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# B35D & B40D 6 X 6

# ARTICULATED DUMP TRUCK

# OPERATION AND TEST MANUAL

**Document Part Number 872091**

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# TO THE SERVICE PERSONEL

**⚠ WARNING**

**Do not operate the machine unless you have read the Operator's Manual and fully understand how to operate the machine properly.**

This manual is written for an experienced technician and are on-the-job guides containing only the vital information needed for diagnosis, analyses, testing and repair. Essential tools required in performing certain service works are identified and in this manual and are recommended for use.

The safe operation of your ***BELL EQUIPMENT*** machines very important to prevent any personal injury and/ or damage. This manual must be read and fully understood before carrying out any tests on your ***BELL EQUIPMENT*** machine.

Right and left hand sides are determined by facing in the direction of forward travel.

This manual is divided into chapters. The information contained in the manual is in logical sequence, with the instructions written in step by step format.

Effective maintenance on your ***BELL EQUIPMENT*** machine is achieved when personnel fully understand the information contained in this manual.

Every effort has been made to ensure that the information contained in this manual was correct at the time of publication. ***BELL EQUIPMENT Co.*** has a policy of continuous product development, improvement, and design. ***BELL EQUIPMENT Co.*** reserves the right to change, amend and update the design of its product at any time without prior notice. With this policy, changes may have occurred that are not included in this manual.

Whilst every endeavour has been made to provide accurate and reliable information, ***BELL EQUIPMENT Co.*** specifically disclaims any actual or implied warranty and under no circumstances shall be liable for any loss, damage or injury to person or property suffered, whether direct, indirect or consequential, arising from the use of this manual. In particular and without detracting from above, the disclaimer also applies in the event of any specification, warning, or representation contained in this manual being inadequate, inaccurate, or unintentionally misleading.

The user is urged to strictly comply with the instructions and warnings that are given in the interests of general safety. Please do not hesitate to contact your ***BELL EQUIPMENT*** Product Support Representative whenever you have a query on your ***BELL EQUIPMENT*** product or this manual.

BELL EQUIPMENT

# SAFETY SYMBOL

The following safety symbol is used for all safety messages. When you see the safety symbol, follow the safety message to avoid personal injury or death.

**WARNINGS** and **CAUTIONS** must be read, fully understood and followed, before carrying out the action or maintenance procedure concerned.

**WARNINGS** and **CAUTIONS** are always placed before any action or maintenance procedure where personal injury and/or damage to the machine could occur if that action, test or maintenance procedure is not carried out correctly.



**WARNING AND CAUTION SYMBOL**

Throughout this manual the word **WARNING** is used to alert the operator and others of the risk of personal injury during the operation of the equipment. **CAUTION** indicates the possible damage to the machine. **NOTE** highlights information of special interest.

**⚠ CALIFORNIA PROPOSITION 65 WARNING**

**Diesel engine exhaust and some of its constituents are known to the state of California to cause Cancer, birth Defects and other Reproductive Harm.**

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# B35D and B40D 6X6 ARTICULATED DUMP TRUCK OPERATION AND TEST MANUAL

## THIS MANUAL IS APPLICABLE TO

## B35D 6X6 (E359835)
## B40D 6X6 (E409840)

**Document Part Number 872091**

**Issue:0**
(Revised:)

Technical Documentation
BELL EQUIPMENT COMPANY
Richards Bay

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## IMPORTANT

Due to ***BELL EQUIPMENT'S*** policy of continuous product improvement, the information contained in this manual was correct up to the time of printing (Revised date of manual). Any changes after this date will only be included in the next update of this manual.

The illustrations in this manual are pictorial and not necessarily true representations of components. Photographs and illustrations may show optional equipment.

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# ABBREVIATION LIST

The table below lists the abbreviations used in this manual:

| Abbreviation | Meaning |
|---|---|
| ºC | degrees Celsius |
| ºF | degrees Fahrenheit |
| A | ampere |
| ADT | Articulated Dump Truck |
| Ah | ampere hours |
| CB | circuit breaker |
| d | diagnostic |
| D | drive |
| DNS | Do Not Shift |
| ECU | Electronic Control Unit |
| FOPS | Falling Objects Protective Structure |
| ft | foot (feet) |
| ft lb | foot pound |
| HP | Horsepower |
| ISO | International Standards Organisation |
| kg | kilogram |
| km | kilometre |
| km/h | kilometres per hour |
| kPa | kilo pascal |
| kW | kilowatt |
| lb | pound |
| LCD | Liquid Crystal Display |
| LED | Light Emitting Diode |

| Abbreviation | Meaning |
|---|---|
| m | metre |
| $m^3$ | cubic metre |
| N | Neutral |
| m.p.h. | miles per hour |
| MSDS | Material Safety Data Sheet |
| Nm | Newton metre |
| psi | pounds per square inch |
| PTO | Power Take-Off |
| R | Reverse |
| r.p.m. | revolutions per minute |
| ROPS | Roll Over Protective Structure |
| SMR | Service Meter Reading |
| USGAL | United States Gallon |
| V | Volt |
| $yd^3$ | cubic yard |
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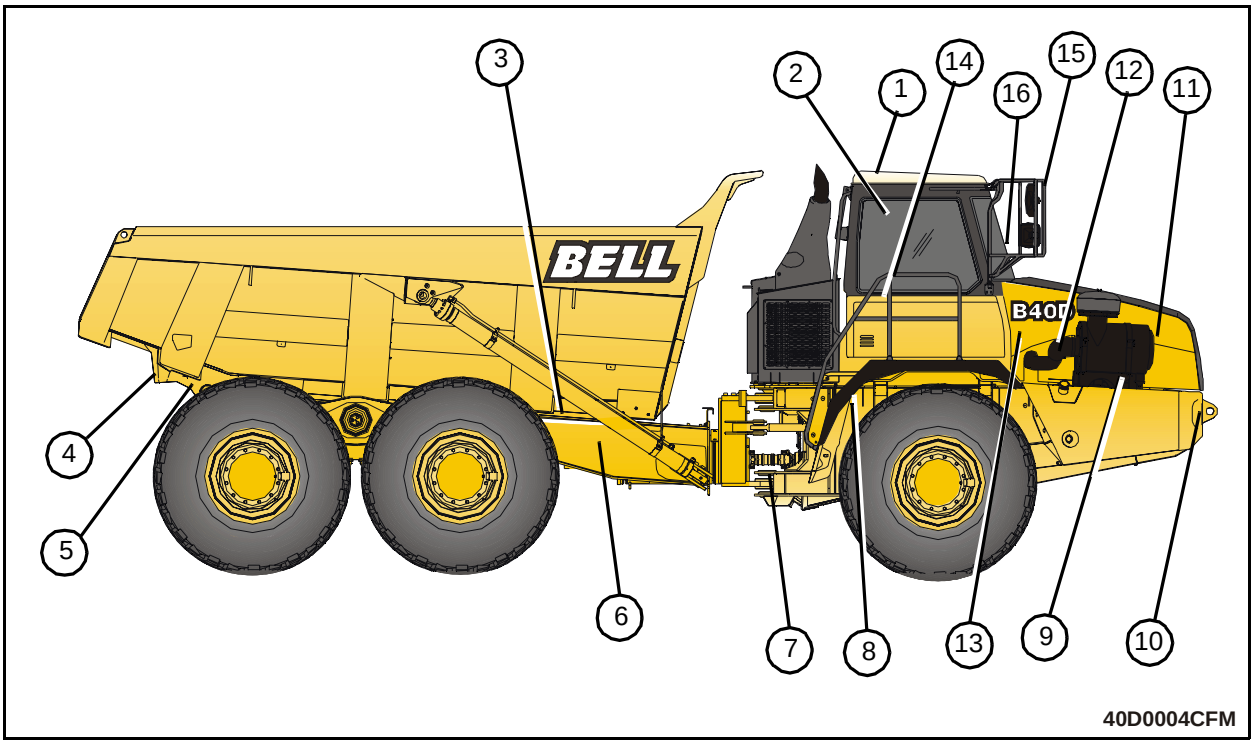
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# SAFETY

## Specification

This machine complies to the CE Specification.

## Safety Features




1. **ROPS/FOPS Cab Protection**. The Roll Over Protective Structure has been certified to meet specified test requirements according to SAE J1040 and ISO 3471. The Falling Objects Structure has been certified to meet specified test requirements according to SAE J/ISO 3449 and ISO 3449.

2. **Cab with Heater/Defroster**. Positive pressure ventilation system circulates both outside and inside air through filters for a clean working environment. Built in defroster vents direct air flow for effective window de-fogging/de-icing.

3. **Bin Service Lock.**

4. **Stop/Back lights**. Highly visible lights.

5. **Backup Alarm.**

6. **Independent Parking Brake**.

7. **Articulation locking Bar.**

8. **Secondary Steering**. Ground driven, continuously in operation. Secondary steering indicator light will light when activated.

9. **Horn**.

10. **Halogen Lights and Turn Signals.**

11. **Engine Fan Guard.**

12. **Bypass Start Protection.**

13. **Exhaust Brake and Transmission Retarder (If Equipped).**

14. **Safety Belt Retractors.**

15. **Mirrors.**

16. **Large Windshield Wiper With Washer.**

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## Material Safety Data Sheets (MSDS)

The Federal Occupational, Safety and Health Administration (OSHA) Standard 29 CFR 1910.1200 and in some cases, State and Local Right-to-Know laws, may require that specific **MSDS** be available to the employees prior to operating this equipment. This may include information on substances contained in this equipment such as antifreeze, engine oil, battery acid, hydraulic fluid and freon (if equipped with an air conditioner).

To ensure a prompt response, please be sure to include your return address and ZIP (postal) code, along with the model, serial number and/or **VIN** number of your machine.

## Unauthorised Modifications of the Roll Over Protective Structure (ROPS) and the Falling Objects Protective Structure (FOPS)

Do not make unauthorised modifications or alterations to the ROPS and FOPS such as: welding on extinguisher brackets, CB aerial brackets, fire suppression systems etc. Unauthorised modifications will affect the structural limits of the ROPS and FOPS and will void the certification.

The Roll Over Protective Structure has been certified to meet specified test requirements according to SAE J1040 and ISO 3471. The Falling Objects Protective Structure has been certified to meet specified test requirements according to SAE J/ISO 3449 and ISO 3449.

Any planned modification or change must be reviewed in advance by the ***BELL EQUIPMENT*** **Engineering Department** to determine if the modification or change can be made within the limits of the certifying tests. It is important that each person in your organisation, including management, be made fully aware of these rules involving **ROPS** and **FOPS**. Whenever anyone sees unauthorised modifications or changes to a machine's **ROPS** or **FOPS** both the customer and manufacturer must be notified in writing.

Make sure that all parts are installed correctly if the **ROPS** or **FOPS** is loosened or removed for any reason. Tighten mounting bolts to the correct torque. The protection offered by **ROPS** or **FOPS** will be impaired if they are subjected to structural damage, is involved in an overturn incident, or is altered in any way. A damaged **ROPS** or **FOPS** must be replaced, not reused.

## Noise Emission Levels

The sound pressure was tested according to ISO 6394 (SAE J/ISO 6394) and the sound power was tested according to ISO 6393 (SAE J 2102).\plain \par

## General Safety

Be sure all operators of this machine understand every safety message. Replace operator's manual and safety decals immediately if missing or damaged.

### Safety Regulation

Every country (State) has its own safety regulations. It is the obligation of the operator to know and follow these. This also applies to local regulations covering different types of work. Should the recommendations in this manual deviate from those of your country, your local safety regulations should be followed.

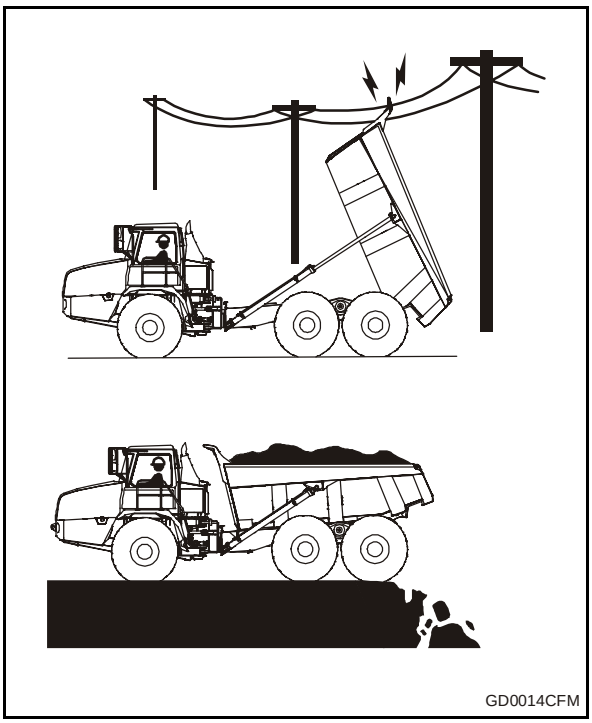
### Mounting and Dismounting the Machine

Always use the handrails and steps provided to get on and off the machine. Use both hands and face the machine. Never get on or off a moving machine. Never jump off the machine. Use a hand line to pull equipment up onto the platform, do not climb on or off the machine carrying tools or supplies.

Use extra care when mud, snow, or moisture present slippery conditions. Keep steps clean and free of grease, oil and foreign objects.

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## Avoid Work Site Hazards




### Avoid Overhead Power Lines

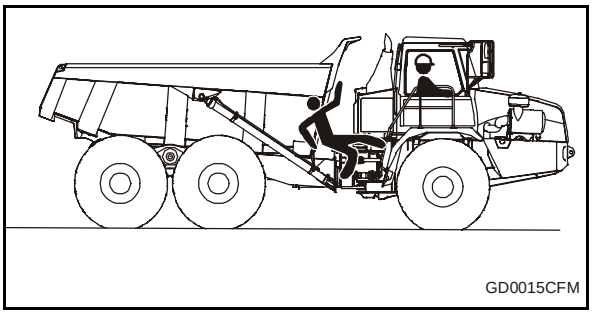
Never move any part of the machine within 3 m (10 ft) plus twice the line insulator length, as serious injury or death may result.

### Operate Only On Solid Footing

Operate only on solid footing with strength sufficient to support machine. Be alert working near embankments, excavations and with bin raised. Avoid working on surfaces that could collapse under machine.

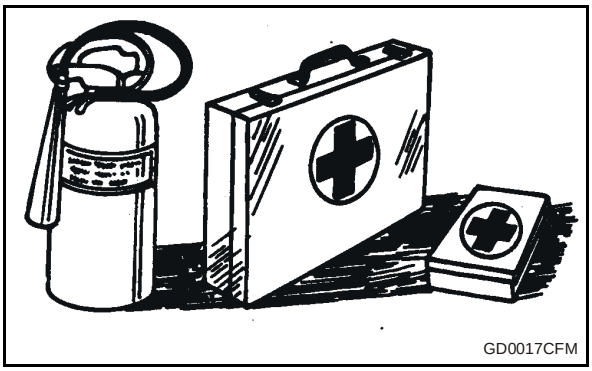
Use caution when backing up to berms before dumping load.

## Keep Riders Off the Machine



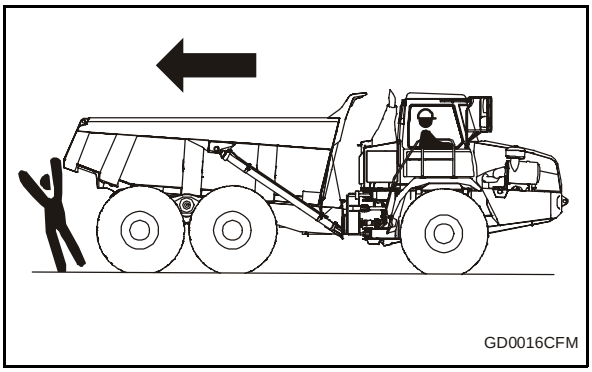

Do not allow unauthorised personnel on the machine.

## Prepare for Emergencies




Keep a first aid kit and fire extinguishers handy and know how to use them. Inspect and have your extinguisher serviced as recommended on its instruction plate. Keep emergency numbers for doctors, ambulance service, hospital and fire department near your telephone.

## Avoid Backing Over Accidents




Make sure all persons are clear of machine path before moving the machine. Where conditions permit, raise bin for better visibility to the rear. Use mirrors to assist in checking all round machine.

Keep windows, mirrors and backup alarm clean and in good condition.

Use a signal person when backing if view is obstructed and/or in close quarters. Keep signal person in view at all times.

Use prearranged hand signals to communicate.

## Handle Chemical Products And Flammable Fluids Safety

Exposure to hazardous chemicals can cause serious injury. Under certain conditions, lubricants, coolants, paints and adhesives used with this machine may be hazardous.

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If uncertain about safe handling or use of these chemical products, contact your authorized dealer for a Material Safety Data Sheet (MSDS).




Handle fuel with care, as it is highly flammable. Do not smoke or go near an open flame or sparks while refuelling. Always stop the engine before refuelling the machine and fill the fuel tank outdoors.

Keep all fuels and lubricants in properly marked containers and away from all unauthorised persons. Do not smoke in the storage areas.

Store oily rags and other flammable material in a protective container, in a safe place.

Do not weld or flame cut pipes or tubes that have contained flammable fluids. Clean them thoroughly with nonflammable solvent before welding or flame cutting them.

Starting fluid is highly flammable. Keep all sparks and flames away when using it. To prevent accidental discharge when storing the pressurised can, keep the cap on the can and store it in a cool protected place. Do not burn or puncture a starting fluid container.

## Clean the Machine Regularly

Wait until the engine has cooled before removing trash from areas such as the engine, radiator, batteries, hydraulic lines, fuel tank and operators cab. Remove any grease, oil or debris build-up. Keep the machine, especially the walkways and steps, free of foreign material, such as debris, oil, tools and other items which are not part of the machine.

## Prevent Battery Explosions and Acid Burns




The standard battery supplied with the machine is a sealed type that does not need maintenance. keep sparks and flames away from the batteries.

If a non-sealed battery is subsequently installed, keep sparks and flames away from the batteries. Use a flashlight to check the battery electrolyte level. Use a voltmeter or hydrometer to check battery charge. Never place a metal object across the posts. Always remove the grounded (Negative -) battery clamp first and replace it last.

Do not smoke in areas where batteries are being charged.

Sulphuric acid in battery electrolyte is poisonous and is strong enough to burn skin, eat holes in clothing and cause blindness if splashed into the eyes.

### Avoid the hazard by:

- Filling the batteries in a well ventilated area.
- Wearing eye protection and rubber gloves.
- Avoid breathing fumes when electrolyte is added.
- Avoid spilling or dripping electrolyte.

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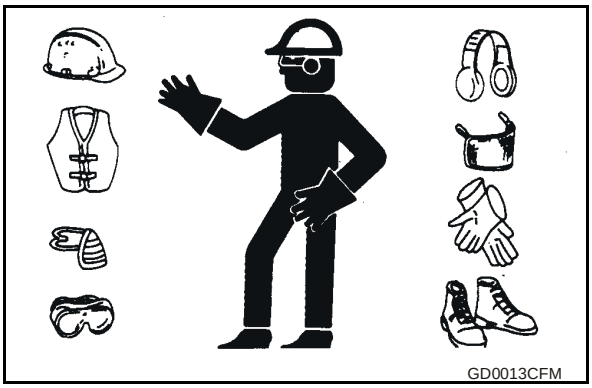
**If you spill acid on yourself:**

- Flush your skin with water.
- Apply baking soda or lime to help neutralise the acid.
- Flush your eyes with water for 10 - 15 minutes and get medical attention immediately.

**If acid is swallowed:**

- Drink large amounts of water or milk.
- Then drink milk of magnesia, beaten eggs, or vegetable oil.
- Get medical attention immediately.

## Wear Protective Equipment




Wear a hard hat, protective glasses and other protective equipment as required by the job conditions. Do not wear loose clothing or jewellery that can catch on controls or other parts of the machine.

When you drive connecting pins in or out, guard against injury from flying pieces of debris by wearing goggles or protective glasses. Prolonged exposure to loud noise can cause impairment or loss of hearing. Wear a suitable hearing protective device such as earmuffs or earplugs. Wear gloves when handling wire rope cable.

## Use the Seat Belt

Use a seat belt at all times to minimise the chance of injury in an accident.

The seat belt must not be altered or modified in any way. Such changes can render the belt ineffective and unsafe.

The seat belt is designed and intended for the seat's occupant to be of adult build and for one occupant of the seat only.

## Avoid High Pressure Fluids

Escaping fluid under pressure can penetrate the skin causing serious injury. Relieve the pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Keep hands and body away from pinholes and nozzles which eject fluids under high pressure. Use a piece of cardboard or paper to search for leaks.

If any fluid is injected into the skin it must be surgically removed within a few hours by a doctor who is familiar with this type of injury or gangrene may result.

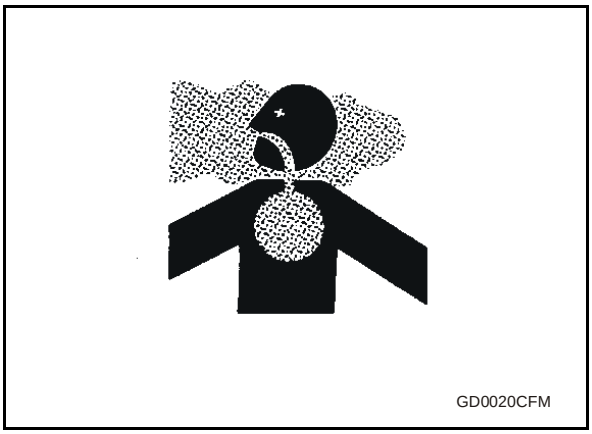
## Stay Clear Of Moving Parts

Entanglements in moving parts can cause serious injury.

Stop engine before examining, adjusting or maintaining any part of the machine with moving parts.

Keep guards and shields in place. Replace any guard or shield that has been removed for access as soon as service or repair is complete.

## Beware of Toxic Fumes




Prevent asphyxiation. Engine exhaust fumes can cause sickness or death.

Operate only in well ventilated indoor areas. Avoid hazardous fumes by first removing paint on painted surfaces before welding.

Wear an approved respirator when sanding or grinding painted surfaces.

If a solvent or paint stripper is used, wash surface with soap and water. Remove solvent or paint containers before welding and allow at least 15 minutes before welding or heating.

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## Dispose of Waste Properly

Improper disposal of waste can threaten the environment. Fuel, oils, coolants, filters and batteries used with this machine may be harmful if not disposed of properly.

Never pour waste onto the ground, down a drain or into any water source.

Air conditioning refrigerants can damage the atmosphere. Government regulations may require using a certified service centre to recover and recycle used refrigerants.

If uncertain about the safe disposal of waste, contact your local environmental centre or your dealer for more information.

## Start Only From Operator's Seat


GD0022CFM

Avoid unexpected machine movement. Start engine only while sitting in operator's seat. Ensure all controls and working tools are in proper position for a parked machine.

Never attempt to start engine from the ground. Do not attempt to start engine by shorting across the starter solenoid terminals.

Lower bin during work interruptions, apply park brake and be careful not to accidentally actuate controls when co-workers are present.

## Operating The Machine

### Avoid Tip Over

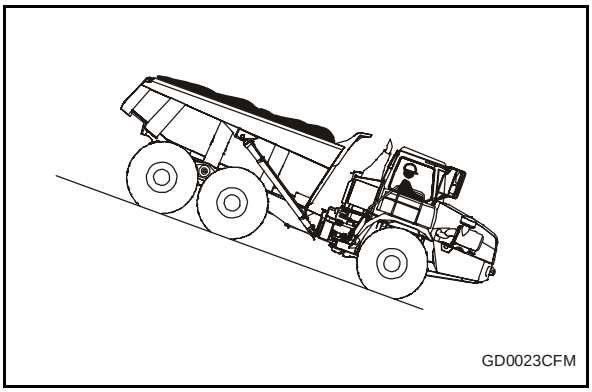
Use safety belt at all times. Do not jump from machine if it tips.

Use extra care when bin is raised. Machine stability is greatly reduced when bin is raised. Drive slowly, avoid sharp turns and uneven ground.

Do not over load the machine.

Before operating machine after it has tipped, carefully inspect all hydraulic and electrical lines.

### Operating on Slopes


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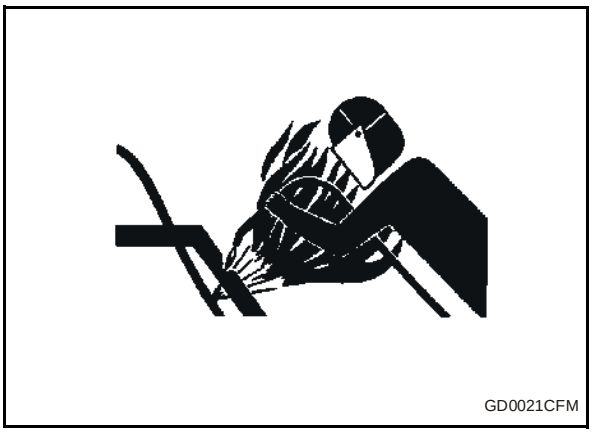
Avoid side slope travel whenever possible.

Check service brakes frequently when operating on slopes

The maximum slope will be limited by the ground conditions.

## Welding Repairs

NOTE:Disable electrical power before welding. Turn off main battery switch or disconnect positive battery cable. Separate harness connectors to engine, alternator and vehicle microprocessors.


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Avoid welding near fluid lines. Do not let heat go beyond work area near fluid lines.

Remove paint properly. Wear eye protection and protective equipment when welding.

Do not inhale dust or fumes.

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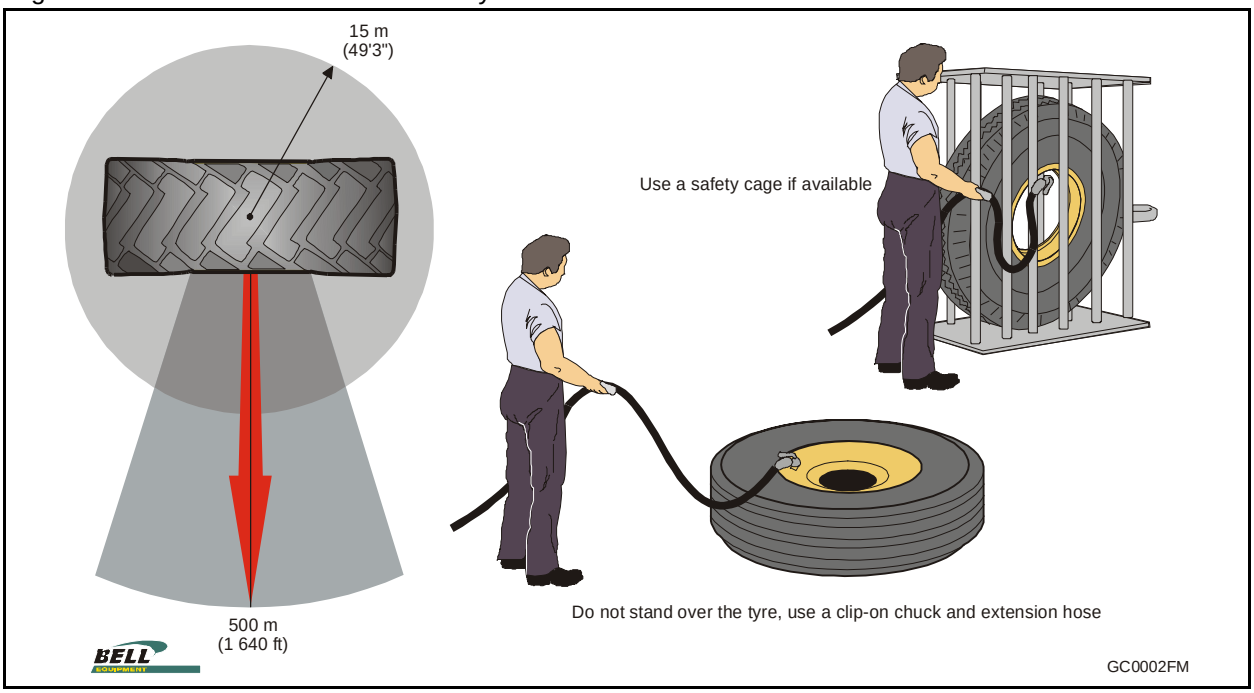
## Tyre Information

Welding or heating of the rim components, external fire or excessive use of brakes can cause overheating of the tyres, which could cause a tyre explosion.

This explosion can propel the tyre, rim and final drive components approximately 500 metres (1 640ft) from the machine, which may cause personal injury or death and/or property damage.

If the tyre is overheating and could explode, do not approach it within the area represented by the shaded area in the drawing, until it has cooled.

Stand behind the tread and use a self attaching chuck with extension hose to inflate the tyres. Use a safety cage if available. Do not stand over the tyre.




NOTE:It is recommended that only trained personnel service and change tyres and rims.

## Inspect and Maintain ROPS

A damages roll-over protective structure (ROPS) should be replaced, not reused.

If the ROPS was loosened or removed for any reason, inspect it carefully before operating the machine again.

### To Maintain the ROPS:

- Replace missing hardware using correct grade hardware.
- Check hardware torque.
- Check isolation mounts for damage, loose-ness or wear; Replace if necessary.
- Check ROPS for cracks or physical damaged.

## Drive Metal Pins

Always wear protective goggles or safety glasses and other safety equipment.

Use soft hammer or a brass bar between hammer and object to prevent chipping.

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# BULLETINS

Record the relevant information from the Technical Documentation Bulletins, Service Bulletins and Parts Bulletins into this manual as follows:

- Ensure the manual number (87--------) reflected in the bulletin is the same as the 87------ number at the top of the main content pages.
- Carry out the instructions as detailed in the bulletin.
- Record the required information below.
- File the bulletins in numerical order in a suitable 3 or 4 ring binder.

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# USER'S INFORMATINON FEEDBACK FORM

Should you, as user of this manual, have any suggestion for improving the manual, or you find any errors or omissions, then we would like to know.

Please complete a facsimile of this form and hand it in to your nearest ***BELL EQUIPMENT*** Product Support Representative or post it directly to your nearest ***BELL EQUIPMENT*** Branch. Addresses are given in the Operator Maintenance Manual.

Ideas, Comments (Please State Page Number):_____

_____

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Machine Model: _____

Serial Number:_____

VIN: _____

Page Number: _____

OVERALL, how would you rate the quality of this publication? (Check one)

| Poor | | Fair | | Good | | Very Good | | Excellent | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

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Technician Name: _____

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# CHAPTER 1. OPERATIONAL CHECK-OUT PROCEDURE

## OPERATIONALCHECK-OUT

Use this procedure to check operation of the machine. This procedure is designed so you can make a quick check of the machine operation while performing specific checks from the operator's seat.

Should you experience a problem with the machine, you will find helpful diagnostic information in this check-out that will help pinpoint the cause.

A location will be required which is level and has adequate space to perform the check-out procedure. No tools or equipment are required to perform the check-out procedure.

Compete the necessary visual checks (oil levels, oil condition, external leaks, loose hardware, linkages, wiring, etc.) prior to doing the operational check-out. The machine must be at operating temperature for many of the checks.

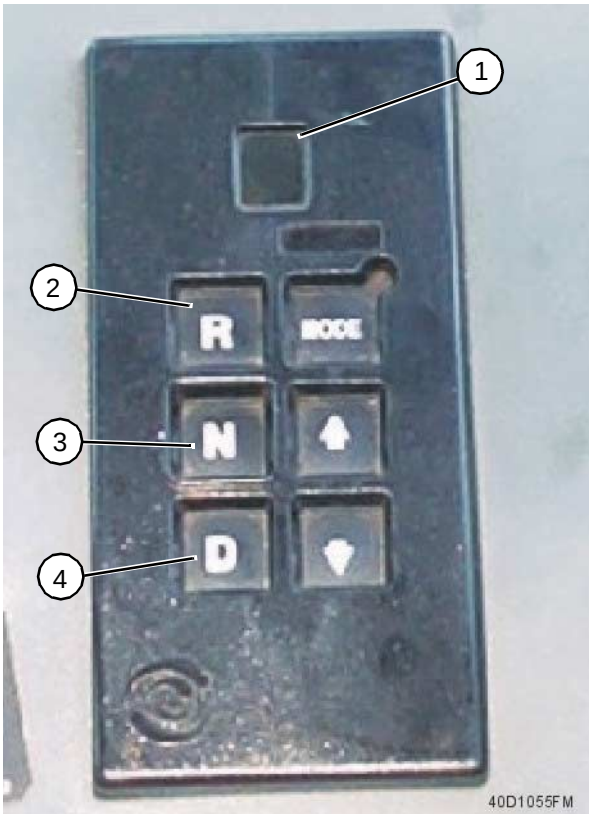
Start at the top of the left column and read completely down column before performing check. Follow this sequence from left to right. In the far right column, if no problem is found, you will be instructed to go to next check. If a problem is indicated, you will be referred to either a chapter in this manual for specific test or the repair manual for repair procedure.

## OPERATIONAL CHECKS - KEY SWITCH ON, ENGINE OFF

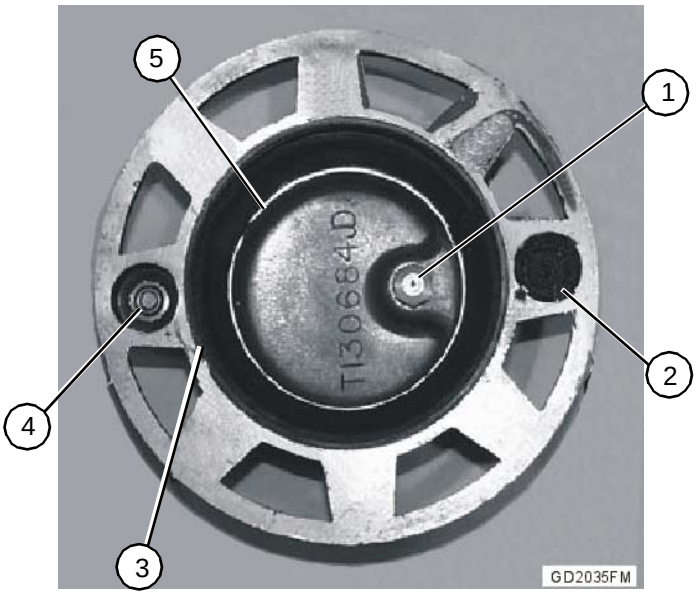
Turn battery disconnect switch **ON**. Turn key switch to **ON** position.

| Checks | Questions/Tasks | Results |
|---|---|---|
| Gauges and Indicator Lights | Do all indicator lights come **ON** or flash?<br>Do all gauges and speedometer move to centre position?<br>Do all sections of monitor liquid crystal display's appear?<br>Do all sections of transmission control display and mode button indicator light come **ON?**<br>Does audible alarm come **ON**?<br>**NOTE:1. Cold start indicator light will remain ON for a maximum of 20 seconds in low ambient temperature conditions.**<br>**2. Air pressure indicator may remain ON, depending on system air pressure.**<br>Do all gauges and displays return to normal operation mode and audible alarm go **OFF** after 3 seconds?<br>Do all indicator lights, except for secondary steering (marked emergency steering), battery charge and park brake go **OFF**? | **YES:** Go to next check.<br>**NO:** Check circuit breakers and fuses. Reset circuit breakers and/or replace fuses as necessary.<br>Check indicator light bulbs. Replace if necessary.<br>Go to **("Menu Display Unit Circuit Theory of Operation" on page 86).** |

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| Checks | Questions/Tasks | Results |
|---|---|---|
| Transmission Shift Control |  <br>Do all sections in display (1) illuminate forming a “**O**” with an “**X**” in it?<br>Does “**N**” appear in the display after 2 seconds?<br>Press “**D**” (Drive) (4) on the gear selector.<br>Does “**6**” appear in the display (1) and remain?<br>Press “**R**” (Reverse) (2) on the gear selector.<br>Does “**R**” appear in the display and remain?<br>Press “**N**” (Neutral) (3) on the gear selector.<br>Does “**N**” appear in the display and remain?<br>Does shift control operate correctly? | **YES:** Go to next check.<br>**NO:** Replace transmission shift control. |

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| Checks | Questions/Tasks | Results |
|---|---|---|
| Fuel cap |  <br>Remove fuel tank cap.<br>Does centre of vacuum valve (1) move freely?<br>Is screen (2) clean and not plugged?<br>Is rubber seal (3) not damaged?<br>Does ball in pressure valve (4) moves freely?<br>Is vent hole (5) not plugged?<br>Are all parts in serviceable condition? | **YES:** Go to next check.<br>**NO:** Replace parts as needed or replace fuel tank cap. |

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## OPERATIONAL CHECKS - ENGINE ON

| Checks | Questions/Tasks | Results |
|---|---|---|
| Gauges and Indicator Lights | Start engine.<br>**NOTE:1. Low air pressure alarm will be ON until air pressure reaches normal operating pressure.**<br>**2. Transmission oil temperature gauge will not begin to indicate temperature until transmission oil is close to operating temperature.**<br>Do all indicator lights, except park brake indicator light, go **OFF** after the engine starts?<br>Does the Menu Display Unit display engine speed?<br>Does engine oil pressure gauge display engine oil pressure?<br>Does needle of gauge indicates pressure is increasing to green (Normal)?<br>Check air pressure gauge immediately after the engine has started.<br>Does needle of gauge indicates pressure is increasing to green (Normal)? | **YES:** Go to next check.<br>**NO:** Go to **("Menu Display Unit Circuit Theory of Operation" on page 86).** |
| Service Brake Accumulator. | Apply brakes repeatedly until main hydraulic pump strokes to charge accumulators. When accumulators are fully charged, pump will destroke. Turn engine "**OFF"**.<br>Turn key switch "**ON**" again and wait for indicator lights to go "**OFF**"<br>Apply the service brakes, counting the number of applications until the accumulator low pressure light illuminates.<br>**B35D:** Does the light illuminates after three brake applications (Minimum)?<br>**B40D:** Does the light illuminates after two brake applications (Minimum)? | **YES:** Go to next check.<br>**NO:** Go to **("FRONT AND REAR BRAKE ACCUMULATORS PRESSURE TEST AND CHARGE PROCEDURE" on page 399).** |

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| Checks | Questions/Tasks | Results |
|---|---|---|
| Service Brake. | **NOTE:Perform this check in an open area where machine can travel at full speed.**<br><br>Drive machine slowly.<br><br>Apply brake pedal to stop machine.<br><br>Release the brake pedal.<br><br>Does brake pedal push easily without binding?<br><br>Does brake pedal return to the released position so brakes are not dragging?<br><br>Do brakes stop machine in a reasonable distance without pulling to one side or making noise?<br><br>Drive machine at full speed.<br><br>Release accelerator and apply brake pedal to stop machine.<br><br>Do brakes stop machine in a reasonable distance without pulling to one side or making noise? | **YES:** Go to next check.<br><br>**NO:** Go to **(“Service Brake System Malfuntion” on page 378)**. |
| Park Brake | **⚠ CAUTION**<br>**Machine will stop abruptly during this check. Fasten seat belt. Perform check in open area.**<br><br>Start engine.<br><br>Move park brake lever forward<br><br>Drive machine at slow idle in 1 st gear at ~ 5 km/h (3 m.p.h.). Pull park brake lever rearward until it locks into position.<br><br>Does park brake indicator light illuminates?<br><br>Does park engages and machine stops | **YES:** Continue check.<br><br>**NO:** Go to **(“DIAGNOSE POWER TRAIN SYSTEM MALFUNTIONS” on page 281)**. |
| | With engine “**ON**”, transmission in “**N**” (Neutral) and park brake “**ON**” move park brake forward.<br><br>Shift transmission to “**D**” (Drive).<br><br>Slowly increase engine speed.<br><br>Does machine move when engine speed is just above slow idle?<br><br>Return engine to slow idle.<br><br>Shift transmission to “**N**” (Neutral). | **YES:** Go to next check.<br><br>**NO:** Go to **(“DIAGNOSE POWER TRAIN SYSTEM MALFUNTIONS” on page 281)**. |

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| Checks | Questions/Tasks | Results |
|---|---|---|
| Steering | Park machine in an open area, on a hard level surface.<br>Turn inter-axle switch to the "**OFF**" position.<br>Release park brake.<br>Release service brakes.<br>Run engine at slow idle.<br>Turn steering wheel fully left and then fully right.<br>Does machine turn smoothly in both directions. | **YES:** Continue check.<br>**NO:** Go to **("Steering System Malfunctions" on page 380)**. |
| | Run engine at fast idle.<br>Turn steering wheel fully left then right.<br>Does machine turn smoothly in both directions. | **YES:** Go to next check.<br>**NO:** Go to **("Steering System Malfunctions" on page 380)**. |

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| Checks | Questions/Tasks | Results |
|---|---|---|
| bin | **⚠ CAUTION**<br>**Avoid possible serious injury from machine movement. Clear area of all bystanders before performing test. Area must have enough overhead clearance to raise bin to full height of 7226 mm (23 ft. 8.5 in.). Do not perform this test within 4 m (13ft.) of high voltage power lines.**<br><br>Perform this check in an open area, clear of bystanders.<br><br>Position the machine frames straight.<br><br>Operate the engine at 1500 r.p.m.<br><br>Pull bin control lever rearward to raise bin.<br><br>When bin is almost complete up, reduce engine speed to slow idle.<br><br>Does bin raise to full height smoothly? | **YES:** Continue check.<br><br>**NO:** Go to **(“Hydraulic System Malfunctions” on page 374).** |
| | Release bin control lever.<br><br>Does bin control lever return to neutral position? | **YES:** Continue check.<br><br>**NO:** Go to bin Control Valve Operation. **(See Chapter 21, SECTION 1, Repair Manual)** |
| | Push bin control lever to full forward detent bin float position and release lever.<br><br>Does the control lever stay in the float position until the last 5% (3.5°) of body travel, at which time the lever returns to neutral position?<br><br>Dos bin lower to full down position smoothly? | **YES:** Go to next check.<br><br>**NO:** Go to (**“Bin Control, Fan Drive and Range Hold Circuit Theory of Operation” on page 78).** |

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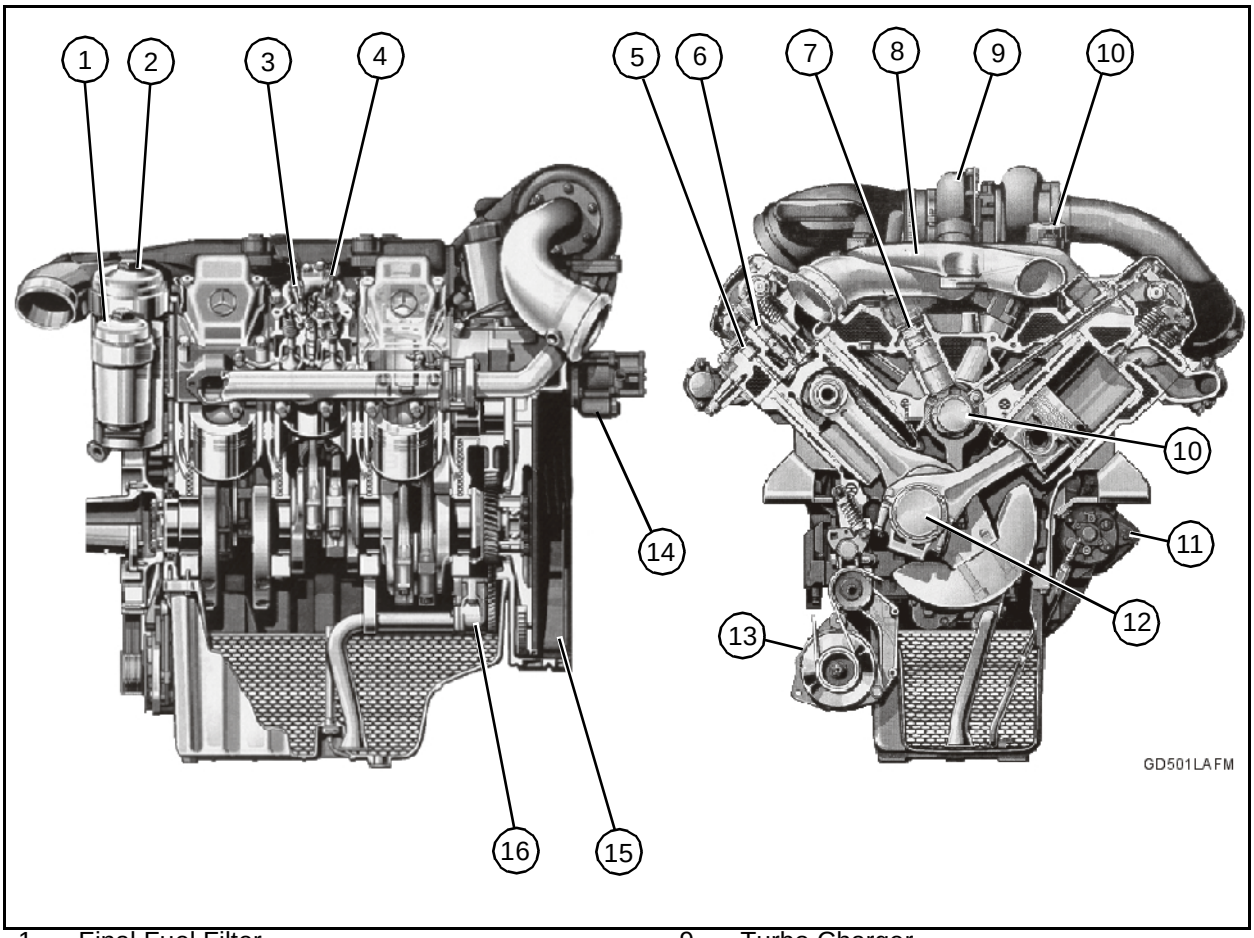
| Checks | Questions/Tasks | Results |
|---|---|---|
| Viscous Fan Drive | **NOTE:Engine must be cool or fan may not turn freely by hand.**<br><br>Allow engine to cool.<br><br>Turn fan by hand, feel for rough bearing or fan not turning freely.<br><br>Does fan turn freely and smoothly?<br><br>Start engine and run 2 -3 minutes.<br><br>Check that fan turns at near engine speed, then slows down. As engine warms to normal operating temperature, fan will speed up to near engine speed.<br><br>Does fan speed increase as engine warms?<br><br>Turn engine "**OFF**" | **YES:** Do to next check.<br><br>**NO:** Replace viscous fan drive. |
| Exhaust Smoke | Start engine and allow to warm to normal working temperature.<br><br>Operate machine under full load at fast engine speed.<br><br>Observe exhaust colour.<br><br>No smoke is normal.<br><br>Blue smoke indicates faulty or stuck piston rings.<br><br>White or grey smoke indicates stuck piston rings, fuel cetane too low or engine running too cold.<br><br>Heavy black smoke indicates injection nozzles faulty, engine injection system incorrect, fuel cetane to low or air filter element clogged.<br><br>Is engine exhaust smoke normal colour? | **YES:** Continue to next check.<br><br>**NO:** Go to **("SECTION 2. DIAGNOSE ENGINE MALFUNCTIONS" on page 45).** |
| Engine Speed | Start engine and warm to normal operating temperature.<br><br>Run engine at slow idle; Record r.p.m.<br><br>Is engine speed 600 ± 20 r.p.m?<br><br>Increase engine speed to fast idle. Record r.p.m.<br><br>Is engine speed 2240 ± 20 r.p.m. | **YES:** Check complete.<br><br>**NO:** Do slow and Fast idle Adjustment. **(See "SLOW AND FAST IDLE ADJUSTMENT" on page 49).** |

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# CHAPTER 2. ENGINE

## SECTION 1. THEORY OF OPERATION

### ENGINE

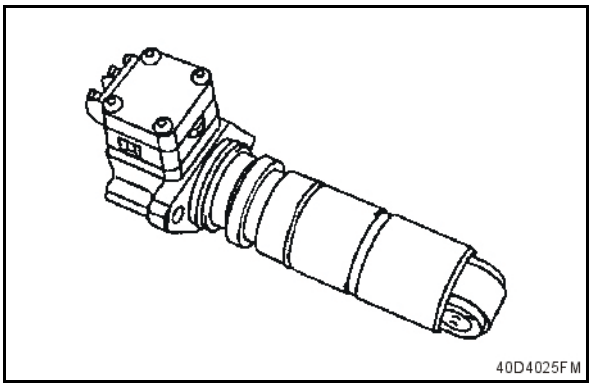



1. Final Fuel Filter.
2. Oil Filter.
3. Engine Exhaust Valve Rocker Arm.
4. Engine Intake Valve Rocker Arm.
5. Engine Exhaust Valve Brake.
6. Fuel Delivery Nozzle.
7. Electronic Unit Injector (EUI).
8. Intake Manifold.
9. Turbo Charger
10. Camshaft
11. Starter Motor.
12. Crankshaft.
13. Alternator.
14. Fuel Pump.
15. Flywheel.
16. Oil Pump.

The engine is liquid cooled, 90° V-6 cylinder. The cast iron block is one piece and each cylinder has a separate cylinder head. It has overhead valves, 4 per cylinder, two intake valves and two exhaust valves. Roller cam followers ride on the camshaft which move the push rods that open and close the valves. The EUI's (Electronic Unit Injectors) also ride on the camshaft which send pressurized fuel through a fuel pipe to the fuel delivery nozzles, which are located directly over the top of the piston. The EUI's are electronically controlled by the EUI controller, a crankshaft position sensor, camshaft position sensor and a solenoid.

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## Electronic Unit Injector Fuel System




The EUI system is designed to precisely control:

- The start of injection,
- An accurate delivery of a calculated amount of fuel.
- A sharp end of injection.

The fuel system consists of four sub-systems;

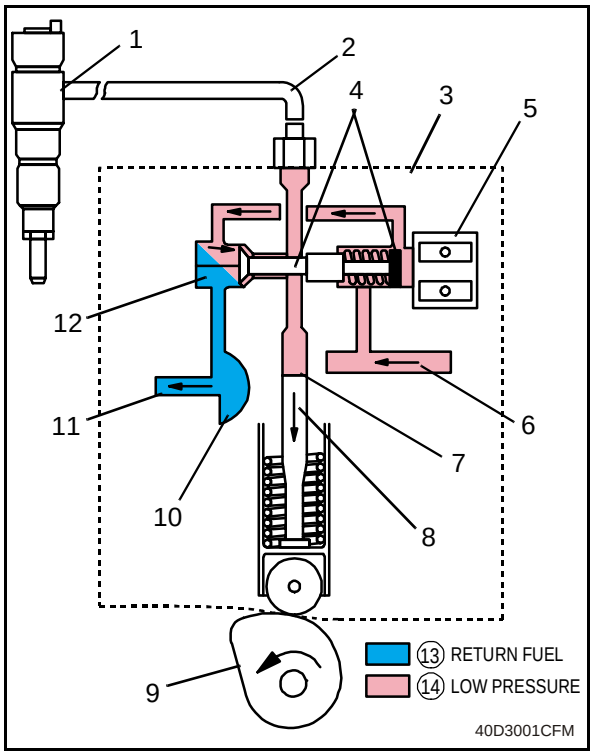
- Low Pressure Supply System,
- High Pressure System - Unit Injectors,
- Fuel Delivery Nozzles,
- Control System.

The electronic unit injector fuel system has these notable features:

- Precision control of timing and fuel delivery,
- Field proven reliability,
- Electronic control of each cylinder,
- One unit injector per cylinder,
- High injection pressures,
- Low emissions,
- Compact design,
- Eliminates injection pump,
- No injection timing adjustment required.

### Fuel Delivery

#### Suction Stage



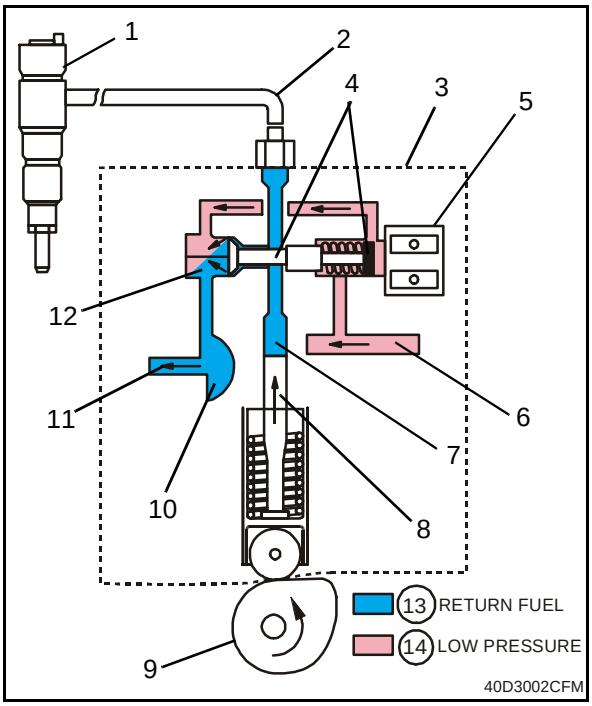

1. Fuel Delivery Nozzle.
2. Connector Pipe.
3. EUI (Electronic Unit Injector).
4. Valve.
5. Solenoid.
6. Supply Gallery in Crankcase.
7. High Pressure Chamber.
8. Pump Plunger.
9. Engine Camshaft.
10. Pressure Relief Chamber.
11. Return Flow Gallery in Crankcase.
12. Bleed-Off Chamber.
13. Return Fuel.
14. Low Pressure.

The EUI's (3) ride on individual lobes on the engine camshaft (9). There is one EUI per cylinder. The EUI's are mounted in the block of the engine under the intake manifold. There are passages in the block that route fuel to and from the EUI's. The fuel delivery nozzles (1) are located in the cylinder head and are positioned directly above the pistons. A connector pipe (2) is used to direct fuel from the EUI's to the nozzles. Internal passages in the cylinder heads allow excess fuel from the nozzles to be bled off. A solenoid (5) controls the fuel metering valve (4). For complete electrical theory of the EUI **SEE "ELECTRONIC UNIT INJECTOR CONTROLLER CIRCUIT THEORY OF OPERATION" on page 62.**

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During the suction stage, the pump plunger (8) moves down. As a result of the constant fuel excess pressure of approximately 600kPa (6 bar) (87 psi) in the fuel low pressure circuit, the high pressure chamber (7) of the unit pump is fitted with fuel through the supply gallery (6).

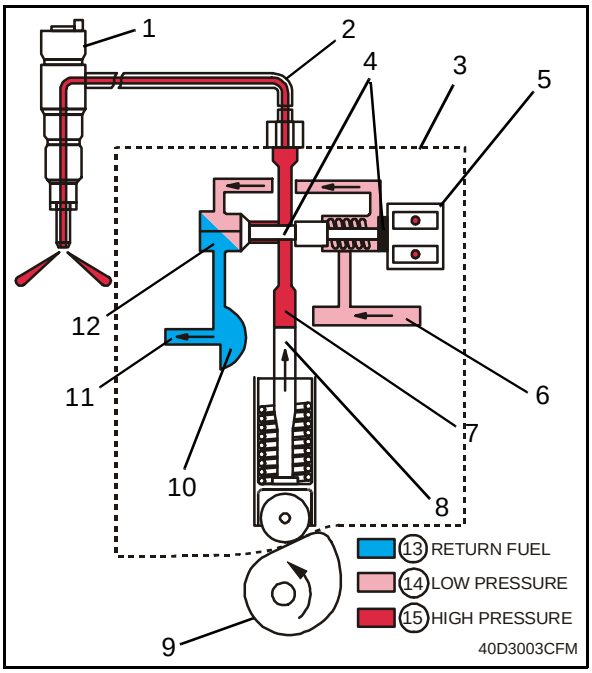
**Pre-Delivery Stage**




1. Fuel Delivery Nozzle.
2. Connector Pipe.
3. EUI (Electronic Unit Injector).
4. Valve.
5. Solenoid.
6. Supply Gallery in Crankcase.
7. High Pressure Chamber.
8. Pump Plunger.
9. Engine Camshaft.
10. Pressure Relief Chamber.
11. Return Flow Gallery in Crankcase.
12. Bleed-Off Chamber.
13. Return Fuel.
14. Low Pressure.

During the pre-delivery stage, the pump plunger (8) moves up. As the valve (4) is not yet closed, the fuel is first forced into the pressure relief chamber (10), then into the return gallery(11).

**Delivery Stage**

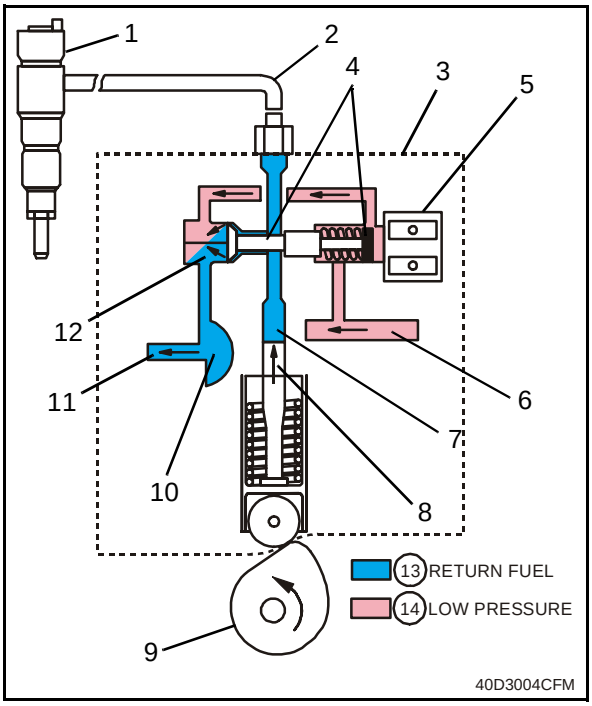



1. Fuel Delivery Nozzle.
2. Connector Pipe.
3. EUI (Electronic Unit Injector).
4. Valve.
5. Solenoid.
6. Supply Gallery in Crankcase.
7. High Pressure Chamber.
8. Pump Plunger.
9. Engine Camshaft.
10. Pressure Relief Chamber.
11. Return Flow Gallery in Crankcase.
12. Bleed-Off Chamber.
13. Return Fuel.
14. Low Pressure.
15. High Pressure.

As soon as the valve (4) is closed while the pump plunger (8) is moving towards its top dead centre, the unit pump is in the delivery stroke. Fuel injection into the combustion chamber takes place in the delivery stage. During this stage the fuel pressure in the high pressure chamber (7) rises to a pressure approximately 160 000 kPa (1600 bar) (23 206 psi).

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**Residual Stage**

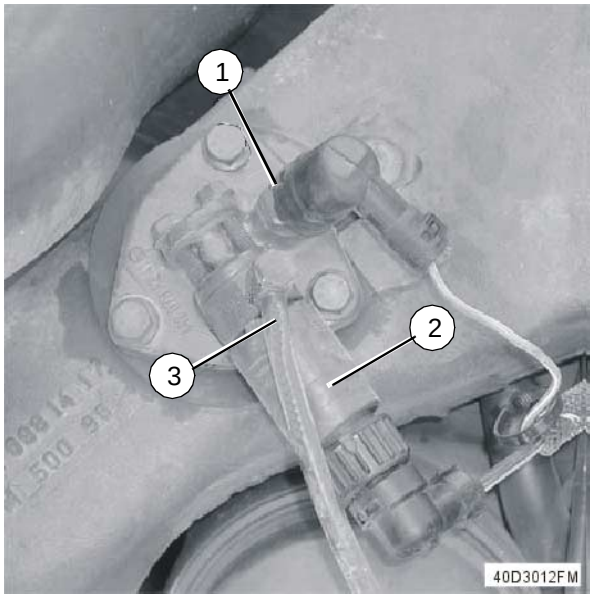



1. Fuel Delivery Nozzle.
2. Connector Pipe.
3. EUI (Electronic Unit Injector).
4. Valve.
5. Solenoid.
6. Supply Gallery in Crankcase.
7. High Pressure Chamber.
8. Pump Plunger.
9. Engine Camshaft.
10. Pressure Relief Chamber.
11. Return Flow Gallery in Crankcase.
12. Bleed-Off Chamber.
13. Return Fuel.
14. Low Pressure.

After the valve (4) has opened (end of delivery), The fuel pressure in the high pressure chamber (7) is collapsing. The remaining fuel delivery by the pump plunger (8) up to the apex of the camshaft (9), is again forced into the pressure relief chamber (10) and the return flow gallery (11).

The pressure relief chamber serves as an expansion chamber for the pressure peaks of the unit pump in the residual stage. This prevents the pressure ratio of the adjacent unit pumps being affected through the return flow gallery.

## Cold Start Operation




1. Glow Plug.
2. Solenoid.
3. Cold Start Jet.

The cold start system operates only when the engine coolant temperature is below 15° C (59° F).

When the key switch is tuned to the "**ON**" the position, the glow plug (1) begins to heat up and the indicator light on the dash will light up. Light will stay on and the glow plug will continue to heat up for approximately twenty seconds.

When the key switch is turned to the START position, the solenoid (2) is energized, allowing fuel to flow to the cold start jet (3). The fuel from the jet is sprayed on the glow plug causing the fuel to atomize. The atomized air/fuel mixture is directed to the cylinders by the incoming air through the intake manifold.

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# CHAPTER 2. ENGINE

## SECTION 2. DIAGNOSE ENGINE MALFUNCTIONS

| Symptom | Problem | Solution |
|---|---|---|
| Starter motor turns engine too slowly | Batteries under charged | Recharge or replace batteries. |
| | Poor engine ground connection. | Repair, clean or secure connections. |
| | Loose or dirty battery terminals. | Clean and tighten battery terminals. |
| | Worn starter motor. | Perform starter load test. |
| | Hydraulic Cut Off Solenoid Valve. | **Go to “Hydraulic System Manifold Operation (Top View)” on page 354.** |
| Hard starting when cold | Defective cold start aid. | **See “Cold Start Operation” on page 44** |
| | Incorrect valve clearance. | Adjust valve clearance **(See “VALVE CLEARANCE ADJUSTMENT” on page 49.)** |
| | Compression too low. | Test compression **(See “CYLINDER COMPRESSION TEST” on page 53.)** |
| Engine turns but does not start | Insufficient fuel in fuel tank. | Fill tank and bleed system. |
| | Compression too low. | Test compression **(See Cylinder Compression Test in SECTION 4.)** |
| | Low fuel pump pressure. | Test fuel pump pressure **(See “CYLINDER COMPRESSION TEST” on page 53.)** |
| Engine stops soon after starting | Insufficient fuel in fuel tank. | Fill tank and bleed system. |
| | Air in fuel system. | Bleed system, check and repair air entry. |
| | Blocked fuel filters. | replace fuel filters. |
| | Low fuel pump pressure. | Test fuel pump pressure **(See “FUEL PUMP PRESSURE TEST” on page 53.)** |
| | Electronic Unit Injector. | Check fault codes. |

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| Symptom | Problem | Solution |
|---|---|---|
| Engine misfires | Incorrect valve clearance. | Adjust valve clearance **(See "VALVE CLEARANCE ADJUSTMENT" on page 49.)** |
| | Compression too low. | Test compression **(See "CYLINDER COMPRESSION TEST" on page 53.)** |
| | Low fuel pump pressure. | Test fuel pump pressure **(See "FUEL PUMP PRESSURE TEST" on page 53.)** |
| Low engine oil pressure | Failed pressure gauge. | Test or replace. |
| | Incorrect grade of oil. | Change oil. |
| | Low pump output. | Test oil pump pressure. Do Oil Pump Pressure Test (See **"OIL PUMP PRESSURE TEST" on page 54** |
| | Pressure relief valve stuck. | Install new pressure relief valve **(See Remove and Install Oil Pressure relief valve in CHAPTER 4, SECTION 5 of Repair Manual.)** |
| | Engine bearings worn. | Remove, inspect and repair. |
| Abnormal oil consumption | Crankcase breather or line blocked. | Inspect and repair. |
| | Valve stem seals worn | Replace valve stem seals. |
| | Valve guides worn. | Replace valve guides. |
| | Piston rings worn; cylinders scored. | Test compression **(See "CYLINDER COMPRESSION TEST" on page 53.)** |
| Excessive vibration at any speed. | Worn or broken engine mountings. | Inspect, repair or replace. |
| | Drive shaft out off balance. | Balance or replace. |
| Black smoke from exhaust. | Inlet system restricted. | Service and repair inlet system. |
| | Incorrect grade of fuel. | Reset valve clearance. |
| | Worn fuel delivery nozzles. | Replace fuel delivery nozzles **(See Remove and Install Fuel Delivery Nozzles in CHAPTER 4, SECTION 8 in repair manual).** |

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| Symptom | Problem | Solution |
|---|---|---|
| White smoke from exhaust. | Engine running too cold. | Check that thermostats are not stuck open. |
| | Worn fuel delivery nozzles. | Replace fuel delivery nozzles **(See Remove and Install Fuel Delivery Nozzles in CHAPTER 4, SECTION 8 in repair manual).** |
| | Pistons, rings or liners scored. | Test compression **(See "CYLINDER COMPRESSION TEST" on page 53.)** |
| | Coolant entering cylinder bores. | Check cylinder head gasket. Replace cylinder head gasket. **(See Cylinder Head in CHAPTER 4, SECTION 6 in repair manual).** |
| | Cold start solenoid defective. | Test solenoid. **(See "COLD START CIRCUIT THEORY OF OPERATION" on page 60.)** |

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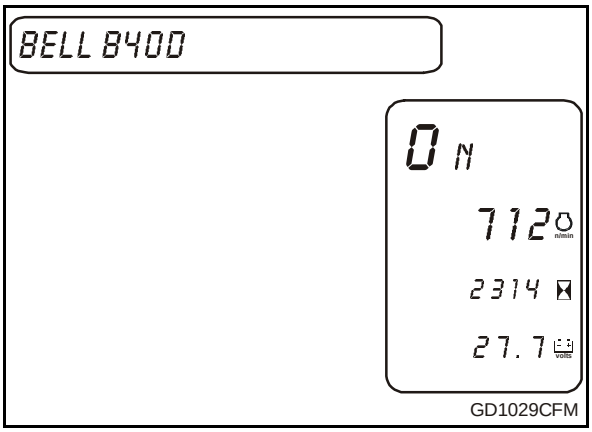
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# CHAPTER 2. ENGINE

## SECTION 3. ADJUSTMENTS

### DISPLAY MENU TACHOMETER




The tachometer on the Menu Display Unit is accurate enough for test work. **(See Operators Manual CHAPTER 2 for more information and CHAPTER 8 for detail operating the Menu Display Unit)**.

### SLOW AND FAST IDLE ADJUSTMENT

There is no slow or fast idle adjustment. If slow or fast idle is not within specification, check for an engine mechanical problem or an electrical failure.

Slow Idle Speed RPM's- - - - - - - - - - - - - - - - -600 ± 20

Fast Idle Speed RPM's - - - - - - - - - - - - - - - - -2240 ± 20

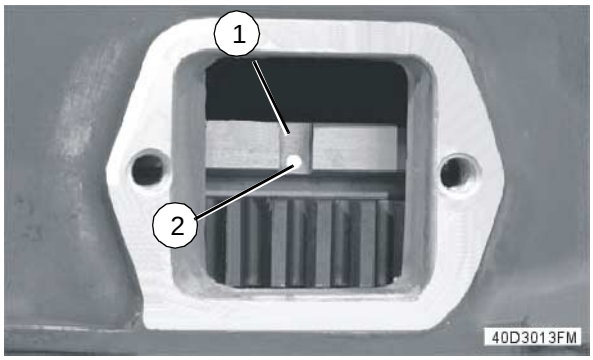
If no mechanical failure is found and the controller is suspected, **See "ENGINE CONTROL UNIT CIRCUIT THEORY OF OPERATION" on page 64 and "ELECTRONIC UNIT INJECTOR CONTROLLER CIRCUIT THEORY OF OPERATION" on page 62.**

### VALVE CLEARANCE ADJUSTMENT

**⚠ CAUTION**

**To prevent accidental starting of the engine while performing valve adjustments, always turn battery disconnect switch to "OFF"**

**NOTE: Check and adjust valve clearance only when engine is COLD.**




Remove rocker arm cover.

Install cranking device DC280088.

There is 37 slots (1) machined in the flywheel. One slot has a dimple in it. This is the TDC timing mark. Turn engine in the direction of rotation until TDC timing mark (2) on flywheel lines up in centre of the window in timing case.

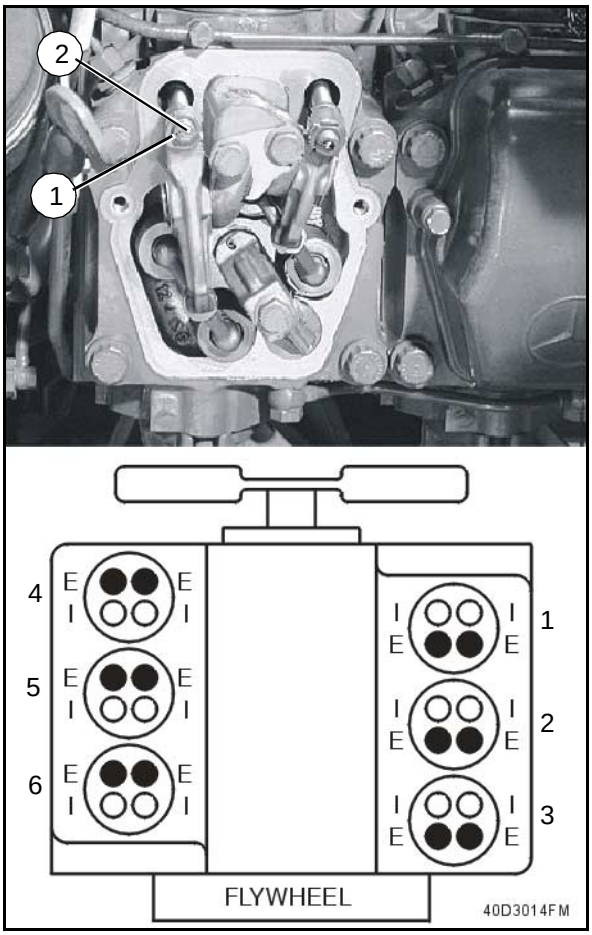
**NOTE: All valves can be adjusted in two crankshaft positions.**

Rocker arms and push rods for number one cylinder should be loose. If not, rotate engine 360°. Engine must be at TDC on the compression stroke for number one cylinder.

**NOTE: When adjusting valve clearance, the bolt on the valve bridge should on no account be loosened.**

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Measure the valve clearance between the rocker arm and the valve bridge with a feeler gauge.




With number one cylinder on TDC, Check the valve clearance on cylinder one - intake and exhaust, cylinder two - exhaust, cylinder three - intake, cylinder four - exhaust and cylinder six - intake.

Crank engine until cylinder five is on TDC (cylinder one valve overlap):

Check valve clearance on cylinder two - intake, cylinder three - exhaust, cylinder four - intake, cylinder five - intake and exhaust and cylinder six - exhaust.

Intake Valve Clearance - - - - - - - - - 0.40 mm (0.016in.)

Exhaust Valve Clearance - - - - - - - - 0.60 mm (0.024in.)

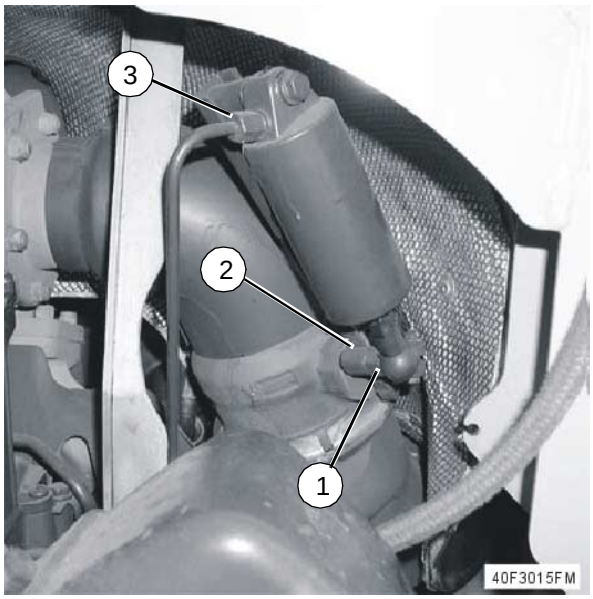
Locknut tightening torque- - - - - - - - - - -50Nm (37 lb-ft)

To adjust clearance: Loosen locknut (1) and turn adjusting screw (2) in or out depending on gap to big or small.

Tighten locknut to specification while holding adjusting screw in position.

Adjust valves in same order used for checking. Check clearance again after tightening locknut.

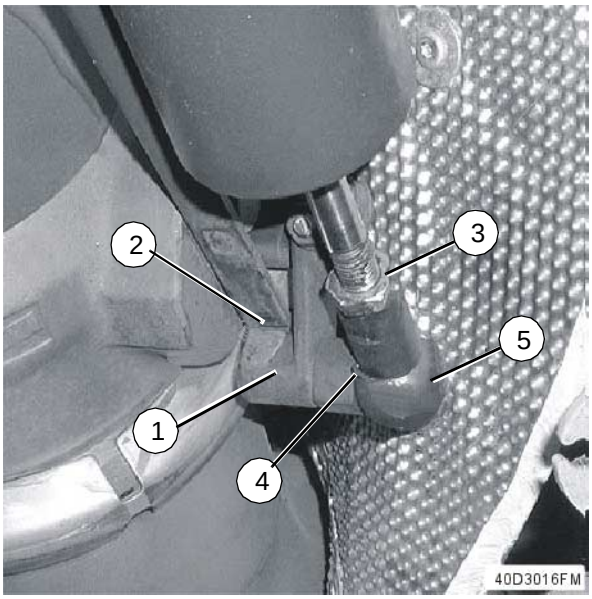
## EXHAUST BRAKE ADJUSTMENT




With engine off, check the clearance between the control arm (1) and the stop (2). In the brake valve "**OFF"** position, the control arm should be resting on the stop.

Disconnect the air line (3) from the cylinder. Connect a regulated air supply line to the cylinder. Regulate air pressure so pressure is approximately 740 - 810 kPa (7.4 - 8.1 bar) (107 - 117 psi).

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Check control arm (1) to stop (2) clearance. The control arm must not rest on the stop. There must be slight clearance between the control arm and stop to ensure that exhaust brake is fully closed.

If adjustment is needed, loosen locknut (3), remove clip (4) and disconnect cylinder from control arm. Turn rod end (5) for adjustment.

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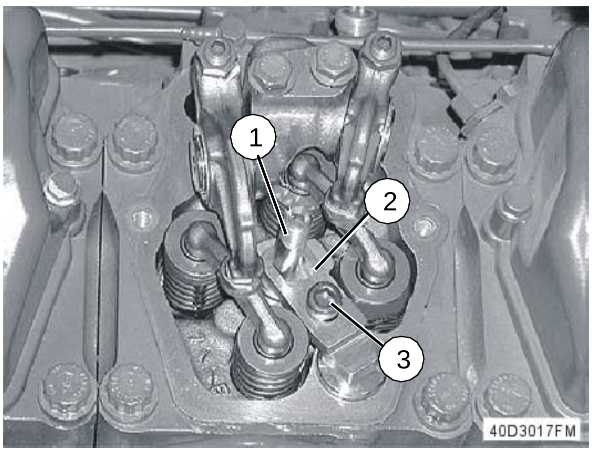
# CHAPTER 2. ENGINE

## SECTION 4. TESTS

### CYLINDER COMPRESSION TEST

**NOTE: Compression pressures are affected by the cranking speed of the engine. Before beginning the test, ensure that the batteries are fully charged and the starter motor is in a good working condition.**

Remove fuel delivery nozzle from cylinder being tested. **See CHAPTER 4, SECTION 8 of repair Manual Remove and Install Fuel Delivery Nozzle**.




Install JDG1599 compression tester adapter (1) into cylinder head.

Install holddown clamp (2) using an M10 x 1.5 x 70 mm long cap screw (3).

Install compression tester to adapter.

**⚠ CAUTION**

**Engine must not be started with fuel line from EUI disconnected. Remove the F16 ECU/EUI Power Relay fuse to prevent engine from starting.**

Remove the F16 ECU/EUI Power Relay Fuse.

Crank engine approximately ten seconds. Record readings and compare to specification.

Engine Compression Pressure - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -2800kPa (28 bar) (406 psi)

Permissible Difference Between Cylinders - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 400kPa (4 bar) (58psi).

### FUEL PUMP PRESSURE TEST

#### Specification

Pressure At Slow Idle - 210 -300 kPa (2.1 - 3 bar) (30 - 44psi).

Pressure At Fast Idle - - - 500 - 600kPa (5 - 6 bar) (73 - 87psi).

#### Essential Tools

Parker No. 34982-16-6: Banjo Union.

Parker No. 0502-12-12: 1 1/16 - 12M x 3/4 - 14NPT F Adapter.

Parker No. 3/4 x 1/2 PTR: 3/4 - 14 NPT M x 1/2 - 14 NPT F Pipe Thread Reducer.

Parker No. 1/2 x 3/8 PTR: 1/2 - 14 NPT M x 3/8 - 18 NPT F Pipe Thread Reducer.

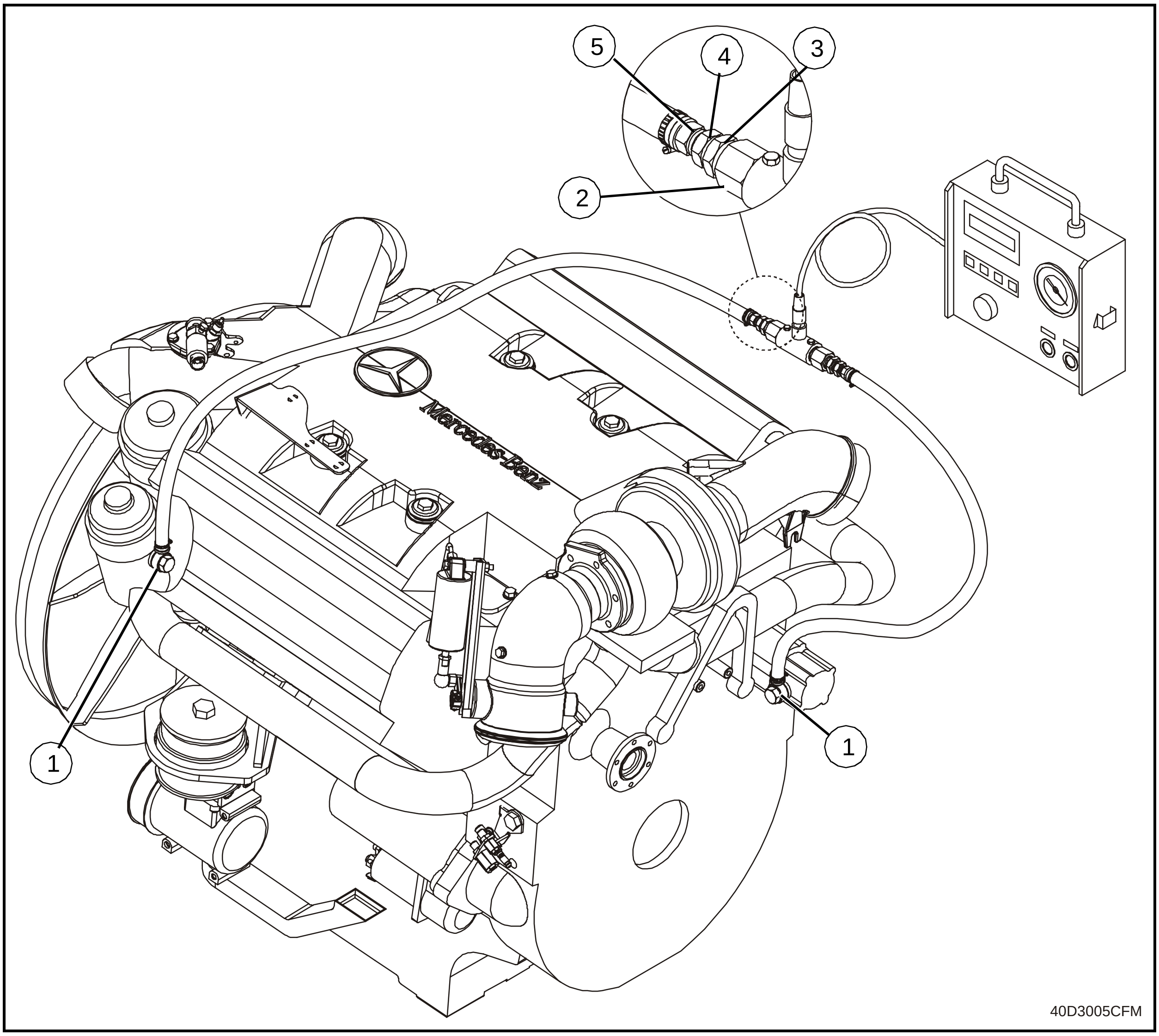
Parker No. 30182-6-6: 3/8 - 18 NPT M x 3/8 Barb Fitting.

#### Service Equipment And Tools

JT07148 Digital Hydraulic Tester.

JT07156 0.5 to 15 GPM Lt. Flow Meter.

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Connect banjo union fittings (1) to fuel pump outlet port and fuel filter inlet.

Connect fittings (2 - 5) to flow meter and flow meter to hydraulic tester.

Run engine at slow idle and measure fuel pump pressure. Compare to specification.

Run engine at fast idle and compare to specification.

## OIL PUMP PRESSURE TEST

### Specification

Engine Oil Pressure at Slow Idle - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 50kPa (0.5 bar) (7.3psi).

Engine Oil Pressure at Fast Idle - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -250 kPa (2.5 bar) (36.3psi).

### Essential Tools

Parker No. 8M16F80MX: M 16 x 1.5 M x 3/4 - 16 M 37° Adapter.

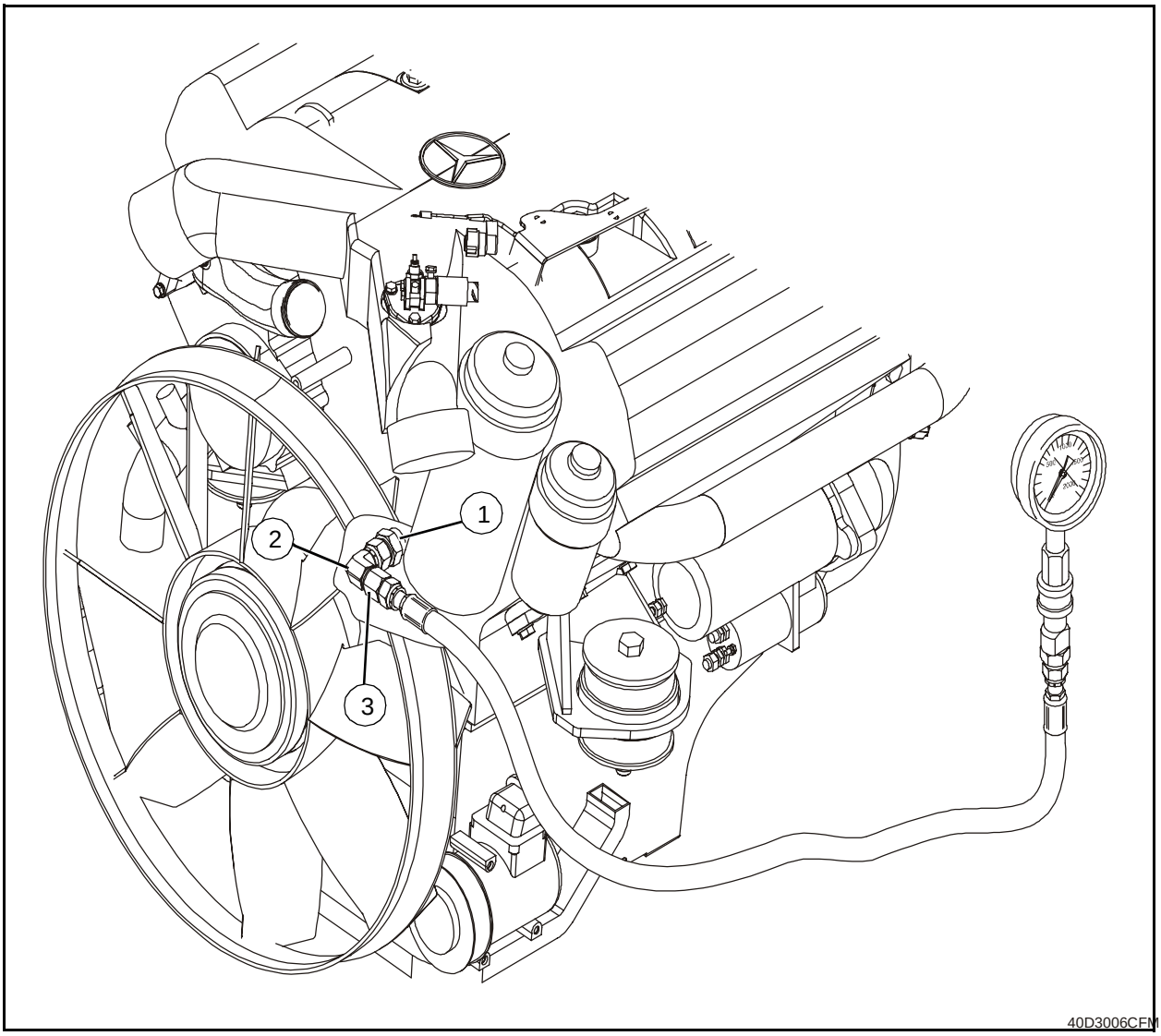
JT03132: 3/4 - 16 M 37° x 3/4 - 16 F 37° Sw 90° Elbow.

JT03003: 7/16 - 20 M 37° x 3/4 - 16 F 37° Reducer.

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## Service Equipment And Tools

413 kPa (4.1 bar) (60psi) Gauge.




Remove engine oil pressure sensor. **(See "Engine Main Harness" on page 14).**

Install adapter (1), elbow (2) and reducer (3) to engine and connect gauges to fittings.

**NOTE: To achieve an accurate oil pressure reading, warm engine to 105° C (220° F).**

Run engine at slow idle. Compare reading to specification.

Run engine at fast idle. Compare reading to specification.

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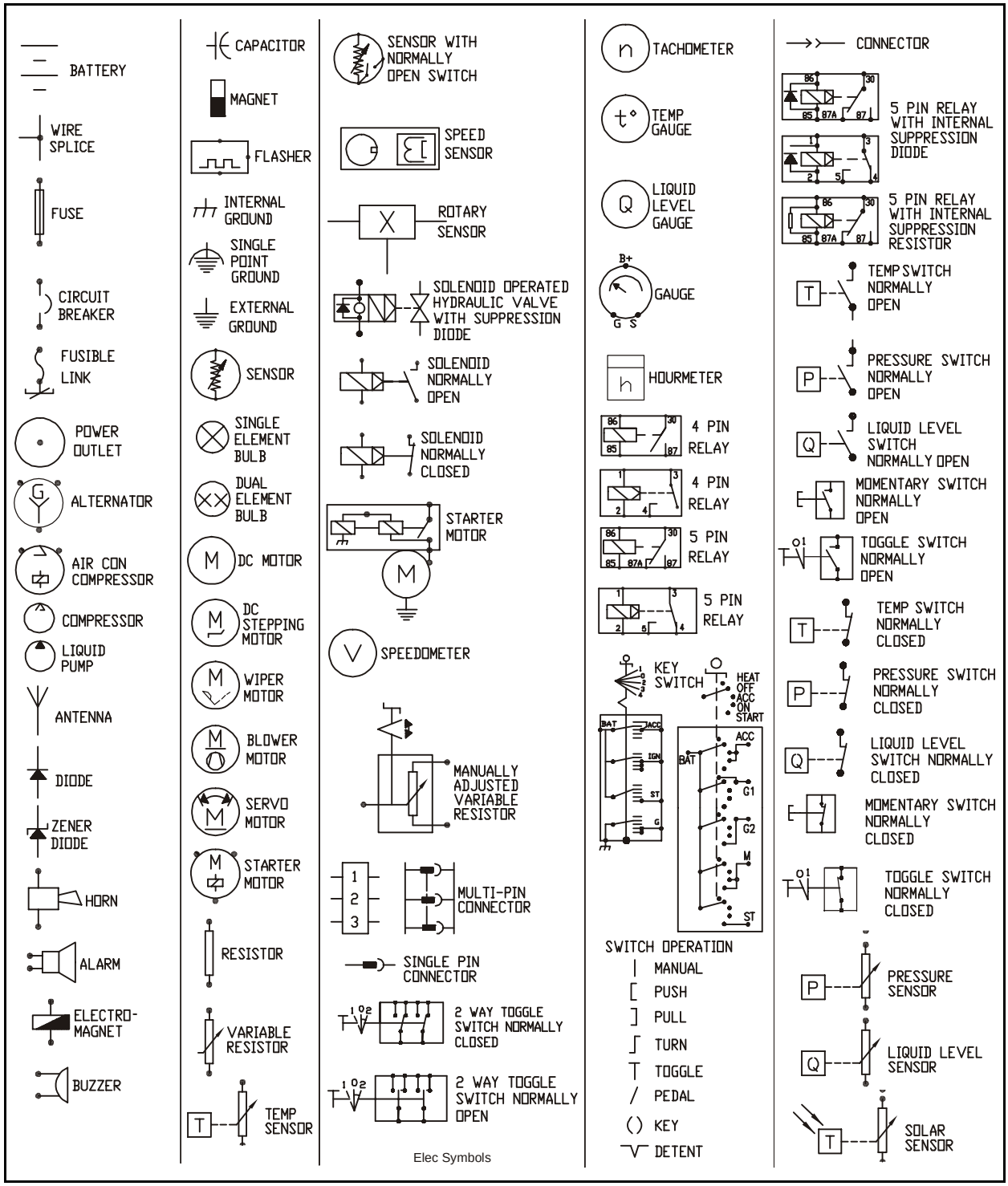
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# CHAPTER 3. ELECTRICAL SYSTEM

## SECTION 1. SYSTEM INFORMATION

### Electrical Schematic Symbols

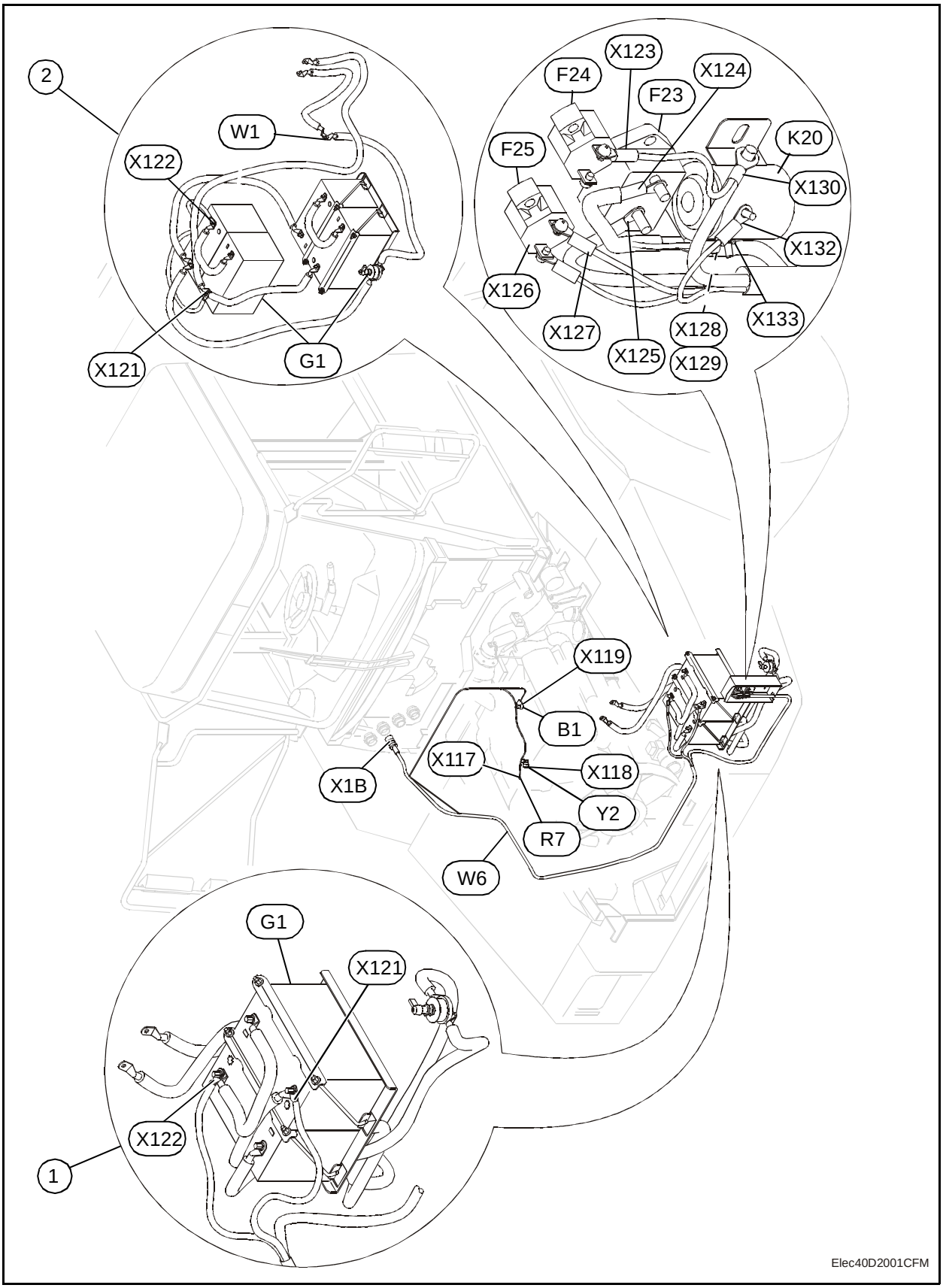


Elec Symbols

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## HARNESSES AND COMPONENT LOCATION

### Main Power Harness

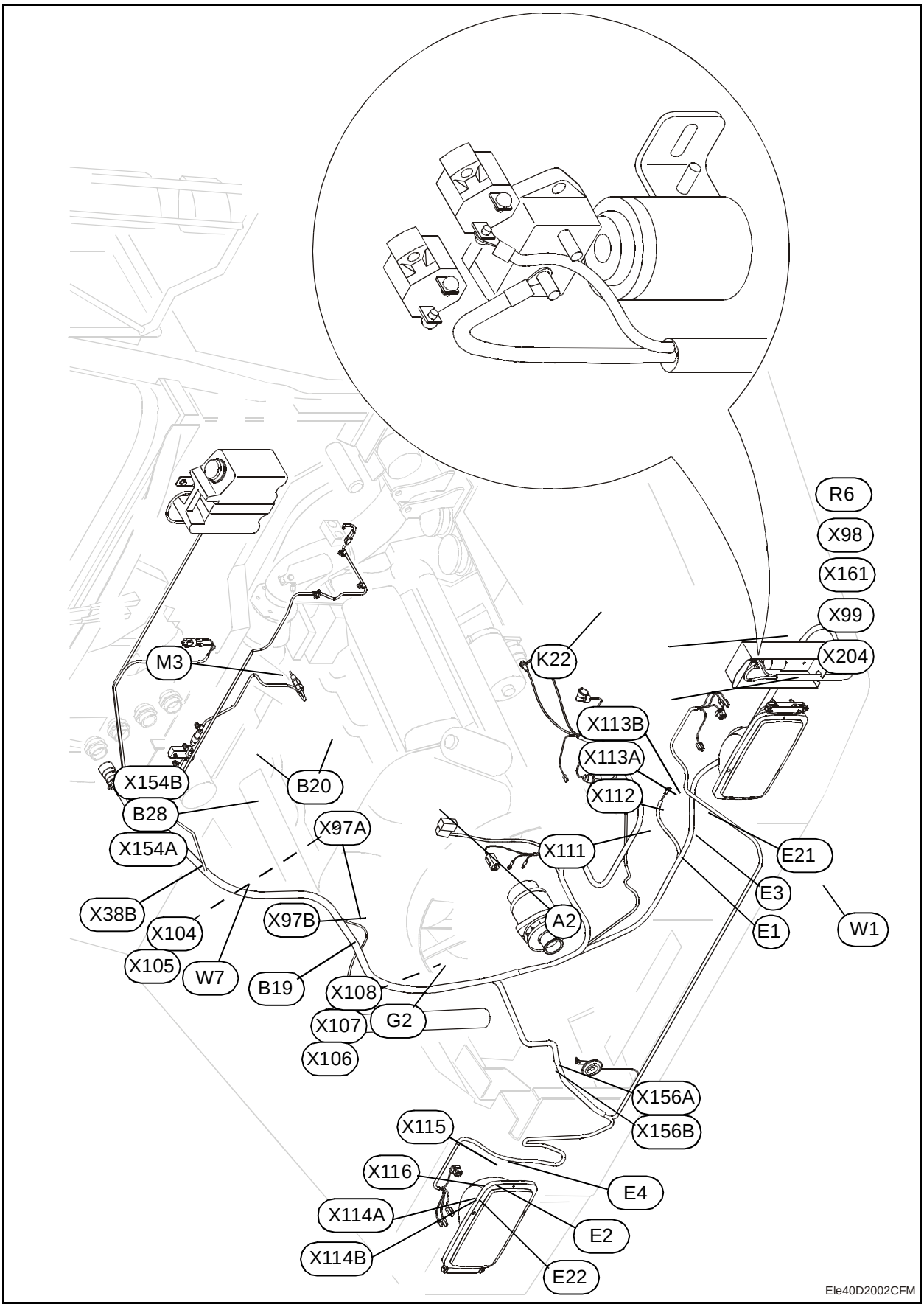


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1 Detail of 2-Battery Configuration (Front View).
2 Detail of Optional 4-Battery Configuration (Rear View).
B1 Cold Start Temperature Sensor.
F23 Main Circuit Breaker (60-Amp).
F24 Fuel Filter Heater, Unloader Valve Heater and Low Coolant Level Circuit Breaker (20-Amp).
F25 Battery Balancer Circuit Breaker (20-Amp).
G1 Batteries (2 used; standard) (4 used; optional).
K20 Battery Relay.
R7 Glow Plug.
W1 Main Ground.
W6 Main Power Harness.
X1B Main Power Harness-to-Cab Power Harness Connector.
X117 Glow Plug Connector.
X118 Cold Start Solenoid (Y2) Connector.
X119 Cold Start Temperature Sensor (B1) Connector.
X121 Battery (G1) 24-Volt Connector.
X122 Battery (G1) 12-Volt Connector.
X123 Circuit Breaker (F24) Connector.
X124 Main Circuit Breaker (F23) Connector.
X125 Main Circuit Breaker (F23) Connector.
X126 Circuit Breaker (F25) Connector.
X127 Circuit Breaker (F25) Connector.
X128 Battery Relay (K20) Terminal 30 (Contact) Connector.
X129 Battery Relay (K20) Terminal 30 (Contact) Connector.
X130 Battery Relay (K20) Terminal 87 (Contact) Connector.
X132 Battery Relay (K20) Connector Terminal 86 (Coil) Connector.
X133 Battery Relay (K20) Terminal 85 (Coil) Connector.

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## Front Frame/Engine Harness

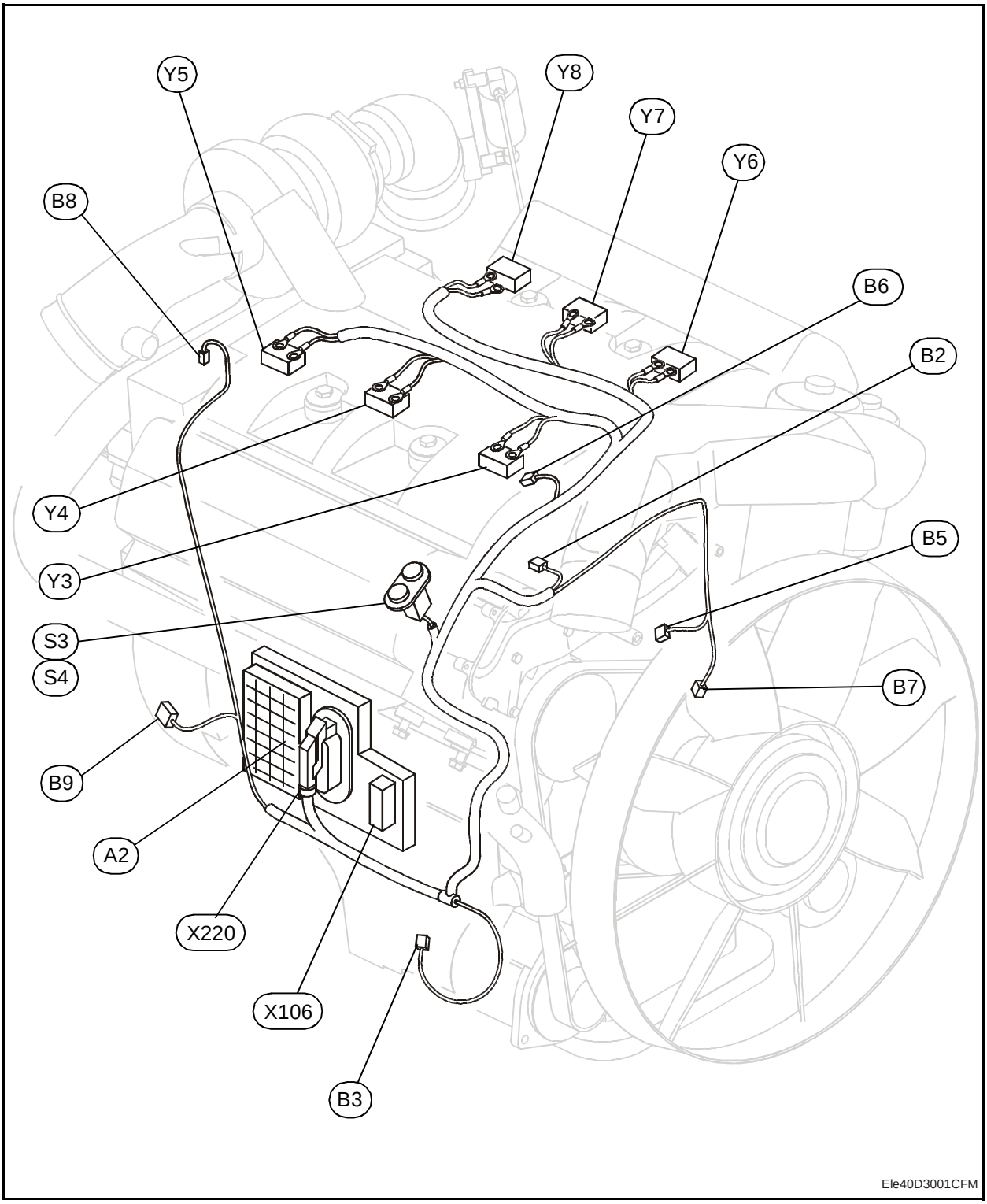


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A2 Electronic Unit Injector (EUI) Controller.
B19 Fuel Level Sensor.
B20 Engine Coolant Low Level Sensor.
B28 Stop Light Pressure Switch.
E1 Left Front Park Light.
E2 Right Front Park Light.
E3 Left Headlight.
E4 Right Headlight.
E21 Left Front Turn Signal.
E22 Right Front Turn Signal.
G2 Alternator.
M3 Washer Pump Motor.
R5 Unloader Valve Heater.???
R6 Fuel Filter Heater (Optional).???
W1 Main Ground.???
W7 Front Frame/Engine Harness.
K22 Transmission Cooler Fan Relay.
X38B Front Frame/Engine Harness-to-Cab Main Harness Connector.
X96 Engine Coolant Low Level Sensor (B20) Connector.
X97A Fuel Sensor (B19) (Signal) Connector.
X97B Fuel Sensor (B19) (Ground) Connector.
X98 Unloader Valve Heater (R5) Connector.
X99 Air System Drain Solenoid (Y16) Connector.
X103 A/C Compressor Clutch (Y20) Connector.
X104 Starter Solenoid (BK/WH Wire) Connector.
X105 Alternator B+ to Starter Solenoid (GN) Wire Connector.
X106 Electronic Unit Injector Controller (A2) 16-Pin Connector.
X107 Alternator (G2) B+ Terminal Connector.
X108 Alternator (G2) Ground Terminal Connector.
X111 Left Front Park Light (E1) Connector.
X112 Left Headlight (E3) Connector.
X113A Left Front Turn Signal Light (E21) (Positive) Connector.
X113B Left Front Turn Signal Light (E21) (Ground) Connector.
X114A Right Front Turn Signal Light (E22) (Positive) Connector.
X114B Right Front Turn Signal Light (E22) (Ground) Connector.
X115 Right Headlight (E4) Connector.
X116 Right Front Park Light (E2) Connector.
X154A Stop Light Pressure Switch (B28) (GY/GN Wire) Connector.
X154B Stop Light Pressure Switch (B28) (GN Wire) Connector.
X155 Washer Pump Motor (M3) Connector.
X161 Optional Fuel Filter Heater (R6) Connector.
X156A Electric Horn (B27) Connector.
X156B Electric Horn (B27) (Ground) Connector.
X204 Alternator (G2) 5-Pin Connector.
Y16 Air System Drain Solenoid.
Y20 A/C Compressor Clutch.

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## Engine Main Harness

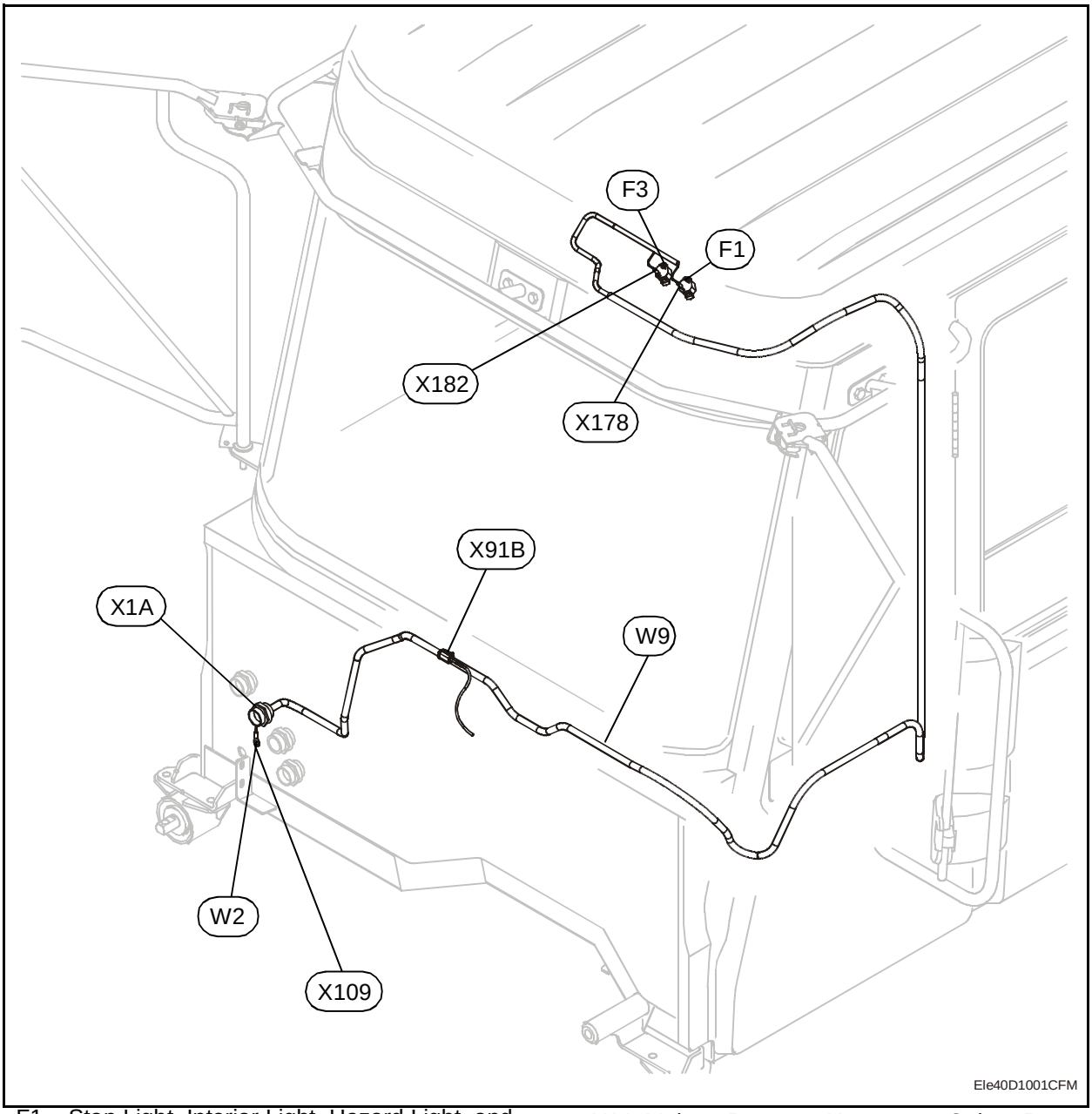


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A2 Electronic Unit Injector (EUI) Controller.
B2 Engine Coolant Temperature Sensor.
B3 Engine Oil Level Sensor.
B5 Engine Oil Pressure Sensor.
B6 Intake Manifold Air Pressure/Temperature Sensor.
B7 Engine Oil Temperature Sensor.
B8 Engine Camshaft Position Sensor.
B9 Engine Crankshaft Position Sensor.
S3 Engine Remote Start Switch (Disabled).
S4 Engine Remote Stop Switch.
X106 Electronic Unit Injector Controller 16-Pin Connector.
X220 Electronic Unit Injector Controller 55-Pin Connector.
Y3 Electronic Unit Injector Solenoid (Cyl #1).
Y4 Electronic Unit Injector Solenoid (Cyl #2).
Y5 Electronic Unit Injector Solenoid (Cyl #3).
Y6 Electronic Unit Injector Solenoid (Cyl #4).
Y7 Electronic Unit Injector Solenoid (Cyl #5).
Y8 Electronic Unit Injector Solenoid (Cyl #6).

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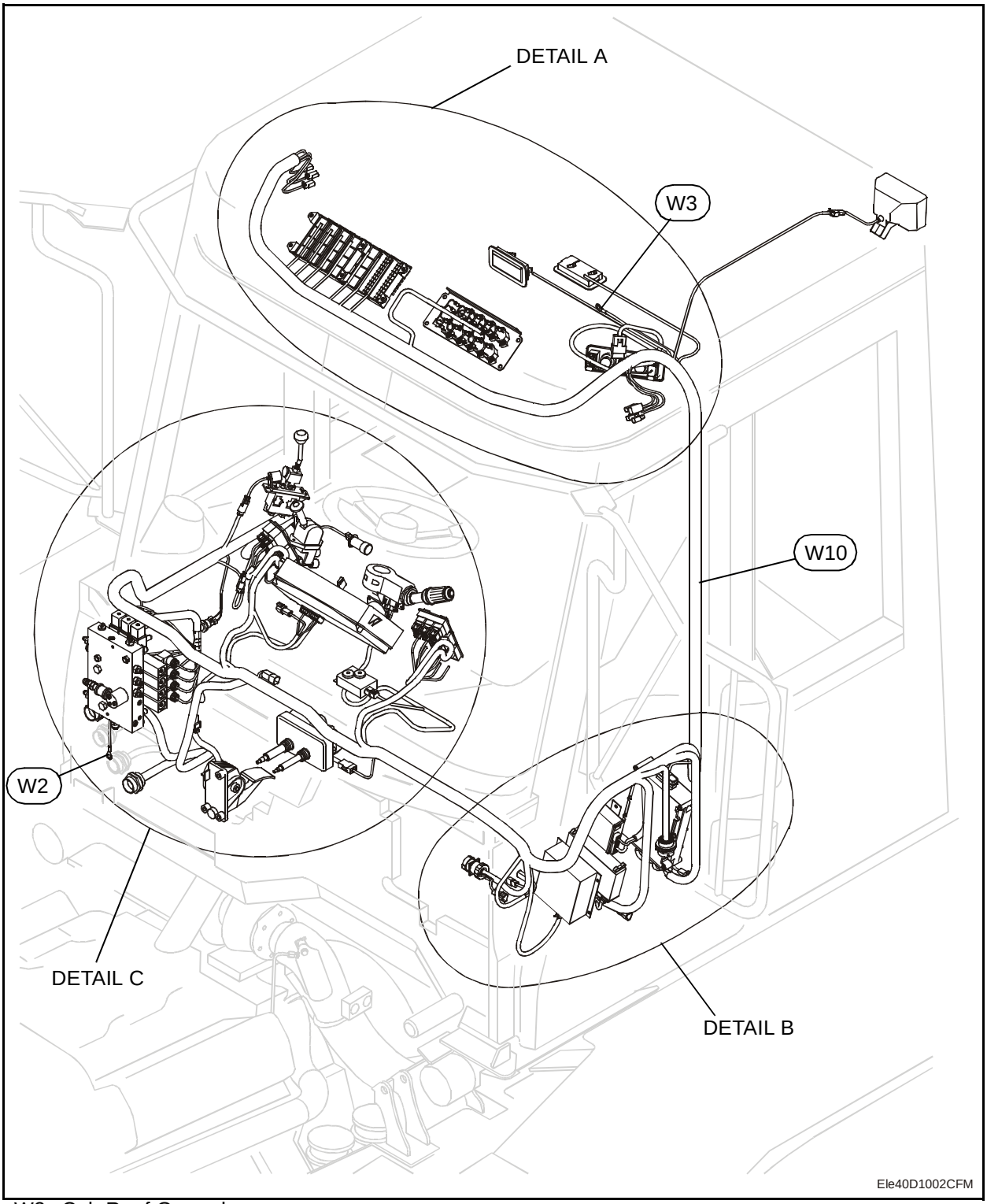
## Cab Power Harness




F1 Stop Light, Interior Light, Hazard Light, and Turn Signal Circuit Breaker (15-Amp).
F3 Switched Power to Fuses F11, F14—F16 Circuit Breaker (20-Amp).
W2 Cab Firewall Ground.
W9 Cab Power Harness.
X1A Main Power Harness-to-Cab Power Harness Connector.
X91B Cold Start and Run Circuits Power Connector.
X109 Cab Firewall Ground Connector.
X178 Circuit Breaker (F1) Connector.
X182 Circuit Breaker (F3) Connector.

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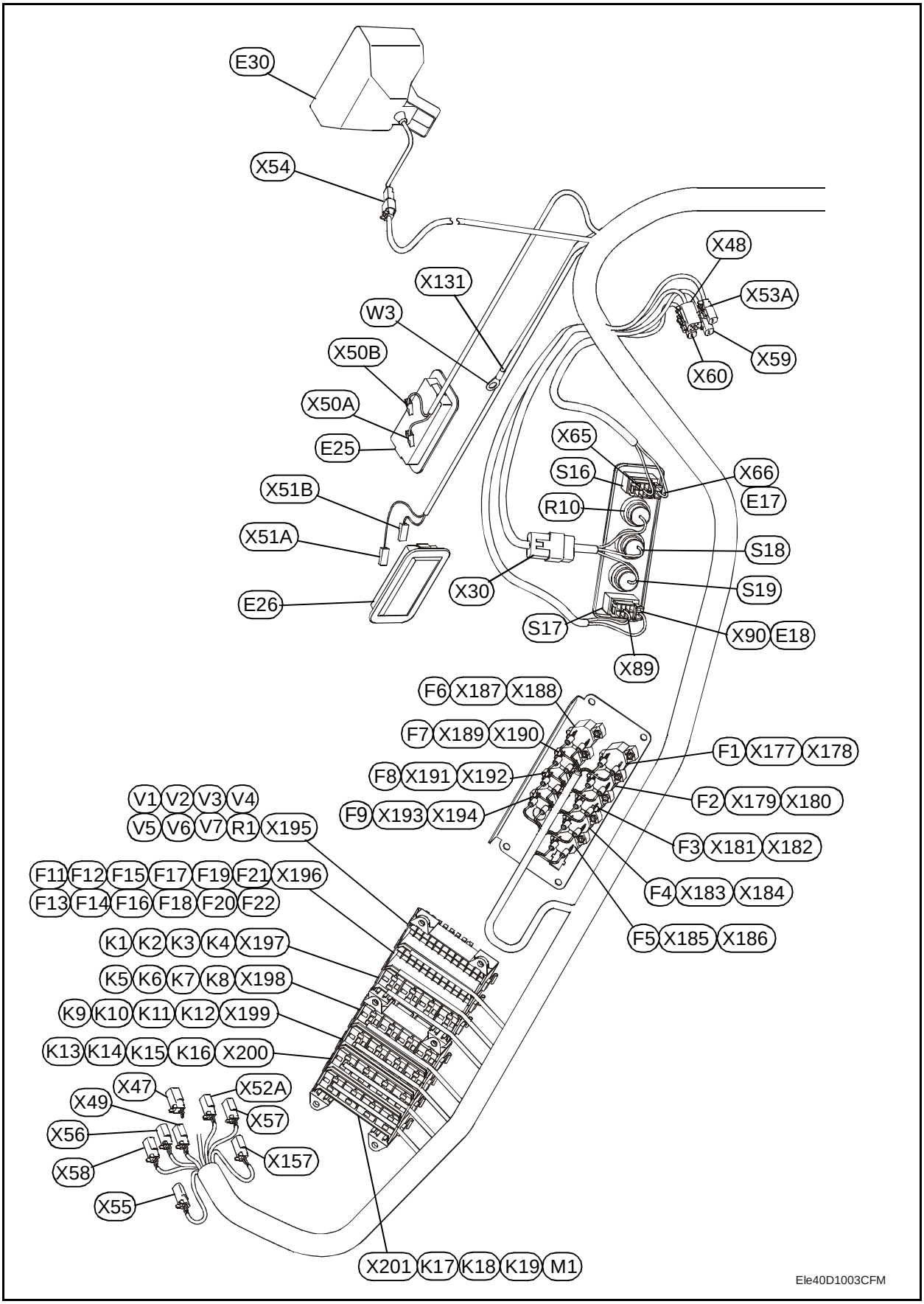
## Cab Main Harness And Electric Mirror Interface Harness




W2 Cab Roof Ground.
W3 Cab Firewall Ground.
W10 Cab Main Harness.

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## Cab Main Harness And Electric Mirror Interface Harness (Continues)

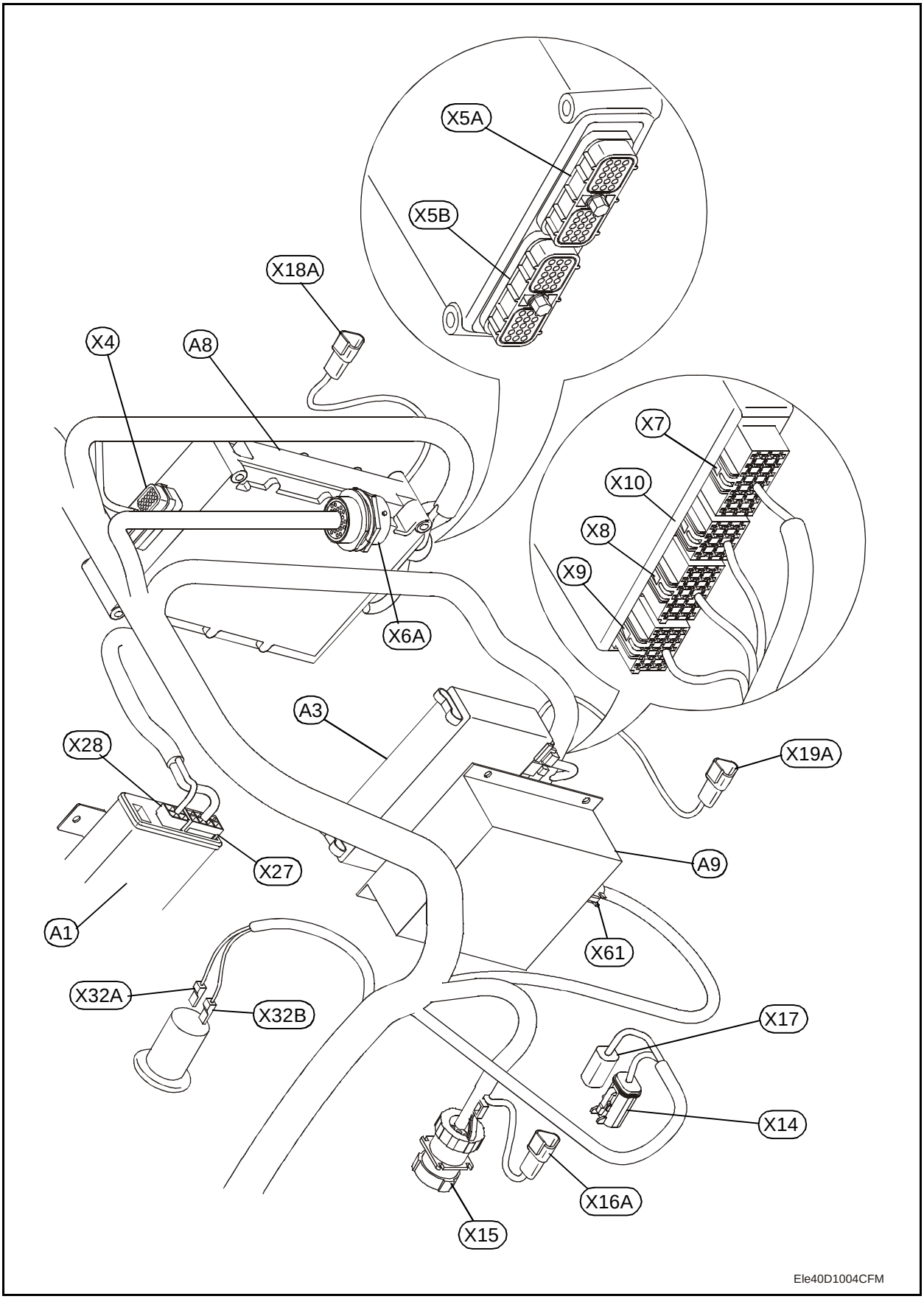


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E17 Backlight (A/C On/Off Switch).
E18 Backlight (Air Re circulation Switch).
E25 Dome Light.
E26 Fuse/Relay Compartment Light.
E30 Articulation Backup Light.
F1 Circuit Breaker - Stop Light, Interior Light, Hazard Light and Turn Signal (15-Amp) (SE9).
F2 Circuit Breaker - Unswitched Power to Fuses F12, F13, F18 - F21 (30-Amp).
F3 Circuit Breaker - Switched Power to Fuses F11 and F14—F16 (20-Amp) (SE1).
F4 Circuit Breaker - Headlight, Work Light, Backup Light and Beacon (30-Amp).
F5 Circuit Breaker - Headlight and A/C (25-Amp).
F6 Circuit Breaker - Park Brake, Differential Lock, Fan Drive, Body Down Detent, and Range Hold (15-Amp).
F7 Circuit Breaker - Wiper, Washer, Horn, and Mirror (25-Amp) (SE7) (W10).
F8 Circuit Breaker - Cold Start (25-Amp) (SE2) (W10).
F9 Circuit Breaker - Start, Neutral, MDU/CCU Power, Exhaust Brake and Body Float (15-Amp).
F11 Retarder/Voltage Regulator Fuse (10-Amp).
F12 Transmission Control Unit (TCU) Fuse (10-Amp).
F13 MDU/CCU Power and Hazard Fuse (5-Amp).
F14 Alternator Excitation Fuse (5-Amp).
F15 Program/Diagnostic Fuse (10-Amp).
F16 ECU/EUI Power Relay Fuse (10-Amp).
F17 AM/FM Radio Fuse (10-Amp).
F18 ECU Fuse (10-Amp).
F19 MDU Fuse (5-Amp).
F20 Diagnostic Fuse (10-Amp).
F21 Battery Balancer/Accessories Fuse (10-Amp).
F22 2-Way Radio Fuse (15-Amp).
K1 Neutral Start Relay.
K2 Start Relay.
K3 Headlights and A/C Cutout Relay.
K4 Backup Relay.
K5 Stop Light Relay.
K6 Exhaust Brake Relay.
K7 Park Brake Relay.
K8 Range Hold Relay.
K9 Left Turn Relay.
K10 Right Turn Relay.
K11 Low Beam Relay.
K12 High Beam Relay.
K13 Body Float Relay.
K14 Intermittent Wiper Relay.
K15 Accessory Relay.
K16 ECU/EUI Power Relay.
K17 MDU/CCI Power Relay.
K18 Blank Relay Socket.
K19 Auxiliary Relay Socket.
N1 Retarder Voltage Regulator.
R1 Air Pressure Sensor Pull-Up Resistor.
R10 Temperature Control.
S16 Air Conditioning On/Off Switch.
S17 Air Re circulation Switch.
S18 Blower Motor Speed Control Switch.
S19 Air Flow Control Switch.
V1 Retarder Stop Light Control Diode (3-Amp).
V2 Stop Light Control Diode (3-Amp).
V3 Alternator Excitation Diode (3-Amp).
V4 Intermittent Wiper Control Diode (3-Amp).
V5 Washer/Wiper Control Diode (3-Amp).
V6 Hazard Control Diode (3-Amp).
V7 MDU/CCU Power Diode (3-Amp).

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## Cab Main Harness And Electric Mirror Interface Harness (Continues)

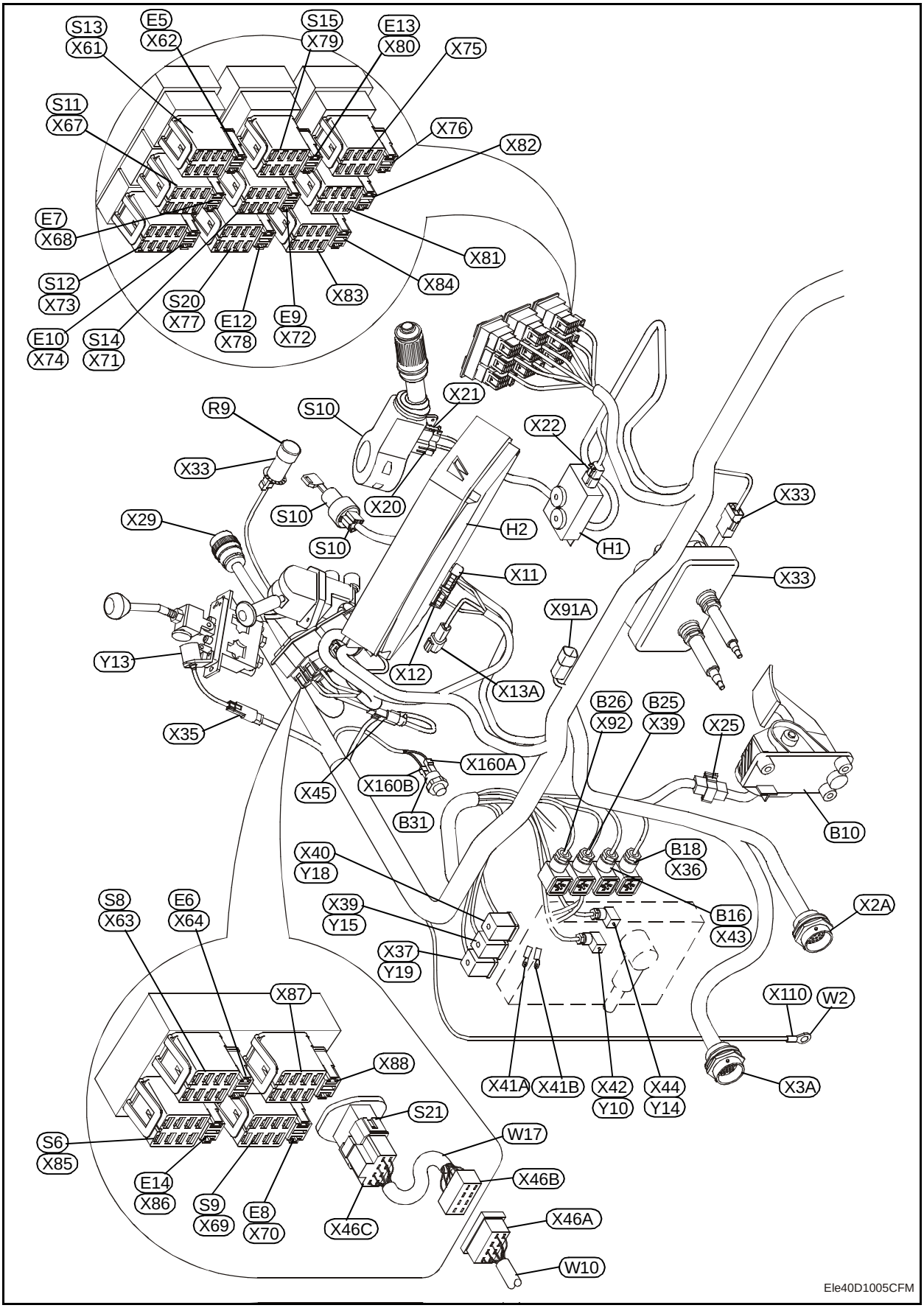


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A1 Cold Start Module.
A3 Engine Control Unit (ECU).
A8 Chassis Control Unit (CCU).
A9 Battery Balancer.
X4 Chassis Control Unit (A8) J3 Connector.
X5A Chassis Control Unit (A8) J1A Connector.
X5B Chassis Control Unit (A8) J1L Connector.
X6A Transmission Control Harness-to-Cab Main Harness Connector.
X7 Engine Control Unit (A3) 21-Pin Connector.
X8 Engine Control Unit (A3) 18-Pin Connector.
X9 Engine Control Unit (A3) 15-Pin Connector.
X10 Engine Control Unit (A3) 12-Pin Connector.
X14 Monitor Display Unit (H2) Programming 4 Pin Connector.
X15 Diagnostic (Service ADVISOR ™) Connector.
X16A Diagnostic CAN Connector.
X17 Chassis Control Unit (A8) Programming 6-Pin Connector.
X18A Chassis Control Unit (A8) CAN Connector.
X19A Engine Control Unit (A3) CAN Connector.
X27 Cold Start Module (A1) 8-Pin Connector.
X28 Cold Start Module (A1) 4-Pin Connector.
X31 Battery Balancer (A9) Connector.
X32A 12-Volt Accessory Power Socket Connector.
X32B 12-Volt Accessory Power Socket Ground Connector.

