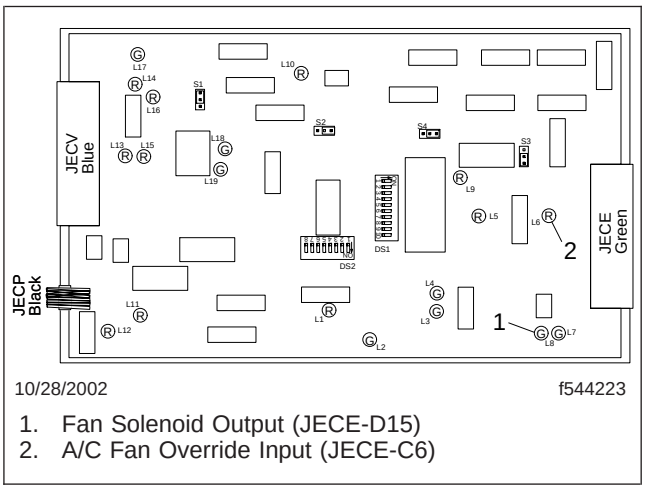



**Fig. 69, Fan Control Circuit**




1. Fan Solenoid Output (JECE-D15)
2. A/C Fan Override Input (JECE-C6)

**Fig. 70, Fan Control LEDs**

turns on. The ECC breaks the ground to wire IN36A, engaging the fan, and the ECC fan solenoid green LED turns off. The ECC holds the fan on for 2 minutes after the signal from the trinary switch is disengaged.

When the ECC tester ignition switch is on, the ECC tester fan red LED should turn on when the engine coolant temperature reaches 203° F (101° C), and should turn off when below 195° F (90° C). Turn the tester potentiometer to test. The fan can also be controlled by the A/C fan override signal. When the tester A/C fan override switch is pressed momentarily, the fan LED should light for 2 minutes, then turn off.

## Low Oil Pressure Alarm and Indicator

The ECC monitors wire IN33A from the low oil pressure sensor. See **Fig. 71**. If the oil pressure drops the sensor opens the ground, and the ECC provides a ground to LB02A which turns on the yellow oil pressure indicator in the dash lightbar and an alarm should sound. The ECC internal low oil pressure input red LED should illuminate. See **Fig. 72**.

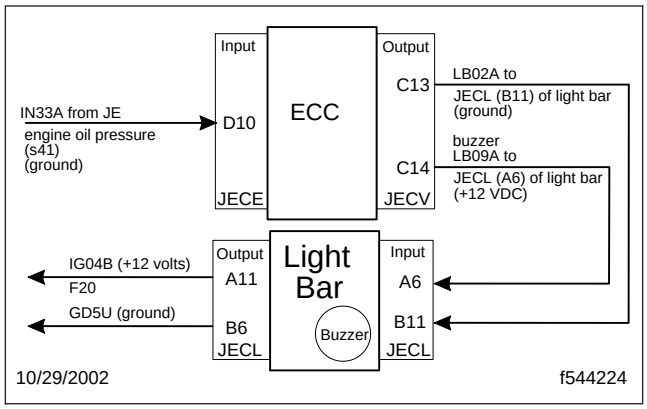
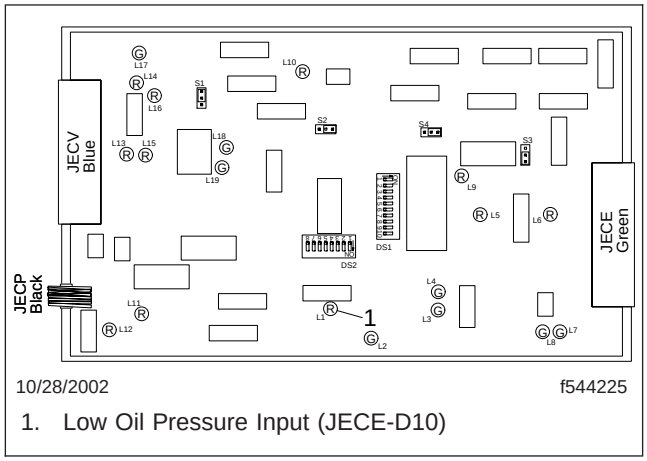



**Fig. 71, Low Oil Pressure Alarm and Indicator Circuit**




1. Low Oil Pressure Input (JECE-D10)

**Fig. 72, Low Oil Pressure Alarm and Indicator LEDs**

With the ECC tester ignition switch on, turning on the ECC tester low oil pressure switch should turn on the lightbar yellow check engine indicator and an alarm. The ECC internal low oil pressure input red LED should illuminate.

## Low Coolant Alarm and Indicator

The ECC monitors IN34A from the low coolant probe. See **Fig. 73**. If the coolant level drops, the probe opens the ground and the ECC provides a ground for LB06A which turns on the red coolant indicator in the dash lightbar. Power is supplied to the lightbar by F20 through wire IG04B. If S1 is enabled, an alarm will sound.

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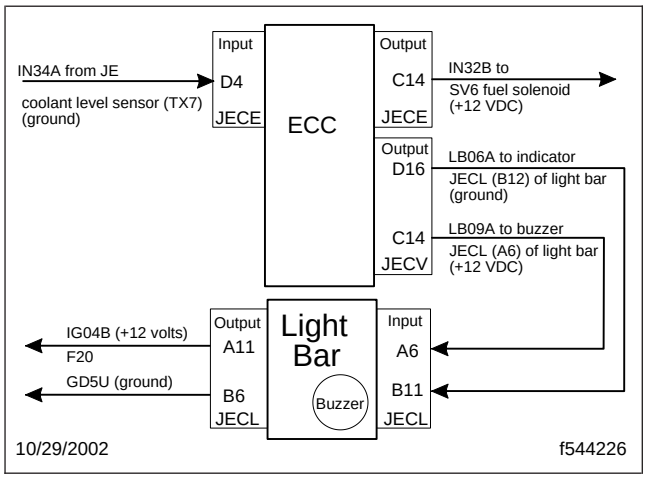



**Fig. 73, Low Coolant Alarm and Indicator Circuit**

With the ECC tester ignition switch on, the ECC tester low coolant switch should turn on the lightbar engine fluids red indicator and an alarm should sound.

## Engine Shutdown

The engine should shutdown from a lack of fuel when the ECC turns off the +12 VDC output to the fuel solenoid via IN32A. The ECC internal fuel solenoid output green LED is off when the engine shuts down. After being turned off, the fuel solenoid can only be enabled by turning the ignition off, then on again.

For shutdown functions there must be power from ignition wire IG04A.

If jumper S2 is enabled, the fuel solenoid should turn off if the park brake is on for 5 minutes. The ECC monitors IN20A from the park brake switch. See **Fig. 74**.

If jumper S3 is enabled, the fuel solenoid should turn off, as long as the engine speed has already been above 750 RPM for 30 seconds, the low oil pressure indicator is on, or if the engine coolant temperature reaches 220° F (104° C). The ECC reads engine speed data from IN31B. The ECC monitors IN33A (see **Fig. 75**) from the low oil pressure sensor, and measures the signal being sent out IN36A from the water temperature sensor.

If jumpers S3 and S4 are both enabled, the fuel solenoid should turn off if the low coolant indicator remains on for 30 seconds, as long as the engine

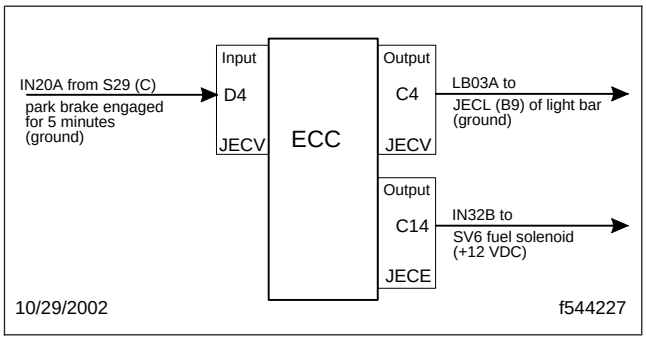



**Fig. 74, Engine Shutdown (park brake engaged) Circuit**

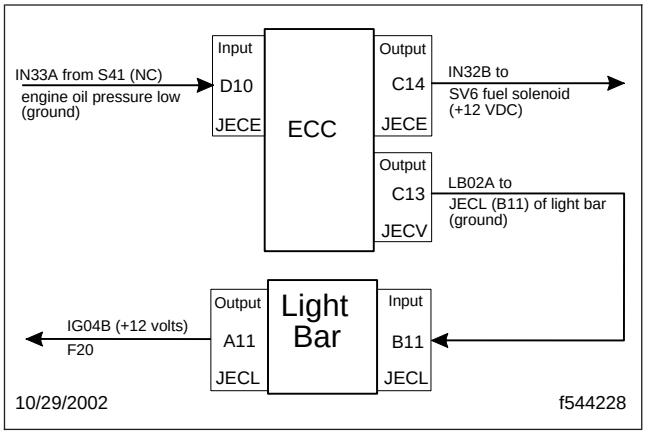



**Fig. 75, Engine Shutdown (low oil pressure) Circuit**

speed has already been above 750 rpm for 30 seconds. The ECC reads engine speed data from IN31B.

The ECC monitors wire IN34A from the low coolant probe. See **Fig. 76**.

With the ECC tester ignition switch on, the tester fuel solenoid red LED and the ECC fuel solenoid output green LED should be illuminated. See **Fig. 77**. The ECC tester fuel solenoid LED and the ECC internal fuel solenoid output green LED will turn off when the engine has been shut down. After being turned off, the fuel solenoid can only be enabled by turning the ignition off, then on again.

## Alarm Sounds

See **Fig. 78** for a depiction of the different alarm sounds for the ECC.

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## ECC Managed Systems (Vehicles Built Before January, 2001)

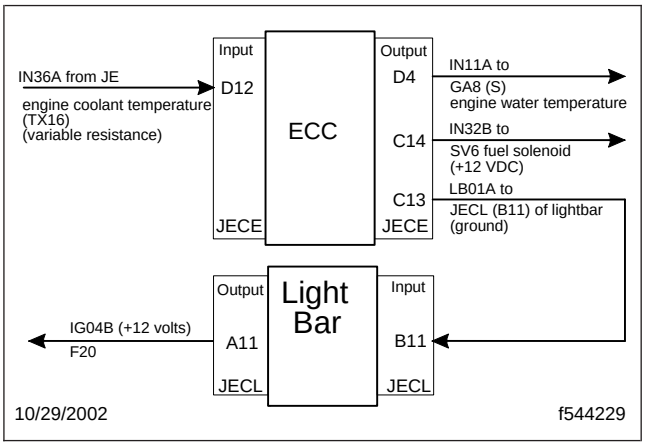
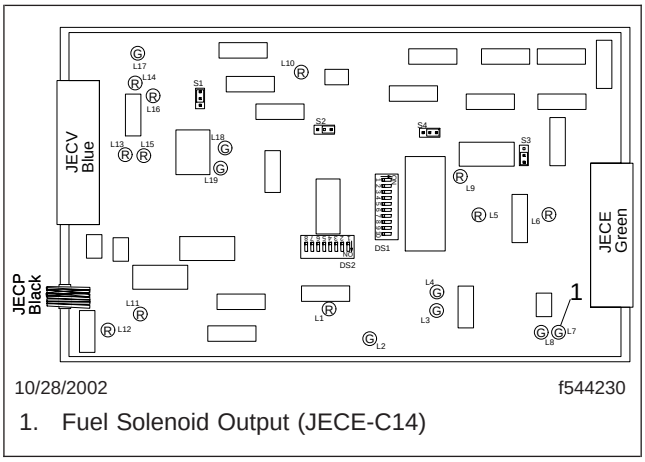



**Fig. 76, Engine Shutdown (engine coolant temperature) Circuit**




1. Fuel Solenoid Output (JECE-C14)

**Fig. 77, Fuel Solenoid LED**

## Star Gauge ECC Test

1. Unplug the three connectors from the ECC. See **Fig. 79**.
2. Plug the corresponding tester connectors into the ECC.

   See **Fig. 80** for the ECC tester.
3. Connect the black lead to ground, and the red lead to a 12 volt DC power source.
4. Turn the switch on the tester to the ON position.

   The tester will perform a full function test. After approximately 30 seconds the green or red LED indicator will illuminate. If the tester illuminates a red LED the ECC needs to be replaced.

See **Table 1** for the JECP connector pin functions, **Table 2** for the JECV connector pin functions, and **Table 3** for the JECE connector pin functions.

| JECP Connector Pin Function | |
|---|---|
| **Pin** | **Function** |
| A | Flasher Out |
| B | Ground |
| C | Windshield Wiper Low |
| D | Windshield Wiper High |
| E | Windshield Washer |
| F | Daytime Running Lights/Dash Lighting Power |
| G | Daytime Running Lights Out |
| H | Flasher Power |

**Table 1, JECP Connector Pin Function**

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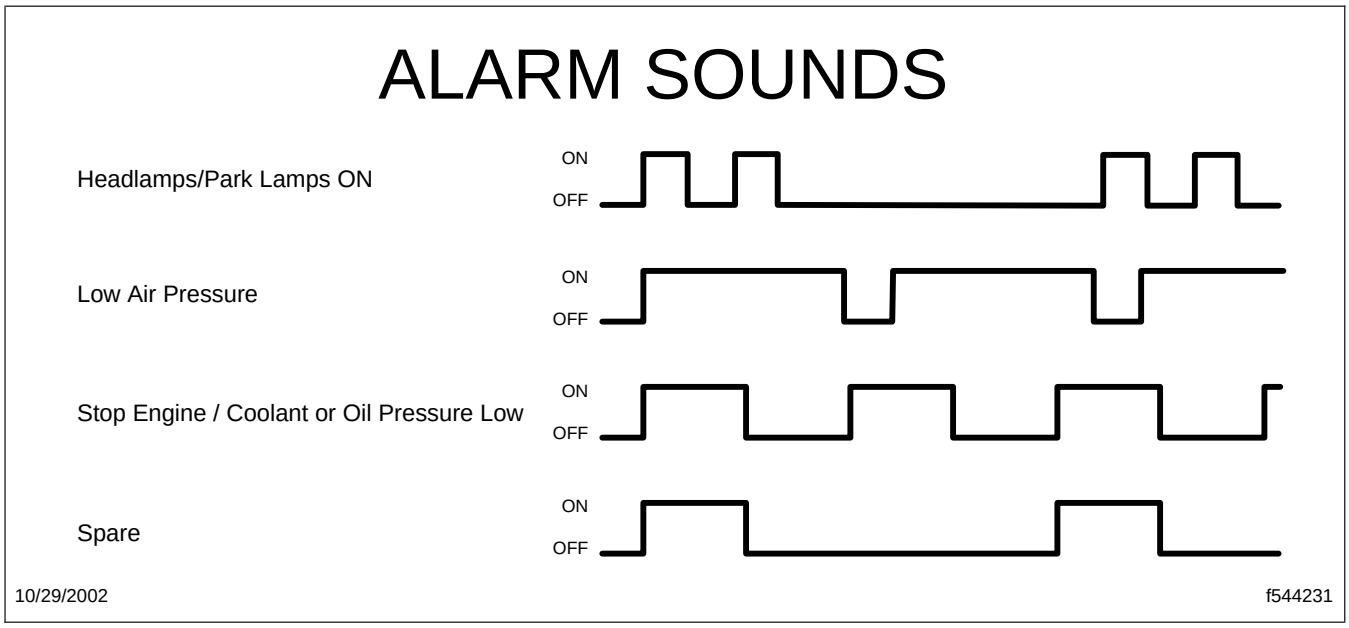



**Fig. 78, ECC Alarm Sounds**

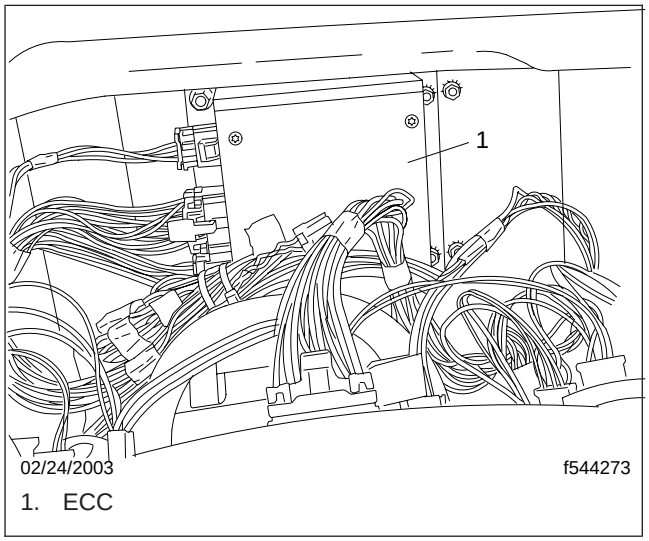



**Fig. 79, ECC**

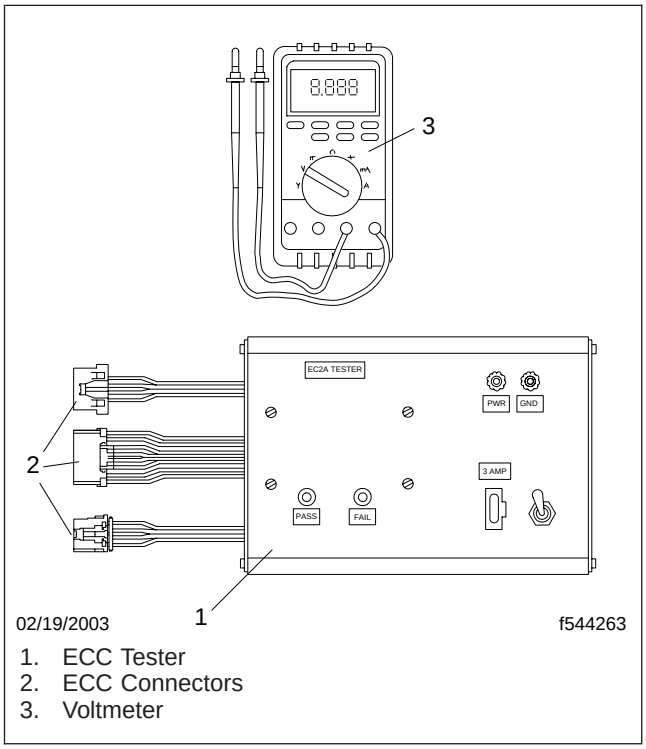



**Fig. 80, EC2A ECC Tester 14322-4401**

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## ECC Managed Systems (Vehicles Built Before January, 2001)

| PECV Connector Pin Function | |
|---|---|
| **Pin** | **Function** |
| A1 | Signal Ground |
| A2 | ECC Power |
| A3 | Windshield Washer |
| A4 | Dash Brighter |
| A5 | Windshield Wiper Park |
| A6 | Windshield Wiper Low |
| A7 | Windshield Wiper High |
| A8 | Low Air Alarm |
| A9 | Ignition |
| A10 | Daytime Running Lights Indicator |
| A11 | High Beam Indicator |
| A12 | Dash Dimming |
| B1 | Windshield Washer In |
| B2 | Buzzer |
| B3 | Dash Dimmer |
| B4 | Windshield Wiper High |
| B5 | Stop Engine Indicator |
| B6 | Check Engine Indicator |
| B7 | Maintenance Indicator |
| B8 | Park Brake Indicator |
| B9 | Park Brake Indicator |
| B10 | Park Brake In |
| B11 | High Beam Indicator |
| B12 | Park Lamps |

**Table 2, PECV Connector Pin Function**

| JECE Connector Pin Function | |
|---|---|
| **Pin** | **Function** |
| A | Maintenance Lamp |
| B | ECM Warning Lamp |
| C | ECM Stop |
| D | Spare Alarm |
| E | Spare Alarm |
| F | Spare Alarm |
| G | Park Brake Output |

| JECE Connector Pin Function | |
|---|---|
| **Pin** | **Function** |
| H | ECM Sensor Common |

**Table 3, JECE Connector Pin Function**

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# System Overview

Instrumentation on Western Star vehicles consists of a lightbar, the Star Gauges®, and the optional Datastar® digital display.

The lightbar houses the telltale indicators and the buzzer. All the input signals to the lightbar are hardwired. It does not communicate over any serial data bus. See **Subject 54.02** for information on the lightbar and the electronic control center (ECC). See **Fig. 1**.

The speedometer is the master gauge of the Star Gauge network. It converts J1587 data and backlighting into the Star Gauge data network which is routed "daisy chain" method to all the other gauges. The speedometer receives and converts data from the engine, RX module, PX/PX-A module, and transmission controller, for the Star Gauges. The 3 wire databus coming out of the speedometer is the source of the Star Gauge network. See **Fig. 2**.

The Datastar is a two line LCD display unit that is user configurable to display vehicle data and clock functions. The Datastar uses J1587 data for its display and has no hardwired signal inputs.

# System Implementation

## Vehicles Manufactured Before EPA10 Systems

The J1587/J1708 data network connects the engine controller, PX/PX-A module, RX module, speedometer, Datastar, and other devices such as Qualcomm. With this data network, the ECUs on the vehicle are able to share information using a 2-wire databus. Each ECU connected to the databus uses only the data it needs to perform its function.

The RX module converts hardwired sensor and voltage inputs into J1587 data. This data is used for the Star Gauges and the Datastar. The signals the RX module converts into J1587 data can be monitored with an off board diagnostic tool, such as DDDL and ServiceLink. The RX module is located on the underside of the cab below the steering shaft, near the clutch linkage. See **Fig. 3**.

The PX and PX-A modules tap into the vehicle air pressure and vacuum systems. These modules convert pressure into J1587 data. This data is used for the Star Gauges, the Datastar and is also available for diagnostics. The PX and PX-A modules are located behind the main dash panel on the plate above the steering column. See **Fig. 4**.

Beginning in April 2005, the PX and PX-A modules were replaced by gauges with air lines that are routed to the individual Star Gauge. These gauges convert the air pressure into an electrical signal that is used to position the gauge pointer. The Star Gauge databus only supplies power, ground, and backlighting information for these gauges. See **Fig. 5**.

## EPA10 Vehicles

Beginning with EPA10 vehicles, the engine controller no longer offered a J1587 databus. The engine, transmission, ABS, and most of the other optional electronic devices on the vehicle communicate using J1939 protocol. The EPA10 RX module is a redesigned module, that incorporates the functions of the earlier RX and PX modules in one unit that also has a gateway function.The EPA10 RX module performs the following functions.

- converts sensor and voltage inputs into J1587 (PI bus) data.
- converts four air pressure inputs into J1587 (PI bus) data.
- converts J1939 data that is required for the DataStar and the Star Gauges into J1587 (PI bus) data.
- broadcasts fuel level over J1939, also ambient air temperature and transmission temperature, on vehicles where these sensors are hardwired to the RX module.

NOTE: The J1587 data network is also called the PI bus in some instances.

The speedometer uses the J1587 data from the RX module as the source of data for the Star Gauges. The Datastar is also on the J1587 (PI bus) network and uses this data. The RX gateway module is located on the underside of the cab below the steering shaft, near the clutch linkage. See **Fig. 6**.

## 24 to 12 Volt Converter

The 24 to 12 volt converter is used on vehicles with 24 volt electrical systems. It is connected between the speedometer and the dash wiring harness and is

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## General Information

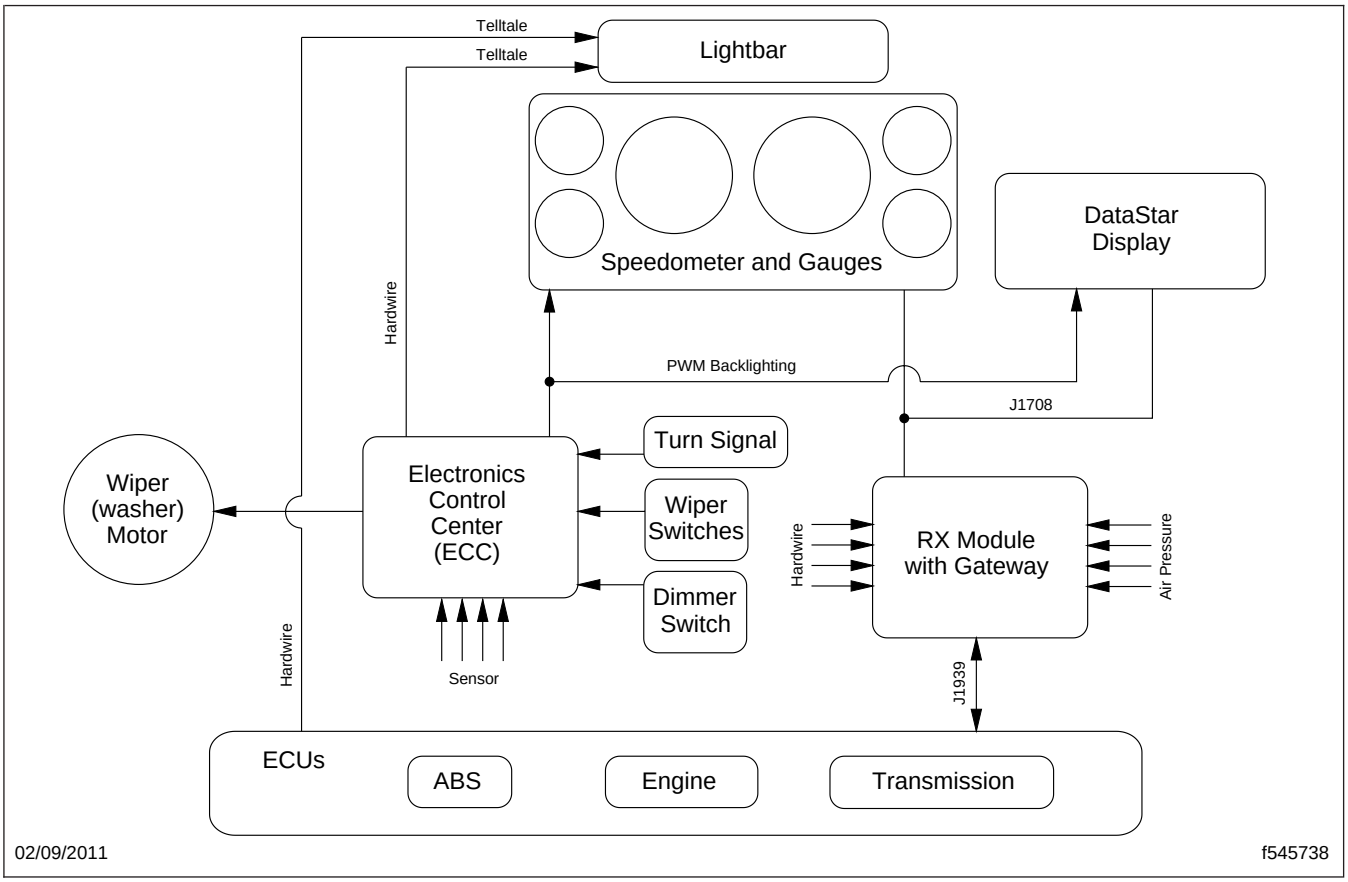
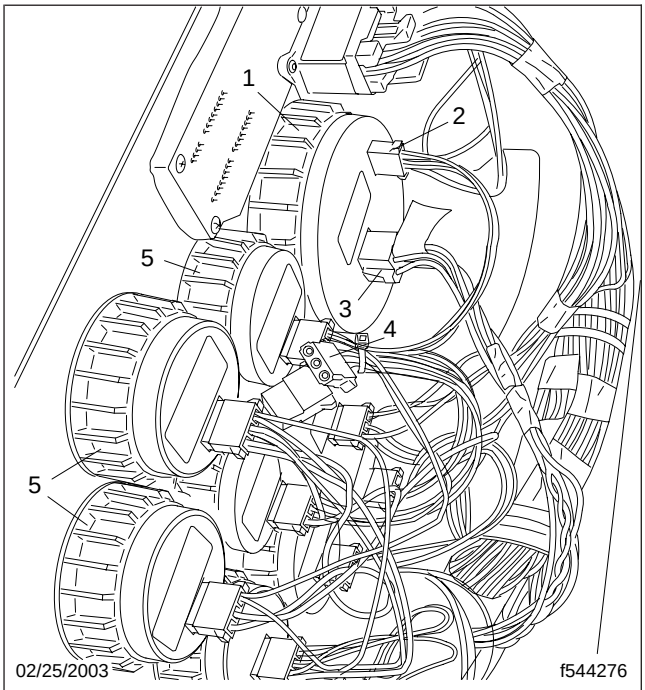



**Fig. 1, EPA10 Instrumentation Architecture**

used for supplying 13.5 volts to the speedometer and Datastar instead of the vehicle system 24 volts. See **Fig. 7**.

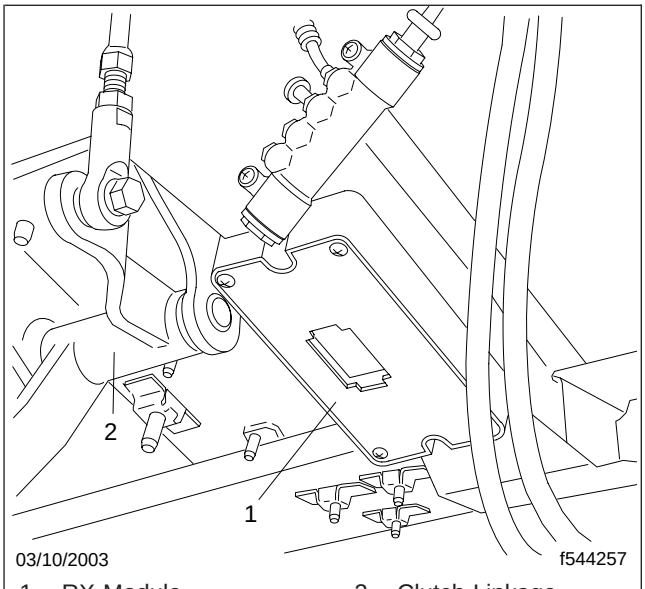
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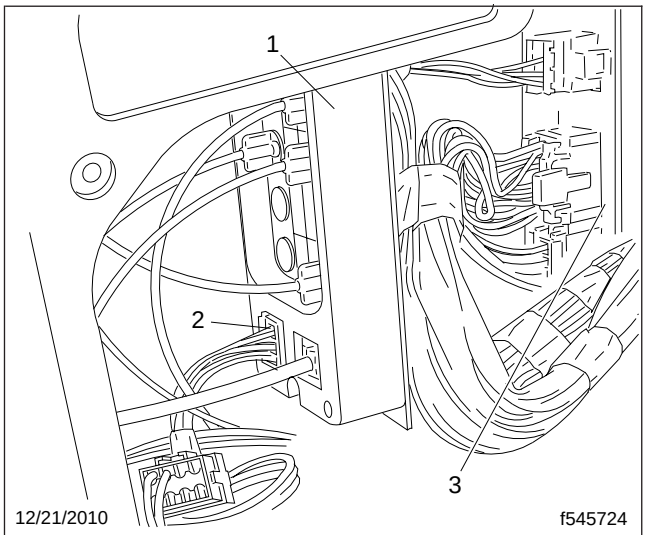

1. Speedometer
2. Star Gauge Databus Connector
3. 6-Way Connector
4. Spare Databus Connector
5. Star Gauges

**Fig. 2, Rear View of Star Gauges**



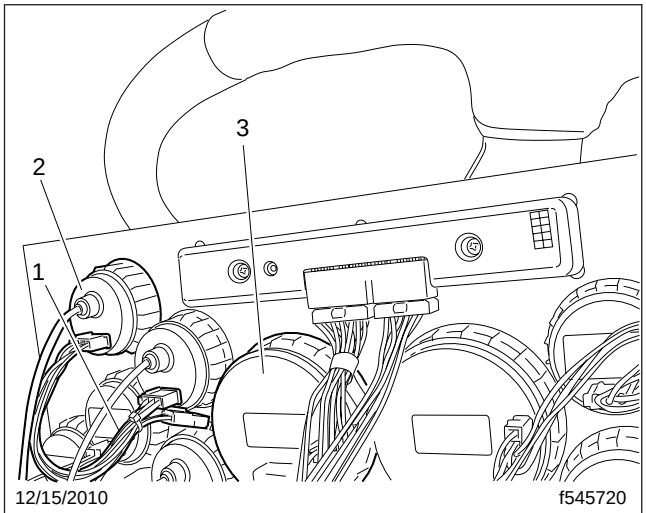

1. RX Module
2. Clutch Linkage

**Fig. 3, EPA07 and Earlier RX Module**




1. PX Module
2. 6-Way Connector
3. ECC

**Fig. 4, PX Module**



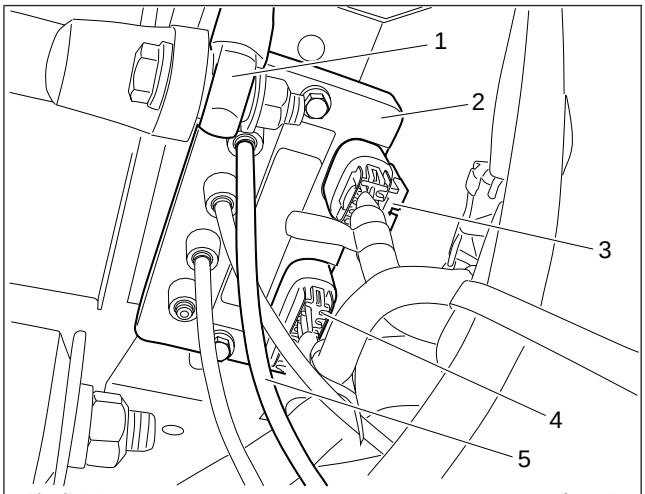

1. Daisy Chain Jumper Harness
2. Star Gauge with Air Pressure Line
3. Speedometer

**Fig. 5, Gauges with Air Pressure Lines**

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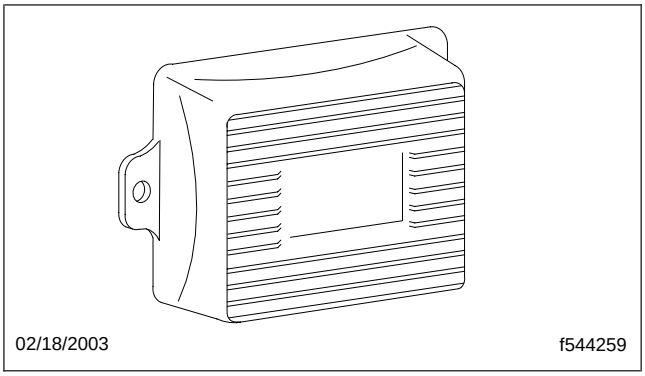
## General Information




12/15/2010 f545721

1. Clutch Linkage
2. RX Gateway Module
3. Connector 1 (Pins A – H)
4. Connector 2 (Pins A – S)
5. Air Line

**Fig. 6, EPA10 RX Gateway Module**



02/18/2003 f544259

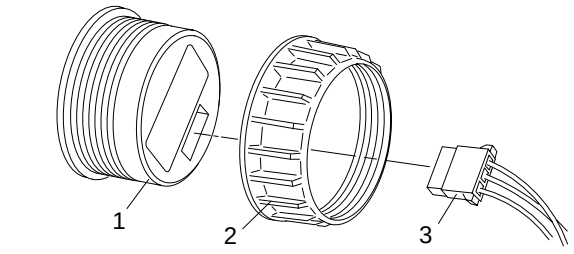
**Fig. 7, 24 to 12 Volt Converter**

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## Removal

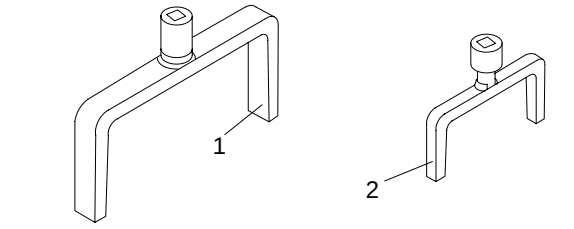
Gauges are secured in the dash by a retaining ring that threads onto the rear of each gauge. See **Fig. 1**. Use gauge removal tool part number 87340-4403 to remove the speedometer and tachometer (3-inch gauges), and tool part number 87340-4404 to remove the Star gauges (2-inch gauges). See **Fig. 2**.




02/26/2003 f544277

1. Gauge
2. Retaining Ring
3. Databus Connector

**Fig. 1, Gauge Removal**




02/19/2003 f580362

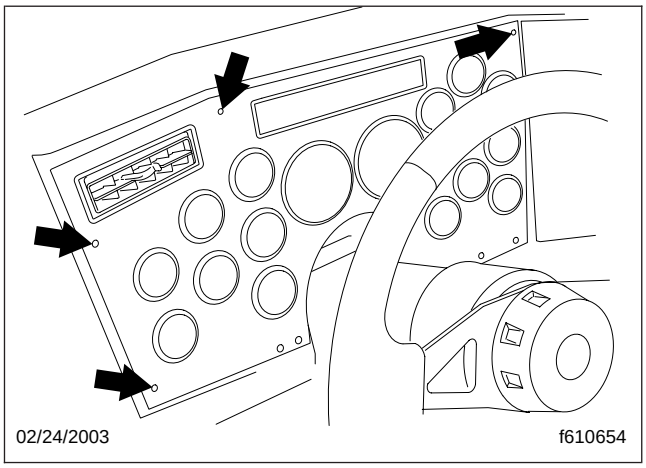
1. 3-Inch Gauge Removal Tool
2. 2-Inch Gauge Removal Tool

**Fig. 2, Gauge Removal Tools**

### NOTICE

**When gauge removal is required use the specified gauge removal tools or damage to the gauge may result.**

1. Lower the steering wheel to its lowest position.
2. Open the main instrument dash panel by removing the four fasteners. See **Fig. 3**. Tip the instrument panel forward to access the rear of the gauges.



02/24/2003 f610654

**Fig. 3, Main Instrument Dash Panel Fasteners**

3. Unplug the connector(s) from the back of the gauge.
4. Place the appropriate gauge removal tool over the retaining ring.
5. Insert the end of a hand ratchet into the end of the removal tool and unscrew the retaining ring.
6. Remove the gauge from the dash panel.

## Installation

1. Insert the gauge into the dash panel and align the index tab with the slot in the panel.
2. Slide the retaining ring onto the back of the gauge and tighten it finger-tight.
3. Place the appropriate gauge removal tool over the retaining ring, and using a small torque wrench inserted into the end of the removal tool, tighten the ring to 35 lbf·in (40 N·cm).

### NOTICE

**Over-tightening of the gauge retaining ring will cause the retaining ring to weld to the gauge, making it impossible to remove the gauge without damaging it.**

4. Plug the connectors into the back of the gauge.
5. Test the gauge for proper operation following the instructions in **Troubleshooting 300**.
6. Close the instrument panel and secure with the four fasteners.

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## Gauge Removal and Installation

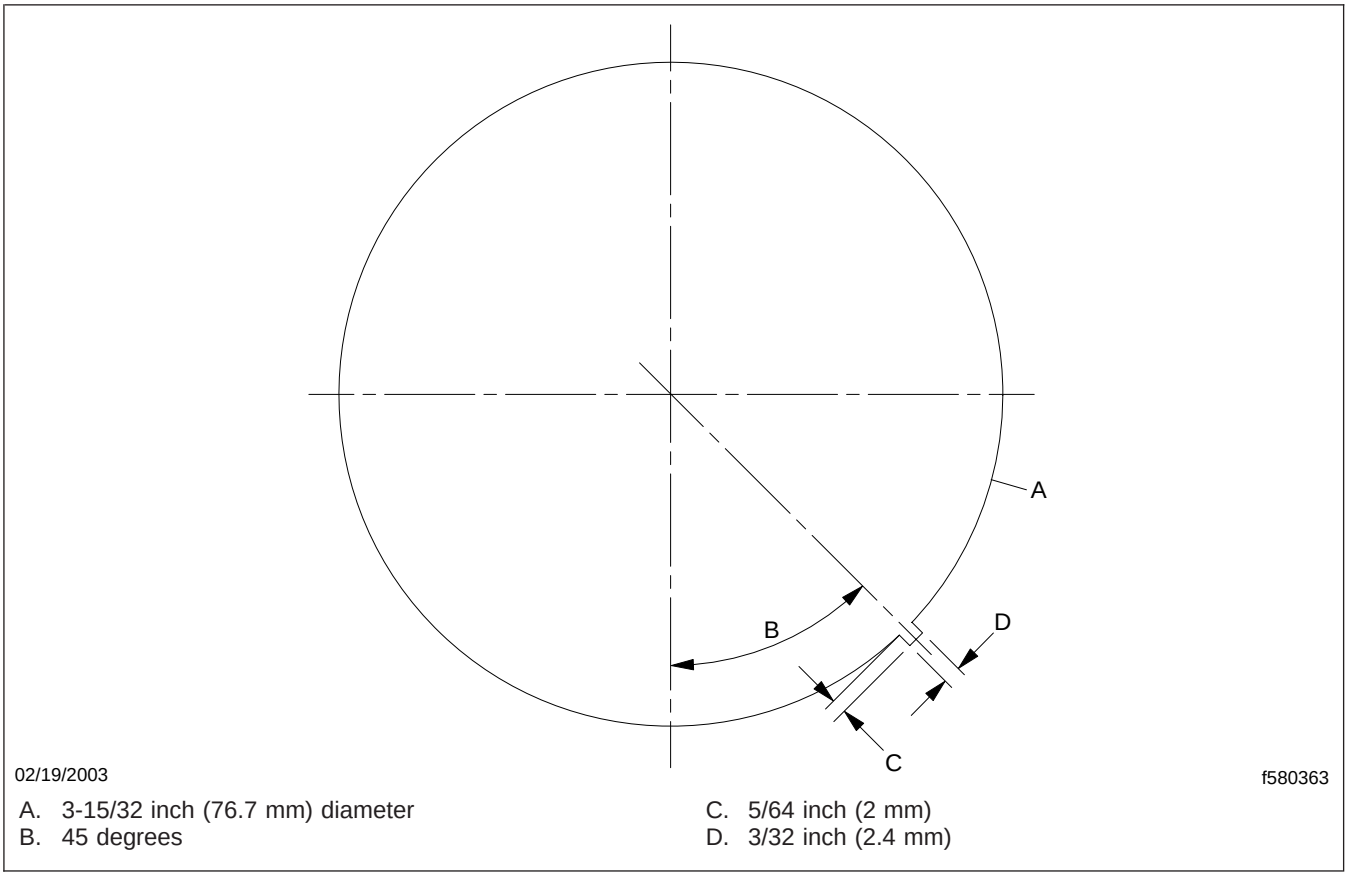
### Adding New Gauges to the Instrument Cluster

New gauges may be added to the instrument cluster by cutting a hole in the dash panel and connecting the new gauge to an existing gauge with a databus jumper cable.

IMPORTANT: Only Star Gauge specified gauges may be added to the system.

IMPORTANT: Due to variations when printing, **Fig. 4** and **Fig. 5** must be confirmed to be to scale before they can be used as templates for cutting the dash panel. Print the figure and measure to confirm that the diameter is the same as callout A in the figure.

1. Using the dimensions in **Fig. 4** as a template for a 3-inch gauge, cut a 3-15/32 inch (88.5 mm) diameter hole into the panel. The hole has an index notch centered 45 degrees counter-clockwise from the bottom. The notch is 3/32 inch (2.4 mm) long, by 5/64 inch (2 mm) wide.
2. Using the dimensions in **Fig. 5** as a template for a 2-inch gauge, cut a 2-3/32 inch (53.2 mm) diameter hole into the panel. The hole has an index notch centered at the bottom. The notch is 3/32-inch (2.4 mm) long, by 5/64-inch (2 mm) wide.
3. Place a new gauge into the dash panel.
4. Install the retaining ring and tighten it finger-tight. Using the gauge removal tool and a torque wrench, tighten the ring to 35 lbf·in (40 N·cm).
5. Plug a spare databus jumper cable (see **Fig. 6**) into the connector on the back of the gauge.

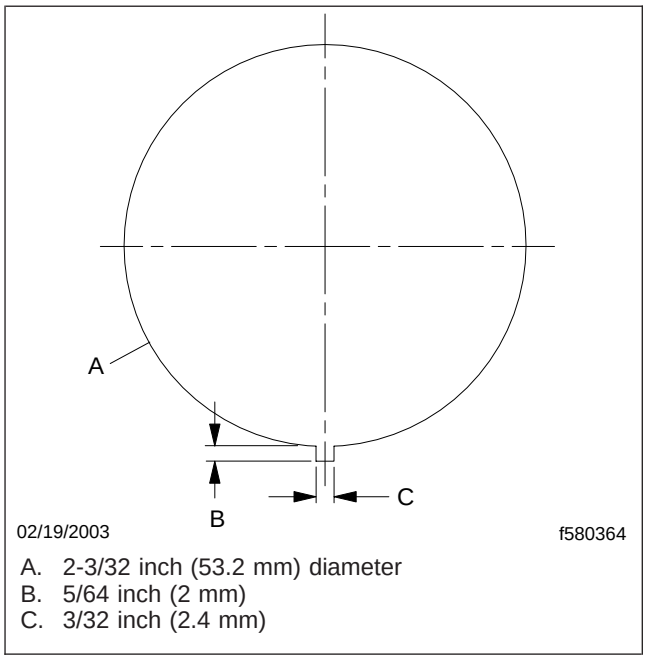



A. 3-15/32 inch (76.7 mm) diameter
B. 45 degrees
C. 5/64 inch (2 mm)
D. 3/32 inch (2.4 mm)

**Fig. 4, 3-Inch Gauge Dash Cutout**

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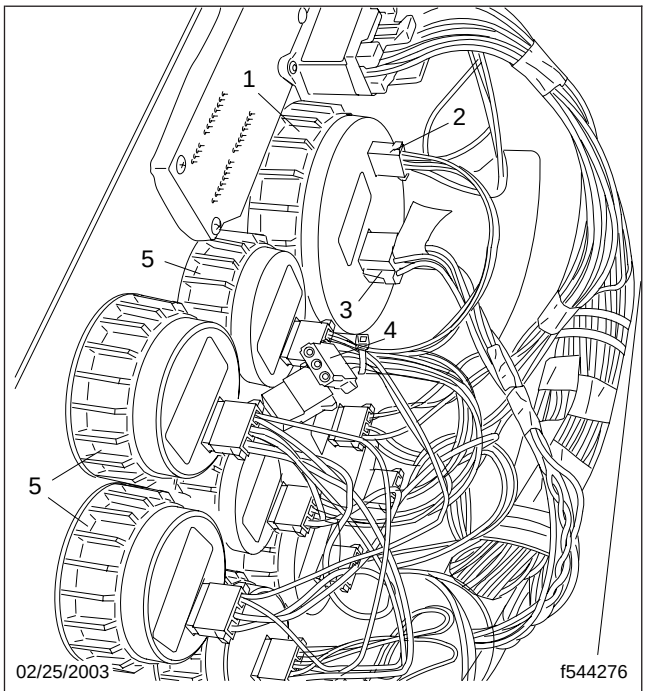





A. 2-3/32 inch (53.2 mm) diameter
B. 5/64 inch (2 mm)
C. 3/32 inch (2.4 mm)

**Fig. 5, 2-Inch Gauge Dash Cutout**

6. Test the gauge following the instructions in **Troubleshooting 300**.
7. Close the instrument panel and secure with the four screws.




1. Speedometer
2. Star Gauge Databus Connector
3. 6-Way Connector
4. Spare Databus Jumper Cable
5. Star Gauges

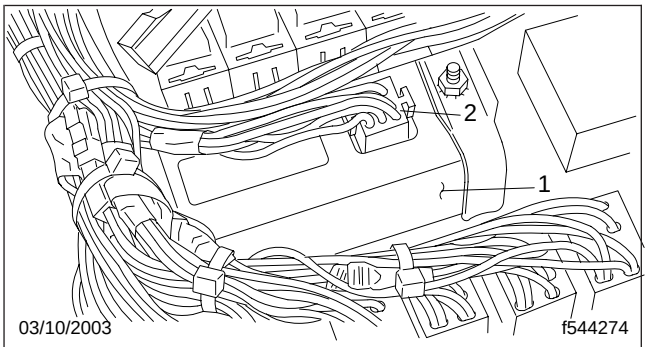
**Fig. 6, Rear View of Gauges**

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## Removal

1. Open the center instrument panel by removing the two fasteners. Tip the panel forward to expose the back of the Datastar. See **Fig. 1**.




1. Rear of Datastar
2. 6-Way Connector

**Fig. 1, Rear View of Datastar**

2. Unplug the 6-way connector from the back of the Datastar.
3. Remove the two hex nuts that secure the mounting bracket to the Datastar. Remove the brackets. See **Fig. 2**.
4. Remove the Datastar from the dash.

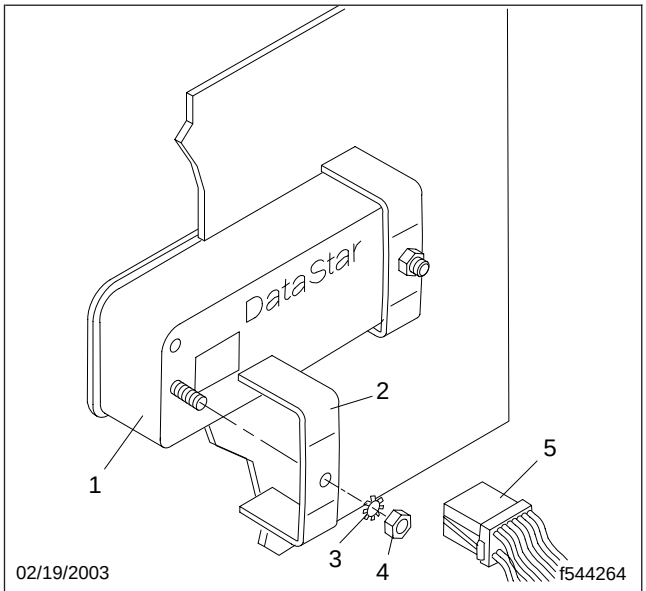
## Installation

1. Insert the Datastar into the dash.
2. Slide the mounting brackets onto the studs on the rear of the Datastar. Make sure the bracket teeth are making contact with the dash panel.
3. Place lockwashers onto the studs and install the hex nuts finger-tight. Torque the nuts to 15 lbf·in (17 N·cm).

### NOTICE

**Over-torquing of the mounting bracket can cause the dash to warp and damage the Datastar.**

4. Plug in the harness connector.
5. Test the Datastar by scrolling through the displays.
6. Close the dash panel and secure with the two fasteners.




1. Datastar
2. Mounting Bracket
3. #8 Lockwasher
4. 8-32 Hex Nut
5. 6-Way Connector

**Fig. 2, Datastar Mounting**

## Adding a Datastar to the Dash

IMPORTANT: Due to variations when printing, **Fig. 3** must be confirmed to be to scale before it can be used as a template for cutting the dash panel. Print the figure and measure to confirm that it matches the dimensions given in the figure callouts before using it as a template.

1. Using the specifications in **Fig. 3**, cut a horizontal rectangle into the dash, measuring 5-3/32 inches (131.8 mm) by 2-3/32 inches (56.6 mm) with 1/4 inch (6.4 mm) radius corners.
2. Insert the Datastar into the dash.
3. Slide the mounting brackets onto the studs on the rear of the Datastar. Make sure the bracket teeth are making contact with the dash panel.
4. Place lockwashers onto the studs and install the hex nuts finger-tight. Torque the nuts to 15 lbf·in (17 N·cm).

### NOTICE

**Over-torquing of the mounting bracket can cause the dash to warp and damage the Datastar.**

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## Datastar Removal and Installation




A. 1/4 inch (6.4 mm)
B. 5-3/16 inch (131.8 mm)
C. 2-3/16 inch (55.6 mm)

**Fig. 3, Datastar Dash Cutout**

5. Plug in the harness connector.
6. Test the Datastar by scrolling through the displays.
7. Close the dash panel and secure with the two fasteners.

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# Testing

## Gauge Test—Using the Star Gauge Tester

NOTE: The databus supplies identical signals to the gauges and the Datastar. If a gauge is suspected of not functioning properly, first compare the gauge reading to the readout on the Datastar. If the readings are the same, it indicates that the gauge is functioning correctly.

A Star Gauge tester, part number 14322-3431 (see **Fig. 1**), is available to perform the gauge test. The tester isolates the gauges from the other system components in order to diagnose a non-functioning or inaccurate gauge.

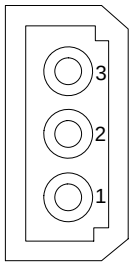
1. Set the battery and ignition switches on the tester to the OFF position.
2. Disconnect the 6-way connector on the back of the speedometer.
3. Plug in the 6-way connector from the tester to the speedometer.
4. Plug the cigar lighter adapter into the dash.
5. Turn the ignition key to ACC to supply power to the tester.
6. Turn the tester battery switch to ON. The illumination of all the gauges should cycle brighter and dimmer.
7. With the tester battery switch set at ON, switch the ignition switch to ON. All the gauges should start to sweep their pointers.
8. Confirm that all the gauges are functioning. If any gauge shows abnormalities (no backlighting, erratic or non-movement of the pointer) check the continuity of the connections between the speedometer and the affected gauge.

   See **Table 1** for the star gauge connector definition. See **Table 2** for the 6-way connector input pin definition.
9. If the connections are secure and the gauge is not functioning, follow the instructions in **Subject 100** to replace the gauge.

## RX Module and PX/PX-A Module Tests

The RX module and the PX/PX-A modules are tested by using an adapter harness to isolate the module signals that they send to the Datastar. Prior to performing the tests, the Datastar must have its parameters set to match the gauges that are in the instrument panel. See **Fig. 2**. The parameter on/off function allows the display of certain menus to be turned off.

**Star Gauge Connector Definition**




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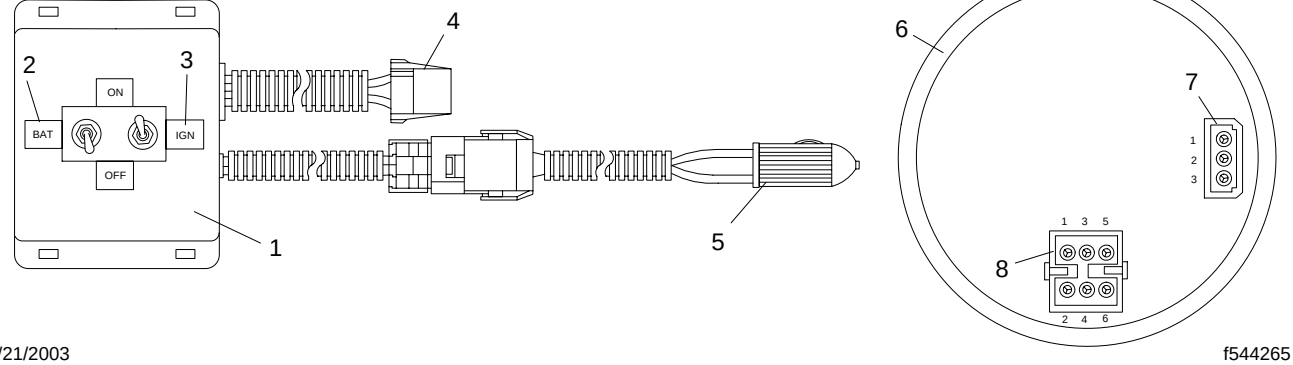
| Pin | Function |
|---|---|
| 1 | +12V Ignition |
| 2 | Data |
| 3 | Ground |

**Table 1, Star Gauge Connector Definition**

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## Troubleshooting

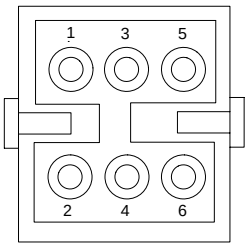



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1. Tester
2. Battery Power Switch
3. Ignition Power Switch
4. 6-Way Connector
5. Cigar Lighter Adaptor
6. Speedometer (shown from rear)
7. Star Gauge Connector
8. 6-Way Connector

**Fig. 1, Gauge Tester**

**6-Way Connector Definition**




02/24/2003 f544272

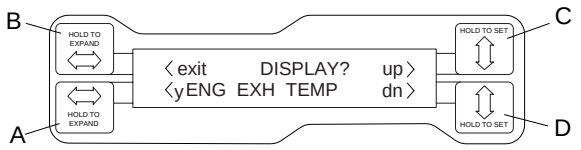
| Pin | Function |
|---|---|
| 1 | +12V Ignition |
| 2 | +12V Battery |
| 3 | Ground |
| 4 | Dash backlighting input |
| 5 | J1587 databus (+) |
| 6 | J1587 databus (–) |

**Table 2, 6-Way Connector Definition**

1. Press and hold the upper EXPAND button while turning on the ignition. The screen should display as shown in **Fig. 2**.

   In the second row of the display, a *y* to the left of the parameter name indicates the parameter will be displayed. An *n* indicates the parameter will not be displayed.

2. Press the lower EXPAND button to toggle the parameter between *y* (yes displayed) and *n* (not displayed).




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A. Lower Expand Button— Press to turn the parameter on/off.
B. Upper Expand Button— Press to return to normal operation.
C. Upper Set Button— Press to scroll the parameter list up.
D. Lower Set Button— Press to scroll the parameter list down.

**Fig. 2, Datastar Display**

NOTE: Only the parameters that there is a matching instrument gauge for should be turned on. Do not turn on a parameter if there is no gauge in the dash that displays that information.

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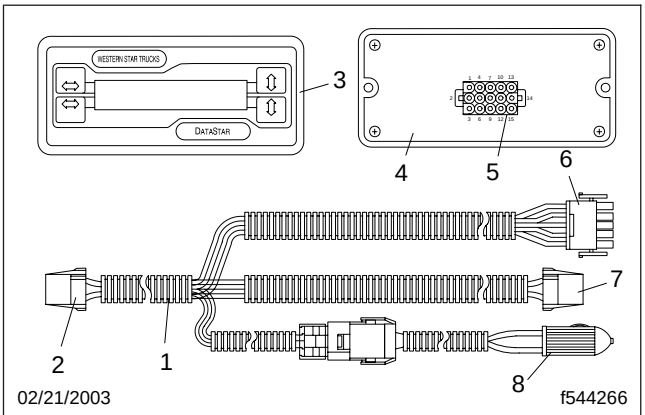
3. Press the upper SET button to scroll the display up through the list of parameters.
4. Press the lower SET button to scroll the display down through the list of parameters.
5. When all the correct parameters are turned on, press the upper EXPAND button to return the Datastar to normal operation. The status of the parameters will be saved in memory.

   The following parameters can be turned on/off:

   - Engine exhaust temperature
   - Fuel level
   - BrakeSaver application pressure
   - BrakeSaver temperature
   - Reservoir A pressure
   - Reservoir B pressure
   - Tractor application pressure
   - Trailer application pressure
   - Trailer emergency pressure
   - Suspension 1 pressure
   - Suspension 2 pressure
   - Transmission temperature
   - Center rear-axle temperature
   - Forward rear-axle temperature
   - Rear rear-axle temperature
   - Air filter restriction pressure
   - Ammeter

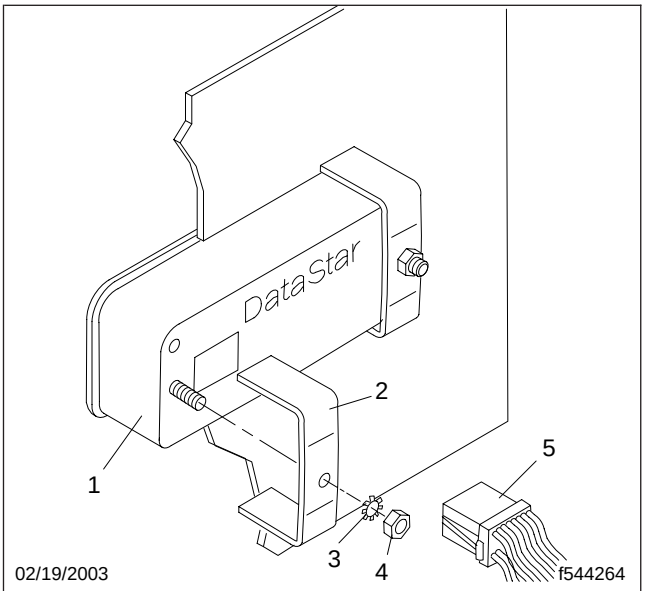
## RX Module Test

1. Unplug the 15-way connector from the RX module.
2. Plug the matching adaptor harness connector into the RX module. See **Fig. 3**.
3. Plug the adapter harness 6-way connector into the Datastar. See **Fig. 4**.
4. Plug the cigar lighter adapter into the dash.
5. Turn the vehicle key to ACC to supply power to the Datastar.
6. Press the "HOLD TO SET" button on the Datastar and scroll through the gauge display readings.




1. Adapter Harness 14405-4401
2. 6-Way Connector (Datastar)
3. Datastar
4. RX Module (shown from rear)
5. 15-Way Connector (RX Module)
6. 15-Way Connector
7. 6-Way Connector (PX Module)
8. Cigar Lighter Adaptor

**Fig. 3, RX Module Test**




1. Datastar
2. Mounting Bracket
3. #8 Lockwasher
4. 8-32 Hexnut
5. 6-Way Connector

**Fig. 4, Rear of Datastar**

See **Table 3** for the readouts that should display if the parameter is turned on for that gauge.

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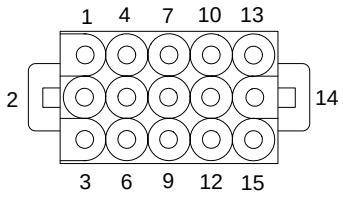


## Troubleshooting

If one of the parameters is not displayed on the Datastar the RX module should be replaced. If all the parameters test okay the fault is not with the RX module. Check the wiring to the sensor for that particular gauge. See **Table 4** for the EPA07 and earlier RX module connector definition.

| Datastar Paramater Display, RX Module | |
|---|---|
| **Parameter** | **Reading °F (°C) unless otherwise indicated** |
| Ammeter | 50 amp ±5 amp |
| Pyrometer | 1130 to 1280 (610 to 683) |
| Brakesaver temperature | 250 (121) ±6 (3) |
| Transmission temperature | 300 (149) ±6 (3) |
| Auxiliary transmission temperature | 225 (107) ±6 (3) |
| Fuel level | 43% ±3% |
| Forward rear-axle temperature | 200 (93) ±6 (3) |
| Center rear-axle temperature | 150 (66) ±6 (3) |
| Rear rear-axle temperature | 125 (52) ±6 (3) |

**Table 3, Datastar Paramater Display, RX Module**

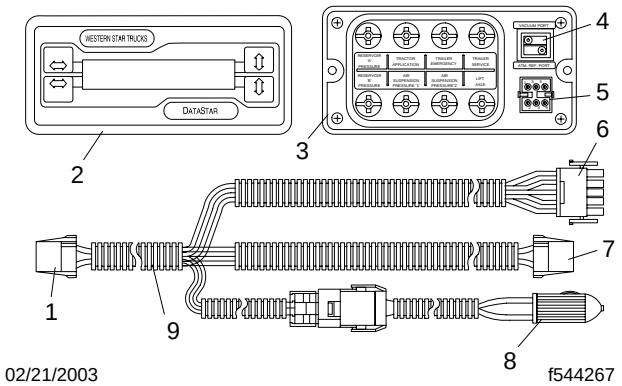
| EPA07 and Earlier RX Module Connector Definition | |
|---|---|
|  03/03/2003 f544279 | |
| **Pin** | **Function** |
| 1 | +12V Ignition |
| 2 | Ground |
| 3 | Databus 1587 (+) |
| 4 | Transmission temperature 1 |
| 5 | Center rear-axle temperature |
| 6 | Databus 1587 (–) |
| 7 | Transmission temperature 2 |

| EPA07 and Earlier RX Module Connector Definition | |
|---|---|
| 8 | Rear rear-axle temperature |
| 9 | Ammeter shunt (high) |
| 10 | Brakesaver temperature |
| 11 | Ammeter shunt (low) |
| 12 | Pyrometer (+) |
| 13 | Forward rear-axle temperature |
| 14 | Pyrometer (–) |
| 15 | Fuel level |

**Table 4, EPA07 and Earlier RX Module Connector Definition**

## PX/PX-A Module Test

1. Unplug the 6-way connector from the back of the PX/PX-A module. See **Fig. 5**.




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1. 6-Way Connector, Datastar
2. Datastar
3. PX Module (rear)
4. Vacuum Port
5. 6-Way Connector (PX Module)
6. 15-Way Connector (RX Module)
7. 6-Way Connector
8. Cigar Lighter Adaptor
9. Adapter Harness 14405-4401

**Fig. 5, PX/PX-A Module Test**

2. Plug the matching adaptor harness connector into the PX/PX-A module.
3. Plug the adapter harness 6-way connector into the Datastar. See **Fig. 4**.
4. Plug the cigar lighter adapter into the dash.

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5. Turn the vehicle key to ACC to supply power to the Datastar.
6. Press the *"HOLD TO SET"* button on the Datastar and scroll through the gauge display readings.

   If the parameter is turned on for that gauge the display should read between 0 to 3 psi (0 to 21 kPa).

   If any of the parameters are not displayed on the Datastar the PX/PX-A module should be replaced. If all the parameters test okay the fault is not with the PX/PX-A module. Check the air lines for that particular gauge for leaks, plugged lines, or kinks and pinches.

   See **Table 2** for the 6-way connector input pin function.

# Instrumentation Troubleshooting

The Star Gauges are electrically operated stepper motor gauges. They receive backlighting and pointer position data over the Star Gauge databus. Some Star Gauges have an air pressure line connected directly to the gauge. These gauges measure the air pressure and convert it into an electrical value to drive the gauge pointer. They also use power, ground, and backlighting data from the Star Gauge databus. The speedometer converts J1587 data into Star Gauge data and is the source of the Star Gauge databus. The Datastar is another user of J1587 data. It will display vehicle parameters received over the J1587 databus and also has clock and timer features.

## Vehicles Built Before EPA10

The J1587 databus is used by almost all the electronic controllers on the vehicle for data communications. Temperature sensors on the axles, turbocharger, brake saver, and manual transmission are measured by the RX module along with fuel level and charging current then transmitted over the J1587 databus. Air pressures in different air systems on the vehicle were measured by the PX module and optionally the PX-A module then transmitted over the J1587 databus. In April 1995, the PX and PX-A modules were eliminated and the air pressures were measured directly at the gauge that displays the pressure for that system. See **Fig. 6** for a block diagram of the instrumentation topology for vehicles built before April 4, 1995. See **Fig. 7** for a block diagram of the instrumentation topology for vehicles built after April 4, 1995.

## EPA10 Vehicles

The vehicle uses a J1939 databus between the engine, transmission, ABS, and most all other electronic devices. The EPA10 RX module translates J1939 data into J1587 data and is the source of the J1587 (PI bus) databus. The speedometer uses this data for the Star Gauge system and the Datastar uses this data for the parameters it displays. The RX module also measures air system pressures and reads the temperature sensors. It converts those measurements into J1587 data for the Star Gauges and Datastar. In some instances, the J1587 databus in EPA10 vehicles is called the PI bus. See **Fig. 8** for a block diagram of the instrumentation topology for EPA10 vehicles.

## Datastar

If the vehicle is equipped with a Datastar, compare the reading from the Datastar display to the gauge. If the gauges are working but the Datastar is not displaying, replace the Datastar. If the Datastar display is difficult to read, the contrast may need to be adjusted. Use the "Datastar Contrast Adjustment" procedure in **Specifications 400**.

## 24 to 12 Volt Converter Troubleshooting

1. Unplug the 6-way connector between the dash harness and the converter. See **Fig. 9**.
2. Use a voltmeter to check if there is 24 volts at pin 1 of the 6-way connector attached to the dash harness. See **Table 5** for the 6-way connector pin definition.

   If there is no power, check for power at the source and check the fuses and breakers.
3. Turn the vehicle ignition to OFF.
4. Reconnect the 6-way connector between the dash harness and converter.
5. Disconnect the 6-way connector between the converter and the speedometer.

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## Troubleshooting

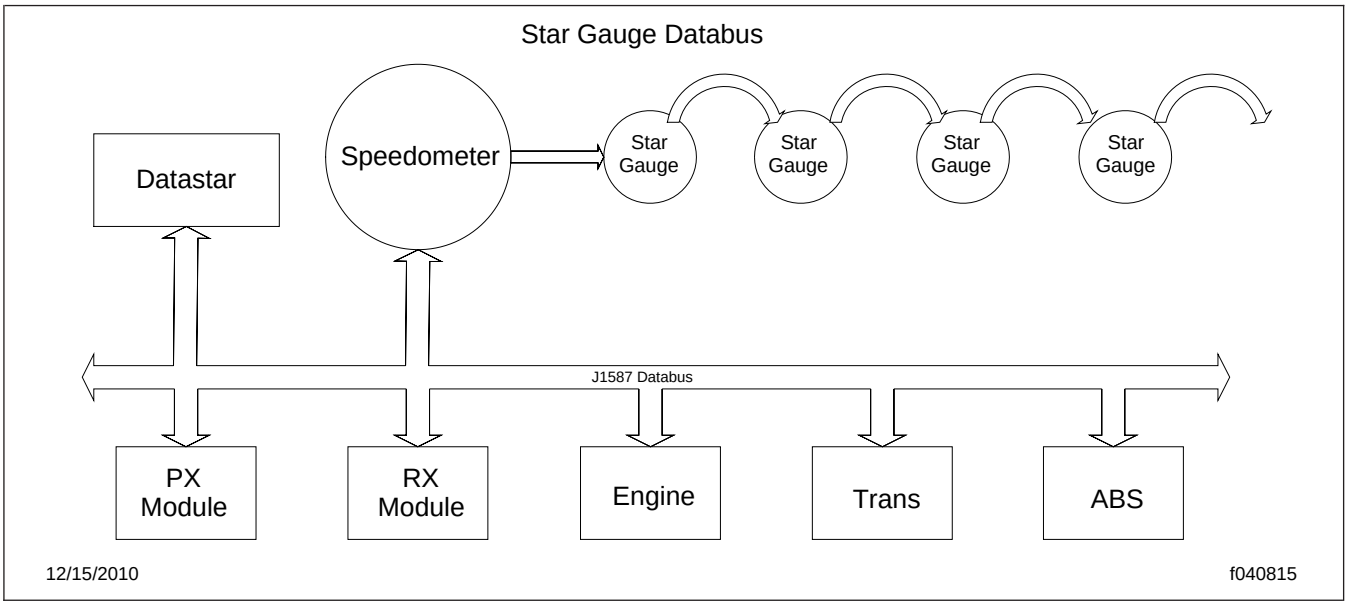



**Fig. 6, Instrumentation Topology (Pre-April 4, 1995)**

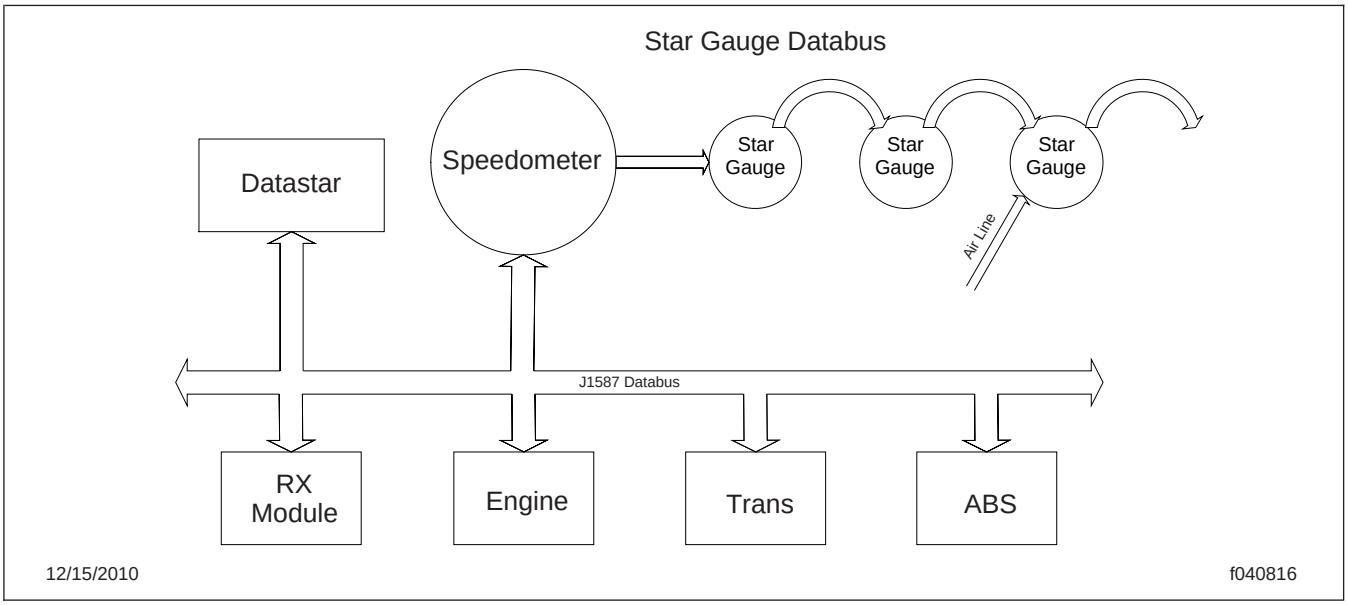



**Fig. 7, Instrumentation Topology ( April 4, 1995 through December 2009)**

6. Turn the vehicle ignition to ON.
7. Use a voltmeter to check if there is between 9 to 16 volts at pin 1 of the connector from the converter.
8. Replace the converter if the reading was not between 9 to 16 volts.

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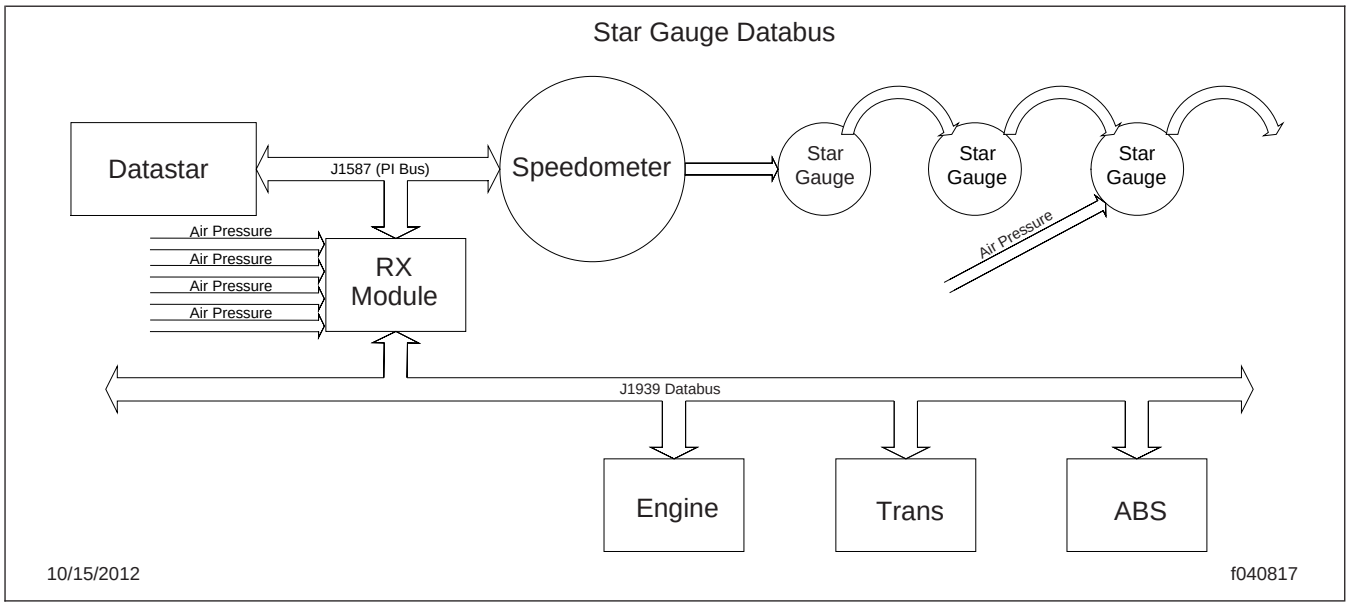
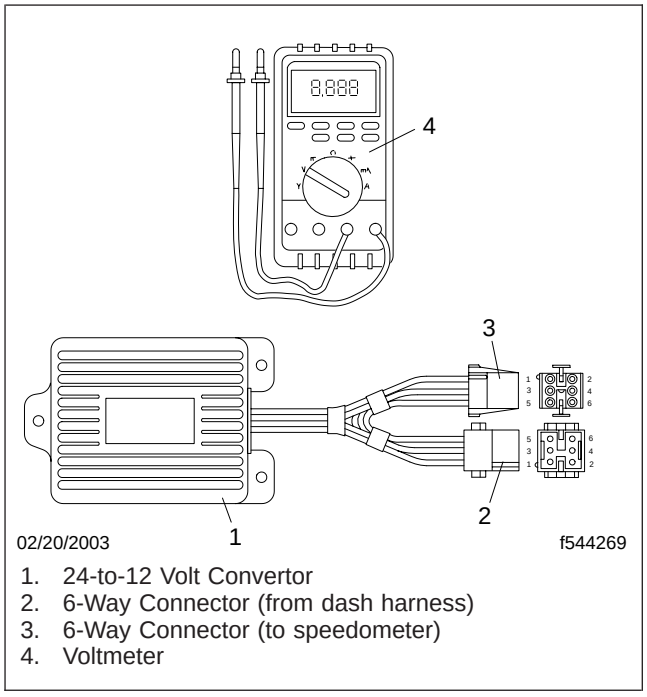


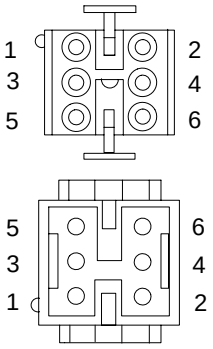

**Fig. 8, Instrumentation Topology (EPA10)**




1. 24-to-12 Volt Convertor
2. 6-Way Connector (from dash harness)
3. 6-Way Connector (to speedometer)
4. Voltmeter

**Fig. 9, 24-to-12 Volt Converter Test**

**6-Way Connector Pin Definition**




| Pin | Function |
|---|---|
| 1 | +12V Ignition |
| 2 | Unused |
| 3 | Ground |
| 4 | Dash lamp dimming |
| 5 | Databus (+) |
| 6 | Databus (–) |

**Table 5, 6-Way Connector Pin Definition**

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## Troubleshooting the Star Gauges

If the speedometer is not receiving valid data for a parameter, it will drive the Star Gauge to zero position or full scale position. When there is a fault with a gauge or gauges properly displaying data use **Table 6** to begin the troubleshooting process. If several gauges are not displaying, determine if they all receive their data from the same source device. If no gauges are displaying, determine if the speedometer is at fault or if the J1587 databus is completely inoperative.

**Star Gauge Troubleshooting**

| Data Source | Parameter | Troubleshooting Procedure |
|---|---|---|
| Engine | Vehicle speed | Use ServiceLink or the Datastar to compare the source data with the gauge. If the source data is valid, replace the gauge. Otherwise, use the engine manufacturers troubleshooting procedures from engine OEM literature. If no data is received from the engine controller, determine if there is a databus fault or the reason for the engine controller going off line. If there is an error with the DEF level indication, use the procedure in **Table 13**. |
| | Engine oil pressure | |
| | Fuel pressure | |
| | Boost pressure | |
| | Extended boost pressure | |
| | Coolant temperature | |
| | Battery voltage | |
| | Engine oil temperature | |
| | Engine speed (tachometer) | |
| | Mileage (odometer) | |
| | DEF level | |
| | Low DEF indicator | |
| RX module | Fuel level | Use **Table 7** to troubleshoot the gauges and electrical systems connected to the RX module. Refer to the table in **Specifications 400** for the message data the EPA10 RX module converts from J1939 to J1587. |
| | Manual transmission #1 oil temperature | |
| | Manual transmission #2 oil temperature | |
| | Charging amperage | |
| | Pyrometer | |
| | Forward rear-axle oil temperature | |
| | Middle rear-axle oil temperature | |
| | Rear rear-axle oil temperature | |
| | Brake saver oil temperature | |
| EPA10 only RX module pressure gauges | Primary air supply | Use **Table 9** to troubleshoot the air pressure gauges and systems connected to the EPA10 RX module. |
| | Secondary air supply | |
| | Tractor application air pressure | |
| | Suspension air pressure | |

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| Star Gauge Troubleshooting | | |
|---|---|---|
| **Data Source** | **Parameter** | **Troubleshooting Procedure** |
| Pressure gauge with air line connected to the gauge | Primary air supply | Beginning in mid-1995, the Star Gauges for air pressures have the air line connected to the gauge. The gauge is a stepper motor type and is electrically operated using the pressure measured at the gauge. Use **Table 10** to troubleshoot these gauges. |
| | Secondary air supply | |
| | Tractor application air pressure | |
| | Lift axle air pressure | |
| | Suspension air pressure | |
| | Trailer service air pressure | |
| | Trailer emergency air pressure | |
| | Brake saver application air pressure | |
| PX module | Lift axle 1 air pressure | Use **Table 11** to troubleshoot the gauges and systems connected to the PX module. |
| | Air filter restriction | |
| | Tractor application air pressure | |
| | Primary air supply | |
| | Secondary air supply | |
| | Suspension 1 air pressure | |
| | Suspension 2 air pressure | |
| | Trailer service air pressure | |
| | Trailer emergency air pressure | |
| PX-A module | Lift axle 2 air pressure | Use **Table 11** to troubleshoot the gauges and systems connected to the PX-A module. |
| | Lift axle 3 air pressure | |
| | Lift axle 4 air pressure | |
| | Air start air pressure | |
| | Brake saver application air pressure | |

**Table 6, Star Gauge Troubleshooting**

| Troubleshooting Gauges with Data Sourced from the RX Module | | | |
|---|---|---|---|
| **Step** | **Test** | **Result** | **Action** |
| 1 | Is the problem with the fuel level display or gauge? | Yes | Use the fuel level troubleshooting procedure in **Table 8**. |
| | | No | Go to Step 2. |

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## Troubleshooting

| Troubleshooting Gauges with Data Sourced from the RX Module | | | |
|---|---|---|---|
| **Step** | **Test** | **Result** | **Action** |
| 2 | Is the problem with the ammeter? If either ammeter circuit is measured from ground, the reading will be close to 6 volts. | Yes | The ammeter uses a 0.0016Ω shunt resistor in the main cab power cable located at the frontwall pass through. The voltage drop across this shunt is measured by the RX module. Using the smallest millivolt scale on the voltmeter, measure the voltage between pins 9 and 11 on the EPA07 and earlier RX module. Measure between pins R and S on EPA10. The measurement will be 1.6mV per amp. Use the Datastar or ServiceLink to see the amperage that the RX module is sending over the databus. Replace the gauge if this testing shows the data going to it is correct. |
| | | No | Go to Step 3. |
| 3 | Is the problem with the pyrometer? | Yes | Apply a heat source to the sensor at the turbocharger. The heat gun used for shrink tubing is a good choice. Use the Datastar or Servicelink to see the temperature that the RX module is sending over the databus. Check for continuity of the wiring from the sensor to pins 12 and 14 of the RX module.<br>Replace the pyrometer sensor if it is not sending temperature information to the module. Replace the gauge if this testing shows the data going to it is correct. |
| | | No | Go to Step 4. |
| 4 | For all other temperature gauges, note whether the gauge stays pegged at full scale or the bottom of the scale reading even though the temperature is at some mid-point or is the complaint an inaccurate reading? | Stays Pegged | Go to Step 5. |
| | | Inaccurate | Go to Step 6. |
| 5 | Disconnect the connector at the sensor and measure the resistance of the sensor. Does the sensor measure open, shorted, or some mid range resistance using the table in **Specifications 400** for that sensor? | Open or Shorted | Replace the sensor. |
| | | Mid Range Resistance | Reconnect the sensor and disconnect the connector at the RX module. Measure the resistance across the circuit for the sensor. If it is open or shorted, locate and repair the wiring fault in the circuit. Otherwise, go to Step 6. |
| 6 | Use the Datastar or Servicelink to see the temperature that the RX module is sending over the databus for the sensor being tested. Is the gauge within about 5% of the Datastar or ServiceLink? | Yes | Go to Step 7. |
| | | No | Replace the gauge. |

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| Troubleshooting Gauges with Data Sourced from the RX Module | | | |
|---|---|---|---|
| **Step** | **Test** | **Result** | **Action** |
| 7 | Remove the sensor and place it in a container of water with a thermometer. Heat the water to a temperature where the resistance can be accurately measured with an ohm meter. Use the resistance table in **Specifications 400** for the sensor to determine if the resistance is appropriate for the temperature. Does the resistance value match the table value? | Yes | Replace the RX module. |
| | | No | Replace the sensor. |

**Table 7, Troubleshooting Gauges with Data Sourced from the RX Module**

| Fuel Level Gauge Troubleshooting | | | |
|---|---|---|---|
| **Step** | **Test** | **Result** | **Action** |
| 1 | If a 100 ohm resistor is available, disconnect the fuel level sender connector and place the resistor across circuit 47 and ground in the wiring harness connector to simulate the fuel level sending unit. Turn the ignition to the ON position and observe the fuel gauge. If, after gauge initialization the gauge points closely to the 1/2 tank mark, then the wiring and ICU are all operating correctly. Jump to Step 4 if there is no problem with the wiring and ICU. Does the fuel level gauge stay at full or empty even though there is fuel in the tank or is the complaint an inaccurate and intermittent reading? NOTE: Turn the ignition to OFF and disconnect the batteries before continuing. | Stays at Full or Empty | Go to Step 2. |
| | | Intermittent or Inaccurate | Go to Step 4. |
| 2 | Disconnect the connector at the fuel level sender and measure the resistance of the sender. What is the resistance? | Greater than 261Ω or less than 21Ω | Go to Step 4. |
| | | Between 261Ω and 21Ω | Go to Step 3. |
| 3 | Connect the fuel level sensor and disconnect the connector on the RX module. Measure the resistance of the vehicle wiring between the RX module connector and the fuel level sender. On EPA07 and earlier this between pins 15, and ground on pin 2. On EPA10 vehicles this is between pins G and ground on pin H on the 16-pin connector.<br>What is the resistance of the circuit? | Greater than 261Ω or less than 21Ω | Troubleshoot and repair a wiring fault in the wiring between the RX module and the fuel level sending unit. |
| | | Between 261Ω and 21Ω | This is the valid resistance range. If the fuel tank is full and the resistance is close to 31 Ω the gauge should read full. If it does not, the fuel gauge is most likely at fault. Use the Datastar or ServiceLink to see the fuel level that the RX module is sending over the databus. Replace the gauge if this testing shows the data going to it is correct. |

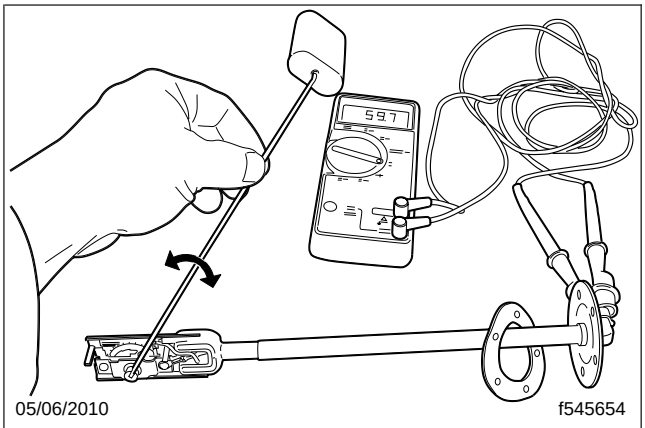
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## Troubleshooting

| Fuel Level Gauge Troubleshooting | | | |
|---|---|---|---|
| **Step** | **Test** | **Result** | **Action** |
| 4 | Remove the fuel level sending unit from the fuel tank. Connect an ohm meter to the pins at the fuel level sender. Slowly move the level of the float arm from full to empty. See **Fig. 10**. Does the resistance vary linearly from 31±2Ω to 247±3Ω? | Yes | Troubleshoot and repair for corrosion or an intermittent connection in the circuitry between the RX module and the sender. |
| | | No | Replace the fuel level sending unit. |

**Table 8, Fuel Level Gauge Troubleshooting**



Slowly move the float arm from full to empty.

**Fig. 10, Testing the Fuel Level Sending Unit**

| EPA10 Pressure Gauge with Data Sourced from the RX Module Troubleshooting | | | |
|---|---|---|---|
| **Step** | **Test** | **Result** | **Action** |
| 1 | Use the Datastar or Servicelink to see the pressure that is being sent over the databus for the gauge being tested. Is the gauge within about 5% of the Datastar or ServiceLink? | Yes | Go to Step 2. |
| | | No | Replace the gauge. |
| 2 | Relieve the pressure from the system being tested, then disconnect the air line from the RX module and connect it to an accurate test gauge. Pressurize the system. Does the test gauge register the pressure that is expected? | Yes | Replace the RX module. |
| | | No | Check the air line for kinks, bends, or clamps and ties that are too tight. Repair the air line. |

**Table 9, EPA10 Pressure Gauge with Data Sourced from the RX Module Troubleshooting**

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| Pressure Gauge with Air Line Connected to Gauge Troubleshooting | | | |
|---|---|---|---|
| **Step** | **Test** | **Result** | **Action** |
| 1 | Determine if there is only one gauge or several gauges that are not working correctly. Does the backlighting operate on the gauge or gauges that have the problem? | Yes | Discharge the air pressure from the system being tested then disconnect the air line from the gauge. Connect the air line to a known good gauge. Charge the system with air/ apply the brakes/etc. to determine if the test gauge correctly registers. If the test gauge works, replace the gauge. |
| | | No | With the keyswitch in the ON position, measure for battery voltage on pin 1 and ground on pin 3 of the Star Gauge wiring at the gauge. If voltage is present, replace the gauge. Otherwise, locate and repair the fault in the Star Gauge daisy chain wiring. |

**Table 10, Pressure Gauge with Air Line Connected to Gauge Troubleshooting**

| PX and PX-A Module Pressure Gauge Troubleshooting | | | |
|---|---|---|---|
| **Step** | **Test** | **Result** | **Action** |
| 1 | Use the Datastar or Servicelink to see the pressure that is being sent over the databus for the gauge being tested. Is the gauge within about 5% of the Datastar or ServiceLink? | Yes | Go to Step 2. |
| | | No | Replace the gauge. |
| 2 | Relieve the pressure from the system being tested, then disconnect the air line from the PX module and connect it to an accurate test gauge. Pressurize the system. Does the test gauge register the pressure that is expected? | Yes | Replace the PX or PX-A module. |
| | | No | Check the air line for kinks, bends or clamps and ties that are too tight. Repair the air line. |

**Table 11, PX and PX-A Module Pressure Gauge Troubleshooting**

## DEF Level Troubleshooting

The DEF level indicator is one of the Star Gauges that uses J1939 data from the aftertreatment control module (ACM). The DEF level is measured by a sealed non-contact variable-resistance sensing assembly located in the DEF tank. The DEF level sensor resistance can be measured at the tank connector. For Detroit Diesel engines, the level sensor signal uses pins 1 and 2. For Cummins engines, the level sensor uses pins 1 and 4. On Detroit Diesel engines, when the DEF tank is empty, the sensor will measure approximately 240Ω. When full, it will measure approximately 19.8KΩ. On Cummins engines, when the DEF tank is empty, the sensor will measure approximately 4.8KΩ. When full, it will measure approximately 68Ω. Use the resistance to float height table in **Specifications 400** to test the resistance for a specific float height. When there is no DEF in the tank or when there is a fault in the DEF level sensing circuit, the indicator will flash the red segment until the fault is corrected, or a sufficient amount of DEF is added to the tank. Perform the recommended action in **Table 12** to troubleshoot faults with the DEF level sensing circuitry indicated by fault codes with SPN 1761.

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## Troubleshooting

| DEF Level Faults from SA 0 or SA 61 | | | | |
|---|---|---|---|---|
| **SPN** | **FMI** | **Description** | **Behavior** | **Action** |
| 1761 | 1 17 18 31 | DEF level low | The DEF level is low. MIL, CEL, STOP engine lamp, and engine derate may be active. | The DEF tank has run too low. Fill the DEF tank so that it is at least 25% full and idle the engine for 5 minutes. If the problem is still present use the DEF level diagnostic procedure in **Table 13**. |
| 1761 | 3 | DEF level circuit out of range high | The voltage on circuit 532F is greater than the ACM expects. | Troubleshoot circuits 532F and 532F- between the ACM and the temperature level sensor for a wiring fault and also for an open level sensor unit. |
| 1761 | 4 | DEF level circuit out of range low | The voltage on circuit 532F is close to 0 volts. | Troubleshoot circuit 532F between the ACM and the temperature level sensor for a wiring fault and also for a shorted level sensor unit. |

**Table 12, DEF Level Faults from SA 0 or SA 61**

| DEF Level Diagnostic Procedure | | | |
|---|---|---|---|
| **Step** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Turn the ignition to ON but do not start the engine. Does the DEF level indicator illuminate all segments green, then turn them off beginning from the right, one at a time until the left one becomes amber then red, before either showing a mid range level, or flashing the left segment red? | Yes | The DEF level indication display is working properly. Go to Step 2. |
| | | No | Troubleshoot and repair for a fuel level gauge/ DEF level indication display that is defective or an interconnecting cable fault. |
| 2 | Use Servicelink to check for any J1939 faults. Is there a fault for SPN 1761 with FMI 3 or 4 (DEF level sensor out of range) or are any J1939 communications fault codes active? NOTE: SPN 1761 FMI 1, 17, 18, or 31 indicate the DEF level is low. There is no wiring fault, but there may be a problem with DEF level indication accuracy. | Yes | If the code is for a FMI 4, troubleshoot for a wiring fault in circuit 532F between the DEF level sensor and the ACM. If the code is FMI 3, go to Step 3. If there is a J1939 communications fault, use the troubleshooting information in this manual to locate and repair communications. |
| | | No or Accuracy Problem | Go to Step 4. |
| 3 | Turn the ignition OFF then disconnect the 4 wire connector at the DEF level sender. Use a short jumper wire to short pins 1 and 2 (for Detroit Diesel engine) or pins 1 and 4 (for Cummins engine) together in the vehicle harness side of the connector. Turn the ignition ON without starting the engine. Allow the indicator initialization sequence to complete, then check for fault codes. Is there an active fault for SPN 1761 FMI 4? | Yes | The wiring indicates continuity. Go to Step 4. |
| | | No | Troubleshoot and repair for an open in circuit 532F and/or circuit 532F- between the DEF level sensor and the ACM. |

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| DEF Level Diagnostic Procedure | | | |
|---|---|---|---|
| **Step** | **Test Procedure** | **Test Result** | **Action** |
| 4 | Turn the ignition off and disconnect the batteries. Remove the temperature/level sender unit from the DEF tank. Connect an ohm meter to pins 1 and 2 (for Detroit Diesel engine) or pins 1 and 4 (for Cummins engine) at the 4 pin connector. Slowly raise the level of the float from empty to full. Record the resistance range measured. Does the vehicle have a Cummins or a DD engine? | Cummins | If the resistance did not vary from approximately 4.8KΩ at empty to 68Ω at the full position replace the temperature/level sender unit. |
| | | Detroit Diesel | If the resistance did not vary from approximately 240Ω at empty to 19.68KΩ at the full position replace the temperature/level sender unit. |

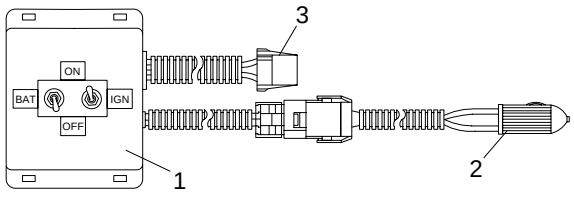
**Table 13, DEF Level Diagnostic Procedure**

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## Test Equipment and Tools

See **Fig. 1** for the gauge tester.

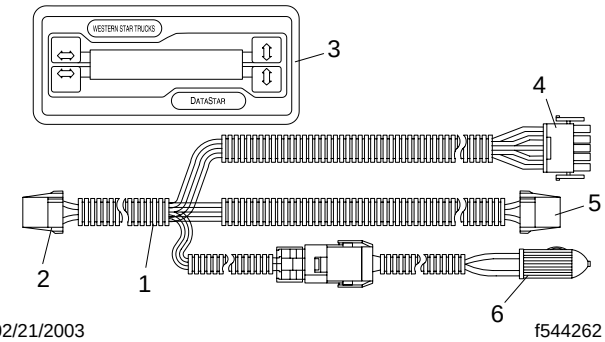



02/19/2003 f544261

1. Tester
2. Cigar Lighter Adaptor
3. 6-way Connector (rear of speedometer)

**Fig. 1, Gauge Tester 14322-3431**

See **Fig. 2** for the adapter harness for the PX and RX test.

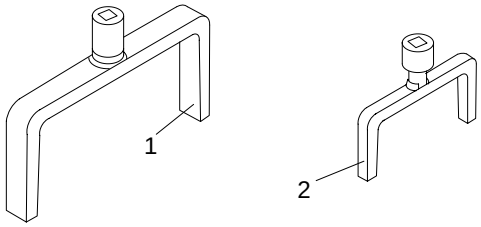



02/21/2003 f544262

1. Adaptor Harness
2. 6-way Plug (Datastar)
3. Datastar
4. 15-way Connector (PX Module)
5. 6-way Connector (RX Module)
6. Cigar Lighter Adaptor

**Fig. 2, Adapter Harness 14405-4401**

See **Fig. 3** for the gauge removal tools.




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1. 3-inch Gauge Removal Tool 87340-4403
2. 2-inch Gauge Removal Tool 87340-4404

**Fig. 3, Gauge Removal Tools**

## Connectors

| Star Gauge Connector | |
|---|---|
| **Pin** | **Description** |
| 1 | +12VDC power |
| 2 | Serial data |
| 3 | Ground |

**Table 1, Star Gauge Connector**

| 6 Way Connector | |
|---|---|
| **Pin** | **Description** |
| 1 | Ignition |
| 2 | Battery |
| 3 | Ground |
| 4 | Backlighting |
| 5 | J1587 (+) |
| 6 | J1587 (-) |

**Table 2, 6 Way Connector**

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## Specifications

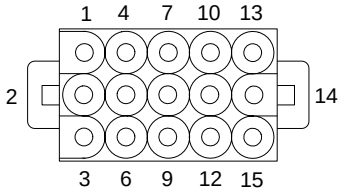
| EPA07 and Earlier RX Module Connector Definition | |
|---|---|
|  03/03/2003 f544279 | |
| **Pin** | **Function** |
| 1 | +12V Ignition |
| 2 | Ground |
| 3 | Databus 1587 (+) |
| 4 | Transmission temperature 1 |
| 5 | Center rear- axle temperature |
| 6 | Databus 1587 (–) |
| 7 | Transmission temperature 2 |
| 8 | Rear rear-axle temperature |
| 9 | Ammeter shunt (high) |
| 10 | Brakesaver temperature |
| 11 | Ammeter shunt (low) |
| 12 | Pyrometer (+) |
| 13 | Forward rear-axle temperature |
| 14 | Pyrometer (–) |
| 15 | Fuel level |

**Table 3, EPA07 and Earlier RX Module Connector Definition**

| EPA10 RX Module Connector 1 | |
|---|---|
| **Pin** | **Description** |
| A | – |
| B | Ignition |
| C | Ground |
| D | – |
| E | J1939 (–) |
| F | J1939 (+) |
| G | PIBus (J1587) (–) |
| H | PIBus (J1587) (+) |

**Table 4, EPA10 RX Module Connector 1**

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## Specifications

| EPA 10 RX Module Connector 2 | | | | |
|---|---|---|---|---|
| **Pin** | **Description** | **Input Type** | **PID** | **SPN** |
| A | Outside air temperature sensor | Resistive | 171 | 171 |
| B | Outside air temperature ground | – | – | – |
| C | Forward rear-axle temp sensor | Resistive | 77 | – |
| D | Center rear-axle temp sensor | Resistive | 373 | – |
| E | Rear rear-axle temp sensor | Resistive | 78 | – |
| F | Rear axle temp sensor ground | – | – | – |
| G | Fuel level sensor | Resistive | 96 | 96 |
| H | Fuel level ground | – | – | – |
| J | Transmission oil temperature sensor | Resistive | 177 (Allison and G) | 177 (Allison and G) |
| K | Transmission oil temperature ground | – | – | – |
| L | Auxiliary transnmission oil temperature sensor | Resistive | 418 | – |
| M | Auxiliary transnmission oil temperature ground | – | – | – |
| N | Not used | | – | – |
| P | Not used | | – | – |
| R | Ammeter + | mV+ | 414 | – |
| S | Ammeter - | mV- | – | – |

**Table 5, EPA 10 RX Module Connector 2**

| J1939 Messages Converted and Broadcast by the RX Module over J1587 | | | |
|---|---|---|---|
| **Source Address** | **SPN** | **Description** | **Broadcast as J1587 PID** |
| 0 | 84 | Wheel based vehicle speed | 84 |
| 0 | 92 | Engine percent load at current speed | 92 |
| 0 | 100 | Engine oil pressure | 100 |
| 0 | 102 | Engine intake manifold pressure | 439 |
| 0 | 110 | Engine coolant temperature | 110 |
| 0 | 168 | Battery potential / power input 1 | 168 |
| 0 | 175 | Engine oil temperature | 175 |
| 0 | 183 | Engine fuel rate | 183 |
| 0 | 184 | Engine instantaneous fuel economy | 184 |
| 0 | 185 | Engine average fuel economy | 185 |
| 0 | 190 | Engine speed | 190 |
| 0 | 245 | Total vehicle distance (unless SPN 917 is available) | 245 |
| 0 | 247 | Engine total hours of operation | 247 |
| 0 | 917 | High resolution total vehicle distance | 245 |
| 0 | 1761 | DEF tank level | 260 |

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## Specifications

| J1939 Messages Converted and Broadcast by the RX Module over J1587 | | | |
|---|---|---|---|
| **Source Address** | **SPN** | **Description** | **Broadcast as J1587 PID** |
| 0 | 3241 | Engine exhaust gas temperature | 173 |
| 0 | 5245 | DEF level low | 154 |
| 3 | 177 | Transmission oil temperature | 177 |

**Table 6, J1939 Messages Converted and Broadcast by the RX Module over J1587**

# Sensor Specifications

Refer to the figures listed below for graphs of the information in the tables that follow.

**Figure 4** Transmission Oil Temperature Sensor Resistance (°F)

**Figure 5** Transmission Oil Temperature Sensor Resistance (°C)

**Figure 6** Axle Oil Temperature Sensor Resistance (°F)

**Figure 7** Axle Oil Temperature Sensor Resistance (°C)

**Figure 8** Cummins DEF Level Sensor Resistance.

**Figure 9** DDC DEF Level Sensor Resistance.

| Fuel Level Sensor Resistance | | |
|---|---|---|
| **Gauge Reading** | **Sensor Resistance (Ohms)** | |
| | **Acceptable Range** | **Nominal** |
| Empty Stop | 244.0 to 249.0 | 246.5 |
| Empty | 232.0 to 239.2 | 235.6 |
| 1/8 | 190.8 to 196.9 | 193.8 |
| 1/4 | 149.6 to 154.5 | 152.1 |
| 3/8 | 126.1 to 129.0 | 127.5 |
| 1/2 | 102.5 to 103.5 | 103 |
| 5/8 | 84.4 to 85.7 | 85 |
| 3/4 | 66.2 to 67.8 | 67 |
| 7/8 | 47.8 to 49.2 | 48.5 |
| Full | 29.4 to 30.6 | 30 |

**Table 7, Fuel Level Sensor Resistance**

NOTE: If the fuel level sender is below the minimum resistance (short to ground) or above the maximum (open), the fuel gauge will read empty. Shorting the sender wires **will not** test the gauge circuit.

| Transmission Oil Temperature Sensor Resistance, Standard Gauge (°F) | |
|---|---|
| **Gauge Temperature (°F)** | **Sensor Resistance (Ohms)** |
| 110 | 4752 |
| 150 | 2079 |
| 190 | 991 |
| 230 | 510 |
| 270 | 285 |
| 310 | 167 |
| 350 | 102 |

**Table 8, Transmission Oil Temperature Sensor Resistance, Standard Gauge**

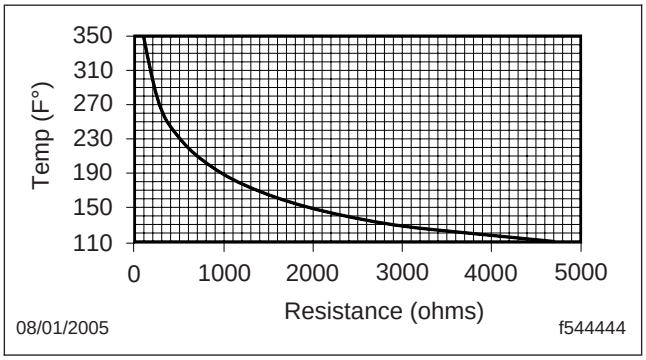



**Fig. 4, Transmission Oil Temperature Sensor Resistance (°F)**

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| Transmission Oil Temperature Sensor Resistance, Metric Gauge (°C) | |
|---|---|
| **Gauge Temperature (°C)** | **Sensor Resistance (Ohms)** |
| 60 | 2490 |
| 80 | 1255 |
| 100 | 680 |
| 120 | 390 |
| 140 | 234 |
| 160 | 145 |
| 180 | 95 |

**Table 9, Transmission Oil Temperature Sensor Resistance, Metric Gauge**

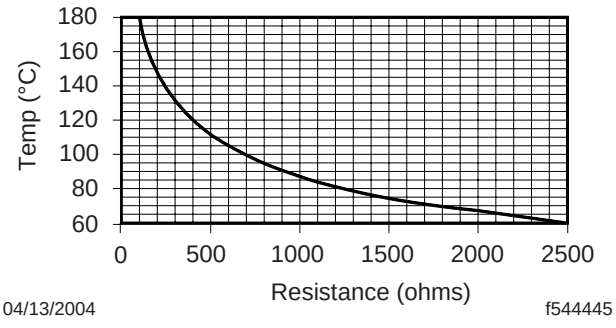



**Fig. 5, Transmission Oil Temperature Sensor Resistance (°C)**

| Axle Oil Temperature Sensor Resistance, Standard Gauge (°F) | |
|---|---|
| **Gauge Temperature (°F)** | **Sensor Resistance (Ohms)** |
| 100 | 5933 |
| 125 | 3419 |
| 150 | 2079 |
| 175 | 1283 |
| 200 | 837 |
| 225 | 557 |
| 250 | 380 |
| 275 | 267 |
| 300 | 190 |

**Table 10, Axle Oil Temperature Sensor Resistance, Standard Gauge**

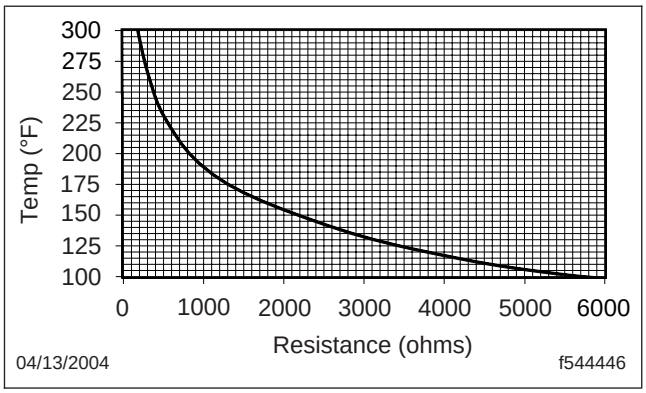



**Fig. 6, Axle Oil Temperature Sensor Resistance (°F)**

| Axle Oil Temperature Sensor Resistance, Metric Gauge (°C) | |
|---|---|
| **Gauge Temperature (°C)** | **Sensor Resistance (Ohms)** |
| 30 | 8060 |
| 45 | 4465 |
| 60 | 2490 |
| 75 | 1503 |
| 90 | 915 |
| 105 | 595 |
| 120 | 390 |
| 135 | 267 |
| 150 | 185 |

**Table 11, Axle Oil Temperature Sensor Resistance, Metric Gauge**

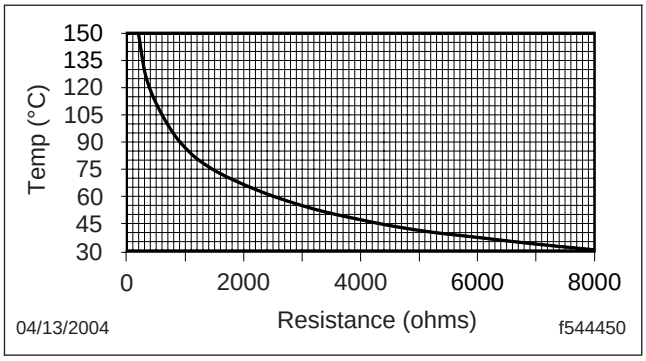



**Fig. 7, Axle Oil Temperature Sensor Resistance (°C)**

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## Specifications

| Cummins DEF Level Sensor Resistance | |
|---|---|
| **Sensor Resistance (Ohms)** | **Float Distance (mm) From Top Plate** |
| 68 | <80 |
| 112 | 80 |
| 157 | 97.6 |
| 207 | 115.2 |
| 261 | 132.8 |
| 320 | 150.4 |
| 385 | 168 |
| 485 | 185.6 |
| 539 | 203.2 |
| 629 | 220.8 |
| 731 | 238.4 |
| 847 | 256 |
| 981 | 273.6 |
| 1135 | 291.2 |
| 1316 | 308.8 |
| 1532 | 326.4 |
| 1793 | 344 |
| 2114 | 361.6 |
| 2521 | 379.2 |
| 3052 | 396.8 |
| 3744 | 414.4 |
| 4812 | 433 |

**Table 12, Cummins DEF Level Sensor Resistance**

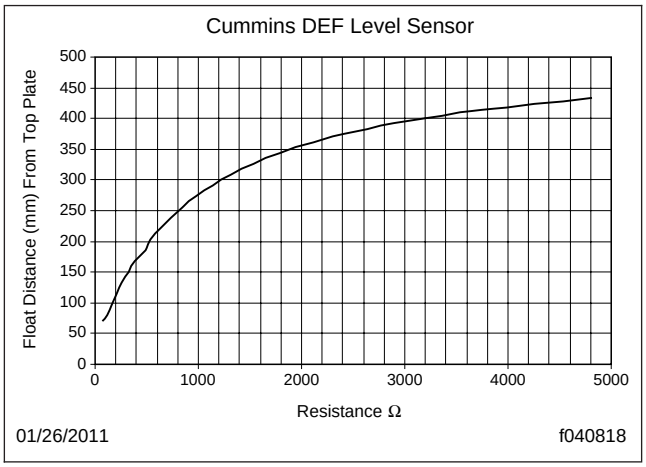



**Fig. 8, Cummins DEF Level Sensor Resistance**

| DDC DEF Level Sensor Resistance | |
|---|---|
| **Sensor Resistance (Ohms)** | **Float Distance (mm) From Top Plate** |
| 19804 | 54 |
| 13764 | 74 |
| 10284 | 93 |
| 8074 | 113 |
| 6534 | 132 |
| 5384 | 152 |
| 4497 | 172 |
| 3799 | 191 |
| 3237 | 211 |
| 2762 | 230 |
| 2375 | 250 |
| 2035 | 270 |
| 1748 | 289 |
| 1493 | 309 |
| 1272 | 328 |
| 1076 | 348 |
| 902 | 368 |
| 744 | 387 |
| 601 | 407 |
| 471 | 426 |
| 353 | 446 |

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| DDC DEF Level Sensor Resistance | |
|---|---|
| **Sensor Resistance (Ohms)** | **Float Distance (mm) From Top Plate** |
| 240 | <446 |

**Table 13, DDC DEF Level Sensor Resistance**

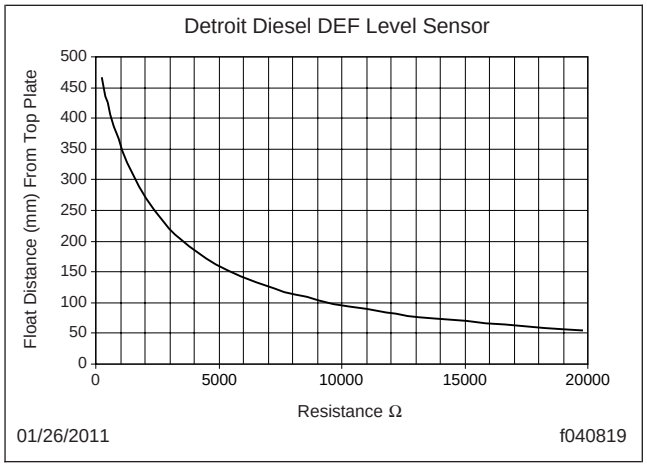



**Fig. 9, DDC DEF Level Sensor Resistance**

## Datastar Contrast Adjustment

NOTE: The contrast setting will return to the default value anytime the batteries are disconnected or when the cab power disconnect switch is turned off.

1. With the key in the ON position, press the upper left button on the DataStar to get to the "SETTINGS" menu.
2. Press the upper right button to get to the "SET CONTRAST" menu.
3. Press and hold the upper right button for two seconds until the contrast adjustment screen appears.
4. Press the lower left "Hold To Expand" button to increase the contrast. Press the lower right "Hold To Set" Button to decrease the contrast.
5. Press either upper button to save the new contrast value to memory and exit this function.

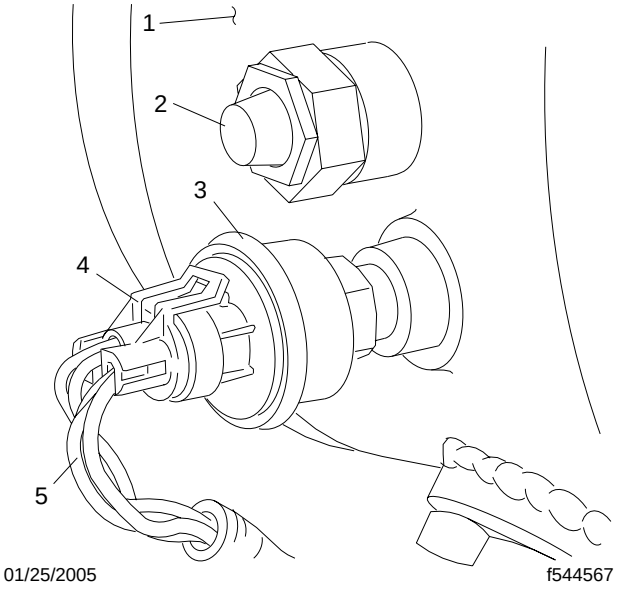
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## General Information

The low coolant level (LCL) probe inserts directly into the surge tank. The connector on the probe attaches to the engine harness which provides electronic signals from the engine electronic control unit.

Vehicles with Cummins (CUM) and Caterpillar (CAT) engines use a four-wire probe. See **Fig. 1**.

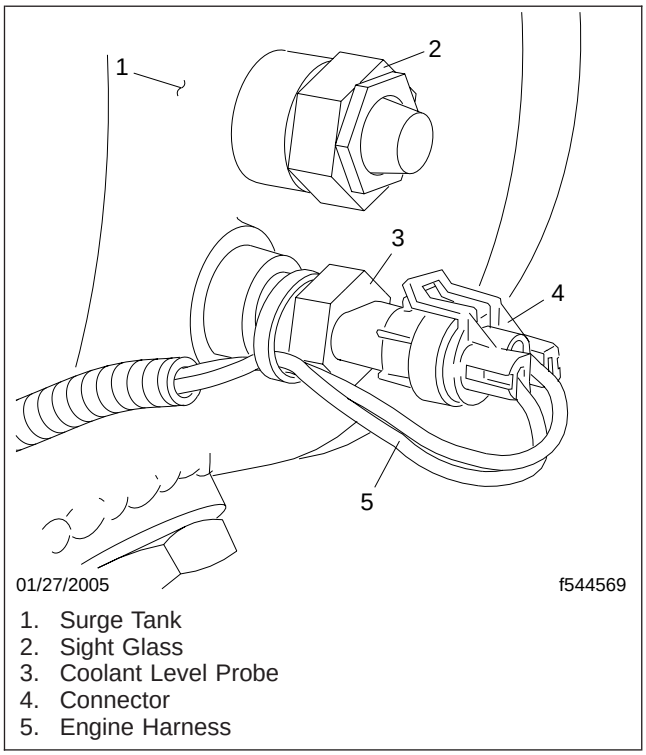



1. Surge Tank
2. Sight Glass
3. Coolant Level Probe
4. Connector
5. Engine Harness

**Fig. 1, Probe Mounted In Surge Tank, CAT/CUM Engines**

Vehicles with Detroit Diesel (DDEC) and Mercedes-Benz (MBE) engines use a two-wire probe. See **Fig. 2**.

For wiring harness drawings, access the specific vehicle information in EZWiring.




1. Surge Tank
2. Sight Glass
3. Coolant Level Probe
4. Connector
5. Engine Harness

**Fig. 2, Probe Mounted In Surge Tank, DDEC/MBE Engines**

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## Low Coolant Probe Removal and Installation

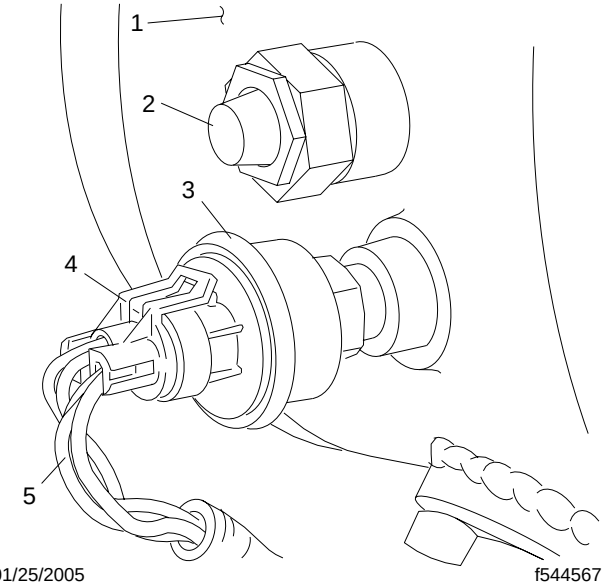
# Removal

1. Park the vehicle on a level surface, set the parking brake, and chock the tires.

**⚠ WARNING**

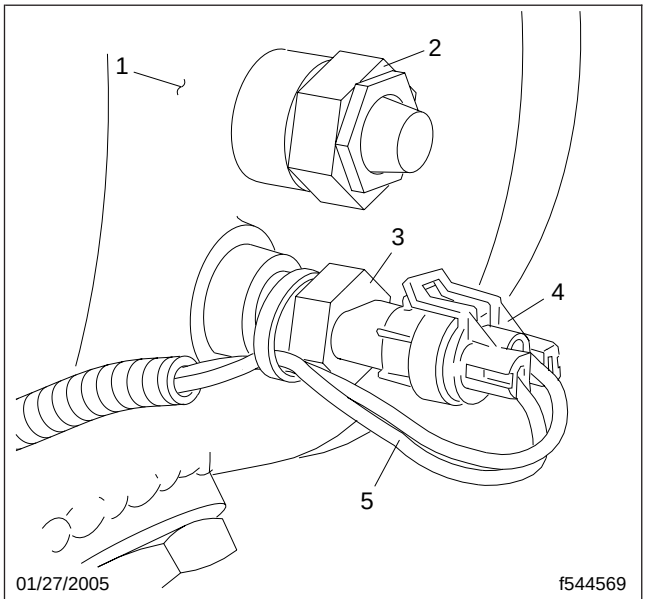
**Drain the coolant only when the coolant and engine are cool. Draining it when these are hot could cause severe personal injury due to scalding.**

2. Drain the coolant out of the surge tank to below the level of the coolant probe. The coolant can be drained by loosening the clamps and removing the makeup line at the bottom of the surge tank and catching the coolant in a suitable container.
3. Disconnect the electrical connector at the probe. See **Fig. 1** for vehicles with Caterpillar (CAT) or Cummins (CUM) engines. See **Fig. 2** for vehicles with Detroit Diesel (DDEC) or Mercedes-Benz (MBE) engines.




NOTE: Hoses removed for clarity.
1. Surge Tank
2. Sight Glass
3. Coolant Level Probe
4. Connector
5. LCL Overlay Harness

**Fig. 1, Probe In Surge Tank, CAT/CUM Engines**




NOTE: Hoses removed for clarity.
1. Surge Tank
2. Sight Glass
3. Coolant Level Probe
4. Connector
5. LCL Overlay Harness

**Fig. 2, Probe In Surge Tank, DDEC/MBE Engines**

4. Unscrew the coolant level probe and remove it from the surge tank.

# Installation

1. Screw the coolant probe into the threaded hole in the surge tank until it is firmly in place.
2. Attach the electrical connector to the probe.
3. Fill the surge tank to the proper level with coolant.
4. Run the engine and check for leaks around the surge tank.
5. Remove the chocks from the tires.

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## General Information

An air restriction indicator (see **Fig. 1**) indicates how much air filter capacity has been used and how much remains. It registers the actual maximum restriction of the filter element (or elements, if two air cleaners are installed) when the engine is operating at full load. There are two types of air restriction indicators used on Western Star vehicles. A direct-reading gauge which is mounted on the air cleaner intake piping under the hood, or an electronic gauge which is installed in the dash and receives its signal from an air pressure and vacuum sensor behind the instrument panel via the data bus. See **Fig. 2** for a typical under-hood installation, or **Fig. 3** for a dash-mounted gauge. The direct-reading indicator has a push-type reset button located at the end opposite the mounting fitting. Only one gauge is used even when two air cleaners are installed. The direct-reading air restriction indicator retains the reading so that the remaining capacity can be read even after the engine is shut down. There is no reset button on the electronic dash-mounted gauge. When the vacuum reading in normal operation equals the applicable level shown under "Service" in **Table 1**, the air cleaner needs to be serviced.

| Intake-Air Restriction | |
|---|---|
| **Engine Type*** | **Service** |
| Cummins | 25 in$H_2O$ (63 cm$H_2O$) |
| Detroit Diesel | 20 in$H_2O$ (50 cm$H_2O$) |
| Caterpillar | 25 in$H_2O$ (63 cm$H_2O$) |
| MBE4000 | 22 in$H_2O$ (56 cm$H_2O$) |

* Turbocharged engines must be checked at full load and governed engine speed.

**Table 1, Intake-Air Restriction**

The air restriction indicator and tap fittings sometimes become plugged from moisture or engine vapors, possibly causing an incorrect reading.

IMPORTANT: Most engine degreasers are harmful to polycarbonate (Lexan) plastics that are used in air restriction indicators. When cleaning an engine or other components, avoid getting degreaser on these plastic parts.

NOTE: Avoid opening the air cleaner and disturbing the seals or filter element until the indicator shows maximum restriction or the maximum allowable reading is indicated on the electronic gauge as shown in **Table 1**. When this occurs, the air cleaner(s) needs to be serviced; however, immediate engine shutdown is not necessary.

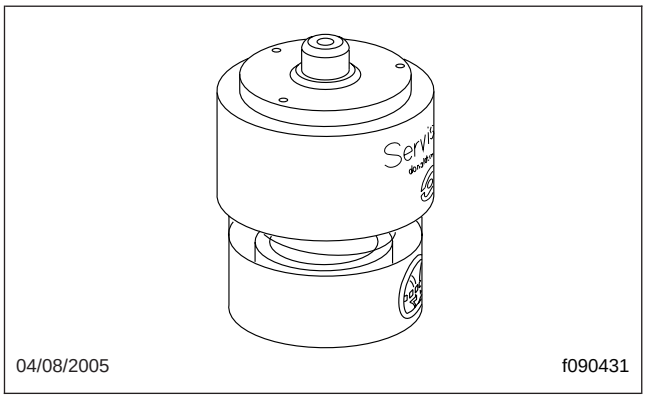
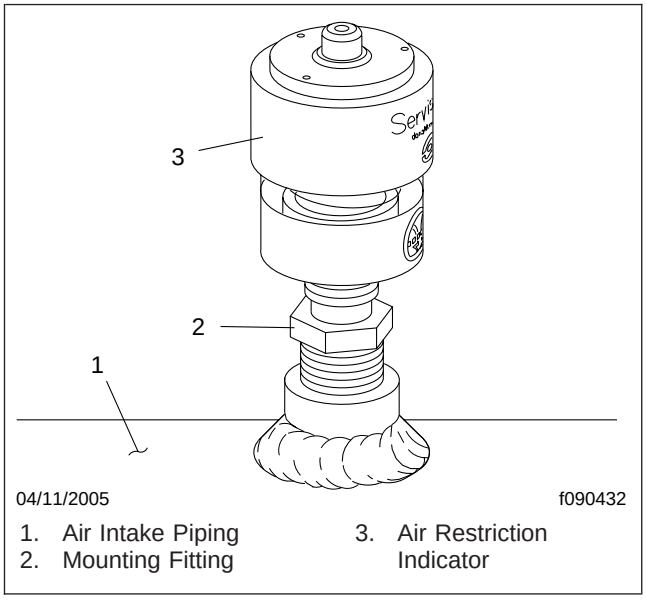



**Fig. 1, Direct-Reading Air Restriction Indicator**




1. Air Intake Piping
2. Mounting Fitting
3. Air Restriction Indicator

**Fig. 2, Under-Hood Installation (typical)**

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## General Information

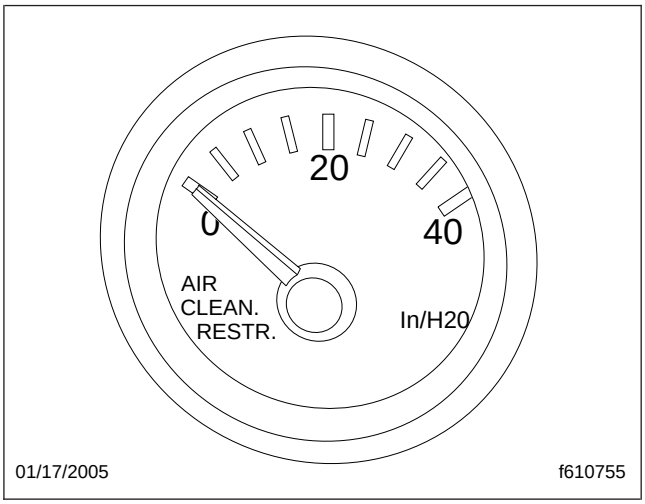



**Fig. 3, Dash-Mounted Air Restriction Gauge**

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# Replacement

## Under-Hood Indicator

1. Park the vehicle on a level surface, apply the parking brake, and shut down the engine.
2. Using a wrench, unscrew the indicator from the air intake piping.
3. Install the new air restriction gauge and tighten it securely.

NOTE: The fitting in the intake pipe is a special fitting incorporating an orifice and a filter. Be sure that the correct fitting is installed.

## Dash-Mounted Gauge

For dash-mounted gauges, see **Section 54.03, Subject 100** for replacement of Star Gauges.

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## Troubleshooting

IMPORTANT: Direct-reading air restriction indicators read in in$H_2O$. Always use the correct test equipment. Applying excessive vacuum to the indicator may damage it.

The following troubleshooting tables are for direct-reading air restriction indicators only. For troubleshooting electronic gauges, see the testing and troubleshooting subjects in **Section 54.03**.

**Problem—No Restriction Reading**

| Problem—No Restriction Reading | |
|---|---|
| **Possible Cause** | **Remedy** |
| The indicator leaks. | Remove the air restriction indicator. Apply a vacuum to the indicator until the indicator reaches the red line. With your thumb on the mounting fitting, close the end of the indicator airtight. Hold in the reset button. The index marker will drop slightly and then not move unless the indicator has a leak. If the indicator is functioning properly, install it and press the reset button.<br><br>If the index marker continues to move, replace the air restriction indicator. Repeat the troubleshooting procedure to verify that the new indicator does not leak. When the indicator is functioning properly, install it and press the reset button. |
| The air cleaner or intake pipe fitting is plugged. | Remove the air restriction indicator. Apply a vacuum to the indicator until the index marker reaches the red line. Connect the indicator to the air cleaner or intake pipe fitting and hold in the reset button. The index marker will fully return to zero unless the fitting or vacuum hose line is plugged. (A slow return is normal due to the safety filter in the fitting.) If the indicator is functioning properly, press the reset button.<br><br>If the index marker does not fully return to zero, clear the fitting and repeat the procedure. |
| Engine airflow is too low to generate a reading. | Turbocharged engines must be at full load to pull full engine airflow. Restrictions can be simulated by gradually closing off air intake. If there is still no restriction reading, check for leaks in the indicator and take corrective action. |

**Problem—High Restriction Readings**

| Problem—High Restriction Readings | |
|---|---|
| **Possible Cause** | **Remedy** |
| The element(s) is plugged or poorly cleaned. | Ultra-fine particles are difficult to remove, and cleaning may not sufficiently lower the restriction. Carefully attempt to unplug or clean the element(s); if unsuccessful, install a new filter element(s). |
| The safety filter is plugged (if equipped). | Do not clean the safety filter. Replace it with a new one. |
| The air cleaner(s) is undersized. | The air cleaner may be too small if a larger engine has been installed. Replace the undersized unit(s) with properly sized air cleaner. |
| The air restriction indicator is too close to the intake of an engine blower or turbo. | Under certain circumstances, air turbulence near the blower intakes may cause a high vacuum reading. Locate the indicator away from the blower intake by at least 1-1/2 times the diameter of the intake tube. |
| The intake screens or ducts are plugged. | Check the system upstream from the air restriction indicator and remove any debris. Check for damage or improper installation, and take any necessary corrective action. |

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## Troubleshooting

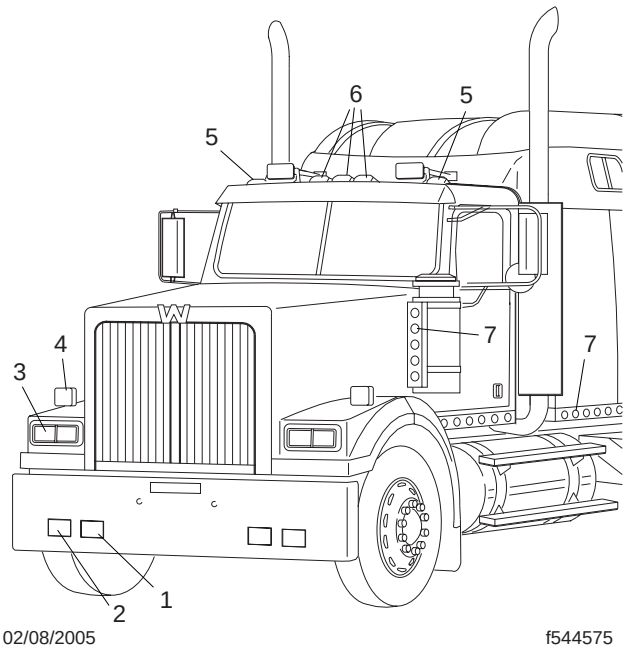
| Problem—High Restriction Readings | |
|---|---|
| **Possible Cause** | **Remedy** |
| Heavy snow or rain. | Temporary high restriction can occur during a rain or snow storm and disappear after drying out. However, the cold air may be so dense that high restriction may not reduce the engine power before the element(s) is damaged. If the indicator reads maximum restriction (red line), check the element(s) for damage and replace if necessary. |

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## General Information

**Figure 1** shows the exterior lighting system. In the front of the vehicle there are headlights, turn-signal lights, and side-marker lights.




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1. Fog Light
2. Road Light
3. Dual Headlights
4. Turn Signal/Side-Marker Lights
5. Clearance Light
6. Identification Lights
7. Clearance Light

**Fig. 1, Exterior Lights**

On the roof of the cab there are clearance and identification lights. At the rear of the vehicle there are taillights, stoplights with turn signals, and optional utility lights. Optional road (fog) lights are mounted in the front bumper.

NOTE: For vehicles built to operate in the United States, the low-beam headlights must be turned on before the road lights can be turned on. The road lights won't go on if the high-beam headlights are already on, and switching from low beams to high beams will switch off the road lights. For vehicles built to operate in Canada, as of June 29, 1990, the taillights and clearance lights must be on before the road lights can be turned on. Unless the headlight switch is all the way up (headlights, taillights, clearance lights, marker lights, and panel lights on) or down (taillights, clearance lights, marker lights, and panel lights on), the road light switch will not turn on the road lights.

Inside the cab are dome lights with high-intensity reading lights, and an instrument panel that features fully lighted gauges and labels for switches and controls. The steering column-mounted turn-signal switch has the headlight dimmer switch built into it. In the bunk or sleeper are accessory lights and high-intensity reading lights. Baggage compartments may be equipped with accessory lights.

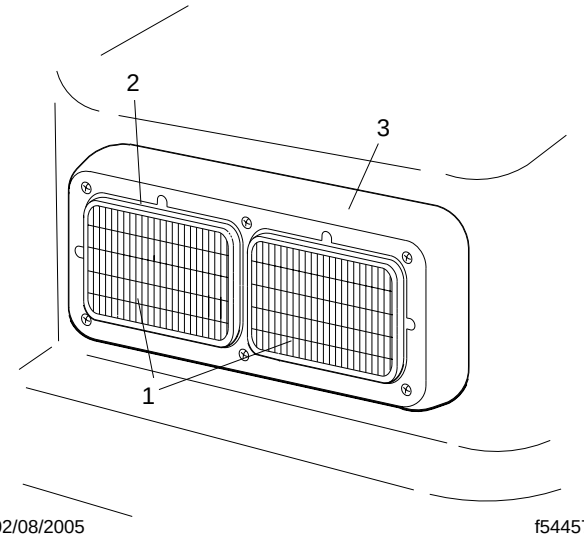
On the dash is a marker light interrupt switch designed to allow the driver of the vehicle to blink the marker lights without turning off the headlights. When activated, the marker, taillight, front turn signal, and dash panel lights all blink. The marker light interrupter operates only with the headlights ON; it will not operate when only the parking lights are on.

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## Headlight Replacement

1. Remove the headlight bezel retaining screws, and remove the bezel. See **Fig. 1**.




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1. Headlight Bulb
2. Headlight Retaining Ring
3. Headlight Bezel

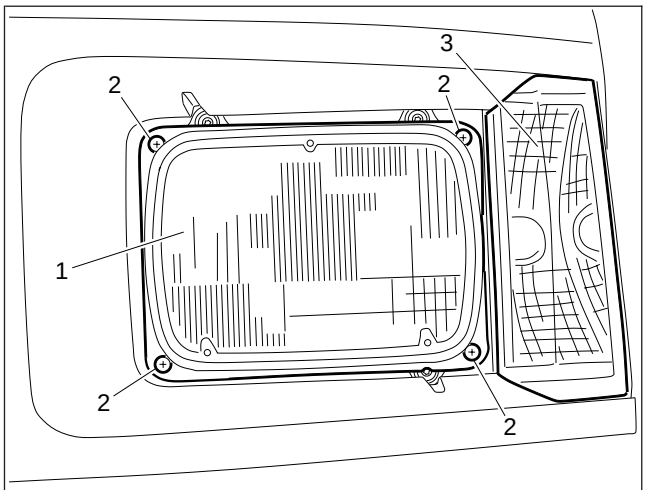
**Fig. 1, Headlight Assembly**

NOTE: Left-hand drive 4700 vehicles do not have a headlight bezel. See **Fig. 2**.

2. Remove the retaining ring screws from one or both lamps.
3. Remove the retaining rings.
4. Remove the lamp from the housing; disconnect the wiring connector from the back of the lamp.
5. To provide corrosion protection, coat the prongs and base of the new lamp with dielectric grease. See **Table 1** for approved electrical lubricants.

| Approved Electrical Lubricants | |
|---|---|
| **Manufacturer** | **Lubricant or Part Number** |
| Standard Oil Co. | White Vasoline |
| Shell Oil Co | No. 71032; No. 71306 |
| Texaco, Inc. | No. 955 |
| Quaker State | No. NYK-77 |

**Table 1, Approved Electrical Lubricants**




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1. Headlight
2. Mounting Screws
3. Turn Signal

**Fig. 2, Headlight Assembly (4700 vehicles)**

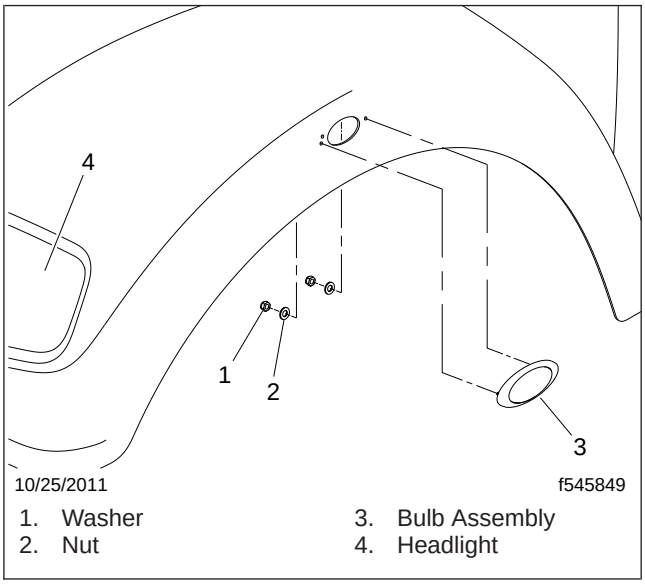
6. Push the wiring connector onto the prongs at the rear of the new lamp.
7. Place the new lamp in the headlight housing; position it so that the embossed number in the lamp lens is on the top.
8. Place the retaining ring over the lamp and install the retaining ring screws; tighten them securely.
9. Check and, if necessary, adjust the headlight aim as described in **Subject 120**.
10. Install the headlight bezel; secure it with the screws.

## Turn/Side-Marker Light Replacement, 4700 Vehicles

1. Open the hood.
2. Remove the nuts and the washers from the bulb assembly. See **Fig. 3**.
3. Disconnect the connector.
4. Replace the marker light.
5. Connect the electrical connector.
6. Position the bulb assembly on the fender and install the nuts and washers.

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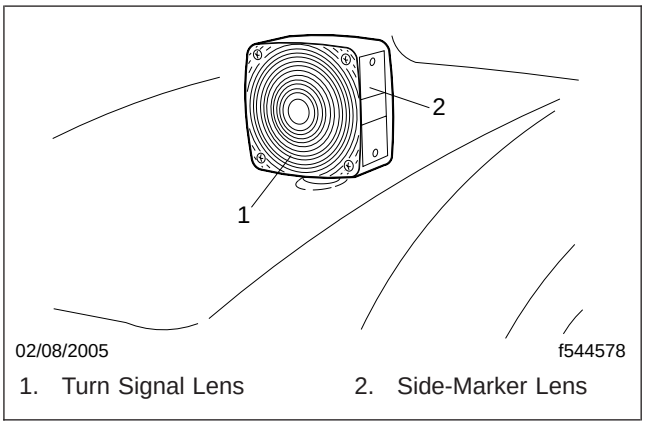

1. Washer
2. Nut
3. Bulb Assembly
4. Headlight

**Fig. 3, Turn/Side-Marker Light (4700 vehicles)**

7. Test the bulb for proper operation.
8. Close the hood.

## Turn/Side-Marker Light Replacement, All Other Vehicles

1. Remove the screws from the lens. See **Fig. 4**.




1. Turn Signal Lens
2. Side-Marker Lens

**Fig. 4, Turn/Side-Marker Light**

2. Remove the bulb from the socket.
3. To provide corrosion protection, coat the prongs and base of the new bulb with dielectric grease then install the bulb. See **Table 1** for approved electrical lubricants.
4. Check for proper operation.
5. Install the lens and screws.

## Road Light Replacement

1. Remove the light assembly from the mounting bracket. See **Fig. 5**.

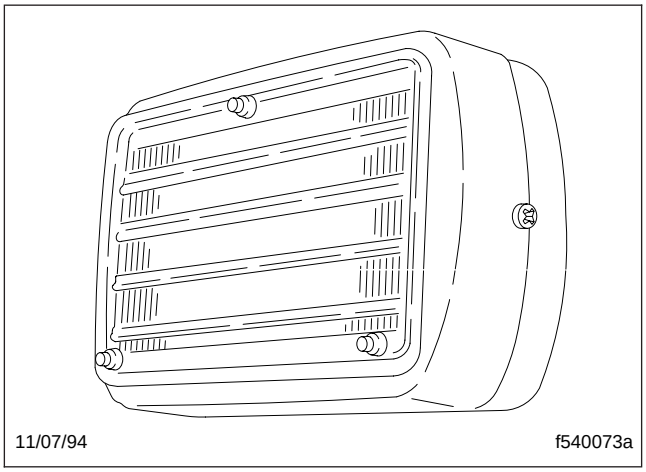
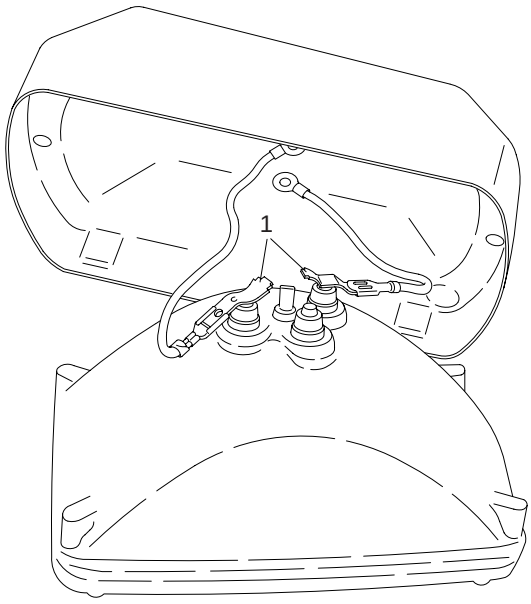



**Fig. 5, Road Light, Per-Lux (typical)**

2. Remove the screws from the lens retainer.
3. Separate the lens retainer and louver from the main housing. Pull the lamp from the housing, and disconnect the blade connectors from the blade terminals on the lamp. See **Fig. 6**.
4. To provide corrosion protection, coat the blade terminals on the new lamp with dielectric grease. See **Table 1** for approved electrical lubricants.
5. Install the blade connectors on the terminals of the new lamp. Place the unit in the housing and test it for proper operation.
6. Place the louver over the lamp. Make sure the word "TOP" appears at the top. See **Fig. 7**. If not properly installed, the beam from the light will be directed upward instead of down.
7. Place the lens retainer over the louver and install the screws.
8. Place the road light assembly in the mounting bracket and install the locknut. Make sure the

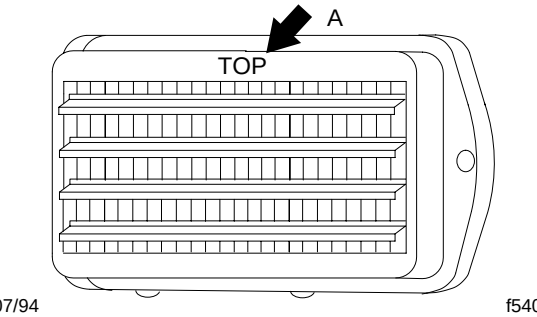
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1. Blade Terminals

**Fig. 6, Lamp Replacement, Per-Lux Road Light**




A. Install louver with "TOP" in this position.

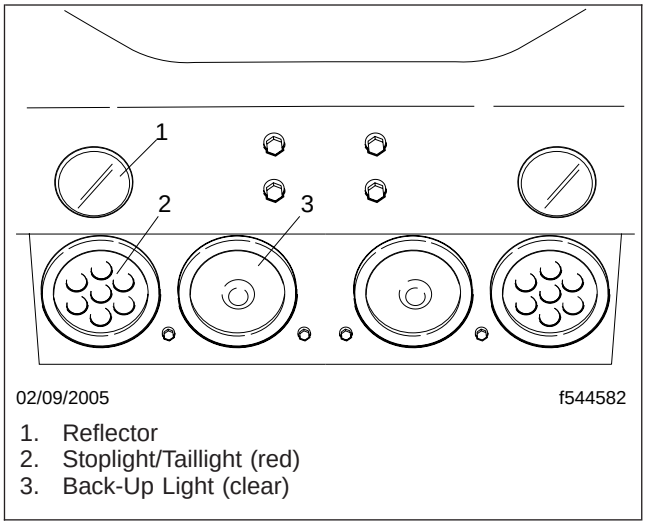
**Fig. 7, Louver Installation, Per-Lux Road Light**

light is aimed directly ahead; then tighten the locknut 75 lbf·ft (102 N·m).

## Stoplight/Taillight, and Back-Up Light Replacement

The stop/taillights and backup lights are mounted in a panel below the rear frame crossmember or outboard of the framerail. See **Fig. 8**.

1. Carefully pry the light from the rubber retainer. See **Fig. 9**.
2. Disconnect the connector from the back of the bulb.
3. To provide corrosion protection, coat the prongs of the connector with dielectric grease. See **Table 1** for approved electrical lubricants.
4. Press the connector into the back of the new bulb. Test the bulb for proper operation.
5. Carefully push the bulb back into the rubber retainer.




1. Reflector
2. Stoplight/Taillight (red)
3. Back-Up Light (clear)

**Fig. 8, Stoplight/Taillight and Back-Up Light Assembly Installation**

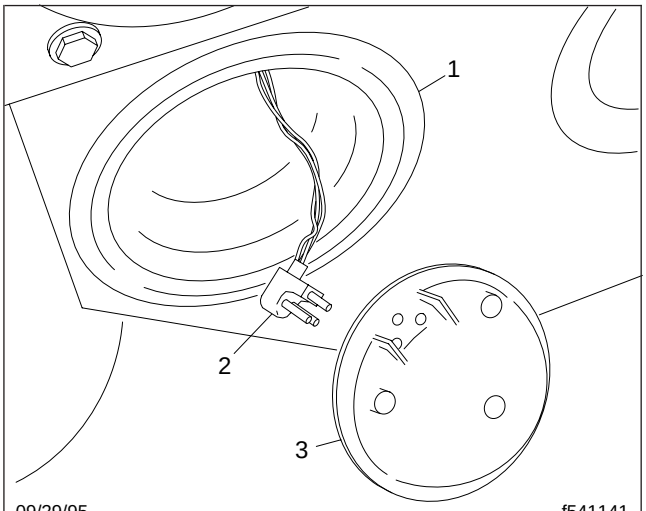
## Clearance Light Bulb Replacement

1. Remove the bezel and lens. See **Fig. 10**.
2. Remove the bulb from the socket.
3. To provide corrosion protection, coat the contacts and base of the new bulb with dielectric grease. See **Table 1** for approved electrical lubricants.
4. Check for proper operation.
5. Install the lens and bezel.

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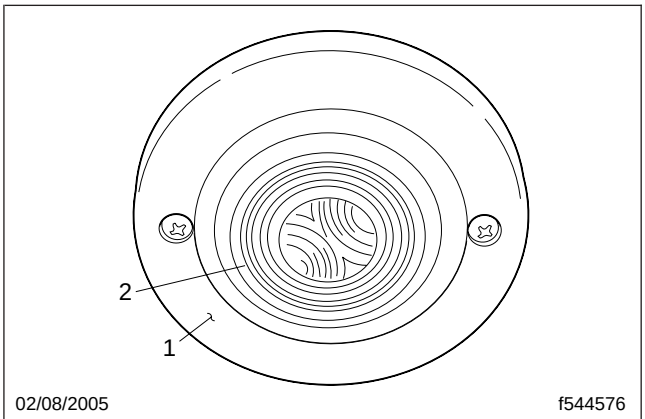


## Exterior Lighting




1. Rubber Retainer
2. Connector
3. Bulb

**Fig. 9, Stoplight/Tailight and Back-Up Light Bulb Replacement**




1. Bezel
2. Lens

**Fig. 10, Clearance Light**

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## General Information

Interior lights vary depending on the vehicle's cab and sleeper configuration. Interior dome and utility light fixtures use conventional automotive bulbs or fluorescent tubes. Dash instrument and switch lights are LEDs and are not servicable.

## Dome and Accessory Light Replacement

1. Remove the lens.
2. Remove the bulb.
3. Install a new bulb making sure the contacts are properly aligned.

   Install the lens.

## Gauge and Instrument Panel Switch Lights

Gauge and toggle switch lights are LEDs and are not servicable. If an LED fails, replace the unit.

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# Headlight Aim Checking and Adjusting

Before checking or adjusting the headlight aim, complete the following inspection:

- Check that the hood is closed and latched.
- Remove any large amounts of mud or ice from the underside of the fenders.
- Check the springs for sagging or broken leaves.
- Check the suspension for proper functioning of the leveling mechanism. On cabs with air suspensions, make sure that the height is properly adjusted.
- Check for damage to the hood and hinge assembly. Repair as necessary.
- With the vehicle unloaded, check that the tires are inflated to the recommended air pressure.
- Clean the headlight lenses. Use a soft cloth with mild, non-caustic soap or detergent, and water.

## Checking

1. Park the vehicle 25 ft (7.6 m) away from, and perpendicular to, a vertical screen or wall. Shut down the engine and set the parking brake. Chock the tires.
2. On each headlight, find the bulb center behind the headlight lens.
3. Measure the distance from the ground to the center of each headlight bulb. See **Fig. 1**, Item A. Note those distances.
4. On the screen or wall, mark the locations of each headlight bulb center using the distances found in step 3. See **Fig. 1**, Items 2 and 3.
5. Turn on the low-beam headlights.

NOTE: See the following heading, **Adjusting Headlight Aim**, for adjustment instructions.

6. Check the horizontal aim of the low beams. The center of each beam projection should fall on or near the marks made during step 4. See **Fig. 1**, Items 2 and 3.

   If the center of any projection is more than 3.9 in (100 mm) to the side of the marks made in step 4, adjust the horizontal aim of that headlight.
7. Check the vertical adjustment of the low beams. The center of each beam projection should fall on or near the marks made during step 4. See **Fig. 2**.
8. Use **Table 1** to determine the maximum vertical distance allowable between the marks on the wall and the center of each low-beam projection.

   If the distance between either projection center and the mark made on the wall or screen is greater than the maximum distance given in **Table 1**, adjust the vertical positioning of that headlight.
9. Turn on the high-beam headlights. Ensure the beam projections are parallel to the ground. If the beam projections are not parallel to the ground, adjust the positioning of the high-beam bulbs.

## Adjusting

NOTE: Western Star vehicles are offered with various headlight assembly options. Because of the various options, the location of adjustment screws on your vehicle's headlight assembly may vary from what is shown here.

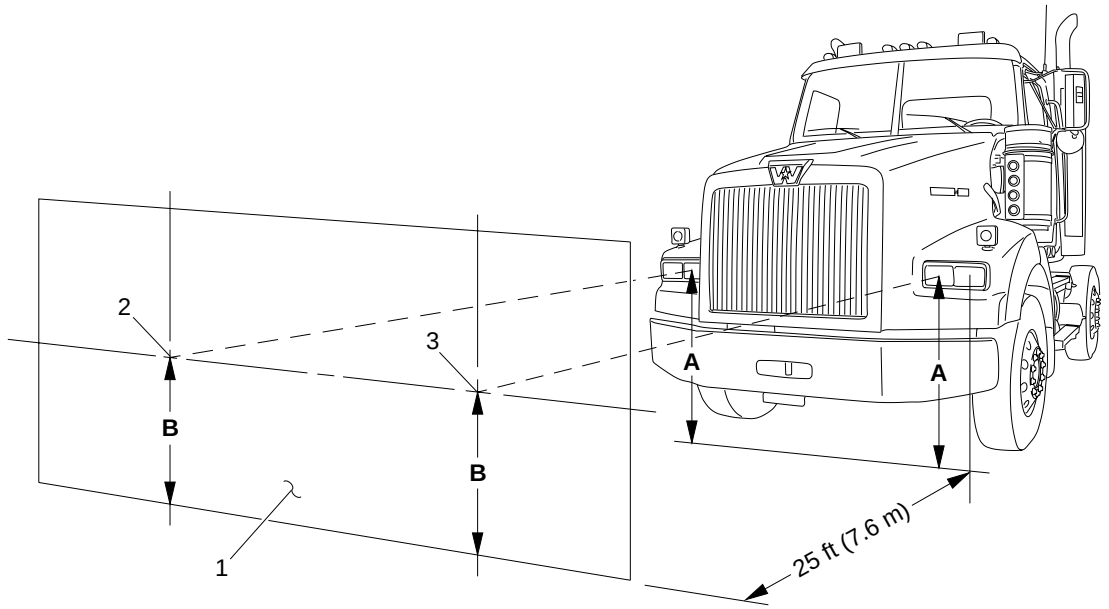
For adjustment screw locations on a vehicle with dual rectangular headlight assemblies, see **Fig. 3**. For adjustment screw locations on a vehicle with dual round headlight assemblies, see **Fig. 4**. For adjustment screw locations on a 4700 model, see **Fig. 5**.

Turn the adjustment screw in either direction until the beam pattern meets the acceptable standard.

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## Headlight Aim Checking and Adjusting

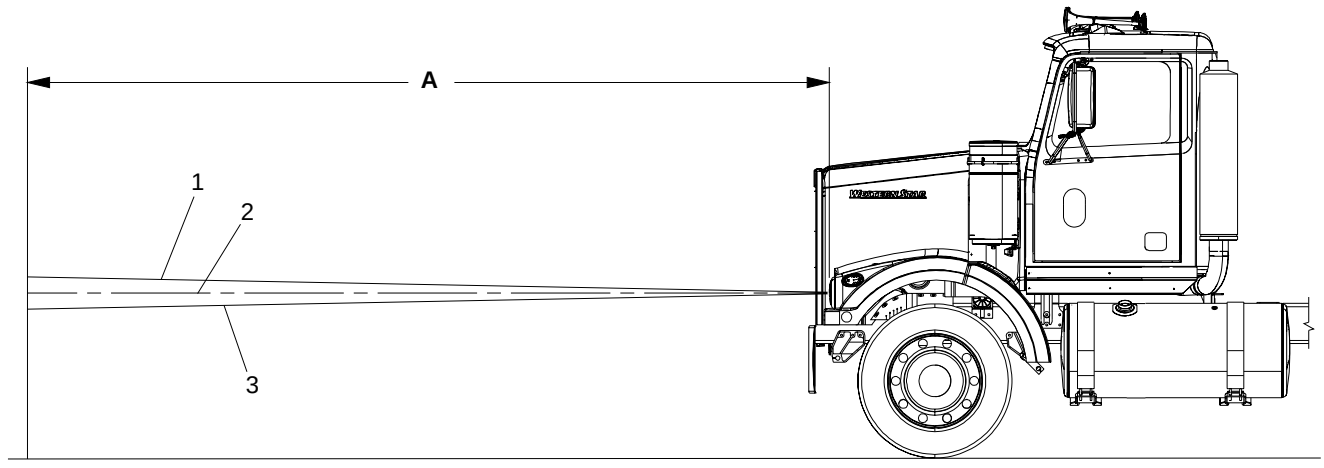



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A. Measure the distance from the ground to the center of each headlight bulb.
B. Mark where the center of each headlight projection should appear.

1. Screen or Wall
2. Center of Right-Hand Headlight Projection
3. Center of Left-Hand Headlight Projection

**Fig. 1, Headlight Aiming Screen/Wall**




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1. Low-Beam Angle Upper Limit
2. Ideal Low-Beam Projection
3. Low-Beam Angle Lower Limit

**Fig. 2, Vertical Low-Beam Headlight Variation Limits**

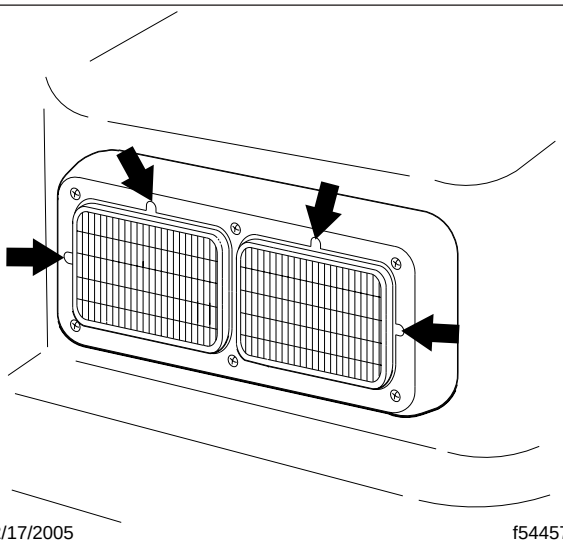
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## Headlight Aim Checking and Adjusting

| Vertical Low-Beam Headlight Variation Limits | | | |
|---|---|---|---|
| **Distance Between Ground and Headlight: in (mm)** | **Desired Variation ( Fig. 2, Item 2) : in (mm)** | **Upper Limit ( Fig. 2, Item 1): in (mm) up** | **Lower Limit ( Fig. 2, Item 3): in (mm) down** |
| 22–36 (560–900) | 0 | 3.9 (100) | 3.9 (100) |
| 36–48 (900–1200) | 2 (50) down | 2 (50) | 6 (150) |
| 48–54 (1200–1400) | 2.5 (64) down | 1.6 (40) | 6.5 (165) |

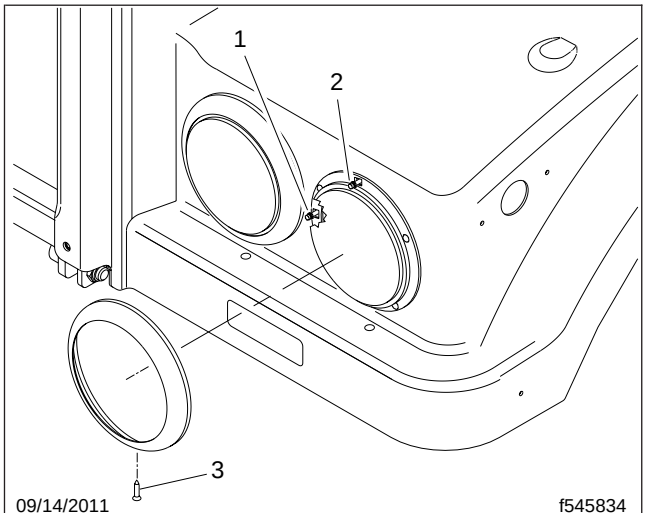
**Table 1, Vertical Low-Beam Headlight Variation Limits**



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NOTE: The vertical adjustment screws are on top of each bulb; the horizontal adjustment screws are on the side of each bulb.

**Fig. 3, Adjustment Screw Locations, Dual Rectangular Headlights**




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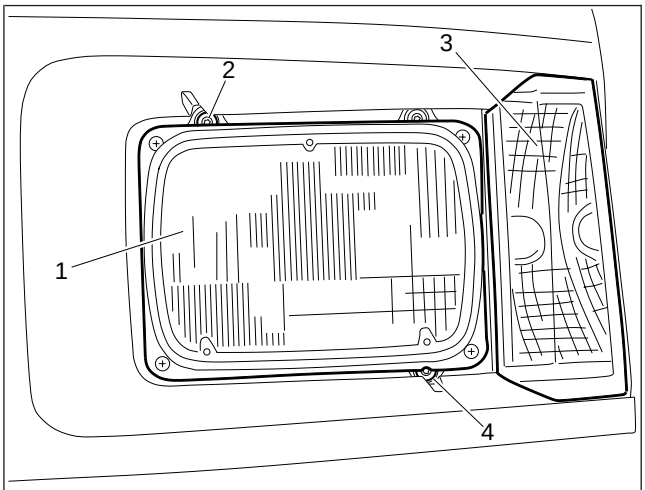
1. Horizontal Adjustment Screw
2. Vertical Adjustment Screw
3. Bezel Mounting Screw

**Fig. 4, Adjustment Screw Locations, Dual Round Headlights**

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## Headlight Aim Checking and Adjusting




NOTE: Adjustment screw locations may vary.

1. Headlight Lens
2. Horizontal Adjusting Screw
3. Turn Signal
4. Vertical Adjusting Screw

**Fig. 5, Single Headlight Assembly (4700 model shown)**

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# Turn Signal Switch Replacement

The turn-signal switch is a non-canceling combination turn-signal, hazard, and headlight-dimmer unit that mounts to a bracket on the left side of the steering column.

NOTE: Before replacing the turn-signal switch, make sure that the trouble is in the switch and not elsewhere in the circuit. Check that the circuit breaker and fuse are working, and inspect the signal light bulbs for broken filaments. Also, check the flasher relay, and replace it if necessary.

## Replacement, Tilt-Telescoping Steering Column

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Disconnect the negative leads from the batteries.
3. Remove the kick panel.
4. Remove the upper steering-column shrouds.
5. Remove any tie wraps and the turn-signal switch cable clamp.
6. Remove the four steering-column mounting bolts and lower the steering column.
7. Remove the two side brackets from the steering column.
8. Slide the lower steering-column shroud down.
9. Disconnect the turn-signal switch connectors from the vehicle harness and feed the harness through the lower steering-column shroud.
10. Remove the turn-signal switch mounting screws. See **Fig. 1**.
11. Remove the turn-signal switch and harness from the steering column.
12. Feed the new turn-signal switch harness down through the lower steering-column shroud.
13. Position the turn-signal switch on the column bracket and install the mounting screws.
14. Attach the connectors.
15. Connect the batteries.
16. Test the switch for proper operation.
17. Slide the lower steering-column shroud into position.
18. Install the side brackets on the steering column and tighten to 30 lbf·ft (40 N·m).
19. Position the steering column against the dash, then install and tighten the column mounting bolts to 17 lbf.ft (22 N·m).
20. Install the wire ties and cable clamp.
21. Install the upper steering-column shrouds.
22. Install the kick panel.

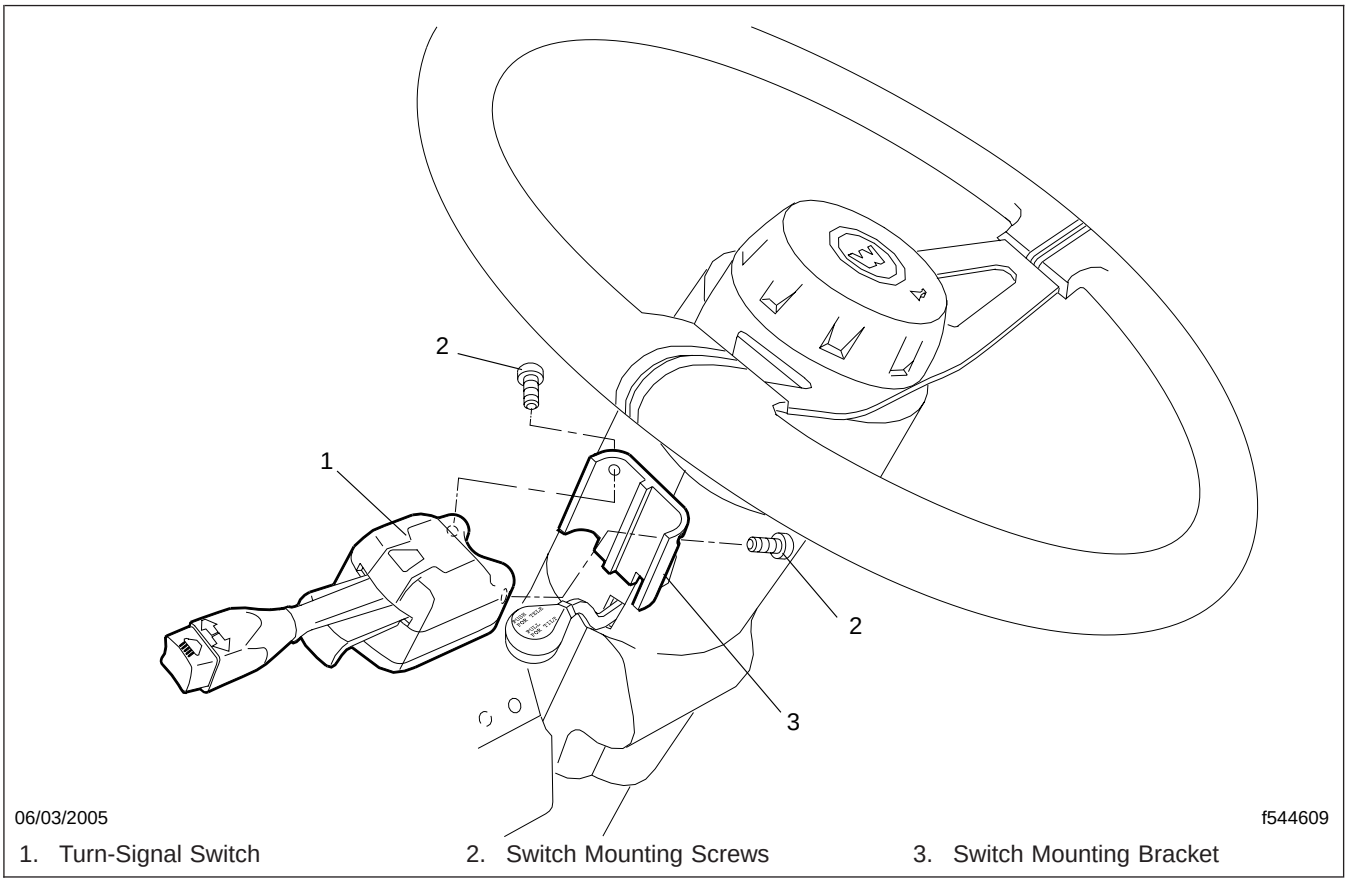
## Replacement, Rigid Steering Column

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Disconnect the negative leads from the batteries.
3. Remove any tie wraps and the turn-signal switch cable clamp.
4. Disconnect the turn-signal switch connectors from the vehicle harness.
5. Remove the turn-signal switch mounting screws.
6. Remove the turn-signal switch and harness from the steering column.
7. Position the turn-signal switch on the column bracket and install the mounting screws.
8. Attach the connectors.
9. Install the wire ties and cable clamp.
10. Connect the batteries.
11. Test the switch for proper operation.

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## Turn Signal Switch Replacement




1. Turn-Signal Switch
2. Switch Mounting Screws
3. Switch Mounting Bracket

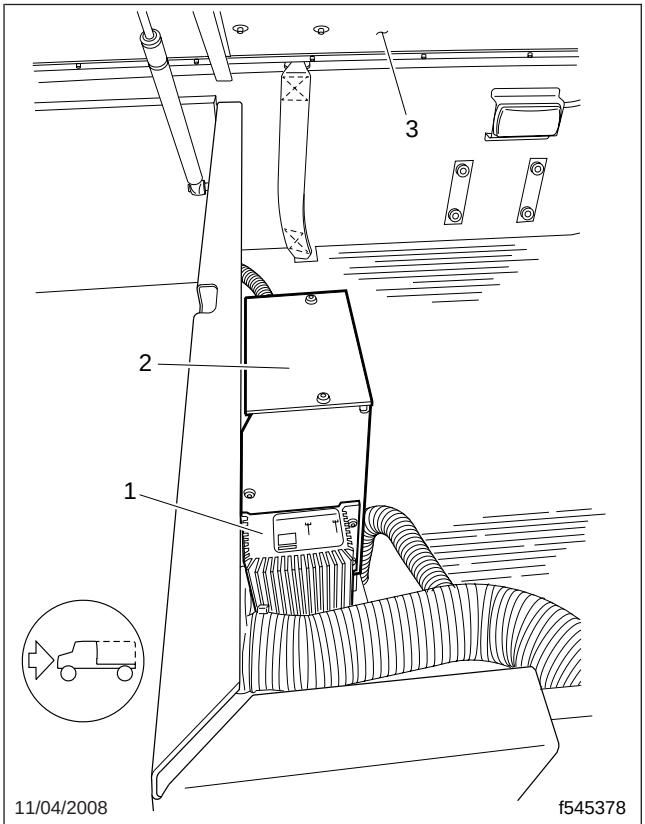
**Fig. 1, Turn-Signal Switch Installation**

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## General Information

The optional low voltage disconnect module (LVD) is mounted inside the driver-side baggage compartment. See **Fig 1**.




1. Low Voltage Disconnect
2. Sleeper Compartment Fuse Box
3. Lower Bunk

**Fig. 1, Low Voltage Disconnect Installation**

The LVD monitors battery voltage levels. If the battery falls below 12.3 volts, the LVD sounds a warning buzzer for 1 minute. If no actions are taken after 60 seconds, the LVD removes power to pre-determined cab and sleeper circuits, and an LED indicator on the module illuminates.

The LVD controls power to the following cab and sleeper circuits:

- Interior Lights
- HVAC
- Control Panel Outlet
- TV/VCR
- Refrigerator
- Under-Dinette Outlet
- Subwoofer
- Spare

Once battery voltage reaches 13 volts, or if the vehicle is stared, the LVD automatically reconnects power to the predetermined circuits.

The LVD incorporates a 60-second time delay to prevent false triggering, and is equipped with internal short circuit protection, over-circuit protection, transient voltage suppression, and thermal protection.

The LVD has two terminal post connections and five screw type terminal connections.

The two terminal post connections are V-in and V-out. The V-in terminal is the voltage supply input from the frontwall power stud. The V-out terminal is the controlled voltage output from the LVD to the sleeper terminal power strip.

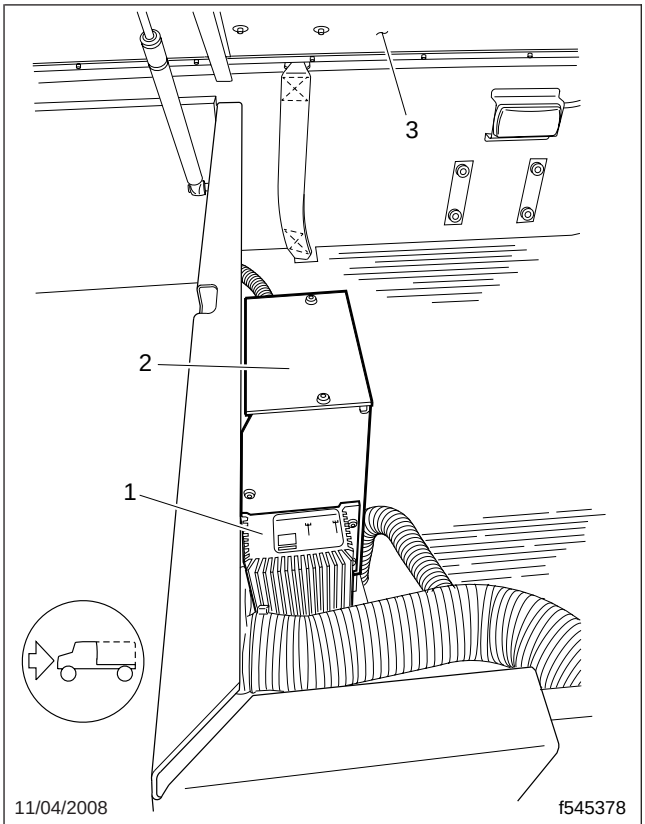
Two of the five screw type terminals used on the LVD is V-sense and ground. The V-sense terminal is used by the LVD to monitor the level of battery voltage, and is connected to the battery. The ground terminal supplies ground for the module and is connected to the battery to ensure a good ground.

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## Removal

1. Shut down the engine.
2. Raise the lower bunk. The LVD is attached to the sleeper compartment fuse box, located in the driver-side baggage compartment.
3. Remove the bolts securing the LVD to the sleeper compartment fuse box. See **Fig. 1**.




1. Low Voltage Disconnect
2. Sleeper Compartment Fuse Box
3. Lower Bunk

**Fig. 1, Low Voltage Disconnect Installation**

4. Disconnect the battery cables.
5. Remove the connector plug.
6. Remove the LVD.

## Installation

1. Attach the connector plug.
2. Connect the battery cables.
3. Position the LVD on the sleeper compartment fuse box, and install the mounting bolts. Tighten the bolts securely.
4. Verify the operation of the LVD.

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## Functional Test

NOTE: If the LVD deactivates (removes power to the cab/sleeper loads), it must be reset prior to performing a functional test. If the batteries are discharged below 12.3 volts, charge the batteries before performing any troubleshooting procedures. The LVD can be reset by starting the engine. Once the LVD senses 13.1 volts or more, it resets automatically.

1. Shut down the engine.
2. Unplug the 10-position connector from the LVD.
3. Remove the wire from cavity E on the connector, and wrap a small piece of electrical tape around the exposed wire.
4. Insert the connector into the LVD with wire BA22D still removed.

NOTE: The red LED indicator light on the LVD should turn on when the connector is inserted.

5. Insert a metal conducting probe into cavity E of the connector, making sure contact is made between the metal probe and pin E on the LVD.
6. Connect a jumper wire between the terminal on wire BA22D and the test probe inserted in cavity E.

NOTE: The electrical loads, such as interior lights, will remain OFF even though an electrical connection exists between circuit BA22D and pin E. The LVD needs to be reset after removing the plug from the LVD.

7. Reset the LVD by starting the engine. The dome lights should come back ON, and the red LED indicator light on the LVD should turn OFF.
8. Shut down the engine.
9. Remove the metal test probe from cavity E.

NOTE: After removing the test probe, there will be a delay before the LVD disconnects the cab/sleeper loads. If equipped with the optional warning buzzer, it will sound for 60 seconds. After the time delay, the cab/sleeper loads (dome lights, for example) will shut OFF, and the optional warning buzzer will shut OFF.

10. Disconnect the jumper wire from BA22D.
11. Remove the 10-position connector from the LVD.
12. Insert wire BA22D into cavity E of the connector.
13. Insert the connector into the LVD.
14. Start the engine to reset the LVD.
15. If the LVD does not operate properly after performing the functional test, perform the troubleshooting procedures in this subject.

## Troubleshooting

| Troubleshooting | |
|---|---|
| **Problem** | **Remedy** |
| Battery voltage goes below 12.1 (nominal) volts without low voltage disconnect system activation. | Check the low voltage disconnect module and associated wiring. See **Fig. 1**. |
| Low voltage disconnect system always activated. | Check the low voltage disconnect module and associated wiring. See **Fig. 2**. |

**Table 1, Troubleshooting**

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## Troubleshooting

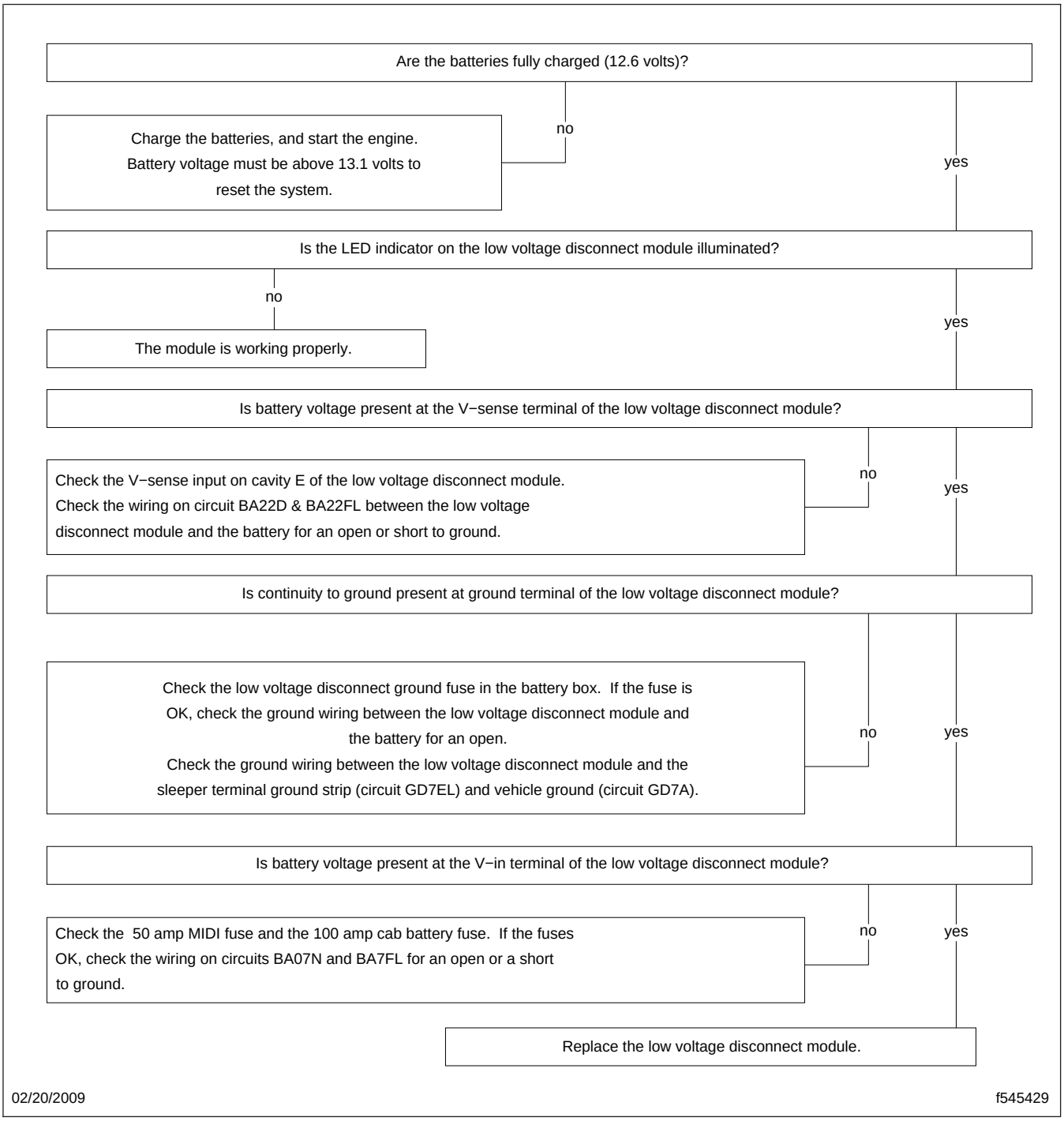



**Fig. 1, Battery Voltage Goes Below 12.1 Volts Without LVD System Activation**

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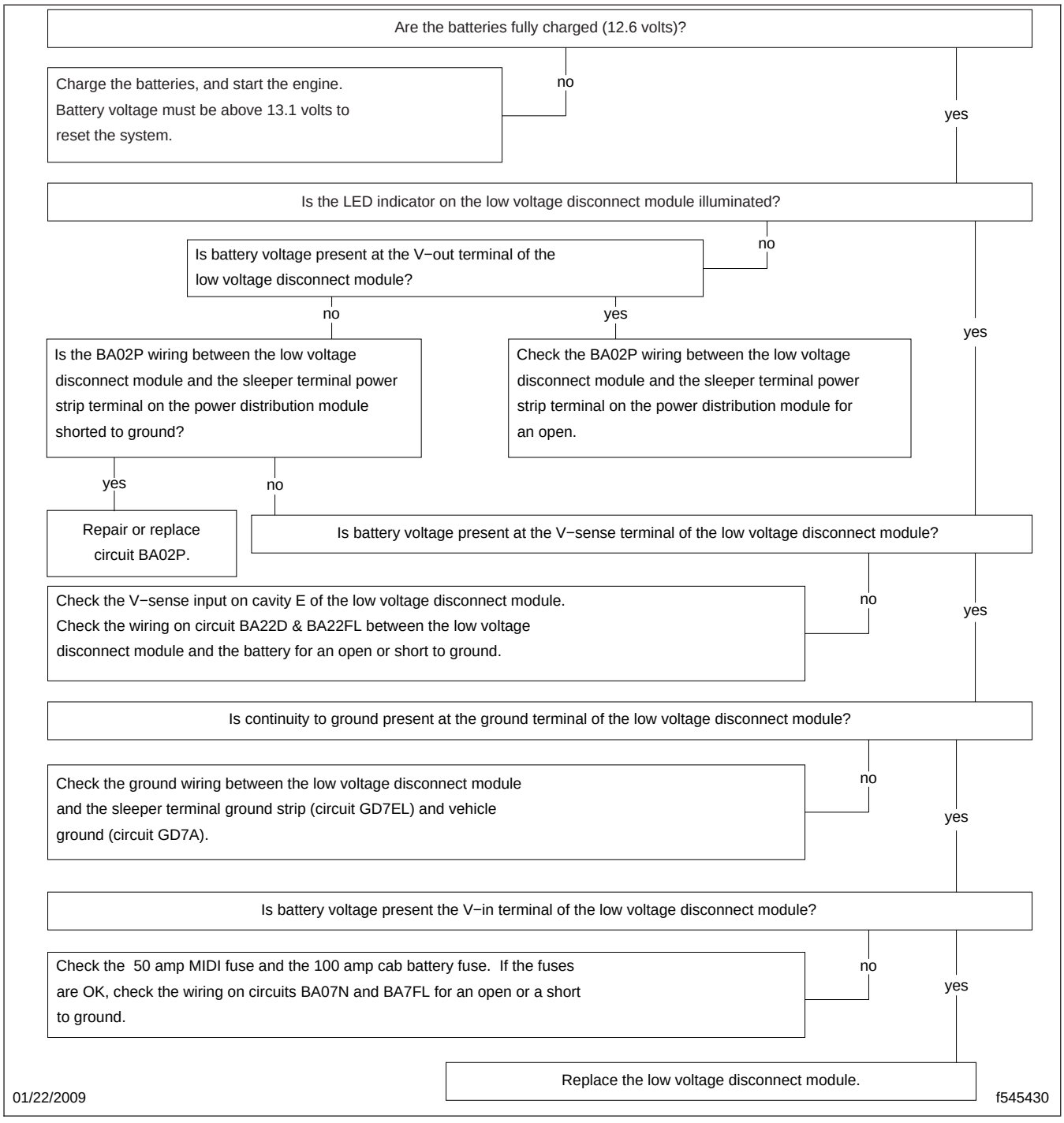



**Fig. 2, LVD System is Always Activated**

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# Specifications

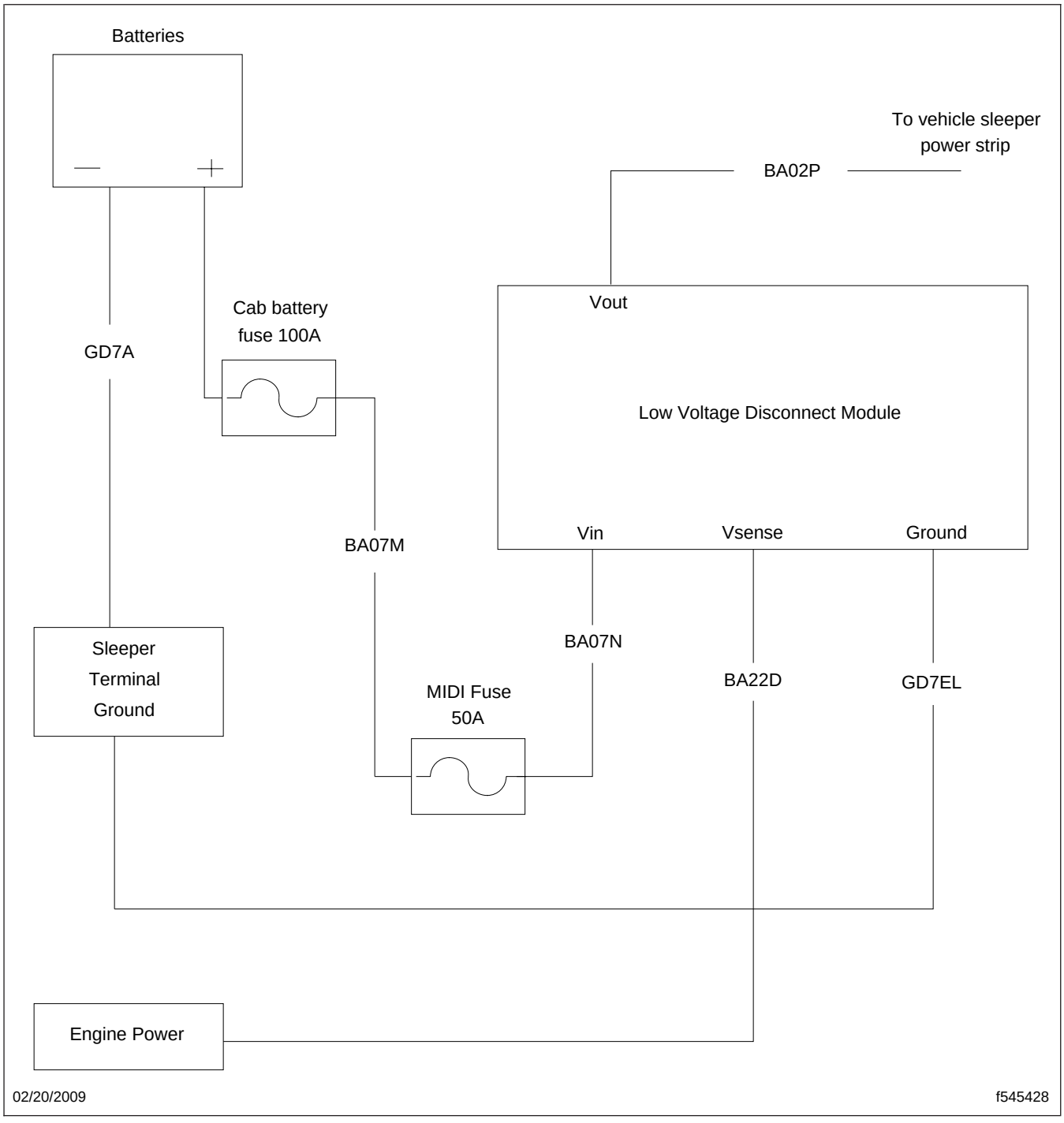



**Fig. 1, LVD System Wiring**

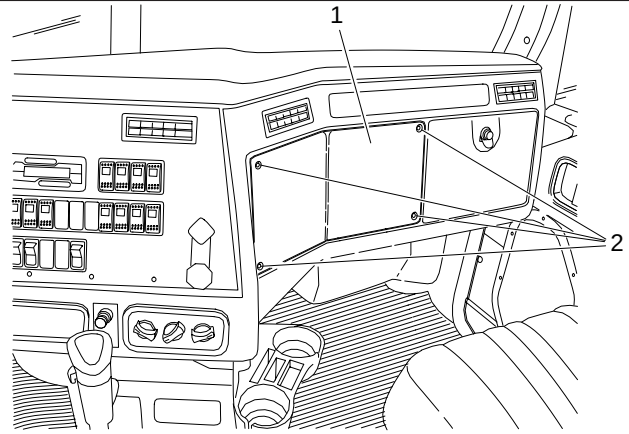
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## General Information

There are three power distribution modules on EPA10 vehicles: the dash electrical panel, the powertrain PDM, and the powernet distribution box (PNDB). On pre-EPA10 vehicles, there is one PDM ( **Fig. 1**) and two MEGA fuses on the frontwall.

