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RAYMOND

Maintenance Manual

Model 7600/7620/7640 Reach-Fork® Truck With *The ACR System™*



Series: A

Serial Number 00001 and UP

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This publication, Publication 1087967 applies to the *Model 7600/7620/7640 Reach-Fork*® Lift Truck, S/N 00001 and above, and to all subsequent releases of this product until otherwise indicated in new editions or bulletins. Changes occur periodically to the information in this publication.

If you need assistance with your lift truck, or to order additional copies of this manual, contact your local authorized Raymond dealer.

To locate your local authorized Raymond dealer, go to www.raymondcorp.com.

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Page Revision Record

This section is a record of all revised pages in this manual. Whenever a page is revised, this section is updated and included in the revision package.

Pages are revised due to technical and non-technical changes described as follows:

- Technical changes – These changes are identified by a vertical line (change bar) in the left margin next to the change. Pages affected by technical changes are identified with "Page Revised: Mo/Day/Yr" in the footer. These pages are also available on the *Raymond* iNet.
- Non-technical changes – These changes consist of typographical and grammatical corrections, paragraph renumbering, repagination, and so on. Non-technical changes are not identifed with a change bar, however, affected pages are identifed with "Revised: Month Year" in the footer.

Document Revision History

1087967A Original Issue . . . . . 15 Apr 2009

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Service Bulletin List

The following Service Bulletins have been incorporated into this manual.

Use the blank rows below to log Service Bulletins when they are added to this manual.

Document Number	Subject	Date

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Product Improvement Notice List

The following Product Improvement Notices have been incorporated into this manual.

Use the blank rows below to log Product Improvement Notices when they are added to this manual.

Document Number	Subject	Date

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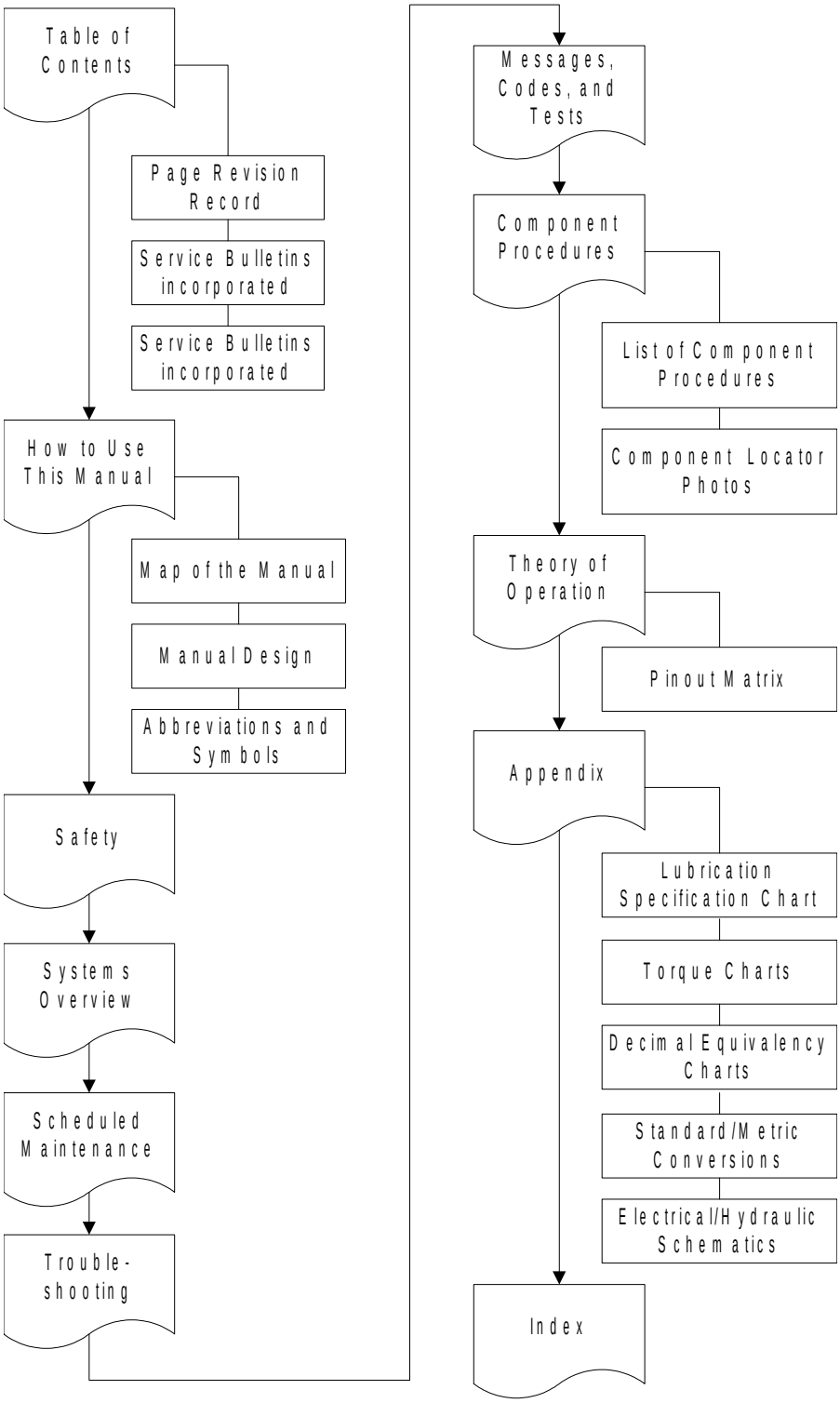
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Section 1. How to Use This Manual



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Map of the Manual



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Manual Design

This manual is designed with the following objectives in mind:

- provide technical coverage for expected levels of user expertise
- anticipate your needs and reduce your decisions regarding maintenance
- reduce page flipping through a “one-stop shopping” approach

The two-line running page header at the top of each page tells you:

- Name of the manual (Model 7600/7620/7640 *Reach-Fork*® Truck)
- Current chapter title (for example, this page *How to Use This Manual*)
- Current topic (for example, this page Manual Design)

This manual consists of the following sections:

- **How to Use This Manual** explains the manual format and design as well as abbreviations and symbols used.
- **Safety** explains warning and caution notes and general safety rules as well as safety rules for batteries, static, jacking, and welding.
- **Systems Overview** includes general lift truck specifications, programming instructions, and configuration menu.
- **Scheduled Maintenance** outlines the recommended schedule of preventive services to keep your lift truck working most efficiently.
- **Troubleshooting** guides the user from fault symptoms to a specific sequence of tests in order to isolate a failing component.
- **Messages, Codes, and Tests** lists the electrical fault codes and procedures for running firmware-based electrical tests.
- **Component Procedures** gives step-by-step procedures for testing, removing, replacing, and servicing individual lift truck components. Components are grouped by lift truck system. To find a component procedure, you may use one of three methods:
  - Look up the component name in the **List of Component Procedures**.
  - Find the component in the **Component Locator Photos**.
  - Look up the component name in the **Index**.
- **Theory of Operations** explains signal flow within the electrical and hydraulic systems for various conditions of lift truck operation. This section also contains a detailed connection point table (Pinout Matrix) designed to assist in testing and troubleshooting the lift truck.
- **Appendix** contains reference information such as torque values, lubricants, standard/metric conversions, and system schematics.
- **Index** lists subjects alphabetically.

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Abbreviations and Symbols

These abbreviations, acronyms, and symbols are used in this manual.

Term/Symbol	Definition
A	Ampere
AC	Alternating Current
AGND	Analog Ground
amp	Ampere or amplifier
ANSI	American National Standards Institute
API	American Petroleum Institute
approx	approximately
aux	auxiliary
AWG	American Wire Gauge
BSOC	Battery State-of-Charge
C	Celsius or Centigrade
CAN	Controller Area Network
CB	Counterbalance valve
CCW	Counterclockwise
CD	Coil Driver
CE	Compensating Element (valve)
cfg	configuration
cm	centimeter
COP	Computer Operating Program
CS	Cold Storage
CV	Check Valve
CW	Clockwise
DC	Direct Current
DdManH	Deadman Pedal Hours
DGND	Digital Ground
diam.	diameter
DOT	US Department of Transportation
DVM	Digital Voltmeter or Multimeter
E	UL Electric Truck Type Certification Rating with safeguards against inherent fire and electrical shock hazards
EE	UL Electric Truck Type Certification Rating where electrical equipment is completely enclosed
EPO	Emergency Power Off
ESD	Electrostatic Discharge
ESDS	Electrostatic Discharge Sensitive
F	Fahrenheit
ft.	foot or feet
ft. lb.	foot pound(s)
FR	Flow Regulator
FU	Fuse
GA	gauge
gal.	gallon or gallons
gm	gram(s)
Gnd	ground
HTI	Height-Tilt Indicator
HTR	Heater
in.	inch or inches
in. lb.	inch pound(s)
JP	jack and pin connector

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Term/Symbol	Definition
K	thousand
KeyH	hours with key switch ON
kg	kilogram(s)
km/cm^2	kilograms per square centimeter
km/hr	kilometers per hour
kPa	kiloPascal(s)
l	liter(s)
lb.	pound or pounds
LPA	Lift Power Amplifier
LED	Light Emitting Diode
LiftH	Lift Hours
L/H	load holding
L/L	lift/lower
LM	Lift Motor
LME	Lift Motor speed Encoder
LMT	Lift Motor Temperature sensor
LPA	Lift Power Amplifier
LPC	Lift Power Contactor
LR	LPA precharge resistor
LS	load shuttle
m	meter(s)
mA	milliampere
mm	millimeter
MM	*Maintenance Minder* ™
mph	miles per hour
MS	steer motor
N/A	Not Applicable or Not Available
N/C	Normally Closed
NLGI	National Lubricating Grease Institute
Nm	Newton Meter
N/O	Normally Open

Term/Symbol	Definition
OACH	Overall Collapsed Height
OCSS	Operator Compartment Sensor System
OD	Operator Display
OSHA	Occupational Safety and Health Association
otm	over-the-mast
oz.	ounce(s)
P	pump or lift contactor
PODS	Priority On Demand Spool valve
pot	potentiometer
psi	pounds per square inch
PWM	Pulse Width Modulation
P/N	Part Number
qt.	quart
RAM	Random Access Memory
REL	relief
RF	Radio Frequency
ROM	Read Only Memory
RPIN	*Raymond* Product Improvement Notice
rpm	revolutions per minute
R/R	reach/retract
RSB	*Raymond* Service Bulletin
S	Switch
SA	Steer Amplifier
SAE	Society of Automotive Engineers
S/N	Serial Number
SOL	Solenoid
spec	specification
SPL	Splice
s/s	Sideshift
SSL	Sideshift Left
SSR	Sideshift Right
STR	Steer Contactor
SWM	Supplier Wireless Module

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Term/Symbol	Definition
temp	temperature
TM	Traction Motor
TME	Traction Motor Encoder
TMT	Traction Motor Temperature sensor
TOTAL D	Total Distance Traveled
TP	Tie Point
TPA	Traction Power Amplifier
TPC	Traction Power Contactor
TS	Terminal Strip
UL	Underwriters Laboratories
UNC	Unified Coarse thread
UNF	Unified Fine thread
V	Volts
VDC	Volts Direct Current
ver.	version
VM	Vehicle Manager
VR	variable resistor
WHLD	Weight Height Limit Display
WMM	Warehouse Management Module
wrt	with respect to
@	at
™	trademark
©	copyright
+	plus or positive
–	minus or negative
±	plus or minus
°	degrees
°F	degrees Fahrenheit
°C	degrees Celsius
<	less than
>	greater than
%	percent
=	equals

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Section 2. Safety



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Definitions

Throughout this manual, you will see two kinds of safety reminders:

⚠ WARNING

Warning means a potentially hazardous situation, which, if not avoided, could result in death or serious injury.

⚠CAUTION

Caution means a potentially hazardous situation, which, if not avoided, may result in minor or moderate injury or in damage to the lift truck or nearby objects. It may also be used to alert against unsafe practices.

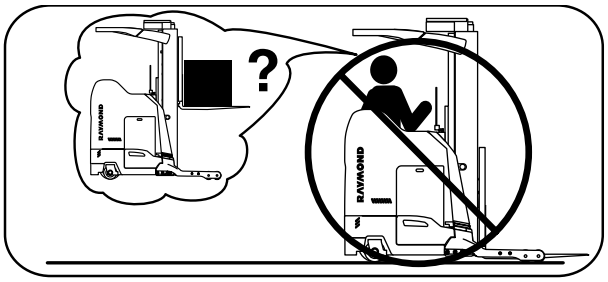
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General Safety

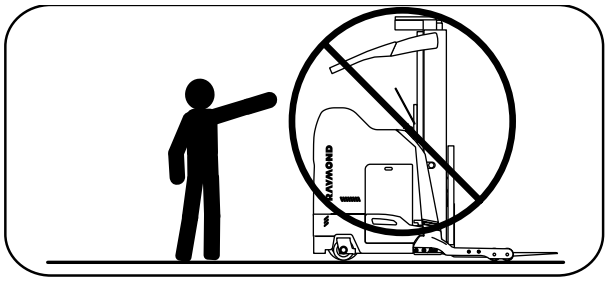
Do *not* operate or work on this lift truck unless you are trained, qualified, and authorized to do so, and have read the Owner and Operator Manuals.



Know the lift truck's controls and what they do.



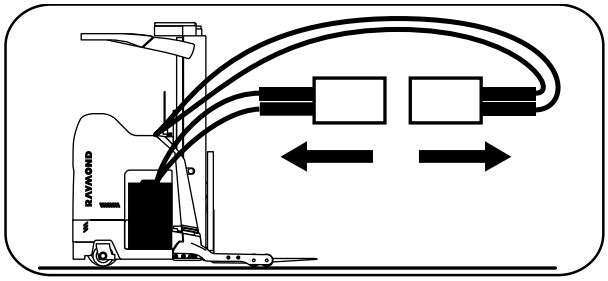
Do *not* operate this lift truck if it needs repair or if it is in any way unsafe.



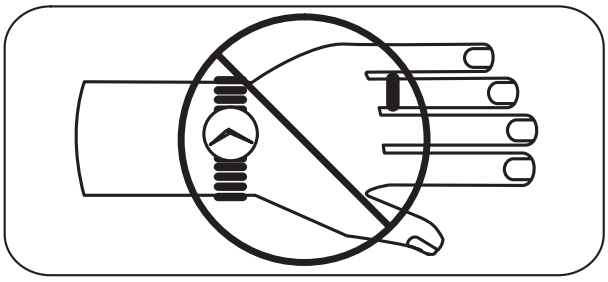
Operate this lift truck only from the operator's position.



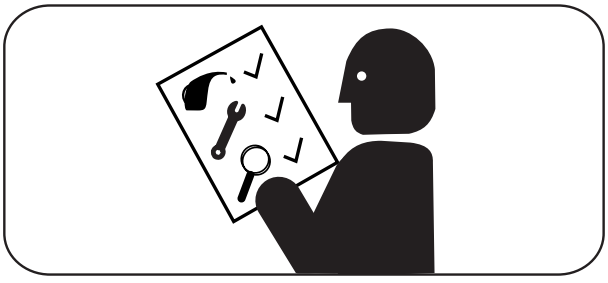
Before working on this lift truck, always turn the key switch OFF and disconnect the lift truck's battery connector (unless this manual tells you otherwise).



Do *not* wear watches, rings, or jewelry when working on this lift truck.



Follow the scheduled lubrication, maintenance, and inspection steps.



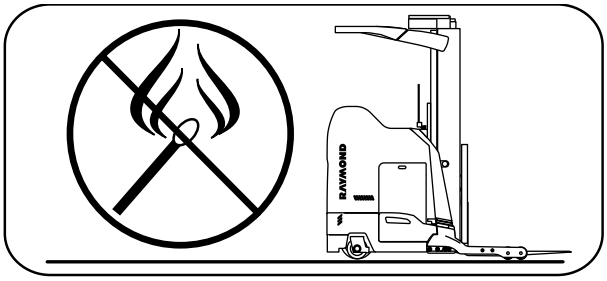
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General Safety

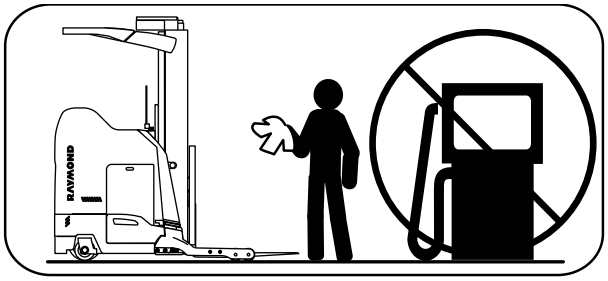
Follow exactly the safety and repair instructions in this manual. Do *not* take "shortcuts."



Do *not* use an open flame near the lift truck.



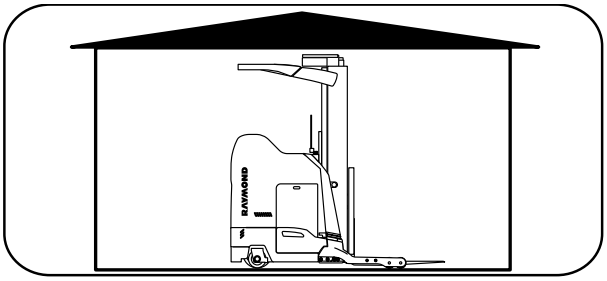
Do *not* use gasoline or other flammable liquids for cleaning parts.



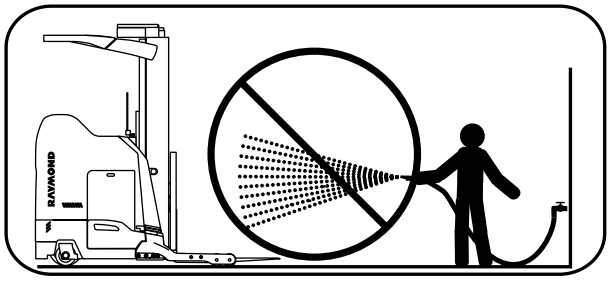
Clean up any hydraulic fluid, oil, or grease that has leaked or spilled on the floor.



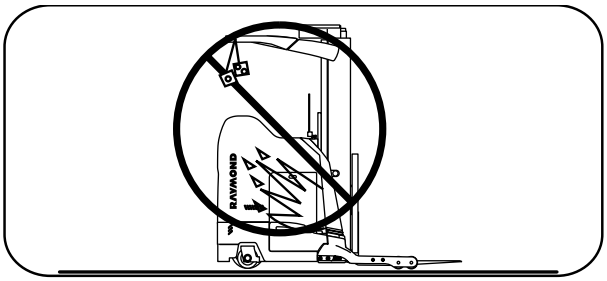
Always operate and park this lift truck indoors.



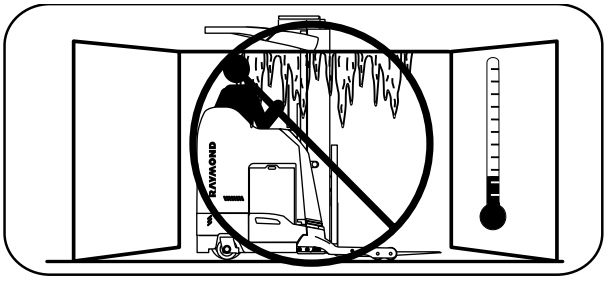
Do *not* wash this lift truck with a hose.



Do *not* add to or modify this lift truck until you contact your local Raymond dealer to receive written manufacturer approval.



Do *not* park this lift truck in a cold storage area overnight.



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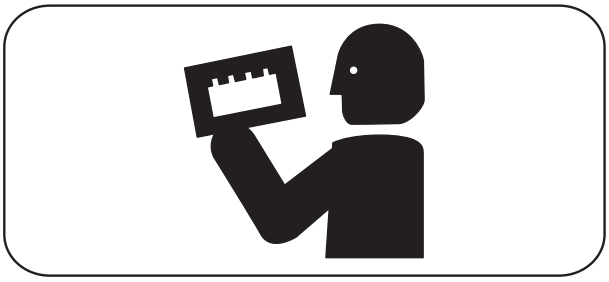
Battery Safety

⚠ WARNING

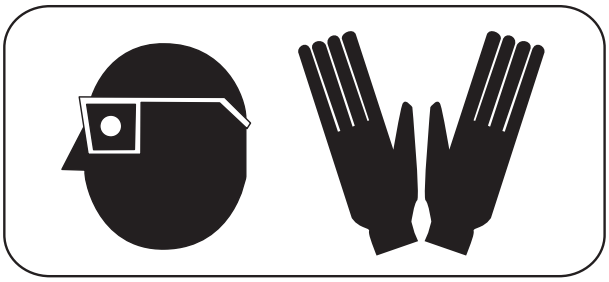
As a battery is being charged, an explosive gas mixture forms within and around each cell. If the area is not correctly ventilated, this explosive gas can remain in or around the battery for several hours after charging. Make sure there are no open flames or sparks in the charging area. An open flame or spark can ignite this gas, resulting in serious damage or injury.

Battery electrolyte is a solution of sulfuric acid and water. Battery acid causes burns. If any electrolyte comes in contact with your clothing or skin, flush the area immediately with cold water. If the solution gets on your face or in your eyes, flush the area with cold water and get medical help immediately.

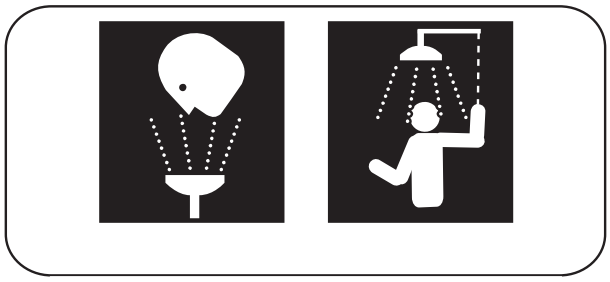
Read, understand, and follow procedures, recommendations, and specifications in the battery and battery charger manufacturer's manuals.



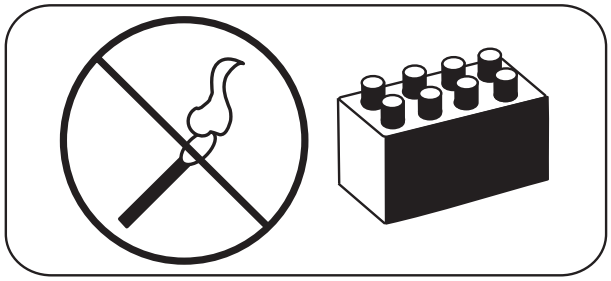
Wear personal protective equipment to protect eyes, face, and skin when checking, handling, or filling batteries. This equipment includes goggles or face shield, rubber gloves (with or without arm shields), and a rubber apron.



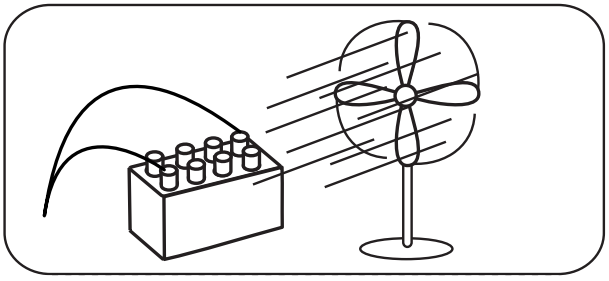
Make sure a shower and eyewash station are nearby in case of an accident.



A battery gives off explosive gases. *Never* smoke, use an open flame, or use anything that gives off sparks near a battery.



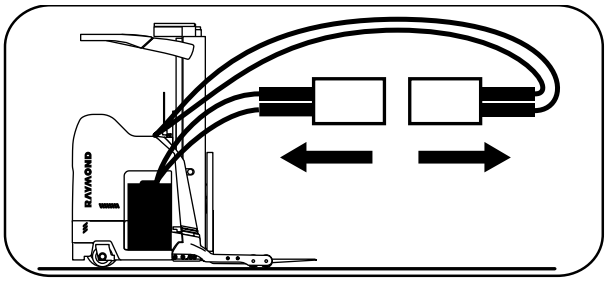
Keep the charging area well-ventilated to avoid hydrogen gas concentration.



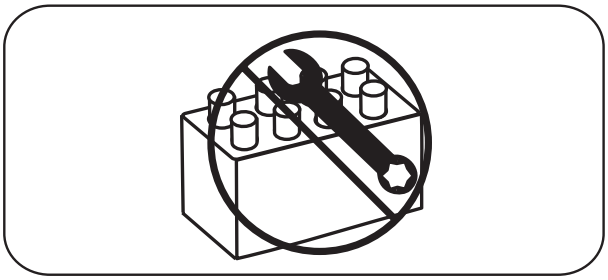
Turn the key switch OFF *before* disconnecting the battery from the lift truck at the battery

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connector. Do *not* break live circuits at the battery terminals. A spark often occurs at the point where a live circuit is broken.

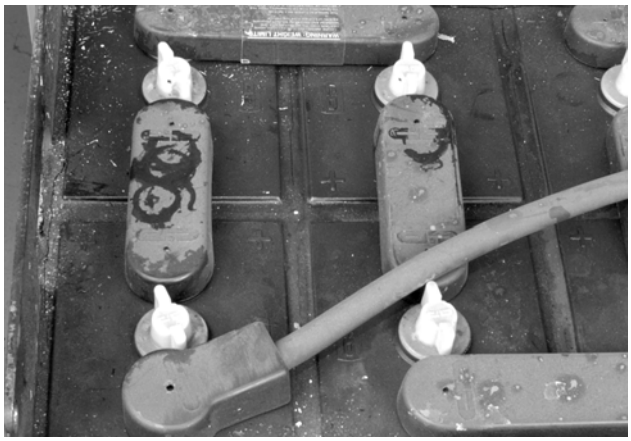


Do not lay tools or metal objects on top of the battery. A short circuit or explosion could result.



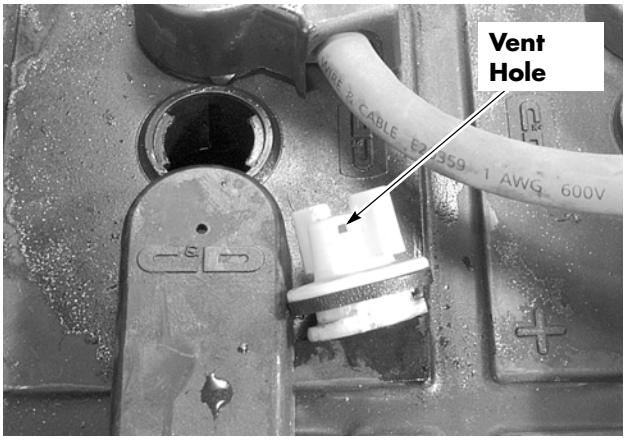
Keep batteries clean. Corrosion causes shorts to the frame and possibly sparks.

Keep plugs, terminals, cables, and receptacles in good condition to avoid shorts and sparks.



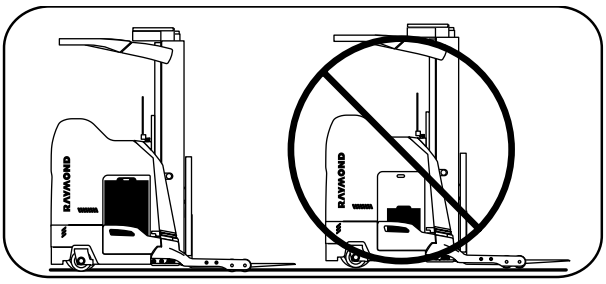
Keep filler plugs firmly in place at all times *except* when the electrolyte level is checked, when water is added to the cells, or when the specific gravity is checked.

Make sure the vent holes in the filler plugs are open to allow the gas to escape from the cells.

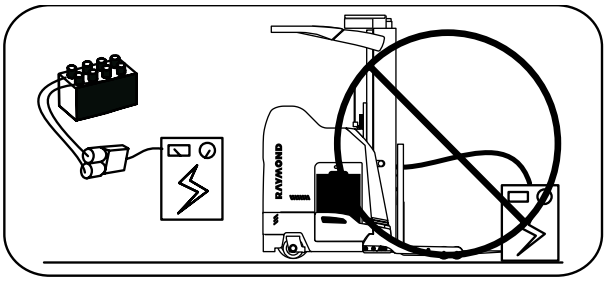


Do *not* allow cleaning solution, dirt, or any foreign matter to enter the cells.

Make sure you install the correct size battery. A smaller or lighter weight battery could seriously affect lift truck stability. See the lift truck's specification plate for more information.



Never plug a battery charger into the lift truck's battery connector. Plug the battery charger only into the battery connector from the battery.



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Static Precautions

Electronic circuit boards can contain Electrostatic Discharge Sensitive (ESDS) devices.

Static charges can accumulate from normal operation of the lift truck as well as movement or contact between non-conductive materials (plastic bags, synthetic clothing, synthetic soles on shoes, styrofoam coffee cups, and so forth).

Accumulated static electricity can be discharged to a circuit board or component by touching the parts. Electrostatic Discharge (ESD) is also possible through the air when a charged object is placed close to another surface at a different electrical potential. *Static discharge can occur without seeing or feeling it.*

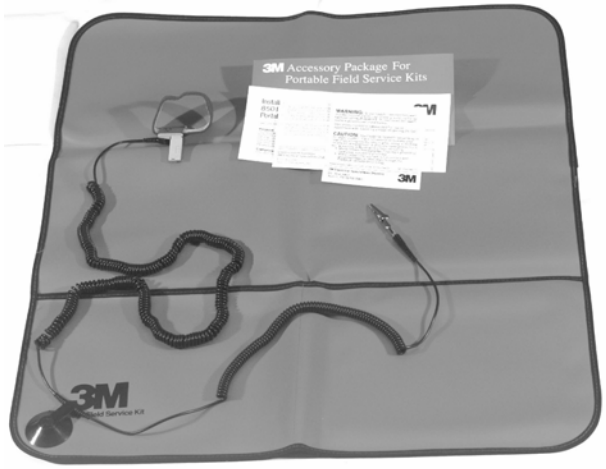
Whenever working on or near ESDS devices, follow these precautions.

- Wear an ESD wrist strap. The wrist strap should be equipped with a 1 megohm resistor to dissipate static charges slowly.
- Connect the wrist strap plug to the ground jack located tractor deck near the lift motor. If you cannot use the ground jack, connect the ground clip to an unpainted, grounded surface on the lift truck frame.
- Handle circuit boards by the edges only. Avoid touching the edge connectors.
- If you are removing or installing static-sensitive components, place them on a correctly grounded anti-static mat.
- To transport static sensitive components, including failed components being returned, place the components in an anti-static bag or box (available from your local authorized Raymond dealer).

Test the wrist strap and related accessories before each use to make sure they are working correctly.

Figure 2-1 shows the components of the Raymond anti-static field service kit, P/N 1-187-059. The kit includes a wrist strap, ground cord, and static-dissipative work surface (mat). Follow the instructions packaged with the kit.

Figure 2-1. Anti-Static Kit with Wrist Strap and Mat



Wrist straps (P/N 1-187-058/001) are available in quantities of 25.

A wrist strap tester (P/N 1-187-060/100) is also available.

Contact your local Raymond dealer for information.

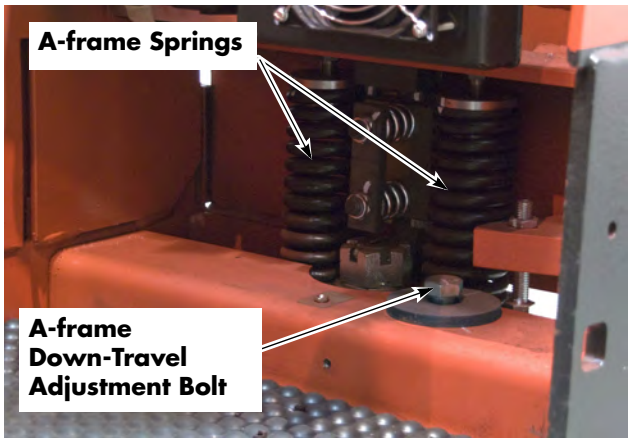
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Jacking Safety

Some maintenance procedures require the lift truck to be jacked up. To safely jack the lift truck:

1. Lower the forks completely. Remove any load.
2. Place all controls in neutral.
3. Block the wheels to prevent movement of the vehicle.
4. Turn the key switch OFF and disconnect the battery connector.
5. If possible, stabilize the top of the mast with an overhead chain hoist.
6. Before jacking the lift truck, examine the A-frame down-travel adjustment bolt. See Figure 2-2. If the bolt is missing, or the hole that it passes through is excessively worn, the A-frame will not be held in place when the lift truck is jacked up; the A-frame could pivot down and allow the springs to fall out.

Figure 2-2. A-frame Down-Travel Adjustment Bolt

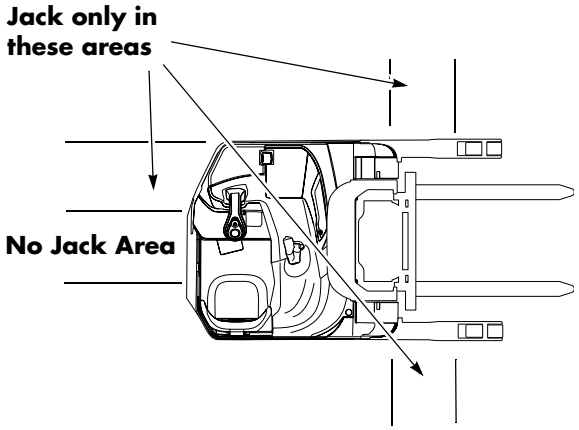


7. Place the jack under the designated jacking points. See Figure 2-3.

⚠ WARNING

Use extreme care when the lift truck is jacked up. Never block the lift truck between the telescopic and the floor. Attach a chain to the top of the mast and an overhead hoist to stabilize the mast if jacking more than described in this procedure. Keep hands and feet clear while jacking the lift truck. After the lift truck is jacked, place solid blocks or jack stands beneath it to support it. Do *not* rely on the jack alone to support the lift truck.

Figure 2-3. Correct Jacking Locations



To elevate the rear of the lift truck:

1. Place the jack in the specified jacking position. See Figure 2-3.
2. Jack the rear of the lift truck so that the drive tire is off the floor no more than 2 in. (50 mm). If you must elevate the drive tire more than 2 in., attach a suitable capacity hoist to the lift truck at the overhead guard.
3. Block the lift truck in place.

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To elevate either side of the lift truck:

1. Place the jack in the specified jacking position. See Figure 2-3.
2. Jack the side of the lift truck so that the load wheel is off the floor no more than 1/2 in. (13 mm).
3. Block the lift truck in place.

NOTE: After working on a vehicle, test all controls and functions to make sure they operate correctly.

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Tie-Down for Transport

To transport your Raymond Model 7600/7620/7640 *Reach-Fork* lift truck in an over-the-road vehicle or rail car, follow these steps:

1. Lower the forks and locate the lift truck in the center of the transport vehicle.
2. Using a suitable lifting device, remove the battery. See “Battery Safety” on page 2-5.
3. Position the adjustable chain over and through the battery compartment.
4. Position an additional adjustable chain over and through the battery compartment.
5. Position the chain ends of one chain toward the front of the vehicle bed and the chain ends of the other chain to the back of the vehicle bed and draw taut.

NOTE: This secures the lift truck to the vehicle bed and prevents tip-over and forward or backward movement.

6. Secure the battery according to the battery manufacturer’s instructions.

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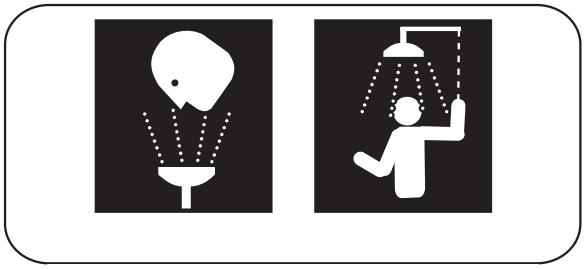
Welding Safety

⚠ WARNING

Flame cutting or welding on painted surfaces can produce potentially harmful fumes, smoke, and vapors. Before doing flame cutting or welding, remove the coating in the area where the operation(s) will occur.

⚠ WARNING

Coating removal can occur by mechanical methods, chemical methods, or a combination of methods. Do flame cutting and/or welding only in well ventilated areas using local exhaust if necessary.

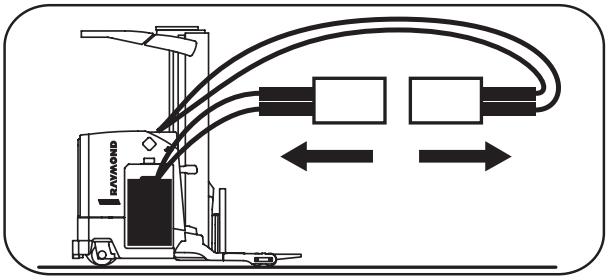


Before working on this lift truck, make sure that:

- Fire protection equipment is nearby.
- You know where the nearest eyewash station is.

⚠CAUTION

Disconnect the battery before you attempt to inspect, service, or repair the lift truck.



- Test for shorts to frame as described in "Shorts to Frame" on page 5-2. If you find any shorts, correct them before you weld.
- Clean the area to be welded.
- Protect all lift truck components from heat, weld spatter and debris.
- Attach the ground cable as close to the weld area as possible.
- Disconnect all electrical connectors from circuit cards before doing any type of electric resistance welding.
- Do *not* weld near electrical components.
- If you must weld near the battery compartment, remove the battery from the lift truck.
- When you are finished welding, re-install connectors on circuit cards and do all ground tests and electrical inspections before operating the lift truck.

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Section 3. Systems Overview



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Introduction

This manual provides information for maintenance and repair of the *Model 7600/7620/7640 Reach-Fork*t® Lift Truck by *Raymond*.

This manual contains the most current and accurate procedures, drawings, and photographs available at the time of publication. Subsequent releases of this product may differ slightly from that shown here. Accordingly, some changes in parts, layout, or procedures may not be reflected in this manual.

For the latest information on your *Raymond* lift truck, contact your nearest authorized Raymond dealer.

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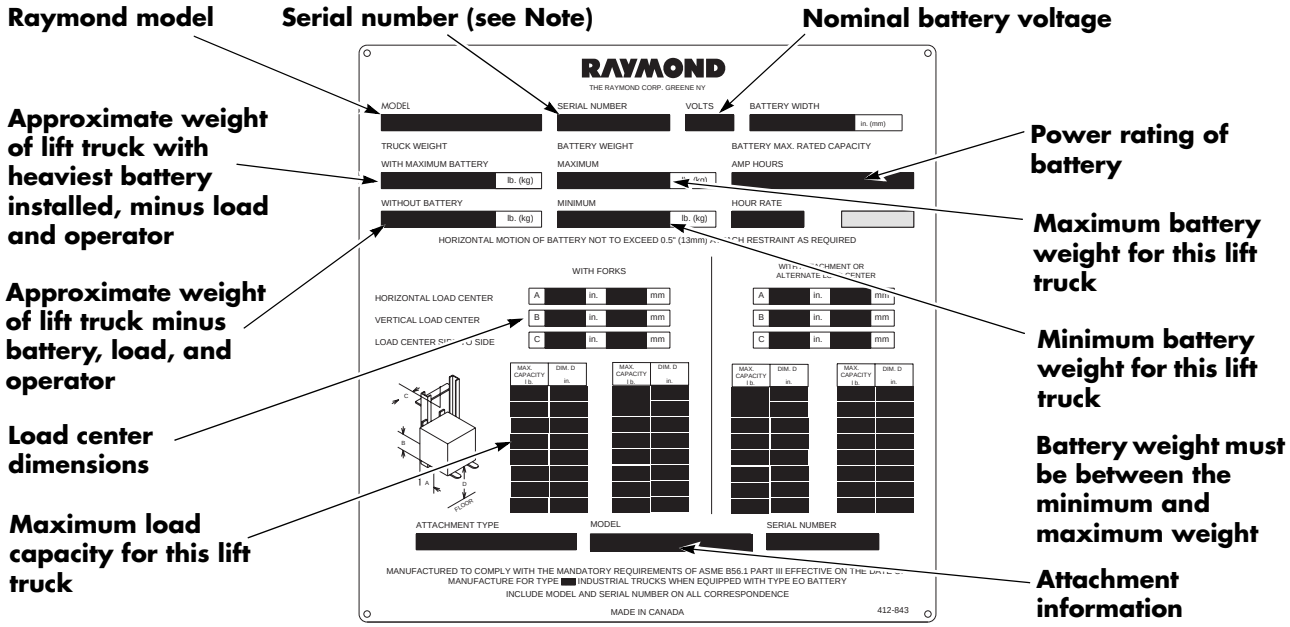
Lift Truck Specifications

This lift truck is rated for performance by load center and load weight.

Review the specification plate located in the operator compartment of the tractor for detailed load capacity and load center information.

Due to continuous product enhancement, specifications are subject to change without notice or obligation.

Figure 3-1. Lift Truck Specification Plate on Tractor



NOTE: Lift truck serial number is also found:

- On the mast specification plate on the lower right mast upright
- Stamped on the top edge of the rear bumper, to the left of center

Load Capacity

Always refer to the specification plate on your lift truck for the correct ratings for your lift truck.

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Model 7600 Designation

Mast Series

The model number includes the model and the mast series designation.

Table 3-1. Mast Series Designation

Model(s)	Mast	Max Load Forks Lowered	Carriage
7600/ 7620/ 7640	R45TT	4500 lb. (2041 kg)	Standard
	DR32TT	3200 lbs. (1451 kg)	*Deep-Reach*®

Tractor

The serial number consists of a three-digit model abbreviation, two-digit year of manufacture, tractor designator, and five-digit serial number.

Table 3-2. Tractor Designation

Model (abbrev.)	Tractor	Lift Motor	Lift Pump	Stance
760/ 762/ 764	A	AC	Single	Sit/Stand Side Stance

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Battery Specifications

Table 3-3. 36V Battery Specifications

Width (in.)	Weight lb. (kg)		Hours	Amps
	Min	Max		
18.5	2300 (1044)	2600 (1180)	6	1085
21.5	2600 (1180)	2900 (1315)		1240

UL note 583 specifies that a battery should have no more than 0.5 in. (13 mm) movement in any horizontal direction.

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FlashWare

Overview

FlashWare allows you to update software, view and configure options on the lift truck through the following features:

- Update Vehicle Manager software
- Clear Primary Memory
- Clear Vehicle Manager
- Reset factory default settings
- Update Display software
- Update Power Amplifier Software

For more detailed FlashWare information, click on Help and select Help Topics from the menu bar.

Requirements

FlashWare can be installed on any IBM-compatible PC. The PC communicates with the lift truck software via a 9-pin serial cable.

NOTE: A USB to 9-pin serial adapter (P/N 610-809/USB) is available for computers without a serial port.

⚠CAUTION

To protect your PC from possible ESD or voltage surge, use of a surge protector (P/N 154-010-801) is recommended.

Installing FlashWare on PC

If you are a customer service technician, obtain FlashWare from your Raymond dealer.

If you are a Raymond dealer technician, obtain FlashWare from the iNet software download site. If you do not have access to the download page on iNet, contact the Parts Distribution Center.

To install FlashWare on the PC, double-click the installation file and follow the instructions on the screen. The software package is a self-extracting executable file. Read the "Readme" file in the software package for the latest detailed installation instructions.

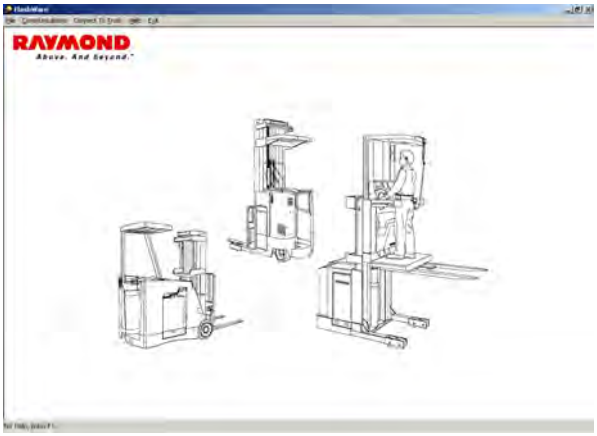
Connecting PC to Truck

1. Turn the lift truck key switch OFF.
2. Connect the surge protector to an available com port on your computer.
3. Connect a standard 9-pin serial cable to the surge protector.
4. Connect the cable to JPT-9 at the VM.
5. Turn the key switch ON.

Starting FlashWare

1. Make sure the lift truck key switch is ON.
2. Double-click the FlashWare icon on the main desktop screen or navigate via Start > Programs > FlashWare. The lift truck opening screen will appear. See Figure 3-2.

Figure 3-2. Truck Opening Screen



NOTE: When entering or using FlashWare, it is normal for a 50 series code to display.

3. From the menu bar, click "Connect to Truck", then select "All Other Trucks". The lift truck setup screen appears on your PC screen. See Figure 3-3.

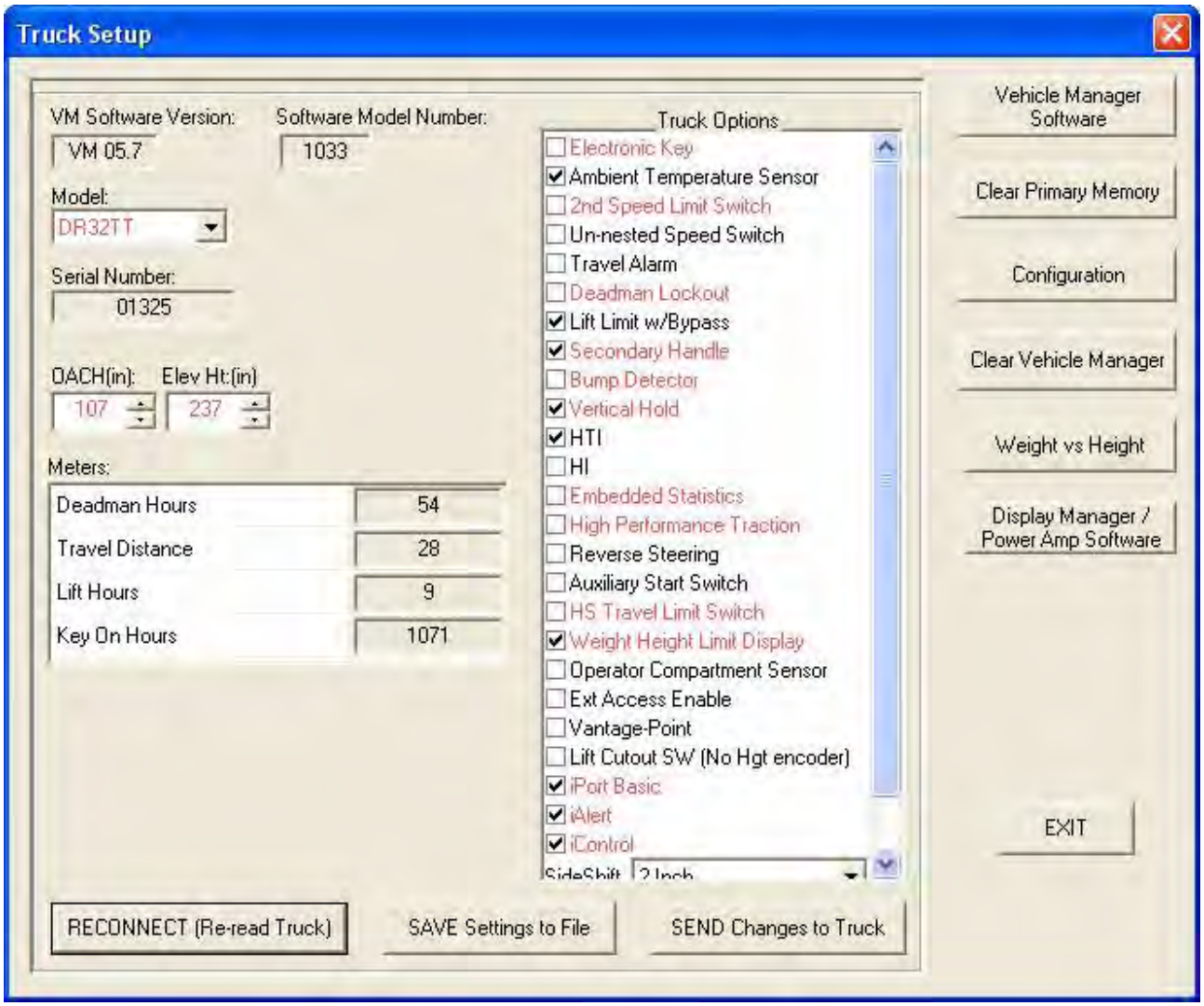
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Configuration and Truck Setup Options

The Truck Setup screen feature allows you to:

- enable options that were added to the lift truck since shipment from the factory
- check the serial number, model number, software model number, OACH, Elev Ht, and Vehicle Manager version, and hour meters of the lift truck. See Figure 3-3.

Figure 3-3. Typical Truck Setup Screen



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To Change an Option Setting:

The pull down screen near the middle of the window lists the Truck Options.

Check the required option box. To disable an option, remove the check mark. See Figure 3-3. When the options are correctly configured, click "SEND Changes to Truck" button.

NOTE: Options displayed in red require authorization codes. When these options are selected, a pop up window appears requesting the authorization code. Contact your local Raymond dealer for the correct forms and procedure for obtaining the authorization code.

Options include (but are not limited to):

Electronic Key - requires the operator to enter a code before operation is allowed.

Ambient Temperature Sensor - senses ambient air temperature required for cold storage options.

2nd Speed Limit Switch - limits the speed of the lift truck above a second programmable height.

Un-nested Speed Switch - limits the speed of the lift truck to a programmable rate if the fork carriage is not fully retracted. Requires the installation of a switch S14.

Travel Alarm - allows the alarm to sound when the lift truck is moving as configured.

Deadman Lockout - allows the operator to lift and lower only when the deadman pedal is depressed.

Lift Limit w/Bypass - limits lift height until bypass switch is depressed.

Vertical Hold - provides operator assistance in storing and retrieving loads from frequently referenced rack heights. Once rack heights are programmed into a lift truck, the information can be copied to other lift trucks. Refer to "Vertical Hold Data Copy" on page 3-11.

NOTE: Vertical Hold requires the Un-nested Speed Switch and HTI options be installed.

HTI - enables digital fork height and tilt indicator.

HI - enables digital fork height indicator.

Embedded Statistics - records lift truck utilization (lift and travel) is programmable in truck configuration.

High Performance Traction - allows travel up to 8.0 mph.

Reverse Steering - enables reverse steering for models with electric steering.

Auxiliary Start Switch - enables additional switch that must be pressed to allow lift truck to be turned ON.

HS Travel Limit Switch - limits speed of lift truck when forks are above the switch height.

Weight Height Limit Display - displays load capacity vs. height information.

Operator Compartment Sensor - enables OCSS system.

Ext Access Enable - enables additional switch that must be pressed to allow lift truck to be turned ON.

Vantage Point - enables *Vantage Point*™ system.

Lift Cutout SW (No Hgt encoder) - inhibits lift when the forks reaches the height of the optional switch.

iPort **Basic** - part of the *iWarehouse* package.

iAlert - part of the *iWarehouse* package.

iControl - part of the *iWarehouse* package.

Sideshift - use to configure the sideshift on the lift truck.

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Reviewing Vehicle Manager Software

Vehicle Manager software information management can be performed in the VM Software window:

- Identify current version of software installed in the lift truck
- Update current version of software with a newer version
- Upload currently installed version of software

1. Click Vehicle Manager Software button on Truck Setup screen. See Figure 3-4.
2. Select Software version to load. See Figure 3-5.
3. Click the Load VM With Selected Software Version button. See Figure 3-5. The new software is then installed in the lift truck.
4. Using the FlashWare application, load to the PC the latest Software Model Table, if one was provided in the package.
5. Open the Software Model Table: Click on Help and select "View Software Model Number Table" from the drop down menu.
6. Compare the software versions listed in the table with the versions in the lift truck. To display software versions in the lift truck, see "Version" under "Program Mode Menu" on page 3-21.
7. Load updates to FlashWare and install software to the lift truck as needed to make sure a matching set of VM/DM software is installed.
8. When installation is complete, click Exit to return to the main Truck Setup screen.

Figure 3-4. Truck Setup Screen

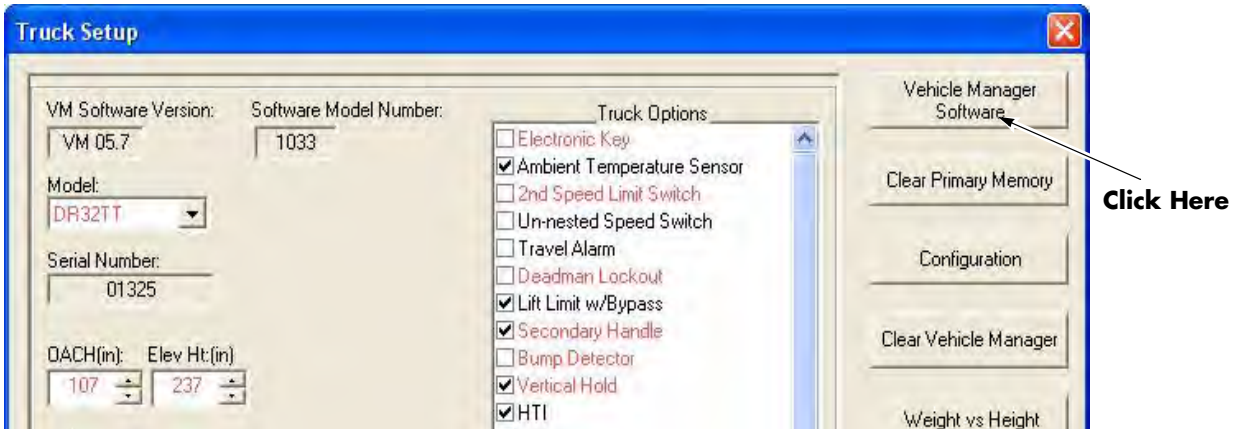
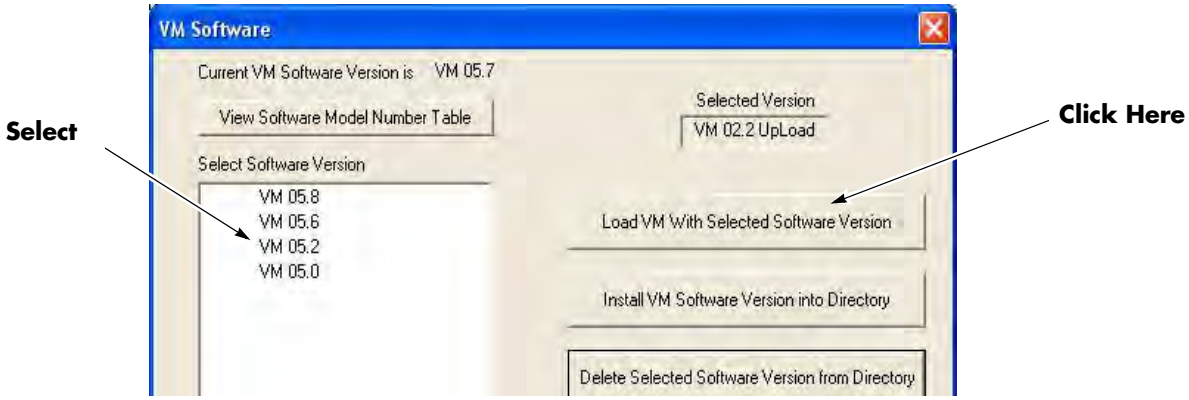


Figure 3-5. VM Software Screen



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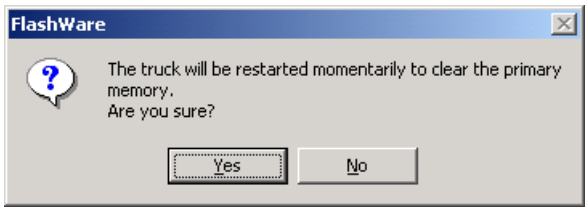
Clearing Primary Memory

The clear primary memory feature allows you to clear a Display Card in a lift truck so it can be used in another lift truck.

NOTE: The Display Card can be replaced without losing truck identity. A copy of the truck identity is stored in both the VM and Traction Power Amplifier. If two of the three memory storage locations agree, the truck assumes that identity. If all three memory locations disagree, a code AV is displayed and a programmed Display Card and VM must be installed.

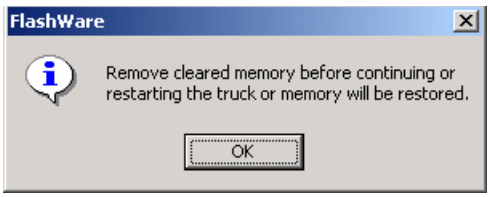
1. Click on the Clear Primary Memory button.
2. After selecting this feature, the clear primary memory screen appears. See Figure 3-6.

Figure 3-6. Clear Primary Memory Screen



3. If you select No, the action is cancelled.
4. If you select Yes, a new prompt appears. See Figure 3-7. Click OK.

Figure 3-7. Remove Cleared Memory Screen



⚠CAUTION

Do *not* cycle the key switch, or the primary memory will be restored to the current lift truck configuration.

5. Remove the Display Card.

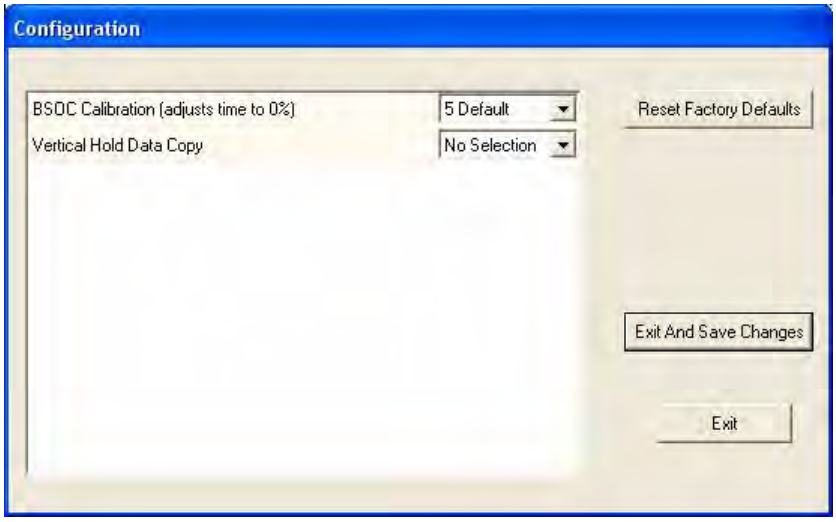
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Reviewing Configuration Settings

Review the Configuration window on the Truck Setup Screen, scrolling through the settings.

Click Configuration on the main Truck Setup screen. See Figure 3-4. The Configuration screen appears. See Figure 3-8.

Figure 3-8. Configuration Screen

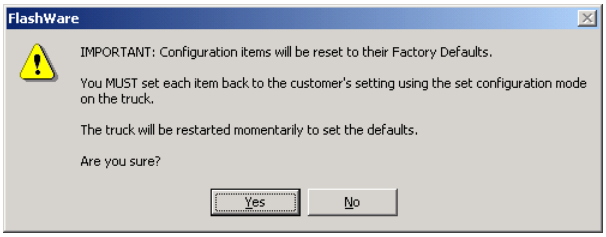


Reset Factory Defaults

Use this feature to reset vehicle configuration including SuperWord and Password. See Figure 3-9.

NOTE: Record customer-specific configurations, for example; speed, acceleration, lift, and coast from the Truck Config screens *before* resetting defaults.

Figure 3-9. Configuration Reset Screen



BSOC Calibration

5 is the factory default and specifies the average voltage that is considered as 0% BSOC.

Making this number smaller (down to 1), lowers the average voltage considered as 0% BSOC, resulting in increasing the time to reach 0% BSOC, by using more battery capacity.

Making this number higher (up to 9) increases the average voltage considered as 0% BSOC, resulting in decreasing the time to reach 0% BSOC, by using less battery capacity.

Vertical Hold Data Copy

1. From the Configuration screen, select Vertical Hold Data Copy.
2. From the drop down menu, click on Read From Truck. Click Save. Extracted data is saved on the laptop with a filename of [mast_type-serial_number.hsd] for example, R45TTB-05546.hsd.

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NOTE: If the file already exists, you will be asked if you want to overwrite the existing file.

3. Exit FlashWare when data copying is complete.
4. Connect the computer to the next lift truck and enter FlashWare.
5. From the Configuration screen, click Vertical Hold Data Copy.
6. From the drop down menu, select Write To Truck.
7. From the file browse window, browse to the desired filename of Vertical Hold data. For example: R45TTB-05546.hsd. Click Open.
8. You are asked if you want to write data to the lift truck. Click Yes.
9. Exit FlashWare when data copying is complete.

Clear Vehicle Manager

The Clear Vehicle Manager feature provides the ability to purge existing memory and software from a Vehicle Manager so that it may be used in a different model lift truck.

1. Click the "Clear Vehicle Manager" button on the right side of the Truck Setup window. See Figure 3-3.
2. The Erase Vehicle Manager Software screen is displayed. Click the "View Software Model Table" button. See Figure 3-10.

Figure 3-10. Erase Vehicle Manager Software Screen

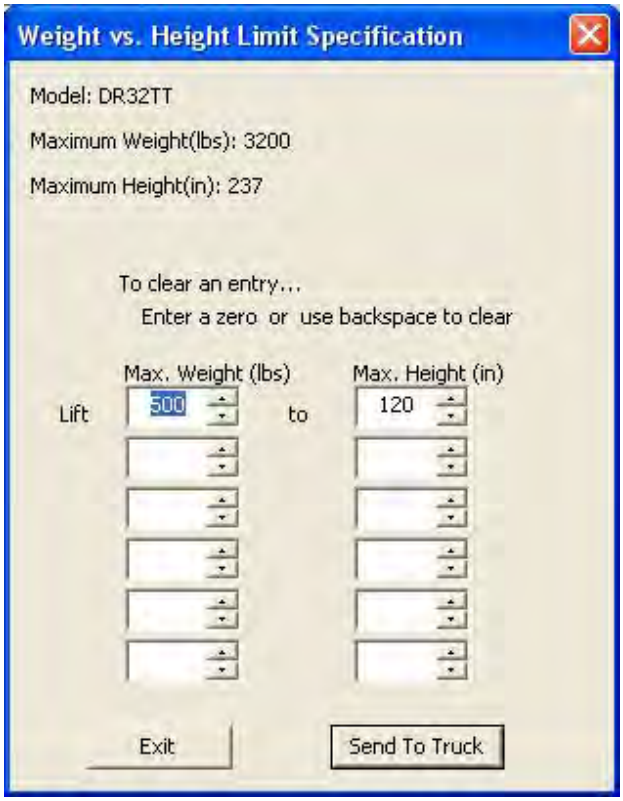


3. If the software model number is incorrect, click "ERASE". Memory is cleared and the correct software model number can now be selected and loaded.

Weight versus Height

This feature is used to specify weight versus height information on lift trucks equipped with an optional Height Tilt Indicator (HTI). Refer to WHLD Cfg in the "Program Mode Menu" on page 3-21.

Figure 3-11. Weight vs. Height



Displaying Manager/Power Amp Software

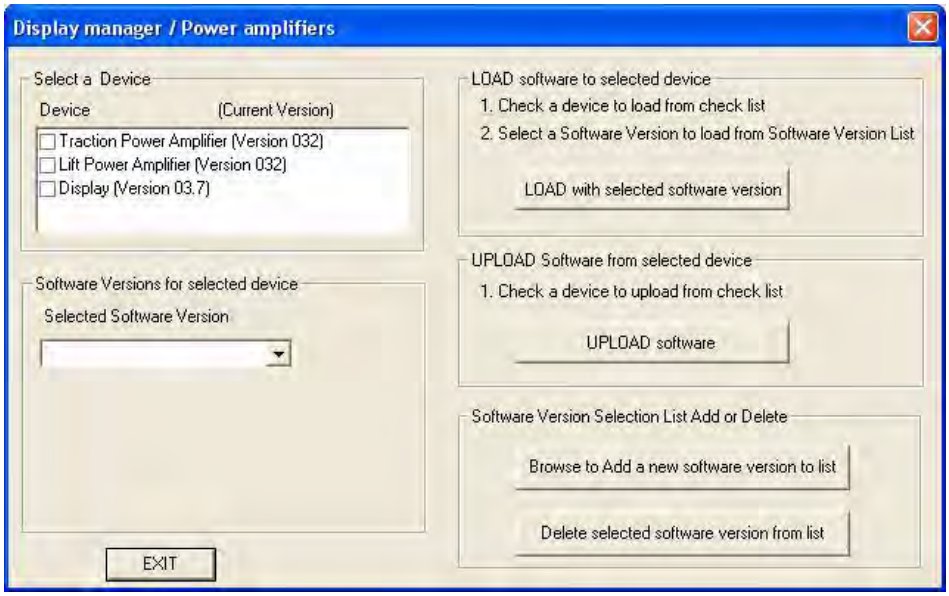
NOTE: Refer to the Software Release Reference Guide posted on iNet for current software version information.

This feature is used to view and/or change the Power Amplifier software.

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1. Click Display Manager/Power Amp Software button in the main Truck Setup screen.
2. When the Display Manager/Power amplifiers screen appears, follow prompts on the screen to Load/Upload software. See Figure 3-12.

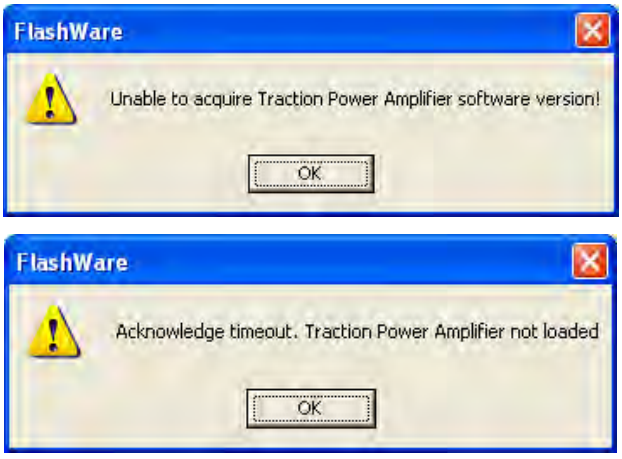
Figure 3-12. Display Manager/Power Amp Screen



Programming the Traction Power Amplifier

Load the software into the Traction Power Amplifier. You may get the following messages while attempting to load new software.

Figure 3-13. Error Messages



If these messages are displayed:

1. Disconnect the PC.
2. Turn the key switch to the OFF position, then to the ON position and wait 60 seconds.
3. Repeat step 2, but do not wait 60 seconds.
4. Connect the PC and verify the software version of the Traction Power Amplifier.
   - If the requested software to be downloaded is listed under (Current Version) in the Display Manager window, the download was a success.
   - If it shows Version ????, you must attempt to load the software again.

NOTE: This procedure may have to be repeated several times until it is completed successfully.

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Programming the Lift Power Amplifier

1. Connect the PC and open FlashWare.
2. Load the software into the Lift Power Amplifier. You may get messages similar to those shown in Figure 3-13 while attempting to load new software. If you get a similar message, disconnect the PC.
3. Turn the key switch OFF, then ON and wait 60 seconds.
4. Repeat step 3, but do not wait 60 seconds.
5. Connect the PC and verify the software version of the Lift Power Amplifier.
   - If the requested software to be downloaded is listed under (Current Version) in Display Manager window, the download was a success.
   - If it shows Version ????, you must attempt to load the software again.

RECONNECT (Re-read Truck)

This feature is used to re-establish communication with the vehicle.

SAVE Settings to File

This feature is used to store the vehicle's current configuration for future reference.

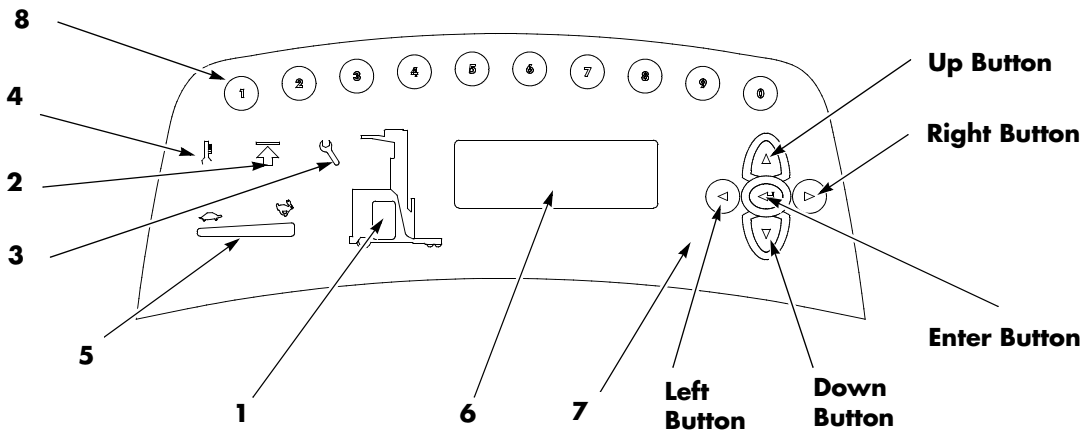
SEND Changes to Truck

This feature is used to transmit desired option and height-related changes to the vehicle.

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Operator Display

Figure 3-14. Operator Display



1. Battery Discharge Indicator
2. Lift Limit (optional)
3. Service Required
4. Traction/Lift Motor or Power Panel Overtemperature
5. Lift Truck Speed
6. SelfTest, Hour Meters, BSOC, Load Weight, Clock/Calendar, and Status Messages
7. Display Dialog Buttons
8. Dashboard Selection and Optional Feature Buttons

Selecting Display Format

The Operator Display shows date, time, BSOC, weight on forks, information/status messages, and ambient temperature (optional). Use the dashboard buttons 1 thru 8 to select the desired layout of these items on the display.

Dashboard button 9 toggles display of up to 8 Active Service tests. See “Active Service Mode” on page 3-29.

Use the display dialog buttons (up, down, left, right, and enter) to navigate through display menus and to select values for parameters.

Dashboard button 0 displays hour meters:

- KeyH: Total hours key switch is turned ON
- DdMan H: Total hours on deadman
- Lift H: Total hours spent lifting
- Total D: Total distance traveled (miles or kilometers, depending on Units specified in Config)

Graphic icons alert operator to other conditions:

- Battery State-of-Charge
- Lift Limit
- Service Required
- Overtemperature
- Lift Truck Speed

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Modes of Operation

Overview of Modes

This lift truck has two modes of operation: Run Mode and Program Mode. Run Mode is the normal operating mode. Program Mode permits configuration, calibration, and diagnostic testing (service).

Run Mode

At power on, on-board firmware performs a number of internal selftests and enters the default mode of operation, Run Mode. In Run Mode, the Operator Display can show date, time, BSOC, weight on forks, and (optionally) ambient temperature. For information on the Operator Display, see "Operator Display" on page 3-15.

Run Mode is also entered when the lift truck exits Program Mode.

Program Mode

Use Program Mode for configuration, calibration, and diagnostic testing of the lift truck. A password is required to enter Program Mode. See "Passwords".

Program Mode is divided into several categories:

- Serial Number
- Version
- WHLD (Weight Height Limit Display)
- Hour Meters
- Configure Mode
- Service Mode

Serial Number

The serial number recorded in firmware must match the serial number on the lift truck tractor and mast specification plates. This field cannot be changed from Program Mode.

Hour Meters and Distance Indicator

The Operator Display shows the following accumulated totals:

- KeyH: Total hours the key switch has been turned ON
- DdMan H: Total hours on deadman
- Lift H: Total hours spent lifting
- Total D: Total distance traveled (miles or kilometers, depending on Units specified in Config)

These accumulated totals cannot be changed from Program Mode.

You can also display hour meters and distance indicator in Run Mode by pressing dashboard button 0 on the Operator Display panel.

Configure Mode

Use Configure Mode to adjust various lift truck performance parameters to specific customer requirements. To enter Configure Mode, you must enter either the Password or SuperWord for the lift truck.

Some items in Configure Mode appear only if the SuperWord is entered.

For detailed description, see "Using Configure Mode" on page 3-19.

Service Mode

Use Service Mode to calibrate, test, cycle, and troubleshoot individual electrical circuits. Service Mode tests are divided into two categories: static and active.

Use the Learn Function to calibrate the lift truck for correct operation. You can select the following categories for calibration:

- Controls (travel, lift/lower)
- Weight

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To enter Learn Function, you must enter Service Mode. To enter Service Mode, you must enter the SuperWord.

For a detailed description, see "Using Service Mode" on page 3-28.

Passwords

For detailed description of how to enter passwords, see "Entering an Electronic Key, Password, or SuperWord" on page 3-18.

Electronic Operator Key

Electronic Operator Key is a configurable software feature that allows the customer to set an operator electronic key or operator password. When the operator turns the key switch ON, the software prompts the operator to enter the electronic key. The lift truck will not enter Run Mode unless the correct electronic key is entered. Up to 20 different electronic keys can be set.

Password

Password permits access to Configure Mode only. It is intended for customer use in setting performance parameters within those features purchased with the lift truck.

SuperWord

SuperWord permits access to all Program Modes. SuperWord is intended to limit service access to qualified and trained service technicians.

It is *strongly* recommended that, during installation, you change the SuperWord from the factory default to a code known only to the dealer and/or owner so that access to Service Mode is limited to approved personnel. Make sure to record the new SuperWord in a safe place. If this code is lost or forgotten, a technician must reset the lift truck to factory default settings. This makes the reconfiguration of all variable settings necessary.

Run Mode Tones

The lift truck signals various situations by using different tone patterns.

1. A single tone (chirp) occurs when the enter button is used to enter a value in a Program Mode.
2. A double tone (high/low) means the system has detected a fault condition. One of the PC contactors may be de-energized (open). Travel, lift/lower, and auxiliary functions are disabled.
3. A triple tone (high/medium/low) means one of the following:
   - Travel performance limitation: The lift truck is limited to a maximum travel speed of 1 MPH (1.6 km/h). Lift, lower, auxiliary functions, steering, and horn all operate normally.
   - Traction system shutdown: The lift truck is disabled for travel. Lift, lower, auxiliary functions, steering, and horn all operate normally.
   - Lift system shutdown: The lift truck is not permitted to lift. Lower, travel, steering, and auxiliary functions all operate normally.
4. A descending "arcade" tone means an incorrect password or electronic key was entered.

Entering Program Mode

To enter Program Mode:

From Run Mode, press the **enter** button on the Operator Display.

You will see an eight character password prompt field, displaying underscores:

_ _ _ _ _ _ _ _

Enter the Password or SuperWord for the lift truck. See "Entering a Password or SuperWord".

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Entering an Electronic Key, Password, or SuperWord

An Electronic Key, Password, or SuperWord may be from one to eight characters in length, having any combination of letters, numbers, and/or spaces (indicated by an underscore). A password of all spaces is not permitted.

NOTE: No two passwords (Electronic Key, Password, or SuperWord) may be set to the same value. If you try to do so, the lift truck will treat the second password as an invalid code and give an error message. Each password must be set to a unique value.

1. When the password prompt displays, an eight character field of underscores appears. Initially, the left-most character position is flashing, showing it is the currently selected position.
2. Use the **left/right** buttons to select a different character position. The selected position flashes.

NOTE: After approximately 3 seconds, the display prompt automatically increments to the next position to the right.

3. Once you select the character position, use the **up/down** buttons to select the number, letter, or space you want. The character set wraps between "0" and "-" (space). In other words, to go quickly from the number "0" to the letter "z," press the **up** button twice.

   0123456789
   abcdefghijklmnopqrstuvwyz-

NOTE: To enter numerical values, you can also use the dashboard keys 1 thru 0 on the Operator Display panel.

4. Repeat steps 2 and 3 for the remaining characters in the Password or SuperWord.
5. When you have completed entering all of the characters in the Password or SuperWord, press the **enter** button once.
6. If you enter an invalid Password or SuperWord, a descending "arcade" tone sounds and the following message appears on the Operator Display:

   Invalid, Try Again
7. If you make a mistake while entering a character, repeat steps 2 thru 5.

When you have entered the correct Password or SuperWord, the following is displayed:

▲Serial # ➡

Version

Hr Mtrs

▼Config

To change Password or SuperWord

1. Enter the Configure Mode using the current Password or SuperWord. See "Using Configure Mode" on page 3-19. If Password is entered, Password is available for change, but SuperWord is not.
2. Use the **up/down** buttons to scroll to Password. Press the **right** button.
3. Use the **up/down** buttons to scroll to the Password or SuperWord item.
4. With Password or SuperWord selected, press the **right** button. (If Password was entered in step 1 above, Password is available for change, but SuperWord is not.)
5. Enter the new password as specified under "Entering an Electronic Key, Password, or SuperWord".
6. With the new password displayed, press the **enter** button.
7. Save the new password as specified under "To Save New Values" on page 3-19.

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Using Configure Mode

Use Configure Mode to adjust various lift truck performance parameters to specific customer requirements. To enter Configure Mode, you must enter either the Password or SuperWord for the lift truck.

Some items in Configure Mode appear only if the SuperWord is entered.

"Program Mode Menu" on page 3-21 lists all possible lift truck configurations and options. If your lift truck does not have one or more of the listed options, those options do not appear in the Operator Display.

To Place the Lift Truck in Configure Mode

1. Enter Program Mode as described on page 3-17.
2. Enter Password or SuperWord as described on page 3-18.
3. The Operator Display shows:

   ▲Serial # ➡

   Version

   Hr Mtrs

   ▼Config
4. Press the **down** button until Config is displayed. Press the **right** button. The Operator Display shows:

   ▲Default ➡

   Travel

   Lift

   ▼BSOC

To Configure an Item

1. Use the **up/down** buttons to move to the item you want. An up (▲) or down (▼) arrow in front of an item indicates there are more items above or below that item.
2. Use the **up/down** buttons to move to the item you want.
3. To configure the selected item, press the **right** button. Follow the directions on the Operator Display. Use **up/down** buttons to select among specified values or to enter a numerical value. Use **right/left** buttons to move to lower/higher menu levels.

NOTE: To enter numerical values, you can also use the dashboard keys 1 thru 0 on the Operator Display panel.

When you have entered the values you want via the **up/down** buttons, press the **enter** button. The values are accepted and the Operator Display shows the name of the item you last selected.

NOTE: Changes are not saved until you exit Configure Mode and reply Save to the Restore/Save prompt.

To Configure Additional Items

After configuring the first item, press the left button. Navigate to the next item as specified under "To configure an item."

If You Make a Mistake

If you make a mistake in configuring an item, simply navigate back to that item and configure it again.

To Save New Values

Changes to configuration values are not saved until you exit Configuration Mode. If you have made changes to configured values:

1. Use the **left** button to back out of the menus.
2. The Operator Display shows:

   Restore

   Save
3. Use the **down** button to select Save. Press the **enter** button. Your new values are saved.

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NOTE: You will not be able to exit to the main menu until you have selected either Restore or Save and pressed the **enter** button.

4. Press the **left** button to back out to the main menu.

   ▲Serial # ➡

   Version

   Hr Mtrs

   ▼Config

5. Press the **left** button to exit to Run Mode. The lift truck enters the Run Mode. SelfTest is not re-run.

If You Change Your Mind About Making Changes

Changes to configuration values are not saved until you exit Configuration Mode. If you made configuration changes, but do not wish to keep the changes:

1. Use the **left** button to back out of the menus.
2. The Operator Display shows:

   Restore

   Save

3. With Restore selected, press the **enter** button. Your new values are discarded.

NOTE: You will not be able to exit to the main menu until you have selected either Restore or Save and pressed the **enter** button.

4. Press the **left** button to back out to the main menu.

   ▲Serial # ➡

   Version

   Hr Mtrs

   ▼Config

5. Press the **left** button to exit to Run Mode. The lift truck enters the Run Mode. SelfTest is not re-run.

To Reinstate Factory Default Settings

1. Enter Configure Mode and use the **down** button to select Default. Press the **right** button. The Operator Display shows:

   Def No

   Def Yes

2. Use the **up/down** buttons to select **Def Yes.** Press the **enter** button.

   Factory default values are restored for all items except:

   - Password
   - SuperWord
   - Electronic Key
   - Error Log
   - Emb Stats (VM Ver. 2.3+)
   - Switch 2H (VM Ver. 2.3+)
   - Lft Lmt (VM Ver. 2.3+)
   - M Lwr Spd (VM Ver. 2.3+)
   - Maximum Reach and Retract Speeds (VM Ver. 2.3+)

   The following factory default values are restored only if menu was entered from SuperWord:

   - BSOC
   - Lift Cutout
   - Travel Alarm

   The following functions are disabled:

   - *Mnt Mind*
   - *Auto Off*

3. Press the **left** button twice to select the main menu.
4. Press the **left** button to exit Program Mode and enter Run Mode.

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Program Mode Menu

Program Mode Menu			
	Note: Upper case value in **Values** column is the Factory Default. Among values displayed on Operator Display, the item with an asterisk (*) is the currently selected value.		
Group	**Item**	**Values**	**Description**
Lift Truck Identification			
	Serial #	SN _ _ _ _ _	Lift truck serial number. Cannot be changed.
	Version	VM xx.y DM xx.y PAT xx.y PAP xx.y VMB xx.y	Lift truck firmware versions. Cannot be changed. Vehicle Manager Display Manager Traction Power Amplifier Lift Power Amplifier VM Bootblock
	WHLD Cfg	Weight 1 xxxx lb Height 1 xxx in . Weight 2 xxxx lb Height 2 xxx in ... Weight 6 xxxx lb Height 6 xxx in	Weight Height Limit Display configuration table. Values for weights and heights are factory-configured and not editable. (Available with VM Ver 3.7+)
	Hr Mtrs	Key H DdMan H Lift H Total D	Display hour meters. Cannot be changed. Key Switch Hours Deadman Hours Lift Hours Traction Distance (mi./km) **Note:** You can also display hour meters by pressing the number 0 dashboard button on the Operator Display.

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Program Mode Menu			
	Note: Upper case value in **Values** column is the Factory Default. Among values displayed on Operator Display, the item with an asterisk (*) is the currently selected value.		
Group	**Item**	**Values**	**Description**
Config Mode Menu			
Default		Def No Def Yes	Do not restore factory default settings. Restore factory values to all settings except: Password and SuperWord Electronic Key Error Log, Emb Stats Lft Lmt Height, M Lwr Spd Max Reach & Retract Speeds Switch 2H Disable: Mnt Mind and *Auto Power Off* Restore factory values only if menu was entered from SuperWord: BSOC, Lift Cutout Travel Alarm
Travel	Speed	7.5	Maximum Travel Speed (depends on model) 0.0 to 8.0 mph (0.0 to 12.8 km/h) (8.0 mph with 7600 High Performance Option)
	T Accel	Soft MEDIUM Hard	Travel Acceleration
	Coast	LONG Medium Short	Coast Distance after releasing directional/speed control
	Switch 1	3.5 [default]	Travel Speed Limit at Height 1 0 to 3.5 mph (0 to 5.6 km/h)
	Switch 2 (option)	1.8 [default]	Travel Speed Limit at Height 2 0 to 1.8 mph (0 to 2.9 km/h)
	Switch 2H (*Superword only*)	OACH [default]	Height at which speed is reduced to Switch 2 configured value. Range - overall collapsed height to maximum elevated height Default = overall collapsed height
	UnNested (option)	3.5 [default]	Travel Speed Limit with Reach Extended 0 to 3.5 mph (0 to 5.6 km/h)
	AlarmT (option) (*Superword only*)	None Fork Ld Fork Trl BOTH	Travel Alarm enabled for forks leading, forks trailing, both directions, or not enabled.

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Program Mode Menu			
	Note: Upper case value in **Values** column is the Factory Default. Among values displayed on Operator Display, the item with an asterisk (*) is the currently selected value.		
Group	**Item**	**Values**	**Description**
Lift	L Accel	Soft Medium HARD	Lift Acceleration
	L Decel	Soft Medium HARD	Lift Deceleration at end of lift
	Lwr Accel	Soft Medium HARD	Lower Acceleration
	Lwr Decel	Soft Medium HARD	Lower Deceleration at end of lower
	M LwrSpd (*Superword only*)	70% to 80% [typical]	Maximum Lower Speed. Factory-set to the original proportional valve installed. 50% (slowest) to 100% (fastest)
	Lft Lmt (*Superword only*)	STD BYP Alt Byp No Byp Lim Hgt	To bypass limit or continue past limit, press and hold Up arrow on Operator Display. To bypass or continue past limit, press and release Up arrow on Operator Display. No bypass even if Up arrow is pressed. Height at which limit cuts out. See Lft Lmt.
BSOC (*Superword only*)			Reset by Config Default only when invoked from SuperWord. Cannot be reset by FlashWare.
	BSOC	75% [default]	The percentage of charge that a new battery must exceed in order for the BSOC display to reset to the new battery. For an explanation of how BSOC is calculated, see "Battery State-of-Charge" on page 5-10. 55% to 100%
	Lift c/o	20% [default]	Battery State-of-Charge value at which Lift Cutout occurs (to permit lift truck to travel to charging station). 0 to 50%
Units		ENGLISH Metric	Measurement units used in display

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Program Mode Menu			
	Note: Upper case value in **Values** column is the Factory Default. Among values displayed on Operator Display, the item with an asterisk (*) is the currently selected value.		
Group	**Item**	**Values**	**Description**
Carriage	Reach	1-Spd 2-SPD	Reach Speed
	MaxHiRch (*Superword only*)	100% [default]	Maximum High Reach Speed Value 0% to 100%
	MaxHiRtr (*Superword only*)	75% [default]	Maximum High Retract Speed Value 0% to 100%
	MaxLoRch (*Superword only*)	40% [default]	Maximum Low Reach Speed Value 0% to 100%
	MaxLoRtr (*Superword only*)	40% [default]	Maximum Low Retract Speed Value 0% to 100%
	Rch Spd . . . . . .High	S * ** *** **** ***** F	High Reach Speed
	Rch Spd . . . . . .Low	S * ** *** **** ***** F	Low Reach Speed
	Rtr Spd . . . . . .High	S * ** *** **** ***** F	High Retract Speed
	Rtr Spd . . . . . .Low	S * ** *** **** ***** F	Low Retract Speed

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Program Mode Menu			
	Note: Upper case value in **Values** column is the Factory Default. Among values displayed on Operator Display, the item with an asterisk (*) is the currently selected value.		
Group	**Item**	**Values**	**Description**
Password	Elec Key (option) (*Superword only*)	_ _ _ _ _ _ _ _	Electronic Key prompt. Up to 20 different keys permitted. **Note:** No two passwords (Electronic Key, Password, SuperWord) may be set to the same value. If you try to do so, the lift truck will treat the second password as an invalid code and give an error message. Each password must be set to a unique value.
	Password	_ _ _ _ _ _ _ _	Change Password. See note under Electronic Key.
	Superwrd (*Superword only*)	_ _ _ _ _ _ _ _	Change SuperWord. See note under Electronic Key.
Embedded Statistics (option)	View ES		Display embedded statistics.
	Interval	Daily Weekly Monthly	Set interval
	Clear ES	NO Yes	Do not clear statistics. Clear statistics log.
Mnt Mind	Status Reset Action . . . . MSG ONLY . . . . L CutOut Interval . . . . 250 [default]	 DISABLE Enable	Maintenance Minder ™ tool Disables the feature (when enabled) Enables the feature, using last stored setup Resets internal timer to current deadman pedal hours (restarts the countdown) Action to be taken at specified interval . . .Display message but do not disable lift . . .Disable lift Set reminder interval from 50 to 500 hours on deadman pedal, by one hour increments. Default is initially 250. **Note:** Action and Interval cannot be reset by Config Default or by FlashWare. See "Maintenance Minder™ Tool" on page 4-3.
Auto Off		0 1 .. 10	*Auto Power Off* device 0 (Disabled), 1, 2, 3, 4, 5, 10 minutes **Note:** ***Auto Power Off*** shuts down a lift truck only when the lift truck is in Run Mode.
Clock	 Time Date 24 hr	 hh:mm a/p mm/dd/yy DISABLED Enabled	Set Time and Date **Note:** Holding Up or Down button changes value faster. 12-hour format (1 PM = 01:00) 24-hour format (1 PM = 13:00)

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Program Mode Menu			
	Note: Upper case value in **Values** column is the Factory Default. Among values displayed on Operator Display, the item with an asterisk (*) is the currently selected value.		
Group	**Item**	**Values**	**Description**
ES Mode		DISABLE Minimum Maximum	Energy Saving Mode is disabled. Minimum Energy Saving Mode is achieved by slightly reducing maximum lift speed. Maximum Energy Saving Mode is achieved by reducing maximum lift speed.
WHLD		 Two Ln H Two Ln W Toggle Fixed	Weight Height Limit Display format (VM Ver 3.7+) Show height, use left and right buttons to change to 2-line height and weight. Show height and weight, use left and right buttons to change to 1-line height. Display toggles automatically between 1-line height and 1-line weight. Use left and right buttons to toggle between 1-line height and 1-line weight.
VH Cfg		xxx nnn	Vertical Hold Configuration 1- to 3-character alphanumeric label, followed by 3-character numeric height (minimum is OACH plus 12 in. or 30 cm)
Quit Cfg		Restore Save	Quit Configuration Mode without saving changes. Quit Configuration Mode after saving changes.

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Program Mode Menu			
	Note: Upper case value in **Values** column is the Factory Default. Among values displayed on Operator Display, the item with an asterisk (*) is the currently selected value.		
Group	**Item**	**Values**	**Description**
Service Mode *(Superword only)*			
Learn			
	Controls		Operator Display message scrolls: "Learning" "Return Handle Controls to Neutral, Press Horn Button." "Lower Carriage to Floor, Press Horn Button When Done." "Done"
	Weight		Operator Display message scrolls: "Learning" "Lower Carriage to Floor, Then Lift 4 Inches, Press Horn Button When Done." "Raise Carriage Out of Free Lift, Press Horn Button When Done"
Analog	A04 Tra Pot ... A41 EPO Sns	1.13 V ...	Use Up and Down buttons to scroll through list of Analog Tests. Test shows real time value.
Input	I00 Dman Sw ... I60 Start Sw	Down/Up ... Open	Use Up and Down buttons to scroll through list of Input Tests. Test shows real time value.
Output	O00 TPC Tgl ... O34 Htr En	Off/On ... Off/On	Operator Display message scrolls: "WARNING...Jack Up the Drive Wheel, Press Enter When Ready." Use Up and Down buttons to scroll through list of Output Tests. Test shows real time value. Use Enter button to toggle test.
Clr Act		Clr No Clr Yes	This item appears only if tests have been selected for active service. Do not clear active service tests. Clear active service tests.
Log		"No errors in log" "Date Time Code BSOC"	Log holds up to 20 errors in order of occurrence. BSOC is normalized to Lift Cutout = 0%.
Clr Log		Clr No Clr Yes	Retain error log entries. Clear error log entries.
LB Test		Analog Input	See "Loop Back Tests" on page 6-117.