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## Cab Main Harness And Electric Mirror Interface Harness (Continues)



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B10 Accelerator Pedal Position Sensor.
B16 Body Up Pressure Switch.
B18 Park Brake Pressure Switch.
B25 Inter-Axle Lock Pressure Switch.
B26 Differential Lock Pressure Switch.
B31 Air Conditioning High/Low Pressure Switch.
E5 Backlight (Interior Light Switch).
E6 Backlight (Inter-Axle Lock Switch).
E7 Backlight (Headlight Switch).
E8 Backlight (Differential Lock Switch).
E9 Backlight (Rotating Beacon Switch).
E10 Backlight (Hazard Light Switch).
E12 Backlight (Mirror Defroster Switch).
E13 Backlight (Work Light Switch).
E14 Backlight (Range Hold Switch).
H1 Audible Alarm.
H2 Menu Display Unit (MDU).
M2 Wiper Motor.
R9 Lighter.
S1 Key Switch.
S6 Range Hold Switch.
S7 Park Brake Latch Switch.
S8 Inter-Axle Lock Switch.
S9 Differential Lock Switch.
S10 Steering Column Switch.
S11 Headlight Switch.
S12 4-Way Flasher Switch.
S13 Interior Light Switch.
S14 Rotating Beacon Switch.
S15 Work Light Switch.
S20 Mirror Defroster Switch.
S21 Mirror Positioning Switch.
W2 Cab Firewall Ground.
W10 Cab Main Harness.
X2A Hydraulic Harness-to-Cab Main Harness Connector.
X3A Front Frame/Engine Harness-to-Cab Main Harness Connector.
X4 Chassis Control Unit (A8) J3 Connector.
X11 Monitor Display Unit (H2) 10-Pin Connector.
X12 Monitor Display Unit (H2) 6-Pin Connector.
X13 Monitor Display Unit (H2) CAN Connector.
X20 Steering Column Switch (S10) 12 - Pin Connector.
X21 Steering Column Switch (S10) 4-Pin Connector.
X22 Audible Alarm (H1) Connector.
X23 Wiper Motor (M2) Connector.
X25 Accelerator Pedal Position Sensor (B10) Connector.
X26 Key Switch (S1) Connector.
X29 Cab Main Harness-to-A/C Actuator Harness (W18) 21-pin Connector.
X33 Lighter (R9) Connector.
X34 Not Used.
X35 Body Down Detent Magnet (Y13) Connector.
X36 Park Brake Pressure Switch (B18) Connector.
X37 Air Horn Solenoid (Y19) Connector.
X38 Inter-Axle Lock Solenoid (Y15) Connector.
X39 Inter-Axle Lock Pressure Switch (B25) Connector.
X40 Differential Lock Solenoid (Y18) Connector.
X41A System Air Pressure Sensor (B15) Connector.
X41B System Air Pressure Sensor (B15) Connector.
X42 Exhaust Brake Solenoid (Y10) Connector.
X43 Body Up Pressure Switch (B16) Connector.
X44 Park Brake Solenoid (Y14) Connector.
X45 Park Brake Latch Switch (S7) Connector.
X46A Cab Harness-To-Mirror Positioning Switch Interface Harness Connector (W10).
X46B Mirror Positioning Switch Interface Harness-To-Cab Harness Connector (W10).
X46C Mirror Positioning Switch Connector (W10).
X61 Interior Light Switch (S13) Connector.
X62 Interior Light Switch Backlight (E5) Connector.
X63 Inter-Axle Lock Switch (S8) Connector.
X64 Inter-Axle Lock Switch Backlight (E6) Connector.
X67 Headlight Switch (S11) Connector.
X68 Headlight Switch Backlight (E7) Connector.
X69 Differential Lock Switch (S9) Connector.
X70 Differential Lock Switch Backlight (E8) Connector.

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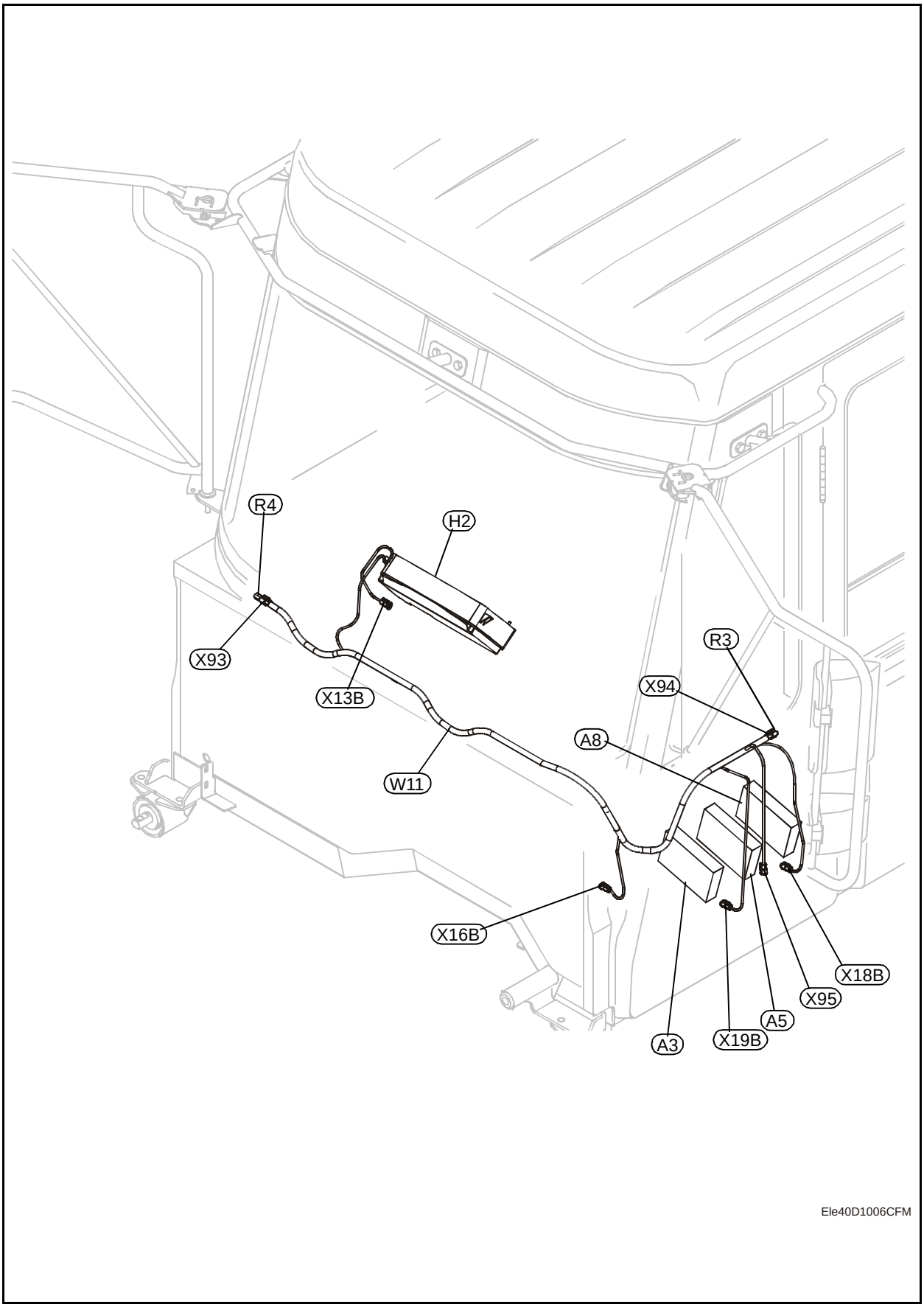
X71 Rotating Beacon Switch (S14) Connector.
X72 Rotating Beacon Switch Backlight (E9) Connector.
X73 4-Way Flasher Switch (S12) Connector.
X74 4-Way Flasher Switch Backlight (E10) Connector.
X75 Not Used.
X76 Not Used.
X77 Mirror Defroster Switch (S20) Connector.
X78 Mirror Defroster Switch Backlight (E12) Connector.
X79 Work Light Switch (S15) Connector.
X80 Work Light Switch Backlight (E13) Connector.
X81 Not Used.
X82 Not Used.
X83 Not Used.
X84 Not Used.
X85 Range Hold Switch (S6) Connector.
X86 Range Hold Switch Backlight (E14) Connector.
X87 Not Used
X88 Not Used.
X91A Cold Start and Run Circuits Power Connector.
X92 Differential Lock Pressure Switch (B26) Connector.
X110 Cab Firewall Ground (W2) Connector.
X160A Air Conditioning High/Low Pressure Switch (B31) Connector.
X160B Air Conditioning High/Low Pressure Switch (B31) Connector.
Y10 Exhaust Brake Solenoid.
Y13 Body Down Detent Magnet.
Y14 Park Brake Solenoid.
Y15 Inter-Axle Lock Solenoid.
Y18 Differential Lock Solenoid.
Y19 Air Horn Solenoid.

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## Controller Area Network (CAN) Harness

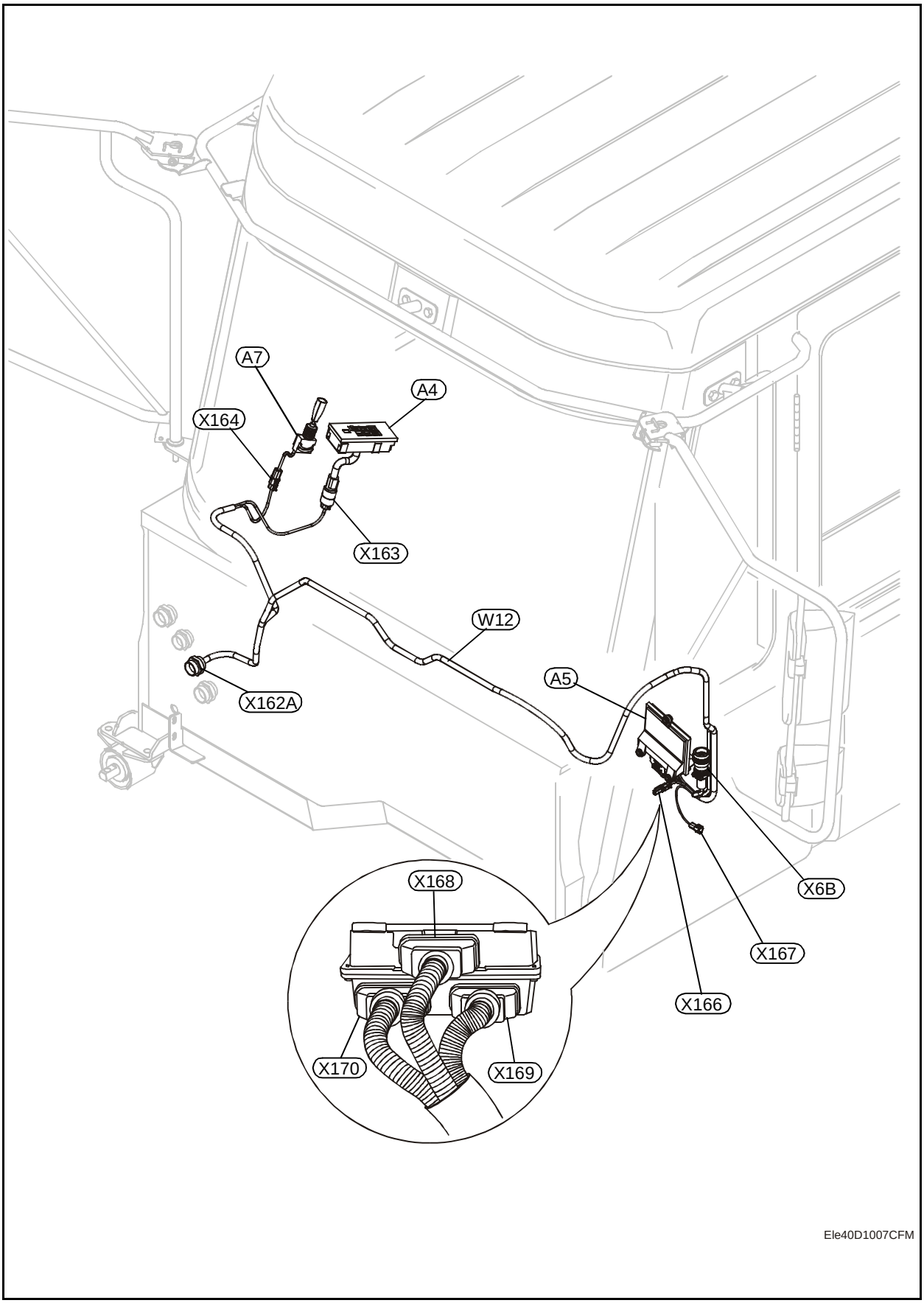


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A3 Engine Control Unit (ECU).
A5 Transmission Control Unit (TCU).
A8 Chassis Control Unit (CCU).
H2 Menu Display Unit (MDU).
R3 120 Ohm CAN Termination.
R4 120 Ohm CAN Termination.
W12 CAN Harness.
X13BMDU (H2) CAN.
X16BCAN Harness-to-Service ADVISOR ™ Connector.
X18BCCU (A8) CAN Connector.
X19BECU (A3) CAN Connector.
X93 120 Ohm CAN Termination Connector.
X94 120 Ohm CAN Termination Connector.
X95 TCU (A5) CAN Connector.

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## Transmission Control Harness

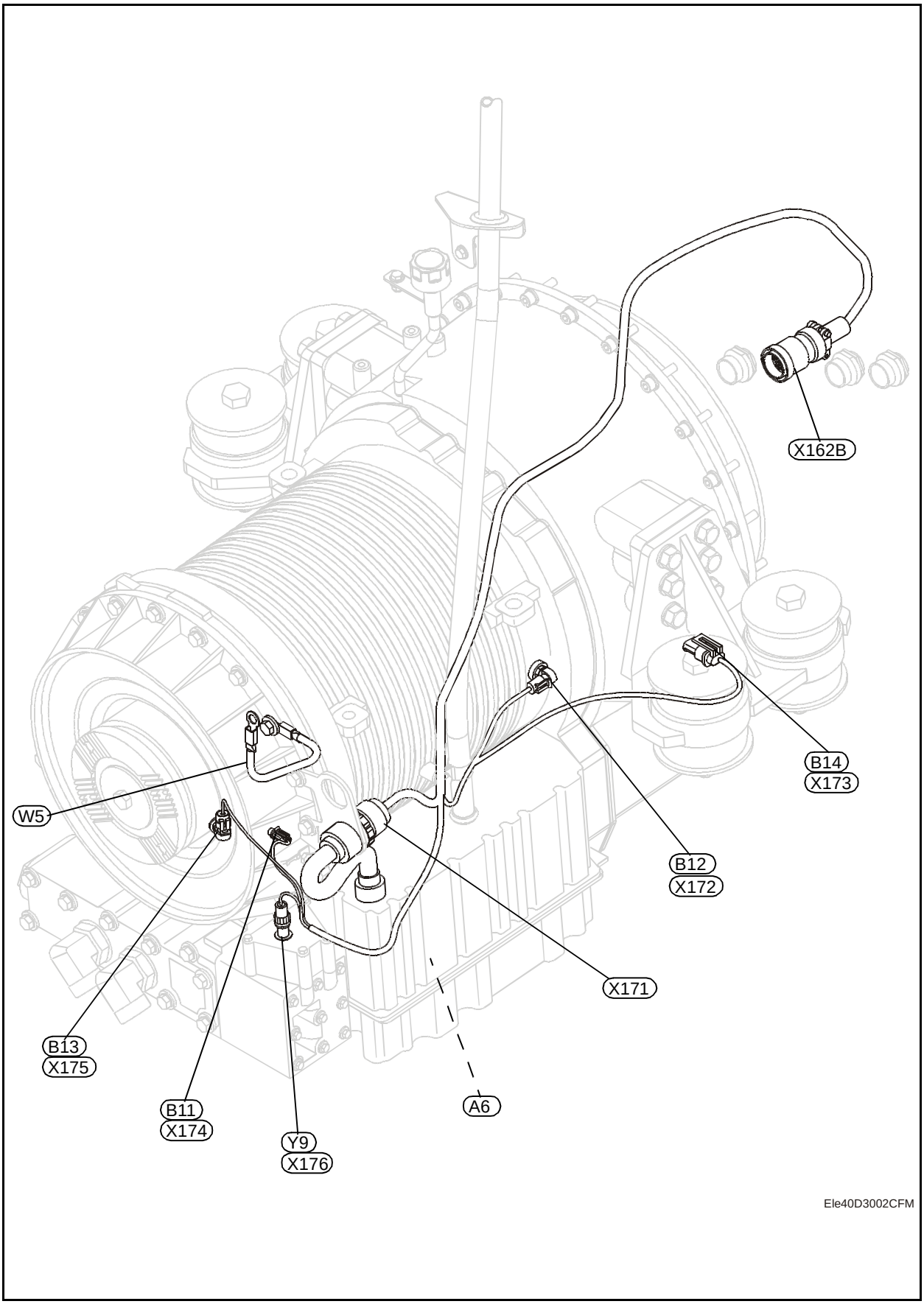


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A4 Transmission Shift Control.
A5 Transmission Control Unit (TCU).
A7 Retarder Control.
W13 Transmission Control Harness.
X6B Transmission Control Harness-to-Cab Main Connector.
X162ATransmission Control Harness-to-Transmission Harness Connector.
X163Transmission Shift Control (A4) Connector.
X164—Retarder Control (A7) Connector.
X166Retarder Resistor (R8) Connector.
X167TCU (A5) CAN Connector.
X168Blue TCU (A5) Connector.
X169Black TCU (A5) Connector.
X170Gray TCU (A5) Connector.

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## Transmission Harness

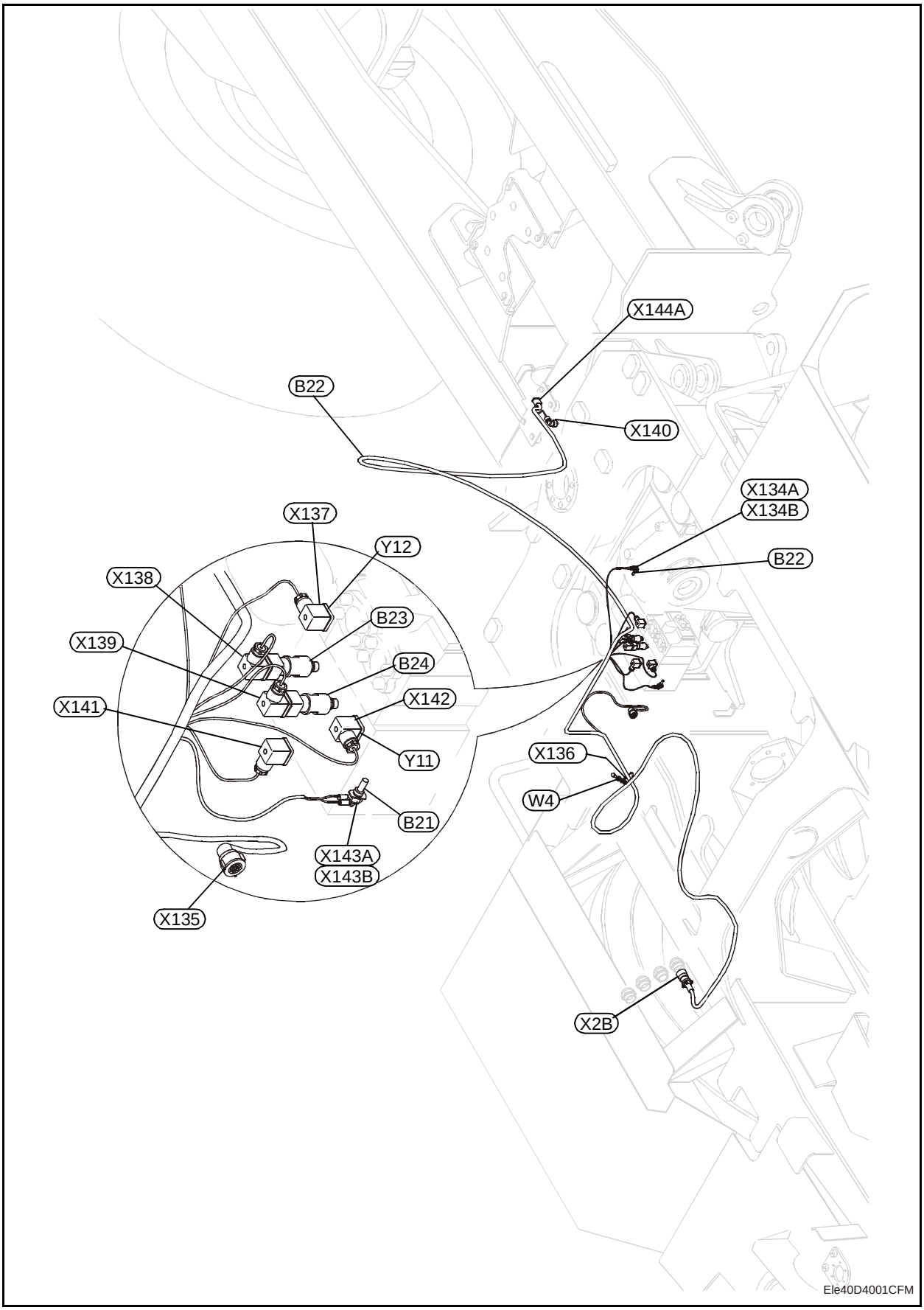


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A6 Transmission Control Module.
B11 Retarder Temperature Sensor.
B12 Turbine Speed Sensor.
B13 Output Speed Sensor.
B14 Input Speed Sensor.
W5 Transmission-to-Frame Ground Strap.
X162 Transmission Control Harness-to-Transmission Harness Connector.
X171 Transmission Control Module (A6) Connector.
X172 Turbine Speed Sensor (B12) Connector.
X173 Input Speed Sensor (B14) Connector.
X174 Retarder Temperature Sensor (B11) Connector.
X175 Output Speed Sensor (B13) Connector.
X176 Retarder Solenoid (Y9) Connector.
Y9 Retarder Solenoid.

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## Hydraulic Harness

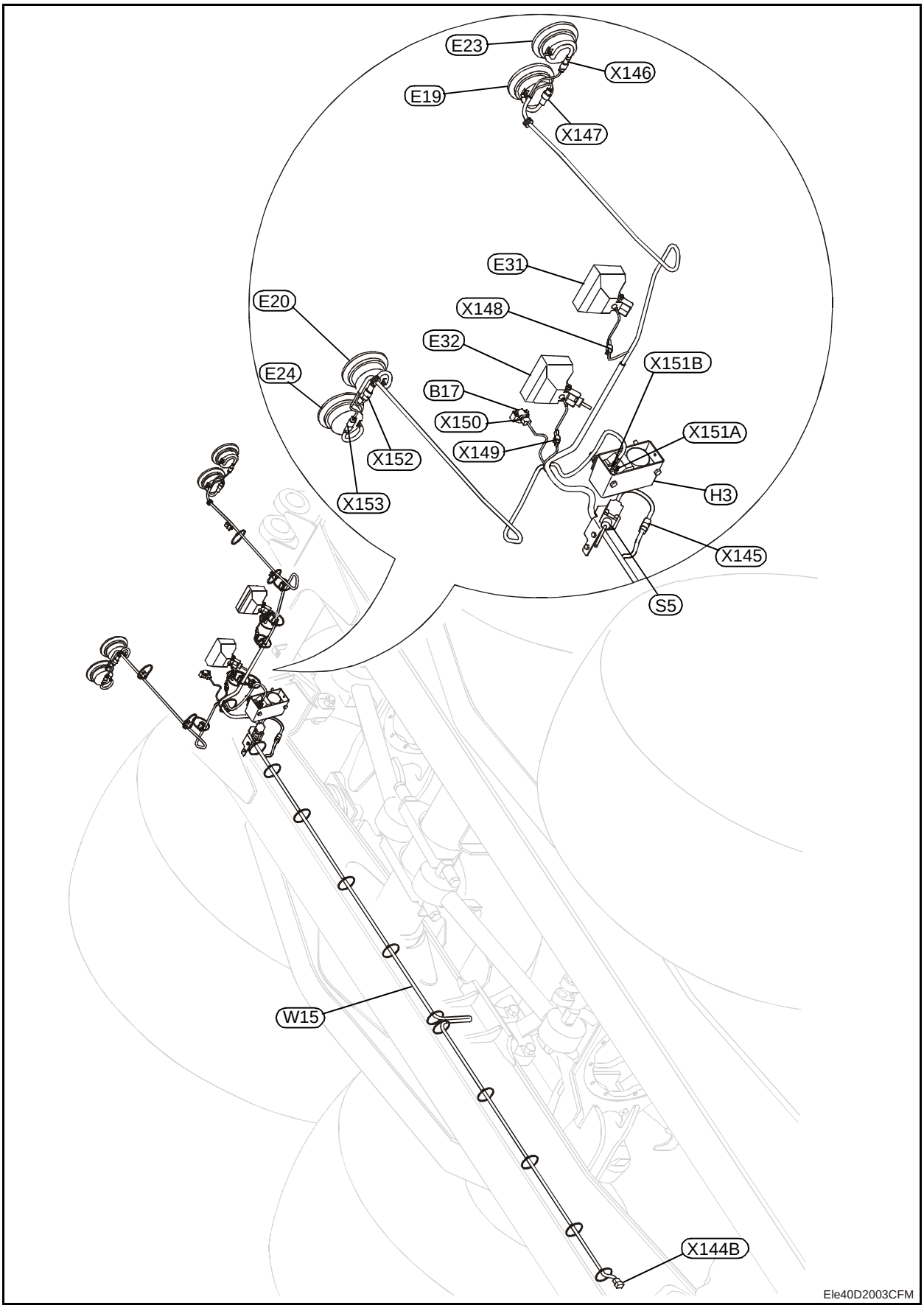


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B21 Hydraulic Temperature Sensor.
B22 Wet Brake Temperature Sensor (400D Only).
B23 Service Brake Low Pressure Switch.
B24 Secondary Steering Pressure Switch.
W4 Front Frame Ground (Under Cab).
W14 Hydraulic Harness.
X2B Hydraulic Harness-to-Cab Main Harness Connector.
X134A Wet Brake Temperature Sensor (B22) (Signal) Connector.
X134B Wet Brake Temperature Sensor (B22) Connector.
X135 Not Used.
X136 Front Frame Ground Connector (Under Cab).
X137 Fan Drive Solenoid (Y12) Connector.
X138 Service Brake Low Pressure Switch (B23) Connector.
X139 Secondary Steering Pressure Switch (B24) Connector.
X140 Not Used.
X141 Hydraulic Cut-Off Solenoid (Y17) Connector.
X142 Body Float Solenoid (Y11) Connector.
X143A Hydraulic Temperature Sensor (B21) (Signal) Connector.
X143B Hydraulic Temperature Sensor (B21) Connector.
X144A Hydraulic Harness-to-Rear Frame Harness Connector.
Y11 Body Float Solenoid.
Y12 Fan Drive Solenoid.
Y17 Hydraulic Cut-Off Solenoid.

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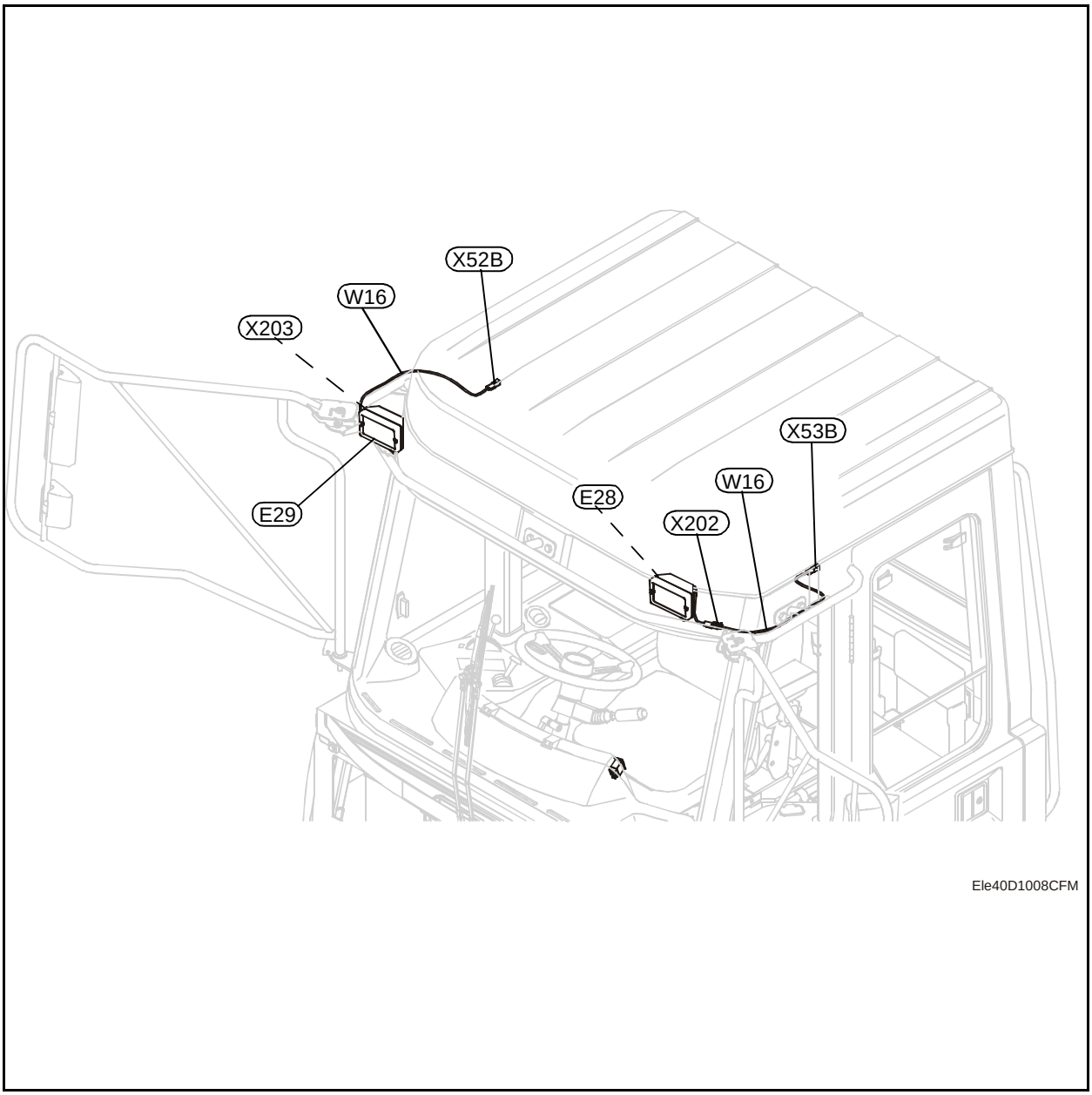
## Rear Frame Harness



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B17 Body Position Sensor.
E19 Left Stop/Park Light.
E20 Right Stop/Park Light.
E23 Left Rear Turn Signal.
E24 Right Rear Turn Signal.
E31 Left Backup Light.
E32 Right Backup Light.
H3 Backup Alarm.
S5 Body Up Switch.
W15 Rear Frame Harness.
X145Body Up Switch (S5) Connector.
X146Left Rear Turn Signal (E23) Connector.
X147Left Stop/Park Light (E19) Connector.
X148Left Backup Light (E31) Connector.
X149Right Backup Light (E32) Connector.
X150Body Position Sensor (B17) Connector.
X151ABackup Alarm (H3) Connector.
X151BBackup Alarm (H3) (Ground) Connector.
X152Right Stop/Park Light (E20) Connector.
X153Right Rear Turn Signal (E24) Connector.

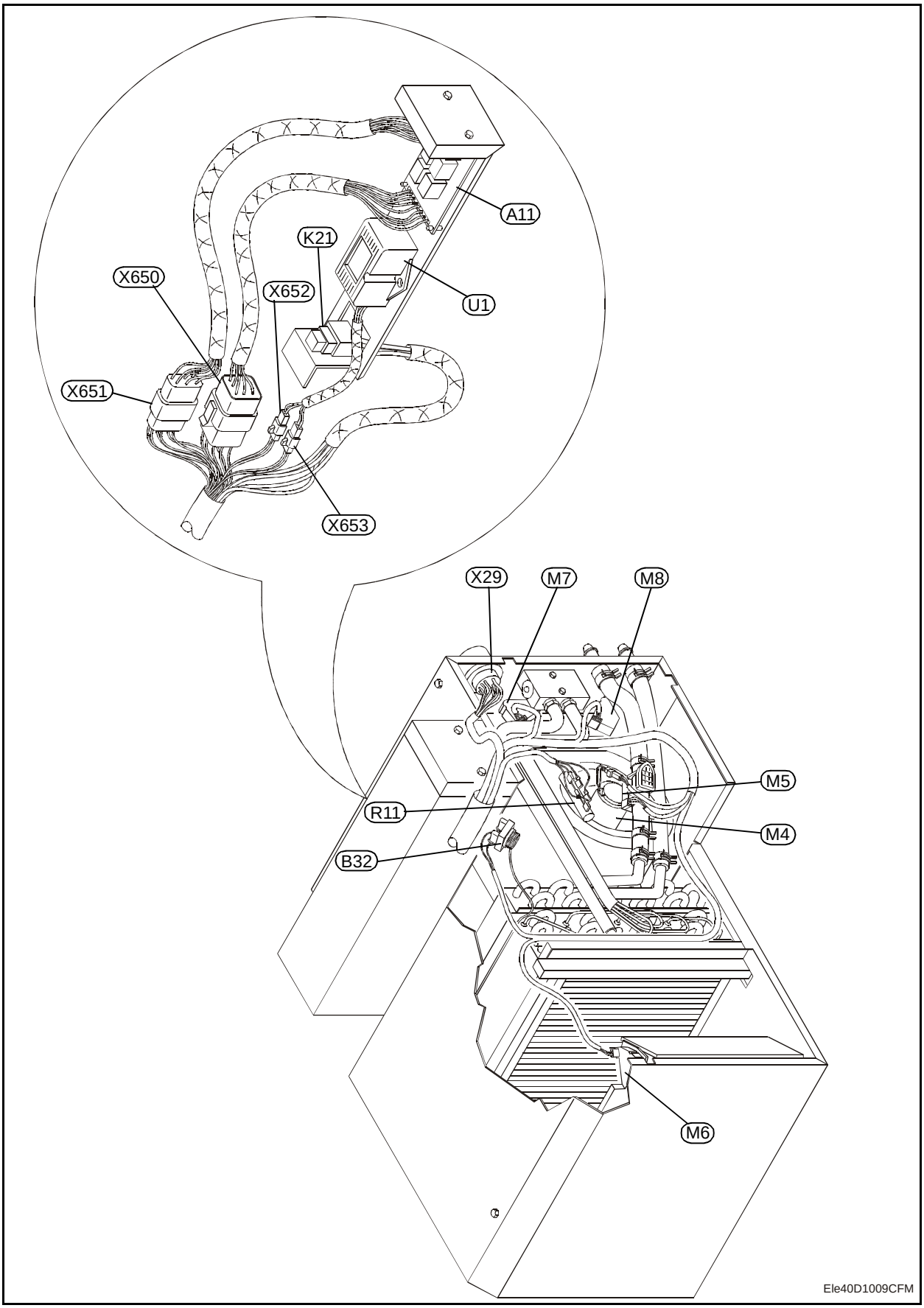
## Work Light Harness




E28 Left Work Light.
E29 Right Work Light.
W16 Work Light Harness.
X52BRight Work Light Harness-to-Cab Harness Connector.
X53BLeft Work Light Harness-to-Cab Harness Connector.
X202Left Work Light (E28) Connector.
X203Right Work Light (E29) Connector.

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## Air Conditioning Actuator Harness



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A11 A/C Relay Panel.
B32 Air Conditioning Freeze Control Switch.
K21 High Fan (Blower) Speed Relay.
M4 Blower Motor.
M5 Heater Control Valve Actuator.
M6 Recirculation Vent Actuator.
M7 Middle and Defroster Vent Actuator.
M8 Floor Vent Actuator.
R11 Blower Motor Resistor/Thermofuse.
X29 Cab Main Harness-to-A/C Actuator Harness 21-Pin Connector.
X650 A/C Relay Panel (A11) 12-Pin Connector.
X651 A/C Relay Panel (A11) 6-Pin Connector.
X652 DC/DC Converter Input Connector.
X653 DC/DC Converter Output Connector.
U1 DC/DC Converter.

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## EXPLANATION OF WIRE MARKINGS

### Wire Colour

The wire colour (Two character code) is simply an abbreviation of the wire colour.

| WIRE COLOUR | SCHEMATIC ABBREVIATION |
|---|---|
| Black | BK |
| Blue | BL |
| Brown | BN |
| Green | GN |
| Gray | GY |
| Orange | OG |
| Pink | PK |
| Purple | PL |
| Red | RD |
| White | WH |
| Yellow | YL |

### Multiple Wire Colours

Wires with more than one colour abbreviation will have a stripe running parallel to the wire.

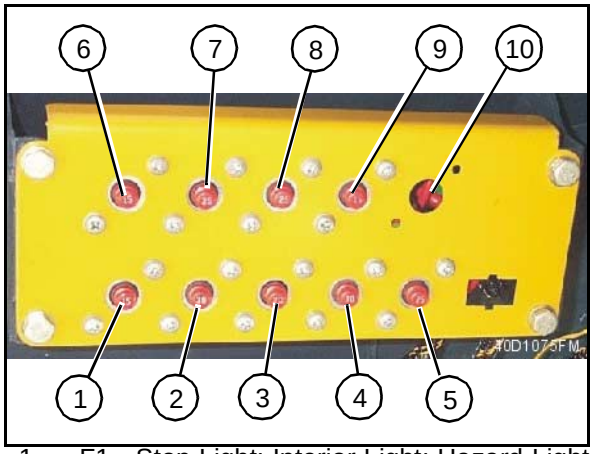
The first colour abbreviation will be the main colour, the second abbreviation will be the colour of the stripe.

Example: WH/BK represents a white wire with a black stripe.

Wires with three colour abbreviations will have two stripes running parallel to the wire. The second and third colour abbreviations will be the colour of the stripes.

Example: BK/WH/GN represents a black wire with a white and green stripe.

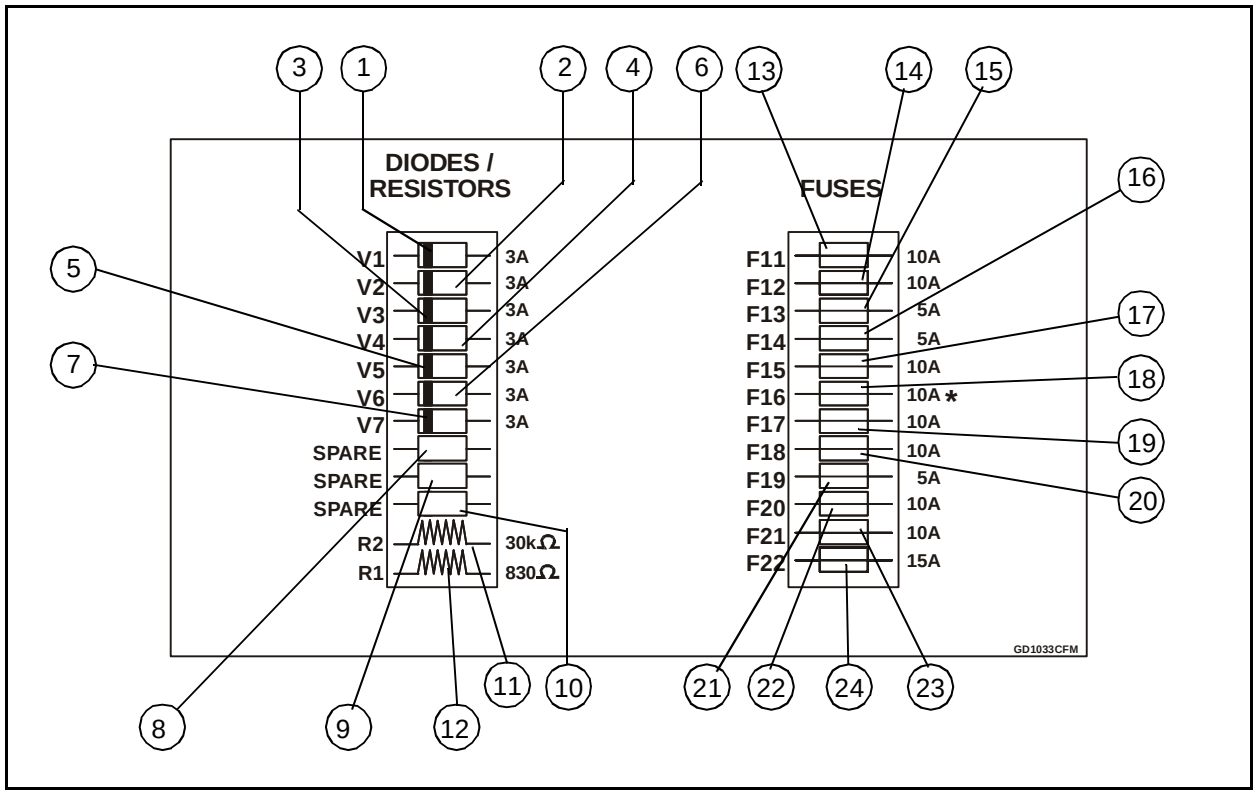
### Circuit Breakers




1. F1 - Stop Light; Interior Light; Hazard Light and Turn Signal Circuit Breaker (15 Amp).
2. F2 - Unswitched Power to Fuses F12; F13; F18; F19; F20 and F21 Circuit Breaker (30 Amp).
3. F3 - Switched Power to Fuses F11; F14; F15 and F16 Circuit Breaker (20Amp).
4. F4 - Headlight; Work Light; Backup Light and Rotating Beacon Circuit Breaker (3 Amp).
5. F5 - Headlight and A/C Circuit Breaker (25 Amp).
6. F6 - Park Brake; Differential Lock; Fan Drive; Body Down Detent and Range Hold Circuit Breaker (15 Amp).
7. F7 - Wiper; Washer; Horn and Mirror Circuit Breaker (25 Amp).
8. F8 - Cold Start Circuit Breaker (25 Amp).
9. F9 - Start; Neutral; MDU/CCU Power; Exhaust Brake and Body Float Circuit Breaker (15 Amp).
10. F10 - Blank.

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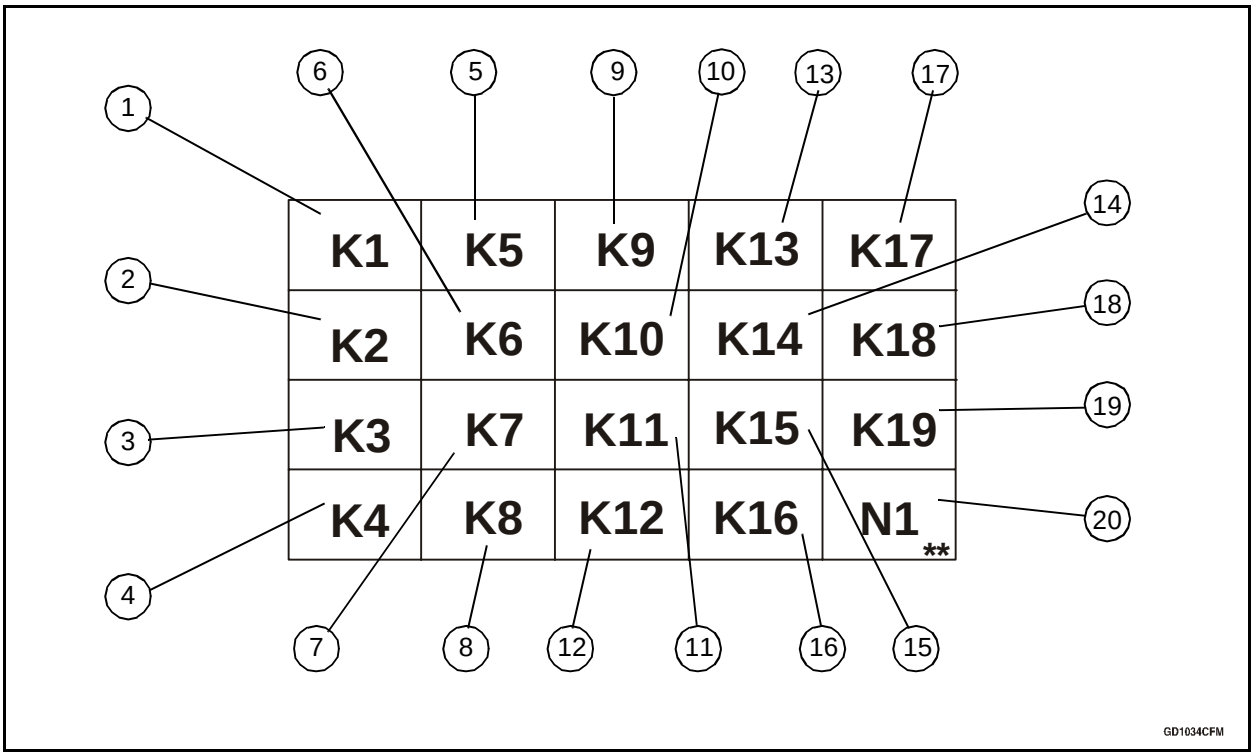
## Diodes/Resistors and Fuses




1. V1 - Retarder; Exhaust Brake Light Control Diode (3 Amp).
2. V2 - Stop Light Control Diode (3 Amp).
3. V3 - Alternator Excitation Diode (3 Amp).
4. V4 - Intermittent Wiper Control Diode (3 Amp).
5. V5 - Washer/Wiper Control Diode (3 Amp).
6. V6 - Hazard Control Diode (3 Amp).
7. V7 - MDU/CCU Power Diode (3 Amp).
8. Spare.
9. Spare.
10. Spare.
11. R2 - Not Used (30 K Ohm).
12. R1 - Air Pressure Sensor Pull-Up Resistor (830 Ohm).
13. F11 - Retarder/Voltage Regulator Fuse (10 Amp).
14. F12 - Transmission Control Unit (TCU) Fuse (10 Amp).
15. F13 - MDU/CCU power and Hazard Fuse (5 Amp).
16. F14 - Alternator Excitation Fuse (5 Amp).
17. F15 - Program/Diagnostic Fuse (10 Amp).
18. F16 - ECU/EUI Power Relay Fuse (10 Amp).
19. F17 - AM/FM Radio Fuse (10 Amp).
20. F18 - ECU Fuse (10 Amp).
21. F19 - MDU Fuse (5 Amp).
22. F20 - Diagnostic Fuse (10 Amp).
23. F21 - Battery Balancer/Accessories Fuse (10 Amp).
24. F22 - 2-Way Radio Fuse (15 Amp).

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## Relays/Voltage Regulator




1. K1 - Neutral Start Relay.
2. K2 - Start Relay.
3. K3 - Headlights and A/C Cutout Relay.
4. K4 - Backup Relay.
5. K5 - Stop Light Relay.
6. K6 - Exhaust Brake Relay.
7. K7 - Park Brake Relay.
8. K8 - Range Hold Relay.
9. K9 - Left Turn Relay.
10. K10 - Right Turn Relay.
11. K11 - Low Beam Relay.
12. K12 - High Beam Relay.
13. K13 - Body Float Relay.
14. K14 - Intermittent Wiper Relay.
15. K15 - Accessory Relay.
16. K16 - ECU/EUI Power Relay.
17. K17 - MDU/CCI Power Relay.
18. K18 - Blank Relay Socket.
19. K19 - Blank Relay Socket.
20. N1 - Retarder Voltage Regulator.

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# CHAPTER 3. ELECTRICAL SYSTEM

## SECTION 2. SYSTEMS AND SUB-SYSTEM DIAGRAMS AND DIAGNOSTICS

### STARTING AND CHARGING CIRCUIT AND THEORY OF OPERATION

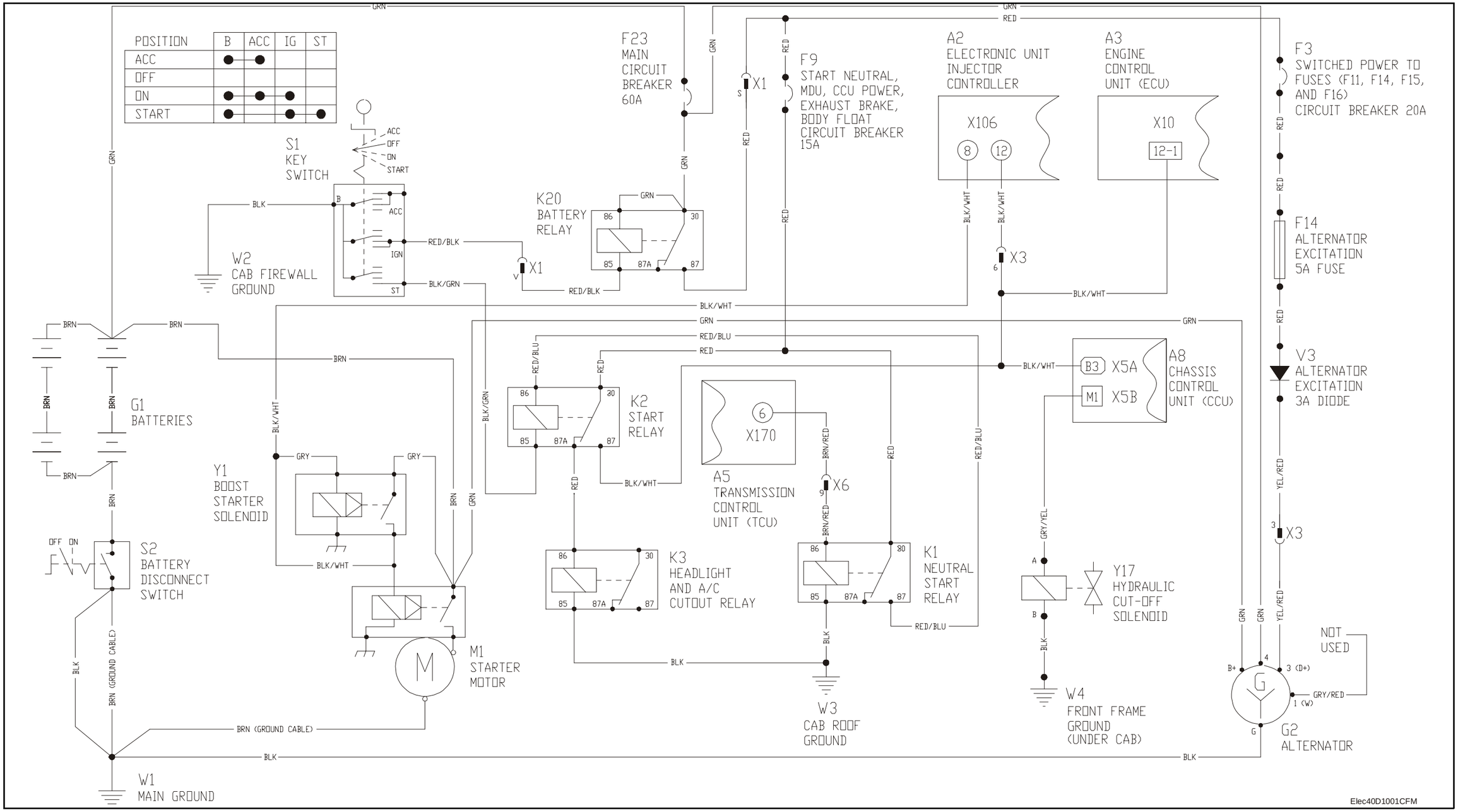



**Figure 3-1**

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The tachometer on the Menu Display Unit is accurate enough for test work. **(See Operators Manual CHAPTER 2 for more information and CHAPTER 8 for detail operating the Menu Display Unit)**.

## Starting Circuit

When key switch (S1) is turned to the "**ON**" position, power becomes available at terminal 30 of neutral start relay (K1). At the same time, current flows across the normally closed contact of start relay (K3), energizing the relay. With relay (K3) energized, current is allowed to flow to the headlight and air conditioning circuits, allowing these circuits to function as needed.

With the key switch in the "**ON**" or "**START**" position, the transmission control unit (**TCU**) (A5) will confirm if transmission is in neutral. When it is confirmed that the transmission is in neutral, the TCU will allow current to flow out terminal 6 of TCU connector X170 to the coil of neutral start relay (K1), energizing the relay. With relay (K1) energized, power is now available at the coil of start relay (K2). The TCU also sends a signal to he transmission shift control (not shown in circuit schematic), to an "**N**" on the range indicator.

Turning key switch (S1) to the "START" position provides a ground to the coil of start relay (K2), energizing the relay. With relay (K2) energized, current flows to the electronic unit injector (EUI) controller (A2), engine control unit (CCU) (A8), signalling the "**START**" process.

When the CCU receives current at terminal B2 of connector X5A, the CCU sends current out terminal M1 of CCU connector X5B to hydraulic cut-off solenoid (Y17), energizing the solenoid. With hydraulic cut-off solenoid (Y17) energized, the hydraulic pump is destroked, which allows the engine to crank easier.

The start signal at terminal B3 of connector X5A also causes the CCU to apply the park brake.

**NOTE:1. For information on operation of the hydraulic pump and load sensing circuit, (See "Main Hydraulic Pump Operation" on page 336).**
**2. For more information on the park brake, See "PARK BRAKE AND EXHAUST BRAKE CIRCUIT THEORY OF OPERATION" on page 76.**

When the ECU receives current at terminal 12-1 of connector X10, it will confirm the start signal then send a signal through the CAN data line to the EUI controller. When the EUI controller receives current at terminal 12 of connector X106, it checks to see if any engine service codes exist.

**NOTE:1. For more information on the ECU, See "ENGINE CONTROL UNIT CIRCUIT THEORY OF OPERATION" on page 64.**
**2. For more information on the EUI controller, See "ELECTRONIC UNIT INJECTOR CONTROLLER CIRCUIT THEORY OF OPERATION" on page 62.**

If no engine service codes exists, the EUI controller will send current out terminal 8 of EUI controller connector X106. This current flows to the starter solenoid of starter motor (M1), and at the same time flows to the coil of boost starter solenoid (Y1), energizing the boost starter solenoid. The current from the output of the EUI controller is not sufficient to energize the starter solenoid by itself, but is sufficient to energize solenoid (Y1).

When solenoid (Y1) is energized, current from the battery flows directly to the starter solenoid, energizing the starter solenoid. With the starter solenoid energized, high current from the batteries is allowed to flow through he starter motor windings, causing the starter motor to crank the engine.

During engine cranking, current flow to headlight and A/C cutout relay (K3) is interrupted, thus de-energizing the relay. With relay (K3) de-energized, current to the headlight and air-conditioning circuits is interrupted, deactivating these systems (if activated). Deactivating the headlights and air-conditioning reduces the cranking load on the engine during start-up.

To assist engine starts in cold weather, a cold start system is provided. For information on the cold start system **See "COLD START CIRCUIT THEORY OF OPERATION" on page 60**.

## Charging Circuit

Alternator (G2) provides power to all machine circuits and charges the batteries when the engine is running. Terminal B+ of the alternator is connected to battery positive (+) at all times.

When key switch (S1) is in the "ON" position, current from circuit breaker (F3) is sent to terminal D+ on the alternator to excite the alternator field windings. Alternator excitation diode (V3) prevents current feedback from the alternator if the alternator circuitry is improperly connected or has a major failure.

The battery charge light on the MDU will come ON if any of the following occur:

- Key Switch (S1) is in the "ON" position with engine speed less than 400 r.p.m.
- Alternator (G2) has malfunctioned.
- Alternator output less than 25.5 volts or more than 29.5 volts.
- Difference between single battery voltage and 1/2 system voltage is more than 1.5 volts. **See "Battery Balancer And 12-Volt Accessory Circuit Theory of Operation" on page 90**

During normal machine operation, system voltage is shown on the monitor display.

The battery charge status is digitally displayed in the menu structure of the MDU, when accessed. For more information on the menu structure, **See CHAPTER 8 in Operator's Manual**.

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## COLD START CIRCUIT THEORY OF OPERATION

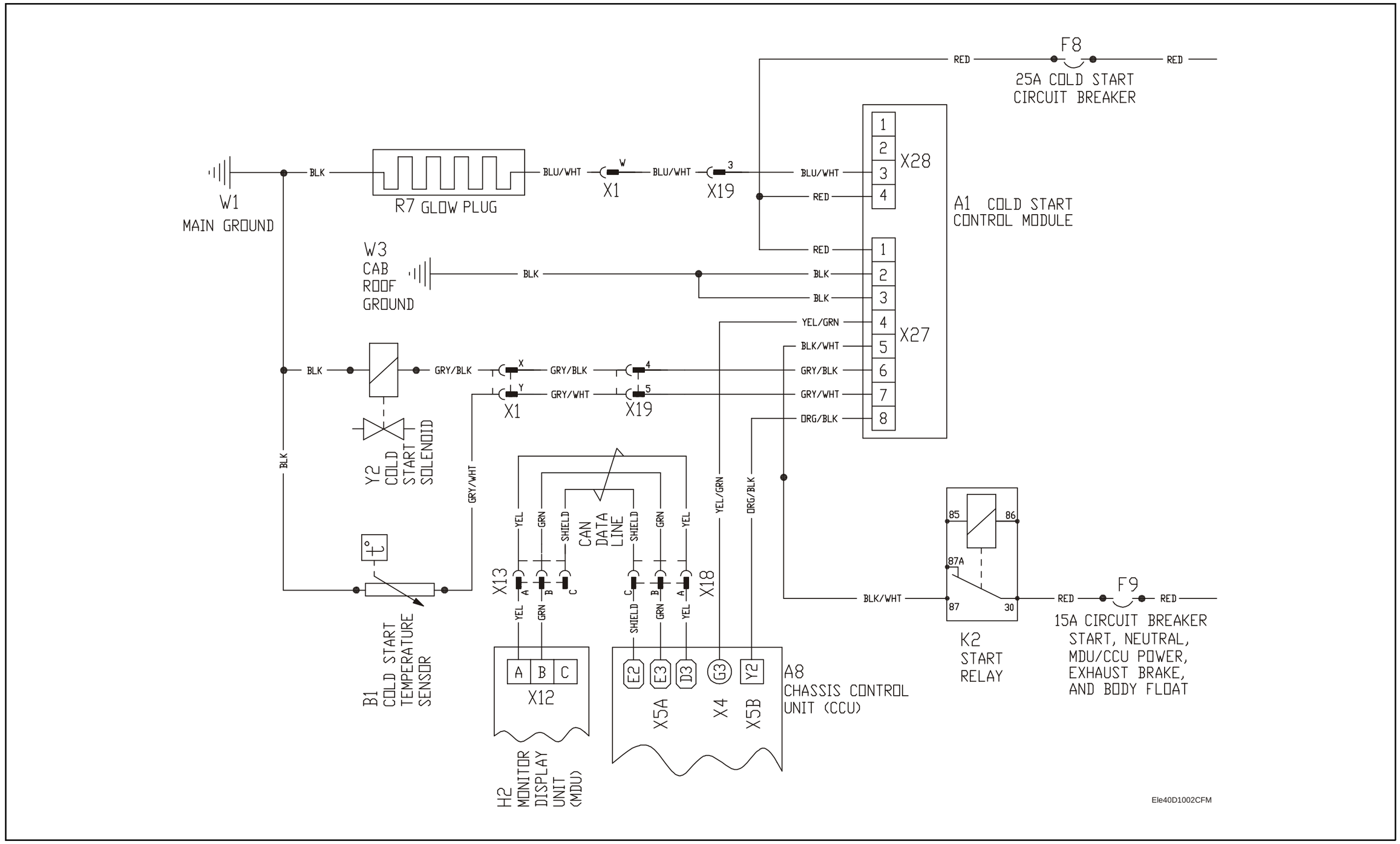



**Figure 3-2**

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When the key switch is turned to the "**ON**" position, power from cold start circuit breaker (F8) is provided at terminal 1 of connector X27 and terminal 4 of connector X28 on cold start module (A1). The cold start control module (A1) will send a signal out terminal 8 of connector X27 to terminal Y2 of connector X5B on chassis control unit (CCU) (A8).

The CCU will then send the signal through the CAN data line to monitor display unit (MDU) (H2), which will cause the COLD START light to come **ON**.

If the ambient air temperature is below 15°C (59°F) the cold start system will remain **ON** for approximately 20 seconds.

If the ambient air temperature is above 15° C (59°F), the cold start light will go **OFF** after 2 seconds.

**NOTE: The cold start status is displayed in the menu structure of the MDU, when accessed. For more information, See CHAPTER 8 in the OMM.**

During a cold start, glow plug (R7) will become hot and the cold start light will lit for approximately 20 seconds then go **OFF,** signalling the engine is ready to be cranked.

During cranking, current from start relay (K2) flows to terminal 5 of connector X27 to let cold start control module (A1) know that the engine is being cranked. During this time, cold start control module (A1) sends current to cold start solenoid (Y2) to allow a small amount of fuel to be sprayed over the hot glow plug, this producing a flame in the combustion chamber located in the intake manifold.

The flame pre-heats the air evenly for all cylinders, which helps reduce fuel consumption during warm-up. This process of glow plug heating and fuel spray will continue until the engine reaches a temperature of 23° C (73° F), then the cold start system will deactivate automatically.

The cold start system will also deactivate if the engine cranking begins before the **COLD START** light goes **OFF**, or if the engine is not stared within 30 seconds after the cold start light goes **OFF**. To let the cold start module know the engine is running, the CCU sends a signal out G3 of connector X4 to terminal 4 of cold start module connector X27.

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## ELECTRONIC UNIT INJECTOR CONTROLLER CIRCUIT THEORY OF OPERATION

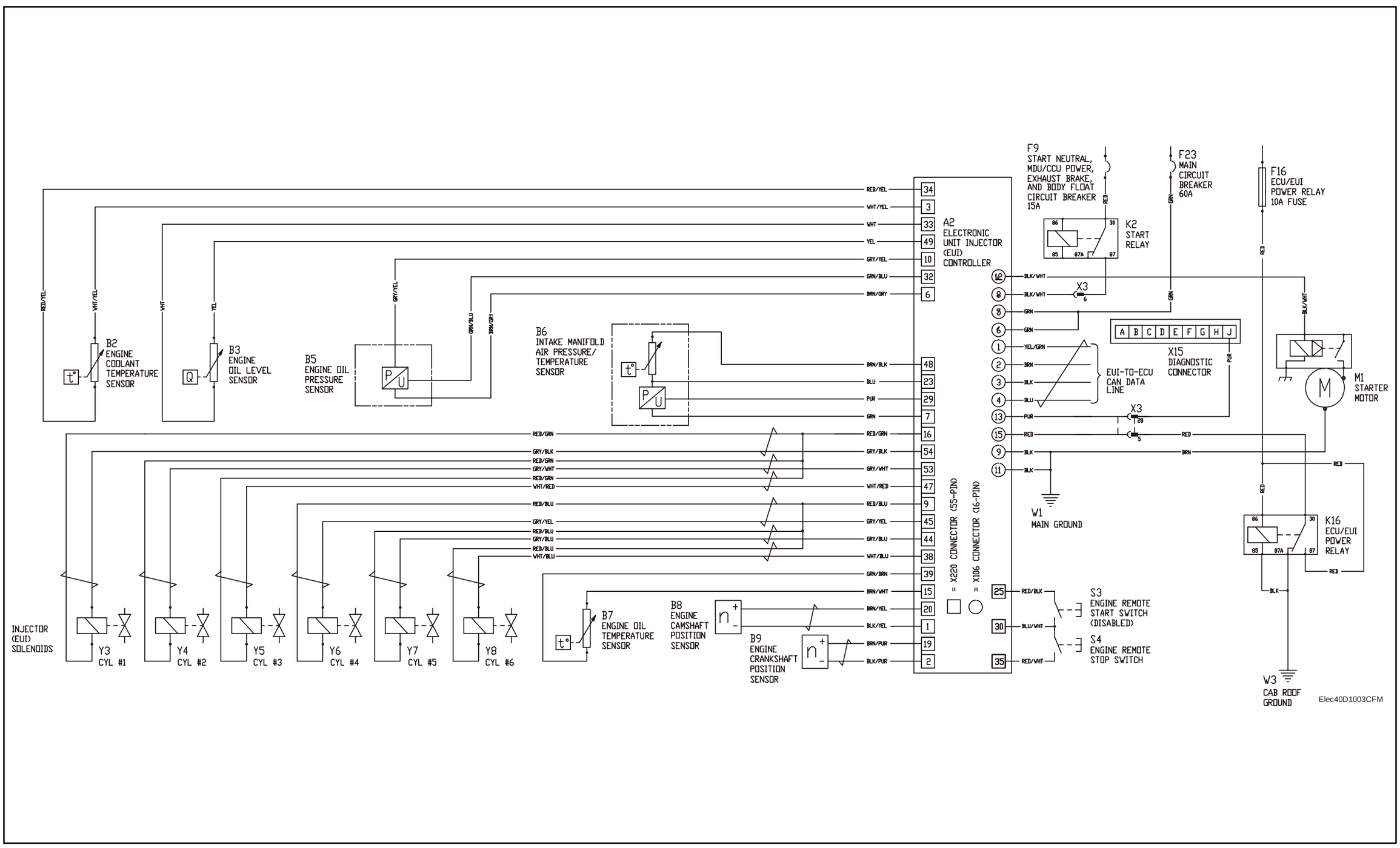



**Figure 3-3**

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The electronic unit injector (EUI) controller (A2) receives unswitched battery power at terminals 5 and 6 of connector X106.

Switched power from the ECU/EUI power relay fuse (F16) is provided at terminal 15 of connector X106.

The EUI controller constantly analyses all relevant engine data (start of injection, load on engine, ambient conditions, etc.) from the engine sensors and data from the engine control unit (ECU), (e.g., accelerator pedal position). For information on the ECU, **See "ENGINE CONTROL UNIT CIRCUIT THEORY OF OPERATION" on page 64.**

The data is stored in the EUI controller and compared with the controller's pre-programmed software. The controller then computes the quantity of fuel needed (delivery angle) and the optimal injection time (start of delivery), then actuates each injector solenoid of the individual cylinders accordingly. For more information on how the Electronic Unit Injectors Function, **See "Electronic Unit Injector Fuel System" on page 42**.

The EUI controller limits the torque request if the governed speed or a specific engine limit is reached.

The EUI controller has to detect the following variables in order to calculate proper start of delivery:

- Engine Speed.
- Specified Torque.
- Engine coolant temperature.
- Intake manifold air temperature (MAT).
- Intake manifold air pressure (MAP).
- Atmospheric pressure.
- Top dead centre (TDC) of cylinder #1.
- Start signal to starter solenoid.

### Engine Speed and TDC

Engine crankshaft position sensor (B9) is the primary sensor for detecting engine speed. It is also used as a backup for detecting top dead centre (TDC) of cylinder #1 should engine camshaft position sensor (B8) malfunction.

To detect engine speed, 36 holes have been machined into the outer edge of the flywheel at 10 degree intervals. A 37th hole, located 65 degrees before top dead centre, is used for the detection of TDC.

Engine camshaft position sensor (B8) is the primary sensor for TDC of cylinder #1. It is also used as backup for detecting engine speed should the engine crankshaft position sensor (B9) Malfunction.

To detect the engine speed, 12 holes has been machined into the outer edge of the camshaft gear at 30-degree intervals. A 13th hole, located 55 degrees before TDC, is for detecting the TDC.

The camshaft and crankshaft position sensors allow the EUI controller to precisely determine piston position in relation to TDC so that the EUI controller can command the correct EUI solenoid at the correct time. The EUI controller then controls the fuel delivery by energizing and de-energizing the individual solenoids that open and close the EUI spill valves.

## Temperature Sensors

All engine related temperature sensors used on the B35D and B40D ADT's have a negative temperature coefficient (i,e., sensor resistance decreases as temperature increases).

The EUI controller sends a low reference voltage to the sensor, monitors the voltage drop across the sensor, then compares the voltage drop to pre-programmed values in the EUI controller memory to determine the temperature.

**⚠ WARNING**

**Do not apply battery voltage to any of the engine temperature sensors. Damage to the sensor will occur.**

### Engine Coolant Temperature Sensor

The EUI controller monitors the signal from engine coolant temperature sensor (B2) for:

- Engine protection purposes.
- Starting fuel quantity determination (The EUI controller will adjust the amount of fuel delivered during start-up based on initial engine coolant temperature).
- Start of fuel delivery determination (The EUI controller will adjust the timing of fuel delivered during start-up based on initial engine coolant temperature).
- Specified torque calculation (Limits engine output).

The EUI controller also sends the engine coolant temperature information to the engine control unit (ECU).

The ECU transmits the information through the CAN data line to the MDU where the information is displayed on the COOLANT TEMP. gauge.

**NOTE:1. For more information on the COOLANT TEMP. gauge and the MDU, See "MENU DISPLAY UNIT CIRCUIT THEORY OF OPERATION" on page 78.**
**2. The engine coolant temperature status is digitally displayed in the menu structure of the MDU, when accessed. For more information on the Menu Display Unit Menu Function, See CHAPTER 8 in Operator's & Maintenance Manual.**

### Engine Oil Temperature Sensor:

The EUI controller monitors the signal from engine oil temperature sensor (B7). The sensor varies voltage with respect to temperature change as follows:

Oil Temperature @ 130° C (266° F)0,41 volts
Oil Temperature @ 115° C (239° F)0,56 volts
Oil Temperature @ 90° C (194° F)0,97 volts
Oil Temperature @ 70° C (158° F)1,50 volts
Oil Temperature @ 10° C (50° F)3,96 volts
Oil Temperature @ -5° C (23° F)4.41 volts
Oil Temperature @ -20° C (4° F)4,71 volts
Oil Temperature @ -40° C (-40° F)4.90 volts

### Manifold Air Temperature (Mat) Sensor

The MAT sensor is an integral part of the intake manifold air pressure/temperature sensor (B6). The EUI controller monitors the intake manifold air temperature in conjunction with the manifold air pressure to determine air density, then adjust the fuel delivery accordingly.

## Pressure Sensors

### Manifold Air Temperature (MAP) Sensor

The MAP sensor is an integral part of the intake manifold air pressure/temperature sensor (B6).

The EUI controller monitors the intake manifold air pressure in conjunction with the manifold air temperature to determine air density, then adjust the fuel delivery accordingly.

The EUI controller compares the MAP sensor data with data from an atmospheric pressure sensor located inside the EUI controller.

The comparing of manifold pressure with atmospheric pressure is used for diagnostics purposes and to protect the engine when operating at full throttle above certain altitudes.

### Engine Oil Pressure Sensor

The EUI controller monitors the signal from engine oil pressure sensor (B5) and passes the information to the engine control unit (ECU).

The ECU sends the information through the CAN data line to the Menu Display Unit where the information is displayed on the Engine Oil Pressure Gauge.

When engine oil pressure becomes less than a predetermined low pressure setting, the red Service light will flash and an audible alarm will sound.

**NOTE:For more information on the Engine Oil Pressure gauge and low oil pressure alarm, See MDU Circuit Theory of Operation in this Section. The engine oil pressure status is digitally displayed in the menu structure of the MDU, when accessed. For more information on the menu structure, See CHAPTER 8 of the Operator's & Maintenance Manual.**

### Switches

Engine remote stop switch (S4), located at the right side of the engine, has a direct connection to the EUI controller for remote engine shut-down. Engine remote start switch (S3), located next to the stop switch, is disabled and has no function.

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## ENGINE CONTROL UNIT CIRCUIT THEORY OF OPERATION

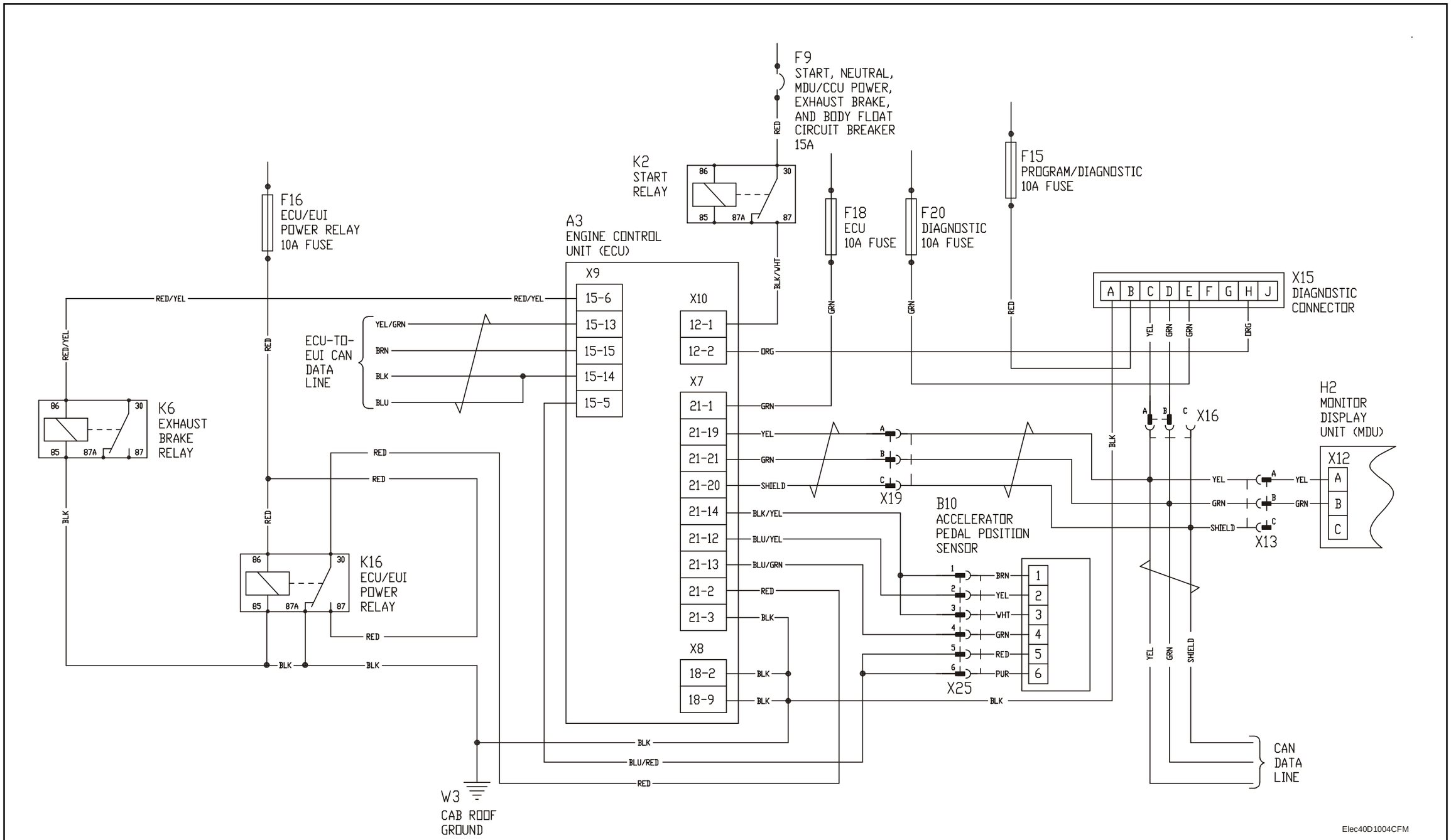



**Figure 3-4**

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When the key switch is in the **ON** position, power for ECU (A3) comes from ECU/EUI power relay fuse (F16). The ECU stores vehicle specific data for operation of the engine and any engine related service codes.

It constantly monitors data from the EUI controller, the accelerator pedal position sensor and the start circuit. For information on the start circuit, **See** “STARTING AND CHARGING CIRCUIT AND THEORY OF OPERATION” on page 58.

The ECU transmits any engine service codes that may occur through the CAN data line to the MDU, causing the engine service light to come **ON** and the service code to be displayed.

**NOTE:1. To diagnose service codes, see Service Code Diagnostics - Engine Control Unit in “Service Code Diagnostics - Engine Control Unit” on page 99.**
**2. The ECU status is digitally displayed in the menu structure of the MDU, when accessed. For More information on the MDU menu functions - See CHAPTER 8 of the Operator’s & Maintenance Manual.**

The engine speed is controlled automatically. There is no mechanical link between the engine and the accelerator pedal. Accelerator pedal position sensor (B10) communicates accelerator position to the ECU using pulse width modulation (PWM).

The ECU receives the PWM signal and compares it to pre-programmed limit values. It then passes a torque request through the CAN data line to the EUI controller. The EUI controller processes the information along with data from the other engine inputs to control the EUI solenoid accordingly. (For information on the EUI controller, **See** “ELECTRONIC UNIT INJECTOR CONTROLLER CIRCUIT THEORY OF OPERATION” on page 62**).**

Engine slow idle and fast idle speeds are pre-programmed into the ECU. When at the maximum speed, the ECU requests only the torque which is necessary for maintaining the speed even if the accelerator is at the full throttle position.

Whenever the ECU or the accelerator pedal position sensor is replaced, it may be necessary to calibrate the accelerator pedal position.

An acceptable margin of error between pedal movement relative to percentage read-out on the MDU will differ from operator to operator. Because of this, the need for re-calibration will be determined by operator preference.

To program the ECU, a special diagnostic tool (The Mini Diag II Version B) is required. The Mini Diag II is capable of reading and deleting engine related service codes and calibrating accelerator pedal position.

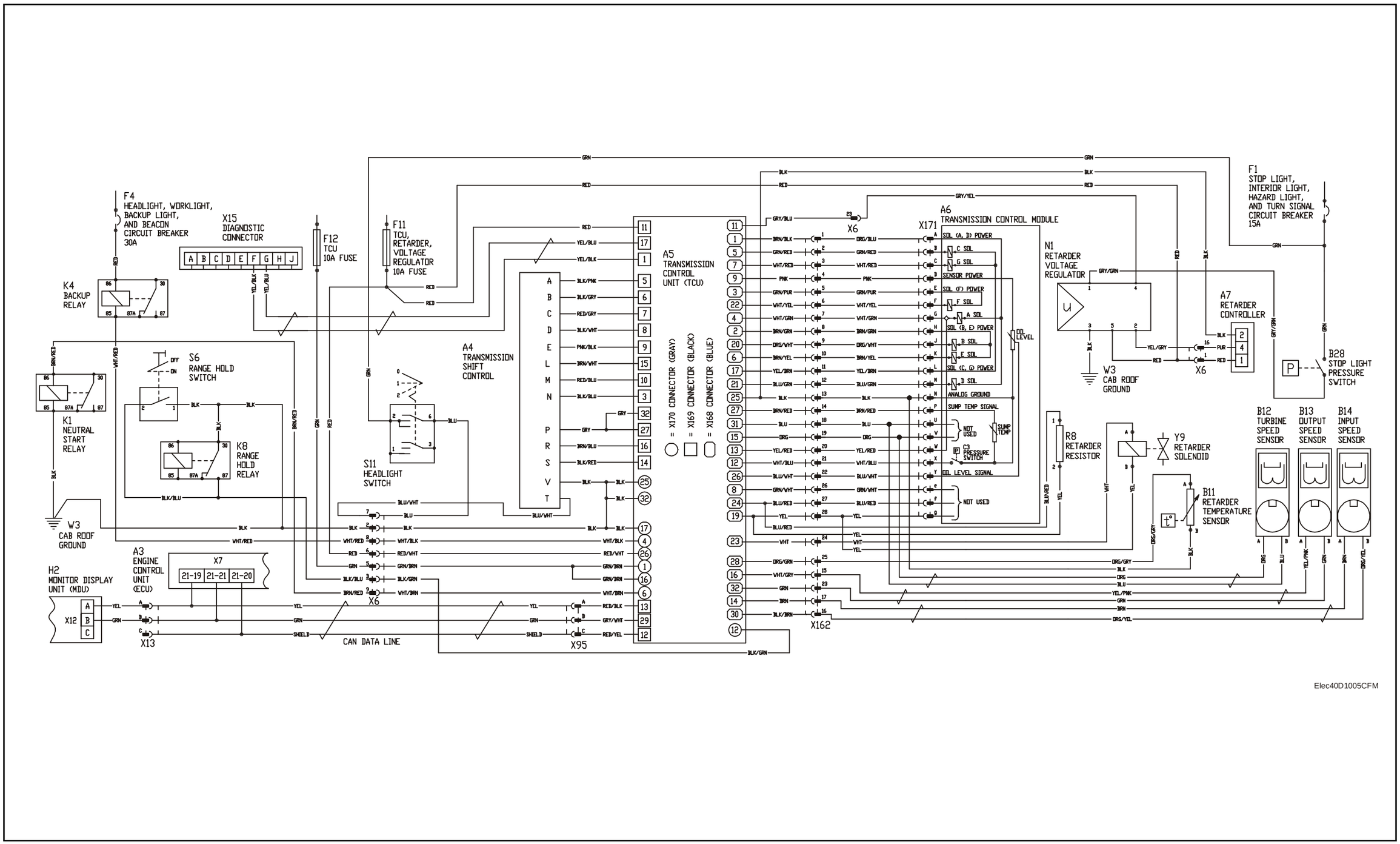
The Mini Diag II can be acquired from ***BELL EQUIPMENT*** Part No. 280479. Follow the instructions that come with the diagnostic tool.

In the event of an overspeed condition or when engine speed is above 800r.p.m., the torque convertor is locked up and the accelerator pedal position is less than 10%, the ECU will send current to the coil of exhaust brake relay (K6), energizing the relay and activating the engine exhaust brake. (For more information on the engine exhaust brake, **See P**“PARK BRAKE AND EXHAUST BRAKE CIRCUIT THEORY OF OPERATION” on page 76**)**.

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## TRANSMISSION CONTROL UNIT AND RETARDER CIRCUIT THEORY OF OPERATION




Elec40D1005CFM

**Figure 3-5**

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## Transmission Control Unit

Transmission control unit (TCU) (A5) receives unswitched battery power at terminals 1 and 16 of connector X170.

When the key switch is in the ON position, power from TCU, retarder, voltage regulator fuse (F11) is provided to terminal 26 of TCU connector X170, terminal 11 of TCU connector X169, terminal 1 of retarder controller (A7) and terminal 5 retarder voltage regulator (N1).

The TCU receives and processes information defining:

- Shift Selector position.
- Accelerator Pedal position.
- Input (Engine) speed.
- Turbine speed.
- Transmission output speed.
- Transmission Sump temperature.
- Engine Coolant temperature.
- Retarder temperature.
- Percentage of retardation.
- C3 Pressure Switch status.
- Transmission Oil level.

**NOTE: The ECU sends the accelerator pedal position and engine coolant temperature data through the CAN data line to the TCU.**

The TCU uses this information to control the transmission solenoids and valves, supply system status and provide diagnostic information such as service codes.

To activate the transmission solenoids, the TCU uses pulse width modulation (PWM) which varies the duty cycle (ON Time) of each corresponding transmission solenoid for optimum shift quality.

**⚠ CAUTION**

**When diagnosing transmission solenoids, never apply system voltage (24 volts) to activate the solenoid (Damage will occur). Use only 5 volt DC. It is recommended that 3 AA batteries connected in series be used to obtain the required 5 volts).**

After a shift is completed, the TCU compares the shift to an ideal shift profile in the TCU program and makes adjustments before the next shift of the same kind is made. This is called “adaptive logic” which establishes the initial conditions for shifts.

There is “fast adaptive” logic and “slow adaptive” logic.

When in fast adaptive mode, the TCU makes large changes in the initial shift conditions to adjust for major system tolerances. Major system tolerances are solenoid - to -solenoid, main pressure and clutch - to - clutch variations.

When in slow adaptive mode, the TCU makes small changes in the initial shift conditions in response to minor system changes. Minor system changes occur slowly and are items such as wear and solenoid degradation or drift.

The TCU changes from fast adaptive to slow adaptive when the profile of an actual shift has nearly reached the ideal profile desired. When a new or newly rebuilt transmission has been installed, the adaptive logic information should be removed from the TCU memory. This is done using the Service ADVISOR ™ application or the PRO-LINK ® Diagnostic Data Reader.

**NOTE: 1. The Pro-Link diagnostic tool requires a special adapter harness, Part No. 207663, to connect to the diagnostic connector (X15).**
**2. The transmission status is digitally displayed in the menu structure of the MDU, when accessed. For more information on the menu structure, see CHAPTER 8 of the OMM.**

The TCU is an integral part of the neutral start system. During engine start, the TCU verifies if the transmission is in neutral. Once neutral is confirmed, the TCU provides an output to the coil of neutral start relay (K1), energizing the relay. For more information of the start circuit, **See “STARTING AND CHARGING CIRCUIT AND THEORY OF OPERATION” on page 58**

When the range hold circuit is enabled, range hold switch (S6) or range hold relay (K8) provide a ground at terminal 12 of TCU connector X170, thus putting the TCU in range hold mode.

When in this mode, the TCU will prevent the transmission from up-shifting to a higher gear than the gear selected at the time of activation. For more information on the range hold system, **See “BIN CONTROL, FAN DRIVE AND RANGE HOLD CIRCUIT THEORY OF OPERATION” on page 74**.

## Retarder Control

The retarder system is activated whenever transmission output is over 300r.p.m. and the accelerator pedal is fully released to slow idle position or service brakes applied.

Activating the retarder will cause the stop lights to come **ON**. For more information, **See “Stop Light Circuit Theory of Operation” on page 84.**

When the service brakes are not applied, the amount of retardation is controlled by retarder controller (A7). The retarder control lever has seven positions with position 0 being the lowest percentage of retardation (12%) and position 6 being the highest percentage of retardation (100%).

Although there are seven lever positions, there are only six levels of retardation. Lever position “0” and “1” send the same amount of voltage to terminal 2 of retarder voltage regulator (N1), while each successive lever position sends a higher voltage to the retarder voltage regulator.

The retarder voltage regulator, in turn, sends a successively higher voltage to terminal 11 of TCU connector X168. Each successive voltage level received at terminal 11 causes the TCU to vary the duty cycle to retarder solenoid (Y9) accordingly.

**NOTE: 1. A low voltage at terminal 11 of TCU connector X168 causes the TCU to produce a short duty cycle (modulated) output to retarder solenoid (Y9), which results in less charge oil flow to the retarder.**
**2. A higher voltage at terminal 11 causes the TCU to produce a longer duty cycle output to the retarder solenoid which results in more charge oil flow to the retarder.**

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If the TCU receives an abnormal speed signal from output speed sensor (B13) or an over-temperature signal from retarder temperature sensor (B11), the TCU will send the appropriate retarder response signal to retarder solenoid (Y9), regardless of the position of the retarder control lever.

When a retarder over-temperature situation exists, sensor (B11) sends a signal to the TCU which activates the retarder light on the MDU, shortens the duty cycle signal to solenoid (Y9) as necessary to reduce oil flow to the retarder, log service codes and down shift the transmission as prescribed by the software program.

Applying the service brakes causes stop light pressure switch (B28) to send current to terminal 1 of retarder voltage regulator (N1).

When this happens, the retarder voltage regulator sends the maximum voltage signal representing 100% retardation to the TCU. The TCU then puts the retarder at 100% retardation regardless of the position of the retarder control lever.

Having the service brake circuit enable, the retarder allows the retarder to function even if the accelerator pedal position sensor malfunction. For more information on how the service brakes interact with the retarder, **See** Table on page 84

**NOTE:The retarder status is digitally displayed in the menu structure of the MDU, when accessed. (For more information on the menu structure, See CHAPTER 8 of the OMM.)**

## Service Codes

The TCU stores both active and historical (non-active) service codes. An active code is any code that is current in the TCU decision making process.

Historical codes are codes that are retained in the TCU's memory and will not necessarily affect the TCU decision making process. Historical codes are useful in determining if a problem is isolated, intermittent or results from a previous malfunction.

Service codes can be accessed and cleared using transmission shift control (A4), the service ADVISOR ™ application, or the PRO-LINK ® Diagnostic Data Reader.

Active codes are cleared when power to the TCU is removed. Some codes are self-clearing when the condition which causes the code is no longer detected by the TCU. Other codes must be manually removed.

**NOTE:1. The Pro-Link diagnostic tool requires a special adapter harness, Part No. 207663, to connect to the diagnostic connector (X15).**
**2. The transmission status is digitally displayed in the menu structure of the MDU, when accessed. For more information on the menu structure, see CHAPTER 8 of the OMM.**

Should an electrical failure to the TCU occur and as long as key switch is not turned to the **OFF** position, the machine may be operated for a limited amount of time in what is called the "Limp Home" mode.

The "Limp Home" mode is a hydraulic latched system designed into the transmission in the event the TCU losses power or has a major malfunction.

When in "Limp Home" mode the transmission shifts to a predetermined gear depending on what gear was operating at the time of the electrical failure. The transmission will not upshift, down shift, shift into reverse or lock up the convertor.

If the engine is stopped (key switch turned to **OFF** position), the next time the machine is started will cause the transmission to remain in neutral until the malfunction is repaired.

In the event of a loss of electrical power, the transmission defaults to the following ranges:

| Attained Range | Default Range |
|---|---|
| Reverse | Neutral |
| Neutral | Neutral |
| Low | 3rd |
| 1st | 3rd |
| 2nd, 3rd, 4th | 4th |
| 5th | 4th |
| 6th | 5th |

For most transmission related service codes, the TCU will send a signal through the CAN data line to the MDU, causing the Transmission Service light to come **ON**.

To diagnose service codes, **See "Service Code Diagnostics -Transmission Control Unit (TCU)" on page 105.**

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## CHASSIS CONTROL UNIT CIRCUIT THEORY OF OPERATION

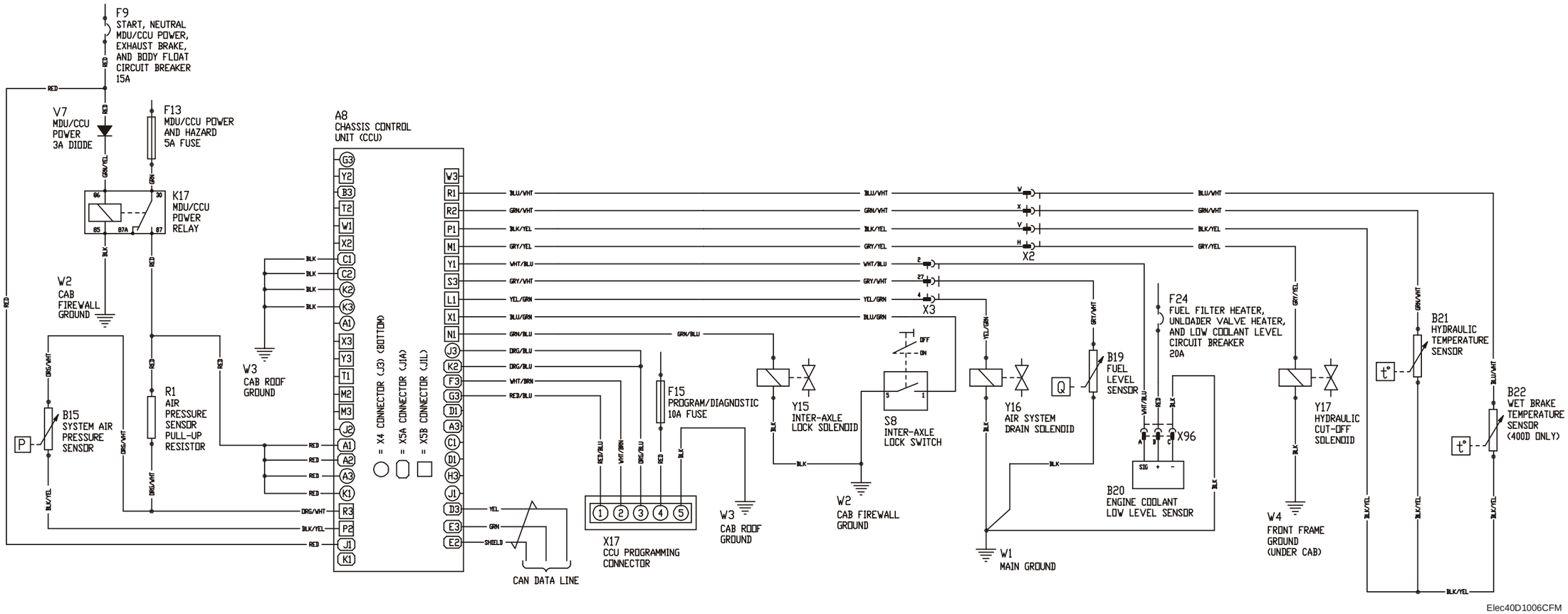



Figure 3-6

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Unswitched power is available at terminal 30 of MDU/CCU power relay (K17). turning the key switch to the **ON** position, sends current from circuit breaker (F9) to the coil of MDU/CCU power relay (K17), energizing the relay. The current also flows to chassis control unit (CCU) (A8) at terminal J1 of connector X5A.

With MDU/CCU power relay (K17) energized, current from MDU/CCU power and hazard fuse (F13) is sent to the CCU at the following terminals:

- Terminals A3 and K1 of connector X4
- Terminals A1 and A2 of connector X5A

CCU programming connector (X17) is provided so software can be down loaded to the CCU using a RS232 interface and laptop computer. The connector receives switched power from program/ diagnostic fuse (F15) at terminal 4.

The following functions are controlled or monitored by the CCU:

- Park Brake and Exhaust Brake - See “PARK BRAKE AND EXHAUST BRAKE CIRCUIT THEORY OF OPERATION” on page 76.
- Bin Control and Range Hold - See “BIN CONTROL, FAN DRIVE AND RANGE HOLD CIRCUIT THEORY OF OPERATION” on page 74.
- Turn Signal and Four-Way Flashers - See “Turn Signal And 4-Way Flasher Circuit Theory of Operation” on page 82.
- Intermittent Wipers - See “Wiper/Washer Circuit Theory of Operation” on page 88.
- Hydraulic Cut-Off - See “STARTING AND CHARGING CIRCUIT AND THEORY OF OPERATION” on page 58.
- Battery Charge and Battery Balance - See “Battery Balancer And 12-Volt Accessory Circuit Theory of Operation” on page 90.
- Inter-Axle Lock
- System Air.
- Engine Coolant Level.
- Fuel Level.
- Hydraulic Temperature.
- Wet Disc Brake Temperature (B40D only).

## Inter-Axle Lock Circuit

**NOTE: 1. For information on the mechanical operation of the inter-axle lock, See “Inter-Axle Lock Operation” on page 279.**
**2. For information on the pneumatic operation of the inter-axle lock, See “Inter-Axle Lock circuit” on page 322.**

Putting the inter-axle lock switch (8) in the **ON** position connects terminal X1 of CCU connector X5B to ground. When this happens and if the engine speed is 900 r.p.m. or less, the CCU sends current out terminal N1 of connector X5B to inter-axle lock solenoid (Y15), energizing the solenoid.

With solenoid (Y15) energized, the planetary gear set (inside the transfer case) locks up, causing the front and rear drive shafts to turn in unison.

When the inter-axle lock is engaged, the inter-axle lock pressure switch (B25) (Not shown in the circuit schematic) sends a signal to the MDU, causing the Inter-Axle Lock Light to come **ON**.

Once engaged, the inter-axle lock will stay engaged as long as the inter-axle lock switch (S8) is in the ON position, even if the engine speed increases above 900 r.p.m.

**NOTE: 1. For more information on the inter-axle lock pressure switch (B25), Inter-Axle Lock Light and the MDU, See “MENU DISPLAY UNIT CIRCUIT THEORY OF OPERATION” on page 78.**
**2. The inter-axle lock status is digitally displayed in the menu structure of the MDU, when accessed. For more information on the menu structure, See CHAPTER 8 of the OMM.**

## Sensors

### System Air Pressure Sensor

The system air pressure sensor (B15) detects system air pressure and sends an analog signal representing the amount of air pressure back to the CCU. The sensor is connected in series with air pressure sensor pull-up resister (R1) so when the key switch is in the ON position, current flows through the 830 ohm resister (R1) and sensor (B15), then to terminal P2 (ground reference) of CC connector X5B.

The pull-up resistor is required because the CCU does not send out a reference voltage of its own to the sensor. Instead, an external voltage (system voltage) is used as the reference voltage.

The pull-up resister absorbs most of the system voltage so the voltage drop across the pressure sensor will be with-in the 0-5 volts required by the CCU.

The signal representing the air pressure is measured across sensor (B15), then sent to terminal R3 of CCU connector X5B. The CCU sends the information through the CAN data line to the MDU where a gauge displays the amount of air pressure to the operator.

**NOTE: 1. For more information on the air pressure gauge and MDU. See “MENU DISPLAY UNIT CIRCUIT THEORY OF OPERATION” on page 78.**
**2. The system air pressure status is digitally displayed in the menu structure of the MDU, when accessed. For more information on the MDU - menu function, See CHAPTER 8 in OMM.**

The air pressure sensor varies resistance with respect to air pressure as follows:

- 0 kPa {0 bar (0 psi)} = 10 Ohms
- 200 kPa {2 bar (29 psi)} = 51 Ohms
- 400 kPa {4 bar (58 psi)} = 86 Ohms
- 600 kPa {6 bar (87 psi)} = 122 Ohms
- 800 kPa {8 bar (116 psi)} = 152 Ohms
- 1000 kPa {10 bar (145 psi)} = 180 Ohms

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**Fuel Level Sensor**

The fuel level sensor (B19) is a variable resistor that sends an analog signal to the CCU at terminal S3 of connector X5B.

The CCU sends the signal through the CAN data line to the MDU where a gauge displays the amount of fuel to the operator.

When the fuel reaches a pre-determined low level, the MDU will activate the audible alarm.

**NOTE:1. For more information on the fuel gauge and MDU. See "MENU DISPLAY UNIT CIRCUIT THEORY OF OPERATION" on page 78.**
**2. The fuel level status is digitally displayed in the menu structure of the MDU, when accessed. For more information on the MDU - menu function, See CHAPTER 8 in OMM.**

When the fuel tank is empty, the fuel level sensor measures 75 ohms of resistance. When the fuel tank is full, the sensor measures 7.5 ohms of resistance.

**Engine Coolant Level Sensor**

The engine coolant level low sensor (B20) consists of two components: a capacitance probe and an interface module.

The probe detects water level using the "princi[ple of capacitance". When two electrically conductive materials are separated by an electrical insulator, a capacitance will exist between the two conductors. The amount of capacitance is directly proportional to the area of the two plates.

The probe consists of a brass rod (1st plate) covered with polytetrafluoroethylene (PTFE) (the insulator). When the probe is covered in water, the water acts as the 2nd plate.

Maximum capacitance is obtained when the probe is fully submersed in water. Minimum capacitance exists when the probe is completely out of the water.

When little or no coolant contacts the probe, the interface module will send a signal (2.5 volts) to terminal Y1 of CCU connector X5B.

With an input at terminal Y1, the CCU will send a signal through the CAN data line to the MDU, causing the Coolant Level light to come **ON**.

**NOTE:The engine coolant low level status is digitally displayed in the menu structure of the MDU, when accessed. For more information on the MDU - menu function, See CHAPTER 8 in OMM.**

**Hydraulic Temperature Sensor**

The hydraulic temperature sensor (B21) sends an analog signal to terminal R2 of CCU connector X5B. The CCU will send the signal through the CAN data line to the MDU where the signal is digitally displayed in the menu structure. **For information on accessing the menu structure of the MDU, See CHAPTER 8 in OMM.**

When the hydraulic temperature reaches 90° C (194° F) the red Service indicator on the MDU will flash, audible alarm (H1) will sound intermittently and the Hydraulic Temperature Light on the MDU will flash.

When the hydraulic temperature reaches 95° C (203° F) the red Service indicator will flash, audible alarm (H1) will sound continuously, and the Hydraulic Temperature Light will flash.

**NOTE:1. The hydraulic temperature status is digitally displayed in the menu structure of the MDU, when accessed. For more information on accessing the menu on the MDU - menu function, See CHAPTER 8 in OMM.**

The temperature sensor varies resistance with respect to temperature as follows:

- 40° C (104° F) = 287.4 Ohms
- 50° C (122° F) = 193.6 Ohms
- 60° C (140° F) = 134.0 Ohms
- 70° C (158° F) = 95.2 Ohms
- 80° C (176° F) = 69.1 Ohms
- 90° C (194° F) = 51.3 Ohms
- 100° C (212° F) = 38.6 Ohms
- 110° C (230° F) = 29.4 Ohms
- 120° C (248° F) = 22.7 Ohms

**Wet Disc Brake Temperature Sensor (B40D Only)**

The wet disc brake temperature sensor(B22) sends an analog signal to terminal R1 of CCU connector X5B.

When the brake temperature reaches a predetermined temperature, the CCU will send a signal through the CAN data line to the MDU, causing the Brake Temperature Light to come **ON**.

**1. The wet disc brake temperature status is digitally displayed in the menu structure of the MDU, when accessed. For information on accessing the menu structure, See CHAPTER 8 in the OMM.**
**2. The specifications (Resistance/temperature) for wet disc brake temperature sensor (B22) are the same as hydraulic temperature sensor (B21).**

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**LEFT BLANK INTENTIONALLY**

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## BIN CONTROL, FAN DRIVE AND RANGE HOLD CIRCUIT THEORY OF OPERATION

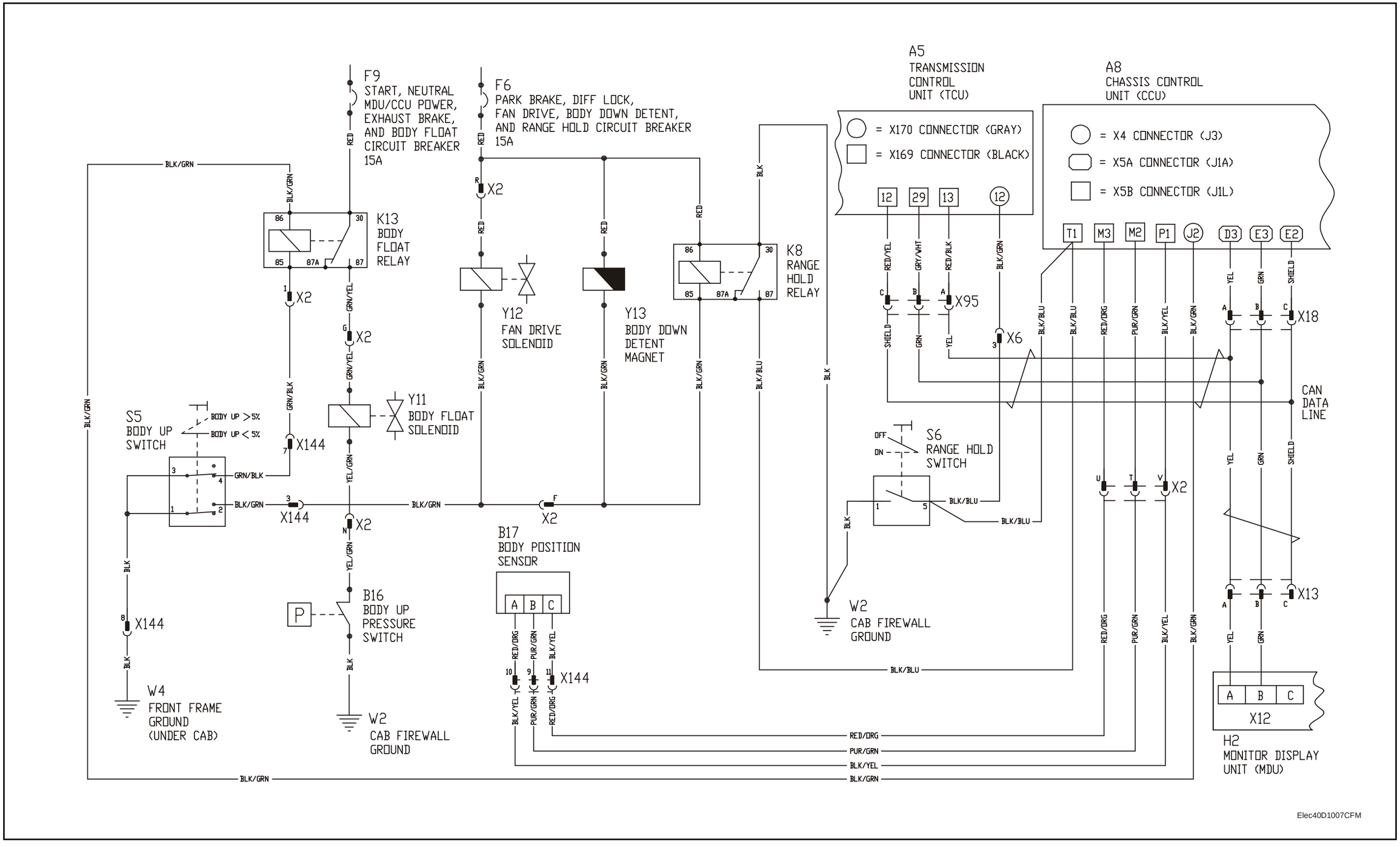



Figure 3-7

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## Bin and Fan Drive Control Circuit

When the key switch is in the **ON** position, power from circuit breaker (F9) is available to terminal 30 of body float relay (K13).

Power from circuit breaker (F6) is available to fan drive solenoid (Y12), body down detent magnet (Y13) and range hold relay (K8).

### Bin Up Mode

Moving the bin control lever to the Bin Up position sends air pressure to the bin hydraulic control valve, which in turn, sends hydraulic oil to the body lift cylinders to raise the bin.

**NOTE:For information on the hydraulic control of the bin, See “Bin Control Valve Operation” on page 364.**

When air pressure in the Bin Up side of the bin pneumatic control circuit reaches 550 kPa (5.5 bar) (79.8 psi), the contacts of bin up pressure switch (B16) open. With the contacts of switch (B16) open, ground is no longer available to bin float solenoid (Y11).

When the angle of the bin increases to more than 5%, as sensed by bin position sensor (B17), the following occurs:

1. The actuator rod of bin up switch (S5) no longer makes contact with the bin causing the following to occur:

- Ground is provided to fan drive solenoid (Y12), energizing the solenoid.
- Ground is provided to bin down detent magnet (Y13), energizing the magnet.
- Ground is provided to range hold relay (K8), energizing the relay.
- Ground is removed from bin float relay (K13), de-energizing the relay.

2. The CCU removes power from terminal J2 of connector X4 to ensure bin float relay (K13) is de-energizing when body angle is more than 5%.

With fan drive solenoid (Y12) energized, the hydraulic oil flow through the fan motor is blocked, giving priority oil flow to the bin lift cylinders as the bin is being raised. For more information on the fan drive, **See “Fan Drive System Operation” on page 362.**

With range hold relay (K8) energized, the transmission is prevented from upshifting to a higher gear. For more information, **See “Range Hold Circuit” on page 75.**

With bin down detent magnet (Y13) energized, the bin tip control lever can be held in the Bin Down position by the detent magnet.

### Bin Down Mode

When the bin tip control lever is moved to the Neutral or Bin Down position, air pressure exhausts from the Bin Up side of the Bin pneumatic control circuit, causing the contacts of bin up pressure switch (B16) to close.

With the bin tip control lever in the Bin Down position, the energized bin down detent magnet (Y13) will hold the bin tip control lever in the Bin Down position. The detent magnet holds the control lever in this position until the bin contacts the actuator rod of the bin up switch (S5) or if the operator moves the lever.

### Float Mode

When the actuator rod of bin up switch (S5) makes contact with the bin the following occurs:

- Ground is removed from bin down detent magnet (Y13) causing the relay to de-energize. Bin tip control lever returns to Neutral position.
- Ground is removed from fan drive solenoid (Y12) causing the relay to de-energize. (Fan now operates normally).
- Ground is removed from range hold relay (K8) causing the relay to de-energize. (Transmission is allowed to upshift).
- Ground is provided to coil of bin float relay (K13).

When bin position sensor (B17) senses the angle of the bin to be 5% or less, the CCU sends power out terminal J2 of connector X4 to the coil of bin float relay (K13), energizing the relay.

With relay (K13) energized and the contacts of bin up pressure switch (B16) closed, current flows from circuit breaker (F9) to bin float solenoid (Y11), energizing the solenoid.

With solenoid (Y11) energized, oil at the head end of the bin tip cylinders will bypass the hydraulic control valve and flow directly to the oil reservoir. This allows the bin to gently lower (float) to the frame when the bin tip control lever is in the neutral position.

## Range Hold Circuit

When in range hold mode, the TCU prevents the transmission from upshifting to a higher gear than the gear selected at the time of activation, thus preventing any further increase in machine speed. Normal down shifting is allowed when in range hold mode.

Putting range hold switch (S8) in the ON position or energizing range hold relay (K8) will connect terminal 12 of C connector X170 to ground, thus putting the TCU in range hold mode.

The range hold switch allows the operator to manually activate range hold mode. The range hold relay allows the bin up circuit to activate range hold mode.

Activation of the range hold circuit by the bin up circuit automatically prevents the transmission from upshifting when the bin is in the raised position.

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## PARK BRAKE AND EXHAUST BRAKE CIRCUIT THEORY OF OPERATION

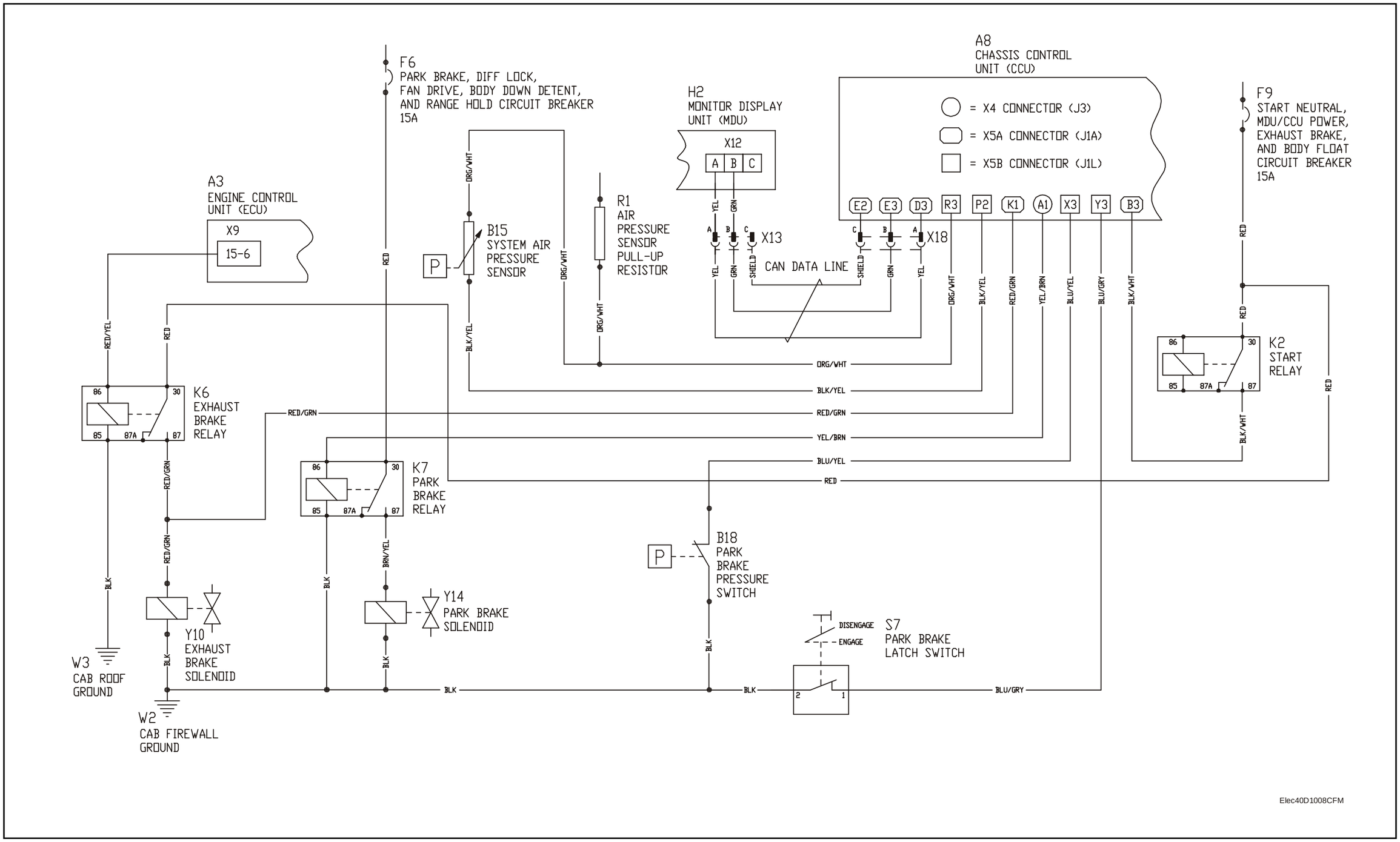



**Figure 3-8**

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## Park Brake Circuit

**NOTE:The park brake is spring applied, pneumatically released.**

The park brake will engage if any of the following events occur:

- Park brake lever moved to the PARK position.
- Key switch turned to the OFF position.
- Engine speed becomes less than 50 r.p.m. and ground speed less than 1 km/h (0.62 m.p.h.).
- System air pressure drops to less than 550 kPa (5.5 bar) (79.8 psi)
- Starting the engine (input exists at terminal B3 of connector X5A).

If any of these events occur, the chassis control unit (CCU) (A8) will not allow an output at terminal A1 of CCU connector X4. With no output at terminal A1, park brake relay (K7) will not energize and thus park brake solenoid (Y14) will not energize.

The de-energized solenoid blocks air pressure to the park brake actuator. It also allows the air in the actuator to vent to atmosphere, ensuring the spring inside the actuator applies the park brake.

The park brake pressure switch (B18) is located between park brake solenoid and park brake actuator. Because of this, switch (B18) senses only atmospheric pressure during the time solenoid (Y14) is de-energized.

This causes the contacts of switch (B18) to close, allowing terminal X3 of CCU connector X5B to connect to ground. When this happens and if the key switch is in the ON position, the CCU will send a signal though the CAN data line to the MDU, which in turn, causes the Park Brake Light to come **ON.**

To release the park brake, the CCU (A8) must detect the following:

- An “engine running” signal from the ECU (sent through the CAN data line).
- An analog signal at terminal R3 of CCU connector X5B indicating system air pressure is more than 550 kPa (5.5 bar) (79.8 psi).
- A signal at terminal Y3 of CCU connector X5B indicating the park brake lever is in the Park Release position. (This signal must be received only after the analog signal at terminal R3 indicates air pressure is more than 550 kPa (5.5 bar) (79.8 psi).

The analog signal at terminal R3 comes from system air pressure sensor (B15). When the analog input indicates system air pressure is more than 550 kPa (5.5 bar) (79.8 psi), the CCU starts monitoring the input at terminal Y3 connector X5B.

The park brake latch switch (S7) is mechanically connected to the park brake lever valve. Because of this, moving the park brake lever to the Park Release position causes switch (S7) to send a signal to terminal Y3.

If this signal is present before system air pressure reaches specification, the CCU will not allow an output at terminal A1 of connector X4. With no output at terminal A1, park brake relay (K7) will not energize, thus the park brake will not release.

When this happens, the park brake lever must first be returned to the Park position, then moved to the Park Release position to release the park brake.

When satisfied, the CCU will allow current to flow out terminal A1 of connector X4 to the coil of park brake relay (K7), energizing the relay. With relay (K7) energized, current flows from circuit breaker (F6) to park brake solenoid (Y14), energizing the solenoid.

With park brake lever valve in the Park Release position and solenoid (Y14), energized, air pressure is supplied to the park brake actuator. When air pressure in the park brake actuator reaches 550 kPa (5.5 bar) (79.8 psi), the contacts of park brake pressure switch (B18) open, interrupting the ground to terminal X3 of CCU connector X5B. This causes the CCU to send a signal through the CAN data line to the monitor display unit, which in turn, causes the Park Brake Light to go **OFF**.

## Exhaust Brake Circuit

During machine operation, the exhaust brake will apply whenever engine speed is above 900 r.p.m., the torque converter is locked up, and the accelerator pedal position is less than 10%. The exhaust brake will also apply if engine speed exceeds 2500 r.p.m. (engine overspeed condition) regardless of position of accelerator pedal or even if torque converter is not locked up.

When an engine overspeed condition is detected, the red Engine Overspeed Light on the MDU comes **ON**.

The ECU (A3) monitors engine speed and the accelerator pedal position. For more information on the accelerator pedal position sensor and the ECU, **See “ENGINE CONTROL UNIT CIRCUIT THEORY OF OPERATION” on page 64.**

When the accelerator pedal position is less than 10%, torque converter is locked up and engine speed is more than 900 r.p.m., the ECU energizes exhaust brake relay (K6). With relay (K6) energized, current is allowed to flow from circuit breaker (F9) to exhaust brake solenoid (Y10), thus energizing the solenoid.

With solenoid (Y10) energized, air pressure is directed to the exhaust flapper valve actuator and each of the exhaust valve brakes (EVB) located inside the cylinder heads. For more information of operation of the flapper valve and the EVB, **See “ENGINE” on page 41.**

With relay (K6) energized, current from circuit breaker (F9) also flows to terminal K1 of CCU connector X5A, causing the CCU to activate the stop lights. For information on operation of the stop lights, See “Stop Light Circuit Theory of Operation” on page 84.

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## MENU DISPLAY UNIT CIRCUIT THEORY OF OPERATION

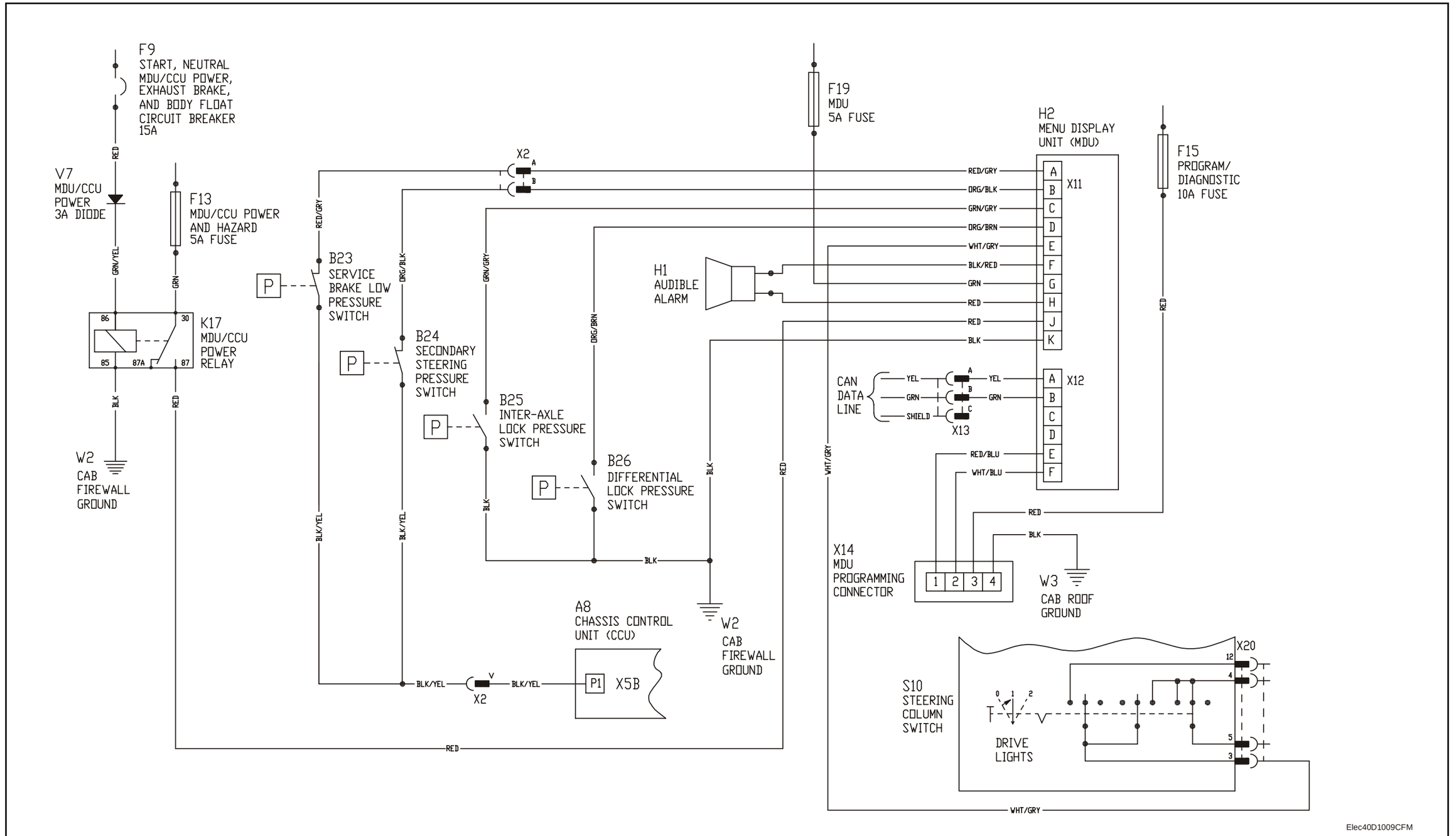
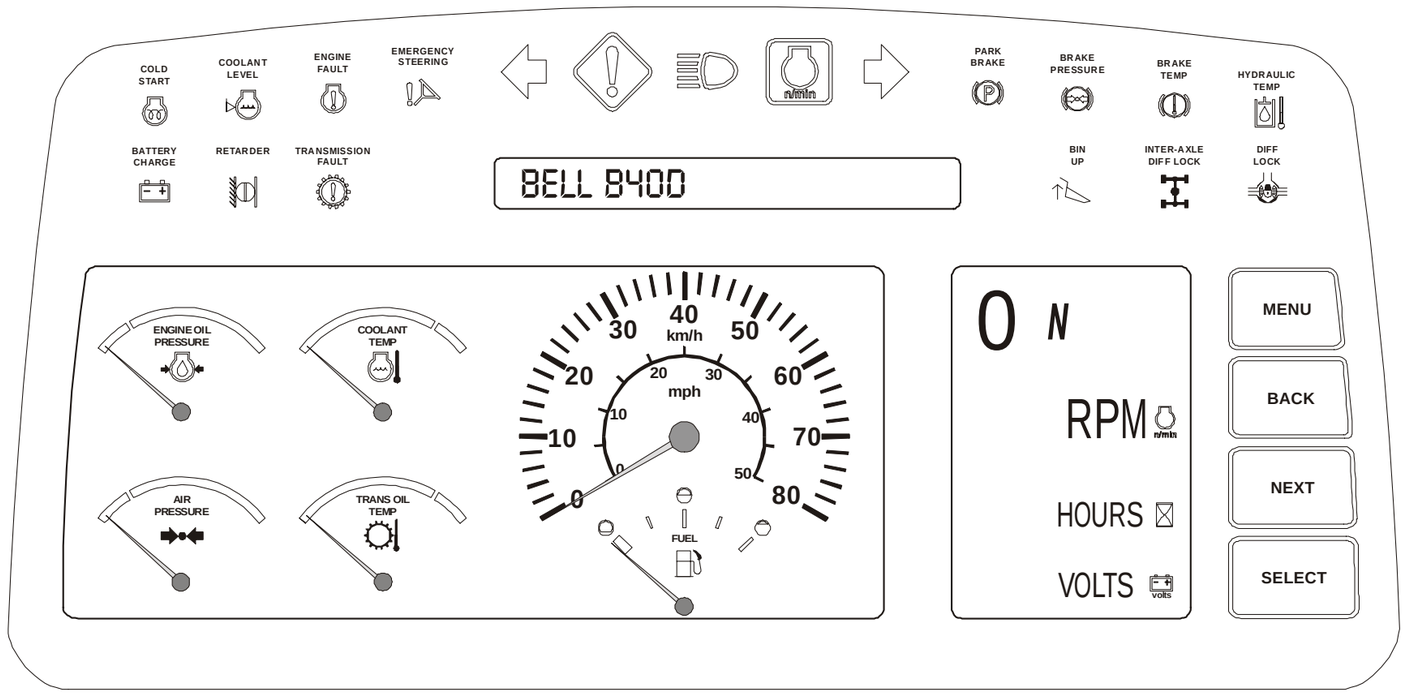



**Figure 3-9**

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## Menu Display Unit




GD1027CFM

GD1027CFM

**NOTE: For a description of all the MDU indicators and their function, See Instrument Panel Functions in CHAPTER 8 of the OMM.**

The MDU (H2) is used to display the status of machine functions. It is controlled by signals received from the TCU, CCU (A8) and ECU. The signals are transmitted across the CAN data line.

Unswitched power is available at terminal G of MDU connector X11 and terminal 30 of MDU/CCU Power Relay (K17). Turning the key switch to the **ON** position, sends current from circuit breaker (F9) to the coil of MDU/CCU power relay (K17), energizing the relay. With MDU/CCU power relay (K17) energized, current from MDU/CCU power and hazard fuse (F13) flows to terminal J of MDU connector X11.

If the MDU detects switched system voltage at terminal J of MDU connector X11 to be less than 17.5 ± 5 volts, the MDU will assume that a power down is in process.

If the MDU is writing data to memory, it sends a signal to energize an internal relay. This relay uses unswitched power from terminal G of MDU connector X11 so that the write operation can be completed.

When two seconds have elapsed, and if the write operation is completed, the MDU signal is disabled causing the internal relay to de-energize and the MDU to shut down.

When the head light switch is in the **ON** position and the drive lights switch inside steering column switch (S10) is set to High Beam position, terminal E of MDU connector X11 is connected to ground. When this happens, the High Beam indicator on the MDU will come **ON**.

MDU programming connector (X14) is provided so software can be down loaded to the MDU using an RS232 interface and laptop computer.

**⚠ CAUTION**

**When a critical warning is detected, the red Service light will come ON (or flash) and the audible alarm will sound. The machine and engine must be stopped immediately or serious damage may result. The flashing Service light and audible alarm alerts the operator to a critical service code condition indicated on the MDU display.**

### Gauges

The MDU contains a speedometer and the following gauges:

- Engine Oil Pressure.
- System Air Pressure.
- Engine Coolant Temperature.
- Transmission Oil Temperature.
- Fuel Level.

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The sensors for these gauges provide analog inputs to CCU (A8). The CCU calculates the temperature, pressure and fuel level then sends the data across the CAN data line to the MDU. When the MDU receives the sensor data, it displays the value on the appropriate gauge as a needle position, then moves the associated needle to such position.

The needle of the fuel, pressure and temperature gauges will deflect to the far left of the scale when communications across the CAN data line are lost or if a sensor error is detected.

**Engine Oil Pressure**

The red Service indicator will flash and audible alarm (H1) will sound continuously when the engine oil pressure is less than a specified pressure at a given engine r.p.m.

- 50 r.p.m. = 20 kPa {0.2 bar (3.0 psi)}
- 600 r.p.m. = 50 kPa {0.5 bar (7.3 psi)}
- 1000 r.p.m. = 90 kPa {0.9 bar (13.0 psi)}
- 1400 r.p.m. = 130 kPa {1.3 bar (18.9 psi)}
- 1800 r.p.m. = 160 kPa {1.6 bar (23.2 psi)}
- 2200 r.p.m. = 200 kPa {2.0 bar (29.0 psi)}
- 2600 r.p.m. = 250 kPa {2.5 bar (36.3 psi)}
- 3000 r.p.m. = 250 kPa {2.5 bar (36.3 psi)}

**Engine Coolant Temperature**

When the engine coolant temperature reaches 103° C (217.4° F) (gauge needle at start of red), the red Service indicator will come **ON** and audible alarm (H1) will sound intermittently. “**ENG TEMP TOO HIGH**” will show on the message display.

When the engine temperature reaches 108° C (226.4° F) (gauge needle at middle of red), the red Service indicator will come **ON** and audible alarm (H1) will sound continuously. “**ENG TEMP TOO HIGH**” will show on the message display.

**Transmission Oil Temperature**

When the transmission temperature reaches 110° C (230° F) (gauge needle at start of red), the red Service indicator will come **ON** and audible alarm (H1) will sound intermittently. “**TRANS TEMP TOO HIGH**” will show on the message display.

When the transmission temperature reaches 115° C (239° F) (gauge needle at middle of red), the red Service indicator will come **ON** and audible alarm (H1) will sound intermittently. “**TRANS TEMP TOO HIGH**” will show on the message display.

**Air System Pressure**

When the system air pressure is at 550 kPa {5.5 bar (79.8 psi)} (gauge needle at start of red) or less, the red Service indicator will flash and audible alarm (H1) will sound intermittently. “**SYS AIR PRES TOO LOW**” will show on the message display.