The dash electrical panel is located inboard of the passenger-side glove box. Access to the panel is achieved by removing the four screws located in each corner of the panel. See **Fig. 1**.




1. Electrical Panel Cover
2. Mounting Screws

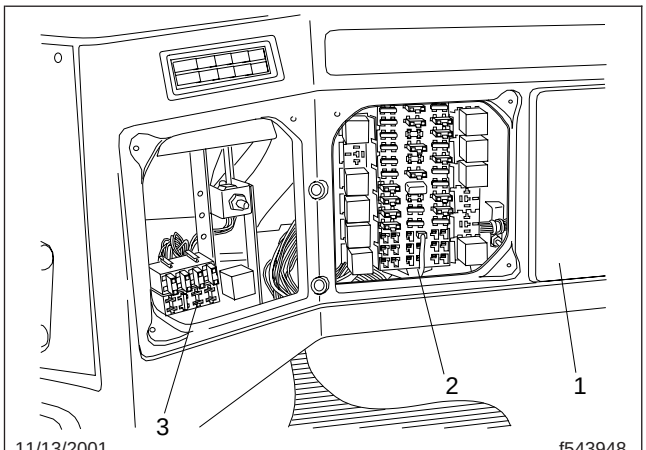
**Fig. 1, Dash Panel**

The opening next to the glove box is the main panel and the opening closer to the driver is the option panel. See **Fig. 2**. The main panel consists of most of the standard fuses, beakers and relays that are usually found on every Western Star vehicle. The option panel fuses, breakers and relays are used for customer ordered options.

The option panel is made up of fuse/breaker blocks each can contain four fuses/breakers. The power feeds for the fuse/breakers in the option panels come from the jumpers at the bottom of the main panel. Relay sockets are installed as required.

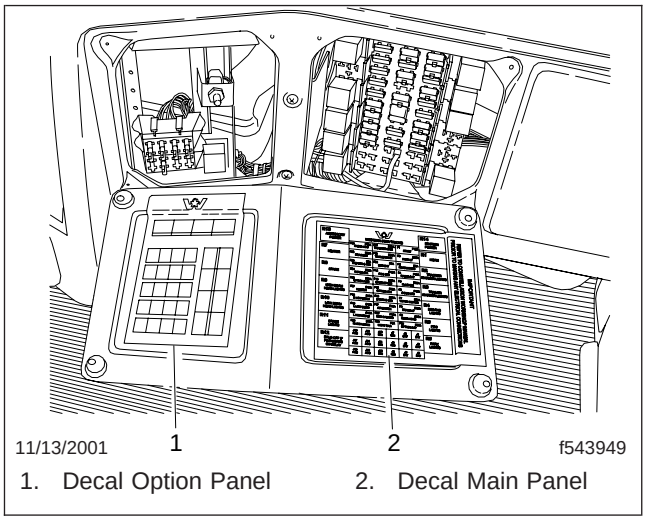
A decal, showing the layout of the fuses, breakers and relays, is on the back of the fuse/breaker/relay panel cover. See **Fig. 3**.

The main panel holds 30 ATO style fuses or circuit breakers. Along the sides of the panel are 14 relays; seven to a side. The top relays on each side are for




1. Glove Box
2. Main Panel
3. Option Panel

**Fig. 2, Open Electrical Panel**




1. Decal Option Panel
2. Decal Main Panel

**Fig. 3, Electrical Panel Decals**

*Accessory Power* and the other for *Ignition Power*. The rest of the relays are for circuits. There are 18 jumper connections in three rows across the bottom for optional equipment power sources. Each column uses a colored and indexed connector specific to the jumper column.

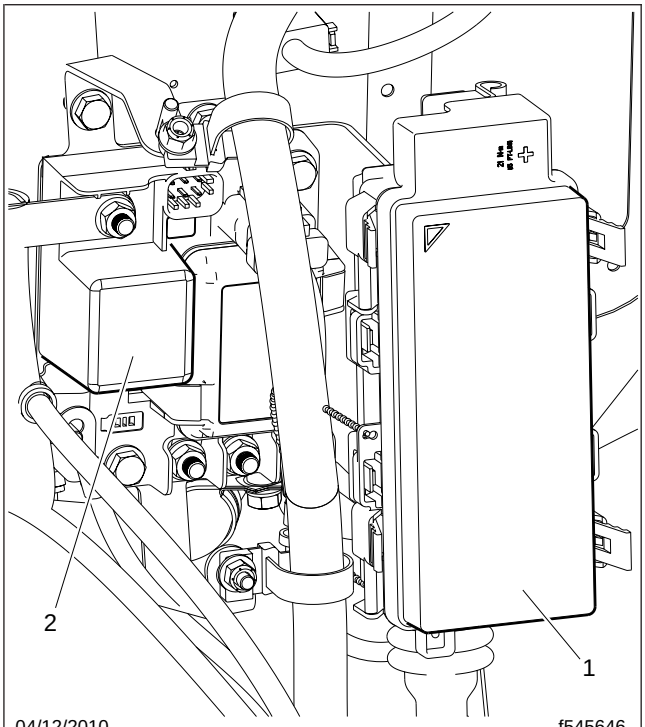
The powertrain power distribution module provides battery and ignition power to the engine, aftertreatment device, and transmission, in addition to other powertrain-related circuits. The PDM contains the fuses and relays that protect and control the power feed circuits to these components. It is mounted in

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## General Information

the engine compartment in front of the powernet distribution box. See **Fig. 4**.




1. Powertrain PDM
2. Powernet Distribution Box

**Fig. 4, Powertrain Power Distribution Module**

The powernet distribution box (PNDB), located on the cab frontwall near the steering column, replaces the MEGA fuse panel on the frontwall. The PNDB supplies power to the powertrain PDM, the aftertreatment control module (ACM), the main PDM, and several cab loads including the clock. There are three MEGA fuses and four ATO fuses behind the cover on the PNDB.

Vehicles may be equipped with an optional load disconnect switch. This switch triggers the PNDB to disconnect power to the powertrain PDM and cab power. The keep-alive circuits for the ACM clock and emergency power stay active.

Vehicles also may be equipped with an optional additional PNDB. The optional PNDB sources power to any of the the following: Qualcomm, trailer end-of-frame connection, shore power inverter, and body builder PDM.

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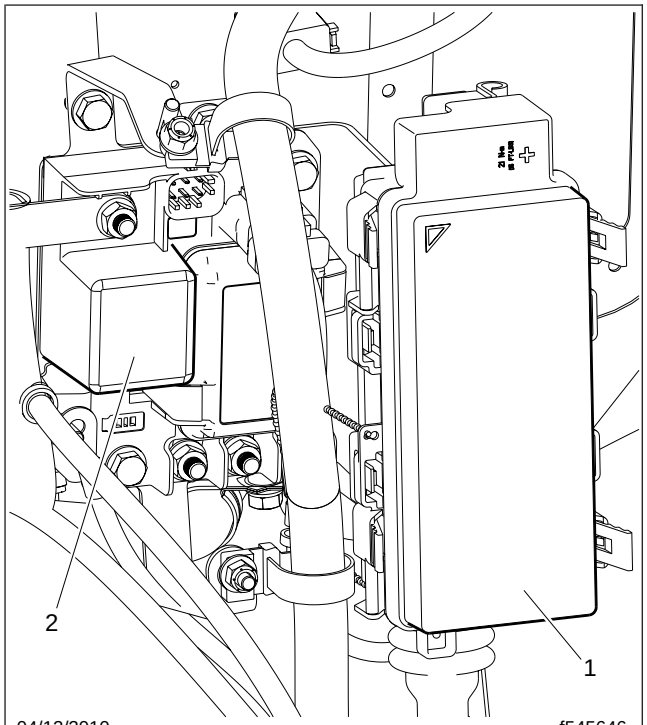
## Powertrain PDM Removal and Installation

# Removal

1. Disconnect the batteries.

NOTE: The powertrain power distribution module (PDM) is mounted in the engine compartment in front of the powernet distribution box. See **Fig. 1**.

2. Using a screwdriver, release the support tabs that secure the PDM to the mounting bracket. Remove the PDM from the bracket.




1. Powertrain PDM
2. Powernet Distribution Box

**Fig. 1, Powertrain PDM**

3. Open the top cover from the PDM.
4. Remove the fuses and relays from the top of the PDM, noting the location of each fuse and relay before removal.
5. Remove the terminal locks. See **Fig. 2**.
6. Release the bottom cover using the tab on the end of the PDM where the wires exit.
7. Mark each wire for reassembly.

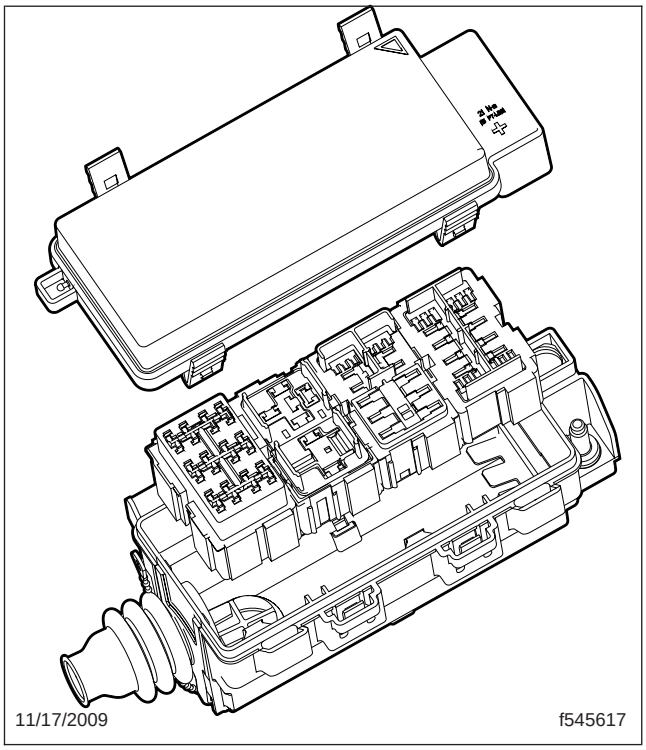



**Fig. 2, Removing the Terminal Locks**

8. Remove the wires under the PDM by pressing each terminal lock with a pick tool.
9. Remove the PDM from the vehicle.

# Installation

1. Attach all wires on the bottom of the PDM. The terminals will click into place when inserted correctly.

NOTE: If the locks are inserted backward, the lock will not press into place.

2. Install the terminal locks.
3. Install the fuses and relays, using the locations noted earlier.
4. Install the bottom cover.
5. Position the PDM on the mounting bracket, and push down until the support tabs snap into place.
6. Close the PDM top cover. Use a wire tie to secure the cover, if necessary.

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## Powertrain PDM Removal and Installation

7. Turn the cab load disconnect switch to the ON position.

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# Powernet Distribution Box Removal and Installation

## Removal

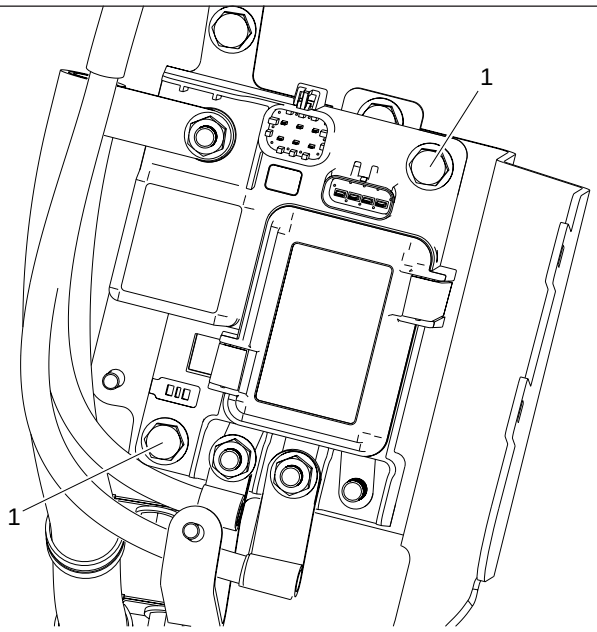
1. Disconnect all batteries. If the vehicle is equipped with an auxiliary battery bank, disconnect these also.
2. Open the hood.

NOTE: The powernet distribution box (PNDB) is located on the cab frontwall, near the steering shaft. See **Fig. 1**.

3. Disconnect the battery cables from the PNDB.

IMPORTANT: Inspect the keep-alive and CLDS connectors to insure that plugs are in unused connector cavities. Install plugs to seal the connector if any are missing.

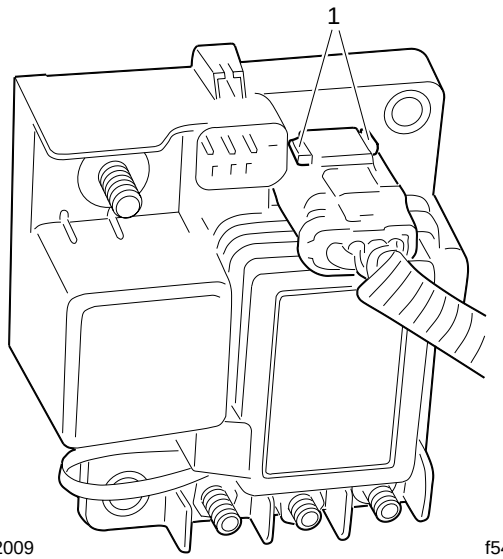
4. Disconnect the "keep alive" circuit connector from the PNDB.
   - 4.1 Using a flat-head screwdriver, push the red locking tab to the side. See **Fig. 2**.
   - 4.2 Press and release the connector retaining tab, then remove the connector.
5. Remove the PNDB from the vehicle.




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1. Mounting Bolts

**Fig. 1, Powernet Distribution Box**




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1. Circuit Connector Locking Tab

**Fig. 2, Removing the Circuit Connector**

## Installation

1. Position the PNDB on the frontwall, and connect the battery cables.
2. Attach the keep-alive circuit connector to the PNDB.
3. Confirm that the correct rated fuses are installed in the PNDB. See **Subject 400** for fuse ratings
4. Connect the batteries.
5. Close the hood.

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## Powernet Distribution Box

Each powernet distribution box (PNDB) on the vehicle provides up to 4 low amperage circuits, and up to three high amperage circuits. On vehicles equipped with a cab load disconnect switch (CLDS), the high amperage circuits are switched on and off with the CLDS. The low amperage circuits are always live. Vehicles may have one or two PNDBs.

When the CLDS is in the on position, an LED on the switch and another on the PNDB will illuminate. When there is an error condition with the PNDB system, the LED on the PNDB and the CLDS may flash. A flashing LED indicates an error. An LED that remains on when the switch is off, or no LED illuminates when the switch is on, also indicated an error condition.

To test for open fuses, use conventional troubleshooting methods. The LEDs in the PNDB and switch are not affected by open fuses or the circuits they connect.

See **Table 1** to troubleshoot a switched PNDB system.

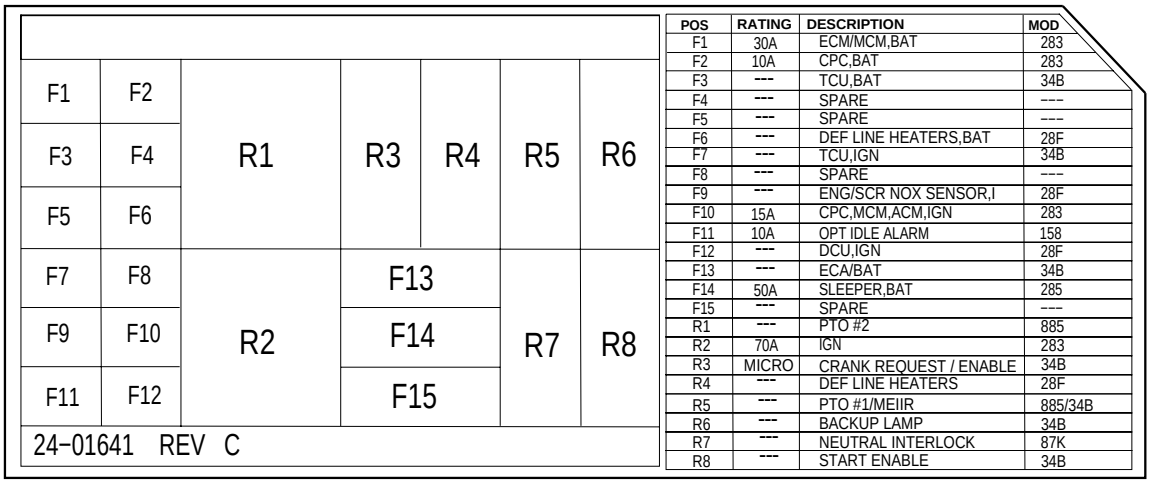
| LED on Cab Load Disconnect Switch (CLDS) is Flashing | | | |
|---|---|---|---|
| **Step** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Does the LED make a double flash for 5 seconds when the switch is first turned on or off? | Yes | The PNDB failed to switch itself on or off when commanded by the switch. Replace a defective PNDB. |
| | | No | Inspect the connectors in the interconnect harness between the PNDB and the cab load disconnect switch (CLDS). If either was not correctly seated or there is corrosion in the connections, clean and reconnect. Otherwise, continue with step 2. |
| 2 | Measure continuity on the harness between the PNDB and the CLDS. Are any of the circuits open or shorted to ground? | Yes | Repair the wiring fault as appropriate. |
| | | No | Substitute a good CLDS to check if this repair solves the problem. Otherwise replace the PNDB. |

**Table 1, LED on Cab Load Disconnect Switch (CLDS) is Flashing**

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NOTE: Refer to 24-01641-024 in EZWiring for a complete schematic of the powertrain PDM.




| POS | RATING | DESCRIPTION | MOD |
|---|---|---|---|
| F1 | 30A | ECM/MCM,BAT | 283 |
| F2 | 10A | CPC,BAT | 283 |
| F3 | --- | TCU,BAT | 34B |
| F4 | --- | SPARE | --- |
| F5 | --- | SPARE | --- |
| F6 | --- | DEF LINE HEATERS,BAT | 28F |
| F7 | --- | TCU,IGN | 34B |
| F8 | --- | SPARE | --- |
| F9 | --- | ENG/SCR NOX SENSOR,I | 28F |
| F10 | 15A | CPC,MCM,ACM,IGN | 283 |
| F11 | 10A | OPT IDLE ALARM | 158 |
| F12 | --- | DCU,IGN | 28F |
| F13 | --- | ECA/BAT | 34B |
| F14 | 50A | SLEEPER,BAT | 285 |
| F15 | --- | SPARE | --- |
| R1 | --- | PTO #2 | 885 |
| R2 | 70A | IGN | 283 |
| R3 | MICRO | CRANK REQUEST / ENABLE | 34B |
| R4 | --- | DEF LINE HEATERS | 28F |
| R5 | --- | PTO #1/MEIIR | 885/34B |
| R6 | --- | BACKUP LAMP | 34B |
| R7 | --- | NEUTRAL INTERLOCK | 87K |
| R8 | --- | START ENABLE | 34B |

**Fig. 1, Powertrain PDM Fuses and Relays**

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## Specifications

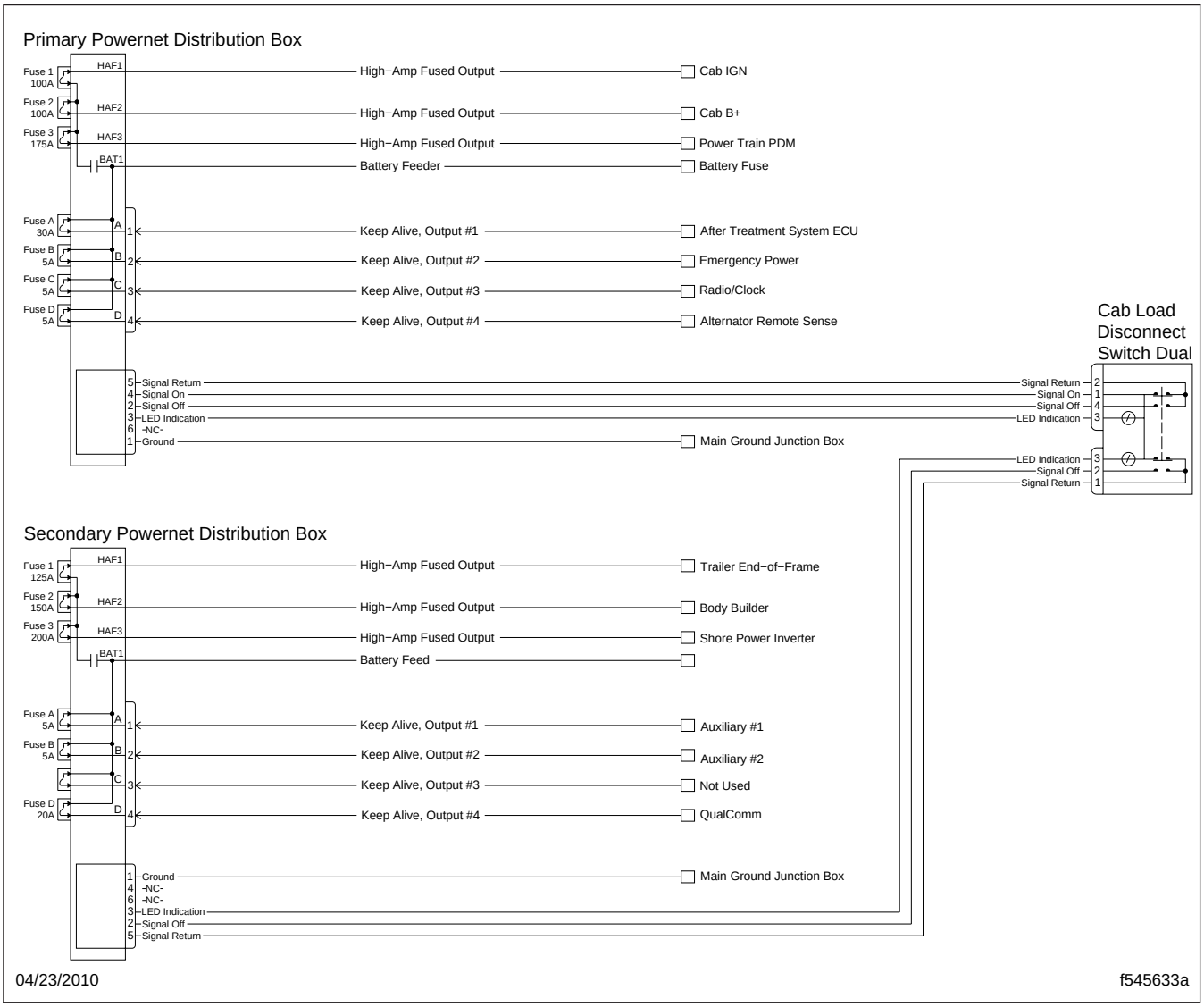



**Fig. 2, Primary and Secondary Powernet Distribution Box (PNDB)**

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# General Information

Remote keyless entry can be programmed for a maximum of four key fobs. The vehicle is delivered with two key fobs. To program additional fobs, use the procedure described in **Subject 100**.

When the unlock button is pressed, both driver and passenger doors are unlocked simultaneously. Both doors are locked when the lock button is pressed.

The power door lock switches ground the lock or unlock input circuits to the module when pressed. The module controls the door lock actuators by reversing polarity on circuits 443U and 443L to the actuators for lock/unlock.

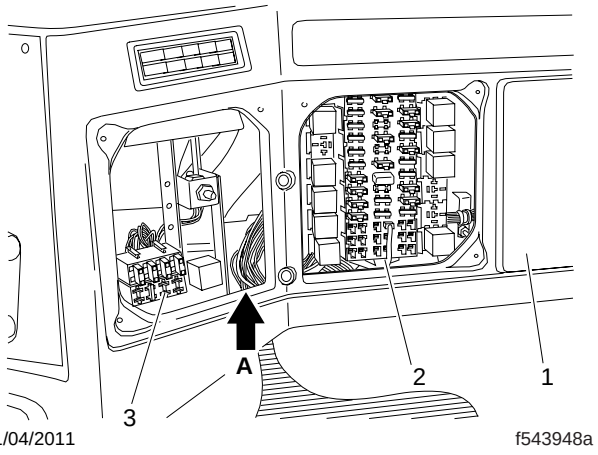
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## Key Fob Programming

The fob programming procedure must be used when replacing a keyless entry module or when a key fob is replaced or added. All key fobs that will be used on the vehicle must be programmed at the same time. Any existing fobs that were previously programmed will no longer work on the vehicle unless they are all reprogrammed to the module at the same time. A maximum of four fobs can be programmed to a vehicle in the programming procedure.

1. Remove the passenger-side electrical access panel, located next to the glove box. See **Fig. 1**.




A. The two-wire connector is located next to the auxiliary power distribution module.

1. Glove Box
2. Main Power Distribution Module
3. Auxiliary Power Distribution Module

**Fig. 1, Passenger-Side Electrical Access Panel (removed)**

2. Locate the two-wire connector in the area between the auxiliary and main power distribution modules with circuit 443* and ground.

NOTE: If the two-wire connector cannot be located, the connector may be hanging below the power distribution module. In this case, remove the heater cover panel, which is located below the fuse panel.

3. Use a short length of wire or a paperclip to short the two terminals together 3 times within 5 seconds.
4. Wait 3 seconds.
5. Press and hold the first fob's lock button for 2 seconds. The LED in the fob will flash while the button is held.
6. Press the lock button on the second fob for 1 second. The LED in the fob will flash while the button is held.
7. Repeat step 6 for any additional fobs up to a maximum of 4.

NOTE: The system will exit program mode after 1 minute of no activity.

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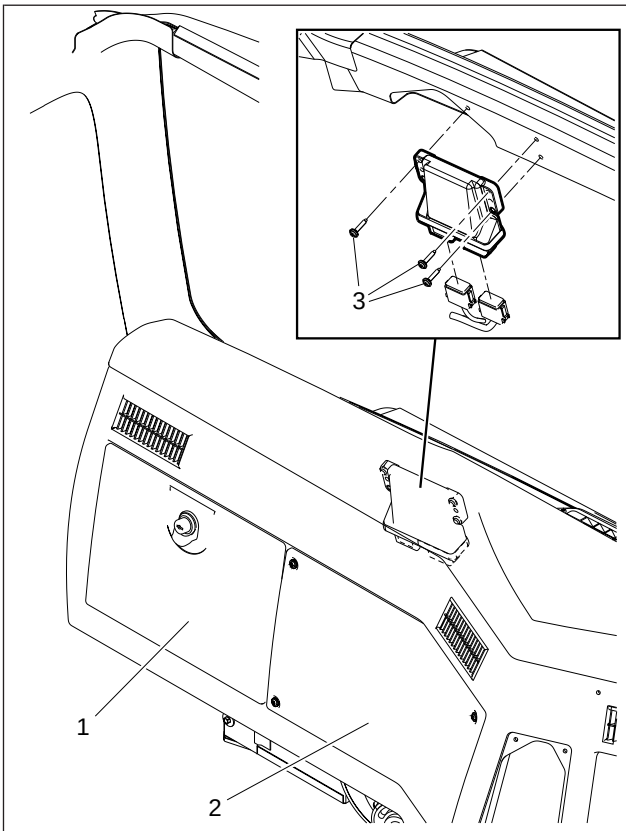
# Keyless Entry Module Replacement

## Removal

1. Shutdown the engine, chock the tires, and disconnect the batteries at the negative terminals.
2. Remove the fuse and relay access panel. See **Fig. 1**.
3. Disconnect the grey and black connectors from the keyless entry module. See **Fig. 1** for right-hand drive vehicles, and **Fig. 2** for left-hand drive vehicles.
4. Remove the two fasteners retaining the module to the bracket on the steering column.

## Installation

1. Position the new module on the steering column and install the two mounting nuts (left-hand drive vehicles) or three mounting screws (right-hand drive vehicles).
2. Connect the black and the grey connector to the module.
3. Install the fuse and relay access panel.
4. Connect the batteries.
5. Synchronize the fobs to the new receiver module using the programming instructions in **Subject 100**.




1. Glove Box
2. Fuse and Relay Access Panel
3. Mounting Screws

**Fig. 1, Keyless Entry Module on Right-Hand Drive Vehicles**

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## Keyless Entry Module Replacement

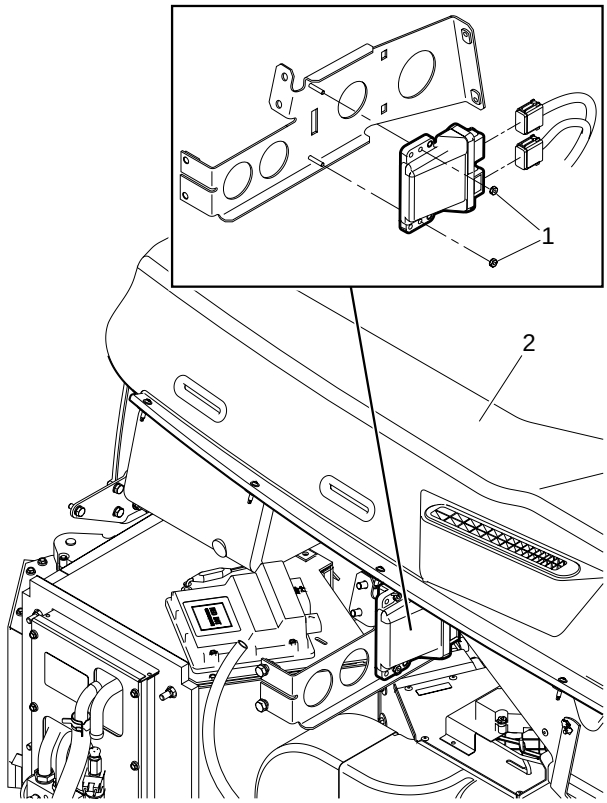



**Fig. 2, Keyless Entry Module on Left-Hand Drive Vehicles (frontwall view shown)**

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## Troubleshooting

The keyless entry module powers the door lock actuators in both doors simultaneously. When locking, the module applies battery power to circuit 443L and ground to circuit 443U. When unlocking, the module applies ground to circuit 443L and battery power to circuit 443U.

The power lock switches are wired as inputs to the keyless entry module. When a switch is pressed in the lock direction, ground is applied to circuit 443L1. When unlocking, ground is applied to circuit 443U1.

See **Table 1** for a list of remote keyless entry troubleshooting topics.

| Remote Keyless Entry Troubleshooting | |
|---|---|
| **Symptom** | **Table** |
| One Fob Only Does Not Operate | **Table2** |
| One Door Only Does Not Lock or Unlock | **Table3** |
| The Door Lock Switches Do Not Lock or Unlock the Doors But The Fobs Work Properly | **Table4** |
| No Key Fobs Operate the Locks, The Switches Work Properly | **Table5** |
| The Power Locks Do Not Operate | **Table6** |

**Table 1, Remote Keyless Entry Troubleshooting**

| One Fob Only Does Not Operate | | | |
|---|---|---|---|
| **Test** | **Test** | **Result** | **Action** |
| 1 | Check the battery in the Fob for corrosion and proper voltage. | — | Replace the battery and clean the contacts, if necessary. |
| 2 | Was the fob that does not operate properly programmed at the same time as fobs that are operating normally? | Yes | Replace the inoperative key fob. |
| | | No | Perform the programming sequence in **Subject 100** for all fobs at the same time. All fobs must be synchronized during the programming procedure. |

**Table 2, One Fob Only Does Not Operate**

| One Door Only Does Not Lock or Unlock | | | |
|---|---|---|---|
| **Test** | **Test** | **Result** | **Action** |
| 1 | Remove the door trim panel on the door that is not working and measure the voltage on circuits 443L and 443U at the door lock actuator when the switch is in the lock and also in the unlock position.<br>Is battery voltage and then negative battery voltage present? | Yes | Inspect the linkage and repair or replace any mechanical defects. If the actuator does not operate at all, replace the door lock actuator. |
| | | No | Locate and repair a wiring fault in circuits 443U and 443L between the door lock actuator and the splice to the door that is working. |

**Table 3, One Door Only Does Not Lock or Unlock**

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## Troubleshooting

| The Door Lock Switches Do Not Lock or Unlock the Doors But The Fobs Work Properly | | | |
|---|---|---|---|
| **Test** | **Test** | **Result** | **Action** |
| 1 | Access the keyless entry module and disconnect the grey connector. Measure the resistance between ground and pin 12 when a door lock switch is in the lock position. Also measure resistance between ground and pin 9 when a switch is in the unlock position.<br>Is there continuity to ground when a switch is operated? | Yes | Replace the keyless entry module and then program all key fobs using the programming sequence described in **Subject 100**. |
| | | No | Go to test 2. |
| 2 | Remove the connector from the inoperative door lock switch and measure for continuity between pins 7 and 3 when the switch is in the lock position, and then between pins 8 and 4 when the switch is in the unlock position.<br>Is there continuity? | Yes | Locate and repair a wiring fault with circuits 443L1, 443U1, or GND. |
| | | No | Replace the switch. |

**Table 4, The Door Lock Switches Do Not Lock or Unlock the Doors But The Fobs Work Properly**

| No Key Fobs Operate the Locks, The Switches Work Properly | | | |
|---|---|---|---|
| **Test** | **Test** | **Result** | **Action** |
| 1 | Check the battery in the fob for corrosion and proper voltage. | — | Replace the battery and clean the contacts, if necessary. |
| 2 | Access the keyless entry module and locate the antenna wire in the grey connector pin 2. Follow the antenna wire to inspect for damage. Is the antenna wiring OK? | Yes | Go to test 3. |
| | | No | Replace or repair the antenna circuit. |
| 3 | Perform the programming sequence for all fobs as described in **Subject 100**. Do the fobs now operate the locks? | Yes | No further action is necessary. |
| | | No | Replace the keyless entry module and then program all key fobs using the programming sequence described in **Subject 100**. |

**Table 5, No Key Fobs Operate the Locks, The Switches Work Properly**

| The Power Locks Do Not Operate | | | |
|---|---|---|---|
| **Test** | **Test** | **Result** | **Action** |
| 1 | Access the keyless entry module and measure for battery voltage on the grey connector pin 7 and the black connector pin 12.<br>Is battery voltage present? | Yes | Go to test 2. |
| | | No | Remove the fuse and relay access panel from the passenger side of the dash. Inspect the fuse in the auxiliary fuse box. If the fuse is open, go to test 3. Otherwise, repair the open circuit 443 between the fuse box and the module. |

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| The Power Locks Do Not Operate | | | |
|---|---|---|---|
| **Test** | **Test** | **Result** | **Action** |
| 2 | Backprobe the grey connector and measure voltage on pins 4 and 8 while shorting pin 9 to ground.<br>Does the volt meter show battery voltage or negative battery voltage? | Yes | Locate and repair the wiring fault in circuit 443L or 443U using the schematic for the vehicle. The schematic is in module 787. |
| | | No | Replace the keyless entry module and then program all key fobs using the programming sequence described in **Subject 100**. |
| 3 | Disconnect the grey and black connectors from the keyless entry module and then replace the fuse.<br>Is battery voltage present on the grey connector pin 7 and the black connector pin 12? | Yes | Go to test 4. |
| | | No | Locate and repair the short in circuit 443 between the fuse box and the module. |
| 4 | With the connector disconnected, measure the resistance between ground and circuits 443L and 443U.<br>Is either circuit shorted to ground? | Yes | Locate and repair the short in circuit 443L or 443U. |
| | | No | If the lock system operates with a replaced fuse, there is possibly an intermittent short somewhere in the wiring. Thoroughly check the wiring for circuit 443 for faults. If the lock system is still not operating, replace the keyless entry module and then program all key fobs using the programming sequence described in **Subject 100**. |

**Table 6, The Power Locks Do Not Operate**

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# Keyless Entry Module Connections

| Keyless Entry Module Connections | | |
|---|---|---|
| **Pin** | **Description** | **Circuit** |
| **Grey Connector** | | |
| 1 | Not used | — |
| 2 | Antenna | No Number |
| 3 | Not used | — |
| 4 | Door lock output | 443L |
| 5 | Not used | — |
| 6 | Ground | GND |
| 7 | Battery Power | 443 |
| 8 | Door unlock output | 443U |
| 9 | Door unlock input | 443U1 |
| 10 | Not used | — |
| 11 | Not used | — |
| 12 | Door lock input | 443L1 |
| **Black Connector** | | |
| 1 | Ground | GND |
| 2 | Not used | — |
| 3 | Not used | — |
| 4 | Not used | — |
| 5 | Not used | — |
| 6 | Not used | — |
| 7 | Programming input | 443* |
| 8 | Not used | — |
| 9 | Not used | — |
| 10 | Not used | — |
| 11 | Not used | — |
| 12 | Battery power | 443 |

**Table 1, Keyless Entry Module Connections**

See **Fig. 1** for an shematic of the remote keyless entry system. For the actual vehicle schematic, use EZ Wiring to access the schematic in module 787.

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## Specifications

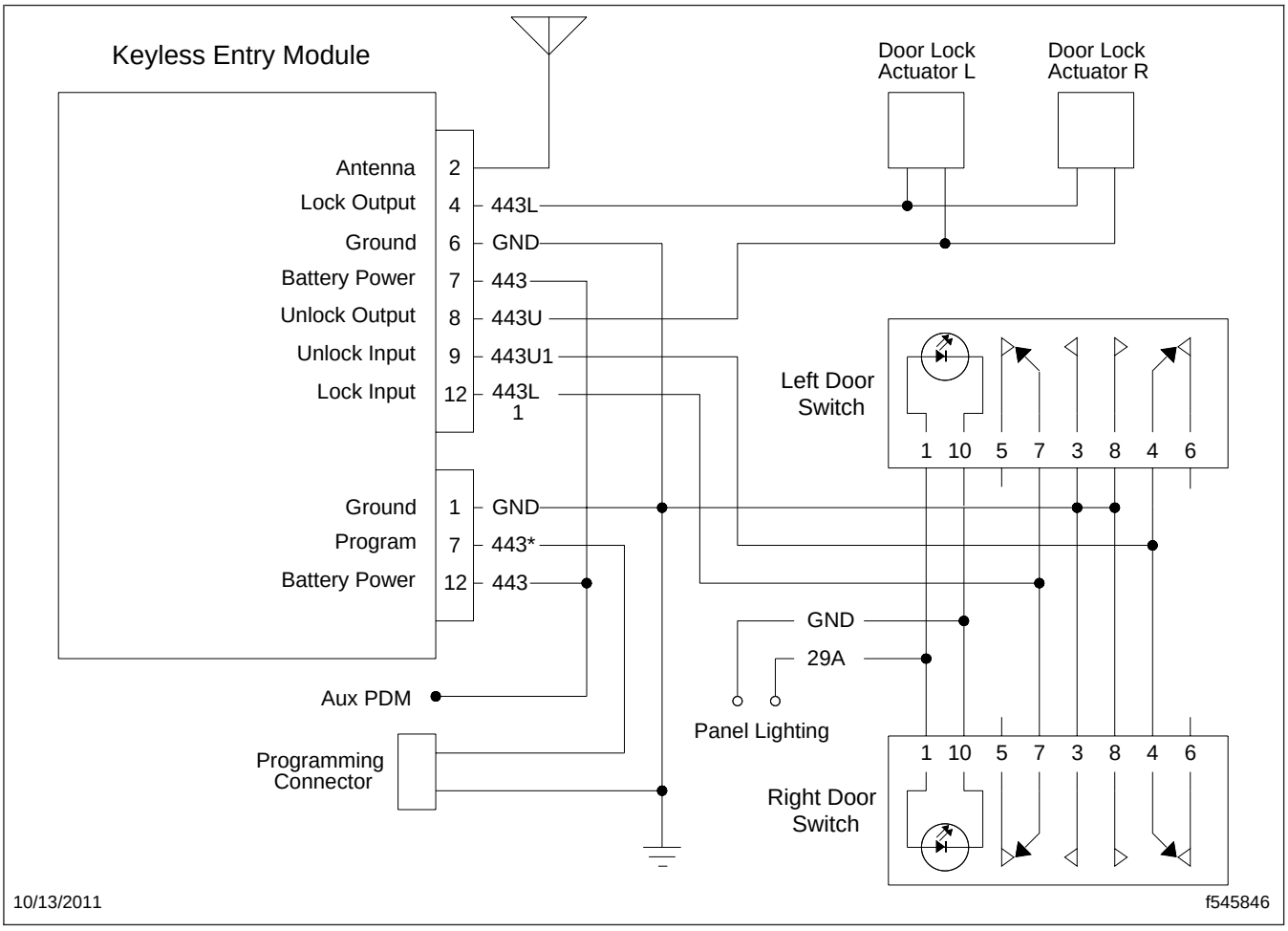



**Fig. 1, Keyless Entry Overview Schematic**

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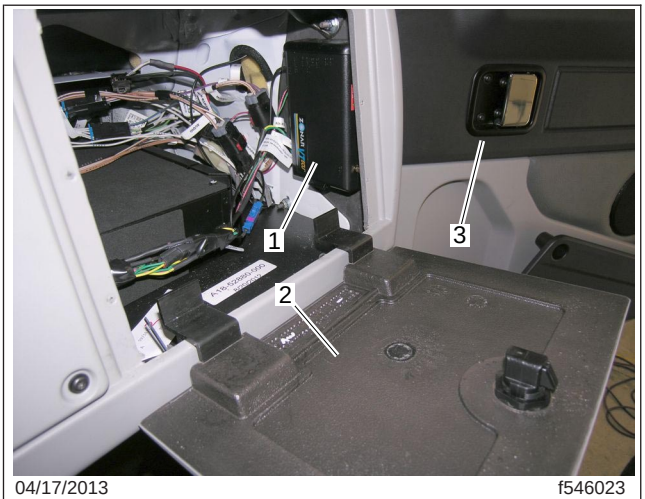
# General Information

The Virtual Technician (VT) ECU generates diagnostic information to aid the Detroit® Customer Support Center and the technician in diagnosing complex engine control issues. The system creates log files, captures fault codes, and sends alert messages and other advanced diagnostic information to the Detroit Customer Support Center. The ECU utilizes GPS position, GSM (cellular telephone) communication, and a J1939 connection for databus monitoring. Virtual Technician does not require any driver input to function.

The Virtual Technician ECU is located behind the glove box along the cab side. See **Fig. 1**.

There are three modes of operation for the Virtual Technician ECU:

- **Registration Mode**: The vehicle identification number (VIN), engine serial number, and GPS ID are gathered at the manufacturing facility in this mode. Registration mode also occurs when a new unit is installed at the dealership.
- **Normal Operation Mode**: This mode occurs after electronic registration of the unit. In this mode, the ECU gathers fault codes, snapshot data files, and GPS data. This mode monitors the databus for general information and fault codes. Transmission of this information to Detroit generally occurs within 4 minutes of collection depending on GSM network availability. Normal mode also allows for over-the-air updates of VT firmware.
- **Dormant Mode**: In dormant mode, activity and data usage is minimized or eliminated. This mode is activated only by remote modification of the firmware settings by the CSC. This may occur if the VT subscription ends.




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1. Virtual Technician ECU
2. Open Glove Box Door (glove box removed)
3. Passenger-Side Door

**Fig. 1, Virtual Technician ECU**

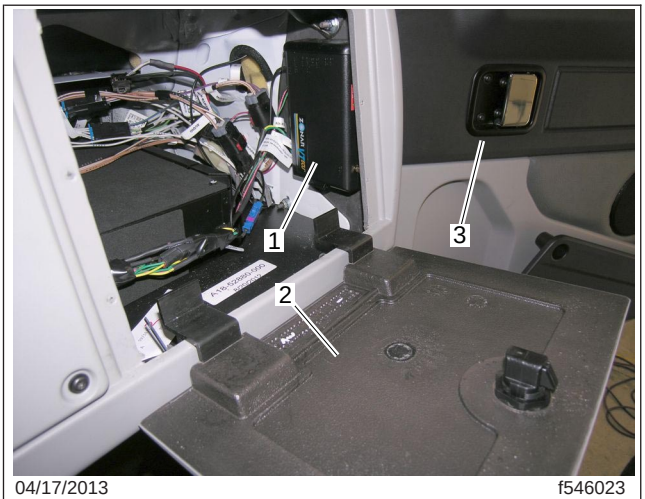
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# Virtual Technician ECU Removal and Installation

## Removal

1. Park the vehicle and shut down the engine.
2. Remove the glove box.
3. Remove the Virtual Technician ECU from the mounting bracket to view LEDs for diagnostic information. See **Fig. 1**. The LEDs are located on the left side of the ECU.
4. Refer to **Troubleshooting 300** for diagnostic information. If the Virtual Technician ECU needs to be replaced, call the *Detroit® Customer Support Center*.
5. Disconnect the 4-pin and 10-pin connectors to the ECU.
6. Disconnect the GPS antenna cable.
7. Remove the ECU from the vehicle.




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1. Virtual Technician ECU
2. Open Glove Box Door (glove box removed)
3. Passenger-Side Door

**Fig. 1, Virtual Technician ECU**

## Installation

1. Connect the 4-pin and 10-pin connectors to the new ECU.
2. Screw on the GPS antenna cable to the threaded GPS connection.
3. Position the new Virtual Technician ECU in the vehicle.
4. Install the glove box
5. Verify the operation of the ECU.
   - 5.1 Start the vehicle and drive to an open area, at least 40 feet (12 meters) away from any buildings. Park the vehicle and keep the ignition in the ON position. Apply the parking brake.
   - 5.2 Call the *Detroit® Customer Support Center*. Make sure to have the vehicle serial number and the Virtual Technician serial number available so that the new ECU can be registered.

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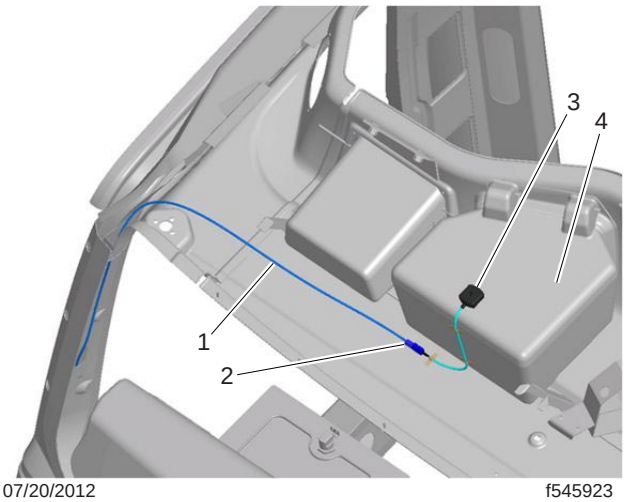


## Replacement

NOTE: Before removing the GPS antenna, call the *Detroit® Customer Support Center* for diagnosis of the problem and instructions for repair.

### Stratosphere Sleepercab

1. Remove the passenger-side sunglass holder in the overhead console.
2. Remove the pigtail connector from the antenna cable.
3. Remove the antenna from the vehicle.
4. Remove the adhesive backing from the new antenna and adhere to the top of the passenger-side overhead console. See **Fig. 1**.




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1. Antenna Cable
2. Pigtail Connector
3. Antenna
4. Passenger-Side Overhead Console

**Fig. 1, Antenna Routing Stratosphere**

5. Connect the antenna pigtail connector to the antenna cable.
6. Install the sunglass holder.

### Daycab and Starlight Sleepercab

1. Remove the headliner.
2. Remove the GPS antenna from the vehicle.
3. Remove the nut from the base of the new GPS Antenna.
4. Feed the connector and cable though the hole and secure it down with the nut. Apply a thin layer of Loctite 595 clear silicone weather sealant (or equivalent) to the foam pad on the base of the antenna. See **Fig. 2**.
5. Connect the antenna pigtail connector to the antenna cable. See **Fig. 3**.




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1. Antenna

**Fig. 2, Antenna Location, Daycab and Starlight Sleepercab**

6. Install the headliner.

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## Antenna Replacement




1. Antenna
2. Pigtail Connector
3. Antenna Cable to VT ECU

**Fig. 3, Antenna Routing, Daycab and Starlight Sleepercab**

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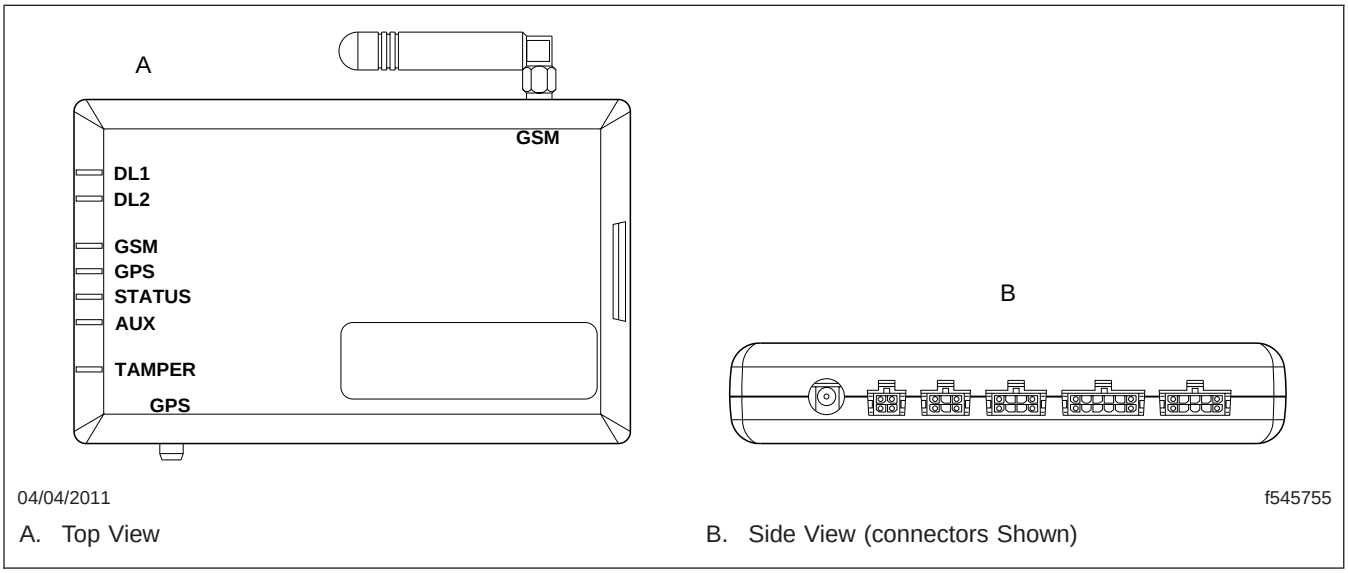


## Diagnostic Overview

All testing of the GPS and cellular reception must be done outside, and at a distance of at least 40 feet (12 meters) from any buildings. This ensures adequate GPS signal strength and good cellular reception.

Diagnosing Virtual Technician requires access to the ECU to view the LEDs on the unit. The LEDs provide diagnostic information needed by the technician and the CSC (Customer Support Center). To access the unit, refer to **Subject 100**. To diagnose the unit, turn the ignition to the ON position.

There are seven LEDs visible on the VT ECU module. If no LEDs light up with the ignition ON, diagnose supplied power and ground to the unit. See **Table 1** and **Fig. 1**.




A. Top View

B. Side View (connectors Shown)

**Fig. 1, Virtual Technician ECU**

| Diagnostic LEDs | | | |
|---|---|---|---|
| **Name** | **Color** | **Function** | **Action** |
| DL1 | Red | **Red Blink (1Hz)**: J1708 connectivity (disabled). | Red is the normal and expected state. There is no J1708 databus connection. |

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## Troubleshooting

| Diagnostic LEDs | | | |
|---|---|---|---|
| **Name** | **Color** | **Function** | **Action** |
| DL2 | Red and Green | **Red Blink (1Hz)**: J1939 connectivity. No J1939 activity detected (device is awake).<br>**Green Blink (1Hz)**: J1939 activity detected (device is awake). | Green blink is expected. If LED is blinking red diagnose J1939 connectivity issue at the terminals. The LED will blink red when the VT is awake but the ignition is OFF. The VT remains awake for 2 minutes after the ignition is turned OFF and will flash red during this time. |
| GSM | Green | **Solid**: GPS connection successful.<br>**One Blink**: Initializing.<br>**Two Blinks**: Acquiring time zone information.<br>**Three Blinks**: Attempting to make a GPS connection. | Solid is expected – if otherwise call the Customer Support Center for further instruction. |
| GPS | Green and Amber | **Solid**: Satellites acquired.<br>**One Blink**: Acquiring satellites. | Solid green when the satellite is acquired with the external antenna, and solid amber when the satellite is acquired with the internal antenna. Amber when no external antenna is connected. |
| Status | Green | **Solid**: Engine running.<br>**One Blink**: Engine not running; no data to send.<br>**Two Blinks**: Data is available to be sent.<br>**Four Blinks**: GPS storage log is full. | Refer to J1939 fault codes if a problem is suspected. |
| AUX | Red | **Solid**: GSM Modem Comm. Error, or panic line is active.<br>**Two Blinks**: Not Used.<br>**Three Blinks**: GSM modem is not starting up.<br>**Four Blinks**: SIM Card read error.<br>**Five Blinks**: GSM CTS (clear-to-send) line is active. | Refer to J1939 fault codes if a problem is suspected. |
| Tamper | Red | Disabled | N/A |

**Table 1, Diagnostic LEDs**

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## Fault Codes

NOTE: The VT ECU source address (SA) is usually 74. Due to the addition of other telematics devices, SA 74 may be taken by another ECU. In this case the VT ECU will be assigned another source address. To reset the VT back to address 74, the 4-pin power connector must be disconnected for 5 seconds then connected.

| Fault Codes | | | | |
|---|---|---|---|---|
| **Fault** | **SPN** | **FMI** | **Details** | **Action** |
| Sim Card Error | 524283 | 11 | Installed SIM Card cannot be read. | Contact CSC/ Replace ECU |
| GPS Shorted | 524286 | 4 | Center lead shorted to ground or cable ground. | Check the antenna cable; replace GPS antenna if necessary |
| GPS Not Connected | 524286 | 5 | Antenna open or cut. | Attach GPS antenna. Replace antenna if wiring damaged |
| NAND Full | 524285 | 0 | Full | Contact CSC/ Replace ECU |
| NAND ++Checksum Error | 524285 | 2 | Error | Contact CSC/ Replace ECU |
| NAND I/O Error | 524285 | 11 | Cannot read/write. | Contact CSC/ Replace ECU |
| uSD Full | 524284 | 0 | Full | Contact CSC/ Replace ECU |
| uSD Checksum Error | 524284 | 2 | Read/write error | Contact CSC/ Replace ECU |
| uSD I/O Error (micro SD) | 524284 | 11 | Cannot read/write – not present | Contact CSC/ Replace ECU |
| RTC Error (real time clock) | 524282 | 11 | VTECU RTC out of range | Contact CSC/ Replace ECU |

**Table 2, Fault Codes**

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# Virtual Technician ECU Connector Reference

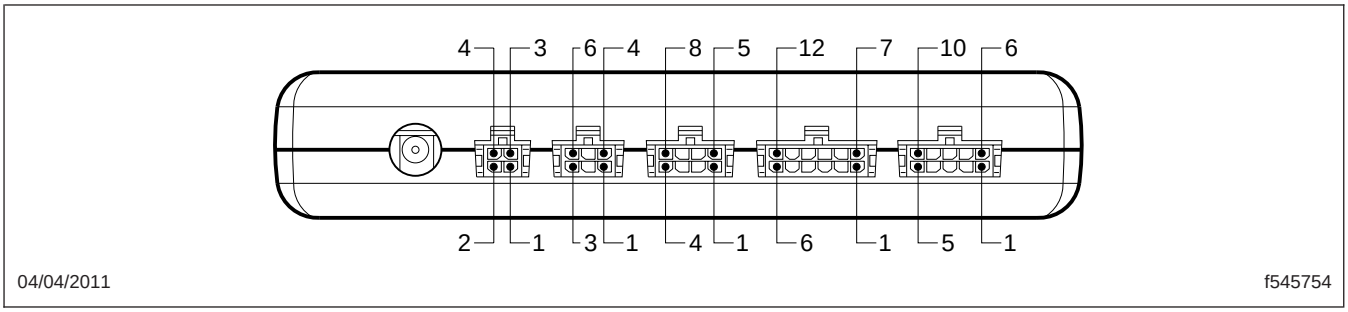



**Fig. 1, ECU Connector Reference**

| Power Connector | | | | | | |
|---|---|---|---|---|---|---|
| **Connector** | **Pin** | **Name** | **Type** | **Minimum** | **Maximum** | **Notes** |
| 4-Pin | 1 | Power | Input | 8 VDC | 30 VDC | Requires External Fuse |
| | 2 | Ignition | Input | 0 VDC | 30 VDC | Requires External Fuse<br>0 VDC = Logic 0<br>1.8 VDC = Logic 1 |
| | 3 | Ground | — | 0 VDC | 0 VDC | — |
| | 4 | — | — | — | — | — |

**Table 1, Power Connector**

| Vehicle Communication Connector | | |
|---|---|---|
| **Connector** | **Pin** | **Name** |
| 10-Pin | 1 | J1939 –H |
| | 2 | NC |
| | 3 | — |
| | 4 | NC |
| | 5 | NC |
| | 6 | J1939 –L |
| | 7 | NC |
| | 8 | NC |
| | 9 | NC |
| | 10 | NC |

**Table 2, Vehicle Communication Connector**

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# General Information

A "datalink" is an electrical network that connects two or more computers to exchange data. The simplest datalink is a pair of wires between two computers. Freightliner uses datalinks to connect the Electronic Control Units (ECUs) for the electronically controlled vehicle systems with each other and with the Instrumentation Control Unit (ICU). A personal computer using Freightliner's ServiceLink diagnostic software can also be connected to the network via a datalink.

## Datalink Systems

Different types of datalinks are used to connect certain ECUs. The vehicle may have any of the following datalinks:

### J1587/J1708

J1587/J1708 is a low speed vehicle datalink that communicates information between the ECUs on the vehicle. The J1587 datalink is also referred to as J1708. See **Fig. 1**. J1708 refers to the SAE standard for the physical part of the datalink, such as the wiring and the electronic components. J1587 refers to the SAE standard for the messaging protocol that communicates on the J1708 network. In the context of vehicle repair, the terms J1708 and J1587 are used interchangeably.

The J1587 datalink uses a twisted pair of wires to reduce interference from digital messages being sent on the wires. Wire colors for the J1587 datalink are:

- Orange **J1587 Low**
- Green **J1587 High**

### J1939

J1939 is a high-speed vehicle datalink that communicates information between ECUs on the vehicle. See **Fig. 2**.

Unlike the J1587 datalink, the J1939 datalink allows an ECU to broadcast requests as well as information. Examples of information that can be communicated on the J1939 datalink are:

- engine rotational speed;
- road speed;
- transmission tailshaft speed;
- engine retarder deactivation request;
- engine torque reduction request.

The J1939 datalink uses a twisted pair of wires to reduce interference from digital messages being sent on the wires. Wire colors for the J1939 datalink are:

- Yellow **J1939 High**
- Green **J1939 Low**

The back bone of the J1939 datalink is the section of the datalink that is between two terminating resistors. An ECU can be connected anywhere along the length of the backbone in between the terminating resistors. The wiring between the ECU and the J1939 backbone is called a circuit. The maximum distance of the terminating resistor is 3 feet from the last ECU or diagnostic connector.

The purpose of the terminating resistors is to minimize the reflection of data on the datalink which can cause J1939 messages to become partially or completely lost. Terminating resistors prevent this from occurring. Each terminating resistor is 120 Ohms, but the equivalent of two 120 Ohms resistors in parallel is 60 Ohms. With both resistors installed in the circuit, there should be 60 Ohms measured at any two points between **J1939 High** and **J1939 Low** in the circuit.

Each ECU is generally connected to the J1939 backbone using a tee connector or splice. See **Fig. 3**.

# Making the Pinout Measurements Easier to See

The pins on the diagnostic connector may be difficult to see when testing. If the pins are difficult to see, use a Y-cable as an extension to the diagnostic connector to make test measurements easier. See **Fig. 4** for a drawing of the connector at the end of the Y-cable and the corresponding 9-pin diagnostic connector pins.

NOTE: Be sure to attach a meter with a proper jumper kit to prevent unintentional shorting to other pins and possible damage to ECUs.

# The Roll Call

To check the readiness of the ECUs on the datalink, the ICU sends a signal to other ECUs and expects a response from each. This "Roll Call" procedure tells the ICU which ECUs are functioning correctly. When

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## General Information

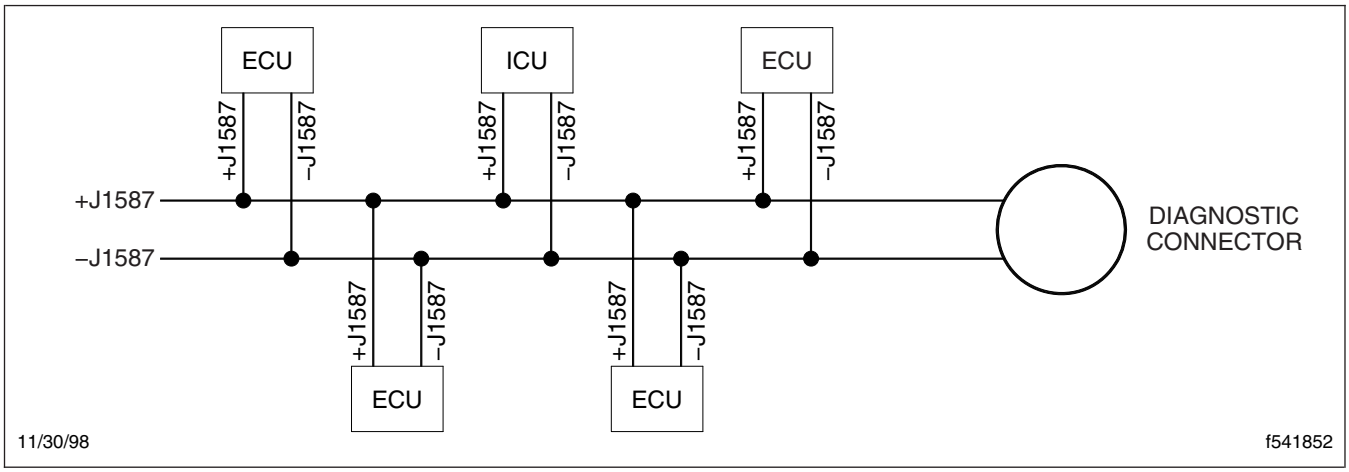



**Fig. 1, J1587 Datalink**

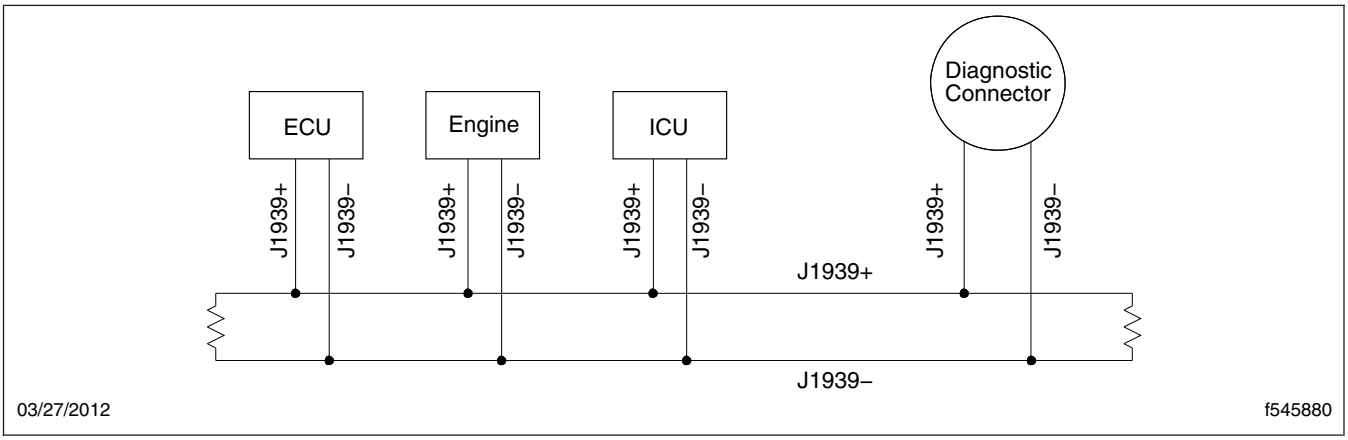



**Fig. 2, J1939 Datalink**

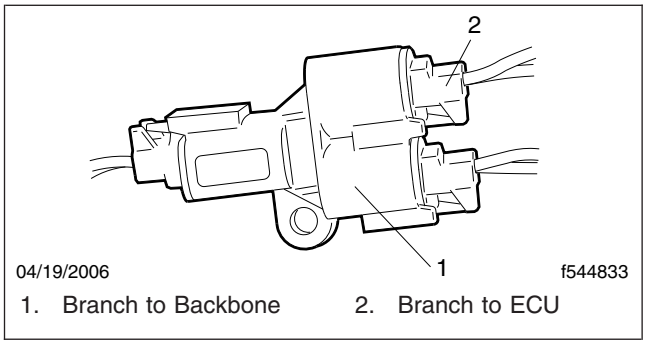



**Fig. 3, J1939 Tee Connector**

the list of functioning ECUs is compared against the parameter list of factory-installed ECUs that are supposed to respond, the technician can determine which ECUs or datalinks are bad.

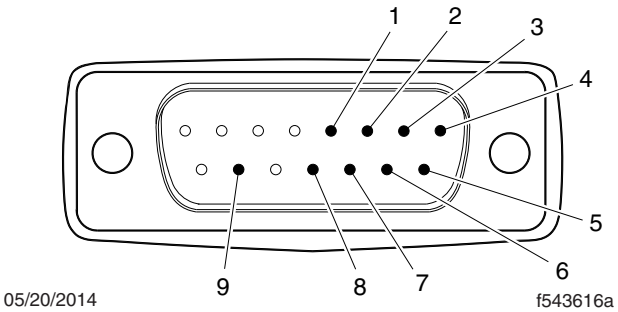
If the ICU does not receive a signal on the datalink from one or more of the active ECUs, it displays a roll call fault. The roll call fault is displayed *only* on the dash driver display screen. It is not broadcast on the datalink; therefore, it cannot be read by Service-Link. However, Servicelink can be used to determine if an ECU is not responding because it polls all ECUs on the datalink when it first connects to the vehicle datalink.

## Datalink Junction Blocks

For the J1587 datalink, the wires routed through the vehicle cab have two datalink junction blocks and two datalink connections. The ICU3 uses only one connection to the ICU.

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1. Pin H (Diagnostic CAN High)
2. Pin A
3. Pin E
4. Pin B
5. Pin F
6. Pin G
7. Pin C (J1939 High)
8. Pin D (J1939 Low)
9. Pin J (Diagnostic CAN Low)

**Fig. 4, Y-Cable Pinouts**

## Locating J1939 Wiring Diagrams

The J1939 wiring diagram can be found in module 160. Other modules may also contain datalink wiring information. See **Table 1**.

Use PartsPro® to obtain drawing numbers for installation drawings, harness assembly drawings, and wiring diagrams applicable to the vehicle being worked on.

| Component Module Locations | |
|---|---|
| **Component** | **Module Number** |
| General J1939 harness drawings, schematics, and installation drawings | 160 |
| Engine harness and installation drawings | 283 and 286 |
| Transmission harness and installation drawings | 34A and 343 |
| ABS harness and installation drawings | 330, 332, and 333 |

**Table 1, Component Module Locations**

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# Datalink Repairs

## J1587 and J1922 Repairs

Use the same methods of repair for the twisted-pair datalink wiring as are used for the other wires on the vehicle. However, the datalink wires must be twisted at a rate of a minimum one turn per inch (25 mm) of length.

## J1939 Repairs

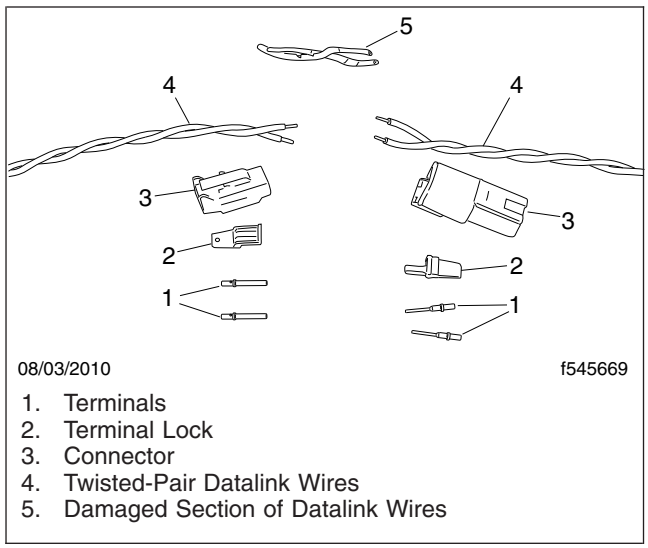
A special cable must be used for repairs to the J1939 datalink wiring. The two types of J1939 cable ("heavy" and "lite") can be spliced together as long as the pass-through connectors are the "heavy" type. The "lite" cable (because of its lower cost) is recommended for repairs on both types of J1939 cable. Refer to Appendix C of SAE J1939-11 for the special procedures for repairing the "heavy" J1939 datalink.

## Parts

Twisted-pair datalink wires may be spliced using a mating connector set. See **Table 1** for a typical set of datalink connector parts.

## Procedure

1. Cut out any damaged section of datalink wire, keeping the lengths of the two wires equal. See **Fig. 1** for an example of a damaged section of datalink wire that has been removed and the datalink prepared for repair.
2. Crimp the terminals onto the wires using the proper crimp tool.
3. Pull test the terminals by hand to ensure the crimp is mechanically solid.
4. Insert the terminated wires into the connector body and install the terminal lock. The protocol for J1939 is for the yellow wire to be in cavity 1 and the green wire to be in cavity 2. Note that the lock is installed while holding the wires in position. Test the installation. If the wires slipped back during the lock installation, they will pull out of the connector.
5. Make certain the wires are twisted as close to the entry point of the connector as possible. Plug the two connector halves together. See **Fig. 2**.




1. Terminals
2. Terminal Lock
3. Connector
4. Twisted-Pair Datalink Wires
5. Damaged Section of Datalink Wires

**Fig. 1, Datalink Splice Parts**

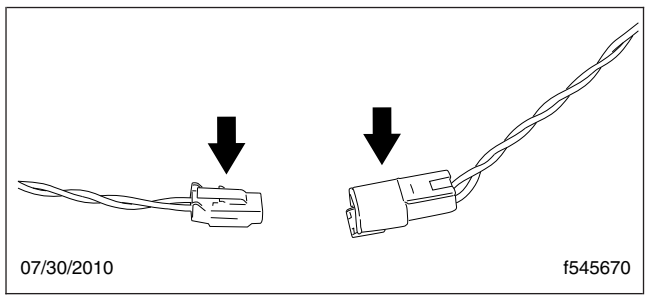



**Fig. 2, Datalink Connectors**

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## Datalink Repairs

| Datalink Connector Parts | | |
|---|---|---|
| **Description** | **Part Number** | **Quantity** |
| Connector Body Plug | 23-13148-204 | 1 |
| Terminal Lock | 23-13303-015 | 1 |
| Terminals | 23-13210-020 | 2 |
| Connector Body Receptacle | 23-13148-206 | 1 |
| Terminal Lock | 23-13303-013 | 1 |
| Terminals | 23-13210-030 | 2 |

**Table 1, Datalink Connector Parts**

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## General Information

This Troubleshooting subject has three main parts:

- Troubleshooting Tables

  Use the Troubleshooting Tables to get ideas on what could be causing the problem and the possible remedies to that problem.

- Troubleshooting Procedures

  Follow the Troubleshooting Procedures section to isolate the areas that have faults and to know which tests to perform.

- Testing Procedures

  The Testing Procedures section has the individual tests and specifications needed to determine whether a part must be repaired or replaced.

NOTE: Be sure to attach a meter with a proper jumper kit to prevent unintentional shorting to other pins and possible damage to ECUs.

## Troubleshooting Tables

Use the following troubleshooting tables to find remedies to possible causes of datalink problems.

**Problem—Power-On Roll Call Reports Fault**

| Problem—Power-On Roll Call Reports Fault | |
|---|---|
| **Possible Cause** | **Remedy** |
| The ECU does not support roll call function (ICU1/2M only). | Reset the ECU parameter to disable roll call. |
| The datalink wiring has a fault. | Repair or replace the wiring. |
| Wrong power supply voltage or ground to ECU. | Replace the fuse or circuit breaker, charge the battery, the check connections. |
| The connector has a fault - (Pass-through, Branch, Diagnostic) | Repair or replace the wiring. |
| The ECU has a fault. | Replace the ECU. |
| The ICU has a fault. | Replace the ICU. |
| The terminating resistor for J1939 datalink is missing or has a fault. | Replace the terminating resistor. |
| The branch length is too long on J1939 datalink. | Shorten "lite" branch to less than 10 feet (3 m). |
| The battery is discharged or is bad. | Charge or replace the battery. |

**Problem—ServiceLink Will Not Connect**

| Problem—ServiceLink Will Not Connect | |
|---|---|
| **Possible Cause** | **Remedy** |
| ICU is older series that does not support roll call. | Use ICU for display of active fault codes only. |
| One or more ECUs has a fault. | Remove suspected ECUs one at a time until ServiceLink can be connected. |
| ServiceLink computer is not configured or connected correctly. | Check the computer settings, communication adaptor and cabling between the computer, communication adaptor, and diagnostic connector. |
| Connector types are different. | The J1939 datalink and new J1587 datalinks have 9-pin connectors. Connect an adapter or use the ICU for the diagnostics information display. |
| Battery is discharged, has a bad connection, or has a fault. | Charge, clean terminals, or replace battery. |

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## Troubleshooting

**Problem—Missing Data on Datalink-Driven Gauges**

| Problem—Missing Data on Datalink-Driven Gauges * | |
|---|---|
| **Possible Cause** | **Remedy** |
| ICU or engine ECU is not communicating on datalink. | Test wiring and ICU or engine ECU. |
| Datalink wiring has a fault. | Test and repair wiring. |
| Connector or junction block has a fault. | Repair or replace connector. |
| Incorrect voltage to ECUs | Test datalink and vehicle wiring. |

* Datalink-driven gauges include: engine oil pressure, coolant temperature, engine oil temperature, turbo air pressure, tachometer, speedometer

# Troubleshooting Procedures

To find the part of the datalink system that is causing a problem, follow the Troubleshooting Procedures and refer to the appropriate Troubleshooting Tests for the test points and specifications. Perform the steps of the Troubleshooting Procedures in sequence until you locate the fault.

The seven steps to diagnosing a datalink problem are:

1. Determine which types of datalink are installed on the vehicle.

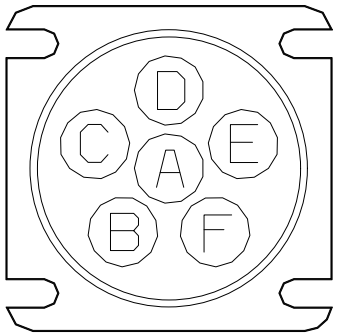
   1.1 Check the diagnostic connector. A 6-pin connector (or a 9-pin connector without pins C and D installed) is used for J1587 datalinks. See **Fig. 1** and **Fig. 2**. J1939 datalinks have pins C and D installed in the 9-pin diagnostics connector.

   1.2 Check the wires. J1939 cable has a heavy jacket. Note that some non-Freightliner ECUs have their J1587 wires inside a jacket as well. If all the wiring has a jacket, the datalink is a J1939 datalink.

   If the J1939 cable has a drain wire inside the shielding, it is a "heavy" cable. The J1939 "lite" cable (with no drain wire) can be spliced into a section of "heavy" cable.

   1.3 Determine whether a Cummins IS Series, Caterpillar CFE, or a Mercedes-Benz engine is installed with an ABS system that has traction control. These systems use a J1939 datalink.

   1.4 A J1939 datalink is used when an Eaton® Fuller® AutoShift transmission is installed. The WABCO EBS (brake-by-wire) system and certain Eaton VORAD EVT-300 systems also require J1939 datalinks. Certain other ECUs may require a J1939 datalink.




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1. Pin A (J1587 High)
2. Pin B (J1587 Low)
3. Pin C (12V+)
4. Pin D (Reserved)
5. Pin E (Ground)
6. Pin F (Reserved)

**Fig. 1, J1587 6-Pin Diagnostics Connector**

2. Determine which ECUs are not communicating with ServiceLink.

   2.1 Connect to the vehicle with ServiceLink

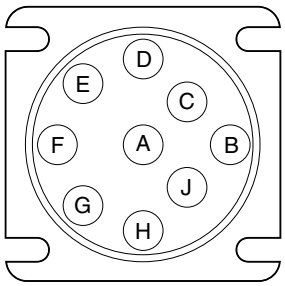
   2.2 Compare the ICU roll call list with ServiceLink ECU list.

   Note: Some ECUs cannot communicate with the ICU, but will appear on the ServiceLink parameter list. The ICU2L and ICU3 rollcall function is limited to the engine ECU and the ABS ECU.

   2.3 If an ECU is not communicating on the datalink, disconnect all the generic ECUs, one at a time, until no faults are displayed on the ICU screen or until ServiceLink

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NOTE: Pins C and D are not installed in the J1587 diagnostics connector.

1. Pin A Battery (Low)
2. Pin B Battery (High)
3. Pin C (J1939 High)
4. Pin D (J1939 Low)
5. Pin E (Shield)
6. Pin F (J1587 High)
7. Pin G (J1587 Low)
8. Pin H (Diagnostic CAN High)
9. Pin J (Diagnostic CAN LOW)

**Fig. 2, J1939/J1587 9-Pin Diagnostics Connector**

connects to the system. The last ECU to be disconnected before the successful ServiceLink connection is the one causing the problem.

3. Check the suspected ECU.
   - 3.1 Check the resistance and voltage at the ECU connectors. See **Testing the ECUs** in the datalink testing procedures section of this subject.
   - 3.2 Temporarily replace the ECU with an ECU known to be good. If the ICU (or ServiceLink) now lists that ECU, install a new ECU.
4. Check the wires and connectors from the ICU at the connector for the suspected faulty ECU. See **Testing the J1587 Datalink** or **Testing the J1939 Datalink** in the datalink testing procedures section of this subject.
   - 4.1 Check the power supply voltage.
   - 4.2 Check the data signal voltage.
   - 4.3 Check the continuity and resistance to ground. If the readings are outside the acceptable range and are found at several test points, suspect that the datalink has a fault.
5. Determine which branch includes the suspected faulty ECU. Find the connectors and junction blocks that are in series with the suspected faulty ECU.
6. Check the wiring between the branch connector and the ECU and the wiring from the ICU to the branch connector. See **Testing the J1587 Datalink** or **Testing the J1939 Datalink** in the datalink testing procedures section of this subject.
   - 6.1 Check power supply voltage.
   - 6.2 Check the data signal voltage.
   - 6.3 Check the continuity and resistance to ground.
7. Check the ICU. See **Testing the ICU** in the datalink testing procedures section of this subject.
   - 7.1 Check the voltages at the junction block to the ICU.
   - 7.2 Replace the ICU with an ICU known to be good.

# Datalink Testing Procedures

The following procedures give the test points and specifications for checking the various types of datalinks, connectors, ECUs and ICUs. Refer to the datalink troubleshooting tables, and the datalink troubleshooting procedures, above, for information on when to test the particular parts of the datalink system.

## Testing at the ECUs

1. Make sure that the vehicle battery is charged and the fuses and circuit breakers are good before testing the ECU connectors.
2. The keyswitch must be in the OFF position. Disconnect the ECU datalink circuit at the connector closest to the ECU. Turn the keyswitch to the ON position and check the voltage at the ECU harness connector. See **Table 1** for the acceptable results.
3. Connect the ECU to the datalink connector when the keyswitch is in the OFF position. Turn the keyswitch to the ON position for this test. Touch the probes of the digital multimeter (on the DC voltmeter scale) to the metal terminals of the ECU connector as shown in **Table 1** to test the ECU. Use the AC scale for the voltage tests if

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the multimeter will not display the rapidly changing DC voltage using the DC scale. If the test results are not within the range shown, replace the ECU and test again.

NOTE: Voltages in **Table 1** will be varying.

| ECU Harness Voltage Tests | | |
|---|---|---|
| **J1587 aDatalink** | | |
| **Meter (High) Probe** | **Meter (Low) Probe** | **Acceptable Meter Reading (VDC)** |
| ECU Datalink High Terminal | ECU Datalink Low Terminal | 1 to 4 VDC (1 to 3V on the AC Scale) |
| Battery Positive Post | ECU Datalink High Terminal | 6 to 11 VDC * |
| | ECU Datalink – Terminal | 9 to 13.5 VDC * |
| **J1939 Datalink** | | |
| Diagnostics Pin C (J1939 High) | Diagnostics Pin D (J1939 Low) | .2 to 5 VDC (.1 to 4V on the AC Scale) |
| Diagnostics Pin B (BAT High) | Diagnostics Pin C | 6 to 11 VDC* |
| | Diagnostics Pin D | 9 to 13.5 VDC* |

* If datalink wire connections are reversed, the results are reversed.

**Table 1, ECU Harness Voltage Tests**

## Testing the J1587 Twisted-Pair Datalink

1. Make sure that all fuses and circuit breakers are in good condition.
2. Turn the keyswitch to the OFF position before disconnecting or connecting any part of the datalink system. Disconnect the J1587 connector for the datalink section you are testing.

IMPORTANT: Do NOT disconnect the datalink by disconnecting the engine, frontwall or chassis electrical connectors.

IMPORTANT: The batteries **MUST** be disconnected and the ignition must be **OFF** prior to any J1587 resistance tests. Failure to do so may result in inconclusive resistance measurements. The J1939 datalink is not completely inactive with only the ignition off. It may be active even if there appears to be no voltage on the the datalink.

3. Turn the keyswitch to the OFF position. Test the continuity of a J1587 twisted-wire pair by touching the red (positive) probe of a digital multimeter (set to the ohmmeter mode) to the **J1587 High** terminal of the connector. Connect the black (negative) probe to the J1587– wire terminal. See **Table 2** for the results.

   Check the datalink isolation to the vehicle ground by holding one ohmmeter probe on the **J1587 Low** wire and the other probe to a good ground. Perform this test again with the ohmmeter leads reversed. **Table 2** shows the acceptable resistances for these tests.

| J1587 Resistance Tests | | |
|---|---|---|
| **Meter (High) Probe** | **Meter (Low) Probe** | **Acceptable Meter Reading (Ohms)** |
| High | Low | 1k to 30k Ohms |
| High | Vehicle Ground | More than 1k Ohms |
| Low | Vehicle Ground | More than 1k Ohms |

**Table 2, J1587 Resistance Tests**

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4. Test the signal voltage on the J1587 twisted pair as shown in **Table 1**. The keyswitch must be in the ON position for the voltage tests. Use the AC scale for the voltage tests if your multimeter will not display the rapidly changing DC voltage using the DC scale.

NOTE: If any voltage reading is a steady 0 VDC or a steady 12 VDC, the ECU or datalink wiring has a fault.

## Testing the J1939 Datalink

Use the following five basic steps in the order given to successfully locate J1939 datalink problems. Do not skip steps or tests unless directed to do so.

### J1939 Resistance Test

This test checks whether or not both terminating resistors are installed, and ensures that there is a complete circuit from the diagnostic connector through the backbone loop. It does not ensure that branch circuits to each ECU are OK.

Tests in this subject are performed using a digital multimeter set to read ohms.

IMPORTANT: The batteries **MUST** be disconnected and the ignition must be **OFF** prior to any J1939 resistance tests. Failure to do so may result in inconclusive resistance measurements. The J1939 datalink is not completely inactive with only the ignition off. It may be active even if there appears to be no voltage on the the datalink.

1. Turn the ignition OFF and disconnect the batteries.
2. Connect the meter leads of a digital multimeter set to read ohms to pins C and D of the 9-pin diagnostic connector and measure the resistance.
3. Reconnect the batteries after the test is completed.

See **Table 3** for test results and possible causes.

| J1939 Resistance Test | |
|---|---|
| **Result** | **Possible Cause** |
| 60Ω ± 6Ω | The J1939 datalink backbone is intact and both terminating resistors are installed. Go to step 2. |
| 120Ω ± 12Ω | Any of the following:<br>• One of the terminating resistors is missing.<br>• One of the terminating resistors is open.<br>• The circuit may be open anywhere between the terminating resistors. |
| 40Ω ± 4Ω | Three terminating resistors have been installed; one must be removed. There must be one terminating resistor at each end of the backbone for a total of two. |
| 0Ω to 5Ω | **J1939 High** and **J1939 Low** have shorted together somewhere in the system. |
| Greater than 1000Ω | The most likely cause is an open circuit between the diagnostic connector and the J1939 backbone. It may also be that both terminating resistors are missing or open. |
| Any other readings | Any of the following:<br>• Incorrect terminating resistor resistance.<br>• Poor or corroded connections.<br>• Short circuit to ground or an open circuit somewhere on the datalink.<br>Go to step 2 to pinpoint the problem. |

**Table 3, J1939 Resistance Test**

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## ECU Communication Test

The following series of tests check for communication with each ECU connected to the J1939 datalink. If one fails to communicate, pinpoint whether the problem is wiring or an ECU. If all ECUs communicate as they should, J1939 is probably not the problem.

1. **Check whether each ECU connected to the J1939 datalink responds.**

   1.1 Connect the computer to the diagnostic connector.

   1.2 Start the J1939 Datalink Monitor template.

   NOTE: The template contains instructions on its use.

   1.3 Check whether each ECU that is supposed to be connected to the datalink responds. See **Table 4** for test results and possible causes.

| Check whether each ECU connected to the J1939 datalink responds | |
|---|---|
| **Result** | **Possible Cause** |
| All ECUs respond | The J1939 datalink is probably not the problem. |
| One ECU fails to respond. | Go to step 2. |
| No ECUs respond | Possible explanations are:<br>• The **J1939 High** and **J1939 Low** pinouts may be reversed at the diagnostic connector, or at any other connector in the system. Check their polarity.<br>• There may be a problem with the PC to vehicle interface.<br>• The entire datalink may be down due to a short to power or short to ground.<br>Go to Step 3 to pinpoint the problem. |

**Table 4, Check Whether Each ECU Connected to the J1939 Datalink Responds**

2. **Check the J1939 datalink wiring to the ECU that does not respond.**

   IMPORTANT: The batteries **MUST** be disconnected and the ignition must be **OFF** prior to any J1939 resistance tests.

   2.1 Turn the ignition OFF and disconnect the batteries.

   2.2 Locate the connector at the ECU in Step 2, Test 1 that did not respond and disconnect it.

   2.3 Locate the pins for **J1939 High** and **J1939 Low**. Refer to Freightliner or component supplier literature or wiring diagrams for the specific component.

   2.4 Check to make sure that **J1939 High** and **J1939 Low** polarity is correct at the component before proceeding. If not, this is the most likely problem.

   2.5 Using a digital multimeter set to read ohms, measure the resistance across the two J1939 datalink pins at the connector to the suspect ECU.

   2.6 Reconnect the batteries after the test is completed. See **Table 5** for test results and possible causes.

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| Check the J1939 datalink wiring to the ECU that does not respond | |
|---|---|
| **Result** | **Possible Cause** |
| 60Ω ± 6Ω | The datalink itself is probably not the problem. Make sure that any changeable J1939 parameters for this ECU are set correctly before proceeding. Also, make sure that there is power and ground to the suspect ECU. Go to **step 3** once the following have been confirmed:<br>• J1939 parameters for the ECU (if they can be changed) are correct.<br>• There is power and ground to the suspect ECU. |
| Not 60Ω ± 6Ω | There is a problem with the J1939 wiring between the ECU connector and its connection to the J1939 backbone. Repair as necessary. |

**Table 5, Check the J1939 Datalink Wiring to the ECU That Does Not Respond**

3. **Install a test ECU to confirm the problem.**
   - 3.1 Install a test ECU and make sure that all J1939 parameters (if changeable) are set correctly.
   - 3.2 Using the J1939 Datalink Monitor template, check to see if every ECU that is supposed to be connected to the datalink responds. See **Table 6** for test results and possible causes.

| Install a test ECU to confirm the problem | |
|---|---|
| **Result** | **Possible Cause** |
| All ECUs respond | The ECU was faulty and the test ECU confirmed this. Replace the ECU. |
| The ECU still does not respond. | The problem has not been confirmed. Carefully repeat all the diagnostics. If the ECU still does not respond, contact your District Service Manager or the ECU supplier directly for assistance. |

**Table 6, Install a Test ECU to Confirm the Problem**

## Test J1939 Voltage for Circuit Faults (Shorts to Power and Ground)

These tests check for shorts to power and shorts to ground on the J1939 datalink.

NOTE: All tests are performed using a digital multimeter set to read voltage.

NOTE: Before proceeding, verify that battery voltage (approximately +12 VDC) is available at pin B of the diagnostic connector. With the ignition ON, use a digital multimeter to test for voltage at pin B by placing the red (+) lead on pin B and the black (-) lead on a good chassis ground.

1. **Test J1939 High for shorts to power and ground.**
   - 1.1 Turn the ignition ON.
   - 1.2 Touch the red (+) lead to pin B (+12 VDC) and the black (-) lead to pin C (**J1939 High**) of the diagnostic connector. See **Table 7** for test results and possible causes.

| Shorts to Power and Ground (J1939 High) | |
|---|---|
| **Result** | **Possible Cause** |
| 0 VDC | **J1939 High** is shorted to power. Continue to the next test, "Pinpointing Short Circuits on the J1939 Datalink." |

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## Troubleshooting

| Shorts to Power and Ground (J1939 High) | |
|---|---|
| **Result** | **Possible Cause** |
| 12 VDC (battery voltage) | **J1939 High** is shorted to ground. Continue to the next test, "Pinpointing Short Circuits on the J1939 Datalink." |
| Any other reading | **J1939 High** is not shorted to power or ground. Go to step 2. |

**Table 7, Shorts to Power and Ground (J1939 High)**

2. **Test J1939 Low for shorts to power and ground.**

   2.1 Turn the ignition ON.

   2.2 Touch the red (+) lead to pin B (+12 VDC) and the black (-) lead to pin D (**J1939 Low**) of the diagnostic connector. See **Table 8** for test results and possible causes.

| Shorts to Power and Ground (J1939 Low) | |
|---|---|
| **Result** | **Possible Cause** |
| 0 VDC | **J1939 Low** is shorted to power. Continue to the next test, "Pinpointing Short Circuits on the J1939 Datalink." |
| 12 VDC (battery voltage) | **J1939 Low** is shorted to ground. Continue to the next test, "Pinpointing Short Circuits on the J1939 Datalink." |
| Any other reading | **J1939 Low** is not shorted to power or ground. There may be a problem with the vehicle to computer interface. The datalink itself appears to be OK. |

**Table 8, Shorts to Power and Ground (J1939 Low)**

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## Databus Quick Test

NOTE: All voltages in **Table 1**, except for BAT + and BAT – will be varying.

| Databus Quick Test | | | | |
|---|---|---|---|---|
| **No.** | **Test** | **Red Lead/Black Lead** | **Specification** | **Result** |
| **Battery Connected – Ignition ON** | | | | |
| 1 | Bat+ to Bat- | Pin B to Pin A | Source Voltage (> 12.4) | |
| 2 | J1587+ to J1587– | Pin F to Pin G | 1 – 5 VDC (0 – 4 VAC) | |
| 3 | Bat+ to J1587+ | Pin B to Pin F | 6 – 11 VDC | |
| 4 | Bat+ to J1587– | Pin B to Pin G | 9 – 13.5 VDC | |
| 5 | J1939+ to J1939– | Pin C to Pin D | .2 – 5 VDC (.1 – 4 VAC) | |
| 6 | Bat+ to J1939+ | Pin B to Pin C | 6 – 11 VDC | |
| 7 | Bat+ to J1939– | Pin B to Pin D | 9 – 13.5 VDC | |
| **Ignition OFF – Battery Disconnected at Batteries – NOT Cab Load Disconnect Switch** | | | | |
| 8 | J1587+ to J1587– | Pin F to Pin G | 1k – 30k Ohms | |
| 9 | J1587+ to Bat– | Pin F to Pin A | > 1k Ohms | |
| 10 | J1587- to Bat– | Pin G to Pin A | > 1k Ohms | |
| 11 | J1939+ to J1939– | Pin C to Pin D | 55 – 65 Ohms | |
| 12 | J1939+ to Bat– | Pin C to Pin A | > 1k Ohms | |
| 13 | J1939- to Bat– | Pin D to Pin A | > 1k Ohms | |
| 14 | Terminating Resistors | — | 110 – 130 ohms | |

**Table 1, Databus Quick Tests**

NOTE: J1939 tests can also be performed on Diagnostic CAN High – Pin H, and Diagnostic CAN Low – Pin J for similar results.

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# General Information

The Star Light sleeper is constructed of aluminum extrusions, aluminum composite panels with a polyurethane honeycomb core, and a fiberglass roof cap. The sleeper assembly is bonded together with Sikaflex adhesive. The rain gutter forms part of the top frame work and is welded together. Aluminum extrusions form the bottom frame and are bonded into the floor panel.

The rear side panel, that forms the rear door opening, is an aluminum extrusion that is riveted to the top and bottom frame. The side panel between the door opening and the exhaust panel is an aluminum composite panel, with an aluminum extrusion bonded into each end. This panel is bonded to the top and bottom frame.

The exhaust panel is a sheet of aluminum bonded to the side panel extrusion and riveted to the top and bottom frame. The rear panel is an aluminum composite panel bonded to the top and bottom frame, and both rear side panels. The roof is bonded into the top frame rain gutter.

The Star Light sleeper is available in 34-inch, 48-inch, 62-inch, and 76-inch models.

The 34-inch model uses a single composite panel on each side, and does not have side doors or windows installed. A rear window and luggage door is available. The 34-inch sleeper has a low roof.

The 48-inch model uses two aluminum extruded panels on each side, and has luggage doors on each side, and emergency doors or windows. The 48-inch sleeper is available with either a high or low roof.

The 62-inch and 76-inch models use composite and aluminum extruded side panels, and have luggage doors on both sides and emergency doors or windows. Both models are available with either a high or low roof.

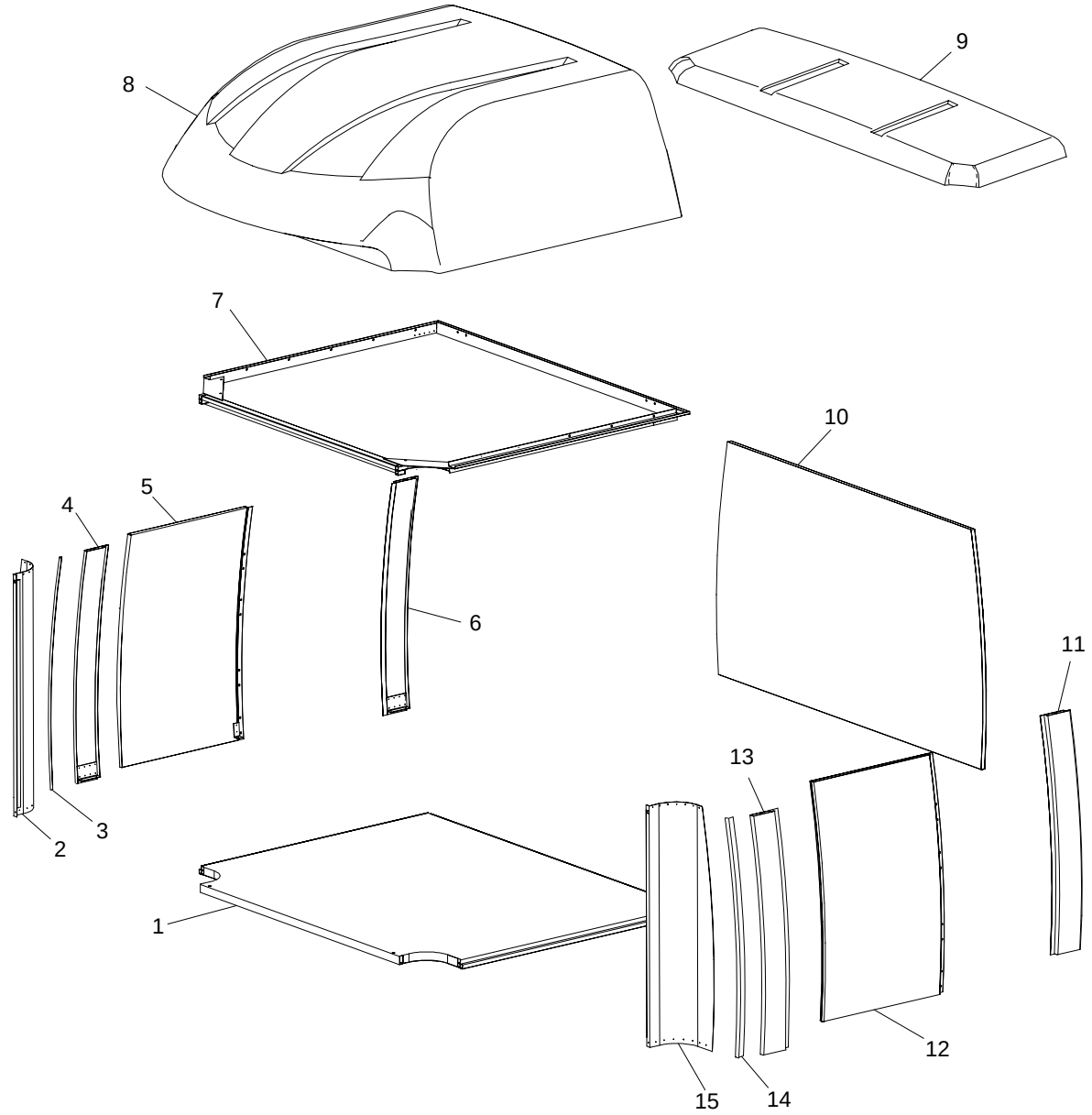
An air powered windshield removal tool with an offset blade is the preferred tool for panel removal, although a utility knife will also work. A utility knife is used to cut strands of adhesive that may still be adhering to the panel. Be sure to understand the contours of any panel joint before attempting to remove a panel, as damage to the frame work may result due to incorrect removal.

See **Fig. 1** for an exploded view of the sleeper panels.

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## General Information




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1. Floor
2. Exhaust Panel, RH
3. Angle, 48-Inch Sleeper, RH
4. Front Side Panel, 48-Inch Sleeper, RH
5. Side Panel, 34, 62, 76-Inch Sleepers, RH
6. Rear Side Panel, 48, 62, 76-Inch Sleepers, RH
7. Drip Rail Assembly
8. High Roof
9. Low Roof
10. Rear Panel
11. Rear Side Panel, 48, 62, 76-Inch Sleepers, LH
12. Side Panel, 34, 62, 76-Inch Sleepers, LH
13. Front Side Panel, 48-Inch Sleeper, LH
14. Angle, 48-Inch Sleeper, LH
15. Exhaust Panel, LH

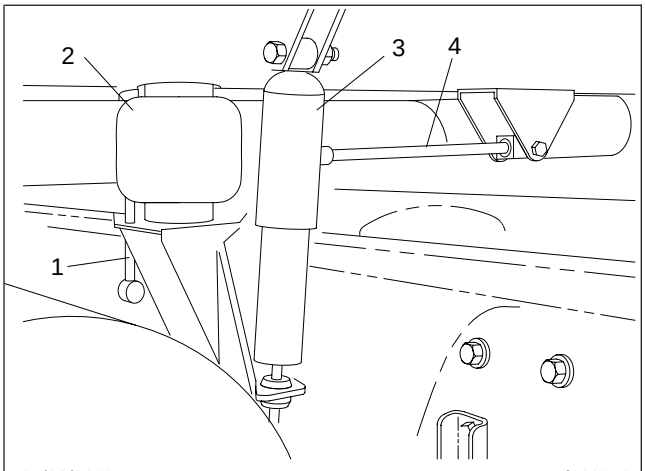
**Fig. 1, Sleeper Exploded View**

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## Removal

1. Remove the cab and sleeper skirts.
2. Evacuate the air conditioning system, recovering all the refrigerant. Disconnect the sleeper air conditioning lines under the sleeper.
3. Turn off the coolant to the sleeper or drain the cooling system if there are no heating system valves. Disconnect the sleeper heater hoses from the cab.
4. Disconnect the sleeper electrical harness from the cab.
5. Place supports under the rear of the cab and sleeper.
6. Disconnect the height adjustment linkage and the lateral restraint rod. See **Fig. 1**.

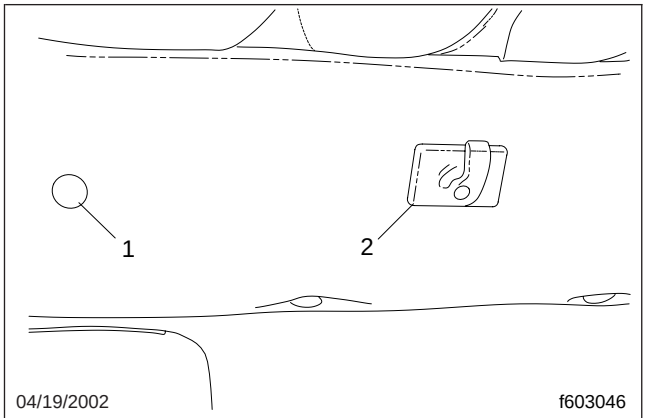



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1. Height Adjustment Rod
2. Air Bag
3. Shock Absorber
4. Lateral Restraint Rod

**Fig. 1, Sleeper Air Ride Components**

7. Disconnect the shock absorbers from the sleeper.
8. Dismount the air bags from the sleeper.
9. Place a support under the front of the sleeper.
10. Remove the upholstery buttons from under the top-side of the sleeper/cab opening and remove the nine screws attaching the panel.
11. Remove the two buttons and screws from the front side of the headliner above the sleeper opening. Remove the coat hook. See **Fig. 2**.

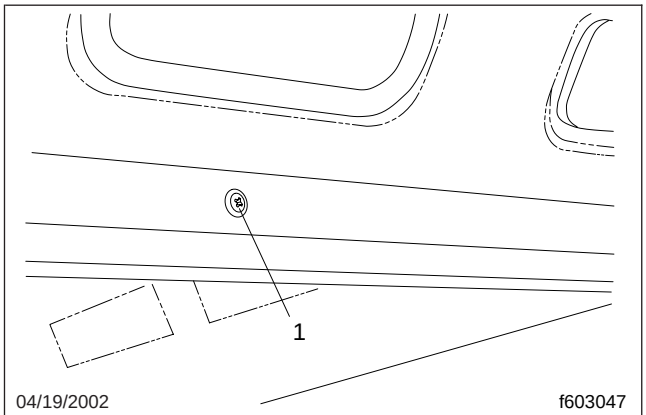



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1. Button
2. Coat Hook

**Fig. 2, Coat Hook and Button**

12. Lift the upholstery above the sleeper/cab opening and remove the three screws if applicable. See **Fig. 3**.




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1. Screw

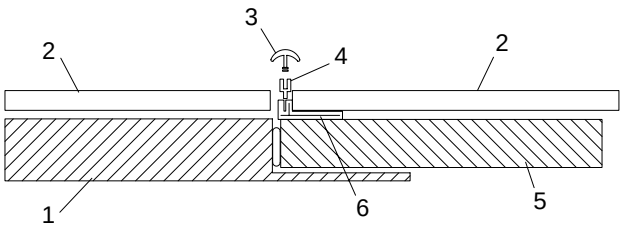
**Fig. 3, Cab/Sleeper Opening**

13. Remove any cabinets mounted to the edge of the sleeper opening.
14. Remove the interior trim covering the joint between the sleeper and the cab. Pull the upholstery back from the joint.
15. Pry up the sleeper/cab carpet joint cover strip. See **Fig. 4**.

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## Sleeper Removal and Installation

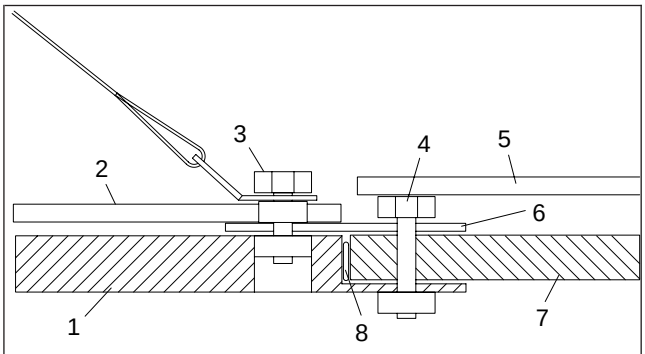



04/23/2002 f603051

1. Cab Floor
2. Carpet/Underlay
3. Carpet Joint Cover
4. Carpet Joint Extender
5. Sleeper Floor
6. Carpet Joint Mount

**Fig. 4, Cross Section Through Cab and Sleeper Floors**

16. Remove the four seat belt bolts that fasten them to the floor. Swing the tie plate under the cab carpet. See **Fig. 5**.




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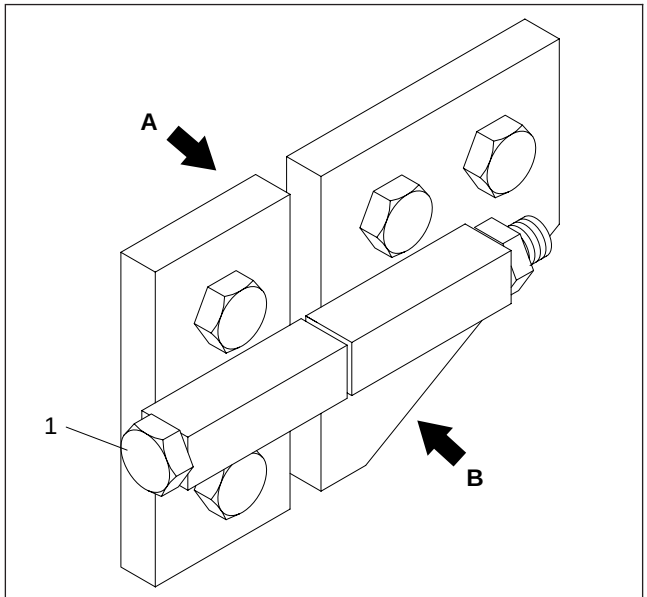
1. Cab Floor
2. Carpet Underlay
3. Seat Belt Bolt
4. Sleeper Bolt
5. Carpet Underlay
6. Mounting Tie Plate
7. Sleeper Floor
8. Adhesive

**Fig. 5, Cross Section View Through Seat Belt Mounting**

17. Remove the clamp bolt from the upper corner mounts. See **Fig. 6**.

18. Insert the blade of the windshield removal tool into the joint between the sleeper and the cab. A utility knife will also work in the same manner. Proceed to cut all the adhesive completely around the sleeper joint. See **Fig. 7**.

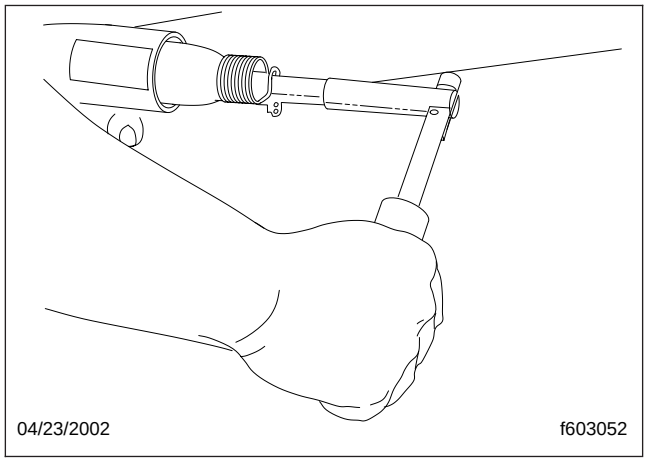
19. Pry lightly, trying not to bend the panels, in the joint to separate the sleeper from the cab.




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A. Cab Side
B. Sleeper Side
1. Clamp Bolt

**Fig. 6, Upper Cab to Sleeper Mount**



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**Fig. 7, Cutting the Adhesive**

20. Lift the sleeper slightly, and pull the sleeper back from the cab.

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## Installation

1. Cut off all tattered and loose adhesive without scraping off the undercoat from the contact surface area.

NOTE: Cured adhesive can only be removed by cutting or scraping it off. It is okay to leave old secure adhesive.

2. Remove the old spacers.
3. If the primer surface is still sound, clean the area of all loose particles and wipe clean with Sika-Cleaner 205 on a lint free towel or cloth. Allow to dry for a minimum of ten minutes, but not more than two hours.

IMPORTANT: If Sika-Cleaner 205 is not transparent, but cloudy or brown, do not use. The cleaner has been contaminated.

4. If the under coat has been removed or is not sound, prepare the contact surface.

NOTE: It is only necessary to clean a spot about 2-inches (50 mm) larger than the area that is missing undercoat.

5. To prepare the contact surface:
   - 5.1 Clean all the surfaces with a 50/50 mix of alcohol and water.
   - 5.2 Use a clean maroon scotch-bright pad to scuff all contact surfaces.
   - 5.3 Thoroughly clean the contact areas of all loose particles, wipe with a lint free towel.
   - 5.4 Wipe all contact surfaces with Sika-Cleaner 205 on a lint free towel. Wipe in one direction, and turn or change the towel as required to avoid wiping a clean surface with a dirty towel. Use another towel to wipe off the cleaner.
   - 5.5 Allow to dry for a minimum of ten minutes, but not more than two hours.
6. To prime the contact area:
   - 6.1 Mask the adjoining panels to prevent the primer or adhesive from getting on the painted surfaces.
   - 6.2 Vigorously shake the can of Sika-Primer 206 G and P until the ball rotates freely in the bottom of the can.
   - 6.3 Use a clean paint brush and coat the contact area with a thin, even, coat of Sika-Primer 206 G and P. See **Fig. 8**.

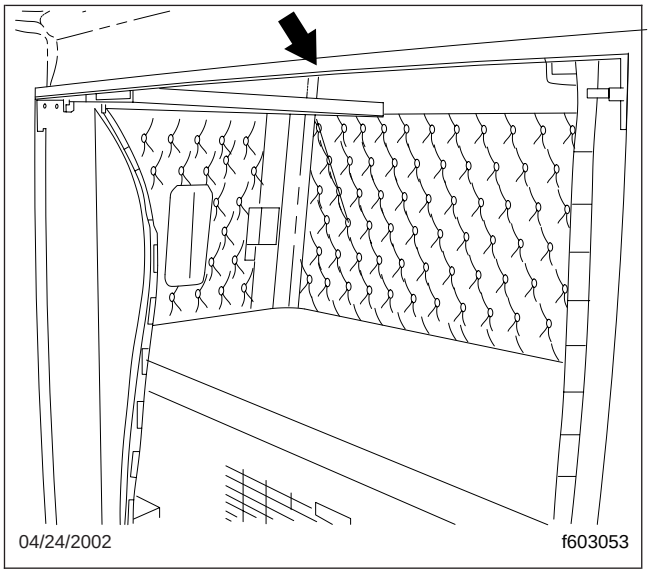



**Fig. 8, Apply Primer Around Sleeper Opening**

NOTE: Always use a clean brush for each application. A new application is defined by a lapse of ten minutes or more.

NOTE: Do not apply Sika-Primer 206 G and P over cured adhesive.

   - 6.4 Allow the primer to dry for thirty minutes. If the primer has sat for more than sixteen hours, wipe it with Sika-Cleaner 205 and allow it to dry for ten minutes before applying adhesive.
7. Replace the 1/8" spacers on the sleeper contact surfaces approximately 24-inches (610 mm) apart. See **Fig. 9**.

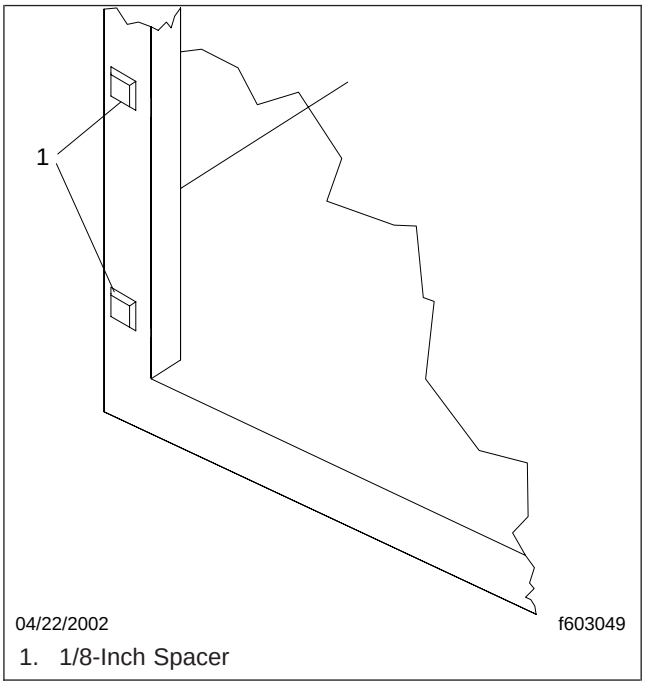
NOTE: Unlike common adhesives where the joint is made as tight as possible, Sikaflex 252 adhesive works best with a minimum 1/8-inch space between surfaces.

8. Place the bolt spacers on the cab floor to sleeper mount lip, aligning them with the mounting holes.

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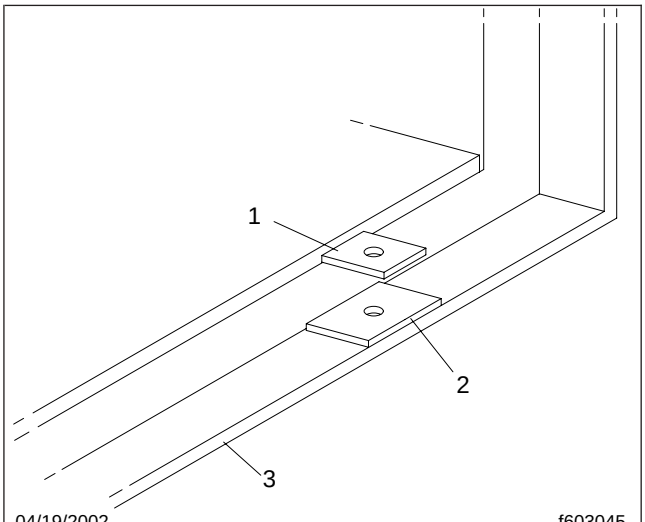
## Sleeper Removal and Installation




1. 1/8-Inch Spacer

**Fig. 9, Spacers**

A small dab of contact glue will help hold the spacers in place during alignment. See **Fig. 10**.




1. Floor Tie Plate
2. Spacer
3. Cab Mounting Lip

**Fig. 10, Cab to Sleeper Mounting**

9. To apply adhesive:

9.1 Cut the tip of a Sikaflex 252 nozzle with a V in one side approximately 5/8-inch (16 mm) deep following the largest size opening guides on the nozzle. See **Fig. 11**.

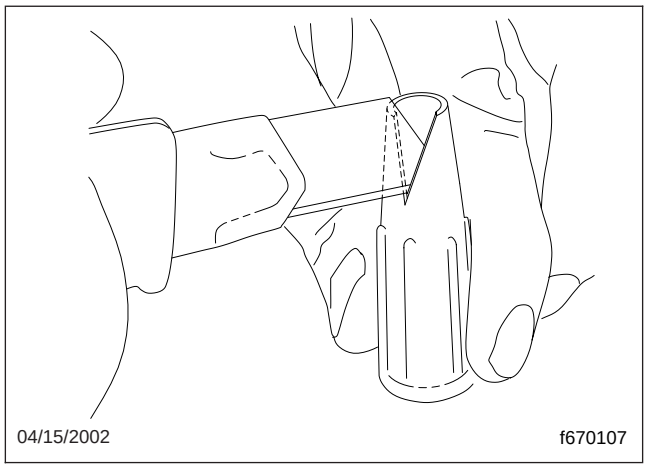
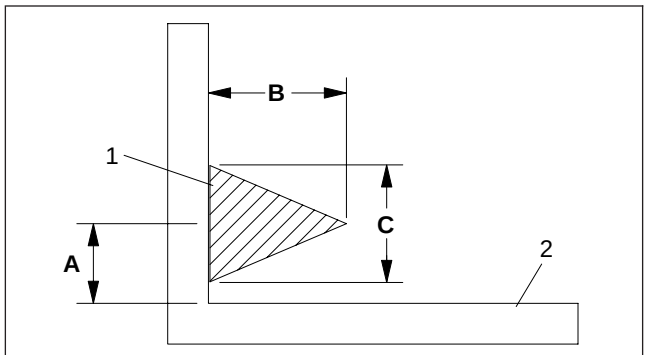



**Fig. 11, Cut the Adhesive Nozzle**

9.2 Run a continuous bead of Sikaflex 252, 3/8-inch wide by 5/8-in high, around the sleeper opening, and over the spacers, on the contact surfaces. Make sure there are no gaps or thin spots in the bead. See **Fig. 12**.




A. 3/4-Inch (19 mm)
B. 5/8-Inch (16 mm)
C. 3/8-Inch (10 mm)
1. Adhesive
2. Frame

**Fig. 12, Cross Section of Adhesive Bead**

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NOTE: Do not use silicone sealant near curing Sikaflex 252 adhesive. The vapors from the silicone cases the adhesive to break down.

If the Sikaflex adhesive appears to be stringy do NOT use it.

If a bead of adhesive over 12-inches (300 mm) will hang from the tip of the application nozzle do NOT use. Good adhesive should fall off the nozzle around 6 to 8-inches (150 to 200 mm) in length.

In dry climates a humidifier can speed up curing time. Do not hose down the seams in an attempt to speed up the curing time.

10. Lift the sleeper slightly, and slide it into the cab opening.

IMPORTANT: Once the sleeper has made contact with the adhesive do not try to move it and reposition it.

11. Use a long round centering punch to align the floor mounting holes. Drop a bolt in each mounting hole to align the sleeper.
12. Install the upper clamp bolt through the mounting brackets. See **Fig. 6**.
13. Swing the tie plate from under the cab carpet. Remove the sleeper floor mounting bolt. Insert the bolt through the tie plate and the sleeper floor. Repeat for all the sleeper floor bolts. See **Fig. 5**.
14. Torque all the sleeper-to-cab bolts, and seat-belt bolts to 40 lbf·ft (54 N·m).
15. Replace the interior trim covering the cab/sleeper joint.
16. Insert the carpet joint cover strip. See **Fig. 4**.
17. Install any cabinets or shelves that were removed.
18. Install the coat hook.
19. Replace the upholstery panels and buttons.
20. Reconnect the air bags, shock absorbers, lateral restraint rod, and height adjustment rod.
21. Connect the sleeper air conditioning lines to the cab. Recharge the air conditioning system.
22. Connect the sleeper heater hoses to the cab. Turn on the coolant to the sleeper and refill the cooling system.
23. Connect the sleeper electrical harness to the cab.
24. Remove the supports under the sleeper.
25. Install the cab and sleeper skirts.

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**⚠ WARNING**

**Do not attempt to weld panels, skin or joints. Heat will melt the polyurethane core and cause toxic fumes, which could cause personal injury.**

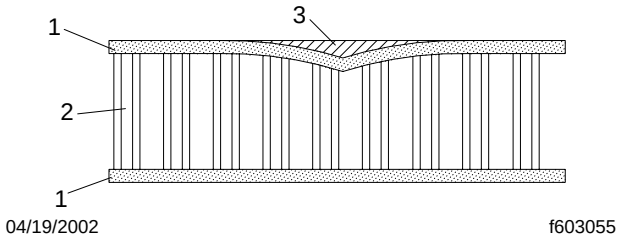
## Repairable Dents

A repairable dent is one that doesn't distort the inner skin, covers less than six to eight inches (150 to 200 mm), and penetrates less than a third the thickness of the panel. Treat sharp creases like tears in the skin.

**⚠ CAUTION**

**Do not attempt to pull dents out. The core may detach from the skin and weaken the structure.**

If a panel is dented, the dent should be filled. Prepare the surface as a normal body repair and fill the damaged area with a good quality automotive filler. See **Fig. 1**. Sand and paint as a normal body repair.

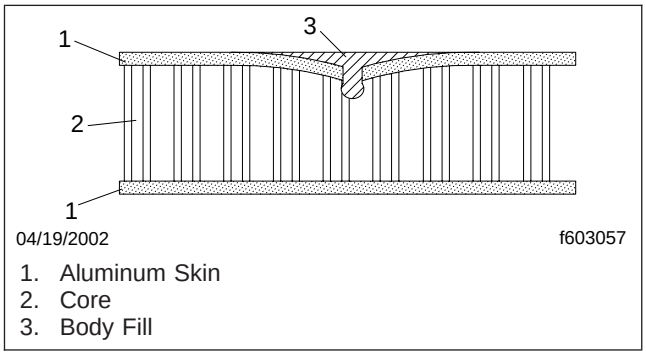



1. Aluminum Skin
2. Core
3. Body Fill

**Fig. 1, Repairable Dent**

## Repairable Punctures

A repairable puncture is a hole one-inch (25 mm) in diameter or less, and at least eight-inches (200 mm) from the edge of the panel. If a panel skin is punctured it should be repaired immediately before dirt or moisture contaminates the honey-comb core. If the hole penetrates into the interior a small patch of aluminum sheet should be riveted over the hole on the inside of the sleeper. Seal around the edges of the patch. Prepare the exterior surface as a normal body repair and fill the damaged area with a good quality automotive filler. See **Fig. 2**. Sand and paint as a normal body repair.




1. Aluminum Skin
2. Core
3. Body Fill

**Fig. 2, Repairable Puncture**

## Repairable Tears

A repairable tear is one that is six to eight inches (150 to 200 mm) in length, penetrates less an one third the thickness of the panel, and at least eight-inches (200 mm) from the edge of the panel.

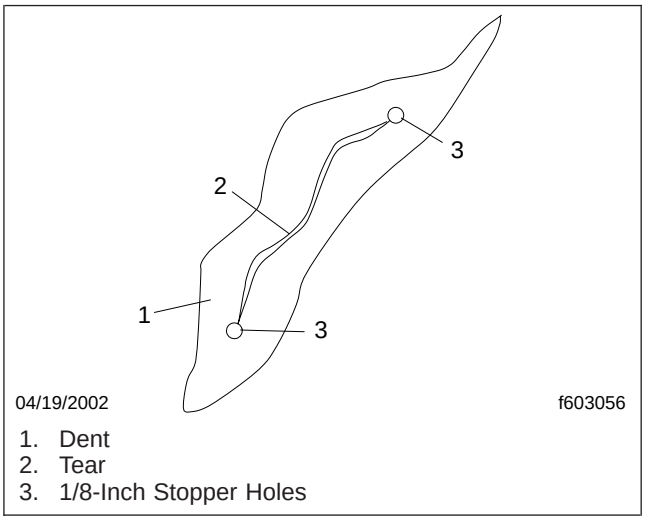
Tears in the skin should have a 1/8-inch (3 mm) stopper hole drilled at each end of the tear. See **Fig. 3**. Prepare the exterior surface as a normal body repair and fill the damaged area with a good quality automotive filler. Sand and paint as a normal body repair.

NOTE: Always use a collar on the drill bit set to stop the drill from penetrating any more than 1/2-inch (12 mm) to prevent damage to the skin on the other side.

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## Sleeper Panel Structural Repairs




1. Dent
2. Tear
3. 1/8-Inch Stopper Holes

**Fig. 3, Repairable Tear**

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# Exhaust Panel Removal and Installation

## Removal

The sleeper must be removed from the cab before the exhaust panel can be removed. See **Subject 100** for instructions on how to remove the sleeper.

1. Remove all cabinets and shelves that attach to the exhaust panel and any adjoining panel.
2. Remove the upholstery from the exhaust panel and adjoining panel. The upholstery is held on with hook and loop tape (velcro). See **Fig. 1**.

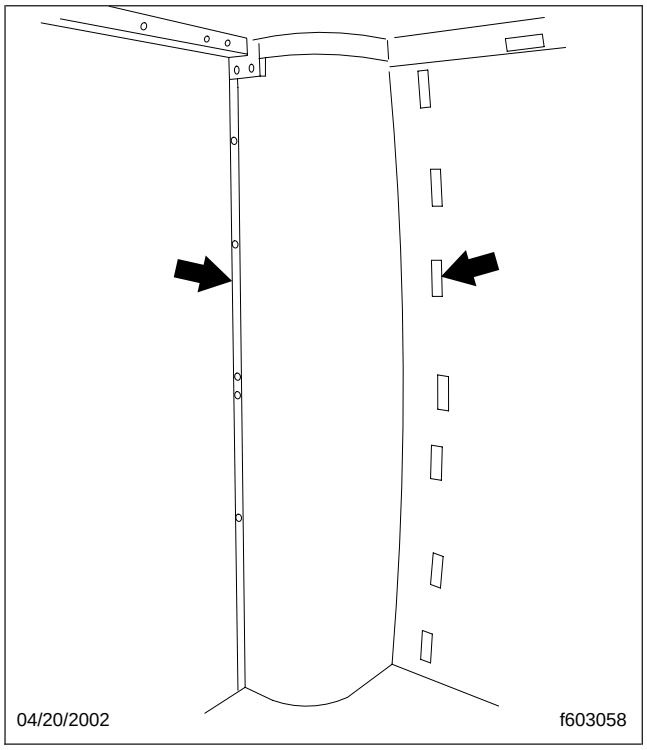



**Fig. 1, Exhaust Panel and Upholstery Fasteners**

3. Remove the insulation from the exhaust panel.
4. Drill out the rivets at the top and bottom of the exhaust panel. See **Fig. 2**.
5. Cut the adhesive at the top of the panel.
6. Cut the adhesive joining the exhaust panel to the side panel (from the inside). See **Fig. 3**.
7. Remove the panel.

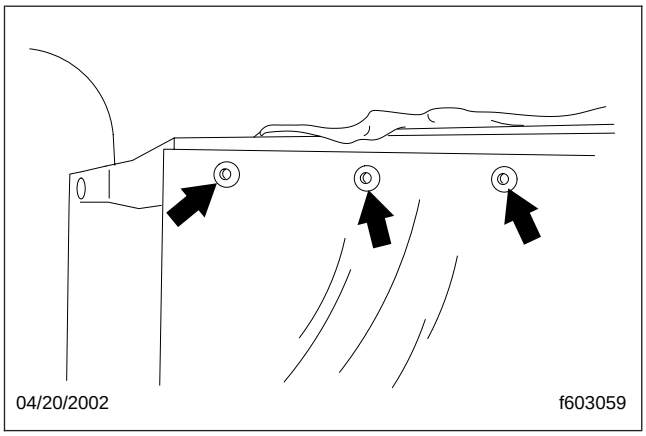
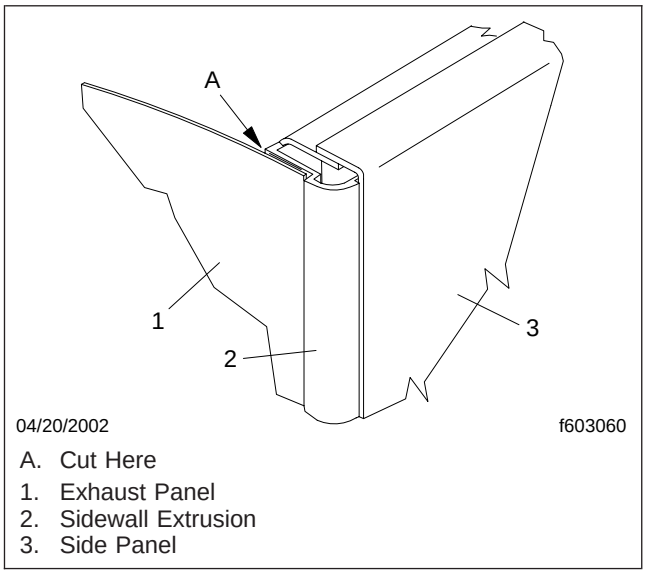



**Fig. 2, Exhaust Panel Upper Rivets**




A. Cut Here
1. Exhaust Panel
2. Sidewall Extrusion
3. Side Panel

**Fig. 3, Exhaust Panel and Side Panel Joint**

## Installation

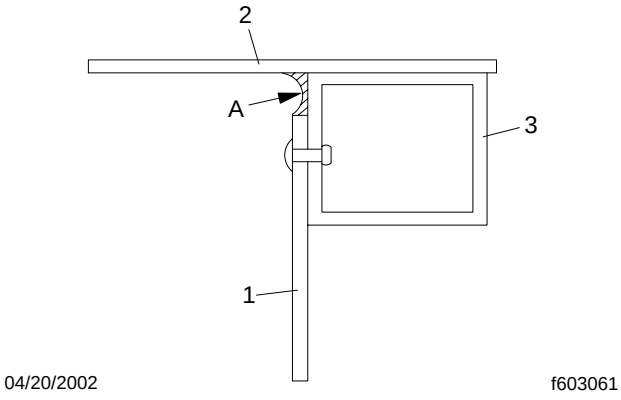
1. Follow the adhesive procedure explained in **Subject 100**.
2. Apply spacers to the side panel where the exhaust panel will will attach to it. Run a bead of adhesive along the top frame, the floor extrusion, the side panel and sleeper opening.
3. Press the exhaust panel to the sleeper, beginning from the sleeper opening and working the exhaust panel progressively to the side panel.

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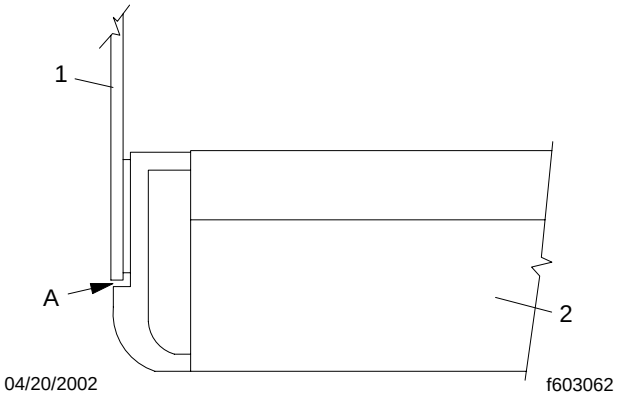
## Exhaust Panel Removal and Installation

4. Install pop-rivets in the top and bottom of the panel.
5. Apply a small bead of Sikaflex 252 along the edges of the panel and smooth with a gloved finger to smooth the joint and seal against leakage. See **Fig. 4** and **Fig. 5**.




A. Finger Fillet
1. Exhaust Panel
2. Top Frame Gusset
3. Top Frame Tube

**Fig. 4, Vertical Section Through Exhaust Panel and Top Frame**




A. Finger Fillet
1. Exhaust Panel
2. Side Panel

**Fig. 5, Top View of Exhaust Panel and Side Panel**

6. Dampen a cloth with DuPont 38125 Enamel Reducer and wipe down the finger fillet.
7. Allow the adhesive 48 hours to cure before painting.
8. Reinstall the sleeper following the instructions in **Subject 100**.

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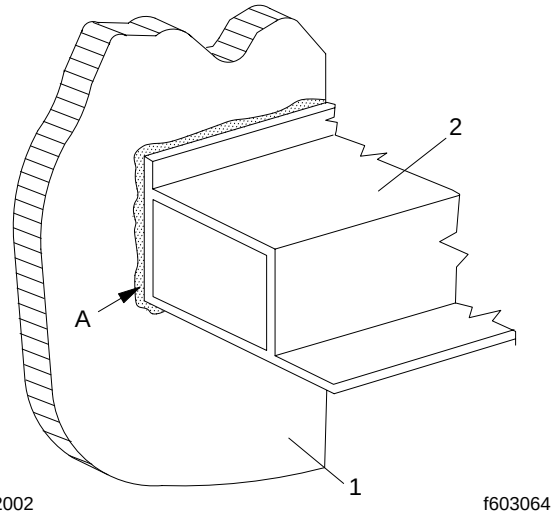


# Removal

## 34-Inch Sleeper

The sleeper does not need to be removed from the cab before the side panel can be removed.

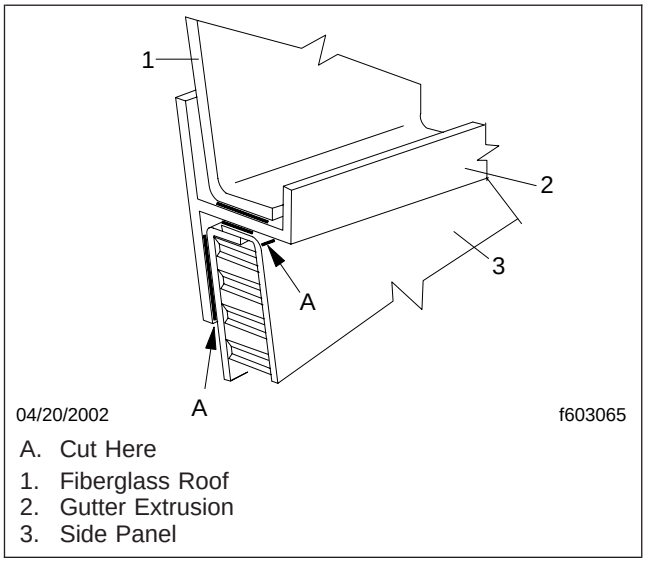
1. Remove the shelves attached to the side panel and exhaust panel.
2. Remove the upholstery from the side panel and adjoining panels. It is attached with hook and loop (velcro) tape. Disconnect any lamps attached to the upholstery panels as it is removed.
3. Lift the bunk and support it in the upright position.
4. Drill out the rivet mounting the heater duct/bunk support to the side panel. Cut the adhesive between the heater duct/bunk support and the side panels. See **Fig. 1**.




A. Adhesive
1. Side Panel
2. Heater Duct/Bunk Support

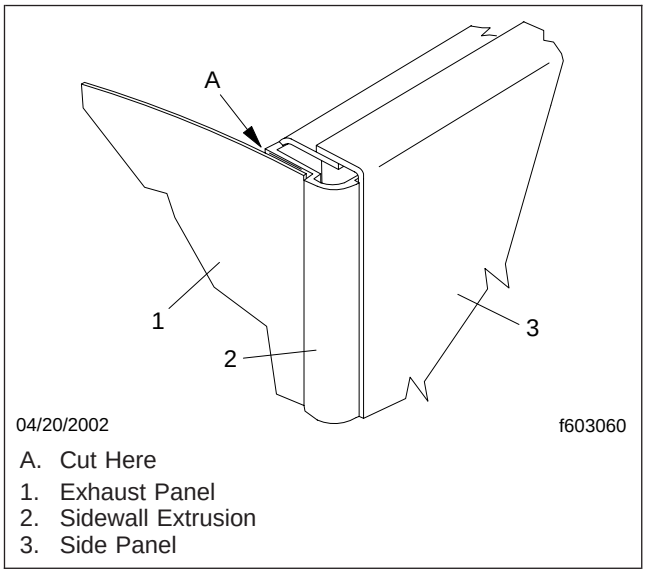
**Fig. 1, Heater Duct/Bunk Support**

5. Cut the adhesive at the top of the panel from both inside and outside. See **Fig. 2**.
6. Cut the adhesive joining the exhaust panel to the side panel (from the inside). See **Fig. 3**.
7. Cut the adhesive between the side panel and the floor. See **Fig. 4**.




A. Cut Here
1. Fiberglass Roof
2. Gutter Extrusion
3. Side Panel

**Fig. 2, Top of Side Panel**




A. Cut Here
1. Exhaust Panel
2. Sidewall Extrusion
3. Side Panel

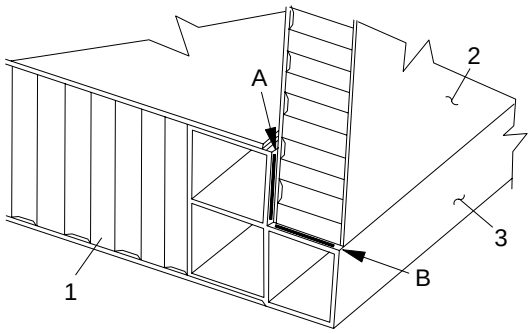
**Fig. 3, Sidewall to Exhaust Panel Joint**

8. Cut the adhesive between the side panel and the back panel. Note that there is backing material in the joint. Make sure that the adhesive is cut close to the back panel. See **Fig. 5**.
9. Remove the side panel from the sleeper

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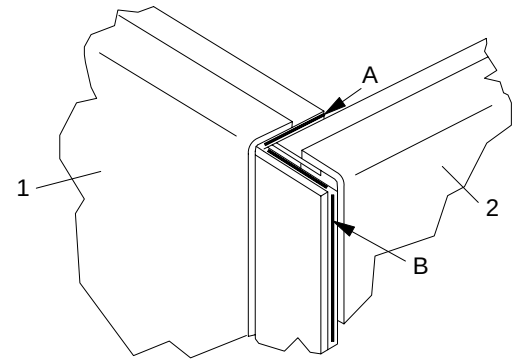
## Side Panel Removal and Installation




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A. Cut Here
B. Cut Here
1. Floor Panel
2. Side Panel
3. Floor Extrusion

**Fig. 4, Side Panel to Floor Panel Joint**



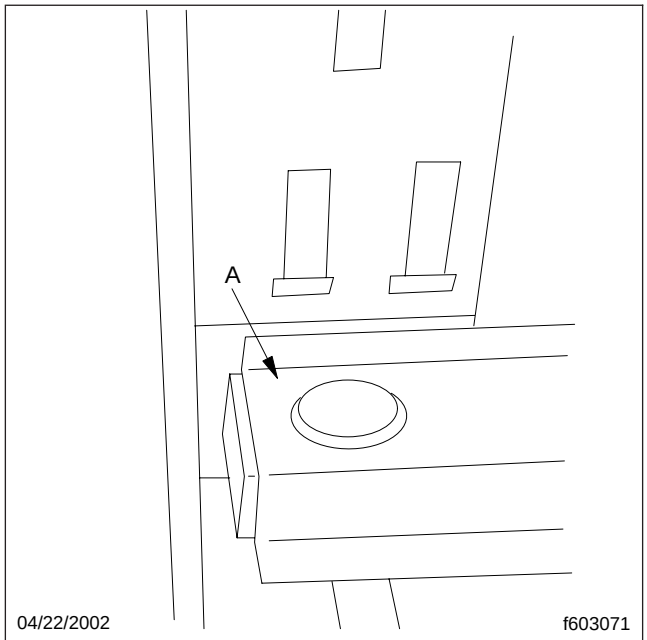

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A. Cut Here
B. Cut Here
1. 34-Inch Sleeper Side Panel
2. Rear Panel

**Fig. 5, Side Panel to Rear Panel Joint**

# Front Side Panel, 48-Inch Sleeper

1. Remove any shelves attached to the side panel and adjoining panels.
2. Remove the upholstery from the side panel and adjoining panels. It is attached with hook and loop (velcro) tape. Disconnect any lamps attached to the upholstery panels as it is removed.
3. Remove the window or door. See **Group 72** for instructions.
4. Lift the bunk and support it in the upright position.
5. Drill out the rivet mounting the heater duct/bunk support to the side panel. Cut the adhesive between the heater duct/bunk support and the side panel. See **Fig. 6**.




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A. Heater Duct/Bunk Support

**Fig. 6, Heater Duct/Bunk Support**

6. Remove the bolts mounting the side panel to the floor. Drill out the rivets that secure the bracket to the side panel. See **Fig. 7**.
7. Drill out the revets that attach the side panel to the rain gutter. See **Fig. 8**.
8. Cut the adhesive at the top of the panel. See **Fig. 2**.
9. Cut the adhesive joining the exhaust panel to the side panel (from the inside). See **Fig. 9**.
10. Cut the adhesive between the side panel and the floor. See **Fig. 4**.
11. Remove the side panel.

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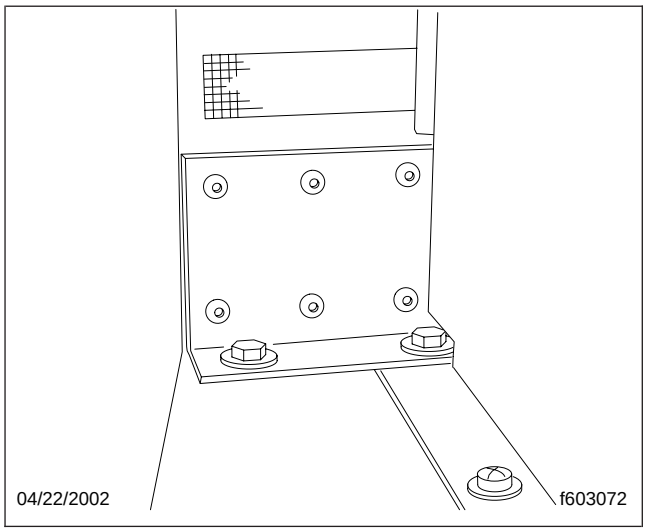



**Fig. 7, Side Panel to Floor Bracket**

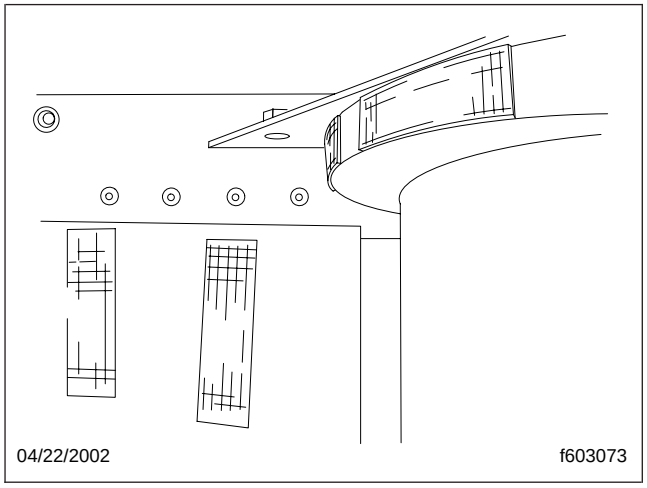
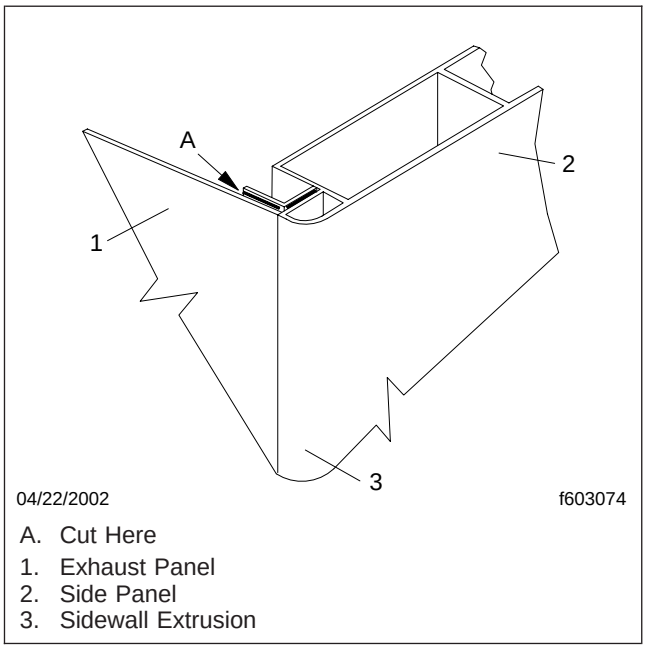



**Fig. 8, Side Panel to Rain Gutter Rivets**

## Rear Side Panel, 48-Inch Sleeper

1. Remove any shelves attached to the rear side panel and rear panel.
2. Remove the upholstery from the side panel being replaced and any adjoining panels.
3. Remove the window or door. See **Group 72** for instructions.
4. Lift the bunk and support it in the upright position.




A. Cut Here
1. Exhaust Panel
2. Side Panel
3. Sidewall Extrusion

**Fig. 9, Exhaust Panel to Side Panel Joint**

5. Drill out the rivet mounting the heater duct/bunk support to the side panel. Cut the adhesive between the heater duct/bunk support and the side panel. See **Fig. 6**.
6. Remove the bolts that mount the side panel to the floor. Drill out the revets that secure the bracket to the side panel. See **Fig. 10**.

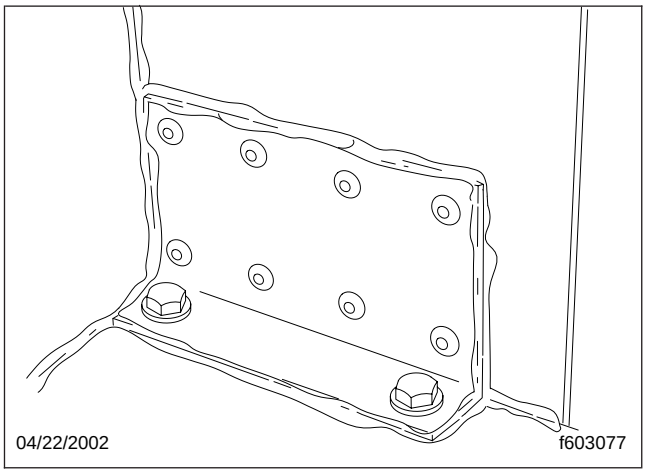



**Fig. 10, Side Panel to Floor Bracket**

7. Drill out the rivets that attach the side panel to the rain gutter. See **Fig. 11**.

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## Side Panel Removal and Installation

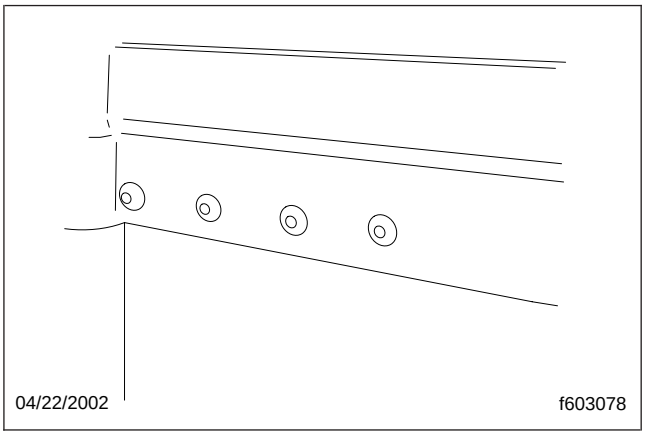
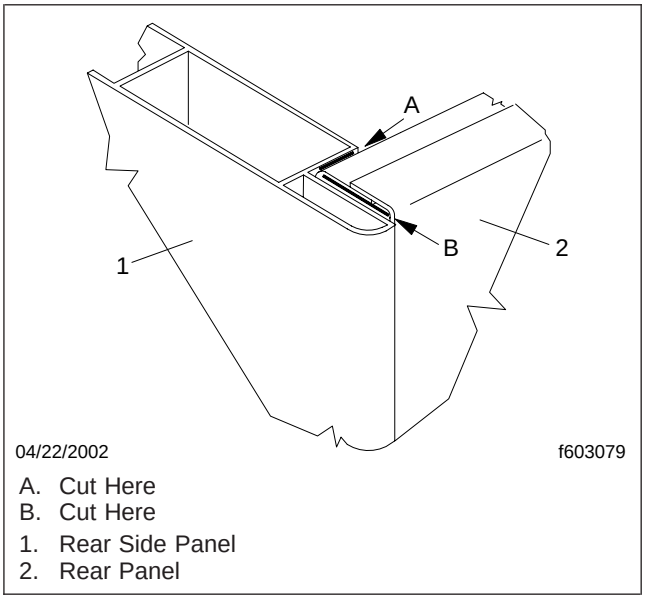



**Fig. 11, Side Panel to Rain Gutter Joint**

8. Cut the adhesive at the top of the panel. See **Fig. 2**.
9. Cut the adhesive joining the rear side panel to the rear panel. See **Fig. 12**.




A. Cut Here
B. Cut Here
1. Rear Side Panel
2. Rear Panel

**Fig. 12, Rear Side Panel to Rear Panel Joint**

10. Cut the adhesive between the side panel and the floor. See **Fig. 4**.
11. Remove the side panel.

## Front Side Panel, 62-Inch and 76-Inch Sleeper

1. Remove the cabinets and shelves attached to the side panel and exhaust panel.
2. Remove the upholstery from the side panel and adjoining panels. See **Fig. 13**.

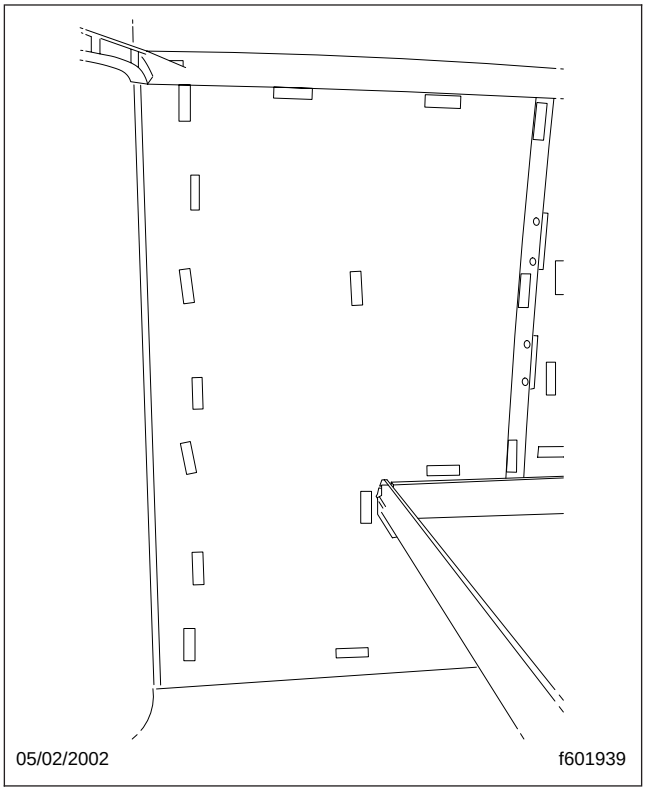
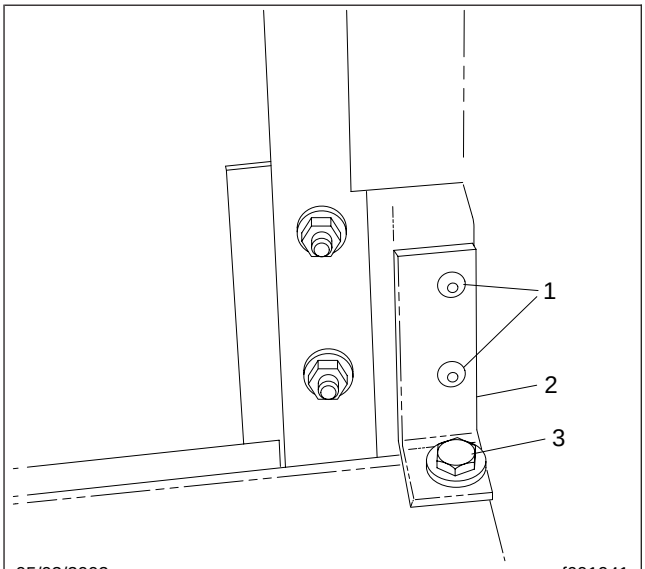



**Fig. 13, Front Side Panel Upholstery Fasteners**

3. Remove the window or door. See **Group 72** for instructions.
4. Lift the bunk and support it in the upright position.
5. Drill out the rivet mounting the heater duct/bunk support to the side panel. Cut the adhesive between the heater duct/bunk support and the side panel. See **Fig. 6**.
6. Remove the bolts that mount the side panel to the floor at the luggage door. Drill out the rivets securing the bracket to the side panel. See **Fig. 14**.

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1. Rivets
2. Bracket
3. Bolt

**Fig. 14, Side Panel to Floor 62 and 76-Inch Sleepers**

7. Cut the adhesive at the top of the panel from both inside and outside. See **Fig. 2**.
8. Cut the adhesive joining the exhaust panel to the side panel (from the inside). See **Fig. 3**.
9. Cut the adhesive between the side panel and the floor. See **Fig. 4**.

## Rear Side Panel, 62-Inch and 76-Inch Sleeper

1. Remove the cabinets and shelves attached to the rear side panel and rear panel.
2. Remove the upholstery from the side panel and adjoining panels.
3. Remove the window or door. See **Group 72** for instructions.
4. Lift the bunk and support it in the upright position.
5. Drill out the rivet mounting the heater duct/bunk support to the side panel. Cut the adhesive between the heater duct/bunk support and the side panel. See **Fig. 1**.
6. Remove the bolts that mount the side panel to the floor. Drill out the rivets securing the bracket to the side panel. See **Fig. 10**.
7. Drill out the rivets attaching the side panel to the rain gutter. See **Fig. 11**.
8. Cut the adhesive at the top of the panel. See **Fig. 2**.
9. Cut the adhesive joining the rear side panel to the rear panel. See **Fig. 12**.
10. Cut the adhesive between the side panel and the floor. See **Fig. 4**.
11. Remove the side panel.

# Installation

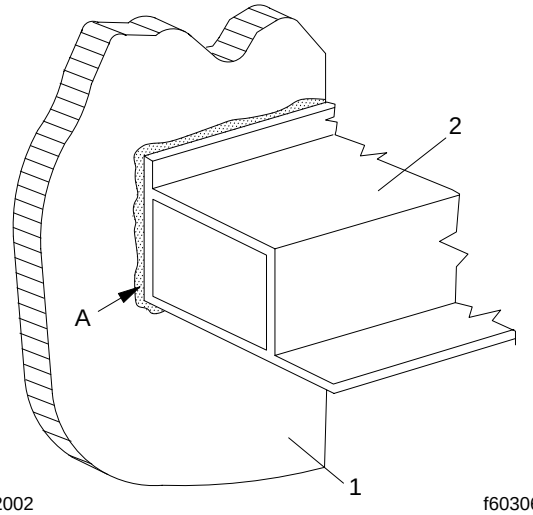
## 34-Inch Sleeper

1. Apply adhesive to the top frame, and floor extrusion. Follow the adhesive procedure described in **Subject 100**. Hold the exhaust panel edge out as the side panel is being placed. Apply spacers to the side panel where the exhaust panel will attach to it. Apply a bead of adhesive down the side panel.
2. Measure the height of the bunk support/heater duct and scribe a small alignment mark on the interior of the side panel. Height should be 18-3/4 inches (477 mm). See **Fig. 15**.
3. Align the support/duct to the scribed marks and firmly press the support/duct into place. Use C-clamps to hold the support/duct until the adhesive cures.
4. Drill 3/16-inch holes as required to attach the heater duct/bunk support to the side panel and install pop-rivets.
5. Install the upholstery panels, connect reading lamps, and install the shelves.
6. Apply a small bead of Sikaflex 252 along the edges of the panel and smooth with a gloved finger to seal against leakage. See **Fig. 16**, **Fig. 17**, **Fig. 18** and **Fig. 19** for locations of finger fillets.

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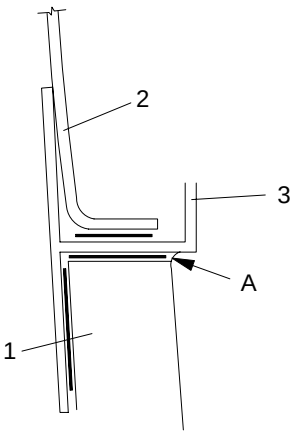
## Side Panel Removal and Installation




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A. Cut Here
1. Side Panel
2. Bunk Support/Heater Duct

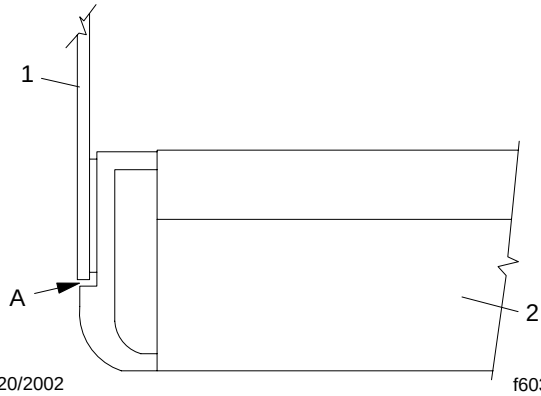
**Fig. 15, Vertical Cross Section Through Floor, Side Panel and Bunk Support/Heater Duct**




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A. Finger Fillet
1. Side Panel
2. Roof
3. Rain Gutter

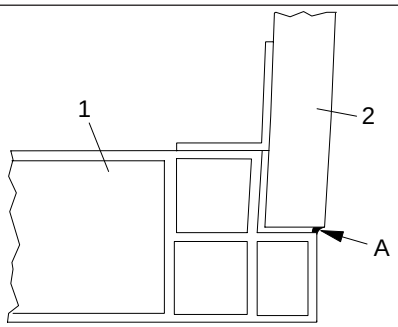
**Fig. 16, Vertical Cross Section Through Side Panel and Roof**




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A. Finger Fillet
1. Exhaust Panel
2. Side Panel

**Fig. 17, Top View of Side Panel and Exhaust Panel Joint**




04/22/2002 f603070

A. Finger Fillet
1. Floor
2. Side Panel

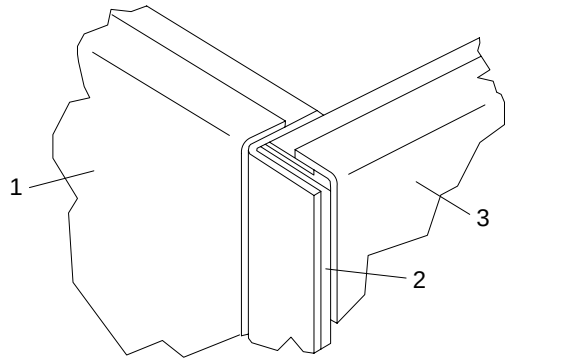
**Fig. 18, Front View Through Floor and Side Panel**

## Front Side Panel, 48-Inch Sleeper

1. Remove all traces of adhesive from the top frame, exhaust panel and floor.
2. If the side panel is being replaced remove the extrusion from the old panel. If the side panel extrusion is damaged install a new angle to the side panel. See **Fig. 20**.
3. Follow the adhesive procedures in **Subject 100** in this section.

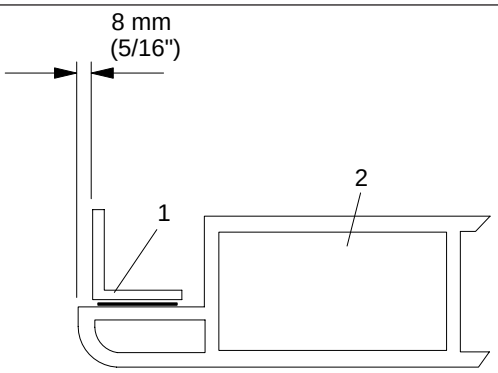
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1. 34-Inch Sleeper Side Panel
2. Finger Fillet
3. Rear Panel

**Fig. 19, 34-Inch Side Panel and Rear Panel Joint**



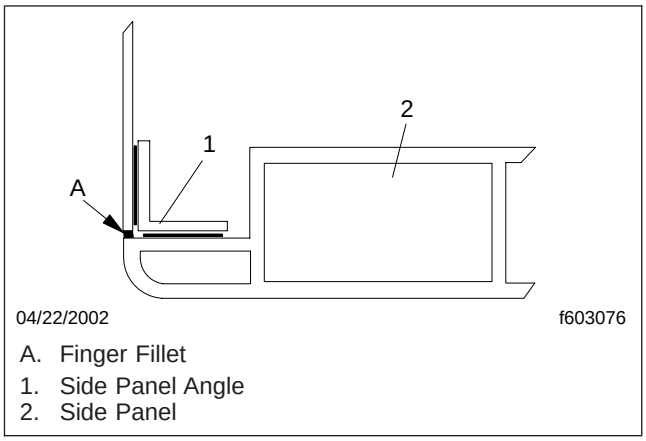

1. 48-Inch Sleeper Side Panel Angle
2. 48-Inch Sleeper Side Panel

**Fig. 20, 48-Inch Sleeper Side Panel and Angle**

4. Drill four equally space 3/16-inch holes through the angle and into the side panel.

NOTE: Do not drill through to the outside of the panel.

5. Install pop-rivets to secure the angle to the side panel.
6. Apply adhesive to the top frame, floor extrusion, and the heater duct/bunk support. Hold the exhaust panel edge out as the side panel is being placed. Apply adhesive down the side panel (with spacers) to attach the exhaust panel to the side panel.
7. Coat the floor mounting bracket with adhesive and bolt it to the floor. Pop-rivet the floor bracket to the side panel. See **Fig. 7**.
8. Install pop-rivets to secure the side panel to the rain gutter. See **Fig. 8**.
9. Drill 3/16-inch holes as required to attach the heater duct/bunk support to the side panel and install pop-rivets.
10. Apply a small bead of Sikaflex 252 along the edges of the panel and smooth with a gloved finger to smooth the joint and seal against leakage. See **Fig. 16**, **Fig. 18**, and **Fig. 21**.




A. Finger Fillet
1. Side Panel Angle
2. Side Panel

**Fig. 21, Finger Fillet**

11. Dampen a cloth with DuPont 38125 enamel reducer and wipe down the finger fillet.
12. Allow the adhesive forty-eight hours to cure before painting.
13. Install the window following the procedure in **Group 72**.
14. Install the doors.
15. Install the upholstery panels and any cabinetry that was removed.

## Rear Side Panel Installation, 48-Inch Sleeper

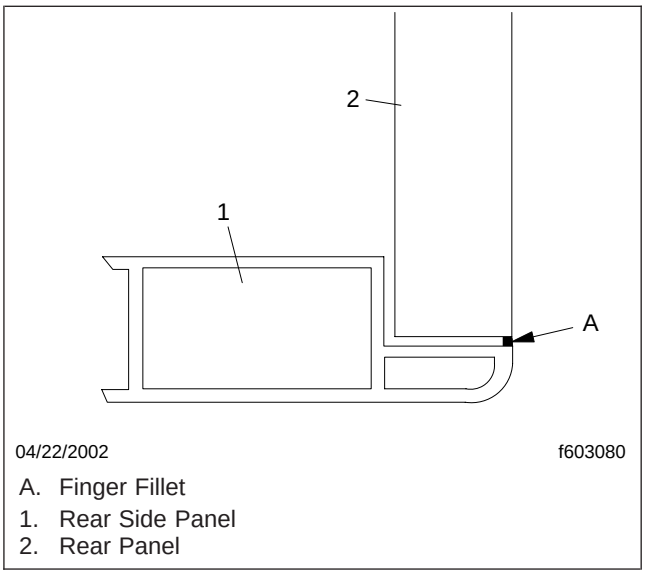
1. Apply adhesive to the top frame, floor extrusion, the rear panel, and coat the back of the heater duct/bunk support. Follow the adhesive procedures in **Subject 100** in this section.

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## Side Panel Removal and Installation

2. Coat the back of the floor mounting bracket with adhesive and bolt it to the floor. Drill and rivet the bracket to the rear side panel. See **Fig. 10**.
3. Drill and rivet the rear side panel to the rain gutter. See **Fig. 11**.
4. Drill 3/16-inch holes as required to attach the heater duct/bunk support to the side panel and install pop-rivets.
5. Install the window or door following the procedures in **Group 72**.
6. Install the upholstery panels, cabinets and shelves.
7. Apply a small bead of Sikaflex 252 along the edges of the panel and smooth with a gloved finger to smooth the joint and seal against leakage. See **Fig. 16**, **Fig. 18**, and **Fig. 22**.




A. Finger Fillet
1. Rear Side Panel
2. Rear Panel

**Fig. 22, Rear Side Panel to Rear Panel Finger Filet**

## Front Side Panel Installation 62-Inch and 76-Inch Sleeper

1. Apply adhesive to the top frame, floor extrusion, and coat the back of the heater duct/bunk support. Follow the adhesive procedure in **Subject 100**. Hold the exhaust panel edge out as the side panel is being positioned. Apply spacers and adhesive down the side panel to attach the exhaust panel to the side panel.
2. Coat the back of the floor mounting bracket with adhesive and bolt it to the floor. Pop-rivet the floor bracket to the side wall next to the door opening and bolt it to the floor.
3. Drill 3/16-inch holes as required to attach the heater duct/bunk support to the side panel and install poprivets.
4. Install the window following the procedure in **Subject 170** in this section
5. Install the door following the procedures in **Group 72** in this manual.
6. Install the upholstery panels, cabinets and shelves.
7. Apply a small bead of Sikaflex 252 along the edges of the panel and smooth with a gloved finger to smooth the joint and seal against leakage. See **Fig. 16**, **Fig. 17**, and **Fig. 18**.
8. Dampen a cloth with DuPont 38125 enamel reducer and wipe down the finger fillet.
9. Allow adhesive 48 hours to cure before painting.

## Rear Side Panel Installation 62-Inch and 76-Inch Sleeper

1. Apply adhesive to the top frame, floor extrusion, rear panel, and coat the back of the heater duct/bunk support.
2. Coat the back of the floor mounting bracket with adhesive and bolt it to the floor. Drill and rivet the bracket to the rear side panel. See **Fig. 10**.
3. Drill and rivet the rear side panel to the rain gutter. See **Fig. 11**.
4. Drill 3/16-inch holes as required to attach the heater duct/bunk support to the side panel and install pop-rivets.
5. Install the window or door following the procedure in **Group 72**.
6. Install the upholstery panels, cabinets and shelves.
7. Apply a small bead of Sikaflex 252 along the edges of the panel and smooth with a gloved finger to smooth the joint and seal against leakage. See **Fig. 16**, **Fig. 22**. and **Fig. 18**.

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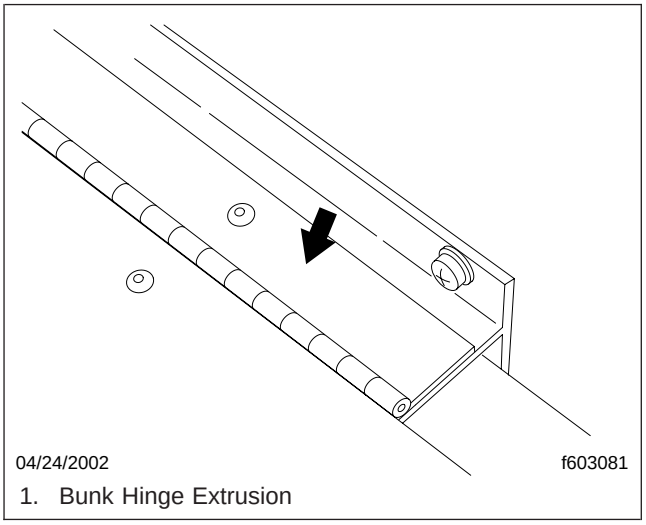


# Rear Panel Removal and Installation

## Removal

It is not necessary to remove the sleeper from the cab in order to replace the rear panel.

1. Remove all cabinets and shelves that attach to the rear panel and side panels.
2. Remove the instrument panel from the control box. Remove the control box.
3. Remove the upholstery from the rear panel and side panels. The upholstery is held on with hook and loop tape (velcro). Disconnect the reading lamps as the panel is being removed.
4. Remove the screws that attach the bunk hinge to the rear panel. Cut the adhesive that attaches the bunk extrusion to the rear panel. Detach the bed supports from the heater enclosure. Remove the bunk. See **Fig. 1**.

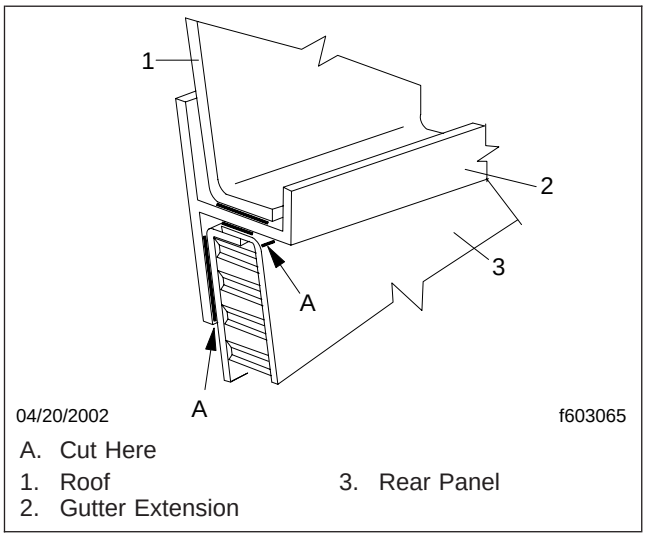


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1. Bunk Hinge Extrusion

**Fig. 1, Bunk Hinge**

5. Disconnect the wiring from the back-of-sleeper backup lamps. Detach the wiring harness from the back panel.
6. Measure and record the height of the rear heater duct. Remove the screws that mount the rear heater duct to the rear panel.
7. Remove the back-of-sleeper lamps, grab handles and side fairings.
8. Cut the adhesive at the top of the rear panel. See **Fig. 2**.

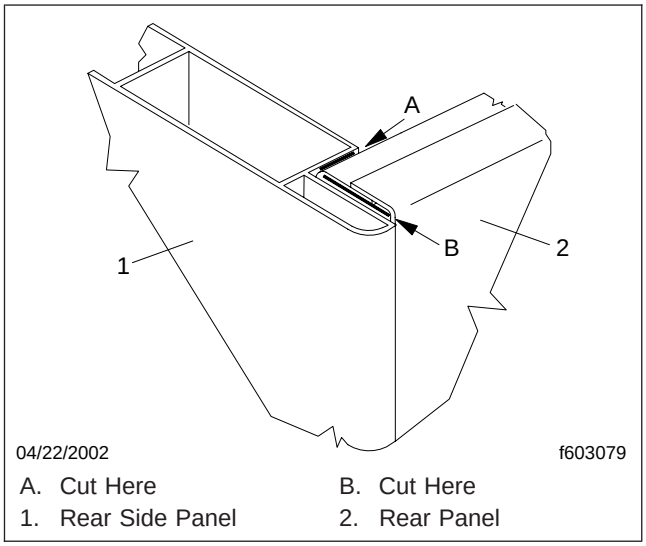



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A. Cut Here
1. Roof
2. Gutter Extension
3. Rear Panel

**Fig. 2, Rear Panel to Roof Joint**

9. Cut the adhesive that attaches the rear side panel to the rear panel. See **Fig. 3**.




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A. Cut Here
B. Cut Here
1. Rear Side Panel
2. Rear Panel

**Fig. 3, Rear Panel to Rear Side Panel Joint**

10. Cut the adhesive between the rear panel and the floor. See **Fig. 4**.

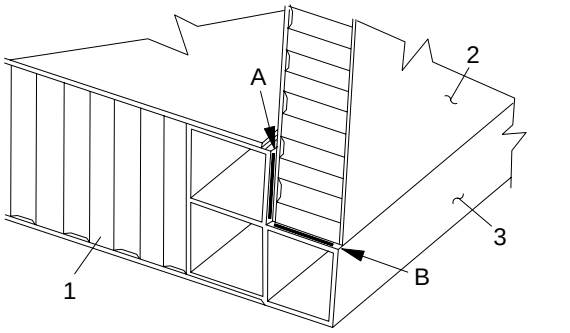
## Installation

1. Follow the adhesive procedures in **Subject 100** to attach the rear panel to the sleeper.

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## Rear Panel Removal and Installation

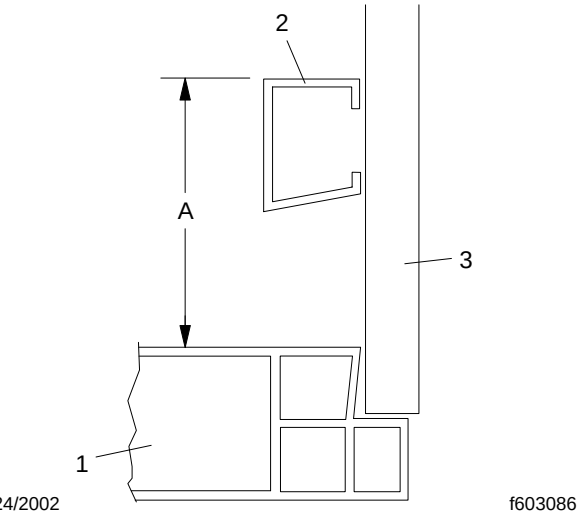



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A. Cut Here
B. Cut Here
1. Floor Panel
2. Rear Panel
3. Floor Extrusion

**Fig. 4, Rear Panel to Floor Joint**

2. Install the back-of-sleeper backup lamp, grab handles and side fairings.
3. Measure 14-1/2 inches (362 mm) above the floor and scribe a line on the back panel to align the rear heater duct. Use adhesive to attach the heater duct to the rear panel. See **Fig. 5**.

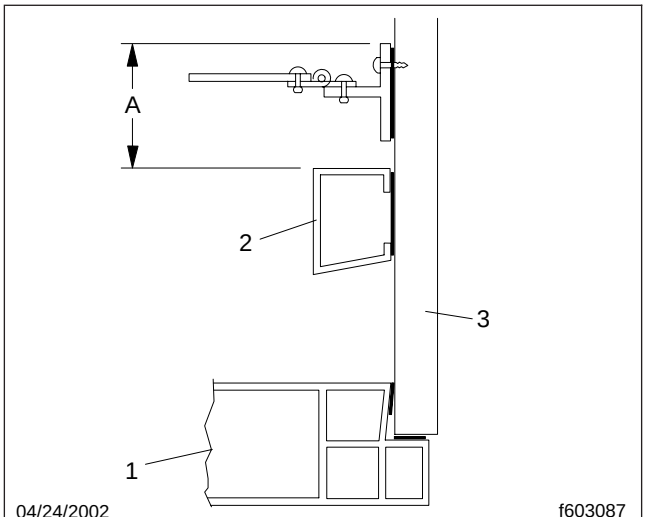



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A. 14-1/4 Inches (360 mm)
1. Floor
2. Rear Heater Duct
3. Rear Panel

**Fig. 5, Rear Heater Duct Mounting**

4. Install mounting screws through the heater duct into the back wall.
5. Measure 2-1/4 inches (57 mm) above the rear heater duct and scribe alignment marks for the bunk hinge extrusion on the rear panel. Prepare the bunk hinge extrusion with adhesive. Align the hinge extrusion to the alignment mark, attach it, and hold in place with screws. See **Fig. 6**.




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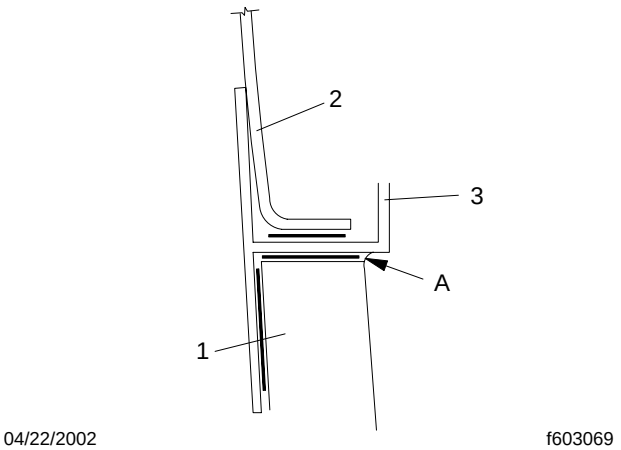
A. 2-1/4 Inches (57 mm)
1. Floor
2. Rear Heater Duct
3. Rear Panel

**Fig. 6, Bunk Hinge Extrusion Mounting**

6. Reconnect the wiring to the back-of-sleeper backup lamps. Reattach the wiring harness to the rear panel. Insert the foam gaskets between the rear duct and the bunk support/heater duct.
7. Install the upholstery panels reconnecting the reading lamp and install the cabinets and shelves.
8. Install the control box and instrument panel.
9. Apply a small bead of Sikaflex 252 along the edges of the panel and smooth with a gloved finger to smooth the joint and seal against leakage. See **Fig. 7**, **Fig. 8**, and **Fig. 9**.
10. Dampen a cloth with DuPont 38125 enamel reducer and wipe down the finger fillets.
11. Allow adhesive 48-hours to cure before painting.

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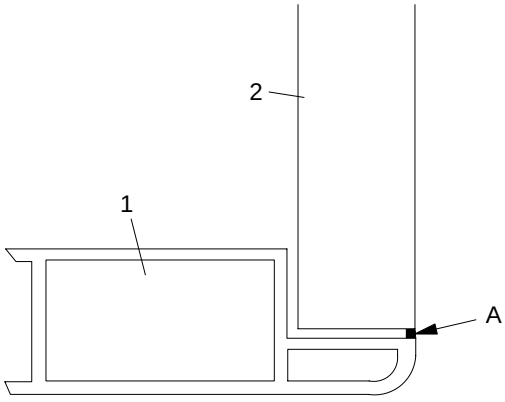





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A. Finger Fillet
1. Rear Panel
2. Roof
3. Rain Gutter

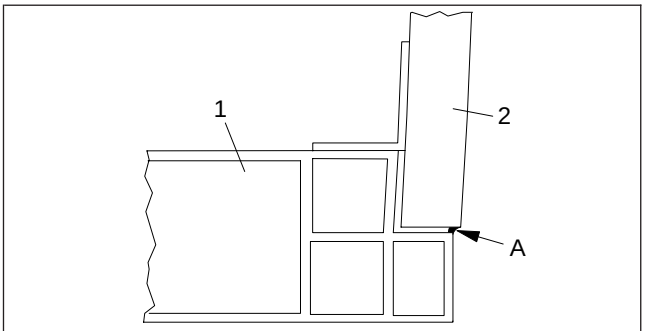
**Fig. 7, Rear Panel to Rain Gutter Joint**




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A. Finger Fillet
1. Rear Side Panel
2. Rear Panel

**Fig. 8, Rear Side Panel to Rear Panel Joint**




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A. Finger Fillet
1. Floor
2. Side Panel

**Fig. 9, Rear Side Panel to Floor Joint**

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# Roof Cap Removal and Installation

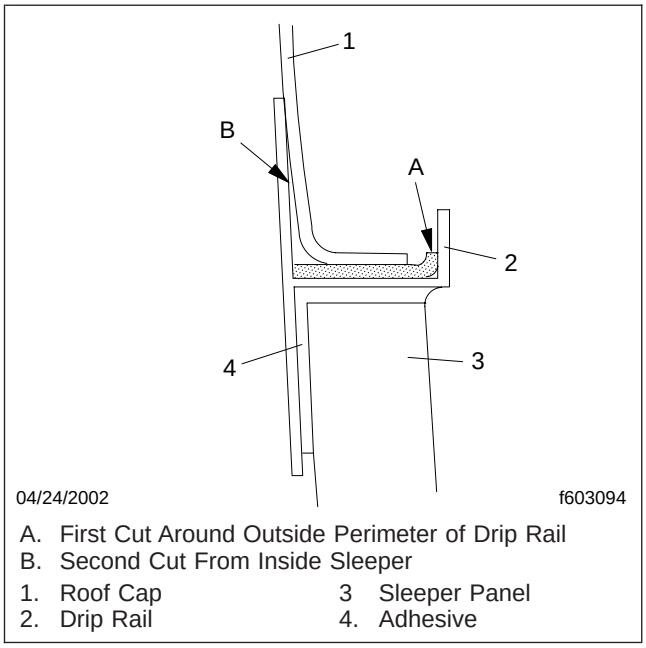
## Removal

It is necessary to remove the sleeper from the cab in order to replace the rear panel. See **Subject 100** for instructions on sleeper removal and installation.

If the sleeper roof cap is being removed because it is damaged beyond repair it is preferable to cut off the roof cap approximately 1-1/2 inches above the drip rail. The remaining strip of fiberglass that is attached to the drip rail can easily be removed with a utility knife.

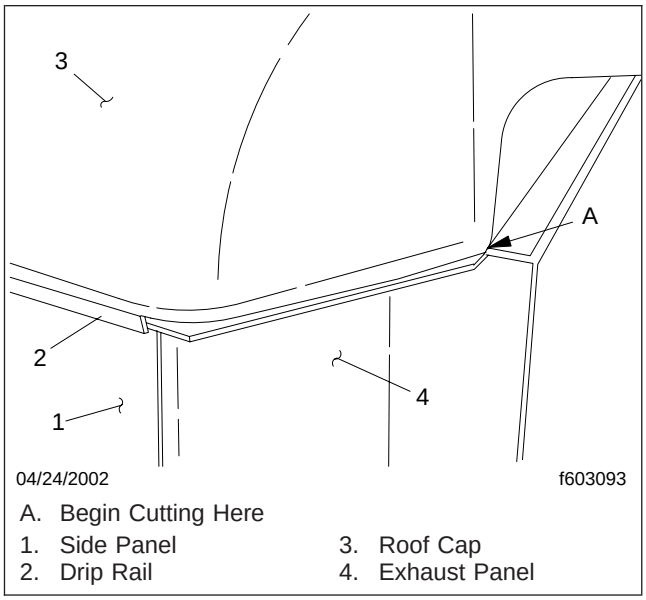
If it is necessary to remove the roof cap intact perform the following steps:

1. Remove any shelves or cabinets that may interfere with the roof cap removal.
2. Remove the sleeper dome lamp.
3. Remove all the upholstery. It is held on with velcro type tape.
4. Disconnect the reading lamps and speakers from the panels as they are being removed.
5. Remove the wiring harness from the roof cap down to the sleeper control panel.
6. Using a utility knife, cut completely around the drip rail from the outside to cut any adhesive on the vertical lip of the drip rail. See **Fig. 1**.
7. Use a windshield removal tool to cut the adhesive in the front corners of the exhaust panel. See **Fig. 2**.
8. After the exhaust panels have been cut free, drive in a wooden wedge to apply pressure against the remaining adhesive around the sides of the sleeper.
9. Working from the inside of the sleeper, use an off-set cutter (**Fig. 3**) to cut around the bottom of the drip rail. See **Fig. 1**.
10. Cut completely around the perimeter from the inside of the sleeper, pushing the wedges in as the adhesive loosens to maintain pressure against the adhesive.
11. When all the adhesive has been cut remove the roof cap.