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Using Service Mode

Service Mode is divided into two categories: static and active.

Static Service Mode

Static Service Mode permits testing of individual circuits while the lift truck is standing still. You can use Static Service Mode for most analog and digital input and digital output tests.

⚠ WARNING

By entering Static Service Mode, you are disabling the safety circuits. Therefore, you must take extra precautions while in Static Service Mode. Follow all instructions in this manual for each test. If you are unsure how to conduct a test while in Service Mode, *Stop: Do Not Proceed* with the test. Contact an authorized Raymond dealer.

While in Static Service Mode elevate the drive tire off the floor. See "Jacking Safety" on page 2-8.

To Place the Lift Truck in Static Service Mode

1. Press the **enter** button to enter Program Mode.
2. Enter the SuperWord and press **enter**.
3. Use the **up/down** buttons to select Service, then press the **right** button.
4. You can select the following from Service Mode:

   Learn

   Analog

   Input

   Output

   Clr Act (only if tests are selected for Active Service)

   Log

   Clr Log

   Use the **up/down** buttons to select the test category desired, then press the **right** button.
5. If you select Output tests, the Operator Display scrolls this warning:

   WARNING: Jack Up The Drive Wheel, Press Enter When Ready...

   After you jack up and block the lift truck, respond to the Ready prompt by pressing the **enter** button.
6. Within a test category, test numbers are displayed in numerical sequence. Use the **up/down** buttons to move to the test you want.
7. Analog and Input test results are displayed to the right of the test number as soon as you select the test. For example, Test A04 might show:

   A04 Tra Pot 1.10 V
8. You must explicitly start output tests. Select the test number you want by scrolling and highlighting the test.

   O01 STR Tgl Off

   Press the **enter** button. The Operator Display shows the test results to the right of the test number.

   O01 STR Tgl On

   Use the **enter** button to toggle the test.

   O01 STR Tgl Off

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To exit output test, press the **left** button.

9. The Error Log stores the last twenty error codes recorded on the lift truck. Entries are stored in order of occurrence, with the most recent error first.
10. To access the Error Log, use the **up/down** buttons to select Log, then press the **right** button.
11. If no errors are stored, the message “No Errors in Log” appears in the display.
12. If errors have been logged, use the **up/down** buttons to scroll through the list.
13. To clear the log, use the **up/down** buttons to scroll to Clr Log. Press the **right** button. Scroll to Clr Yes and press the **enter** button.

Active Service Mode

Active Service Mode permits testing circuits while the lift truck is enabled for normal operation. You can use Active Service Mode for all analog and digital input tests.

You can select up to eight tests at a time to run in Active Service Mode. Tests can be displayed whether you are on or off the deadman pedal.

Tests selected for Active Service are stored in memory even if the key switch is turned OFF.

To Enable a Test For Active Service Mode

1. Enter Static Service Mode.
2. Scroll to the test you want. Press one of the **dashboard buttons** 1 thru 8 on the Operator Display. The button number appears to the left of the test number in the test list to show that this test is selected for Active Service Mode.
3. Assigning a test to a particular dashboard button resets any previous assignment for that button.
4. Use the **up/down** buttons to select more tests from the same category. To select more tests from a different category, exit the current category and select the other category from the Service menu. Use the **up/down** buttons and remaining **dashboard buttons** to select more tests from that category.
5. Quit Service Mode and Program Mode. Let the lift truck enter Run Mode.
6. To display Active Service tests while in Run Mode, press **dashboard button 9**. Four tests will display at a time. Use the **up/down** buttons to scroll through the list of selected tests.

To Clear All Active Maintenance Tests At Once

1. Go to Program Mode.
2. Use the **up/down** buttons to select Service, then press the right button.
3. Use the **up/down** buttons to select Clr Act. This item only appears if you have selected one or more tests for active service.
4. Press the **enter** button. Active service tests are cleared. Exit Service Mode and Program Mode.

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Section 4. Scheduled Maintenance



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Maintenance Guidelines

Following a regularly scheduled maintenance program:

- Promotes maximum lift truck performance
- Prolongs maximum lift truck life
- Reduces costly down time
- Prevents unnecessary repairs

Scheduled maintenance includes:

- Lubrication
- Cleaning
- Inspection
- Service

Perform all the scheduled inspections and maintenance at the suggested intervals. The time intervals given in this guide are based on deadman hours under normal operating conditions. When operating under severe or extreme conditions, do these services more often as specified in Table 4-1.

Table 4-1. Maintenance Frequency

Operating Conditions	Working Environment	Service Frequency
Light to Moderate	An eight hour day of basic material handling	180 days or 500 hours, whichever comes first
Severe	• Extended heavy duty operation • Freezer operation • Sudden temperature changes such as going from freezer to room temperature	250 hours
Extreme	• All UL Type EE rated lift trucks • Dusty or sandy conditions such as in cement plants, lumber or flour mills, coal dust or stone-crushing areas • High temperature areas such as in steel mills, foundries, enclosed (Type EE) applications • Corrosive atmosphere such as chlorine or salt-sea air environments	100 hours

See "Lubrication Specification Chart" on page A-2 in the Appendix for lubrication specifications. Refer to the manufacturer's supplements for components not listed on the following pages.

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Maintenance Minder™ Tool

Maintenance Minder Tool is a feature that permits prompting of a customer when the lift truck is due for scheduled maintenance.

Maintenance Minder, when configured and enabled, monitors the Hours on Deadman (HD) meter. When the time interval for scheduled maintenance is exceeded, the operator is informed in the following ways:

- One of two messages appears on the Operator Display following the "Daily Checklist" message.
  - "Scheduled Maintenance Due"
  - "Lift Cutout, Scheduled Maintenance Due"
- A wrench icon flashes
- The audible alarm sounds the high-low tone for approximately 5 seconds.

Lift Cutout, when active, will not disable the lift function until power to the control circuits is cycled (key switch OFF or battery disconnected). When control circuit power is cycled, lift is disabled until *Maintenance Minder* is reset or disabled, or the lift cutout option is turned OFF.

Factory Configuration

For field installations, this feature must be added to the configuration options via the FlashWare program. The factory default is Disable.

Maintenance Minder settings are not changed by resetting Defaults in the Config menu.

Enabling

Once installed, *Maintenance Minder* appears in the Configure Mode menu. The initial factory setting is "Disable." To enable the feature, enter Configure Mode.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 3-16.

With Configuration Mode selected, use the **down** button to display the "Mnt Mind" item. Press the **right** button. With "Status" highlighted, press the **right** button. Use the **down** button to select "Enable." Press the **enter** button. *Maintenance Minder* is enabled with the last stored time interval and action option.

Exit program mode as described under "Exiting Program Mode" on page 4-4.

Setting or Changing Time Interval and Action Option

With Configuration Mode selected, use the **down** button to display the "Mnt Mind" item. Press the **right** button. Use the **down** button to select "Setup." Press the **right** button.

Use the **up/down** buttons to scroll to "Interval." Press the **right** button. The first time you enter the time interval menu, the Operator Display shows the Factory Suggested setting. When the time interval menu is entered, the Operator Display shows the last used setting. Values from 50 to 500 deadman pedal hours are available. Press the **right** button. Use the **up/down** buttons to scroll to the desired time interval. With the selected value displayed, press the **enter** button. Press the **left** button to return to the Setup menu.

Use the **up/down** buttons to select "Action." Then press the **right** button. The following options are available:

- "Msg Only" causes the Operator Display to show "Scheduled Maintenance Due" when the scheduled maintenance time interval is exceeded.
- "L Cut Out" causes the Operator Display to show "Lift Cut Out, Scheduled Maintenance Due" when the scheduled maintenance time interval is exceeded. Lift is disabled the next time the power circuits are cycled.

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Use the **up/down** buttons to select the option you want, then press the **enter** button.

Exit Program Mode as described under "Exiting Program Mode".

Resetting *Maintenance Minder*™

If you want to reset the reminder prompt when *Maintenance Minder* is active and you have completed scheduled maintenance, enter Configure Mode.

With Configuration Mode selected, use the **down** button to display the "Mnt Mind" item. Press the **right** button. Use the **down** button to select "Setup." Press the **right** button.

With "Reset" highlighted, press the **right** button. Use the **down** button to scroll to "Yes." Press the **enter** button.

Exit Program Mode as described under "Exiting Program Mode".

Disabling

When *Maintenance Minder* is active and you want to disable it, enter Configure Mode.

With Configuration Mode selected, use the **down** button to display the "Mnt Mind" item. Press the **right** button. With "Status" highlighted, press the **right** button. Use the **up** button to select "Disable." Press the **enter** button.

Exit Program Mode as described under "Exiting Program Mode".

Exiting Program Mode

1. Use the **left** button to back out of the menus.
2. The Operator Display shows:

   Restore

   Save

3. Use the **down** button to select Save. Press the **enter** button. Your new values are saved.

NOTE: You will not be able to exit to the main menu until you have selected either Restore or Save and pressed the **enter** button.

4. Press the left button to back out to the main menu.

   ▲Serial # ➠

   Version

   Hr Mtrs

   ▼Config

   Press the **left** button to exit to Run Mode. The lift truck enters the Run Mode.

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Initial 90 Day/250 Deadman Hours (HD) Maintenance

Perform the following maintenance tasks 90 days after the lift truck was put into service or at 250 HD, whichever comes first.	
Component	**Task**
Drive Unit	Break free, reapply thread-locking compound (P/N 990-544), and retorque mounting bolts to 150 ft. lb. (204 Nm). Change fluid.
Hydraulic Reservoir and Manifold	Change fluid and filter(s). See "Hydraulic Filter" on page 7-75 and "Lubrication Specification Chart" on page A-2.
Mast	Break mast to tractor mounting bolts free. Clean threads, reapply primer (P/N 990-666) and thread-locking compound (P/N 990-544). Re-torque mounting bolts to 165 ft. lb. (224 Nm).
Power Amplifiers	Retorque power cable terminal nuts to 11 ft. lb. (15 Nm).

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Every 180 Days or 500 HD

Perform the following maintenance tasks every 180 days or 500 HD, whichever comes first.	
Component	**Task**
Battery	Check the weight stamped on the battery in the lift truck against the minimum and maximum allowable weights on the spec tag for the lift truck. Report any lift trucks that are running with batteries under the minimum or over the maximum allowable weight. Inspect all battery connectors and leads for damage and cuts in protective coatings. Make sure the battery gates are in place and not damaged. Make sure the battery has no more than 0.5 in. (13 mm) free play in any direction.
Brake	In a open area, measure stopping distance. Traveling at 2 to 3 mph (3.2 to 4.8 km/hr) empty, push the EPO switch; the empty lift truck should stop within 2 to 4 feet (0.6 to 1.2 m). During normal operation, with a rated load and traveling at top speed, the lift truck should stop within approx one and one-half truck lengths. Stopping distance depends on the load, floor, and tire conditions. Examine for signs of oil on the pads or rotor. If oil is present, disassemble brake, clean rotor, and replace pads. Measure for correct air gap between armature and armature plate: 0.040 in. (1 mm) max. See “Brake” on page 7-50. Failure to keep brakes adjusted causes premature pad and rotor wear and excessive motor heat.
Caster Wheel	Examine for bond failure, chunking, and excessive or uneven wear. Inspect bearings for binding or excessive play. Check adjustment of caster wheel.
Contactors	Inspect contactor tips for burnt or pitted surfaces. Failure to replace the tips can cause surfaces to weld together, causing unscheduled down time. With the key switch OFF and the battery disconnected, examine the plunger for smooth operation with no binding. If binding occurs, the lift truck could malfunction or display intermittent fault codes.
Control Handle(s)	Verify lift/lower function is smooth and controllable. Verify travel function is smooth and responsive through full range of motion. Check for play in the center position of lift or travel control; repair/replace control handle if necessary. Verify no codes on display. Verify function of all switches. Make sure nylon insert is in the lift knob set screw hole.
Cylinders	Check free lift cylinder piston position. With forks completely lowered, make sure one piston is not higher than the other.
Deadman Pedal	The deadman pedals must operate smoothly with no binding. Check for correct activation and deactivation of the deadman switch under the pedal.
Drain Holes	Make sure the drain holes in the battery compartment are free of any debris.
Drive Unit	Check oil level. Inspect for leaks. Make sure O-ring is present on the dipstick. Check drive axle for play. Examine for drive unit radial ring wear (7600/7620). See “Radial Ring Inspection” on page 7-37.

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Perform the following maintenance tasks every 180 days or 500 HD, whichever comes first.	
Component	**Task**
Electrical Cables	Inspect all power cables for nicks or cuts. Give special attention to those cables that are not stationary, for example, cables to the Traction Motor. Replace any cable that is damaged or shows signs of excessive heat. Failure to do so causes intermittent system shutdowns and/or electronic failures. Check the tension of the over-the-mast cables. Set the tension on the spring at the carriage by sliding the cable grip to produce a length of 1.75 ±0.12 in. (44.5 ±3.0 mm) across the coils. Do not over tension. Tighten the cable tie on the cable grip.
Fans	Check for correct operation. Run "Test O23 - Toggle Fans" on page 6-112.
Forks	Check fork mounting surfaces for wear. Make sure fork positioning lock is working correctly. Examine for excessive wear, bends, cracks, welding arcs, excessive heat, or unauthorized modifications. Replace if found. Measure fork thickness (Tool P/N 922-369). See "Fork Inspection" on page 4-17.
Frame and Baselegs	Perform a visual inspection of structural members for cracks, including but not limited to baselegs, main frame, and tractor.
Hardware	Check bolt torque of major components (motors, pumps, brake, drive unit, mast-to-tractor mounting bolts, overhead guard). Tighten any loose hardware. Replace any broken or missing hardware. See "Appendix".
Horn	Make sure horn sounds correctly when activated.
Hydraulic Hoses	Inspect all hydraulic hoses for leaks, nicks, cut, chafing, and bulges. Replace damaged hoses as soon as possible. Inspect all fittings for leaks. Repair any leaks immediately. Inspect over-the-mast hoses for correct tension. Make sure over-the-mast hose pulleys spin freely and show no signs of wear.
Hydraulic Reservoir	Check fluid level.
Lift Chains	Check adjustment. Inspect for excessive stretch or wear (tool P/N 950-350/CG). Lubricate. See "Chain Maintenance" on page 4-16.
Lubrication	Lubricate all grease points. See "Lubrication Points" on page 4-10.
Mast	Wipe old grease off mast uprights and apply new grease. Inspect anti-rattle pads and anti-bow pads (*7600 only*). Anti-bow pad minimum thickness is 0.187 in. (4.75 mm) and correct gap is 0.03 to 0.09 in. (0.8 to 2.3 mm). Examine mast bearings. Inspect carriage stops for tightness and wear. Inspect the outside of the main frame for wear, especially if the lift truck is used in drive-in racks. Inspect rails for abnormal wear, metal flakes, or shavings. Repair any grooves worn in the mast deeper than 1/8 in. (3 mm).

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Every 180 Days or 500 HD

Perform the following maintenance tasks every 180 days or 500 HD, whichever comes first.	
Component	**Task**
Motors	**AC** - Check the cable lugs to make sure they are tight to the terminal studs. Both the inside and outside nut should be torqued to the values listed. Replace any cable that shows signs of excessive heat. Check sensor wires for sound connection and condition. Blow out the inside of the motor with compressed air.
	DC - Inspect commutator. Inspect brushes for excessive heat (discoloration of the pigtails). If excessive heat is evident, inspect the armature circuit for loose connections. Check condition of commutator per photos on page 5-6. Inspect the brush for even wear over the full surface of the brush. If the brush is not contacting the complete surface, replace the brushes. Inspect the brush rigging for damage or loose brush holders. Make sure that the connections on the brush leads are tight. Check brush spring tension. Blow out the inside of the motor with compressed air. Blow out impeller and cooling fins. Check the cable lugs to make sure they are tight to the terminal studs. Torque both the inside and outside nut to the values listed. Replace any cable that shows signs of excessive heat. Check sensor wires for sound connection and condition.
Overhead Guard	Inspect guard for physical damage. If structurally damaged, replace the guard.
Power Amplifiers	Make sure power amplifier heatsink fins are free of debris and that air flows freely through them. Check torque of power cable hardware.
Shorts to Frame	Check for electrical shorts to frame. See “Shorts to Frame” on page 5-2. Wipe compartments clean.
Static Straps	Make sure static straps are not worn or broken. Clean debris from straps. Check resistance of resistor in standoff. EE trucks require a phosphor bronze static strap; do not use steel braided cable on EE trucks.
Steering	Check that steering system function is smooth and responsive. Inspect pivot points and bearings in the steering linkage. Inspect teeth on the steering gear and drive unit for wear. Check adjustment of the steerable caster. See “Steerable Caster” on page 7-22. Lubricate the steer axle assembly. Make sure steering is smooth and responsive, without binding or excess play. Refer to “Steering Encoder” on page 7-20. Check the gap on the steer limit switch (S11). See “Steer Limit Switch (S11)” on page 7-21.
Switches	Check all switches for correct operation and adjust as needed. See “Component Specific Service/Torque Chart” on page A-4.
Ventilation Slots	Make sure ventilation slots in the tractor frame are open, with no obstructions or debris.
Warning Decals	Replace any illegible or damaged decals.
Warning Lights	Check for correct operation.
Wheels/Tires	Examine for bond failure, chunking, and excessive or uneven wear. Inspect load wheel bearings for binding or excessive play. Inspect drive axle and idler axle for excessive play.

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Every 360 Days or 2000 HD

Perform the following maintenance tasks every 360 days or 2000 HD, whichever comes first.	
Component	**Task**
Drive Unit	Change fluid.
Hydraulic Reservoir and Manifold	Change hydraulic fluid and filter. Filter is located in main manifold.
Lift Pump Coupling	Separate pump and motor. Apply molybdenum anti-seize compound (P/N 990-638) to the splines.

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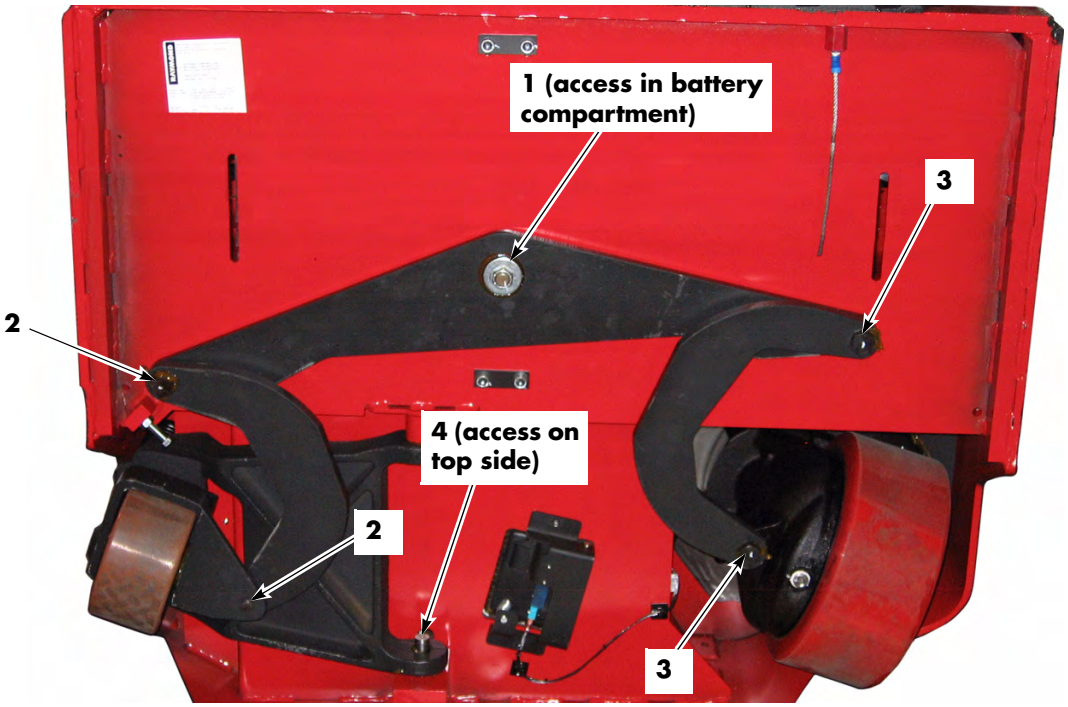
Lubrication Points

NOTE: Locate items by numbers on the photos that follow this list:

1. Steering linkage arm, pivot point
2. Steering linkage, steerable idler arm
3. Steering linkage, drive wheel arm
4. A-frame pivot bolts
5. Idler wheel bearing
6. Idler wheel axle
7. Drive unit radial rings and steer gear
8. Scissors mechanism
9. Reach cylinder
10. Inner telescopic channels (left and right, both sides)
11. Lift chains (spray)
12. Sideshift carriage
13. Load Wheels

Lubrication Point Locator Photos

Figure 4-1. Lubrication Points, Steering Linkage and A-frame (underside view)



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Figure 4-2. Lubrication Points, Steering Linkage and A-frame (top views)

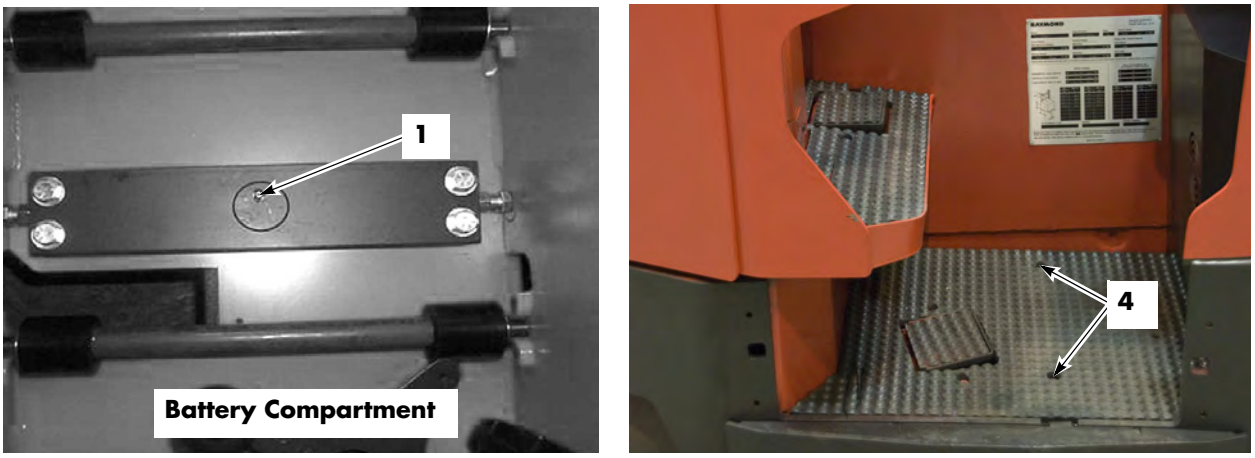


Figure 4-3. Lubrication Points, Idler Wheel bearing and axle

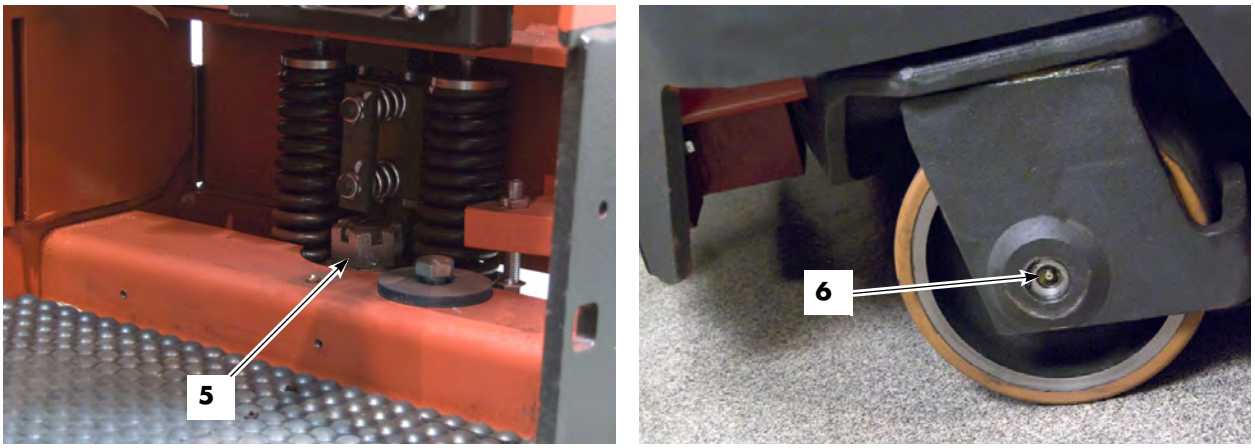
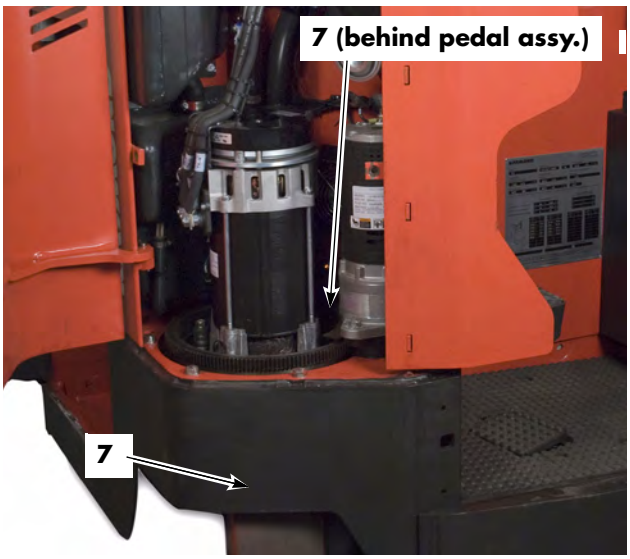


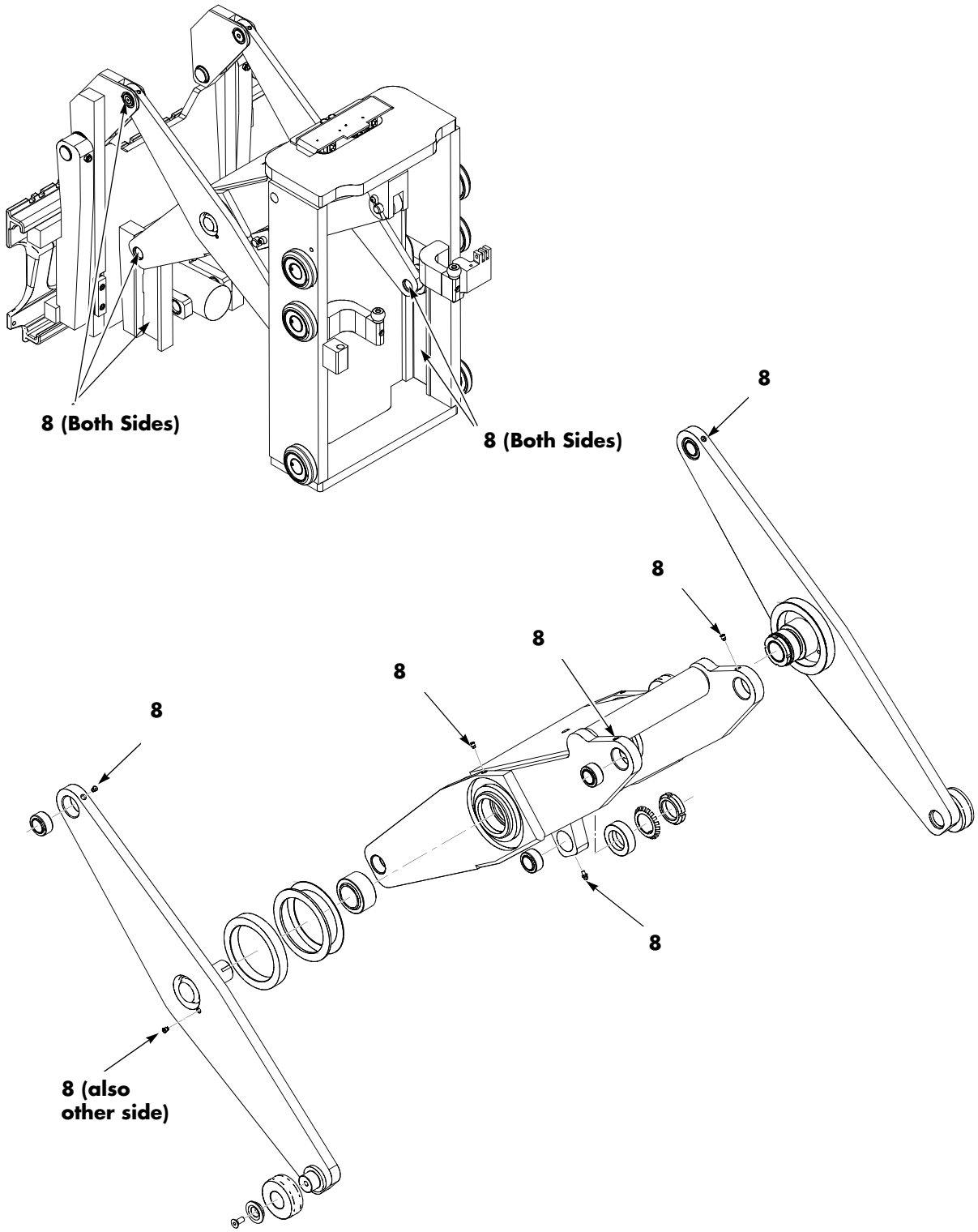
Figure 4-4. Lubrication Points, Drive Unit



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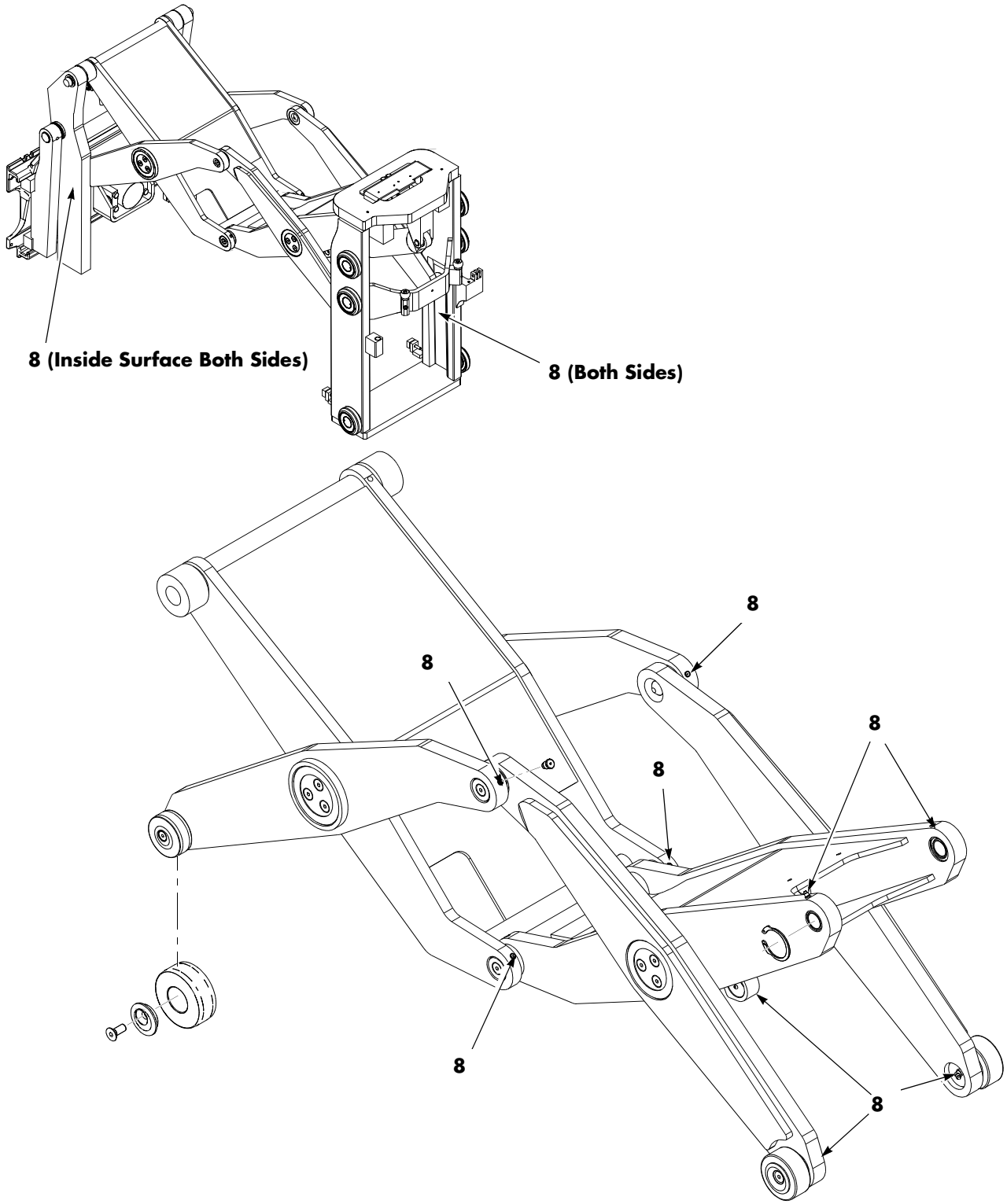
Lubrication Points

Figure 4-5. Lubrication Points, Scissor Mechanism R45TT



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Figure 4-6. Lubrication Points, Scissor Mechanism DR32TT



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Lubrication Points

Figure 4-7. Lubrication Points, Reach Cylinder

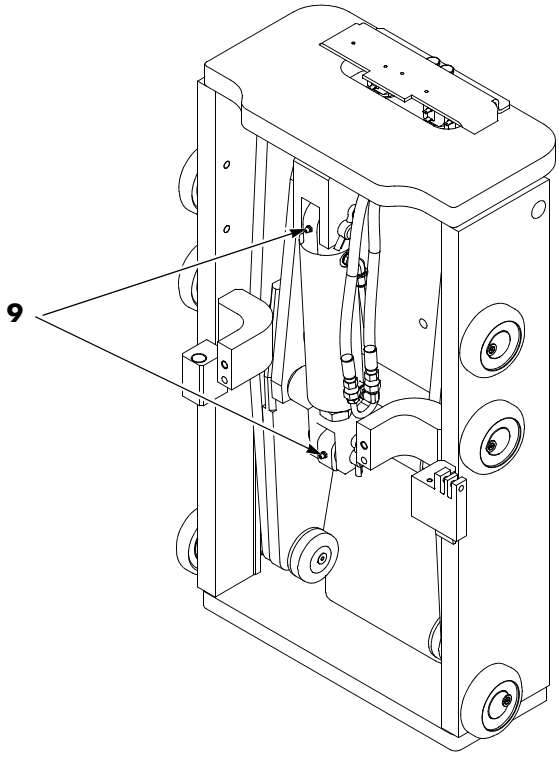
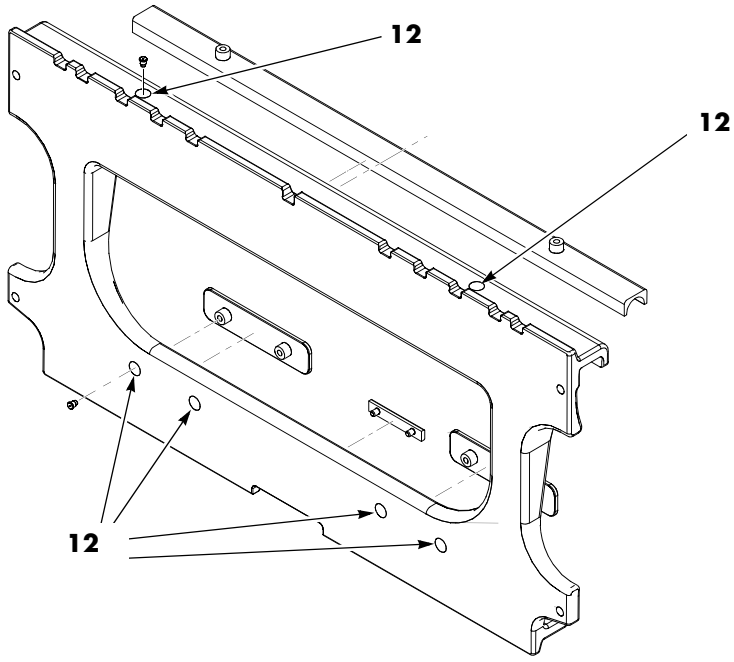
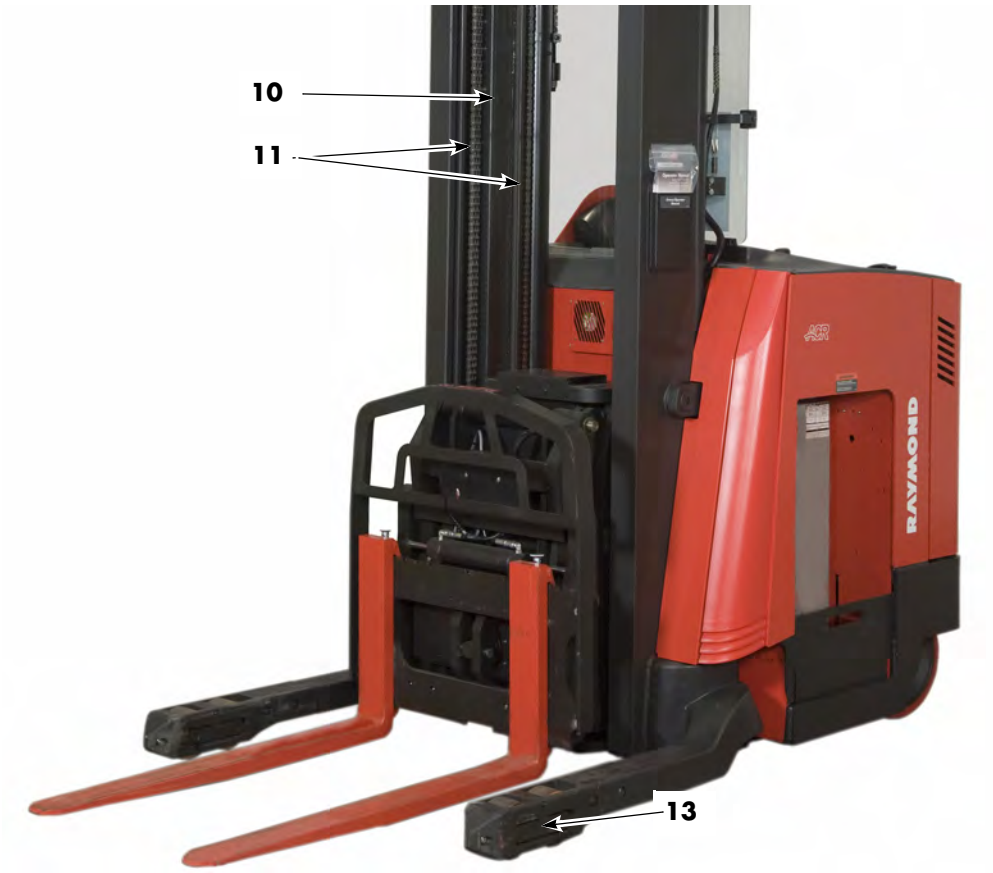


Figure 4-8. Lubrication Points, Sideshift Carriage



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Figure 4-9. Lubrication Points, Mast and Carriage



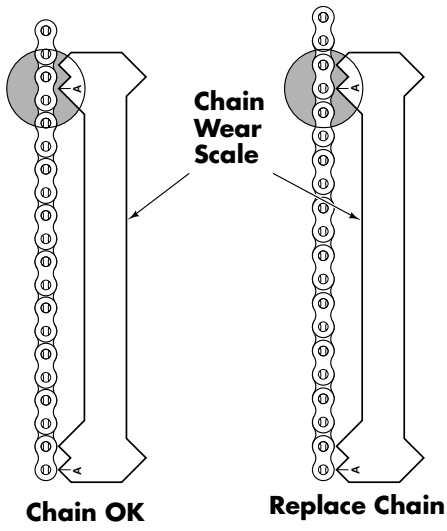
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Chain Maintenance

Lift Chain Inspection

Make sure chains are not damaged. Check the chain for wear using a Chain Gauge (P/N 950-350/CG). See Figure 4-10.

Figure 4-10. Chain Gauge



Replace chains with genuine *Raymond* spare parts. See "Lift Chains" on page 7-70.

Condition-Cause Chart

Condition	Cause	Maintenance Procedure
Chain Elongation	Wear	Use a chain gauge or lay the chain on a flat surface and push it together. Measure and mark a 12 in. (305 mm) length that has operated over the pulley sheave. Stretch the chain; if more than 1/3 in. (8.5 mm) play is detected, replace the chain.
Rust and corrosion	Steam cleaning or degreasing new lift truck chains	Lubricate chain frequently.
Cracked Plates	Infrequent Oiling	Replace the chain.
	Rust	
	Corrosion	
	Chain Fatigue	
Tight Joints	Bent pins or plates	Replace the chain.
	Rusty joints or peened plate edges	Replace the chain.
Chain side wear	Chain misalignment	Replace the chain.

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Fork Inspection

The following tools are required to perform fork inspection:

- Fork Wear Caliper (P/N 922-369)
- Tape Measure or ruler
- 24 in. Framing Square
- 4 ft. Level

Do the following when performing Scheduled Maintenance.

Surface Inspection

Remove the forks from the carriage. Visually inspect all fork surfaces for signs of damage, including, but not limited to:

- cracks
- excessive wear
- excessive heat
- deformation
- unauthorized modifications

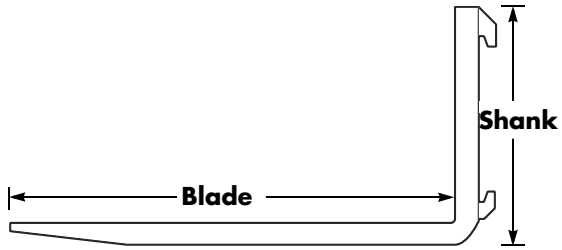
Pay special attention to the heel and welds attaching mounting components. If any damage is found, remove the fork from service.

Straightness of Blade and Shank

NOTE: This measurement can be done with the forks on or removed from the carriage.

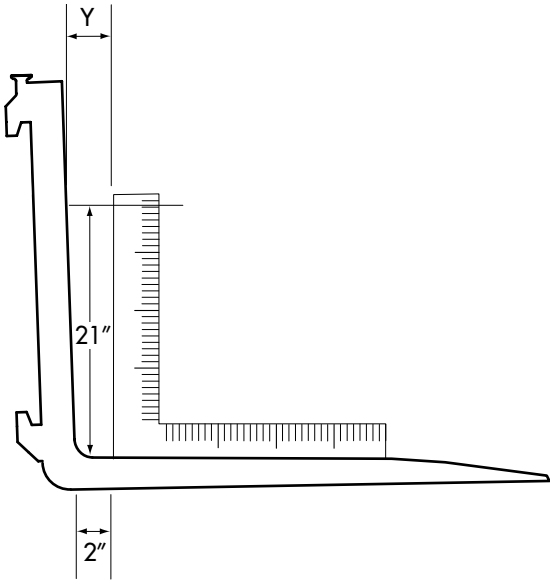
1. Measure the length of the blade and the height of the shank. See Figure 4-11.

Figure 4-11. Measuring Fork Blade and Shank



2. Multiply these numbers by 0.5%. The smallest number is your maximum deviation.
   - *Length of blade* _____ x 0.5% = _____
   - *Height of shank* _____ x 0.5% = _____
3. Place a 24 in. framing square on the blade of the fork, 2 in. away from the heel of the fork. See Figure 4-12.
4. At 21 in., measure the distance between the face of the shank and the framing square. See Figure 4-12.

Figure 4-12. Fork Measurement with Framing Square



5. Compare this measurement to the smallest maximum deviation number determined in step 2.
6. If the maximum deviation number is exceeded, remove the fork from service.

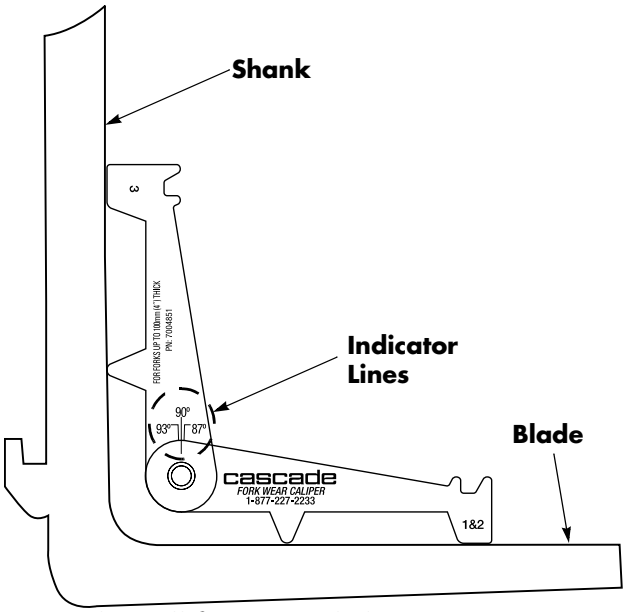
Fork Angle

NOTE: This measurement can be done with the forks on or removed from the carriage.

1. Place the fork caliper on the blade. Make sure that the two extruded points are touching the blade of the fork. See Figure 4-13.
2. Now open and move the caliper so the two extruded points are touching the shank. See Figure 4-13.

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Figure 4-13. Fork Angle



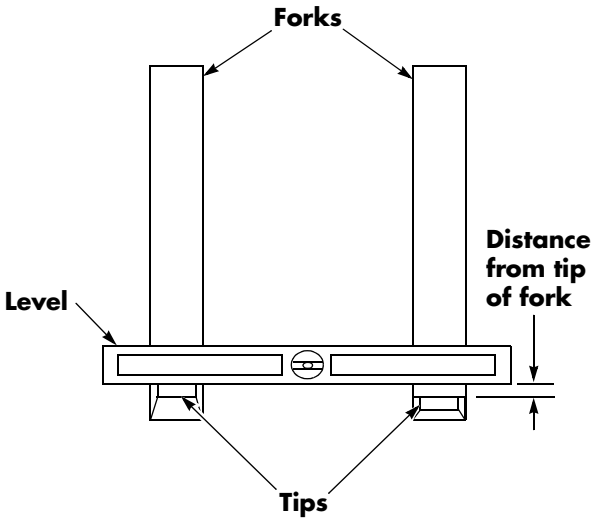
3. When all four extruded points are in contact with the fork, gently remove the caliper and note the reading on the indicator line, located right above the hinge pin. See Figure 4-13.
4. If the deviation is greater than 3° of the original angle, remove the fork from service.

NOTE: Most forks are manufactured with a 90° angle; therefore, a reading greater than 93° or less than 87° is unacceptable. However, there are some forks that are purposely manufactured to angles greater than or less than 90°.

Fork Tip Height

1. With forks on the carriage, measure the length of the blade. See Figure 4-11.
   - For forks 42 in. (106.7 cm) or less, max. deviation is 0.25 in. (6.3 mm).
   - If length of fork is >42 in. (106.7 cm), multiply length of blade by 3%. *Blade length* _____in. x 3% = _____in. This is the maximum deviation.
2. Elevate forks approx. 4 ft. (1.2 m) off the floor.
3. Place a 4 ft. level across the tips of the forks. See Figure 4-14.
4. Raise one end of the level to make it level. See Figure 4-14.
5. Measure the distance from the tip of the fork. See Figure 4-14.

Figure 4-14. Measuring Fork Tip Height



6. Compare this measurement to the maximum deviation.
7. If the maximum deviation number is exceeded, remove the fork from service.

Positioning Locks (if applicable)

1. With the forks on the carriage, visually inspect the positioning locks for damage.
2. Test the positioning locks to verify they work correctly.
3. If the positioning locks are damaged or do not work correctly, remove the fork from service.

Wear

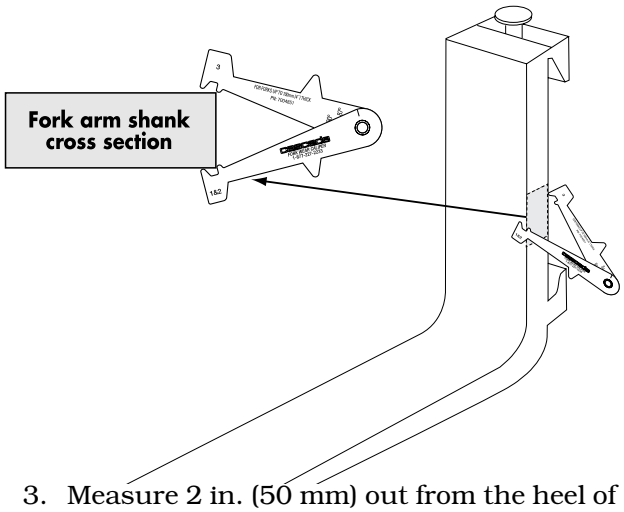
Fork Blade and Shank

1. Remove the forks from the carriage.
2. Approx. half way up the shank, set the front teeth of the jaws of the caliper on the shank. Make sure the caliper is held square across the shank to get an accurate reading. The caliper is now set to measure fork blade wear. Carefully remove

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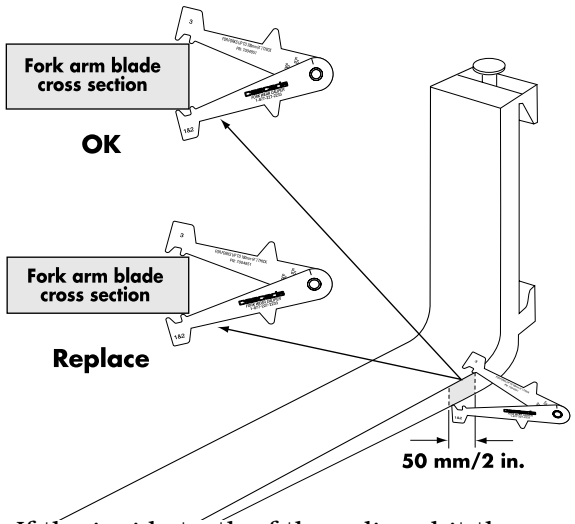
the caliper from the shank. See Figure 4-15.

Figure 4-15. Measuring Fork Shank



3. Measure 2 in. (50 mm) out from the heel of the fork.
4. Place the caliper over the flanks of the fork arm blade at this 2 in. (50 mm) point. See Figure 4-16.

Figure 4-16. Measuring Fork Blade Wear



5. If the inside teeth of the caliper hit the fork, there is <10% wear. If the inside teeth pass freely over the fork arm, there is >10% wear and the fork must be removed from service.

⚠CAUTION

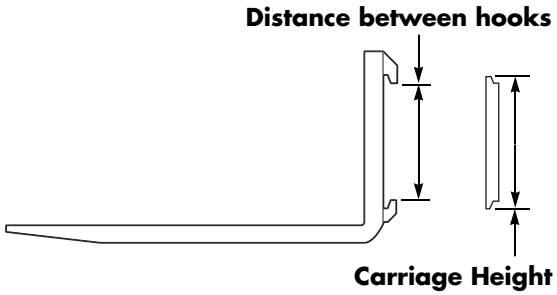
If there is greater than 10% wear of the fork arm, the fork has at least a 20% reduction in capacity.

NOTE: The caliper is designed to measure forks up to 4 in. (100 mm). It is not to be used on full or lumber tapered forks. For these forks, you must know the original fork blade thickness and take a measurement of the fork arm thickness. If the difference in the measurement exceeds 10% of the original thickness, the fork must be removed from service.

Fork Hooks

1. Remove the forks from the carriage.
2. Determine the fork mounting class.
   a. Measure the height of the carriage or the distance between the hooks. See Figure 4-17.

Figure 4-17. Determining Fork Mounting Class



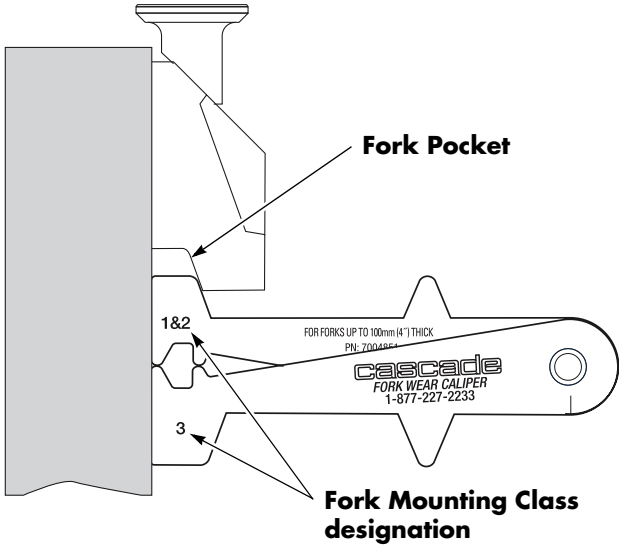
   b. Compare this measurement to the table below.

Fork Mounting Class	Distance Between Hooks in. (mm)	Carriage Height in. (mm)
1	12.05 (306)	13 (331)
2	15.04 (382)	16 (407)
3	18.78 (477)	20 (508)

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3. Locate the correct extruded edge on the caliper for the fork mounting class. See Figure 4-18.
4. Slide the extruded edge up into the hook pocket. See Figure 4-18.
5. If the caliper's extruded edge *completely slides up into the fork pocket*, remove the fork from service. See Figure 4-18.

Figure 4-18. Fork Hook Inspection



Markings

Make sure the fork's marking (individual load rating) is legible (typically located on side of fork). If fork marking is not legible, remove the fork from service.

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Section 5. Troubleshooting



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Electrical Troubleshooting

General

⚠ WARNING

Block the lift truck so that the drive tires are off the floor whenever a troubleshooting procedure requires turning the key switch ON. This prevents accidents caused by unexpected lift truck travel.

Unless otherwise directed, disconnect the battery connector when you check electrical ciruits or components with an ohmmeter. Electrical current can damage an ohmmeter.

Before removing a power amplifier, discharge the amplifier's internal capacitor by jumpering the + and – terminals with a 100 ohm 25W resistor.

- Many problems can be caused by a dirty battery. Make sure the battery is clean.
- Save time and trouble by looking for simple causes first.
- Use a Digital MultiMeter (DMM) such as a Fluke meter for all measurements. Analog meters can give inaccurate readings and load down sensitive electronic circuits enough to cause failure. Make sure meter cables are connected to the correct meter jacks and that the correct function and scale are selected.
- Printed circuit boards are conformal coated. Make sure meter leads make a good electrical connection with test points.
- When measuring voltage, connect the positive meter lead to the connector or probe point marked (+) in the test. Connect the negative meter lead to the connector or probe point marked (–).
- Whenever measuring resistance, turn the key switch OFF and disconnect the battery connector. Battery current can damage an ohmmeter. Isolate the component from the circuit.

Shorts to Frame

"Shorts to frame" is an industry term for unintentional current leakage paths between normally isolated electrical circuits and their metal enclosures.

Shorts to frame may be metallic connections, such as a wire conductor contacting metal through worn insulation. More often, shorts to frame are resistive "leakage" paths caused by contamination and/or moisture.

These leakage paths can result in unwanted electrical noise on the metallic lift truck structure and can cause incorrect operation.

Shorts to frame are caused by:

- Accumulation of dirt
- Battery electrolyte leakage
- Motor brush dust
- Motor brush leads touching the housing
- Breakdown in insulation
- Bare wires
- Pinched wiring harness
- Incorrect mounting of circuit cards

Shorts to frame can occur at numerous locations on a lift truck, including:

- Batteries
- Motors
- Cables, wiring, and harnesses
- Heatsinks
- Bus bars
- Solenoids
- Contactors
- Terminal strips
- Switches
- Power panel insulation
- Circuit card mounts

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Shorts to Frame Test:

1. Turn the key switch OFF and disconnect the battery connector.
2. To test the battery for shorts to case, connect a 12V test light to the battery case from battery B+, and then to the battery case from battery B–. If the light illuminates at all, even momentarily, there is a serious problem with the battery, either external contamination or internal damage. Do not continue until this condition is corrected. The meter may be damaged if you proceed before correcting this condition.

   Install another battery in the lift truck and repeat this procedure from Step 1.

   If the test light does not illuminate, continue to the next step.
3. Use a DMM set on the ampere function to measure the current leakage from the battery case to battery B+ and from the battery case to battery B–. Begin measuring at the highest ampere scale and work toward the lowest. A reading of more than 0.001A (1mA) indicates a serious short. Do not continue until this condition is corrected. The meter may be damaged if you proceed before correcting this condition.

   Install another battery in the lift truck and repeat this procedure from Step 1.

   If the current is <0.0002A (0.2mA), go to Step 4. If the current is >0.0002A (0.2mA) and <0.001A (1mA), remove the battery from the lift truck, then continue with Step 4. Make sure the battery case does not touch the lift truck frame during the remaining tests.
4. With the battery disconnected (or removed and disconnected) from the lift truck, use a DMM to measure the resistance from lift truck frame to truck B+, to truck B– (not battery B+ and B–), and to all fuses and motors. A reading of <1000 ohms indicates a serious short. Do not continue until this condition is corrected. The meter may be damaged if you proceed before correcting this condition.
   a. To identify the cause of the short to frame, disconnect circuit components until the low resistance condition disappears. Do not reconnect components one at a time, but leave them disconnected until the low resistance reading disappears. Prevent disconnected terminals or connectors from touching the lift truck frame or other conductive surfaces.
   b. The most likely areas to check are:
      - Motors
      - Heatsinks
      - Power cables
      - Power circuit components
      - Control circuit components
   c. Repair or replace the component causing the low resistance condition. Repeat Step 4.
   d. Reconnect all other components previously disconnected, one at a time, measuring resistance between steps. If a reading is <1000 ohms when reconnecting a component, that component or its wiring is faulty; repair or replace as appropriate.
   e. When, after all components are reconnected, you get readings >1000 ohms, continue with the next step.
5. Reconnect the battery connector and turn the key switch ON. If the battery was previously removed, make sure the battery case does not touch the lift truck frame.

NOTE: The functions being checked must be energized. Example: to check for shorts to frame in the travel circuit, travel must be requested.

6. Use a DVM set to the current function to measure current leakage to the truck frame from B+, B–, and all fuses and motor terminals. Begin measuring at the highest ampere scale and work toward the lowest. If the current is <0.001A (1mA), go to step 7. If the current is more than

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0.001A (1mA), continue with the following steps:

a. To identify the cause of the short to frame, disconnect circuit components until the leakage current reads <0.001A (1mA). Do not reconnect components one at a time, but leave them disconnected until the leakage current reads <0.001A (1mA). Prevent disconnected terminals or connectors from touching the lift truck frame or other conductive surfaces.

b. The most likely areas to check are:

- Motors
- Heatsinks
- Power cables
- Power circuit components
- Control circuit components

c. Repair or replace the component(s) causing the leakage current. Repeat Step 6.

d. Reconnect all other components previously disconnected, measuring current between steps. If a reading is more than 0.001A (1mA) when reconnecting a component, that component or its wiring is faulty. Repair or replace as appropriate.

7. When, after all components are reconnected, you get a reading <0.001A (1mA) there is no short to frame condition with the lift truck or the battery. If you previously removed the battery from the lift truck, re-install the battery.

Fuses

Test/Inspection

Examine the fuse for signs of overheating, discoloration, cracking, or other physical damage. Replace as necessary.

To test a fuse, remove it from the lift truck. The resistance should be <1 ohm.

Table 5-1. Fuse Chart

Fuse	Amps	Location	Function
FU1	150	Contactor/Fuse Panel	Power fuse for steering
FU2	350	Contactor/Fuse Panel	Power fuse for travel
FU3	500	Contactor/Fuse Panel	Power fuse for lift
FU5	15	Fuse/Relay Card	Control fuse for Vehicle Manager B+
FU6	15	Fuse/Relay Card	Control fuse for Vehicle Manager B–
FU7	15/5	Fuse/Relay Card	Control fuse for aux power B+
FU8	15/5	Fuse/Relay Card	Control fuse for aux power B–
FU9	10	Travel alarm	Control fuse for travel alarm
FU11	10	In-line harness	Control fuse for warning light and strobe
FU12	10	In-line harness	Control fuse for working lights and fan
FU13	n/a	Control Handle	Thermal fuse for control handle external heater
FU14	10	*ThermaKit* Control Module	Control Fuse for *ThermaKit* handle
FU15	2	TS2	Control Fuse for Fork-Laser Module B+
FU16	2	In-line harness near TP4	Control Fuse for Fork-Laser Module B–

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DC Motors

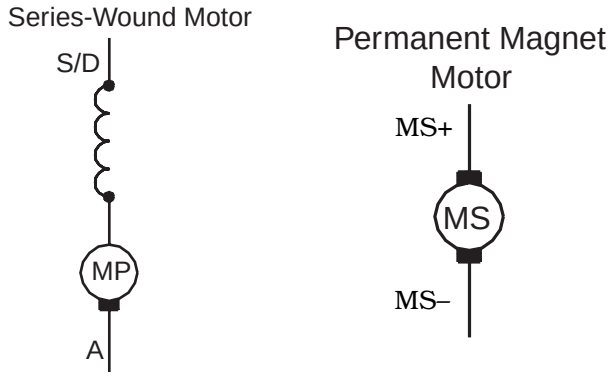
Types of DC Motors

There are two primary types of DC Motors (refer to Figure 5-1):

- A series-wound motor has only two external connections because the armature and field windings are connected internally.
- A permanent magnet motor has two external connections. The field is produced by an internal magnet.

NOTE: Field connections may be labeled A or S. Series wound motor field connections may be labeled D.

Figure 5-1. Motor circuits



Inspection

Inspect the commutator for surface condition and high mica. Most armatures have the mica undercut. If the armature on your motor does not, do not attempt to cut it.

The commutator must be smooth and clean to provide maximum brush wear. When commutators are not correctly maintained, carbon dust can collect in the grooves between the segments. This can lead to a short circuit in the armature.

Good commutation is indicated by a dark brown polished commutator and an evenly polished brush wearing surface. See Table 5-2, "Commutator Surfaces."

If the commutator appears rough, pitted, or has signs of burning or heavy arcing between the commutator bars, remove the motor for servicing.

Servicing

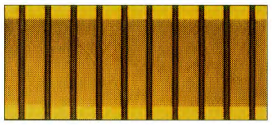
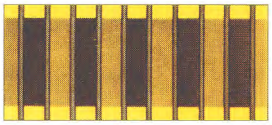
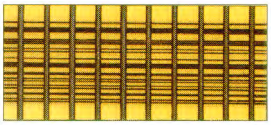
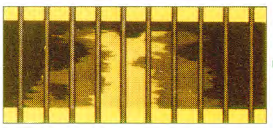
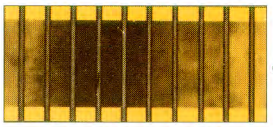
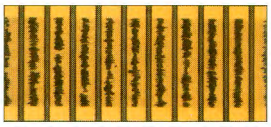
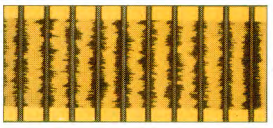
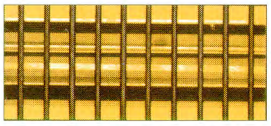
If the commutator requires service, you must remove the armature from the motor.

Do not use a stone to even out high and low spots on the commutator.

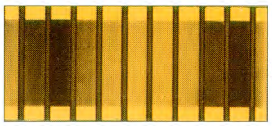
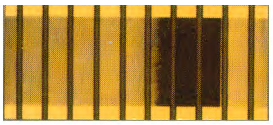
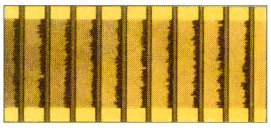
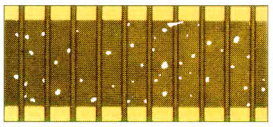
Servicing a motor for an abnormal commutator surface condition and high mica or mica undercutting requires special equipment at a motor rebuilding facility.

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Table 5-2. Commutator Surfaces

Condition	Probable Cause	Commutator Surface
Good Condition-Light Film	Uniform coloring indicates satisfactory operation of machine and brushes. Film color is largely an effect of thickness; therefore, provided the film is uniform, it is perfectly acceptable.	
Satisfactory Condition-Light and Dark Pattern	This is not a good condition but in our experience it is known that machines having this commutator pattern have operated with satisfactory results for long periods of time. This condition can appear in alternating bars as shown or every 3rd or 4th bar. This is related to the winding design of the armature or difficulty caused from split windings crossing in the same slot.	
Unsatisfactory Condition-Streaky Film With No Commutator Wear	Frequently due to under-loaded operation, machine grossly over-brushed, or brush grade incorrect for particular machine application. Atmosphere and environmental conditions can contribute.	
Unsatisfactory Condition-Uneven Film	Patchy colors of varying densities and shape. Due to unclean operating conditions or incorrect physical condition of commutator.	
Unsatisfactory Condition-Film With Dark Areas	These areas can be isolated or regular. Commutator out-of-round. This can be caused by vibration or mechanical deficiencies in equipment operation, bearings, couplings, and so forth.	
Unsatisfactory Condition-Example of Poor Commutator Machining	Bars are low on entry and leaving edges giving rise to the brushes riding on the middle of the bars.	
Unsatisfactory Condition-Example of Poor Commutator Machining	Bars are low in the middle giving rise to the brushes riding on entry and leaving bar edges. This and the previous illustration indicate the need for better maintenance.	
Unsatisfactory Condition-Streaky Film With Commutator Wear	This is a further development of the third example. Brush grade, machine applications, and working environment are all suspect. Earlier corrective action should have been taken.	

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Condition	Probable Cause	Commutator Surface
Unsatisfactory Condition-Double Pole Pitch	Darkening of commutator in sequences two pole pitches apart is due to armature fault, bad coil, riser bars, or equalizer connections.	
Unsatisfactory Condition-Brush Contact Mark	Storage of machines, for lengthy periods, with brushes in position. This can also result from operation of machine in prolonged stall conditions.	
Unsatisfactory Condition-Bar Edge Burning-Cause High Mica	Illustration shows high mica in every slot. Same effect can occur on one bar only. Similar conditions can be caused by a high or low bar.	
Unsatisfactory Condition-Small Bright Spots	Related to overloaded machines and low brush pressure. Due to sparking under brush, that gives rise to spots being of a random distribution. If not corrected, will result in scored commutator.	

Open Circuit Motor Test

An open circuit is an electrical circuit within the motor that is broken. This can be caused by:

- bad brushes or brush springs
- a broken wire in the field or armature winding
- loose or bad connections

Refer to Figure 5-1 on page 5-5 while performing the following procedure:

1. Isolate the motor from the lift truck circuit by removing the power cables. Use two wrenches to avoid twisting the terminal stud.
2. With the motor at room temperature, connect the leads of a digital ohmmeter between the individual circuits in the motor.
3. Observe the following measurements:

DC Motor	Probe Points	Resistance
Lift	A to S	<1 ohm
	A to Frame	>100,000 ohms
Auxiliary	A1 or A2 to Frame	
Steer	MS+ or MS– to Frame	

4. If the meter indicates high resistance in the armature, check the condition of the brushes before replacing the motor.
5. If you find an open circuit in a series-wound motor, the motor must be disassembled by a motor rebuilding facility to isolate the problem to the field or armature circuit.

Grounded Motor Test

In a grounded motor, an electrical circuit exists between the current-carrying conductors and the motor housing. This can be caused either by direct contact or through conductive foreign material.

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The ground may be caused by:

- insulation breakdown
- brush leads touching the motor housing
- build-up of carbon dust or other materials

Isolate the motor from the lift truck circuit by removing the power cables. Use two wrenches to avoid twisting the terminal studs.

Attach one lead of a megohm meter or a digital ohmmeter to a motor terminal and the other lead to an unpainted surface of the motor housing. Set the ohmmeter to the highest scale.

If the ohmmeter reads resistance of <100,000 ohms, the motor is grounded. Clean, repair, or replace the motor as necessary.

Short Circuited Armature or Field Winding

A short circuited winding is one that the insulation on the field or armature has broken down at two or more points. The breakdown creates a low resistance path, allowing current to flow from one turn of the coil to another adjacent coil turn, without actually flowing through the coil wire. The result is a decrease in total resistance of the motor winding and an increase in the current flow. The severity of the short circuit depends on its location.

A shorted motor may be indicated by:

- Slow or sluggish operation
- Running faster than usual (suggests a short in the field)
- Overheating
- Blowing a power fuse
- Burning of brush wires
- Severe burning or discoloration on armature coil
- Severe burning or discoloration on one or two commutator segments every 90° of rotation.

These symptoms can be caused by problems other than the motor itself, such as binding in a related pump, hose, or solenoid valve.

Testing a motor for short circuited windings requires special equipment at a motor rebuilding facility.

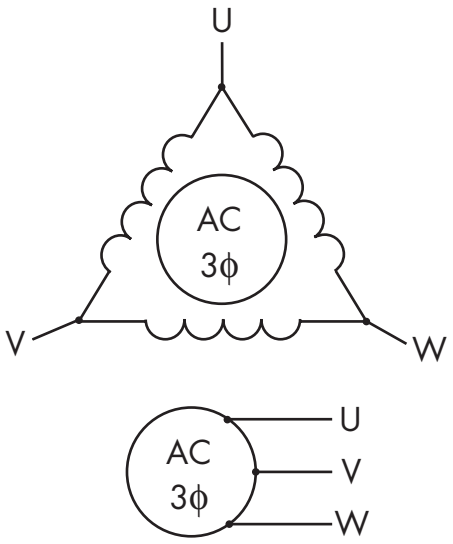
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AC Motors

AC motors used on this lift truck are brushless, 3-phase, internally delta-connected, variable speed motors.

The AC motor has a rotor (in place of the DC armature) and a stator (in place of the DC field). There is no electrical connection to the rotor; current is induced in the rotor. The stator has three windings staggered 120° apart, and three external connections labeled U, V, and W. See Figure 5-2.

Figure 5-2. Traction Motor Circuits



Open Winding

If the AC motor fails with an open winding, the motor moves erratically, as if hunting, and there is a ticking sound. Rotation is much slower than usual.

Using a clamping ammeter, measure current in each of the motor power cables. The open phase will read significantly lower than the other two phases.

Shorted Winding

If the AC motor fails with a shorted winding, the motor moves erratically, as if hunting, and there is a high-pitched sound.

Using a clamping ammeter, measure current in each of the motor power cables. The shorted phase will read significantly higher than the other two phases.

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Battery State-of-Charge

Battery State-of-Charge (BSOC) is a feature that monitors and remembers the charge level of the battery connected to the lift truck and helps to prevent excessive discharging of that battery. Operating a lift truck using a discharged battery can damage both the battery and the electrical components of the lift truck.

At power-up, BSOC tests the battery voltage to determine if it is the same as it was at power-down. If the voltage is the same, BSOC assumes it is the same battery and continues to monitor the battery for discharge and updates the Operator Display as required.

If a different battery voltage is detected, BSOC assumes a different battery is installed and tests to determine the state-of-charge of the replacement battery. The replacement battery must meet one of the following criteria before the display resets and lift is restored.

- The replacement battery must have a charge level at least 50% different from the previously installed battery.
- The charge value of the replacement battery must be greater than the configured BSOC setting.

The criteria are determined in this way:

- BSOC compares the charge of the battery that was connected to the lift truck with the replacement battery's charge. A charge difference of at least 50% between the two batteries resets BSOC to show the state-of-charge of the replacement battery, that is, the measured state-of-charge of the replacement battery minus the remembered state-of-charge of the old battery must equal or exceed 50%. This reset can be higher or lower than the old battery.
- BSOC looks at the configured reset point. BSOC reset is programmable from 55% to 100% of total battery charge and can be changed by entering the Configure Mode using the SuperWord. The replacement battery must be greater than the configured percent of charge before BSOC changes. Example - BSOC configured at 95%. Plugging in a battery at anything below 95% charge will not change the Operator Display. Older batteries or applications providing inadequate charging time could require a lower configured value for BSOC since older batteries might be unable to reach a higher percent charge. Therefore, some batteries could require BSOC configured as low as 55% before lift cutout resets and the Operator Display shows the charge of the replacement battery.

Setting Battery State-of-Charge Cutout

1. Fill, charge, and install a battery that is typical of the batteries normally used in this application.
2. Have a customer operator use the lift truck in normal application until cutout occurs.
3. Allow the battery to cool and stabilize for at least two hours.
4. Before filling the battery, either take specific gravity readings or measure open circuit voltage of the battery cells.
5. Compare the measurements with the battery manufacturer's recommendations for maximum discharge.
6. Adjust the cutout value as needed and repeat the previous steps until battery cutout occurs at the desired discharge level.

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Hydraulic Troubleshooting Guidelines

NOTE: After elevating or reaching the carriage for troubleshooting, make sure to use blocks to secure the carriage.

NOTE: Use extreme care when blocking the mast for any reason. Never remove a block when it is supporting the mast.

Lower the carriage fully and retract the reach mechanism fully.

Stabilize the top of the mast with an overhead chain hoist.

When you measure voltage at solenoids, make sure hydraulic lines and components are fully installed.

Whenever possible, keep the key switch OFF and the battery connector disconnected.

Cap open hydraulic lines to prevent contamination.

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Symptom Tables: Hydraulic Functions

NOTE: If a component fails due to hydraulic fluid contamination, replace the failed component, flush, fill, and bleed the hydraulic system. Refer to **"Hydraulic System Bleeding" on page 7-74**.

NOTE: Reference electrical schematics beginning on page A-17 and hydraulic schematics beginning on page A-22.

Auxiliary Functions

No Auxiliary Functions Work (Reach/Retract, Tilt, Sideshift)

Possible Cause	Action
Bad K2 relay circuit	Troubleshoot K2 relay circuit.
Bad LS1 shuttle	Replace LS1.
Bad aux directional solenoid 5B or 5T (valve or wiring)	Run Tests O04 and O05. Follow test recommendations.

All Auxiliary Functions are Slow

Possible Cause	Action
Incorrect hydraulic fluid for application	Replace hydraulic fluid with correct fluid. See "Lubrication Specification Chart" on page A-2.
Bad POD-1 valve	Replace POD-1 valve.
Aux system relief pressure too low	Adjust aux pressure. See "Auxiliary Pressure Adjustment" on page 7-80.
Bad LS1 shuttle	Replace LS1.

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No Tilt or Tilt One Direction Only; Other Aux Functions OK

Possible Cause	Action
Bad tilt switch (S6 and/or S7)	Run Test I08 and/or I09. Follow recommendations in test.
Bad tilt solenoid valve or coil, or wiring. Check for contamination.	Run Test O07. Follow recommendations in test. If contamination is found, flush, refill, and bleed hydraulic system. Swap hoses with sideshift to check valve and cylinder.
Broken tilt cylinder pin	Replace tilt cylinder pin.
Mechanical binding in tilt cylinder or carriage	Measure pressure; normal operation should be below bypass pressure. See "Auxiliary Pressure Adjustment" on page 7-80. Binding produces higher pressures. Repair/replace cylinder or other binding components.

Slow Tilt; Other Aux Functions OK

Possible Cause	Action
Mechanical binding in tilt cylinder or carriage	Measure pressure; normal operation should be below bypass pressure. See "Auxiliary Pressure Adjustment" on page 7-80. Binding produces higher pressures. Repair/replace cylinder or other binding components.
Bad tilt solenoid	Examine for binding or contamination. Swap hoses with sideshift to check valve and cylinder.

No Sideshift or One Direction Only; Other Aux Functions OK

Possible Cause	Action
Bad sideshift switch (S8 and/or S9)	Run Test I10 and/or I11. Follow recommendations in test.
Bad sideshift solenoid, or wiring	Run Test O08. Follow recommendations in test. Swap hoses with tilt to check valve and cylinder.
Mechanical binding in sideshift cylinder or carriage	Measure pressure; normal operation should be below bypass pressure. See "Auxiliary Pressure Adjustment" on page 7-80. Binding produces higher pressures. Repair/replace cylinder or other binding components.

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Slow Sideshift; Other Aux Functions OK

Possible Cause	Action
Mechanical binding in sideshift cylinder or carriage	Measure pressure; normal operation should be below bypass pressure. See "Auxiliary Pressure Adjustment" on page 7-80. Binding produces higher pressures. Repair/replace cylinder or other binding components.
Bad sideshift solenoid valve	Repair/replace sideshift solenoid valve.

Reach and Retract Do Not Work or are Slow; Other Functions OK

Possible Cause	Action
Bad reach solenoid (valve or wiring)	Run Test I06. Check wiring. Check valve for binding.
Damaged or worn reach cylinders	Inspect cylinder. Measure pressure; normal operation should be below bypass pressure. See "Auxiliary Pressure Adjustment" on page 7-80. Binding produces higher pressures. Repair/replace cylinder or other binding components.
Damaged or worn scissors assembly	Inspect for damage. Measure pressure; normal operation should be below bypass pressure. See "Auxiliary Pressure Adjustment" on page 7-80. Binding produces higher pressures. Repair/replace cylinder or other binding components.
Switches S4 and S5 both bad (or wiring)	Run tests I06 and I07. Follow recommendations in tests.

Reach Does Not Work; Other Functions OK

Possible Cause	Action
Bad reach switch (S4)	Run Test I06. Follow recommendations in test.

Retract Does Not Work; Other Functions OK

Possible Cause	Action
Bad retract switch (S5)	Run Test I07. Follow recommendations in test.

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Lift/Lower System

No Lift - Motor Runs

Possible Cause	Action
Bad POD-1 valve	Replace POD-1 valve.
SOL3 main relief dump valve pressure too low	Run Test O09. Replace SOL3.
SOL2 lift/lower valve open	Run Test O12. Follow recommendations in test.

No Lift - Motor Does Not Run

Possible Cause	Action
Battery below BSOC cutout setting	Check battery voltage and BSOC settings.
Maintenance Minder™ interval exceeded with LCutout specified	Display config settings for *Maintenance Minder*.

Slow Lift with No Load

Possible Cause	Action
Plugged or malfunctioning flow limiter in lift cylinder	Replace flow limiter. If contamination is present, flush, fill, and bleed the hydraulic system.
Binding in the mast	Check for binding.
Bad SOL3	Run Test O09. Follow recommendations in test.

Unable to Pick Up a Load

Possible Cause	Action
Bad SOL3	Run Test O09. Follow recommendations in test.
Bad lift pump	Check pressures. Replace pump.

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Slow Lower

Possible Cause	Action
Clogged hydraulic filter	Replace hydraulic filter.
Mechanical binding in bearings or telescopics	Adjust or replace bearings. Check shimming.
Bad lift/lower proportional solenoid valve SOL2	Run Test O12. Follow recommendations in test.
Maximum Lower Speed not matching SOL2	In Configure Mode, adjust Lift M LwrSpd.
Contamination in load holding solenoid valve SOL1	Inspect load holding solenoid SOL1 for contamination.
Plugged or malfunctioning flow limiter valves	Replace flow limiters.

Intermittent Lower

Possible Cause	Action
Bad SOL2 solenoid (valve or wiring)	Run Test O12. Check wiring. Replace SOL2.
Bad SOL1 load holding solenoid (valve or wiring)	Run Test O11. Check wiring. Replace SOL1.
Plugged or malfunctioning flow limiter valves	Replace flow limiters.

Load Drifting/Settling

Possible Cause	Action
Load too large for lift truck capacity	Check load weight.
DC Only: Incorrect lift pressure adjustment	Check and adjust lift pressure setting.
DC Only: Contaminated or bad relief valve REL1	Replace relief valve REL1. If contamination is present, flush, fill, and bleed the hydraulic system.
AC Only: Leaking or contaminated proportional relief solenoid SOL3	Replace SOL3.
Leaking or contaminated load holding solenoid SOL1	Replace SOL1.

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Symptom Tables: Travel Functions

Slow or Sluggish Acceleration

Possible Cause	Action
Configuration:	
Accel set to “soft”	Set accel to “medium” or “hard.” See “Configuration and Truck Setup Options” on page 3-7.
Mechanical:	Measure current draw.
Worn load wheel or idler assembly	Replace load wheel/idler assembly as required.
Debris in load wheel axle or idler	Remove debris.
Dragging brake	Check brake. See “Brake” on page 7-50.
Binding drive unit	Inspect for wear.
Electrical:	
Current is limited due to high temperature	Check temperature and temperature sensors for Traction Motor and power amplifier. Run tests A08, A10, and A24.

Slow Travel

Possible Cause	Action
Mechanical:	
Binding drive unit	Check for excessive current draw in Traction Motor.
Dragging brake	Check brake. See “Brake” on page 7-50.
Electrical:	
Incorrect configuration of speed	Reconfigure the lift truck. See “Using Configure Mode” on page 3-19.
If equipped with nested switch option, bad S14 switch	Run Test I01.
Speed limited due to high temperature	Run Tests A08, A10, A24. Follow recommendations in tests.
Bad height encoder (causing false speed limiting)	Run Test I26. Follow recommendations in test.

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Symptom Tables: Electrical Symptoms

NOTE: Reference electrical schematics beginning on page A-17 and hydraulic schematics beginning on page A-22.

Motor Overheating

Possible Cause	Action
Application exceeds designed workload -- short runs with plugging/acceleration or heavy-duty lifting cycles	Contact Dealer Service Manager to make sure of application.
Incorrect BSOC Cutout value	Measure battery specific gravity at cutout, after battery has stabilized. Compare to battery manufacturer specifications for discharged battery. Adjust BSOC Cutout as needed.
Clogged motor vents	Examine and clear motor vent openings.
DC Motors: worn, damaged, or bad brushes or springs (lift and aux motor only)	Check motor brushes. Check brush spring tension.
Cable, terminal, or wiring problems. Look for loose or discolored terminals, loose or damaged crimps.	Replace wiring or cables as needed. Make sure motor cables are torqued correctly.
High motor current due to binding gearbox, pump, or dragging brake	Inspect gearbox or pump for binding. Check brake. See "Brake" on page 7-50.
Note: See also "DC Motors" on page 5-5 and "AC Motors" on page 5-9.	

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Scrambled or Intermittent Display

Possible Cause	Action
Electrostatic discharge resulting from dirty, worn, or wrong type static straps	Clean or replace static straps as needed.
Loose display harness or card connectors; intermittent wires or connectors in harness	Reseat cards and harness connections. Test for continuity while flexing harness. If no continuity is found, replace wiring harness. See "Wiring and Harness Connectors" on page 7-59.
Short to frame	See "Shorts to Frame" on page 5-2.
Unmatched Vehicle Manager and Display Manager software	Install matching Vehicle Manager and Display Manager software. VM and DM versions may not have the same version number. See "Reviewing Vehicle Manager Software" on page 3-9.
Incorrect installation of options or unauthorized parts	Verify correct installation of options.
Bad Operator Display card	Replace Operator Display card.

Display is Dark; Lift Truck is Not Operational

Possible Cause	Action
Fuse FU5 or FU6 could be blown	Remove fuses and test fuse continuity. If continuity is missing, replace fuse.
Problem in key switch circuit or with B+ to Vehicle Manager or bad Vehicle Manager	Troubleshoot B+ to B+KEY circuits from battery to VM.
Problem with +12V power supply	Troubleshoot +12V supply at VM. Run Test A14.
Bad Operator Display	Replace Operator Display.
Bad battery cables or connector	Repair or replace as necessary.

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Symptom Tables: *Vantage Point* System

NOTE: Reference Electrical Schematic - Optional Equipment on page A-18.

Monitor is Blank

Indication and Possible Cause	Action
Button 3 LED lit - monitor in standby mode, Monitor Standby disabled, Carriage below free lift transition	Normal condition: To activate display, elevate above free lift transition.
Button 3 LED lit - monitor in standby mode, Monitor Standby enabled, Carriage below free lift transition	Normal condition: To activate display, elevate above free lift transition. *Or* unlock keypad. Press Button 3. Lock keypad.
Button 8 LED off - monitor turned off, Powersave Mode is enabled	Unlock keypad. Press Button 8. *Or* unlock keypad. Press and hold Buttons 4 and 5 for 60 seconds to disable Powersave Mode. Lock keypad.
Button 1 LED and camera LED both blinking - Ambient temperature out of operating range (–13°F/–25°C to +167°F/+75°C)	Return lift truck to operating temperature range of unit.
Button 8 LED off - one or both power fuses blown	Replace fuse(s) in Aux Power circuit.

Keypad Inoperative

Indication and Possible Cause	Action
Monitor is OK- keypad locked	Press and hold Buttons 1 and 5 for 15 seconds to unlock the keypad. *Do not leave keypad unlocked.*

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Video Problems

Indication and Possible Cause	Action
Black horizontal bar in picture: Wrong monitor frequency	Unlock keypad. Press and hold Button 4 for 15 seconds. Lock keypad.
Picture is reversed (mirror-image): Image reversed	Unlock keypad. Press and hold Buttons 1 and 3 for 5 seconds. Lock keypad.
Picture is inverted (upside-down): Image inverted	Unlock keypad. Press and hold Buttons 1 and 2 for 35 seconds. Lock keypad.
Picture too light or too dark, Button 2 LED is OFF	Unlock keypad. Press Button 2 to turn automatic brightness ON. Button 2 LED turns ON. Lock keypad. If picture is still too light or too dark, go to next action.
Picture too light or too dark, Button 2 LED is ON	Unlock keypad, press Button 2 to turn automatic brightness OFF. To adjust brightness, press Button 5, then Button 6 to decrease, Button 7 to increase. To adjust contract, press Button 4, then Button 6 to decrease, Button 7 to increase. Press Button 2 to turn automatic brightness ON. Lock keypad.

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Section 6. Messages, Codes, and Tests



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Power Amplifier LED Diagnostics

Most error conditions are displayed as a message or fault code on the Operator Display.

The power amps also contain a Light Emitting Diode (LED) status indicator, which provides basic diagnostic information.

- When the LED is illuminated (steady or blinking), the amplifier is receiving power.
- A steady LED indicates the amplifier is operating normally.
- A blinking LED indicates a malfunction.

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Messages and Codes

Deadman?

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Deadman? Both deadman switches closed at the same time.	Test I00 - Deadman Switch (DS1) (Page 6-60) Test I32 - Deadman Switch (DS2) (Page 6-79)	Open one of the deadman switches.

Code 1H Overheated. Allow Time to Cool

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	**Code 1H - TPA Overheated** The TPA has reported its internal temperature is >239°F (115°C).	Test A10 - TPA Temperature (Page 6-38) Test O23 - Toggle Fans (Page 6-112)	Travel is disabled. Cycle key switch to clear after TPA has cooled. **Note:** The VM cannot cause this code.

Lift Cut-Out Pending...Low Battery

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 1T - Battery Low Lift cutout point configured for BSOC has been reached.	None	Change battery. Self resetting.

Code 1V Overheated, Allow Time to Cool

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	**Code 1V - LPA Overheated** LPA has reported its internal temperature is >239°F (115°C).	Test A19 - LPA Temp (Page 6-43) Test O23 - Toggle Fans (Page 6-112)	Lift is disabled. Cycle key switch to clear after LPA has cooled. **Note:** The VM cannot cause this code.

Code 2A Overheated, Allow Time to Cool

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	**Code 2A - Traction Motor Approaching Overtemp** TPA senses the Traction Motor is approaching overtemperature.	Test A08 - Traction Motor Temperature (Page 6-36)	Traction performance is limited. Self resetting after motor has cooled. **Note:** The VM cannot cause this code.

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Code 2C Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	**Code 2C - TPA Temp Sensor Out-of-Range** TPA temperature sensor is open or shorted.	Test A10 - TPA Temperature (Page 6-38)	Traction performance is limited. Cycle key switch to clear. **Note:** The VM cannot cause this code.

Code 2E Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	**Code 2E - Traction Motor Temp Sensor Out-of-Range** Traction Motor temperature sensor is open or shorted.	Test A08 - Traction Motor Temperature (Page 6-36)	Traction performance is limited. Self resetting. **Note:** The VM cannot cause this code.

Code 2H Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	**Code 2H - Traction Motor Speed Sensor Failure** Traction Motor speed sensor circuit is inoperative.	Test I19 - Traction Motor Speed Sensor (Page 6-71)	Traction performance is limited. Self resetting. **Note:** The VM cannot cause this code.

Code 2M Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	**Code 2M - TPA Failed** TPA failed to precharge correctly.	None	Traction is disabled. Check for B+ at the TPA+ terminal. Cycle key switch to clear. If code will not clear, replace TPA. **Note:** The VM cannot cause this code.

Code 2P Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	**Code 2P - TPA Reverted to Default Parameters** TPA has detected an internal malfunction with the amplifier software.	None	Should clear automatically after 30 seconds; if not, cycle key switch. This code may appear when first turning key switch ON after installing a new VM, TPA, or after updating software. If code appears infrequently, keep running. If code appears often, reload FlashWare; if problem continues, replace TPA.

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Code 2T Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 2T - TPA Current Calibration Error TPA has detected a current calibration error.	None	Traction performance is limited. Cycle key switch to clear. If code does not clear, replace TPA. **Note:** The VM cannot cause this code.

Code 2U Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 2U - TPA Overcurrent or Short Circuit TPA has sensed current in excess of 540A.	Test A11 - Traction Motor Current (Page 6-39)	Traction is disabled. Cycle key switch to clear. **Note:** This code may be caused by a shorted TPC diode. **Note:** The VM cannot cause this code.

Code 2V Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 2V - TPA High DC Bus Voltage TPA has detected >50VDC at TPA+.	None	Traction is disabled. Cycle key switch to clear. If code occurs during plugging, replace all battery cables and connections that show signs of heat or corrosion. Install a battery that is in good condition. If code persists, replace the TPA. **Note:** The VM cannot cause this code.

Code 42 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 42 - LPC Detected Closed When Commanded Open LPA detected an incorrect voltage at LPA+ during SelfTest.	Test O02 - Toggle the LPC Contactor (Page 6-100)	Cycle key switch to clear. **Note:** Low battery voltage can contribute to burnt tips. If contactor tips are welded or burnt, check the BSOC setting in Config Mode menu.