**Speedometer**

The speedometer is calibrated to show the machine speed in Km/h and m.p.h. The transmission output shaft speed sensor sends a signal to the TCU representing the speed of the output shaft. The TCU transmits the speed sensor data to the MDU across the CAN data line. The MDU uses the data to move the speedometer needle in correlation to machine travel speed.

**If speedometer seems to be miscalibrated, check machine model on the MDU at start-up and check the tire size in the menu structure of the MDU. For information on accessing the menu structure, See CHAPTER 8 in the OMM.**

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## Pressure Switches

The following pressure switches send their signals directly to the MDU:

- Service Brake Low Pressure Switch (B23).
- Secondary Steering Pressure Switch (B24).
- Inter-Axle Lock Pressure Switch (B25).
- Differential Lock Pressure Switch(B26).

### Service Brake Low Pressure Switch

The contacts of service brake low pressure switch (B23) are open during normal operation. When oil pressure in the service brake system decreases to 12 300 kPa (123 bar) (1784 psi), the contacts of pressure switch (B23) will close, sending a signal to terminal A of MDU connector X11.

When this happens, the Brake Pressure Light on the MDU will come ON, the Service light will flash, and audible alarm (H1) will sound.

### Secondary Steering Switch

The contacts of secondary steering pressure switch (B24) are open during normal operation.

When oil pressure in the main hydraulic system decreases to 500 kPa {5 bar (72.5 psi)} the contacts of pressure switch (B24) close, sending a signal to terminal **B** of MDU connector X11.

When this happens, the secondary steering (marked EMERGENCY STEERING) light on the MDU will come **ON**, the service light on the MDU will come **ON**, the Service light will flash and audible alarm (H1) will sound.

### Inter-Axle Lock Pressure Switch

When the inter-axle lock is engaged, the air pressure to the inter-axle lock actuator is sensed by the inter-axle lock pressure switch (B25).

When the air pressure reaches 550 kPa {5.5 bar) 79.8 psi)} the pressure switch contacts close, connecting terminal “**C**” of MDU connector X11 to ground.

When this happens the “Inter-Axle DIFF LOCK) light on the MDU will come **ON**.

### Differential Lock Pressure

When the differential lock is engaged, the air pressure to the differential Lock actuator is sensed by differential lock pressure switch (B26).

When the air pressure reaches 550 kPa {5.5 bar (79.8 psi)} the pressure switch contacts X11 to ground. When this happens, the Diff Lock light on the MDU will come **ON**.

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## Turn Signal And 4-Way Flasher Circuit Theory of Operation

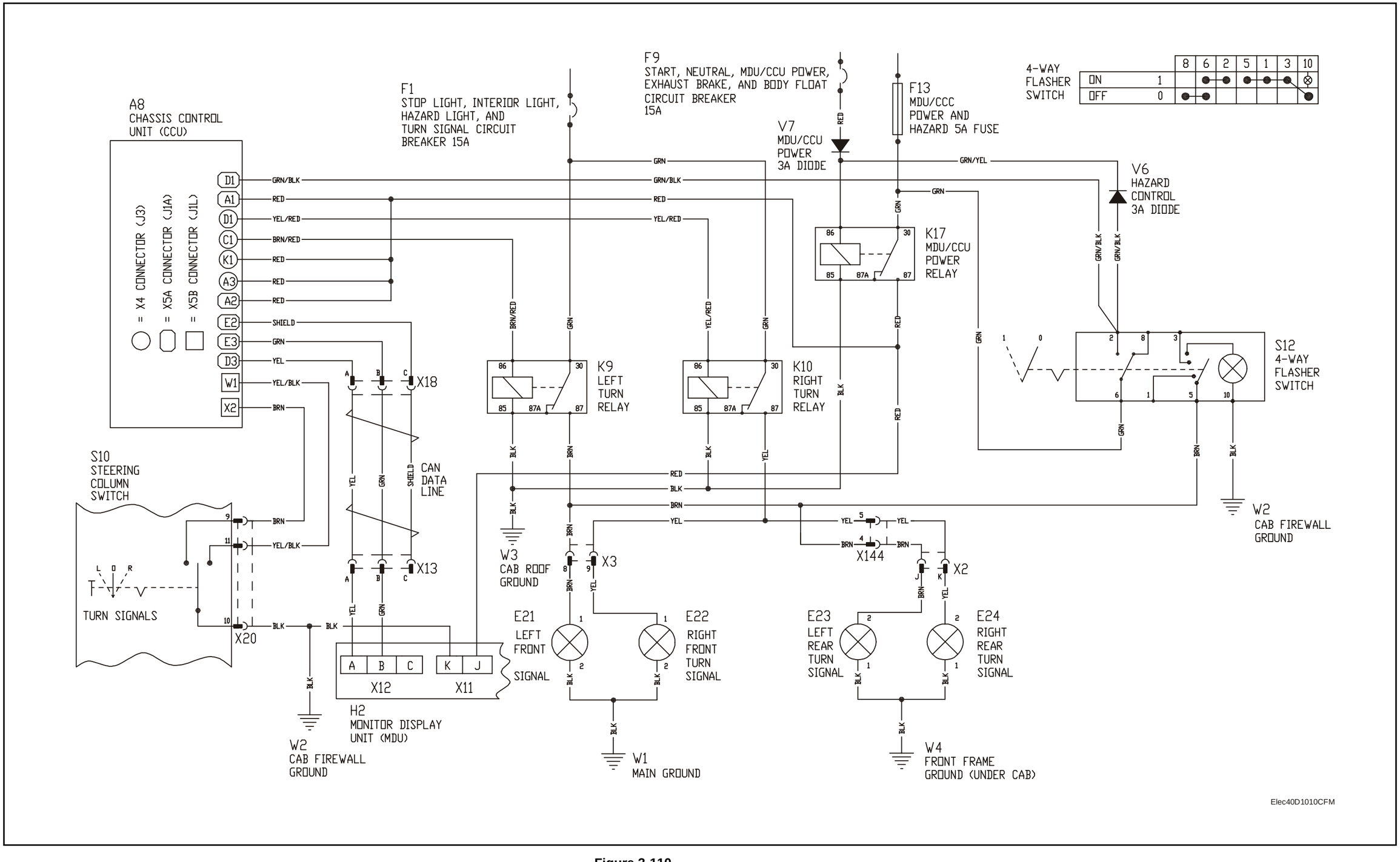



**Figure 3-110**

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Unswitched power from circuit breaker (F1) is available at terminal 30 of left turn relay (K9) and right turn relay (K10). Unswitched power from MDU/CCU power and hazard fuse (F13) is available at terminal 6 of 4-way flasher switch (S12) and terminal 30 of MDU/CCU power relay (K17).

### Turn Signal

Moving the lever of steering column switch (S10) to the left-turn position connects terminal X2 of CCU (A8) connector X5B to ground.

When this happens, the CCU sends pulsing DC current out terminal C1 of connector X4 to the coil of left turn relay (K9), causing the relay to continuously energize and de-energize.

The energizing and de-energizing relay causes current from circuit breaker (F1) to pulse as it flows to left front turn signal (E23), causing these lights to flash. The CCU also sends a signal across the CAN data line to the MDU, causing the Left Turn Arrow to flash.

Moving the lever of steering columns witch (S10) to the right-turn position connects terminal W1 of CCU connector X5B to ground.

When this happens, the CCU sends pulsing DC current out terminal D1 of connector X4 to the coil of the right turn relay (K10), causing the relay to continuously energize and de-energize.

The energizing and de-energizing relay causes current from circuit breaker (F1) to pulse as it flows to right front turn signal (E22) and right rear turn signal (E24), causing these lights to flash.

The CCU also sends a signal across the CAN data line to the MDU, causing the Right Turn Arrow to flash.

### Four-Way Flasher

Because the CCU and MDU are essential for the 4-way flashers to function, it is necessary that the CCU and MDU receive power during 4-way flashers activation whether key switch is in the **ON** or **OFF** position.

When the key switch is in the ON position, current from circuit breaker (F9) flows to the coil of the MDU/CCU power relay (K17), energizing the relay.

With relay (K17) energized, current from MDU/CCU power and hazard fuse (F13) flows to the CCU and MDU, powering the controllers.

If the key switch is in the OFF position, but 4-way flasher switch (S12) is moved to the ON position, unswitched current from fuse (F13) flows into terminal 6 of 4-way flasher switch (S12), then flows out terminal 2 to the coil of relay (K17), energizing the relay.

With relay (K17) energized current from fuse (F13) flows to the CCU and MDU.

During this time the 4-way flasher switch provides the necessary power to the CCU and MDU.

From terminal 2 of 4-way flasher switch (S12), current also flows to terminal D1 of CCU connector X5A.

When this happens, the CCU sends pulsing current out both terminals C1 and D1 of connector X4.

The pulsing current simultaneously energizes and de-energizes left turn relay (K9) and right turn relay (K10).

The relays, in turn, cause current from circuit breaker (F1) to pulse as it flows to turn signals (E21 - E24), causing all four lights to flash.

This pulsing current also flows back to 4-way flasher switch (S12) at terminal 5, causing the light in the 4-way flasher switch to flash.

The CCU also sends a signal across the CAN data line to the MDU, causing both the Left Turn Arrow and the Right Turn Arrow to flash.

If the lever of the steering column switch (S10) is moved to left-turn position with the 4-way flasher switch in the **ON** position, the CCU causes the left turn signals to flash while the right turn signals stay continuously lit.

The opposite is true when the steering column switch lever is moved to the right-turn position with 4-way flasher switch in the **ON** position.

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## Stop Light Circuit Theory of Operation

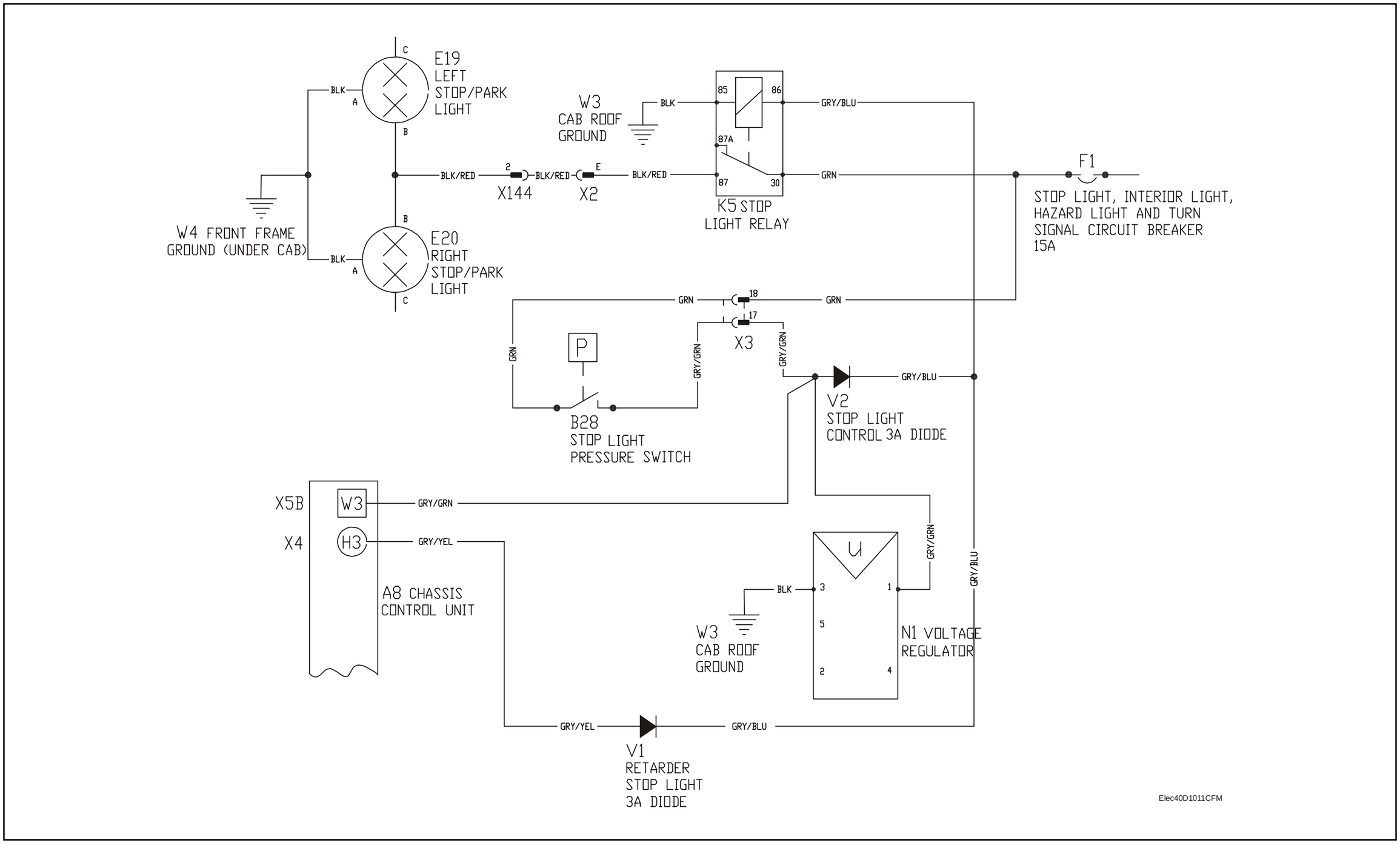



**Figure 3-111**

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Unswitched power from circuit breaker (F1) is available at stop light pressure switch (B28) and terminal 30 of stop light relay (K5).

When the service brakes are applied, hydraulic pressure closes the contacts of stop light pressure switch (B28), allowing current from circuit breaker (F1) to flow to the coil of stop light relay (K5), thus energizing the relay.

With relay (K5) energized, current flows from circuit breaker (F1) to left stop/park light (E20), causing the stop lights to come **ON**.

**NOTE: Contacts of stop light pressure switch (B28) open and close at 500 kPa {5 bar (72.5 psi)}.**

With the contacts of stop light pressure switch (B28) closed, current also flows to terminal W3 of CCU (A8) connector X5B and terminal 1 of retarder voltage regulator (N1).

The signal to the CCU lets the control system know the service brakes are applied.

The signal to voltage regulator (N1) puts the retarder system at 100% retardation.

For more information on the retarder system, **See "TRANSMISSION CONTROL UNIT AND RETARDER CIRCUIT THEORY OF OPERATION" on page 66**.

The retarder and/or exhaust brake will activate the stop lights if the service brakes are not applied. During the time the retarder and/or exhaust brake is active, the CCU sends current out terminal H3 of connector X4 to the coil of the stop relay (K5), energizing the relay, which causes the stop lights to come **ON**.

The retarder stop light control diode (V1) prevents current from stop light pressure switch (B28) from reaching terminal H3 of CCU connector X4 whenever the service brakes are applied.

Stop light control diode (V2) prevents current flowing from terminal H3 of CCU connector X4 from reaching terminal 1 of voltage regulator (N1) and terminal W3 of CCU connector X5B whenever the retarder and/or exhaust brake is active, but service brakes are not applied.

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## Backup Alarm and Backup Light Circuit Theory of Operation

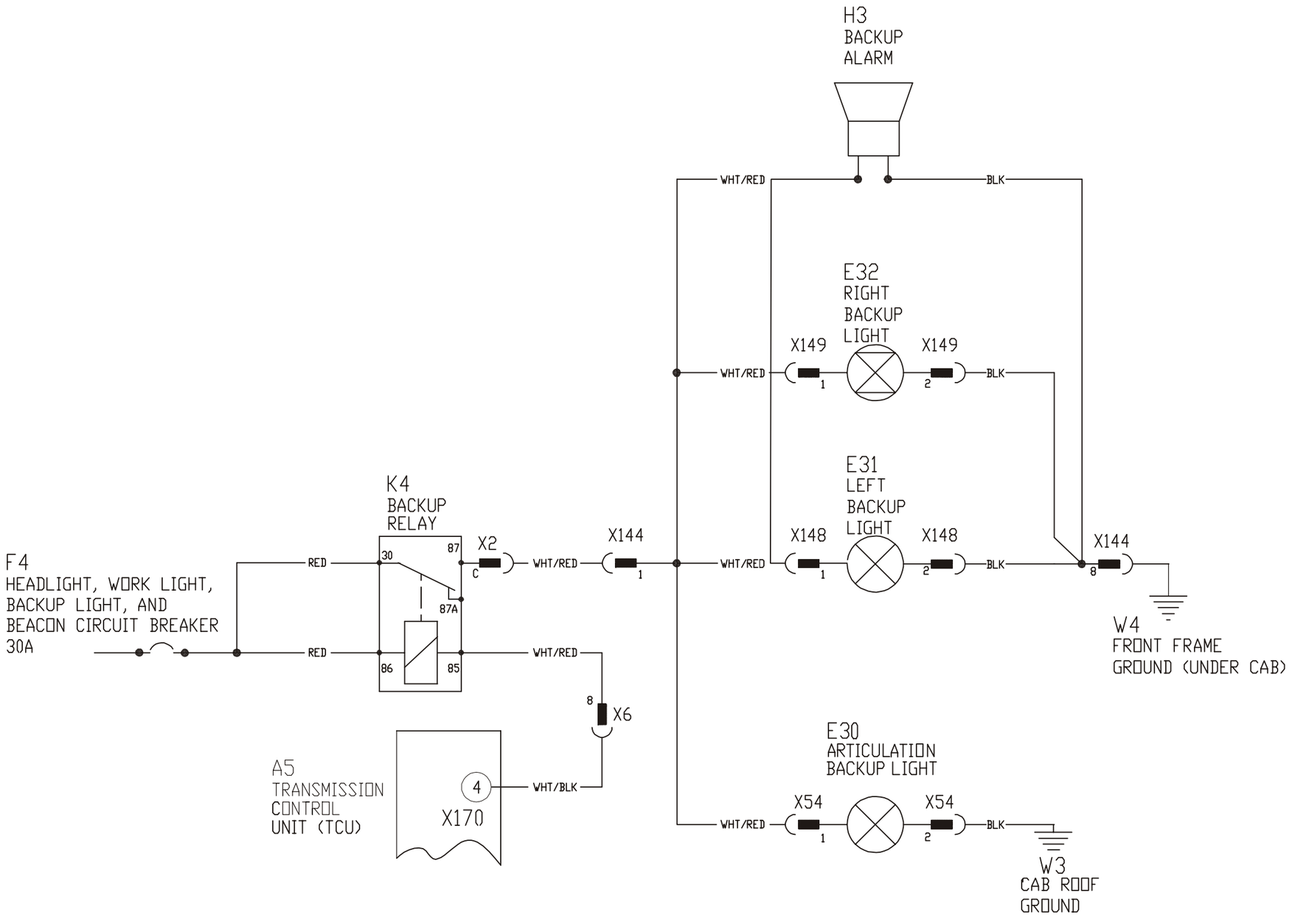



Figure 3-112

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When the key switch is in the **ON** position, power from circuit breaker (F4) is available to terminal 30 and 86 of backup relay (K4).

When the operator selects revers gear, the TCU (A5) supplies a ground to relay(K4), energizing the relay.

With relay (K4) energized, current flows to left and right backup lights (E31 and E32) and, if equipped, to articulation backup light (E30), causing the lights to come **ON**.

Current also flows to backup alarm (H3), activating the backup alarm.

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## Wiper/Washer Circuit Theory of Operation

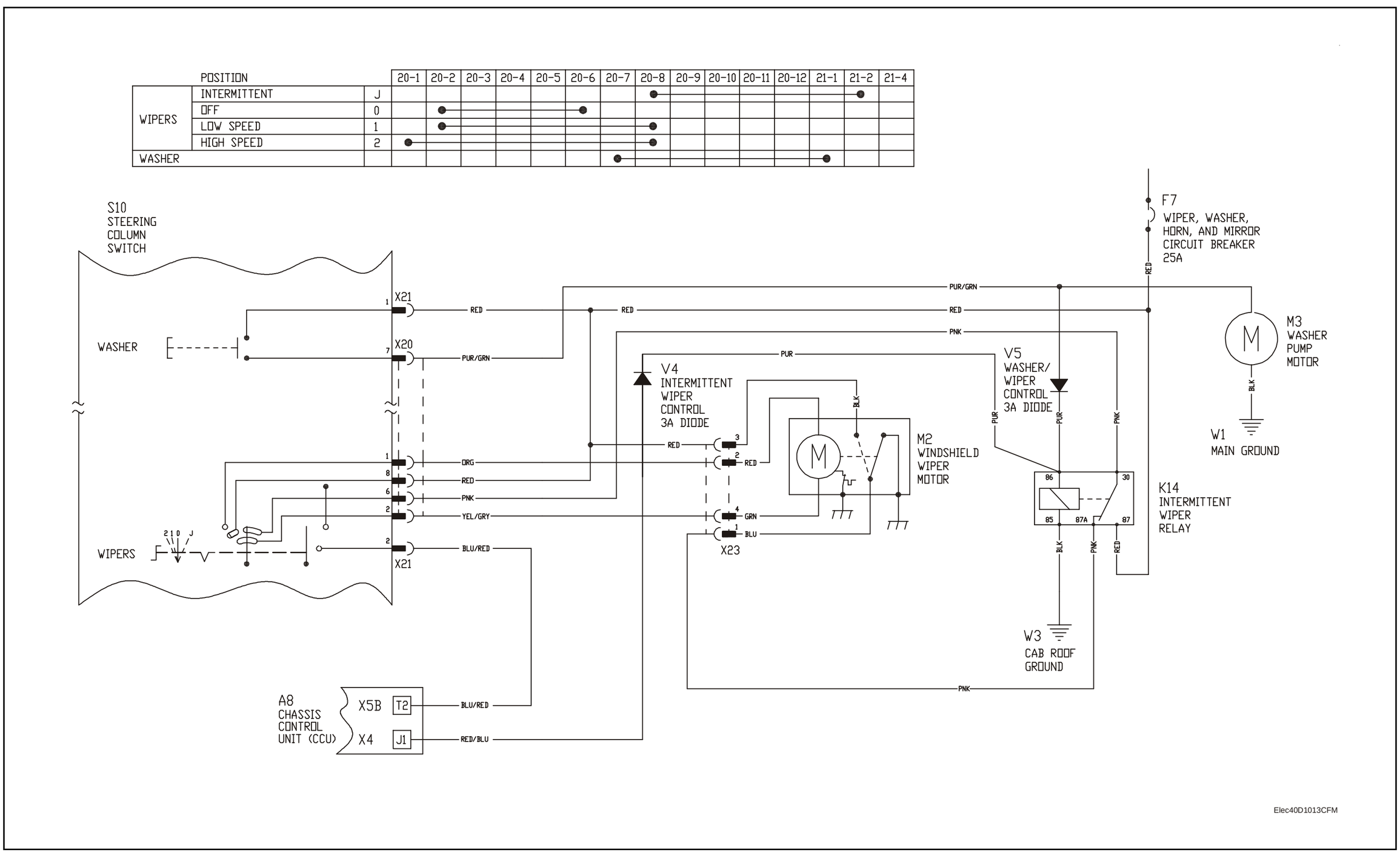



**Figure 3-113**

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When the key switch is in the ON position, power from circuit breaker (F7) is available at the following locations:

- Intermittent Wiper Relay (K14) - Terminal 87
- Steering Column Switch (S10) - Terminal 8 of connector (X20)
- Steering Column Switch (S10) - Terminal 1 of connector (X21)
- Windshield Wiper Motor (M2) - Terminal 3 of connector (X23)

### Intermittent Wiper Control

When the wiper control sleeve on the steering column switch lever is turned to position “J”, current from circuit breaker (F7) flows in terminal 8 of connector X20, then out terminal 2 of connector X21, to terminal T2 of CCU (A8) connector X5B.

The CCU will then send an intermittent current out terminal J1 of connector X4 to the coil of intermittent wiper relay (K14), energizing the relay intermittently.

During the time intermittent wiper relay (K14) is energized, current from circuit breaker (F7) will flow across the relay contacts, to terminal 6 of connector X20.

The current then flows out terminal 2 of wind shield wiper motor (M2), activating the motor intermittently.

The purpose of intermittent wiper control diode (V4) is to block current flow to terminal J1 of CCU connector X4 when only the washer circuit is activated.

The timing intervals of the intermittent wipers can be adjusted so the wiper will actuate anywhere between3 and 20 seconds.

**NOTE: The intermittent wipers status and timing is digitally displayed in the menu structure of the MDU, when accessed. For information on accessing the menu structure, See MDU - Menu Function CHAPTER 8 in the OMM.**

### Low and High Speed Wiper Control

When the wiper control sleeve on the steering column switch lever is turned to position “I”, current from circuit breaker (F7) flows in terminal 8 of connector X20, then out terminal 2 of connector X20 to terminal 4 of connector X23 on wind shield wiper motor (M2), activating the motor in low speed.

When the wiper control sleeve on the steering column switch lever is turned to position “II”, current from circuit breaker (F7) flows in terminal 8 of connector X20, then out terminal 1 of connector X20 to terminal 2 of connector X23 on wind shield wiper motor (M2), activating the motor in high speed.

### Washer Control

Pushing the momentary wind shield washer button allows current from circuit breaker (F7) to flow in terminal 1 of connector X21, then out terminal 7 of connector X20 to washer pump motor (M3), activating the washer pump motor.

At the same time, current flows through washer/ wiper control diode (V5) to the coil of intermittent wiper relay (K14), energizing the relay.

With relay (K14) energized, current from circuit breaker (7) will flow across the relay contacts, to terminal 6 of connector X20.

The current then flows out terminal 2 of connector X20 to terminal 4 of connector X23 on wind shield wiper motor (M2), temporarily activating the wiper motor.

The purpose of washer/wiper control diode (V5) is to block current flow to the washer pump when only the intermittent wiper circuit is activated.

### Wiper Park Control

When the wiper control sleeve on the steering column switch lever is turned to position”0” and the wiper is not at Park position, the contacts in wind shield wiper motor (M2) are closed.

With the wiper motor contacts closed, current from circuit breaker (F7) is allowed to flow to terminal 3 of wiper motor connector X23, across the wiper motor contacts, then out terminal 1 of connector X23 to terminal 87A of intermittent wiper relay (K14).

The current flows across the normally closed relay contacts to terminal 6 of connector X20.

Because the wiper switch is in the OFF position, current will flow out terminal 2 of connector X20 to terminal 4 of connector X23, activating the wiper motor.

When the wiper reaches the Park position, the wiper motor contacts open, thus deactivating the wiper motor.

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## Battery Balancer And 12-Volt Accessory Circuit Theory of Operation

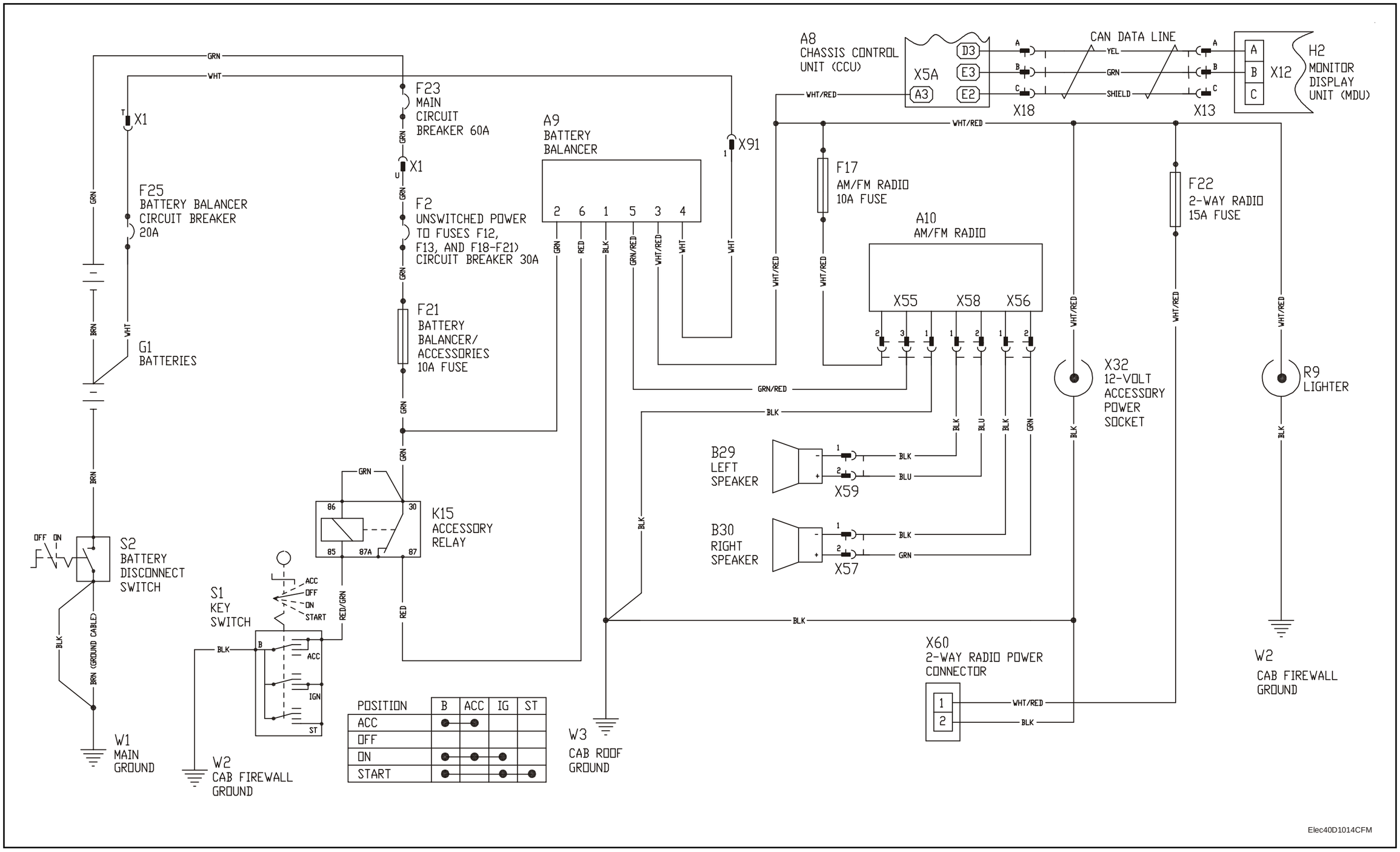



Figure 3-114

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The main function of battery balancer (A9) is to equalize the charge between the two batteries. It does this by directing more charging current to the bottom battery voltage equals 1/2 system voltage.

The battery balancer accomplishes this by sensing unswitched single battery voltage (12+ volts) at terminal 4. It divides the system voltage by two, then compares the results with the single battery voltage.

If a difference exists, the battery balancer will take current available at terminal 2 and send the extra current out terminal 4 to the bottom battery until the batteries are “balanced” within 0.5 volts.

Turning the key switch to the ON position, sends system voltage to terminal 6 of the battery balancer. The voltage at terminal 6 energizes an internal relay that connects terminals 3 and 4 of the battery voltage balancer.

When this happens, the single battery voltage (12+ volts) is sent to the AM/FM radio (A10) 12-Volt accessory power socket (X32), lighter (R9), 2-way radio power connector (X60) and to terminal A3 of connector X5A on CCU (A8).

The CCU senses the single battery voltage (12+ volts) from terminal 3 and also the system voltage (24+ volts).

It then divides the system voltage by two, then compares the results with the single battery voltage.

If the difference is more than 1.5 volts, the CCU sends a signal through the CAN data line to the MDU (H2), causing the Battery Charge Light to come **ON**.

**NOTE: 1. The battery charge voltage is digitally displayed in the MDU, when accessed. For more information on accessing the menu structure, see MDU function, CHAPTER 8 in the OMM.**

**2. When the battery disconnect switch is turned to OFF position, there is no 12-volt power available for the AM/FM radio station memory presets and clock. As a result, any station preset and clock setting are lost. The station presets will need to be reprogrammed and the clock reset when the battery disconnect switch is turned to the ON position.**

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## Air Conditioning Circuit Theory of Operation

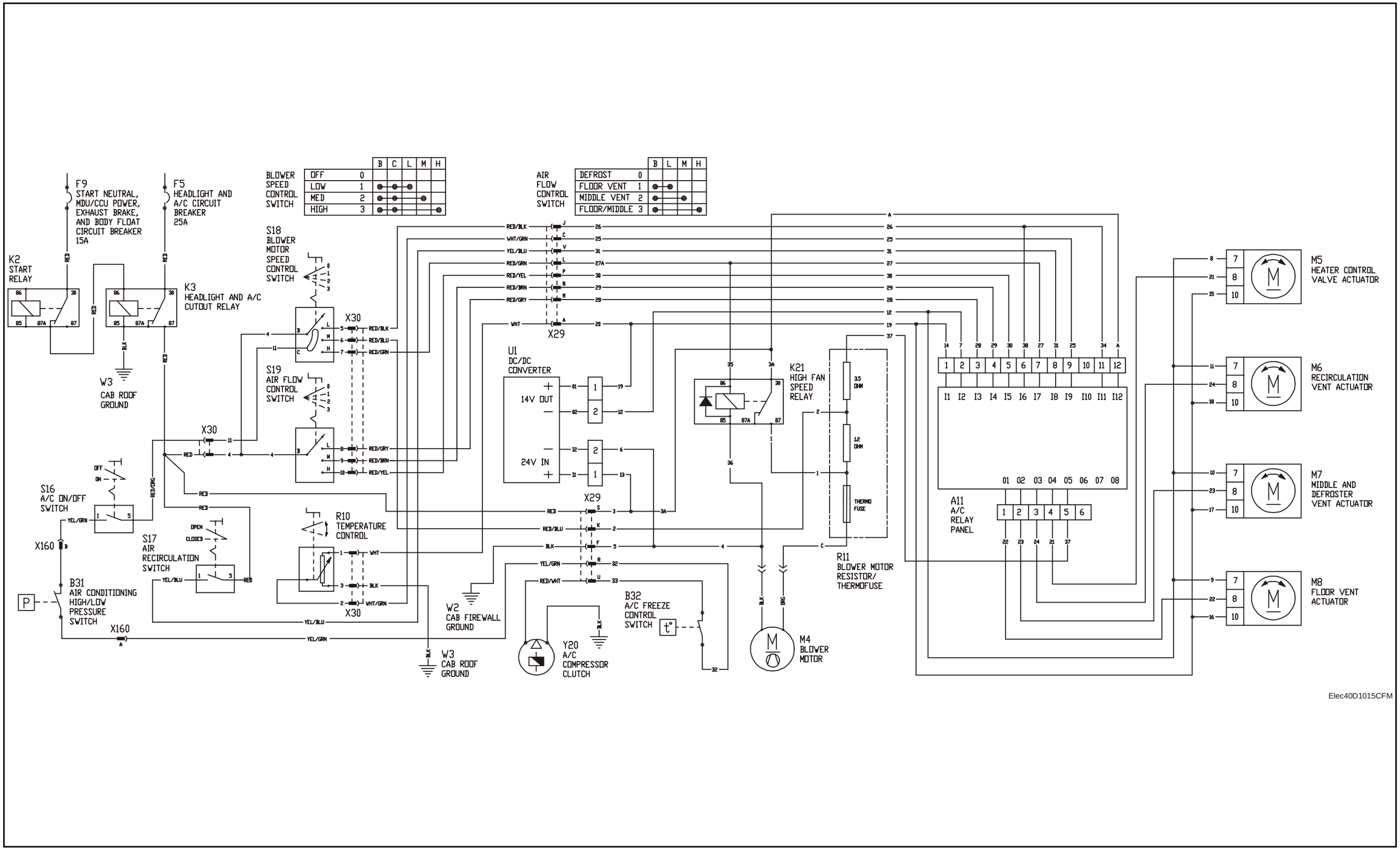



Figure 3-115

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When the key switch is in the **ON** position, current flows from circuit breaker (F9), across the normally closed contacts of start relay (K2), to the coil of head light and A/C cut-out relay (K3), energizing the relay. With relay (K3) energized, current from circuit breaker (F5) is available at the following components:

- Air re-circulation switch (S17).
- Blower motor speed control switch (S18).
- Air flow control switch (S19).
- DC/DC convertor (U1).
- High fan sped relay (K21).
- A/C relay panel (A11).

Whenever the engine is cranked, current flowing from circuit breaker (F9) to the coil of head light and A/C cut-out relay (K3) is interrupted, causing the relay to de-energize.

With relay (K3) de-energized, the air conditioning system de-activates so the starting load on the engine is reduced. For more information on the starting circuit, **See "STARTING AND CHARGING CIRCUIT AND THEORY OF OPERATION" on page 58**.

## Air Conditioning System

For the air conditioning system to operate, A/C on/off switch (S16) must be in the **ON** position and blower motor speed control switch (S18) must be in any position but the **OFF** position.

As long as the contacts of air conditioning high/low pressure switch (B31) and A/C freeze control switch (B32) are closed, current from circuit breaker (F5) will flow to blower motor speed control switch (S18) at terminal B.

The current flows out terminal C of the blower switch, through A/C on/off switch (S16) and A/C freeze control switch (B32), to A/C compressor clutch (Y20), energizing the clutch.

### Air Conditioning High/Low Pressure Switch

The air conditioning high/low pressure switch (B31) protects the A/C system if the refrigerant pressure becomes too high. It also protects the A/C system if the pressure becomes too low caused by loss of refrigerant. If either of these conditions occur, the switch contacts will pen and cause A/C clutch compressor (Y20) to de-energize.

### A/C Freeze Control Switch

The A/C freeze control switch (B32) senses the temperature in the evaporator core through a gas-filled capillary tube. The switch closes when the evaporator temperature is above the switch setting and opens when the evaporator is cooled to the switch setting.

## DC/DC Converter

The heater valve actuator and the tree vent actuators require approximately 14 volts to operate.

Because of this, DC/DC convertor (U1) is needed to convert the system voltage (27.5 ± 1.5 volts) to the required voltage.

The 14 volts is supplied to terminal I-1 of A/C relay panel (A11), terminal 1 of temperature control(R10) and to terminal 10 on all the actuators.

## Blower Motor Speed Control Switch

When the blower motor speed control switch (S8) is in the **LOW** position, current flows from terminal 5 of the blower switch to terminals I-6 and I-11 of A/C relay panel (A11).

The current at terminal I-11 energizes a relay on the A/C relay panel.

With this "onboard" relay energized, current is allowed to flow in terminal I-12 of the A/C relay panel, then out terminal O-5 to Blower Motor Resistor/Thermofuse (R11).

The current flows through the 3.5 ohm resistor, the 1.2 ohm resistor and the thermofuse, then to blower motor (M4), activating the motor in low speed.

At the same time, current at terminal I-6 energizes another onboard relay that directs current from the 14 volt system out terminal O03, to terminal 8 of re-circulation vent actuator (M6).

If air re-circulation switch (S17) is in the ON position, the vent actuator will cause the re-circulation flapper door to move to the fully open position, thus allowing outside air to enter the cab

When the blower motor speed control switch (S18) is in the **MEDIUM** position, current flows from terminal 6 of the blower switch directly to blower motor resistor/thermofuse (R11). The current flows through the 1.2 ohm resistor and the thermofuse, then to blower motor (M4), activating the motor in medium speed.

If air re-circulation switch (S17) is in the **ON** position and blower speed switch in the **MEDIUM** position, the re-circulation flapper door will move to the half-way position.

When the blower motor speed control switch (S18) is in the HIGH position, current flows from terminal 7 of the blower switch to the coil of high fan speed relay (K21), energizing the relay.

With relay (K21) energized, current flows to blower motor resistor/thermofuse (R11).

The current only flows through the thermofuse, then to blower motor (M4), activating the motor in high speed.

At the same time, current flows to terminal I-7 of A/C relay panel (A11), energizing an onboard relay that connects system ground to terminal O-3.

If air re-circulation switch (S17) is in the **ON** position, the ground is supplied to terminal 8 of Re-circulation vent actuator (M6), causing actuator (M6) to move the re-circulation flapper door to the fully closed position. Air is re-circulated through the cab.

## Air Re-circulation Switch

When air re-circulation switch (S17) is in the OFF position, no current flows from the switch.

The re-circulation flapper door stays in the fully open position regardless of blower speed setting.

When the air re-circulation switch is in the **ON** position, current flows to terminal I-8 of A/C relay panel (A11).

The current energizes an onboard relay that directs current from the 14 volt system out terminal O-3 to terminal 8 of re-circulation vent actuator (M6), activating the vent actuator.

The vent actuator moves the re-circulation flapper door to the fully closed position, causing the air to re-circulate through the cab.

## Air Flow Control Switch

When air flow control switch (S19) is in the **DEFROST** position, no vent actuators are activated. Air flow is directed to the wind shield.

When the air flow control switch is in the **FLOOR VENT** position, current flows out terminal I-3 of A/C relay panel (A11).

The current energizes an onboard relay that directs current from the 14 volt system out terminal O-1 to terminal 8 of floor vent actuator (M8), activating the vent actuator and causing air flow to be directed to the floor vents.

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When the air flow control switch is in the **MIDDLE VENT** position, current flows out terminal 9 of air flow switch to terminal I-4 of the A/C relay panel.

The current energizes an onboard relay that directs current from the 14 volt system out terminal O-2 to terminal 8 of the middle and de-froster vent actuator (M7), activating the vent actuator and causing air flow to be directed to the middle vents.

When the air flow control switch is in the **FLOOR/ MIDDLE VENT** position, current flows out terminal 10 of air flow switch to terminal I-5 of the A/C relay panel.

The current energizes an onboard relay that directs current from the 14 volt system out terminal O-1 and O-2 to terminal 8 of middle and defroster vent actuator (M7) and floor vent actuator (M8), activating both vent actuators and causing air flow to be directed to both the middle vents and the floor vents.

### Temperature Control

The temperature control (R10) is a variable resistor that sends an analog current from the 14 volt system to terminal I-9 of A/C relay panel (A11).

The current flows through an onboard fixed resistor, out terminal O-4 of the relay panel, to terminal 8 of heater control valve actuator (M5), activating the valve actuator.

The actuator opens and closes a valve in the heater core line. The movement of the valve corresponds directly with the position of temperature control (R10).

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## Electric Mirror Circuit Theory of Operation

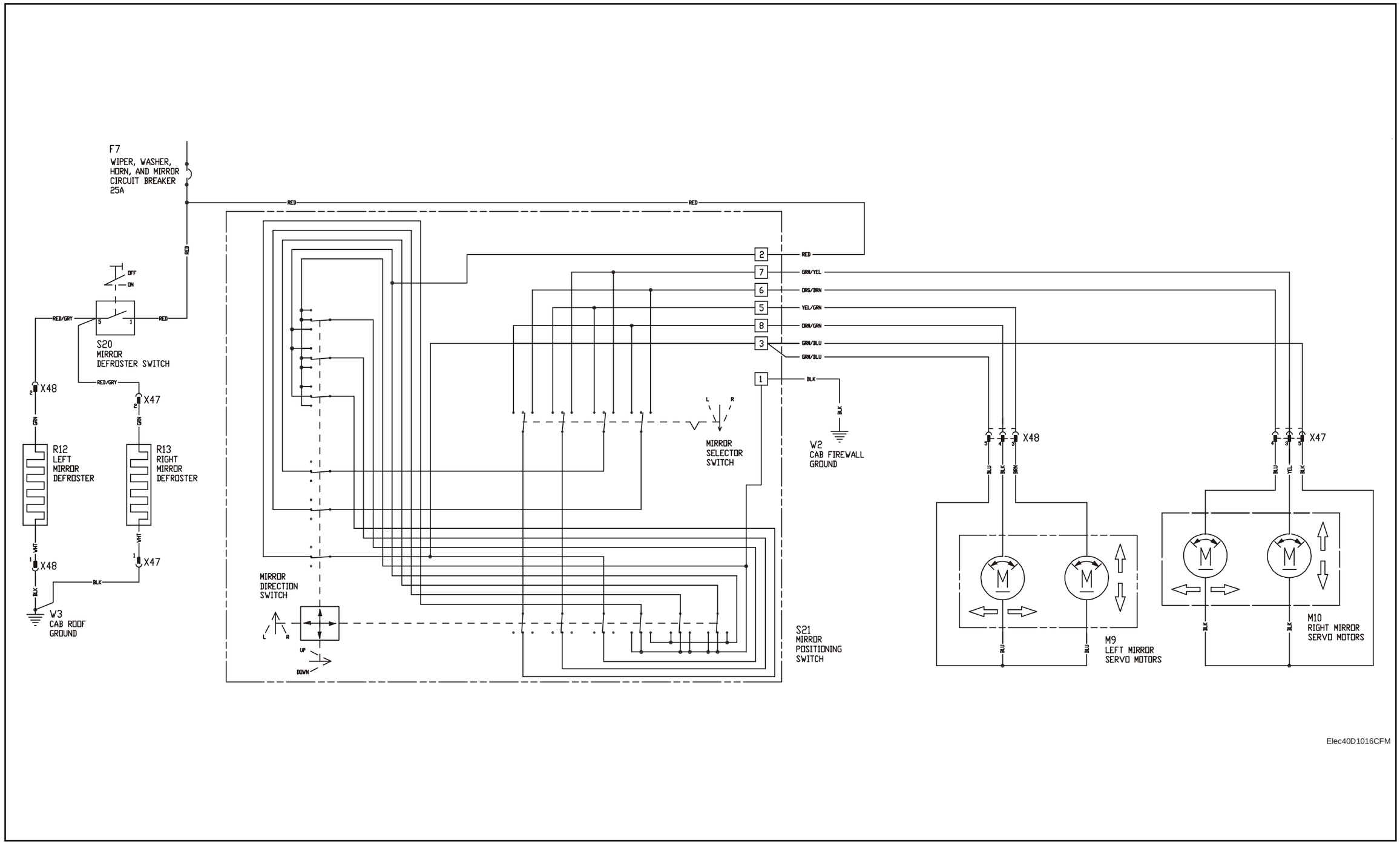



Figure 3-116

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### Mirror Positioning Circuit

Movement of the optional electric mirrors is controlled by mirror positioning switch (S21). The mirror positioning switch is a multi-functional switch consisting of a mirror selector switch and a mirror direction switch.

The mirror selector switch enables the circuitry of the mirror to be adjusted. Moving the switch to the left detent allows the left mirror to be adjusted. Moving the switch to the right detent allows the right mirror to be adjusted. Moving the switch to the centre detent disables both the mirrors.

The mirror switch is a four-way switch that operates two servo motors in each mirror. One servo motor controls the mirror up and down movement. The other servo motor controls mirror side-to-side movement.

**NOTE: The following discusses the operation of the left mirror. Operation of the right mirror is similar.**

#### Up/Down Positioning

When the mirror selector switch is at position "**L**" and the mirror direction switch is moved to the **UP** position, ground is supplied to left servo motors (M9) at terminals 4 and 5 of connector X48.

At the same time, power is available at terminal 3 of connector X48. Because of this, current flows through the up/down motor of left mirror servo motors (M9), activating the motor which causes the mirror lens to rotate upward.

The side-to-side motor of left mirror servo motor (M9) does not activate because ground is supplied to both sides of the motor during this time.

When the mirror selector switch is at position "**L**" and the mirror direction switch is moved to the **DOWN** position, ground is supplied to left mirror servo motors (M9) at terminal 3 of connector X48. At the same time, power is available at terminals 4 and 5 of connector X48.

Because of this, current flows through the up/down motor of left mirror servo motors (M9), but in the opposite direction. This causes the motor to activate in reverse which rotates the mirror lens downward.

The side-to-side motor of left mirror servo motors (M9) does not activate because power is supplied to both sides of the motor during this time.

#### Left/Right Positioning

When the mirror selector switch is at position "**L**" and the mirror direction switch is moved to the **LEFT,** ground is supplied to left servo motors (M9) at terminals 3 and 5 of connector X48.

At the same time, power is available at terminal 4 of connector X48. Current flows through the side-to-side motor of left mirror servo motors (M9), activating the motor which causes the mirror lens to rotate to the left.

The up/down motor of left mirror servo motor (M9) does not activate because ground is supplied to both sides of the motor during this time.

When the mirror selector switch is at position "**L**" and the mirror direction switch is moved to the **RIGHT,** ground is supplied to left servo motors (M9) at terminals 4 of connector X48.

At the same time, power is available at terminal 3 and 5 of connector X48. Because of this, current flows through the side-to-side motor of left mirror servo motors (M9), but in the opposite direction. This causes the motor to activate in reverse which rotates the mirror lens to the right.

The up/down motor of left mirror servo motor (M9) does not activate because ground is supplied to both sides of the motor during this time.

#### Mirror Defroster Circuit

The optional electrical mirrors contain a heating element that is attached to the mirror's reflective lens for defrosting and defogging purposes.

With both the key switch and mirror defroster switch (S20) in the ON position, current flows through left mirror defroster (R12) and right mirror defroster (R13). Heat is produced because of resistance in the heater elements.

### Unloader Valve Heater Circuit Theory of Operation

the unloader valve, located inside the air dryer, contains unloader valve heater (R5). The purpose of this heating element is to prevent the unloader valve from freezing so the purge cycle can continue to remove moisture from the pneumatic system.

The heating element is controlled by an internal temperature switch. The temperature switch contacts are closed when the temperature is below 4.4° C (40° F). The contacts are open when the temperature is above 29.5° C (85° F).

When the temperature is below 4.4° C (40° F) and the key switch is in the **ON** position, current flows through circuit breaker (F24) to unloader valve heater (R5).

The current flowing through the heating element warms the unloader valve to prevent moisture from freezing inside the valve.

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# CHAPTER 3. ELECTRICAL SYSTEM

## SECTION 3. REFERENCES

## SERVICE CODE DIAGNOSTICS - AFTER MACHINE REPAIR

After repairing a malfunction involving a service code, deletion of the service code is necessary to verify if malfunction was indeed repaired.

- To delete a service code that displays on the MDU, See Delete MDU Displayed Service Codes.
- To delete a service code that displays on the transmission shift control, See Delete Transmission Shift Control Displayed Service Codes.

### Delete MDU Displayed Service Codes

**NOTE: The MDU displayed codes can be read and deleted by one of the following methods:**
**1. Menu Display Unit**
**2. Service ADVISOR ™ application. (See instructions that came with the Service ADVISOR ™).**

To delete all service codes from memory using the MDU, perform the following:

1. Go to the Diagnostics Menu “C01” in the menu structure of the MDU. For information on accessing the Diagnostic Menu, **See MDU - Menu Function, CHAPTER 8 in the OMM.**

2. Display the service code, then press and hold the **SELECT** key. The monitor will beep and the service code will be cleared.

3. Repeat step 2 for each service code until **END** is displayed.

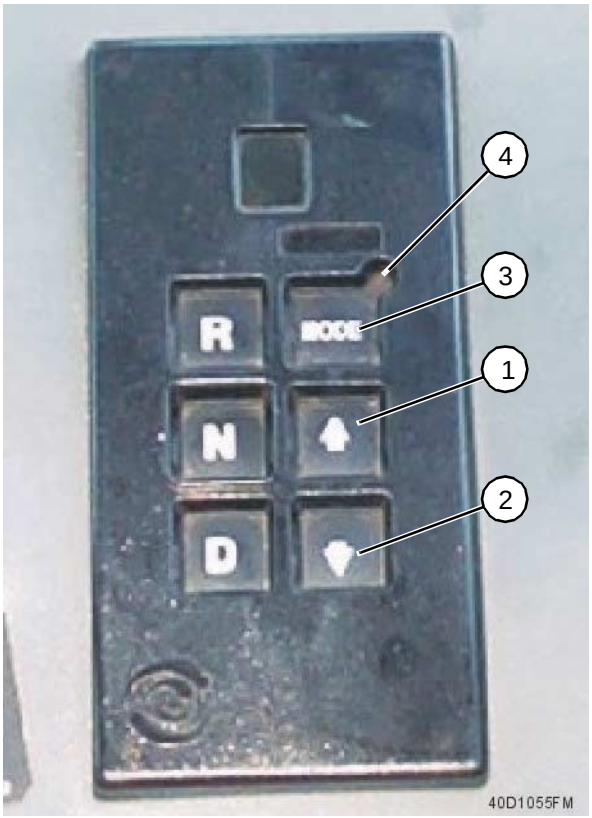
Operate the machine, then access the Diagnostic Menu on the MDU to make sure the problem has been corrected and that the previously repaired service code or a new service code is not displayed. If a new service code exists, diagnose and repair the malfunction that is displayed, then repeat steps 1 - 3.

### Delete Transmission Shift Control Displayed Service Codes

**NOTE: The transmission service codes can be read and deleted by one of the following methods:**
**1. Transmission shift control.**
**2. Service ADVISOR application (See instructions that come with Service ADVISOR).**
**3. PRO-LINK ® 9000 Diagnostic Tool. (See instructions that come with PRO-LINK 9000).**
**The PRO-LINK diagnostic tool requires a special adapter harness 207663 to connect to the diagnostic connector (X15).**

To delete service codes using the transmission shift control, perform the following:

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Simultaneously push both the up and down buttons (1) and (2) on the push-button selector to enter the diagnostic display mode.

To delete all active indicators, push and hold the mode button (3) until the **MODE** indicator **LED** (4) flashes three times.

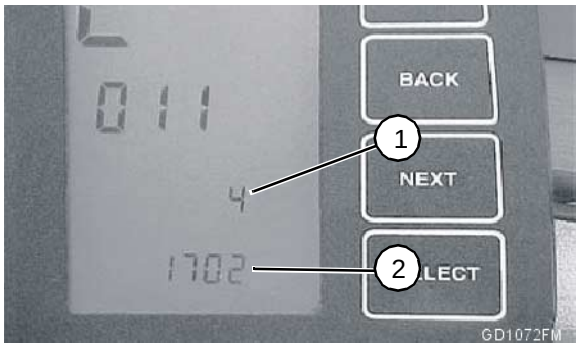
Release mode button.

To remove all inactive codes, push and hold the **MODE** button until the **LED** indicator flashes six times.

**NOTE:All active indicators will be cleared at TCU power down.**

Exit the diagnostic display mode by simultaneously pushing both the **UP** and **DOWN** buttons, or push one of the **D**, **N** or **Range** buttons.

## Service Code Diagnostics - How Codes Are Displayed On Menu Display Unit




the service codes that display on the MDU follow the J1939 standard. The code consists of a SPN number (2) and a FMI number (1). These codes are written with the SPN number first, then the FMI number (e.g.:1702.4).

## Service Code Diagnostics - How To Use Listing For Transmission Codes

The transmission control unit (TCU) provides the following responses to service codes to allow for safe transmission operation:

- Do Not Shift (DNS)
  - Release lockup clutch and inhibit lockup operation.
  - Inhibit all shifts.
  - Turns on the DNS caution indicator.
  - Display the range permitted.
  - Ignore any gear selection inputs from the gear shift control.
- Do Not Adapt (DNA)
  - The TCU stops adaptive shift control while code is active.
- Solenoid Off (SOL OFF)
  - All solenoids are commanded **OFF**.

**NOTE:When solenoids A and B are electrically de-energized (OFF), the solenoids are hydraulically ON.**

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- Return TO Previous Range (RPR)
  - When the speed sensor ratio or C3 pressure switch tests associated with a shift are not successful, the TCU commands the same gear as commanded before the shift.
- Neutral - No Clutches (NNC)
  - When certain speed sensor ratio or C3 pressure switch tests are not successful, the TCU commands a neutral condition with no clutches engaged.
- Computer Operation Properly (COP)
  - Hardware protection that causes the TCU to reset if software gets lost.
- General Purpose Output (GPO)
  - Output signal from the TCU to control vehicle components or allow a special operating mode or condition.

### Service Code Diagnostics - Engine Control Unit

**NOTE: For information on how the service code is displayed on the menu display unit, See "Service Code Diagnostics - How Codes Are Displayed On Menu Display Unit" on page 98.**

| Code - Symptom | Problem | Solution |
|---|---|---|
| 45.3 - Constant Throttle (EVB) Open Circuit. | Exhaust Brake Relay (K6).<br><br>Broken or poor wire connection between ECU and exhaust brake relay (K6). | Check relay. **(See "Relay Test" on page 190)**.<br><br>Check cab main harness (W10). |
| 45.5 - Constant Throttle (EVB) Closed Circuit. | Exhaust Brake Relay (K6).<br><br>Shorted wire between ECU and exhaust brake relay (K6). | Check relay. **(See "Relay Test" on page 190)**.<br><br>Check cab main harness (W10). |
| 98.0 - Oil Level Too High. | Excessive oil in crankcase. | Drain oil from crankcase until proper oil level is obtained. |
| 98.1 - Oil Level Too Low. | Too little oil in crankcase. | Add oil to proper level. For type of oil, **(See CHAPTER 1 in the OMM).** |
| 98.14 - Oil Level Dangerously Low. | Oil leak.<br><br>Worn engine. | Drain oil. Repair oil leak. Fill with correct viscosity oil. **(See CHAPTER 1 in the OMM).**<br><br>Repair or replace engine. **(See Engine, CHAPTER 4, SECTION 1 in the Repair Manual)**. |
| 100.1 - Oil Pressure Low. | Oil pressure sensor (B5). | Replace oil pressure sensor. |
| 100.14 - Oil Pressure Very low. | Oil pressure sensor (B5).<br><br>Broken wire or poor connection.<br><br>EUI controller or ECU. | Replace oil pressure sensor.<br><br>Check front frame/engine harness (W7), engine main harness (W8) and cab main harness(W10).<br><br>Replace control unit. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 158.0 - Switched Voltage To Engine EUI Controller and ECU Too High. | Alternator. | Check alternator. Replace if necessary. |
| 158.1 - Switched Voltage To Engine EUI Controller and ECU Too Low. | Alternator.<br>Batteries. | Check alternator. Replace if necessary.<br>Check batteries. Recharge or re[place as necessary. |
| 625.2 - CAN Data Line Error Between EUI Controller And ECU. | Broken or shorted wire; poor connection. | Check front frame/engine harness (W7) and cab harness (W10). |
| 625.14 - CAN Data Line Error With One Wire Capability Between EUI COntroller And ECU. | Broken wire or poor connection. | Check front frame/engine harness (W7) and cab harness (W10). |
| 629.12 - ECU Internal Failure. | Faulty ECU. | Replace ECU. **(See “Remove and Install Engine Control Unit” on page 200)**. |
| 1005.3 - Pulse Width Modulation Accelerator Pedal Position Sensor PWM Output Malfunction Open Circuit. | Accelerator pedal position sensor (B10).<br>Broken wire or poor connection. | Check accelerator pedal position sensor. Replace sensor.<br>Check cab main harness (W10). |
| 1005.4 - Pulse Width Modulation Accelerator Pedal Position Sensor PWM Output Malfunction Closed Circuit. | Accelerator pedal position sensor (B10).<br>Shorted wire. | Check accelerator pedal position sensor. Replace sensor.<br>Check cab main harness (W10). |
| 1006.3 - Exhaust Brake Open Circuit. | Exhaust brake relay (K6).<br>Broken or poor wire connection between ECU and exhaust brake relay (K6). | Check relay. **(See “Relay Test” on page 190)**.<br>Check cab main harness (W10). |
| 1006.4 - Exhaust Brake Short To Ground. | Exhaust brake relay (K6).<br>Shorted wire between ECU and exhaust brake relay (K6). | Check relay. **(See “Relay Test” on page 190)**.<br>Check cab main harness (W10). |
| 1015.1 - Pulse Width Modulation Accelerator Pedal Position Sensor No Input Voltage. | Broken wire or poor connection. | Check connections of cab power harness (W9) and main cab harness (W10). |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 1015.3 - Pulse Width Modulation Accelerator Pedal Position Sensor Both PWM Signal #2 Missing. | Accelerator pedal position sensor (B10).<br>Broken wire or poor connection. | Check accelerator pedal position sensor. Replace sensor.<br>Check cab main harness (W10). |
| 1015.4 - Pulse Width Modulation Accelerator Pedal Position Sensor Both PWM Signal #1 Missing. | Accelerator pedal position sensor (B10).<br>Broken wire or poor connection. | Check accelerator pedal position sensor. Replace sensor.<br>Check cab main harness (W10). |
| 1015.5 - Pulse Width Modulation Accelerator Pedal Position Sensor Both PWM Signal Not Set or Programmed. | ECU not properly programmed for accelerator pedal position sensor. | Program ECU. |
| 1015.6 - Pulse Width Modulation Accelerator Pedal Position Sensor Slow Idle Not Set or Programmed. | ECU not properly programmed for accelerator pedal position sensor. | Program ECU. |
| 1015.7 - Pulse Width Modulation Accelerator Pedal Position Sensor Fast Idle Not Set or Programmed. | ECU not properly programmed for accelerator pedal position sensor. | Program ECU. |

## Service Code Diagnostics - Electronic Unit Injector (EUI) Controller

**NOTE:For information on how the service code is displayed on the menu display unit, (See “Service Code Diagnostics - How Codes Are Displayed On Menu Display Unit” on page 98).**

| Code - Symptom | Problem | Solution |
|---|---|---|
| 98.2 - Engine Oil Level Sensor Value Not Recognized. | Broken wire or poor connection. | Check front frame/engine harness(W7) and cab main harness(W10). |
| 98.3 - Oil Level Sensor Out Of Range High. | Engine oil level sensor (B3).<br>Wire shorted to positive. | Check oil level sensor. Replace sensor.<br>Check engine main harness (W8). |
| 98.4 - Oil Level Sensor Out Of Range Low. | Engine oil level sensor (B3).<br>Wire shorted to ground. | Check oil level sensor. Replace sensor.<br>Check engine main harness (W8). |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 98.5 - Oil Level Sensor Open Circuit. | Engine oil level sensor (B3).<br>Broken wire or poor connection. | Check oil level sensor. Replace sensor.<br>Check engine main harness (W8). |
| 100.2 - Engine Oil Pressure Sensor Value Not Recognized. | Broken wire or poor connection. | Check front frame/engine harness (W7) and Cab Main harness (W10). |
| 100.3 - Engine Oil Pressure Sensor Out of Range High. | Engine oil pressure sensor (B5).<br>Wire shorted to positive. | Check oil pressure sensor. Replace sensor.<br>Check engine main harness (W8). |
| 100.4 - Engine Oil Pressure Sensor Out of Range Low. | Engine oil pressure sensor (B5).<br>Wire shorted to ground. | Check oil pressure sensor. Replace sensor.<br>Check engine main harness (W8). |
| 102.2 - Manifold Air Pressure (MAP) Sensor Value Not Recognized. | Broken wire or poor connection. | Check front frame/engine harness (W7) and Cab Main harness (W10). |
| 102.3 - Manifold Air Pressure (MAP) Sensor out Of Range High. | Intake manifold air pressure/ temperature sensor (B6).<br>Wire shorted to positive. | Check intake manifold air pressure/ temperature sensor. Replace sensor.<br>Check engine main harness (W8). |
| 102.4 - Manifold Air Pressure (MAP) Sensor out Of Range Low. | Intake manifold air pressure/ temperature sensor (B6).<br>Wire shorted to ground. | Check intake manifold air pressure/ temperature sensor. Replace sensor.<br>Check engine main harness (W8). |

## Service Code Diagnostics - Chassis Control Unit (CCU)

**NOTE:For information on how the service code is displayed on the menu display unit, (See “Service Code Diagnostics - How Codes Are Displayed On Menu Display Unit” on page 98).**

| Code - Symptom | Problem | Solution |
|---|---|---|
| 1702.3 - Bin Position Above Normal. | Bin position sensor (B17) not calibrated.<br>Wiring or connections.<br>Bin position sensor (B17).<br>CCU (A8). | Calibrate bin position sensor. **(See menu function D04 in the MDU menu structure in CHAPTER 8 in the OMM)**.<br>Check rear frame harness (W15), hydraulic harness (W14) and cab main harness (W10).<br>Check bin position sensor. **(See “Bin Position Sensor Test” on page 196)**.<br>Replace CCU. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 1702.3 - Bin Position Below Normal. | Bin position sensor (B17) not calibrated. | Calibrate bin position sensor. **(See menu function D04 in the MDU menu structure in CHAPTER 8 in the OMM)**. |
| | Wiring or connections. | Check rear frame harness (W15), hydraulic harness (W14) and cab main harness (W10). |
| | Bin position sensor (B17). | Check bin position sensor. **(See "Bin Position Sensor Test" on page 196)**. |
| | CCU (A8). | Replace CCU. |
| 1703.3 - System Air Pressure Above Normal. | Wiring or connections. | Check cab main harness (W10). |
| | System air pressure sensor (B15). | Check system air pressure sensor. **(See "Pneumatic System Solenoids, Pressure Switches, and Sensor Tests" on page 192)**. |
| | CCU (A8). | Replace CCU. |
| 1703.4 - System Air Pressure Below Normal. | Wiring or connections. | Check cab main harness (W10). |
| | System air pressure sensor (B15). | Check system air pressure sensor. **(See "Pneumatic System Solenoids, Pressure Switches, and Sensor Tests" on page 192)**. |
| | CCU (A8). | Replace CCU. |
| 1704.3 - Hydraulic Temperature Above Normal. | Wiring or connections. | Check cab main harness (W10) and hydraulic harness (W14). |
| | Hydraulic temperature sensor (B21). | Check hydraulic temperature sensor. **(See "Hydraulic Temperature Sensors Test" on page 195).** |
| | CCU (A8). | Replace CCU. |
| 1704.4 - Hydraulic Temperature Below Normal. | Wiring or connections. | Check cab main harness (W10) and hydraulic harness (W14). |
| | Hydraulic temperature sensor (B21). | Check hydraulic temperature sensor. **(See "Hydraulic Temperature Sensors Test" on page 195).** |
| | CCU (A8). | Replace CCU. |
| 1705.3 - Wet Disk Brake Temperature Above Normal. (B40D Only). | Wiring or connections. | Check cab main harness (W10) and hydraulic harness (W14). |
| | Wet disk brake temperature sensor (B22). | Check wet disk brake temperature sensor. **(See "Hydraulic Temperature Sensors Test" on page 195)**. |
| | CCU (A8). | Replace CCU. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 1705.4 - Wet Disk Brake Temperature Below Normal. (B40D Only). | Wiring or connections. | Check cab main harness (W10) and hydraulic harness (W14). |
| | Wet disk brake temperature sensor (B22). | Check wet disk brake temperature sensor. **(See “Hydraulic Temperature Sensors Test” on page 195)**. |
| | CCU (A8). | Replace CCU. |
| 96.3 - Engine Oil Pressure Sensor Out of Range High. | Wiring or connections. | Check front frame/engine harness (W7) and cab main harness (W10). |
| | Fuel level sensor (B19). | Check level sensor. |
| | CCU (A8). | Replace CCU. |
| 96.4 - Engine Oil Pressure Sensor Out of Range Low. | Wiring or connections. | Check front frame/engine harness (W7) and cab main harness (W10). |
| | Fuel level sensor (B19). | Check level sensor. |
| | CCU (A8). | Replace CCU. |
| 2000.2 - VIN Number Mismatch. | CCU (A8) has incorrect program. | Install correct program in CCU. |

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## Service Code Diagnostics -Transmission Control Unit (TCU)

**NOTE:For explanation of acronyms DNS, DNA NNC etc., (See "Service Code Diagnostics - How To Use Listing For Transmission Codes" on page 98).**

| Code - Symptom | Problem | Solution |
|---|---|---|
| 1312 - TCU Input Voltage Low.<br>DNS, DNA and SOL OFF conditions exists.<br>Transmission Service Light **ON**. | Alternator.<br>Batteries.<br>Loose or corroded connections. | Check alternator. Replace if necessary.<br>Check batteries. Recharge or replace as necessary.<br>Check connections of wire harness (W6 and W9). |
| 1313 - TCU Input Voltage Medium Low.<br>DNA condition exists.<br>Transmission Service Light **OFF**. | Alternator.<br>Batteries.<br>Loose or corroded connections. | Check alternator. Replace if necessary.<br>Check batteries. Recharge or replace as necessary.<br>Check connections of wire harness (W6 and W9). |
| 1312 - TCU Input Voltage High.<br>DNS and SOL OFF conditions exists.<br>Transmission Service Light **ON**. | Alternator. | Check alternator. Replace if necessary. |
| 1412 - Transmission Oil Level Sensor Circuit Malfunction Low.<br>Transmission Fault Light **OFF**. | Oil level sensor.<br>Wiring or connections.<br>TCU (A5). | Replace oil level sensor. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Repair Manual)**.<br>Check transmission control harness (W12) and transmission harness (W13).<br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 2112 - Accelerator Pedal Position Sensor (B10) Circuit Malfunction - Low.<br>TCU senses accelerator pedal position counts of 14 or less.<br>Throttle default values are used, DNA.<br>Transmission service light **OFF**. | Accelerator pedal position sensor (B10).<br>Wiring or connections.<br>TCU (A5). | Check accelerator pedal position sensor. Replace. **(See "Remove, Install, and Calibrate Accelerator Pedal Position Sensor" on page 206)**.<br>Check cab main harness (W10) and CAN data line harness (W11).<br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 2123 - Accelerator Pedal Position Sensor (B10) Circuit Malfunction - High. | Accelerator pedal position sensor (B10). | Check accelerator pedal position sensor. Replace. **(See "Remove, Install, and Calibrate Accelerator Pedal Position Sensor" on page 206)**. |
| TCU senses accelerator pedal position counts 233 - 255. | Wiring or connections. | Check cab main harness (W10) and CAN data line harness (W11). |
| Throttle default values are used, DNA. | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| Transmission service light **OFF**. | | |
| 2214 - Engine Speed Sensor Reasonableness Test. | Input speed sensor (B14). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| Default engine speeds are used, DNA. | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| Transmission service light **OFF**. | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 2215 - Turbine Speed Sensor Reasonableness Test.<br><br>DNA, DNS Locked in Current Range.<br><br>Transmission service light **ON**. | Input sensor (B12).<br><br>**NOTE: A malfunctioning turbine speed sensor or a dragging C1 or C3 clutch is indicated, if turbine speed is less than 150 r.p.m.; when output speed is less than 100 r.p.m. and engine speed is more than 400 r.p.m.; when neutral (N) is selected. When this happens, the TCU will put the transmission in Neutral Very Low (NVL) mode. When in NVL mode, the D solenoid is energized in addition to the E solenoid to apply C4 and C5 clutches, which causes the transmission output to lock up.**<br><br>Wiring or connections.<br><br>TCU (A5). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check transmission control harness (W12) and transmission harness (W13).<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 2216 - Output Speed Sensor reasonableness Test.<br><br>DNA, DNS Locked in Current Range.<br><br>Transmission service light **ON**. | Output speed sensor (B13).<br><br>Wiring or connections.<br><br>TCU (A5). | Replace speed sensor.<br><br>Check transmission control harness (W12) and transmission harness (W13).<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 2312 - Primary Shift Selector or RSI Link Open or Short Circuit.<br>Holds in last valid displayed.<br>Transmission Service light **OFF**. | Transmission shift control (A4).<br>Wiring or connections.<br>TCU (A5). | Replace shift control.<br>Check transmission control harness (W12).<br>Replace TCU **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 2313 - Primary Shift Selector Mode Function Malfunction.<br>Mode change not permitted.<br>Transmission Service light **OFF**. | Transmission shift control (A4).<br>Wiring or connections.<br>TCU (A5). | Replace shift control.<br>Check transmission control harness (W12).<br>Replace TCU **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 2316 - Shift Selector Display Line Open or Short Circuit.<br>No inhibited operation.<br>Cateye (-/-) may be displayed.<br>Transmission Service light **OFF**. | Transmission shift control (A4).<br>Wiring or connections.<br>TCU (A5). | Replace shift control.<br>Check transmission control harness (W12).<br>Replace TCU **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 2412 - Sump Fluid Temperature Cold.<br>DNS locked in neutral.<br>Transmission Service light **ON**. | Transmission oil too cold. Air temperature is below -32° C (-25° F).<br>Transmission oil sump temperature sensor.<br>Wiring or connections. | Warm transmission oil to normal operating temperature. **(See "TRANSMISSION WARM-UP PROCEDURE" on page 297)**.<br>Replace temperature sensor. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Repair Manual)**.<br>Check transmission control harness (W12) and transmission harness (W13). |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 2423 - Sump Fluid Temperature Hot.<br>No upshifts above a calibration range.<br>Transmission Service light **OFF**. | Transmission oil low. | Add oil as necessary. **(See CHAPTER 1 in the OMM for quantities and specifications)**. |
| | Transmission oil too hot because engine is overheating. | Check cause of engine overheating. **(See "SECTION 2. DIAGNOSE ENGINE MALFUNCTIONS" on page 45)**. |
| | Transmission thermal valve. | |
| | Transmission oil cooler is restricted. | Check oil cooler **(See "Transmission Oil Cooler Restriction Test" on page 305)**. |
| | Transmission oil sump temperature sensor. | Replace temperature sensor. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| 2511 - Output Speed Sensor Detected Zero Speed (1at Range).<br>DNA, DNS, Locked in current range (1st).<br>Transmission service light **ON**.<br>This code is locked to real time to protect the transmission in case a loss of power to the TCU (power interrupted code 3500) occurs. | Output speed sensor (B13).<br>**NOTE:May also cause service code 2216 to occur.** | Check resistance of sped sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Turbine speed sensor (B12).<br>**NOTE:May also cause service code 2215 to occur.** | Check resistance of sped sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | Transmission internal clutch malfunction. | Repair or replace transmission. **(See Remove and Install Transmission In CHAPTER 3, SECTION 1 and Disassemble Transmission In CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| 2522 - Output Speed Sensor Detected Zero Speed (2nd Range).<br>DNA, DNS, Locked in current range (2nd).<br>Transmission service light **ON**.<br>This code is locked to real time to protect the transmission in case a loss of power to the TCU (power interrupted code 3500) occurs. | Output speed sensor (B13).<br>**NOTE:May also cause service code 2216 to occur.** | Check resistance of sped sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | Transmission internal clutch malfunction. | Repair or replace transmission. **(See Remove and Install Transmission In CHAPTER 3, SECTION 1 and Disassemble Transmission In CHAPTER 3, SECTION 3 in the Repair Manual)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 2533 - Output Speed Sensor Detected Zero Speed (3rd Range).<br>DNA, DNS, Locked in current range (3rd).<br>Transmission service light **ON**.<br>This code is locked to real time to protect the transmission in case a loss of power to the TCU (power interrupted code 3500) occurs. | Output speed sensor (B13).<br>**NOTE:May also cause service code 2216 to occur.**<br>Wiring or connections.<br>Transmission internal clutch malfunction. | Check resistance of sped sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br>Check transmission control harness (W12) and transmission harness (W13).<br>Repair or replace transmission. **(See Remove and Install Transmission In CHAPTER 3, SECTION 1 and Disassemble Transmission In CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| 2544 - Output Speed Sensor Detected Zero Speed (4th Range).<br>DNA, DNS, Locked in current range (4th).<br>Transmission service light **ON**.<br>This code is locked to real time to protect the transmission in case a loss of power to the TCU (power interrupted code 3500) occurs. | Output speed sensor (B13).<br>**NOTE:May also cause service code 2216 to occur.**<br>Wiring or connections.<br>Transmission internal clutch malfunction. | Check resistance of sped sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br>Check transmission control harness (W12) and transmission harness (W13).<br>Repair or replace transmission. **(See Remove and Install Transmission In CHAPTER 3, SECTION 1 and Disassemble Transmission In CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| 2555 - Output Speed Sensor Detected Zero Speed (5th Range).<br>DNA, DNS, Locked in current range (5th).<br>Transmission service light **ON**.<br>This code is locked to real time to protect the transmission in case a loss of power to the TCU (power interrupted code 3500) occurs. | Output speed sensor (B13).<br>**NOTE:May also cause service code 2216 to occur.**<br>Wiring or connections.<br>Transmission internal clutch malfunction. | Check resistance of sped sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br>Check transmission control harness (W12) and transmission harness (W13).<br>Repair or replace transmission. **(See Remove and Install Transmission In CHAPTER 3, SECTION 1 and Disassemble Transmission In CHAPTER 3, SECTION 3 in the Repair Manual)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 2566 - Output Speed Sensor Detected Zero Speed (6th Range).<br><br>DNA, DNS, Locked in current range (6th).<br><br>Transmission service light **ON**.<br><br>This code is locked to real time to protect the transmission in case a loss of power to the TCU (power interrupted code 3500) occurs. | Output speed sensor (B13).<br><br>**NOTE:May also cause service code 2216 to occur.**<br><br>Wiring or connections.<br><br>Transmission internal clutch malfunction. | Check resistance of sped sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check transmission control harness (W12) and transmission harness (W13).<br><br>Repair or replace transmission. **(See Remove and Install Transmission In CHAPTER 3, SECTION 1 and Disassemble Transmission In CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| 2577 - Output Speed Sensor Detected Zero Speed (Reverse).<br><br>DNA, DNS, Locked in current range (Reverse).<br><br>Transmission service light **ON**.<br><br>This code is locked to real time to protect the transmission in case a loss of power to the TCU (power interrupted code 3500) occurs. | Output speed sensor (B13).<br><br>**NOTE:May also cause service code 2216 to occur.**<br><br>Wiring or connections.<br><br>Transmission internal clutch malfunction. | Check resistance of sped sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check transmission control harness (W12) and transmission harness (W13).<br><br>Repair or replace transmission. **(See Remove and Install Transmission In CHAPTER 3, SECTION 1 and Disassemble Transmission In CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| 2600 - Throttle Source Not Detected.<br><br>Throttle default values are used, DNA.<br><br>Transmission service light **OFF**. | Wiring or connections.<br><br>Accelerator pedal position sensor (B10).<br><br>ECU (A3). | Check CAN harness (W11) and cab main harness (W10).<br><br>Replace accelerator pedal position sensor. Calibrate accelerator pedal position sensor to ECU, if necessary. **(See "Remove and Install Engine Control Unit" on page 200)**.<br><br>Replace ECU. Calibrate accelerator pedal position sensor to ECU, if necessary. **(See "Remove and Install Engine Control Unit" on page 200)**. |
| 2611 - Engine Coolant Source Not Detected.<br><br>Default temperature value of -18° C (0° F) used.<br><br>Transmission service light **OFF**. | Engine coolant temperature sensor (B2).<br><br>Wiring or connections. | Replace sensor.<br><br>Check engine main harness (W8), front frame/engine harness (W7) and cab main harness (W10). |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 3233 - C3 Pressure Switch Open (3rd Range).<br>DNA, DNS, locked in current range (3rd).<br>Transmission service light **ON**. | Wiring or connections.<br>Transmission (C3) pressure switch or internal wire harness.<br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br>Replace (C3) pressure switch or internal wire harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Repair Manual)**.<br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 3255 - C3 Pressure Switch Open (5th Range).<br>DNA, DNS, locked in current range (5th).<br>Transmission service light **ON**. | Wiring or connections.<br>Transmission (C3) pressure switch or internal wire harness.<br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br>Replace (C3) pressure switch or internal wire harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Repair Manual)**.<br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 2577 - C3 Pressure Switch Open (Reverse).<br>DNA, DNS, Locked in current range (Reverse).<br>Transmission service light **ON**. | Wiring or connections.<br>Transmission (C3) pressure switch or internal wire harness.<br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br>Replace (C3) pressure switch or internal wire harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Repair Manual)**.<br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 3312 - Sump Oil Temperature Sensor Circuit Malfunction Low.<br>Default value 93° C (200° F) used.<br>Transmission service light **OFF**. | Wiring or connections.<br>Transmission oil temperature sensor or internal wire harness.<br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br>Replace sensor or internal harness.(**See Disassembly and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Repair Manual).**<br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 3323 - Sump Oil Temperature Sensor Circuit Malfunction High.<br>Default value 93° C (200° F) used.<br>Transmission service light **OFF**. | Wiring or connections.<br>Transmission oil temperature sensor or internal wire harness.<br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br>Replace sensor or internal harness.(**See Disassembly and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Repair Manual).**<br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 3412 - Factory Calibration Compatibility Number Wrong.<br><br>DNS, DNA and SOL OFF (hydraulic default) condition exists.<br><br>Transmission Service light **ON**. | TCU (A5) re-quires re-calibration.<br><br>TCU (A5). | Download the factory calibration data to the TCU.<br><br>**NOTE: Copying the current calibration data from the TCU and then reloading it will not correct the malfunction. The calibration data must be downloaded directly from the software installation program.**<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 3413 - Factory Calibration Block Check Sum.<br><br>DNS, DNA and SOL OFF (hydraulic default) condition exists.<br><br>Transmission Service light **ON**. | TCU (A5) re-quires re-calibration.<br><br>TCU (A5). | Download the factory calibration data to the TCU.<br><br>**NOTE: Copying the current calibration data from the TCU and then reloading it will not correct the malfunction. The calibration data must be downloaded directly from the software installation program. Make sure calibration and software versions are compatible.**<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 3414 - Power Off Block Check Sum.<br><br>DNS condition exists.<br><br>Transmission Service light **OFF**. | No power to TCU. Power interrupt service code 3500 occurs.<br><br>TCU (A5). | Check fuses and wire harness.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 3415 - Diagnostic Queue Block Check Sum.<br><br>DNS condition exists.<br><br>Transmission Service light **OFF**. | TCU diagnostic queue.<br><br>TCU (A5). | Clear diagnostic queue.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 3416 - Real Time Block Check Sum.<br><br>DNS, DNA and SOL OFF (hydraulic default) condition exists.<br><br>Transmission Service light **ON**. | Re-calibrate TCU.<br><br>TCU (A5). | Download the factory calibration data to the TCU.<br><br>**NOTE: Copying the current calibration data from the TCU and then reloading it will not correct the malfunction. The calibration data must be downloaded directly from the software installation program. Make sure calibration and software versions are compatible.**<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 3417 - Customer Modifiable Constants Check Sum.<br><br>DNS, DNA and SOL OFF (hydraulic default) condition exists.<br><br>Transmission Service light **ON**. | Re-calibrate TCU.<br><br>TCU (A5). | Download the factory calibration data to the TCU.<br><br>Reprogram the GPI/GPO package after re-calibrating the TCU.<br><br>**NOTE: Copying the current calibration data from the TCU and then reloading it will not correct the malfunction. The calibration data must be downloaded directly from the software installation program. Make sure calibration and software versions are compatible.**<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 3500 - Power Interruption (Code Set After Power Restored).<br><br>SOL OFF (Hydraulic default) condition exists during interruption.<br><br>Transmission Service light **OFF**. | Battery disconnect switch turned to the **OFF** position before turning the key switch **OFF.**<br><br>Wiring or connections.<br><br>TCU (A5). | Always turn key switch **OFF** first before turning battery disconnect switch **OFF**.<br><br>Check cab main harness (W10) and transmission harness (W12).<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 3516 - Real Time Write Interruption.<br><br>DNS, DNA and SOL OFF (hydraulic default) conditions exists.<br><br>Transmission service light **ON**. | Battery disconnect switch turned to OFF position before TCU shutdown is complete.<br><br>Wiring or connections.<br><br>TCU (A5). | Allow a few seconds for TCU shutdown to complete before turning battery disconnect switch to OFF position.<br><br>Check cab main harness (W10) and transmission control harness (W12).<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 3600 - Hardware/ Software Not Compatible.<br><br>DNS, DNA and SOL OFF (hydraulic default) conditions exists.<br><br>Transmission service light **ON**. | Mismatch between TCU hardware and TCU software. | Install correct software for hardware used.<br><br>**NOTE: Re-calibration of TCU may be necessary. Make sure calibration and software versions are comPatible.** |
| 4212 - Short to Battery (A Solenoid Circuit).<br><br>DNS, DNA and SOL OFF (hydraulic default) conditions exists.<br><br>Transmission service light **ON**.<br><br>Neutral Start Is Disabled.<br><br>A malfunction TCU is usually indicated if multiple service codes (e.g., 4212, 4213, 4214, etc.) occur when wiring and solenoids are okay. | Wiring or connections.<br><br>Transmission internal wiring or malfunctioning solenoid.<br><br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br><br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 4213 - Short to Battery (B Solenoid Circuit).<br><br>DNS, DNA and SOL OFF (hydraulic default) conditions exists.<br><br>Transmission service light **ON**.<br><br>Neutral Start Is Disabled.<br><br>A malfunction TCU is usually indicated if multiple service codes (e.g., 4212, 4213, 4214, etc.) occur when wiring and solenoids are okay. | Wiring or connections.<br><br>Transmission internal wiring or malfunctioning solenoid.<br><br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br><br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 4214 - Short To Battery (C Solenoid Circuit).<br><br>DNS, DNA and SOL OFF (hydraulic default) conditions exists.<br><br>Transmission service light **ON**.<br><br>Neutral Start Is Disabled.<br><br>A malfunction TCU is usually indicated if multiple service codes (e.g., 4212, 4213, 4214, etc.) occur when wiring and solenoids are okay. | Wiring or connections.<br><br>Transmission internal wiring or malfunctioning solenoid.<br><br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br><br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 4215 - Short To Battery (D Solenoid Circuit).<br><br>DNS, DNA and SOL OFF (hydraulic default) conditions exists.<br><br>Transmission service light **ON**.<br><br>Neutral Start Is Disabled.<br><br>A malfunction TCU is usually indicated if multiple service codes (e.g., 4212, 4213, 4214, etc.) occur when wiring and solenoids are okay. | Wiring or connections.<br><br>Transmission internal wiring or malfunctioning solenoid.<br><br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br><br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 4216 - Short To Battery (E Solenoid Circuit).<br><br>DNS, DNA and SOL OFF (hydraulic default) conditions exists.<br><br>Transmission service light **ON**.<br><br>Neutral Start Is Disabled.<br><br>A malfunction TCU is usually indicated if multiple service codes (e.g., 4212, 4213, 4214, etc.) occur when wiring and solenoids are okay. | Wiring or connections.<br><br>Transmission internal wiring or malfunctioning solenoid.<br><br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br><br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 4221 - Short To Battery (F Solenoid Circuit).<br><br>DNA and Lockup inhibited conditions exists.<br><br>Transmission service light **OFF**.<br><br>A malfunction TCU is usually indicated if multiple service codes (e.g., 4212, 4213, 4214, etc.) occur when wiring and solenoids are okay. | Wiring or connections.<br><br>Transmission internal wiring or malfunctioning solenoid.<br><br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br><br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 4222 - Short To Battery (G Solenoid Circuit).<br><br>DNS, DNA and SOL OFF (hydraulic default) conditions exists.<br><br>Transmission service light **ON**.<br><br>Neutral Start Is Disabled.<br><br>A malfunction TCU is usually indicated if multiple service codes (e.g., 4212, 4213, 4214, etc.) occur when wiring and solenoids are okay. | Wiring or connections.<br><br>Transmission internal wiring or malfunctioning solenoid.<br><br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br><br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 4223 - Short To Battery (H Solenoid Circuit).<br><br>Retarder inhibited.<br><br>Transmission service light **OFF**.<br><br>A malfunction TCU is usually indicated if multiple service codes (e.g., 4212, 4213, 4214, etc.) occur when wiring and solenoids are okay. | Wiring or connections.<br><br>Transmission internal wiring or malfunctioning solenoid.<br><br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br><br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 4412 - Short To Ground (A Solenoid Circuit).<br><br>DNS, DNA and SOL OFF (hydraulic default) conditions exists.<br><br>Transmission service light **ON**.<br><br>Neutral Start Is Disabled.<br><br>A malfunction TCU is usually indicated if multiple service codes (e.g., 4412, 4413, 4414, etc.) occur when wiring and solenoids are okay. | Wiring or connections.<br><br>Transmission internal wiring or malfunctioning solenoid.<br><br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br><br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 4413 - Short To Ground (B Solenoid Circuit).<br><br>DNS, DNA and SOL OFF (hydraulic default) conditions exists.<br><br>Transmission service light **ON**.<br><br>Neutral Start Is Disabled.<br><br>A malfunction TCU is usually indicated if multiple service codes (e.g., 4412, 4413, 4414, etc.) occur when wiring and solenoids are okay. | Wiring or connections.<br><br>Transmission internal wiring or malfunctioning solenoid.<br><br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br><br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 4414 - Short To Ground (C Solenoid Circuit).<br>DNS, DNA and SOL OFF (hydraulic default) conditions exists.<br>Transmission service light **ON**.<br>Neutral Start Is Disabled.<br>A malfunction TCU is usually indicated if multiple service codes (e.g., 4412, 4413, 4414, etc.) occur when wiring and solenoids are okay. | Wiring or connections.<br>Transmission internal wiring or malfunctioning solenoid.<br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 4415 - Short To Ground (D Solenoid Circuit).<br>DNS, DNA and SOL OFF (hydraulic default) conditions exists.<br>Transmission service light **ON**.<br>Neutral Start Is Disabled.<br>A malfunction TCU is usually indicated if multiple service codes (e.g., 4412, 4413, 4414, etc.) occur when wiring and solenoids are okay. | Wiring or connections.<br>Transmission internal wiring or malfunctioning solenoid.<br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 4416 - Short To Ground (E Solenoid Circuit).<br>DNS, DNA and SOL OFF (hydraulic default) conditions exists.<br>Transmission service light **ON**.<br>Neutral Start Is Disabled. | Wiring or connections.<br>Transmission internal wiring or malfunctioning solenoid.<br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 4421 - Short To Ground (F Solenoid Circuit).<br>DNA and lockup inhibited conditions exists.<br>Transmission service light **OFF**. | Wiring or connections.<br>Transmission internal wiring or malfunctioning solenoid.<br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 4422 - Short To Ground (G Solenoid Circuit).<br>DNS, DNA and SOL OFF (hydraulic default) conditions exists.<br>Transmission service light **ON**.<br>Neutral Start Is Disabled. | Wiring or connections.<br>Transmission internal wiring or malfunctioning solenoid.<br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 4423 - Short To Ground (H Solenoid Circuit).<br>Retarder operation inhibited.<br>Transmission service light **OFF**. | Wiring or connections.<br>Transmission internal wiring or malfunctioning solenoid.<br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 4512 - Open Circuit (A Solenoid Circuit).<br><br>DNS, DNA and SOL OFF (hydraulic default) conditions exists.<br><br>Transmission service light **ON**.<br><br>A malfunction TCU is usually indicated if multiple service codes (e.g., 4512, 4513, 4514, etc.) occur when wiring and solenoids are okay. | Wiring or connections.<br><br>Transmission internal wiring or malfunctioning solenoid.<br><br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br><br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 4513 - Open Circuit (B Solenoid Circuit).<br><br>DNS, DNA and SOL OFF (hydraulic default) conditions exists.<br><br>Transmission service light **ON**.<br><br>A malfunction TCU is usually indicated if multiple service codes (e.g., 4512, 4513, 4514, etc.) occur when wiring and solenoids are okay. | Wiring or connections.<br><br>Transmission internal wiring or malfunctioning solenoid.<br><br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br><br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 4514 - Open Circuit (C Solenoid Circuit).<br><br>DNS, DNA and SOL OFF (hydraulic default) conditions exists.<br><br>Transmission service light **ON**.<br><br>A malfunction TCU is usually indicated if multiple service codes (e.g., 4512, 4513, 4514, etc.) occur when wiring and solenoids are okay. | Wiring or connections.<br><br>Transmission internal wiring or malfunctioning solenoid.<br><br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br><br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 4515 - Open Circuit (D Solenoid Circuit).<br><br>DNS, DNA and SOL OFF (hydraulic default) conditions exists.<br><br>Transmission service light **ON**.<br><br>A malfunction TCU is usually indicated if multiple service codes (e.g., 4512, 4513, 4514, etc.) occur when wiring and solenoids are okay. | Wiring or connections.<br><br>Transmission internal wiring or malfunctioning solenoid.<br><br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br><br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 4516 - Open Circuit (E Solenoid Circuit).<br><br>DNS, DNA and SOL OFF (hydraulic default) conditions exists.<br><br>Transmission service light **ON**.<br><br>A malfunction TCU is usually indicated if multiple service codes (e.g., 4512, 4513, 4514, etc.) occur when wiring and solenoids are okay. | Wiring or connections.<br><br>Transmission internal wiring or malfunctioning solenoid.<br><br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br><br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 4521 - Open Circuit (F Solenoid Circuit).<br><br>DNA and lockup inhibited conditions exists.<br><br>Transmission service light **OFF**.<br><br>A malfunction TCU is usually indicated if multiple service codes (e.g., 4512, 4513, 4514, etc.) occur when wiring and solenoids are okay. | Wiring or connections.<br><br>Transmission internal wiring or malfunctioning solenoid.<br><br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br><br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 4522 - Open Circuit (G Solenoid Circuit).<br><br>DNS, DNA and SOL OFF (hydraulic default) conditions exists.<br><br>Transmission service light **ON**.<br><br>A malfunction TCU is usually indicated if multiple service codes (e.g., 4512, 4513, 4514, etc.) occur when wiring and solenoids are okay. | Wiring or connections.<br><br>Transmission internal wiring or malfunctioning solenoid.<br><br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br><br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 4523 - Open Circuit (H Solenoid Circuit).<br><br>Retarder inhibited.<br><br>Transmission service light **OFF**.<br><br>A malfunction TCU is usually indicated if multiple service codes (e.g., 4512, 4513, 4514, etc.) occur when wiring and solenoids are okay. | Wiring or connections.<br><br>Transmission internal wiring or malfunctioning solenoid.<br><br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br><br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 4621 - Over Current (F Solenoid High Circuit).<br><br>DNA and Lockup inhibited conditions exists.<br><br>Transmission service light **OFF**. | Wiring or connections.<br><br>Transmission internal wiring or malfunctioning solenoid.<br><br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br><br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 4626 - Over Current (H Solenoid High Circuit).<br><br>DNA, low and 1st or retarder inhibited conditions exists.<br><br>Transmission service light **OFF**. | Wiring or connections.<br><br>Transmission internal wiring or malfunctioning solenoid.<br><br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br><br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 4627 - Over Current (A Solenoid High Circuit).<br><br>DNS,DNA and SOL OFF (hydraulic fault) conditions exists.<br><br>Transmission service light **ON**. | Wiring or connections.<br><br>Transmission internal wiring or malfunctioning solenoid.<br><br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br><br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 5112 - Ofgoing Ratio Test During 1 to 2 Upshift.<br><br>DNS, DNA and RPR conditions exists.<br><br>Transmission service light **ON**. | Incorrect transmission oil level.<br><br>Wiring or connections.<br><br>Turbine speed sensor (B12).<br><br>Output speed sensor (B13).<br><br>Transmission internal wiring or malfunctioning solenoid.<br><br>TCU (A5). | Add or drain oil to obtain correct level.<br><br>Check transmission control harness (W12) and transmission harness (W13).<br><br>Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br><br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5121 - Ofgoing Ratio Test During 2 to 1 Downshift.<br>DNS, DNA and RPR conditions exists.<br>Transmission service light **ON**. | Incorrect transmission oil level. | Add or drain oil to obtain correct level. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Transmission internal wiring or malfunctioning solenoid. | Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**. |
| | | Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 5123 - Ofgoing Ratio Test During 2 to 3 Upshift.<br>DNS, DNA and RPR conditions exists.<br>Transmission service light **ON**. | Incorrect transmission oil level. | Add or drain oil to obtain correct level. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Transmission internal wiring or malfunctioning solenoid. | Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**. |
| | | Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5124 - Ofgoing Ratio Test During 2 to 4 Upshift.<br>DNS, DNA and RPR conditions exists.<br>Transmission service light **ON**. | Incorrect transmission oil level. | Add or drain oil to obtain correct level. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Transmission internal wiring or malfunctioning solenoid. | Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**. |
| | | Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 5135 - Ofgoing Ratio Test During 3 to 5 Upshift.<br>DNS, DNA and RPR conditions exists.<br>Transmission service light **ON**. | Incorrect transmission oil level. | Add or drain oil to obtain correct level. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Transmission internal wiring or malfunctioning solenoid. | Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**. |
| | | Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5142 - Ofgoing Ratio Test During 4 to 2 Downshift.<br>DNS, DNA and RPR conditions exists.<br>Transmission service light **ON**. | Incorrect transmission oil level. | Add or drain oil to obtain correct level. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Transmission internal wiring or malfunctioning solenoid. | Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**. |
| | | Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 5143 - Ofgoing Ratio Test During 4 to 3 Downshift.<br>DNS, DNA and RPR conditions exists.<br>Transmission service light **ON**.<br>This code is logged to real time to protect the transmission in case a loss of power to the TCU (power interruption code 3500) occurs. | Incorrect transmission oil level. | Add or drain oil to obtain correct level. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Transmission internal wiring or malfunctioning solenoid. | Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**. |
| | | Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5145 - Ofgoing Ratio Test During 4 to 5 Upshift.<br>DNS, DNA and RPR conditions exists.<br>Transmission service light **ON**.<br>This code is logged to real time to protect the transmission in case a loss of power to the TCU (power interruption code 3500) occurs. | Incorrect transmission oil level. | Add or drain oil to obtain correct level. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Transmission internal wiring or malfunctioning solenoid. | Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**. |
| | | Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 5146 - Ofgoing Ratio Test During 4 to 6 Upshift.<br>DNS, DNA and RPR conditions exists.<br>Transmission service light **ON**. | Incorrect transmission oil level. | Add or drain oil to obtain correct level. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Transmission internal wiring or malfunctioning solenoid. | Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**. |
| | | Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5153 - Ofgoing Ratio Test During 5 to 3 Downshift.<br>DNS, DNA and RPR conditions exists.<br>Transmission service light **ON**. | Incorrect transmission oil level. | Add or drain oil to obtain correct level. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Transmission internal wiring or malfunctioning solenoid. | Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**. |
| | | Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 5164 - Ofgoing Ratio Test During 6 to 4 Downshift.<br>DNS, DNA and RPR conditions exists.<br>Transmission service light **ON**. | Incorrect transmission oil level. | Add or drain oil to obtain correct level. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Transmission internal wiring or malfunctioning solenoid. | Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**. |
| | | Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5165 - Ofgoing Ratio Test During 6 to 5 Downshift.<br>DNS, DNA and RPR conditions exists.<br>Transmission service light **ON**. | Incorrect transmission oil level. | Add or drain oil to obtain correct level. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Transmission internal wiring or malfunctioning solenoid. | Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**. |
| | | Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 51XY - Ofgoing Ratio Test During **X** to **Y** Shift.<br>Additional codes could be logged for other shifts where **X** indicates range shifted from and **Y** indicates range shifted to. | Incorrect transmission oil level. | Add or drain oil to obtain correct level. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Transmission internal wiring or malfunctioning solenoid. | Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**. |
| | | Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5232 - Ofgoing C3PS Test During 3 to 2 Downshift.<br>DNS, DNA and RPR conditions exists.<br>Transmission service light **ON**. | Incorrect transmission oil level. | Add or drain oil to obtain correct level. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Transmission internal wiring or malfunctioning solenoid. | Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**. |
| | | Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 5234 - Ofgoing C3PS Test During 3 to 4 Upshift.<br>DNS, DNA and RPR conditions exists.<br>Transmission service light **ON**. | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | Transmission internal wiring or malfunctioning C3 pressure switch. | Replace transmission harness or C3 pressure switch. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5254 - Ofgoing C3PS Test During 5 to 4 Upshift.<br>DNS, DNA and RPR conditions exists.<br>Transmission service light **ON**. | Wiring or connections.<br>Transmission internal wiring or malfunctioning C3 pressure switch.<br>Damaged valve body gaskets or stuck (or sticky) valves.<br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br>Check the solenoid. **(See "Transmission Solenoids Test" on page 199)**.<br>Replace transmission harness or C3 pressure switch. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Replace gaskets. Clean or replace valves as necessary. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 5256 - Ofgoing C3PS Test During 5 to 6 Upshift.<br>DNS, DNA and RPR conditions exists.<br>Transmission service light **ON**. | Wiring or connections.<br>Transmission internal wiring or malfunctioning C3 pressure switch.<br>Damaged valve body gaskets or stuck (or sticky) valves.<br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br>Replace transmission harness or C3 pressure switch. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 5271 - Ofgoing C3PS Test During R to 1 Shift.<br>DNS, DNA and NNC conditions exists.<br>Transmission service light **ON**. | Wiring or connections.<br>Transmission internal wiring or malfunctioning C3 pressure switch.<br>Damaged valve body gaskets or stuck (or sticky) valves.<br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br>Replace transmission harness or C3 pressure switch. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5272 - Ofgoing C3PS Test During R to 2 Shift.<br>DNS, DNA and NNC conditions exists.<br>Transmission service light **ON**. | Wiring or connections.<br>Transmission internal wiring or malfunctioning C3 pressure switch.<br>Damaged valve body gaskets or stuck (or sticky) valves.<br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br>Replace transmission harness or C3 pressure switch. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Replace TCU. **(See “Remove and Install Transmission Control Unit” on page 202)**. |
| 5278 - Ofgoing C3PS Test During R to N1 Shift.<br>DNS, DNA and NNC conditions exists.<br>Transmission service light **ON**. | Wiring or connections.<br>Transmission internal wiring or malfunctioning C3 pressure switch.<br>Damaged valve body gaskets or stuck (or sticky) valves.<br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br>Replace transmission harness or C3 pressure switch. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Replace TCU. **(See “Remove and Install Transmission Control Unit” on page 202)**. |
| 5299 - Ofgoing C3PS Test During N3 to N2 Shift.<br>DNS, DNA and RPR conditions exists.<br>Transmission service light **ON**. | Wiring or connections.<br>Transmission internal wiring or malfunctioning C3 pressure switch.<br>Damaged valve body gaskets or stuck (or sticky) valves.<br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br>Replace transmission harness or C3 pressure switch. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Replace TCU. **(See “Remove and Install Transmission Control Unit” on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 52XY - Ofgoing C3PS Test During X to Y Shift.<br><br>Additional codes could be logged for other shifts where X indicates range shifted from and Y indicates range shifted to. | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | Transmission internal wiring or malfunctioning C3 pressure switch. | Replace transmission harness or C3 pressure switch. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 5318 - Ofgoing C3PS Test During N3 to N2 Shift.<br><br>DNS, DNA and NNC conditions exists.<br><br>Transmission service light **ON**.<br><br>This code is logged to real time to protect the transmission in case a loss of power to the TCU (power interruption code 3500) occurs. | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Input speed sensor (B14). | Check resistance of speed sensor. (See "Transmission Speed Sensors Test" on page 199). |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5328 - Ofgoing C3PS Test During N3 to N2 Shift.<br><br>DNS, DNA and NNC conditions exists.<br><br>Transmission service light **ON**.<br><br>The ofgoing speed test is not performed if neutral output is less than 200r.p.m. or when temperature is below a calibrated 0° C (32° F).<br><br>This code is logged to real time to protect the transmission in case a loss of power to the TCU (power interruption code 3500) occurs. | Turbine speed sensor (B12).<br><br>Input speed sensor (B14).<br><br>Wiring or connections.<br><br>Damaged valve body gaskets or stuck (or sticky) valves.<br><br>TCU (A5). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 5329 - Ofgoing C3PS Test During N3 to N2 Shift.<br><br>DNS, DNA and RPR conditions exists.<br><br>Transmission service light **ON**.<br><br>The ofgoing speed test is not performed if neutral output is less than 200r.p.m. or when temperature is below a calibrated 0° C (32° F).<br><br>This code is logged to real time to protect the transmission in case a loss of power to the TCU (power interruption code 3500) occurs. | Turbine speed sensor (B12).<br><br>Input speed sensor (B14).<br><br>Wiring or connections.<br><br>Damaged valve body gaskets or stuck (or sticky) valves.<br><br>TCU (A5). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5338 - Ofgoing C3PS Test During 3 to N1 Shift.<br><br>DNS, DNA and NNC conditions exists.<br><br>Transmission service light **ON**.<br><br>The ofgoing speed test is not performed if neutral output is less than 200r.p.m. or when temperature is below a calibrated 0° C (32° F).<br><br>This code is logged to real time to protect the transmission in case a loss of power to the TCU (power interruption code 3500) occurs. | Turbine speed sensor (B12).<br><br>Input speed sensor (B14).<br><br>Wiring or connections.<br><br>Damaged valve body gaskets or stuck (or sticky) valves.<br><br>TCU (A5). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 5339 - Ofgoing C3PS Test During 3 to N3 Shift.<br><br>DNS, DNA and RPR conditions exists.<br><br>Transmission service light **ON**.<br><br>The ofgoing speed test is not performed if neutral output is less than 200r.p.m. or when temperature is below a calibrated 0° C (32° F).<br><br>This code is logged to real time to protect the transmission in case a loss of power to the TCU (power interruption code 3500) occurs. | Turbine speed sensor (B12).<br><br>Input speed sensor (B14).<br><br>Wiring or connections.<br><br>Damaged valve body gaskets or stuck (or sticky) valves.<br><br>TCU (A5). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5348 - Ofgoing C3PS Test During 4 to N1 Shift.<br><br>DNS, DNA and NNC conditions exists.<br><br>Transmission service light **ON**.<br><br>The ofgoing speed test is not performed if neutral output is less than 200r.p.m. or when temperature is below a calibrated 0° C (32° F).<br><br>This code is logged to real time to protect the transmission in case a loss of power to the TCU (power interruption code 3500) occurs. | Turbine speed sensor (B12).<br><br>Input speed sensor (B14).<br><br>Wiring or connections.<br><br>Damaged valve body gaskets or stuck (or sticky) valves.<br><br>TCU (A5). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 5348 - Ofgoing C3PS Test During 4 to N3 Shift.<br><br>DNS, DNA and RPR conditions exists.<br><br>Transmission service light **ON**.<br><br>The ofgoing speed test is not performed if neutral output is less than 200r.p.m. or when temperature is below a calibrated 0° C (32° F).<br><br>This code is logged to real time to protect the transmission in case a loss of power to the TCU (power interruption code 3500) occurs. | Turbine speed sensor (B12).<br><br>Input speed sensor (B14).<br><br>Wiring or connections.<br><br>Damaged valve body gaskets or stuck (or sticky) valves.<br><br>TCU (A5). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5358 - Ofgoing C3PS Test During 5 to N1 Shift.<br><br>DNS, DNA and NNC conditions exists.<br><br>Transmission service light **ON**.<br><br>The ofgoing speed test is not performed if neutral output is less than 200r.p.m. or when temperature is below a calibrated 0° C (32° F).<br><br>This code is logged to real time to protect the transmission in case a loss of power to the TCU (power interruption code 3500) occurs. | Turbine speed sensor (B12).<br><br>Input speed sensor (B14).<br><br>Wiring or connections.<br><br>Damaged valve body gaskets or stuck (or sticky) valves.<br><br>TCU (A5). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 5359 - Ofgoing C3PS Test During 5 to N3 Shift.<br><br>DNS, DNA and RPR conditions exists.<br><br>Transmission service light **ON**.<br><br>The ofgoing speed test is not performed if neutral output is less than 200r.p.m. or when temperature is below a calibrated 0° C (32° F).<br><br>This code is logged to real time to protect the transmission in case a loss of power to the TCU (power interruption code 3500) occurs. | Turbine speed sensor (B12).<br><br>Input speed sensor (B14).<br><br>Wiring or connections.<br><br>Damaged valve body gaskets or stuck (or sticky) valves.<br><br>TCU (A5). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5368 - Ofgoing C3PS Test During 6 to N1 Shift.<br><br>DNS, DNA and NNC conditions exists.<br><br>Transmission service light **ON**.<br><br>The ofgoing speed test is not performed if neutral output is less than 200r.p.m. or when temperature is below a calibrated 0° C (32° F).<br><br>This code is logged to real time to protect the transmission in case a loss of power to the TCU (power interruption code 3500) occurs. | Turbine speed sensor (B12).<br><br>Input speed sensor (B14).<br><br>Wiring or connections.<br><br>Damaged valve body gaskets or stuck (or sticky) valves.<br><br>TCU (A5). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 5369 - Ofgoing C3PS Test During 4 to N1 Shift.<br><br>DNS, DNA and RPR conditions exists.<br><br>Transmission service light **ON**.<br><br>The ofgoing speed test is not performed if neutral output is less than 200r.p.m. or when temperature is below a calibrated 0° C (32° F).<br><br>This code is logged to real time to protect the transmission in case a loss of power to the TCU (power interruption code 3500) occurs. | Turbine speed sensor (B12).<br><br>Input speed sensor (B14).<br><br>Wiring or connections.<br><br>Damaged valve body gaskets or stuck (or sticky) valves.<br><br>TCU (A5). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5378 - Ofgoing C3PS Test During 4 to N1 Shift.<br><br>DNS, DNA and NNC conditions exists.<br><br>Transmission service light **ON**.<br><br>The ofgoing speed test is not performed if neutral output is less than 200r.p.m. or when temperature is below a calibrated 0° C (32° F). | Turbine speed sensor (B12).<br><br>Input speed sensor (B14).<br><br>Wiring or connections.<br><br>Damaged valve body gaskets or stuck (or sticky) valves.<br><br>TCU (A5). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 5399 - Ofgoing C3PS Test During 4 to N1 Shift.<br><br>DNS, DNA and RPR conditions exists.<br><br>Transmission service light **ON**.<br><br>The ofgoing speed test is not performed if neutral output is less than 200r.p.m. or when temperature is below a calibrated 0° C (32° F). | Turbine speed sensor (B12).<br><br>Input speed sensor (B14).<br><br>Wiring or connections.<br><br>Damaged valve body gaskets or stuck (or sticky) valves.<br><br>TCU (A5). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**.<br><br>Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 53XY - Ofgoing Speed Test During X to Y Shift. | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| Additional codes could be logged for other shifts where X indicates range shifted from and Y indicates range shifted to. | Input speed sensor (B14). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| The ofgoing speed test is not performed if neutral output is less than 200r.p.m. or when temperature is below a calibrated 0° C (32° F). | | Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 5412 - Oncoming Ratio Test After 1 to 2 Upshift. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| DNS, DNA and RPR conditions exists. | TCU calibrated for wrong transmission. | Calibrate TCU so it's compatible to transmission. |
| Transmission service light **ON**. | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | | Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5417 - Oncoming Ratio Test After 1 to R Upshift.<br><br>DNS, DNA and NNC conditions exists.<br><br>Transmission service light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5421 - Oncoming Ratio Test After 2 to 1 Downshift.<br><br>DNS, DNA and RPR conditions exists.<br><br>Transmission service light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5423 - Oncoming Ratio Test After 2 to 3 Upshift.<br><br>DNS, DNA and RPR conditions exists.<br><br>Transmission service light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5424 - Oncoming Ratio Test After 2 to 4 Upshift.<br><br>DNS, DNA and RPR conditions exists.<br><br>Transmission service light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5427 - Oncoming Ratio Test After 2 to R Shift.<br><br>DNS, DNA and RPR conditions exists.<br><br>Transmission service light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5412 - Oncoming Ratio Test After 3 to 2 Downshift.<br><br>DNS, DNA and RPR conditions exists.<br><br>Transmission service light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5434 - Oncoming Ratio Test After 3 to 4 Upshift. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| DNS, DNA and RPR conditions exists. | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| Transmission service light **ON**. | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | | Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5435 - Oncoming Ratio Test After 3 to 5 Upshift. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| DNS, DNA and RPR conditions exists. | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| Transmission service light **ON**. | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | | Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5442 - Oncoming Ratio Test After 4 to 2 Downshift.<br><br>DNS, DNA and RPR conditions exists.<br><br>Transmission service light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5443 - Oncoming Ratio Test After 4 to 3 Downshift.<br>DNS, DNA and RPR conditions exists.<br>Transmission service light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5445 - Oncoming Ratio Test After 4 to 5 Upshift.<br><br>DNS, DNA and RPR {or SOL OFF (hydraulic default)} conditions exists.<br><br>Transmission service light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5446 - Oncoming Ratio Test After 4 to 6 Upshift.<br><br>DNS, DNA and RPR conditions exists.<br><br>Transmission service light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5453 - Oncoming Ratio Test After 5 to 3 Downshift.<br><br>DNS, DNA and RPR conditions exists.<br><br>Transmission service light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5454 - Oncoming Ratio Test After 5 to 4 Downshift.<br>DNS, DNA and RPR conditions exists.<br>Transmission service light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5456 - Oncoming Ratio Test After 5 to 6 Upshift.<br><br>DNS, DNA and RPR conditions exists.<br><br>Transmission service light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5464 - Oncoming Ratio Test After 6 to 4 Downshift.<br>DNS, DNA and RPR conditions exists.<br>Transmission service light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5465 - Oncoming Ratio Test After 6 to 5 Downshift.<br><br>DNS, DNA and RPR conditions exists.<br><br>Transmission service light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5471 - Oncoming Ratio Test After R to 1 Shift.<br><br>DNS, DNA and NNC conditions exists.<br><br>Transmission service light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5471 - Oncoming Ratio Test After R to 2 Shift.<br><br>DNS, DNA and NNC conditions exists.<br><br>Transmission service light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5481 - Oncoming Ratio Test After N1 to 1 Shift.<br><br>DNS, DNA and RPR conditions exists.<br><br>Transmission service light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5482 - Oncoming Ratio Test After N1 to 2 Shift. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| DNS, DNA and RPR conditions exists. | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| Transmission service light **ON**. | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | | Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5483 - Oncoming Ratio Test After N1 to 3 Shift.<br><br>DNS, DNA and RPR conditions exists.<br><br>Transmission service light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5485 - Oncoming Ratio Test After N1 to 5 Shift. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| DNS, DNA and RPR conditions exists. | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| Transmission service light **ON**. | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | | Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5486 - Oncoming Ratio Test After N1 to 6 Shift.<br><br>DNS, DNA and RPR conditions exists.<br><br>Transmission service light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5492 - Oncoming Ratio Test After N2 to 2 Shift.<br><br>DNS, DNA and RPR conditions exists.<br><br>Transmission service light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5493 - Oncoming Ratio Test After N3 to 3 Shift.<br><br>DNS, DNA and RPR conditions exists.<br><br>Transmission service light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5495 - Oncoming Ratio Test After N3 to 5 Shift. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| DNS, DNA and RPR conditions exists. | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| Transmission service light **ON**. | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | | Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5496 - Oncoming Ratio Test After N4 to 6 Shift.<br><br>DNS, DNA and RPR conditions exists.<br><br>Transmission service light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 54XY - Oncoming Ratio Test After X to Y Shift.<br><br>Additional codes could be logged for other shifts where X indicates range shifted from and Y indicates range shifted to. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check internal transmission harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5517 - Oncoming C3PS Test After 1 to R Shift.<br><br>DNS, DNA and NNC conditions exists.<br><br>Transmission service light **ON**.<br><br>This code is logged to real time to protect the transmission in case a loss of power to the TCU (power interruption code 3500) occurs. | Oil level too low or too high.<br><br>Worn oil pump.<br><br>Wiring or connections.<br><br>Transmission internal wiring harness or C3 pressure switch.<br><br>Damaged valve body gaskets or stuck (or sticky) valves.<br><br>Worn or damaged clutches.<br><br>TCU (A5). | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).**<br><br>Repair pump. **(See Disassemble and Assemble Front Support and Charging Oil Pump in CHAPTER 3, SECTION 3 in the Repair Manual)**.<br><br>Check transmission control harness (W12) and transmission harness (W13).<br><br>Repair or replace wiring harness or C3 pressure switch. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**.<br><br>Replace TCU. **(See “Remove and Install Transmission Control Unit” on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5527 - Oncoming C3PS Test After 2 to R Shift.<br><br>DNS, DNA and NNC conditions exists.<br><br>Transmission service light **ON**.<br><br>This code is logged to real time to protect the transmission in case a loss of power to the TCU (power interruption code 3500) occurs. | Oil level too low or too high.<br><br>Worn oil pump.<br><br>Wiring or connections.<br><br>Transmission internal wiring harness or C3 pressure switch.<br><br>Damaged valve body gaskets or stuck (or sticky) valves.<br><br>Worn or damaged clutches.<br><br>TCU (A5). | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).**<br><br>Repair pump. **(See Disassemble and Assemble Front Support and Charging Oil Pump in CHAPTER 3, SECTION 3 in the Repair Manual)**.<br><br>Check transmission control harness (W12) and transmission harness (W13).<br><br>Repair or replace wiring harness or C3 pressure switch. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br><br>Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**.<br><br>Replace TCU. **(See “Remove and Install Transmission Control Unit” on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5587 - Oncoming C3PS Test After N1 to R Shift.<br><br>DNS, DNA and RPR conditions exists.<br><br>Transmission service light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Worn oil pump. | Repair pump. **(See Disassemble and Assemble Front Support and Charging Oil Pump in CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | Transmission internal wiring harness or C3 pressure switch. | Repair or replace wiring harness or C3 pressure switch. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See “Remove and Install Transmission Control Unit” on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 55XY - Oncoming C3PS Test After X to Y Shift.<br><br>Additional codes could be logged for other shifts where X indicates range shifted from and Y indicates range shifted to. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Worn oil pump. | Repair pump. **(See Disassemble and Assemble Front Support and Charging Oil Pump in CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | Transmission internal wiring harness or C3 pressure switch. | Repair or replace wiring harness or C3 pressure switch. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See “Remove and Install Transmission Control Unit” on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5611 - Range Verification Test (Between Shift) (1st Range).<br>DNS, DNA, 6th range conditions exists.<br>Transmission light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Worn oil pump. | Repair pump. **(See Disassemble and Assemble Front Support and Charging Oil Pump in CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br>Check transmission internal wiring harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5622 - Range Verification Test (Between Shift) (2nd Range).<br><br>DNS, DNA, 5th or 6th range conditions exists.<br><br>Transmission light **ON**.<br><br>This code is logged to real time to protect the transmission in case a loss of power to the TCU (power interruption code 3500) occurs. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Worn oil pump. | Repair pump. **(See Disassemble and Assemble Front Support and Charging Oil Pump in CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check transmission internal wiring harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5633 - Range Verification Test (Between Shift) (3rd Range).<br><br>DNS, DNA, 5th range or SOL OFF (4th range) conditions exists.<br><br>Transmission light **ON**.<br><br>This code is logged to real time to protect the transmission in case a loss of power to the TCU (power interruption code 3500) occurs. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Worn oil pump. | Repair pump. **(See Disassemble and Assemble Front Support and Charging Oil Pump in CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check transmission internal wiring harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5644 - Range Verification Test (Between Shift) (4th Range).<br><br>DNS, DNA, 3rd or 5th range conditions exists. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Worn oil pump. | Repair pump. **(See Disassemble and Assemble Front Support and Charging Oil Pump in CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| Transmission light **ON**. | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check transmission internal wiring harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5655 - Range Verification Test (Between Shift) (5th Range).<br><br>DNS, DNA, 3rd range or SOL OFF (5th range) conditions exists.<br><br>Transmission light **ON**.<br><br>This code is logged to real time to protect the transmission in case a loss of power to the TCU (power interruption code 3500) occurs. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Worn oil pump. | Repair pump. **(See Disassemble and Assemble Front Support and Charging Oil Pump in CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check transmission internal wiring harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5666 - Range Verification Test (Between Shift) (6th Range).<br><br>DNS, DNA, 3rd, 5th range or SOL OFF (3rd range) conditions exists.<br><br>Transmission light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Worn oil pump. | Repair pump. **(See Disassemble and Assemble Front Support and Charging Oil Pump in CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check transmission internal wiring harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5677 - Range Verification Test (Between Shift) (Reverse).<br><br>DNS, DNA, N2 or N3 conditions exists.<br><br>Transmission light **ON**. | Oil level too low or too high. | Add or remove oil to obtain correct level. **(See CHAPTER 1 in the OMM for correct oil specifications).** |
| | Worn oil pump. | Repair pump. **(See Disassemble and Assemble Front Support and Charging Oil Pump in CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | Turbine speed sensor (B12). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Output speed sensor (B13). | Check resistance of speed sensor. **(See "Transmission Speed Sensors Test" on page 199)**. |
| | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13).<br><br>Check transmission internal wiring harness. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5711 - Range Verification C3PS Test (3rd Range).<br>DNS, DNA, SOL OFF (3rd range) conditions exists.<br>Transmission light **ON**. | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | Transmission internal wiring harness or C3 pressure switch. | Repair or replace wiring harness or C3 pressure switch. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See “Remove and Install Transmission Control Unit” on page 202)**. |
| 5722 - Range Verification C3PS Test (2nd Range).<br>DNS, DNA, 3rd range conditions exists.<br>Transmission light **ON**. | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | Transmission internal wiring harness or C3 pressure switch. | Repair or replace wiring harness or C3 pressure switch. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See “Remove and Install Transmission Control Unit” on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5744 - Range Verification C3PS Test (4th Range).<br>DNS, DNA, 5th range, or SOL OFF (3rd range) conditions exists.<br>Transmission light **ON**. | Wiring or connections.<br>Transmission internal wiring harness or C3 pressure switch.<br>Damaged valve body gaskets or stuck (or sticky) valves.<br>Worn or damaged clutches.<br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br>Repair or replace wiring harness or C3 pressure switch. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**.<br>Replace TCU. **(See “Remove and Install Transmission Control Unit” on page 202)**. |
| 5766 - Range Verification C3PS Test (6th Range).<br>DNS, DNA, SOL OFF (5th range) conditions exists.<br>Transmission light **ON**. | Wiring or connections.<br>Transmission internal wiring harness or C3 pressure switch.<br>Damaged valve body gaskets or stuck (or sticky) valves.<br>Worn or damaged clutches.<br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br>Repair or replace wiring harness or C3 pressure switch. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**.<br>Replace TCU. **(See “Remove and Install Transmission Control Unit” on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 5788 - Range Verification C3PS Test (N1).<br>DNS, DNA, N3 conditions exists.<br>Transmission light **ON**. | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | Transmission internal wiring harness or C3 pressure switch. | Repair or replace wiring harness or C3 pressure switch. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 5799 - Range Verification C3PS Test (N2 or N4).<br>DNS, DNA, N3 conditions exists.<br>Transmission light **ON**. | Wiring or connections. | Check transmission control harness (W12) and transmission harness (W13). |
| | Transmission internal wiring harness or C3 pressure switch. | Repair or replace wiring harness or C3 pressure switch. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Damaged valve body gaskets or stuck (or sticky) valves. | Replace gaskets. Clean or replace valves as necessary **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**. |
| | Worn or damaged clutches. | Repair or replace transmission. **(See Remove and Install Transmission CHAPTER 3, SECTION 1 and CHAPTER 3, SECTION 3 in the Repair Manual)**. |
| | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 6100 - Retarder Oil Temperature is Hot.<br>No conditions exists.<br>Transmission service light **OFF.** | Prolonged retarder use. | Allow transmission oil to cool down. |
| | Oil level too low or too high. | Add or drain oil to obtain correct level. **(See CHAPTER 1 in OMM for correct oil specifications).** |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 6212 - Retarder Oil Temperature Sensor Circuit Malfunction Low.<br>No conditions exists.<br>Transmission service light **OFF.** | Wiring or connections.<br>Retarder temperature sensor (B11).<br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br>Replace sensor.<br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 6223 - Retarder Oil Temperature Sensor Circuit Malfunction High.<br>No conditions exists.<br>Transmission service light **OFF.** | Wiring or connections.<br>Retarder temperature sensor (B11).<br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br>Replace sensor.<br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 6412 - Retarder Modulation Request Sensor Circuit Malfunction Low (14 Counts or Less).<br>Retarder operation inhibited.<br>Transmission service light **OFF.** | Retarder controller (A7).<br>Retarder voltage regulator (N1).<br>Wiring or connections.<br>TCU (A5). | Replace retarder controller.<br>Check voltage regulator. **(See "Retarder Voltage Regulator Test" on page 198)**.<br>Check transmission control harness (W12) and transmission harness (W13).<br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 6423 - Retarder Modulation Request Sensor Circuit Malfunction Low (14 Counts or Less).<br>Retarder operation inhibited.<br>Transmission service light **OFF.** | Retarder controller (A7).<br>Retarder voltage regulator (N1).<br>Wiring or connections.<br>TCU (A5). | Replace retarder controller.<br>Check voltage regulator. **(See "Retarder Voltage Regulator Test" on page 198)**.<br>Check transmission control harness (W12) and transmission harness (W13).<br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 6500 - Engine Speed Rating Too High.<br>DNS and locked-in-neutral conditions exists.<br>Transmission service light **ON**. | Engine governed speed specification does not match transmission. | Calibrate engine speed to transmission. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 6927 - TCU A-HI Switch Inoperative.<br>DNS, DNA, NNC conditions exists.<br>Transmission service light **ON**. | Wiring or connections.<br>Transmission internal wiring or malfunctioning solenoid.<br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 6928 - TCU A-HI Switch Inoperative.<br>DNA and lockup inhibited conditions exists.<br>Transmission service light **ON**. | Wiring or connections.<br>Transmission internal wiring or malfunctioning solenoid.<br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 6929 - TCU A-HI Switch Inoperative.<br>DNA, 1st and retarder inhibited conditions exists.<br>Transmission service light **ON**. | Wiring or connections.<br>Transmission internal wiring or malfunctioning solenoid.<br>TCU (A5). | Check transmission control harness (W12) and transmission harness (W13).<br>Replace transmission harness or solenoid. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Rapier Manual)**.<br>Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 6933 - TCU "Computer Operating Properly" Function Times Out.<br>Reset TCU, shutdown TCU on 2nd occurrence (power loss; hydraulic defaults).<br>DNA (COP reset will clear the active inhibit).<br>May cause cateye (-/-) display or all segments blank display.<br>Transmission service light **OFF.** | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

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| Code - Symptom | Problem | Solution |
|---|---|---|
| 6934 - TCU Write Function Times Out.<br><br>DNS, DNA, SOL OFF (hydraulic default) conditions exists.<br><br>Transmission service light **ON**. | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 6935 - TCU Checksum Test<br><br>Induce COP time out (reset TCU), DNA (COP reset will clear the active inhibit).<br><br>Transmission service light **OFF**. | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 6936 - TCU RAM Self-Test Malfunction.<br><br>Induce COP time out (reset TCU), DNA (COP reset will clear the active inhibit).<br><br>Transmission service light **OFF**. | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 6939 - Communication Chip Addressing Error.<br><br>Use defaults for J1939 data, DNA.<br><br>Transmission service light **OFF**. | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |
| 6941 - TCU I/O ASCIC Addressing Test.<br><br>Induce COP time out (reset TCU), DNA (COP reset will clear the active inhibit).<br><br>Transmission service light **OFF**. | TCU (A5). | Replace TCU. **(See "Remove and Install Transmission Control Unit" on page 202)**. |

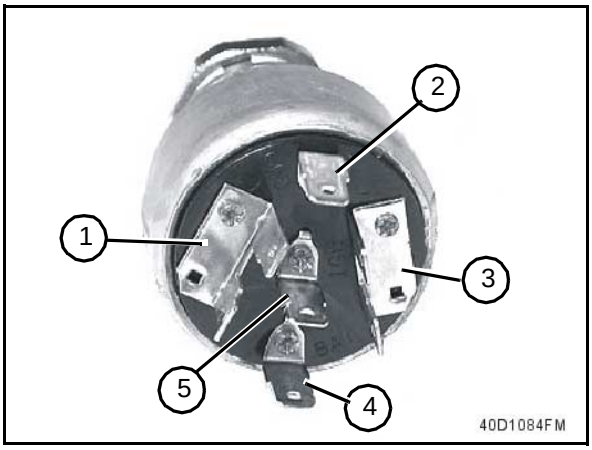
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| Code - Symptom | Problem | Solution |
|---|---|---|
| 6942 - Serial Peripheral Interface (SPI) Output Malfunction.<br><br>GPO 1-8 and reverse warning inoperable.<br><br>Transmission service light **ON**. | TCU (A5). | Replace TCU. **(See “Remove and Install Transmission Control Unit” on page 202)**. |
| 6943 - Serial Peripheral Interface (SPI) Input Malfunction.<br><br>DNS, DNA, locked-in-range conditions exists.<br><br>Transmission service light **ON**. | TCU (A5). | Replace TCU. **(See “Remove and Install Transmission Control Unit” on page 202)**. |

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## Key Switch Test

### Key Switch Terminals




1. ACC
2. GRD
3. GN
4. BAT (B)
5. ST

Remove key switch.

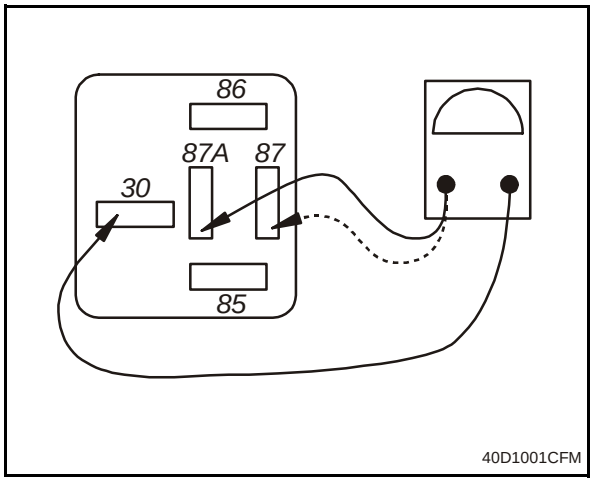
With key switch in the **OFF** position, check for continuity across all terminals (1—5). If continuity is indicated, replace switch.

| Position | B | ACC | IG | ST |
|---|---|---|---|---|
| ACC | ● | ● | | |
| OFF | | | | |
| ON | ● | ● | ● | |
| START | ● | | ● | ● |

Put key switch in each position (ACC, ON, START) and check for continuity across appropriate terminals (see legend). Replace key switch if continuity is not indicated between terminals as shown in legend.