A. First Cut Around Outside Perimeter of Drip Rail
B. Second Cut From Inside Sleeper
1. Roof Cap
2. Drip Rail
3 Sleeper Panel
4. Adhesive

**Fig. 1, Cross Section View Through Drip Rail**




A. Begin Cutting Here
1. Side Panel
2. Drip Rail
3. Roof Cap
4. Exhaust Panel

**Fig. 2, Exhaust Panel Cut**

## Installation

1. Follow the adhesive procedures in **Subject 100** to attach the roof cap to the sleeper.

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## Roof Cap Removal and Installation

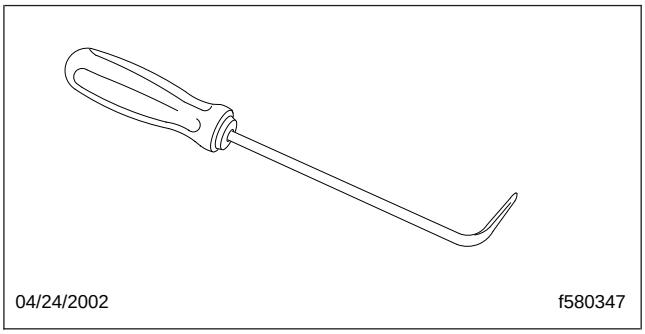



**Fig. 3, Off-Set Cutting Tool**

2. Attach the sleeper to the cab following the instructions in **Subject 100**.
3. Install the wiring harness into the roof cap.
4. Reconnect the reading lamps and speakers as the upholstery panels are installed.
5. Install the dome lamp onto the roof cap.
6. Install the shelving and cabinets.

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## Star Light Sleeper Double Bunk

# General Information

These instructions are written for the installation of the aftermarket upper bunk. See **Fig. 1**. The upper bunk is available for either the 62-inch or 76-inch sleepers. The bunk swings up and conveniently secures out of the way to provide an open sleeper interior space.

The installation of an upper bunk requires that the rear upholstery panel be replaced or the control panel cutout lowered and an upholstery filler inserted. Holes are drilled into the sleeper and rivnuts are installed. The sleeper control panel is relocated. The sleeper shelves are replaced or added.

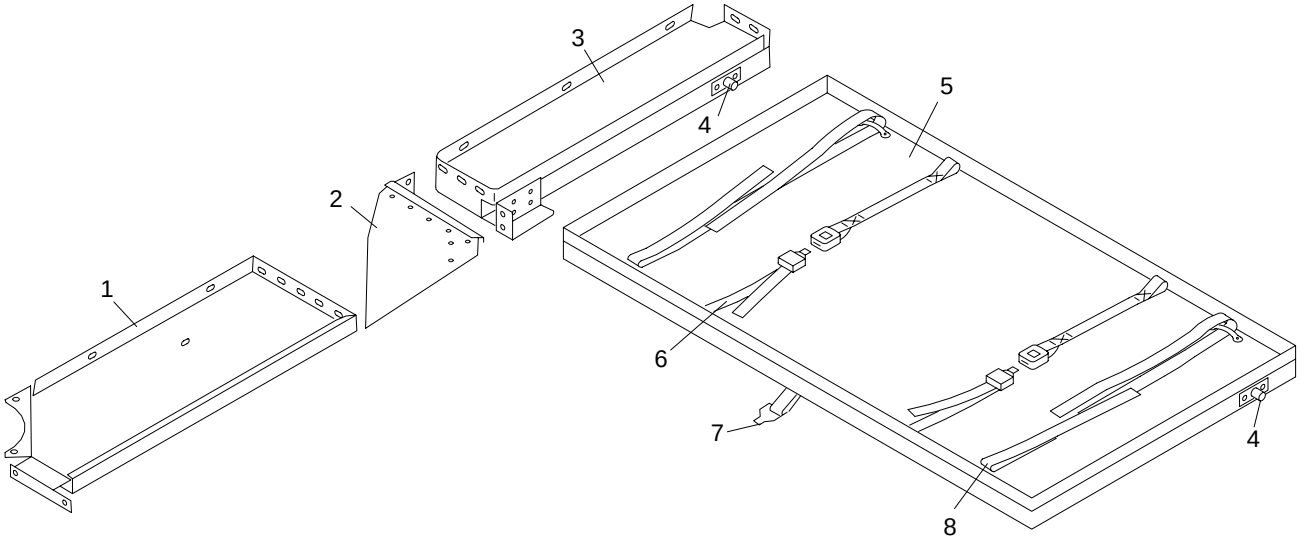
When ordering a double bunk kit make sure to order the upholstery including the style and color. See the Western Star Parts Manual for the part numbers of the required upholstery panels.

# Double Bunk Installation

1. Remove the upholstery panels from the sleeper. It is not necessary to remove the upper front panel or the exhaust corner upholstery.
2. Remove all installed shelves.
3. Remove the sleeper control panel housing.
4. Unmount the fuse/breaker block, terminal strip and relay blocks from the rear wall. They must be relocated.

NOTE: When drilling holes in the sleeper place a stopper on the drill bit to ensure a maximum hole depth of 3/4-inch (20 mm).

5. The sleeper control box panel and electrical components must be lowered 4 inches (100 mm). Drill all the holes exactly 4 inches (100 mm) directly below the current rivnuts. There are eleven 19/64-inch holes, and five 25/64-inch holes. See **Fig. 2**.
6. Install the eleven aluminum #10-24 rivnuts (part number 4013-3442) into the 19/64-inch diameter holes, and the five aluminum 1/4-20 rivnuts (part number 4013-3441) into the 25/64-inch diameter holes.
7. Remove the upholstery tape from the top center upholstery support. See **Fig. 3**.



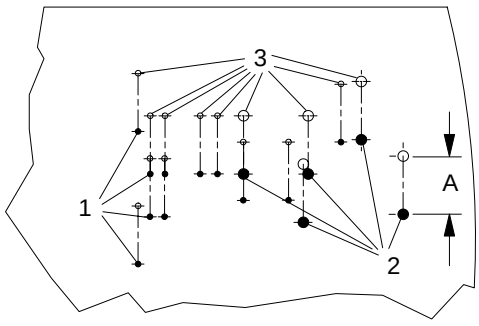

1. Forward Shelf
2. Bunk Bulkhead
3. Bunk Wing
4. Pivot Bushing
5. Bunk Tray
6. Bunk Restraint
7. Stowage Strap
8. Mattress Strap

**Fig. 1, Sleeper Double Bunk Kit**

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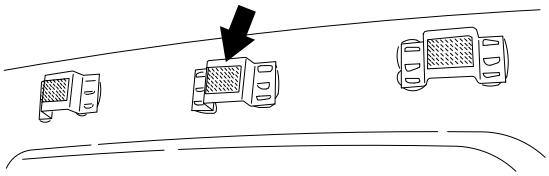
## Star Light Sleeper Double Bunk




05/03/2002 f601920

A. All Holes Redrilled 4 Inches Down
1. 11 small holes 19/64" Dia.
2. 5 large holes 25/64" Dia.
3. Old Hole Locations

**Fig. 2, Drilling Pattern, Electrical Components**

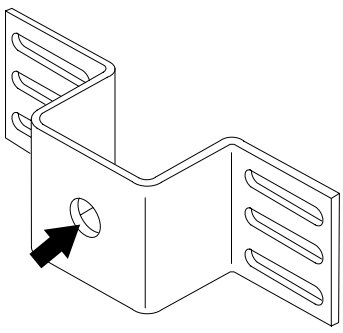


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1. Top Center Upholstery Support

**Fig. 3, Upholstery Supports**

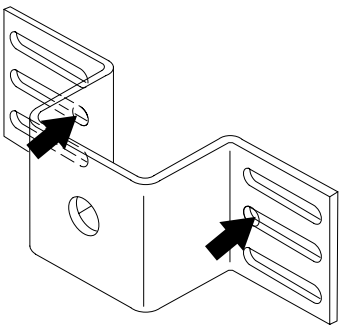
8. Drill a 1/2-inch diameter hole through the center of the support, but not through the roof cap. See **Fig. 4**.



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**Fig. 4, Center Support First Drilling**

9. Drill two 9/32-inch diameter holes through the inner end of the centre slots completely through the sleeper cap. See **Fig. 5**. These are the **ONLY** holes to be drilled completely through the sleeper.



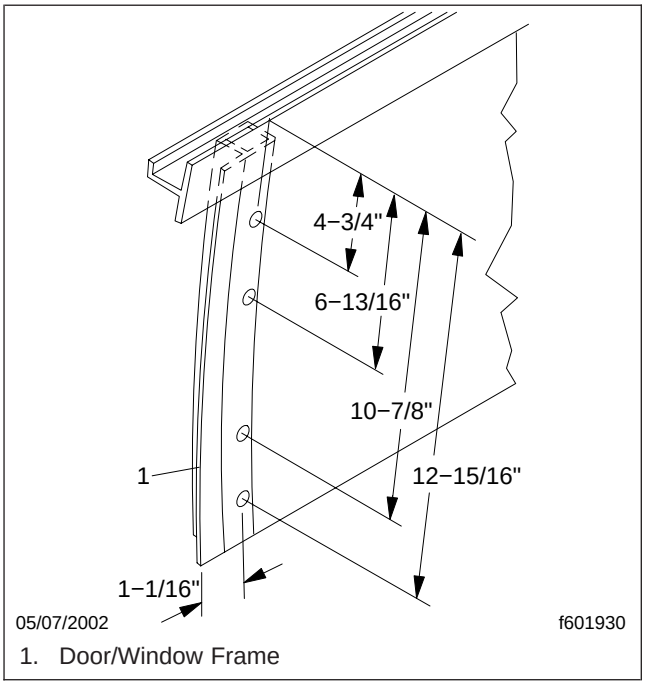
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**Fig. 5, Center Support Second Drilling**

10. Drill four 25/64-inch diameter holes; 1-1/16 inch (27 mm) from the front edge of the window/door opening, and 4-3/4 inches (121 mm), 6-3/16 inches (172 mm), 10-7/8 inches (276 mm), 12-15/16 inches (329 mm) down from the top if the inner frame. See **Fig. 6**. Repeat this pattern on the other side of the sleeper as well.
11. Install the eight steel 1/4-20 rivnuts (part number 4013-3435) into the four holes drilled into the door/window posts on each side of the sleeper.
12. Install the electrical components to the new lower locations prepared. See **Fig. 7**. Install the control panel housing.
13. Place a 1/4-inch stainless steel flatwasher (part number 4002-3404) and a 1/4 x 1/2-inch nylon washer (part number 9054012) on a 1/4-20 x 2-1/4 inch stainless steel pan head screw (part number 4009-3406). Insert the assembled screws through each of the holes drilled in the upholstery bracket from the outside. Place a 1/4-inch lockwasher (part number 4004-3401) and a hexnut (part number 4006-3401) on the screw and tighten. See **Fig. 8**.
14. Install a new rear lower upholstery panel if purchased.
15. If the old panel is being modified, cutout a new control panel opening.

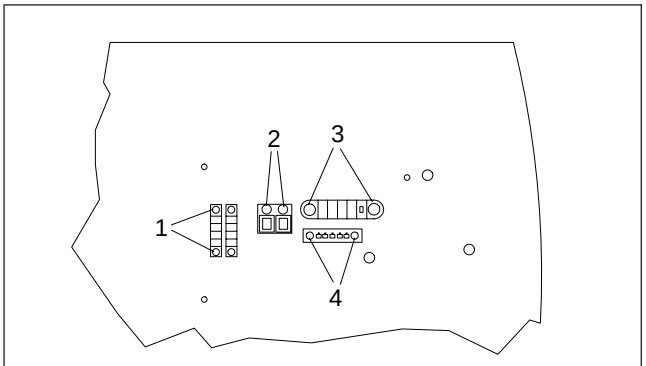
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1. Door/Window Frame

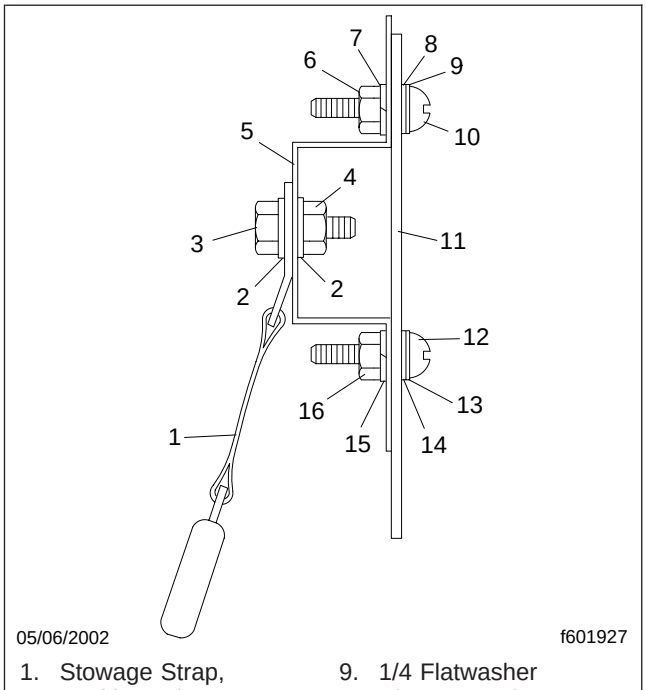
**Fig. 6, Door/Window Frame Drilling**




1. Fuse/Breaker Block, #10-24 x 5/8-Inch Screw
2. Relay Block, #10-24 x 5/8-Inch Screw
3. Power Terminal Strip, 1/4-20 x 3/4-Inch Screw
4. Ground Terminal Strip, #10-24 x 5/8-Inch Screw

**Fig. 7, Electrical Components**

15.1 Lay the removed upholstery panel face up on a flat surface. Place a piece of cardboard under the control panel opening and trace the opening onto the cardboard. Cut the traced opening out of the cardboard. Turn the panel over. Remove the staples and free the upholstery along the bottom of the control panel opening. Measure 4 inches (100 mm) down below the panel opening. See **Fig. 9**.




1. Stowage Strap, Buckle End
2. 7/16 x 7/8 Flatwasher
3. 3/8-20 x 1-1/4 UNC Hex Bolt
4. 3/8-20 UNC Hexnut
5. Upholstery Bracket
6. 1/4-20 UNC Hexnut
7. 1/4 Lockwasher
8. 1/4 x 1/2 Nylon Washer
9. 1/4 Flatwasher
10. 1/4-20 x 2-1/4 UNC Screw
11. Roof Cap
12. 1/4-20 x 2-1/4 UNC Screw
13. 1/4 Flatwasher
14. 1/4 x 1/2 Nylon Washer
15 1/4 Lockwasher
16. 1/4-20 UNC Hexnut

**Fig. 8, Stowage Strap to Roof Cap Attachment**

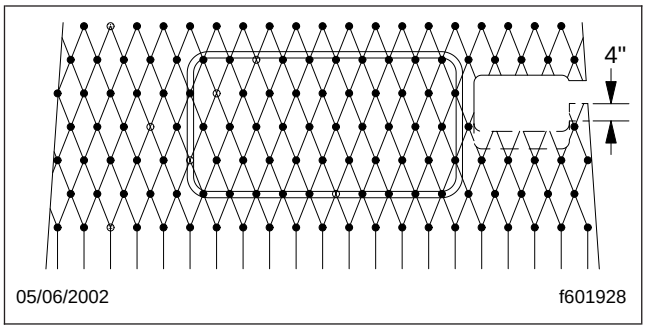



**Fig. 9, Rear Lower Upholstery Panel Measurement**

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## Star Light Sleeper Double Bunk

15.2 Align the traced cardboard opening to the 4-inch mark and trace the new location on to the backing board. Without cutting the upholstery, carefully cut along the edge of the new opening as shown in **Fig. 9**. Cut the padding and fold the upholstery around the new opening, then glue it in place with a good contact adhesive. See **Fig. 10**.

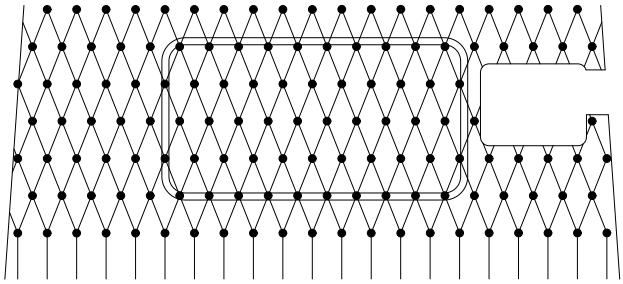
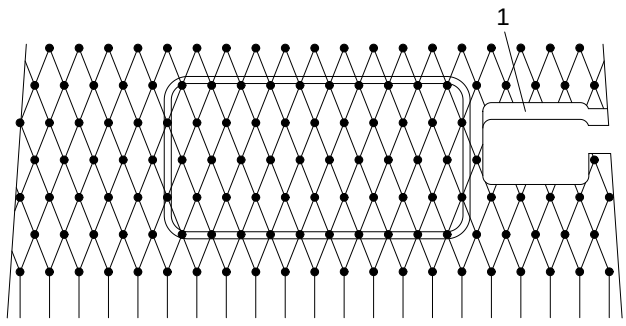



**Fig. 10, New Control Panel Cutout**

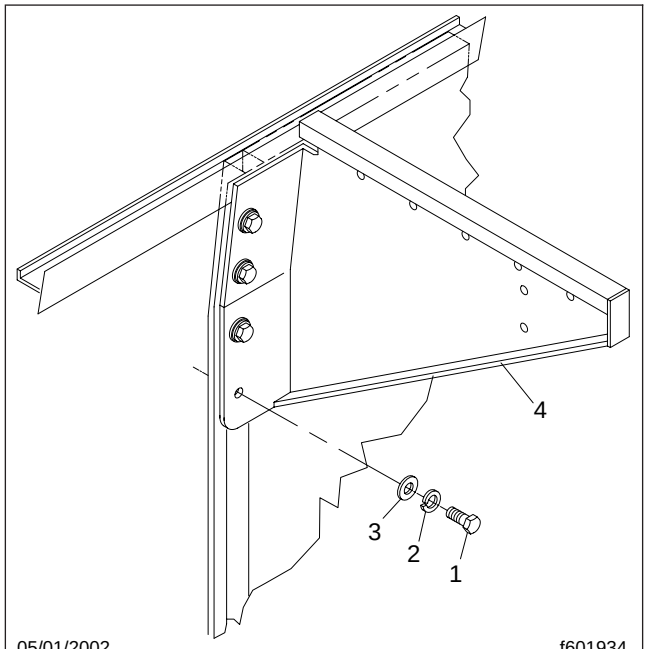
16. Install the rear lower upholstery panel.
17. Glue the velcro tapes from the back wall into the space above the control panel, near the edges of the opening. Glue the velcro tapes to the double bunk control panel filler, in line with the tapes on the back wall. When the glue has set install the double bunk control panel filler. See **Fig. 11**.




1. Control Panel Filler

**Fig. 11, Control Panel Filler**

18. Install the lower side panels. Cut out holes to align them with the four holes on the side of the door/window opening. Install the exhaust upholstery panels. If removed, install the black retainer strip above the sleeper opening.
19. Install the right and left bunk bulkheads to the four holes at the leading edge of the window/door opening. The mounting flange is oriented towards the rear. Assemble a 1/4-inch lockwasher (part number 4004-3401), a 1/4 x 1-1/4 inch flatwasher (part number 4002-3405) onto 1/4-20 x 3/4-inch screws (part number 4009-3405). Mount the bunk bulkheads with four screw assemblies each. Do not tighten. See **Fig. 12**.



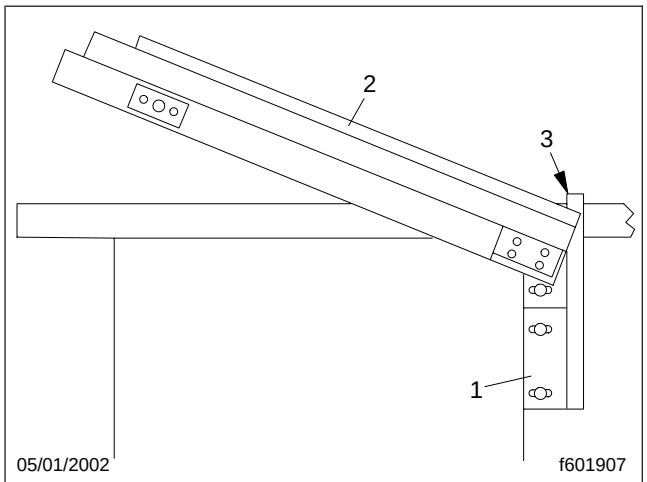

1. 1/4-20 x 3/4-Inch SS Screw
2. 1/4" Lockwasher
3. 1/4" Flatwasher
4. Bunk Bulkhead Bracket

**Fig. 12, Bunk Bulkhead Mounting**

20. Insert the front edge of a bunk wing under the lip of the bunk bulkhead. See **Fig. 13**.
21. Lower the rear edge of the bunk wing. Assemble 1/4-inch lockwasher (part number 4004-3401), 1/4 x 1-1/4 inch flatwasher (part number 4002-3405) onto 1/4-20 x 3/4-inch screws (part number 4009-3405). Mount the bunk wing to the side wall and back wall with five screw assemblies (three to the side wall and two to the back wall). Do not tighten. See **Fig. 14**.

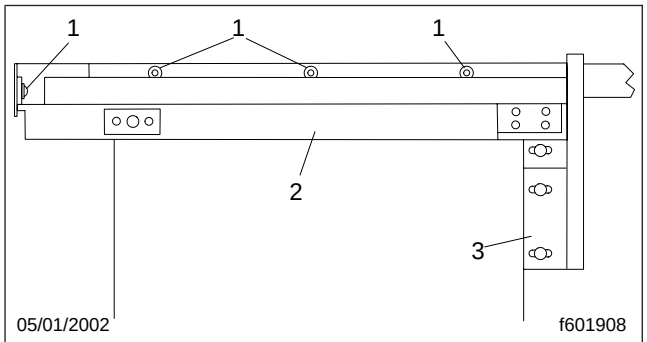
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1. Bunk Bulkhead
2. Bunk Wing
3. Bulkhead Lip

**Fig. 13, Installing the Bunk Wing**

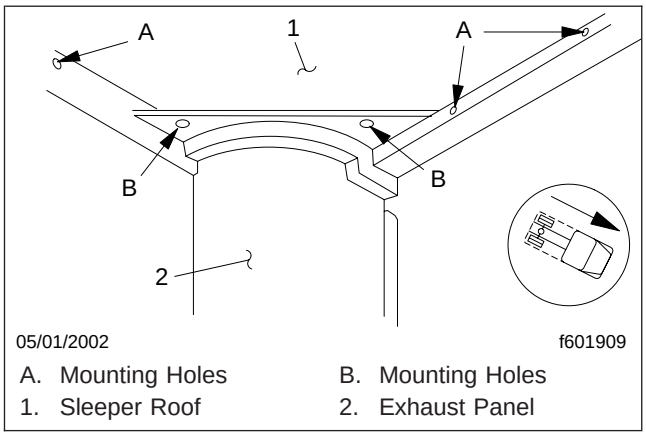



1. Screw, Flatwasher, and Lockwasher Assembly
2. Bunk Wing
3. Bunk Bulkhead

**Fig. 14, Bunk Wing Fastened to Sleeper**

22. Note the shelf mounting locations at the exhaust corners of the sleeper. See **Fig. 15**. Cover the exhaust corner upholstery with a piece of box card to protect the upholstery when installing the shelf. The shelf mounts under the exhaust corner frame.

23. Remove the screws from the curtain track above the cab/sleeper opening. Drill a 5/16-inch diameter hole through the curtain track, in-line with the rivnuts at the ends of the cab/sleeper opening.




A. Mounting Holes
B. Mounting Holes
1. Sleeper Roof
2. Exhaust Panel

**Fig. 15, Exhaust Panel Corner**

24. Tip up the rear edge of the forward shelf and place the front edge under the exhaust corner frame. See **Fig. 16**.

25. Assemble 1/4-inch lockwasher (part number 4004-3401), and 1/4 x 1-1/4 inch flatwasher (part number 4002-3405) onto 1/4-20 x 3/4-inch screws (part number 4009-3405). Lower the back edge of the shelf flush with the bunk bulkhead. Align the shelf with the mounting holes. Insert a screw assembly up through the shelf and the corner bracket. Install the screws into the side wall. See **Fig. 17**.

26. Install the curtain track across the top of the cab/sleeper opening, passing over the shelf front support. Place 1/4-inch lockwasher (part number 4004-3401) and 1/4-20 x 3/4-inch screws, through the curtain track and the front shelf support into the frame above the sleeper/cab opening. See **Fig. 18**.

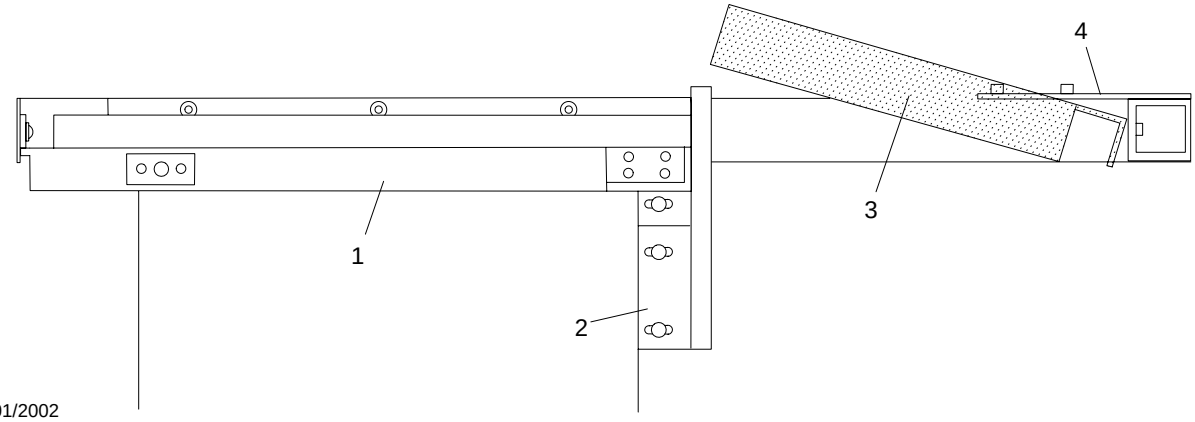
27. Assemble 1/4-inch flatwashers (part number 4002-3404) onto 1/4-20 x 1-inch screws (part number 9028591). Insert them through the shelf, bulkhead and bunk wing. Place a 1/4-inch flat washer (part number 4002-3404) on each screw and a 1/4-20 nylock nut (part number 4003-3404). Level the bunk wing and the forward shelf. Tighten all the fasteners. Place seven covers (part number 63322-3444) over the exposed nut and screw shafts. See **Fig. 19**.

28. Lay the upper rear upholstery panel face down on a flat surface. Remove the velcro tape in the center of the panel that is 3 inches (75 mm) down from the top edge. See **Fig. 20**.

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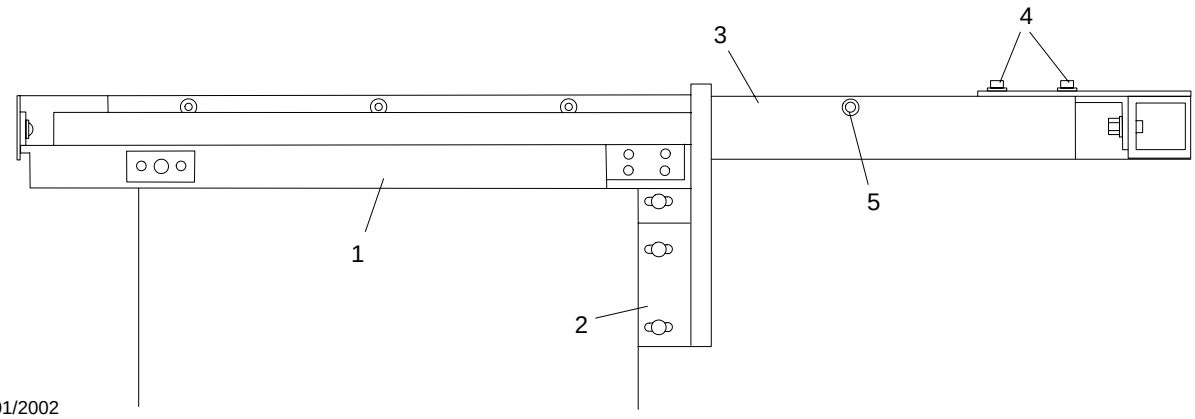


## Star Light Sleeper Double Bunk




1. Bunk Wing
2. Bunk Bulkhead
3. Forward Shelf
4. Exhaust Corner Frame

**Fig. 16, Forward Shelf Installation**



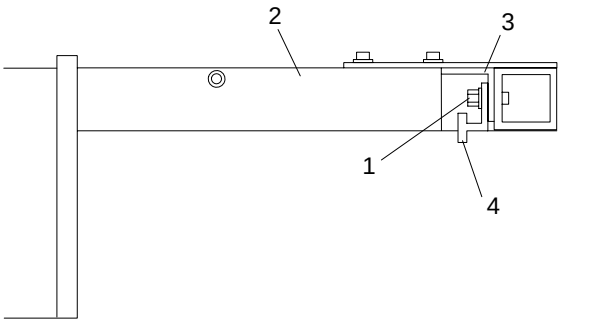

1. Bunk Wing
2. Bunk Bulkhead
3. Bunk Forward Shelf
4. Screw, Flatwasher, and Lockwasher Assembly
5. Screw, Flatwasher, and Lockwasher Assembly

**Fig. 17, Forward Shelf Installed**

29. Locate a scribed mark that should be on the cardboard backing directly under where the tape was that you removed. With a sharp knife carefully cut the rectangle out of the cardboard backing only. **DO NOT CUT THE UPHOLSTERY AT THIS TIME.** With the cardboard backing removed cut out a similar rectangle of foam. See **Fig. 21**.
30. Make a center horizontal cut in the upholstery, then make four diagonal cuts from the corners of the rectangle to the horizontal cut. See **Fig. 22**.
31. Coat the edges of the cardboard backing around the opening with a good quality adhesive. Pull the upholstery flaps through and bold back pressing onto the adhesive. See **Fig. 23**.

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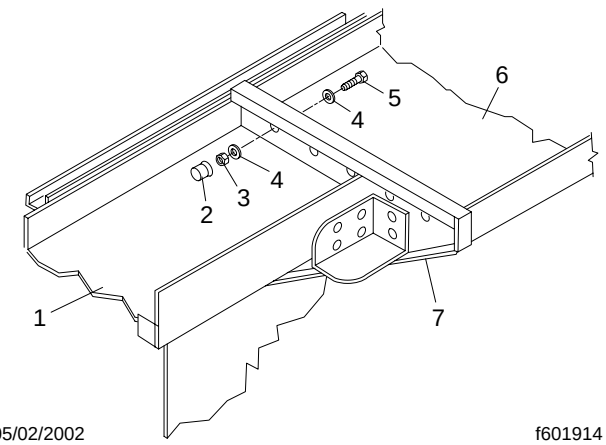





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1. Screw and Washer Assembly
2. Bunk Forward Shelf
3. Front Support
4. Curtain Track

**Fig. 18, Curtain Track Installation**



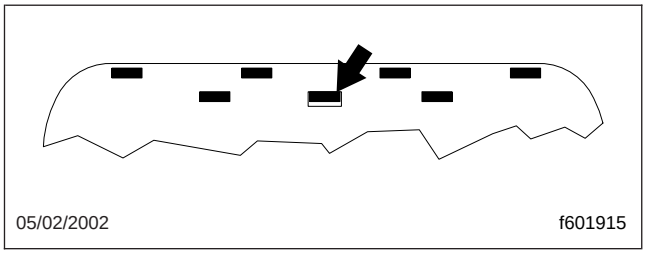

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1. Bunk Wing
2. Cover
3. 1/4-20 Nylock Nut
4. 1/4 Flatwasher
5. 1/4-20 x 1-inch SS Screw
6. Bunk Forward Shelf
7. Bunk Bulkhead Bracket

**Fig. 19, Attaching Forward Shelf to Bulkhead Bracket**

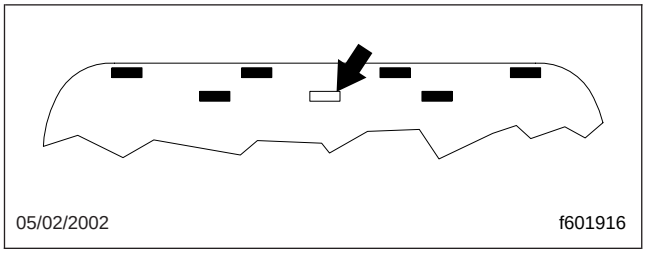
32. Install the upper rear upholstery panel, making sure to thread the stowage strap through the slot in the panel. Reinstall all the roof upholstery panels.

33. Assemble 1/2-inch flat washers (part number 4011-3413) onto 1/2-20 x 5-inch UNF bolt (part number 4019-3408-5.00). Insert a bolt/washer into the pivot bushings from the underside of the



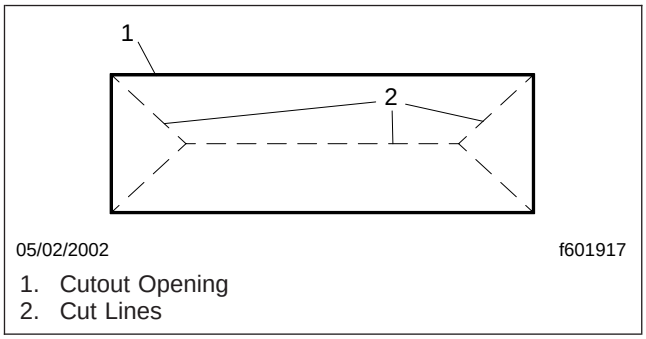
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**Fig. 20, Remove Tape**



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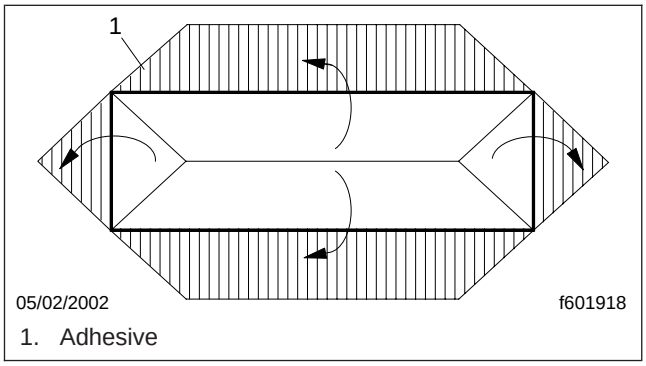
**Fig. 21, Cut Cardboard Backing**




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1. Cutout Opening
2. Cut Lines

**Fig. 22, Upholstery Cutout**




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1. Adhesive

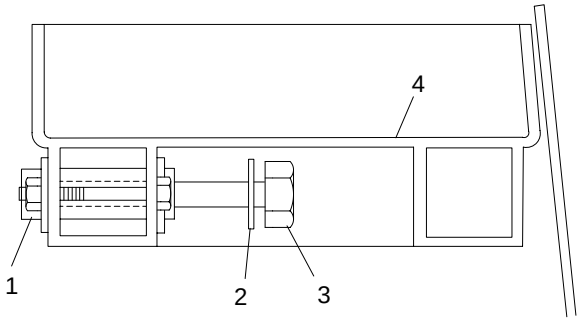
**Fig. 23, Upholstery Flaps**

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## Star Light Sleeper Double Bunk

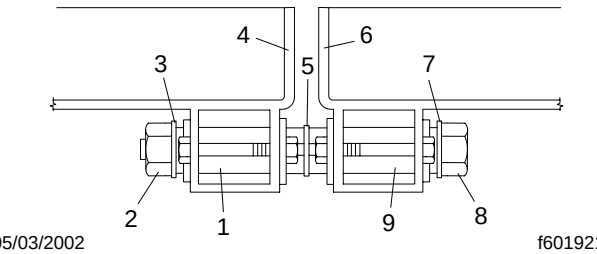
bunk wings. Do not push them all the way through. See **Fig. 24**.




1. Pivot Bushing
2. 1/2-Inch Flatwasher
3. 1/2-20 x 5 Hex Bolt
4. Bunk Wing

**Fig. 24, Attaching the Pivot Bushing**

34. Set the bunk tray into the sleeper so that the mattress side of the tray is towards the back wall and the pivot bushing end is down. Place a 1/2-inch nylon washer (part number 4011-3403) between the bunk and the wing pivot and push the 1/2-20 x 5 bolt through the washer and the bunk tray pivot bushing. Install a 1/2-inch flatwasher (part number 4011-3413) and a 1/2-20 nylock nut (part number 656141) onto the bolt. Repeat for the other side. Snug up the 1/2-inch bolt, but do not over tighten. See **Fig. 25**.



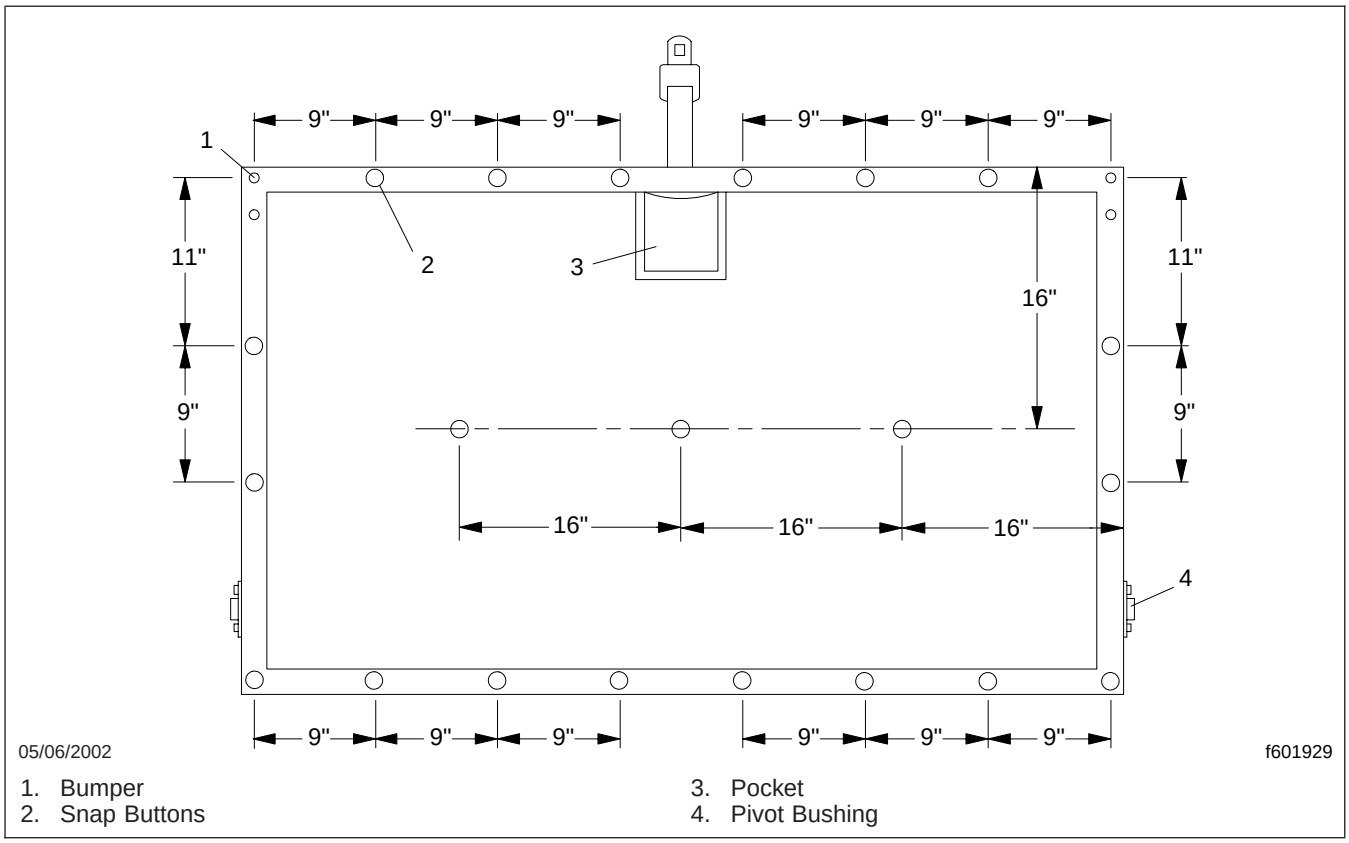

1. Pivot Bushing
2. 1/2-20 Nylok Nut
3. 1/2-Inch Flatwasher
4. Bunk Tray
5. 1/2 Nylon Washer
6. Bunk Wing
7. 1/2-Inch Flatwasher
8. 1/2-20 x 5 Hex Bolt
9. Pivot Bushing

**Fig. 25, Bunk Tray Mounting**

35. Tilt up the bunk and secure with the stowage strap. Place the bunk bottom upholstery against the bottom of the bunk. The pocket goes to the top (same edge as the stowage strap). See **Fig. 26**. The stowage strap should pass from under the edge of the upholstery. Install two rubber bumpers (part number 63322-3446) using #8-18 x 1-inch black, self taping screws (part number 4015-3409) each side at the top corners of the bunk, through the upholstery into the bunk tray. The bumpers are placed 1/2 inch (13 mm) from the sides, 3/4 inch (19 mm) from the front edge, and 2-3/4 inches (70 mm) from the front edge. See **Fig. 27**.
36. Install the twenty-one upholstery button snap screws around the perimeter and across the center of the bunk upholstery panel. See **Fig. 26**. Install the covered buttons onto the snap screws.
37. Set the wing mattresses (part number 56001-3458) onto each of the bunk wings. Install the bunk mattress (part number 56001-3457) onto the bunk tray. Fasten the mattress straps over the mattress to hold it in place when putting the bunk into the storage position.

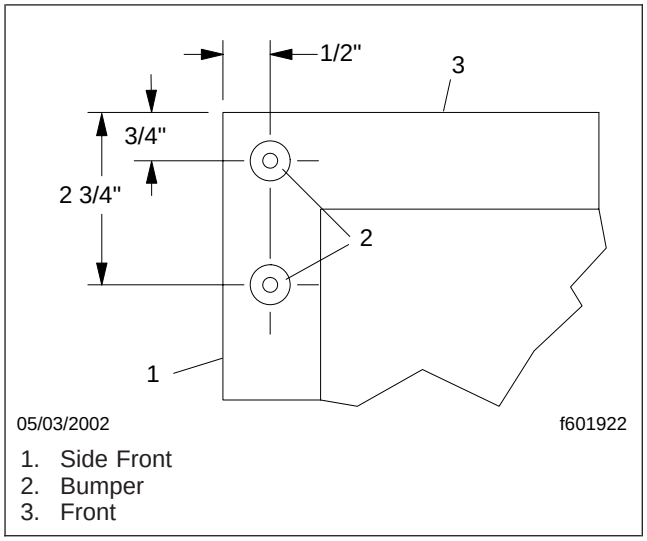
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1. Bumper
2. Snap Buttons
3. Pocket
4. Pivot Bushing

**Fig. 26, Bunk Snap Button Layout**




1. Side Front
2. Bumper
3. Front

**Fig. 27, Bumper Installation**

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## Side Window Replacement

48-inch, 62-inch and 76-inch sleepers may have optional side windows in place of side doors. See **Fig. 1**.

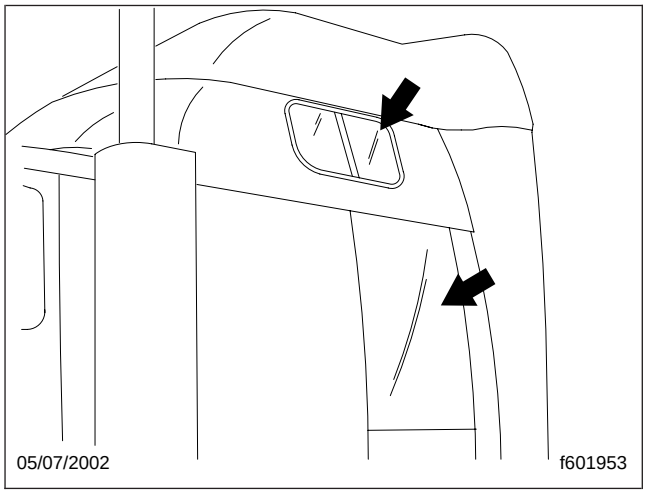



**Fig. 1, Sleeper Side Windows**

1. Remove the rubber seal from around the window. With the luggage door open pull the seal out, starting from a bottom corner.
2. Cut the adhesive between the window and the sleeper with a powered windshield removal tool or utility knife. See **Fig. 2**. This must be done from the inside of the sleeper.

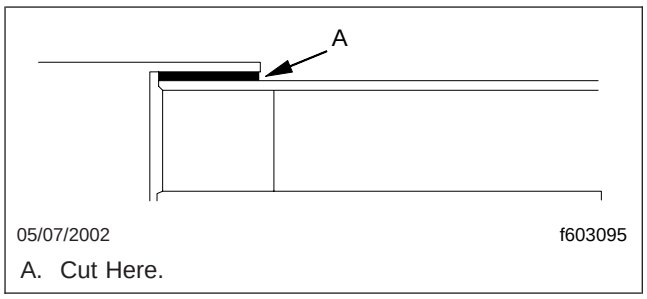



**Fig. 2, Side Window and Wall Crossection**

3. Cut off all tattered and loose adhesive from the frame without scraping off the undercoat from the contact surface areas (a utility knife works well). Cured adhesive can only be removed by cutting or scraping it off. It is okay to leave old *secure* adhesive.
4. Remove the old spacers.
5. If the primer surface is still unmarked, clean the area of all loose particles and wipe it clean with Sika Cleaner 205 applied to a lint-free towel. Allow to dry for a minimum of ten minuts, but not more than two hours.

If Sika cleaner 205 is not transparent but cloudy or brown do not use.

Never apply adhesive near on on wet alcohol based cleaners (Sika cleaner 205 contains alcohol).

6. If the undercoat has been removed or is scraped:
   - 6.1 Clean the contact surface about 2-inches larger than the area that is marred with a 50/50 mix of alcohol and water.
   - 6.2 Use a clean maroon scotch-bright pad to scuff all cntact surfaces.
   - 6.3 Wipe all contact surfaces with Sika Cleaner 205 on a lint free towel. Wipe in one direction and change the towel as required to avoid wiping a clean surface with a dirty towel.
   - 6.4 Wipe off the Sika Cleaner 205 with a lclean dry towel. Allow to dry for a minimum of ten minutes, but not more than two hours.
7. Prime the contact area.
   - 7.1 Mask the adjoining panels to prevent primer and adhesive from getting on to the painted surfaces.
   - 7.2 Vigorously shake the can of Sika Primer 206 until the ball rotates freely about the bottom rim of the can.
   - 7.3 Use a clean paint brush and coat the contact area with a thin even coat of Sika Primer 206. Always use a clean brush for each application. A new application is defined by a lapse of ten minutes or more.
   - 7.4 Allow primer to dry for thirty minutes. If the primer has sat for more than sixteen hours, wipe the primer with Sika Cleaner 205 and allow it to dry for ten minutes before aplying the adhesive.

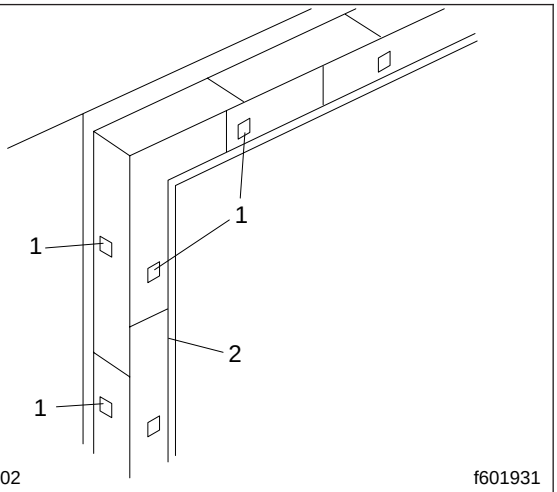
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## Sleeper Windows Replacement

NOTE: Do not apply Sika Primer 206 G/P over cured adhesive. If priming is required the contat surface Must be taken back down to bare metal.

8. Clean the glass contact surface with Sika Cleaner 205 on a lint free towel. Allow it to dry for a minimum of ten minutes, but not more than twohours.
9. Unlike common adhesives where the joint is made as tight as possible, Sikaflex 252 adhesive works best with a spaced joint. Place two 1/4-inch spacers on each side of the window opening, then center another spacer in between them. See **Fig. 3**.




1. Spacers
2. Contact Surface

**Fig. 3, Window Opening**

NOTE: The maximum time allowed to apply the adhesive, and put the window in place and clamp it, is twenty-five minutes.

Sikaflex 252 cures at a rate of 3/16-inch per 24 hours at 70°F (21°C) and 65 percent humidity. More time may be required depending n temperature and humidity. Lower temperature and/or lower humidity will increase the curing time.

10. Apply Adhesive.
    - 10.1 Cut the tip of a Sikaflex 252 nozzle with a V in one side approximately 5/8-inches (16 mm) deep, following the largest size opening guides on the nozzle. See **Fig. 4**.

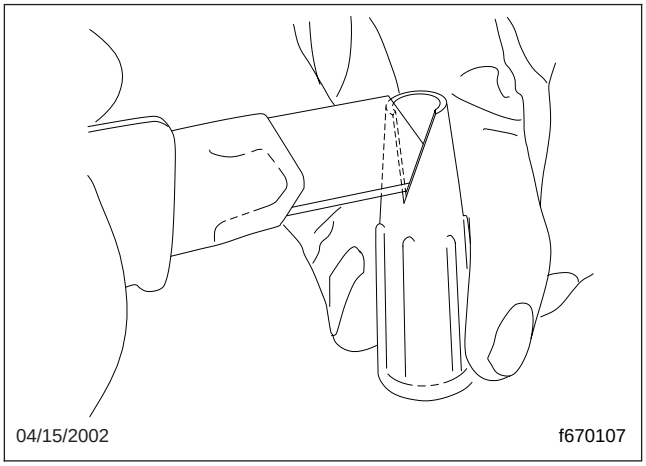
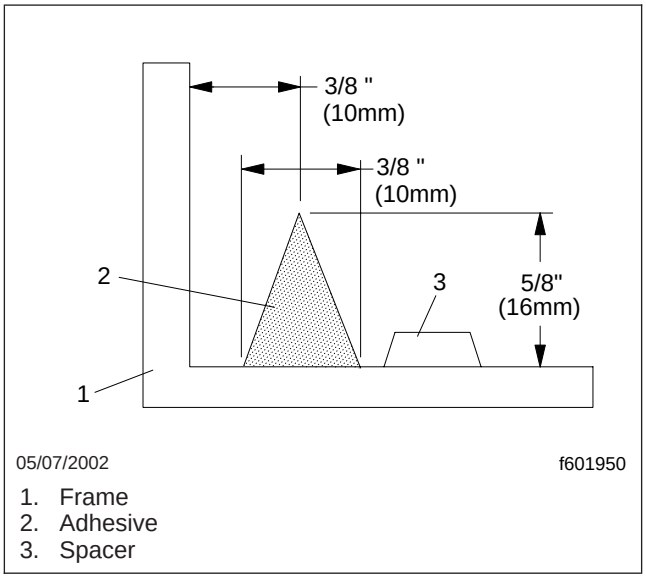



**Fig. 4, Sikaflex Nozzle**

- 10.2 Run a continuous 3/8-inch (10 mm) by 5/8-inch (15 mm) bead of Sikaflex 252 adhesive on the contact surfaces. See **Fig. 5**. The adhesive is laid down so that it forms a V. This is to prevent air gaps from forming when the panel is put in place. Rest the nozzle on the surface and pull it along, do not push it. Run the bead over the spacers on the contact surface.




1. Frame
2. Adhesive
3. Spacer

**Fig. 5, Crossection of Adhesive Bead**

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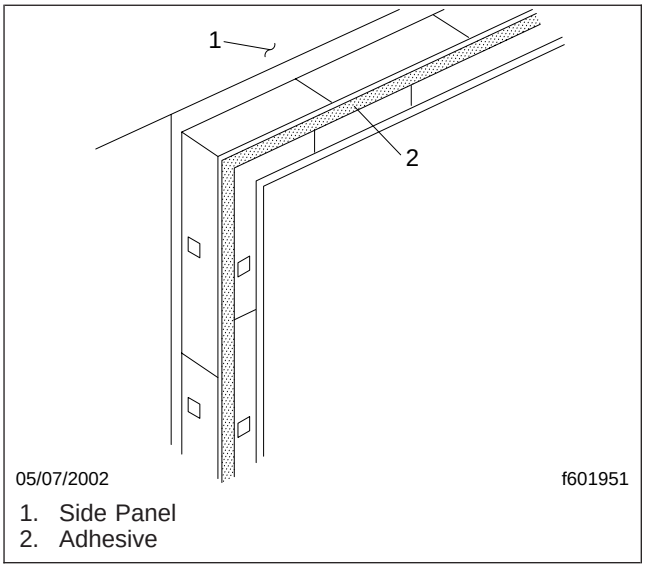
NOTE: Do not use silicone sealant near curing Sikaflex 252 adhesive. The vapors from the silicone causes the adhesive to break down.

If the Sikaflex adhesive appears to be stringy do not use it.

If a bead of adhesive over 12 inches (300 mm) will hang from the tip of the applicator nozzle do not use it. Good adhesive should fall off the nozzle around 6 to 8 inches (150 to 200 mm) in length.

In dry climates a humidifier can speed up curing time. Do not hose down the seams in an attempt to speed up curing time.

11. Run the bead of adhesive completely around the window opening. See **Fig. 6**.

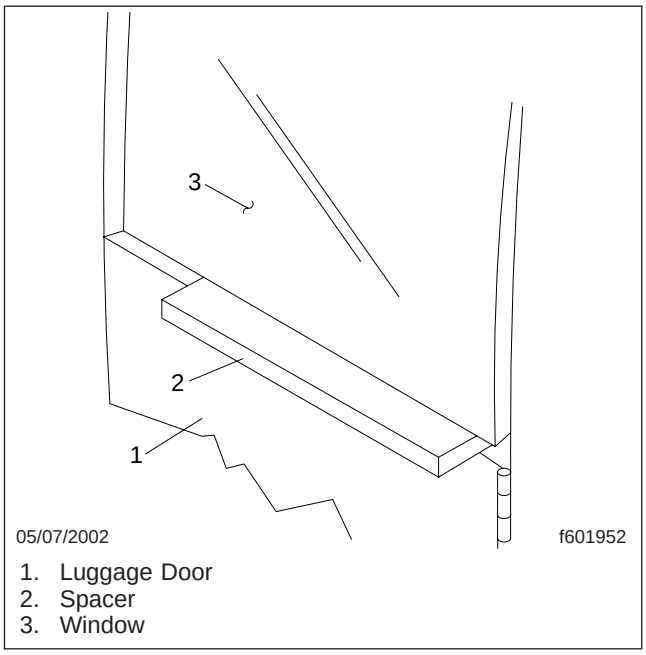



1. Side Panel
2. Adhesive

**Fig. 6, Window Opening**

12. With the luggage door closed, place a 3/8-inch thick piece of aluminum or wood to hold the window up until the adhesive cures. See **Fig. 7**.
13. Carefully place the bottom of the window on the spacer. Center the window and slowly tip it up into place.

NOTE: Once the window has made contact with the adhesive do not try to remove it or reposition it.




1. Luggage Door
2. Spacer
3. Window

**Fig. 7, Window Installation**

14. Carefully align the window and press it firmly to the adhesive. Use wide masking tape or suctin cups to hold the window in place. Devise a system that can applylight pressure to the windw and allow the adhesive twenty-four hours to cure.

NOTE: Wipe any adhesive off the painted surface immediately before the adhesive sets.

15. Insert the rubber seal around the window starting with a bottom corner and with the luggage door open.

## Sleeper Side Vent Window Replacement

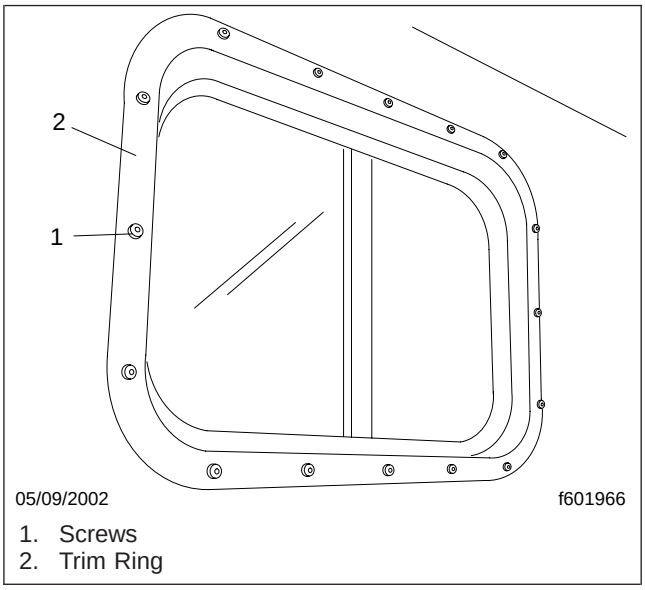
High roof sleepers may have optional vent windows. These windows are made up of two aluminum frames. The outside frame holds the glass and the inside frame secures the window in place.

1. On the inside of the sleeper, remove the screws from the trim ring and remove the trim ring. See **Fig. 8**.
2. Remove the upholstery from the roof side and remove the upholstery backing from around the window. See **Fig. 9**.

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## Sleeper Windows Replacement




1. Screws
2. Trim Ring

**Fig. 8, Vent Window Interior Trim Ring**

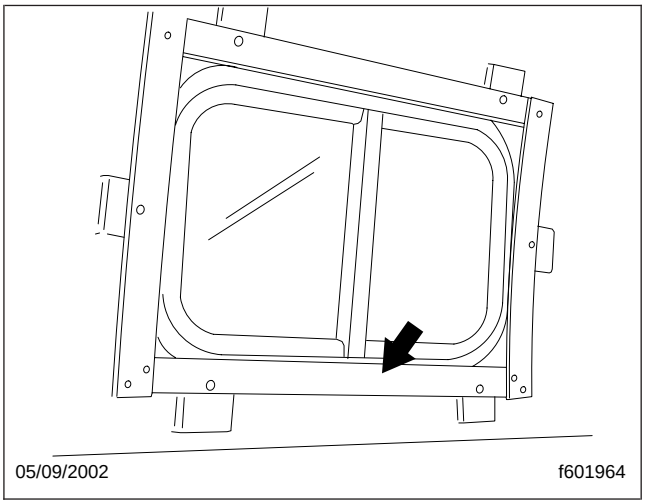
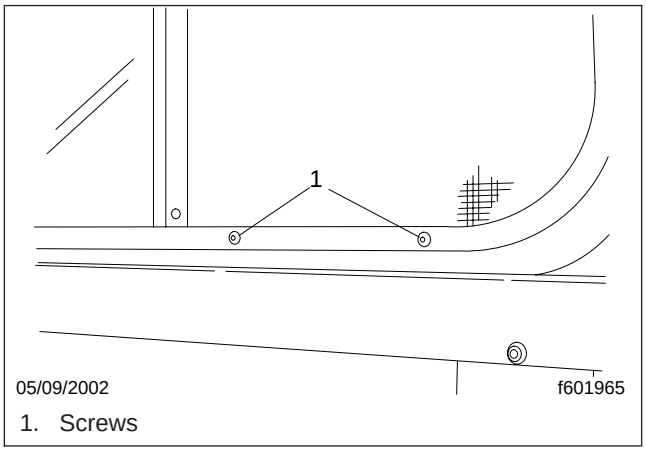


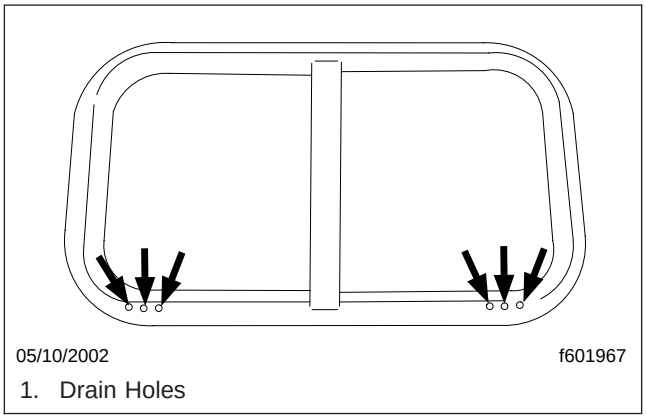

**Fig. 9, Upholstery Backing**

3. Remove the screws around the frame from the inside. See **Fig. 10**.
4. Clean the caulking from the window frame and window opening. Add new calking around the window frame. Place the window into the opening ensuring that the six drain holes in the frame are on the bottom. See **Fig. 11**.
5. Install the inside frame and screw it to the window.




1. Screws

**Fig. 10, Window Frame**




1. Drain Holes

**Fig. 11, Exterior of Vent Window**

6. Install the upholstery backing around the window and install the upholstery.
7. Position the trim ing in place and secure it in place with the screws.

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# Sleeper Water-Leak Detection and Repair

Use the following procedures to locate and repair areas where water may intrude into the sleeper.

## Water-Leak Detection

1. Spray the cab and sleeper with a soap-and-water solution, and pressurize the cab and sleeper to locate leaks; see **Section 60.05, Subject 100**, "Water-Leak Detection".
2. To pinpoint and repair leaks in a specific area, see the appropriate heading below. For cab water-intrusion issues, see **Section 60.05, Subject 100**.

## Walk-Through Cab Roof and Integration Joint

NOTE: Repairs in this area may require the disassembly and removal of the overhead console and interior upholstery.

To repair a leak at the top front corner of the sleeper, dry the area, and fill the seam in the affected area with sealant. See **Fig. 1**.

The cab-body/roof-cap joint has a continuous bead of sealant running the length of the seam. The sunvisor studs should have a bead of sealant around the stud mount, inside the cab. Check and repair the following areas, as needed.

- Sunvisor Studs—leaks through the sunvisor studs can be repaired by pulling back the insulation inside the cab and applying a 3/8-inch (10-mm) bead of sealant around the stud mount. Only the upper (rear) studs are likely to cause leaks. See **Fig. 2**.
- Cab-Body/Roof-Cap Front Seam—from inside the cab, check the length of the front seam where the roof cap contacts the cab body. See **Fig. 3**. Potential leak points can be identified by using a flashlight on the outside and watching for light along the inside seam. If necessary, remove the overhead console and add a new bead of sealant along the front seal.
- Cab-Body/Roof-Cap Side Seams—leaks can occur above the door under the roof cap. Since this area is not accessible from the inside, fill voids in the sealant under the roof cap from the outside. Use a length of air line or tubing to place sealant in hard-to-reach areas.
- Cab/Sleeper Sides—check the joints for visible voids or thin beads along the seams. If necessary, fill them with sealant.

## Sleeper Roof

A leak higher than the exhaust well usually originates in the sleeper roof-cap joint. See **Fig. 4**.

Check the drip rail for any pinholes or cracks in the caulking. For a small leak, dry the affected area, and seal the leak from the outside with a bead of clear sealant.

Check that the bottom edge of the roof cap is below the rim of the drip rail along the entire length of the drip rail. If the roof cap is above the drip rail and leaks are detected, seal the channel from inside the cab by applying bonding material into the roof cap joint from inside the cab. See **Fig. 5**. If the leak is severe, apply bonding material along the full length of the joint. Smooth the bonding material with a tongue depressor into the joint.

## Sleeper Exit Door

Check the sleeper exit door upholstery for interference with the door frame. Incorrectly positioned upholstery may keep the door from sealing.

If the baggage door upholstery requires repositioning, detach the upholstery panel from the Velcro® strips and reposition it. It should be level with the bottom of the door rivet that the stop cable is attached to, and 1/4 inch (6 mm) from the inside of the door edge, as shown in **Fig. 6**.

## Sleeper Baggage Door

Check the baggage door latch adjustment. The distance between the adjustment bolt and the door skin should be about 9/16 inch (14 mm). See **Fig. 7**. In case of a water leak at the door seal, adjust the setting for a tighter seal.

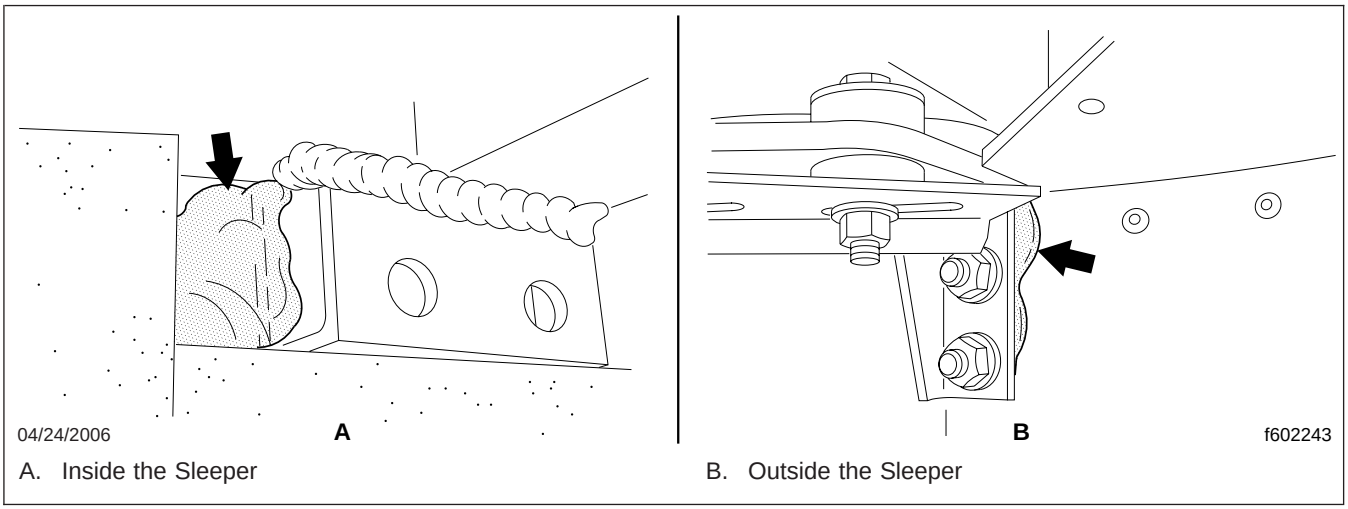
**⚠ CAUTION**

**Take care not to adjust the door latch too tightly. Too much pressure can deform the baggage door interior panel.**

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## Sleeper Water-Leak Detection and Repair




A. Inside the Sleeper

B. Outside the Sleeper

**Fig. 1, Sleeper Top Front Corner**

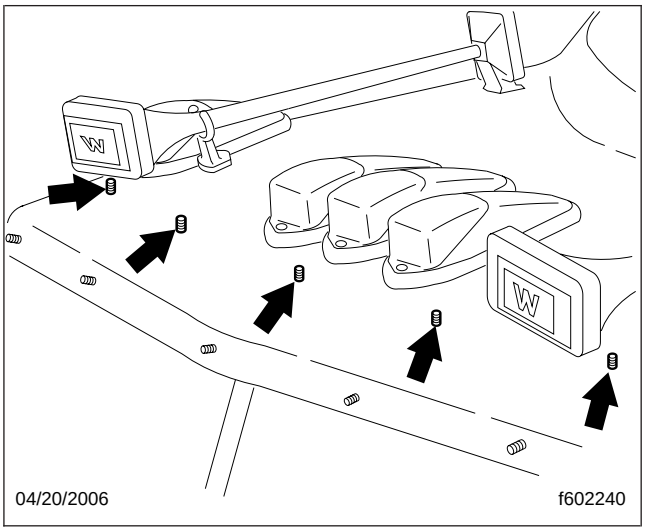
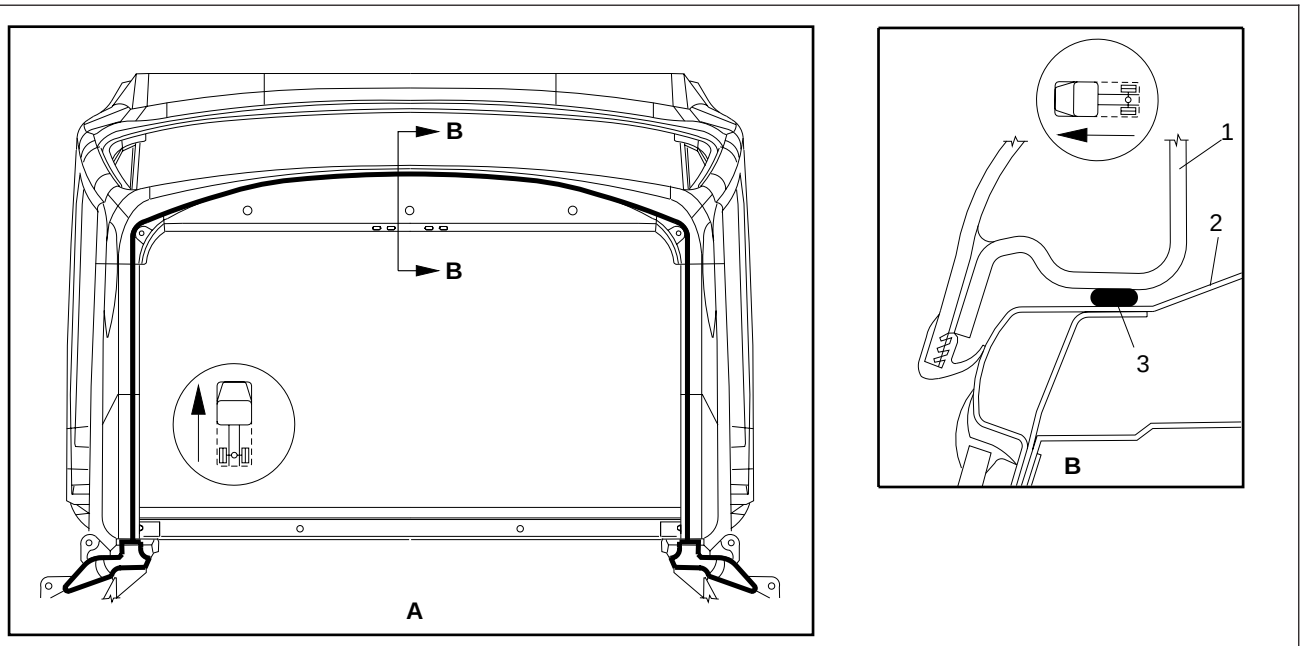



**Fig. 2, Sunvisor Studs**

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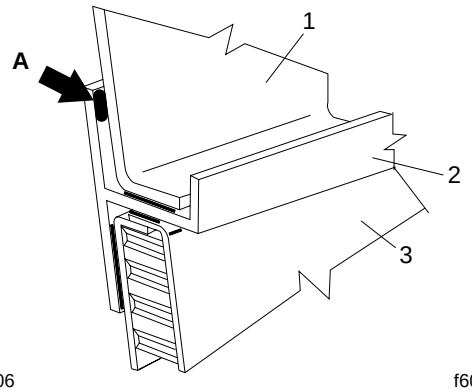





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A. Top View
B. Cab/Roof-Cap Seam Section
1. Roof Cap
2. Cab Body
3. Sealant Bead

**Fig. 3, Walk-Through Cab/Sleeper Seam**




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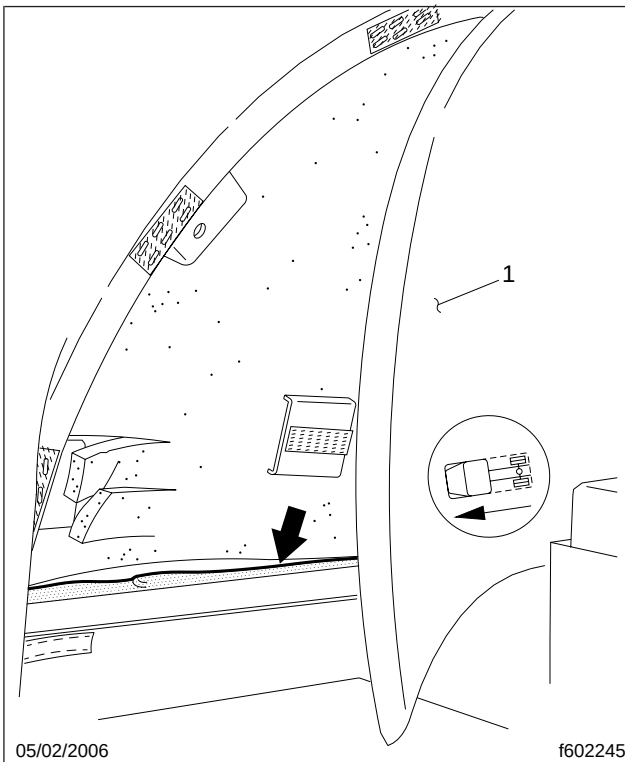
A. Add sealant here as required.
1. Sleeper Roof Cap
2. Drip Rail
3. Sleeper Side Panel

**Fig. 4, Drip Rail Cross Section**

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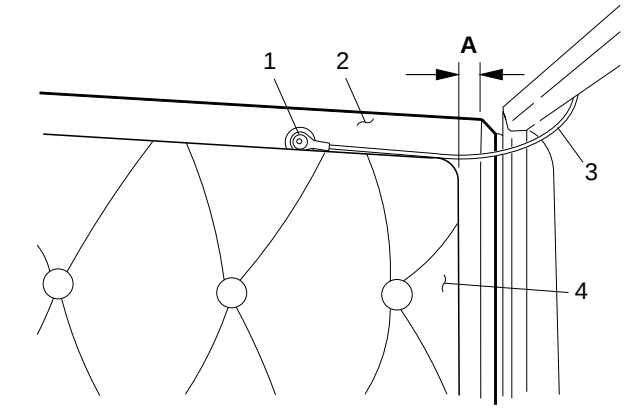
## Sleeper Water-Leak Detection and Repair




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1. Upholstery Panel (shown partially removed)

**Fig. 5, Sealant in the Sleeper Roof Seam**

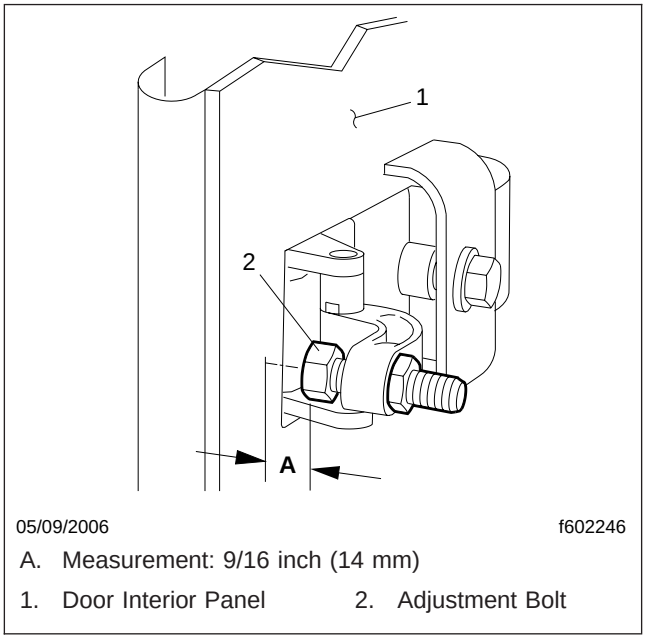



05/02/2006 f602247

A. Measurement: 1/4 inch (6 mm)

1. Door Rivet
2. Sleeper Exit Door
3. Stop Cable
4. Door Upholstery

**Fig. 6, Sleeper Exit Door Upholstery Positioning**




05/09/2006 f602246

A. Measurement: 9/16 inch (14 mm)

1. Door Interior Panel
2. Adjustment Bolt

**Fig. 7, Sleeper Baggage-Door Latch Adjustment**

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## Material Specifications

| Sleeper Panel Replacement Required Materials | |
|---|---|
| **Description** | **Quantity** |
| Sika Ultrafast Sealant or Sika 255 FC Sealant | One Tube |
| Sika Aktivator | One Can |
| Sika Cleaner 205 | One Can |
| Sika Primer | One Can |
| Locktite 410 | One Bottle |
| Sikaflex 252 Adhesive | As Required |
| Utility Knife and/or Powered Windshield Removal Tool | |
| Off-set Cutting Tool | |
| Cartridge Gun | |
| Disposable Activator Applicators | |
| Paper Towels | |
| Plastic Putty Knife | |
| Rubber Safety Gloves | |
| Drill With 3/16-inch Metal Bit | |
| Fine Scotch-Bright Pads | |

**Table 1, Sleeper Panel Replacement Required Materials**

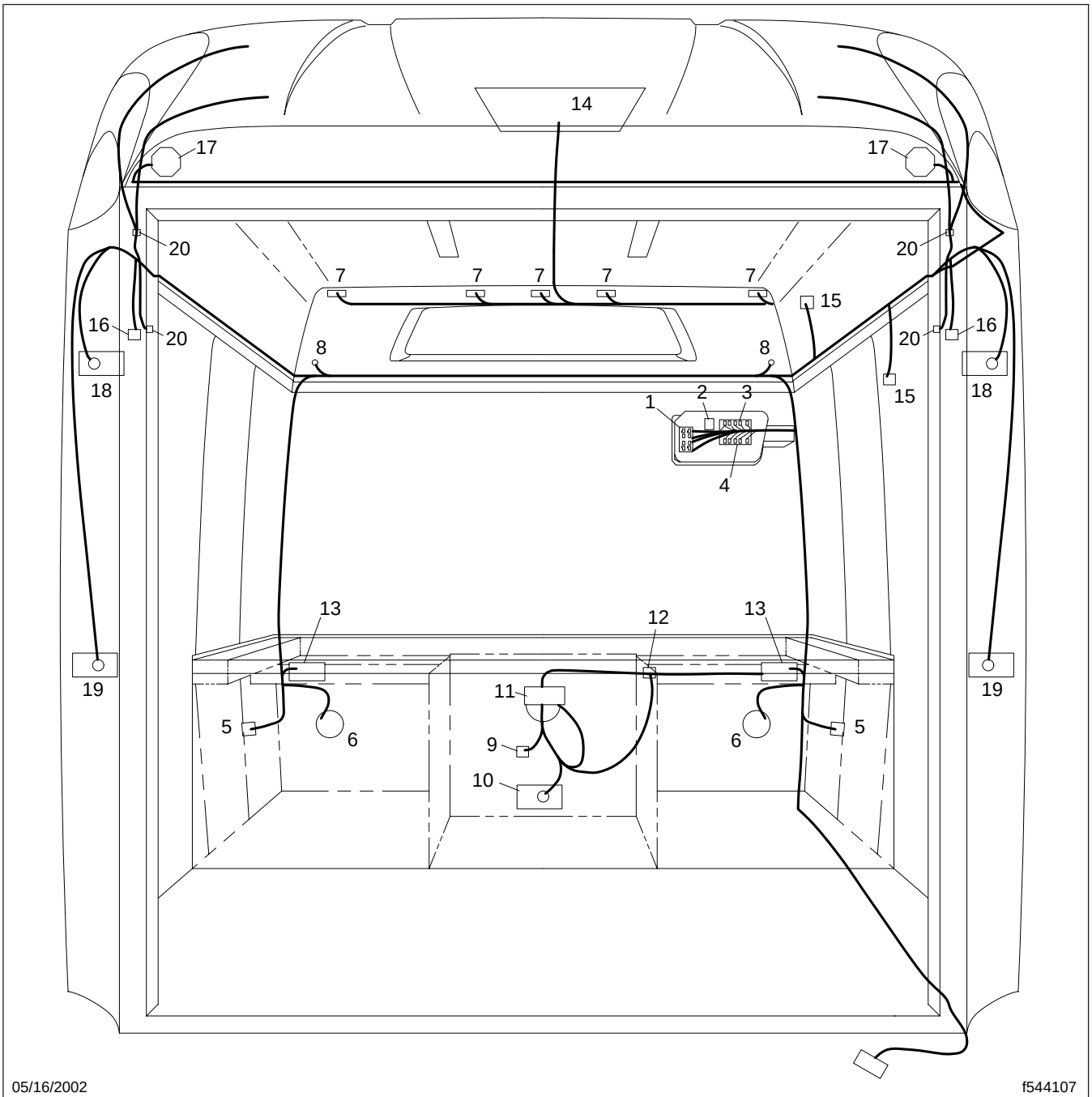
## Sleeper Electrical

**Figure 1** shows the location and routing of normal sleeper harnesses. Some wiring such as the TV, refrigerator, and some lighting are shown in both left- and right-side locations. These circuits will be installed on the vehicle on one side only as the location is optional for left or right.

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## Specifications




05/16/2002 f544107

1. Fuse Block
2. Relay
3. Terminal Strip
4. Grounds
5. Door Switch
6. Back-up Lamps
7. Marker Lamps
8. Work Lamps
9. Heater
10. Accessory 12V Power
11. Floor Lamp
12. Bunk Switch
13. Luggage Lamps
14. Dome Lamp
15. Reading Lamps
16. Desk Lamps
17. Speakers
18. TV Outlet
19. Refrigerator Outlet
20. TV Antenna

**Fig. 1, Star Light Sleeper Electrical Harnesses**

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# Bonded Windshield Removal and Installation

## Removal

**WARNING**

**Rubber safety gloves should be worn throughout the entire windshield preparation and installation procedure. Failure to do so may result in severe skin irritation, and risk serious health problems over the long term, from exposure to harsh chemicals.**

1. Pry up the exterior center post seal, starting from the bottom. See **Fig. 1**. Continue working the seal out of the windshield center post until removed. If the exterior center post seal is damaged, discard it. A new seal will be required.

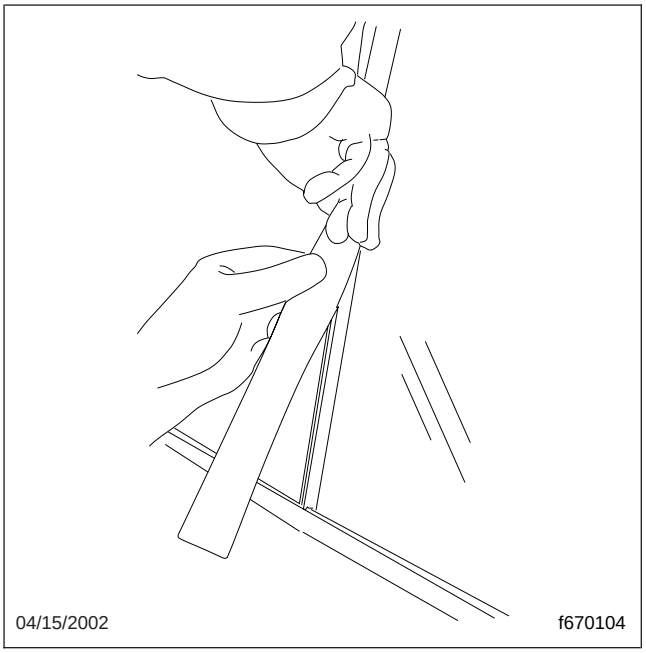
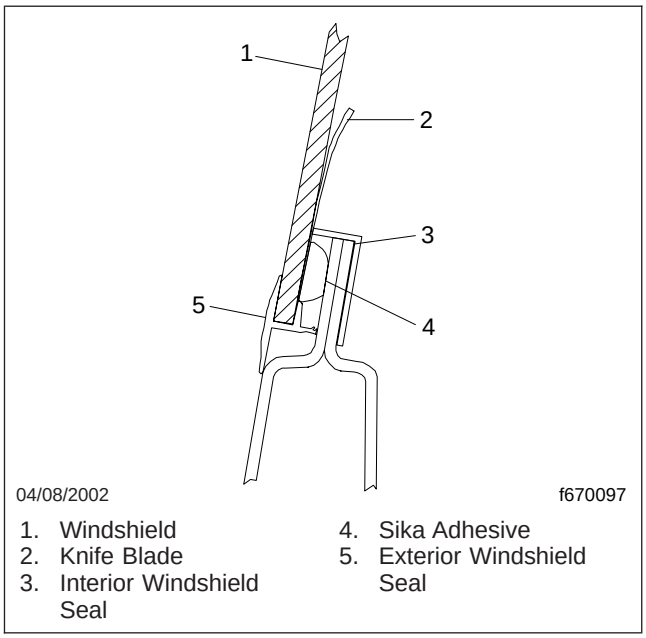



**Fig. 1, Removing The Exterior Center Post Seal**

2. Only the damaged side of the windshield needs to be removed. Insert a knife blade from inside the cab, between the window opening and the windshield. See **Fig. 2**. Press the knife tight against the windshield to avoid cutting the interior windshield seal. Cut completely around the windshield opening to remove the windshield and exterior seal intact. If the interior windshield seal is damaged, see **Subject 110** for instructions.




1. Windshield
2. Knife Blade
3. Interior Windshield Seal
4. Sika Adhesive
5. Exterior Windshield Seal

**Fig. 2, Section View Through Windshield**

NOTE: A power windshield removal tool will speed the removal of the windshield, but a utility knife will work.

3. Lift the damaged windshield from the opening with the exterior seal still attached.
4. Remove the exterior windshield seal from the outside edges of the windshield. If the seal is damaged, a new seal is required.

## Installation

1. Using duct tape, or a similar material, tape the interior windshield seal at the upper and lower corners, and pull it back to hold it away from the windshield opening. See **Fig. 3**. This helps to keep the interior seal from getting trapped between the windshield and the cab at the corners.
2. Remove any loose or tattered adhesive without scraping off the paint undercoat. Thin the adhesive by scraping with the utility knife. If a thin layer of old adhesive is securely bonded to the windshield opening, it is okay to leave it.
3. If the paint undercoat has been removed clean the surface with a mixture of 50/50 alcohol and water.

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## Bonded Windshield Removal and Installation

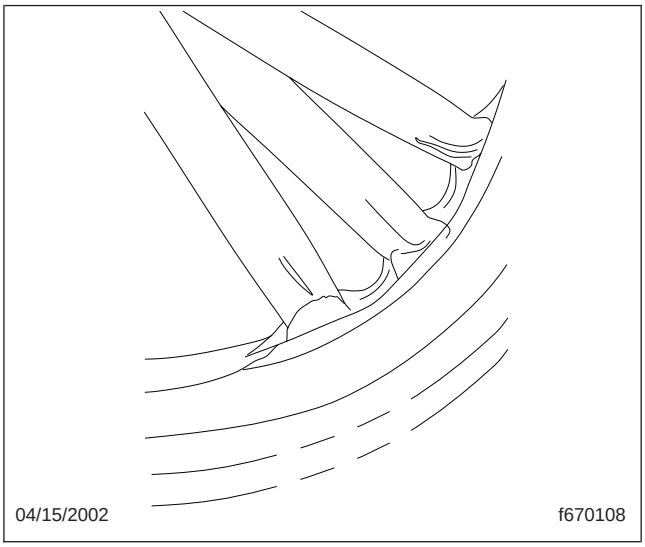



**Fig. 3, Lower Corner of Interior Windshield Seal**

4. Use a maroon scotch-bright pad to scuff the surface.
5. Wipe the area to clean it of all loose particles and dust.
6. Use a new, clean applicator to apply a coat of Sika-Aktivator around the windshield opening, and down the center post. Apply the activator in one continuous strip. See **Fig. 4**.

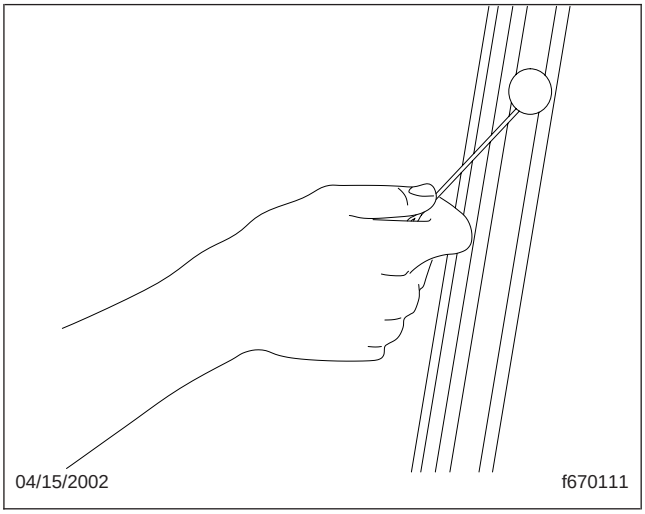



**Fig. 4, Applying Activator to Windshield Opening**

IMPORTANT: Use an applicator only one time. A used applicator must never be put back into the activator, as it will contaminate the solution. Contaminated activator will appear cloudy.

7. Using a paper towel, wipe the wet activator immediately, in one motion and in one direction. The activator will etch the cab surface to produce a firm bond to the glass.

IMPORTANT: No more than five minutes should elapse between etching and installing the windshield.

8. Place a new LH or RH windshield, exterior side facing up, on a surface that will not scratch the glass. Place two lift suction cups midway up the glass and firmly attach them. See **Fig. 5**. Test lift the windshield to ensure the cups are securely attached.

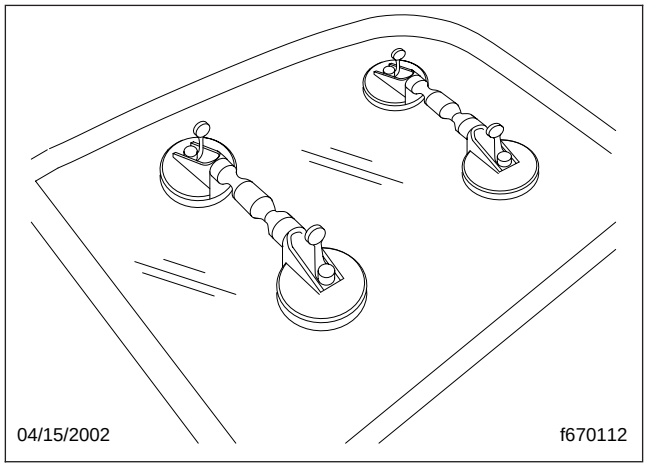


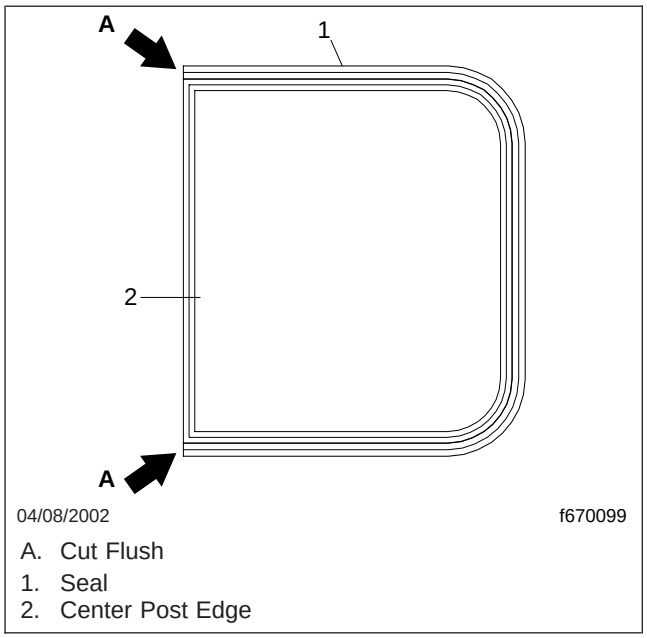

**Fig. 5, Windshield Lift Cups**

9. Turn the windshield over so the interior side is facing up.
10. Clean both sides of the glass along the blackened strip with Sika-Cleaner 205.
11. Position the exterior seal around three sides of the windshield, omitting the side where the center post is. See **Fig. 6**. Ensure that the flat, larger surface of the seal is on the exterior side of the glass. See **Fig. 7**. The soft material of the new seal should adhere to the glass. If it doesn't stay in place, a small amount of Loctite 410 can be used. If required, trim the ends of the seal flush with the center post edge of the glass.

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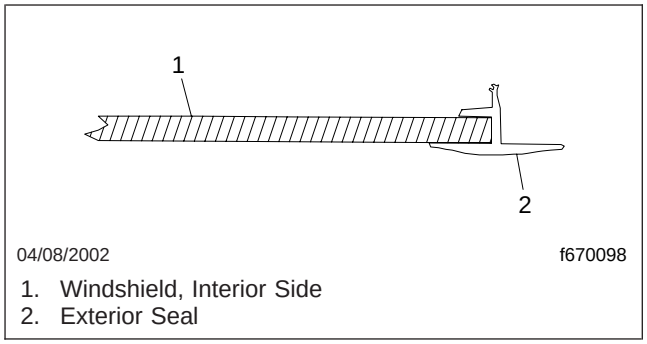


## Bonded Windshield Removal and Installation




A. Cut Flush
1. Seal
2. Center Post Edge

**Fig. 6, Windshield Exterior Seal**




1. Windshield, Interior Side
2. Exterior Seal

**Fig. 7, Cross-Section Through Windshield and Exterior Seal**

12. Use a new, clean applicator to apply a coat of Sika-Aktivator around the windshield, next to the seal, to etch the glass.

IMPORTANT: Apply the activator in a continuous strip. Wipe the activator in just one direction only.

13. Prepare a tube of Sika Tack® Ultrafast or Sikaflex® 255FC adhesive (see **Specifications 400** for a description and curing times).

    13.1 Use a utility knife to cut the applicator tip of a tube of adhesive at the third ring scored from the tip. See **Fig. 8**.

    13.2 Hold the tip vertically and cut a V in the applicator tip where the third V is scored. See **Fig. 9**.

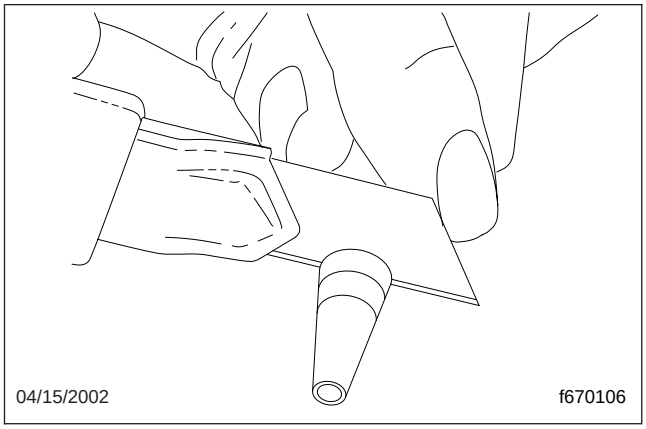



**Fig. 8, Applicator Tip**

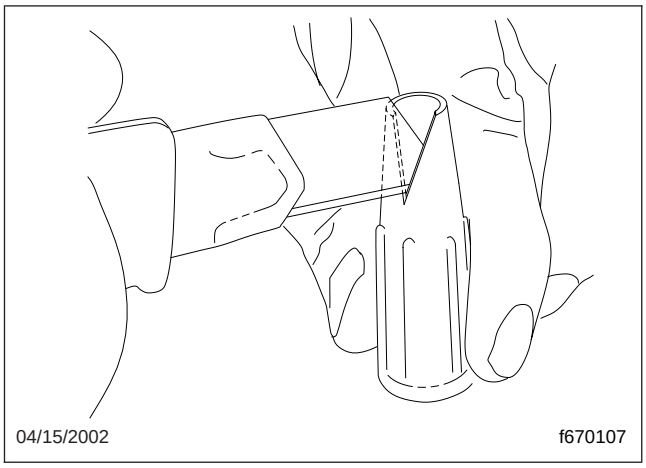



**Fig. 9, V Cut-away**

    13.3 Apply a test bead on a piece of cardboard, holding the applicator at 85 to 90 degrees. The bead should be approximately 5/16-inch wide x 1/2-inch high (8-mm wide x 12-mm high). The shape of the bead is such, that when the glass is pressed into the window opening, air pockets are minimized. See **Fig. 10**.

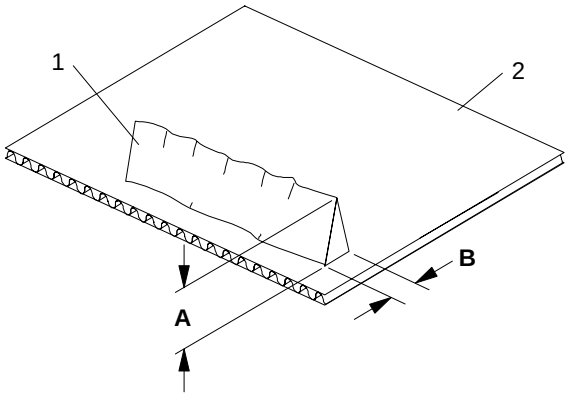
14. Start laying a bead of adhesive on the interior side of the windshield, beginning from the center divider side of the windshield, keeping in the center of the blacked-out strip. See **Fig. 11**.

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## Bonded Windshield Removal and Installation

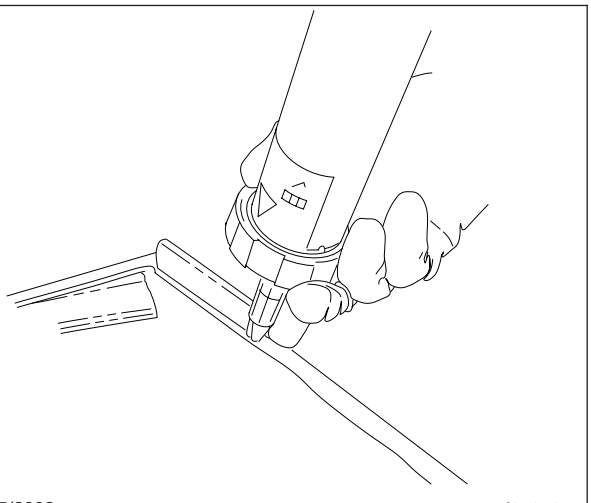
15. Apply one continuous bead of adhesive, 5/16-inch wide x 1/2-inch high (8-mm wide x 12-mm high). along the darkened perimeter of the windshield. See **Fig. 12**. Keep a steady bead moving around the corners.
16. Use a plastic putty knife to blend where the bead starts and finishes. This will avoid forming air pockets between the adhesive and the glass, which could result in water leakage.




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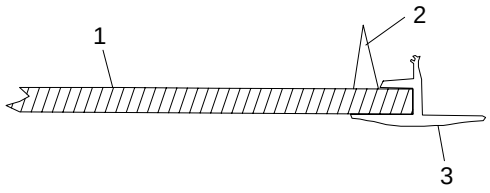
A. 1/2-inch (12-mm) High
B. 5/16-inch (8-mm) Wide
1. Sika Adhesive
2. Cardboard

**Fig. 10, Test Bead of Adhesive**



04/15/2002 f670105

**Fig. 11, Dispenser at an 85 to 90 Degree Angle**




04/08/2002 f670101

1. Interior of Windshield
2. Sika Adhesive Bead
3. Exterior Windshield Seal

**Fig. 12, Cross Section View of Windshield with Sika Adhesive Bead**

17. Using the lift cup handles, carry the windshield over to the appropriate side of the cab. Carefully align the windshield, centered in the opening. Gently press the windshield glass in tight around the opening until a complete seal has been formed. Use a plastic putty knife to adjust the outer edge seal to lay flat against the cab surface. Use masking tape to hold the windshield in place while the adhesive cures.

IMPORTANT: The windshield may be moved around in the opening, but do not pull it off to reposition it. This could form air bubbles and produce a poor bond, and possible water leaks.

18. Install the exterior center post seal.
    - 18.1 Apply a small amount of Loctite 410 along the center post groove. See **Fig. 13**. Starting at the top, align the center post seal with the top edge of the exterior windshield seal. Press the seal into the groove of the center post. Work progressively down the center post. Run a hard roller up and down the seal to ensure it is seated. See **Fig. 14**.
    - 18.2 Use the putty knife to lift the top and bottom corner of the center post seal, where it overlaps the windshield seal. Apply dabs of Loctite 410 to the back of the seal in the corners and press it down.
    - 18.3 Use wide masking tape to hold the seal down while the Loctite sets.

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## Bonded Windshield Removal and Installation

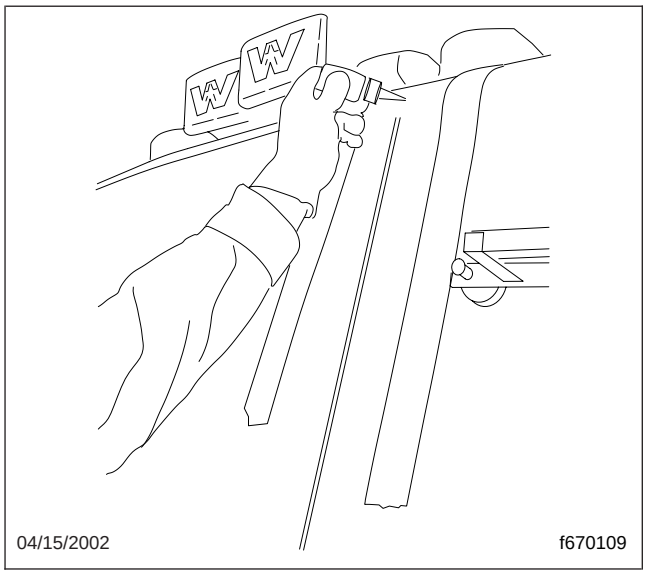



**Fig. 13, Apply Loctite 410 to Center Post Groove**

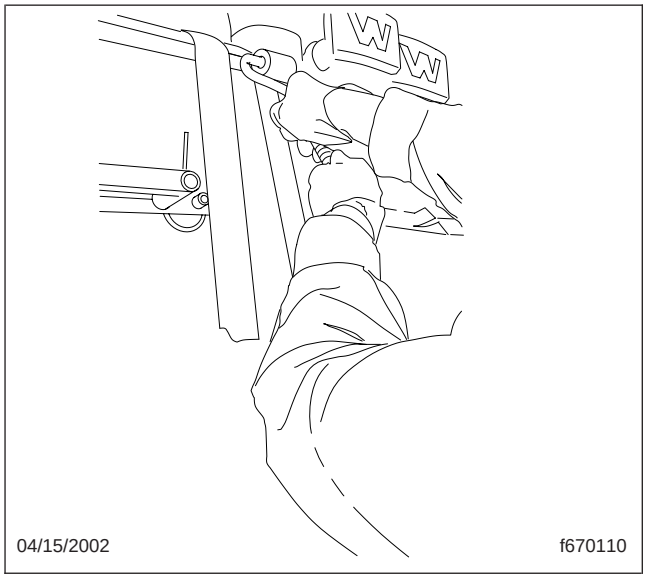



**Fig. 14, Install Center Post Seal**

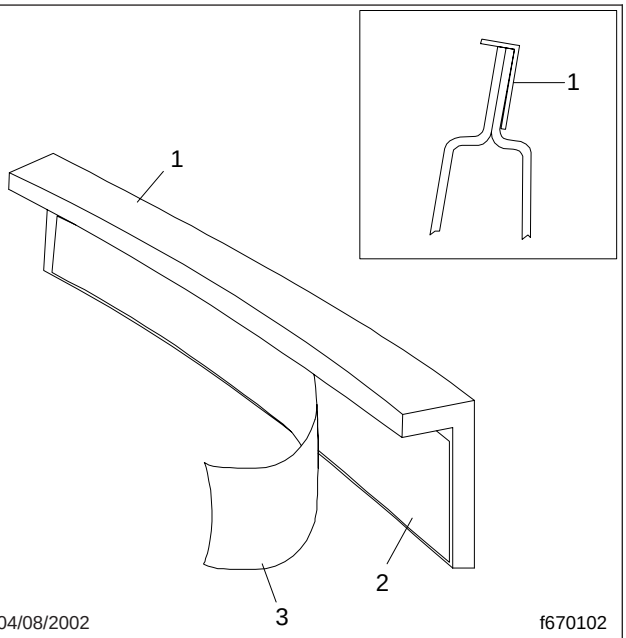
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## Interior L Seal Replacement

NOTE: The interior L seal (part number 51006-3428-2345) is affixed to the inside of the windshield opening with a self adhesive strip.

1. Pull off the damaged seal then remove any trace of adhesive from the windshield frame. Clean the inside edge of the windshield with Sika Cleaner.
2. Peel approximately six inches of the backing tape from the L seal. See **Fig. 1**.




1. Interior L Seal
2. Adhesive Tape
3. Backing Tape

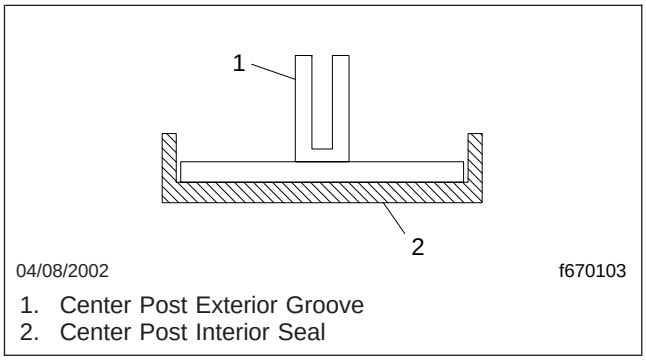
**Fig. 1, Interior L Seal**

3. Beginning at the top of the windshield, tight against the center post, orient the new seal with the short leg of the seal facing out, and projecting out of the windshield opening.
4. Press the seal firmly to the windshield frame. Work around the windshield opening and around the corners, making sure not to stretch the seal.
5. Install the full length of the seal, then use a utility knife to trim the end flush with the other edge of the center post.

## Interior Center Post Seal Replacement

NOTE: The interior center post seal is affixed to the inside of the center post with a self adhesive strip.

1. Pull off the damaged seal, then remove any trace of adhesive from the center post. Clean the inside edge of the center post with Sika cleaner.
2. Remove the backing tape from the new seal.
3. Beginning at the top of the center post, align the seal with the top edge of the L seal. Orient the center post seal with the short legs of the seal facing out, and projecting out each side of the center post. See **Fig. 2**.




1. Center Post Exterior Groove
2. Center Post Interior Seal

**Fig. 2, Cross Section View of Center Post with Interior Seal Attached**

4. Press the seal firmly to the center post, working from top to bottom, making sure not to stretch the seal.
5. Use a utility knife to trim the seal flush with the edge of the interior windshield L seal.

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| Windshield Replacement, Required Materials | |
|---|---|
| **Description** | **Quantity** |
| Sika Ultrafast Sealant or Sika 255 FC Sealant | One Tube |
| Sika Aktivator | One Can |
| Sika Cleaner | One Can |
| Locktite 410 | One Bottle |
| Utility Knife and/or Powered Windshield Removal Tool | |
| Windshield Lift Cups | |
| Cartridge Gun | |
| Disposable Activator Applicators | |
| Paper Towels | |
| Plastic Putty Knife | |
| Rubber Safety Gloves | |

**Table 1, Windshield Replacement, Required Materials**

## Sika Tack® Ultrafast Adhesive

This is a fast curing adhesive that requires heating to 176°F (80°C). Tack-free time is about ten minutes. Clamping time is 30 minutes. Total cure time is about 24 hours, depending on temperature and humidity. Higher temperature and humidity speeds up cure time.

## Sikaflex® 255FC

This is a fast curing adhesive that does not require heating. Tack-free time is about twenty minutes. Clamping time is one hour. Total cure time is about 36 hours, depending on temperature and humidity. Higher temperature and humidity speeds up cure time.

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## Front Cab Mounts Removal and Installation

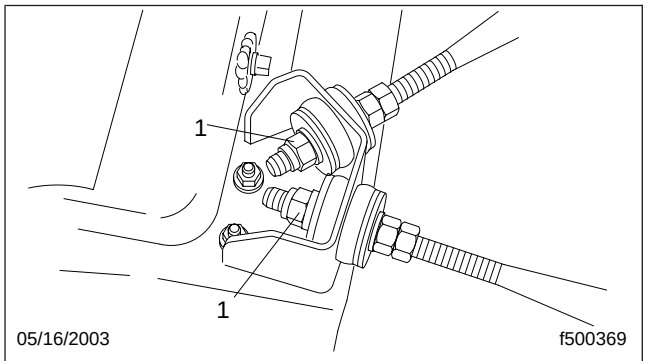
# Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Open the hood.
3. Support the rear of the cab with jack stands or blocks of wood between the frame rail and the cab.

## NOTICE

**When blocking up the cab be sure to place the blocks on a structural crossmember or spread the load over a large area of the cab floor, or they may damage the composite flooring.**

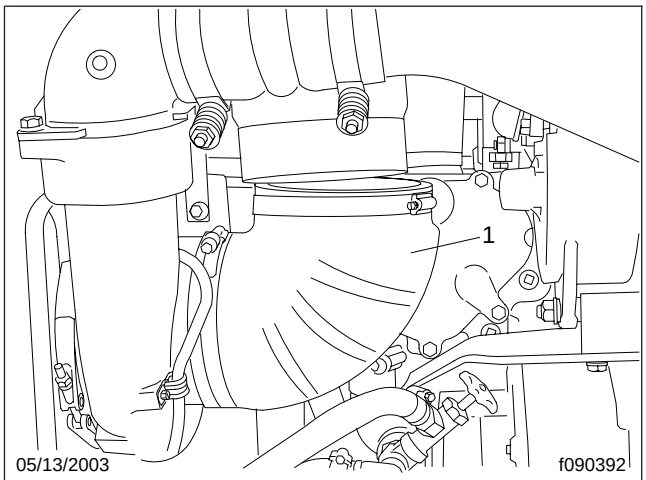
4. Loosen the nuts holding the radiator supports to the radiator, then remove the 1/2–20 fasteners holding the supports to the cowl. See **Fig. 1**.




1. Radiator Support at Radiator

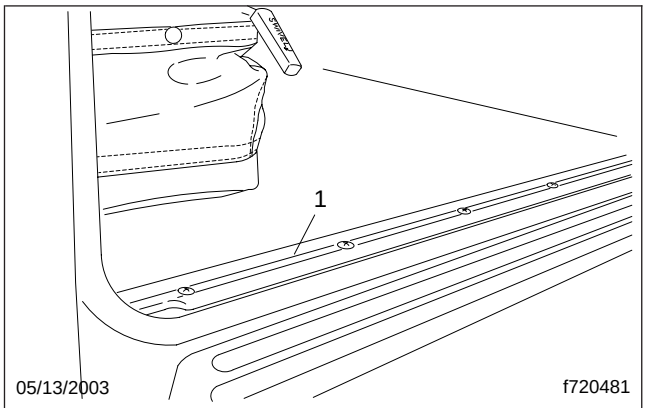
**Fig. 1, Radiator Supports**

5. Loosen any air, electrical, or heater lines that may bind when the cab is lifted.
6. Disconnect the air intake at the turbo-inlet elbow. See **Fig. 2**.
7. Remove the left and right cab skirts. If necessary, remove the heater plug from the cab skirt.
8. Remove the left and right treadplates that fasten the edge of the carpet or floormat at the door opening. See **Fig. 3**.
9. Roll back the carpet or floormat to expose the cab-mount access cover plates. See **Fig. 4**. Using a heat gun, apply heat to soften the adhesive and remove the cover plates.



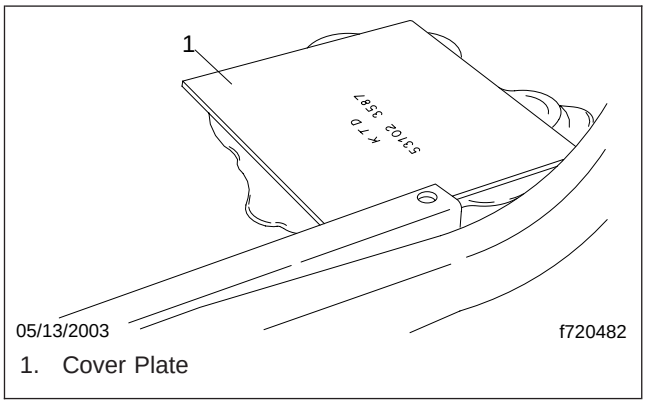

1. Rubber Elbow

**Fig. 2, Air-Intake Turbo Inlet Elbow**




1. Treadplate

**Fig. 3, Cab Door Opening**




1. Cover Plate

**Fig. 4, Cab Mount Access**

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## Front Cab Mounts Removal and Installation

10. Remove the mounting bolts, nuts and washers from the isolators. See **Fig. 5** (pre-EPA10 and pre-ADR 80/03 vehicles) or **Fig. 6** (EPA10 and ADR 80/03 vehicles).
11. Lift the front of the cab with an overhead hoist or jacks then support the front of the cab with blocks.

**⚠ WARNING**

**Before lifting the cab from the chassis, make sure the cab is correctly balanced and is supported in at least four places. If a hoist is being used, make sure it is strong enough to support the cab. Failure to do so could result in the cab falling, which could cause serious personal injury and damage to the cab.**

**NOTICE**

**When blocking up the cab be sure to place the blocks on a structural crossmember or spread the load over a large area of the cab floor, or the blocks may damage the composite flooring.**

12. Pry the rubber isolators out of the cab-mount frame bracket.
13. Remove any fuel or air line support clamps from the front cab crossmember.
14. *For pre-EPA10 and pre-ADR 80/03 vehicles,* remove the 1/2–20 fasteners that hold the right-hand and left-hand front cab-crossmember clamps to the front cab-mount frame brackets, and remove the clamps.

    *For EPA10 and ADR 80/03 vehicles,* remove the M14 nuts and the washers that hold the right-hand and left-hand front cab-crossmember U-bolts to the front cab-mount frame brackets, then remove the U-bolts.
15. Remove the front cab crossmember. See **Fig. 5** and **Fig. 6**.
16. Remove the 1/2–20 (pre-EPA10 and pre-ADR 80/03 vehicles) or 5/8–18 (EPA10 and ADR 80/03 vehicles) fasteners that fasten the front cab-mount frame bracket to the frame rail. Remove the bracket.

## Installation

1. Attach the front cab-mount frame bracket to the frame using the 1/2–20 (pre-EPA10 and pre-ADR 80/03 vehicles) or 5/8–18 (EPA10 and ADR 80/03 vehicles) fasteners that were removed. Tighten the nuts to 77 lbf·ft (105 N·m).
2. If installing a new crossmember, weld studs onto the new crossmember, using the old crossmember as a guide for placement.
3. Install the front cab crossmember, making sure the dowel in the cab support aligns with the hole in the crossmember tube.
4. Install the right-hand and left-hand front cab-support clamps, making sure the dowels on the clamps and supports align with the holes in the crossmember.

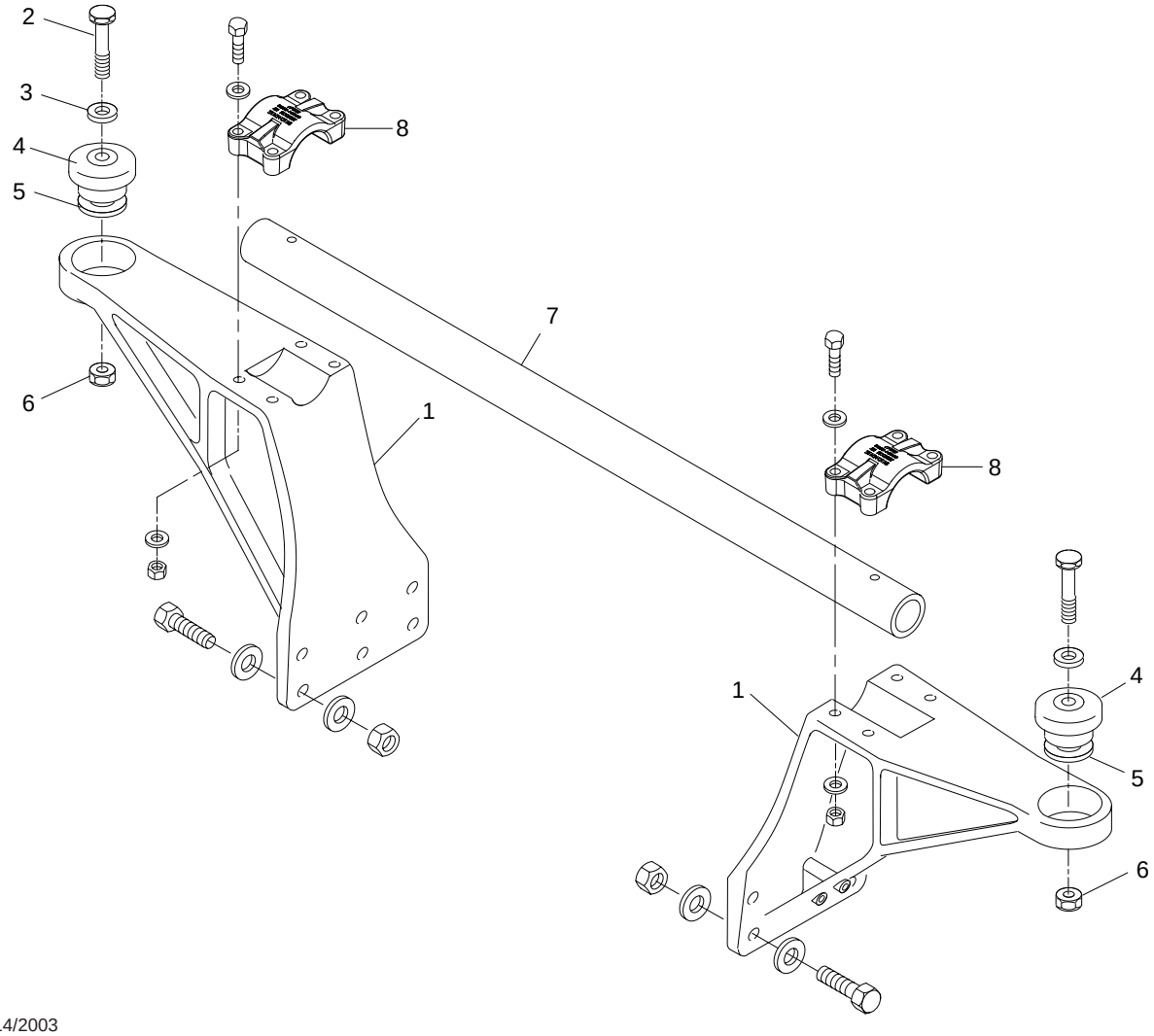
    *For pre-EPA10 and pre-ADR 80/03 vehicles,* tighten the nuts 77 lbf·ft (105 N·m).

    *For EPA10 and ADR 80/03 vehicles,* tighten the nuts 106 lbf·ft (144 N·m).
5. Attach any fuel, air, or electrical lines to the front cab crossmember.
6. Install the isolators into the cab-mount brackets, using soapy water to lubricate the isolators, if necessary.
7. Install the cab-mounting bolts through the cab floor.
8. Lower the cab, making sure the cab-mounting bolts align with the holes in the isolators.
9. Install the nuts and washers onto the cab-mounting bolts. Torque the nuts to 154 lbf·ft (210 N·m).
10. Applying heat, soften the adhesive around the cab mount access holes and press the cover plates into place.
11. Lay out the carpet or floormat on the floor and install the treadplates.
12. If necessary, install the heater plug into the cab skirt. Install the cab skirts.
13. Install the intake ducting. Tighten the clamps to 60 lbf·in (677 N·cm).
14. Attach any air, electrical, or heater lines that were disconnected.

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## Front Cab Mounts Removal and Installation




1. Frame Bracket, Front Cab Mount
2. Bolt, Cab Mount
3. Washer
4. Isolator, Front Cab Mount
5. Washer, Flat, Hard, 5/8 x 2.5 x 0.19 PRMD
6. Nut, Cab Mount
7. Crossmember, Tubular Front Cab Support
8. Clamp, Front Cab Crossmember

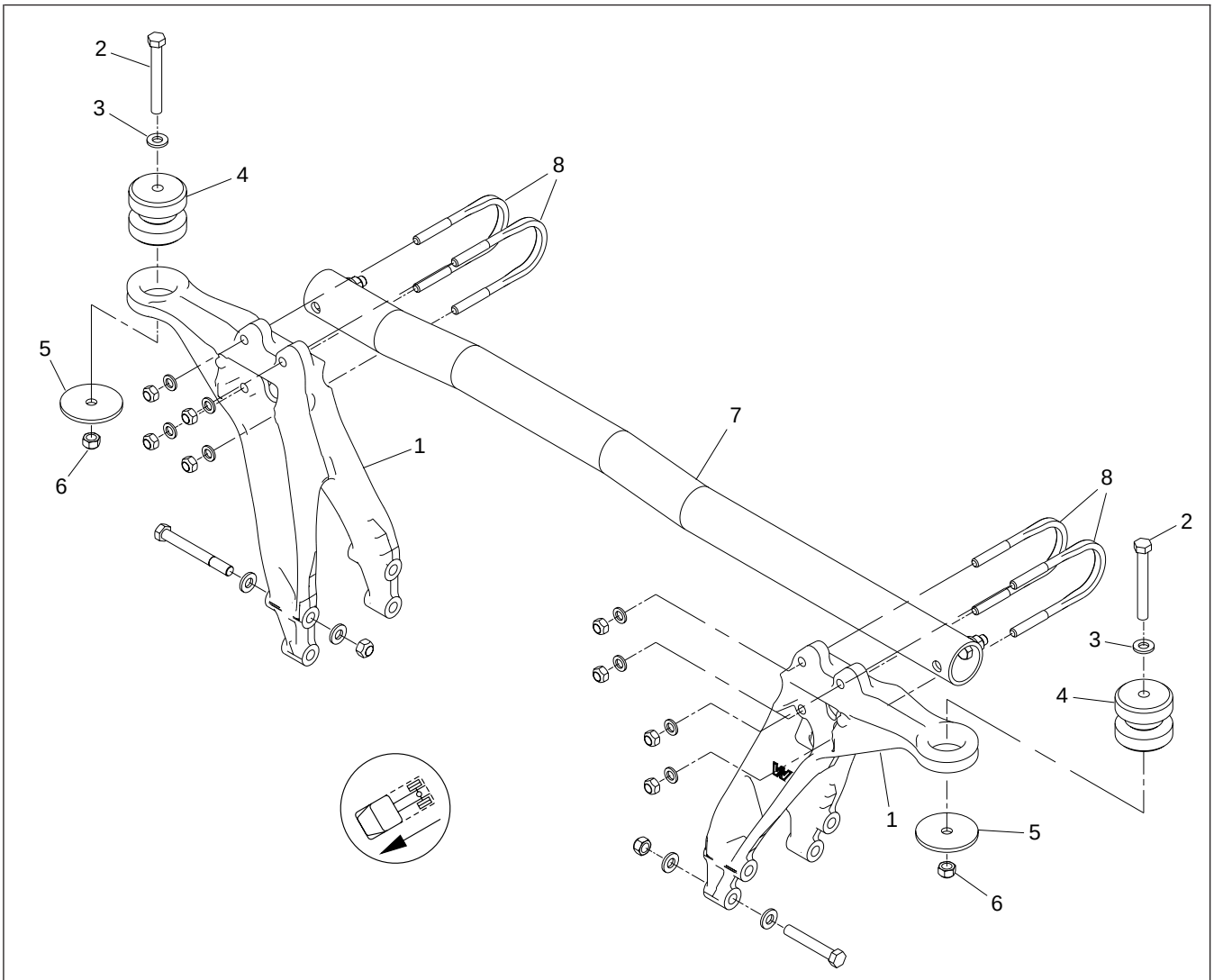
**Fig. 5, Front Cab Mount, Standard Cab Height (Pre-EPA10 and Pre-ADR 80/03)**

15. Install the radiator supports to the cowl and tighten them to 77 lbf·ft (105 N·m). Tighten the radiator support-to-radiator nuts until the bushing is snug.

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## Front Cab Mounts Removal and Installation




1. Frame Bracket, Front Cab Mount
2. Bolt, Cab Mount
3. Washer
4. Isolator, Front Cab Mount
5. Flatwasher
6. Nut, Cab Mount
7. Crossmember, Tubular Front Cab Support
8. U-Bolts

**Fig. 6, Front Cab Mount, Standard and Raised Cab Height (EPA10 and ADR 80/03)**

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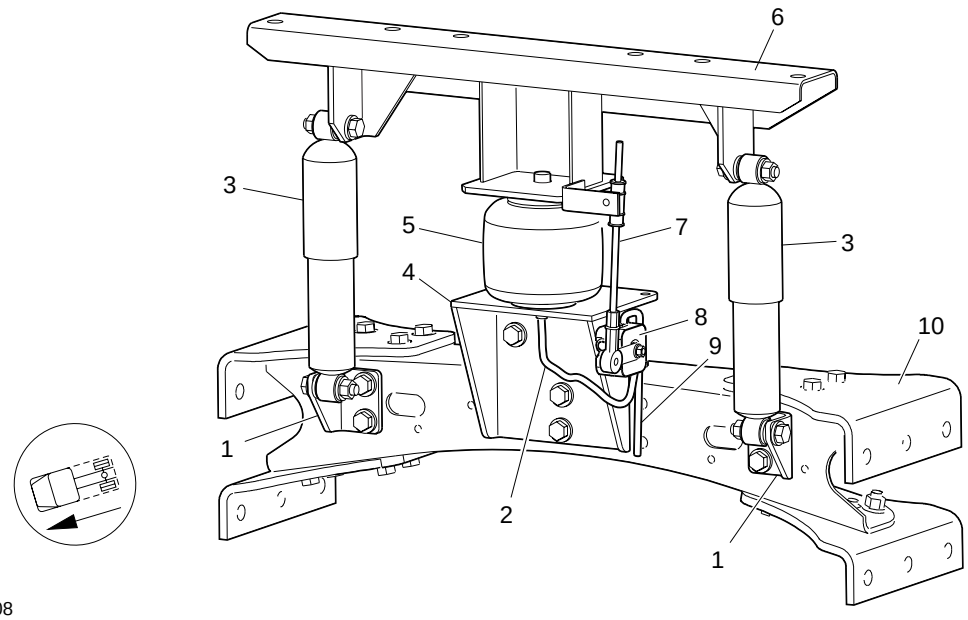
# General Information

The cab rear air-suspension system absorbs road shocks better than a solid-mount system, and thus provides a smoother ride for cab occupants and cab-mounted equipment.

The Western Star day cab (except 4700 Model) air-suspension system consists of a single air spring attached to the cab crossmember, a height-control valve, a vertical linkage, and two shock absorbers; see **Fig. 1** and **Fig. 2**. The 4700 Model air-suspension system has two combination air spring/shock units, a height-control valve, a vertical linkage, and a lateral control rod; see **Fig. 3**. The SleeperCab air-suspension system uses two or four air springs that are attached to frame rail brackets, a height-control valve, a vertical linkage, two or four shock absorbers, and a lateral control rod; see **Fig. 4**.

## Height-Control Valve

All of the air in the cab and sleeper air-suspension system is supplied through or exhausted from the height-control valve. It mounts on the air spring support bracket welded to the crossmember or the frame bracket. The height-control valve has a horizontal control lever, the outboard end of which is connected to the vertical linkage. The upper end of the vertical linkage is attached to a fixed support bracket attached to either the cab or sleeper.




03/17/2008 f311061

1. Lower Shock Absorber Bracket
2. Air Spring Tubing
3. Shock Absorber
4. Air Spring Lower Bracket
5. Air Spring
6. Cab Rear Support Bracket
7. Vertical Linkage
8. Height-Control Valve
9. Supply Air Tubing
10. BOC Crossmember

**Fig. 1, Cab Rear Air Suspension, Day Cab with 5-Piece Bolted BOC Crossmember**

## Air Springs

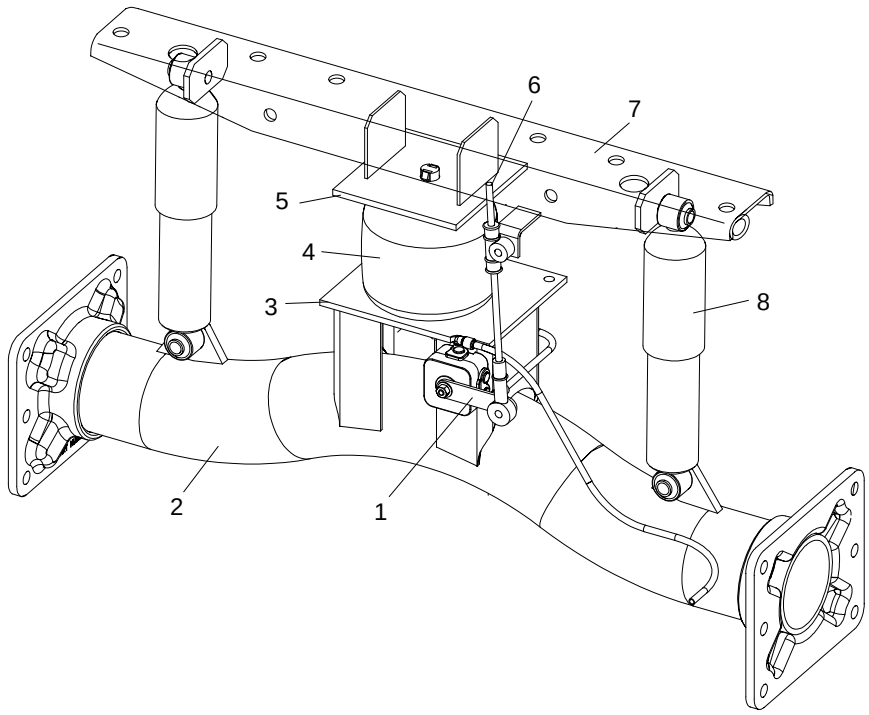
On the day cab suspension, the top of the air spring is attached to the cab support bracket, and the bottom is attached to the crossmember. On a SleeperCab, the tops of the air springs are attached to the sleeper support bracket, and the bottoms are attached to the air spring frame brackets. Together with the height-control valve, the air spring compensates for changes in load by maintaining the correct height at the rear of the cab or sleeper.

When the load on the cab increases, the distance between the cab and the crossmember decreases, causing the vertical linkage to push downward on the end of the horizontal control lever. This turns the

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## General Information




02/27/2003 f310939

1. Height-Control Valve Horizontal Control Lever
2. Crossmember
3. Air Spring Lower Support Plate
4. Air Spring
5. Air Spring Upper Plate
6. Vertical Linkage
7. Cab Rear Support Bracket
8. Shock Absorber

**Fig. 2, Cab Rear Air Suspension, Day Cab with Tubular BOC Crossmember**

height-control valve shaft, which activates the height-control valve. Air flows through the valve and into the air spring(s) until the pressure in the spring(s) raises the cab to the correct height. At this height, the control lever and the control shaft are returned to their neutral positions, closing the intake air supply.

When the load on the cab decreases, the rear of the cab rises, causing the vertical linkage to pull up on the end of the horizontal control lever. Turning the height-control valve shaft in this direction activates an exhaust port in the valve. This allows air pressure in the air spring(s) to decrease until the cab is lowered to the correct height. Again, the control lever and control shaft are returned to their neutral positions, and air flow is stopped.

When the vehicle is in motion, small and abrupt movements of the cab will occur, resulting in small or abrupt movements of the control lever. These movements of the control lever do not activate the height-control valve to correct the cab ride height.

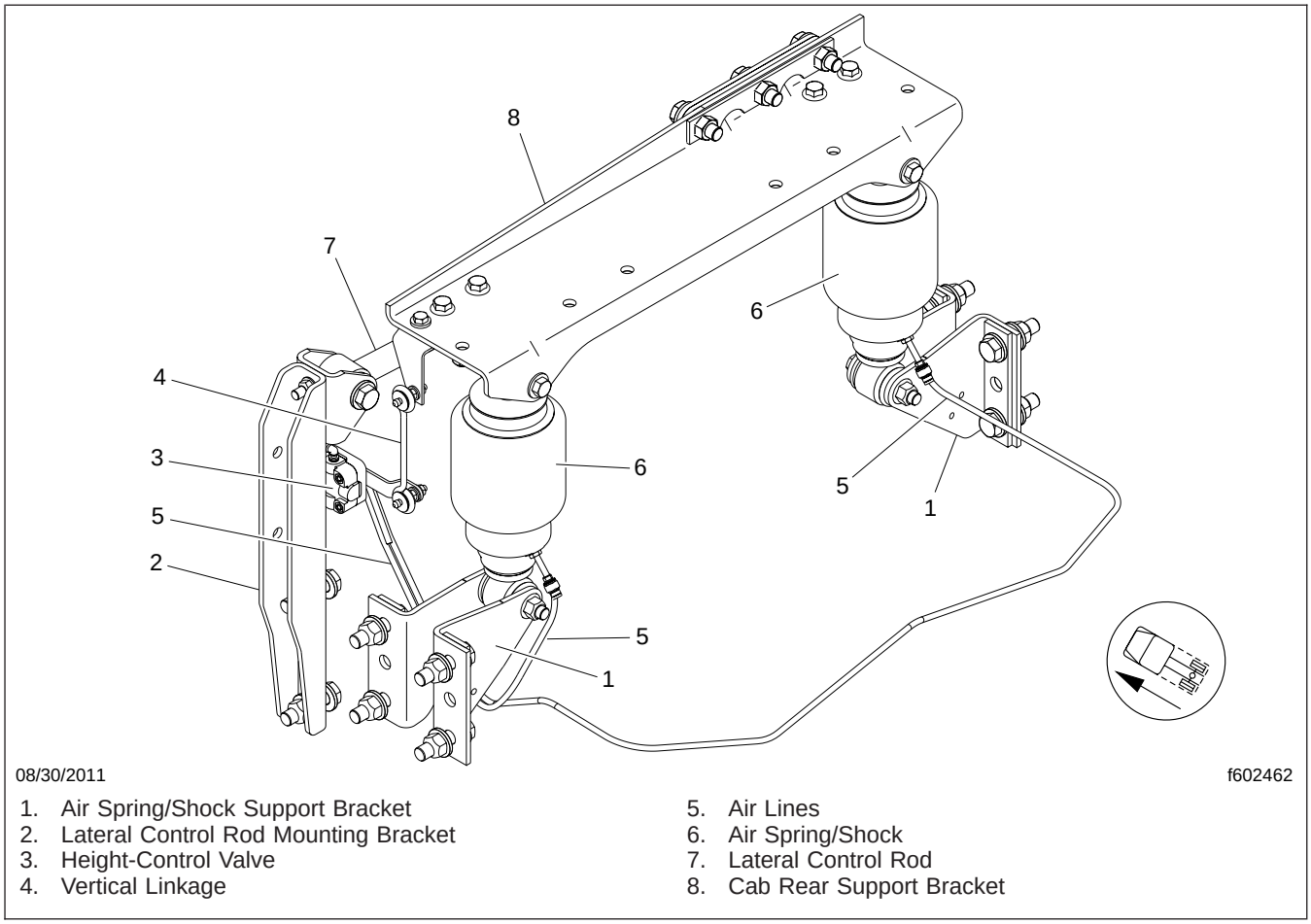
Changes in load that occur when occupants or heavy items are added to or removed from the cab will activate the height-control valve to correct the cab ride height. Also, when the vehicle is moving forward at high speed or in a high headwind, a major change in load occurs from the downforce applied to an optional air shield or air fairing. When these changes in load occur, the cab air-suspension system will correct the cab ride height at the rear of the cab.

## Lateral Control Rod

On the SleeperCab suspension, the lateral control rod limits the side-to-side motion of the rear of the sleeper. One end of the control rod is attached to a bracket on the frame rail, the other to a bracket on the sleeper underbody.

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1. Air Spring/Shock Support Bracket
2. Lateral Control Rod Mounting Bracket
3. Height-Control Valve
4. Vertical Linkage
5. Air Lines
6. Air Spring/Shock
7. Lateral Control Rod
8. Cab Rear Support Bracket

**Fig. 3, Cab Rear Air Suspension, 4700 Model**

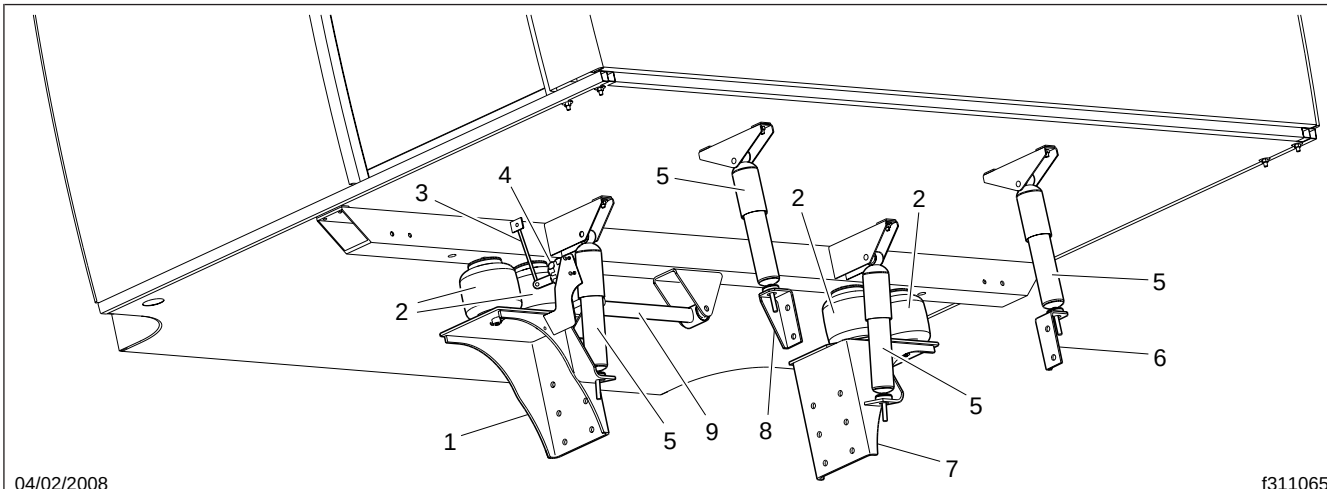
## Shock Absorbers

Shock absorbers control the air spring and cab suspension movement, and reduce the amount of oscillation in the cab suspension system. They are attached to the cab support bracket and to the crossmember (on a day cab) or air spring frame bracket (on a SleeperCab). Two additional rear shock absorbers are used with 48-inch, 54-inch, 62-inch, 68-inch, 76-inch, and 82-inch sleepers. In addition to absorbing road shock, the shock absorbers limit upward motion of the rear of the cab, and help support the cab.

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## General Information




NOTE: Vehicle with sleeper rear shock absorbers and a 4-spring suspension system shown.

1. Air Spring Frame Bracket, LH
2. Air Spring
3. Vertical Linkage
4. Height-Control Valve
5. Shock Absorber
6. Rear Shock Absorber Bracket, RH
7. Air Spring Frame Bracket, RH
8. Rear Shock Absorber Bracket, LH
9. Lateral Control Rod

**Fig. 4, SleeperCab Air Suspension**

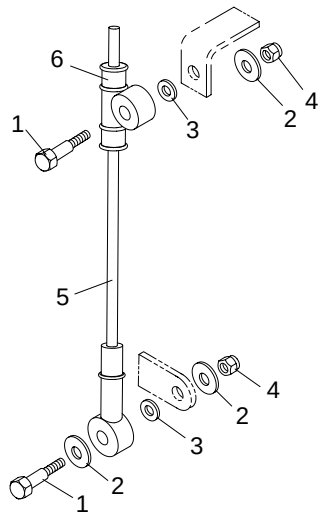
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## Adjustment

NOTE: The 4700 Model cab ride height is not adjustable.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa). Turn off the engine and wait 5 to 10 minutes for the system to equalize.
3. Disconnect the vertical linkage from the bracket that is attached to the cab rear support bracket; see **Fig. 1**.

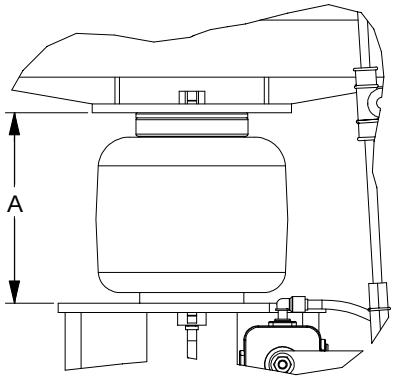



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1. Shoulder Bolt
2. Flatwasher
3. #12 Flatwasher
4. 1/4-Inch Nylon Locknut
5. 9-1/4 Inch Rod
6. Cannon-Style Rubber Grommet

**Fig. 1, Vertical Linkage**

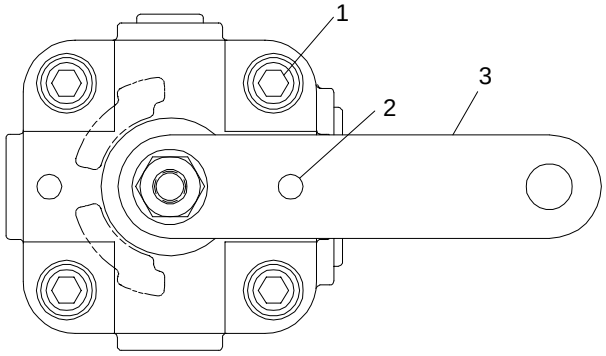
4. Pull up on the control lever of the height-control valve to exhaust the air from the air spring(s).
5. Lower the control lever to fill the air spring(s). Inflate the air spring(s) until the distance from the air spring top plate to the air spring lower support plate is 5-1/4 inches (133 mm); see **Fig. 2**.
6. Lock the height-control valve in the neutral position by inserting a 5/32-inch (4-mm) pin or drill bit through the key hole in the horizontal control lever and the height-control valve; see **Fig. 3**.




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A. 5-1/4 inches (133 mm) Installed Air Spring Height

**Fig. 2, Rear Air Suspension Height, View from Front (day cab shown)**




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1. Mounting Stud
2. Key Hole
3. Horizontal Control Lever

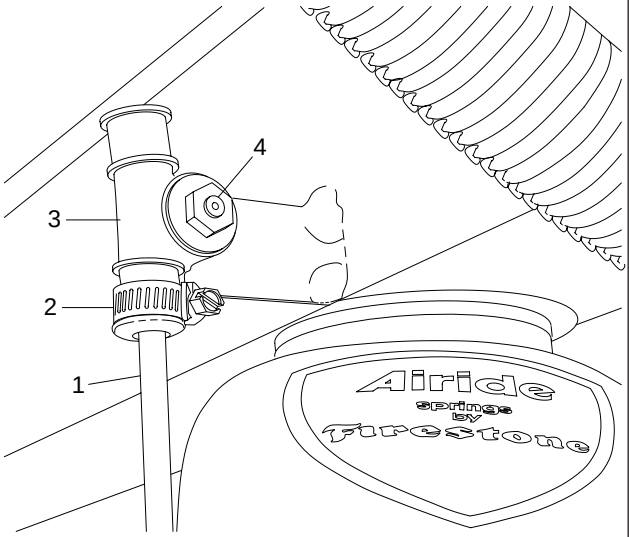
**Fig. 3, Height-Control Valve**

7. Loosen the clamps around the rubber grommet on the vertical linkage so the rod will push up or down through it to adjust the length of the rod; see **Fig. 4**. Connect the vertical linkage and tighten the mounting nut 24 to 48 lbf·in (270 to 540 N·cm). Tighten the grommet clamps to secure the rod at the desired height.
8. Remove the pin or drill bit previously inserted in the neutral position key hole.
9. Check the cab height again. If the height is not correct, repeat the entire procedure.

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## Cab Ride-Height Adjustment




1. Vertical Rod
2. Clamp
3. Rubber Grommet
4. Mounting Nut

**Fig. 4, Vertical Rod Adjustment**

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## Height-Control Valve Checking

It is normal to hear air leaking from the height-control valve for as much as five minutes after getting out of the vehicle. This air leakage is just the height-control valve exhausting air from the cab suspension air spring to reach the neutral position.

The height-control valves used on the Western Star are Barksdale valves. Two methods are available to check the operation of the Barksdale height-control valves. A leak in the valve may be discovered without using a test kit, but a test kit is necessary to determine if the valve has an unacceptable rate of leakage.

Some Barksdale height-control valves have been returned for warranty because the four bolts in the valve housing were overtightened, often, enough to crack the valve housing. These bolts should not be loose, and should not normally require tightening, as there are no serviceable parts in the valve.

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing if you detect leaks in the housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- If it is necessary to remove a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, crushing the valve body and damaging the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

## Checking the Height-Control Valve Without Using a Test Kit

**⚠ WARNING**

**Keep your hands and all objects away from the area under and around the cab when removing the pressure from the air system. Parts will move as the air is released and can cause personal injury or damage to any objects that are between the moving parts.**

1. With the vehicle parked on a level surface, run the engine to build vehicle air pressure to at least 100 psi (690 kPa), then shut off the engine, apply the parking brakes, and chock the tires.
2. Shut off the engine and wait 5 to 10 minutes for the air suspension system to equalize.

NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal, and does not indicate a defective valve.

3. Check all of the fittings and the valve body using a soap-and-water solution. Seal any leaks as necessary.
4. Check the valve exhaust port and the rubber exhaust flapper using a soap-and-water solution.

NOTE: If a leak is detected, go to "Checking the Height-Control Valve Using a Test Kit." Barksdale valves have an acceptable leakage rate of 3 cubic inches (50 cc) per minute. You can determine if a leak is acceptable only by using the Barksdale test kit.

5. Remove the chocks.

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## Height-Control Valve Checking

# Checking the Height-Control Valve Using a Test Kit

**WARNING**

**Keep your hands and all objects away from the area under and around the cab when removing the pressure from the air system. Parts will move as the air is released and can cause personal injury or damage to any objects that are between the moving parts.**

NOTE: The Barksdale field test kit is designed to be used with the height-control valve installed on the vehicle.

NOTE: Refer to **Specifications 400** for information on ordering this Barksdale height-control valve test kit.

1. If not already done, park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa).
3. Shut off the engine and wait 5 to 10 minutes for the air suspension system to equalize.

NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal, and does not indicate a defective valve.

4. Check the rubber exhaust flapper at the back of the valve housing for leaks. Use a soapy solution.
5. Disconnect the vertical linkage from the control lever.
6. Rotate and hold the control lever up at about 45 degrees to exhaust air from the air springs.
7. Disconnect the air lines from the air spring ports on the height-control valve. Leave the elbow fittings (if equipped) in place. Install a Parker plug into each air spring port (or elbow fitting); see **Fig. 1**.
8. If a flapper is present on the exhaust port of the height-control valve, remove it using needlenose pliers.
9. Clean the surface around the exhaust port, then install the test fitting into the exhaust port. The centering pin on the fitting must align with the slot on the exhaust port. Rotate the test fitting 45 degrees clockwise to lock it in place; see **Fig. 1**.
10. Connect one end of the air hose from the kit to the test connector on the exhaust port, and the other end to the test gauge.
11. Check the height-control valve in the fill mode, as follows.
    - 11.1 Rotate the valve control lever down 45 degrees from the horizontal to the fill position.
    - 11.2 Press the reset button on the test gauge.
    - 11.3 Observe the test gauge for 30 seconds. Refer to **Fig. 2** for the maximum allowable exhaust pressure change versus inlet pressure.

      The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

      If the gauge reads less than the maximum allowable pressure change in 30 seconds, the valve is okay.

NOTE: The test gauge will register the exhausting air. *This does not indicate a defective valve.*

12. Check the height-control valve in the exhaust mode, as follows.
    - 12.1 Rotate the valve control lever up 45 degrees from the horizontal to the exhaust position.
    - 12.2 Press the reset button on the test gauge.
    - 12.3 Observe the test gauge for 30 seconds. Refer to **Fig. 2** for the maximum allowable exhaust pressure change versus inlet pressure.

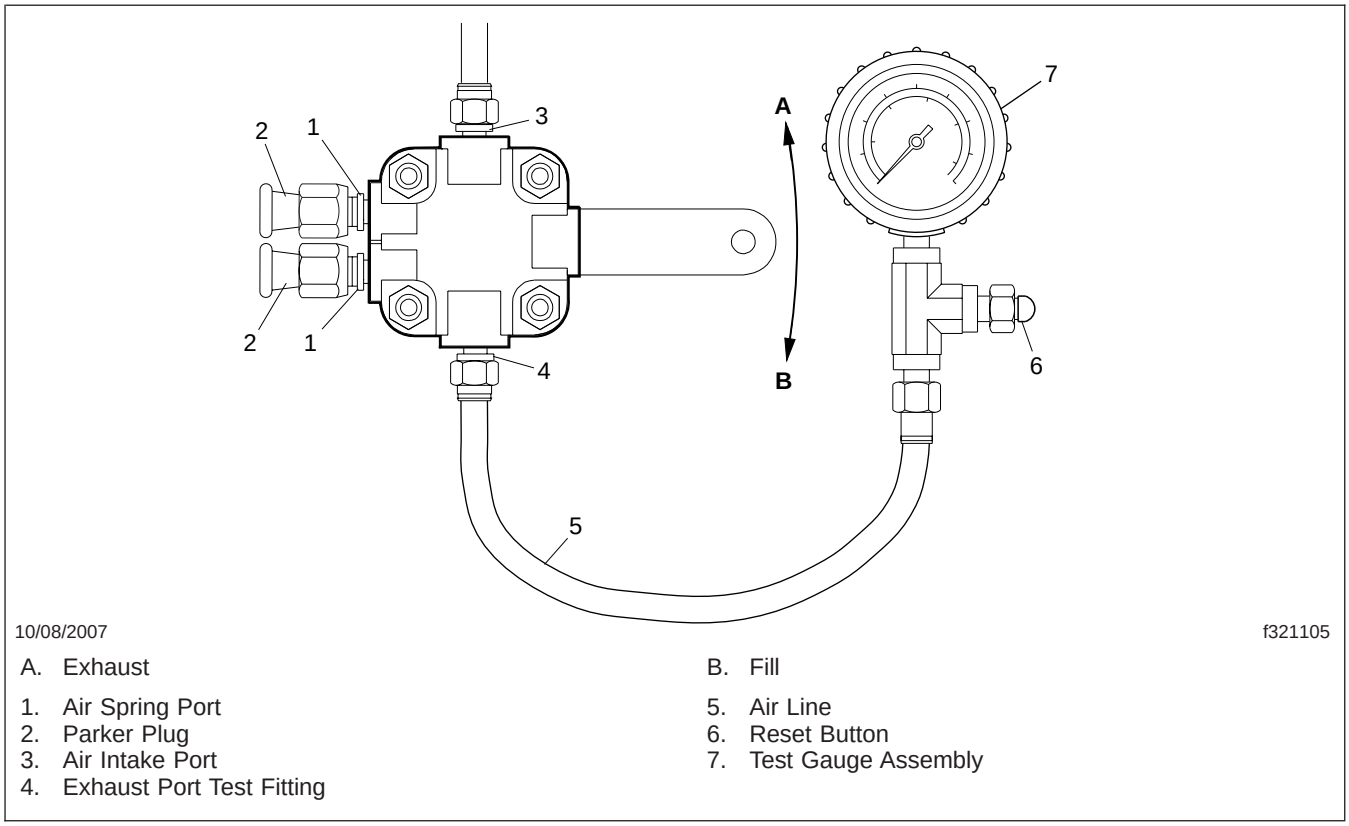
      The valve is not working correctly if the gauge pressure reading exceeds the maximum allowable within 30 seconds.

      If the gauge reads less than the maximum allowable pressure change in 30 seconds, the valve is okay.

NOTE: The test gauge will register the exhausting air. *This does not indicate a defective valve.*

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A. Exhaust
B. Fill

1. Air Spring Port
2. Parker Plug
3. Air Intake Port
4. Exhaust Port Test Fitting
5. Air Line
6. Reset Button
7. Test Gauge Assembly

**Fig. 1, Test Connections**

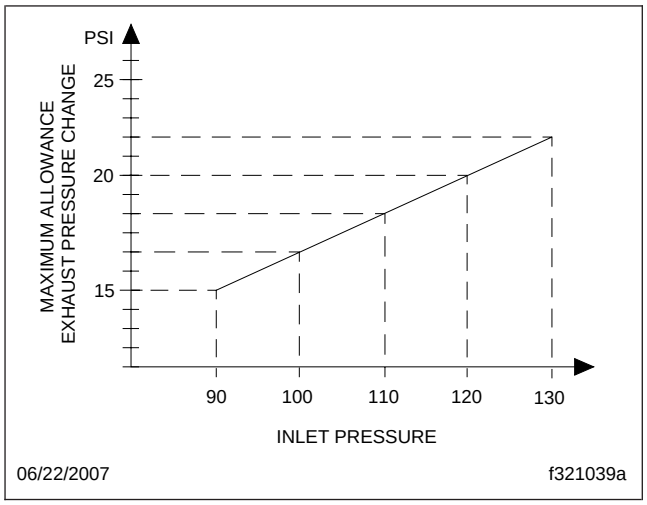



**Fig. 2, Inlet Pressure vs. Exhaust Pressure Change in 30 Seconds**

13. Disconnect the test gauge and connector from the valve exhaust port.
14. If the height-control valve is defective, replace it; see **Subject 120**.
15. Install the flapper on the exhaust port by pressing it into place.
16. Remove the two Parker plugs from the air spring ports, and connect the air lines to the air spring ports (or elbow fittings). Connect the vertical linkage to the height-control valve control lever. The ride height will automatically return to the correct position.
17. Remove the chocks.

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# Height-Control Valve Replacement

IMPORTANT: Before replacing the height-control valve, perform the steps in **Subject 110** to see if the height-control valve is actually damaged or just out of adjustment.

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.

**⚠ WARNING**

**Do not disconnect any air lines in the cab suspension system without first blocking the cab securely. If the cab isn't securely blocked, disconnecting an air line could cause the cab to fall abruptly, possibly resulting in serious injury.**

2. Place blocks between the frame and the bottom of the cab, or use jack stands to keep the cab in position when the air springs are deflated.
3. Drain all air from the air tanks.

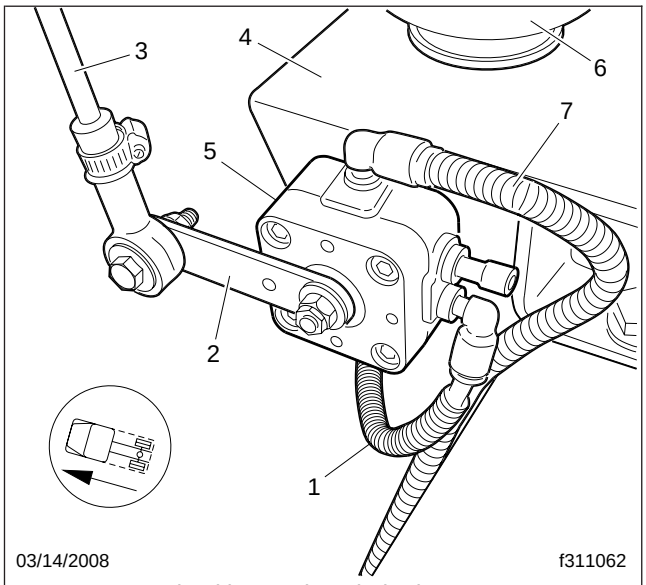
**⚠ WARNING**

**Air lines under pressure can whip dangerously if disconnected under pressure. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.**

4. Remove the nut and washer that attaches the vertical linkage to the horizontal control lever. Disconnect the vertical linkage from the control lever; see **Fig. 1**.
5. Rotate and hold the horizontal control lever up until all air is exhausted from the air spring.
6. Mark the air tubing to the height-control valve for later reference, then disconnect the tubing.

**⚠ CAUTION**

**When removing or loosening a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, which can crush the valve body and damage the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.**




NOTE: Day cab with a 5-piece bolted BOC crossmember shown.

1. Air Spring Tubing
2. Horizontal Control Lever
3. Vertical Linkage
4. Air Spring Bracket
5. Height-Control Valve
6. Air Spring
7. Supply Air Tubing

**Fig. 1, Cab Height-Control Valve**

7. While holding the height-control valve mounting studs in place with an Allen wrench, remove the nuts and washers that attach the valve to the mounting bracket. Remove the height-control valve.
8. Position the new height-control valve on the height-control bracket. While holding the height-control valve mounting studs in place with an Allen wrench, install the nuts and washers, and tighten 45 lbf·in (500 N·cm). Do not overtighten.
9. Connect the air tubing to the height-control valve.
10. Align the vertical linkage with the horizontal control lever and install the washer and nut.
11. Start the engine and run it until air pressure builds to at least 100 psi (690 kPa).
12. Check all air tubing and fittings for leaks.
13. Remove the cab supports.

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## Height-Control Valve Replacement

14. Set the cab/sleeper height to the correct measurement; see **Subject 100**.
15. Remove the chocks.

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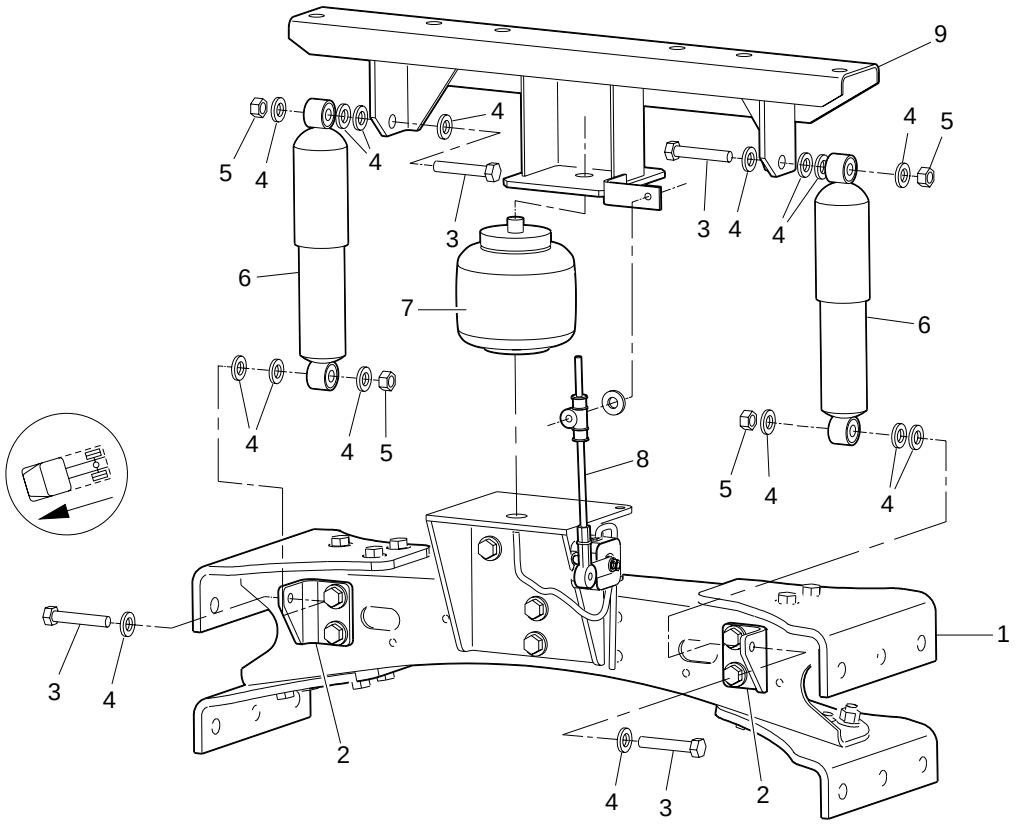


## Replacement

NOTE: To replace the combination air spring/ shock absorber units installed on the 4700 Model, see **Subject 150**.

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.
2. Place blocks between the frame and the bottom of the cab, or use jack stands to keep the cab in position when the shock is removed.
3. On a day cab, remove the nut, bolt, and washers that attach the shock absorber to the bracket on the crossmember; see **Fig. 1**.

   On a SleeperCab, remove the nut and washer that attaches the shock absorber mounting stud to the air-spring frame bracket; see **Fig. 2**.
4. Remove the nut, bolt, and washers that attach the shock absorber to the rear cab support bracket. Remove the shock absorber.
5. Position the upper end of the new shock absorber in the upper bracket and install the bolt, washers, and nut. Tighten the nut 70 lbf·ft (95 N·m).




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NOTE: Vehicle with a 5-piece bolted BOC crossmember shown.

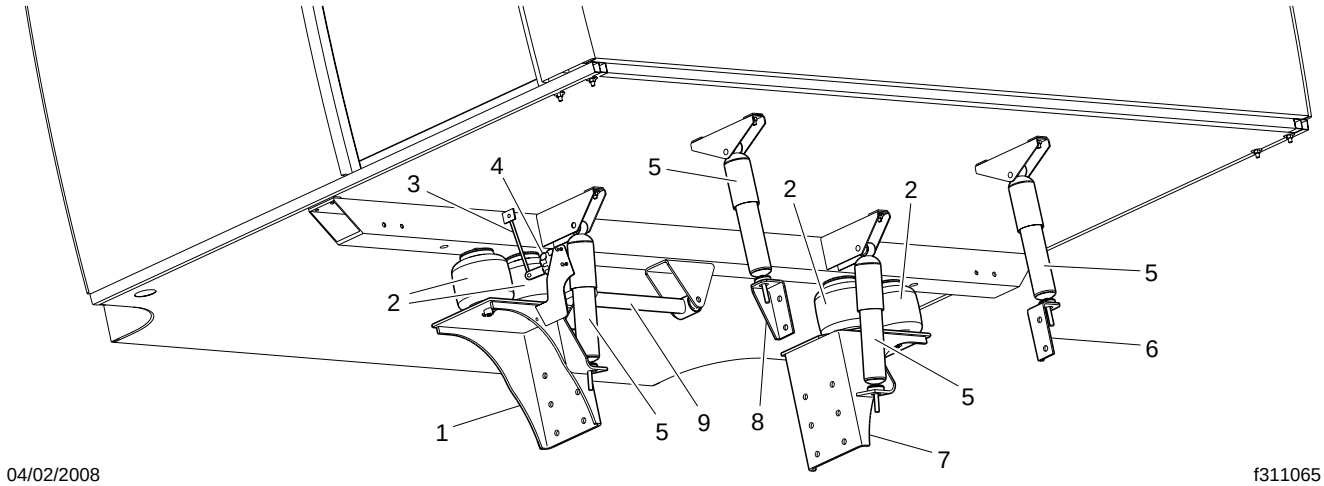
1. BOC Crossmember
2. Lower Shock Absorber Bracket
3. Bolt
4. Washer
5. Nut
6. Shock Absorber
7. Air Spring
8. Vertical Linkage
9. Rear Cab Support Bracket

**Fig. 1, Day Cab Suspension Shock Absorber Installation**

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## Shock Absorber Replacement




NOTE: Vehicle with sleeper rear shock absorbers and a 4-spring suspension system shown.

1. Air Spring Frame Bracket, LH
2. Air Spring
3. Vertical Linkage
4. Height-Control Valve
5. Shock Absorber
6. Rear Shock Absorber Bracket, RH
7. Air Spring Frame Bracket, RH
8. Rear Shock Absorber Bracket, LH
9. Lateral Control Rod

**Fig. 2, SleeperCab Air Suspension**

6. On a day cab, install the lower mounting bolt through the mounting bracket and new shock absorber and attach the washers and the nut.

   On a SleeperCab, install the nut and washer onto the mounting stud and tighten until the diameter of the rubber bushing is the same as the diameter of the washer.

7. Remove the cab supports.

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## Replacement

NOTE: To replace the combination air spring/shock absorber units installed on the 4700 Model, see **Subject 150**.

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.

**⚠ WARNING**

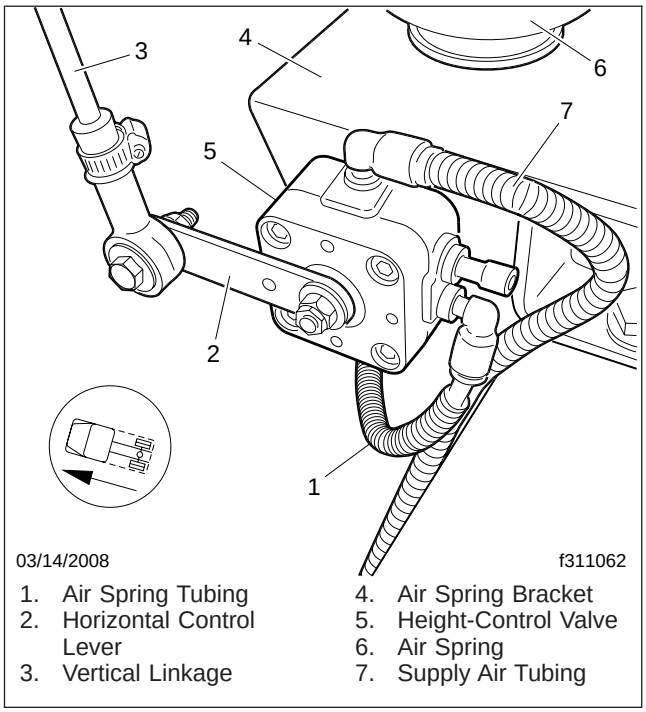
**Do not disconnect any air lines in the cab suspension system without first blocking the cab securely. If the cab isn't securely blocked, disconnecting an air line could cause the cab to fall abruptly, possibly resulting in serious injury.**

2. Place blocks between the frame and the bottom of the cab or sleeper, or use jack stands to keep the cab in position when the air spring is deflated.
3. Drain all air from the air tanks.

**⚠ WARNING**

**Air lines under pressure can whip dangerously if disconnected under pressure. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.**

4. Remove the nut and washer that attaches the vertical linkage to the horizontal control lever. Disconnect the vertical linkage from the control lever; see **Fig. 1**.
5. Rotate and hold the horizontal control lever up until all air is exhausted from the air spring.
6. Disconnect the supply air tubing from the bottom of the air spring; see **Fig. 2**. If the new air spring will not be installed immediately, cover the open end of the air tubing to prevent dirt or other foreign material from entering.
7. Using a screwdriver inserted between the top of the air spring and the upper mounting bracket, pry the air spring away from the bracket, and pop the air spring tangs loose. Repeat for the bottom of the air spring.
8. Install the new air spring by snapping the bottom of the air spring into the lower air spring bracket, then snapping the top of the air spring into the top bracket.




1. Air Spring Tubing
2. Horizontal Control Lever
3. Vertical Linkage
4. Air Spring Bracket
5. Height-Control Valve
6. Air Spring
7. Supply Air Tubing

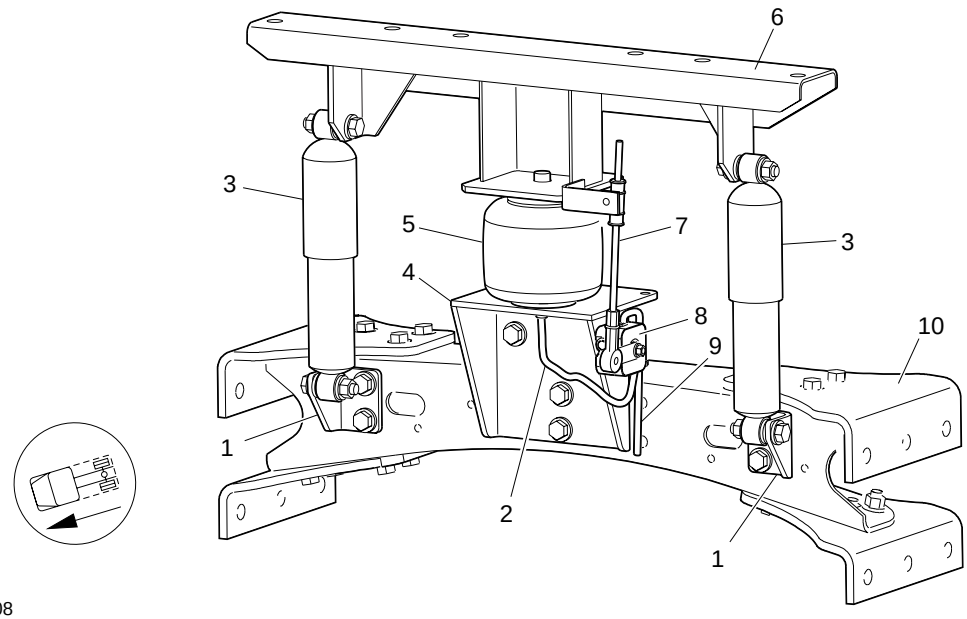
**Fig. 1, Cab Height-Control Valve**

9. Remove the cover from the air tubing, then connect it to the bottom of the new air spring.
10. Align the vertical linkage with the horizontal control lever and install the washer and nut.
11. Start the engine, and run it until air pressure builds to at least 100 psi (690 kPa). Check for air leaks at the air spring.
12. Remove the cab supports.

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## Air Spring Replacement




03/17/2008 f311061

1. Lower Shock Absorber Bracket
2. Air Spring Tubing
3. Shock Absorber
4. Air Spring Lower Bracket
5. Air Spring
6. Rear Cab Support Bracket
7. Vertical Linkage
8. Height-Control Valve
9. Supply Air Tubing
10. BOC Crossmember

**Fig. 2, Cab Rear Air Suspension, Day Cab with 5-Piece Bolted BOC Crossmember**

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## Replacement

NOTE: This procedure applies to the 4700 Model vehicles equipped with combination air spring/shock absorber units.

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.

**⚠ WARNING**

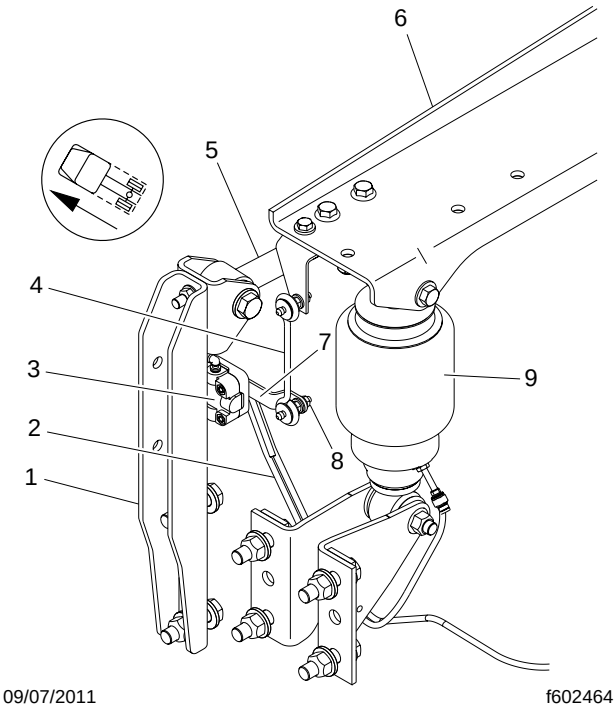
**Do not disconnect any air lines in the cab suspension system without first blocking the cab securely. If the cab is not securely blocked, disconnecting an air line could cause the cab to fall abruptly, possibly resulting in serious injury.**

2. Place blocks between the frame and the bottom of the cab or sleeper, or use jack stands to keep the cab in position when the air spring is deflated.
3. Drain all air from the air tanks.

**⚠ WARNING**

**Air lines can whip dangerously if disconnected while pressurized. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.**

4. Remove the nut and washer that attach the vertical linkage to the horizontal control lever. Disconnect the vertical linkage from the control lever; see **Fig. 1**.
5. Rotate and hold the horizontal control lever up until all air is exhausted from the air spring.
6. Disconnect the supply air line from the bottom of the air spring/shock; see **Fig. 2**. If the new air spring/shock will not be installed immediately, cover the open end of the air line to prevent dirt or other foreign material from entering.
7. Remove the flange nuts, mounting bolts, and washers that attach the air spring/shock to the cab rear support bracket and the lower support bracket. Remove the air spring/shock.
8. Position the upper end of the new air spring/shock in the cab rear support bracket and the lower end in the lower support bracket. Install the mounting bolts, washers, and flange nuts. Tighten the flange nuts 57 to 71 lbf·ft (78 to 96 N·m).
9. If the air line is covered, remove the cover, then connect the air line to the bottom of the new air spring/shock.
10. Align the vertical linkage with the horizontal control lever and install the washer and nut.
11. Start the engine, and run it until air pressure builds to at least 100 psi (690 kPa). Check for air leaks at the air spring/shock.
12. Remove the cab supports.



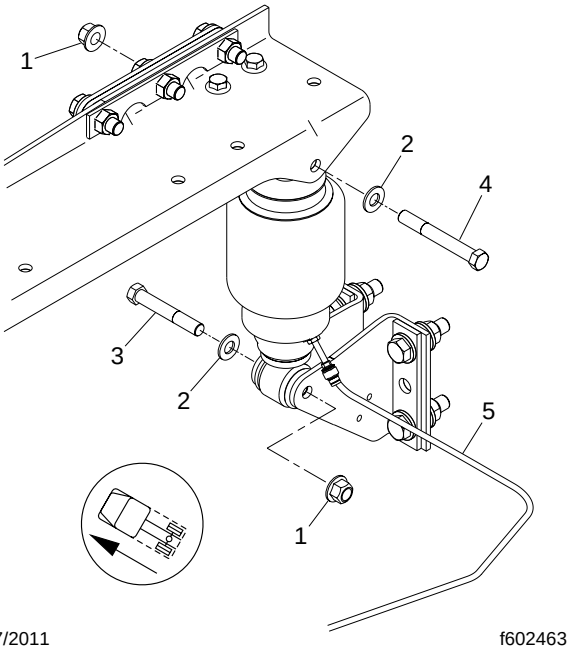

1. Lateral Control Rod Mounting Bracket
2. Air Lines
3. Height-Control Valve
4. Vertical Linkage
5. Lateral Control Rod
6. Cab Rear Support Bracket
7. Horizontal Control Lever
8. Vertical Linkage Nut
9. Air Spring/Shock

**Fig. 1, Vertical Linkage Installation**

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## Air Spring/Shock Replacement




1. Flange Nut
2. Flatwasher
3. Lower Mounting Bolt
4. Upper Mounting Bolt
5. Air Line

**Fig. 2, Air Spring/Shock Installation**

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## Fitting Leakage Repair

1. With the vehicle parked on a level surface, apply the parking brakes and chock the tires.

**⚠ WARNING**

**Do not disconnect any air lines in the cab suspension system without first blocking the cab securely. If the cab isn't securely blocked, disconnecting an air line could cause the cab to fall abruptly, possibly resulting in serious injury.**

2. Place blocks between the frame and the bottom of the cab to keep the cab in position when the air spring is deflated.
3. Drain all air from the air tanks.

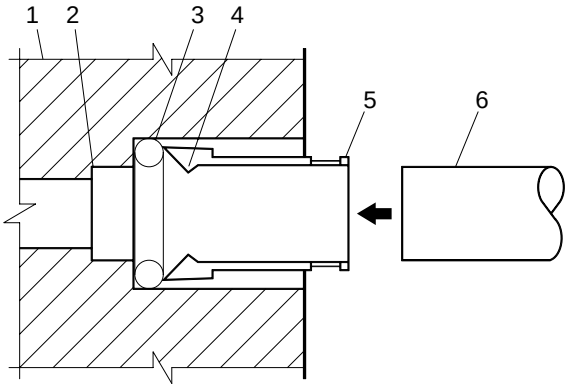
**⚠ WARNING**

**Air lines under pressure can whip dangerously if disconnected under pressure. Drain all air from the air tanks before disconnecting air lines. Disconnecting pressurized air lines can cause personal injury and/or property damage.**

4. Remove the nut and washer that attach the vertical linkage to the horizontal control lever. Disconnect the vertical linkage from the control lever.
5. Rotate and hold the control lever up until all air is exhausted from the air spring.
6. Push the collar of the quick-connect fitting into the fitting body with a 1/4-inch (7-mm) open-end wrench; see **Fig. 1**. With the collar pushed into the fitting, pull the tubing from the fitting. The fitting should easily release the tubing.

NOTE: Find the mark on the tubing, about 1/4 inch (7 mm) from the end, where the collar clamped the tubing; see **Fig. 2**. If this mark is less than 1/4 inch (7 mm) from the end of the tubing, the fitting was not assembled correctly and could have caused an air leak.

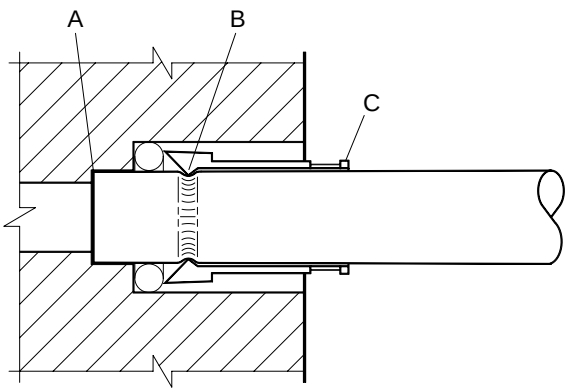
7. Inspect the end of the tubing for paint or debris that could prevent full insertion of the tubing into the fitting. Remove any dirt from the tubing and fitting.
8. Check that the end of the tubing is cut square. If the tubing is cut at an angle other than 90 degrees, the fitting will not seal correctly; cut the end of the tubing at a 90-degree angle.
9. Insert the squared end of the tubing into the fitting. An initial resistance is felt when the tubing touches the clamping ring section of the collar. Push the tubing past this resistance another 1/4 inch (7 mm) or so until the tubing is fully seated against the shoulder.




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1. Fitting Body
2. Shoulder
3. Release Ring
4. Clamping Ring
5. Collar
6. Nylon Tube

**Fig. 1, Parts of the Quick-Connect Fitting**




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A. Square end of the tube against the shoulder.
B. The collar clamps the tube here.
C. Push the collar to release the tube.

**Fig. 2, Correctly Installed Quick-Connect Fitting**

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## Quick-Connect Fittings

10. Tug on the air tubing to ensure the tubing is clamped in the collar.
11. Align the vertical linkage with the control lever, and install the washer and nut.
12. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa). Check for air leaks.
13. Remove the blocks that were installed to support the cab.

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# Troubleshooting Tables

**Problem—Air Spring is Flat**

| Problem—Air Spring is Flat | |
|---|---|
| **Possible Cause** | **Remedy** |
| Low air pressure in the secondary air system. | Check the air pressure gauge on the instrument panel. If secondary air pressure is low, run the engine until at least 70 psi (482 kPa) is indicated. |
| Air is leaking from the air-suspension system. | Check for leakage from fittings, air lines, air springs, and the height-control valve. Tighten loose fittings to stop leakage; replace worn or damaged parts. |
| The height-control valve is out of adjustment. | Adjust the height control valve; see **Subject 100**. |
| The height-control valve is inoperative. | If upward movement of the lever on a properly adjusted valve fails to deflate the air springs, check the height-control valve; see **Subject 110**. If necessary, replace the height-control valve; see **Subject 120**. |
| The height-control valve linkage is damaged. | Check for damage to the height-control valve linkage and the horizontal control lever. Repair or replace damaged linkage parts. |

**Problem—Air Spring Deflates Rapidly When the Engine Is Not Running**

| Problem—Air Spring Deflates Rapidly When the Engine Is Not Running | |
|---|---|
| **Possible Cause** | **Remedy** |
| Air is leaking from the air-suspension system. | Check for leakage from fittings, air lines, air springs, and the height-control valve; see "Checking the Cab Height-Control System for Air Leaks" and "Diagnostics and Testing" below. Tighten loose fittings to stop leakage; replace worn or damaged parts. |

**Problem—Rear of Cab Rides Too High or Too Low**

| Problem—Rear of Cab or Sleeper Rides Too High or Too Low | |
|---|---|
| **Possible Cause** | **Remedy** |
| The height-control valve is out of adjustment. | Adjust the height-control valve; see **Subject 100**. |

**Problem—Collapsed Air Spring**

| Problem—Collapsed Air Spring | |
|---|---|
| **Possible Cause** | **Remedy** |
| Air spring is punctured. | Locate leaks by listening for escaping air, or by applying a soap and water solution to the air spring and watching for bubbles. Repair punctures and cuts that are less than 1/8 inch (3 mm). Replace the air spring if damage is greater. Check the area around the damaged air spring for contact with other components. Correct the problem areas as needed. |
| The air spring is continually or repeatedly over-extended. | Check the cab ride height. Make sure the correct height is maintained. If necessary, adjust the cab ride height; see **Subject 100**. Check for a broken shock absorber or shock bracket; see "Diagnostics and Testing" below. If necessary, replace the broken shock absorber; see **Subject 130**. To replace a combination air spring/shock absorber unit, see **Subject 150**. |

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# Troubleshooting Procedures

## Checking the Cab Height-Control System for Air Leaks

**⚠ WARNING**

**Keep your hands and all objects away from the area under and around the cab when removing the pressure from the air system. Parts will move as the air is released and can cause personal injury or damage to any objects that are between the moving parts.**

IMPORTANT: To prevent voiding the warranty on Barksdale height-control valves, note the following:

- Do not overtighten the bolts in the Barksdale height-control valve housing if you detect leaks in the housing. The bolts should not be loose, and should not require tightening. Only if necessary, tighten the valve housing bolts 45 lbf·in (500 N·cm). Any damage to the valve housing will void the warranty.
- If it is necessary to remove a Barksdale height-control valve from a mounting bracket, always hold the valve-side mounting studs in place with an Allen wrench while loosening or tightening the nuts that attach the valve to the bracket. Because the mounting studs are threaded into the valve body, loosening the nuts without holding the studs can tighten the studs, crushing the valve body and damaging the valve. Conversely, tightening the nuts without holding the studs can back the studs out, causing a separation of the two halves of the valve body, and possibly a leak.
- Do not attempt to disassemble the Barksdale valve body or the control lever. There are no serviceable parts in the valve, and any disassembly will void the warranty.

1. Park the vehicle on a level surface, apply the parking brakes, and chock the tires.
2. Run the engine to build vehicle air pressure to at least 100 psi (690 kPa). Turn off the engine and wait 5 to 10 minutes for the system to equalize.

   NOTE: Normal operation of the height-control valve requires a maximum of 10 minutes to settle. Any air leakage during this time is considered normal and does not indicate a damaged valve.
3. Apply a soap-and-water solution to the outside of the air fittings on the height-control valve and on the suspension air springs. Look for bubbles indicating an air leak.
4. If bubbles are seen, check that the air tubing is installed correctly into the fitting; see **Subject 150**.

   If no bubbles are seen, check the height-control valve for air leaks; see **Subject 110**.

## Diagnostics and Testing

### Air Spring

Inspect the exterior surfaces of the air spring, looking for wear. With the air spring fully inflated, check to see if there is sufficient clearance around the air spring to prevent lines or objects from rubbing against the air spring. Air tubing or cab components that rub against the air spring will cause damage to the air spring. If the air spring is not capable of lifting the cab to its proper ride height, check to see if the shock absorber is damaged. A binding shock absorber will limit the air spring's ability to extend. To clean the air spring, use soap and water.

NOTE: Do not use organic solvents, abrasives, or pressurized steam cleaners to clean the air spring.