Code 43 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 43 - LPC Detected Open When Commanded Closed LPA detected <12VDC at LPA+ after the LPC coil was energized.	Test O02 - Toggle the LPC Contactor (Page 6-100)	Cycle key switch to clear. **Note:** The VM cannot cause this code.

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Code 44 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 44 - TPC Detected Closed When Commanded Open TPA detected an incorrect voltage at TPA+ during SelfTest.	Test O00 - Toggle the TPC Contactor (Page 6-98)	Cycle key switch to clear. **Note:** Low battery voltage can contribute to burnt tips. If contactor tips are welded or burnt, check the BSOC setting in Config Mode menu. **Note:** The VM cannot cause this code.

Code 45 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 45 - TPC Detected Open When Commanded Closed The TPA detected <12VDC at TPA+ after the TPC coil was energized.	Test O00 - Toggle the TPC Contactor (Page 6-98) In Active Service, run Test A15 - Battery Voltage (Page 6-42) to verify battery voltage	Cycle key switch to clear. **Note:** The VM cannot cause this code.

Code 4B Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 4B - Steer Contactor Detected Closed When Commanded Open The VM detected >10VDC at JPC22-19 when the STR coil was de-energized.	Test O01 - Toggle the STR Contactor (Page 6-99) If open, run Test I14 - Steering Fuse (FU1) (Page 6-69)	Cycle key switch to clear.

Code 4C Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 4C - Steer Contactor Detected Open When Commanded Closed The VM detected <10VDC at JPC22-19 when the STR coil was energized.	If contactor closes, run Test I14 - Steering Fuse (FU1) (Page 6-69), if contactor does not close, run Test O01 - Toggle the STR Contactor (Page 6-99)	Cycle key switch to clear.

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Code 4D Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 4D - No Pre-Charge Traction DC Input Voltage During Start-Up The TPA detected an incorrect pre-charge voltage (<25VDC) at TPA+.	None	Cycle key switch to clear. Check components, connections, and wiring between JPF1-5 and TPA+ for correct resistance and continuity. TPA Pre-Charge Resistor (TR) = 12 ohms Thermistor on Fuse/Relay Card = 6 to 12 ohms at room temp (70°F/21°C).

Code 4E Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 4E - No Pre-Charge Lift DC Input Voltage During Start-Up The LPA detected an incorrect pre-charge voltage (<25VDC) at LPA+.	None	Cycle key switch to clear. Check components, connections, and wiring between JPF1-3 and LPA+ for correct resistance and continuity. LPA Pre-Charge Resistor (LR) = 12 ohms. Thermistor on Fuse/Relay Card = 6 to 12 ohms at room temp (70°F/21°C).

Code 57 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 57- VM Not Responding to Operator Display The Operator Display has lost communication with the VM over the CAN bus. This code is initiated by the Operator Display.	Test I23 - CAN Bus Test (Page 6-74)	Self resetting. **Note:** This code will not normally be recorded in the error log since the log resides in the VM. A code 5Q is often recorded in the error log when a code 57 is on the Operator Display.

Code 58 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 58 - OCSS CAN Communication Error No communication received from the OCSS controller.	None.	Cycle key switch to clear. Check for +12V at JPX1-1 and 0V at JPX1-4 on the OCSS CAN I/O Expander Module.

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Code 59 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 59 - CAN Transmission Buffer Error The VM has detected a CAN transmission buffer error.	Test I23 - CAN Bus Test (Page 6-74)	Cycle key switch to clear. Check for shorts to frame, static, and electrical leakage from battery.

Code 5A Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 5A - CAN Bus Error/VM for BUS_I The VM detected an error in the CAN Bus.	Test I23 - CAN Bus Test (Page 6-74)	Cycle key switch to clear. Check for shorts to frame, static, and electrical leakage from battery. **Note:** This code cannot be caused by an error on the secondary bus BUS_E.

Code 5B Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 5B - CAN Receive Bus Error/VM CAN Receive Bus error in VM for BUS_I.	Test I23 - CAN Bus Test (Page 6-74)	Cycle key switch to clear. Check for shorts to frame, static, and electrical leakage from battery. **Note:** This code cannot be caused by an error on the secondary bus BUS_E.

Code 5G Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 5G - No Communications Received from TPA The VM has received no communication from the TPA.	Test I23 - CAN Bus Test (Page 6-74)	Cycle key switch to clear. Check for shorts to frame, static, and electrical leakage from battery. **Note:** This code can be caused by bad K3 relay tips. Check LEDs on both power amplifiers. If both are not illuminated, check the K3 relay.

Code 5J Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 5J - No Communications Received from LPA The VM has received no communication from the LPA.	Test I23 - CAN Bus Test (Page 6-74)	Cycle key switch to clear. Check for shorts to frame, static, and electrical leakage from battery.

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Code 5M Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 5M - TPA CAN Watchdog Timeout CAN watchdog circuit timeout detected by TPA.	Test I23 - CAN Bus Test (Page 6-74)	Cycle key switch to clear. This code is generated by the TPA. This fault can be caused by a source external to the amplifier. Check for shorts to frame, static, electrical leakage from battery, bad power amp cables or wiring, and CAN Bus.

Code 5P Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 5P - LPA CAN Watchdog Timeout The CAN watchdog circuit has not received communication from other amplifier circuits.	Test I23 - CAN Bus Test (Page 6-74)	Cycle key switch to clear. This code is generated by the LPA. This fault can be caused by a source external to the amplifier. Check for shorts to frame, static, electrical leakage from battery, bad power amp cables or wiring, and CAN Bus.

Code 5Q Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 5Q - Display Manager Not Responding The VM is not receiving communication from the Display Manager. This code appears in the error log but not usually on the Operator Display.	Test I23 - CAN Bus Test (Page 6-74)	Self resetting. **Note:** Code 5Q is recorded in the error log. The Operator Display will most likely display Code 57.

Code 5R Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 5R - Secondary CAN Bus Error for BUS_E There is a transmission error between the VM and the secondary CAN BUS_E to which external equipment is connected.	Test I23 - CAN Bus Test (Page 6-74)	Cycle key switch to clear. This code could be caused by system noise, static discharge, or shorts to frame. **Note:** Primary BUS_I and secondary BUS_E are totally independent. Therefore, this code cannot be caused by devices connected to BUS_I.

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Code 5T Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 5T - No CAN Message from any Node The VM is not receiving CAN message from any node.	Test I23 - CAN Bus Test (Page 6-74)	Cycle key switch to clear.

Code 61 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 61 - Mast Switch #1 Not Crossed Too many height encoder pulses were seen without detecting mast switch #1 opening.	Test I02 - First Speed Limiting Switch (S12) (Page 6-62)	Cross mast switch #1.

Code 62 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 62 - LPA Reverted to Default Parameters The LPA has detected a change in internal software.	None	Resets after 30 seconds; if not, cycle key switch. If code continues to appear infrequently, keep running. If code continues to appear often, reload FlashWare; if problem continues, replace LPA. **Note:** This code may appear when first turning key switch ON after installing a new VM or LPA.

Code 63 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 63 - HS Travel and First Speed Limiting Switches Do Not Agree The VM reads the 1st speed limiting switch as closed when the HS travel switch or Switch 2 reads open.	Test I02 - First Speed Limiting Switch (S12) (Page 6-62) Test I61 - High Speed Travel Switch (S25) (Page 6-86)	[VM ver. < 2.1] Cycle key switch to clear. [VM ver. 2.1+] Cross the first speed limiting switch several times. **Note:** Check the error log to see if Code 64 or 67 preceded the Code 63. If so, troubleshoot per that code. **Note:** Switch 2 must be on for trucks with an elevated height above 331 in.

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Code 64 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	**Code 64 - No Pulses Seen from Height Indicator Encoder** With the lift pump running or SOL2 energized, the first mast limit switch is open, but the VM detected no pulses from the Height Indicator encoder.	Test I02 - First Speed Limiting Switch (S12) (Page 6-62) Test I86 - Lift Height (Page 6-91)	Lower the carriage, then lift past the first mast switch. Troubleshoot HTI system. Code clears when pulses are detected. Cycle key switch. If code is intermittent, cause could be proportional valve. Adjust valve - see "Proportional Valve Adjustment" on page 7-79.

Code 66 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	**Code 66 - Calculated Height Greater Than Configured Height** The carriage height calculated by the VM from information from the Height Indicator is more than 6 in. (15 cm) greater than the configured height of the lift truck.	Test I86 - Lift Height (Page 6-91)	Lower the carriage below the configured maximum height to clear. Check actual mast height against configured height. Check actual fork height against indicated fork height when HTI counting begins.

Code 67 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	**Code 67 - Calculated Height Does Not Match First Speed Limiting Switch (S12)** The VM detected S12 closed at an incorrect calculated height when lowering.	Test I02 - First Speed Limiting Switch (S12) (Page 6-62)	Lift the carriage through the first speed limiting switch height or cycle the key switch to clear.

Code 6D Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	**Code 6D - Pressure Sensor Out-of-Range** Voltage is <0.7V (indicating <300 psi) or >5.0V (indicating >3999 psi).	Test A13 - Pressure Sensor Voltage (Page 6-40)	Cycle key switch to clear.

Code 6F Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	**Code 6F - Lift Motor Overtemp** The LPA has detected Lift Motor is overheated (>300°F/149°C).	Test A09 - Lift Motor Temperature (Page 6-37)	Allow time to cool. Self resetting.

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Code 6G Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 6G - Lift Motor Temp Sensor Out-of-Range Lift motor temperature sensor is out-of-range.	Test A09 - Lift Motor Temperature (Page 6-37)	Self resetting. **Note:** The VM cannot cause this code.

Code 6S Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 6S - LPA Temp Sensor Out-of-Range The LPA reported to the VM that its internal temperature is not within acceptable limits.	None	Cycle key switch to clear. Replace the LPA. **Note:** The VM cannot cause this code.

Code 6T Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 6T - LPA Current Calibration Error The LPA has detected an internal fault.	None	Cycle key switch to clear. Replace the LPA. **Note:** The VM cannot cause this code.

Code 6V Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 6V - LPA Failure The LPA has detected an internal fault.	None	Cycle key switch to clear. Replace the LPA. **Note:** The VM cannot cause this code.

Code 6W Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 6W - Failure Detected in Lift Motor Speed Sensor The lift feedback circuit, as seen by the LPA, is not functioning.	Test I20 - Lift Motor Speed Sensor (Page 6-72)	Self resetting. **Note:** The VM cannot cause this code.

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Code 6X Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 6X - LPA Fault: Overcurrent The LPA has detected >675A or a shorted output.	Test A20 - Lift Motor Current (Page 6-44)	Cycle key switch to clear. **Note:** The VM cannot cause this code.

Code 6Y Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 6Y - LPA Fault: High DC Voltage The LPA has detected a DC input voltage exceeding 50V at LPA (+).	None	Cycle key switch to clear. Install battery that is in good condition. Replace TPA.

Code 6Z Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 6Z - FlashWare Parameters Do Not Match Stored Values Fork height, as calculated by the display, is at least 6 in. higher than the maximum elevated height programmed in the truck's memory.	None	Cycle key switch to clear. Verify programmed height is correct in FlashWare.

Code 80 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 80 - Primary Throttle Pot Out-of-Range The VM detects <0.15V or >2.1V at JPC12-3.	Test A04 - Primary Throttle Pot (VR1) Voltage (Page 6-34) Test A26 - +5VDC Power Supply (Page 6-47)	Cycle key switch to clear.

Code 81 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 81 - Lift/Lower Pot Out-of-Range The VM detected <0.15V or >2.1V at JPC12-2.	Test A05 - Lift/Lower Pot Voltage (Page 6-35) Test A26 - +5VDC Power Supply (Page 6-47)	Lift is disabled. Cycle key switch to clear.

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Code 83 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 83 - Primary Throttle Pot Out-of-Neutral Primary throttle pot (VR1) out of learned neutral value.	Test A04 - Primary Throttle Pot (VR1) Voltage (Page 6-34) Test A26 - +5VDC Power Supply (Page 6-47)	Travel is disabled. Return control handle to neutral. Cycle key switch to clear.

Code 84 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 84 - Brake Not Applied The Traction Motor speed sensor indicated movement during SelfTest.	Test I19 - Traction Motor Speed Sensor (Page 6-71)	Cycle key switch to clear. Check brake. See “Brake” on page 7-50.

Code 88 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 88 - +5VDC Power Supply Out-of-Range Control Handle +5VDC power supply (located on the VM) is out-of-range.	Test A26 - +5VDC Power Supply (Page 6-47)	Cycle key switch to clear.

Code 8A Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 8A - OCSS Photo Sensor Fault The VM senses the beams are ON with the deadman pedal UP.	Test I80 - OCSS Upper Beam (Page 6-87) Test I81 - OCSS Lower Beam (Page 6-89)	Cycle key switch to clear.

Code 8F Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 8F - Lift/Lower Pot Out-of-Neutral Lift/Lower pot (VR2) out of learned neutral value.	Test A05 - Lift/Lower Pot Voltage (Page 6-35)	Lift/lower disabled. Return control handle to neutral. Cycle key switch to clear.

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Code 8J Inform Service (temperature display is "- -")

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 8J - Ambient Air Temp Sensor Out-of-Range The voltage measured from the ambient air temp sensor is outside the reference range.	Test A36 - Ambient Air Temp Sensor (Page 6-53)	Cycle key switch to clear. **Note:** Control handle heaters are off when this code is present.

Code 8L Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 8L - Brake Feedback Current Out-of-Range The current measured in the brake feedback circuit is zero, or outside the reference range.	Test A35 - Brake Armature (Page 6-52)	Cycle key switch to clear. **Note:** The brake is either fully engaged or fully disengaged when this code is present.

Code 8M Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 8M - Internal Handle Heater Failure The internal heater in the control handle has malfunctioned.	Test A40 - Handle Heater Reference Voltage (optional) (Page 6-56)	Self resetting.

Code 8N Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code 8N - Optional Start Switch Closed at Start-Up The VM senses switch closed.	Test I60 - Security Start Switch (S23) (optional) (Page 6-85)	Open, then close the optional start switch.

Code A0 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code A0 - Mismatched Software Versions The Display Card and VM software versions incompatible.	None	Cycle key switch to clear. Re-flash the VM with correct software. See "FlashWare" on page 3-6.

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Code AH Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code AH - Bad Operator Display Checksum The Operator Display and VM software checksums do not match.	None	Cycle key switch to clear. 1. If the problem is intermittent, check for shorts to frame. See "Shorts to Frame" on page 5-2. 2. Re-flash the software. See "FlashWare" on page 3-6. 3. Replace the VM. 4. If the correct software version appears on the Operator Display, replace the Operator Display.

Code AJ Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code AJ - Bad VM Flash Memory The VM flash memory test failed during SelfTest.	None	Cycle key switch to clear. 1. If the problem is intermittent, check for shorts to frame. See "Shorts to Frame" on page 5-2. 2. Re-flash the software. See "FlashWare" on page 3-6. 3. Replace the VM.

Code AK Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code AK - Bad VM RAM The VM RAM test failed during SelfTest.	None	Cycle key switch to clear. 1. If the problem is intermittent, check for shorts to frame. See "Shorts to Frame" on page 5-2. 2. Re-flash the software. See "FlashWare" on page 3-6. 3. Replace the VM.

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Code AL Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code AL - Bad VM Battery Backed-Up RAM The non-volatile RAM memory test failed during SelfTest.	None	Cycle key switch to clear. 1. If the problem is intermittent, check for shorts to frame. See "Shorts to Frame" on page 5-2. 2. Re-flash the software. See "FlashWare" on page 3-6. 3. Replace the VM.

Code AM Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code AM - Bad Operator Display Flash Memory The Operator Display flash memory test failed during SelfTest. The Operator Display and VM software versions do not match.	None	Cycle key switch to clear. Re-flash the software. See "FlashWare" on page 3-6. Replace Operator Display.

Code AN Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code AN - Bad Operator Display The Operator Display is bad.	None	Cycle key switch to clear. Replace Operator Display.

Code AV Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code AV - Primary Memory Mismatch The three primary memory locations do not agree.	None	Cycle key switch to clear. Install a preprogrammed Operator Display and a preprogrammed VM.

Table 6-1. Code EH Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code EH - Invalid Interrupt - Operator Display There was a software malfunction on the Operator Display card.	None	Cycle key switch to clear. 1. If the problem is intermittent, check for shorts to frame. See "Shorts to Frame" on page 5-2. 2. Re-flash the software. See "FlashWare" on page 3-6. 3. Replace Operator Display.

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Code F4 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code F4 - VM COP Time-out The COP circuit has timed out before a reset was generated.	None	Cycle key switch to clear. 1. If the problem is intermittent, check for shorts to frame. See "Shorts to Frame" on page 5-2. 2. Re-flash the software. See "FlashWare" on page 3-6. 3. Replace the VM.

Code F5 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code F5 - Bad Op Code Bad code was detected during SelfTest. Results in total shutdown.	None	Cycle key switch to clear. 1. If the problem is intermittent, check for shorts to frame. See "Shorts to Frame" on page 5-2. 2. Re-flash the software. See "FlashWare" on page 3-6. 3. Replace the VM.

Code F8 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code F8 - VM COP Not Enabled	None	Cycle key switch to clear. 1. If the problem is intermittent, check for shorts to frame. See "Shorts to Frame" on page 5-2. 2. Re-flash the software. See "FlashWare" on page 3-6. 3. Replace the VM.

Code FE Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code FE - VM Not Calibrated The VM detected an internal calibration error. BSOC information could be inaccurate.	None	Message clears in 30 seconds. Cycle key switch. Make sure lift truck firmware at VM version 3.3/Display Manager version 2.4 or higher is installed. If code continues, replace VM.

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Code FG Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code FG - 5 and/or 12V Power Supply Out-of-Range The +5 and/or +12V power supply voltage is out-of-range.	Test A14 - +12VDC Power Supply (Page 6-41)	Cycle key switch. Make sure lift truck firmware at VM version 3.3/Display Manager version 2.4 or higher is installed.

Code FH Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code FH - Battery Voltage Out-of-Range Battery voltage is <28V or >45V at SelfTest. Results in total shutdown.	Test A15 - Battery Voltage (Page 6-42)	Cycle key switch. Check Fuse FU10.

Code FN Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code FN - Relays Did Not Open at Power Off	Test O32 - Toggle Relays K1, K2, K3, and K4 (Page 6-116)	Brake engages. Disconnect, then re-connect battery connector. Check other relays and circuits associated with the K4 relay tips.

Code FP Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code FP - VM Internal Fault	None	Brake engages. Cycle key switch. Replace VM.

Code FR Inform Service (displays for 5 seconds)

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code FR - VM Config Item Out-of-Range The value of a configurable parameter is out of the reference range.	None	Out-of-range parameter is reset after 5 seconds to the default value.

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Code FT Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code FT - VM Internal Software Error	None	Brake engages. Cycle key switch. Document the sequence of events that occurred just before the code displayed. Have the dealer service technician supply them to Raymond Field Service.

Code FV Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code FV - Display Internal Software Error	None	Cycle key switch. Document the sequence of events that occurred just before the code displayed. Have the dealer service technician supply them to Raymond Field Service.

Code G0 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code G0 - Steer Tiller 1 Channel A/B Fault Steer tiller 1 is missing pulses compared to steer tiller 2, or intermittent connection detected at JPC10-6 or JPC18-5.	Test I33 - Steer Tiller Encoder 1 Connect Detect (Page 6-80) Test I35 - Steer Tiller Encoder 1 - Channels A & B (Page 6-82)	Cycle key switch.

Code G3 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code G3 - Steer Feedback Prox Sensor Fault A steer motor encoder count should have put the steer feedback prox sensor past the steer limit flag, but the flag was not sensed. The steer prox sensor is either low or high all the time.	Test I24 - Steer Feedback Prox Sensor (Page 6-76)	Cycle key switch.

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Code G4 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	**Code G4 - Open Detected in Steer Control Circuit** The VM did not detect either neutral pulses at JPC6-1 or tiller encoder inputs at JPC22-5, JPC22-12, JPC22-13, and JPC22-14.	Test I39 - Neutral Pulses (Page 6-84)	Cycle key switch.

Code G5 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	**Code G5 - Short Detected in Steer Motor Encoder Circuit** A steer command or steer motor encoder pulses were detected without steer tiller encoder pulses detected.	Test I25 - Steer Motor Encoder (Page 6-77)	Cycle key switch.

Code G7 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	**Code G7 - Steer Tiller 2 Channel A/B Fault** Steer tiller 2 is missing pulses compared to steer tiller 1, or intermittent connection detected at JPC10-7 or JPC18-6.	Test I34 - Steer Tiller Encoder 2 Connect Detect (Page 6-81) Test I36 - Steer Tiller Encoder 2 - Channels A & B (Page 6-83)	Cycle key switch.

Code GD Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	**Code GD - Open Detected in Steer Motor Encoder Circuit** A steer command was issued while traveling >1 mph but no steer position feedback encoder pulses were detected.	Test I25 - Steer Motor Encoder (Page 6-77) Test I90 - Degrees Turned Past Steer Flag (Page 6-92)	Cycle key switch. Verify correct steer flag is installed.

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Code GE Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code GE - Steer Tiller Encoder Failure The VM detected connect-detect failures or abnormal inputs on both channels of the steer tiller encoder.	Test I33 - Steer Tiller Encoder 1 Connect Detect (Page 6-80) Test I34 - Steer Tiller Encoder 2 Connect Detect (Page 6-81) Test I35 - Steer Tiller Encoder 1 - Channels A & B (Page 6-82) Test I36 - Steer Tiller Encoder 2 - Channels A & B (Page 6-83)	Cycle key switch.

Code T0 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code T0 - SOL5T Current Incorrect Current being drawn by SOL5T, as seen by the VM, is not at the expected level.	Test A31 - Solenoid 5T (AUX1) Current (Page 6-48)	Cycle key switch.

Code T1 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code T1 - SOL5B Current Incorrect Current being drawn by SOL5B, as seen by the VM, is not at the expected level.	Test A32 - Solenoid 5B (AUX2) Current (Page 6-49)	Cycle key switch.

Code T2 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code T2 - SOL3 Current Incorrect Current being drawn by SOL3, as seen by the VM, is not at the expected level.	Test A33 - Aux Dump (SOL3) (Page 6-50)	Cycle key to clear. Dump valve fault causes shut down of aux functions.

Code T3 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	Code T3 - SOL2 Current Incorrect Current being drawn by soleniod 2 as seen by the VM is not at the expected level.	Test O12 - Ramp the Proportional Lower (SOL2) Solenoid (Page 6-108)	Cycle key switch.

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Code X4 Inform Service

Icon	Code Title/Reason	Test to Run	Notes/Corrective Action
	**Code X4 - Switch Mismatch** System detects both S12 (First Speed Limit Switch) and S27 (Lift Cutout Switch) ON at the same time.	Test I02 - First Speed Limiting Switch (S12) (Page 6-62) Test I22 - Lift Cutout Switch (S27) (Page 6-73)	Cycle key switch. Cross First Speed Limit Switch (S12) and/or Lift Cutout Switch (S27).

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Electrical Connections

Terminology

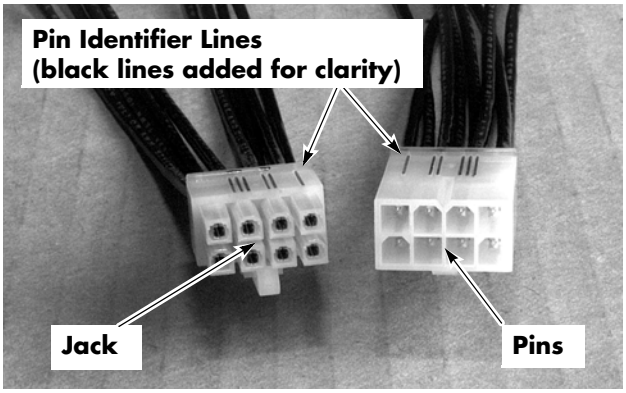
The term “connector JPx” means a mated connector having two connector halves. One half has male connectors, or pins (P); the other half has female connectors, or jacks (J).

When you disconnect a mated JP connector, you have two connector halves. The individual connector halves are specified by “Jx” and “Px.” If you cannot find a connector designated “Jx” or “Px,” look for “JPx,” and vice versa.

For example, connector JP1 is the mated main Operator Display connector. J1 represents the jack connections (in the harness). P1 represents the pin connections (on the Operator Display).

Molex connectors have ridges on the sides to help locate pin number 1. The short side has a single ridge at pin number 1. The long side has 1, 2, and 3 raised ridges at pin numbers 1, 2, and 3. See Figure 6-1.

Figure 6-1. Molex Jack and Pin Connector



Electrical Connector Locator Chart

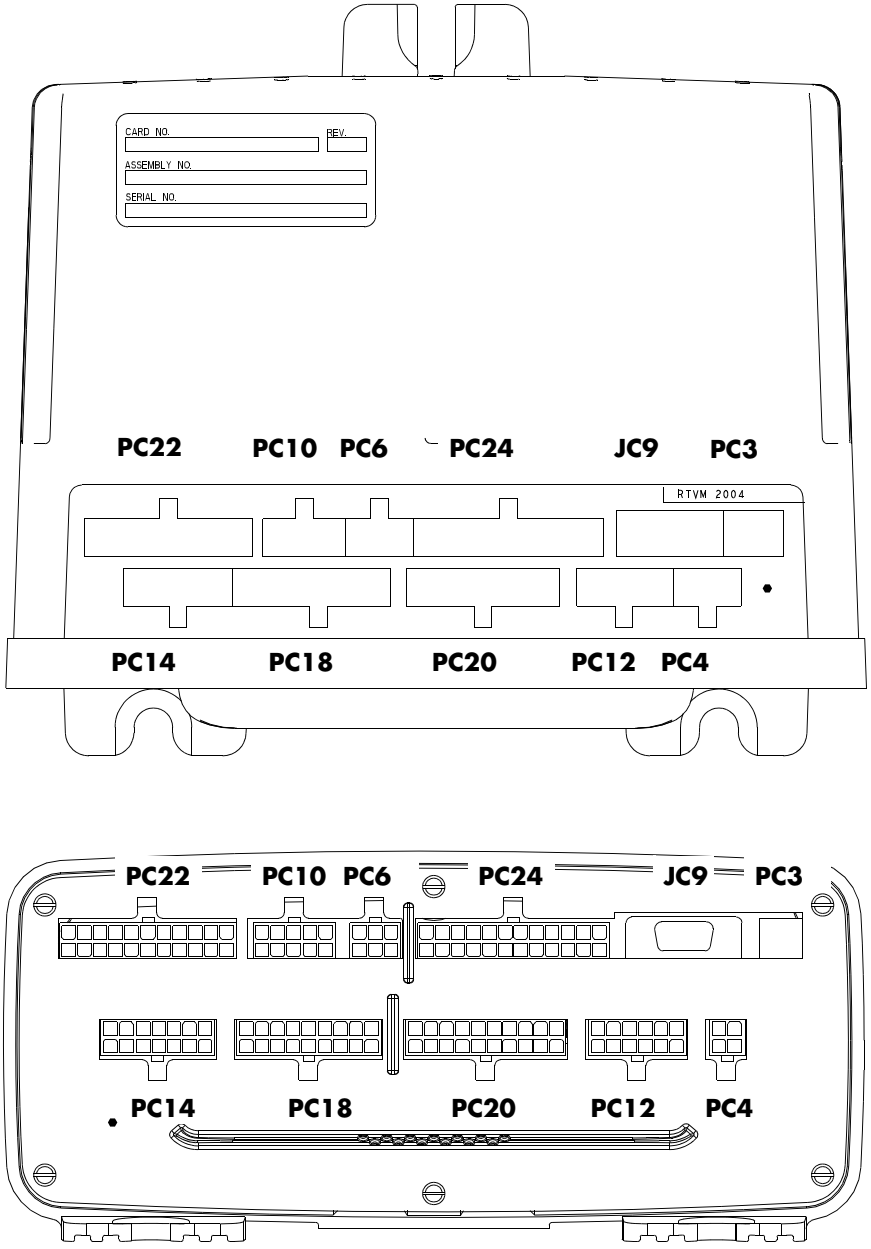
See legend on electrical schematic beginning on page A-17.

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Circuit Card Connectors

Vehicle Manager

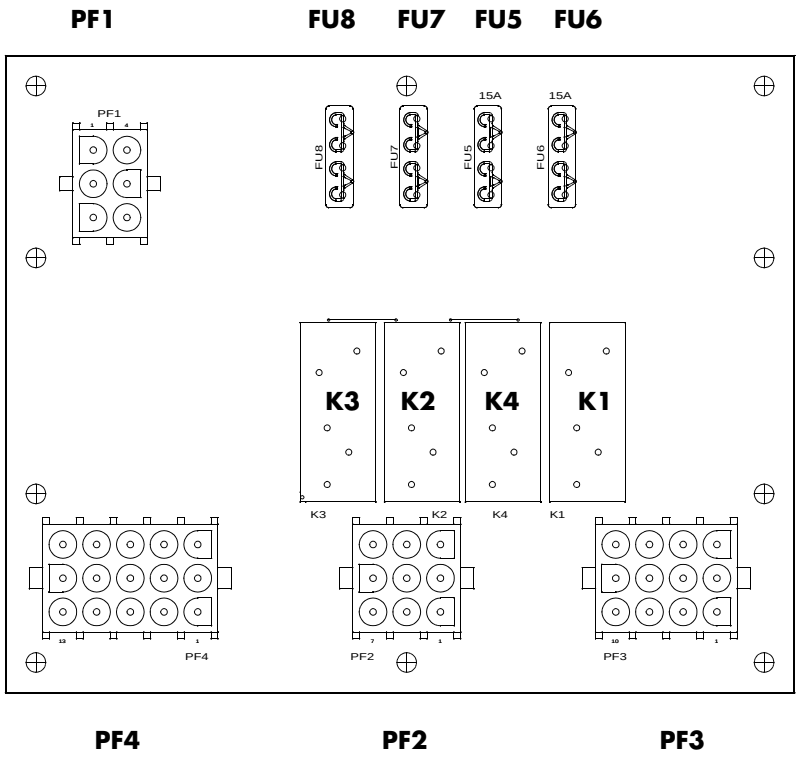
Figure 6-2. Vehicle Manager Connectors



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Fuse/Relay Card

Figure 6-3. Fuse/Relay Card Connectors



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Electrical Tests - Summary List

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Loop Back Tests 6-117

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Analog Tests

A Diagnosis and Repair table is provided for most tests. If a test fails, refer to the Diagnosis and Repair table.

Through the process of elimination, these tables provide a step-by-step approach to diagnosing a problem and the necessary corrective action. See the example below.

Table 6-1. Example Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
Do the testing in this order.	This column identifies any actions required before testing the circuit, such as disconnecting certain connectors. If no instructions are given, all circuits must be connected. **Note:** If something was disconnected in the prior step, reconnect it before performing the next step. This column also identifies the required setting on the meter for this step.	Probe point for the positive (+) meter lead.	Probe point for the negative (–) meter lead.	The reading required to consider the step a success.	The next action to perform if the Expected Results are met.	The next action to perform if the Expected Results are *not* met.

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Test A04 - Primary Throttle Pot (VR1) Voltage

This test displays the voltage the Vehicle Manager reads from the control handle throttle potentiometer (VR1).

NOTE: Run Learn after you replace, repair, or adjust the throttle assembly.

NOTE: For information on how to use Service Mode, see "Using Service Mode" on page 3-28.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

1. The Operator Display shows the voltage the Vehicle Manager reads from the primary throttle potentiometer (VR1).
2. The test is a success if the voltage displayed is within these limits:

Throttle Position	Value Displayed
Full Tractor-First	0.45 to 0.8
Neutral	0.9 to 1.3
Full Forks-First	1.4 to 1.8

   - The values should change smoothly and evenly as the handle is moved from full tractor-first to full forks-first direction.
   - If voltages are not within reference ranges, the test has failed.
3. In Active Service Mode, if the voltage fluctuates erratically as you move the handle back and forth, replace the control handle cable.
4. If there is a problem after reconnecting the control handle cable, inspect the pins in the DB15 connector.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC12/Ohms	JPC12-1 JPC12-12 JPC12-3	JPH1-1 JPH1-12 JPH1-3	0 Ohms	Perform step 2	Replace cable
2	Disconnect JPC12/DCV	JC12-1	JC12-12	4.75 to 5.25V	Replace control handle or pot VR1	Run Test A26 - +5VDC Power Supply (Page 6-47)

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Test A05 - Lift/Lower Pot Voltage

This test displays the voltage the Vehicle Manager reads from the lift/lower potentiometer (VR2).

NOTE: Run Learn after you replace, repair, or adjust the lift/lower potentiometer.

NOTE: For information on how to use Service Mode, see "Using Service Mode" on page 3-28.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

1. The Operator Display shows the voltage the Vehicle Manager reads from the lift/lower potentiometer (VR2).
2. The test is a success if the voltage displayed is within these limits:

Throttle Position	Value Displayed
Full Lift	0.45 to 0.8
Neutral	0.9 to 1.3
Full Lower	1.4 to 1.8

   - The values should change smoothly and evenly as the handle is moved from full lower to full lift.
   - If voltages are not within reference ranges, the test has failed.
3. In Active Service Mode, run the test while moving the travel pot back and forth. If the voltage fluctuates erratically, replace the control handle cable.
4. If there is a problem after reconnecting the control handle cable, inspect the pins in the DB15 connector.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC12/Ohms	JPC12-1 JPC12-12 JPC12-2	JPH1-1 JPH1-12 JPH1-2	0 Ohms	Perform step 2	Replace cable
2	Disconnect JPC12/DCV	JC12-1	JC12-12	4.75 to 5.25V	Replace control handle or pot VR1	Run Test A26 - +5VDC Power Supply (Page 6-47)

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Test A08 - Traction Motor Temperature

This test displays Traction Motor temperature.

Limits

- Normal operation: ambient to 258°F (125°C)
- Speed is linearly reduced to 1.0 mph at:
  - *Danaher Motor*: 266°F (130°C) to 300°F (149°C)
  - *Sauer Danfoss Motor*: 278°F (137°C) to 311°F (155°C)
- Temperature icon illuminates at 275°F (135°C)
- Fault Code 2A and travel disabled at:
  - *Danaher Motor*: 300°F (149°C)
  - *Sauer Danfoss Motor*: 311°F (155°C)

Run Test

NOTE: For information on how to use Service Mode, see “Using Service Mode” on page 3-28.

If the temperature displayed matches the lift truck operation to the limits listed, allow the lift truck to cool and investigate the operation of the brake and drive unit. If the brake and drive unit are functioning correctly, look at the lift truck application for over use. If the temperature displayed does not match the limits listed, proceed to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
Temperature Icon is illuminated or Fault Code 2A is present and Traction Motor is hot to touch						
1	Disconnect JPT1/Ohms	JPT1-16	JPT1-17	>1200 ohms	Perform step 2	Replace TPA
2	Repeat step 1 after cooling for one hour.			Less than measurement in step 1	See section on motor overheating	Perform step 3
3	Disconnect JPT1/Ohms	JPT3-2	JPT3-1	Less than measurement in step 1	Troubleshoot Traction Motor sensor wires	Replace Traction Motor temp sensor
Temperature Icon is illuminated or Fault Code 2A is present and Traction Motor is NOT hot to touch						
1	Disconnect JPT1/Ohms	JPT1-16	JPT1-17	<800 ohms	Replace TPA	Perform step 2
2	Disconnect JPT3/Ohms	JPT3-2	JPT3-1		Troubleshoot Traction Motor sensor wires	Replace Traction Motor temp sensor

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Test A09 - Lift Motor Temperature

This test measures the temperature of the Lift Motor.

Limits

- Normal operation: ambient to 294°F (145°C)
- Temperature icon illuminates at 295°F (146°C)
- Fault Code 6F and lift shutdown at 300°F (149°C)

Run Test

NOTE: For information on how to use Service Mode, see “Using Service Mode” on page 3-28.

If the temperature displayed matches the lift truck operation to the limits listed, allow the lift truck to cool. Check the mast for binding and investigate the operation of the pump. If the mast and pump are functioning correctly, look at the lift truck application for over use. If the temperature displayed does not match the limits listed, proceed to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
Temperature Icon is illuminated or Fault Code 6F is present and Lift Motor is hot to touch						
1	Disconnect JPL1/Ohms	JPL1-16	JPL1-17	>1200 ohms	Perform step 2	Replace LPA
2	Repeat step 1 after cooling for one hour.			Less than measurement in step 1	See section on motor overheating	Perform step 3
3	Disconnect JPL3/Ohms	JPL3-2	JPL3-1	Less than measurement in step 1	T/S Lift Motor sensor wires	Replace Lift Motor temp sensor
Temperature Icon is illuminated or Fault Code 6F is present and Lift Motor is NOT hot to touch						
1	Disconnect JPL1/Ohms	JPL1-16	JPL1-17	<800 ohms	Replace LPA	Perform step 2
2	Disconnect JPL3/Ohms	JPL3-2	JPL3-1		T/S Lift Motor sensor wires	Replace Lift Motor temp sensor

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Test A10 - TPA Temperature

This test measures the temperature of the TPA.

Limits

- Normal operation: ambient to 175°F (79°C)
- Fans toggle on/off at 113°F (45°C)
- Starting at 176°F (80°C), speed is linearly reduced by the TPA to 0 mph at 239°F (115°C), when traction is disabled.
- Temperature icon illuminates at 194°F (90°C)
- Fault Code 1H at 239°F (115°C)

Run Test

NOTE: For information on how to use Service Mode, see “Using Service Mode” on page 3-28.

The TPA heatsink temperature is displayed.

As lift truck is operated, the readings should increase evenly over time. If not, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Operate lift truck for 15 to 20 minutes of hard operation.	N/A	N/A	Heatsink should heat up and fans turn on at approx 113°F (45°C)	Replace TPA	Run Test O23 - Toggle Fans (Page 6-112)

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Test A11 - Traction Motor Current

This test displays the current in the Traction Motor power circuits.

Limits

- 0 to 450A while driving or plugging
- Above 266°F (130°C) current is reduced linearly
- Maximum current up to 540A when deadman pedal is released, unaffected and unreduced by temperature

Run Test

NOTE: For information on how to use Service Mode, see "Using Service Mode" on page 3-28.

This test shows better results in Active Service.

The Operator Display shows the current the TPA reads from one phase of the Traction Motor.

NOTE: Set speed to 3.0 mph (4.8 km/hr) in Configure Mode. See "Using Configure Mode" on page 3-19.

System Condition	Value Displayed (amps)
Static at Rest	<20
Travel 0 to 3.0 mph (4.8 km/hr)	240 at 0 mph 80 at 3.0 mph (4.8 km/hr)
Plugging (from 3.0 mph) (4.8 km/hr)	275 Max

Because Test A11 measures only one phase, the test might not always reveal a current problem.

Diagnosis and Repair

NOTE: Check all motor and power amplifier connections for tightness and corrosion.

Check individual phase currents with a clamp-on ammeter.

- The current should ramp evenly as the lift truck accelerates and decelerates.
- Phase currents should be approximately equal. Gross differences indicate a problem.

If readings are not within reference limits, the test has failed.

1. If any one phase differs significantly from the other two, check power cable continuity. Replace cables as necessary. See "Terminal Nuts" on page 7-64.
   - If power cable continuity is OK, troubleshoot the Traction Motor. See "AC Motors" on page 5-9.
   - If all phases give high readings, the drive unit may be binding. Check drive unit.
2. The TPA may be bad. Run "Test O29 - Ramp Traction Motor" on page 6-114.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 3-16.

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Test A13 - Pressure Sensor Voltage

This test measures the voltage from the pressure sensor used for load weight sensing.

⚠CAUTION

Use extreme caution when working near the elevated forks.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

NOTE: For information on how to use Service Mode, see “Using Service Mode” on page 3-28.

The voltage shown on the Operator Display should increase and decrease linearly as the load weight is increased or decreased. If it does not, the test has failed. If the weight display is inaccurate, the test has failed.

Carriage Position	Value Displayed (Volts)
Fully Lowered	approx. 1.0
Lifted in Free Lift	approx. 1.5
Lifted in Second Stage	approx. 2.0

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPY1-2	JPY1-3	1.0V lowered 1.5V Lifted in free lift 2.0V Lifted in second stage	Perform step 2	Perform step 3
2		JPC24-18	JPC24-6		Replace VM	Troubleshoot pressure sensor harness
3		JPY1-1	JPY1-3	10.5 to 13V	Replace pressure transducer	

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Test A14 - +12VDC Power Supply

This test displays the VM +12V Power Supply voltage.

Run Test

NOTE: For information on how to use Service Mode, see “Using Service Mode” on page 3-28.

1. The Operator Display shows the voltage measured from the +12V power supply.
2. The test is a success if the voltage displayed is within these limits:

System Condition	Value Displayed
Lift truck at rest	10.1 to 13.0V

If the reading fluctuates by more than 0.8V in 10 seconds, the test has failed.

Diagnosis and Repair

Disconnect everything powered by +12V except JPC14 (includes Operator Display and Power Amps). Monitor the +12V and reconnect each connector. Troubleshoot the circuit that causes the +12V supply to go out-of-range. Otherwise, replace VM.

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Test A15 - Battery Voltage

This test displays the voltage used to calculate Battery State-of-Charge (BSOC).

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

NOTE: For information on how to use Service Mode, see “Using Service Mode” on page 3-28.

1. The battery voltage as shown on the Operator Display should be 28 to 45VDC.
2. If the numbers displayed are not in this range, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	TP1	TP4	B+	Perform step 2	Check battery voltage/ specific gravity. Replace battery. Troubleshoot or replace battery cables
2		JPF4-1			Perform step 3	Troubleshoot harness TP1 to JPF4-1
3		JPF4-7			Perform step 4	Replace Fuse/Relay Card
4		JPC24-24			Replace VM	Troubleshoot harness from Fuse/Relay Card to VM

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Test A19 - LPA Temp

This test displays the temperature of the Lift Power Amplifier.

Limits

- Normal operation: ambient to 175°F (79°C)
- Fans toggle on/off at 113°F (45°C)
- Starting at 176°F (80°C), speed is linearly reduced to 0 fpm at 239°F (115°C), when lift is disabled.
- Temperature icon illuminates at 189°F (87°C)
- Fault Code 1V at 239°F (115°C)

Run Test

NOTE: For information on how to use Service Mode, see “Using Service Mode” on page 3-28.

The Operator Display shows the heatsink temperature the LPA reads.

As the lift is operated, the readings should increase evenly over time. If not, the test has failed.

Diagnosis and Repair

1. Check for dirt and debris in the LPA cooling fins.
2. Run lift truck hard for 15 to 20 minutes. Check operation of the LPA cooling fans. Run Test O23 - Toggle Fans (Page 6-112).
3. The LPA may be bad. Replace the LPA.

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Test A20 - Lift Motor Current

This test measures the Lift Motor current through the Lift Power Amplifier.

⚠ WARNING

The lift carriage and forks will move during this test.

⚠CAUTION

The area around the forks should be clear. The ceiling clearance should allow for the highest lift.

Limits

- 0 to 550A lifting
- Maximum current 675A

Run Test

NOTE: For information on how to use Service Mode, see “Using Service Mode” on page 3-28.

NOTE: This test shows better results in Active Service.

The Operator Display shows the current the LPA reads from one phase of the Lift Motor.

Because Test A20 measures only one phase, the test might not always reveal a current problem.

Lifting an empty carriage in free lift gives readings of 280 to 320 amps. Readings are approximately the same if a clamp-on ammeter is used.

Diagnosis and Repair

NOTE: Check all motor and power amplifier connections for tightness and corrosion.

Check individual phase currents with a clamp-on ammeter.

- The current should ramp evenly as the lift truck accelerates and decelerates.
- Phase currents should be approximately equal. Gross differences indicate a problem.
- If readings are not within reference limits, the test has failed.

If any one phase differs significantly from the other two, check power cable continuity. Replace cables as necessary. See “Terminal Nuts” on page 7-64.

- If power cable continuity is OK, troubleshoot the Lift Motor. See “AC Motors” on page 5-9.
- If all phases give high readings, the mast may be binding. Check mast.

NOTE: For instructions on selecting Modes of Operation, see “Modes of Operation” on page 3-16.

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Test A22 - Traction Throttle (VR1) Request

This test displays the percentage of primary control handle traction throttle request from VR1 being read by the VM.

Run Test

NOTE: Run Learn after you replace, repair, or adjust the throttle assembly.

NOTE: For information on how to use Service Mode, see "Using Service Mode" on page 3-28.

The Operator Display shows the percentage of throttle request the VM reads from VR1.

Throttle Position	Value Displayed
Full Tractor-First	0 to +100
Neutral	0
Full Forks-First	0 to –100

The values must change smoothly and evenly as the handle moves from full tractor-first to full forks-first.

If percentages are not within reference limits, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC12 /Ohms	JPC12-1 JPC12-12 JPC12-3	JPH1-1 JPH1-12 JPH1-3	0 Ohms	Perform step 2	Replace cable
2	Disconnect JPC12/DCV	JC12-1	JC12-12	4.75 to 5.25V	Perform step 3	Run Test A26 - +5VDC Power Supply (Page 6-47)
3	DCV	JPC12-3	JPC12-12	Neutral: 0.9 to 1.3V Full tractor-first: 0.45 to 0.8V Full forks-first: 1.4 to 1.8V	Replace VM	Replace VR1

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Test A23 - Lift Throttle (VR2) Request

This test displays the percentage of lift throttle request from VR2 being read by the VM.

Run Test

NOTE: Run Learn after you replace, repair, or adjust the lift/lower potentiometer.

NOTE: For information on how to use Service Mode, see "Using Service Mode" on page 3-28.

The Operator Display shows the percentage of lift request the VM reads from VR2.

Throttle Position	Value Displayed
Full Lower	0 to –100
Neutral	0
Full Lift	0 to +100

The values must change smoothly and evenly as the handle moves from full lower to full lift.

If percentages are not within reference limits, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC12 /Ohms	JPC12-1 JPC12-12 JPC12-2	JPH1-1 JPH1-12 JPH1-2	0 Ohms	Perform step 2	Replace cable
2	Disconnect JPC12 /DCV	JC12-1	JC12-12	4.75 to 5.25V	Perform step 3	Run Test A26 - +5VDC Power Supply (Page 6-47)
3	DCV	JPC12-2	JPC12-12	Neutral: 0.9 to 1.3V Full lift: 0.45 to 0.8V Full lower: 1.4 to 1.8V	Replace VM	Replace VR2

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Test A26 - +5VDC Power Supply

This test measures the +5V Power Supply voltage used for the control handle switches and potentiometers.

Run Test

NOTE: For information on how to use Service Mode, see “Using Service Mode” on page 3-28.

If the Operator Display does not read +5 ±0.25V, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC12 and JCP4/DCV	PC12-1	PC12-12	4.75 to 5.25V	Troubleshoot wires and control handle	Replace VM

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Test A31 - Solenoid 5T (AUX1) Current

This test displays the current the Aux1 directional solenoid coil is drawing.

It does *not* prove the Aux1 directional solenoid valve is functioning correctly mechanically. It does *not* prove the condition of the wiring or the VM itself.

Run Test

NOTE: For information on how to use Service Mode, see “Using Service Mode” on page 3-28.

The test is a success if the current displayed is:

Function	Value Displayed (amps)
Retract - Slow	approx. 0.3
Retract - High	approx. 0.6
Tilt Down/Sideshift Left	approx. 0.6

Because the directional coil is proportional, current for tilt/sideshift can be different from the current for reach/retract. If any one function passes, run input test for failed functions (I07, I09, or I11).

If results do not match the preceding table, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC20/Ohms	JC20-17	JC20-18	approx. 40 Ohms	Perform step 2	Troubleshoot wires and coil
2	DCV		TP4	B+	Replace VM	Troubleshoot B+K2 from Fuse/Relay Card

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Test A32 - Solenoid 5B (AUX2) Current

This test displays the current the Aux2 directional solenoid coil is drawing.

It does *not* prove the Aux2 directional solenoid valve is functioning correctly mechanically. It does *not* prove the condition of the wiring or the VM itself.

Run Test

NOTE: For information on how to use Service Mode, see "Using Service Mode" on page 3-28.

The test is a success if the current displayed is:

Function	Value Displayed (amps)
Retract - Slow	approx. 0.2
Retract - High	approx. 0.6
Tilt Down/Sideshift Left	approx. 0.6

Because the directional coil is proportional, current for tilt/sideshift can be different from the current for reach/retract. If any one function passes, run input test for failed functions (I06, I08, or I10).

If results do not match the preceding table, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC20/Ohms	JC20-19	JC20-20	approx. 40 Ohms	Perform step 2	Troubleshoot wires and coil
2	DCV		TP4	B+	Replace VM	Troubleshoot B+K2 from Fuse/Relay Card

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Test A33 - Aux Dump (SOL3)

This test displays the current the dump solenoid coil is drawing.

Run Test

NOTE: For information on how to use Service Mode, see “Using Service Mode” on page 3-28.

The test is a success if the current displayed is:

Function	Value Displayed (amps)
Any Aux Function Activated	approx. 0.8

If results do not match the preceding table, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC20/Ohms	JC20-13	JC20-12	approx. 39 Ohms	Perform step 2	Troubleshoot wires and coil
2	DCV		TP4	B+	Replace VM	Troubleshoot B+K2 from Fuse/Relay Card

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Test A34 - Lift/Lower Current (SOL2)

This test displays the current the proportional lift/lower solenoid coil is drawing.

Run Test

NOTE: For information on how to use Service Mode, see "Using Service Mode" on page 3-28.

The test is a success if the current displayed is:

State	Value Displayed (amps)
Neutral	approx. 0
Full Lower	approx. 1.5

If results do not match the preceding table, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC20/Ohms	JC20-15	JC20-16	approx. 13 Ohms	Perform step 2	Troubleshoot wires and coil
2	DCV	PC20-15	TP4	B+	Replace VM	Troubleshoot B+K2 from Fuse/Relay Card

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Test A35 - Brake Armature

The brake coil is activated by a coil driver located inside the Vehicle Manager. This test displays the voltage measured across that coil driver.

Run Test

NOTE: For information on how to use Service Mode, see "Using Service Mode" on page 3-28.

The test is a success if the voltage displayed is within these limits:

State of Brake	Value Displayed (Volts)
Brake Pulling In	approx. 0.25 for 2 seconds
Deadman Pedal Depressed/ Travel Requested	approx. 9.0

If results do not match the preceding table, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC20/Ohms	JF2-2	JC20-14	approx. 9 Ohms	Perform step 2	Troubleshoot wires and coil
2	DCV	PF2-2	TP4	B+	Replace VM	Troubleshoot B+K2 from Fuse/Relay Card

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Test A36 - Ambient Air Temp Sensor

This test displays the ambient air temperature of the area around the lift truck.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

NOTE: For information on how to use Service Mode, see “Using Service Mode” on page 3-28.

The Operator Display should display the temperature of the room where the lift truck is located.

If not, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPA/DCV	JPC24-23	JPC24-11	approx. 5V	Perform step 2	Replace VM
2	Ohms	JPC24-23 JPC24-11	JPA-1 JPA-2	0 Ohms	Replace temp sensor	Troubleshoot wires as indicated by test

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Test A37 - Steer Power Amp Current

This test displays the current the steer motor is drawing.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

NOTE: For information on how to use Service Mode, see “Using Service Mode” on page 3-28.

The test is a success if the current displayed is:

Steer Direction	Value Displayed (amps)
At rest	<3
Clockwise (CW)	–30 to –50
Counterclockwise (CCW)	30 to 50
Note: CW and CCW is drive unit direction.	

If results do not match the preceding table, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPC6-3	TP4	At rest: approx. 2.5V Steering CCW: less than voltage at rest Steering CW: more than voltage at rest	Replace VM	Replace Steer Amp

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Test A39 - Analog Reference Voltage

This test displays the voltage used by the Vehicle Manager to verify all analog voltages.

Run Test

NOTE: For information on how to use Service Mode, see “Using Service Mode” on page 3-28.

You should see 2.4 to 2.6V. If not, the test has failed.

Diagnosis and Repair

Replace Vehicle Manager.

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Test A40 - Handle Heater Reference Voltage (optional)

This test displays the voltage the Vehicle Manager sees going through the internal primary control handle heater (HTR6).

NOTE: Heater operation requires ambient temperature sensor to be activated. Heaters then turn on at 40°F (4.4°C).

Run Test

NOTE: For information on how to use Service Mode, see “Using Service Mode” on page 3-28.

The test is a success if the voltage displayed is within these limits:

Heater OFF	Heater ON
0V	approx. 8V

If results do not match the preceding table, the test has failed. Verify option is turned on.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC12/Ohms	JPC12-7	JPC12-12	9 to 10 Ohms	Perform step 2	Check cable wiring. If OK, replace handle or internal heater
2	Disconnect JPC12/DCV	JPC12-7 on VM	JPC12-12 on VM	Heater ON: approx. 8V Test OFF: 0V	Perform step 1	Replace VM

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Test A41 - Emergency Power Off (EPO) Switch

This test shows the Vehicle Manager reading from the EPO switch.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

NOTE: For information on how to use Service Mode, see “Using Service Mode” on page 3-28.

The test is a success if the voltage displayed is within these limits:

State of Switch	Displayed Value (Volts)
Up (closed)	B+
Down (open)	0

If results do not match the preceding table, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPF4-12	TP4 (B–)	B+	Perform step 2	Clean pin connection then replace Fuse/Relay Card
2		JPF4-5			Perform step 3	Repair/replace wiring or switch
3		JPF4-6			Perform step 4	Clean pin connection then replace Fuse/Relay Card
4		JPC22-21			Replace VM	Repair/replace wiring or switch

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Digital Input Tests

A Diagnosis and Repair table is provided for most tests. If a test fails, refer to the Diagnosis and Repair table.

Through the process of elimination, these tables provide a step-by-step approach to diagnosing a problem and the necessary corrective action. See the example below.

Table 6-2. Example Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
Do the testing in this order.	This column identifies any actions required before testing the circuit, such as disconnecting certain connectors. If no instructions are given, all circuits should be connected. **Note:** If something was disconnected in the prior step, reconnect it before performing the next step. This column also identifies the required scale on the meter for this step.	Probe point for the positive (+) meter lead.	Probe point for the negative (–) meter lead.	The reading required to consider the step a success.	The next action to perform if the Expected Results are met.	The next action to perform if the Expected Results are *not* met.

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Test I00 - Deadman Switch (DS1)

This test shows the Vehicle Manager reading from the deadman switch (DS1).

⚠ WARNING

DO NOT perform this test on a ramp.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

NOTE: For information on how to use maintenance mode, see “Using Service Mode” on page 3-28.

The Operator Display shows the state of the switch.

Operator Action	Message Displayed
Off deadman	Up
On deadman	Down

If the display does not change when you step on the pedal, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC22 and JPC18/Ohms	JC22-8	JC18-7	DS1 closed: 0 Ohms DS1 open: open circuit	Perform step 2	Troubleshoot wires and switch
2	Disconnect JPS12/DCV	JPS12-2	JPS12-3	4.5V	Recheck step 1	Replace VM

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Test I01 - Nested Switch (S14)

NOTE: This test applies only to lift trucks with the nested switch option.

This test shows the Vehicle Manager reading from the nested switch (S14).

⚠CAUTION

Use extreme caution when working around an elevated mast.

⚠ WARNING

Lift only in an area with a ceiling height greater than the lift truck's maximum elevated height.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

The Operator Display shows the state of the switch:

Mast Position	Message Displayed
Nested	In
Unnested	Out

If these results are not observed, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPF2/Ohms	JPF2-8	JPC22-18	S14 open: open circuit S14 closed: 0 Ohms	Perform step 2	Troubleshoot wires and switch
2	Disconnect JPC22/DCV	JPC22-18	TP4	S14 closed: B+	Verify options are on, then replace VM	Troubleshoot K2 circuit

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Test I02 - First Speed Limiting Switch (S12)

This test shows the Vehicle Manager reading from the first speed limiting mast switch (S12).

⚠CAUTION

Use extreme caution when working around an elevated mast.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

Run this test in Active Service Mode.

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

The Operator Display should show the following:

Mast Position	Message Displayed
Lowered	Below
Raised	Above

If these results are not observed, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
Proximity Sensor Switch						
1	Disconnect JPS4/DCV	JS4-1	JS4-3	10.5 to 13V	Perform step 4	Perform step 2
2	Disconnect JPS4 and JPC20/Ohms		JC20-1	0 Ohms	Perform step 3	Repair or replace wire
3	Disconnect JPS4 and JPF3/Ohms	JS4-3	JF3-8		Inspect pin connection to FRC	Repair or replace wire
4	DCV	JPS4-1	JPS4-2	Mast lowered: 10.5 to 13V Mast elevated: 0V	Perform step 5	Replace S12
5		JC20-1	JC22-1		Replace VM	Repair or replace wire

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Test I06 - Reach Switch (S4)

Use this test to monitor the state of reach switch (S4). This test shows what the Vehicle Manager is reading from the switch.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

NOTE: For information on how to use maintenance mode, see “Using Service Mode” on page 3-28.

The Operator Display shows the state of the switch:

State of Switch	Message Displayed
Depressed	In
Released	Out

1. If results do not match the preceding table, the test has failed. Perform diagnosis.
2. In Active Service Mode, run the test while moving the travel pot back and forth. If the voltage fluctuates erratically as you move the handle back and forth, replace the control handle cable.
3. If there is a problem after reconnecting the control handle cable, inspect the pins in the DB15 connector.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC12/DCV	JPC12-4	JPC12-12	>4V	Perform step 2	Replace VM
2	Disconnect JPH1/DCV	JPH1-4	JPH1-12		Perform step 3	Repair or replace cable to VM
3	DCV	JPH1-4	JPH1-12	S4 open: >4V S4 closed: <1V	Replace VM	Replace control handle
Note: Voltage to switch being tested may drop when any other control handle switch is depressed.						

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Test I07 - Retract Switch (S5)

Use this test to monitor the state of retract switch (S5). This test shows what the Vehicle Manager is reading from the switch.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

The Operator Display shows the state of the switch:

State of Switch	Message Displayed
Depressed	In
Released	Out

1. If results do not match the preceding table, the test has failed. Perform diagnosis.
2. In Active Service Mode, run the test while moving the travel pot back and forth. If the voltage fluctuates erratically as you move the handle back and forth, replace the control handle cable.
3. If there is a problem after reconnecting the control handle cable, inspect the pins in the DB15 connector.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC12/DCV	JPC12-11	JPC12-12	>4V	Perform step 2	Replace VM
2	Disconnect JPH1/DCV	JPH1-11	JPH1-12		Perform step 3	Repair or replace cable to VM
3	DCV			S5 open: >4V S5 closed: <1V	Replace VM	Replace control handle
Note: Voltage to switch being tested may drop when any other control handle switch is depressed.						

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Test I08 - Tilt Up Switch (S6)

Use this test to monitor the state of tilt up switch (S6). This test shows what the Vehicle Manager is reading from the switch.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

NOTE: For information on how to use maintenance mode, see “Using Service Mode” on page 3-28.

The Operator Display shows the state of the switch:

State of Switch	Message Displayed
Depressed	In
Released	Out

1. If results do not match the preceding table, the test has failed. Perform diagnosis.
2. In Active Service Mode, run the test while moving the travel pot back and forth. If the voltage fluctuates erratically as you move the handle back and forth, replace the control handle cable.
3. If there is a problem after reconnecting the control handle cable, inspect the pins in the DB15 connector.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC12/DCV	JPC12-5	JPC12-12	>4V	Perform step 2	Replace VM
2	Disconnect JPH1/DCV	JPH1-5	JPH1-12		Perform step 3	Repair or replace cable to VM
3	DCV			S6 open: >4V S6 closed: <1V	Replace VM	Replace control handle
Note: Voltage to switch being tested may drop when any other control handle switch is depressed.						

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Test I09 - Tilt Down Switch (S7)

Use this test to monitor the state of tilt down switch (S7). This test shows what the Vehicle Manager is reading from the switch.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

The Operator Display shows the state of the switch:

State of Switch	Message Displayed
Depressed	In
Released	Out

1. If results do not match the preceding table, the test has failed. Perform diagnosis.
2. In Active Service Mode, run the test while moving the travel pot back and forth. If the voltage fluctuates erratically as you move the handle back and forth, replace the control handle cable.
3. If there is a problem after reconnecting the control handle cable, inspect the pins in the DB15 connector.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC12/DCV	JPC12-6	JPC12-12	>4V	Perform step 2	Replace VM
2	Disconnect JPH1/DCV	JPH1-6	JPH1-12		Perform step 3	Repair or replace cable to VM
3	DCV			S7 open: >4V S7 closed: <1V	Replace VM	Replace control handle
Note: Voltage to switch being tested may drop when any other control handle switch is depressed.						

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Test I10 - Sideshift Right Switch (S9)

Use this test to monitor the state of sideshift right switch (S9). This test shows what the Vehicle Manager is reading from the switch.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

NOTE: For information on how to use maintenance mode, see “Using Service Mode” on page 3-28.

The Operator Display shows the state of the switch:

State of Switch	Message Displayed
Depressed	In
Released	Out

1. If results do not match the preceding table, the test has failed. Perform diagnosis.
2. In Active Service Mode, run the test while moving the travel pot back and forth. If the voltage fluctuates erratically as you move the handle back and forth, replace the control handle cable.
3. If there is a problem after reconnecting the control handle cable, inspect the pins in the DB15 connector.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC12/DCV	JPC12-9	JPC12-12	>4V	Perform step 2	Replace VM
2	Disconnect JPH1/DCV	JPH1-9	JPH1-12		Perform step 3	Repair or replace cable to VM
3	DCV			S9 open: >4V S9 closed: <1V	Replace VM	Replace control handle
Note: Voltage to switch being tested may drop when any other control handle switch is depressed.						

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Test I11 - Sideshift Left Switch (S8)

Use this test to monitor the state of sideshift left switch (S8). This test shows the Vehicle Manager reading from the switch.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

The Operator Display shows the state of the switch:

State of Switch	Message Displayed
Depressed	In
Released	Out

1. If results do not match the preceding table, the test has failed. Perform diagnosis.
2. In Active Service Mode, run the test while moving the travel pot back and forth. If the voltage fluctuates erratically as you move the handle back and forth, replace the control handle cable.
3. If there is a problem after reconnecting the control handle cable, inspect the pins in the DB15 connector.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC12/DCV	JPC12-8	JPC12-12	>4V	Perform step 2	Replace VM
2	Disconnect JPH1/DCV	JPH1-8	JPH1-12		Perform step 3	Repair or replace cable to VM
3	DCV			S8 open: >4V S8 closed: <1V	Replace VM	Replace control handle
Note: Voltage to switch being tested may drop when any other control handle switch is depressed.						

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Test I14 - Steering Fuse (FU1)

This test reports the absence or presence of B+ voltage at the load side of the steer motor (STR) contactor.

⚠CAUTION

When this test is activated and the deadman pedal is depressed, the steer motor/pump activates.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

NOTE: For information on how to use maintenance mode, see “Using Service Mode” on page 3-28.

Use the following table as a guideline.

Deadman Pedal Position	Message Displayed
Down	Clsd (closed)
Up	Open

NOTE: The display shows CLSD until the TPC and LPC timeout. The contactor opens but capacitors in the steer amplifier take some time to bleed off.

If the STR contactor tips do not close, run Test O01 - Toggle the STR Contactor (Page 6-99).

If the display message does not change when the test is activated, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Remove FU1/ Ohms	Fuse	Fuse	0 Ohms	Perform step 2	Replace fuse FU1
2	DCV	STR-1	STR-2	STR Tips open: 0V STR Tips closed: B+	Perform step 3	Replace STR contactor tips
3		JPC22-19	TP4	STR Tips open: 0V STR Tips closed: B+	Replace VM	Troubleshoot wiring from VM to contactor

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Test I15 - Horn Switch (S3)

Use this test to monitor the state of the horn switch (S3). This test shows the Vehicle Manager reading from the switch.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

NOTE: For information on how to use maintenance mode, see “Using Service Mode” on page 3-28.

The Operator Display shows the state of the switch:

State of Switch	Message Displayed
Depressed	In
Released	Out

If results do not match the preceding table, the test has failed. Perform diagnosis.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC12/DCV	JPC12-10	JPC12-12	>4V	Perform step 2	Replace VM
2	Disconnect JPH1/DCV	JPH1-10	JPH1-12		Perform step 3	Repair or replace cable to VM
3	DCV			S3 open: >4V S3 closed: <1V	Replace VM	Replace control handle
Note: Voltage to switch being tested may drop when any other control handle switch is depressed.						

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Test I19 - Traction Motor Speed Sensor

This test displays the Traction Motor speed sensor output as seen by the TPA.

⚠CAUTION

Do this test in an area free of obstructions with ample room for maneuvering.

Run Test

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

"0000 to ±3200 rpm" should be displayed.

NOTE: The Operator Display shows rpm as measured by the TPA.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPT1-3	JPT1-4	10.5 to 13V	Perform step 2	Replace TPA
2	Disconnect JPT2/DCV	JPT2-1	JPT2-4		Perform step 3	Troubleshoot wiring TPA to Traction Motor
3	Reconnect JPT2/DCV	JPT2-2		At rest: 0V or 10.5 to 13V Traveling: approx. 5V	Perform step 4	Replace Traction Motor speed sensor
4	DCV	JPT2-3			Perform step 5	
5		JPT1-5	JPT1-4		Perform step 6	Troubleshoot wiring TPA to Traction Motor
6		JPT1-6			Replace TPA	

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Test I20 - Lift Motor Speed Sensor

This test displays the input from the speed sensor on the Lift Motor as seen by the lift power amplifier.

⚠CAUTION

Do this test in an area free of obstructions with ample room for lifting.

Run Test

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

This test shows best results in Active Service.

"0000 to ±2450 rpm" should be displayed.

NOTE: The Operator Display shows rpm as measured by the LPA.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPL1-3	JPL1-4	10.5 to 13V	Perform step 2	Replace LPA
2		JPL2-1	JPL2-4		Perform step 3	Troubleshoot wiring from LPA to Lift Motor
3		JPL2-2		At rest: 0V or 10.5 to 13V Lifting: approx. 5V	Perform step 4	Replace Lift Motor speed sensor
4		JPL2-3			Perform step 5	
5		JPL1-5	JPL1-4		Perform step 6	Troubleshoot wiring LPA to Lift Motor
6		JPL1-6			Replace LPA	

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Test I22 - Lift Cutout Switch (S27)

This test displays what the VM is reading from the Lift Cutout switch (S27).

Run Test

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

The Operator Display shows the state of the switch:

Mast Position	Message Displayed
Over Flag	ON
Not Over Flag	OFF

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPS5/DCV	JS5-1	JS5-3	10.5 to 13V	Perform step 4	Perform step 2
2	Disconnect JPS5 and JPC20/Ohms		JC20-6	0 Ohms	Perform step 3	Repair or replace wiring
3	Disconnect JPS5 and JPF3/Ohms	JS5-3	JF3-12		Check wiring to Fuse/Relay Card	
4	DCV	JPS5-1	JPS5-2	Mast lowered: 10.5 to 13V Mast elevated: 6V	Perform step 5	Replace S27
5		JC20-6	JC22-6		Replace VM	Repair or replace wiring

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Test I23 - CAN Bus Test

This test verifies the VM is communicating with the TPA, LPA, and Operator Display.

Run Test

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

The Operator Display shows:

- **T** if the TPA is communicating with the VM
- **L** if the LPA is communicating with the VM
- **V** if the Operator Display is communicating with the VM

If T, L, or V is not present, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
Unable to enter the test and see letters						
1	Remove JPD1-2 and JPD1-3 from connector	n/a	n/a	V visible in test	Perform step 2	Perform step 5
2	Disconnect JPT1			L and V visible in test	Replace TPA	Perform step 3
3	Disconnect JPL1 and jumpers between JPL1-14 and JPL1-15; and between JPL1-22 and JPL1-23			T and V visible in test	Replace LPA	Perform step 4
4	Disconnect JPT1 and JPD1/Ohms	JPD1-2	JPD1-3	approx. 38 Ohms	Perform step 1	Test wires for continuity. Make sure they are not shorted together.
5	Disconnect JPD1/Ohms	JPD1-6	JPD1-7	approx. 120 Ohms	Replace display	Test wires for continuity. Make sure they are not shorted together. If OK, replace VM.

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Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
T Missing						
1	DCV	JPT1-1	JPT1-7	B+	Verify LED's on TPA are lit. If not, test Traction Motor temp sensor and speed encoder circuits. Replace TPA. If OK, perform step 2.	Troubleshoot B+ from K3 Relay and DGND from LPA.
2	Disconnect JPT1 and JPL1/Ohms	JPT1-22	JPL1-23	0 Ohms	Perform step 3	Repair wiring
3	Disconnect JPT1 and JPL1/Ohms	JPT1-14	JPL1-15	0 Ohms	Replace TPA	Repair wiring
L Missing						
1	DCV	JPL1-1	JPL1-7	B+	Verify LED's on LPA are lit. If not, test Lift Motor temp sensor and speed encoder circuits. Replace LPA. If OK, perform step 2.	Troubleshoot B+ from K3 Relay and DGND from Display.
2	Disconnect JPD1 and JPL1/Ohms	JPL1-22	JPD1-2	0 Ohms	Perform step 3	Repair wiring
3		JPL1-14	JPD1-3	0 Ohms	Replace TPA	Repair wiring

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Test I24 - Steer Feedback Prox Sensor

This test reads the input to the Vehicle Manager from the Steer Feedback Proximity Sensor.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

NOTE: For information on how to use maintenance mode, see “Using Service Mode” on page 3-28.

The Operator Display shows the state of the sensor:

Sensor Position	Message Displayed
Over Metal	On
Not Over Metal	Off

If results do not match the preceding table, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC20/DCV	PC20-9	PC20-11	12V	Perform step 2	Replace VM
2	DCV	JPST-1	JPST-3		Perform step 3	Repair or replace wiring
3		JPST-2	JPST-3	Sensor over metal: 5V Sensor not over metal: <1V	Perform step 4	Replace sensor
4		JPC22-22	JPC22-11		Replace VM	Repair or replace wiring

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Test I25 - Steer Motor Encoder

This test displays the encoder counts from the steer motor encoder.

Run Test

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

You should see "0 to 255" while steering. If not, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPC20-7	JPC10-9	12V	Perform step 2	Replace VM
2		JPE4-1	JPE4-4		Perform step 3	Troubleshoot wiring to VM
3		JPE4-3		Steering: approx. 1.8V Not steering: 0 or 4.5V	Perform step 4	Replace Steer Motor encoder
4		JPE4-2			Perform step 5	
5		JPC22-10	JPC10-9		Perform step 6	Troubleshoot wiring to encoder
6		JPC22-9			Replace VM.	

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Test I26 - Height Indicator Encoder

This test reads the input from the height encoder to the Operator's Display.

Run Test

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

Above free lift: counts increase "0 to 255" lifting
counts decrease "255 to 0" lowering

If not, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPD2-1	JPD2-2	10.5 to 13V	Perform step 2	Replace Operator Display
2		JPE3-1	JPE3-4		Perform step 3	Repair or replace wiring
3		JPE3-3 (Channel A)		Not lifting: approx. 5 or 0V Lifting above free lift: approx. 2.3V	Perform step 4	Replace height encoder
4		JPE3-2 (Channel B)	JPE3-4		Perform step 5	
5		JPD2-3 (Channel A)	JPD2-2		Perform step 6	Repair or replace wiring
6		JPD2-4 (Channel B)			Replace Operator Display	

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Test I32 - Deadman Switch (DS2)

This test shows what the Vehicle Manager is reading from the deadman switch (DS2).

⚠ WARNING

DO NOT perform this test on a ramp.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

NOTE: For information on how to use maintenance mode, see “Using Service Mode” on page 3-28.

The Operator Display shows the state of the switch.

Operator Action	Message Displayed
Off deadman	Up
On deadman	Down

If the display does not change when you step on the pedal, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC22 and JPC10/Ohms	JC22-8	JC10-8	DS2 closed: 0 Ohms DS2 open: open circuit	Perform step 2	T/S wires and switch
2	Disconnect JPS12/DCV	JPS12-1	JPS12-3	4.5V	Recheck step 1	Replace VM

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Test I33 - Steer Tiller Encoder 1 Connect Detect

This test verifies the Vehicle Manager sees the 12V circuit connected to the Steer Tiller Encoder Channel 1.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

NOTE: For information on how to use maintenance mode, see “Using Service Mode” on page 3-28.

The Operator Display should show the following:

Connection Status	Message Displayed
Connected	Yes
Not Connected	No

If results do not match the preceding table, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPC10-6	JPC18-5	10.5 to 13V	Perform step 2	Replace VM
2		JPE1-1	JPE1-4		Replace Steer Tiller Encoder	Repair wiring from VM

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Test I34 - Steer Tiller Encoder 2 Connect Detect

This test verifies the Vehicle Manager sees the 12V circuit connected to the Steer Tiller Encoder Channel 2.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

NOTE: For information on how to use maintenance mode, see “Using Service Mode” on page 3-28.

The Operator Display should show the following:

Connection Status	Message Displayed
Connected	Yes
Not Connected	No

If results do not match the preceding table, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPC10-7	JPC18-6	10.5 to 13V	Perform step 2	Replace VM
2		JPE2-1	JPE2-4		Replace Steer Tiller Encoder	Repair wiring from VM

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Test I35 - Steer Tiller Encoder 1 - Channels A & B

This test monitors input to Vehicle Manager from Channel 1.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

NOTE: For information on how to use maintenance mode, see “Using Service Mode” on page 3-28.

Count should increase CW; decrease CCW. If not, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPC10-6	JPC18-5	10.5 to 13V	Perform step 2	Replace VM
2		JPE1-1	JPE1-4		Perform step 3	Repair wiring from VM
3		JPE1-3		Turning tiller: approx. 2.5V	Perform step 4	Replace Steer Tiller Encoder
4		JPE1-2			Perform step 5	
5		JPC22-5	JPC18-5		Perform step 6	Repair or replace wiring
6		JPC22-12			Replace VM	

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Test I36 - Steer Tiller Encoder 2 - Channels A & B

This test monitors input to Vehicle Manager from Channel 2.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

NOTE: For information on how to use maintenance mode, see “Using Service Mode” on page 3-28.

Count should increase CW; decrease CCW. If not, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPC10-7	JPC18-6	10.5 to 13V	Perform step 2	Replace VM
2		JPE2-1	JPE2-4		Perform step 3	Repair wiring from VM
3		JPE2-3		Turning tiller: approx. 2.5V	Perform step 4	Replace Steer Tiller Encoder
4		JPE2-2			Perform step 5	
5		JPC22-13	JPC18-6		Perform step 6	Repair or replace wiring
6		JPC22-14			Replace VM	

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Test I39 - Neutral Pulses

This test displays the neutral pulses seen by the Vehicle Manager from the Steer Power Amplifier.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

NOTE: For information on how to use maintenance mode, see “Using Service Mode” on page 3-28.

The Operator Display should show the following:

Deadman Pedal	Message Displayed
Depressed	Toggles between On and Off
Released	>15 sec = On or Off

If results do not match the preceding table, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPC6-6	JPC6-4	10.5 to 13V	Perform step 2	Replace VM
2		JPC6-1		Deadman Pedal Up: >4V Down: 1.7 to 3.4V	Replace VM	Repair wiring or replace Steer Power Amp

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Test I60 - Security Start Switch (S23) (optional)

This test shows the Vehicle Manager reading from S23.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

NOTE: For information on how to use maintenance mode, see “Using Service Mode” on page 3-28.

The Operator Display shows the state of the switch:

State of Switch	Message Displayed
Depressed	In
Released	Out

If results do not match the preceding table, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC10/DCV	JPC10-2	JPC10-4	>4.0V	Perform step 2	Verify option is ON
2	DCV			S23 open: >4.0V S23 closed: 0V	Replace VM	Troubleshoot switch and wires

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Test I61 - High Speed Travel Switch (S25)

This test shows the Vehicle Manager reading from the High Speed Travel Switch (S25).

⚠CAUTION

Use extreme caution when working around an elevated mast.

Run Test

NOTE: This test can be run in Loop Back mode. See Loop Back Tests (Page 6-117).

Run this test in Active Service Mode.

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

The Operator Display should show the following:

Mast Position	Message Displayed
Lowered	Below
Raised	Above

If these results are not observed, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
Proximity Sensor Switch						
1	Disconnect JPC20/DCV	JPC20-3	TP4	10.5 to 13.0V	Perform step 2	Replace VM
2	Disconnect JPC22/DCV	JPC22-4		approx. 5.0V	Perform step 3	
3	Disconnect JPS6/DCV	TP1	JPS6-3	B+	Perform step 4	Troubleshoot wire to Fuse/Relay Card
4		JPS6-2	TP4	approx. 5.0 Watts	Perform step 5	Troubleshoot wire to VM
5		JPS6-1		10.5 to 13.0V	Perform step 6	
6	DCV	JPS6-1		Switch not over metal: approx. 5.0V Switch over metal: approx. 5.0V	Replace VM	Replace switch

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Test I80 - OCSS Upper Beam

This test verifies the upper beam is working correctly.

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

Run Test

Make sure the beam is not blocked by objects, debris, or dirt. The Operator Display shows the state of the beam:

Deadman Pedal	Message Displayed
Down	On
Up	Off

If results do not match the preceding table, the test has failed. Perform Diagnosis and Repair.

Diagnosis and Repair

Remove sensor housing covers. Turn key switch ON and verify LEDs are illuminated as follows:

Component	Deadman Pedal Position	LED	Status
Receiver (3 wires)	Up or Down	Green ON	+12V present at RCVR_1
	Down	Yellow ON	Receiver is receiving light beam (correctly aligned)
Emitter (2 wires)	Down	Green ON	+12V present at EMTR_1

If the LEDs do not illuminate as described above, troubleshoot per the following table:

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
Fault: All LEDS not illuminated						
1	Deadman pedal down, disconnect JPX1/DCV	JX1-1	JX1-4	10.7 to 13V	Replace Expander Module	Perform step 2
2		PD1-1	PT1-8		Replace harness between Expander Module and OD/PA JX1 to JD1-1/JT1	Troubleshoot VM
Fault: EMITTER - Green LED not illuminated						
1	Deadman pedal down, disconnect JPCS1/DCV	JCS1-1	JCS1-2	10.7 to 13V	Replace Emitter harness PCS1	Perform step 2
2	Deadman pedal down, disconnect JPX2/DCV	PX2-4	PX2-9		Replace harness between Expander Module and Emitter harness JX2 to JCS1	Replace Expander Module

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Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
Fault: RECEIVER - Green LED not illuminated						
1	Deadman pedal up, disconnect JPCS2/DCV	JCS2-1	JCS2-4	10.7 to 13V	Replace Receiver harness PCS2	Perform step 2
2	Deadman pedal up, disconnect JPX2/DCV	PX2-1	PX2-6		Replace harness between Expander Module and Receiver harness JX2 to JCS2	Replace Expander Module
Fault: RECEIVER - Yellow LED not illuminated						
1	Disconnect JPCS2 and JPX2/Ohms	JCS2-2	PX2-2	0 Ohms	Perform step 2	Replace harness between Expander Module and Receiver harness JX2 to JPCS2
2	Make sure Emitter is not obscured (dirty) and is aligned correctly				Perform step 3	Clean Emitter eye and/or align correctly
3	Disconnect JPX2/DCV	PX2-2	PX2-6	approx. 5V	Replace Receiver harness PCS2	Replace Expander Module
Fault Code 58 - Previous Tests Pass						
1	Disconnect JPX1 and JPT1/Ohms	JX1-5	JT1-15	0 Ohms	Perform step 2	Repair/Replace harness JX1-JT1
2		JX1-2	JT1-23		Replace Expander Module	

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Test I81 - OCSS Lower Beam

This test verifies the lower beam is working correctly.

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

Run Test

Make sure the beam is not blocked by objects, debris, or dirt. The Operator Display shows the state of the beam:

Deadman Pedal	Message Displayed
Down	On
Up	Off

If results do not match the preceding table, the test has failed. Perform Diagnosis and Repair.

Diagnosis and Repair

Remove sensor housing covers. Turn key switch ON and verify LEDs are illuminated as follows:

Component	Deadman Pedal Position	LED	Status
Receiver (3 wires)	Up or Down	Green ON	+12V present at RCVR_2
	Down	Yellow ON	Receiver is receiving light beam (correctly aligned)
Emitter (2 wires)	Down	Green ON	+12V present at EMTR_2

If the LEDs do not illuminate as described above, troubleshoot as follows:

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Step Passed	Expected Results	Step Failed
Fault: All LEDS not illuminated						
1	Deadman pedal down, disconnect JPX1/DCV	JX1-1	JX1-4	10.7 to 13V	Replace Expander Module	Perform step 2
2		PD1-1	PT1-8		Replace harness between Expander Module and OD/TPA JX1 to JD1-1/JT1	Troubleshoot VM

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Step	Action/ Meter Scale	(+) Lead	(–) Lead	Step Passed	Expected Results	Step Failed
Fault: EMITTER - Green LED not illuminated						
1	Deadman pedal down, disconnect JPCS3/DCV	JCS3-1	JCS3-2	10.7 to 13V	Replace Emitter harness PCS3	Perform step 2
2	Deadman pedal down, disconnect JPX2/DCV	PX2-5	PX2-10		Replace harness between Expander Module and Emitter harness PX2 to JCS1	Replace Expander Module.
Fault: RECEIVER - Green LED not illuminated						
1	Deadman pedal up, disconnect JPCS4/DCV	JCS4-1	JCS4-4	10.7 to 13V	Replace Receiver harness PCS4	Perform step 2
2	Deadman pedal up, disconnect JPX2/DCV	PX2-3	PX2-8		Replace harness between Expander Module and Receiver harness JX2 to JPCS4	Replace Expander Module
Fault: RECEIVER - Yellow LED not illuminated						
1	Disconnect JPCS4 and JPX2/Ohms	JCS4-3	PX2-7	0 Ohms	Perform step 2	Replace harness between Expander Module and Receiver harness JX2 to JCS4
2	Make sure Emitter is not obscured (dirty) and is aligned correctly				Perform step 3	Clean Emitter eye and/or align correctly
3	Disconnect JPX2/DCV	PX2-7	PX2-8	approx. 5V	Replace Receiver harness PCS4	Replace Expander Module
Fault Code 58 - Previous Tests Pass						
1	Disconnect harness at JPX1 and JPT1/ Ohms	JX1-5	JT1-15	0 Ohms	Perform step 2	Repair/replace harness JX1-JT1
2	Disconnect harness at JPX1 and JPT1/ Ohms	JX1-2	JT1-23	0 Ohms	Replace Expander Module	

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Test I86 - Lift Height

NOTE: This test applies to lift trucks with VM versions 3.7 and above.

This test displays fork height above free lift.

Run Test

NOTE: This test cannot be run in Active Service Mode. For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

You should see: below free lift = 0; height increase going up; height decrease going down.

If not, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPD-2 disconnected /DCV	JPD2-1	JPD2-2	10.5 to 13V	Perform step 2	Replace display
2	DCV	JPE3-1	JPE3-4		Perform step 3	Troubleshoot wiring
3		JPE3-3		Lifting: approx. 2.4V	Perform step 4	Replace encoder
4		JPE3-2	JPE3-4		Perform step 5	
5		JPD2-3	JPD2-2		Perform step 6	Troubleshoot wiring
6		JPD2-4			Replace display	

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Test I90 - Degrees Turned Past Steer Flag

This test shows the number of degrees the drive unit has turned after the steer flag is no longer under the steer proximity switch.

Use this test to adjust the switch so the drive unit does not contact the hard stop on either side during normal operation.

NOTE: To verify a 10° steering rail is installed, enter Test I90. Steer until the steering is at the stop. 7 to 10 is displayed for a 10° rail; 2 or 3 is displayed for older rails.

Run Test

Turn the steering wheel all the way in one direction until the drive unit is against the mechanical stop. Record the steering degrees displayed. Turn the steering wheel all the way in the opposite direction against the mechanical stop. Compare this reading to the reading from the opposite side.

Both sides should be approx. 10°.

Diagnosis and Repair

Adjust the Steer Limit Switch (S11) mounting bracket so the reading on both ends is as close to 10° as possible.

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Test I91 - *iPort* ™ Communication Test

This test shows the status of communication between the VM and Supplier Wireless Module (SWM).

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

Run Test

When running the test, the numbers may alternate:

- between 2 and 3, indicating correct operation of SWM and VM
- between 1 and 2, indicating a communication error; perform Diagnosis and Repair

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Connect FlashWare to VM and attempt to communicate	N/A	N/A	FlashWare can communicate with the VM	Perform step 2	Connect FlashWare to another truck to make sure the cable and program are functioning correctly. If OK, reconnect to the original truck. If still unable to communicate, replace VM.

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Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
2	DCV	JRDP1-6	B–	B+	Perform step 3	Check connection at TP1, in-line fuse, and wire continuity.
3		B+	JRDP1-5		Perform step 4	Check connection at TP4 and wire continuity.
4			JRDP1-3		Perform step 5	
5		JRDP1-2	B–	–5 to –10V	Perform Step 6	Check connection at VM and wire continuity.
6		JRDP1-1	B–		Make sure VM and SWM are loaded with latest software and option is enabled	Check connection at SWM and wire continuity. Refer to SWM documentation.

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Test I92 - *iPort* ™ Error Bitmap Test

This test is for factory use only.

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RAYMOND

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Digital Output Tests

A Diagnosis and Repair table is provided for most tests. If a test fails, refer to the Diagnosis and Repair table.

Through the process of elimination, these tables provide a step-by-step approach to diagnosing a problem and the necessary corrective action. See the example below.

Table 6-3. Example Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
Do the testing in this order.	This column identifies any actions required before testing the circuit, such as disconnecting certain connectors. If no instructions are given, all circuits should be connected. **Note:** If something was disconnected in the prior step, reconnect it before performing the next step. This column also identifies the required scale on the meter for this step.	Probe point for the positive (+) meter lead.	Probe point for the negative (–) meter lead.	The reading required to consider the step a success.	The next action to perform if the Expected Results are met.	The next action to perform if the Expected Results are *not* met.

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Test O00 - Toggle the TPC Contactor

This test turns the TPC contactor ON and OFF.

⚠CAUTION

Jack the drive wheels off the floor for this test.

Run Test

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

Use the ENTER button to toggle the test ON and OFF. The Operator Display shows ON or OFF.

If the contactor does not cycle in/out when the test is toggled, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPS1 from contactor panel/Ohms	JPS1-10	JPS1-8	approx. 38 ohms	Perform step 2	Troubleshoot wires and coil
2	DCV		TP4	B+	Perform step 3	Troubleshoot K2 relay and Fuse/Relay Card
3		B+	JPS1-8	Test ON: 18V Test OFF: 0V	Test contactor for binding	Test wire to TPA. If OK, replace TPA

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Test O01 - Toggle the STR Contactor

This test turns the STR contactor ON and OFF.

⚠ WARNING

DO NOT attempt to drive the lift truck while conducting this test.

Run Test

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

Use the ENTER button to toggle the test ON and OFF. The Operator Display shows ON or OFF.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPS1/Ohms	JPS1-10	JPS1-11	approx. 40 Ohms	Perform step 2	Troubleshoot wires and coil
2	DCV		TP4	B+	Perform step 4	Perform step 3
3		JPF2-1			Troubleshoot wire to JPS1-10	Replace Fuse/Relay Card
4		B+	JPS1-11	Test OFF: 0V Test ON: approx. 24V	Test contactor for binding	Perform step 5
5			JPC18-11		Troubleshoot wire to JPS1-11	Replace VM

If the contactor does not cycle in/out when the test is toggled, the test has failed.

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Test O02 - Toggle the LPC Contactor

This test turns the LPC contactor ON and OFF.

⚠CAUTION

Ceiling height must be higher than the maximum elevated height of the lift truck under test.

⚠ WARNING

The lift system on a truck with DC lift might not act as expected during this test. If the STR contactor is shorted, the carriage lifts when the LPC contactor is toggled ON.
This does not happen on a truck with AC lift, because the AC Lift Motor does not turn without power from the LPA.

Run Test

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

Use the ENTER button to toggle the test ON and OFF. The Operator Display shows ON or OFF.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPS1 from contactor panel/Ohms	JPS1-10	JPS1-9	approx. 38 Ohms	Perform step 2	Troubleshoot wires and coil
2	DCV		TP4	B+	Perform step 3	Troubleshoot K2 relay and Fuse/Relay Card
3		B+	JPS1-9	Test ON: 18V Test OFF: 0V	Test contactor for binding	Test wire to LPA or VM. If OK, replace LPA or VM.

If the contactor does not cycle in/out when the test is toggled, the test has failed.

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Test O04 - Toggle Aux1 Directional (SOL5T) Solenoid

Refer to Test A31 - Solenoid 5T (AUX1) Current (Page 6-48).

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Test O05 - Toggle Aux2 Directional (SOL5B) Solenoid

Refer to Test A32 - Solenoid 5B (AUX2) Current (Page 6-49).

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Test O06 - Toggle the Reach Solenoid

This test turns the reach solenoid ON and OFF, verifying its correct operation electrically.

A successful test proves the reach solenoid coil, wiring, and related circuitry in the Vehicle Manager are functioning correctly.

It does *not* prove the reach solenoid valve is functioning mechanically.

Run Test

NOTE: For information on how to use maintenance mode, see “Using Service Mode” on page 3-28.

1. Turn the key switch OFF and disconnect the battery connector.
2. Disconnect wire REACH-1 from the reach solenoid.
3. Connect a digital ammeter in series with the reach solenoid coil, positive lead (+) to the wire removed and the negative lead (–) to terminal REACH-1 on the solenoid.
4. Reconnect the battery connector and turn the key switch ON.
5. Run Test O06 and toggle the solenoid coil ON. Use the ENTER button to toggle the test ON and OFF. The Operator Display shows ON or OFF. The ammeter must read approx 560 mA.
   a. If the ammeter reading is correct, the solenoid coil is functioning electrically.
   b. If the solenoid is not working correctly, check for a mechanical problem in the valve, such as binding or contamination.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC18 and JPF2/Ohms	JPF2-8	JPC18-12	approx. 41 Ohms	Perform step 2	Troubleshoot coil and wires
2	DCV		TP4	B+	Replace VM	Troubleshoot K2 circuit

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Test O07 - Toggle the Tilt Solenoid

This test turns the tilt solenoid ON and OFF, verifying its correct operation electrically.

A successful test proves the tilt solenoid coil, wiring, and related circuitry in the Vehicle Manager are functioning correctly.