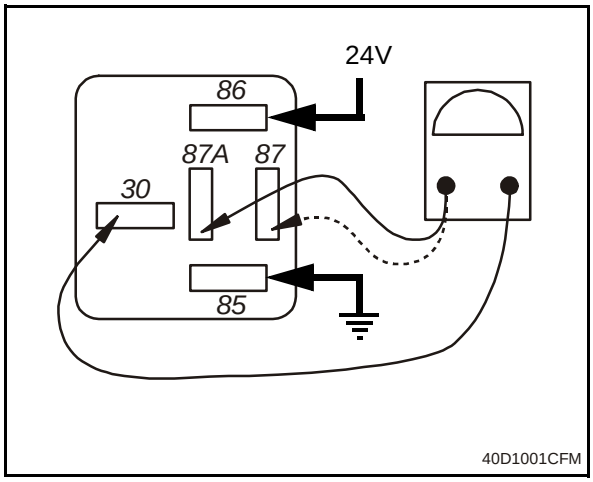
## Relay Test

Remove relay.




With relay de-energized, check for continuity across terminals 30, 87A and 87 as shown. Replace relay if checks indicated the following:

- • No continuity across terminals 30 and 87A.
- • Continuity exists across terminals 30 and 87.




Energize relay by grounding terminal 85 and applying 24 volts to terminal 86.

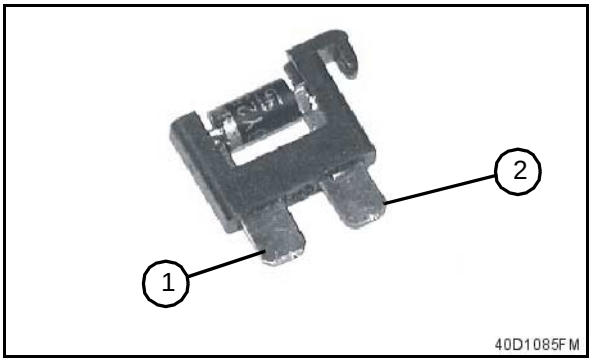
With relay energized, check for continuity across terminals 30, 87A and 87 as shown. Replace relay if checks indicated the following:

- • No continuity across terminals 30 and 87
- • Continuity exists across terminals 30 and 87A.

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## Diode Test

Remove diode.

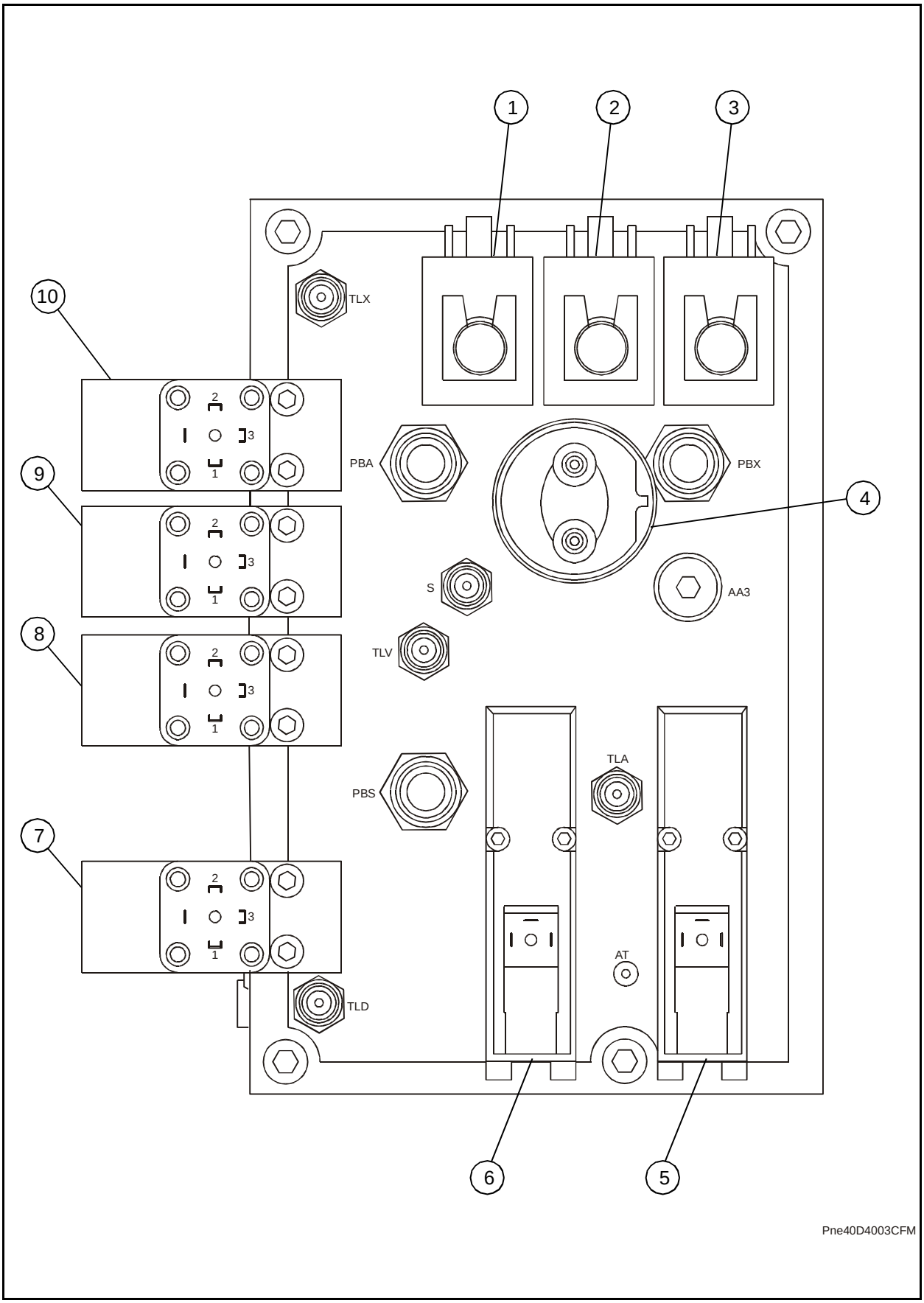



Check for continuity across terminals (1 and 2), then reverse test leads and repeat continuity check.

- If continuity is indicated in one check and not the other, diode is good.
- If continuity is indicated in both checks, diode is shorted, replace diode.
- If no continuity is indicated in either check, diode is open, replace diode.

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## Pneumatic System Solenoids, Pressure Switches, and Sensor Tests



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1. Differential Lock Solenoid.
2. Inter-Axle Lock Solenoid.
3. Horn Solenoid.
4. System Air Pressure Sensor.
5. Exhaust Brake Solenoid.
6. Park Brake Solenoid.
7. Park Brake Pressure Switch.
8. Bin Up Pressure Switch.
9. Inter-Axle Lock Pressure Switch.
10. Differential Lock Pressure Switch.

## Specifications

### Pneumatic Pressure Switches

Bin Up Pressure Switch (B16) Pressure - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - Contacts are closed at and below 550 kPa (5.5 bar) (79.8 psi)

Park Brake Pressure Switch (B18) Pressure - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - Contacts are closed at and above 550 kPa (5.5 bar) (79.8 psi)

Inter-Axle Lock Pressure Switch (B25) Pressure - - - - - - - - - - - - - - - - - - - - - - - - - - - Contacts are closed at and above 550 kPa (5.5 bar) (79.8 psi)

Differential Lock Pressure Switch (B26) Pressure - - - - - - - - - - - - - - - - - - - - - - - - - - Contacts are closed at and above 550 kPa (5.5 bar) (79.8 psi)

### System Air Pressure Sensor

Air Pressure at 0 kPa (0 bar) (0 psi) Resistance - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 10 Ohms

Air Pressure at 200 kPa (2 bar) (29 psi) Resistance - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 51 Ohms

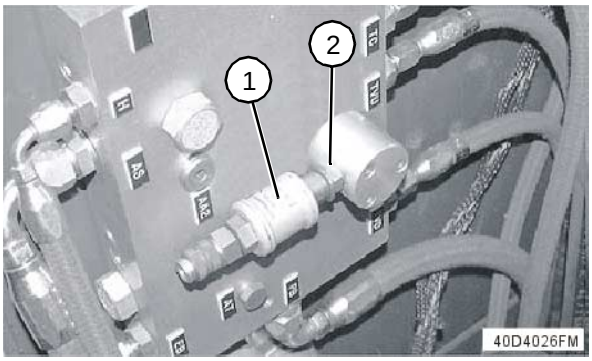
Air Pressure at 400 kPa (4 bar) (58 psi) Resistance - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 86 Ohms

Air Pressure at 600 kPa (6 bar) (87 psi) Resistance - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 122 Ohms

Air Pressure at 800 kPa (8 bar) (116 psi) Resistance

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 152 Ohms

Air Pressure at 1000 kPa (10 bar) (145 psi) Resistance 180 Ohms



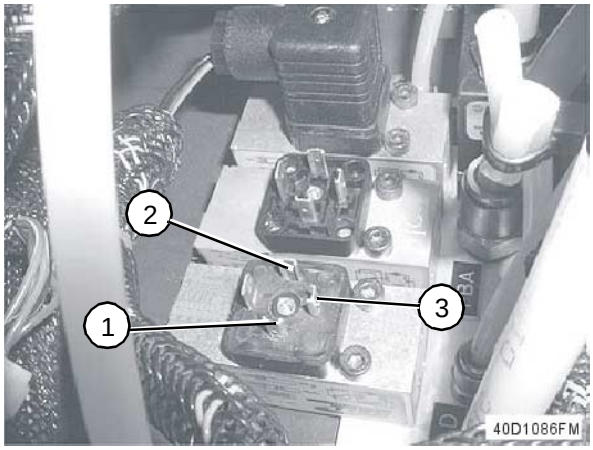

The following tests require a regulated air source applied to port (2). To do this, remove the existing coupler assembly (1).

Install an appropriate coupler using a 1/4 NPT adapter and attach a regulated air supply to the newly installed coupler.

### Pneumatic Pressure Switches (B16, B18, B25, B26) Test

Disconnect wire harness connector from pressure switch to be tested.

**NOTE: 1. Body up pressure switch (B16) uses the normally closed contacts.**
**2. Park brake pressure switch (B18), inter-axle lock pressure switch (B25), and differential lock pressure switch (B26) use the normally open contacts.**




With no air pressure applied to pressure switch, continuity must exist across terminals (1 and 2), but continuity must **NOT** exist across terminals (1 and 3).

**NOTE: Before performing this part of the continuity check, make sure the related pneumatic solenoid and the pneumatic system is functioning properly.**

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Apply 550 kPa (5.5 bar) (79.8 psi) air pressure to the external port of the pneumatic manifold, then perform the following:

- For body up pressure switch (B16), move and hold body up control lever in the RAISE position.

**⚠ CAUTION**

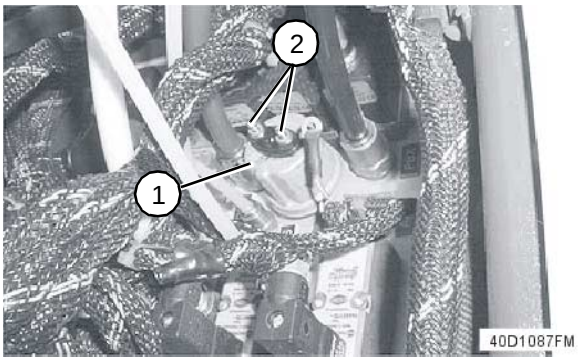
**Chock wheels to prevent vehicle from moving. Park brake may disengage when performing this test.**

- For park brake pressure switch (B18), turn key switch to **ON** position, then move park brake lever to the **DISENGAGE** position.
- For inter-axle lock pressure switch (B25), turn key switch to **ON** position, then push inter-axle lock switch to the **ENGAGE** position.

For differential lock pressure switch (B26), turn key switch to **ON** position, then push differential lock pressure switch to the **ENGAGE** position. The differential lock circuit will energize for 30 seconds then will automatically deactivate.

With air pressure applied to pressure switch, continuity must **NOT** exist across terminals (1 and 2), but continuity must exist across terminals (1 and 3).

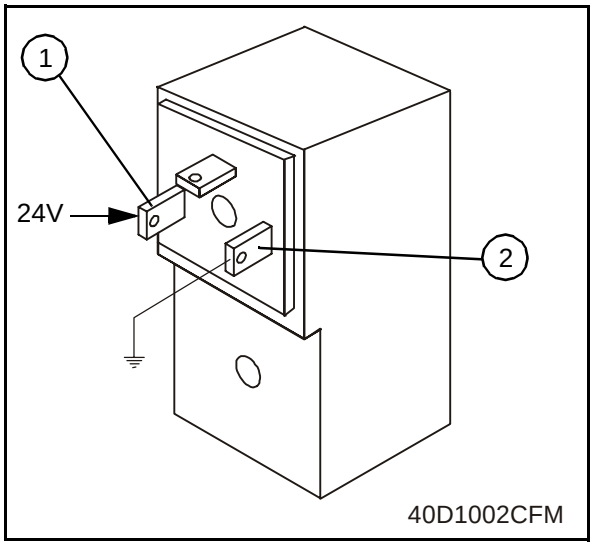
### System Air Pressure Sensor (B15) Test




Apply specified air pressure to sensor (at external port of manifold) while checking resistance across sensor terminals. Replace sensor if not to specification.

### Pneumatic Solenoid Test

Disconnect wire harness from solenoid.




Apply 24 volts across solenoid terminals (1 and 2).

Replace solenoid if solenoid does not click when voltage is applied.

## Hydraulic Pressure Switches Test

### Specifications

Service Brake Low Pressure Switch (B23) Pressure
- - - - - - - - - - - - - - - Contacts are closed at and above
- - - - - - - - - - - - - - - 11 000 kPa (110 bar) (1595.4 psi)

Secondary Steering Pressure Switch (B24) Pressure
- - - - - - - - - - - - - - - Contacts are closed at and above
- - - - - - - - - - - - - - - - - - - - 500 kPa (5 bar) (72.5 psi)

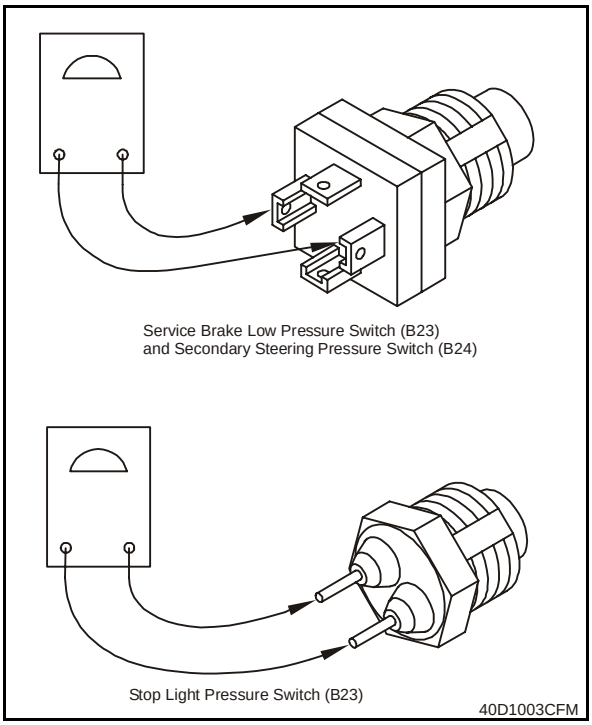
Stop Light Pressure Switch (B27) Pressure
- - - - - - - - - - - - - - - Contacts are closed at and above
- - - - - - - - - - - - - - - - - - - - 600 kPa (6 bar) (87 psi)

Remove pressure switch.

**NOTE:1. The normally closed contacts are used on service brake low pressure (B23) and secondary steering pressure (B24).**
**2. The stop light pressure switch (B27) is a normally open switch.**

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With no pressure applied to pressure switch, check for continuity across the switch terminals.




- For service brake low pressure switch (B23) and secondary steering pressure switch (B24), replace switch if no continuity is indicated.
- For stop light pressure switch (B27), replace switch if continuity is indicated.

Apply specified pressure to switch while checking for continuity across the switch terminals.

- For service brake low pressure switch (B23) and secondary steering pressure switch (B24), replace switch if continuity is indicated.
- For stop light pressure switch (B27), replace switch if no continuity is indicated.

## Hydraulic Temperature Sensors Test

**NOTE: This test applies to both the Hydraulic Temperature Sensor (B21) and Wet Brake Temperature Sensor (B22).**

### Specification

Temperature at 40°C (104°F) - Resistance
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 287.4 Ohms

Temperature at 50°C (122°F) - Resistance
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 193.6 Ohms

Temperature at 60°C (140°F) - Resistance
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 134 Ohms

Temperature at 70°C (158°F) - Resistance
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 92.5 Ohms

Temperature at 80°C (176°F) - Resistance
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 69.1 Ohms

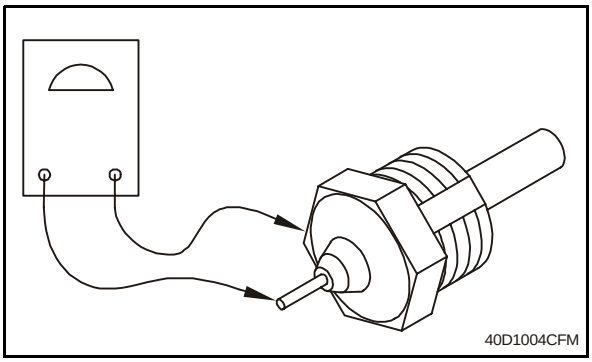
Temperature at 90°C (194°F) - Resistance
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 51.3 Ohms

Temperature at 100°C (212°F) - Resistance
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 38.6 Ohms

Temperature at 110°C (230°F) - Resistance
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 29.4 Ohms

Temperature at 120°C (248°F) - Resistance
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 22.7 Ohms

Remove sensor.




Apply specified heat to sensor while checking resistance between sensor terminal and body of sensor. Replace sensor if not to specification.

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## Bin Position Sensor Test

### Specifications

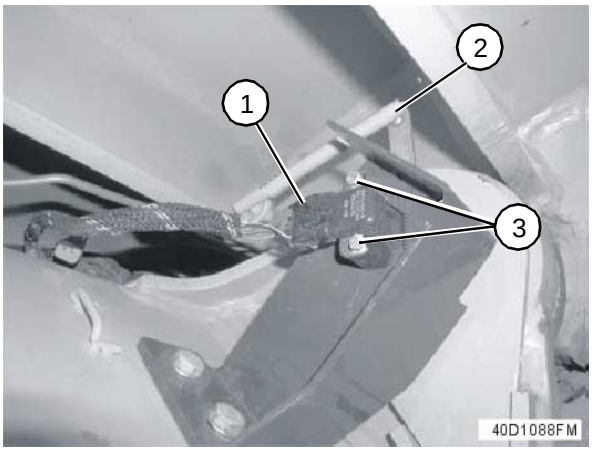
Check Resistance Across Terminals A and C
Resistance - - - - - - - - - - - - - - - - - 5000 ± 1000 Ohms

Check Terminals A and B (Sensor Lever Rotated Fully Clockwise) Resistance - - - - - - - - - - - 350 ± 70 Ohms

Check Terminals B and C Ohms (Sensor Lever Rotated Fully Clockwise) Resistance- - - - 5350 ± 1070

Check Terminals A and B (Sensor Lever Rotated Fully Counter clockwise) Resistance - - 5350 ± 1070 Ohms

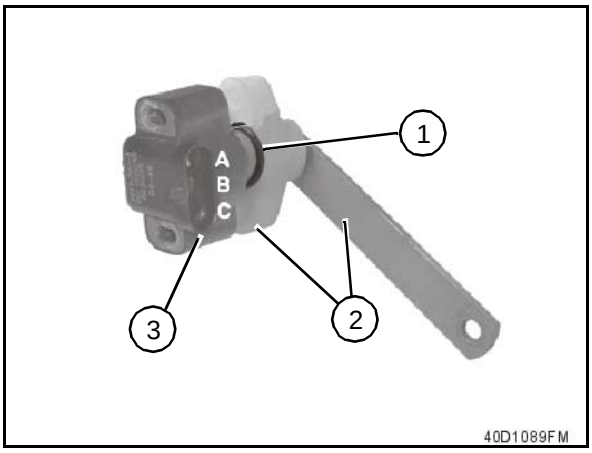
Check Terminals B and C (Sensor Lever Rotated Fully Counter clockwise) Resistance - - - - - 350 ± 70 Ohms




Disconnect wire connector (1) and linkage (2) from sensor lever.

**NOTE: It is necessary to remove sensor from mounting bracket to give the sensor lever full travel.**

Remove cap screws and nuts (3).




Remove sensor by separating support and lever (2) from body position sensor (3).

Measure resistance across terminals A and C of body position sensor. Replace sensor if not to specification.

Insert shaft of support and lever (2) into body position sensor (3) and rotate lever fully clockwise (as viewed from lever side of sensor). Measure resistance across sensor terminals A and B, then across terminals B and C.

Replace sensor if resistance is not to specification.

With test leads of ohmmeter attached to terminals A and B or B and C, slowly rotate sensor lever fully counter clockwise (as viewed from lever side of sensor).

The change in resistance from stop-to-stop must be smooth and continuous in correlation to lever movement.

Replace sensor if resistance is not to specification when lever is fully rotated or if change in resistance is uneven or stops changing as sensor lever is rotated.

Install body position sensor (3), support and lever (2), and cap screws and nuts. Make sure O-rings (1) are in position.

Connect linkage (2) and wire connector (1).

**NOTE: The body position sensor needs to be calibrated whenever the sensor, CCU, or MDU is replaced. The sensor may also need re-calibrating if the key switch is turned to the ON position while sensor is disconnected.**

Calibrate sensor to the full body down and full body up positions.

**To calibrate sensor:**

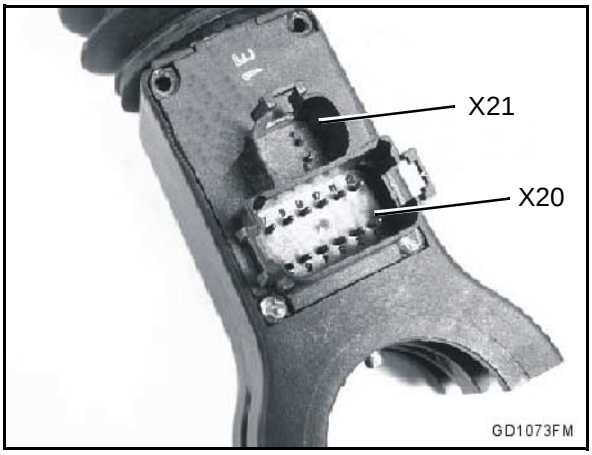
- Start engine. Make sure bin is at the full down position.
- Access menu function D041 on menu display unit (MDU). For information on accessing the
- MDU menu structure, **(See CHAPTER 8 in the OMM)**.
- Push and hold the SELECT button on the MDU for a least 3 seconds to set the 0% position.
- Raise bin to the full raised position.
- Access menu function D042. Push and hold the SELECT button for at least 3 seconds to set the 100% position.
- Lower bin fully. Stop engine.

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## Steering Column Switch Test

| | POSITION | | CONNECTOR X20 | | | | | | | | | | | | CONNECTOR X21 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 4 |
| Wipers | Intermittent | J | | | | | | | | ● | | | | | | ● | |
| | Off | 0 | | ● | | | | ● | | | | | | | | | |
| | Low Speed | 1 | | ● | | | | | | ● | | | | | | | |
| | High Speed | 2 | ● | | | | | | | ● | | | | | | | |
| Washer | | L | | | | | | | ● | | | | | | ● | | |
| Turn Signals | Left | | | | | | | | | | ● | ● | | | | | |
| | | R | | | | | | | | | | | | | | | |
| | Right | 2 | | | | | | | | | | ● | ● | | | | |
| Drive Lights | High Beam | 1 | | | ● | ● | | | | | | | | | | | |
| | Low Beam | | | | | ● | ● | | | | | | | | | | |
| | Momentary High Beam | 0 | | | ● | | | | | | | | | ● | | | |
| Horn | | | | | | | | | | | | | | | ● | | ● |

Remove the steering column switch assembly.




While operating the switch functions, check for continuity across terminals as indicated in the switch legend.

Replace the switch assembly if continuity is not according to the switch legend.

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## Retarder Voltage Regulator Test

### Specifications At Terminal 2 and 4

Control Lever at Position **0** (12%) voltage
- - - - - - - - - 0.8 volts at terminal 2 of Voltage regulator
- - - - - - - - - 1.6 volts at terminal 4 of voltage regulator

Control Lever at Position **1** voltage
- - - - - - - - - 1.2 volts at terminal 2 of Voltage regulator
- - - - - - - - - 1.6 volts at terminal 4 of voltage regulator

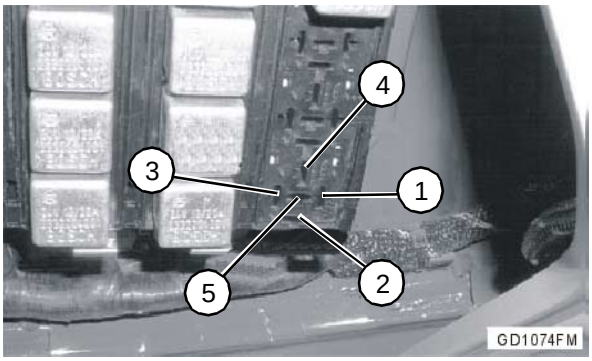
Control Lever at Position **2** voltage
- - - - - - - - - 1.6 volts at terminal 2 of Voltage regulator
- - - - - - - - - 1.7 volts at terminal 4 of voltage regulator

Control Lever at Position **3** Voltage
- - - - - - - - - 2.1 volts at terminal 2 of voltage regulator
- - - - - - - - - 2.1 volts at terminal 4 of voltage regulator

Control Lever at Position **4** Voltage
- - - - - - - - - 2.7 volts at terminal 2 of voltage regulator
- - - - - - - - - 2.7 volts at terminal 4 of voltage regulator

Control Lever at Position **5** Voltage
- - - - - - - - - 3.4 volts at terminal 2 of voltage regulator
- - - - - - - - - 3.4 volts at terminal 4 of voltage regulator

Control Lever at Position **6** (100%) Voltage
- - - - - - - - - 4.2 volts at terminal 2 of voltage regulator
- - - - - - - - - 4.3 volts at terminal 4 of voltage regulator




1. Terminal 1 (Voltage from Stop Light Pressure Switch).
2. Terminal 2 (Input Control Voltage).
3. Terminal 3 (Ground).
4. Terminal 4 (Output Control Voltage).
5. Terminal 5 (System Voltage).

Remove retarder voltage regulator.

Check for continuity between ground and terminal (3) of retarder voltage regulator socket. If continuity is not indicated, check cab main harness (W10).

**NOTE:The battery disconnect switch must be in the ON position when performing the following checks.**

Turn key switch to **ON** position and check for system voltage at terminal (5). If system voltage is not measured, check fuse F11 and circuit breaker F3. If OK, check cab main harness (W10).

Check for voltage at terminal (2) while slowly moving retarder controller lever to each detent position.

Voltage should be approximately as specifications.

Start engine. Check terminal (1) for voltage while applying the service brakes, then check for voltage while brakes are released.

System voltage must be measured when service brakes are applied. Zero voltage must be measured when brakes are released.

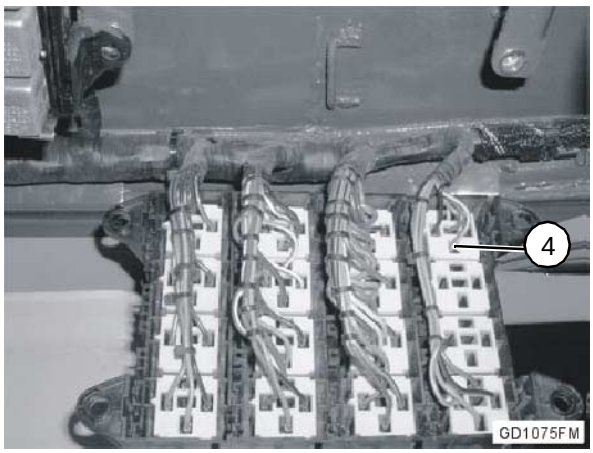
If these conditions do not occur as described, check the stop light circuit.

Stop engine. Key switch at **OFF** position.

Install retarder voltage regulator.

Remove the four mounting screws to access the backside of the right relay socket array.

Turn key switch to **ON** position.




Check for voltage at terminal (4) while slowly moving retarder controller lever to each detent position.

Voltage should be approximately as specifications.

Start engine and move the retarder controller lever to position 0 (12% retardation).

Apply the service brakes while checking for voltage at terminal (4). With the service brakes applied, voltage at terminal (4) must be at maximum output voltage (approximately 4.3 volts).

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Stop engine. Install relay socket array.

If specified voltages exist at terminals (1,2, and 5) and ground exists at terminal 3, but voltage at terminal (4) is not to specification, replace retarder voltage regulator.

## Transmission Speed Sensors Test

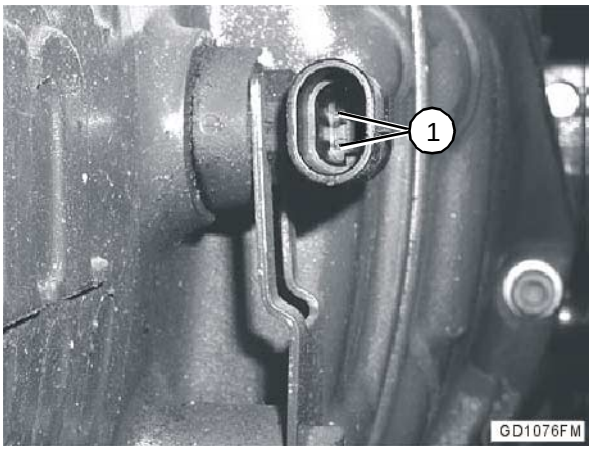
### Specifications

Transmission Temperature at 40°C (–40°F) Resistance - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 200 Ohms.

Transmission Temperature at 20°C (68°F) Resistance - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 300 Ohms.

Transmission Temperature at 110°C (230°F Resistance - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 400 Ohms.

Disconnect speed sensor connector.




Measure resistance across sensor terminals (1).

Replace sensor if not within specification.

## Transmission Solenoids Test

Disconnect transmission control module connector (X171).

Measure resistance of each solenoid across appropriate terminals.

### Specification

Transmission Temperature at 20°C (4°F) - Resistance - - - - - - - - - - - - - - - - - - - - - - - - - - - - 2.50 - 2.90 Ohms/

Transmission Temperature at 0°C (32°F) - Resistance - - - - - - - - - - - - - - - - - - - - - - - - - - - - 2.75 - 3.20 Ohms.

Transmission Temperature at 20°C (68°F) - Resistance - - - - - - - - - - - - - - - - - - - - - - - - - - - - 2.95 - 3.50 Ohms.

Transmission Temperature at 40°C (104°F) - Resistance - - - - - - - - - - - - - - - - - - - - 3.20 - 3.75 Ohms.

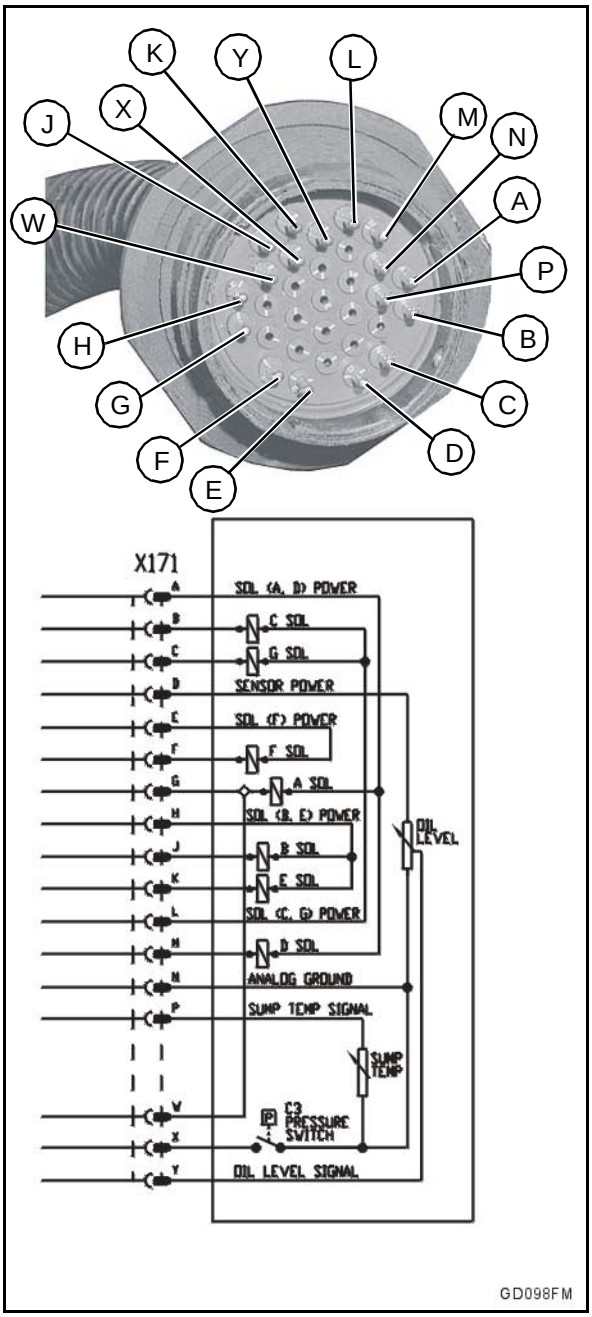
Transmission Temperature at 60°C (140°F) Resistance - - - - - - - - - - - - - - - - - - - - - - - - - - - - 3.45 - 4.00 Ohms.

Transmission Temperature at 80°C (176°F) - Resistance- - - - - - - - - - - - - - - - - - - - 3.70 - 4.25 Ohms.

Transmission Temperature at 100°C (212°F) Resistance - - - - - - - - - - - - - - - - - - - - 3.90 - 4.50 Ohms.

Transmission Temperature at 120°C (248°F) - Resistance - - - - - - - - - - - - - - - - - - - - 4.20 - 4.75 hms.

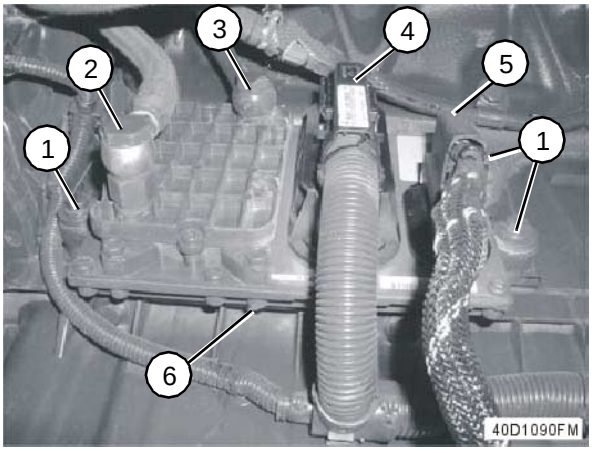
Transmission Temperature at 140°C (284°F) - Resistance - - - - - - - - - - - - - - - - - - - - 4.45 - 5.05 Ohms,




- Solenoid A = Terminals A and G
- Solenoid B = Terminals H and J
- Solenoid C = Terminals B and L
- Solenoid D = Terminals A and M
- Solenoid E = Terminals H and K
- Solenoid F = Terminals E and F
- Solenoid G = Terminals C and L

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## Remove and Install Electronic Unit Injector (EUI) Controller




Turn key switch and battery disconnect switch to **OFF** position.

Disconnect harness connectors (4 and 5).

Disconnect fuel lines (2 and 3).

Remove cap screws and washers (1) to remove EUI controller (6).

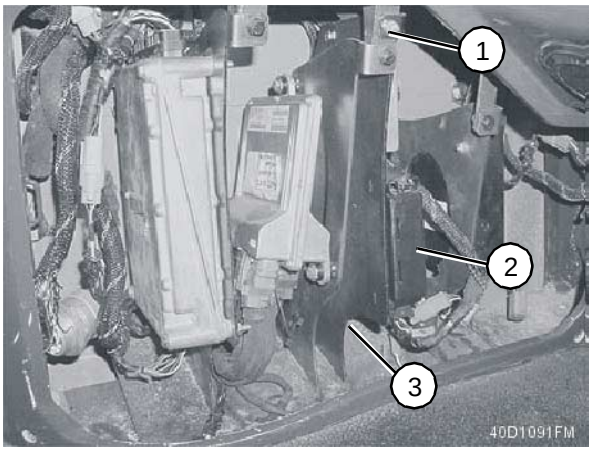
Install EUI controller (6).

Connect fuel lines (2 and 3) and wire harnesses (4 and 5).

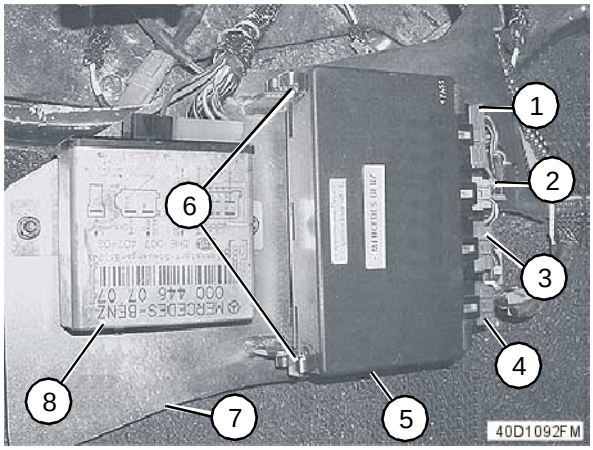
## Remove and Install Engine Control Unit

Turn key switch and battery disconnect switch to **OFF** position.

Remove controller access panel located under left console.




Remove cap screw (1). Remove engine control unit (ECU) (2) and mounting plate (3) as an assembly.




To separate ECU (5) from mounting plate (7), push ECU against spring clips (6) until opposite end of ECU is free of mounting.

Disconnect harness connectors (1 to 4).

To install, push ECU against spring clips (6) until opposite side of ECU snaps into position on mounting plate.

Connect harness connectors (1 to 4).

Install the ECU and mounting plate as an assembly in slot provided in controller compartment.

Install controller access panel.

Turn battery switch to ON position.

Turn key switch to ON position and access the MDU menu function B013. For information on accessing the MDU menu structure, **(See CHAPTER 8 in the OMM)**.

While observing the number that represents pedal position as a percentage on the MDU data display, depress accelerator pedal fully to fast idle position, then allow pedal to return fully to slow idle position.

Movement of the accelerator pedal (slow idle to the fast idle) should correspond from 0% to 100% on the data display.

**NOTE: An acceptable margin of error between pedal movement relative to percentage read-out will differ from operator to operator. Because of this, the need for re-calibration will be determined by operator preference.**

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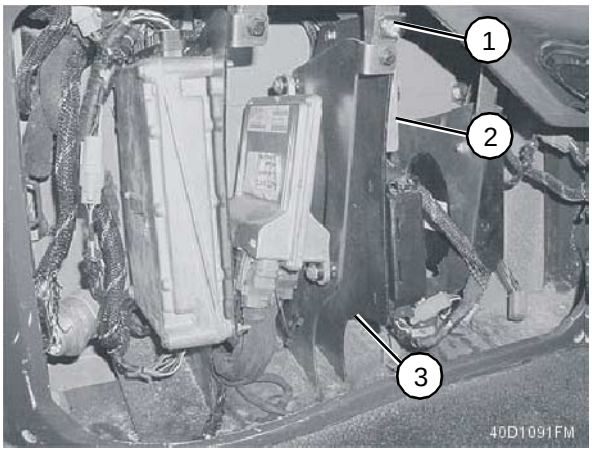
If the percentage read-out relative to pedal movement is not acceptable, calibration of accelerator pedal position sensor is required. To perform this procedure, a special diagnostic tool called the MiniDiag II (Version B) is needed. The MiniDiag II can be acquired from ***BELL EQUIPMENT*** Product Support.

**NOTE:1. The MiniDiag II is capable of reading and deleting engine related service codes and calibrating accelerator pedal position. Follow the instructions that come with the diagnostic tool.**
**2. Call DTAC (*BELL EQUIPMENT* Product Support) for additional help.**

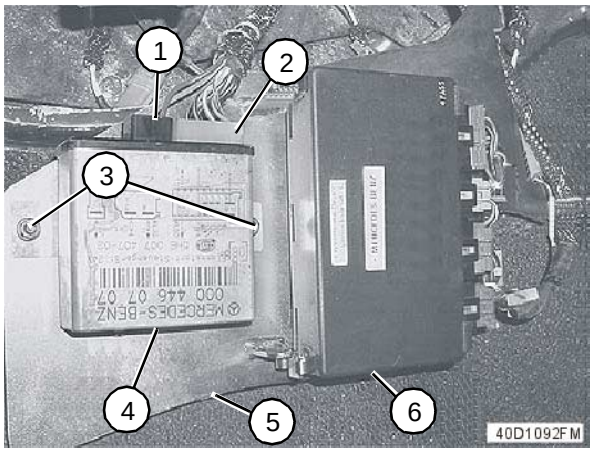
## Remove and Install Cold Start Module

Turn key switch and battery disconnect switch to **OFF** position.

Remove controller access panel located under left console.




Remove cap screw and washer (1). Remove cold start module (2) and mounting plate (3) as an assembly.




Disconnect harness connectors (1 and 2).

Remove cap screws, washers, and nuts (3) to separate cold start module (4) from mounting plate (5).

Fasten cold start module to mounting plate and connect harness connectors.

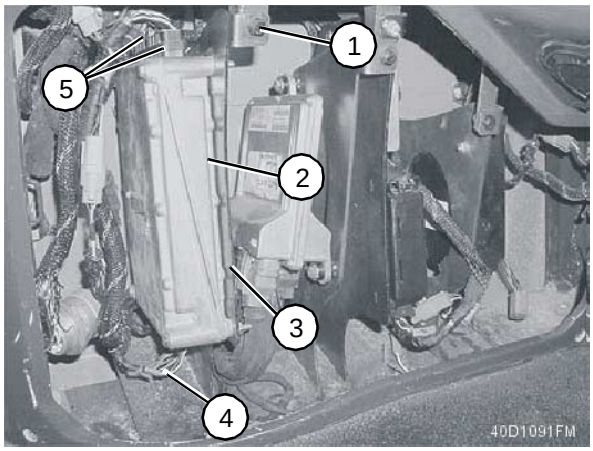
Install the cold start module and mounting plate as an assembly in slot provided in controller compartment.

Install controller access panel.

## Remove and Install Chassis Control Unit

Turn key switch and battery disconnect switch to **OFF** position.

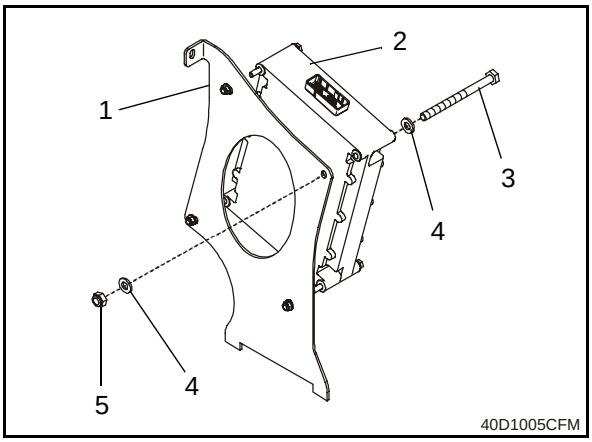
Remove controller access panel located under left console.




Remove cap screw and washer (1). Remove chassis control unit (CCU) (2) and mounting plate as an assembly.

Disconnect harness connectors (4 and 5).

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Remove lock nuts (5), washers (4), and cap screws (3) to separate CCU (2) from mounting plate (1).

Fasten CCU to mounting plate and connect harness connectors.

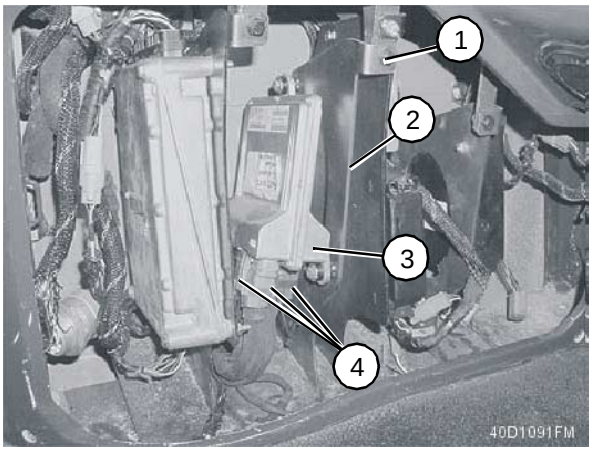
Install CCU and mounting plate as an assembly in slot provided in controller compartment.

Install controller access panel.

## Remove and Install Transmission Control Unit

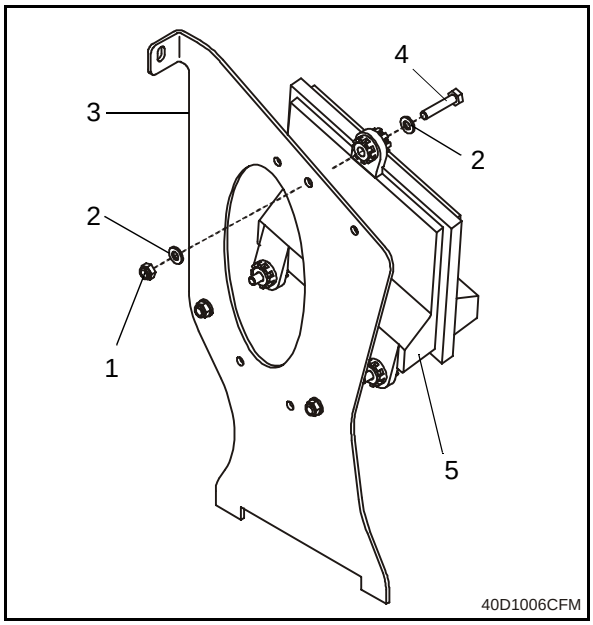
Turn key switch and battery disconnect switch to **OFF** position.

Remove controller access panel located under left console.




Remove cap screw and washer (1). Remove transmission control unit (TCU) (3) and mounting plate (2) as an assembly.

Disconnect harness connectors (4).




Remove lock nuts (1), washers (2), and cap screws (4) to separate TCU (5) from mounting plate (3).

Fasten TCU to mounting plate and connect harness connectors.

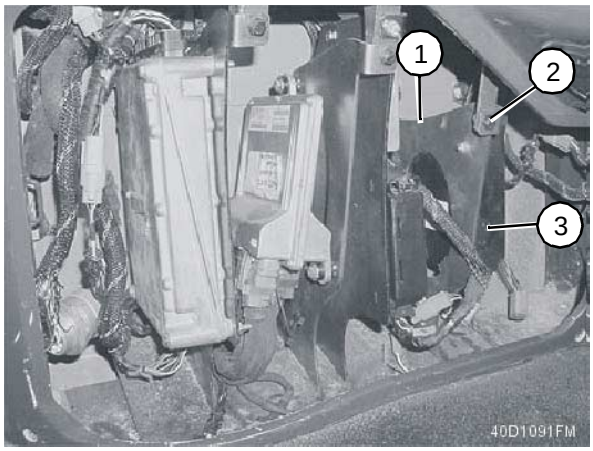
Install TCU and mounting plate as an assembly in slot provided in controller compartment.

Install controller access panel.

## Remove and Install Battery Balancer

Turn key switch and battery disconnect switch to **OFF** position.

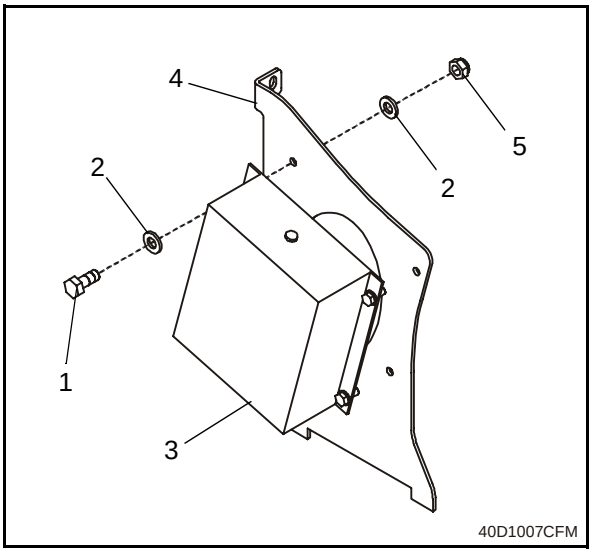
Remove controller access panel located under left console.




Remove cap screw and washer (2). Remove battery balancer (3) and mounting plate (1) as an assembly.

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Disconnect harness connector.




Remove nuts (5), washers (2), and cap screws (1) to separate battery balancer (3) from mounting plate (4).

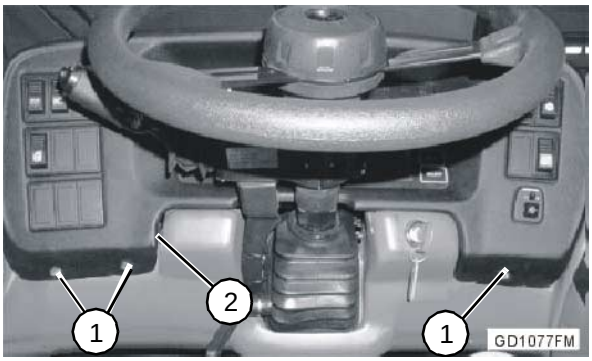
Fasten battery balancer to mounting plate and connect harness connector.

Install battery balancer/mounting plate assembly in slot provided in controller compartment.

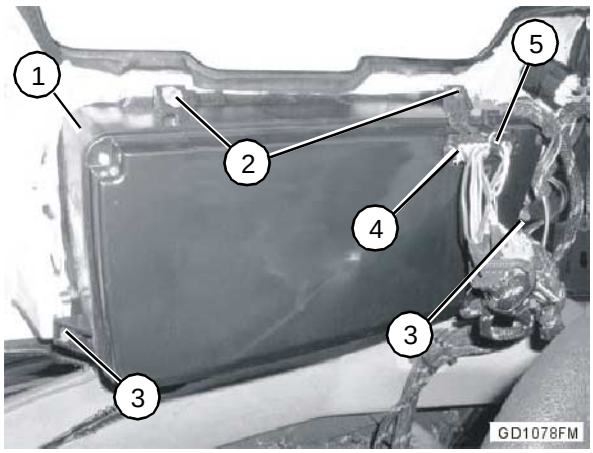
Install controller access panel.

## Remove and Install Menu Display Unit

Turn key switch and battery disconnect switch to **OFF** position.




Remove screws (1) and pivot front console (2) upward to access backside of MDU.




Disconnect harness connectors (4 and 5).

Remove screws (2 and 3) to remove MDU.

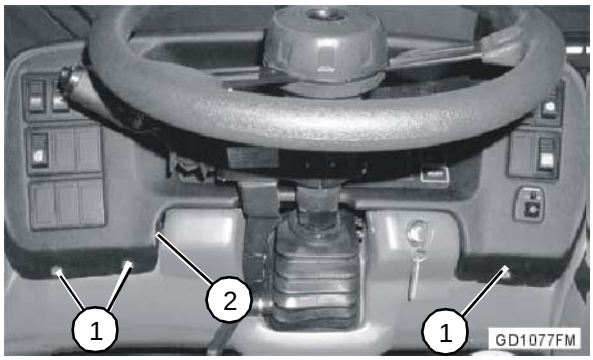
Install MDU and fasten with screws (2 and 3). Make sure screws with four washers (2) are at bottom (connector) side of MDU.

Connector harness connectors (4 and 5).

Close front console and fasten with three screws.

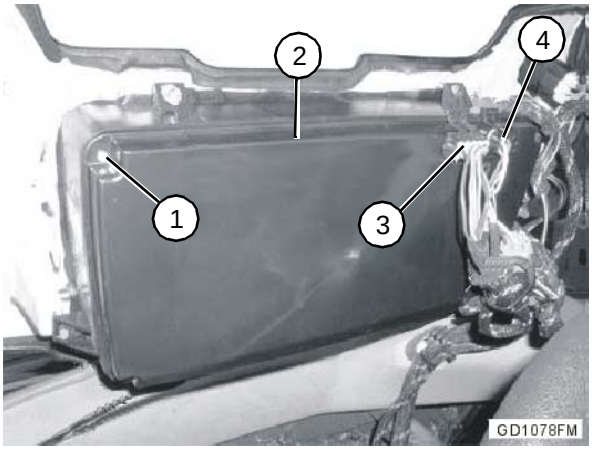
## Replace Monitor Display Unit Bulbs

Turn key switch and battery disconnect switch to **OFF** position.




Remove screws (1) and pivot front console (2) upward to access backside of MDU.

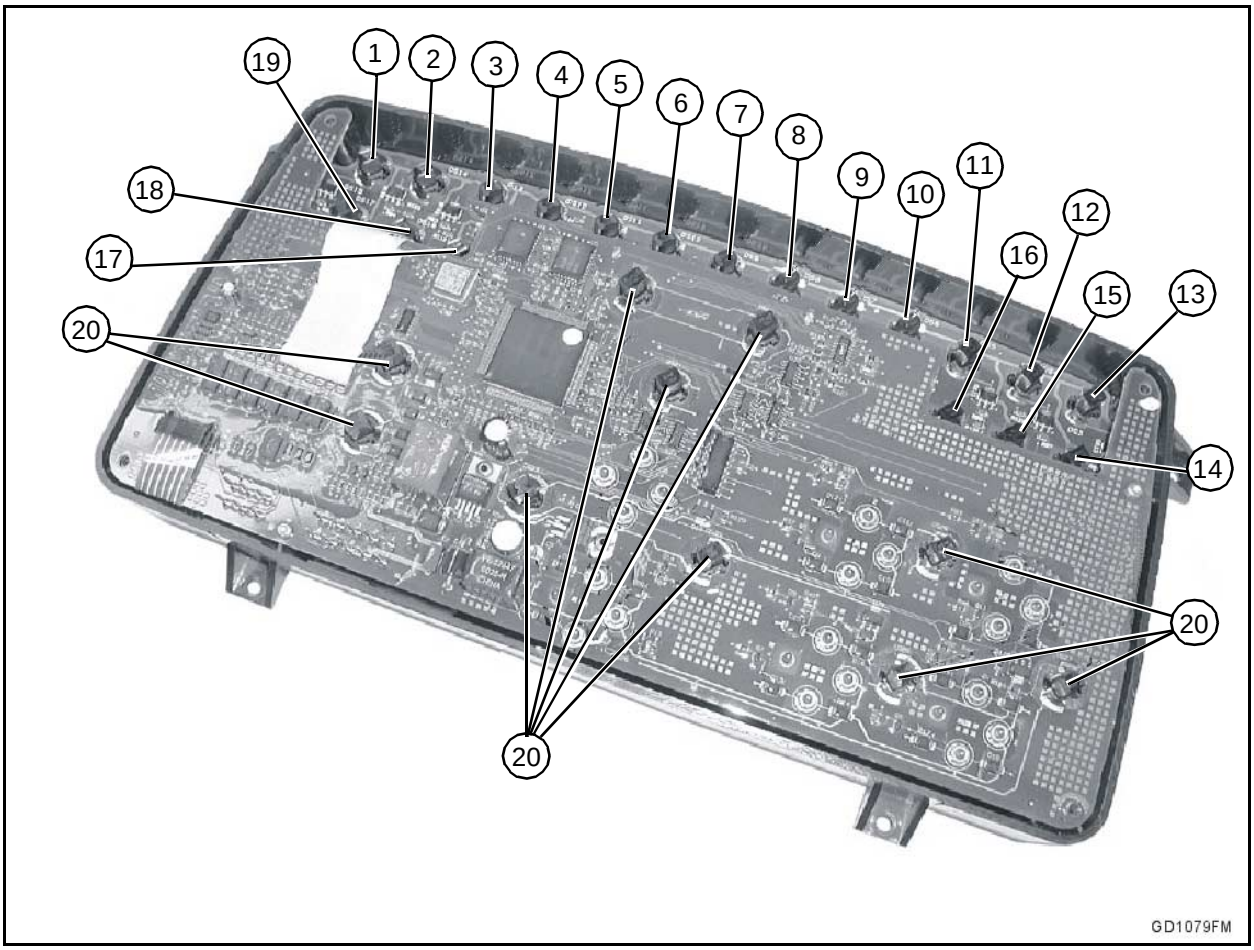
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Disconnect harness connectors (3 and 4).

Remove four screws (1) to remove back panel (2).

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1. Hydraulic Temperature Light.
2. Brake Temperature Light.
3. Brake Pressure Light.
4. Park Brake Light.
5. Right Turn Indicator.
6. Engine Overspeed Light.
7. High Beam Indicator.
8. Service Required Light.
9. Left Turn Indicator.
10. Secondary Steering (Marked Emergency Steering) Light.
11. Engine Service (Marked Engine Fault) Light.
12. Coolant Level Light.
13. Cold Start Light.
14. Battery Charge Light.
15. Transmission Retarder Light.
16. Transmission Service (Marked Transmission Fault) Light.
17. Bin Raised Light (Marked Bin Up) Light.
18. Inter-Axle Lock Light.
19. Differential Lock Light.
20. Back Lights.

**NOTE: MDU shown removed for illustration purposes only.**

Replace bulb(s) as necessary.

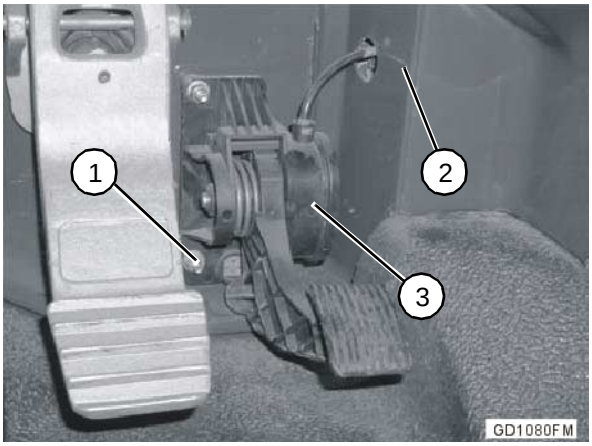
Install MDU back panel and connector harness connectors.

Close front console and fasten with three screws.

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## Remove, Install, and Calibrate Accelerator Pedal Position Sensor

**NOTE:The accelerator pedal position sensor connector is accessed through the A/C compartment door located on right side of cab.**




Disconnect harness connector (2) located in the air conditioning compartment.

Remove two cap screws and lock nuts (1) to remove accelerator pedal position sensor (3).

Install sensor and connect harness connector.

Turn key switch to ON position and access the MDU menu function B013. For information on accessing the MDU menu structure, **(See CHAPTER 8 in the OMM)**.

While observing the number that represents pedal position as a percentage on the MDU data display, depress accelerator pedal fully to fast idle position, then allow pedal to return fully to slow idle position.

Movement of the accelerator pedal (slow idle to the fast idle) should correspond from 0% to 100% on the data display.

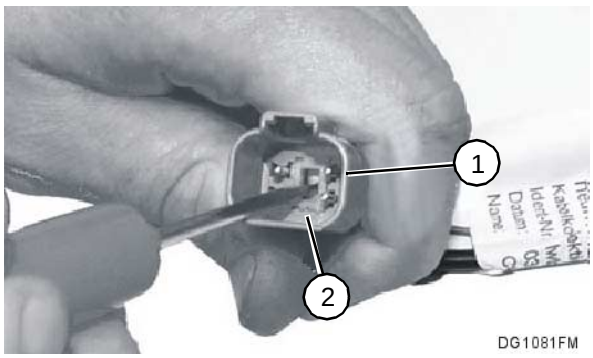
**NOTE:An acceptable margin of error between pedal movement relative to percentage read-out will differ from operator to operator. Because of this, the need for re-calibration will be determined by operator preference.**

If the percentage read-out relative to pedal movement is not acceptable, calibration of accelerator pedal position sensor is required. To perform this procedure, a special diagnostic tool called the MiniDiag II (Version B) is needed. The MiniDiag II can be acquired from ***BELL EQUIPMENT*** Product Support.

**NOTE:The MiniDiag II is capable of reading and deleting engine related service codes and calibrating accelerator pedal position. Follow the instructions that come with the diagnostic tool. Call DTAC (*BELL EQUIPMENT* Product Support) for additional help.**

## Replace DEUTSCH™ Rectangular or Triangular Connectors

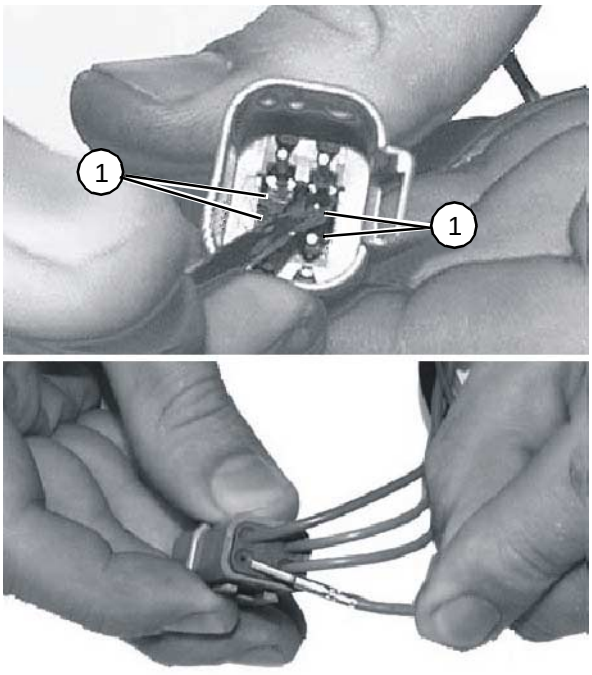
**NOTE:Connector shown is the female half or a 4-pin square connector. Other similar styles of Deutsch connectors can be serviced using the same procedure.**




Pull connector (1) apart. Inspect and clean connector seal and contacts.

Remove locking wedge (2) from connector using hook on JDG1383 service tool.

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GD1082FM

Release primary locking latch (1) next to the pin to be removed using screwdriver on JDG1383 service tool.

Gently pull wire out from back of connector. Replace connector contact as necessary. **See "Install DEUTSCH™ Contact" on page 208.**

Install wire terminal back into connector until it clicks into place.

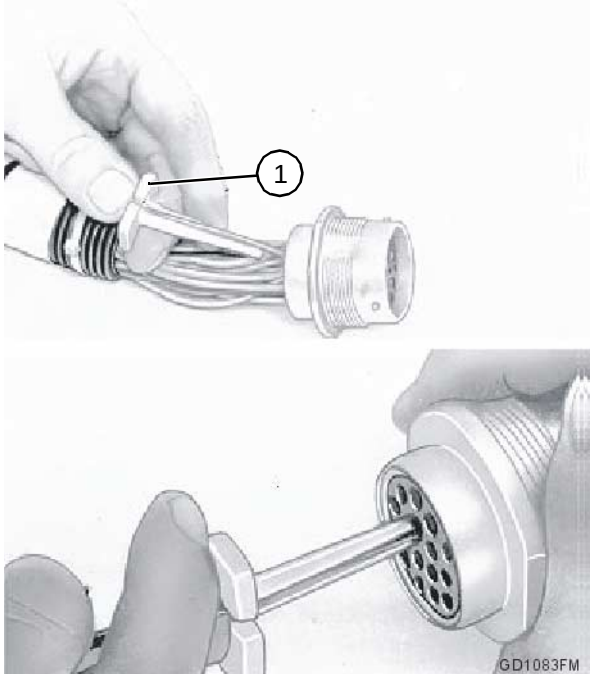
**NOTE:Locking wedge in 2-pin connector is not symmetrical. Position latch shoulder next to terminals.**

Install locking wedge until it snaps into place.

## Replace DEUTSCH™ Connectors

1. Select correct size extractor tool for size of wire to be removed:

- JDG361 Extractor Tool for 12 to 14 gauge wire.
- JDG362 Extractor Tool for 16 to 18 gauge wire.
- JDG363 Extractor Tool for 20 gauge wire.




Start correct size extractor tool over wire at handle (1).

Slide extractor tool rearward along wire until tool tip snaps onto wire.

**⚠ CAUTION**

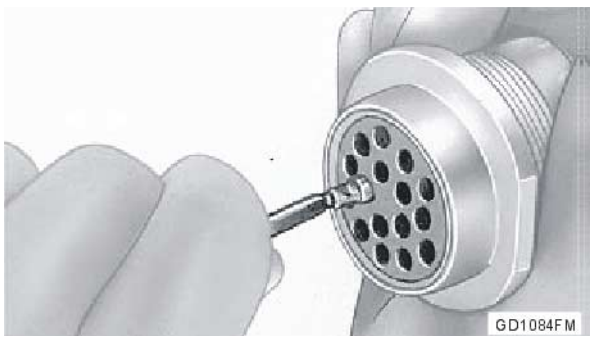
**Do NOT twist tool when inserting in connector.**

Slide extractor tool along wire into connector body until it is positioned over terminal contact.

Pull wire out of connector body, using extractor tool.

**⚠ WARNING**

**Install contact in proper location using correct size grommet.**




Push contact straight into connector body until positive stop is felt.

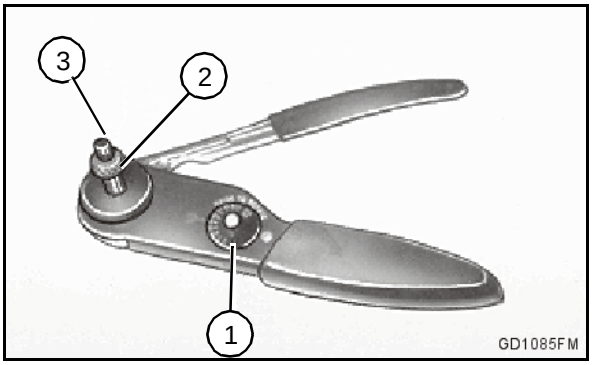
https://truckmanualshub.com/

Pull on wire slightly to be certain contact is locked in place.

Transfer remaining wires to correct terminal in new connector.

## Install DEUTSCH™ Contact

Strip 6 mm (1/4 in.) insulation from wire.

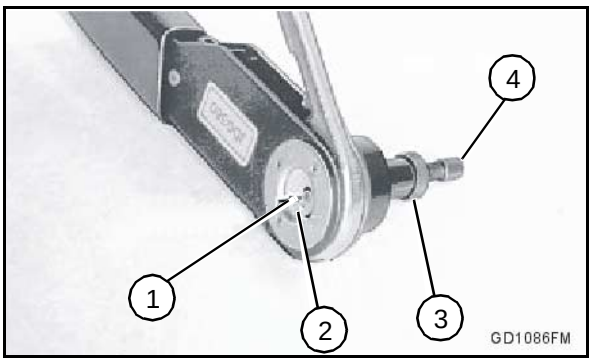



Adjust selector (1) on JDG360 Crimper for correct wire size.

Loosen lock nut (2) and turn adjusting screw (3) in until it stops.

**⚠ WARNING**

**Select proper size contact "sleeve" or "pin" to fit connector body.**

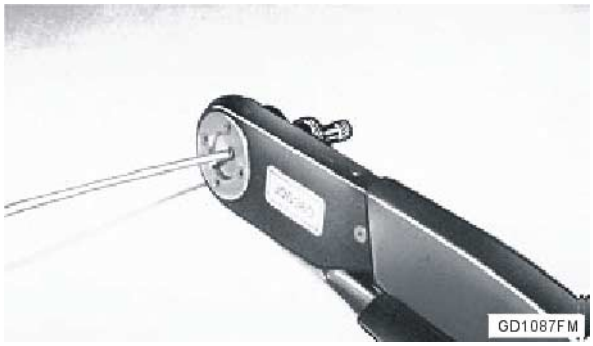



Insert contact (1) and turn adjusting screw (4) until contact is flush with cover (2).

Tighten lock nut (3).

**⚠ WARNING**

**Contact must remain centred between indentures while crimping.**



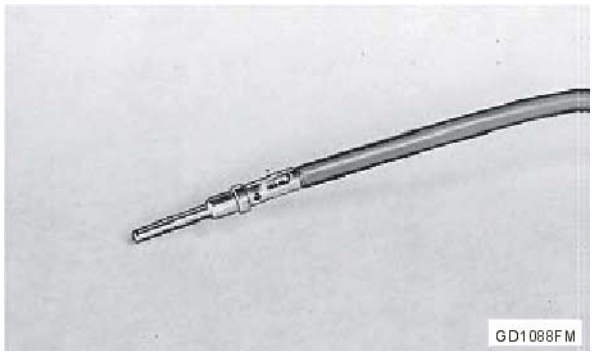

Insert wire in contact and crimp until handle touches stop.

Release handle and remove contact.

**⚠ WARNING**

**If all wire strands are not crimped into contact, cut off wire at contact and repeat contact installation procedures.**

**NOTE: Readjust crimping tool for each crimping procedure.**




Inspect contact to be certain all wires are in crimped barrel.

## Replace WEATHER PACK™ Connector

**⚠ WARNING**

**Identify wire colour locations with connector terminal letters.**

Open connector body.

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Insert JDG364 Extraction Tool over terminal contact in connector body.

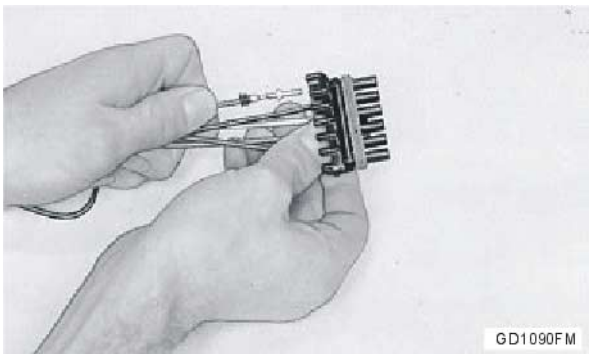
Hold extractor tool fully seated and pull wire from connector body.

**NOTE: If terminal cannot be removed, insert wire or nail through extractor tool handle and push terminal contact from connector.**

**⚠ WARNING**

**Carefully spread contact lances to assure good seating on connector body.**

**NOTE: Connector bodies are "keyed" for proper contact mating. Be sure contacts are in proper alignment.**




Push contact into new connector body until fully seated.

Pull on wire slightly to be certain contact is locked in place.

Transfer remaining wires to correct terminal in new connector.

Close connector body.

## Install WEATHER PACK™ Contact

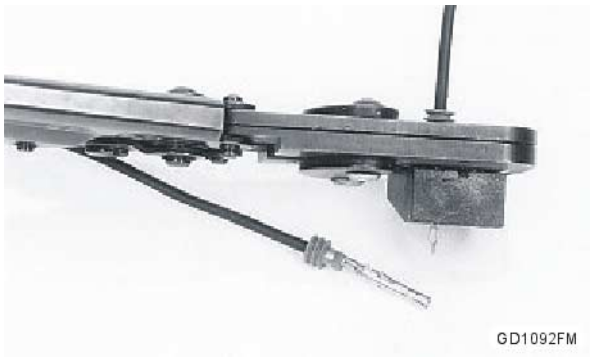
**NOTE: Cable seals are colour coded for three sizes of wire:**
**Green - 18 to 20 gauge wire**
**Gray - 14 to 16 gauge wire**
**Blue - 10 to 12 gauge wire**




Slip correct size cable seal on wire.

Strip insulation from wire to expose 6 mm (1/4 in.) and align cable seal with edge of insulation.

**NOTE: Contacts have numbered identification for two sizes of wire:**
**a) #15 for 14 to 16 gauge wire**
**b) #19 for 18 to 20 gauge wire**

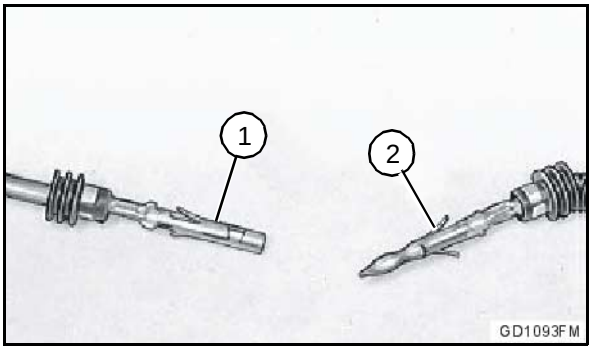



Put proper size contact on wire and crimp in place with a "**W**" type crimp, using JDG783 Terminal Applicator.

**⚠ WARNING**

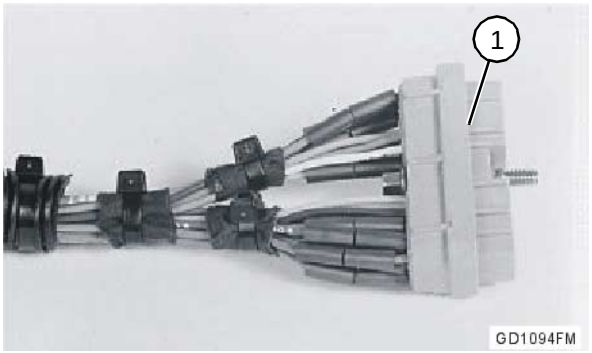
**Proper contact installation for "sleeve" (1) and "pin" (2) is shown.**

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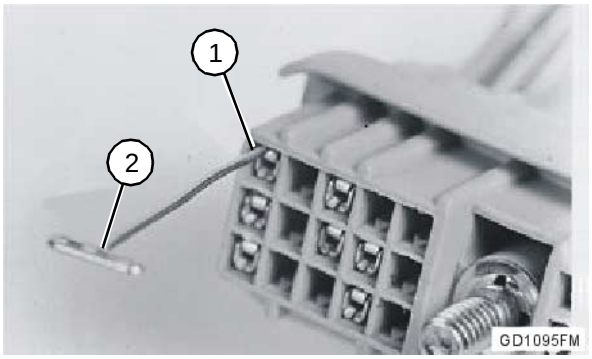



Secure cable seal to contact as shown, using JDG783 Terminal Applicator.

## Replace (Pull Type) Metri-Pack™ Connectors

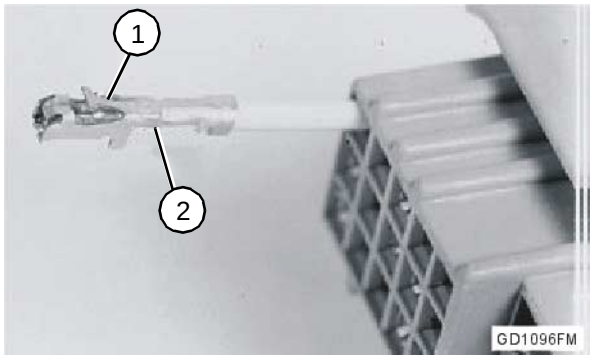



Disconnect the Metri-Pack connector (1). Remove tie bands and tape.




Insert a "**T**" pin (2) 6.4 mm (1/4 in.) into connector body socket (1).

**NOTE:Use JDG777 Terminal Extraction Tool or "T" pin to remove terminals.**




Angle "T" pin so pin tip slides close to the plastic socket edge pushing terminal locking tab (1) inward.

Remove "T" pin and push terminal (2) out of socket.

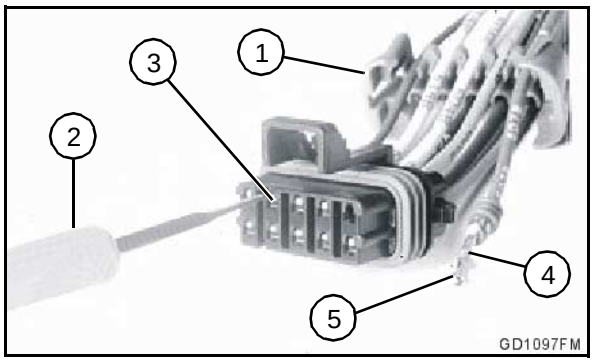
Remove terminal, cut strip and crimp wire through connector.

Check to make sure locking tab on new terminal is in outward position, then pull on wire until terminal locks in connector body socket.

**NOTE:Terminal will seat only one way. If terminal does not pull into the connector body socket, check to make sure terminal is aligned correctly.**

## Replace (Push Type) Metri-Pack™ Connectors

Disconnect the Metri-Pack connector. Remove the tie bands and tape.




Remove the connector lock (1), and mark wire colours for identification.

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Identify wire colour locations with connector terminal letters.

Insert JDG776 or JDG777 Terminal Extraction Tool (2) into connector body socket (3) pushing the terminal locking tab inward.

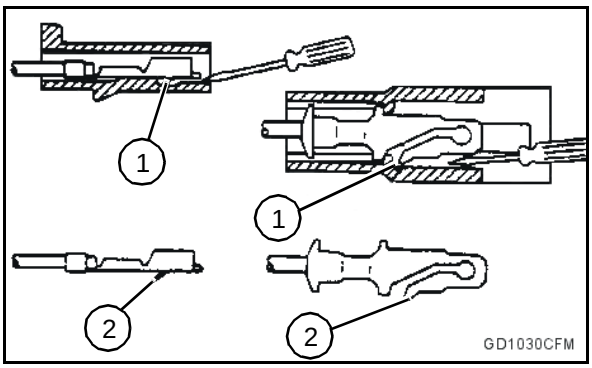
**NOTE:Use JDG776 Extraction Tool with 56, 280 and 630 series METRI-PACK terminals. Use JDG777 Extraction Tool with 150 series METRI-PACK terminals.**

Remove extraction tool and pull terminal (4) out of the socket.

Replace terminal. Make sure locking tab (5) on the new terminal is in the outward position.

Push terminal into connector body socket until terminal locks.

## Remove Connector Body from Blade Terminals




Depress locking tang (1) on terminal, using a small screw driver. Slide connector body off.

Be sure to bend locking tang back to its original position (2) before installing connector body.

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# CHAPTER 4.TRANSMISSION HD4560

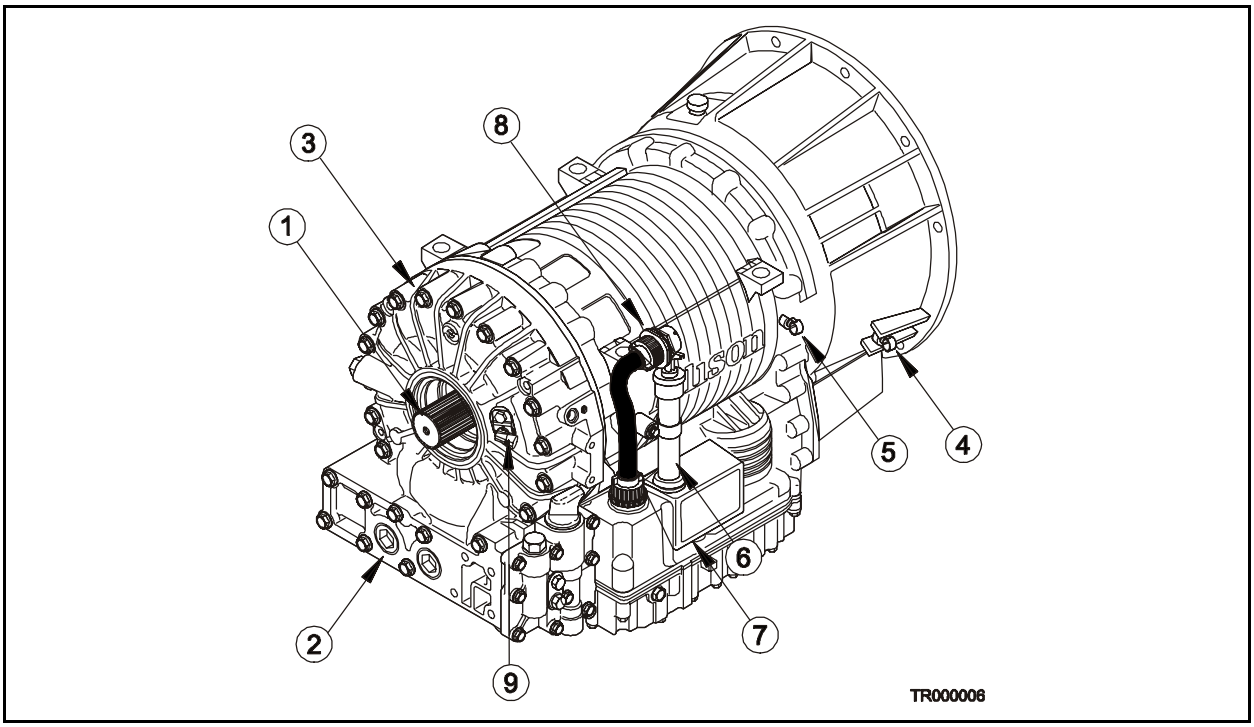
## SECTION 1. THEORY OF OPERATION

## GENERAL DESCRIPTIONS

### Allison HD 4560 PR

- **HD** Automatic Truck Transmission
- **4** Heavy Duty
- **5** Wide Ratio
- **6** Number Of Forward Ranges
- **O** Reserved For Major Model Changes
- **P** Power Takeoff (Pto) N/a To B40D
- **R** Output Retarder

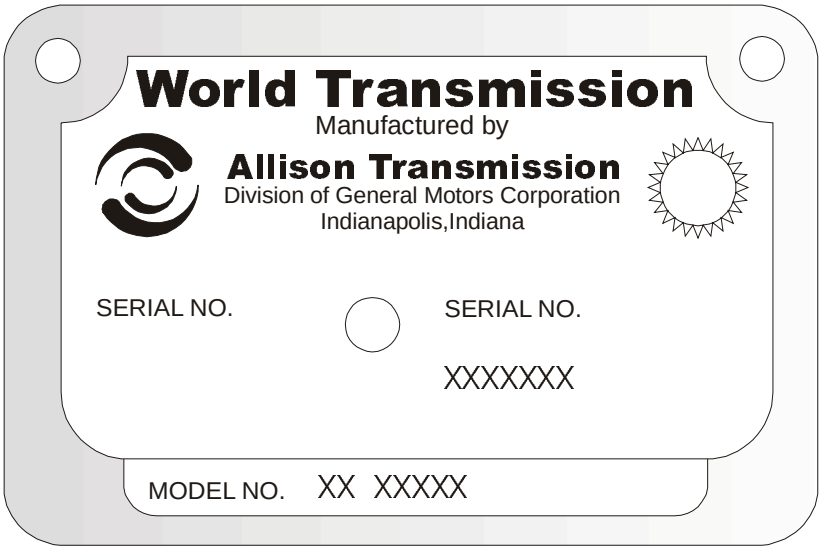
### HD 4560R Transmission




1. Output Shaft
2. Cooler Ports
3. Retarder
4. Engine speed Sensor
5. Turbine speed Sensor.
6. Filler Tube.
7. Identification Plate.
8. Wiring Harness.
9. Output Speed Sensor.

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## TRANSMISSION IDENTIFICATION



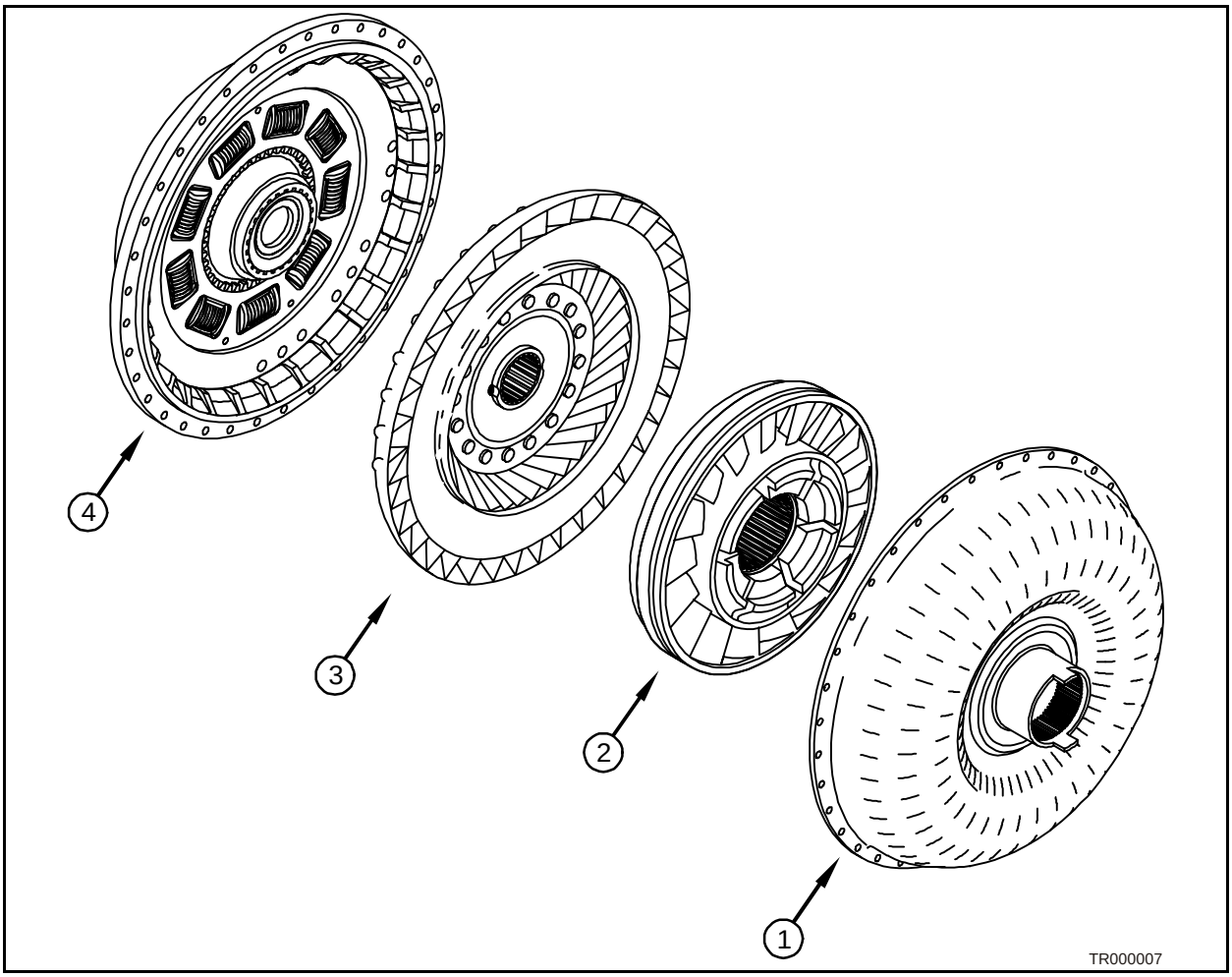

The transmission identification plate is located on the right-rear side of the transmission.

The identification plate shows the transmission serial number, part number (assembly number), and model number.

Use all three numbers when ordering parts.

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## TORQUE CONVERTER




1. Pump.
2. Stator.
3. Turbine.
4. Lock-up Clutch.

### Operational Overview

The torque converter provides a hydro-mechanical coupling that supplies rotational input from the engine to the transmission's gearing.

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## TORQUE CONVERTER OPERATION

The HD torque converter has four main components:

- Pump.
- Stator.
- Turbine.
- Lock-up clutch.

The converter's pump is bolted to the converter cover.

The pump rotates at engine speed

- As the pump rotates, fluid enters from around the pump hub.
- Centrifugal force causes fluid to be thrown around the outside of the pump and over to the converter turbine.
- Once the force reaches a certain point, the fluid begins to spin the turbine.

The converter's turbine is splined to the transmission turbine shaft.

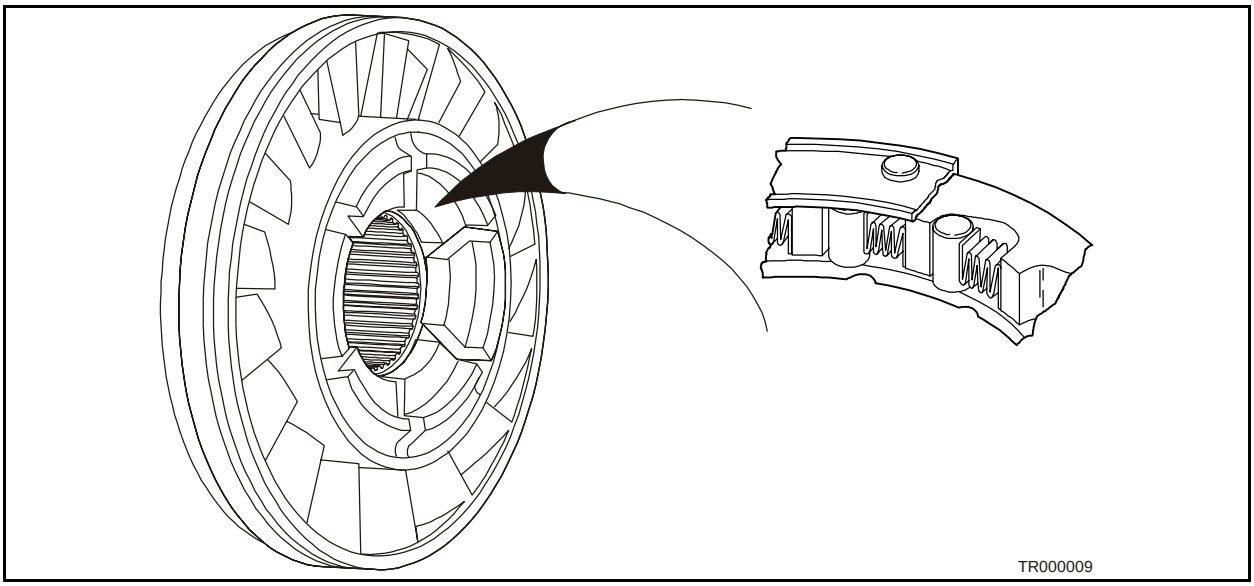
- Fluid from the converter pump strikes the turbine's vanes and eventually forces the turbine to rotate.
- Since the turbine is splined to the turbine shaft, the turbine shaft rotates and supplies input to the transmission's gearing.
- Fluid exits the turbine near its hub and flows to the stator.

The stator redirects fluid back to the converter pump.

- When fluid from the turbine hits the front of the stator blades, the stator locks against its one-way clutch.
- Fluid leaving the locked stator is directed back to the pump at an accelerated rate, increasing torque.
- As the turbine gains speed, it directs oil to the back side of the stator blades, causing the stator to "freewheel".
- Fluid flowing through the freewheeling stator is no longer accelerated and does not increase torque.
- As turbine speed increases, flow through the stator becomes smoother and eventually stops.

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## Stator One-way Clutch Operation

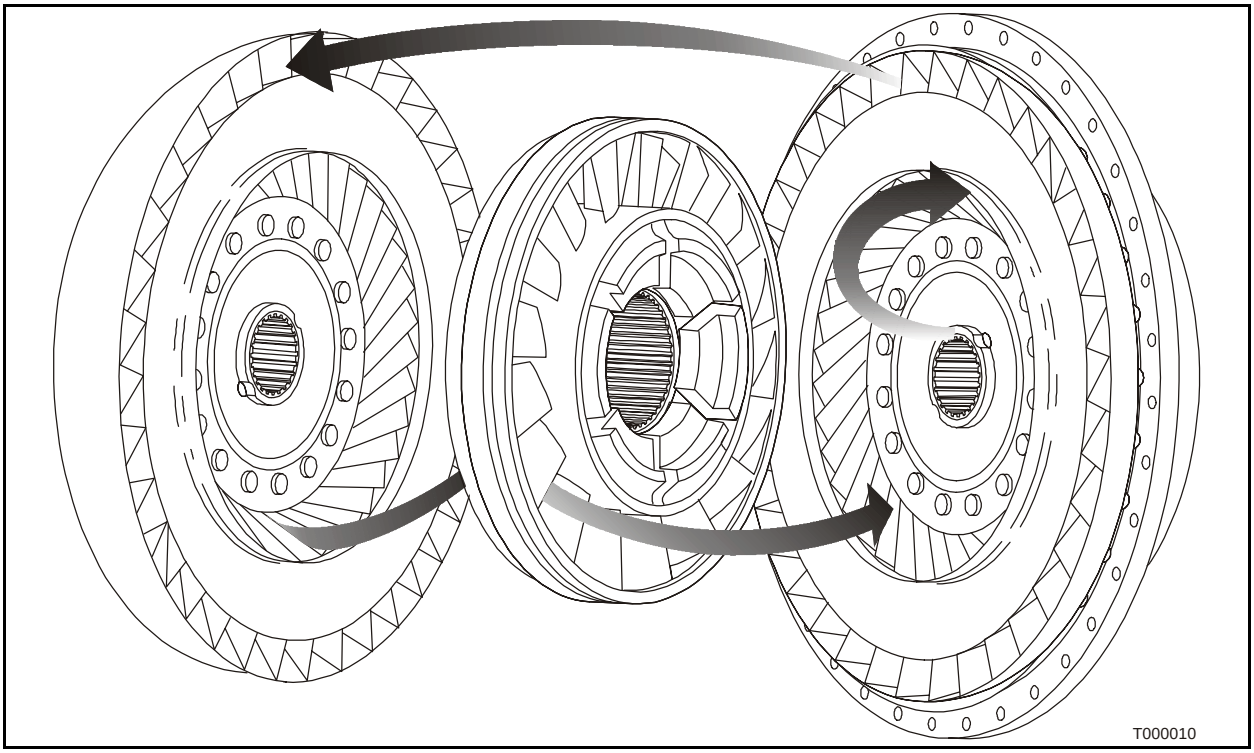



The stator's one-way clutch provides locking and freewheeling action.

- A series of rollers and springs are located inside the stator.
- When fluid strikes the front of the stator blades, the stator tries to rotate in a counter clockwise direction.
- This wedges the rollers into the small side of the tapered cavity, the stator is locked and can't rotate that direction.
- When fluid strikes the back side of the stator blades, the stator begins to rotate in a clockwise direction.
- The wedged rollers are released, and the one-way clutch's design allows the stator to rotate in a clockwise direction.

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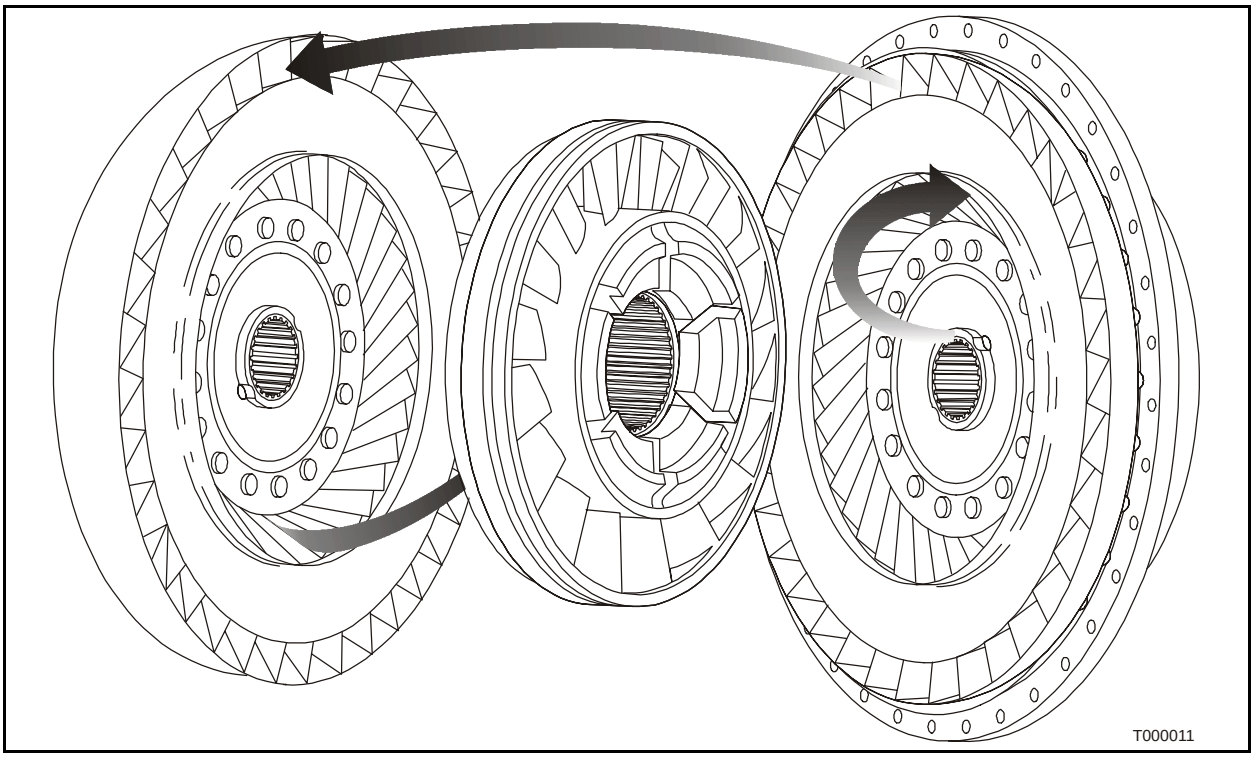
## Vortex Flow




- Vortex flow occurs when the stator is in the locked position.
- The turbine is still stalled or moving slowly.
- Fluid exiting the turbine strikes the front face of the stator blades.
- This locks the stator
- The locked stator directs fluid back to the pump at an accelerated rate.
- This helps the pump increase torque by adding an extra “**push**.”

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## Rotary Flow



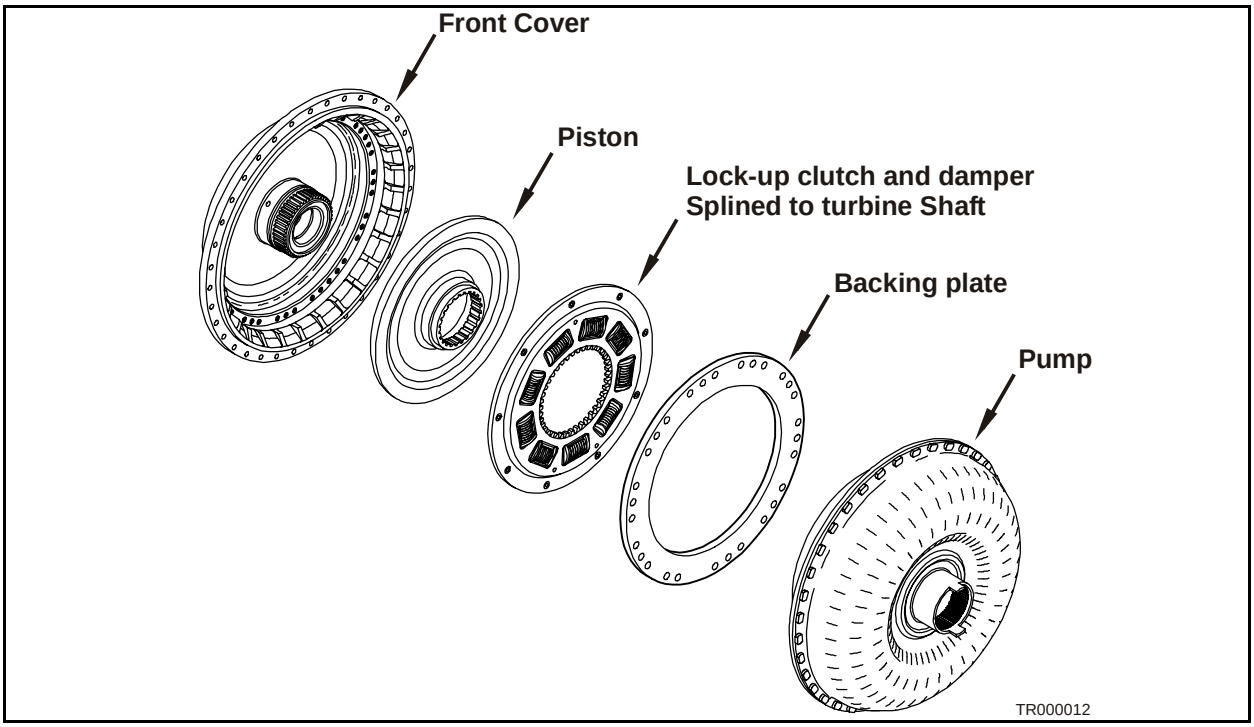

Rotary flow occurs when the stator is in the freewheeling position.

As the turbine begins to rotate and its speed increases, the fluid exiting the turbine strikes the back of the stator blades.

- This frees the one-way clutch and allows the stator to rotate.
- The fluid flow through the stator becomes much smoother and slowly ceases.
- This eliminates the torque increase.

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## LOCK-UP CLUTCH OPERATION




The torque converter's fluid coupling will never allow turbine speed to equal engine speed.

- Once rotary flow has been achieved and certain speed and range requirements are met, the torque converter attains "lock-up."
- This physical connection between the converter turbine and pump allows the turbine to rotate at engine speed.

Lock-up clutch components include:

- The backing plate always rotates at engine speed.
- A torsional damper and lock-up clutch plate assembly - located next to the backing plate. It's splined directly to the turbine.
- The lock-up clutch piston - located inside the converter front cover.
- It's splined to the converter front cover and always rotates at engine speed.
- Hydraulic fluid forced between the front cover and lock-up clutch piston causes the piston to move. This "sandwiches" the clutch plate between the piston and backing plate, forcing the clutch plate to rotate at engine speed.
- Since the clutch plate is splined to the turbine, the transmission's input equals engine RPM.

## Stall Testing

Stall testing is performed to determine whether a power complaint is due to an engine problem or transmission malfunction.

Stall speed is the maximum engine RPM attainable when the engine is at full throttle and when the torque converter turbine is not moving, or "stalled."

During stall test, compare actual engine speed at full throttle stall with established engine manufacturer's specifications

### Stall Test Procedure

To bring oil temperature up to stall testing temperature:

- Before starting check that the oil on the dipstick is within the safe operating band.
- Place chocks in front and behind wheels.
- Ensure that no person is working on or under the machine.
- Start the engine and let it idle.

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- If Prolink is available connect it, select "**Diagnostic Data**" and scroll to "**sump temperature**". If no Pro-Link is available the MDU can be used by selecting "**Actual Values** "and pressing "**Select**" and then "**Next**", taking you to **"Transmission values"**. Press "**select**" and this will bring you to **"Transmission Temp"**. The transmission sump temperature must be monitored at all times during stall test.
- 6. Apply the park brake.
- 7. Let the air pressure build up until the low air pressure buzzer goes off.
- 8. Push the service brake pedal down and keep it down.
- 9. Select first gear.
- 10. Push accelerator pedal until engine is running at 1000RPM and keep at this RPM for no longer than 15 - 20 seconds.
- 11. Remove foot from accelerator pedal and select neutral.
- 12. Push accelerator until engine is running at 1500RPM and hold for approximately 30 seconds. (This will allow the oil to circulate, preventing a large temperature difference within the pump, thus preventing any damage to the pump).
- 13. Remove foot from accelerator pedal.
- 14. Repeat steps 9 to 13 until the sump temperature stabilizes around 70 ºC - 80 ºC (160 ºF- 175 ºF).

**Checking of stall RPM:**

- 1. Bring sump temperature as described above.
- 2. Select first gear and apply foot brake pedal and keep it down.
- 3. Push accelerator pedal all the way down.
- 4. After 10 - 15 seconds the RPM will stabilize.(Do not exceed 20 seconds).
- 5. This stabilised RPM will be the stall RPM. (Refer to table:1on the next page.)
- 6. Remove foot from accelerator pedal.
- 7. Select neutral. Accelerate to 1500RPM for 2 minutes to cool the transmission.
- 8. Let engine idle for at least 1 minute before switching off.

**NOTE:1. Never stall for longer than 20 seconds.**
**2. If you have a prolink available the optimum range to stall in is fourth range.**
**3. Always refer to latest service bulletin for stall speed specifications.**

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## B40D/B35D STALL SPEEDS

| Model | Low idle | High idle | Stall speed |
|---|---|---|---|
| B40D | 600 rpm | 2240 rpm | 1637 rpm |
| B35D | 600 rpm | 2240 rpm | 1596 rpm |

## Analysing Stall Test Results

If stall test readings are 150 RPM higher or lower than specifications...

- The stall test readings are acceptable.
- Stall test readings may vary slightly above or below specifications, depending on ambient temperature, altitude, tachometer variations and other conditions.

If stall test readings are 200 RPM or more below specifications...

- The engine may be down on power.
- The engine may not be attaining full fuel.

If stall test readings are extremely low (about 30% lower than specifications...)

- The engine may be severely down on power.
- The engine may not be attaining full fuel.
- The converter stator may be freewheeling.

If stall test readings are 200 RPM or more above specifications...

- The transmission may have slipping clutches.
- Transmission oil level might be too low or high.
- Converter out pressure may be too low due to internal transmission problem.

If stall test readings are normal, but there are high converter out temperatures after cool down...

- The converter stator may be stuck.
- The transmission cooling system may not be operating properly.
- The engine cooling system may not be operating properly.

## Trouble Shooting A Freewheeling Stator

A freewheeling stator can cause extremely low stall speeds.

- To verify a freewheeling stator prior to tear down, road test the vehicle.
- If the vehicle has no power at low speed, but performs normally at high speeds, the stator may be freewheeling.
- Elevated oil temperatures or no full-throttle upshifts can also indicate a freewheeling stator.

## Troubleshooting A Stuck Stator

A stuck stator can cause high converter out temperatures after cool down, despite normal stall test readings.

- A stuck stator can also prevent the vehicle from reaching its top speed and/or transmission overheating at highway speeds.
- To verify a stuck stator prior to tear down, stall test as follows:
- Stall until converter out temperature reaches 120-130°C (250- 270 ° F.)
- Place the transmission in neutral, then accelerate the engine to between 1200 and 1500-RPM for 2 to 3 minutes.
- If the converter out temperature doesn't drop, the stator may be stuck or the engine/ transmission cooling system may be malfunctioning.

If tests confirms that the converter stator is suspect, remove the transmission, disassemble the torque converter and inspect the stator, springs, rollers and race.

## Stall Torque Ratio

Stall torque ratio reflects the amount of turbine shaft torque the converter develops compared to the amount of torque the engine develops.

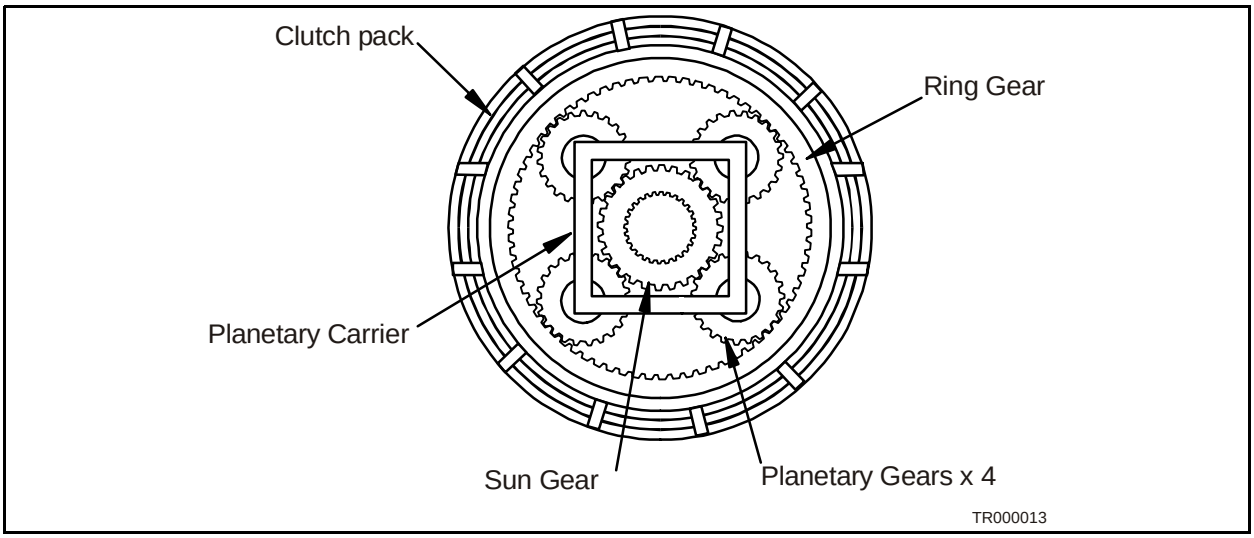
Example: If the converter configuration provides a 2:1 stall torque ratio, the torque converter is capable of delivering twice the engine's torque to the transmission gearing.

**NOTE:The Stall Torque Ratio Of The B40D Is 1.9: 1**

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# PLANETARY GEARS AND POWER FLOWS

## Planetary Gear Sets




The HD transmission uses three sets of planetary gears.

- Understanding basic planetary gear operation is critical to understanding the HD's operating principles.
- Planetary gear sets consist of a sun gear, planetary pinion gears (held by a carrier) and a ring gear.

**Gear relationships:**

- When two gears with external teeth mesh, their rotation is opposite each other.
- Example - the sun gear and pinion gears.
- When a gear with external teeth meshes with a gear with internal teeth, they rotate in the same direction.
- Example - the pinion gears and the ring gear.
- These gear relationships provide the basis for planetary gear operation.

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## THE BASIC LAWS OF PLANETARY GEAR SETS

| SUN | CARRIER | RING | SPEED | TORQUE | DIRECTION |
|---|---|---|---|---|---|
| INPUT | OUTPUT | HELD | MAXIMUM REDUCTION | INCREASE | SAME AS INPUT |
| HELD | OUTPUT | INPUT | MINIMUM REDUCTION | INCREASE | SAME AS INPUT |
| OUTPUT | INPUT | HELD | MAXIMUM INCREASE | REDUCTION | SAME AS INPUT |
| HELD | INPUT | OUTPUT | MINIMUM INCREASE | REDUCTION | SAME AS INPUT |
| INPUT | HELD | OUTPUT | REDUCTION | INCREASE | OPPOSITE OF INPUT |
| OUTPUT | HELD | INPUT | INCREASE | REDUCTION | OPPOSITE OF INPUT |

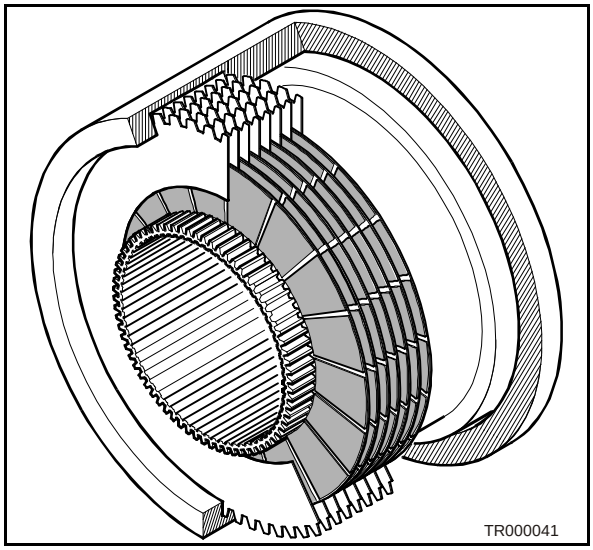
**NOTE: When any two members are held together speed and direction are same as input. The ratio will be 1:1**

When one planetary component is held and another is rotated, or "**input**," the third member becomes an output mechanism.

Depending on which components are held and input, the planetary gear set can develop various output ratios:

- Decrease input speed
- Increase input speed
- Provide direct, 1:1 drive
- Create reverse

## CLUTCHES



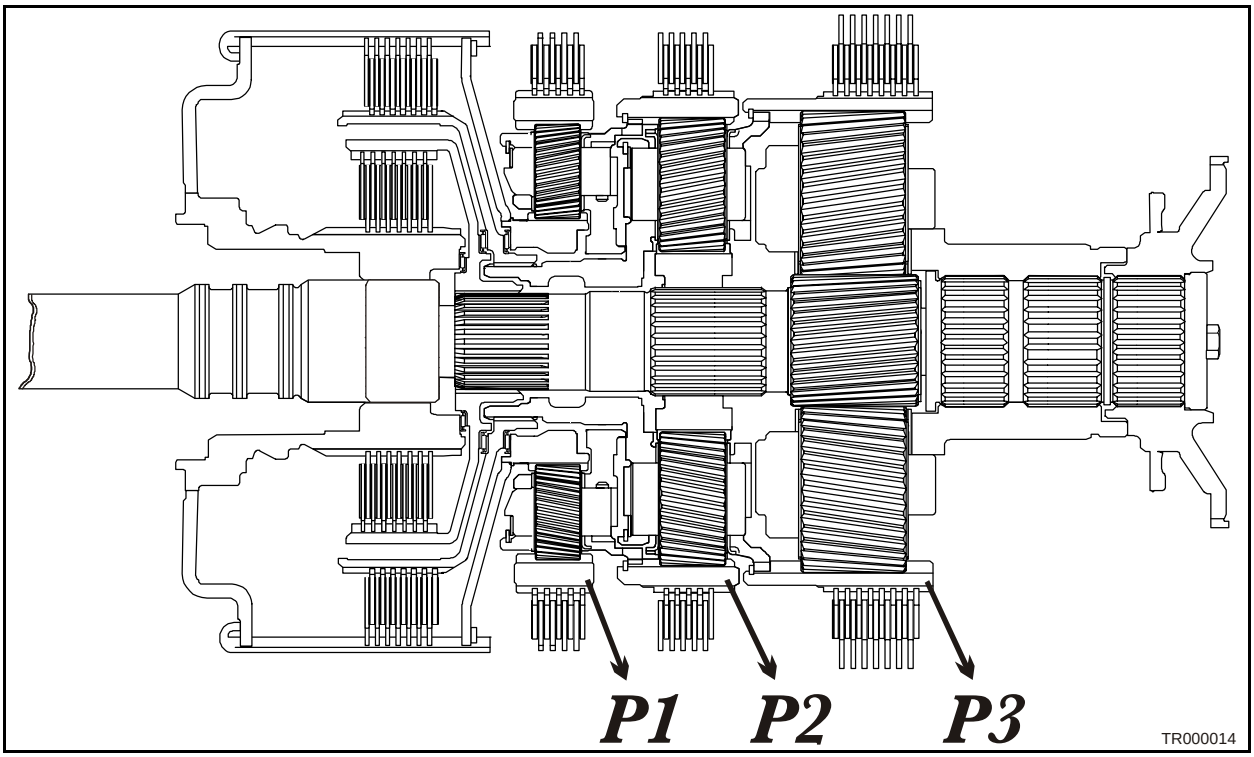

Clutches provide the input and holding power planetary gear sets required for operation.

- Clutches in the HD transmission can be either rotating or stationary.
- Rotating clutches supply rotational input to other shafts or components.
- The HD transmission's rotating clutches are located in the rotating clutch module.

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- Stationary clutches hold components in place, allowing other components to be input and output.
- The HD has three stationary clutches that hold planetary gear components.
- Clutches consist of two intertwined sets of clutch plates and a piston.
- Two kinds of plates are used - fibre, “**friction**,” plated and steel, “**reaction**” plates.
- Plates are alternated in the clutch assembly so that they sandwich each other.
- One set of clutch plates is splined to an inner component, the other is splined to an outer component (The housing).
- Even though the plates are intertwined, they rotate independently, when not applied.
- The clutch assembly has a piston and spring assembly.
- When the clutch is applied, the piston forces The intertwined plates together as one unit.
- When the clutch is released, the spring assembly returns the piston.
- If one of the components splined to the clutch plates is stationary, the clutch is a “**stationary clutch**”.
- If both components splined to the clutch plates are capable of rotating the clutch is a “**rotating clutch**.”

## HD TRANSMISSION PLANETARY CONFIGURATION




The HD’s planetary gear sets are labelled P1, P2 and P3.

### P3 Planetary configuration:

- The P3 carrier is connected directly to the output shaft.
- The P3 sun gear is part of the main shaft module.
- The P3 ring gear is connected directly to the P2 carrier.

### P2 Planetary configuration:

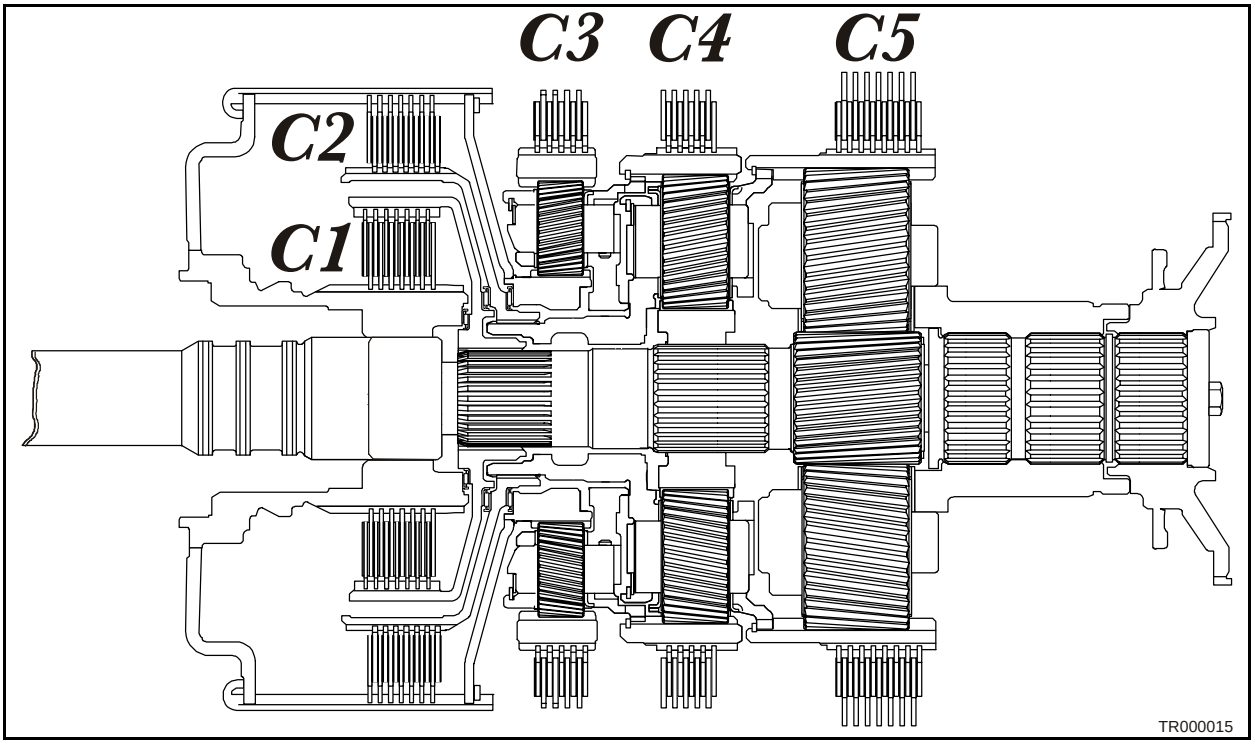
- The P2 carrier is connected directly to the P3 ring gear.
- The P2 sun gear is part of the main shaft module.
- The P2 ring gear is connected directly to the P1 carrier.

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**P1 Planetary configuration:**

- The P1 carrier is connected directly to the P3 ring gear.
- The P1 sun gear is connected directly to the rotating clutch module (it always rotates at turbine speed).
- The P1 ring gear is not connected to any planetary components.

## HD TRANSMISSION CLUTCH CONFIGURATION




Each ring gear has a corresponding clutch.

- Clutches are labelled C5 (holds the P3 ring gear), C4 (holds the P2 ring gear) and C3 (holds the P1 ring gear).
- Two rotating clutches are located inside the rotating clutch module.
- C1 is the smaller inner clutch - when applied, it transmits rotational input to the main shaft.
- C2 is the larger outer clutch - when applied, it rotates the P2 carrier.

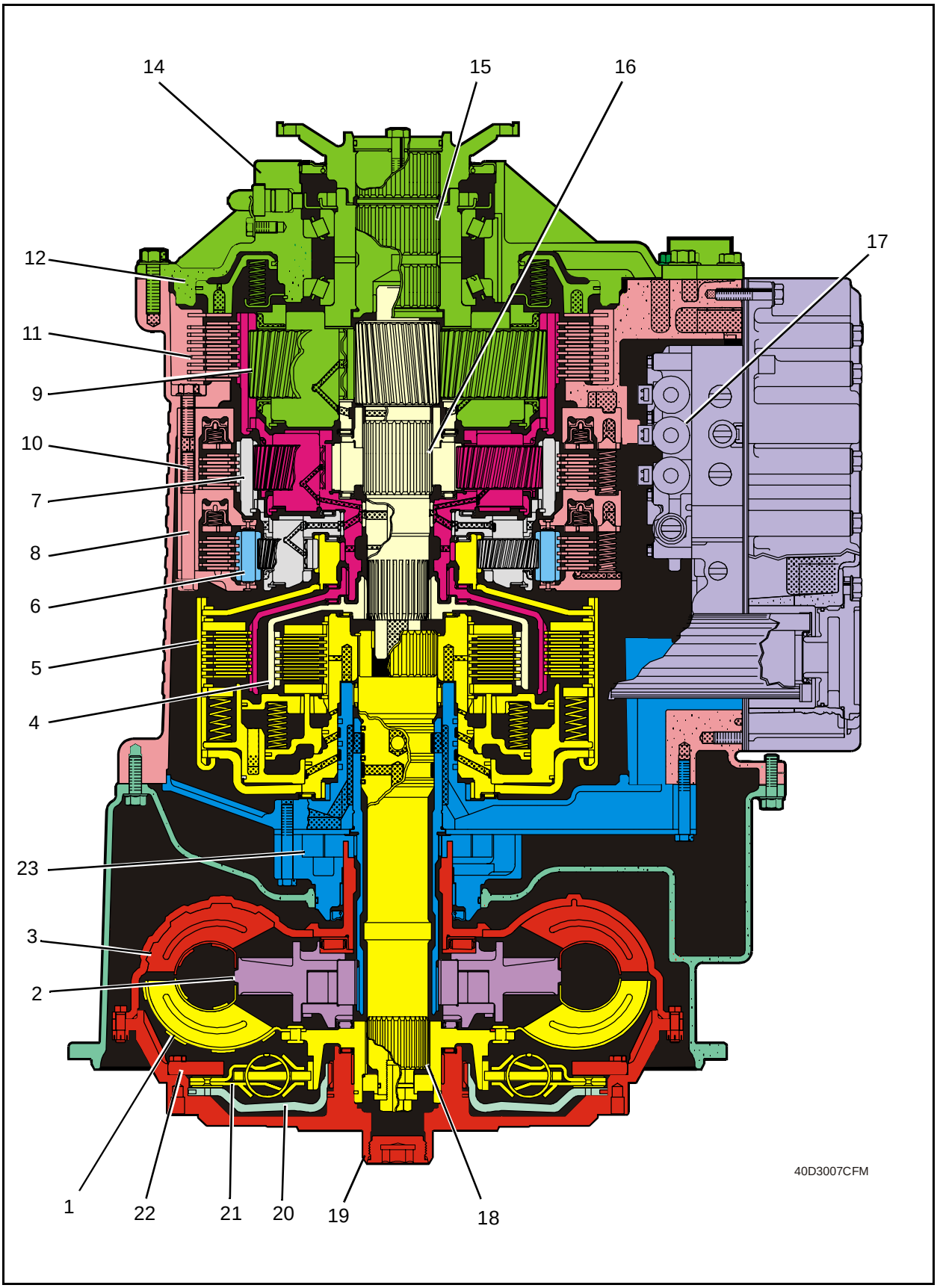
| CLUTCHES | C1 | C2 | C3 | C4 | C5 |
|---|---|---|---|---|---|
| NEUTRAL | | | | | X |
| FIRST | X | | | | X |
| SECOND | X | | | X | |
| THIRD | X | | X | | |
| FOURTH | X | X | | | |
| FIFTH | | X | X | | |
| SIXTH | | X | | X | |
| REVERSE | | | X | | X |

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## Transmission Cross Sectional Diagram

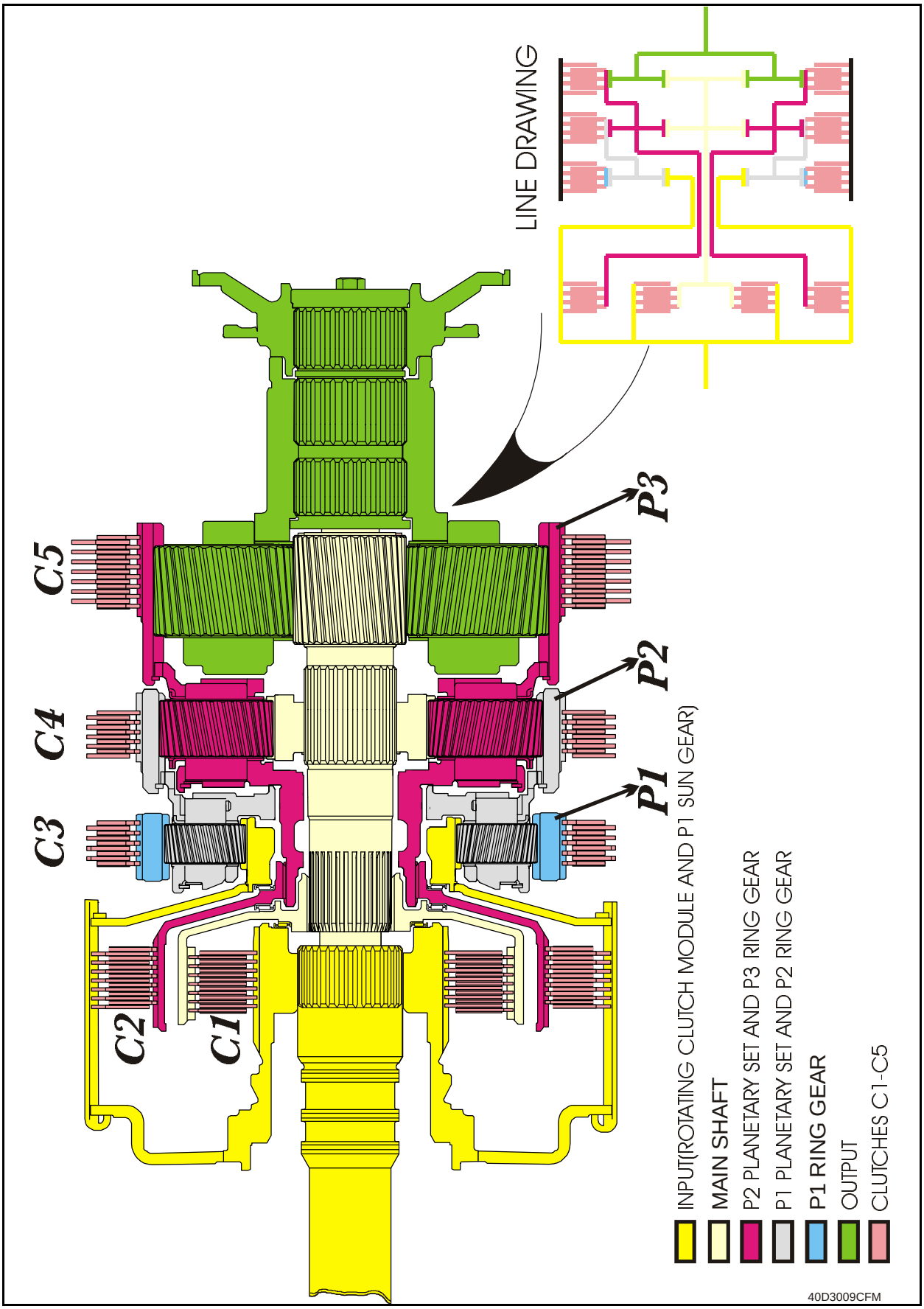


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1. Torque Converter Turbine.
2. Torque Converter Stator.
3. Torque Converter Pump.
4. C1 Clutch.
5. C2 Clutch.
6. P1 Planetary.
7. P2 Planetary.
8. C3 Clutch.
9. P3 Planetary.
10. C4 Clutch.
11. C5 Clutch.
12. Retarder Stator.
13. Retarder Rotor (Not Shown).
14. Retarder Housing.
15. Output Shaft.
16. Main Shaft.
17. Clutch Solenoid.
18. Turbine Shaft.
19. Engine Input.
20. Lockup Clutch Piston.
21. Lockup Clutch Plate and Damper.
22. Lockup Clutch Backing Plate.