### Shock Absorber

Inspect the shock body for damage such as bends or dents in the piston. Bends or dents in the shock body will negatively affect the operation of the shock. Inspect the shock body for signs of leaking fluid. Normal operation of the shock will result in some misting of the hydraulic fluid onto the exterior shock body. Large streams of fluid indicate a leak and the shock should be replaced; see **Fig. 1**.

To test the operation of a shock absorber, hold the shock in an upright position and cycle the piston at least five times by pushing the piston up and down.

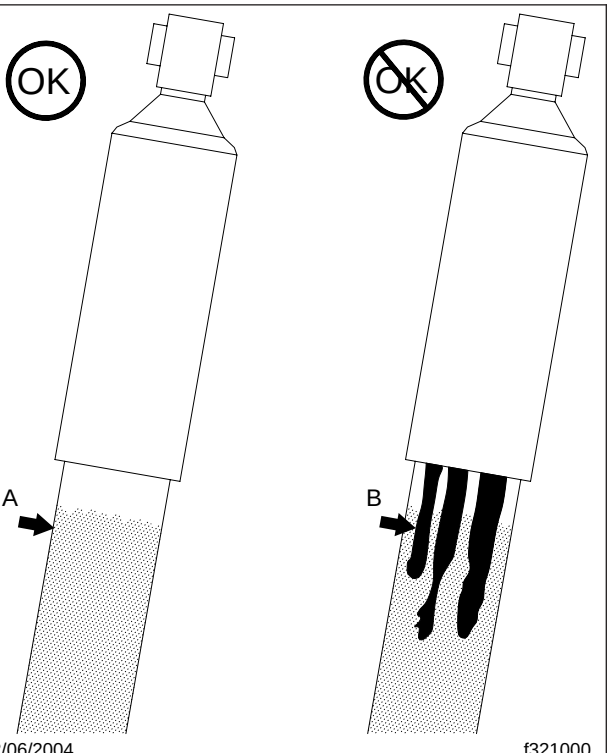
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The piston should move evenly throughout each section of the cycle. If the shock does not move evenly when pushed down or pulled up, the shock should be replaced.

Noises such as squeaks, which may be intermittent, may be caused by the valves used to regulate the internal hydraulic fluid. This problem is not repairable and the shock will need to be replaced. Noises from the shock, such as knocking or rattling, may be due to movement between the bushings and mounting brackets. Inspect the bushings or mounting brackets for wear. Repair worn components as necessary. Check the torque of the shock absorber mounting nuts and tighten if necessary.

NOTE: The shock absorber bushings do not require any type of lubrication. Do not attempt to stop bushing noise by lubricating them; grease and mineral-oil-base lubricants will deteriorate the bushing rubber.




A. Dust covered mist (normal).
B. Hydraulic fluid streaks indicating an actual leak.

**Fig. 1, Differences Between Misting and Leaking**

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## Torque Specifications

Unless listed in **Table 1**, tighten all fasteners using the torque specifications found in **Section 00.05**.

| Torque Specifications | | | | |
|---|---|---|---|---|
| **Fastener Description** | **lbf·ft** | **N·m** | **lbf·in** | **N·cm** |
| Adjustable Vertical Linkage Mounting Nut | — | — | 24–48 | 270–540 |
| Shock Absorber Upper Nut | 70 | 95 | — | — |
| Height-Control Valve Mounting Nut | — | — | 45 | 500 |
| Combination Air Spring/Shock Absorber Mounting Nuts | 57–71 | 78–96 | — | — |

**Table 1, Torque Specifications**

## Special Tools

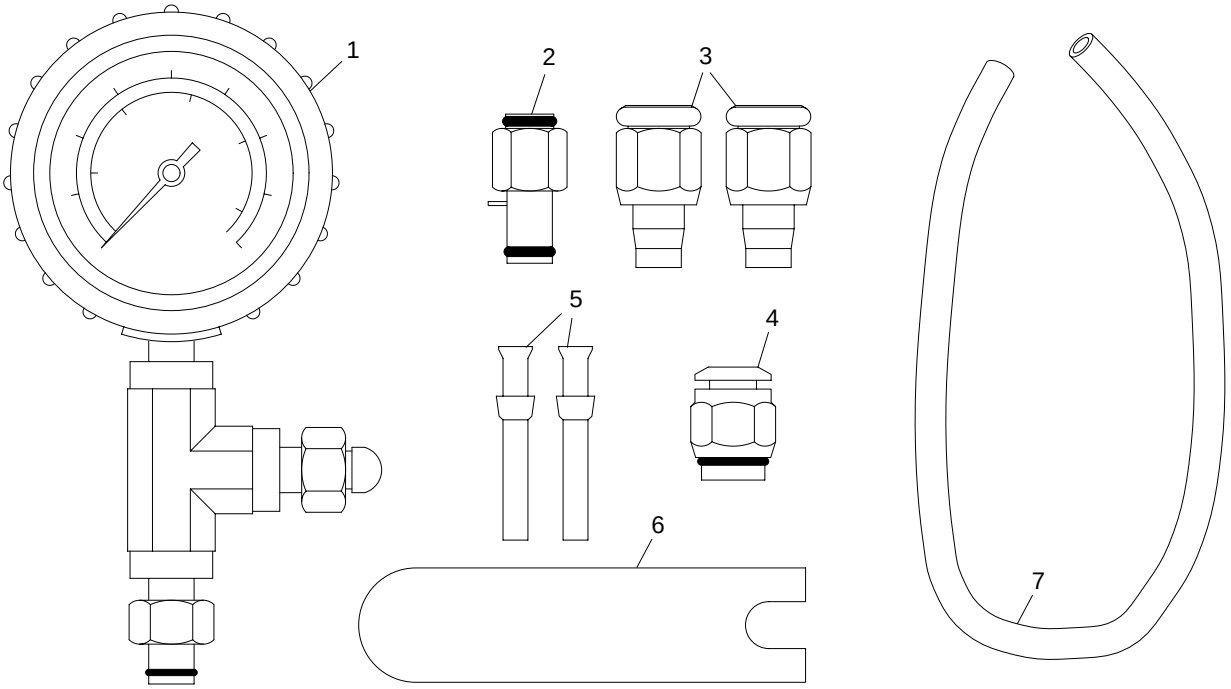
Use the kit shown in **Fig. 1** to test a Barksdale height-control valve. Test kit BKS KD2264 is available via the Direct Ship program in paragon, or directly from Barksdale, at **www.barksdale.com**, or:

Barksdale, Inc.
3211 Fruitland Avenue
Los Angeles, California 90058
Telephone: 866-832-6278

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## Specifications




1. Test Gauge Assembly with Reset Button
2. Exhaust Port Test Connector for Cab Suspension Valve
3. Parker Plugs
4. Exhaust Port Test Connector for Chassis Suspension Valve
5. Test Plugs for Cab Suspension Valve
6. Special Tool for Disconnecting Air Line
7. Air Line

**Fig. 1, Barksdale Height-Control Valve Test Kit BKS KD2264**

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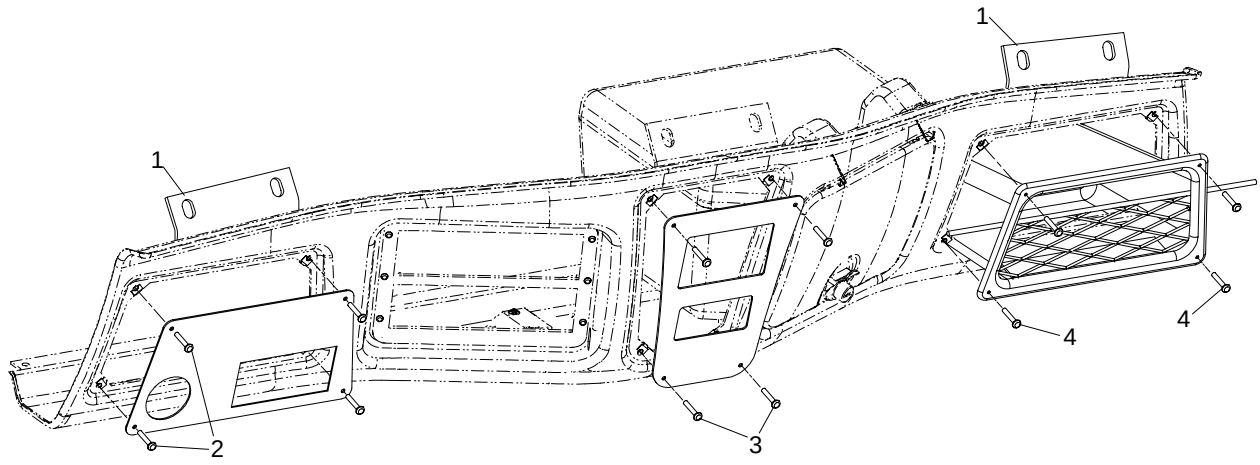
## Overhead Console Removal and Installation

# Removal

1. Park the vehicle on a level surface, shut down the engine, apply the parking brake, and chock the front and rear tires.
2. Remove the privacy curtains.
   - 2.1 Remove the inboard screw from the left and right privacy curtain rails.
   - 2.2 Pull the driver's side rail down and slide the curtain off of the rail.
   - 2.3 Remove the curtain on the passenger's side of the vehicle.
3. Remove the curtain rail center screw. Remove the left and right curtain rail.
4. Remove the center fascia panel. See **Fig. 1**.
5. Remove the driver's side fascia panel.
   - 5.1 Remove the four screws holding the fascia panel to the overhead console.
   - 5.2 Pull the panel out and disconnect the clock.
6. Remove the map pocket from the passenger's side of the vehicle.
7. Remove the radio assembly.
   - 7.1 Slide the radio out of the overhead console.
   - 7.2 Remove the tie-straps from the connectors.
   - 7.3 Remove the connectors from the radio.
   - 7.4 Remove the radio.
   - 7.5 Remove the six screws holding the radio assembly to the overhead console.
8. Disconnect the lights and the speaker electrical connectors.
9. Remove the nuts from the overhead console support brackets.
10. Remove the overhead console.

# Installation

1. Position the overhead console in the cab.
2. Install the six nuts securing the overhead console to the vehicle. Tighten the nuts 28 lbf·ft (37.7 N·m).
3. Connect the console lights and speaker electrical connectors.




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1. Support Bracket
2. CB Radio Panel Screws
3. Center Fascia Screws
4. Map Pocket Screws

**Fig. 1, Overhead Console Assembly**

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## Overhead Console Removal and Installation

4. Connect the radio connectors and slide the radio into the overhead console.
5. Install the map pocket.
6. Install the center fascia panel.
7. Install the clock and the driver's side fascia panel.
8. Position the curtain rail on the overhead console.
9. Install the curtains and the inboard curtain rail screws.
10. Remove the chocks from the tires.

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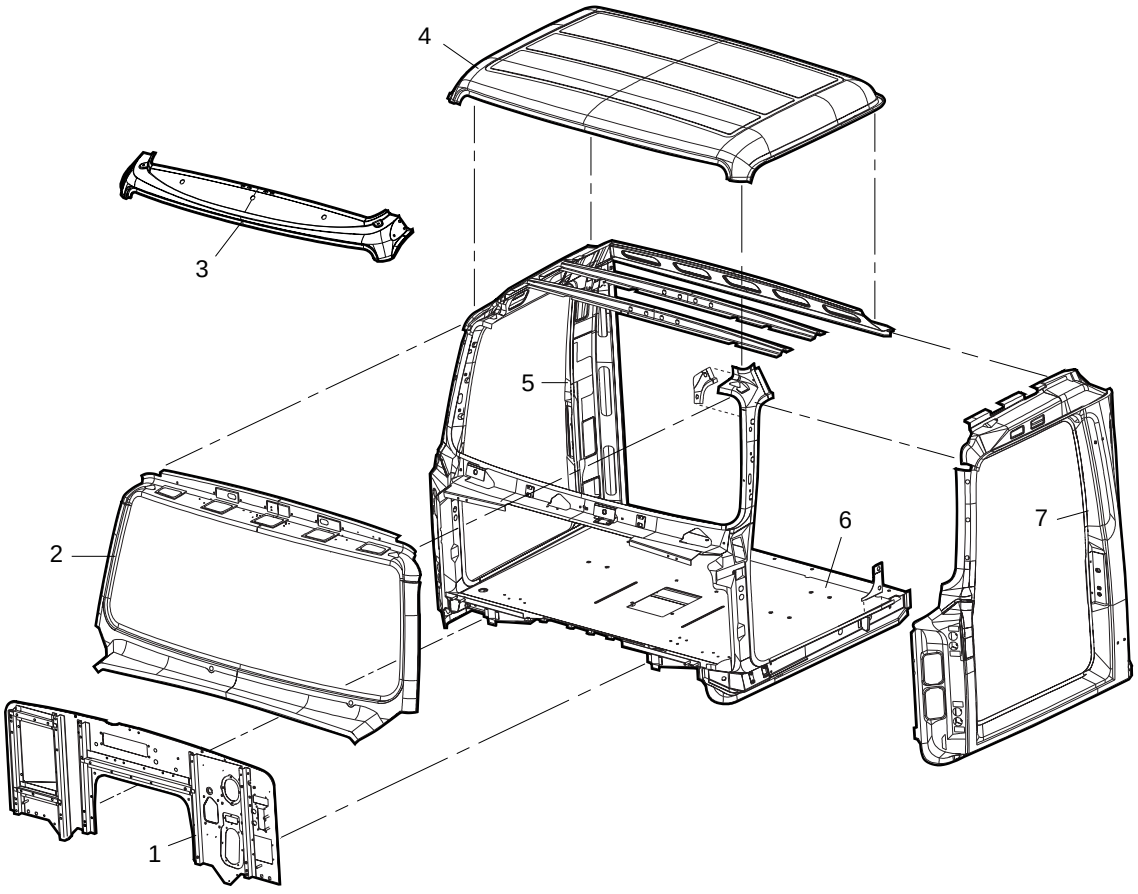
## General Information

The cab is a monocoque design, constructed of welded galvanized steel. See **Fig. 1**.

The major cab parts are the front-wall assembly, right and left side-wall assemblies, cab deck assembly, and the cab understructure. Cabs without an integrated sleeper have a roof assembly. Day cabs have a back-wall assembly. Cabs with integrated Stratosphere sleepers have a windshield header instead of a roof assembly.

The cab deck is attached to a ladder-style understructure. See **Fig. 2**.

When any repairs are done to the cab, it is necessary to check the frame rails for correct alignment and squaring. Then the cab must be leveled and squared. If the cab is repaired without straightening the frame rails, undue stress could be put on the cab, which could weaken it. Also, it may be impossible to square the cab.




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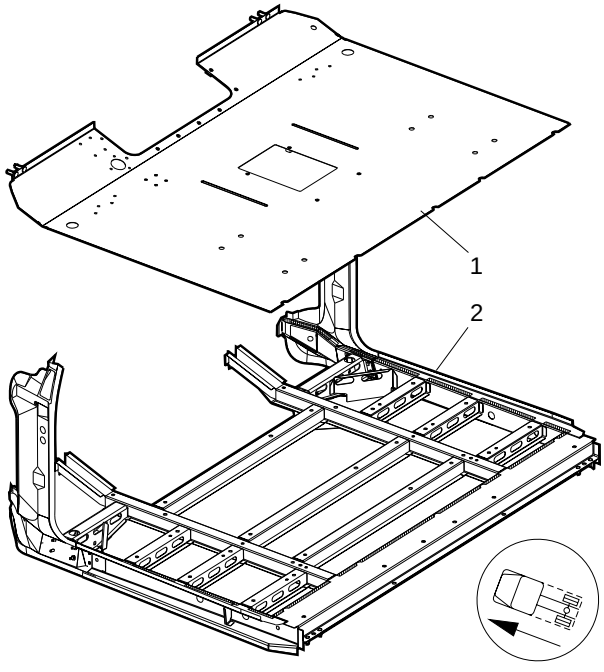
1. Front Wall
2. Windscreen Surround
3. Roof Front Panel (for walk-through sleepers)
4. Roof Cap
5. Right Side Wall
6. Cab Deck
7. Left Side Wall

**Fig. 1, Cab Structure**

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## General Information




1. Cab Deck
2. Cab Understructure

**Fig. 2, Cab Deck and Understructure**

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# Cab Water-Leak Detection and Repair

Use the following procedures to locate and repair areas where water may intrude into the cab.

## Water-Leak Detection

1. With the vehicle parked, apply the parking brake and chock the tires.
2. Prepare a wash solution of at least one-quarter cup of soap to one gallon of water in a spray bottle.
3. Place tape over the cab exhausters, if so equipped.
4. Close all doors, windows, and vents.
5. With the HVAC system in "Fresh Air" mode, turn the fan blower motor on high.

NOTE: Perform the leak detection test with the HVAC system in the "Fresh Air" mode only. Do not set the system in the "Recirculation" mode.

6. Spray the cab, and sleeper if so equipped, with the wash solution, and look for bubbles. See **Fig. 1**. Inspect all applicable areas listed below:
    - cab front wall
    - cab door seals and visibility windows
    - sunvisor upper (rear) mounting studs
    - air horns and marker lights
    - roof deflector mounts (if so equipped)
    - windshield perimeter and center post
    - rear window seal (if so equipped)
    - skylight window
    - sleeper roof side windows (if so equipped)
    - cab and sleeper roof seams
    - sleeper boot (if so equipped)
    - sleeper exit door seal (if present)
    - sleeper baggage door seal (if present)

NOTE: This method of leak detection may also identify areas that will not leak water, even though those areas produce bubbles. If small bubbles are found in an area that is not suspected to leak, a repair may not be necessary.

7. Mark areas of suspected leaks. To pinpoint and repair leaks in a specific area, see the appropriate heading below. For sleeper water-intrusion issues, see **Section 60.00, Subject 180**.
8. Rinse the wash solution off the vehicle with water.
9. Turn off the fan blower motor.
10. If the vehicle is equipped with cab exhausters, remove the tape placed over them.
11. Remove the chocks.

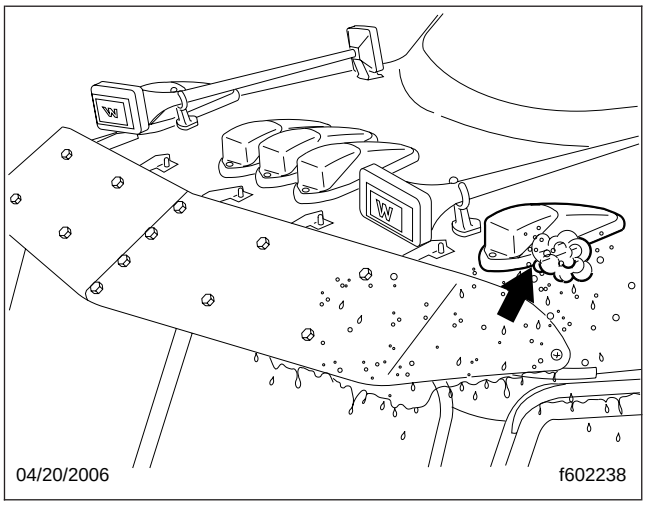



**Fig. 1, Cab Water-Leak Detection with Wash Solution**

## Front Wall

On the engine side of the front wall, check the seals for the foot valve, A/C unit, electrical panel, and dog house. These are likely locations for water leaks. See **Fig. 2**.

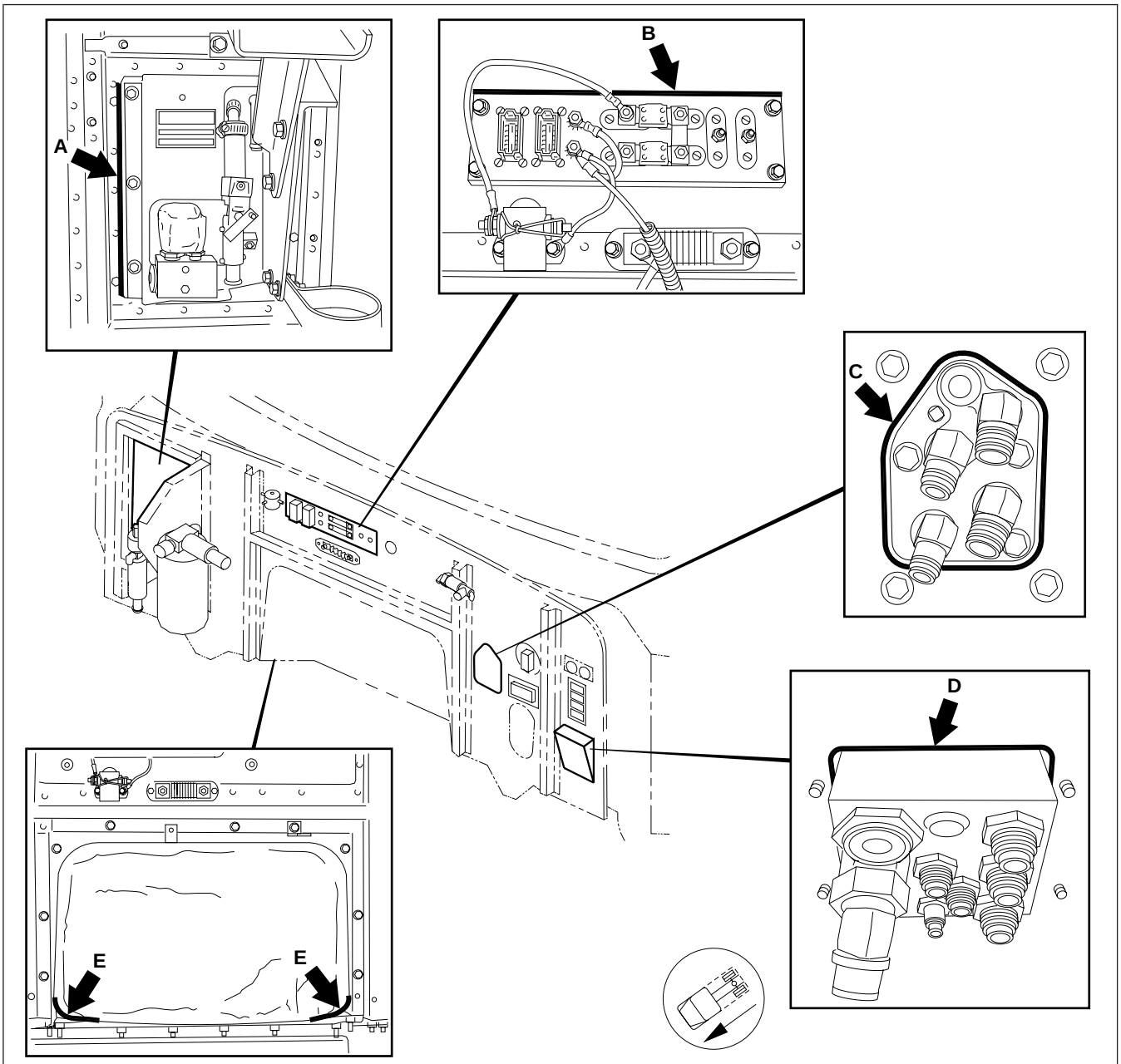
Repair any leaks as follows.

- Foot Valve—if sealing is required, run a bead of sealant around the outside lip of the foot valve/front-wall joint.
- A/C Unit—water tends to sit on top the unit and run down the vertical joints. Apply sealant to both sides.
- Air Manifold—apply a bead of sealant along the top seam.
- Doghouse—apply a generous amount of sealant to the front lower corners of the doghouse. Check that the corner radii are sufficiently filled with sealant, as these are most likely to leak.

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## Cab Water-Leak Detection and Repair




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Check for leaks at the locations listed below, and apply sealant as required.

A. Along both sides of the A/C unit.
B. Along the top edge of the electrical panel.
C. Around the edge of the foot valve joint.
D. Along the top seam of the air manifold.
E. At the lower front corners of the doghouse.

**Fig. 2, Checking for Front-Wall Leaks**

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- Electrical Panel—apply a small bead of sealant along the top edge of the panel. Do not overtighten the fasteners at the ends of the panel, as this can cause bowing of the panel in the middle, and result in a leak. A sagging gasket along the bottom edge of the panel is an indicator that the top edge may leak unless a sealant is applied.

NOTE: Only use clear, non-silicon-based sealant for all painted-surface applications.

## Cab Doors

NOTE: The Western Star cab door is a "wet door," and it is normal for water to flow down the outside of the window into the door. The water drains out through a drain hole on the bottom of the door.

1. Check that the cab door seals are tight against the cab. Check the seals by using one of the following tests.
   - Grease Test—apply a thin film of grease on the seal. Close and open the door. Check for grease transfer.
   - Paper Test—insert a sheet of paper into the joint of a closed door. If the paper slides easily, there is a gap.
2. If either test fails, check the door for misalignment or poor adhesion of the rubber seal. Align the door or repair the seal as necessary.
3. Check the exterior seal on the cab door visibility window. Ensure that the seal is not creased.

**CAUTION**

**Do not use a hammer to tap the seal around the visibility window in place. Doing so may dent the door exterior panel.**

NOTE: The presence of water between the panes of the visibility window does not indicate a leak. The visibility window is not a "sealed" unit, and it is normal for water running into the "wet door" to also run between the panes of the visibility window.

4. Check the drain hole on the bottom of the door. See **Fig. 3**. Ensure that the hole is not plugged. There should also be a gap in the door seal for water to drain. Cut a gap in the seal if necessary, either directly below the drain hole or at the center of the door's bottom edge.

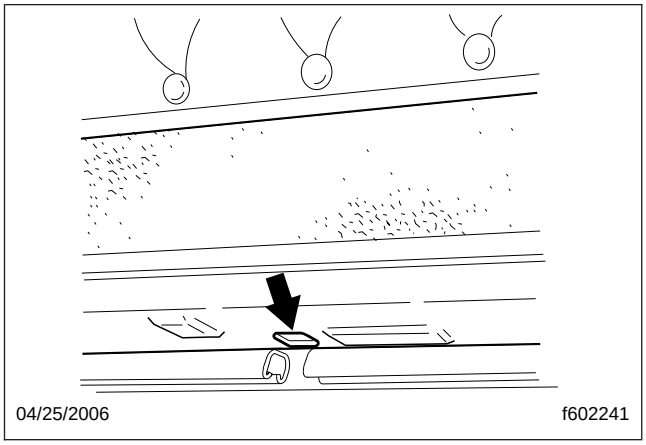
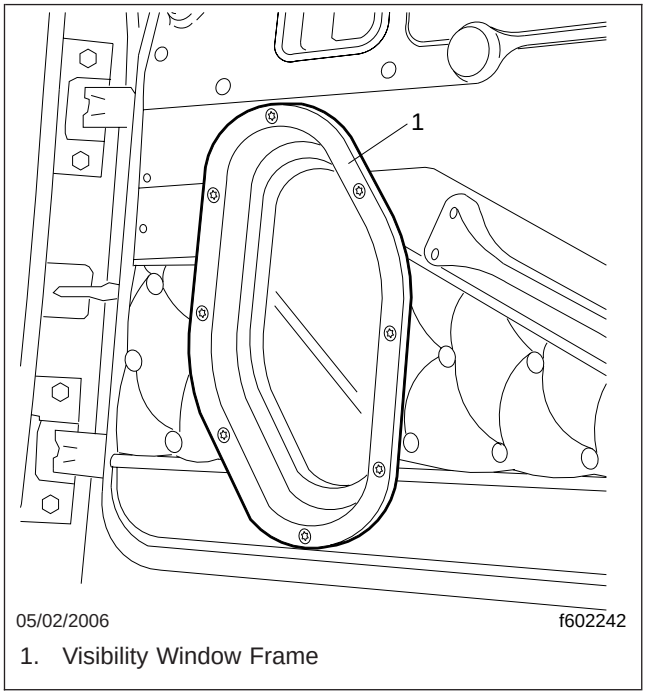



**Fig. 3, Cab Door Drain Hole**

5. Check the screws that attach the visibility window frame to the interior door panel. Make sure that they are all snugly and evenly tightened. See **Fig. 4**.




1. Visibility Window Frame

**Fig. 4, Visibility Window**

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# Cab Water-Leak Detection and Repair

## Cab Body and Roof

NOTE: Water leaks repaired from inside the cab may require removal of interior upholstery.

Leaks at the cab roof-cap joint must be sealed from the inside. Apply sealant along the entire length of the seam inside the cab.

Check the joints on the cab sides for visible voids or thin beads along the seams. If necessary, fill them with sealant.

If the rear window perimeter leaks, the rubber seal may not be completely seated. Tap the window with a rubber mallet until it is locked and flush.

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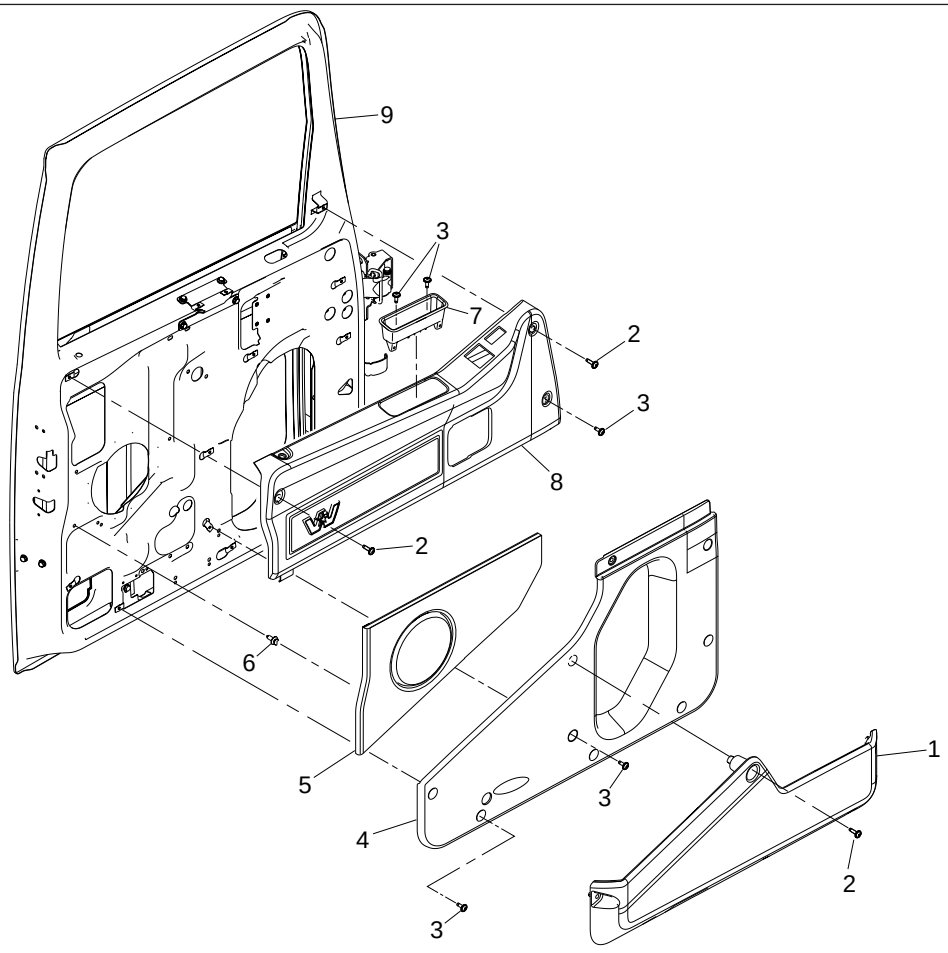


## Door Trim Panels Removal and Installation

# Vehicles Built From November 7, 2011

## Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Pull the switches off the top of the upper door trim panel, then disconnect the wiring.
3. Remove the manual window crank handle (if equipped).
4. Remove the knob from the end of the lock rod.
5. Remove the four screws from the interior release handle. The handle must be held up to access two of the screws. Leave the handle in place.
6. Remove the upper trim panel as follows:
   - 6.1 Remove the two screws from the bottom of the pull cup. See **Fig. 1**.




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NOTE: Door without a visibility window shown.

1. Map Pocket Panel
2. Screw, Long
3. Screw, Short
4. Lower Trim Panel
5. Upholstery Panel
6. Christmas Tree Fastener
7. Pull Cup
8. Upper Trim Panel
9. Door Structure

**Fig. 1, Door Trim Panels, Vehicles Built From November 7, 2011**

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## Door Trim Panels Removal and Installation

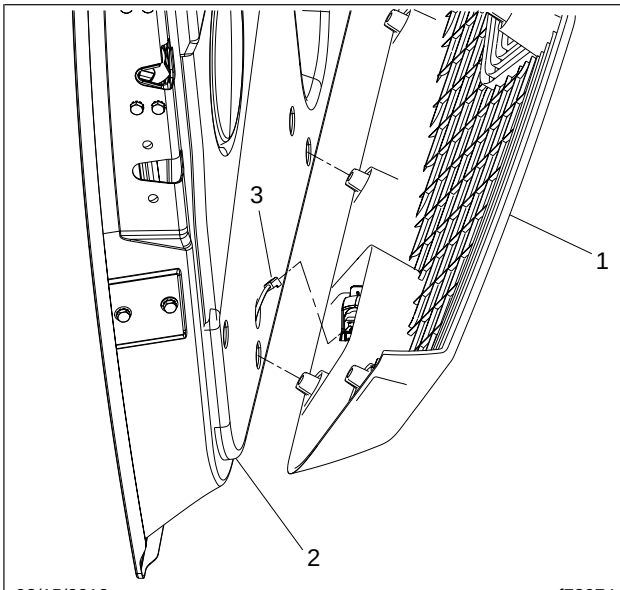
6.2 Remove the three screws that attach the upper trim panel to the door.

6.3 Slide the upper trim panel up to disengage the hook (behind the lower rear corner of the panel) from the door. Rotate the panel to allow the interior release handle to pass through the opening in the panel. Remove the panel, leaving the interior release handle in place on the door.

7. Remove the map pocket panel as follows:

7.1 Remove the screws that attach the map pocket panel to the lower trim panel and the door.

7.2 Disconnect the courtesy lamp wiring behind the pocket, then remove the pocket panel. See **Fig. 2**.




1. Map Pocket Panel
2. Door Structure
3. Courtesy Lamp Connector

**Fig. 2, Courtesy Lamp Wiring Connector**

8. Remove the lower trim panel. See **Fig. 3**.
9. Pull the center upholstery panel loose from the door.

# Installation

1. Press the center upholstery panel into place on the door. See **Fig. 1**.
2. Using short screws, install the lower trim panel. For fastener locations, see **Fig. 3**. The remaining holes are used for the map pocket panel installation.
3. Install the map pocket panel as follows:

3.1 Connect the courtesy lamp wiring to the door wiring harness. See **Fig. 2**.

3.2 Using long screws, attach the map pocket to the lower trim panel and the door.

4. Install the upper trim panel as follows:

4.1 Pull the wiring connectors through the switch opening on top of the panel. See **Fig. 4**, Ref. A.

4.2 Set the upper panel against the door, rotating it to allow the interior release handle to pass through the opening. See **Fig. 4**, Ref. B.

4.3 Position the hook at the lower rear corner of the panel behind the uphostery panel. Maneuver the hook through the slit in the vapor barrier and behind the edge of the latch opening. See **Fig. 4**, Ref. C.

4.4 Lower the panel down over the lock rod. The bottom edge of the panel should cover the top edge of the center upholstery panel. Smooth the upholstery under the edge of the upper panel.

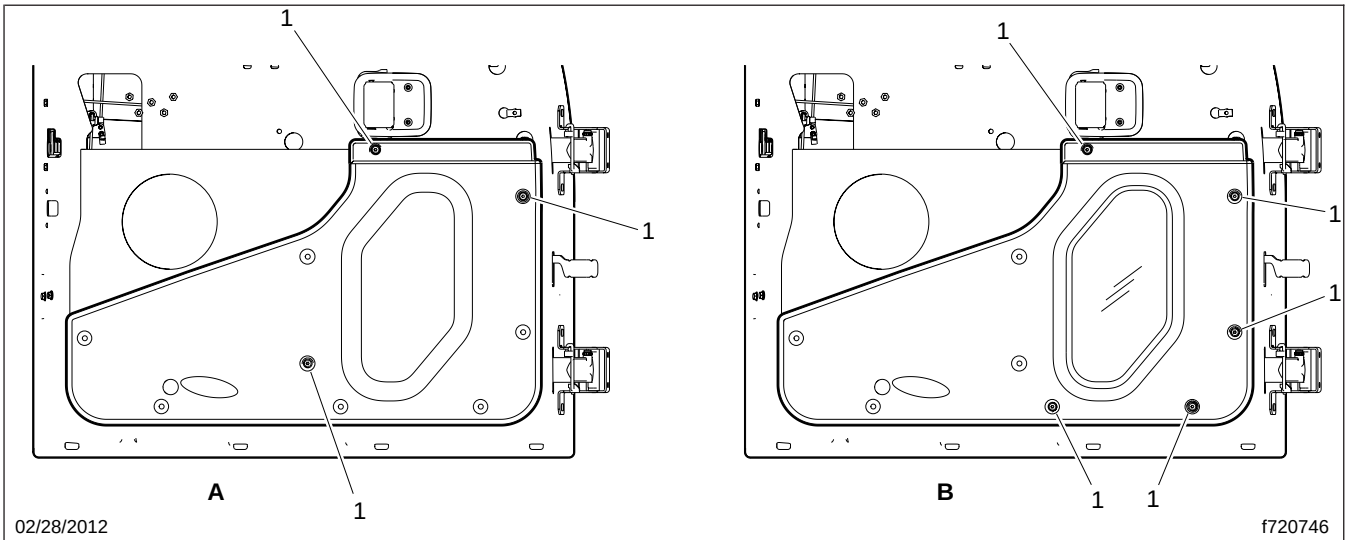
4.5 Install two short screws in the bottom of the pull cup.

4.6 Install one short screw in the lower forward corner and two long screws in the upper forward and rear corners.

5. Screw the lock rod knob onto the end of the lock rod.
6. Using four screws, install the interior release handle.
7. Install the manual window crank handle (if equipped).
8. Connect the switches to the door wiring, then snap the switches into the panel openings. Make sure the switches are oriented properly.

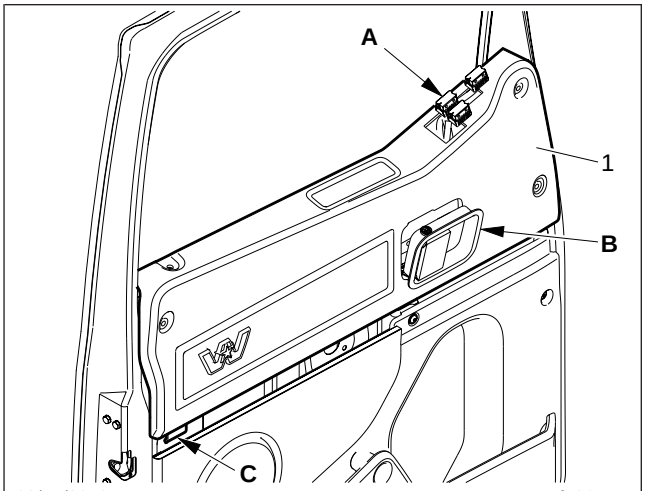
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A. Door Without a Visibility Window
B. Door With a Visibility Window
1. Lower Trim Panel Screw

**Fig. 3, Lower Trim Panel Screw Locations**




A. Pull the wiring connectors through the switch opening.
B. Pass the inside release handle through the opening.
C. Pass the hook through the slit in the vapor barrier and behind the edge of the latch opening.

1. Upper Trim Panel

**Fig. 4, Upper Trim Panel Installation**

## Vehicles Built Before November 7, 2011

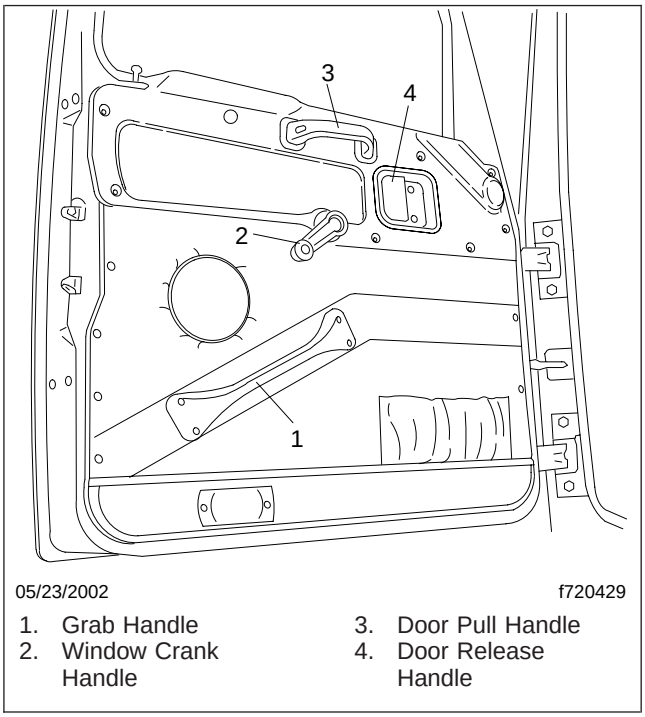
### Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Remove the two screws from the door pull handle, then remove the handle. See **Fig. 5**.
3. Remove the four screws from the door grab handle, then remove the handle.
4. Remove the four screws from the door release handle. The handle must be held up to access two of the screws. Leave the handle in place.
5. Remove the screw from the window crank handle (if equipped) and remove the handle.
6. Remove the screws from the molded upper door panel. See **Fig. 6**. Rotate the panel to allow the door release handle to be pushed through the panel and remove the panel.
7. Remove the screws along the edge of the upholstery. If the upholstery style is diamond-tufted, there is one snap button (**Fig. 6**, item 2) that must be removed first to remove the screw un-

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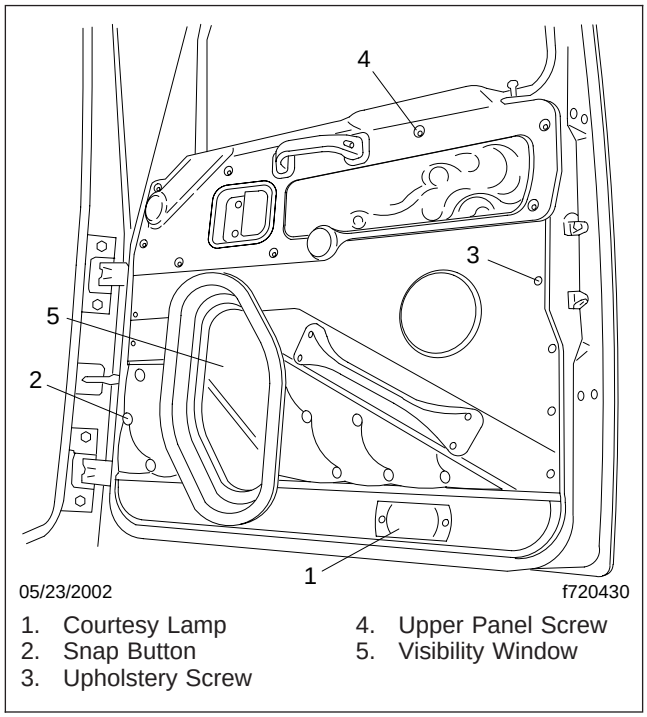


## Door Trim Panels Removal and Installation




1. Grab Handle
2. Window Crank Handle
3. Door Pull Handle
4. Door Release Handle

**Fig. 5, Door Pull Handles, Vehicles Built Before November 7, 2011**




1. Courtesy Lamp
2. Snap Button
3. Upholstery Screw
4. Upper Panel Screw
5. Visibility Window

**Fig. 6, Door Upholstery Fasteners, Vehicles Built Before November 7, 2011**

derneath it. The snap button is the center one along the edge closest to the door hinge.

8. Remove the courtesy lamp as follows:
   - 8.1 Release the tabs that hold the lens to the lamp housing by pushing a flat-tipped screwdriver in the slots along the upper and lower edges of the lens. Remove the lens.
   - 8.2 Remove the screws that attach the lamp housing to the door panel.
   - 8.3 Pull out the lamp housing and disconnect the the wires.
9. If the door has a visibility window, remove the eight screws mounting it and remove the window.
10. Remove the upholstery panel from the door.

## Installation

1. Install the upholstery panel. If the upholstery style is diamond-tufted with buttons, install the snap button (**Fig. 6**, item 2).
2. Install the visibility window (if equipped).
3. Connect the courtesy lamp wiring. Attach the lamp, then snap the lens on the housing.
4. Install the molded upper door panel as follows:
   - 4.1 Position the panel against the door, rotating it to allow the interior release handle to pass through the opening.
   - 4.2 Attach the panel to the door.
5. Install the window crank handle (if equipped).
6. Using four screws, attach the interior release handle to the door and the molded upper door panel. The handle must be held up to install two of the screws.
7. Using four screws, install the door grab handle.
8. Using two screws, install the door pull handle.

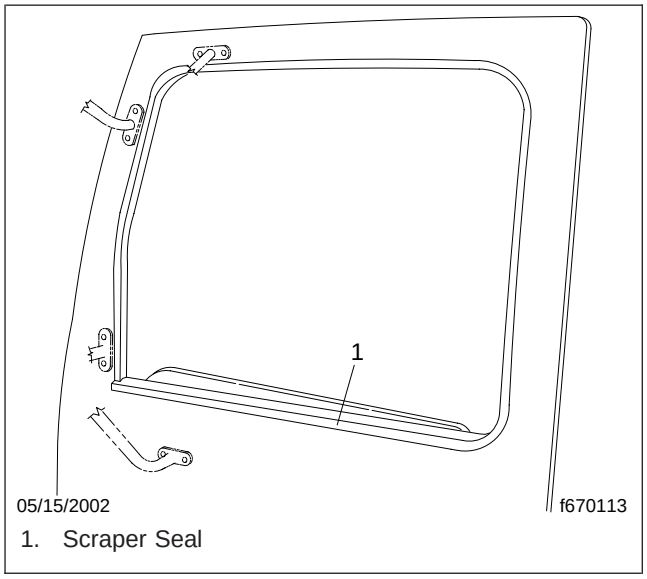
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# Door Windows Removal, Installation, and Adjustment

## Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Remove the door upholstery panel; see **Subject 100**.
3. Remove the inner and outer scraper seals by prying them up. See **Fig. 1**.



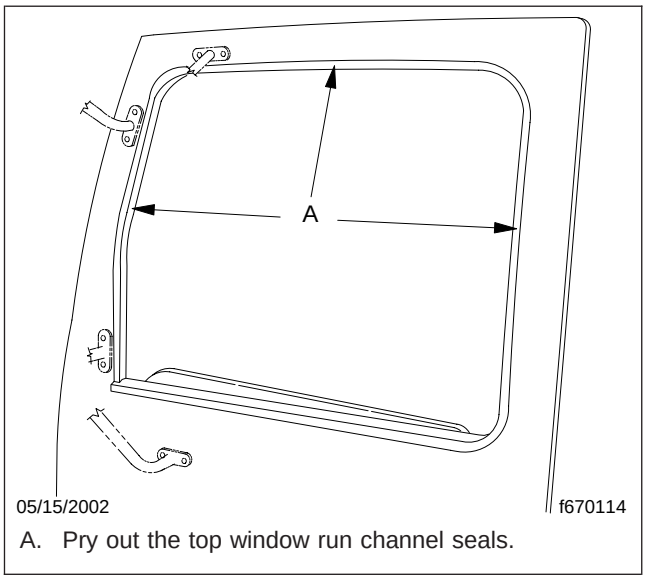

1. Scraper Seal

**Fig. 1, Cab Door Window**

4. Remove the top window run channel seals by prying them out. See **Fig. 2**.
5. Remove the upper mirror arm mounting bracket screws and swing the arms to the side. See **Fig. 3**. The lower arms do not need to be removed.
6. Crank or power the window down until the window mounting bolts are aligned with the two access holes in the inner door skin. See **Fig. 4**.

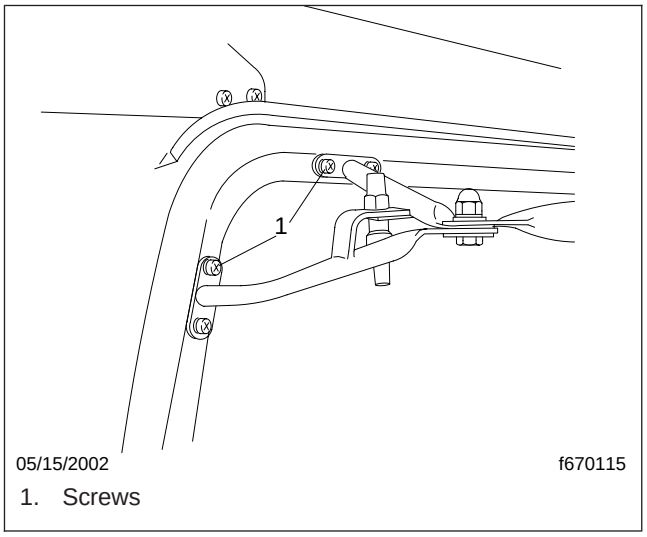
**⚠ WARNING**

**Wear protective gloves and safety glasses when replacing window glass. Gloves will protect your hands from sharp edges, and allow a better grip. Failure to wear gloves and safety glasses when handling glass could result in injury to hands or eyes.**




A. Pry out the top window run channel seals.

**Fig. 2, Top Run Channels.**




1. Screws

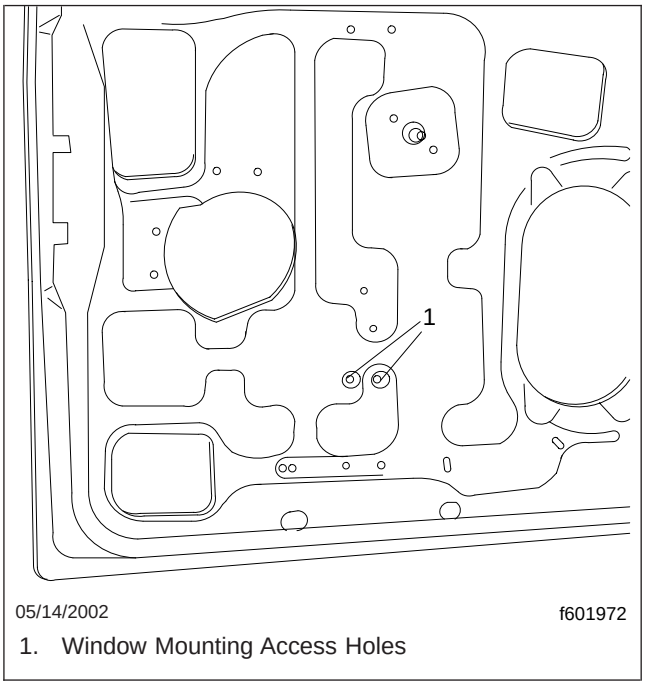
**Fig. 3, Mirror Arm Mounting**

7. Through one of the door openings, hold the glass in place while removing the window mounting bolts. Slide the glass up and place a padded C-clamp over the top of the door to hold the glass. See **Fig. 5**.
8. Remove the window regulator by removing the mounting bolts. See **Fig. 6**. Watch for the spacer as the top bolts are removed. It must be reinstalled when assembling the regulator back into

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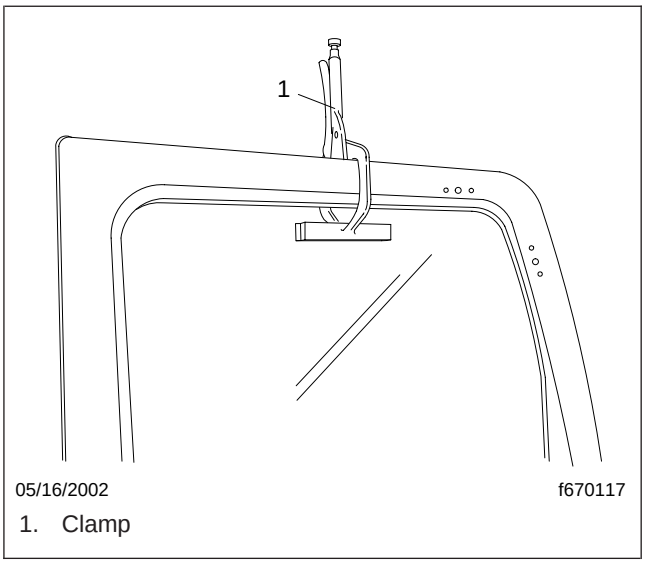
## Door Windows Removal, Installation, and Adjustment




05/14/2002 f601972

1. Window Mounting Access Holes

**Fig. 4, Window Mounting**

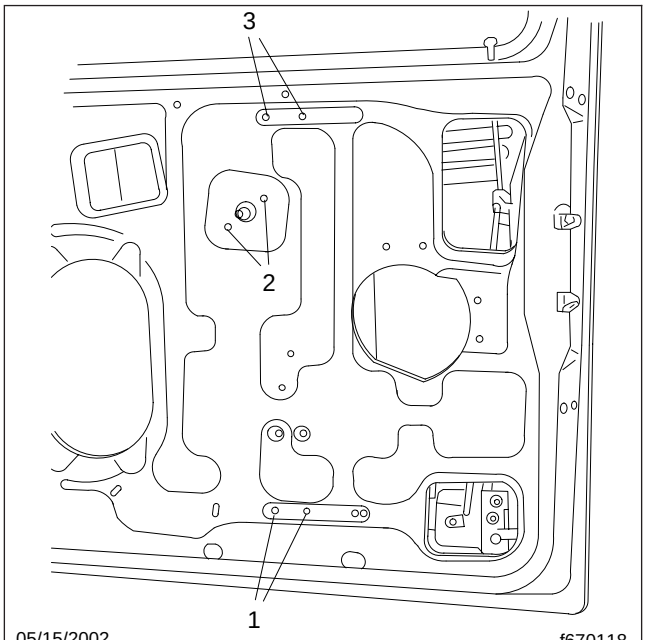



05/16/2002 f670117

1. Clamp

**Fig. 5, Window Clamping**

the door. Slide the window regulator out of the visibility window access hole in the inner door panel.




05/15/2002 f670118

1. Regulator Guide Bottom Mounting Bolts
2. Regulator Mounting Bolts
3. Regulator Guide Top Mounting Bolts

**Fig. 6, Regulator Mounting**

9. Remove the forward window channel by removing the mounting bolts. See **Fig. 7**. Slide the window guide out of the access hole in the door panel.
10. Disconnect the door lock rod by prying it loose from the lock clip. Lift the door lock knob to pull the rod up out of the way. See **Fig. 8**.
11. Remove the rear window channel by removing the mounting bolts. See **Fig. 9**. Slide the window guide out of one of the access holes in the door.
12. Hold the glass and remove the clamp. Lower the window part way down into the door. Rotate the window, lowering the front edge down. See **Fig. 10**. Lift the window out of the door.

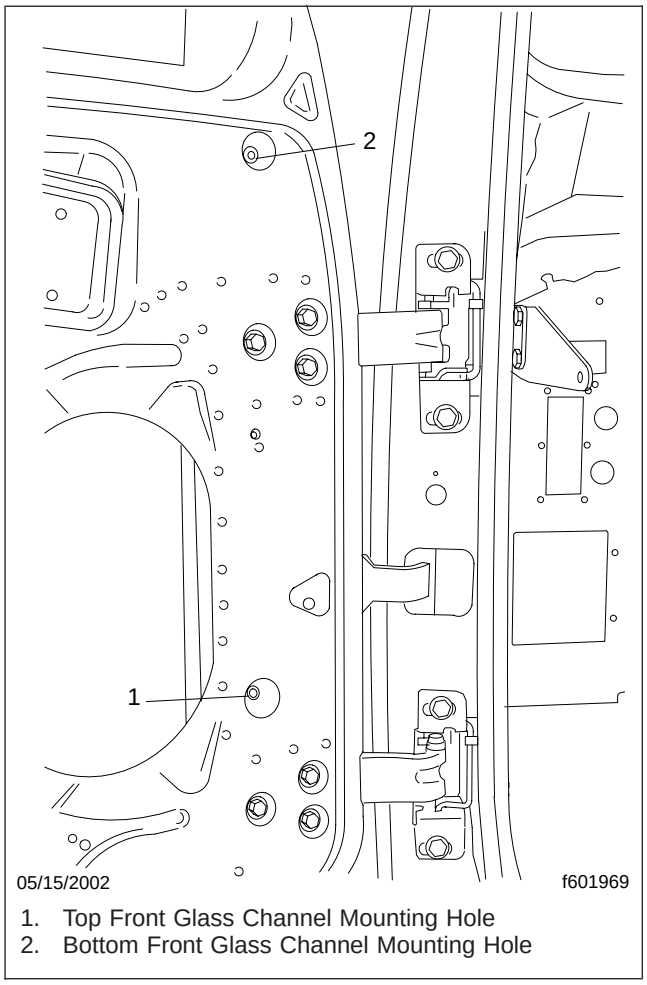
## Installation

1. If the window is being replaced, pry the lift channel from the old window. Set the new glass top side down on a padded support. Place a new glass retainer strip on the bottom edge of the door glass. See **Fig. 11**.

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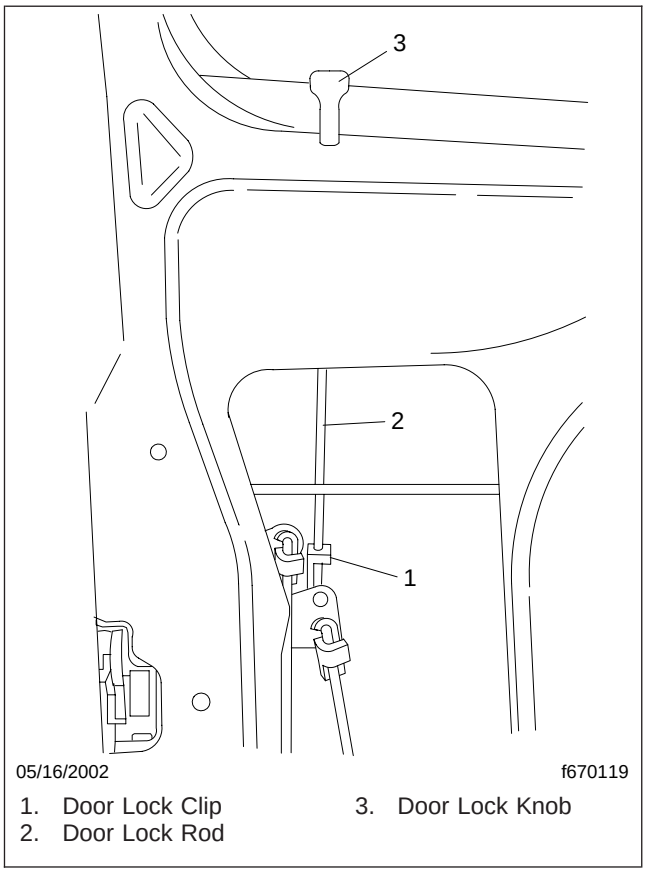
## Door Windows Removal, Installation, and Adjustment




1. Top Front Glass Channel Mounting Hole
2. Bottom Front Glass Channel Mounting Hole

**Fig. 7, Glass Channel Mounting Holes**

2. Place the lift channel on the glass retainer strip. The mounting tab (on manual crank windows) or mounting stud (on power windows) faces inward. See **Fig. 12**. Position the lift channel 8-13/16 inches (224 mm) from the front edge of the window. See **Fig. 13** and **Fig. 14**.
3. Place the window glass in the door, holding it up with a padded C-clamp over the door frame; see **Fig. 5**.
4. Slide the rear window channel in through the access hole in the door, then attach it to the door with the four mounting bolts. See **Fig. 9**.
5. Attach the door lock rod to the lock clip. See **Fig. 8**.




1. Door Lock Clip
2. Door Lock Rod
3. Door Lock Knob

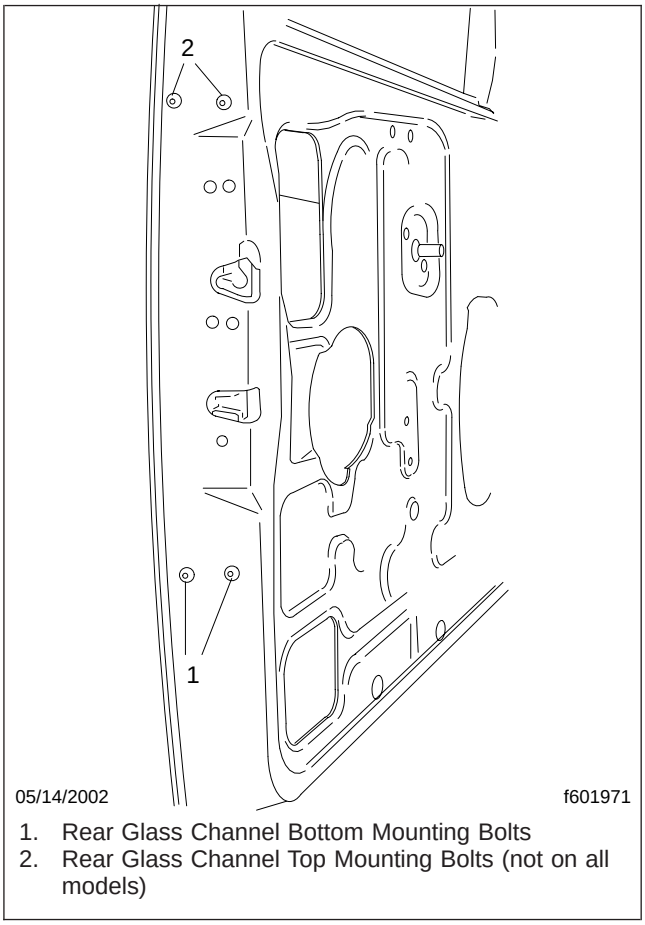
**Fig. 8, Door Lock Mechanism**

6. Slide the forward window channel in through the access hole in the door panel, then attach it to the door panel with the two mounting screws. See **Fig. 7**.
7. Insert the regulator and the spacer in through visibility window access hole, then attach them to the door panel with the mounting bolts. See **Fig. 6**.
8. Using care, release the glass from the C-clamp and lower it in place. If necessary, crank or power the window up or down until the lift channel mounting holes are lined up with the two access holes in the inner door panel. Install the window mounting bolts. See **Fig. 4**.
9. Attach the upper mirror mounting brackets to the cab door. See **Fig. 3**.
10. Install the top window run channel seals. See **Fig. 2**.

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## Door Windows Removal, Installation, and Adjustment



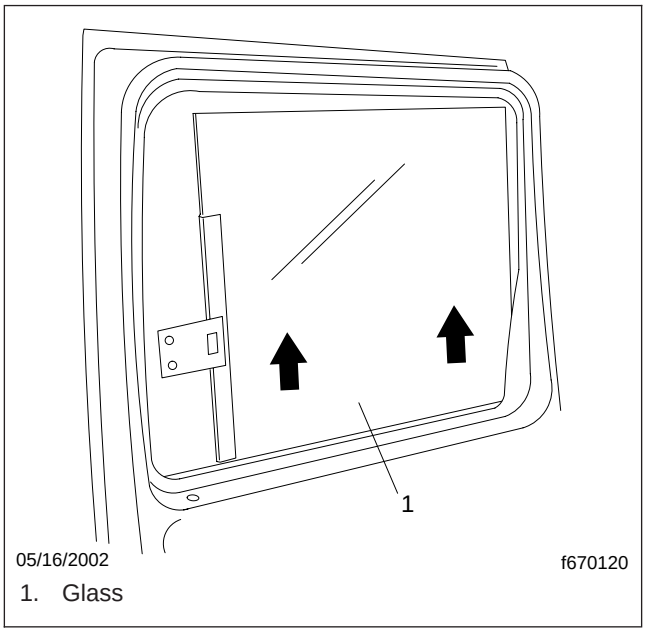

1. Rear Glass Channel Bottom Mounting Bolts
2. Rear Glass Channel Top Mounting Bolts (not on all models)

**Fig. 9, Rear Window Channel Mounting**

11. Install the inner and outer waist seals. See **Fig. 1**.
12. Adjust the door window; see "Door Window Adjustment" below.

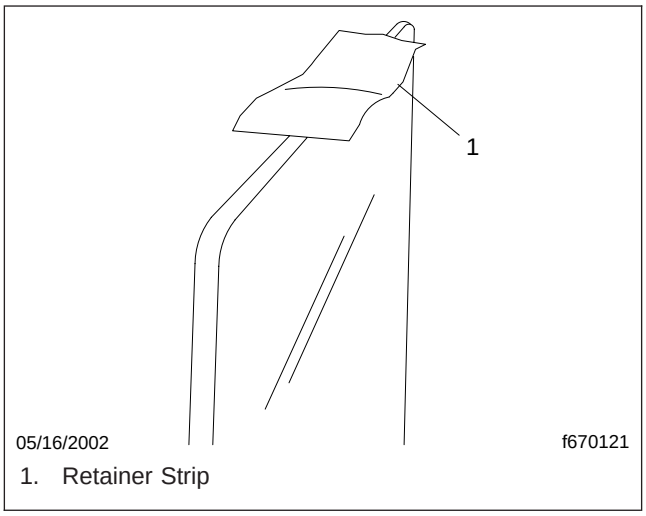
# Door Window Adjustment

1. Loosen the top and bottom front glass channel mounting bolts. See **Fig. 7**. Then, move the top of the window channel forwards or backwards. See **Fig. 15** and **Fig. 16**. Tighten the glass channel mounting bolts when it is aligned.
2. Align the door's rear upper and lower window channels in a side to side direction. This is accomplished by loosening the top and bottom mounting bolts, and moving the guide to one side or the other. The mounting holes are slotted.




1. Glass

**Fig. 10, Lifting the Door Window Out**




1. Retainer Strip

**Fig. 11, Glass Retainer Strip**

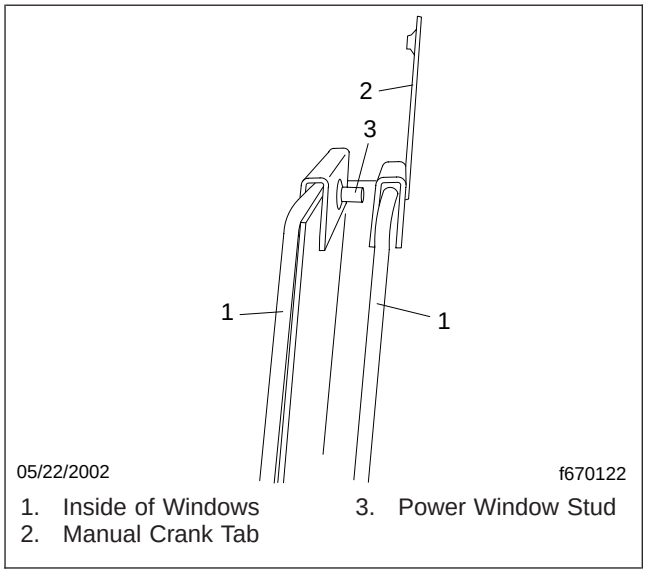
Retighten the mounting bolts after the adjustment has been made. See **Fig. 9**.

3. Lower the window until the lift channel mounting bolts are visible in the access holes. Back off the bolts or nuts enough to allow the window to move. Run the window up and down about three times. The mounting holes are slotted to allow

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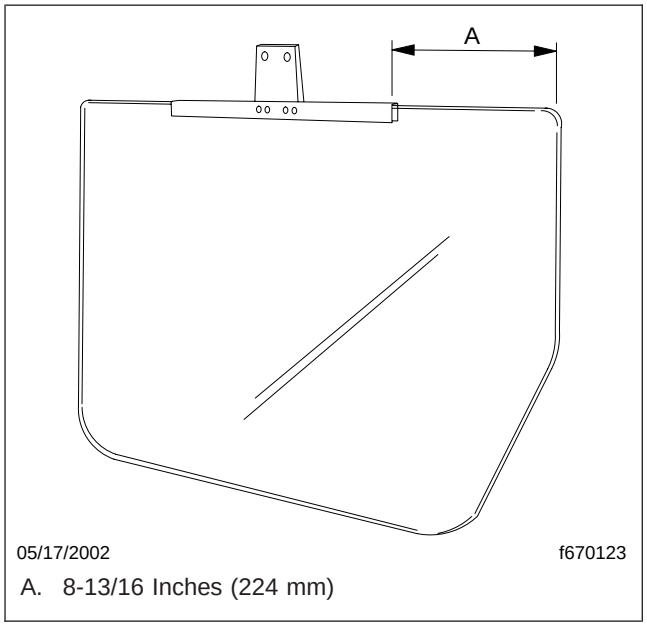


## Door Windows Removal, Installation, and Adjustment




1. Inside of Windows
2. Manual Crank Tab
3. Power Window Stud

**Fig. 12, Installing the Lift Channel**

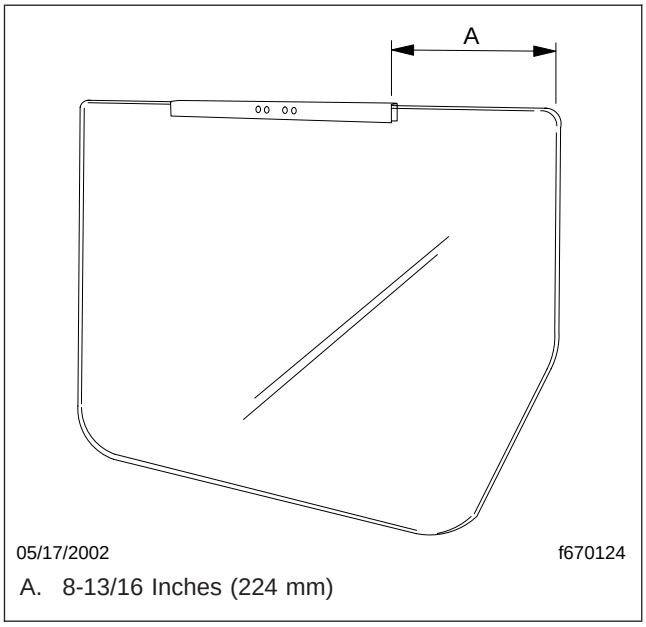



A. 8-13/16 Inches (224 mm)

**Fig. 13, Mechanical Window Lift Channel**

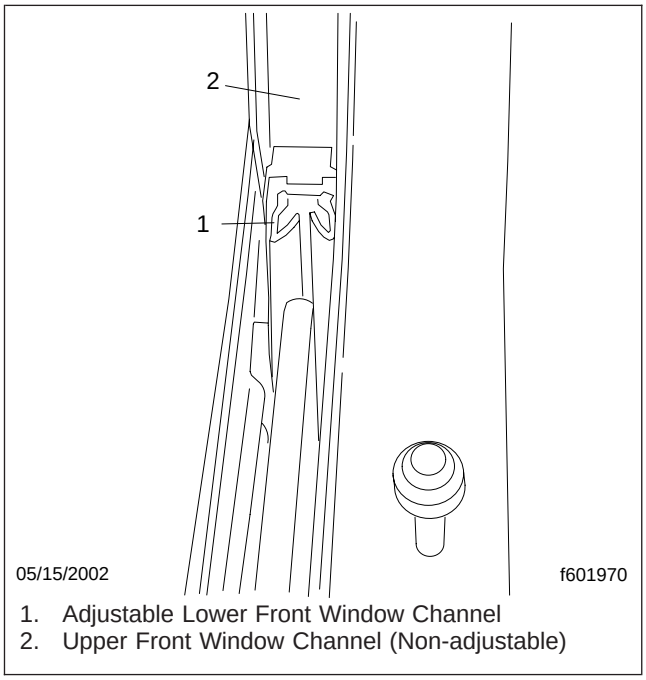
adjustment. When the window is in the correct position re-tighten the mounting bolts. See **Fig. 17**.

4. On manual crank windows measure the cranking effort. Do not include the initial "break-free" effort. The effort should not exceed 35 lbf·in (400 N·cm) after the break-free point.




A. 8-13/16 Inches (224 mm)

**Fig. 14, Power Window Lift Channel**




1. Adjustable Lower Front Window Channel
2. Upper Front Window Channel (Non-adjustable)

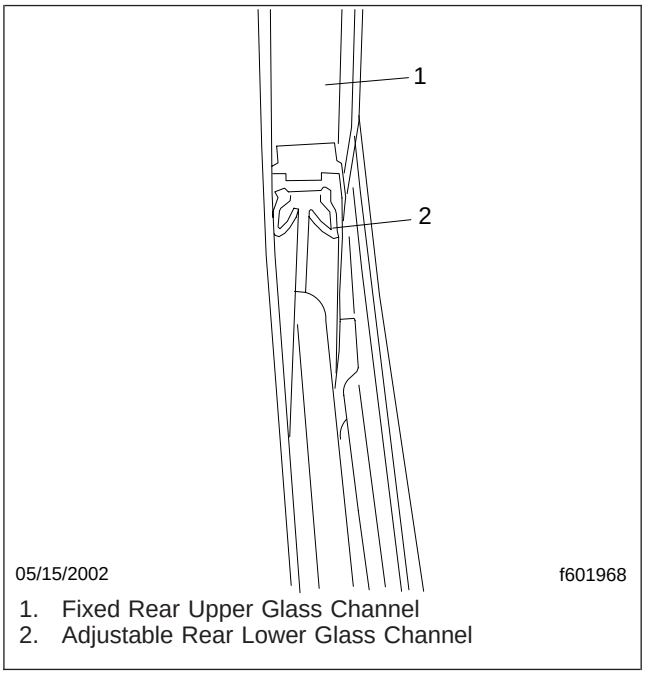
**Fig. 15, Front Glass Channels**

5. On power windows connect an amp meter and measure the amperage required by the power window motor to raise and lower the window. The amperage should not exceed 11 amps at

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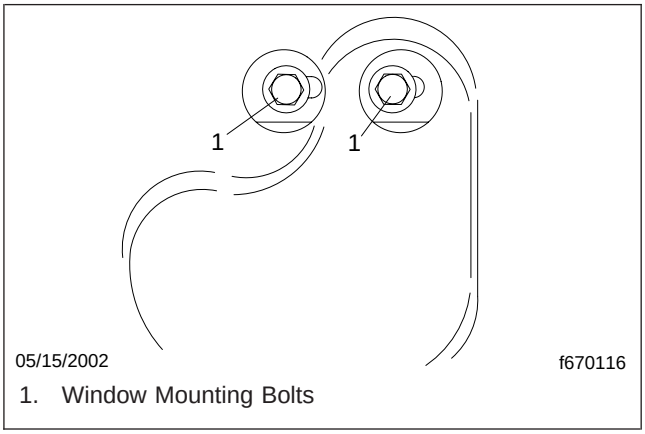


## Door Windows Removal, Installation, and Adjustment




1. Fixed Rear Upper Glass Channel
2. Adjustable Rear Lower Glass Channel

**Fig. 16, Rear Glass Channels**




1. Window Mounting Bolts

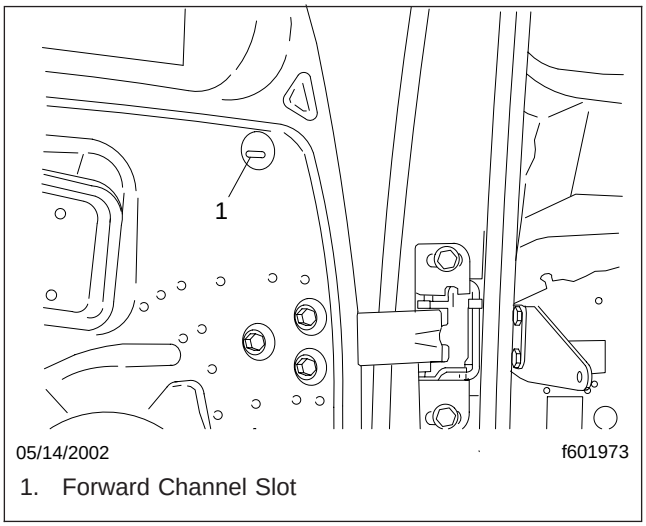
**Fig. 17, Window Mounting**

13.5 volts, or 12.5 amps at 12 volts, after the break-free point.

6. If the effort to raise and lower the window exceeds these values, the following items should be checked.

   6.1 Align or spread the forward or rear channels.

   6.2 Rework the forward channel slot to 1/4-inch (6 mm) maximum. See **Fig. 18**.



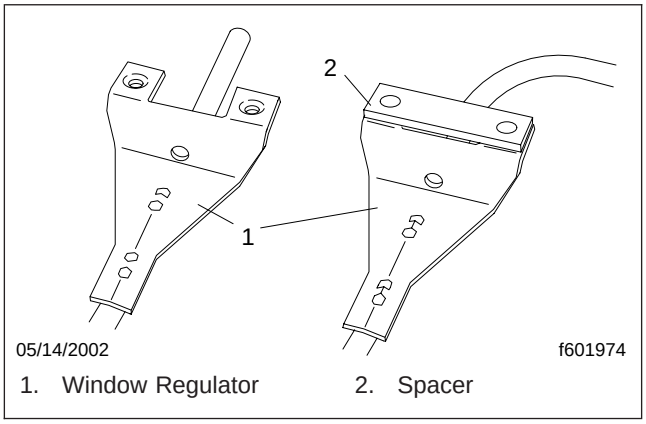

1. Forward Channel Slot

**Fig. 18, Rework the Forward Channel Slot**

   6.3 Replace the upper or lower window channel seals.

   6.4 Replace the inner or outer waist seal.

   6.5 If not installed, add a spacer to the top mount of the window regulator. See **Fig. 19** and **Fig. 20**.




1. Window Regulator
2. Spacer

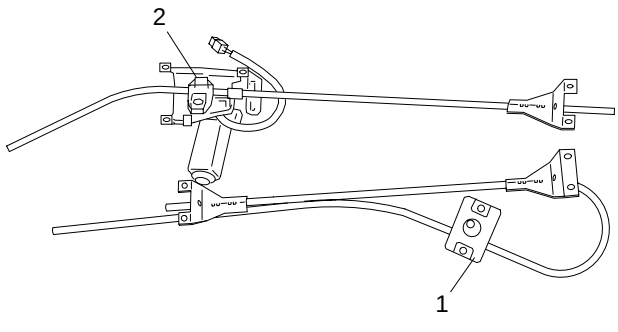
**Fig. 19, Window Regulator Spacer**

7. Install the door upholstery panel; see **Subject 100**.

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## Door Windows Removal, Installation, and Adjustment




05/15/2002 f601976

1. Manual Window Regulator
2. Power Window Regulator

**Fig. 20, Power and Manual Window Regulators**

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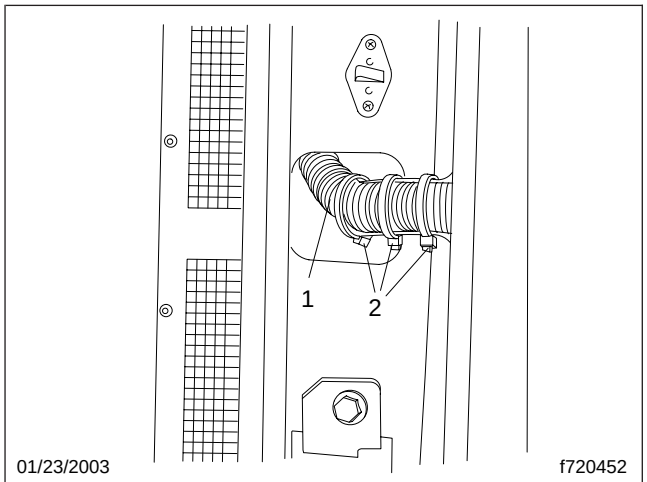


## Removal

NOTE: If the door is being replaced, the recommended procedure is to remove the hinge bolts at the door, and leave the hinges mounted to the cab as instructed in this subject.

If the door is to be removed then reinstalled it is recommended to remove the hinge bolts at the A-pillar and leave the hinges mounted to the door. See **Subject 130** for instructions for removing the hinge from the A-pillar.

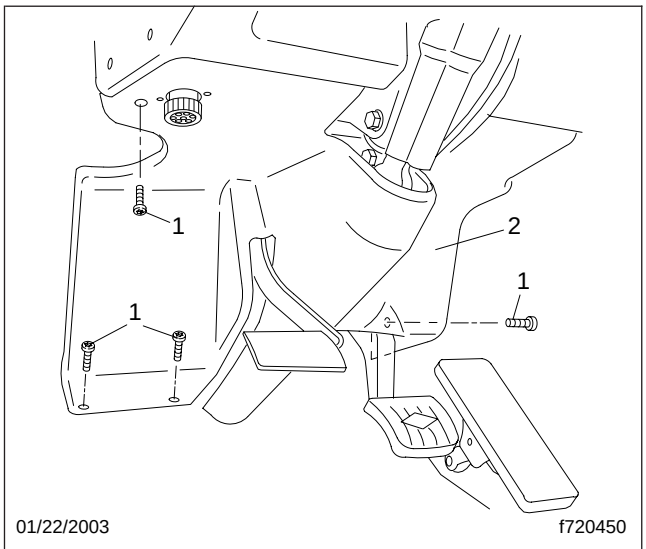
1. Apply the parking brakes, and chock the tires.
2. Lower the window.
3. Disconnect the batteries.
4. Remove the door upholstery panels following the instructions in **Subject 100**.
5. Cut the tie straps around the door wiring harness and remove the cover. See **Fig. 1**.




1. Plastic Cover
2. Tie Straps

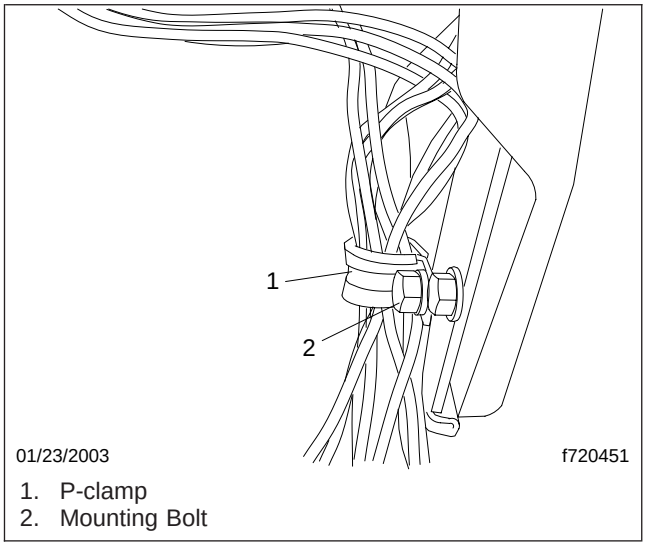
**Fig. 1, Harness Cover**

6. On the driver side, remove the lower dash panel from below the steering wheel. See **Fig. 2**.
7. On the passenger side, remove the P-clamp that holds the wires under the dash panel. See **Fig. 3**.




1. Mounting Bolts
2. Lower Dash Panel

**Fig. 2, Lower Dash Panel**




1. P-clamp
2. Mounting Bolt

**Fig. 3, Passenger Side Wiring**

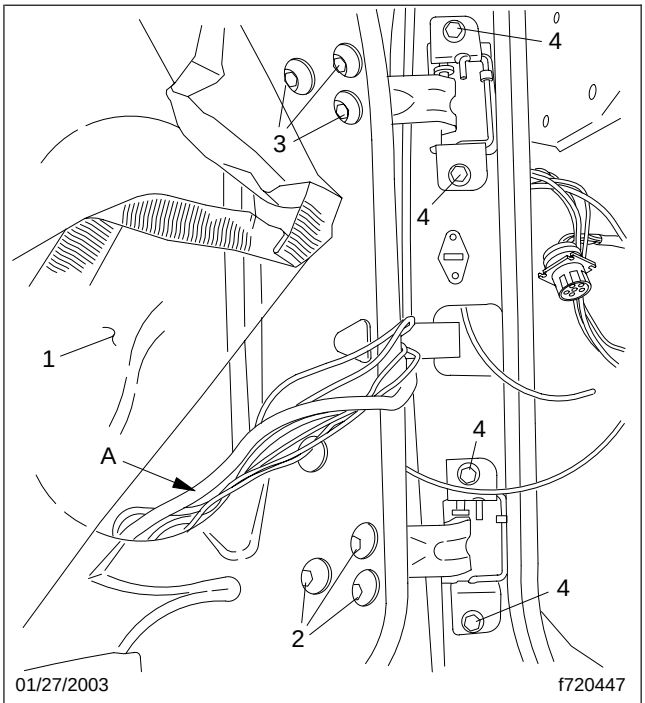
8. Mark the wires for identification, then remove the connectors from the wires so they can be pulled through the door jamb.
9. Pull the CB antenna cable down inside the A-pillar to reach the connector, and disconnect it.
10. Pull the wires and the CB antenna cable through the door jamb and back to the door.

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## Door Removal and Installation

11. Peel back the plastic water seal on the door to expose the six door hinge bolts. Set the wires and CB cable inside the door access opening to support them out of the way. See **Fig. 4**.




A. Set the wires inside the door access opening.
1. Door Access Opening
2. Lower Hinge Bolts
3. Upper Hinge Bolts
4. Hinge Mounting Bolt on Door Jamb

**Fig. 4, Door Interior**

12. Supporting the door, remove the six hinge bolts on the door. See **Fig. 5**. Mark the position of the bolts to aid in reinstalling the door.

**⚠ WARNING**

**Do not attempt to lift the door without support. Lifting or dropping the door could result in personal injury or damage to the door assembly and other components.**

13. Supporting the door, slide it off the hinges. See **Fig. 6**.

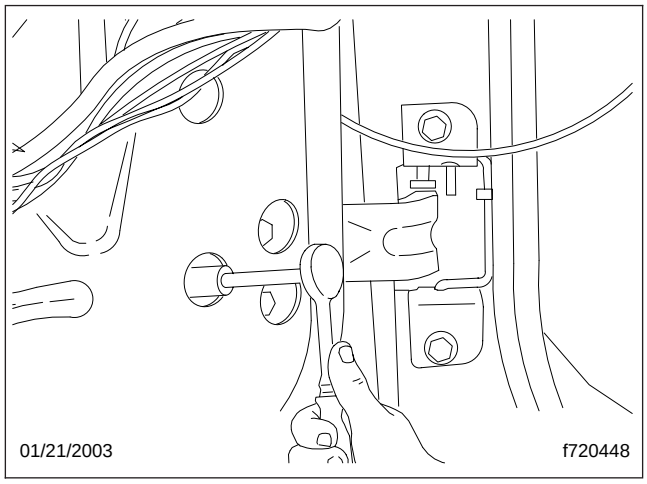
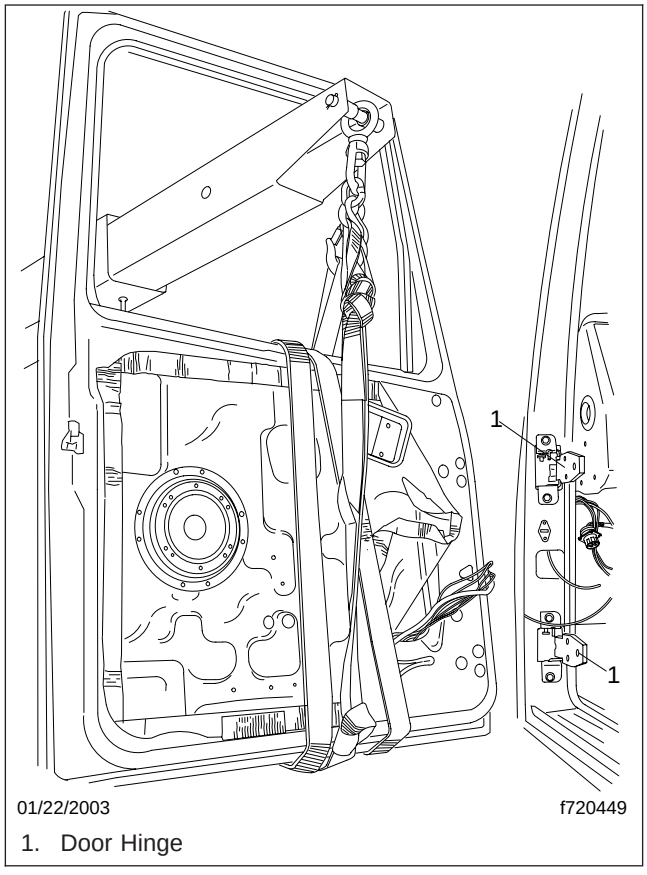



**Fig. 5, Door Hinge Bolts**




1. Door Hinge

**Fig. 6, Slide the Door Off the Hinges**

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## Installation

1. Supporting the door, align the door hinge pockets over the hinges and slide the door into position. See **Fig. 6**.

NOTE: The bolt holes are "over-sized" to allow for alignment of the door against the door opening.

2. Using a drift pin, align the door and hinge holes (top and bottom).
3. Apply Loctite to the bolt threads, then install a bolt and washer into each of the six mounting holes (removing the drift pins and installing those bolts last). Tighten each bolt finger-tight. See **Fig. 5**.
4. With the bolts snug, carefully close the door.
5. Inspect the door for proper alignment. It should have a uniform gap and the panels should sit flush at the corners except at the upper front. In this location the door should sit in approximately 1/4 inch (6 mm).
6. If the door is not aligned properly, adjust it using the hinge bolts at the door jamb for front in and out alignment. If enough adjustment isn't available, follow the instructions in **Subject 130** to access the outer hinge bolts.

   Use the hinge bolts on the door to adjust the forward and rear alignment, and adjust the striker pin for in and out alignment at the rear of the door.

   Once the door is aligned, tighten the hinge-to-door mounting bolts to 16 lbf·ft (22 N·m).
7. Run the wires through the door jamb and into the cab. Connect the wires to the connectors and plug in the connectors. Reconnect the CB antenna.
8. Connect the batteries.
9. Check to be sure the door electrical components are operating correctly.
10. Install the plastic harness cover and tie straps and secure the wiring to the door spring. See **Fig. 1**. On the passenger side, install the P-clamp.
11. On the driver side, install the lower dash panel.
12. Reattach the water barrier.
13. Install the upholstery panels and hardware. See **Subject 100** for instructions.

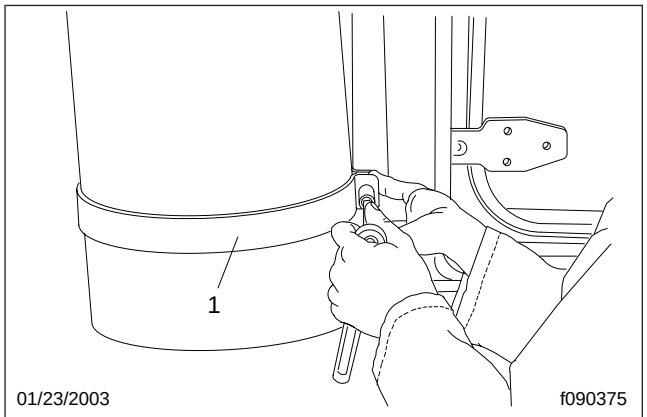
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# Door Hinge Removal and Installation

## Removal

1. Remove the door following the instructions in **Subject 120**.
2. Raise the hood.
3. Disconnect the air inlet hose clamp from the air cleaner.
4. Remove the air cleaner mounting bands (**Fig. 1**). Remove the air cleaner.



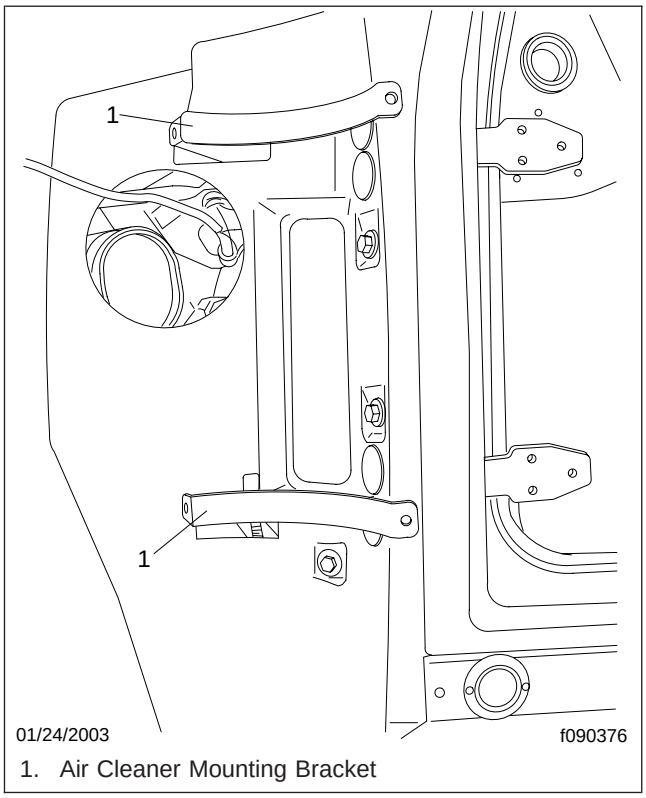

1. Air Cleaner Mounting Band

**Fig. 1, Remove the Air Cleaner Mounting Bands**

5. Remove the two bolts that fasten the air cleaner mounting bracket to the firewall. Remove the bracket. See **Fig. 2**.
6. Remove the plastic plugs and caps that cover the access holes for the outer hinge bolts. See **Fig. 3**. Remove the four bolts through the access holes, then remove the four bolts on the inside of the door jamb.
7. Remove the door hinges.

## Installation

1. Install new hinges and tighten the fastners finger-tight. Follow the instructions in **Subject 120** to install the door and align it. Tighten the hinge-to-A-pillar mounting bolts 30 lbf·ft (40 N·m).
2. Replace the plastic caps over the mounting bolts, and the plastic plugs over the access holes.
3. Install the air cleaner mounting bracket and tighten the mounting bolts 26 lbf·ft (35 N·m). Install the air cleaner and tighten the mounting bands to 16 lbf·ft (22 N·m).
4. Return the hood to the operating position.



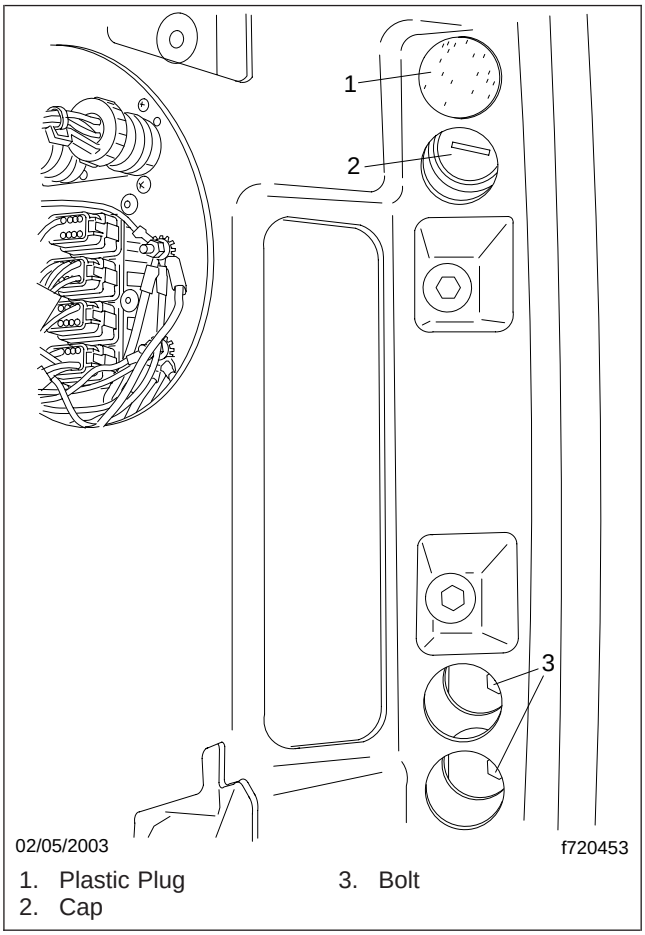

1. Air Cleaner Mounting Bracket

**Fig. 2, Remove the Air Cleaner Mounting Bracket**

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## Door Hinge Removal and Installation




1. Plastic Plug
2. Cap
3. Bolt

**Fig. 3, Hinge Mounting Bolt Access Holes**

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## Special Tool

A special tool is required for this procedure. See **Table 1**.

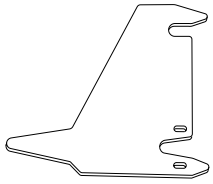
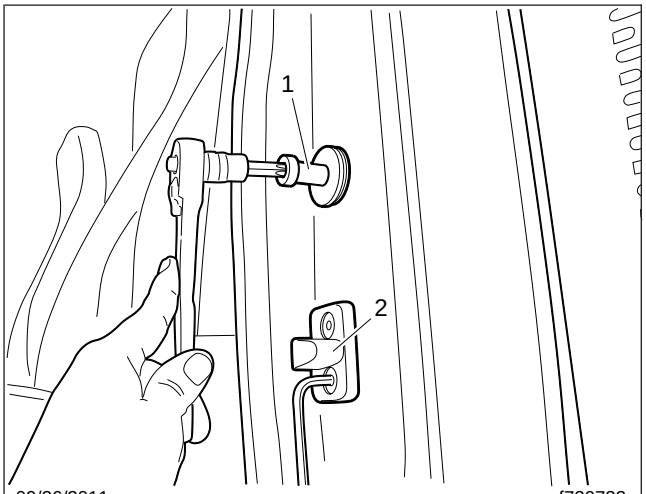
| Special Tool for Door Latching Adjustment | | | |
|---|---|---|---|
| **Tool** | **Description** | **Manufacturer** | **Part Number** |
|  f720730 | Door Latching Adjustment Tool | Kent-Moore | WWS J-50807 |

**Table 1, Special Tool for Door Latching Adjustment**

## Adjustment

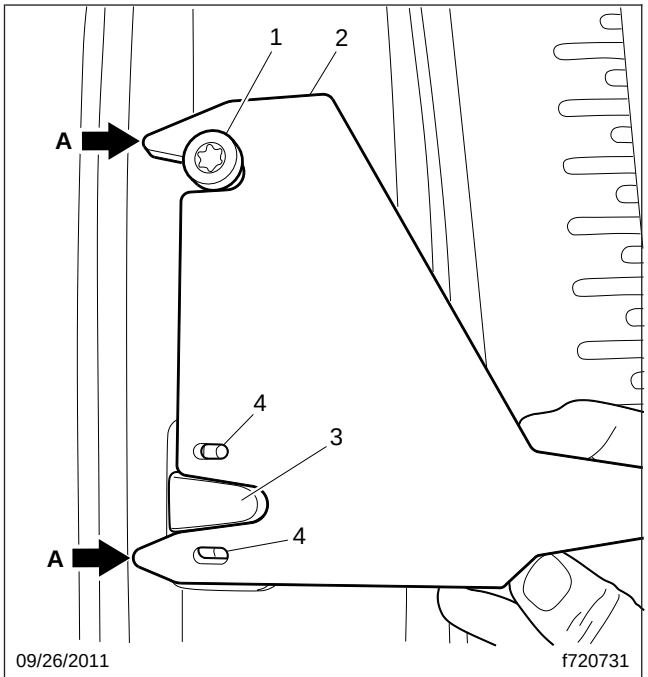
1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Loosen both the dove-tail wedge and the the striker pin for adjustment. See **Fig. 1**.




1. Striker Pin
2. Dove-Tail Wedge

**Fig. 1, Loosening the Striker Pin and Dove-Tail Wedge**

3. From inside the cab, position the special tool WWS J-50807 so that the two contact points are touching the door frame. See **Fig. 2**.




A. The tool should make contact with the door frame at these two points.

1. Striker Pin
2. Adjustment Tool
3. Dove-Tail Wedge
4. Wedge Mounting Fastener

**Fig. 2, Positioning the Adjustment Tool**

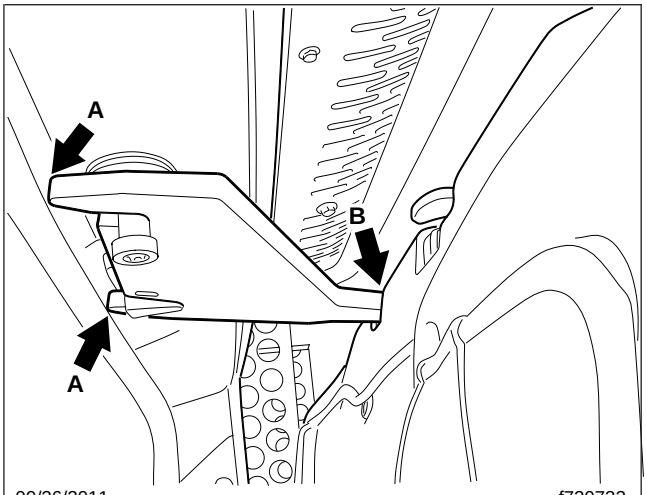
4. Align the dove-tail wedge height with the door latch by pulling the door in until the outboard end

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## Door Latching Adjustment

of the adjustment tool fits snugly into the latch jaws. See **Fig. 3**.




A. The tool should make contact with the door frame at these two points.
B. Set the outboard end of the tool snugly into the latch jaws.

**Fig. 3, Setting the Dove-Tail Wedge Height**

5. While keeping the tool in place, slide the dove-tail wedge fully into the slot on the tool, and tighten.
6. With the door open, and the tool flat against the striker pin and the wedge, set the striker pin position. See **Fig. 4**. When the position is set, tighten the striker pin.
7. Test the door to make sure that it closes to the fully latched position (second click) with normal closing effort. If it does not, reposition the striker pin slightly outboard. Use the special tool to make sure that the proper distance from the dove-tail wedge is retained. Test the door again.

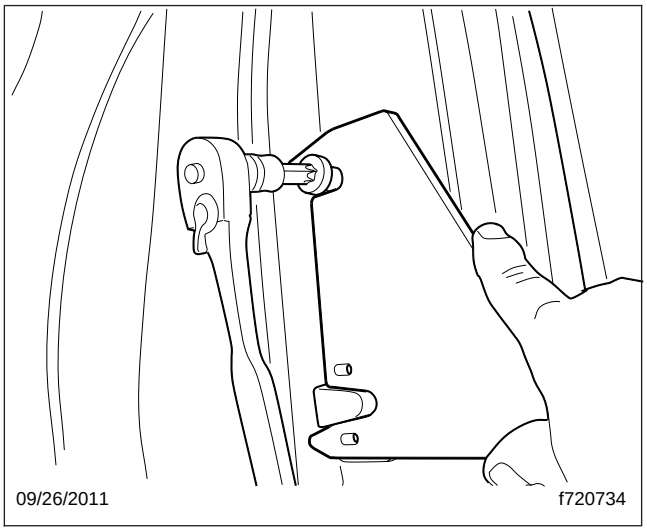



**Fig. 4, Locating the Striker Pin**

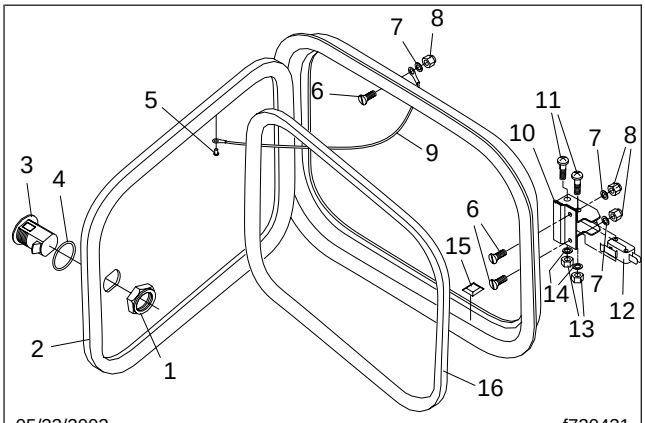
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## 34-Inch Sleeper Aftermarket Luggage Door

# General Information

See **Fig. 1** for the parts required to install the aftermarket luggage door.




05/23/2002 f720431

1. Nut, Thin 1-20 UNEF 4032-3401
2. Door and Frame Assembly 63324-3481
3. Latch Assembly 63324-3484
4. Latch O-ring 63324-3483
5. Rivet, 3/16x1/8 SS, 4013-3412
6. Flat Screw, 10-24 UNC x 3/4-inch, 4015-3436
7. Lockwasher, #10, 131183
8. Elastic Locknut, #10-24, 656140
9. Stop Cable 54503-3402
10. Striker Plate 63324-3482
11. Bolt 4014-3419
12. Door Switch 86403-3404
13. Hexnut 4012-3413
14. Lockwasher 131183
15. Spacers 4007-3460
16. Door Seal 50246-3447

**Fig. 1, Luggage Door Kit**

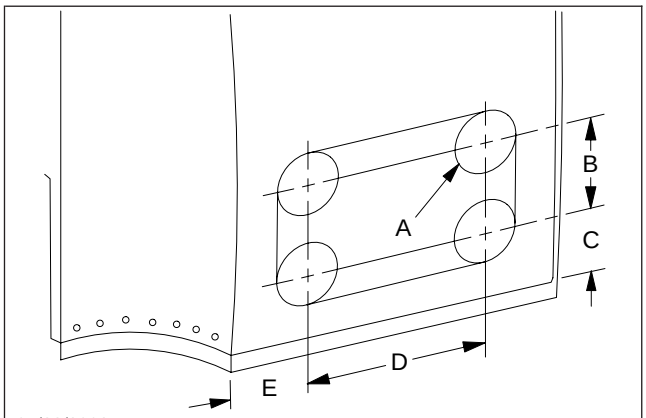
# Installation

## Door Opening

1. Measure 6-3/8 inches (162 mm) from the front edge of the sleeper side panel. Do not include the exhaust cutout in the measurement.

   Measure 4-3/4 inches (29 mm) up from the bottom edge of the side panel. Do not measure from the bottom of the sleeper skirt.

   Scribe a 7-1/4 inch (184 mm) diameter circle centered where the two measurements cross. See **Fig. 2**.




05/23/2002 f720434

A. 6-3/8 Inches (162 mm)
B. 10-1/32 Inches (254 mm)
C. 7-1/4 Inches (184 mm) Diameter
D. 7-13/16 Inches (198 mm)
E. 4-3/4 Inches (120 mm)

**Fig. 2, Luggage Door Opening**

2. Measure 10-1/32 inches (254 mm) from the center of the previous circle horizontally towards the rear.

   Measure 4-3/4 inches (120 mm) up from the bottom edge of the side panel. Do not measure from the bottom of the sleeper skirt.

   Scribe a 7-1/4 inch (184 mm) diameter circle centered where the two measurements cross. See **Fig. 2**.

3. Measure 6-3/8 inches (162 mm) from the front edge of the sleeper side panel. Do not include the exhaust cutout in the measurement.

   Measure 7-13/16 inches (198 mm) up from the center of the previous circle.

   Scribe a 7-1/4 inch (184 mm) diameter circle centered where the two measurements cross. See **Fig. 2**.

4. Measure 10-1/32 inches (254 mm) from the center of the upper front circle horizontally towards the rear.

   Measure 7-13/16 inches (198 mm) up from the center of the bottom rear circle.

   Scribe a 7-1/4 inch (184 mm) diameter circle centered where the two measurements cross.

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## 34-Inch Sleeper Aftermarket Luggage Door

Scribe a line joining the edges of the drawn circles. See **Fig. 2**.

5. Drill a hole through the panel inside the area laid out. The hole needs to be large enough for the blade of the jig saw or saber saw used for cutting.
6. Follow the layout to cut out the door opening using a jig saw or saber saw.
7. Clean the edges of the opening of burrs.

# Door Assembly

1. Remove the protective cover strip from the door seal and press it onto the door opening frame. Place the joint at the bottom.
2. Place the O-ring over the latch, then insert the latch through the door. The sliding catch faces out. Install the locknut to secure the latch into the door. See **Fig. 3**.

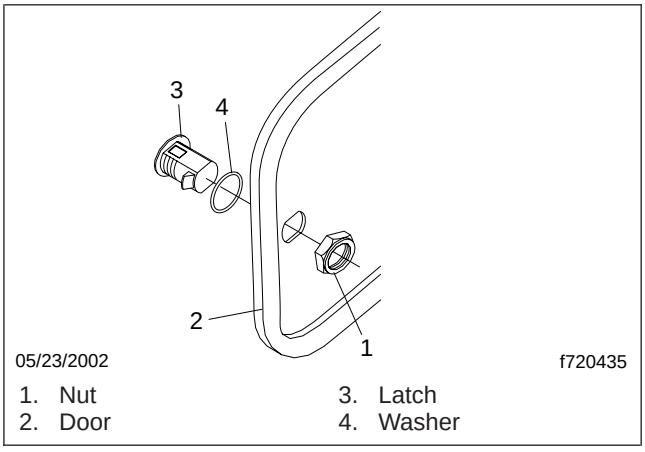



**Fig. 3, Door Latch Installation**

3. Rivet the stop cable to the underside of the upper frame on the door.

   Put a counter sunk screw in the upper hole of the frame for the door opening. Place the stop cable over the end of the screw, a lockwasher and nut, then tighten. See **Fig. 1**.
4. Place the self adhesive 1/4-inch spacer on the bottom edge of the door opening. Locate the spacer near the opening side and near the edge of the opening. See **Fig. 4**.

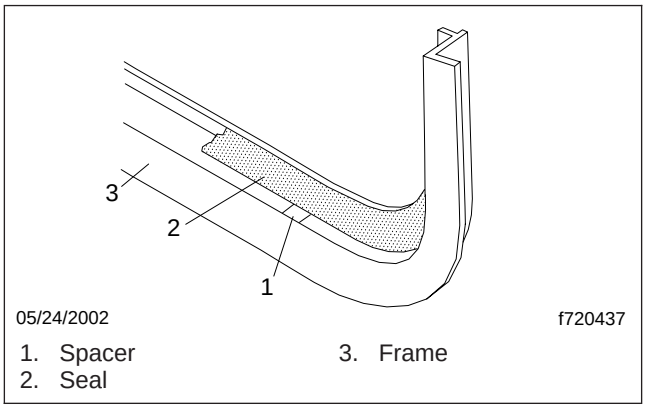



**Fig. 4, Door Frame**

# Door Installation

1. Test the fit of the door assembly in the opening and make any adjustments that are necessary.
2. Clean the surface of the door opening frame and the area around the door cutout with a 50/50 mix of alcohol and water applied to a lint free cloth.
3. Scuff all contact surfaces with a maroon scotch-bright pad. Wipe off all loose particles with a dry, lint-free cloth.
4. Wipe all contact surfaces with Sika-Cleaner 205 applied to a lint free cloth. Wipe in one direction and turn or replace the cloth as required to avoid wiping a clean surface with a dirty cloth. Wipe off the cleaner with a clean dry cloth. Allow to dry for a minimum of ten minutes, but not more than two hours.
5. Mask the adjoining surfaces to prevent primer and adhesive from getting on to painted surfaces.
6. Vigorously shake a can of Sika-Primer 206G+P until the ball rotates freely about the bottom rim of the can. Coat the contact area with a thin even coat of primer using a clean paint brush. If the procedure is interrupted for more than ten minutes a new paint brush must be used.

   Allow the primer to dry for thirty minutes. If the primer has sat for sixteen hours wipe it with Sika-cleaner 205 and allow it to dry for ten minutes.
7. Prepare a tube of Sikaflex 252 nozzle by cutting a vee in one side approximately 1/2-inch (12-

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mm) deep by following the second largest size opening guides on the nozzle. See **Fig. 5**.

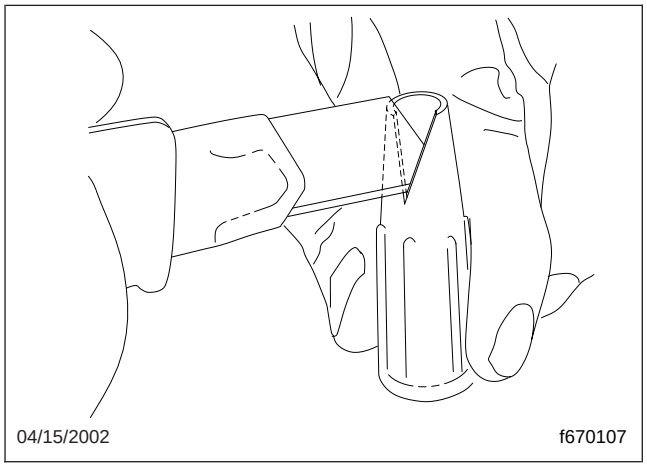
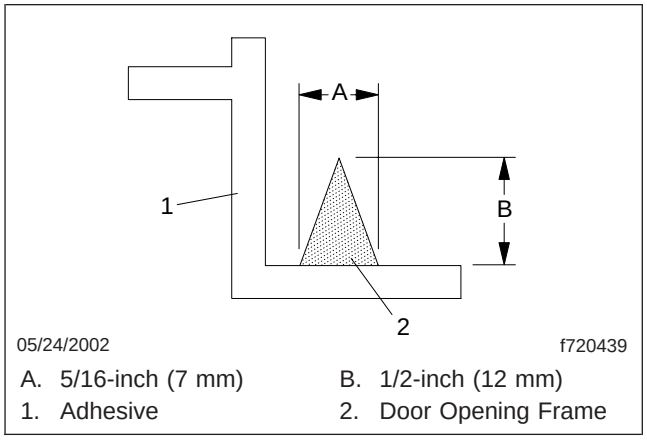



**Fig. 5, Sikaflex 252 Nozzle**

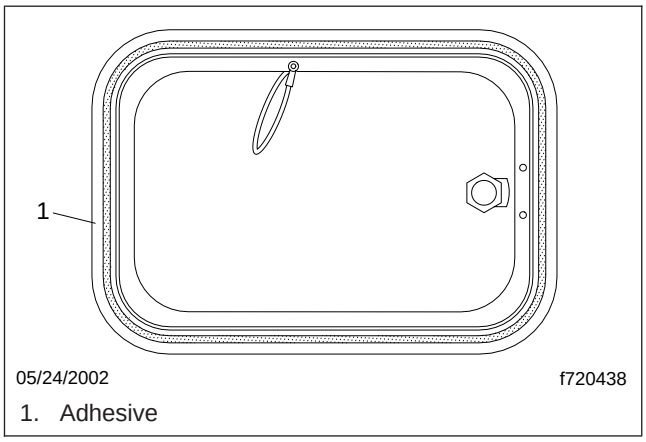
8. Rest the nozzle of the tube of adhesive on the surface and pull it along so that it forms a vee shaped bead. This prevents air gaps from forming when the door opening frame is put in place. Run a continuous 5/16-inch by 1/2-inch (7-mm by 12-mm) bead of adhesive (see **Fig. 6**) completely around the contact surface of the door opening frame. See **Fig. 7**.




A. 5/16-inch (7 mm)
B. 1/2-inch (12 mm)
1. Adhesive
2. Door Opening Frame

**Fig. 6, Adhesive Bead Cross-section**

9. Carefully place the bottom of the door assembly into the opening. Center the door assembly and slowly tip it up into place. Carefully align the door assembly and press it firmly into the adhesive. Once it has been pressed into the adhesive do not reposition it. Clamp the assembly in place,



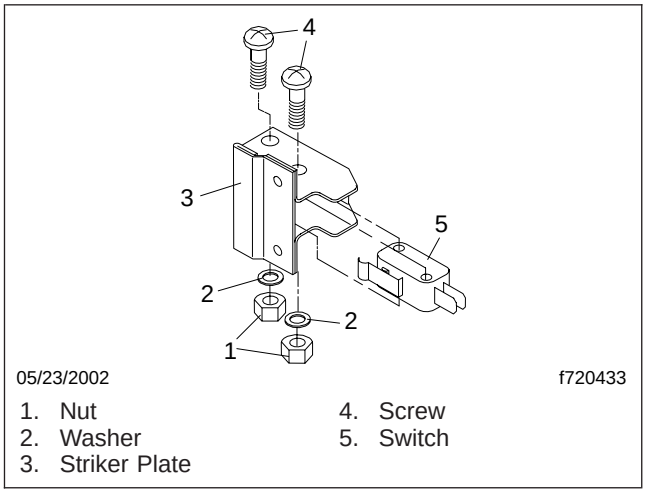

1. Adhesive

**Fig. 7, Adhesive Application**

apply light pressure to the door, and allow the adhesive to cure for twenty-four hours. Immediately wipe any adhesive off painted surfaces before it sets.

## Striker and Switch Assembly

1. Assemble the door switch into the striker plate. See **Fig. 8**.




1. Nut
2. Washer
3. Striker Plate
4. Screw
5. Switch

**Fig. 8, Striker and Switch Assembly**

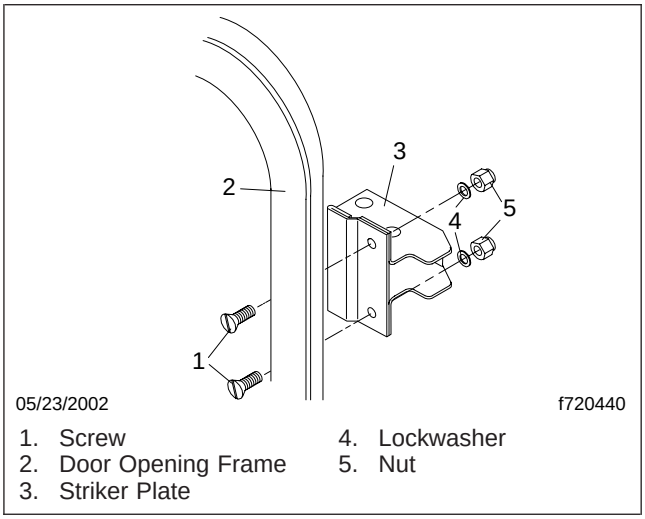
2. Crimp two wires to the wiring terminals 7821-3447, and slip one onto the C (common) terminal and the other onto the NC (normally closed) terminal.
3. Lift the edge of the door seal and put two screws through the frame. Slide the striker over the

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## 34-Inch Sleeper Aftermarket Luggage Door

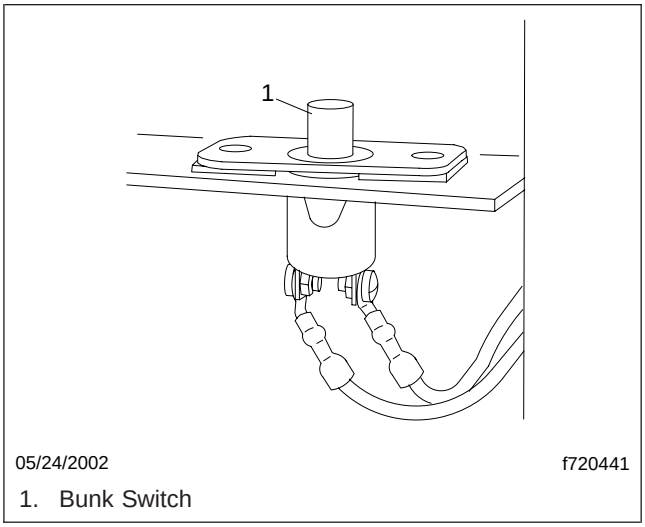
screws and secure with a lockwasher and nut. See **Fig. 9**.




1. Screw
2. Door Opening Frame
3. Striker Plate
4. Lockwasher
5. Nut

**Fig. 9, Striker Installation**

4. Splice the wires to the bunk button switch. See **Fig. 10**. The wire from the C terminal of the door switch should be spliced to the wire LS01AC and the wire from the NC terminal of the door switch should be spliced into the wire LSDE. Refer to schematic 875B1-3414.




1. Bunk Switch

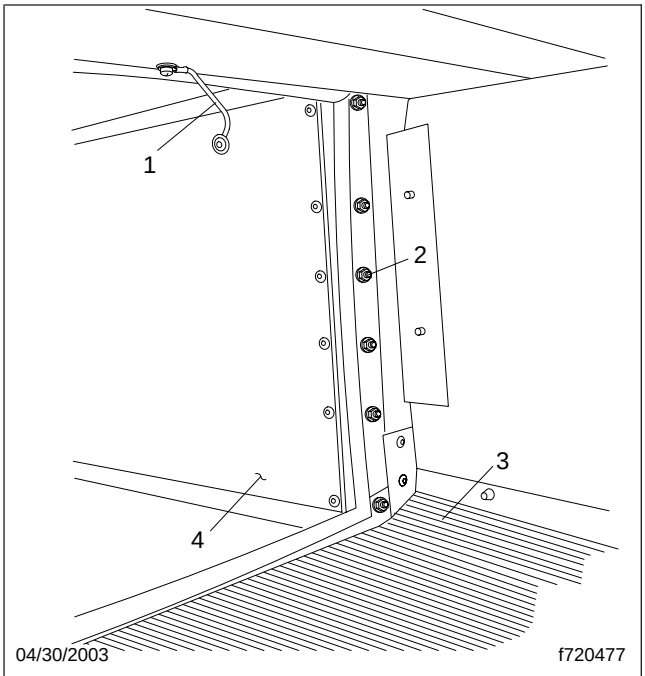
**Fig. 10, Bunk Switch**

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## Removal

1. Park the vehicle on a flat surface. Shut down the engine. Set the parking brake. Chock the tires.
2. Remove the screw that fastens the safety check cable to the inside of the luggage compartment. See **Fig. 1**.




1. Safety Check Cable
2. Hinge Nuts
3. Luggage Compartment Floor
4. Luggage Door

**Fig. 1, Luggage Compartment**

3. Lift the bunk and open the luggage door to access the door hinge inside the luggage compartment. Remove the six hinge nuts. See **Fig. 1**.
4. Remove the luggage door.

## Installation

1. Hold the door in place and install the six hinge nuts on the inside of the sleeper luggage compartment. Tighten the nuts to 40 lbf·in (5 N·m).
2. Attach the safety check cable to the inside of the luggage ocmpartment with the screw.
3. Remove the chocks from the tires.

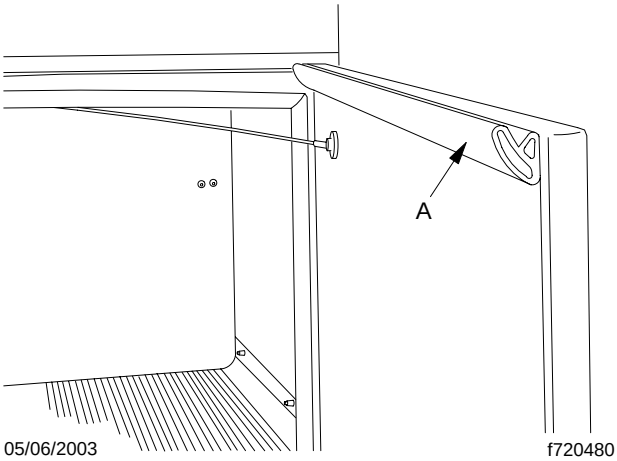
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## Luggage Door Seal Replacement

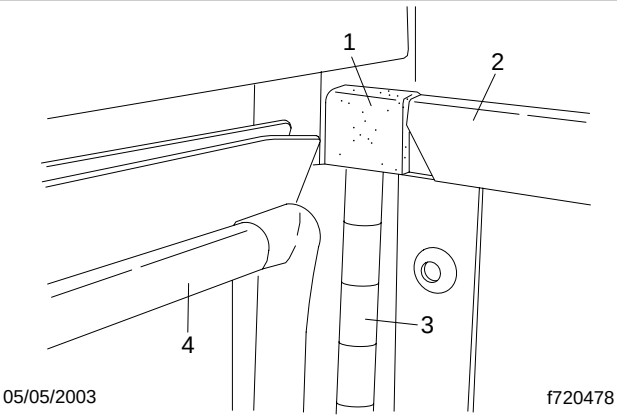
## Replacement

1. Park the vehicle on a flat surface. Shut down the engine. Set the parking brake. Chock the tires.
2. Open the luggage door.
3. Pry up the outer edge of the main seal and work around the perimeter of the door opening.
4. Remove the door seals from around the door opening and the top of the luggage door.
5. Clean the surfaces with isopropyl alcohol.
6. Starting at the upper left hand and right hand corners of the door opening, alternately snap and push the main seal onto the door frame flange, working your way around the door frame opening.
7. Using a utility knife, notch the rubber above and below the door latch. Trim the rubber between the notches.
8. Remove the blue strip from the back of the rubber seal. Press the main seal firmly to the flange all the way around the door opening, making sure there are no unsealed ripples in the seal.
9. Remove the orange backing from the secondary seal that will be applied to the door. Cut a taper on the hinge-end of the rubber to relieve stress when closing the door.
10. Starting at the hinge, place the secondary seal flush with the top edge of the door, with the groove in the seal facing upward. See **Fig. 1**.
11. Press the seal firmly to the door.
12. Cut a 3/4-inch strip of foam and remove the backing. Press it firmly into place above the hinge. See **Fig. 2**.
13. Close the luggage door.
14. Remove the chocks from the tires.




A. Install the secondary seal with the groove facing upward.

**Fig. 1, Secondary Seal on the Luggage Door**




1. 3/4-Inch Foam Strip
2. Secondary Seal
3. Door Hinge
4. Main Seal

**Fig. 2, Luggage Door Seals**

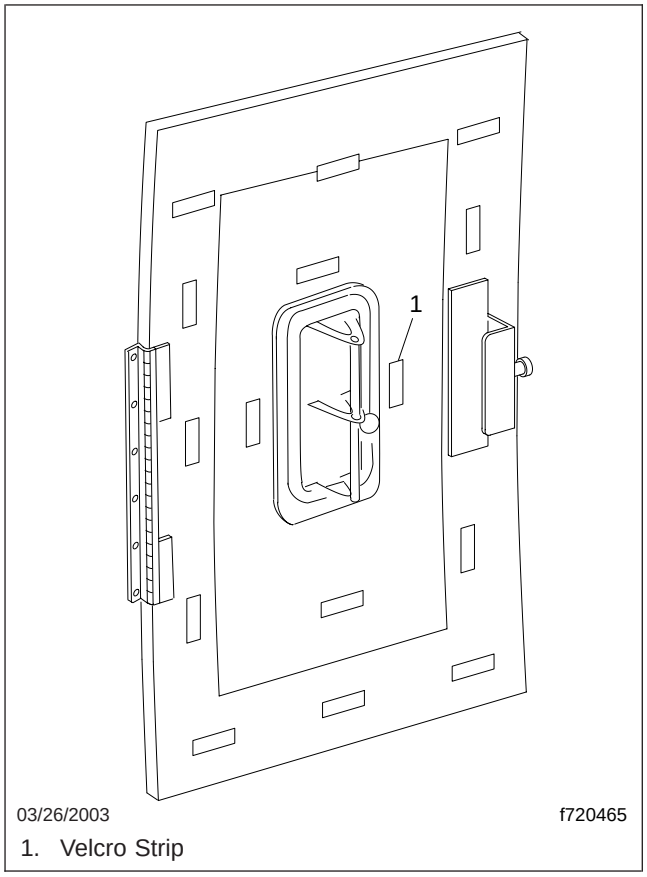
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## Exit Door Removal and Installation

# Removal

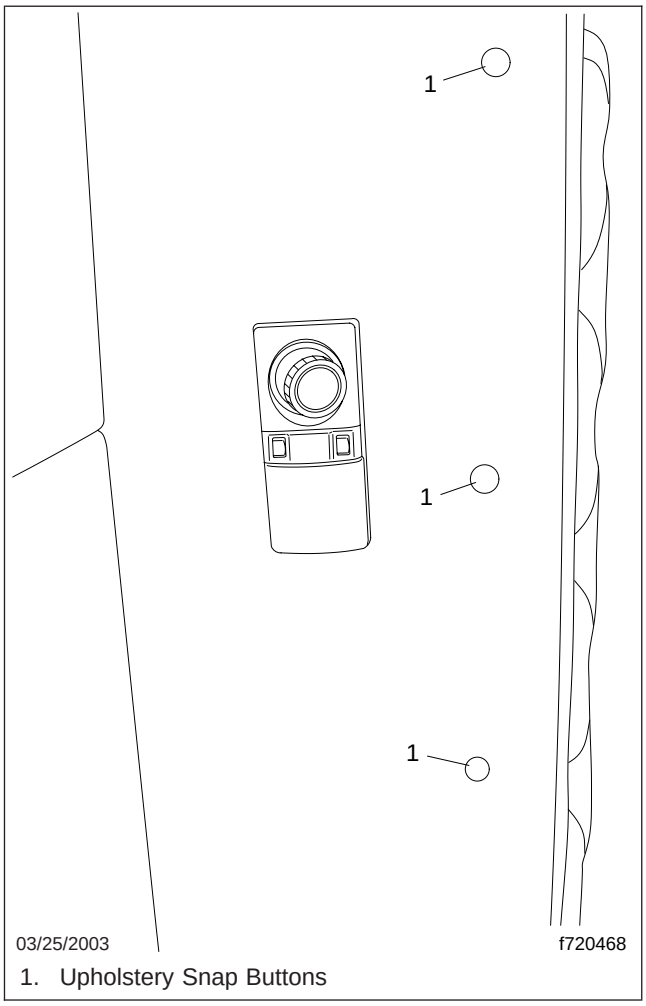
1. Park the vehicle on a flat surface. Shut down the engine. Set the parking brake. Chock the tires.
2. Open the exit door.
3. Remove the exit door upholstery by pulling the panel free from the velcro strips. See **Fig. 1**.




1. Velcro Strip

**Fig. 1, Sleeper Exit Door**

4. Using a 3/16-inch drill, remove the rivet that fastens the safety check cable to the top of the exit door.
5. Remove the three snap buttons and covers from the sleeper side panel upholstery. See **Fig. 2**.
6. Pull back the upholstery from the door opening far enough to access the six hinge nuts. See **Fig. 3**.
7. Remove the hinge nuts.




1. Upholstery Snap Buttons

**Fig. 2, Side Panel Upholstery**

8. Remove the door.

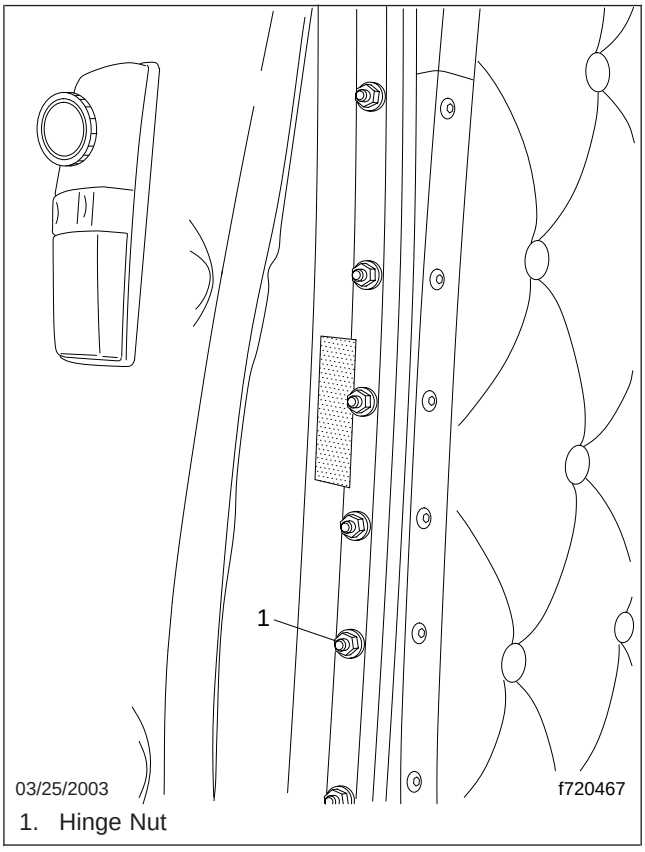
# Installation

1. Hold the door in place and install the six hinge nuts on the inside of the sleeper. Tighten the nuts to 40 lbf·in (45 N·cm).
2. Using a 3/16-inch rivet, attach the top of the safety check cable to the exit door.
3. Adjust the striker pin until the door is flush with the outside wall of the cab. See **Fig. 4**.
4. Install the door upholstery by firmly pressing it against the velcro strips on the door.

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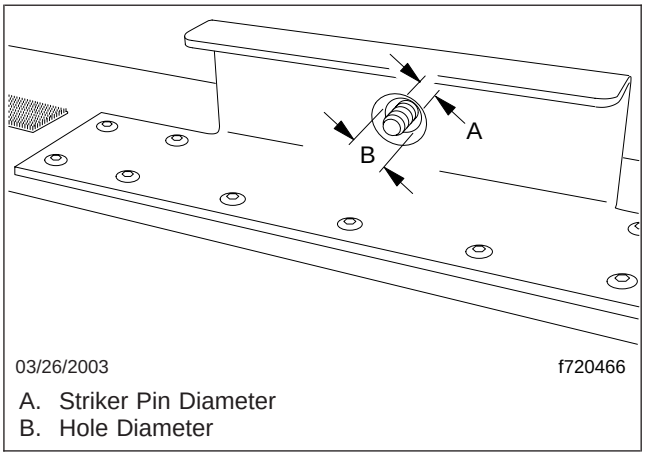


## Exit Door Removal and Installation




1. Hinge Nut

**Fig. 3, Sleeper Door Hinge**




A. Striker Pin Diameter
B. Hole Diameter

**Fig. 4, Striker Pin Adjustment Allowance**

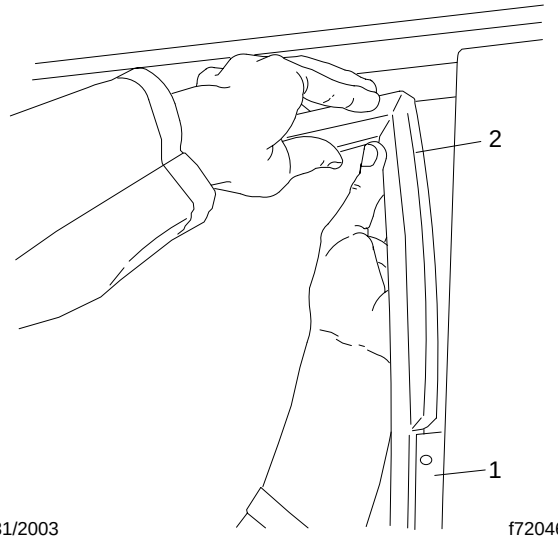
5. Close the exit door and remove the chocks from the tires.

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## Replacement

1. Park the vehicle on a flat surface. Shut down the engine. Set the parking brake. Chock the tires.
2. Remove the trim strip on the lower edge of the door opening.
3. Pry up the outer edge of the door seal and work around the perimeter of the door.
4. Clean around the perimeter of the door with isopropyl alcohol.
5. Starting at the upper left hand and right hand corners of the door opening, alternately snap and push the door seal onto the door frame flange, working your way around the door frame opening. See **Fig. 1**.

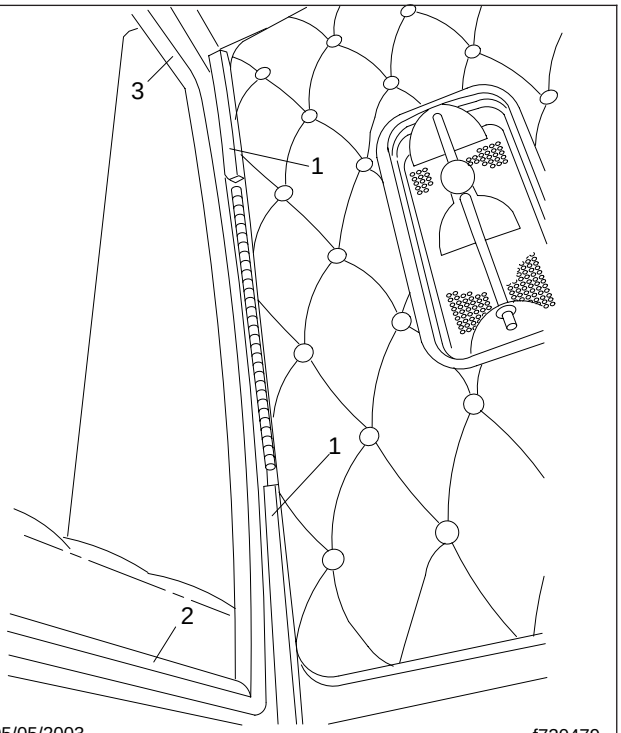



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1. Door Hinge Cuttout
2. Main Seal

**Fig. 1, Main Door Seal**

6. Using a utility knife, notch the rubber above and below the door latch. Trim the rubber between the notches.
7. Remove the blue strip from the back of the seal. Press the seal firmly to the flange all the way around the door opening, making sure there are no unsealed ripples in the seal.
8. Cut two 10-inch strips of foam and remove the backing.
9. Place them in the channel above and below the hinge and press firmly into place. See **Fig. 2**




05/05/2003 f720479

1. Foam Strips
2. Lower Trim Strip
3. Main Door Seal

**Fig. 2, Exit Door Seals**

10. Install the lower trim strip by pressing it over the edge along the bottom of the door opening.
11. Close the door and remove the chocks from the tires.

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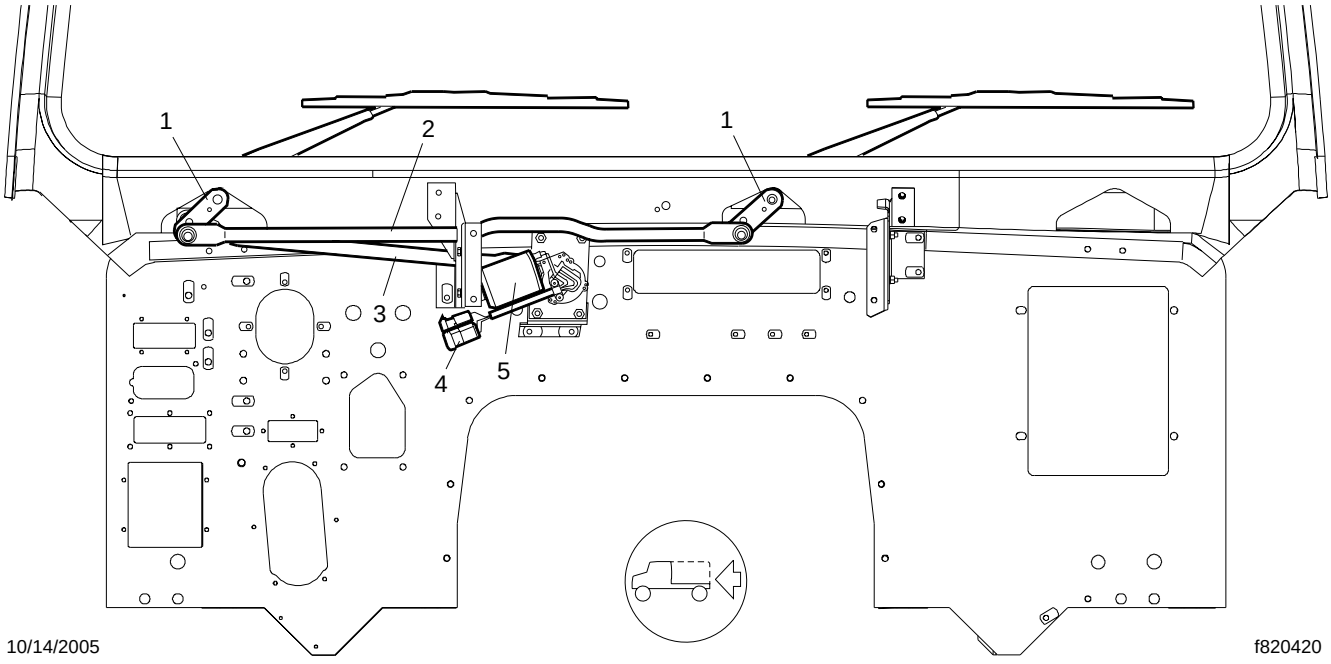


## General Information

The windshield wipers and washer are operated by switches on the lower dash control panel. A single wiper motor powers both wipers. It is mounted behind the dash, as is the linkage assembly that connects it to the wiper arms. See **Fig. 1**.

The motor is a sealed unit packaged together with a weather seal and drive crank. It is not serviceable. If a wiper motor does not work because of internal problems, replace it.

The windshield washer reservoir is located either under the cab floor on the driver side (accessed by removing the driver-side battery cover/step), or in the engine compartment, behind the radiator. A pump attached to the reservoir supplies washer fluid to each wiper arm. A purge mechanism empties the lines after use to prevent fluid from freezing in the lines during cold weather.




1. Pivot Arm
2. Drag Link
3. Drive Link
4. Electrical Connector
5. Wiper Motor

**Fig. 1, Windshield Wiper System**

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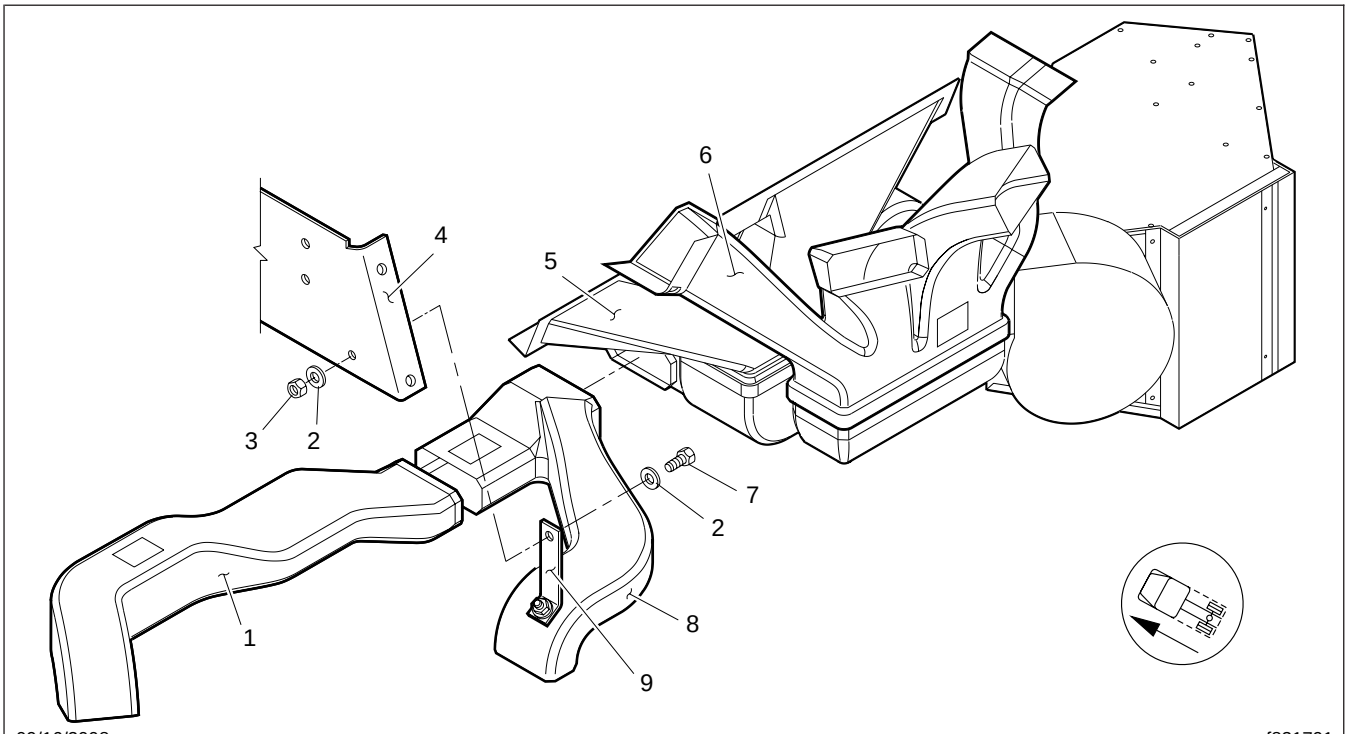
## Replacement

1. Apply the parking brakes and chock the tires.
2. Disconnect the batteries at the negative cables.

**⚠ WARNING**

**Disconnect the batteries before working on the wiper motor or linkage. Otherwise, if the driveshaft is forced out of the parked position, the motor could cycle, possibly resulting in personal injury.**

3. From underneath the dash, remove the HVAC wye duct, located under the center of the dash. A bracket attaches it to the dash, with a bolt, nut, and two washers; see **Fig. 1**.
4. Disconnect the motor wiring from the electrical harness.
5. Reach behind the mounting plate and remove the nut, item 3 in **Fig. 2**, that attaches the drive crank to the wiper motor drive shaft. It may be helpful to hold the linkage in place with large locking pliers. Remove the drive crank and the linkage from the drive shaft. Use care not to bend the linkage when pulling the drive crank loose from the drive shaft.
6. Remove the four nuts and lockwashers, items 7 and 8 in **Fig. 2**, that hold the mounting plate to the brackets. Remove the wiper motor and mounting plate.
7. Remove the three Torx screws that secure the wiper motor to the mounting plate. Note the orientation of the motor to the plate for installation.
8. Attach the new wiper motor to the mounting plate, using the three Torx screws. Tighten the screws 54 lbf·in (610 N·cm).




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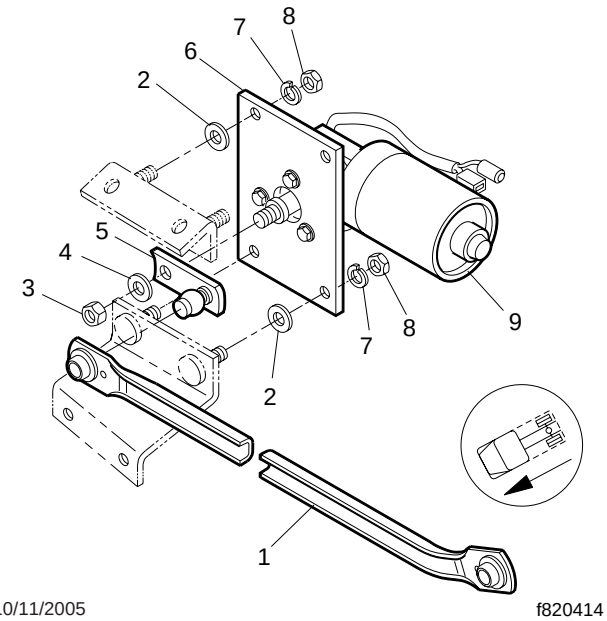
1. Driver-Side Heater Duct
2. Washer
3. Nut
4. Fascia Bracket
5. Defrost Wye Duct
6. A/C W-Duct Assembly
7. Bolt
8. HVAC Wye Duct
9. Bracket

**Fig. 1, HVAC Wye Duct Installation**

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## Wiper Motor Replacement




1. Drive Link
2. Flatwasher
3. Hexnut
4. Washer, Dished
5. Drive Crank
6. Mounting Plate
7. Lockwasher
8. Nut
9. Wiper Motor Assembly

**Fig. 2, Wiper Motor Installation**

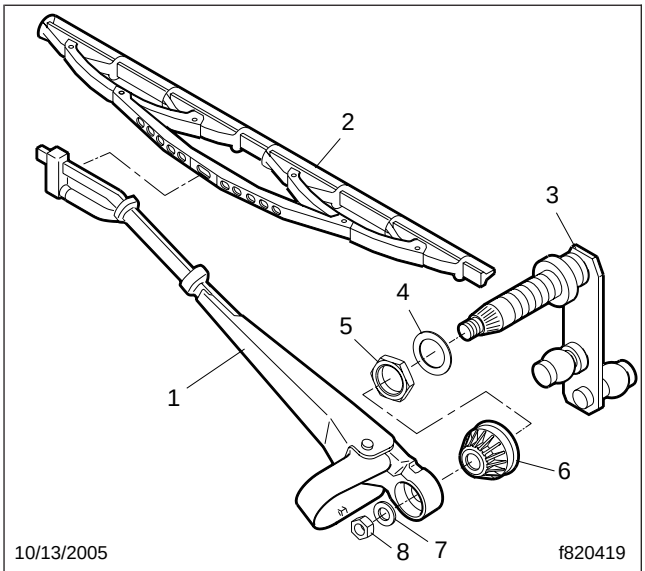
9. Place the linkage on the wiper motor drive shaft, then start the nut on the shaft, but do not tighten it yet.
10. Position the mounting plate on the brackets, then install the four lockwashers and nuts. Tighten the nuts 13 to 17 lbf·ft (18 to 23 N·m).
11. Make sure that the wiper arms are in proper parking position, then tighten the nut on the drive shaft 15 to 18 lbf·ft (20 to 25 N·m).
12. Connect the wiper motor wiring to the electrical harness.
13. Install the HVAC wye duct under the dash. Attach the duct bracket to the fascia bracket on the dash with the bolt, nut, and two washers; see **Fig. 1**.
14. Connect the batteries.
15. Remove the chocks.

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## Wiper Arm Removal and Installation

Two types of windshield wiper systems are used. The Bosch wiper arm has a cap on the pivot end that flips up to reveal the nut that attaches the arm to the wiper shaft. See **Fig. 1**. The Sprague wiper arm is held by a spring clip, on the underside of the arm, to the wiper shaft. See **Fig. 2** and **Fig. 3**. When removing the wiper arm only, it is not necessary to remove the cap and fasteners that attach the pivot arm drive shaft to the cab.




10/13/2005 f820419

NOTE: When removing the wiper arm only, it is not necessary to remove items 4, 5, and 6.

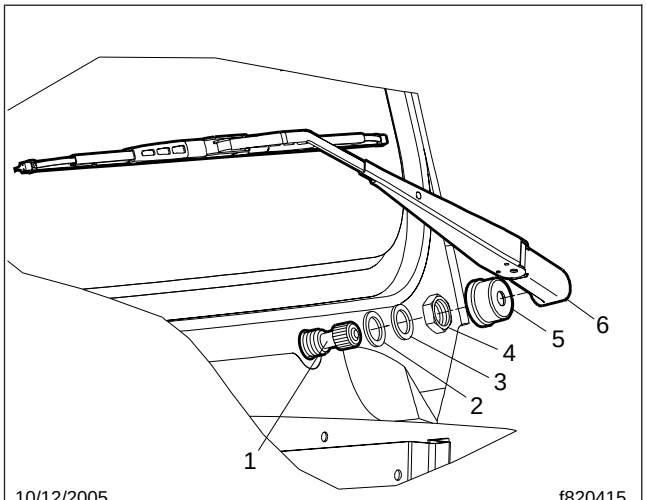
1. Wiper Arm
2. Wiper Blade
3. Pivot Arm
4. Washer
5. Nut
6. Cap
7. Spring Washer
8. Hexnut

**Fig. 1, Bosch Wiper Arm Installation**

# Bosch Wiper Arm

## Removal

1. Park the vehicle, apply the parking brakes, shut down the engine, and chock the front and rear tires.
2. Park the wiper blades.
3. Flip up the cap on the pivot-end of the wiper arm.
4. Remove the nut and washer that attach the wiper arm to the pivot arm drive shaft.

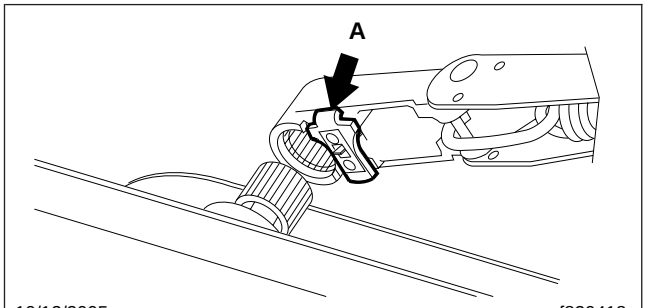



10/12/2005 f820415

NOTE: When removing the wiper arm only, it is not necessary to remove items 2 through 5.

1. Pivot Arm Drive Shaft
2. Washer
3. Washer
4. Nut
5. Cap
6. Wiper Arm

**Fig. 2, Sprague Wiper Arm Installation**




10/12/2005 f820418

A. Pull clip back to release the wiper arm from the shaft.

**Fig. 3, Locking Spring Clip**

5. Disconnect the washer line, and pull it out of the clips on the wiper arm.
6. Remove the wiper arm by carefully pulling it free of the knurled drive knob at end of the drive shaft.

## Installation

1. Install the wiper arm on the pivot arm drive shaft, making sure that the blade is properly positioned along the lower edge of the windshield. See

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## Wiper Arm Removal and Installation

**Fig. 4**. Push the wiper arm snugly onto the knurled drive knob on the end of the drive shaft.

2. Attach the wiper arm to the drive shaft with the nut and washer.
3. Flip the wiper-pivot cap closed.
4. Connect the washer hose to the wiper arm and push it into the clips in the wiper arm.
5. Remove the chocks from the tires.

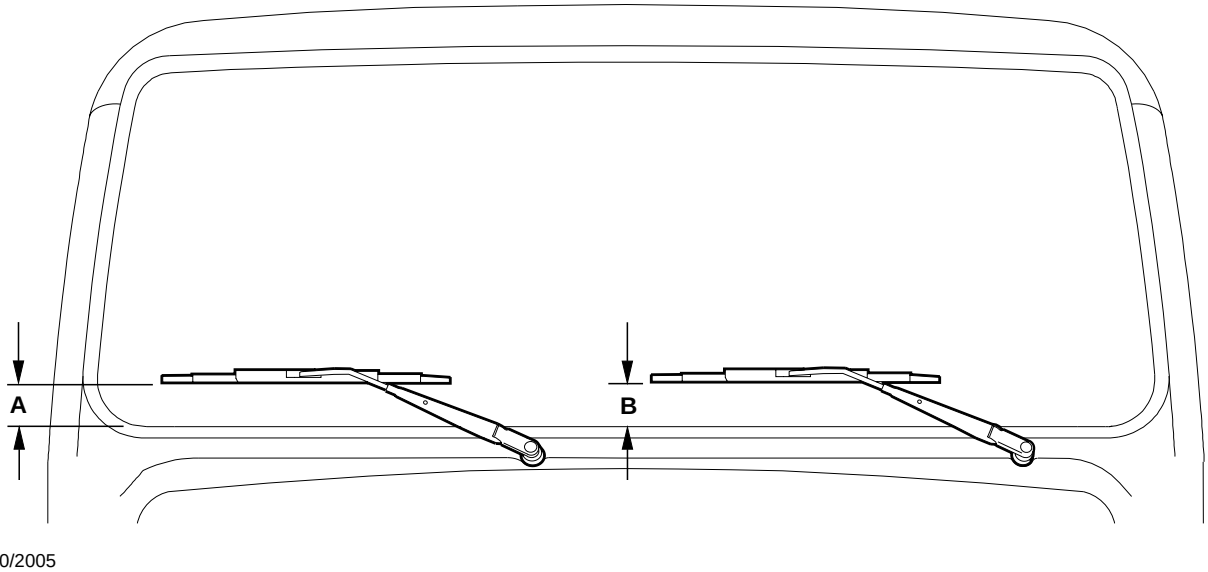
# Sprague Wiper Arm

## Removal

1. Park the vehicle, apply the parking brakes, shut down the engine, and chock the front and rear tires.
2. Park the wiper blades.
3. Pull the washer hose out of the clips and disconnect it from the wiper arm.
4. Under the pivot end of the wiper arm, slide the spring clip back to unlock the arm from the pivot arm drive shaft. See **Fig. 3**. Holding the spring clip back, remove the wiper arm by carefully pulling it free of the knurled drive knob at the end of the drive shaft.

## Installation

1. Under the pivot end of the wiper arm, slide the spring clip back (**Fig. 3**) and, while holding it, install the wiper arm on the pivot arm drive shaft, making sure that the blade is properly positioned along the lower edge of the windshield. See **Fig. 4**. Push the wiper arm so it fits snugly on the knurled drive knob on the end of the drive shaft. Release the spring clip to lock the wiper arm on the drive shaft.
2. Connect the washer line to the wiper arm.
3. Remove the chocks from the tires.




A. 3-1/2 in (9 cm) for bonded windshield; 3 in (7.5 cm) for gasketed windshield.
B. 3-1/2 in (9 cm) for bonded windshield; 2-1/2 in (7 cm) for gasketed windshield.

**Fig. 4, Wiper Arm Positioning**

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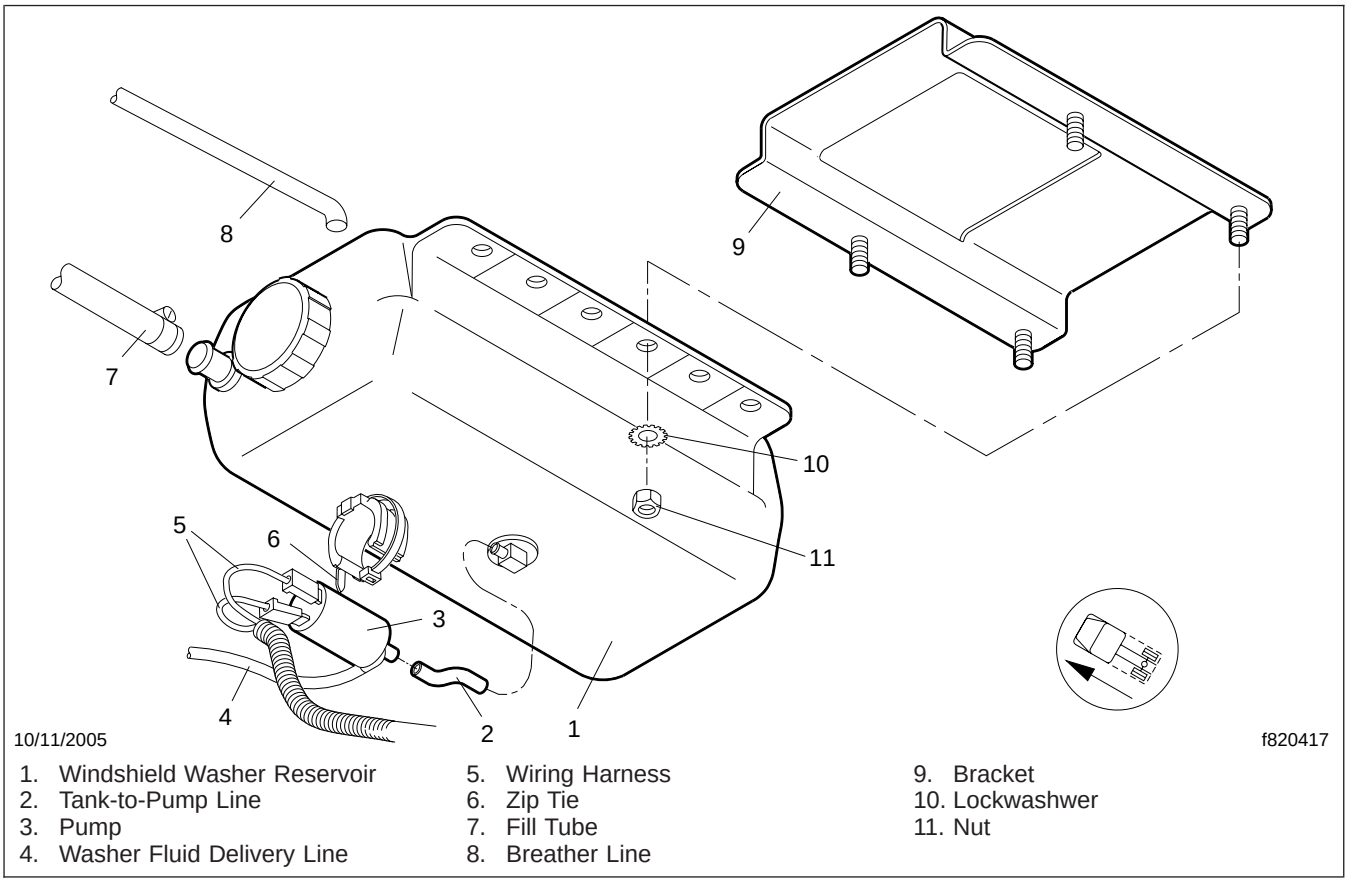
# Washer Reservoir Removal and Installation

## Removal

1. Park the vehicle, apply the parking brakes, shut down the engine, and chock the front and rear tires.
2. If the windshield washer reservoir is located under the cab deck, access it by removing the driver-side battery cover/step. If it is located in the engine compartment, access it by opening the hood.
3. Disconnect the wiring from the pump. See **Fig. 1**.
4. Drain the tank into a container, by disconnecting the line from the pump to the tank.
5. Cut off the zip tie that holds the pump to the tank. Remove the pump.
6. Place tape over the tank outlet to keep the tank from dripping.
7. Detach the fill tube from the tank by removing the clamp.
8. Detach the breather line from the tank.
9. Remove the four nuts and washers that attach the tank to the tank bracket. Remove the tank.

## Installation

1. Position the tank in place and attach it to the bracket using the four nuts and washers. See **Fig. 1**.
2. Attach the breather line to the tank.
3. Attach the filler hose to the tank with the clamp.
4. Remove the tape from the tank outlet.
5. Clip the pump to the tank.




1. Windshield Washer Reservoir
2. Tank-to-Pump Line
3. Pump
4. Washer Fluid Delivery Line
5. Wiring Harness
6. Zip Tie
7. Fill Tube
8. Breather Line
9. Bracket
10. Lockwashwer
11. Nut

**Fig. 1, Windshield Washer Reservoir (Under-Cab Installation Shown)**

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## Washer Reservoir Removal and Installation

6. Attach the tank-to-pump line and the washer fluid delivery line to the pump.
7. Connect the wiring harness to the pump.
8. Using new zip ties, clamp the pump to the tank, and tie the wiring harness in a bundle to prevent it from hanging loose.
9. Fill the tank with windshield washer fluid.
10. Install the battery cover/step, or close the hood, as applicable.
11. Remove the chocks from the tires.

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NOTE: The wiper linkage is located inside the cab. Some disassembly of the dash components and/or HVAC ducting is required for access.

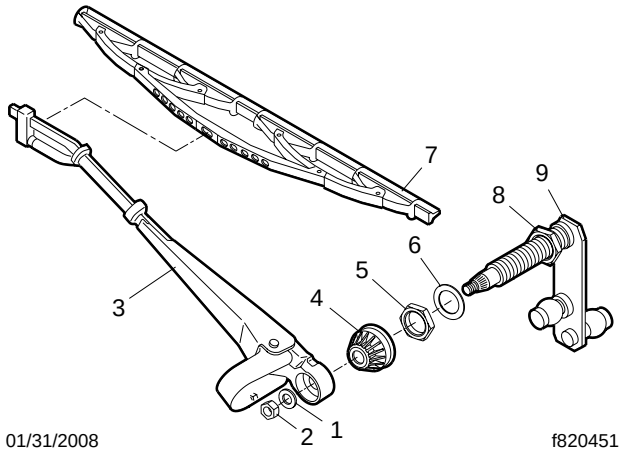
## Driver-Side Wiper Pivot Replacement

1. Apply the parking brakes and chock the tires.
2. Disconnect the batteries at the negative cables.

**⚠ WARNING**

**Disconnect the batteries before working on the wiper motor or linkage. Otherwise, if the driveshaft is forced out of the parked position, the motor could cycle, possibly resulting in personal injury.**

3. Remove the driver-side wiper arm; see **Subject 110**.
4. Remove the cap and the retaining nut from the driver-side pivot drive shaft; see **Fig. 1**.




1. Spring Washer
2. Hexnut
3. Wiper Arm
4. Cap
5. Nut
6. Washer
7. Wiper Blade
8. Interior Retaining Nut
9. Pivot

**Fig. 1, Wiper Arm Installation (Bosch shown)**

5. Tilt the steering wheel down, or, if the vehicle has a non-tilting steering wheel, lower the steering column as follows.
   - 5.1 Remove the wiring clamp from the side of the steering column, to access the steering column capscrews.
   - 5.2 While supporting the steering column, remove the four 3/8-inch capscrews and washers that attach the steering column to the steering column bracket. Carefully lower the steering column.
6. Remove the four Phillips screws that secure the main dash panel, then swing the panel open; see **Fig. 2**.

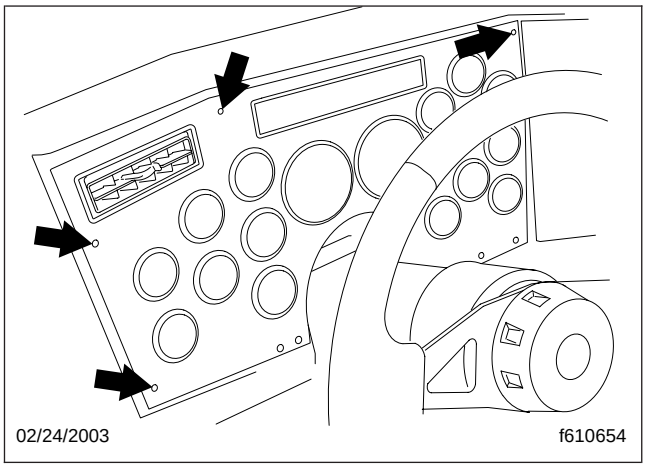



**Fig. 2, Main Dash Panel Screws**

7. Remove the three capscrews that secure the ECU mounting plate; see **Fig. 3**. Rock the mounting plate out of the way to gain access to the driver-side pivot.

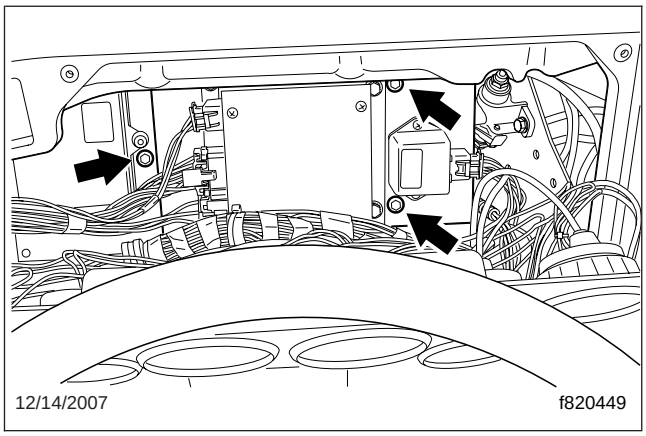


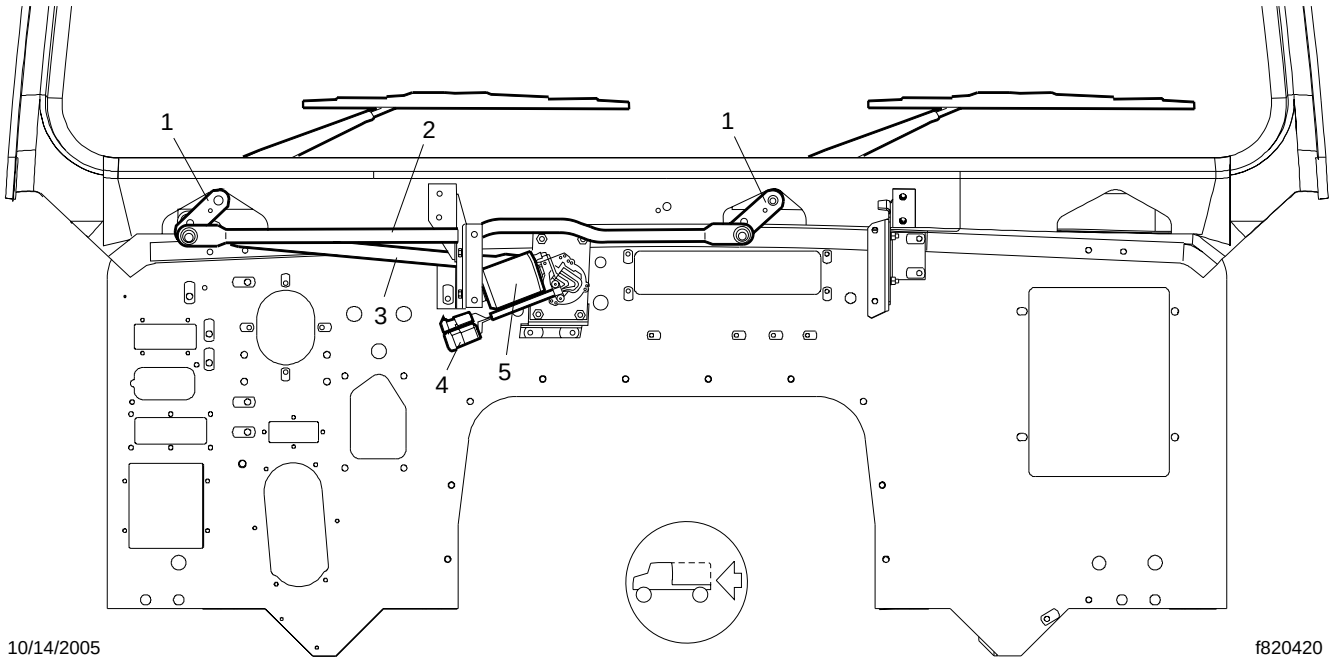

**Fig. 3, ECU Mounting Plate Capscrews**

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## Wiper Pivot Replacement

8. Pop the linkage from the mounting knobs on the pivot. The drive link connects to the mounting knob on the forward side of the pivot, and the drag link connects on the aft side; see **Fig. 4**. Use care not to bend the linkage.




1. Pivot
2. Drag Link
3. Drive Link
4. Electrical Connector
5. Wiper Motor

**Fig. 4, Windshield Wiper Linkage**

9. Remove the pivot. Note the position of the inner retaining nut on the pivot shaft.
10. Position the inner retaining nut on the new pivot, at the position noted on the old pivot.
11. Position the new pivot in place.
12. Press the linkage onto mounting knobs on the pivot. The drive link attaches to the forward side of the pivot, and the drag link to the aft side.
13. Position the ECU mounting plate in place, and secure it with the three capscrews; see **Fig. 3**.
14. Close the main dash panel, and secure it with the four Phillips screws; see **Fig. 2**.
15. If the steering column was lowered, raise and install it as follows.
    15.1 Lift the steering column into place, and install the four 3/8-inch capscrews and washers that attach the steering column to the steering column bracket. Tighten the nuts 23 to 29 lbf·ft (31 to 39 N·m).
    15.2 Install the wiring clamp on the side of the steering column.
16. Outside the cab, install the retaining nut on the driver-side pivot drive shaft. Tighten the nut 12 to 15 lbf·ft (16 to 20 N·m), then install the cap on the drive shaft; see **Fig. 1**.
17. Install the driver-side wiper arm; see **Subject 110**.
18. Connect the batteries, and test the wiper system operation.
19. Remove the chocks.

## Passenger-Side Wiper Pivot Replacement

1. Apply the parking brakes and chock the tires.

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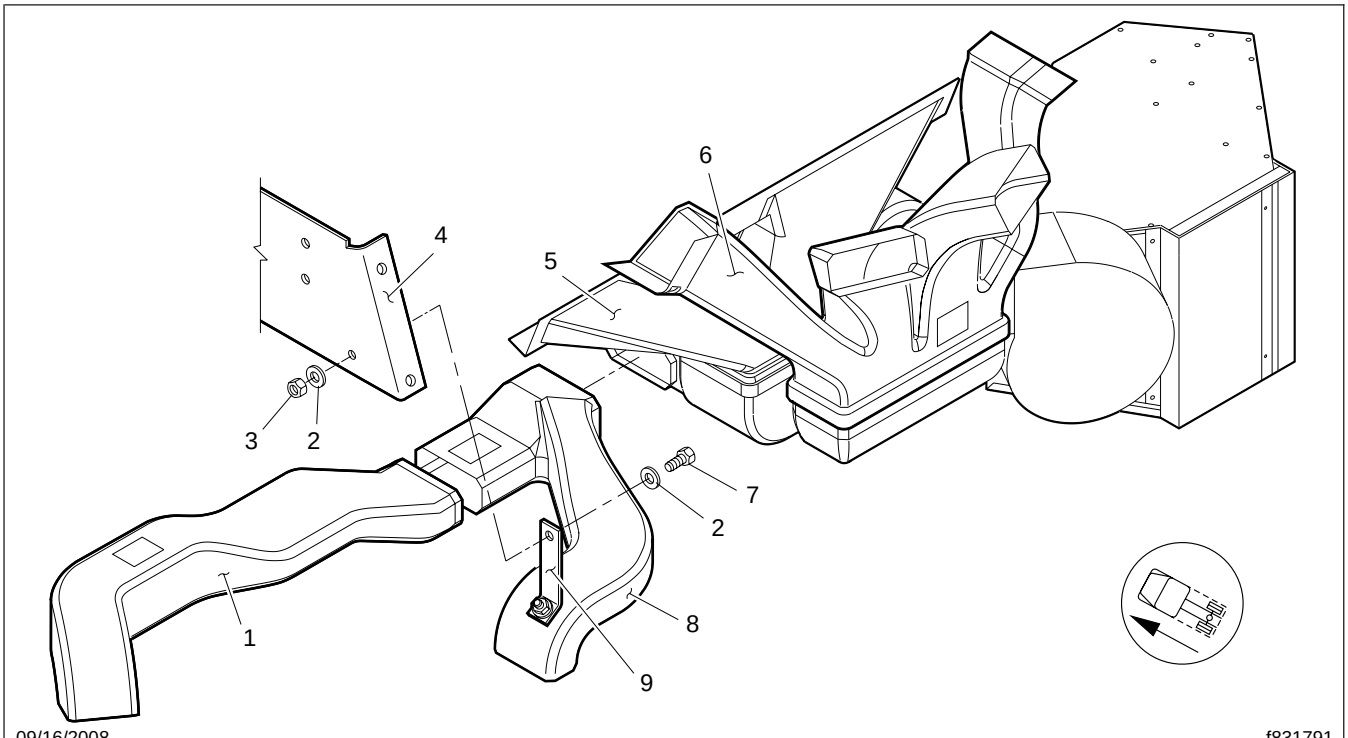
## Wiper Pivot Replacement

2. Disconnect the batteries at the negative cables.

**WARNING**

**Disconnect the batteries before working on the wiper motor or linkage. Otherwise, if the driveshaft is forced out of the parked position, the motor could cycle, possibly resulting in personal injury.**

3. Remove the passenger-side wiper arm; see **Subject 110**.
4. Remove the cap and the retaining nut from the passenger-side pivot drive shaft; see **Fig. 1**.
5. From underneath the dash, remove the HVAC wye duct, located under the center of the dash. A bracket attaches it to the fascia bracket, with a bolt, nut, and two washers; see **Fig. 5**.
6. Pop the drag link from the mounting knob on the passenger-side pivot; see **Fig. 4**. To reach the passenger-side pivot, lie on the floor under the dash with your feet out the passenger-side door, and look up behind the HVAC ducting.
7. Remove the pivot. Note the position of the inner retaining nut on the pivot shaft.
8. Position the inner retaining nut on the new pivot, at the position noted on the old pivot.
9. Position the new pivot in place, with the pivot shaft through the hole in the cab.
10. Snap the drag link onto the mounting knob on the pivot.
11. Install the HVAC wye duct under the dash. Attach the duct bracket to the fascia bracket with the bolt, nut, and two washers; see **Fig. 5**.




1. Driver-Side Heater Duct
2. Washer
3. Nut
4. Fascia Bracket
5. Defrost Wye Duct
6. A/C W-Duct Assembly
7. Bolt
8. HVAC Wye Duct
9. Bracket

**Fig. 5, HVAC Wye Duct Installation**

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## Wiper Pivot Replacement

12. Outside the cab, install the retaining nut on the passenger-side pivot drive shaft. Tighten the nut 12 to 15 lbf·ft (16 to 20 N·m), then install the cap on the drive shaft; see **Fig. 1**.
13. Install the passenger-side wiper arm; see **Subject 110**.
14. Connect the batteries, and test the wiper system operation.
15. Remove the chocks.

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## Wiper Linkage Replacement

NOTE: The wiper linkage is located inside the cab. Some disassembly of the dash components and/or HVAC ducting is required for access.

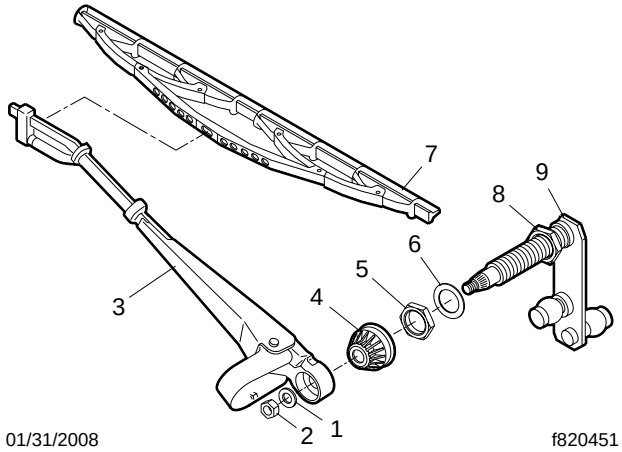
## Replacement

1. Apply the parking brakes and chock the tires.
2. Disconnect the batteries at the negative cables.

**⚠ WARNING**

**Disconnect the batteries before working on the wiper motor or linkage. Otherwise, if the driveshaft is forced out of the parked position, the motor could cycle, possibly resulting in personal injury.**

3. Remove the driver-side wiper arm; see **Subject 110**.
4. Remove the cap from the driver-side pivot drive shaft, then loosen, but do not remove, the pivot shaft retaining nut; see **Fig. 1**.




1. Spring Washer
2. Hexnut
3. Wiper Arm
4. Cap
5. Nut
6. Washer
7. Wiper Blade
8. Interior Retaining Nut
9. Pivot

**Fig. 1, Wiper Arm Installation (Bosch shown)**

5. Tilt the steering wheel down, or, if the vehicle has a non-tilting steering wheel, lower the steering column as follows.
   - 5.1 Remove the wiring clamp from the side of the steering column, to access the steering column capscrews.
   - 5.2 While supporting the steering column, remove the four 3/8-inch capscrews and washers that attach the steering column to the steering column bracket. Carefully lower the steering column.
6. Remove the four Phillips screws that secure the main dash panel, then swing the panel open; see **Fig. 2**.

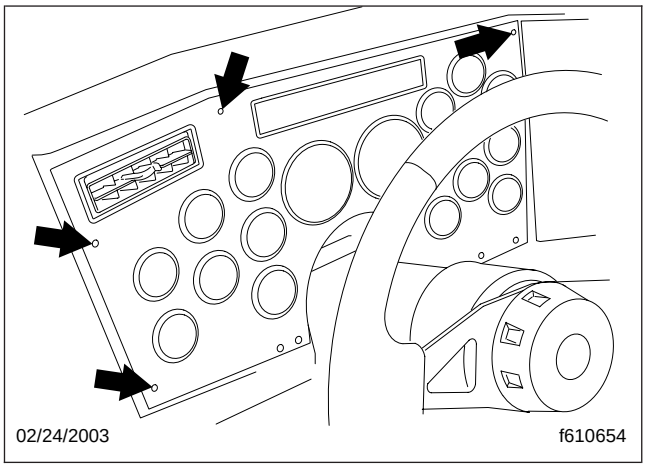



**Fig. 2, Main Dash Panel Screws**

7. Remove the three capscrews that secure the ECU mounting plate; see **Fig. 3**. Rock the mounting plate out of the way to gain access to the driver-side pivot.

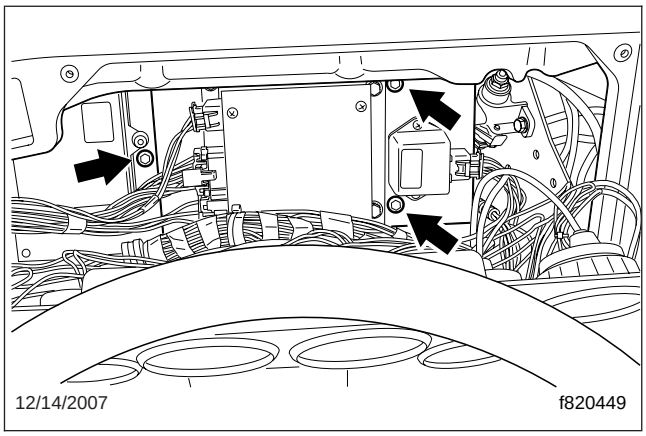



**Fig. 3, ECU Mounting Plate Capscrews**

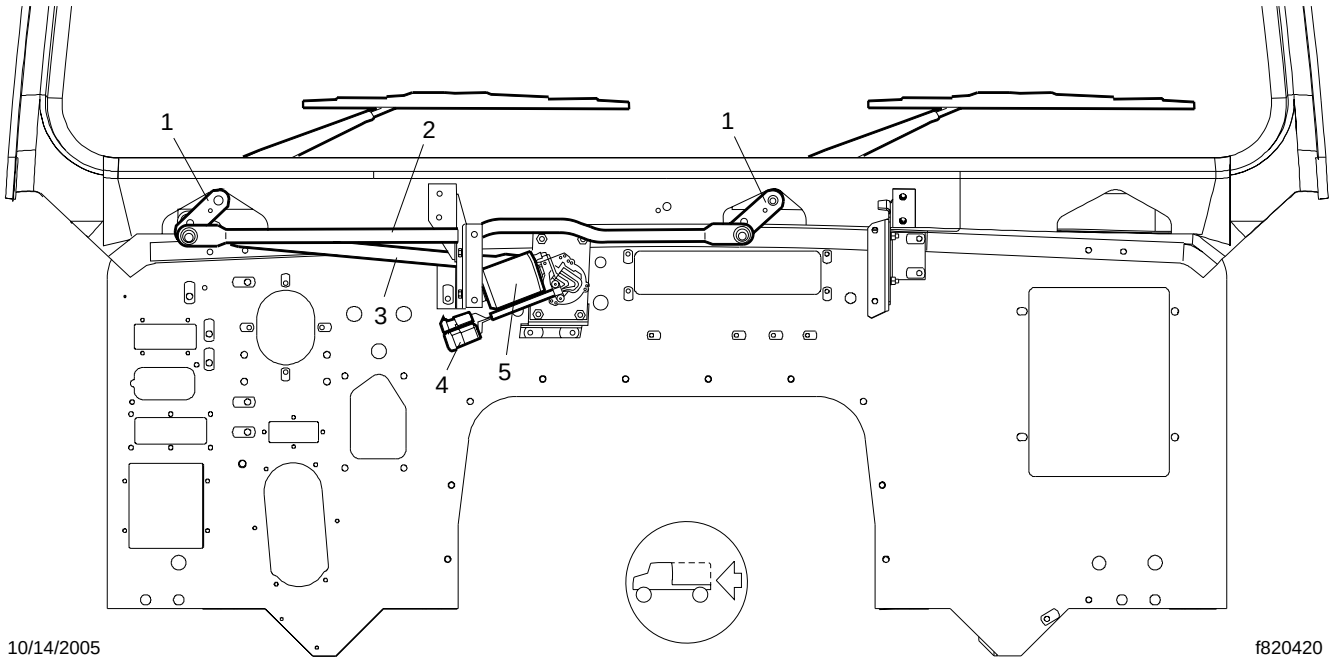
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## Wiper Linkage Replacement

8. Pop the linkage from the mounting knobs on the driver-side pivot. The drive link connects to the mounting knob on the forward side of the pivot, and the drag link connects on the aft side; see **Fig. 4**. Use care not to bend the linkage.

15. Install a new drag link through the glove box opening, routing it through the proper oval opening in the bracket at the center of the dash; see **Fig. 7**.