It does *not* prove the tilt solenoid valve is functioning mechanically.

Run Test

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

NOTE: This test is available only if the tilt option is configured for the lift truck.

1. Turn the key switch OFF and disconnect the battery connector.
2. Disconnect wire TILT-1 from the tilt solenoid.
3. Connect a digital ammeter in series with the tilt solenoid coil, positive lead (+) to the wire removed, and the negative lead (–) to terminal TILT-1 on the solenoid.
4. Reconnect the battery connector and turn the key switch ON.
5. Run Test O07 and toggle the solenoid coil ON. Use the ENTER button to toggle the test ON and OFF. The Operator Display shows ON or OFF. The ammeter must read approx 560 mA.
   a. If the ammeter reading is correct, the solenoid coil is functioning electrically.
   b. If the solenoid is not working correctly, check for a mechanical problem in the valve, such as binding or contamination.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC18 and JPF2/Ohms	JPF2-8	JPC18-15	approx. 41 Ohms	Perform step 2	Troubleshoot coil and wires
2	DCV		TP4	B+	Replace VM	Troubleshoot K2 circuit

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Test O08 - Toggle the Sideshift Solenoid

This test turns the sideshift solenoid ON and OFF, verifying its correct operation electrically.

A successful test proves the sideshift solenoid coil, wiring, and related circuitry in the Vehicle Manager are functioning correctly.

It does *not* prove the sideshift solenoid valve is functioning mechanically.

Run Test

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

NOTE: This test is available only if the sideshift option is configured for the lift truck.

1. Turn the key switch OFF and disconnect the battery connector.
2. Disconnect wire SIDESHIFT-1 from the sideshift solenoid.
3. Connect a digital ammeter in series with the sideshift solenoid coil, positive lead (+) to the wire removed and the negative lead (–) to terminal SIDESHIFT-1 on the solenoid.
4. Reconnect the battery connector and turn the key switch ON.
5. Run Test O08 and toggle the solenoid coil ON. Use the ENTER button to toggle the test ON and OFF. The Operator Display shows ON or OFF. The ammeter must read approx 560 mA.
   a. If the ammeter reading is correct, the solenoid coil is functioning electrically.
   b. If the solenoid is not working correctly, check for a mechanical problem in the valve, such as binding or contamination.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC18 and JPF2/Ohms	JPF2-8	JPC18-14	approx. 41 Ohms	Perform step 2	Troubleshoot coil and wires
2	DCV		TP4	B+	Replace VM	Troubleshoot K2 circuit

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Test O09 - Aux Dump (SOL3)/ Main Relief Dump (SOL8) Current

Refer to Test A33 - Aux Dump (SOL3) (Page 6-50).

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Test O11 - Toggle the Load Hold (SOL1) Solenoid

This test turns the load hold solenoid ON and OFF, verifying its correct operation electrically.

A successful test proves the load hold solenoid coil, wiring, and related circuitry in the Vehicle Manager are functioning correctly.

It does *not* prove the load hold solenoid valve is functioning mechanically.

Run Test

NOTE: For information on how to use maintenance mode, see “Using Service Mode” on page 3-28.

1. Turn the key switch OFF and disconnect the battery connector.
2. Disconnect wire SOL1-1 from the load hold solenoid.
3. Connect a digital ammeter in series with the load hold solenoid coil, positive lead (+) to the wire removed, and the negative lead (–) to terminal SOL1-1 on the solenoid.
4. Reconnect the battery connector and turn the key switch ON.
5. Run Test O11 and toggle the solenoid coil ON. Use the ENTER button to toggle the test ON and OFF. The Operator Display shows ON or OFF. The ammeter must read approx 800 mA.
   a. If the ammeter reading is correct, the solenoid coil is functioning electrically.
   b. If the solenoid is not working correctly, check for a mechanical problem in the valve, such as binding or contamination.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC18 and JPF2/Ohms	JPF2-5	JPC18-10	approx. 30 Ohms	Perform step 2	Troubleshoot coil and wires
2	DCV	JPC18-10	TP4	B+	Replace VM	Troubleshoot K2 circuit

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Test O12 - Ramp the Proportional Lower (SOL2) Solenoid

Refer to Test A34 - Lift/Lower Current (SOL2) (Page 6-51).

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Test O18 - Toggle the Horn

This test turns the lift truck's horn ON and OFF.

Run Test

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

1. Run this test in Active Service Mode while taking readings,
2. Use the ENTER button to toggle the test ON and OFF. The Operator Display shows ON or OFF.
3. When the ENTER key is pressed, the horn must sound. If it does not sound, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	H2	TP4	B+	Perform step 2	Troubleshoot wires and Fuse/Relay Card
2		TP1	H1	Test ON: B+ Test OFF: 0V	Replace horn	Perform step 3
3			JPC18-16		Troubleshoot wires to horn	Replace VM

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Test O19 - Audible Alarm

This test turns on the Operator Display alarm by gradually increasing the PWM voltage.

Run Test

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

If the alarm does not sound when you depress the ENTER button, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPD3-1	JPD3-2	Button Up: 0V Hold the Up Button ON for 6 seconds: approx. 4.0V	Perform step 2	Replace Operator Display card
2		Sounder B1	Sounder B2		Replace sounder	Troubleshoot wiring to sounder

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Test O20 - Travel Alarm

NOTE: This test only applies to lift trucks with Travel Alarm option.

This test toggles the travel alarm ON and OFF.

Run Test

NOTE: For information on how to use maintenance mode, see “Using Service Mode” on page 3-28.

Use the ENTER button to toggle the test ON and OFF. The Operator Display shows ON or OFF.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	H2+	H2–	Test ON: B+ Test OFF: 0V	Replace travel alarm	Perform step 2
2			TP4		Perform step 3	Troubleshoot FU9 and wiring
3		TP1	JPC18-18		Troubleshoot wiring to horn	Replace VM

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Test O23 - Toggle Fans

This test toggles the power amplifier fans and motor compartment cooling fans ON and OFF.

Run Test

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

Use the TILT UP/DOWN buttons to toggle the test ON and OFF. The Operator Display shows ON or OFF.

NOTE: Upon exiting this test, the power amplifier fans remains in the state last chosen (ON or OFF), until the technician exits Program Mode. This permits running Test O23 in conjunction with other tests.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	TP1	JPC18-17	Test OFF: 0V Test ON: B+	Perform step 2	Replace VM
2		JPF2-3	TP4	B+	Troubleshoot wires and fans	Troubleshoot K2 circuitry

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Test O28 - Ramp Lift Motor

This test ramps the Lift Motor by gradually increasing the command to the Lift Power Amplifier via the CAN Bus. This test verifies the Lift Power Amplifier can drive the Lift Motor.

⚠ WARNING

The Lift Motor may rotate during this test. Make sure lift truck is in an area with sufficient overhead clearance for lifting the mast.

⚠CAUTION

Running this test for an extended period of time can cause damage to the Lift Motor, Lift Power Amplifier, or wiring.

Run Test

NOTE: For information on how to use maintenance mode, see “Using Service Mode” on page 3-28.

The Operator Display first shows the current RPM request.

Use the tilt down button to increase the RPM request by 25 RPM increments, from a minimum of 775 RPM to a maximum of 1500 RPM.

Once the maximum RPM request is reached, pressing tilt down again resets the request to 775. To prevent lift pump damage due to very low RPM, the minimum Lift Motor speed request is 775 RPM. Tilt up resets the request to 0.

Use the horn button to stop the motor, reset the RPM request to 0, de-energize the lift contactor, and exit the test. If instead, you press tilt up, tilt down, sideshift left, or sideshift right, the test is still active with the request set to 0.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Current probe (amp clamp) on phases U, V, and W	N/A	N/A	Current must be even on all phases and ramp up as the percentage increases	Replace LPA	If current does not ramp on one or two phases, test cables to Lift Motor. If OK, replace Lift Motor. If phases are low or unequal, replace the LPA. If phases are equal and high but motor runs slowly, check for binding. If not binding, replace Lift Motor.

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Test O29 - Ramp Traction Motor

This test ramps the Traction Motor by gradually increasing the command to the Traction Power Amplifier via the CAN Bus. This test verifies the Traction Power Amplifier can drive the Traction Motor.

⚠ WARNING

The Traction Motor *will* rotate during this test. Jack the drive wheels off the floor. Use extreme caution whenever the lift truck is jacked up. Never block the lift truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from vehicle while jacking the lift truck. After the lift truck is jacked, place solid blocks or jack stands beneath it to support it. DO NOT rely on the jack alone to support the lift truck. See "Jacking Safety" on page 2-8.

⚠ CAUTION

Running this test for an extended period of time can cause damage to the Traction Motor, Traction Power Amplifier, or wiring.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Current probe (amp clamp) on phases U, V, and W	N/A	N/A	Current must be even on all phases and ramp up as the percentage increases	Replace TPA	If current does not ramp on one or two phases, test cables to Traction Motor. If OK, replace Traction Motor. If phases are low or unequal, replace the TPA. If phases are equal and high but motor runs slowly, check for binding. If not binding, replace Traction Motor.

Run Test

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

NOTE: The deadman pedal must be depressed for the brake to release.

The Operator Display first shows the current RPM request.

Use the tilt down button to increase the RPM request by 25 RPM increments, from a minimum of 25 RPM to a maximum of 750 RPM.

Once the maximum RPM request is reached, pressing tilt down again resets the request to 0. Tilt up also resets the request to 0.

Use the horn button to stop the motor, reset the RPM request to 0, and exit the test. If instead, you press tilt up, tilt down, sideshift left, or sideshift right, the test is still active with the request set to 0.

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Test O30 - Toggle the Brake Coil

See "Test A35 - Brake Armature" on page 6-52.

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Test O32 - Toggle Relays K1, K2, K3, and K4

This test toggles the relays ON and OFF.

Run Test

NOTE: For information on how to use maintenance mode, see "Using Service Mode" on page 3-28.

NOTE: OFF is displayed when entering the test even if the relays are closed.

Press the ENTER button to toggle the test.

The Operator Display shows:

Test Status	Relay Status
ON	Tips closed
OFF	Tips open

The test will cause codes to be written to the error log. Clear the error log after test is complete.

NOTE: Codes are written to the Error Log when this test is run. Clear the Error Log when done.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPF4 /Ohms	JPF4-13	JPF4-5	approx. 1.6 Megohms	Perform step 2	Check K1, K2, and K3 relay coils. If OK, replace Fuse/Relay Card.
2			JPF4-10	approx. 1.7K Ohms	Perform step 3	Check K4 relay coil. If OK, replace Fuse/Relay Card.
3	DCV		TP4	B+	Perform step 4	Replace Fuse/Relay Card
4		JPC14-6			Replace VM	Troubleshoot wiring from Fuse/Relay Card

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Loop Back Tests

The Loop Back Test (LBT) feature is standard on the *Model 7400/7420/7440 Reach-Fork*® Lift Truck. This feature allows you to toggle inputs and monitor their respective values on the Operator Display.

Access this feature via the SuperWord level. It is nested inside the Service submenu.

Upon entering the Loop Back Test, the display shows the status of the LBT (defaults to Disabled) and the first three entries. You can scroll through the list, locating the test of interest.

The layout for the tests is very similar to the standard Analog and Digital Input tests. The major difference is the LBT references a connector on the Vehicle Manager. Disconnect this connector from the Vehicle Manager prior to enabling the LBT function. Then observe the reading indicated in Table 6-4 under "Disabled Value". Next, apply the LBT voltage by pressing the Enter key on the display keypad. The status of the LBT will read "LOOP BACK ENABLED". Observe the reading in Table 6-4 column "Enabled Value" for the particular test.

NOTE: When testing any of the entries where JPC-22 is disconnected, the lift truck restarts after LBT is toggled from Enabled to Disabled. The reason for this is the EPO is wired to JPC-22. Toggling the input simulates the EPO engaged then disengaged, thus restarting the vehicle.

If any loop back test fails, replace the Vehicle Manager.

When exiting LBT, the lift truck will restart when the Service submenu is exited.

Table 6-4. Loop Back Tests

Test	Connector	Disabled Value	Enabled Value
Test A04 - Primary Throttle Pot (VR1) Voltage (Page 6-34)	JPC-12	0.00	5.0V ±0.2V
Test A05 - Lift/Lower Pot Voltage (Page 6-35)	JPC-12	0.00	5.00V ±0.2V
Test A13 - Pressure Sensor Voltage (Page 6-40)	JPC-24	0.00	5.00V ±0.2V
Test A15 - Battery Voltage (Page 6-42)	JPC-24	0.00	35.00 V ±2V
Test A36 - Ambient Air Temp Sensor (Page 6-53)	JPC-24	400 to 460°F/ 204 to 238°C	44°F/6°C ±10°F/6°C
Test A37 - Steer Power Amp Current (Page 6-54)	JPC-6	650A ±20A	2A ±10A
Test A41 - Emergency Power Off (EPO) Switch (Page 6-57)	JPC-22	Down	Up
Test I00 - Deadman Switch (DS1) (Page 6-60)	JPC-22	Up	Down
Test I01 - Nested Switch (S14) (Page 6-61)	JPC-22	Out	In
Test I02 - First Speed Limiting Switch (S12) (Page 6-62)	JPC-22	Above	Below
Test I06 - Reach Switch (S4) (Page 6-63)	JPC-12	Out	In
Test I07 - Retract Switch (S5) (Page 6-64)	JPC-12	Out	In
Test I08 - Tilt Up Switch (S6) (Page 6-65)	JPC-12	Out	In
Test I09 - Tilt Down Switch (S7) (Page 6-66)	JPC-12	Out	In
Test I10 - Sideshift Right Switch (S9) (Page 6-67)	JPC-12	Out	In

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Test	Connector	Disabled Value	Enabled Value
Test I11 - Sideshift Left Switch (S8) (Page 6-68)	JPC-12	Out	In
Test I14 - Steering Fuse (FU1) (Page 6-69)	JPC-22	Blown	OK
Test I15 - Horn Switch (S3) (Page 6-70)	JPC-12	Out	In
Test I24 - Steer Feedback Prox Sensor (Page 6-76)	JPC-22	Off	On
Test I32 - Deadman Switch (DS2) (Page 6-79)	JPC-10	Up	Down
Test I33 - Steer Tiller Encoder 1 Connect Detect (Page 6-80)	JPC-10	No	Yes
Test I34 - Steer Tiller Encoder 2 Connect Detect (Page 6-81)	JPC-10	No	Yes
Test I35 - Steer Tiller Encoder 1 - Channels A & B (Page 6-82) (35A and 35B displayed separately)	JPC-22	High	Low
Test I36 - Steer Tiller Encoder 2 - Channels A & B (Page 6-83) (36A and 36B displayed separately)	JPC-22	High	Low
Test I39 - Neutral Pulses (Page 6-84)	JPC-6	On	Off
Test I60 - Security Start Switch (S23) (optional) (Page 6-85)	JPC-10	Out	In

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Section 7. Component Procedures



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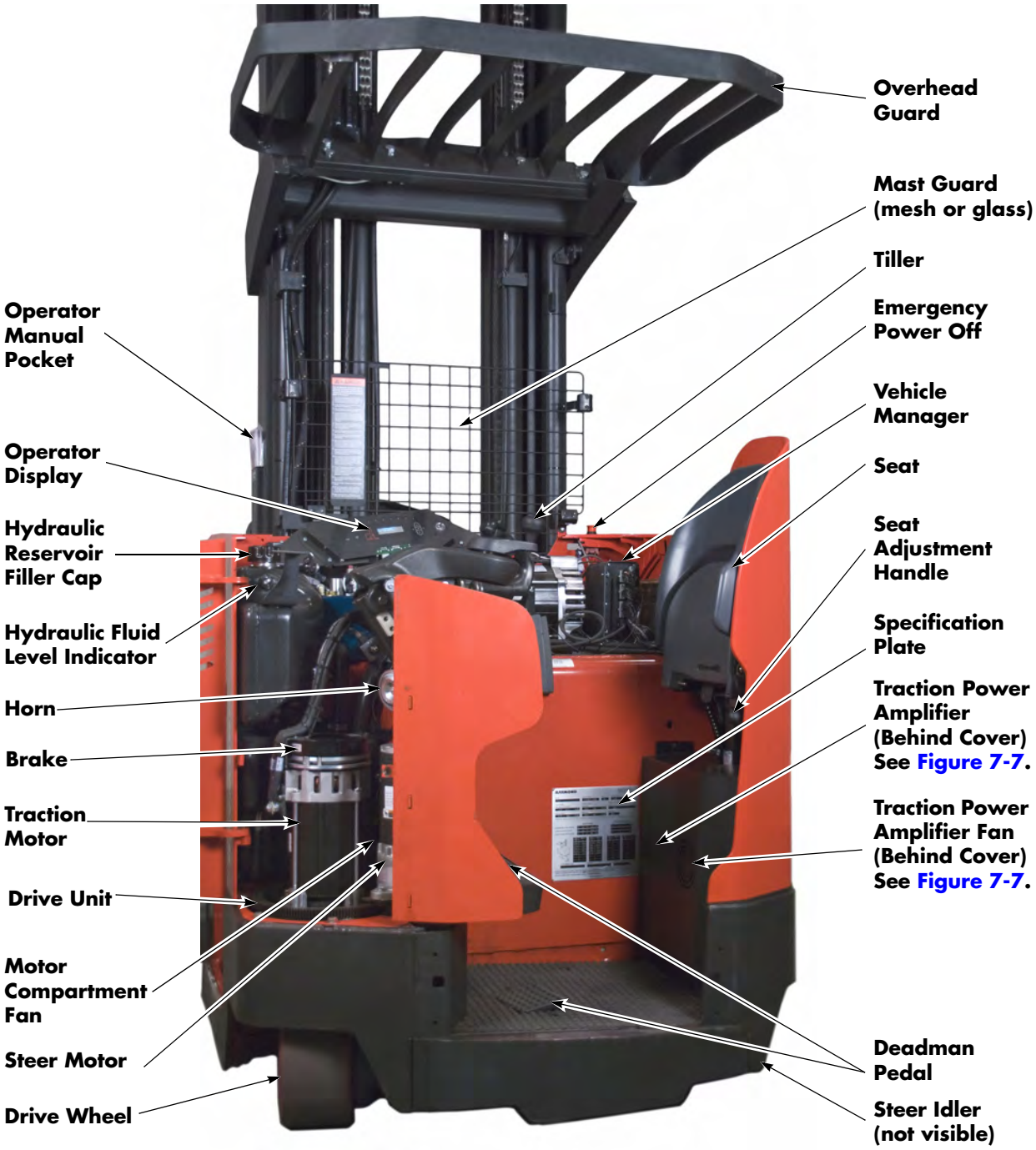
Component Locator Photos

Figure 7-1. Mast and Tractor



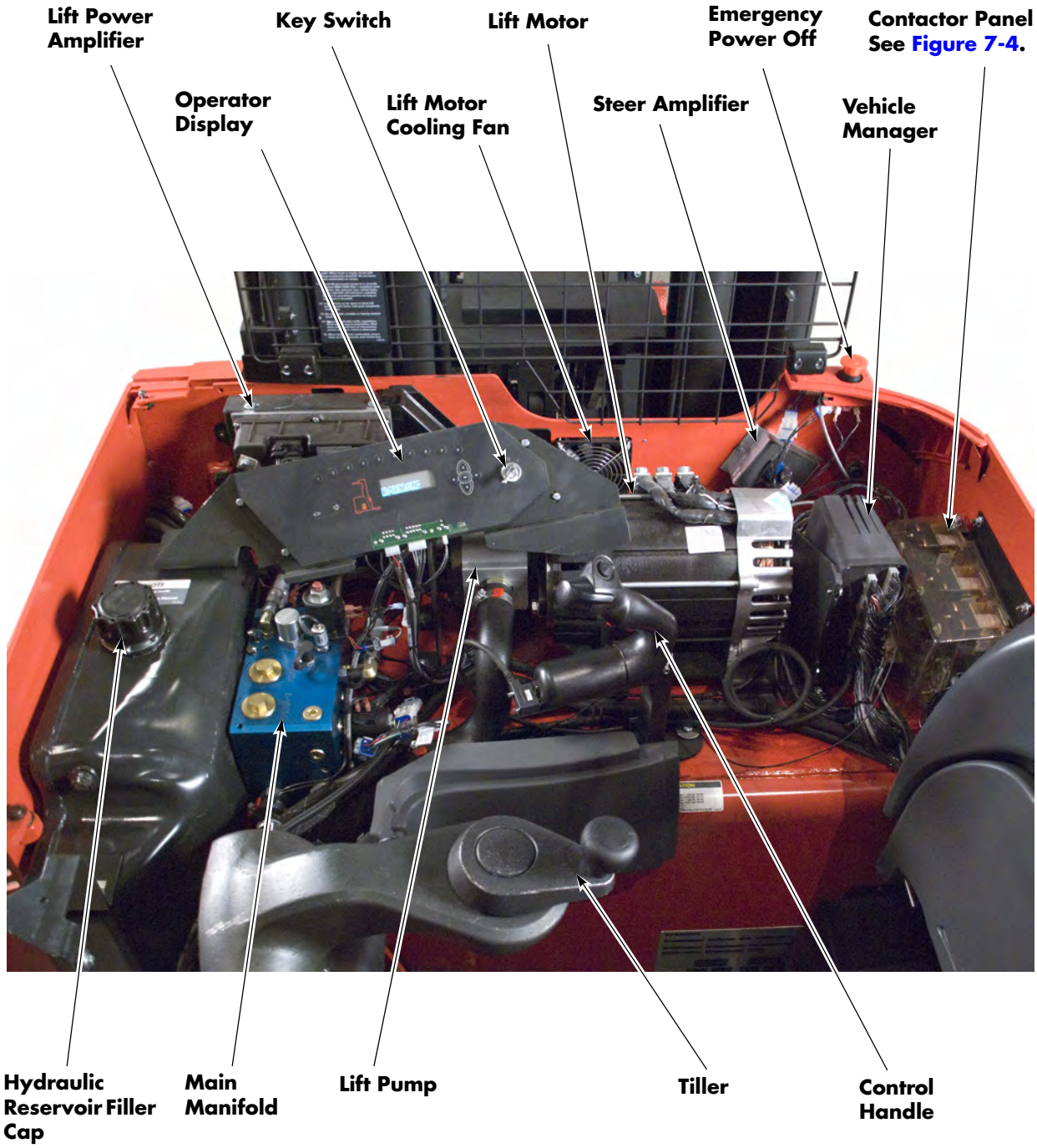
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Figure 7-2. Tractor



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Figure 7-3. Tractor Deck



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Component Locator Photos

Figure 7-4. Contactor Panel

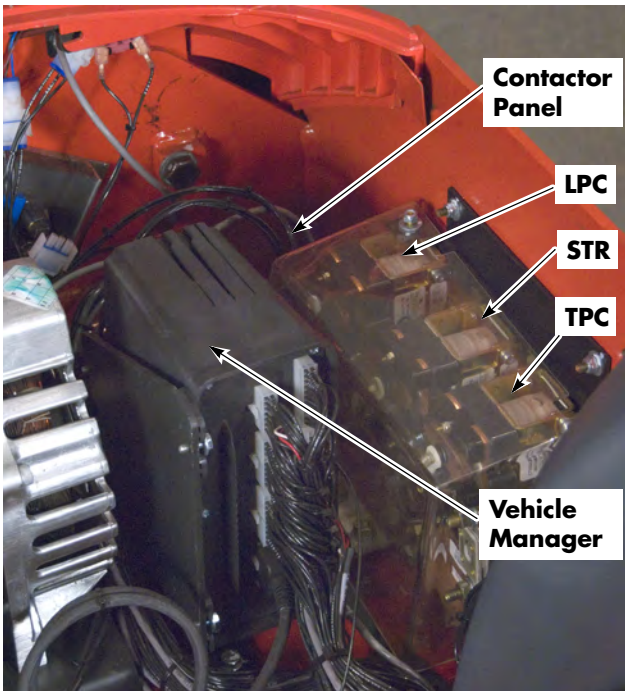


Figure 7-5. Fuse/Relay Card

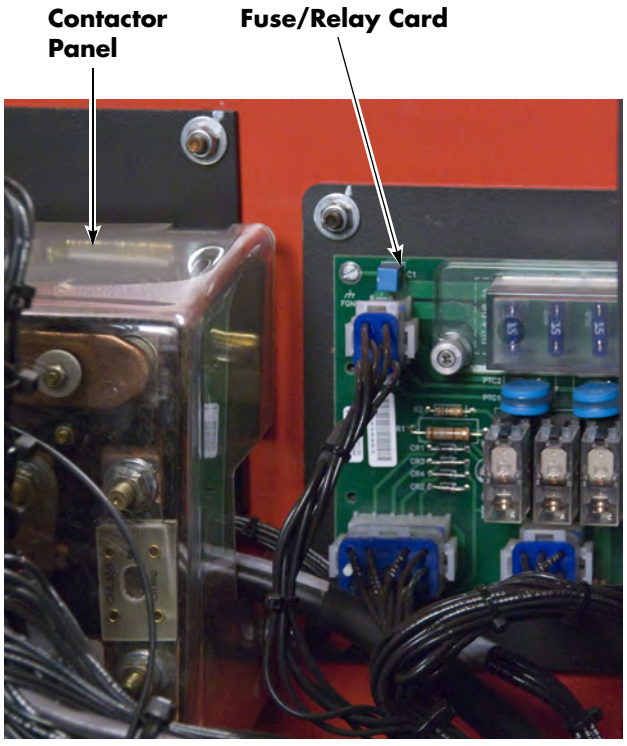


Figure 7-6. TP4

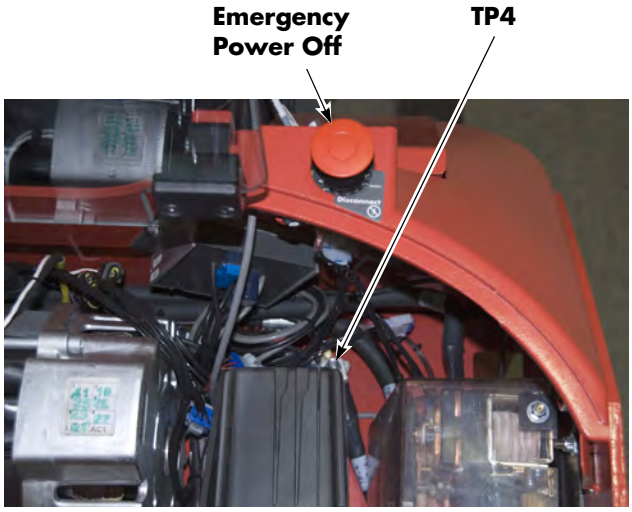
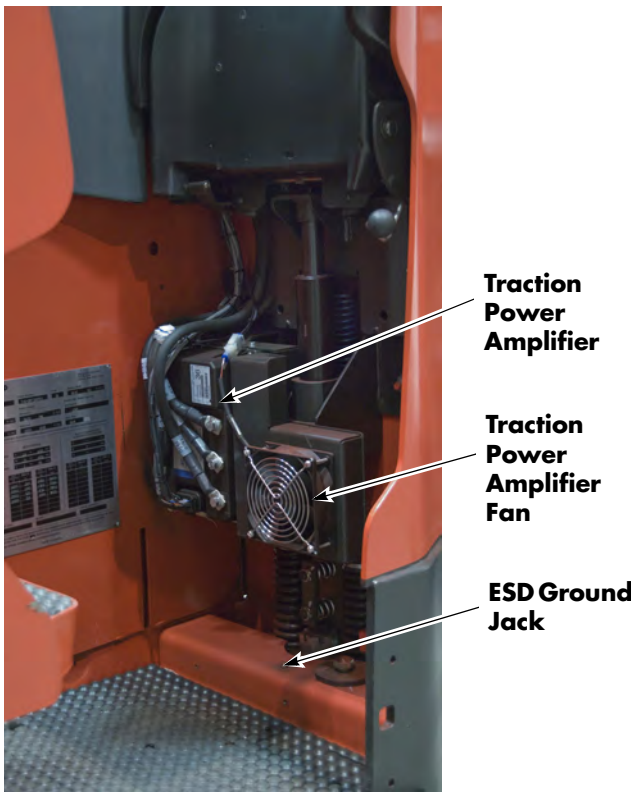
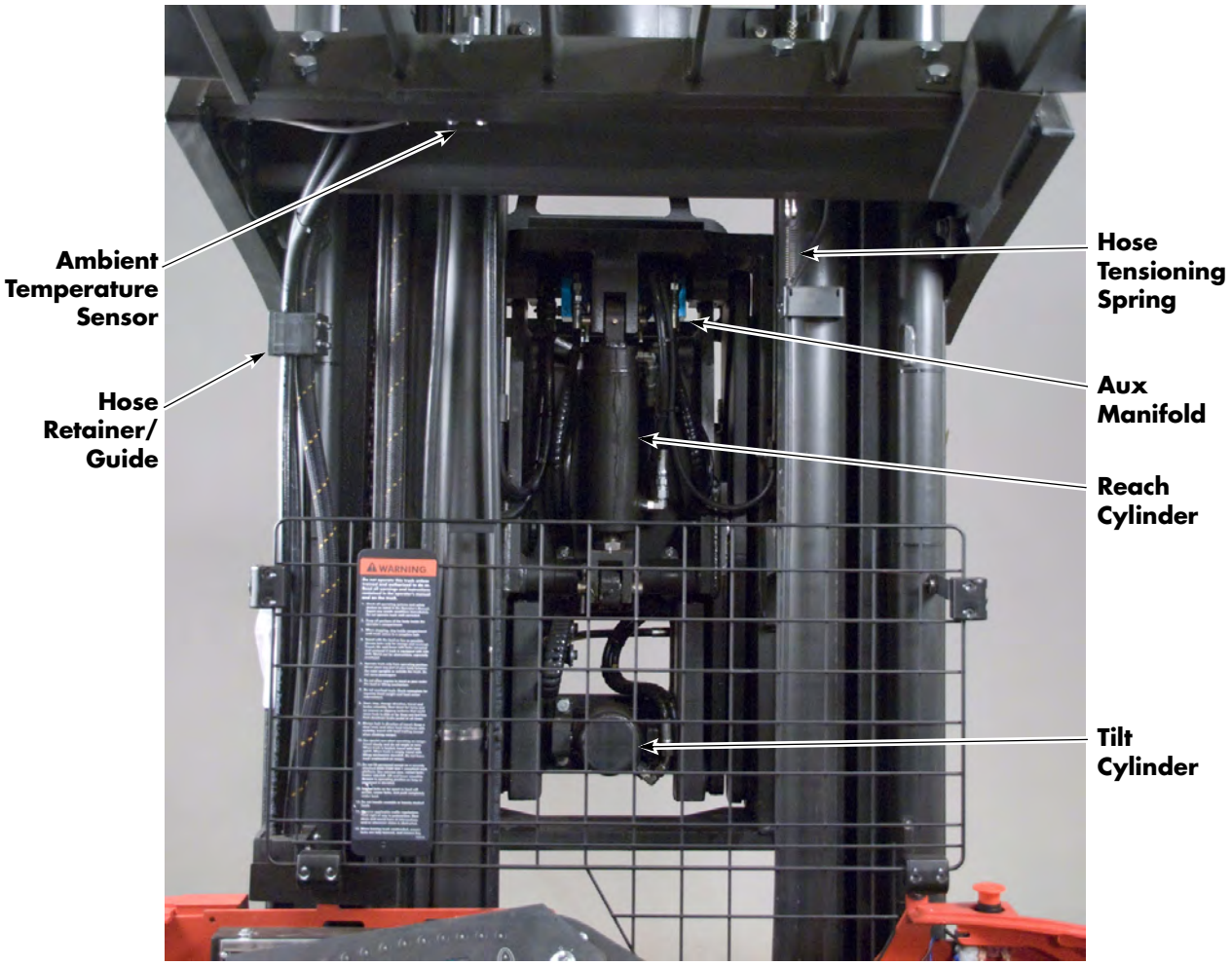


Figure 7-7. Traction Power Amplifier



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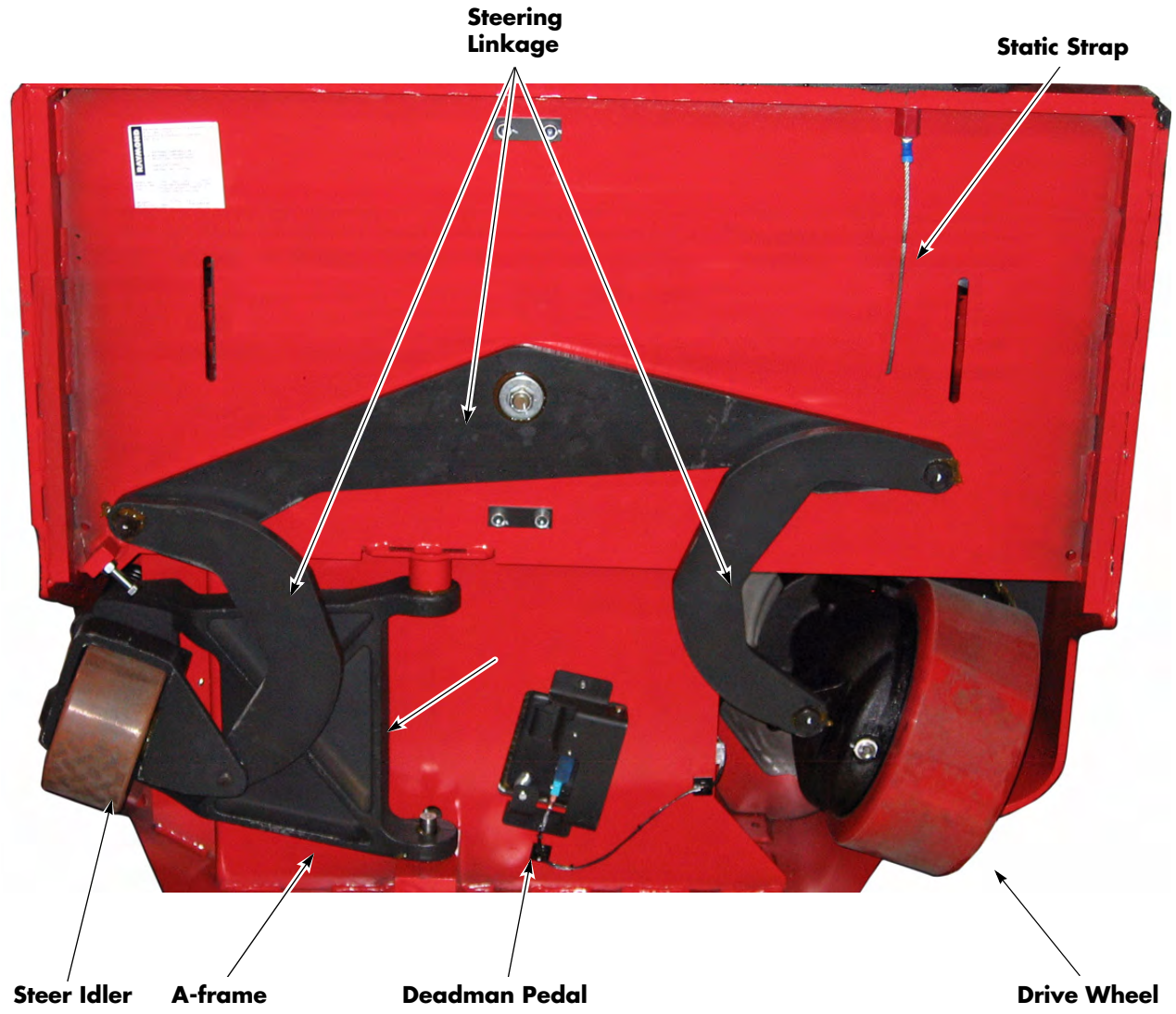
Figure 7-8. Reach Carriage, Operator View



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Component Locator Photos

Figure 7-9. Underside Components



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Special Tools, Decals, and Chassis

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Special Tools

The following tools are available from your local authorized Raymond dealer.

Table 7-1. Special Tools

Tool	Used On	Part Number	Purpose
Connector Unlatching	All	950-042	Separate AMP connectors
End Cap	7620/7640	1090761/004	Free Lift Cylinder end cap removal/installation
End Cap	7600	1090761/005	Free Lift Cylinder *w/staging* end cap removal/installation
End Cap	7620/7640	1090761/005	Main Lift Cylinder end cap removal/installation
End Cap	7600	1090761/007	Main Lift and Free Lift Cylinder *w/o staging* end cap removal/installation
Pin Extraction	All	950-009	AMP connector pin extraction
Pin Extraction	All	950-026	MOLEX connector pin extraction
Seal Driver	All	401-000-051	Free Lift Cylinder seal installation

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Decals and Plates

Table 7-2. Decal and Plate Location Chart

Decal and Specification Plate Locations		
Identifier	**Description**	**Location**
1	Raymond	Tractor frame, aft of battery compartment (both sides)
2	ACR	Tractor frame, with respect to battery compartment opening, 1.0 in. from front edge, bottom of decal 5.8 in. (147 mm) above opening (both sides)
3	EE Compliance (optional)	Tractor frame, centered 5.0 in. (127 mm) above battery opening (both sides), above battery warning decal
4	*Battery Warning Decal*	*Tractor frame, centered 0.25 in.* (6.35 mm) *above battery compartment opening (both sides)*
5	Battery Connector Polarity	Battery connector mounted on right side of tractor frame – centered over battery connector opening. Negative sign towards front of tractor, positive sign toward rear of tractor Battery connector mounted on left side of tractor frame – centered over battery connector opening. Negative sign towards rear of tractor, positive sign toward front of tractor
6	*EPO Function*	*On surface below EPO knob towards operator*
7	Primary Control Handle Functions	In recess provided in top cover
8	*General Safety Decal*	*Mast guard, bottom edge of decal 1.5 in.* (38 mm) *above bottom of guard, left edge of decal 2.88 in.* (292 mm) *from left edge of guard*
9	Specification Plate	Front of operator compartment
10	Aux Specification Plate	Front of operator compartment, below spec plate
11	Type E Specification Plate	Front of operator compartment, below aux specification plate
12	Type EE Specification Plate	Front of operator compartment, below aux specification plate
13	Torque Specs	Front of operator compartment, under top cover, centered on sloping deck of toe plate
14	Lubrication Decal	Inside of Traction Motor compartment door, above and centered with ventilation slots

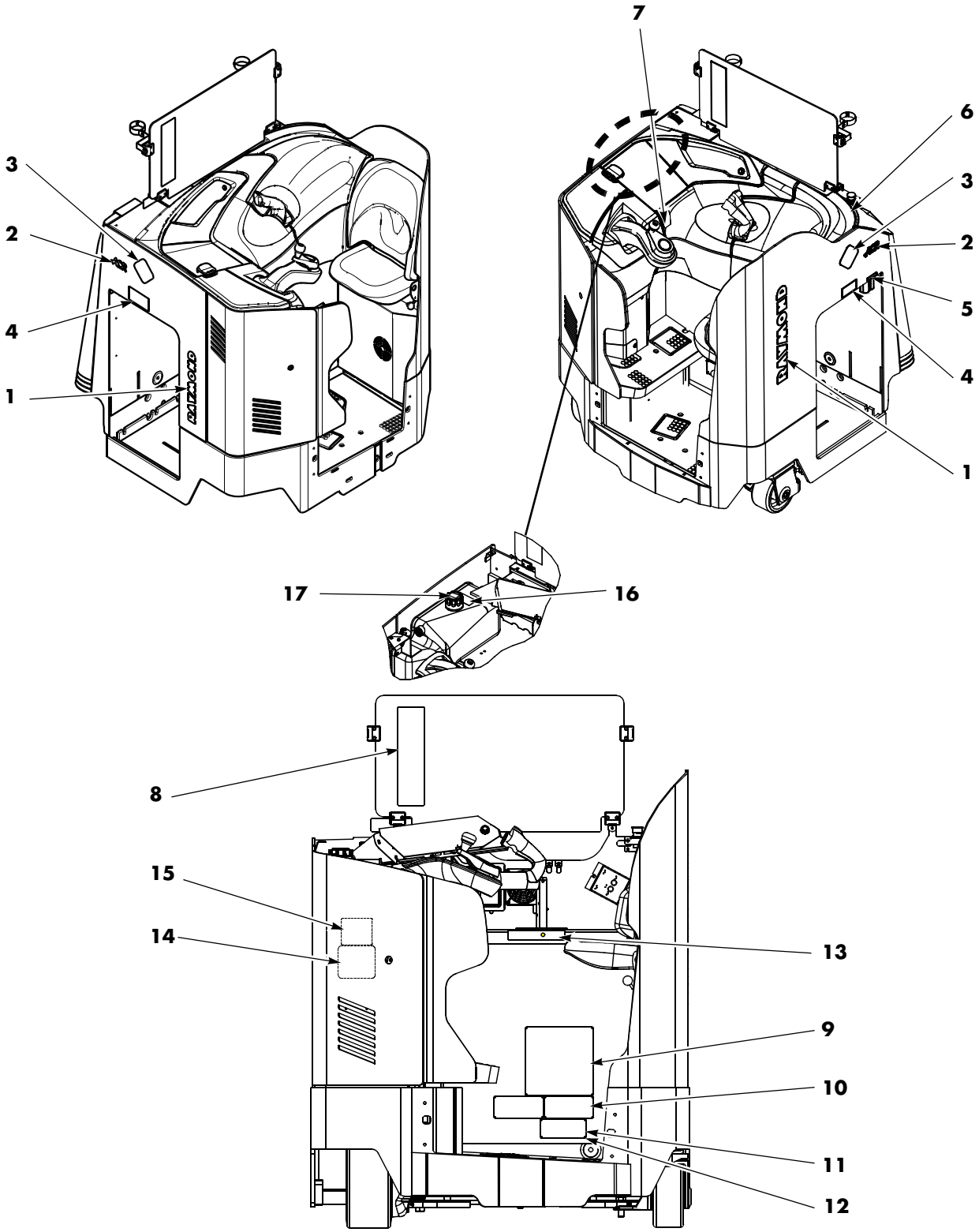
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Decal and Specification Plate Locations		
Identifier	**Description**	**Location**
15	*Traction Motor Warning Decal*	*Inside of Traction Motor compartment door, centered with ventilation slots, above lubrication decal*
16	Hydraulic Filter Locator	On reservoir, forward of filler cap
17	Cold Storage Oil Installed (Optional)	Top of filler cap
18	Mast Specification Plate	Right side of mast, 2 in. (50.8 mm) above top of baseleg
19	ISO 9001 Decal	Centered on mast main frame (both sides), 61.7 in. (156.7 cm) above floor
20	Operating Instructions	Centered on left mast upright under ISO9001 decal
21	Manual Replacement	Centered at top of operator manual pocket
22	*No Riding*	*Centered on load backrest*
23	Overhead Guard ANSI/ITSDF conformance	Inside left side of overhead guard

NOTE: Items in *italics* are safety decals.

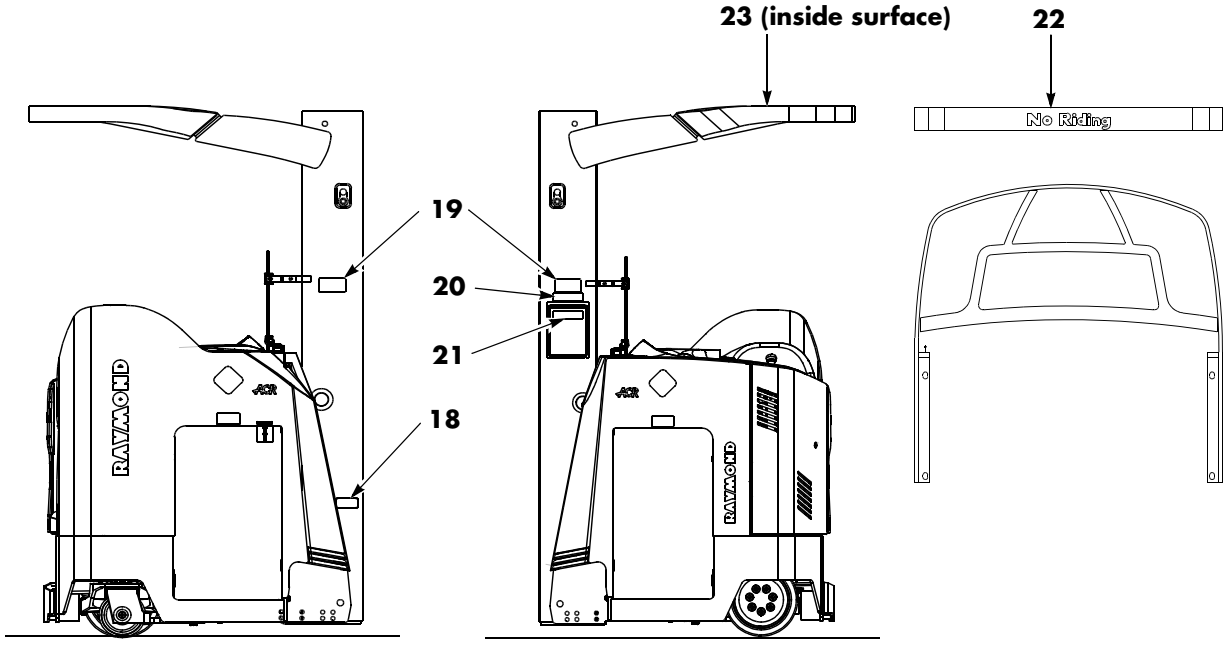
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Figure 7-10. Decal and Specification Plate Location, Tractor



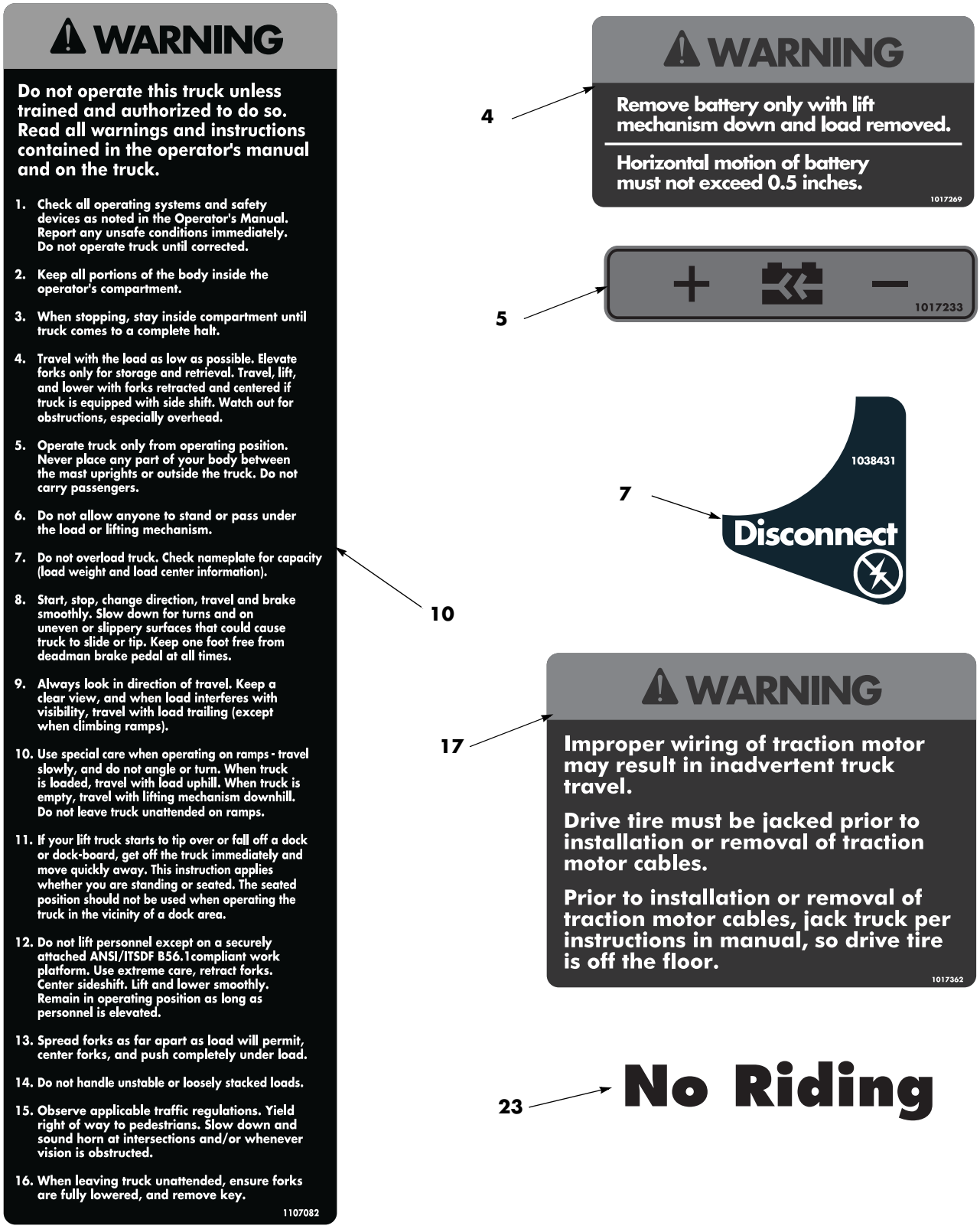
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Figure 7-11. Decal and Specification Plate Locations, Mast



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Figure 7-12. Warning/Safety Decals



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Baselegs

Removal

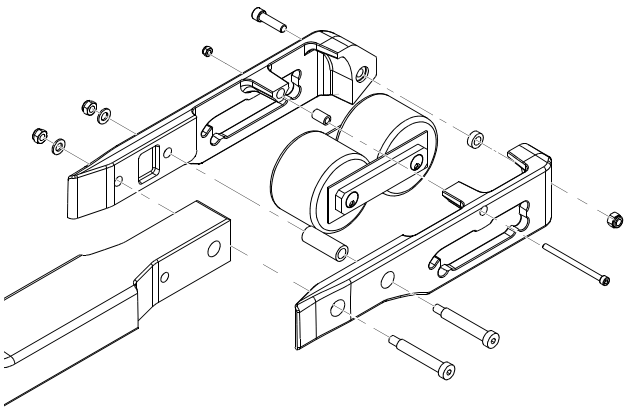
1. Lower the mast and retract the carriage completely.
2. Turn the key switch OFF and disconnect the battery connector.
3. Remove the right or left front cover.
4. Remove the battery gate on the side being repaired.

⚠ WARNING

Use extreme caution whenever the lift truck is jacked up. Never block the lift truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from vehicle while jacking the lift truck. After the lift truck is jacked, place solid blocks or jack stands beneath it to support it. DO NOT rely on the jack alone to support the lift truck. See "Jacking Safety" on page 2-8.

5. Jack and block the lift truck under the side of the tractor.
6. Remove the bolts holding the load wheel plates to the baseleg. Slide the load wheel assembly forward off the baseleg. See Figure 7-13.

Figure 7-13. Load Wheel Assembly and Baseleg (closed toe version shown)



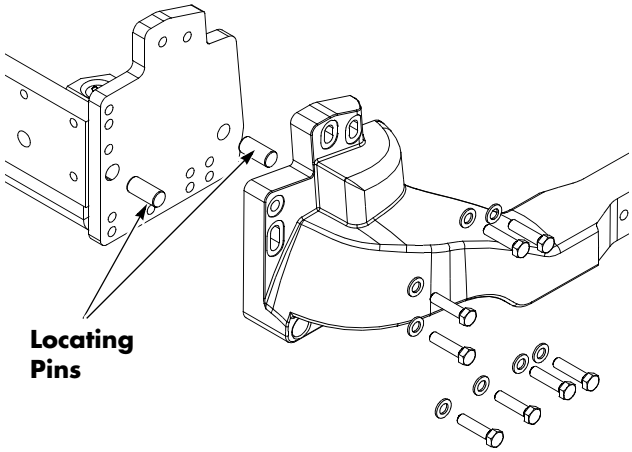
7. Remove the bolts holding the baseleg to the main frame.

⚠CAUTION

Baseleg weighs over 100 pounds (45 kg). Use a suitable lifting device to assist in removing baseleg.

8. Slide the baseleg off the locating pins. See Figure 7-14. If added force is needed to separate the baseleg from the mast, protect the casting from direct blows.

Figure 7-14. Baseleg Removal, Model 7600 shown



Installation

1. Apply anti-seize compound (P/N 990-452) to the baseleg alignment pins and mating surfaces of main frame, baseleg, and baseleg shim, if used. Insert locating pins into the mast.
2. Using a suitable lifting device to assist, mount the baseleg over the alignment pins.
3. Apply thread-locking compound (P/N 990-669) to the baseleg mounting bolts.
4. Install baseleg mounting bolts and washers. Torque as shown in Table 7-3.

Table 7-3. Baseleg mounting bolt torque values

Model 7600	Model 7620/7640
165 ft. lb. (223 Nm)	295 ft. lb. (434 Nm)

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5. Slide load wheel assembly over baseleg.
6. Apply Solvent (P/N 990-589), primer (P/N 990-533), and retaining compound (P/N 990-575) to the outside of the mounting bolt sleeve and the inside of the baseleg hole.
7. Apply thread-locking compound (P/N 1013829) to the load wheel plate mounting bolts. Install mounting bolts, washers and nuts. Torque as shown in Table 7-4.

Table 7-4. Wheel plate torque values

Bolt	**Torque**
Wheel Plate, Mounting, 7600	50 ft. lb. (68 Nm)
Wheel Plate, Mounting, 7620/7640	150 ft. lb. (203 Nm)
Wheel Plate, Top	21 ft. lb. (28 Nm)
Nose, Closed Toe	55 ft. lb. (74.5 Nm)

8. Remove blocking and lower the baseleg to the floor.
9. Install right or left front cover.
10. Install battery gate.

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Steering and Controls

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Steering Encoder

Removal

1. Turn the key switch OFF and disconnect the battery connector.

NOTE: Use correct electrostatic discharge precautions. See “Static Precautions” on page 2-7.

2. Remove the center tiller cap.
3. Remove the 2 cap screws holding the steering tiller to the steering encoder. Remove the tiller.
4. Disconnect encoder harness connectors JPE1 and JPE2. Cut cable ties as needed.
5. Remove three screws, washers, and nuts holding the steering encoder to the steering tiller stem.

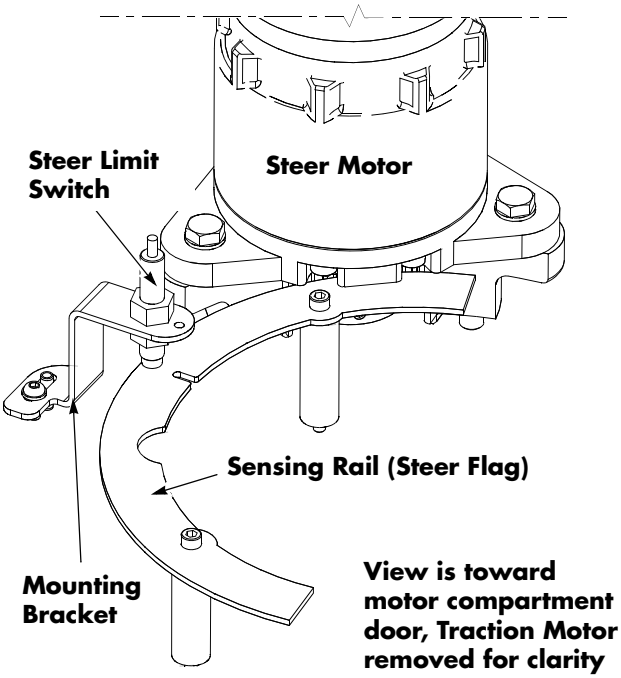
Installation

1. Install steering encoder to steering tiller stem with three screws, washers, and nuts previously removed. Torque to 9 ft. lb. (12 Nm).
2. Route encoder harness and install cable ties where previously removed. Connect harness connectors JPE1 and JPE2.
3. Apply thread-locking compound (P/N 990-536) to the steering wheel cap screws.
4. Position the steering tiller over the steering encoder. Apply medium strength adhesive (P/N 1013829) to two cap screws previously removed. Install cap screws and washers. Torque to 21 ft. lb. (29 Nm).
5. Apply sealant (P/N 990-542) to the tiller cap seat area in the steering tiller. Install tiller cap.

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Steer Limit Switch (S11)

Figure 7-15. Steer Limit Switch



Vertical Gap Adjustment

1. Turn the key switch OFF and disconnect the battery connector.
2. Open the Traction Motor compartment door.
3. Loosen the nuts securing the switch to the bracket.
4. Adjust the vertical gap between the switch and the sensing rail to 0.12 to 0.25 in. (3.0 to 6.4 mm). Tighten the nuts.

Lateral Adjustment

1. Run Test I90 - Degrees Turned Past Steer Flag (Page 6-97).
2. Adjust the mounting bracket so the reading on both ends is as close to 10° as possible.

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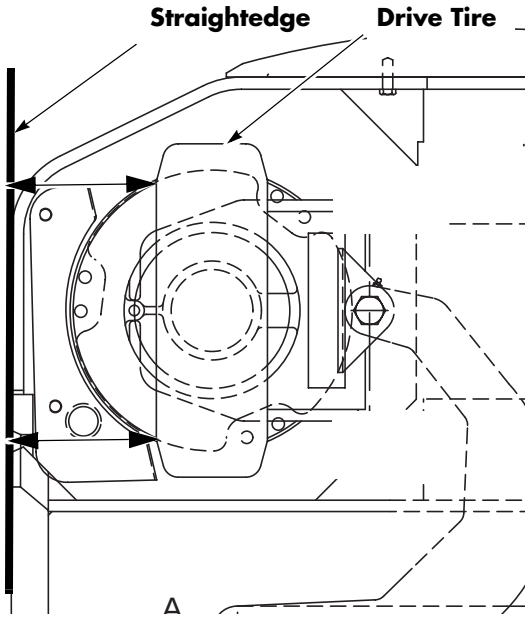
Steerable Caster

Correct caster adjustment is critical for correct performance. A misadjusted caster can cause excessive braking distances, poor stability, or damage to inertial dampener components.

Initial Adjustment

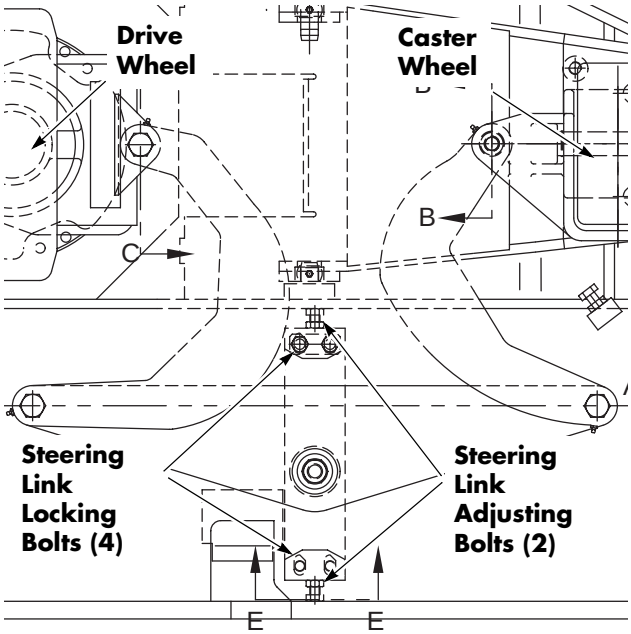
1. The drive and caster wheels should be parallel.
2. Place a straightedge along the tractor frame. Measure the distance from the straightedge to the front edge of the drive tire and to the back edge. Adjust steering until the measurements are equal. The drive wheel is now parallel to the tractor frame. See Figure 7-16.

Figure 7-16. Setting Drive Wheel Parallel



3. Place a straightedge along the opposite side tractor frame. Measure the distance from the straightedge to the front edge of the caster wheel and to the back edge. If the dimensions are not equal, adjust as follows:
   a. Turn the key switch OFF and disconnect the battery connector. Remove battery gates. Using a suitable battery removal device, remove the battery and battery rollers from the lift truck to provide access to adjustment bolts underneath.
   b. Loosen the center steering link locking bolts. See Figure 7-17.

Figure 7-17. Steering Adjustments



   c. Loosen jam nuts on center steering link adjusting bolts and adjust the bolts to get both wheels parallel to the tractor frame.
   d. Apply thread-locking compound (P/N 1013829) to steering link adjusting bolts and locking bolts.
   e. Tighten the jam nuts on the adjusting bolts.
   f. Tighten locking bolts and torque to 70 ft. lb. (95 Nm).
   g. Re-install the battery rollers. Using a suitable battery removing device, re-install the lift truck battery. Re-install battery gates.

Caster height adjustment varies, depending upon the type of mast. See “Caster Height Adjustment” on page 7-23.

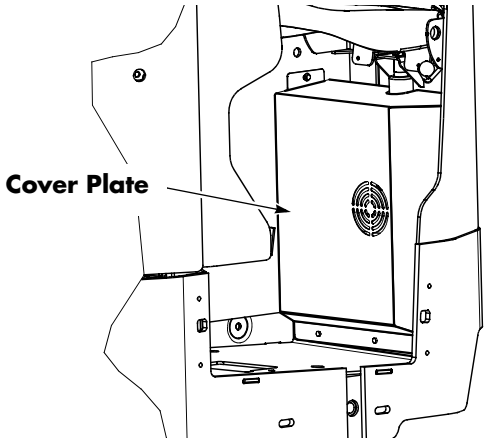
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Caster Height Adjustment

NOTE: Make sure a correctly rated battery is installed in the lift truck prior to making this adjustment.

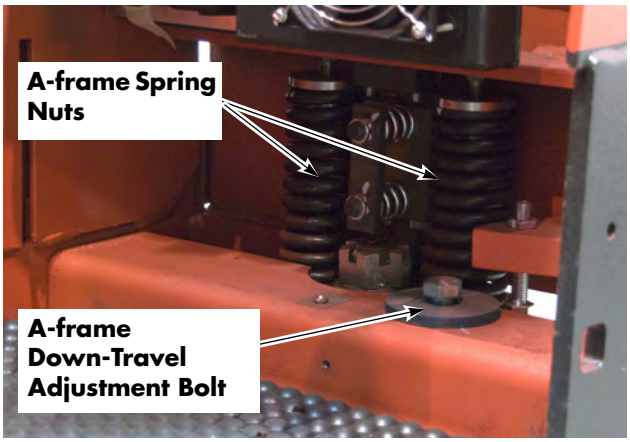
1. Remove the inertial dampener cover plate. See Figure 7-18.

Figure 7-18. Inertial Dampener Cover Plate



2. Check the A-frame down-travel adjustment bolt in Figure 7-19. Make sure it is installed correctly. If the bolt is missing, the A-frame could drop and allow the springs to escape when the truck is jacked up.

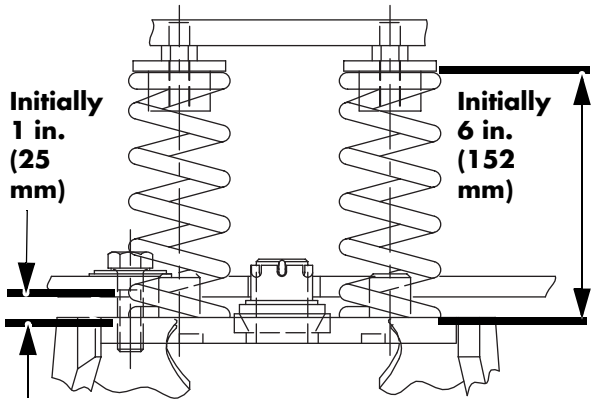
Figure 7-19. A-frame Down-Travel Adjustment Bolt



⚠ WARNING

Use extreme caution whenever the lift truck is jacked up. Never block the lift truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from vehicle while jacking the lift truck. See "Jacking Safety" on page 2-8.

Figure 7-20. A-frame Spring Adjustments



3. Jack the lift truck until the caster is clear of the floor.
4. Turn the A-frame down-travel adjustment bolt to obtain an initial gap of 1.0 in. (25 mm) between the arm and frame. Adjust the A-frame spring nuts to obtain an initial spring length of 6.0 in. (152 mm). See Figure 7-19 and Figure 7-20.
5. Lower the lift truck back onto the floor. Make sure the lift truck is sitting on a flat floor surface.
6. Adjust the A-frame spring nuts to obtain the spring length shown in Table 7-5. The dimension is measured from the top of the spring to the top of the caster, *not the frame.*

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Table 7-5. A-frame spring length

Elevated Height	Spring Length
Below 330 in. (8328 mm)	5.75 in. (146 mm)
Above 331 in. (8407 mm)	5.50 in. (140 mm)

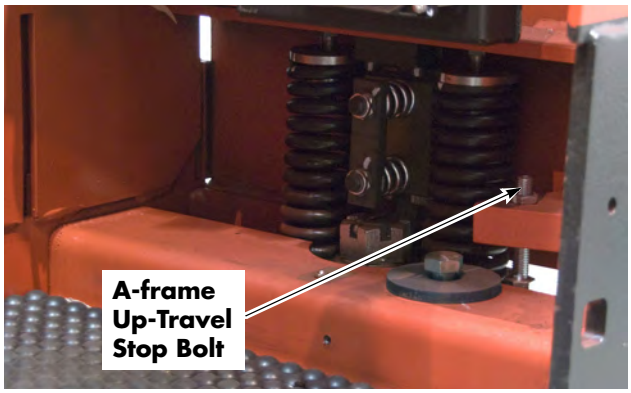
7. Apply thread-locking compound (P/N 990-536) and turn the A-frame down-travel adjustment bolt to set the correct gap between the bottom of the bolt head and the top of the flat washer. See Figure 7-19 and Table 7-6.

Table 7-6. A-frame down-travel gap

Elevated Height	Gap
All	0.12 in. (3.05 mm)
Note: DO NOT overtighten the bolt. The bolt head should apply slight pressure on the flat washer.	

8. Loosen the jam nut on the A-frame up-travel stop bolt. See Figure 7-21.

Figure 7-21. A-frame Up-Travel Stop Adjustment



9. Turn the A-frame up-travel stop bolt to adjust the gap between the bolt head and the top of the A-frame. See Figure 7-21 and Table 7-7.

Table 7-7. A-frame up-travel stop bolt gap

Elevated Height	Gap
Below 330 in. (8328 mm)	0.38 in. (9.65 mm)
Above 331 in. (8407 mm)	0.25 in. (6.35 mm)

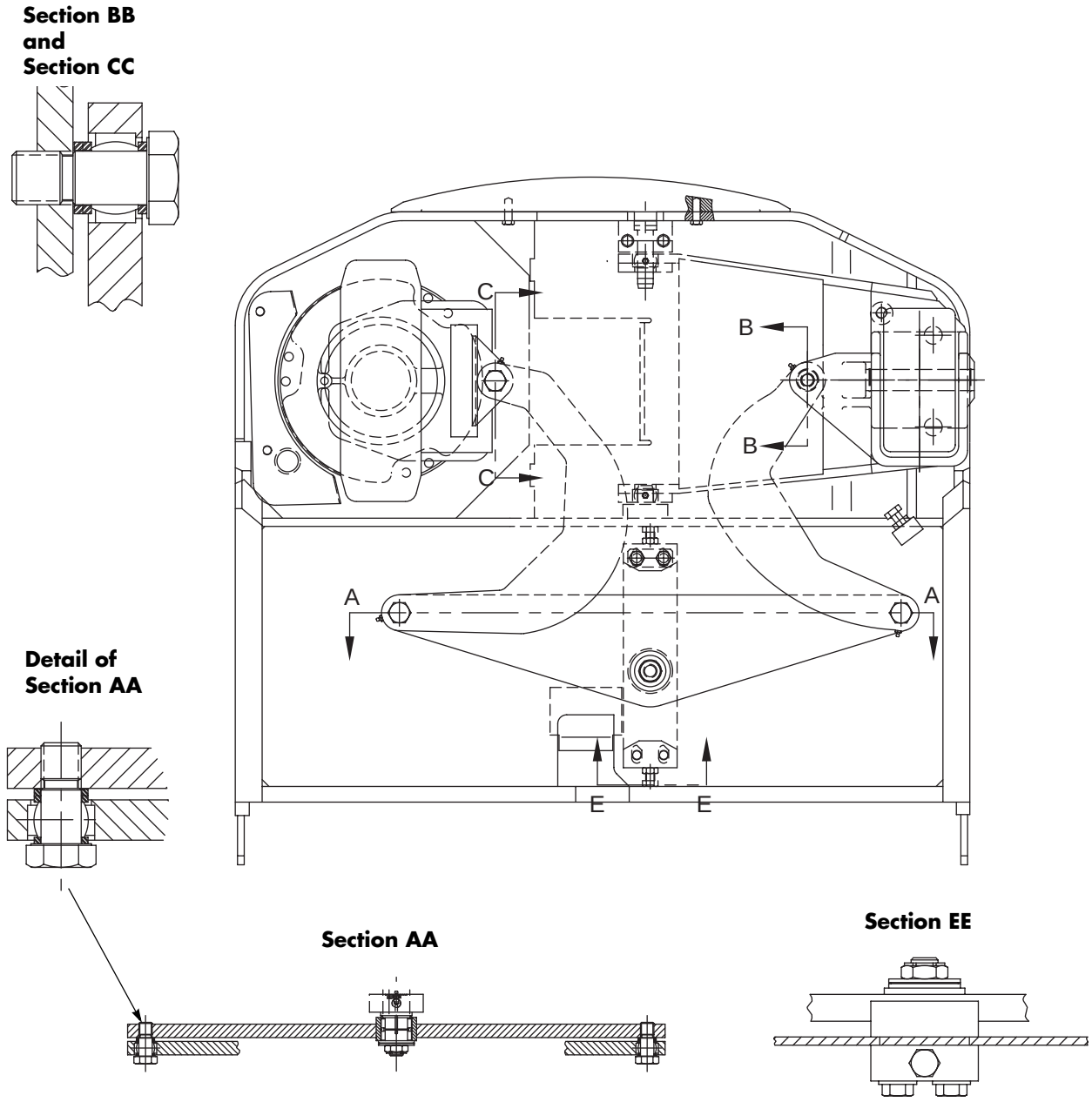
10. Apply thread-locking compound (P/N 990-536) to the A-frame up-travel stop bolt. Tighten the jam nut.
11. Test the lift truck for correct braking action.
12. Reinstall the inertial dampener cover plate.

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Steering Linkage

Use Figure 7-22 as a reference when removing/replacing steering linkage components. After replacing any components, make sure the steering is adjusted correctly.

Figure 7-22. Steering Linkage



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Control Handle

If a *ThermaKit* component has failed in the control handle; replace both handle shells. In this case, it is more cost effective to replace the entire handle than to rebuild it.

Disassembly

1. Remove the lift knob.

NOTE: The outer spring paddle may fall off when the lift knob is removed.

⚠CAUTION

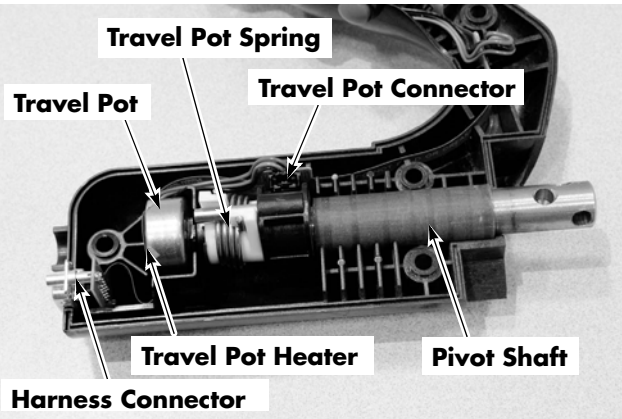
Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-7.

2. Remove the socket head cap screws from the handle shell.
3. Lift off the upper handle shell. If *ThermaKit* equipped, the upper shell can be removed but wiring will connect the two halves.

Travel Pot Repair/Replacement

1. Carefully peel the flex heater from the travel pot. It is attached to the pot with double-sided tape.
2. Remove harness connector and travel pot heater from lower shell. See Figure 7-23.

Figure 7-23. Pivot Shaft Components



3. Press the latch on the travel pot connector and disconnect the travel pot from the flex circuit. See Figure 7-23.
4. Lift the travel pot shaft out of the lower handle shell.
5. Slide the travel pot out of the pivot shaft assembly. See Figure 7-23.

NOTE: Do *not* lose the D-shaped clip inside the pivot shaft.

6. Remove the external snap ring.

Figure 7-24. Pivot Shaft Assembly



NOTE: Observe orientation of the spring and paddles on the pivot shaft.

7. Remove the spring and paddles from the pivot shaft. See Figure 7-24.
8. Apply a thin coat of lubricant (P/N 990-635) to the inside surface of the spring. Assemble spring between the spring paddles. See Figure 7-25.

Figure 7-25. Travel Pot Spring Assembly

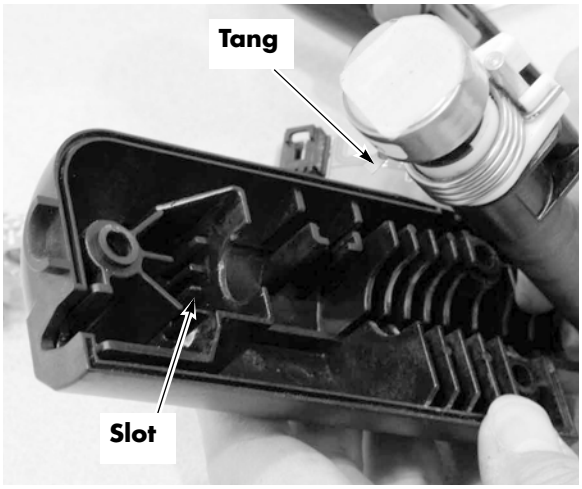


9. Slide the spring and paddles part way down the pivot shaft to engage the lower spring tang.

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10. Using the upper paddle, press the upper spring tang over the pin on the pivot shaft. With one paddle and one spring tang on each side of the pin, slide all parts down to expose the snap ring groove. See Figure 7-25.
11. Install the external snap ring. See Figure 7-24.
12. Slide the travel pot shaft into the pivot shaft assembly (make sure D-clip is in pivot shaft).
13. Insert the pivot shaft assembly into the lower handle shell. Make sure the tang on the travel pot enters the center slot in the shell. See Figure 7-26.

Figure 7-26. Travel Pot Tang Alignment



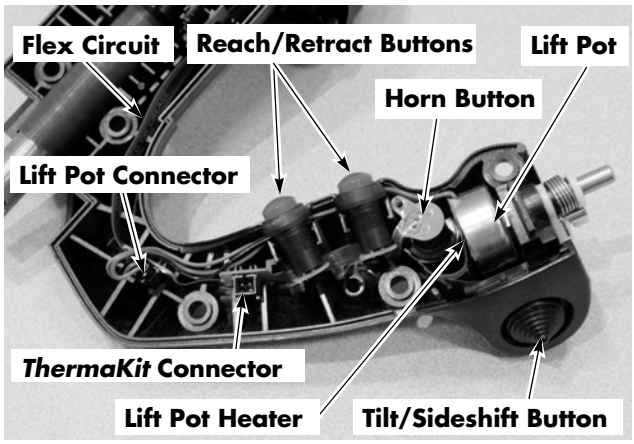
14. Re-tape the flex heater to the travel pot body. Replace the double-sided tape if necessary. See Figure 7-23.
15. Re-seat the travel pot flex connector in the handle shell. Re-connect the travel pot to the flex circuit. See Figure 7-23.

Lift Pot Repair/Replacement

1. Slide the outer paddle and lift pot spring off the lift pot shaft. See Figure 7-27.

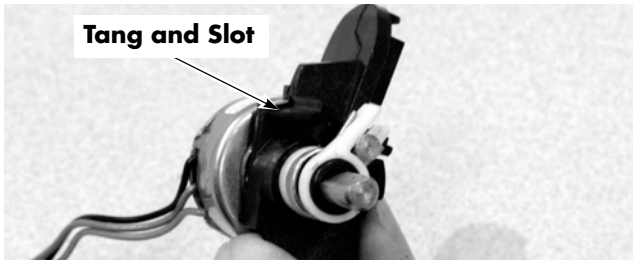
NOTE: Observe orientation of the lift pot spring, paddles, and dowel pin.

Figure 7-27. Handle Shell



2. Slide the inner spring paddle off the lift pot shaft.
3. Press the latch on the lift pot connector and disconnect the lift pot from the flex circuit. See Figure 7-27.
4. Carefully peel the flex heater from the lift pot. It is attached to the pot with double-sided tape.
5. Pull the lift pot/bracket assembly out of the handle shell.
6. Slide the lift pot out of the lift pot bracket.
7. Slide a new lift pot into the lift pot bracket. The lift pot tang must slide into the slot on the lift pot bracket. See Figure 7-28.

Figure 7-28. Lift Pot Tang and Bracket Slot

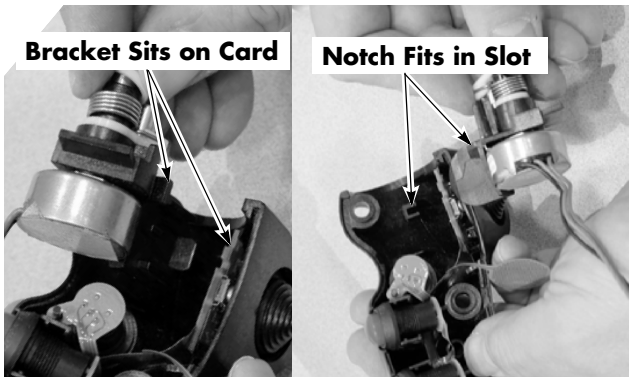


8. Slide the inner spring paddle onto the lift pot bracket.
9. Apply a thin coat of lubricant (P/N 990-635) to the inside surface of the spring. Install the spring with one tang resting on the inner spring paddle (not the dowel pin).
10. Slide the outer spring paddle part way onto the lift pot shaft to engage the outer spring tang.

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11. Using the outer paddle, press the outer spring tang over the dowel. Slide parts together until the outer paddle is flush with the lift pot bracket. See Figure 7-28.
12. Make sure the tilt/sideshift card is correctly positioned. Slide the lift pot/bracket assembly into the handle shell. See Figure 7-29.

Figure 7-29. Lift Pot/Bracket Assembly Insertion

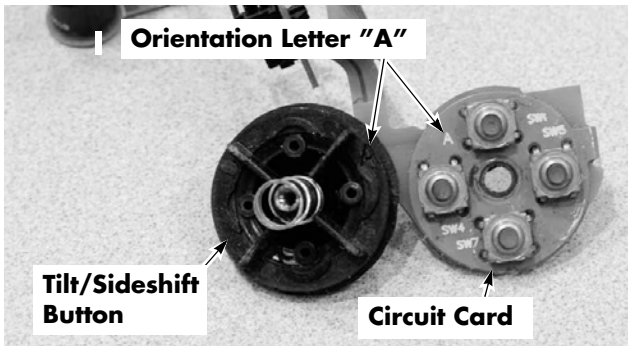


13. Re-tape the flex heater to the lift pot body. Replace the double-sided tape if necessary. Use a screwdriver blade to press the heater against the pot body.
14. Route lift pot wires under the reach/retract buttons. Re-connect the lift pot to the flex circuit at the connector.
15. Re-connect the *ThermaKit* (if so equipped) to the flex circuit.

Flex Circuit Repair/Replacement

1. Press the latch on the *ThermaKit* connector and disconnect the *ThermaKit* (if so equipped) from the flex circuit. See Figure 7-27.
2. Hold the tilt/sideshift button and card between thumb and forefinger. Tip the card back and remove from the handle shell (the gasket on the tilt/sideshift button may fall off as the tilt/sideshift card is removed from the lower handle shell).
3. Lift the horn button off the positioning pin.
4. Carefully remove the lift pot connector from the slot in the handle shell.
5. Carefully remove the *ThermaKit* and travel pot connectors from the slots in the handle shell. See Figure 7-27.
6. Lift the flex circuit out of the handle shell.
7. Remove the tilt/sideshift button and spring from the flex circuit by removing one screw from the back of the tilt/sideshift card.
8. To install the tilt/sideshift button and spring on the tilt/sideshift card, place the spring over the post on the back of the tilt/sideshift button. Align the “A” on the back of the button with the “A” on the card. See Figure 7-30. Press the button against the card so the post protrudes through the back of the card. Thread the screw into the post until it just bottoms, then tighten an additional 1/8 turn. Do not overtighten.

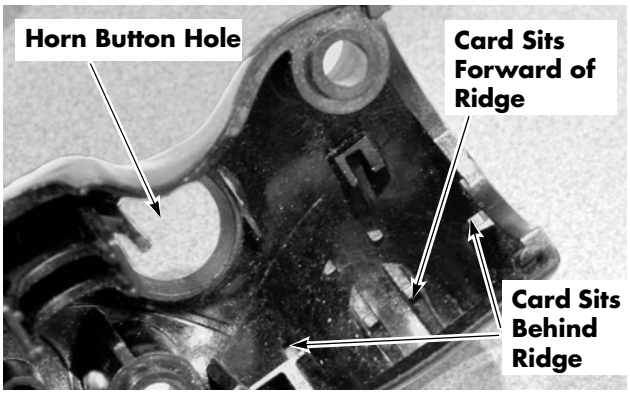
Figure 7-30. Tilt/Sideshift Card and Button



9. Press the *ThermaKit* and travel pot connectors into the slots in the handle shell. See Figure 7-27.
10. Place the gasket over the tilt/sideshift button. Gently position the tilt/sideshift card in the handle shell. The bottom of the card sits forward of a ridge in the handle; the card edge nearest the lift knob sits behind a ridge in the handle. Confirm that the gasket is in place on the tilt/sideshift button. See Figure 7-31.

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Figure 7-31. Tilt/Sideshift Card Insertion

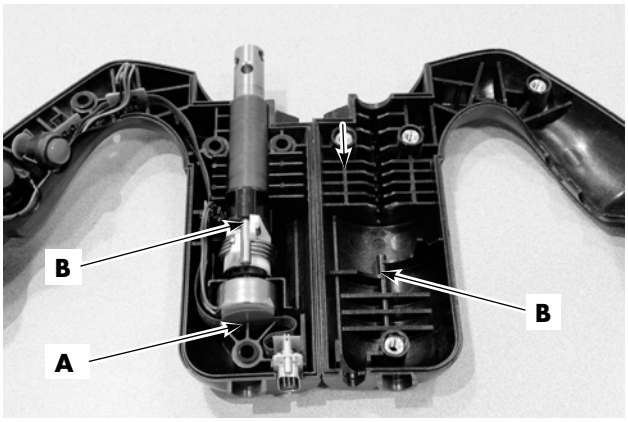


11. Correctly position the reach/retract buttons and re-connect the *ThermaKit* (if so equipped) to the flex circuit.

Assembly

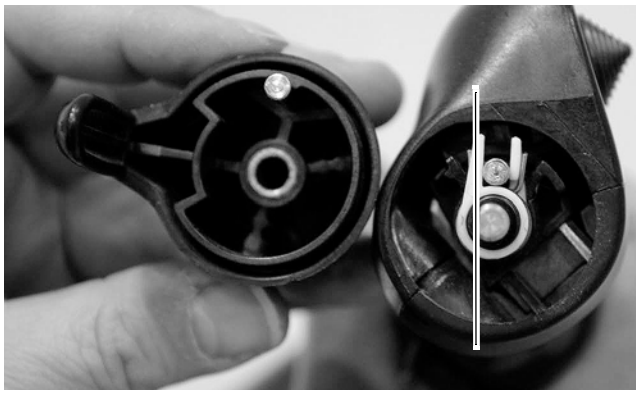
1. Confirm the flex circuit is routed correctly through the locating slots.
2. Position the upper handle shell over the lower shell and ease it into position. See Figure 7-32. Make sure:
   - **A** - travel pot tang is entering the slot in the shell
   - **B** - travel shaft rib on upper shell is passing between the paddles of the pivot shaft assembly

Figure 7-32. Handle Assembly



3. Squeeze the handle halves together.
4. Place the tip of a screwdriver into the pivot shaft set screw hole. Gently rotate the shaft in both directions to confirm that the pin in the upper handle shell is between the paddles. Do not over-rotate the shaft, as this can cause damage. You should feel spring tension immediately and there should be no free play in the pivot shaft. If you do not feel spring tension, lift off the upper handle shell, and repeat step 2.
5. Fasten the harness connector to the upper handle shell. Tighten each screw until it bottoms, plus an additional 1/16 turn. Do not overtighten.
6. Install the socket head cap screws. Tighten each screw until it bottoms, plus an additional 1/4 turn. Do not overtighten.
7. Confirm the two spring paddles and spring are in place. The outer paddle must be flush with the end of the lift pot bracket.
8. Set the flat on the lift pot shaft parallel to the top spring paddle. See Figure 7-33.

Figure 7-33. Lift Pot Shaft Alignment



9. Install the lift knob with the dowel pin in between the paddles.
10. Tighten the steel set screw until it bottoms, plus an additional 1/4 turn.
11. Install the nylon set screw. Run the nylon set screw down flush or below the surface of the knob.

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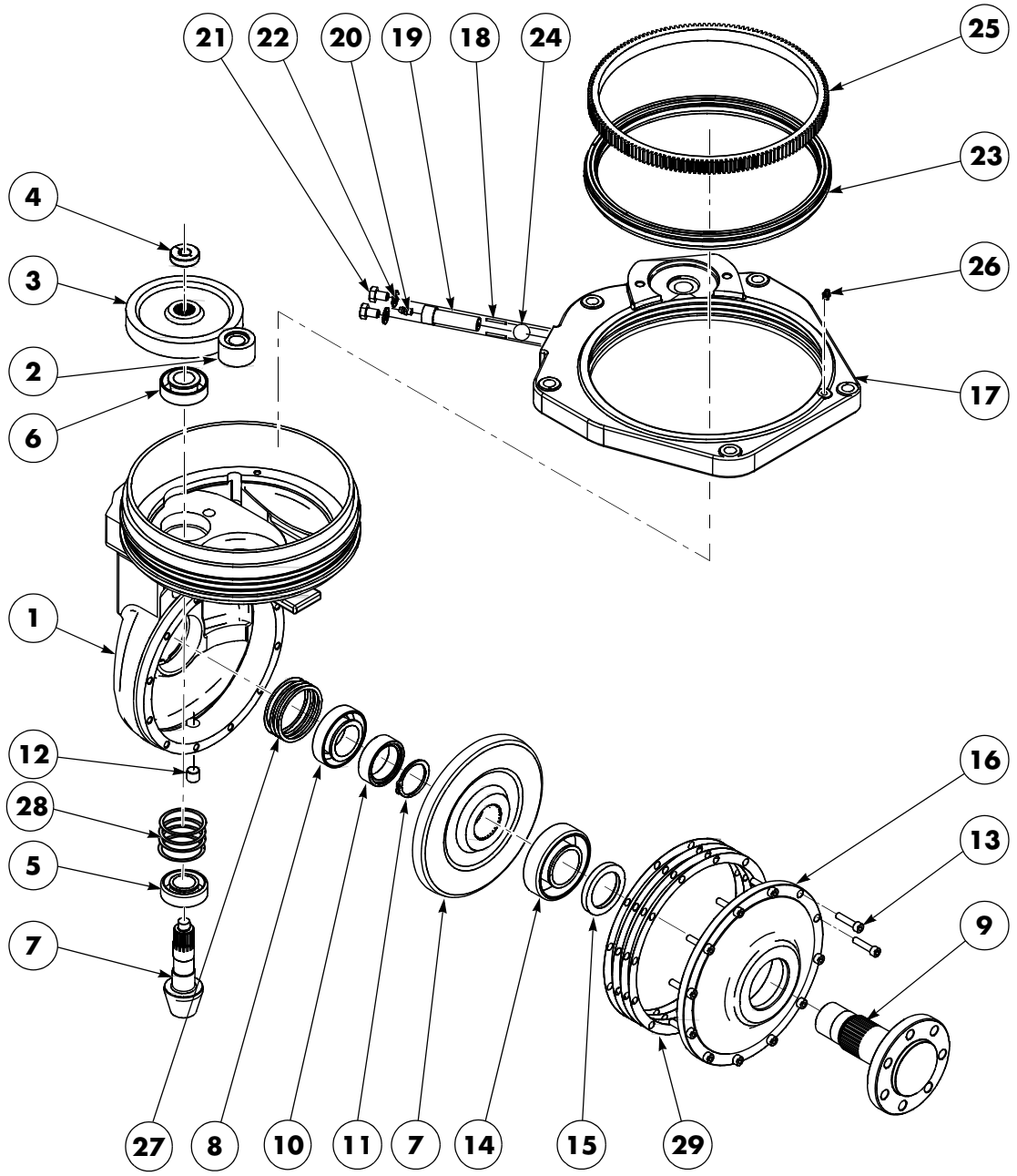
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Drive and Brake

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Drive Unit

Figure 7-34. Drive Unit Exploded View



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Table 7-7. Legend for Figure 7-1

Item	Description
1	Housing, Drive Unit
2	Gear, Pinion, Drive Unit
3	Gear, Helical, Drive Unit
4	Nut, Clamp
5	Bearing Set, Drive Unit
6	Bearing Set, Drive Unit
7	Gear and Pinion Set, Drive Unit
8	Bearing Set, Drive Unit
9	Shaft, Flanged Output, Drive
10	Shim, Drive Unit Output Bearing
11	Ring, Retaining
12	Plug, Pipe
13	Screw
14	Bearing Set, Drive Unit
15	Seal, Lip
16	Cover
17	Ring, Pivot
18	Pin, Spiral
19	Plug, Bearing Filler
20	Fitting, Grease
21	Screw
22	Washer, Flat
23	Kit, Ring Set
24	Bearing, Ball
25	Gear, Spur, Drive Unit
26	Fitting, Grease
27	Shim
28	Shim
29	Cover, Shim

Required Tools

Before performing any maintenance on the drive unit, note the tools required. Also, make sure that any maintenance performed does not void warranty.

Standard Tools

The tools listed in Table 7-8 are required for performing maintenance tasks on the drive unit.