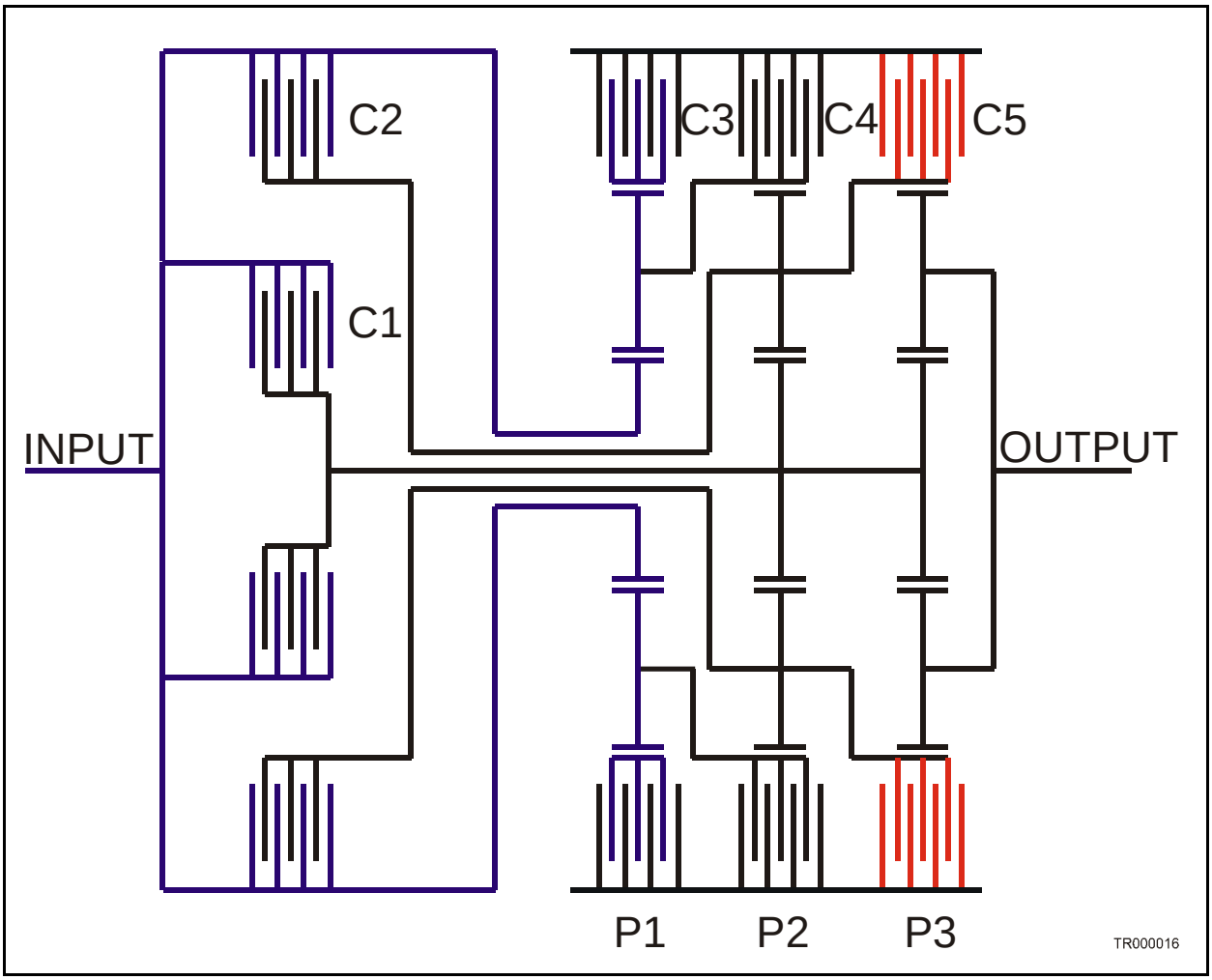
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## POWER FLOW



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## Neutral Power Flow

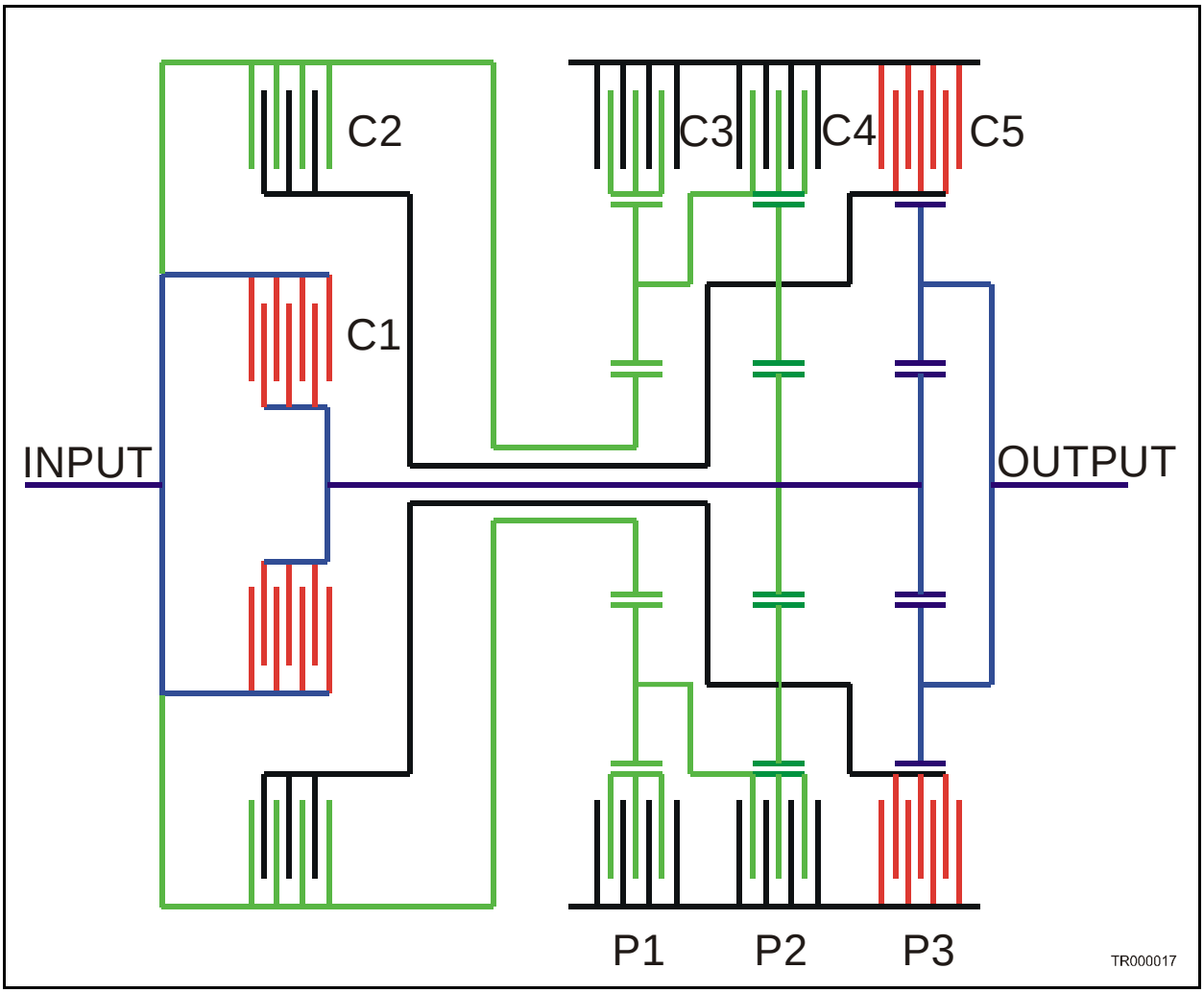



In neutral, only C5 clutch is applied

- Rotational power from the torque converter is not transmitted beyond the rotating clutch module and the P1 planetary sun gear.
- If the vehicle is rolling while in neutral, different clutches may be applied.
- This controls the speed of rotating components under varying conditions.
- Depending on output shaft speed, the transmission may attain N1, N2, N3 or N4 - this corresponds to clutches C5, C4, C3 and C4 respectively.

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## 1st Range Power Flow

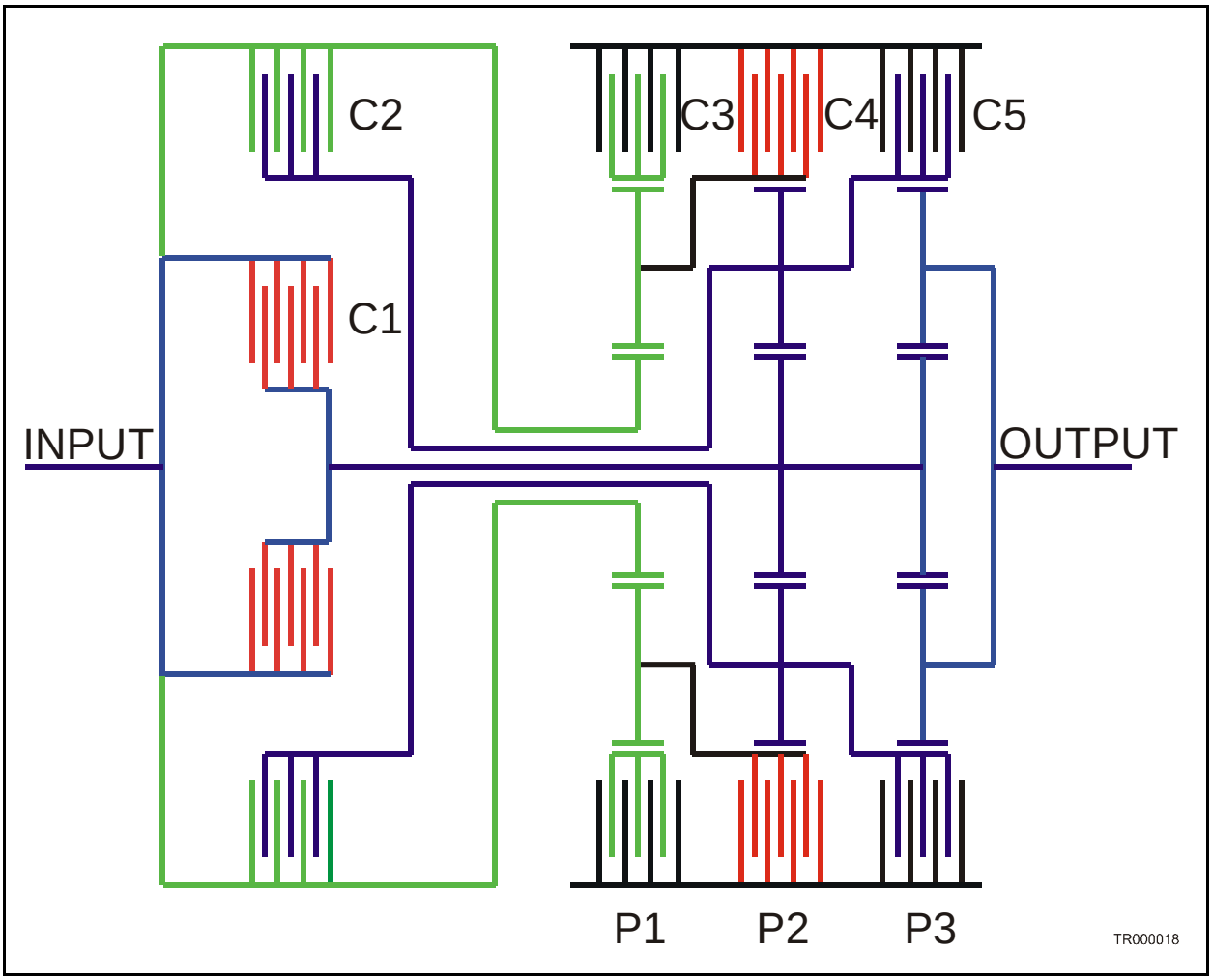



In first range, the C1 and C5 clutches are applied.

- C1 locks the turbine shaft and main shaft together.
- The P3 sun gear is part of the main shaft module, so it becomes input for the P3 Planetary set.
- C5 holds the P3 ring gear.
- Since the P3 sun gear is input and the P3 ring gear is held, the P3 carrier becomes the output.
- The P3 carrier is splined directly to the output shaft.

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## 2nd Range Power Flow

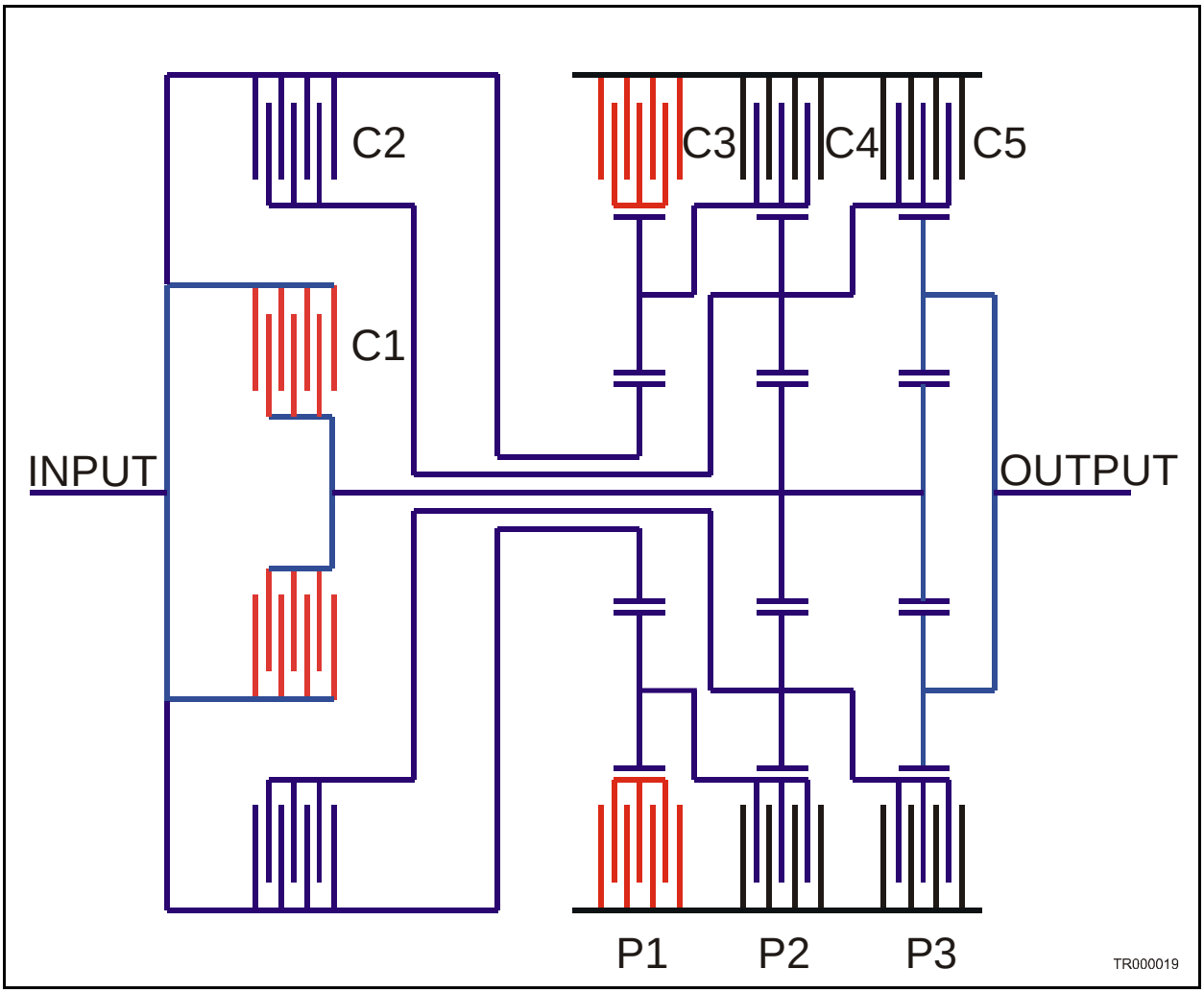



In second range, the C1 and C4 clutches are applied and the P2 and P3 planetary sets work together to provide the appropriate output.

- The C1 clutch locks the turbine shaft and main shaft together.
- This drives the P2 sun gear.
- The C4 clutch holds the P2 ring gear.
- Since the P2 sun gear is input and the P2 ring gear is held, the P2 carrier becomes output.
- The P3 sun gear is splined to the main shaft, so it's rotating.
- The P3 ring gear is splined to the P2 carrier, so it's rotating, but at a slower rate than the P3 sun gear.
- The P3 ring gear acts like a held member, and the P3 sun gear becomes input.
- The P3 carrier becomes output, and it's splined to the output shaft.

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## 3rd Range Power Flow

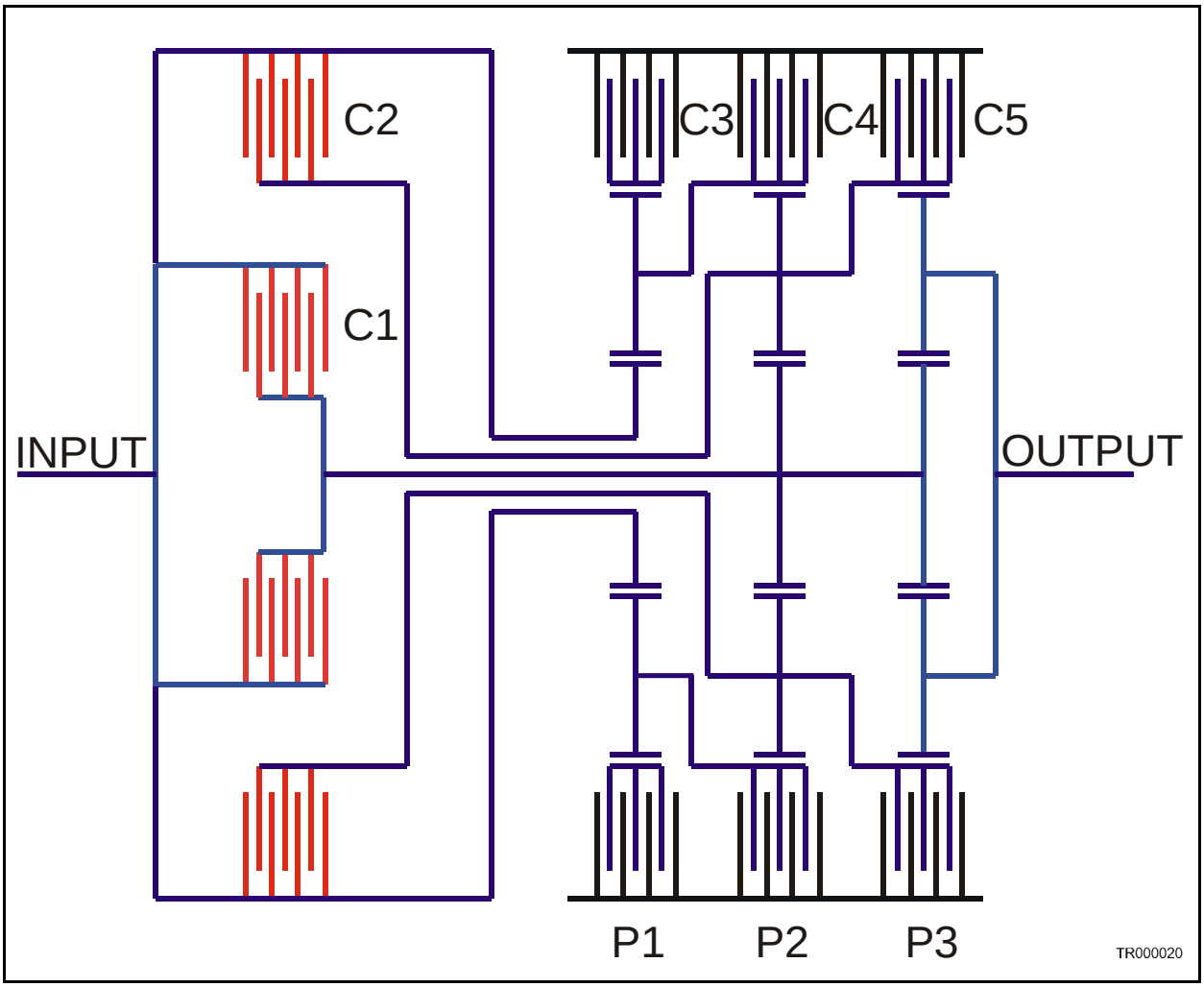



In third range C1 and C3 clutches are applied and all three planetaries work together to provide the appropriate output.

- The C1 clutch locks the main shaft to the turbine shaft, and the rotating clutch module rotates the P1 ring gear.The C3 clutch holds the P1 ring gear.
- Since the P1 sun gear is input and the P1 ring gear is held, the P1carrier becomes output.The P2 sun gear is rotating with the main shaft.
- The P2 ring gear is splined to the P1 carrier, so its rotating.
- Since the P2 ring gear is rotating slower than the P2 sun gear, it acts like a held member. The P2 sun gear is input , the P2 ring gear is held so the P2 carrier becomes output.The P3 sun gear is rotating with the main shaft.
- The P3 ring gear is splined to the P2 carrier, so it's rotating with the P2 carrier, at a slower speed than the P3 sun gear.
- The P3 sun gear is input, the P3 ring gear acts like a held member, and the P3 carrier (which is splined to the output shaft) becomes output.

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## 4th Range Power Flow

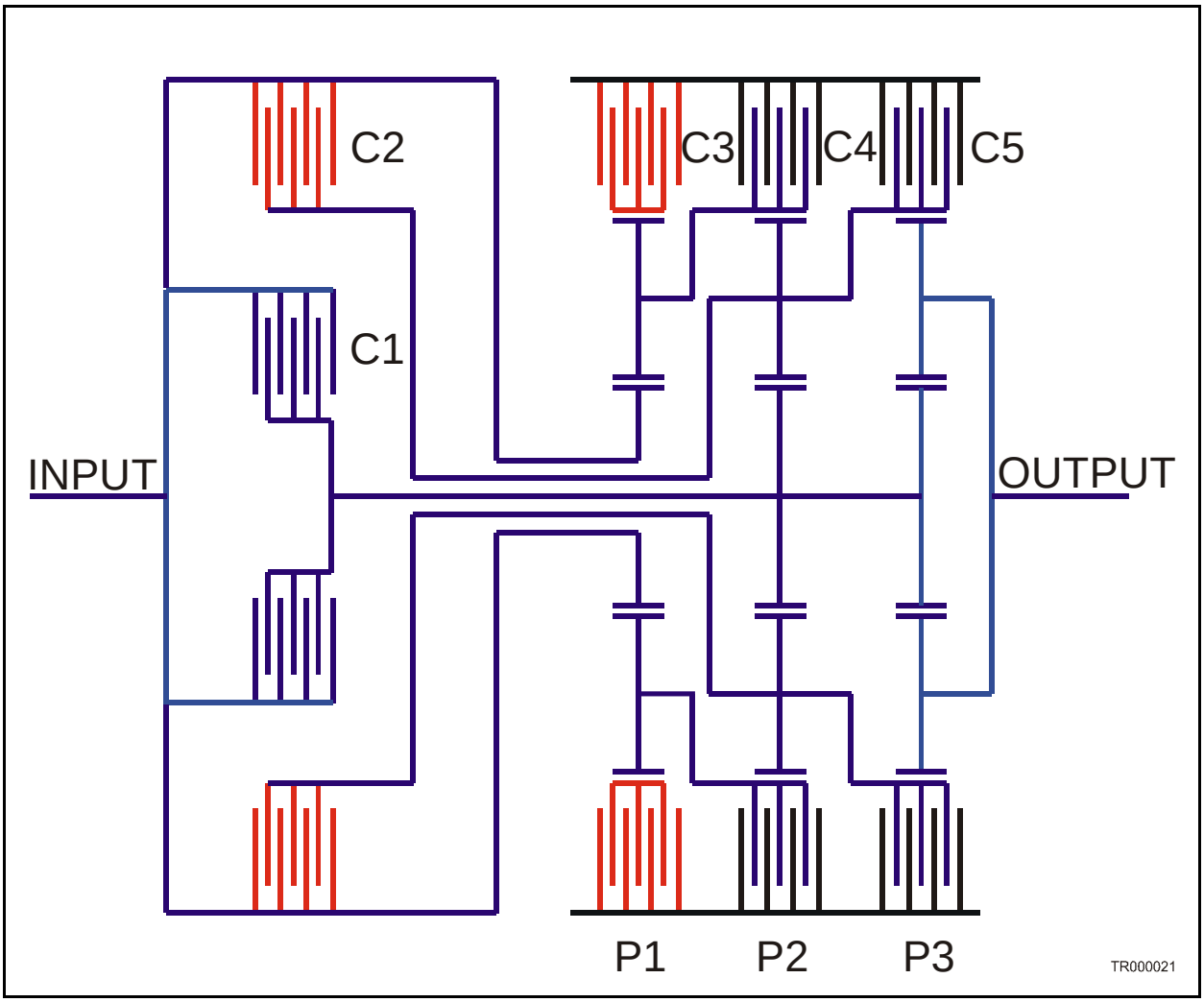



In fourth range, both rotating clutches (C1 and C2) are applied.

- The C1 clutch locks the turbine shaft to the main shaft.
- The C2 clutch locks the turbine shaft to the P2 carrier.
- Since no stationary clutches are applied, all three planetary sun gears, carriers and ring gears rotate the same speed and direction as the turbine shaft.
- The P3 carrier is the output and it's splines directly to the output shaft.
- Since all components are rotating together, the fourth range final gear ratio is 1 to 1, or direct drive.

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## 5th Range Power Flow

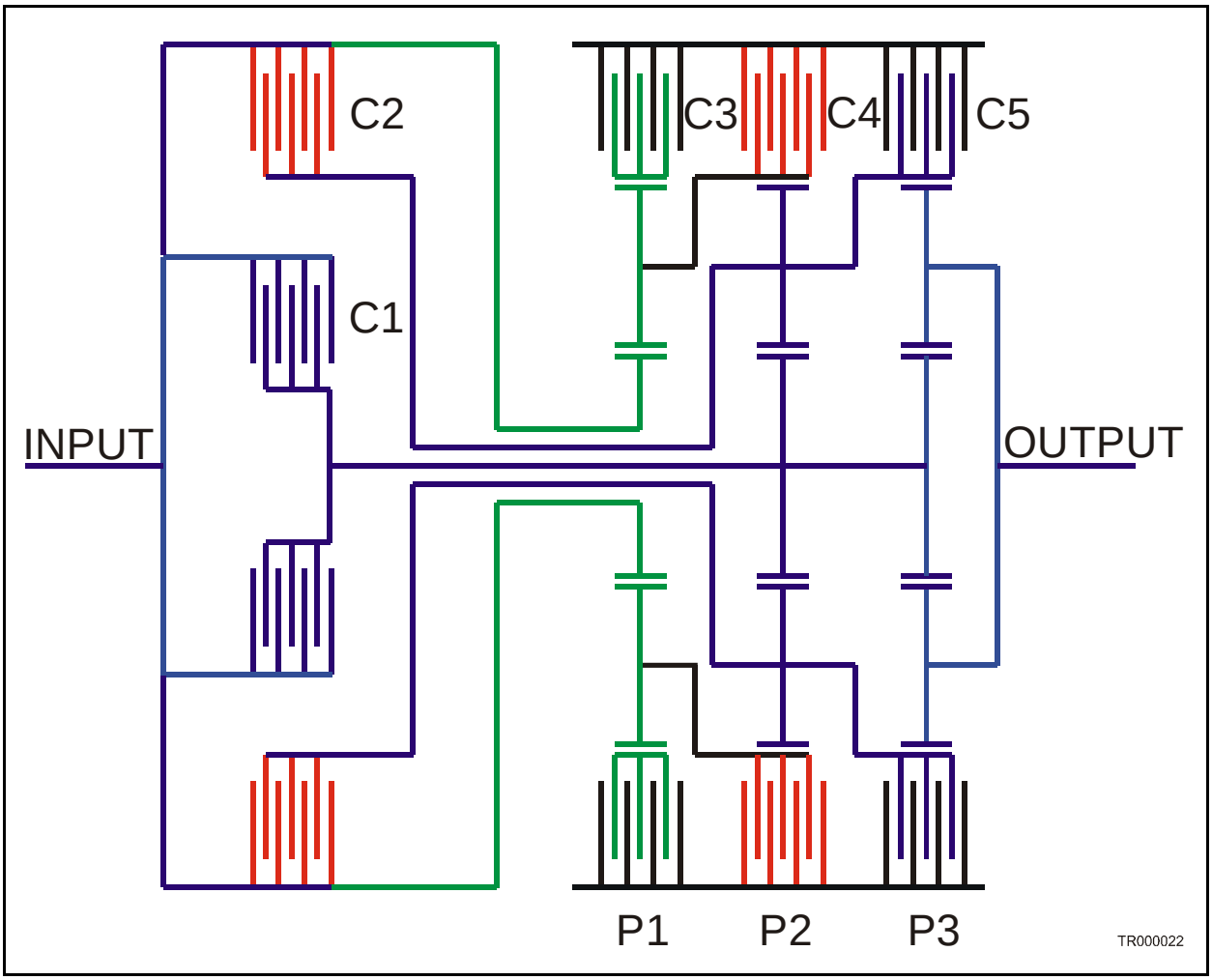



In fifth range, the C2 and C3 clutches are applied and all three planetary sets work together to create the appropriate output.

- The P1 sun gear is rotating with the rotating clutch module.The C3 clutch is holding the P1 ring gear stationary.The P1 carrier becomes output.
- The P2 carrier is rotating at turbine speed (the C2 clutch locks the turbine to the P2 carrier). The P2 ring gear is splined to and rotating with the P1 carrier.
- The P2 carrier is rotating faster than the P2 ring gear, so it's input and the ring gear acts like a held member.The P2 sun gear acts like a held member.
- The P2 sun gear rotates the main shaft and the P3 sun gear.The P3 ring gear is splined to and rotating with the P2 carrier.
- The P3 sun gear is rotating faster than the P3 ring gear, so the sun gear is input and the ring gear acts a a held member.The P3 carrier becomes output, and it's splined to the output shaft.This gearing combination creates an overdrive.

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## 6th Range Power Flow

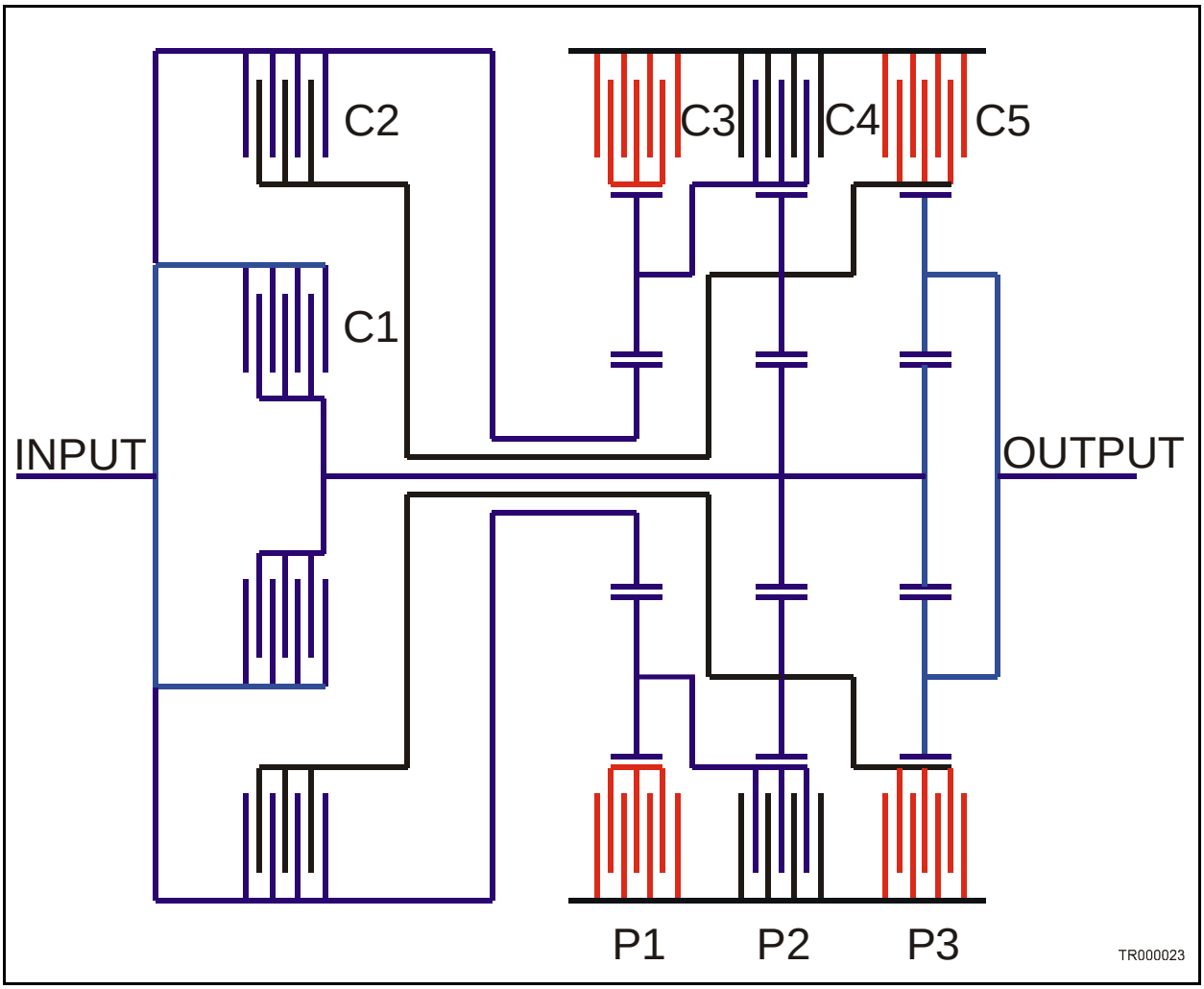



In six range, the C2 and C4 clutches are applied and the P2 and P3 planetary sets work together to create the appropriate output.

- The C2 clutch locks the P2 carrier to the turbine shaft.
- The C4 clutch holds the P2 ring gear.
- Since the P2 carrier is input and the P2 ring gear is held, the P2 sun gear becomes output.
- The P2 sun gear rotates the main shaft and the P3 sun gear.
- The P2 carrier is splined to and rotating the P3 ring gear.
- The P3 sun gear is input, the P3 ring gear acts like a held member.
- The P3 carrier becomes output, and it's splined to the output shaft.
- This gearing combination creates overdrive.

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## Reverse Range Power Flow




In reverse, the C3 and C5 clutches are applied and all three planetary gears work together to create output.

- The P1 sun gear is rotating with the rotating clutch module. The P1 ring gear is held by the C3 clutch. The P1 carrier becomes output.
- The P1 carrier is splined to the P2 ring gear. The P2 ring gear becomes input for the P2 planetary set.
- The C5 clutch holds the P3 ring gear. T he P3 ring gear is splined to the P2 carrier. Since the P2 ring gear is input and the P2 carrier is held, the P2 sun gear becomes output.
- Since the carrier is the held member, the P2 sun gear rotates opposite (counter-clockwise) the input component's direction. The P2 sun gear rotates the main shaft in the opposite direction (counter-clockwise).
- Since the P3 sun gear rotates with the main shaft, it also rotates in the opposite direction (counter-clockwise). The P3 sun gear becomes reverse input for the P3 planetary set. The P3 ring gear is held by the C5 clutch.
- The P3 carrier becomes reverse output, and it's splined to the output shafts.

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# HYDRAULIC SYSTEM

## System Function

The hydraulic system generates, directs, and controls the pressure and flow of transmission fluid (hydraulic fluid) within the transmission.

Transmission fluid is the power-transmitting medium in the torque converter. Its velocity drives the converter turbine.

Its flow cools and lubricates the transmission. Its pressure operated the various control valves that apply the clutches.

The primary components of the transmission hydraulic system is the transmission fluid, the charging pump, three integral filters, the control module, the breather, the cooler, and the C3 pressure switch.

The hydraulic system circuits are the main pressure circuit, the main control circuit, the torque converter circuit, the cooler lubrication circuit, the clutch-apply circuits, the exhaust circuit, and the exhaust backfill circuit.

The charging pump supplies transmission pressure and flow throughout the hydraulic system.

The charging pump draws fluid through the suction filter from the transmission sump, and pumps the fluid, under pressure, into the hydraulic system through the main filter.

Solenoids and valves, located in the transmission control module, control the flow and pressure of the hydraulic fluid.

Transmission fluid flows to specific clutches to achieve range shifts. Fluid for the cooler/ lubrication circuit flows through the lubrication filter.

The C3 pressure switch, located in the C3 clutch circuit, monitors circuit pressure. The TCU receives data from the C3 pressure switch to determine if C3 clutch operations have performed as expected.

An accumulator/relay valve is located ahead of the C3 pressure switch to dampen high-frequency hydraulic pulses in the clutch-apply circuit to prevent early failure of the C3 pressure switch.

# MAIN-PRESSURE CIRCUIT

The main pressure circuit supplies the primary source of fluid pressure to the hydraulic system.

The main pressure regulator valve controls the pressure in this circuit. The main-pressure regulator valve converts charging pump pressure to main pressure and regulates main pressure based upon input from the overdrive knockdown valve, the converter flow valve, and control main pressure.

The main-pressure regulator valve is held upward by spring force at the bottom of the valve. Main-pressure flows to the top of the regulator valve.

The main-pressure regulator valve is pushed downward when the main fluid pressure reaches a level high enough to overcome the spring force, pressing downward the main-pressure regulator valve and permitting excess fluid to exhaust, reducing main pressure.

This regulated main pressure is routed to seven areas in the hydraulic system. Passages in the control module direct main pressure to the input side of each of the six-solenoid regulator valves and to the control main regulator valve.

Pressure at the output side of each solenoid regulator valve is “**clutch feed pressure**.” Pressure at the output side of the control main regulator valve is “**control main pressure**.”

## Regulator Valves

The TCU controls the solenoids in the control module and the solenoids control the solenoid regulator valve.

The solenoids direct control main pressure to the top of a solenoid regulator valve, causing it to move against its spring.

Control main pressure forces the valve downward against spring force, blocks off the exhaust backfill circuit, and allows main pressure to move through the valve passage into the clutch feed circuit, applying the clutch.

When control main pressure is cut off from the top of the solenoid regulator valve, the valve spring forces the valve back to the top of its travel allowing the clutch-apply circuit to be exhausted to sump through passages in the exhaust backfill circuit and the clutch is released.

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## Clutch Application

Two clutches must be applied to attain a forward or reverse range. The clutch application chart lists the clutches that are applied in each of the forward ranges, neutral, and reverse, the corresponding energized solenoids, the C1 and C2 latch valve positions, and the converter flow valve position.

## Hydraulic Operation During Electrical Interruption

The solenoid regulator valves are controlled by solenoids that control transmission clutch applications.

The TCU electrically controls the solenoids, which control the solenoid regulator valves. Interruption of electrical power results in the solenoid regulator valves locking in their normally open or closed state.

To minimize the impact of an electrical interruption , WT series incorporate a system that enables the transmission to default to totally hydraulic operation.

The C1 and C2 latch valves have been designed into the clutch circuits to provide this default feature.

| Range | Clutches Applied | Solenoids Enerergized | C1 Latch Valve | C2 Latch Valve | Convertor Flow Valve |
|---|---|---|---|---|---|
| Neutral N1 | C5 | A,B,E | UP | UP | DOWN |
| Reverse | C3,C5 | A,B,C,E | UP | UP | DOWN |
| First | C1,C5 L/U | B,E,G* | DOWN | DOWN | DOWN |
| Second | C1,C4 L/U | B,D,F,G* | DOWN | DOWN | UP |
| Third | C1,C3 L/U | B,C,F,G | DOWN | DOWN | UP |
| Fourth | C1,C2 L/U | F,G | DOWN | DOWN | UP |
| Fifth | C2,C3 L/U | A,C,G,F | DOWN | DOWN | UP |
| Sixth | C2,C4 L/U | A,D,F | UP | DOWN | UP |

A and B solenoids are normally open (when not energized).

C,D,E,F and G solenoids are normally closed (when not energized).

*G solenoid is ON in 1st and 2nd range but is switched OFF for the duration of the 1st to 2nd upshift and the 2nd to 1st downshift.

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## Latch Valves

When a clutch is applied, clutch feed pressure is routed through the latch valve to the clutch piston.

Clutch-apply pressure against the lands of the latch valve hold the latch valve in place or, in normally closed valve, allows the fluid to simply flow through the valves.

During an electrical interruption, the latch valve cause the transmission to engage specific clutches based on the range in which transmission was operating when the interruption occurred.

The latch valves are activated by normally closed solenoid G. When solenoid G is energized, control main pressure flows to the top of the C1 and C2 latch valves.

This pressure forces the valves downward to connect the necessary flow passages for clutch engagement.

During an electrical interruption, the latch valves and the two normally open solenoids (A and B) enable the transmission to operate in a "**limp home**" mode allowing the operator to drive the vehicle to a location where it can be serviced.

The default system enables the transmission to revert to total hydraulic operation and provides safe operation during a electrical power interruption by shifting to a specific pre-determined range.

The following lists the operating range and the pre-determined default range the transmission will shift to in the event of an electrical interruption:

| Operating Range | Limp Home Range |
|---|---|
| Reverse | NNC |
| Neutral | NNC |
| First | Third |
| Second - Fifth | Fourth |
| Sixth | Fifth |

**NOTE:1. NNC : Neutral no Clutches.**
**2. The lockup clutch will always disengage during an electrical interruption or during critical transmission malfunction.**

## CONTROL MAIN CIRCUIT

The control main circuit supplies the steady pressure necessary to actuate the solenoid regulator valves.

The control main circuit receives its pressure from the main pressure circuit and, when needed, helps lower main pressure.

The control main regulator valve removes pressure to provide smooth, consistent control main pressure which aids accurate solenoid regulator valve movement.

Control main pressure is directed to each solenoid regulator valve and the overdrive knockdown valve.

When control main pressure is directed to the top of the solenoid regulator valve, control main pressure pushes against the valve, overcomes spring force and moves the valve downward.

Downward movement of a solenoid regulator valve opens passages that allow main pressure to flow past the valve to the clutch circuits.

## TORQUE CONVERTER CIRCUIT

When the torque converter is operating as a hydraulic coupling, a high, constant flow of fluid is required to cool and fill the converter.

During lockup operation, cooling is no longer required and high flow is unnecessary.

The converter flow valve, located in the control module, opens to release the fluid pressure in the converter, allowing the fluid to flow from the converter into the cooler/lubrication circuit.

To attain lockup, pressurized fluid must flow to the lockup piston. The lockup solenoid regulator valve in the control module directs fluid pressure to the lockup clutch piston.

Movement of the solenoid regulator valve allows regulated main pressure to be delivered to the lockup piston and engage the clutch.

If a critical transmission malfunction or electrical interruption occurs, the ECU disengages the lockup clutch.

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## CONVERTER-IN PRESSURE CIRCUIT

The converter regulator valve is located in the torque converter circuit and ensures the converter receives correct pressure from the main pressure regulator.

### Low (Below Normal) Converter-in Pressure

The converter regulator valve remains seated due to converter-in pressure being less than the valve spring force.

The converter-in fluid flows through the converter flow valve, through the converter, back through the converter flow valve, through the orifice in the valve body separator plate, and through the converter regulator valve to the cooler.

The orifice in the valve body separator plate allows increased converter pressure at low charging pump (engine) speed.

### Normal Converter-in Pressure

Converter-in pressure is sufficient to move the converter regulator valve slightly against its spring force.

This slight movement allows converter-out fluid to flow through the converter regulator regulator valve from both the separator plate orifice and the converter flow valve.

Fluid flow to the cooler is increased, reducing converter-out pressure.

### Excessive Converter-in Pressure

Converter-in pressure in excess of approximately 900kPa (130 psi) moves the converter regulator valve far enough against its spring to route excessive pressure to the suction side of the charging pump.

Converter-out fluid continues to flow through the converter flow valve, through both fluid passages, and to the cooler.

### Extremely High Converter-in Pressure

Transmission fluid not only transmits torque and pressure but also lubricates and cools the transmission, protecting it from wear, rust, and failure due to overheating.

Heat and wear-control is essential to ensuring the transmission will perform satisfactorily throughout its service life.

The cooler/lubrication circuit is fed by the converter flow valve as fluid is calculated to and from the torque converter.

A lubrication regulator valve in the cooler/ lubrication circuit ensures sufficient lubrication pressure.

The lubrication pressure, fed through the converter flow valve, overcomes lubrication regulator valve spring force.

Fluid is calculated through the cooler/lubrication circuit to the cooler unit, it is then moved through the cooler/lubrication circuit to lubricate and cool bearings, planetary gears, clutches, shafts, support equipment and all other moving components of the transmission.

### Exhaust Circuit

The exhaust circuit is the relief circuit for the transmission hydraulic system.

Pressure in this circuit is minimal and the fluid flowing through the exhaust circuit is returned to the sump.

Fluid flows into the exhaust circuit from the main pressure circuit and the exhaust backfill circuit when the pressures exceed the levels maintained by the regulator valves.

### Exhaust Backfill Circuit

When a clutch is disengaged, pressure in the clutch circuit is exhausted to sump through the exhaust backfill circuit.

Low exhaust backfill pressure exists in the clutch feed passage. When a clutch is released pressure in the exhaust backfill circuit is controlled by the exhaust backfill valve.

The low pressure keeps the clutch feed passages free of air. The absence of air in the system is vital for controlling clutches since air compresses, causing a shift to be either too hard or too soft.

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## HYDRAULICS (OPERATION)

The HD's hydraulic system is closed loop.

- Hydraulic fluid begins its journey in the sump, travels though the system to perform various tasks, then returns to the sump to cycle again and again.
- Hydraulic fluid is the basis for valve and clutch operation .Fluid also provides cooling and lubrication for the transmission's internal components.
- The flow of hydraulic fluid through the system is initiated by the charging pump.
- The charging pump is driven by the torque converter pump and always rotates at engine speed.

### Main Pressure Regulator

The charging pump draws fluid from the sump and forces it into the main pressure regulator.

- This valve adjusts and controls the system's main pressure.
- Charging pump pressure is directed through the main pressure regulator to the top of the valve.
- This forces the valve down against spring pressure and allows a certain amount of pressure to exhaust.
- The spring pressure and fluid pressure equalize themselves at a preset pressure rating.
- During certain ranges, additional pressurized fluid is directed to the main pressure regulator to help lower main pressure.

### Control Main Regulator

Main pressure leaving the main pressure regulator is directed to the control main pressure regulator.

The control main pressure regulator is another regulating valve.

- Main pressure enters, then is directed to the top of the valve.
- This forces the valve down against spring pressure, reducing main pressure to about 690 kPa (6.9 bar) (100 psi).
- This new pressure is called "control main pressure".
- Control main pressure is directed to a series of solenoids.
- Solenoids are energized and de-energized by signals from the Electronic Control System's Electronic Control Unit (TCU).
- Pressure from the control main regulator is directed to each solenoid.
- Solenoid design allows control main pressure to "**cascade**" to the next solenoid in line.
- Main pressure from the main pressure regulator is directed to each solenoid regulator valve.
- Solenoid regulator valve design allows main pressure to "**cascade**" to the next solenoid regulator valve.

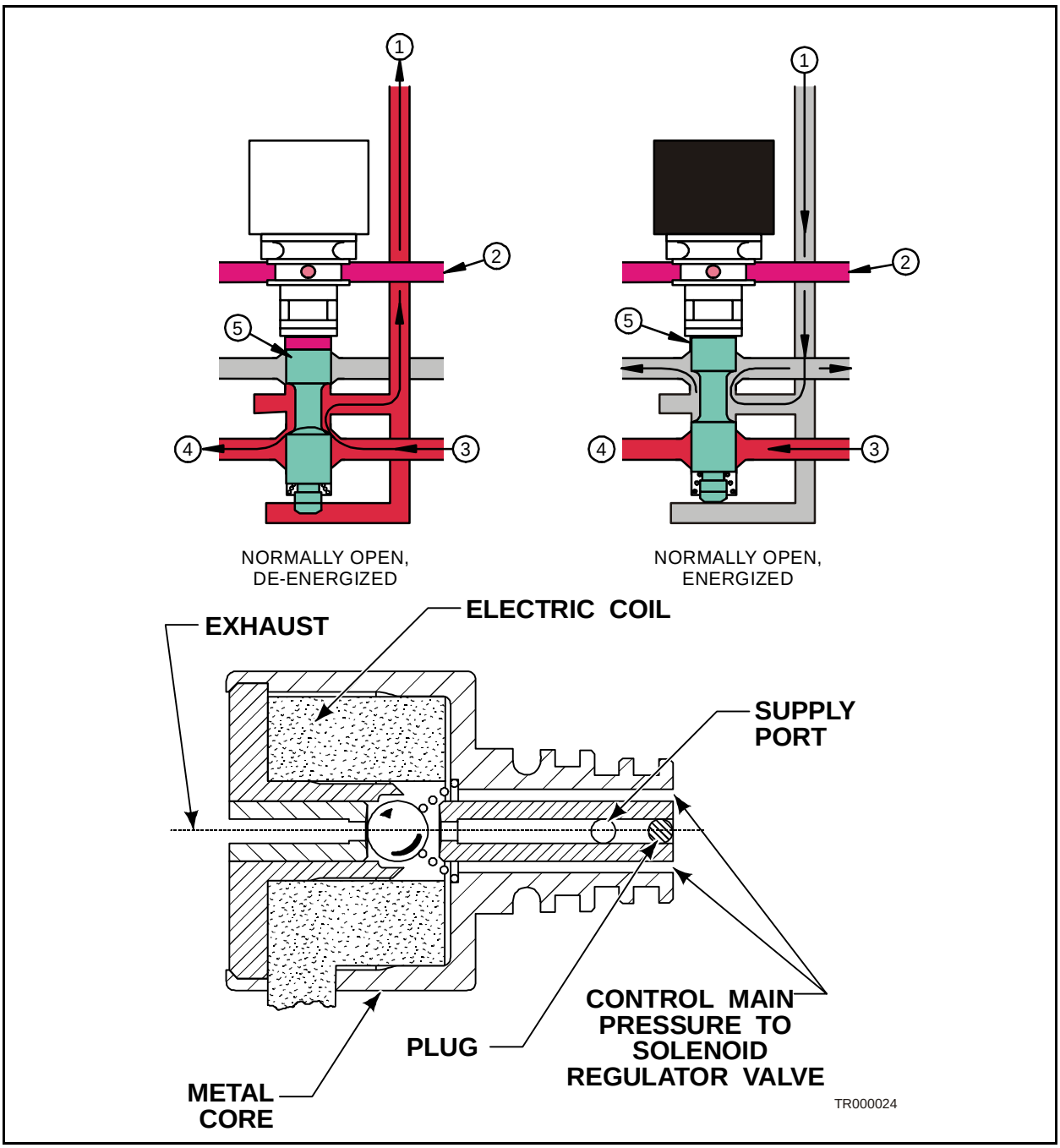
## SOLENOIDS

Solenoids can be either **"normally open"**, or **"normally closed"**.

- Normally closed solenoids are closed when they are de-energized.They must be electrically energized to allow control main pressure to move the solenoid regulator valve down.
- Normally open solenoids are open when they are de-energized.They must be energized to exhaust control main pressure on top of the solenoid regulator valve, allowing the valve to move up.

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## NORMALLY OPEN SOLENOIDS




When normally open solenoids are de-energized they're open.

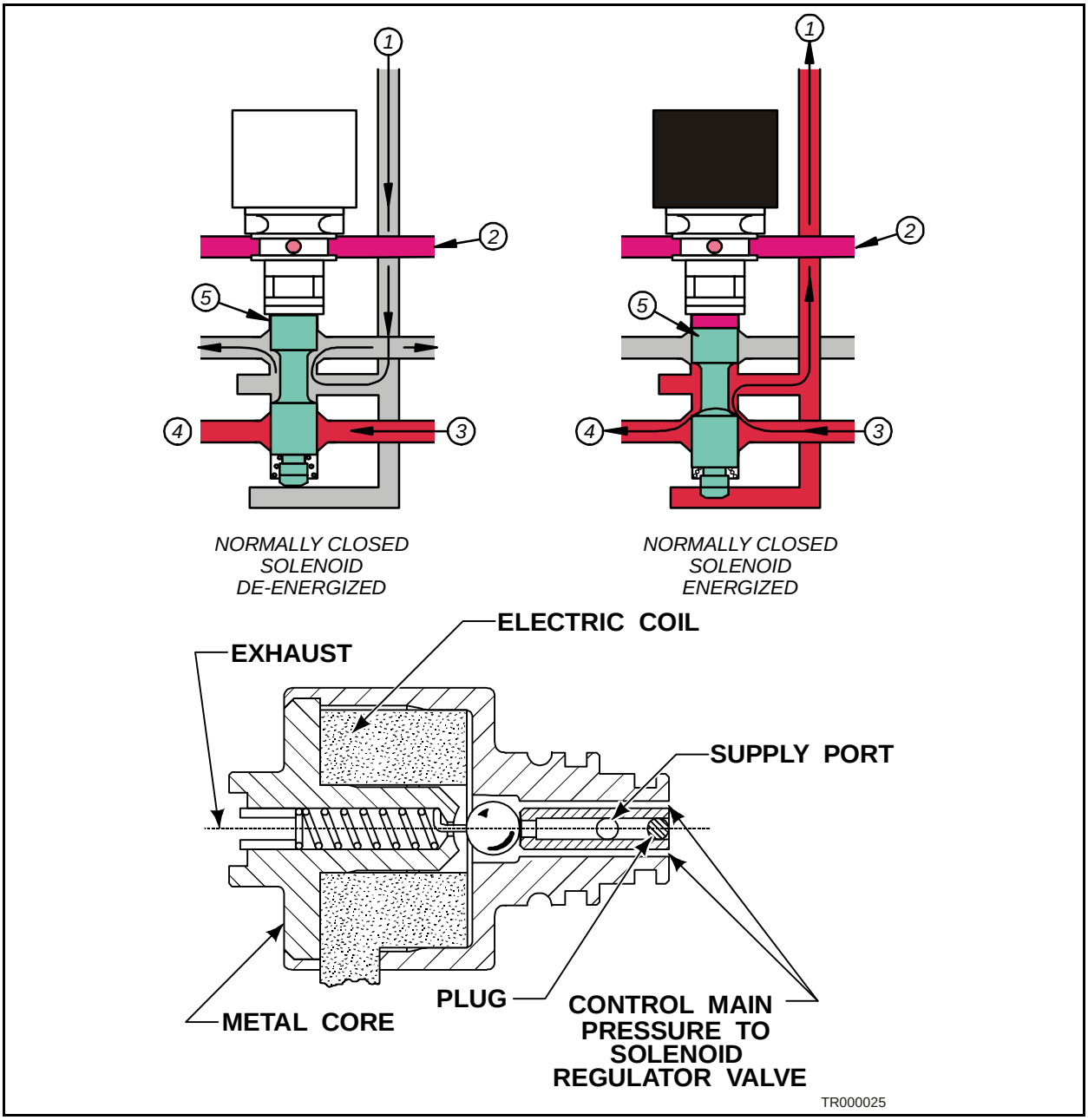
Main pressure oil (3) goes through them to the other solenoids (4) and to the clutch apply circuit (1).

When normally open solenoids are energized, control pressure (2) moves the regulator valve (5) blocking main pressure oil to the clutch apply circuit (1).

Clutch apply (1) is open to the exhaust backfill valve venting the oil to tank (sump).

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## NORMALLY CLOSED SOLENOIDS




When normally closed solenoids are de-energized they are closed, main pressure oil (3) is blocked from the clutch apply circuit (1).

Control pressure is exhausted from the top of the regulator valve (5) and it moves up.

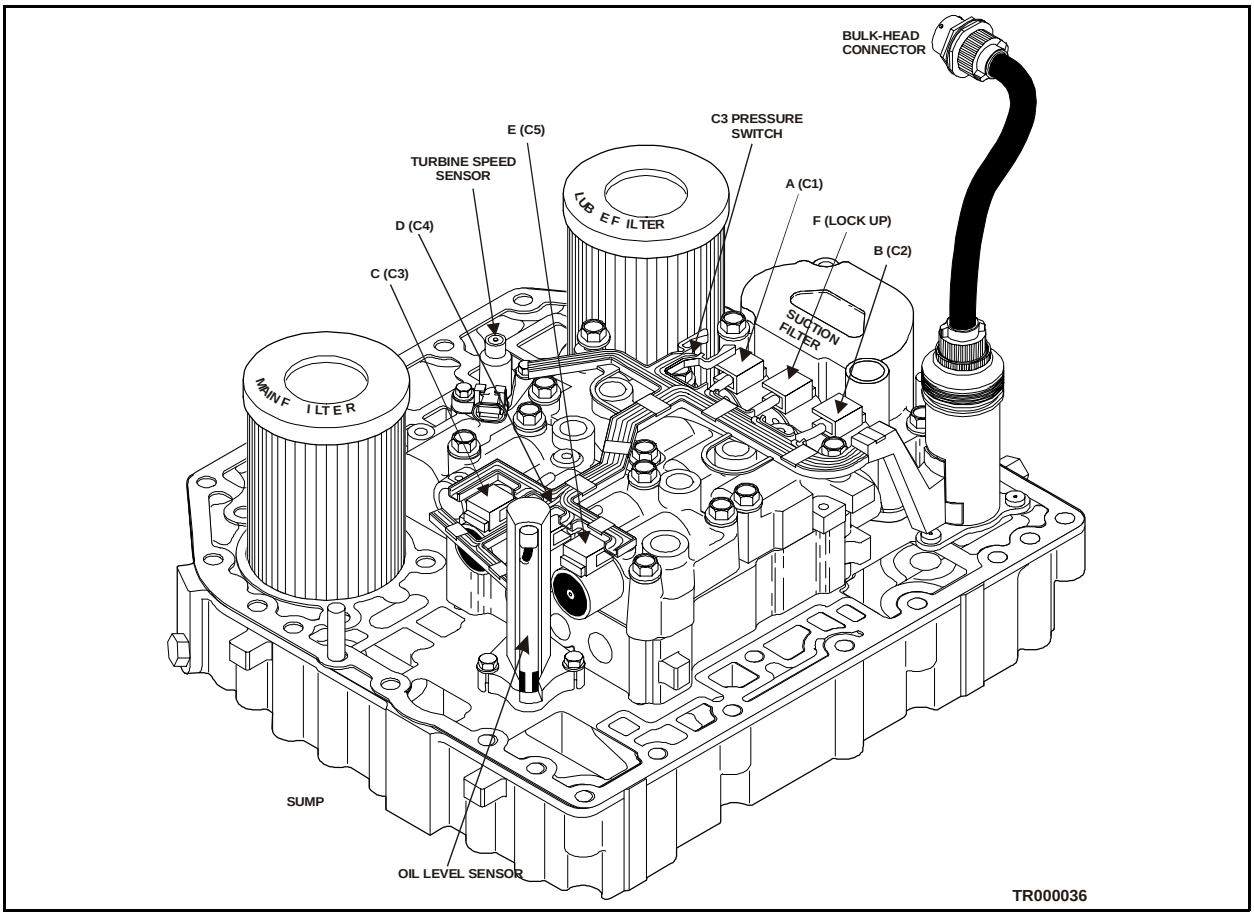
Oil from the clutch apply circuit (1) is allowed into the backfill circuit and is regulated at a low pressure by the backfill valve.

When normally closed solenoids are energized control pressure (2) moves the regulator valve and main pressure oil (3) is sent to the clutch apply circuit (1).

Main pressure oil also Cascades to other solenoids (4).

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**NOTE:The HD's hydraulic system utilizes six solenoids and regulator valve assemblies.**




- Each solenoid is labeled by a letter.
- Solenoids A and B are normally open.
- All other solenoids are normally closed.
- Each solenoid and solenoid regulator valve controls a clutch applies circuit.

1. Solenoid A controls the C1 clutch apply circuit.

2. Solenoid B controls the C2 clutch apply circuit.

3. Solenoid C controls the C3 clutch apply circuit.

4. Solenoid D controls the C4 clutch apply circuit.

5. Solenoid E controls the C5 clutch apply circuit.

6. Solenoid F controls the lock-up clutch apply circuit.

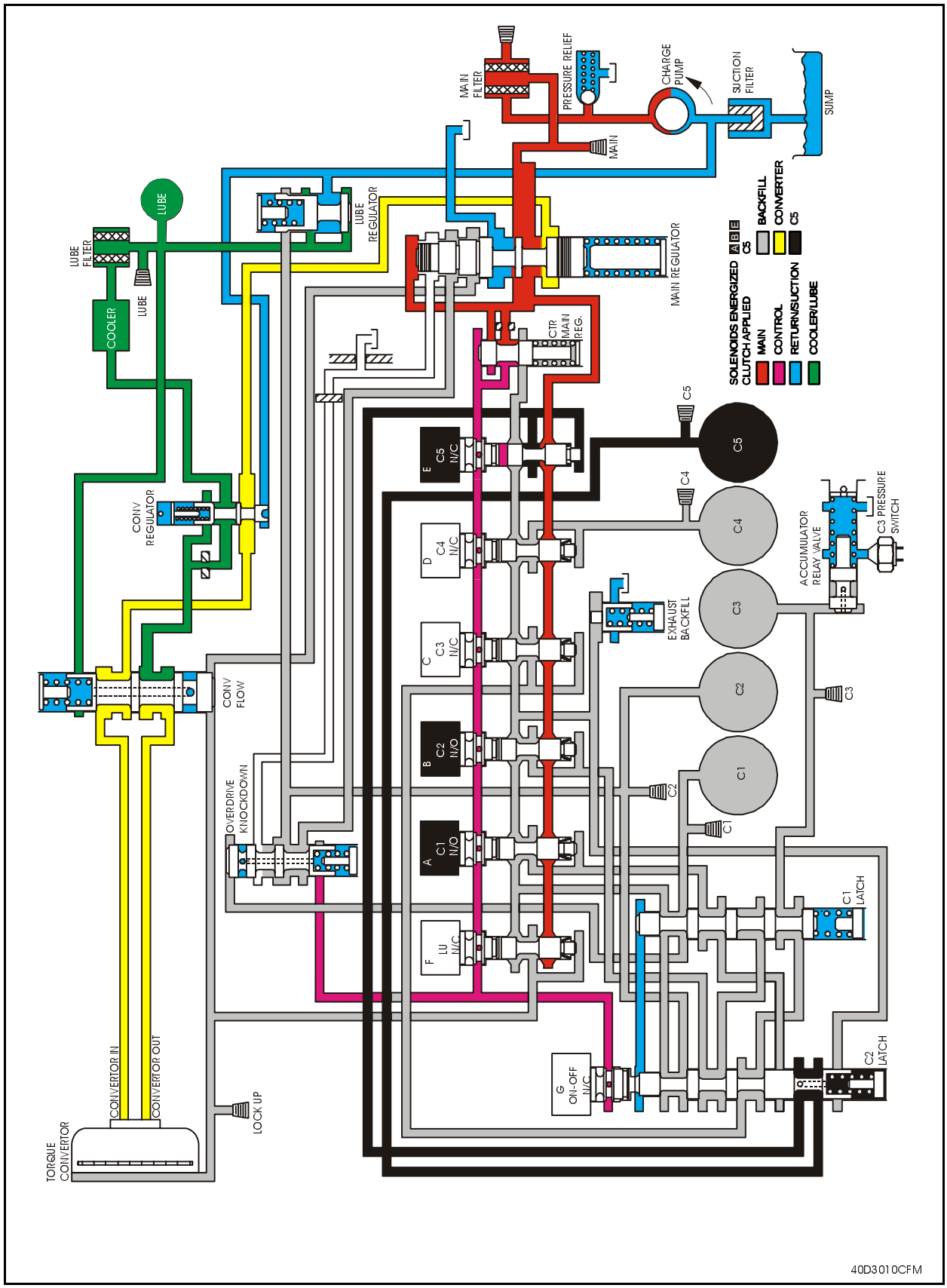
7. Solenoid G controls the latching valves. (C1 and C2)

8. Solenoid H controls the retarder function.

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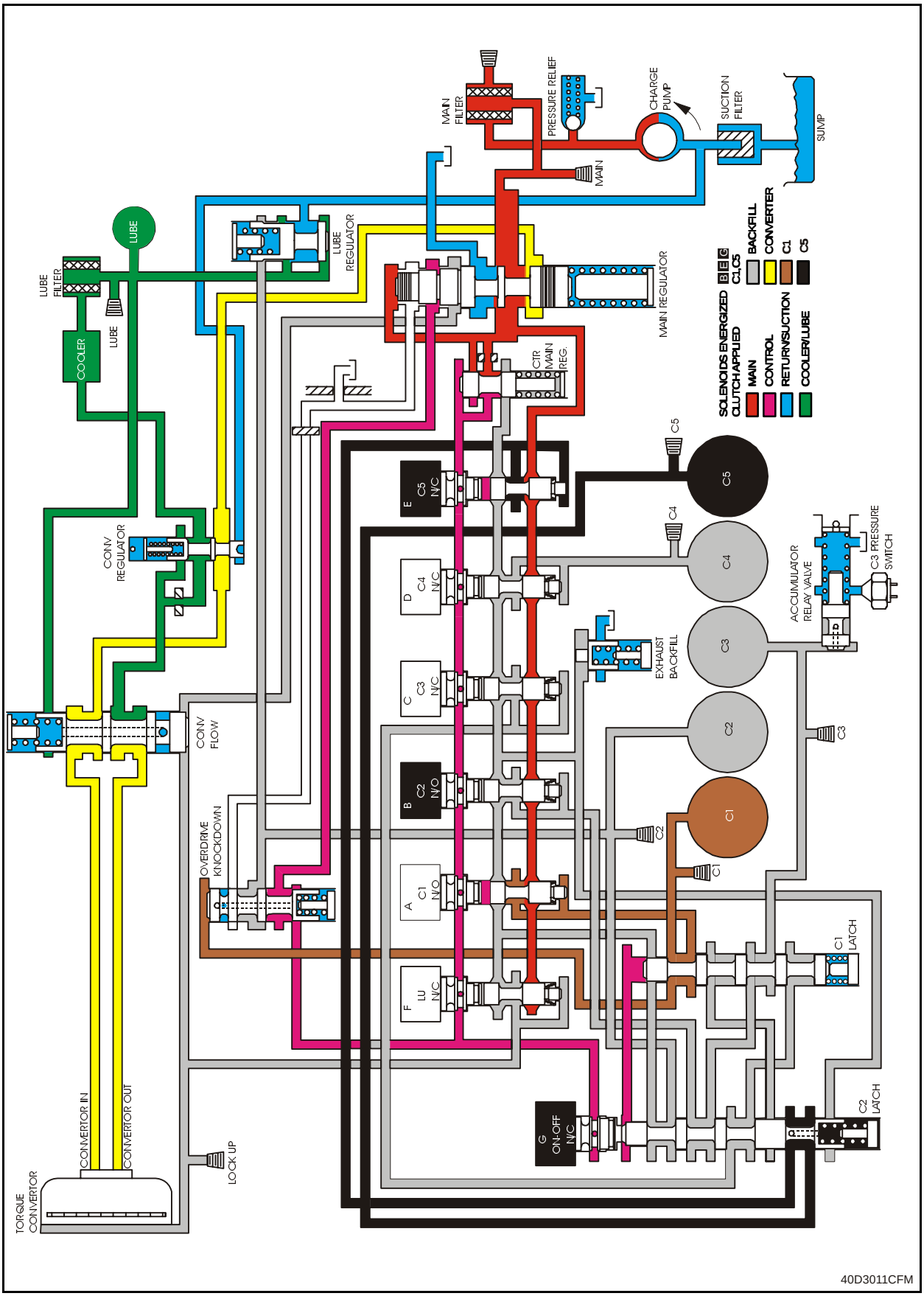
# HYDRAULIC CIRCUITS

## Neutral



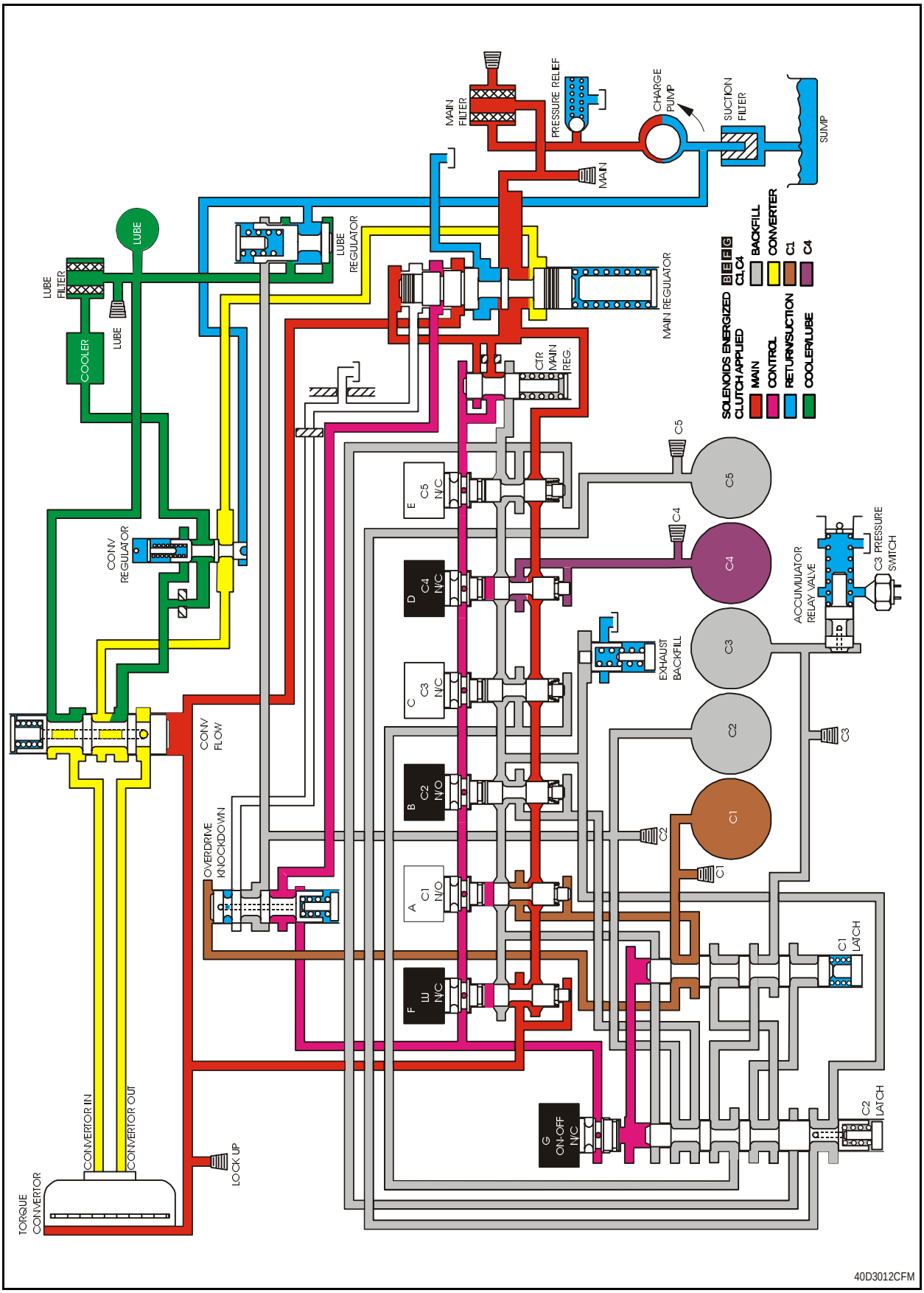
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## First



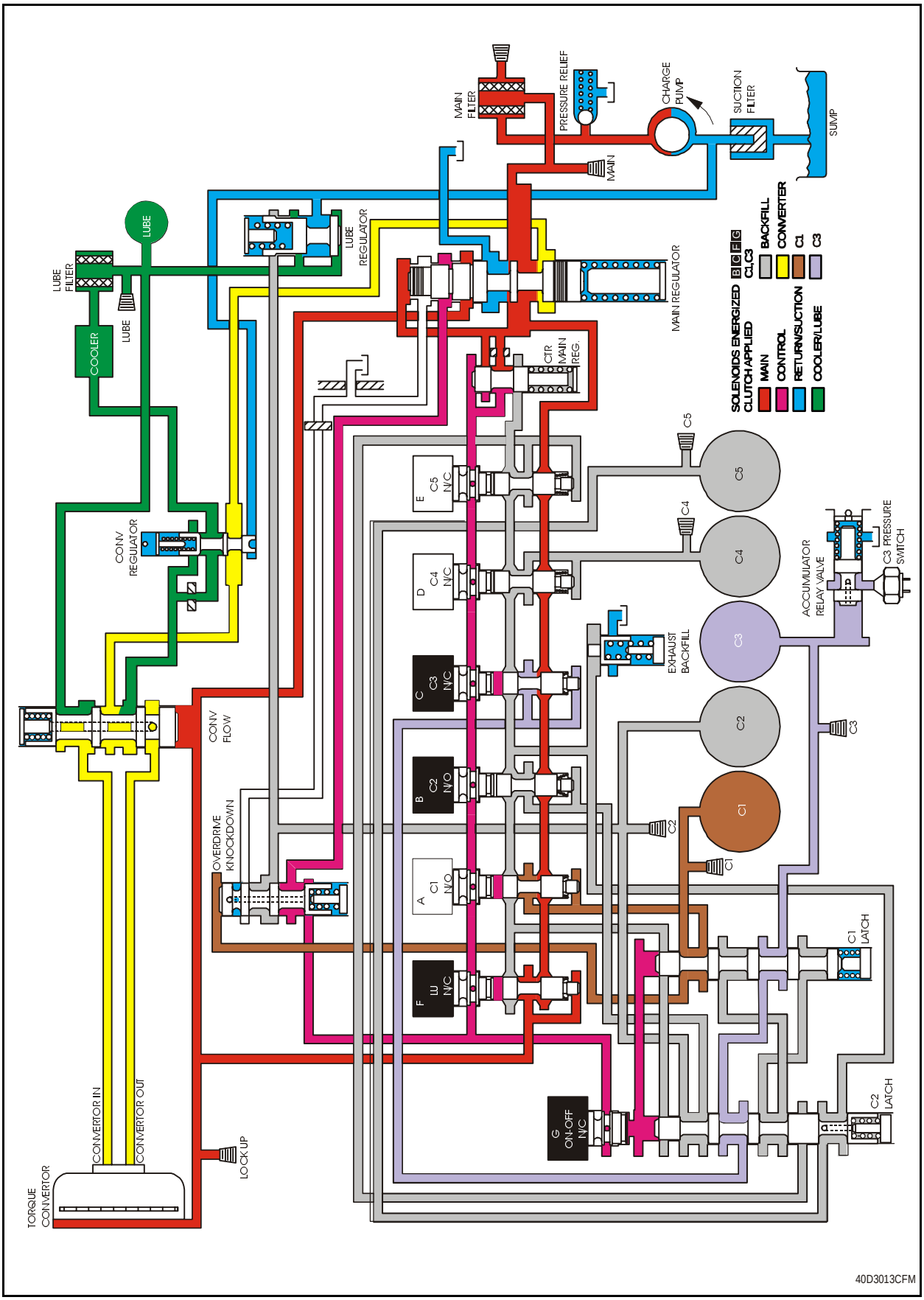
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## Second



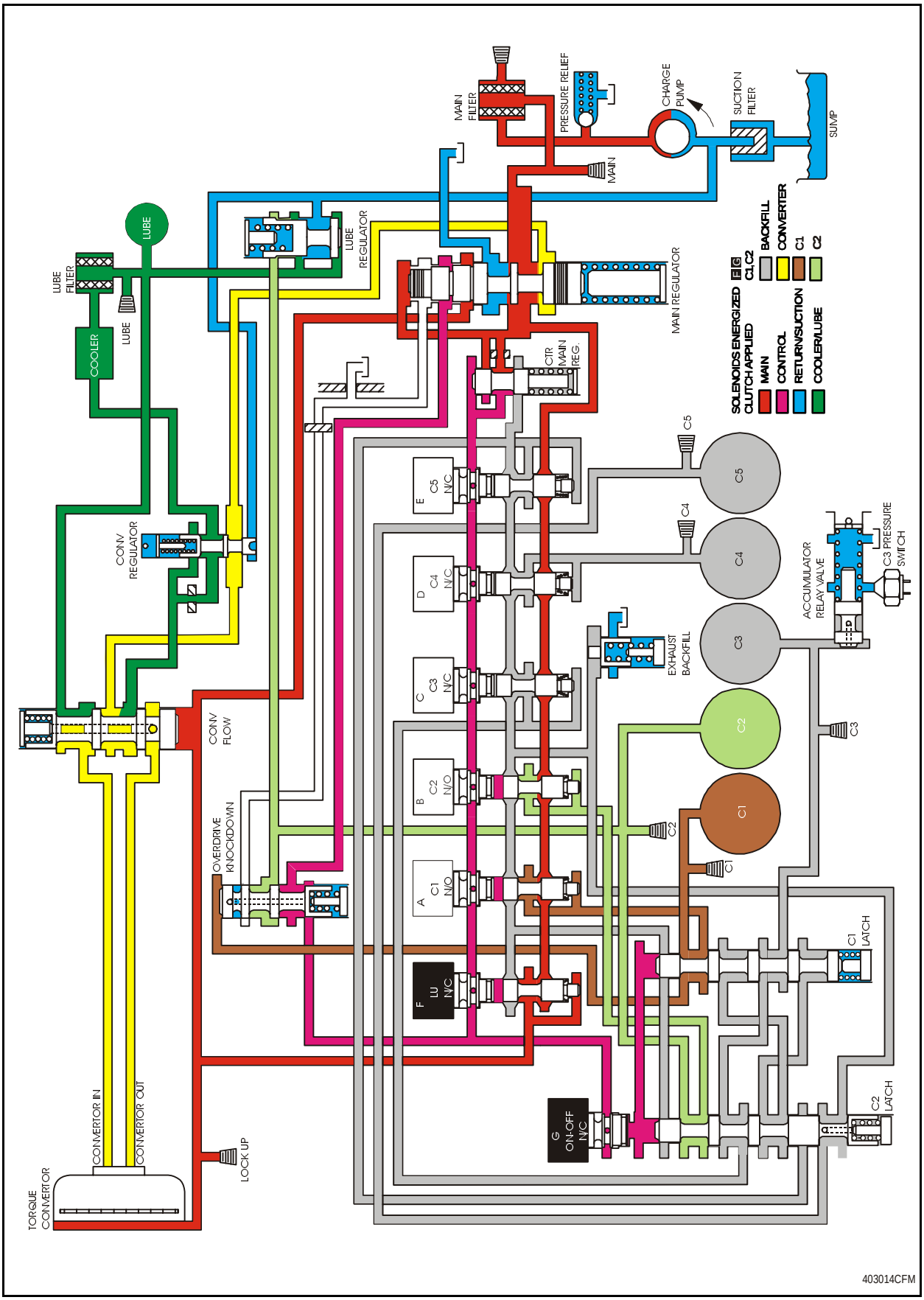
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## Third



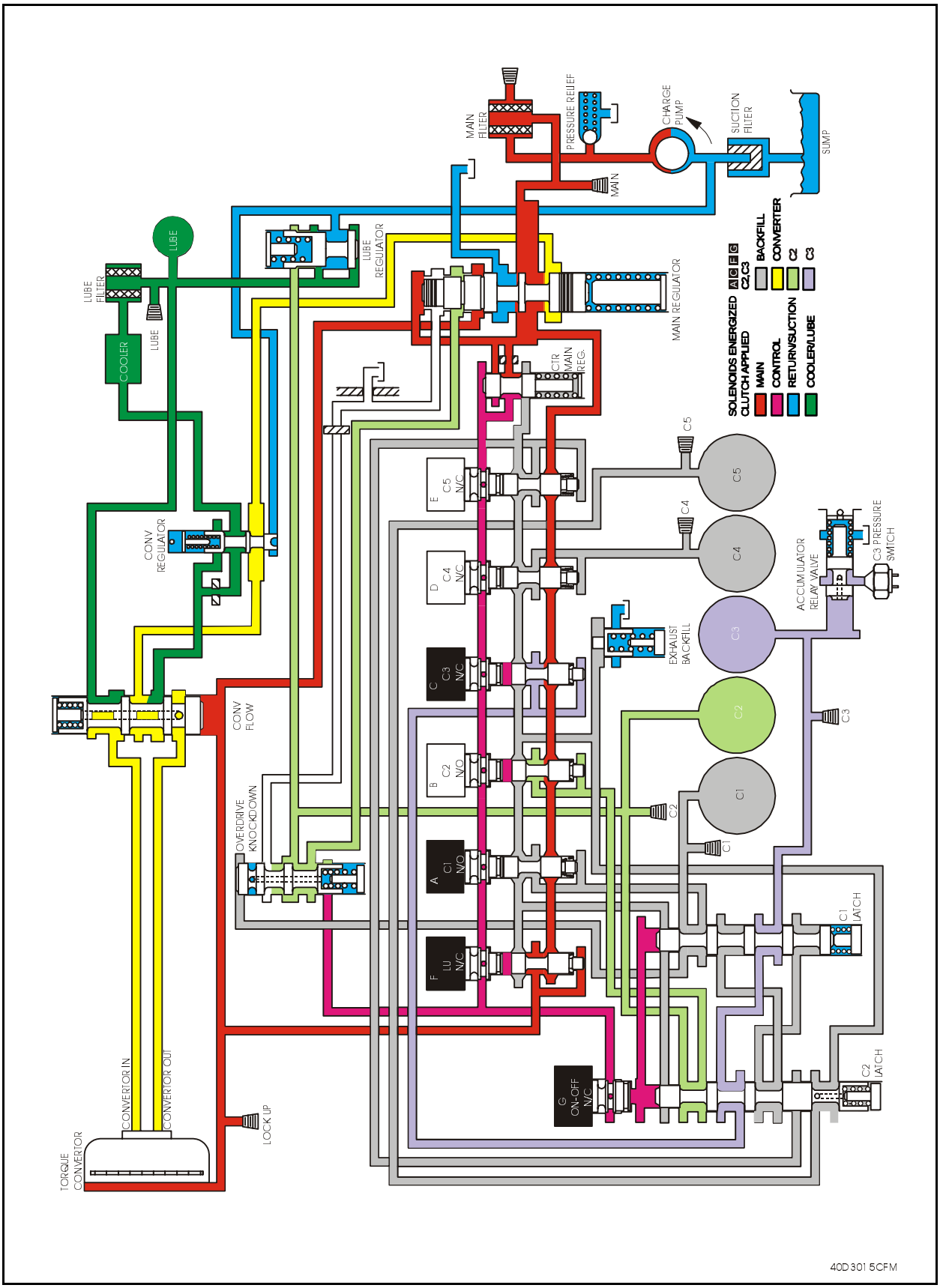
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## Fourth



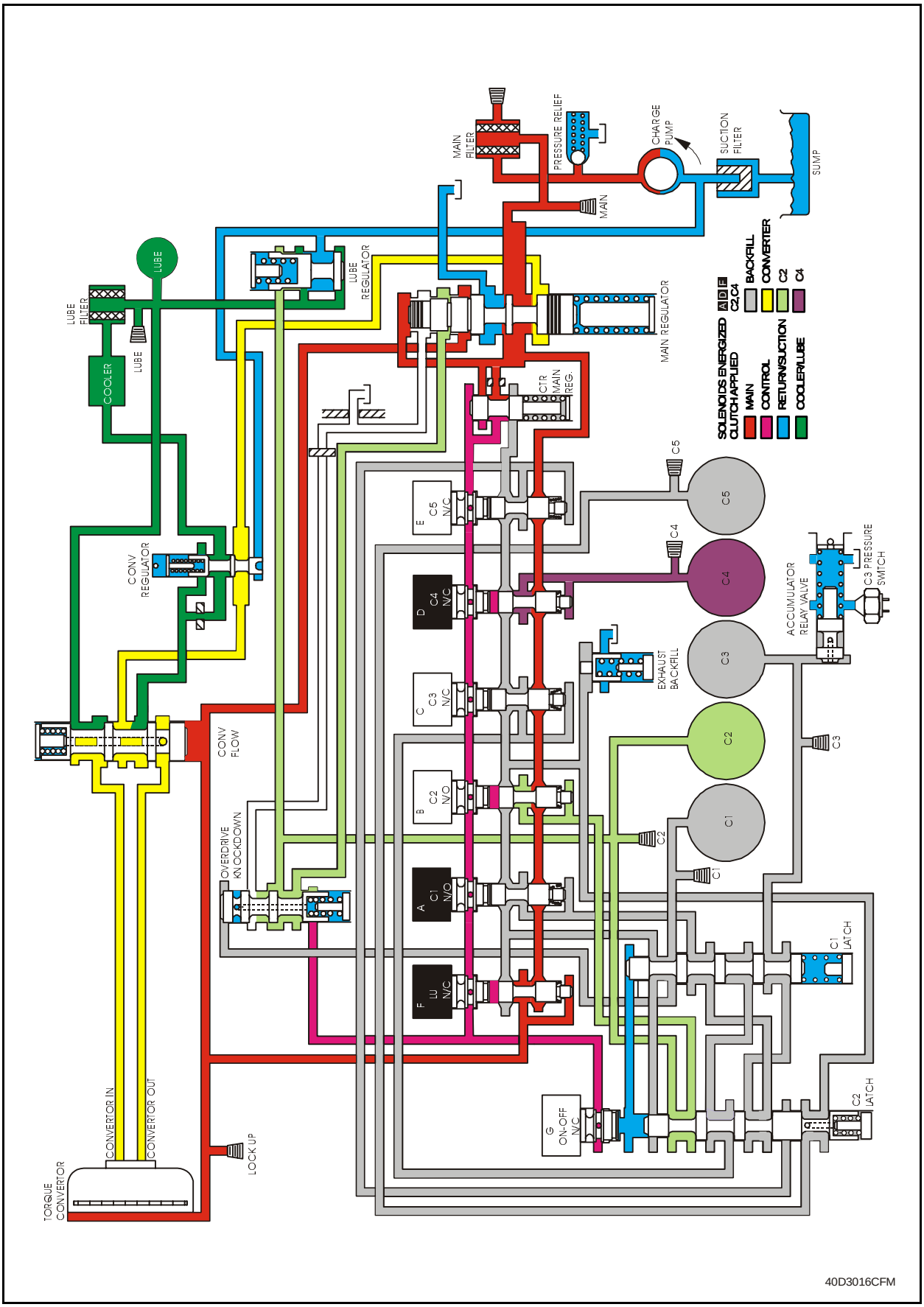
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## Fifth



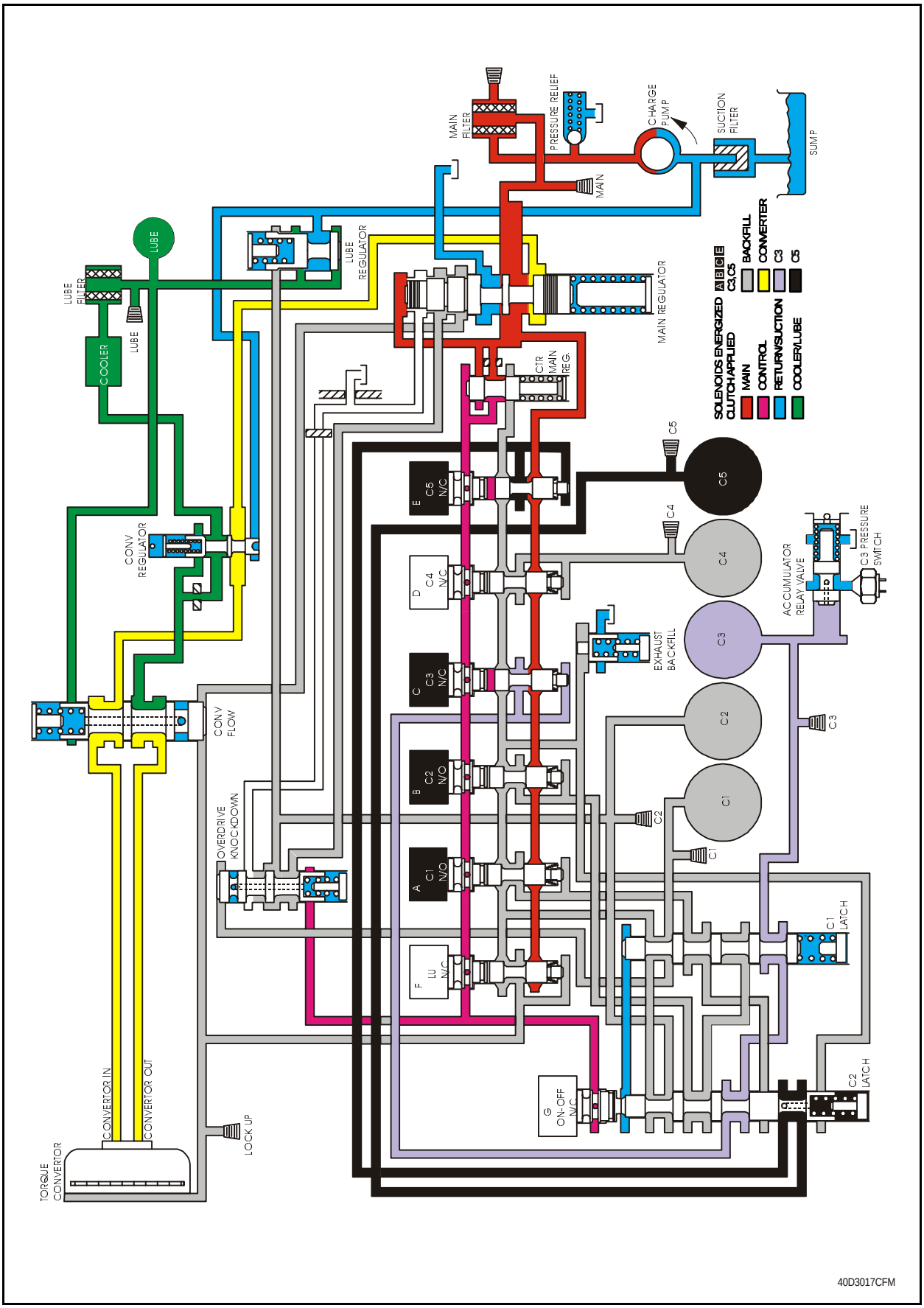
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## Sixth



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## Reverse



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## TORQUE CONVERTER AND LUBE PRESSURE CIRCUITS - OVERVIEW

As the main pressure regulator valve moves down, it allows pressure into the torque converter circuit.

- Pressure flows from the main pressure regulator, through the converter flow valve, through the converter and back to the converter.
- Pressure exiting the converter flow valve is directed into the lube circuit.
- Here, pressure flows through the cooler, the lube filter, out to lubricated parts, then "**deadheads**" at the converter flow valve.
- The lube circuit's pressure is controlled by the lube pressure regulator.
- Depending on the range, lube pressure runs at either 151 kPa (1.5 bar) (22 psi) or 117 kPa (1.17 bar) (17 psi).
- The lube pressure regulator also controls converter circuit pressure, but the converter relief valve protects against extremely high pressure and surges 896 kPa (8.96 bar) (130 psi).
- Pressure exhausted from the lube pressure regulator and converter relief valves is directed to the inlet side of the charging pump.
- This minimizes oil churn and aeration that might occur if the valves exhausted to sump.

## CONVERTER FLOW VALVE OPERATION

- The converter flow valve's position is controlled by the lock-up clutch apply circuit.
- When solenoid F is energized the main pressure enters the lock-up clutch apply circuit, the converter flow valve is forced up.
- When the converter flow valve is up (during lock-up), pressure from the main pressure regulator flows through the converter flow valve directly into the lube pressure circuit.
- Fluid flows through the cooler, lube filter, lube pressure regulator and out to lubricated components.
- But since the converter flow valve is up, lube pressure is directed through the flow valve and feeds the torque converter.
- Fluid flows through the converter flow valve, through the converter and back to the converter flow valve.
- Fluid exhausts through an orifice in the converter flow valve.
- The converter is receiving less fluid / pressure than it was when the flow valve was down. But since the converter is in lock-up, less fluid is required.
- When solenoid F is energized, main pressure in the clutch apply circuit is also directed to the main pressure regulator.This helps lower main pressure.

## OVERDRIVE KNOCKDOWN VALVE

The overdrive knockdown valve receives constant control main pressure.

- This valve is also two clutch apply circuits directed to it - C1 and C2.
- Depending on the transmission range, the overdrive knockdown valve sends either control main or main pressure to the main pressure regulator.
- These pressures help the main pressure regulator reduce main pressure.

### Overdrive Knockdown Valve Operation - C1 Applied

When the C1 clutch is applied (1st, 2nd, 3rd and 4th), the overdrive knockdown valve is positioned down.

- This sends control main pressure to the main pressure regulator.
- This "boost" of control main pressure helps the main pressure regulator lower main pressure.

### Overdrive Knockdown Valve Operation - C2 Applied

In 5th and 6th, the C2 clutch is applied and the overdrive knockdown valve is positioned up (C1 clutch is exhausted).

- This sends main pressure to the main pressure regulator.
- This "**boost**" of main pressure helps the main pressure regulator lower main pressure even more.
- This also sends main pressure to the lube pressure regulator.
- This helps lift the lube regulator off its seat, lowering lube pressure from 151 kPa (1.5 bar) (22 psi) to 117 kPa (1.17 bar) (17 psi).

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- The lube pressure schedule:
- In neutral, reverse, 1st, 2nd and 3rd 22 psi.
- In 4th, 5th and 6th 117 kPa (1.17 bar) (17 psi).
- In 4th range, both the C1 and C2 clutches are applied.
- The pressure in the C1 clutch apply circuit keeps the overdrive knockdown valve positioned down, so only control main pressure flows to the main pressure regulator.
- Main pressure from the C2 clutch apply circuit "**deadheads**" at the overdrive knockdown valve, but is directed to the lube pressure regulator.

## Main Pressure In Neutral And Reverse

Main pressure in the HD transmission varies depending on the range attained.

- In neutral and reverse, the main pressure regulator doesn't receive outside help.
- Main pressure is 1896 kPa (18.96 bar) (275psi) to 2103 kPa (21.03 bar) (305 psi).

## Main Pressure In 1st And 2nd, No Lock-up

In 1st and 2nd, before lock-up, control main pressure from the overdrive knockdown valve assists main pressure regulator operation.

- Main pressure is 235 to 265 psi.

## Main Pressure In 2nd, 3rd And 4th, Lock-up

In 2nd, 3rd and 4th ranges with lock-up applied, control main pressure from the overdrive knockdown valve and main pressure from the lock-up apply circuit assist main pressure regulator operation.

- Main pressure is 1172 kPa (11.72 bar) (170 psi) to 1338 kPa (13.38 bar) (194 psi).

## Main Pressure In 5th And 6th, Lock-up

In 5th and 6th ranges with lock-up applied, main pressure from the overdrive knockdown valve and the lock-up apply circuit assist main pressure regulator operation.

- Main pressure is 160 to 178 psi.

## EXHAUST BACKFILL PRESSURE

Exhausted clutch apply circuits are charged with exhaust backfill pressure.

- This low pressure ensures clutches are applied smoothly, with no delays.
- Exhaust backfill pressure is maintained by the exhaust backfill valve.
- The exhaust backfill circuit is initially charged through the control main pressure regulator valve's exhaust port.
- When the exhaust backfill valve needs to relieve, it moves down against its spring, exhausting to sump.
- Once backfill pressure is sufficient, the valve moves back to its seat.
- Exhaust backfill pressure is approximately 13.8 kPa (0.138 bar) (2 psi) to 20.7 kPa (0.207 bar) (3 psi).

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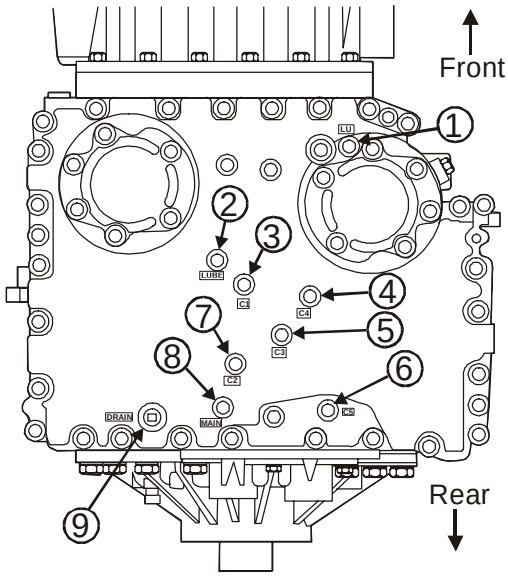
## PRESSURE TABLE AND TEST PIONTS

### Main Pressures

| | | |
|---|---|---|
| N,R | | 1896 - 2103 kPa (18.96 - 21.03 bar (275 - 305 psi) |
| 1,2 | No Lock-up | 1620 - 1827 kPa (16.2 - 18.27 bar) (235 - 265 psi) |
| 2,3,4 | Lock-up Applied | 1172 - 1338 kPa (11.72 - 13.38 bar) (170-194 psi) |
| 5,6 | Lock-up Applied | 1103 - 1227 kPa (11.03 - 12.27 bar) (160-178 psi) |

### Lube Pressure

| | |
|---|---|
| N,R,1,2,3 | 151 kPa (1.5 bar) (22 psi) |
| 4,5,6 | 117 kPa (1.17 bar) (17 psi) |




Bottom View

① Lock- up Clutch
② Lube Pressure
③ C1 Clutch
④ C4 Clutch
⑤ C3 Clutch
⑥ C5 Clutch
⑦ C2 Clutch
⑧ Main Pressure
⑨ Drain Plug

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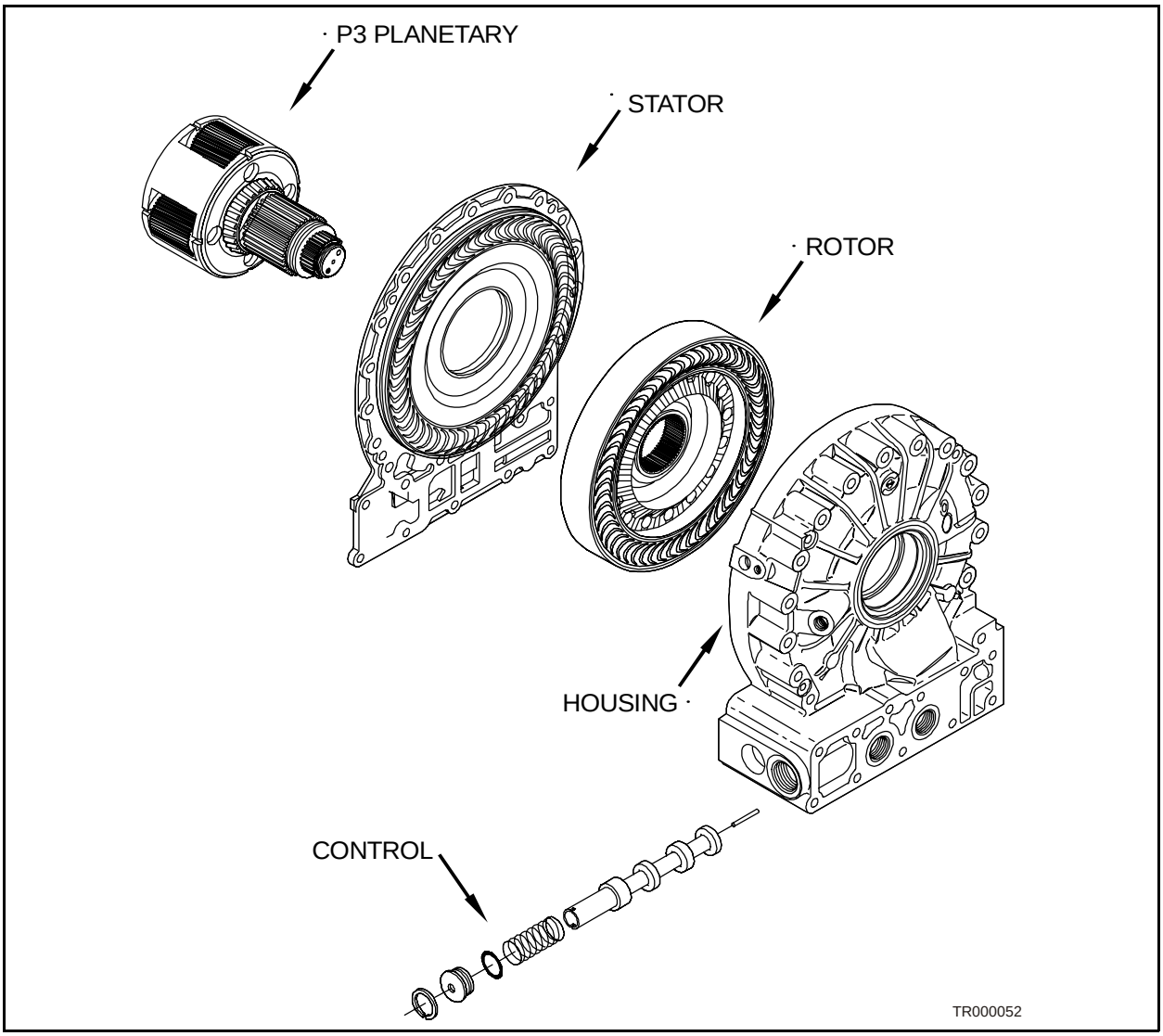
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# RETARDER

## Retarder Operation




The retarder helps slow the vehicle in "**stop-and-go**" and "**on-grade**" situations.

- The retarder extends the life of the vehicle service brakes and provides greater operator control during braking.

The retarder is an integral part of the transmission, attached to the rear of the main case.

- Main components include the stator, rotor, housing and control valve body.
- The stator, rotor, and housing have torus cups, which are similar to the vanes found in a torque converter.
- The rotor is splined to the output shaft and is always driven at output shaft speed.
- When the retarder is applied, the retarder housing fills with pressurized transmission fluid which works against the torus cups to slow the rotation of the rotor and output shaft.

## APPLICATIONS AND CAPACITIES

The suffix **R** denotes a World Transmission equipped with the retarder option.

- Example: HD 4560**R**

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| HD retarders are capable of absorbing the following torque and horsepower: | | |
|---|---|---|
| **Capacity** | **Power** | **Torque** |
| Low | 373 kw (500 hp) | 1763 N.m (1,300 lb ft) |
| Medium | 447 kw (600 hp) | 2170 N.m (1,600 lb ft) |
| High | 447 kw (600 hp) | 2712 N.m (2,000 lb ft) |

WT retarders are available in Low, Medium and High capacities.

- Retarder capacity is determined by the spring under the retarder control valve (located in the retarder control valve body).
- The retarder fitted to the B40D is a Low, the spring colour is Orange.

## Retarder Control - Overview

The Transmission Control Unit (TCU) controls retarder operation. An operator-controlled apply device supplies input to the TCU.

An apply device is not necessarily required.The TCU can be programmed to automatically apply the retarder.The TCU also looks at signals from the throttle position.(J1939), the retarder temperature sensor and the output speed sensor.

Based on apply device and additional input signals (service brakes), the TCU controls retarder operation.

Additional outputs provide operational features:

- Retarder indicator output (activates the vehicle brake lights and an retarder “on” light when the retarder is applied).

## Apply Controls

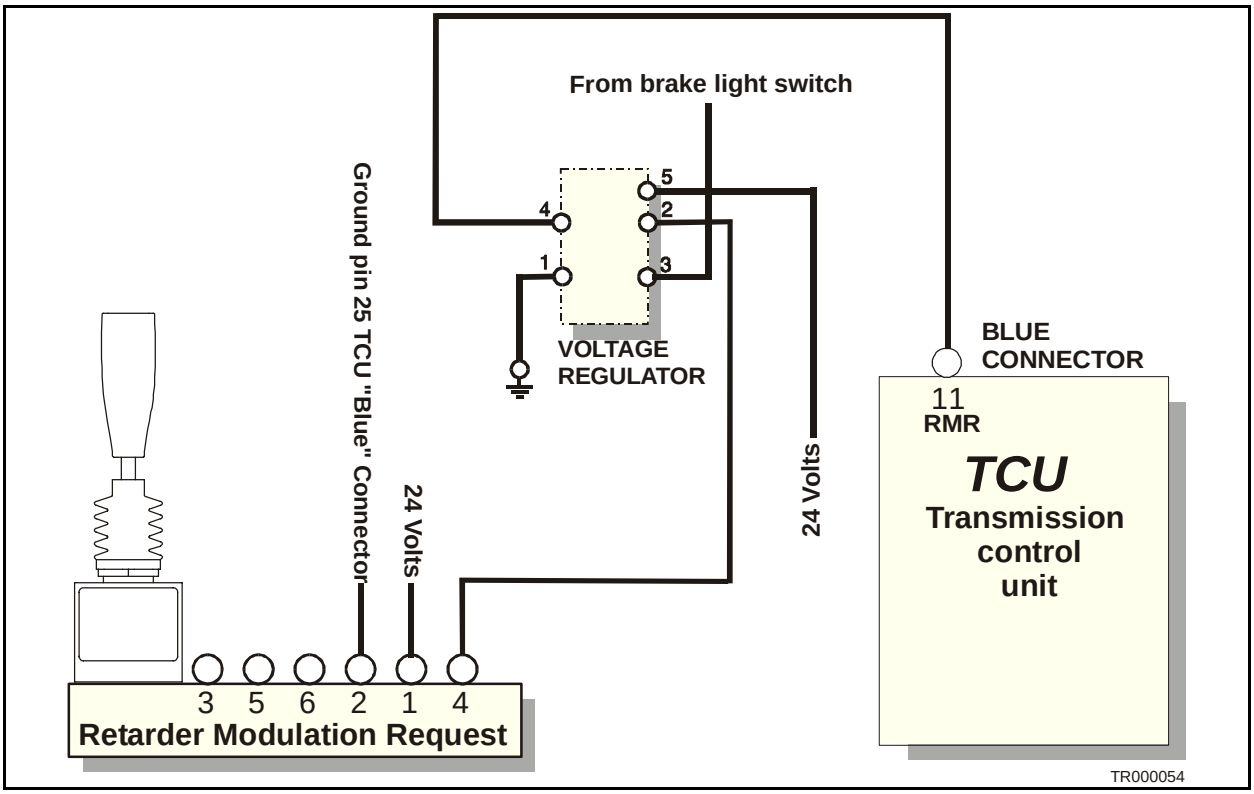
Apply controls signal the TCU to command the retarder “on” or “off”.

The Apply control is a operator-controlled device, but the Voltage Regulator is set (1.6 V) to apply the retarder without using operator-controlled devices at 1st stage retardation when activating the exhaust brake by removing your foot off the accelerator pedal.

The TCU therefore commands the retarder on at 16.6% or first stage.

When applying the service brake the retarder is applied at 100% or sixth stage to improve braking and pro-long service brake life.

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Hand lever apply controls is in the dash.

- The lever can be positioned to select "**off**" but the voltage regulator actually still sends 1.6 Volts to the TCU in order to always apply 1st stage retardation when the exhaust brake is applied
- One of five levels of retardation can be applied when the brake pedal is not actuated
- When the brake pedal is actuated the voltage regulator send a voltage 4.2 Volts to the TCU to apply the retarder to 100%
- The lever varies a 5-volt signal which is sent through the voltage regulator to the TCU.

## INPUTS AND OUTPUTS

- Throttle position must be closed before the TCU will allow retarder application.
- The retarder temperature sensor sends retarder temperature information to the TCU.This signals the TCU to log diagnostic codes, control retarder capacity and invoke a per-select down shift schedule.
- The output speed sensor provides output shaft speed information to the TCU.
- When output shaft speed is between calibrated limits, retarder capacity is at its maximum.
- If output shaft speed goes above or below these limits, the TCU begins to modulate retarder charging pressure.
- If retarder operation is still being requested and output shaft speed falls below 350 rpm, the TCU deactivates the retarder to provide a smooth transition to the service brakes.

## RETARDER CONTROL HYDRAULICS

### Solenoid Operation

The TCU controls retarder application using one solenoid designed K.

Solenoid K controls the flow of controls main pressure to the top of the retarder control valve.

- When Solenoid K is energized, control main pressure forces the retarder control valve "**down**."
- When Solenoid K is de-energized, control main pressure is exhausted, allowing the retarder control valve to move "**up**."
- The TCU varies Solenoid K's duty cycle depending on the percent of retarder requested, output shaft speed, range attained and retarder temperature.

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## TESTING RETARDER CHARGING PRESSURE

**NOTE:Always check the transmission fluid level when trouble shooting retarder performance complaints. If the fluid level is low; retarder charging pressure may be correct.But due to aerated oil, torque and horsepower absorption is decreased.Fluid aeration increases when the retarder is applied.**

A 7/16 x 20 UNF pressure tap is located on the retarder control valve body.Connect a pressure gauge and compare your readings to the appropriate specification. Readings must be within 48 kPa (0.48 bar) (7 psi).

| Capacity | Pressure | Colour | Wire Dia. | Free Length | Length under load |
|---|---|---|---|---|---|
| Low | 372 kPa (3.72 bar) (54 psi) | ORANGE | 1.625mm | 27.82mm | 17.98mm |

**NOTE:When testing maximum retarder charging pressure, retarder requested must be 100%. Output shaft speeds must be as follows:**

HD - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 1500 rpm to 2500 rpm

### Retarder On

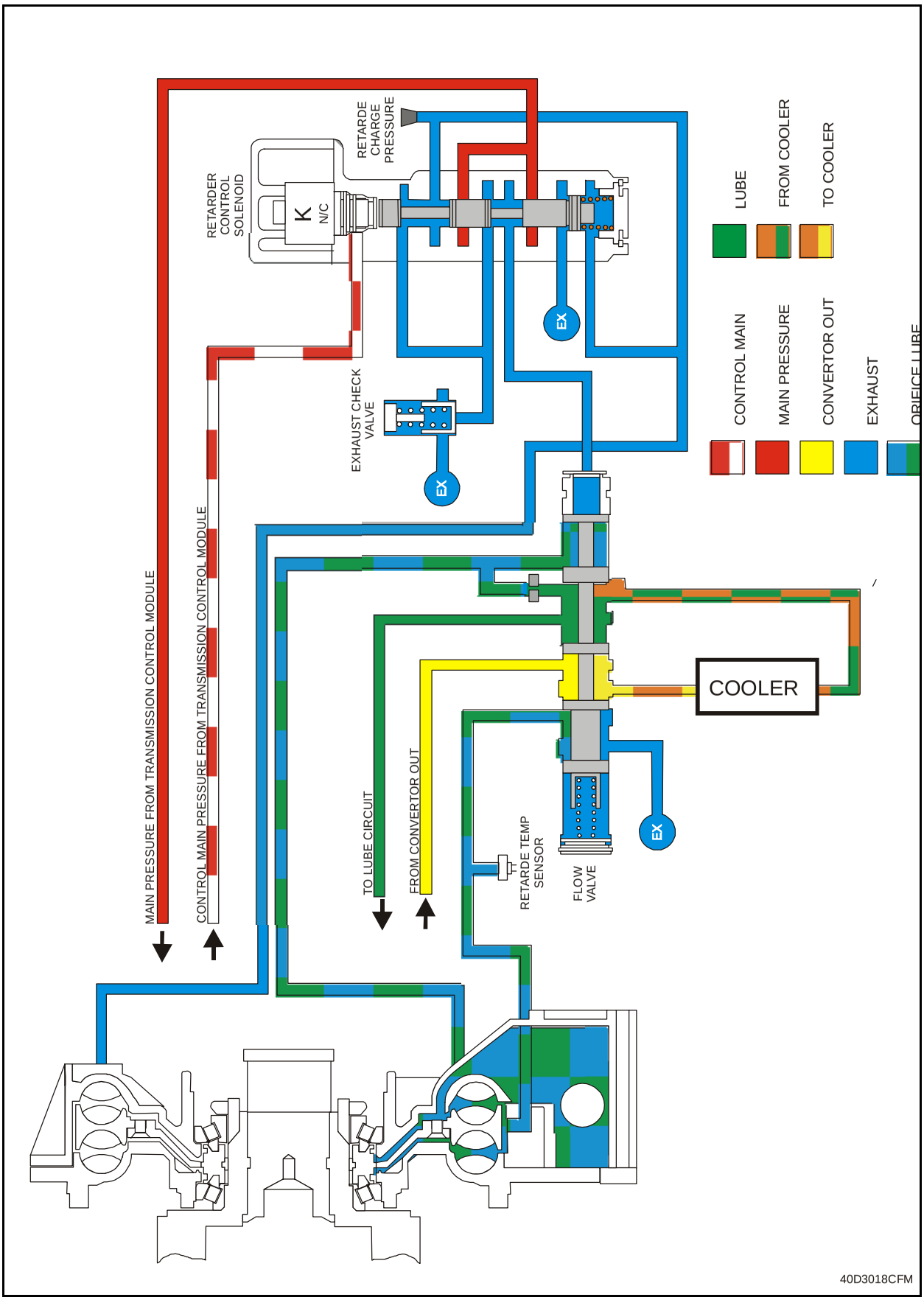
- When retarder operation is requested by the operator, Solenoid K is commanded “on” at a calibrated rate.
- Control main pressure on top of the retarder control valve strokes the valve “down” against spring pressure.
- Main pressure can now flow into the retarder charging circuit and under the retarder control valve to help stabilize valve movement.
- Main pressure is also directed to the flow valve, stroking the valve to the left.
- Once the flow valve moves left against spring pressure, Solenoid H is commanded “full on” by the TCU.(Solenoid H is simulated by a resistor as the accumulator is no longer used.)
- The continual feed of retarder charging pressure forces fluid out of the retarder housing, through the “to cooler” line, through the cooler, and back into the retarder housing.
- Converter out oil is diverted directly into the lube circuit while the retarder is applied.

### Retarder Off

- When the retarder is deactivated, At the same time, Solenoid K is commanded “off” at a fixed rate.
- This allows converter out pressure to stroke the accumulator piston to the left, recharging the accumulator.
- The retarder control valve is forced up by spring pressure as control main pressure is exhausted.
- This exhausts main pressure on top of the flow valve.
- This also exhausts the charging circuit.
- Spring pressure forces the flow valve right, directing converter out oil through the cooler and into the lube circuit.
- A small amount of fluid returning from the cooler is directed into the retarder housing through an orifice to provide lubrication.

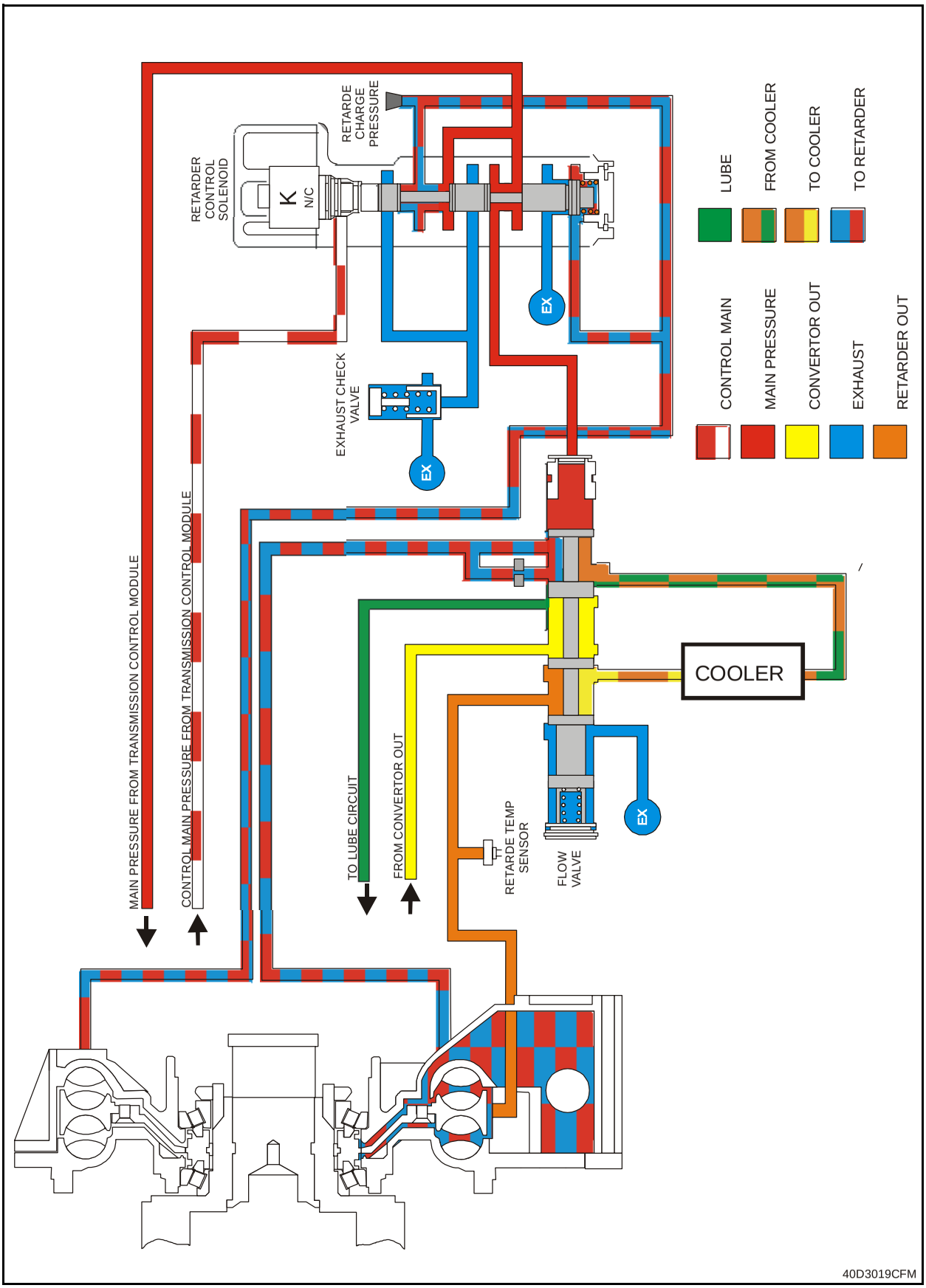
**NOTE:HD retarders contain one additional valve - an exhaust check valve. The function of the exhaust check valve is to ensure lube oil goes into the retarder housing and not directly to exhaust. This is specific only to the HD retarder due to the diameter of the retarder housing and the placement of the retarder valve body.**

## HD RETARDER HYDRAULIC SCHEMATIC RETARDER OFF




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## HD RETARDER HYDRAULIC SCHEMATIC RETARDER ON




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# ELECTRONIC CONTROL SYSTEM

## SYSTEM COMPONENTS

The electronic control system for the WT Series consists of two major groups, external controls and internal controls.

External electronic control system components:

- Transmission control unit (TCU).
- Engine speed sensor.
- Output speed sensor.
- Shift selector.
- Wiring harness.

Internal electronic control system components:

- C3 pressure switch.
- Turbine speed sensor.
- A through E clutch solenoids.
- Lock-up clutch solenoid F.
- Forward latch solenoid G.
- Retarder solenoid H.
- Sump temperature sensor.
- Internal wiring harness.

## TRANSMISSION CONTROL UNIT (T C U)

The Transmission Control Unit (TCU) is a microcomputer that is the brain of the control system.

Input from the operator is sent to the TCU via the shift selector and vehicle interface wiring. The TCU determines shift sequences, shift timing, and clutch apply and release pressures.

Data sent to the TCU are: shift selector position; throttle position; engine, turbine and output speeds; and any special function(s) operating. The TCU compiles and processes this data.

The TCU is programmed to provide the most suitable operating characteristics for variations in load terrain, or environment, and to adjust for clutch wear.

Signals processed by the TCU allow the microcomputer to determine the characteristics of a shift in progress.

The TCU includes an Electrically Erasable Programmable Read Only Memory (EEPROM) chip programmed with the optimum shift calibration for the specific vocation.

Shift characteristics are compared to the programmed optimum shift profile stored in the EEPROM.

If the reported shift characteristics are not within programmed limits, the TCU alters solenoid valve modulation to bring the shift within the limits.

This “**learning**” process of comparing and adjusting shift parameters is referred to as “**closed loop logic**”.

When optimum shift parameters are first programmed into the TCU, the adaptive control is in “**Fast Adaptive mode**”.

In Fast Adaptive mode, the TCU makes large changes to the shift parameters. The Slow Adaptive mode starts after a shift is repeated and the turbine speed matches the stored optimum.

In Slow Adaptive mode, adaptive changes are smaller.Change the TCU back to Fast Adaptive with the DDR after any transmission replacement.

By changing to Fast Adaptive mode, the TCU will adapt to the different transmission more quickly.

The TCU is also programmed to protect the transmission and other vehicle drive line components from abuse by inhibiting actions such as full-throttle neutral-to-range shifts and high-speed direction changes.

In addition, the TCU determines if a system malfunction exists and stores diagnostic codes related to the malfunction.The codes, accesses by the operator or service mechanic, are used in diagnosing persistent or intermittent trouble in the system.

## PULSE WIDTH MODULATION (P W M)

During application and release of a clutch, the signal from the TCU to a solenoid is modulated at an established frequency, causing the steel check ball in the solenoid to rapidly open and close the solenoid passage.

This is known as Pulse Width Modulation (PWM). This action allows control main pressure to gradually build to a maximum.

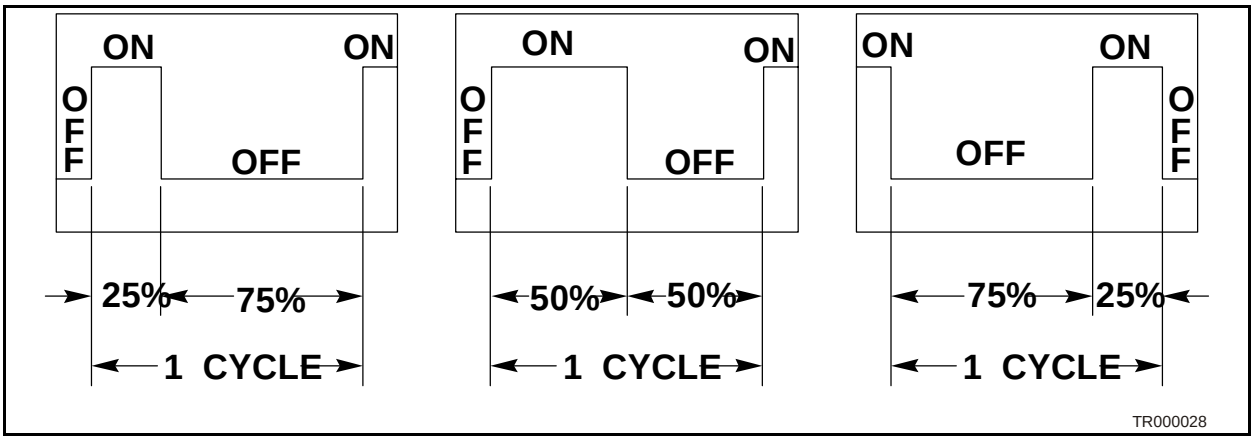
The gradual increase in control main pressure to the top of the solenoid regulator valve causes the valve to move downward gradually and smoothly.

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The hydraulic pressure in the clutch circuit increases steadily with the gradual movement of the solenoid regulator valve.

Frequency is defined as the number of times in one second that a modulated electrical signal (voltage in this case) completes an on-off cycle.

Frequency is measured in units of hertz (Hz). Cycles per second and hertz are the same. For example, a signal modulated at a frequency of 10 Hz completes ten cycles every second.




An example of a modulated signal is illustrated.

## Pulse Width Modulation Waveforms (Solenoid Duty Cycle)

The electrical signal to the WT solenoids has a frequency of 63 Hz during a shift.

This means that each second is divided into 63 cycles of segments during which the voltage will be **ON** for a period of time.

The percentage of time the voltage is present inside each 1/63rd of a second is called the solenoid duty cycle.

A 100 percent duty cycle indicates a maximum signal to the solenoid.

A zero percent duty cycle indicates minimum or no signal to the solenoid.

The TCU, using the pulse width modulation programming, varies the width (percentage) of the voltage **ON** time during a cycle.

As the pulse width (or duty cycle) is increased, the solenoid is On longer.

This, in turn, causes the solenoid regulator valve to apply or exhaust a clutch with optimum shift quality.

A typical WT clutch apply solenoid command curve is presented in upshift clutch control on the following page to demonstrate how duty cycle affects clutch-apply pressure.

The upper curve represents the clutch pressure command or duty cycle during a shift.

The lower waveform represents the actual pressure at the clutch piston during the same shift.

## UPSHIFT CLUTCH CONTROL

The upper curve on the chart represents turbine speed during a typical upshift. The middle curve represents an example of the solenoid duty cycle for the oncoming clutch.

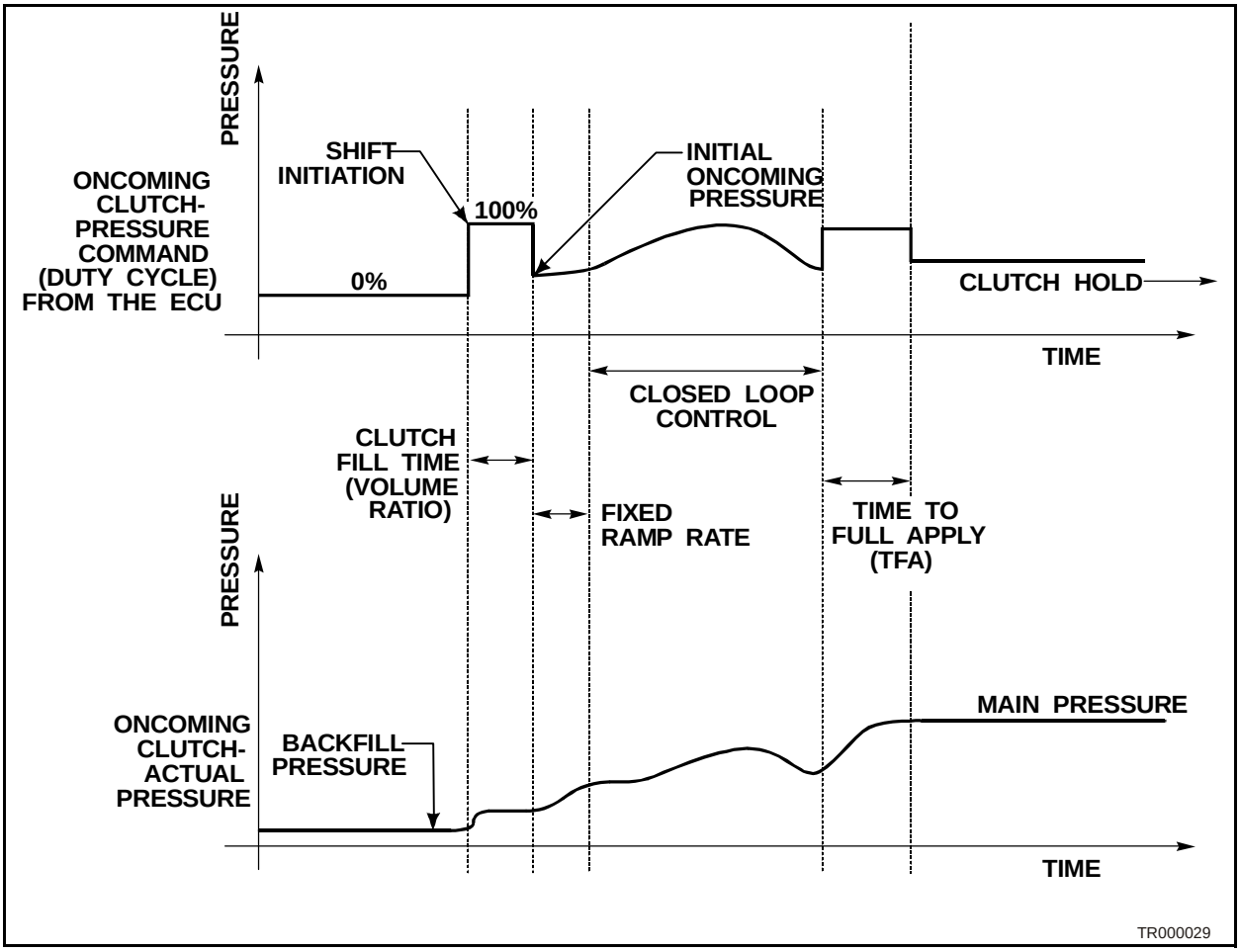
The lower curve represents the solenoid duty cycle for the off-going clutch. During a shift, changes in engine speed are reflected by changes in turbine speed.

When an upshift occurs, turbine speed decreases reflecting the change in the transmission mechanical gear ratio.

After the shift is complete, the vehicle continues to accelerate, and the turbine speed will begin to rise.

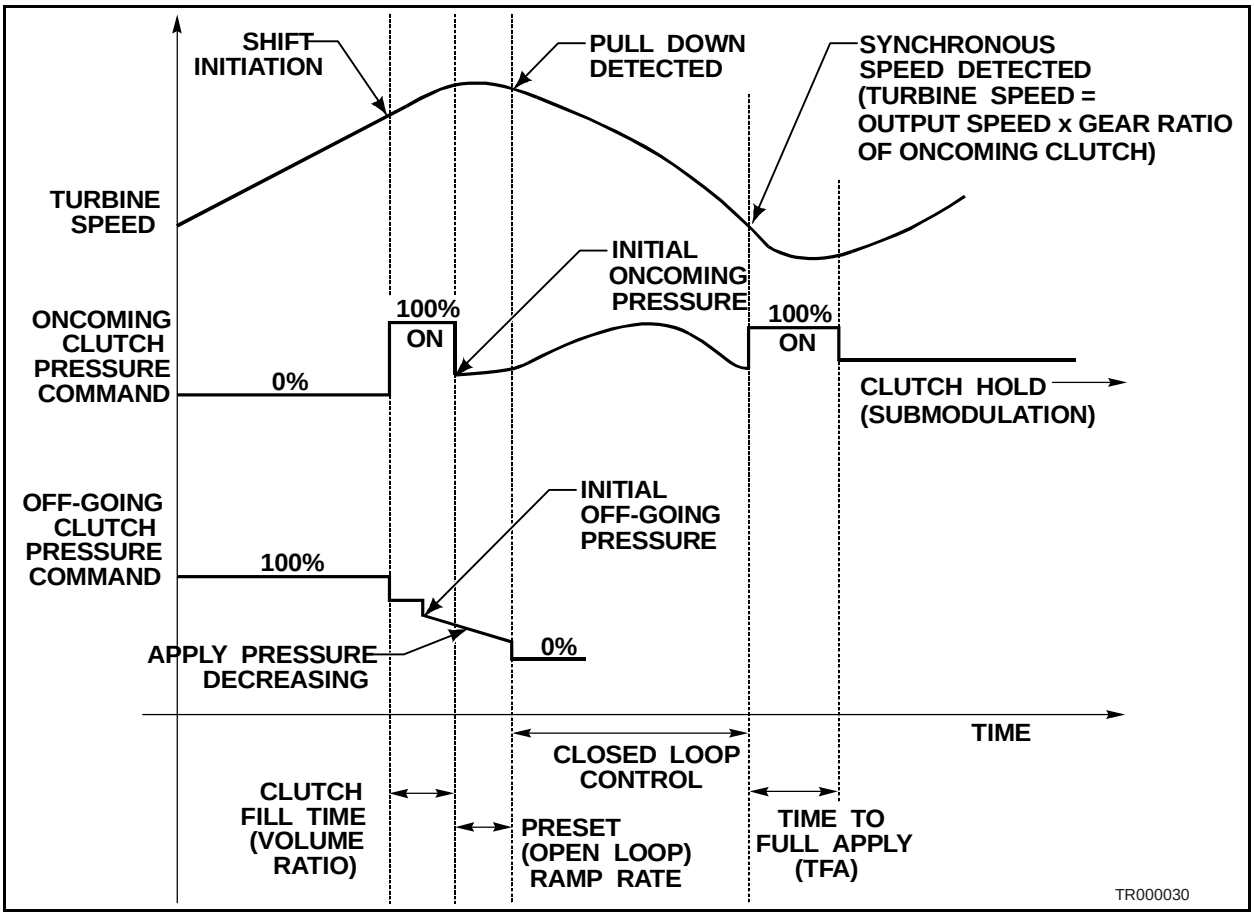
When the turbine reaches a designated rpm, the shift initiation point, the TCU commands an automatic range upshift to begin.