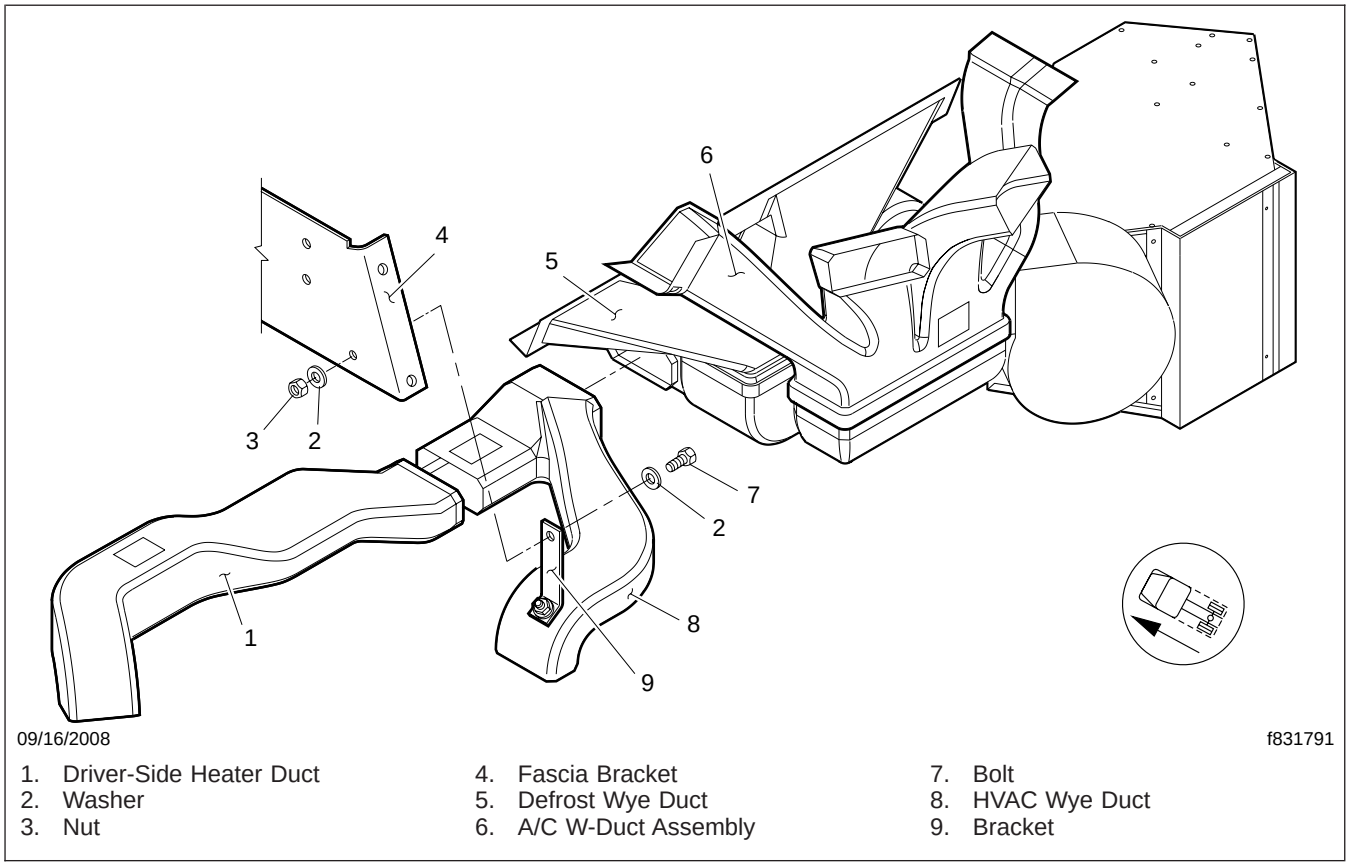

1. Pivot
2. Drag Link
3. Drive Link
4. Electrical Connector
5. Wiper Motor

**Fig. 4, Windshield Wiper Linkage**

9. From underneath the dash, remove the HVAC wye duct located under the center of the dash. A bracket attaches it to the dash with a bolt, nut, and two washers; see **Fig. 5**.
10. Detach the drive link from the wiper motor drive crank, then remove the link.
11. Remove the wiper motor; see **Subject 100**.
12. Pop the drag link from the mounting knob on the passenger-side pivot. To reach the passenger-side pivot, lie on the floor under the dash with your feet out the passenger-side door, and look up behind the HVAC ducting.
13. Open the glove box, then remove the eight screws that attach it to the dash; see **Fig. 6**. Remove the glove box.
14. Remove the drag link through the glove box opening.
16. Attach the linkage to the mounting knobs on the driver-side pivot, the drive link on the forward side of the pivot, and the drag link on the aft side.
17. Attach the drag link to the mounting knob on the passenger-side pivot.
18. Install the wiper motor; see **Subject 100**.
19. Attach the drive link to the wiper motor drive crank.
20. Attach the glove box to the dash with eight screws; see **Fig. 6**.
21. Position the ECU mounting plate in place, and secure it with three capscrews; see **Fig. 3**.
22. Close the main dash panel, then secure it with the four Phillips screws; see **Fig. 2**.

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1. Driver-Side Heater Duct
2. Washer
3. Nut
4. Fascia Bracket
5. Defrost Wye Duct
6. A/C W-Duct Assembly
7. Bolt
8. HVAC Wye Duct
9. Bracket

**Fig. 5, HVAC Wye Duct Installation**

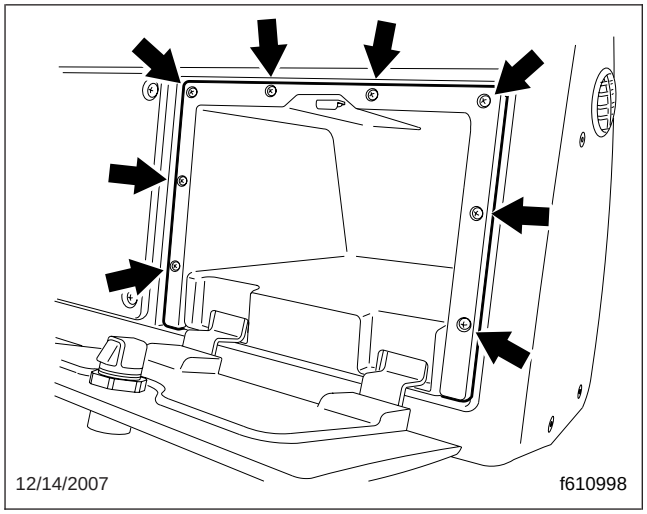


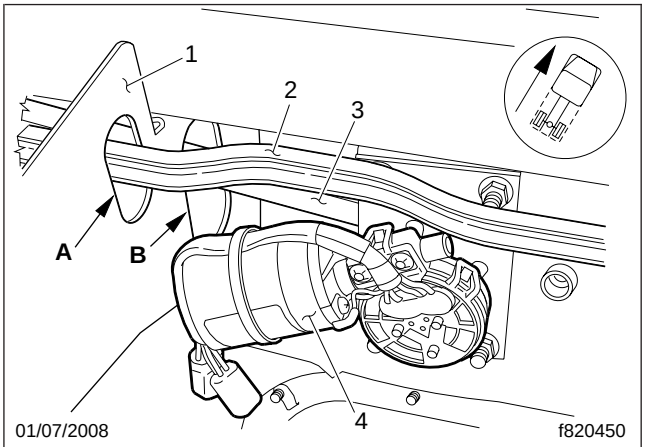

**Fig. 6, Glove Box Screws**

23. If the steering column was lowered, raise and install it as follows.
    - 23.1 Lift the steering column into place, and install the four 3/8-inch capscrews and washers that attach the steering column to the steering column bracket. Tighten the nuts 23 to 29 lbf·ft (31 to 39 N·m).
    - 23.2 Install the wiring clamp on the side of the steering column.
24. Install the HVAC wye duct under the dash. Attach the duct bracket to the fascia bracket on the dash with the bolt, nut, and two washers; see **Fig. 5**.
25. Outside the cab, tighten the driver-side pivot shaft retaining nut 12 to 15 lbf·ft (16 to 20 N·m), then install the cap on the shaft; see **Fig. 1**.
26. Install the driver-side wiper arm; see **Subject 110**.

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## Wiper Linkage Replacement




A. Route the drag link through the aft access hole.
B. Route the drive link through the forward access hole.

1. Left Center Fascia Bracket
2. Drag Link
3. Drive Link
4. Wiper Motor

**Fig. 7, Routing the Linkage Through Access Holes in the Fascia Bracket**

27. Connect the batteries, and test the wiper system operation.
28. Remove the chocks.

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## Wiper Motor Replacement, Right-Hand Drive

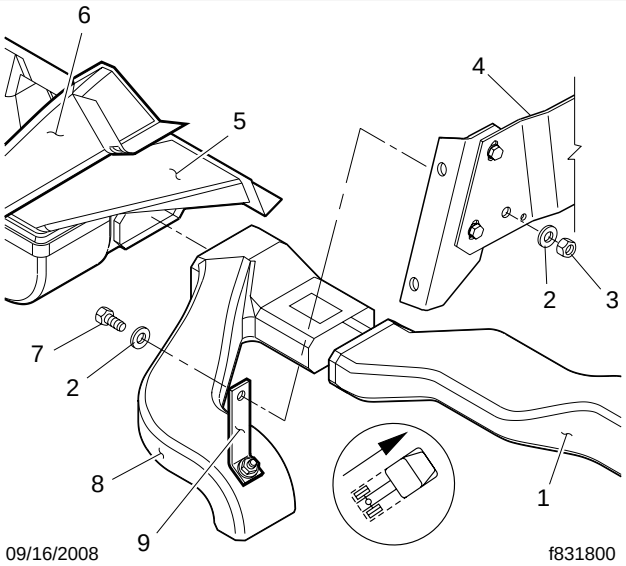
## Replacement

1. Apply the parking brakes and chock the tires.
2. Disconnect the batteries at the negative cables.

**⚠ WARNING**

**Disconnect the batteries before working on the wiper motor or linkage. Otherwise, if the driveshaft is forced out of the parked position, the motor could cycle, possibly resulting in personal injury.**

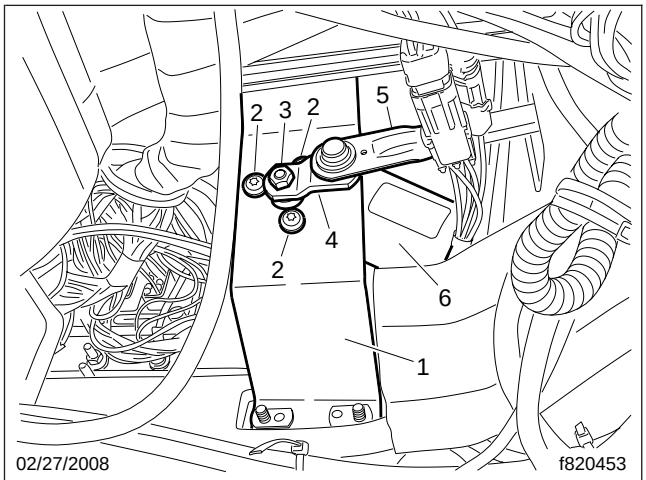
3. From underneath the dash, remove the HVAC wye duct located under the center of the dash. A bracket attaches it to the dash with a bolt, nut, and two washers; see **Fig. 1**.




1. Driver-Side Heater Duct
2. Washer
3. Nut
4. Fascia Bracket
5. Defrost Wye Duct
6. A/C W-Duct Assembly
7. Bolt
8. HVAC Wye Duct
9. Bracket

**Fig. 1, HVAC Wye Duct Installation**

4. Disconnect the wiper motor electrical connectors.
5. Remove the nut (**Fig. 2**, item 3) that attaches the drive crank to the wiper motor drive shaft. It may be helpful to hold the linkage in place with large locking pliers. Remove the drive crank and the linkage from the drive shaft. Use care not to bend the linkage when pulling the drive crank loose from the drive shaft.




NOTE: View looking up from under the dash.

1. Mounting Plate
2. Motor Mount Screw
3. Drive Shaft Nut
4. Drive Crank
5. Drive Link
6. Wiper Motor

**Fig. 2, Wiper Motor Installation**

6. Remove the three Torx screws that attach the wiper motor to the mounting plate. Remove the wiper motor from the plate.
7. Attach the new wiper motor to the mounting plate, using the three Torx screws. Tighten the screws 54 lbf·in (610 N·cm).
8. Place the linkage on the wiper motor drive shaft, then start the nut on the shaft, but do not tighten it yet.
9. Make sure that the wiper arms are in proper parking position, then tighten the nut on the drive shaft 15 to 18 lbf·ft (20 to 25 N·m).
10. Connect the wiper motor wiring to the electrical harness.
11. Install the HVAC wye duct under the dash. Attach the duct bracket to the fascia bracket on the dash with the bolt, nut, and two washers; see **Fig. 1**.
12. Connect the batteries.
13. Remove the chocks.

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## Wiper Pivot Replacement, Right-Hand Drive

NOTE: The wiper linkage is located inside the cab. Some disassembly of the dash components and/or HVAC ducting is required for access.

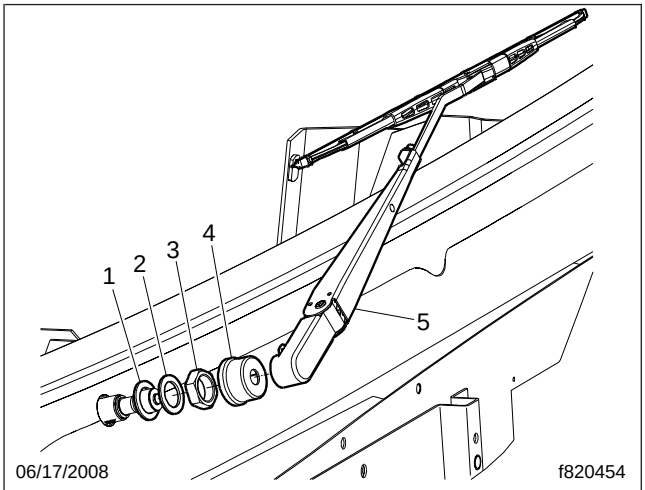
# Driver-Side Wiper Pivot Replacement

1. Apply the parking brakes and chock the tires.
2. Disconnect the batteries at the negative cables.

**⚠ WARNING**

**Disconnect the batteries before working on the wiper motor or linkage. Otherwise, if the driveshaft is forced out of the parked position, the motor could cycle, possibly resulting in personal injury.**

3. Remove the driver-side wiper arm; see **Subject 110**.
4. Remove the cap and the retaining nut from the driver-side pivot drive shaft; see **Fig. 1**.




1. Seal Washer
2. Washer
3. Retaining Nut, M20
4. Cap
5. Wiper Arm

**Fig. 1, Wiper Arm Installation (Bosch shown)**

5. Tilt the steering wheel down, or, if the vehicle has a non-tilting steering wheel, lower the steering column as follows.

5.1 Remove the wiring clamp from the side of the steering column, to access the steering column capscrews.

5.2 While supporting the steering column, remove the four 3/8-inch capscrews and washers that attach the steering column to the steering column bracket; see **Fig. 2**. Carefully lower the steering column.

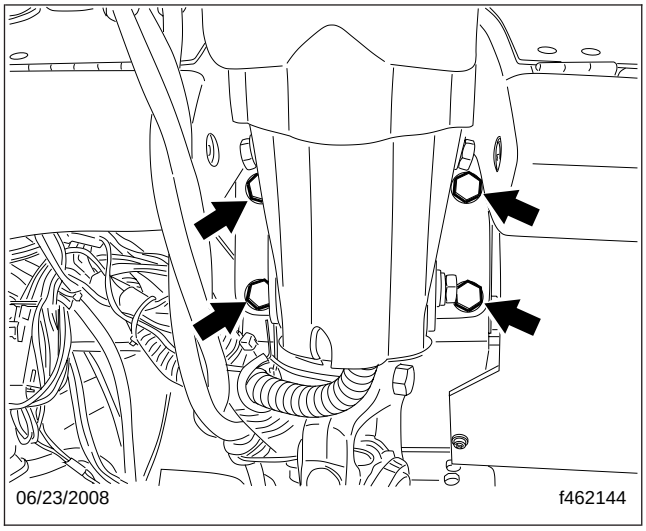



**Fig. 2, Steering Column Capscrews**

6. Remove the four Phillips screws that secure the main dash panel, then swing the panel open; see **Fig. 3**.

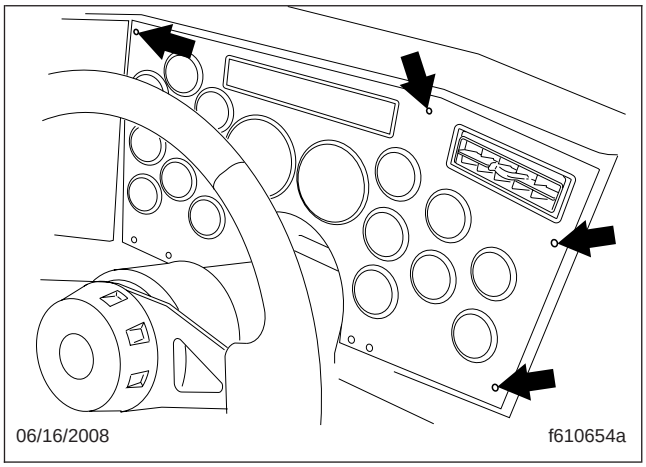



**Fig. 3, Main Dash Panel Screws**

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## Wiper Pivot Replacement, Right-Hand Drive

7. Remove the three capscrews that secure the ECU mounting plate; see **Fig. 4**. Rock the mounting plate out of the way to gain access to the driver-side pivot.

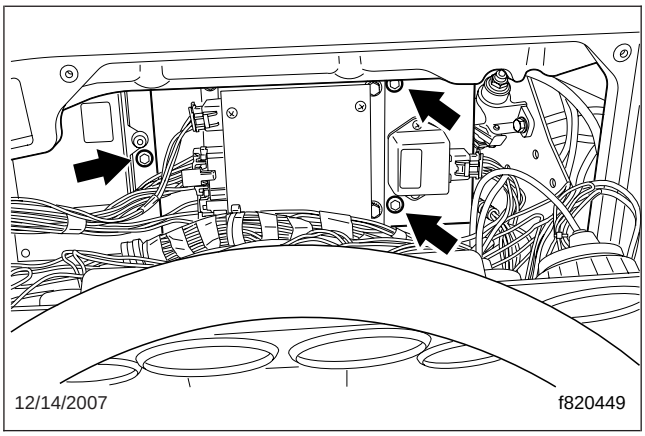



**Fig. 4, ECU Mounting Plate Capscrews**

8. Pop the linkage from the mounting knobs on the pivot. The drive link connects to the mounting knob on the forward side of the pivot, and the drag link connects on the aft side; see **Fig. 5**. Use care not to bend the linkage.
9. Remove the pivot. Note the position of the inner retaining nut on the pivot shaft.
10. Position the inner retaining nut on the new pivot, at the position noted on the old pivot.
11. Position the new pivot in place.
12. Using large locking pliers, press the linkage onto mounting knobs on the pivot. The drive link attaches to the forward side of the pivot, and the drag link to the aft side.
13. Position the ECU mounting plate in place, and secure it with the three capscrews; see **Fig. 4**.
14. Close the main dash panel, and secure it with the four Phillips screws; see **Fig. 3**.
15. If the steering column was lowered, raise and install it as follows.
    - 15.1 Lift the steering column into place, and install the four 3/8-inch capscrews and washers that attach the steering column to the steering column bracket; see **Fig. 2**. Tighten the nuts 23 to 29 lbf·ft (31 to 39 N·m).
    - 15.2 Install the wiring clamp on the side of the steering column.
16. Outside the cab, install the retaining nut on the driver-side pivot drive shaft. Tighten the nut 12 to 15 lbf·ft (16 to 20 N·m), then install the cap on the drive shaft; see **Fig. 1**.
17. Install the driver-side wiper arm; see **Subject 110**.
18. Connect the batteries, and test the wiper system operation.
19. Remove the chocks.

## Passenger-Side Wiper Pivot Replacement

1. Apply the parking brakes and chock the tires.
2. Disconnect the batteries at the negative cables.

**WARNING**

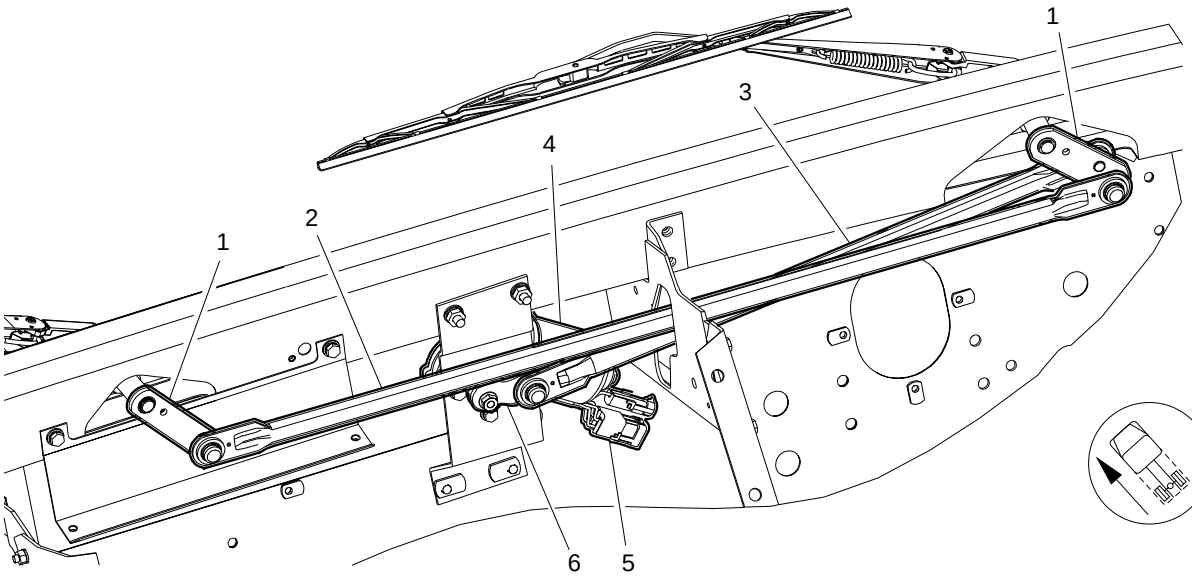
**Disconnect the batteries before working on the wiper motor or linkage. Otherwise, if the driveshaft is forced out of the parked position, the motor could cycle, possibly resulting in personal injury.**

3. Drain the air tanks.
4. Remove the passenger-side wiper arm; see **Subject 110**.
5. Remove the cap and the retaining nut from the passenger-side pivot drive shaft; see **Fig. 1**.
6. Lower the steering column as follows.
    - 6.1 Remove the wiring clamp from the side of the steering column, to access the steering column capscrews.
    - 6.2 While supporting the steering column, remove the four 3/8-inch capscrews and washers that attach the steering column to the steering column bracket; see **Fig. 2**. Carefully lower the steering column.
7. Move the dash back enough to access the wiper linkage from the top, as follows.
    - 7.1 Open the glove box, then remove the eight screws that attach it to the dash; see **Fig. 6**. Remove the glove box.

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## Wiper Pivot Replacement, Right-Hand Drive




1. Pivot
2. Drag Link
3. Drive Link
4. Wiper Motor
5. Electrical Connector
6. Drive Crank

**Fig. 5, Windshield Wiper Linkage**

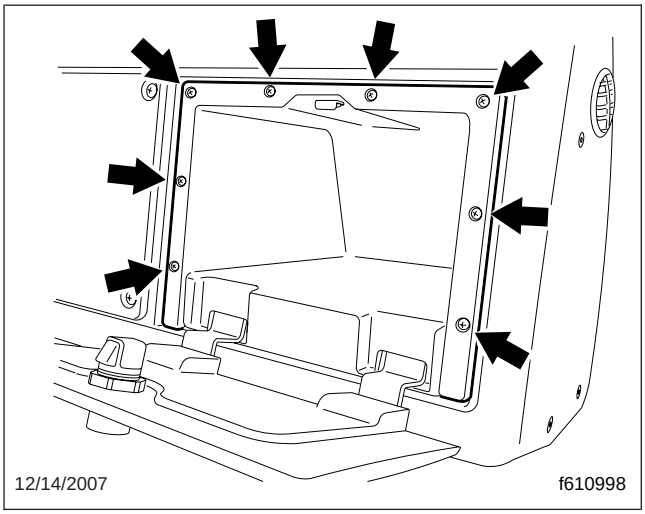



**Fig. 6, Glove Box Screws**

7.2 Remove the seven Torx screws that attach the top front of the dash assembly to the front wall.

7.3 At the right-hand end of the dash, remove the two T25 bolts and nuts, and the washers, that attach the dash to the dash bracket; see **Fig. 7**. Note that the forward bolt and nut also secure the diagnostic connector plate.

7.4 Remove the two 3/16-inch Allen screws that attach the dash to brackets on either side of the steering column location; see **Fig. 8**.

7.5 Between the main and auxiliary dash panels, remove the two nuts and washers (**Fig. 9**, items 5 and 6) from the studs on the backside of the dash.

7.6 Under the center of the dash, remove the bolt and nut, and the washers, that attach the dash to the dash brace; see **Fig. 9**.

7.7 On the passenger side of the dash, remove the fuse access panel(s). The panel(s) are secured by four screws; see **Fig. 10**.

7.8 Remove the two T30 screws and washers between the fuse access openings; see **Fig. 11**.

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## Wiper Pivot Replacement, Right-Hand Drive

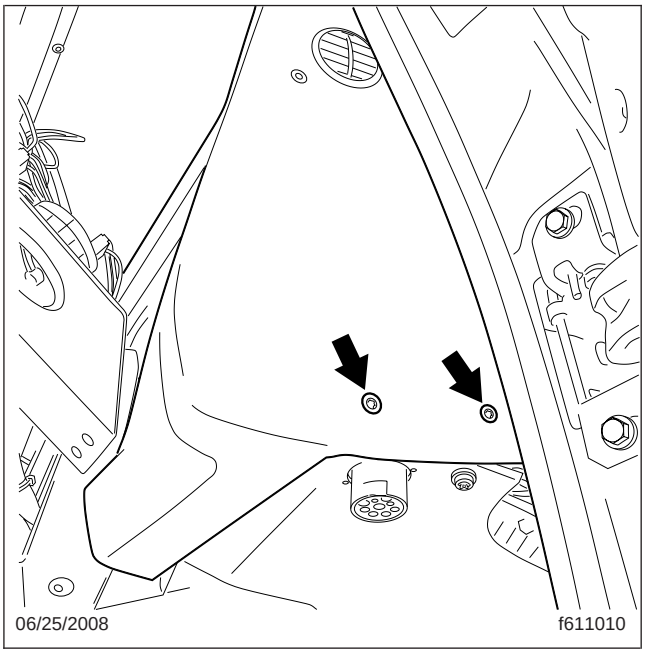



**Fig. 7, Dash Bolts, Right-Hand End**

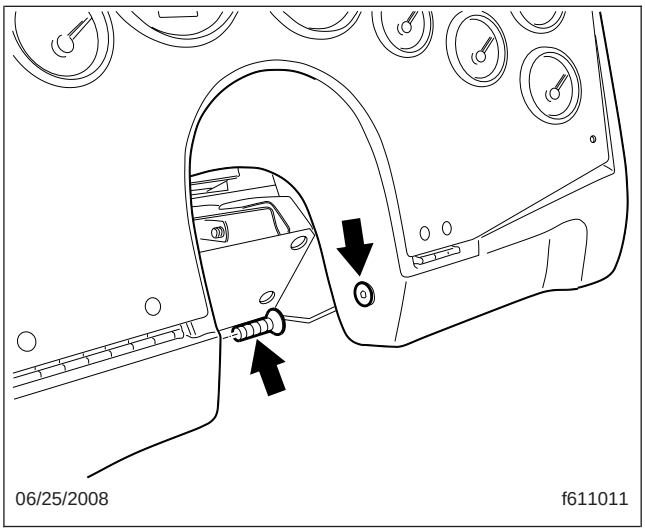
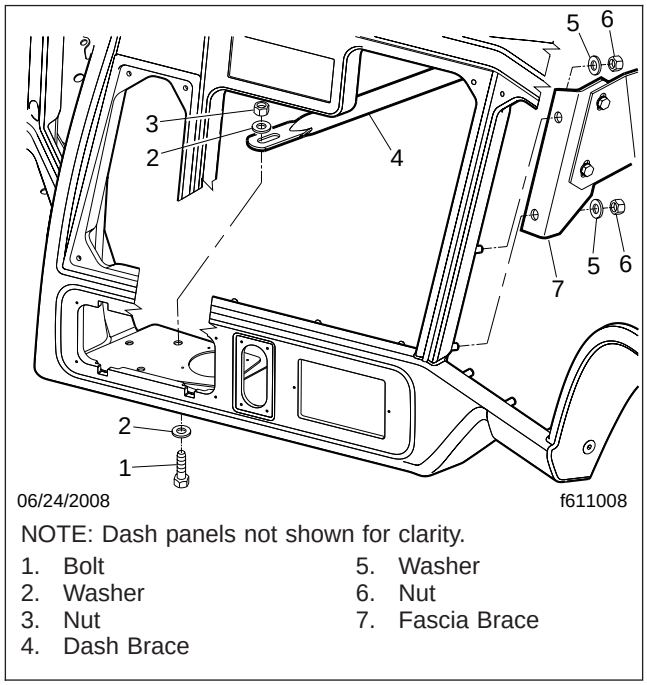



**Fig. 8, Dash Screws, Steering Column Location**

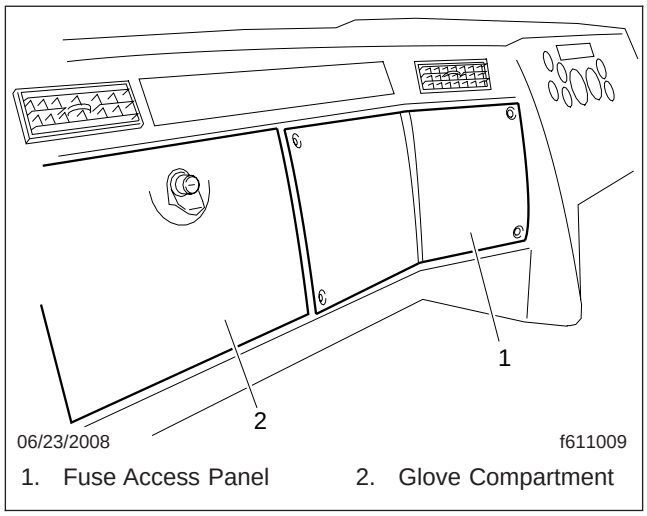
7.9 At the left-hand end of the dash, remove the two T25 bolts and nuts, and the washers, that attach the dash to the dash bracket. Note the position of the angle bracket attached to the forward bolt and nut inside the dash.




NOTE: Dash panels not shown for clarity.

1. Bolt
2. Washer
3. Nut
4. Dash Brace
5. Washer
6. Nut
7. Fascia Brace

**Fig. 9, Dash Fasteners, Center of Dash**




1. Fuse Access Panel
2. Glove Compartment

**Fig. 10, Fuse Access Panel**

7.10 Lift the dash off the HVAC ducts, then pull it back far enough to access the wiper linkage attached to the front wall.

8. From above, using a large flat screwdriver, pop the drag link from the mounting knob on the passenger-side pivot (**Fig. 5**, item 1).

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## Wiper Pivot Replacement, Right-Hand Drive




**Fig. 11, Dash Screws, Fuse Panel Opening**

9. Remove the pivot. Note the position of the inner retaining nut on the pivot shaft.
10. Position the inner retaining nut on the new pivot, at the position noted on the old pivot.
11. Position the new pivot in place, with the pivot shaft through the hole in the cab.
12. Using large locking pliers, press the drag link onto the mounting knob on the pivot.
13. Install the dash as follows.
    - 13.1 Move the dash over the center HVAC ducts, and lower it in place, making sure that the HVAC ducts are mated to the dash, and that no wires, hoses, or ducts are pinched.
    - 13.2 To hold the dash in position, loosely install the seven dash top front screws.
    - 13.3 Install the two T30 screws and washers between the fuse access openings; see **Fig. 11**.
    - 13.4 Install the fuse access panel(s); see **Fig. 10**.
    - 13.5 At the left-hand end of the dash, install the two T25 bolts and nuts, and the washers, that attach the dash to the dash bracket. Also install the angle bracket inside the dash at the forward fastener position.
    - 13.6 Under the center of the dash, attach the dash to the brace, using the bolt, nut, and washers; see **Fig. 9**.
    - 13.7 Between the main and auxiliary dash panels, install the two washers and nuts (**Fig. 9**, items 5 and 6) on the studs on the back of the dash.
    - 13.8 On each side of the steering column location, install the two 3/16-inch Allen screws that attach the dash to the dash brackets; see **Fig. 8**.
    - 13.9 On the right-hand end of the dash, install the two T25 bolts and nuts, and the washers, that attach the dash to the dash bracket; see **Fig. 7**. Note that the forward bolt and nut also attach to a bracket that holds the diagnostic connector plate.
    - 13.10 Tighten the seven previously installed Torx screws that attach the top front of the dash to the front wall.
    - 13.11 Install the glove box, using eight screws to attach it to the dash; see **Fig. 6**.
    - 13.12 Make sure that all wiring and air lines are connected to the gauges on the dash panels. Close any open dash panels and secure them with screws.
14. Raise and install the steering column as follows.
    - 14.1 Lift the steering column into place, and install the four 3/8-inch capscrews and washers that attach the steering column to the steering column bracket; see **Fig. 2**. Tighten the nuts 23 to 29 lbf·ft (31 to 39 N·m).
    - 14.2 Install the wiring clamp on the side of the steering column.
15. Outside the cab, install the retaining nut on the passenger-side pivot drive shaft. Tighten the nut 12 to 15 lbf·ft (16 to 20 N·m), then install the cap on the drive shaft; see **Fig. 1**.
16. Install the passenger-side wiper arm; see **Subject 110**.
17. Connect the batteries, and test the wiper system operation.

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## Wiper Pivot Replacement, Right-Hand Drive

18. Remove the chocks.

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## Wiper Linkage Replacement, Right-Hand Drive

NOTE: The wiper linkage is located inside the cab. Some disassembly of the dash components and/or HVAC ducting is required for access.

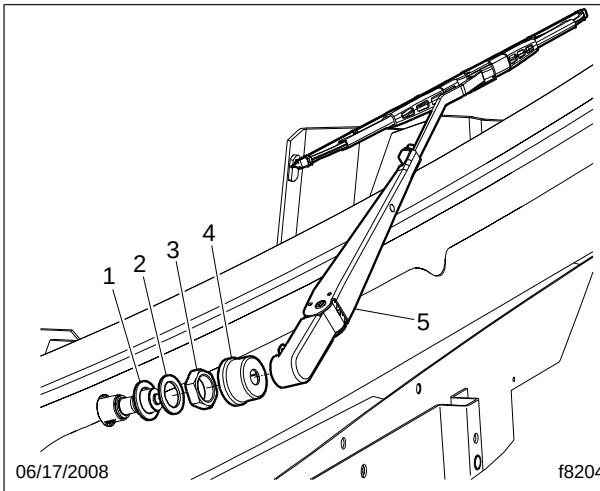
## Drive Link Replacement

1. Apply the parking brakes and chock the tires.
2. Disconnect the batteries at the negative cables.

**⚠ WARNING**

**Disconnect the batteries before working on the wiper motor or linkage. Otherwise, if the driveshaft is forced out of the parked position, the motor could cycle, possibly resulting in personal injury.**

3. Remove the driver-side wiper arm; see **Subject 110**.
4. Remove the cap from the driver-side pivot drive shaft, then loosen, but do not remove, the pivot shaft retaining nut; see **Fig. 1**.




1. Seal Washer
2. Washer
3. Retaining Nut, M20
4. Cap
5. Wiper Arm

**Fig. 1, Wiper Arm Installation (Bosch shown)**

5. Tilt the steering wheel down, or, if the vehicle has a non-tilting steering wheel, lower the steering column as follows.

5.1 Remove the wiring clamp from the side of the steering column, to access the steering column capscrews.

5.2 While supporting the steering column, remove the four 3/8-inch capscrews and washers that attach the steering column to the steering column bracket; see **Fig. 2**. Carefully lower the steering column.

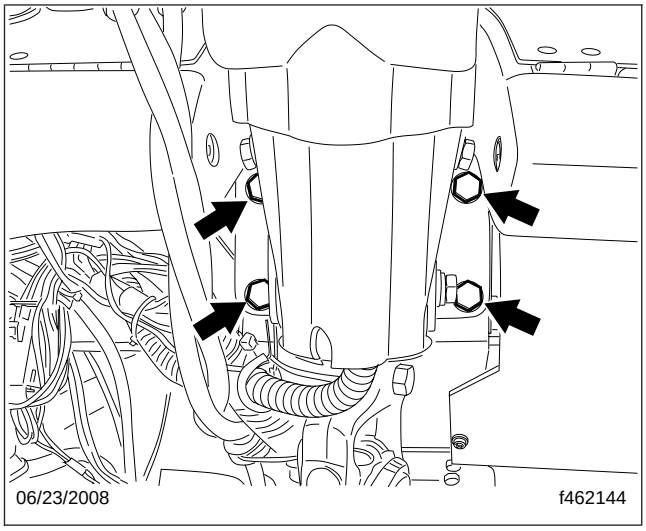



**Fig. 2, Steering Column Capscrews**

6. Remove the four Phillips screws that secure the main dash panel, then swing the panel open; see **Fig. 3**.

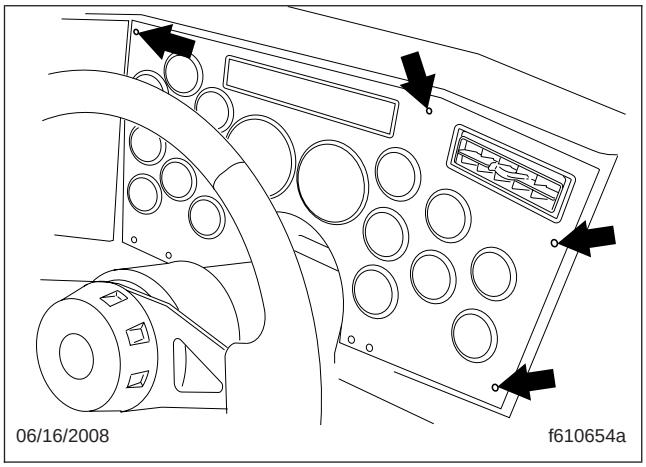



**Fig. 3, Main Dash Panel Screws**

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## Wiper Linkage Replacement, Right-Hand Drive

7. Remove the three capscrews that secure the ECU mounting plate; see **Fig. 4**. Rock the mounting plate out of the way to gain access to the driver-side pivot.

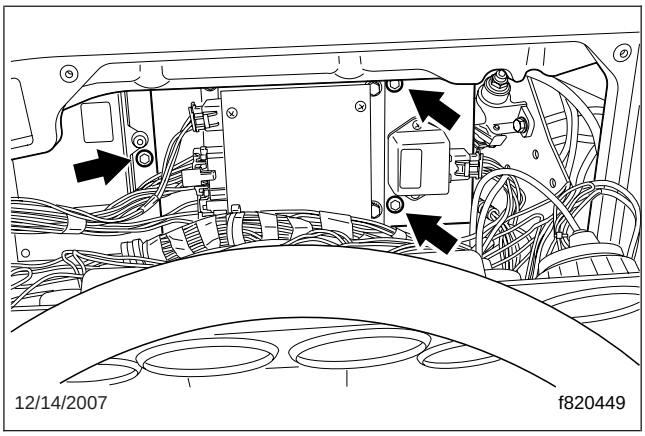
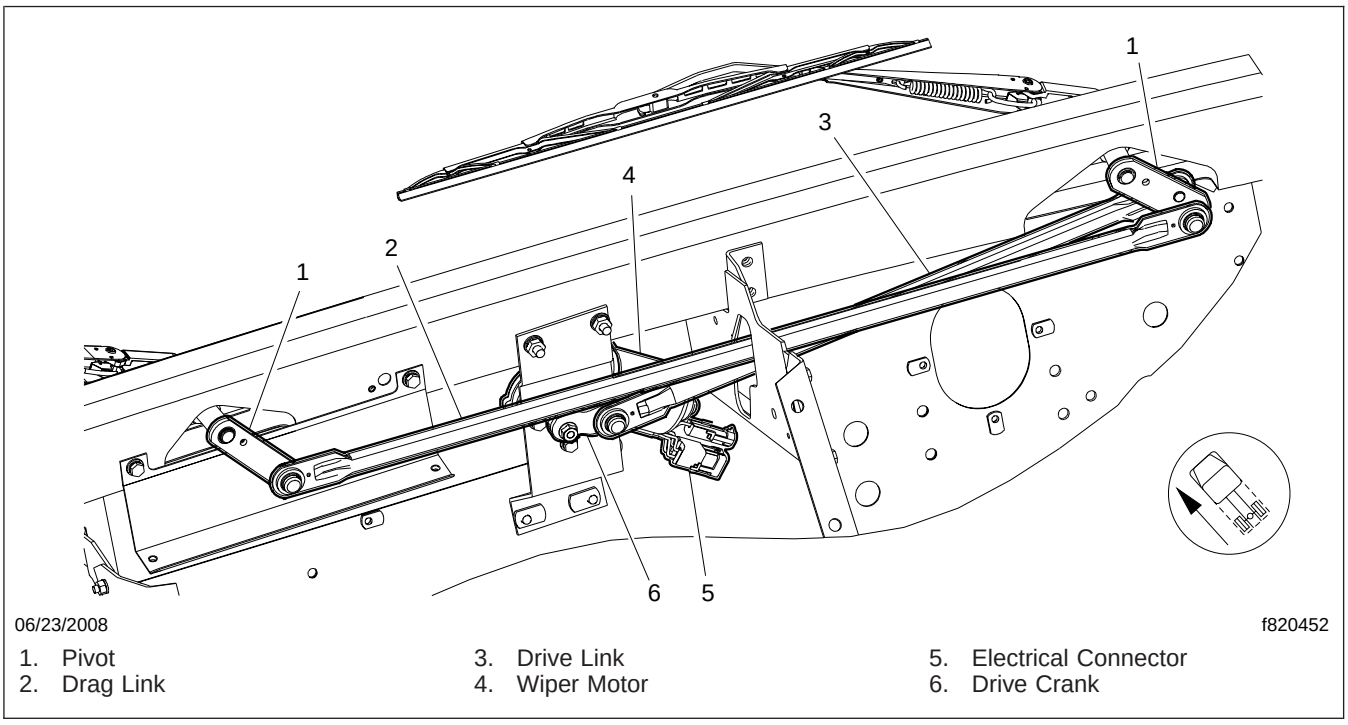



**Fig. 4, ECU Mounting Plate Capscrews**

8. Pop the drive link from the mounting knob on the driver-side pivot. The drive link connects to the mounting knob on the forward side of the pivot; see **Fig. 5**. Use care not to bend the linkage.
9. From underneath the center of the dash, remove the HVAC wye duct. A bracket attaches it to the dash with a bolt, nut, and two washers; see **Fig. 6**.
10. Detach the drive link from the wiper motor drive crank, then remove the link.
11. Using large locking pliers, press the new drive link on the mounting knob on the forward side of the driver-side pivot.
12. Attach the drive link to the wiper motor drive crank.
13. Position the ECU mounting plate in place, and secure it with three capscrews; see **Fig. 4**.
14. Close the main dash panel, then secure it with the four Phillips screws; see **Fig. 3**.
15. If the steering column was lowered, raise and install it as follows.
    15.1 Lift the steering column into place, and install the four 3/8-inch capscrews and washers that attach the steering column to

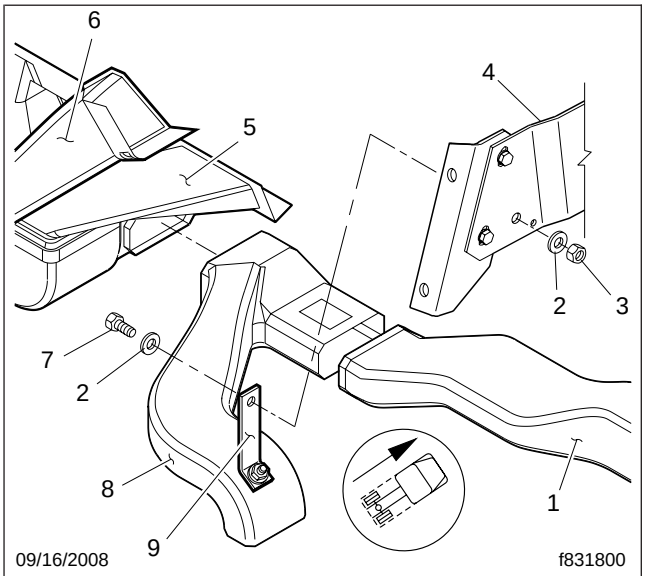



1. Pivot
2. Drag Link
3. Drive Link
4. Wiper Motor
5. Electrical Connector
6. Drive Crank

**Fig. 5, Windshield Wiper Linkage**

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1. Driver-Side Heater Duct
2. Washer
3. Nut
4. Fascia Bracket
5. Defrost Wye Duct
6. A/C W-Duct Assembly
7. Bolt
8. HVAC Wye Duct
9. Bracket

**Fig. 6, HVAC Wye Duct Installation**

the steering column bracket; see **Fig. 2**. Tighten the nuts 23 to 29 lbf·ft (31 to 39 N·m).

15.2 Install the wiring clamp on the side of the steering column.

16. Install the HVAC wye duct under the dash. Attach the duct bracket to the fascia bracket with the bolt, nut, and two washers; see **Fig. 6**.
17. Outside the cab, tighten the driver-side pivot shaft retaining nut 12 to 15 lbf·ft (16 to 20 N·m), then install the cap on the shaft; see **Fig. 1**.
18. Install the driver-side wiper arm; see **Subject 110**.
19. Connect the batteries, and test the wiper system operation.
20. Remove the chocks.

## Drag Link Replacement

1. Apply the parking brakes and chock the tires.
2. Disconnect the batteries at the negative cables.

**⚠ WARNING**

**Disconnect the batteries before working on the wiper motor or linkage. Otherwise, if the driveshaft is forced out of the parked position, the motor could cycle, possibly resulting in personal injury.**

3. Remove the driver-side wiper arm; see **Subject 110**.
4. Remove the cap from the driver-side pivot drive shaft, then loosen, but do not remove, the pivot shaft retaining nut; see **Fig. 1**.
5. Lower the steering column as follows.

   5.1 Remove the wiring clamp from the side of the steering column, to access the steering column capscrews.

   5.2 While supporting the steering column, remove the four 3/8-inch capscrews and washers that attach the steering column to the steering column bracket; see **Fig. 2**. Carefully lower the steering column.

6. Move the dash back enough to access the wiper linkage from the top, as follows.

   6.1 Open the glove box, then remove the eight screws that attach it to the dash; see **Fig. 7**. Remove the glove box.

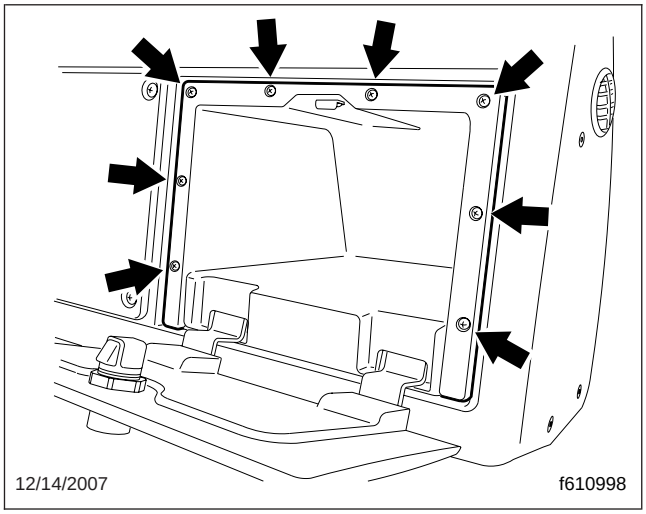



**Fig. 7, Glove Box Screws**

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## Wiper Linkage Replacement, Right-Hand Drive

6.2 Remove the seven Torx screws that attach the top front of the dash assembly to the front wall.

6.3 At the right-hand end of the dash, remove the two T25 bolts and nuts, and the washers, that attach the dash to the dash bracket; see **Fig. 8**. Note that the forward bolt and nut also secure the diagnostic connector plate.

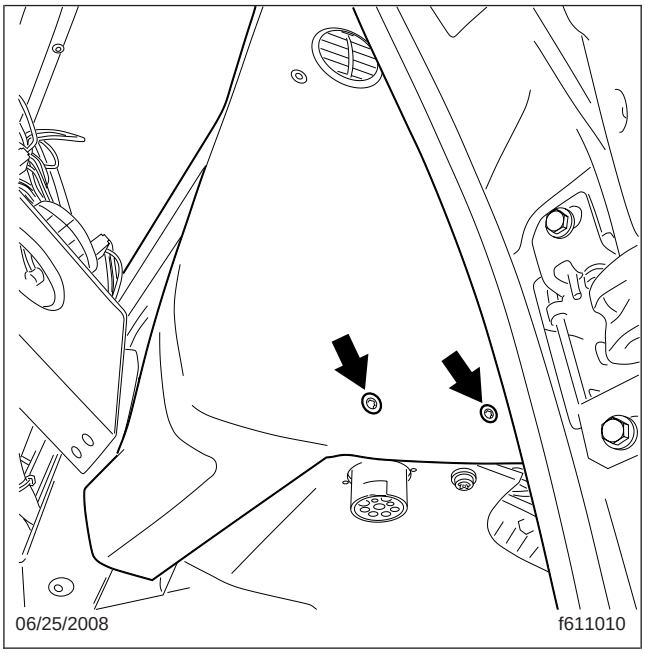



**Fig. 8, Dash Bolts, Right-Hand End**

6.4 Remove the two 3/16-inch Allen screws that attach the dash to brackets on either side of the steering column location; see **Fig. 9**.

6.5 Between the main and auxiliary dash panels, remove the two nuts and washers (**Fig. 10**, items 5 and 6) from the studs on the backside of the dash.

6.6 Under the center of the dash, remove the bolt and nut, and the washers, that attach the dash to the dash brace; see **Fig. 10**.

6.7 On the passenger side of the dash, remove the fuse access panel(s). The panel(s) are secured by four screws; see **Fig. 11**.

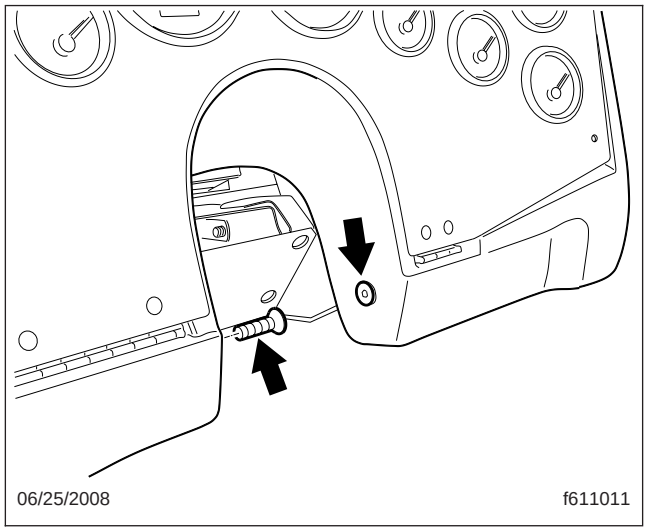
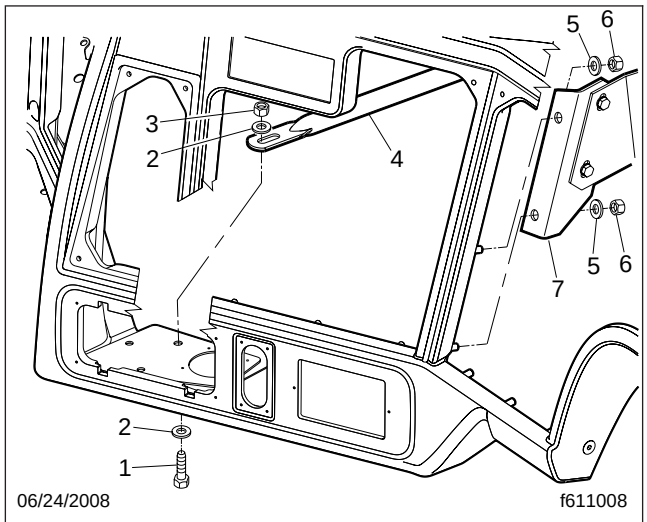



**Fig. 9, Dash Screws, Steering Column Location**




NOTE: Dash panels not shown for clarity.

1. Bolt
2. Washer
3. Nut
4. Dash Brace
5. Washer
6. Nut
7. Fascia Brace

**Fig. 10, Dash Fasteners, Center of Dash**

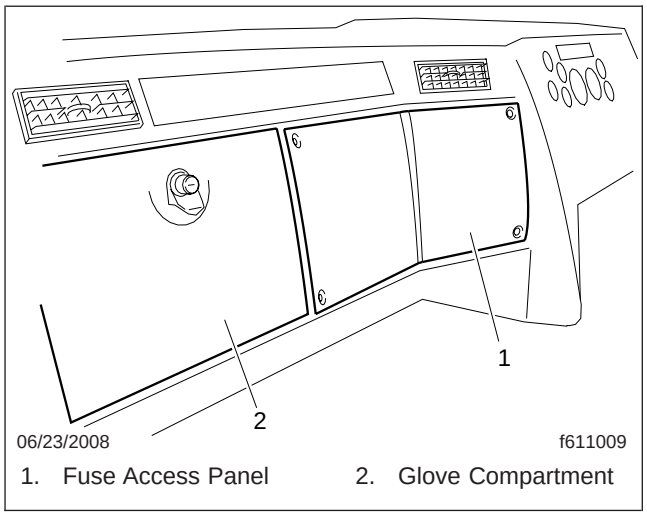
6.8 Remove the two T30 screws and washers between the fuse access openings; see **Fig. 12**.

6.9 At the left-hand end of the dash, remove the two T25 bolts and nuts, and the washers, that attach the dash to the dash

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## Wiper Linkage Replacement, Right-Hand Drive




1. Fuse Access Panel 2. Glove Compartment

**Fig. 11, Fuse Access Panel**

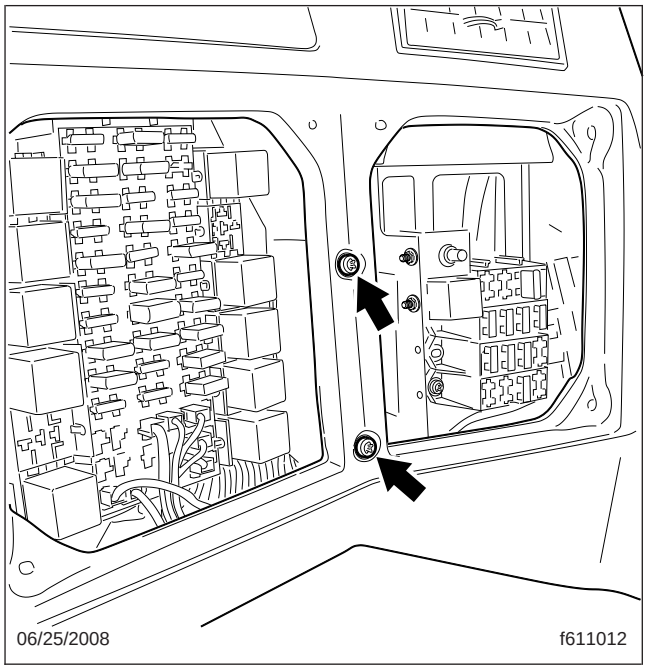



**Fig. 12, Dash Screws, Fuse Panel Opening**

bracket. Note the position of the angle bracket attached to the forward bolt and nut inside the dash.

6.10 Lift the dash off the HVAC ducts, then pull it back far enough to access the wiper linkage attached to the front wall.

7. From above, pop the drag link from the mounting knobs on the pivots; see **Fig. 5**.
8. Using large locking pliers, press the new drag link on the mounting knob on the aft side of the driver-side pivot.
9. Press the drag link on the mounting knob on the passenger-side pivot.
10. Install the dash as follows.

    10.1 Move the dash over the center HVAC ducts, and lower it in place, making sure that the HVAC ducts are mated to the dash, and that no wires, hoses, or ducts are pinched.

    10.2 To hold the dash in position, loosely install the seven dash top front screws.

    10.3 Install the two T30 screws and washers between the fuse access openings; see **Fig. 12**.

    10.4 Install the fuse access panel(s); see **Fig. 11**.

    10.5 At the left-hand end of the dash, install the two T25 bolts and nuts, and the washers, that attach the dash to the dash bracket. Also install the angle bracket inside the dash at the forward fastener position.

    10.6 Under the center of the dash, attach the dash to the brace, using the bolt, nut, and washers; see **Fig. 10**.

    10.7 Between the main and auxiliary dash panels, install the two washers and nuts (**Fig. 10**, items 5 and 6) on the studs on the back of the dash.

    10.8 On each side of the steering column location, install the two 3/16-inch Allen screws that attach the dash to the dash brackets; see **Fig. 9**.

    10.9 On the right-hand end of the dash, install the two T25 bolts and nuts, and the washers, that attach the dash to the dash bracket; see **Fig. 8**. Note that the forward bolt and nut also attach to a bracket that holds the diagnostic connector plate.

    10.10 Tighten the seven previously installed Torx screws that attach the top front of the dash to the front wall.

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## Wiper Linkage Replacement, Right-Hand Drive

10.11 Install the glove box, using eight screws to attach it to the dash; see **Fig. 7**.

10.12 Make sure that all wiring and air lines are connected to the gauges on the dash panels. Close any open dash panels and secure them with screws.

11. Raise and install the steering column as follows.

11.1 Lift the steering column into place, and install the four 3/8-inch capscrews and washers that attach the steering column to the steering column bracket; see **Fig. 2**. Tighten the nuts 23 to 29 lbf·ft (31 to 39 N·m).

11.2 Install the wiring clamp on the side of the steering column.

12. Outside the cab, tighten the driver-side pivot shaft retaining nut 12 to 15 lbf·ft (16 to 20 N·m), then install the cap on the shaft; see **Fig. 1**.
13. Install the driver-side wiper arm; see **Subject 110**.
14. Connect the batteries, and test the wiper system operation.
15. Remove the chocks.

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## Specifications

Unless listed in **Table 1**, tighten all fasteners using the torque specifications found in **Section 00.05**.

| Torque Specifications | | |
|---|---|---|
| **Fastener Description** | **Torque** | |
| | **lbf·ft (N·m)** | **lbf·in (N·cm)** |
| Wiper Motor Drive Shaft Nut | 15–18 (20–25) | — |
| Wiper Motor Mounting Screws | — | 54 (610) |
| Wiper Motor Mounting Plate Nuts | 13–17 (18–23) | — |
| Pivot Retaining Nut | 12–15 (16–20) | — |

**Table 1, Torque Specifications**

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## General Information

The main purpose of the refrigerant compressor is to draw refrigerant gas from the evaporator and squeeze it into high-pressure gas. High pressure raises the condensation point of refrigerant gas, which allows the condenser to change it to a liquid so that it can be used for cooling again. A second purpose of the compressor is to move refrigerant through the air conditioner system.

The Climate Control compressor is a two-piston design. The pistons are driven by a crankshaft and connecting rods.

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## Safety Precautions

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

Refrigerant R–134a is safe when used under the right conditions. Always wear safety goggles and nonleather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves. When refrigerant gas or liquid contacts leather, the leather will stick to your skin.

**⚠ WARNING**

**Use care to prevent refrigerant from touching your skin or eyes because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.**

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure; however, it can be combustible at pressures as low as 5.5 psig (139 kPa absolute) at 350°F (177°C) when mixed with air concentrations that are greater than 60 percent.

**⚠ WARNING**

**R–134a air conditioning systems should not be pressure tested or leak tested with compressed air. Combustible mixtures of air and R–134a may form, resulting in a fire or explosion that could cause personal injury or property damage.**

You must work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R–134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

When handling refrigerant oil, observe the following guidelines:

- Keep the oil free of contaminants.
- Do not expose the air conditioning system or the refrigerant oil container to air for more than five minutes. Refrigerant oil has a high moisture absorption capacity and the oil container should be immediately sealed after each use.
- Use care when handling. Spilled oil could damage painted surfaces, plastic parts, and other components such as drive belts.
- Never mix different types of refrigerant oil.

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## Pre-Service Checks

**⚠ WARNING**

**Before doing any work, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant could lead to serious personal injury.**

Some special tools are needed for doing repair work on the compressor. Refer to the special tools table in **Specifications 400**. Tool kits can be bought from the distributor listed under the special tools table in **Specifications 400**.

Compressor problems usually show in one of four ways:

- abnormal noise
- seizure
- leakage
- low suction and discharge pressures

Resonant compressor noises are not causes for alarm. Irregular noise or rattles are likely to be caused by broken parts. To check for seizure, de-energize the magnetic clutch and see if the drive plate can be turned. If it won't turn, the compressor has seized.

Do the following checks whenever the air conditioner system is not cooling enough and the causes are unknown.

1. Be sure to check the moisture indicator to see if moisture is the cause of the problems. The air conditioner should be on when checking the indicator. It is better to check it at the end of the day.
2. Check the drive belt and mounting.
   - 2.1 On the drive belt look for wear, damage, or oil. If worn, oil-soaked, or damaged, remove it and install a new one.
   - 2.2 Check the compressor mounting parts for loose fasteners, cracks, or other damage. Tighten loose fasteners to the torque specifications in **Specifications 400**. Repair or replace cracked or damaged brackets.
   - 2.3 Check the tension of the compressor drive belt.
   - 2.4 Check the compressor oil level. See **Subject 130** for instructions.
3. Check the wiring and connections to the compressor clutch. Replace damaged wiring and tighten loose connections.
4. Check for road debris buildup on the condenser coil fins. Using air pressure and a whiskbroom or a solution of soap and water, carefully clean the condenser. Be careful not to bend the fins.
5. Check the refrigerant charge in the air conditioner system. For instructions, see **Section 83.02**, Subject 110.
6. Check the valve plate, cylinder gasket, and the shaft seal for damage. Replace as needed. For instructions, see **Subject 160** and **Subject 150** respectively.

NOTE: For other possible causes of air conditioner problems, refer to **Section 83.02** or refer to the applicable fan clutch section in **Group 20**.

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## Refrigerant Compressor Replacement

# Replacement

**⚠ WARNING**

**Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.**

1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Determine the reason for the refrigerant compressor failure. See the cab HVAC troubleshooting procedures in **Section 83.02**, Subject 300.
4. Look for signs of refrigerant leakage and leak test the system. For instructions, see **Section 83.02**, Subject 110.
5. Recover the refrigerant. For instructions, see **Section 83.02**, Subject 110.
6. While the refrigerant is being recovered, perform the following substeps.
   - 6.1 Remove the belt(s) from the refrigerant compressor.
   - 6.2 If the refrigerant compressor has hose brackets on it, remove the capscrews that attach the brackets to the compressor and remove the brackets.
   - 6.3 Remove two of the capscrews that attach the refrigerant compressor to the mounting pad.
   - 6.4 Disconnect the compressor clutch wiring harness.
7. After the refrigerant is recovered, disconnect the discharge and suction lines from the refrigerant compressor. Quickly cap the discharge and suction ports and plug the fittings.

IMPORTANT: Under no circumstances should the ports on the compressor remain uncapped or the fittings remain unplugged for longer than five minutes total. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

8. Remove the remaining capscrews that attach the refrigerant compressor to the mounting pad. Remove the compressor.
9. If the clutch on the refrigerant compressor is not being replaced, remove the clutch from the compressor. For instructions, see **Subject 140**.
10. If the clutch was removed from refrigerant compressor, install the clutch on the new compressor. For instructions, see **Subject 140**.

IMPORTANT: A new refrigerant compressor is filled with refrigerant oil and nitrogen gas. The type of oil used in the compressor is printed on a label attached to the compressor. When installing a new compressor, do all of the steps below. When installing a used compressor, disregard the first step.

11. Prepare a new refrigerant compressor.
    - 11.1 Gently release the nitrogen gas from the discharge side of the compressor. Be careful not to let the oil flow out.
    - 11.2 Turn the compressor shaft several times by hand to distribute oil that has settled in the cylinder.
    - 11.3 Check the oil level in the refrigerant compressor. For instructions, see **Subject 130**.
12. Using two capscrews, attach the refrigerant compressor to the mounting pad.
13. Uncap the discharge and suction ports. Unplug the fittings. Check the fittings and the discharge and suction ports. They must be clean and free of nicks, gasket residue, and other foreign material.
14. Replace the O-rings on the threaded fittings. Lubricate the O-rings with mineral oil before installing.
15. Connect the refrigerant lines to the compressor. Torque the fittings 21 to 27 lbf·ft (28 to 37 N·m).
16. Evacuate the refrigerant system. For instructions, see **Section 83.02**, Subject 110.
17. While evacuating the system, perform the following substeps.
    - 17.1 Install the remaining capscrews that attach the refrigerant compressor to the mounting

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## Refrigerant Compressor Replacement

pad. Torque all the mounting capscrews 28 lbf·ft (38 N·m).

17.2 If the refrigerant compressor is equipped with hose brackets, use capscrews to attach the brackets to the compressor.

17.3 Connect the compressor clutch wiring harness.

17.4 Install the belt(s) on the refrigerant compressor.

18. Check to make sure that the system holds a vacuum.
19. Charge the system with refrigerant. The correct amount of refrigerant is printed on the "Air Conditioner" label on the radiator.
20. Leak check all fittings that were removed during the replacement procedure. For instructions, see **Section 83.02**, Subject 110.
21. Check operation of the air conditioner.
22. Close the hood.
23. Remove the chocks from the tires.

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# Oil Check and Adding Oil to the Refrigerant Compressor

## General Information

IMPORTANT: On an R–134a air conditioning system, a new compressor is factory-charged with about 14 fl oz (414 mL) of refrigerant oil. Some refrigerant oil is circulated through the system with the refrigerant and cannot leave the system except through a leak, when the system is discharged or recovered, or when a system part is replaced.

Oil must be from a container that has not been opened, or that has been tightly sealed since its last use. Refer to the applicable refrigerant oils table in **Specifications 400** for recommended oils. Tubing, funnels, or other equipment used to transfer the oil should be very clean and dry.

Listed below are the approximate refill amounts for the R–134a air conditioning system and the system components.

- Oil charge: The entire system should have about 14 fl oz (414 mL) of refrigerant oil. There should be 10 fl oz (296 mL) in the refrigerant compressor. Each major component has about 2 fl oz (59 mL) of refrigerant oil. This amount has been rounded off for ease of adding oil to the compressor. Additional oil must be added to the compressor when a major component is replaced.

  As an example, if the condenser and the receiver-drier are to be replaced, first check the oil level of the compressor. The compressor should have 10 fl oz (296 mL). Add oil if needed. Then, after replacing the condenser and the receiver-drier, add an additional 4 fl oz (118 mL) of oil to the compressor. The entire system should then have about 14 fl oz (414 mL).

  IMPORTANT: Replacing only the amount of oil that is removed during evacuation may result in the wrong oil charge because the oil charge may have been incorrect prior to evacuation. The only way to ensure the proper oil charge is to check the oil level of the compressor with a dipstick.

- Receiver-drier: When the receiver-drier is replaced, about 2 fl oz (59 mL) must be added to the compressor in addition to the 10 fl oz (296 mL) that the compressor requires.

  IMPORTANT: A new receiver-drier does not contain any refrigerant oil.

- Condenser: When the condenser is replaced, about 2 fl oz (59 mL) must be added to the compressor in addition to the 10 fl oz (296 mL) that the compressor requires.

- Evaporator: When the evaporator is replaced, about 2 fl oz (59 mL) must be added to the compressor in addition to the 10 fl oz (296 mL) that the compressor requires.

  IMPORTANT: Check the compressor oil level whenever the system has been opened.

When handling refrigerant oil:

- Be sure that the oil is free of water, dust, metal powder, and other foreign substances;
- Do not mix the refrigerant oil with other types or viscosities of oil;
- Quickly seal the oil container after use. Refrigerant oil absorbs moisture when exposed to the air for any period of time.

**⚠ WARNING**

**Don't remove the oil fill plug without first recovering the system. Failure to recover the system could cause uncontrolled release of high-pressure refrigerant, which can freeze skin and eye tissue causing serious injury or blindness.**

1. Recover the refrigerant from the air conditioner system. For instructions, see **Section 83.02**, Subject 110.
2. Remove the oil fill plug and the O-ring.
3. Check the oil level with the dipstick. When the compressor is mounted vertically, use either port. When mounted in any other orientation, use the upper port. **Fig. 1** shows the oil level with the refrigerant compressor mounted at 22 degrees. **Fig. 2** shows the oil level with the refrigerant compressor mounted at 45 degrees.

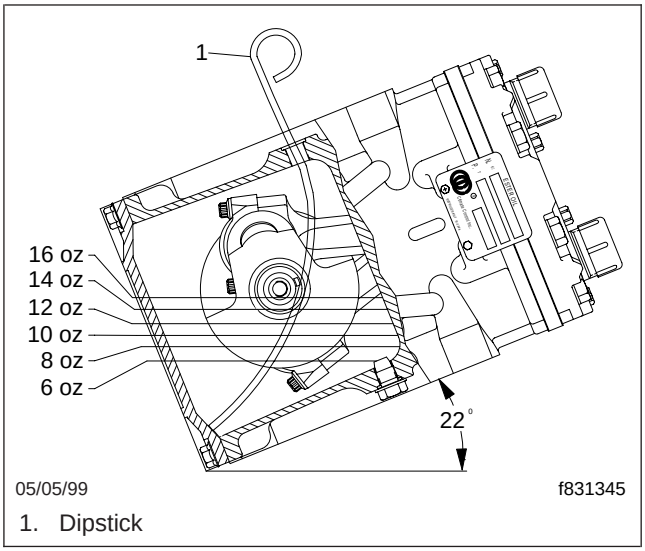
   If the dipstick bottoms out before going in more than 3 inches (76 mm), it is hitting the compressor crankshaft. Rotate the drive plate by hand and insert the dipstick again until it contacts the bottom of the sump. See **Table 1** to determine

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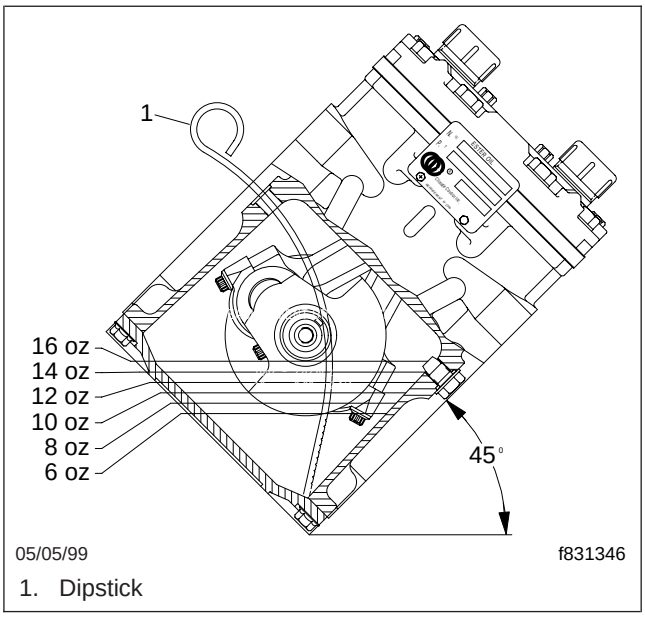
## Oil Check and Adding Oil to the Refrigerant Compressor

the oil quantity. Add or remove oil from the compressor so that the oil charge is 10 fl oz (296 mL).




1. Dipstick

**Fig. 1, Oil Level With Refrigerant Compressor Mounted at 22 Degrees**

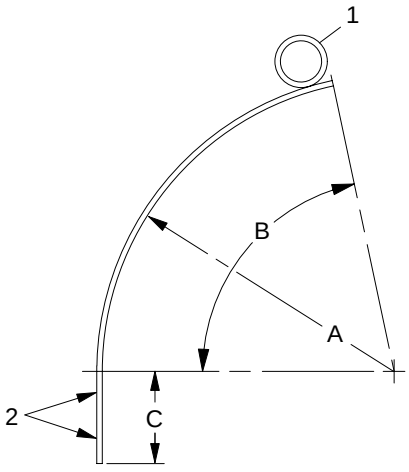



1. Dipstick

**Fig. 2, Oil Level With Refrigerant Compressor Mounted at 45 Degrees**

NOTE: A dipstick can be made locally or purchased from a special tools supplier. Refer to the special tools table in **Specifications 400**. If made locally, it can be formed from 1/8-inch diameter by 8-5/16 inch long stock. See **Fig. 3**. Use a nonferrous material that is not subject to corrosion. Notching the end makes it easier to see the oil depth.

4. Being careful not to twist the O-ring, slip it over the oil fill plug threads. Insert the plug in the oil fill port and tighten it until snug. If the plug leaks, don't attempt to stop the leak by overtightening. Leaks may be caused by dirt under the O-ring, dirt on the seat, a broken O-ring, or a damaged seat on the oil fill plug or port. Correct the problem and install a new O-ring.




NOTE: Left-Hand Mounting: Check oil when shaft key is down. Right-Hand Mounting: Check oil when shaft key is up.

A. 4-3/4 Inches (121 mm) Radius
B. 78 degrees
C. 1-1/2 Inches (38 mm)

1. Finger Ring
2. 12 Notches, 1/8 Inch (3.2 mm) apart

**Fig. 3, Dipstick Specifications**

5. Evacuate, charge, and leak test the refrigerant system. For instructions, see **Section 83.02**, Subject 110.

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## Oil Check and Adding Oil to the Refrigerant Compressor

| Oil Quantity at Various Dipstick Depths | | | | |
|---|---|---|---|---|
| Dipstick Depth | | | | Oil Quantity fl oz (mL) |
| 0-Degree Mount (horizontal): inches (mm) | 22-Degree Mount: inches (mm) | 45-Degree Mount: inches (mm) | 90-Degree Mount (vertical); inches (mm) | |
| 13/16 (20.6) | 1-3/4 (44.5) | 1-5/8 (41.3) | 7/8 (22.2) | 6 (177) |
| 1 (25.4) | 2-1/16 (52.4) | 1-13/16 (46) | 1 (25.4) | 8 (237) |
| 1-13/16 (30.2) | 2-5/16 (58.7) | 2 (50.8) | 1-1/8 (28.6) | 10 (296) |
| 1-5/8 (41.3) | 2-9/16 (65.1) | 2-1/4 (57.2) | 1-7/16 (36.5) | 12 (355) |
| 1-13/16 (46) | 2-7/8 (73) | 2-7/16 (61.9) | 1-11/16 (43) | 14 (414) |
| 1-15/16 (49.2) | 3-1/8 (79.4) | 2-5/8 (66.7) | 1-7/8 (47.6) | 16 (473) |

**Table 1, Oil Quantity at Various Dipstick Depths**

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# Refrigerant Compressor Magnetic Clutch Assembly Removal, Inspection, and Installation

## Removal

1. Remove the pulley rotor retaining capscrew from the center of the pulley rotor assembly. See **Fig. 1**.
2. Install the clutch removing bolt in the hub of the pulley rotor assembly.

**⚠ CAUTION**

**Do not try to remove the pulley rotor assembly by prying or hammering. This can damage the assembly.**

3. Tighten the clutch removing bolt to pull the pulley rotor assembly off the compressor shaft.
4. Disconnect the field coil electrical lead wire.
5. Remove the four capscrews that attach the field coil assembly to the compressor housing.
6. Remove the field coil assembly.
7. Remove the clutch removing bolt from the hub of the pulley rotor assembly.

## Inspection

1. Inspect the drive plate. If the friction surface shows signs of damage due to too much heat, replace the drive plate and pulley rotor assembly.
2. Check the appearance of the pulley rotor assembly. If the frictional surface of the pulley shows

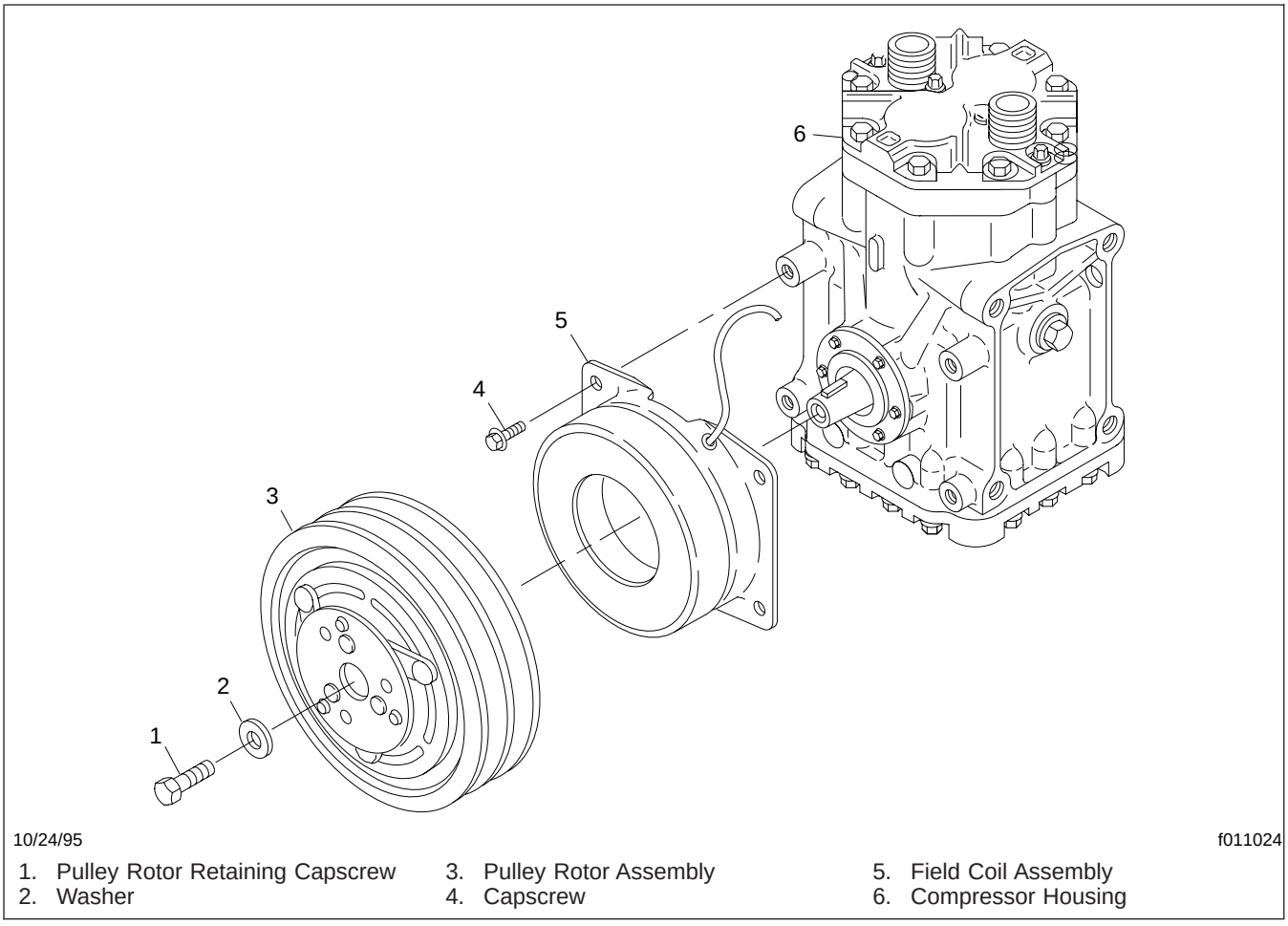



**Fig. 1, Pulley Rotor and Field Coil Assemblies**

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## Refrigerant Compressor Magnetic Clutch Assembly Removal, Inspection, and Installation

signs of too much grooving due to slippage, replace both the pulley and the drive plate. Clean the friction surfaces of the pulley rotor assembly before installing it.

3. Check the coil for a loose connector and for cracked insulation. Check the field coil assembly for cracks or damage at the mounting holes. Replace the components if necessary.

## Installation

1. Install the field coil assembly.
   - 1.1 Place the field coil assembly on the compressor housing.
   - 1.2 Apply Loctite® 262 or 680 to the threads of the capscrews.
   - 1.3 Install the capscrews and gradually tighten them to 15 lbf·ft (20 N·m).
2. Taking care to properly align and seat the shaft and hub keyways, attach the pulley rotor assembly to the compressor shaft.
3. Install the pulley rotor retaining capscrew and washer. Tighten the capscrew to 20 lbf·ft (27 N·m).
4. Turn the pulley rotor assembly by hand to make sure it moves freely without interference with the field coil assembly.
5. Connect the field coil electrical lead wire.
6. Engage and disengage the compressor clutch several times to check for correct operation.

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## Specifications

Special tools can be ordered from your local tool supplier.

| Recommended Refrigerant Oils, R-134a Systems* | | |
|---|---|---|
| **Description** | **Part Number** | **Compressor Manufacture Date** |
| Polyalkylene Glycol (PAG) | ABP N83 326055 | Prior to May 5, 1995, and from April 2003 |
| Polyol Ester (POE) | ABP N83 326008 | May 5, 1995, through April 2003 |

* Look at the identification tag on the refrigerant compressor to determine the type of refrigerant oil that should be used in the air conditioning system. If the type of oil is not specified on the identification tag, use the compressor manufacture date to determine the type of oil to use.

**Table 1, Recommended Refrigerant Oils, R-134a Systems**

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# General Information

The main purpose of the refrigerant compressor is to draw refrigerant gas from the evaporator and squeeze it into high-pressure gas. High pressure raises the condensation point of refrigerant gas, which allows the condenser to change the gas to a liquid so that it can be used for cooling again. Another purpose of the compressor is to move refrigerant through the air conditioning system.

During operation the clutch is energized, engaging the compressor. When the cab temperature drops sufficiently, the system breaks the circuit to the compressor clutch, disengaging the clutch.

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## Safety Precautions

Whenever repairs are made to any air conditioner component that holds R–134a refrigerant, you must recover, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

Refrigerant R–134a is safe when used under the right conditions. Always wear safety goggles and non-leather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves. When refrigerant gas or liquid contacts leather, the leather will stick to your skin.

**⚠ WARNING**

**Use care to prevent refrigerant from touching your skin or eyes because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.**

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure. However, it can be combustible at pressures as low as 5.5 psig (139 kPa absolute) at 350°F (177°C) when mixed with air concentrations that are greater than 60 percent.

**⚠ WARNING**

**R–134a air conditioning systems should not be pressure tested or leak tested with compressed air. Combustible mixtures of air and R–134a may form, resulting in a fire or explosion that could cause personal injury or property damage.**

Always work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R–134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

On R–134a refrigerant systems, polyalkylene glycol (PAG) oil is used in the compressor. When handling PAG oil, observe the following guidelines:

- Keep the oil free of contaminants.
- Do not expose the air conditioning system or the PAG oil container to air for more than five minutes. PAG oil has a high moisture absorption capacity and the oil container should be immediately sealed after each use.
- Use care when handling. Spilled oil could damage painted surfaces, plastic parts, and other components such as drive belts.
- Never mix PAG oil with other types of refrigerant oil.

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## Pre-Service Checks

**WARNING**

**Before doing any work, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.**

Refrigerant compressor problems usually show in one of four ways:

- abnormal noise
- seizure
- leakage
- low suction and discharge pressures

Resonant compressor noises are not cause for alarm. Irregular noise or rattles are likely to be caused by broken parts. To check for seizure, de-energize the magnetic clutch with the engine shut off and see if the drive plate can be turned. If it can't be turned, the compressor has seized.

Do the following checks whenever the air conditioner system is not cooling enough and the cause is unknown.

1. Be sure to check the moisture indicator, to see if moisture is the cause of the problems. The air conditioner should be on when checking the indicator. It is better to check it at the end of the day.
2. Check the drive belt and mounting.
   - 2.1 On the drive belt, look for wear, damage, or oil. If worn, oil-soaked, or damaged, remove it and install a new one.
   - 2.2 Check the compressor mounting parts for loose fasteners, cracks, or other damage. Tighten loose fasteners to the torque value in the correct torque specification. See **Specifications 400**. Repair or replace cracked or damaged brackets.
   - 2.3 Check the tension of the compressor drive belt.
   - 2.4 Check the compressor oil level. See **Subject 120** for instructions.
3. Check the wiring and connections to the compressor clutch. Replace damaged wiring and tighten loose connections.
4. Check for road debris buildup on the condenser coil fins. Using air pressure and a whiskbroom or a solution of soap and water, carefully clean the condenser. Be careful not to bend the fins.
5. Check the refrigerant charge in the air conditioner system. For instructions, see **Section 83.02**, Subject 110.

NOTE: For other possible causes of air conditioner problems, see **Section 83.02** or refer to the applicable fan clutch section in **Group 20**.

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# Oil Check and Adding Oil to the Compressor

## General Information

Compressors are factory-charged with 10.1 oz (300 mL) of refrigerant oil and have a two-wire clutch. Some refrigerant oil is circulated through the system with the refrigerant and cannot leave the system except through a leak, when the system is recovered, or when a system part is replaced.

IMPORTANT: Add the same amount of oil that is removed when the system is discharged or recovered, or when a system part is replaced. Oil must be from a container that has not been opened, or that has been tightly sealed since its last use.

For R–134a systems, order Sanden PAG oil ABP N83 326055 (type SP–15) from your local parts distribution center. Tubing, funnels, or other equipment used to transfer the oil should be very clean and dry.

The list below contains approximate refill amounts for R–134a air conditioning systems.

*A. Refrigerant charge*—0.7 fl oz (20 mL): This amount of oil may be lost from the system each time the system loses its charge, due to routine recovery or due to a slow leak; no other parts of the system have been replaced.

IMPORTANT: The items below list oil quantities that include the amounts that are lost during recovery. Do not add an additional 0.7 fl oz (20 mL)—the amount described in the item above—to the quantities listed.

*B. Receiver-drier*—2.7 fl oz (80 mL);

IMPORTANT: A new receiver-drier does not contain any refrigerant oil.

*C. Condenser*—1.0 fl oz (30 mL);

*D. Evaporator coil*—0.7 fl oz (20 mL);

*E. Entire system with or without an auxiliary heater/air-conditioner*—10.1 fl oz (300 mL); Add the appropriate amount of oil to the compressor if the entire system (including the compressor) has been recovered of refrigerant and oil, and if the system has been evacuated.

When handling refrigerant oil:

- The oil should be free of water, dust, metal powder, and other foreign substances.
- Don't mix refrigerant oil with other types or viscosities of oil.
- Refrigerant oil absorbs moisture when exposed to the air for any period. After use, quickly seal the oil container.

IMPORTANT: Check the compressor oil level at the time of installation and whenever a loss of refrigerant oil has occurred.

**⚠ WARNING**

**Don't remove the oil fill plug without first recovering the system. Failure to recover the system could cause uncontrolled release of high-pressure refrigerant, which can freeze skin and eye tissue causing serious injury or blindness.**

1. Run the compressor for 10 minutes with the engine at idle. Shut down the engine.
2. Recover all of the refrigerant from the system. For instructions, see **Section 83.02**, Subject 110.
3. Determine the mounting angle of the compressor from horizontal (oil fill plug on top).
4. Remove the oil fill plug. Using a socket wrench on the armature retaining nut, turn the shaft clockwise until the counterweight is positioned correctly. The 2 o'clock and 10 o'clock positions of the counterweight are relative to the fill plug. See **Fig. 1**.
5. Check the oil level with the dipstick. Make sure the angle of the dipstick stop is pointing in the right direction. See **Fig. 1**.

   Remove the dipstick and count the number of notches covered by the oil. If the number of notches covered by oil does not match the specifications for the appropriate mounting angle in **Table 1**, add or subtract oil to the midrange value. For example, if the mounting angle is zero degree, add oil until 6 notches on the dipstick are covered by oil.

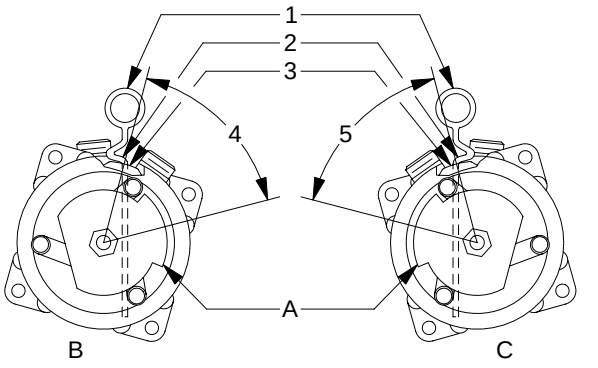
NOTE: A dipstick can be made locally or purchased from a special tools supplier. Refer to the list of special tool suppliers in **Specifications 400**.

6. Being careful not to twist the O-ring, insert the plug in the oil fill opening. Tighten the plug 11 to 18 lbf·ft (15 to 24 N·m).

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## Oil Check and Adding Oil to the Compressor




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A. Position of counterweight.
B. Mounting angle right.
C. Mounting angle left.

1. Dipstick
2. Dipstick Stop
3. Oil Fill Hole
4. 2 o'Clock
5. 10 o'Clock

**Fig. 1, Checking the Oil Level**

7. Evacuate, charge, and leak test the refrigerant system. For instructions, see **Section 83.02**, Subject 110.

| Oil Specifications at Various Mounting Angles | |
|---|---|
| **Mounting Angle (degrees)** | **Number of Notches Covered by Oil** |
| 0 | 5 to 7 |
| 10 | 6 to 8 |
| 20 | 7 to 9 |
| 30 | 8 to 10 |
| 40 | 9 to 11 |
| 50 | 10 to 12 |
| 60 | 11 to 13 |
| 90 | 16 to 18 |

**Table 1, Oil Specifications at Various Mounting Angles**

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# Clutch Assembly Removal, Inspection, and Installation

## Removal

See **Fig. 1** for an exploded view of the refrigerant compressor.

1. Insert the pins of the drive plate spanner into the threaded holes of the drive plate. Hold the drive plate securely while removing the retaining nut. See **Fig. 2**.
2. Using the drive-plate puller, thread the three puller bolts into the drive plate. Turn the center screw clockwise to loosen and remove the drive plate. See **Fig. 3**.
3. Remove the pulley bearing dust cover (if equipped), the shaft key, and the clutch shims. Use a slotted screwdriver and hammer to tap the shaft key loose. See **Fig. 4**.
4. Using external snap-ring pliers, remove the pulley assembly snap ring.
5. Remove the pulley assembly.
   - 5.1 Insert the lip of the pulley puller jaws into the snap ring groove. See **Fig. 5**.
   - 5.2 Place the puller shaft protector over the exposed shaft.
   - 5.3 Align the thumb screws to the puller jaws. Tighten the screws finger tight.
   - 5.4 Using a socket wrench, turn the puller center bolt clockwise and remove the pulley.
6. Remove the field coil assembly.
   - 6.1 Remove the field coil assembly lead wire from the wire holder on the compressor.
   - 6.2 Disconnect the wiring harness.
   - 6.3 Remove the snap ring, then remove the field coil assembly. See **Fig. 6**.

## Inspection

1. Inspect the drive plate. If the frictional surface shows signs of damage due to too much heat, replace the drive plate and pulley assembly.
2. Check the appearance of the pulley assembly. If the friction surface of the pulley shows signs of too much grooving due to slippage, replace both the pulley and drive plate. Clean the friction surfaces of the pulley assembly before installing it.
3. Check the coil for a loose connector and for cracked insulation. Replace it if necessary.

## Installation

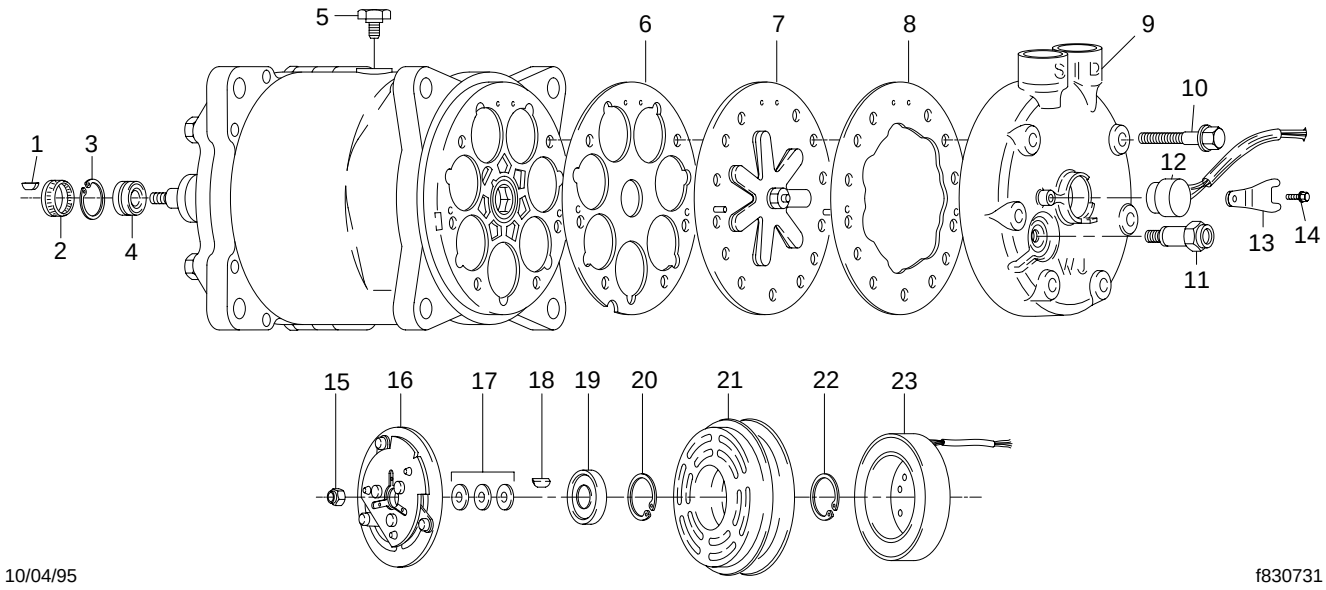
NOTE: When supporting the compressor in a vise, clamp only on the mounting ears, never on the body of the compressor.

1. Install the field coil assembly.
   - 1.1 Position the field coil assembly on the compressor.
   - 1.2 Install the snap ring.
   - 1.3 Attach the field coil assembly lead wire to the wire holder on the compressor.
   - 1.4 Connect the wiring harness.
2. Install the pulley assembly.
   - 2.1 Position the pulley over the boss of the front housing.
   - 2.2 Place the pulley installer ring into the bearing bore. Make sure that the edge rests only on the inner race of the bearing, not on the seal, pulley, or outer race of the bearing.
   - 2.3 Place the driver into the ring. Using a hammer or arbor press, drive the pulley down against the front housing step. See **Fig. 7**.
   - 2.4 Using internal snap ring pliers, install the pulley bearing snap ring.
   - 2.5 Using external snap ring pliers, install the pulley snap ring. If a bevel is present on the snap ring, make sure that it is facing up, away from the body of the compressor.
   - 2.6 Install the pulley bearing dust cover by gently tapping it into place.
3. Install the drive plate assembly.
   - 3.1 Using pliers, install the shaft key. See **Fig. 8**.
   - 3.2 Install the shims.

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## Clutch Assembly Removal, Inspection, and Installation




1. Shaft Key
2. Felt Ring
3. Shaft Seal Snap Ring
4. Shaft Seal (with O-ring)
5. Oil Plug
6. Block Gasket
7. Valve Plate Assembly
8. Head Gasket
9. Cylinder Head
10. Cylinder Head Bolt
11. Pressure Relief Valve
12. Thermal Protector Switch, TPS (optional)
13. TPS Clip (optional)
14. TPS Screw (optional)
15. Shaft Nut
16. Drive Plate Assembly
17. Clutch Shims
18. Shaft Key
19. Pulley Bearing Dust Cover
20. Pulley Snap Ring
21. Pulley Assembly
22. Field Coil Assembly Snap Ring
23. Field Coil Assembly

**Fig. 1, Refrigerant Compressor**

3.3 Align the keyway in the drive plate assembly with the shaft key. Using a driver, and a hammer or an arbor press, drive the assembly down over the shaft until it bottoms on the shims. See **Fig. 9**.

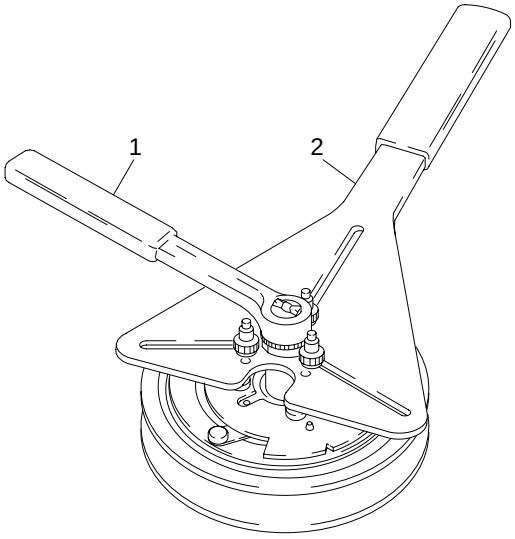
3.4 Install the retaining nut. Tighten the nut to the torque in **Specifications 400**.

4. Using a feeler gauge, check that the clutch clearance is 0.016 to 0.031 inch (0.40 to 0.78 mm). See **Fig. 10**. Adjust the clearance by gently tapping down on the front plate at the high spots, or gently prying up at the low spots.
5. Install the drive plate dust cover. Tighten the bolts to the torque in **Specifications 400**.
6. Install the compressor on the vehicle.

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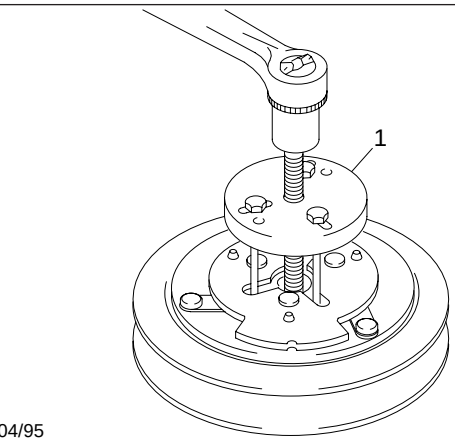
## Clutch Assembly Removal, Inspection, and Installation




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1. Socket Wrench
2. Drive Plate Spanner

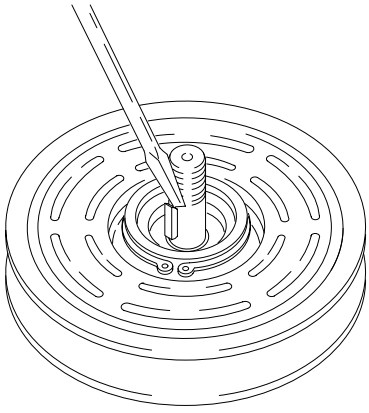
**Fig. 2, Remove the Retaining Nut**




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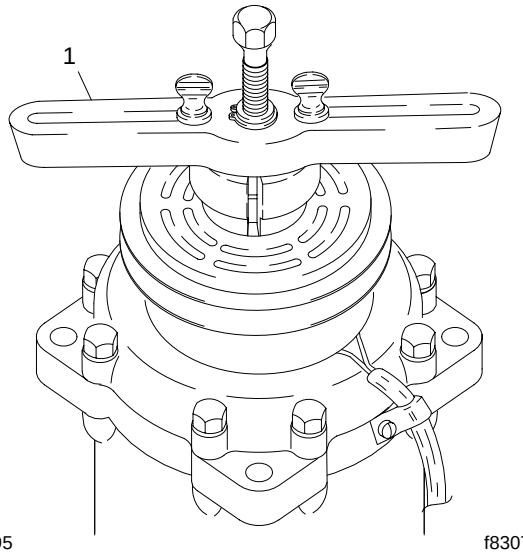
1. Puller

**Fig. 3, Remove the Drive Plate**



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**Fig. 4, Remove the Shaft Key**




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1. Pulley Puller

**Fig. 5, Position the Pulley Puller Jaws**

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## Clutch Assembly Removal, Inspection, and Installation

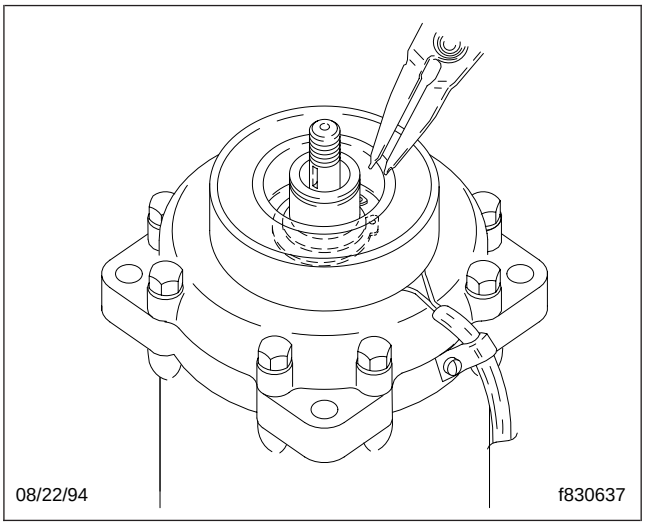



**Fig. 6, Remove the Snap Ring**

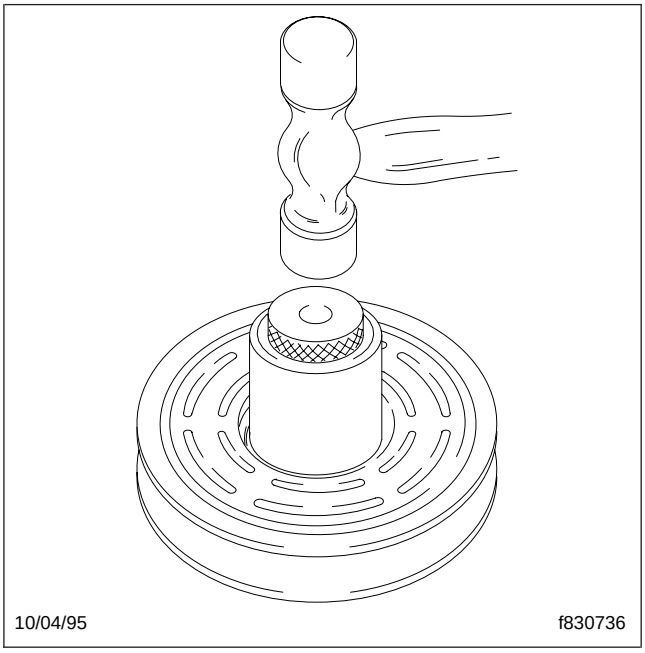



**Fig. 7, Drive the Pulley Down Against the Front Housing Step**

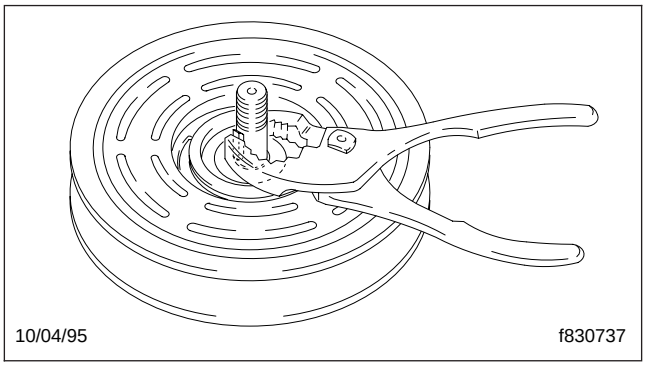



**Fig. 8, Install the Shaft Key**

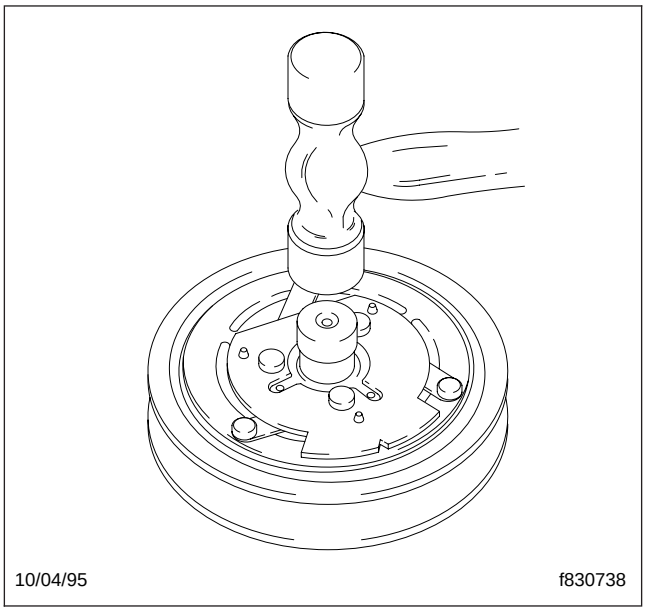



**Fig. 9, Install the Drive Plate Assembly**

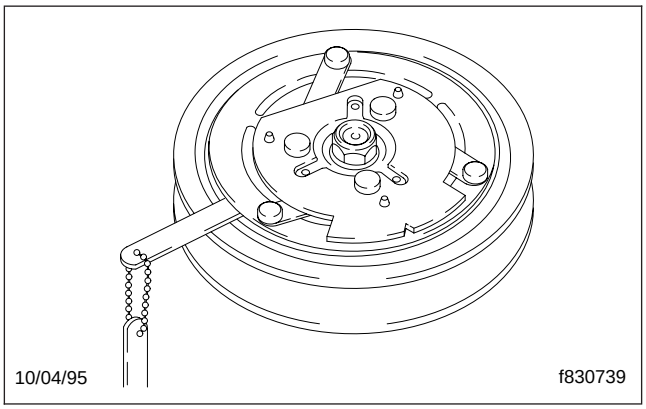



**Fig. 10, Check the Clutch Clearance**

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# Refrigerant Compressor Removal and Installation

## Removal

1. Recover the refrigerant from the air conditioning system. For instructions, see **Section 83.02**, Subject 110.
2. Remove the drive belt.
3. Disconnect the discharge and suction lines from the compressor. Quickly cap the discharge and suction ports and plug the refrigerant lines.

IMPORTANT: Under no circumstances should the ports on the compressor or the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

4. Cut any tie straps that secure the wiring. Disconnect the electrical connector.
5. Remove the four mounting fasteners, then remove the compressor.

## Installation

IMPORTANT: A new compressor is filled with nitrogen gas and refrigerant oil. When installing a new compressor on the vehicle, perform all of the steps below. If installing a used compressor, skip the first step and proceed with the installation.

1. Prepare a new compressor.
   - 1.1 Slowly release the nitrogen from the discharge side of the compressor. Be careful not to let the oil flow out.
   - 1.2 Turn the compressor shaft several times by hand to distribute oil that has settled in the cylinders.
2. Position the compressor on the mounting block.
3. Install the four mounting fasteners and tighten them 20 to 25 lbf·ft (27 to 34 N·m).
4. Uncap the suction and discharge ports on the compressor. Unplug the refrigerant lines. Check the refrigerant line connections and the surface of the suction and discharge ports. They must be clean and free of nicks, gasket residue, and other foreign material.
5. Replace the O-rings in the fittings. Lubricate the O-rings with mineral oil before installing.
6. Install the refrigerant lines on the compressor and torque the fittings 21 to 27 lbf·ft (28 to 37 N·m)
7. While evacuating and charging the refrigerant system, connect the electrical connector, install the drive belt, and replace any tie straps that were removed. For instructions on evacuating and charging the refrigerant system, see **Section 83.02**, Subject 110.
8. Leak test the air conditioning system. For instructions, see **Section 83.02**, Subject 110.

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## Specifications

Special tools can be purchased from the following independent suppliers:

Classic Tool Design
31 Walnut St.
New Windsor, New York 12550
(914) 562–8700

Mastercool USA Inc.
216 Route 10, Bldg. 3
Randolph, New Jersey 07869
(201) 366–1101

| Torque Specifications | | |
|---|---|---|
| **Description** | **Torque** | |
| | **lbf·in (N·cm)** | **lbf·ft (N·m)** |
| Adjusting Rod Jam Nut | — | 140 (190) |
| Compressor Mounting Fasteners | — | 20 to 25 (27 to 34) |
| Clutch Retaining Nut, 1/2 Inch | — | 22 (30) |
| Clutch Retaining Nut, M8 | — | 13 (18) |
| Oil Drain Plug | — | 15 (20) |
| Cylinder Head Bolt, M6 | — | 10 (14) |
| Cylinder Head Bolt, M8 | — | 25 (34) |
| Pressure Relief Valve | 11 (120) | — |
| Dust Cover Screw, M5 | 78 (880) | — |
| Clutch Lead Wire Clamp Screw | 132 (1500) | — |
| Rotalock Valve | — | 27 (37) |

**Table 1, Torque Specifications**

| SlimLine Seal Assembly Torque Specifications | |
|---|---|
| **HVAC Component** | **Torque lbf·ft (N·m)** |
| A/C Compressor | 11 to 15 (15 to 20) |
| Condenser | 11 to 15 (15 to 20) |
| Receiver-Drier | 11 to 15 (15 to 20) |
| Thermal Expansion Valve | 11 to 15 (15 to 20) |
| Evaporator | 11 to 15 (15 to 20) |
| Junction Block | 11 to 15 (15 to 20) |

**Table 2, SlimLine Seal Assembly Torque Specifications**

| O-Ring Fitting Torque Specifications | |
|---|---|
| **Hose Size** | **Torque lbf·ft (N·m)** |
| #6 | 20–25 (27–34) |
| #8 | 30–35 (41–47) |

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## Specifications

| O-Ring Fitting Torque Specifications | |
|---|---|
| **Hose Size** | **Torque lbf·ft (N·m)** |
| #10/12 | 35–40 (47–54) |
| One-Inch Fitting on Compressor | 21–27 (28–37) |

**Table 3, O-Ring Fitting Torque Specifications**

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# General Information

The heater and air conditioner assembly consists of a heater core, evaporator, blower motor, control valves, and air ducts. The system is controlled using the climate control panel. The control panel allows you to control all of the heating, air conditioning, defrosting, and ventilating functions. By controlling the coolant flow through the heater core, or refrigerant flow through the evaporator, an even cab temperature is maintained. Refer to chapter 4 of the *Western Star Driver's Manual* for heater and air conditioner operating instructions.

# Thermodynamic Principles

Air conditioning is the cooling or refrigeration of the air in the passenger compartment. Refrigeration is accomplished by making practical use of three thermodynamic principles. These principles and their practical application are described below.

## Heat Transfer

If two objects of different temperatures are placed near each other, the heat in the warmer object will always travel to the cooler object until both are of equal temperature.

For example, a block of ice in a refrigerator does not transfer its coldness to a nearby carton of milk. Rather, the heat in the warm milk automatically flows to the ice.

The British Thermal Unit (BTU) is used to determine the amount of heat transferred from one object to another. One BTU is the amount of heat required to raise the temperature of 1 pound (0.45 kg) of water 1°F (0.55°C).

For example, to raise the temperature of 1 pound (0.45 kg) of water from 32°F to 212°F (0°C to 100°C), one BTU of heat must be added for 1°F (0.55°C) rise in temperature or a total of 180 BTUs of heat. Conversely, in order to lower the temperature of 1 pound (0.45 kg) of water from 212°F to 32°F (100°C to 0°C), 180 BTUs of heat must be removed from the water.

## Latent Heat of Vaporization

When a liquid boils, it absorbs heat without raising the temperature of the resulting gas. When the gas condenses (changes back to a liquid), it gives off heat without lowering the temperature of the resulting liquid.

For example, when 1 pound (0.45 kg) of water at 32°F (0°C) is placed in a container over a flame, the temperature of the water rises 1°F (0.55°C) with each BTU of heat that the water absorbs from the flame. Thus, after it has absorbed 180 BTUs of heat, the water reaches a temperature of 212°F (100°C).

Even though the flame continues to give its heat to the water, the temperature of the water remains at 212°F (100°C). The water however starts to boil or change from a liquid to a gaseous state. It continues to boil until the water has passed off into the atmosphere as vapor. If this vapor were checked with a thermometer, it also would show a temperature of 212°F (100°C).

In other words, there was a rise of only 180°F (from 32°F to 212°F or 0°C to 100°C) in the water and vapor temperature even though the flame applied many more than 180 BTUs of heat. In this case, the heat is absorbed by the liquid in the process of boiling and disappears in the vapor. If the vapor were brought in contact with cool air, the hidden heat would flow into the cooler air and the vapor condensed back to water. Scientists refer to this principle as the latent (hidden) heat of vaporization.

Water has a latent heat of vaporization of 970 BTUs and a boiling point of 212°F (100°C). This means that 1 pound (0.45 kg) of water at 212°F (100°C), will absorb 970 BTUs of heat when changing to vapor at 212°F (100°C). Conversely, the vapor will give off 970 BTUs of heat when condensing back to water at 212°F (100°C).

This heat transfer, occurring when a liquid boils or a vapor condenses, forms the basic principle of all conventional refrigerant systems.

For a liquid to be a refrigerant, it must also have a low boiling point. That is, the temperature at which it boils must be lower than the substance to be cooled.

R–134a is a non-CFC refrigerant. Its temperature/pressure relationship makes it suitable for mobile air conditioning systems.

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## General Information

### Effect of Pressure on Boiling or Condensation

As refrigerant passes through an air conditioning system, it flows under high-pressure conditions, first as a high-pressure vapor between the refrigerant compressor and the condenser, then as a high-pressure liquid between the condenser and the evaporator orifice. It expands to a low-pressure vapor between the evaporator orifice and the refrigerant return port in the refrigerant compressor. As pressures in the closed refrigerant circuit vary, temperatures will also vary. As pressure increases, temperatures also increase; as the pressure decreases, temperatures also decrease. See **Fig. 1** for a diagram of the refrigerant flow.

## Description of Components

### Blower Motor and Resistor Block Assembly

The blower motor draws air over the evaporator and forces it through the heater core and into the cab. The resistor block assembly controls the speed of the blower motor by reducing the voltage to the motor. The resistor block assembly has a thermal cutout which shuts off current to the blower motor if the circuit overheats.

### Climate Control Panel

The fan switch, temperature control switch, and the mode control switch are mounted on the climate control panel. On an HVAC system with air conditioning, the air conditioner switch is also mounted on the climate control panel.

On an HVAC system with Automatic Temperature Control (ATC), the fan switch, temperature up/down switch, and the mode control switch are mounted on the climate control panel.

### Condenser

A condenser turns hot refrigerant gas coming from the compressor into liquid. The condenser is mounted in front of the radiator. Because of its location, the condenser transfers heat to air that is drawn in by the engine fan and by air that is forced into the engine compartment as the vehicle moves forward.

### Evaporator

Because the evaporator is an area of low pressure in the system, the boiling point of refrigerant lowers, which causes it to absorb heat from the tubing walls and fins. As it absorbs heat, liquid refrigerant quickly boils and turns into a gas.

As heat is absorbed from the outside surfaces of the evaporator, air passing over the unit loses its heat to these cooler surfaces. Moisture in the air condenses on the outside of the evaporator and drains off as water, which dehumidifies the air.

### Expansion Valve

The expansion valve is a dividing point between the high- and low-pressure parts of the refrigerant system. High-pressure liquid refrigerant from the condenser passes through the expansion valve and moves into the low-pressure area of the evaporator.

The expansion valve controls the flow rate of refrigerant in proportion to the rate of evaporation in the evaporator. If the amount of liquid in the evaporator drops off, the temperature of the gas going to the compressor rises. This causes a sensor tube in the expansion valve to react to the temperature changes, which causes an orifice in the valve to open or close. Through the orifice, liquid refrigerant is metered into the evaporator as needed.

### Heater Core

When the engine is on, coolant flows through the heater core tubes heating the tubes and fins. The heat is absorbed by air that is forced through the heater core by the blower motor.

### Receiver-Drier

Used as a reservoir and filter for liquid refrigerant from the condenser, the receiver-drier also removes water and acids from the refrigerant. The water-absorbing material, or desiccant, in the receiver-drier helps stop blockages caused by moisture forming in the expansion valve and other parts of the system.

### Refrigerant

Refrigerant absorbs heat from the air in the cab and releases it to the air outside the cab.

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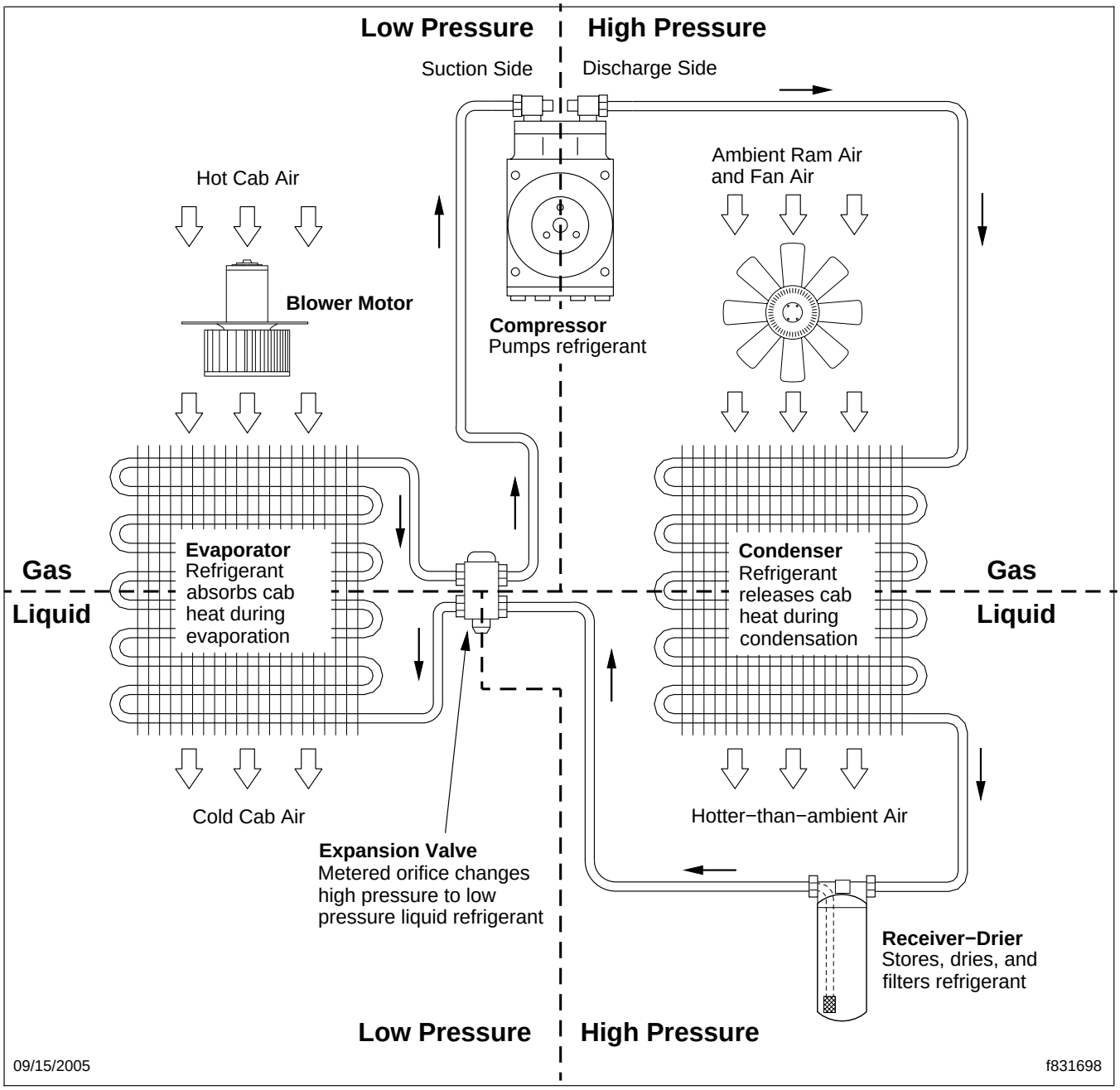



**Fig. 1, Refrigerant Flow Diagram**

In an open container, refrigerants boil at temperatures below the freezing point of water. Sealing and pressurizing refrigerant in the air conditioning system raises its boiling point temperature.

During refrigerant compressor operation, refrigerant constantly changes from a liquid to a gas. It absorbs heat (boiling) in the low-pressure evaporator and it changes from a gas to a liquid as it releases absorbed heat in the high-pressure condenser.

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## General Information

### Refrigerant Compressor

Heat in the low-pressure gas of the evaporator is not heat that can be noticed by touch because liquid refrigerant boils at a temperature much lower than the temperature at which water turns to ice. By touch, the heated gas in the evaporator is very cold. As a result, there is the problem of how to remove heat from cool gas using outside air that may be higher than 100°F (38°C).

With a refrigerant compressor, low-pressure gas from the evaporator can be squeezed into a much smaller space. When the gas is compressed, the heat it contains becomes concentrated. In this way, the gas is made hotter than the outside air without adding heat.

If the system pressure should ever rise above 550 ±50 psi (3792 ±345 kPa), a pressure relief valve will vent, disengaging the compressor clutch until the pressure drops to 400 psi (2758 kPa).

Another function of the compressor is to move refrigerant through the system.

### Water Regulating Valve

The water regulating valve is controlled by the temperature control switch or the temperature up/down switch on the climate control panel. On vehicles equipped with a mechanically-controlled water regulating valve, a cable opens and closes the valve regulating the amount of coolant flowing through the heater core. On vehicles equipped with an electronically-controlled water regulating valve, the amount of coolant flowing through the heater core is regulated electronically.

## Definition of Terms

Refer to the following terms for a better understanding of the heater and air-conditioner system.

**Air Conditioner** A system used to control the temperature, humidity, and movement of air in the cab.

**Air Cylinder** Air-operated device used to open or close vents through which air is pushed into the cab by the blower.

**Air Pressure** The pressure exerted in every direction at any given point. Normal atmospheric pressure (that is, the pressure caused by the weight of the atmosphere) at sea level is 14.696 psia (101.33 kPa).

**Ambient Air Temperature** The temperature of air around an object or the outside temperature.

**Binary Switch** This switch disengages the refrigerant compressor clutch to protect the compressor from harmful operating conditions.

**Blower Motor** A blower motor forces air through the HVAC assembly and through the duct work.

**Blower Resistor Block Assembly** Inline resistors that control the amount of voltage going to the blower motor. By controlling the voltage, the fan speed can be controlled.

**Boiling Point** The temperature at which a liquid changes to a gas. The boiling point varies with pressure.

**Bulk Charging** Use of large containers of refrigerant for charging a refrigerant system. Normally used for charging empty systems.

**CFM** Cubic feet per minute.

**Charge** A specific amount of refrigerant or oil by volume or weight. Also, the act of placing an amount of refrigerant or oil into the air conditioning system.

**Condensate** Water taken from the air, which forms on the outer surface of the evaporator.

**Condenser** A heat exchanger that is used to remove heat from the refrigerant, changing it from a high-pressure hot gas to a high-pressure warm liquid. Typically the condenser is mounted in front of the radiator.

**Contaminants** Anything other than refrigerant or refrigerant oil in the system. Usually means water, dirt, or air in the system.

**Cycling Clutch System** A system that controls compressor clutch operation in order to raise or lower the temperature in the cab.

**Dehumidify** To remove water from the air at the evaporator.

**Dehydrate** To remove all traces of moisture from the refrigerant system. This process occurs during evacuation.

**Desiccant** A drying agent used in the receiver-drier to remove moisture and create an extremely dry condition.

**Discharge Line** Connects the refrigerant compressor outlet to the condenser inlet.

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**Discharge Pressure** High-side pressure or condensing pressure being discharged from the refrigerant compressor.

**Discharge Service Valve** A device that allows high-side pressure to be checked and other service operations to be performed. This valve is located between the receiver-drier and the expansion valve.

**Drive Pulley** A pulley attached to the front of the engine crankshaft. It drives the compressor clutch pulley with a belt.

**Duct** A passageway for the transfer of air from one point to another.

**Evacuate** To place a high vacuum in the refrigerant system to remove air and dehydrate or remove traces of moisture.

**Evaporate** A change of state from a liquid to a gas.

**Evaporator** A component in which liquid refrigerant changes to a gas after it absorbs heat from the air. It also removes some moisture from the cab air.

**Expansion Valve** A device that causes a pressure drop of the refrigerant and also regulates its flow.

**Flooding** A condition caused by too much liquid refrigerant going into the evaporator. Usually caused by an expansion valve that is stuck open.

**Flushing** A process of passing liquid refrigerant through an air-conditioner component to remove dirt and water from the part. Liquid refrigerant removes heavy contamination, such as gritty dirt and large dirt buildup.

**Freeze-Up** Failure of a unit to operate properly because of ice forming at the expansion valve orifice or on the evaporator.

**Heater Core** A part of the heating system through which hot engine coolant flows to provide heat to the cab or to adjust the temperature produced by the air conditioner.

**Humidity** The amount of water vapor in the air.

**Hydraulic Lock** The return of liquid refrigerant to the compressor, which could destroy the unit.

**Leak Detector** Any device used to detect refrigerant leaks in a refrigerant system.

**Liquid Pressure** Pressure of refrigerant in the liquid line from the receiver-drier to the thermostatic expansion valve.

**Low-Suction Pressure** Low-side pressure that is lower than normal due to a system problem.

**Magnetic Clutch** An electrical coupling device used to engage or disengage the compressor.

**Manifold** A device used to control refrigerant flow for system test purposes. It is used with manifold gauges.

**Manifold Gauge** A calibrated instrument used for measuring system pressures.

**Manifold Gauge Set** A manifold that is complete with gauges and charging hoses and is used to measure or test pressure.

**Micron** A metric unit of length equal to one-millionth of a meter. The unit of measure used to measure vacuum drawn from a refrigerant system by a vacuum pump.

**Nitrogen** A colorless, odorless, dry inert gas.

**Opacity** A condition that is used to describe contamination of refrigerant oil in the compressor. Fresh refrigerant oil is clear; when contaminated, it appears cloudy or may have fine particles held in suspension.

**Overcharge** Too much refrigerant or oil in the system.

**psia** Pounds per square inch. Pressure exerted by the air at sea level. Atmospheric pressure is usually measured with a mercury barometer.

**psig** Pounds per square inch, gauge pressure. Any pressure above normal atmospheric pressure of 14.7 psi (101 kPa) is referred to as gauge pressure.

**Receiver-Drier** A combination desiccant, filter, and storage container for liquid refrigerant.

**Recovery** Removal of the refrigerant from the air conditioning system.

**Recycling** Removal of contaminants and moisture from R–134a using a recovery and recycling station.

**Refrigerant Compressor** A device used to draw low-pressure refrigerant gas from the evaporator and squeeze it into a high-temperature, high-pressure gas. Another purpose of the compressor is to move refrigerant through the system.

**Refrigerant R–134a** The cooling agent used in automotive air conditioning systems. The chemical name for R–134a is tetrafluoroethane.

**Refrigerant Oil** Highly refined synthetic oil used in R–134a air conditioning systems.

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## General Information

**Refrigeration Cycle** The complete circulation of refrigerant through an air conditioning system, accompanied by changes in temperature and pressure.

**Relative Humidity** The actual water content of the air in relation to the total water the air can hold at a given temperature.

**Resistor** A voltage-dropping device, usually wire wound, for controlling fan speed.

**Sensor** A temperature- or pressure-sensing unit that is used to sense air temperatures or pressures and provide a control voltage for operation of automatic temperature control units.

**Suction Line** The line connecting the evaporator outlet to the compressor inlet.

**Suction Pressure** Compressor inlet pressure or the system's low-side pressure.

**Suction Service Valve** A device that allows low-side pressure to be checked and other service operations to be performed.

**Suction Side** The low-pressure area of the system extending from the expansion valve to the compressor inlet.

**Thermistor** A vacuum pressure sensor that is used to measure, in microns of mercury, the internal system vacuum level after evacuation.

**Thermostatic Vacuum Gauge** A high-vacuum gauge sensitive to pressures ranging from atmospheric pressure to less than 1 micron of mercury, with scales reading from 25,000 microns to 1 micron of mercury.

**Thermostatic Switch** A temperature-sensitive switch used to control system temperature and prevent evaporator freeze-up. It does this by controlling the operation of the compressor clutch.

**Vacuum** Refers to pressure that is less than atmospheric pressure.

**Vacuum Pump** A mechanical device used to evacuate and create a high vacuum in the refrigerant system.

**Vacuum Pump Oil** Water soluble oil used in some vacuum pumps to absorb moisture from the refrigerant system.

**Vapor** The gaseous state of a material.

**Water Regulating Valve** A mechanically- or electronically-controlled valve used for controlling the flow of coolant to the heater core.

## Principles of Operation

### Air Conditioner

When the air conditioner is on, the motion of the compressor squeezes the refrigerant into a high-pressure, high-temperature gas. High pressure raises the condensation point of refrigerant gas, which allows the condenser to change it to a liquid. After it is compressed, refrigerant gas moves out of the discharge port of the compressor and on to the condenser.

At the condenser, air passing over the fins absorbs heat from the hot refrigerant gas and causes it to change into a liquid. The liquid moves to the receiver-drier, which filters it and removes traces of moisture and acids.

From the receiver-drier, liquid refrigerant moves to the expansion valve, which meters the flow into the evaporator and acts as a boundary between the high- and low-pressure sides of the system. The metered release of the expansion valve greatly drops the pressure of the liquid, causing it to expand. The pressure drop lowers the boiling point of the refrigerant and causes it to evaporate quickly as it absorbs heat from air passing over the evaporator. The resulting cool air is forced into the cab by the blower. The heated refrigerant gas is drawn back into the compressor where the cycle is repeated.

### Automatic Temperature Control

Automatic Temperature Control (ATC) is an optional HVAC system. ATC provides true cab temperature control and continuously variable blower fan speed. This is accomplished through the use of advanced microprocessor and sensor technology.

### Heater

Turning the temperature control switch or the temperature up/down switch from cool to warm opens the water regulating valve, which allows engine-heated coolant to flow through the heater core. Air heated by the air passing over the heater core fins is forced through ducts and into the cab.

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## Safety Precautions

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

Refrigerant R–134a is safe when used under the right conditions. Always wear safety goggles and nonleather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves. When refrigerant gas or liquid contacts leather, the leather will stick to your skin.

**⚠ WARNING**

**Use care to prevent refrigerant from touching your skin or eyes because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.**

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure; however, it can be combustible at pressures as low as 5.5 psig (139 kPa absolute) at 350°F (177°C) when mixed with air concentrations that are greater than 60 percent.

**⚠ WARNING**

**R–134a air conditioning systems should not be pressure tested or leak tested with compressed air. Combustible mixtures of air and R–134a may form, resulting in a fire or explosion that could cause personal injury or property damage.**

Always work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R–134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

When handling refrigerant oil, observe the following guidelines:

- Keep the oil free of contaminants.
- Do not expose the air conditioning system or the refrigerant oil container to air for more than five minutes. Refrigerant oil has a high moisture absorption capacity and the oil container should be immediately sealed after each use.
- Use care when handling. Spilled oil could damage painted surfaces, plastic parts, and other components such as drive belts.
- Never mix different types of refrigerant oil.

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## Required Equipment

You will need a machine, or machines, to identify the refrigerant and to recover, evacuate, flush, and charge the refrigerant system. Ideally, one machine can perform all the following functions:

- Identification–The machine must be able to verify the purity of the refrigerant in the refrigerant system and the presence of hydrocarbon-based refrigerants or other unapproved refrigerants.
- Recovery–The machine must be able to fully recover the refrigerant from the refrigerant system.
- Evacuation–Ideally, the machine should have a vacuum pump rated at 6 cfm and be maintenance free. A machine that requires maintenance is acceptable as long as it is properly maintained.
- Charging–The scale used in charging should be accurate to within ±1 ounce (30 mL).
- Flushing–Adaptors for the compressor(s), expansion device(s), and receiver-drier should be purchased or fabricated to flush the system with refrigerant.

## Refrigerant Identification

**WARNING**

**Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.**

IMPORTANT: Identify the refrigerant in the refrigerant system if you suspect one of the following conditions:

- an excess noncondensable gas, such as nitrogen or air, is in the system
- an unapproved refrigerant is in the system
- the history of refrigerant system repairs is unknown

1. Using a high-quality refrigerant identifier and the manufacturer's instructions, attach the identifier to the vehicle and perform the test.
2. If the vehicle passed the test, it is safe to recover the refrigerant.
3. If the vehicle failed the test due to an excessive amount of noncondensable gas, recover the refrigerant system, then purge the recovery tank of the noncondensable gas.
4. If the vehicle failed the test due to the presence of a hydrocarbon-based refrigerant or a refrigerant other than R-134a, **do not recover the refrigerant into the general-use machine.** To recover the refrigerant system, recover the refrigerant into a separate container that contains refrigerant that must be recycled by a qualified recycling center. It is best to refer the customer to the place where the vehicle was last serviced.

## Recovery

**WARNING**

**Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.**

The recovery process removes most of the refrigerant charge in the system.

1. Turn off the engine, apply the parking brakes, chock the tires, and open the hood.
2. Remove the caps from the suction and discharge service valves.
3. If the history of refrigerant system repairs is unknown, or if you suspect that the system is charged with an unapproved refrigerant, identify the refrigerant using the "Refrigerant Identification" procedures.
4. Wearing protective goggles and nonleather gloves, attach the refrigerant recovery and charging machine hoses to the valves.

IMPORTANT: Push down firmly on the hose connectors until a clicking sound is heard. This will ensure that the coupler is locked.

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5. Follow the refrigerant recovery and charging machine manufacturer's instructions and recover all of the refrigerant from the refrigerant system.

IMPORTANT: Always comply with all federal and local regulations regarding refrigerant recovery and disposal. You may be subject to substantial penalties for improper procedures.

6. Measure the oil recovered during the recovery process. The refrigerant system will have to be filled with the same quantity of new refrigerant oil. If the system is contaminated with moisture, all of the compressor oil must be replaced with clean oil. If the system is heavily contaminated with desiccant or grit, replace the compressor, expansion valve, and receiver-drier, and flush the condenser and evaporator(s). After the system is charged, perform a performance check to ensure that the heat exchangers are not plugged.

## Evacuating

The main purpose in evacuating the refrigerant system is to remove noncondensable gases (NCG), such as nitrogen and air. The secondary purpose is to boil off free water molecules.

In rare cases, water forms ice crystals at the expansion valve. Ice crystals retard or stop the flow of refrigerant, causing a reduction or complete loss of cooling. As the expansion valve warms due to the lack of refrigerant, the ice melts and passes through the expansion valve. Then refrigerant will flow again until the ice crystals re-form. The result is intermittent cooling.

Refrigerant oil has an extremely high moisture absorption capacity. Typically, the moisture picked up by the oil is passed on to the receiver-drier. If excessive moisture exists in the system, the lubricating ability of the oil is reduced, which could damage the compressor and other components.

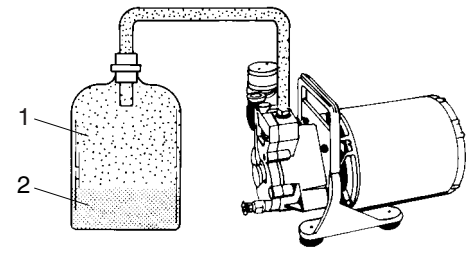
## Effects of Pressure on the Boiling Point of Water

**⚠ WARNING**

**Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.**

Water boils at 212°F (100°C) at an atmospheric pressure of 14.7 psi (101 kPa) at sea level. At higher elevations the atmospheric pressure is lower, which allows water to boil at lower temperatures. See Table 1 for boiling temperatures of water at converted pressures.

Similarly you can boil and remove water from the air conditioning system by lowering the system pressure to a vacuum to cause the moisture to vaporize at normal ambient temperatures. A vacuum pump can reduce the pressure in the system. Since the pressure is lowest at the pump, NCG and water vapor are pulled out of the system. This process is called evacuation or dehydration. See Fig. 1.




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1. Vapor 2. Water

**Fig. 1, Water to Vapor**

## Measuring Vacuum

Vacuum should be measured with an electronic thermistor vacuum gauge, which is designed for use with high vacuum pumps and can accurately read as low as 100 microns. This gauge can have an analog scale or a digital (LED or LCD) display.

The location of the vacuum gauge will affect the reading. The closer to the vacuum source, the lower the reading will be. Follow the manufacturer's instructions for proper use of the vacuum gauge.

If the pressure will not stabilize, it is an indication of a leak. If it does stabilize at a vacuum that is too high, for example 1500 microns Hg, it is an indication of moisture and more evacuation is required.

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| Boiling Temperatures of Water at Converted Pressures | | |
|---|---|---|
| **Boiling Temperature of Water: °F (°C)** | **Absolute Pressure: psi (microns Hg)** | **Vacuum: inHg (mmHg)** |
| 212 (100) | 14.696 (759993.4) | 0 (0) |
| 205 (96) | 12.770 (660400.0) | 3.92 (99.6) |
| 194 (90) | 10.169 (523881.6) | 9.22 (234.2) |
| 176 (80) | 6.8699 (355269.8) | 15.93 (404.6) |
| 158 (70) | 4.5207 (233786.7) | 20.72 (526.3) |
| 140 (60) | 2.8900 (149580.7) | 24.04 (610.6) |
| 122 (50) | 1.7987 (92555.1) | 26.28 (667.5) |
| 104 (40) | 1.0700 (55336.4) | 27.74 (704.6) |
| 89 (30) | 0.61540 (31826.2) | 28.67 (728.2) |
| 86 (27) | 0.57010 (26220.4) | 28.89 (733.8) |
| 76 (24) | 0.44435 (22979.9) | 29.02 (737.1) |
| 72 (22) | 0.38856 (20094.7) | 29.13 (739.9) |
| 69 (21) | 0.35084 (18143.7) | 29.21 (741.9) |
| 64 (18) | 0.29505 (15258.5) | 29.32 (744.7) |
| 59 (15) | 0.24720 (12783.8) | 29.42 (747.3) |
| 53 (12) | 0.19888 (10285.0) | 29.52 (749.8) |
| 45 (7) | 0.14746 (7625.8) | 29.62 (752.3) |
| 32 (0) | 0.08858 (4579.6) | 29.74 (755.4) |
| 21 (–6) | 0.05293 (2738.1) | 29.81 (757.2) |
| 6 (–14) | 0.02521 (1304.0) | 29.87 (758.7) |
| –24 (–31) | 0.004905 (253.7) | 29.911 (759.74) |
| –35 (–37) | 0.002544 (131.6) | 29.915 (759.84) |
| –60 (–51) | 0.0004972 (25.7) | 29.9200 (759.968) |
| –70 (–57) | 0.0002443 (12.69) | 29.92050 (759.9807) |
| –90 (–68) | 0.0000526 (2.72) | 29.92089 (759.9906) |

**Table 1, Boiling Temperatures of Water at Converted Pressures**

Holding a vacuum is only an indication that there are not any leaks that are present under a vacuum. Other leaks may exist when the system is pressurized, so a proper leak test must be performed in conjunction with holding a vacuum.

## Maintaining an Oil-Lubricated Vacuum Pump

Maintenance is important for a high-vacuum pump. The oil must be changed at regular intervals to prevent moisture buildup, which will cause decreased pump performance and eventual pump failure.

Pumping down for extremely wet air conditioning systems can completely saturate the pump oil, which will require the replacement of the vacuum pump oil.

**⚠ CAUTION**

**Flush the vacuum pump every fourth time it is used, and before storing for long periods of time.**

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**Acid will form and corrode the pump, if water-laden oil remains in the pump for an extended period.**

Vacuum pump oil is water soluble. This aids the pump in reaching a high vacuum by absorbing water and sealing the pump.

Use only vacuum pump oil as a lubricant. Do not use any solvent or any other oil. Clean oil should be run through the pump until it runs out clear. Oil should be added to the fill level indicated on the pump. Check the oil level before each use.

## Evacuation Procedure

1. The system must have been recovered and the refrigerant compressor filled with the correct amount of refrigerant oil. Replace the receiver-drier if the system conditions require it.
2. Make sure the vacuum pump has been properly maintained.
3. Wearing protective goggles and nonleather gloves, attach the refrigerant recovery and charging machine hoses, or a vacuum pump, to the valves.

IMPORTANT: Push down firmly on the hose connectors until a clicking sound is heard. This will ensure that the coupler is locked.

4. Follow the refrigerant recovery and charging machine manufacturer's instructions and evacuate the refrigerant system.
5. A minimum of 10 minutes with a 6-cfm pump should be used to evacuate the system. Evacuate the system for a longer period of time if using a smaller pump. Make sure that the vacuum level reaches a point where water would boil and does not go back toward zero, then proceed with charging and leak testing the system.

# Flushing

**⚠ WARNING**

**Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.**

Flushing removes moisture-laden oil and some contamination, such as dirty oil and some particles. When a part is flushed, liquid refrigerant is forced through it. The liquid picks up the contaminants and flushes them out.

Whether to flush, or replace a part depends on how much contamination there is as previously described.

Normally the system always has pressure in it. Some loss of refrigerant from one season to the next is normal and does not mean that the system is dirty. If refrigerant parts show signs of internal corrosion and grit, the system is contaminated.

If the system is contaminated with moisture, flush all sections of the system. Then change the oil in the compressor and replace the receiver-drier prior to evacuating and charging the system.

If the system is heavily contaminated or if desiccant has circulated through the system, replace the receiver-drier, expansion valve(s), and inspect the compressor.

Do not flush the receiver-drier or the compressor.

Flush the system in segments to lessen the chance of blowing deposits against a port.

Flush the system in the opposite direction of refrigerant flow. In other words, backflush the sections.

Flushing parts with refrigerant requires a refrigerant recovery and charging machine.

## Flushing Procedure

### Method 1

NOTE: Use this method when the recovery and charging machine is equipped with a flush cycle.

1. Recover the refrigerant from the air conditioning system.
2. Disconnect both ends of the line or part(s) being flushed. Tightly cap the lines to the rest of the system.

NOTE: You must remove the expansion device(s), receiver-drier, and compressor(s) when flushing. These components must be removed and bypassed when performing a system flush.

3. Install the flushing adaptors and an inline filter and follow the instructions from the manufacturer of the recovery and charging machine to perform the flush. When flushing the entire system, use

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an adaptor that fits where the compressor was located and backflush.

4. Remove the adaptors and bypass devices and install the expansion device(s), the compressor, and a new receiver-drier.
5. If installing the existing compressor, remove the oil in it and replace the oil with new oil. New compressors may or may not have a full charge of oil.
6. Charge the system with refrigerant and check the system performance.

### Method 2

NOTE: Use this method when two recovery and charging machines are available.

1. Recover the refrigerant from the air conditioning system.
2. Disconnect both ends of the line or part(s) being flushed. Tightly cap the lines to the rest of the system.

NOTE: You must remove the expansion device(s), receiver-drier, and compressor(s) when flushing. These components must be removed and bypassed when performing a system flush.

3. Install the flushing adaptors and an inline filter. When flushing the entire system, use an adaptor that fits where the compressor was located and backflush.
4. Charge the part with 2 pounds (0.9 kg) of refrigerant or the system with 5 pounds (2.3 kg) of refrigerant, then recover the refrigerant with a second machine. It is desirable to start the recovery slightly before the charge cycle is done since this helps to push fluid through the system. Repeat the process several times until you think that all the oil has been removed.
5. Remove the adaptors and bypass devices and install the expansion device(s), the compressor(s), and a new receiver-drier.
6. If installing the existing compressor, remove the oil in it and replace the oil with new oil. New compressors may or may not have a full charge of oil.
7. Charge the system with refrigerant and check the system performance.

## Oil Balancing

### General Information

Compressors require refrigerant oil to function. When the air conditioning system is operating, some of the oil leaves the compressor and is circulated through the system with the refrigerant. The refrigerant oil cannot leave the system except when there is a leak, the refrigerant is recovered, or when a system part is replaced. It is important that the air conditioning system has the correct amount of refrigerant oil for proper operation. Too little oil will result in compressor failure. Too much oil will degrade the performance of the air conditioner, and cause damage to the compressor.

IMPORTANT: Whenever the air conditioning system is discharged or recovered, the recovered oil, from the charging machine, must be measured in order to know how much oil must be returned to the system. When a system component is replaced, a quantity of new oil equal to the recovered oil plus the oil coating the inside of the component must be returned to the system.

IMPORTANT: Refrigerant oil is hygroscopic (attracts moisture from its surroundings), and must not be exposed to the moisture that is present in the air. New oil must be from a container that has not been opened or that has been tightly sealed since its last use.

Tubing, funnels, or other equipment used to transfer the oil must be very clean and dry. When handling refrigerant oil:

- Be sure that the oil is free of water, dust, metal powder, and other foreign substances;
- Do not mix the refrigerant oil with other types or viscosities of oil;
- Quickly seal the oil container after use. Refrigerant oil absorbs moisture when exposed to the air for any period of time.

### Compressor Oil Balancing

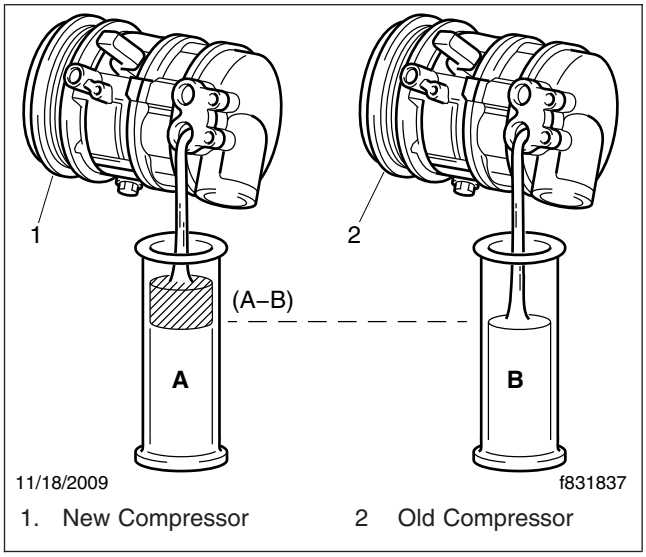
Replacement refrigerant compressors are supplied with some refrigerant oil. If the air conditioning system has been flushed, the system will need a complete new charge of oil. If the system has not been

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flushed, use the following procedures to adjust the oil level, when a new compressor or other system component has been installed. The type of oil required depends on the brand of compressor used on the system. Refer to the workshop manual for the specific compressor on the vehicle being serviced for details about how the total system volume is determined. See PartsPro MOD 700 to determine the oil type and vehicle specific oil quantities.

1. Drain the remaining oil from the compressor into a container holding the oil collected during the refrigerant recovery. See **Fig. 2**.




1. New Compressor 2 Old Compressor

**Fig. 2, Oil Balancing**

2. Make note of the total volume of oil recovered.
3. Drain the oil from new compressor into a clean calibrated container, and compare the two quantities of oil.
4. Add only the amount of oil removed during recovery and from the old compressor to the system.
5. Add the new compressor oil as described in the supplier specific compressor service section of the workshop manual.

## System Oil Balancing

After repairs are finished, refer to **Table 2** and use the following equation to determine the quantity of refrigerant oil that needs to be added to the system.

[Quantity Recovered] + [Quantity for All Replaced Components ] = [Quantity Added to the System]

**Table 2** provides the quantities of oil that need to be added to the system for each component that was replaced. Add the quantities listed in the table for each component that was replaced. Use the sum of the quantities or 6 fl oz (177 mL), whichever is less. Inject the calculated oil volume at the high-side pressure port during the refrigerant charging process.

| Refrigerant Oil Quantities for Replaced Components | |
|---|---|
| **Add the quantities listed in this table for each component that was replaced. Use the sum of the quantities or 6 fl oz (177 mL), whichever is less.** | |
| **Component** | **Quantity oz (mL)** |
| High Pressure Line (main A/C) | 1 (30) |
| Low Pressure Line (main A/C) | 2 (59) |
| High Pressure Line (auxiliary A/C) | 1 (30) |
| Low Pressure Line (auxiliary A/C) | 3 (89) |
| Condenser | 1 (30) |
| Evaporator (main A/C) | 3 (89) |
| Evaporator (auxiliary A/C) | 2 (59) |
| Receiver-Drier | 3 (89) |
| Minor Leak at Connector Only | 0.5 (15) |
| Major Leak at Connector Only | 2 (59) |

**Table 2, Refrigerant Oil Quantities for Replaced Components**

## Charging

**WARNING**

**Before doing any of the work below, read the information in Safety Precautions 100. Failure to read and understand the safety precautions, and to take necessary precautions against the dangers involved when working with refrigerant could lead to serious personal injury.**

NOTE: Before charging, the system must be recovered and evacuated with the recovery and charging machine connected to the service and discharge port connections.

1. Obtain enough refrigerant to fully charge the system. To determine the amount of refrigerant needed to fully charge the system, read the Air Con-

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ditioner label on the vehicle or see **Specifications 400**.

2. Charge the system on the high side following the refrigerant recovery and charging machine manufacturer's instructions.
3. While the compressor is engaged, check the duct temperature and operating pressures at the suction and discharge ports. Compare the temperature and pressures to those in **Specifications 400**. If the operating pressures are not acceptable, see **Subject 300** or **Subject 310** for troubleshooting procedures.
4. Disconnect the hoses.
5. Shut down the engine.
6. Recover the refrigerant that is in the hoses.

# Leak Testing Methods

## General

The information in this section is intended to convey a general method of leak detecting that should be used to enhance the usefulness of a leak detector being used in accordance with operator's instructions provided by the manufacturer. A technician should not attempt to perform leak detection without reading and understanding the owner's manuals for the tools being used, and should expect to review those instructions from time to time, to ensure the proper method continues to be used. The process described here was developed using the published list of recommended tools and warranty evaluation guides as a basis for the expectations for repair competence. The only way to confirm that a refrigerant leak exists is by finding a failed or damaged component. A UV flashlight and goggles can be used to provide an indication of a leak, but a approved electronic leak detector must be used to confirm the existence of a leak, and approximate the leak rate. The connections used for A/C refrigerant are intended to seal properly, but given the high level of sensitivity provided by current leak detecting equipment, the detector may indicate a leak even though the connection meets the design specifications. To balance this, the "Acceptable Leak Rates by Component" table in **Specifications, 400** contains the qualifying leak rates for the components used on these vehicles. The leak rates, in oz/yr, correspond to the sensitivity values required for all detectors that meet the SAE J2791 functional specifications. By switching between the sensitivity levels, it is possible to discern between leaks of varying sizes and qualify each potential leak. It is expected that a leak rate relates to each component, as it arrives at the factory, but the Mini-Stato seals that connect the components together are specified separately. Additionally, due to the possible difficulty of distinguishing between two minor leaks at a multi-port connection, the leak rate for two Mini-Stato seals should be considered a condemning value if it is not completely clear which seal is leaking.

## Method

IMPORTANT: The refrigerant system should be warmed up from completion of the initial inspection, but the engine is off.

IMPORTANT: Refrigerant oil residue on a part may be an indication of a refrigerant leak in that area, but it is not an acceptable method of determining if a part is defective.

1. Shut down the engine.
2. Before testing for compressor leaks, blow shop air near the compressor shaft seal to clear any refrigerant that may have collected.
3. Install the caps before testing the service ports.
4. Minimize the amount of wind blowing through the test area, as this will make small leaks harder to find.
5. Set the detector on the most sensitive setting.
6. Start at a point along the refrigerant loop, and methodically follow the refrigerant path, test all around O-ring connections and crimped ends until you reach the starting point.
7. When the detector indicates a suspected leak, move it away from the suspect area, then recheck to the location after the detector has cleared.
    - If the detector continues to indicate a leak, adjust the sensitivity of the detector to match the designed leak specifications shown in "Acceptable Leak Rates by Component" Table, in **Specifications, 400**, and retest the suspected area to confirm the leak.
    - Mark any confirmed leaks, then change the sensitivity back to high and continue checking the system.

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## Refrigerant Service Operations

8. After the entire system has been checked, recover the refrigerant, investigate each leak point to determine what component failed, and how, then repair the leak.
9. Recharge the refrigerant system, then use the electronic leak detector to confirm that each connection opened during the repair is sealed within the design specifications provided in the "Acceptable Leak Rates by Component" table in **Specifications, 400**.

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## Replacement

1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. Look for signs of refrigerant leakage and leak test the system. For instructions, see **Subject 110**.
4. Recover the refrigerant. For instructions, see **Subject 110**.
5. Disconnect the refrigerant lines from the receiver-drier. Quickly cap the refrigerant lines.

IMPORTANT: Under no circumstances should the refrigerant lines remain uncapped for longer than five minutes total. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

6. Loosen the bolt and nut that attach the receiver-drier mounting clamp to the mounting bracket. Remove the receiver-drier.
7. Install a new receiver-drier and tighten the bolt and nut on the mounting clamp.
8. Uncap the refrigerant lines.
9. Connect the refrigerant lines to the receiver-drier.
10. Evacuate the refrigerant system. For instructions, see **Subject 110**.
11. Check to make sure that the refrigerant system holds a vacuum.
12. Charge the system with refrigerant. The correct amount of refrigerant is printed on the "Air Conditioner" label on the radiator.
13. Leak test all fittings that were removed during the replacement procedure. For instructions, see **Subject 110**.
14. Close the hood.
15. Remove the chocks from the tires.

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## Replacement

1. Shut down the engine, apply the parking brakes, and chock the tires.
2. Open the hood.
3. If the grille is mounted on the radiator, remove the grille.
4. Look for signs of refrigerant leakage and leak test the system. For instructions, see **Subject 110**.
5. Recover the refrigerant. For instructions, see **Subject 110**.
6. Disconnect the refrigerant lines from the condenser. Quickly cap the refrigerant lines.

IMPORTANT: Under no circumstances should the refrigerant lines remain uncapped for longer than five minutes total. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).

7. Remove the capscrews and washers that attach the condenser to the radiator. Remove the condenser.
8. Using capscrews and washers, install a new condenser.
9. Uncap the refrigerant lines.
10. Connect the refrigerant lines to the condenser.
11. Evacuate the refrigerant system. For instructions, see **Subject 110**.
12. Check to make sure that the refrigerant system holds a vacuum.
13. Charge the system with refrigerant. The correct amount of refrigerant is printed on the "Air Conditioner" label on the radiator.
14. Leak test all fittings that were removed during the replacement procedure. For instructions, see **Subject 110**.
15. If the grille was removed, install the grille.
16. Close the hood.
17. Remove the chocks from the tires.

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## Replacement

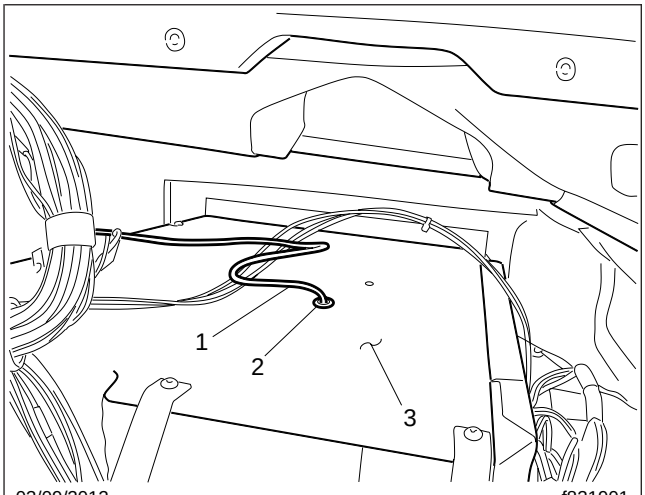
1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the tires.
2. Open the hood.
3. Recover the refrigerant from the air conditioning system. For instructions, see **Subject 110**.
4. Remove the evaporator temperature probe from the evaporator through the top of the HVAC assembly as follows.

   4.1 Remove the glove box and glove box door.

**NOTICE**

**Do not kink or otherwise damage the evaporator temperature probe capillary tube. Doing so may cause it to not function.**

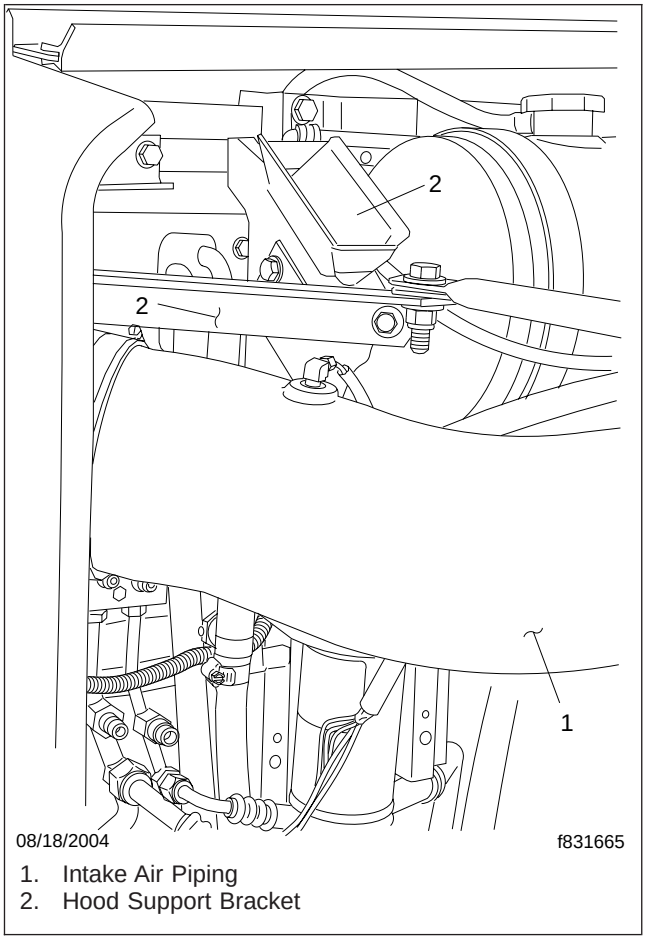
   4.2 Mark the evaporator temperature probe capillary tube with tape where it enters the top of the HVAC assembly, then slide it and the grommet out of the top of the assembly. See **Fig. 1**.




1. Evaporator Temperature Probe Capillary Tube
2. Grommet
3. HVAC Assembly

**Fig. 1, Removing the Evaporator Temperature Probe Capillary Tube**

5. If the intake air piping is in the way of the heater core, remove the piping. For instructions, see **Section 09.00, Subject 100**. See **Fig. 2**.




1. Intake Air Piping
2. Hood Support Bracket

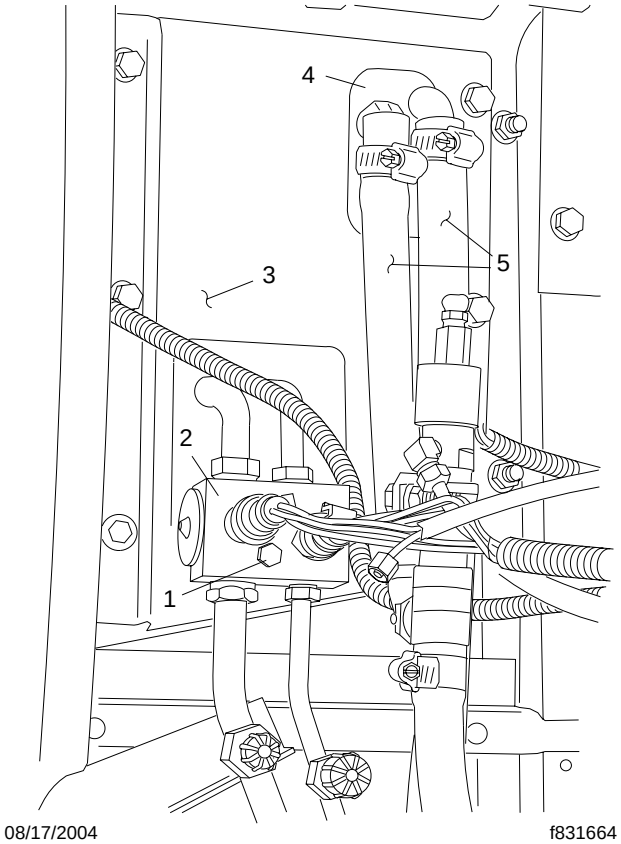
**Fig. 2, Remove the Hood Support Brackets**

6. Remove the two hood support brackets as an assembly.
7. Shut off the water supply to the heater core by closing the valves or by clamping the hoses.
8. Place a drain pan under the heater hoses. Remove the heater hoses from the heater core, and allow the coolant from the hoses to drain into the pan. See **Fig. 3**.
9. Disconnect the refrigerant lines from the top of the expansion valve.
10. Remove the capscrew that attaches the expansion valve to the heater and evaporator cover, and move the expansion valve out of the way.

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## Heater Core Replacement




1. Capscrew
2. Expansion Valve
3. Heater Core and Evaporator Cover
4 Heater Core
5 Heater Hose

**Fig. 3, Heater Core and Evaporator Cover**

11. Remove the capscrews that attach the heater core and evaporator cover to the HVAC assembly, and remove the cover.
12. Remove the evaporator and heater core from the HVAC assembly.
13. Separate the evaporator and heater core.
14. Clip the new heater core to the evaporator.
15. Slide the evaporator and new heater core into the HVAC assembly.
16. Using capscrews, attach the heater core and evaporator cover to the HVAC assembly.
17. Install new O-rings, lubricated with mineral oil, on the evaporator, then connect the refrigerant lines to the evaporator. Do not tighten at this time.
18. Using a capscrew, attach the expansion valve to the heater and evaporator cover.
19. Tighten the refrigerant lines to the values shown in **Table 1**.

| O-Ring Joint Torque: Steel Fitting to Alumimun TXV | |
|---|---|
| **Tube Size** | **Torque Value** |
| 3/8-in OD | 11–13 lbf·ft |
| 5/8-in OD | 24–26 lbf·ft |

**Table 1, O-Ring Joint Torque: Steel Fitting to Alumimun TXV**

20. Connect the heater hoses to the heater core.
21. Open the water supply valves, or remove the clamps from the hoses.
22. Install the hood support brackets.
23. If the intake air piping was removed, install the piping. For instructions, see **Section 09.00, Subject 100**.
24. Fill the cooling system with coolant.
25. Evacuate and charge the air conditioning system with refrigerant. For instructions, see **Subject 110**.

## NOTICE

**Do not kink or otherwise damage the evaporator temperature probe capillary tube. Doing so may cause it to not function.**

26. Install the evaporator temperature probe into the evaporator through the top of the HVAC assembly as follows.
    - 26.1 Slide the grommet onto the evaporator temperature probe capillary tube, then slide the tube into the hole in the top of the HVAC assembly. Stop when the tape is at the point where it enters the top of the HVAC assembly.
    - 26.2 Set the grommet into the top of the HVAC assembly. See **Fig. 1**.
    - 26.3 Install the glove box and glove box door.

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## Replacement

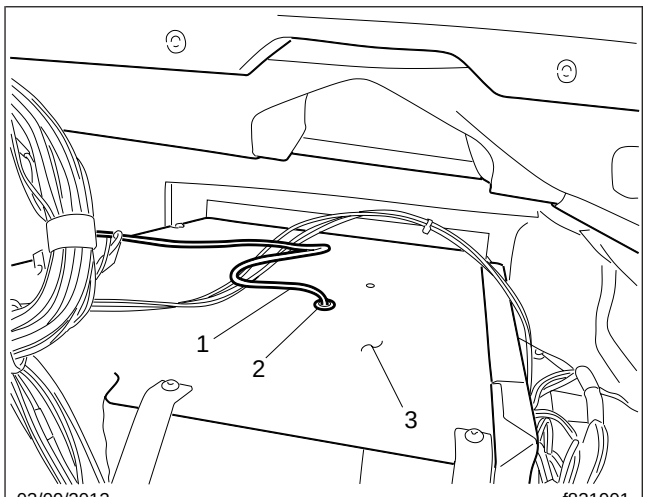
1. Park the vehicle on a level surface, shut down the engine, and apply the parking brakes. Chock the tires.
2. Open the hood.
3. Recover the refrigerant from the air conditioning system. For instructions, see **Subject 110**.
4. Remove the evaporator temperature probe from the evaporator through the top of the HVAC assembly as follows.

   4.1 Remove the glove box and glove box door.

**NOTICE**

**Do not kink or otherwise damage the evaporator temperature probe capillary tube. Doing so may cause it to not function.**

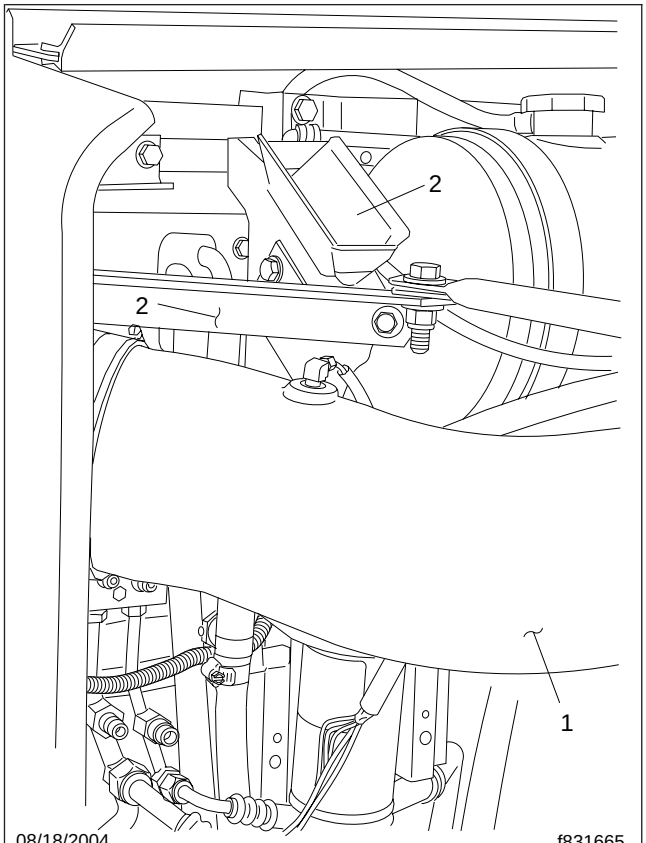
   4.2 Mark the evaporator temperature probe capillary tube with tape where it enters the top of the HVAC assembly, then slide it and the grommet out of the top of the assembly. See **Fig. 1**.




1. Evaporator Temperature Probe Capillary Tube
2. Grommet
3. HVAC Assembly

**Fig. 1, Removing the Evaporator Temperature Probe Capillary Tube**

5. If the intake air piping is in the way of the heater core, remove the piping. For instructions, see **Section 09.00**, Subject 100. See **Fig. 2**.




1. Intake Air Piping
2. Hood Support Bracket

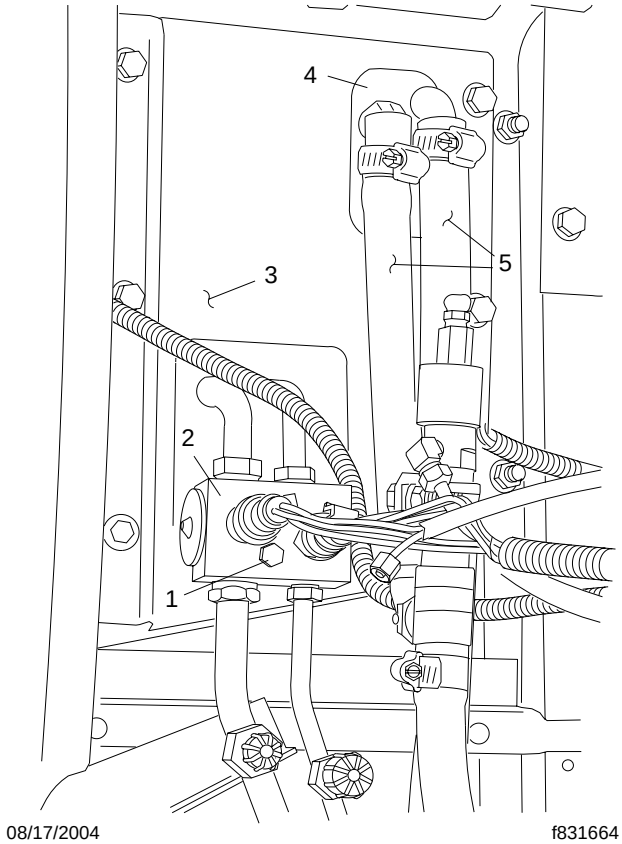
**Fig. 2, Remove the Hood Support Brackets**

6. Remove the two hood support brackets as an assembly.
7. Shut off the water supply to the heater core by closing the valves or by clamping the hoses.
8. Place a drain pan under the heater hoses. Remove the heater hoses from the heater core, and allow the coolant from the hoses to drain into the pan. See **Fig. 3**.
9. Disconnect the refrigerant lines from the top of the expansion valve.
10. Remove the capscrew that attaches the expansion valve to the heater and evaporator cover, and move the expansion valve out of the way.

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## Evaporator Replacement




1. Capscrew
2. Expansion Valve
3. Heater Core and Evaporator Cover
4 Heater Core
5 Heater Hose

**Fig. 3, Heater Core and Evaporator Cover**

11. Remove the capscrews that attach the heater core and evaporator cover to the HVAC assembly, and remove the cover.
12. Remove the evaporator and heater core from the HVAC assembly.
13. Separate the evaporator and heater core.
14. Clip the new evaporator to the heater core.
15. Slide the new evaporator and heater core into the HVAC assembly.
16. Using capscrews, attach the heater core and evaporator cover to the HVAC assembly.
17. Install new O-rings, lubricated with mineral oil, on the evaporator, then connect the refrigerant lines to the evaporator. Do not tighten at this time.
18. Using a capscrew, attach the expansion valve to the heater core and evaporator cover.
19. Tighten the refrigerant lines to the values shown in **Table 1**.

| O-Ring Joint Torque: Steel Fitting to Alumimun TXV | |
|---|---|
| **Tube size** | **Torque Value** |
| 3/8-in OD | 11–13 lbf·ft |
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**Table 1, O-Ring Joint Torque: Steel Fitting to Alumimun TXV**

20. Connect the heater hoses to the heater core.
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22. Install the hood support brackets.
23. If the intake air piping was removed, install the piping. For instructions, see **Section 09.00**, Subject 100.
24. Fill the cooling system with coolant.
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### NOTICE

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    - 26.2 Set the grommet into the top of the HVAC assembly. See **Fig. 1**.
    - 26.3 Install the glove box and glove box door.

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# Troubleshooting for the Non-ATC Heater and Air Conditioner

## Preliminary Checks

Before testing the operation of the air conditioning system, check the following items:

1. Make sure the drive belt on the refrigerant compressor is not damaged. Make sure the compressor mounting capscrews are tight.
2. Check the refrigerant compressor for correct clutch clearance.

   On a vehicle with a Sanden refrigerant compressor, use a feeler gauge to check that the drive clutch clearance is 0.016 to 0.031 inch (0.40 to 0.78 mm). See **Fig. 1**. If the drive plate clutch needs adjustment, see **Section 83.01**, Subject 130.

   On a vehicle with a Climate Control refrigerant compressor, place a feeler gauge between the refrigerant compressor clutch and the pulley. Drive plate to pulley clearance should be 0.020 to 0.030 inch (0.50 to 0.76 mm). If the clearance is 0.035 inch (0.89 mm) or greater, replace the clutch. For instructions, see **Section 83.00**, Subject 140.

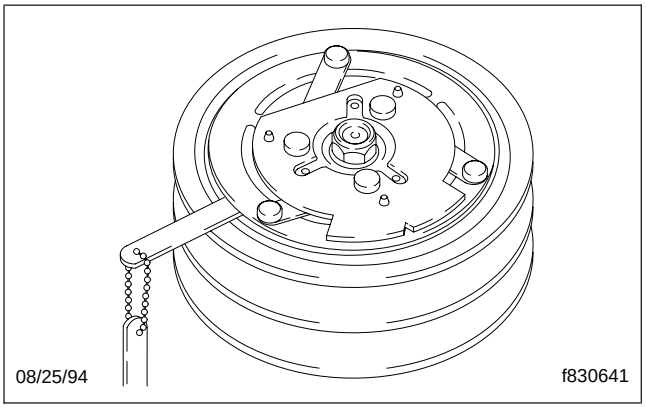



**Fig. 1, Drive Plate Clearance Inspection**

3. Check for broken or cut hoses. Check for loose fittings on all parts.
4. Check for road debris buildup on the condenser fins. Using air pressure and a whisk broom or a soapy spray of water, carefully clean off the condenser. Be careful not to bend the fins.
5. If there is not enough airflow, make sure that leaves or other debris have not entered the fresh air ports under the windshield. If debris is present, it could clog the air inlet and block airflow.

   Be sure that all ducts are connected to the dash outlets.

   Check to make sure the fresh air filter in the HVAC assembly is clean.

## HVAC Components

Following is a brief description of symptoms or conditions that could exist if something goes wrong with a refrigerant component.

### Receiver-Drier

The receiver-drier is normally at outside temperature. To the touch, the entire length of the unit should be the same temperature. If noticeable cool spots exist, replace the receiver-drier.

A blockage at the inlet of the receiver-drier will cause high head pressures. A blockage at the outlet will cause low head pressures and little or no cooling.

### Cooling System

There is a close tie between the air conditioner and the cooling system, although they are not physically connected. Poor air conditioner cooling can be the result of a problem in the cooling system.

If the cooling system does not work correctly, the heat of the engine will rise to abnormal levels. The added heat will transfer to the air conditioner, other under-hood parts, and may make its way into the cab. The added heat makes it necessary for the air conditioner to work harder. It also reduces the ability of the air conditioner to cool the air in the cab. If the water regulating valve isn't closing all the way, heat will enter the cab giving the impression that the air conditioning system is not working.

See **Group 20** for cooling system troubleshooting or to the engine manufacturer's service manual for details about cooling system problems.

### Expansion Valve

Problems that start in the expansion valve are apparent when the valve is stuck closed or stuck open. When stuck closed, the evaporator coil and the expansion valve will be at outside temperature. When

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## Troubleshooting for the Non-ATC Heater and Air Conditioner

stuck open, both the coil and the valve will be extremely cold with frost or ice buildup.

Because the expansion valve channels are very small, blockages in the system tend to be found here. The expansion valve is very sensitive to contamination. Usually, the contaminant is water. Less than a drop of water is all it takes to make the valve inoperative. When water reaches the valve, the extreme cold that results from the pressure drop freezes the water, forming a block of ice in the valve. After the system shuts down and the valve warms up, the ice melts and the valve operates again only to freeze-up when the moisture returns.

On-and-off operation of the expansion valve means that the receiver-drier is not removing moisture from the system.

### Refrigerant Compressor

Compressor problems usually show in one of four ways:

- abnormal noise
- seizure
- leakage
- low suction and discharge pressures

Resonant compressor noises are not causes for alarm. Irregular noise or rattles are likely to be caused by broken parts. To check for seizure, de-energize the magnetic clutch and see if the drive plate can be turned. If it won't turn, the compressor has seized.

Low discharge pressure may be caused by not enough refrigerant, not enough belt tension, or a blockage somewhere in the system. These things should be checked before servicing the compressor.

### Evaporator

The evaporator coils are basically trouble-free when airflow over the fins is not blocked. External or, less often, internal blockages will cause low suction pressure as well as little or no cooling.

If a leak exists in the system and it cannot be traced to other parts or fittings, suspect damage to one of the evaporator coils.

### Condenser

The condenser is usually trouble-free. Normally, the temperature of the condenser outlet line is noticeably cooler than the inlet line. However, when road debris, such as leaves or dirt, build up, airflow over the condenser fins is blocked. Air is not able to absorb enough heat to turn the hot refrigerant gas into a liquid. High head pressures will result. In these cases, carefully clean off the outer surfaces of the condenser with compressed air or a soap and water solution. Be careful not to bend the fins.

High head pressures will also occur if the condenser tubing is bent, blocking the flow of refrigerant. Frost will appear at the point where the flow is restricted.

Less common internal blockages (bits of foreign material or metallic grit buildup) will stop the flow of refrigerant.

A quick test to check that poor system performance is caused by the condenser is to direct a spray of water on the condenser while the system is running. If the air conditioner cools better because of the assist provided by the water, it is a sign that the condenser is not working.

When troubleshooting a suspected condenser problem, remember that the problem may be caused by the radiator transferring high levels of heat to the condenser. See **Group 20** for cooling system troubleshooting or to the engine manufacturer's service manual for details about cooling system problems.

### Line Restrictions

A restricted suction line causes low suction pressure at the compressor and little or no cooling. A restriction in a line between the compressor and the expansion valve can cause high discharge, low suction pressure, and insufficient cooling.

Usually areas of ice or frost buildup mean a blockage. Components that often freeze-up are probably corroded or inoperative and should be replaced. Components (such as the expansion valve) that freeze-up once in a while may do so because of moisture in the system. If this happens, recover the refrigerant, evacuate/recycle the system, replace the receiver-drier, and add a full refrigerant charge.

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## Fault Analysis Flow Chart

See **Fig. 2** for the fault analysis flow chart.

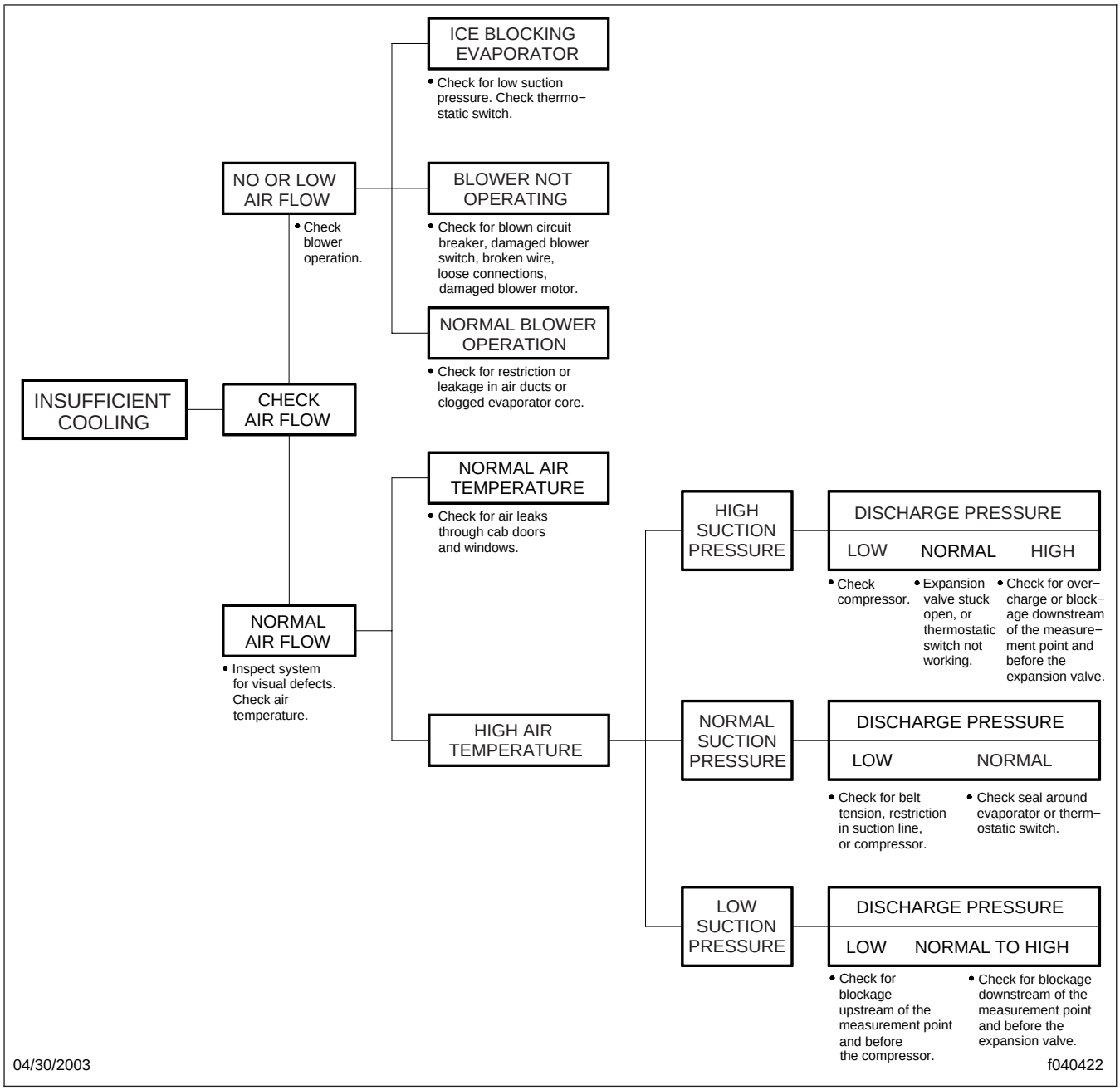



**Fig. 2, Fault Analysis Flow Chart**

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## Troubleshooting for the Non-ATC Heater and Air Conditioner

# Troubleshooting Tables for the Cab Heater and Air Conditioner

Before beginning the troubleshooting procedures, be sure the electrical system is functioning properly. The system voltage should be approximately 12 volts.