Table 7-8. Standard Hand Tools for Servicing Drive Unit

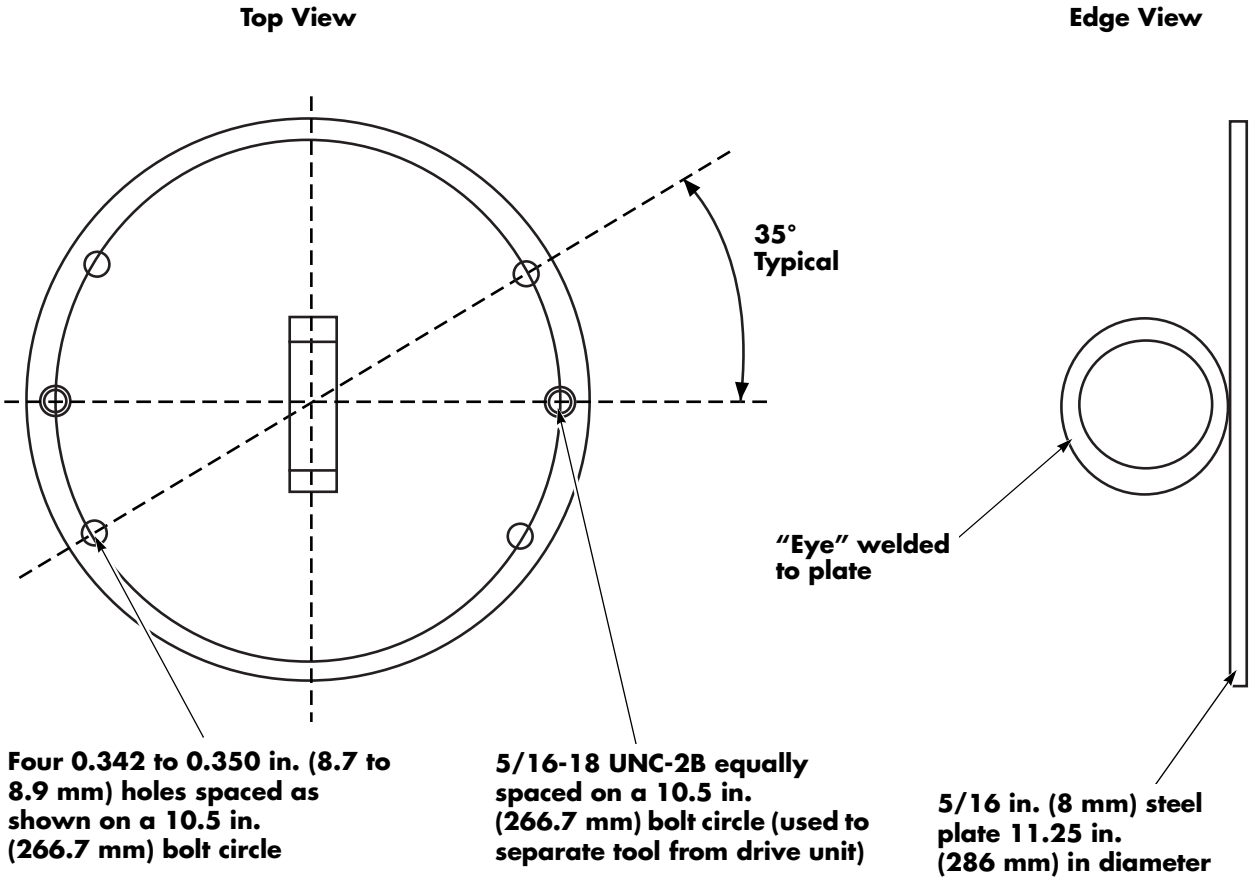
Bearing puller
Bearing press
Micrometer
Hammer or mallet
Brass punch
Pinion gauge
Bearing heater
Screwdriver
Magnetic dial indicator
Pry bars
Tube 12 in. diam. x 6 in. long
Tube 8 in. diam. x 6 in. long
Torque wrench, 150 ft. lb. (210 Nm) capacity

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Special Tools

The tool shown in Figure 7-35 is recommended for removal/installation of the drive unit.

Figure 7-35. Drive Unit Removal/Installation Tool



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Troubleshooting

Table 7-9. Troubleshooting Drive Unit Symptoms

Symptom	Probable Cause	Required Action	Available Kits
Oil leaks	Damaged lip seal	Replace lip seal, main cover and bearing shims, and output shaft bearings	Seal Kit P/N 410-029/50
	Worn or damaged output shaft	Replace lip seal, main cover and bearing shims, output shaft bearings, and output shaft	Axle Shaft Kit P/N 410-029/51
	Housing/main cover joint	Reseal	N/A
	Worn or damaged housing	Replace drive unit	N/A
Drive wheel wobbles	Worn or damaged output shaft bearings	Replace lip seal, main cover and bearing shims, and output shaft bearings	Seal Kit P/N 410-029/50
	Worn or damaged output shaft	Replace lip seal, main cover and bearing shims, output shaft bearings, and output shaft	Axle Shaft Kit P/N 410-029/51
	Loose wheel mounting hardware	Inspect housing and main cover for damage, retorque mounting hardware	N/A
Noise	Worn or damaged output shaft bearings	Replace lip seal, main cover and bearing shims, and output shaft bearings	Seal Kit P/N 410-029/50
	Worn or damaged pinion bearings	Replace pinion bearings and clamp nut	N/A
	Worn or damaged gear set - Output shaft is in good condition	Replace lip seal, main cover and bearing shims, output shaft bearings, pinion bearings, gear set, and clamp nut	Seal Kit P/N 410-029/50 Drive Gear Kit P/N 410-029/52
	Worn or damaged gear set - Output shaft is worn or damaged	Replace lip seal, main cover and bearing shims, output shaft bearings, pinion bearings, gear set, clamp nut, and output shaft	Axle Shaft Kit P/N 410-029/51 Drive Gear Kit P/N 410-029/52
	Worn or damaged helical gear and pinion	Replace helical gear and pinion	N/A
Steering binds	Inadequate bearing lubrication	Grease pivot bearing and spherical bearing	N/A
	Worn or damaged pivot bearing	Replace radial ring set, steel balls, bearing filler plug, and spherical bearing	Steer Kit P/N 410-029/53

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Symptom	Probable Cause	Required Action	Available Kits
Steering binds	Worn or damaged spur gear	Replace spur gear and spherical bearing	N/A
	Worn or damaged spherical bearing	Replace spherical bearing and grease fittings	N/A
	Worn or damaged pivot ring	Replace pivot ring, radial ring set, steel balls, bearing filler plug, and spherical bearing	Steer Kit P/N 410-029/53

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Radial Ring Inspection

NOTE: This inspection applies to Model 7600 and 7620 trucks only.

If worn radial rings are suspected as the cause of play in the drive unit, perform the following steps to determine if the rings should be replaced.

⚠ WARNING

Use extreme caution whenever the lift truck is jacked up. Never block the lift truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from vehicle while jacking the lift truck. See "Jacking Safety" on page 2-8.

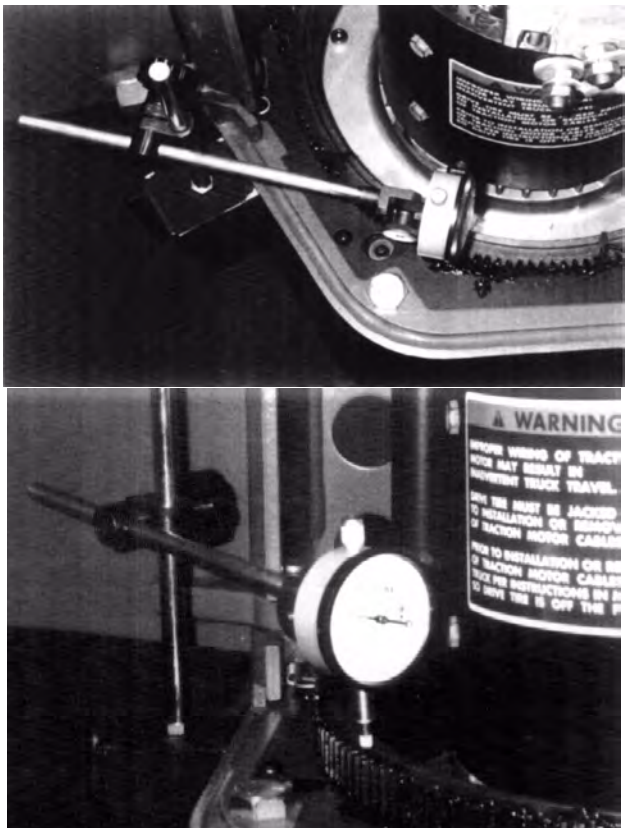
1. Jack the rear of the truck up until the drive tire is clear of the floor.
2. Place a magnetic base dial indicator on the tractor bumper. Place the indicator pin on top of the ring gear. See Figure 7-36.

NOTE: When positioning the indicator, align it with a feature on the truck (such as a grease fitting). This will help maintain consistent results between trucks.

3. Zero the indicator and lower the truck to the floor. Observe the new indicator reading.
4. If the reading exceeds 0.090 in. (2.3 mm), the radial rings should be replaced.

NOTE: Any looseness that results in the pivot ring casting contacting the drive unit housing as the unit turns during steering requires the radial rings to be changed immediately.

Figure 7-36. Dial Indicator Placement



Drive Unit Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Drain the oil from the drive unit.
3. Loosen the drive tire lug nuts.
4. Remove the horn assembly.
5. Disconnect the power cables from the Traction Motor, labeling the cables if necessary for later installation. Use two wrenches to avoid twisting the motor studs.
6. Disconnect remainder of wires and brake hose.
7. Remove mounting bolts for cable bracket.
8. Remove Traction Motor mounting bolts. Lift brake assembly and motor off drive unit.
9. Remove the steering shaft.
10. To facilitate the removal of the drive unit, construct the tool shown in Figure 7-35.

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Attach the tool to the top of the drive unit using the screws that held the Traction Motor.

11. Remove the dust shield between the ring gear and the tractor frame.

⚠ WARNING

Use extreme caution whenever the lift truck is jacked up. Never block the lift truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from vehicle while jacking the lift truck. See "Jacking Safety" on page 2-8.

12. Secure the lift truck with a suitable capacity hoist attached to the overhead guard. Jack the rear of tractor so that the bottom edge of the bumper is approx 6.5 in. (16.5 cm) off the floor.
13. Remove the drive wheel.
14. Disconnect the steer linkage from the drive unit; swing the linkage clear (if the lift truck has a steered idler).
15. Place a temporary support under the drive unit or attach a hoist to the tool installed in Step 10.

⚠CAUTION

Drive unit weighs approx 175 lb. (80 kg.)

16. Loosen, then remove the four mounting screws holding the drive unit to the tractor frame. The steering stop also becomes unattached at this stage.
17. Lower the drive unit to the floor. Tip the drive unit over on its side and remove the hoist.
18. If you have trouble separating the tool from the drive unit, thread mounting screws in the threaded holes in the tool to push the tool off the drive unit.

Drive Unit Disassembly

All item numbers refer to exploded view, Figure 7-34 on page 7-32.

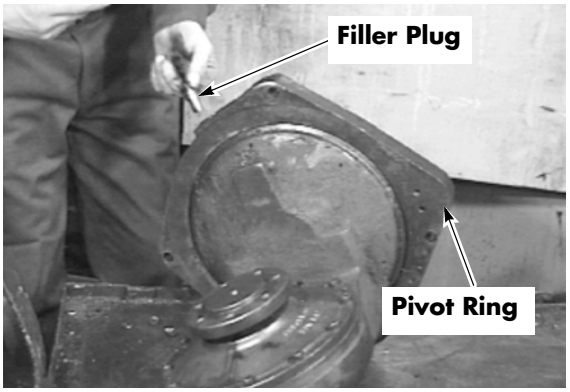
Clean the outside of the drive unit thoroughly and drain any remaining oil from the drive unit by removing the drain plug [Item 12].

Visually inspect the outside of the housing [Item 1] for damage, wear, or cracks.

Pivot Ring Disassembly

1. On the pivot ring [Item 17], remove the grease fitting [Item 20] and the bearing filler plug [Item 19]. Inspect the bearing filler plug hole for uneven wear. See Figure 7-37.

Figure 7-37. Remove Grease Fitting and Filler Plug

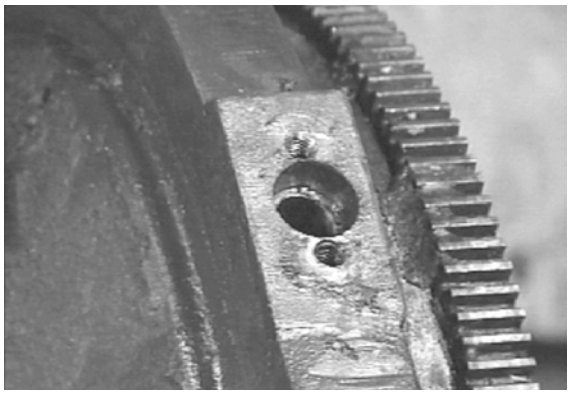


2. Turn the pivot ring [Item 17] to remove the steel balls [Item 24] through the bearing filler plug hole. See Figure 7-38.

NOTE: If the pivot ring does not spin or even turn, it is an indication of damaged radial rings and/or excessive wear to the channel in housing. If this is the case, replace the entire drive unit. No further disassembly is necessary.

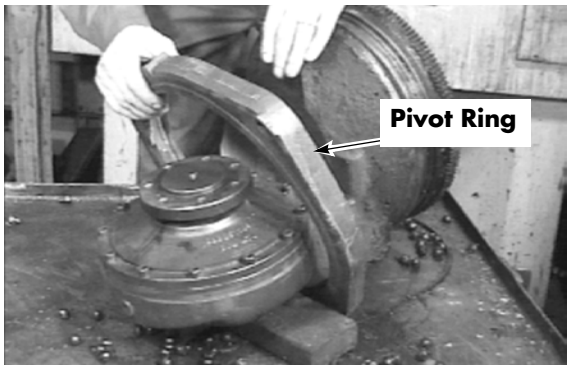
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Figure 7-38. Remove Steel Ball Bearings



3. After removing all the steel balls, remove the pivot ring [Item 17] by working it off toward drive end of the housing. See Figure 7-39.

Figure 7-39. Remove Pivot Ring



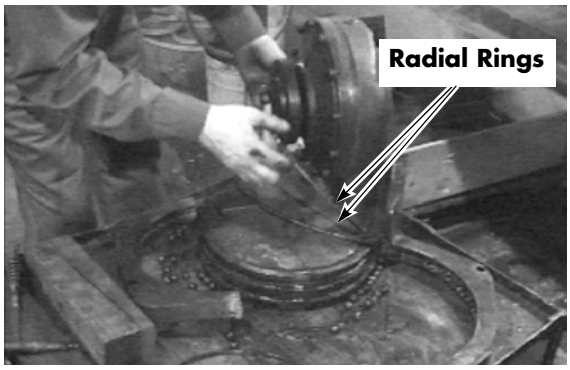
4. Remove the radial rings [Item 23] from the channel in the housing and inside the pivot ring.

⚠CAUTION

Due to normal wear, the edges of the radial rings could be very sharp.

5. Clean the grease from the radial ring channel in the housing. Inspect the channel for uneven wear. Also clean and inspect the inside of the pivot ring. See Figure 7-40.

Figure 7-40. Remove Radial Rings

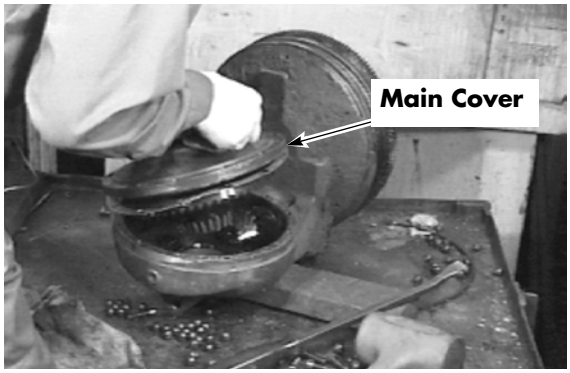


Main Cover and Output Shaft Disassembly

1. Visually inspect the housing around the main cover [Item 16] for wear outside the cover bolts [Item 13]. See Figure 7-41.

NOTE: Excessive housing wear outside the cover bolts can make them difficult to remove. If this occurs, replace the entire drive unit. No further disassembly is necessary.

Figure 7-41. Remove Cover and Output Shaft



2. Remove the main cover bolts [Item 13].
3. Using a mallet, knock the flanged output shaft [Item 9] to break the seal on the main cover [Item 16].
4. Remove the main cover and output shaft assembly. See Figure 7-41.
5. You need a press and 8 x 6 in. tube to remove the bearing cup [Item 14] on the end of the output shaft.

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⚠CAUTION

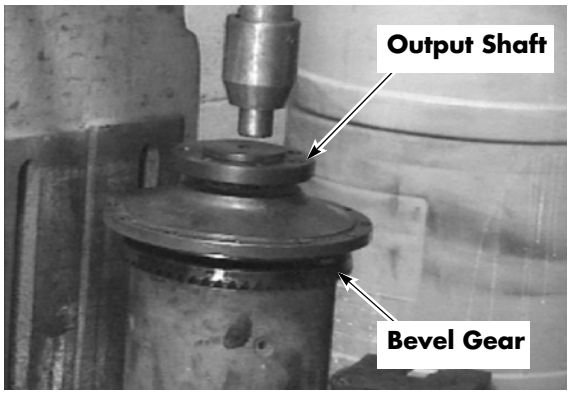
Always watch for pinch points when using a press or pressing tools.

⚠CAUTION

Safety glasses are required after this point in disassembly.

6. Place the main cover assembly, gear side down, on the tube under press. Press the output shaft [Item 9] down slightly to create a space between the bevel gear [Item 7] and the output bearing spacer [Item 10]. See Figure 7-42.

Figure 7-42. Press Down Output Shaft



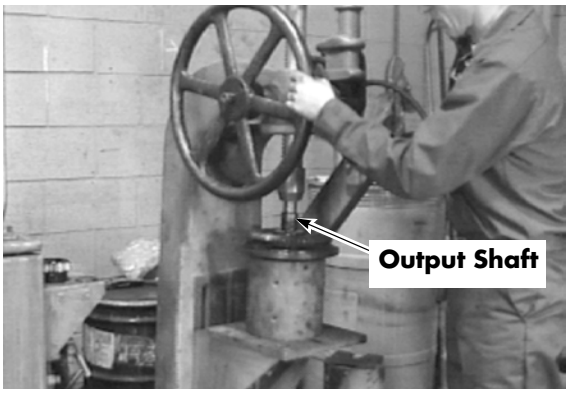
7. Tighten a bearing puller clamp under the lip of the output bearing spacer, being careful not to catch the exterior retaining ring [Item 11]. See Figure 7-43.

Figure 7-43. Press Out Output Shaft



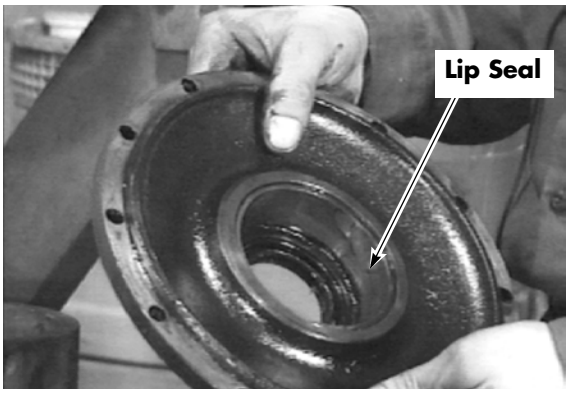
8. Place the main cover assembly, gear side up, on 12 x 6 in. tube so the bearing puller clamp is resting on the tube. Press the flanged output shaft [Item 9] and the output bearing spacer [Item 10] out.
9. Remove the exterior retaining ring [Item 11]. See Figure 7-43.
10. To remove the bevel gear [Item 7], support the main cover assembly on 8 x 6 in. tube under press. Press the output shaft [Item 9] down through the bevel gear. The bearing cone [Item 14] will be removed at the same time. See Figure 7-44.

Figure 7-44. Remove Bevel Gear



11. Remove the bearing cup [Item 8] from the main cover with a race driver and pry bars.
12. Remove the lip seal [Item 15] from the main cover. See Figure 7-45.

Figure 7-45. Remove Bearing Cup and Lip Seal



13. Remove the output shaft bearing cone [Item 8] in the base of the housing using two pry bars. Insert the pry bars under bottom edge of the cone on opposite sides. Apply even pressure on both tools to lift the cone out. See Figure 7-46.

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Figure 7-46. Remove Output Shaft Bearing Cone



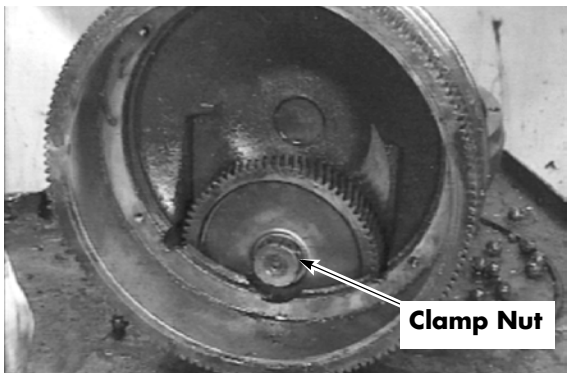
14. Remove the shims [Item 27] from the housing bore. Save shims for reference only, as they are usually damaged when removing the bearing cone. New shims are provided with Kits #1 and #2.
15. Remove the cover shims [Item 29]. Save the shims for reference only. Replacement shims are provided with Kits #1 and #2.

Spiral Pinion Disassembly

NOTE: *The spiral pinion and bevel gear are a matched set. Their alignment is critical. Do not replace them separately.*

1. Loosen the set screw on the clamp nut [Item 4] on the spiral pinion [Item 7]. Remove the clamp nut. See Figure 7-47.

Figure 7-47. Remove Clamp Nut



2. Using a brass punch and hammer, drive the spiral pinion [Item 7] out of the housing. See Figure 7-48.

NOTE: You may need to remove the spiral pinion with a press or pressing device equivalent.

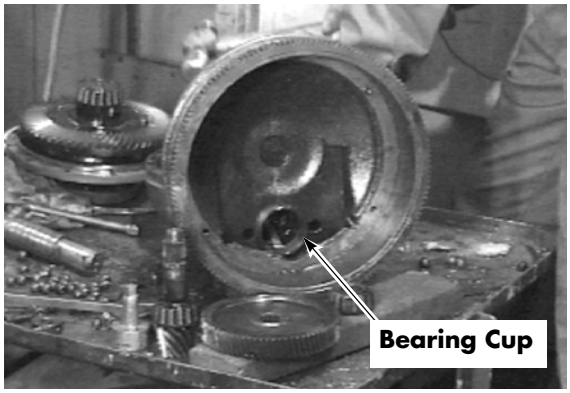
Figure 7-48. Remove Spiral Pinion



3. Remove the helical gear [Item 3] and the bearing cone [Item 5] from the housing. See Figure 7-48.
4. Drive out the bearing cup [Item 6]. Inspect the bearing cup and housing bores for wear. See Figure 7-49.

NOTE: The bearing cups and cones are usually damaged during removal. Replace them as sets; they are included with Kits #1 and #2.

Figure 7-49. Remove Bearing Cup



Thoroughly wash the housing and visually inspect entire housing again for excessive damage, wear, or cracks.

Drive Unit Assembly

⚠CAUTION
Safety glasses are required.

Prepare the housing for assembly by running a tap through all bolt and screw holes. Cleaning

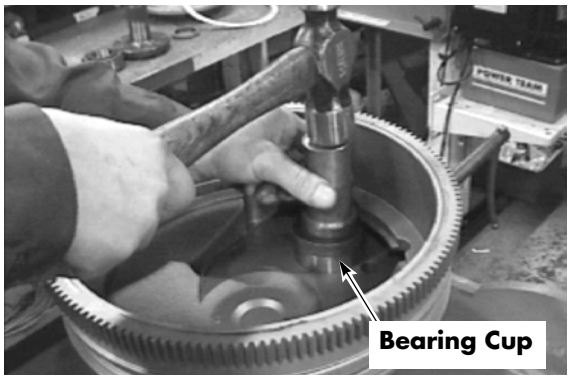
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the threads also makes sure that there is no damage.

Spiral Pinion Assembly

1. Using a press or mallet, install the bearing cup into the housing bore. See Figure 7-50.

Figure 7-50. Drive In Bearing Cup



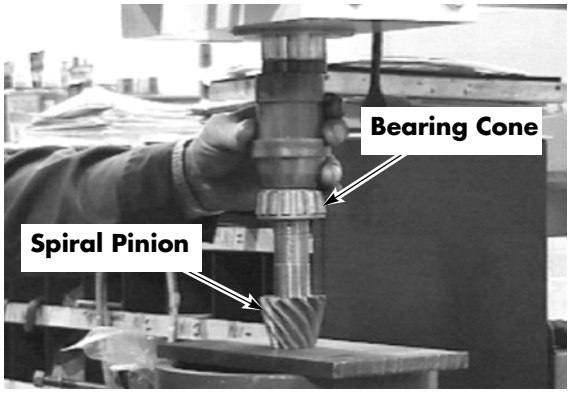
2. Install the second bearing cup [Item 6] into the housing bore on the opposite side.

⚠CAUTION

Always watch for pinch points when using a press or pressing tools.

3. Press the bearing cone [Item 5] onto the spiral pinion [Item 7] until it is seated. See Figure 7-51.

Figure 7-51. Press Bearing onto Spiral Pinion



Main Cover and Output Shaft Assembly

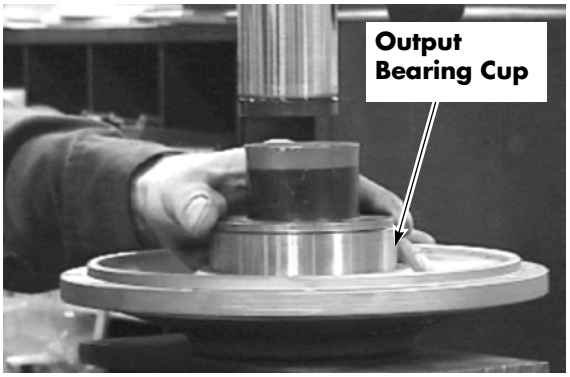
1. Prior to installing the output shaft lip seal [Item 15], apply a thin layer of sealing adhesive around the seal surface of the main housing, to prevent leaking. Install the lip seal, spring side down, in the housing.
2. Press the lip seal [Item 15] into the housing until it is just below flush with housing surface. See Figure 7-52.

Figure 7-52. Press Lip Seal



3. Press the output bearing cup [Item 14] into main cover until it is seated. Place the bearing cone into the bearing cup. See Figure 7-53.

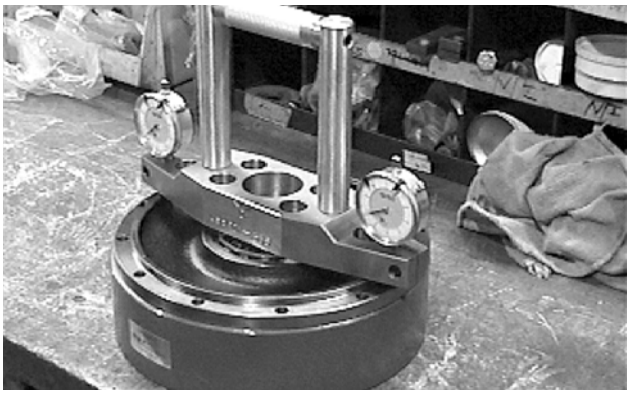
Figure 7-53. Press Output Bearing Cup



4. Push down on the bearing and turn to seat bearing into the bearing cup.
5. Take a measurement from the edge of the bearing cone [Item 14] to the flange surface of main cover [Item 16]. Make sure that dial indicator tips come into contact with flange surface. See Figure 7-54.

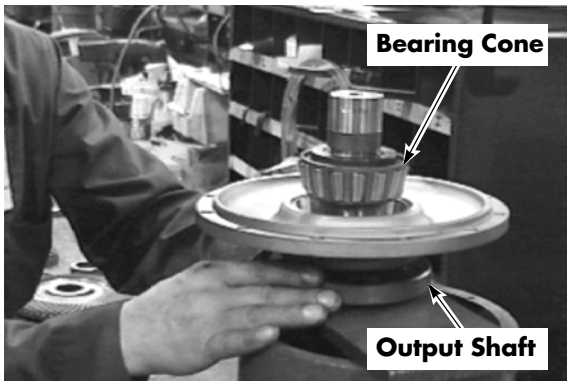
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Figure 7-54. Bearing Cone to Flange Measurement



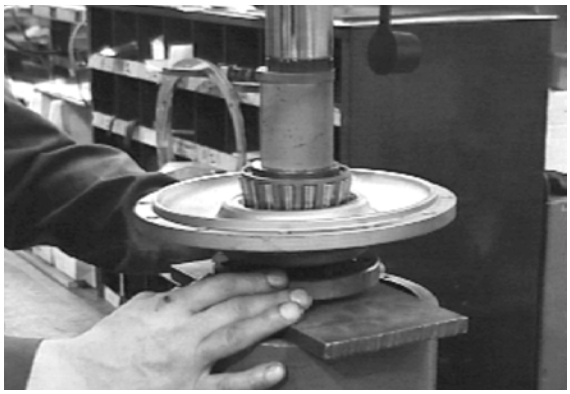
6. The reading on the two dial indicators should be the same. If they are different, repeat steps 4 and 5 until the readings are identical. Record final reading as Measurement D on flange surface. This is required during final assembly.
7. Remove the bearing cone [Item 14] in preparation for installing the flanged output bearing shaft [Item 9].
8. Use a light oil on the surface of the lip seal [Item 15] and inside the bearing cup [Item 14].
9. Place the main cover down over the output shaft, flange side up. Place the bearing cone [Item 14] down over the output shaft [Item 9]. See Figure 7-55.

Figure 7-55. Install Main Cover and Bearing Cone



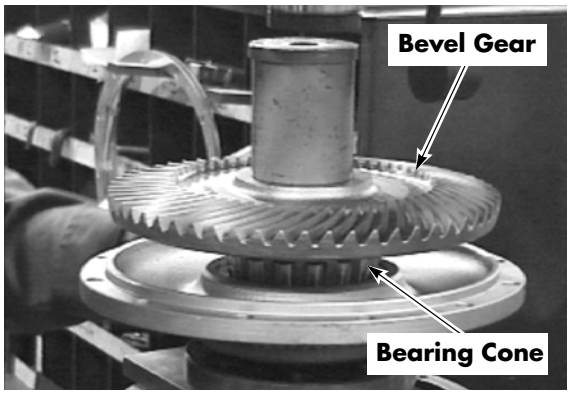
10. Press the bearing cone onto the output shaft. See Figure 7-56.

Figure 7-56. Press on Bearing Cone



11. Place the bevel gear [Item 7] down over the output shaft, teeth side up. Press the bevel gear down, seating the bearing cone [Item 14] into the bearing cup. See Figure 7-57.

Figure 7-57. Press on Bevel Gear



12. Install the external retaining ring [Item 11] on the output shaft [Item 9]. Pull up on the bevel gear [Item 7] to make sure the external retaining ring is installed securely.
13. Place the output bearing spacer [Item 10], with the recessed area down, over the output shaft. Place the bearing cone [Item 8] on top of the output shaft.
14. Press the bearing cone [Item 8] down until it is fully seated against the spacer and snap ring. See Figure 7-58.

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Figure 7-58. Press Down Bearing Cone



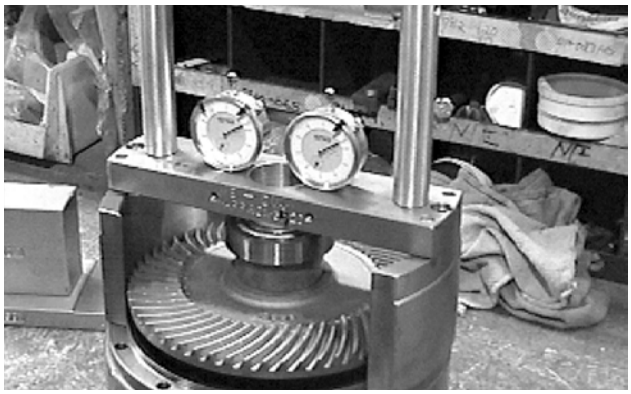
15. Place the main cover assembly, flange side up. Press the bearing cone [Item 8] into place. At the same time, pull the gear sideways to eliminate any backlash in the spline area. See Figure 7-59.

Figure 7-59. Eliminate Backlash



16. Place bearing cup [Item 8] onto bearing and rotate cup while applying downward pressure to seat bearing.
17. Position dial indicator onto the main cover so that the tips rest on the bearing cup. The readings on the two dial indicators should be the same. If they are different, repeat steps 15 and 16 until the readings are identical. See Figure 7-60.

Figure 7-60. Bearing Cup to Flange Measurement



18. Record final readings as Measurement E. This is required during final assembly.

Helical Gear Assembly

NOTE: The pinion shaft and bevel gear are a matched set. Their alignment is critical. Do not replace them separately.

⚠ WARNING

Bearing can become extremely hot. Use gloves to protect hands from burns.

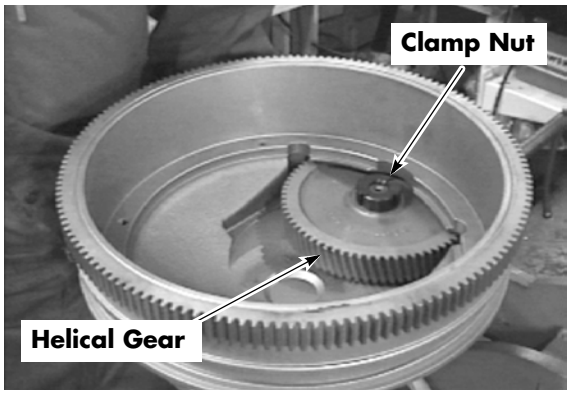
1. Preheat the bearing cone with a bearing heater. Install the heated bearing cone in the bearing cup [Item 6] in the housing.

NOTE: Complete steps 2 through 4 before the bearing cools.

2. Place the helical gear [Item 3] into the housing.
3. Install the spiral pinion [Item 7] up through the helical gear [Item 3].
4. Put the clamp nut [Item 4] on the end of the spiral pinion [Item 7] and hand tighten until the bearing cools. See Figure 7-61.

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Figure 7-61. Install Helical Gear and Pinion



5. Remove clamp nut [Item 4]. Apply thread-locking compound (P/N 990-669) to the threads of the spiral pinion. Re-assemble clamp nut on spiral pinion and hand tighten.
6. While the bearing cone [Item 6] is cooling, calculate the formula for determining the required shim thickness.

Calculate Shim Formulas

- A = Dimension A stamped on housing (2.102/2.108)
- B = Dimension B stamped on housing (3.409/3.412)
- C = Number etched on back of gear (nominal 1.812)
- D = Distance from bearing cone to flange surface (see Figure 7-62)
- E = Distance from bearing cup to flange surface (see Figure 7-63)
- F = Mounting distance etched on spiral pinion
- G = Distance from top of teeth on spiral pinion to top of lower bearing cup on spiral pinon
- J = Distance from centerline of output shaft to top of lower bearing cup on spiral pinion

S1 = (B - A - E + D + C)

S1 = Shim amount behind bearing cup in main housing to position gear for correct backlash.

S2 = E + S1 - B - 0.006 preload

S2 = Shim amount between cover plate face to set preload of bearings for output shaft.

S3 = J – F – G

S3 = Shim amount between drive unit housing and lower bearing on spiral pinion.

Figure 7-62. Bearing Cone to Flange Measurement

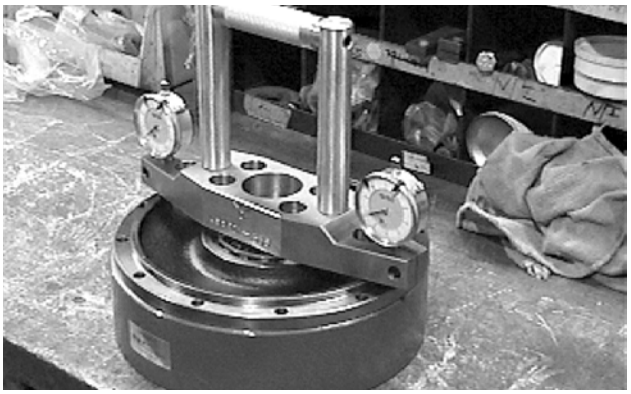
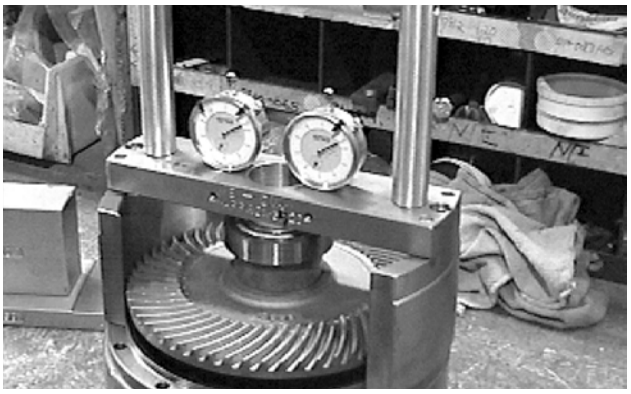


Figure 7-63. Bearing Cup to Flange Measurement

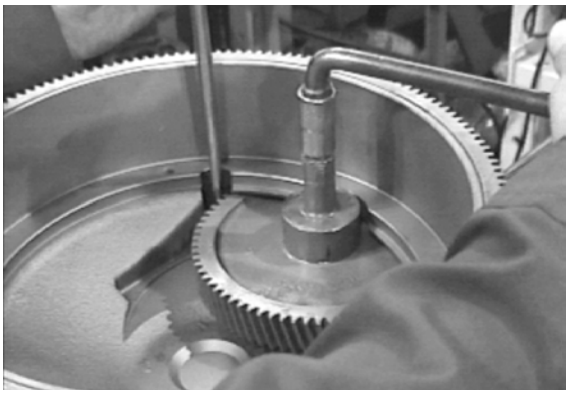


Installing and Testing Shims

1. Remove any end play in the bearings between the helical gear [Item 3] and the spiral gear [Item 7] using lock nut wrench. Wedge the helical gear, and tighten the clamp nut [Item 4] until there is no end play between the gears. See Figure 7-64.

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Figure 7-64. Remove End Play



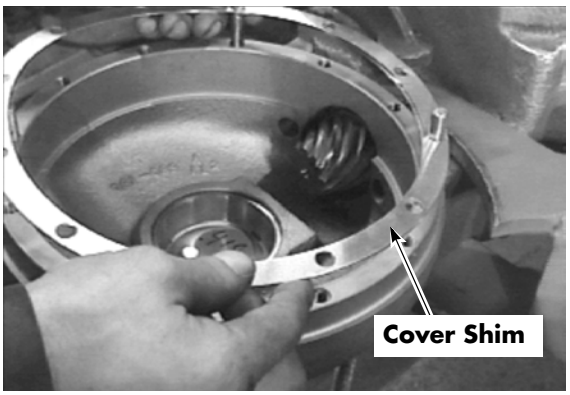
2. Preload the helical gear [Item 3] for 0.000 to 0.002.
3. Remove any oil from the clamp nut [Item 4]. Apply thread-locking compound (P/N 1013829) to the threads in the clamp nut. Tighten the set screw in the clamp nut to 140 in. lb. (15.8 Nm).
4. Spin the helical gear [Item 3] to make sure that the bearings are not too tight. The helical gear must spin freely for at least one full rotation.
5. Only perform the following procedure if the helical gear assembly is too tight.
   a. Unscrew the clamp nut [Item 4] the width of one spanner slot (0.188 in. [4.77 mm]).
   b. Tap the spiral bevel gear [Item 7] to unseat the bearing cone.
   c. Place the predetermined shims [Item 28] in the housing bore for the bearing cup [Item 5].
   d. Install the spiral pinion gear and helical gear. See “Helical Gear Assembly” on page 7-44.
   e. Repeat steps 1 thru 4 until the helical gear spins at least one full rotation.
6. One tooth on the spiral gear [Item 7] is etched or marked with an X. With a marker, mark that tooth surface for the purpose of lining up the spiral and bevel gears [Item 7] to check backlash. One tooth on the matching bevel gear is also marked. Mark that tooth surface also. See Figure 7-65.

Figure 7-65. Mark Spiral and Bevel Gears



7. Place the predetermined shims [Item 27] into the housing bore for the bearing cup [Item 8]. Install the bearing cup into the housing bore over the shims.
8. Install the cover shims [Item 29]. See Figure 7-66.

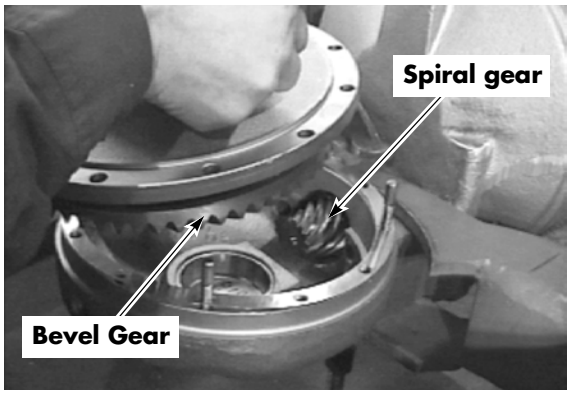
Figure 7-66. Install Cover Shims



9. Place the main cover assembly over the shims, making sure to line up the marked teeth on both the spiral and bevel gears [Item 7]. See Figure 7-67.

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Figure 7-67. Line Up Spiral and Bevel Gears



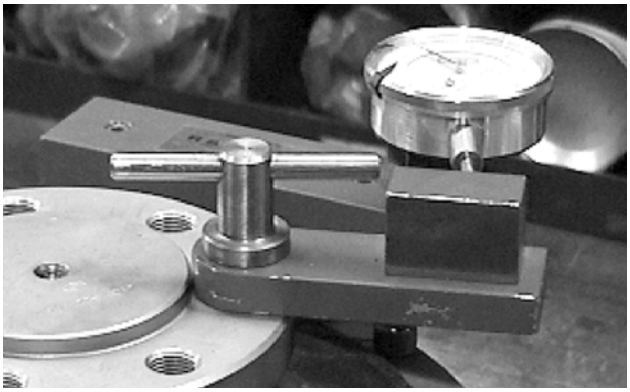
10. Put in four housing cover bolts [Item 13], evenly spaced, and tighten to 40 ft. lb. (54 Nm).

Measuring Backlash

NOTE: *Backlash tolerance is critical to the performance of the drive unit. Incorrectly adjusted units will experience premature failure.*

1. Wedge the helical gear [Item 3], then slightly turn the output shaft to determine backlash. *Backlash reading on the dial indicator should be between 0.004 and 0.006.* See Figure 7-68.

Figure 7-68. Backlash Measurement



2. Calculate any necessary adjustments to the shims. Remove the main cover assembly and the bearing cup, and adjust the shims. Repeat Steps 6 through 9 “Installing and Testing Shims” until backlash is between 0.004 and 0.006.
3. When backlash is within acceptable range, remove the main cover assembly and the cover shims.

Main Cover Installation

1. Clean the cover mating surface on the housing, then apply thread-locking compound (P/N 990-411) sparingly.
2. Install the cover shims [Item 29] and the main cover assembly. Install the main cover bolts [Item 13], and torque to 40 ft. lb. (54 Nm).

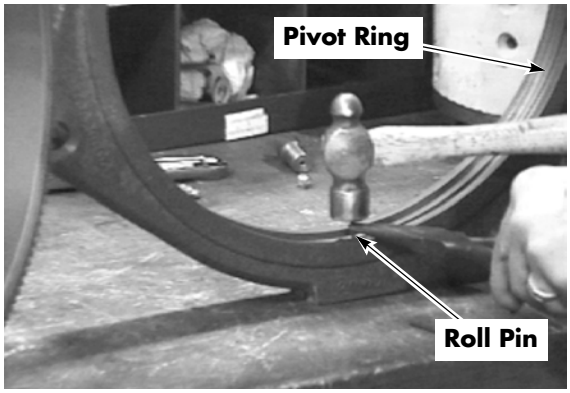
Pivot Ring Assembly

⚠CAUTION

Safety glasses are required.

1. On the inside of the pivot ring [Item 17], make sure the roll pins [Item 18] are installed and in good condition on either side of the bearing filler plug hole. If they are missing or damaged, install new roll pins. See Figure 7-69.

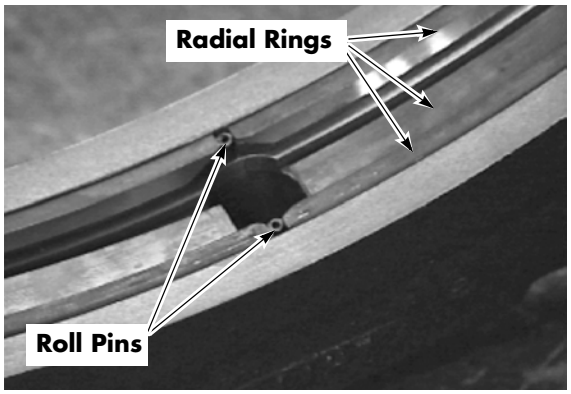
Figure 7-69. Install Roll Pins



2. Install the grease fitting [Item 26] on the outside of the pivot ring.
3. Screw the grease fitting [Item 20] in the bearing filler plug.
4. Install radial rings [Item 23]. Install the flat radial ring on the inside flat surface of the pivot ring. Place the ends of the chamfered radial rings against the roll pins [Item 18] to install them in the pivot ring. See Figure 7-70.

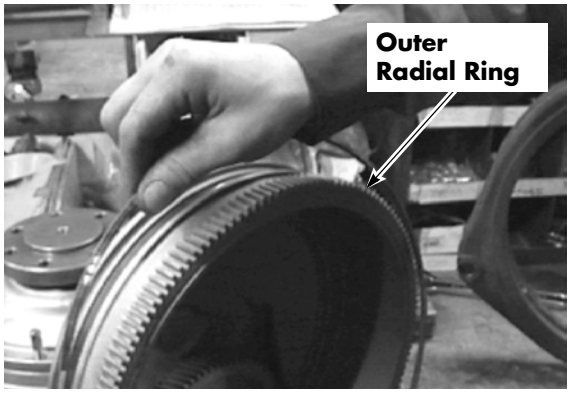
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Figure 7-70. Install Radial Rings



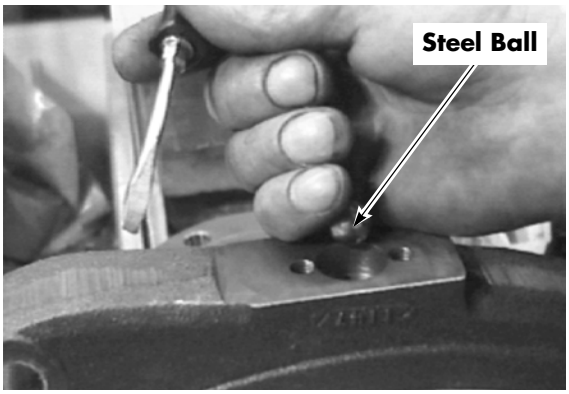
5. Install the outer radial rings [Item 23] on the housing. See Figure 7-71.

Figure 7-71. Install Outer Radial Rings



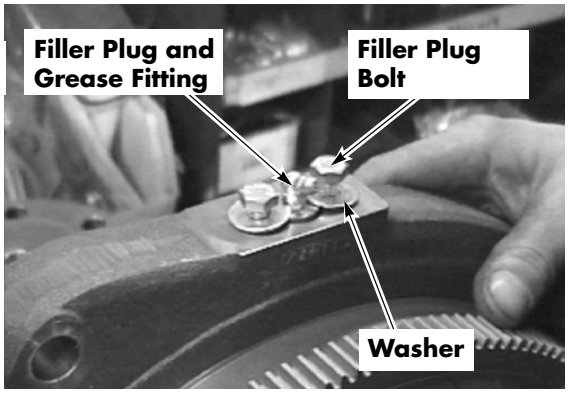
6. Lift the drive end of the housing and slide the pivot ring over the housing. Be careful not to jar the radial rings out of place. Slide the pivot ring into place just behind the spur gear [Item 25].
7. Make sure the pivot ring bearing filler plug hole is on top, in preparation for installing the steel balls [Item 24].
8. Put one ball at a time into the pivot ring filler hole. Use a screwdriver to direct the steel balls first to one side then the other. Continue until all 70 balls are installed. See Figure 7-72.

Figure 7-72. Install Ball Bearings



9. Intall the bearing filler plug [Item 19] with the grease fitting [Item 20] pointing toward the spur gear [Item 25]. See Figure 7-73.

Figure 7-73. Install Bearing Filler Plug



⚠CAUTION

Excessive thread-locking compound will damage the ball bearings and pivot ring. Use thread-locking compound sparingly.

10. Apply thread-locking compound (P/N 990-536) sparingly to the filler plug bolts [Item 21]. Install the bolts [Item 21] and washers [Item 22] on either side of the bearing filler plug [Item19] and tighten to 20 ft. lb. (27 Nm).
11. Grease and then test the pivot ring, checking to see that it spins freely.

Drive Unit Installation

1. Place the new drive unit in position.

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2. Apply thread-locking compound (P/N 990-544) to the drive unit mounting bolts. Install and torque the drive unit mounting bolts to 130 ft. lb. (176 Nm).
3. Apply thread-locking compound (P/N 990-536) to the steer linkage bolt threads. Reconnect the steering linkage. Torque bolts to 150 ft. lb. (204 Nm).
4. Reinstall the steering shaft and hydraulic motor.
5. Refill the drive unit with the correct type fluid. Add fluid until level reaches the bottom of the helical gear.
6. Install the Traction Motor and brake. Use a fiber gasket between Traction Motor and drive unit.
7. Install mounting bolts for Traction Motor and drive unit and torque to 13 ft. lb. (17.6 Nm).
8. Connect cables, wires, and brake line. Torque motor cables to 18 ft. lb. (24.4 Nm).
9. Install the drive unit dust shield.
10. Install the drive wheel. Torque the drive tire lug bolts to 170 ft. lb. (230 Nm).
11. Install the horn assembly.
12. Check the drive unit fluid level.
13. Test the brake for correct operation.

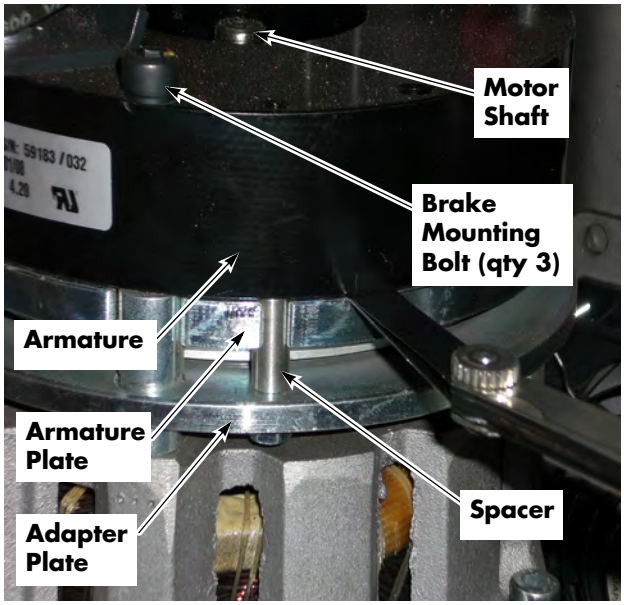
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Brake

Inspection

1. Turn the key switch OFF and disconnect the battery connector.
2. Open the motor compartment door.
3. Check air gap between the armature and armature plate near all three spacers. See Figure 7-74. If air gap exceeds 0.040 in. (1 mm), replace the brake pads. See "Pad Replacement".

Figure 7-74. Checking Brake Air Gap



Brake Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Block the drive tire to prevent movement.
3. Open the motor compartment door.
4. Note the location of cable ties securing the motor cable bundle to the cable bracket. Cut cable ties to free the cables from the bracket. Remove the cable bracket.
5. Disconnect brake armature lead connection.
6. Loosen one of the locking bolts and obtain a spacer approx. 0.005 to 0.015 in. (0.12 to 0.38 mm) thicker than the measured total air gap (non-energized). Insert spacer between the armature plate and the coil body. Tighten the locking bolt just enough to prevent rotation of the motor shaft.
7. Remove the retaining nut and washer from the motor shaft. See Figure 7-74.
8. Remove the three brake mounting bolts.
9. Use a brake puller to remove the brake assembly from the motor.

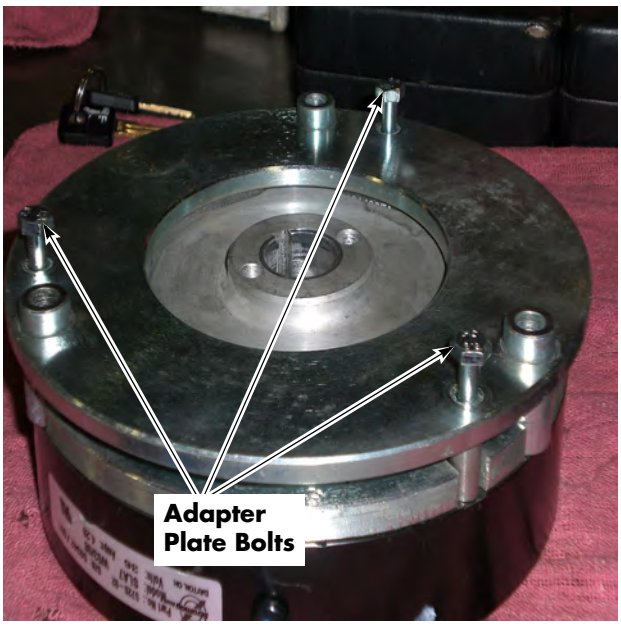
Pad Replacement

1. Install the brake release bolts.

NOTE: Do not overtighten the brake release bolts.

2. Turn the brake assembly over and remove the three bolts securing the adapter plate. See Figure 7-75.

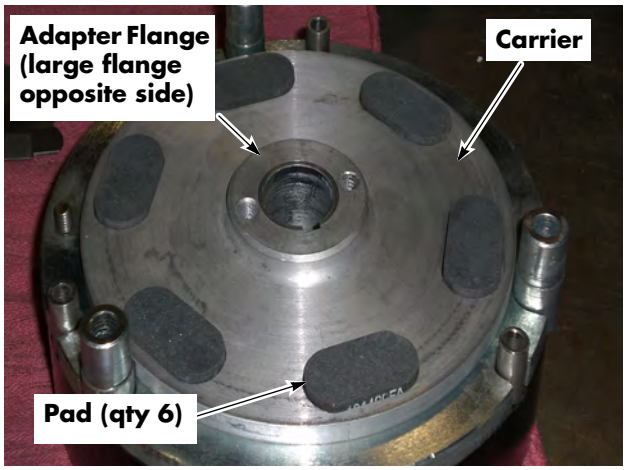
Figure 7-75. Adapter Plate Removal



3. Remove adapter plate. Inspect spacers and replace if damaged.
4. Remove old pads from carrier and install new pads. See Figure 7-76.

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Figure 7-76. Pad Replacement



5. Install adapter plate. Torque adapter plate bolts to 6 ft. lb. (8.6 Nm).

NOTE: Leave the brake release bolts installed for reassembly to motor.

Coil Replacement

1. If installed, *carefully* remove the brake release bolts. Separate the coil from the armature plate.

NOTE: The brake release bolts are under tension from the springs inside the coil body.

2. With the coil inverted, make sure all eight springs are inserted into the cavities.

NOTE: On coils with ten spring cavities, the two empty cavities must be 180° apart.

3. Place the thin washer shaped spacer over the springs.
4. Note the orientation and place the inverted armature plate on the coil directly over the spacer.
5. Assemble the armature and coil:
   a. Using a clamp, mate the armature plate to the coil, make sure the thin washer is correctly aligned.
   b. Install the brake release bolts through the coil and armature plate and tighten.
6. Install carrier, pads, and adapter plate. Torque adapter plate bolts to 6 ft. lb. (8.6 Nm).

Brake Installation

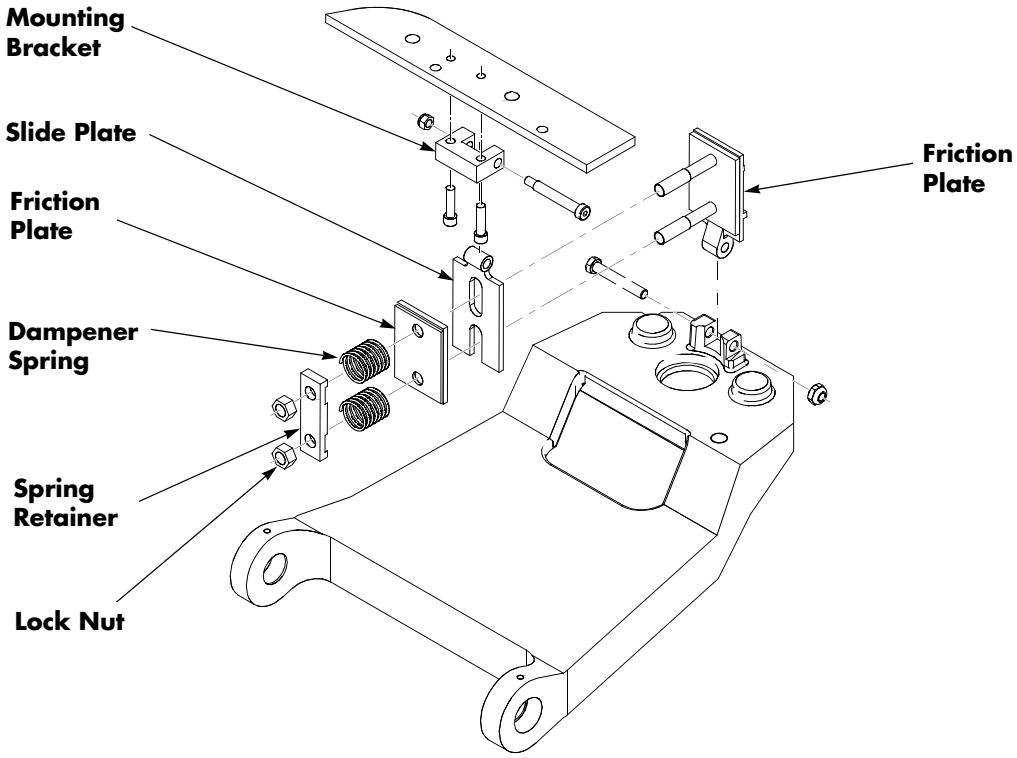
1. Correctly position brake assembly on motor, making sure the keyways on the motor shaft and carrier are correctly aligned.
2. Gently tap the carrier flange onto motor shaft until seated.
3. Apply thread-locking compound (P/N 990-536) and install the three brake mounting bolts. Torque to 16 ft. lb. (21.7 Nm).
4. Remove brake release bolts and install in their storage locations.
5. Loosen one of the retainer bolts and insert a 0.030 to 0.040 in. (0.76 to 1 mm) spacer between the armature plate and coil body. Tighten the retainer bolt just enough to prevent rotation of the motor shaft as the retaining nut is being torqued.
6. Install retaining nut and a new washer to motor shaft. Torque retaining nut to 150 ft. lb. (203 Nm).
7. Loosen the retainer bolt and remove the spacer.
8. Attach the motor cable bracket. Apply thread-locking compound (P/N 990-536) to the bolts and torque to 6 ft. lb. (8.6 Nm).
9. Attach the cable bundle to the cable bracket with cable ties and connect the brake armature lead connector.
10. Unblock the drive tire. Reconnect the battery connector and turn the key switch ON.
11. Make sure brake operates correctly and traction motor rotates without interference to motor cables.

NOTE: When the truck is stationary, depressing and releasing the deadman pedal should cause the brake to release and engage. When the truck is traveling, the brake should remain released (coil energized) until the truck speed reaches 0.5 mph (0.8 km/hr).

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Inertial Dampener

Figure 7-77. Inertial Dampener Assembly

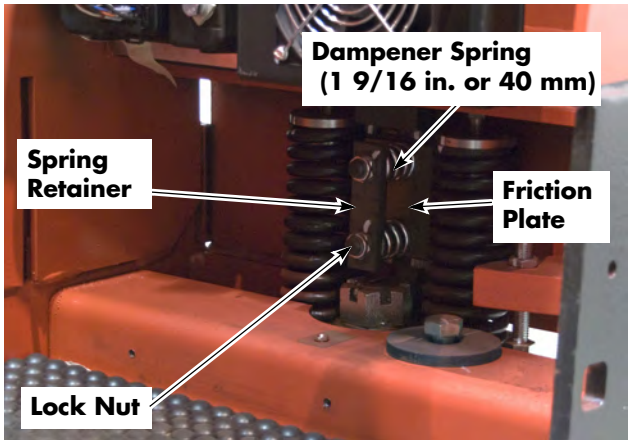


NOTE: The A-frame up-travel stop bolt adjustment is critical. Incorrect adjustment will result in damage to the inertial dampener. See "Steerable Caster" on page 7-22. If extra A-frame travel is required such that stop bolt adjustment cannot be maintained, remove the inertial dampener.

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the right side cover.
3. Remove the inertial dampener cover plate.
4. Loosen and remove the inertial dampener lock nuts, spring retainer, two springs, and friction plate. See Figure 7-78.

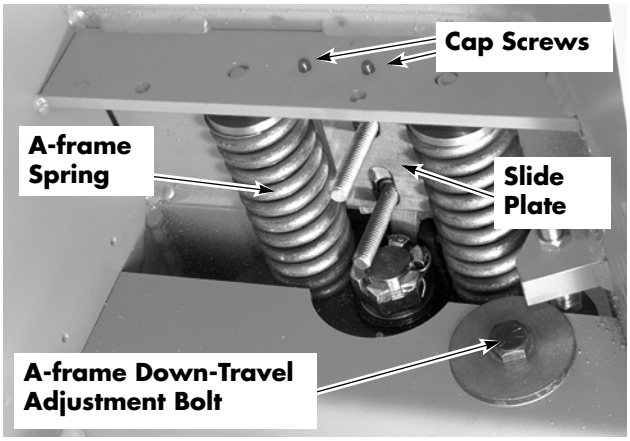
Figure 7-78. Inertial Dampener (unrelated parts removed for clarity)



5. If necessary, turn the A-frame down-travel adjustment bolt clockwise until there is clearance between the dampener bolts and the bottom of the slot in the slide plate. See Figure 7-79.

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Figure 7-79. Inertial Dampener (nuts, retainer, springs, friction plate removed)



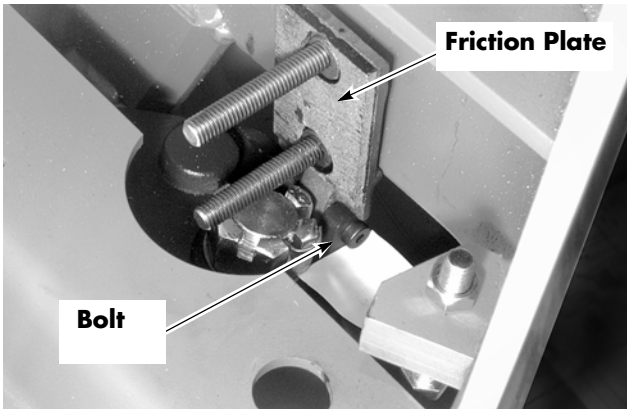
6. Remove the cap screws holding the slide plate mounting bracket to the frame. Remove the bracket. See Figure 7-79.
7. Loosen the A-frame down-travel adjustment bolt and remove the bolt and washers.

⚠ WARNING

Use extreme caution whenever the lift truck is jacked up. Never block the lift truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from vehicle while jacking the lift truck. See "Jacking Safety" on page 2-8.

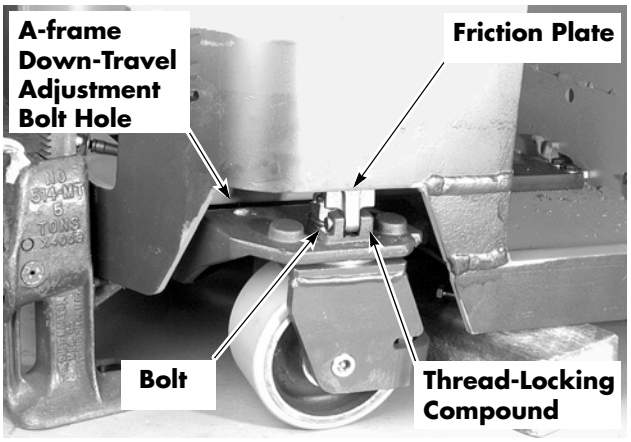
8. Jack the tractor up approx 2 in. (5 cm) at the tractor frame and block.
9. Remove the A-frame springs. See Figure 7-79 and Figure 7-80.

Figure 7-80. Inertial Dampener (A-frame springs, slide plate removed)



10. Remove the bolt holding the friction plate to the A-frame yoke. See Figure 7-80 and Figure 7-81.

Figure 7-81. Inertial Dampener (jacked up for shoulder bolt removal)

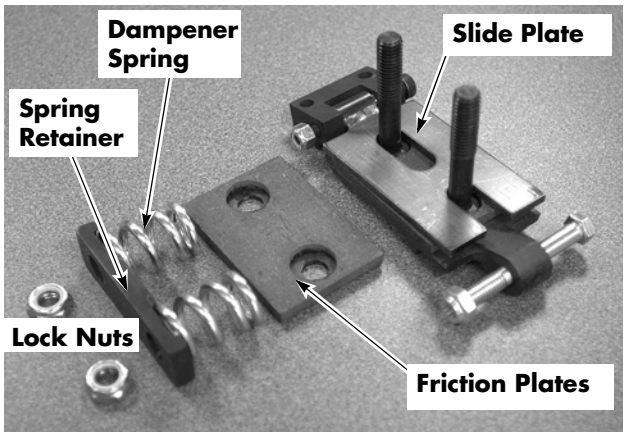


Installation and Adjustment

1. Attach the friction plate to the A-frame yoke with the bolt and nylon lock nut.
2. Install the A-frame springs. Lower the lift truck slightly on the jack to seat the springs in their retainer holes. See Figure 7-82.
3. Install the A-frame down-travel adjustment bolt with the plastic washer between the metal washer and the frame. Tighten until the distance between the top of the A-frame and the bottom of the A-frame spring upper weldment is 7 in. (17.7 cm).

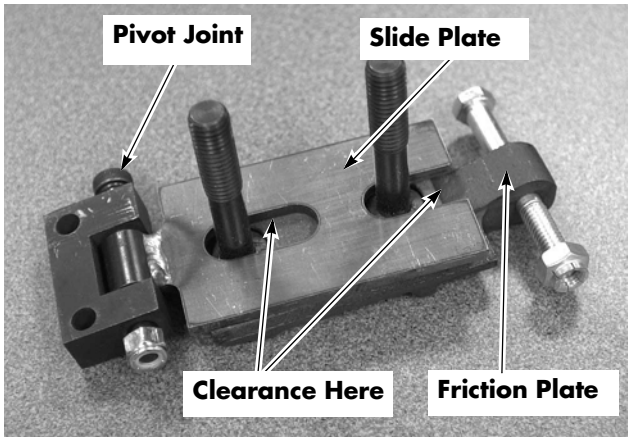
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Figure 7-82. Inertial Dampener parts



4. Attach the slide plate over the dampener bolts. Apply thread-locking compound (P/N 1013829) to the threads in the frame. Attach the slide plate mounting bracket to the frame with the two cap screws. Pivot joint on mounting bracket should be free to flex. Torque the slide plate mounting cap screws to 18 ft. lb. (24.4 Nm). See Figure 7-80.

Figure 7-83. Inertial Dampener adjustment



5. Unblock and lower the lift truck to the floor.
6. Attach the friction plate, two springs, spring retainer, and two lock nuts. See Figure 7-82 for orientation of parts. Tighten the lock nuts until the distance between the top of the spring retainer and the friction plate is 1 9/16 in. (40 mm) at both bolts. See Figure 7-78 on page 7-52.
7. Adjust the idler. See “Steerable Caster” on page 7-22.
8. Install the inertial dampener cover plate.
9. Reattach the right side cover.

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Electrical Components

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Battery Procedures

⚠CAUTION

Before working on the battery, review Battery Safety, beginning on page 2-5. Batteries for this lift truck weigh between 2000 and 2900 lb. (908 to 1316 kg). Use extreme care during replacement. Use a suitable battery moving device or hoist for lifting. DO NOT extend a battery more than 1/3 of its length outside the battery compartment without being attached to a battery-moving device.

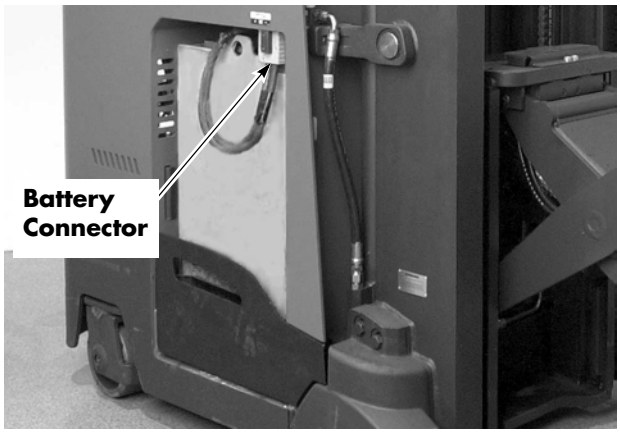
Battery Connector/Cables

Location

The battery connector is located at the front right of the tractor, above the battery.

NOTE: An optional kit is available to allow the battery connector to be relocated to the front left of the tractor. Refer to Parts Manual.

Figure 7-84. Battery Connector location



Inspection

1. Turn the key switch OFF and disconnect the battery connector.
2. Check the battery connector for damaged cables.
3. Check to see if battery cables are pulling out of the connector.
4. Check the cables at the battery terminals. Connections should be tight, with no corrosion.
5. Look inside the connector. Check all internal contacts for damage, dirt, or corrosion. Do not use a metal object to clean the connector.

⚠CAUTION

Some degreasers and parts cleaners will cause the connector shell to disintegrate. Avoid contacting battery connectors with solvents.

Removal, Replacement, and Installation

The cables to either half of the connector have a lip on their forward end. This lip snaps over a spring-loaded retainer that is part of the connector.

⚠ WARNING

When replacing battery cable ends, remove only one end at a time from the connector, to avoid the cable ends touching and causing a short circuit. DO NOT allow the metal cable end to touch the battery. Use insulated tools and avoid contact with battery case or cable ends.

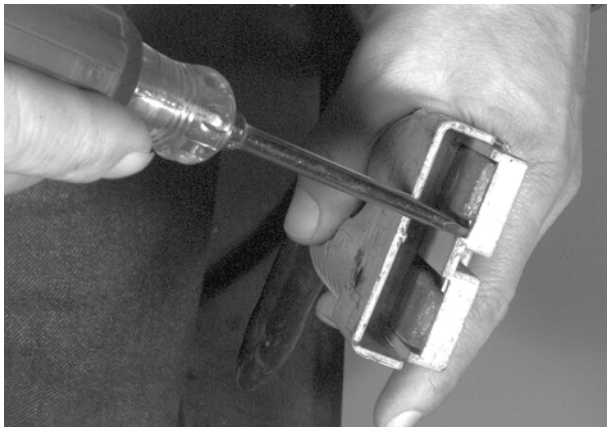
1. To remove a cable from the connector, push the retainer down while pulling the battery cable towards the rear and out of the connector. See Figure 7-85 and Figure 7-86.

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Figure 7-85. Battery Cable and Connector



Figure 7-86. Battery Cable Removal from Connector



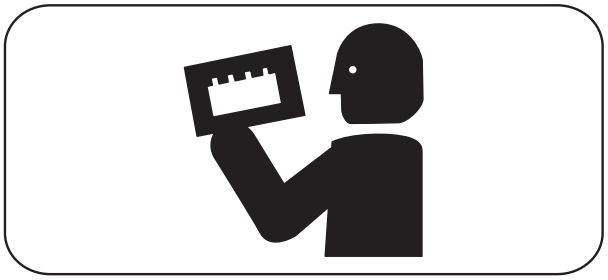
2. Do not attempt to repair battery cables by crimping new terminals. Replace the cable.

Disconnect Blocks

Model 7600/7620/7640 lift trucks use an electrical EPO system. Battery connectors do not need to have battery disconnect blocks installed.

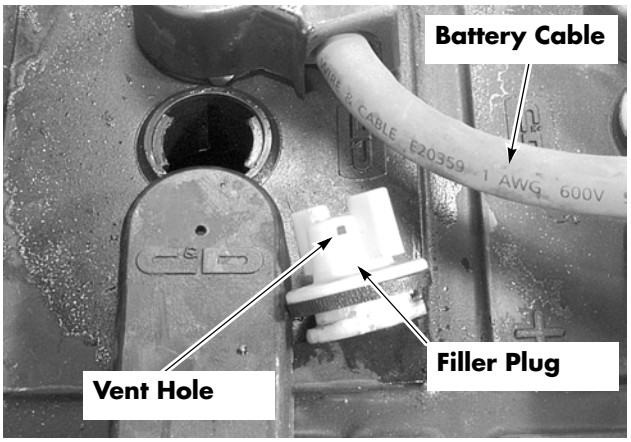
Battery Exterior Cleaning

1. Read, understand, and follow procedures, recommendations and specifications in the battery and battery charger manufacturer's manuals.



2. Wear personal protective equipment. See "Battery Safety" on page 2-5.
3. Turn the key switch OFF and disconnect the battery connector. Remove the battery from the lift truck.
4. Inspect the battery cables to make sure they are not frayed or loose. Inspect the battery connector to make sure there is no foreign material inside the connector. Make sure the filler plugs are tight and the vent holes in the filler plugs are open.

Figure 7-87. Battery Cable and Filler Plug



5. Keep the top of the battery clean and dry. Corrosion, dust, and moisture provide a conducting path to short-circuit cells or create shorts to ground.

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⚠CAUTION

DO NOT clean the top of the battery with the soda solution while it is installed in the lift truck. Water can seep into the electrical components and cause serious damage.

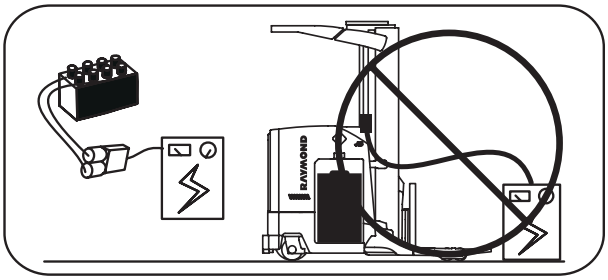
6. Wash dirty batteries (or any that have had electrolyte spilled on them) with a solution of 1 lb. (0.45 kg) of baking soda added to 0.5 gal. (1.9 liters) of hot water.
7. Use a brush with flexible bristles to clean the entire top of the battery with the soda solution. Wait until all foaming stops, indicating that the battery exterior is neutralized.
8. Rinse the battery with clean water.
9. Dry the battery completely before reinstalling it.
10. Reinstall the battery in the lift truck, using a suitable battery moving device. Reconnect the battery connector.

Testing, Charging, and Maintenance

For information on testing, charging, and maintaining your lift truck battery, consult the battery manufacturer's specifications and instruction manual.

⚠CAUTION

***Never* plug the battery charger into the lift truck. This will severely damage the lift truck's electrical system. Plug the charger *only* into the connector from the battery.**



Battery State-of-Charge

Battery State-of-Charge (BSOC) is a feature that monitors and remembers the charge level of the battery connected to the lift truck and prevents excessive discharging of that battery. Operating a lift truck using a discharged battery can damage both the battery and the electrical components of the lift truck. See page 5-10 for a detailed description of how BSOC works. See page 5-10 for the procedure for setting BSOC Cutout.

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Wiring and Harness Connectors

General Repair Procedures

See "Electrical Troubleshooting" on page 5-2.

Whenever working on the lift truck, use care around wiring harnesses.

- Carefully connect and disconnect all connections.
- Do not pry connectors apart with unspecified tools.

There should be a wire marker at each termination. If the marker is missing or unreadable, remark the wire to allow easier identification.

NOTE: It is normal to find unused connectors for uninstalled options that have had heat shrink applied over them and have been strapped to the harness.

Repair

⚠CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-7.

When pulling a wire out through a bundle, cut off the pin or socket so it does not snag. When replacing wires, tape or solder one end of a new wire to one end of the failed wire. Pull the new wire into the bundle. Make sure to disconnect the old wire from the new wire.

In other cases, it is easier to secure a new wire to the outside of the existing wire bundle with straps of an appropriate size. Leave the failed wire in the bundle, or pull it by one end to remove it from the bundle.

When replacing wires, follow these guidelines:

- Use the appropriate tools to remove and insert terminations at each connector.
- Remove damaged terminations and discard. Never reuse a termination from a wire.
- Do not cut away a terminal lug and reuse the wire strands that were crimped into the original lug.
- When stripping wire, use new wire strands for new terminations. Make sure to use a new wire with extra length to allow for cutting and stripping of the ends to install new terminations.
- Use a new wire that is the same gauge (typically gauge 18 AWG), size, type, and color as the wire it is replacing.
- Use a hand stripper capable of stripping by wire gauge number. Use care not to nick or cut any of the wire strands. Discard and replace a wire with damaged strands. Insert the wire strands the correct length into termination before crimping.

Soldering Procedures

To prevent damage from excessive heat when soldering small components in assemblies, follow these guidelines:

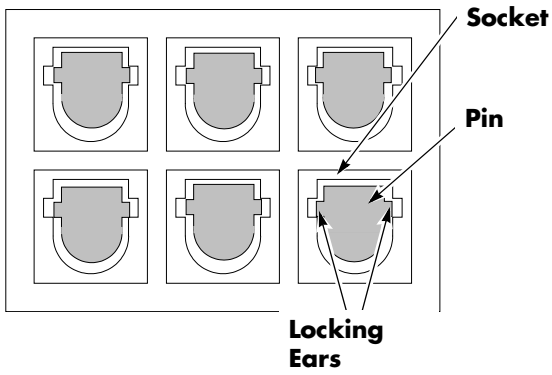
- Make sure the soldering tip is clean. A dirty tip does not transfer heat well and encourages long dwell time and greater pressure. Apply light pressure on the terminal.
- Flux: rosin base
- Solder: 60/40 rosin core or equivalent
- Solder Iron: 15-25 watt "pencil-type" maximum
- Tip Size: 3 mm (0.118 in.) diameter x 30 mm (1.182 in.) long screwdriver tip. Make sure the tip is clean.
- After soldering, clean the terminals with a brush dampened with an alcohol-based cleaner (P/N 990-600/FOF). Do not allow any cleaner to seep into the switches or potentiometers, or contact contamination may occur.

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Molex Connectors

For pin orientation of Molex connectors, see Figure 6-1 on page 6-27. Molex connectors have pins with locking ears that engage ridges in the plastic connector body. To remove a pin from a Molex connector, depress these locking ears far enough to clear the ridge in the connector. See Figure 7-88.

Figure 7-88. Molex Connector, end view



Pin Extraction

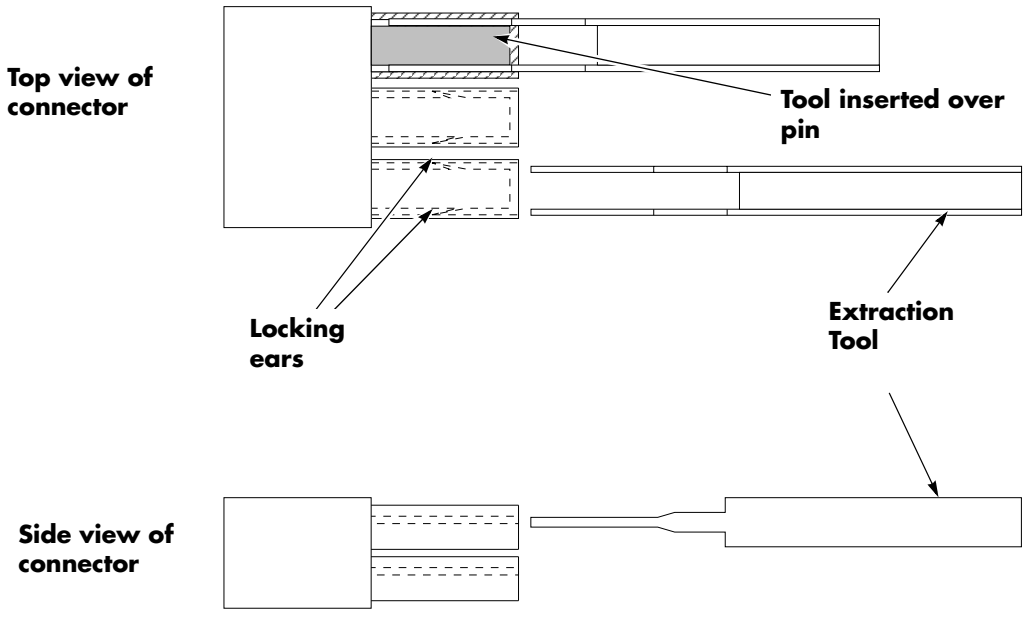
To remove a pin from a Molex connector, use pin extraction tool P/N 950-026.

1. Insert the extraction tool over the pin and push all the way into the connector. This releases the locking ears on the pin.
2. Pull the wire and pin from the connector.

Pin Insertion

To insert a pin into a Molex connector, insert the pin into the back side of the connector and push the wire all the way in until it clicks. The locking ears have now engaged the connector. See Figure 7-89.

Figure 7-89. Pin Extraction

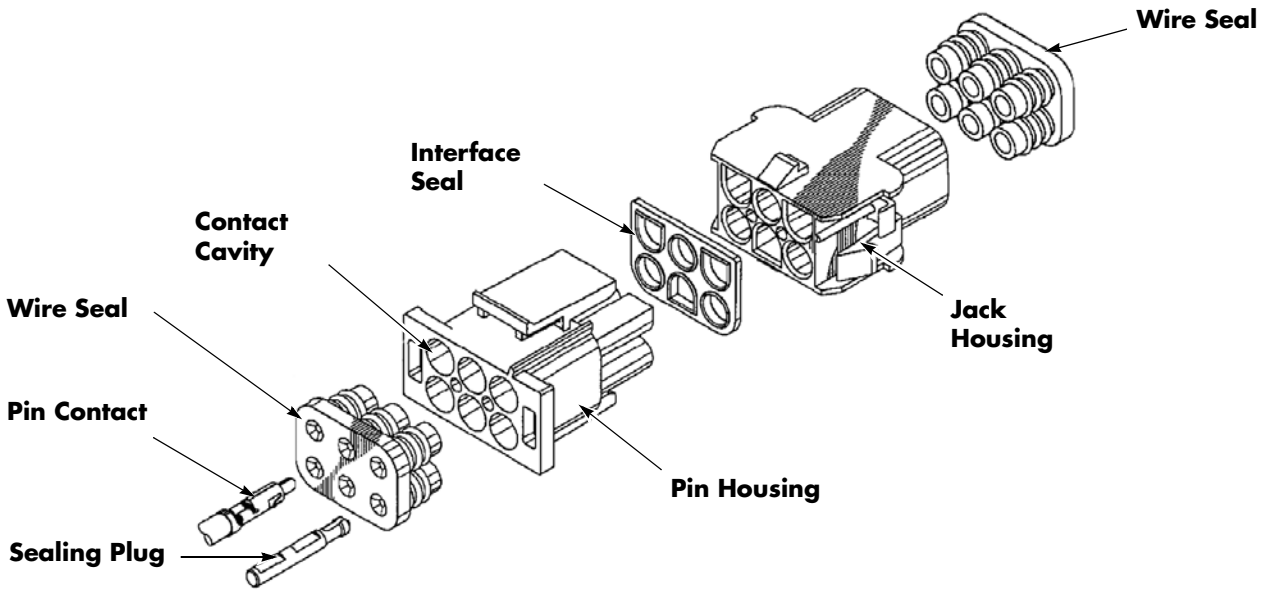


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AMP Water-Resistant Connectors

AMP connectors provide water-resistant connection by the use of seals between wires and connectors and between the mating connector halves. See Figure 7-90.

Figure 7-90. AMP Water-Resistant Connector



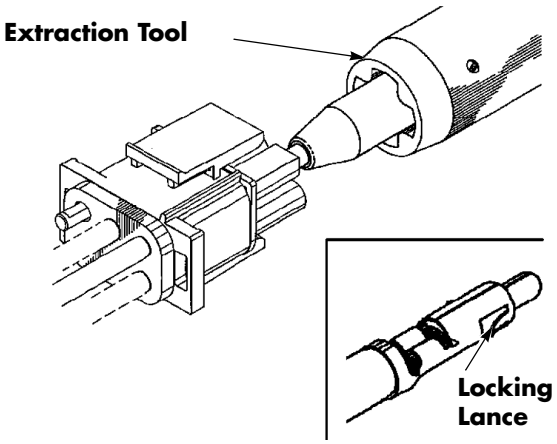
To maintain the integrity of water-resistant seals, use the following procedures when working with AMP connectors.

Pin Extraction

To aid in separating AMP connectors, use unlatching tool Raymond P/N 950-042. To remove a pin from an AMP connector, use pin extraction tool Raymond P/N 950-009.

1. While holding the wire seal, push the selected wire forward, then insert the extraction tool into the contact socket. See Figure 7-91.

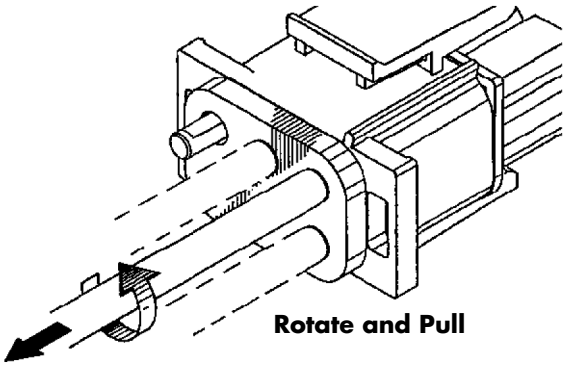
Figure 7-91. AMP Pin Extraction



2. Pull the wire gently until you feel the contact locking lances disengage.
3. Holding the wire seal and connector housing together, rotate the wire while pulling it through the wire seal. This prevents damage to the seal. See Figure 7-92.

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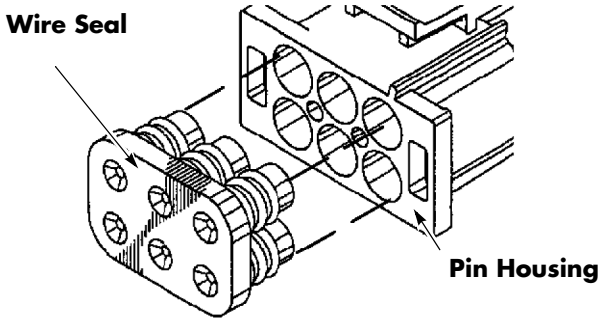
Figure 7-92. Removing Wire



Pin Insertion

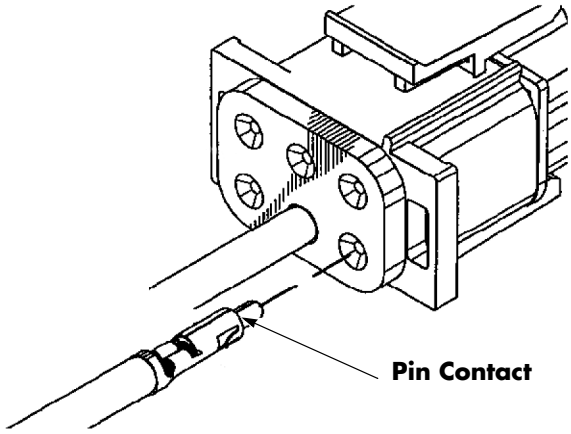
1. Make sure the connector has a wire seal attached to the connector back. See Figure 7-93.

Figure 7-93. Wire Seal



2. If re-inserting a wire previously removed, check the pin contact locking lances to make sure they are extended to their original position.
3. Grasp the wire close behind the contact insulation barrel and push the wire straight through the wire seal into the socket until it clicks. Pull back gently to make sure the contact is locked in place. See Figure 7-94.

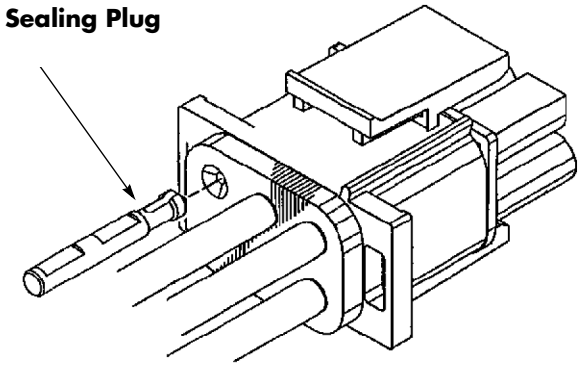
Figure 7-94. Wire Insertion



Seals

1. Use a wire seal at the back (wire end) of each connector half. See Figure 7-93.
2. Plug unused pin positions with sealing plugs. See Figure 7-95.

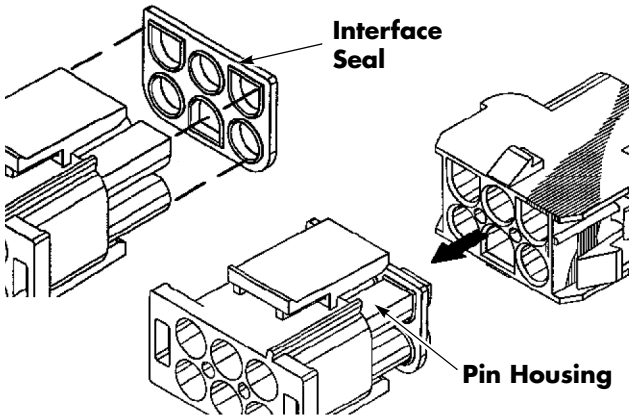
Figure 7-95. Sealing Plug



3. Align the split tapered end of the sealing plug with the unused opening in the wire seal. Push the plug through the wire seal into the connector until it snaps into position.
4. Remove sealing plugs by pulling with needle-nose pliers while grasping the wire seal and connector.
5. Use an interface seal between pin and jack halves of the connector. To prevent damage to the seal, use the matching connector cap to slide the interface seal over the contact silos on the pin housing. See Figure 7-96.