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- At shift initiation, the solenoid is commanded full **ON** for a period of time. This time is called Volume Ratio and refers to the amount of time needed to fill the cavity behind the clutch piston with fluid and begin the piston moving. The solenoid duty cycle during this period is 100% (maximum flow).
- At the end of Volume Ratio, the oncoming clutch is at its Initial Oncoming Pressure.
- The solenoid is signalled by the TCU to increase pressure to the oncoming clutch at the Open Loop Ramp Rate. During Volume Ratio and Open Loop Ramp Rate of the oncoming clutch, the off-going clutch-apply pressure is decreasing.

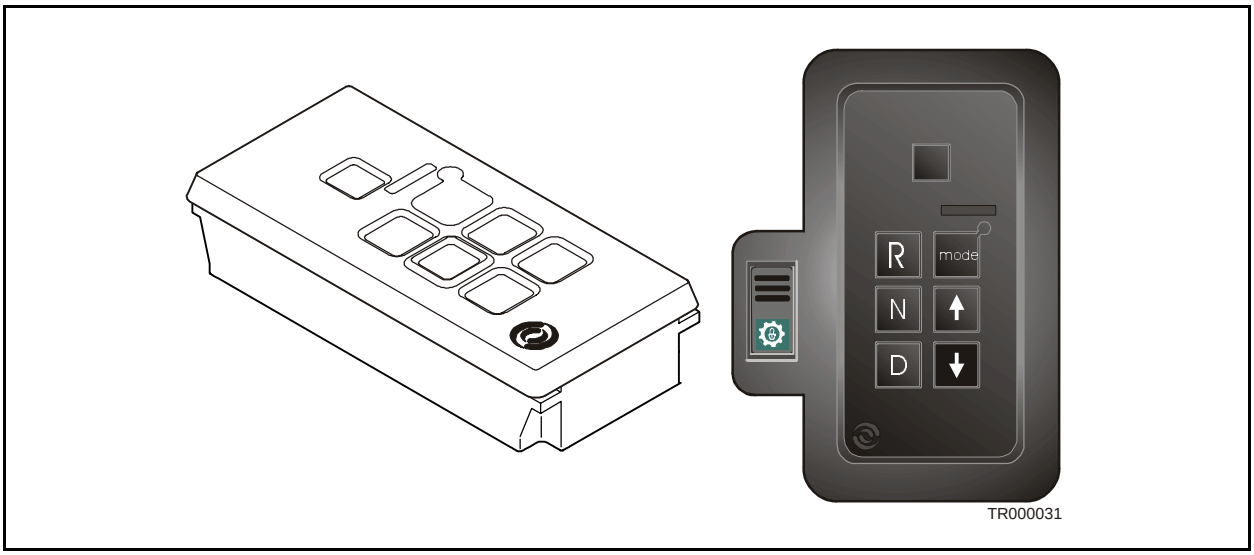
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- After Turbine Speed Pull Down is detected, the TCU enters Closed Loop Control of the oncoming clutch. Closed Loop Control is the period when the TCU is actively controlling shift quality by modulating the signal to the solenoid. Closed Loop Control continues until the clutch has almost completely stopped slipping. This enables the change in turbine speed to be maintained at an optimum rate.
- When synchronous speed associated with the oncoming clutch is detected by the TCU, the oncoming clutch is commanded to Time To Full Apply.
- During this interval, the TCU sends a full ON command to the solenoid that fully applies the clutch and completes the upshift. After Time To Full Apply, the solenoid enters a Clutch Hold state, also referred to as Sub modulation. In Sub modulation, the solenoid is controlled by a very high frequency PWM signal. This process limits the amount of electrical current passing through the solenoid coil, keeping the solenoid coil temperature down.

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## PUSH BUTTON SHIFT SELECTOR




Push button selectors contain an illuminated digital display. If a transmission fluid level sensor is installed, the digital display shows transmission fluid level. When diagnostic mode is selected, the digital display shows current or historical diagnostic code(s).

The buttons available on the push button selector are:

- R - Press this button to select Reverse
- N - Press this button to select Neutral. The TCU automatically places the transmission in Neutral at start-up.
- D - Press this button to select Drive Range. The number of forward ranges will appear.
- Up arrow
- Down arrow

The up and down arrows, are used when a specific range is required.When the up and down arrows are pressed simultaneously the display will give you the oil level display.

When pressed again simultaneously the diagnostic display is shown.When pressed again the neutral is displayed

### Mode

The MODE button is used when diagnostic codes are logged and you need to erase them.To erase the codes the mode button is held until the led has flashed three times twice.

### Hold Upshift Shift Schedule Or Range Hold

The hold upshift shift schedule prevents engine over speed by upshifting the transmission into the next higher range.

The hold upshift shift schedule is not activated unless the transmission is in a range lower than the highest available range.

Hold upshifts occur at speeds higher than those for normal upshifts.

### Pre-select Downshift Shift Schedule

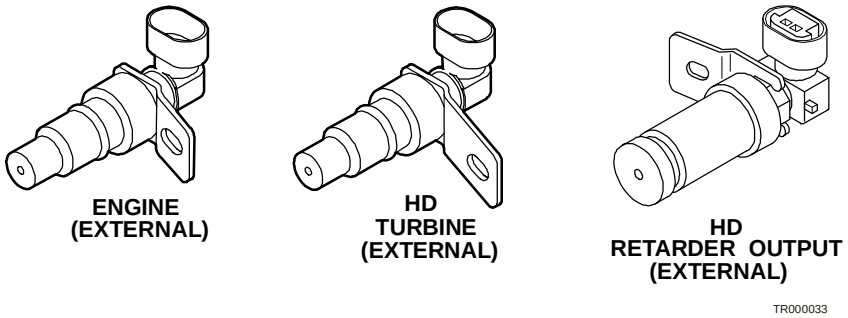
The pre-select downshift shift schedule permits the driver to pre-select a lower range.

The transmission will downshift when an over speed condition will not result after the shift.

The downshifts occur at speeds higher than those at which normal downshifts occur.

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# SPEED SENSORS




There are three speed sensors in the WT Series.

They are the engine speed sensor, the turbine speed sensor, and the output speed sensor (The speed sensors send rpm information to the TCU).

The TCU processes speed sensor data and throttle position data to determine proper shift points, to monitor the current range, to perform ratio tests, and to compile diagnostic data.

The speed sensors operate on the magnetic flux principle.

Each sensor is constructed of insulated wire wrapped around an iron core enclosed in a moulded casing.

The tip of the iron core is exposed at the end of the sensor and is directed at raised ribs or gear teeth on the rotating component.

An electrical current is passed through the coils of the sensor producing a magnetic field, or flux, at the end of the iron core.

This flux is disturbed by the ribs or gear teeth on the rotating member causing the current at the sensor to pulse.

When this occurs, a voltage in the form of positive to negative pulse waves is produced. The TCU converts the pulses to rpm for speed determination.

## Speed Sensor Locations

Engine speed sensors are externally mounted in the torque converter housing, directed at the ribs producing from the torque converter.

The turbine speed sensor is externally mounted in the housing, directed at ribs protruding from the rotating clutch module.

The output speed sensor is externally mounted in the rear cover or in the retarder housing.

The output speed sensor is directed at the teeth of a gear splined to the output shaft.

## WIRING HARNESSES

## External Wiring Harness

The transmission uses a single external wiring harness to connect the various electronic system components.

Control system configuration for various vocations may be adapted to operator needs and to vehicle requirements.

The basic harness provides connections to the TCU from the following:

- Shift selector.
- Transmission bulkhead connector.
- Serial Communication Interface (SCI) data link (J1939 CANBUS).
- Engine speed sensor.
- Transmission output speed sensor.
- Diagnostic data reader (DDR).
- Vehicle interface wiring.
- Retarder connectors.

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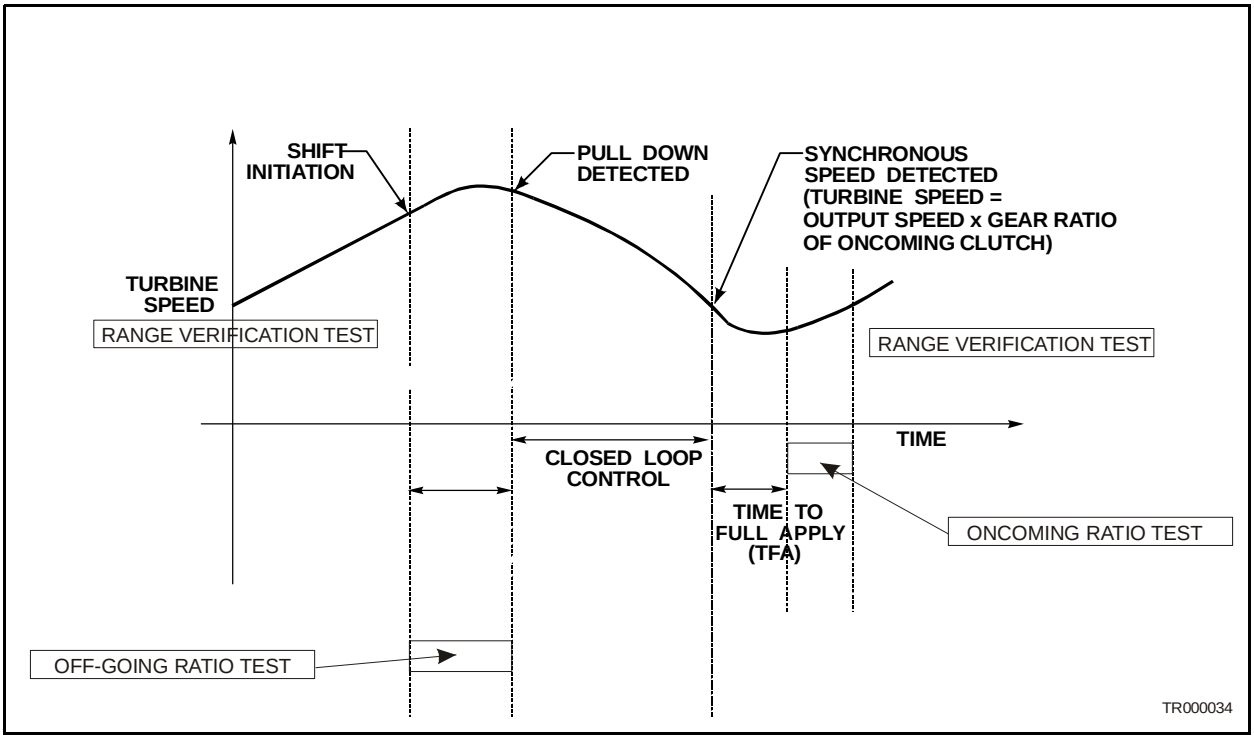
## Internal Wiring Harness

The internal wiring harness provides connection between the external harness and the solenoids, C3 pressure switch, transmission fluid level sensor, and the sump temperature sensor.

## RANGE / SHIFT TESTS

During each shift the TCU performs three tests to check the range of transmission is in and to verify that a shift is being made properly.

These tests are the range verification test, the off-going ratio test, and the oncoming ratio test.




### Range Verification

Range verification is continuously tested when a shift is not in progress.

Range verification verifies that the current range attained is the range commanded by the TCU.

This test checks the current gear ratio by comparing the turbine and output speeds.

This speed ratio is then compared to the speed ratio (stored in memory) of the range the TCU has commanded.

If the two ratios do not match, a diagnostic code is logged and the TCU commands an appropriate response to the condition.

### Off-going Ratio Test

The off-going ratio test is performed while a shift is in progress.

Within a set time after a shift has been commanded, the TCU determines the ratio between turbine speed and output speed.

The speed ratio is compared to the speed ratio of the previous range.

If the previous speed ratio is still present after a period of time, the TCU assumes the off-going clutch did not release.

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The shift will be tried twice to verify the condition. If the previous speed ratio is still present, a diagnostic code is logged and the TCU commands the transmission to the previous range.

The off-going ratio test is applied during the interval between the turbine speed Shift Initiation point and the Pull Down Detected point.

## Oncoming Ratio Test

The oncoming ratio test is performed near the end of a shift in progress.

The oncoming ratio test checks turbine speed and output speed to determine if the transmission is in the range commanded by the TCU.

When the ratios do not match, the TCU assumes the oncoming clutch did not come on and will log a diagnostic code.

## DO NOT SHIFT LIGHT

The electronic control system is programmed to inform the operator of a problem with the transmission system and automatically take action to protect the operator, vehicle, and transmission.

To do this, the TCU restricts shifting, turns on the DO NOT SHIFT (DNS) light on the instrument panel (MDU), and registers a diagnostic code.

**NOTE: For some problems, diagnostic codes may be registered without the TCU activating the DO NOT SHIFT light. Check the TCU periodically for the presence of diagnostic codes or any time there is a transmission-related concern.**

Each time the engine is started, the DO NOT SHIFT light will illuminate, then turn off after a few seconds.

This momentary lighting is to show that the light does not illuminate during ignition, or if the light remains on after ignition, the system should be checked immediately.

Continued illumination of the DNS light during vehicle operation (other than start-up) indicates that the TCU has signalled a diagnostic code.

Illumination of the DNS light is accompanied by eight seconds of short beeps from the shift selector.

The beeps are audible indications that shifts are being restricted.The SELECT digit on the shift selector display will be blank and the TCU may not respond to shift selector requests.

Use a Diagnostic Data Reader (**DDR**) and the instructions that are with the Reader to gain access to diagnostic code information.

The indications from the shift selector are provided to inform the operator that the transmission is not performing as designed and is operating with reduced capabilities.

Before turning the ignition off, the transmission may be operated for a short time in the selected range in order to "**limp home**" for service assistance.

Generally, while the DNS light is on, upshifts and downshifts will be restricted and direction changes will not occur.

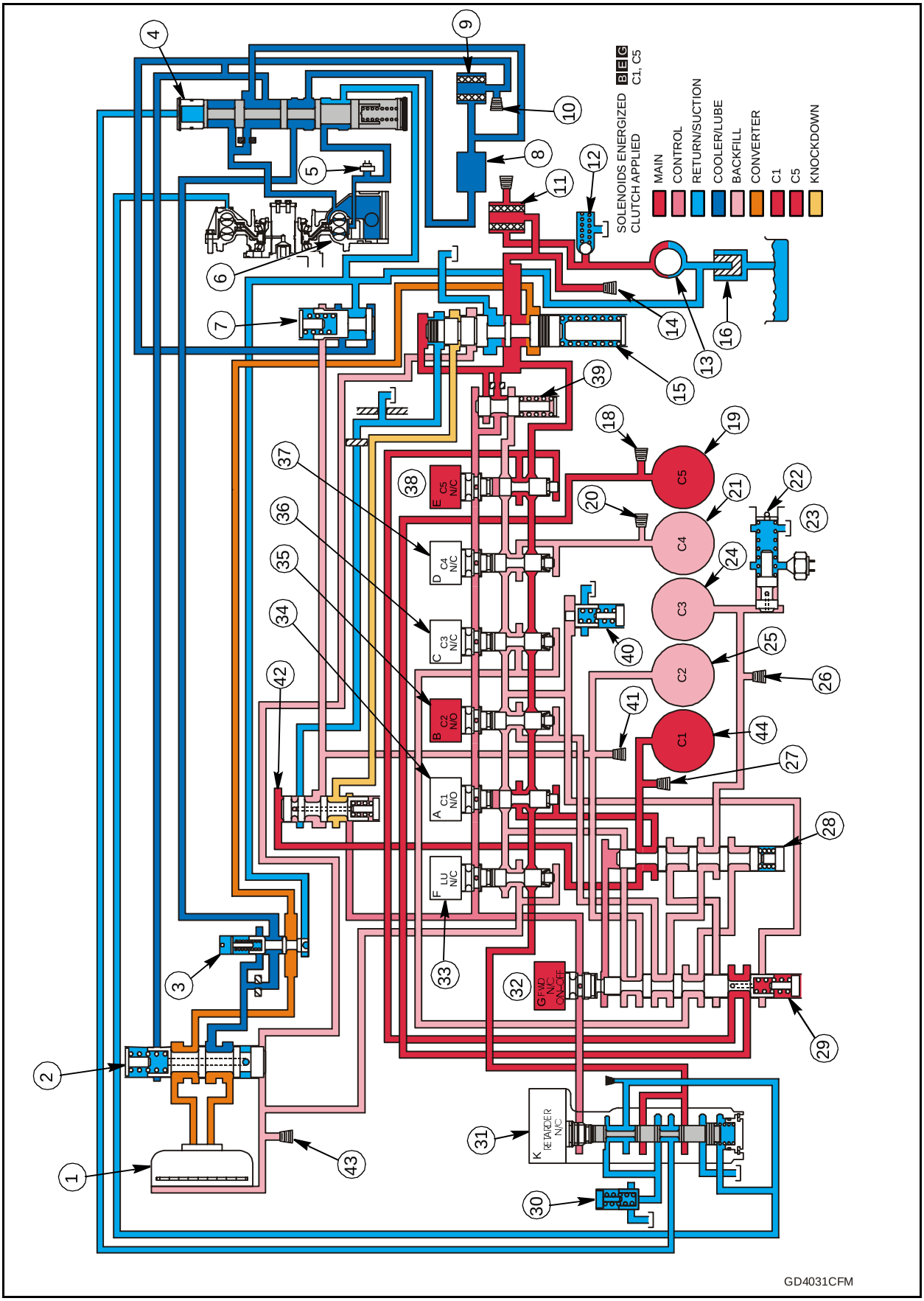
Push button shift selectors do not respond to any operator shift requests while the DNS light is illuminated.

The lockup clutch is disengaged when transmission shifting is restricted or during any critical transmission malfunction.

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**LEFT BLANK INTENTIONALLY**

## Backfill Pressure




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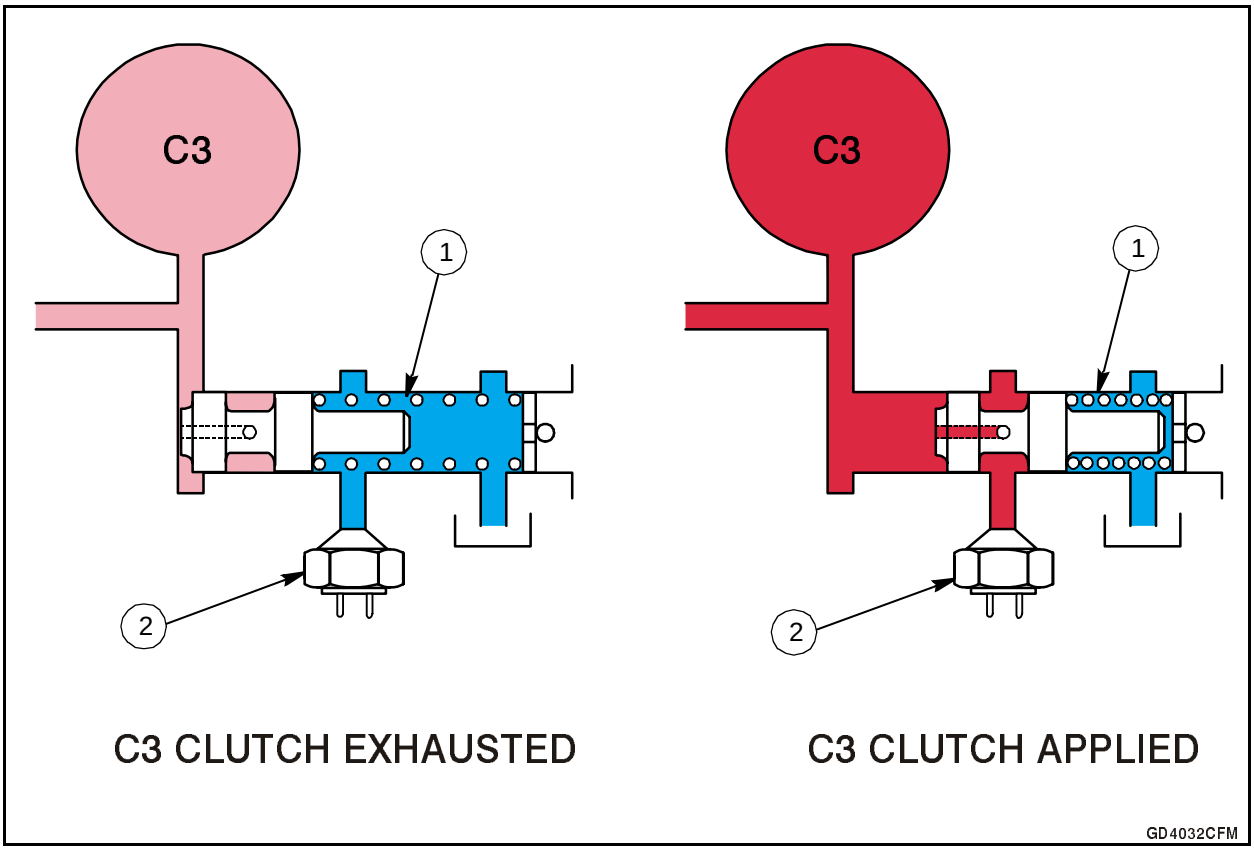
1. Torque Converter.
2. Converter Flow Valve.
3. Converter Regulator Valve.
4. Retarder Flow Valve.
5. Transmission Oil Temperature Sensor.
6. Retarder Housing.
7. Lube Pressure Regulator.
8. Transmission Cooler.
9. Lube Filter.
10. Lube Oil Pressure Test Port.
11. Main Filter.
12. Pressure Relief Valve.
13. Transmission Pump.
14. Main Pressure Test Port.
15. Main Pressure Regulator.
16. Suction Filter.
17. Transmission Oil Sump.
18. C5 Clutch Pressure Test Port.
19. C5 Clutch.
20. C4 Clutch Pressure Test Port.
21. C4 Clutch.
22. Accumulator/Relay Valve.
23. C3 Pressure Switch.
24. C3 Clutch.
25. C2 Clutch.
26. C3 Clutch Pressure Test Port.
27. C1 Clutch Pressure Test Port.
28. C1 Latch Valve.
29. C2 Latch Valve.
30. Retarder Check Valve.
31. Solenoid K.
32. Solenoid G.
33. Solenoid F.
34. Solenoid A.
35. Solenoid B.
36. Solenoid C.
37. Solenoid D.
38. Solenoid E.
39. Control Pressure Regulator.
40. Backfill Valve.
41. C2 Clutch Pressure Test Port.
42. Overdrive Knockdown Valve.
43. Torque Converter Lockup Pressure Test Port.
44. C1 Clutch.

When clutch apply pressure is released from the clutches, backfill pressure is sent to them as in C2 (23), C3 (22) and C4 (18). This is a pressure low enough that the clutches don't come on, but they stay full of oil so there's no delay due to clutch fill time when they apply.

Backfill is initially charged through the control pressure regulator (36), backfill pressure is regulated by the backfill valve (35), excess pressure is dumped to the sump (13).

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## Accumulator Relay Valve




1. Accumulator Relay Valve.
2. C3 Pressure Switch.

C3 pressure switch (2) sends a signal to the TCU when Clutch is applied.

Oil to apply C3 clutch comes from solenoid valves as hydraulic pressure pulses.

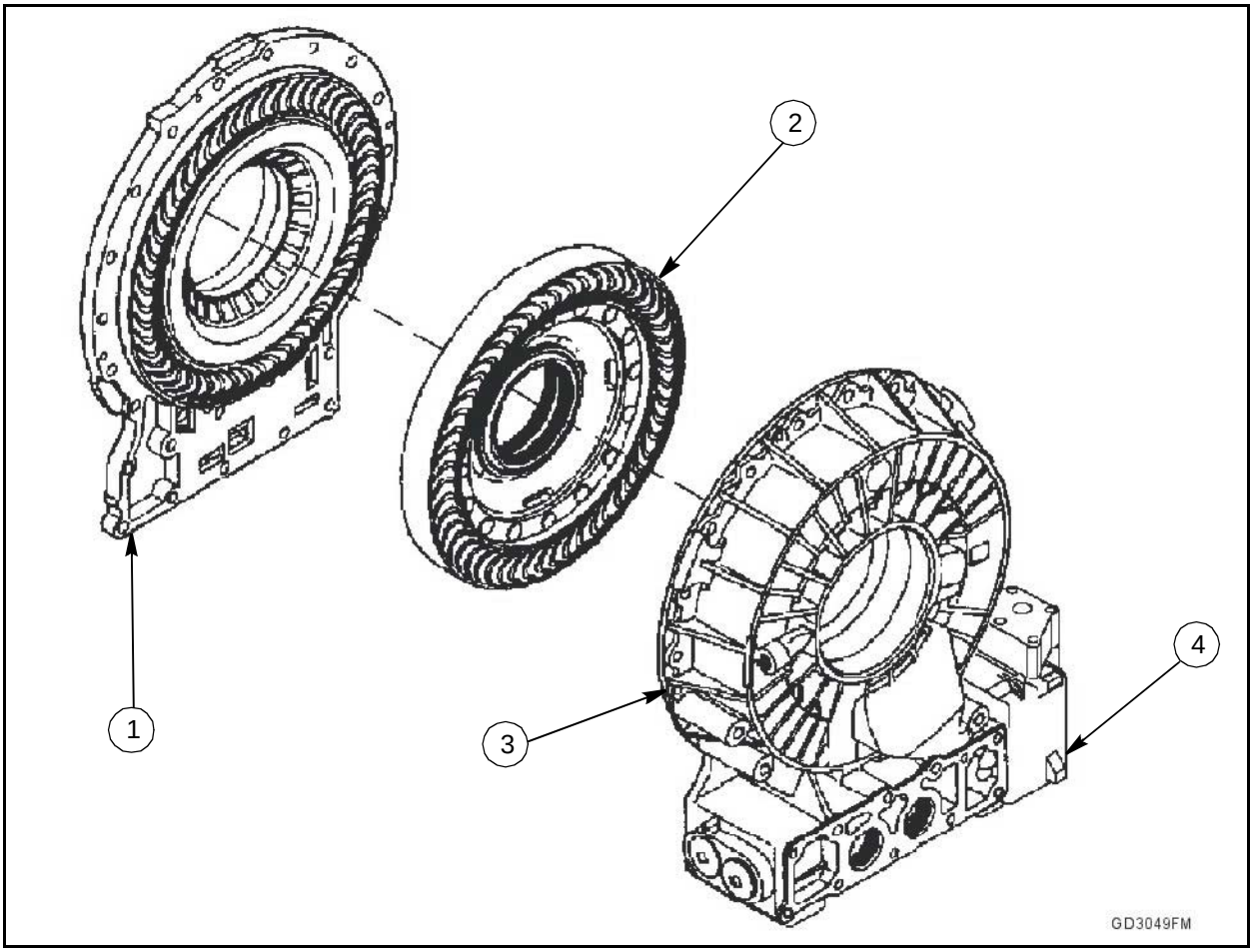
the accumulator valve (1) dampens these pulses so the pressure switch doesn't cycle on and off.

As pressure in C3 clutch increases, the valve is forced against its spring.

Oil pressure is felt by the pressure switch through a drilled passage in the valve spool.

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## Transmission Retarder Operation




1. Stator.
2. Rotor.
3. Housing.
4. Retarder Control Valve.

The transmission retarder system consists of the following components:

- Retarder control valve body.
- Retarder valve.
- Housing.
- Rotor.
- Stator.

The retarder section of the transmission includes the P3 carrier of the P3 planetary gear set, output shaft assembly, C5 clutch piston, speed sensor and the output flange.

The rotor (2) is splined to the output shaft and is driven at output shaft speed. The retarder stator (1), rotor (2) and housing (30 all have integral vanes. The rotor rotates between the stationary stator and retarder housing.

Retardation occurs when the retarder housing is filled with transmission oil and pressurized, causing the rotor, output shaft and truck to slow down speed.

Retarder intensity is determined by one of six positions of the retarder hand control lever, transmission output speed, retarder oil temperature and the transmission gear attained.

The retarder hand control lever sends a signal to the transmission control unit (TCU) which control the control valve body assembly (4) mounted on the outside of the retarder housing.

The control valve sends the proper amount of transmission oil to the retarder for the intensity of retardation selected by the retarder hand control lever.

For electrical operation of retarder, **See "Transmission Control Unit and Retarder Circuit Theory of Operation" on page 70).**

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### Retarder Activated

1. Retarder Housing.
2. Temperature Sensor.
3. Flow Valve.
4. Orifice.
5. Transmission Cooler.
6. Check Valve.
7. Retarder Control Valve.

When retarder operation is requested, the TCU commands a duty cycle to the retarder control valve solenoid, dependent on the intensity selected by the hand control lever in the cab.

Main oil pressure is regulated to a valve, dependent on the spring force below the retarder control valve (7) and the duty cycle of the retarder control valve solenoid.

8. Retarder Charge Pressure Test Port.
9. Control Oil.
10. Main Oil.
11. Converter Oil.
12. Return/Suction Oil.
13. Retarder Oil.

Main oil pressure acting on the flow valve (3) strokes the valve against its spring. This initial charge of oil, continuously supplemented by retarder charging pressure, produces the retarding of the retarder motor within the retarder housing.

Transmission oil used in the retarder is sent to the cooler and then returned to the retarder housing. During retarder operation, torque converter oil is routed directly to the lube circuit.

### Retarder Deactivated

1. Retarder Housing.
2. Temperature Sensor.
3. Flow Valve.
4. Orifice.
5. Transmission Cooler.
6. Check Valve.
7. Retarder Control Valve.
8. Retarder Charge Pressure Test Port.
9. Control Oil.
10. Main Oil.
11. Converter Oil.
12. Return/Suction Oil.
13. Cooler Lube Oil.

When the retarder is de-activated, the apply process is reversed. During the de-activating process, the retarder control valve (7) solenoid is de-activated at a fixed rate.

The retarder control valve moves due to the spring force on one side and the absence of main oil pressure on the other side.

As the valve moves, an exhaust passage opens to release main oil pressure and retarder control valve charging pressure.

When main oil pressure is no longer acting on the flow valve, the flow valve moves due to spring force acting upon the valve.

The movement of the flow valve opens an exhaust port which evacuates retarder charging pressure and directs torque converter-out oil to he oil cooler and then back into the lube circuit.

Some oil cooler return oil is directed through an orifice (4) and into the retarder housing to provide lubrication for components inside the retarder housing.

The exhaust check valve (6) ensures that lube oil flows into the retarder housing and not directly to exhaust.

## Transmission Thermal Valve Operation

The transmission thermal valve is a heat-activated hydraulic valve used to control the cooler fan speed according to transmission oil temperature.

When the transmission oil temperature is cold the thermal valve is fully open, dumping the load sense signal to tank.

The thermal valve senses transmission oil temperature and controls the speed of the fan motor by limiting oil to the fan drive load sense line to tank.

The cooler fan is turning at full speed when the transmission oil temperature is at 97° C (207° F) or higher.

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## Differential Lock Operation

A controlled traction clutch (differential lock) is used in all axles. A momentary rocker switch in the cab enables air to actuate the air solenoid mounted on the axle to shift the splined collar into the friction disks.

Compression springs press the friction disks to allow the clutch pack to resist wheel spin and direct torque to the wheel with better traction. The clutch pack also dampens the impact created by off-road traction conditions.

## Inter-Axle Lock Operation

The inter-axle lock is a planetary gear set in the transfer case. The planetary gear set allows the front and rear axles to turn at different speeds due to a differential action.

The inter-axle lock will only activate if the throttle position is less than 10%. When the inter-axle lock collar is engaged, the planetary goes into a lockup configuration and torque is 1:1 front and rear.

With the inter-axle lock in lockup, both axles turn at the same speed and equal power is sent to all three axles.

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# CHAPTER 4. POWER TRAIN

## SECTION 2. DIAGNOSTIC INFORMATION

### DIAGNOSTIC PROCEDURE

Follow the six basic steps below to carry out trouble shooting efficiently.

### Know The System

Study the machine technical manual. Understand the system and circuits. Use schematics, component location drawings and theory of operation for each circuit and circuit components work.

### Ask The Operator

What type of work was the machine doing when the trouble was noticed?

Did the trouble start suddenly or has it been getting worse?

Did the machine have any previous problem? if so, which parts were repaired?

### Inspect The Machine

Check all daily maintenance points. (See Section 3-4min the Operators Manual). Check batteries, fuses, circuit breaker and electrical connections.

### Perform Operational Check-out.

Check all systems and functions on the machine. Use the helpful diagnostic information in the check-out to pinpoint the possible cause of the problem.

### Perform Troubleshooting

Connect laptop computer, if available. The self-diagnostic function lists any service codes and give corrective action information.

Before starting troubleshooting, first check battery voltage, circuit breakers and fuses.

Go to test groups to check pressures and voltages. Make sure adjustments are correct.

### Trace And Cause

Before reaching a conclusion, check the most probable and simplest to verify. Use the flow charts and symptom, problem, solution charts to help identify probable problem components.

Make a plan for appropriate repair to avoid other malfunctions.

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## DIAGNOSE POWER TRAIN SYSTEM MALFUNTIONS

**NOTE:Diagnose malfunction charts are arranged from most probable and simplest to verify, to least likely and most difficult to verify.**

| Symptom | Problem | Solution |
|---|---|---|
| Axle Breather Leaking. | Differential oil level incorrect | Adjust oil level (See **CHAPTER 15, SECTION 2 in the OMM**). |
| Final Drive Overheating. | Final drive oil level incorrect. | Adjust oil level (See **CHAPTER 15, SECTION 2 in the OMM**). |
| Final Drive Noisy. | Final drive oil level incorrect. | Adjust oil level (See **CHAPTER 15, SECTION 2 in the OMM**). |
| Final Drive Leaking Oil. | Final drive cover cap screws loose. | Tighten cap screws **(See Axle Outboard Planetaries in CHAPTER 2, SECTION 5 of Repair Manual).** |
| | Drain plug loose. | Tighten drain plug. |
| | Damaged O-Ring on cover. | Replace O-ring **(See Axle Outboard Planetaries in CHAPTER 2, SECTION 5 of Repair Manual).** |
| | Breather plugged. | Clean or replace breather. |
| Differential Assembly Noisy and/ or Overheating. | Differential oil level incorrect. | Adjust oil level **(See CHECK AXLE OIL LEVELS in CHAPTER 13, SECTION 2 in OMM)**. |
| | Differential oil type Incorrect. | Drain and refill with correct type oil **(See Change Axle Oil in CHAPTER 15, SECTION 2 of OMM).** |
| | Differential Lock Bearing Used Excessively. | Use differential lock only when needed. |
| | Internal Differential Failure: | Disassemble and repair (**See CHAPTER 2, SECTION 5 in Repair Manual**). |

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| Symptom | Problem | Solution |
|---|---|---|
| Premature Brake Pad Wear - B35D | Operator “Riding” the brakes | Instruct operator on proper brake usage. |
| | Brake mud guard missing. | Replace mud guard (**See Service Brakes - B35D in CHAPTER 9, SECTION 1 in Repair Manual**). |
| | Mud or sand getting into brake pads. | Replace mud guard (**See Service Brakes - B35D in CHAPTER 9, SECTION 1 in Repair Manual**). |
| Premature Brake Pad Wear - B40D | Operator “Riding” the brakes. | Instruct operator on proper brake usage. |
| | Pressure applied to brake system when pedal is released. | Replace brake valve **(See Brake Valve in CHAPTER 9, SECTION 2).** |
| Poor Braking Performance | Brake pads worn (B35D) | Replace brake pads (**See Service Brakes - B35D in CHAPTER 9, SECTION 1 in Repair Manual**) |
| | Worn or damaged disks (B40D) | Disassemble and replace brake disks (**See Service Brakes - B40D in CHAPTER 9, SECTION 1 in Repair Manual**). |
| | Overheated seals and/or disks (B40D) | Disassemble and replace piston seals and/or disks (**See Service Brakes - B40D in CHAPTER 9, SECTION 1 in Repair Manual**) |
| | Dirty or contaminated cooling oil (B40D) | Drain and flush cooling oil from brakes **(See Change Wet Disk Brake Cooling Oil CHAPTER 15, SECTION 2 in OMM)**. |
| | | Clean or replace brake cooling oil filter **(See Replace Wet Disk Brake Cooling Oil Filter CHAPTER 15, SECTION 2 in OMM).** |
| | Brake valve failed | Replace brake valve **(See Brake Valve in CHAPTER 9, SECTION 2 in Repair Manual)**. |
| | Brake calliper sticking (B35D) | Clean and repair calliper (**See Service Brakes - B35D in CHAPTER 9, SECTION 1 in Repair Manual**). |
| Poor Braking Performance | Retarder not coming on | Service code diagnostics - TCU **(See CHAPTER 3, SECTION 4 in this manual).** |

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| Symptom | Problem | Solution |
|---|---|---|
| Brake Cooling Oil Leaking - B40D | Axle housing filling with brake cooling oil. | Worn or damaged spindle to hub seal **(See Axle Hubs in CHAPTER 2, SECTION 5 in Repair Manual).** |
| Brake Noise and Vibration - B40D | Brakes produce noise, chatter and vibration - Incorrect cooling oil | Replace wet disk brake cooling oil **(See Change Wet Disk Brake Cooling Oil CHAPTER 15, SECTION 2 in OMM)**. |
| Brakes Overheat - B40D | Incorrect Cooling Oil Flow | Check cooling pump output **(See "WET DISK BRAKE COOLING SYSTEM BYPASS CHECK VALVE TEST" on page 404)**. |
| | | Blocked filter **(See Replace Wet Disk Brake Cooling Oil Filter CHAPTER 15, SECTION 2 in OMM).** |
| | Brake cooling oil cooler restricted | Check for restricted oil cooler **(See "WET DISK BRAKE COOLER RESTRICTION TEST" on page 404)**. |
| | Low or no cooling oil | Check for oil leaks |
| | | Face seal leaking **(See Service Brakes - B40D in CHAPTER 9, SECTION 2 in the Repair Manual)**. |
| Service Brakes Do Not Release Fully | Brake calliper piston sticking (B35D) | Clean or replace pistons (**See Service Brakes - B35D in CHAPTER 9, SECTION 1 in Repair Manual**) |
| | Piston return spring damaged (B40D) | Disassemble and repair/replace spring assembly **(See Service Brakes - B40D in CHAPTER 9, SECTION 1 in Repair Manual)**. |
| | Brake valve failed | Replace brake valve **(See Brake Valve in CHAPTER 9, SECTION 2 in Repair Manual)**. |

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| Symptom | Problem | Solution |
|---|---|---|
| Park Brake Does Not Release | Chassis Control Unit (CCU) | Check CCU **(See "Remove and Install Chassis Control Unit" on page 201).** |
| | Park brake control valve failed | Replace park brake control valve **(See Remove and Install Park Brake Control Valve in CHAPTER 15, SECTION 2 in Repair Manual).** |
| | Air pressure low | Check system air pressure **(See "PARK BRAKE PRESSURE TEST" on page 332).** |
| | Park brake relay does not energize | Check park brake relay **(See "Park Brake and Exhaust Brake Circuit Theory of Operation" on page 82).** |
| | Park brake solenoid will not energize | Check park brake solenoid **(See "Park Brake and Exhaust Brake Circuit Theory of Operation" on page 82).** |
| | Park brake actuator failed | Replace actuator **(See Remove and Install Park Brake Actuator in CHAPTER 15, SECTION 2 in Repair Manual).** |
| | Park brake incorrectly adjusted | Adjust park brake **(See "Park Brake Adjustment" on page 306).** |
| Park Brake Will Not Hold | Park brake pads oily | Replace pads and clean disk **(See Park Brake in CHAPTER 10, SECTION 1 in Repair Manual).** |
| | Park brake incorrectly adjusted | Adjust park brake **(See "Park Brake Adjustment" on page 306).** |
| | Park brake control valve failed | Replace park brake control valve **(See Remove And Install Park Brake Control Valve, CHAPTER 15, SECTION 2 in Repair Manual).** |
| Engine Will Not Start (Turn Over) | Gear selector not in neutral | Push **N** (Neutral) on gear selector panel. |
| | Shift Control failed | Replace shift control |
| | Voltage to TCU too low or not present | Recharge or replace batteries Check and repair open harness |
| | TCU failed | Replace TCU **(See "Remove and Install Transmission Control Unit" on page 202).** |

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| Symptom | Problem | Solution |
|---|---|---|
| Machine Will Not Move | Transmission or vehicle harness disconnected or failed. | Connect, repair or replace harness. |
| | TCU failed. | Replace TCU **(See "Remove and Install Transmission Control Unit" on page 202).** |
| Transmission Will Not Shift to Forward or Reverse | Engine speed to high | Calibrate accelerator pedal **(See "Remove, Install, and Calibrate Accelerator Pedal Position Sensor" on page 206).** |
| | Oil level to low | Adjust to correct level **(See Check Transmission Oil Level in CHAPTER 15, SECTION 2 in the OMM).** |
| | Accelerator pedal failed | Replace accelerator pedal **(See "Remove, Install, and Calibrate Accelerator Pedal Position Sensor" on page 206).** |
| | Transmission harness disconnected or failed | Connect, repair or replace harness. |
| | Voltage to TCU too low | Check battery voltage, or repair open harness. |
| | Speed sensor failed | Replace speed sensor. |
| | TCU failed | Replace TCU **(See Remove "Remove and Install Transmission Control Unit" on page 202).** |
| Excessive Creep in First and Reverse | Engine idle speed too high | Calibrate accelerator pedal **(See "Remove, Install, and Calibrate Accelerator Pedal Position Sensor" on page 206).** |
| No Response To Shift Selector | Transmission oil level low | Add transmission oil. |
| | Shift selector failed | Replace shift selector. |
| | Transmission main oil pressure low | Transmission pump or pressure regulator failed. Check transmission pressure **(See "Transmission Pressure Test" on page 297).** |
| Machine Moves Backward in Neutral | C3 Clutch failed. | Disassemble and repair. **(See Disassemble and Assemble C3/C4 Clutch and Main Housing in CHAPTER 3, SECTION 3 in repair manual).** |

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| Symptom | Problem | Solution |
|---|---|---|
| Machine Moves Forward in Neutral | C1 Clutch failed. | Disassemble and repair. **(See Disassemble and Assemble C1/C2 Clutch and Main Housing in CHAPTER 3, SECTION 3 in repair manual).** |
| Engine Speed too High during Torque Convertor Stall. | C1 Clutch failed. | Disassemble and repair. **(See Disassemble and Assemble C1/C2 Clutch and Main Housing in CHAPTER 3, SECTION 3 in repair manual).** |
| | C5 Clutch failed. | Disassemble and repair. **(See Disassemble and Assemble C3/C4 Clutch and Main Housing in CHAPTER 3, SECTION 3 in repair manual).** |
| | Engine power too high. | Calibrate accelerator pedal **(See "Remove, Install, and Calibrate Accelerator Pedal Position Sensor" on page 206).** |
| Engine Speed too Low During Torque Converter Stall. | Engine power low. | Determine Cause of low power. |
| | Torque convertor failure | Replace torque convertor **(See Disassemble Transmission in CHAPTER 3, SECTION 3 of repair manual.** |
| Low Transmission Lube Pressure. | Transmission oil level low. | Add Transmission oil. |
| | Lube filter plugged. | Replace lube filter **(See Replace Transmission Oil Filters in CHAPTER 15, SECTION 2 van OMM).** |
| | Torque converter regulator valve failed. | Disassemble and repair. **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in repair manual).** |
| | Transmission cooler lines restricted or damaged. | Repair or replace cooler lines. |
| | Lube pressure regulator failed. | Disassemble and replace regulator **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in repair manual).** |
| | Transmission cooler plugged. | Clean or replace cooler **(See Remove and Install Transmission Oil Cooler CHAPTER 3, SECTION 4 in Repair Manual).** |

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| Symptom | Problem | Solution |
|---|---|---|
| Low Main Pressure in All Gears | Transmission oil level low. | Add transmission oil. |
| | Transmission oil filter plugged. | Replace filter **(See Replace Transmission Oil Filters in CHAPTER 15, SECTION 2 in OMM).** |
| | Transmission pump suction filter plugged. | Disassemble and clean filter **(See Replace Transmission Oil Filters in CHAPTER 15, SECTION 2 in OMM).** |
| | Transmission oil pressure gauge failed. | Replace MDU **(See Remove and Install Menu Display Unit in CHAPTER 3, SECTION 4 in the OMM).** |
| | Transmission main pressure regulator sticking or failed. | Repair or replace main pressure regulator **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Repair Manual).** |
| | Control module leaking. | Disassemble, check gaskets and housing **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Repair Manual).** |
| Low Main Pressure in All Gears | Transmission pump failed. | Disassemble and replace pump **(See Disassemble Transmission in CHAPTER 3, SECTION 4 in the Repair Manual).** |

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| Symptom | Problem | Solution |
|---|---|---|
| Excessive Clutch Slippage and Chatter. | Accelerator pedal miscalibrated. | Calibrate accelerator pedal **(See "Remove, Install, and Calibrate Accelerator Pedal Position Sensor" on page 206).** |
| | Transmission oil level low. | Add transmission oil. |
| | Transmission main pressure regulator sticking or failed. | Repair or replace main pressure regulator **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Repair Manual).** |
| | Transmission control solenoid F sticking. | Disassemble control valve and clean or replace solenoid F **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Repair Manual).** |
| | Torque converter lockup clutch failed. | Disassemble torque converter **(See Disassemble and Assemble Torque Converter in CHAPTER 3, SECTION 3 in the Repair Manual).** |
| | Transmission control solenoid F Green Wire 107-T22 failed. | Disassemble control valve and repair wire **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Repair Manual).** |
| | Transmission control solenoid F White Wire 107-T22 failed. | Disassemble control valve and repair wire **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Repair Manual).** |
| Excessive Slippage and Clutch Chatter in 1st, 2nd, 3rd and 4th Gears Only. | C1 Clutch failed. | Disassemble and repair **(See Disassemble and Assemble C1/C2 Clutch in CHAPTER 3, SECTION 3 in repair manual).** |
| Excessive Slippage and Clutch Chatter in 1st and Reverse Gears Only. | C5 Clutch failed. | Disassemble and repair **(See Disassemble and Assemble C3/C4 Clutch and Main Housing in CHAPTER 3, SECTION 3 in repair manual).** |
| Excessive Slippage and Clutch Chatter in 2nd and 6th Gears Only. | C4 Clutch failed. | Disassemble and repair **(See Disassemble and Assemble C3/C4 Clutch and Main Housing in CHAPTER 3, SECTION 3 in repair manual).** |

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| Symptom | Problem | Solution |
|---|---|---|
| Excessive Slippage and Clutch Chatter in 3rd, 5th and Reverse Gears Only. | C3 Clutch failed | Disassemble and repair **(See Disassemble and Assemble C3/C4 Clutch and Main Housing in CHAPTER 3, SECTION 3 in repair manual).** |
| Excessive Slippage and Clutch Chatter in 4th, 5th and 6th Gears Only. | C2 Clutch failed | Disassemble and repair **(See Disassemble and Assemble C1/C2 Clutch in CHAPTER 3, SECTION 3 in repair manual).** |
| Oil Comes Out of Transmission Oil Fill Tube. | Dipstick loose or seal failed. | Install dipstick correctly or replace. |
| | Incorrect dipstick. | Replace dipstick. |
| | Transmission oil level high. | Drain oil to correct level **(See Change Transmission Oil in CHAPTER 15, SECTION 2 in the OMM).** |
| | Transmission breather clogged. | Remove and clean breather **(See Clean, Check and Replace Breathers in CHAPTER 13, SECTION 2 in the OMM).** |
| | Transmission oil contaminated. | Drain oil, replace filters and refill oil **(See Change Transmission Oil in CHAPTER 15, SECTION 2 in the OMM).** |
| Buzzing Noise Coming From Transmission. | Transmission oil level too high | Drain oil to correct level **(See Change Transmission Oil in CHAPTER 15, SECTION 2 in the OMM).** |
| | Transmission filter plugged. | Replace filter **(See Replace Transmission Oil Filters in CHAPTER 15, SECTION 2 in OMM).** |
| | Transmission pump suction filter plugged. | Clean filter **(See Replace Transmission Oil Filters in CHAPTER 15, SECTION 2 in OMM).** |
| | Main pressure low. | Check transmission main pressure **(See “Transmission Pressure Test” on page 297).** |

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| Symptom | Problem | Solution |
|---|---|---|
| Transmission Overheating in All Gears. | Transmission oil level too low or too high. | Adjust oil level **(See Change Transmission Oil in CHAPTER 15, SECTION 2 in the OMM).** |
| | Transmission oil cooler plugged. | Clean or replace cooler **(See Remove and Install Transmission Oil Cooler CHAPTER 3, SECTION 4 in Repair Manual).** |
| | | Check cooling fan **(See"FAN DRIVE CONTROLLER TEST AND ADJUSTMENT" on page 403).** |
| Shift Selector Displays **N** (Neutral) and Machine Will Not Move | Transmission harness connector disconnected. | Reconnect harness connector. |
| | Electrical failure. | **See "Service Code Diagnostics -Transmission Control Unit (TCU)" on page 105).** |
| | TCU failed. | Replace TCU **(See "Remove and Install Transmission Control Unit" on page 202).** |
| | Transmission shift control failed. | Replace transmission shift control. |
| Transmission Will Not Shift to Forward or Reverse (Stays in Neutral) | Transmission harness disconnected. | Connect harness. |
| | Transmission oil level low. | Add transmission oil. |
| | Accelerator pedal failed. | Replace accelerator pedal **(See "Remove, Install, and Calibrate Accelerator Pedal Position Sensor" on page 206).** |
| | TCU input voltage too low. | Reset circuit breaker. |
| | Transmission shift control failed. | Replace transmission shift control. |
| | TCU failed. | Replace TCU **(See "Remove and Install Transmission Control Unit" on page 202).** |

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| Symptom | Problem | Solution |
|---|---|---|
| Transmission Not Shifting Properly (Rough Shifts, Shifting at Too Low or Too High Speed). | Engine slow idle speed too high. | Calibrate accelerator pedal **(See Remove, Install and Calibrate Accelerator Pedal Position Sensor in CHAPTER 3, SECTION 4 in this manual).** |
| | Accelerator pedal miscalibrated. | Calibrate accelerator pedal **(See Remove, Install and Calibrate Accelerator Pedal Position Sensor in CHAPTER 3, SECTION 4 in this manual).** |
| | Transmission ratio calibration incorrect. | See **"Service Code Diagnostics -Transmission Control Unit (TCU)" on page 105).** |
| | TCU voltage too low or too high. | Check charging system voltage and circuit breakers. |
| | Transmission oil level low. | Adjust oil level. |
| Transmission Will Not Make a Specific Shift. | Transmission oil level low. | Adjust oil level. |
| | Engine power low. | Check engine power **(See "Torque Converter Stall Test" on page 303).** |
| | TCU failed. | Replace TCU **(See "Remove and Install Transmission Control Unit" on page 202).** |
| | Transmission temperature sensor failed. | Replace sensor. |
| | Harness failure. | Check wire harness. |
| | Transmission overheating (Will Not Shift). | Clean plugged oil cooler **(See Inspect and Clean Cooling Systems in CHAPTER 11, SECTION 1 in the OMM)**. |
| | Transmission ratio calibration incorrect. | **See "Service Code Diagnostics -Transmission Control Unit (TCU)" on page 105).** |
| | Transmission shift control failed. | Replace shift control. |
| Transmission Oil Leaking Into Torque Converter Housing. | Transmission pump seal worn. | Replace seal (**See Disassemble Transmission and Assemble Transmission in CHAPTER 3, SECTION 3 in the Repair Manual).** |
| | Rear engine seal leaking. | Replace seal **(See Crankshaft Oil Seals in CHAPTER 4, SECTION 2 in the Repair Manual).** |

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| Symptom | Problem | Solution |
|---|---|---|
| Transmission Retarder Does Not Function. | Solenoid H open circuit. | Replace solenoid **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Repair Manual).** |
| | Retarder regulator valve sticking | Replace regulator valve **(See Disassemble and Assemble Retarder and P3 Planetary in CHAPTER 3, SECTION 3 in the Repair Manual).** |
| | Retarder relay valve sticking | Replace relay valve **(See Disassemble and Assemble Retarder and P3 Planetary in CHAPTER 3, SECTION 3 in the Repair Manual).** |
| | Retarder flow valve sticking. | Replace flow valve **(See Disassemble and Assemble Retarder and P3 Planetary in CHAPTER 3, SECTION 3 in the Repair Manual).** |
| | Accelerator pedal greater than 1%. | Calibrate accelerator pedal **(See "Remove, Install, and Calibrate Accelerator Pedal Position Sensor" on page 206).** |
| | Codes 64-12 or 64-23. | Check codes **(See "Service Code Diagnostics - Transmission Control Unit (TCU)" on page 105).** |
| | Transmission output speed incorrect. | Check output speed **(See "Transmission Speed Sensors Test" on page 199).** |

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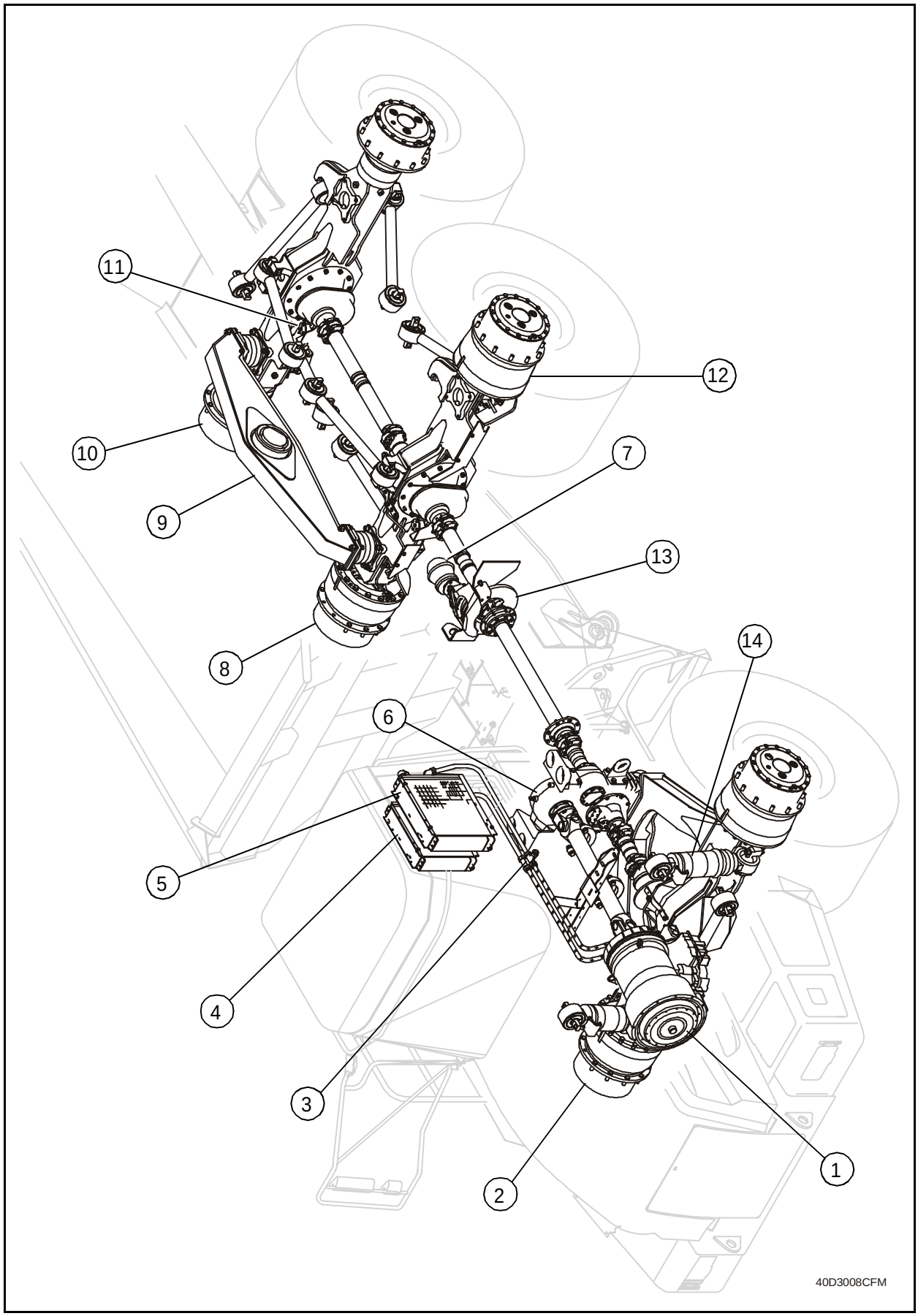
| Symptom | Problem | Solution |
|---|---|---|
| Transmission Retarder Weak. | Solenoid H open circuit or leaking. | Replace solenoid **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Repair Manual).** |
| | Retarder regulator valve sticking | Replace regulator valve **(See Disassemble and Assemble Retarder and P3 Planetary in CHAPTER 3, SECTION 3 in the Repair Manual).** |
| | Retarder relay valve sticking. | Replace relay valve **(See Disassemble and Assemble Retarder and P3 Planetary in CHAPTER 3, SECTION 3 in the Repair Manual).** |
| | Retarder flow valve sticking. | Replace flow valve **(See Disassemble and Assemble Retarder and P3 Planetary in CHAPTER 3, SECTION 3 in the Repair Manual).** |
| | Retarder temperature sensor damaged. | Replace temperature sensor. |
| | Retarder intensity spring damaged. | Disassemble retarder control valve **(See Disassemble and Assemble Retarder and P3 Planetary in CHAPTER 3, SECTION 3 in the Repair Manual).** |
| | Transmission charge pump worn. | Disassemble transmission charge pump **(See Disassemble Transmission Charge Pump in CHAPTER 3, SECTION 3 in the Repair Manual).** |
| | Worn components causing internal leak. | Disassemble retarder housing **(See Disassemble Transmission in CHAPTER 3, SECTION 3 in the Repair Manual).** |

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| Symptom | Problem | Solution |
|---|---|---|
| Retarder Stays On When Not Requested. | Solenoid H open circuit. | Replace solenoid **(See Disassemble and Assemble Control Valve in CHAPTER 3, SECTION 3 in the Repair Manual).** |
| | Retarder regulator valve sticking. | Replace regulator valve **(See Disassemble and Assemble Retarder and P3 Planetary in CHAPTER 3, SECTION 3 in the Repair Manual).** |
| | Retarder relay valve sticking. | Replace relay valve **(See Disassemble and Assemble Retarder and P3 Planetary in CHAPTER 3, SECTION 3 in the Repair Manual).** |
| | Retarder flow valve sticking. | Replace flow valve **(See Disassemble and Assemble Retarder and P3 Planetary in CHAPTER 3, SECTION 3 in the Repair Manual).** |
| Transmission Retarder Too Aggressive. | Retarder intensity spring damaged. | Disassemble retarder control valve **(See Disassemble and Assemble Retarder and P3 Planetary in CHAPTER 3, SECTION 3 in the Repair Manual).** |
| | Retarder regulator valve sticking. | Disassemble retarder control valve **(See Disassemble and Assemble Retarder and P3 Planetary in CHAPTER 3, SECTION 3 in the Repair Manual).** |

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## Power Train Component Location Diagram



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1. Transmission.
2. Front Axle.
3. Transmission Oil Thermal Valve.
4. Wet Disc Brake Oil Cooler (B40D Only).
5. Transmission Oil Cooler.
6. Transfer Case.
7. Park Brake Actuator.
8. Middle Axle.
9. Walking Beam.
10. Rear Axle.
11. Differential Lock Actuator.
12. Wet Disc Brake (40D Only).
13. Park Brake Disk.
14. Suspension Absorber.

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# CHAPTER 4. TRANSMISSION

## SECTION 3. TESTS

### TRANSMISSION WARM-UP PROCEDURE

**⚠ CAUTION**

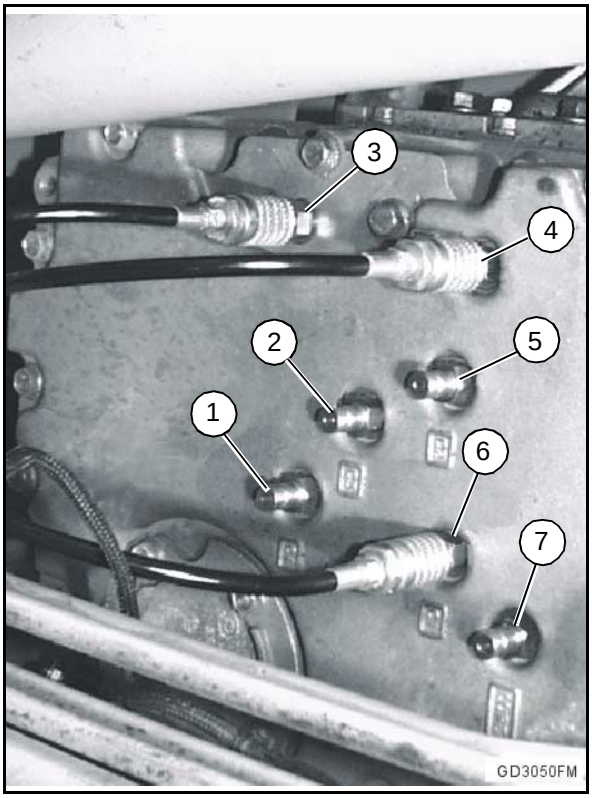
**Perform procedure in an open area away from other people or machines. Machine may move unexpectedly.**

**⚠ WARNING**

**1. Never stall torque converter for more than 30 seconds. Do not allow transmission temperature to exceed 100° C (212° F). Transmission damage will result if temperature is allowed to exceed the specification.**
**2. Never stall torque converter in reverse. Drive shaft, transfer case or differential damage may result. Reverse gear ratio is lower than 1st gear ratio and excessive torque will be transferred to the drive shaft, transfer case or differential.**

- Select transmission temperature on the MDU. (See MDU - menu functions in Chapter 8 of the OMM). watch transmission temperature and tachometer display.
- Apply park brake. Push service brake pedal and hold it down during warm-up.
- Raise bin past the float position to tun off the transmission oil cooler fan, helping to increase transmission temperature.
- Shift transmission into 1st gear. accelerate throttle to maximum r.p.m. and hold (approximately 30 seconds). When the engine r.p.m. drops to 600 r.p.m. select neutral on the gear selector. Engine r.p.m.'s will now increase to 1200 r.p.m. Release the accelerator pedal. Repeat until transmission temperature reaches 76° C (170° F).

### Transmission Pressure Test




1. C4 Clutch Port.
2. C3 Clutch Port.
3. C5 Clutch Port.
4. Main Pressure Port.
5. C2 Clutch Port.
6. C1 Clutch Port.
7. Lube Pressure port.

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| SPECIFICATIONS Transmission Pressure | |
|---|---|
| Transmission Oil Temperature | 71 - 93° C (160 - 200° F) |
| Slow idle 580 - 620 r.p.m., Gear - Neutral, Clutch Applied - C5 Pressure | Main: 1500 - 2070 kPa {15.0 - 20.7 bar (216 - 300 psi)}. |
| Slow idle 580 - 620 r.p.m., Gear - Neutral, Clutch Applied - C5 | Clutch: Within 70 kPa {0.7 bar (10 psi)} of main pressure. |
| Slow idle 580 - 620 r.p.m., Gear - Reverse, Clutch Applied - C3, C5 Pressure | Main: 1917 - 1993 kPa {19.2 - 19.9 bar (279 - 298 psi)}. |
| Slow idle 580 - 620 r.p.m., Gear - Reverse, Clutch Applied - C3, C5 | Clutch: Within 70 kPa {0.7 bar (10 psi)} of main pressure. |
| Slow idle 580 - 620 r.p.m., Gear - 1st, Clutch Applied - C5 Pressure | Main: 1300 - 1800 kPa {13.0 - 18.0 bar (189 - 260 psi)}. |
| Slow idle 580 - 620 r.p.m., Gear - 1st, Clutch Applied - C5 Pressure | Clutch: Within 70 kPa {0.7 bar (10 psi)} of main pressure. |
| 1780 - 1820 r.p.m., Gear - Neutral, Clutch Applied - C5 Pressure. | Main: 1800 - 2100 kPa {18.0 - 21.0 bar (261 - 305 psi)}. |
| 1780 - 1820 r.p.m., Gear - Neutral, Clutch Applied - C5. | Lube: 117 - 193 kPa {1.2 - 1.9 bar (17 - 28 psi)}. |
| 1780 - 1820 r.p.m., Gear - Neutral, Clutch Applied - C5. | Clutch: Within 70 kPa {0.7 bar (10 psi)} of main pressure. |
| 1780 - 1820 r.p.m., Gear - Reverse, Clutch Applied - C3, C5 Pressure. | Main: 1800 - 2100 kPa {18.0 - 21.0 bar (261 - 305 psi)}. |
| 1780 - 1820 r.p.m., Gear - Reverse, Clutch Applied - C3, C5. | Lube: 117 - 193 kPa {1.2 - 1.9 bar (17 - 28 psi)}. |
| 1780 - 1820 r.p.m., Gear - Reverse, Clutch Applied - C3, C5. | Clutch: Within 70 kPa {0.7 bar (10 psi)} of main pressure. |
| 1780 - 1820 r.p.m., Gear - 1st, Clutch Applied - C1, C5 Pressure. | Main: 1550 - 1800 kPa {15.5 - 18.0 bar (225 - 261 psi)}. |
| 1780 - 1820 r.p.m., Gear - 1st, Clutch Applied - C1, C5. | Lube: 117 - 193 kPa {1.2 - 1.9 bar (17 - 28 psi)}. |
| 1780 - 1820 r.p.m., Gear - 1st, Clutch Applied - C1, C5. | Clutch: Within 70 kPa {0.7 bar (10 psi)} of main pressure. |
| 1780 - 1820 r.p.m., Gear - 2nd, Clutch Applied - C1, C4 Pressure. | Main: 1550 - 1800 kPa {15.5 - 18.0 bar (225 - 261 psi)}. |
| 1780 - 1820 r.p.m., Gear - 2nd, Clutch Applied - C1, C4 | Lube: 117 - 193 kPa {1.2 - 1.9 bar (17 - 28 psi)}. |
| 1780 - 1820 r.p.m., Gear - 2nd, Clutch Applied - C1, C4. | Clutch: Within 70 kPa {0.7 bar (10 psi)} of main pressure. |
| 1780 - 1820 r.p.m., Gear - 1st Lockup, Clutch Applied - C1, C5 Pressure. | Main: 1886 - 1324 kPa {18.9 - 13.2 bar (172 - 192 psi)}. |
| 1780 - 1820 r.p.m., Gear - 1st Lockup, Clutch Applied - C1, C5. | Lube: 117 - 193 kPa {1.2 - 1.9 bar (17 - 28 psi)}. |

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| SPECIFICATIONS Transmission Pressure | |
|---|---|
| 1780 - 1820 r.p.m., Gear - 1st Lockup, Clutch Applied - C1, C5. | Clutch: Within 70 kPa {0.7 bar (10 psi)} of main pressure. |
| 1780 - 1820 r.p.m., Gear - 1st Lockup, Clutch Applied - C1, C5. | Lockup Clutch: 950 - 1400 kPa {9.5 - 14.0 bar (138 - 203 psi)} |
| 1780 - 1820 r.p.m., Gear - 2nd Lockup, Clutch Applied - C1, C4, Lockup Pressure. | Main: 1050 - 1400 kPa {10.5 - 14.0 bar (152 - 203 psi)}. |
| 1780 - 1820 r.p.m., Gear - 2nd Lockup, Clutch Applied - C1, C4, Lockup. | Lube: 117 - 193 kPa {1.2 - 1.9 bar (17 - 28 psi)}. |
| 1780 - 1820 r.p.m., Gear - 2nd Lockup, Clutch Applied - C1, C4, Lockup. | Clutch: Within 70 kPa {0.7 bar (10 psi)} of main pressure. |
| 1780 - 1820 r.p.m., Gear - 2nd Lockup, Clutch Applied - C1, C4, Lockup. | Lockup Clutch: 950 - 1400 kPa {9.5 - 14.0 bar (138 - 203 psi)} |
| 1780 - 1820 r.p.m., Gear - 3rd Lockup, Clutch Applied - C1, C3, Lockup Pressure. | Main: 1050 - 1400 kPa {10.5 - 14.0 bar (152 - 203 psi)}. |
| 1780 - 1820 r.p.m., Gear - 3rd Lockup, Clutch Applied - C1, C3, Lockup. | Lube: 117 - 193 kPa {1.2 - 1.9 bar (17 - 28 psi)}. |
| 1780 - 1820 r.p.m., Gear - 3rd Lockup, Clutch Applied - C1, C3, Lockup. | Clutch: Within 70 kPa {0.7 bar (10 psi)} of main pressure. |
| 1780 - 1820 r.p.m., Gear - 3rd Lockup, Clutch Applied - C1, C3, Lockup. | Lockup Clutch: 950 - 1400 kPa {9.5 - 14.0 bar (138 - 203 psi)} |
| 1780 - 1820 r.p.m., Gear - 4th Lockup, Clutch Applied - C1, C2, Lockup Pressure. | Main: 1050 - 1400 kPa {10.5 - 14.0 bar (152 - 203 psi)}. |
| 1780 - 1820 r.p.m., Gear - 4th Lockup, Clutch Applied - C1, C2, Lockup. | Lube: 110 - 152 kPa {1.1 - 1.52 bar (16 - 22 psi)}. |
| 1780 - 1820 r.p.m., Gear - 4th Lockup, Clutch Applied - C1, C2, Lockup. | Clutch: Within 70 kPa {0.7 bar (10 psi)} of main pressure. |
| 1780 - 1820 r.p.m., Gear - 4th Lockup, Clutch Applied - C1, C2, Lockup. | Lockup Clutch: 950 - 1400 kPa {9.5 - 14.0 bar (138 - 203 psi)} |
| 1780 - 1820 r.p.m., Gear - 5th Lockup, Clutch Applied - C2, C3, Lockup Pressure. | Main: 900 - 1250 kPa {9.0 - 12.5 bar (131 - 181 psi)}. |
| 1780 - 1820 r.p.m., Gear - 5th Lockup, Clutch Applied - C2, C3, Lockup. | Lube: 110 - 152 kPa {1.1 - 1.52 bar (16 - 22 psi)}. |
| 1780 - 1820 r.p.m., Gear - 5th Lockup, Clutch Applied - C2, C3, Lockup. | Clutch: Within 70 kPa {0.7 bar (10 psi)} of main pressure. |
| 1780 - 1820 r.p.m., Gear - 5th Lockup, Clutch Applied - C2, C3, Lockup. | Lockup Clutch: 850 - 1300 kPa {8.5 - 13.0 bar (124 - 189 psi)} |
| 1780 - 1820 r.p.m., Gear - 6th Lockup, Clutch Applied - C2, C4, Lockup Pressure. | Main: 900 - 1250 kPa {9.0 - 12.5 bar (131 - 181 psi)}. |
| 1780 - 1820 r.p.m., Gear - 6th Lockup, Clutch Applied - C2, C4, Lockup. | Lube: 110 - 152 kPa {1.1 - 1.52 bar (16 - 22 psi)}. |
| 1780 - 1820 r.p.m., Gear - 6th Lockup, Clutch Applied - C2, C4, Lockup. | Clutch: Within 70 kPa {0.7 bar (10 psi)} of main pressure. |

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| SPECIFICATIONS Transmission Pressure | |
|---|---|
| 1780 - 1820 r.p.m., Gear - 6th Lockup, Clutch Applied - C2, C4, Lockup. | Lockup Clutch: 850 - 1300 kPa {8.5 - 13.0 bar (124 - 189 psi)} |

| ESSENTIAL TOOLS | SERVICE EQUIPMENT AND TOOLS |
|---|---|
| 202839 Fitting | 4136 kPa {41.4 bar (600 psi)} Gauge |

Shut engine **OFF** and apply park brake.

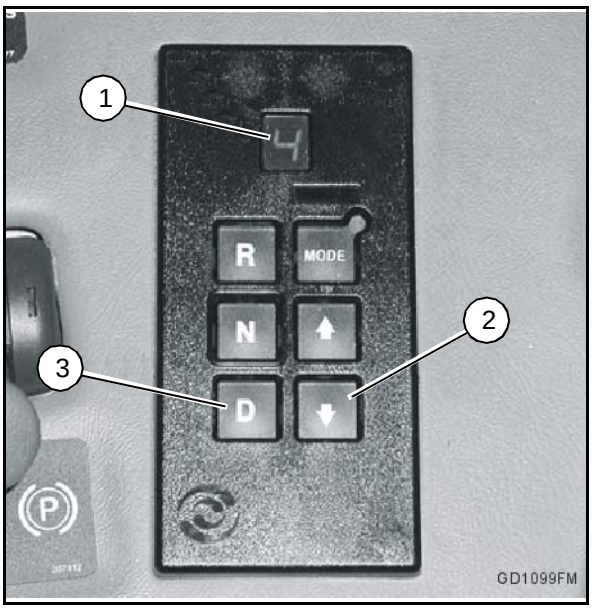
Remove plugs and install fittings in pressure ports (1 - 7).

Attach hoses and gauges to fittings.

Start machine and warm transmission to normal temperature {71 - 93° C(160 - 200° F)}.

Drive machine in gear indicated in Table above.

To take clutch pressure readings in a specific gear, e.g. 4th:




- Start engine
- Apply park brake
- Hold service brake
- Press **D** (Drive) (3) on the gear selector.
- Press down arrow (2) until desired gear is displayed on the read-out (1).
- When 4 is displayed, 4th gear is the highest gear the machine will shift into.
- To return to fully automatic operation, press **D** (3) again.

Drive machine on hard surface in an open area as flat as possible, away from people and other machines.

Torque converter lockup occurs when turbine speed is approximately 80% of engine speed.

Operate machine in gear specified and record clutch pressures as indicated.

## Transmission Engagement Chart

| Gear | Solenoids | Clutches Engaged |
|---|---|---|
| Neutral | A, B and E Energized | C5 |
| 1st | B, E and F Energized | C1, C5 |
| 2nd | B, D, F and G[a] Energized | C1, C4 |
| 3rd | B, D, F and G[a] Energized | C1, C3 |
| 4th | A and B De-energized F and G[a] Energized | C1, C2 |
| 5th | A, C, F and G[a] Energized | C2, C3 |
| 6th | A, D, F and G[a] Energized | C2, C4 |
| Reverse | A, B, C and E Energized | C3, C5 |

**[a]Lockup occurs in second gear or above when torque converter turbine speed is approximately 80% of engine speed**

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## Clutch Enable Test With Service ADVISER™

| SPECIFICATIONS Transmission Pressure | |
|---|---|
| Transmission Oil Temperature | 71 - 93° C (160 - 200° F) |
| 1780 - 1820 r.p.m., Gear - Neutral, Clutch Applied - C5 Pressure. | Main: 1800 - 2100 kPa {18.0 - 21.0 bar (261 - 305 psi)}. |
| 1780 - 1820 r.p.m., Gear - Neutral, Clutch Applied - C5. | Clutch: Within 70 kPa {0.7 bar (10 psi)} of main pressure. |
| 1780 - 1820 r.p.m., Gear - Reverse, Clutch Applied - C3, C5 Pressure. | Main: 1800 - 2100 kPa {18.0 - 21.0 bar (261 - 305 psi)}. |
| 1780 - 1820 r.p.m., Gear - Reverse, Clutch Applied - C3, C5. | Clutch: Within 70 kPa {0.7 bar (10 psi)} of main pressure. |
| 1780 - 1820 r.p.m., Gear - 1st, Clutch Applied - C1, C5 Pressure. | Main: 1550 - 1800 kPa {15.5 - 18.0 bar (225 - 261 psi)}. |
| 1780 - 1820 r.p.m., Gear - 1st, Clutch Applied - C1, C5. | Clutch: Within 70 kPa {0.7 bar (10 psi)} of main pressure. |
| 1780 - 1820 r.p.m., Gear - 2nd, Clutch Applied - C1, C4 Pressure. | Main: 1550 - 1800 kPa {15.5 - 18.0 bar (225 - 261 psi)}. |
| 1780 - 1820 r.p.m., Gear - 2nd, Clutch Applied - C1, C4. | Clutch: Within 70 kPa {0.7 bar (10 psi)} of main pressure. |
| 1780 - 1820 r.p.m., Gear - 3rd, Clutch Applied - C1, C3, Pressure. | Main: 1550 - 1800 kPa {15.5 - 18.0 bar (225 - 261 psi)}. |
| 1780 - 1820 r.p.m., Gear - 3rd, Clutch Applied - C1, C3. | Clutch: Within 70 kPa {0.7 bar (10 psi)} of main pressure. |
| 1780 - 1820 r.p.m., Gear - 4th, Clutch Applied - C1, C2, Pressure. | Main: 1550 - 1800 kPa {15.5 - 18.0 bar (225 - 261 psi)}. |
| 1780 - 1820 r.p.m., Gear - 4th, Clutch Applied - C1, C2. | Clutch: Within 70 kPa {0.7 bar (10 psi)} of main pressure. |
| 1780 - 1820 r.p.m., Gear - 5th, Clutch Applied - C2, C3, Pressure. | Main: 1317 - 1565 kPa {13.2 - 15.7 bar (191 - 227 psi)}. |
| 1780 - 1820 r.p.m., Gear - 5th, Clutch Applied - C2, C3. | Clutch: Within 70 kPa {0.7 bar (10 psi)} of main pressure. |
| 1780 - 1820 r.p.m., Gear - 6th, Clutch Applied - C2, C4, Pressure. | Main: 1317 - 1565 kPa {13.2 - 15.7 bar (191 - 227 psi)}. |
| 1780 - 1820 r.p.m., Gear - 6th, Clutch Applied - C2, C4. | Clutch: Within 70 kPa {0.7 bar (10 psi)} of main pressure. |

### Essential Tools

| ESSENTIAL TOOLS | SERVICE EQUIPMENT AND TOOLS |
|---|---|
| 202839 Fitting | 4136 kPa {41.4 bar (600 psi)} Gauge |

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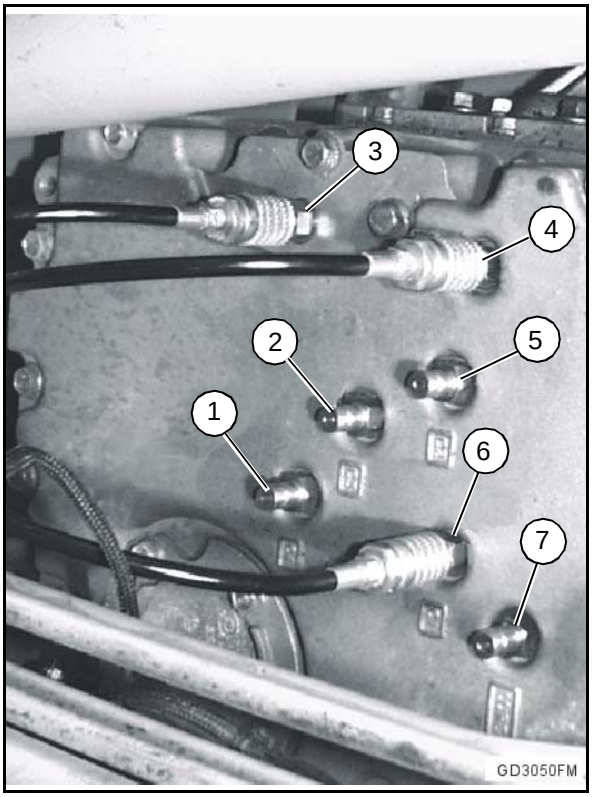
The clutch enable test allows the technician to diagnose a machine that has clutch slippage.

Solenoid may not be energized or solenoid failed or clutch pressure may be out of specification.

**⚠ CAUTION**

**Perform test away from people or other machines. Machine may move unexpectedly resulting in personal injury.**

Operate the machine in an open area away from people or other machines.




Connect hoses and gauges to C1 clutch port (6), C2 clutch port (5), C3 clutch port (2), C4 clutch port (1), C5 clutch port (3) and main pressure port (4).

Warm transmission oil to normal operating temperature.

Stop machine on the level and shift to Neutral (**N**). Apply service brake and park brake.

Start Service ADVISOR™.

Select READINGS from Service ADVISOR™ pulldown headings.

- Select PROCEDURE from list.
- Select CLUTCH TEST ENABLE.
- Select PERFORM.
- Select OK.
- Select OPEN TEMPLATE.
- Select TRANSMISSION.
- Select SOLENOID VOTAGE.
- Select **D** (Drive) on the gear shift control.

**NOTE: Arrows on the gear shift control change gear selection.**

Select **N** (Neutral) to disable clutch enable test.

Check clutch pressure and compare to chart.

**NOTE: When performing clutch test using Service ADVISOR™ lockup will not occur; therefore solenoid F will not energize and clutch pressures will be lower than operating specifications.**

## Transmission Clutch Drag Test

he clutch drag test allows the technician to diagnose a machine that “creeps” in neutral.

Clutch plates may be warped and dragging or a clutch may have pressure in it when it isn’t supposed to.

**⚠ CAUTION**

**Perform test away from people or other machines. Machine may move unexpectedly resulting in personal injury.**

Operate the machine in an open area away from people and other machines.

Warm the transmission oil to normal operating temperature {71 - 93° C (160 - 200° F)}.

Stop machine on a level, hard surface and shift to Neutral. Release service brake and park brake.

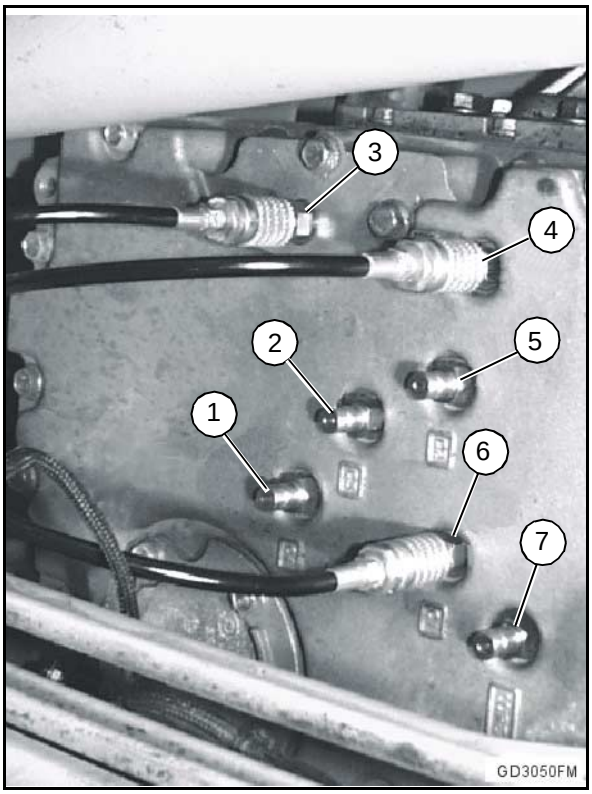
Run engine at fast idle for about one minute. Watch the tires to see if the machine is “creeping” forward or backward.

Transmission clutch drag:
Engine - speed - - - - - - - - - - - - - - - - -2240 ± 20 r.p.m.

If machine “creeps”, check transmission clutch pressures.

For essential tools **See “Essential Tools” on page 301**.

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Connect hoses and gauges to C1 clutch port(6), C2 clutch port (5), C3 clutch port (2) and C4 clutch port (1).

Operate the machine in a area large enough to get into 4th gear.

Watch the pressure gauges as pressure is exhausted from the clutches. Pressure must drop to zero when the clutches go "**OFF**". There must be no residual pressure in a clutch when it is "**OFF**".

If clutch pressures are **OK**, a clutch plate is warped and must be replaced.

For transmission engagement chart see "Transmission Engagement Chart" on page 300.

## Torque Converter Stall Test

### Torque Converter Stall Test Specification

Engine Slow Idle - Speed: - - - - - - - - - - 600 ± 20 r.p.m.

Engine Fast Idle - Speed - - - - - - - - - - 2240 ± 20 r.p.m.

Stall Speed B35D - - - - - - - - - - - - - - - 1596 ± 80 r.p.m.

Stall Speed B40D - - - - - - - - - - - - - - - 1637 ± 80 r.p.m.

**⚠ WARNING**

**1. Never stall torque converter for more than 30 seconds. Do not allow transmission temperature to exceed 100° C (212° F). Transmission damage will result if temperature is allowed to exceed the specification.**
**2. Never perform stall test in reverse. Drive shaft or transfer case damage may result. Reverse gear ratio and excessive torque will be transferred to the drive shaft, transfer case or differential.**

**⚠ CAUTION**

**Perform test in an open area away from other people and machines. Machine may move unexpectedly during test.**

Perform test in an open area away from other people and machines.

Ensure that all oil levels are correct.

Ensure that engine slow and fast idle speeds are correct.

Place chocks in front and behind all wheels.

Start engine and let air pressure build to normal operating pressure.

Do the transmission warm-up procedure to heat transmission oil, see transmission warm-up procedure **"TRANSMISSION WARM-UP PROCEDURE" on page 297**.

Check stall speed.

- Hold service brakes so machine cannot roll.
- Shift transmission into 1st gear. Push accelerator pedal to the floor and hold it for 10 - 15 seconds until the engine sped stabilizes. Record this stall speed. (See stall speed specification on this page).

Shift transmission into neutral and run engine at slow idle to cool for one minute before turning off.

If engine stall speed is below specification and the engine is smoking, it may be low on power.

If engine stall speed is above specification, the transmission may be slipping.

If engine stall speed is below specification and the engine is not smoking, the torque converter stator could be stuck.

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If engine stall speed is a little below specification, but the transmission oil overheats during normal operation and will not cool down while idling, the torque converter stator could be stuck.

## Torque Converter Stator Test

### Torque Converter Stator Specification

Freewheeling Stator Transmission
Oil Temperature- - - - - - - - - - 71 - 93° C (160 - 200° F)

Stuck Stator Transmission
Oil Temperature- - - - - - - - - - - - - - - - - 100° C (212° F)

The torque converter stator clutch can fail in two ways:

- Freewheeling, when the clutch will not lock.
- Locked, when the clutch will not release.

### Freewheeling Stator Test

A freewheeling stator can cause sluggish slow speed operation, but machine will seem to operate normally at high speeds.

Transmission oil will get hot or overheat quickly.

Transmission may not upshift with engine at full speed.

- Operate loaded machine in a normal manner and monitor transmission oil temperature.
- While operating machine, notice how and when transmission upshifts.
- If transmission temperature is hotter than normal and transmission upshifts sluggishly or not at all, stator is freewheeling. Torque converter must be repaired.

A stuck stator will cause transmission oil to overheat and not cool to normal temperature during non-operation.

Transmission will overheat at fast operating speeds.

Machine may not reach full operating speeds.

Torque converter stall test results will be normal.

Perform transmission warm-up procedure to warm transmission oil, See “TRANSMISSION WARM-UP PROCEDURE” on page 297. (See specification on this page).

Shift transmission to neutral and run engine at

1200 - 1500 r.p.m. for two to three minutes. Monitor transmission temperature.

If transmission temperature does not cool to normal operating temperature, stator may be stuck.

**NOTE:Ensure transmission cooler or radiator is not clogged.**

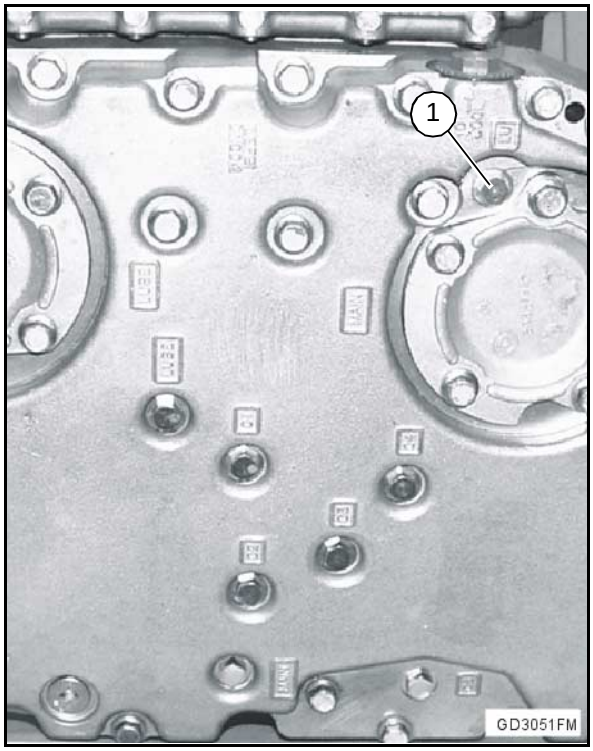
Torque converter must be removed and repaired.

## Torque Converter Lockup Test

### Torque Converter Lockup Specification

Torque Converter Lockup Pressure
- - - - - - - 950 - 1400 kPa {9.5 - 14 bar (138 - 203 psi)}

Tools - Gauge- - - - - - - - 4136 kPa {41.4 bar (600 psi)}




Install a hose and pressure gauge in LU pressure port (1) of transmission control module.

Hold transmission on 1st gear by using range hold or arrow down to 1st gear selector.

**NOTE:Torque converter clutch lockup occurs when output is approximately 80% of output.**

Drive the machine and increase engine speed so that lockup pressure increases and torque converter clutch lockup occurs.

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If pressure is never seen at LU pressure port, solenoid F may have failed.

If pressure at LU pressure port is not to specification, torque converter lockup clutch may have failed. Transmission will overheat if operated with a failed lockup clutch.

## Transmission Thermal Valve Test

### Transmission Thermal Valve Specification

Transmission Oil Temperature - - - - - - - - - - - 97 - 99° C (207 - 210° F).

Engine Speed Idle - - - - - - - - - - - - - - - 600 ± 20 r.p.m.

Fan Drive Controller Load Sense Pressure - - - - - - - - - - - - - - - - - - - 12000 - 13000 kPa {120 - 130 bar (1740 - 1885 psi).

### Equipment and Tools

High Pressure Test Hose Kit - - - - - - - - - - - - JT03482

Digital Pressure/Temperature Analyser - - - JT02156A

The purpose of this test is to verify operation of transmission thermal valve.

**NOTE: Before performing this test, load sense relief valve must be properly adjusted to specifications. (See "FAN DRIVE CONTROLLER TEST AND ADJUSTMENT" on page 403).**

Connect digital pressure/temperature analyser and transducer or gauge to port M1 of fan drive controller.

Perform Transmission Warm-Up Procedure, see **"TRANSMISSION WARM-UP PROCEDURE" on page 297**.

Monitor transmission oil temperature until oil reaches specification. **See MDU menu function CHAPTER 8 in the OMM**.

Lower bin to the frame. Run engine at idle speed. (See specification above).

Fan drive controller pressure reading must be to specification. If not, replace thermal valve. (See specification above).

## Transmission Oil Cooler Restriction Test

### Transmission Oil Cooler Restriction Specification

Transmission Oil Temperature - - - - - - - 88° C (190° F).

Engine Speed: Fast Idle - - - - - - - - - - 2240 ± 20 r.p.m.

Cooler Flow: Flow-Rate - - - - - - 215 l/min (57 gal/min).

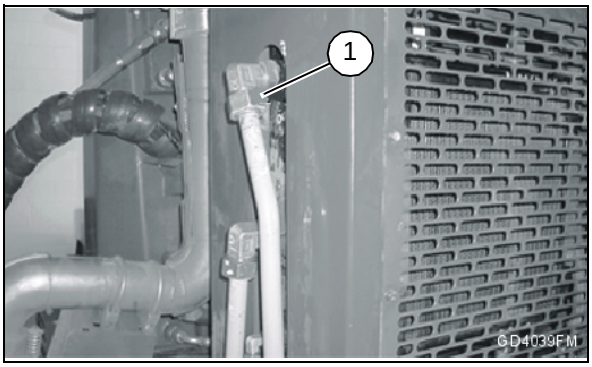
Specified Test Pressure Pressure - - - - - - - - - - - - - - 276 kPa {2.8 bar (40 psi)}

### Equipment and Tools

Flow Test Kit - - - - - - - - - - - - - - - - - - - - - - - - JT05418

Digital Hydraulic Tester - - - - - - - - - - - - - - JT07148.

The transmission oil cooler restriction test allows the technician to diagnose a restricted transmission oil cooler.




Disconnect transmission cooler out line (1) and install flow meter.

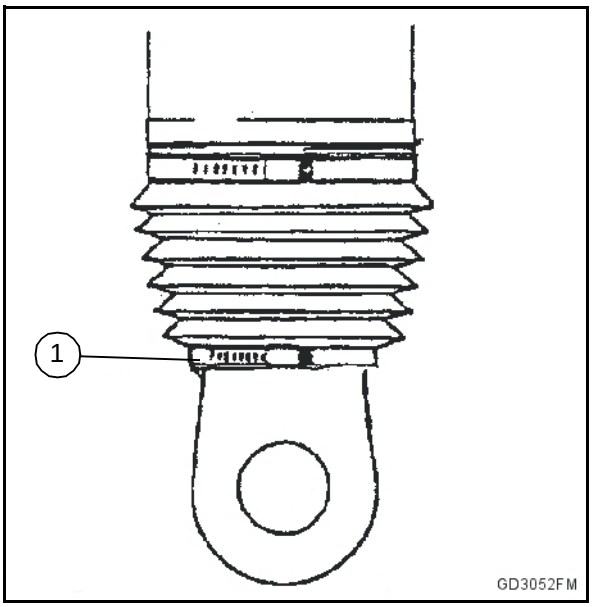
Start machine and warm transmission to specification temperature (See specification above).

Operate engine at fast idle and read flow at specified pressure.

If flow rate is less than specification, the cooler is restricted.

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## Front Suspension Strut Leakage Check




If machine is lower on one side than the other, check front struts for oil leakage.

If struts are not leaking oil, recharge struts with dry nitrogen.

Remove bottom clamp (1) from boot.

Slide boot up to expose strut rod. Any oil leakage will accumulate in boot.

A light coating of oil on strut rod is OK. Recharge strut with dry nitrogen.

Any oil accumulated in boot indicates a leak. Replace strut.

## Park brake Test

**⚠ CAUTION**

**Perform test in an open area away from people and other machines. Machine may move unexpectedly during this test.**

Apply park brake.

Apply inter-axle lock to prevent wheel slippage.

Push **D** (Drive) on shift selector.

Release service brakes.

Increase engine speed to fast idle for a few seconds.

Park brake must not let machine move.

If machine moves, check pad brake thickness and park brake adjustment. **(See "Park Brake Pad Thickness Check" on page 306 and "Park Brake Adjustment" on page 306)**.

## Park Brake Pad Thickness Check

### Park Brake Pad Thickness Specification

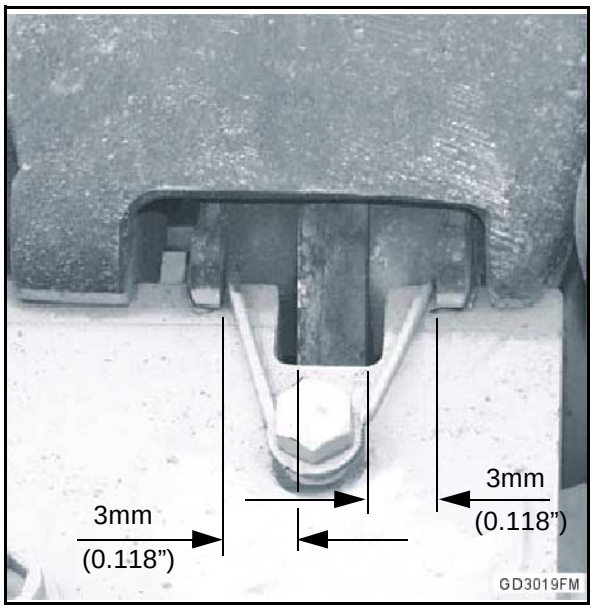
**⚠ CAUTION**

**Always install bin prop when working under the raised bin. Personal injury may result if the bin lowers unexpectedly.**

Raise bin and install bin prop. **(See Install Bin Prop in CHAPTER 7, SECTION 1 in the OMM)**.

### Park Brake Pad Thickness Specification

Park Brake Pad Thickness Min. - - - - - - 3mm (0.118 ").




Measure park brake pad thickness. Change park brake pads when they are less than specification

## Park Brake Adjustment

### Park Brake Adjustment Specification

Air System Pressure - - - - - 807 kPa {8.1 bar (117 psi)}

Actuator Rod Travel Distance - - - -50.8 mm (2")} max.

### Equipment and Tools

6mm Allen Key

Move the machine to a level surface.

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**⚠ CAUTION**

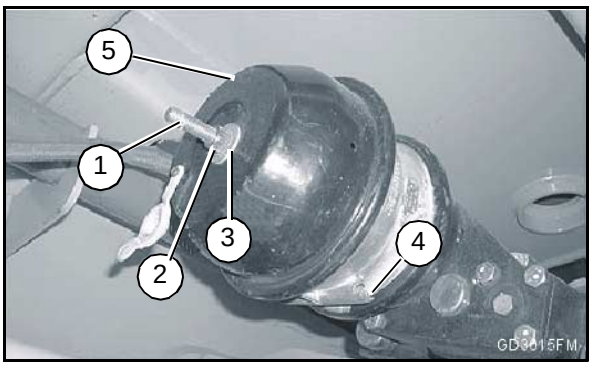
**Always install the bin prop when working under the raised bin. Personal injury may result if the bin lowers unexpectedly.**

Raise bin and install bin prop. **(See Install Bin prop in CHAPTER 7, SECTION 1 in the OMM).**

**⚠ CAUTION**

**Machine may roll when park brake is released. Chock all wheels in front of and behind wheels to keep machine from rolling when park brake is released.**

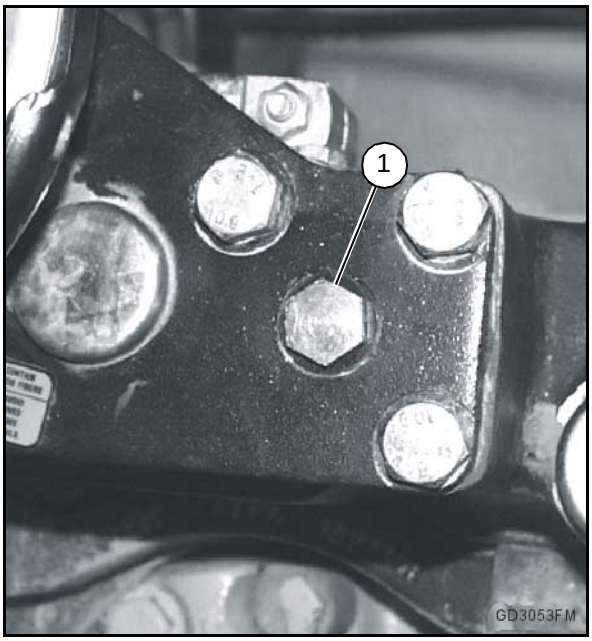
Release park brake.




Remove release stud (1), nut (2) and washer (3) from storage position (4).

Install release stud in hole at rear of park brake actuator housing and rotate a 1/4 turn to lock into place.

Install washer and nut onto release stud and tighten until park brake releases.




Remove plug and washer (1) covering the adjusting screw.

**NOTE: Plug is located on the back side of the park brake actuator bracket.**




Insert a 6 mm Allen Key into the adjusting screw and turn counter clockwise until resistance is felt.

**NOTE: A clicking sound is heard as adjusting screw is turned.**

Tun Allen Key clockwise until resistance is felt.

Then turn Allen Key counter clockwise seven clicks.

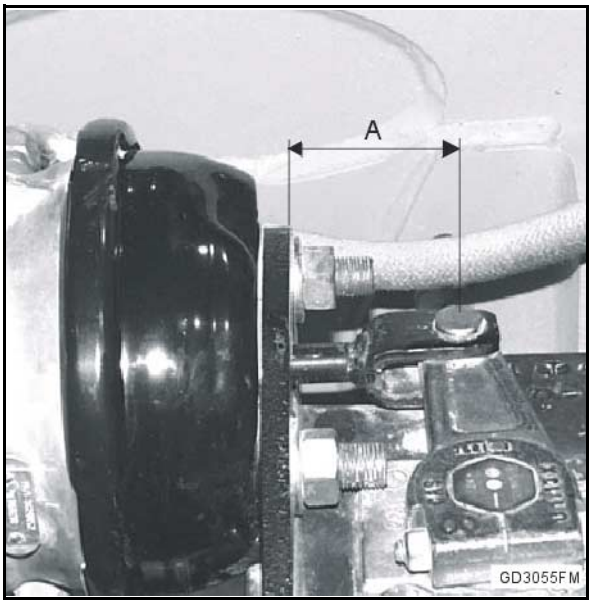
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Remove Allen Key and install adjuster plug and washer.

Remove park brake release stud from actuator.

Start engine. Allow air system to increase to normal operating pressure (See specification).

Release the park brake. Measure from bottom of park brake actuator to centre of clevis on actuator rod.




Record measurement.

Apply park brake. Measure from bottom of park brake actuator to centre of clevis on actuator rod.

Subtract smallest measurement from the largest to get actuator rod travel.

If actuator rod travel is more than specified, start engine; release and apply park brake 20 times to help seat parts.

Re-take actuator rod travel measurements. If travel is still more than specification, actuator has failed and must be replaced.

## Checking Controlled Traction Clutch (Differential Lock) Condition

### Controlled Traction Clutch Specifications

Slippage Torque - - - - - - - - - - - - 125Nm (92 lb-ft) min.

Slippage- - - - - - - - - - - - - - - - 325 Nm (240 lb-ft) Max.

Disconnect drive shaft from input yoke.

Raise one wheel of the ground and place a 20 - ton floor stand under axle housing.

Chock all wheels still on the ground in front and at the back of each wheel.

Using a torque wrench, turn the input yoke and record torque required.

Compare recorded torque to specifications.

Replace controlled traction clutch if torque is below specification.

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# CHAPTER 5. PNEUMATIC SYSTEM

## SECTION 1. THEORY OF OPERATION

### PNEUMATIC SYSTEM OPERATION

All pneumatic functions are supplied pressurized air by the engine driven compressor.

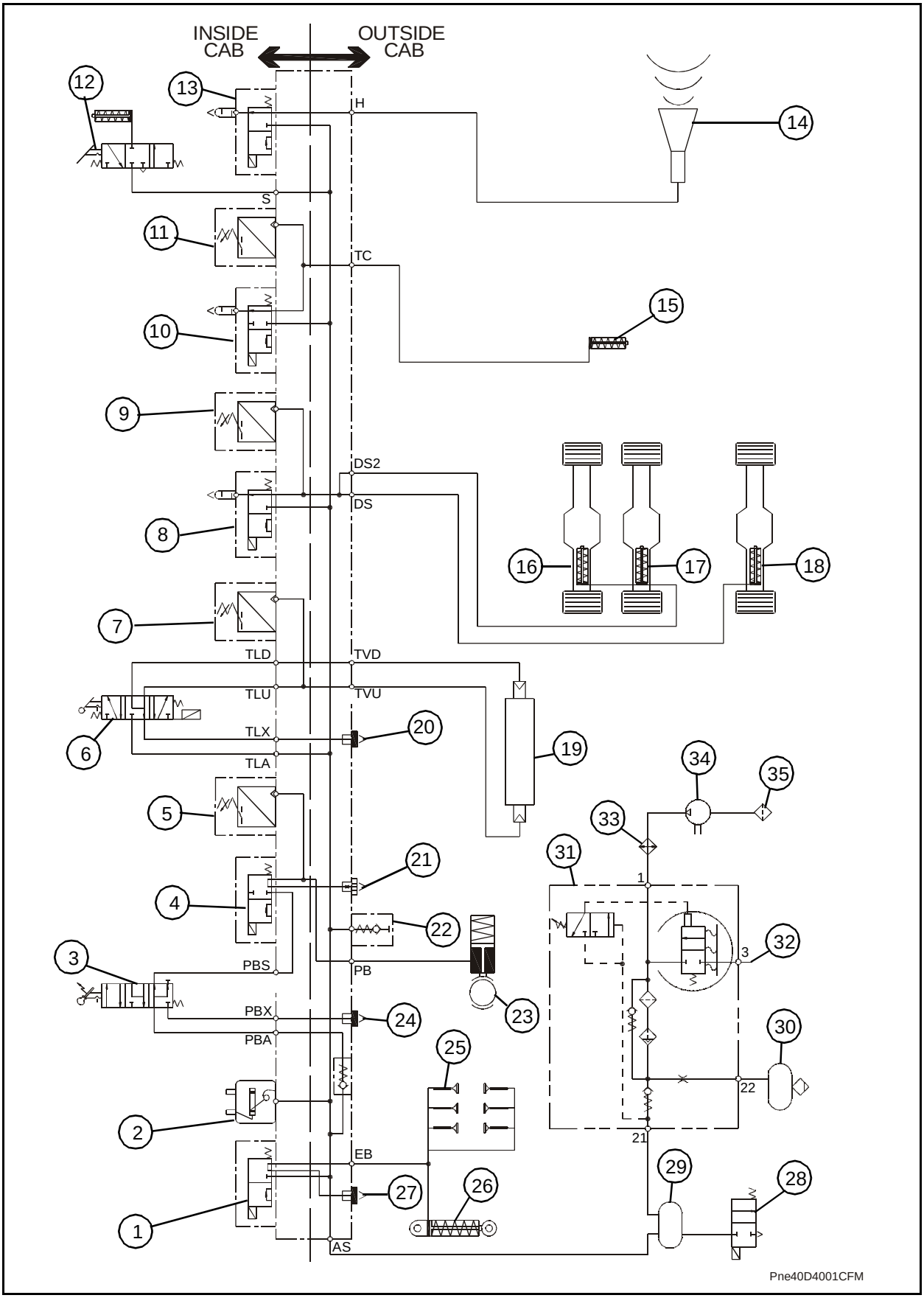
Air from the compressor passes through the air dryer to remove moisture and avoid contamination of pneumatic components.

The air dryer contains an unloader valve that regulates system pressure.

After air leaves the dryer it goes to the pneumatic manifold and is throughout the pneumatic system.

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## PNEUMATIC SYSTEM SCHEMATIC

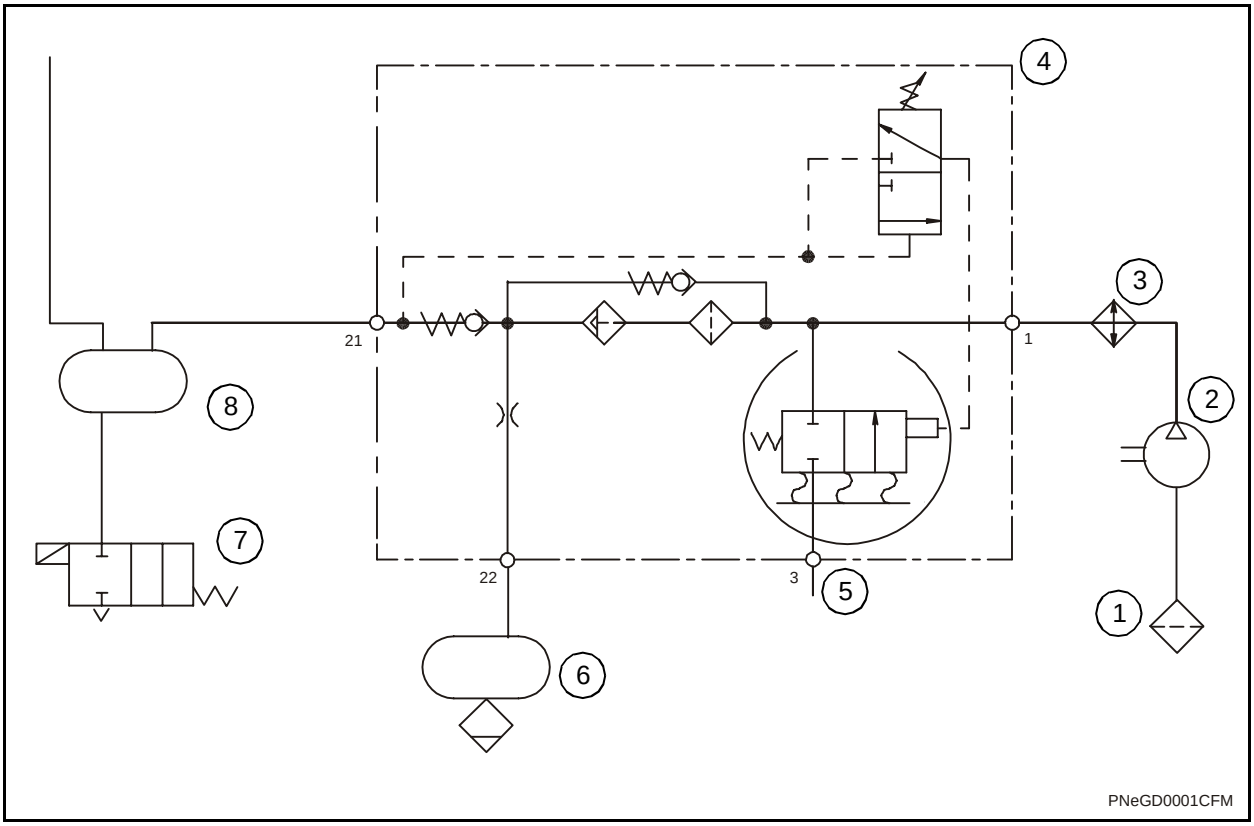


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1. Exhaust Brake and Exhaust Valve Brake Solenoid.
2. System Air Pressure Sensor.
3. Park Brake Valve.
4. Park Brake Solenoid.
5. Park Brake Pressure Switch.
6. Body Pilot Control Valve.
7. Bin Up Pressure Switch.
8. Differential Lock Solenoid.
9. Differential Lock Pressure Switch.
10. Inter-Axle Lock Solenoid.
11. Inter-Axle Lock Pressure Switch.
12. Seat Valve.
13. Horn Solenoid.
14. Horn.
15. Inter-Axle Lock Actuator.
16. Rear Axle Differential Lock Actuator.
17. Middle Axle Differential Lock Actuator.
18. Front Axle Differential Lock Actuator.
19. Body Control Valve.
20. Exhaust Silencer.
21. Exhaust Orifice.
22. Quick Coupler.
23. Park Brake Actuator.
24. Exhaust Silencer.
25. Exhaust Valve Brake.
26. Exhaust Brake Cylinder.
27. Exhaust Silencer.
28. Drain Solenoid.
29. Air Reservoir.
30. Regeneration Air Reservoir.
31. Air Dryer and Unloader Valve.
32. Exhaust Port.
33. Cooling Pipe.
34. Air Compressor.
35. Engine Air Filter.

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## Air Pressure Supply Circuit Operation




1. Engine Air Filter
2. Air Compressor.
3. Cooling Pipe.
4. Air Dryer and Unloader Valve.
5. Exhaust Port.
6. Regeneration Air Reservoir.
7. Drain Solenoid.
8. Air Reservoir.

### Compressor

The compressor (2) is gear driven off the engine and is a single cylinder piston-type compressor.

Air is drawn into the compressor through the engine air filter (1), compressed and sent through a cooling pipe (3), then delivered to the air dryer and unloader valve (4).

The drain solenoid (7) is controlled by the CCU. After each new engine start the CCU timer is set.

After the timer reaches 10 minutes the drain solenoid valve is activated for a half second.

A new engine start is when the key switch is set to the **OFF** position and it has been at least 10 minutes from the last engine start.

### Air Dryer and Unloader Valve

The air dryer and unloader valve has four functions.

**Drying The Air:**

As air from the compressor comes into the air dryer and unloader valve it passes through a fine screen filter and desiccant.

Moisture collects on the surface of the desiccant and is prevented from going to the air system components.

**Unloading The Compressor:**

When air pressure reaches a specified amount, the unloader valve acts as a relief valve and will “blow off”, out port 3 (5), regulating air system pressure.

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**Charging The Regeneration Air Reservoir:**

Air coming into the air dryer and unloader valve is sent out port 22 to the regeneration air reservoir.

The unloader valve, acting as a relief valve, maintains system pressure in the regeneration air reservoir.

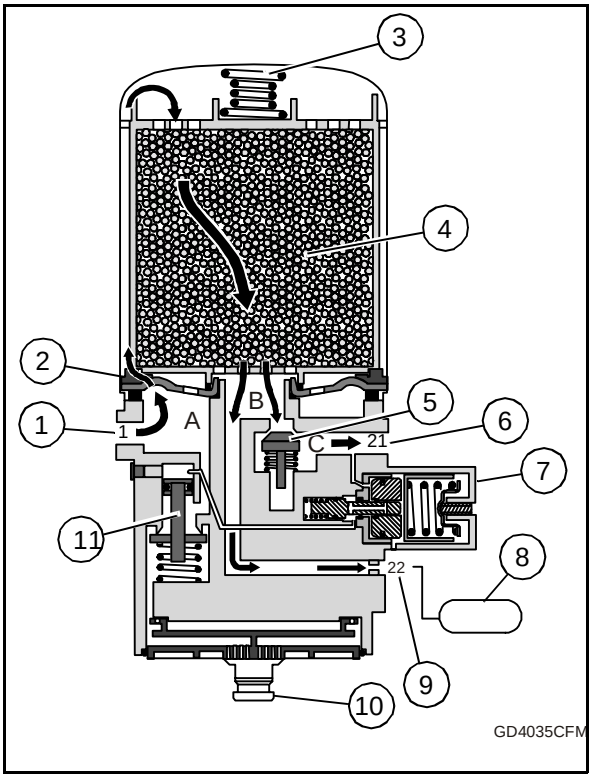
The regeneration air reservoir air supply is used to blow backwards through the desiccant cartridge and purge collected moisture from the cartridge.

**Supplying The Pneumatic Manifold:**

System pressure air is sent to the pneumatic manifold for distribution to all pneumatic circuits.

## Air Dryer and Unloader Valve

### Charging The Pneumatic System




1. Port 1
2. Filter.
3. Bypass Spring.
4. Desiccant.
5. Check Valve.
6. Port 21.
7. Unloader Valve.
8. Regeneration Air Reservoir.
9. Port 22.
10. Port 3.
11. Purge Valve.

Compressed air from the compressor goes to port 1 (1) into chamber A. Air passes through a fine screen filter (2) and along the outside of the desiccant cartridge (4).

Air passes through the desiccant, moisture is removed and collects on the outside of the desiccant cartridge.

Air flows through the desiccant, unseats check valve (5) then goes out port 21 (6) to the air reservoir.

From the reservoir air flows to the pneumatic manifold where it is distributed to the pneumatic system.

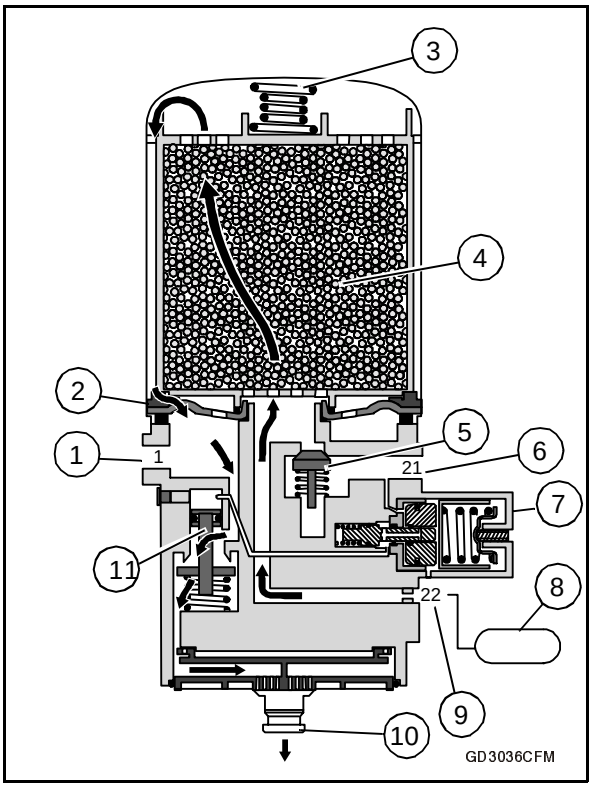
Air also flows out port 22 (9) and pressurizes the regeneration air reservoir (8).

If the desiccant cartridge becomes clogged, filter bypass spring (3) will compress, allowing the desiccant cartridge to move up.

Air would then come in port 1 through chamber A, flow under the cartridge through chamber B and out port 21 to the reservoir. The air will not be dried, but the system will function.

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### Purging The Air Dryer




1. Port 1
2. Filter.
3. Bypass Spring.
4. Desiccant.
5. Check Valve.
6. Port 21.
7. Unloader Valve.
8. Regeneration Air Reservoir.
9. Port 22.
10. Port 3.
11. Purge Valve.

During the charging cycle, moisture is removed from the air going to the system and collects on the fine screen filter and the outside of the desiccant cartridge.

System air pressure is sensed through chamber C on the unloader valve (7). As the system is charging, pressurized air is also being sent to the regeneration air reservoir (8) through port 22 (9).

When system pressure reaches 810 kPa (8.1 bar) (117 psi), air pressure on the diaphragm of the unloader valve forces the diaphragm against the spring, which opens a port to allow pressure to assist in opening the purge valve (11).

As the pure valve is opening it allows air pressure from the regeneration air reservoir to escape up to chamber B and passes through the desiccant and filter, carrying the collected moisture with it.

Any additional moisture collected in chamber A is also picked up, sent by purge valve and then out exhaust port 3.

When the pressure in chamber B drops below 810 kPa (8.1 bar) (117 psi), check valve (5) will close maintaining system pressure in chamber C and in the air reservoir.

When purge valve (11) is open, compressed air from compressor entering through port 1 into chamber A is sent directly out exhaust port 3 (10).

There is zero pressure in regeneration air reservoir while system is in the “unloading” stage. When system pressure drops approximately 48 kPa (0.48 bar) (7 psi), check valve (5) opens, spring in unloader valve (7) pushes against the diaphragm, closing the port to purge valve (11) and starts the charging cycle again.

## Pneumatic Manifold

The pneumatic manifold receives pressurized air from the air reservoir and distribute s it throughout the pneumatic system.

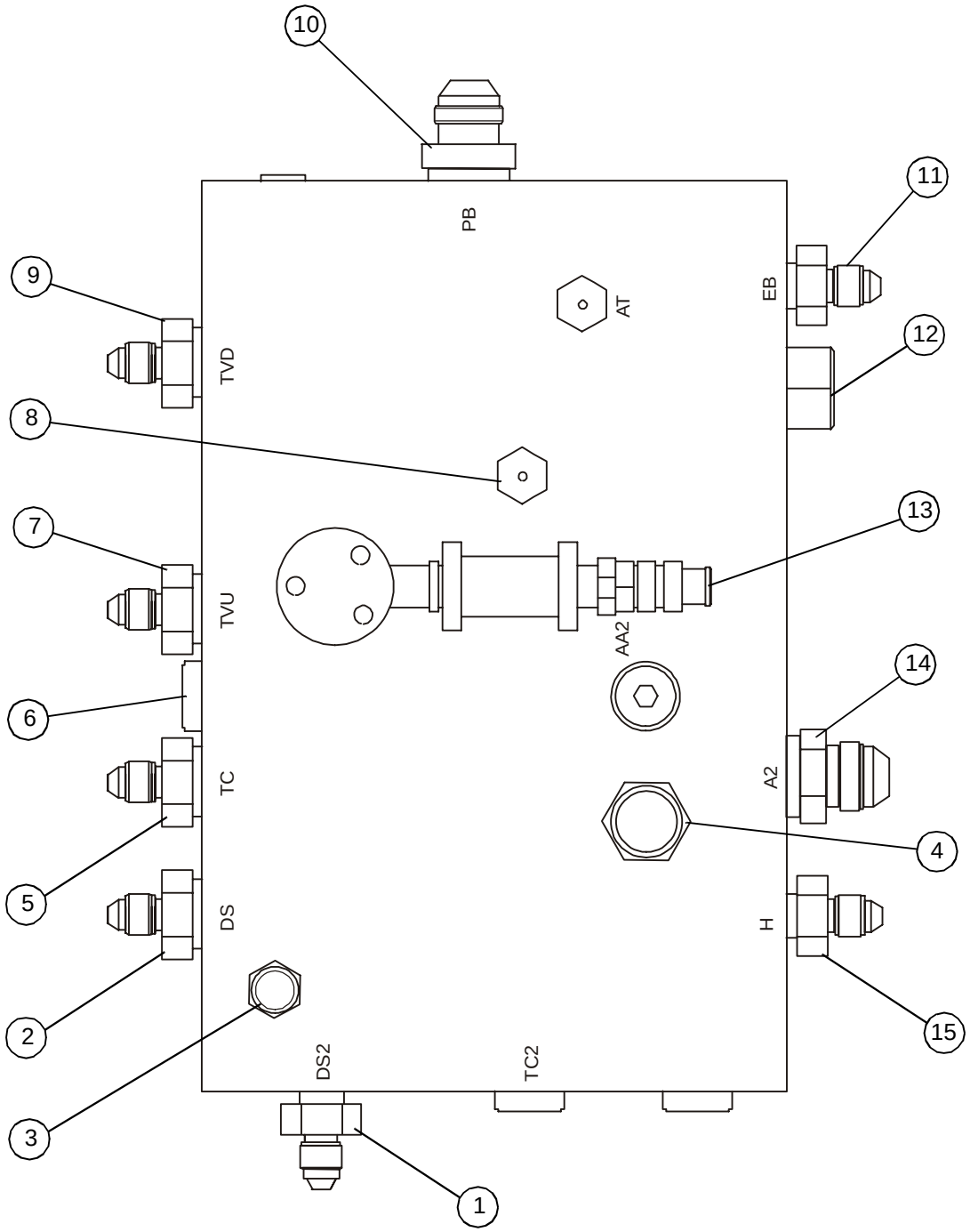
Exhaust air is routed through the pneumatic manifold and exits out the exhaust silencers and orifice outside the cab.

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## Pneumatic Manifold - Outside Cab

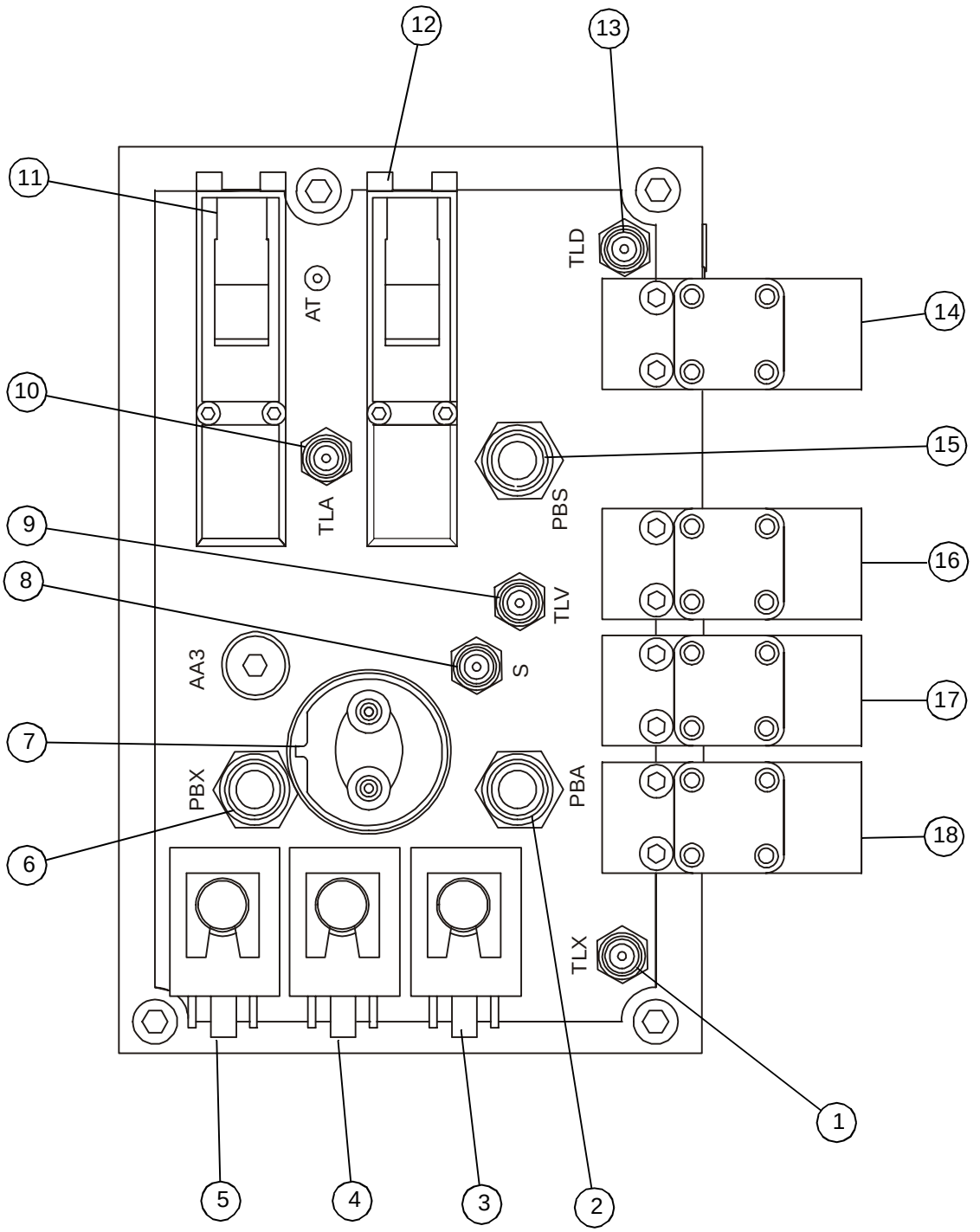


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1. Middle and Rear Axle Differential Lock.
2. Front Axle Differential Lock.
3. Body Pilot Control Valve Exhaust.
4. Park Brake Exhaust.
5. Inter - Axle Lock.
6. Park Brake Check Valve.
7. Body Pilot Control Valve Up.
8. Park Brake Exhaust Orifice.
9. Body Pilot Control Valve Down.
10. Park Brake.
11. Exhaust Brake and Exhaust Valve Brake.
12. Exhaust Brake and Exhaust Valve Brake Exhaust.
13. Quick Coupler.
14. Pneumatic System Supply.
15. Air Horn.