**Problem—Dash Display Does Not Light Up**

| Problem—Dash Display Does Not Light Up | |
|---|---|
| **Possible Cause** | **Remedy** |
| The control panel is not receiving power. | Verify that the control panel is plugged in to the wiring harness.<br>Verify that the wiring harness is wired to the vehicle properly<br>Turn on the display using the blower fan switch. |

**Problem—Little or No Airflow**

| Problem—Little or No Airflow | |
|---|---|
| **Possible Cause** | **Remedy** |
| The blower is not operating. | Check for an open circuit breaker. An open circuit indicates a short in the electrical system, which must be located and repaired.<br>Check the air conditioner relays for operation. Replace if necessary.<br>Make sure the blower motor switch is working. Replace if necessary.<br>Check the wiring to the blower motor. If any connections are loose, tighten them.<br>Check the blower motor for operation. Replace if sticking or otherwise inoperative.<br>Check the resistor block. Replace if necessary. |
| There are restrictions or leaks in the air ducts. | Examine all air ducts and remove any blockages. Stop any leaks or replace any portion where the leaks cannot be stopped.<br>Check to make sure the fresh air filter in the HVAC assembly is clean. |
| Ice has formed on the evaporator coil. | Defrost the evaporator coil before resuming operation of the air conditioner. Review "HVAC Components" for possible causes and corrective action. |

**Problem—Warm Airflow When the Air Conditioner Is On**

| Problem—Warm Airflow When the Air Conditioner Is On | |
|---|---|
| **Possible Cause** | **Remedy** |
| There is no refrigerant charge in the system. | Perform a leak test. Repair any leaks, evacuate the system, replace the receiver-drier, and add a full charge of refrigerant. |
| Moisture in the system. | If moisture is in the system, ice crystals may form at the expansion valve, blocking the flow of refrigerant (off and on). Recover the refrigerant charge, replace the receiver-drier, evacuate the system, and add a full charge of refrigerant. |

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## Troubleshooting for the Non-ATC Heater and Air Conditioner

| Problem—Warm Airflow When the Air Conditioner Is On | |
|---|---|
| **Possible Cause** | **Remedy** |
| The refrigerant compressor is not operating. | If the refrigerant charge is low, charge and leak test the system. Repair any leaks.<br>The refrigerant compressor clutch or drive belt needs repair or replacement. For instructions, see the applicable refrigerant compressor section. |
| Ice has formed on the evaporator coil. | Defrost the evaporator coil before resuming operation of the air conditioner. Review "HVAC Components" for possible causes and corrective action. |
| The water valve is open. | Check the water valve. |

**Problem—Low Evaporator Coil Outlet Pressure (low compressor suction pressure)**

| Problem—Low Evaporator Coil Outlet Pressure (low compressor suction pressure) | |
|---|---|
| **Possible Cause** | **Remedy** |
| The expansion valve is not working. | Replace the expansion valve. |
| There are restrictions in the line to the expansion valve. | Remove the line restrictions. |
| There is an insufficient refrigerant charge in the system. | Locate the leak. Recover the charge, replace the receiver-drier, and add a full refrigerant charge. |

**Problem—High Compressor Discharge Pressure**

| Problem—High Compressor Discharge Pressure | |
|---|---|
| **Possible Cause** | **Remedy** |
| Airflow through the condenser is restricted. | Remove the debris from the condenser. |
| There is an internal restriction in the condenser. Ice buildup on the condenser or a cool spot on the line from the condenser to the receiver-drier. | Replace the condenser. |
| Air is present in the system. | Perform a leak test. Repair any leaks, evacuate the system, and add a full charge of refrigerant. |
| Heavy frost on the suction line suggests that the evaporator coil is flooded. | Defrost the evaporator coil before resuming operation of the air conditioner. |
| The engine is overheated. | See the engine manufacturer’s service manual for corrective measures. |
| Restriction in the compressor discharge line. Frost usually appears at the point of restriction. | Repair or replace the line. |

**Problem—Evaporator Outlet Air Temperature Increases as the Compressor Discharge Pressure Drops**

| Problem—Evaporator Outlet Air Temperature Increases as the Compressor Discharge Pressure Drops | |
|---|---|
| **Possible Cause** | **Remedy** |
| There are leaks in the system. | Leak test the system. |
| The expansion valve setting is too low. | Replace the expansion valve. Add a full charge of refrigerant. |

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## Troubleshooting for the Non-ATC Heater and Air Conditioner

**Problem—Compressor Operates Too Often**

| Problem—Compressor Operates Too Often | |
|---|---|
| **Possible Cause** | **Remedy** |
| There is too little refrigerant in the system. | Perform a leak test. Repair any leaks and add a full charge of refrigerant. |
| Ice has formed on the evaporator coil. | Defrost the evaporator coil before resuming operation of the air conditioner.<br>Check the operation of the thermostatic switch and replace if necessary. |
| There is a restriction in the refrigerant system. | Remove the restriction from the line. |
| Dirt and debris are clogging the condenser fins. | Remove all dirt and debris from the condenser fins. |
| The thermostatic switch isn't working. | Replace the thermostatic switch. |

**Problem—Temperature in the Cab Too Low or No Heat**

| Problem—Temperature in the Cab Too Low or No Heat | |
|---|---|
| **Possible Cause** | **Remedy** |
| The water regulating valve is not opened. | Move the temperature control knob toward warm. |
| The water regulating valve is not opening all the way. | Adjust the water regulating valve cable. |
| The water regulating valve isn't working. | Replace the water regulating valve. |
| A heater hose is pinched or twisted. | Repair or replace the heater hose. |
| Coolant is leaking from the system. | Check for leakage at the heater core and at all hose connections from the heater core to the engine. Check the radiator coolant level as instructed in the driver's manual and add coolant if necessary. Check and repair any leaks at the radiator. |
| Dust or dirt is clogging the heater core fins. | Remove and clean the heater core. |

**Problem—Condensed Water Is Leaking from the Air Conditioner**

| Problem—Condensed Water Is Leaking from the Air Conditioner | |
|---|---|
| **Possible Cause** | **Remedy** |
| The drain tubes are plugged. | Clean the drain holes and drain tubes. |

## Troubleshooting Tables for the Sleeper Heater and Air Conditioner

**Problem—No Heating**

| Problem—No Heating | |
|---|---|
| **Problem Area** | **Remedy** |
| Coolant flow | Check the temperature of the heater core to verify that hot coolant is flowing through the core. |

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## Troubleshooting for the Non-ATC Heater and Air Conditioner

| Problem—No Heating | |
|---|---|
| **Problem Area** | **Remedy** |
| Actuator | Measure the voltage between ground terminal 7 (black wire) and supply terminal 10 (blue wire). This should be the same as the vehicle supply voltage. See **Fig. 3**.<br><br>Measure the voltage between control terminal 8 (purple wire) and ground terminal 7 (black wire). This should vary between 2 and 11 volts when the air conditioner switch is turned from on to off with the temperature control switch turned to the hottest position. This change in voltage should result in movement of the blend air door from the heater core to the A/C evaporator. If the voltage remains at 2 volts at terminal 8, then check for a shorted thermistor connection or a control panel problem. If the voltage remains at 11 volts, check for an open thermistor or a control panel problem. |
| Thermistor | Disconnect the thermistor from the wiring harness and check the resistance at room temperature. The resistance should be between 2500 and 3500 ohms at 77°F (25°C). Thermistor resistance will go down with an increase in temperature, and the resistance will go up with a decrease in temperature. The voltage across the thermistor while connected to the system should be about 4 volts in the A/C mode and 8 volts in the heat mode. The most likely thermistor problems are either a shorted thermistor or an open circuit thermistor. |
| Control panel | Verify that 12 volts on the red wire and ground on the black wire exist for the circuit board. The short black wire with the 90-degree female connector is the supply for the fan speed switch and should have 12 volts present with the air conditioner switch on or off. The voltage between the brown wire and ground (black) should be the same as described in the thermistor diagnostic procedure. If the voltage is not correct and the thermistor is good, then the control panel must be replaced. The voltage between the purple wire and ground (black) should be the same as pin 8 of the actuator. If the actuator operates correctly, then the control panel should be replaced. See **Fig. 4**. |

**Problem—No Cooling**

| Problem—No Cooling | |
|---|---|
| **Problem Area** | **Remedy** |
| Refrigerant system | Check the temperature of the evaporator core to verify that it is cool and indicate proper refrigerant system operation. |
| Actuator | Measure the voltage between ground terminal 7 (black wire) and supply terminal 10 (blue wire). This should be the same as the vehicle supply voltage. See **Fig. 3**.<br><br>Measure the voltage between control terminal 8 (purple wire) and ground terminal 7 (black wire). This should vary between 2 and 11 volts when the air conditioner switch is turned from on to off with the temperature control switch turned to the hottest position. This change in voltage should result in movement of the blend air door from the heater core to the A/C evaporator. If the voltage remains at 2 volts at terminal 8, then check for a shorted thermistor connection or a control panel problem. If the voltage remains at 11 volts, check for an open thermistor or a control panel problem. |
| Thermistor | Disconnect the thermistor from the wiring harness and check the resistance at room temperature. The resistance should be between 2500 and 3500 ohms at 77°F (25°C). Thermistor resistance will go down with an increase in temperature, and the resistance will go up with a decrease in temperature. The voltage across the thermistor while connected to the system should be about 4 volts in the A/C mode and 8 volts in the heat mode. The most likely thermistor problems are either a shorted thermistor or an open circuit thermistor. |

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## Troubleshooting for the Non-ATC Heater and Air Conditioner

| Problem—No Cooling | |
|---|---|
| **Problem Area** | **Remedy** |
| Control panel | Verify that 12 volts on the red wire and ground on the black wire exist for the circuit board. The short black wire with the 90-degree female connector is the supply for the fan speed switch and should have 12 volts present with the air conditioner switch on or off. The voltage between the brown wire and ground (black) should be the same as described in the thermistor diagnostic procedure. If the voltage is not correct and the thermistor is good, then the control panel must be replaced. The voltage between the purple wire and ground (black) should be the same as pin 8 of the actuator. If the actuator operates correctly, then the control panel should be replaced. See **Fig. 4**. |
| Expansion valve | Check the expansion valve. |

**Problem—No Temperature Modulation**

| Problem—No Temperature Modulation | |
|---|---|
| **Problem Area** | **Remedy** |
| Coolant flow | Check the temperature of the heater core to verify that hot coolant is flowing through the core. |
| Refrigerant system | Check the temperature of the evaporator core to verify that it is cool and indicate proper refrigerant system operation. |
| Actuator | Measure the voltage between ground terminal 7 (black wire) and supply terminal 10 (blue wire). This should be the same as the vehicle supply voltage. See **Fig. 3**.<br><br>Measure the voltage between control terminal 8 (purple wire) and ground terminal 7 (black wire). This should vary between 2 and 11 volts when the air conditioner switch is turned from on to off with the temperature control switch turned to the hottest position. This change in voltage should result in movement of the blend air door from the heater core to the A/C evaporator. If the voltage remains at 2 volts at terminal 8, then check for a shorted thermistor connection or a control panel problem. If the voltage remains at 11 volts, check for an open thermistor or a control panel problem. |
| Thermistor | Disconnect the thermistor from the wiring harness and check the resistance at room temperature. The resistance should be between 2500 and 3500 ohms at 77°F (25°C). Thermistor resistance will go down with an increase in temperature, and the resistance will go up with a decrease in temperature. The voltage across the thermistor while connected to the system should be about 4 volts in the A/C mode and 8 volts in the heat mode. The most likely thermistor problems are either a shorted thermistor or an open circuit thermistor. |
| Control Panel | Verify that 12 volts on the red wire and ground on the black wire exist for the circuit board. The short black wire with the 90-degree female connector is the supply for the fan speed switch and should have 12 volts present with the air conditioner switch on or off. The voltage between the brown wire and ground (black) should be the same as described in the thermistor diagnostic procedure. If the voltage is not correct and the thermistor is good, then the control panel must be replaced. The voltage between the purple wire and ground (black) should be the same as pin 8 of the actuator. If the actuator operates correctly, then the control panel should be replaced. See **Fig. 4**. |

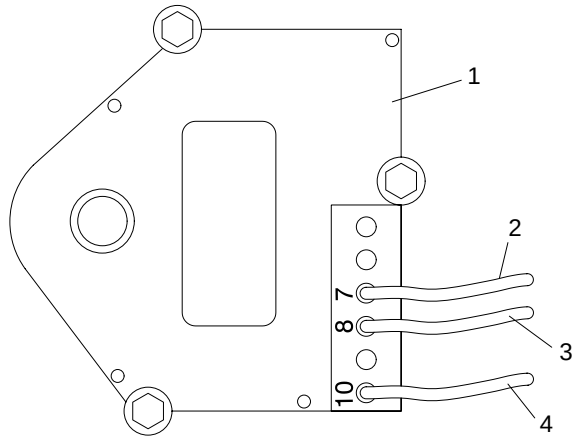
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## Troubleshooting for the Non-ATC Heater and Air Conditioner

**Problem—No Airflow**

| Problem—No Airflow | |
|---|---|
| **Problem Area** | **Remedy** |
| Motor, locked blower wheel | Verify the presence of 12 volts at the motor leads when in high fan speed. If 12 volts exists at the motor and the blower is not turning, look for a locked rotor or a possible intermittent connection in the wiring harness. If 12 volts are not present, inspect the wiring harness. |
| Control Panel | Verify that 12 volts on the red wire and ground on the black wire exist for the circuit board. The short black wire with the 90-degree female connector is the supply for the fan speed switch and should have 12 volts present with the air conditioner switch on or off. The voltage between the brown wire and ground (black) should be the same as described in the thermistor diagnostic procedure. If the voltage is not correct and the thermistor is good, then the control panel must be replaced. The voltage between the purple wire and ground (black) should be the same as pin 8 of the actuator. If the actuator operates correctly, then the control panel should be replaced. See **Fig. 4**. |




1. Actuator
2. Black Wire
3. Purple Wire
4. Blue Wire

**Fig. 3, Actuator**

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## Troubleshooting for the Non-ATC Heater and Air Conditioner

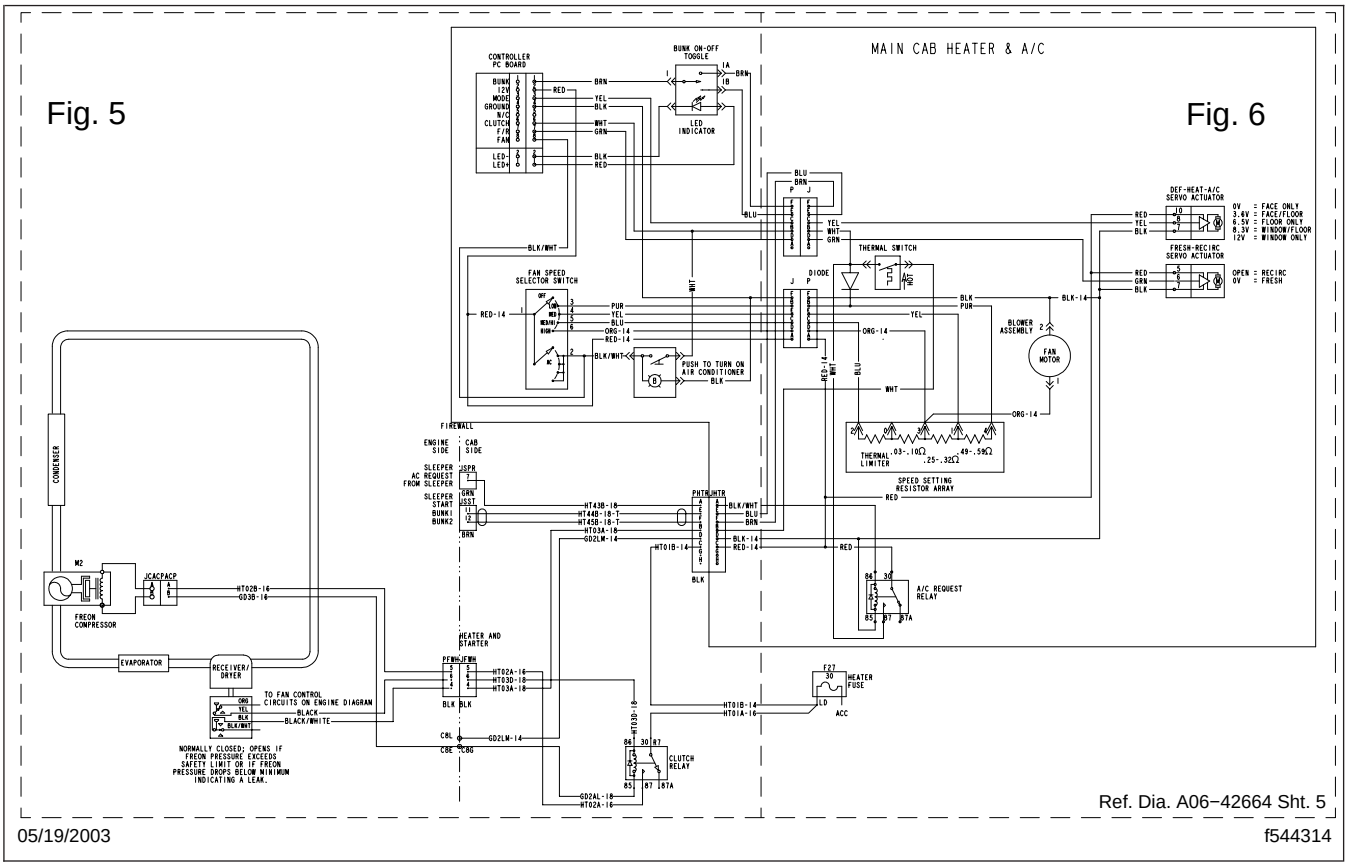



**Fig. 4, Non-ATC Cab Heater and Air Conditioner Wiring Schematic**

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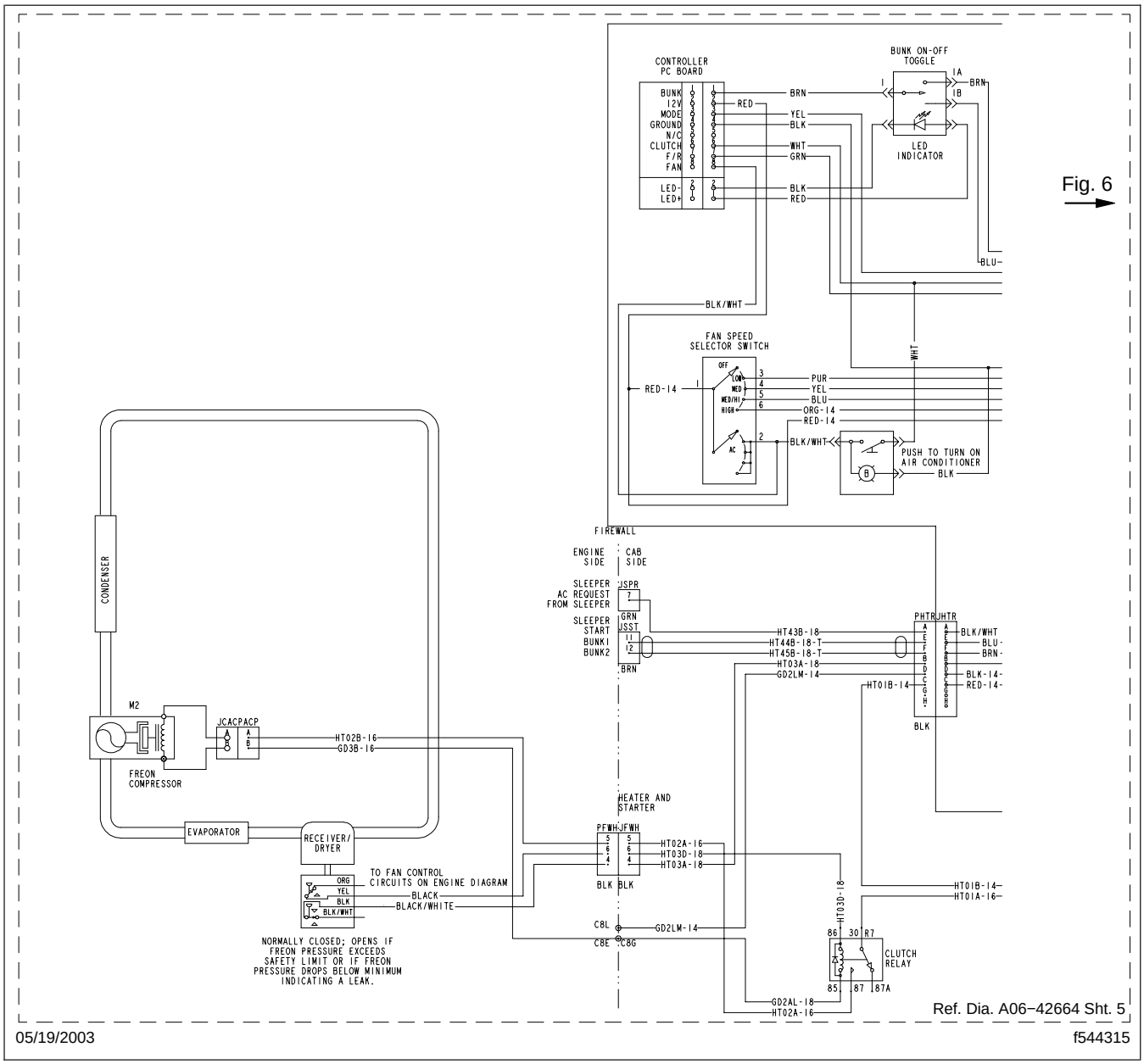



**Fig. 5, Non-ATC Cab Heater and Air Conditioner Wiring Schematic**

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## Troubleshooting for the Non-ATC Heater and Air Conditioner

Fig. 5

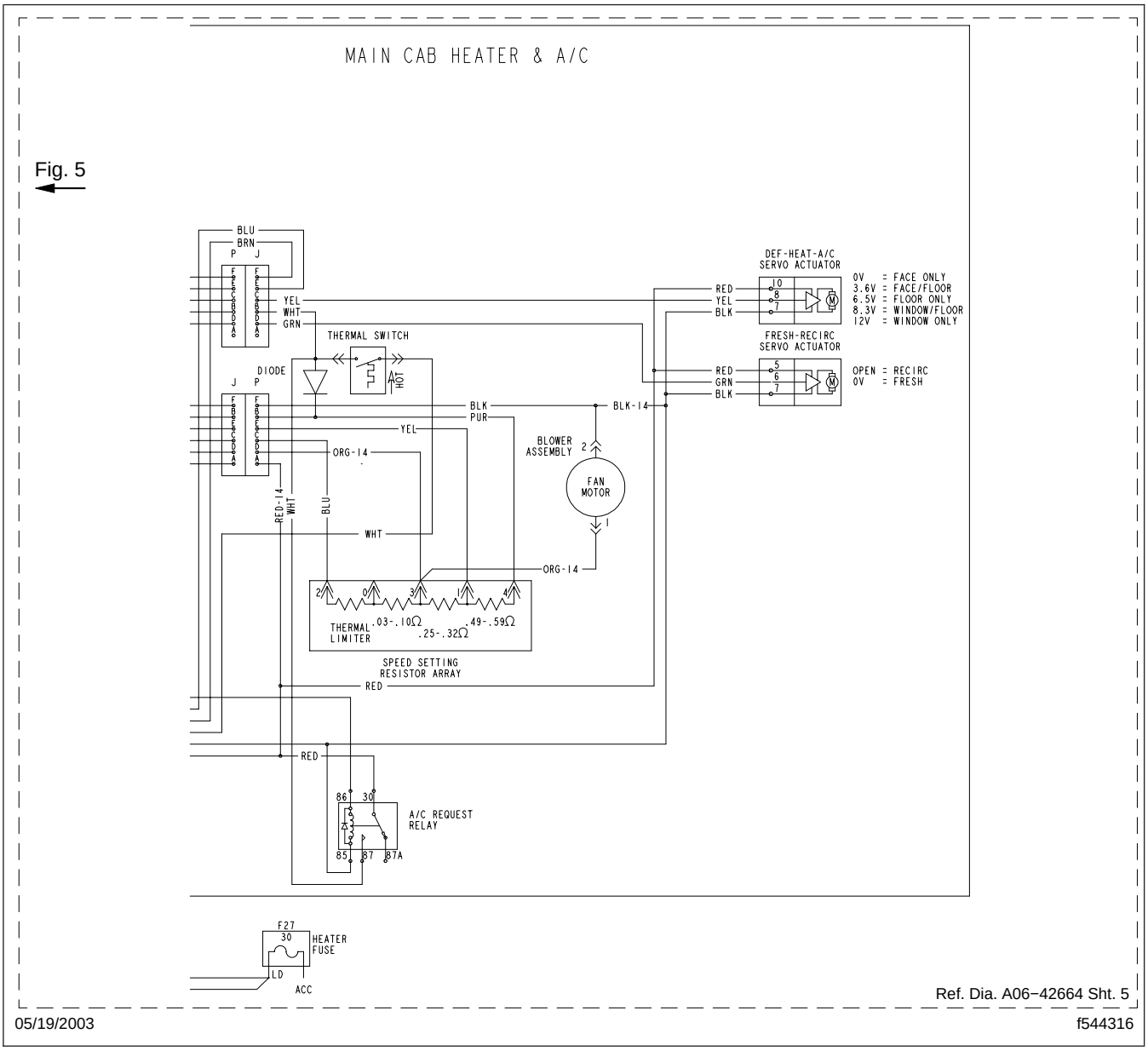



**Fig. 6, Non-ATC Cab Heater and Air Conditioner Wiring Schematic**

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## Troubleshooting for the Non-ATC Heater and Air Conditioner

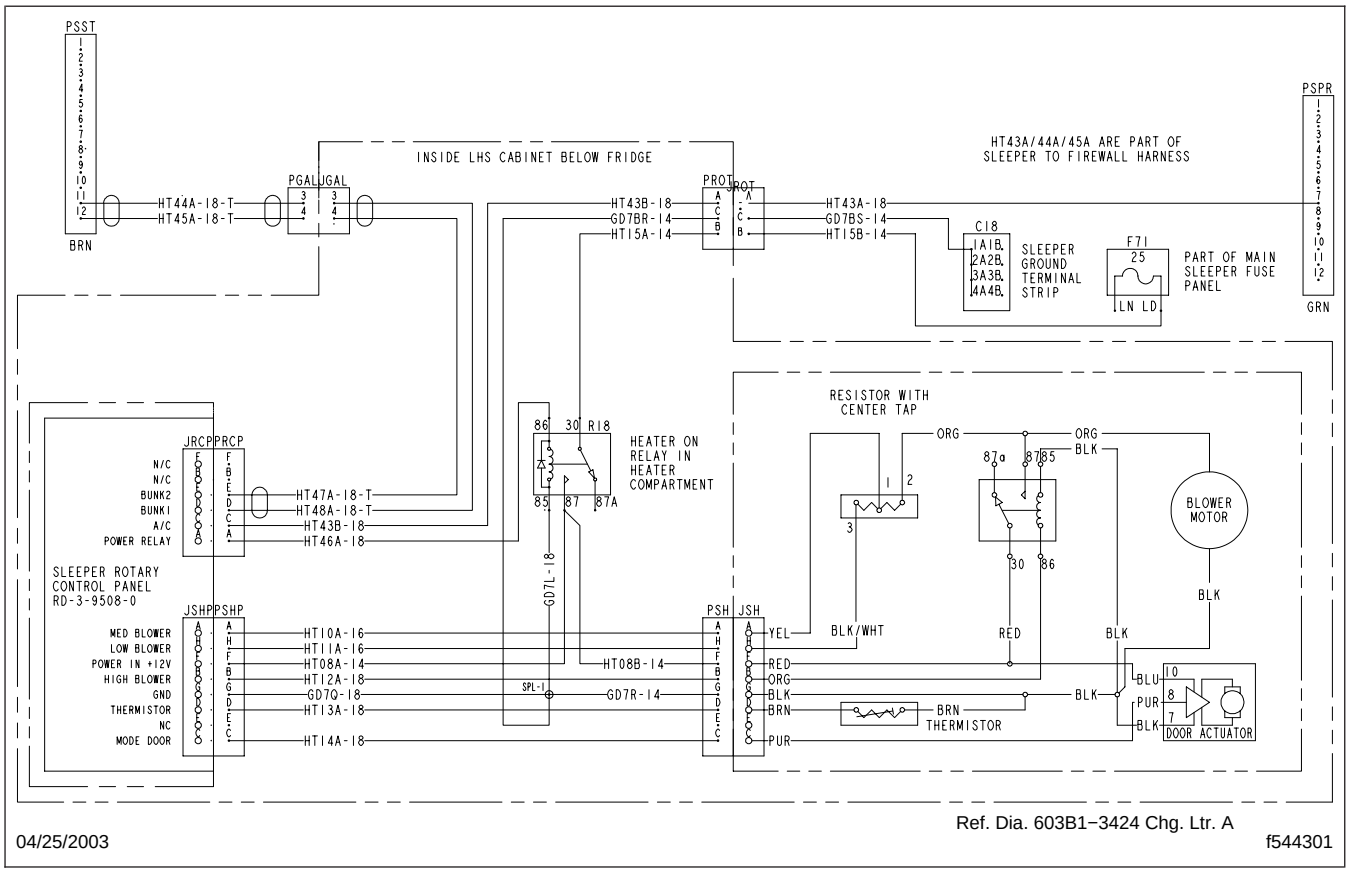



**Fig. 7, Non-ATC Sleeper Heater and Air Conditioner Wiring Schematic**

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# Troubleshooting for the ATC Heater and Air Conditioner With System Protection

## General Information

The Automatic Temperature Control (ATC) system is the latest in Red Dot electronic controllers. The ATC provides true cab temperature control and continuously variable blower fan speed. This is accomplished through the use of advanced microprocessor and sensor technology.

The troubleshooting procedures in this subject pertain to the Red Dot ATC heater and air conditioner with System Protection. Between August 16, 1999, and November 2001, Western Star offered the ATC heater and air conditioner with System Protection.

In November 2001, Western Star began offering the Red Dot ATC heater and air conditioner with Advanced Diagnostics. For information and troubleshooting procedures on the ATC heater and air conditioner with Advanced Diagnostics, see **Subject 320**.

## Control Operation Specifications

Temperature Control Range

- 60 to 90°F (16 to 32°C)

Blower Fan Control

- Pulse Width Modulation, maximum current handling: 25 amps

Temperature Sensors

- Cab Air Temperature: monitors the average cab air temperature, micro fan insures air flow across the sensor
- Duct Outlet Temperature: When heat is required, the sensor prevents high speed cold air from blowing out of the ducts until the heater core warms up (AUTO mode only).
- Evaporator Core Probe: Prevents ice from forming in the evaporator core: less than 31°F (–1°C) clutch cut out, greater than 37°F (3°C) clutch turn on

High Side Pressure Control

- high side transducer
- prevents operation at low ambient temperatures: less than 40 psig (276 kPa)–no A/C operation
- high pressure protection: greater than 350 psig (2413 kPa) clutch cut out, less than 275 psig (1896 kPa) clutch turn on
- condenser fan request: greater than 275 psig (1896 kPa) condenser fan turn on, less than 225 psig (1551 kPa) condenser fan turn off
- minimum condenser fan on time: 30 seconds

Low Side Pressure Control

- low side transducer
- low pressure protection: less than 7 psig (48 kPa) clutch cut out, greater than 25 psig (172 kPa) clutch turn on

Controlled Devices

- A/C compressor clutch circuit–maximum clutch cycle rate: five cycles/minute
- blower fan motor
- water valve
- bunk power unit

## Operation of the Cab ATC

### Controls

#### Blower Fan Speed Rotary Switch

The heater or air conditioner is turned on when the blower fan speed rotary switch is turned clockwise from the off position. When the heater or air conditioner is turned on, the LED display is illuminated. See **Fig. 1**. The display shows the current temperature set point. The blower fan switch has four speed settings. The AUTO setting on the blower fan switch places the HVAC system in the automatic blower fan speed control mode. When in the automatic mode, the fan speed can vary in infinite increments as necessary to maintain the temperature set by the user. As the cab temperature reaches the set point temperature, the blower speed decreases.

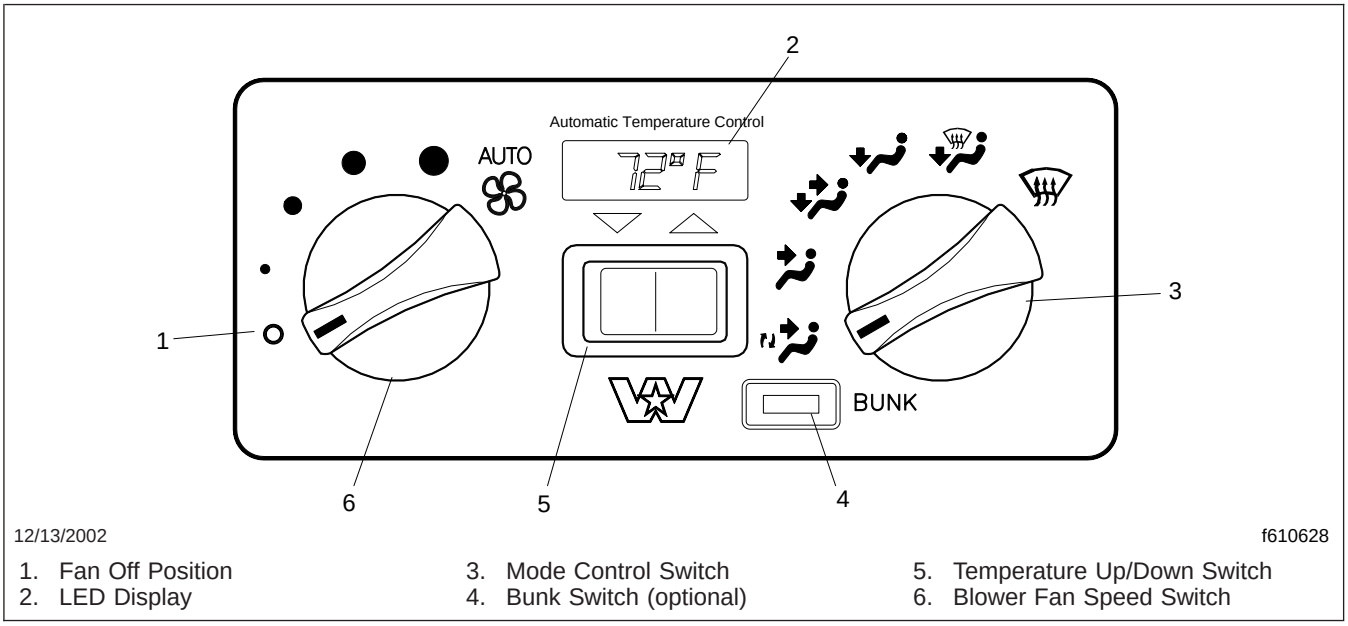
#### Temperature Up/Down Rocker Switch

Press and release the temperature up/down rocker switch to set the desired temperature. See **Fig. 1**. Pressing and holding the temperature up/down switch will cause the set point temperature to continuously increase or decrease. The HVAC system will attempt to achieve and hold the desired set point

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection




1. Fan Off Position
2. LED Display
3. Mode Control Switch
4. Bunk Switch (optional)
5. Temperature Up/Down Switch
6. Blower Fan Speed Switch

**Fig. 1, ATC Cab Climate Control Panel**

temperature by controlling the compressor clutch and water valve. When in AUTO mode, the blower fan speed is controlled automatically as well.

### Mode Control Rotary Switch

The mode control rotary switch sets the discharge mode of air flow. See **Fig. 2**.

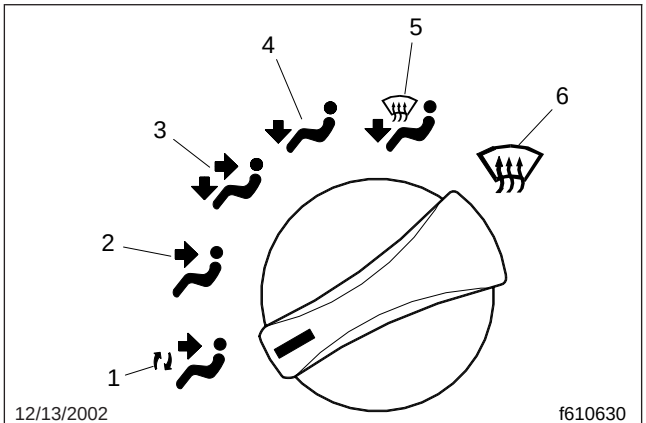
### Bunk Switch

The bunk switch enables or disables the bunk heater and air conditioner. When the bunk switch is on, the switch is illuminated. The bunk switch is optional.

## Heater Operation

The ATC automatically controls the HVAC system to maintain the cab air temperature close to the set point selected by the user. The ATC adjusts the air temperature blown through the outlets to maintain this temperature. If more heat is desired, increase the set point temperature by pressing and releasing the right side of the temperature up/down switch. If less heat is desired, decrease the set point by pressing and releasing the left side of the temperature up/down switch.

To obtain maximum heating, set the temperature to 90°F (32°C). The system will put out maximum heat continuously, even if the cab temperature exceeds




1. Dash Vents (recirculating air)
2. Dash Vents (fresh air)
3. Bi-Level (fresh air)
4. Floor (fresh air)
5. Floor and Defrost (fresh air)
6. Defrost (fresh air)

**Fig. 2, Mode Control Switch Settings**

the set point temperature. For maximum heating, turn the blower fan speed switch to the highest speed setting, not AUTO.

With the fan switch in AUTO mode, the fan speed will remain low until the air temperature warms up. Once the air temperature is warm, the fan speed will

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increase as necessary to warm up the cab to the set point temperature. Once the cab reaches the set point temperature, the fan speed will decrease.

A comfortable set point for heating is between 72 to 78°F (22 to 26°C). Change the temperature set point in small increments for best results. Once a comfortable temperature is reached, this temperature will be maintained without adjusting the set point.

## Defrosting or Defogging Operation

The defrost mode is used to deice, defrost, or defog the windows. Turn the mode control switch to the defrost mode. See **Fig. 2**. The ATC automatically increases the blower speed and the air temperature to quickly defrost the windows.

In cold or humid conditions, more heat and air flow are required to clear the windows. The set point temperature and the blower speed should be adjusted as necessary to maintain a clear windshield at all times. For maximum defrost, increase the set point temperature to the maximum setting (90°F or 32°C) and increase the blower speed to maximum fan, not AUTO.

NOTE: The air conditioner is enabled when in defrost mode. The air conditioner is used to dehumidify the air entering the cab and to remove the moisture from the windshield.

## Air Conditioner Operation

The ATC feature automatically controls the HVAC system to maintain the cab air temperature close to the set point selected by the user. The ATC adjusts the air temperature blown through the ducts to maintain the selected temperature. If more cooling is desired, decrease the set point temperature by pressing the left side of the temperature up/down switch. If less cooling is desired, increase the set point by pressing the right side of the temperature up/down switch.

To obtain maximum cooling, set the set point temperature to 60°F (16°C). The system will put out maximum cooling continuously, even if the cab temperature drops below the set point temperature. Turn the blower fan switch to highest fan speed, not AUTO.

In AUTO mode, the fan speed adjusts as necessary to keep the cab at the set point temperature. The further away the cab temperature is from the set point, the higher the fan speed.

For maximum cooling, turn the mode control switch to the recirculation mode. See **Fig. 2**. Once the cab is cool, any of the other modes can be used, such as dash vents or bi-level.

A comfortable set point for cooling is between 68 to 74°F (20 to 23°C). Change the temperature set point in small increments for best results. Once a comfortable temperature is reached, this temperature will be maintained without adjusting the set point.

## Ventilation

The dash vents (recirculating air) mode is the only mode that recirculates the air in the cab. All other modes draw in fresh air from the outside of the vehicle. Use the recirculation mode for short periods of time to prevent fumes or dust from entering the cab or to obtain maximum cooling or heating.

## Changing Temperature Units

The temperature units can be changed from Fahrenheit (°F) to Celsius (°C) or from Celsius to Fahrenheit by turning the ignition on, the blower fan speed switch to off, and pressing and holding the temperature up/down switch on the side with the blue arrow for five seconds. The current temperature unit will then be shown on the LED display. Press the temperature down switch again to toggle between the °F and °C temperature units. Changing the temperature units on the cab climate control panel will also effect the corresponding units on the bunk control panel. To obtain more accurate temperature control, use the Fahrenheit (°F) setting.

# Cab System Logic

## Automatic Fan Speed Control

The fan speed is determined by the system as required. The fan speed is based on the difference between the set point temperature and the actual cab temperature. The greater the difference, the greater the fan speed. When the temperature is too hot and heating is occurring, or if the temperature is too cold and cooling is occurring, then the fan speed will be held at minimum. This condition can occur when the

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection

cab is heating or cooling quickly and the temperature overshoots the set point temperature. The fan speed will be set to high if a cab temperature sensor error occurs. In AUTO fan speed mode, when heating is occurring, the fan speed is also limited by the outlet duct temperature. If the duct temperature is less than 72°F (22°C), then the fan speed will be limited to low fan speed. The fan speed limit will gradually increase as the duct temperature increases until the duct temperature reaches 95°F (35°C). This limit is disabled if a duct temperature sensor error occurs. In AUTO fan speed mode, all fan speed changes are done gradually. See **Table 1** for a list of the controls for the fan speed.

| Fan Speed Control | |
|---|---|
| **Fan Speed** | **Control** |
| O | Manual mode fan off |
| 1 | Manual mode fan low |
| 2 | Manual mode fan medium 1 |
| 3 | Manual mode fan medium 2 |
| 4 | Manual mode fan high |
| 5 | Automatic fan speed control |

**Table 1, Fan Speed Control**

In either automatic or manual mode, the initial fan speed on startup will gradually increase from off to the desired fan speed.

### Compressor Clutch Control

The compressor clutch can be active in any mode when the fan speed is not off. The clutch is activated as required to maintain the set point temperature.

In defrost mode, the compressor clutch is forced on to provide cab air dehumidification.

In the event of a cab temperature sensor error, the system will operate in a manual temperature control mode with a set point of 60°F (16°C) corresponding to full air conditioning, 75°F (24°C) corresponding to neutral, and 90°F (33°C) corresponding to full heat.

In any mode, the clutch activation can be disabled by the evaporator temperature sensor, the low pressure transducer, or the high pressure transducer. The evaporator temperature sensor trip points will be determined by the system to maintain the desired cab temperature. As less cooling is required, the evaporator temperature sensor trip points will increase, so as to maintain a fairly constant core temperature. In the case of full A/C or defrost mode, the evaporator temperature sensor trip points will be 31°F (–1°C) clutch off and 37°F (3°C) clutch on. The clutch will stay off for a minimum of 11 seconds before reengaging.

The low side pressure transducer trip points are 7 psig (48 kPa) clutch off and 25 psig (172 kPa) clutch on. The high pressure transducer high trip points are 350 psig (2413 kPa) clutch off and 275 psig (1896 kPa) clutch on. The high pressure transducer low trip points are 40 psig (276 kPa) clutch off and 50 psig (345 kPa) clutch on. If a high pressure transducer error or a low pressure transducer error occurs, then clutch activation will be disabled.

### Condenser Fan Control

The condenser fan trip points are 275 psig (1896 kPa) fan on and 225 psig (1551 kPa) fan off. The fan will immediately be engaged if the high side pressure exceeds 275 psig (1896 kPa). This is accomplished by breaking continuity between E and F on the six-pin Packard Vehicle Interface Connector which generates a fan on request to the engine fan control circuitry. The fan will remain on for a minimum of 30 seconds. The fan will turn off if the high side pressure drops below 225 psig (1551 kPa) **and** if 30 seconds has elapsed since the fan was last turned on. The fan will be disengaged by creating continuity between terminals E and F on the six-pin Packard vehicle interface connector which triggers the engine fan control circuitry.

## Cab System Function Check

See **Table 2** for the ATC HVAC system testing procedure.

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection

| ATC HVAC System Testing Procedure | | |
|---|---|---|
| **Control or Display** | **Action** | **Test Reaction** |
| Control Panel Display | Turn fan off.<br>Turn ignition on. | Display flashes **8888** briefly. |
| Blower Fan Speed Switch | Turn fan on. | Display reads 75°F (24°C) or last set point.<br>Air should be blowing. |
| Blower Fan Speed Switch | Turn fan to all speeds. | Amount of air flow should change accordingly. |
| Temperature Up/Down Switch* | Set temperature to lowest setting.<br>Set fan to AUTO. | Blower fan increases to high.<br>Air conditioner turns on. |
| Temperature Up/Down Switch† | Set temperature to highest setting.<br>Set fan to AUTO. | Blower fan speed increases to high.<br>Heater turns on. |
| Temperature Up/Down Switch | Set temperature to approximate cab temperature. | Blower fan speed decreases to low. |
| Mode Control Switch | Mode door control position changed. | Vent mode should change accordingly. |
| Mode Control Switch | Mode set to defrost. | A/C clutch should engage. |
| Bunk Switch | Press BUNK switch | BUNK switch illuminates.<br>Bunk unit turns on. |
| Error Codes | Turn blower switch to off.<br>Press and hold the up side of temperature up/down switch.<br>Press up side of temperature up/down switch again to scroll through errors. | Error codes displayed.<br>E0 indicates no faults detected. |
| Degree Units Change | Turn blower switch to off.<br>Press and hold the down side of temperature up/down switch.<br>Press down side of temperature up/down switch again to change units. | Temperature unit displayed.<br>Units change when the rocker switch is pressed. |

* Ambient and cab air temperatures should be between 67 to 77°F (19 to 25°C).

† Ambient and cab air temperatures should be between 67 to 77°F (19 to 25°C) and vehicle engine should be at normal operating temperature.

**Table 2, ATC HVAC System Testing Procedure**

# Cab HVAC System Troubleshooting

## System Diagnostics/Error Codes

Error codes can be displayed by turning the ignition on, the blower fan speed switch to off, and pressing and holding the temperature up switch for five seconds. The current error status will be shown on the LED display. Pressing the temperature up switch again repeatedly will scroll the display through any existing error codes. See **Table 3** for a list of the error codes.

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection

| Error Codes | |
|---|---|
| **Error Code** | **Problem** |
| E0 | No fault detected |
| E1 | Cab sensor shorted |
| E2 | Cab sensor disconnected |
| E3 | Evaporator probe shorted |
| E4 | Evaporator probe disconnected |
| E5 | Duct sensor shorted |
| E6 | Duct sensor disconnected |
| E7 | Low pressure transducer fault–disconnected or shorted |
| E8 | High pressure transducer fault–disconnected or shorted |
| E9* | High pressure and low pressure transducer connectors switched |
| E17 | ECU module failure, disconnected, or no power, or serial communication wires disconnected or reversed |

* This error code will not be displayed if the ambient temperature is below 40°F (4°C) or if the pressure in the A/C system is lower than 30 psig (207 kPa); however, the A/C clutch will not engage under these conditions even if the connectors are switched. This error code may be displayed if the A/C has been engaged in the last 10 minutes prior to checking for error codes. If this error code is displayed, allow the vehicle to sit with the engine off for at least 10 minutes and check errors again.

**Table 3, Error Codes**

# Cab System Troubleshooting Procedures

**Problem—No Display on Control Panel**

- Turn on control panel with blower fan speed switch.
- Check to see if the display illuminates.
- Verify that the control panel is plugged in to the wiring harness.
- Check to see if wiring harness is wired in to vehicle properly.
- Check the control panel.

**Problem—Fan Does Not Work**

- Using the fan speed switch, turn the fan to the highest setting.
- Verify that 12 volts is supplied to the ECU.
- Make sure blower fan is plugged in to wiring harness.
- Verify that 12V is supplied to fan.
- Check the fan.
- Check the ECU.

**Problem—No Heating**

- Using the temperature up/down switch, increase the temperature to the highest setting.
- Verify that warm coolant is flowing to the heater core by feeling the heater hoses.
- Verify that the water valve solenoid is wired correctly (one side to +12V).
- Check the water valve.

**Problem—No Cooling**

- Using the temperature up/down switch, decrease the temperature to the lowest setting and turn the mode switch to enable the defrost mode.
- Verify that the low pressure and high pressure transducers are connected properly.
- Verify that voltage is present at the compressor clutch.
- Verify that the circuit breakers or fuses are intact.
- Verify that the correct voltage is present at the clutch relay on the wiring harness.
- Check for frozen evaporator core.
- Verify that the correct voltage is present at the thermostat.

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection

- Verify that the system is fully charged with refrigerant.
- Check for moisture in the system.
- Inspect the clutch relay and replace if necessary.
- Check the water valve.
- Check the A/C clutch.

**Problem—System emits cool air when heat is needed**

- Verify that the cab temperature sensor is connected correctly and the fan in the sensor is spinning.
- Verify that the water valve is working properly. See "Problem—No Heating."
- Check the cab temperature sensor.
- Check the ECU.

**Problem—System emits hot air when cooling is needed**

- Verify that the cab temperature sensor is connected correctly and the fan in the sensor is spinning.
- Verify that the compressor clutch is working properly. See "Problem—No Cooling."
- Check the cab temperature sensor.
- Check the ECU.

**Problem—The engine fan not engaging or disengaging correctly**

- Verify that high pressure transducer is connected properly. Inspect and replace fan relay if necessary.
- Verify wiring harness connections.

**Problem—The sleeper unit is not engaging or disengaging correctly**

- Verify that bunk indicator is illuminated.
- Verify that the sleeper unit is working correctly.
- Inspect and test the vehicle wiring harness for incorrect wiring.

**Problem—Low Evaporator Coil Outlet Pressure (low compressor suction pressure)**

- Verify that the expansion valve is working.
- Verify that there are no restrictions in the line to the expansion valve.
- Verify that there is a sufficient refrigerant charge in the system.

**Problem—High Compressor Discharge Pressure**

- Verify that the airflow through the condenser is not restricted.
- Verify that there is no restriction in the condenser.
- Verify that there is no air in the system.
- Verify that the evaporator coil is not flooded.
- Verify that the engine is not overheated.
- Verify that there is no restriction in the compressor discharge line.

**Problem—Compressor Operates Too Often**

- Verify that there is a sufficient refrigerant charge in the system.
- Verify that there is no ice on the evaporator coil.
- Verify that there is no restriction in the refrigerant system.
- Verify that there is no dirt or debris clogging the condenser fins.
- Verify that the thermostatic switch is working.

# Voltage Levels

See **Table 4** and **Table 5** for the function of the wires in the vehicle interface harnesses.

| Eight-Pin Packard Vehicle Interface Harness | | |
|---|---|---|
| **Color** | **Line** | **Function** |
| Brown | Water Valve Solenoid | Output pulls to ground when active (water valve required to be off). With a water valve connected, the pin will be pulled up to +12V by the water valve load (water valve required to be on). |

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection

| Eight-Pin Packard Vehicle Interface Harness | | |
|---|---|---|
| **Color** | **Line** | **Function** |
| White | Clutch | Output goes to +12V when active (clutch on). Output floating when inactive (clutch off). With the harness connected, the output will be 0V when the clutch is not requested and +12V when the clutch is requested. |
| Red | Ignition | Input provides power for the HVAC unit. Should be +12V. |
| Black | Ground | Input provides ground for the HVAC unit. Should be 0V. |
| Green | Bunk1 | Input/output provides serial information link between the sleeper HVAC and the cab HVAC. This line should be connected to the bunk1 line on the bunk harness, if used. In use, this line will be a serial stream of 0V/5V signals. The average voltage reading on this pin will be around 2.5V. |
| Purple | Bunk2 | Input/output provides serial information link between the bunk HVAC and the cab HVAC. This line should be connected to the bunk2 line on the bunk harness, if used. In use, this line will be a serial stream of 0V/5V signals. The average voltage reading on this pin will be around 2.5V. |

**Table 4, Eight-Pin Packard Vehicle Interface Harness**

| Six-Pin Packard Vehicle Interface Harness | | |
|---|---|---|
| **Color** | **Line** | **Function** |
| Black | Analog Ground | Output provides analog ground for the pressure transducers. Should be 0V. |
| White | +5V Reference Voltage | Output provides power for the pressure transducers. Should be +5V. |
| Green | LS Pressure | Input signal from low side pressure transducer. This voltage will be related to the low side pressure by the function V=0.25 + psig x 0.030. |
| Purple | HS Pressure | Input signal from high side pressure transducer. This voltage will be related to the high side pressure by the function V=0.25 + psig x 0.009. |
| Yellow | Engine Fan | Output for engine fan activation. This pin will be connected to pin F (continuity with pin F) to request the engine fan off from the fan control circuits. |
| Orange | Engine Fan | Output for engine fan activation. This pin will be connected to pin E (continuity with pin E) to request the engine fan off from the fan control circuits. |

**Table 5, Six-Pin Packard Vehicle Interface Harness**

# Sleeper System Logic

## Fan Speed Control

The manual fan control mode provides 11 fan speed settings: LO, 10, 20, 30, 40, 50, 60, 70, 80, 90, HI.

## Automatic Fan Speed Control

The fan speed is determined by the system as required. The fan speed is based on the difference between the set point temperature and the actual sleeper cab temperature. The greater the difference, the greater the fan speed. When the temperature is too hot and heating is occurring, or if the temperature is too cold and cooling is occurring, the fan speed will be held at minimum. This condition can occur when the sleeper cab is heating or cooling quickly and the temperature overshoots the set point temperature. The fan speed will be set to high if a cab temperature sensor error occurs. In automatic fan speed mode, all fan speed changes are done gradually.

In automatic or manual mode, the initial fan speed at startup will gradually increase from off to the desired fan speed.

## Blend Door Control

The blend door is controlled as required to maintain the sleeper cab temperature at the set point temperature. The blend door has a motor that allows the

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actuator to be turned clockwise, counterclockwise, or held steady. The feedback potentiometer provides a signal proportional to the current position of the blend door actuator.

If a sleeper cab temperature sensor error occurs, then the system will go into manual temperature control mode ranging from full cool to full heat.

## Cab HVAC Communications

The communications link between the sleeper HVAC unit and the cab HVAC unit provides several functions. Because the sleeper HVAC unit is dependent on the cab HVAC unit to provide clutch activation, the communications link provides this function. Any time the sleeper unit moves the blend door to the full cool position, the sleeper controller requests the A/C clutch to be turned on. Upon receiving the A/C clutch request, the cab HVAC controller will turn on the A/C clutch. If the cab HVAC unit is off, then the cab HVAC blower will be turned to the LO position.

Another function of the communications link is to allow the BUNK switch on the ATC cab control panel to turn the sleeper HVAC on or off. A third function of the communications link is the function of the set point temperature slave mode.

# Wiring Diagrams

See **Fig. 3** and **Fig. 4** for the ATC cab HVAC wiring diagram.

# Sleeper ATC With Alarm Clock

## General Information

The Red Dot Automatic Temperature Control (ATC) sleeper heater and air conditioner is designed as the complement to the Red Dot ATC cab heater and air conditioner. The ATC sleeper heater and air conditioner provides true interior sleeper compartment temperature control and continuously variable blower fan speed. This is accomplished through the use of advanced microprocessor and sensor technology. The control keypad features full HVAC control as well as a clock with alarm. The sleeper unit can be turned on and off without turning on the cab HVAC unit.

## Specifications

### Display

The display is vacuum fluorescent and has five digits that are 0.33 inch (8 mm) high. Time is displayed in a 12-hour format with a separate PM LED indicator. Temperature is displayed with a three-digit annotation and can be displayed either in degrees Celsius or degrees Fahrenheit. A capital C or F is displayed for the appropriate temperature scale.

### ATC Sleeper Control Panel

The control panel is comprised of a membrane switch assembly with a Lexan outer covering. The panel has incorporated physical mechanical tactile feedback to ensure easily identifiable switch actuation. Indicator LEDs illuminate when a switch activation has occurred, thus providing both physical and visual indication of circuit activation. The control panel has backlighting to allow rapid and positive switch location even in dim ambient light conditions.

### Clock

The clock is crystal controlled with a low temperature drift oscillator for long term stability.

### Blower Motor Drive

Power MOSFET circuitry provides 20-amp drive capacity with multiple times instantaneous current ability. There is internal protection from voltage transients and current overloads.

### Voltage Input

The unit is designed to operate on standard truck operating voltages, 13.5 volts typical. The unit will operate correctly with input from 8 to 16 volts.

# Operation of Sleeper ATC

## Controls

### Clock Control

The clock controls are located on the left side of the ATC sleeper control panel under the display. The display will show the clock time as the default mode. See **Fig. 5**.

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection

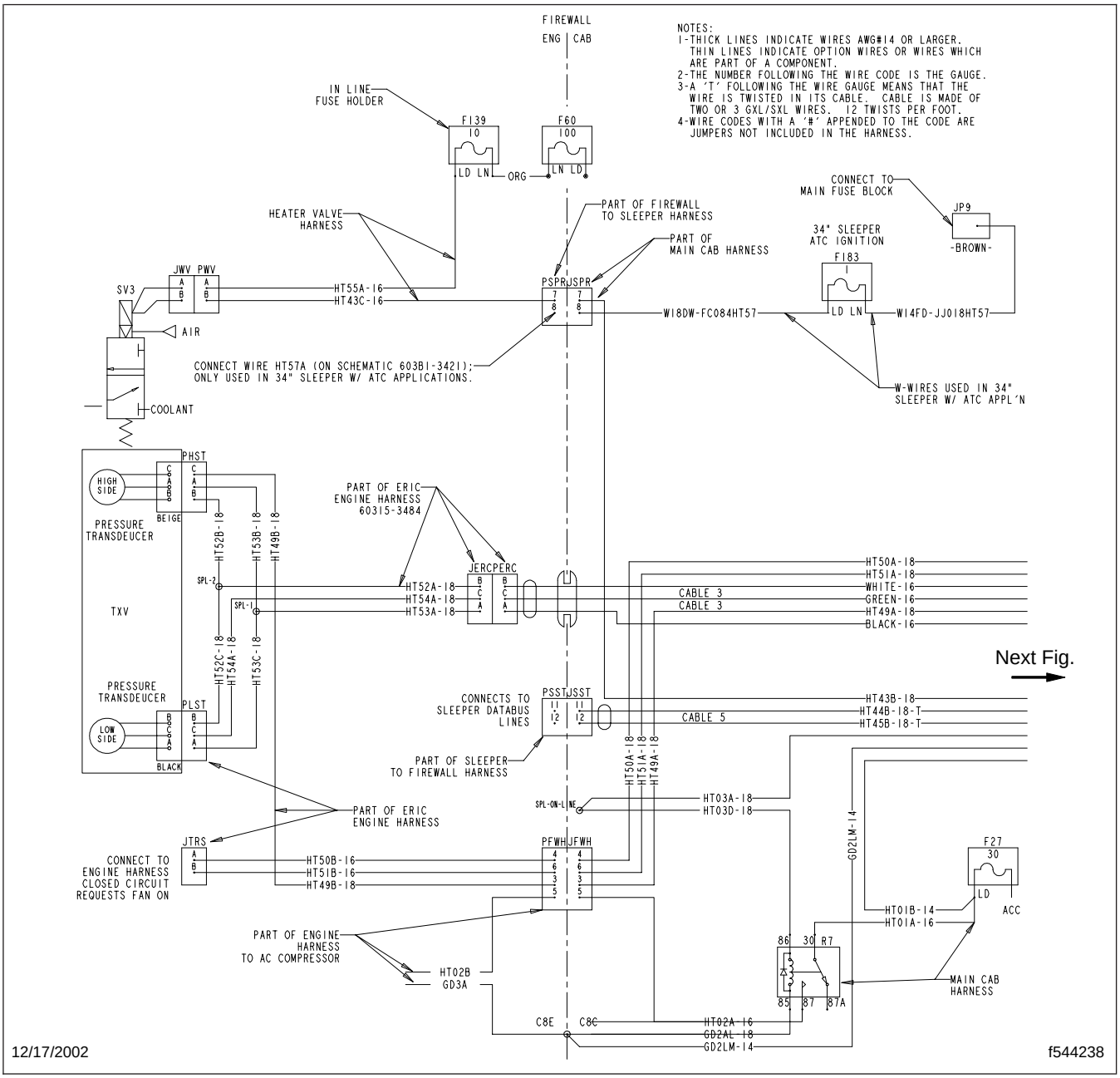



**Fig. 3, ATC Cab HVAC Wiring Diagram, Part 1**

## Alarm Button

Momentarily press the ALARM button to turn the alarm on and to illuminate the alarm indicator light above the alarm button. Momentarily press the button again to deactivate the alarm.

When pressing the ALARM button, the display shows the alarm time setting for five seconds before returning to the current time display. If the alarm button is pressed and held down continuously for more than one second, the alarm time setting can be viewed without changing the state of the alarm indicator. If

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection

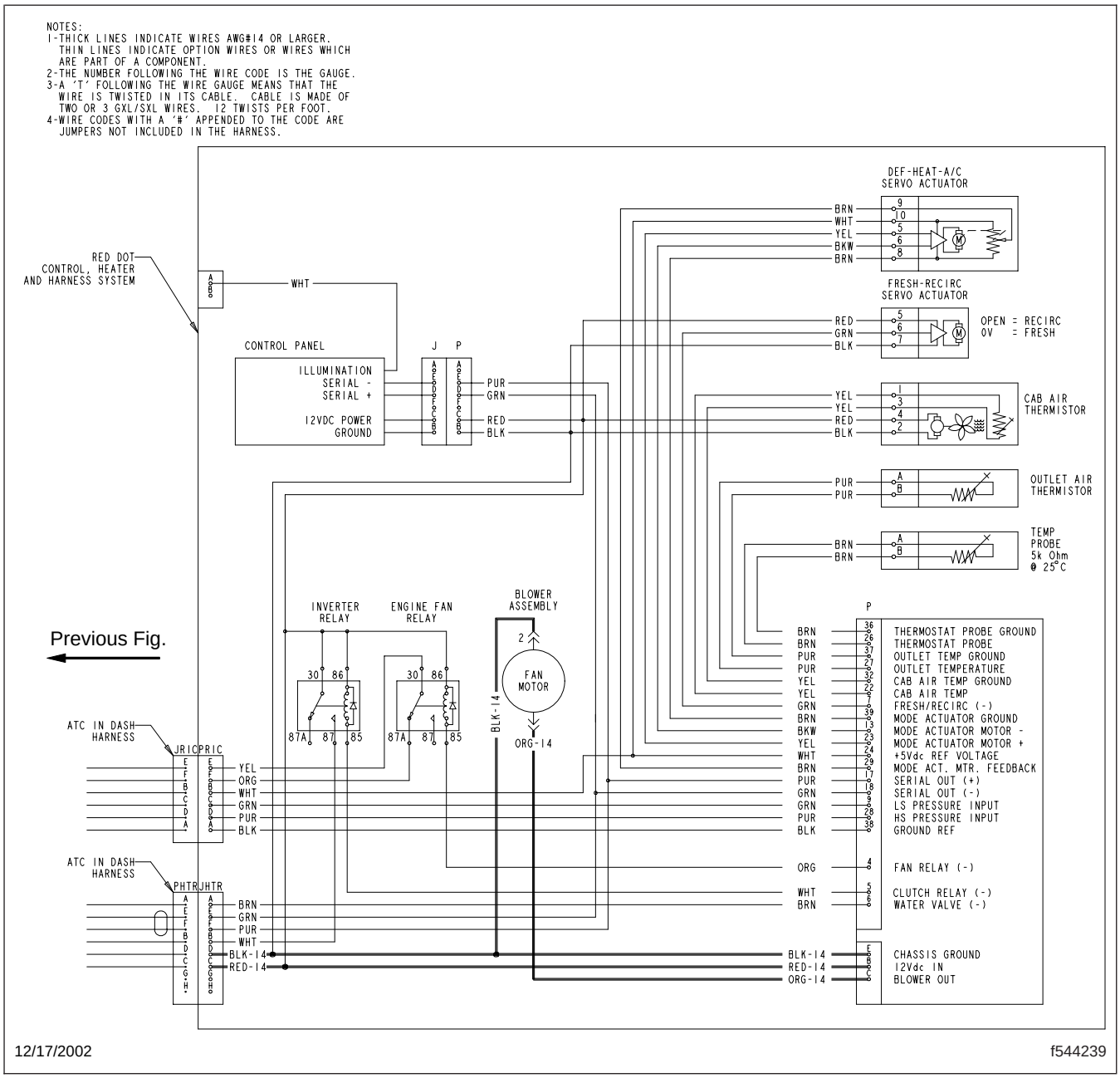



**Fig. 4, ATC Cab Wiring Diagram, Part 2**

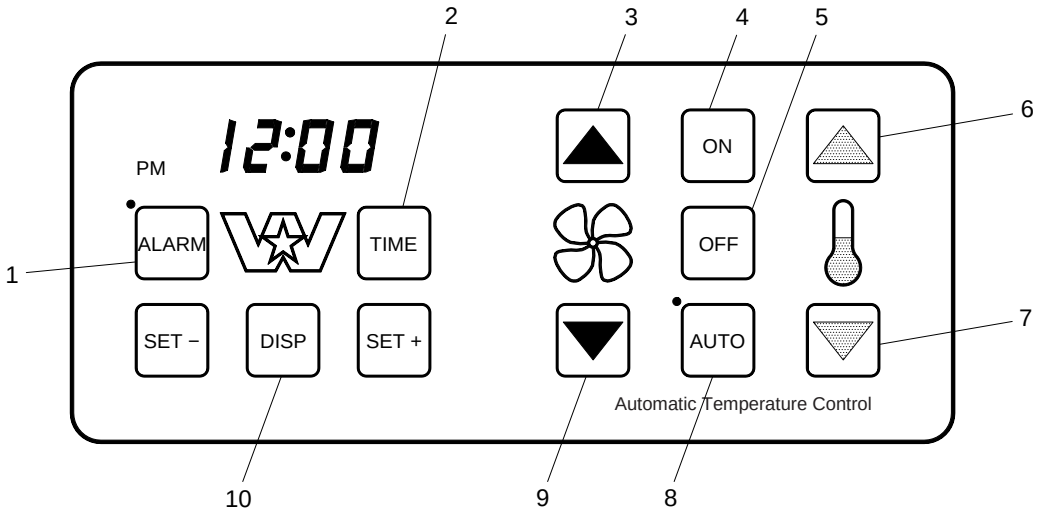
either the SET+ or SET– buttons are pressed simultaneously with the ALARM button held down, the alarm time setting will increase or decrease. When the ALARM button is released after changing the alarm time, the alarm will be turned on and the indicator will be illuminated. When the ALARM is sounding, press the ALARM button to turn the alarm off and to reset the alarm for the next 24-hour cycle.

NOTE: If any button other than the ALARM button is pressed when the alarm is sounding, the snooze function will be engaged.

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection




1. Alarm Button
2. Time Button
3. Fan Up Button
4. HVAC On Button
5. HVAC Off Button
6. Temperature Up Button
7. Temperature Down Button
8. Automatic Blower Fan Speed
9. Fan Down Button
10. Display Button

**Fig. 5, ATC Sleeper Control Panel**

If the snooze function is active, as indicated by a blinking alarm indicator light, press the ALARM button to cancel the snooze function and to reset the alarm for the next 24-hour cycle.

### Time Button

Press the TIME button to display the current time. If the TIME button is held down and either the SET+ or SET– buttons are pressed simultaneously with the TIME button, the clock setting will increase or decrease.

### Display

Depress the DISP button to allow the display and illumination of the control panel to scroll through three illumination levels: bright, dim, and off. If you want the ALARM, TIME, or HVAC setting to be displayed when the display is in the off mode, press the ALARM, TIME, or HVAC buttons to display the corresponding display for five seconds. After five seconds, the display will turn off. If the alarm sounds while in the display off mode, the current time will be displayed simultaneously. The display will remain on for five minutes, then turn off.

### Snooze Feature

To enable the snooze alarm, press any button on the control panel, except the ALARM button, when the alarm is sounding. The alarm will turn off for seven minutes. The alarm indicator light flashes when the snooze alarm is enabled. The snooze alarm can be enabled indefinitely.

### AM/PM

PM is displayed at the left side of the display and is illuminated during PM hours. When PM is not displayed, AM hours are displayed. When setting the time or alarm, note the presence or absence of the PM.

## Automatic Temperature Control

The controls for the sleeper heater and air conditioner are located on the right side of the ATC sleeper control panel. See **Fig. 5**.

### On Button

To turn the sleeper heater and air conditioner on, press the ON button. The display will show the current temperature control set point for five seconds

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then return to the time display. The fan and temperature control will not engage unless the ignition is on. If the engine is on, but the cab ATC heater and air conditioner is off, turning the sleeper heater and air conditioner on will engage the compressor clutch and turn the cab unit blower fan to a low setting.

## Off Button

To turn the sleeper heater and air conditioner off, press the OFF button.

## Auto Button

Press the AUTO (default on) button to enable automatic control of the blower fan speed. When automatic control is enabled, the indicator light above the AUTO button will illuminate. The display will show the current temperature control set point for five seconds, then return to the normal time display. When in this mode, the fan speed can vary in infinite increments as necessary to maintain the temperature set by the user.

## Temperature Up/Down Buttons

The temperature up/down buttons increase or decrease the control set point temperature. Each button may be pressed repeatedly to incrementally increase or decrease the set point. Press either button for at least two seconds to continuously increase or decrease the set point temperature. The display will show the current set point temperature. The display returns to the normal time display five seconds after a button is pressed and released.

## Fan Up/Down Buttons

The fan up/down buttons increase or decrease the blower fan speed. Each button may be pressed repeatedly to incrementally increase or decrease the set point. Press either button for at lease two seconds to continuously increase or decrease the set point. The display indicates the fan speed setting in 10 percent increments or HI when the maximum speed is selected and LO when the minimum speed is selected. The display returns to the normal display five seconds after a button is pressed. The AUTO fan function is disabled if either of these buttons is pressed.

# Turning on the Sleeper HVAC When the Cab HVAC is Off

The sleeper ATC control panel can turn on the air conditioner even if the cab HVAC unit is turned off but the engine is running. By pressing the ON button, the ATC sleeper control panel will turn on the cab unit and the bunk indicator light on the cab control panel will be illuminated. If cooling is needed in the sleeper, the cab HVAC unit will switch on to a low blower fan setting and the A/C compressor clutch will engage. If cooling is no longer required in the sleeper or if heat is needed, the cab unit fan and the compressor clutch will be turned off after a five-minute delay.

# Changing Temperature Units

The temperature units can be changed from °F to °C or from °C to °F by pressing the temperature up and temperature down buttons simultaneously. Changing the temperature units on the ATC sleeper control panel will also change the temperature units on the ATC cab control panel.

# Set Point Temperature Slave Mode Feature

The set point temperature slave mode allows the set point temperatures of the cab HVAC unit and the sleeper HVAC unit to be tied together automatically. In this mode, the temperature set point in the vehicle will always be the same whether the set point is changed on the cab control panel or the sleeper control panel. To enable the set point temperature slave mode, press the SET+ and SET– buttons simultaneously. The display will read S–ON when the set point temperature slave mode is enabled.

The set point temperature slave mode can be disabled by simultaneously pressing the SET+ and SET– buttons. The display will read S–OFF indicating that the mode is disabled. If disabled, the set points for the cab and sleeper control panels can be changed independently for separate temperature control. If you wish to maintain a temperature in the sleeper that is different than the temperature in the front of the cab, it is recommended that a curtain be used between the sleeper and the front of the cab.

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection

### Sleep Mode

The ATC sleeper control panel will immediately enter a power saving sleep mode when the vehicle ignition is not powered. The display and control panel illumination will turn off while all of the clock functions, including the alarm, continue to work internally. This feature is designed to reduce the power draw on the battery when the engine is not running by dropping the required current. If the DISP button is pressed while the ignition is turned off, the display will be illuminated for five minutes. After five minutes, the display will turn off and the electronics will go back to the sleep mode.

## Sleeper System Function Check

See **Table 6** for the sleeper HVAC system testing procedure.

| Sleeper HVAC System Testing Procedure | | |
|---|---|---|
| **Control or Display** | **Action** | **Test Reaction** |
| Control Panel Display Test | Battery connected (first time)<br>Press DISP button if display is blank | Display shows **8888** then the current time. |
| Control Panel Fan Control Test | Ignition on<br>HVAC on<br>Fan turned to different speeds | Amount of air flow should change accordingly. |
| Control Panel Temperature Control Test* | Set temperature to lowest setting.<br>Set fan to AUTO. | Blower fan increases to high.<br>Air conditioner turns on. |
| Control Panel Temperature Control Test* | Set temperature to highest setting.<br>Set fan to AUTO. | Blower fan increases to high.<br>Heater turns on. |
| Control Panel Temperature Control Test | Set temperature to approximate sleeper temperature. | Blower fan speed decreases to low. |
| Control Panel Clock Control Time Set | Press TIME and SET+ or SET– buttons simultaneously. | Current time is changed. |
| Control Panel Clock Control Alarm Set | Press ALARM and SET+ or SET– buttons simultaneously. | Alarm time is changed. |
| Control Panel Clock Control Alarm On/Off | Press and release ALARM button. | Alarm indicator light turned on or off, alarm enabled if light on. |
| Control Panel Clock Control Alarm Display | Press and hold ALARM button for more than 1 second. | Alarm time displayed without changing the state of the alarm indicator. |
| Control Panel Clock Control Display | Press DISP button. | Display brightness should change (bright, dim, off). |
| Control Panel Clock Control Test | Display set to off.<br>Press TIME button. | Current time is displayed. |

* Ambient and cab air temperatures should be between 67 to 77°F (19 to 25°C).

**Table 6, Sleeper HVAC System Testing Procedure**

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection

# Sleeper System Troubleshooting

## System Diagnostic Error Codes

Error codes can be displayed by pressing the fan up and fan down buttons simultaneously. The current error status will be shown on the digital display. Pressing the fan up button repeatedly will scroll the display through any existing error codes. See **Table 7** for a list of the error codes.

| Error Codes | |
|---|---|
| **Error Code** | **Problem** |
| E0 | No fault detected |
| E1 | Bunk sensor shorted |
| E2 | Bunk sensor disconnected |
| E3 | Not assigned |
| E4 | Not assigned |
| E5 | Not assigned |
| E6 | Not assigned |
| E7 | Not assigned |
| E8 | Not assigned |
| E9* | Actuator shorted |
| E10* | Actuator disconnected |

* This feature was not available prior to November 1999.

**Table 7, Error Codes**

# Sleeper HVAC System Troubleshooting Procedures

**Problem—No Display on Control Panel**

- Turn on control panel with ON button.
- Check to see if the display illuminates.
- Verify that the control panel is plugged in to the wiring harness.
- Check to see if the wiring harness is wired to vehicle properly and the battery is good.
- Verify that all fuses are intact.
- Check the control panel.

**Problem—Fan Does Not Work**

- Turn up fan with the fan up button.
- Verify that the ignition is on.
- Make sure blower fan is plugged in to wiring harness.
- Verify that the wiring between the sleeper control panel and the sleeper unit is correct.
- Verify that 12V is supplied to fan.
- Check the fan.
- Check the control panel.

**Problem—No Heating**

- Using the temperature up button, increase the temperature.
- Verify that warm coolant is flowing to the heater core by feeling the heater hoses in the sleeper box under the bunk.
- Verify that the actuator on the unit is moving the blend door when the temperature set point is changed from cold to hot.

**Problem—No Cooling**

- Using the temperature down button, decrease the temperature.
- Verify that the actuator on the unit is moving the blend door when the temperature set point is changed from hot to cold.
- Verify that compressor clutch is engaging.
- Verify that the circuit breakers or fuses are intact.
- Verify that the system is fully charged with refrigerant.
- See "Cab System Troubleshooting Procedures."

**Problem—Sleeper Unit Cannot be Turned on From the Cab Unit**

- Verify that both the sleeper control panel and the cab control panel are getting correct power and ground lines.
- Verify that the two serial communication wires connecting the front unit to the sleeper unit are correctly connected and not reversed.

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection

## Voltage Levels

See **Table 8** and **Table 9** for the function of the wires in the vehicle interface harnesses. Eight wires run from the sleeper control panel to the sleeper HVAC unit wiring harness. These wires are connected directly through, such as A to A, B to B, and so on.

| Eight-Pin Packard Vehicle Interface Harness | | |
|---|---|---|
| **Color** | **Line** | **Function** |
| Orange | Blower High | Should be +12V when the blower fan is on the highest speed. |
| Red | Blend Door (+) | Output signal to blend door actuator motor. This signal connects to the motor built into the blend door actuator. The voltage level between this pin and pin C, –blend door (–) will be –12V, 0V, or +12V depending on the desired rotation of the blend door actuator. |
| Brown | Blend Door (–) | Output signal to blend door actuator motor. This signal connects to the motor built into the blend door actuator. The voltage level between this pin and pin B, –blend door (+) will be –12V, 0V, or +12V depending on the desired rotation of the blend door actuator. |
| Purple | +5V Reference Voltage | Output provides 5 volt reference voltage for the blend door actuator feedback potentiometer. Should be +5V. |
| Purple | Blend Door Feedback | Input signal from blend door actuator feedback potentiometer. This signal will be in the range of 0V to 5V depending on blend door position. |
| Yellow | Return Air Temperature Sensor Signal | Input signal from return air temperature sensor. This thermistor probe is installed in the return air duct to measure sleeper cab temperature. The temperature measured at this point is used to control the HVAC system. Should be in the range of 0V to 5V depending on temperature. |
| Black | Analog Ground | Output provides analog ground for the blend door actuator feedback potentiometer and the return air temperature sensor. Should be 0V. |
| Black | Blower Ground | Output provides high current ground for the blower fan. Should be 0V. |

**Table 8, Eight-Pin Packard Vehicle Interface Harness**

| Six-Pin Packard Vehicle Interface Harness | | |
|---|---|---|
| **Color** | **Line** | **Function** |
| Red | Power | Input provides +12VDC battery power for the HVAC system. This line provides power to the HVAC system for all functions. Should be 12V. |
| Orange | Ignition | Input provides +12VDC power for the HVAC system when the power is on. This is a low current input to provide a signal that the ignition is on. Should be 12V when the ignition is on. |
| Blue | Serial (+) Bunk1 | Input/output provides serial information link between the sleeper HVAC and the cab HVAC. This line should be connected to the bunk1 line on the cab HVAC unit. In use, this line will be a serial stream of 0V/5V signals. The average voltage reading on this pin will be around 2.5V. |
| White | Serial (–) Bunk2 | Input/output provides serial information link between the sleeper HVAC unit and the cab HVAC unit. This line should be connected to the bunk2 line on the cab HVAC unit. In use, this line will be a serial stream of 0V/5V signals. The average voltage reading on this pin is around 2.5V. |
| Black | Ground | Input provides ground for the HVAC system. Should be 0V. |

**Table 9, Six-Pin Packard Vehicle Interface Harness**

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection

# Wiring Diagrams

See **Fig. 6** for the ATC sleeper HVAC wiring diagram.

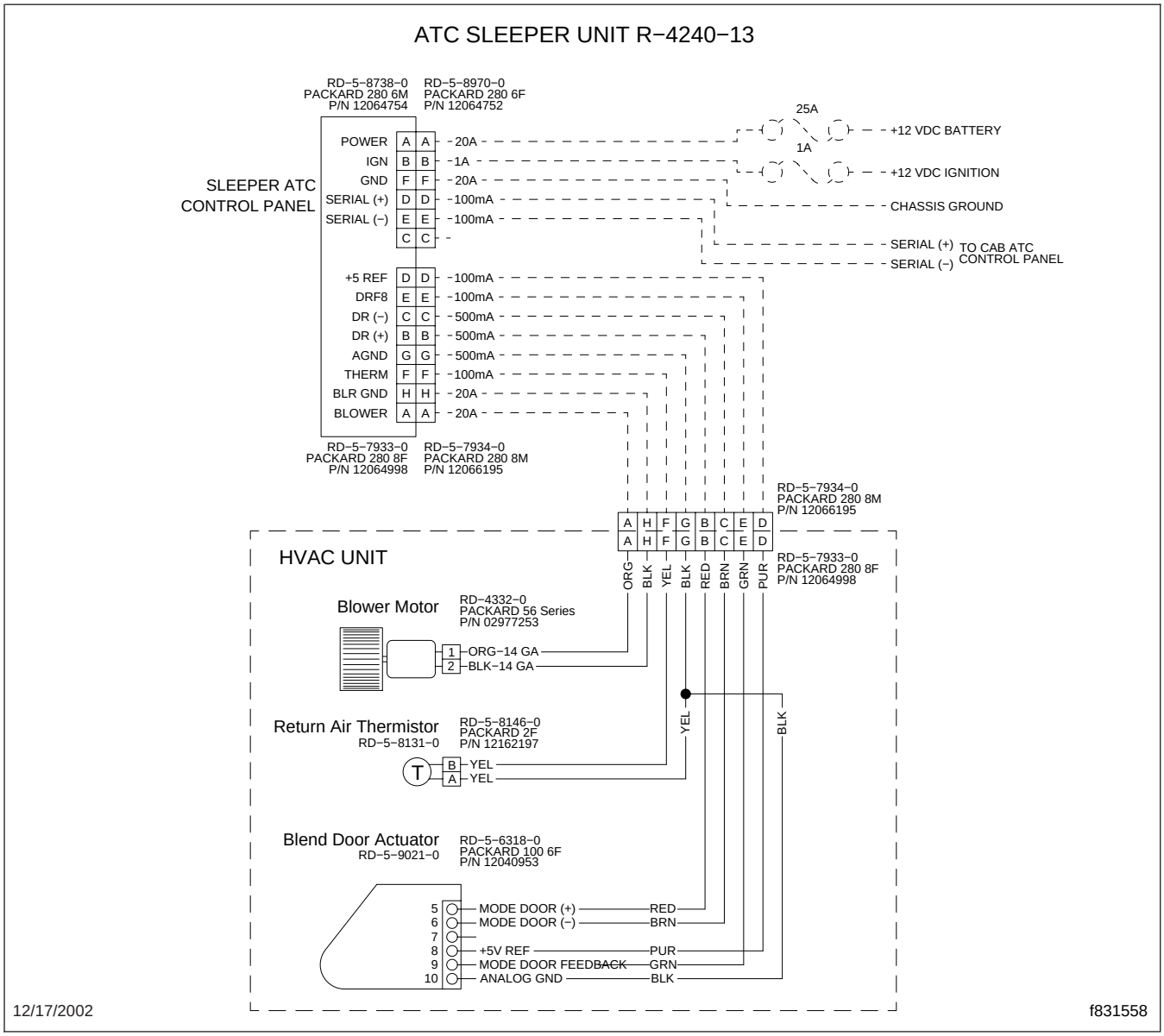



**Fig. 6, ATC Sleeper HVAC Wiring Diagram**

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# Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

## General Information

The Automatic Temperature Control (ATC) system is the latest in Red Dot electronic controllers. The ATC provides true cab temperature control and continuously variable blower fan speed. This is accomplished through the use of advanced microprocessor and sensor technology.

The troubleshooting procedures in this subject pertain to the Red Dot ATC heater and air conditioner with Advanced Diagnostics. In November 2001, Western Star began offering the Red Dot ATC heater and air conditioner with Advanced Diagnostics.

Between August 16, 1999, and November 2001, Western Star offered the ATC heater and air conditioner with System Protection. For information and troubleshooting procedures on the ATC heater and air conditioner with System Protection, see **Subject 310**.

## Control Operation Specifications

Temperature Control Range

- 60 to 90°F (16 to 32°C)

Blower Fan Control

- Pulse Width Modulation, maximum current handling: 25 amps

Temperature Sensors

- Cab Air Temperature: monitors the average cab air temperature, micro fan insures air flow across the sensor
- Duct Outlet Temperature: When heat is required, the sensor prevents high speed cold air from blowing out of the ducts until the heater core warms up (AUTO mode only).
- Evaporator Core Probe: Prevents ice from forming in the evaporator core: less than 34°F (1°C) clutch cut out, greater than 37°F (3°C) clutch turn on

High Side Pressure Control

- high side transducer
- prevents operation at low ambient temperatures: less than 40 psig (276 kPa)–no A/C operation
- high pressure protection: greater than 350 psig (2413 kPa) clutch cut out, less than 275 psig (1896 kPa) clutch turn on
- condenser fan request: greater than 275 psig (1896 kPa) condenser fan turn on, less than 225 psig (1551 kPa) condenser fan turn off
- minimum condenser fan on time: 30 seconds

Low Side Pressure Control

- low side transducer
- low pressure protection: less than 7 psig (48 kPa) clutch cut out, greater than 25 psig (172 kPa) clutch turn on

Controlled Devices

- A/C compressor clutch circuit–maximum clutch cycle rate: five cycles/minute
- blower fan motor
- water valve
- bunk power unit

## Operation of the Cab ATC

### Controls

#### Blower Fan Speed Rotary Switch

The heater or air conditioner is turned on when the blower fan speed rotary switch is turned clockwise from the off position. When the heater or air conditioner is turned on, the LED display is illuminated. See **Fig. 1**. The display shows the current temperature set point. The blower fan switch has four speed settings. The AUTO setting on the blower fan switch places the HVAC system in the automatic blower fan speed control mode. When in the automatic mode, the fan speed can vary in infinite increments as necessary to maintain the temperature set by the user. As the cab temperature reaches the set point temperature, the blower speed decreases.

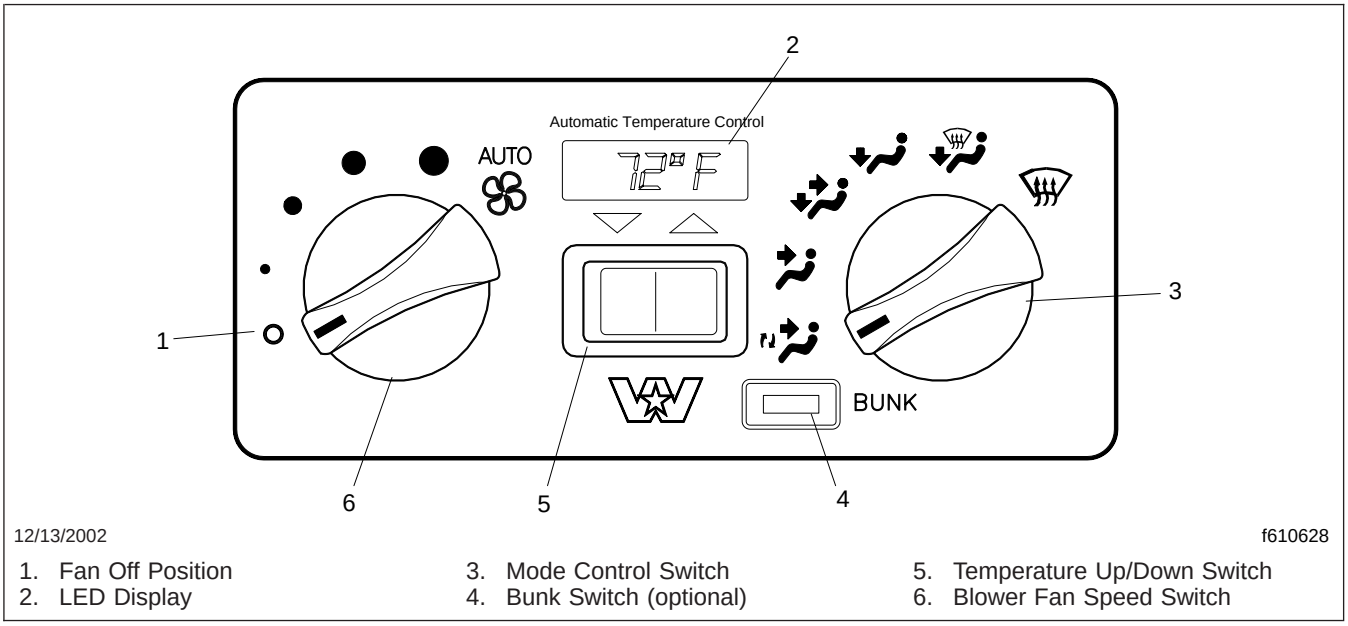
#### Temperature Up/Down Rocker Switch

Press and release the temperature up/down rocker switch to set the desired temperature. See **Fig. 1**. Pressing and holding the temperature up/down switch will cause the set point temperature to continuously increase or decrease. The HVAC system will attempt to achieve and hold the desired set point

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics




1. Fan Off Position
2. LED Display
3. Mode Control Switch
4. Bunk Switch (optional)
5. Temperature Up/Down Switch
6. Blower Fan Speed Switch

**Fig. 1, ATC Cab Climate Control Panel**

temperature by controlling the compressor clutch and water valve. When in AUTO mode, the blower fan speed is controlled automatically as well.

### Mode Control Rotary Switch

The mode control rotary switch sets the discharge mode of air flow. See **Fig. 2**.

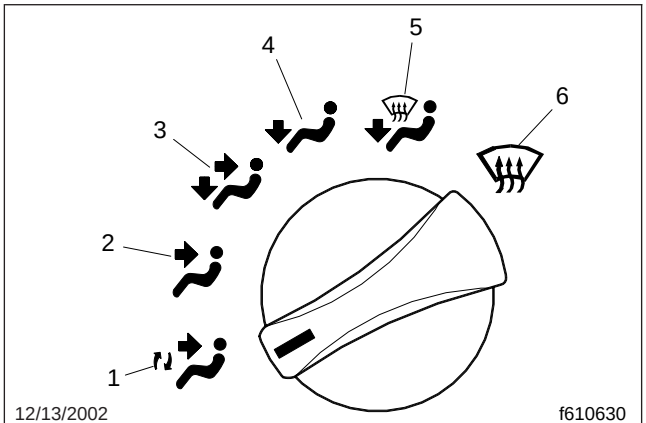
### Bunk Switch

The bunk switch enables or disables the bunk heater and air conditioner. When the bunk switch is on, the switch is illuminated. The bunk switch is optional.

## Heater Operation

The ATC automatically controls the HVAC system to maintain the cab air temperature close to the set point selected by the user. The ATC adjusts the air temperature blown through the outlets to maintain this temperature. If more heat is desired, increase the set point temperature by pressing and releasing the right side of the temperature up/down switch. If less heat is desired, decrease the set point by pressing and releasing the left side of the temperature up/down switch.

To obtain maximum heating, set the temperature to 90°F (32°C). The system will put out maximum heat continuously, even if the cab temperature exceeds




1. Dash Vents (recirculating air)
2. Dash Vents (fresh air)
3. Bi-Level (fresh air)
4. Floor (fresh air)
5. Floor and Defrost (fresh air)
6. Defrost (fresh air)

**Fig. 2, Mode Control Switch Settings**

the set point temperature. For maximum heating, turn the blower fan speed switch to the highest speed setting, not AUTO.

With the fan switch in AUTO mode, the fan speed will remain low until the air temperature warms up. Once the air temperature is warm, the fan speed will

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increase as necessary to warm up the cab to the set point temperature. Once the cab reaches the set point temperature, the fan speed will decrease.

A comfortable set point for heating is between 72 to 78°F (22 to 26°C). Change the temperature set point in small increments for best results. Once a comfortable temperature is reached, this temperature will be maintained without adjusting the set point.

## Defrosting or Defogging Operation

The defrost mode is used to deice, defrost, or defog the windows. Turn the mode control switch to the defrost mode. See **Fig. 2**. The ATC automatically increases the blower speed and the air temperature to quickly defrost the windows.

In cold or humid conditions, more heat and air flow are required to clear the windows. The set point temperature and the blower speed should be adjusted as necessary to maintain a clear windshield at all times. For maximum defrost, increase the set point temperature to the maximum setting (90°F or 32°C) and increase the blower speed to maximum fan, not AUTO.

NOTE: The air conditioner is enabled when in defrost mode. The air conditioner is used to dehumidify the air entering the cab and to remove the moisture from the windshield.

## Air Conditioner Operation

The ATC feature automatically controls the HVAC system to maintain the cab air temperature close to the set point selected by the user. The ATC adjusts the air temperature blown through the ducts to maintain the selected temperature. If more cooling is desired, decrease the set point temperature by pressing the left side of the temperature up/down switch. If less cooling is desired, increase the set point by pressing the right side of the temperature up/down switch.

To obtain maximum cooling, set the set point temperature to 60°F (16°C). The system will put out maximum cooling continuously, even if the cab temperature drops below the set point temperature. Turn the blower fan switch to highest fan speed, not AUTO.

In AUTO mode, the fan speed adjusts as necessary to keep the cab at the set point temperature. The further away the cab temperature is from the set point, the higher the fan speed.

For maximum cooling, turn the mode control switch to the recirculation mode. See **Fig. 2**. Once the cab is cool, any of the other modes can be used, such as dash vents or bi-level.

A comfortable set point for cooling is between 68 to 74°F (20 to 23°C). Change the temperature set point in small increments for best results. Once a comfortable temperature is reached, this temperature will be maintained without adjusting the set point.

## Ventilation

The dash vents (recirculating air) mode is the only mode that recirculates the air in the cab. All other modes draw in fresh air from the outside of the vehicle. Use the recirculation mode for short periods of time to prevent fumes or dust from entering the cab or to obtain maximum cooling or heating.

## Changing Temperature Units

The temperature units can be changed from Fahrenheit (°F) to Celsius (°C) or from Celsius to Fahrenheit by turning the ignition on, the blower fan speed switch to off, and pressing and holding the temperature up/down switch on the side with the blue arrow for five seconds. The current temperature unit will then be shown on the LED display. Press the temperature down switch again to toggle between the °F and °C temperature units. Changing the temperature units on the cab climate control panel will also effect the corresponding units on the bunk control panel. To obtain more accurate temperature control, use the Fahrenheit (°F) setting.

# Cab System Logic

## Automatic Fan Speed Control

The fan speed is determined by the system as required. The fan speed is based on the difference between the set point temperature and the actual cab temperature. The greater the difference, the greater the fan speed. When the temperature is too hot and heating is occurring, or if the temperature is too cold and cooling is occurring, then the fan speed will be held at minimum. This condition can occur when the

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

cab is heating or cooling quickly and the temperature overshoots the set point temperature. The fan speed will be set to high if a cab temperature sensor error occurs. In AUTO fan speed mode, when heating is occurring, the fan speed is also limited by the outlet duct temperature. If the duct temperature is less than 72°F (22°C), then the fan speed will be limited to low fan speed. The fan speed limit will gradually increase as the duct temperature increases until the duct temperature reaches 95°F (35°C). This limit is disabled if a duct temperature sensor error occurs. In AUTO fan speed mode, all fan speed changes are done gradually. See **Table 1** for a list of the controls for the fan speed.

| Fan Speed Control | |
|---|---|
| **Fan Speed** | **Control** |
| O | Manual mode fan off |
| 1 | Manual mode fan low |
| 2 | Manual mode fan medium 1 |
| 3 | Manual mode fan medium 2 |
| 4 | Manual mode fan high |
| 5 | Automatic fan speed control |

**Table 1, Fan Speed Control**

In either automatic or manual mode, the initial fan speed on startup will gradually increase from off to the desired fan speed.

### Compressor Clutch Control

The clutch can be active in any mode when the fan speed is not off. The clutch is activated as required to maintain the set point temperature.

In defrost mode, the clutch is forced on to provide cab air dehumidification.

In the event of a cab temperature sensor error, the system will operate in a manual temperature control mode with a set point of 60°F (16°C) corresponding to full air conditioning, 75°F (24°C) corresponding to neutral, and 90°F (33°C) corresponding to full heat.

In any mode, the clutch activation can be disabled by the evaporator temperature sensor, the low pressure transducer, or the high pressure transducer. The evaporator temperature sensor trip points will be determined by the system to maintain the desired cab temperature. As less cooling is required, the evaporator temperature sensor trip points will increase, so as to maintain a fairly constant core temperature. In the case of full A/C or defrost mode, the evaporator temperature sensor trip points will be 34°F (1°C) clutch off and 37°F (3°C) clutch on. The clutch will stay off for a minimum of 11 seconds before reengaging.

The low side pressure transducer trip points are 7 psig (48 kPa) clutch off and 25 psig (172 kPa) clutch on. The high pressure transducer high trip points are 350 psig (2450 kPa) clutch off and 275 psig (1896 kPa) clutch on. The high pressure transducer low trip points are 40 psig (276 kPa) clutch off and 50 psig (345 kPa) clutch on. If a high pressure transducer error or a low pressure transducer error occurs, then clutch activation will be disabled.

### Condenser Fan Control

The condenser fan trip points are 275 psig (1896 kPa) fan on and 225 psig (1551 kPa) fan off. The fan will immediately be engaged if the high side pressure exceeds 275 psig (1896 kPa). This is accomplished by breaking continuity between E and F on the six-pin Packard Vehicle Interface Connector which generates a fan on request to the engine fan control circuitry. The fan will remain on for a minimum of 30 seconds. The fan will turn off if the high side pressure drops below 225 psig (1551 kPa) **and** if 30 seconds has elapsed since the fan was last turned on. The fan will be disengaged by creating continuity between terminals E and F on the six-pin Packard vehicle interface connector which triggers the engine fan control circuitry.

## Cab System Function Check

See **Table 2** for the ATC HVAC system testing procedure.

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| ATC HVAC System Testing Procedure | | |
|---|---|---|
| **Control or Display** | **Action** | **Test Reaction** |
| Control Panel Display | Turn fan off.<br>Turn ignition on. | Display flashes **8888** briefly. |
| Blower Fan Speed Switch | Turn fan on. | Display reads 75°F (24°C) or last set point.<br>Air should be blowing. |
| Blower Fan Speed Switch | Turn fan to all speeds. | Amount of air flow should change accordingly. |
| Temperature Up/Down Switch* | Set temperature to lowest setting.<br>Set fan to AUTO. | Blower fan increases to high.<br>Air conditioner turns on. |
| Temperature Up/Down Switch† | Set temperature to highest setting.<br>Set fan to AUTO. | Blower fan speed increases to high.<br>Heater turns on. |
| Temperature Up/Down Switch | Set temperature to approximate cab temperature. | Blower fan speed decreases to low. |
| Mode Control Switch | Mode door control position changed. | Vent mode should change accordingly. |
| Mode Control Switch | Mode set to defrost. | A/C clutch should engage. |
| Bunk Switch | Press BUNK switch | BUNK switch illuminates.<br>Bunk unit turns on. |
| Error Codes | Turn blower switch to off.<br>Press and hold the up side of temperature up/down switch.<br>Press up side of temperature up/down switch again to scroll through errors. | Error codes displayed.<br>E0 indicates no faults detected. |
| Degree Units Change | Turn blower switch to off.<br>Press and hold the down side of temperature up/down switch.<br>Press down side of temperature up/down switch again to change units. | Temperature unit displayed.<br>Units change when the rocker switch is pressed. |

* Ambient and cab air temperatures should be between 67 to 77°F (19 to 25°C).

† Ambient and cab air temperatures should be between 67 to 77°F (19 to 25°C) and vehicle engine should be at normal operating temperature.

**Table 2, ATC HVAC System Testing Procedure**

# Cab HVAC System Troubleshooting

## System Diagnostics/Error Codes

Error codes can be displayed by turning the ignition on, the blower fan speed switch to off, and pressing and holding the temperature up switch for five seconds. The current error status will be shown on the LED display. Pressing the temperature up switch again repeatedly will scroll the display through any existing error codes. See **Table 3** for a list of the error codes.

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Error Codes | |
|---|---|
| **Error Code** | **Problem** |
| E0 | No fault detected |
| E1 | Cab sensor shorted |
| E2 | Cab sensor disconnected |
| E3 | Evaporator probe shorted |
| E4 | Evaporator probe disconnected |
| E5 | Duct sensor shorted |
| E6 | Duct sensor disconnected |
| E7 | Low pressure transducer fault–disconnected or shorted |
| E8 | High pressure transducer fault–disconnected or shorted |
| E9* | High pressure and low pressure transducer connectors switched |
| E17 | ECU module failure, disconnected, or no power, or serial communication wires disconnected or reversed |

* This error code will not be displayed if the ambient temperature is below 40°F (4°C) or if the pressure in the A/C system is lower than 30 psig (207 kPa); however, the A/C clutch will not engage under these conditions even if the connectors are switched. This error code may be displayed if the A/C has been engaged in the last 10 minutes prior to checking for error codes. If this error code is displayed, allow the vehicle to sit with the ignition off for at least 10 minutes and check errors again or use the advanced diagnostics to verify refrigerant pressures.

**Table 3, Error Codes**

## Red Dot ATC Advanced Diagnostics

NOTE: The advanced diagnostics are applicable only to vehicles built from November 2001.

The Red Dot ATC Advanced Diagnostics control panel allows the technician to see real time system information on the control panel display that will assist in servicing the HVAC system. This real time information can help the service technician diagnose A/C system problems without attaching a pressure gauge set or using a voltmeter.

### Entering the Diagnostic Mode

With the blower fan speed switch in the off position, press and hold the temperature up switch for five seconds to view standard error codes, E0 to E17. See **Fig. 3**.

With the blower fan speed switch still in the off position, release the temperature up switch, then press and hold the temperature up switch for five seconds to view real time diagnostics. See **Fig. 4** and **Table 4**.

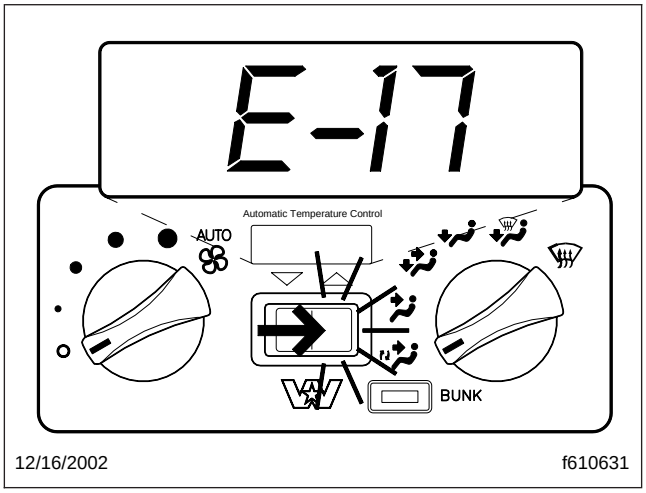



**Fig. 3, Standard Error Code**

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

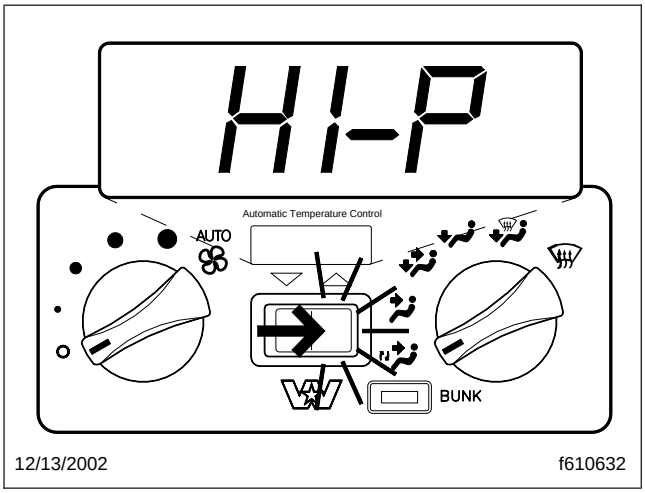



**Fig. 4, Real Time Diagnostic Code**

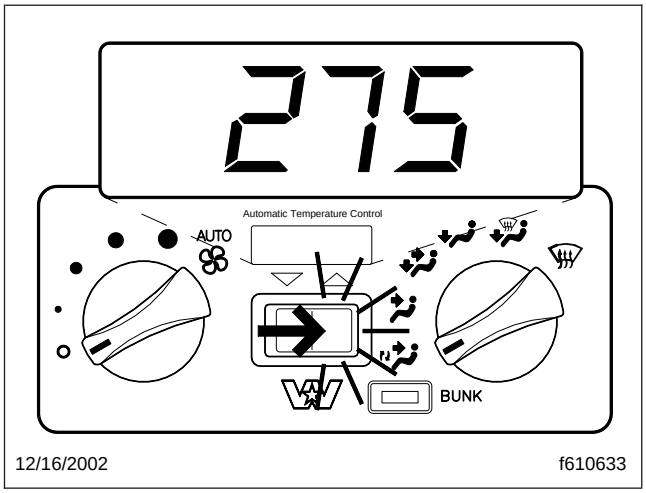



**Fig. 5, Real Time Diagnostic Value**

| Diagnostic Codes | |
|---|---|
| **Diagnostic Code** | **Diagnostic** |
| HI–P | High side refrigerant pressure |
| LO–P | Low side (suction) refrigerant pressure |
| CAB | Cab air temperature |
| DUCT | Duct air temperature |
| EVAP | Evaporator core temperature |
| A–C | A/C clutch request (on/off) |
| HEAT | Water valve request (on/off) |
| FAN | Engine fan request (on/off) |

**Table 4, Diagnostic Codes**

After a few seconds, the real time value measured by the ATC is displayed. This value will continuously update. See **Fig. 5**.

Pressing the temperature up/down switch repeatedly scrolls through all of the available diagnostic information.

See **Table 4** for a list of the real time diagnostics that can be displayed by pressing the temperature up/down switch in either direction.

The blower fan can be turned on while in diagnostic mode allowing the system to be checked under various conditions. Turn the blower fan speed switch off to return to normal operation. Turning off ignition power also returns the system to normal operation.

## Cab HVAC System Troubleshooting Tables

For troubleshooting the cab HVAC system, see **Table 5**, **Table 6**, **Table 7**, **Table 8**, **Table 9**, **Table 10**, **Table 11**, **Table 12**, **Table 13**, **Table 14**, **Table 15**, and the five unnumbered tables following **Table 15**.

| Problem—No Display on Control Panel | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Check to make sure control panel connector is plugged in. | Illuminates | No problem found. |
| | Set blower speed to any speed (not off). The display should illuminate. | Does not illuminate | **Go to step 2**. |

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Problem—No Display on Control Panel | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 2 | Check power and ground circuits to control panel (pins B and C). | Okay | Replace control panel. |
| | | Not okay | Check wiring and repair as necessary. |

**Table 5, Problem—No Display on Control Panel**

| Problem—Fan Does Not Work | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Check to make sure fan is plugged in to the wiring harness. | Okay | **Go to step 2**. |
| | | Not okay | Plug fan in, check operation. |
| 2 | Set blower speed to high.<br>Check voltage drop across blower motor terminals (with connector plugged in). | 12V or more | Check for obstructed blower wheel. If okay, replace blower motor. |
| | | Less than 12V | **Go to step 3**. |
| 3 | Check power and ground to the ECU.<br>Check fan power circuit between the fan and the ECU.<br>Check fan ground circuit. | Okay | **Go to step 4**. |
| | | Not okay | Repair wiring as necessary. |
| 4 | Check fan power output from ECU. Backprobe pin C at the ECU (with fan on high). | 12V | No problem found. |
| | | 0V (much less than 12V) | Replace ECU. |

**Table 6, Problem—Fan Does Not Work**

| Problem—No Heating | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Check the system for error codes. | Error code(s) active | Repair fault. Proceed to **step 2** if problem persists. |
| | | No error codes | **Go to step 2**. |
| 2 | Using the temperature up/down switch, increase the temperature to the highest setting.<br>Verify that warm coolant is flowing to the heater core by feeling the heater hoses.<br>NOTE: The engine must be at operating temperature. | Okay | No problem found. |
| | | Not okay | Make sure the heater hose valves on the engine block (if equipped) are open. If so, **go to step 3**. |

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Problem—No Heating | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 3 | Using the Advanced Diagnostics on the control panel, check the status of the water valve (HEAT). When the temperature is adjusted to maximum, the water valve status (HEAT) should be ON. When the temperature is adjusted to minimum, the water valve status should be OFF.<br>Check the following:<br>Check voltage at water valve connector and make sure it corresponds to the water valve (HEAT) status on the display as follows:<br>HEAT ON = 0V<br>HEAT OFF = 12V<br>NOTE: Connector must be disconnected. Measure voltage across both pins on the harness side of the connector (opposite side of water valve).<br>NOTE: A condition in which the water valve will cycle open and closed can be obtained by exiting the diagnostic mode. Turn the blower speed to off, then back on. Set the temperature to about 5 degrees higher than the cab temperature, then enter the advanced diagnostic mode again. | Okay | Check air lines to water valve. If okay, replace the water valve. |
| | | Not okay | Check the water valve circuit between the water valve connector and the ECU. Repair as necessary. Check heater core fins for blockage. If okay, replace the ECU. |

**Table 7, Problem—No Heating**

| Problem—No Cooling | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Check the system for error codes. | Error code(s) active | Repair fault(s). Proceed to **step 2** if problem persists. |
| | | No error codes | **Go to step 2**. |
| 2 | Using the temperature up/down switch, decrease the temperature to the lowest setting with the engine running.<br>Set the mode control switch to defrost.<br>Using the Advanced Diagnostics on the control panel, check if the A/C clutch request (A-C) is on. | Okay | **Go to step 3**. |
| | | Not okay | **Go to step 5**. |

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Problem—No Cooling | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 3 | The compressor clutch should have engaged in the previous step. Did the clutch engage? | Yes | Check to make sure that water valve is closed by feeling the heater hoses. If not, repair wiring or replace water valve as necessary.<br>If water valve is closed, check refrigerant charge and perform diagnostics on the refrigerant system. Repair as necessary. Also see diagnostics in **Table 10**. |
| | | No | **Go to step 4**. |
| 4 | Check for power and ground at the compressor clutch. | Okay | Check A/C clutch, replace as necessary. |
| | | Not okay | Check A/C clutch circuit fuses, relays, and wiring. Repair as necessary. |
| 5 | Using the Advanced Diagnostics on the control panel, check the HI-P (high pressure value) with the engine off. If the pressure is below 50 psi (345 kPa), the clutch will not engage. Assuming the compressor does not engage, the pressure should correspond to the values in **Table 16**.<br>NOTE: High pressure transducer trip points are as follows:<br>• High 350 psi (2413 kPa) clutch off, 275 psi (1896 kPa) clutch on<br>• Low 40 psi (276 kPa) clutch off, 50 psi (345 kPa) clutch on | Okay | **Go to step 6**. |
| | | Not okay | Check refrigerant charge. If low, check for leaks and repair as necessary. |
| 6 | Using the Advanced Diagnostics on the control panel, check the EVAP (evaporator temperature value).<br>First verify that the system is fully charged with the correct amount of refrigerant. The evaporator temperature probe, located at the top of the HVAC unit, should prevent the front evaporator from freezing. In the event that a freezing evaporator coil is diagnosed, enter the advanced diagnostic mode and select EVAP.<br>The value displayed is the temperature measured by the evaporator probe. Make sure that the value drops when the A/C is turned on. The ATC system will not allow the clutch to engage if the temperature measured by the probe is lower than 34°F (1°C). If the temperature displayed is greater than 34°F (1°C) and the core is still freezing, try repositioning the probe by pulling it up and out of the housing in small increments and checking the display for the coldest spot. | Okay | Problem resolved. |
| | | Not okay | Replace evaporator. |

**Table 8, Problem—No Cooling**

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Problem—System Emits Cool Air When Heat is Needed | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Check the system for error codes. | Error code(s) active | Repair fault(s). Proceed to **step 2** if problem persists. |
| | | No error codes | **Go to step 2**. |
| 2 | Using the temperature up/down switch, increase the temperature to the highest setting.<br>Verify that warm coolant is flowing to the heater core by feeling the heater hoses.<br>NOTE: The engine must be at operating temperature. | Okay | **Go to step 3**. |
| | | Not okay | Make sure the heater hose valves on the engine block (if equipped) are open. If they are, **go to step 3** of troubleshooting **Table 7**. |
| 3 | Check the connection of the cab air temperature sensor (thermistor) and make sure the fan in the sensor is spinning. | Okay | **Go to step 5**. |
| | | Not okay | If connector is unplugged, connect or repair as necessary.<br>If sensor fan is not spinning, **go to step 4**. |
| 4 | At the cab air temperature sensor connector, measure voltage across pins 2 and 4.<br>There should be 12V at these pins. They supply power and ground to the sensor fan. | Okay | Replace cab air temperature sensor. |
| | | Not okay | Repair sensor fan power and ground circuits as necessary. |
| 5 | Using the Advanced Diagnostics on the control panel, check the CAB temperature. This is the temperature sensed by the cab air temperature sensor.<br>The CAB temperature value should read close to the ambient temperature in the cab (measure with a thermometer if necessary). If the sensor reading is below the set temperature on the control panel, then heat should be available. If the CAB value does not read the approximate ambient temperature in the cab, then the test result is not okay. | Okay | No problem found. Repeat diagnostics, check water valve circuit. |
| | | Not okay | Check the sensor accuracy. Replace the sensor if necessary. |

**Table 9, Problem—System Emits Cool Air When Heat is Needed**

| Problem—System Emits Hot Air When Cooling is Needed | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Check the system for error codes. | Error code(s) active | Repair fault(s). Proceed to **step 2** if problem persists. |
| | | No error codes | **Go to step 2**. |
| 2 | Using the temperature up/down switch, decrease the temperature to the lowest setting.<br>Verify that warm coolant is not flowing to the heater core by feeling the heater hoses.<br>NOTE: The engine must be at operating temperature. | Okay | **Go to step 3**. |
| | | Not okay | **Go to step 3** of **Table 7** to check water valve operation. |

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Problem—System Emits Hot Air When Cooling is Needed | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 3 | Using the temperature up/down switch, set the temperature to the lowest setting (engine running).<br>Set the mode control switch to defrost.<br>Using the Advanced Diagnostics on the control panel, check if the A/C clutch request A-C is on. | Okay | **Go to step 4**. |
| | | Not okay | **Go to step 5** of **Table 8**. |
| 4 | The compressor clutch should have engaged in the previous step. Did the clutch engage? | Yes | **Go to step 6**. |
| | | No | **Go to step 5**. |
| 5 | Check for power and ground at the compressor clutch. | Okay | Check A/C clutch, replace as necessary. |
| | | Not okay | Check A/C clutch circuit fuses, relays, and wiring. Repair as necessary. |
| 6 | Check the connection of the cab air temperature sensor (thermistor) and make sure the fan in the sensor is spinning. | Okay | **Go to step 8**. |
| | | Not okay | If connector is unplugged, connect or repair as necessary.<br>If sensor fan is not spinning, **go to step 7**. |
| 7 | At the cab air temperature sensor connector, measure voltage across pins 2 and 4.<br>There should be 12V at these pins. They supply power and ground to the sensor fan. | Okay | Replace cab air temperature sensor. |
| | | Not okay | Repair sensor fan power and ground circuits as necessary. |
| 8 | Using the Advance Diagnostics on the control panel, check the CAB temperature. This is the temperature sensed by the cab air temperature sensor.<br>The CAB temperature value should read close to the ambient temperature in the cab (measure with a thermometer if necessary). If the sensor reading is above the set temperature on the control panel, then cooling should be available. If the CAB value does not read the approximate ambient temperature in the cab, then the test result is not okay. | Okay | Diagnosis refrigerant system, repair as necessary. |
| | | Not okay | Check the sensor accuracy. Replace the sensor if necessary. |

**Table 10, Problem—System Emits Hot Air When Cooling is Needed**

| Problem—Cab Temperature Control is Inconsistent | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Check the system for error codes. | Error code(s) active | Repair fault(s). Proceed to **step 2** if problem persists. |
| | | No error codes | **Go to step 2**. |
| 2 | Check for any excessive air leaking from the ducts behind the dash that is effecting the temperature cab temperature sensor. | Okay | **Go to step 3**. |
| | | Not okay | Repair leaks as necessary. |

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Problem—Cab Temperature Control is Inconsistent | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 3 | Check the connection of the cab air temperature sensor (thermistor) and make sure the fan in the sensor is spinning. | Okay | **Go to step 5**. |
| | | Not okay | If connector is unplugged, connect or repair as necessary.<br>If sensor fan is not spinning, **go to step 4**. |
| 4 | At the cab air temperature sensor connector, measure voltage across pins 2 and 4.<br>There should be 12V at these pins. They supply power and ground to the sensor fan. | Okay | Replace cab air temperature sensor. |
| | | Not okay | Repair sensor fan power and ground circuits as necessary. |
| 5 | Using the Advanced Diagnostics on the control panel, check the CAB temperature. This is the temperature sensed by the cab air temperature sensor.<br>The CAB temperature value should read within 4 degrees of the ambient temperature in the cab (measure with a thermometer if necessary). If the CAB value does not read the approximate ambient temperature in the cab, then the test result is not okay. | Okay | **Go to step 6**. |
| | | Not okay | Check the sensor accuracy. Replace the sensor if necessary. |
| 6 | Verify that most recent version of the ECU is installed (RD-6-5108-0). | Okay | No problem found. |
| | | Not okay | Replace ECU if vehicle is still under warranty. |

**Table 11, Problem—Cab Temperature Control is Inconsistent**

| Problem—Engine Fan Not Engaging or Disengaging Correctly | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Check the system for error codes. | Error code(s) active | Repair fault(s). Proceed to **step 2** if problem persists. |
| | | No error codes | **Go to step 2**. |
| 2 | What is the symptom? | Engine fan stays on. | **Go to step 3**. |
| | | Engine fan won't turn on. | **Go to step 4**. |

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Problem—Engine Fan Not Engaging or Disengaging Correctly | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 3 | Using the Advanced Diagnostics on the control panel, check the FAN status while the air conditioning is operating. Check if the FAN status remains on or cycles between on/off. | Status always on | Check high side system pressure using the Advanced Diagnostics. Pressure above 275 psi (1896 kPa) will cause the engine fan status to be on. If pressure remains high, diagnose refrigerant system. For example, check for restricted airflow across the condenser. |
| | | Status cycles between on/off | Check if engine ECU is calling for the fan to be on (consult engine manufacturer's software). If not, the following are possible causes:<br>• faulty engine fan relay<br>• open circuit between engine fan relay and HVAC ECU<br>• no ignition 12V supply to engine fan relay<br>• shorted fan control circuit wiring between relay and engine ECU<br>Check the possible causes and repair as necessary. |
| 4 | Using the Advanced Diagnostics on the control panel, check the FAN status while the air conditioning is operating. Check if the FAN status remains off or cycles between on/off. | Status always off | Check high side system pressure using the Advanced Diagnostics. Pressure above 275 psi (1896 kPa) will cause the engine fan status to be on. Pressure may be too low to call for engine fan to be on. Diagnose refrigerant system. |
| | | Status cycles between on/off | The following are possible causes:<br>• faulty engine fan relay<br>• open fan control circuit wiring between relay and engine ECU<br>Check the possible causes and repair as necessary. |

**Table 12, Problem—Engine Fan Not Engaging or Disengaging Correctly**

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Problem—Sleeper Unit Not Engaging or Disengaging Correctly | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Check the system for error codes. | Error code(s) active | Repair fault(s). Proceed to **step 2** if problem persists. |
| | | No error codes | **Go to step 2**. |
| 2 | Check if bunk switch indicator is illuminating. | Okay | Check if sleeper unit is operating correctly. If not, check sleeper unit power and ground wiring. Diagnose sleeper unit if necessary. |
| | | Not okay | Check serial bus wiring and connections. Repair as necessary. Check ECU, replace if necessary. |

**Table 13, Problem—Sleeper Unit Not Engaging or Disengaging Correctly**

| Problem—Mode Door Not Working Properly | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Is the mode door actuator making noise or oscillating back and forth? | Yes | Check if ECU PN RD-6-5108-0 or later is installed. If not and the vehicle is still under warranty, replace the ECU. |
| | | No | **Go to step 2**. |
| 2 | If the mode door moves, **go to step 3**. If not, verify the ECU power and ground circuits and that there are no other errors in the system. | Okay | **Go to step 3**. |
| | | Not okay | Repair as necessary. |
| 3 | Disconnect the five-wire connector from the mode actuator at the top of the plenum. With the system operating, take this connector and make the following measurements:<br>• Voltage across the white and black wires should read 5V.<br>• Voltage across the yellow and black/white wires should momentarily read +12V when the mode actuator is moved to face and –12V when moved to defrost mode. | Okay | **Go to step 4**. |
| | | Not okay | Check the wiring between the actuator and ECU. Repair as necessary. If okay, replace ECU. |
| 4 | Remove the blower assembly and reach up into the air distribution plenum and locate the mode doors. Verify that the mode doors are not obstructed or jammed. | Okay | Replace actuator. |
| | | Not okay | Remove obstruction or repair as necessary. |

**Table 14, Problem—Mode Door Not Working Properly**

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Problem—Fresh/Recirc Door Not Working Properly | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Disconnect the three-wire connector from the fresh/recirc actuator. With the system operating, take this connector and make the following measurements:<br>Voltage across the red and black wires should read 12V.<br>There should be continuity across the green and black wires when in recirc mode. When in fresh mode, there should not be continuity. | Okay | **Go to step 2**. |
| | | Not okay | Check wiring between the actuator and the ECU. Repair as necessary. If okay, replace the ECU. |
| 2 | Inspect the fresh/recirc door for mechanical damage or jamming. | Okay | Replace actuator. |
| | | Not okay | Repair as necessary. |

**Table 15, Problem—Fresh/Recirc Door Not Working Properly**

**Problem—Little or No Airflow**

| Problem—Little or No Airflow | |
|---|---|
| **Possible Cause** | **Remedy** |
| The blower is not operating. | See **Table 6**. |
| There are restrictions or leaks in the air ducts. | Examine all air ducts and remove any blockages. Stop any leaks or replace any portion where the leaks cannot be stopped.<br>Check to make sure the fresh air filter in the HVAC assembly is clean. |
| Frozen evaporator core. | See **Table 8**. |

**Problem—Low Compressor Suction Pressure**

| Problem—Low Compressor Suction Pressure | |
|---|---|
| **Possible Cause** | **Remedy** |
| The expansion valve is not working. | Check and replace the expansion valve as necessary. |
| There are restrictions in the line to the expansion valve. Frost usually appears at the point of restriction. | Remove the line restrictions or replace component as necessary. |
| There is an insufficient refrigerant charge in the system. | Recover the system. If low, check for and repair leaks. Evacuate and add a full refrigerant charge. |

**Problem—High Compressor Discharge Pressure**

| Problem—High Compressor Discharge Pressure | |
|---|---|
| **Possible Cause** | **Remedy** |
| Airflow through the condenser is restricted. | Remove the debris from the condenser. |
| There is a restriction in the condenser or refrigerant line between the condenser and receiver-drier. Frost usually appears at the point of restriction. | Remove the restriction or replace the condenser if necessary. |

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Problem—High Compressor Discharge Pressure | |
|---|---|
| **Possible Cause** | **Remedy** |
| Air is present in the system. | Recover the system. If low, check for and repair leaks. Evacuate and add a full refrigerant charge. |
| Heavy frosting on the suction line suggests that the evaporator coil is flooded. | Defrost the evaporator coil before resuming operation of the air conditioner. |
| The engine is overheated. | See the engine manufacturer's service manual for corrective measures. |
| Engine fan is not engaging. | Check and repair as necessary. |

**Problem—Compressor Cycles Rapidly**

| Problem—Compressor Cycles Rapidly | |
|---|---|
| **Possible Cause** | **Remedy** |
| There is too little refrigerant in the system. | Recover the system. If low, check for and repair leaks. Evacuate and add a full refrigerant charge. |
| Frozen evaporator core. | Check the evaporator sensor (thermostat probe) and wiring. Replace if necessary. |
| There is a restriction in the refrigerant system. | Inspect the entire system for frost buildup. Frost usually appears at the point of restriction. |
| Airflow through the condenser is restricted. | Remove the debris from the condenser. |
| The evaporator sensor (thermostat probe) is not working. | Check and replace as necessary. |

**Problem—Condensed Water Is Leaking from the Air Conditioner**

| Problem—Condensed Water Is Leaking from the Air Conditioner | |
|---|---|
| **Possible Cause** | **Remedy** |
| The drain tubes are plugged. | Clean the drain holes and drain tubes. |

| High Side Refrigerant Pressure Value (engine off) | |
|---|---|
| **Ambient Air Temperature** | **Approximate HI–P PSI Gauge (kPa)** |
| 40°F (4°C) | 35 (241) |
| 50°F (10°C) | 45 (310) |
| 60°F (16°C) | 60 (414) |
| 70°F (21°C) | 70 (483) |
| 80°F (27°C) | 85 (586) |
| 90°F (32°C) | 105 (724) |
| 100°F (38°C) | 125 (862) |

**Table 16, High Side Refrigerant Pressure Value (engine off)**

## Wiring Diagrams

See **Fig. 6** and **Fig. 7** for the ATC cab HVAC wiring diagram.

## Sleeper ATC With Alarm Clock

### General Information

The Red Dot Automatic Temperature Control (ATC) sleeper heater and air conditioner is designed as the complement to the Red Dot ATC cab heater and air conditioner. The ATC sleeper heater and air conditioner provides true interior sleeper compartment temperature control and continuously variable blower fan speed. This is accomplished through the use of

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

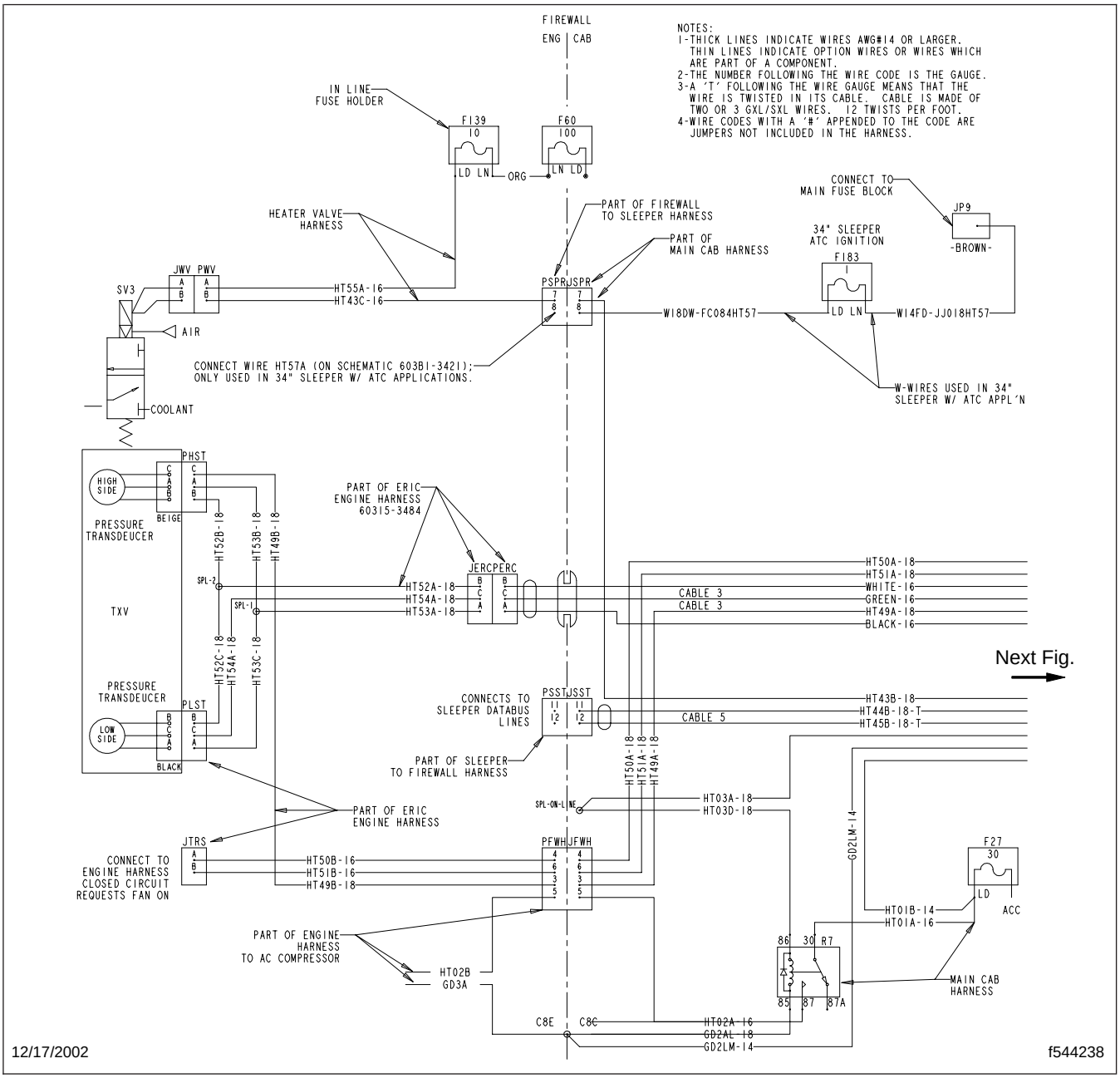



**Fig. 6, ATC Cab HVAC Wiring Diagram, Part 1**

advanced microprocessor and sensor technology. The control keypad features full HVAC control as well as a clock with alarm. The sleeper heater and air conditioner can be turned on and off without turning on the cab heater and air conditioner.

# Specifications

## Display

The display is vacuum fluorescent and has five digits that are 0.33 inch (8 mm) high. Time is displayed in

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

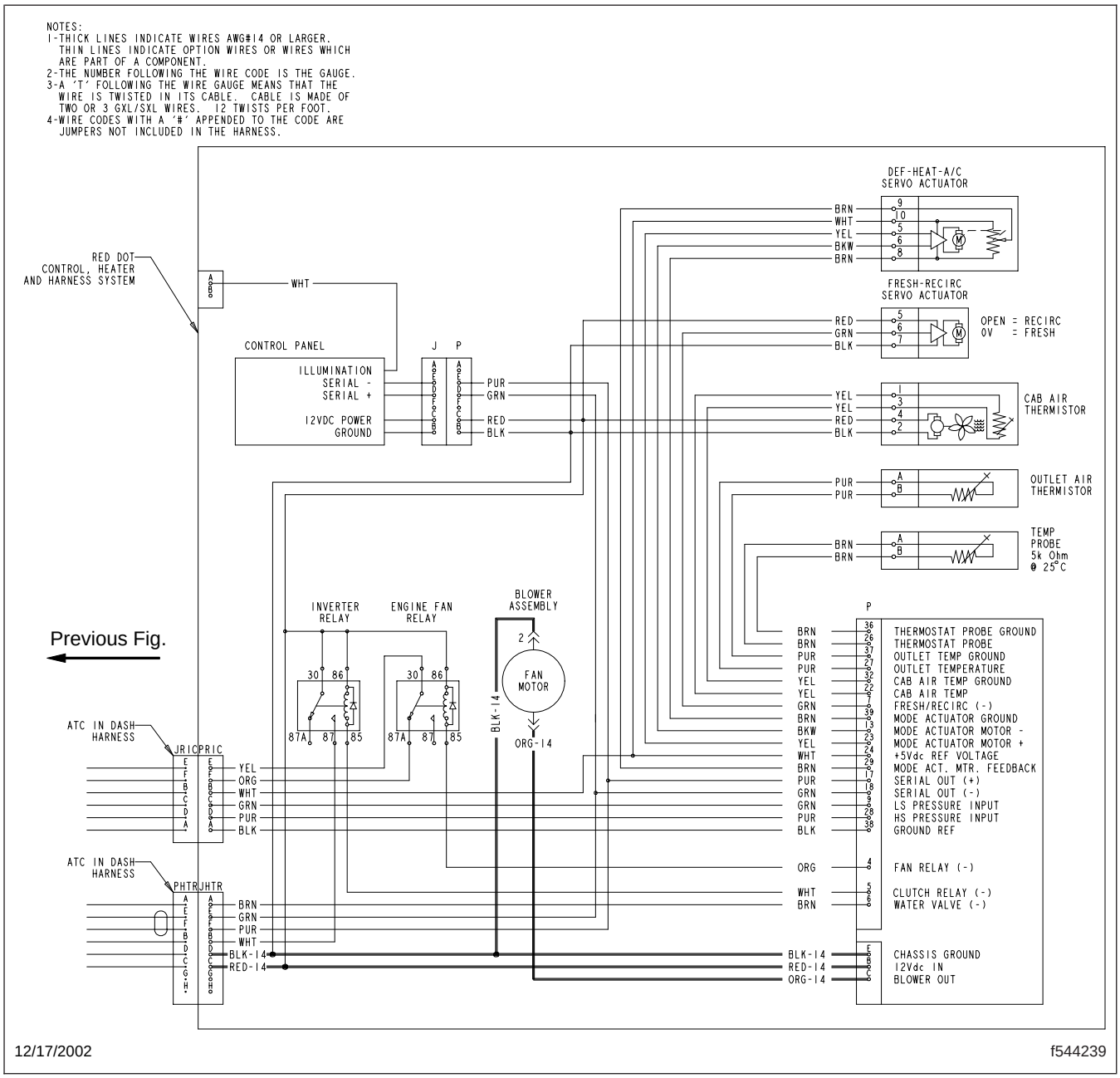



**Fig. 7, ATC Cab Wiring Diagram, Part 2**

a 12-hour format with a separate PM LED indicator. Temperature is displayed with a three-digit annotation and can be displayed either in degrees Celsius or degrees Fahrenheit. A capital C or F is displayed for the appropriate temperature scale.

## Control Panel

The control panel is comprised of a membrane switch assembly with a Lexan outer covering. The panel has incorporated physical mechanical tactile feedback to ensure easily identifiable switch actua-

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

tion. Indicator LEDs illuminate when a switch activation has occurred, thus providing both physical and visual indication of circuit activation. The control panel has backlighting to allow rapid and positive switch location even in dim ambient light conditions.

### Clock

The clock is crystal controlled with a low temperature drift oscillator for long term stability.

### Blower Motor Drive

Power MOSFET circuitry provides 20-amp drive capacity with multiple times instantaneous current ability. There is internal protection from voltage transients and current overloads.

### Voltage Input

The unit is designed to operate on standard truck operating voltages, 13.5 volts typical. The unit will operate correctly with input from 8 to 16 volts.

# Operation of Sleeper ATC

## Controls

### Clock Control

The clock controls are located on the left side of the ATC sleeper control panel under the display. The display will show the clock time as the default mode. See **Fig. 8**.

#### Alarm Button

Momentarily press the ALARM button to turn the alarm on and to illuminate the alarm indicator light above the alarm button. Momentarily press the button again to deactivate the alarm.

When pressing the ALARM button, the display shows the alarm time setting for five seconds before returning to the current time display. If the alarm button is pressed and held down continuously for more than one second, the alarm time setting can be viewed without changing the state of the alarm indicator. If either the SET+ or SET– buttons are pressed simultaneously with the ALARM button held down, the alarm time setting will increase or decrease. When the ALARM button is released after changing the alarm time, the alarm will be turned on and the indicator will be illuminated. When the ALARM is sounding, press the ALARM button to turn the alarm off and to reset the alarm for the next 24-hour cycle.

NOTE: If any button other than the ALARM button is pressed when the alarm is sounding, the snooze function will be engaged.

If the snooze function is active, as indicated by a blinking alarm indicator light, press the ALARM button to cancel the snooze function and to reset the alarm for the next 24-hour cycle.

#### Time Button

Press the TIME button to display the current time. If the TIME button is held down and either the SET+ or SET– buttons are pressed simultaneously with the TIME button, the clock setting will increase or decrease.

#### Display

Depress the DISP button to allow the display and illumination of the control panel to scroll through three illumination levels: bright, dim, and off. If you want the ALARM, TIME, or HVAC setting to be displayed when the display is in the off mode, press the ALARM, TIME, or HVAC buttons to display the corresponding display for five seconds. After five seconds, the display will turn off. If the alarm sounds while in the display off mode, the current time will be displayed simultaneously. The display will remain on for five minutes, then turn off.

#### Snooze Feature

To enable the snooze alarm, press any button on the control panel, except the ALARM button, when the alarm is sounding. The alarm will turn off for seven minutes. The alarm indicator light flashes when the snooze alarm is enabled. The snooze alarm can be enabled indefinitely.

#### AM/PM

PM is displayed at the left side of the display and is illuminated during PM hours. When PM is not displayed, AM hours are displayed. When setting the time or alarm, note the presence or absence of the PM.

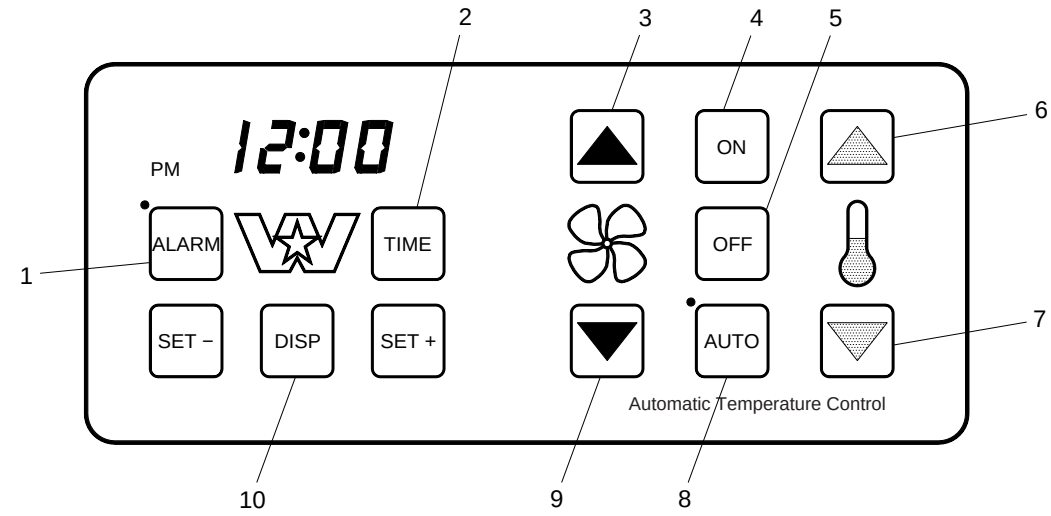
### Automatic Temperature Control

The controls for the sleeper heater and air conditioner are located on the right side of the ATC sleeper control panel. See **Fig. 8**.

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics




1. Alarm Button
2. Time Button
3. Fan Up Button
4. HVAC On Button
5. HVAC Off Button
6. Temperature Up Button
7. Temperature Down Button
8. Automatic Blower Fan Speed
9. Fan Down Button
10. Display Button

**Fig. 8, ATC Sleeper Control Panel**

### On Button

To turn the sleeper heater and air conditioner on, press the ON button. The display will show the current temperature control set point for five seconds then return to the time display. The fan and temperature control will not engage unless the ignition is on. If the engine is on, but the cab ATC heater and air conditioner is off, turning the sleeper HVAC system on will engage the compressor clutch and turn the cab unit blower fan to a low setting.

### Off Button

To turn the sleeper heater and air conditioner off, press the OFF button.

### Auto Button

Press the AUTO (default on) button to enable automatic control of the blower fan speed. When automatic control is enabled, the indicator light above the AUTO button will illuminate. The display will show the current temperature control set point for five seconds, then return to the normal time display. When in this mode, the fan speed can vary in infinite increments as necessary to maintain the temperature set by the user.

### Temperature Up/Down Buttons

The temperature up/down buttons increase or decrease the control set point temperature. Each button may be pressed repeatedly to incrementally increase or decrease the set point. Press either button for at least two seconds to continuously increase or decrease the set point temperature. The display will show the current set point temperature. The display returns to the normal time display five seconds after a button is pressed and released.

### Fan Up/Down Buttons

The fan up/down buttons increase or decrease the blower fan speed. Each button may be pressed repeatedly to incrementally increase or decrease the set point. Press either button for at lease two seconds to continuously increase or decrease the set point. The display indicates the fan speed setting in 10 percent increments or HI when the maximum speed is selected and LO when the minimum speed is selected. The display returns to the normal display five seconds after a button is pressed. The AUTO fan function is disabled if either of these buttons is pressed.

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

### Turning on the Sleeper HVAC When the Cab HVAC is Off

The sleeper ATC control panel can turn on the air conditioner even if the cab HVAC unit is turned off but the engine is running. By pressing the ON button, the ATC sleeper control panel will turn on the cab unit and the bunk indicator light on the cab control panel will be illuminated. If cooling is needed in the sleeper, the cab HVAC unit will switch on to a low blower fan setting and the A/C compressor clutch will engage. If cooling is no longer required in the sleeper or if heat is needed, the cab unit fan and the compressor clutch will be turned off after a five-minute delay.

### Changing Temperature Units

The temperature units can be changed from °F to °C or from °C to °F by pressing the temperature up and temperature down buttons simultaneously. Changing the temperature units on the ATC sleeper control panel will also change the temperature units on the ATC cab control panel.

### Set Point Temperature Slave Mode Feature

The set point temperature slave mode allows the set point temperatures of the cab heater and air conditioner and the sleeper heater and air conditioner to be tied together automatically. In this mode, the temperature set point in the vehicle will always be the same whether the set point is changed on the cab control panel or the sleeper control panel. To enable the set point temperature slave mode, press the SET+ and SET– buttons simultaneously. The display will read S–ON when the set point temperature slave mode is enabled.

The set point temperature slave mode can be disabled by simultaneously pressing the SET+ and SET– buttons. The display will read S–OFF indicating that the mode is disabled. If disabled, the set points for the cab and sleeper control panels can be changed independently for separate temperature control. If you wish to maintain a temperature in the sleeper that is different than the temperature in the front of the cab, it is recommended that a curtain be used between the sleeper and the front of the cab.

### Sleep Mode

The ATC sleeper control panel will immediately enter a power saving sleep mode when the vehicle ignition is not powered. The display and control panel illumination will turn off while all of the clock functions, including the alarm, continue to work internally. This feature is designed to reduce the power draw on the battery when the engine is not running by dropping the required current. If the DISP button is pressed while the ignition is turned off, the display will be illuminated for five minutes. After five minutes, the display will turn off and the electronics will go back to the sleep mode.

## Sleeper System Logic

### Fan Speed Control

The manual fan control mode provides 11 fan speed settings: LO, 10, 20, 30, 40, 50, 60, 70, 80, 90, HI.

### Automatic Fan Speed Control

The fan speed is determined by the system as required. The fan speed is based on the difference between the set point temperature and the actual sleeper cab temperature. The greater the difference, the greater the fan speed. When the temperature is too hot and heating is occurring, or if the temperature is too cold and cooling is occurring, the fan speed will be held at minimum. This condition can occur when the sleeper cab is heating or cooling quickly and the temperature overshoots the set point temperature. The fan speed will be set to high if a cab temperature sensor error occurs. In automatic fan speed mode, all fan speed changes are done gradually.

In automatic or manual mode, the initial fan speed at startup will gradually increase from off to the desired fan speed.

### Blend Door Control

The blend door is controlled as required to maintain the sleeper cab temperature at the set point temperature. The blend door has a motor that allows the actuator to be turned clockwise, counterclockwise, or held steady. The feedback potentiometer provides a signal proportional to the current position of the blend door actuator.

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

If a sleeper cab temperature sensor error occurs, then the system will go into manual temperature control mode ranging from full cool to full heat.

## Cab HVAC Communications

The communications link between the sleeper HVAC unit and the cab HVAC unit provides several functions. Because the sleeper HVAC unit is dependent on the cab HVAC unit to provide clutch activation, the communications link provides this function. Any time the sleeper unit moves the blend door to the full cool position, the sleeper controller requests the A/C clutch to be turned on. Upon receiving the A/C clutch request, the cab HVAC controller will turn on the A/C clutch. If the cab HVAC unit is off, then the cab HVAC blower will be turned to the LO position.

Another function of the communications link is to allow the BUNK switch on the ATC cab control panel to turn the sleeper HVAC on or off. A third function of the communications link is the function of the set point temperature slave mode.

## Sleeper System Function Check

See **Table 17** for the sleeper HVAC system testing procedure.

| Sleeper HVAC System Testing Procedure | | |
|---|---|---|
| **Control or Display** | **Action** | **Test Reaction** |
| Control Panel Display Test | Battery connected (first time)<br>Press DISP button if display is blank | Display shows **8888** then the current time. |
| Control Panel Fan Control Test | Ignition on<br>HVAC on<br>Fan turned to different speeds | Amount of air flow should change accordingly. |
| Control Panel Temperature Control Test* | Set temperature to lowest setting.<br>Set fan to AUTO. | Blower fan increases to high.<br>Air conditioner turns on. |
| Control Panel Temperature Control Test* | Set temperature to highest setting.<br>Set fan to AUTO. | Blower fan increases to high.<br>Heater turns on. |
| Control Panel Temperature Control Test | Set temperature to approximate sleeper temperature. | Blower fan speed decreases to low. |
| Control Panel Clock Control Time Set | Press TIME and SET+ or SET– buttons simultaneously. | Current time is changed. |
| Control Panel Clock Control Alarm Set | Press ALARM and SET+ or SET– buttons simultaneously. | Alarm time is changed. |
| Control Panel Clock Control Alarm On/Off | Press and release ALARM button. | Alarm indicator light turned on or off, alarm enabled if light on. |
| Control Panel Clock Control Alarm Display | Press and hold ALARM button for more than 1 second. | Alarm time displayed without changing the state of the alarm indicator. |
| Control Panel Clock Control Display | Press DISP button. | Display brightness should change (bright, dim, off). |
| Control Panel Clock Control Test | Display set to off.<br>Press TIME button. | Current time is displayed. |

* Ambient and cab air temperatures should be between 67 to 77°F (19 to 25°C).

**Table 17, Sleeper HVAC System Testing Procedure**

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# Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

## Sleeper System Troubleshooting

### System Diagnostic Error Codes

Error codes can be displayed by pressing the fan up and fan down buttons simultaneously. The current error status will be shown on the digital display. Pressing the fan up button repeatedly will scroll the display through any existing error codes. See **Table 18** for a list of the error codes.

| Error Codes | |
|---|---|
| **Error Code** | **Problem** |
| E0 | No fault detected |
| E1 | Bunk sensor shorted |
| E2 | Bunk sensor disconnected |
| E3 | Not assigned |
| E4 | Not assigned |
| E5 | Not assigned |
| E6 | Not assigned |
| E7 | Not assigned |
| E8 | Not assigned |
| E9 | Not assigned |
| E10 | Actuator disconnected |

**Table 18, Error Codes**

### Sleeper HVAC System Troubleshooting Tables

For troubleshooting the sleeper HVAC system, see **Table 19**, **Table 20**, **Table 21**, **Table 22**, and **Table 23**.

| Problem—No Display on Control Panel | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Check to make sure control panel connector is plugged in.<br>Press the ON button on the sleeper control panel to turn the system on. Check if the display illuminates. | Illuminates | No problem found. |
| | | Does not illuminate | **Go to step 2**. |
| 2 | Check power and ground circuits to control panel in the six-wire connector:<br>• 12V at pin A<br>• 12V at pin B (with ignition on)<br>• ground at pin F | Okay | Replace control panel. |
| | | Not okay | Check wiring and fuses, repair as necessary. |

**Table 19, Problem—No Display on Control Panel**

| Problem—Fan Does Not Work | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Check to make fan connector is plugged in to wiring harness.<br>Press the ON button on the sleeper control panel to turn the system on. Check if the display illuminates. | Okay | **Go to step 2**. |
| | | Not okay | Connect fan to wiring harness, check operation. |

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Problem—Fan Does Not Work | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 2 | Turn ignition on, set blower speed to high.<br>Check voltage drop across blower motor terminals with connector connected. | 12V or more | Check for obstructed blower wheel. If okay, replace blower motor. |
| | | Less than 12V | **Go to step 3**. |
| 3 | Check power and ground to the ECU.<br>Check fan power circuit between the fan and the ECU.<br>Check fan ground circuit. | Okay | **Go to step 4**. |
| | | Not okay | Repair wiring as necessary. |
| 4 | Check fan power output from ECU. Backprobe pin A of the eight-wire connector at the back of the control panel (with fan on high). | 12V | No problem found. |
| | | 0V (much less than 12V) | Replace ECU. |

**Table 20, Problem—Fan Does Not Work**

| Problem—No Heating | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Is the problem only in the sleeper, or is there no heat in both the front and rear units. | Both | Diagnose front system first. See **Table 7**. |
| | | Rear only | **Go to step 2**. |
| 2 | Check the system for error codes. | Error code(s) active | Repair fault(s). Proceed to **step 3** if problem persists. |
| | | No error codes | **Go to step 3**. |
| 3 | Check if the actuator is moving the blend door when the temperature set point is changed from cold to hot. | Okay | Make sure blend door is not partially obstructed. Make sure it goes to full hot position. If okay, check for restriction in hoses and heater core. |
| | | Not okay | **Go to step 4**. |
| 4 | Check the following at the actuator connector by backprobing:<br>• Voltage across pins 5 and 8 while changing the temperature up and down. The voltage should be +12V, 0V, –12V depending on direction. It will be 0V when no change is required.<br>• Voltage between pins 8 and 10 should be +5V.<br>• Voltage between pins 9 and 10 should range between 0V and 5V depending on position. | Okay | Make sure blend door is not obstructed. If okay, replace actuator. |
| | | Not okay | Check wiring, repair as necessary. If wiring is okay, replace sleeper control panel. |

**Table 21, Problem—No Heating**

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Problem—No Cooling | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Is the problem only in the sleeper, or is there no cooling in both the front and rear units. | Both | Diagnose front system first. See **Table 8**. |
| | | Rear only | **Go to step 2**. |
| 2 | Check the system for error codes. | Error code(s) active | Repair fault(s). Proceed to **step 3** if problem persists. |
| | | No error codes | **Go to step 3**. |
| 3 | Check if the actuator is moving the blend door when the temperature set point is changed from hot to cold. | Okay | Make sure blend door is not partially obstructed. Make sure it goes to full cold position. If okay, check for a restriction in the evaporator and refrigerant lines. |
| | | Not okay | **Go to step 4**. |
| 4 | Check the following at the actuator connector by backprobing:<br>• Voltage across pins 5 and 8 while changing the temperature up and down. The voltage should be +12V, 0V, –12V depending on direction. It will be 0V when no change is required.<br>• Voltage between pins 8 and 10 should be +5V.<br>• Voltage between pins 9 and 10 should range between 0V and 5V depending on position. | Okay | Make sure blend door is not obstructed. If okay, replace actuator. |
| | | Not okay | Check wiring, repair as necessary. If wiring is okay, replace sleeper control panel. |

**Table 22, Problem—No Cooling**

| Problem—Sleeper HVAC Unit Cannot Be Turned On From the Front Unit | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Can the sleeper unit be turned on from the rear control panel? | Yes | **Go to step 2**. |
| | | No | Check power and ground circuits to rear control panel and repair as necessary. Check wiring between the rear control panel and the sleeper unit and repair as necessary. Check sleeper unit blower fan. |
| 2 | Press the bunk switch on the front control panel and check if it illuminates. | Okay | No problem found. |
| | | Not okay | Check power and ground circuits to front control panel and repair as necessary. Check serial bus wiring and connections between the front control panel and rear control panel. Repair as necessary. If okay, replace the front control panel. |

**Table 23, Problem—Sleeper HVAC Unit Cannot Be Turned On From the Front Unit**

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

## Voltage Levels

See **Table 24** and **Table 25** for the function of the wires in the vehicle interface harnesses. Eight wires run from the sleeper control panel to the sleeper HVAC unit wiring harness. These wires are connected directly through, such as A to A, B to B, and so on.

| Eight-Pin Packard Vehicle Interface Harness | | | |
|---|---|---|---|
| **ID** | **Color** | **Line** | **Function** |
| A | Orange | Blower High | Should be +12V when the blower fan is on the highest speed. |
| B | Red | Blend Door (+) | Output signal to blend door actuator motor. This signal connects to the motor built into the blend door actuator. The voltage level between this pin and pin C, –blend door (–) will be –12V, 0V, or +12V depending on the desired rotation of the blend door actuator. |
| C | Brown | Blend Door (–) | Output signal to blend door actuator motor. This signal connects to the motor built into the blend door actuator. The voltage level between this pin and pin B, –blend door (+) will be –12V, 0V, or +12V depending on the desired rotation of the blend door actuator. |
| D | Purple | +5V Reference Voltage | Output provides 5 volt reference voltage for the blend door actuator feedback potentiometer. Should be +5V. |
| E | Purple | Blend Door Feedback | Input signal from blend door actuator feedback potentiometer. This signal will be in the range of 0V to 5V depending on blend door position. |
| F | Yellow | Return Air Temperature Sensor Signal | Input signal from return air temperature sensor. This thermistor probe is installed in the return air duct to measure sleeper cab temperature. The temperature measured at this point is used to control the HVAC system. Should be in the range of 0V to 5V depending on temperature. |
| G | Black | Analog Ground | Output provides analog ground for the blend door actuator feedback potentiometer and the return air temperature sensor. Should be 0V. |
| H | Black | Blower Ground | Output provides high current ground for the blower fan. Should be 0V. |

**Table 24, Eight-Pin Packard Vehicle Interface Harness**

| Six-Pin Packard Vehicle Interface Harness | | | |
|---|---|---|---|
| **ID** | **Color** | **Line** | **Function** |
| A | Red | Power | Input provides +12VDC battery power for the HVAC system. This line provides power to the HVAC system for all functions. Should be 12V. |
| B | Orange | Ignition | Input provides +12VDC power for the HVAC system when the power is on. This is a low current input to provide a signal that the ignition is on. Should be 12V when the ignition is on. |
| D | Blue | Serial (+) Bunk1 | Input/output provides serial information link between the sleeper HVAC and the cab HVAC. This line should be connected to the bunk1 line on the cab HVAC unit. In use, this line will be a serial stream of 0V/5V signals. The average voltage reading on this pin will be around 2.5V. |
| E | White | Serial (–) Bunk2 | Input/output provides serial information link between the sleeper HVAC unit and the cab HVAC unit. This line should be connected to the bunk2 line on the cab HVAC unit. In use, this line will be a serial stream of 0V/5V signals. The average voltage reading on this pin is around 2.5V. |
| F | Black | Ground | Input provides ground for the HVAC system. Should be 0V. |

**Table 25, Six-Pin Packard Vehicle Interface Harness**

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

## Wiring Diagrams

See **Fig. 9** for the ATC sleeper HVAC wiring diagram.

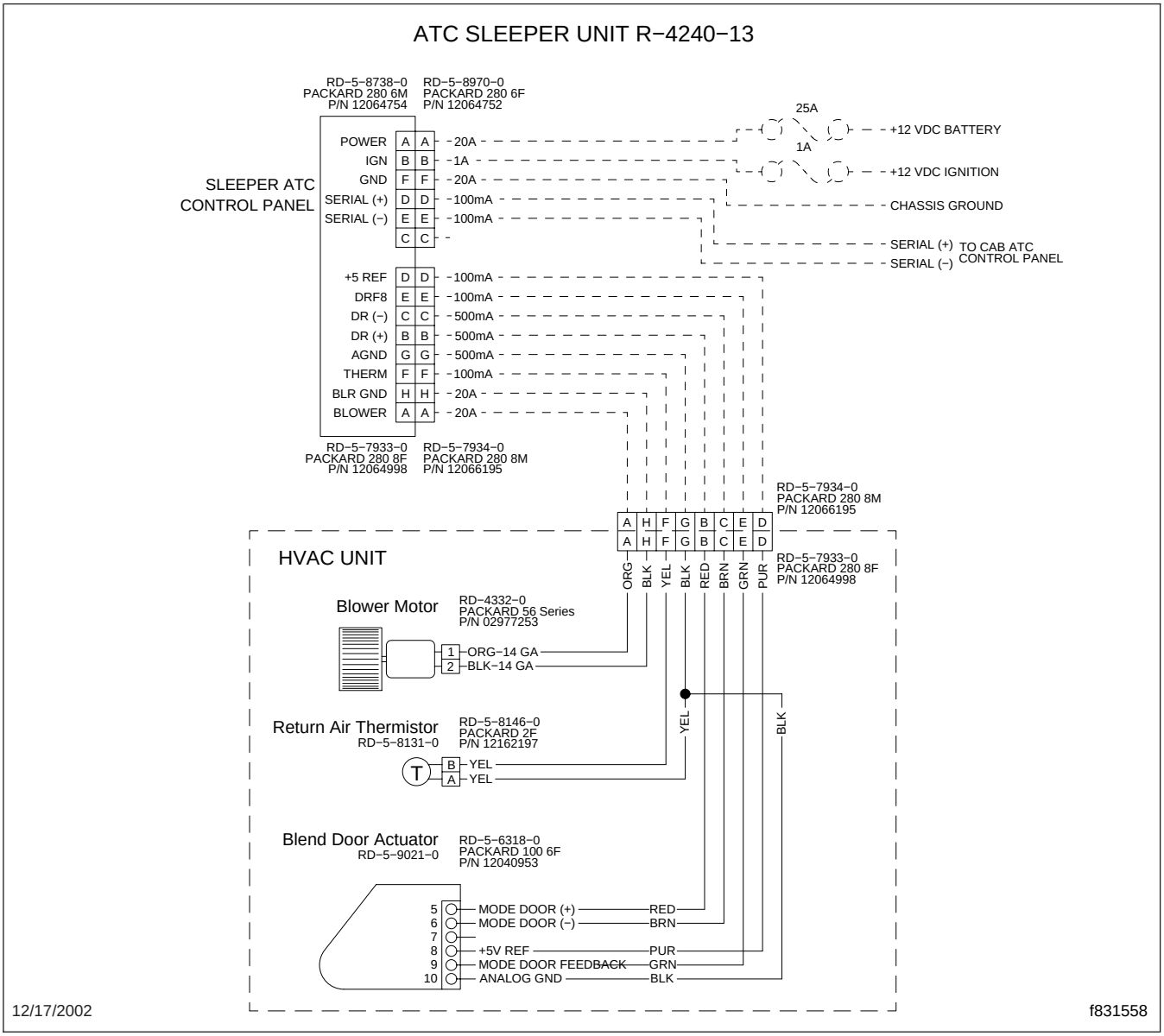



**Fig. 9, ATC Sleeper HVAC Wiring Diagram**

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## Specifications

**⚠ WARNING**

**R–134a is the only refrigerant that is approved for use on Western Star vehicles. Several companies offer less expensive, hydrocarbon-based refrigerant, such as propane and methane. Use of these refrigerants will void the warranty on the air conditioning system, cause damage to the air conditioning system, and possibly result in personal injury or property damage. Leaking air conditioning systems charged with hydrocarbon-based refrigerants pose a serious risk of fire or explosion under the hood, or inside the passenger compartment. No vehicle built by Western Star Trucks can be safely charged with hydrocarbon-based refrigerants, regardless of what the refrigerant supplier states.**

When servicing an air conditioning system, be sure to use a refrigerant identifier to ensure that the system has not been charged with something other than R–134a. This should be standard practice since there is no way to tell what services have been previously performed. Identification by service technicians will help to avoid the risk of explosion and guard against contamination of equipment when refrigerant is recovered and recycled.

| 3/4- and 5/8-Inch Heater Hose Clamp Torque Specifications | |
|---|---|
| **Description** | **Torque: lbf·in (N·cm)** |
| Standard Hose Clamp | 40 (452) |
| Worm Gear Hose Clamp | 40 (452) |
| Breeze Constant Torque Hose Clamp | 40 (452) |
| Oetiker Constant Torque Hose Clamp | 18 (203) |

**Table 1, 3/4- and 5/8-Inch Heater Hose Clamp Torque Specifications**

| Voltage Levels, 6-Pin Packard Vehicle Interface Harness | | |
|---|---|---|
| **Color** | **Function** | **Description** |
| Black | Analog Ground | Output provides analog ground for the pressure transducers. Should be 0V. |
| White | +5V Reference Voltage | Output provides power for the pressure transducers. Should be +5V. |
| Green | LS Pressure | Input signal from low side pressure transducer. This voltage will be related to the low side pressure by the function V = 0.25 + psig x 0.030. |
| Purple | HS Pressure | Input signal from high side pressure transducer. This voltage will be related to the high side pressure by the function V = 0.25 + psig x 0.009. |
| Yellow | Engine Fan | Output for engine fan activation. This pin will be connected to pin F (continuity with pin F) to request the engine fan off from the fan control circuits. |
| Orange | Engine Fan | Output for engine fan activation. This pin will be connected to pin E (continuity with pin E) to request the engine fan off from the fan control circuits. |

**Table 2, Voltage Levels, 6-Pin Packard Vehicle Interface Harness**

| Refrigerant Charge Amounts | | | | | |
|---|---|---|---|---|---|
| **A/C Condenser** | | **A/C Compresor Brand** | **Number of Evaporators** | **Full Refrigerant Charge: lb (kg)** | |
| **Location** | **Brand** | | | **For Vehicles Built Prior to Dec. 10, 2004** | **For Vehicles Built from Dec. 10, 2004** |
| Radiator | Red Dot | Climate Control | 1 | 5.10 (2.31) | 4.20 (1.91) |
| Roof | Red Dot | Climate Control | 1 | 5.30 (2.40) | 4.70 (2.13) |

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## Specifications

| Refrigerant Charge Amounts | | | | | |
|---|---|---|---|---|---|
| A/C Condenser | | A/C Compresor Brand | Number of Evaporators | Full Refrigerant Charge: lb (kg) | |
| Location | Brand | | | For Vehicles Built Prior to Dec. 10, 2004 | For Vehicles Built from Dec. 10, 2004 |
| Radiator | Red Dot | Climate Control | 2 | 5.80 (2.63) | 4.80 (2.18) |
| Roof | Red Dot | Climate Control | 2 | 6.10 (2.77) | 5.50 (2.49) |
| Radiator | Red Dot | Sanden | 1 | 4.20 (1.91) | 4.20 (1.91) |
| Radiator | Modine | Sanden | 1 | — | 4.50 (2.04) |
| Roof | Red Dot | Sanden | 1 | 4.70 (2.13) | 4.70 (2.13) |
| Radiator | Red Dot | Sanden | 2 | 4.80 (2.18) | 4.80 (2.18) |
| Radiator | Modine | Sanden | 2 | — | 4.95 (2.25) |
| Roof | Red Dot | Sanden | 2 | 5.50 (2.49) | 5.50 (2.49) |

**Table 3, Refrigerant Charge Amounts**

| Temperature/Pressure Specifications for a Vehicle Without a Sleeper | | | | | | |
|---|---|---|---|---|---|---|
| Ambient Air Temp. | Humidity (approximate) % RH | Dash Outlet Temperature | Service Port Pressures | | Clutch | Comments |
| | | | Low Side psi (kPa) | High Side psi (kPa) | Cycle yes/no | |
| 70°F (21°C) | Low 25% | 45–55°F (7–13°C) | 20 (138) | 75–100 (517–689) | yes | compressor on 15 seconds, off 15 seconds |
| | High 55% | 46–55°F (8–13°C) | 20 (138) | 75–105 (517–724) | yes | compressor on 20 seconds, off 15 seconds |
| 80°F (27°C) | Low 25% | 46–56°F (8–13°C) | 22 (152) | 95–140 (655–965) | yes | compressor on 20 seconds, off 15 seconds |
| | High 55% | 47–58°F (8–14°C) | 25 (172) | 100–145 (689–1000) | yes | compressor on 45 seconds, off 15 seconds |
| 90°F (32°C) | Low 25% | 50°F (10°C) | 20 (138) | 150 (1034) | no | on steady |
| | High 55% | 54°F (12°C) | 30 (207) | 160 (1103) | no | on steady |
| 100°F (38°C) | Low 25% | 54°F (12°C) | 30 (207) | 200 (1379) | no | on steady |
| | High 55% | 64°F (18°C) | 40 (276) | 205 (1413) | no | on steady |

Test conditions:

- engine at 1200 rpm
- engine fan locked on
- fresh air A/C mode
- cab doors open
- hood open
- no solar load
- no wind speed or less than 5 mph (8 km/h)

**Table 4, Temperature/Pressure Specifications for a Vehicle Without a Sleeper**

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## Specifications

| Temperature/Pressure Specifications for a Vehicle With a Sleeper | | | | | | |
|---|---|---|---|---|---|---|
| Ambient Air Temp. | Humidity (approximate) % RH | Dash Outlet Temperature | Service Port Pressures | | Clutch | Comments |
| | | | Low Side psi (kPa) | High Side psi (kPa) | Cycle yes/no | |
| 70°F (21°C) | Low 25% | 46–55°F (8–13°C) | 25 (172) | 110 (758) | yes | compressor on 1 minute, off 20 seconds |
| | High 55% | 46–58°F (8–14°C) | 28 (193) | 110 (758) | yes | compressor on 2 minutes, off 20 seconds |
| 80°F (27°C) | Low 25% | 54–55°F (12–13°C) | 28 (193) | 128 (883) | no | on steady |
| | High 55% | 59°F (15°C) | 32 (221) | 140 (965) | no | on steady |
| 90°F (32°C) | Low 25% | 60°F (16°C) | 32 (221) | 165 (1138) | no | on steady |
| | High 55% | 67°F (19°C) | 40 (276) | 175 (1207) | no | on steady |
| 100°F (38°C) | Low 25% | 65°F (18°C) | 37 (255) | 200 (1379) | no | on steady |
| | High 55% | 68°F (20°C) | 54 (372) | 240 (1655) | no | on steady |
| Test conditions:<br>• engine at 1200 rpm<br>• engine fan locked on<br>• fresh air A/C mode<br>• cab doors open<br>• hood open<br>• no solar load<br>• no wind speed or less than 5 mph (8 km/h) | | | | | | |

**Table 5, Temperature/Pressure Specifications for a Vehicle With a Sleeper**

| Acceptable Leak Rates by Component | |
|---|---|
| **Component** | **Acceptable Leak Rates** |
| J-Block Body | 0.25 oz/yr and greater condemns these components |
| Evaporators (main and auxiliary) | |
| Condenser | |
| Receiver Dryer (Body) | |
| Lines/Hoses | |
| Capped Charge Ports | |
| Mini-Stato seal (1 - when the leak can be tied to a single seal) | |

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## Specifications

| Acceptable Leak Rates by Component | |
|---|---|
| **Component** | **Acceptable Leak Rates** |
| Mini-Stato seals (2 - when the leak cannot be tied to a single seal) | 0.50 oz/yr and greater condemns these components |
| Compressor (shaft seal, housing, etc.) | |
| TXV (Power Valve and Super Heat Cap) | |
| Sensor/Switches (O-ring and crimped body connections) | |

**Table 6, Acceptable Leak Rates by Component**

See **Fig. 1** and **Fig. 2** for the wiring schematics for the cab ATC heater and air conditioner.

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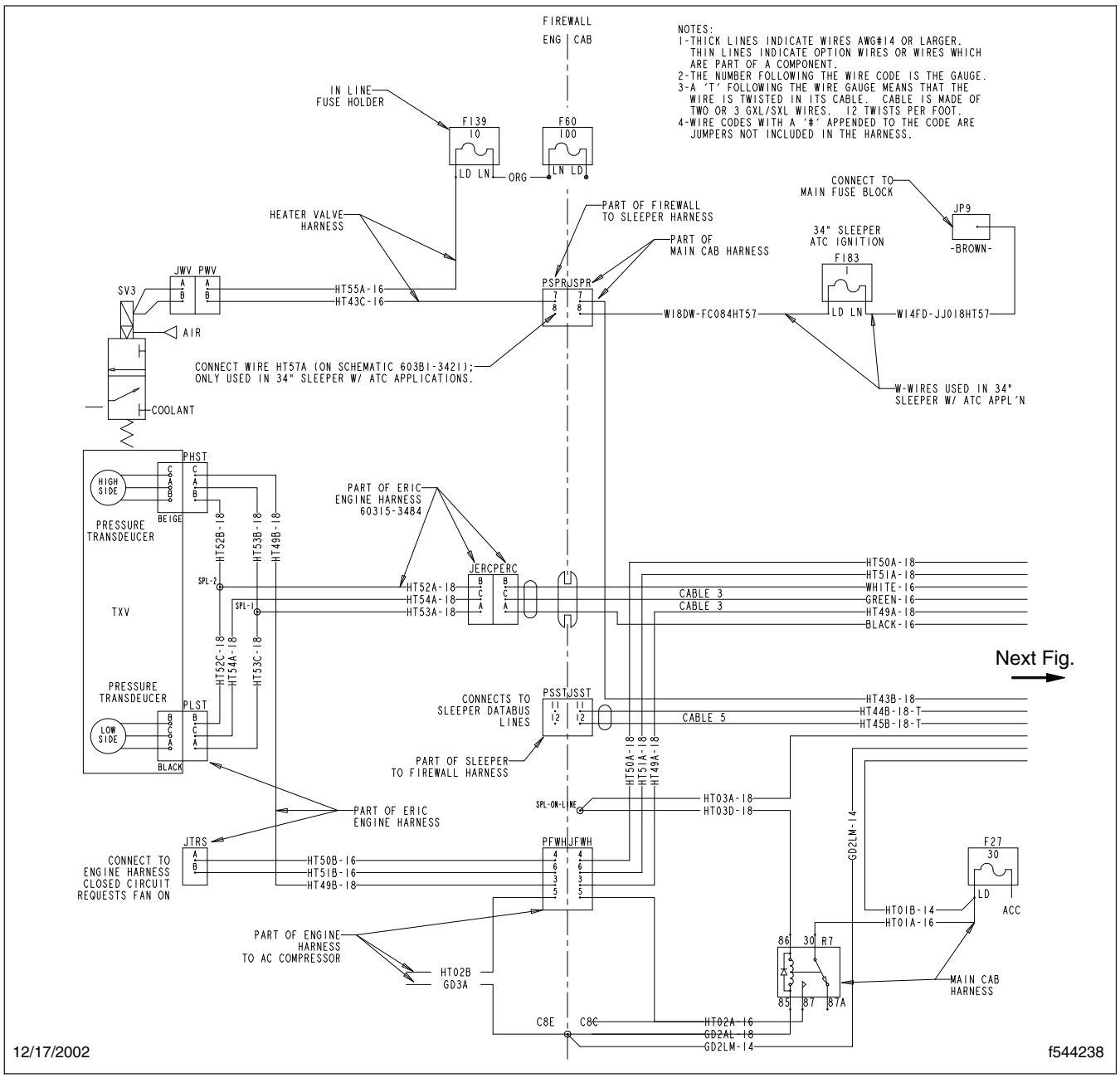



**Fig. 1, Wiring Schematic for the Cab ATC Heater and Air Conditioner, Part 1**

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## Specifications

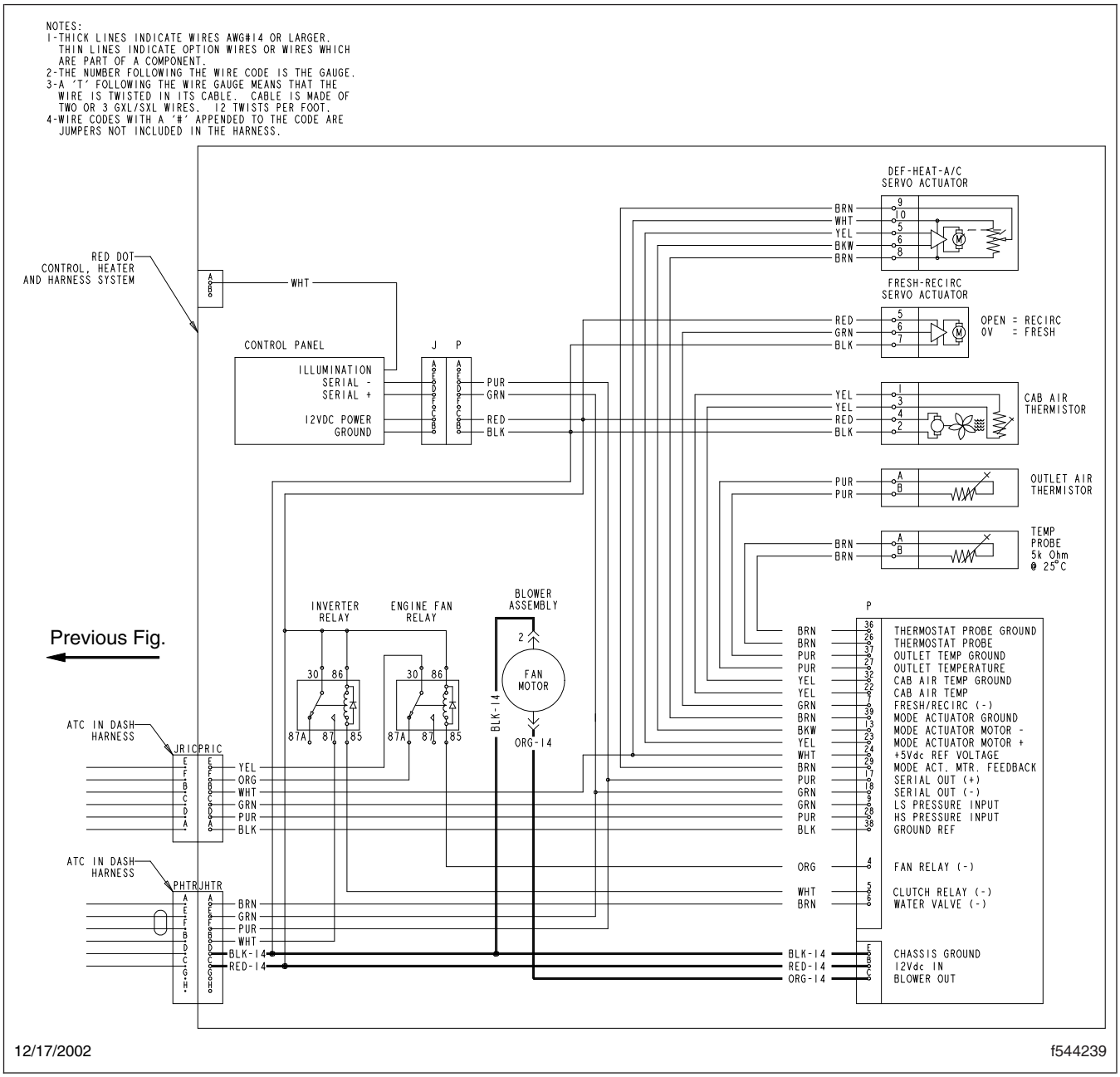



**Fig. 2, Wiring Schematic for the Cab ATC Heater and Air Conditioner, Part 2**

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# General Information

The sleeper heater and air conditioner system consists of the sleeper heater and air conditioner assembly and the climate control panel. The sleeper heater and air conditioner assembly contains a heater core, evaporator, blend air door, blend air door actuator, and an air temperature sensing thermistor. The sleeper climate control panel has a fan switch, a temperature control switch, and a power switch that allow you to control the heating and air conditioning functions in the sleeper. A vehicle with an air conditioner has an air conditioner switch on the control panel.

The blend air door is controlled by the actuator, which is located on top of the sleeper heater and air conditioner assembly. The climate control panel compares the readings from the air temperature sensing thermistor and the temperature control switch (potentiometer) to determine the proper position for the blend air door. A signal is then sent to the actuator, which moves the blend air door to achieve the desired outlet air temperature.

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## Safety Precautions

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

Refrigerant R–134a is safe when used under the right conditions. Always wear safety goggles and nonleather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves. When refrigerant gas or liquid contacts leather, the leather will stick to your skin.

**⚠ WARNING**

**Use care to prevent refrigerant from touching your skin or eyes because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.**

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure; however, it can be combustible at pressures as low as 5.5 psig (139 kPa absolute) at 350°F (177°C) when mixed with air concentrations that are greater than 60 percent.

**⚠ WARNING**

**R–134a air conditioning systems should not be pressure tested or leak tested with compressed air. Combustible mixtures of air and R–134a may form, resulting in a fire or explosion that could cause personal injury or property damage.**

Always work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, charged, and leak tested. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R–134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

When handling refrigerant oil, observe the following guidelines:

- Keep the oil free of contaminants.
- Do not expose the air conditioning system or the refrigerant oil container to air for more than five minutes. Refrigerant oil has a high moisture absorption capacity and the oil container should be immediately sealed after each use.
- Use care when handling. Spilled oil could damage painted surfaces, plastic parts, and other components such as drive belts.
- Never mix different types of refrigerant oil.

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# Troubleshooting for the Non-ATC Heater and Air Conditioner

## Preliminary Checks

Before testing the operation of the air conditioning system, check the following items:

1. Make sure the drive belt on the refrigerant compressor is not damaged. Make sure the compressor mounting capscrews are tight.
2. Check the refrigerant compressor for correct clutch clearance.

   On a vehicle with a Sanden refrigerant compressor, use a feeler gauge to check that the drive clutch clearance is 0.016 to 0.031 inch (0.40 to 0.78 mm). See **Fig. 1**. If the drive plate clutch needs adjustment, see **Section 83.01**, Subject 130.

   On a vehicle with a Climate Control refrigerant compressor, place a feeler gauge between the refrigerant compressor clutch and the pulley. Drive plate to pulley clearance should be 0.020 to 0.030 inch (0.50 to 0.76 mm). If the clearance is 0.035 inch (0.89 mm) or greater, replace the clutch. For instructions, see **Section 83.00**, Subject 140.

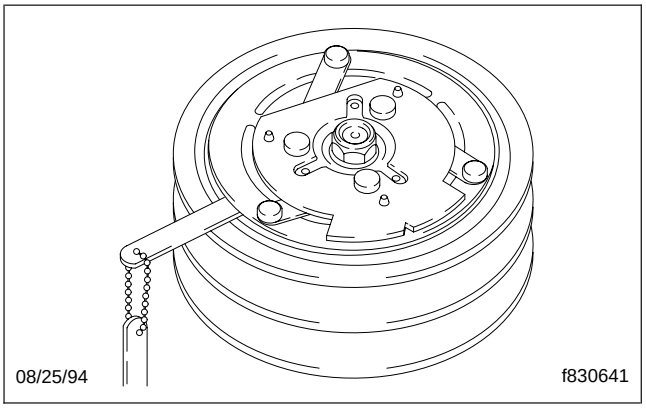



**Fig. 1, Drive Plate Clearance Inspection**

3. Check for broken or cut hoses. Check for loose fittings on all parts.
4. Check for road debris buildup on the condenser fins. Using air pressure and a whisk broom or a soapy spray of water, carefully clean off the condenser. Be careful not to bend the fins.
5. If there is not enough airflow, make sure that leaves or other debris have not entered the fresh air ports under the windshield. If debris is present, it could clog the air inlet and block airflow.

   Be sure that all ducts are connected to the dash outlets.

   Check to make sure the fresh air filter in the HVAC assembly is clean.

## HVAC Components

Following is a brief description of symptoms or conditions that could exist if something goes wrong with a refrigerant component.

### Receiver-Drier

The receiver-drier is normally at outside temperature. To the touch, the entire length of the unit should be the same temperature. If noticeable cool spots exist, replace the receiver-drier.

A blockage at the inlet of the receiver-drier will cause high head pressures. A blockage at the outlet will cause low head pressures and little or no cooling.

### Cooling System

There is a close tie between the air conditioner and the cooling system, although they are not physically connected. Poor air conditioner cooling can be the result of a problem in the cooling system.

If the cooling system does not work correctly, the heat of the engine will rise to abnormal levels. The added heat will transfer to the air conditioner, other under-hood parts, and may make its way into the cab. The added heat makes it necessary for the air conditioner to work harder. It also reduces the ability of the air conditioner to cool the air in the cab. If the water regulating valve isn't closing all the way, heat will enter the cab giving the impression that the air conditioning system is not working.

See **Group 20** for cooling system troubleshooting or to the engine manufacturer's service manual for details about cooling system problems.

### Expansion Valve

Problems that start in the expansion valve are apparent when the valve is stuck closed or stuck open. When stuck closed, the evaporator coil and the expansion valve will be at outside temperature. When

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## Troubleshooting for the Non-ATC Heater and Air Conditioner

stuck open, both the coil and the valve will be extremely cold with frost or ice buildup.

Because the expansion valve channels are very small, blockages in the system tend to be found here. The expansion valve is very sensitive to contamination. Usually, the contaminant is water. Less than a drop of water is all it takes to make the valve inoperative. When water reaches the valve, the extreme cold that results from the pressure drop freezes the water, forming a block of ice in the valve. After the system shuts down and the valve warms up, the ice melts and the valve operates again only to freeze-up when the moisture returns.

On-and-off operation of the expansion valve means that the receiver-drier is not removing moisture from the system.

### Refrigerant Compressor

Compressor problems usually show in one of four ways:

- abnormal noise
- seizure
- leakage
- low suction and discharge pressures

Resonant compressor noises are not causes for alarm. Irregular noise or rattles are likely to be caused by broken parts. To check for seizure, de-energize the magnetic clutch and see if the drive plate can be turned. If it won't turn, the compressor has seized.

Low discharge pressure may be caused by not enough refrigerant, not enough belt tension, or a blockage somewhere in the system. These things should be checked before servicing the compressor.

### Evaporator

The evaporator coils are basically trouble-free when airflow over the fins is not blocked. External or, less often, internal blockages will cause low suction pressure as well as little or no cooling.

If a leak exists in the system and it cannot be traced to other parts or fittings, suspect damage to one of the evaporator coils.

### Condenser

The condenser is usually trouble-free. Normally, the temperature of the condenser outlet line is noticeably cooler than the inlet line. However, when road debris, such as leaves or dirt, build up, airflow over the condenser fins is blocked. Air is not able to absorb enough heat to turn the hot refrigerant gas into a liquid. High head pressures will result. In these cases, carefully clean off the outer surfaces of the condenser with compressed air or a soap and water solution. Be careful not to bend the fins.

High head pressures will also occur if the condenser tubing is bent, blocking the flow of refrigerant. Frost will appear at the point where the flow is restricted.

Less common internal blockages (bits of foreign material or metallic grit buildup) will stop the flow of refrigerant.

A quick test to check that poor system performance is caused by the condenser is to direct a spray of water on the condenser while the system is running. If the air conditioner cools better because of the assist provided by the water, it is a sign that the condenser is not working.

When troubleshooting a suspected condenser problem, remember that the problem may be caused by the radiator transferring high levels of heat to the condenser. See **Group 20** for cooling system troubleshooting or to the engine manufacturer's service manual for details about cooling system problems.

### Line Restrictions

A restricted suction line causes low suction pressure at the compressor and little or no cooling. A restriction in a line between the compressor and the expansion valve can cause high discharge, low suction pressure, and insufficient cooling.

Usually areas of ice or frost buildup mean a blockage. Components that often freeze-up are probably corroded or inoperative and should be replaced. Components (such as the expansion valve) that freeze-up once in a while may do so because of moisture in the system. If this happens, recover the refrigerant, evacuate/recycle the system, replace the receiver-drier, and add a full refrigerant charge.

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## Fault Analysis Flow Chart

See **Fig. 2** for the fault analysis flow chart.

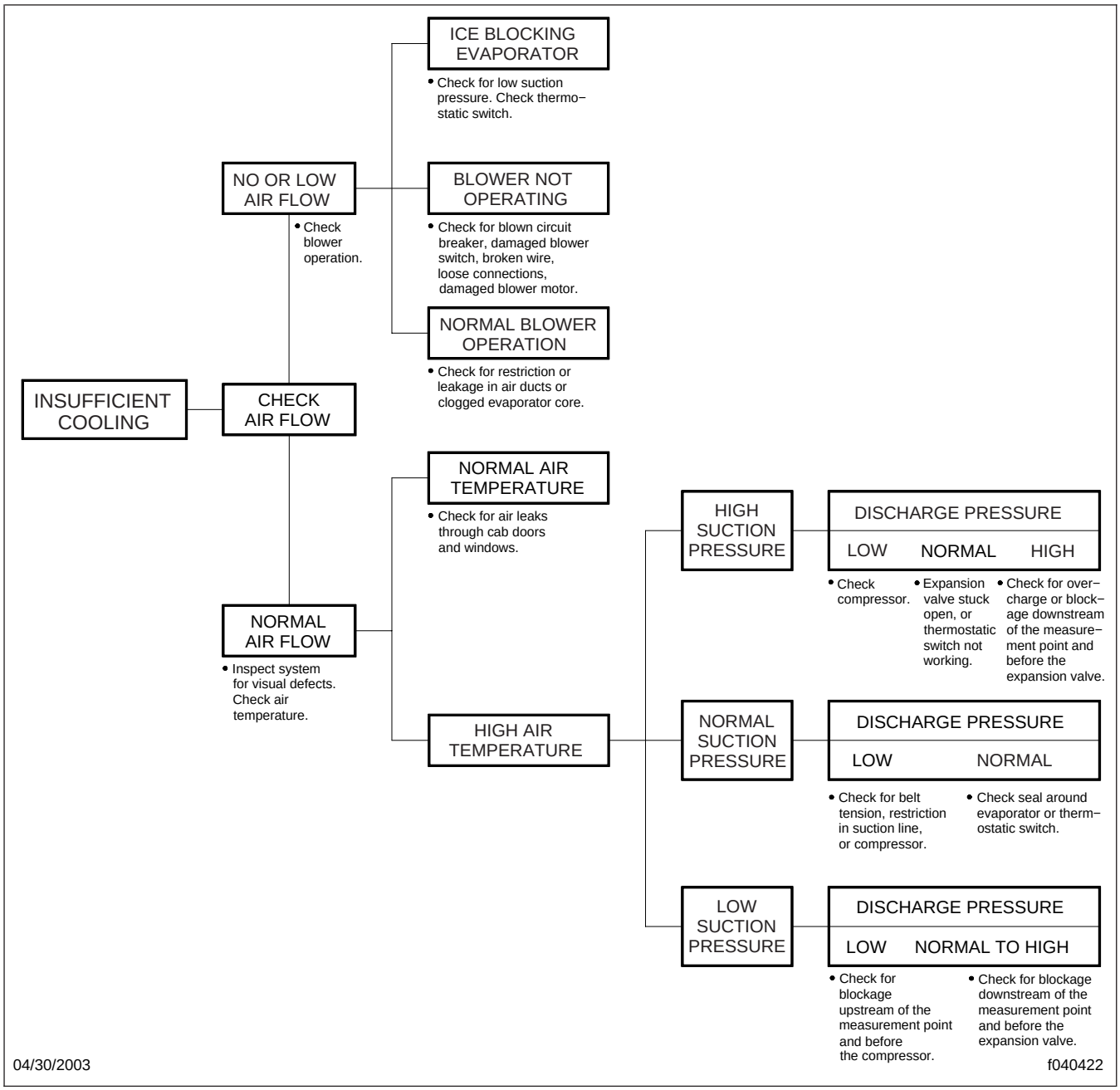



**Fig. 2, Fault Analysis Flow Chart**

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## Troubleshooting for the Non-ATC Heater and Air Conditioner

# Troubleshooting Tables for the Cab Heater and Air Conditioner

Before beginning the troubleshooting procedures, be sure the electrical system is functioning properly. The system voltage should be approximately 12 volts.