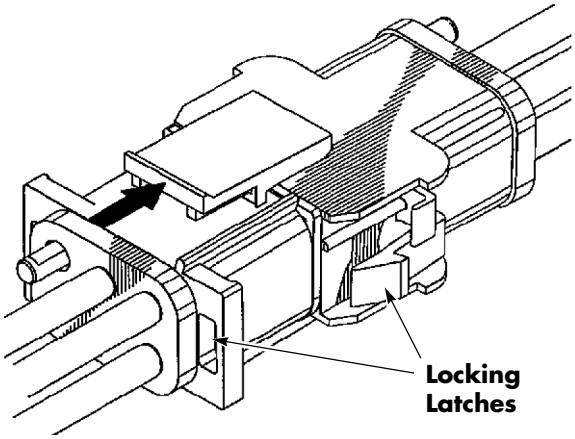
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Figure 7-96. Interface Seal



6. When mating connectors, make sure polarized silos are correctly oriented. Push pin and jack halves of the connector together until locking latches engage. See Figure 7-97.

Figure 7-97. Latching AMP Connector



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Motors

Terminal Nuts

Table 7-10. Power Cable Terminal Torques

Stud Size/Type	Torque
Motors	
M8 top nut	18 ft. lb. (24.4 Nm)
Power Amplifiers and Contactors	
Aluminum	132 in. lb. (15 Nm)
M6 steel	50 in. lb. (5.6 Nm)
M8 steel	180 in. lb. (20.3 Nm)
M8 brass/copper	70 in. lb. (7.8 Nm)

DC Motor Troubleshooting

See “DC Motors” on page 5-5.

AC Motor Troubleshooting

See “AC Motors” on page 5-9.

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AC Motor Service

Temperature Sensor Replacement

Traction Motor

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the brake assembly.
3. Disconnect the temperature sensor connector.
4. Disconnect motor power cables. Note locations for reassembly later.
5. Remove the terminal board.
6. Remove the four bolts that secure the top end bell to the bottom end bell.
7. Remove the top end bell using a puller.
8. Cut the bad temperature sensor cable.
9. Install a new temperature sensor using the high temperature silicone (neutral curing) supplied with the temperature sensor. Mount the sensor close to the location of the original. Secure the cable with a cable tie to one of the power leads for stress relief.
10. Re-install the top end bell.
11. Re-install the four bolts that secure the top end bell to the bottom end bell.
12. Re-install the brake assembly.
13. Connect the new temperature sensor cable.
14. Install the terminal board and reconnect power cables. Torque motor cable securing nuts to 18 ft. lb. (24 Nm).
15. Reconnect the battery connector and turn the key switch ON.

Lift Motor

1. Turn the key switch OFF and disconnect the battery connector.
2. Disconnect the temperature sensor connector.
3. Remove the four bolts that secure the top end bell to the bottom end bell.
4. Remove the top end bell.
5. Cut the bad temperature sensor cable.
6. Install a new temperature sensor using the high temperature silicone (neutral curing) supplied with the temperature sensor. Mount the sensor close to the location of the original.
7. Re-install the top end bell.
8. Re-install the four bolts that secure the top end bell to the bottom end bell.
9. Connect the new temperature sensor cable.
10. Reconnect the battery connector and turn the key switch ON.

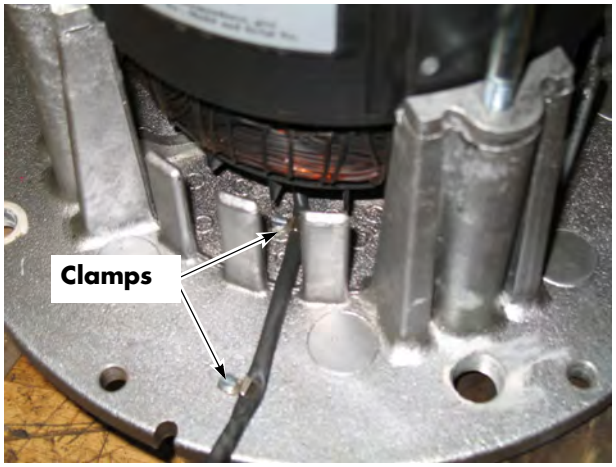
Speed Sensor Replacement - Internal Bearing Type

Traction Motor

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the brake assembly.
3. Disconnect the temperature sensor connector.
4. Disconnect motor power cables. Note locations for reassembly later.
5. Remove the traction motor.
6. Place the motor on a suitable work surface and remove the nut that secures the pinion gear. Remove the gear and key using a suitable puller.
7. Remove the clamps that secure the encoder bearing cable. See Figure 7-98. (Pry the inner clamp up to release the cable.)

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Figure 7-98. Sensor Bearing Cable Clamps



8. Mark the position of the top end bell and bottom end bell relative to the stator. See Figure 7-99.

Figure 7-99. Component Orientation Marking



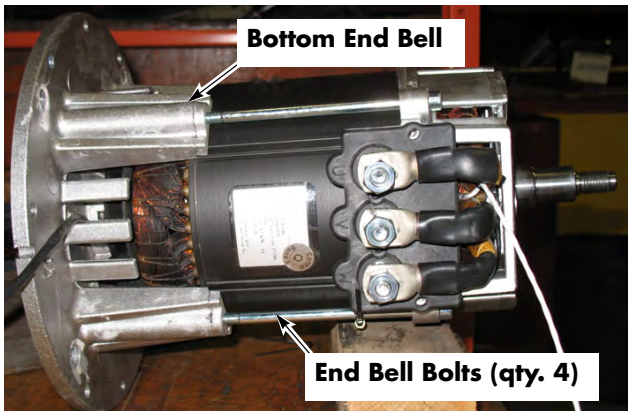
9. Unscrew the four bolts securing the brake end flange and remove. See Figure 7-100.

Figure 7-100. Brake Flange Bolts



10. Remove the four bolts that secure the top end bell to the bottom end bell. See Figure 7-101.

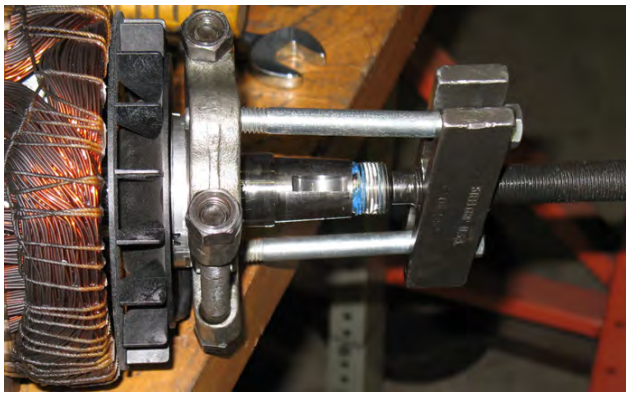
Figure 7-101. Motor Disassembly



11. Remove the bottom end bell using a puller.
12. Remove the encoder bearing from the rotor using a suitable puller, pulling on the outer race only. See Figure 7-102.

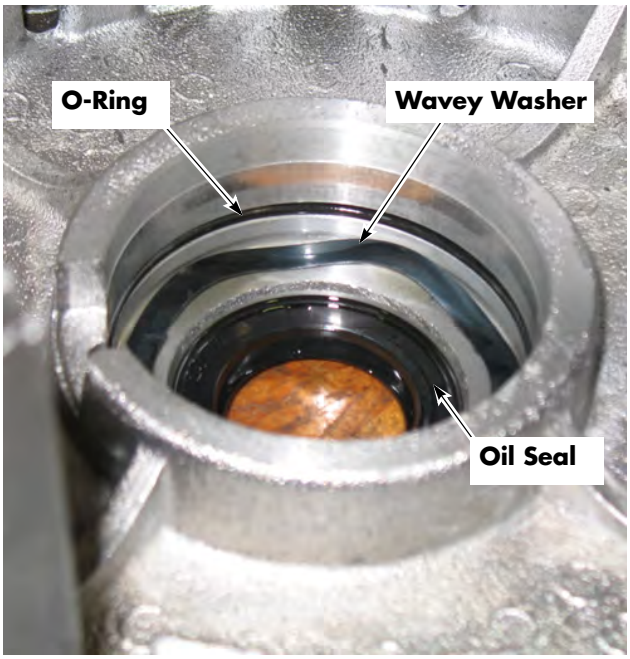
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Figure 7-102. Sensor Bearing Removal



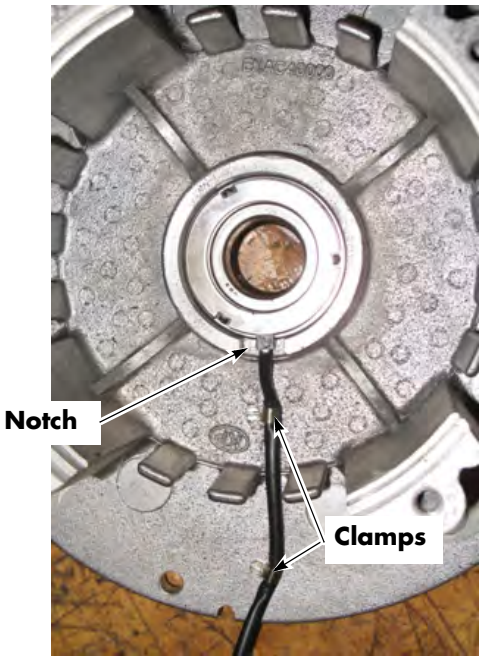
13. Remove the oil seal. See Figure 7-103.
14. Make sure the O-ring and wavey washer are correctly positioned in the bottom bell bearing pocket. See Figure 7-103.

Figure 7-103. Bearing Pocket Components



15. Position the new encoder bearing in the bottom end bell with the cable oriented in the middle of the notch in the side of the bearing pocket. See Figure 7-104.
16. Use an assembly bushing on the outer race and press the bearing into place. Do not press on the encoder part of the bearing.
17. Reinstall encoder bearing cable clamps. See Figure 7-104.

Figure 7-104. Sensor Bearing Alignment and Insertion



18. Carefully press the bottom end bell to the stator. See Figure 7-105.

NOTE: Press on inner race of bearing only.

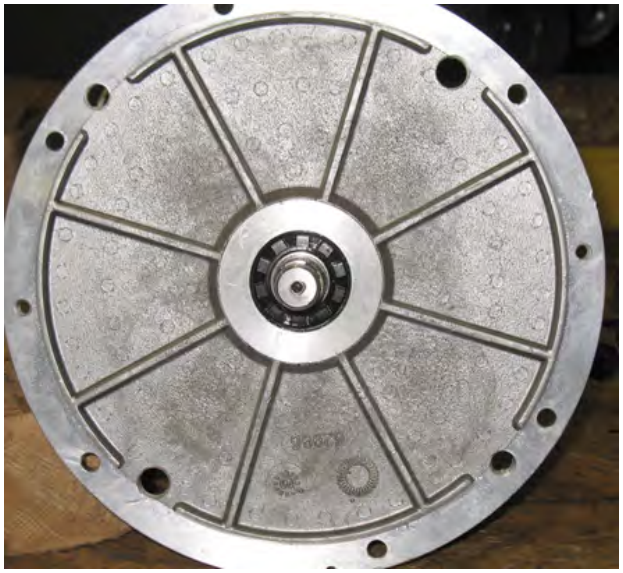
Figure 7-105. Pressing Bottom End Bell onto Rotor



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19. Align top and bottom end bells to stator using marks from step 8. Secure the top end bell to the bottom end bell using the four bolts previously removed. Torque to 8 ft. lb. (11 Nm).
20. Reinstall brake end flange using the previously removed bolts. Torque to 20 ft. lb. (28 Nm).
21. Install new oil seal. See Figure 7-106.

Figure 7-106. Oil Seal



22. Install key, pinion gear, and nut to the bottom of the traction motor. Make sure all oil is removed from the threads of shaft and nut. Apply thread-locking compound P/N 1013829 and torque to 85 ft. lb. (115 Nm). Reinstall traction motor.

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Steer Amplifier

Removal

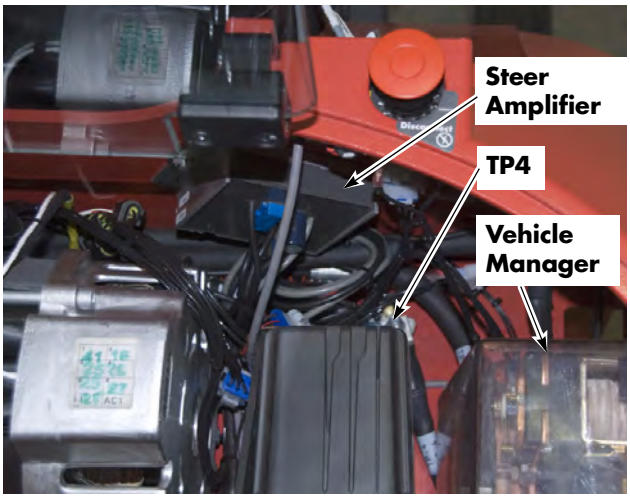
1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the top cover, right side cover, control handle cover, and right front cover.

⚠CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-7.

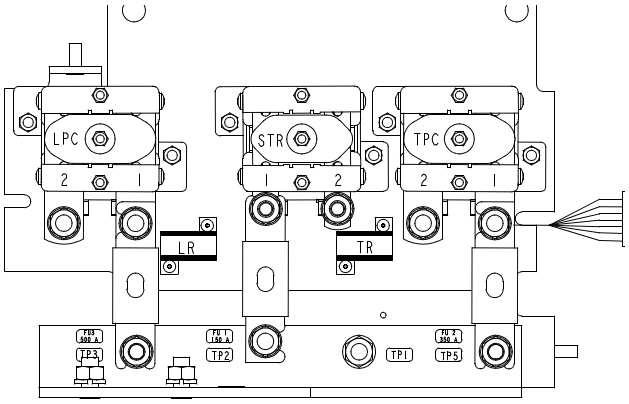
3. Disconnect wire from TP4. See Figure 7-107.

Figure 7-107. Steer Amplifier Removal



4. Remove the contactor panel cover.
5. Disconnect wire STR-1 from the contactor, removing cable ties as necessary. See Figure 7-108.

Figure 7-108. Contactor Panel



6. Open the Traction Motor compartment.
7. Disconnect the steer motor primary power wires at A1 and A2 on the motor. Cut cable ties as needed.
8. Remove bolts holding steer amplifier to frame.

Installation

1. Install steer amplifier to frame with bolts.
2. Route steer motor wires to steer motor and connect. Install cable ties where previously removed.
3. Route wire STR-1 to the contactor panel and connect to STR-2 on the steer contactor. Install cable ties where previously removed. Make sure cable is not pinched behind traction power amplifier.
4. Connect the remaining wire to TP4.
5. Install the contactor cover, right front cover, primary control handle cover, right side cover, and front cover. Close the Traction Motor compartment door.

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Cold Storage Conditioning

NOTE: Conversion of Model 7400/7420/7440 lift trucks for cold storage operation requires prior Raymond approval via Form S207.

New Model 7400/7420/7440 lift trucks to be operated in a cold storage environment require the following:

Components

- All-weather hydraulic fluid (P/N 1017238)

NOTE: Do *not* add any additve to this hydraulic fluid.

- Ambient temperature sensor
- Special cold storage control handle assemblies with heaters
- Wire mesh mast guard

Lubricants

See the "Lubrication Specification Chart" on page A-2 for special hydraulic fluid and drive unit lubricants for cold storage operation.

Coat battery roller shafts with all-weather grease (P/N 1012992).

Grease carriage fittings with all-weather grease (P/N 1012992).

Sealing Treatment

Fill sockets and the front and back of both halves of unsealed connectors with cold storage sealing compound (P/N 990-445). Connect wires and connectors. Coat the outside and where connectors attach to the circuit board. Coat terminals and terminal strips.

NOTE: Self-sealing AMP connectors (reference page 7-61) do not need sealing treatment.

Treat the following parts with sealing compound (P/N 990-564) to prevent moisture from entering:

- EPO button
- Key switch terminals
- Light and fan switch terminals, if not sealed
- Deadman switch terminals
- Proportional valve (SOL2) terminals
- Operator display interface card: coat both sides completely
- All control wire (18 GA) terminals and terminal strip posts (TS1, TS2)
- Any unsealed connectors not located in a heated compartment.

Corrosion Inhibitor Coating

Coat or spray bare metal surfaces listed below with Corrosion Inhibitor Coating (P/N 990-644):

- Reach cylinder cotter pins
- Main and free lift chain pulleys and shafts
- Main and free lift chain anchors and threaded pins
- Drive unit dipstick

Condensation Drip Guard

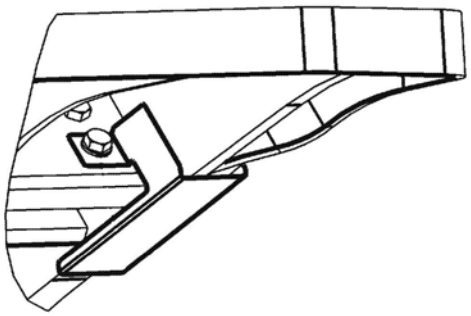
To add the control handle condensation drip guard (P/N 1036240) to the overhead guard, do the following:

1. Remove the right-hand lower hex head cap screw located almost directly above the control handle on the overhead guard.
2. Install an M16 flat washer onto the cap screw.
3. Reinstall the cap screw with flat washer and drip guard. See Figure 7-109.

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Figure 7-109. Condensation Drip Guard

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Hydraulic Components

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Hydraulic System Bleeding

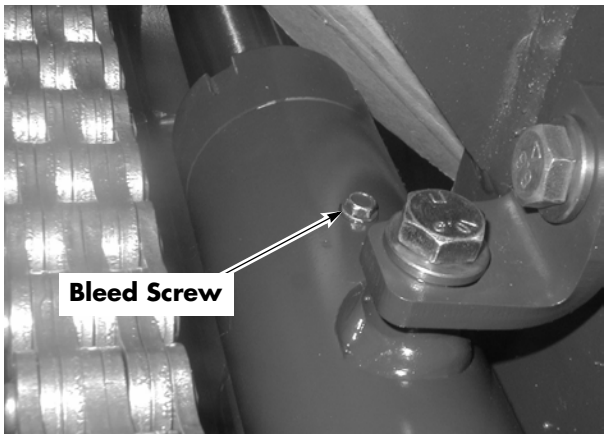
You must bleed the hydraulic system to remove any trapped air whenever you:

- Change a hydraulic hose
- Disconnect a hydraulic fitting
- Remove a hydraulic cylinder
- Remove the hydraulic pump
- Remove the hydraulic reservoir
- Notice that the load is bouncing

Procedure

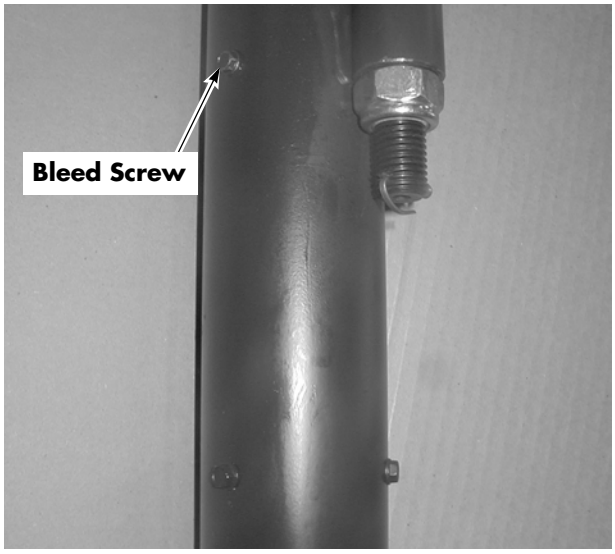
1. Elevate the fork carriage past free lift and lower it to the floor. Repeat several times. This tends to encourage any trapped air bubbles to migrate to the top of the cylinders.
2. With no load on the forks, elevate the forks 2 to 3 in. (5 to 7.5 cm) off the floor.
3. Turn the key switch OFF and disconnect the battery connector.
4. Loosen (*do not remove*) the bleed screw at the top of the main lift cylinder. Hold a rag close to and beneath the bleed screw to keep hydraulic fluid from spraying out. See Figure 7-110.

Figure 7-110. Bleed Screw, Main Lift Cylinder



5. Securely tighten the bleed screw when hydraulic fluid starts flowing from the bleed screw hole.
6. Repeat steps 4 and 5 for the other main lift cylinder.
7. Repeat steps 4 and 5 for each of the two free lift cylinders. See Figure 7-111.

Figure 7-111. Bleed Screw, Free Lift Cylinder



8. Reconnect the battery connector and turn the key switch ON.
9. Lower the forks all the way down to the floor.
10. Fully extend and retract the reach mechanism several times.
11. If the truck is equipped with tilt, tilt the carriage all the way forward and backward several times.
12. If the truck is equipped with sideshift, shift the carriage all the way to the left and right several times.
13. Thoroughly clean up any spilled hydraulic fluid.
14. Check the hydraulic reservoir level and refill as necessary. Do *not* overfill the reservoir.

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Hydraulic Filter

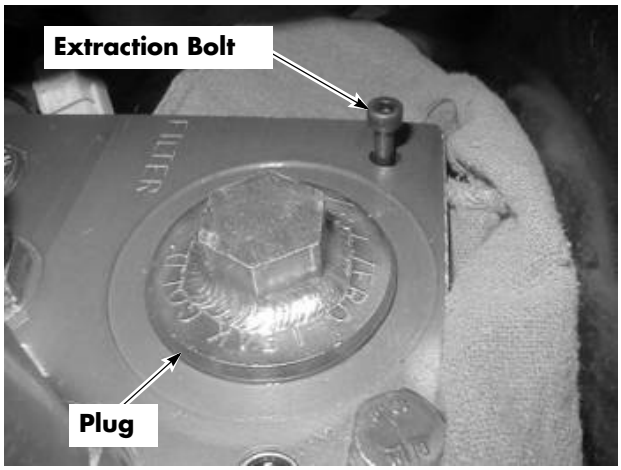
One of two types of hydraulic filters is installed in the main manifold, herein referred to as Type 1 and Type 2.

Filter Type 1

Removal

1. Remove the top cover.
2. If you are not draining the reservoir, elevate the mast to lower the hydraulic oil level in the reservoir to minimize oil leakage.
3. Turn the key switch OFF and disconnect the battery connector.
4. Remove the plug retaining the oil filter using a 3/4 in. socket. See Figure 7-112.

Figure 7-112. Filter Plug



5. Remove the spring on top of the filter.
6. Using the extraction bolt installed in the manifold, remove the filter. See Figure 7-113.

Figure 7-113. Filter Extraction



Installation

1. Check the cavity for contamination and clean as required.
2. Install the new filter, making sure it seats into the cavity correctly.
3. Install the spring on top of the filter.
4. Install and torque the hex plug to 30 ft. lb. (40 Nm).
5. Reinstall the extraction bolt into the manifold.
6. Reconnect the battery connector and turn the key switch ON.
7. Lower the mast and check for leaks.
8. Install the top cover.

Filter Type 2

Removal

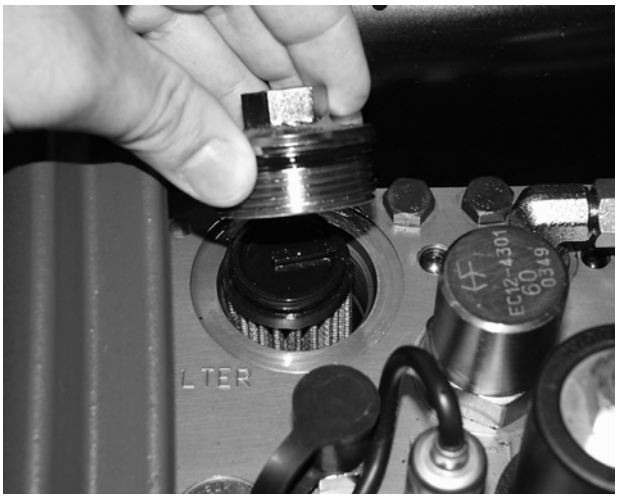
NOTE: Model 7620/7640 use two filter cartridges in the main manifold.

1. Remove the top cover.
2. If you have not drained the reservoir, elevate the mast to lower the hydraulic fluid level to minimize hydraulic fluid leakage.
3. Turn the key switch OFF and disconnect the battery connector.

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4. Remove the plug retaining the hydraulic fluid filter, using a 3/4 in. socket. See Figure 7-114.

Figure 7-114. Filter Plug



5. Remove the filter cartridge.
6. If contamination is evident, remove the cartridge core and clean as required.
7. Inspect the O-ring on the core and replace if necessary.

Installation

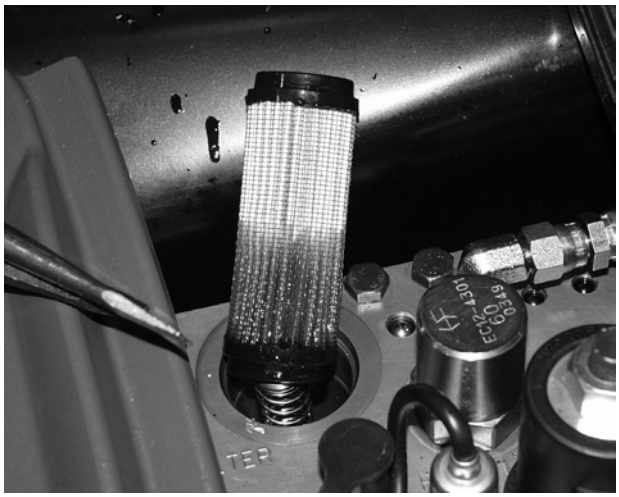
1. Install the cartridge core into the manifold making sure the core seats correctly into the nose of the cavity. See Figure 7-115.

Figure 7-115. Cartridge Core



2. Install the new filter cartridge on the cartridge core. See Figure 7-116.

Figure 7-116. Filter Cartridge (without shield)



3. Install and torque the hex plug to 30 ft. lb. (40 Nm).
4. Reconnect the battery connector and turn the key switch ON.
5. Lower the mast and check for leaks.
6. Install the top cover.

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Lift Pressure

Lift pressure is set by software in trucks. See Table 7-11 for maximum lift pressure.

Table 7-11. Maximum LIft Pressures

Model/Mast	Maximum Lift Pressure
7600/R45TT mast	3300 psi (22,753 kPa)
7600/DR32TT mast	3600 psi (24,821 kPa)
7620 and 7640/R45TT mast	2950 psi (20,339 kPa)
7620 and 7640/DR32TT mast	2600 psi (17,926 kPa)

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Manual Lowering of Fork Carriage

If the fork carriage is hung up and unable to lower normally, use the following procedure to lower the carriage.

NOTE: Make sure the forks and carriage are free from racks and other obstructions before lowering.

1. Manually open the load holding valve SOL1. See "Manifold, Main, Model 7600" on page 7-81. On the top of SOL1 is a small knurled knob. Depress the knob and turn counterclockwise until the knob pops up.
2. If there is power on the lift truck, try to lower by using the lift/lower knob.
   a. If this is successful, go to step 4.
   b. If this is unsuccessful, continue to the next step.
3. Manually adjust the proportional lift/lower valve SOL2 to cause the carriage to lower.
   a. Loosen the lock nut on top of SOL2.
   b. Using a hex-key wrench, adjust the brass adjustment screw clockwise until the carriage begins to move.
   c. Turning the screw clockwise increases lowering speed. Turning the screw counterclockwise slows the lowering speed.
4. After making necessary repairs to the lift truck, return SOL1 and SOL2 to their original positions.
   a. Depress the knob on top of SOL1 and turn the knob clockwise until it locks in the depressed position.
   b. Adjust the proportional lift/lower valve as described under "Proportional Valve Adjustment" on page 7-79.

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Proportional Valve Adjustment

If the carriage hesitates when being lowered, or cannot be feathered, adjust the proportional valve as follows:

1. Raise the fork carriage to eye level.
2. Turn the key switch OFF and disconnect the battery connector.
3. Remove the top cover.
4. Remove one of the coil wires from SOL2. See "Manifold, Main, Model 7600" on page 7-81. Loosen the jam nut and lock nut holding the adjusting screw on the proportional valve.
5. Reconnect the battery connector and turn the key switch ON.
6. Energize the load holding solenoid by requesting "lower" with the lift/lower potentiometer.
7. Slowly rotate the adjusting screw clockwise until the carriage just starts to creep downward. Turn the screw counterclockwise until the carriage stops. Repeat several times in order to refine the adjustment point. When adjustment is complete, tighten the lock nut and jam nut.
8. Turn the key switch OFF and disconnect the battery connector.
9. Reconnect the coil wire previously removed.
10. Reconnect the battery connector and turn the key switch ON.
11. Check for correct lowering operation empty and loaded, using "Test A23 - Lift Throttle (VR2) Request" on page 6-46 in Active Service Mode. Carriage movement should start at approximately 9 to 10% request.
12. Reinstall the top cover.

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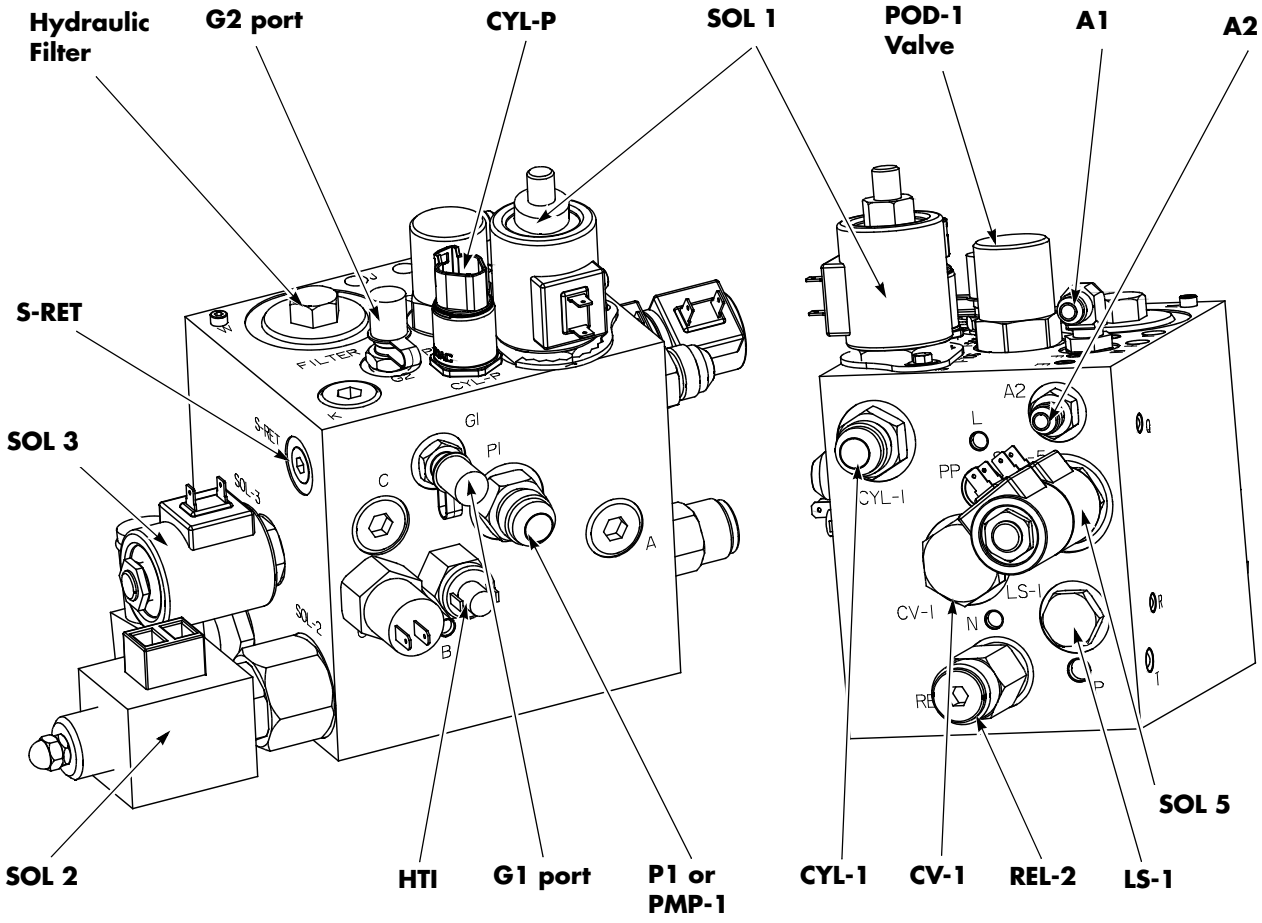
Auxiliary Pressure Adjustment

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the top cover.
3. Loosen the lock nut on the aux pressure relief valve (REL2) on the main manifold. See Figure 7-117 on page 7-81.
4. Remove the cap from the G2 auxiliary test port on the main manifold. Connect a pressure gauge capable of measuring 5000 psi (34,470 kPa).
5. Reconnect the battery connector and turn the key switch ON.
6. Tilt the carriage all the way back against the stops.
7. While continuing to try tilting the carriage backward, use a hex key to turn the auxiliary pressure adjusting screw to obtain a pressure of 2000 psi (13,790 kPa).
8. Turn the key switch OFF and disconnect the battery connector.
9. Tighten the lock nut on the aux pressure relief valve. Remove the pressure gauge from the auxiliary pressure test port and replace the cap.
10. Reinstall the top cover.

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Manifold, Main, Model 7600

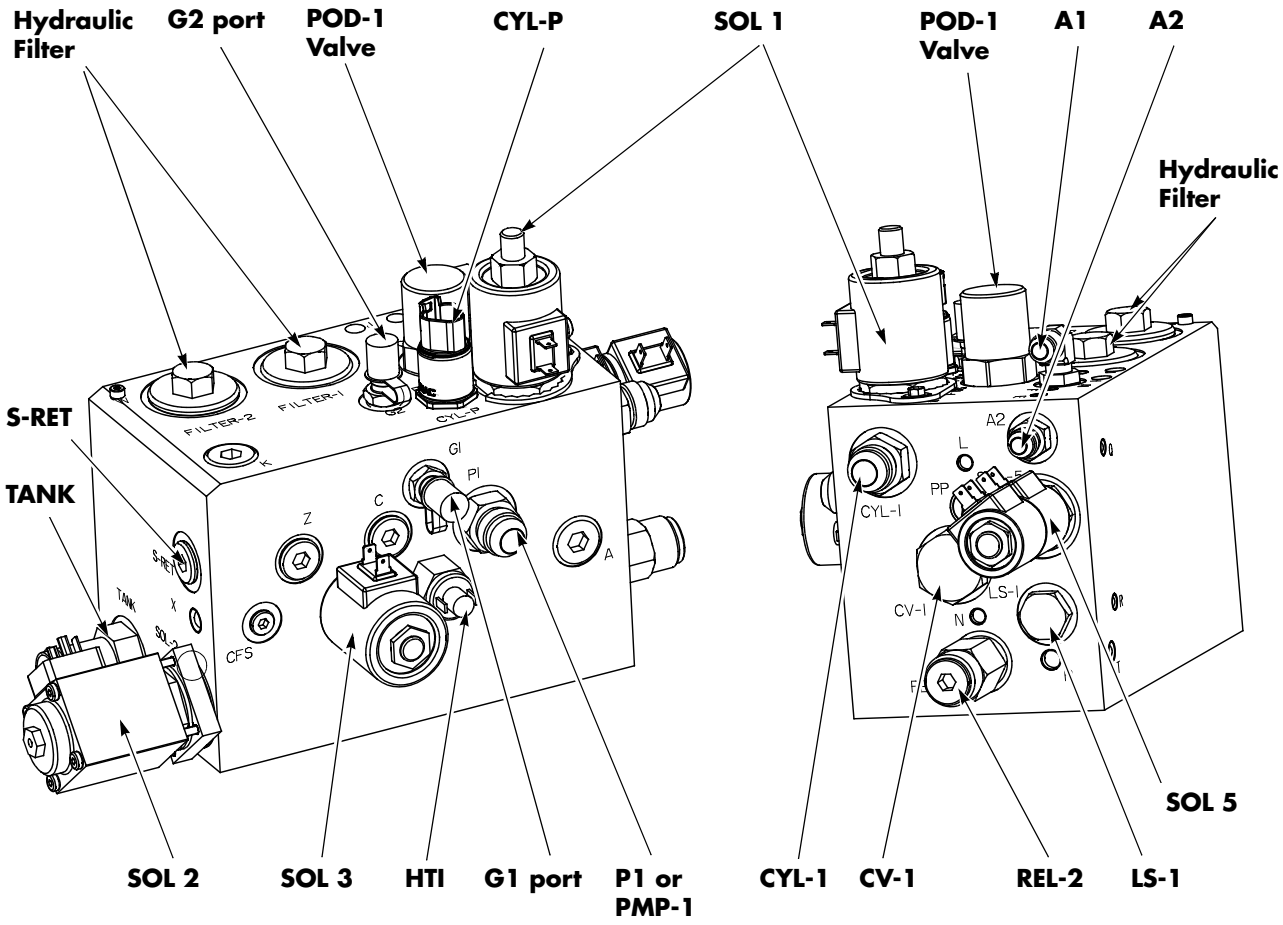
Figure 7-117. Main Manifold, Model 7600



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Manifold, Main, Model 7620/7640

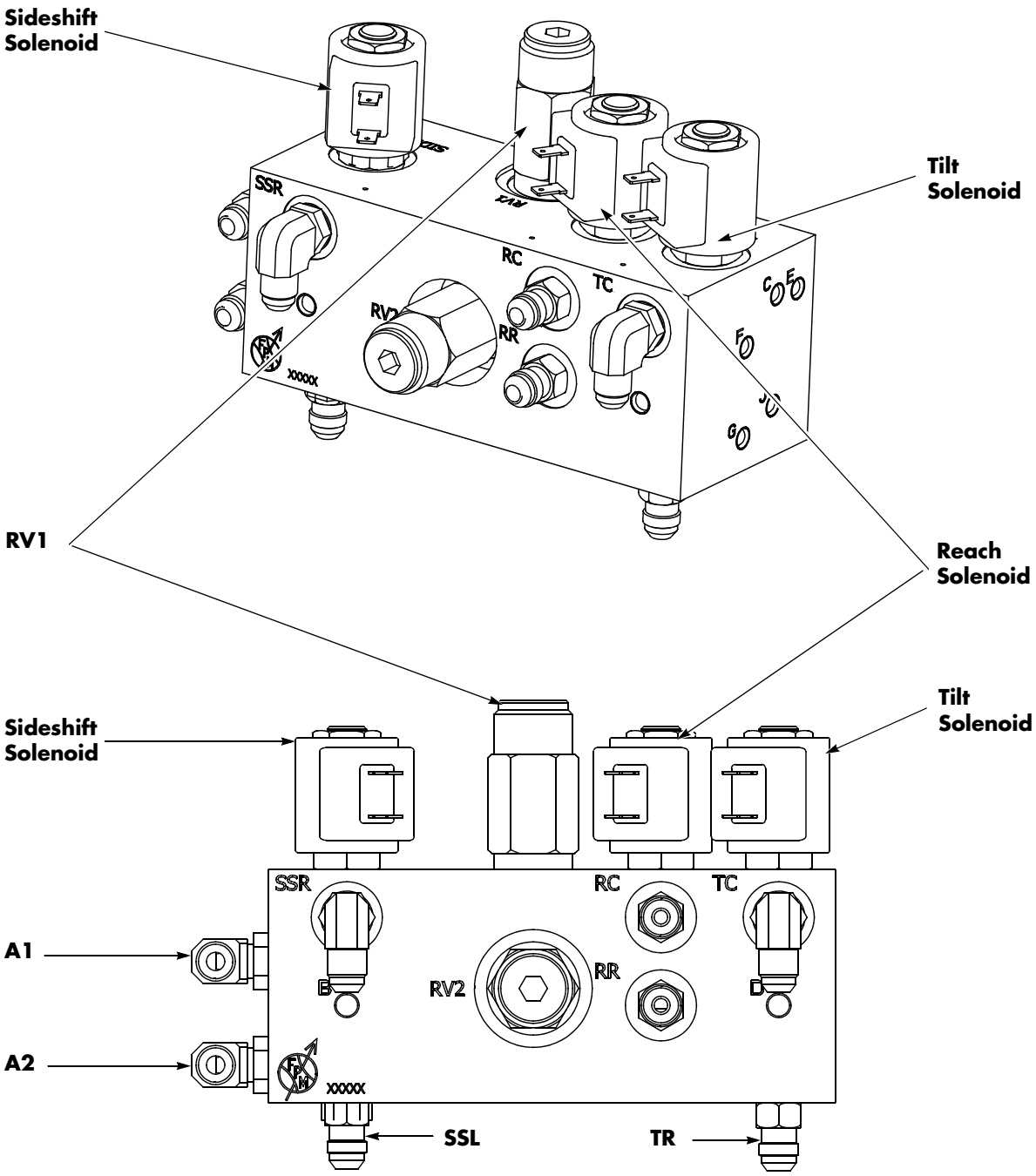
Figure 7-118. Main Manifold, Model 7620/7640



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Manifold, Auxiliary (Standard Reach)

Figure 7-119. Manifold, Aux (Standard Reach), with Reach, Tilt, Sideshift



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Removal

1. Reach (extend) the fork carriage fully.
2. Block the scissor assembly so that the scissors cannot retract.
3. Turn the key switch OFF and disconnect the battery connector.
4. Remove auxiliary carriage cover. Disconnect solenoid wires. Label as needed for correct re-connection.
5. Reconnect the battery connector and turn the key switch ON.
6. Elevate the carriage approximately 2.5 ft. (0.75 m).
7. Block the carriage so it cannot lower.
8. Tilt forks completely down.
9. Turn the key switch OFF and disconnect the battery connector.
10. Remove mast guard.
11. Disconnect the reach cylinder at the inner scissor to permit removal of the manifold.
12. Remove auxiliary manifold mounting screws.
13. Disconnect and cap the auxiliary hoses from the manifold. Label as needed for correct re-connection.
14. Place manifold in a vice and remove the solenoid coils and valves from the manifold. Note the position of all the fittings and remove them.

Installation

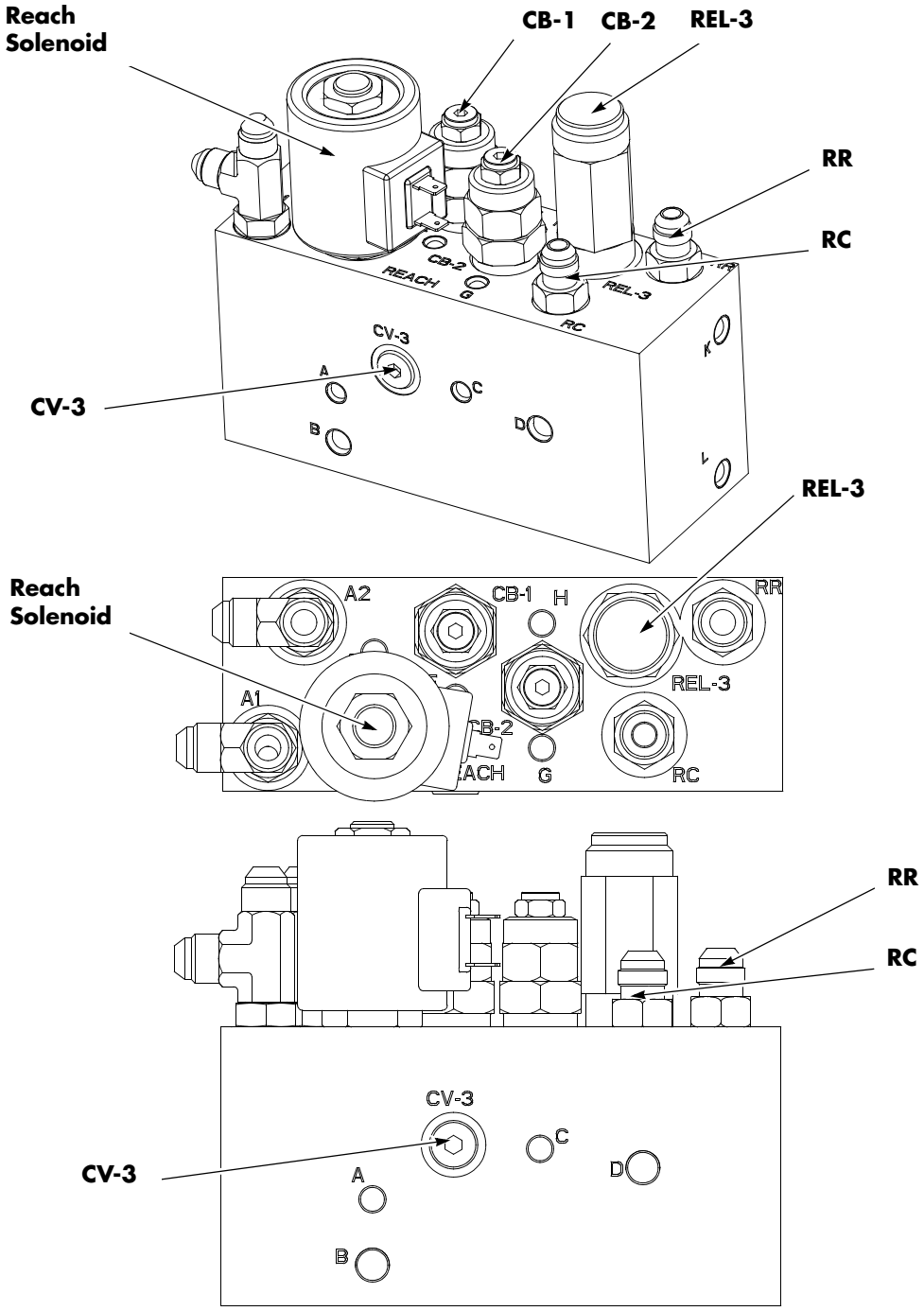
NOTE: For torque values, see Table 7-13 on page 7-88.

1. Install all fittings in the new manifold in the same orientation as they were in the manifold removed.
2. Install and torque all valves and solenoid coils.
3. Position the manifold and connect all auxiliary hoses.
4. Mount auxiliary manifold to carriage. Apply thread-locking compound (P/N 990-536) to mounting bolt threads. Torque to 21 ft. lb. (29 Nm).
5. Connect reach cylinder to inner scissor. Apply thread-locking compound (P/N 1013829) to threads of cylinder pin screws.
6. Install mast guard.
7. Reconnect the battery connector and turn the key switch ON. Remove the carriage blocking.
8. Lower the carriage completely.
9. Turn the key switch OFF and disconnect the battery connector.
10. Connect the solenoid coil wires and attach the manifold cover to the carriage.
11. Reconnect the battery connector and turn the key switch ON.
12. Bleed the hydraulic system as necessary. See “Hydraulic System Bleeding” on page 7-74.
13. Test auxiliary functions for correct operation. Check the manifold connections for leaks.

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Manifold, Reach (*Deep-Reach*®)

Figure 7-120. Manifold, Reach (Deep-Reach Carriage)



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Removal

1. Reach the carriage out and lower to the floor. Block the reach mechanism so that the scissors cannot retract.
2. Turn the key switch OFF and disconnect the battery connector.
3. Remove the two manifold mounting bolts to gain access to all hydraulic fittings.
4. Label as required all the solenoid wires and remove.
5. Disconnect and cap all hydraulic hoses. Note the location of each of the hoses.
6. Remove the manifold from the truck.

Installation

NOTE: For torque values, see Table 7-13 on page 7-88.

1. Install all fittings in the new manifold in the same orientation that they were in the manifold removed.
2. Install and torque all valves and solenoid coils.
3. Position the manifold and connect all the hydraulic hoses.
4. Reconnect the solenoid wires.
5. Mount the manifold to the scissors.
6. Reconnect the battery connector and turn the key switch ON.
7. Remove the blocking.
8. Bleed the hydraulic system. See "Hydraulic System Bleeding" on page 7-74.
9. Test the auxiliary functions for correct operation and check connections for leaks.

Reducing Carriage Drift

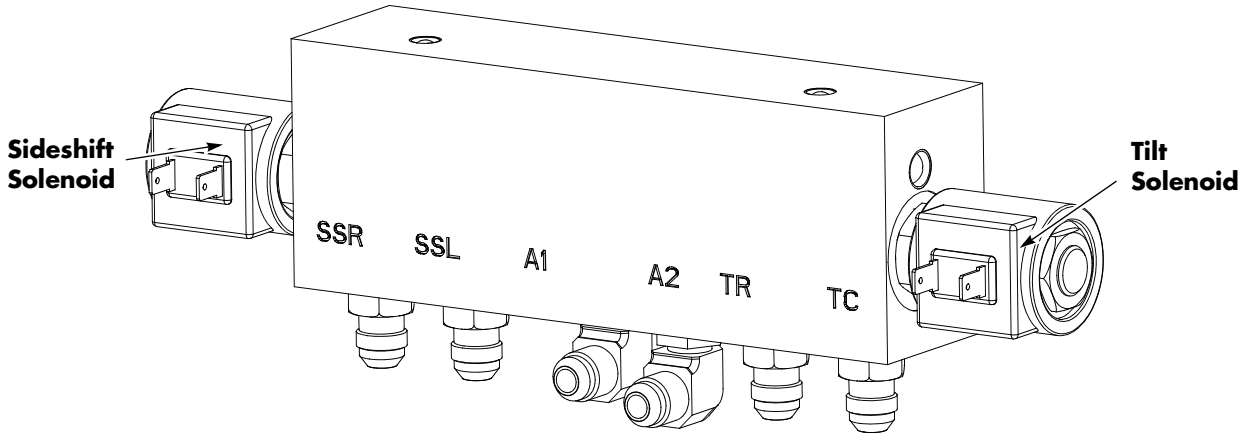
If carriage drifts, replace Counterbalance Valve (CB-1) P/N 1020951/001 with 1020951/004, and Relief Valve (REL-3) P/N 1007104/001 with 1009281/013.

1. Fully extend and block the scissor mechanism.
2. Turn the key switch OFF and disconnect the battery connector.
3. Clean the surface of the reach manifold to avoid contamination.
4. Remove relief valve REL-3.
5. Remove counterbalance valve CB-1.
6. Removed the reach solenoid coil.
7. Remove counterbalance valve CB-2, using an offset 15/16 in. open-end wrench.
8. Install the new relief valve REL-3.
9. Reinstall counterbalance valve CB-2.
10. Install the new counterbalance valve CB-1.
11. Reinstall the reach solenoid coil.
12. Remove the blocking from the scissor mechanism.
13. Reconnect the battery connector and turn the key switch ON.
14. Bleed the auxiliary system by fully extending the reach mechanism several times. Hold over the relief until the system times out if air remains present.
15. Test reach and retract functions for correct operation.

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Manifold, Tilt/Sideshift (*Deep-Reach*®)

Figure 7-121. Manifold, Tilt/Sideshift (Deep-Reach Carriage)



Refer to Parts Manual for "Tilt Only" Manifold

Removal

1. Reach the fork carriage out and fully lower to the floor.
2. Tilt the forks fully down.
3. Turn the key switch OFF and disconnect the battery connector.
4. Disconnect the wiring for the solenoids.
5. Disconnect and cap the hydraulic hoses. Note the location of the hoses.
6. Remove the manifold from the truck.
7. Remove the solenoid valves from the manifold.
8. Note the position of all fittings and remove them from the manifold.

Installation

NOTE: For torque values, see Table 7-13 on page 7-88.

1. Install all fittings in the new manifold in the same orientation that they were in the manifold removed.
2. Install and torque all valves and solenoid coils.
3. Mount the manifold to the carriage.
4. Connect the hydraulic hoses.
5. Connect the wiring to the solenoids.
6. Reconnect the battery connector and turn the key switch ON.
7. Bleed the hydraulic system.
8. Test the auxiliary functions for correct operation and the connections for leaks.

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Manifold Solenoids, Fittings, and Attachments

Table 7-12. Main Manifold Attachment Torques

Solenoid/ Attachment/Fitting	Torque ft. lb. (Nm)
SOL1 Load Holding w/locking tab	50 (68) coil nut: 5 (6.8)
SOL2 Lift/Lower	95 (129) coil nut: 0.5 (0.7)
SOL3 Proportional Main Relief/Dump	25 (34) coil nut: 5 (6.8)
SOL5B/5T Aux	20 (27) coil nut: 5 (6.8)
A1 & A2	21 (28)
CV-1 Check Valve	30 (41)
CYL-1	55 (75)
CYL-P Pressure Transducer	12 (16)
Filter Plug	30 (41)
G1 & G2	21 (28)
HTI Pressure Switch	12 (16)
LS-1 Load Shuttle	20 (27)
P1	55 (75)
POD-1 Priority on Demand	35 (47)
REL-2 Aux Relief	25 (34)
Return (Suction) to Pump	55 (75)
S-RET	21 (28)
TANK	55 (75)

Table 7-13. Aux Manifold and Cylinder Attachment Torques

Solenoid/ Attachment/Fitting	Torque ft. lb. (Nm)
A1 & A2 (Standard Reach)	15 (20)
Reach Valve	20 (27) standard 25 (34) *Deep-Reach* coil nut: 5 (6.8)
RC & RR	15 (20)
Tilt Valve	20 (27) coil nut: 5 (6.8)
TC & TR	15 (20)
Sideshift Valve	20 (27) coil nut: 5 (6.8)
SSR & SSL	15 (20)
Flow Limiter (7620/7640 Free Lift Cylinder)	85 (115)
Pump & Tank	15 (20)
A1 & A2 (*Deep-Reach*)	15
A1 & A2 (*Deep-Reach* Tilt or Tilt/Sideshift)	15
REL-3 *Deep-Reach* Relief	n/a
CV-3 *Deep-Reach* Check valve	25 (34)
CB-1 & CB-2 *Deep-Reach* Counterbalance	35 (47)

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Hydraulic Components, Cylinder

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Lift Cylinder, Free Lift, Remove/Install

Model 7600

Left Side Free Lift Cylinder

Removal

1. Remove mast guard.
2. Elevate telescopics to access the over-the-mast (OTM) hoses/cable clamp at the bottom of the free lift cylinder.
3. Remove the clamp and the free lift cylinder set screw at the bottom of the cylinder mounting bracket. Remove any cable ties securing the hoses/cable to the cylinder.
4. Fully lower the telescopics carefully so as not to damage the hoses and cable.
5. Using a suitable lifting device, lift the carriage to relieve the tension on the lift chains and hoses.
6. Turn the key switch OFF and disconnect the battery connector.
7. Remove the master link from the free lift chain at the free lift cylinder anchor bolt.
8. Drape the chain over the carriage assembly.
9. Remove the chain pulley to access the pulley bracket assembly mounting bolt. Remove the pulley bracket assembly from the piston and set to the side with the hoses and cable in place.
10. Mark the OTM hoses and cable at the upper free lift cylinder retainer for the correct stretch when re-assembled. Remove the retainer.
11. Using the lifting device, lift and block the carriage assembly to a height that permits access to the tubing at the bottom of the cylinder.

NOTE: As the carriage is being lifted, feed the right side free lift chain towards the operator compartment to avoid jamming of the chain.

12. Disconnect the hydraulic line at the bottom of the cylinder. Plug and cap the fittings to prevent contamination from entering the system.

NOTE: Place a pan below the main frame to catch any hydraulic fluid when the line is disconnected.

13. Position the carriage at an appropriate height to allow removal of the cylinder.
14. Using a suitable lifting device, remove the cylinder.

Installation

NOTE: The left side free lift cylinder contains a flow limiter located in the manifold block at the bottom of the cylinder. See “Flow Limiter, Free Lift” on page 7-116.

1. Install the flow control, fitting, and feed hose at the bottom of the cylinder.
2. Position the cylinder into the truck.
3. Connect the hydraulic line at the bottom of the cylinder.
4. Lift the carriage assembly to provide slack in the lift chains and hoses for assembly.
5. Apply thread-locking compound (P/N 1013829) to the threads of the mounting bolt and install the pulley bracket assembly.
6. Install the chain pulley and the free lift chain.
7. Install the OTM upper free lift cylinder retainer, noting the marks made on the hoses/cable when removed.
8. Lower the carriage and remove the lifting device.
9. Reconnect the battery connector and turn the key switch ON.
10. Carefully lift the telescopics to access the bottom of the free lift cylinder.
11. Install the OTM hoses/cable clamp at the bottom of the free lift cylinder. Make sure there is correct clearance between the bracket, hoses/cable, and the front plate of the tractor.
12. Bleed the hydraulic system. See “Hydraulic System Bleeding” on page 7-74.

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13. Check the truck for leaks and correct operation.
14. Install the mast guard.

Right Side Free Lift Cylinder

Removal

1. Fully lower the forks to the floor.
2. Turn the key switch OFF and disconnect the battery connector.
3. Remove the mast guard.
4. Using a suitable lifting device, lift the carriage to relieve the tension on the lift chain.
5. Remove the master link from the free lift chain at the free lift anchor bolt.
6. Remove and drape the chain over the carriage assembly.

NOTE: Twist the pulley assembly to permit the removal of the chain.

7. Remove the chain pulley to access the pulley bracket assembly mounting bolt.
8. Remove the pulley bracket assembly and ring adapter.
9. Using the lifting device, lift and block the carriage assembly to a height that permits access to the bottom of the cylinder.

NOTE: As the carriage is being lifted, feed the left side free lift chain toward the operator compartment to avoid jamming the chain.

10. Disconnect the hydraulic line at the bottom of the cylinder. Plug and cap the fitting to avoid contamination from entering the system.

NOTE: Place a pan below the main frame to catch any hydraulic fluid when the line is disconnected.

11. Remove the set screw at the bottom of the cylinder.
12. Position the carriage at an appropriate height to permit removal of the cylinder.
13. Using a suitable lifting device, remove the cylinder.

Installation

1. Position the cylinder into the truck.
2. Position and block carriage to permit access to bottom of the cylinder.
3. Install the set screw at the bottom of the cylinder.
4. Connect the hydraulic line at the bottom of the cylinder.
5. Lift the carriage assembly to provide slack to install the free lift chain.
6. Install the ring adapter. Apply thread-locking compound (P/N 1013829) to the mounting bolt threads and install the pulley bracket assembly to the piston.
7. Install the chain pulley and the free lift chain.
8. Lower the carriage and remove the lifting device.
9. Reconnect the battery connector and turn the key switch ON.
10. Bleed the hydraulic system. See “Hydraulic System Bleeding” on page 7-74.
11. Check the truck for leaks and correct operation.
12. Install the mast guard.

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Model 7620/7640

Left Side Free Lift Cylinder

Removal

1. Elevate the fork carriage approx 4 in. (10 cm) above the floor.
2. Place hardwood blocks under the carriage.
3. Lower the carriage to slacken the chains.
4. Request lower and collapse the free lift cylinder. This minimizes the amount of hydraulic fluid in the cylinder.
5. Turn the key switch OFF and disconnect the battery connector.
6. Remove the mast guard.
7. Cut the cable ties on the hose clamps.
8. Place a chalk witness mark on the hoses to aid in reassembly.
9. Remove the hose retainer brackets near the top of the cylinder.
10. Disconnect the free lift chain at the adjusting chain anchor and feed the chain over the pulley.
11. Remove the pulley shaft securing screw, pin, and the pulley.
12. Remove the pulley bracket from the cylinder.
13. Disconnect and cap/plug the hydraulic line at the bottom of the cylinder.
14. Remove the nut from the cylinder retaining anchor at the inner telescopic crosstie.
15. Wrap a hoist strap securely around the cylinder at the retaining bracket.
16. Using a hoist or other suitable lifting device, carefully lift the cylinder out.

Installation

1. Wrap a hoist strap securely around the cylinder at the retaining bracket.
2. Using a hoist or other suitable lifting device, carefully lower the cylinder onto the two locating pins on the inner telescopic lower crosstie.
3. Connect the hydraulic line.
4. Attach the cylinder retaining nylon nut snug to the shoulder.
5. Reattach the pulley bracket to the cylinder.
6. Install the pulley, pin, and securing screw.
7. Using a new master link, install the free lift chain to the upper chain anchor.
8. Secure the hoses to the hose clamps with cable ties.
9. Reattach the mast guard.
10. Reconnect the battery connector and turn the key switch ON.
11. Elevate the fork carriage.
12. Remove blocking.
13. Test lift and lower function for correct operation. Check for hydraulic leaks.

Right Side Free Lift Cylinder

Removal

1. Remove the auxiliary manifold top cover on the carriage.
2. Disconnect the over-the-mast (OTM) cable at terminal strip TS-2.
3. Elevate the fork carriage approximately 4 in. (10 cm) above the floor.
4. Place hardwood blocks under the carriage.
5. Lower the carriage to slacken the chains.
6. Request lower and collapse the free lift cylinder. This minimizes the amount of hydraulic fluid in the cylinder.
7. Turn the key switch OFF and disconnect the battery connector.
8. Loosen the U-clamp and feed the OTM cable through.
9. Cut the cable ties on the cable clamps.
10. Feed the OTM cable over the pulley.
11. Disconnect the free lift chain at the adjusting chain anchor and feed the chain over the pulley.
12. Remove the pulley shaft securing screw, pin, and the pulley.
13. Remove the pulley bracket from the cylinder.

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14. Disconnect and cap/plug the hydraulic line at the bottom of the cylinder.
15. Remove the nut from the cylinder retaining anchor at the inner telescopic crosstie.
16. Wrap a hoist strap securely around the cylinder at the retaining bracket.
17. Using a hoist or other suitable lifting device, carefully lift the cylinder out.

Installation

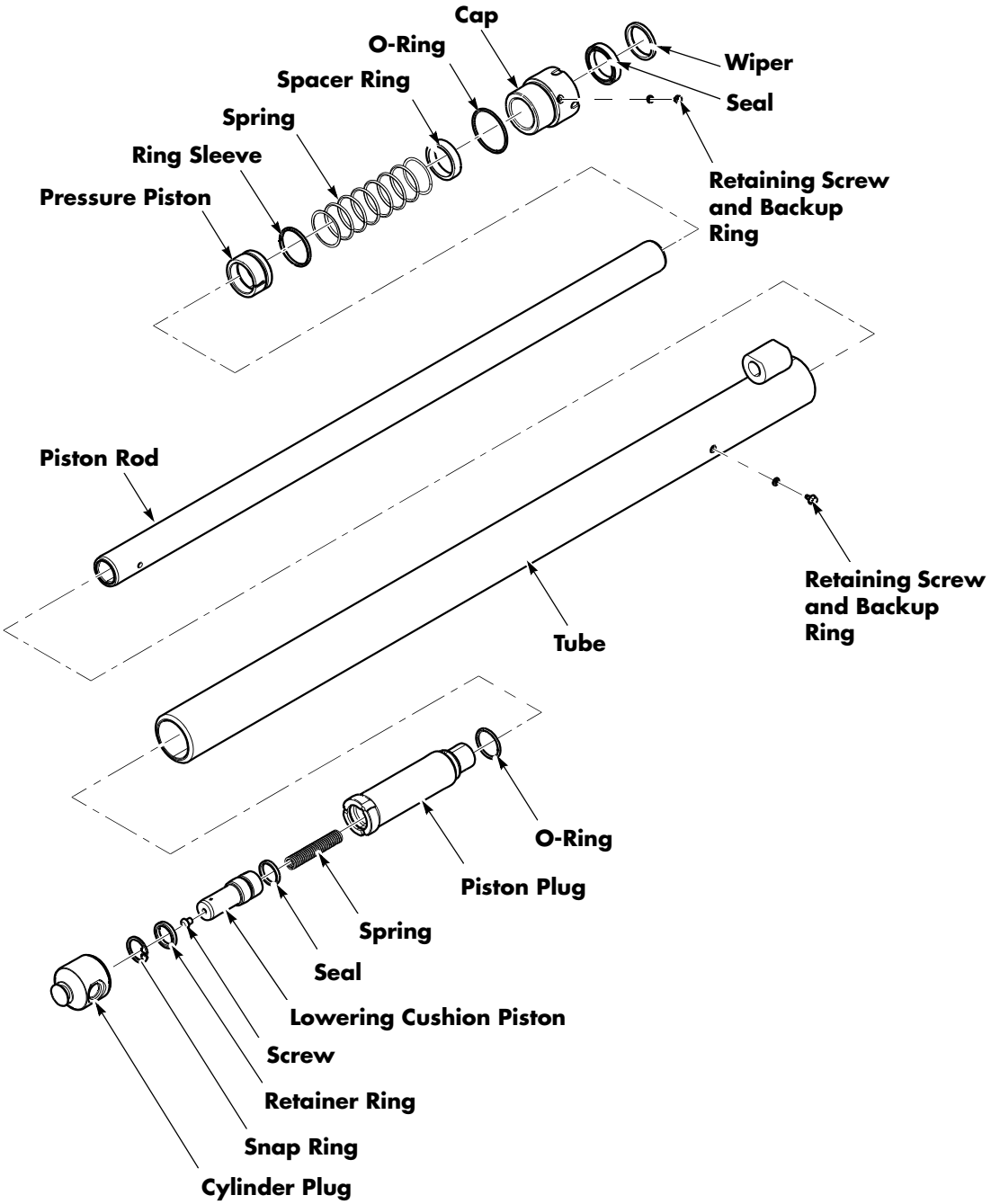
1. Wrap a hoist strap securely around the cylinder at the retaining bracket.
2. Using a hoist or other suitable lifting device, carefully lower the cylinder onto the two locating pins on the inner telescopic lower crosstie.
3. Connect the hydraulic line.
4. Attach the cylinder retaining nylon nut snug to the shoulder.
5. Reattach the pulley bracket to the cylinder.
6. Install the pulley, pin, and securing screw.
7. Using a new master link, install the free lift chain to the upper chain anchor.
8. Route the OTM cable through the spring tension bracket, over the pulley, and through the U-clamp to terminal strip TS2 in the auxiliary manifold cover.
9. Hook the cable tensioner to the bracket.
10. Tighten the U-clamp.
11. Connect the OTM cable wires at terminal strip TS2.
12. Reattach the auxiliary manifold top cover on the carriage.
13. Secure the cable to the cable brackets with cable ties.
14. Reattach the mast guard.
15. Reconnect the battery connector and turn the key switch ON.
16. Elevate the fork carriage.
17. Remove blocking.
18. Test lift and lower function for correct operation. Check for hydraulic leaks.

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Lift Cylinder, Free Lift, Exploded Parts Drawing

Model 7600, Staging

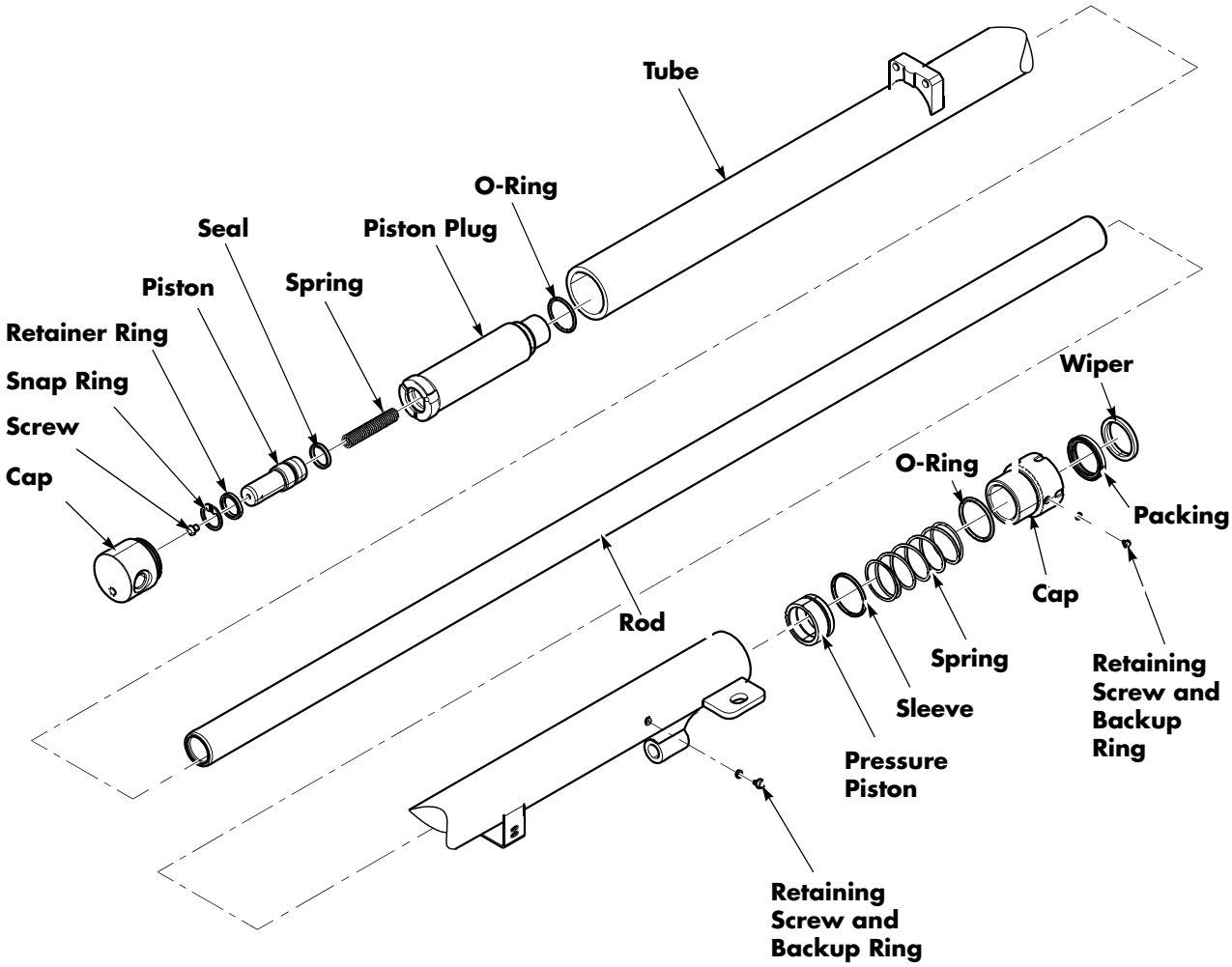
Figure 7-122. Free Lift Cylinder, Staging, Model 7600



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Model 7620/7640, Staging

Figure 7-123. Free Lift Cylinder, Staging, Model 7620/7640



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Lift Cylinder, Free Lift, Seal Repacking

Model 7600

Refer to Figure 7-122.

Disassembly

There is a staging zone mechanism in the free lift cylinders in addition to a cushion at the bottom of the cylinder.

1. Remove the mast guard.
2. Lower the carriage onto a suitable block and fully lower cylinder to relieve the tension on the hoses, cable, and free lift chains.
3. Turn the key switch OFF and disconnect the battery connector.
4. Remove the free lift chain master link at the free lift cylinder anchor bolt and lay the chain over the carriage.

NOTE: Twist the right side pulley to remove the chain from the pulley.

5. Remove the chain pulley to access the pulley bracket mounting bolt.
6. Remove the pulley bracket assembly. Set the left side to one side keeping the hoses and cable in place.
7. For 3 in. lowered height option, remove the adapter ring.
8. If you are removing the piston, remove the three staging zone mechanism stop screws and the bleeder screw. It may be necessary to loosen the upper OTM retainer to allow the removal of the three stop screws.

NOTE: Mark the hoses and cable to make sure the correct stretch when re-assembled.

9. Remove the snap ring and gland.

NOTE: When the snap ring is removed, a spring behind the packing plug should push the gland out of the housing.

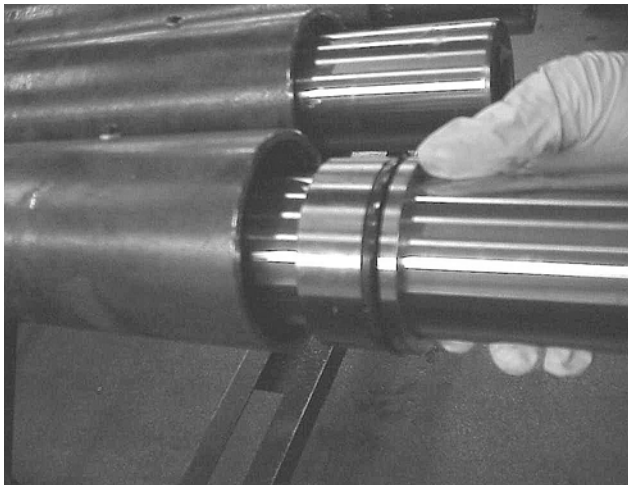
NOTE: If necessary, use the piston to extract the gland by removing the three staging zone stop screws and the bleeder screw and lifting the cylinder with the use of a hoist.

10. On a clean work surface, remove the wiper seal, packing seal, O-rings, and backup ring from the gland. Note the position and orientation of each when removing.
11. Inspect the surfaces of the gland for any scratches or damage. Remove minor imperfections using fine emery cloth.
12. Clean the gland.
13. Inspect the inside of the housing for damage and clean as required.

Reassembly

1. If the piston was removed, install the piston and the three staging zone mechanism stop screws that were removed in step 8 of the disassembly procedure.
2. Lubricate the wiper seal, packing seal, O-rings, and backup ring with new hydraulic fluid and install into their respective grooves on the gland. Make sure that they are correctly positioned.
3. Install the pressure ring with the seal towards the open end of the housing. See Figure 7-124.

Figure 7-124. Pressure Ring Orientation



4. Apply lubricant (P/N 990-652) to the outside surface of gland.

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5. Lubricate the piston rod with new hydraulic fluid. Carefully slide the gland over it.
6. Using the seal installation driver (P/N 401-000-051), push the gland into the housing and compress the spring.
7. Apply a film of lubricant (P/N 990-652) to the top of the gland and housing to prevent moisture entry.
8. Install the snap ring inside the housing. Make sure that the snap ring is fully seated in the groove.
9. Wipe away any excess hydraulic fluid.
10. Tighten the upper OTM retainer, if previously loosened.
11. For 3 in. lowered height option, install the adapter ring.
12. Apply thread-locking compound (P/N 1013829) to the threads of the mounting bolt and install the pulley bracket assembly.
13. Install the chain pulley and the free lift chain.
14. Reconnect the battery connector and turn the key switch ON.
15. Remove the block from beneath the carriage.
16. Bleed the hydraulic system. See "Hydraulic System Bleeding".
17. Check the truck for leaks and correct operation.
18. Install the mast guard.

Model 7620/7640

Refer to Figure 7-123.

Disassembly

1. Elevate the carriage about 4 in. (10 cm) and lower the carriage onto blocks to slacken the chains.
2. Turn the key switch OFF and disconnect the battery connector.
3. Collapse the cylinder.
4. Disconnect the lift chain master link from the chain anchor.
5. Secure the lift chain to the crosstie with a welding or sheet metal locking clamp. This minimizes rethreading of chain later.
6. Remove the nut from the tractor side of the free lift cylinder mounting bracket.
7. Remove the locking screw from the pulley shaft.
8. Drive out the pulley shaft.
9. Remove the pulley bracket.

NOTE: With slack in hoses and cable, it is not necessary to remove the hoses or cable.

10. Using a 2 in. spanner wrench, remove the end cap (gland).
11. On a clean work surface, remove the wiper seal, packing seal, and O-ring from the gland.
12. Inspect the surfaces of the gland for any scratches or damage. Remove minor imperfections using fine emery cloth.

Reassembly

1. Lubricate with new hydraulic fluid the packing seal, wiper seal, and O-ring and install into their respective grooves on the gland. Make sure that they are correctly seated within the grooves.
2. Apply thread-locking compound (P/N 990-571) to the threads of the gland. Do not apply compound to the first threads to engage.
3. Lubricate the piston rod with new hydraulic fluid. Carefully slide the gland over the piston rod.
4. Torque the gland to 200 ft. lb. (271 Nm).
5. Apply thread-locking compound (P/N 990-571) to the threads of the mounting bolt and install the pulley bracket assembly.
6. Install the pulley and pulley shaft on the bracket.
7. Install the pulley shaft locking screw.
8. Route the free lift chain over the pulley and attach to the chain anchor with a master link.

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9. Reconnect the battery connector and turn the key switch ON.
10. Slowly request lift, lift the carriage, remove the blocking, and lower the carriage.
11. Bleed the cylinder as required. See "Hydraulic System Bleeding".
12. Test lift and lower functions. Check for leaks.

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Lift Cylinder, Main, Remove/Install

Model 7600

Left Side Main Lift Cylinder

Removal

1. Remove mast guard, top cover, and left front cover.
2. Remove the retainer bolt at the bottom of the cylinder.
3. Place a block approx 18 in. long between the inner telescopic crosstie and the outer telescopic crosstie. Place a block approx 12 in. (305 mm) in length between the outer telescopic crosstie and the main frame crosstie.

NOTE: This provides the necessary hose/cable slack and clearance to remove the cylinder.

4. Fully lower the carriage.
5. Turn the key switch OFF and disconnect the battery connector.
6. Remove the bolt, washer, and spacer at the top of the piston.
7. Remove the cylinder mounting L-bracket(s).

NOTE: Models with an OACH of 131 in. (333 cm) and above have two brackets.

8. Remove the OTM hose/cable retainer bracket from the cylinder.
9. Place a pan below the tractor and disconnect the cylinder feed hose at the tractor bulkhead fitting.

NOTE: The feed hose can remain connected to the bottom of the cylinder to assist in removal.

10. From inside the battery compartment, loosen the right side mast connector mounting bolts.
11. Remove the left side mast bolts and the mast connector snap ring.
12. Place a jack beneath the tractor to slightly spread the tractor and the attachment to allow the removal of the connector.
13. Remove the connector.
14. Using a suitable lifting device, remove the cylinder from the truck.

Installation

1. Install the fitting and feed hose at the bottom of the cylinder.
2. Attach the mast guard bracket onto the cylinder.
3. Position the cylinder into the truck.
4. Apply thread-locking primer (P/N 990-666) to both the right and left mast mounting bolt threads and the hole threads. Permit to dry for several minutes. Apply thread-locking compound (P/N 990-544) to the threads of the mast mounting bolts. Install the mast connector and torque the bolts to 160/170 ft. lb. (217/230 Nm).
5. Install the mast connector snap ring.
6. Remove the jack.
7. Connect the feed hose at the bulkhead fitting.
8. Attach the OTM hose/cable retainer bracket to the cylinder.
9. Install the cylinder mounting L-bracket(s) with sleeves and bolts. Do not tighten at this time.
10. Reconnect the battery connector and turn the key switch ON.
11. Carefully rotate the lift knob to raise the piston to the telescopic crosstie.
12. Install the bolt, washer, and spacer at the crosstie to the top of the piston.
13. Apply thread-locking compound (P/N 1013829) to the threads and tighten, leaving a 0.12 in. (3 mm) gap between the head of the bolt and the washer.
14. Tighten the cylinder mounting L-bracket bolts to 55 ft. lb. (75 Nm).
15. Remove the blocks from the telescopics and the main frame.

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16. Install the retainer bolt at the bottom of the cylinder.
17. Bleed the hydraulic system. See "Hydraulic System Bleeding" on page 7-74.
18. Check for leaks and correct operation.
19. Install the mast guard, top cover, and left front cover.

Right Side Main Lift Cylinder

Removal

1. Remove mast guard, top cover, and right front cover.
2. Elevate telescopics and remove the retainer bolt at bottom of cylinder.
3. Place a block at least 12 in. (305 mm) in length between the main frame and the outer telescopic crosstie and fully lower the carriage.

NOTE: This length provides the clearance required to remove the cylinder.

4. Fully lower the carriage.
5. Turn the key switch OFF and disconnect the battery connector.
6. Remove the bolt, washer, and spacer at the top of the piston and outer telescopic crosstie.
7. Remove the cylinder mounting L-bracket(s).

NOTE: Models with an OACH of 131 in. (333 cm) and above have two upper brackets.

8. Place a pan below the tractor. Disconnect the cylinder feed hose at the tractor bulkhead. Plug and cap the fittings to prevent contamination from entering the system.

NOTE: The feed hose can remain connected to the cylinder to assist in removal of the cylinder.

9. From inside the battery compartment, loosen the left side mast bolts.
10. Remove the right side mast bolts and the mast connector snap ring.
11. Place a jack beneath the tractor to slightly spread the tractor and attachment to allow the removal of the connector.
12. Remove the connector.
13. Using a suitable lifting device, remove the cylinder from the truck.

Installation

NOTE: The right side main lift cylinder houses a flow limiter located in the manifold block at the bottom of the cylinder. See "Flow Limiter, Main Lift" on page 7-115.

1. Install the flow control, fitting, and feed hose at the bottom of the cylinder.
2. Attach mast guard bracket to cylinder.
3. Position the cylinder into the truck.
4. Apply thread-locking primer (P/N 990-666) to mast mounting bolt threads and the hole threads. Permit to dry for several minutes. Apply thread-locking compound (P/N 990-544) to the threads of the mast mounting bolts. Install the mast connector and torque the bolts to 160/170 ft. lb. (217/230 Nm).
5. Install the mast connector snap ring.
6. Remove the jack from the truck.
7. Connect the feed hose at the tractor bulkhead fitting.
8. Install the cylinder mounting L-bracket(s) with sleeves and bolts. Do not tighten at this time.
9. Install the retainer bolt at the bottom of the cylinder.
10. Reconnect the battery connector and turn the key switch ON.
11. Carefully rotate the lift knob to raise the piston to the telescopic crosstie.
12. Install the bolt, washer, and spacer at the crosstie to the top of the piston.

NOTE: Install thread-locking compound (P/N 1013829) to bolt threads and tighten, leaving a 0.12 in. (3 mm) gap between head of the bolt and washer.

13. Tighten the cylinder mounting L-bracket bolts to 55 ft. lb. (75 Nm).

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14. Remove the block from between the telescopic and the main frame.
15. Bleed the hydraulic system. See "Hydraulic System Bleeding" on page 7-74.
16. Check the truck for leaks and correct operation.
17. Install the mast guard, top cover, and right front cover.

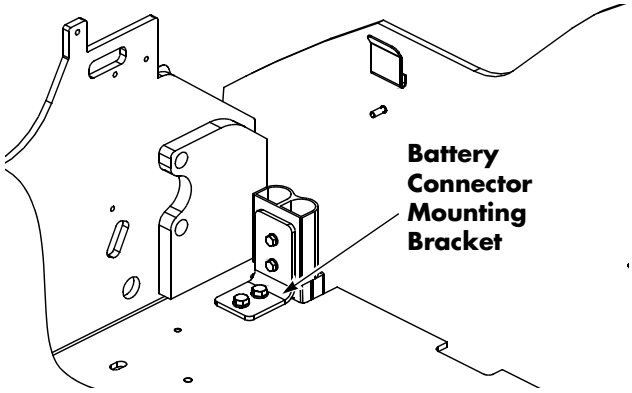
Model 7620/7640

Left and Right Side Main Lift Cylinder

Removal

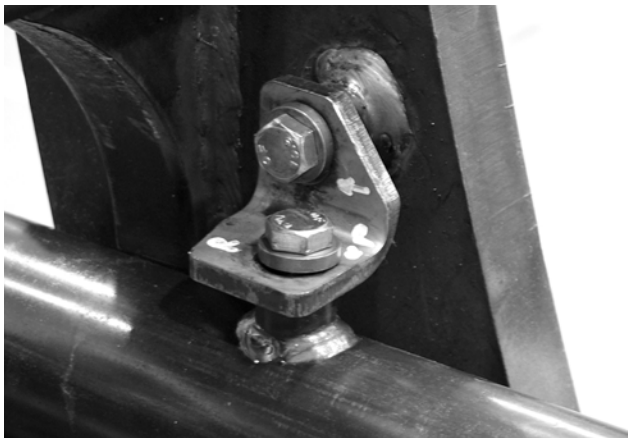
1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the top cover.
3. Remove the mast guard.
4. Disconnect the auxiliary hydraulic hoses at the main manifold. Cap hoses and plug ports.
5. Disconnect the over-the-mast electrical cable at connector JPS3 near the main manifold.
6. Remove the battery gate. Using a suitable battery moving device, remove the battery.
7. Remove the battery connector mounting bracket (for access to the mast mounting bolts). See Figure 7-125.

Figure 7-125. Battery Connector and Mast Mounting Block



8. Remove the forks from the fork carriage.
9. Disconnect the main lift hoses at the tractor bulkhead. Cap the hoses and plug the fittings.
10. Attach a hoist strap under the top crosstie of the main frame and support the mast with a 3-ton hoist or other suitable lifting device.
11. Place blocks snugly under the tractor near the mast. These blocks take the weight of the tractor when the tractor is unbolted from the mast.
12. Working inside the battery compartment, remove eight mast mounting bolts from the bottom of the tractor frame.
13. Working from the top of the tractor, remove two mast mounting bolts from each side.
14. Remove the tractor to provide working space at the mast.
15. Wrap hoist straps around each baseleg where they join the mast. Extend the hoist straps in the direction of the tractor and attach to a 3-ton hoist or other suitable lifting device.
16. Keeping tension on the top of the mast, carefully begin lifting at the baseleg straps. The mast will tip forward toward the carriage.
17. Continue lowering the mast into jack stands.
18. Remove the main lift hose at the cylinder manifold. Plug the fitting.
19. Remove the upper and lower cylinder mounting bolts and sleeves at the main frame crossties.

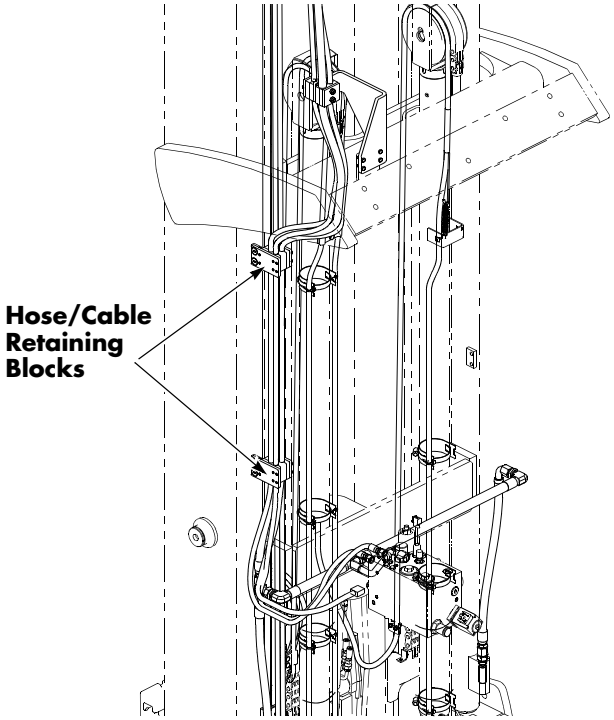
Figure 7-126. Cylinder Mounting Bolts, Model 7620/7640



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20. Extend the outer telescopic about 6 in. (15 cm) to access the cylinder top mounting bolt.
21. Remove the cylinder top mounting bolt.
22. Left-side only: Remove the two hose/cable retaining block assemblies. Do not disassemble the retainers, but remove the entire assembly by removing two countersunk Allen head screws. See Figure 7-127.

Figure 7-127. Hose/Cable Retainer Block Assemblies



23. Remove the set screw at the bottom of the cylinder.
24. Wrap several turns of a hoist strap around the lift cylinder at its midpoint.
25. Using a hoist or other suitable lifting device, carefully remove the cylinder via the bottom of the mast.

Installation

1. Support the mast securely on jack stands, carriage side down. Wrap hoist straps around each baseleg where they join the mast. Extend the hoist straps in the direction of the tractor and attach to a 3-ton hoist or other suitable lifting device. Attach a hoist strap under the top crosstie of the main frame.
2. Wrap several turns of a hoist strap around the lift cylinder at its midpoint.
3. Using a hoist or other suitable lifting device, carefully guide the cylinder into position via the bottom of the mast, engaging the cylinder mounting studs on the main frame crossties.
4. Install the cylinder top mounting bolt.
5. Left-side only: Attach the two hose/cable retaining block assemblies, using two countersunk Allen head screws for each.
6. Attach the main lift hose at the cylinder manifold.
7. Install the upper and lower cylinder mounting bolts and sleeves at the main frame crossties. Torque bolts to 55 ft. lb. (75 Nm).
8. Using a hoist of other suitable lifting device, carefully lift the mast by the hoist strap at the top until the mast is erect.
9. Move the tractor into location with the mast. Support the tractor frame near the mast with blocks to align the mast mounting bolt holes.
10. Working inside the battery compartment, install eight mast mounting bolts at the bottom of the tractor frame. Apply threading-locking compound (P/N 990-669) and torque to 170 ft. lb. (230 Nm).
11. Working from the top of the tractor, install two mast mounting bolts on each side. Apply threading-locking compound (P/N 990-669) and torque to 170 ft. lb. (230 Nm).
12. Connect the main lift hoses at the tractor bulkhead.
13. Connect the auxiliary hydraulic hoses at the main manifold.
14. Connect the over-the-mast electrical cable at connector JPS3 near the main manifold.
15. Attach the forks onto the fork carriage.
16. Attach the battery connector mounting bracket near the mast mounting bolts on the right side.