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## Pneumatic Manifold - Inside Cab

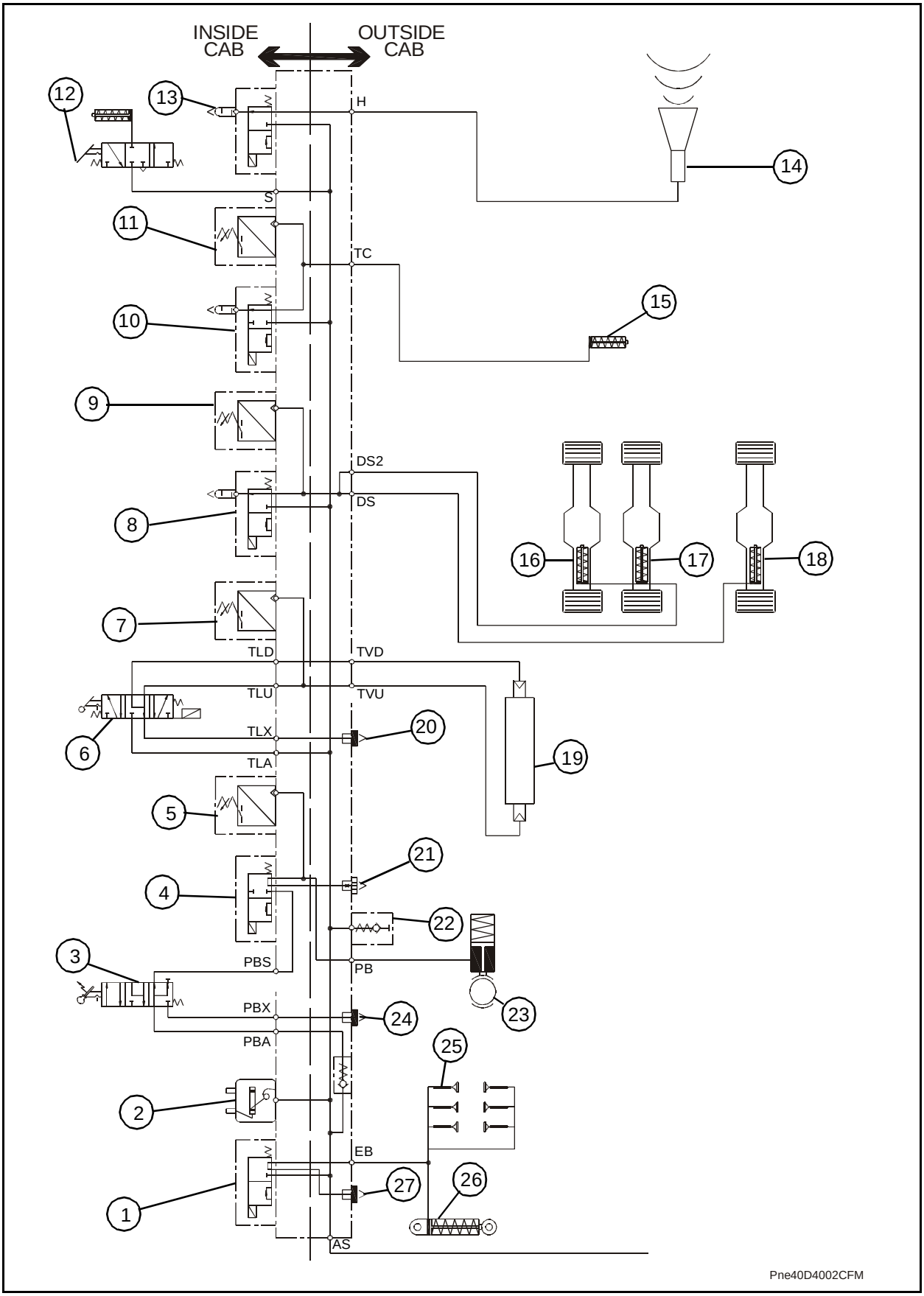


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1. Body Pilot Control Valve Exhaust.
2. Park Brake Supply.
3. Differential Lock Solenoid.
4. Inter-Axle Lock Solenoid.
5. Air Horn Solenoid.
6. Park Brake Exhaust.
7. Supply Air Pressure Sensor.
8. Seat Valve Supply.
9. Body Pilot Control Valve Up.
10. Body Pilot Control Valve Supply.
11. Exhaust Brake and Exhaust Valve Brake Solenoid.
12. Park Brake Solenoid.
13. Body Pilot Control Valve Down.
14. Park Brake Pressure Switch.
15. Park Brake Solenoid Supply.
16. Bin Up Pressure Switch.
17. Inter-Axle Lock Pressure Switch.
18. Differential Lock Pressure Switch.

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## Pneumatic Circuit



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1. Exhaust Brake and Exhaust Valve Brake Solenoid.
2. System Air Pressure Sensor.
3. Park Brake Valve.
4. park Brake Solenoid.
5. Park Brake Pressure Switch.
6. Bin Pilot Control Valve.
7. Bin Up Pressure Switch.
8. Differential Lock Solenoid.
9. Differential Lock Pressure Switch.
10. Inter-Axle Lock Solenoid.
11. Inter-Axle Lock Pressure Switch.
12. Seat Valve.
13. Air Horn Solenoid.
14. Air Horn.
15. Inter-Axle Lock Actuator.
16. Rear Axle Differential Lock Actuator.
17. Middle Axle Differential Lock Actuator.
18. Front Axle Differential Lock Actuator.
19. Bin Control Valve.
20. Exhaust Silencer.
21. Exhaust Orifice.
22. Quick Coupler.
23. Park Brake Actuator.
24. Exhaust Silencer.
25. Exhaust Valve Brake.
26. Exhaust Brake Cylinder.
27. Exhaust Silencer.

The pneumatic circuit contains the following:

- Exhaust Brake and Exhaust Valve Brake Circuit.
- Park Brake Circuit.
- Body Pilot Control Valve Circuit.
- Differential Lock Circuit.
- Inter-Axle Lock Circuit.
- Seat Circuit.
- Air Horn Circuit.

### Exhaust Brake and Exhaust Valve Brake Circuit.

Air from the pneumatic manifold goes to the exhaust brake and exhaust valve brake solenoid (1). The solenoid is energized when all the following conditions occur:

- Accelerator pedal is in the slow idle position.
- Torque converter is in lock-up.
- There must be no electrical failure.

If any of the above items change while the exhaust brakes are applied, the exhaust brake solenoid will de-energize, the quick release valve will open to vent and the exhaust valve system will disengage.

### Park Brake Circuit

The park brake is spring applied and released with compressed air. The function of the park brake circuit is to engage and disengage the park brake by controlling the flow of the compressed air to park brake actuator (23).

System air pressure from the pneumatic manifold is available at park brake valve (3). When the park brake valve lever is moved to the OFF (brake disengage) position, compressed air is sent to park bake solenoid (4).

When the CCU receives the appropriate signals from the system air pressure sensor and the park brake latch switch, the CCU energizes the park brake relay, which in turn energizes the park brake solenoid.

With the park brake solenoid energized, compressed air flows to park brake actuator (23), releasing the park brake.

When the park brake valve lever is moved to the **ON** (brake engaged) position, compressed air in the park brake pneumatic circuit vents to atmosphere through the park brake solenoid and park brake valve. It exits out the exhaust silencer (24).

If the key switch is turned to the **OFF** position with the park brake valve lever in the **OFF** position, the park brake solenoid will de-energize and the compressed air from the actuator will exit out of exhaust orifice (21), causing the park brake to engage.

If the system air pressure falls below 600 kPa (6 bar) (87 psi), the CCU will de-energize the park brake solenoid, causing the park brake to engage.

When the park brake is engaged, park brake pressure switch (5) causes the park brake light, located on the MDU, to come on.

If the engine is started with the park brake valve lever in the **OFF** position, even if the system air pressure specification has been met, the park brake valve lever must be cycled to the **ON** position for the park brake to release.

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### BIn Pilot Control Valve Circuit

The function of the body control valve is to raise and lower the bin. Actuating the bin pilot control valve (6) routes compressed air to the air cylinder on the bin control valve (19), shifting the spool.

The spool routes supply oil to and return oil from the bin tip cylinders to raise or lower the bin.

### Differential Lock Circuit

Each of the three axles contain a differential lock. All three axle locks engage at the same time when the differential lock rocker switch on the control console is pushed to the **ENGAGE** position.

The differential lock rocker switch is a momentary type switch that must be held down for the duration that the differential locks are to be engaged.

With the differential lock rocker switch in the ENGAGE position, differential lock solenoid (8) is energized, allowing compressed air to flow to the differential lock actuators (16, 17 and 18), which applies the differential locks.

The compressed air between the differential lock solenoid and the differential lock actuators closes the contacts of differential lock pressure switch (9).

The closed contacts allow an electrical current to flow to a light on the MDU, causing the light to come on.

When the differential lock rocker switch is released, the differential lock solenoid de-energizes. The de-energized solenoid blocks the flow of compressed air to the actuators and allows the compressed air to the actuators and allows the compressed air within the differential lock circuit to vent to atmosphere, thus allowing the spring inside the actuators to move the differential locks to the release position.

### Inter-Axle Lock circuit

The inter-axle lock is similar to the differential lock, but is located in the transfer case. The purpose of the inter-axle lock is to lock the front and rear axles together so power is applied evenly to all axles.

The inter-axle lock can not be engaged unless the accelerator pedal is in the slow idle position (Less than 10% throttle position). It can be disengaged at any time.

When the inter-axle lock rocker switch is pushed to the EGAGE position, the inter-axle lock solenoid (10) is energized, allowing compressed air to flow to the inter-axle lock actuator (15), which applies the inter-axle locks.

The compressed air between the inter-axle lock solenoid and the inter-axle lock actuator closes the contacts of the inter-axle lock pressure switch (11).

The closed contacts allow an electrical current to flow to a light on the MDU, causing the light to come on.

When the inter-axle lock rocker switch is pushed to the DISENGAGE position, the inter-axle lock solenoid de-energizes. The de-energized solenoid blocks the flow of compressed air to the actuator and allows the compressed air within the inter-axle lock circuit to vent to atmosphere, thus allowing the spring inside the actuator to move the inter-axle lock to the release position.

### Seat Circuit

Seat suspension stiffness is dependent on the amount of air pressure in the seat accumulator.

To increase the air pressure in the seat suspension accumulator, move seat valve (12) to the **INCREASE** position.

To decrease air pressure in the seat suspension accumulator, move seat valve (12) to the **VENT** position. The spring loaded seat valve holds the seat at the desired position.

### Horn Circuit

Pushing the horn button, energizes air horn solenoid (13), which causes compressed air to flow to air horn (14).

Releasing the horn button de-energizes the horn solenoid, causing the compressed air to vent to atmosphere through the air horn solenoid.

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# CHAPTER 5. PNEUMATIC SYSTEM

## SECTION 2. DIAGNOSTIC INFORMATION

## DIAGNOSTIC PROCEDURE

Follow the six basic steps below to carry out troubleshooting efficiently:

**Know The System**

- Study the machine technical manual. Understand the system and circuits. Use schematics, component location drawings and theory of operation for each circuit and circuit components to better understand how the system, circuits and components work.

**Ask The Operator**

What type of work was the machine doing when the trouble was noticed?

Did the trouble start suddenly or has it been getting worse?

Did the machine have any previous problems? If so, which parts were repaired?

**Inspect the machine**

Check all daily maintenance points **(See CHAPTER 12 in OMM).** Check batteries, fuses circuit breakers and electrical connections.

**Perform Operational Check-out.**

Check all systems and functions on the machine. Use the helpful diagnostic information in the check-out to pinpoint the possible cause of the problem.

**Perform Troubleshooting**

Connect laptop computer, if available. The self-diagnosing function lists any service codes and gives corrective action information.

Before starting any trouble shooting, first check battery voltage, circuit breakers and fuses.

Go to test groups to check pressures and voltages. Make sure adjustments are correct.

**Trace a Cause.**

Before reaching a conclusion, check the most probable and simplest to verify. Use the flow charts and symptom, problem, solution charts to help identify probable problem components.

Make a plan for appropriate repair to avoid other malfunctions.

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## DIAGNOSE PNEUMATIC SYSTEM MALFUNCTIONS

**NOTE:Diagnose Malfunction charts are arranged from most probable and simplest to verify, to least likely and most difficult to verify**

| Symptom | Problem | Solution |
|---|---|---|
| System Does Not Reach Operating Pressure. | Air dryer and unloader valve not adjusted correctly. | Adjust air dryer and unloader valve. Do Pneumatic System Main Pressure Test And Adjustment **(See CHAPTER 8 in the OMM.)** |
| | Leakage at fittings or from lines. | Tighten fittings. Repair lines. |
| | Air reservoir drain valve. | Check drain valve for leakage. Repair or replace drain valve. |
| | Hoses and lines connected to wrong ports. | Connect hoses and lines to the correct ports. **(See "Pneumatic Manifold" on page 314)** |
| | System air pressure sensor. | Test sensor. Do Pneumatic System Solenoids, Pressure Switches And Sensor Tests. **(See CHAPTER 5, SECTION 2).** |
| | Park brake actuator. | Check park brake pressure. **( See "PARK BRAKE PRESSURE TEST" on page 332).** |
| | Unloader valve. | Check pressure setting. Do Pneumatic System Main Pressure Test And Adjustment. **(See CHAPTER 5, SECTION 3)**. |
| | Air compressor | Repair or replace compressor. **(See remove and install air compressor in CHAPTER 15, SECTION 1 of the Repair Manual).** |
| Park Brake Light Does Not Go Off. | park brake pressure switch failed. | Test park brake pressure switch. Do Pneumatic System Solenoids, Pressure Switches and Sensor Tests. **(See CHAPTER 3, SECTION 4).** |

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| Symptom | Problem | Solution |
|---|---|---|
| Park Brake Does Not Hold | Park brake calliper adjustment. | Adjust park brake calliper. Do Park Brake Adjustment **(See "Park Brake Adjustment" on page 306)**. |
| | Park brake disc and pads. | Checks thickness of pads. Do Park Brake Pad Thickness Check **(See "Park Brake Pad Thickness Check" on page 306)**. |
| | Park brake solenoid. | Test park brake solenoid. Do Pneumatic System Solenoids, Pressure Switches and Sensor Tests **(See CHAPTER 3, SECTION 4).** |
| | Park brake valve. | Test park brake pressure. Do Park Brake Pressure Test **(See "PARK BRAKE PRESSURE TEST" on page 332).** |
| Inter-Axle Lock Not Working. | Inter-axle lock switch. | Test inter-axle lock switch. |
| | Inter-axle lock solenoid. | Test inter-axle lock solenoid. Do Pneumatic System Solenoids, Pressure Switches and Sensor Tests **(See CHAPTER 3, SECTION 4).** |
| | Inter-axle lock actuator. | Check inter-axle lock actuator for binding internally **(See Transfer Case in CHAPTER 7, SECTION 2 in the Repair Manual).** |
| Engine Valve Brakes or Exhaust Brakes Not Operating Correctly. | Exhaust brake solenoid. | Test exhaust brake solenoid. Do Pneumatic System Solenoids, Pressure Switches and Sensor Tests **(See CHAPTER 3, SECTION 4).** |
| | Engine valve brakes. | Check engine valve brakes for binding, not opening **(See Remove and Install Engine Exhaust Valve Brake in CHAPTER 4, SECTION 6 in Repair Manual).** |
| | Exhaust brakes. | Check engine exhaust brake adjustment. Do Exhaust Brake Adjustment **(See "EXHAUST BRAKE ADJUSTMENT" on page 50)** |

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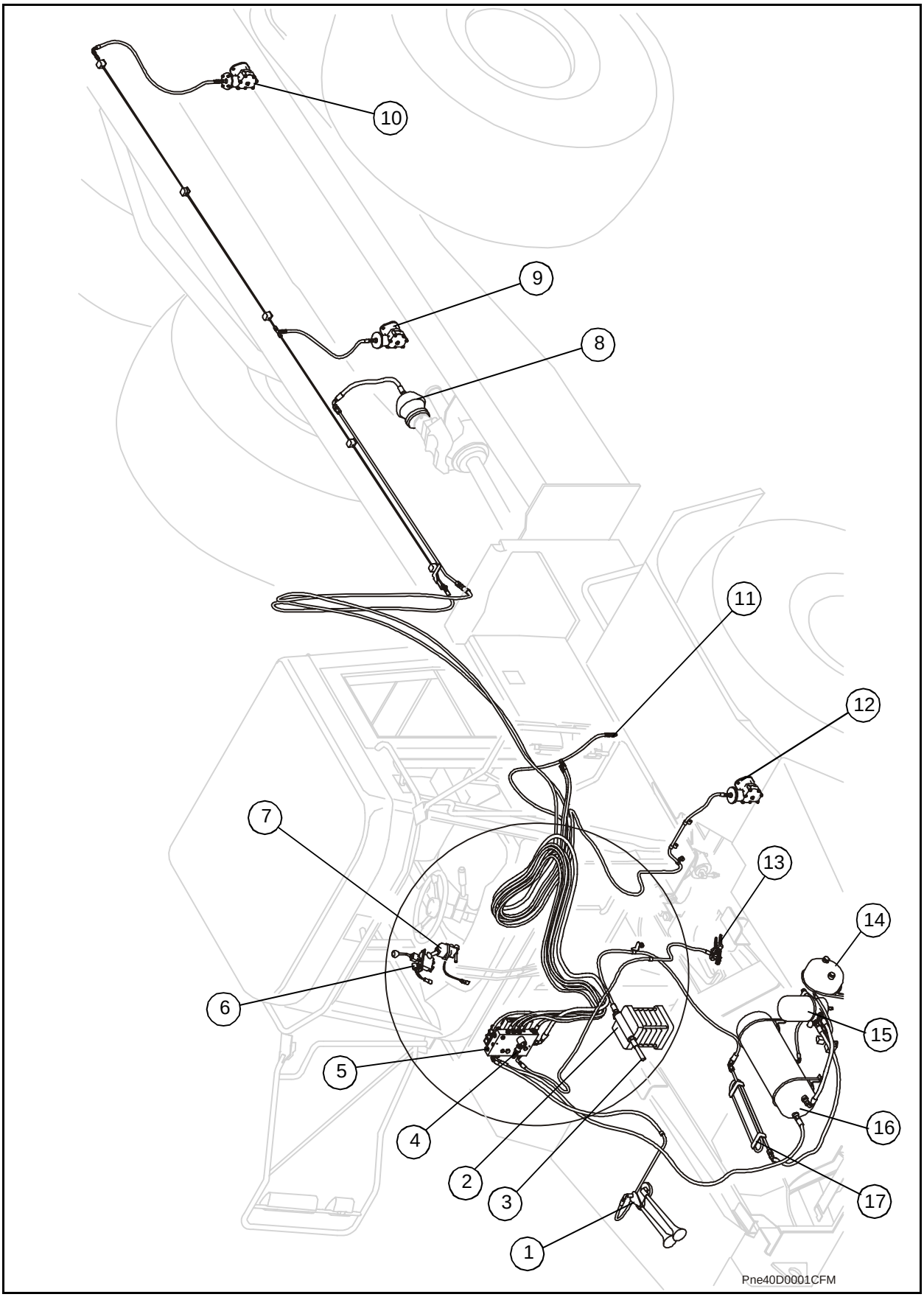
| Symptom | Problem | Solution |
|---|---|---|
| Horn not Working | Horn solenoid. | Test horn solenoid. Do Pneumatic System Solenoids, Pressure Switches and Sensor Tests **(See CHAPTER 3, SECTION 4).** |
| | Horn switch. | Test horn switch. Do Steering Column Switch Test **(SEE “Steering Column Switch Test” on page 197).** |
| Differential Lock Not Operating | Differential lock switch. | Test differential lock switch. |
| | Differential lock solenoid. | Test differential lock solenoid. Do Pneumatic System Solenoids, Pressure Switches and Sensor Tests **(See CHAPTER 3, SECTION 4).** |
| | Differential lock actuator (font axle, middle axle or rear axle). | Check differential lock actuator for binding or failure. **(See CHAPTER 15, SECTION 2).** |

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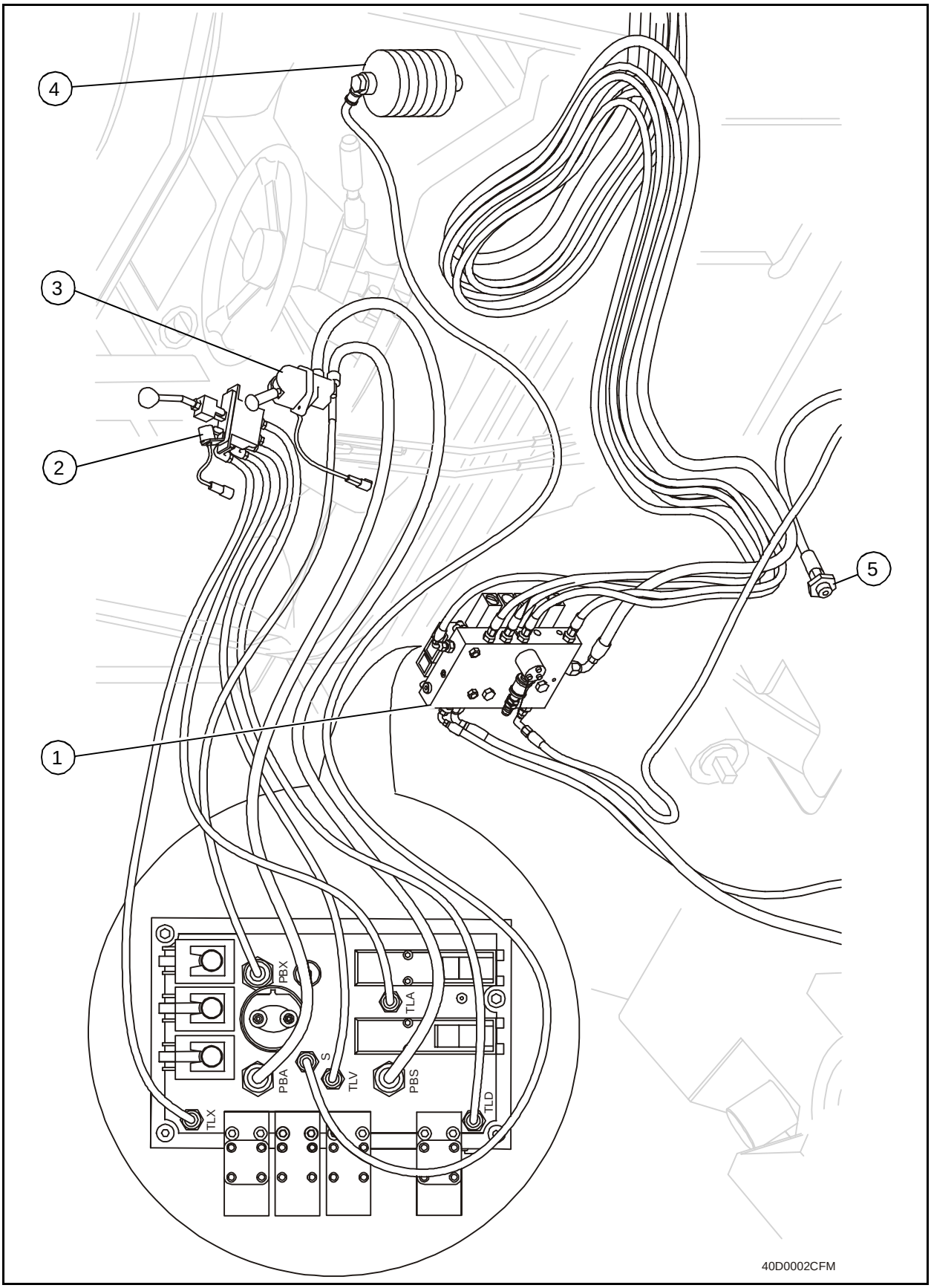
## Pneumatic System Component Location Diagram



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1. Horn.
2. Air Compressor.
3. Compressor Inlet Hose From Air Cleaner.
4. Auxiliary Quick Coupler.
5. Pneumatic Manifold.
6. Bin Pilot Control Valve.
7. Park Brake Valve.
8. Park Brake Actuator.
9. Middle Axle Differential Lock Actuator.
10. Rear Axle differential Lock Actuator.
11. Inter-Axle Lock.
12. Middle Axle Differential Lock Actuator.
13. Exhaust Brake Cylinder.
14. Regeneration Air.
15. Air Dryer And Unloader Valve.
16. Air Reservoir.
17. Cooling Pipe.

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1. Pneumatic Manifold.
2. Bin Pilot Control Valve.
3. Park Brake Valve.
4. Seat Air Spring.
5. Air Compressor Output Line.

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# CHAPTER 5. PNEUMATIC SYSTEM

## SECTION 3. TESTS

## PNEUMATIC SYSTEM MAIN PRESSURE TEST AND ADJUSTMENT

### Pneumatic System Main Specification

Pneumatic System
Pressure - - - - - - - - - - - - - 810 kPa {8.1 bar (117 psi)}.

Adjusting Screw
1/2 Turn Equals - - - - - - - - - - - 50 kPa {0.5 bar (7 psi)}.

### Essential Tools

Tee fitting - - - - - - 202862 3/4-16 M 37° x 3/4-16 F 37°
- - - - - - - - - - - - - - - - - - - - - - - - - - - Sw x 7/16-20 M 37°

### Service Equipment and Tools

Gauge - - - - - - - - - - - - 2068 kPa {20.6 bar (300 psi)}.

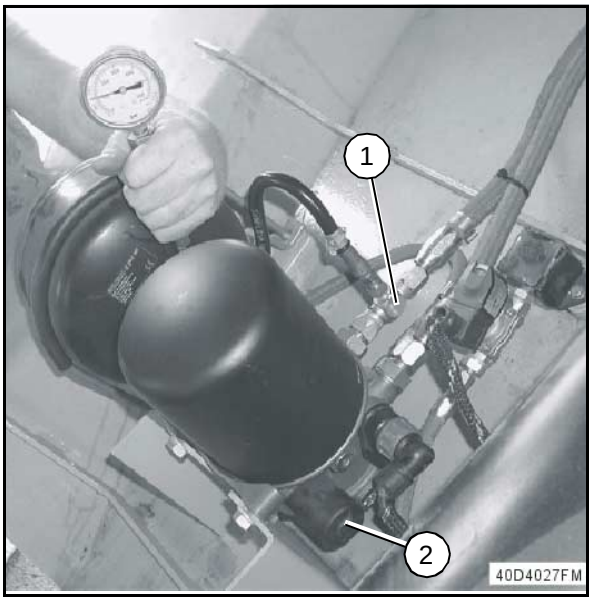
Stop machine and lower front bottom guard.

**⚠ CAUTION**

**Discharge pneumatic system completely before removing any fittings or components.**

Discharge air pressure from front pneumatic system by pulling the drain plug ring on the regeneration air reservoir.

Disconnect air line from port 21 of air dryer and unloader valve.




Disconnect “T” fitting (1) to dryer/unloader valve and air line.

Connect pressure gauge to tee fitting.

Start engine and observe air pressure on gauge.

Record pressure when unloader valve “unloads”.

Adjust pressure that unloader valve “unloads” by turning adjusting screw (2) with a 3mm hex. wrench. Turning screw clockwise will increase unloading pressure.

If pressure cannot be adjusted within specification, replace air dryer and unloader valve.

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# PARK BRAKE PRESSURE TEST

## Park Brake Pressure Specifications

Park Brake Lever ON - - - - - - - - 0 kPa {0 bar (0 psi)}.

Park Brake Lever OFF - - - 810 kPa {8.1 bar (117 psi)}.

## Essential Tools

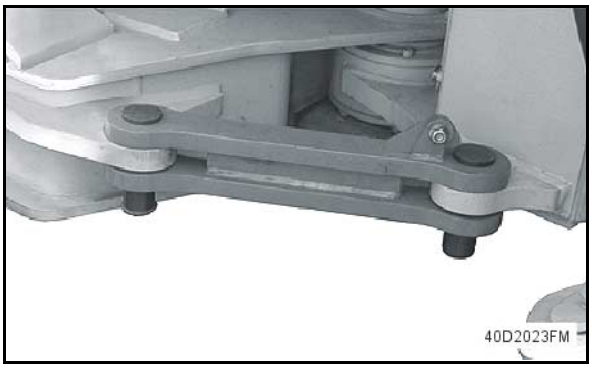
Tee fitting - - - - - - 202862 3/4-16 M 37° x 3/4-16 F 37° Sw x 7/16-20 M 37°

## Service Equipment and Tools

Gauge 2068 kPa {20.6 bar (300 psi)}.Park the machine on a level surface and chock the wheels to prevent machine from rolling.

**⚠ CAUTION**

**1. Install articulation locking bar before working in pivot area.**
**2. Discharge pneumatic system completely before removing any fittings or components.**




Install articulation lock bar.

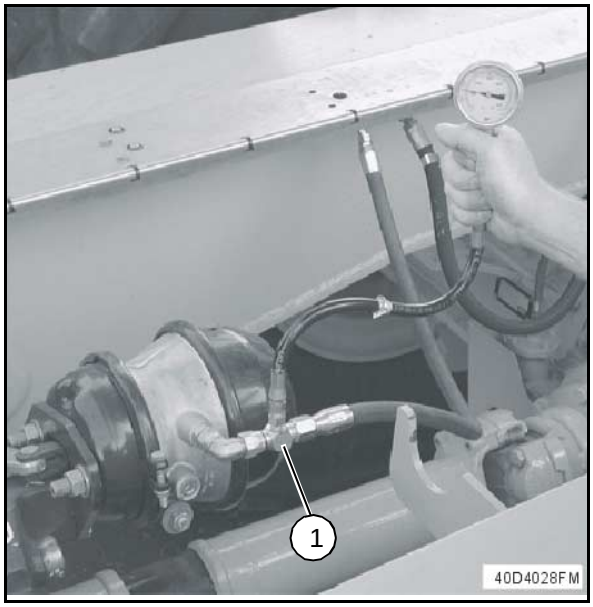
**⚠ CAUTION**

**Always install the bin prop when working under the raised bin. Personal injury may result if the body lowers unexpectedly.**




Raise the bin and install the bin prop.

Move park brake lever to the **ON** position to engage park brake and relieve system pressure from park brake circuit. Shut off engine.




Disconnect line from park brake actuator and install tee fitting (1). Connect gauge to fitting.

Start engine and observe pressure on gauge. Pressure must remain at zero with park brake lever **ON**. If pressure is more than zero, park brake valve is leaking internally and must be replaced.

With engine running, release park brake and observe pressure on gauge.

Observe system pressure on gauge.

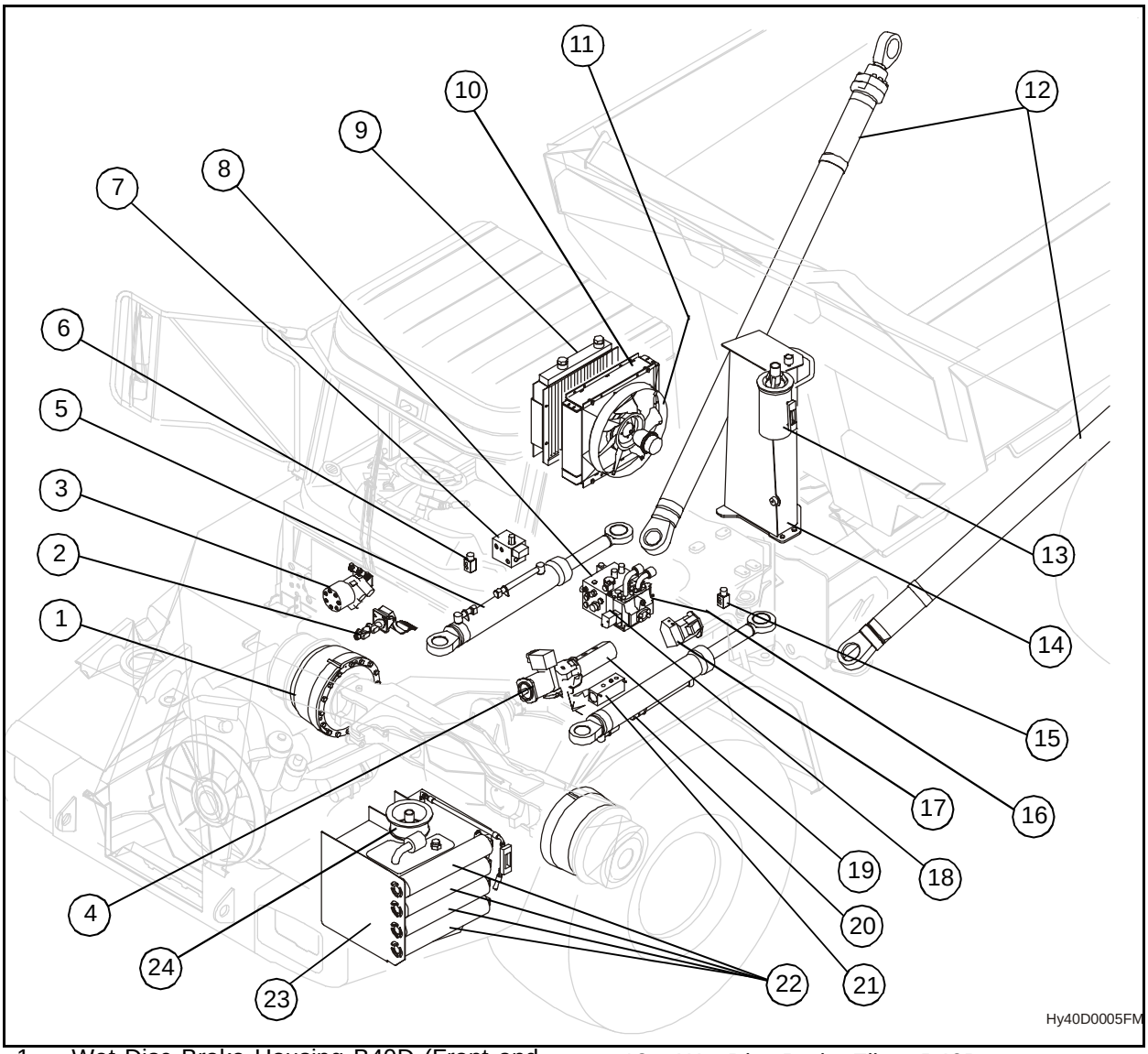
If pressure is low, go to **“PNEUMATIC SYSTEM MAIN PRESSURE TEST AND ADJUSTMENT” on page 331**.

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# CHAPTER 6. HYDRAULIC SYSTEM

## SECTION 1. THEORY OF OPERATION

## ARTICULATED DUMP TRUCK HYDRAULIC SYSTEM OPERATION




1. Wet Disc Brake Housing B40D (Front and Middle Axles).
2. Brake Valve.
3. Steering Valve.
4. Main Hydraulic Pump.
5. Right Steering Cylinder.
6. Transmission Thermal Valve.
7. Fan Drive Controller.
8. Hydraulic System Manifold.
9. Wet Disc Brake Coolers, B40D.
10. Hydraulic Oil Cooler (Bottom Section).
11. Hydraulic Fan Motor.
12. Bin Tip Cylinders.
13. Wet Disc Brake Filter, B40D.
14. Wet Disc Brake Oil Reservoir, B40D.
15. Wet Disc Brake Thermal Valve.
16. Bin Control Valve.
17. Secondary Steering Pump.
18. Fan Drive Valve.
19. Wet Disc Brake Cooling Pumps, B40D.
20. Left Steering Cylinder.
21. Hydraulic Reservoir Return Manifold.
22. Front And Rear Brake Accumulators (B35D, 2 Used, B40D, 4 Used).
23. Hydraulic Reservoir.
24. Return Filter.

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The articulated dump truck hydraulic system is a closed-centre, load-sensing system and consists of the steering circuit, secondary steering circuit, fan drive circuit, bin control circuit and service brake circuit.

The system oil is stored in the hydraulic reservoir (23). the suction strainer removes any large particles that may have collected in the hydraulic reservoir before the oil is sent to the main hydraulic pump (4).

The main hydraulic pump consists of two, in-line, variable-displacement, axial-piston pumps with load sensing and pressure compensating regulator valves.

The regulator valves control pump flow rate by changing swash plate angle to meet load demand of functions actuated and to destroke the pump to residual (low stand-by) pressure when all functions are in neutral. **(See "Main Hydraulic Pump Load Sense Operation" on page 338)**.

The pump is driven by a drive shaft connected to the engine accessory drive. The pump is mounted to the frame with the drive shaft connected to the pump through a dampener.

The pump provides hydraulic oil flow to the steering, service brake, fan drive and bin control circuits. **(See "Main Hydraulic Pump Operation" on page 336)**.

The hydraulic oil cooler (10) is mounted behind the cab and utilizes a hydraulic fan motor (11) to turn the cooling fan. Oil from the hydraulic fan motor outlet flows into the hydraulic cooler, through the return filter (24) and then into the hydraulic reservoir.

The hydraulic system manifold (8) controls and distributes hydraulic oil through outlet ports to all components in the hydraulic system.

The manifold is a replaceable cartridge-valve-type manifold. The steering and brake accumulator charging circuits are given priority by the valve located in the manifold. **(See "Hydraulic System Manifold Operation (Top View)" on page 354)**.

The fan drive valve (18) is mounted on the hydraulic system manifold. It contains the fan drive solenoid valve which controls the supply oil flow to the fan drive controller (7), a check valve that allows return oil to enter the supply circuit when fan drive solenoid is energized allowing fan to free spin, and a signal shuttle valve to isolate the fan load sense circuit from the bin load sense circuit. **(See "Fan Drive System Operation" on page 362).**

The bin control valve (16) is a closed-centre valve with a load sense passage. The valve is mounted on the hydraulic system manifold.

The function of the bin control valve is to route hydraulic oil to the right and left bin cylinders (12).

The bin tip cylinders are double-acting cylinders that raise and lower the bin. The load sense passage is used to send a signal from the work ports through the hydraulic system manifold to the pump regulator valve when the valve is actuated.

The load sense passage is open to return when the valve is in neutral. The valve also contains a bin raise circuit relief valve and bin lower circuit relief valve. **(See "Bin Control Valve Operation" on page 364)**.

The steering valve (3) is a closed-centre valve with a load sense passage. The valve is a wide angle, variable displacement (flow amplification) with integrated anti-cavitation and relief valves.

The effective displacement of the steering valve depends on the speed at which the valve is turned. The steering valve routes and controls hydraulic oil to the left steering cylinder (20) and right steering cylinder (5).

The load sense passage is used to send a signal from the work port to the hydraulic system manifold and then to the pump regulator valve when the valve is actuated.

The load sense passage is open to return when the valve is in neutral. The steering cylinders are double-acting cylinders that steer the truck by articulating the front and rear frames. **(See "Steering And Secondary Steering System Operation" on page 346)**.

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A ground driven secondary steering system is used to provide supply oil flow for the steering circuit while the machine is still moving in the event there is a malfunction of the engine or main hydraulic pump.

The system consists of the secondary steering pump (17), anti-cavitation valve, and two check valves located in the hydraulic system manifold. The pump is a variable-displacement, axial-piston pump with a load sensing and pressure compensating regulator valve.

The residual pressure setting for the secondary steering pump is lower than the residual pressure setting for the main hydraulic pump. The pump is mounted on the transfer case and is ground driven as long as the gear train is being turned by the moving machine.

The check valves are used to isolate the main hydraulic circuit and the secondary steering circuit. The secondary steering pump anti-cavitation valve provides a path for oil flow from the suction side of pump to the outlet side when the machine is moving in reverse.

The brake accumulator, which is attached to the hydraulic system manifold is a diaphragm type, nitrogen charged accumulator and the front and rear brake accumulators (22), are piston type, nitrogen charged accumulators.

The accumulators are not serviceable. The function of the brake accumulator is to provide a signal to the brake accumulator charge valve, regulating load sense signal to main hydraulic pump to maintain the pressure of brake accumulators between a lower and upper charge limit.

The front and rear brake accumulators are used to store brake oil under pressure which is then used to apply the service brakes when the brake valve is actuated. The brake valve (2) is a dual circuit, modulated valve.

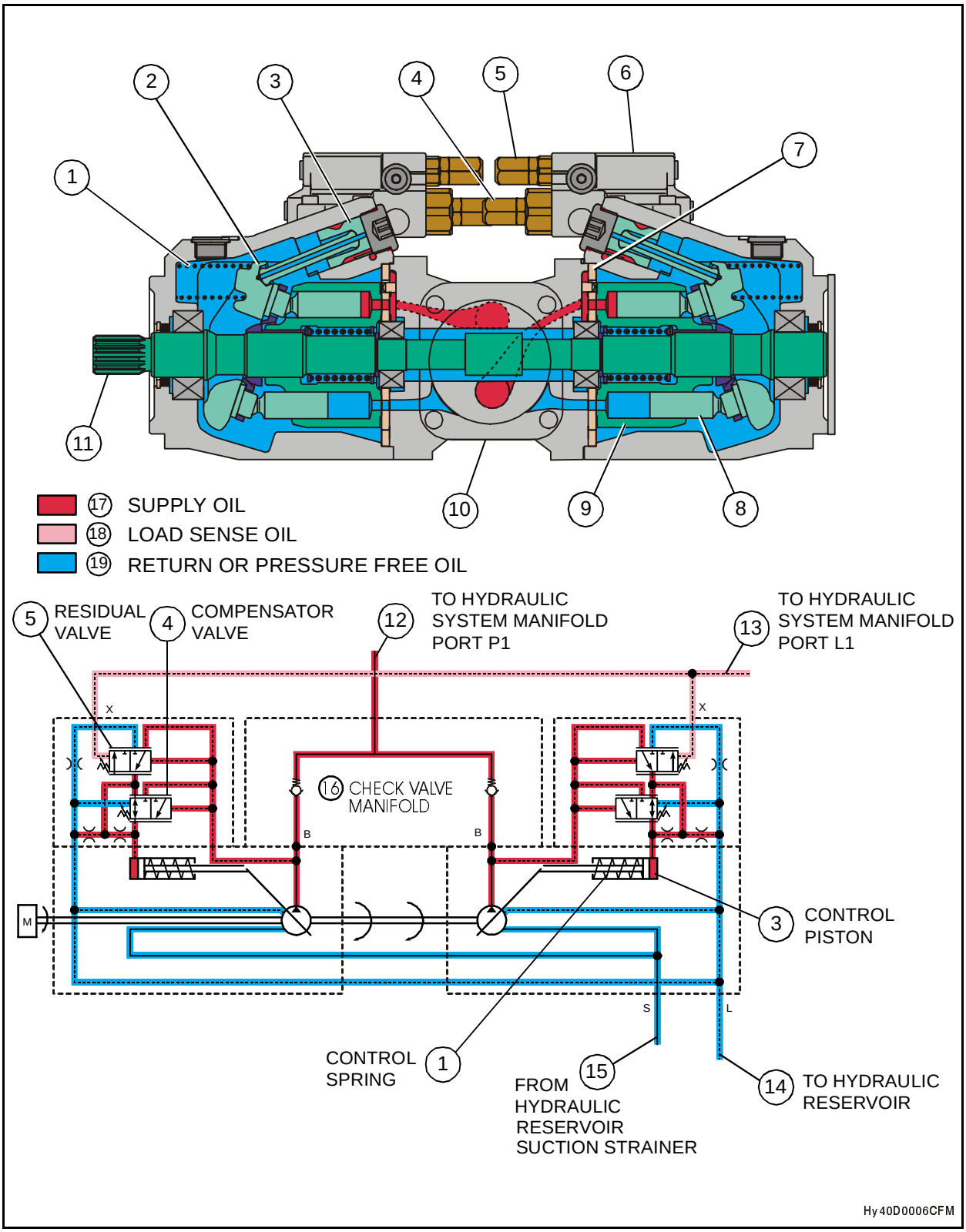
The function of the valve is to control the charged brake oil from the accumulators to actuate the service brake callipers or internal brake pistons. The valve contains two separate circuits, each supplied by its own accumulators (B35D uses two accumulators, B40D uses four accumulators).

The top valve section is for the front axle brakes and the bottom valve section is for the rear axle or axles. The brake valve supplies charged brake oil to the rear brake callipers or internal brake pistons first and then to the front brake callipers or internal brake pistons. **(See “Service Brake System Operation” on page 342)**.

Return filter (24) is used to filter return oil before entering the hydraulic reservoir.

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## Main Hydraulic Pump Operation



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1 Control Spring.
2 Swash Plate.
3 Control Piston.
4 Compensator Valve.
5 Residual Valve.
6 Pump Regulator.
7 Valve Plate.
8 Piston.
9 Cylinder Block.
10 Pump Manifold.
11 Pump Shaft.
12 To Hydraulic System Manifold Port P1.
13 To Hydraulic System Manifold Port L1.
14 To Hydraulic Reservoir.
15 From Hydraulic Reservoir Suction Strainer.
16 Check Valve Manifold.
17 Supply Oil.
18 Load Sense Oil.
19 Return or Pressure Free Oil.

The main hydraulic pump consists of two in-line pumps joined together by a pump manifold (10). The pumps are variable-displacement, axial-piston pumps with load-sensing and pressure-compensating pump regulators (6).

Pump displacement is varied by the angle of swash plate (2). Swash plate angle is controlled by the control spring (1) and control piston (3). The swash plate has spring pressure applied to it at all times trying to keep the pump at maximum displacement.

Supply oil (17) is applied to or released from the control piston by the residual valve (5) varying pump displacement per load demand. At full system pressure the compensator valve (4) shifts to route supply oil to the control piston de-stroking the pump.

As the angle of swash plate is increased, the pistons (8) move in and out of their bores and displace oil as the cylinder block (9) is turned by the pump shaft (11).

The pistons move into their bores during the first half of each revolution, and out of their bores during the last half of the revolution. The piston bores are filled with oil through the inlet port and valve plate (7) as the pistons move out of their bores.

The pistons moving into their bores push oil out through the valve plate to the pump regulator, pump manifold, check valve manifold (16), and outlet port to the hydraulic system manifold.

The pump is driven by the engine accessory drive through a drive shaft. Pressure compensation is a constant pressure system that requires a closed-centre hydraulic system.

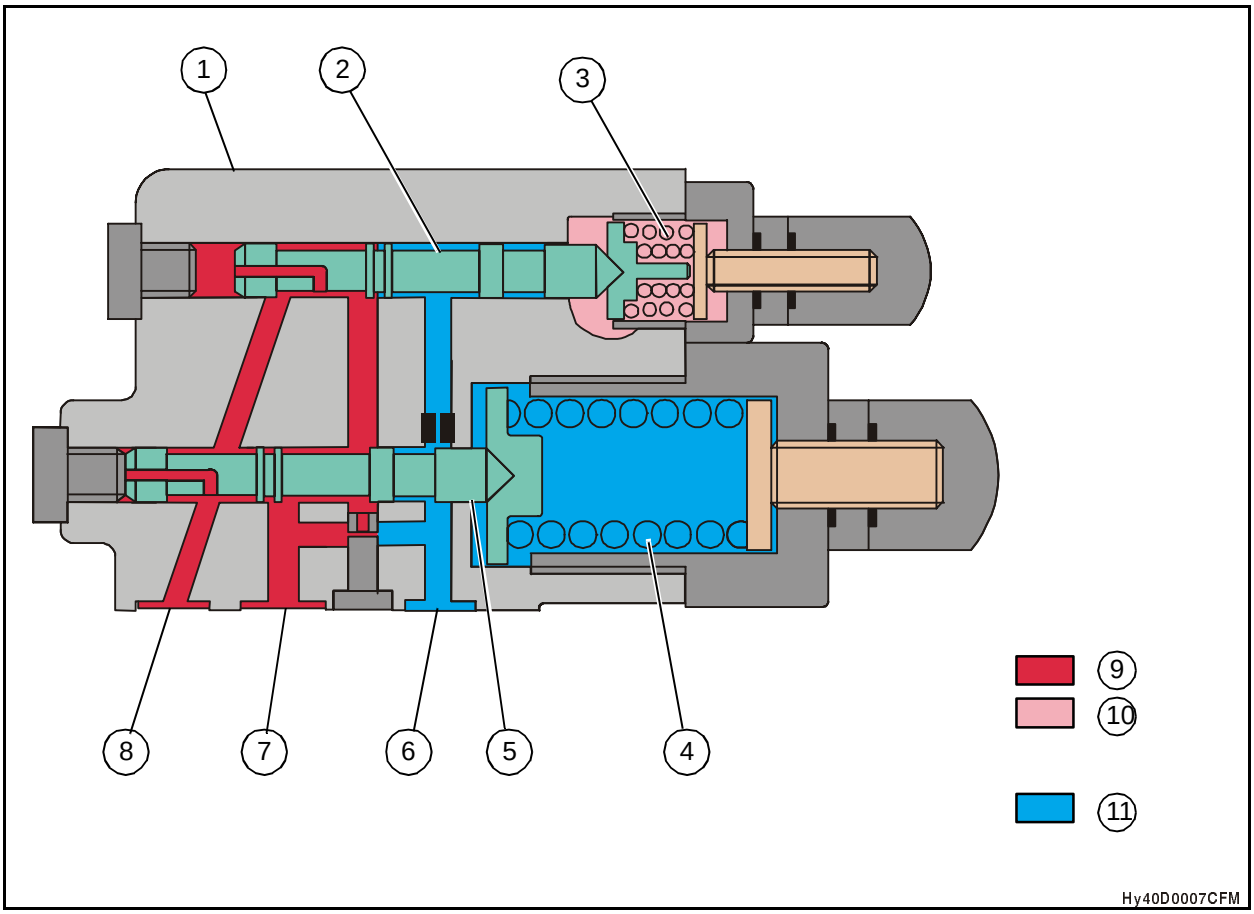
As soon as the engine is started, supply oil flows from the pump to the closed-centre valves. The pressure in the hydraulic system increases and causes the residual valve to destroke the pump at residual pressure.

The residual pressure ensures that immediate system pressure is available on demand when a function is actuated. Load sense system pressure is used to regulate the residual valve to stroke or destroke the pump as needed.

No matter what the load demand is, even when using more than one function, as long as the total demand does not exceed the pump’s capability, the pump will deliver the exact amount of oil required to move the load

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## Main Hydraulic Pump Load Sense Operation




1 Pump Regulator.
2 Residual Spool.
3 Residual Spring.
4 Compensator Spring.
5 Compensator Spool.
6 Case Drain.
7 To Control Piston.
8 From Pump Outlet.
9 Supply Oil.
10 Load Sense Oil (Minimal Pressure).
11 Return Oil.

### Residual Pressure

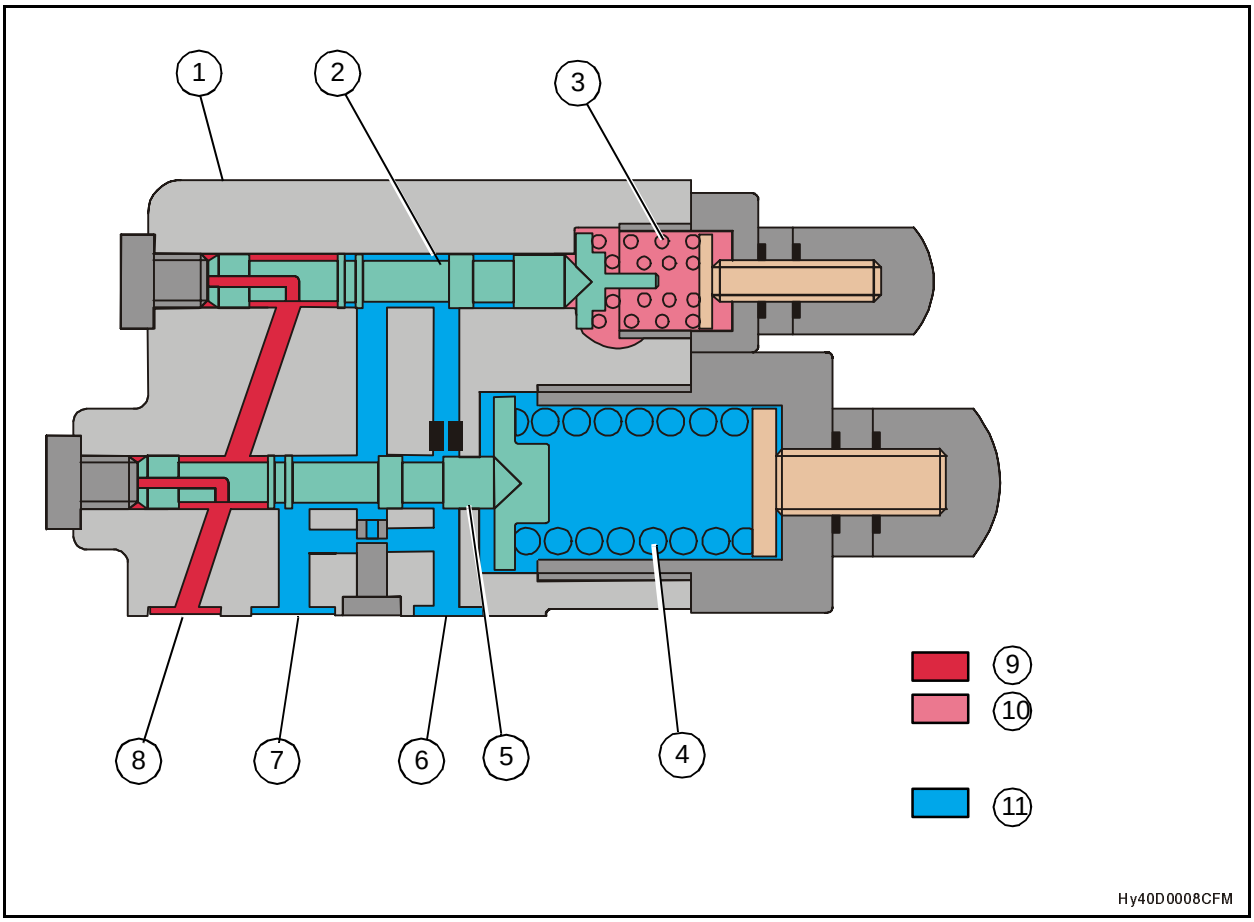
As soon as pump is driven, supply oil (9) flows to pump regulator (1) which consists of the residual valve and compensating valve. As the supply oil pressure rises, the residual spool (2) having the smaller spring will start to shift.

The spool will shift toward the residual spring (3) until it allows supply oil to be directed into the control piston (7), destroking the pump and reducing flow until the pressure at the pump outlet (8) is equal to the residual pressure setting.

The pump will maintain this residual pressure until the hydraulic system's needs are greater (function actuated).

When hydraulic functions are not actuated the pump produces only enough flow to maintain the residual pressure. The load sense oil (10) at this time is at a minimal pressure because the load sense circuits are open to return.

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1 Pump Regulator.
2 Residual Spool.
3 Residual Spring.
4 Compensator Spring.
5 Compensator Spool.
6 Case Drain.
7 To Control Piston.
8 From Pump Outlet.
9 Supply Oil.
10 Load Sense Oil (Mid-Range Pressure).
11 Return Oil.

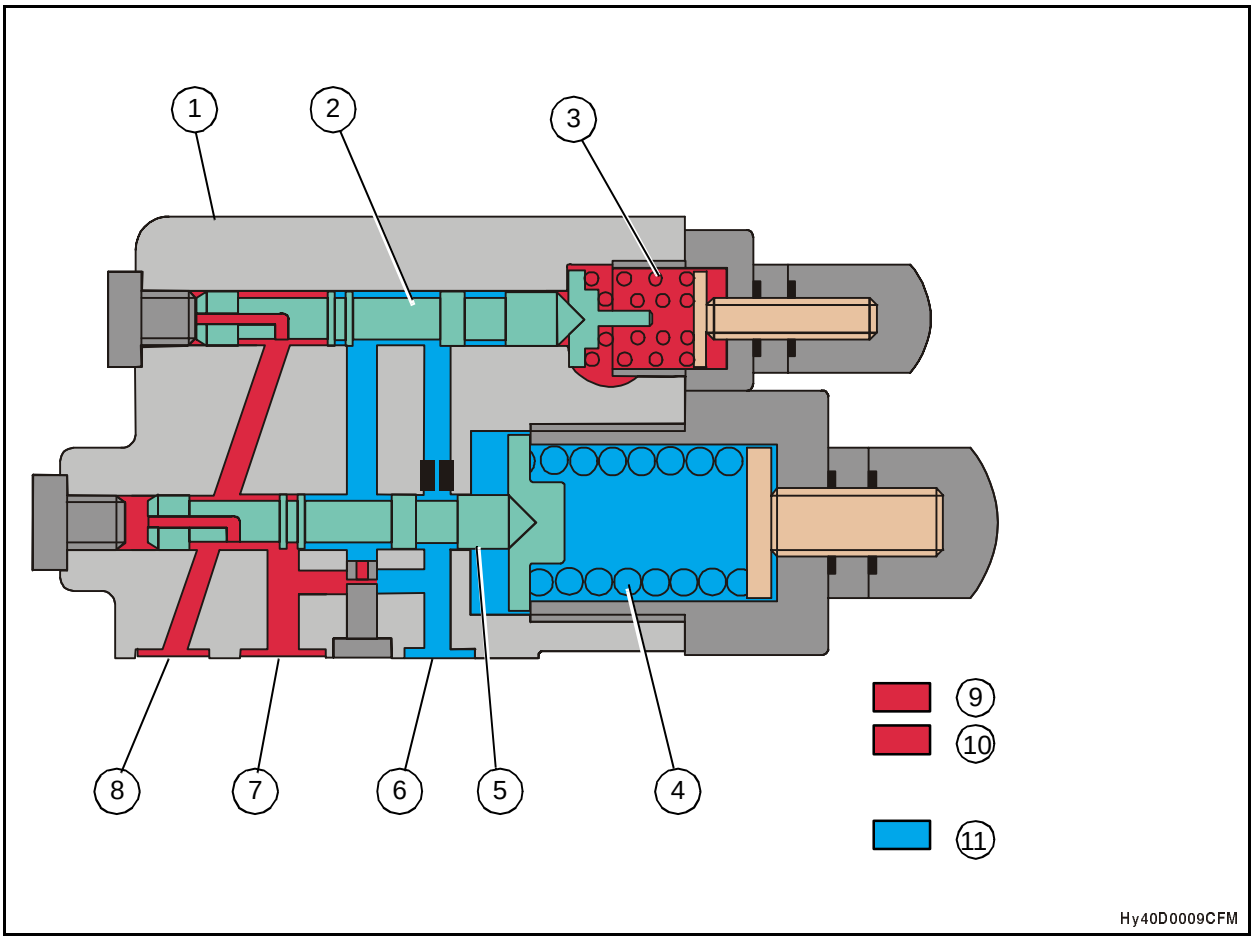
## Working Pressure

When a function is actuated, load sense oil pressure (10) to the pump regulator (1) rises.

This rising load sense pressure and the force of the residual (3) work together to overcome the pressure of the supply oil (9) on the opposite side of the residual spool (2).

The spool will then slide over (away from spring), opening the control piston (7) to case drain (6), stroking the pump and increasing flow as needed.

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1 Pump Regulator.
2 Residual Spool.
3 Residual Spring.
4 Compensator Spring.
5 Compensator Spool.
6 Case Drain.
7 To Control Piston.
8 From Pump Outlet.
9 Supply Oil.
10 Load Sense Oil (High Pressure).
11 Return Oil.

## Compensating Pressure

As the hydraulic system needs are met and the supply oil (9) pressure continues to rise, the increasing supply oil pressure starts to overcome the compensator spring (4), sliding the compensator spool (5) toward the spring.

The spool will then direct the high pressure supply oil into the control piston (7) destroking the maintain pressure. The system relief valve is used to protect the system against sudden pressure spikes.

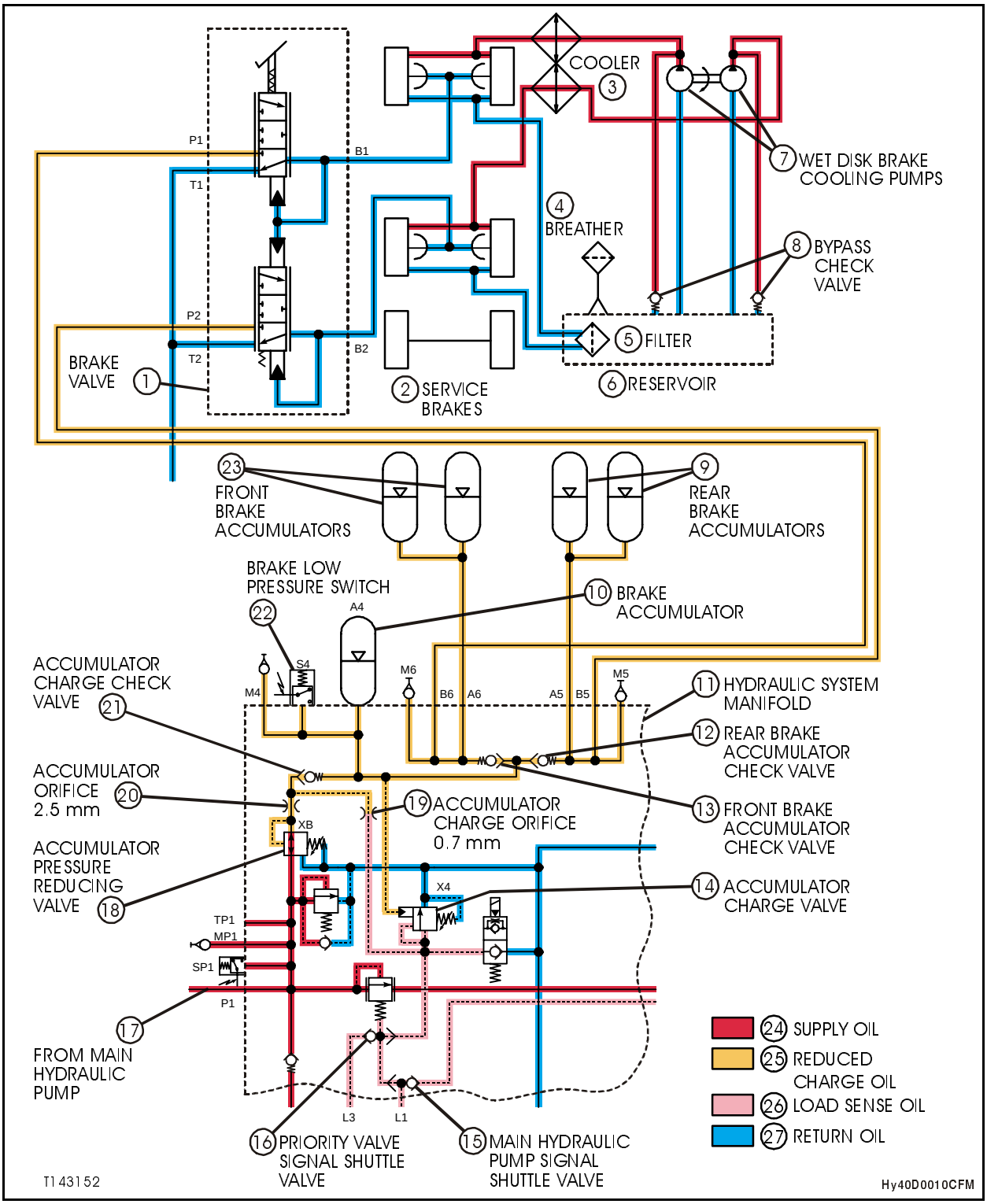
High system pressure oil is also conveyed into the load sense circuit. The high pressure load sense oil (10) plus the force of the residual spring (3) will keep residual spool (2) shifted away from the spring.

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## Service Brake System Operation



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1 Brake Valve.
2 Service Brakes.
3 Cooler.
4 Breather.
5 Filter.
6 Hydraulic Reservoir.
7 Wet Disk Brake Cooling Pumps.
8 Bypass Check Valve.
9 Rear Brake Accumulators.
10 Brake Accumulator.
11 Hydraulic System Manifold.
12 Rear Brake Accumulator Check Valve.
13 Front Brake Accumulator Check Valve.
14 Accumulator Charge Valve.
15 Main Hydraulic Pump Signal Shuttle Valve.
16 Priority Valve Signal Shuttle Valve.
17 From Main Hydraulic Pump.
18 Accumulator Pressure Reducing Valve.
19 Accumulator Charge Orifice 0.7 mm.
20 Accumulator Orifice 2.5 mm.
21 Accumulator Charge Check Valve.
22 Brake Low Pressure Switch.
23 Front Brake Accumulators.
24 Supply Oil.
25 Reduced Charge Oil.
26 Load Sense Oil
27 Return Oil

## Charging System

When operating the service brake valve (1), charge oil (25) pressure in the front brake accumulators (23), rear brake accumulators (9) and brake accumulator (10) decreases.

The decrease of charge oil pressure in the brake accumulators is sensed by the accumulator charge valve (14).

When the accumulator charge oil pressure decreases below the lower pressure setting of the accumulator charge valve, the charge valve spring shifts the spool, blocking the flow of load sense oil (26) to the return circuit.

Charge oil continues to flow through the brake accumulator charge orifice (19), increasing load sense pressure.

The increasing load sense pressure shifts the priority valve signal shuttle valve (16) and main hydraulic pump signal shuttle valve (15) sending the load sense signal out of port L1 to the main hydraulic pump port X, stroking the pump, increasing flow, causing supply oil (24) pressure to increase.

This supply oil then flows through the accumulator pressure reducing valve (18), accumulator orifice (20), and accumulator charge check valve (21) charging the brake accumulator.

As pressure increases, the rear and front brake accumulator check valves (12 and 13) are opened allowing all the accumulators to be charged. Pressure to the accumulators is limited by accumulator pressure reducing valve. The accumulator orifice controls the rate of oil flow to charge the accumulators.

When brake accumulator charge oil pressure increases to the upper pressure setting of accumulator charge valve, the charge valve spool shifts to the open position allowing load sense oil to flow to return, decreasing the load sense signal to the main hydraulic pump. The pump de-strokes decreasing supply oil flow to the accumulators.

## Charged System

When all accumulators are charged, charge oil (25) pressure in the brake accumulator (10) holds the accumulator charge check valve (21) closed. The brake accumulator charge oil pressure keeps the accumulator charge valve (14) open allowing pump load sense oil (26) to flow to return.

The rear and front brake accumulator check valves (12 and 13) separate the circuits and hold charge oil in the rear and front brake accumulators (9 and 23) and brake valve (1). The check valves enable the circuits to work independently of each other in the event of a malfunction in either circuit.

The pressure setting of the accumulator charge valve and accumulator pressure reducing valve (18) is critical to operation of the main hydraulic pump. If pressure setting of accumulator charge valve is higher than accumulator pressure reducing valve, the load sense signal to the main hydraulic pump will remain high because the charge oil pressure from brake accumulator cannot open the charge valve allowing load sense oil to flow to return.

The pump will remain in stroke and not return to low stand-by (residual) pressure when all functions are in neutral.

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### Brake Valve - Neutral

The service brake valve (1) is a dual circuit, modulated valve. The function of valve is to control the charge oil (25) from the rear and front brake accumulators (9 and 23) to actuate the service brakes (2).

The brake valve contains two separate circuits, each supplied by their own set of accumulators. The top valve is for the front axle brakes and the bottom valve is for the rear axle brakes.

The brake valve supplies charged oil to the rear brakes first and then the front brakes. In neutral, charge oil is blocked by the brake valve spools and the brake pistons are open to return.

### Brake Valve - Actuated

When service brakes (2) are actuated, the charge oil (25) in the accumulators flows through the brake valve (1) to the brake pistons, applying the brakes.

The pressure applied at the pistons and the force applied to the spring by the brake pedal act on opposite ends of the spools in the brake valve.

The pressure to the pistons is proportional to the force applied to the brake pedal (pressure to the pistons increases as the force on the brake pedal increases).

The pressure on the end of the spools balances against the spring force modulating the pressure to the pistons. The charge oil pressure is reduced by the amount of oil it takes to move the pistons.

Each application of the brake pedal reduces the charge pressure until the brake accumulator charge circuit is actuated by the accumulator charge valve (14).

### Wet Disk Brake Cooling System - B40D Only

The wet disk brake cooling system is a separate closed hydraulic system which consists of two wet disk brake cooling pumps (7), two bypass check valves (8), two coolers (one unit) (3), return filter (5), reservoir (6), and reservoir breather (4).

Each axle (front and rear) has its own sub-system including a pump, bypass check valve, and cooler. The pump circulates cooling oil from the reservoir, through the cooler, and into the brake housing where it removes heat from the brake disks.

The oil then flows out of the brake housing, through a return filter, and into the reservoir. A hub seal separates the brake housing cooling oil from the wheel end lubricant.

There is a bypass check valve after the pump that will return oil back to the reservoir if coolers become plugged or if oil is cold due to low ambient temperatures.

The wet disk brake thermal valve located in the fan drive circuit, monitors the wet disk brake cooling system oil temperature.

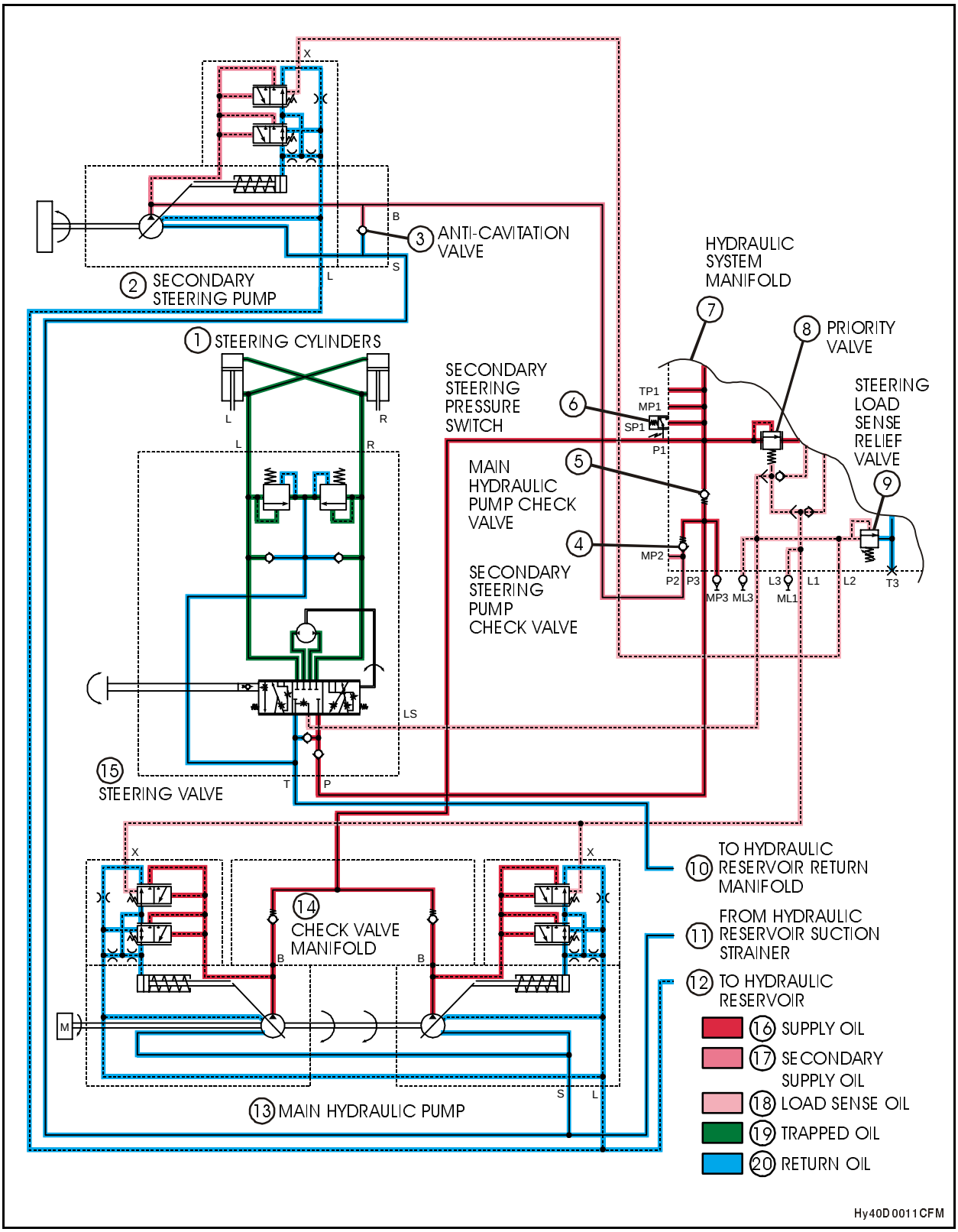
As the cooling oil temperature rises the thermal valve regulates load sense oil pressure to the main hydraulic pump thus regulating the speed of the fan. **(See “Fan Drive System Operation” on page 362).**

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## Steering And Secondary Steering System Operation



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1 Steering Cylinders.
2 Secondary Steering Pump.
3 Anti-Cavitation Valve.
4 Secondary Steering Pump Check Valve.
5 Main Hydraulic Pump Check Valve.
6 Secondary Steering Pressure Switch.
7 Hydraulic System Manifold
8 Priority Valve.
9 Steering Load Sense Relief Valve.
10 To Hydraulic Reservoir Return Manifold.
11 From Hydraulic Reservoir Suction Strainer.
12 To Hydraulic Reservoir.
13 Main Hydraulic Pump.
14 Check Valve Manifold.
15 Steering Valve.
16 Supply Oil.
17 Secondary Supply Oil.
18 Load Sense Oil.
19 Trapped Oil.
20 Return Oil.

The function of the steering system is to route supply oil (16) from the main hydraulic pump (13) to the steering valve (15). The steering valve then controls the oil flow used to extend and retract the steering cylinders (1).

When the steering wheel is turned, the load sense signal from the steering valve enters the hydraulic system manifold (7) at port L3. The load sense signal is then sensed at the secondary steering pump (2) via port L2.

At the same time, the load sense signal shifts the shuttle valves, pressurizes the spring chamber of priority valve (8), and sends a signal to the main hydraulic pump via port L1.

The load sense signal will not exceed the steering load sense relief valve (9) pressure setting. The main hydraulic pump supplies the required flow rate through port P1, main hydraulic pump check valve (5), and out of port P3 to steering valve port P.

When the steering wheel is not being turned, the load sense signal is open to hydraulic reservoir through the steering valve and the main hydraulic pump will return to residual pressure.

The oil in the steering cylinders is trapped and the machine is held at that relative position. The ground driven secondary steering pump will assist with oil flow to steer the machine if main hydraulic pump cannot deliver the flow required.

Low oil flow may occur during an attempt to rapidly steer machine at slow engine speed. (Machine must be moving for secondary steering pump to work.)

Under normal steering operation, the pressure of secondary steering pump at port P2 is just below that of the main hydraulic pump at port P1 creating a differential pressure across secondary steering pump check valve (4).

When the main hydraulic pump cannot meet the flow requirements to steer the machine, the pressure in the main hydraulic pump circuit decreases the load sense signal at port L1.

The load sense signal to the secondary steering pump via port L2 is the same as that of the main hydraulic pump at port L1, enabling the pressure of secondary steering pump at port P2 to increase and overcome the pressure differential across secondary steering pump check valve.

Flow from the secondary steering pump, via port P2, eventually supplements the flow from the main hydraulic pump to the steering valve via port P3.

The rpm of the secondary steering pump is dependent on the machine travel speed. Supply oil flow available to steer the machine is reduced proportionately as the travel speed decreases.

When the machine stops, there is no secondary steering pump flow. The secondary steering system is also used to provide oil flow to the steering circuit (while the machine is still moving) in the event there is a malfunction of the engine, transmission, power takeoff, pump drive shaft, or main hydraulic pump.

The system consists of the secondary steering pump, main hydraulic pump check valve, secondary steering pump check valve, and secondary steering pump anti-cavitation valve (3).

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The secondary steering pump is a variable-displacement, axial-piston pump with a load sensing and pressure compensating regulator valve.

Operation of the secondary steering pump is similar to the main hydraulic pump. The residual valve pressure setting for the secondary steering pump is lower than the residual valve pressure setting for the main hydraulic pump.

When the machine is moving, the pressure at test port MP2 remains just below the pressure at test port MP1. The secondary steering pump is mounted on the transfer case and is ground-driven as long as the gear train is being turned by the moving machine.

The secondary steering pump check valve is used to block oil flow from the main hydraulic pump to the secondary steering pump circuit.

In the event of a malfunction, main hydraulic pump check valve manifold oil flow from the secondary steering pump to the main hydraulic pump, fan drive valve, bin control valve, and brake accumulator charging circuit.

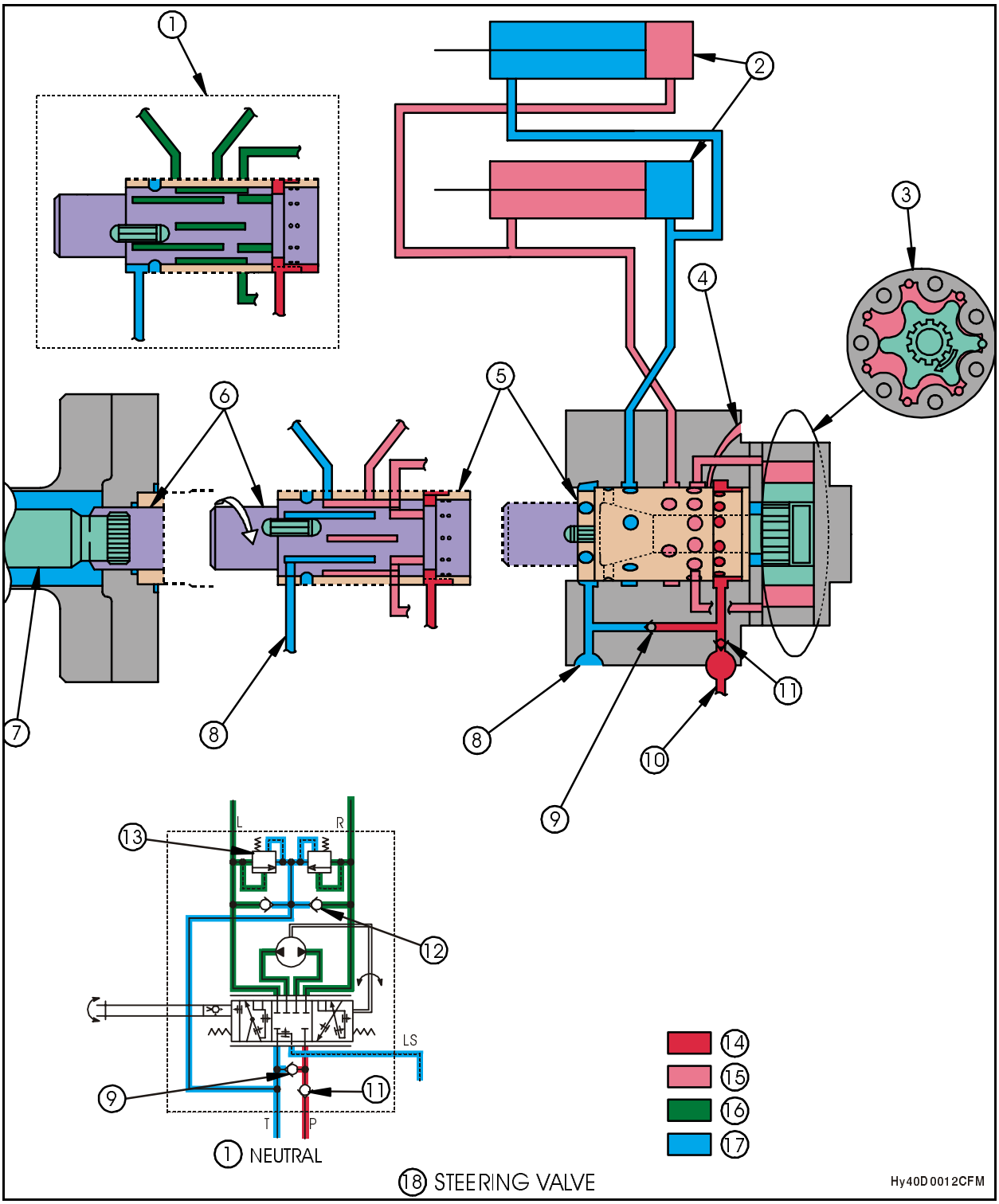
The secondary steering pump anti-cavitation valve provides a path for oil flow from the suction side of the pump to the outlet side, forming a loop circuit when the machine is travelling in reverse.

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## Steering Valve Operation



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1 Neutral.
2 Steering Cylinder.
3 Gerotor.
4 Load Sense Port to Hydraulic System Manifold Port L3.
5 Sleeve.
6 Spool.
7 Steering Shaft.
8 Return.
9 Make-Up Check Valve.
10 From Hydraulic System Manifold Port P3.
11 Inlet Check Valve.
12 Anti-Cavitation Valve.
13 Relief Valve.
14 Supply Oil.
15 Work Pressure Oil.
16 Trapped Oil.
17 Return Oil.
18 Steering Valve.

The steering valve (18) is a variable-displacement (flow amplification), closed-centre valve. Main valve components are the spool (6) inside a sleeve (5) within a housing and the gerotor (3).

Also included are the make-up check valve (9), inlet check valve (11), anti-cavitation valves (12), and relief valves (13).

When steering the wheel is not being turned, the valve is in neutral (1). In neutral, the spool and sleeve are held in alignment by the centring spring blocking the flow of supply oil (14) through the sleeve to the spool and gerotor.

Oil at the left and right work ports to the steering cylinders is trapped (16) by the sleeve holding the machine frames stationary.

Turning the steering wheel and shaft (7) left or right turns the spool relative to the sleeve, opening passages so supply oil flows from the hydraulic system manifold port P3 (10) through the sleeve into the spool.

From the spool, work pressure oil (15) flows to the gerotor (3) causing the gerotor gear and sleeve to turn. Work pressure oil flow is metered by the gerotor back into the spool where it is routed through the sleeve and out the left or right work port to the respective ends of the steering cylinders turning the machine.

Work pressure oil also flows out the load sense port (4) sending a load sense signal back through the hydraulic system manifold port L3 to the main hydraulic pump regulator valve to regulate pump flow. Load sense signal also goes to the spring chamber of the priority valve and to the steering load sense relief valve.

Return oil (17) flows back from steering cylinders, through the right or left work port, through the sleeve and spool to the return circuit (8).

As steering operation is stopped, the centring spring and gerotor continue to turn the sleeve until the sleeve and spool are in alignment, stopping the flow of oil through the spool to the gerotor. At this point, the valve is in neutral and remains there until the steering wheel and shaft are turned again.

The valve's variable-displacement (flow amplification) is proportional to the speed at which the steering wheel is turned.

When the steering wheel is turned slowly, the valve only meters oil through the gerotor to the steering cylinders and thus the effective displacement is equal to the gerotor displacement.

When the steering wheel is turned rapidly, the spool moves more, relative to the sleeve opening passages, so additional oil is allowed to bypass the gerotor, thus increasing the effective valve displacement, hence flow amplification occurs.

Relief valves (13) are used to relieve high pressure oil from a pressure spike created in the steering cylinders while steering is in neutral. In neutral, the steering valve blocks the flow of oil to and from the cylinders.

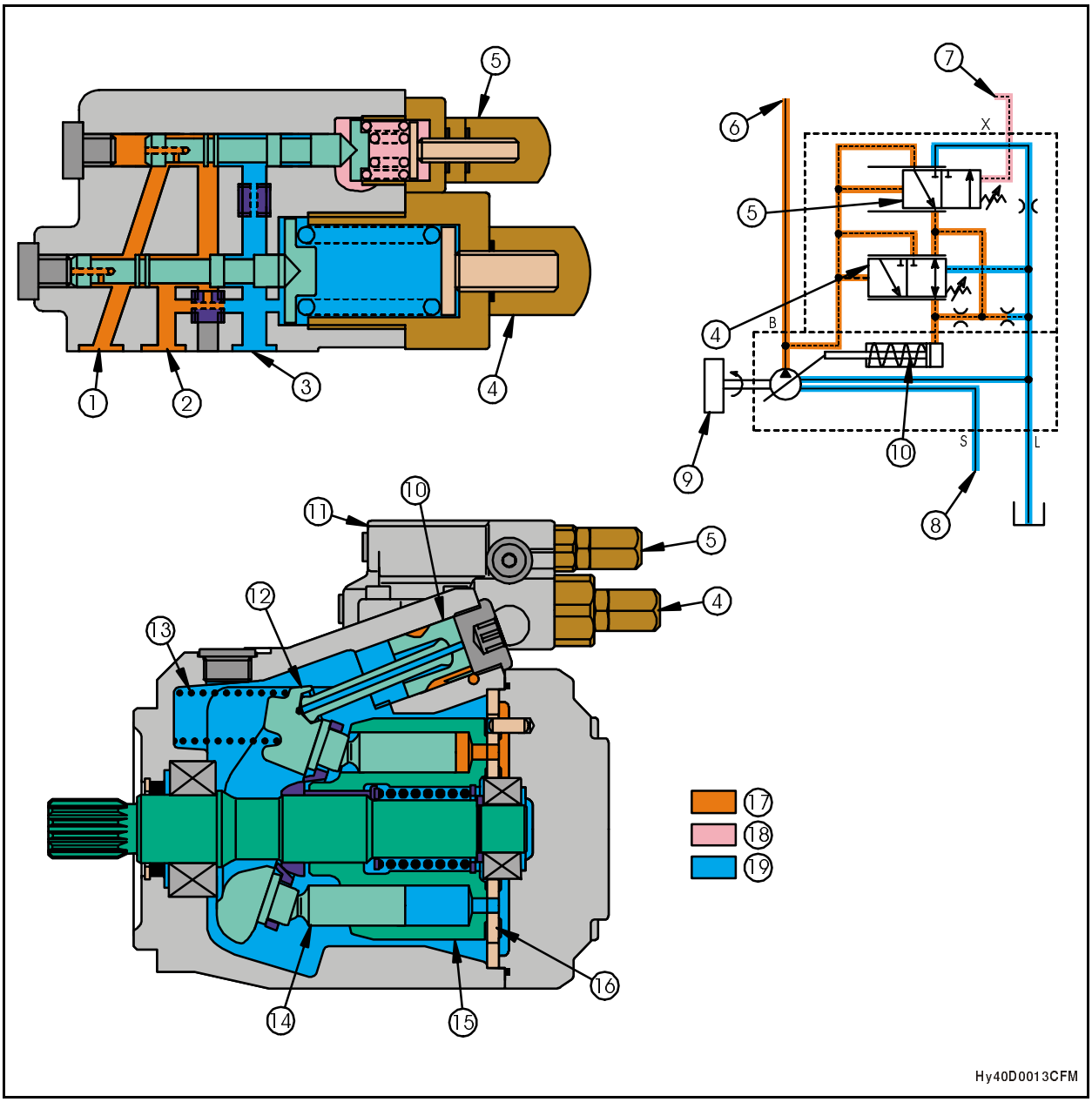
A pressure spike is created by the impact of the front or rear wheels against an obstacle, which is transmitted to the steering cylinders causing slight cylinder movement.

The cylinder movement that caused the pressure spike also causes a pressure drop and a void in the opposite end of the cylinders. Because of the pressure differential across the anti-cavitation valve (12), the pressure in the return passage pushes the valve open and oil flows into the void preventing cavitation.

Oil not used flows out port T and then back to the hydraulic reservoir.

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## Secondary Steering Pump Operation



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1 From Pump Outlet.
2 To Control Piston.
3 To Case Drain.
4 Compensator Valve.
5 Residual Valve.
6 To Hydraulic System Manifold Port P2.
7 From Hydraulic System.
8 From Main Hydraulic Pump Manifold Port L2.
9 Transfer Case.
10 Control Piston.
11 Pump Regulator Valve.
12 Swash Plate.
13 Spring.
14 Piston.
15 Cylinder Block Oil.
16 Valve Plate.
17 Supply Oil.
18 Load Sense Oil.
19 Return or Pressure-Free Oil.

The secondary steering hydraulic pump is a load-sensing, pressure-compensating, variable-displacement axial-piston pump.

Pump displacement is varied by the angle of the swash plate (12). The swash plate angle is controlled by the control piston (10) and spring (13).

Spring pressure is applied to the swash plate at all times, trying to keep the pump at maximum displacement. Secondary supply oil (17) is applied to or released from the control piston by the residual valve (5) in response to load sense signal from hydraulic system manifold port L2 to load sense port X, varying displacement per load demand.

At full system pressure, the compensator valve (4) is shifted to route secondary supply oil to the control piston, destroking the pump.

As the angle of the swash plate is increased, the pistons (14) move in and out of their bores and displace oil as the cylinder block (15) is turned.

The pistons move into their bores during the first half of each revolution, and out of their bores during the last half of the revolution.

The piston bores are filled with oil through the valve plate (16) as the pistons move out of the bores.

The pistons moving into their bores push oil out through the valve plate, through the secondary steering pump anti-cavitation valve, and to the hydraulic system manifold port P2 (6).

The pump displacement is regulated by the compensator valve and residual valve (load sensing).

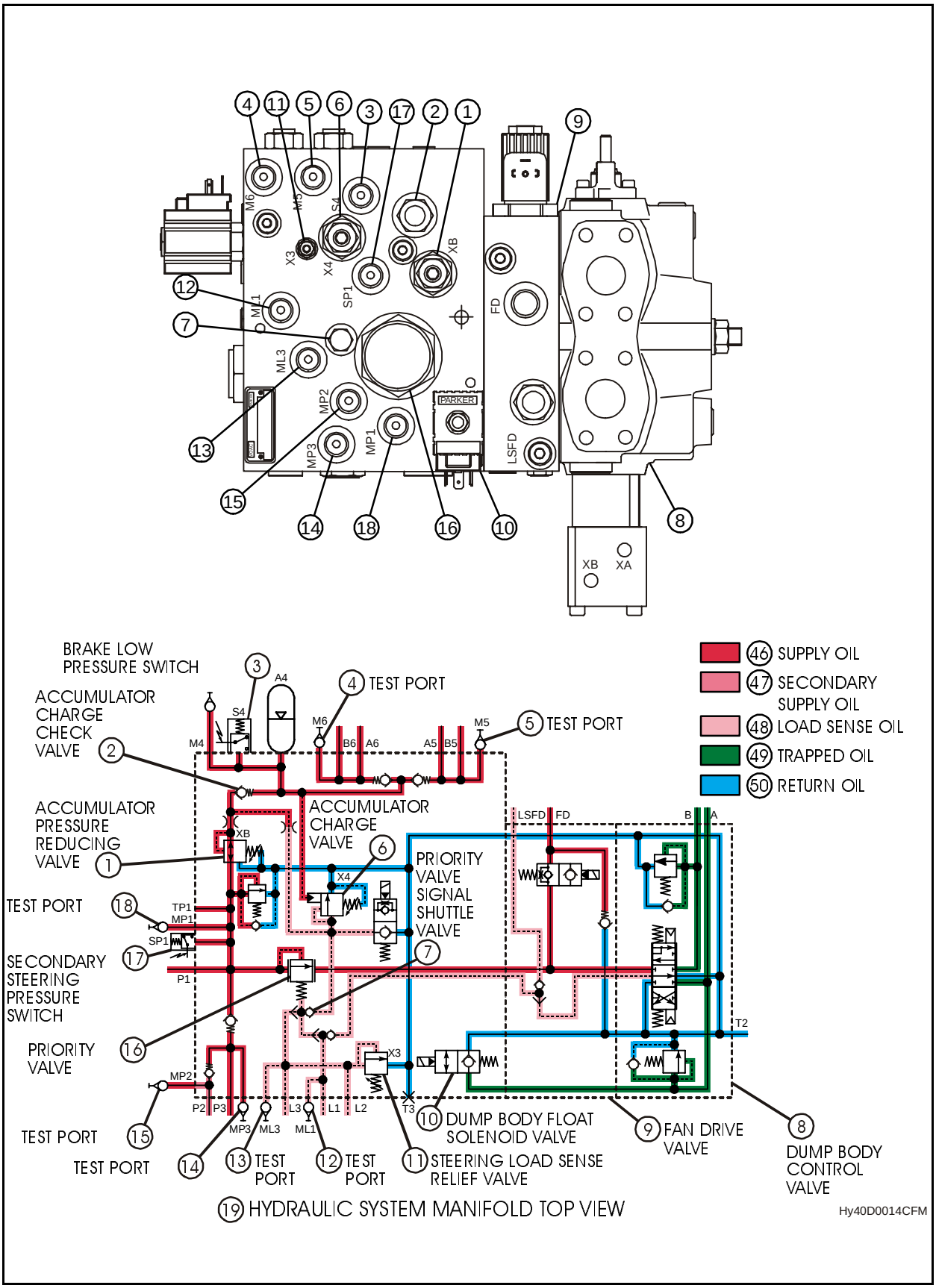
Normal leakage to the pump case through clearance between the pistons, valve plate and cylinder block provides cooling and lubrication before flowing back to the hydraulic reservoir.

The secondary steering pump is mounted on the transfer case (9) and is ground driven as long as the gear train is being turned by the moving machine.

When the machine is not moving, there is no secondary steering pump flow. The secondary steering pump will not operate when machine is moving in reverse.

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## Hydraulic System Manifold Operation (Top View)



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1. Accumulator Pressure Reducing Valve, XB.
2. Accumulator Charge Check Valve.
3. Brake Low Pressure Switch, S4.
4. Test Port, M6.
5. Test Port, M5.
6. Accumulator Charge Valve, X4.
7. Priority Valve Signal Shuttle Valve.
8. Bin Control Valve.
9. Bin Float Solenoid Valve.
10. Steering Load Sense Relief Valve, X3.
11. Test Port, ML1.
12. Test Port, ML3.
13. Test Port, MP3.
14. Test Port, MP2.
15. Priority Valve.
16. Secondary Steering Pressure Switch, SP1.
17. Test Port, MP1.
41. Supply Oil.
42. Secondary Supply Oil.
43. Load Sense Oil.
44. Trapped Oil.
45. Return Oil.

The hydraulic system manifold controls and distributes hydraulic oil through outlet ports to all components in the hydraulic system.

The hydraulic system manifold is a replaceable cartridge-valve-type manifold. The dump body control valve (8) is mounted on the hydraulic system manifold.

Numbers and letters are stamped on the manifold to help locate and identify components and ports. The illustrated views given are with the hydraulic system manifold installed in the machine.

Test ports ML1 (11), ML3 (12), MP3 (13), M5 (5), and M6 (4) are equipped with high pressure quick couplers for making test connections to hydraulic system.

Test ports MP1 (17), MP2 (14), and M4 (34) are connected by hydraulic lines to a test port manifold located behind the cab.

The brake low pressure switch, S4 (3) closes when brake accumulator pressure decreases below the lower limit of accumulator charge valve band.

The switch actuates the brake low pressure indicator light. The priority valve (15) gives priority to the steering valve and brake accumulator charging circuit over the dump body control valve if supply oil flow from main hydraulic pump is not enough to satisfy the load demand.

During dump body raise operation the priority valve remains open if the pressure to operate the brake accumulator charging and steering circuits is less than that of the dump body raise circuit.

Oil takes the path of least resistance, meeting the load demand of charging and steering circuits.

When pressure to operate the brake accumulator charging or steering circuits is higher, their higher load sense signal assists the priority valve spring to move the valve spool, reducing the flow of oil to the dump body control valve.

The main hydraulic pump can now meet the charging or steering circuit load demand.

The priority valve signal shuttle valve (7) routes the higher load sense signal from the steering valve or brake accumulator charging circuit to the spring chamber of the priority valve and to the main hydraulic pump signal shuttle valve (37).

The steering load sense relief valve, X3 (10) relieves excess load sense signal from the steering valve.

The secondary steering pressure switch, SP1 (16) closes when the main hydraulic pump loses pressure.

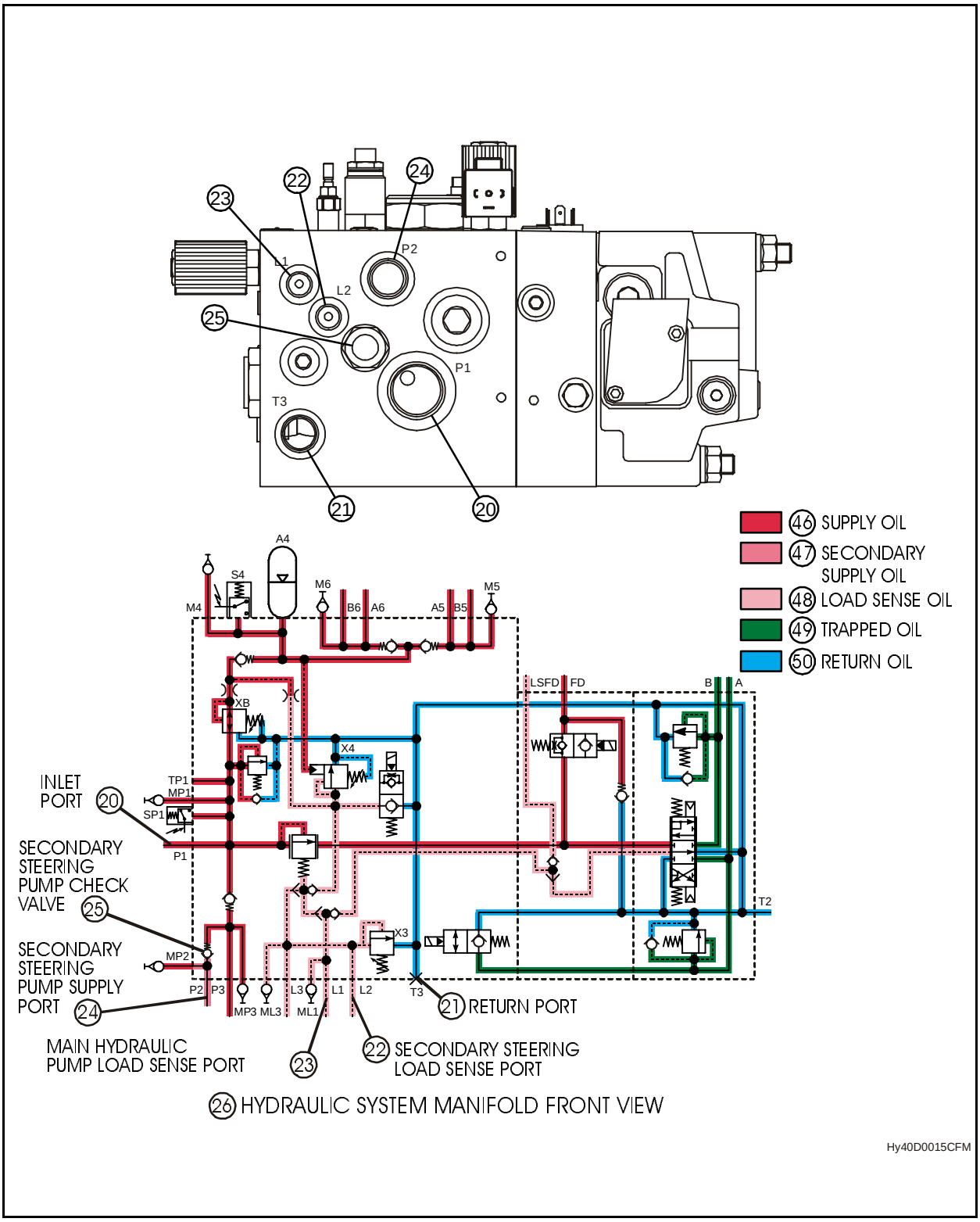
The switch actuates the secondary steering indicator light. The brake accumulator charge valve, X4 (6) maintains brake charge accumulator, A4 (26) pressure between upper and lower limit of the charge band.

The brake accumulator pressure reducing valve, XB (1) limits pressure to the brake accumulators. The brake accumulator charge check valve (2) holds charge pressure in the brake charge accumulator so oil does not flow to the steering and dump body control circuits when system pressure is less than charge pressure.

The dump body float solenoid valve (9) (when energized) opens, allowing the dump body cylinder head end circuit to dump into the hydraulic reservoir. **(See “Bin Control Valve Operation” on page 364).**

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## Hydraulic System Manifold Operation (Front View)



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18. Inlet Port, P1.
19. Return Port, T3 (not used).
20. Secondary Steering Load Sense Port, L2.
21. Main Hydraulic Pump Load Sense Port, L1.
22. Secondary Steering Pump Supply Port, P2
23. Secondary Steering Pump Check Valve.

Supply oil (41) flows from the main hydraulic pump to the inlet port P1 (18).

Supply oil flows from the secondary steering pump to the secondary steering pump port, P2 (22).

The secondary steering pump check valve (23) blocks supply oil flow from the main hydraulic pump to the secondary steering pump.

It also functions as the closed-center valve for the secondary steering pump.

41. Supply Oil.
42. Secondary Supply Oil.
43. Load Sense Oil.
44. Trapped Oil.
45. Return Oil.

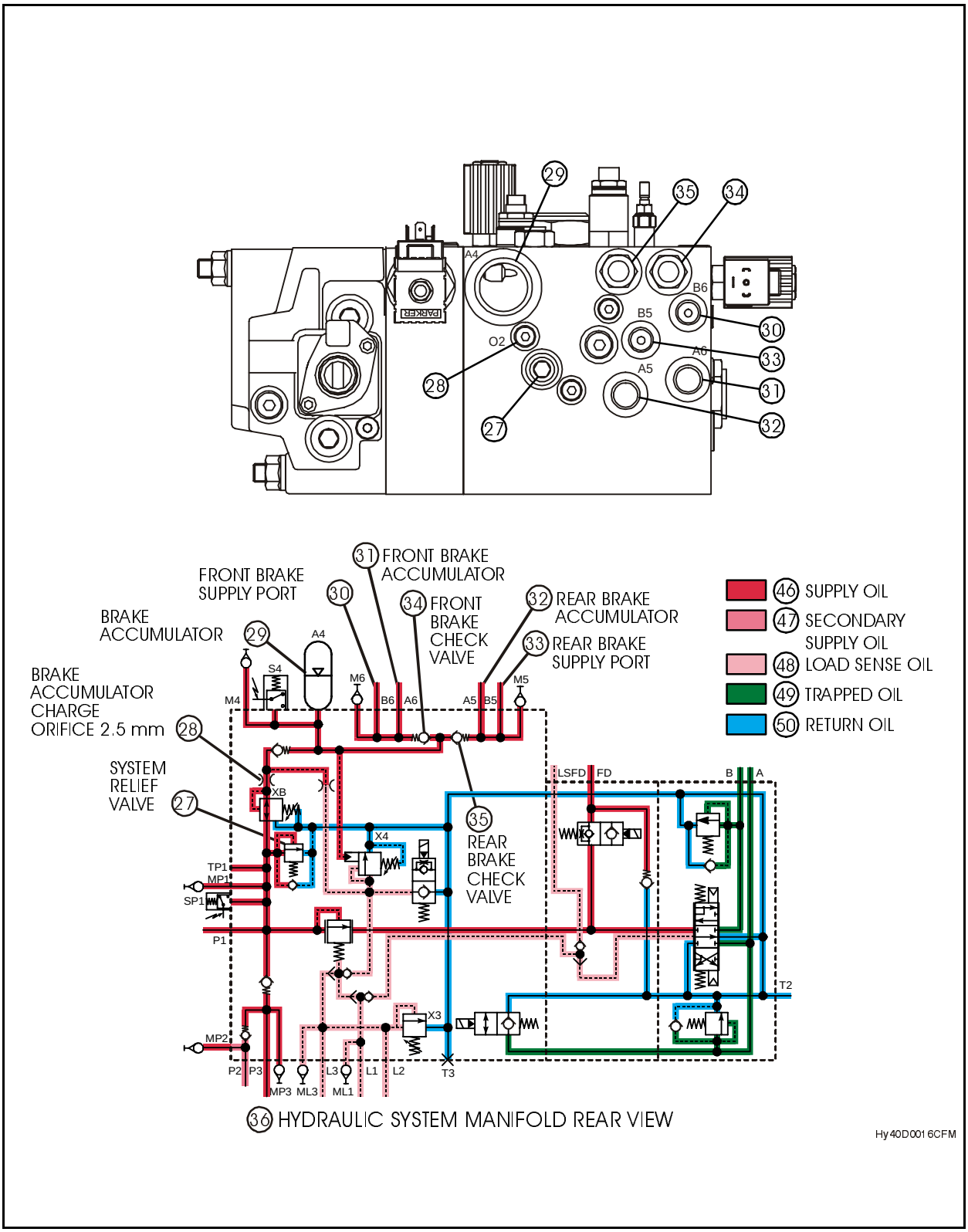
The check valve will open when the main hydraulic pump flow is low enough so that pressure drops below the pressure of the secondary steering pump, allowing the secondary steering pump to supply oil to the steering valve as long as the machine is moving.

The load sense signal from the main hydraulic pump load sense port, L1 (21) to the main hydraulic pump port, X causes the pump to go into stroke.

The load sense signal from the secondary steering load sense port, L2 (20) to the secondary steering hydraulic pump port, X.

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## Hydraulic System Manifold Operation (Rear View)



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24. System Relief Valve.
25. Brake Accumulator Orifice, 2.5 mm.
26. Brake Charge Accumulator, A4.
27. Rear Brake Supply Port, B6.
28. Rear Brake Apply Accumulator A6.
29. Rear Brake Apply Accumulator, A5.
30. Front Brake Supply Port, B5.
31. Rear Brake Check Valve.
32. Front Brake Check Valve.

The system relief valve (24) relieves supply oil pressure spikes to the return circuit.

The brake accumulator orifice, 2.5 mm (25) controls the rate of supply oil flow to the accumulators.

Supply oil flows from the rear brake supply port B6 (27) to the rear brake valve.

Supply oil flows from port A6 (28) to the rear brake apply accumulator.

Supply oil flows from port A5 (29) to the front brake apply accumulator.

Supply oil flows from front brake supply port, B5 (30) to the front brake valve.

The rear brake check valve (31) separates and holds charged oil for the rear brake circuit from the front brake circuit.

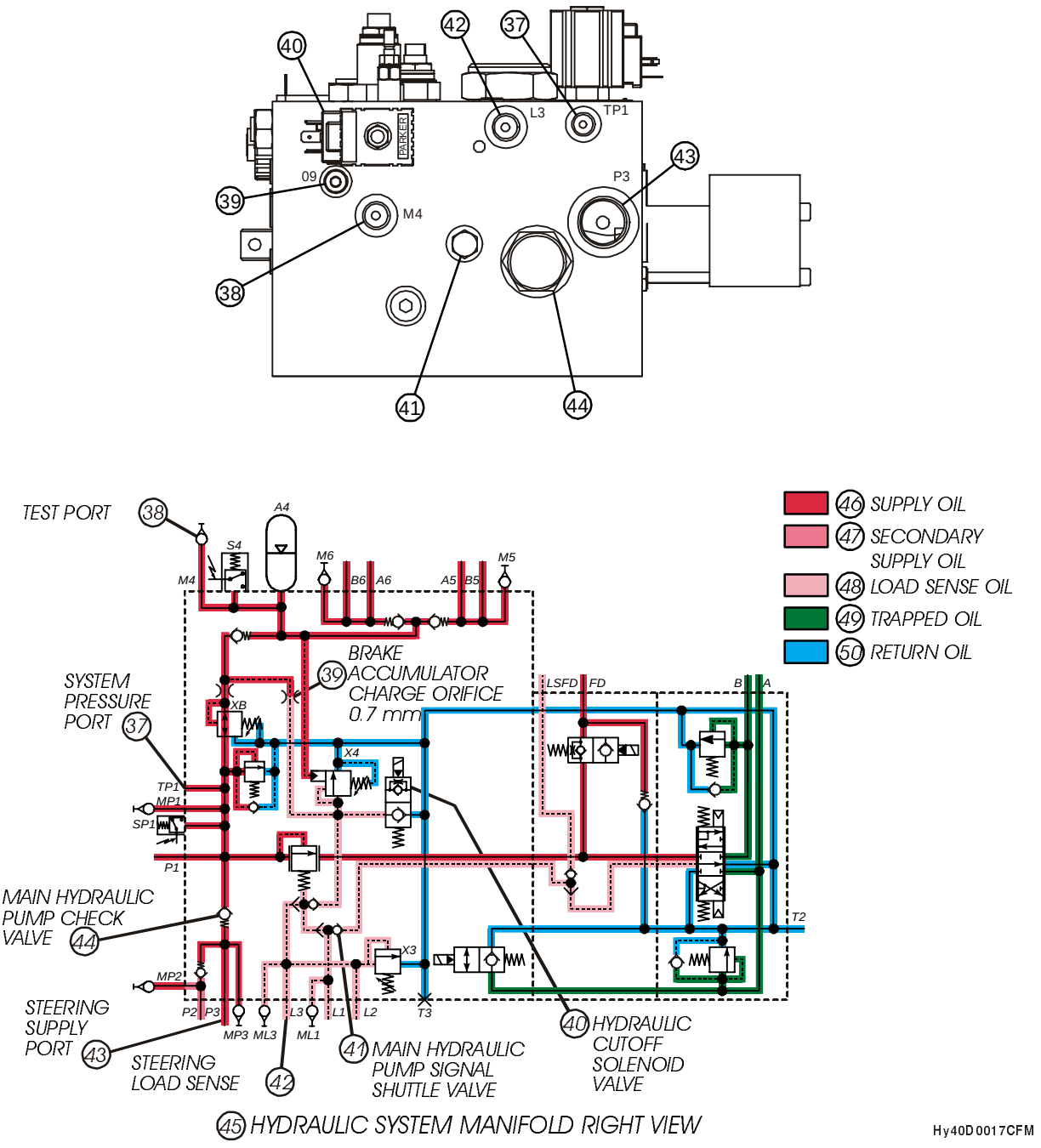
This enables the circuit to work independently in the event of a malfunction in the other circuit.

The front brake check valve (32) separates and holds charged oil for the front brake circuit from the rear brake circuit.

This enables the circuit to work independently in the event of a malfunction in the other circuit.

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## Hydraulic System Manifold Operation (Right View)




45 HYDRAULIC SYSTEM MANIFOLD RIGHT VIEW

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33. System Pressure Port, TP1.
34. Test Port, M4.
35. Brake Accumulator Charge Orifice, 0.7 mm.
36. Hydraulic Cutoff Solenoid Valve.
37. Main Hydraulic Pump Signal Shuttle Valve.
38. Steering Load Sense, L3.
39. Steering Supply Port, P3.
40. Main Hydraulic Pump Check Valve.
41. Supply Oil.
42. Secondary Supply Oil.
43. Load Sense Oil.
44. Trapped Oil.
45. Return Oil.

The brake accumulator charge orifice, 0.7 mm (35) controls the rate of oil flow through the accumulator charge valve, X4 (6) to the return circuit when the brake charge accumulator, A4 (26) is charged.

The hydraulic cutoff solenoid valve (36) prevents the brake charge accumulator and front and rear brake apply accumulators from being charged while starting the engine by opening the load sense signal to the return circuit.

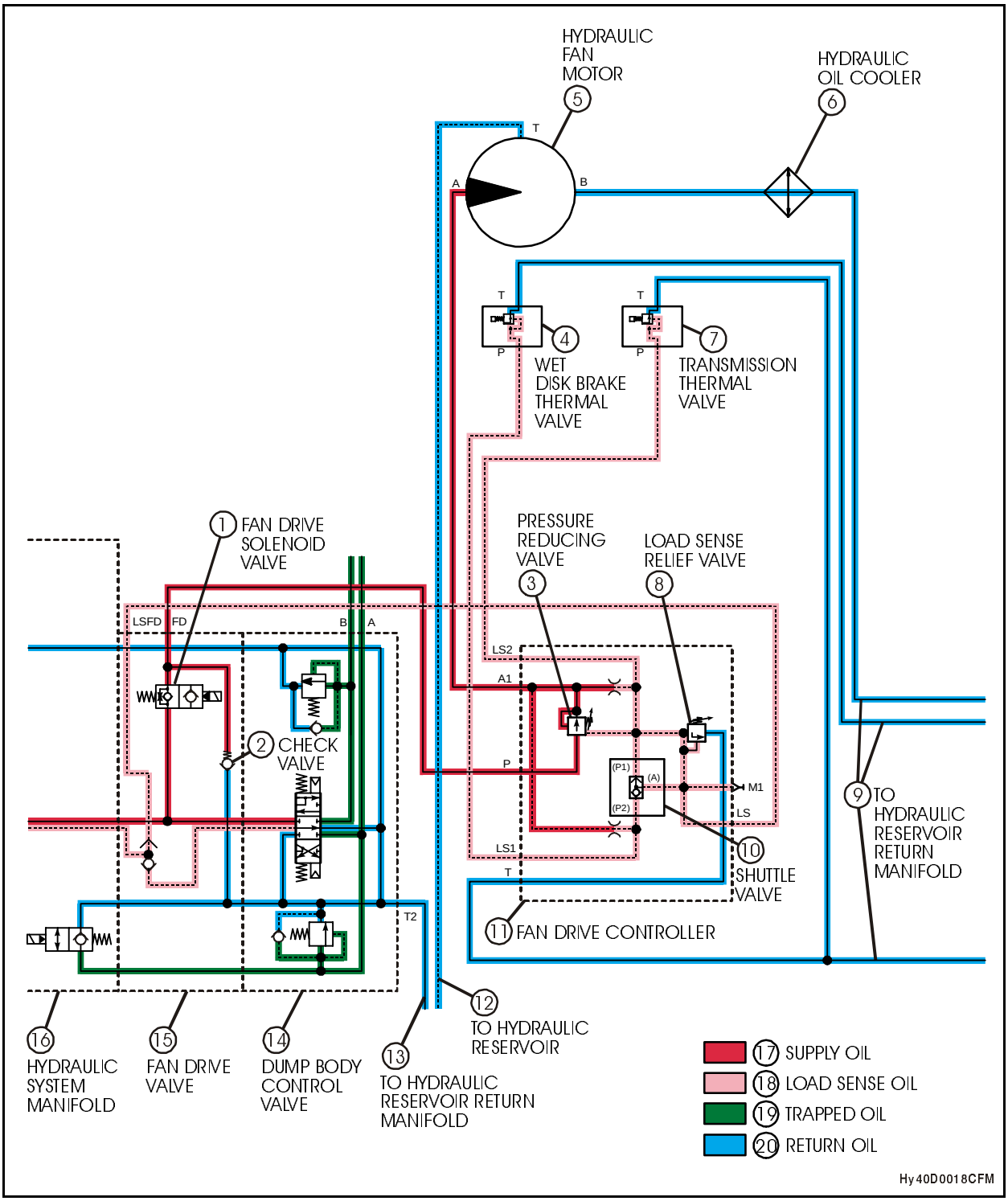
The main hydraulic pump signal shuttle valve (37) routes the higher load sense signal from the dump body control valve (8) or the priority valve signal shuttle valve (7) to the main hydraulic pump port, X.

The steering load sense port, L3 (38) receives the load sense signal from the steering valve port, LS. The steering supply port, P3 (39) sends supply oil to the steering valve port, P.

The main hydraulic pump check valve (40), prevents supply oil flow from the secondary steering pump from entering the brake charging circuit, and dump body control circuit.

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## Fan Drive System Operation



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Supply oil (17) from the hydraulic system manifold (16), enters the fan drive valve (15) and is allowed or not allowed by the fan drive solenoid valve (1) to continue on to the fan drive controller (11).

Whenever the dump body is in the raised or partially raised position, the fan drive solenoid is energized, closing off supply oil to the fan drive controller.

The check valve (2) will supply oil to the circuit when the fan drive solenoid is energized allowing the fan to coast to a stop.

The pressure reducing valve (3) controls the flow to the fixed displacement axial piston hydraulic fan motor (5).

When the wet disk brake or transmission oil is cold, only a small amount of oil flow is sent to the hydraulic fan motor, turning the fan at low speed, allowing the oil to warm up.

As the oil temperatures rise, the wet disk brake thermal valve (4) and the transmission thermal valve (7), located in their respective circuits, begin to close off load sense oil (18) to hydraulic reservoir causing load sense signal pressure to rise.

This higher load sense pressure will cause the pressure reducing valve to shift, allowing maximum available flow to the hydraulic fan motor.

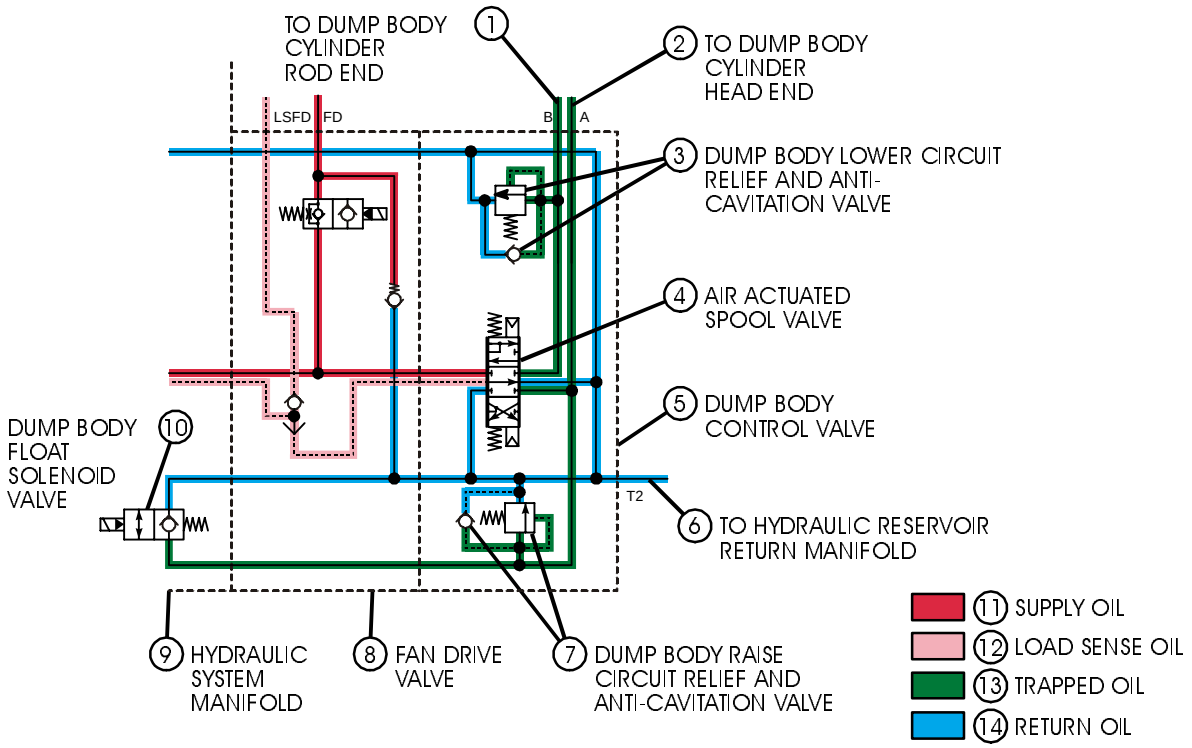
The main hydraulic pump will respond to the rising load sense signal by producing more flow, causing the hydraulic fan motor to turn faster.

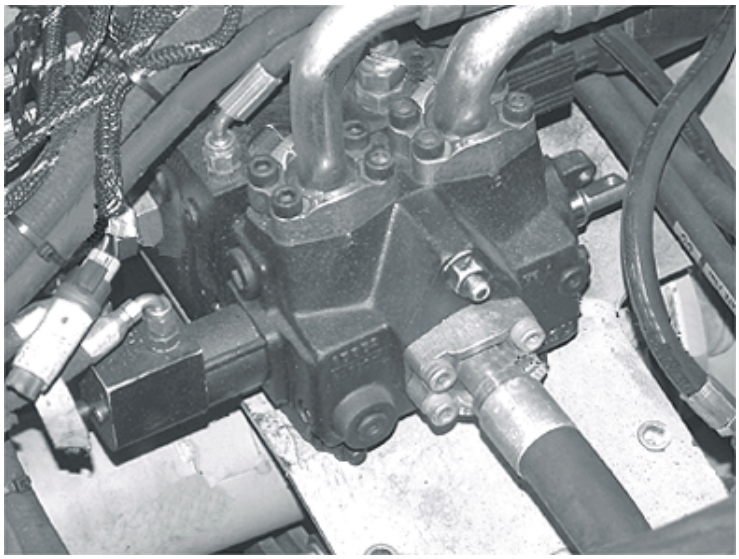
When either the wet disk brake thermal valve or the transmission thermal valve reaches its maximum allowable temperature, it will completely close off its passage to hydraulic reservoir.

The shuttle valve (10) will shift, isolating that circuit, allowing the load sense signal pressure to rise, opening the load sense relief valve (8) to hydraulic reservoir, controlling the maximum load sense signal pressure thus controlling the maximum speed of the hydraulic fan motor.

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## Bin Control Valve Operation



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1 To Bin Cylinder Rod End.
2 To Bin Cylinder Head End.
3 Bin Lower Circuit Relief and Anti-Cavitation Valve.
4 Air Actuated Spool Valve.
5 Bin Control Valve.
6 To Hydraulic Reservoir Return Filter.
7 Bin Raise Circuit Relief and Anti-Cavitation Valve.
8 Hydraulic System Manifold.
9 Bin Float Solenoid Valve.
10 Supply Oil.
11 Load Sense Oil.
12 Trapped Oil.
13 Return Oil.

As mounted on machine, the dump body control valve (5) is mounted on the left side of fan drive valve (8) which is mounted on the hydraulic system manifold (9).

The dump body lower circuit relief and anti-cavitation valve (3) relieves pressure in the dump body cylinder rod end circuit.

The relief valve pressure setting is lower than the pressure setting for dump body raise circuit relief valve.

The anti-cavitation valve prevents cavitation from occurring when lowing the dump body with the engine not running.

Port B is connected to the dump body cylinder rod end (1). Return oil (14) flows from port T2 to hydraulic reservoir return manifold (6).

In neutral, the load sense circuit for the dump body control valve is connected to return port T2 so there is no load sense signal.

Port A is connected to the dump body cylinder head end (2). The dump body raise circuit relief and anti-cavitation valve (7), relieves pressure in the dump body cylinder head end circuit.

The anti-cavitation valve prevents cavitation in the circuit if the cylinder is extended while the control valve is in neutral.

The air actuated spool valve (4) uses air pressure from the pneumatic system to shift the spool to the raise or lower position.

The spool is self-centering into the neutral position whenever the valve is not actuated. A magnetic dump body down detent is also provided.

When the dump body is lowered or stopped at approximately the last 5% (3.5°) of travel, the dump body float solenoid valve (10) will energize (open), allowing the dump body cylinder head end circuit to dump into hydraulic reservoir.

The dump body will then float down until it contacts the frame. **See "BIN CONTROL, FAN DRIVE AND RANGE HOLD CIRCUIT THEORY OF OPERATION" on page 74.**

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## Hydraulic System Circuit Symbols

### PUMPS

- Hydraulic Pump: Fixed Displacement Unindirectional
- Hydraulic Pump: Variable Displacement Unindirectional

### MOTORS and CYLINDERS

- Hydraulic Pump: Fixed Displacement Unindirectional
- Hydraulic Pump: Variable Displacement Unindirectional
- Cylinder Single Acting
- Cylinder Double Acting
  - Single End Rod
  - Double End Rod
  - Differential Piston

### Miscellaneous Units

- Electric Motor
- Accumulator, Spring Loaded
- Accumulator, Gas Charged
- Heater
- Cooler
- Temperature Controller
- Filter Strainer
- Pressure Switch
- Pressure Indicator
- Temperature Indicator
- Direction Of Shaft Rotation Assume Arrow On Near Side Of Shaft

### Valves

- Check
- ON - OFF (Manual Shut - OFF)
- Pressure Relief
- Pressure Reducing
- Flow Control Adjustable Non Compensated
- Three Position Four Connection
- Flow Control Adjustable (Temperature and Pressure Compensated)
- Two Position Two Connection
- Two Position Three Connection
- Two Position Four Connection
- Two Position In Transition
- Valves Capable Of Infinite Positioning (Horizontal Bars Indicate Infinite Positions Ability)

### Methods of Operation

- Spring
- Manual
- Push Button
- Push - Pull Lever
- Pedal or Treadle
- Mechanical
- Detent
- Pressure Compensated

- Solenoid, Single Winding
- Reversing Motor
- Pilot Pressure Remote Supply
- Internal Supply

### Lines

- Lines Crossing
- Line With Fixed Restriction
- Line, Flexible
- Station, Testing, Measurement Or Power Take - Off
- Temperature Cause or Effect
- Reservoir Vented
- Reservoir Pressurized
- Line To Reservoir Above Fluid Level
- Line To Reservoir Below Fluid Level
- Line, Working (Main)
- Line, Pilot (For Control)
- Line, Liquid Drain
- Flow Direction: Hydraulic; Pneumatic
- Lines Crossing (or)

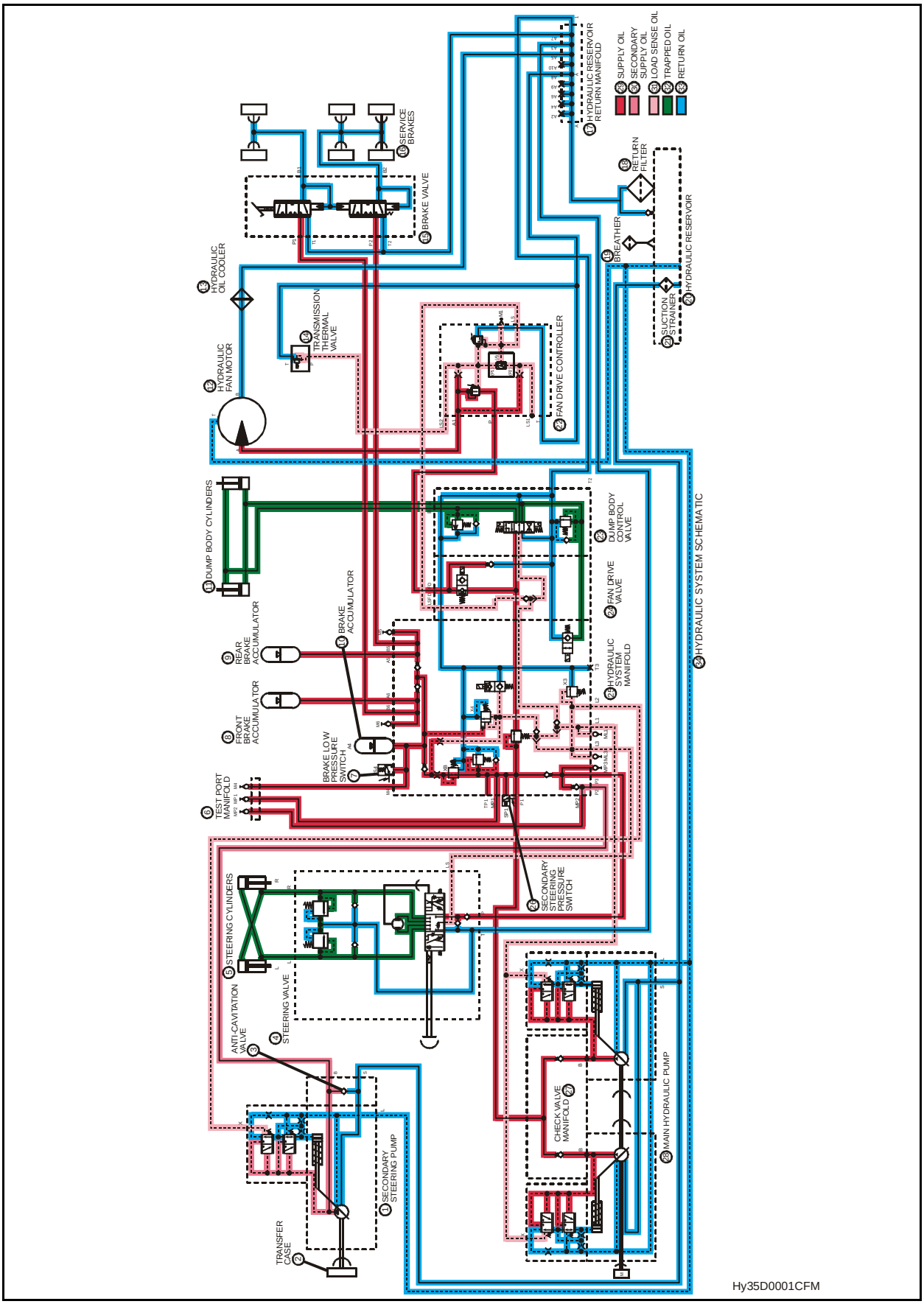
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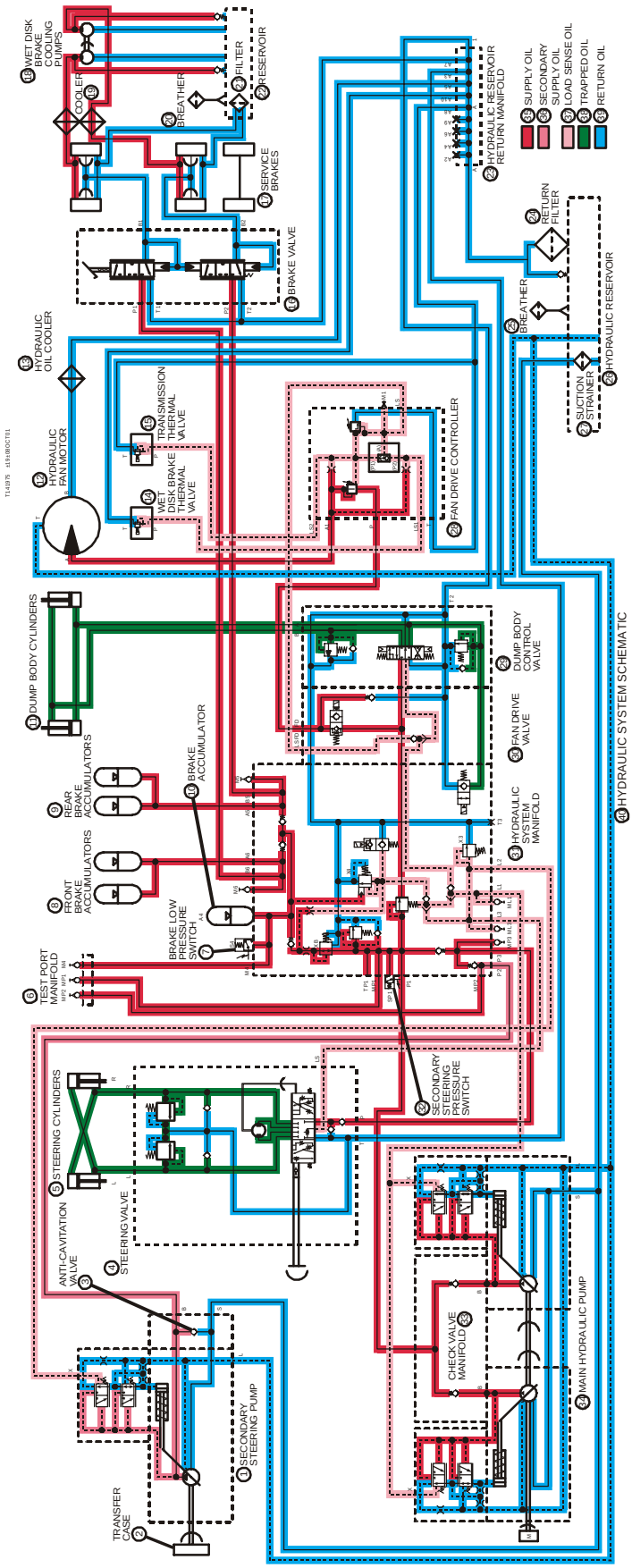
## Hydraulic System Schematics



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1. Secondary Steering Pump.
2. Transfer Case.
3. Anti-Cavitation Valve.
4. Steering Valve.
5. Steering Cylinders.
6. Test Port Manifold Valve.
7. Brake Low Pressure Switch, S4.
8. Front Brake Accumulator.
9. Rear Brake Accumulator.
10. Brake Accumulator, A4.
11. Bin Tip Cylinders.
12. Hydraulic Fan Motor
13. Hydraulic Oil Cooler
14. Transmission Thermal Valve.
15. Brake Valve.
16. Service Brakes.
17. Hydraulic Reservoir Return Manifold.
18. Return Filter.
19. Breather.
20. Hydraulic Reservoir.
21. Suction Strainer.
22. Fan Drive Controller.
23. Bin Control Valve.
24. Fan Drive Valve.
25. Hydraulic System Manifold.
26. Secondary Steering Pressure Switch, SP1.
27. Check Valve Manifold.
28. Main Hydraulic Pump.
29. Supply Oil
30. Secondary Supply Oil.
31. Load Sense Oil.
32. Trapped Oil.
33. Return Oil.
34. Hydraulic System Schematic - B35D.