**Problem—Dash Display Does Not Light Up**

| Problem—Dash Display Does Not Light Up | |
|---|---|
| **Possible Cause** | **Remedy** |
| The control panel is not receiving power. | Verify that the control panel is plugged in to the wiring harness.<br>Verify that the wiring harness is wired to the vehicle properly<br>Turn on the display using the blower fan switch. |

**Problem—Little or No Airflow**

| Problem—Little or No Airflow | |
|---|---|
| **Possible Cause** | **Remedy** |
| The blower is not operating. | Check for an open circuit breaker. An open circuit indicates a short in the electrical system, which must be located and repaired.<br>Check the air conditioner relays for operation. Replace if necessary.<br>Make sure the blower motor switch is working. Replace if necessary.<br>Check the wiring to the blower motor. If any connections are loose, tighten them.<br>Check the blower motor for operation. Replace if sticking or otherwise inoperative.<br>Check the resistor block. Replace if necessary. |
| There are restrictions or leaks in the air ducts. | Examine all air ducts and remove any blockages. Stop any leaks or replace any portion where the leaks cannot be stopped.<br>Check to make sure the fresh air filter in the HVAC assembly is clean. |
| Ice has formed on the evaporator coil. | Defrost the evaporator coil before resuming operation of the air conditioner. Review "HVAC Components" for possible causes and corrective action. |

**Problem—Warm Airflow When the Air Conditioner Is On**

| Problem—Warm Airflow When the Air Conditioner Is On | |
|---|---|
| **Possible Cause** | **Remedy** |
| There is no refrigerant charge in the system. | Perform a leak test. Repair any leaks, evacuate the system, replace the receiver-drier, and add a full charge of refrigerant. |
| Moisture in the system. | If moisture is in the system, ice crystals may form at the expansion valve, blocking the flow of refrigerant (off and on). Recover the refrigerant charge, replace the receiver-drier, evacuate the system, and add a full charge of refrigerant. |

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## Troubleshooting for the Non-ATC Heater and Air Conditioner

| Problem—Warm Airflow When the Air Conditioner Is On | |
|---|---|
| **Possible Cause** | **Remedy** |
| The refrigerant compressor is not operating. | If the refrigerant charge is low, charge and leak test the system. Repair any leaks.<br>The refrigerant compressor clutch or drive belt needs repair or replacement. For instructions, see the applicable refrigerant compressor section. |
| Ice has formed on the evaporator coil. | Defrost the evaporator coil before resuming operation of the air conditioner. Review "HVAC Components" for possible causes and corrective action. |
| Water valve open. | Check the water valve. |

**Problem—Low Evaporator Coil Outlet Pressure (low compressor suction pressure)**

| Problem—Low Evaporator Coil Outlet Pressure (low compressor suction pressure) | |
|---|---|
| **Possible Cause** | **Remedy** |
| The expansion valve is not working. | Replace the expansion valve. |
| There are restrictions in the line to the expansion valve. | Remove the line restrictions. |
| There is an insufficient refrigerant charge in the system. | Locate the leak. Recover the charge, replace the receiver-drier, and add a full refrigerant charge. |

**Problem—High Compressor Discharge Pressure**

| Problem—High Compressor Discharge Pressure | |
|---|---|
| **Possible Cause** | **Remedy** |
| The shutters are not opening. | Replace the shutter solenoid valve, Air Conditioning Protection Unit high pressure switch, or both. |
| Airflow through the condenser is restricted. | Remove the debris from the condenser. |
| There is an internal restriction in the condenser. Ice buildup on the condenser or a cool spot on the line from the condenser to the receiver-drier. | Replace the condenser. |
| Air is present in the system. | Perform a leak test. Repair any leaks, evacuate the system, and add a full charge of refrigerant. |
| Heavy frost on the suction line suggests that the evaporator coil is flooded. | Defrost the evaporator coil before resuming operation of the air conditioner. |
| The engine is overheated. | See the engine manufacturer’s service manual for corrective measures. |
| Restriction in the compressor discharge line. Frost usually appears at the point of restriction. | Repair or replace the line. |

**Problem—Evaporator Outlet Air Temperature Increases as the Compressor Discharge Pressure Drops**

| Problem—Evaporator Outlet Air Temperature Increases as the Compressor Discharge Pressure Drops | |
|---|---|
| **Possible Cause** | **Remedy** |
| There are leaks in the system. | Leak test the system. |

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## Troubleshooting for the Non-ATC Heater and Air Conditioner

| Problem—Evaporator Outlet Air Temperature Increases as the Compressor Discharge Pressure Drops | |
|---|---|
| **Possible Cause** | **Remedy** |
| The expansion valve setting is too low. | Replace the expansion valve. Add a full charge of refrigerant. |

**Problem—Compressor Operates Too Often**

| Problem—Compressor Operates Too Often | |
|---|---|
| **Possible Cause** | **Remedy** |
| There is too little refrigerant in the system. | Perform a leak test. Repair any leaks and add a full charge of refrigerant. |
| Ice has formed on the evaporator coil. | Defrost the evaporator coil before resuming operation of the air conditioner.<br>Check the operation of the thermostatic switch and replace if necessary. |
| There is a restriction in the refrigerant system. | Remove the restriction from the line. |
| Dirt and debris are clogging the condenser fins. | Remove all dirt and debris from the condenser fins. |
| The thermostatic switch isn't working. | Replace the thermostatic switch. |

**Problem—Temperature in the Cab Too Low or No Heat**

| Problem—Temperature in the Cab Too Low or No Heat | |
|---|---|
| **Possible Cause** | **Remedy** |
| The water regulating valve is not opened. | Move the temperature control knob toward warm. |
| The water regulating valve is not opening all the way. | Adjust the water regulating valve cable. |
| The water regulating valve isn't working. | Replace the water regulating valve. |
| A heater hose is pinched or twisted. | Repair or replace the heater hose. |
| Coolant is leaking from the system. | Check for leakage at the heater core and at all hose connections from the heater core to the engine. Check the radiator coolant level as instructed in the driver's manual and add coolant if necessary. Check and repair any leaks at the radiator. |
| Dust or dirt is clogging the heater core fins. | Remove and clean the heater core. |

**Problem—Condensed Water Is Leaking from the Air Conditioner**

| Problem—Condensed Water Is Leaking from the Air Conditioner | |
|---|---|
| **Possible Cause** | **Remedy** |
| The drain tubes are plugged. | Clean the drain holes and drain tubes. |

## Troubleshooting Tables for the Sleeper Heater and Air Conditioner

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## Troubleshooting for the Non-ATC Heater and Air Conditioner

**Problem—No Heating**

| Problem—No Heating | |
|---|---|
| **Problem Area** | **Remedy** |
| Coolant flow | Check the temperature of the heater core to verify that hot coolant is flowing through the core. |
| Actuator | Measure the voltage between ground terminal 7 (black wire) and supply terminal 10 (blue wire). This should be the same as the vehicle supply voltage. See **Fig. 3**.<br><br>Measure the voltage between control terminal 8 (purple wire) and ground terminal 7 (black wire). This should vary between 2 and 11 volts when the air conditioner switch is turned from on to off with the temperature control switch turned to the hottest position. This change in voltage should result in movement of the blend air door from the heater core to the A/C evaporator. If the voltage remains at 2 volts at terminal 8, then check for a shorted thermistor connection or a control panel problem. If the voltage remains at 11 volts, check for an open thermistor or a control panel problem. |
| Thermistor | Disconnect the thermistor from the wiring harness and check the resistance at room temperature. The resistance should be between 2500 and 3500 ohms at 77°F (25°C). Thermistor resistance will go down with an increase in temperature, and the resistance will go up with a decrease in temperature. The voltage across the thermistor while connected to the system should be about 4 volts in the A/C mode and 8 volts in the heat mode. The most likely thermistor problems are either a shorted thermistor or an open circuit thermistor. |
| Control panel | Verify that 12 volts on the red wire and ground on the black wire exist for the circuit board. The short black wire with the 90-degree female connector is the supply for the fan speed switch and should have 12 volts present with the air conditioner switch on or off. The voltage between the brown wire and ground (black) should be the same as described in the thermistor diagnostic procedure. If the voltage is not correct and the thermistor is good, then the control panel must be replaced. The voltage between the purple wire and ground (black) should be the same as pin 8 of the actuator. If the actuator operates correctly, then the control panel should be replaced. See **Fig. 4**. |

**Problem—No Cooling**

| Problem—No Cooling | |
|---|---|
| **Problem Area** | **Remedy** |
| Refrigerant system | Check the temperature of the evaporator core to verify that it is cool and indicate proper refrigerant system operation. |
| Actuator | Measure the voltage between ground terminal 7 (black wire) and supply terminal 10 (blue wire). This should be the same as the vehicle supply voltage. See **Fig. 3**.<br><br>Measure the voltage between control terminal 8 (purple wire) and ground terminal 7 (black wire). This should vary between 2 and 11 volts when the air conditioner switch is turned from on to off with the temperature control switch turned to the hottest position. This change in voltage should result in movement of the blend air door from the heater core to the A/C evaporator. If the voltage remains at 2 volts at terminal 8, then check for a shorted thermistor connection or a control panel problem. If the voltage remains at 11 volts, check for an open thermistor or a control panel problem. |
| Thermistor | Disconnect the thermistor from the wiring harness and check the resistance at room temperature. The resistance should be between 2500 and 3500 ohms at 77°F (25°C). Thermistor resistance will go down with an increase in temperature, and the resistance will go up with a decrease in temperature. The voltage across the thermistor while connected to the system should be about 4 volts in the A/C mode and 8 volts in the heat mode. The most likely thermistor problems are either a shorted thermistor or an open circuit thermistor. |

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## Troubleshooting for the Non-ATC Heater and Air Conditioner

| Problem—No Cooling | |
|---|---|
| **Problem Area** | **Remedy** |
| Control panel | Verify that 12 volts on the red wire and ground on the black wire exist for the circuit board. The short black wire with the 90-degree female connector is the supply for the fan speed switch and should have 12 volts present with the air conditioner switch on or off. The voltage between the brown wire and ground (black) should be the same as described in the thermistor diagnostic procedure. If the voltage is not correct and the thermistor is good, then the control panel must be replaced. The voltage between the purple wire and ground (black) should be the same as pin 8 of the actuator. If the actuator operates correctly, then the control panel should be replaced. See **Fig. 4**. |
| Expansion valve | Check the expansion valve. |

**Problem—No Temperature Modulation**

| Problem—No Temperature Modulation | |
|---|---|
| **Problem Area** | **Remedy** |
| Coolant flow | Check the temperature of the heater core to verify that hot coolant is flowing through the core. |
| Refrigerant system | Check the temperature of the evaporator core to verify that it is cool and indicate proper refrigerant system operation. |
| Actuator | Measure the voltage between ground terminal 7 (black wire) and supply terminal 10 (blue wire). This should be the same as the vehicle supply voltage. See **Fig. 3**.<br><br>Measure the voltage between control terminal 8 (purple wire) and ground terminal 7 (black wire). This should vary between 2 and 11 volts when the air conditioner switch is turned from on to off with the temperature control switch turned to the hottest position. This change in voltage should result in movement of the blend air door from the heater core to the A/C evaporator. If the voltage remains at 2 volts at terminal 8, then check for a shorted thermistor connection or a control panel problem. If the voltage remains at 11 volts, check for an open thermistor or a control panel problem. |
| Thermistor | Disconnect the thermistor from the wiring harness and check the resistance at room temperature. The resistance should be between 2500 and 3500 ohms at 77°F (25°C). Thermistor resistance will go down with an increase in temperature, and the resistance will go up with a decrease in temperature. The voltage across the thermistor while connected to the system should be about 4 volts in the A/C mode and 8 volts in the heat mode. The most likely thermistor problems are either a shorted thermistor or an open circuit thermistor. |
| Control Panel | Verify that 12 volts on the red wire and ground on the black wire exist for the circuit board. The short black wire with the 90-degree female connector is the supply for the fan speed switch and should have 12 volts present with the air conditioner switch on or off. The voltage between the brown wire and ground (black) should be the same as described in the thermistor diagnostic procedure. If the voltage is not correct and the thermistor is good, then the control panel must be replaced. The voltage between the purple wire and ground (black) should be the same as pin 8 of the actuator. If the actuator operates correctly, then the control panel should be replaced. See **Fig. 4**. |

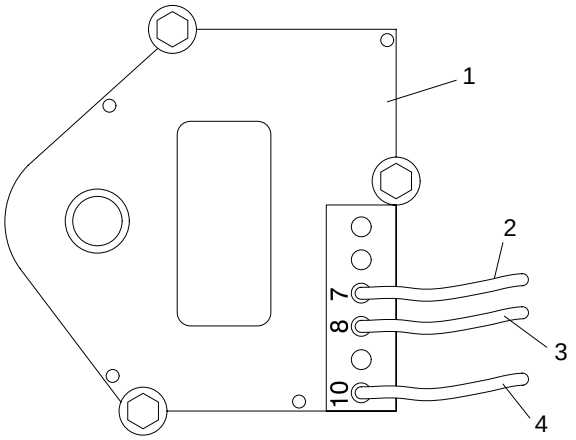
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## Troubleshooting for the Non-ATC Heater and Air Conditioner

**Problem—No Airflow**

| Problem—No Airflow | |
|---|---|
| **Problem Area** | **Remedy** |
| Motor, locked blower wheel | Verify the presence of 12 volts at the motor leads when in high fan speed. If 12 volts exists at the motor and the blower is not turning, look for a locked rotor or a possible intermittent connection in the wiring harness. If 12 volts are not present, inspect the wiring harness. |
| Control Panel | Verify that 12 volts on the red wire and ground on the black wire exist for the circuit board. The short black wire with the 90-degree female connector is the supply for the fan speed switch and should have 12 volts present with the air conditioner switch on or off. The voltage between the brown wire and ground (black) should be the same as described in the thermistor diagnostic procedure. If the voltage is not correct and the thermistor is good, then the control panel must be replaced. The voltage between the purple wire and ground (black) should be the same as pin 8 of the actuator. If the actuator operates correctly, then the control panel should be replaced. See **Fig. 4**. |




1. Actuator
2. Black Wire
3. Purple Wire
4. Blue Wire

**Fig. 3, Actuator**

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## Troubleshooting for the Non-ATC Heater and Air Conditioner

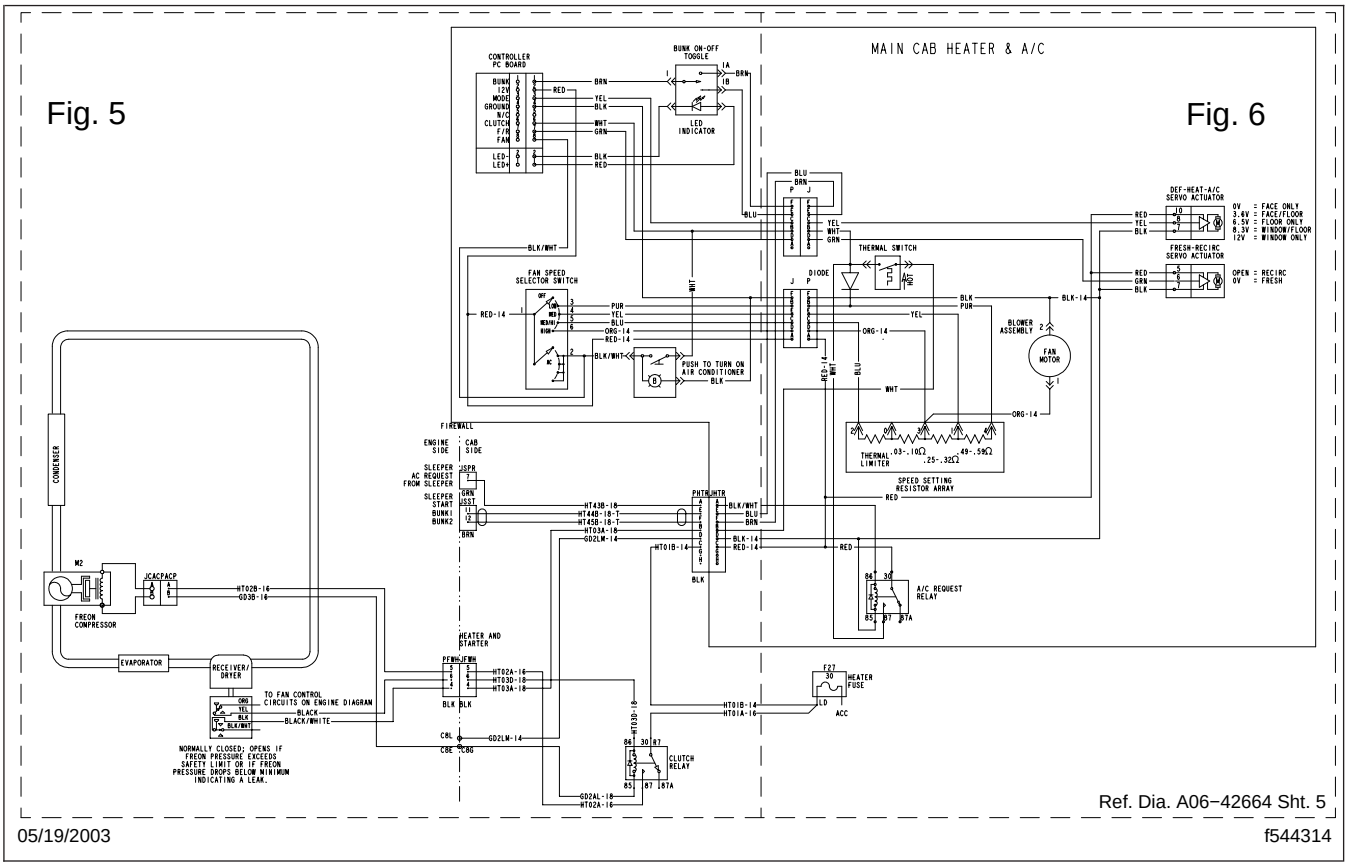



**Fig. 4, Non-ATC Cab Heater and Air Conditioner Wiring Schematic**

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## Troubleshooting for the Non-ATC Heater and Air Conditioner

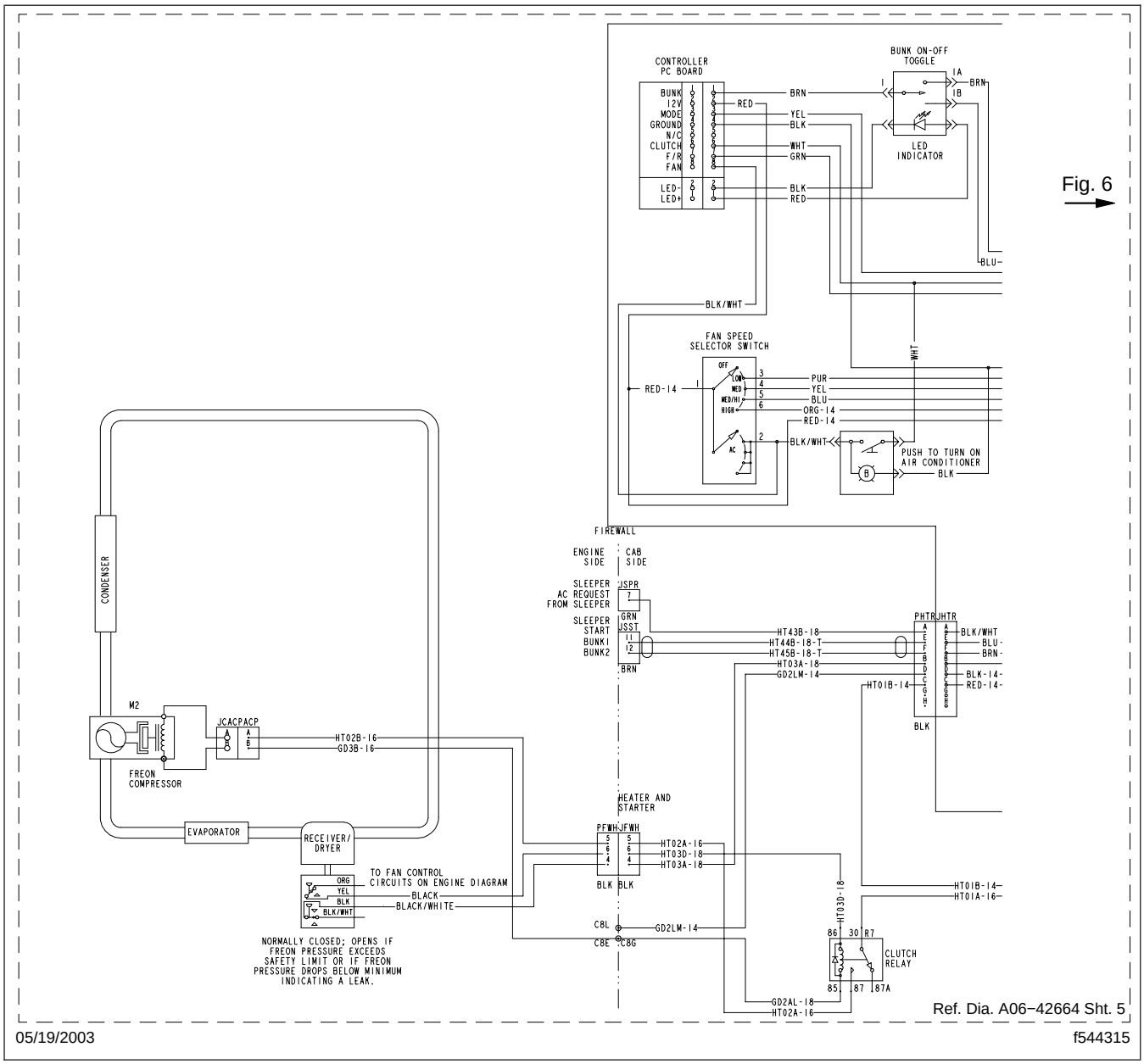



**Fig. 5, Non-ATC Cab Heater and Air Conditioner Wiring Schematic**

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## Troubleshooting for the Non-ATC Heater and Air Conditioner

Fig. 5

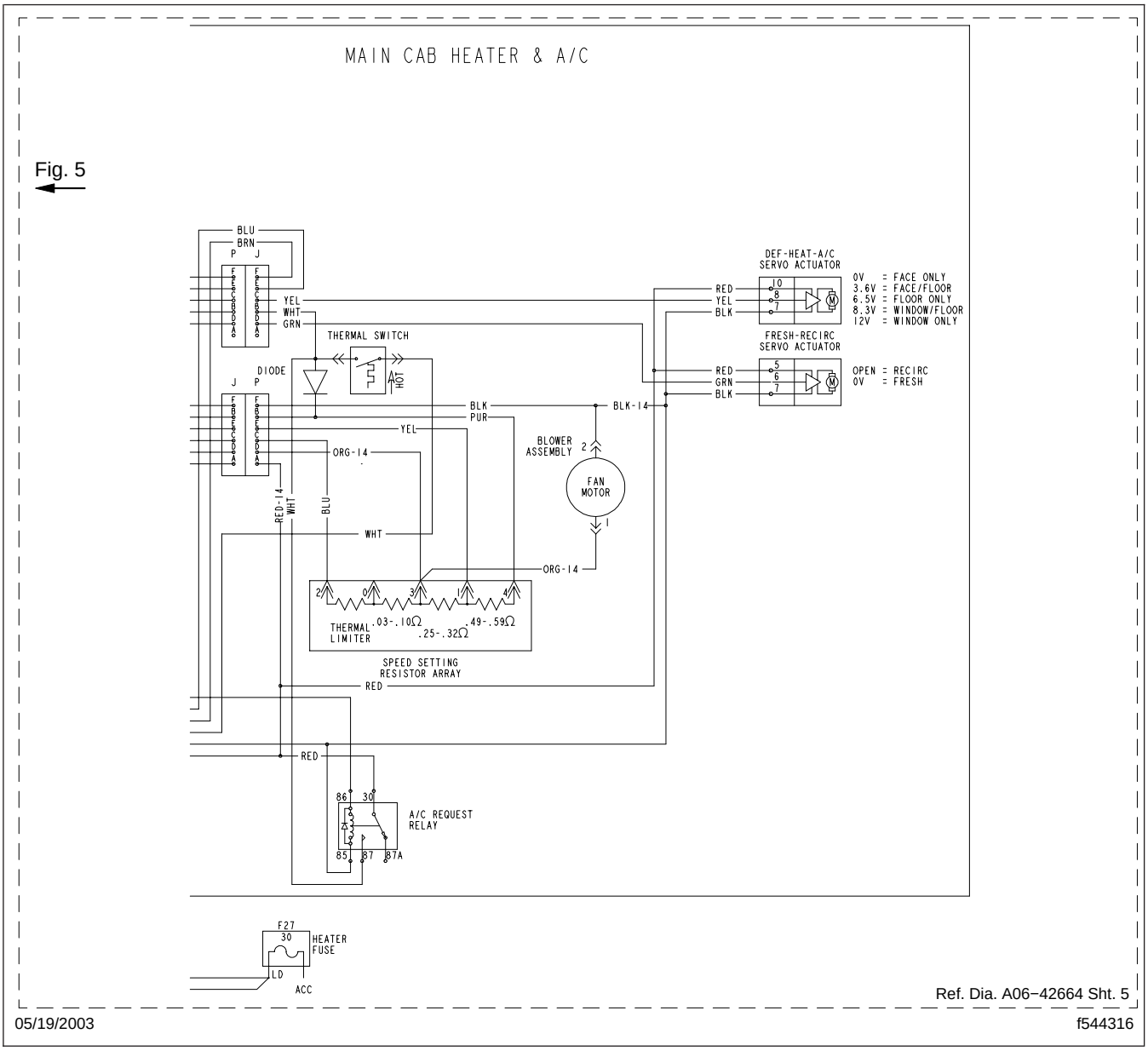



**Fig. 6, Non-ATC Cab Heater and Air Conditioner Wiring Schematic**

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## Troubleshooting for the Non-ATC Heater and Air Conditioner

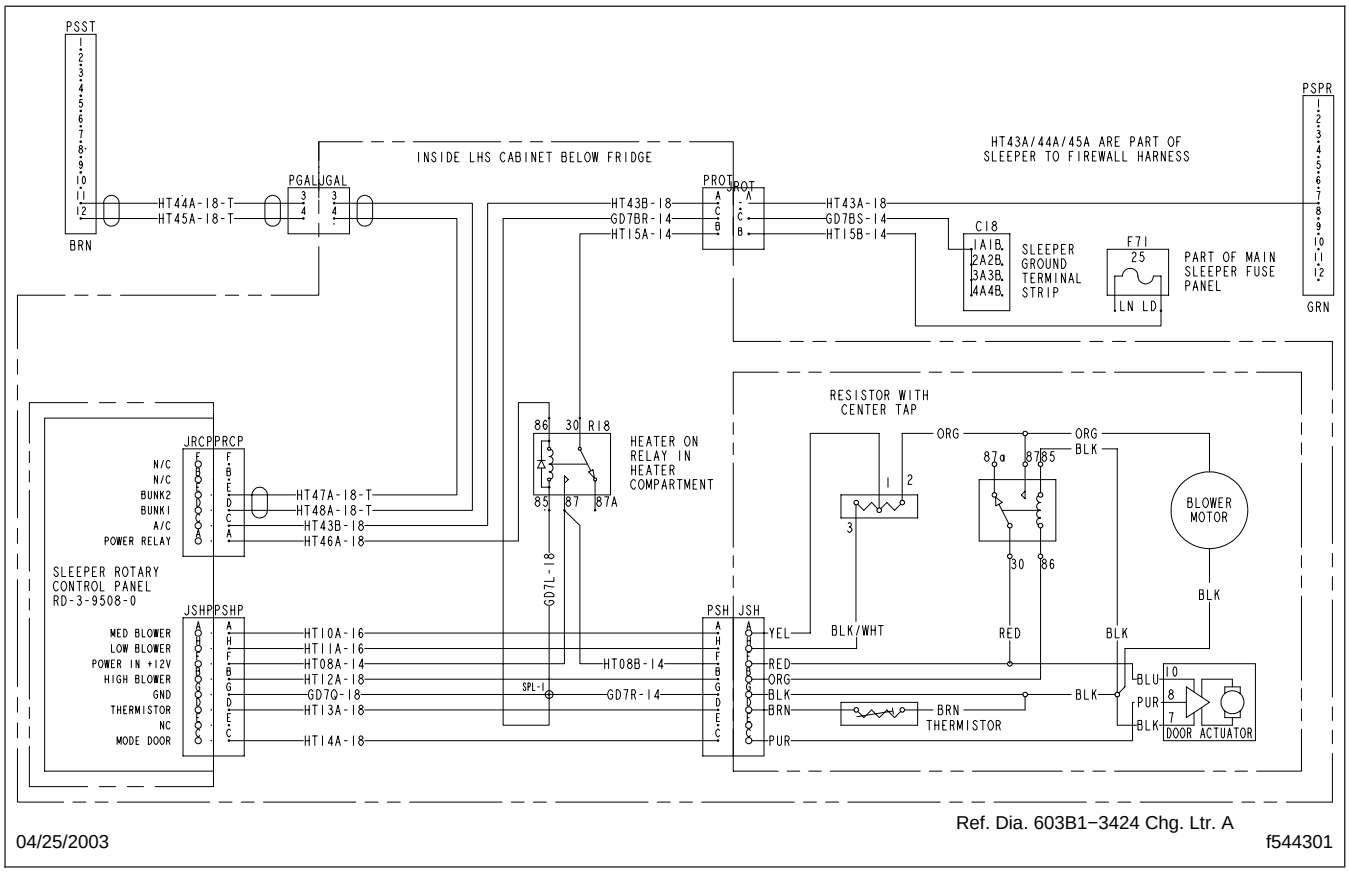



**Fig. 7, Non-ATC Sleeper Heater and Air Conditioner Wiring Schematic**

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# Troubleshooting for the ATC Heater and Air Conditioner With System Protection

## General Information

The Automatic Temperature Control (ATC) system is the latest in Red Dot electronic controllers. The ATC provides true cab temperature control and continuously variable blower fan speed. This is accomplished through the use of advanced microprocessor and sensor technology.

The troubleshooting procedures in this subject pertain to the Red Dot ATC heater and air conditioner with System Protection. Between August 16, 1999, and November 2001, Western Star offered the ATC heater and air conditioner with System Protection.

In November 2001, Western Star began offering the Red Dot ATC heater and air conditioner with Advanced Diagnostics. For information and troubleshooting procedures on the ATC heater and air conditioner with Advanced Diagnostics, see **Subject 320**.

## Control Operation Specifications

Temperature Control Range

- 60 to 90°F (16 to 32°C)

Blower Fan Control

- Pulse Width Modulation, maximum current handling: 25 amps

Temperature Sensors

- Cab Air Temperature: monitors the average cab air temperature, micro fan insures air flow across the sensor
- Duct Outlet Temperature: When heat is required, the sensor prevents high speed cold air from blowing out of the ducts until the heater core warms up (AUTO mode only).
- Evaporator Core Probe: Prevents ice from forming in the evaporator core: less than 31°F (–1°C) clutch cut out, greater than 37°F (3°C) clutch turn on

High Side Pressure Control

- high side transducer
- prevents operation at low ambient temperatures: less than 40 psig (276 kPa)–no A/C operation
- high pressure protection: greater than 350 psig (2413 kPa) clutch cut out, less than 275 psig (1896 kPa) clutch turn on
- condenser fan request: greater than 275 psig (1896 kPa) condenser fan turn on, less than 225 psig (1551 kPa) condenser fan turn off
- minimum condenser fan on time: 30 seconds

Low Side Pressure Control

- low side transducer
- low pressure protection: less than 7 psig (48 kPa) clutch cut out, greater than 25 psig (172 kPa) clutch turn on

Controlled Devices

- A/C compressor clutch circuit–maximum clutch cycle rate: five cycles/minute
- blower fan motor
- water valve
- bunk power unit

## Operation of the Cab ATC

### Controls

#### Blower Fan Speed Rotary Switch

The heater or air conditioner is turned on when the blower fan speed rotary switch is turned clockwise from the off position. When the heater or air conditioner is turned on, the LED display is illuminated. See **Fig. 1**. The display shows the current temperature set point. The blower fan switch has four speed settings. The AUTO setting on the blower fan switch places the HVAC system in the automatic blower fan speed control mode. When in the automatic mode, the fan speed can vary in infinite increments as necessary to maintain the temperature set by the user. As the cab temperature reaches the set point temperature, the blower speed decreases.

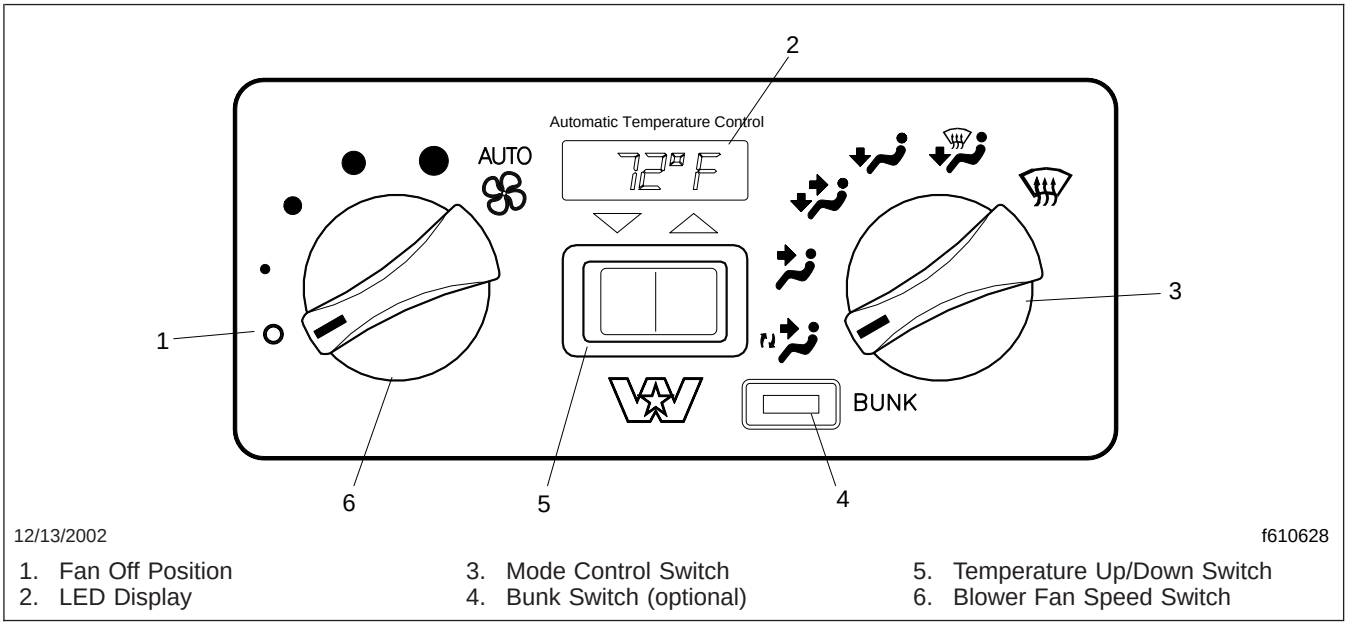
#### Temperature Up/Down Rocker Switch

Press and release the temperature up/down rocker switch to set the desired temperature. See **Fig. 1**. Pressing and holding the temperature up/down switch will cause the set point temperature to continuously increase or decrease. The HVAC system will attempt to achieve and hold the desired set point

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection




1. Fan Off Position
2. LED Display
3. Mode Control Switch
4. Bunk Switch (optional)
5. Temperature Up/Down Switch
6. Blower Fan Speed Switch

**Fig. 1, ATC Cab Climate Control Panel**

temperature by controlling the compressor clutch and water valve. When in AUTO mode, the blower fan speed is controlled automatically as well.

### Mode Control Rotary Switch

The mode control rotary switch sets the discharge mode of air flow. See **Fig. 2**.

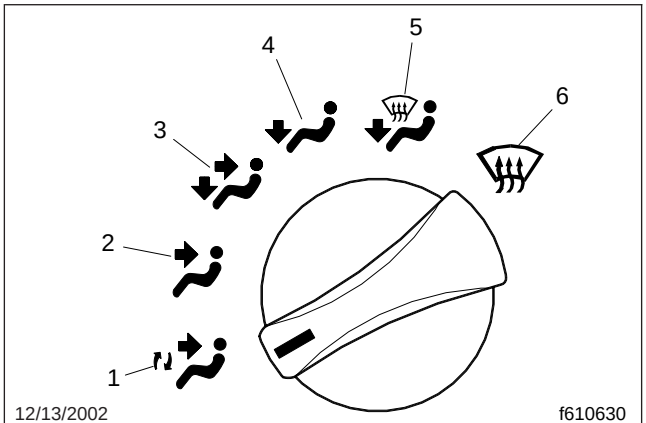
### Bunk Switch

The bunk switch enables or disables the bunk heater and air conditioner. When the bunk switch is on, the switch is illuminated. The bunk switch is optional.

## Heater Operation

The ATC automatically controls the HVAC system to maintain the cab air temperature close to the set point selected by the user. The ATC adjusts the air temperature blown through the outlets to maintain this temperature. If more heat is desired, increase the set point temperature by pressing and releasing the right side of the temperature up/down switch. If less heat is desired, decrease the set point by pressing and releasing the left side of the temperature up/down switch.

To obtain maximum heating, set the temperature to 90°F (32°C). The system will put out maximum heat continuously, even if the cab temperature exceeds




1. Dash Vents (recirculating air)
2. Dash Vents (fresh air)
3. Bi-Level (fresh air)
4. Floor (fresh air)
5. Floor and Defrost (fresh air)
6. Defrost (fresh air)

**Fig. 2, Mode Control Switch Settings**

the set point temperature. For maximum heating, turn the blower fan speed switch to the highest speed setting, not AUTO.

With the fan switch in AUTO mode, the fan speed will remain low until the air temperature warms up. Once the air temperature is warm, the fan speed will

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increase as necessary to warm up the cab to the set point temperature. Once the cab reaches the set point temperature, the fan speed will decrease.

A comfortable set point for heating is between 72 to 78°F (22 to 26°C). Change the temperature set point in small increments for best results. Once a comfortable temperature is reached, this temperature will be maintained without adjusting the set point.

## Defrosting or Defogging Operation

The defrost mode is used to deice, defrost, or defog the windows. Turn the mode control switch to the defrost mode. See **Fig. 2**. The ATC automatically increases the blower speed and the air temperature to quickly defrost the windows.

In cold or humid conditions, more heat and air flow are required to clear the windows. The set point temperature and the blower speed should be adjusted as necessary to maintain a clear windshield at all times. For maximum defrost, increase the set point temperature to the maximum setting (90°F or 32°C) and increase the blower speed to maximum fan, not AUTO.

NOTE: The air conditioner is enabled when in defrost mode. The air conditioner is used to dehumidify the air entering the cab and to remove the moisture from the windshield.

## Air Conditioner Operation

The ATC feature automatically controls the HVAC system to maintain the cab air temperature close to the set point selected by the user. The ATC adjusts the air temperature blown through the ducts to maintain the selected temperature. If more cooling is desired, decrease the set point temperature by pressing the left side of the temperature up/down switch. If less cooling is desired, increase the set point by pressing the right side of the temperature up/down switch.

To obtain maximum cooling, set the set point temperature to 60°F (16°C). The system will put out maximum cooling continuously, even if the cab temperature drops below the set point temperature. Turn the blower fan switch to highest fan speed, not AUTO.

In AUTO mode, the fan speed adjusts as necessary to keep the cab at the set point temperature. The further away the cab temperature is from the set point, the higher the fan speed.

For maximum cooling, turn the mode control switch to the recirculation mode. See **Fig. 2**. Once the cab is cool, any of the other modes can be used, such as dash vents or bi-level.

A comfortable set point for cooling is between 68 to 74°F (20 to 23°C). Change the temperature set point in small increments for best results. Once a comfortable temperature is reached, this temperature will be maintained without adjusting the set point.

## Ventilation

The dash vents (recirculating air) mode is the only mode that recirculates the air in the cab. All other modes draw in fresh air from the outside of the vehicle. Use the recirculation mode for short periods of time to prevent fumes or dust from entering the cab or to obtain maximum cooling or heating.

## Changing Temperature Units

The temperature units can be changed from Fahrenheit (°F) to Celsius (°C) or from Celsius to Fahrenheit by turning the ignition on, the blower fan speed switch to off, and pressing and holding the temperature up/down switch on the side with the blue arrow for five seconds. The current temperature unit will then be shown on the LED display. Press the temperature down switch again to toggle between the °F and °C temperature units. Changing the temperature units on the cab climate control panel will also effect the corresponding units on the bunk control panel. To obtain more accurate temperature control, use the Fahrenheit (°F) setting.

# Cab System Logic

## Automatic Fan Speed Control

The fan speed is determined by the system as required. The fan speed is based on the difference between the set point temperature and the actual cab temperature. The greater the difference, the greater the fan speed. When the temperature is too hot and heating is occurring, or if the temperature is too cold and cooling is occurring, then the fan speed will be held at minimum. This condition can occur when the

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection

cab is heating or cooling quickly and the temperature overshoots the set point temperature. The fan speed will be set to high if a cab temperature sensor error occurs. In AUTO fan speed mode, when heating is occurring, the fan speed is also limited by the outlet duct temperature. If the duct temperature is less than 72°F (22°C), then the fan speed will be limited to low fan speed. The fan speed limit will gradually increase as the duct temperature increases until the duct temperature reaches 95°F (35°C). This limit is disabled if a duct temperature sensor error occurs. In AUTO fan speed mode, all fan speed changes are done gradually. See **Table 1** for a list of the controls for the fan speed.

| Fan Speed Control | |
|---|---|
| **Fan Speed** | **Control** |
| O | Manual mode fan off |
| 1 | Manual mode fan low |
| 2 | Manual mode fan medium 1 |
| 3 | Manual mode fan medium 2 |
| 4 | Manual mode fan high |
| 5 | Automatic fan speed control |

**Table 1, Fan Speed Control**

In either automatic or manual mode, the initial fan speed on startup will gradually increase from off to the desired fan speed.

### Compressor Clutch Control

The compressor clutch can be active in any mode when the fan speed is not off. The clutch is activated as required to maintain the set point temperature.

In defrost mode, the compressor clutch is forced on to provide cab air dehumidification.

In the event of a cab temperature sensor error, the system will operate in a manual temperature control mode with a set point of 60°F (16°C) corresponding to full air conditioning, 75°F (24°C) corresponding to neutral, and 90°F (33°C) corresponding to full heat.

In any mode, the clutch activation can be disabled by the evaporator temperature sensor, the low pressure transducer, or the high pressure transducer. The evaporator temperature sensor trip points will be determined by the system to maintain the desired cab temperature. As less cooling is required, the evaporator temperature sensor trip points will increase, so as to maintain a fairly constant core temperature. In the case of full A/C or defrost mode, the evaporator temperature sensor trip points will be 31°F (–1°C) clutch off and 37°F (3°C) clutch on. The clutch will stay off for a minimum of 11 seconds before reengaging.

The low side pressure transducer trip points are 7 psig (48 kPa) clutch off and 25 psig (172 kPa) clutch on. The high pressure transducer high trip points are 350 psig (2413 kPa) clutch off and 275 psig (1896 kPa) clutch on. The high pressure transducer low trip points are 40 psig (276 kPa) clutch off and 50 psig (345 kPa) clutch on. If a high pressure transducer error or a low pressure transducer error occurs, then clutch activation will be disabled.

### Condenser Fan Control

The condenser fan trip points are 275 psig (1896 kPa) fan on and 225 psig (1551 kPa) fan off. The fan will immediately be engaged if the high side pressure exceeds 275 psig (1896 kPa). This is accomplished by breaking continuity between E and F on the six-pin Packard Vehicle Interface Connector which generates a fan on request to the engine fan control circuitry. The fan will remain on for a minimum of 30 seconds. The fan will turn off if the high side pressure drops below 225 psig (1551 kPa) **and** if 30 seconds has elapsed since the fan was last turned on. The fan will be disengaged by creating continuity between terminals E and F on the six-pin Packard vehicle interface connector which triggers the engine fan control circuitry.

## Cab System Function Check

See **Table 2** for the ATC HVAC system testing procedure.

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection

| ATC HVAC System Testing Procedure | | |
|---|---|---|
| **Control or Display** | **Action** | **Test Reaction** |
| Control Panel Display | Turn fan off.<br>Turn ignition on. | Display flashes **8888** briefly. |
| Blower Fan Speed Switch | Turn fan on. | Display reads 75°F (24°C) or last set point.<br>Air should be blowing. |
| Blower Fan Speed Switch | Turn fan to all speeds. | Amount of air flow should change accordingly. |
| Temperature Up/Down Switch* | Set temperature to lowest setting.<br>Set fan to AUTO. | Blower fan increases to high.<br>Air conditioner turns on. |
| Temperature Up/Down Switch† | Set temperature to highest setting.<br>Set fan to AUTO. | Blower fan speed increases to high.<br>Heater turns on. |
| Temperature Up/Down Switch | Set temperature to approximate cab temperature. | Blower fan speed decreases to low. |
| Mode Control Switch | Mode door control position changed. | Vent mode should change accordingly. |
| Mode Control Switch | Mode set to defrost. | A/C clutch should engage. |
| Bunk Switch | Press BUNK switch | BUNK switch illuminates.<br>Bunk unit turns on. |
| Error Codes | Turn blower switch to off.<br>Press and hold the up side of temperature up/down switch.<br>Press up side of temperature up/down switch again to scroll through errors. | Error codes displayed.<br>E0 indicates no faults detected. |
| Degree Units Change | Turn blower switch to off.<br>Press and hold the down side of temperature up/down switch.<br>Press down side of temperature up/down switch again to change units. | Temperature unit displayed.<br>Units change when the rocker switch is pressed. |

* Ambient and cab air temperatures should be between 67 to 77°F (19 to 25°C).

† Ambient and cab air temperatures should be between 67 to 77°F (19 to 25°C) and vehicle engine should be at normal operating temperature.

**Table 2, ATC HVAC System Testing Procedure**

# Cab HVAC System Troubleshooting

## System Diagnostics/Error Codes

Error codes can be displayed by turning the ignition on, the blower fan speed switch to off, and pressing and holding the temperature up switch for five seconds. The current error status will be shown on the LED display. Pressing the temperature up switch again repeatedly will scroll the display through any existing error codes. See **Table 3** for a list of the error codes.

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection

| Error Codes | |
|---|---|
| **Error Code** | **Problem** |
| E0 | No fault detected |
| E1 | Cab sensor shorted |
| E2 | Cab sensor disconnected |
| E3 | Evaporator probe shorted |
| E4 | Evaporator probe disconnected |
| E5 | Duct sensor shorted |
| E6 | Duct sensor disconnected |
| E7 | Low pressure transducer fault–disconnected or shorted |
| E8 | High pressure transducer fault–disconnected or shorted |
| E9* | High pressure and low pressure transducer connectors switched |
| E17 | ECU module failure, disconnected, or no power, or serial communication wires disconnected or reversed |

* This error code will not be displayed if the ambient temperature is below 40°F (4°C) or if the pressure in the A/C system is lower than 30 psig (207 kPa); however, the A/C clutch will not engage under these conditions even if the connectors are switched. This error code may be displayed if the A/C has been engaged in the last 10 minutes prior to checking for error codes. If this error code is displayed, allow the vehicle to sit with the engine off for at least 10 minutes and check errors again.

**Table 3, Error Codes**

# Cab System Troubleshooting Procedures

**Problem—No Display on Control Panel**

- Turn on control panel with blower fan speed switch.
- Check to see if the display illuminates.
- Verify that the control panel is plugged in to the wiring harness.
- Check to see if wiring harness is wired in to vehicle properly.
- Check the control panel.

**Problem—Fan Does Not Work**

- Using the fan speed switch, turn the fan to the highest setting.
- Verify that 12 volts is supplied to the ECU.
- Make sure blower fan is plugged in to wiring harness.
- Verify that 12V is supplied to fan.
- Check the fan.
- Check the ECU.

**Problem—No Heating**

- Using the temperature up/down switch, increase the temperature to the highest setting.
- Verify that warm coolant is flowing to the heater core by feeling the heater hoses.
- Verify that the water valve solenoid is wired correctly (one side to +12V).
- Check the water valve.

**Problem—No Cooling**

- Using the temperature up/down switch, decrease the temperature to the lowest setting and turn the mode switch to enable the defrost mode.
- Verify that the low pressure and high pressure transducers are connected properly.
- Verify that voltage is present at the compressor clutch.
- Verify that the circuit breakers or fuses are intact.
- Verify that the correct voltage is present at the clutch relay on the wiring harness.
- Check for frozen evaporator core.
- Verify that the correct voltage is present at the thermostat.

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection

- Verify that the system is fully charged with refrigerant.
- Check for moisture in the system.
- Inspect the clutch relay and replace if necessary.
- Check the water valve.
- Check the A/C clutch.

**Problem—System emits cool air when heat is needed**

- Verify that the cab temperature sensor is connected correctly and the fan in the sensor is spinning.
- Verify that the water valve is working properly. See "Problem—No Heating."
- Check the cab temperature sensor.
- Check the ECU.

**Problem—System emits hot air when cooling is needed**

- Verify that the cab temperature sensor is connected correctly and the fan in the sensor is spinning.
- Verify that the compressor clutch is working properly. See "Problem—No Cooling."
- Check the cab temperature sensor.
- Check the ECU.

**Problem—The engine fan not engaging or disengaging correctly**

- Verify that high pressure transducer is connected properly. Inspect and replace fan relay if necessary.
- Verify wiring harness connections.

**Problem—The sleeper unit is not engaging or disengaging correctly**

- Verify that bunk indicator is illuminated.
- Verify that the sleeper unit is working correctly.
- Inspect and test the vehicle wiring harness for incorrect wiring.

**Problem—Low Evaporator Coil Outlet Pressure (low compressor suction pressure)**

- Verify that the expansion valve is working.
- Verify that there are no restrictions in the line to the expansion valve.
- Verify that there is a sufficient refrigerant charge in the system.

**Problem—High Compressor Discharge Pressure**

- Verify that the airflow through the condenser is not restricted.
- Verify that there is no restriction in the condenser.
- Verify that there is no air in the system.
- Verify that the evaporator coil is not flooded.
- Verify that the engine is not overheated.
- Verify that there is no restriction in the compressor discharge line.

**Problem—Compressor Operates Too Often**

- Verify that there is a sufficient refrigerant charge in the system.
- Verify that there is no ice on the evaporator coil.
- Verify that there is no restriction in the refrigerant system.
- Verify that there is no dirt or debris clogging the condenser fins.
- Verify that the thermostatic switch is working.

# Voltage Levels

See **Table 4** and **Table 5** for the function of the wires in the vehicle interface harnesses.

| Eight-Pin Packard Vehicle Interface Harness | | |
|---|---|---|
| **Color** | **Line** | **Function** |
| Brown | Water Valve Solenoid | Output pulls to ground when active (water valve required to be off). With a water valve connected, the pin will be pulled up to +12V by the water valve load (water valve required to be on). |

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection

| Eight-Pin Packard Vehicle Interface Harness | | |
|---|---|---|
| **Color** | **Line** | **Function** |
| White | Clutch | Output goes to +12V when active (clutch on). Output floating when inactive (clutch off). With the harness connected, the output will be 0V when the clutch is not requested and +12V when the clutch is requested. |
| Red | Ignition | Input provides power for the HVAC unit. Should be +12V. |
| Black | Ground | Input provides ground for the HVAC unit. Should be 0V. |
| Green | Bunk1 | Input/output provides serial information link between the sleeper HVAC and the cab HVAC. This line should be connected to the bunk1 line on the bunk harness, if used. In use, this line will be a serial stream of 0V/5V signals. The average voltage reading on this pin will be around 2.5V. |
| Purple | Bunk2 | Input/output provides serial information link between the bunk HVAC and the cab HVAC. This line should be connected to the bunk2 line on the bunk harness, if used. In use, this line will be a serial stream of 0V/5V signals. The average voltage reading on this pin will be around 2.5V. |

**Table 4, Eight-Pin Packard Vehicle Interface Harness**

| Six-Pin Packard Vehicle Interface Harness | | |
|---|---|---|
| **Color** | **Line** | **Function** |
| Black | Analog Ground | Output provides analog ground for the pressure transducers. Should be 0V. |
| White | +5V Reference Voltage | Output provides power for the pressure transducers. Should be +5V. |
| Green | LS Pressure | Input signal from low side pressure transducer. This voltage will be related to the low side pressure by the function V=0.25 + psig x 0.030. |
| Purple | HS Pressure | Input signal from high side pressure transducer. This voltage will be related to the high side pressure by the function V=0.25 + psig x 0.009. |
| Yellow | Engine Fan | Output for engine fan activation. This pin will be connected to pin F (continuity with pin F) to request the engine fan off from the fan control circuits. |
| Orange | Engine Fan | Output for engine fan activation. This pin will be connected to pin E (continuity with pin E) to request the engine fan off from the fan control circuits. |

**Table 5, Six-Pin Packard Vehicle Interface Harness**

# Sleeper System Logic

## Fan Speed Control

The manual fan control mode provides 11 fan speed settings: LO, 10, 20, 30, 40, 50, 60, 70, 80, 90, HI.

## Automatic Fan Speed Control

The fan speed is determined by the system as required. The fan speed is based on the difference between the set point temperature and the actual sleeper cab temperature. The greater the difference, the greater the fan speed. When the temperature is too hot and heating is occurring, or if the temperature is too cold and cooling is occurring, the fan speed will be held at minimum. This condition can occur when the sleeper cab is heating or cooling quickly and the temperature overshoots the set point temperature. The fan speed will be set to high if a cab temperature sensor error occurs. In automatic fan speed mode, all fan speed changes are done gradually.

In automatic or manual mode, the initial fan speed at startup will gradually increase from off to the desired fan speed.

## Blend Door Control

The blend door is controlled as required to maintain the sleeper cab temperature at the set point temperature. The blend door has a motor that allows the

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actuator to be turned clockwise, counterclockwise, or held steady. The feedback potentiometer provides a signal proportional to the current position of the blend door actuator.

If a sleeper cab temperature sensor error occurs, then the system will go into manual temperature control mode ranging from full cool to full heat.

## Cab HVAC Communications

The communications link between the sleeper HVAC unit and the cab HVAC unit provides several functions. Because the sleeper HVAC unit is dependent on the cab HVAC unit to provide clutch activation, the communications link provides this function. Any time the sleeper unit moves the blend door to the full cool position, the sleeper controller requests the A/C clutch to be turned on. Upon receiving the A/C clutch request, the cab HVAC controller will turn on the A/C clutch. If the cab HVAC unit is off, then the cab HVAC blower will be turned to the LO position.

Another function of the communications link is to allow the BUNK switch on the ATC cab control panel to turn the sleeper HVAC on or off. A third function of the communications link is the function of the set point temperature slave mode.

# Wiring Diagrams

See **Fig. 3** and **Fig. 4** for the ATC cab HVAC wiring diagram.

# Sleeper ATC With Alarm Clock

## General Information

The Red Dot Automatic Temperature Control (ATC) sleeper heater and air conditioner is designed as the complement to the Red Dot ATC cab heater and air conditioner. The ATC sleeper heater and air conditioner provides true interior sleeper compartment temperature control and continuously variable blower fan speed. This is accomplished through the use of advanced microprocessor and sensor technology. The control keypad features full HVAC control as well as a clock with alarm. The sleeper unit can be turned on and off without turning on the cab HVAC unit.

## Specifications

### Display

The display is vacuum fluorescent and has five digits that are 0.33 inch (8 mm) high. Time is displayed in a 12-hour format with a separate PM LED indicator. Temperature is displayed with a three-digit annotation and can be displayed either in degrees Celsius or degrees Fahrenheit. A capital C or F is displayed for the appropriate temperature scale.

### ATC Sleeper Control Panel

The control panel is comprised of a membrane switch assembly with a Lexan outer covering. The panel has incorporated physical mechanical tactile feedback to ensure easily identifiable switch actuation. Indicator LEDs illuminate when a switch activation has occurred, thus providing both physical and visual indication of circuit activation. The control panel has backlighting to allow rapid and positive switch location even in dim ambient light conditions.

### Clock

The clock is crystal controlled with a low temperature drift oscillator for long term stability.

### Blower Motor Drive

Power MOSFET circuitry provides 20-amp drive capacity with multiple times instantaneous current ability. There is internal protection from voltage transients and current overloads.

### Voltage Input

The unit is designed to operate on standard truck operating voltages, 13.5 volts typical. The unit will operate correctly with input from 8 to 16 volts.

# Operation of Sleeper ATC

## Controls

### Clock Control

The clock controls are located on the left side of the ATC sleeper control panel under the display. The display will show the clock time as the default mode. See **Fig. 5**.

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection

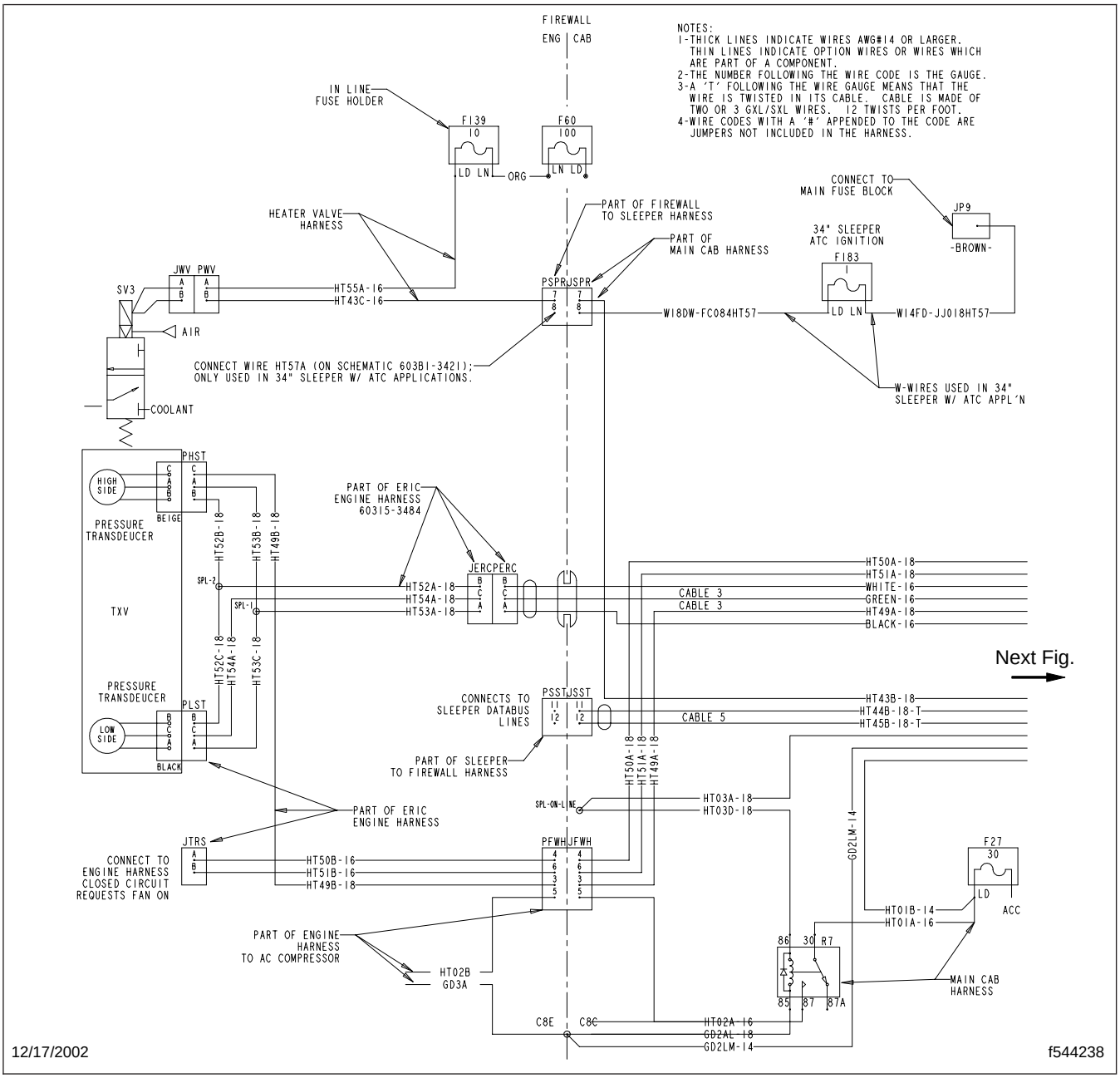



**Fig. 3, ATC Cab HVAC Wiring Diagram, Part 1**

## Alarm Button

Momentarily press the ALARM button to turn the alarm on and to illuminate the alarm indicator light above the alarm button. Momentarily press the button again to deactivate the alarm.

When pressing the ALARM button, the display shows the alarm time setting for five seconds before returning to the current time display. If the alarm button is pressed and held down continuously for more than one second, the alarm time setting can be viewed without changing the state of the alarm indicator. If

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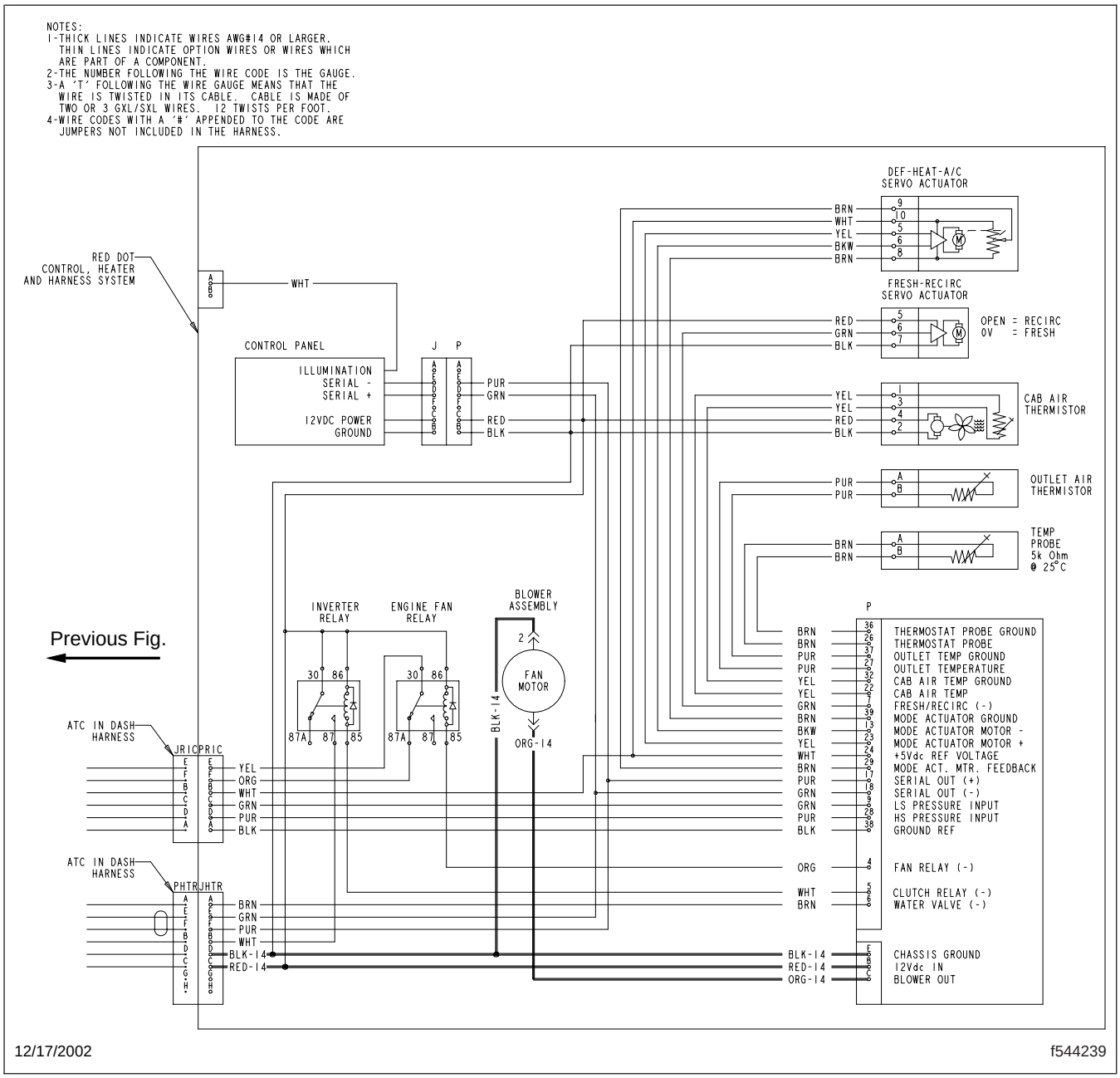



**Fig. 4, ATC Cab Wiring Diagram, Part 2**

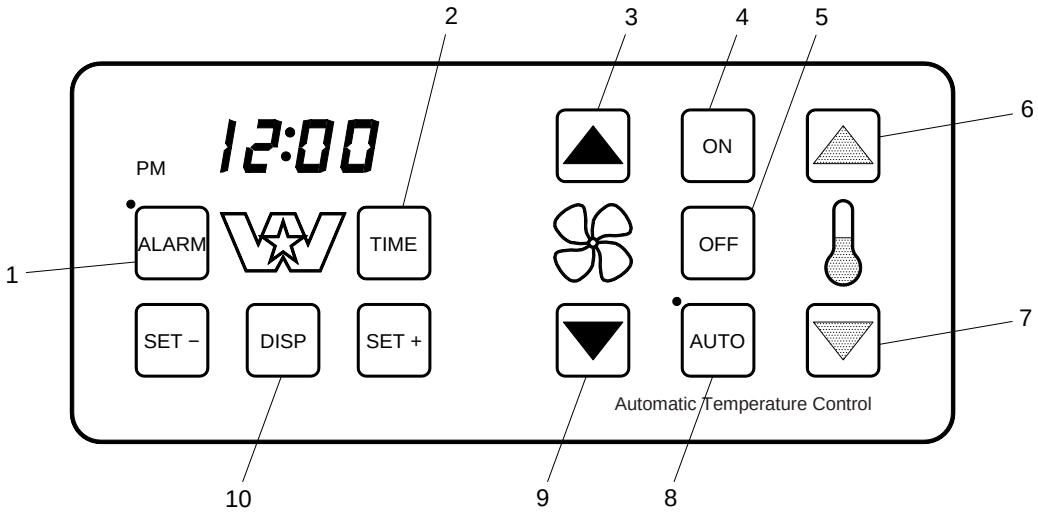
either the SET+ or SET– buttons are pressed simultaneously with the ALARM button held down, the alarm time setting will increase or decrease. When the ALARM button is released after changing the alarm time, the alarm will be turned on and the indicator will be illuminated. When the ALARM is sounding, press the ALARM button to turn the alarm off and to reset the alarm for the next 24-hour cycle.

NOTE: If any button other than the ALARM button is pressed when the alarm is sounding, the snooze function will be engaged.

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection




1. Alarm Button
2. Time Button
3. Fan Up Button
4. HVAC On Button
5. HVAC Off Button
6. Temperature Up Button
7. Temperature Down Button
8. Automatic Blower Fan Speed
9. Fan Down Button
10. Display Button

**Fig. 5, ATC Sleeper Control Panel**

If the snooze function is active, as indicated by a blinking alarm indicator light, press the ALARM button to cancel the snooze function and to reset the alarm for the next 24-hour cycle.

### Time Button

Press the TIME button to display the current time. If the TIME button is held down and either the SET+ or SET– buttons are pressed simultaneously with the TIME button, the clock setting will increase or decrease.

### Display

Depress the DISP button to allow the display and illumination of the control panel to scroll through three illumination levels: bright, dim, and off. If you want the ALARM, TIME, or HVAC setting to be displayed when the display is in the off mode, press the ALARM, TIME, or HVAC buttons to display the corresponding display for five seconds. After five seconds, the display will turn off. If the alarm sounds while in the display off mode, the current time will be displayed simultaneously. The display will remain on for five minutes, then turn off.

### Snooze Feature

To enable the snooze alarm, press any button on the control panel, except the ALARM button, when the alarm is sounding. The alarm will turn off for seven minutes. The alarm indicator light flashes when the snooze alarm is enabled. The snooze alarm can be enabled indefinitely.

### AM/PM

PM is displayed at the left side of the display and is illuminated during PM hours. When PM is not displayed, AM hours are displayed. When setting the time or alarm, note the presence or absence of the PM.

## Automatic Temperature Control

The controls for the sleeper heater and air conditioner are located on the right side of the ATC sleeper control panel. See **Fig. 5**.

### On Button

To turn the sleeper heater and air conditioner on, press the ON button. The display will show the current temperature control set point for five seconds

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then return to the time display. The fan and temperature control will not engage unless the ignition is on. If the engine is on, but the cab ATC heater and air conditioner is off, turning the sleeper heater and air conditioner on will engage the compressor clutch and turn the cab unit blower fan to a low setting.

## Off Button

To turn the sleeper heater and air conditioner off, press the OFF button.

## Auto Button

Press the AUTO (default on) button to enable automatic control of the blower fan speed. When automatic control is enabled, the indicator light above the AUTO button will illuminate. The display will show the current temperature control set point for five seconds, then return to the normal time display. When in this mode, the fan speed can vary in infinite increments as necessary to maintain the temperature set by the user.

## Temperature Up/Down Buttons

The temperature up/down buttons increase or decrease the control set point temperature. Each button may be pressed repeatedly to incrementally increase or decrease the set point. Press either button for at least two seconds to continuously increase or decrease the set point temperature. The display will show the current set point temperature. The display returns to the normal time display five seconds after a button is pressed and released.

## Fan Up/Down Buttons

The fan up/down buttons increase or decrease the blower fan speed. Each button may be pressed repeatedly to incrementally increase or decrease the set point. Press either button for at lease two seconds to continuously increase or decrease the set point. The display indicates the fan speed setting in 10 percent increments or HI when the maximum speed is selected and LO when the minimum speed is selected. The display returns to the normal display five seconds after a button is pressed. The AUTO fan function is disabled if either of these buttons is pressed.

# Turning on the Sleeper HVAC When the Cab HVAC is Off

The sleeper ATC control panel can turn on the air conditioner even if the cab HVAC unit is turned off but the engine is running. By pressing the ON button, the ATC sleeper control panel will turn on the cab unit and the bunk indicator light on the cab control panel will be illuminated. If cooling is needed in the sleeper, the cab HVAC unit will switch on to a low blower fan setting and the A/C compressor clutch will engage. If cooling is no longer required in the sleeper or if heat is needed, the cab unit fan and the compressor clutch will be turned off after a five-minute delay.

# Changing Temperature Units

The temperature units can be changed from °F to °C or from °C to °F by pressing the temperature up and temperature down buttons simultaneously. Changing the temperature units on the ATC sleeper control panel will also change the temperature units on the ATC cab control panel.

# Set Point Temperature Slave Mode Feature

The set point temperature slave mode allows the set point temperatures of the cab HVAC unit and the sleeper HVAC unit to be tied together automatically. In this mode, the temperature set point in the vehicle will always be the same whether the set point is changed on the cab control panel or the sleeper control panel. To enable the set point temperature slave mode, press the SET+ and SET– buttons simultaneously. The display will read S–ON when the set point temperature slave mode is enabled.

The set point temperature slave mode can be disabled by simultaneously pressing the SET+ and SET– buttons. The display will read S–OFF indicating that the mode is disabled. If disabled, the set points for the cab and sleeper control panels can be changed independently for separate temperature control. If you wish to maintain a temperature in the sleeper that is different than the temperature in the front of the cab, it is recommended that a curtain be used between the sleeper and the front of the cab.

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection

### Sleep Mode

The ATC sleeper control panel will immediately enter a power saving sleep mode when the vehicle ignition is not powered. The display and control panel illumination will turn off while all of the clock functions, including the alarm, continue to work internally. This feature is designed to reduce the power draw on the battery when the engine is not running by dropping the required current. If the DISP button is pressed while the ignition is turned off, the display will be illuminated for five minutes. After five minutes, the display will turn off and the electronics will go back to the sleep mode.

## Sleeper System Function Check

See **Table 6** for the sleeper HVAC system testing procedure.

| Sleeper HVAC System Testing Procedure | | |
|---|---|---|
| **Control or Display** | **Action** | **Test Reaction** |
| Control Panel Display Test | Battery connected (first time)<br>Press DISP button if display is blank | Display shows **8888** then the current time. |
| Control Panel Fan Control Test | Ignition on<br>HVAC on<br>Fan turned to different speeds | Amount of air flow should change accordingly. |
| Control Panel Temperature Control Test* | Set temperature to lowest setting.<br>Set fan to AUTO. | Blower fan increases to high.<br>Air conditioner turns on. |
| Control Panel Temperature Control Test* | Set temperature to highest setting.<br>Set fan to AUTO. | Blower fan increases to high.<br>Heater turns on. |
| Control Panel Temperature Control Test | Set temperature to approximate sleeper temperature. | Blower fan speed decreases to low. |
| Control Panel Clock Control Time Set | Press TIME and SET+ or SET– buttons simultaneously. | Current time is changed. |
| Control Panel Clock Control Alarm Set | Press ALARM and SET+ or SET– buttons simultaneously. | Alarm time is changed. |
| Control Panel Clock Control Alarm On/Off | Press and release ALARM button. | Alarm indicator light turned on or off, alarm enabled if light on. |
| Control Panel Clock Control Alarm Display | Press and hold ALARM button for more than 1 second. | Alarm time displayed without changing the state of the alarm indicator. |
| Control Panel Clock Control Display | Press DISP button. | Display brightness should change (bright, dim, off). |
| Control Panel Clock Control Test | Display set to off.<br>Press TIME button. | Current time is displayed. |

* Ambient and cab air temperatures should be between 67 to 77°F (19 to 25°C).

**Table 6, Sleeper HVAC System Testing Procedure**

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection

# Sleeper System Troubleshooting

## System Diagnostic Error Codes

Error codes can be displayed by pressing the fan up and fan down buttons simultaneously. The current error status will be shown on the digital display. Pressing the fan up button repeatedly will scroll the display through any existing error codes. See **Table 7** for a list of the error codes.

| Error Codes | |
|---|---|
| **Error Code** | **Problem** |
| E0 | No fault detected |
| E1 | Bunk sensor shorted |
| E2 | Bunk sensor disconnected |
| E3 | Not assigned |
| E4 | Not assigned |
| E5 | Not assigned |
| E6 | Not assigned |
| E7 | Not assigned |
| E8 | Not assigned |
| E9* | Actuator shorted |
| E10* | Actuator disconnected |

* This feature was not available prior to November 1999.

**Table 7, Error Codes**

# Sleeper HVAC System Troubleshooting Procedures

**Problem—No Display on Control Panel**

- Turn on control panel with ON button.
- Check to see if the display illuminates.
- Verify that the control panel is plugged in to the wiring harness.
- Check to see if the wiring harness is wired to vehicle properly and the battery is good.
- Verify that all fuses are intact.
- Check the control panel.

**Problem—Fan Does Not Work**

- Turn up fan with the fan up button.
- Verify that the ignition is on.
- Make sure blower fan is plugged in to wiring harness.
- Verify that the wiring between the sleeper control panel and the sleeper unit is correct.
- Verify that 12V is supplied to fan.
- Check the fan.
- Check the control panel.

**Problem—No Heating**

- Using the temperature up button, increase the temperature.
- Verify that warm coolant is flowing to the heater core by feeling the heater hoses in the sleeper box under the bunk.
- Verify that the actuator on the unit is moving the blend door when the temperature set point is changed from cold to hot.

**Problem—No Cooling**

- Using the temperature down button, decrease the temperature.
- Verify that the actuator on the unit is moving the blend door when the temperature set point is changed from hot to cold.
- Verify that compressor clutch is engaging.
- Verify that the circuit breakers or fuses are intact.
- Verify that the system is fully charged with refrigerant.
- See "Cab System Troubleshooting Procedures."

**Problem—Sleeper Unit Cannot be Turned on From the Cab Unit**

- Verify that both the sleeper control panel and the cab control panel are getting correct power and ground lines.
- Verify that the two serial communication wires connecting the front unit to the sleeper unit are correctly connected and not reversed.

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection

## Voltage Levels

See **Table 8** and **Table 9** for the function of the wires in the vehicle interface harnesses. Eight wires run from the sleeper control panel to the sleeper HVAC unit wiring harness. These wires are connected directly through, such as A to A, B to B, and so on.

| Eight-Pin Packard Vehicle Interface Harness | | |
|---|---|---|
| **Color** | **Line** | **Function** |
| Orange | Blower High | Should be +12V when the blower fan is on the highest speed. |
| Red | Blend Door (+) | Output signal to blend door actuator motor. This signal connects to the motor built into the blend door actuator. The voltage level between this pin and pin C, –blend door (–) will be –12V, 0V, or +12V depending on the desired rotation of the blend door actuator. |
| Brown | Blend Door (–) | Output signal to blend door actuator motor. This signal connects to the motor built into the blend door actuator. The voltage level between this pin and pin B, –blend door (+) will be –12V, 0V, or +12V depending on the desired rotation of the blend door actuator. |
| Purple | +5V Reference Voltage | Output provides 5 volt reference voltage for the blend door actuator feedback potentiometer. Should be +5V. |
| Purple | Blend Door Feedback | Input signal from blend door actuator feedback potentiometer. This signal will be in the range of 0V to 5V depending on blend door position. |
| Yellow | Return Air Temperature Sensor Signal | Input signal from return air temperature sensor. This thermistor probe is installed in the return air duct to measure sleeper cab temperature. The temperature measured at this point is used to control the HVAC system. Should be in the range of 0V to 5V depending on temperature. |
| Black | Analog Ground | Output provides analog ground for the blend door actuator feedback potentiometer and the return air temperature sensor. Should be 0V. |
| Black | Blower Ground | Output provides high current ground for the blower fan. Should be 0V. |

**Table 8, Eight-Pin Packard Vehicle Interface Harness**

| Six-Pin Packard Vehicle Interface Harness | | |
|---|---|---|
| **Color** | **Line** | **Function** |
| Red | Power | Input provides +12VDC battery power for the HVAC system. This line provides power to the HVAC system for all functions. Should be 12V. |
| Orange | Ignition | Input provides +12VDC power for the HVAC system when the power is on. This is a low current input to provide a signal that the ignition is on. Should be 12V when the ignition is on. |
| Blue | Serial (+) Bunk1 | Input/output provides serial information link between the sleeper HVAC and the cab HVAC. This line should be connected to the bunk1 line on the cab HVAC unit. In use, this line will be a serial stream of 0V/5V signals. The average voltage reading on this pin will be around 2.5V. |
| White | Serial (–) Bunk2 | Input/output provides serial information link between the sleeper HVAC unit and the cab HVAC unit. This line should be connected to the bunk2 line on the cab HVAC unit. In use, this line will be a serial stream of 0V/5V signals. The average voltage reading on this pin is around 2.5V. |
| Black | Ground | Input provides ground for the HVAC system. Should be 0V. |

**Table 9, Six-Pin Packard Vehicle Interface Harness**

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## Troubleshooting for the ATC Heater and Air Conditioner With System Protection

# Wiring Diagrams

See **Fig. 6** for the ATC sleeper HVAC wiring diagram.

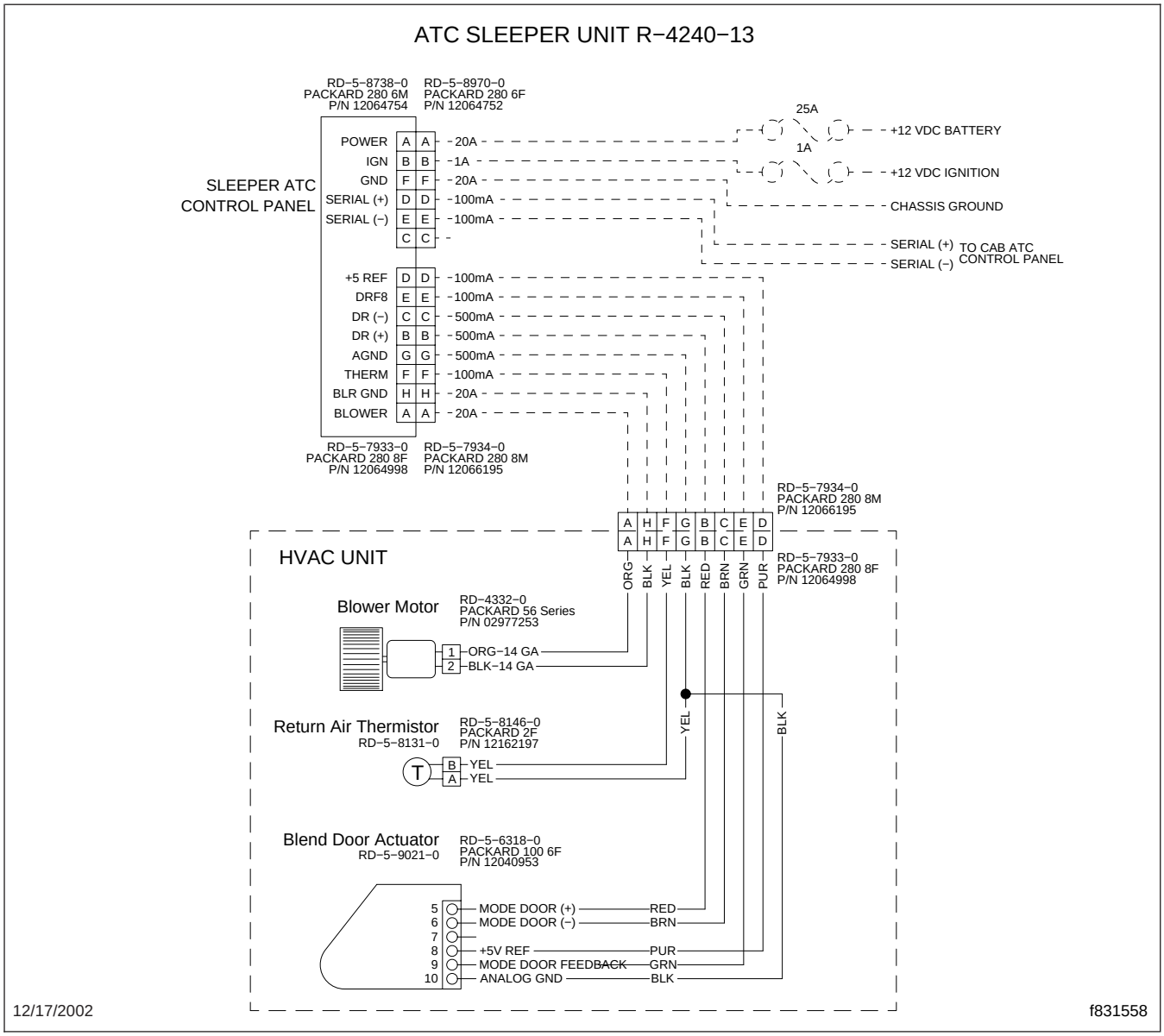



**Fig. 6, ATC Sleeper HVAC Wiring Diagram**

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# Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

## General Information

The Automatic Temperature Control (ATC) system is the latest in Red Dot electronic controllers. The ATC provides true cab temperature control and continuously variable blower fan speed. This is accomplished through the use of advanced microprocessor and sensor technology.

The troubleshooting procedures in this subject pertain to the Red Dot ATC heater and air conditioner with Advanced Diagnostics. In November 2001, Western Star began offering the Red Dot ATC heater and air conditioner with Advanced Diagnostics.

Between August 16, 1999, and November 2001, Western Star offered the ATC heater and air conditioner with System Protection. For information and troubleshooting procedures on the ATC heater and air conditioner with System Protection, see **Subject 310**.

## Control Operation Specifications

Temperature Control Range

- 60 to 90°F (16 to 32°C)

Blower Fan Control

- Pulse Width Modulation, maximum current handling: 25 amps

Temperature Sensors

- Cab Air Temperature: monitors the average cab air temperature, micro fan insures air flow across the sensor
- Duct Outlet Temperature: When heat is required, the sensor prevents high speed cold air from blowing out of the ducts until the heater core warms up (AUTO mode only).
- Evaporator Core Probe: Prevents ice from forming in the evaporator core: less than 34°F (1°C) clutch cut out, greater than 37°F (3°C) clutch turn on

High Side Pressure Control

- high side transducer
- prevents operation at low ambient temperatures: less than 40 psig (276 kPa)–no A/C operation
- high pressure protection: greater than 350 psig (2413 kPa) clutch cut out, less than 275 psig (1896 kPa) clutch turn on
- condenser fan request: greater than 275 psig (1896 kPa) condenser fan turn on, less than 225 psig (1551 kPa) condenser fan turn off
- minimum condenser fan on time: 30 seconds

Low Side Pressure Control

- low side transducer
- low pressure protection: less than 7 psig (48 kPa) clutch cut out, greater than 25 psig (172 kPa) clutch turn on

Controlled Devices

- A/C compressor clutch circuit–maximum clutch cycle rate: five cycles/minute
- blower fan motor
- water valve
- bunk power unit

## Operation of the Cab ATC

### Controls

#### Blower Fan Speed Rotary Switch

The heater or air conditioner is turned on when the blower fan speed rotary switch is turned clockwise from the off position. When the heater or air conditioner is turned on, the LED display is illuminated. See **Fig. 1**. The display shows the current temperature set point. The blower fan switch has four speed settings. The AUTO setting on the blower fan switch places the HVAC system in the automatic blower fan speed control mode. When in the automatic mode, the fan speed can vary in infinite increments as necessary to maintain the temperature set by the user. As the cab temperature reaches the set point temperature, the blower speed decreases.

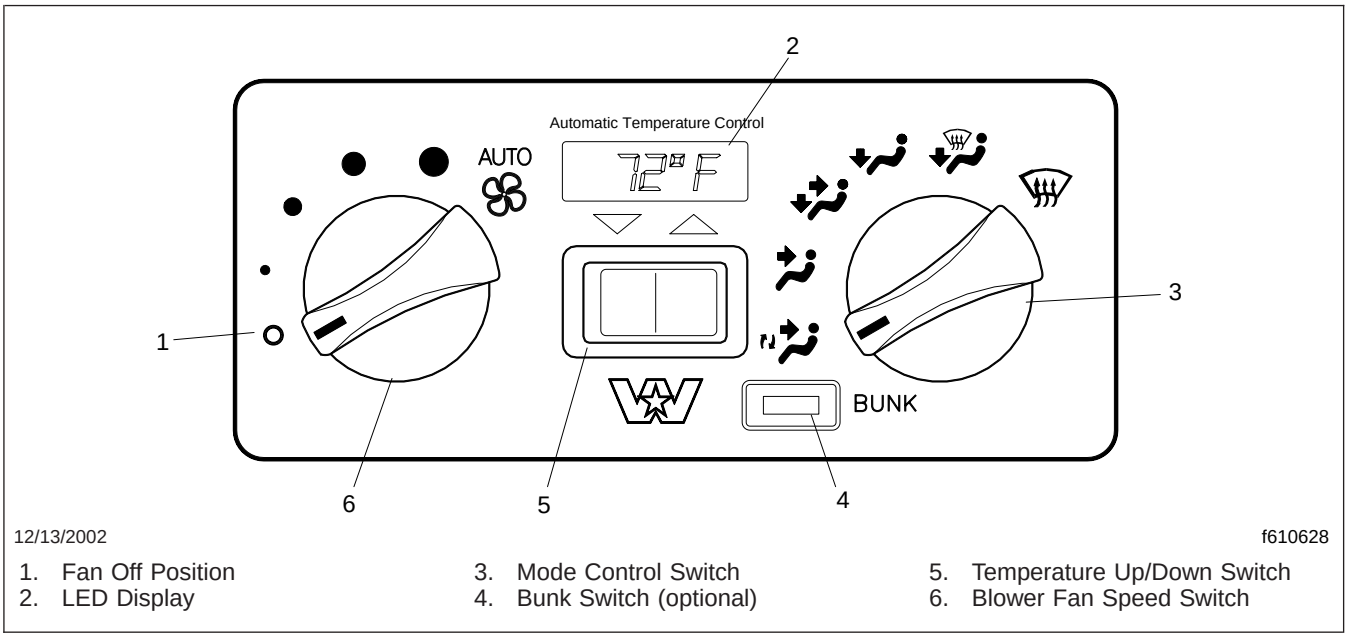
#### Temperature Up/Down Rocker Switch

Press and release the temperature up/down rocker switch to set the desired temperature. See **Fig. 1**. Pressing and holding the temperature up/down switch will cause the set point temperature to continuously increase or decrease. The HVAC system will attempt to achieve and hold the desired set point

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics




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1. Fan Off Position
2. LED Display
3. Mode Control Switch
4. Bunk Switch (optional)
5. Temperature Up/Down Switch
6. Blower Fan Speed Switch

**Fig. 1, ATC Cab Climate Control Panel**

temperature by controlling the compressor clutch and water valve. When in AUTO mode, the blower fan speed is controlled automatically as well.

### Mode Control Rotary Switch

The mode control rotary switch sets the discharge mode of air flow. See **Fig. 2**.

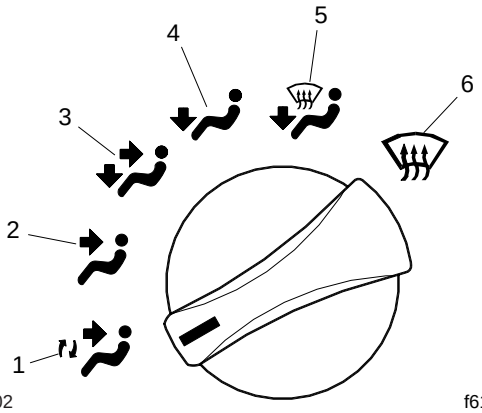
### Bunk Switch

The bunk switch enables or disables the bunk heater and air conditioner. When the bunk switch is on, the switch is illuminated. The bunk switch is optional.

## Heater Operation

The ATC automatically controls the HVAC system to maintain the cab air temperature close to the set point selected by the user. The ATC adjusts the air temperature blown through the outlets to maintain this temperature. If more heat is desired, increase the set point temperature by pressing and releasing the right side of the temperature up/down switch. If less heat is desired, decrease the set point by pressing and releasing the left side of the temperature up/down switch.

To obtain maximum heating, set the temperature to 90°F (32°C). The system will put out maximum heat




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1. Dash Vents (recirculating air)
2. Dash Vents (fresh air)
3. Bi-Level (fresh air)
4. Floor (fresh air)
5. Floor and Defrost (fresh air)
6. Defrost (fresh air)

**Fig. 2, Mode Control Switch Settings**

continuously, even if the cab temperature exceeds the set point temperature. For maximum heating, turn the blower fan speed switch to the highest speed setting, not AUTO.

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

With the fan switch in AUTO mode, the fan speed will remain low until the air temperature warms up. Once the air temperature is warm, the fan speed will increase as necessary to warm up the cab to the set point temperature. Once the cab reaches the set point temperature, the fan speed will decrease.

A comfortable set point for heating is between 72 to 78°F (22 to 26°C). Change the temperature set point in small increments for best results. Once a comfortable temperature is reached, this temperature will be maintained without adjusting the set point.

### Defrosting or Defogging Operation

The defrost mode is used to deice, defrost, or defog the windows. Turn the mode control switch to the defrost mode. See **Fig. 2**. The ATC automatically increases the blower speed and the air temperature to quickly defrost the windows.

In cold or humid conditions, more heat and air flow are required to clear the windows. The set point temperature and the blower speed should be adjusted as necessary to maintain a clear windshield at all times. For maximum defrost, increase the set point temperature to the maximum setting (90°F or 32°C) and increase the blower speed to maximum fan, not AUTO.

NOTE: The air conditioner is enabled when in defrost mode. The air conditioner is used to dehumidify the air entering the cab and to remove the moisture from the windshield.

### Air Conditioner Operation

The ATC feature automatically controls the HVAC system to maintain the cab air temperature close to the set point selected by the user. The ATC adjusts the air temperature blown through the ducts to maintain the selected temperature. If more cooling is desired, decrease the set point temperature by pressing the left side of the temperature up/down switch. If less cooling is desired, increase the set point by pressing the right side of the temperature up/down switch.

To obtain maximum cooling, set the set point temperature to 60°F (16°C). The system will put out maximum cooling continuously, even if the cab temperature drops below the set point temperature. Turn the blower fan switch to highest fan speed, not AUTO.

In AUTO mode, the fan speed adjusts as necessary to keep the cab at the set point temperature. The further away the cab temperature is from the set point, the higher the fan speed.

For maximum cooling, turn the mode control switch to the recirculation mode. See **Fig. 2**. Once the cab is cool, any of the other modes can be used, such as dash vents or bi-level.

A comfortable set point for cooling is between 68 to 74°F (20 to 23°C). Change the temperature set point in small increments for best results. Once a comfortable temperature is reached, this temperature will be maintained without adjusting the set point.

### Ventilation

The dash vents (recirculating air) mode is the only mode that recirculates the air in the cab. All other modes draw in fresh air from the outside of the vehicle. Use the recirculation mode for short periods of time to prevent fumes or dust from entering the cab or to obtain maximum cooling or heating.

### Changing Temperature Units

The temperature units can be changed from Fahrenheit (°F) to Celsius (°C) or from Celsius to Fahrenheit by turning the ignition on, the blower fan speed switch to off, and pressing and holding the temperature up/down switch on the side with the blue arrow for five seconds. The current temperature unit will then be shown on the LED display. Press the temperature down switch again to toggle between the °F and °C temperature units. Changing the temperature units on the cab climate control panel will also effect the corresponding units on the bunk control panel. To obtain more accurate temperature control, use the Fahrenheit (°F) setting.

## Cab System Logic

### Automatic Fan Speed Control

The fan speed is determined by the system as required. The fan speed is based on the difference between the set point temperature and the actual cab temperature. The greater the difference, the greater the fan speed. When the temperature is too hot and

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

heating is occurring, or if the temperature is too cold and cooling is occurring, then the fan speed will be held at minimum. This condition can occur when the cab is heating or cooling quickly and the temperature overshoots the set point temperature. The fan speed will be set to high if a cab temperature sensor error occurs. In AUTO fan speed mode, when heating is occurring, the fan speed is also limited by the outlet duct temperature. If the duct temperature is less than 72°F (22°C), then the fan speed will be limited to low fan speed. The fan speed limit will gradually increase as the duct temperature increases until the duct temperature reaches 95°F (35°C). This limit is disabled if a duct temperature sensor error occurs. In AUTO fan speed mode, all fan speed changes are done gradually. See **Table 1** for a list of the controls for the fan speed.

| Fan Speed Control | |
|---|---|
| **Fan Speed** | **Control** |
| O | Manual mode fan off |
| 1 | Manual mode fan low |
| 2 | Manual mode fan medium 1 |
| 3 | Manual mode fan medium 2 |
| 4 | Manual mode fan high |
| 5 | Automatic fan speed control |

**Table 1, Fan Speed Control**

In either automatic or manual mode, the initial fan speed on startup will gradually increase from off to the desired fan speed.

### Compressor Clutch Control

The clutch can be active in any mode when the fan speed is not off. The clutch is activated as required to maintain the set point temperature.

In defrost mode, the clutch is forced on to provide cab air dehumidification.

In the event of a cab temperature sensor error, the system will operate in a manual temperature control mode with a set point of 60°F (16°C) corresponding to full air conditioning, 75°F (24°C) corresponding to neutral, and 90°F (33°C) corresponding to full heat.

In any mode, the clutch activation can be disabled by the evaporator temperature sensor, the low pressure transducer, or the high pressure transducer. The evaporator temperature sensor trip points will be determined by the system to maintain the desired cab temperature. As less cooling is required, the evaporator temperature sensor trip points will increase, so as to maintain a fairly constant core temperature. In the case of full A/C or defrost mode, the evaporator temperature sensor trip points will be 34°F (1°C) clutch off and 37°F (3°C) clutch on. The clutch will stay off for a minimum of 11 seconds before reengaging.

The low side pressure transducer trip points are 7 psig (48 kPa) clutch off and 25 psig (172 kPa) clutch on. The high pressure transducer high trip points are 350 psig (2450 kPa) clutch off and 275 psig (1896 kPa) clutch on. The high pressure transducer low trip points are 40 psig (276 kPa) clutch off and 50 psig (345 kPa) clutch on. If a high pressure transducer error or a low pressure transducer error occurs, then clutch activation will be disabled.

### Condenser Fan Control

The condenser fan trip points are 275 psig (1896 kPa) fan on and 225 psig (1551 kPa) fan off. The fan will immediately be engaged if the high side pressure exceeds 275 psig (1896 kPa). This is accomplished by breaking continuity between E and F on the six-pin Packard Vehicle Interface Connector which generates a fan on request to the engine fan control circuitry. The fan will remain on for a minimum of 30 seconds. The fan will turn off if the high side pressure drops below 225 psig (1551 kPa) **and** if 30 seconds has elapsed since the fan was last turned on. The fan will be disengaged by creating continuity between terminals E and F on the six-pin Packard vehicle interface connector which triggers the engine fan control circuitry.

## Cab System Function Check

See **Table 2** for the ATC HVAC system testing procedure.

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| ATC HVAC System Testing Procedure | | |
|---|---|---|
| **Control or Display** | **Action** | **Test Reaction** |
| Control Panel Display | Turn fan off.<br>Turn ignition on. | Display flashes **8888** briefly. |
| Blower Fan Speed Switch | Turn fan on. | Display reads 75°F (24°C) or last set point.<br>Air should be blowing. |
| Blower Fan Speed Switch | Turn fan to all speeds. | Amount of air flow should change accordingly. |
| Temperature Up/Down Switch* | Set temperature to lowest setting.<br>Set fan to AUTO. | Blower fan increases to high.<br>Air conditioner turns on. |
| Temperature Up/Down Switch† | Set temperature to highest setting.<br>Set fan to AUTO. | Blower fan speed increases to high.<br>Heater turns on. |
| Temperature Up/Down Switch | Set temperature to approximate cab temperature. | Blower fan speed decreases to low. |
| Mode Control Switch | Mode door control position changed. | Vent mode should change accordingly. |
| Mode Control Switch | Mode set to defrost. | A/C clutch should engage. |
| Bunk Switch | Press BUNK switch | BUNK switch illuminates.<br>Bunk unit turns on. |
| Error Codes | Turn blower switch to off.<br>Press and hold the up side of temperature up/down switch.<br>Press up side of temperature up/down switch again to scroll through errors. | Error codes displayed.<br>E0 indicates no faults detected. |
| Degree Units Change | Turn blower switch to off.<br>Press and hold the down side of temperature up/down switch.<br>Press down side of temperature up/down switch again to change units. | Temperature unit displayed.<br>Units change when the rocker switch is pressed. |

* Ambient and cab air temperatures should be between 67 to 77°F (19 to 25°C).

† Ambient and cab air temperatures should be between 67 to 77°F (19 to 25°C) and vehicle engine should be at normal operating temperature.

**Table 2, ATC HVAC System Testing Procedure**

# Cab HVAC System Troubleshooting

## System Diagnostics/Error Codes

Error codes can be displayed by turning the ignition on, the blower fan speed switch to off, and pressing and holding the temperature up switch for five seconds. The current error status will be shown on the LED display. Pressing the temperature up switch again repeatedly will scroll the display through any existing error codes. See **Table 3** for a list of the error codes.

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Error Codes | |
|---|---|
| **Error Code** | **Problem** |
| E0 | No fault detected |
| E1 | Cab sensor shorted |
| E2 | Cab sensor disconnected |
| E3 | Evaporator probe shorted |
| E4 | Evaporator probe disconnected |
| E5 | Duct sensor shorted |
| E6 | Duct sensor disconnected |
| E7 | Low pressure transducer fault–disconnected or shorted |
| E8 | High pressure transducer fault–disconnected or shorted |
| E9* | High pressure and low pressure transducer connectors switched |
| E17 | ECU module failure, disconnected, or no power, or serial communication wires disconnected or reversed |

* This error code will not be displayed if the ambient temperature is below 40°F (4°C) or if the pressure in the A/C system is lower than 30 psig (207 kPa); however, the A/C clutch will not engage under these conditions even if the connectors are switched. This error code may be displayed if the A/C has been engaged in the last 10 minutes prior to checking for error codes. If this error code is displayed, allow the vehicle to sit with the ignition off for at least 10 minutes and check errors again or use the advanced diagnostics to verify refrigerant pressures.

**Table 3, Error Codes**

# Red Dot ATC Advanced Diagnostics

NOTE: The advanced diagnostics are applicable only to vehicles built from November 2001.

The Red Dot ATC Advanced Diagnostics control panel allows the technician to see real time system information on the control panel display that will assist in servicing the HVAC system. This real time information can help the service technician diagnose A/C system problems without attaching a pressure gauge set or using a voltmeter.

## Entering the Diagnostic Mode

With the blower fan speed switch in the off position, press and hold the temperature up switch for five seconds to view standard error codes, E0 to E17. See **Fig. 3**.

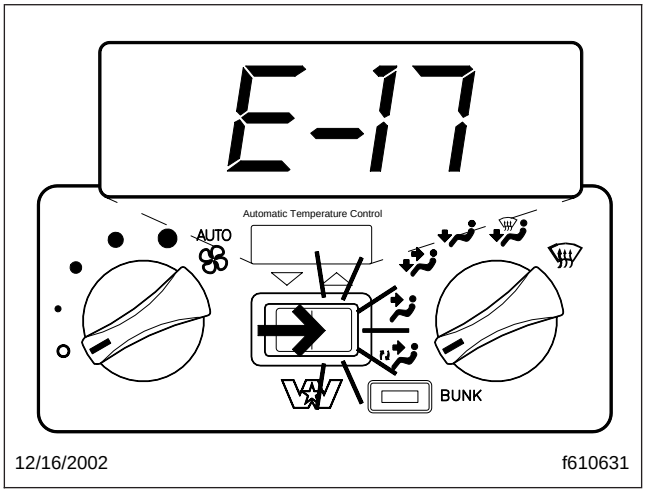



**Fig. 3, Standard Error Code**

With the blower fan speed switch still in the off position, release the temperature up switch, then press and hold the temperature up switch for five seconds to view real time diagnostics. See **Fig. 4** and **Table 4**.

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

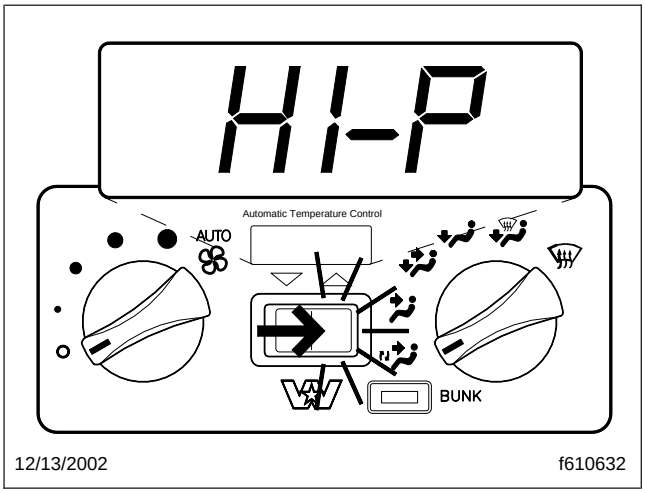



**Fig. 4, Real Time Diagnostic Code**

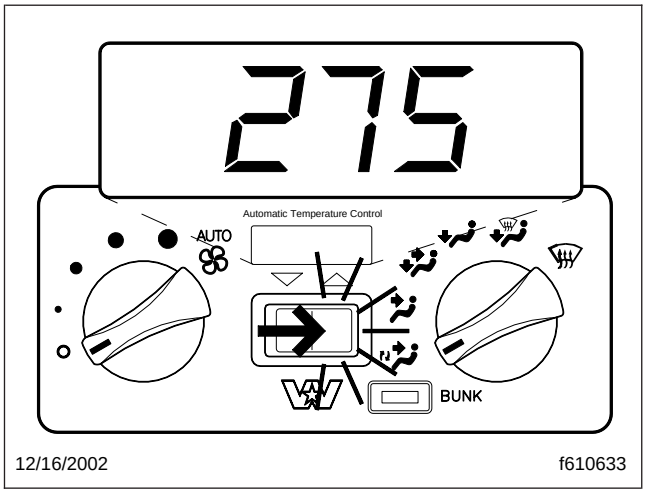



**Fig. 5, Real Time Diagnostic Value**

| Diagnostic Codes | |
|---|---|
| **Diagnostic Code** | **Diagnostic** |
| HI–P | High side refrigerant pressure |
| LO–P | Low side (suction) refrigerant pressure |
| CAB | Cab air temperature |
| DUCT | Duct air temperature |
| EVAP | Evaporator core temperature |
| A–C | A/C clutch request (on/off) |
| HEAT | Water valve request (on/off) |
| FAN | Engine fan request (on/off) |

**Table 4, Diagnostic Codes**

After a few seconds, the real time value measured by the ATC is displayed. This value will continuously update. See **Fig. 5**.

Pressing the temperature up/down switch repeatedly scrolls through all of the available diagnostic information.

See **Table 4** for a list of the real time diagnostics that can be displayed by pressing the temperature up/down switch in either direction.

The blower fan can be turned on while in diagnostic mode allowing the system to be checked under various conditions. Turn the blower fan speed switch off to return to normal operation. Turning off ignition power also returns the system to normal operation.

## Cab HVAC System Troubleshooting Tables

For troubleshooting the cab HVAC system, see **Table 5**, **Table 6**, **Table 7**, **Table 8**, **Table 9**, **Table 10**, **Table 11**, **Table 12**, **Table 13**, **Table 14**, **Table 15**, and the five unnumbered tables following **Table 15**.

| Problem—No Display on Control Panel | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Check to make sure control panel connector is plugged in. | Illuminates | No problem found. |
| | Set blower speed to any speed (not off). The display should illuminate. | Does not illuminate | **Go to step 2**. |

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Problem—No Display on Control Panel | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 2 | Check power and ground circuits to control panel (pins B and C). | Okay | Replace control panel. |
| | | Not okay | Check wiring and repair as necessary. |

**Table 5, Problem—No Display on Control Panel**

| Problem—Fan Does Not Work | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Check to make sure fan is plugged in to the wiring harness. | Okay | **Go to step 2**. |
| | | Not okay | Plug fan in, check operation. |
| 2 | Set blower speed to high.<br>Check voltage drop across blower motor terminals (with connector plugged in). | 12V or more | Check for obstructed blower wheel. If okay, replace blower motor. |
| | | Less than 12V | **Go to step 3**. |
| 3 | Check power and ground to the ECU.<br>Check fan power circuit between the fan and the ECU.<br>Check fan ground circuit. | Okay | **Go to step 4**. |
| | | Not okay | Repair wiring as necessary. |
| 4 | Check fan power output from ECU. Backprobe pin C at the ECU (with fan on high). | 12V | No problem found. |
| | | 0V (much less than 12V) | Replace ECU. |

**Table 6, Problem—Fan Does Not Work**

| Problem—No Heating | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Check the system for error codes. | Error code(s) active | Repair fault. Proceed to **step 2** if problem persists. |
| | | No error codes | **Go to step 2**. |
| 2 | Using the temperature up/down switch, increase the temperature to the highest setting.<br>Verify that warm coolant is flowing to the heater core by feeling the heater hoses.<br>NOTE: The engine must be at operating temperature. | Okay | No problem found. |
| | | Not okay | Make sure the heater hose valves on the engine block (if equipped) are open. If so, **go to step 3**. |

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Problem—No Heating | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 3 | Using the Advanced Diagnostics on the control panel, check the status of the water valve (HEAT). When the temperature is adjusted to maximum, the water valve status (HEAT) should be ON. When the temperature is adjusted to minimum, the water valve status should be OFF.<br>Check the following:<br>Check voltage at water valve connector and make sure it corresponds to the water valve (HEAT) status on the display as follows:<br>HEAT ON = 0V<br>HEAT OFF = 12V<br>NOTE: Connector must be disconnected. Measure voltage across both pins on the harness side of the connector (opposite side of water valve).<br>NOTE: A condition in which the water valve will cycle open and closed can be obtained by exiting the diagnostic mode. Turn the blower speed to off, then back on. Set the temperature to about 5 degrees higher than the cab temperature, then enter the advanced diagnostic mode again. | Okay | Check air lines to water valve. If okay, replace the water valve. |
| | | Not okay | Check the water valve circuit between the water valve connector and the ECU. Repair as necessary. Check the heater core fins for blockage. If okay, replace the ECU. |

**Table 7, Problem—No Heating**

| Problem—No Cooling | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Check the system for error codes. | Error code(s) active | Repair fault(s). Proceed to **step 2** if problem persists. |
| | | No error codes | **Go to step 2**. |
| 2 | Using the temperature up/down switch, decrease the temperature to the lowest setting with the engine running.<br>Set the mode control switch to defrost.<br>Using the Advanced Diagnostics on the control panel, check if the A/C clutch request (A-C) is on. | Okay | **Go to step 3**. |
| | | Not okay | **Go to step 5**. |

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Problem—No Cooling | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 3 | The compressor clutch should have engaged in the previous step. Did the clutch engage? | Yes | Check to make sure that water valve is closed by feeling the heater hoses. If not, repair wiring or replace water valve as necessary.<br>If water valve is closed, check refrigerant charge and perform diagnostics on the refrigerant system. Repair as necessary. Also see diagnostics in **Table 10** . |
| | | No | **Go to step 4**. |
| 4 | Check for power and ground at the compressor clutch. | Okay | Check A/C clutch, replace as necessary. |
| | | Not okay | Check A/C clutch circuit fuses, relays, and wiring. Repair as necessary. |
| 5 | Using the Advanced Diagnostics on the control panel, check the HI-P (high pressure value) with the engine off. If the pressure is below 50 psi (345 kPa), the clutch will not engage. Assuming the compressor does not engage, the pressure should correspond to the values in **Table 16**.<br>NOTE: High pressure transducer trip points are as follows:<br>• High 350 psi (2413 kPa) clutch off, 275 psi (1896 kPa) clutch on<br>• Low 40 psi (276 kPa) clutch off, 50 psi (345 kPa) clutch on | Okay | **Go to step 6**. |
| | | Not okay | Check refrigerant charge. If low, check for leaks and repair as necessary. |
| 6 | Using the Advanced Diagnostics on the control panel, check the EVAP (evaporator temperature value).<br>First verify that the system is fully charged with the correct amount of refrigerant. The evaporator temperature probe, located at the top of the HVAC unit, should prevent the front evaporator from freezing. In the event that a freezing evaporator coil is diagnosed, enter the advanced diagnostic mode and select EVAP.<br>The value displayed is the temperature measured by the evaporator probe. Make sure that the value drops when the A/C is turned on. The ATC system will not allow the clutch to engage if the temperature measured by the probe is lower than 34°F (1°C). If the temperature displayed is greater than 34°F (1°C) and the core is still freezing, try repositioning the probe by pulling it up and out of the housing in small increments and checking the display for the coldest spot. | Okay | Problem resolved. |
| | | Not okay | Replace evaporator. |

**Table 8, Problem—No Cooling**

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Problem—System Emits Cool Air When Heat is Needed | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Check the system for error codes. | Error code(s) active | Repair fault(s). Proceed to **step 2** if problem persists. |
| | | No error codes | **Go to step 2**. |
| 2 | Using the temperature up/down switch, increase the temperature to the highest setting.<br>Verify that warm coolant is flowing to the heater core by feeling the heater hoses.<br>NOTE: The engine must be at operating temperature. | Okay | **Go to step 3**. |
| | | Not okay | Make sure the heater hose valves on the engine block (if equipped) are open. If they are, **go to step 3** of troubleshooting **Table 7**. |
| 3 | Check the connection of the cab air temperature sensor (thermistor) and make sure the fan in the sensor is spinning. | Okay | **Go to step 5**. |
| | | Not okay | If connector is unplugged, connect or repair as necessary.<br>If sensor fan is not spinning, **go to step 4**. |
| 4 | At the cab air temperature sensor connector, measure voltage across pins 2 and 4.<br>There should be 12V at these pins. They supply power and ground to the sensor fan. | Okay | Replace cab air temperature sensor. |
| | | Not okay | Repair sensor fan power and ground circuits as necessary. |
| 5 | Using the Advanced Diagnostics on the control panel, check the CAB temperature. This is the temperature sensed by the cab air temperature sensor.<br>The CAB temperature value should read close to the ambient temperature in the cab (measure with a thermometer if necessary). If the sensor reading is below the set temperature on the control panel, then heat should be available. If the CAB value does not read the approximate ambient temperature in the cab, then the test result is not okay. | Okay | No problem found. Repeat diagnostics, check water valve circuit. |
| | | Not okay | Check the sensor accuracy. Replace the sensor if necessary. |

**Table 9, Problem—System Emits Cool Air When Heat is Needed**

| Problem—System Emits Hot Air When Heat is Needed | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Check the system for error codes. | Error code(s) active | Repair fault(s). Proceed to **step 2** if problem persists. |
| | | No error codes | **Go to step 2**. |
| 2 | Using the temperature up/down switch, decrease the temperature to the lowest setting.<br>Verify that warm coolant is not flowing to the heater core by feeling the heater hoses.<br>NOTE: The engine must be at operating temperature. | Okay | **Go to step 3**. |
| | | Not okay | **Go to step 3** of **Table 7** to check water valve operation. |

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Problem—System Emits Hot Air When Heat is Needed | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 3 | Using the temperature up/down switch, set the temperature to the lowest setting (engine running).<br>Set the mode control switch to defrost.<br>Using the Advanced Diagnostics on the control panel, check if the A/C clutch request A-C is on. | Okay | **Go to step 4**. |
| | | Not okay | **Go to step 5** of **Table 8**. |
| 4 | The compressor clutch should have engaged in the previous step. Did the clutch engage? | Yes | **Go to step 6**. |
| | | No | **Go to step 5**. |
| 5 | Check for power and ground at the compressor clutch. | Okay | Check A/C clutch, replace as necessary. |
| | | Not okay | Check A/C clutch circuit fuses, relays, and wiring. Repair as necessary. |
| 6 | Check the connection of the cab air temperature sensor (thermistor) and make sure the fan in the sensor is spinning. | Okay | **Go to step 8**. |
| | | Not okay | If connector is unplugged, connect or repair as necessary.<br>If sensor fan is not spinning, **go to step 7**. |
| 7 | At the cab air temperature sensor connector, measure voltage across pins 2 and 4.<br>There should be 12V at these pins. They supply power and ground to the sensor fan. | Okay | Replace cab air temperature sensor. |
| | | Not okay | Repair sensor fan power and ground circuits as necessary. |
| 8 | Using the Advance Diagnostics on the control panel, check the CAB temperature. This is the temperature sensed by the cab air temperature sensor.<br>The CAB temperature value should read close to the ambient temperature in the cab (measure with a thermometer if necessary). If the sensor reading is above the set temperature on the control panel, then cooling should be available. If the CAB value does not read the approximate ambient temperature in the cab, then the test result is not okay. | Okay | Diagnosis refrigerant system, repair as necessary. |
| | | Not okay | Check the sensor accuracy. Replace the sensor if necessary. |

**Table 10, Problem—System Emits Hot Air When Cooling is Needed**

| Problem—Cab Temperature Control is Inconsistent | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Check the system for error codes. | Error code(s) active | Repair fault(s). Proceed to **step 2** if problem persists. |
| | | No error codes | **Go to step 2**. |
| 2 | Check for any excessive air leaking from the ducts behind the dash that is effecting the temperature cab temperature sensor. | Okay | **Go to step 3**. |
| | | Not okay | Repair leaks as necessary. |

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Problem—Cab Temperature Control is Inconsistent | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 3 | Check the connection of the cab air temperature sensor (thermistor) and make sure the fan in the sensor is spinning. | Okay | **Go to step 5**. |
| | | Not okay | If connector is unplugged, connect or repair as necessary.<br>If sensor fan is not spinning, **go to step 4**. |
| 4 | At the cab air temperature sensor connector, measure voltage across pins 2 and 4.<br>There should be 12V at these pins. They supply power and ground to the sensor fan. | Okay | Replace cab air temperature sensor. |
| | | Not okay | Repair sensor fan power and ground circuits as necessary. |
| 5 | Using the Advanced Diagnostics on the control panel, check the CAB temperature. This is the temperature sensed by the cab air temperature sensor.<br>The CAB temperature value should read within 4 degrees of the ambient temperature in the cab (measure with a thermometer if necessary). If the CAB value does not read the approximate ambient temperature in the cab, then the test result is not okay. | Okay | **Go to step 6**. |
| | | Not okay | Check the sensor accuracy. Replace the sensor if necessary. |
| 6 | Verify that most recent version of the ECU is installed (RD-6-5108-0). | Okay | No problem found. |
| | | Not okay | Replace ECU if vehicle is still under warranty. |

**Table 11, Problem—Cab Temperature Control is Inconsistent**

| Problem—Engine Fan Not Engaging or Disengaging Correctly | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Check the system for error codes. | Error code(s) active | Repair fault(s). Proceed to **step 2** if problem persists. |
| | | No error codes | **Go to step 2**. |
| 2 | What is the symptom? | Engine fan stays on. | **Go to step 3**. |
| | | Engine fan won't turn on. | **Go to step 4**. |

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Problem—Engine Fan Not Engaging or Disengaging Correctly | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 3 | Using the Advanced Diagnostics on the control panel, check the FAN status while the air conditioning is operating. Check if the FAN status remains on or cycles between on/off. | Status always on | Check high side system pressure using the Advanced Diagnostics. Pressure above 275 psi (1896 kPa) will cause the engine fan status to be on. If pressure remains high, diagnose refrigerant system. For example, check for restricted airflow across the condenser. |
| | | Status cycles between on/off | Check if engine ECU is calling for the fan to be on (consult engine manufacturer's software). If not, the following are possible causes:<br>• faulty engine fan relay<br>• open circuit between engine fan relay and HVAC ECU<br>• no ignition 12V supply to engine fan relay<br>• shorted fan control circuit wiring between relay and engine ECU<br>Check the possible causes and repair as necessary. |
| 4 | Using the Advanced Diagnostics on the control panel, check the FAN status while the air conditioning is operating. Check if the FAN status remains off or cycles between on/off. | Status always off | Check high side system pressure using the Advanced Diagnostics. Pressure above 275 psi (1896 kPa) will cause the engine fan status to be on. Pressure may be too low to call for engine fan to be on. Diagnose refrigerant system. |
| | | Status cycles between on/off | The following are possible causes:<br>• faulty engine fan relay<br>• open fan control circuit wiring between relay and engine ECU<br>Check the possible causes and repair as necessary. |

**Table 12, Problem—Engine Fan Not Engaging or Disengaging Correctly**

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Problem—Sleeper Unit Not Engaging or Disengaging Correctly | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Check the system for error codes. | Error code(s) active | Repair fault(s). Proceed to **step 2** if problem persists. |
| | | No error codes | **Go to step 2**. |
| 2 | Check if bunk switch indicator is illuminating. | Okay | Check if sleeper unit is operating correctly. If not, check sleeper unit power and ground wiring. Diagnose sleeper unit if necessary. |
| | | Not okay | Check serial bus wiring and connections. Repair as necessary. Check ECU, replace if necessary. |

**Table 13, Problem—Sleeper Unit Not Engaging or Disengaging Correctly**

| Problem—Mode Door Not Working Properly | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Is the mode door actuator making noise or oscillating back and forth? | Yes | Check if ECU PN RD-6-5108-0 or later is installed. If not and the vehicle is still under warranty, replace the ECU. |
| | | No | **Go to step 2**. |
| 2 | If the mode door moves, **go to step 3**. If not, verify the ECU power and ground circuits and that there are no other errors in the system. | Okay | **Go to step 3**. |
| | | Not okay | Repair as necessary. |
| 3 | Disconnect the five-wire connector from the mode actuator at the top of the plenum. With the system operating, take this connector and make the following measurements:<br>• Voltage across the white and black wires should read 5V.<br>• Voltage across the yellow and black/white wires should momentarily read +12V when the mode actuator is moved to face and –12V when moved to defrost mode. | Okay | **Go to step 4**. |
| | | Not okay | Check the wiring between the actuator and ECU. Repair as necessary. If okay, replace ECU. |
| 4 | Remove the blower assembly and reach up into the air distribution plenum and locate the mode doors. Verify that the mode doors are not obstructed or jammed. | Okay | Replace actuator. |
| | | Not okay | Remove obstruction or repair as necessary. |

**Table 14, Problem—Mode Door Not Working Properly**

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Problem—Fresh/Recirc Door Not Working Properly | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Disconnect the three-wire connector from the fresh/recirc actuator. With the system operating, take this connector and make the following measurements:<br>Voltage across the red and black wires should read 12V.<br>There should be continuity across the green and black wires when in recirc mode. When in fresh mode, there should not be continuity. | Okay | **Go to step 2**. |
| | | Not okay | Check wiring between the actuator and the ECU. Repair as necessary. If okay, replace the ECU. |
| 2 | Inspect the fresh/recirc door for mechanical damage or jamming. | Okay | Replace actuator. |
| | | Not okay | Repair as necessary. |

**Table 15, Problem—Fresh/Recirc Door Not Working Properly**

**Problem—Little or No Airflow**

| Problem—Little or No Airflow | |
|---|---|
| **Possible Cause** | **Remedy** |
| The blower is not operating. | See **Table 6**. |
| There are restrictions or leaks in the air ducts. | Examine all air ducts and remove any blockages. Stop any leaks or replace any portion where the leaks cannot be stopped.<br>Check to make sure the fresh air filter in the HVAC assembly is clean. |
| Frozen evaporator core. | See **Table 8**. |

**Problem—Low Compressor Suction Pressure**

| Problem—Low Compressor Suction Pressure | |
|---|---|
| **Possible Cause** | **Remedy** |
| The expansion valve is not working. | Check and replace the expansion valve as necessary. |
| There are restrictions in the line to the expansion valve. Frost usually appears at the point of restriction. | Remove the line restrictions or replace component as necessary. |
| There is an insufficient refrigerant charge in the system. | Recover the system. If low, check for and repair leaks. Evacuate and add a full refrigerant charge. |

**Problem—High Compressor Discharge Pressure**

| Problem—High Compressor Discharge Pressure | |
|---|---|
| **Possible Cause** | **Remedy** |
| Airflow through the condenser is restricted. | Remove the debris from the condenser. |
| There is a restriction in the condenser or refrigerant line between the condenser and receiver-drier. Frost usually appears at the point of restriction. | Remove the restriction or replace the condenser if necessary. |

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Problem—High Compressor Discharge Pressure | |
|---|---|
| **Possible Cause** | **Remedy** |
| Air is present in the system. | Recover the system. If low, check for and repair leaks. Evacuate and add a full refrigerant charge. |
| Heavy frosting on the suction line suggests that the evaporator coil is flooded. | Defrost the evaporator coil before resuming operation of the air conditioner. |
| The engine is overheated. | See the engine manufacturer's service manual for corrective measures. |
| Engine fan is not engaging. | Check and repair as necessary. |

**Problem—Compressor Cycles Rapidly**

| Problem—Compressor Cycles Rapidly | |
|---|---|
| **Possible Cause** | **Remedy** |
| There is too little refrigerant in the system. | Recover the system. If low, check for and repair leaks. Evacuate and add a full refrigerant charge. |
| Frozen evaporator core. | Check the evaporator sensor (thermostat probe) and wiring. Replace if necessary. |
| There is a restriction in the refrigerant system. | Inspect the entire system for frost buildup. Frost usually appears at the point of restriction. |
| Airflow through the condenser is restricted. | Remove the debris from the condenser. |
| The evaporator sensor (thermostat probe) is not working. | Check and replace as necessary. |

**Problem—Condensed Water Is Leaking from the Air Conditioner**

| Problem—Condensed Water Is Leaking from the Air Conditioner | |
|---|---|
| **Possible Cause** | **Remedy** |
| The drain tubes are plugged. | Clean the drain holes and drain tubes. |

| High Side Refrigerant Pressure Value (engine off) | |
|---|---|
| **Ambient Air Temperature** | **Approximate HI–P PSI Gauge (kPa)** |
| 40°F (4°C) | 35 (241) |
| 50°F (10°C) | 45 (310) |
| 60°F (16°C) | 60 (414) |
| 70°F (21°C) | 70 (483) |
| 80°F (27°C) | 85 (586) |
| 90°F (32°C) | 105 (724) |
| 100°F (38°C) | 125 (862) |

**Table 16, High Side Refrigerant Pressure Value (engine off)**

## Wiring Diagrams

See **Fig. 6** and **Fig. 7** for the ATC cab HVAC wiring diagram.

## Sleeper ATC With Alarm Clock

### General Information

The Red Dot Automatic Temperature Control (ATC) sleeper heater and air conditioner is designed as the complement to the Red Dot ATC cab heater and air conditioner. The ATC sleeper heater and air conditioner provides true interior sleeper compartment temperature control and continuously variable blower fan speed. This is accomplished through the use of

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

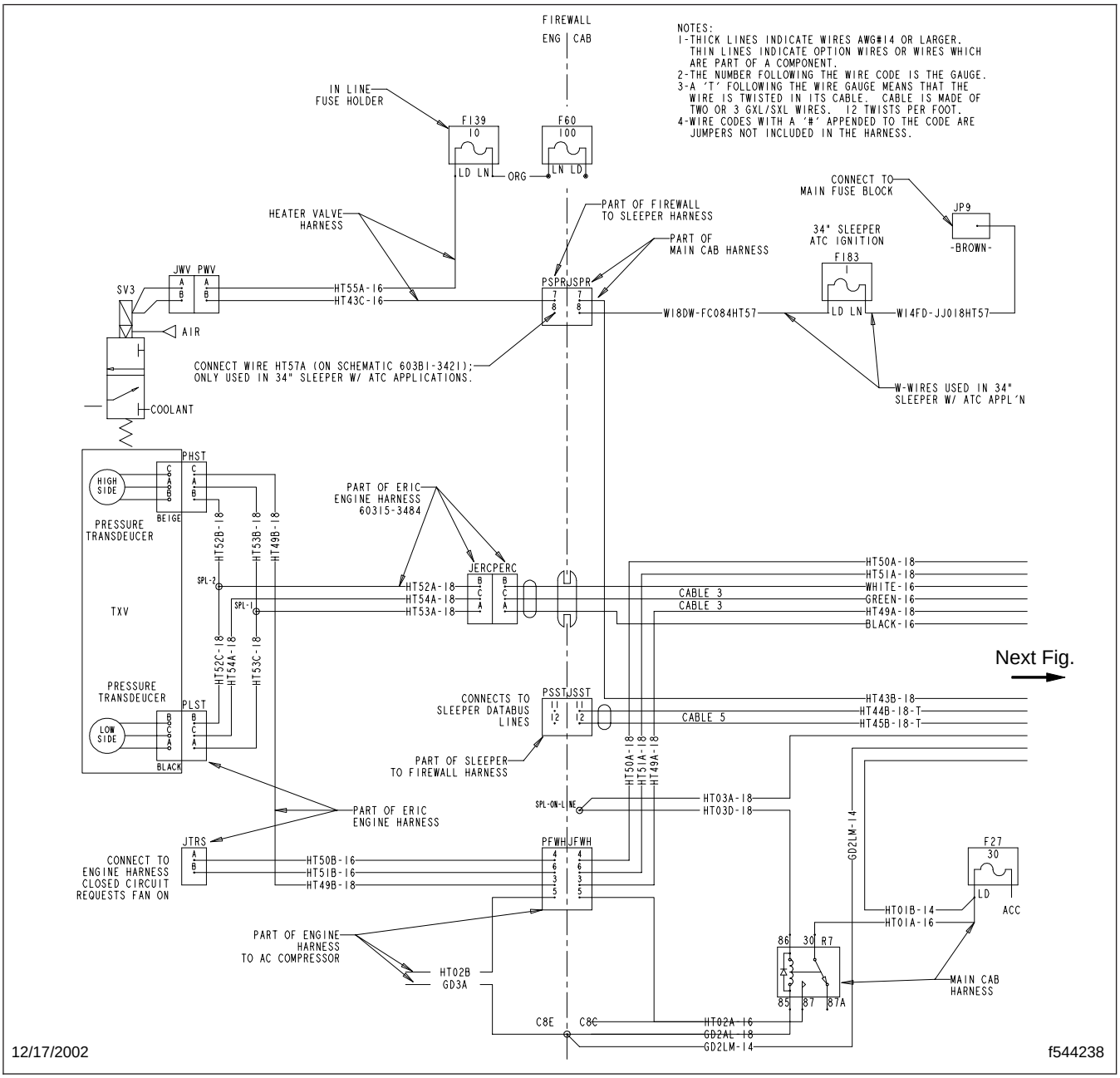



**Fig. 6, ATC Cab HVAC Wiring Diagram, Part 1**

advanced microprocessor and sensor technology. The control keypad features full HVAC control as well as a clock with alarm. The sleeper heater and air conditioner can be turned on and off without turning on the cab heater and air conditioner.

# Specifications

## Display

The display is vacuum fluorescent and has five digits that are 0.33 inch (8 mm) high. Time is displayed in

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

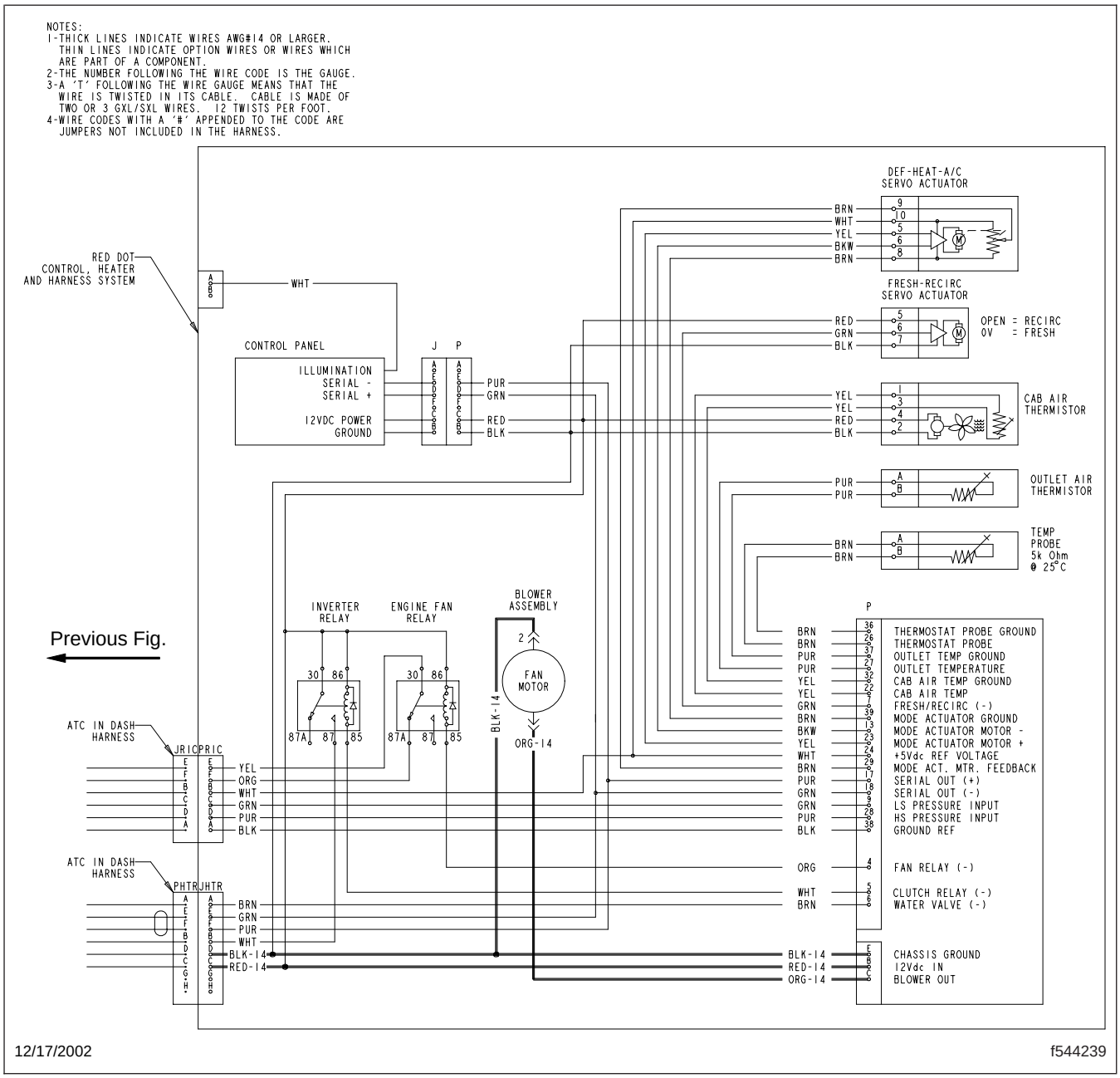



**Fig. 7, ATC Cab Wiring Diagram, Part 2**

a 12-hour format with a separate PM LED indicator. Temperature is displayed with a three-digit annotation and can be displayed either in degrees Celsius or degrees Fahrenheit. A capital C or F is displayed for the appropriate temperature scale.

## Control Panel

The control panel is comprised of a membrane switch assembly with a Lexan outer covering. The panel has incorporated physical mechanical tactile feedback to ensure easily identifiable switch actua-

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

tion. Indicator LEDs illuminate when a switch activation has occurred, thus providing both physical and visual indication of circuit activation. The control panel has backlighting to allow rapid and positive switch location even in dim ambient light conditions.

### Clock

The clock is crystal controlled with a low temperature drift oscillator for long term stability.

### Blower Motor Drive

Power MOSFET circuitry provides 20-amp drive capacity with multiple times instantaneous current ability. There is internal protection from voltage transients and current overloads.

### Voltage Input

The unit is designed to operate on standard truck operating voltages, 13.5 volts typical. The unit will operate correctly with input from 8 to 16 volts.

# Operation of Sleeper ATC

## Controls

### Clock Control

The clock controls are located on the left side of the ATC sleeper control panel under the display. The display will show the clock time as the default mode. See **Fig. 8**.

#### Alarm Button

Momentarily press the ALARM button to turn the alarm on and to illuminate the alarm indicator light above the alarm button. Momentarily press the button again to deactivate the alarm.

When pressing the ALARM button, the display shows the alarm time setting for five seconds before returning to the current time display. If the alarm button is pressed and held down continuously for more than one second, the alarm time setting can be viewed without changing the state of the alarm indicator. If either the SET+ or SET– buttons are pressed simultaneously with the ALARM button held down, the alarm time setting will increase or decrease. When the ALARM button is released after changing the alarm time, the alarm will be turned on and the indicator will be illuminated. When the ALARM is sounding, press the ALARM button to turn the alarm off and to reset the alarm for the next 24-hour cycle.

NOTE: If any button other than the ALARM button is pressed when the alarm is sounding, the snooze function will be engaged.

If the snooze function is active, as indicated by a blinking alarm indicator light, press the ALARM button to cancel the snooze function and to reset the alarm for the next 24-hour cycle.

#### Time Button

Press the TIME button to display the current time. If the TIME button is held down and either the SET+ or SET– buttons are pressed simultaneously with the TIME button, the clock setting will increase or decrease.

#### Display

Depress the DISP button to allow the display and illumination of the control panel to scroll through three illumination levels: bright, dim, and off. If you want the ALARM, TIME, or HVAC setting to be displayed when the display is in the off mode, press the ALARM, TIME, or HVAC buttons to display the corresponding display for five seconds. After five seconds, the display will turn off. If the alarm sounds while in the display off mode, the current time will be displayed simultaneously. The display will remain on for five minutes, then turn off.

#### Snooze Feature

To enable the snooze alarm, press any button on the control panel, except the ALARM button, when the alarm is sounding. The alarm will turn off for seven minutes. The alarm indicator light flashes when the snooze alarm is enabled. The snooze alarm can be enabled indefinitely.

#### AM/PM

PM is displayed at the left side of the display and is illuminated during PM hours. When PM is not displayed, AM hours are displayed. When setting the time or alarm, note the presence or absence of the PM.

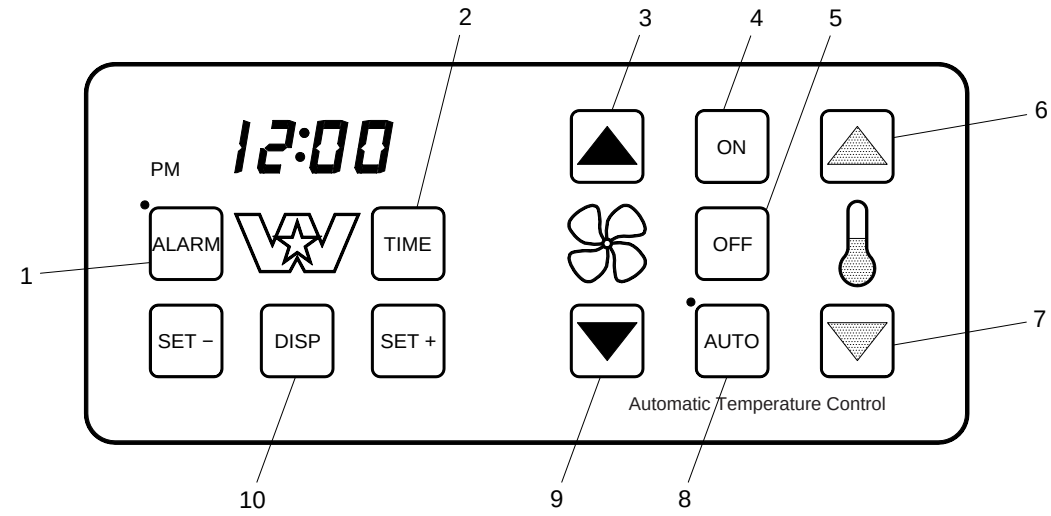
### Automatic Temperature Control

The controls for the sleeper heater and air conditioner are located on the right side of the ATC sleeper control panel. See **Fig. 8**.

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics




1. Alarm Button
2. Time Button
3. Fan Up Button
4. HVAC On Button
5. HVAC Off Button
6. Temperature Up Button
7. Temperature Down Button
8. Automatic Blower Fan Speed
9. Fan Down Button
10. Display Button

**Fig. 8, ATC Sleeper Control Panel**

### On Button

To turn the sleeper heater and air conditioner on, press the ON button. The display will show the current temperature control set point for five seconds then return to the time display. The fan and temperature control will not engage unless the ignition is on. If the engine is on, but the cab ATC heater and air conditioner is off, turning the sleeper HVAC system on will engage the compressor clutch and turn the cab unit blower fan to a low setting.

### Off Button

To turn the sleeper heater and air conditioner off, press the OFF button.

### Auto Button

Press the AUTO (default on) button to enable automatic control of the blower fan speed. When automatic control is enabled, the indicator light above the AUTO button will illuminate. The display will show the current temperature control set point for five seconds, then return to the normal time display. When in this mode, the fan speed can vary in infinite increments as necessary to maintain the temperature set by the user.

### Temperature Up/Down Buttons

The temperature up/down buttons increase or decrease the control set point temperature. Each button may be pressed repeatedly to incrementally increase or decrease the set point. Press either button for at least two seconds to continuously increase or decrease the set point temperature. The display will show the current set point temperature. The display returns to the normal time display five seconds after a button is pressed and released.

### Fan Up/Down Buttons

The fan up/down buttons increase or decrease the blower fan speed. Each button may be pressed repeatedly to incrementally increase or decrease the set point. Press either button for at lease two seconds to continuously increase or decrease the set point. The display indicates the fan speed setting in 10 percent increments or HI when the maximum speed is selected and LO when the minimum speed is selected. The display returns to the normal display

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

five seconds after a button is pressed. The AUTO fan function is disabled if either of these buttons is pressed.

### Turning on the Sleeper HVAC When the Cab HVAC is Off

The sleeper ATC control panel can turn on the air conditioner even if the cab HVAC unit is turned off but the engine is running. By pressing the ON button, the ATC sleeper control panel will turn on the cab unit and the bunk indicator light on the cab control panel will be illuminated. If cooling is needed in the sleeper, the cab HVAC unit will switch on to a low blower fan setting and the A/C compressor clutch will engage. If cooling is no longer required in the sleeper or if heat is needed, the cab unit fan and the compressor clutch will be turned off after a five-minute delay.

### Changing Temperature Units

The temperature units can be changed from °F to °C or from °C to °F by pressing the temperature up and temperature down buttons simultaneously. Changing the temperature units on the ATC sleeper control panel will also change the temperature units on the ATC cab control panel.

### Set Point Temperature Slave Mode Feature

The set point temperature slave mode allows the set point temperatures of the cab heater and air conditioner and the sleeper heater and air conditioner to be tied together automatically. In this mode, the temperature set point in the vehicle will always be the same whether the set point is changed on the cab control panel or the sleeper control panel. To enable the set point temperature slave mode, press the SET+ and SET– buttons simultaneously. The display will read S–ON when the set point temperature slave mode is enabled.

The set point temperature slave mode can be disabled by simultaneously pressing the SET+ and SET– buttons. The display will read S–OFF indicating that the mode is disabled. If disabled, the set points for the cab and sleeper control panels can be changed independently for separate temperature control. If you wish to maintain a temperature in the sleeper that is different than the temperature in the front of the cab, it is recommended that a curtain be used between the sleeper and the front of the cab.

### Sleep Mode

The ATC sleeper control panel will immediately enter a power saving sleep mode when the vehicle ignition is not powered. The display and control panel illumination will turn off while all of the clock functions, including the alarm, continue to work internally. This feature is designed to reduce the power draw on the battery when the engine is not running by dropping the required current. If the DISP button is pressed while the ignition is turned off, the display will be illuminated for five minutes. After five minutes, the display will turn off and the electronics will go back to the sleep mode.

## Sleeper System Logic

### Fan Speed Control

The manual fan control mode provides 11 fan speed settings: LO, 10, 20, 30, 40, 50, 60, 70, 80, 90, HI.

### Automatic Fan Speed Control

The fan speed is determined by the system as required. The fan speed is based on the difference between the set point temperature and the actual sleeper cab temperature. The greater the difference, the greater the fan speed. When the temperature is too hot and heating is occurring, or if the temperature is too cold and cooling is occurring, the fan speed will be held at minimum. This condition can occur when the sleeper cab is heating or cooling quickly and the temperature overshoots the set point temperature. The fan speed will be set to high if a cab temperature sensor error occurs. In automatic fan speed mode, all fan speed changes are done gradually.

In automatic or manual mode, the initial fan speed at startup will gradually increase from off to the desired fan speed.

### Blend Door Control

The blend door is controlled as required to maintain the sleeper cab temperature at the set point temperature. The blend door has a motor that allows the actuator to be turned clockwise, counterclockwise, or held steady. The feedback potentiometer provides a

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signal proportional to the current position of the blend door actuator.

If a sleeper cab temperature sensor error occurs, then the system will go into manual temperature control mode ranging from full cool to full heat.

## Cab HVAC Communications

The communications link between the sleeper HVAC unit and the cab HVAC unit provides several functions. Because the sleeper HVAC unit is dependent on the cab HVAC unit to provide clutch activation, the communications link provides this function. Any time the sleeper unit moves the blend door to the full cool position, the sleeper controller requests the A/C clutch to be turned on. Upon receiving the A/C clutch request, the cab HVAC controller will turn on the A/C clutch. If the cab HVAC unit is off, then the cab HVAC blower will be turned to the LO position.

Another function of the communications link is to allow the BUNK switch on the ATC cab control panel to turn the sleeper HVAC on or off. A third function of the communications link is the function of the set point temperature slave mode.

## Sleeper System Function Check

See **Table 17** for the sleeper HVAC system testing procedure.

| Sleeper HVAC System Testing Procedure | | |
|---|---|---|
| **Control or Display** | **Action** | **Test Reaction** |
| Control Panel Display Test | Battery connected (first time)<br>Press DISP button if display is blank | Display shows **8888** then the current time. |
| Control Panel Fan Control Test | Ignition on<br>HVAC on<br>Fan turned to different speeds | Amount of air flow should change accordingly. |
| Control Panel Temperature Control Test* | Set temperature to lowest setting.<br>Set fan to AUTO. | Blower fan increases to high.<br>Air conditioner turns on. |
| Control Panel Temperature Control Test* | Set temperature to highest setting.<br>Set fan to AUTO. | Blower fan increases to high.<br>Heater turns on. |
| Control Panel Temperature Control Test | Set temperature to approximate sleeper temperature. | Blower fan speed decreases to low. |
| Control Panel Clock Control Time Set | Press TIME and SET+ or SET– buttons simultaneously. | Current time is changed. |
| Control Panel Clock Control Alarm Set | Press ALARM and SET+ or SET– buttons simultaneously. | Alarm time is changed. |
| Control Panel Clock Control Alarm On/Off | Press and release ALARM button. | Alarm indicator light turned on or off, alarm enabled if light on. |
| Control Panel Clock Control Alarm Display | Press and hold ALARM button for more than 1 second. | Alarm time displayed without changing the state of the alarm indicator. |
| Control Panel Clock Control Display | Press DISP button. | Display brightness should change (bright, dim, off). |
| Control Panel Clock Control Test | Display set to off.<br>Press TIME button. | Current time is displayed. |

* Ambient and cab air temperatures should be between 67 to 77°F (19 to 25°C).

**Table 17, Sleeper HVAC System Testing Procedure**

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

# Sleeper System Troubleshooting

## System Diagnostic Error Codes

Error codes can be displayed by pressing the fan up and fan down buttons simultaneously. The current error status will be shown on the digital display. Pressing the fan up button repeatedly will scroll the display through any existing error codes. See **Table 18** for a list of the error codes.

## Sleeper HVAC System Troubleshooting Tables

For troubleshooting the sleeper HVAC system, see **Table 19**, **Table 20**, **Table 21**, **Table 22**, and **Table 23**.

| Error Codes | |
|---|---|
| **Error Code** | **Problem** |
| E0 | No fault detected |
| E1 | Bunk sensor shorted |
| E2 | Bunk sensor disconnected |
| E3 | Not assigned |
| E4 | Not assigned |
| E5 | Not assigned |
| E6 | Not assigned |
| E7 | Not assigned |
| E8 | Not assigned |
| E9 | Not assigned |
| E10 | Actuator disconnected |

**Table 18, Error Codes**

| Problem—No Display on Control Panel | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Check to make sure control panel connector is plugged in.<br>Press the ON button on the sleeper control panel to turn the system on. Check if the display illuminates. | Illuminates | No problem found. |
| | | Does not illuminate | **Go to step 2**. |
| 2 | Check power and ground circuits to control panel in the six-wire connector:<br>• 12V at pin A<br>• 12V at pin B (with ignition on)<br>• ground at pin F | Okay | Replace control panel. |
| | | Not okay | Check wiring and fuses, repair as necessary. |

**Table 19, Problem—No Display on Control Panel**

| Problem—Fan Does Not Work | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Check to make fan connector is plugged in to wiring harness.<br>Press the ON button on the sleeper control panel to turn the system on. Check if the display illuminates. | Okay | **Go to step 2**. |
| | | Not okay | Connect fan to wiring harness, check operation. |

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Problem—Fan Does Not Work | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 2 | Turn ignition on, set blower speed to high.<br>Check voltage drop across blower motor terminals with connector connected. | 12V or more | Check for obstructed blower wheel. If okay, replace blower motor. |
| | | Less than 12V | **Go to step 3**. |
| 3 | Check power and ground to the ECU.<br>Check fan power circuit between the fan and the ECU.<br>Check fan ground circuit. | Okay | **Go to step 4**. |
| | | Not okay | Repair wiring as necessary. |
| 4 | Check fan power output from ECU. Backprobe pin A of the eight-wire connector at the back of the control panel (with fan on high). | 12V | No problem found. |
| | | 0V (much less than 12V) | Replace ECU. |

**Table 20, Problem—Fan Does Not Work**

| Problem—No Heating | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Is the problem only in the sleeper, or is there no heat in both the front and rear units. | Both | Diagnose front system first. See **Table 7**. |
| | | Rear only | **Go to step 2**. |
| 2 | Check the system for error codes. | Error code(s) active | Repair fault(s). Proceed to **step 3** if problem persists. |
| | | No error codes | **Go to step 3**. |
| 3 | Check if the actuator is moving the blend door when the temperature set point is changed from cold to hot. | Okay | Make sure blend door is not partially obstructed. Make sure it goes to full hot position. If okay, check for restriction in hoses and heater core. |
| | | Not okay | **Go to step 4**. |
| 4 | Check the following at the actuator connector by backprobing:<br>• Voltage across pins 5 and 8 while changing the temperature up and down. The voltage should be +12V, 0V, –12V depending on direction. It will be 0V when no change is required.<br>• Voltage between pins 8 and 10 should be +5V.<br>• Voltage between pins 9 and 10 should range between 0V and 5V depending on position. | Okay | Make sure blend door is not obstructed. If okay, replace actuator. |
| | | Not okay | Check wiring, repair as necessary. If wiring is okay, replace sleeper control panel. |

**Table 21, Problem—No Heating**

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

| Problem—No Cooling | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Is the problem only in the sleeper, or is there no cooling in both the front and rear units. | Both | Diagnose front system first. See **Table 8**. |
| | | Rear only | **Go to step 2**. |
| 2 | Check the system for error codes. | Error code(s) active | Repair fault(s). Proceed to **step 3** if problem persists. |
| | | No error codes | **Go to step 3**. |
| 3 | Check if the actuator is moving the blend door when the temperature set point is changed from hot to cold. | Okay | Make sure blend door is not partially obstructed. Make sure it goes to full cold position. If okay, check for a restriction in the evaporator and refrigerant lines. |
| | | Not okay | **Go to step 4**. |
| 4 | Check the following at the actuator connector by backprobing:<br>• Voltage across pins 5 and 8 while changing the temperature up and down. The voltage should be +12V, 0V, –12V depending on direction. It will be 0V when no change is required.<br>• Voltage between pins 8 and 10 should be +5V.<br>• Voltage between pins 9 and 10 should range between 0V and 5V depending on position. | Okay | Make sure blend door is not obstructed. If okay, replace actuator. |
| | | Not okay | Check wiring, repair as necessary. If wiring is okay, replace sleeper control panel. |

**Table 22, Problem—No Cooling**

| Problem—Sleeper HVAC Unit Cannot Be Turned On From the Front Unit | | | |
|---|---|---|---|
| **Step No.** | **Test Procedure** | **Test Result** | **Action** |
| 1 | Can the sleeper unit be turned on from the rear control panel? | Yes | **Go to step 2**. |
| | | No | Check power and ground circuits to rear control panel and repair as necessary. Check wiring between the rear control panel and the sleeper unit and repair as necessary. Check sleeper unit blower fan. |
| 2 | Press the bunk switch on the front control panel and check if it illuminates. | Okay | No problem found. |
| | | Not okay | Check power and ground circuits to front control panel and repair as necessary. Check serial bus wiring and connections between the front control panel and rear control panel. Repair as necessary. If okay, replace the front control panel. |

**Table 23, Problem—Sleeper HVAC Unit Cannot Be Turned On From the Front Unit**

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

## Voltage Levels

See **Table 24** and **Table 25** for the function of the wires in the vehicle interface harnesses. Eight wires run from the sleeper control panel to the sleeper HVAC unit wiring harness. These wires are connected directly through, such as A to A, B to B, and so on.

| Eight-Pin Packard Vehicle Interface Harness | | | |
|---|---|---|---|
| **ID** | **Color** | **Line** | **Function** |
| A | Orange | Blower High | Should be +12V when the blower fan is on the highest speed. |
| B | Red | Blend Door (+) | Output signal to blend door actuator motor. This signal connects to the motor built into the blend door actuator. The voltage level between this pin and pin C, –blend door (–) will be –12V, 0V, or +12V depending on the desired rotation of the blend door actuator. |
| C | Brown | Blend Door (–) | Output signal to blend door actuator motor. This signal connects to the motor built into the blend door actuator. The voltage level between this pin and pin B, –blend door (+) will be –12V, 0V, or +12V depending on the desired rotation of the blend door actuator. |
| D | Purple | +5V Reference Voltage | Output provides 5 volt reference voltage for the blend door actuator feedback potentiometer. Should be +5V. |
| E | Purple | Blend Door Feedback | Input signal from blend door actuator feedback potentiometer. This signal will be in the range of 0V to 5V depending on blend door position. |
| F | Yellow | Return Air Temperature Sensor Signal | Input signal from return air temperature sensor. This thermistor probe is installed in the return air duct to measure sleeper cab temperature. The temperature measured at this point is used to control the HVAC system. Should be in the range of 0V to 5V depending on temperature. |
| G | Black | Analog Ground | Output provides analog ground for the blend door actuator feedback potentiometer and the return air temperature sensor. Should be 0V. |
| H | Black | Blower Ground | Output provides high current ground for the blower fan. Should be 0V. |

**Table 24, Eight-Pin Packard Vehicle Interface Harness**

| Six-Pin Packard Vehicle Interface Harness | | | |
|---|---|---|---|
| **ID** | **Color** | **Line** | **Function** |
| A | Red | Power | Input provides +12VDC battery power for the HVAC system. This line provides power to the HVAC system for all functions. Should be 12V. |
| B | Orange | Ignition | Input provides +12VDC power for the HVAC system when the power is on. This is a low current input to provide a signal that the ignition is on. Should be 12V when the ignition is on. |
| D | Blue | Serial (+) Bunk1 | Input/output provides serial information link between the sleeper HVAC and the cab HVAC. This line should be connected to the bunk1 line on the cab HVAC unit. In use, this line will be a serial stream of 0V/5V signals. The average voltage reading on this pin will be around 2.5V. |
| E | White | Serial (–) Bunk2 | Input/output provides serial information link between the sleeper HVAC unit and the cab HVAC unit. This line should be connected to the bunk2 line on the cab HVAC unit. In use, this line will be a serial stream of 0V/5V signals. The average voltage reading on this pin is around 2.5V. |
| F | Black | Ground | Input provides ground for the HVAC system. Should be 0V. |

**Table 25, Six-Pin Packard Vehicle Interface Harness**

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## Troubleshooting for the ATC Heater and Air Conditioner With Advanced Diagnostics

## Wiring Diagrams

See **Fig. 9** for the ATC sleeper HVAC wiring diagram.

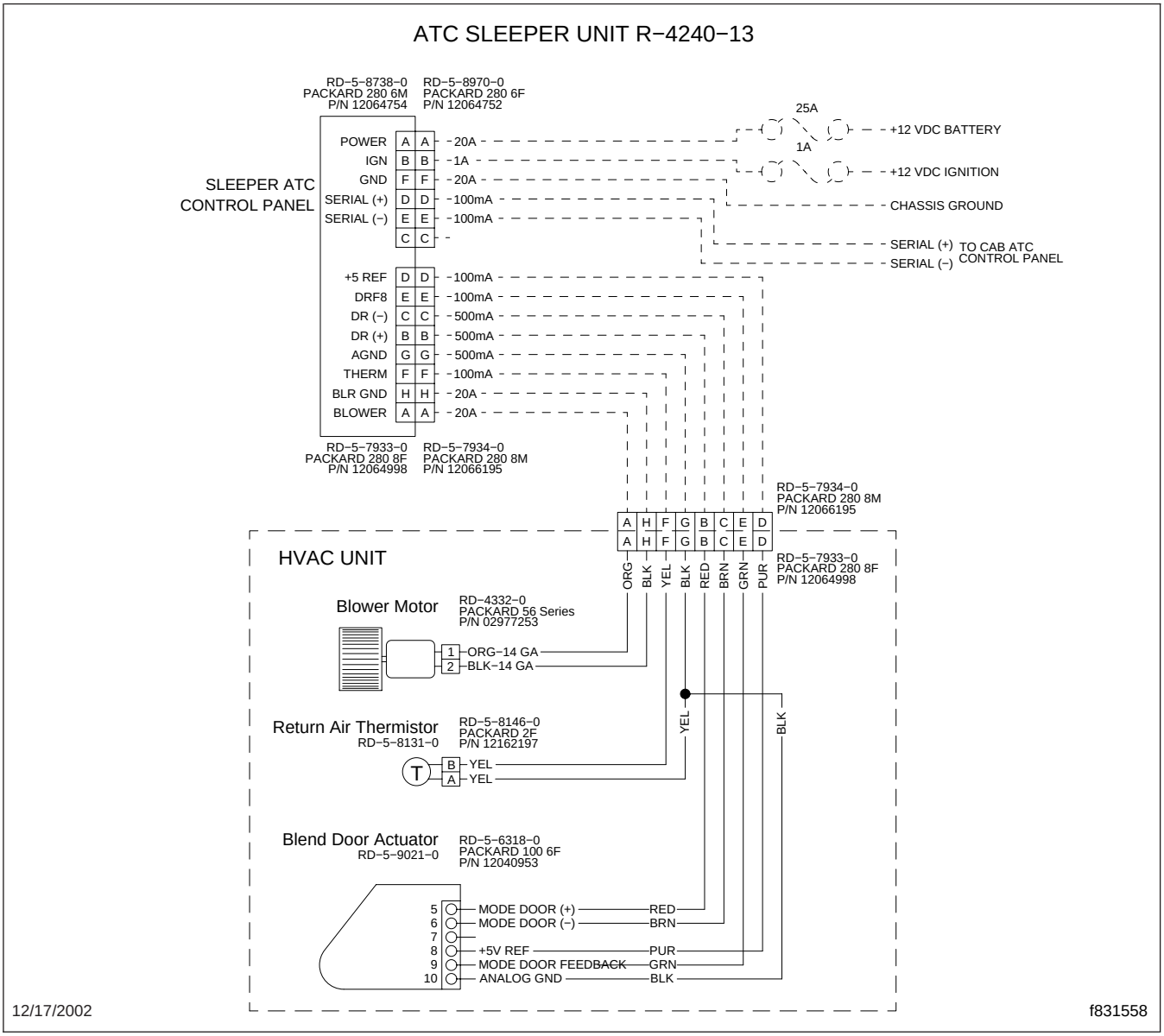



**Fig. 9, ATC Sleeper HVAC Wiring Diagram**

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## Specifications

| 3/4- and 5/8-Inch Heater Hose Clamp Torque Values | |
|---|---|
| **Description** | **Torque lbf·in (N·cm)** |
| Standard Hose Clamp | 40 (452) |
| Worm Gear Hose Clamp | 40 (452) |
| Breeze Constant Torque Hose Clamp | 40 (452) |
| Oetiker Constant Torque Hose Clamp | 18 (203) |

**Table 1, 3/4- and 5/8-Inch Heater Hose Clamp Torque Values**

| Temperature/Pressure Specifications for a Vehicle Without a Sleeper | | | | | | |
|---|---|---|---|---|---|---|
| **Ambient Air Temp.** | **Humidity (approximate) % RH** | **Dash Outlet Temperature** | **Service Port Pressures** | | **Clutch** | **Comments** |
| | | | **Low Side psi (kPa)** | **High Side psi (kPa)** | **Cycle yes/no** | |
| 70°F (21°C) | Low 25% | 45–55°F (7–13°C) | 20 (138) | 75–100 (517–689) | yes | compressor on 15 seconds, off 15 seconds |
| | High 55% | 46–55°F (8–13°C) | 20 (138) | 75–105 (517–724) | yes | compressor on 20 seconds, off 15 seconds |
| 80°F (27°C) | Low 25% | 46–56°F (8–13°C) | 22 (152) | 95–140 (655–965) | yes | compressor on 20 seconds, off 15 seconds |
| | High 55% | 47–58°F (8–14°C) | 25 (172) | 100–145 (689–1000) | yes | compressor on 45 seconds, off 15 seconds |
| 90°F (32°C) | Low 25% | 50°F (10°C) | 20 (138) | 150 (1034) | no | on steady |
| | High 55% | 54°F (12°C) | 30 (207) | 160 (1103) | no | on steady |
| 100°F (38°C) | Low 25% | 54°F (12°C) | 30 (207) | 200 (1379) | no | on steady |
| | High 55% | 64°F (18°C) | 40 (276) | 205 (1413) | no | on steady |
| Test conditions:<br>• engine at 1200 rpm<br>• engine fan locked on<br>• fresh air A/C mode<br>• cab doors open<br>• hood open<br>• no solar load<br>• no wind speed or less than 5 mph (8 km/h) | | | | | | |

**Table 2, Temperature/Pressure Specifications for a Vehicle Without a Sleeper**

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## Specifications

| Temperature/Pressure Specifications for a Vehicle With a Sleeper | | | | | | |
|---|---|---|---|---|---|---|
| Ambient Air Temp. | Humidity (approximate) % RH | Dash Outlet Temperature | Service Port Pressures | | Clutch | Comments |
| | | | Low Side psi (kPa) | High Side psi (kPa) | Cycle yes/no | |
| 70°F (21°C) | Low 25% | 46–55°F (8–13°C) | 25 (172) | 110 (758) | yes | compressor on 1 minute, off 20 seconds |
| | High 55% | 46–58°F (8–14°C) | 28 (193) | 110 (758) | yes | compressor on 2 minutes, off 20 seconds |
| 80°F (27°C) | Low 25% | 54–55°F (12–13°C) | 28 (193) | 128 (883) | no | on steady |
| | High 55% | 59°F (15°C) | 32 (221) | 140 (965) | no | on steady |
| 90°F (32°C) | Low 25% | 60°F (16°C) | 32 (221) | 165 (1138) | no | on steady |
| | High 55% | 67°F (19°C) | 40 (276) | 175 (1207) | no | on steady |
| 100°F (38°C) | Low 25% | 65°F (18°C) | 37 (255) | 200 (1379) | no | on steady |
| | High 55% | 68°F (20°C) | 54 (372) | 240 (1655) | no | on steady |

Test conditions:

- engine at 1200 rpm
- engine fan locked on
- fresh air A/C mode
- cab doors open
- hood open
- no solar load
- no wind speed or less than 5 mph (8 km/h)

**Table 3, Temperature/Pressure Specifications for a Vehicle With a Sleeper**

| Refrigerant Charge Amounts | | | | | |
|---|---|---|---|---|---|
| A/C Condenser | | A/C Compresor Brand | Number of Evaporators | Full Refrigerant Charge: lb (kg) | |
| Location | Brand | | | For Vehicles Built Prior to Dec. 10, 2004 | For Vehicles Built from Dec. 10, 2004 |
| Radiator | Red Dot | Climate Control | 1 | 5.10 (2.31) | 4.20 (1.91) |
| Roof | Red Dot | Climate Control | 1 | 5.30 (2.40) | 4.70 (2.13) |
| Radiator | Red Dot | Climate Control | 2 | 5.80 (2.63) | 4.80 (2.18) |
| Roof | Red Dot | Climate Control | 2 | 6.10 (2.77) | 5.50 (2.49) |
| Radiator | Red Dot | Sanden | 1 | 4.20 (1.91) | 4.20 (1.91) |
| Radiator | Modine | Sanden | 1 | — | 4.50 (2.04) |
| Roof | Red Dot | Sanden | 1 | 4.70 (2.13) | 4.70 (2.13) |
| Radiator | Red Dot | Sanden | 2 | 4.80 (2.18) | 4.80 (2.18) |
| Radiator | Modine | Sanden | 2 | — | 4.95 (2.25) |

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## Specifications

| Refrigerant Charge Amounts | | | | | |
|---|---|---|---|---|---|
| A/C Condenser | | A/C Compresor Brand | Number of Evaporators | Full Refrigerant Charge: lb (kg) | |
| Location | Brand | | | For Vehicles Built Prior to Dec. 10, 2004 | For Vehicles Built from Dec. 10, 2004 |
| Roof | Red Dot | Sanden | 2 | 5.50 (2.49) | 5.50 (2.49) |

**Table 4, Refrigerant Charge Amounts**

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# General Information

The compressor compresses low-temperature, low-pressure gas refrigerant gasified in the evaporator, into high-temperature, high-pressure gas refrigerant. The compressor then sends the refrigerant to the condenser.

The main purpose of the refrigerant compressor is to draw refrigerant gas from the evaporator and squeeze it into high-pressure gas. High pressure raises the condensation point of refrigerant gas, which allows the condenser to change it to a liquid so that it can be used for cooling again. A second purpose of the compressor is to move refrigerant through the air conditioning system.

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## Safety Precautions

Whenever repairs are made to any air conditioner parts that hold R–134a refrigerant, you must recover, purge or flush (if contaminated), evacuate, charge, and leak test the system. In a good system, refrigerant lines are always under pressure and you should disconnect them only after the refrigerant charge has been recovered (discharged) at the service valves.

Refrigerant R–134a is safe when used under the right conditions. Always wear safety goggles and non-leather gloves while recovering, evacuating, charging, and leak testing the system. Do not wear leather gloves; when refrigerant gas or liquid contacts leather, the leather will stick to your skin.

**⚠ WARNING**

**Use care to prevent refrigerant from touching your skin or eyes, because liquid refrigerant, when exposed to the air, quickly evaporates and will freeze skin or eye tissue. Serious injury or blindness could result if you come into contact with liquid refrigerant.**

Refrigerant splashed in the eyes should be rinsed with lukewarm water, not hot or cold. Do not rub the eyes. Apply a light bandage and contact a physician right away.

Refrigerant splashed on the skin should be rinsed with lukewarm water, not hot or cold. Do not rub the skin. Apply a light coat of a nonmedicated ointment, such as petroleum jelly. Contact a physician right away.

R–134a refrigerant does not burn at ambient temperatures and atmospheric pressure. However, it can be combustible at pressures as low as 5.5 psig (139 kPa absolute) at 350°F (177°C) when mixed with air concentrations that are greater than 60 percent.

**⚠ WARNING**

**R–134a air conditioning systems should not be pressure tested or leak tested with compressed air. Combustible mixtures of air and R–134a may form, resulting in a fire or explosion, which could cause personal injury or property damage.**

Always work in an area where there is a constant flow of fresh air when the system is recovered, evacuated, and charged. R–134a vapors have a slightly sweet odor that is difficult to detect. Frequent leak checks and air monitoring equipment are recommended to ensure a safe working environment.

IMPORTANT: When servicing an R–134a air conditioning system, use only service equipment certified to meet the requirements of SAE J2210 (R–134a recycling equipment). The equipment should be operated only by qualified personnel who are familiar with the recycling station manufacturer's instructions.

Because of its very low boiling point, refrigerant must be stored under pressure. To prevent the refrigerant containers from exploding, never expose them to temperatures higher than 125°F (52°C).

On R–134a refrigerant systems, polyalkylene glycol (PAG) oil is used in the compressor. When handling PAG oil, observe the following:

- keep the oil free of contaminants
- do not expose the air conditioning system or the PAG oil container to air for more than 30 minutes; PAG oil has a high moisture absorption capacity and the oil container should be immediately sealed after each use
- use care when handling: spilled oil could damage painted surfaces, plastic parts, and other components (drive belts)
- **never** mix PAG oil with other types of refrigerant oil

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**⚠ WARNING**

**Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.**

## Pre-Service Checks

Some special tools are needed for doing repair work on the compressor. See the special tools table in **Specifications 400**. Tool kits can be bought from the distributors listed in **Specifications 400**.

NOTE: Compressor problems usually show in one of four ways: abnormal noise, seizure, leakage, or low discharge pressure. Resonant compressor noises are not causes for alarm; irregular noise or rattles are likely to be caused by broken parts. To check for seizure, de-energize the magnetic clutch and see if the drive plate can be turned. If it won't turn, the compressor has seized.

Make the following checks whenever the air conditioner system is not cooling enough and the causes are unknown.

1. Check the drive belt and mounting:
   - 1.1 On the drive belt, look for wear, damage, or oil. If worn, oil-soaked, or damaged, remove it and install a new one. See the drive belt section in **Group 01** for instructions.
   - 1.2 Check the compressor mounting parts for loose fasteners, cracks, or other damage. Tighten loose fasteners to the torque value in the torque specifications table under **Specifications 400**. Repair or replace cracked or damaged brackets.
   - 1.3 Check the tension of the compressor drive belt. See the drive belt section in **Group 01** for instructions.
2. Check the wiring and connections to the compressor clutch. Replace damaged wiring and tighten loose connections.
3. Check for road debris build-up on the condenser coil fins. Using air pressure and a whiskbroom or a solution of soap and water, carefully clean the condenser; be careful not to bend the fins.

NOTE: For other possible causes of air conditioner problems, see **Section 83.02** *Heater and Air Conditioner Troubleshooting* and the applicable fan clutch section in **Group 20**.

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## Refrigerant Compressor Removal and Installation

**⚠ WARNING**

**Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.**

# Removal

1. Apply the parking brakes, and chock the tires.
2. Raise the hood.
3. Begin recovery of the refrigerant from the air conditioning system; for instructions, see **Section 83.02, Subject 110**.
4. Turn off the engine.
5. Remove the drive belt. Do not pry or roll the belt off the pulleys. See the drive belt section in **Group 01** for instructions.
6. Disconnect the wiring harness from the compressor.

**NOTICE**

**Under no circumstances should the ports on the compressor or the refrigerant lines remain uncapped for longer than five minutes. Water and dirt can damage the refrigerant system. Do not blow shop air through refrigerant lines since shop air is wet (humid).**

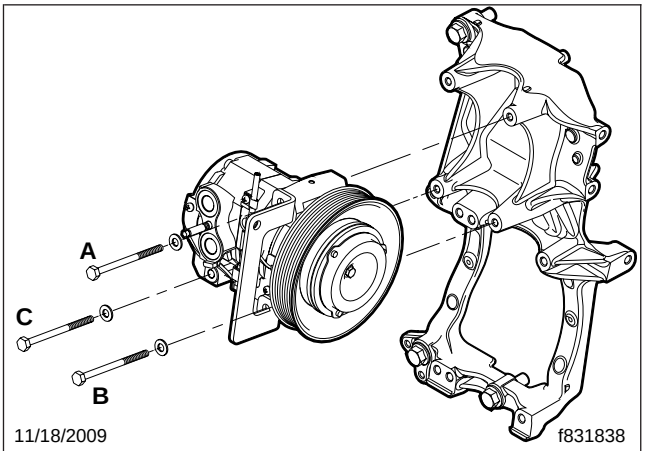
7. After the refrigerant has been fully recovered, remove the capscrews that attach the refrigerant lines and retaining plate(s) to the compressor. Remove the refrigerant lines and the retaining plates. Remove and discard the Mini Stat-O-Seals. Cap the discharge and suction ports and the refrigerant lines.
8. Being careful not to spill any refrigerant oil, remove the capscrews and washers that attach the refrigerant compressor to the engine, and remove the compressor.

# Installation

IMPORTANT: A new compressor is filled with refrigerant oil and nitrogen gas. The oil quantity is printed on a label attached to the compressor.

When installing a new compressor on the vehicle, gently release the nitrogen gas from the discharge side of the compressor.

1. Adjust the refrigerant oil level in the compressor; for instructions, see **Subject 130**.
2. Position the compressor on the mounting bracket and install the capscrews and washers. Tighten 15 to 19 lbf·ft (21 to 26 N·m) in the sequence shown in **Fig. 1**.




Tighten A, then B, then C.

A. Front Top
B. Front Bottom
C. Rear

**Fig. 1, Tightening Sequence (typical installation shown)**

3. Uncap the discharge and suction ports and the refrigerant lines. Check the refrigerant lines and the discharge and suction ports. They must be clean and free of nicks, gasket residue, and other foreign material.
4. Install new Mini Stat-O-Seals on the refrigerant lines.
5. Attach the refrigerant lines to the compressor. Tighten the capscrew 14 to 16 lbf·ft (19 to 22 N·m).
6. Connect the wiring harness to the compressor.
7. Install the drive belt.
8. If installing a new compressor, or if the system was without any refrigerant pressure before repairs were started, replace the receiver-drier; for instructions, see **Section 83.02, Subject 120**.

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## Refrigerant Compressor Removal and Installation

9. Evacuate, charge, and leak test the refrigerant system; for instructions, see **Section 83.02, Subject 110**.
10. Return the hood to the operating position.

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**WARNING**

**Before doing any of the work below, read the information under Safety Precautions 100. Failure to read the safety precautions and to be aware of the dangers involved when working with refrigerant, could lead to serious personal injury.**

## General Information

Denso compressors require ND-8 PAG refrigerant oil. When the air conditioning system is operating, refrigerant oil can leave the compressor and circulate through the system with the refrigerant, but the refrigerant oil cannot leave the system except when there is a leak, when the refrigerant is recovered, or when a system part is replaced.

It is important that the air conditioning system has the correct amount of refrigerant oil for proper operation. Too little oil will result in compressor failure. Too much oil will degrade the performance of the air conditioner, and cause damage to the compressor.

IMPORTANT: Whenever the air conditioning system is discharged or recovered, the recovered oil, from the charging machine, must be measured in order to know how much oil must be returned to the system. When a system component is replaced, a quantity of new oil equal to the recovered oil plus the oil coating the inside of the component must be returned to the system. New oil must be from a container that has not been opened or that has been tightly sealed since its last use. Tubing, funnels, or other equipment used to transfer the oil must be very clean and dry.

When handling refrigerant oil:

- Be sure that the oil is free of water, dust, metal powder, and other foreign substances;
- Do not mix the refrigerant oil with other types or viscosities of oil;
- Quickly seal the oil container after use. Refrigerant oil absorbs moisture when exposed to the air for any period of time.

Order Denso PAG oil (ND-8OIL, P/N DII LA446963 0040) from your local Freightliner parts distribution center, it is the only acceptable oil to use in a system with a Denso compressor.

## Denso Total System Oil Volume

Denso refrigerant compressors are supplied with approximately 4.5 oz. of ND-8 oil, but the vehicle configuration affects the total charge volume. If a complete new oil charge is required, the amount will be determined by the volume stated in the new compressor literature, and the volume listed in PartsPro. The two amounts will be combined to give the total oil charge required. If a complete new oil charge is not required, use the oil balancing info in **Section 83.02, Subject 110**.

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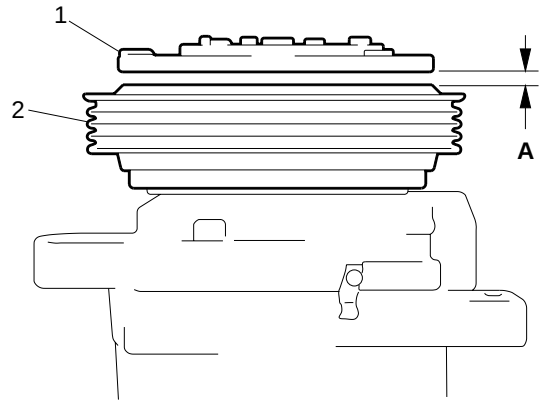
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## Clutch Assembly Removal, Inspection, and Installation

IMPORTANT: The clutch should be replaced if it is worn.

Before replacing the clutch, check the air gap at three equally spaced points around the perimeter. The air gap should be at least 0.014 in (0.35 mm), and no greater than 0.024 inch (0.60 mm). The gap must be greater than 0.024 inch (0.60 mm) at all three points for the clutch to need replacing. See **Fig. 1**.




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Check at three equally spaced points.
A. 0.014 to 0.024 in (0.35 to 0.60 mm)
1. Hub Sub-Assembly
2. Magnetic Clutch

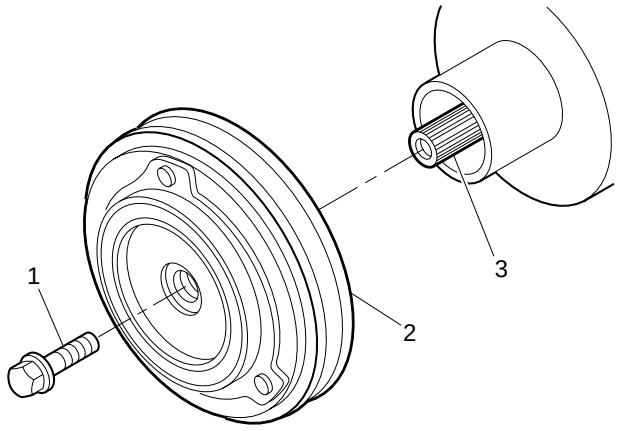
**Fig. 1, Checking the Clutch Clearance**

## Removal

NOTE: The hub is secured with a bolt (splined shaft is used for connection with compressor).

1. Remove the compressor from the vehicle. For instructions, see **Subject 110**.
2. Remove the clutch retaining capscrew from the compressor shaft. See **Fig. 2**.
3. Remove the shims from the pressure plate.
   NOTE: Save the air gap shims for reassembly.

NOTE: If the rotor cannot be removed easily, tap the rotor lightly with a plastic hammer, then remove it from the compressor shaft being careful not to damage the pulley when tapping on the rotor.

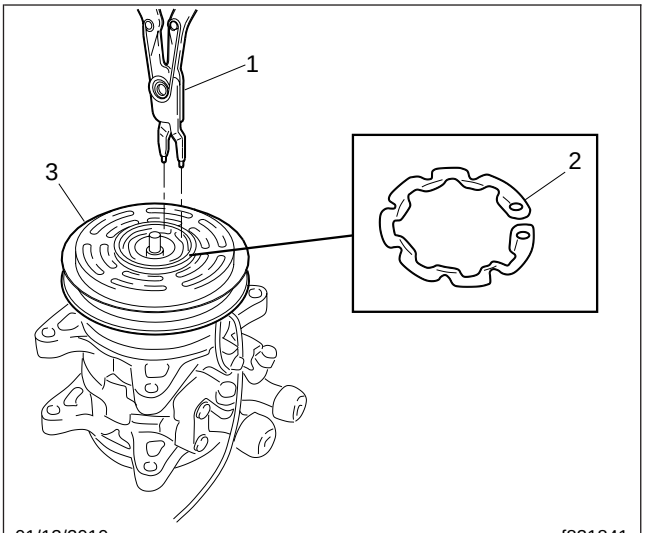



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1. Clutch Retaining Capscrew
2. Hub and Rotor Assembly
3. Splined Shaft

**Fig. 2, Removing the Retaining Capscrew**

4. Using snap ring pliers, remove the snap ring, then remove the rotor. Discard the snap ring. See **Fig. 3**.
5. Using snap ring pliers, remove the snap ring, then remove the stator. Discard the snap ring. See **Fig. 4**.




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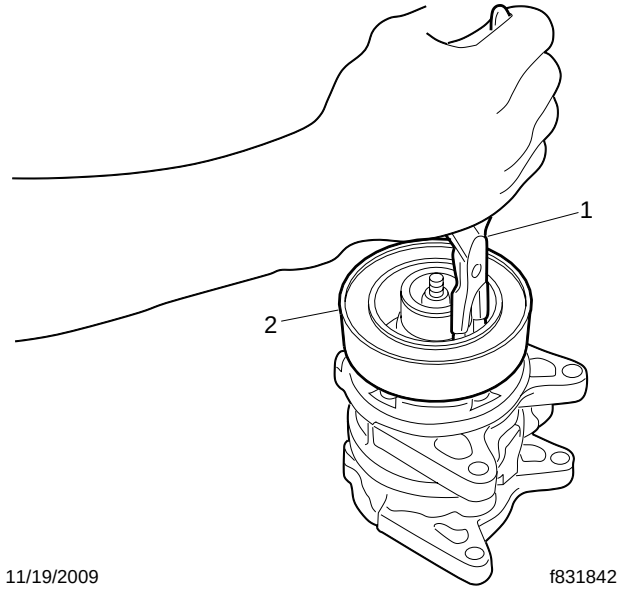
1. Snap Ring Pliers
2. Snap Ring
3. Rotor

**Fig. 3, Rotor Removal**

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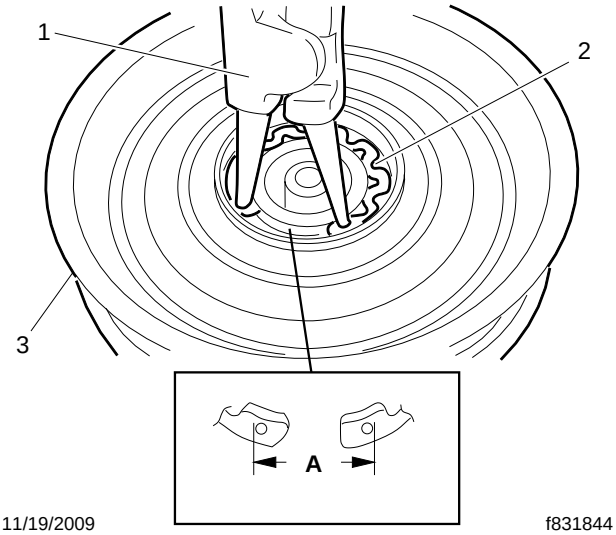


## Clutch Assembly Removal, Inspection, and Installation




1. Snap Ring Pliers
2. Stator

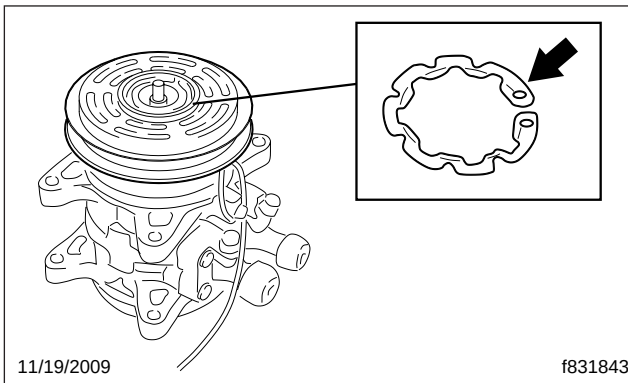
**Fig. 4, Stator Removal**




A. Do not exceed 1.2 in (30.9 mm).

1. Snap Ring Pliers
2. Snap Ring
3. Rotor

**Fig. 5, Snap Ring Installation**




Chamfered side up.

**Fig. 6, Snap Ring Installation**

## Inspection

After the magnetic clutch is disassembled, inspect each component and decide whether they can be reused. Refer to **Table 1** for clutch inspection and recommended action.

## Installation

### NOTICE

**Excessive opening of the snap rings may weaken the fixing force of the snap ring. Maximum allowed opening must not exceed 1.2 in (30.9 mm). See Fig. 5.**

1. Align the stator to the compressor housing by positioning the index pin into its indexing hole/slot.

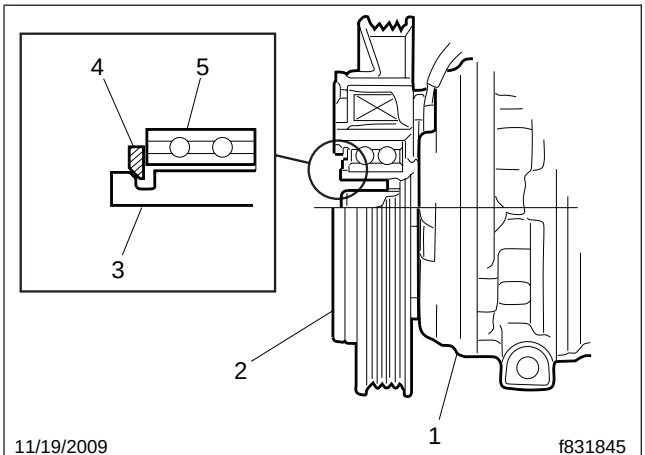
IMPORTANT: The snap ring must be installed with the chamfered side facing up. See **Fig. 6**.

2. Secure the stator with a new snap ring. Make sure the snap ring is fully seated. See **Fig. 7**.
3. Install the rotor in the compressor and secure it with a new snap ring.
4. Temporarily install the hub to verify the gap clearance. See **Fig. 1**.
5. Check the air gap. The air gap between the hub and rotor should be 0.014 to 0.024 in (0.35 to 0.60 mm). Check the clearance at 3 locations.
6. Set the air gap clearance between the pressure plate and rotor by adding or removing compressor shaft shims so that the air gap clearance is within the specified range and distance.