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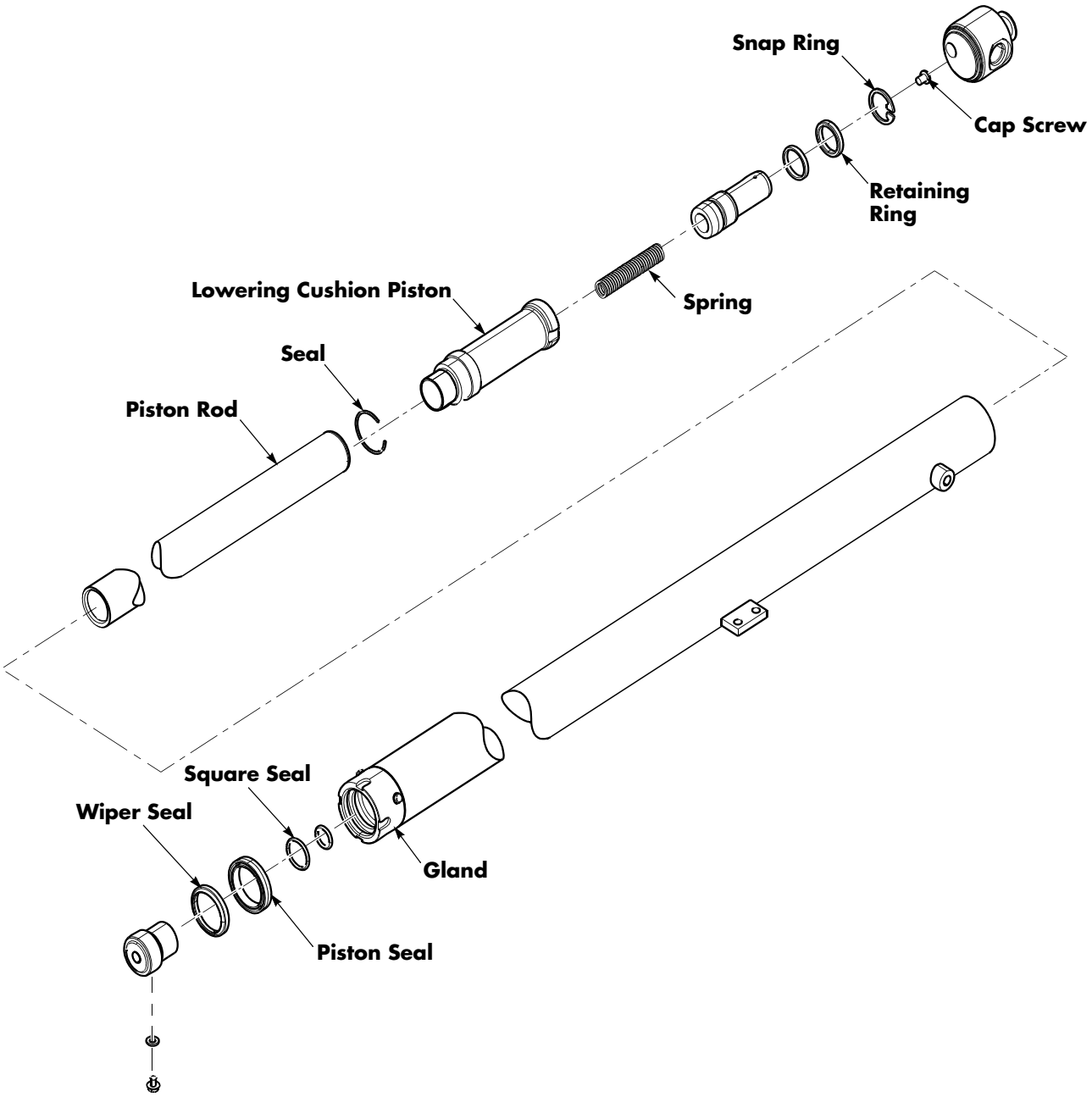
17. Using a suitable battery moving device, install the battery. Install the battery gate.
18. Install the mast guard.
19. Install the top cover.
20. Reconnect the battery connector and turn the key switch ON.
21. Test lift and lower functions for correct operation. Check for hydraulic fluid leaks.

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Lift Cylinder, Main Lift, Exploded Parts Drawing

Model 7600

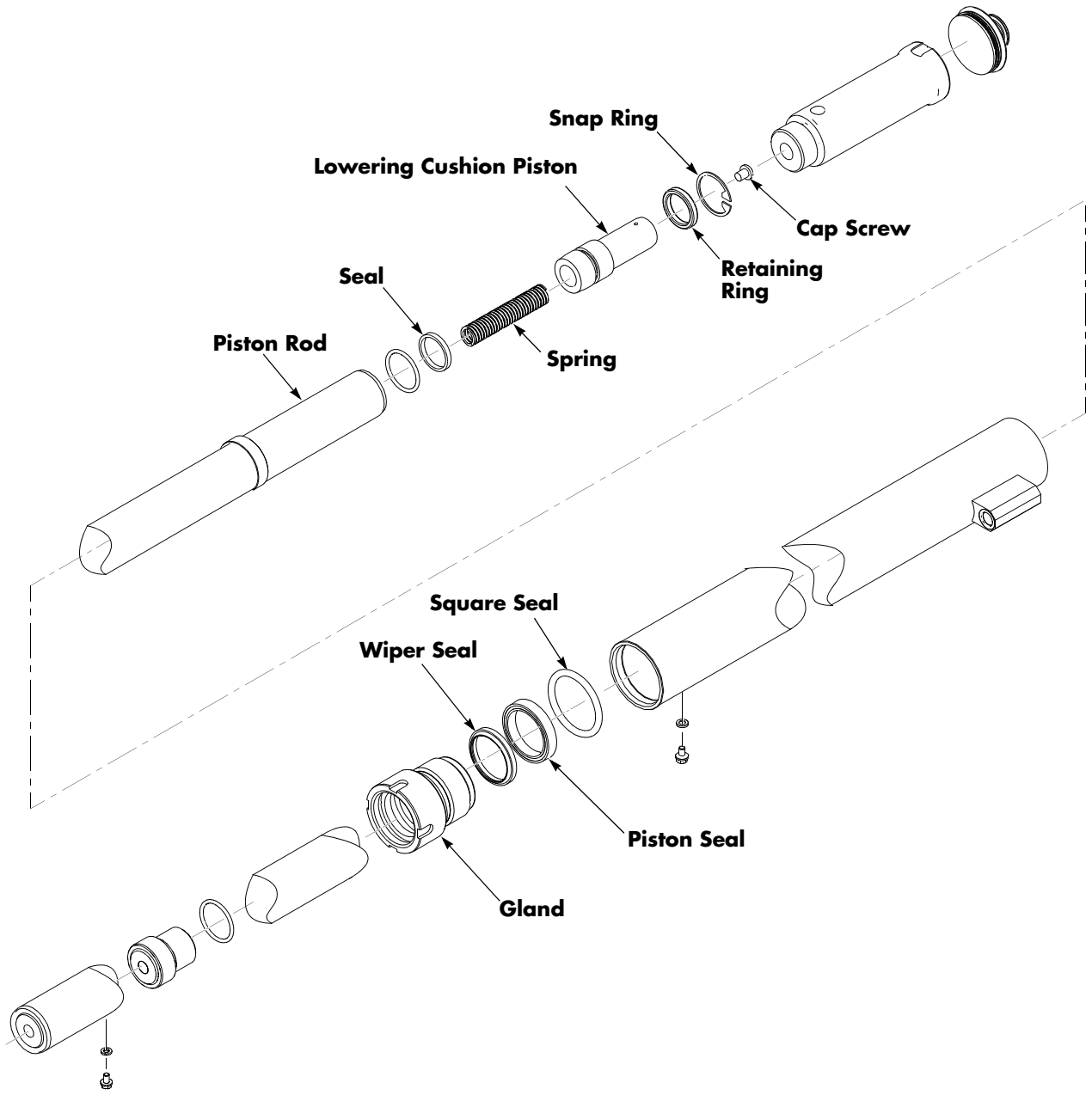
Figure 7-128. Main Lift Cylinder, Model 7600



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Model 7620/7640

Figure 7-129. Main Lift Cylinder, Model 7620/7640



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Lift Cylinder, Main, Seal Repacking

Model 7600

Refer to Figure 7-128.

Disassembly

1. Slightly elevate the mast and place a block between the outer telescopic crosstie and the main frame.
2. Fully lower the carriage.
3. Turn the key switch OFF and disconnect the battery connector.
4. Remove the bolt, washer, and spacer at the top of the piston and the outer telescopic crosstie.
5. Retract the piston into the housing enough to allow the removal of the end cap (gland).
6. Using cylinder end cap tool (P/N 1090761/007), remove the end cap (gland).
7. On a clean working surface, remove the packing seal, wiper seal, and square seal from the end cap. Note position and orientation of each when removing.
8. Inspect the surfaces of the gland for any scratches or damage. Remove minor imperfections using fine emery cloth.
9. Inspect the inside of the housing for damage and clean as required.
10. Clean the threads on the gland and the cylinder.

Reassembly

1. Lubricate with new hydraulic fluid, the packing seal, wiper seal, and square seal and install into their respective grooves on the gland. Make sure they are correctly seated within the grooves and are not twisted.
2. Apply thread-locking compound (P/N 990-571) to the last three threads of the gland.
3. Lubricate the piston rod with new hydraulic fluid and carefully install the gland.
4. Torque the gland to 200 ft. lb. (271 Nm).
5. Reconnect the battery connector and turn the key switch ON.
6. Carefully rotate the lift knob to raise the piston to the telescopic crosstie.
7. Install the bolt, washer, and spacer at the crosstie to the top of the piston.

NOTE: Apply thread-locking compound (P/N 1013829) to the threads of the bolt and tighten, leaving a 0.12 in. (3 mm) gap between the head of the bolt and the washer.

8. Remove the block from between the outer telescopic crosstie and the main frame.
9. Bleed the hydraulic system.
10. Check the truck for leaks and correct operation.

Model 7620/7640

Refer to Figure 7-129.

Disassembly

1. Elevate the mast to produce a 6 to 8 in. (15 to 20 cm) gap between the outer telescopic crosstie and the main frame.
2. Block the mast between the inner and outer telescopics and between the outer telescopic and the main frame.
3. Remove the cylinder mounting bolt at the top of the cylinder.
4. Collapse the cylinder (push on cylinder while requesting lower).
5. Turn the key switch OFF and disconnect the battery connector.
6. Using a 2 in. spanner wrench, remove the end cap (gland).
7. On a clean working surface, remove the packing seal, wiper seal, and O-ring from the gland. Note position and orientation of each when removing.

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8. Inspect the surfaces of the gland for any scratches or damage. Remove minor imperfections using fine emery cloth.
9. Clean the threads on the gland and the cylinder.

Reassembly

1. Lubricate with new hydraulic fluid, the packing seal, wiper seal, and square seal, and install into their respective grooves on the end cap. Make sure they are correctly seated within the grooves and are not twisted.
2. Apply thread-locking compound (P/N 990-571) to the last three threads of the gland.
3. Lubricate the piston rod with new hydraulic fluid and carefully install the gland.
4. Torque the gland to 200 ft. lb. (271 Nm).
5. Reconnect the battery connector and turn the key switch ON.
6. Carefully rotate the lift knob to raise the piston to the telescopic crosstie.
7. Install the bolt, washer, and spacer at the crosstie to the top of the piston.

NOTE: Apply thread-locking compound (P/N 1013829) to the threads of the bolt and tighten, leaving a 0.12 in. (3 mm) gap between the head of the bolt and the washer.

8. Remove the blocking from between the inner and outer telescopics and between the outer telescopic and the main frame.
9. Bleed the hydraulic system.
10. Check the lift truck for leaks and correct operation.

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Lift Cylinder Lowering Cushion

Main Lift Cylinders

For Model 7600, refer to Figure 7-128. For Models 7620/7640, refer to Figure 7-129.

Removal

1. Remove the main lift cylinder.
   a. For Model 7600, refer to "Lift Cylinder, Main, Remove/Install", "Model 7600".
   b. For Model 7620/7640, refer to "Lift Cylinder, Main, Remove/Install", "Model 7620/7640".
2. Remove the piston rod from the cylinder. See "Lift Cylinder, Main, Seal Repacking".
3. Place the piston rod on a clean padded working surface.
4. Compress the spring and hold it in place with a drill bit or drift pin inserted in one of the hydraulic fluid ports in the cushion housing.

⚠CAUTION

When the snap ring is removed, the cushion spring ejects the cushion from the piston. Keep body away from the piston end when performing this procedure.

5. Remove the snap ring from inside of the cylinder.
6. Release the cushion slowly.
7. Remove the ring retainer and seal from the cushion.
8. Replace the cushion, spring, seal, and/or retainer components as necessary. If replacing the cushion, install the cap screw in the end of the cushion.

Reassembly

1. Lubricate the inside of the piston surface with clean hydraulic fluid.
2. Lubricate the seal with clean hydraulic fluid and install on the cushion. Install the retainer ring on the cushion.
3. Insert and seat the cushion spring in the center of the piston. Insert and seat the cushion on the end of the cushion spring.
4. Compress the spring and hold it in place with a drill bit or drift pin inserted in one of the hydraulic fluid ports in the cushion housing.
5. Install the snap ring.
6. Carefully release cushion pressure.
7. Reassemble the cylinder. See "Lift Cylinder, Main, Seal Repacking".
8. Install the cylinder.
   a. For Model 7600, refer to "Lift Cylinder, Main, Remove/Install", "Model 7600".
   b. For Model 7620/7640, refer to "Lift Cylinder, Main, Remove/Install", "Model 7620/7640".

Free Lift Cylinders

NOTE: For Model 7600, refer to Figure 7-122. For Model 7620/7640, refer to Figure 7-123.

Removal

There is a staging zone mechanism in the free lift cylinders in addition to a cushion at the bottom of the cylinder.

1. Using an eye bolt and hoist, remove the piston rod from the cylinder.
   a. For Model 7600, perform steps 1 thru 9 of "Lift Cylinder, Free Lift, Seal Repacking", "Model 7600", "Disassembly".
   b. For Model 7620/7640, perform steps 1 thru 10 of "Lift Cylinder, Free Lift, Seal Repacking", "Model 7620/7640", "Disassembly",
2. Place the piston rod on a clean padded working surface.

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3. Compress the spring and hold it in place with a drill bit or drift pin inserted in one of the hydraulic fluid ports in the cushion housing.

⚠CAUTION

When the snap ring is removed, the cushion spring ejects the cushion from the piston. Keep body away from the piston end when performing this procedure.

4. Remove the snap ring from inside of the cylinder.
5. Release the cushion slowly.
6. Remove the retaining ring and the two O-rings on the inside and outside of the ring.
7. Remove the spring and decel piston.
8. Remove the decel bearing and piston ring from the decel piston.
9. Remove the spring and plug from the cushion housing (piston plug).
10. Remove the O-ring from the plug.

Reassembly

1. Lubricate new O-rings, piston ring, and decel bearing with clean hydraulic fluid.
2. Install the new piston ring and decel bearing in the decel piston.
3. Lubricate the inside of the piston surface with clean hydraulic fluid.
4. Install the new O-ring in the groove in the plug and install the plug in the cushion housing.
5. Seat the plug in the housing by inserting the spring and the decel piston in the cushion housing.
6. Install the other spring.
7. Install new O-rings on the inside and outside of the retaining ring.
8. Install the retaining ring on the shaft of the decel piston.
9. Compress the spring and hold it in place with a drill bit or drift pin inserted in one of the hydraulic fluid ports in the cushion housing.
10. Install the snap ring in the cushion housing.
11. Release the cushion slowly.
12. Reassemble the cylinder.
    a. For Model 7600, perform steps 2 thru 14 of "Lift Cylinder, Free Lift, Seal Repacking", "Model 7600", "Reassembly".
    b. For Model 7620/7640, perform steps 3 thru 12 of "Lift Cylinder, Free Lift, Seal Repacking", "Model 7620/7640", "Reassembly".

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Reach Cylinder

Reach Cylinder, Standard and *Deep-Reach*

Removal

1. Remove the mast guard.
2. Raise the carriage until the reach cylinder is accessible from the operator's compartment.
3. Fully retract the carriage.
4. Turn the key switch OFF and disconnect the battery connector.
5. Place a pan below the reach cylinder.
6. Remove and cap the reach hoses at the reach cylinder.
7. Remove the screw and cotter pin holding the piston yoke in place.
8. Remove the clevis pin and spacers.
9. Remove the screw and cotter pin at the housing end.
10. While supporting the cylinder, remove the clevis pin and spacers holding the cylinder in place.

Disassembly

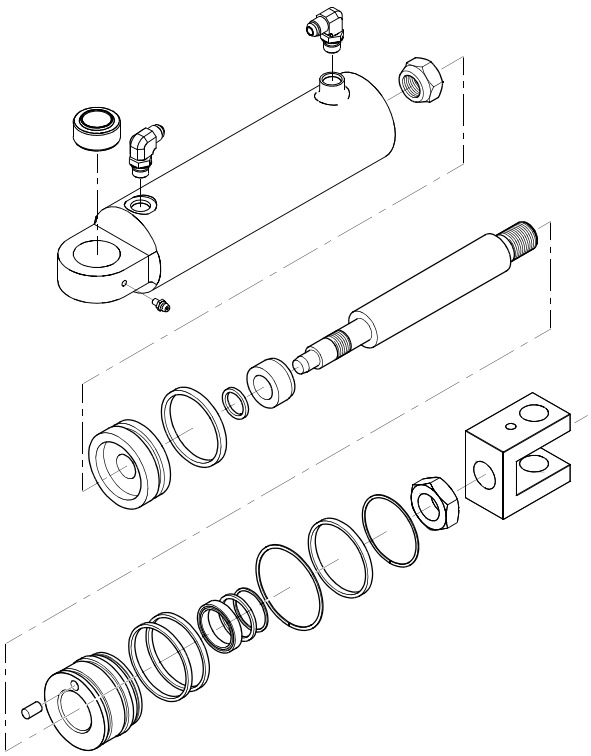
1. With the cylinder removed, drain all hydraulic fluid from the cylinder assembly.
2. Clamp the cylinder base end in a bench vise. Cover the ports with a clean rag.
3. Remove the external lock ring.
4. Push the head assembly into the tube assembly approximately 3/4 in. (19 mm).
5. Remove the spacer.
6. Remove the internal lock ring.
7. *Important:* Look for and remove any sharp edges from the back corner of the internal lock ring groove, if present.
8. Grip the rod firmly and pull the rod assembly out of the tube assembly. (Oil can spray out of the cylinder ports).
9. Clamp the rod at the wrench flats or clevis in a soft-jawed vise. Loosen the retaining nut on the piston assembly.
10. Slide the piston assembly off the end of the rod.
11. Slide the cushion sleeve off the rod. Note the direction of the taper.
12. Remove the head assembly.
13. Remove the head static seal O-rings, backup washers, rod inside diameter dynamic seal, and the rod wiper. Use care to avoid scratching the groove.
14. Remove the O-ring and backup washers from the piston assembly.

Reassembly

1. Remove any burrs or sharp edges caused from disassembly before installing the new seals.
2. Clean all parts with solvent. Lubricate parts with petroleum jelly or clean hydraulic fluid as indicated.
3. Lubricate and install the new rod, dynamic seal, and rod wiper in their respective inside grooves of the head assembly.
4. Lubricate and install the new head static seal O-rings and head static seal backup washers on the outside grooves of the head assembly.
5. Lubricate the head assembly inside seals and carefully slide the head assembly onto the rod assembly.

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Figure 7-130. Reach Cylinder



6. Install the piston O-ring and backup washers in the outside groove of the piston assembly.
7. Slide the cushion sleeve onto the rod.

NOTE: The taper on the cushion faces the head assembly.

8. Carefully slide the piston assembly onto the rod assembly. Install a new prevailing torque nut and tighten.
9. Lubricate the piston and head assembly and carefully slide it into the tube assembly.
10. Push the head assembly into the tube assembly approximately 3/4 in. (19 mm).
11. Install a new internal lock ring in the groove in the tube assembly bore.
12. Grip the rod firmly and pull outward until the head assembly is tight against the lock ring.
13. Install the spacer and external lock ring in the head assembly.

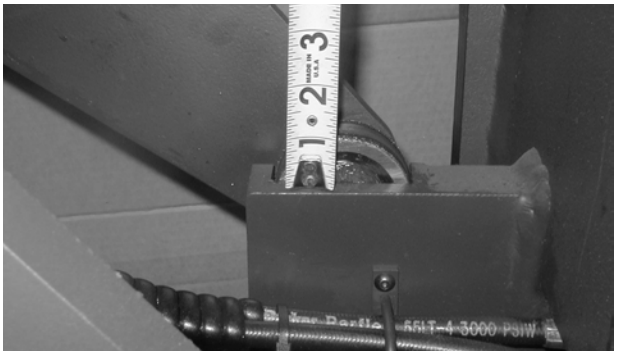
Installation

1. Place the spacers on the cylinder (hold them in place with grease) and position the cylinder housing into the yoke on the carriage. Insert the clevis pin and secure with the cotter pin and screw.
2. Place the spacers on the carriage bracket (hold them in place with grease). Position the piston yoke and insert the clevis pin. Secure with the cotter pin and screw.
3. Reconnect the hydraulic hoses.
4. Reconnect the battery connector and turn the key switch ON.
5. Bleed the hydraulic system.
6. Adjust the reach cylinder. See "Adjustment".
7. Check the truck for leaks and correct operation.
8. Install the mast guard.

Adjustment

The top of the scissor roller must not protrude more than 0.90 in. (22.8 mm) from the top of the roller channel on the fork carriage. This takes precedence over the extended dimension.

Figure 7-131. Scissor Roller Dimension



When the reach is fully extended, the dimension from the front of the main frame to the face of the forks when level should be as listed in Table 7-14.

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Table 7-14. Reach Dimension

Carriage	Dimension
R45TT	28.38 in. (720.00 mm)
DR32TT	53.40 in. (1356.4 mm)

Figure 7-132. Reach Fully Extended Dimension



NOTE: The face of the fork to the front of the load wheel (or wheel box) should be a minimum of 0.50 in. (13 mm). If not, perform the adjustment procedure.

Adjustment Procedure

1. Loosen the jam nut that holds the piston to the yoke.
2. Turn the piston to obtain the correct dimension.
3. Apply thread-locking compound (P/N 1013829) to the threads on the piston and torque the jam nut to 175 ft. lb. (237 Nm).

Retract Adjustment

Model 7600/7620/7640 lift trucks are designed with reach and retract stops inside the reach cylinder at both ends of the stroke. When the scissors mechanism is fully retracted, there should be a gap between the plastic block and the metal block (*Deep-Reach*) or fixed carriage (Standard Reach). This is a backup stop only. Shim the plastic block to produce the gap listed in Table 7-15.

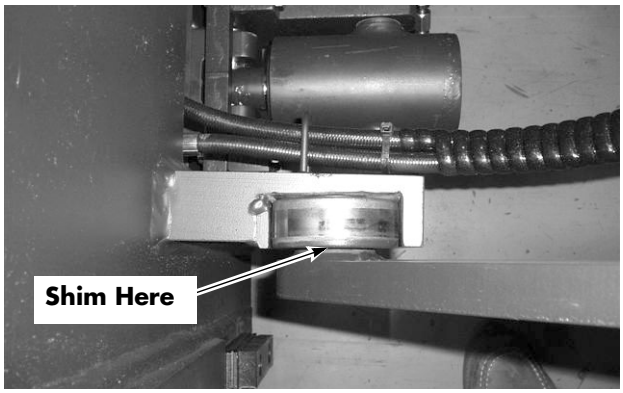
Table 7-15. Gap Dimension

Carriage	Gap
Standard Reach	0.125 to 0.250 in. (3.2 to 6.4 mm)
Deep-Reach	0.125 to 0.375 in. (3.2 to 9.5 mm)

Reach Scissor Roller Shimming

Make sure at least half of the thickness of the scissor roller is running on the roll plate wear bar. Shim as needed between the shoulder of the scissor arm stud and the bearing inner race. See Figure 7-133.

Figure 7-133. Reach Scissor Roller Bearing Shimming



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Tilt Cylinder

Removal

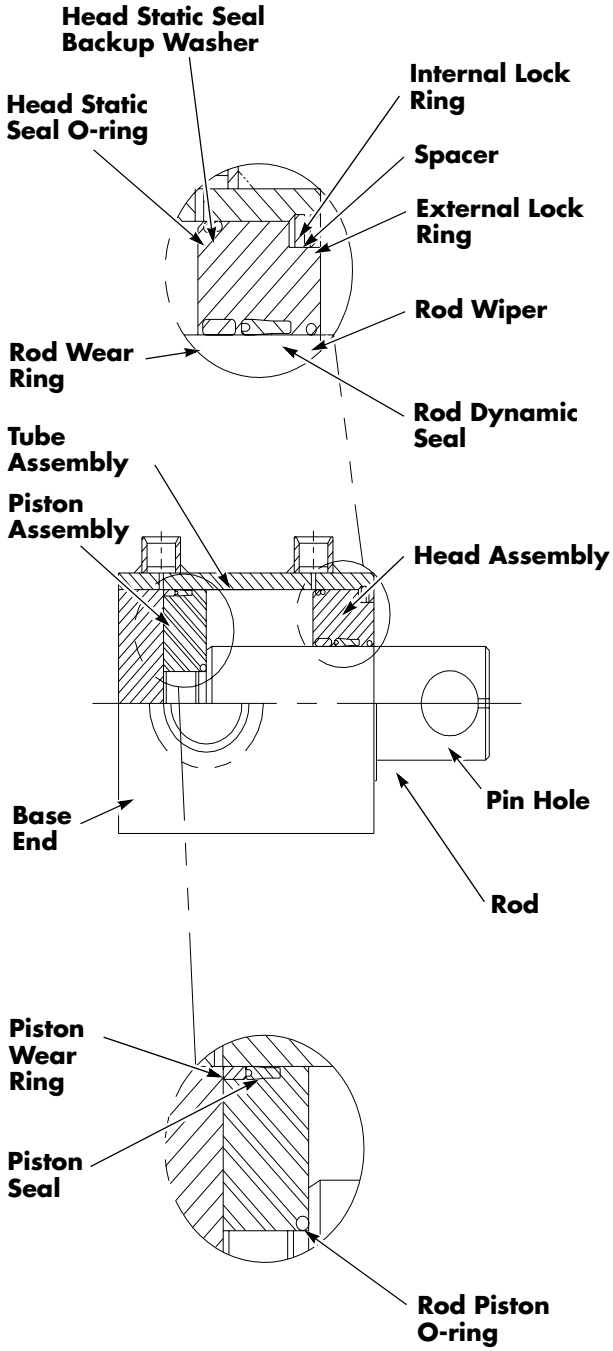
1. Extend and block the scissor assembly so it cannot retract.
2. Position and block the carriage at a comfortable working height.
3. Spread the forks on the carriage to gain complete access to the tilt cylinder.
4. Tilt the forks completely up.
5. Turn the key switch OFF and disconnect the battery connector.
6. Remove the snap rings from the tilt pin.
7. Place a block between the fork carriage and the carriage frame.
8. Remove the tilt pin.
9. Place a pan below the tilt cylinder and disconnect and cap the hydraulic hoses. Note the orientation of the fittings and position of the hoses.
10. Support the tilt cylinder and remove the mounting bolts from the mounting blocks.

Disassembly

With the cylinder removed, drain all hydraulic fluid from the cylinder assembly. Clamp the cylinder at the base end in a bench vise. Cover the ports with a clean rag. Refer to Figure 7-134 for the following steps.

1. Remove the external lock ring.
2. Remove the spacer.
3. Push the head assembly into the tube assembly approximately 3/4 in. (19 mm).
4. Remove the internal lock ring.
5. *Important:* Remove the sharp edge from the back corner of the internal lock ring groove.
6. Grip the rod through the hole in the pin and pull the rod assembly out of the tube assembly.
7. Clamp the rod in a bench vise at the pin hole end.

Figure 7-134. Tilt Cylinder, Disassembly



8. Loosen the piston assembly with a spanner wrench. Unthread the piston assembly from the rod.
9. Slide the head assembly off the rod from the piston end.

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10. Clean the male threads of the rod. Remove the rod piston O-ring.
11. Remove the head static seal O-ring, backup washer, wear ring, rod dynamic seal, and rod wiper. Use care to avoid scratching grooves.
12. Remove the wear ring and piston dynamic seal from the piston assembly. Use care to avoid scratching grooves.
13. Clean all parts in solvent.

Reassembly

1. Remove any burrs or sharp edges caused from disassembly before installing new seals.
2. Lubricate parts as indicated below with petroleum jelly or clean hydraulic fluid.
3. Lubricate and install a new rod wear ring, rod dynamic seal, and rod wiper in their respective inside grooves of the head assembly.
4. Lubricate and install a new head static seal, O-ring, and head static seal backup washer on the outside grooves of the head assembly.
5. Lubricate the head assembly inside seals with hydraulic fluid and carefully slide the head assembly onto the rod assembly.
6. Install the piston wear ring and piston seal in their respective outside grooves of the piston assembly.
7. Install the rod piston O-ring in the groove of the rod.
8. Apply red thread-locking compound (P/N 990-571) to the male threads of the piston. Carefully thread the piston assembly onto the rod assembly. Torque to 200 ft. lbs. (271 Nm).
9. Lubricate the piston and head assembly with hydraulic fluid and carefully slide it into the tube assembly.
10. Push the head assembly into the tube assembly approximately 3/4 in. (19 mm).
11. Install a new internal lock ring in the groove in the tube assembly bore.
12. Grip the rod through the pin hole and pull outward until the head assembly is tight against the lock ring.
13. Install the spacer and external lock ring on the head assembly.
14. Stroke the cylinder rod back and forth by hand. It should move smoothly, without binding or heavy drag.
15. Install the cylinder assembly in the lift truck.

Installation

1. Make sure the hydraulic fittings are in the same orientation on the cylinder as when removed.
2. Install the yokes on the cylinder and position the cylinder in place. Bolt the yokes to the carriage.
3. Connect the hydraulic hoses noting their correct orientation and position.
4. Coat the tilt cylinder pin with all weather grease (P/N 1012992). Install the tilt cylinder pin and snap rings.
5. Reconnect the battery connector and turn the key switch ON.
6. Remove the blocks.
7. Check for clearance between the free lift feed hose assembly, tilt hoses, and fittings when the carriage is fully lowered and retracted.
8. Check the tilt function for correct operation and leaks.
9. Bleed the hydraulic system. See "Hydraulic System Bleeding" on page 7-74.

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Flow Limiter, Main Lift

The main lift cylinder flow limiter restricts lowering flow to 15 gpm (57 l per minute). These flow limiters can be replaced without removing the cylinder.

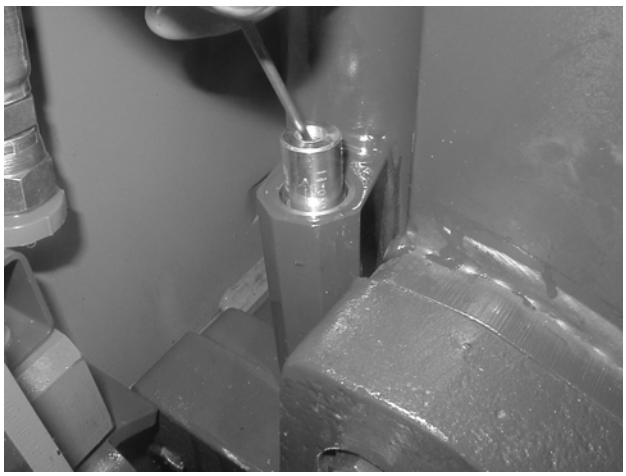
On Model 7600, a single main lift cylinder flow limiter is located in the manifold block at the bottom of the right side main lift cylinder.

On Models 7620 and 7640, there are two main lift cylinder flow limiters, one in the manifold block at the bottom of each main lift cylinder.

Removal

1. Fully lower the carriage to the floor.
2. Turn the key switch OFF and disconnect the battery connector.
3. Remove the top cover and front cover(s).
4. Place a pan below the baseleg at the cylinder.
5. Disconnect and cap the hose at the bottom of the cylinder.
6. Remove the fitting from the manifold block.
7. Remove the flow limiter noting the direction of the arrow.

Figure 7-135. Flow Limiter



Installation

1. Install the flow limiter. Make sure the arrow points in the up direction.
2. Install the fitting in the manifold block.
3. Reconnect the hose to the cylinder.
4. Reconnect the battery connector and turn the key switch ON.
5. Bleed the hydraulic system. See "Hydraulic System Bleeding" on page 7-74.
6. Check the truck for leaks and correct operation.
7. Install the top and front covers.

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Flow Limiter, Free Lift

On Model 7600, the free lift flow limiter is located in the manifold block at the bottom of the left side free lift cylinder.

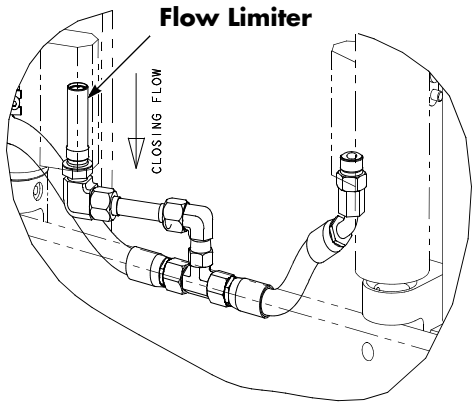
On Models 7620 and 7640, the free lift flow limiter is located inline between the free lift cylinder and hydraulic line. The number and location of flow limiter(s) may vary among trucks.

Model 7600

Removal

1. Remove the mast guard.
2. Raise the telescopics until the bottom of the left free lift cylinder is accessible from the operator's compartment.
3. Place a block of sufficient length (approximately 24 in./610 mm) between the outer telescopic crosstie and the main frame to hold the position in step 2.
4. Fully lower the carriage.
5. Extend the reach mechanism to allow easier removal of the free lift lines and fittings.
6. Turn the key switch OFF and disconnect the battery connector.
7. Place a pan below the baseleg at the left free lift cylinder.
8. From the operator's compartment, remove and cap the hydraulic line at the bottom of the free lift cylinder. See Figure 7-136.
9. Remove the set screw at the bottom of the free lift cylinder to permit the cylinder to rotate for the removal of the fitting.
10. Remove the fitting from the manifold block.
11. Remove the flow limiter, noting the direction of the arrow.

Figure 7-136. Free Lift Flow Limiter, Model 7600



Installation

1. Install the flow limiter. Make sure the arrow points in the down direction.
2. Install the fitting in the manifold block.
3. Install the set screw at the bottom of the cylinder.
4. Reconnect the hydraulic line at the bottom of the cylinder.
5. Reconnect the battery connector and turn the key switch ON.
6. Remove the block between the outer telescopic and main frame.
7. Bleed the hydraulic system. See "Hydraulic System Bleeding" on page 7-74.
8. Check the truck for leaks and correct operation.
9. Install the mast guard.

Model 7620/7640

NOTE: The number and location of flow limiter(s) may vary among trucks.

Removal

1. Fully lower the mast.
2. Turn the key switch OFF and disconnect the battery connector.
3. Using a suitable hoist, raise the carriage at least 4 feet (1.2 m) and secure.
4. Place a shallow pan below the flow limiter.

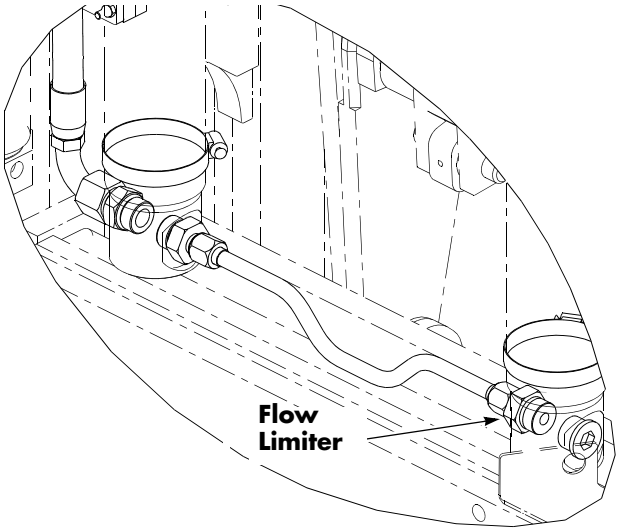
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5. Disconnect and cap the hydraulic hose at the bottom of the cylinder.
6. Remove the flow limiter from the cylinder, noting the direction of the arrow.

Installation

1. Install the flow limiter in the cylinder. Make sure the arrow points toward the outside of the truck.
2. Reconnect the hydraulic hose at the bottom of the cylinder.
3. Reconnect the battery connector and turn the key switch ON.
4. Using the hoist, lower the carriage completely.
5. Bleed the hydraulic system. See "Hydraulic System Bleeding" on page 7-74.
6. Check the truck for leaks and correct operation.

Figure 7-137. Free Lift Flow Limiter, Model 7620/7640



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RAYMOND

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Mast, Chain, Hose, Cable

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Reach Carriage Bearings

The upper reach carriage roller bearing is accessible when the carriage is elevated. The reach carriage must be removed to access the middle and lower bearings. The bearings are shimmed at the factory to a 0.00 ±0.010 overall interference between the bearings and the inner telescopic after the inner telescopic is shimmed and inserted in the outer telescopic. Inspect bearings for damage or wear and replace as required.

Removal

1. Remove the carriage. See “Carriage” on page 7-124.
2. Remove the socket head cap screw and washer on the end of the bearing.
3. The bearing should slide off the shaft with hand pressure. A suitable bearing puller can be used if required.

Installation

Shim the top and middle bearings to obtain an overall width equal to the minimum inner telescopic dimension (±0.010 in. [.25 mm]) taken from the inside to inside of the I-beam webs at the front flange of the inner telescopic.

Shim the bottom bearings to obtain an overall width equal to the minimum inner telescopic dimension (±0.010 in./0.25 mm) taken from the inside to inside of the I-beam webs at the rear of the inner telescopic.

If possible, maintain an equal amount of shim thickness on each side of the carriage when shimming the bearings.

1. Install or remove the required amount of shims.
2. Install the bearing on the shaft.
3. Apply thread-locking compound (P/N 990-536) to the socket head cap screw and fasten the screw and washer in place.
4. If the inner race of the bearing does not protrude past the end of the shaft when the bearing is fully seated, bend the flat washer to contact the bearing so the bearing does not walk on the shaft.
5. Repeat steps 1 thru 4 for the five remaining bearings.
6. Clean and re-grease the telescopic channels.
7. Re-install the carriage. See “Carriage” on page 7-124.
8. Test the reach/retract functions of the carriage.

Adjustment

Test reach carriage operation. If there is any kick or forks are not level, adjust eccentric pins as necessary. Start with lower carriage roller bearing pins.

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Mast Shimming

Shimming a mast makes a smooth running unit that is not too tight or too loose. If you find any marks within the telescopics or main frame where the rollers have been running, remove them, using a sanding disc and 80 grit paper. Do not attempt to remove all marks, only the ridges. Shim the bearings to the tightest spot on the assembly (as the rollers run up and down the rail). Buff small areas that are slightly higher than the rest of the web to avoid shimming the major portion of the rail too loose. The shims used under each roller bearing come in the following sizes: thin, medium and thick. Although you can use different combinations of shims to obtain the correct adjustment, you should try to maintain equal shim thickness on each side of the mast.

Shimming Procedure

1. Elevate the mast to gain access to the bearings.
2. Place a block between the outer telescopic crosstie and the main frame.
3. Fully lower the carriage.
4. Turn the key switch OFF and disconnect the battery connector.

NOTE: When removing the upper bearings, use caution not to let the bearing fall down into the mast assembly. If the bearings are worn or damaged, replace them.

5. Remove the bolt and roller stud sleeve securing the roller bearing to the respective mast or telescopic.
6. Remove the bearing.

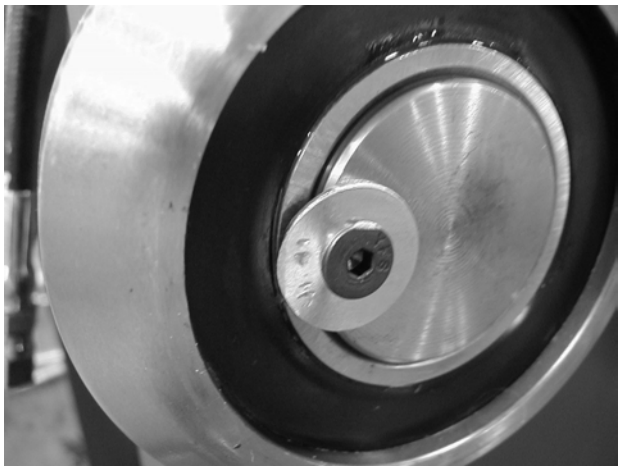
NOTE: It may be necessary to drive a wedge between the respective telescopics to provide clearance for removal and installation.

7. Remove the socket head cap screw and washer retaining the bearing on the stud.

NOTE: Shim the main frame top bearing and the outer telescopic lower bearing set to a 0.030 ±0.010 in. overall interference.

8. Shim the outer telescopic upper bearing set to 0.000 ±0.010 in. overall interference with the inner telescopic after the top main frame bearings have been correctly shimmed.
9. Shim the inner telescopic lower bearing set to 0.030 ±0.010 in. overall interference with the outer telescopic after the outer telescopic lower bearings have been set.
10. Install or remove the required amount of shims.
11. Install the bearing on the shaft.
12. Apply thread-locking compound (P/N 990-536) to the socket head cap screw and fasten the screw and washer in place.
13. If the inner race of the bearing does not protrude past the end of the bearing stud when the bearing is fully seated, bend the flat washer to contact the bearing to prevent the bearing from walking on the stud shaft.

Figure 7-138. Inner Race



14. Install the bearing assembly into its respective mast or telescopic. Make sure that the flat spot of the bearing stud aligns with the welded stop on the mast or telescopic.
15. Install the roller stud sleeve.
16. Apply thread-locking compound (P/N 1013829) to the threads of the mounting bolt and torque to 260 ft. lb. (352.5 Nm).

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17. Reconnect the battery connector and turn the key switch ON.
18. Remove the block from between the outer telescopic and the main frame.
19. Test the operation of the elevating assembly.

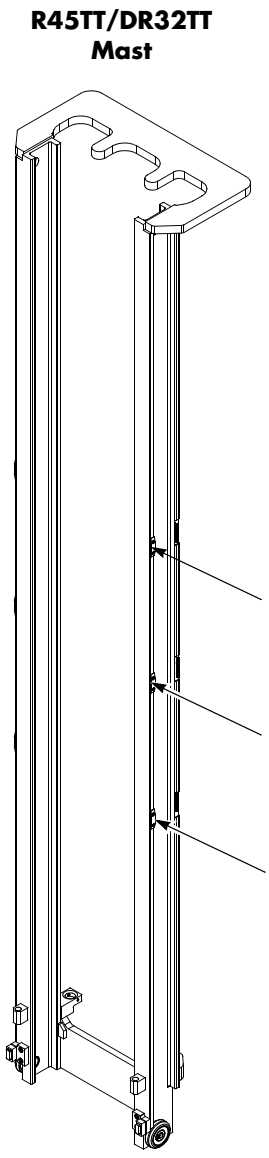
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Bow Pads - Model 7600

Inspection and Adjustment R45TT and DR32TT

1. Elevate the mast to expose the bow pads mounted on the outside of the inner telescopic. Pads are on the leading (forks side) edge of the rail. See Figure 7-139.

Figure 7-139. Bow Pad Locations



2. Examine each bow pad and measure its thickness. If the thickness is <0.187 in. (4.75 mm), replace the pad. Lower the mast. Using a suitable feeler gauge, check the clearance gap of the bow pads between the inner telescopic and the outer telescopic. See Figure 7-140 and Figure 7-141.

Figure 7-140. Inner Telescopic Bow Pads Model 7600 R45TT/DR32TT Mast

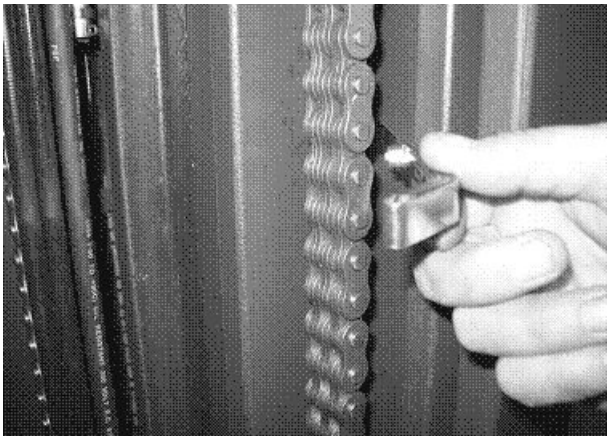


Figure 7-141. Inner Telescopic Bow Pads



3. Shim as required to obtain a gap of 0.03 to 0.09 in. (0.8 to 2.3 mm).

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Carriage

Model 7600

The carriage is removed through the top of the mast.

⚠ WARNING

A standard carriage without forks weighs approximately 880 lbs. (363 kg). A *Deep-Reach*® carriage without forks weighs approximately 1100 lbs. (500 kg).

Removal

1. Remove mast guard and top cover.
2. Remove forks.
3. Remove the mounting bolts from the hose/cable guide and retainer at the back of the carriage.
4. Retract scissor assembly.
5. Disconnect the OTM cable at JPS3 in the tractor.
6. Remove the auxiliary manifold cover and disconnect the over-the-mast (OTM) cable at TS2. Remove the auxiliary manifold mounting screws.
7. Elevate the carriage to gain access from the operator's compartment to the carriage stops and the OTM hose fittings at the auxiliary manifold.
8. Turn the key switch OFF and disconnect the battery.
9. Remove the OTM hoses from the carriage manifold. Cap hoses and plug the fittings.
10. Remove the carriage stops.
11. Using a suitable lifting device, lift the carriage assembly to relieve the tension from the free lift chains.
12. Remove the master link from the free lift chains at the free lift cylinder anchor bolts. Twist the right side pulley to allow the removal of the chain.
13. Drape the chains over the carriage assembly.
14. Carefully lift the carriage assembly out of the mast assembly.

NOTE: Twist the left side free lift pulley to allow the carriage stop mounting block to clear.

Installation

1. Lower the carriage assembly into telescopic.
2. Continue lowering carriage to an appropriate height and reconnect free lift chains to the anchors.
3. Connect the OTM hoses to the auxiliary manifold.
4. Remove the lifting device.
5. Connect the cable to TS2 at carriage and JPS3 in tractor.
6. Attach the manifold cover to the carriage. Apply thread-locking compound (P/N 1013829) to the mounting bolts and torque to 30 ft. lb. (42 Nm).
7. Mount the auxiliary manifold to the carriage. Apply thread-locking compound (P/N 990-536) to the mounting bolts and torque to 21 ft. lb. (29 Nm).
8. Extend the reach. Block the carriage at an appropriate height to relieve the tension on the OTM hoses and cable to install the hose/cable guide retainer at the back of the carriage.
9. Apply thread-locking compound (P/N 1013829) to the mounting bolts and install the hose/cable guide retainer at the back of the carriage.
10. Install the carriage stops.
11. Install the forks.
12. Check the tension of the hoses, cable, and free lift chains. Adjust as required.
13. Bleed the hydraulic system. See "Hydraulic System Bleeding" on page 7-74.
14. Check for leaks and test the truck for correct operation.
15. Install the top cover and mast guard.

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Model 7620/7640

The carriage is removed from the top of the mast.

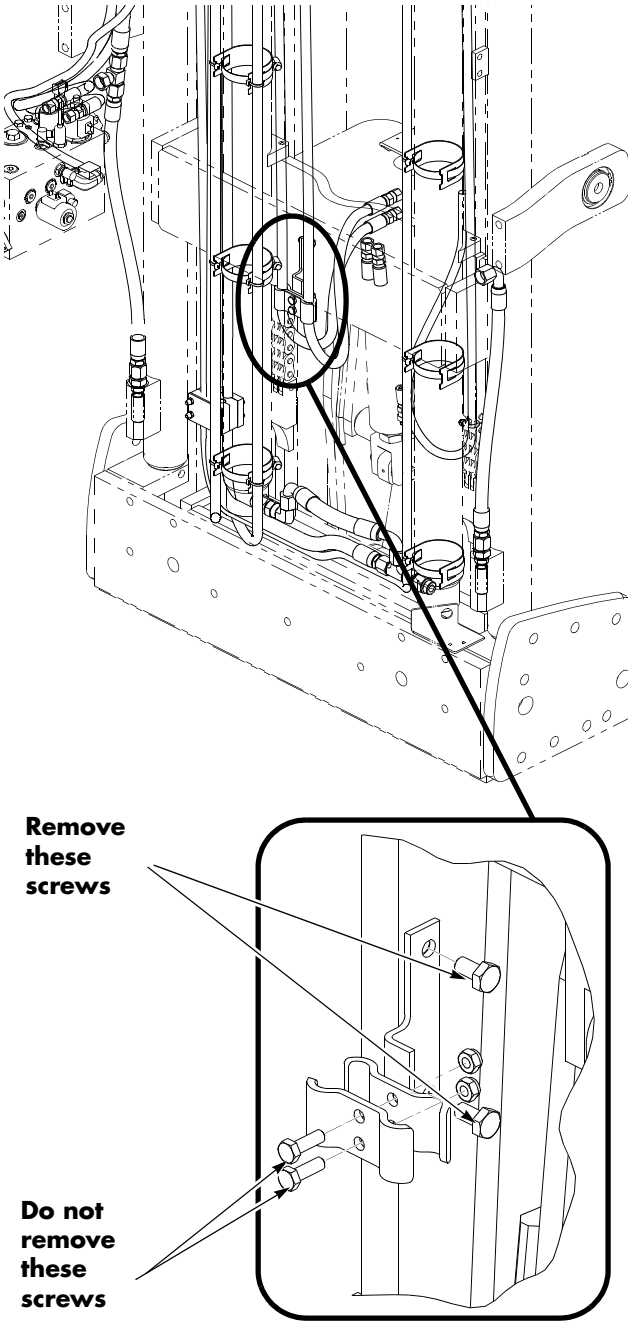
⚠ WARNING

A standard carriage without forks weighs approximately 880 lbs. (363 kg). A *Deep-Reach*® carriage without forks weighs approximately 1100 lbs. (500 kg).

Removal

1. Using a suitable work platform, remove the carriage stops at the top of the inner telescopic.
2. Remove the mast guard and top cover.
3. Remove the forks.
4. Elevate the carriage approximately 3 ft. (1 m) for access to the auxiliary manifold.
5. Slightly extend the carriage. Attach hoist straps at three points to keep the carriage level.
6. Using a hoist or other suitable lifting device, lift the carriage slightly to slacken the chains.
7. Remove the auxiliary manifold cover.
8. Disconnect the over-the-mast (OTM) cable at terminal strip TS2, marking wires as needed to aid in reconnection.
9. Loosen the auxiliary manifold mounting bolts.
10. Remove the auxiliary hoses at the auxiliary manifold, marking them if necessary for re-assembly.
11. Loosen and remove the auxiliary hose clamp on the carriage. See Figure 7-142.

Figure 7-142. Model 7640 Auxiliary Hose CLamp



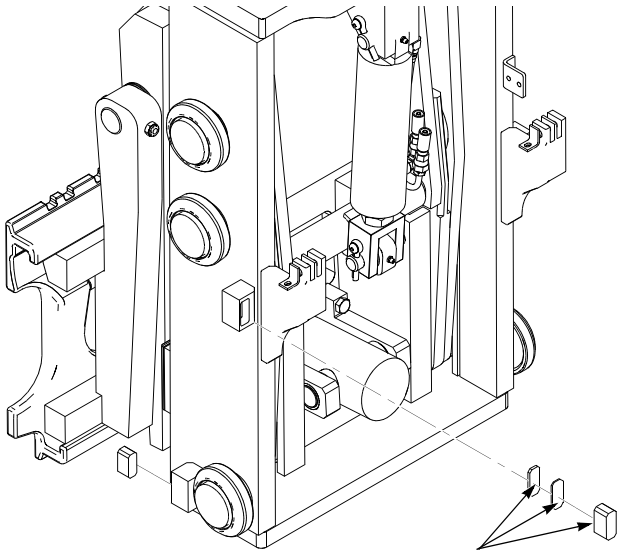
12. Loosen the U-clamp and feed the OTM cable through.
13. Disconnect the OTM tensioning spring and feed the cable through the bracket on the free lift cylinder.
14. Remove the button head screw from both chain anchor pin retainers. Remove the pins to free the chains from the anchors.

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15. Using a hoist or other suitable lifting device, carefully lift the carriage out the top of the mast.

NOTE: Observe the four kickback pads and shims located between the carriage and the inner telescopic. They may fall out as the carriage emerges from the mast.

Figure 7-143. Carriage Kickback Pads



Kickback Pad and Shims (both sides)

Installation

1. Make sure the free lift cylinder pulleys are pivoted 90°.
2. Make sure the top carriage bearing keepers are in place.
3. Using a hoist or other suitable lifting device, carefully lower the carriage into the mast.

NOTE: Make sure the four kickback pads are in place and shimmed snug to the mast as the carriage is lowered into the mast. A dab of grease will hold the pads and shims in place while lowering.

4. Pivot the free lift cylinder pulleys fore-aft.
5. Reattach the auxiliary hose bracket.
6. Reconnect the auxiliary hoses to the auxiliary manifold.
7. Tighten the auxiliary manifold mounting bolts.
8. Feed the over-the-mast cable through the U-clamp and tighten the U-clamp snug. Do not overtighten.
9. Connect the over-the-mast cable wires at terminal strip TS2.
10. Reinstall the auxiliary manifold cover.
11. Release hoist tension on the carriage. Remove hoist straps.
12. Reinstall the forks.
13. Reinstall the mast guard and top cover.
14. Reconnect the battery connector and turn the key switch ON.
15. Test all carriage functions for correct operation. Check for hydraulic leaks.

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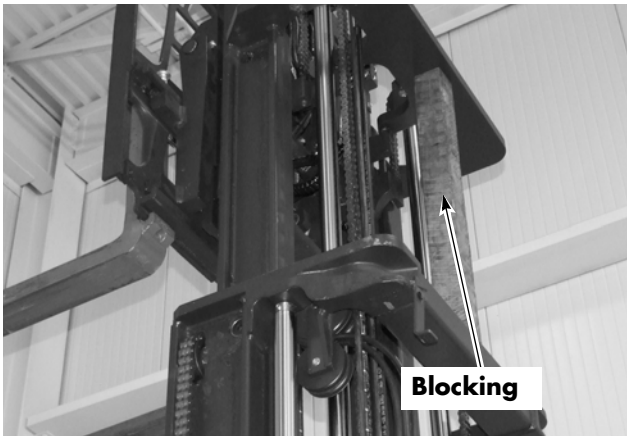
Chain Anchors

Main Lift Chain Anchors

Preparation for Removal - 7600 and 7620

1. Place a block between the outer telescopic crosstie and the main frame crosstie and a slightly longer block between the inner telescopic crosstie and the outer telescopic crosstie. This provides the required slack in the chains. See Figure 7-144.

Figure 7-144. Blocking Telescopics

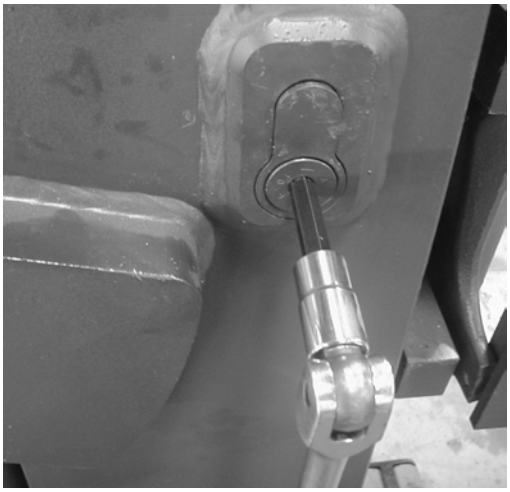


2. Lower the carriage and block at a height that allows access to the lower chain anchors at the bottom of the inner telescopic. If only the upper anchors are being removed, fully lower the carriage.
3. Turn the key switch OFF and disconnect the battery connector.

Upper Chain Anchor Removal - 7600 and 7620

1. Remove the chain anchor bolt and the anchor pin retainer. See Figure 7-145.

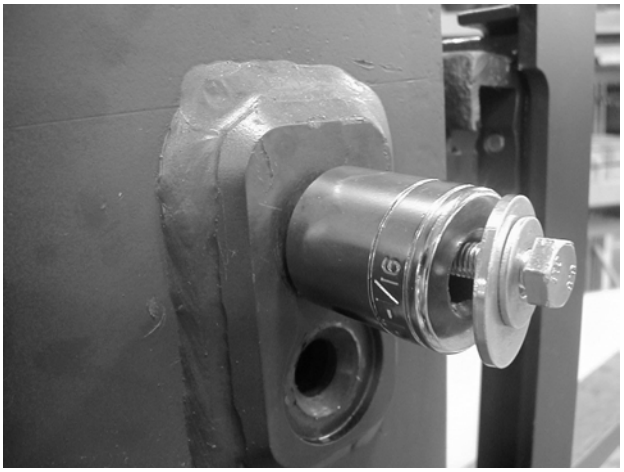
Figure 7-145. Upper Main Lift Chain Anchor Removal, Model 7600/7620



2. Grasp the chain and remove the anchor pin.

NOTE: You can remove the pin by using a slide hammer or by using a large socket (1 1/16 in.), a M8 x 50 mm bolt, and washers to act as a pulling device. See Figure 7-146.

Figure 7-146. Anchor Pin Removal, Model 7600/7620



3. To hold the chain in position, attach a pair of locking pliers to the chain nearest the chain sheave.
4. Remove the chain anchor from the lift chain.

Upper Chain Anchor Removal - 7640

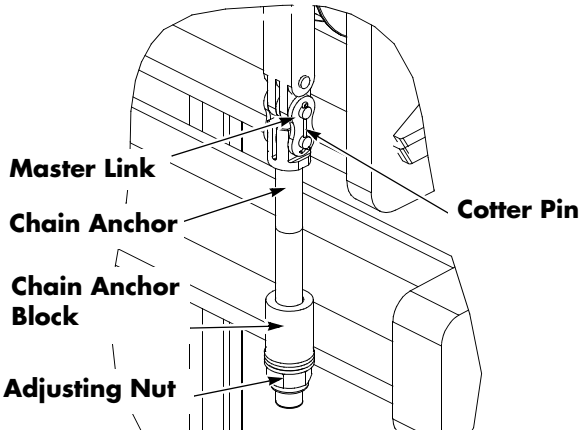
1. Place a block between the outer telescopic crosstie and the main frame crosstie and a

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slightly longer block between the inner telescopic crosstie and the outer telescopic crosstie. This provides the required slack in the chains. See Figure 7-144 on page 7-127.

2. Turn the key switch OFF and disconnect the battery connector.
3. Disconnect the lift chain master link from the chain anchor.
4. Note the distance of the adjusting nut. This distance is used as a preliminary adjustment when re-installing.
5. Remove the adjusting nut from the anchor.
6. Remove the chain anchor from the telescopic.

Figure 7-147. Upper Main Lift Chain Anchor, Model 7640



Upper Chain Anchor Installation - 7600 and 7620

1. Install the mast stop to the chain anchor.
2. Attach the chain anchor to the lift chain, making sure that the two holes in the anchor are facing towards the outside.
3. Remove the locking pliers, position the chain anchor and install the anchor pin. You can install the chain anchor bolt temporarily to assist in the installation of the pin.
4. Install the chain anchor pin retainer. Apply thread-locking compound (P/N 1013829) to the threads of the anchor bolt and torque to 130 ft. lb. (174 Nm).
5. Reconnect the battery connector and turn the key switch ON.
6. Remove the blocks from between the telescopic crossties.
7. Adjust the lift chains until there is a 0.25 in. (6.4 mm) - *Model 7600*
   0.375 in. (9.5 mm) - *Model 7620*
   gap at the narrowest point between the inner and outer telescopics when the carriage is fully lowered. Make sure there is equal tension on the lift chains after the adjustment.
8. Test the truck for correct operation.

Upper Chain Anchor Installation - 7640

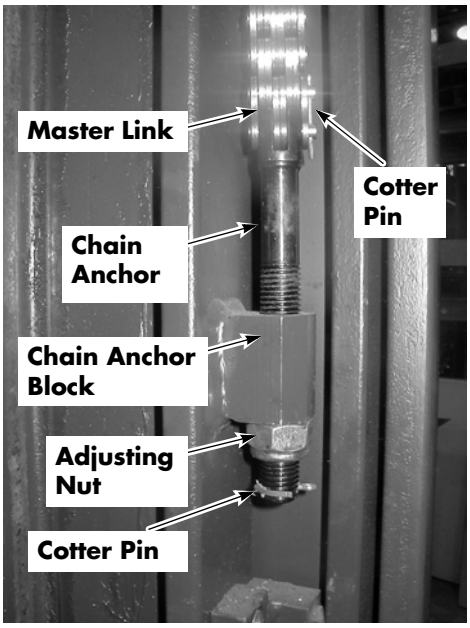
1. Install a new master link to the lift chain anchor and secure with a new cotter pin.
2. Install the chain anchor into the chain anchor block and thread the adjusting nut on to the distance recorded earlier.
3. Reconnect the battery connector and turn the key switch ON.
4. Remove the blocks from between the telescopic crossties.
5. Adjust the lift chains until there is a 0.5 in. (13 mm) gap at the narrowest point between the inner and outer telescopics when the carriage is fully lowered. Make sure there is equal tension on the lift chains after the adjustment.
6. Test the truck for correct operation.

Lower Chain Anchor Removal - 7600

1. Disconnect the lift chain master link from the chain anchor at the bottom of the inner telescopic.
2. Note the distance of the adjusting nut. This distance is used as a preliminary adjustment when re-installing.
3. Remove the cotter pin and chain anchor adjusting nut.
4. Remove the chain anchor from the telescopic.

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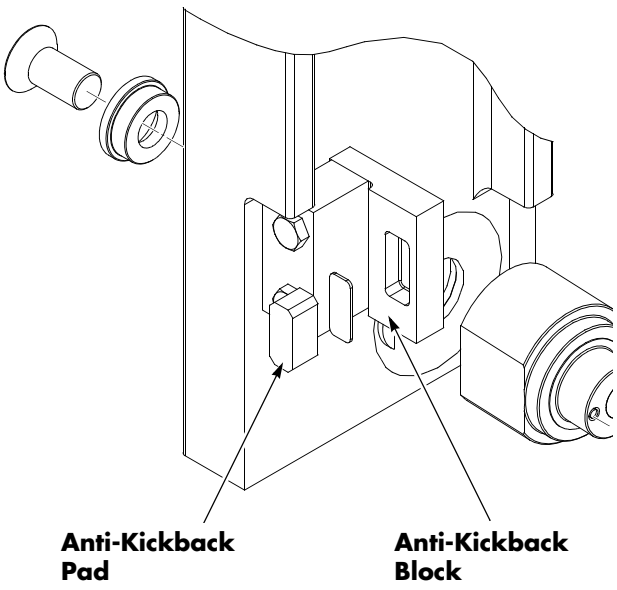
Figure 7-148. Lower Main Lift Chain Anchor, Model 7600



Lower Chain Anchor Removal - 7620

1. Remove the anti-kickback pad and block from the bottom of the inner telescopic. See Figure 7-149.

Figure 7-149. Anti-Kickback Pad and Block, Model 7620

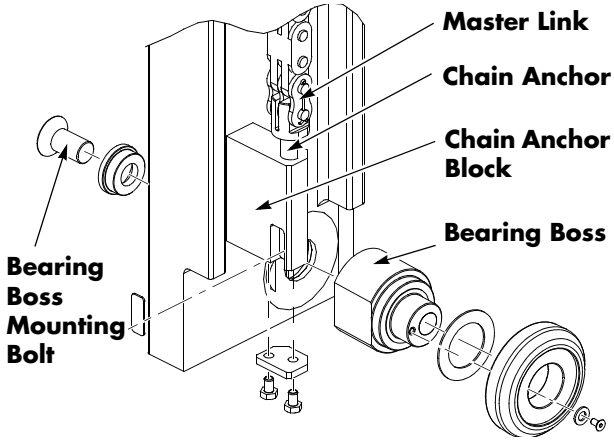


2. Note the distance of the adjusting nut threads. This distance is used as a preliminary adjustment when re-installing.
3. Remove the nut from the chain anchor bolt.
4. Remove the chain anchor from the telescopic by pulling the chain out at the main lift pulley.
5. Disconnect the lift chain master link from the chain anchor.

Lower Chain Anchor Removal - 7640

1. Attach a hoist strap around the top plate of the inner telescopic.
2. Using a suitable hoist, lift the inner telescopic to slacken the chains.
3. Remove the lower bearings in the inner telescopic by removing the mounting bolts for the bosses. See Figure 7-150.
4. Use a pry bar to increase the access space between the inner and outer telescopics.
5. Disconnect the lift chain master link from the chain anchor. Twist the chain if necessary to reveal the master link.
6. Unscrew the chain anchor from the chain anchor block.

Figure 7-150. Lower Main Lift Chain Anchor, Model 7460



Lower Chain Anchor Installation - 7600

1. Reinstall the master link to the lift chain and chain anchor.
2. Install the chain anchor into the chain anchor block and thread the adjusting nut on to the distance recorded earlier. Install

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the cotter pin at the end of the chain anchor.

3. Reconnect the battery connector and turn the key switch ON.
4. Remove the blocks from between the telescopic crossties.
5. Adjust the lift chains until there is a 0.25 in. (6.4 mm) gap at the narrowest point between the inner and outer telescopics when the carriage is fully lowered. Make sure there is equal tension on the lift chains after the adjustment.
6. Test the truck for correct operation.

Lower Chain Anchor Installation - 7620

1. Reinstall the master link to the lift chain and chain anchor.
2. Feed the lift chain over the main lift chain pulley and down the telescopic.
3. Install the chain anchor into the chain anchor block and thread the adjusting nut on to the distance recorded earlier.
4. Reinstall the anti-kickback pad and block at the bottom of the inner telescopic.
5. Reconnect the battery connector and turn the key switch ON.
6. Remove the blocks from between the telescopic crossties.
7. Adjust the lift chains until there is a 0.375 in. (9.5 mm) gap at the narrowest point between the inner and outer telescopics when the carriage is fully lowered. Make sure there is equal tension on the lift chains after the adjustment.
8. Test the truck for correct operation.

Lower Chain Anchor Installation - 7640

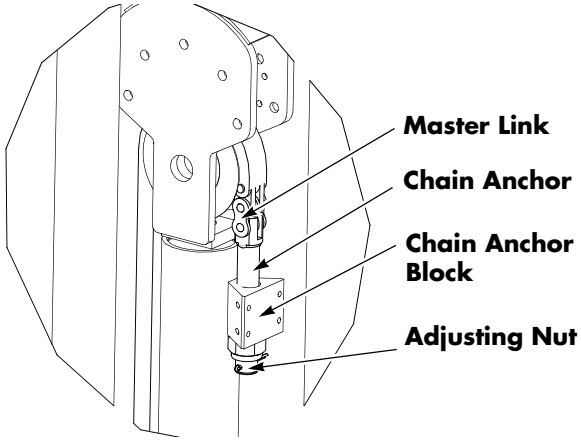
1. Thread the chain anchor into the chain anchor block.
2. Install a new master link to the lift chain and chain anchor and secure with a new cotter pin.
3. Reattach the lower bearing bosses and bearings in the inner telescopic. Apply thread-locking compound (P/N 1013829) to the bosses and torque to 260 ft. lb. (353 Nm).
4. Lower the inner telescopic to slacken the hoist strap. Remove the strap.
5. Adjust the lift chains until there is a 0.5 in. (13 mm) gap at the narrowest point between the inner and outer telescopics when the carriage is fully lowered. Make sure there is equal tension on the lift chains after the adjustment.
6. Test the truck for correct operation.

Free Lift Chain Anchors

Upper Chain Anchor Removal - 7600

1. Elevate and block the carriage at a convenient working height.
2. Lower the carriage to relieve tension on the chains.
3. Turn the key switch OFF and disconnect the battery connector.
4. Remove the mast guard.
5. *Left side only*: Remove the hose/cable retaining block.
6. Disconnect the lift chain master link from the chain anchor.
7. Note the distance of the adjusting nut. This distance is used as a preliminary adjustment when re-installing.
8. Remove the nut from the chain anchor bolt. Remove anchor from anchor block.

Figure 7-151. Upper Free Lift Chain Anchor, Model 7600



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Upper Chain Anchor Removal - 7620 and 7640

1. Elevate the carriage to a convenient working height.
2. Lower the carriage onto blocks to slacken the chains.
3. Turn the key switch OFF and disconnect the battery connector.
4. Disconnect the master link from the chain anchor.
5. Note the distance of the adjusting nut. This distance is used as a preliminary adjustment when re-installing.
6. Remove the chain anchor from the free lift cylinder.

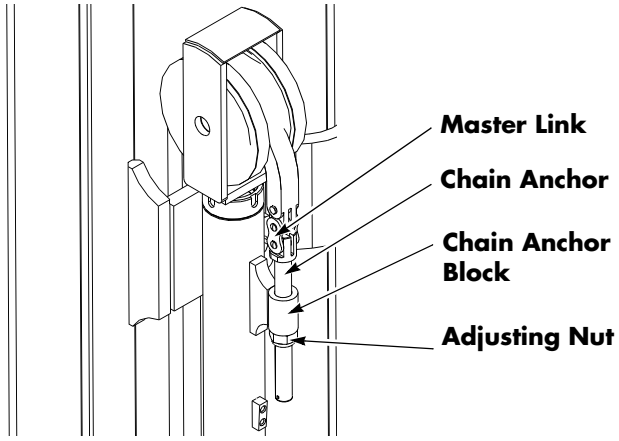
Upper Chain Anchor Installation - 7600

1. Insert the chain anchor in the chain anchor block.
2. Install a new master link to the lift chain anchor and secure with a new cotter pin.
3. Thread the adjusting nut on the chain anchor bolt to the distance recorded earlier.
4. *Left side only*: Reattach the hose/cable retaining block.
5. Reinstall the mast guard.
6. Reconnect the battery connector and turn the key switch ON.
7. Remove blocking from carriage.
8. Test the truck for correct operation.

Upper Chain Anchor Installation - 7620 and 7640

1. Install a new master link to the lift chain anchor and secure with a new cotter pin.
2. Install the chain anchor into the chain anchor block and thread the adjusting nut on to the distance recorded earlier.
3. Reconnect the battery connector and turn the key switch ON.
4. Elevate the carriage, remove blocks, and lower carriage completely.
5. Test the truck for correct operation.

Figure 7-152. Upper Free Lift Chain Anchor, Model 7620/7640



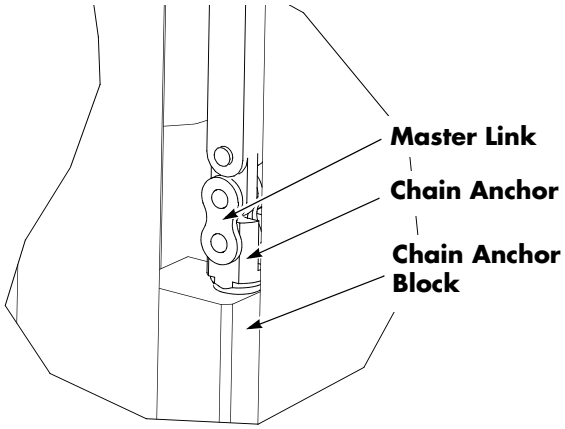
Lower Chain Anchor Removal - 7600

NOTE: Model 7600 right side lower free lift chain anchors are welded to the carriage. Use the following procedure to remove the left side chain anchor.

1. Elevate and block the carriage at a convenient working height.
2. Lower the carriage to relieve tension on the chains.
3. Turn the key switch OFF and disconnect the battery connector.
4. Remove the mast guard.
5. Disconnect the lift chain master link from the chain anchor.
6. Unscrew the anchor from the anchor block.

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Figure 7-153. Lower Free Lift Chain Anchor, Model 7600



Lower Chain Anchor Installation - 7600

1. Screw the chain anchor into the chain anchor block.
2. Attach a new master link to the chain anchor block and secure with a new cotter pin.
3. Reinstall the mast guard.
4. Reconnect the battery connector and turn the key switch ON.
5. Remove blocking from the carriage.
6. Test truck for correct operation.

Lower Chain Anchors - 7620 and 7640

Model 7620/7640 lower free lift chain anchors are welded to the carriage.

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Lift Chains

Chains, Main Lift

Model 7600

Removal

1. Place a block between the outer telescopic crosstie and the main frame crosstie and a slightly longer block between the inner telescopic crosstie and the outer telescopic crosstie. This provides the required slack in the chains for their removal. See Figure 7-144 on page 7-127.
2. Lower the carriage and block at a height that allows access to the chain anchor at the bottom of the inner telescopic.
3. Turn the key switch OFF and disconnect the battery connector.
4. Disconnect the lift chain master link from the lower chain anchor at bottom of inner telescopic.
5. Remove the chain anchor bolt and the anchor pin retainer. See Figure 7-146 on page 7-127.
6. Grasp the chain and remove the anchor pin.

NOTE: You can remove the pin by using a slide hammer or by using a large socket (1 1/16 in.), an M8 x 50 mm bolt, and washers to act as a pulling device.

1. Remove the chain anchor and chain from the telescopic.
2. Remove the master link between chain and chain anchor.

Installation

NOTE: Replace both chains when either is bad.

1. Attach the upper chain anchor to the new chain using a new master link and cotter pin.
2. Make sure the two holes in the upper chain anchor are facing towards the outside. Feed the chain from the outside to the inside over the chain sheave.
3. Position the upper chain anchor and install the anchor pin. You can install the chain anchor bolt temporarily to assist in the installation of the pin.
4. Install the anchor pin retainer. Apply thread-locking compound (P/N 1013829) to the threads of the anchor bolt and torque to 130 ft. lb. (174 Nm).
5. Attach the chain and the lower chain anchor, using a new master link and cotter pin.
6. Remove the blocks between the telescopics and the main frame and fully lower the forks to the floor.
7. Adjust the lift chains until there is a 0.25 in. (6.4 mm) gap at the narrowest point between the inner and outer telescopics when the carriage is fully lowered. Make sure there is equal tension on the lift chains after the adjustment.
8. Lubricate the chains and test the truck operation.

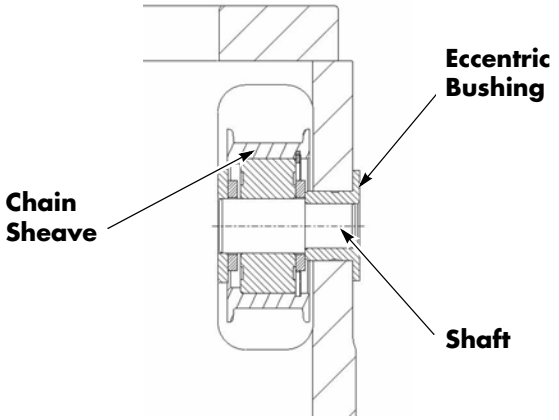
Chain Sheave Alignment

If the main lift chain sheave becomes misaligned so that the chain scrubs one side wall of the sheave, install a new shaft with an eccentric bushing to correct the alignment.

1. Elevate and block the mast to provide slack in the main lift chain.
2. Turn the key switch OFF and disconnect the battery connector.
3. Disconnect the main lift chain from the inner telescopic chain anchor bolt.
4. Loosen the set screw and remove the pulley shaft.
5. Insert the new pulley shaft into position.
6. Insert the eccentric bushing. (Two different bushings are available, depending on the amount of eccentricity.)

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Figure 7-154. Eccentric Bushing for Main Lift Chain Sheave



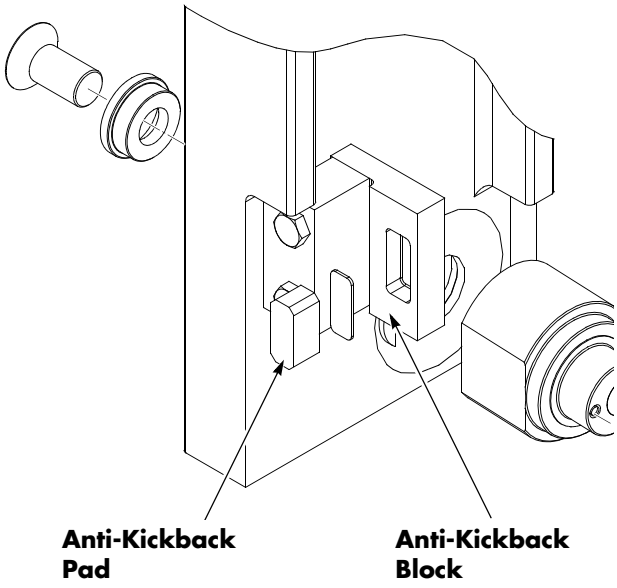
7. Reconnect the lift chain to the chain anchor block.
8. Remove the blocks to permit normal operation of the mast.
9. Adjust the eccentric bushing with a spanner wrench until the lift chain is tracking parallel with the telescopic profile.
10. Reconnect the battery connector and turn the key switch ON.
11. Cycle the telescopic several times to make sure the lift chain is tracking correctly.
12. Prick punch the eccentric bushing through the existing set screw hole.
13. Drill a hole 0.13 in. deep on the prick punch mark, using a 7/32 in. drill bit.
14. Apply thread-locking compound to the threads of the set screw and install the set screw to lock the eccentric bushing in place.

Model 7620

Removal

1. Place a block between the outer telescopic crosstie and the main frame crosstie and a slightly longer block between the inner telescopic crosstie and the outer telescopic crosstie. This provides the required slack in the chains for their removal. See Figure 7-144 on page 7-127.
2. Lower the carriage and block at a height that allows access to the chain anchor at the bottom of the inner telescopic.
3. Turn the key switch OFF and disconnect the battery connector.
4. Remove the anti-kickback pad and block from the bottom of the inner telescopic. See Figure 7-155.

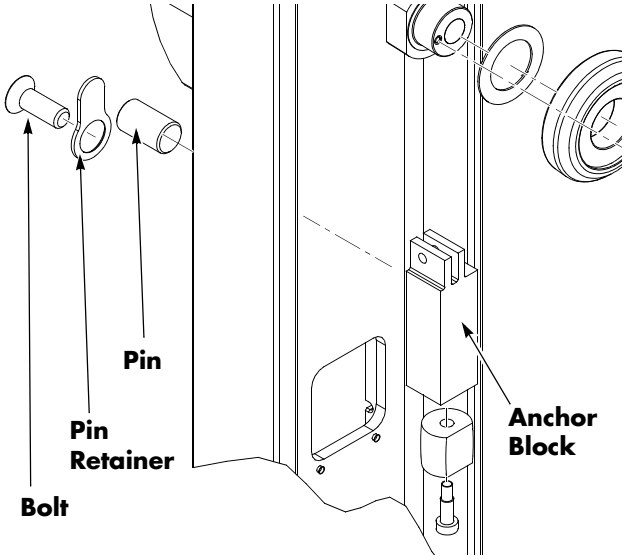
Figure 7-155. Anti-Kickback Pad and Block, Model 7620



5. Note the distance of the adjusting nut threads. This distance is used as a preliminary adjustment when re-installing.
6. Remove the nut from the chain anchor bolt.
7. Remove the upper chain anchor bolt and the anchor pin retainer. See Figure 7-156.

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Figure 7-156. Upper Main Lift Chain Anchor Removal, Model 7620



8. Grasp the chain and remove the anchor pin. See Figure 7-146.

NOTE: You can remove the pin by using a slide hammer or by using a large socket (1 1/16 in.), an M8 x 50 mm bolt, and washers to act as a pulling device.

9. Remove the chain anchors and chain from the telescopic.
10. Disconnect the master links between chain and chain anchors.

Installation

NOTE: Replace both chains when either is bad.

1. Attach the chain anchors to the new chain using new master links and cotter pins.
2. Make sure the two holes in the upper chain anchor are facing towards the outside. Feed the chain from the outside to the inside over the chain sheave.
3. Position the upper chain anchor and install the anchor pin. You can install the chain anchor bolt temporarily to assist in the installation of the pin.
4. Install the anchor pin retainer. Apply thread-locking compound (P/N 1013829) to the threads of the anchor bolt and torque to 130 ft. lb. (174 Nm).
5. Feed the lift chain over the main lift chain pulley and down the telescopic.
6. Install the chain anchor into the chain anchor block and thread the adjusting nut on to the distance recorded earlier.
7. Reinstall the anti-kickback pad and block at the bottom of the inner telescopic.
8. Remove the blocks between the telescopics and the main frame and fully lower the forks to the floor.
9. Adjust the lift chains until there is a 0.375 in. (9.5 mm) gap at the narrowest point between the inner and outer telescopics when the carriage is fully lowered. Make sure there is equal tension on the lift chains after the adjustment.
10. Lubricate the chains and test the truck operation.

Model 7640

Removal

1. Attach a hoist strap around the top plate of the inner telescopic.
2. Using a suitable hoist, lift the inner telescopic to slacken the chains.
3. Remove the lower bearings in the inner telescopic by removing the mounting bolts for the bosses.
4. Use a pry bar to increase the access space between the inner and outer telescopics.
5. Remove the cotter pin and disconnect the lift chain master link from the lower chain anchor. Twist the chain if necessary to reveal the master link.
6. Remove the cotter pin and disconnect the lift chain master link from the upper chain anchor.

Installation

1. Connect the chain to the upper chain anchor with a new master link and new cotter pin.
2. Route the chain over the main lift chain pulley and between the inner and outer telescopics.
3. Connect the chain to the lower chain anchor with a new master link and new cotter pin.

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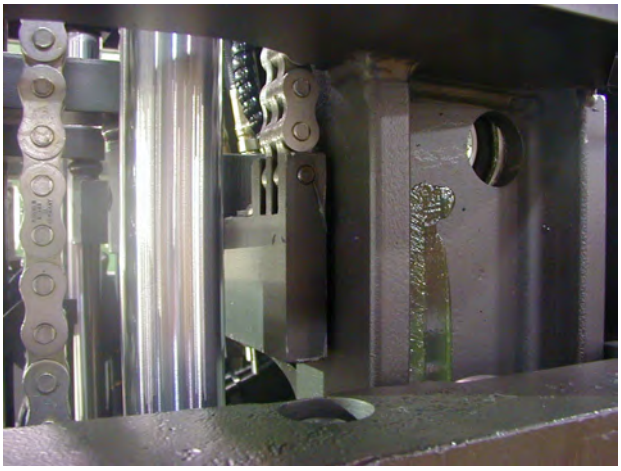
4. Reattach the lower bearing bosses and bearings in the inner telescopic. Torque to 130 ft. lb. (176 Nm).
5. Lower the inner telescopic to slacken the hoist strap. Remove the strap.
6. Adjust the lift chains until there is a 0.5 in. (12.7 mm) gap at the narrowest point between the inner and outer telescopics when the carriage is fully lowered. Make sure there is equal tension on the lift chains after the adjustment.
7. Lubricate the chains and test the truck operation.

Chains, Free Lift

Removal

1. For easy access to the lift chain master links at the carriage anchor blocks, elevate the carriage to a convenient working height. Using a suitable hoist or stand, secure the carriage at this height. See Figure 7-157.

Figure 7-157. Carriage Chain Anchor



2. Activate “lower” to relieve the tension on the free lift chains.
3. Turn the key switch OFF and disconnect the battery connector.
4. Remove the mast guard.
5. Remove the master links at the adjustable chain anchors.
6. Remove the master links at the carriage chain anchors.
   a. *Model 7600*: The right side requires the removal of a retainer tab and pin rather than a cotter pin. See Figure 7-157.
   b. *Model 7620/7640*: Both sides require the removal of a retainer tab and pin rather than a cotter pin. See Figure 7-157.

Figure 7-158. Retainer Tab (right side)



7. Remove the chains.

Installation

1. Position the chain over the pulley and fasten the chain to the carriage anchor with a new master link.
   a. *Model 7600*: Secure the left side with a cotter pin and the right side with the pin and retainer tab, applying thread-locking compound (P/N 1013829) to the threads of the retainer screw.
   b. *Model 7620/7640*: Secure both sides with the pin and retainer tab, applying thread-locking compound (P/N 1013829) to the threads of the retainer screw.
2. Fasten the chain to the adjustable chain anchor with a new master link and secure with a new cotter pin.

NOTE: Bend the ends of the cotter pins over 90° after installation.

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3. Reinstall the mast guard.
4. Reconnect the battery connector and turn the key switch ON.
5. Slowly raise the carriage, using the lift button to place the weight of the carriage on the free lift chains.
6. Remove the hoist.
7. Fully lower the carriage.
8. With the reach mechanism retracted, forks level with the floor and the key switch OFF, adjust the anchor nuts equally until the forks are approx 3 in. (76 mm) off the floor (or just touching the floor with the floor lower height option). Make sure there is equal pressure on the chains when the carriage is fully lowered.

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Height Encoder Belt

Model 7620

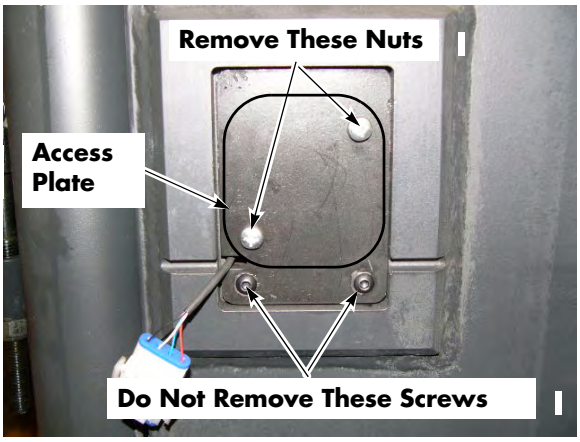
Removal

1. Lift and block the mast high enough to access the belt and its mounting eye.

NOTE: The tensioning spring is at the *bottom* of the belt, hooked to a bracket.

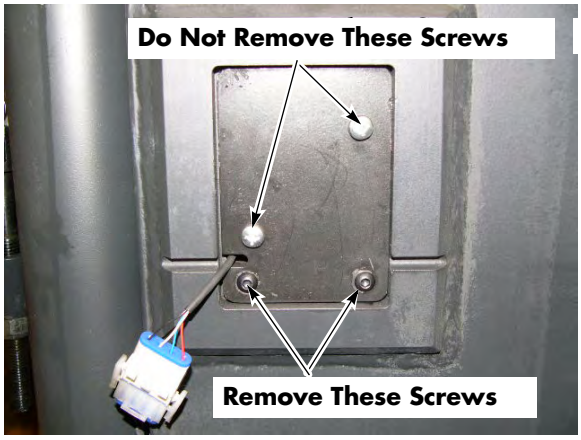
2. Turn the key switch OFF and disconnect the battery connector.
3. Access the height encoder assembly.
   a. If there is an access plate secured by diagonally opposed nuts, remove the nuts. Do not remove the bottom button-head screws. See Figure 7-159.

Figure 7-159. Height Encoder Assembly, 7620



   b. If there is no access plate, remove the *bottom* two button-head screws. Do not remove the diagonally opposed screws, as they hold the encoder assembly together. See Figure 7-160.

Figure 7-160. Height Encoder Assembly, 7620

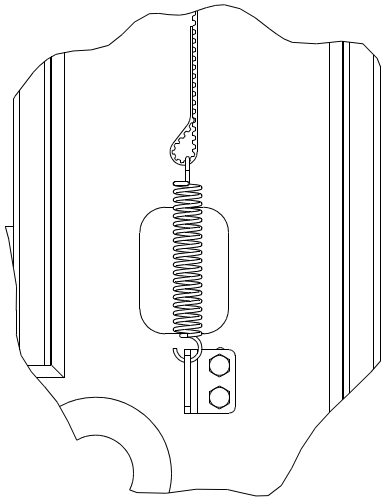


4. Remove the old belt. Make sure you retrieve the tension spring through the access hole at the bottom of the outer telescopic.

Installation

1. Using cable ties, make a 1 in. (25 mm) loop in the bottom of the new encoder belt and attach it to the tension spring.
2. Attach a small weight on the tension spring. Drop the weighted spring down the mast channel. Clamp the belt at the top so it does not fall completely down into the channel.
3. Access the spring through the hole at the bottom of the mast channel, attach the spring to the bracket. See Figure 7-161.

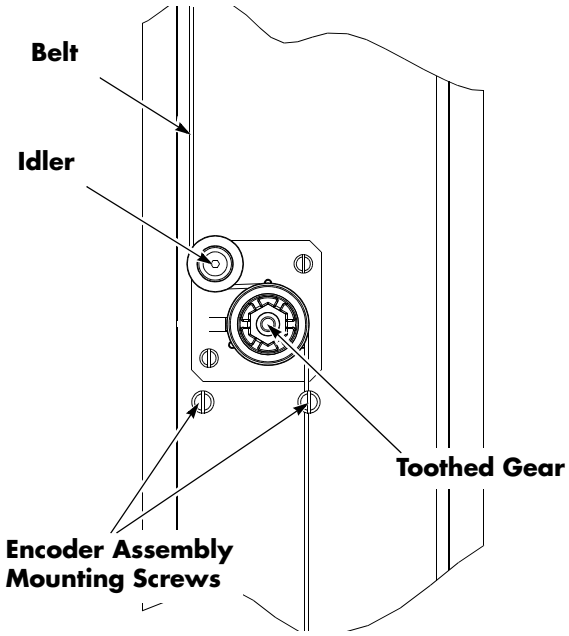
Figure 7-161. Height Encoder Belt Tension Spring, 7620



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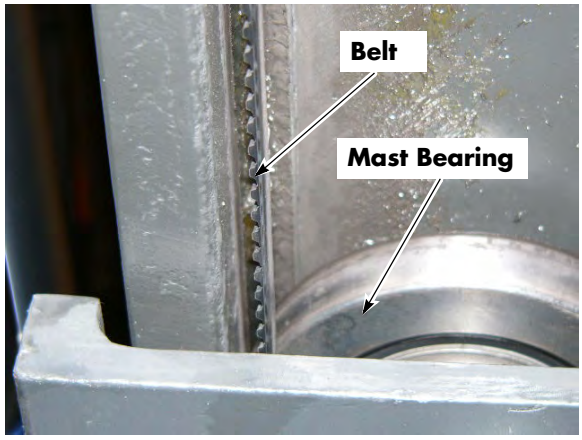
4. Thread the belt through the encoder assembly, making sure it is routed correctly around the toothed gear and idler. See Figure 7-162.

Figure 7-162. Height Encoder Belt Routing, 7620



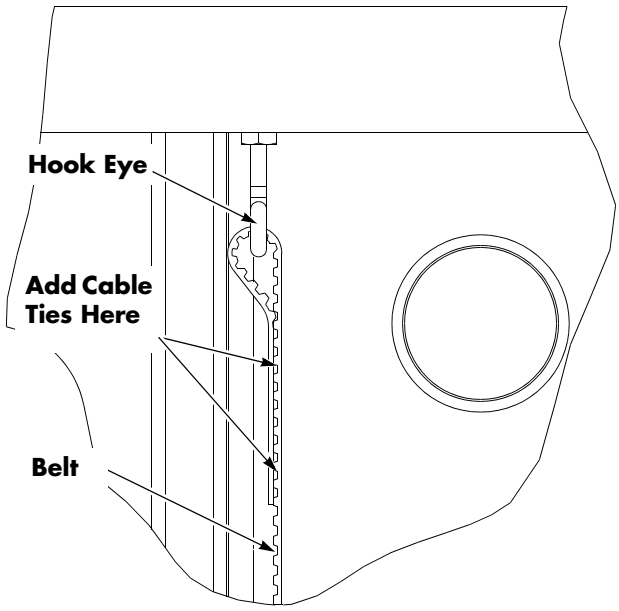
5. Attach the top end of the belt to a stiff wire and feed the belt up through the encoder assembly hole.
6. Loop the belt around the eye at the top of the mast and clamp it temporarily in place.
7. Secure the height encoder assembly.
   a. If there is an access plate, install the access plate with the nylon locking nuts. See Figure 7-159.
   b. If there is no access plate, fit the encoder assembly back into the mast channel. Keep slight tension on the belt and make sure the belt wraps correctly around the gear and idler. Secure the encoder assembly with mounting screws. See Figure 7-160.
8. Make sure the belt feeds past the mast bearing without becoming entangled in the bearing. See Figure 7-163.