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1. Secondary Steering Pump.
2. Transfer Case.
3. Anti-Cavitation Valve.
4. Steering Valve.
5. Steering Cylinders.
6. Test Port Manifold Valve.
7. Brake Low Pressure Switch, S4.
8. Front Brake Accumulators.
9. .Rear Brake Accumulators
10. Brake Accumulator, A4.
11. Bin Tip Cylinders.
12. Hydraulic Fan Motor.
13. Hydraulic Oil Cooler.
14. Wet Disk Brake Thermal Valve.
15. Transmission Thermal Valve.
16. Brake Valve.
17. Service Brakes.
18. Wet Disk Brake Cooling Pumps.
19. Cooler.
20. Breather.
21. Filter.
22. Hydraulic Reservoir.
23. Hydraulic Reservoir Return Manifold.
24. Return Filter.
25. Breather.
26. Hydraulic Reservoir.
27. Suction Strainer.
28. Fan Drive Controller.
29. Bin Control Valve
30. Fan Drive Valve
31. Hydraulic System Manifold.
32. Secondary Steering Pressure Switch, SP1.
33. Check Valve Manifold.
34. Main Hydraulic Pump.
35. Supply Oil.
36. Secondary Supply Oil.
37. Load Sense Oil.
38. Trapped Oil.
39. Return Oil.
40. Hydraulic System Schematic - 400D.

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# CHAPTER 6. HYDRAULIC SYSTEM

## SECTION 2. DIAGNOSTIC INFORMATION

### DIAGNOSTIC PROCEDURE

Follow the six basic steps below to carry out troubleshooting efficiently.

#### Know the system.

Study the machine technical manual. Understand the system and circuits.

Use schematics, component location drawings, and theory of operation for each circuit and circuit components to better understand how the system, circuits, and components work.

#### Ask the operator.

What type of work was the machine doing when the trouble was noticed?

Did the trouble start suddenly or has it been getting worse?

Did the machine have any previous problems? If so, which parts were repaired?

#### Inspect the machine.

Check all daily maintenance points. **(See CHAPTER 12 in the OMM).** Check batteries, battery disconnect switch, circuit breakers, fuses, and electrical connections.

#### Perform Operational Check-out.

Check all systems and functions on the machine. Use the helpful diagnostic information in the check-out to pinpoint the possible cause of the problem.

#### Perform troubleshooting.

Connect the laptop computer with diagnostic software, if available. The self-diagnosing function lists any service codes.

Before starting any troubleshooting, first check battery voltage, battery disconnect switch, fuses, and circuit breakers.

Go to test groups to check pressures and voltages. Make sure adjustments are correct.

#### Trace a cause.

Before reaching a conclusion, check the most probable and simplest to verify.

Use the symptom, problem, solution charts to help identify probable problem components.

Make a plan for appropriate repair to avoid other malfunctions.

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## DIAGNOSE HYDRAULIC SYSTEM MALFUNCTIONS

**NOTE:Diagnose system malfunction charts are arranged from most probable and simplest to verify. Remember the following steps when troubleshooting a problem:**
**Step 1. Operational Check-out Procedure (See "OPERATIONALCHECK-OUT" on page 1).**
**Step 2. Diagnose System Malfunction Charts in this group.**
**Step 3. Tests (See "SECTION 3. TESTS" on page 391).**

### Hydraulic System Malfunctions

| Symptom | Problem | Solution |
|---|---|---|
| No Hydraulic Functions | Low or no oil. | Check oil level in hydraulic reservoir. Add hydraulic oil. **(See CHAPTER 1 in the OMM for oil specifications and quantities).** |
| | Pump suction strainer restricted. | Clean pump Suction Strainer. **(See CHAPTER 14, SECTION 1 in the Repair Manual).** |
| All Hydraulic Functions Slow | Oil level low. | Check oil level in hydraulic reservoir. Add hydraulic oil. **(See CHAPTER 1 in the OMM for oil specifications and quantities).** |
| | Wrong oil in system. | Wrong oil in system. Use recommended hydraulic oil. **(See CHAPTER 1 in the OMM for oil specifications and quantities).** |
| | Engine speed too slow. | Check engine Slow and Fast Idle Adjustment. **(See "SLOW AND FAST IDLE ADJUSTMENT" on page 49)** |
| | Cold hydraulic oil. | Do Hydraulic System Warm-up**. (See Hydraulic Warm-Up Procedure in this group).** |
| | Air leak in pump suction line. | Check for air bubbles in oil. Tighten clamps, replace "O"-rings as necessary. |

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| Symptom | Problem | Solution |
|---|---|---|
| All Hydraulic Functions Slow | Pump suction strainer restricted. | Clean pump suction strainer **(See CHAPTER 14, SECTION 1 in the Repair Manual)**. |
| | Residual valve pressure setting too low or malfunctioning. | Check residual valve pressure setting. Do Main Hydraulic Pump Residual and Compensator Valves Test and Adjustment **(See CHAPTER 6, SECTION 3)**. |
| | | Inspect Residual Valve **(See Main Hydraulic Pump CHAPTER 14, SECTION 1 in the Repair Manual)**. |
| | Compensator valve pressure setting too low or malfunctioning. | Check compensator valve pressure setting. Do Main Hydraulic Pump Residual and Compensator Valves Test and Adjustment **(See CHAPTER 6, SECTION 3)**. |
| | | Inspect Compensator Valve **(See Main Hydraulic Pump CHAPTER 14, SECTION 1 in the Repair Manual)**. |
| | System relief valve pressure too low or malfunctioning. | Check system relief valve pressure setting (not adjustable). Do System Relief Valve and Bin Raise Circuit Relief Valve Test **(See CHAPTER 6, SECTION 3)**. |
| | | Inspect System Relief Valve **(See Hydraulic System Manifold Assembly, CHAPTER 14, SECTION 1 in the Repair Manual)**. |
| | Main hydraulic pump worn. | Check cycle times. Do Cycle time Test **(See CHAPTER 6, SECTION 3)** |

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| Symptom | Problem | Solution |
|---|---|---|
| Hydraulic Oil Overheats. | Oil level too low. | Check oil level in hydraulic reservoir. Add hydraulic oil **(See CHAPTER 1 in OMM for specifications and oil quantities)**. |
| | Wrong oil in system. | Use recommended hydraulic oil. **(See CHAPTER 1 in OMM for specifications and oil quantities)**. |
| | Return filter plugged. | Replace Hydraulic System Oil Return Filter **(See CHAPTER 16, SECTION 1 in the OMM)**. |
| | System relief valve. | Check system relief valve pressure setting (Not adjustable). Do System Relief Valve and Bin Raise Circuit Relief Valve Test **(See CHAPTER 6, SECTION 3).** |
| | | Inspect System Relief Valve **(See Hydraulic System Manifold Assembly, CHAPTER 14, SECTION 1 in the Repair Manual).** |
| | Main hydraulic pump compensator valve setting too high. | Check compensator valve pressure setting. Do Main Hydraulic Pump Residual and Compensator Valves Test and Adjustment **(See CHAPTER 6, SECTION 3)**. |
| | Brake accumulator charge valve pressure setting too high. | Check brake accumulator charge valve pressure setting. Do Brake Accumulator Charge Valve Test and Adjustment. **(See CHAPTER 6, SECTION 3)**. |
| | Cylinder leakage. | Check cylinders for hot spot indicating oil bypassing piston. **(See steering Cylinder CHAPTER 8, SECTION 2 and Body Lift Cylinder, CHAPTER 16, SECTION 2 in the Repair Manual)**. |
| | Main hydraulic pump stuck at maximum displacement. | Disassemble and inspect main hydraulic pump. **(See CHAPTER 14, SECTION 1)**. |
| | Main hydraulic pump worn. | Check using cycle times. do Cycle Time Test. **(See CHAPTER 6, SECTION 3)**. |

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| Symptom | Problem | Solution |
|---|---|---|
| Main Hydraulic Pump Noisy. | Oil level low. | Check oil level in hydraulic reservoir. Add hydraulic oil **(See CHAPTER 1 in OMM for specifications and oil quantities)**. |
| | Wrong oil in system. | Use recommended hydraulic oil. **(See CHAPTER 1 in OMM for specifications and oil quantities)**. |
| | Pump suction strainer restricted. | Clean pump suction strainer **(See CHAPTER 14, SECTION 1 in the Repair Manual)**. |
| | Air leak in pump suction line. | Check for air bubbles in oil. Tighten clamps, replace “O”-rings as necessary. |
| | Main hydraulic pump drive shaft oil seal. | Check oil seal. **(See Main hydraulic Pump, CHAPTER 14, SECTION 1)**. |
| Bin Will Not Rise. | Main hydraulic pump compensator valve setting too low. | Check compensator valve pressure setting. Do Main Hydraulic Pump Residual and Compensator Valves Test and Adjustment **(See CHAPTER 6, SECTION 3)**. |
| | System relief valve. | Check system relief valve pressure setting (Not adjustable). Do System Relief Valve and Bin Raise Circuit Relief Valve Test **(See CHAPTER 6, SECTION 3).** |
| | | If pressure is low, replace system relief valve. If pressure is still low, replace bin raise circuit relief valve. **(See Hydraulic System Manifold Assembly, CHAPTER 14, SECTION 1 in the Repair Manual)**. |
| Hydraulic Fan Motor Not Working. | Fan drive solenoid valve. | Check fan drive solenoid valve. **See “Fan Drive System Operation” on page 362** |
| | | Do Component Checks. **(See “SECTION 3. REFERENCES” on page 97.)** |
| | Fan drive controller. | Check fan drive controller. **Do “FAN DRIVE CONTROLLER TEST AND ADJUSTMENT” on page 403.** |

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## Service Brake System Malfuntion

| Symptom | Problem | Solution |
|---|---|---|
| Poor or no Service Brakes. | Service brake pedal. | Check brake pedal for obstructions around and under pedal. Check that the pedal can be pushed down to the end of its stroke and returns to released position. |
| | Service brake calliper pads. | Check service brake calliper pads for wear. Replace worn pads. **(See Remove and Install Brake Pads CHAPTER 9, SECTION 1 in the Repair Manual).** |
| | Service brake calliper piston seals. | Check for leakage at brake calliper piston. Replace seals. **(See Remove and Install Service Brake Caliper CHAPTER 9, SECTION 1 in the Repair Manual).** |
| | Air in system. | Check for foamy oil. Tighten loose fitting. Replace damaged lines and “O”-rings. Bleed Service Brake Hydraulic System. **(See CHAPTER 9, SECTION 2 in the Repair Manual)**. |
| | Low or no oil pressure. | Check brake accumulator pressure reducing valve and brake accumulator charge valve. **(See Accumulator Pressure Reducing Valve Test and Adjustment and Brake Accumulator Charge Valve Test and Adjustment, CHAPTER 6, SECTION 3)**. |
| Service Brake Pads Wearing Excessively. | Driving technique - constantly using service brakes to slow the machine. | Allow the exhaust brake to slow the machine. |
| | Exhaust brake. | Check exhaust brake operation. |
| | Service brake valve. | Spools sticking or binding in valve housing. Repair or replace brake valve **(See CHAPTER 9, SECTION 2 in the Repair Manual).** |
| | Restriction in service brake valve return lines. | Check return lines for restriction. |

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| Symptom | Problem | Solution |
|---|---|---|
| Time Between Brake Accumulator Charging Cycles Too Short | Brake accumulators. | Gas charge in brake accumulators too low. Check accumulator operation. **Do "BRAKE LOW PRESSURE SWITCH AND BRAKE ACCUMULATOR TEST" on page 398, "BRAKE ACCUMULATOR CHARGE VALVE TEST AND ADJUSTMENT" on page 397 and "FRONT AND REAR BRAKE ACCUMULATORS PRESSURE TEST AND CHARGE PROCEDURE" on page 399.** |
| Wet Disk Brake Cooling Oil Overheats - B40D | Oil level low. | Check oil level in wet disk brake reservoir. Add oil. **(See CHAPTER 1 in the OMM for correct oil and qty's.)** |
| | Wrong oil in system. | Use recommended wet disk brake cooling oil. **(See CHAPTER 1 in the OMM for correct oil and qty's.)** |
| | Hydraulic fan motor not turning at proper speed. | Check fan drive circuit. **Do "FAN DRIVE CONTROLLER TEST AND ADJUSTMENT" on page 403 and "WET DISK BRAKE THERMAL VALVE TEST" on page 403.** |
| | Oil cooler air flow blocked. | Check air flow through oil cooler. Clean oil cooler. |
| | Return filter plugged. | Wet Disk Brake Cooling Oil Filter Restriction Test. **(See "WET DISK BRAKE COOLING OIL FILTER RESTRICTION TEST" on page 405).** |
| | Oil cooler(s) plugged. | Check cooler(s) for restriction. **Do "WET DISK BRAKE COOLER RESTRICTION TEST" on page 404.** |
| | Low cooling circuit pressure. | Check cooling pump relief valve. **Do "WET DISK BRAKE COOLING SYSTEM BYPASS CHECK VALVE TEST" on page 404.** |

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| Symptom | Problem | Solution |
|---|---|---|
| Wet Disk Brake Cooling Oil Overheats - B40D (Continue) | Cooling pump(s) worn. | Test pumps, replace as necessary. **Do “WET DISK BRAKE COOLING SYSTEM BYPASS CHECK VALVE TEST” on page 404.**<br>**See Wet Disk Brake Cooling Oil PumpsCHAPTER 9, SECTION 2 in Repair Manual.** |
| | Wet disk brake disks. | Check wet disk brake disks for wear. Replace worn disks. **See Service Brakes - 400DCHAPTER 9, SeECTION 1 in Repair Manual.** |

## Steering System Malfunctions

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| Symptom | Problem | Solution |
|---|---|---|
| Slow or No Steering Function | Articulation locking bar installed. | Disconnect articulation locking bar and place in storage position. |
| | Oil level low. | Check hydraulic oil level. Add hydraulic oil. **(See CHAPTER 1 in the OMM for recommended oils).** |
| | Steering load sense relief valve pressure setting too low or malfunctioning. | Check steering load sense relief valve pressure. **Do "STEERING RELIEF VALVE PRESSURE TEST AND ADJUSTMENT" on page 400.** |
| | | Inspect steering load sense relief valve. **(See hydraulic System Manifold Assembly CHAPTER 14, SECTION 1 in the Repair Manual).** |
| | Steering lines damaged. | Inspect and replace lines. **(See "HYDRAULIC SYSTEM COMPONENT LOCATION" on page 384.** |
| | Priority valve in hydraulic system manifold. | Check priority valve operation. Do Priority Valve Test. **(See CHAPTER 6, SECTION 3).** |
| | | Remove priority valve and inspect. **(See Hydraulic System Manifold Assembly CHAPTER 14, SECTION 1 in Repair manual).** |
| | Steering valve. | Check steering cylinder for leakage. **Do "HYDRAULIC SYSTEM COMPONENT LOCATION" on page 384.** |
| | Steering cylinders piston seals. | Check steering cylinder for leakage. **Do "STEERING CYLINDER LEAKAGE TEST" on page 401.** |
| | | Replace piston seals as needed. **(See Steering Cylinder CHAPTER 8, SECTION 2 in the Repair Manual).** |
| Constant Steering to Maintain Straight Travel. | Air in steering system. | Check for foamy oil. Tighten loose fittings. Replace damaged lines. **(See "HYDRAULIC SYSTEM COMPONENT LOCATION" on page 384).** |

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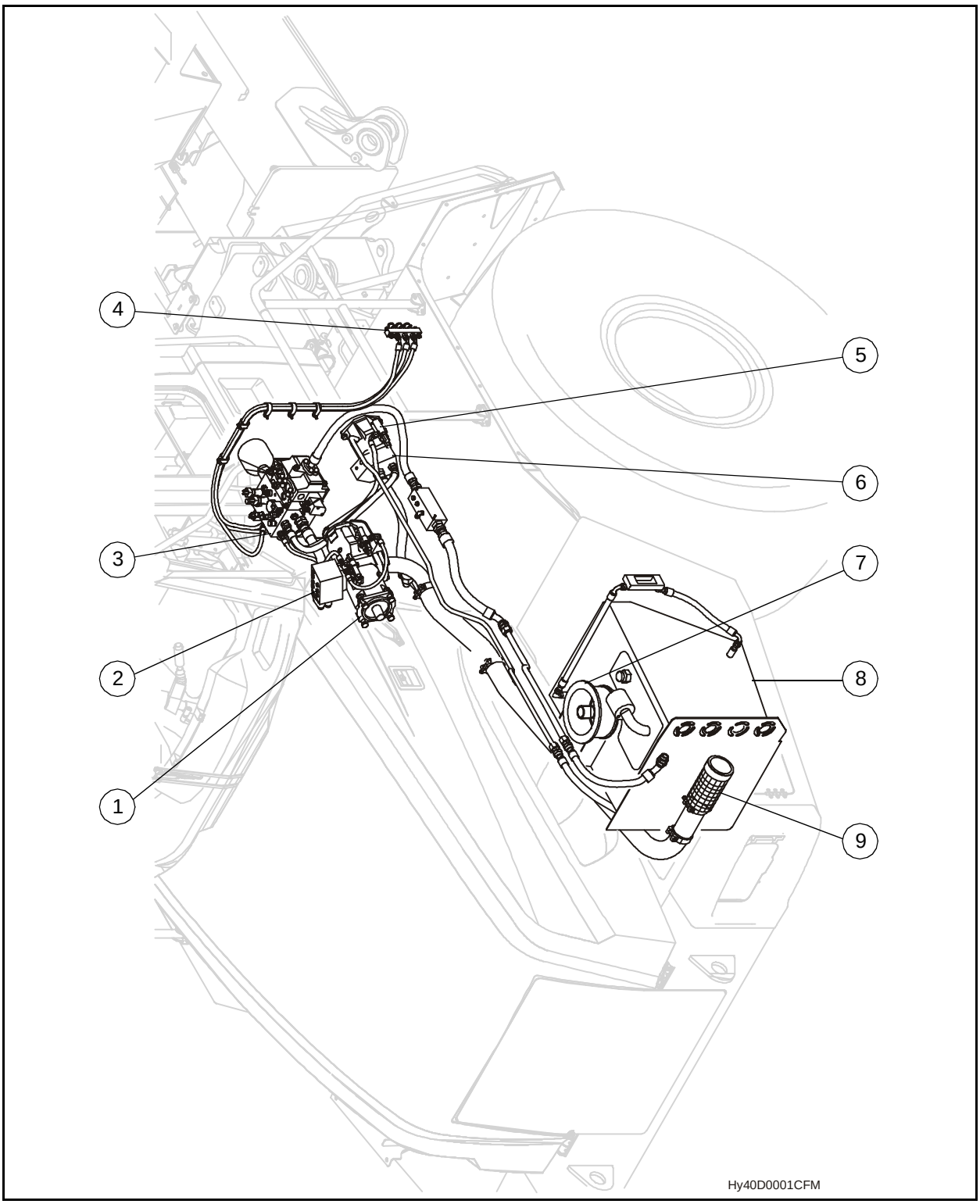
| Symptom | Problem | Solution |
|---|---|---|
| Constant Steering to Maintain Straight Travel. (Continues). | Steering cylinder piston seals. | Check steering cylinders for leakage. **Do "HYDRAULIC SYSTEM COMPONENT LOCATION (Continues)" on page 387.** |
| | | Replace piston seals as needed. **(See Steering Cylinder CHAPTER 8, SECTION 2 in Repair Manual)**. |
| | Steering valve. | Disassemble steering valve and inspect. **(See Steering Valve CHAPTER 8, SECTION 2 in Repair Manual)**. |
| Erratic Steering. | Air in steering system. | Check for foamy oil. Tighten loose fittings. Replace damaged lines. **(See "HYDRAULIC SYSTEM COMPONENT LOCATION" on page 384).** |
| | Oil level low. | Check hydraulic oil level. Add hydraulic oil. **(See CHAPTER 1 in the OMM for recommended oils).** |
| | Cylinder piston loose. | Disassembly cylinder and inspect. **(See Steering Cylinder CHAPTER 8, SECTION 2 in Repair Manual)**. |
| | Steering valve. | Disassemble steering valve and inspect. **(See Steering Valve CHAPTER 8, SECTION 2 in Repair Manual)**. |
| Spongy or Soft Steering. | Air in steering system. | Check for foamy oil. Tighten loose fittings. Replace damaged lines. **(See "HYDRAULIC SYSTEM COMPONENT LOCATION (Continues)" on page 385).** |
| | Oil level low. | Check hydraulic oil level. Add hydraulic oil. **(See CHAPTER 1 in the OMM for recommended oils).** |
| Free Play at Steering Wheel. | Steering wheel-to-shaft nut loose. | Tighten nut. |
| | Splines on steering shaft or valve worn or damaged. | Inspect and replace worn or damaged parts. **(See Steering Valve CHAPTER 8, SECTION 2 in Repair Manual).** |

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| Symptom | Problem | Solution |
|---|---|---|
| Steering Locks Up. | Large particles of contamination in steering valve. | Inspect return filters for contamination. Repair cause of contamination. Replace Hydraulic System Oil Return Filter. **(See CHAPTER 16, SECTION 1 in the OMM).**<br><br>Flush hydraulic system. **(See "HYDRAULIC OIL CLEANUP PROCEDURE USING PORTABLE FILTER CADDY" on page 391).**<br><br>Disassemble steering valve and inspect. **(See Steering Valve CHAPTER 8, SECTION 2 in Repair Manual)**. |
| Abrupt Steering Wheel Oscillation. | Steering valve gerotor not limited correctly. | Time gerotor gear. **(See Steering Valve CHAPTER 8, SECTION 2 in Repair Manual).** |
| Steering Wheel Turns by Itself. | Lines connected to wrong ports. | Connect lines to correct ports. (**See "Hydraulic System Schematics" on page 368).** |
| Machine Turns in Opposite Direction. | Lines to steering cylinders connected to wrong ports at steering valve. | Connect lines to correct ports. (**See "Hydraulic System Schematics" on page 368).** |
| Machine Turns When Steering Valve is in Neutral. | Steering valve leakage. | Disassemble steering valve and inspect. **(See Steering Valve CHAPTER 8, SECTION 2 in Repair Manual)**. |

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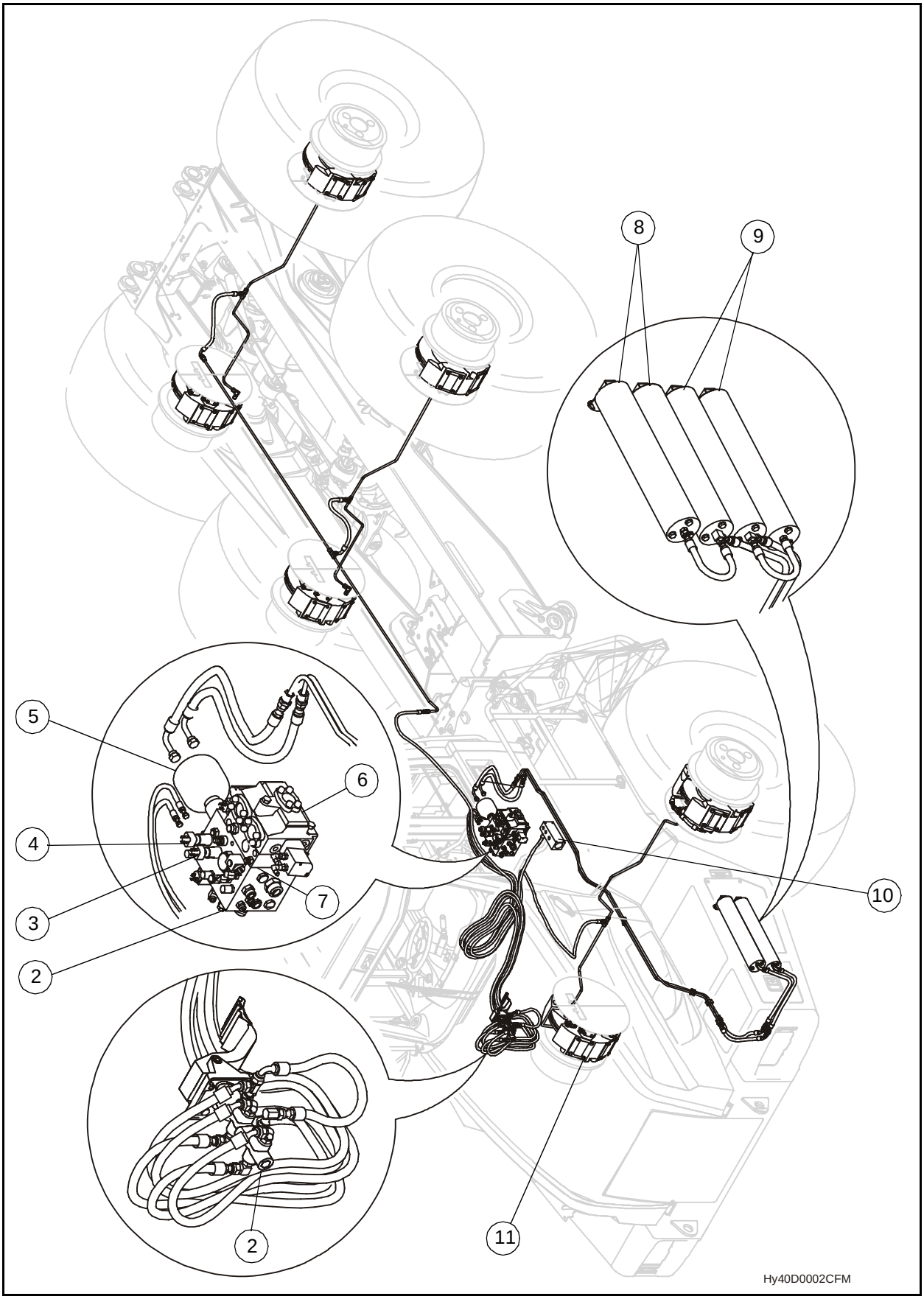
## HYDRAULIC SYSTEM COMPONENT LOCATION




1. Main Hydraulic Pump.
2. Check Valve Manifold.
3. Hydraulic System Manifold.
4. Test Port Manifold.
5. Secondary Steering Pump.
6. Anti-Cavitation Valve.
7. Return Filter.
8. Hydraulic Reservoir.
9. Suction Strainer.

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## HYDRAULIC SYSTEM COMPONENT LOCATION (Continues)

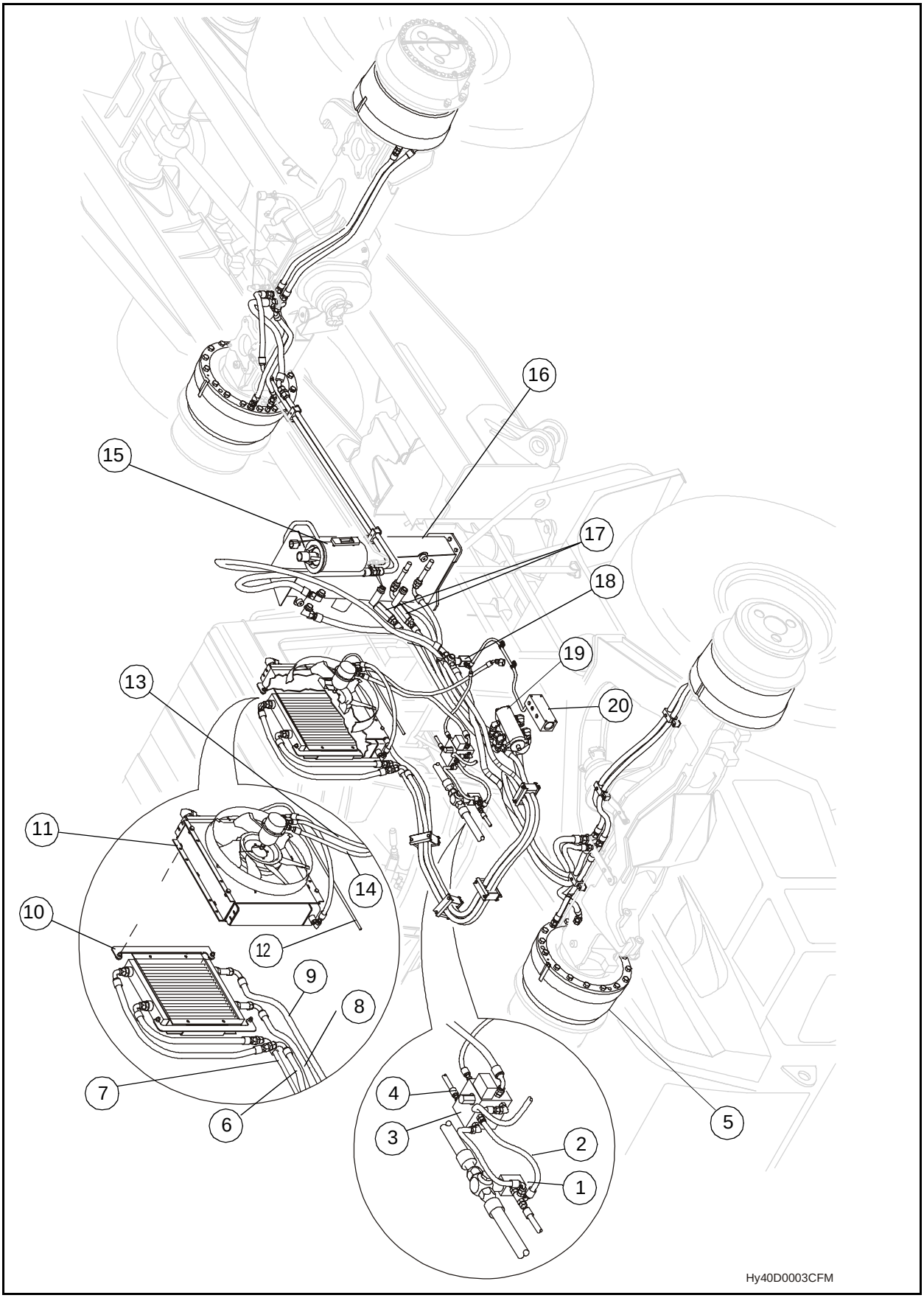


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1. Brake Valve.
2. Hydraulic System Manifold.
3. Secondary Steering Pressure Switch.
4. Brake Low Pressure Switch.
5. Brake Accumulator.
6. bin Control Valve.
7. Fan Drive Valve.
8. Rear Brake Accumulators (B40D 2 off; B35D 1 off).
9. Front Brake Accumulators (B40D 2 off; B35D 1 off).
10. Hydraulic Reservoir Return Manifold.
11. Brake Calliper (B35D).

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## HYDRAULIC SYSTEM COMPONENT LOCATION (Continues)

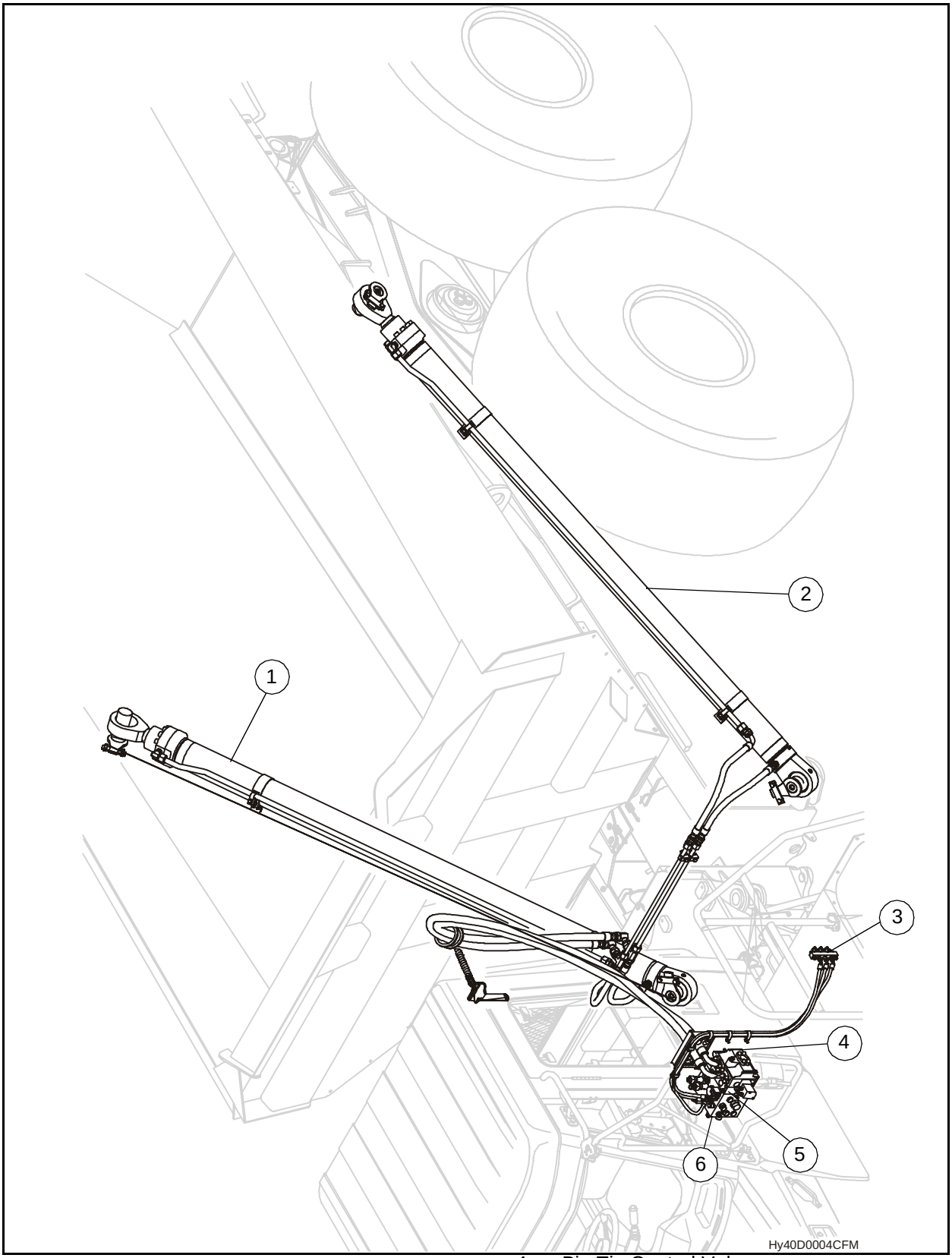


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1 Transmission Thermal Valve.
2 Fan Drive Controller Port P-to-Fan Drive Valve FD Port Line.
3 Fan Drive Controller.
4 Fan Drive Controller Port LS-to-Fan Drive Valve LSFD Port Line.
5 Wet Disk Brake Housing (4 used).
6 Wet Disk Brake Oil Cooler Outlet-to-Front Axle Line.
7 Wet Disk Brake Oil Cooler Outlet-to-Rear Axle Line.
8 Wet Disk Brake Oil Cooler Inlet-to-Rear Axle Line.
9 Wet Disk Brake Oil Cooler Inlet-to-Front Axle Line.
10 Wet Disk Brake Oil Cooler.
11 Transmission and Hydraulic Oil Cooler.
12 - Hydraulic Oil Cooler-to-Hydraulic Reservoir Return Manifold Line.
13 Fan Drive Controller Port A1-to-Hydraulic Fan Motor Port A Line.
14 Hydraulic Fan Motor Port T-to-Hydraulic Reservoir Line.
15 Wet Disk Brake Cooling Oil Return Filter.
16 Wet Disk Brake Cooling Oil Reservoir.
17 Wet Disk Brake Cooling System Bypass Check Valve (2 used).
18 Wet Disk Brake Thermal Valve.
19 Wet Disk Brake Cooling Pumps.
20 Hydraulic Reservoir Return Manifold.

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## HYDRAULIC SYSTEM COMPONENT LOCATION (Continues)




1 Right Bin Tip Cylinder.
2 Left Bin Tip Cylinder.
3 Test Port Manifold.
4 Bin Tip Control Valve.
5 Fan Drive Valve.
6 Hydraulic System Manifold.

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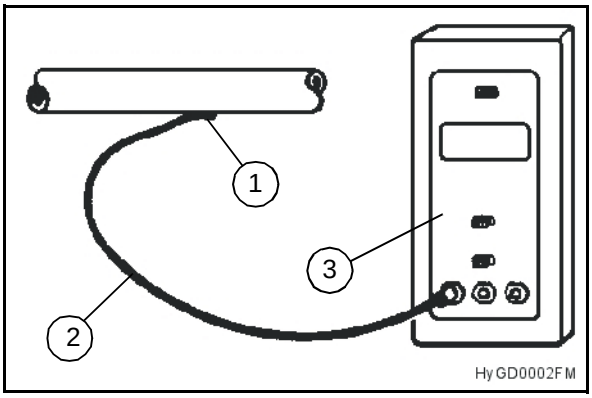
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# CHAPTER6. HYDRAULIC SYSTEM

## SECTION 3. TESTS

### JT05800 DIGITAL THERMOMETER INSTALLATION

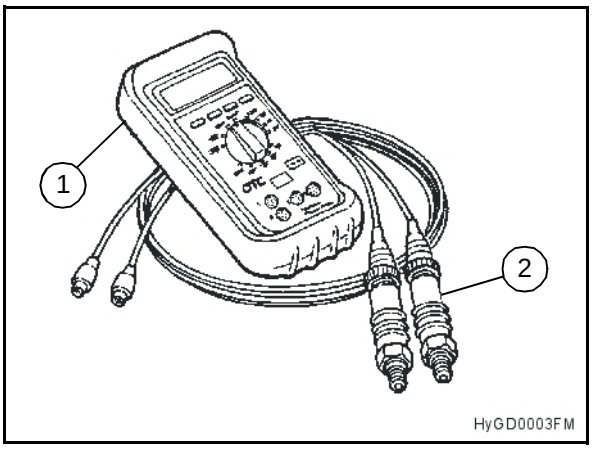



1. Temperature Probe
2. Cable
3. JT05800 Digital Thermometer

Fasten temperature probe (1) to a bare metal hydraulic line using a tie band.

Wrap temperature probe and line with a shop towel.

### JT02156A DIGITAL PRESSURE/ TEMPERATURE ANALYZER INSTALLATION




1. JT02156A Digital Pressure/Temperature Analyser.
2. Transducers.

Use the digital pressure/temperature analyser (1) and transducers (2) in place of analog gauges and a separate temperature reader.

Transducers are temperature sensitive. Allow transducer to warm to system temperature.

After transducer is warmed and no pressure applied, push sensor zero button for one second to set the true zero point.

When using for different pressures, turn selector to **OFF** for two seconds and then to the pressure range. Readings are inaccurate if proper range for transducer is not used.

Transducers:

- • 3400 kPa (35 bar) (500 psi)
- • 34 000 kPa (350 bar) (5000 psi)
- • 70 000 kPa (700 bar) (10,000 psi) Install cranking device DC280088.

### HYDRAULIC OIL CLEANUP PROCEDURE USING PORTABLE FILTER CADDY

#### Specifications

Hydraulic Reservoir Capacity - - - - -185 L (49 USGAL)

Hydraulic Reservoir
Filtering Time- - - - - - - - - - - - 16 minutes approximate.

Hydraulic System Capacity - - - - - -299 L (79 USGAL)

Hydraulic System
Filtering Time- - - - - - - - - - - - 47 minutes approximate.

#### Service Equipment And Tools

Portable Filter Caddy

Two 3658 mm (12 ft) x 3/4 in. ID 100R1 Hoses with 3/4 M NPT Ends

Quick Disconnect Fittings

Suction Wand

Discharge Wand

This procedure must be used to clean complete hydraulic system after any major component failure.

Install new return filter elements.

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**NOTE:1. For a failure that creates a lot of debris, remove access cover from hydraulic reservoir. Drain the hydraulic reservoir. Connect filter caddy suction line to drain port. Add a minimum of 19 L (5 gal) of oil to the hydraulic reservoir. Operate filter caddy and wash out the hydraulic reservoir.**
**2. The minimum ID for a connector is 1/2 in. to prevent cavitation of filter caddy pump.**

Put filter caddy suction and discharge wands into the hydraulic reservoir filler hole so ends are as far apart as possible to obtain a thorough cleaning of oil.

Start the filter caddy. Check to be sure oil is flowing through the filters. Operate filter caddy until all oil in the hydraulic reservoir has been circulated through the filter a minimum of four times.

**NOTE:Filtering time for hydraulic reservoir is 0.089 minute x number of litres (0.33 minutes x number of gallons).**

Leave filter caddy operating for the next step.

Start the engine and run it at specification.

## Specification

Engine - Speed - - - - - - - - - - - - - - - - -2240 ± 20 r.p.m.

**NOTE:For the most effective results, cleaning procedure must start with the smallest capacity circuit then proceed to the next larger capacity circuit.**

Starting with the smallest capacity circuit, operate each function through a complete cycle.

Repeat procedure until the total system capacity has circulated through filter caddy seven times.

Each function must go through a minimum of three complete cycles for a thorough cleaning of oil.

**NOTE:Filtering time for complete hydraulic system is 0.158 minute x number of litres (0.6 minute x number of gallons). Filtering time for machines with auxiliary hydraulic functions must be increased because system capacity is larger.**

Stop engine. Remove filter caddy.

Install new return filter elements.

Check oil level in hydraulic reservoir; add hydraulic oil if necessary. **(See CHAPTER 1 of the OMM for oil specifications and quantities).**

## HYDRAULIC SYSTEM WARM-UP PROCEDURE

## Service Equipment And Tools

JT05800 Digital Thermometer

**NOTE:If machine temperature is below –18°C (0°F), start procedure with engine running at 1/2 speed. Failure to do this could cause pump cavitation. Once oil temperature is above -18°C (0°F) the engine speed can be increased to fast idle.**

Below –18°C (0°F) an extended warm-up period may be necessary. Hydraulic function will move slowly and lubrication of parts may not be adequate with cold oil.

Do not attempt normal machine operation until hydraulic functions move at or close to normal cycle times.

Operate functions slowly and avoid sudden movements until engine and hydraulic oils are thoroughly warmed.

Operate a function by moving it a short distance in each direction. Continue operating the function increasing the distance travelled in each cycle until full stroke is reached.

For faster warm-up, restrict air flow through oil cooler using cardboard or other similar material. Use correct viscosity hydraulic oil to minimize warm-up period. **(See CHAPTER 1 in the OMM for oil specifications.)**

Connect digital thermometer. Install temperature probe on hydraulic reservoir-to-pump inlet line. **See "JT05800 DIGITAL THERMOMETER INSTALLATION" on page 391**.

**⚠ CAUTION**

**Avoid possible serious injury from machine movement during warm-up procedure. Clear the area of all bystanders before doing the warm-up procedure.**

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Clear the area of all bystanders to allow for machine movement.

Start engine. Do not accelerate engine rapidly during warm-up. Run engine at 1/2 speed for approximately 5 minutes before operating any functions.

Engage park brake.

**⚠ CAUTION**

**Holding a function over relief for more than 10 seconds can cause damage to control valve.**

Operate steering and bin raise and lower functions over relief to heat hydraulic system.

Once oil temperature is above –18°C (0°F), increase engine speed to fast idle.

Stop periodically and operate all hydraulic functions to distribute the heated oil.

## CYCLE TIME TEST

## Specifications

Hydraulic Oil Temperature - - - - - 50 ± 5°C (120± 10°F).
Engine Speed - - - - - - - - - - - - - - - - - 2240 ± 20 r.p.m.
bin Raise
(New Pump) Cycle Time - - - - - - - - - - - - - - - - - -13 sec.
bin Lower
(New Pump) Cycle Time - - - - - - - - - - - - - - - - 7 sec.
bin Raise
(Used Pump) Cycle Time - - - - - - - - - - - - - - - - -16 sec.
bin Lower
(Used Pump) Cycle Time - - - - - - - - - - - - - - - - 9 sec.
Engine Speed - - - - - - - - - - - - - - - - - - 600 ± 20 r.p.m.
Steering Wheel
Stop-to-Stop Cycle Time - - - - - - - - - - - - - - - 7—8 sec.
Steering Wheel
Stop-to-Stop - - - - - - - - - - - - - - - - - - - - - - 4.7 Turns

## Service Equipment And Tools

Stop Watch

Test is used as an indication of hydraulic circuit performance. A slow cycle time is an indication of a restriction or leakage in that circuit.

Cycle times are also a general indication of hydraulic pump performance. Always record the average of at least three complete cycle times.

Do Hydraulic System Warm-Up Procedure to heat hydraulic oil to specified temperature. (See procedure in this group.) Use monitor display menu “B 034” to monitor hydraulic oil temperature. See Monitor Display Unit—Menu Function (in Section 2-1 of operators manual).

**⚠ CAUTION**

**Avoid possible serious injury from machine movement. Clear area of all bystanders before performing test. Area must have enough overhead clearance to raise bin to full height of 7226 mm (23 ft. 8.5 in.). Do not perform this test within 4 m (13 ft.) of high voltage power lines.**

Park machine on level ground in the straight ahead position.

### Bin

Select “**N**” (Neutral) on gear shift control and engage park brake.

Operate machine at specification.

Actuate bin control valve to full stroke for each function. Record cycle times.

### Steering

Select “**N**” (Neutral) on gear shift control and disengage park brake.

Operate machine at specification.

Starting with machine turned against the left or right stop, turn steering wheel to opposite stop.

Record the time and number of steering wheel turns stop-to-stop. Repeat several times, in both directions, to verify count.

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# MAIN HYDRAULIC PUMP RESIDUAL AND COMPENSATOR VALVES TEST AND ADJUSTMENT

## Specifications Residual Valve

Hydraulic Oil
Temperature - - - - - - - - - - - - - - - 50 ± 5°C (120± 10°F)

Engine Speed - - - - - - - - - - - - - - - - - 600 ± 20 r.p.m.

First Residual Valve Pressure

- - - - - - - 2800 ± 100 kPa (28 ± 1 bar) (406 ± 14.5 psi)

Second Residual Valve Pressure
- - - - - - - 3000 ± 100 kPa (30 ± 1 bar) (435 ± 14.5 psi)

## Compensator Valve

Hydraulic Oil
Temperature - - - - - - - - - - - - - - - 50 ± 5°C (120± 10°F)

Engine Speed - - - - - - - - - - - - - - - - -1500 ± 20 r.p.m.

First Compensator Valve Pressure - - - - - - - - - - - - - -
- - - - - - - - - - - - - - - - - - - - - - - 25 000—26 000 kPa
- - - - - - - - - - - - - - (250—260 bar) (3625—3770 psi)

Second Compensator Valve Pressure

- - - - - - - - - - - - - - - - - - - - - - - 25 000—26 000 kPa
- - - - - - - - - - - - - - (250—260 bar) (3625—3770 psi)

## Essential Tools

JT03482 High Pressure Test Hose Kit

## Service Equipment And Tools

JT02156A Digital Pressure/Temperature Analyser

The purpose of test is to check the residual valve and compensator valve pressure settings and adjust as necessary.

Residual (low stand-by) pressure is maintained by the pump when no functions are actuated. The compensator valve destrokes the pump at full system pressure, thereby limiting system pressure.

**⚠ CAUTION**

**To perform this test, machine MUST be parked in an area that will allow bin to be raised to full height.**

Install articulation locking bar.

Connect digital pressure/temperature analyser and transducer or a gauge to port MP1 of test port manifold.

## Residual Valve Pressure Setting

Do Hydraulic System Warm-Up Procedure to heat hydraulic oil to specified temperature. **(See "HYDRAULIC SYSTEM WARM-UP PROCEDURE" on page 392.)** Use monitor display menu "B 034" to monitor hydraulic oil temperature. **(See Menu Display Unit - Menu Function in CHAPTER 8 of OMM)**.

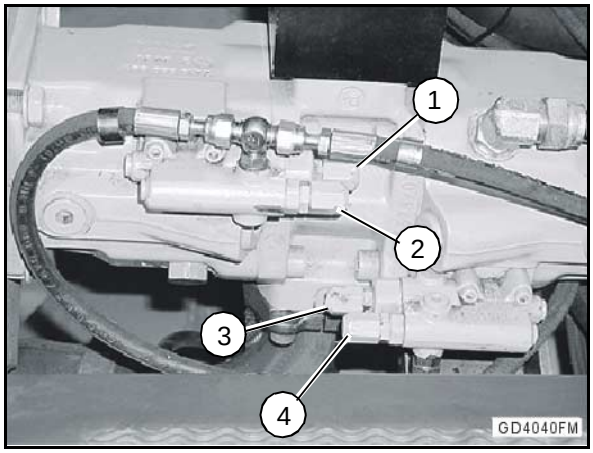
Run engine at specification.

Record pressure reading. Adjust pressure as necessary.

Tilt cab for access to main hydraulic pump. Do Tilt and lower the cab procedure. (**See CHAPTER 7, SECTION 1 in OMM.)**

**⚠ CAUTION**

**Beware of rotating drive shaft when making adjustment on main hydraulic pump. Keep all tools and equipment stored away from openings so they do not fall into the drive shaft. Wear close fitting clothing.**




Remove both residual valve caps, loosen nut, and turn adjusting screws out one full turn.

Adjust first residual valve (4) to specification. Turn adjusting screw in to increase pressure.

Tighten nut and install cap.

Adjust second residual valve (2) to specification.

Tighten nut and install cap.

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## Compensator Valve Pressure Setting

Do Hydraulic System Warm-Up Procedure to heat hydraulic oil to specified temperature. **(See "HYDRAULIC SYSTEM WARM-UP PROCEDURE" on page 392.)** Use monitor display menu "B 034" to monitor hydraulic oil temperature. **(See Menu Display Unit - Menu Function in CHAPTER 8 of OMM)**.

Run engine at specification.

Raise the bin to full height.

Actuate bin raise function over relief.

Record pressure reading. Adjust as necessary.

Remove both compensator valve caps, loosen nut, and turn adjusting screws out one full turn.

Adjust first compensator valve (3) to specification.

Turn adjusting screw in to increase pressure.

Tighten nut and install cap.

**NOTE: Turn second compensator valve adjusting screw in until a slight pressure rise is noticed, then tighten nut.**

Adjust second compensator valve (1) to specification.

Tighten nut and install cap.

# SYSTEM RELIEF VALVE AND BIN RAISE CIRCUIT RELIEF VALVE TEST

## Specifications

Hydraulic Oil Temperature - - - - - 50 ± 5°C (120± 10°F)

Engine Speed - - - - - - - - - - - - - - - - - 1500 ± 20 r.p.m.

System Relief Valve Pressure
- - - - - - - - - - - - - - - - - - - - - - - - - 28 000 + 2000 –0 kPa
- - - - - - - - - - - - (280 + 20 – 0 bar) (4061 + 290 – 0 psi)

Bin Raise Circuit Relief Valve Pressure - - - - - - - - - - -
- - - - - - - - - - - - - - - - - - - - - - - - - 28 000 + 2000 –0 kPa
- - - - - - - - - - - - (280 + 20 – 0 bar) (4061 + 290 – 0 psi)

Main Hydraulic Pump Compensator Valve Pressure - -
- - - - - - - - - - - - - - - - - - - - - - - - - 25 000—26 000 kPa
- - - - - - - - - - - - - - - - (250—260 bar) (3625—3770 psi)

## Essential Tools

JT03482 High Pressure Test Hose Kit.

## Service Equipment And Tools

JT02156A Digital Pressure/Temperature Analyser.

The purpose of this test is to check the pressure settings of the system relief valve and the bin raise circuit relief valve.

System and bin raise circuit relief valves are not adjustable. It will be necessary to replace relief valve(s) if not within specification.

**⚠ CAUTION**

**To perform this test, machine MUST be parked in an area that will allow bin to be raised to full height.**

Install articulation locking bar.

Connect digital pressure/temperature analyser and transducer or a gauge to port MP1 of test port manifold.

Do Hydraulic System Warm-Up Procedure to heat hydraulic oil to specified temperature. **(See "HYDRAULIC SYSTEM WARM-UP PROCEDURE" on page 392.)** Use monitor display menu "B 034" to monitor hydraulic oil temperature. **(See Menu Display Unit - Menu Function in CHAPTER 8 of OMM)**.

Run engine at specification.

Raise the bin to full height.

Actuate bin raise function over relief.

**⚠ CAUTION**

**It is only necessary to adjust one main pump compensator valve for this test. Compensator valve MUST be adjusted to specification after test is complete.**

While monitoring pressure gauge, adjust one main hydraulic pump compensator valve **IN** to increase pressure. The point at which the pressure ceases to increase is the system and bin raise circuit relief valves setting.

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If pressure reading is low, replace system relief and repeat test. If pressure reading is still low replace bin raise circuit relief valve.

Adjust compensator valve to specification. **(See "MAIN HYDRAULIC PUMP RESIDUAL AND COMPENSATOR VALVES TEST AND ADJUSTMENT" on page 394)**.

## PRIORITY VALVE TEST

### Specifications

Hydraulic Oil Temperature - - - - - 50 ± 5°C (120± 10°F)

Engine Speed - - - - - - - - - - - - - - - - - - 600 ± 20 r.p.m.

Main Hydraulic Pump Load Sense Pressure - - - - - - - - - - - - - - - - - - - 1500 kPa (15 bar) (218 psi) minimum

### Essential Tools

JT03482 High Pressure Test Hose Kit

### Service Equipment And Tools

JT02156A Digital Pressure/Temperature Analyser 0—1000 psi Gauge

The purpose of this test is to verify the operation of the priority valve.

Connect digital pressure/temperature analyser and transducer or a gauge to port ML1 of hydraulic system manifold. **(See "Hydraulic System Manifold Operation (Top View)" on page 354)**.

Do Hydraulic System Warm-Up Procedure to heat hydraulic oil to specified temperature. **(See "HYDRAULIC SYSTEM WARM-UP PROCEDURE" on page 392.)** Use monitor display menu "B 034" to monitor hydraulic oil temperature. **(See Menu Display Unit - Menu Function in CHAPTER 8 of OMM)**.

Run engine at specification.

Starting with machine against right or left steering stop, steer machine in opposite direction as fast as the hydraulics will allow.

Read pressure gauge while steering. Pressure should be no less than specification. If pressure is less, replace priority valve. **(See Hydraulic System Manifold Assembly CHAPTER 14, SECTION 1 in the Repair Manual).**

## ACCUMULATOR PRESSURE REDUCING VALVE TEST AND ADJUSTMENT

### Specifications

Hydraulic Oil Temperature - - - - - 50 ± 5°C (120± 10°F)

Engine Speed - - - - - - - - - - - - - - - - - 1000 ± 20 r.p.m.

Accumulator Pressure Reducing Valve Pressure - - - - - - - - - - - - - - - - - - - - - - - - - - - - -18 500—19 500 kPa - - - - - - - - - - - - - - - - (185—195 bar) (2685—2830 psi).

### Essential Tools

JT03482 High Pressure Test Hose Kit

### Service Equipment And Tools

JT02156A Digital Pressure/Temperature Analyser

The purpose of this test is to check the accumulator pressure reducing valve pressure setting and adjust as necessary.

**⚠ CAUTION**

**To avoid injury from escaping fluid under pressure, stop engine and relieve pressure in the system before disconnecting hydraulic lines. Tighten all connections before applying pressure.**

Apply and release brake pedal approximately 35 - 40 times to relieve pressure from system.

Connect digital pressure/temperature analyser and transducer or a gauge to port M4 of test port manifold.

Do Hydraulic System Warm-Up Procedure to heat hydraulic oil to specified temperature. **(See "HYDRAULIC SYSTEM WARM-UP PROCEDURE" on page 392.)** Use monitor display menu "B 034" to monitor hydraulic oil temperature. **(See Menu Display Unit - Menu Function in CHAPTER 8 of OMM)**.

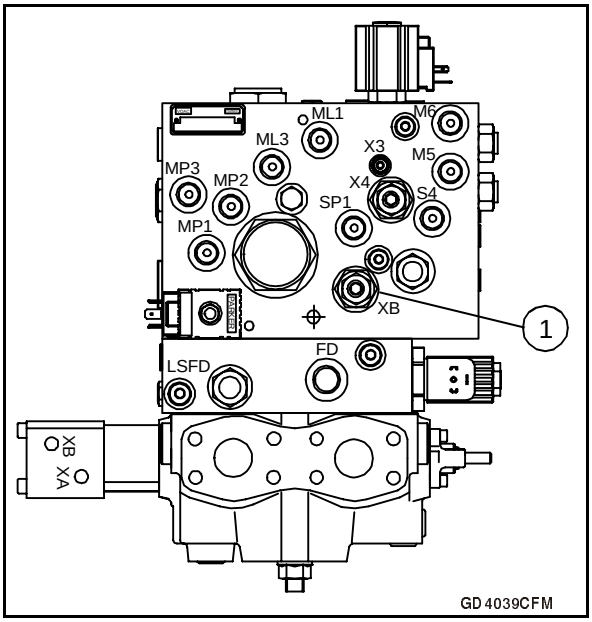
Run engine at specification.

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**⚠ CAUTION**

**Brake accumulators must be completely charged before taking pressure reading.**

Actuate brake pedal repeatedly until main hydraulic pump goes into stroke to charge brake accumulators. Allow accumulators to charge completely.




Actuate bin raise function over relief. Record pressure reading. Adjust accumulator pressure reducing valve XB (1) as necessary.

## BRAKE ACCUMULATOR CHARGE VALVE TEST AND ADJUSTMENT

### Specifications

Hydraulic Oil Temperature - - - - - 50 ± 5°C (120± 10°F)

Engine Speed - - - - - - - - - - - - - - - - - 1000 ± 20 r.p.m.

Accumulator Circuit
Charge Pressure - - - - - - - - - - - - - 16 500—17 500 kPa
- - - - - - - - - - - - - - - - - (165—175 bar) (2393—2538 psi)

### Essential Tools

JT03482 High Pressure Test Hose Kit

### Service Equipment And Tools

JT02156A Digital Pressure/Temperature Analyser

The purpose of this test is to check the brake accumulator charge valve pressure setting and adjust as necessary.

**⚠ CAUTION**

**To avoid injury from escaping fluid under pressure, stop engine and relieve pressure in the system before disconnecting hydraulic lines. Tighten all connections before applying pressure.**

Apply and release brake pedal approximately 35 - 40 times to relieve pressure from system.

Connect digital pressure/temperature analyser and transducer or a gauge to port M4 of test port manifold.

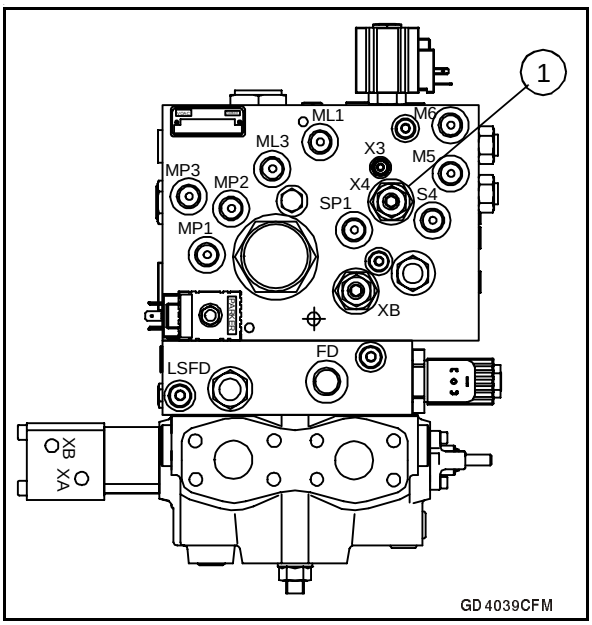
Do Hydraulic System Warm-Up Procedure to heat hydraulic oil to specified temperature. **(See "HYDRAULIC SYSTEM WARM-UP PROCEDURE" on page 392.)** Use monitor display menu "B 034" to monitor hydraulic oil temperature. **(See Menu Display Unit - Menu Function in CHAPTER 8 of OMM)**.

Run engine at specification.

**NOTE: Main hydraulic pump will go into stroke and charge pressure will start to rise at approximately 13 000 kPa (130 bar) (1885 psi). This pressure cannot be adjusted.**

Actuate brake pedal repeatedly until main hydraulic pump goes into stroke to charge brake accumulators

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The pressure will rise until accumulators are fully charged. Take pressure reading at this time. If reading is not to specification, adjust accumulator charge valve X4 (1) as necessary.

Accumulators must be discharged and main hydraulic pump allowed to go to stroke after each adjustment to obtain proper reading.

## BRAKE LOW PRESSURE SWITCH AND BRAKE ACCUMULATOR TEST

### Specifications

Hydraulic Oil Temperature - - - - - 50 ± 5°C (120± 10°F)

Brake Low Pressure Indicator
Light Actuation Pressure - - - - - - 12 300—12 500 kPa
- - - - - - - - - - - - - - - - - 123—125 bar) (1785—1815 psi)

Brake Accumulator Gas
Charge Pressure - - - - - - - - - - - - - - - 8000 ± 350 kPa
- - - - - - - - - - - - - - - - - - (80 ± 3.5 bar) (1160 ± 50 psi)

### Essential Tools

JT03482 High Pressure Test Hose Kit.

### Service Equipment And Tools

JT02156A Digital Pressure/Temperature Analyser.

The purpose of this test is to check operation of brake low pressure switch S4 and to check the gas charge pressure of the brake accumulator in port A4 of hydraulic system manifold.

The brake low pressure switch S4 and the secondary steering pressure switch SP1 are identical and may be exchanged to test either switch.

Connect digital pressure/temperature analyser and transducer or a gauge to port M4 of test port manifold.

Do Hydraulic System Warm-Up Procedure to heat hydraulic oil to specified temperature. **(See "HYDRAULIC SYSTEM WARM-UP PROCEDURE" on page 392.)** Use monitor display menu "B 034" to monitor hydraulic oil temperature. **(See Menu Display Unit - Menu Function in CHAPTER 8 of OMM)**.

Stop engine.

Turn key switch to **ON** position. **DO NOT** start engine.

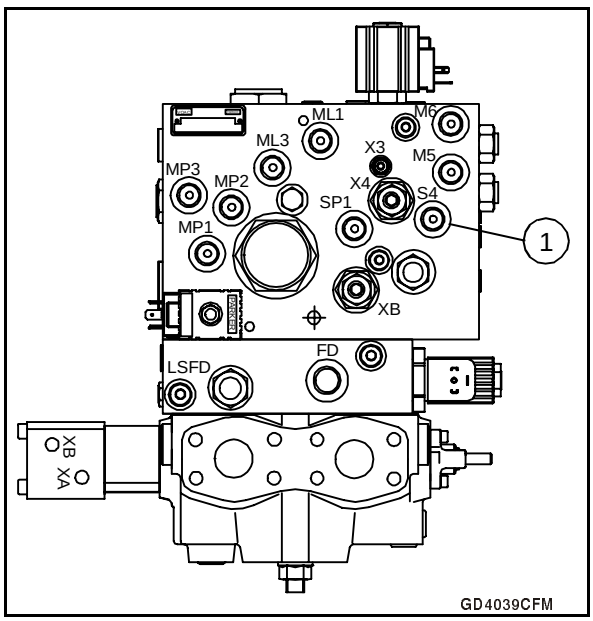
**NOTE: Other indicator lights may be ON or flashing but buzzer does not sound because engine is not running.**

Apply and release brake pedal until brake low pressure indicator light comes **ON**. Record the pressure reading when indicator light comes **ON**.

**NOTE: Brake accumulator is not serviceable.**

Continue applying and releasing brake pedal until the decreasing pressure reading makes a large drop. The point at which pressure drops is the gas charge pressure of brake accumulator in port A4.

If brake accumulator is not to specification, replace accumulator.




If indicator light does not come ON at specification, replace brake low pressure switch S4 (1).

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## FRONT AND REAR BRAKE ACCUMULATORS PRESSURE TEST AND CHARGE PROCEDURE

### Specifications

Accumulator Pre-Charge Pressure
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - 8000 ± 350 kPa
- - - - - - - - - - - - - - - - - - - (80 ± 3.5 bar) (1160 ± 50 psi)

### Essential Tools

JT03522 Charging Adapter

The purpose of this test is to measure pre-charge pressure in each individual front and rear brake accumulator and charge if necessary.

Apply and release brake pedal approximately 35 - 40 times to relieve pressure from system.

Remove accumulator charging valve guard and cap.

**⚠ WARNING**

**USE ONLY dry nitrogen to charge brake accumulators. DO NOT use compressed air or any other gas as they may be combustible or cause oxidation and condensation in the accumulator.**

Connect charging adapter and hose to charging valve of accumulator.

**⚠ CAUTION**

**Loosen outer nut ONLY to open charging valve. DO NOT loosen the inner nut, to do so will remove charging valve fitting. If charging valve fitting is removed with pressure in accumulator, personal injury may result.**

Turn outer nut of charging valve counter clockwise to open. Do not loosen inner nut.

Record accumulator pre-charge pressure. Charge accumulator to specification if necessary.

Apply and release brake pedal approximately 3 - 4 times to relieve any pressure buildup in system.

Turn outer nut of charging valve clockwise to close.

Close nitrogen regulator and remove charging adapter and hose.

Install charging valve cap and guard.

Repeat procedure for each accumulator.

## SERVICE BRAKE VALVE TEST

### Specifications

Hydraulic Oil Temperature - - - - - 50 ± 5°C (120± 10°F)

Engine Speed - - - - - - - - - - - - - - - - - 1000 ± 20 r.p.m.

Full Pedal Travel Pressure
- B**35D** - - - - - - - - - - - - - - - - - - - - 12 000 ± 500 kPa
- - - - - - - - - - - - - - - - - - (120 ± 5 bar) (1740 ± 70 psi)

Full Pedal Travel Pressure
- **B40D** - - - - - - - - - - - - - - - - - - - - 10 000 ± 500 kPa
- - - - - - - - - - - - - - - - - - (100 ± 5 bar) (1450 ± 70 psi)

Pedal Released Pressure - - - - - - - - - - - - - - - - 70 kPa
- - - - - - - - - - - - - - - - - - - - - (0.70 bar) (10 psi) or less

### Essential Tools

38H1031 (–8M x –8M x –8F ORFS)
(Parker No. 8R6LO) Swivel Run Tee

JT03479 (1/2 Male Quick Coupler x –8 F ORFS)
Adapter

### Service Equipment And Tools

JT05412 Pressure Test Kit

JT02156A Digital Pressure/Temperature Analyser

The purpose of this test is to check operation of the brake valve and record brake pressures at full pedal travel and with pedal released.

**⚠ CAUTION**

**Prevent personal injury from unexpected machine movement. Always install articulation locking bar before working in the articulation joint area.**

Install articulation locking bar.

**⚠ CAUTION**

**To avoid injury from escaping fluid under pressure, stop engine and relieve pressure in the system before disconnecting hydraulic lines. Tighten all connections before applying pressure.**

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Apply and release brake pedal approximately 35 - 40 times to relieve pressure from system.

For front axle, disconnect brake line at axle tee fitting. For rear axles, disconnect brake line at articulation joint or axle tee fitting.

Connect digital pressure/temperature analyser and transducer or a gauge to brake line using swivel run tee and adapter.

Do Hydraulic System Warm-Up Procedure to heat hydraulic oil to specified temperature. **(See "HYDRAULIC SYSTEM WARM-UP PROCEDURE" on page 392.)** Use monitor display menu "B 034" to monitor hydraulic oil temperature. **(See Menu Display Unit - Menu Function in CHAPTER 8 of OMM)**.

Run engine at specified speed.

**⚠ CAUTION**

**Brake pressure must decrease to 70 kPa (0.70 bar) (10 psi) or less after brake pedal release to prevent excessive drag which causes premature wear to brake pads and disks.**

While observing pressure reading, slowly depress brake pedal to the end of its travel and then slowly release the pedal.

Record pressure reading at end of pedal travel and after pedal is released.

The pressure must increase gradually and reach specification at full pedal travel and gradually decrease to specification upon pedal release.

If pressure is not to specification with pedal depressed, do **"ACCUMULATOR PRESSURE REDUCING VALVE TEST AND ADJUSTMENT" on page 396 and "BRAKE ACCUMULATOR CHARGE VALVE TEST AND ADJUSTMENT" on page 397.**

If pressure does not increase or decrease gradually as pedal is depressed and released, inspect brake valve. **See Disassemble and Assemble Brake Valve. CHAPTER 9, SECTION 2 in the Repair Manual)**.

## STEERING RELIEF VALVE PRESSURE TEST AND ADJUSTMENT

### Specifications

Hydraulic Oil Temperature - - - - - 50 ± 5°C (120± 10°F)

Engine Speed - - - - - - - - - - - - - - - - - 1500 ± 20 r.p.m.)

Steering Relief Valve Pressure
- - - - - - - - - - - - - - - - 22 000 kPa (220 bar) (3190 psi)

### Essential Tools

JT03482 High Pressure Test Hose Kit

### Service Equipment And Tools

JT02156A Digital Pressure/Temperature Analyser

The purpose of this test is to check the steering relief valve pressure setting and adjust as necessary.

Connect digital pressure/temperature analyser and transducer or a gauge to port MP1 of test port manifold.

Do Hydraulic System Warm-Up Procedure to heat hydraulic oil to specified temperature. **(See "HYDRAULIC SYSTEM WARM-UP PROCEDURE" on page 392.)** Use monitor display menu "B 034" to monitor hydraulic oil temperature. **(See Menu Display Unit - Menu Function in CHAPTER 8 of OMM)**.

Run engine at specification.

Turn machine left or right against steering stop, allowing steering circuit to go over relief. Record pressure reading.

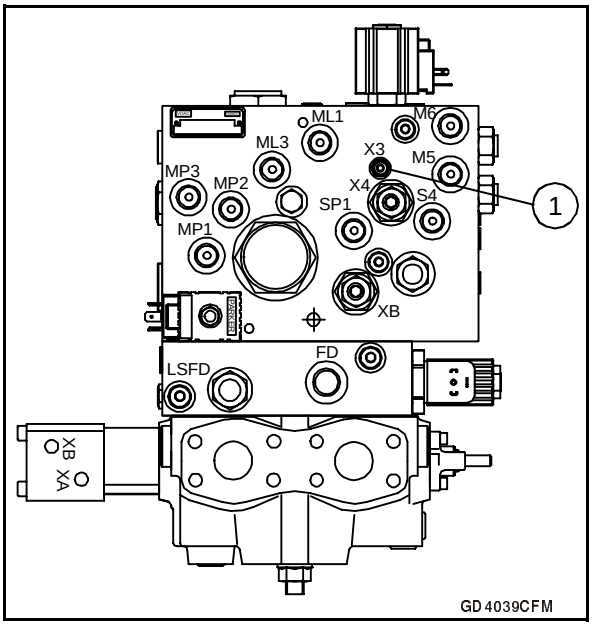
Adjust pressure as necessary.

Tilt cab for access to main hydraulic pump. Do Tilt and lower the cab procedure. (**See CHAPTER 7, SECTION 1 in OMM.)**

**⚠ CAUTION**

**Beware of rotating drive shaft when making adjustment on the hydraulic system manifold. Keep all tools and equipment stored away from openings so they do not fall into the drive shaft. Wear close fitting clothing.**

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Adjust steering relief valve X3 (1) to specification.

## STEERING CYLINDER LEAKAGE TEST

### Specifications

Hydraulic Oil Temperature - - - - - 50 ± 5°C (120± 10°F)

Engine Speed - - - - - - - - - - - - - - - - - 600 ± 20 r.p.m.

Steering Against Stop Time - - - - - - - - - - 20 seconds

Piston Seal Leakage- - - - - - - - 15 mL/min (1/2 oz/min) - - - - - - - - - - - - - - - - - - - - - - - - - - - - - approximate.

The purpose of this test is to measure steering cylinder piston seal leakage.

Do Hydraulic System Warm-Up Procedure to heat hydraulic oil to specified temperature. **(See "HYDRAULIC SYSTEM WARM-UP PROCEDURE" on page 392.)** Use monitor display menu "B 034" to monitor hydraulic oil temperature. **(See Menu Display Unit - Menu Function in CHAPTER 8 of OMM)**.

**NOTE: Check steering cylinder for leakage in fully extend position. In retracted position, piston contacts head end of cylinder, blocking leakage flow across piston seal to head end port.**

Turn machine left or right against steering stop to extend steering cylinder to be checked. Stop engine.

Disconnect line from rod end port of the extended cylinder. Install plug in open line. Place a graduated measuring container under open cylinder port to catch leakage.

Start engine and run at specification.

Turn steering wheel against stop in same direction as machine is turned. Hold against stop for 20 seconds. Record leakage and multiply reading by three (x 3).

If leakage is over specification, inspect Steering Cylinder piston seals. **(See CHAPTER 8, SECTION 2 in the Repair Manual.)**

## SECONDARY STEERING PUMP RESIDUAL AND COMPENSATOR VALVES TEST AND ADJUSTMENT

### Specifications

Hydraulic Oil Temperature - - - - - 50 ± 5°C (120± 10°F)

Engine Speed - - - - - - - - - - - - - - - - - 1500 ± 20 r.p.m.

Residual Valve Pressure - - - - - - - - - -2000 ± 100 kPa - - - - - - - - - - - - - - - - - - - - (20 ± 1 bar) (290 ± 15 psi)

Compensator Valve Pressure - - - - - - - - - - 21 000 kPa - - - - - - - - - - - - - - - - - - - - - - - - (210 bar) (3045 psi)

### Essential Tools

JT03482 High Pressure Test Hose Kit

### Service Equipment And Tools

JT02156A Digital Pressure/Temperature Analyser

The purpose of this test is to check the residual and compensator valve pressure settings and adjust as necessary.

Install articulation locking bar.

**⚠ CAUTION**

**Inter-axle lock MUST be disengaged and transfer case-to-oscillation joint drive shaft MUST be removed to prevent movement of machine while performing this test.**

Apply park brake and put inter-axle lock switch into the disengage position.

Remove Drive Shafts. **(See CHAPTER 2, SECTION 3 in the Repair Manual.)**

Connect digital pressure/temperature analyser and transducer or a gauge to port MP2 of test port manifold.

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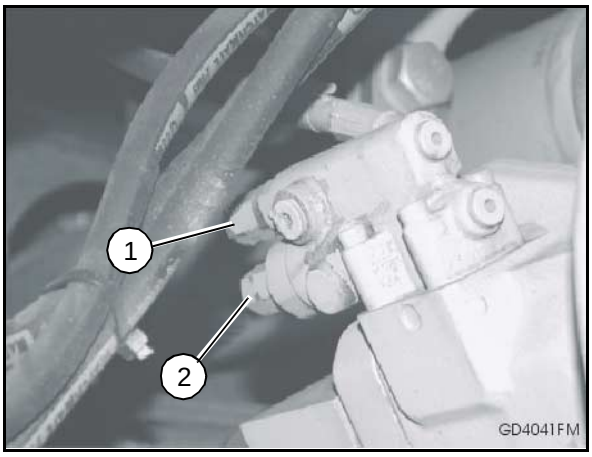
Do Hydraulic System Warm-Up Procedure to heat hydraulic oil to specified temperature. **(See "HYDRAULIC SYSTEM WARM-UP PROCEDURE" on page 392.)** Use monitor display menu "B 034" to monitor hydraulic oil temperature. **(See Menu Display Unit - Menu Function in CHAPTER 8 of OMM)**.

Start machine and shift to "**D**" (forward), range "**1**", and activate "**Range Hold**" function. Run engine at specification.

## Residual Valve Adjustment

### Specification

Residual Valve - Pressure - - - - - - - - - 2000 ± 100 kPa
- - - - - - - - - - - - - - - - - - - - - (20 ± 1 bar) (290 ± 15 psi)




Record pressure reading. Adjust residual valve (1) to specification. Turn adjusting screw in to increase pressure.

Tighten nut and install cap.

## Compensator Valve Adjustment

Turn machine left or right against steering stop, allowing steering circuit to go over relief. Record pressure reading. Adjust compensator valve (2) to specification.

### Specification

Compensator Valve - Pressure - - - - - - - - 21 000 kPa
- - - - - - - - - - - - - - - - - - - - - - - - - 210 bar) (3045 psi)

Tighten nut and install cap.

## BIN LOWER CIRCUIT RELIEF VALVE TEST

### Specifications

Hydraulic Oil Temperature - - - - - 50 ± 5°C (120± 10°F)

Engine Speed - - - - - - - - - - - - - - - - - 1500 ± 20 r.p.m.

Bin Lower Circuit Pressure- - - - - - - 8000 - 10 000 kPa
- - - - - - - - - - - - - - - - - (80 - 100 bar) (1160 - 1450 psi)

### Essential Tools

JT03482 High Pressure Test Hose Kit

### Service Equipment And Tools

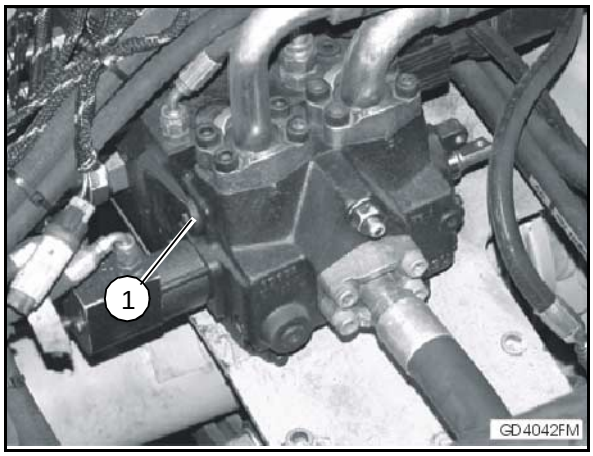
JT02156A Digital Pressure/Temperature Analyser

The purpose of this test is to check that the bin lower circuit relief valve is operating within its specified range.

Connect digital pressure/temperature analyser and transducer or a gauge to port MP1 of test port manifold.

Do Hydraulic System Warm-Up Procedure to heat hydraulic oil to specified temperature. **(See "HYDRAULIC SYSTEM WARM-UP PROCEDURE" on page 392.)** Use monitor display menu "B 034" to monitor hydraulic oil temperature. **(See Menu Display Unit - Menu Function in CHAPTER 8 of OMM)**.

Run engine at specification.




Hold bin tip lever in the lower position until bin lower circuit is over relief. Record pressure reading. Replace bin lower circuit relief valve (1) if pressure reading is not within specification.

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## FAN DRIVE CONTROLLER TEST AND ADJUSTMENT

### Specifications

Hydraulic Oil Temperature - - - - - 50 ± 5°C (120± 10°F)

Engine Speed - - - - - - - - - - - - - - - - - - 600 ± 20 r.p.m.

Load Sense Relief Valve Pressure
- - - - - - - - - - - - - - - - - - - - - - - - - 12 000 - 13 000 kPa
- - - - - - - - - - - - - - - - (120 - 130 bar) (1740 - 1885 psi)

Fan Speed - - - - - - - - - - - - - - - - - - - 2800 ± 50 r.p.m.

### Essential Tools

JT03482 High Pressure Test Hose Kit

38H1414 (-4 F ORFS) Cap

38H1145 (-4 M ORFS) Plug

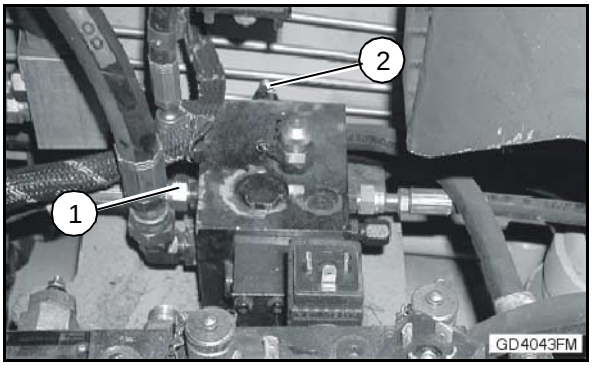
### Service Equipment And Tools

JT02156A Digital Pressure/Temperature Analyser

JT05719 Hand Held Digital Photo Tachometer

The purpose of this test is to check and adjust the pressure setting of the load sense relief valve and check the operation of the pressure reducing valve (not adjustable).

Connect digital pressure/temperature analyser and transducer or a gauge to port M1 of fan drive controller.




Disconnect line from “LS2” port (1) of the fan drive controller. Close line and “LS2” port fitting using a cap and plug.

Do Hydraulic System Warm-Up Procedure to heat hydraulic oil to specified temperature. **(See “HYDRAULIC SYSTEM WARM-UP PROCEDURE” on page 392.)** Use monitor display menu “B 034” to monitor hydraulic oil temperature. **(See Menu Display Unit—Menu Function in CHAPTER 8 of OMM)**.

Start and run engine at specification.

With steering valve in neutral, bin in down position, and **NO** function being used, pressure reading on gauge must be to specification. Adjust load sense relief valve (2) as needed.

Measure and record fan speed using photo tachometer.

Turn machine left or right against steering stop, allowing steering circuit to go over relief. Fan speed must remain the same. If fan speed increases, inspect pressure reducing replace as necessary.

## WET DISK BRAKE THERMAL VALVE TEST

### Specifications

Wet Disk Brake Oil Temperature
- - - - - - - - - - - - - - - - - - - - - 97 - 99 °C (207—210 °F)

Engine Speed - - - - - - - - - - - - - - - - - - 600 ± 20 r.p.m.

Fan Drive Controller Load Sense Pressure
- - - - - - - - - - - - - - - - - - - - - - - - 12 000 - 13 000 kPa
( - - - - - - - - - - - - - - - - 120 - 130 bar) (1740 - 1885 psi)

### Essential Tools

JT03482 High Pressure Test Hose Kit

### Service Equipment And Tools

JT02156A Digital Pressure/Temperature Analyser

The purpose of this test is to verify operation of wet disk brake thermal valve.

**⚠ CAUTION**

**Before performing this test, load sense relief valve must be properly adjusted. See.**

Connect digital pressure/temperature analyser and transducer or a gauge to port M1 of fan drive controller.

Raise bin from frame until hydraulic fan motor stops (approximately 3° - 4°).

Drive machine in first gear forward. Gradually applying service brakes, without bringing machine to a full stop.

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Menu wet disk brake oil temperature (menu "**B 035**") until oil reaches specification. **(See Menu Display Unit—Menu Function in CHAPTER 8 the of OMM)**.

Stop machine, place gear selector in neutral, and lower bin to frame. Run engine at specification.

**⚠ CAUTION**

**To insure correct test results, pressure reading must be taken immediately after stopping machine to insure wet disk brake oil temperature is to test specification.**

Fan drive controller pressure reading must be to specification. If not replace thermal valve. **(See Wet Disk Brake Thermal Valve in CHAPTER 1060, SECTION 1060 in the Repair Manual)**.

## WET DISK BRAKE COOLING SYSTEM BYPASS CHECK VALVE TEST

### Specifications

Wet Disk Brake Cooling Oil Temperature
- - - - - - - - - - - - - - - - - - - - - - - - - 20 ± 5°C (68± 10°F)

Engine Speed - - - - - - - - - - - - - - - - - - - - 600 ± 20 rpm

Wet Disk Brake Cooling Circuit Pressure
- - - - - - - - - - - 80 ± 50 kPa (4.8 ± 0.5 bar) (69 ± 7 psi)

### Essential Tools

Parker No. 12R6X S Swivel Nut Run Tee

Parker No. 12-8F6X S Swivel Connector

Parker No. 1/2X1/4FG S Adapter

### Service Equipment And Tools

JT02156A Digital Pressure/Temperature Analyser

The purpose of this test is to check the pressure setting of the wet disk brake cooling system bypass check valves.

The cooling system is divided into two separate circuits (front axle and rear axle). Perform this procedure for each circuit.

Install a tee fitting on pump side of relief valve to be tested. Connect a digital pressure/temperature analyser and transducer or a gauge to tee fitting using a swivel connector and adapter.

Heat wet disk brake cooling oil to the specified temperature. Use menu display menu "B 035" to monitor wet disk brake oil temperature. **(See Menu Display Unit—Menu Function CHAPTER 8 in the OMM).**

Run engine at specification.

Measure wet disk brake cooling oil pressure. If not to specification, inspect relief valve. Replace as necessary.

## WET DISK BRAKE COOLER RESTRICTION TEST

### Specifications

Wet Disk Brake Cooling Oil Temperature
- - - - - - - - - - - - - - - - - - - - - - - - - 20 ± 5°C (68 ± 10°F)

Engine Speed - - - - - - - - - - - - - - - - - - 2240 ± 20 rpm

Wet Disk Brake Cooler Pressure
- - - - - - - - - - - - - - 160 kPa (1.6 bar) (23 psi)difference

### Essential Tools

Parker No. 12R6X S Swivel Nut Run Tee

Parker No. 12-8F6X S Swivel Connector

Parker No. 1/2X1/4FG S Adapter

### Service Equipment And Tools

JT02156A Digital Pressure/Temperature Analyser

The purpose of this test is to measure the pressure differential between the cooler inlet and cooler outlet.

The higher the pressure differential the higher the restriction in the cooler. Follow this procedure for both wet disk brake coolers.

Install a tee fitting on inlet and outlet of cooler to be tested. Connect a digital pressure/temperature analyser and transducer or a gauge to tee fittings using swivel connectors and adapters.

Heat wet disk brake cooling oil to the specified temperature. Use menu display menu "B 035" to monitor wet disk brake oil temperature. **(See Menu Display Unit - Menu Function CHAPTER 8 in the OMM)**.

Run engine at specification.

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Record pressure readings from both gauges. The pressure difference should be no higher than specification. If pressure is above specification remove and backflush cooler. **(See Wet Disk Brake Cooling Oil Cooler in CHAPTER 9, SECTION 2 in the Repair Manual)**.

## WET DISK BRAKE COOLING OIL FILTER RESTRICTION TEST

### Specifications

Wet Disk Brake Cooling Oil Temperature
- - - - - - - - - - - - - - - - - - - - - - - - - 20 ± 5°C (68 ± 10°F)

Engine Speed - - - - - - - - - - - - - - - - - - 2240 ± 20 rpm

Wet Disk Brake Cooling Oil Filter Restriction Pressure
- - - - - - - - - - - - - - - - -40 kPa (0.4 bar) (6 psi) maximum

### Essential Tools

Parker No. 16R6X S Swivel Nut Run Tee

Parker No. 16-12F6X S Swivel Connector

Parker No. 3/4X1/4FG S Adapter

### Service Equipment And Tools

JT02156A Digital Pressure/Temperature Analyser

The purpose of this test is to measure wet disk brake cooling oil filter restriction pressure.

**NOTE: Gauge may be installed in wet disk brake cooling oil filter inlet line.**

Install a tee fitting at wet disk brake cooling oil filter inlet line. Connect a digital pressure/temperature analyser and transducer or a gauge to tee fitting using a swivel connector and adapter.

Heat wet disk brake cooling oil to the specified temperature. Use monitor display menu “B 035” to monitor wet disk brake oil temperature. **(See Menu Display Unit—Menu Function in CHAPTER 8 in the OMM)**.

Run engine at specification.

Record pressure. Pressure should be at or below specification. If pressure is above specification, replace filter. **(See Replace Wet Disk Brake Cooling Oil Filter - If Equipped in CHAPTER 15,SECTION 2 of OMM)**.

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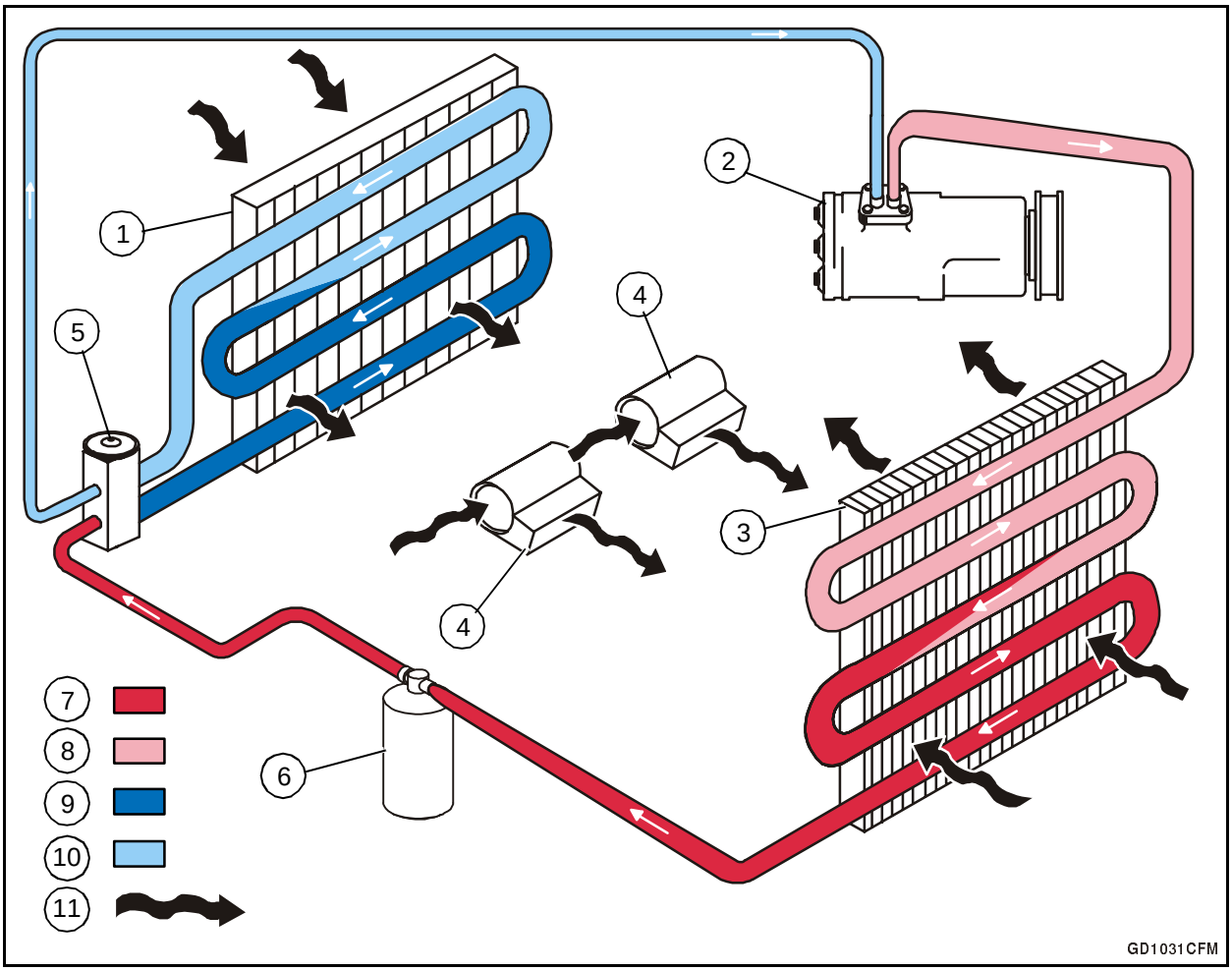
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# CHAPTER 7. HEATING AND AIR CONDITIONING

## SECTION 1. THEORY OF OPERATION

### AIR CONDITIONING SYSTEM CYCLE OF OPERATION




1 Evaporator Core.
2 Compressor.
3 Condenser Core.
4 Circulation Blower Motor.
5 Expansion Valve.
6 Receiver-Dryer.
7 High Pressure Liquid.
8 High Pressure Gas.
9 Low Pressure Liquid.
10 Low Pressure Gas.
11 Air Flow.

The compressor is belt driven and engaged by an electromagnetic clutch. The air conditioning circuit automatically controls compressor engagement or disengagement when system is in operation. **(See "Air Conditioning Circuit Theory of Operation" on page 92.)**

Compressor draws low pressure gas from evaporator and compresses it into high pressure gas. This causes temperature of refrigerant to rise higher than that of outside air.

High pressure gas leaves compressor and flows through condenser where heat is removed and transferred to outside air being drawn through condenser core by engine fan. Cooling refrigerant causes it to condense and refrigerant leaves condenser as high pressure liquid.

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High pressure liquid flows into receiver-dryer where moisture and contaminants (acid, solids, etc.) are removed.

Receiver-dryer contains a colour moisture indicator. Blue indicates no moisture is present. Pink indicates moisture is present.

Should moisture be combined with refrigerant, hydrofluoric and hydrochloric acids are formed. These acids are very corrosive to metal surfaces and leakage will eventually develop.

Receiver-dryer also stores refrigerant allowing a longer period of time before additional refrigerant is needed. Refrigerant hoses allow a small amount of refrigerant to migrate through their walls. Refrigerant flows from receiver-dryer through expansion valve to evaporator.

Expansion valve senses refrigerant temperature and pressure to modulate refrigerant flow. Expansion valve changes refrigerant to low pressure liquid entering evaporator.

Actual cooling and drying of cab air takes place at evaporator. Heat absorbed by evaporator and transferred to refrigerant causes refrigerant to vaporize into low pressure gas.

Low pressure gas is drawn from evaporator by compressor and cycle is repeated. A freeze control switch senses temperature of evaporator coil through a capillary tube.

This prevents the evaporator from becoming cold enough to freeze moisture that condenses on evaporator coil. Condensed moisture is drained away through drain tubes connected to drain pan under evaporator.

System pressure is monitored by high/low pressure switch, located on high pressure side of expansion valve. If pressure becomes too high or too low the switch opens and stops compressor, interrupting the cycle

. Accumulator (if equipped) is located between evaporator and compressor in low pressure gas hose to retain a quantity of oil to protect compressor from a dry start after long periods of not being used. **(See "HEATING/AIR CONDITIONING COMPONENT LOCATION" on page 412).**

## HEATER CORE OPERATION

The heater core is located near evaporator in heating and air conditioning module on right side of cab.

Filtered air flows through evaporator removing moisture before flowing though heater core.

The heater core uses warm engine coolant to heat a mixture of inside cab air as well as outside air pulled across heater core.

Coolant flow through the heater core is regulated by the heater valve. The heater valve is regulated by an actuator which is controlled by the heater valve control module in response to the position of temperature control switch. (**See "HEATING/AIR CONDITIONING COMPONENT LOCATION" on page 412).**

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# CHAPTER 7. HEATING AND AIR CONDITIONING

## SECTION 2. DIAGNOSTIC INFORMATION

## DIAGNOSE AIR CONDITIONING SYSTEM MALFUNCTIONS

**NOTE:Diagnostic charts are arranged from most probable and simplest to verify, to least likely more difficult to verify.**

| Symptom | Problem | Solution |
|---|---|---|
| Air Conditioning System Does Not Operate | A/C - heater blower fuse. | Replace fuse. |
| | Blower motor switch. | Check switch. |
| | A/C - heater **ON/OFF** switch. | Check switch |
| | A/C freeze control switch. | **See "A/C FREEZE CONTROL SWITCH TEST" on page 419.** |
| | A/C high/low pressure switch. | **See "A/C HIGH/LOW PRESSURE SWITCH TEST" on page 419.** |
| | A/C compressor clutch. | **See "A/C COMPRESSOR CLUTCH TEST" on page 419.** |
| | Wiring harness. | Check engine and side console harness wiring. |
| Air Conditioner Does Not Cool Interior of Cab. | Fresh air filter restricted. | Clean or replace filter. |
| | Condenser fins restricted witch debris. | Clean condenser fins. |
| | Re circulating air filter restricted. | Clean or replace filter. |
| | Compressor belt loose. | **See Fan Belt in CHAPTER 5, SECTION 1 in the Repair Manual.** |
| | Refrigerant hose kinked, pinched or collapsed. | Re-route or re-index hoses. Replace collapsed hoses. |
| | Heater or evaporator core fins restricted with dirt or dust. | Clean heater or evaporator core fins. |
| | A/C heater blower motor failed or operating too slowly. | Check blower motor. |
| | | **See "HEATING/AIR CONDITIONING COMPONENT LOCATION" on page 412.** |
| | Compressor clutch slipping or failed. | Inspect and/or replace compressor clutch. |
| | Warm outside air leaking into cab. | Inspect, repair or replace door and rear cab shield. |

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| Symptom | Problem | Solution |
|---|---|---|
| Air Conditioner Does Not Cool Interior of Cab (Continues). | Cab heat deflectors missing or damaged. | Inspect, repair or replace cowl baffle and rear cab shield. |
| | Heater valve remains open. | Inspect, repair, adjust or replace heater valve or cable.<br>**See "HEATING/AIR CONDITIONING COMPONENT LOCATION" on page 412.** |
| | System refrigerant (R134A) charge low. | Do "R134A AIR CONDITIONING SYSTEM TEST" on page 416. |
| | Evaporator fins frosting or freezing. | Freeze control switch capillary tube not positioned correctly in evaporator coil.<br>Do "A/C FREEZE CONTROL SWITCH TEST" on page 419. |
| Air Conditioner Runs Constantly, Too Cold. | Temperature control switch. | Inspect, replace temperature control switch. |
| | Heater valve. | Valve is stuck closed,. Inspect. Replace heater valve. |
| | Freeze control switch, capillary tube not positioned in evaporator properly. | Reposition capillary tube in evaporator coil. |
| | Compressor clutch engaged constantly. | **See "A/C FREEZE CONTROL SWITCH TEST" on page 419.** |
| Interior Windows Continue To Fog. | Fresh air filter restricted. | Clean or replace filter. |
| | A/C system off. | Move A/C - heater ON/OFF switch to A/C position. |

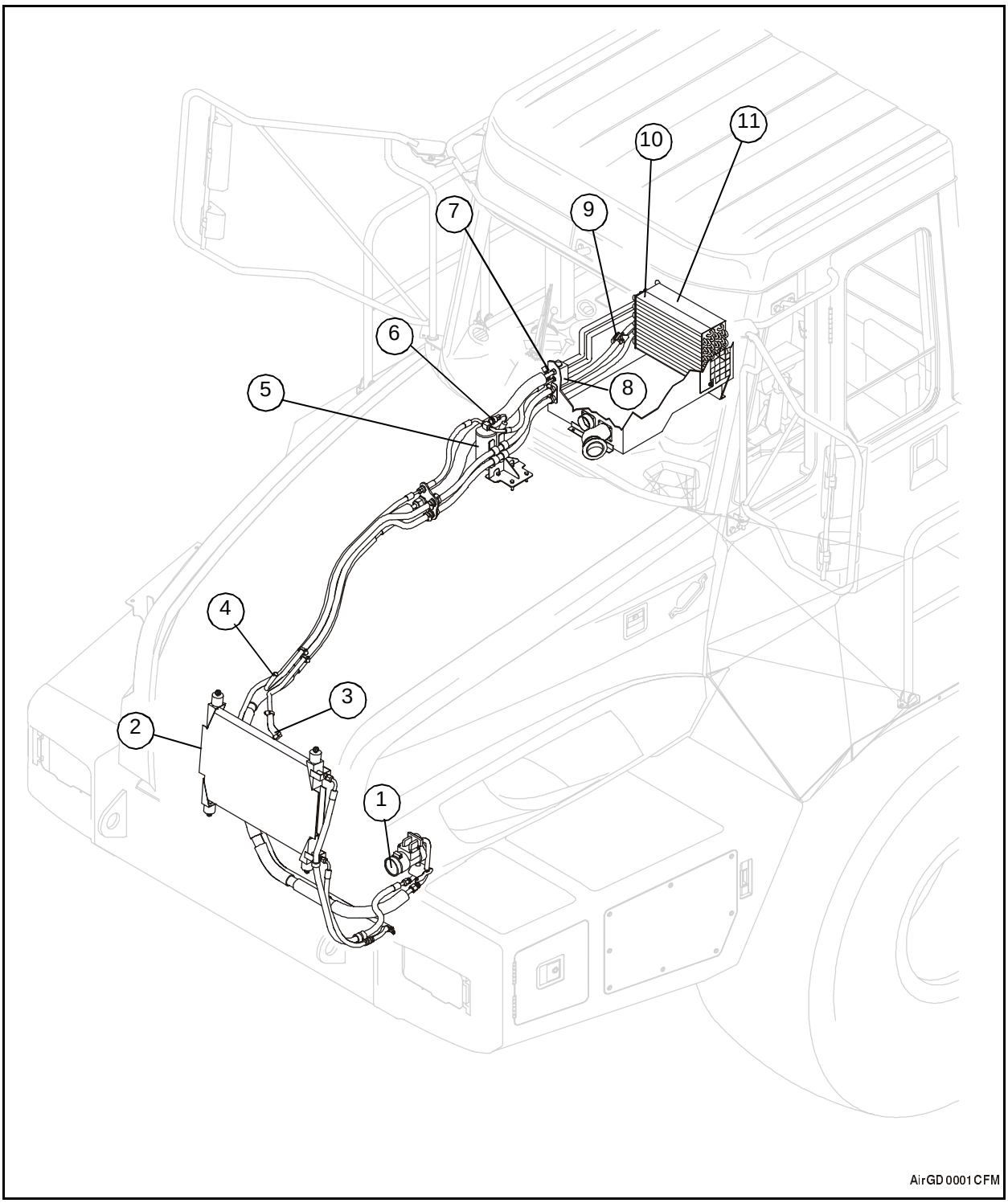
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## DIAGNOSE HEATER SYSTEM MALFUNCTIONS

| Symptom | Problem | Solution |
|---|---|---|
| Heater System Does Not Operate. | A/C - heater blower fuse. | Replace fuse. |
| | Blower motor switch/blower motor fan switch (if required). | Check switch. |
| | Wiring harness. | Check side console harness and roof harness wiring. |
| Heater Does Not Warm Interior of Cab. | Engine coolant temperature cold. | Engine must be at operating temperature. |
| | Fresh air filter restricted. | Clean or replace filter. |
| | Re circulating air filter restricted. | Clean or replace filter. |
| | Heater hose kinked, pinched or collapsed. | Re-route or re-index hoses. Replace collapsed hoses. |
| | Heater coil fins clogged with dirt or dust. | Clean heater fins. |
| | A/C heater blower motor or heater blower motor (if equipped) failed or operating too slowly. | Check motor. **See "HEATING/AIR CONDITIONING COMPONENT LOCATION" on page 412.** |
| | Heater valve does not open. | Inspect, repair, adjust or replace heater valve or cable. |
| Air Conditioner Runs Constantly, Too Cold. | Temperature control switch. | Inspect, replace temperature control switch. |
| | Heater valve. | Valve is stuck closed,. Inspect. Replace heater valve. |
| | Freeze control switch, capillary tube not positioned in evaporator properly. | Reposition capillary tube in evaporator coil. |
| | Compressor clutch engaged constantly. | **See "A/C FREEZE CONTROL SWITCH TEST" on page 419.** |
| Interior Windows Continue To Fog. | Fresh air filter restricted. | Clean or replace filter. |
| | A/C system off (If Equipped). | Move A/C - heater ON/OFF switch to A/C position. |

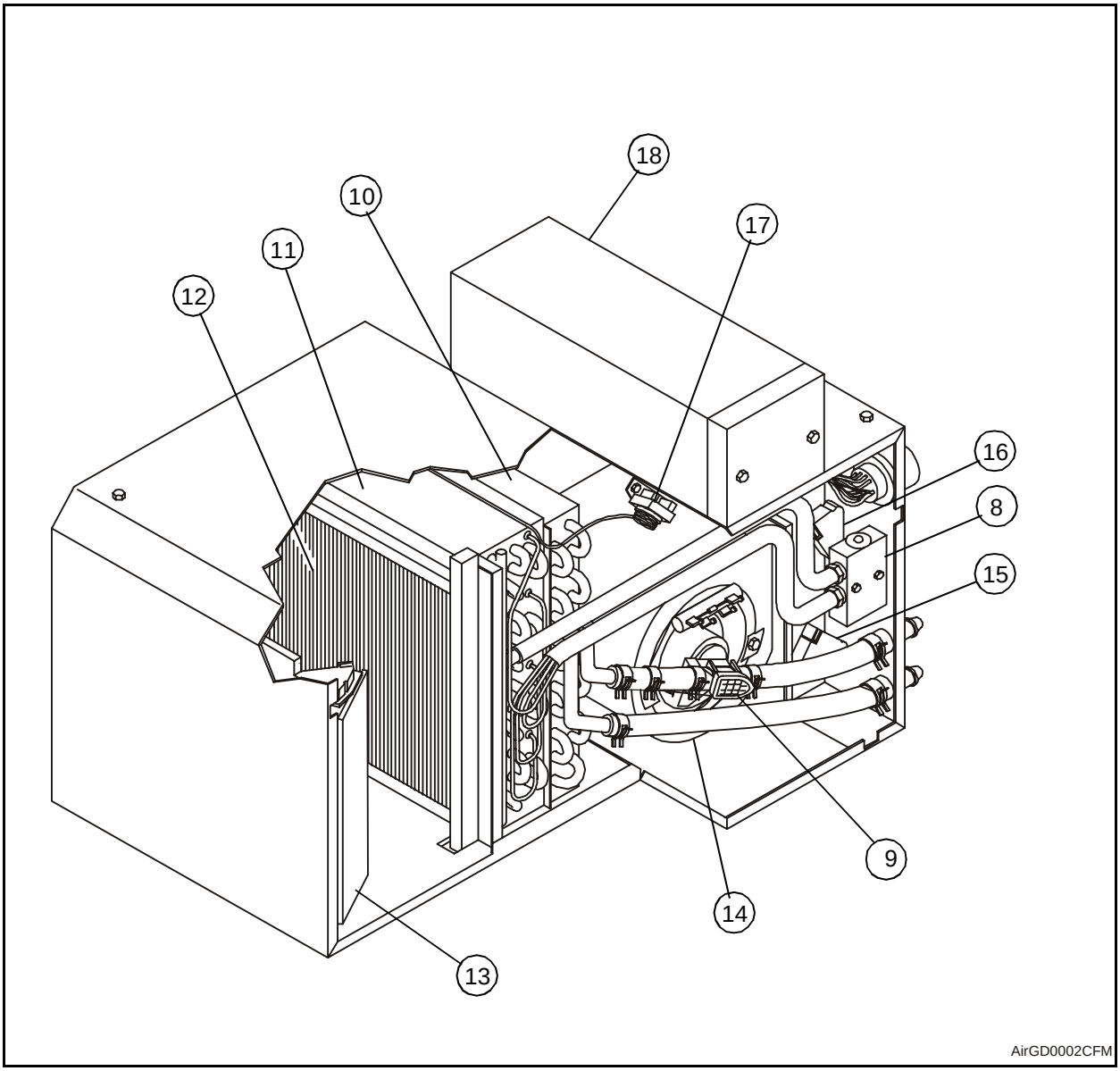
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## HEATING/AIR CONDITIONING COMPONENT LOCATION




1 Compressor.
2 Condenser.
3 Heater Return Line.
4 Heater Supply Line.
5 Receiver-Dryer.
6 Air Conditioning High/Low Pressure Switch.
7 Low Pressure Charging Port.
8 Expansion Valve Heater Core.
9 Heater Control Valve.
10 Heater Core.
11 Evaporator Core.

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8 Expansion Valve.
9 Heater Control Valve.
10 Heater Core.
11 Evaporator Core.
12 Air Intake Filter.
13 Re circulating Damper.
14 Blower Motor and Housing.
15 Floor Vent Actuator.
16 Defrost Actuator.
17 Freeze Control Switch.
18 Relay Box.

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# CHAPTER 7. HEATING AND AIR CONDITIONING

## SECTION 3. TESTS

## AIR CONDITIONING OPERATIONAL CHECKS

### Visual Inspection of Components

**NOTE:Do visual inspection of component checks prior to diagnosis and component tests. These conditions may affect diagnostic and test results.**

#### All Lines and Hoses

Inspect all lines and hoses. **(See "HEATING/AIR CONDITIONING COMPONENT LOCATION" on page 412).**

Are all lines and hoses straight, **NOT** kinked, worn from rubbing on other machine parts or "weather checked"?

Are hose and line connections clean, **NOT** showing signs of leakage, such as oil or dust accumulation at fittings?

All hose and line clamps must be in place and tight. Clamps must have rubber inserts or cushions in place to prevent clamps from crushing or wearing into hoses or lines.

**Yes:** Check complete.

**No:** Reposition hoses or lines and tighten or replace clamps. Tighten fittings or replace O-rings in fittings. Replace hoses or lines as required.

#### Air Conditioner Compressor Check

Inspect compressor.

Is compressor drive belt tight?

Is belt in good condition, **NOT** frayed, worn or glazed?

Is belt tensioner worn or damaged?

Is compressor belt pulley in good condition and in line with engine pulley?

Are compressor mounting brackets in good condition, and bracket mounting cap screws tight?

Are electrical connections to compressor clutch clean and tight? Is wiring to compressor in good condition?

**Yes:** Check complete.

**No:** Repair or replace components as required.

#### Condenser Check

Inspect condenser core.

Is condenser core free of dirt or debris?

Does condenser show signs of leakage, dust accumulation or oily areas?

Are condenser fins straight, not bent or damaged?

Inspect condenser fan or fan blade.

Are fan blades in good condition, not worn, bent, broken or missing?

**Yes:** Check complete.

**No:** Clean, repair or replace condenser core. Replace condenser fan or fan blade.

#### Heater/Evaporator Core Check

Inspect core.

Are fins straight?

Is core free of dirt and debris?

Are evaporator drain tubes plugged?

**Yes**: Check complete.

**No:** Repair, replace or clean heater/evaporator core and drain tubes. **(See Remove and Install Heater Core and Evaporator Core CHAPTER 12, SECTION 3)**.

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### Freeze Control Switch Capillary Tube Check

Inspect freeze control switch capillary tube.

Is capillary tube straight, **NOT** kinked or broken?

Is capillary tube properly positioned and inserted securely in place in evaporator core?

**Yes:** Check complete.

**No:** If capillary tube is kinked, replace freeze control switch.

**No:** If capillary tube is positioned in evaporator incorrectly, see A/C Freeze Control Switch Test.xxx

### Cab Door and Window Seals Check

Open and close door and windows. Inspect seals.

Do door and windows contact seals evenly?

Are seals in position and in good condition?

**Yes:** Check complete.

**No:** Adjust door and windows to close against seals properly. Replace seals as necessary.

### Filter Check

Inspect fresh air filter and re circulating filter.

Are filters clean and free of debris?

**Yes:** Check complete.

**No:** Clean or replace filters.

## R134A AIR CONDITIONING SYSTEM TEST

## Specifications

R134a Air Conditioner System Test

Engine Speed High Idle

Low Side Refrigerant - Pressure
- - - - - - - - - - - - - 80 kPa (0.8 bar) (11.6 psi) minimum

- - - - - - - - - - - - - - -200 kPa (2 bar) (29 psi) maximum

High Side Refrigerant - Pressure
- - - - - - - - - - - - - - 800 kPa (8 bar) (116 psi) minimum

- - - - - - - - - - 2 100 kPa (21 bar) (304.5 psi) maximum

## Service Equipment And Tools

JT02167A Prism Pro Refrigerant Identification Instrument

Thermometer

**⚠ WARNING**

**Use correct refrigerant recovery, recycling and charging stations. Never use refrigerant, hoses, fittings, components or refrigerant oils intended for R12 refrigerant systems. Identify refrigerant before recovering, recycling and charging system.**

Stop the engine.

Follow refrigerant cautions and proper handling procedures. **(See Refrigerant Cautions and Proper Handling in CHAPTER 12, SECTION 2 in the Repair Manual.)**

Identify refrigerant type using JT02167A refrigerant identification instrument.

Connect refrigerant recovery, recycling and charging station. **(See R134a Refrigerant Recovery/Recycling and Charging Station Installation Procedure in CHAPTER 12, SECTION 3 in the Repair Manual.)**

Open both low and high pressure valves on refrigerant recovery, recycling and charging station.

Open cab doors and windows.

Follow manufacturer's instructions when using the refrigerant recovery, recycling and charging system.

Start engine and run at rated engine high idle speed.

Move A/C-heater switch to A/C position.

Turn temperature control switch to maximum cooling position.

Turn blower switch to high speed.

Check sight glass (if equipped) in receiver-dryer.

Run unit for at least 5 minutes.

Measure and record air temperature at condenser air inlet and at air ducts in air conditioning unit.

Observe low-side pressure and high-side pressure on gauges.

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Compare pressures and air duct temperature to specifications.

**NOTE: Because low pressure switch is located on high pressure side of expansion valve, the low pressure gauge reading shown does not affect the low pressure switch operating range.**

- Air conditioner set at maximum cooling.
- Air conditioner compressor clutch engaged.
- Operate at maximum setting for minimum of 12 minutes.
- Air duct temperature should be below 12° C (53.5° F) with ambient temperature at 26° C (79° F) and 60% relative humidity. Refrigerant pressure within specification.

Diagnose malfunction using Operating Pressure Diagnostic Chart.

## OPERATING PRESSURE DIAGNOSTIC CHART

Do the following procedures in 1830 to service A/C system:

- • Recover R134a Refrigerant (**CHAPTER 12, SECTION 3 in the Repair Manual.**).
- • Evacuate R134a System (**CHAPTER 12, SECTION 3 in the Repair Manual.**).
- • Charge R134a System (**CHAPTER 12, SECTION 3 in the Repair Manual.**).

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| Condition | Low Side kPa (bar) (psi) | High Side kPa (bar) (psi) | Sight Glass | Suction Line | Receiver-Drier | Liquid Line | Discharge Line | Discharge Air |
|---|---|---|---|---|---|---|---|---|
| Lack of Refrigerant | Very Low | Very Low | Clear | Slightly Cool | Slightly Warm | Slightly Warm | Slightly Warm | Warm |
| Loss of Refrigerant | Low | Low | Bubbles | Cool | Warm to Hot | Warm | Warm to Hot | Slightly Cool |
| High Side Restriction | Low | Low | Clear | Cool | Cool, Sweating or Frosting | Cool, Sweating or Frosting | Hot to Point of Restriction | Slightly Cool |
| Expansion Valve Closed | Low | Low | Clear | Cold, Sweating or Frosting Heavily at Valve Outlet | Warm | Warm | Hot | Slightly Cool |
| Loose Belt or Compressor Failure | Low | Low | Clear | Cool | Warm | Warm | Hot | Slightly Cool |
| Condenser Malfunction | High | Low | Clear | Slightly Cool to Warm | Hot | Hot | Hot | Warm |
| Refrigerant Contaminated and Air in System | High | High | Clear to Occasional Bubbles | Warm to Hot | Warm | Warm | Hot | Warm |
| Expansion Valve Open | High | High | Clear | Cold, Sweating or Frosting Heavily | Warm | Warm | Hot | Slightly Cool |
| Plugged Condenser, Overcharge of Refrigerant | High | High | Clear | Cool | Warm | Warm | Hot | Slightly Cool |
| Moisture in System | Normal (May Drop) | Normal (May Drop) | Clear | Cool | Warm | Warm | Hot | Cool to Warm |
| Heater Valve Stuck Open | Normal | Normal | Clear | Cool | Warm | Warm | Hot | Warm |
| Lack of Refrigerant and Air in System | Normal (No Drop) | Normal | Occasional Bubbles | Warm to HOt | Warm | Warm | Warm | Slightly Cool |

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## A/C FREEZE CONTROL SWITCH TEST

### Specifications

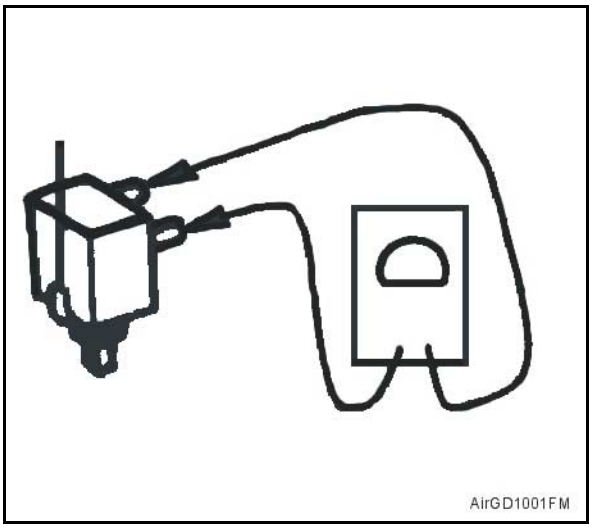
Freeze Control Switch Opens (Normally Closed) - Temperature Drops Temperature
- - - - - - - - - - - - - - - - - - - - - - - - - 1—3°C (34—37.5°F)

Freeze Control Switch Closes (Normally Closed) - Temperature Rises Temperature
- - - - - - - - - - - - - - - - - - - - - - - - - 1—3°C (34—37.5°F)

Key switch **OFF**.

Mark position of capillary tube. Tube should be near centre of evaporator.

Disconnect and remove freeze control switch.




With freeze control switch at room temperature, connect terminals to ohmmeter and measure continuity between terminals.

Is continuity measured?

**Yes:** Switch is good. Check wiring harness.

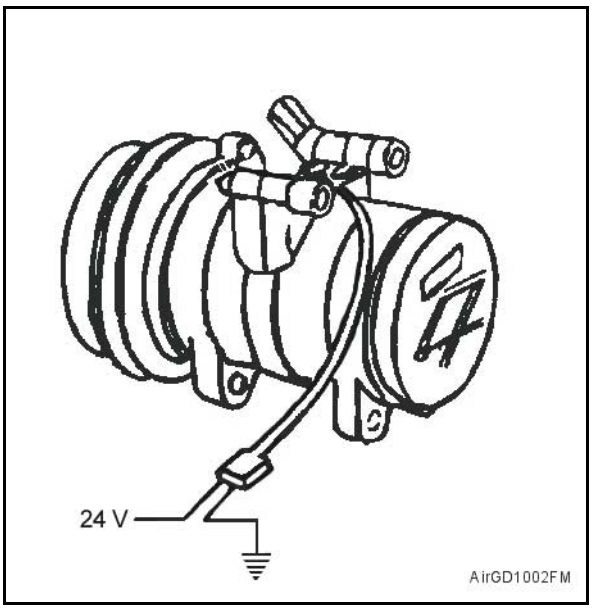
**No:** Replace freeze control switch.

Put freeze control switch in freezer. Temperature must be below 1°—3°C (34°—37.5°F). Switch must be open and continuity must not be read.

Remove switch from freezer and put sensing tube into a glass of warm water. As switch warms it must close and continuity must be read.

## A/C COMPRESSOR CLUTCH TEST

Disconnect harness from clutch.




Connect battery voltage to connector terminal for orange wire. Ground terminal for black wire.

Does clutch "**click**"?

**Yes:** Clutch coil is good. Check wiring harness.

**No:** Replace clutch coil.

## A/C HIGH/LOW PRESSURE SWITCH TEST

### Specifications

A/C Low Pressure Switch (Normally Open) - Closes on Increasing Pressure
- - - - - - - 207 ± 30 kPa (2.1 ± 0.3 bar) (30.5 ± 4.4 psi)

A/C Low Pressure Switch (Normally Open) - Opens on Decreasing Pressure
- - - - - - - - - 200 ± 20 kPa (2.0 ± 0.2 bar) (29 ± 2.9 psi)

A/C High Pressure Switch (Normally Closed)—Opens on Increasing Pressure
- - - - - - - 2700 ± 200 kPa (27 ± 2 bar) (391.6 ± 29 psi)

A/C High Pressure Switch (Normally Closed)—Closes on Decreasing Pressure
- - - - - - - 2100 ± 200 kPa (21 ± 2 bar) (304.6 ± 29 psi)

### Service Equipment And Tools

Hydraulic Hand Pump

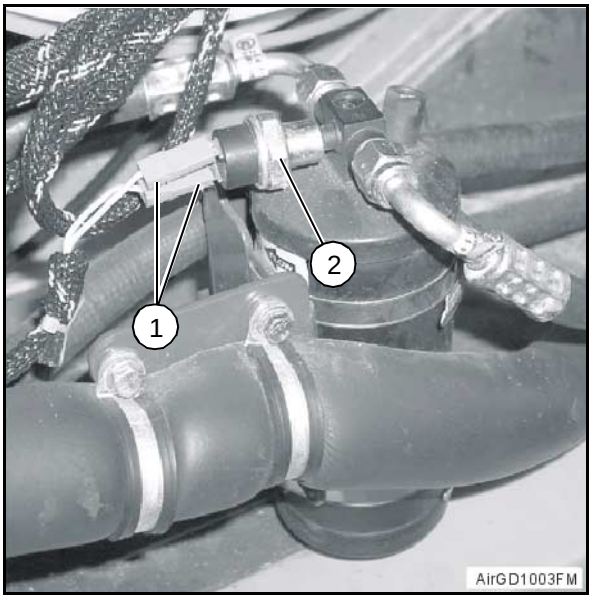
Volt-Ohm-Amp Meter

Volt-Ohm-Amp Meter

Air Conditioning Gauge Set

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**NOTE:The line that attaches A/C high/low pressure switch has a valve under it to prevent discharging air conditioning system when switch is removed.**




Remove A/C high/low pressure switch (1).

Connect a portable pressure source, such as a regulated air supply or a hydraulic hand pump, to A/C high/low pressure switch.

Switch must not have continuity between terminals until pressure increases to low pressure switch specification.

Slowly release pressure. Switch must have continuity until pressure decreases to switch opening pressure specification.

Switch must have continuity between terminals until pressure increases to high pressure opening specification.

Slowly release pressure. Switch must not have continuity until pressure decreases to switch closing pressure specification.

**NOTE:The switch can also be checked when installed in air conditioning system; however, pressure is slow to increase to test specification.**

Connect an air conditioning gauge set to service fittings at compressor. Cover condenser with paper or plastic to stop air flow.

Operate air conditioner on maximum cooling. Note high-side pressure when A/C high pressure switch opens and then closes.

## A/C EXPANSION VALVE TEST

### Specifications

Engine Speed - - - - - - - - - - - - - - - - - - - - - - - High Idle

Blower Speed - - - - - - - - - - - - - - - - - - - - - - - - High

Temperature Control Switch Position
- - - - - - - - - - - - - - - - - - - - - - - - - Maximum Cooling

### Essential Tools

Refrigerant Recovery, Recycling and Charging System

### Service Equipment And Tools

Thermometer

**⚠ WARNING**

**Use correct refrigerant recovery/recycling and charging stations. DO NOT mix refrigerant, hoses, fittings, components or refrigerant oils.**

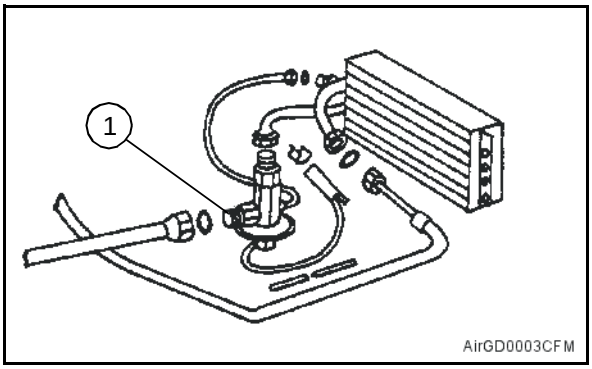
Follow Refrigerant Cautions and Proper Handling procedures **CHAPTER 12, SECTION 3 in the Repair Manual.**

Connect refrigerant recovery, recycling and charging system. **(See R134a Refrigerant Recovery/Recycling and Charging Station Installation Procedure CHAPTER 12, SECTION 3 in the Repair Manual).**

Recover R134a Refrigerant **(CHAPTER 12, SECTION 3 in the Repair Manual)**.

Remove insulating tape from expansion valve sensing bulb.

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Remove sensing bulb (1).

Start engine and run at high idle.

Turn blower motor switch on high. Turn temperature control switch to maximum cooling.

Warm sensing bulb in the hand for one minute. Note low-side pressure.

Cool sensing bulb in ice water. Note low-side pressure. If low-side pressure decreases when sensing bulb is cooled, expansion valve is operating. If low-side pressure does not decrease, do Expansion Valve Bench Test.

Before fastening sensing bulb to evaporator outlet line, make sure line and bulb are not corroded. Fasten sensing bulb to side of line with clamp. Install insulating tape to completely cover sensing bulb and line.

## EXPANSION VALVE BENCH TEST

### Specifications

High-Side Valve Pressure Setting Pressure
- - - - - - - - - - - - - - - - - - - - - - 520 kPa (5.2 bar) (75 psi)

Expansion Valve—Opens on increasing Pressure
- - - - - - - - - - 280 - 380 kPa (2.8 - 3.8 bar) (40 - 55 psi)

Expansion Valve—Closes on Decreasing Pressure
- - - - - - - - - - 140 - 170 kPa (1.4 - 1.7 bar) (20 - 25 psi)

### Essential Tools

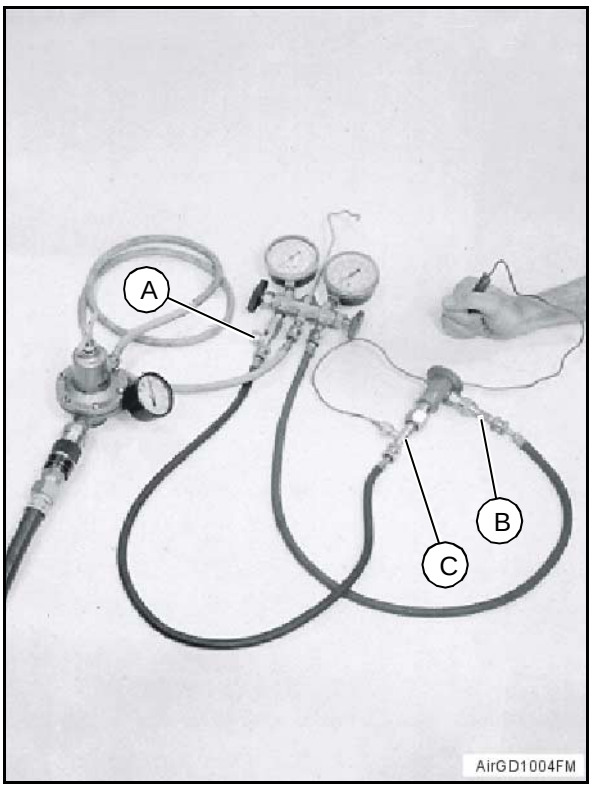
JT05419 Air Conditioning Service Fitting Kit

### Service Equipment And Tools

Air Conditioning Gauge Set

Follow Refrigerant Cautions and Proper Handling procedures **(CHAPTER 12, SECTION 3 in the Repair Manual)**.

Remove expansion valve. See Remove and Install Expansion Valve **(CHAPTER 12, SECTION 3 in the Repair Manual)**.




Connect A/C expansion valve to air conditioning gauge set using fittings (A - C).

Connect yellow hose to a regulated air supply.

Close low-side valve and open high-side valve.

Adjust pressure on high-side valve to 520 kPa (5.2 bar) (75 psi) using a pressure regulator or by adjusting high-side valve.

Hold sensing bulb in hand until pressure on low-side gauge stops increasing. Pressure must be 280 - 380 kPa (2.8 - 3.8 bar) (40 - 55 psi).

Put sensing bulb in a container of ice water until pressure on low-side gauge stops decreasing.

Pressure must be 140 - 170 kPa (1.4 - 1.7 bar) (20 - 25 psi).

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# REFRIGERANT LEAK TEST

## Specifications

Leak Detector Probe Movement Speed
- - - - - - - - - - - - - - - - - - - - - - 25 mm (1 in.) per second

Inspect all lines, fittings, and components for oily or dusty spots. When refrigerant leaks from system, a small amount of oil is carried out with it.

A soap and water solution can be sprayed on the components in system to form bubbles at source of leak.

If a leak detector is used, move leak detector probe under hoses and around connections at a rate of 25 mm (1 in.) per second.

**NOTE: Some refrigerant manufacturers add dye to refrigerant to aid in leak detection.**

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