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## Clutch Assembly Removal, Inspection, and Installation




1. Compressor
2. Clutch Assembly
3. Compressor Shaft
4. Snap Ring
5. Bearing

**Fig. 7, Seating the Snap Ring**

7. Install the clutch retaining capscrew in the compressor shaft. Tighten 15 to 19 lbf·ft (21 to 26 N·m).

8. After the clutch is assembled, turn the rotor by hand to verify it does not contact either the pressure plate or stator.

| Magnetic Clutch Inspection | | |
|---|---|---|
| **Part Name** | **Check Point and Expected Damage** | **Action** |
| Hub | Dislocation or peeling of rubber. | Replace or Repair |
| | Roughness, burn, rust, slip or extreme wear on mating surface. | Replace |
| Rotor | Play, unusual sound, rust, insufficient grease or seizure of bearing. | |
| | Roughness, burn, rust, slip or extreme wear on mating surface. | |
| Stator | Burn, wire breakage or layer short circuit of stator coil. Resistance of stator coil at 68°F (20°C) should be 2.8 to 3.2 ohms. | |
| | Damage of deformation of rotor (pulley) groove(s). | |

**Table 1, Magnetic Clutch Inspection**

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## Specifications

Special tools can be purchased from the following independent suppliers:

Classic Tool Design
31 Walnut St.
New Windsor, NY 12553
845-562-8700

Mastercool USA Inc.
One Aspen Drive
Randolph, NJ 07869
(973) 252-9119

| Torque Values | | |
|---|---|---|
| **Description** | **Torque** | |
| | **lbf·in (N·cm)** | **lbf·ft (N·m)** |
| Compressor Mounting Fasteners | — | 15–19 (21–26) |
| Clutch Retaining Capscrew | — | 22 (30) |
| Clutch Lead Wire Clamp Screw | 132 (1500) | — |

**Table 1, Torque Values**

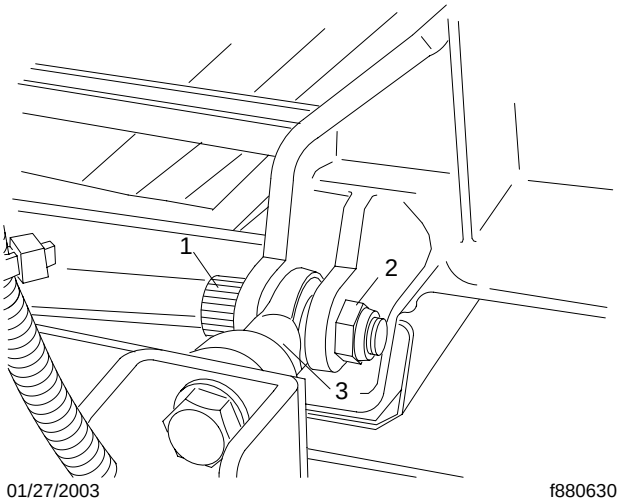
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## General Information

Western Star hoods are constructed from fiberglass with reinforcing members, and on 4700-series vehicles, an air intake plenum, bonded to the engine side of the hood. The grille assembly may be mounted on the hood or the radiator, depending on the vehicle configuration. Three-piece hoods have frame-mounted fenders at the rear of the hood.

The hood is mounted on the frame rails or the radiator at the front hood pivots (**Fig. 1** and **Fig. 2**), and it can be tilted forward for vehicle service. Tilt-assist springs or struts, and check cables are mounted from the hood to the left and right sides of the radiator.

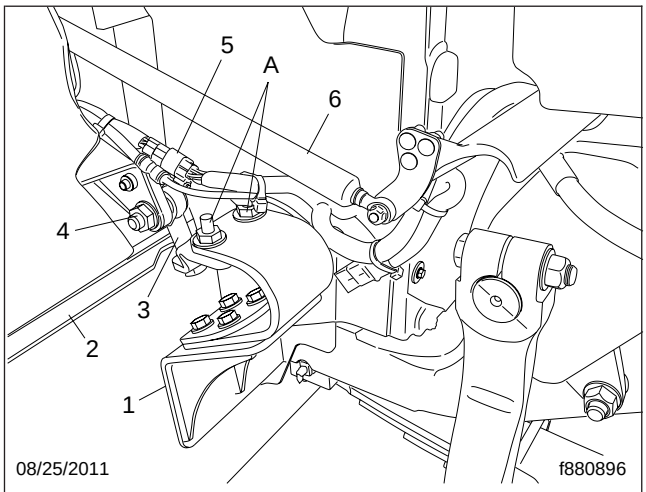



1. Pivot Bolt
2. Nut
3. Hood Pivot

**Fig. 1, Front Hood Pivot (typical non-4700 series)**

On all except 4700-series vehicles, two plastic V-block or rectangular block isolators (**Fig. 3**) are mounted on the inside rear of the hood. With the hood in the closed position, the blocks rest in saddle brackets (**Fig. 4**) mounted on the cab front wall. Lateral stabilizer brackets (**Fig. 5**) or rubber posts (**Fig. 6**) are mounted on both sides of the vehicle under the hood. The stabilizer brackets and posts are not load bearing, but help with the alignment of the hood at the rear lower cowl area, and prevent lateral movement of the hood in the cowl and side-panel area.

On 4700-series vehicles, the rear of the hood is supported by brackets attached to the cab front wall.




NOTE: LH shown.

A. Loosen to adjust hood fore-aft alignment.

1. Hood Pivot Support Bracket
2. Hood
3. Hood Pivot, Rod-End
4. Pivot Hexnut
5. Wiring Harness Connector
6. Strut

**Fig. 2, Front Hood Pivot (4700 series)**

The hood rear support brackets hold the hood in the correct position for operation; see **Fig. 7**.

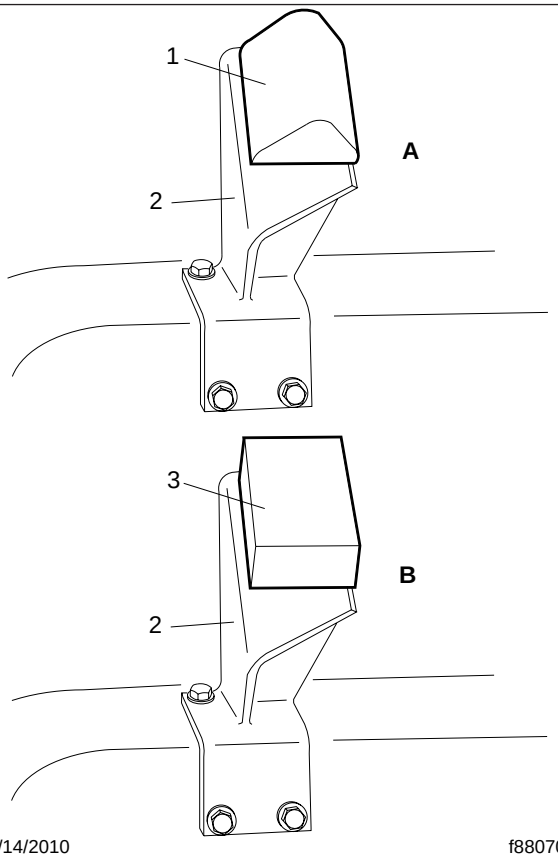
When closed, the rear of the hood is held in place with latches, one on each side.

The hood is equipped with a headlight assembly on each fender. Some models have air intake grilles on both sides of the hood. Optional access doors (butterfly hatches) allow under-hood servicing without the need to tilt the hood.

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## General Information

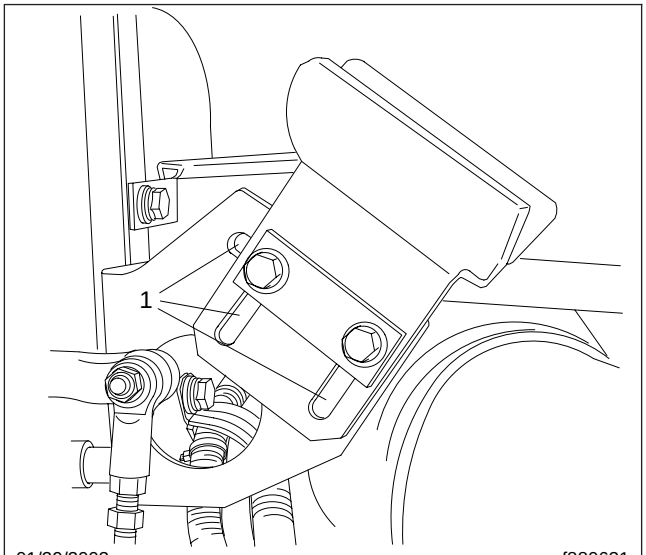



09/14/2010 f880704a

A. Standard-Duty Application Only
B. Heavy-Duty or Standard-Duty Application

1. V-Block Isolator
2. Hood Rear Support Bracket
3. Rectangular Block Isolator

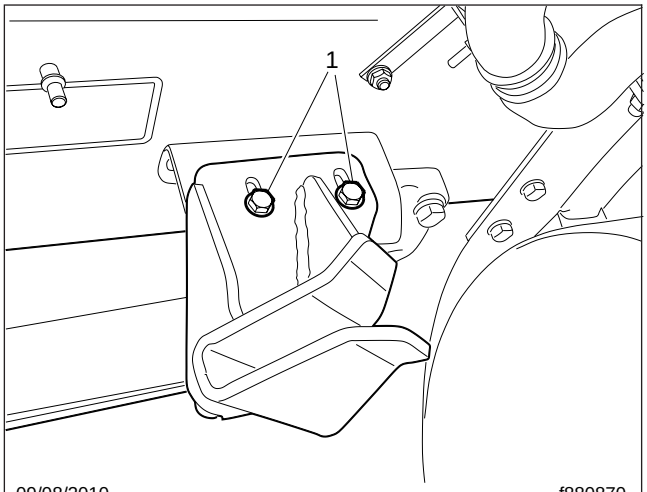
**Fig. 3, Hood Rear Support Bracket and Isolator**




01/29/2003 f880631

1. Adjusting Slots

**Fig. 4, Saddle Bracket (for V-block shown)**



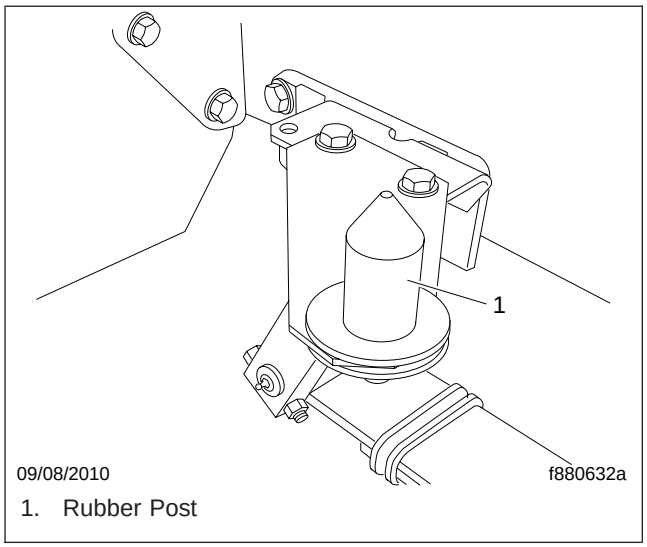

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1. Capscrews

**Fig. 5, Hood Stabilizer Bracket (frame-mounted shown)**

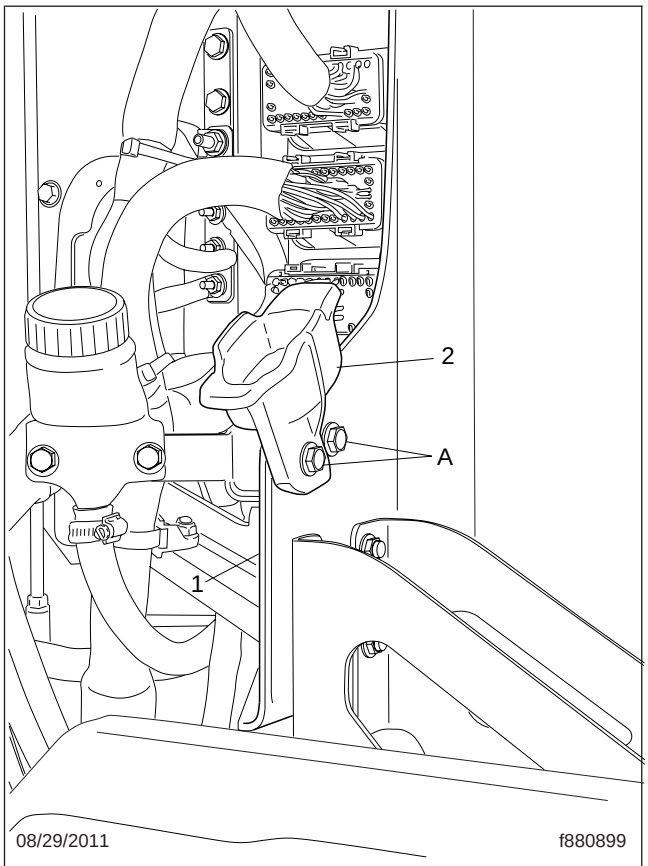
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1. Rubber Post

**Fig. 6, Hood Post**




NOTE: LH shown.

A. Loosen to adjust the hood up-and-down alignment.

1. Hood Rear Support Bracket
2. Hood Rear Locator

**Fig. 7, Hood Rear Support, 4700 Series**

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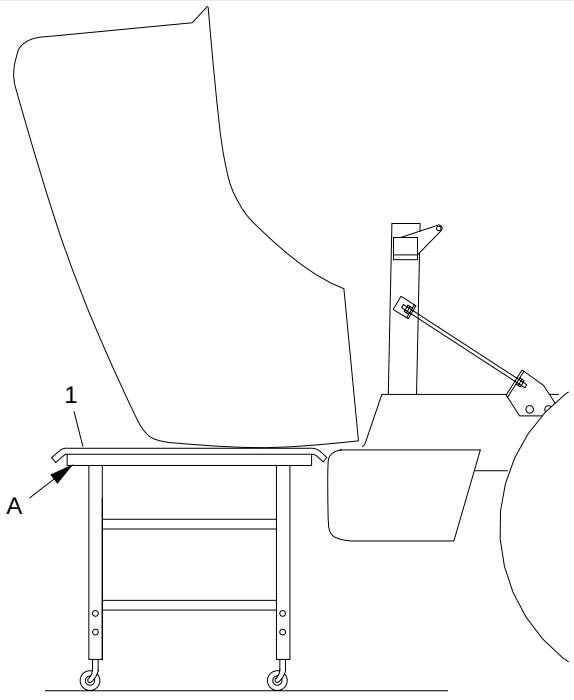
# Hood Removal and Installation

NOTE: These procedures apply to all except 4700-series vehicles.

## Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Place a support between the floor and the front of the hood; see **Fig. 1**.

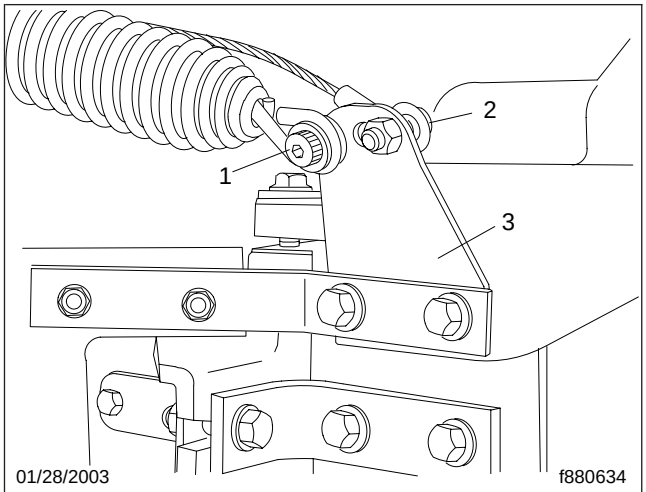
   The support should be as wide and as long as the front of the hood, and should be the same height as the lowest edge of the hood. Place cardboard, carpet, rags or other padding on top of the support to protect the hood.




A. The top of the support should be at same height as the lowest edge of the hood.
1. Cardboard, Carpet, or Furniture Pad

**Fig. 1, Supporting the Hood**

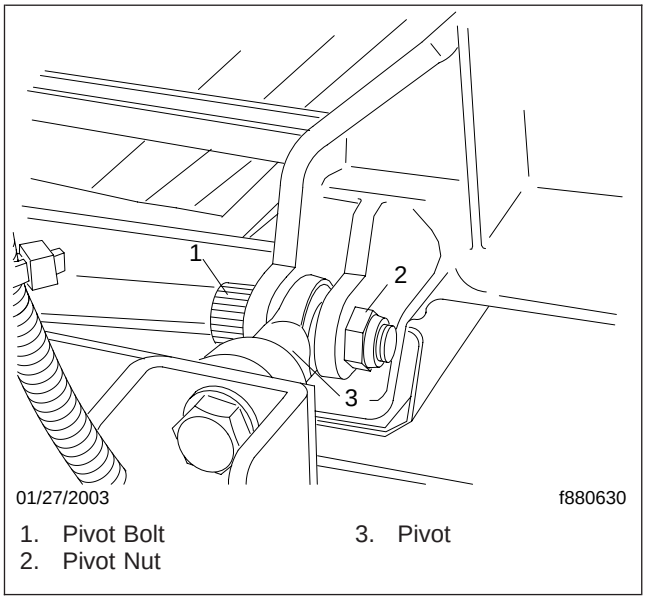
3. Tip the hood back about half-way, until it is balanced over the pivot, to remove the tension on the torsion springs. Prop the hood in this position or have another person support it there.
4. Remove the bolts that attach the springs and the safety cable to the radiator mounted bracket. See **Fig. 2**.




1. Spring Bolt
2. Cable Bolt
3. Radiator Bracket

**Fig. 2, Torsion Spring and Safety Cable**

5. Rest the hood fully open on the support.
6. Cut the tie straps that retain the headlight harness, and unplug the headlight connectors.
7. Remove the hood pivot nut and bolt. See **Fig. 3**.




1. Pivot Bolt
2. Pivot Nut
3. Pivot

**Fig. 3, Hood Pivot**

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## Hood Removal and Installation

8. Carefully roll or slide the hood support and hood away from the vehicle.

# Installation

1. Supporting the hood, align the pivot bracket on the hood to the pivot attached to the frame.
2. Insert the pivot bolt and secure with the nut. Tighten the nut 136 lbf·ft (184 N·m).
3. Plug in the headlight harness connectors and use tie straps to fasten them securely to the hood.
4. Close the hood half-way and support it. Bolt the torsion springs and safety cables to the radiator bracket. Tighten the torsion spring and safety cables 16 lbf·ft (21 N·m).
5. Remove the hood support and close and latch the hood.
6. Check and adjust the hood alignment following the instructions in **Subject 110**.

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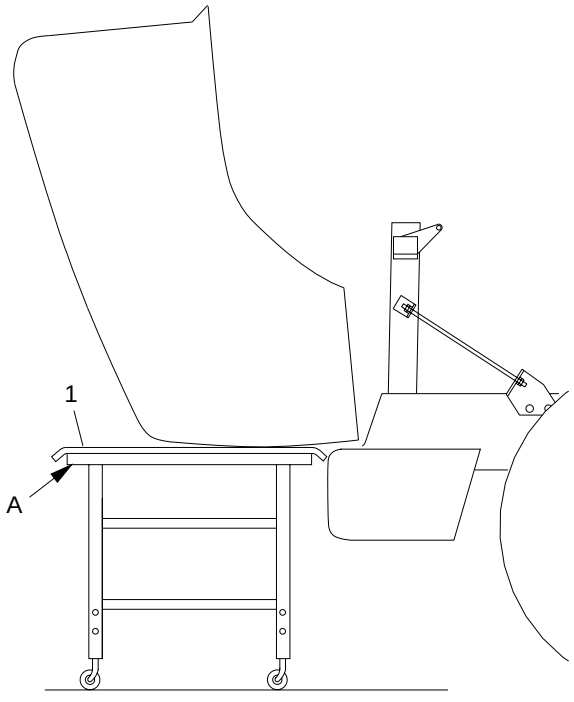


# Hood Removal and Installation, 4700 Series

## Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Place a support between the floor and the front of the hood; see **Fig. 1**.

   The support should be as wide and as long as the front of the hood, and should be the same height as the lowest edge of the hood. Place cardboard, carpet, rags, or other padding on top of the support to protect the hood.



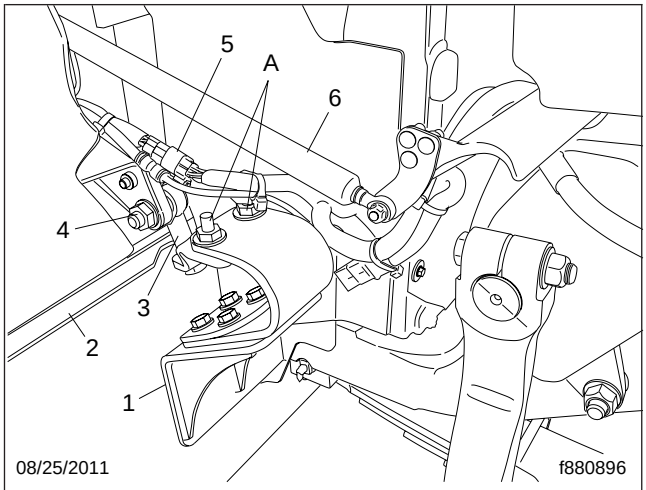

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A. The top of the support should be at same height as the lowest edge of the hood.

1. Cardboard, Carpet, or Furniture Pad

**Fig. 1, Supporting the Hood**

3. Open the hood.
4. On each side of the vehicle, disconnect the wiring harness between the chassis and the hood; see **Fig. 2**.
5. With an assistant holding the hood balanced over the hood pivots, remove the tilt-assist spring struts by removing the fasteners that secure the struts to the frame assembly and the hood; see **Fig. 2** and **Fig. 3**.



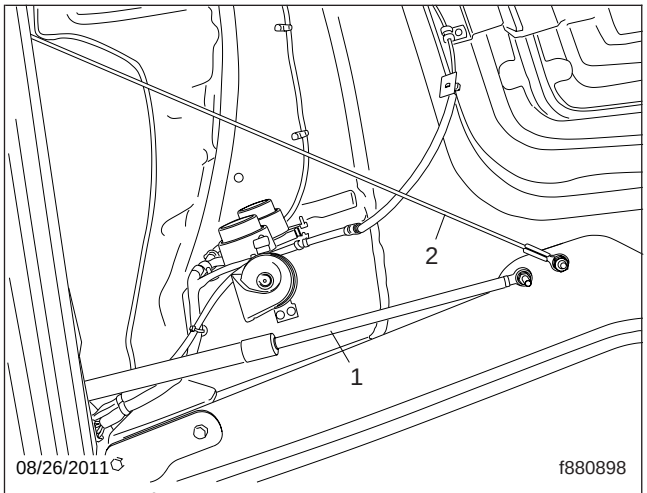

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NOTE: LH shown.

A. Loosen to adjust hood fore-aft alignment.

1. Hood Pivot Support Bracket
2. Hood
3. Hood Pivot, Rod-End
4. Pivot Hexnut
5. Wiring Harness Connector
6. Strut

**Fig. 2, Hood Hinge and Spring Strut**




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NOTE: LH shown.

1. Strut
2. Check Cable

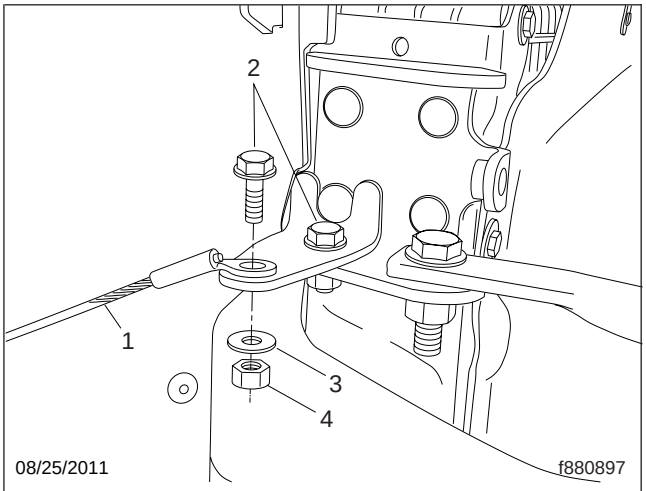
**Fig. 3, Spring Strut and Check Cable**

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## Hood Removal and Installation, 4700 Series

6. Lower the hood until it is balanced over the pivots, to relieve tension on the check cables. Have an assistant hold the hood in this position.
7. Disconnect the check cables from the brackets on the radiator; see **Fig. 4**.




NOTE: LH shown.

1. Hood Check Cable
2. Flange Bolts
3. Flatwasher
4. Locknut

**Fig. 4, Hood Check Cable Installation**

8. Tilt the hood fully open, and rest it on the support.
9. Remove the hood-hinge pivot bolts; see **Fig. 2**.
10. Carefully roll or slide the hood support away from the vehicle; do not try to lift the hood.

## Installation

1. With the tires chocked, move the support and hood into alignment with the front of the vehicle. Do not try to lift the hood.
2. Align the holes of the hood pivot brackets with the rod-end pivots. Install the hood-hinge pivot bolts. Install the washers and nuts. Tighten the nuts 128 to 162 lbf·ft (173 to 219 N·m). See **Fig. 2**.
3. Lower the hood until it is balanced over the pivots, then have an assistant hold the hood in this position.
4. Connect the check cables to the brackets on the radiator; see **Fig. 4**. Tighten the nuts 60 lbf·in (680 N·cm).
5. Install the tilt-assist spring struts on the frame assembly and the hood. Tighten the nuts 15 to 19 lbf·ft (20 to 26 N·m). See **Fig. 2** and **Fig. 3**.
6. Open the hood to the full-tilt position.
7. Connect the wiring harness on both sides of the hood.

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## Checking and Alignment, All Except 4700 Series

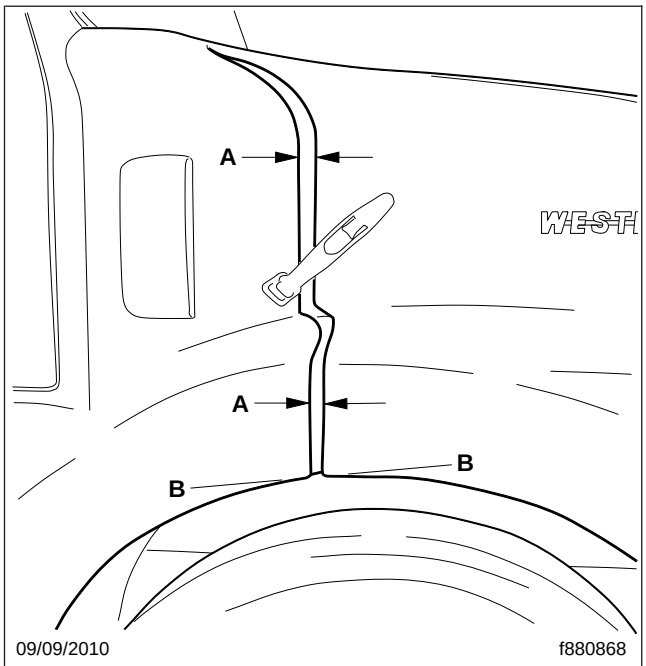
NOTE: If the vehicle has had damage to the chassis, the frame must be straightened before adjusting the hood alignment.

NOTE: Tighten all adjusting fasteners using the torque specifications found in **Section 00.05**.

The hood is aligned on three planes: the front edge, the rear edge, and the rear sides of the hood. These features align to corresponding semi-fixed features: the front tow crossmember or bumper, the hood cowl, and the quarter fenders or side cowl.

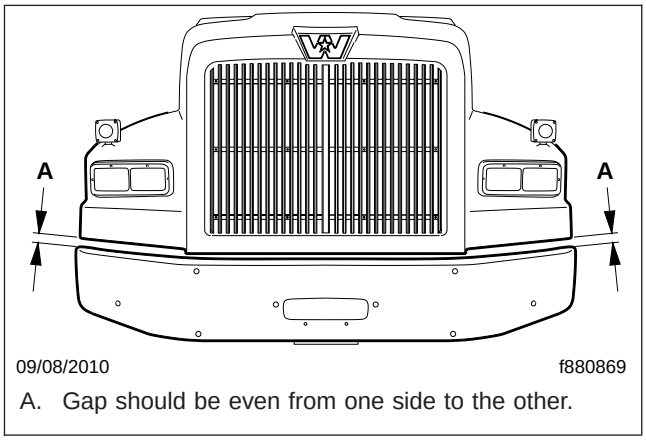
1. Drive the vehicle back and forth to settle the frame and suspension.
2. Park the vehicle on a flat, level surface. Shut down the engine, apply the parking brakes, and chock the tires.
3. With the hood in the operating position, and both hood latches latched, check the following to determine whether adjusting the hood alignment is necessary:
    - *Hood rear support*—the weight of the hood should be supported by the isolators in the saddle brackets, not by the quarter fenders or the hood stabilizer brackets.
    - *Hood-to-cowl side panel alignment*—the gap should be even from top to bottom, 3/8 to 1 inch (9 to 25 mm) wide. The gap and fender slope should be the same on both sides of the vehicle. See **Fig. 1**.
    - *Hood-to-quarter fender alignment*—the gap should be even from top to bottom, 3/8 to 1 inch (9 to 25 mm) wide.
    - *Paint line alignment*—paint lines on the hood should line up with paint lines on the cab/sleeper.
    - *Hood-to-bumper alignment*—the gap between the hood and bumper should be even from one side to the other, when the bumper is horizontally aligned with the frame. See **Fig. 2**.

If necessary, follow the steps below to align the hood.




A. Gap should be even from top to bottom, 3/8 to 1 inch (9 to 25 mm).
B. Hood and cowl should line up at the wheel well.

**Fig. 1, Hood-to-Cowl Side Panel Alignment**




A. Gap should be even from one side to the other.

**Fig. 2, Hood-to-Bumper Alignment**

4. Check the cab ride height. Adjust if needed; see **Section 60.03, Subject 100**.
5. Make sure the bumper is horizontally aligned with the frame before beginning hood alignment. If necessary, loosen and adjust the bumper.

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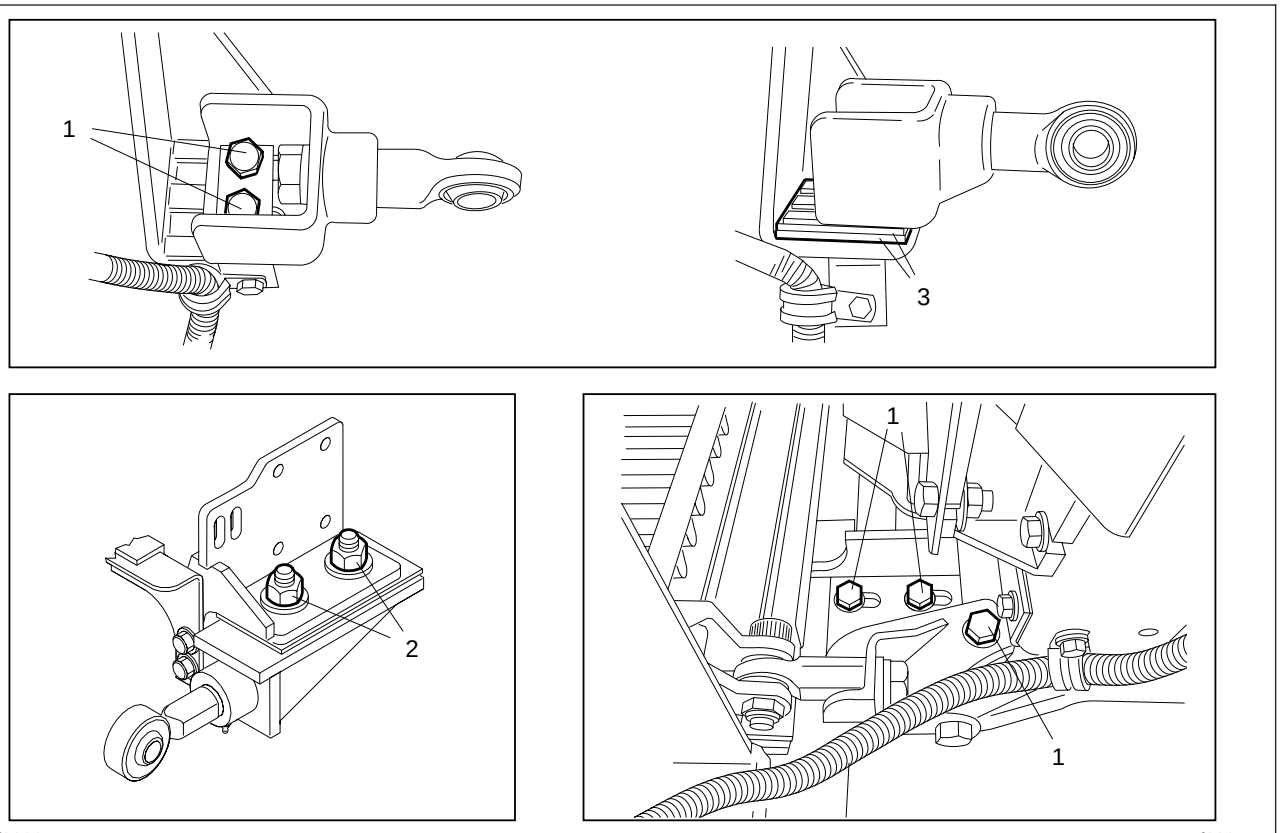


## Hood Checking and Alignment

6. Adjust the front of the hood so that the gap between the hood and the bumper is uniform from side to side; see **Fig. 2**. The hood pivot configuration may vary; see **Fig. 3** for the locations of the adjusting bolts and nuts. If necessary, use shims to adjust the mount vertically.

NOTE: Only use shims designed and approved for adjusting the hood. Do not use more than three shims per side.

7. If equipped with V-block isolators at the rear of the hood, adjust the lateral position of the hood isolators by loosening and lightly tightening the nuts that attach the isolators to the mounting brackets. Close and open the hood, then tighten the nuts.
8. Adjust the rear of the hood vertically by moving the saddle bracket along the adjusting slots. See **Fig. 4**. Adjust the brackets so that when the hood is closed, both isolators are resting in the saddle brackets. Make sure that the weight of the hood is not supported on the fenders. The hood and cowl should line up at the wheel well; see **Fig. 1**.
9. Adjust the hood stabilizer brackets (**Fig. 5**) or hood posts (**Fig. 6**) so they fit snugly without dragging when the hood is closed. A hood post can be moved off-center on its mounting bracket, but make sure that the washers are centered under the post. Apply grease to check for smooth engagement.



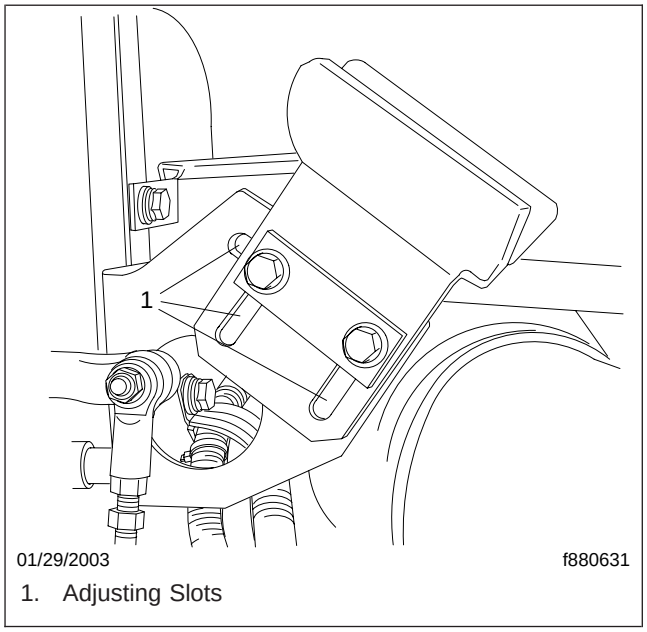

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1. Adjusting Bolt
2. Adjusting Nut
3. Shim

**Fig. 3, Hood Pivot Configurations and Adjustment**

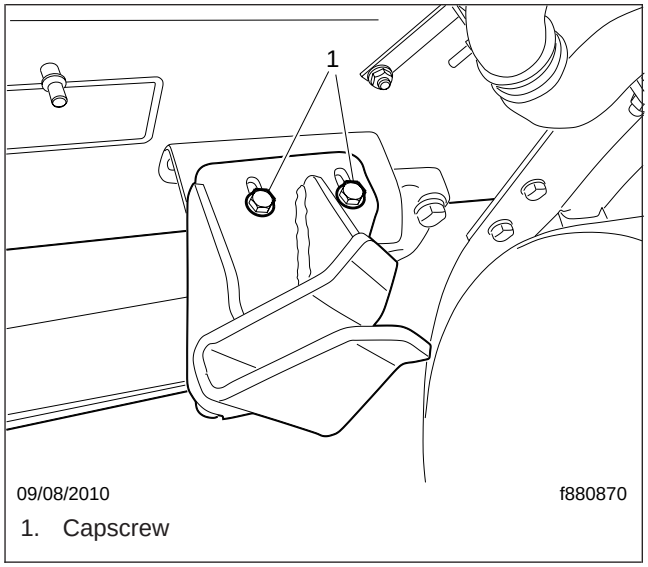
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1. Adjusting Slots

**Fig. 4, Saddle Bracket**

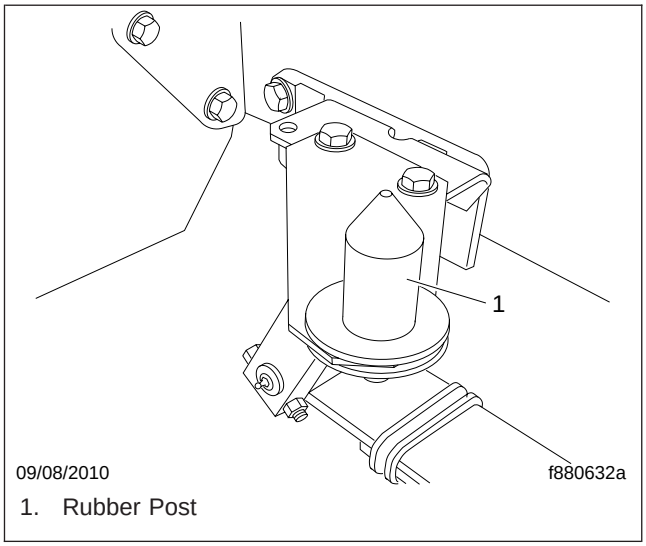



1. Capscrew

**Fig. 5, Hood Stabilizer Bracket (frame-mounted shown)**

NOTE: The stabilizers and hood posts are designed to control lateral movement. They should never support the weight of the hood.

10. Close and latch the hood.




1. Rubber Post

**Fig. 6, Hood Post**

## Checking and Alignment, 4700 Series

NOTE: If the vehicle has had damage to the chassis, the frame must be straightened before adjusting the hood alignment.

The hood is aligned on three planes: the front edge, the rear edge, and the rear sides of the hood. These features align to corresponding semi-fixed features: the front tow crossmember or bumper, the hood cowl, and the quarter fenders or side cowl.

1. Drive the vehicle back and forth to settle the frame and suspension.
2. Park the vehicle on a flat, level surface. Shut down the engine, apply the parking brakes, and chock the tires.
3. With the hood in the operating position, and both hood latches latched, check the following to determine whether adjusting the hood alignment is necessary:
   - The character lines of the hood and cab should line up.
   - The gap between the rear edge of the hood and the side cowl panel should be uniform on both sides of the vehicle with a gap between 3/4 and 1 inch (19 to 27 mm).

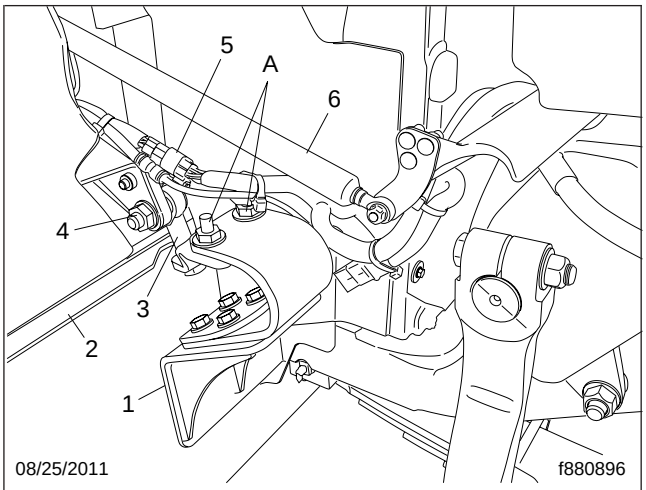
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## Hood Checking and Alignment

If necessary, follow the steps below to align the hood.

4. To adjust the hood fore-and-aft at the front, loosen, but do not remove, the two nuts on each side of the hood that attach the hood pivot adapter plate to the hood hinge; see **Fig. 7**. After adjustment, tighten the nuts 57 to 72 lbf·ft (77 to 98 N·m).



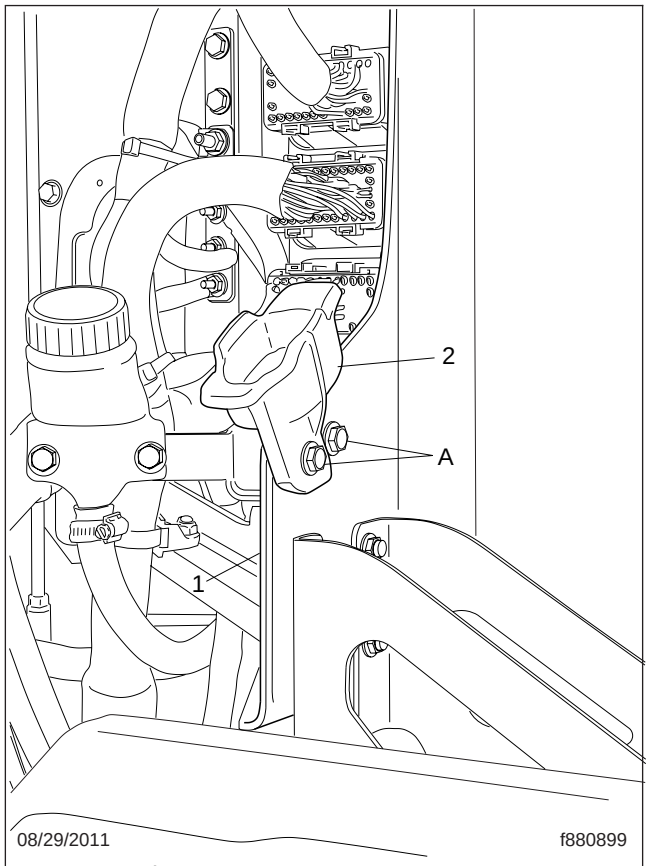

NOTE: LH shown.

A. Loosen to adjust hood fore-aft alignment.

1. Hood Pivot Support Bracket
2. Hood
3. Hood Pivot, Rod-End
4. Pivot Hexnut
5. Wiring Harness Connector
6. Strut

**Fig. 7, Hood Hinge, 4700 Series**

5. To adjust the rear of the hood up-and-down on each side of the hood, loosen, but do not remove, the two fasteners that attach the hood rear locator to the hood rear support bracket. See **Fig. 8**. After adjustment, tighten the fasteners 23 to 29 lbf·ft (31 to 40 N·m).
6. Close and latch the hood.




NOTE: LH shown.

A. Loosen to adjust the hood up-and-down alignment.

1. Hood Rear Support Bracket
2. Hood Rear Locator

**Fig. 8, Hood Rear Support, 4700 Series**

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## Specifications

Unless listed in **Table 1**, tighten all fasteners using the torque specifications found in **Section 00.05**.

| Torque Specifications | | | | |
|---|---|---|---|---|
| **Fastener Description** | **lbf·ft** | **N·m** | **lbf·in** | **N·cm** |
| Hood Pivot-Bolt Nuts (all except 4700 Series) | 136 | 184 | — | — |
| Hood Pivot-Bolt Nuts (4700 Series) | 128–162 | 173–219 | — | — |
| Check Cable Nuts (all except 4700 Series) | 16 | 21 | — | — |
| Check Cable Nuts (4700 Series) | — | — | 60 | 680 |
| Torsion Spring Nuts | 16 | 21 | — | — |
| Tilt-Assist Strut Mounting Nuts | 15–19 | 20–26 | — | — |
| Hood Pivot Adapter Plate Nuts | 57–72 | 77–98 | — | — |
| Hood Rear Locator Fasteners (4700 Series) | 23–29 | 31–40 | — | — |

**Table 1, Torque Specifications**

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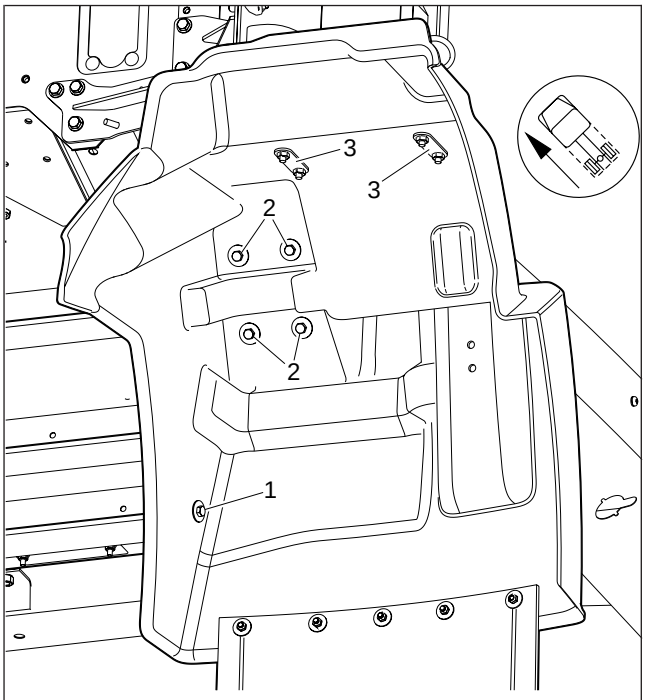
# Cab-Mounted Quarter Fender Removal and Installation, 4700 Model

NOTE: This procedure applies to the 4700 Model.

## Removal

1. Park the vehicle on a level surface, shut down the engine, and set the parking brake. Chock the tires.
2. Open the hood.
3. *On set-forward axle vehicles,* remove the capscrews and flatwashers that attach the quarter fender to the quarter-fender brace and the cab-mount bracket; see **Fig. 1**.

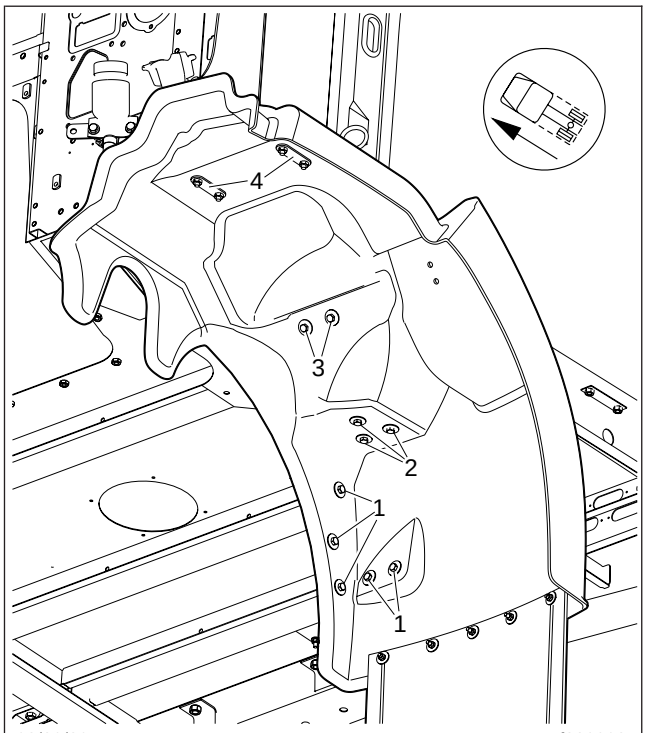
   *On set-back axle vehicles,* remove the capscrews and flatwashers that attach the quarter fender to the aft inboard bracket, the aft upper bracket, and the crossmember bracket; see **Fig. 2**.




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1. Quarter-Fender Brace Capscrew
2. Cab-Mount Bracket Capscrews
3. Nut Plate

**Fig. 1, Underside of Quarter Fender, Set-Forward Axle**




08/30/2011 f880902

1. Aft Inboard Bracket Capscrews
2. Aft Upper Bracket Capscrews
3. Crossmember Bracket Capscrews
4. Nut Plates

**Fig. 2, Underside of Quarter Fender, Set-Back Axle**

4. While supporting the quarter fender, remove the capscrews and flatwashers that attach the quarter fender to the upper support bracket; see **Fig. 3**. Remove the quarter fender.

## Installation

1. While supporting the quarter fender in place, install, but do not tighten, the capscrews and flatwashers that secure it to the upper support bracket; see **Fig. 3**.
2. *On set-forward axle vehicles,* install, but do not tighten, the capscrews and flatwashers that attach the quarter fender to the quarter-fender brace and the cab-mount bracket; see **Fig. 1**.

   *On set-back axle vehicles,* install, but do not tighten, the capscrews and flatwashers that attach the quarter fender to the aft inboard bracket,

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## Cab-Mounted Quarter Fender Removal and Installation, 4700 Model

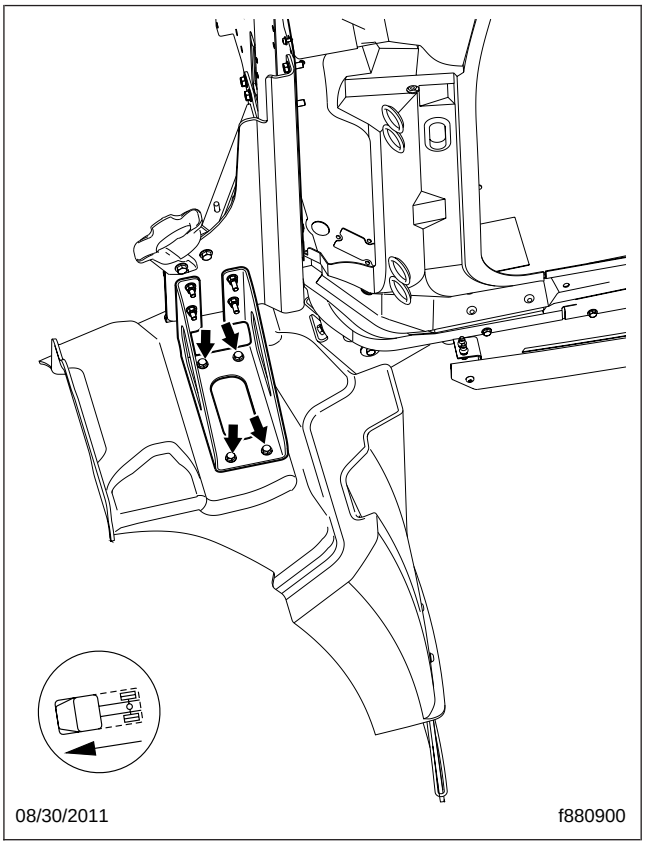



**Fig. 3, Upper Support Bracket Capscrews**

the aft upper bracket, and the crossmember bracket; see **Fig. 2**.

3. Tighten all capscrews 15 lbf·ft (20 N·m).

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## Specifications

Unless listed in **Table 1**, tighten all fasteners using the torque specifications found in **Section 00.05**.

| Torque Specifications | | |
|---|---|---|
| **Fastener Description** | **Torque** | |
| | **lbf·ft** | **N·m** |
| Quarter Fender Mounting Capscrews (4700 Model) | 15 | 20 |

**Table 1, Torque Specifications**

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# General Information

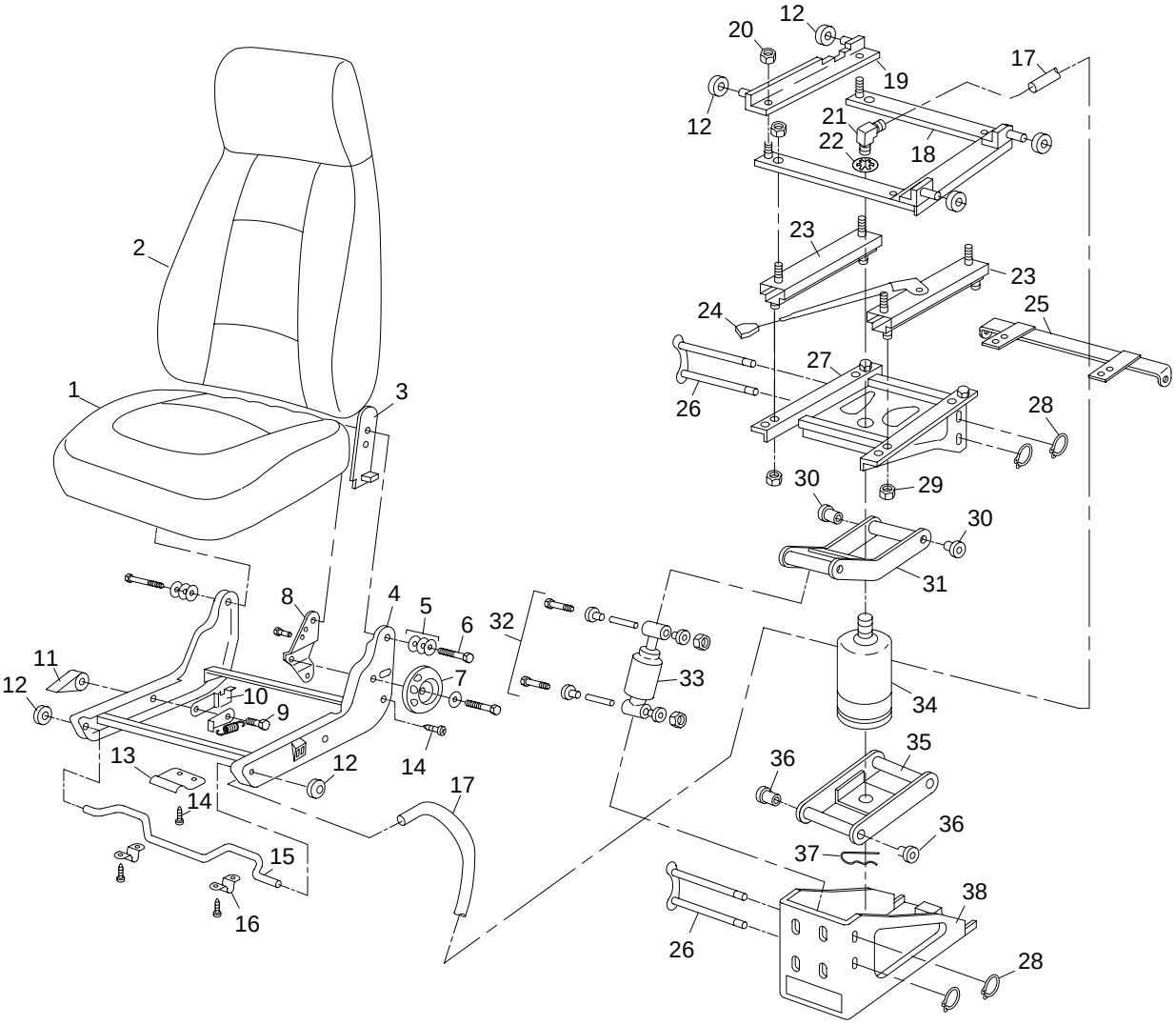
National Cush-N-Aire II air suspension seats (see **Fig. 1**) offer adjustment features for height, fore and aft positioning, back cushion tilt, lumbar support, and seat cushion tilt. The air suspension and height-adjustment features are provided by an inflatable air spring (air bag) that receives air pressure from the vehicle air system; pressure in the air spring is controlled by a set of switches attached to the seat frame. Each seat is equipped with a shock absorber to dampen unwanted up and down motion of the seat. An isolator (Chugger-Snubber®) allows the seat to move in a simple pendulum motion to isolate its occupant from the cab's fore and aft motion; at the side of the seat's lower frame is an isolator lockout handle that can be used whenever the isolator feature is not desired.

For a complete description of, and operating instructions for, all seat adjustment features, see the *Constellation Driver's Manual*.

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## General Information




04/22/96 f910156

1. Seat Cushion
2. Seat Back
3. Back Frame Bracket
4. Upper Seat Frame
5. Flatwashers
6. Back Frame Bolt
7. Back Recline Adjustment Knob
8. Back Limit Bolt Bracket
9. Cushion Adjustment Bolt
10. Cushion Adjustment Bracket
11. Cushion Adjustment Lever
12. Bearing
13. Adjustment Rod Bracket
14. Fastener
15. Adjustment Rod
16. Adjustment Rod Bracket
17. Air Hose
18. Isolator
19. Isolator Bar
20. Locknut
21. Hose Barbed Fitting
22. Retaining Ring
23. Track
24. Fore-and-Aft Adjustment Lever
25. Belt Bar
26. Connected Shaft
27. Seat Support
28. Snap Ring
29. Locknut
30. Bearing
31. Upper Arm
32. Shock Absorber Assembly
33. Shock Absorber
34. Air Spring
35. Lower Arm
36. Bearing
37. Pin Clip
38. Seat Base

**Fig. 1, National Cush-N-Aire II Seat**

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## Removal

1. Apply the parking brakes, and chock the tires.
2. Push in on the top of the seat ride-height rocker switch until the seat is adjusted to its maximum height.
3. If the seat is equipped with a seat suspension shroud, remove the shroud. It is held in place with Velcro and upholstery-panel fasteners.
4. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the air suspension seat base and the rear crosstube of the lower arm.
5. Drain the vehicle air reservoirs. Then push in on the bottom of the seat ride-height rocker switch until all air is exhausted from the air spring.
6. Disconnect the air valve air-supply hose at the quick-connect union behind the seat.
7. Using an 11/16-inch wrench or a T50 Torx wrench, unscrew the capscrews that attach the seat-belt straps and tether straps to the intermediate-connecting-point threaded rod.
8. Remove the capscrews and washers that attach the seat to the cab deck. Remove the seat from the cab.

## Installation

1. Place the seat on the cab deck. Insert the capscrews through the washers and the seat base. Tighten the capscrews 27 lbf·ft (37 N·m).
2. Attach the brackets of the seat-belt straps and tether straps to the intermediate-connecting-point threaded rod. Tighten the capscrews 40 lbf·ft (54 N·m).
3. Attach the air valve air-supply hose by pressing the pneumatic tubing into the quick-connect union behind the seat.
4. Start the engine and allow the air reservoirs to fill. Push in on the top of the seat ride-height rocker switch until the seat is adjusted to its maximum height, then remove the wooden block that supports the seat suspension.
5. If the seat is equipped with a seat suspension shroud, install the shroud.

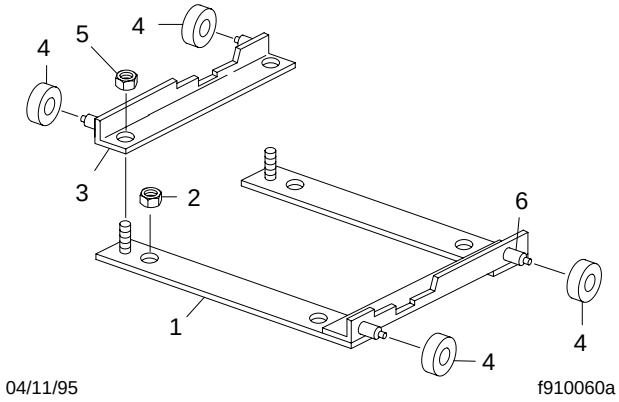
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# Isolator Assembly (Chugger-Snubber®) Replacement

## Replacement

1. Remove the air spring supply hose from the seat.
2. Cut off the air spring supply hose close to the barbed fitting; minimize hose length loss. Remove the scrap hose from the barbed fitting. Tape the hose and fitting ends to prevent dirt or other matter from entering.
3. Remove the hexnuts that attach the isolator bearing support rail to the studs on the isolator bearing support frame. See **Fig. 1**.




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1. Welded Bearing Support Frame
2. Locknut
3. Bearing Support Rail
4. Bearing
5. Hexnut
6. Bearing Stud

**Fig. 1, Isolator Assembly**

4. Lift up on the side of the seat's lower frame, to slide the bearing support rail up and off the bearing support frame.

NOTE: Two of the isolator bearings will fall off when the bearing support rail is removed.

5. Push the seat's upper seat frame toward the opposite side, to remove the other two bearings. Remove the bearings and the unattached upper seat components.
6. Remove the four 5/16–18 locknuts from the bearing support frame. Remove the bearing support frame.
7. Using a multi-purpose chassis grease, lubricate the bearing cups and new isolator bearings.
8. Install the welded bearing support frame on the track assembly. Tighten the four 5/16–18 locknuts 15 lbf·ft (20 N·m).
9. Install two of the isolator bearings on the bearing studs of the bearing support frame, then align the bearing cups on the upper seat frame over the bearings.
10. Assemble the isolator bearing support rail and the two remaining isolator bearings. With the seat cushion tilted forward, install the support rail's bearings in the upper seat frame, and lower the seat frame and support rail assembly onto the isolator bearing support frame. Install the 5/16–18 hexnuts, and tighten them finger-tight.

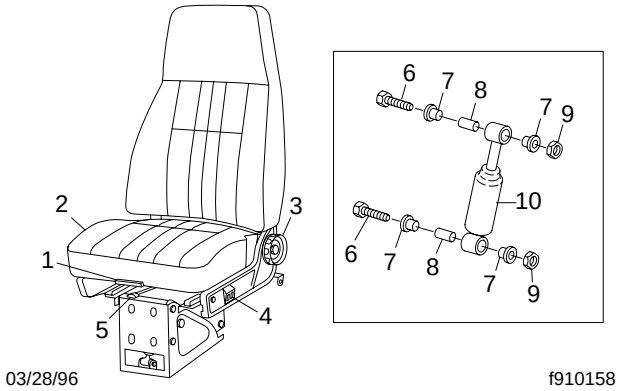
    Push the isolator assembly fore and aft, and check the position of the isolator bearing support rail before tightening the hexnuts. The isolator should be tight enough to eliminate side play without interfering with the fore-and-aft movement of the seat. Tighten the 5/16–18 hexnuts 15 lbf·ft (20 N·m).
11. Install the air spring supply hose.

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## Removal

1. Move the fore-and-aft adjustment lever to the right, and slide the upper seat assembly back as far as possible. See **Fig. 1**.




1. Shock Absorber Mounting Bracket
2. Seat Cushion
3. Back Recline Adjustment Knob
4. Seat Adjustment Switches
5. Fore-and-Aft Alignment Lever
6. Hexbolt
7. Bearing
8. Bushing
9. Locknut
10. Shock Absorber

**Fig. 1, Shock Absorber Removal/Installation**

2. Raise the upper seat assembly to maximum height. Support the seat in this position by placing a wooden block between the lower arm and the seat base.
3. Remove the shock absorber, bushings, and bearings.
   - 3.1 Remove the nuts and bolts that attach the shock absorber to the upper arm and the seat base. Remove the shock absorber.
   - 3.2 Remove the bushings and bearings from the shock absorber.

## Installation

1. Check the operation of the shock absorber, and replace it if needed.
2. Install the shock absorber and new bearings and bushings. See **Fig. 1**.
   - 2.1 Install new bearings and bushings in the shock absorber eyes.
   - 2.2 With the upper arm blocked up, position the shock absorber so its piston-rod end is in the mounting bracket of the upper arm. Install the bolt and locknut to attach the shock absorber to the bracket. Tighten the locknut 25 lbf·ft (34 N·m).
   - 2.3 Position the cylinder end of the shock absorber in the mounting bracket of the seat base. Attach the shock absorber to the seat base. Tighten the locknut 25 lbf·ft (34 N·m).
3. Raise the seat. Remove the wooden block.

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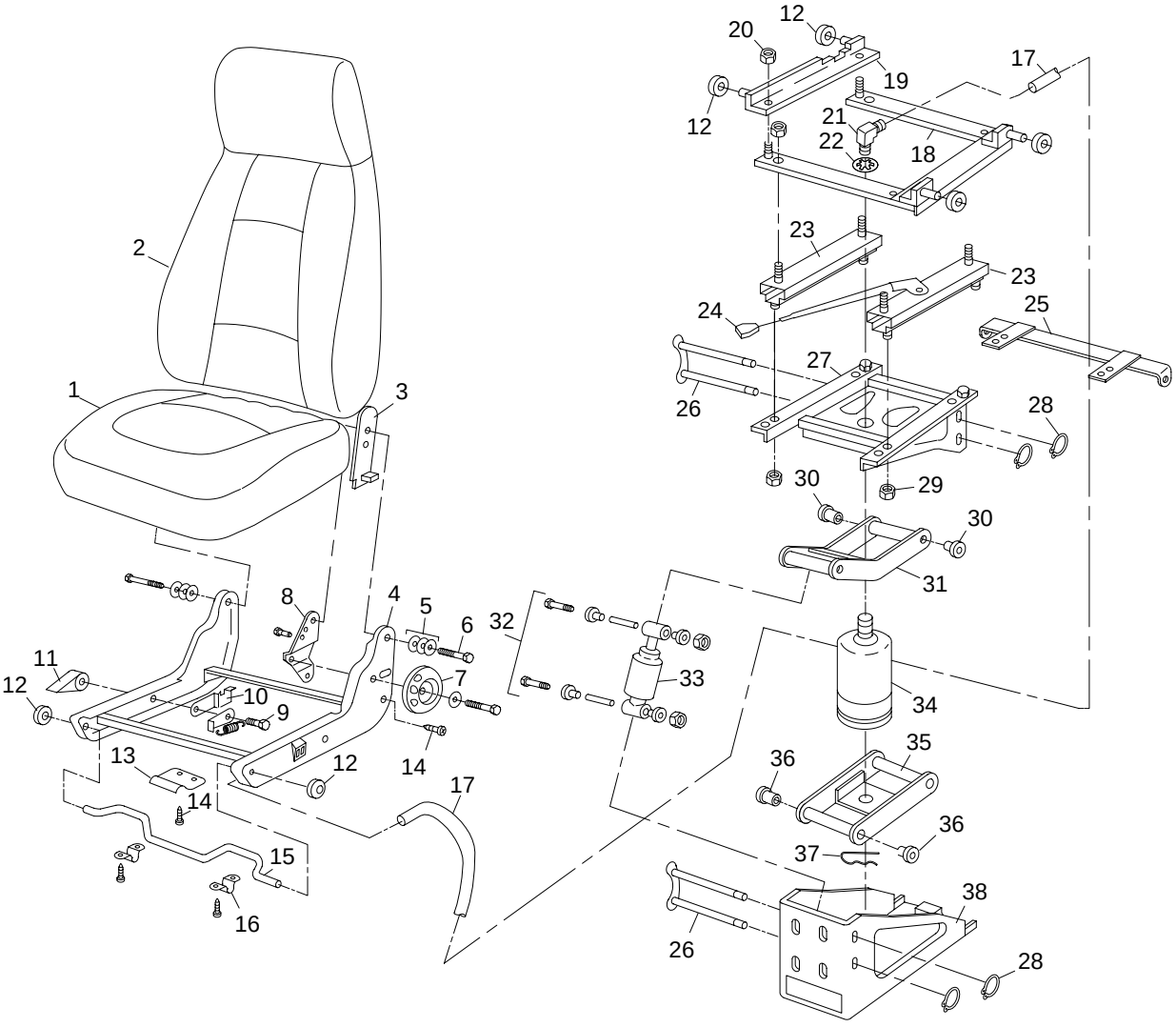
## Replacement

1. Raise the upper seat assembly to maximum height. Support the seat in this position by placing a wooden block between the lower arm and the seat base.
2. Remove the seat from the vehicle as instructed in **Subject 100**.
3. Lay the seat on its side, with the wooden block still in place.
4. Remove, as an assembly, the fitting and the air hose from the air spring. Tape the end of the fitting to prevent dirt or other matter from entering.
5. Pry the pin clip from the bottom of the air spring. See **Fig. 1**.
6. Remove the retaining ring that secures the air spring to the upper arm. Remove the air spring.
7. Position the new air spring in the seat base, and secure it with a new pin clip.
8. Insert the top of the air spring in the opening of the upper arm. Install the retaining ring on the air spring.
9. Install the air spring fitting and air hose in the top of the air spring.
10. Install the seat as instructed in **Subject 100**.
11. Raise the seat. Remove the wooden block.

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## Air Spring Replacement




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1. Seat Cushion
2. Seat Back
3. Back Frame Bracket
4. Upper Seat Frame
5. Flatwashers
6. Back Frame Bolt
7. Back Recline Adjustment Knob
8. Back Limit Bolt Bracket
9. Cushion Adjuster Bolt
10. Cushion Adjustment Bracket
11. Cushion Adjustment Lever
12. Bearing
13. Adjustment Rod Bracket
14. Fastener
15. Adjustment Rod
16. Adjustment Rod Bracket
17. Air Hose
18. Isolator
19. Isolator Bar
20. Locknut
21. Hose Barbed Fitting
22. Retaining Ring
23. Track
24. Fore-and-Aft Adjustment Lever
25. Belt Bar
26. Connected Shaft
27. Seat Support
28. Snap Ring
29. Locknut
30. Bearing
31. Upper Arm
32. Shock Absorber Assembly
33. Shock Absorber
34. Air Spring
35. Lower Arm
36. Bearing
37. Pin Clip
38. Seat Base

**Fig. 1, National Cush-N-Aire II Seat**

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# Base Assembly Bearing/Sleeve Replacement

## Replacement

1. Remove the shock absorber as instructed in **Subject 120**.
2. Remove the seat as instructed in **Subject 100**.
3. Remove the four locknuts that attach the track assemblies, seat track stop, belt bar and bearings, and upper seat assembly to the seat support. Remove the upper seat assembly, track assemblies, seat track stop, and belt bar and spacers.
4. Remove the retaining ring that secures the air spring to the upper arm. See **Fig. 1**.
5. Remove the bearings and/or sleeves from the seat support and the seat base and the upper and lower arms.
   - 5.1 Use snap ring pliers to remove the four snap rings from the connected shaft assemblies. Then, using a drift punch, drive out the shaft assemblies from the seat support and the seat base.

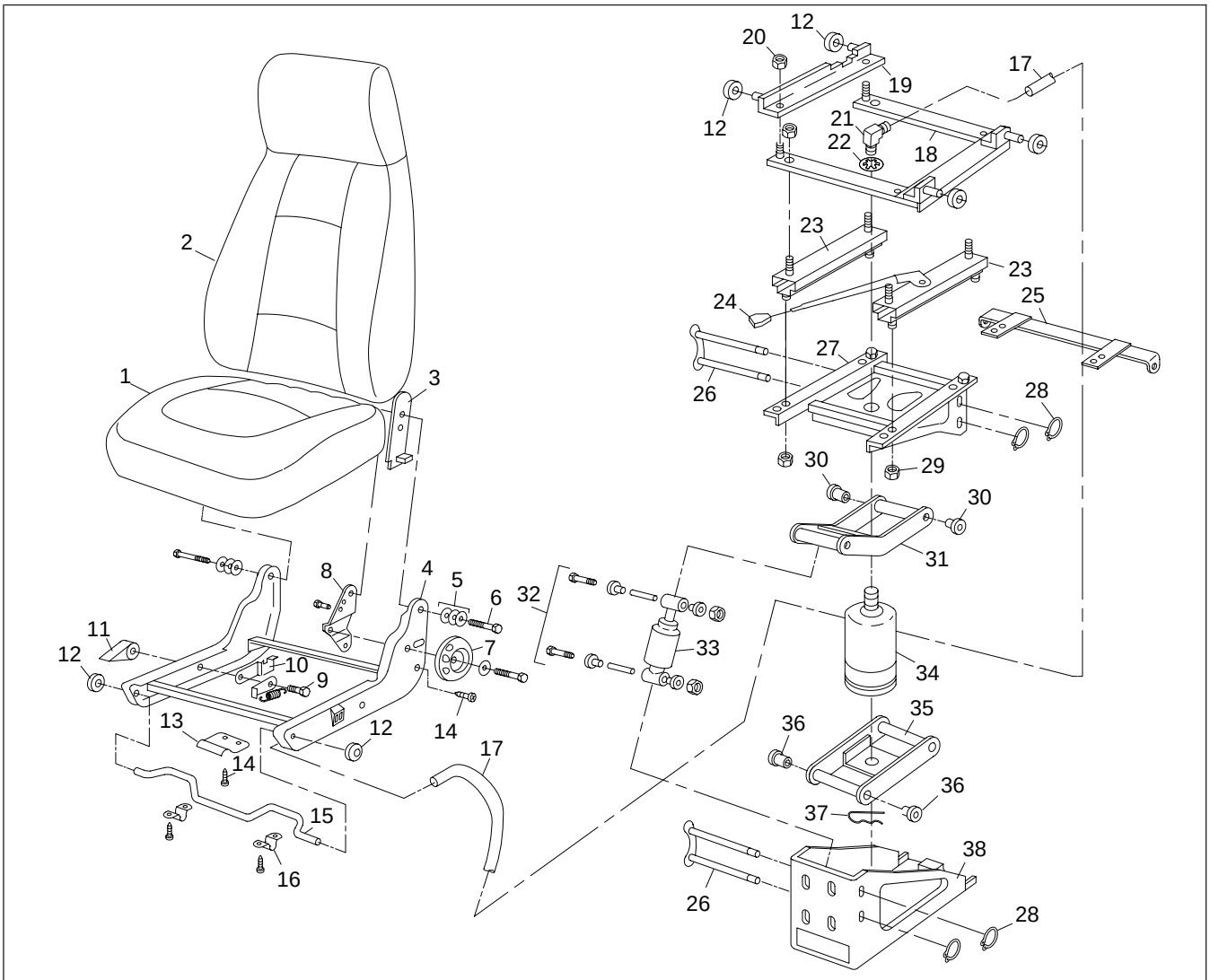
   NOTE: Place the punch against the snap ring end of the shafts. Drive each shaft end a little at a time; the two shafts are connected to each other on the opposite side.

   - 5.2 Remove the seat support, and the upper and lower arms from the air spring and seat base.
   - 5.3 Remove the bearings/sleeves from the upper and lower arms. Discard the bearings/sleeves.
   - 5.4 If so equipped, remove the sleeves/bearings from the seat support and the seat base. Discard the sleeves/bearings.
6. Install new bearings/sleeves, as equipped. See **Fig. 1**.
   - 6.1 Install new bearings/sleeves in the upper and lower arm tubes.
   - 6.2 If so equipped, install new sleeves/bearings in the seat support and the seat base.
   - 6.3 Align the tubes of the lower and upper arms with the holes in the seat base. Be sure the notch in the lower arm is forward and up, and the notch in the upper arm is to the rear and down.
   - 6.4 Install the connected shaft assembly through the seat base and the upper and lower arm forward tubes.
   - 6.5 Align the holes of the seat support with the rear tubes of the lower and upper arms.
   - 6.6 As equipped, install and tighten the pivot bolts, or install the connected shaft assembly through the seat support and the upper and lower arm tubes.
   - 6.7 For connected shaft assemblies, use snap ring pliers to install the snap rings that secure the shafts and the arms to the seat base and the seat support.
7. Insert the top of the air spring through the upper arm. Install the retaining ring.
8. Set the seat base assembly upright.
9. Install the shock absorber as instructed in **Subject 120**.
10. Place the belt bar and bearings, seat track stop, track assemblies, and upper seat assembly on the seat base. Install the locknuts, and tighten 15 lbf·ft (20 N·m).
11. Install the seat as instructed in **Subject 100**.

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## Base Assembly Bearing/Sleeve Replacement




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1. Seat Cushion
2. Seat Back
3. Back Frame Bracket
4. Lower Frame
5. Flatwashers
6. Back Frame Bolt
7. Back Recline Adjustment Knob
8. Back Limit Bolt Bracket
9. Cushion Adjustment Bolt
10. Cushion Adjustment Bracket
11. Cushion Adjustment Lever
12. Bearing
13. Adjustment Rod Bracket
14. Fastener
15. Adjustment Rod
16. Adjustment Rod Bracket
17. Air Hose
18. Isolator
19. Isolator Bar
20. Locknut
21. Hose Barbed Fitting
22. Retaining Ring
23. Track
24. Fore-and-Aft Adjustment Lever
25. Belt Bar
26. Connected Shaft
27. Seat Support
28. Snap Ring
29. Locknut
30. Bearing
31. Upper Arm
32. Shock Absorber Assembly
33. Shock Absorber
34. Air Spring
35. Lower Arm
36. Bearing
37. Pin Clip
38. Seat Base

**Fig. 1, National Cush-N-Aire II Seat**

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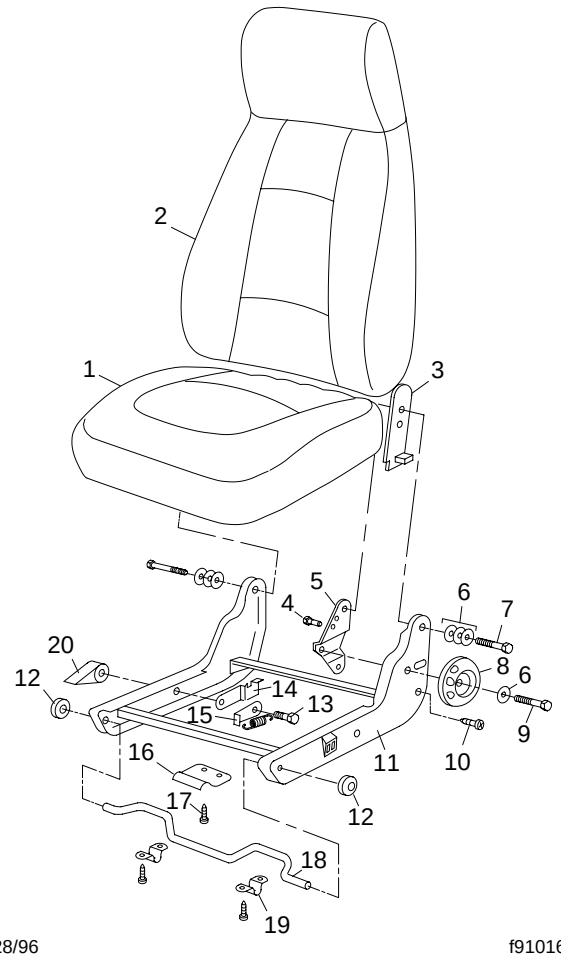
# Upper Seat Frame Removal and Installation

## Removal

1. Remove the suspension shroud (if equipped) from the seat base.
2. Remove the plastic tie strap that attaches the seat cushion to the upper seat frame assembly.
3. Remove the fasteners that attach the seat cushion to the front cushion adjustment rod. See **Fig. 1**. Remove the seat cushion.
4. Disconnect the air spring supply hose from the air spring.
5. Remove the four locknuts from under the top flange of the seat support assembly.
6. Remove the lower frame from the seat base.

## Installation

1. Place the lower frame on the seat support assembly. Install the locknuts under the top flange of the seat support assembly. Tighten the locknuts 10 lbf·ft (15 N·m).
2. Attach the air spring supply hose to the air spring. Make sure that the air hose moves without any restrictions when the seat is moved forward or rearward.
3. Position the seat cushion, then install the fasteners that attach the seat cushion to the front cushion adjustment rod.
4. Install a new plastic tie strap to secure the seat cushion to the lower frame assembly.
5. Install the suspension shroud (if equipped) on the seat base.




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1. Seat Cushion
2. Seat Back
3. Back Frame Bracket
4. Back Limit Bolt
5. Back Limit Bolt Bracket
6. Flatwashers
7. Back Frame Bolt
8. Back Recline Adjustment Knob
9. Hexbolt
10. Screw
11. Lower Frame
12. Bearing
13. Cushion Adjustment Bolt
14. Cushion Adjustment Bracket
15. Cushion Adjustment Spring Bracket
16. Adjustment Rod Bracket
17. Fastener
18. Adjustment Rod
19. Adjustment Rod Bracket
20. Cushion Adjustment Lever

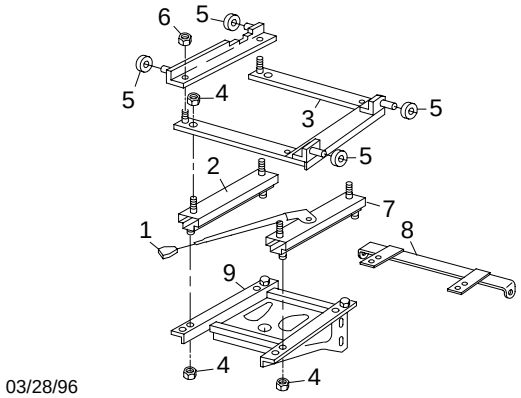
**Fig. 1, Upper Seat Frame Assembly (exploded view)**

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## Replacement

1. Raise the upper seat assembly to maximum height. Support the seat in this position by placing a wooden block between the lower base and lower arm.
2. Pull up and support the rear edge of the seat cushion as needed to gain access to the isolator-assembly-to-track-assembly 5/16–18 locknuts. See **Fig. 1**.




1. Fore-and-Aft Adjustment Lever
2. Right-Side Track
3. Welded Bearing Support Frame
4. Locknut
5. Bearing
6. Hexnut
7. Left-Side Track
8. Belt Bar
9. Seat Support

**Fig. 1, Track Assembly (exploded view)**

3. Remove the air spring supply hose from the seat.
   - 3.1 Cut and remove the tie strap that attaches the air spring supply hose to the track assembly latch mechanism.
   - 3.2 Remove the air spring supply hose (as an assembly), and lay it on the cab deck, behind the seat.
4. Remove the four 5/16–18 locknuts that attach the isolator assembly to the top of the track assemblies. Remove the upper seat assembly.
5. Remove the four 5/16–18 locknuts that attach the track assemblies to the top of the seat support. Remove the track assemblies.
6. With the holes in the belt bar, belt bar spacers, and seat track stop aligned with the holes in the seat support, install the new track assemblies on the seat support. Install and tighten the four 5/16–18 locknuts 15 lbf·ft (20 N·m).
7. Move the upper half of the track assemblies as needed to align their studs with the holes in the isolator assembly. Place the upper seat assembly on the track assemblies. Install and tighten the four 5/16–18 locknuts 15 lbf·ft (20 N·m).
8. Install the air spring supply hose.
   - 8.1 Install a new tie strap to attach the air spring supply hose to the track assembly latch mechanism.
   - 8.2 Install a new tie strap to attach the air valve supply hose to the belt bar.
9. Move the fore-and-aft adjustment lever to the right, and slide the upper seat assembly forward and rearward while making sure that the air hose moves without restriction. Return the seat cushion to its original position.
10. Raise the seat. Remove the wooden block.

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## Specifications

| Description | Torque: lbf·ft (N·m) |
|---|---|
| Seat Base to Cab Deck Socket-Head Bolts | 13 (18) |
| Seat Belt/Tether Belt to Belt Bar Capscrews | 40 (54) |
| Shock Absorber to Bracket Locknuts | 25 (34) |
| Track Assembly to Isolator Assembly Locknuts | 15 (20) |
| Track Assembly to Upper Seat Frame Locknuts | 15 (20) |

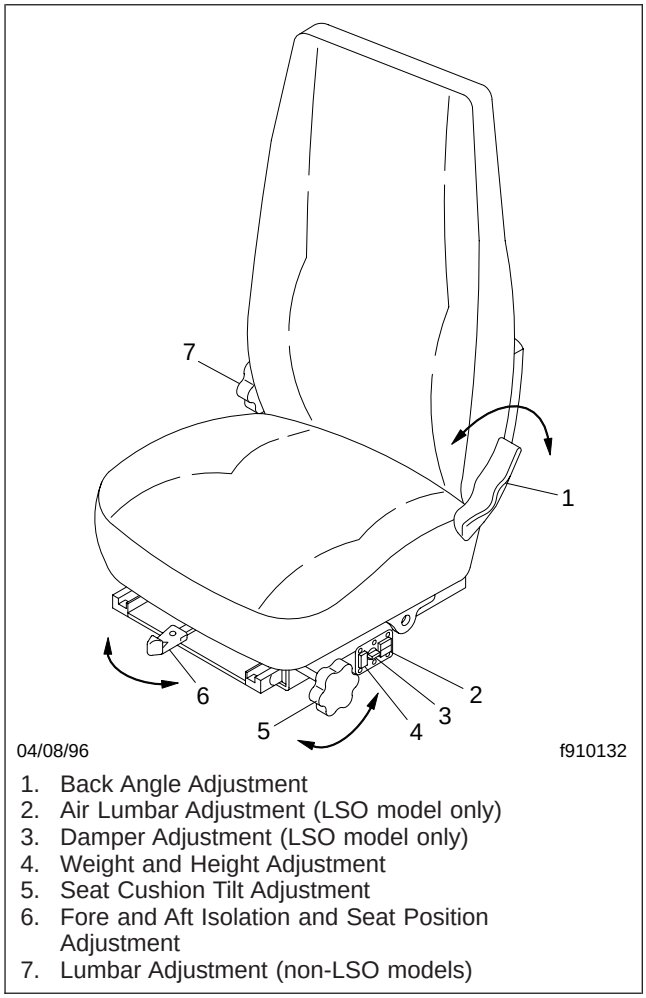
**Table 1, Fastener Torques**

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## General Information

The Bostrom Talladega 900 series air suspension seats offer weight-height adjustment, infinite adjustment Parabar II lumbar support and a fore and aft roller track isolator system. See **Fig. 1**.




1. Back Angle Adjustment
2. Air Lumbar Adjustment (LSO model only)
3. Damper Adjustment (LSO model only)
4. Weight and Height Adjustment
5. Seat Cushion Tilt Adjustment
6. Fore and Aft Isolation and Seat Position Adjustment
7. Lumbar Adjustment (non-LSO models)

**Fig. 1, Bostrom Talladega 900 Series Seat**

For complete operating instructions, see the *Western Star Driver's Manual*.

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# Air Spring Removal and Installation

## Removal

NOTE: The seat, the seat/back assembly, and the channel assembly do not need to be removed. Move the channel assembly to the rearmost position to provide access to the air spring.

1. Fill the air spring so that the seat is at maximum height.
2. Block the suspension up with a spacer placed between the base riser and the upper frame.
3. Release the air pressure from the air spring so that the seat is supported by the spacer.
4. Disconnect the air line from the air spring by pushing in the collar of the fitting while pullling the air line out of the fitting.
5. Remove the top capscrew, and loosen the bottom capscrew through the rear opening in the base riser. See **Fig. 1**. Remove the air spring from the suspension.

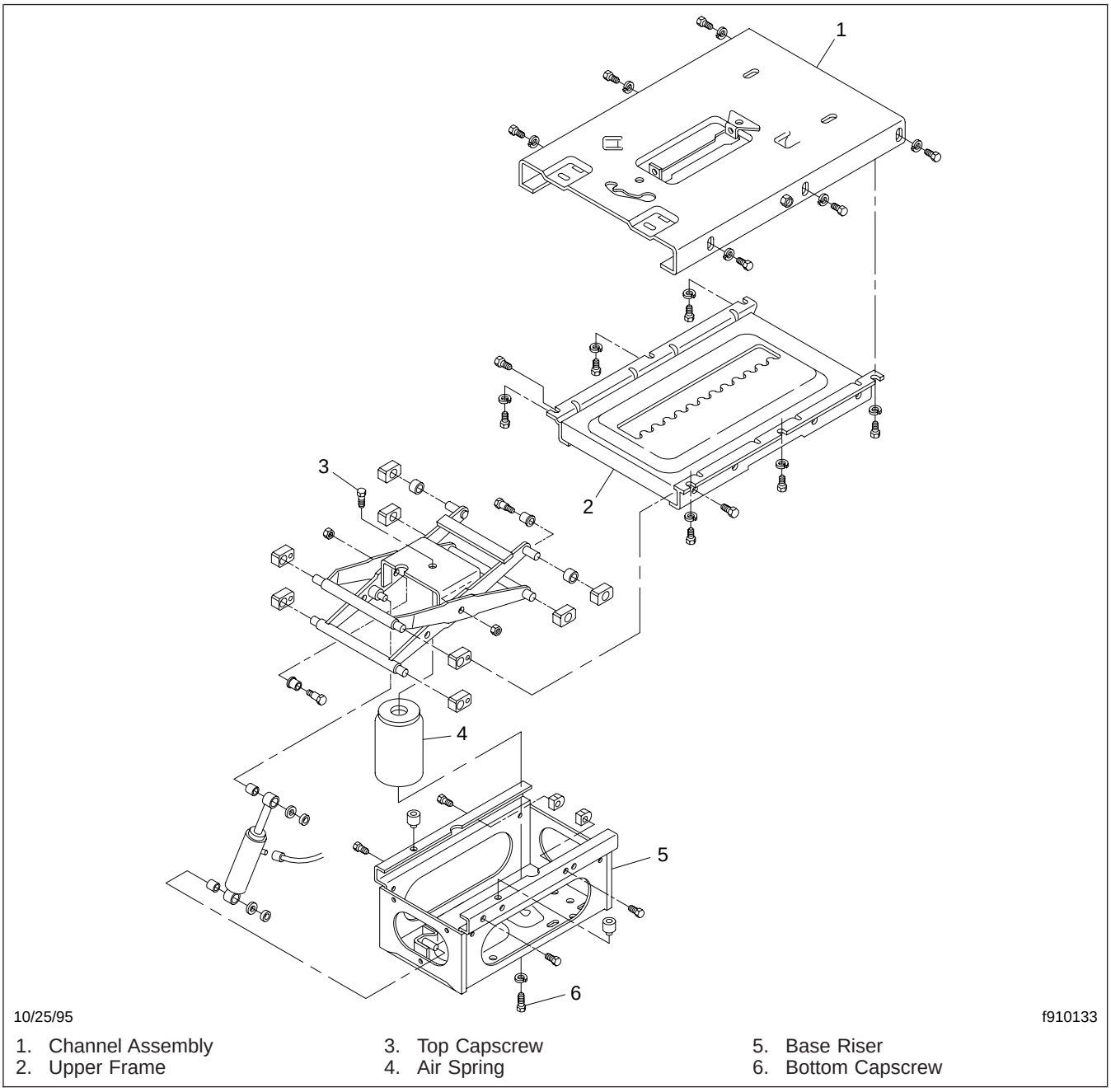
## Installation

1. Assemble the bottom capscrew to the new air spring. Install the air spring by fitting the bottom capscrew into the key hole opening in the bottom of the base riser. Position the air spring so the fitting at the bottom of the air spring is toward the front of the seat. See **Fig. 1**.
2. Tighten the bottom capscrew 9 to 11 lbf·ft (12 to 15 N·m).
3. Install the top capscrew and torque 15 to 19 lbf·ft (20 to 26 N·m).
4. Connect the air line to the fitting in the air spring by pushing the tube into the fitting.
5. Fill the air spring and remove the spacer block.

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## Air Spring Removal and Installation




1. Channel Assembly
2. Upper Frame
3. Top Capscrew
4. Air Spring
5. Base Riser
6. Bottom Capscrew

**Fig. 1, Bostrom Talladega 900 Series Seat Air Spring**

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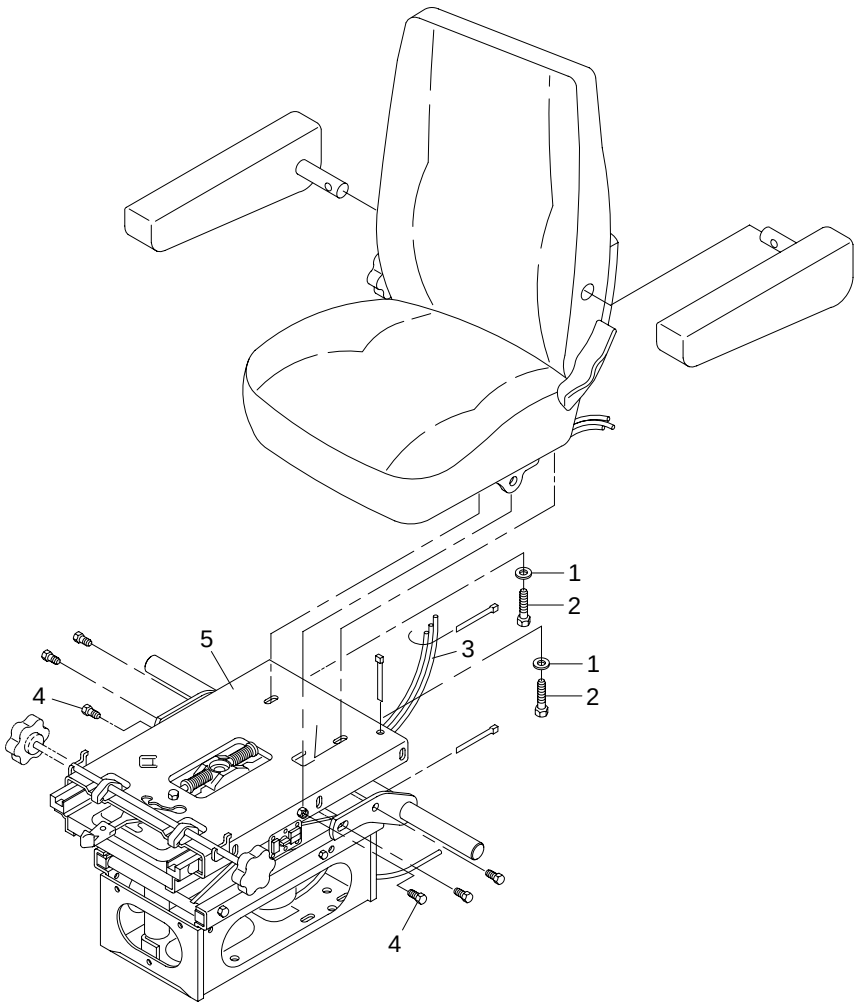
# Seat/Back Assembly Removal and Installation

## Removal

1. Adjust the seat/back assembly to the most rearward position and remove the two capscrews and flatwashers from the underside of the channel assembly. See **Fig. 1**.
2. Remove the two shoulder bolts from the channel assembly.
3. Disconnect the air lines.
4. Remove the seat/back assembly.

## Installation

1. Place the seat/back assembly onto the channel assembly. See **Fig. 1**.
2. Connect the air lines to the air spring, and the air line to the vehicle air supply.
3. Install the two shoulder bolts in the channel assembly.
4. Install the two capscrews and flatwashers in the underside of the channel assembly.




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1. Flatwasher
2. Capscrew
3. Air Lines
4. Shoulder Bolt
5. Channel Assembly

**Fig. 1, Bostrom Talladega 900 Series Seat**

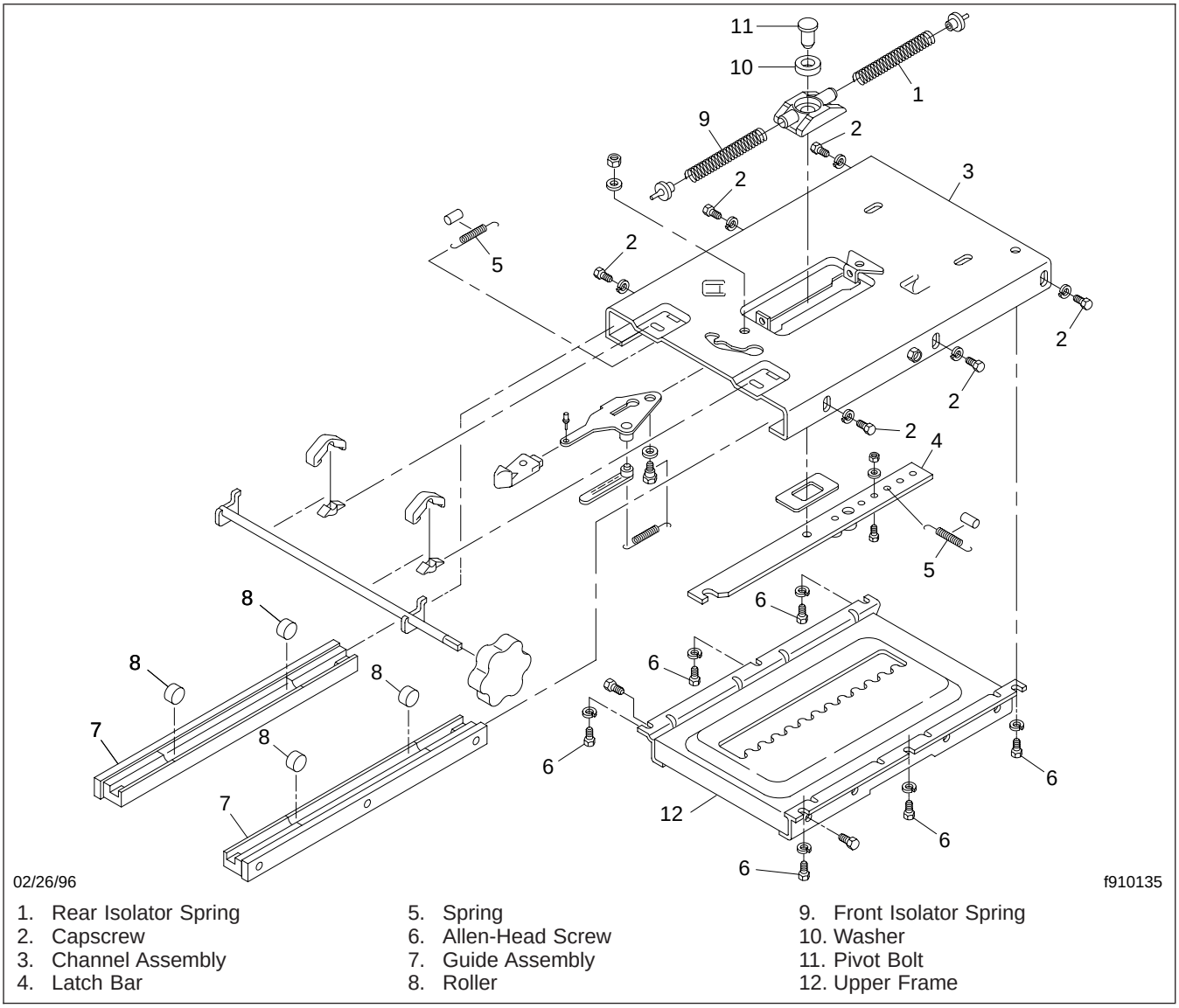
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# Fore and Aft Isolation Channel Removal and Installation

## Removal

1. Remove the seat/back assembly. See **Subject 110**.
2. With the channel assembly set in its unlocked position, or in the "isolation position," push the channel assembly rearward and remove the rear isolator spring. See **Fig. 1**. Pull the channel assembly forward and remove the front isolator spring.
3. Adjust the channel assembly until the cutouts in the underside of the channel line up with the allen-head screws. Remove the allen-head screws.
4. Remove the three capscrews on each side of the channel assembly.
5. Remove both guide assemblies and the four rollers.
6. Disconnect the spring from the latch bar.




1. Rear Isolator Spring
2. Capscrew
3. Channel Assembly
4. Latch Bar
5. Spring
6. Allen-Head Screw
7. Guide Assembly
8. Roller
9. Front Isolator Spring
10. Washer
11. Pivot Bolt
12. Upper Frame

**Fig. 1, Channel Assembly (exploded view)**

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## Fore and Aft Isolation Channel Removal and Installation

7. Remove the pivot bolt and washer, slide the latch bar out, and remove the channel assembly.

## Installation

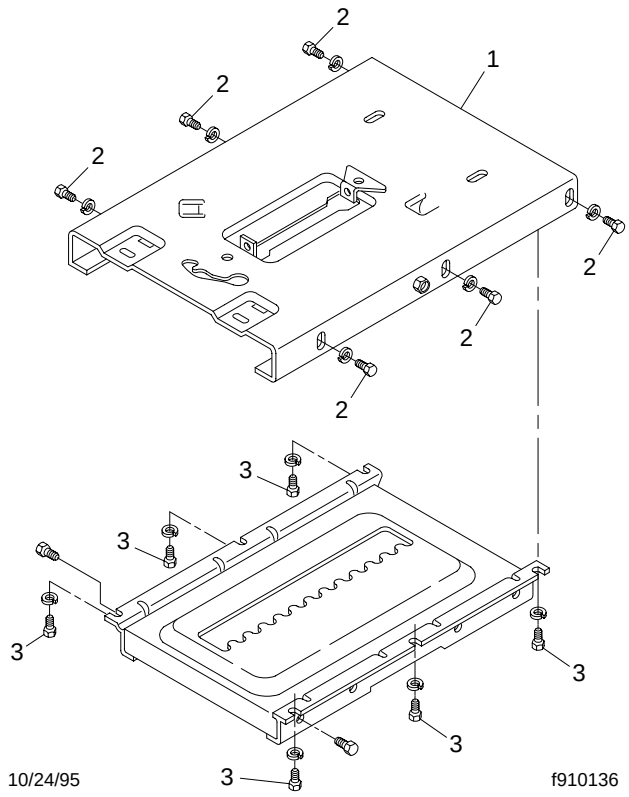
1. Place the channel assembly onto the upper frame, slide the latch bar in, and install the pivot bolt and washer. Torque the bolt 26 to 34 lbf·ft (36 to 46 N·m). See **Fig. 1**.
2. Connect the springs to the latch bar.
3. Install both guide assemblies and the four rollers.
4. Install the three screws on each side of the channel assembly. Torque the screws 15 to 17 lbf·ft (20 to 23 N·m).
5. Install the six allen-head screws on the underside of the channel assembly. Torque the screws 15 to 17 lbf·ft (20 to 23 N·m).
6. With the channel assembly in the isolation position, pull the assembly forward and install the front isolator spring. Push the assembly rearward and install the rear isolator spring.
7. Adjust the channel assembly using the instructions in **Subject 130**.
8. Install the seat/back assembly. See **Subject 110**.

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## Adjustment

1. Remove the seat/back assembly from the channel assembly using the instructions in **Subject 110**.
2. Adjust the channel assembly so the cutouts in the underside of the channel assembly line up with the Allen-head screws. See **Fig. 1**.




1. Channel Assembly
2. Capscrew
3. Allen-Head Screw

**Fig. 1, Channel Assembly**

3. Use a 5/32-inch Allen wrench to loosen the six screws underneath the channel assembly.
4. Push the slide track outward to take up excessive lateral movement and retighten the six screws. Torque the screws 5 to 7 lbf·ft (7 to 9 N·m).
5. Loosen the six capscrews along the side of the channel assembly.
6. Push down on the channel assembly to adjust vertical play and tighten the six capscrews 5 to 7 lbf·ft (7 to 9 N·m).

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# Damper Removal and Installation

## Removal

NOTE: The seat/back assembly does not need to be removed.

1. Move the channel assembly to the rearmost position to provide access to the damper assembly. See **Fig. 1**.
2. Fill the air spring so that the seat is at maximum height.
3. Use pliers or a screwdriver to twist off the push-on fasteners. The push-on fasteners are not reusable.
4. On LSO models only, disconnect the control cable from the damper. Remove the damper.

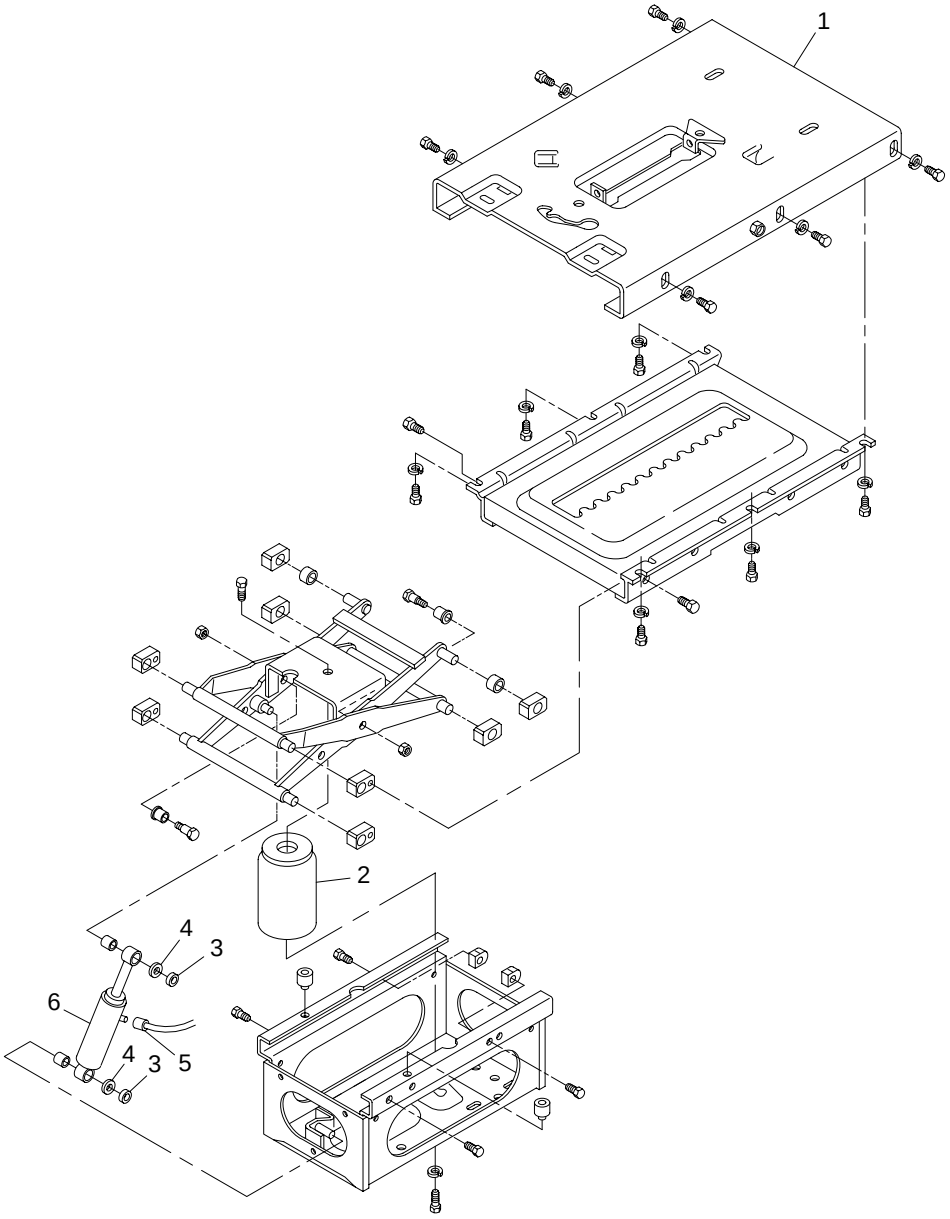
## Installation

1. Install the new damper with the flanges of the bearings to the outside of the suspension. On LSO model only, connect the control cable. See **Fig. 1**.
2. Install the thrustwashers and the new push-on fasteners until they seat. A 1/2-inch box-end wrench works well to push the fasteners on.

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## Damper Removal and Installation




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1. Channel Assembly
2. Air Spring
3. Push-On Fastener
4. Thrust Washer
5. Control Cable (LSO model only)
6. Damper

**Fig. 1, Channel Assembly (exploded view)**

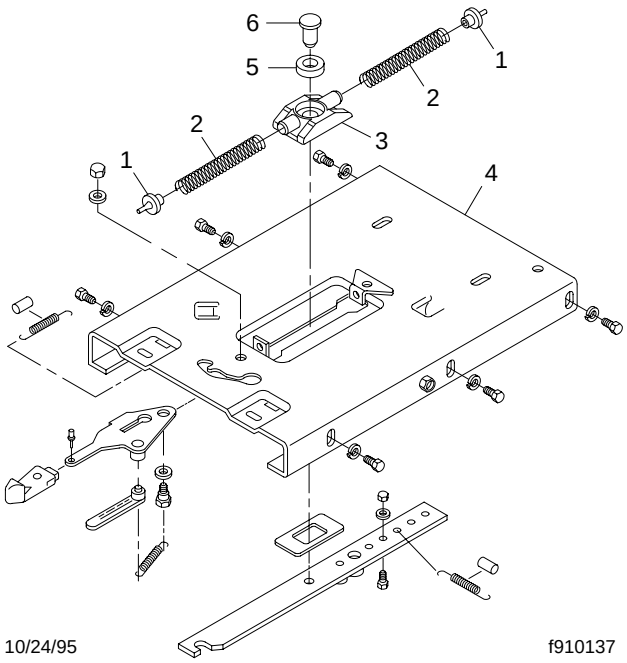
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# Isolation Bumper Removal and Installation

## Removal

1. Remove the seat/back assembly using the instructions in **Subject 110**.
2. Remove the two isolation springs by pushing the channel assembly rearward to remove the rear spring and pulling the channel assembly forward to remove the front spring. See **Fig. 1**.




1. Isolation Bumper
2. Isolation Spring
3. Pivot Block
4. Channel Assembly
5. Washer
6. Pivot Bolt

**Fig. 1, Channel and Isolation Bumper Assembly**

3. Remove the isolation bumpers.

## Installation

1. If the pivot block was removed, install the pivot block with the pivot bolt and washer. Torque the bolt 26 to 34 lbf·ft (36 to 46 N·m). See **Fig. 1**.
2. Install the isolation bumpers.
3. Install the two isolation springs by pulling the channel assembly forward to install the front spring and pushing the channel assembly rearward to install the rear spring.
4. Install the seat/back assembly using the instructions in **Subject 110**.

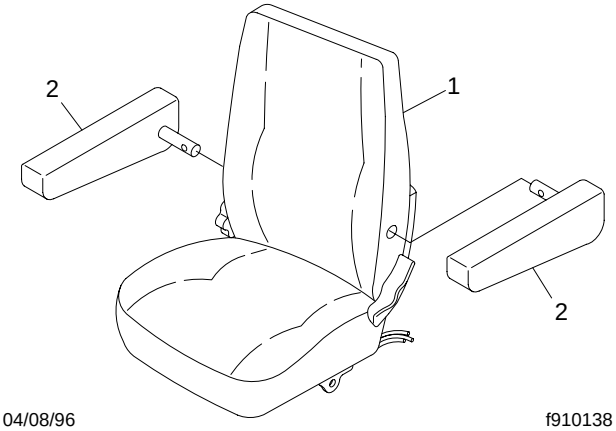
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# Back Cover/Pad Assembly Removal and Installation

## Removal

1. Remove the seat/back assembly from the suspension, using the instructions in **Subject 110**. Remove the armrests if the seat assembly has armrests. See **Fig. 1**.




1. Upper Seat Assembly
2. Armrest

**Fig. 1, Upper Seat Assembly (armrests removed)**

2. Remove the back cover and pad from the seat frame assembly. Note the location of the fasteners on the existing back cover.

## Installation

1. Place a new pad over the back frame. If the seat has lumbar adjustment, make a cut in the edge of the pad to fit around the handle.
2. Place the cover (inside out) over the top of the back pad. Pull down the cover until the three tie-down tabs are even with the three slots in the pad. Pull the tie down tabs through the slots in the pad and run a short wire through all three tabs. Continue to pull the cover down completely over the pad. Tuck the front flap of the back cover between the seat cushion and the bottom of the back pad and lock the J welt together.

NOTE: If the seat is a high back, there will be two sets of tie down tabs (six total with two wires) to be pulled through the back pad and wired.

3. Attach the upper seat assembly to the suspension using the instructions in **Subject 110**. Install the armrests if the seat has armrests.

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# Suspension Rebuild Bearing/Slide Block Removal and Installation

## Removal

1. Bleed all the air from the supply line. Disconnect the air supply line from the seat. Using the air valve, exhaust all air from the air spring. Remove the complete seat assembly from the vehicle.
2. Remove the seat/back assembly using the instructions in **Subject 110**.
3. Remove the channel assembly using the instructions in **Subject 120**.
4. Remove the capscrews and the ICP bracket. See **Fig. 1**. If the seat assembly has a suspension cover, remove the fasteners and the suspension cover.
5. Block the suspension up with a spacer block placed between the base riser and the upper frame.
6. Remove the capscrews from the upper bearing blocks.
7. Remove the upper frame assembly by sliding it forward off the bearing blocks and the slide blocks.
8. Remove the air spring using the instructions in **Subject 100**. Mark the air lines for reassembly.
9. Remove the damper using the instructions in **Subject 140**.
10. Remove the capscrews from the lower bearing blocks and slide the lever assemblies forward until the bearing blocks are removed from the channel on the base riser. Slide the lever assemblies rearward to remove the slide blocks from the channel.
11. Remove the shoulder bolts and nuts from the pivots of the lever assemblies and inspect the bolts. If the bolts are worn, replace them.

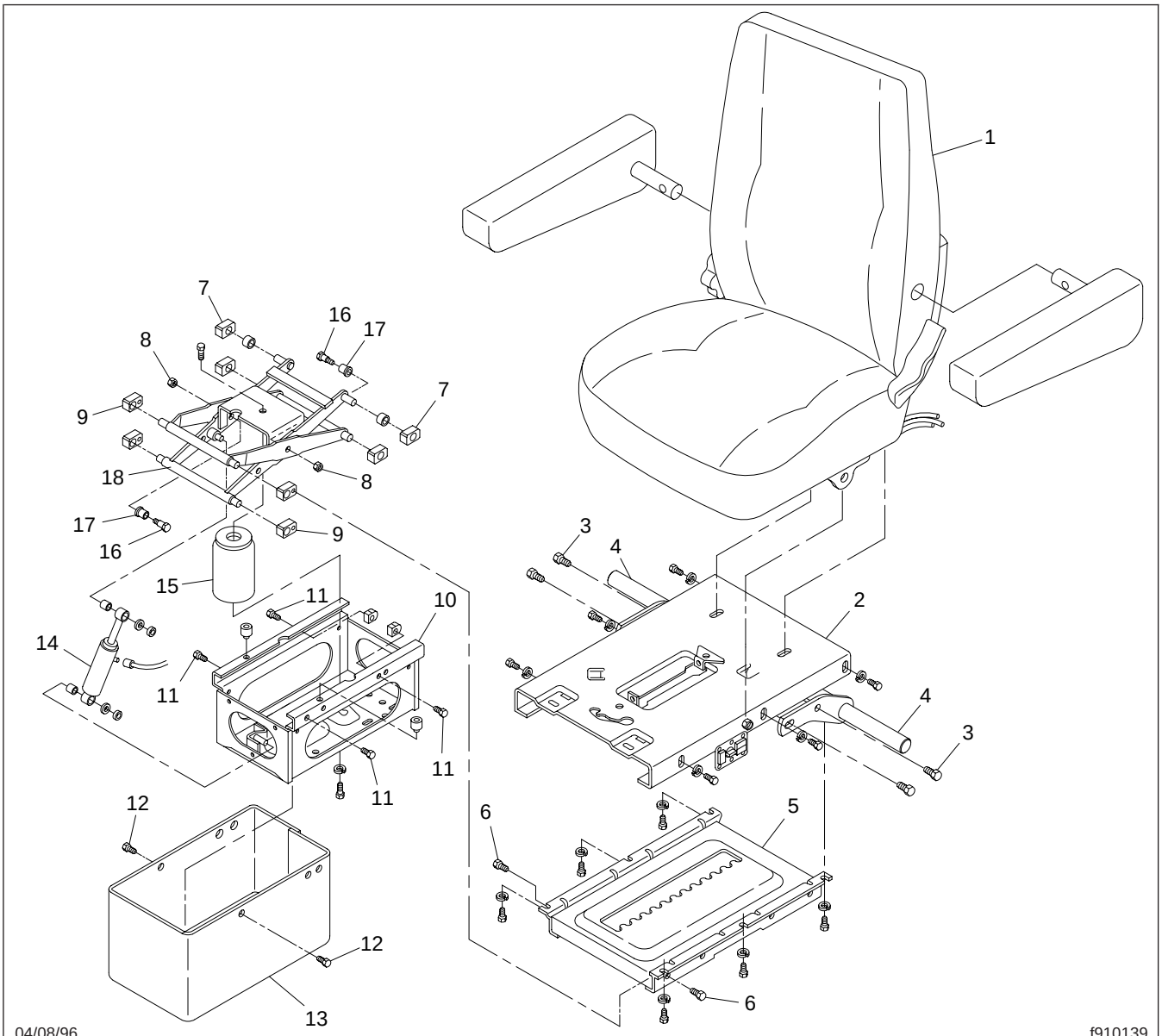
## Installation

1. Replace the bearings at the pivots on the lever assembly by pushing out the old bearings and pressing in the new bearings. The flange of the bearings should be on the outside of the lever assembly.
2. Install the shoulder bolts and nuts into the pivots of the lever assemblies. Torque the bolts 18 to 22 lbf·ft (24 to 30 N·m).
3. Install new bearing blocks, spacers, and slide blocks on the levers with the beveled surfaces outward, then slide the levers with blocks into the channel on the base riser. Torque the capscrews 27 to 33 lbf·ft (37 to 45 N·m).
4. Slide the upper frame assembly over the blocks. Line up the capscrews with the bearing blocks (Ref. 9) and torque the capscrews 27 to 33 lbf·ft (37 to 45 N·m).
5. Manually move the suspension up and down to make sure there are no clearance problems.
6. Block the suspension up with a spacer block placed between the base riser and the upper frame. Install the air spring using the instructions in **Subject 100**.
7. Install the damper using the instructions in **Subject 140**.
8. Install the ICP bracket and capscrews. If the seat assembly has a suspension cover, install the suspension cover and the fasteners.
9. Install the channel assembly using the instructions in **Subject 120**.
10. Install the seat/back assembly using the instructions in **Subject 110**.
11. Adjust lateral (side) play using the instructions in **Subject 130**.
12. Install the seat assembly in the vehicle. Connect the air supply line to the seat.

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## Suspension Rebuild Bearing/Slide Block Removal and Installation




1. Seat/Back Assembly
2. Channel Assembly
3. Capscrew
4. ICP Bracket
5. Upper Frame
6. Capscrew
7. Slide Block
8. Nut
9. Bearing Block
10. Base Riser
11. Capscrew
12. Fastener
13. Suspension Cover
14. Damper
15. Air Spring
16. Shoulder Bolt
17. Bearing
18. Slide Lever Assembly

**Fig. 1, Bostrom Talladega 900 Series Seat (exploded view)**

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# General Information

**⚠ WARNING**

**Inspect and maintain seat belts. When any part of a seat belt system needs replacement, the entire seat belt must be replaced, both retractor and buckle side. Any time a vehicle is involved in an accident, and the seat belt system was in use, the entire vehicle seat belt system must be replaced before operating the vehicle. Do not attempt to modify the seat belt system; doing so could change the effectiveness of the system. Failure to replace worn or damaged seat belts, or making any modifications to the system, may result in personal injury or death.**

Although the three-point seat belts installed in Western Star vehicles appear similar to the seat belts used in passenger cars, there are some important differences that can affect service life:

- A heavy truck can travel more miles in a year than a car might go in its lifetime.
- There is more movement in a truck seat belt system, especially with air ride seats.
- Trucks often operate in more severe environments than cars, such as gravel pits, cement plants, and grain elevators, where the belts are exposed to abrasive dirt and dust.

Because of these factors, truck seat belt systems need to be inspected regularly to ensure that they are in proper condition; see **Subject 110**.

IMPORTANT: When any part of a seat-belt system needs replacement, the entire seat-belt system must be replaced—both the retractor side and the buckle side and, if equipped, both tether belts.

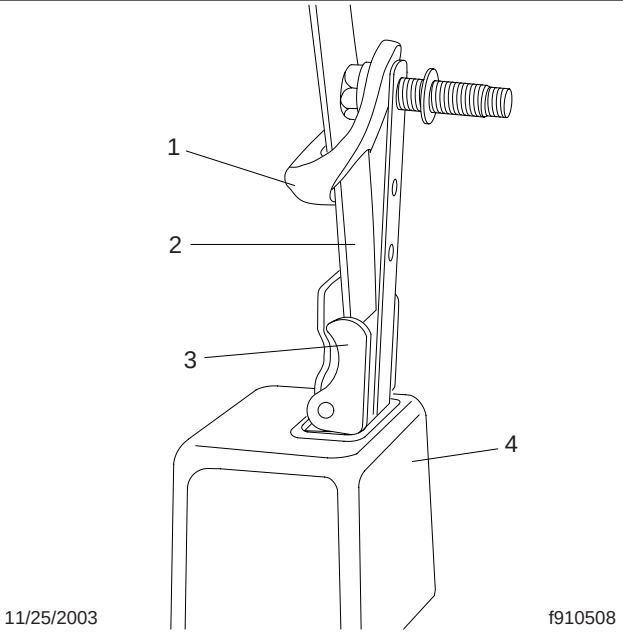
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## Unlocking an Installed Retractor

Seat belt retractors are locking up and preventing the webbing from being extracted. This condition is known as reverse lock-up and is caused by excessive webbing spooling into the retractor before installation in the vehicle.

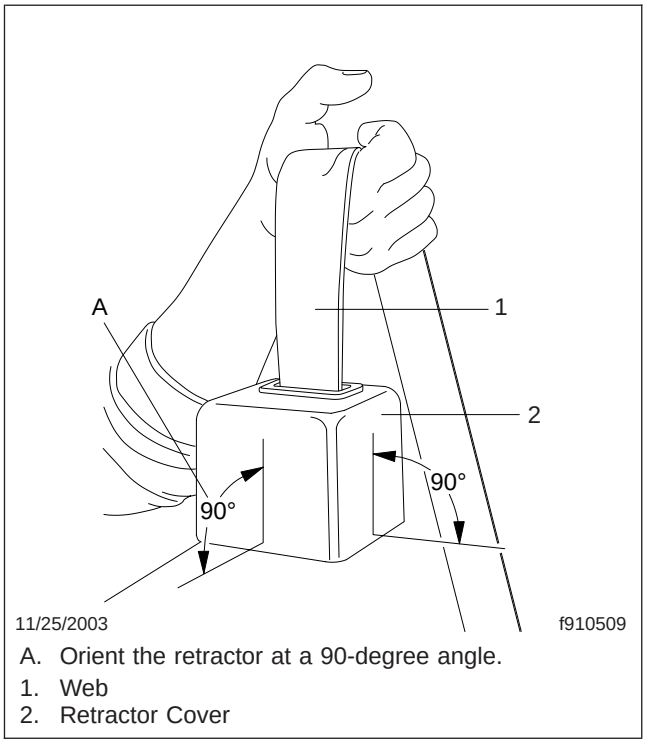
1. Park the vehicle, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Verify that the retractor is mounted in the 90-degree position. See **Fig. 1**.
3. Firmly grasp the web close to the retractor. See **Fig. 2**.




1. Web Guide Loop
2. Web
3. Komfort Latch®
4. Retractor Cover

**Fig. 1, Retractor in the 90-Degree Position**

4. Pull on the web with enough force to tighten the web onto the spool until the webbing locks back onto the retractor. The retractor should unlock when tension is released.
5. Remove the chocks from the tires.




A. Orient the retractor at a 90-degree angle.
1. Web
2. Retractor Cover

**Fig. 2, Firmly Grasp the Webbing**

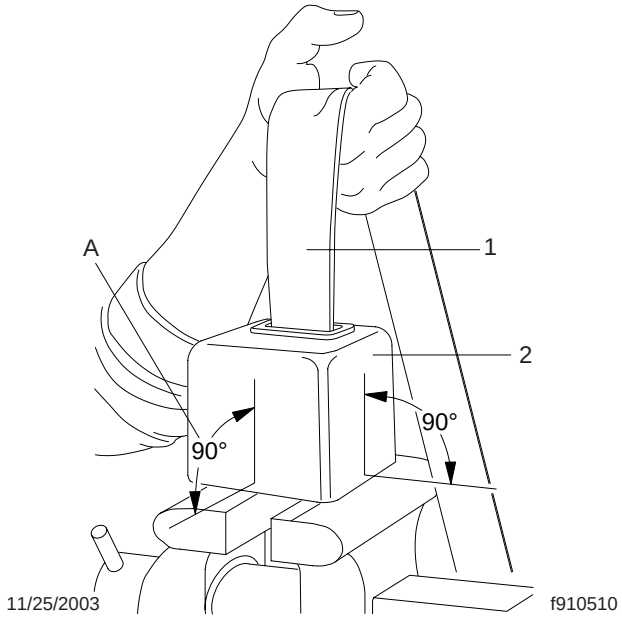
## Unlocking an Uninstalled Retractor

1. Clamp the retractor in a vice at a 90-degree angle. See **Fig. 3**.
2. Pull on the web with enough force to tighten the web onto the spool.
3. Release the web. This allows 1/2-inch (12.7-mm) of the webbing to feed back into the retractor storage housing and unlock the retractor.
4. Pull all the webbing out of the retractor, and allow only 12 to 15 inches (304 to 381 mm) to retract. Lock the Komfort Latch on the web. See **Fig. 4**.

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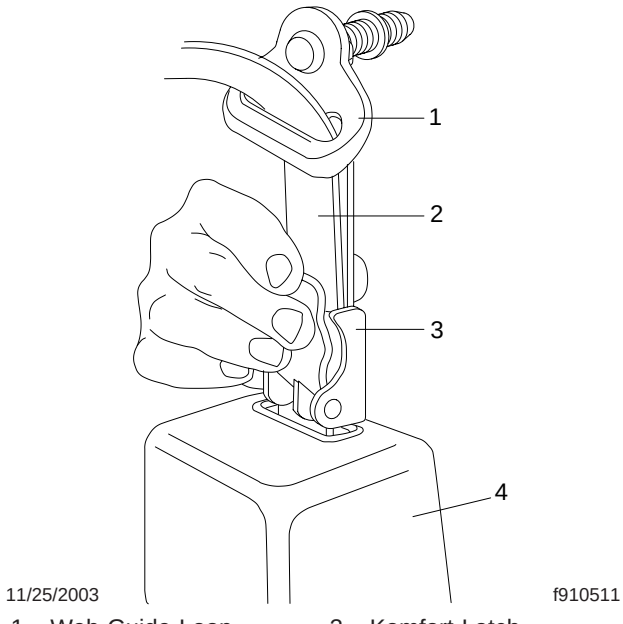


## Seat Belt Retractor Unlocking




A. Retractor oriented at a 90-degree angle.
1. Web
2. Retractor Cover

**Fig. 3, Place the Retractor in a Vice**




1. Web Guide Loop
2. Web
3. Komfort Latch
4. Retractor Cover

**Fig. 4, Lock the Komfort Latch**

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## Inspection

**⚠ WARNING**

**Inspect and maintain seat belts. When any part of a seat belt system needs replacement, the entire seat belt must be replaced, both retractor and buckle side. Any time a vehicle is involved in an accident, and the seat belt system was in use, the entire vehicle seat belt system must be replaced before operating the vehicle. Do not attempt to modify the seat belt system; doing so could change the effectiveness of the system. Failure to replace worn or damaged seat belts, or making any modifications to the system, may result in personal injury or death.**

Seat belts and tether belts have a finite life which may be much shorter than the life of the vehicle. Regular inspections and replacement as needed are the only assurance of adequate seat belt security over the life of the vehicle.

1. Check the web for fraying, cuts, extreme dirt and dust, or for severe fading from exposure to sunlight, especially near the buckle latch plate and in the D-loop guide area.
2. Check operation of the buckle, latch, Komfort Latch or Sliding Komfort Latch (if equipped), web retractor, and upper seat belt mount on the door pillar. Check all visible components for wear or damage.
3. Check the seat belt and tether belt connection points, and tighten any that are loose.

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## Removal

1. Park the vehicle on a level surface, apply the parking brake, shut down the engine, and chock the front and rear tires.
2. Push up on the seat ride-height rocker switch until the seat is adjusted to its maximum height.
3. Remove the seat suspension skirt. It is held in place with Velcro and upholstery-panel fasteners.
4. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the air suspension seat base and the rear crosstube of the lower arm.
5. Drain the vehicle air reservoirs. Then push in on the bottom of the seat ride-height rocker switch until all air is exhausted from the air spring.
6. Disconnect the air valve air-supply hose at the quick-connect union behind the seat.
7. Using an 11/16-inch wrench or a T50 Torx wrench, unscrew the capscrews that attach the seat-belt straps and tether straps to the intermediate-connecting-point threaded rod.
8. Remove the capscrews and washers that attach the seat to the cab deck. Remove the seat from the cab.

## Installation

1. Place the seat on the cab deck. Insert the capscrews through the washers and the seat base. Tighten the capscrews 27 lbf·ft (37 N·m).
2. Attach the brackets of the seat-belt straps and tether straps to the intermediate-connecting-point threaded rod. Tighten the capscrews 40 lbf·ft (54 N·m).
3. Attach the air valve air-supply hose by pressing the pneumatic tubing into the quick-connect union behind the seat.
4. Start the engine and allow the air reservoirs to fill. Push in on the top of the seat ride-height rocker switch until the seat is adjusted to its maximum height, then remove the wooden block that supports the seat suspension.
5. Install the seat suspension skirt.
6. Remove the chocks from the tires.

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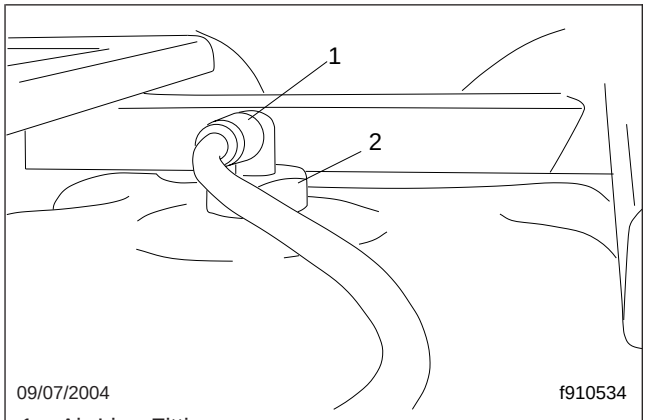


## Air Spring Replacement

1. Park the vehicle, apply the parking brakes, shut down the engine, and chock the front and rear tires.
2. Inflate the seat suspension to the maximum height.
3. Pull the slide lever, and slide the seat to the forward position.
4. Lift the suspension skirt up and out of the way.
5. Cut a wooden block to the length required to support the seat at its maximum height, and place the block between the air suspension seat base and the rear crosstube of the lower arm.

NOTE: The seat must be secured with a block when replacing the air spring.

6. Drain the vehicle air reservoirs. Then push in on the bottom of the seat ride-height rocker switch until all air is exhausted from the air spring.
7. Remove the air line from the air spring. See **Fig. 1**.




1. Air Line Fitting
2. Spring Plate Mounting Nut

**Fig. 1, Air Line and Fitting**

8. Remove the air fitting from the top of the air spring.
9. Remove the nut that secures the air spring to the spring plate.
10. Use a 9/16-inch socket wrench to remove the lower air spring bolt.
11. Remove the air spring.
12. Install the new air spring.
13. Install the spring plate mounting nut and torque 130 lbf·in (1470 N·cm).
14. Install the air fitting and tighten securely. Make sure that the fitting is oriented forward.
15. Cut 1/4 inch (6 mm) off of the air line using a hose cutter.
16. Insert the air line into the air fitting.
17. Apply Loctite™ 454 to the bottom six threads of the mounting bolt. See **Fig. 2**.

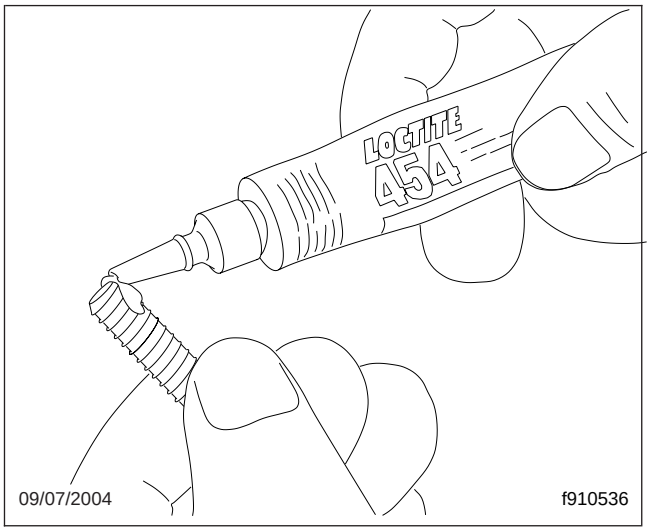



**Fig. 2, Apply Loctite 454**

18. Install the bolt through the bottom casting of the seat to the air spring and tighten the bolt 45 lbf·in (510 N·cm).
19. Start the engine and allow the air reservoirs to fill. Push in on the top of the seat ride-height rocker switch until the seat is adjusted to its maximum height, then remove the wooden block that supports the seat suspension.
20. Remove the chocks from the tires.

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## General Information

Western Star vehicles built at the Portland Truck Manufacturing Plant (TMP) prior to January 1, 2004, were painted with DuPont® single-stage Imron® 5000 or Imron Elite EA, or two-stage (base coat and clear coat) Imron 6000 or Imron Elite EB high-solids polyurethane enamel on the vehicle cab at the factory.

Black standard urethane or Imron Elite EA is used on the vehicle chassis. The chassis includes the frame, hubs, running gear, and any components attached to the frame. Aluminum fuel tanks are not painted.

To meet the air quality regulations imposed by the EPA and local jurisdictions, these products contain lower levels of volatile organic compounds (VOCs) than earlier types (916Y, Centari®, and Imron), and are formulated free of lead and chrome.

The procedures in this section are for use with DuPont products. Unless otherwise noted, all products are manufactured by E. I. du Pont de Nemours and Company, Inc. Obtain approval from a Western Star Regional Office for use of topcoats produced by other manufacturers.

## Color-Matching

The recommended aftermarket paints for color-matching factory-applied paint are as follows:

- Use Imron 5000 or Elite EA for cabs that were factory-painted single-stage Elite EA.
- Use Imron 6000 or Elite EB for cabs that were factory-painted two-stage Elite EB.
- Use Imron 5000 or Elite EA for the chassis.

To ensure proper gloss, durability, and color-matching of the enamel, use only single-stage Imron 5000 or Elite EA on panels that were previously painted with Imron 5000, and use only Imron 6000 on panels painted with Elite EB.

To determine the correct paint number for color-matching any original finish on a vehicle, refer to the paint specification on the vehicle specification decal. Refer to the *Western Star Driver's Manual* for the location of this decal.

NOTE: The high-solids Standard Urethane applied to the chassis at the factory is sold to original equipment manufacturers (OEMs) only, and is not available for aftermarket use. Use Imron 5000, N0001 Black, for repainting.

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## General Guidelines

This subject provides instructions for preparing large panels or the entire cab for topcoating with DuPont® products. For spot repairs or touch-ups, see **Subject 120**.

Before topcoating, the surface must be thoroughly cleaned and sanded. Any bare areas must also be conditioned and primed.

1. Preparation materials specified for one type of surface should not be used for any other type of surface.
2. Limit intermediate coatings, such as primers, to the brand and type specified by the finish-coat manufacturer.

**NOTICE**

**Only experienced, qualified persons using proper equipment should attempt repainting or touch-up painting. Incorrect application of chemicals or paint could damage the surface or impair the finish.**

## Preparation for Prime Coat

Use the cleaners and conditioners specified in each step to prepare the surface for priming. See **Specifications, 400** for a summary of the products used in this procedure.

**⚠ WARNING**

**Do not use solvent-based cleaners on large areas of plastic or fiberglass, such as the hood or air fairing. Wiping down these large areas may cause a buildup of static electricity. The resulting spark could cause a flash fire, which could result in personal injury or property damage.**

### Cab and Hood Preparation

1. Wash the entire vehicle with a mild detergent, and dry.
2. Wipe all surfaces to be painted with a clean cloth soaked with solvent or cleaner. Remove all traces of wax, polish, grease, and silicones.
   - Metal—use DuPont Prep-Sol 3919 S.
   - Plastic—use DuPont Plastic Prep 2319 S.
   - Fiberglass—use DuPont Prep-N-Solv.

   2.1 Work on small areas at a time, wetting the surface liberally.

   2.2 Quickly wipe the surface with a clean cloth before the solvent or cleaner has a chance to dry. Change cloths frequently.
3. Feather the edge of all repaired areas, chipped surfaces, and scratches.

   3.1 Cut down the edges of broken spots with 220 sandpaper.

   3.2 Feather the edges by hand, using a sanding block with 400 sandpaper.
4. Sand the entire area to be painted. Using a sanding block and 400 sandpaper, remove the gloss to improve adhesion of the primer.
5. Using a clean cloth soaked with cleaner, remove any sanding dust.
   - On metal surfaces, use DuPont First Klean 3900S, DuPont Final Klean 3901S, or DuPont 3939 S Lacquer and Enamel Cleaner. Do not use these cleaners on plastic or fiberglass substrates.
   - On plastic or fiberglass substrates, use DuPont Low VOC Final Klean 3909S.
6. Treat bare metal and rusted areas.
   - Aluminum—use DuPont 225 S aluminum cleaner.
   - Steel—use DuPont 5717 S metal conditioner.

   6.1 Mix one part of the cleaner with two parts of water in a plastic bucket.

   6.2 Apply the cleaner with a cloth or sponge. If corrosion is present, work the surface with a stiff plastic brush or 3M Scotch-Brite® pad. Do not use any pads containing iron.

   6.3 While the metal is still wet, wipe thoroughly with a clean, dry cloth. Allow the surface to dry before applying a conversion coating.
7. Apply a conversion coating to all bare metal.

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- Aluminum—use DuPont 226 S aluminum conversion coating.
- Steel—use DuPont 5718 S metal conversion coating.
- Zinc casings or galvanized surfaces (iron or steel)—use DuPont 5718 S metal conversion coating.

7.1 Pour the conversion coating into a plastic container (do not dilute). Using a 3M Scotch-Brite or similar non-iron abrasive pad, apply the conversion coating to the metal surface. Work only as much area as can be coated and rinsed before the solution dries.

7.2 Leave the coating on the surface for two to five minutes. Then, rinse off the solution with cold water, or mop with a sponge or cloth rinsed frequently in clean water.

If the metal surface dries before rinsing, reapply the conversion coating, then repeat the previous substep.

7.3 Wipe the surface dry with a clean cloth, or air dry.

8. Mask all areas that are not to be painted.

## Air Fairing Kit Preparation

Before installing a new air fairing, prepare the surface for topcoating.

1. Wash the air fairing with a mild detergent. Dry with a clean, absorbent, lint-free cloth or paper towels.
2. Using a clean cloth soaked with DuPont Prep-N-Solv, wipe the entire surface to remove any trace of grease or oil.
3. Scuff-sand the air fairing with 320 grit sandpaper.
4. Wipe the air fairing with a clean cloth soaked in DuPont Low VOC Final Klean 3909S, or a solution of one part water and one part isopropyl alcohol. Allow 10 to 15 minutes for the air fairing to dry.
5. Mask all areas that are not to be painted.

## Prime Coat

Prime all bare and feathered areas before topcoating. The specified primers can be used on any surface.

1. Clean all cracks and surfaces with dry compressed air.
2. Using a tack cloth, wipe all surfaces to be painted.

**⚠ WARNING**

**Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying primer, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.**

3. Prime all bare metal and feathered areas with DuPont Corlar® 824 S epoxy primer.

3.1 Stir Corlar 824 S primer thoroughly.

3.2 Mix two parts Corlar 824 S primer with one part DuPont 826 S activator.

3.3 Reduce three parts of this mixture with one part DuPont 3602 S lacquer thinner (viscosity reading is 18 to 22 seconds in a no. 2 Zahn cup). Stir thoroughly.

3.4 Wait 1 to 2 hours from time of mixing before using. This provides time for complete chemical induction.

3.5 Spray one full wet coat to give a dry film thickness of 0.7 to 1.0 mil (0.018 to 0.025 mm).

3.6 Clean equipment immediately after use with DuPont 3602 S lacquer thinner.

3.7 Air dry 2 hours or force dry 20 minutes.

4. Wet sand the primer with 400 grit or finer sandpaper. Feather the edge into the surrounding area.
5. Dry the surface. Using a clean cloth soaked with cleaner, remove any sanding dust.
   - On metal surfaces, use DuPont First Klean 3900S, DuPont Final Klean 3901S, or DuPont 3939 S Lacquer and Enamel Cleaner.

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Do not use these cleaners on plastic or fiberglass substrates.

- On plastic or fiberglass substrates, use DuPont Low VOC Final Klean 3909S.

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## General Guidelines

This subject provides instructions for applying a topcoat of DuPont® enamel to full panels, or the entire cab. For spot repairs or touch-ups, see **Subject 120**.

### NOTICE

**Only experienced, qualified persons using proper equipment should attempt repainting or touch-up painting. Incorrect application of chemicals or paint could damage the surface or impair the finish.**

Do not mix additives with the finish coats unless they are specified by the finish-coat manufacturer. See **Specifications, 400** for a summary of the products used in this procedure.

Do not apply if the paint temperature is less than 70°F (21°C). Use warm water or paint heaters to heat the paint to an optimum temperature of 85 to 95°F (29 to 35°C). The material, substrate, or ambient temperature should be above 50°F (10°C) and below 110°F (43°C).

Before applying any topcoat:

1. Prepare the surface for topcoating. See **Subject 100** for instructions.
2. Clean all cracks and surfaces with dry compressed air.
3. Using a tack cloth, wipe all surfaces to be painted.

## Imron Elite EA Topcoating

Imron Elite EA (also called Elite SS) is a single-stage, low VOC, high-solids polyurethane enamel. It provides a durable, high-gloss surface with good chemical resistance. It requires the addition of an activator.

### ⚠ WARNING

**Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying paint products, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.**

### Mixing

1. Stir the Imron Elite EA enamel thoroughly.
2. Mix three parts Imron Elite EA enamel with one part of DuPont 193 S or 194 S activator. No further reduction is necessary for application.

NOTE: The pot life of the mixture is about 2 to 4 hours at 70°F (21°C), unless an accelerator is added.

3. If faster curing time is desired, add DuPont 389 S fast-dry accelerator. Add up to 2 ounces (60 mL) to 1 gallon (3.8 L) of mixed material.
4. Mix thoroughly and strain.

NOTE: The viscosity of the mixture is about 10 to 19 seconds in a no. 3 Zahn cup, depending on the color. Adding reducer could affect the color match on some metallics.

### Application

1. Set the air pressure at the spray gun to 60 to 65 psi (414 to 448 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (354 to 473 mL) per minute.
2. Apply the topcoating.
   - 2.1 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.
   - 2.2 Using a cross-coat technique, spray one medium-wet coat in a north-to-south direction.
   - 2.3 Allow 5 to 10 minutes drying time between each application. Do not sand.
   - 2.4 Apply a second medium-wet coat in an east-to-west direction.
   - 2.5 A third medium-wet coat may be needed for good coverage of some colors.
3. To air dry, allow 2 to 4 hours with accelerator 389 S, and 6 to 8 hours without the accelerator.

   To force dry, wait 15 minutes following the application of the final coat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).
4. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.

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5. Clean the equipment immediately after use with DuPont 3602 S lacquer thinner or 8685 S reducer.

## Recoating or Decorating

Two-toning, striping, or lettering may be applied in 4 to 6 hours if DuPont 389 S accelerator is used. Wait 10 to 12 hours, if no accelerator is used.

Decals may be applied in 12 to 16 hours, if 389 S accelerator is used. Wait 24 hours if no accelerator is used.

For topcoats cured over 72 hours, scuff-sand with 400-grit sandpaper and wipe with a clean tack cloth before recoating, striping, lettering, or applying decals.

# Imron Elite EB Topcoating

Imron Elite EB (also called Elite BC) is a two-stage, high-solids polyurethane enamel. It provides good cover with one cross-coat of the base color followed by one coat of Imron Elite EB clear coat. Both the base color and clear coat require the addition of an activator.

**⚠ WARNING**

**Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying paint products, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.**

## Mixing

1. Stir the Imron Elite EB base color thoroughly.
2. Mix three parts Imron Elite EB base color with one part DuPont 193 S or 194 S activator. No further reduction is necessary for application.

NOTE: The pot life of the mixture is about 2 to 4 hours at 70°F (21°C), unless an accelerator is added.

3. If faster curing time is desired, add DuPont 389 S fast-dry accelerator. Add up to 2 ounces (60 mL) to 1 gallon (3.8 L) of mixed material.
4. Mix thoroughly and strain.

NOTE: The viscosity of the mixture is about 10 to 19 seconds in a no. 3 Zahn cup, depending on the color. Adding reducer could affect the color match on some metallics.

## Application

1. Set the air pressure at the spray gun to 60 to 65 psi (414 to 448 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (354 to 473 mL) per minute.
2. Apply the topcoating.
   - 2.1 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.
   - 2.2 Apply one cross-coat of the Imron Elite EB base color.
   - 2.3 Flash 10 minutes minimum. Do not sand.
   - 2.4 Purge the equipment with DuPont 3602 S lacquer thinner, or 8685 S reducer.
3. Apply clearcoat.
   - 3.1 Mix three parts DuPont 3440 S or 3480 S clear, with one part DuPont 193 S or 194 S activator.
   - 3.2 Apply one coat of the activated DuPont 3440 S or 3480 S clear. Some colors may require additional cross-coats.
4. To air dry, allow 2 to 4 hours if DuPont 389 S accelerator is used, and 6 to 8 hours if no accelerator is used.

   To force dry, wait 15 minutes following the application of the clear coat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).
5. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.
6. Clean the equipment immediately after use, with DuPont 3602 S lacquer thinner or 8685 S reducer.

## Recoating or Decorating

Two-toning, striping, and lettering may be applied in 4 to 6 hours, if DuPont 389 S accelerator is used. Wait 10 to 12 hours, if no accelerator is used.

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Decals may be applied in 12 to 16 hours, if 389 S accelerator is used. Wait 24 hours, if no accelerator is used.

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## General Guidelines

This subject provides instructions for making spot repairs or touch-ups with DuPont® enamels. Buffing may correct minor imperfections; more serious repairs require surface preparation before a topcoating can be applied. For striping, lettering, or decal application after the repair is complete, see **Subject 110**.

1. Specific types of surfaces to be painted, require specific types of preparation materials. Do not use preparation materials specified for a given type of surface on another surface, for which it is not specified.

   See **Specifications, 400** for a summary of the materials used in this section.
2. Use only the intermediate coatings, such as primers, of the brand and type specified by the finish-coat manufacturer.
3. Do not mix additives with the finish coats unless they are specified by the finish-coat manufacturer.
4. Do not apply if the paint temperature is less than 70°F (21°C). Use warm water or paint heaters to heat the paint to an optimum temperature of 85 to 95°F (29 to 35°C). The material, substrate or ambient temperature should be above 50°F (10°C) and below 110°F (43°C).

### NOTICE

**Only experienced, qualified persons using proper equipment should attempt repainting or touch-up painting. Incorrect application of chemicals or paint could damage the surface or impair the finish.**

## Buffing Minor Imperfections

1. Clean the area carefully with a mild detergent, then rinse.
2. Remove imperfections using ultra-fine or micro-fine sandpaper (1500- or 2000-grit) and water. Rinse the area with clean water, then dry.
3. Buff the area.

   3.1 Use a clean foam pad at low speed (about 1600 rpm) with one of the following products:

   - DuPont 1500 S
   - Meguiar's No. 2 Fine-Cut Cleaner
   - 3M Finesse-it II 05928

   3.2 Using medium pressure, buff slowly in an overlapping pattern until the imperfection has been eliminated. Repeat as necessary.

   3.3 Rinse the area with clean water, then dry.
4. Polish the area.

   4.1 Apply one of the following products with a clean pad (3M Waffle Pad):

   - DuPont 3000 S
   - Meguiar's No. 9 Swirl Remover
   - 3M Perfect-it 05996

   4.2 Using medium pressure, work small areas using an even, overlapping pattern until the gloss is restored. As the polish dries and the gloss appears, ease the pressure on the polishing pad. Repeat as necessary.

## Preparing for Topcoating

1. Wash the entire panel with mild detergent, containing no lanolin or additives. Before the solution dries, rinse with fresh water. Dry with a clean, lint-free cloth.
2. Cover areas around the repair area to prevent damage to surrounding objects from solvent overspray or drips.

### ⚠ WARNING

**Solvents are flammable. Keep the container closed. Use only with adequate ventilation. Keep solvents away from heat, sparks, and open flame. Breathing the vapor can cause headache, nausea, impaired reaction time, and impaired coordination.**

3. Clean the area to be repaired with DuPont 3939 S solvent and quickly wipe the surface with a clean, lint-free cloth before the solvent dries. Remove all traces of wax, polish, grease, and silicones.
4. Sand or grind all dents and scratches.

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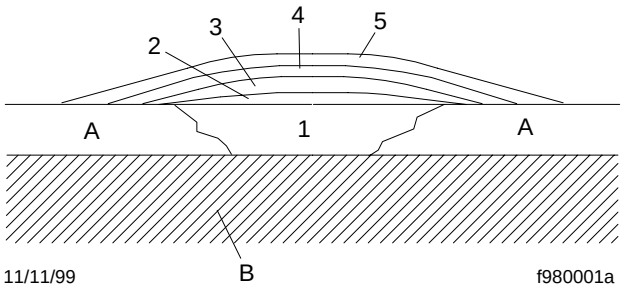
## Spot Repair

5. Wet sand the area being repaired with 320-grit or finer sandpaper, or a 3M Scotch-Brite® or similar non-iron abrasive pad. Feather the edge.
6. Remove the sanding dust. Use the same solvent and wipe-on, wipe-off method used earlier to clean the area.
7. Mask all areas that will not be painted.
8. Clean all cracks and surfaces with dry compressed air.
9. Using a tack cloth, wipe all surfaces to be painted.

**⚠ WARNING**

**Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying paint products, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.**

10. Prime all bare metal and feathered areas with DuPont primer. See **Fig. 1**.
    - Steel and aluminum—use Corlar 824 S epoxy primer.
    - Fiberglass—use Corlar 825 S epoxy primer.




NOTE: Scale exaggerated for clarity. The number of layers depends on the specific application.

A. Existing Paint
B. Panel Material (substrate)

1. Primer
2. First Color Topcoat
3. Second Color Topcoat
4. Third Color Topcoat
5. Clear Coat

**Fig. 1, Spot Repair Cross-Section**

10.1 Stir primer thoroughly.

10.2 Mix two parts Corlar epoxy primer with one part DuPont 826 S activator.

10.3 Reduce three parts of this mixture with one part DuPont 3602 S lacquer thinner (viscosity reading is 18 to 22 seconds in a no. 2 Zahn cup). Stir thoroughly.

10.4 Wait 1 to 2 hours from time of mixing before using. This provides time for complete chemical induction.

10.5 Set the air pressure at the spray gun to 45 psi (310 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (354 to 473 mL) per minute.

10.6 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.

10.7 Spray one wet coat to give a dry film thickness of 0.7 to 1.0 mil (18 to 25 µm).

10.8 Clean the equipment immediately after use with DuPont 3602 S lacquer thinner.

10.9 Air dry 2 to 4 hours or force dry 20 minutes.

11. Wet sand the primer with 400-grit or finer sandpaper. Feather the edge into the surrounding area.
12. If the original paint was Imron Elite EB (also called Elite BC) hand-rub the area around the spot repair with a medium grade compound to ensure a seamless finish.
13. Remove the sanding dust. Use the same solvent and wipe-on, wipe-off method used earlier to clean the area.
14. Wipe the repair area with a tack cloth.
15. If the finish is old, apply one coat of DuPont 222 S adhesion promoter over the entire repair area.

15.1 Set the air pressure to 35 psi (241 kPa) at the spray gun.

15.2 Flash for 5 to 10 minutes at 70°F (21°C) before topcoating.

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## Topcoating a Spot Repair

**⚠ WARNING**

**Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying paint products, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.**

### Imron Elite EB Topcoating

1. Mix the Elite EB polyurethane enamel.
   - 1.1 Stir the Elite EB base color thoroughly.
   - 1.2 Mix three parts Elite EB base color with one part DuPont 193 S or 194 S activator. No further reduction is necessary for application.
   - 1.3 Mix thoroughly and strain.

Note: The viscosity of the mixture is about 10 to 19 seconds in a no. 3 Zahn cup, depending on the color. Adding reducer could affect the color match on some metallics.

2. Set the air pressure at the spray gun at 60 to 65 psi (414 to 448 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (354 to 473 mL) per minute.
3. Apply the topcoating.
   - 3.1 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.
   - 3.2 Apply one cross-coat of the Elite EB base color over the primed area. No flash time is required before applying a clear coat.
   - 3.3 Purge the equipment with DuPont 3602 S lacquer thinner or 8685 S reducer.
   - 3.4 Mix three parts DuPont 3440 S or 3480 S clear with one part DuPont 193 S or 194 S activator.

   NOTE: For best results, apply the clear coat over the entire panel. If a blend of the repair area is attempted, apply the clear coat only over the repair area, overspraying the edge slightly.
   - 3.5 Apply one coat of the activated DuPont 3440 S or 3480 S clear.
4. Purge the equipment with DuPont 3602 S lacquer thinner or 8685 S reducer.
5. Blend the 3440 S or 3480 S clear into the surrounding topcoat.
   - 5.1 Set the air pressure to 25 psi (172 kPa) at the spray gun.
   - 5.2 Apply one coat of 3401 S blending clear over the repair area, only to the overspray edge.
   - 5.3 Flash 2 minutes. Repeat if necessary.
6. To air dry, allow 2 to 4 hours if DuPont 389 S accelerator is used, and 6 to 8 hours if no accelerator is used.

   To force dry, wait 15 minutes following the application of the final coat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).
7. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.
8. Clean the equipment immediately after use, with DuPont 3602 S lacquer thinner or 8685 S reducer.

### Imron Elite EA Topcoating

1. Mix the Elite EA polyurethane enamel.
   - 1.1 Stir the Elite EA enamel thoroughly.
   - 1.2 Mix three parts Elite EA base color with one part DuPont 193 S or 194 S activator. No further reduction is necessary for application.
   - 1.3 Mix thoroughly and strain.

   Note: The viscosity of the mixture is about 10 to 19 seconds in a no. 3 Zahn cup, depending on the color. Adding reducer could affect the color match on some metallics.
2. Set the air pressure at the spray gun at 60 to 65 psi (414 to 448 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (354 to 473 mL) per minute.
3. For metallic topcoats only, apply one coat of DuPont 500 S urethane clear.

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## Spot Repair

3.1 Mix eight parts of 500 S urethane with one part 193 S activator.

3.2 Reduce the activated 500 S urethane mixture 50 percent with 8685 S reducer.

3.3 Apply a medium-wet coat of the reduced 500 S urethane over the entire repair area, and well beyond where the color will be applied.

3.4 Flash 3 minutes before applying the Elite EA topcoat.

4. Apply the solid color or metallic topcoating.

4.1 Hold the spray gun about 10 to 12 inches (25 to 30 cm) from the surface.

4.2 Spray one medium-wet coat over the primed area.

4.3 Flash 5 to 10 minutes.

4.4 Apply a second medium-wet coat. Extend the spray area slightly to taper the edge and avoid a visible ring.

4.5 A third medium-wet coat may be needed for good coverage of some colors. Allow each coat to flash before applying the next coat.

NOTE: A mist coat of five parts of color to three parts of 8022 S is recommended when applying metallics. Hold the gun about 18 inches (46 cm) from the surface.

5. Blend the repair area into the OEM finish.

5.1 Lower the air pressure to 15 to 20 psi (103 to 138 kPa) at the spray gun.

5.2 Empty the spray cup and refill it with DuPont 8022 S reducer or a blend of 8022 S and 8093 S.

5.3 Carefully blend the edge of the repair with even coats to melt in the overspray.

5.4 Spray one or two medium coats of the reducer over the entire area.

5.5 If a haze appears around the edge after the reducer has dried, lightly rub the edge with DuPont 1500 S one-step polish.

6. To air dry, allow 2 to 4 hours if DuPont 389 S accelerator is used, and 6 to 8 hours if no accelerator is used.

To force dry, wait 15 minutes following the application of the final coat, then dry for 30 minutes at 140 to 180°F (60 to 82°C).

7. To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied. Avoid contacting the freshly painted surface with masking paper.

8. Clean the equipment immediately after use with DuPont 3602 S lacquer thinner or 8685 S reducer.

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## Specifications

| DuPont Surface Preparation Materials | | | | |
|---|---|---|---|---|
| **Step** | **Aluminum** | **Steel** | **Plastic** | **Fiberglass** |
| Wash and dry | Mild detergent, such as dish washing detergent | | | |
| Wipe with cleaner | Prep-Sol 3919 S | | Plastic Prep 2319 S | Prep-N-Solv |
| Sand and feather | 220 grit, then 400 grit | | | 320 grit |
| Remove sanding dust | 3939 S lacquer and enamel cleaner | | | Mix:<br>- 1 part water<br>- 1 part isopropyl alcohol |
| Treat bare metal | 225 S aluminum cleaner | 5717 S metal conditioner | — | — |
| Apply conversion coating to bare metal | 226 S aluminum conversion coating | 5718 S metal conversion coating | — | — |
| Apply sealer primer | Mix:<br>- 2 parts Corlar 824 S primer with 1 part DuPont 826 S activator<br>- reduce 3 parts of mixture with 1 part DuPont 3602 S lacquer thinner | | | |

**Table 1, DuPont Surface Preparation Materials**

| DuPont Topcoating Materials | |
|---|---|
| **Step** | **Topcoating Materials** |
| Mix enamel | Mix:<br>- 3 parts Imron 5000 with 1 part 193 S or 194 S activator |
| Add accelerator (optional) | 389 S accelerator (up to 2 oz/gal of activated enamel) |
| Pressure at gun | 60 psi (414 kPa) |
| Equipment cleanup | 3939 S lacquer and enamel cleaner or 8685 S reducer |

**Table 2, DuPont Topcoating Materials**

| DuPont Spot Repair Materials | |
|---|---|
| **Step** | **Spot Repair Materials** |
| Cleaning | 3939 S lacquer and enamel cleaner |
| Sanding | 320 grit or finer |
| Sealer primer | Mix:<br>- 2 parts Corlar 824 S primer with 1 part DuPont 826 S activator<br>- reduce 3 parts of mixture with 1 part DuPont 3602 S lacquer thinner |
| Adhesion promoter | 222 S adhesion promoter |
| Topcoat | Mix:<br>- 3 parts Imron 5000 with 1 part 193 S or 194 S activator |
| Topcoat viscosity | 9–20 sec (#3 Zahn cup) |
| Accelerator (optional) | 389 S accelerator |

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## Specifications

| DuPont Spot Repair Materials | |
|---|---|
| **Step** | **Spot Repair Materials** |
| Blending clear | 1 coat 3401 S blending clear |
| Equipment cleanup | 3939 S lacquer and enamel cleaner or 8685 S reducer |

**Table 3, DuPont Spot Repair Materials**

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## General Description

PPG Delta® DUHS base-coat and DCU2070 clear-coat paint is used on the vehicle cab. To meet the federal air quality regulations imposed by the EPA and local jurisdictions, these products contain low amounts of solvent and are formulated to be free of lead and chrome.

The procedures in this section are for use with PPG products. Unless otherwise noted, all products are manufactured by PPG. Obtain approval from Daimler Trucks North America (DTNA) for use of topcoats produced by other manufacturers.

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## Color Matching

PPG Delta® high solids polyurethane is the recommended aftermarket PPG paint. For repairs, use PPG Delta DFHS paint for color-matching the chassis and PPG Delta DUHS base coat with DCU2070 clearcoat paint for color-matching the cab.

To determine the correct paint number for color-matching of any original finish on a vehicle, refer to the paint specification on the vehicle specification decal. See **Fig. 1**. Refer to the vehicle operator's manual for the location of this decal.

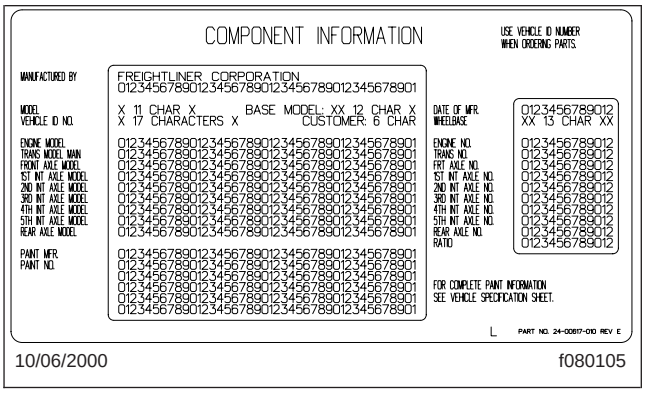



**Fig. 1, Vehicle Specification Decal**

## General Guidelines

1. Preparation materials specified for one type of surface should not be used for any other type of surface.
2. Limit intermediate coatings, such as sealers, to the brand and type specified by the finish coat manufacturer.
3. Do not mix additives with the finish coats, unless the finish coat manufacturer specifies them.

IMPORTANT: Only experienced, qualified persons, using proper equipment, should attempt repainting and touch-up painting.

## Preparation for Topcoating

1. Wash and dry the entire surface to be painted.
2. Using a clean cloth soaked with PPG DX436 Wax and Grease Remover, remove all traces of wax, polish, grease, and silicones, as follows:
   - 2.1 Work on small areas at a time, wetting the surface liberally.
   - 2.2 Change cloths frequently.
   - 2.3 Wipe off the surface with a clean cloth before the PPG DX436 Wax and Grease Remover has a chance to dry.
3. Feather-edge all repaired areas, chipped surfaces, and scratches, as follows:
   - 3.1 Cut down the edges of broken spots with 220-grit sandpaper.
   - 3.2 Feather the edges by hand, using a sanding block with 400-grit sandpaper.
4. Sand the entire area to be repainted. Use a sanding block and 400-grit sandpaper to remove the gloss and to improve adhesion of the primer.
5. Using a clean cloth soaked with PPG DX436 Wax and Grease Remover, remove any sanding dust from the area to be painted. Remove all traces of wax, polish, grease, dust, and silicones, as follows:
   - 5.1 Work on small areas at a time, wetting the surface liberally.
   - 5.2 Change cloths frequently.
   - 5.3 Wipe off the surface with a clean cloth before the PPG DX436 wax and grease remover has a chance to dry.
6. Treat bare metal and corroded areas. For aluminum, use PPG DX533 Aluminum Cleaner; for all other metals, use PPG DX579 Metal Cleaner.
   - 6.1 For aluminum, mix one part of PPG DX533 Aluminum Cleaner with three parts of water in a plastic bucket.

     For all other metals, mix one part of the PPG DX579 Metal Cleaner with two parts of water in a plastic bucket.
   - 6.2 All corroded areas must be abraded until the area is free of rust or corrosion. Use 80-grit followed by 220-grit sandpaper to abrade the area.
   - 6.3 Spray cleaner on the surface and allow it to react for 2 to 3 minutes.
   - 6.4 Rinse off the cleaner with fresh water and dry thoroughly with a clean, lint-free, dry cloth.

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## Preparing for Topcoating

IMPORTANT: Carbon steel must be primed immediately after abrading and cleaning. Aluminum must be primed within 4 to 8 hours of abrading and cleaning.

7. With paper and tape, mask all areas that are not to be painted, then prime immediately.

# Primers for the Cab

PPG has several compatible primers to use when repainting or repairing. The recommended primers are:

- DP-LF — A chrome- and lead-free epoxy primer with excellent corrosion resistance.
- DPU217 — A chrome-free polyurethane primer that can be applied as low as 2.1 lb/gal VOC with excellent adhesion and corrosion resistance properties.
- DEP351 — A 3.5 VOC chrome- and lead-free epoxy primer with excellent adhesion and corrosion resistance properties.
- DPHS-52 — A non-isocyanate, chrome- and lead-free, corrosion resistant, sandable primer with excellent adhesion and filling properties.

## DP-LF Primer

NOTE: Refer to PPG Product Information Bulletin P-196 for additional information.

**WARNING**

**Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying paint products, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.**

1. Stir the DP-LF Primer thoroughly. Then, mix two parts of DP-LP with one part of DP 401LF.
2. Stir thoroughly and allow a 30-minute induction time to obtain maximum performance.
3. Apply two light-to-medium wet coats to achieve a 1.0 mil minimum to 2.0 mil maximum dry film thickness (DFT).
4. Allow 15 minutes flash time between coats.
5. Allow a drying time of 1 hour at 70°F (21°C) before topcoating.
6. Clean all cracks and surfaces with dry compressed air.
7. Using a tack cloth, wipe all surfaces to be painted.

## DPU217 Primer

NOTE: Refer to PPG Product Information Bulletin FL304 for additional information.

**WARNING**

**Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying paint products, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.**

NOTE: This mixture has a VOC of 2.8 lb/gal. To spray at 2.1 lb/gal do not add the DRS reducer.

1. Stir the DPU217 primer thoroughly.
2. Mix five parts of DPU217 with one part of DPU218.
3. Add 6 fluid ounces (177 mL) of DX39/DX53 per ready-to-spray gallon (3.8 L).
4. Add one part of DRS reducers.

NOTE: When adding DRS reducers in the 2.8 VOC blend, for best results, the DRS solvents must be added last, after the addition of the DX39/DX53.

5. Apply one to two coats.
6. Allow 10 to 15 minutes flash time between coats.
7. Allow a drying time of 60 minutes at 70°F (21°C) before topcoating.

NOTE: After four days, DPU217 must be sanded before additional primer or topcoat can be applied.

8. Clean all cracks and surfaces with dry compressed air.
9. Using a tack cloth, wipe all surfaces to be painted.

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## DEP351 Primer

NOTE: Refer to PPG Product Information Bulletin FL305 for additional information.

**⚠ WARNING**

**Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying paint products, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.**

1. Stir the DEP351 Primer thoroughly. Then, mix two parts of DEP351 with one part of DEP352.

   The addition of 10 to 20 percent Acetone or DES1570 Exempt Solvent Blend should be used for sealer application.
2. Apply one to two coats.
3. Allow 5 minutes flash time between coats.
4. Allow a drying time of 60 minutes at 70°F (21°C) before topcoating.
5. Clean all cracks and surfaces with dry compressed air.
6. Using a tack cloth, wipe all surfaces to be painted.

## DPHS52 Primer

NOTE: Refer to PPG Product Information Bulletin FL301 for additional information.

**⚠ WARNING**

**Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying paint products, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.**

1. Stir the DPHS52 Primer thoroughly. Then, mix two parts of DPHS52 with one part of DPHS521 and mix thoroughly.
2. Apply two to three wet coats to achieve a 2.0 mil minimum to 3.0 mil maximum DFT.
3. Allow 10 minutes flash time between coats.

NOTE: A minimum of 2.0 mil DFT after sanding must be maintained to ensure proper adhesion and corrosion protection.

4. Allow a drying time of 45 minutes at 70°F (21°C) before topcoating.

   Or, if sanding before topcoating, allow a drying time of 3 to 4 hours, then DA sand with 320- to 360-grit dry sandpaper, followed with a finish DA sanding using 1500-grit or finer paper.
5. Clean all cracks and surfaces with dry compressed air.
6. Using a tack cloth, wipe all surfaces to be painted.

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## Delta® DFHS High Solids Polyurethane

NOTE: Refer to PPG Product Information Bulletin P-FL504 for additional information.

**⚠ WARNING**

**Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying paint products, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.**

### Mixing

1. Stir Delta DFHS Single Stage thoroughly.
2. Mix four parts Delta DFHS Single Stage with one part DFH535/DFH536.
3. Add six fluid ounces (177 ml) DX39 per ready-to-spray (RTS) gal.

NOTE: May substitute with DX53 or DX49, but pot life, dry times, and recoat ability may be affected.

4. Mix thoroughly and strain.

### Spraying

1. For High Velocity, Low Pressure (HVLP) systems, the air pressure at the air cap should be set at 10 psi (69 kPa).

   For conventional spray guns, set the air pressure to 45 to 60 psi (310 to 414 kPa) at the gun.

   The fluid tip size for conventional HVLP guns should be 1.3 to 1.7 mm.

   The fluid tip size for pressure-feed HVLP guns should be 1.0 to 1.4 mm.
2. Apply two coats, or until hiding is achieved. Flash time between coats is 5 to 10 minutes at 70°F (21°C).
3. Dry times: See **Table 1** for air dry times. See **Table 2** for force dry times.

## Delta® DUHS Basecoat

NOTE: Refer to PPG Product Information Bulletin P-FL507 for additional information.

**⚠ WARNING**

**Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying paint products, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.**

| Air Dry Time - at 70°F (21°C) With DFH535 | |
|---|---|
| Using DX39 | 12 hours |
| Using DX53 | 16 hours |
| Using DX49 | 5 hours |

**Table 1, Air Dry Time - at 70°F (21°C) With DFH535**

| Force Dry With DX53 Only | |
|---|---|
| Flash | 10 minutes |
| 120°F (49°C) | 30 minutes |
| 180°F (82°C) | 15 minutes |

**Table 2, Force Dry With DX53 Only**

### Mixing

NOTE: One-quarter part DHSX Converter is the minimum quantity and one part is the maximum quantity of converter to add to DUHS Basecoat. Increasing the level of DHSX will speed dry time, but will shorten pot time, especially in warm and humid conditions.

1. Stir Delta DUHS Basecoat thoroughly.
2. Mix two parts of Delta DUHS Basecoat with one-quarter to one part of DHSX Converter.
3. Add one part DDH526.
4. Mix thoroughly and strain.

### Spraying

1. For HVLP systems, the air pressure at the air cap should be set at 10 psi (69 kPa).

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For conventional spray guns, set the air pressure to 45 to 60 psi (310 to 414 kPa) at the gun.

The fluid tip size should be 1.3 to 1.7 mm for conventional HVLP guns and 1.0 to 1.4 mm for pressure feed HVLP guns.

2. Apply two coats of the basecoat, or until hiding is achieved. Minimum film build for each coat should be 1.5 mils wet and no more than 2.0 mil wet. Flash time between coats is 5 to 10 minutes at 70°F (21°C).
3. Dry time to clearcoat is 10 to 15 minutes minimum and up to 72 hours maximum at 70°F (21°C). After 72 hours the DUHS basecoat must be sanded and additional color applied before clearcoating.
4. Allow a drying time of 60 minutes at 70°F (21°C) before topcoating.

## Delta® Urethane Clear DCU2070

NOTE: Refer to PPG Product Information Bulletin FL600 for additional information.

**⚠ WARNING**

**Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying paint products, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.**

### Mixing

1. Mix four parts of DCU2070 with one part of DRS Reducer.
2. Add two parts DCX2071/DCX2072.
3. Add four fluid ounces (118mL) of DX39/DX54 per RTS gallon (3.8 L) of mixed material.
4. Mix thoroughly and strain.

### Spraying

1. For HVLP systems, the air pressure at the air cap should be set at 10 psi (69 kPa).

   For conventional spray guns, set the air pressure to 55 to 60 psi (379 to 414 kPa) at the gun.

   The fluid tip size should be 1.0 to 1.4 mm for pressure feed HVLP and 1.3 to 1.5 mm for conventional feed HVLP.
2. Apply two coats allowing 10 to 15 minutes between coats.
3. For dry times at 70°F (21°C), See **Table 3**. Force dry time is 30 minutes at 140°F (60°C).

| Dry Times | | |
|---|---|---|
| **DCU2070** | **With DCX2071** | **With DCX2072** |
| With DX39 | 3 hours | 1 to 2 hours |
| With DX53 | 4 to 5 hours | 2 hours |

**Table 3, Dry Times**

4. Buffing may begin 4 to 6 hours after the unit is air dried, or immediately after cool off, if force dried.

NOTE: If polishing is required, use DCX2071 Polish within 24 hours.

## Buffing

Refer to PPG Product Information Bulletin PD768 for polishing and compounding.

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## General Guidelines

These are instructions for making spot repairs or touch-ups with PPG Delfleet® Evolution urethane topcoat single stage or basecoat/clearcoat.

Buffing may correct minor imperfections; more serious repairs require surface preparation before a topcoating can be applied.

1. Preparation materials specified for one type of surface should not be used for any other type of surface.
2. Limit intermediate coatings, such as primers, to the brand and type specified by the paint manufacturer.
3. Do not use any products or additives that are not specifically recommended by the paint manufacturer in published literature.
4. Substrate and ambient temperature should be above 65°F (18°C) for optimum performance.

## Buffing Minor Imperfections

1. Clean the area carefully with a mild detergent, then rinse.
2. Remove imperfections using ultra-fine or micro-fine sandpaper (1500- or 2000-grit) and water.
3. Rinse the area with clean water, then dry.
4. Buff the area, using a clean foam pad at low speed (about 1600 rpm). Using medium pressure, buff slowly in an overlapping pattern until the imperfection has been eliminated. Repeat as necessary.

   Use one of the following products:

   - Meguiar's No. 2 Fine-Cut Cleaner
   - 3M Finesse-it II 05928
5. Rinse the area with clean water, then dry.
6. Polish the area with a clean pad, such as a 3M Waffle Pad. Using medium pressure, work small areas using an even, overlapping pattern until the gloss is restored. As the polish dries and the gloss appears, ease the pressure on the polishing pad. Repeat as necessary.

   Use one of the following products:

   - Meguiar's No. 9 Swirl Remover
   - 3M Perfect-It 05996

## Preparing for Topcoating

1. Wash the entire panel in mild detergent, containing no lanolin or additives. Before the solution dries, rinse with fresh water. Dry with a clean, lint-free cloth.
2. Cover areas around the repair area to prevent damage to surrounding objects from solvent overspray or drips.

**⚠ WARNING**

**Solvents are flammable. Keep the container closed. Use only with adequate ventilation. Keep solvents away from heat, sparks, and open flame. Breathing the vapor can cause headache, nausea, impaired reaction time, and impaired coordination.**

3. Clean the area to be repaired with PPG D436/DX437/DX438 Substrate Cleaner. Choose the product depending on local regulations and degree of contamination. Quickly wipe the surface with a clean, lint-free cloth before the substrate cleaner dries.

   Remove all traces of substrate contamination such as wax, polish, grease, diesel exhaust residue, and silicones. Do not allow substrate cleaners to air dry on the repair area.
4. Sand or grind all dents and scratches.
5. DA sand the area being repaired with 320- or 400-grit, or finer sandpaper, or a 3M Scotch-Brite® pad. Feather the edge.
6. Remove sanding dust using the method detailed in step 3 above.
7. Mask all areas not to be painted.
8. Clean all cracks and surfaces with dry compressed air.
9. Use a tack cloth to wipe all surfaces to be painted.

**⚠ WARNING**

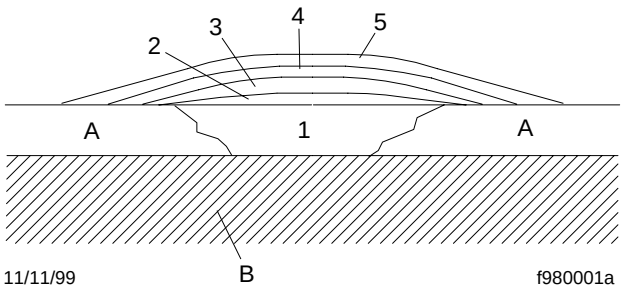
**Wear a positive-pressure, supplied-air, vapor and particulate respirator, approved by NIOSH or MSHA (TC-19C) when mixing or spraying paint**

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**products, and until the work area has been exhausted of all vapor and spray mist. Breathing paint fumes can cause serious personal injury.**

10. Prime all bare metal and feathered areas with PPG primer. Use F3995 primer for fiberglass, steel, and aluminum. See **Fig. 1**.




NOTE: The number of paint layers depends on the specific use.

A. Existing Paint
B. Panel Material (Substrate)

1. Primer
2. First Color Topcoat
3. Second Color Topcoat
4. Third Color Topcoat
5. Clearcoat

**Fig. 1, Spot Repair Cross Section, Scale Exaggerated for Clarity**

10.1 Stir or shake primer thoroughly.

10.2 Mix three parts F3995 epoxy primer with one part F3996 activator and one-half part F–series reducer.

10.3 Set the air pressure at the spray gun to 55 psi (379 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 ml) per minute.

10.4 Spray one wet coat to yield a minimum dry film thickness of 0.7 mils (18µm).

10.5 Clean equipment immediately after use with PPG Gun Cleaning Solvent.

10.6 Air dry 1 hour or force dry 20 minutes at 120 to 130°F (49 to 54°C).

11. If the original paint was a basecoat/clearcoat, hand rub the area around the spot repair with a medium grade compound to ensure a seamless finish. Use Scotch–Brite® 7448 or 2000-grit wet or dry sandpaper.

12. Remove the sanding dust. Use the same cleaner and wipe on, wipe off method used earlier to clean the area.

13. Wipe the repair area with a tack cloth.

# Topcoating a Spot Repair

## Delfleet® Evolution Single Stage Topcoating

1. Mix the Delfleet® Evolution Single Stage (FDGH) polyurethane enamel.

1.1 Stir the Delfleet® Evolution Single Stage (FDGH) polyurethane enamel thoroughly.

1.2 Mix three parts Delfleet® Evolution color (FDGH) with one part F3260 activator to 6 ounces additive F34XX per RTS gallon (44 ml per liter), to an optional 10 percent F33XX reducer. The pot life is 2 to 3 hours at 70°F (21°C). See **Table 1**.

| PPG Additives and Reducers | | |
|---|---|---|
| **Speed Rating** | **F34XX Additives** | **F33XX Reducers** |
| Fast Dry | F3400 | F3320 |
| Medium Dry | F3405 | F3330 |
| Slow Dry | F3410 | F3340 |
| Extra Slow Dry | — | F3350 |

**Table 1, PPG Additives and Reducers**

1.3 Mix thoroughly and strain.

NOTE: the viscosity of the mixture should be at 25 to 35 seconds in a No. 2 Zahn cup. Check the designated shelf life if using a product from a previously opened container.

2. Set the air pressure at 50 to 60 psi (345 to 414 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 ml) per minute. The fluid tip should be 1.3 to 1.5 mm.

3. Apply the solid or metallic color topcoat.

3.1 Spray one medium-wet coat over the primed area.

3.2 Flash 10 to 15 minutes.

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3.3 Apply a second medium-wet coat. Extend the spray area slightly to taper the edge and avoid a visible ring.

4. FDGH dry film thickness must be a minimum of 1.5 mils (38µm).
5. To air dry, allow overnight cure at 65°F (18°C) minimum.
6. To force dry, flash 5 to 10 minutes, then cure 40 minutes at 140°F (60°C) metal temperature.
7. If taping, allow 3 hours at 68°F (20°C). To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied.
8. If decals are to be applied, let the paint cure at 70°F (21°C) for 3 days prior to putting them on.
9. Clean the equipment immediately after use with PPG Gun Cleaning Solvent.

## Delfleet Evolution Basecoat/ Clearcoat Topcoating

1. **Option 1:** Mix the Delfleet Evolution Basecoat (FBCH) polyurethane enamel.
   1.1 Stir/shake the Delfleet Evolution Basecoat (FBCH) thoroughly.
   1.2 Mix three parts FBCH basecoat color with one part F3260 activator to one-half part F3440 converter. Pot life is 1 to 2 hours at 70°F (21°C) and 50 percent relative humidity.
   1.3 Mix thoroughly and strain.
   1.4 The viscosity of the mixture is 20 to 25 seconds in a No. 2 Zahn cup, depending on the color.
2. **Option 2:** Mix the Delfleet Evolution Basecoat-Fast (FBCS) polyurethane enamel.
   2.1 Stir or shake the Delfleet Evolution Basecoat-Fast (FBCS) color thoroughly.
   2.2 Mix three parts FBCS basecoat color with one part F3200. Ten percent F33XX Reducer is optional for this application. Pot life is 1 hour at 70°F (21°C) and 50 percent relative humidity.
   2.3 Mix thoroughly and strain.
   2.4 The viscosity of the mixture is 20 to 30 seconds in a No. 2 Zahn cup, depending on the color.
3. Set the air pressure at 50 to 60 psi (345 to 414 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 ml) per minute. The fluid tip should be 1.3 to 1.5 mm.
4. Apply the basecoat (FBCH or FBCS): Apply one or two coats of FBCH or FBCS basecoat color over the primed area until full hiding is achieved. Allow 5 to 10 minutes between coats.
5. If blending the repair area into the OEM finish, see instructions at the end of the top coat instructions.
6. Allow 30 minutes flash, prior to applying clearcoat.
7. If clearcoat is not applied within 8 hours, FBCH/ FBCS basecoat color must be sanded and recoated.
8. Mix the Delfleet Evolution High Build Clearcoat.
   8.1 Mix three parts Delfleet Evolution Clearcoat F3905 with one part F3240 activator to one-half part reducer (F33XX) to 2 ounces accelerator per RTS gallon (16 ml per liter). Pot life is 1 hour to 1.5 hours at 70°F (21°C) and 50 percent relative humidity. See **Table 2**.

| F33XX Thinner Selection | |
|---|---|
| **Speed Rating** | **F33XX Reducers** |
| Fast | F3320 |
| Medium | F3330 |
| Slow | F3340 |
| Extra Slow | F3350 |

**Table 2, F33XX Thinner Selection**

   8.2 Mix thoroughly and strain.
   8.3 The viscosity of the mixture is 32 seconds in a No. 2 Zahn cup.
9. Set the clearcoat air pressure at the spray gun at 45 to 55 psi (310 to 379 kPa). For pressure feed systems, set the fluid delivery at 12 to 16 ounces (350 to 470 ml) per minute. Use a 1.3 to 1.5 mm fluid tip.

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10. Apply 2 coats of F3905 clearcoat with a 10 to 15 minute flash time between coats to reach 2.0 mils (50 µm) minimum dry film thickness.

NOTE: For best results, apply the clearcoat over the entire panel.

11. Follow the steps below to blend the clearcoat:

    11.1 Apply one coat of the activated Delfleet Evolution F3905 Clearcoat.

    11.2 Mix one part DX840 to one part ready-to-spray F3905 clearcoat and apply this mixture to the blend edge. Additional DX840 may be added if a second coat to extend the blend edge is necessary or desired.

    11.3 Moving the gun from the outside in, mist a light coat onto the edge of the repair to melt in the dry overspray.

    11.4 To air dry, allow overnight cure at 65°F (18°C).

    11.5 If taping, allow 6 hours at 68°F (20°C). To prevent tape marking, remove all masking tape and paper immediately after the final coat is applied.

    11.6 To force dry, flash off up to 5 minutes, then dry for 40 minutes at 150°F (66°C).

    11.7 If sanding or polishing are desired, allow the finish to sit 16 hours if air dried, and 4 to 8 hours after bake cool-down before polishing.

    11.8 Clean the equipment immediately after use with PPG Gun Cleaning Solvent.

## Solid Color Blends in FBCH/FBCS/FDGH

1. Prepare the repair area as outlined above.
2. Spray color to full hiding in two or three coats, allowing specified flash time between coats.
3. Once hiding is achieved, pour out the remaining ready-to-spray (RTS) color from the gun.
4. Add several ounces of DX840 to the gun that still contains residual RTS color and lightly blend the outside edge.

NOTE: It is very important to add DX840 to the gun that still contains some residual RTS color. This keeps the outside edge from breaking or de-wetting.

5. For FBCH or FBCS repair jobs, apply clearcoat following a 30 minute flash time, or a similar force-dry.

## Blending Metallic Colors in FDGH and Blending Metallic/Pearl Colors in FBCH/FBCS

NOTE: Spot repairs in high-solid colors often show a dark ring or halo around their edges. Spraying a wet bed helps prevent the ring or halo when repairing high-solid colors.

On very light colors, it may be necessary to spray the wet bed completely to the edge of the panel but not over the repair area, to prevent the halo effect.

1. Follow the steps outlined above to prepare the area for applying the wet bed.
2. Prior to applying the wet bed, the area that is to receive the wet bed should be scuffed with a gray scuff pad and cleaned with an appropriate substrate cleaner.
3. Mix F3905. Reduce the RTS F3905 1:1 by volume with DX840 and spray a wet bed on the outside of the spot.

    3.1 Spray one medium-wet coat to establish the wet bed. Keep the wet bed 4 to 6 inches (10 to 15 cm) outside the repair spot.

    3.2 Apply the color system mixed as detailed in previous headings, but do not add DX840 in this step. Spray from the repair spot into the wet bed, while the wet bed is still wet.

    NOTE: Do not apply DX840 to the edge of the color in this application. Doing so causes a halo effect.

    3.3 For basecoat repairs, allow the color to become tack-free before applying the final overall color. The overall clearcoat (F3905) is not reduced with DX840. DX840 can be used to melt in the edges of the clearcoat, once this step is complete.