Figure 7-163. Height Encoder Belt and Mast Bearing, 7620



9. With the belt snug around the hook eye, trim the belt 1 in. (25 mm) longer. Attach two cable ties loosely to form a loop of the belt around the hook eye. With the belt snug, pull the belt approx. 0.5 in. (13 mm) tighter to apply tension to the spring, and tighten the cable ties. Trim any excess belt at the loop. See Figure 7-164.

Figure 7-164. Height Encoder Belt, Top, 7620



10. Reconnect the battery connector and turn the key switch ON.
11. Elevate the mast, remove the blocking. Lift and lower the carriage to test correct operation.

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Model 7640

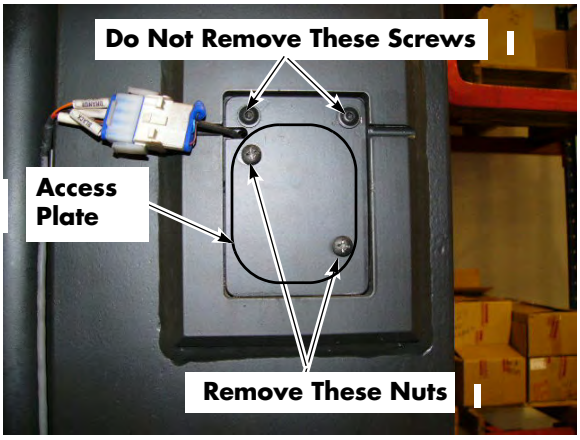
Removal

1. Lift and block the mast high enough to access the belt and its mounting eye.

NOTE: The tensioning spring is at the *top* of the belt, hooked to a bracket.

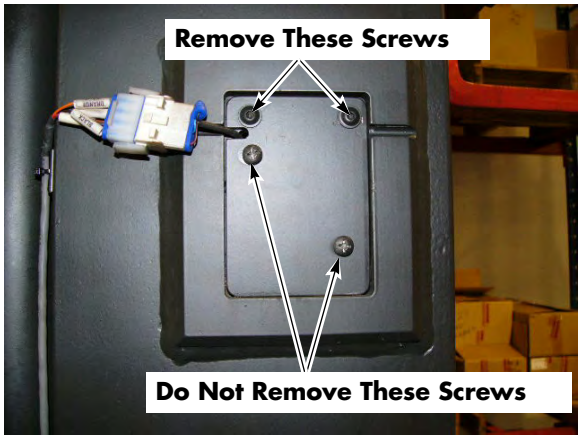
2. Turn the key switch OFF and disconnect the battery connector.
3. Access the height encoder assembly.
   a. If there is an access plate secured by diagonally opposed nuts, remove the nuts. Do not remove the top button-head screws. See Figure 7-165.

Figure 7-165. Height Encoder Assembly, 7640



   b. If there is no access plate, remove the *top* two button-head screws. Do not remove the diagonally opposed screws, as they hold the encoder assembly together. See Figure 7-166.

Figure 7-166. Height Encoder Assembly, 7640

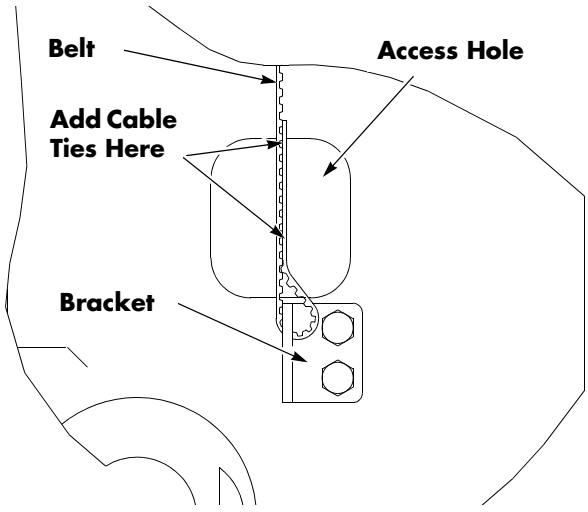


4. Remove the old belt. Make sure you retrieve all the broken pieces. There is an access hole at the bottom of the outer telescopic.

Installation

1. Attach a small weight to the belt. Drop the weighted belt down the mast channel. Clamp the belt at the top so it does not fall completely down into the channel.
2. Accessing the bracket through the hole at the bottom of the mast channel, loop the belt through the bracket to form a 1 in. (25 mm) loop. Secure the loop with cable ties. See Figure 7-167.

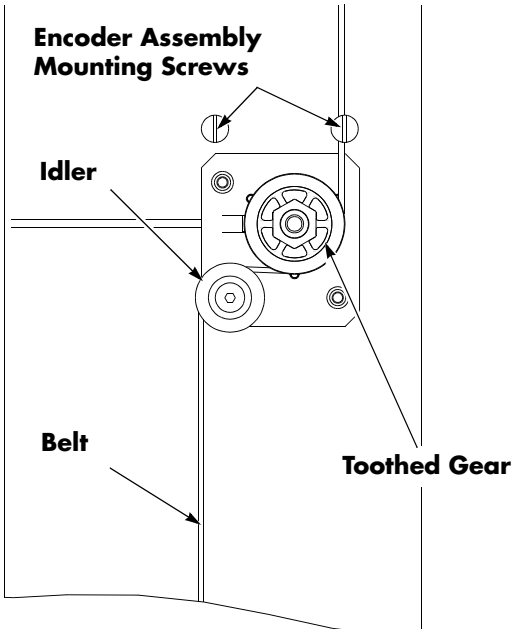
Figure 7-167. Height Encoder Belt Tension Spring, 7640



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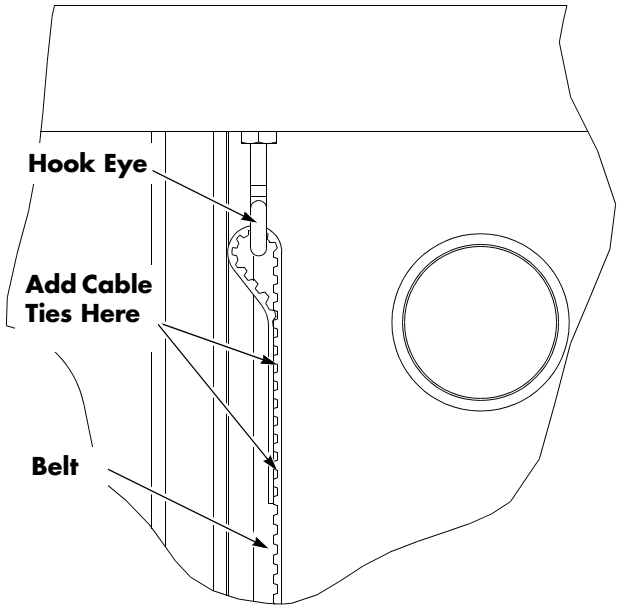
3. Thread the belt through the encoder assembly, making sure it is routed correctly around the toothed gear and idler. See Figure 7-168.

Figure 7-168. Height Encoder Belt Routing, 7640



4. Attach the top end of the belt to a stiff wire and feed the belt up through the encoder assembly hole.
5. Loop the belt around the eye at the top of the mast and clamp it temporarily in place.
6. Secure the height encoder assembly.
   a. If there is an access plate, install the access plate with the nylon locking nuts. See Figure 7-165.
   b. If there is no access plate, fit the encoder assembly back into the mast channel. Keep slight tension on the belt and make sure the belt wraps correctly around the gear and idler. Secure the encoder assembly with mounting screws. See Figure 7-166.
7. With the belt snug around the hook eye, trim the belt 1 in. (25 mm) longer. Attach two cable ties loosely to form a loop of the belt around the hook eye. With the belt snug, pull the belt approx 0.5 in. (12 mm) tighter to apply tension to the spring, and tighten the cable ties. Trim any excess belt at the loop. See Figure 7-169.

Figure 7-169. Height Encoder Belt, Top, 7620



8. Reconnect the battery connector and turn the key switch ON.
9. Elevate the mast, remove the blocking. Lift and lower the carriage to test correct operation.

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Hose, Main Lift

Removal

1. Fully lower forks to the floor.
2. Turn the key switch OFF and disconnect the battery connector.
3. Remove the battery from the truck to access the display and Lift Motor mounting bracket bolts.
4. Remove the top cover and the front left and right covers.
5. Remove the 4 mounting bolts from both the display bracket and the Lift Motor mounting bracket to gain access to the lift hose.
6. If applicable, remove the lift amp/shroud assembly as one unit. It is retained by four bolts on the mast side of the front tractor plate.
7. Disconnect and cap the main lift cylinder feed hoses at the front tractor plate.

NOTE: Place a small container below the fittings to allow the main lift hose to drain.

8. Disconnect the lift hose from the main manifold and remove from the truck.

Installation

1. Position the lift hose in the truck.
2. Connect the fittings at the manifold and the main lift cylinder feed hoses.
3. If applicable, reinstall the lift amp/shroud assembly. See “Component Specific Service/Torque Chart” on page A-4.
4. Position and reinstall the display and Lift Motor mounting bracket bolts. See “Component Specific Service/Torque Chart” on page A-4.
5. Reconnect the battery connector and turn the key switch ON.
6. Bleed the hydraulic system. See “Hydraulic System Bleeding” on page 7-74.
7. Check the truck for leaks and correct operation.
8. Install the top cover and the right and left front cover.

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Hose and Cable, Over-the-Mast

Figure 7-170. Over-the-Mast Hose/Cable, view from tractor

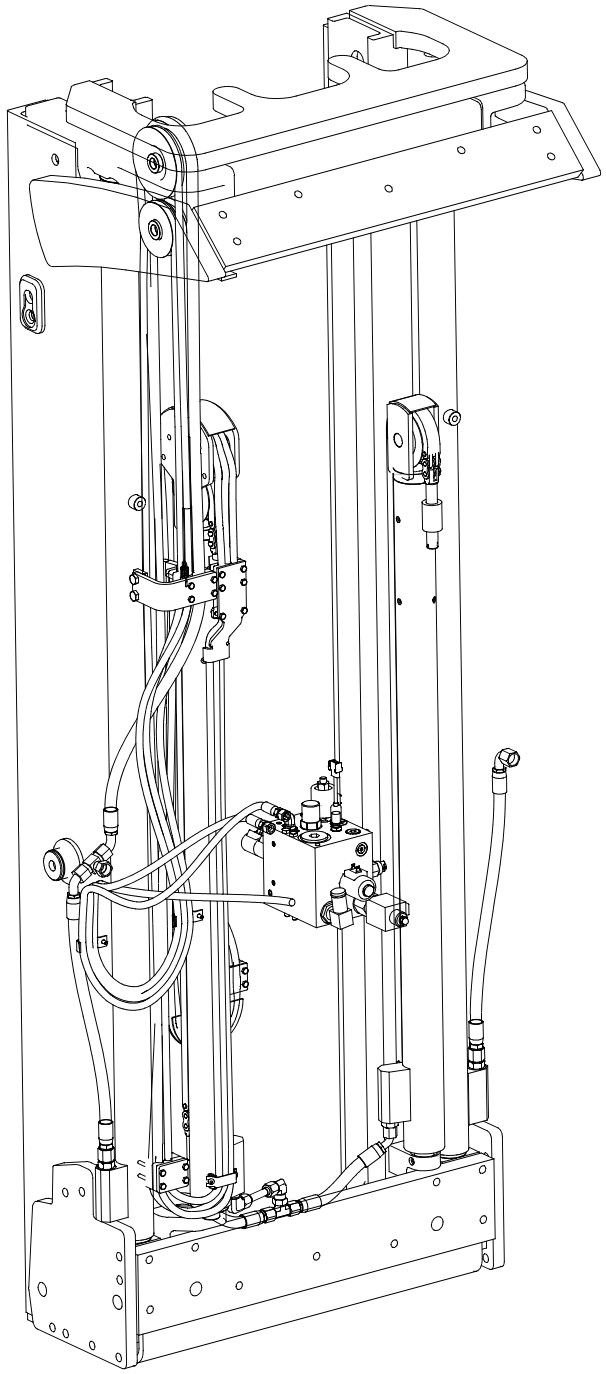
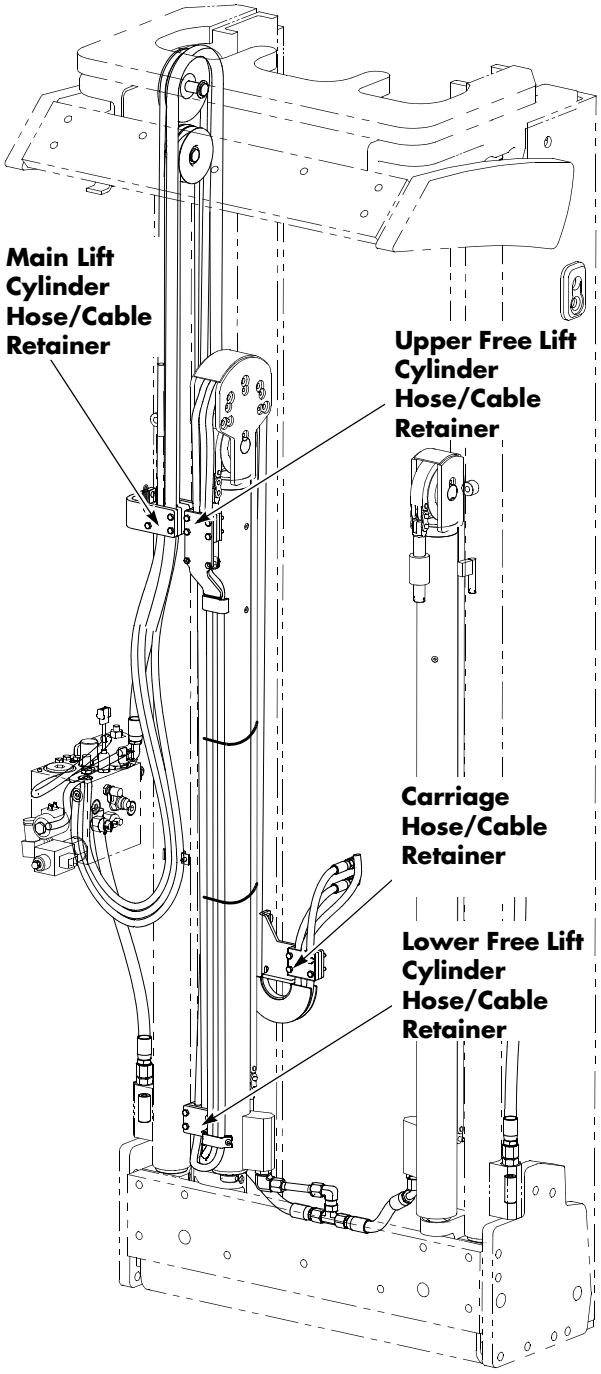


Figure 7-171. Over-the-Mast Hose/Cable, view from forks



NOTE: For replacement of the over-the-mast electrical cable only, see "Cable, Over-the-Mast" on page 7-149.

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Removal

1. Remove top cover, left front cover, and mast guard.
2. Lower carriage to floor and block scissor assembly. See Figure 7-172.

Figure 7-172. Blocking Scissor Assembly



3. Turn the key switch OFF and disconnect the battery connector.
4. Disconnect the over-the-mast cable at connector JPS3 in tractor.
5. Remove auxiliary manifold cover from carriage and disconnect the over-the-mast cable at terminal strip TS2. See Figure 7-173.

Figure 7-173. Auxiliary Manifold access

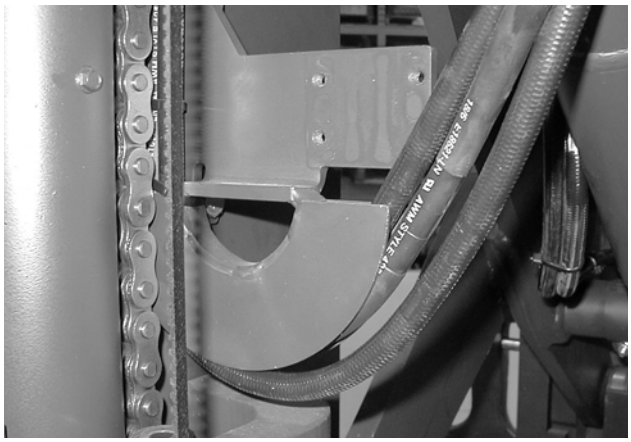


6. Remove auxiliary manifold mounting screws to permit access to the over-the-mast hose fittings at the manifold.

NOTE: There may be shims between the manifold and carriage.

7. Disconnect and plug/cap the over-the-mast hoses and fittings at the auxiliary manifold.
8. Reconnect the battery connector and turn the key switch ON.
9. Elevate and block carriage at an appropriate height to access the hose/cable retainer and guide at the back of the carriage from the tractor side.
10. Turn the key switch OFF and disconnect the battery connector.
11. Remove hose/cable retaining block from back of carriage. See Figure 7-174.

Figure 7-174. Hose/Cable Retainer on Carriage



12. Feed hoses and cable through guide at back of carriage.
13. Feed hoses and cable through pulley bracket at top of free lift cylinder.
14. Remove upper hose/cable retainer from free lift cylinder. See Figure 7-171 on page 7-143.
15. Reconnect the battery connector and turn the key switch ON.
16. Carefully elevate the telescopics high enough to access the lower retainer on free lift cylinder and the retainer on the telescopic from the tractor side. Place a hardwood block of sufficient length between the outer and inner telescopics. This removes tension from the over-the-mast hoses and the lift hose and makes the removal and installation of the

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retainers easier. Carefully lower the mast until you have the desired tension. See Figure 7-175.

Figure 7-175. Blocking telescopics

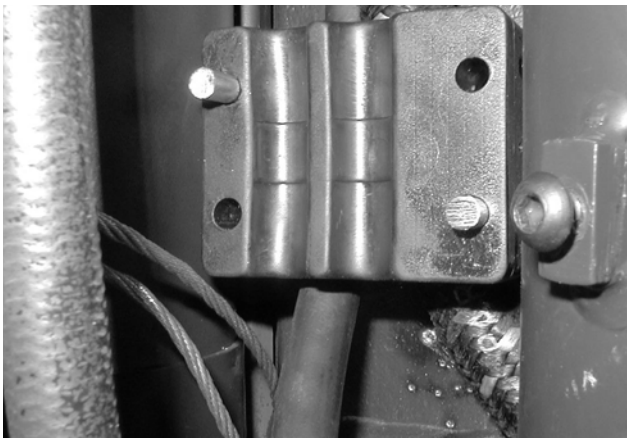


17. Turn the key switch OFF and disconnect the battery connector.
18. Remove the lower free lift cylinder hose/cable retainer and the hose/cable retainer from the bottom of the inner telescopic.
19. Feed hoses and cable through pulley at top of inner telescopic.
20. Remove hose/cable retainer at left main lift cylinder.
21. Reconnect the battery connector and turn the key switch ON.
22. Carefully elevate telescopics and remove blocking.
23. Fully lower mast and carriage.
24. Turn the key switch OFF and disconnect the battery connector.
25. Disconnect and plug/cap hoses and fittings at A1 and A2 on the main manifold.
26. Feed hoses and cable through opening in tractor bulkhead.

Installation

NOTE: To help install the retainers, use two modified (M6-1 x 70) bolts to locate and support the retainer during assembly. See Figure 7-176.

Figure 7-176. Positioning hose retainer

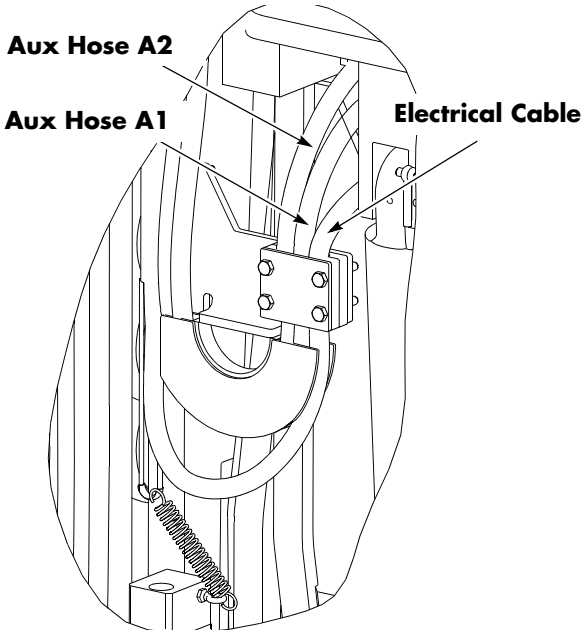


NOTE: Over-the-mast hose lengths on Model 7600 lift trucks are equal. Reference Figure 7-200 on page 7-161 for correct hose/cable routing.

1. While observing correct routing, connect hoses to auxiliary manifold at carriage and the cable to terminal strip TS2.
2. Mount auxiliary manifold to carriage. Apply thread-locking compound (P/N 990-536) to mounting bolt threads and torque to 21 ft. lb. (29 Nm).
3. Reconnect the battery connector and turn the key switch ON.
4. Carefully elevate and block carriage high enough to access the hose/cable retainer and guide at the back of the carriage.
5. Turn the key switch OFF and disconnect the battery connector.
6. Feed hoses and cable through guide and retainer.
7. Remove slack from hoses and cable between retainer and manifold. Adjust and tension the cable to allow the cable to loop away at the bottom edge of the hose/cable bracket on the carriage. This loop should be 0.75 ±0.25 in. (19 ±6.35 mm) below the bracket. Make sure the cable is long enough to remove the auxiliary manifold cover and access TS2. Tighten the retainer. See Figure 7-177.

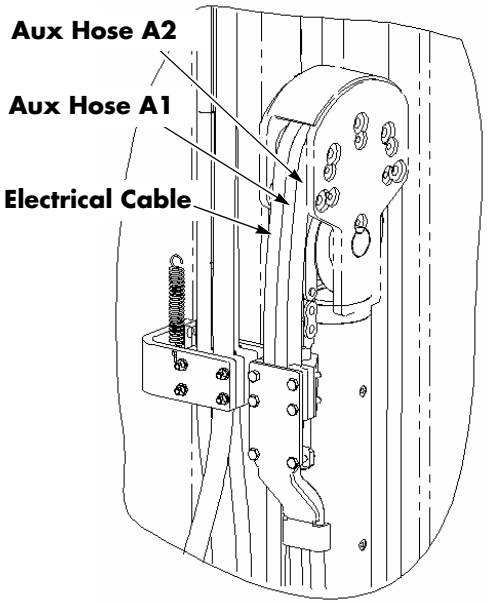
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Figure 7-177. Carriage Hose/Cable Retainer



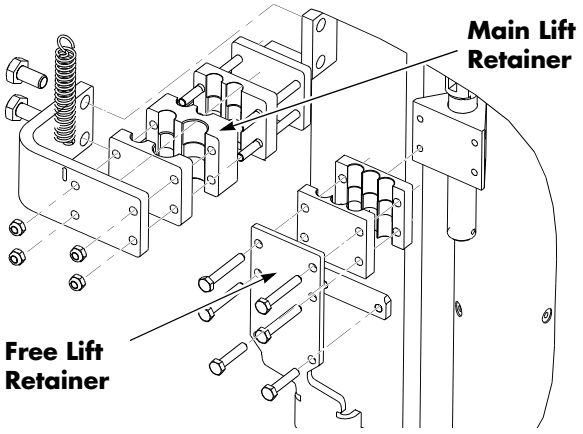
8. Attach manifold cover to carriage. Apply thread-locking compound (P/N 990-536) to the mounting bolt threads and torque to 30 ft. lb. (42 Nm).
9. Reconnect the battery connector and turn the key switch ON.
10. Fully lower carriage to the floor.
11. Turn the key switch OFF and disconnect the battery connector.
12. Feed hoses and cable through free lift pulley, from fork side to tractor side. Make sure hoses and cable do not cross each other. The electrical cable is in the left-hand position. See Figure 7-178.

Figure 7-178. Free Lift Pulley Routing of Hoses and Cable



13. Install hoses, cable, and retainer at top of free lift cylinder. See Figure 7-179.

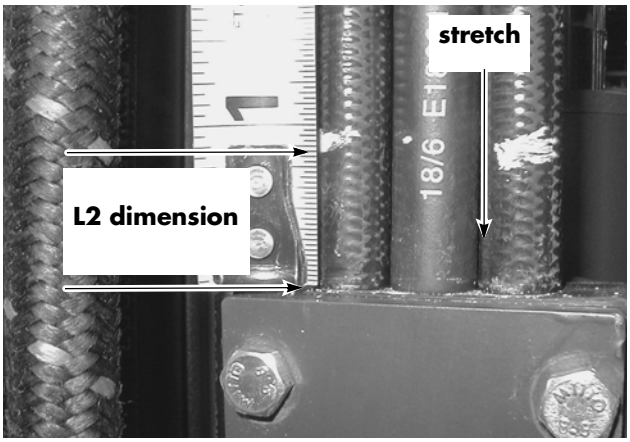
Figure 7-179. Upper Hose/Cable Retainer, Main Lift and Free Lift Cylinders



14. Remove slack from hoses and cable between upper free lift cylinder and carriage retainers. Temporarily tighten retainer.
15. Find the correct L2 value from Table 7-16. Measure and mark hoses above the upper free lift cylinder retainer, using the L2 value. L2 equals the length the hoses are to be stretched over the free lift cylinder. See Figure 7-180.

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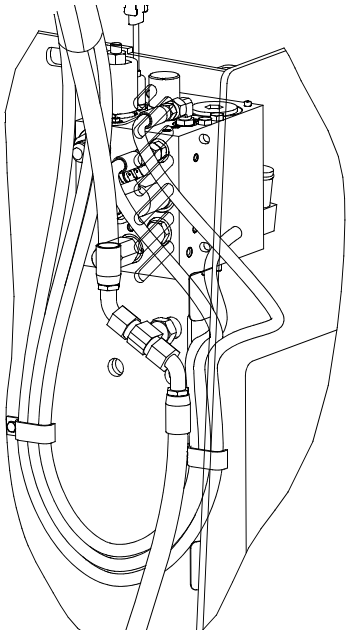
Figure 7-180. Marking L2 dimension



16. Reconnect the battery connector and turn the key switch ON.
17. Place block under carriage and lower carriage to relieve tension on hoses.
18. Pull down on the hoses until marks are flush with top of retainers. Tighten the four retainer bolts. Do not tighten the lower clamp bolts on the retainer assembly yet.
19. Install hoses, cable, retainer, and clamp at bottom of free lift cylinder and inner telescopic. Carefully elevate the telescopics high enough to access the lower retainer on free lift cylinder and the retainer on the telescopic from the tractor side. Place a hardwood block of sufficient length between the outer and inner telescopics. Carefully lower the mast until you have the desired tension. Observe correct routing to make sure hoses and cable have sufficient clearance. See Figure 7-175.
20. Turn the key switch OFF and disconnect the battery connector.
21. Remove slack from hoses and cable between inner telescopic retainer and upper retainer on free lift cylinder. Temporarily tighten retainer and clamp.
22. Reconnect the battery connector and turn the key switch ON. Remove blocking from telescopics. Turn the key switch OFF and disconnect the battery connector.
23. Feed hoses and cable through pulleys at top of telescopic, from fork side to tractor side. Make sure hoses and cable do not cross each other.
24. Install over-the-mast hoses, lift hose, and cable in retainer at left main lift cylinder.
25. Remove slack from hoses and cable. Adjust cable grip and spring so that spring is stretched to an overall length of 1.75 ±0.12 in. (44.5 ±3 mm) across the coils. Leave sufficient bend of slack hose so that an additional 0.5 in. (13 mm) of cable length can be taken up if required. Temporarily tighten retainer.
26. Measure and mark the lift hose above the retainer with the appropriate L3 value in Table 7-16. Measure and mark the over-the-mast hoses above the retainer with the appropriate L1 value in Table 7-16.
27. Repeat step 17 of installation procedure.
28. Pull down on the hoses until marks are flush with the top of the retainers. Tighten retainers.
29. Reconnect the battery connector and turn the key switch ON. Remove blocking from telescopics. Turn the key switch OFF and disconnect the battery connector.
30. Tighten two lower clamp bolts on upper free lift cylinder hose/cable retainer.
31. Secure hoses and cable to the free lift cylinder with cable ties every 16 to 24 in. (40 to 60 cm).
32. Route hoses and cable through the tractor opening, along the tractor bulkhead and attach with the hose/cable clamps. See Figure 7-181.

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Figure 7-181. Hose/Cable Retainer Clamps on Tractor



33. Observing correct routing, connect over-the-mast hoses to A1 and A2 at the main manifold. Connect the over-the-mast cable to connector JPS3.
34. Reconnect the battery connector and turn the key switch ON. Test the lift truck for correct operation and check for leaks.
35. Cycle all auxiliary functions several times to purge air from the hydraulic system.
36. Check hydraulic fluid level and add fluid as required.
37. Install mast guard and covers.

Table 7-16. Over-the-Mast Hose Stretch Values

OACH	L1 (OTM hoses over tele)	L2 (over free lift cyl)	L3 (lift hose over tele)
	in. (mm)	in. (mm)	in. (mm)
87	1.29 (32.8)	0.87 (22.1)	1.45 (36.8)
95	1.53 (38.9)	0.93 (23.6)	1.69 (42.9)
100	1.68 (42.7)	0.97 (24.6)	1.84 (46.7)
102	1.74 (44.2)	0.98 (24.9)	1.90 (48.3)
104	1.80 (45.7)	1.00 (25.4)	1.96 (49.8)
107	1.89 (48)	1.02 (25.9)	2.05 (52.1)
110	1.98 (50.3)	1.04 (26.4)	2.14 (54.4)
114	2.10 (53.3)	1.07 (27.2)	2.26 (57.4)
118	2.22 (56.4)	1.10 (27.9)	2.38 (60.5)
122	2.34 (59.4)	1.13 (28.7)	2.50 (63.5)
128	2.52 (64)	1.18 (30)	2.68 (68.1)
131	2.61 (66.3)	1.20 (30.5)	2.77 (70.4)
133	2.67 (67.8)	1.21 (30.7)	2.83 (71.9)
135	2.73 (69.3)	1.23 (31.2)	2.89 (73.4)
138	2.82 (71.6)	1.25 (31.8)	2.98 (75.7)
141	2.91 (73.9)	1.27 (32.3)	3.07 (78)
143	2.97 (75.4)	1.29 (32.8)	3.13 (79.5)
146	3.09 (78.5)	1.31 (33.3)	3.25 (82.6)

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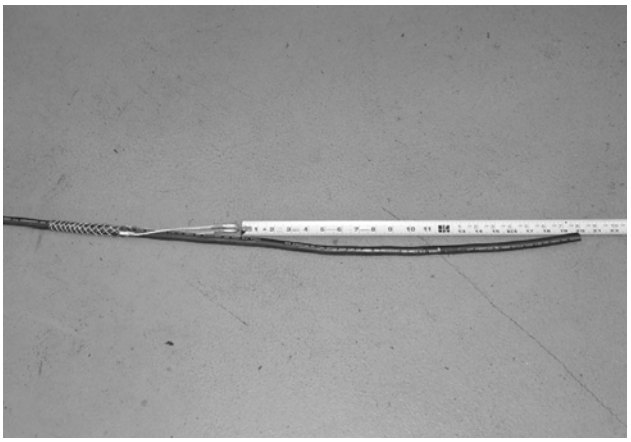
Cable, Over-the-Mast

Over-the-Mast Cable Replacement

This procedure describes the installation of the new cable as the old one is being removed.

1. Mark the OTM hoses at all the hose/cable retainers to make sure the correct stretch when reassembled. (If required use Table 7-16.)
2. Remove the top cover, left front cover, and mast guard.
3. Turn the key switch OFF and disconnect the battery connector.
4. Disconnect the OTM cable at connector TS3 in the tractor.
5. Remove the auxiliary manifold cover from the carriage and disconnect the OTM cable at TS2.
6. Reconnect battery connector and turn key switch ON.
7. Elevate and block the carriage at an appropriate height to access the hose/retainer and guide at the back of the carriage from the operator compartment. This also relieves tension on the hoses for easier assembly.
8. Turn the key switch OFF and disconnect the battery connector.
9. Remove the cable from the retainer/guide at the back of the carriage and the free lift cylinder pulley. See Figure 7-171.
10. Position the cable grip on the replacement cable so that the spring anchor end of the cable grip is oriented towards the TS2 end of the cable and the loop is approx 20 in. (51 cm) from the end of the cable. See Figure 7-182.

Figure 7-182. Cable Grip on TS2 end of OTM cable



11. If installing bulk cable, strip 3 in. (76 mm) of insulation from cable, strip wires, and attach spade lugs.
12. Attach a cable tie around the braided end of the cable grip to prevent the grip from slipping. Do not tighten at this time.
13. Install the new cable in the carriage retainer/guide and route to TS2.

NOTE: Position the hoses using the marks made in step 1 and make sure that there is enough slack in the cable for the installation and removal of the auxiliary manifold cover.

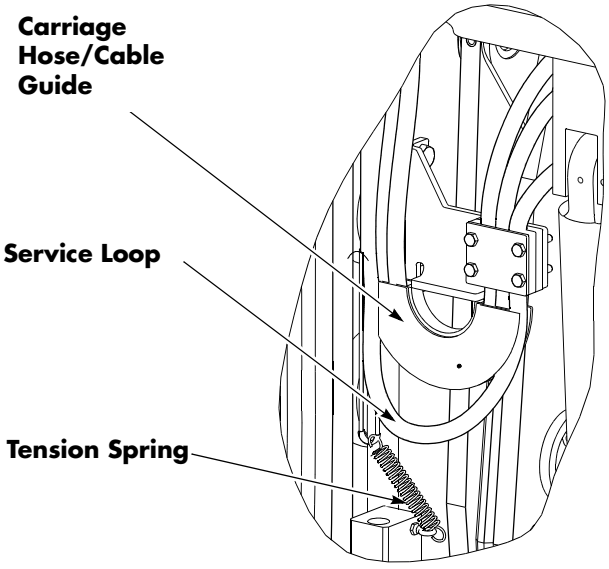
14. Reconnect battery connector and turn key switch ON. Remove blocking and lower the carriage. Turn key switch OFF and disconnect battery connector.
15. Connect cable spade lugs to TS2.
16. Attach aux manifold cover to carriage.
17. Reconnect the battery connector and turn the key switch ON. Elevate and block carriage as in step 7. Turn the key switch OFF.
18. Tighten the carriage hose and cable retainer.
19. Turn the key switch ON. Remove blocking and lower the carriage. Turn the key switch OFF.
20. Feed the cable through the free lift pulley and position it in the upper free lift cylinder retainer. Do not tighten at this time.

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NOTE: Remove all twist from the cable when installing.

21. Turn the key switch ON. Elevate and block carriage. Turn the key switch OFF.
22. Adjust and tension the cable to allow the cable to loop away at the bottom edge of the hose/cable bracket on the carriage. This loop should be 0.75 ±0.25 in. (19 ±6.35 mm) below the bracket. See Figure 7-183.

Figure 7-183. Service Loop (Standard Carriage shown)



23. Position the hoses and cable using the marks made in step 1 and tighten the upper 4 bolts, but not the bottom 2 bolts of the upper free lift cylinder retainer.
24. Set the tension on the spring at the carriage by sliding the cable grip to produce a length of 1.75 ±0.12 in. (44.5 ±3.0 mm) across the coils. Do not over tension. Tighten the cable tie on the cable grip. See Figure 7-183.

NOTE: Orient the loop of the cable grip fore-aft so that as the cable passes through the loop of the cable grip and the latch of the cable tie, it does not interfere with the free lift cylinder mounting pin.

25. Turn the key switch ON. Carefully elevate the telescopics high enough to access the lower retainer on the free lift cylinder and the retainer on the telescopic from the operator's compartment.
26. Place a hardwood block of sufficient length (approx 30 in. [0.75 m]) between the outer and inner telescopics. This removes the tension from the OTM hoses and the lift hose to make the removal and installation of the retainers easier. Carefully lower the mast until you have the desired tension. See Figure 7-184.

Figure 7-184. Blocking Telescopics

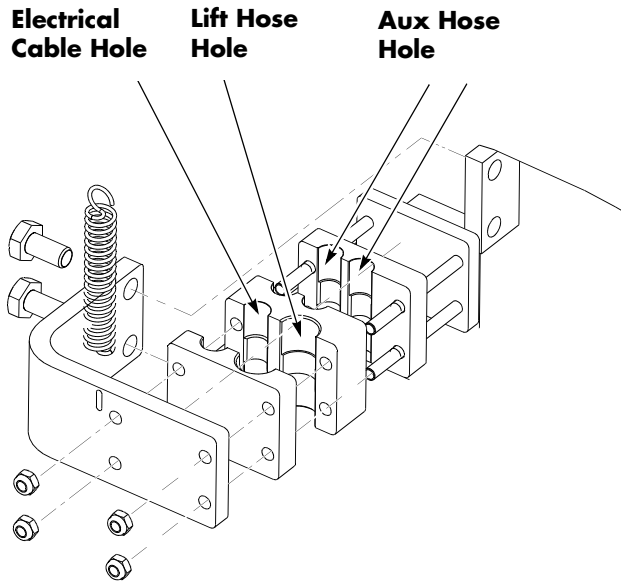


27. Turn the key switch OFF.
28. Remove and install the cable at the lower free lift cylinder and bottom inner telescopic hose/cable retainers. Observe correct routing to make sure hoses and cable have sufficient clearance. Tighten the retainers.
29. Remove and feed the cable through the pulley at the top of the inner telescopic. Observe correct routing and make sure the cable is not twisted.
30. For bulk cable installation:
    a. If old cable is loose in the main lift cylinder cable retainer, the passage hole in the retainer has already been enlarged. Remove the old cable and insert the new cable through the passage hole.

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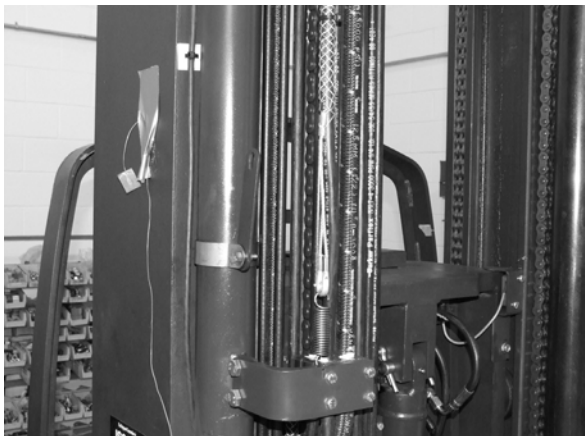
b. If the old cable is held in place by the main lift cylinder cable retainer, you must enlarge the passage hole. To do this, remove both parts of the retainer, clamp them together, and drill out the passage hole for the electrical cable (not the hoses) with a 9/16 in. drill bit. Reassemble the retainer, aligning witness marks on the hoses, and tighten the bolts. Insert the new cable through the passage hole. See Figure 7-185.

Figure 7-185. Retainer Modification for Electrical Cable



31. If installing bulk cable, install cable grip with the loop pointing down towards the tractor. Go to step 33.
32. Turn the key switch ON. Remove the blocking between the inner and outer telescopic.
33. Tighten the bottom two bolts of the free lift cylinder hose/cable retainer.
34. Secure hoses and cable to the free lift cylinder with cable ties every 16 to 24 in. (40.6 to 60.9 mm) as you lower the carriage all the way. Turn the key switch OFF.
35. If installing exact replacement cable, pull the cable through the main lift cylinder retainer until all slack is removed. Mark the cable at the top of the retainer. Tighten the retainer bolts.
36. Set the tension on the spring at the carriage by sliding the cable grip to produce a length of 1.75 ±0.12 in. (44.5 ±3.0 mm) across the coils. Do *not* over tension. Tighten the cable tie on the cable grip. See Figure 7-186.

Figure 7-186. Main Lift Cylinder Retainer Cable Spring Tension



37. For bulk cable installation, see "For bulk cable installation, do the following:" on page 7-152.

For exact replacement cable installation, do the following:

1. Turn the key switch ON. Elevate the carriage and place a hardwood block between the inner and outer telescopic. Carefully lower the carriage to relieve the hose and cable tension. Turn the key switch OFF.
2. Position the cable so that the mark on the cable is 0.5 in. (13 mm) above the retainer.
3. Position the OTM hoses and the lift hose as marked in step 1 of Over-the-Mast Cable Replacement. Tighten the retainer.
4. Turn the key switch ON. Remove the block between the inner and outer telescopic.
5. Lower the carriage. Turn the key switch OFF.
6. Remove and route the cable along the tractor bulkhead, through the tractor

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opening and attach with the hose/cable clamps.

7. Connect the OTM cable to connector TS3. See Figure 7-187. Go to step 5 in Bulk Cable Replacement procedure. See Table 7-17.

Figure 7-187. Cabling at Terminal Strip

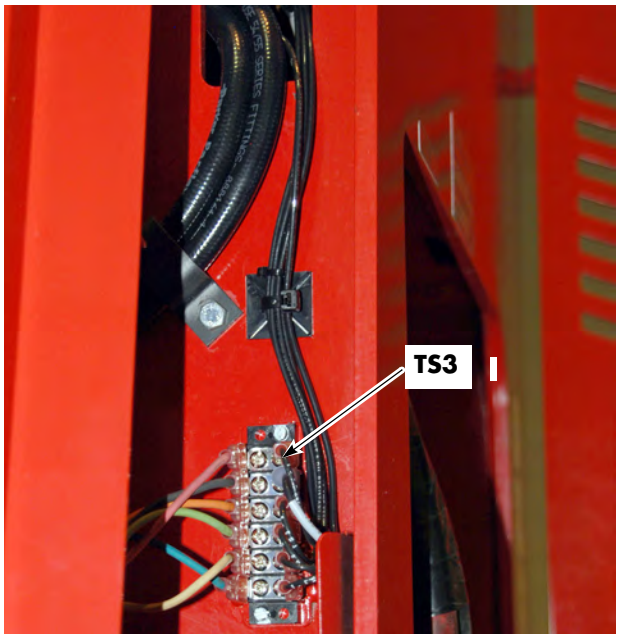


Table 7-17. OTM Cable Connections

New Terminal Strip TS3	Carriage Terminal Strip TS2
TS3-1	TS2-1
TS3-2	TS2-2
TS3-3	TS2-3
TS3-4	TS2-4
TS3-5	TS2-5
TS3-6	TS2-6

For bulk cable installation, do the following:

1. Cut the OTM cable 20 in. (508 mm) past the bottom of the main lift cylinder retainer.
2. Strip 3 in. of insulation from the cable, strip the wires, and attach spade lugs.
3. Connect the wires to the terminal strip. See Table 7-17.

NOTE: Colors will not match at TS2.

4. Attach cable to frame with cable tie and self-adhesive cable tie anchor. See Figure 7-187.
5. Install the mast guard, top cover and front left cover.

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Hose/Tubing, Free Lift Feed

Removal

1. Remove the mast guard.
2. Raise the telescopics until the bottom of the free lift feed tubing is accessible from the operator's compartment.
3. Place a block of sufficient length between the outer telescopic crosstie and the main frame to hold the position in step 2.
4. Fully lower the carriage.
5. Extend the reach mechanism to allow easier removal of the free lift feed tubing.
6. Turn the key switch OFF and disconnect the battery connector.
7. Place a pan below the free lift tubing.
8. Remove the necessary components. See Figure 7-188 and Figure 7-189.

Installation

1. Replace the necessary components. Make sure the assembly is tight and correctly positioned on the crosstie.
2. Reconnect the battery connector and turn the key switch ON.
3. Remove the block between the outer telescopic crosstie and the main frame.
4. Bleed the hydraulic system. See "Hydraulic System Bleeding" on page 7-74.
5. Check the truck for leaks and correct operation.
6. Install the mast guard.

Figure 7-188. Free Lift Feed Hose/Tube, Model 7600

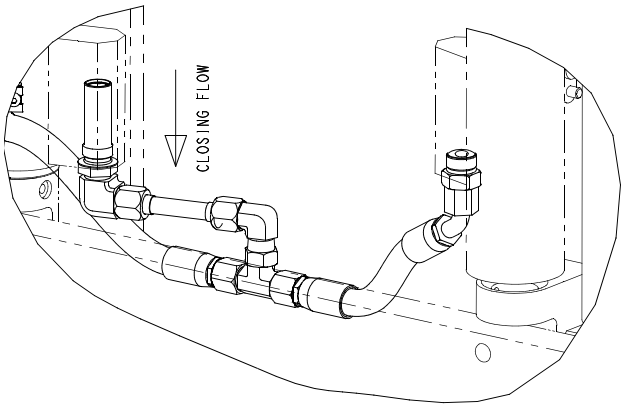
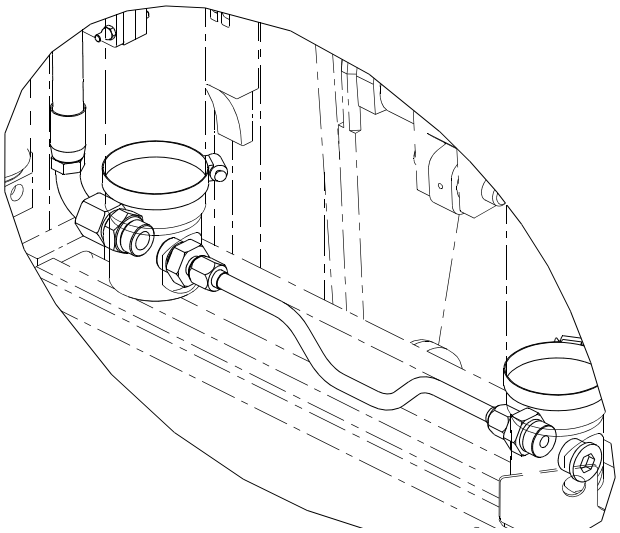


Figure 7-189. Free Lift Tubing, Model 7620/7640



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Mast, Model 7600

Disassembly

Separation of Tractor and Mast

- **Do this procedure with a minimum of two technicians in a shop equipped with a suitable hoist.**
- **Do *not* permit observers to stand nearby.**
- **Wear gloves, safety glasses, steel-toed safety boots, and a safety helmet (hard hat).**

1. Lower and retract the fork carriage completely.
2. Turn the key switch OFF and disconnect the battery connector. Remove battery gates. Using a suitable battery removal device, remove the battery.
3. Remove the top cover and the left and right front covers.
4. Remove the mast guard.
5. Secure a hoist strap around the overhead guard. Take the weight off the guard. Remove mounting bolts. Remove the guard.
6. Disconnect and cap right side main lift hose at the tractor bulkhead fitting.
7. Disconnect the ambient temperature sensor connector JPA on the tractor deck.
8. Disconnect the mast switch connector JPS4 (near the lift pump). Feed harness through tractor opening at left side.
9. Disconnect over-the-mast cable connector TS3.
10. Disconnect the hose/cable retaining clamp from the left front corner of the tractor near the opening in the bulkhead.
11. Disconnect and plug hydraulic hoses A1 and A2 at the main manifold, labeling as needed for correct reassembly. Feed hoses through opening in tractor bulkhead.
12. Disconnect the main lift hose fitting at the left side of the tractor.

NOTE: Make sure the weight of the mast is fully supported by the hoist and the tractor is blocked where it meets the mast before loosening the mast mounting bolts.

13. Place blocks snugly under the tractor near the mast.
14. Attach a lifting strap around the top crossties of all three mast sections. Draw tight with hoist. Make sure the weight of the mast is supported by the hoist.
15. Use an impact wrench to remove the mast mounting bolts inside the battery compartment; four on the top, eight on the bottom.
16. Using a lift truck, carefully separate the tractor about 6 in. (15 cm).
17. Remove the hose/cable retaining bracket on the front of the tractor bulkhead.
18. Remove the hose/cable retainer on the main lift cylinder.
19. Reinstall mast mounting bolts and washers and tighten lightly (to prevent misplacing them).

Hose/Cable, Free Lift Cylinder, and Carriage Removal

1. Remove the auxiliary manifold cover from the carriage. See Figure 7-190.

Figure 7-190. Auxiliary Manifold Access



2. Disconnect the wires of the over-the-mast cable from the terminal strip, labeling as needed for reconnection.

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3. Remove auxiliary manifold mounting screws to permit access to the over-the-mast hose fittings at the manifold.

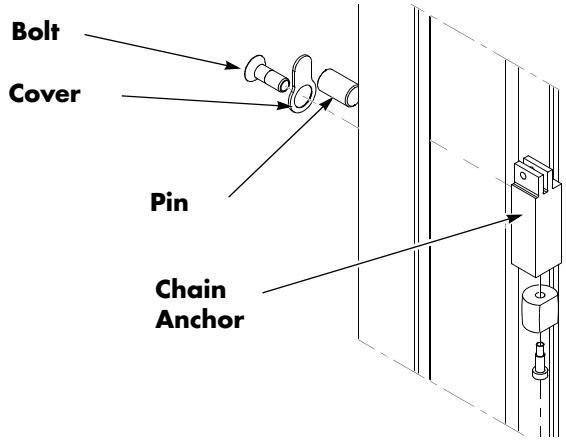
NOTE: There may be shims between the manifold and carriage.

4. Disconnect and plug/cap the over-the-mast hoses and fittings at the auxiliary manifold. Label as needed to make sure correct reconnection.
5. Remove cable ties on upper hose retaining block. Loosen upper and lower hose/cable retaining blocks.
6. Jack carriage up about 3 in. (7.6 cm). Remove master links on free lift chains. Feed free lift chains through pulleys and drape over front of carriage.
7. Remove hose/cable retaining block on back of carriage.
8. Remove hoses and cable from guide at back of carriage.
9. Remove upper and lower hose/cable retainers from free lift cylinder.
10. Feed hoses and cable through right side free lift cylinder pulley.
11. Remove tee tubing from free lift cylinders.
12. Remove set screws from bottom of right free lift cylinders. Lift each free lift cylinder off the mounting hook at the top and the mounting block at the bottom. Install set screws so they are not misplaced.
13. Remove carriage stops from back of carriage.
14. Remove the lower hose/cable pulley from the top of the outer telescopic.
15. Remove the upper hose/cable pulley from the top of the outer telescopic.
16. Disconnect the tee tubing to the right side main lift cylinder.
17. Disconnect and cap the hose to the left main lift cylinder.
18. Rig lifting straps around the carriage. Using a hoist, carefully lift the carriage out of the inner telescopic and lower the carriage to the floor.

Main Lift Chain Removal

1. Rig a lifting strap of one hoist around the lower crosstie of the main frame (the one where the overhead guard attaches).
2. Rig a lifting strap of another hoist around the top crossties of both inner and outer telescopics. Using the hoist, raise the telescopics about 10 in. (25 cm).
3. Remove chain anchor bolt and access cover from sides of main frame.
4. Remove the chain anchor pin by using a slide hammer or by using a large socket (1 1/16 in.), an M8 x 50 mm bolt, and washers to act as a pulling device. See Figure 7-191 and Figure 7-146.

Figure 7-191. Main Lift Chain Upper Chain Anchor



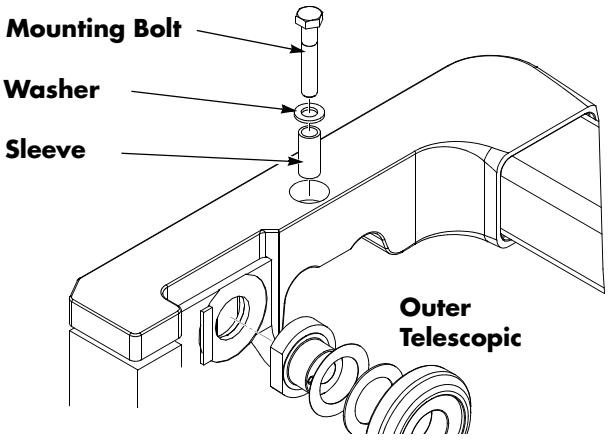
5. Pull the chain anchor/mast stop out of the main frame.
6. Feed main lift chains from inside to outside over the chain sheave.

Separation of Telescopics

1. Using the hoists, carefully lower the mast to a horizontal position on jack stands.
2. Loosen the L-bracket bolts holding the main lift cylinders to the telescopic.
3. Remove the top mounting bolt, washer, and sleeve holding the main lift cylinder to the outer telescopic. See Figure 7-192.

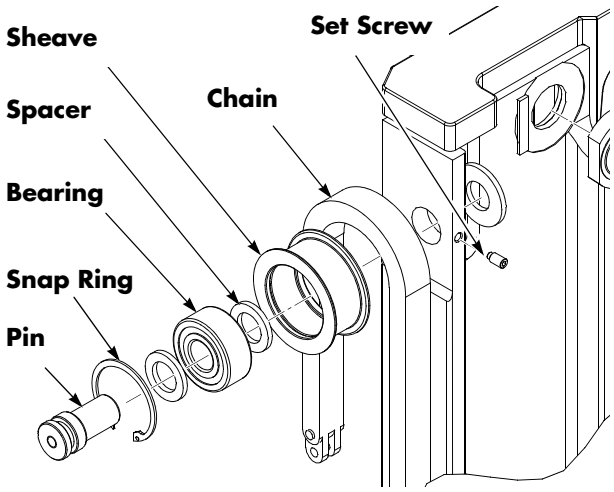
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Figure 7-192. Main Lift Cylinder Mounting Hardware



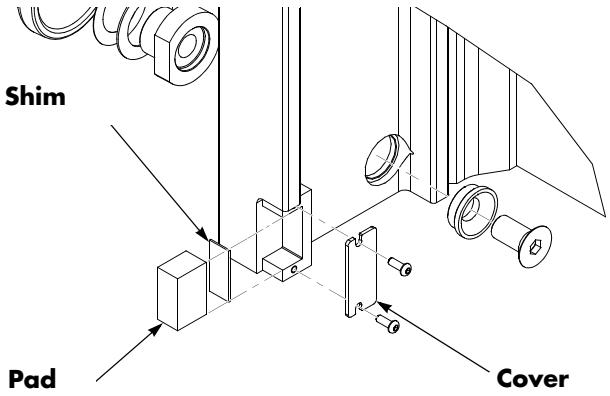
4. Remove main lift chain sheaves from top of outer telescopic. Sheaves attach with a pin and a set screw on the inside. See Figure 7-193.

Figure 7-193. Main Lift Chain Sheave



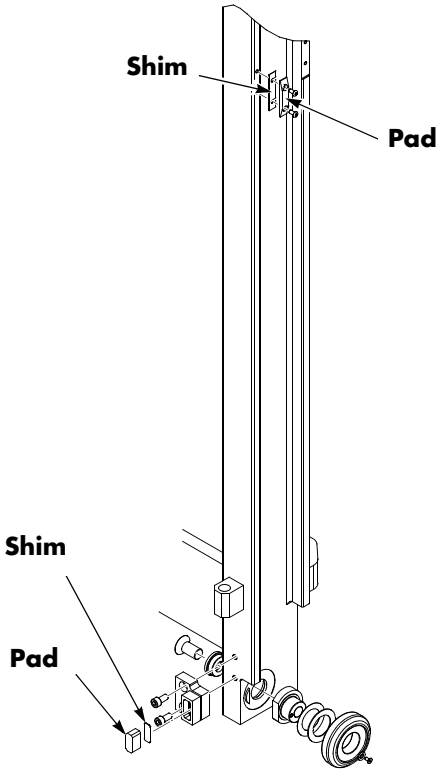
5. Remove anti-rattle pads and shims from bottom of outer telescopic. See Figure 7-194.

Figure 7-194. Outer Telescopic Lower Bearing and Anti-Rattle Pads



6. Remove anti-rattle pads and shims from bottom of inner telescopic. See Figure 7-195.

Figure 7-195. Inner Telescopic Lower Bearing and Anti-Rattle Pads

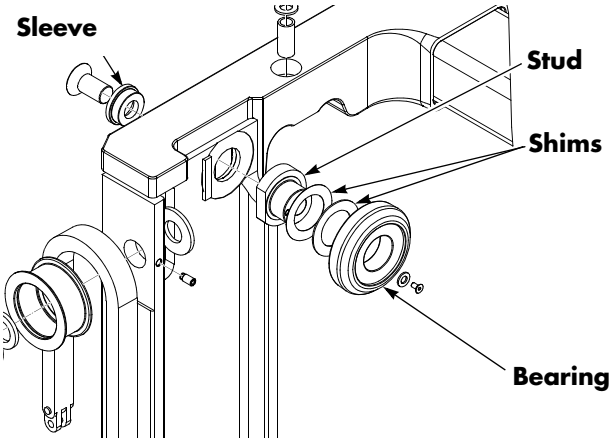


7. Using a suitable hoist, pull the inner telescopic halfway out of the outer telescopic.

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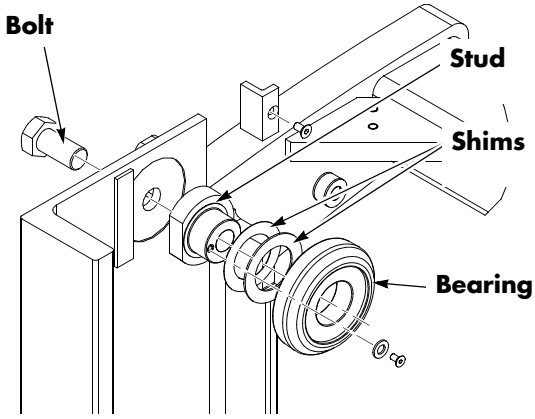
8. Remove the upper roller bearings and shims from the top of the outer telescopic. See Figure 7-196.

Figure 7-196. Outer Telescopic Upper Bearing



9. Remove the lower roller bearings and shims from the bottom of the inner telescopic. See Figure 7-195.
10. Using a suitable hoist, remove the inner telescopic from the outer telescopic.
11. Using a suitable hoist, pull the outer telescopic halfway out of the main frame.
12. Remove the upper roller bearings and shims from the main frame. See Figure 7-197.

Figure 7-197. Main Frame Upper Bearing



13. Remove the lower roller bearings and shims from the outer telescopic. See Figure 7-194.
14. Using a suitable hoist, remove the outer telescopic from the main frame.

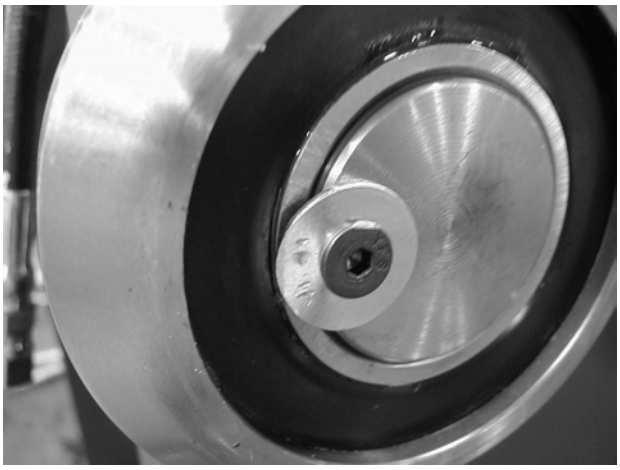
Assembling and Shimming Outer Telescopic to Main Frame

Lower Bearings of Outer Telescopic

1. Begin the assembly with the main frame positioned horizontally on jack stands.
2. Attach the lower roller bearing to one side of the outer telescopic. Make sure the flat spot on the bearing outer stud is correctly positioned against the mast. This is important because the correct bearing alignment is canted with respect to the channel. See Figure 7-194.
3. Using a suitable hoist, insert the outer telescopic into the main frame as far as the crosstie.
4. Attach the lower roller bearing to the other side of the outer telescopic.
5. Using a pry bar, move the outer telescopic and bearing to one side.
6. Use spare shims as a gauge to determine the amount of shims required to cause the roller bearing to contact the main frame.
7. Remove both lower bearings. Install one half of the total shim thickness required to each roller bearing. Reinstall the bearings. Apply thread-locking compound (P/N 990-536) to the bearing mounting bolt and torque to 260 ft. lb. (352 Nm).
8. If the inner race of the bearing does not protrude past the end of the bearing stud when the bearing is fully seated, bend the flat washer to contact the bearing to prevent the bearing from walking on the stud shaft. See Figure 7-198.

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Figure 7-198. Inner Race



9. Using the hoist, slide the outer telescopic the entire length of the main frame, checking for binding. The tightest spots are generally at the crossties. Add or remove shims as necessary to maintain a snug but free-running fit.

Upper Bearings of Main Frame

1. With the outer telescopic inserted halfway into the main frame, attach the upper roller bearing to one side of the main frame. Make sure the flat spot on the bearing outer stud is correctly positioned against the mast. See Figure 7-197.
2. Attach, but do not tighten, the upper roller bearing to the other side of the main frame.
3. Use spare shims as a gauge to determine the amount of shims required to cause the roller bearing to contact the outer telescopic.
4. Remove both upper bearings. Install one half of the total shim thickness required to each roller bearing. Reinstall the bearings. Apply thread-locking compound (P/N 990-536) to the bearing mounting bolt and torque to 260 ft. lb. (352 Nm).
5. If the inner race of the bearing does not protrude past the end of the bearing stud when the bearing is fully seated, bend the flat washer to contact the bearing to prevent the bearing from walking on the stud shaft. See Figure 7-198.
6. Using the hoist, slide the outer telescopic the entire length of the main frame, checking for binding. Add or remove shims as necessary to maintain a snug but free-running fit.

Assembling and Shimming Inner Telescopic to Outer Telescopic

Lower Bearings of Inner Telescopic

1. Attach the lower roller bearing to one side of the inner telescopic. Make sure the flat spot on the bearing outer stud is correctly positioned against the mast. See Figure 7-195.
2. Using a suitable hoist, insert the inner telescopic into the outer telescopic as far as the crosstie.
3. Attach the lower roller bearing to the other side of the inner telescopic.
4. Using a pry bar, move the inner telescopic and bearing to one side.
5. Use spare shims as a gauge to determine the amount of shims required to cause the roller bearing to contact the outer tele.
6. Remove both lower bearings. Install one half of the total shim thickness required to each roller bearing. Reinstall the bearings. Apply thread-locking compound (P/N 990-536) to the bearing mounting bolt and torque to 260 ft. lb. (352 Nm).
7. If the inner race of the bearing does not protrude past the end of the bearing stud when the bearing is fully seated, bend the flat washer to contact the bearing to prevent the bearing from walking on the stud shaft. See Figure 7-198.
8. Using the hoist, slide the inner telescopic the entire length of the outer telescopic, checking for binding. Add or remove shims as necessary to maintain a snug but free-running fit.

Upper Bearings of Outer Telescopic

1. With the inner telescopic inserted halfway into the main frame, attach the upper

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roller bearing to one side of the outer telescopic. Make sure the flat spot on the bearing outer stud is correctly positioned against the mast. See Figure 7-196.

2. Attach, but do not tighten, the upper roller bearing to the other side of the outer telescopic.
3. Use spare shims as a gauge to determine the amount of shims required to cause the roller bearing to contact the inner telescopic.
4. Remove both upper bearings. Install one half of the total shim thickness required to each roller bearing. Reinstall the bearings. Apply thread-locking compound (P/N 990-536) to the bearing mounting bolt and torque to 260 ft. lb. (352 Nm).
5. If the inner race of the bearing does not protrude past the end of the bearing stud when the bearing is fully seated, bend the flat washer to contact the bearing to prevent the bearing from walking on the stud shaft. See Figure 7-198.
6. Using the hoist, slide the inner telescopic the entire length of the outer telescopic, checking for binding. Add or remove shims as necessary to maintain a snug but free-running fit.
7. Check the clearance gap of the bow pads between inner telescopic and outer telescopic. Shim as required to obtain a gap of 0.03 to 0.09 in. (0.8 to 2.3 mm).

Main Lift Chain Installation

1. Install anti-rattle pads and shims at bottom of inner and outer telescopics. Shim so pads are snug against mast. See Figure 7-194 and Figure 7-195.
2. Install the main lift chain sheaves to the top of the outer telescopic. Sheaves install with a large pin and a set screw on the inside. See Figure 7-193.
3. Install but do not tighten a new sleeve and collar, washer, and mounting bolt through the telescopic crosstie and into the cylinder housing of each main lift cylinder. See Figure 7-192.
4. Rig lifting straps around the upper crossties of all three mast sections.
5. Using a suitable hoist, raise the mast to a vertical position.
6. Rig a lifting strap of one hoist around the lower crosstie of the main frame (the one where the overhead guard attaches).
7. Rig a lifting strap of another hoist around the top crossties of both inner and outer telescopics. Using the hoist, lower the telescopics to about 10 in. (25 cm) from the floor.
8. Make sure the two holes in the upper chain anchor block are towards the outside. Feed the main lift chain from the outside to the inside over the chain sheave.
9. Feed the upper chain anchor block down between the main frame and outer telescopic until holes are aligned between block and main frame. Insert the chain anchor bolt (without the access cover) and lightly tighten the bolt to draw the chain anchor block to the main frame.
10. Thread a bolt into the hole in the chain anchor retaining pin. Insert the pin and drive it in. Remove the bolt from the pin.
11. Remove the chain anchor bolt. Apply thread-locking compound (P/N 990-544) to bolt threads. Install access cover and torque bolt to 130 ft. lb. (174 Nm).
12. Lower the telescopics into the main frame approx 3 in. (7.6 cm) from the floor.
13. Install master links to attach the main lift chains to the lower chain anchor blocks. Lower the telescopics completely. Tighten the chain anchor nuts until the inner telescopic just lifts off its stops.

Shimming Carriage to Inner Telescopic

1. Drape the free lift chains forward over the carriage backrest. Rig lifting straps around the carriage.
2. Install the lower set of roller bearings, without shims, in the carriage.

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3. Using a hoist, carefully lift the carriage and insert it into the inner telescopic until the bearings just enter the telescopic.
4. Using a pry bar, move the carriage bearings to one side.
5. Use spare shim(s) as a gauge to determine the amount of shims required to remove side play.
6. Remove the carriage from the inner telescopic far enough to expose the bearings being shimmed.
7. Remove the bearings being shimmed from the carriage. Install one half of the total shim thickness required to each roller bearing.
8. Using the hoist, reinsert the carriage into the inner telescopic. Check for tight areas while moving the carriage to the bottom of the inner telescopic.
9. Remove the carriage from the inner telescopic far enough to expose the bearings being shimmed.
10. Remove the bearings being shimmed from the carriage.

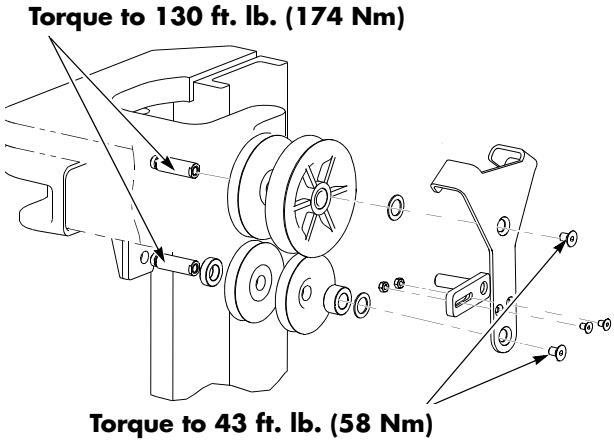
NOTE: The carriage may have to be removed several times to obtain the correct fit.

11. Install the center set of roller bearings, without shims, in the carriage.
12. Repeat steps 4 through 10 for the center set of bearings.
13. Install the upper set of roller bearings, without shims, in the carriage.
14. Repeat steps 4 through 10 for the upper set of bearings.

Carriage, Free Lift Cylinder, and Hose/Cable Installation

1. Drape the free lift chains forward over the carriage backrest. Rig lifting straps around the carriage. Using a hoist, carefully lift the carriage, insert it into the inner telescopic, and lower the carriage to about 3 in. (7.6 cm) above the floor.
2. Route cable and hoses around upper pulleys. Attach upper hose/cable pulley to the top of the outer telescopic. Apply thread-locking compound (P/N 1013829) to the threads of the studs and torque as shown in Figure 7-199.
3. Route auxiliary hoses around lower pulleys. Attach lower hose pulley to the top of the outer telescopic. Apply thread-locking compound (P/N 1013829) to the threads of the studs and torque as shown in Figure 7-199.

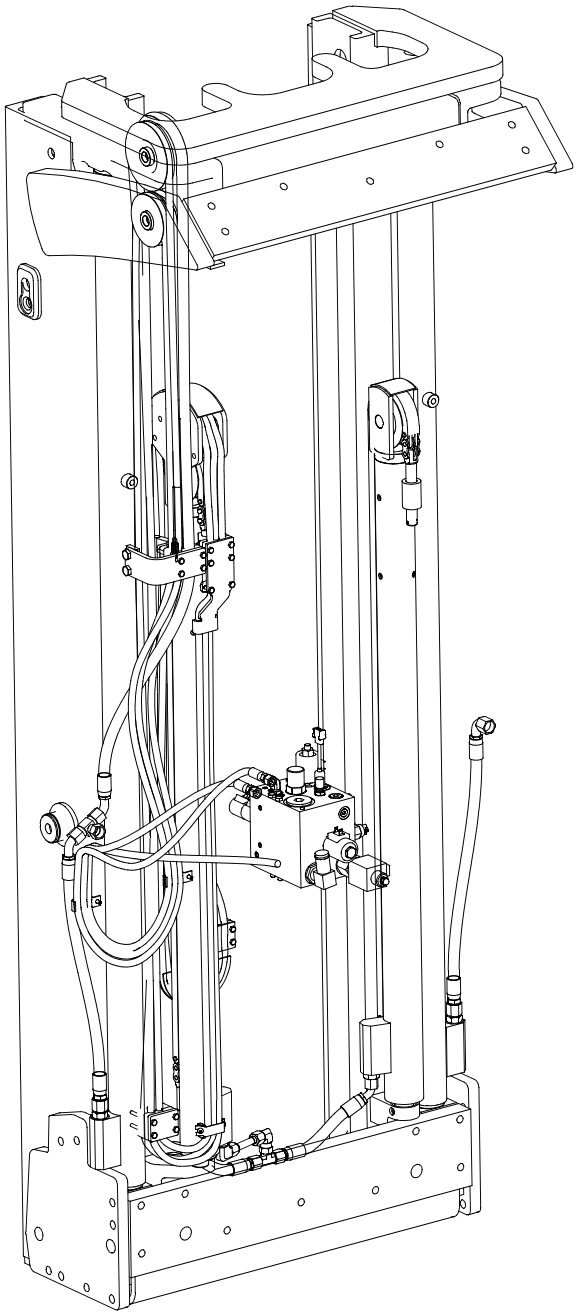
Figure 7-199. Over-the-Mast Hose/Cable Pulleys



4. Install carriage stops. Apply thread-locking compound (P/N 990-536) to mounting bolts and torque to 35 ft. lb. (47.5 Nm).
5. Remove set screws from free lift mounting blocks. Lift each free lift cylinder into place over the mounting hook at the top and the mounting block at the bottom. Apply thread-locking compound (P/N 990-403) to set screw threads and install set screws in mounting blocks.
6. Reference Figure 7-200 for the following steps that route the hoses/cable.

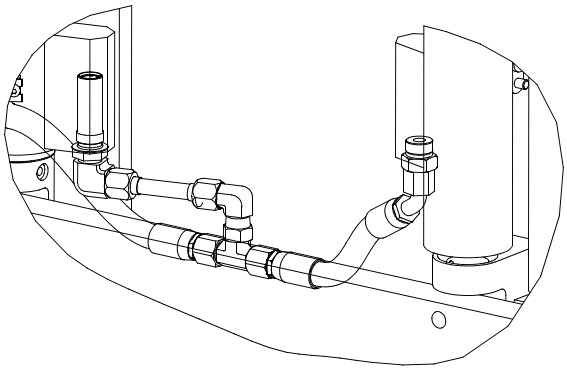
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Figure 7-200. Over-the-Mast Hose and Cable Installation



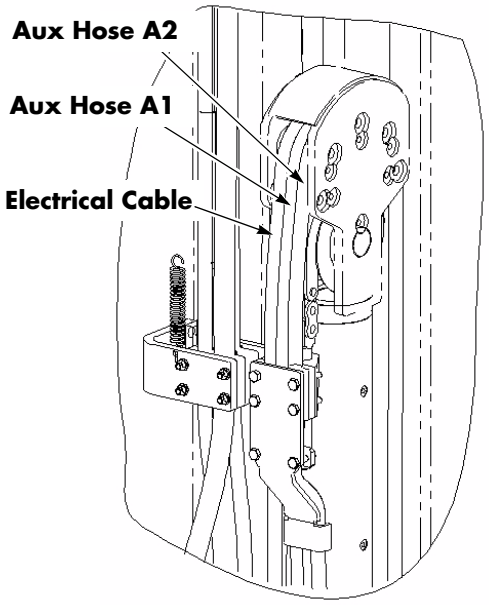
7. Connect tee tubing to free lift cylinders. See Figure 7-201.

Figure 7-201. Free Lift Cylinder Tee Tubing



8. Feed hydraulic hoses and electrical cable through the free lift pulley, from tractor side to forks side. The electrical cable must be on the left-hand side. See Figure 7-202.

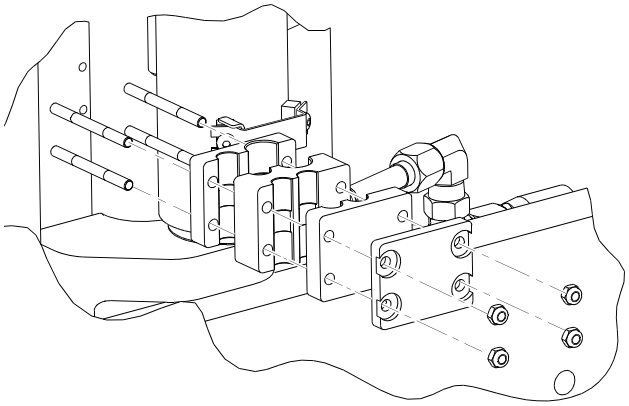
Figure 7-202. OTM Hoses and Cable at Free Lift Pulley



9. Attach, but do not tighten, the hose/cable retainer bracket at the bottom of the free lift cylinder. See Figure 7-203.

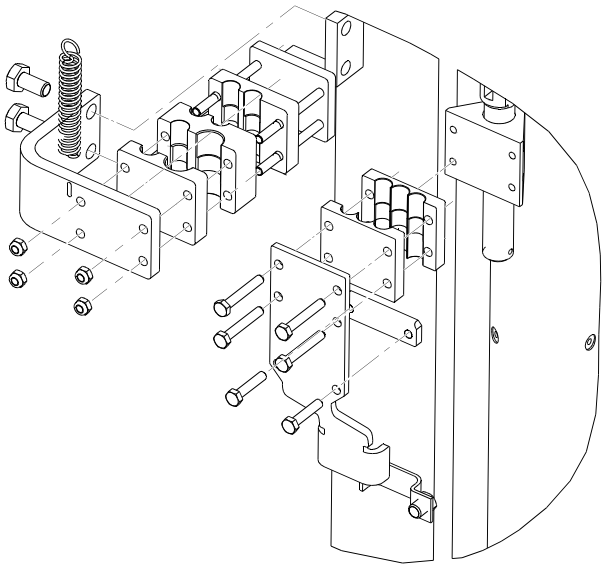
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Figure 7-203. Lower Hose/Cable Retainer, Free Lift Cylinder



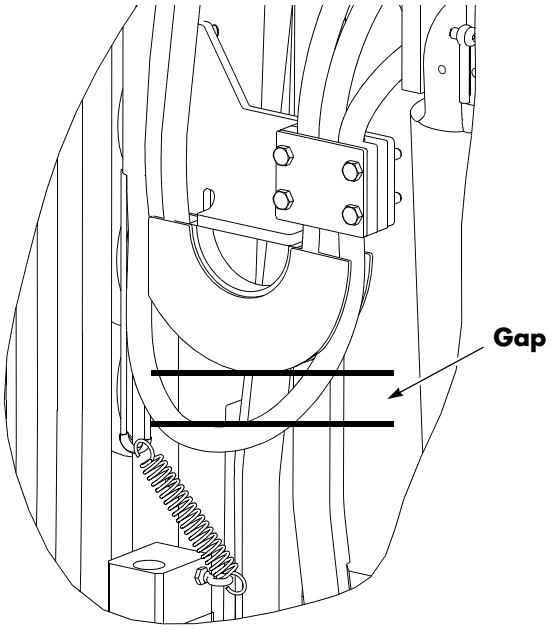
10. Assemble, but do not tighten, the hose/cable retainer at the top of the free lift cylinder. See Figure 7-204.

Figure 7-204. Upper Hose/Cable Retainer, Free Lift Cylinder



11. Feed hoses and cable around the guide on the carriage. Attach the cable tension spring and position the cable grip to provide a 0.75 in. (19 mm) gap between the over-the-mast electrical cable and the bottom of the hose guide. See Figure 7-205.

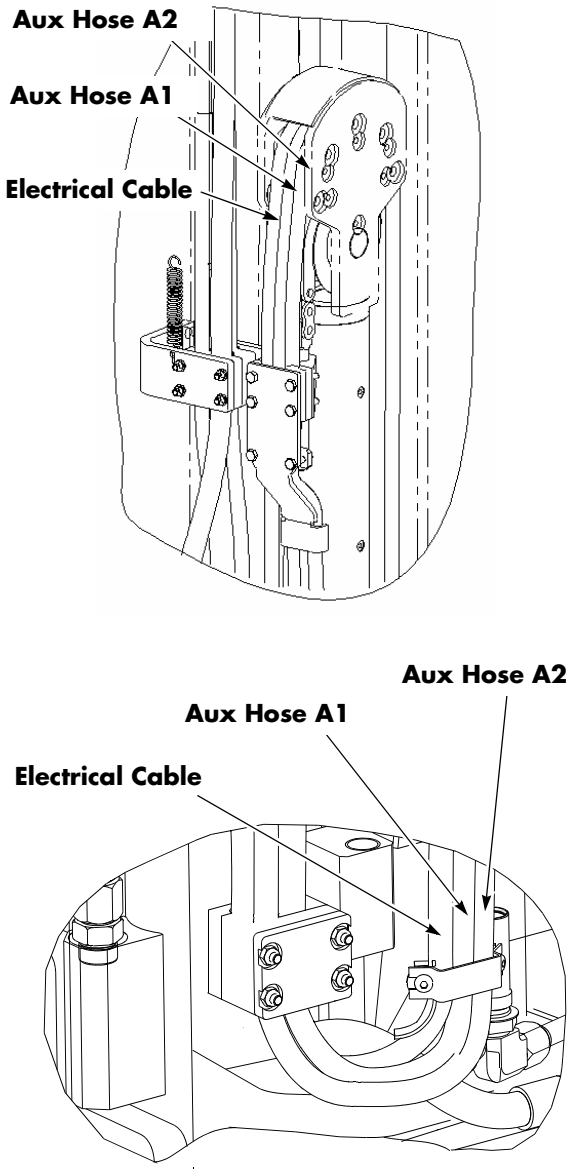
Figure 7-205. Hose/Cable Guide on Carriage



12. Feed the free lift chains over free lift pulleys, from forks side to tractor side. Install master links to attach the free lift chains to the chain anchor blocks.
13. Take slack out of hoses and cable. Make sure hoses do not cross each other. See Figure 7-206.

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Figure 7-206. OTM hose and cable routing



14. Install hose/cable retainer on carriage. See Figure 7-205.
15. Lower the carriage all the way to the floor.
16. Tighten the upper and lower hose/cable retainers on the free cylinders. Attach two cable ties on the upper retainer.
17. With the auxiliary manifold removed from the carriage, connect auxiliary hydraulic hoses to the manifold, making sure to observe correct labeling.
18. Attach the manifold to the carriage. Apply thread-locking compound (P/N 990-536) to the mounting bolt threads and torque to 21 ft. lb. (29 Nm).
19. Connect the over-the-mast cable wires to the terminal block on the auxiliary manifold cover. Attach the manifold cover to the carriage. Apply thread-locking compound (P/N 990-536) to the mounting bolt threads and torque to 30 ft. lb. (42 Nm).
20. Assemble, but do not tighten, the hose/cable retainer on the left side main lift cylinder. See Figure 7-204.
21. Secure the mast with hoist lifting strap wrapped loosely around the top crossties of all three mast sections. Wrap the lifting strap of a second hoist around the upper crosstie of the inner telescopic. Using the hoist, lift the inner telescopic about 6 in. (15 cm).
22. Tighten the hose/cable retainer on the left side main lift cylinder.
23. Lower the inner telescopic.

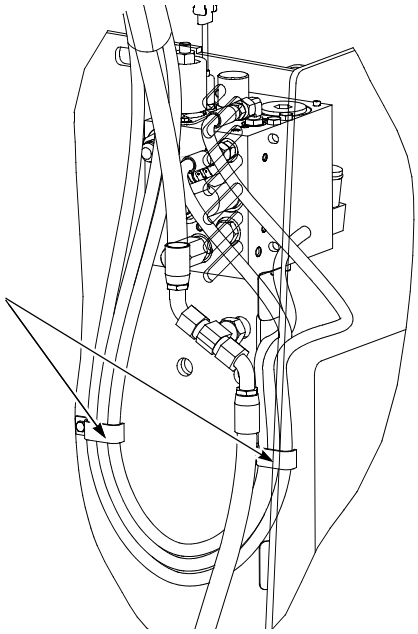
Mating Tractor to Mast

1. Position the tractor about 10 in. (25 cm) from the mast. Place blocks under the tractor near the mast to match the bolt hole height in tractor and mast.
2. Attach the hose/cable retaining bracket on the front (mast side) of the tractor bulkhead. See Figure 7-207.
3. With the mast secured by a hoist, use a lift truck to mate the tractor to the mast.
4. Apply thread-locking primer (P/N 990-666) to mast mounting bolt threads and hole threads. Permit to dry for several minutes.
5. Apply thread-locking compound (P/N 990-544) to threads of mast mounting bolts.

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6. From the battery compartment, thread eight mounting bolts and washers through bottom of the tractor frame into the mast. Thread four mounting bolts and washers through the top of the tractor frame into the mast. Torque bolts to 165 ft. lb. (224 Nm).
7. Connect the main lift hose fitting at the left side of the tractor.
8. Route the auxiliary hoses and electrical cable through the tractor opening. Secure hoses and cable with retainer clamp. See Figure 7-207.

Figure 7-207. Hose/Cable Retainer Clamps on Tractor



9. Connect auxiliary hoses A1 and A2 at the main manifold, observing labels.
10. Connect over-the-mast cable connector JPS3 on the tractor deck. See Figure 7-169.
11. Feed the mast switch harness into the tractor, across the top of the deck to the right side near the lift pump. Connect connector JPS4.
12. Connect the ambient temperature sensor cable connector JPA on the tractor deck.
13. Connect the right side main lift hose to the fitting on the tractor bulkhead.
14. Secure a hoist strap around the overhead guard or position a lift truck with pallet under the overhead guard. Lift the guard into position at the lower crosstie of the main frame.
15. Apply thread-locking compound (P/N 990-536) to the mounting bolt threads. Install mounting bolts and torque to 130 ft. lb. (174 Nm).
16. Install the mast guard.
17. Using a suitable battery moving device, install the battery. Install battery gates.
18. Attach front covers and top cover.
19. Make sure all hoist straps and blocks are removed.
20. Reconnect the battery connector and turn the key switch ON.
21. Bleed the hydraulic system. See "Hydraulic System Bleeding" on page 7-74.
22. Test all lift truck functions.
23. Elevate the inner telescopic about 12 in. (30 cm). Torque the main cylinder top mounting bolts. Tighten main lift cylinder L-bracket mounting bolts to 55 ft. lb. (74.5 Nm).
24. Using a work basket and lift truck, grease the channels of all sections of the mast.

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Mast, Model 7620

Disassembly

Separation of Tractor and Mast

- **Do this procedure with a minimum of two technicians in a shop equipped with a suitable hoist.**
- **Do *not* permit observers to stand nearby.**
- **Wear gloves, safety glasses, steel-toed safety boots, and a safety helmet (hard hat).**

1. Lower and retract the fork carriage completely.
2. Turn the key switch OFF and disconnect the battery connector. Remove battery gates. Using a suitable battery removal device, remove the battery.
3. Remove the top cover and the left and right front covers.
4. Remove the mast guard.
5. Secure a hoist strap around the overhead guard. Take the weight off the guard. Remove mounting bolts. Remove the guard.
6. Disconnect and cap right side main lift hose at the tractor bulkhead fitting.
7. Disconnect the ambient temperature sensor connector JPA on the tractor deck.
8. Disconnect the mast switch connector JPS4 (near the lift pump). Feed harness through tractor opening at right side.
9. Disconnect over-the-mast cable connector TS3 on the tractor deck.
10. Disconnect and plug hydraulic hoses A1 and A2 at the main manifold, labeling as needed for correct reassembly. Feed hoses through opening in tractor bulkhead.
11. Disconnect the main lift hose fitting at the left side of the tractor.

NOTE: Make sure the weight of the mast is fully supported by the hoist and the tractor is blocked where it meets the mast before loosening the mast mounting bolts.

12. Place blocks snugly under the tractor near the mast.
13. Attach a lifting strap around the top crossties of all three mast sections. Draw tight with hoist. Make sure the weight of the mast is supported by the hoist.
14. Remove the battery connector bracket to permit access to the top right mast mounting bolts.
15. Use an impact wrench to remove the mast mounting bolts inside the battery compartment; four on the top, eight on the bottom.
16. Using a lift truck, carefully separate the tractor about 6 in. (15 cm).
17. Reinstall mast mounting bolts and washers and tighten lightly (to prevent misplacing them).

Hose/Cable, Free Lift Cylinder, and Carriage Removal

1. Remove the auxiliary manifold cover from the carriage. See Figure 7-208.
2. Disconnect the wires of the over-the-mast cable from terminal strip TS2, labeling as needed for reconnection.
3. Remove auxiliary manifold mounting screws to permit access to the over-the-mast hose fittings at the manifold.

NOTE: There may be shims between the manifold and carriage.

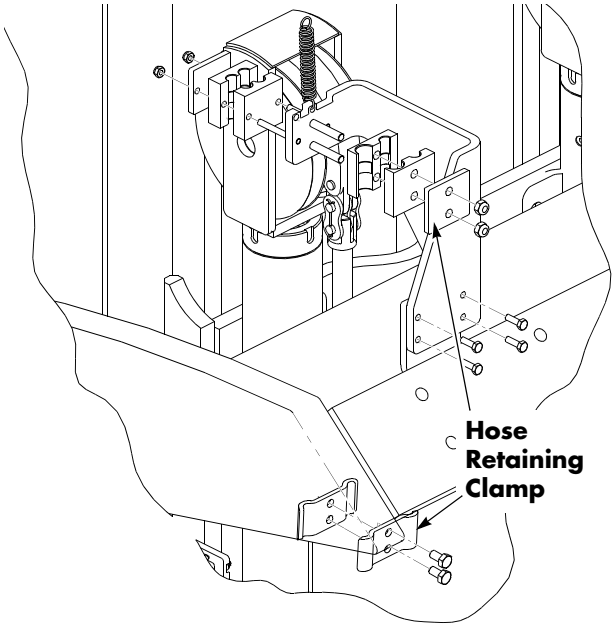
Figure 7-208. Auxiliary Manifold Access



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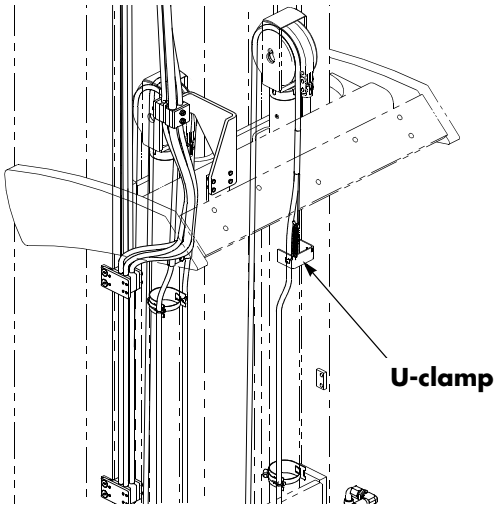
4. Disconnect and plug/cap the over-the-mast hoses and fittings at the auxiliary manifold. Label as needed to make sure correct reconnection.
5. Place a chalk witness mark on the hoses to aid in reassembly.
6. Remove hose retaining clamp near top of the left side free lift cylinder. See Figure 7-209.

Figure 7-209. Hose Retaining Clamp, Left Free Lift Cylinder



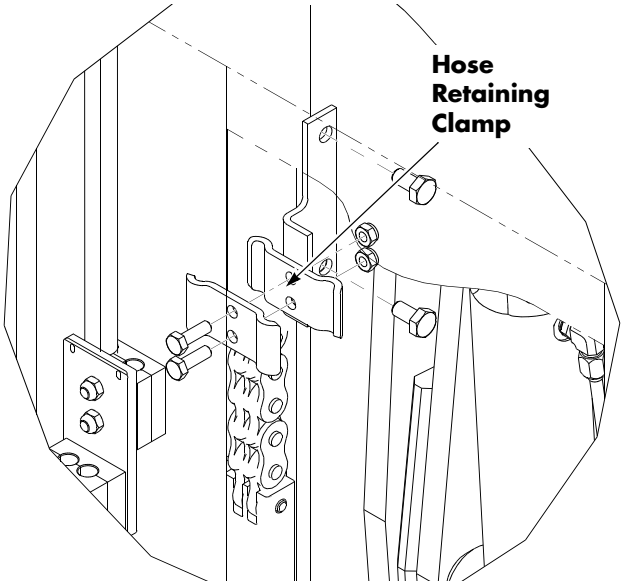
7. Loosen the U-clamp on the right side free lift cylinder and feed the over-the-mast (OTM) cable through. See Figure 7-210.

Figure 7-210. U-clamp, OTM Electrical Cable



8. Cut cable ties on hose clamps on left side free lift cylinder.
9. Loosen the hose retaining clamp on the carriage near the bottom of the left side free lift cylinder. Slide clamp inward to free the hoses. See Figure 7-211.

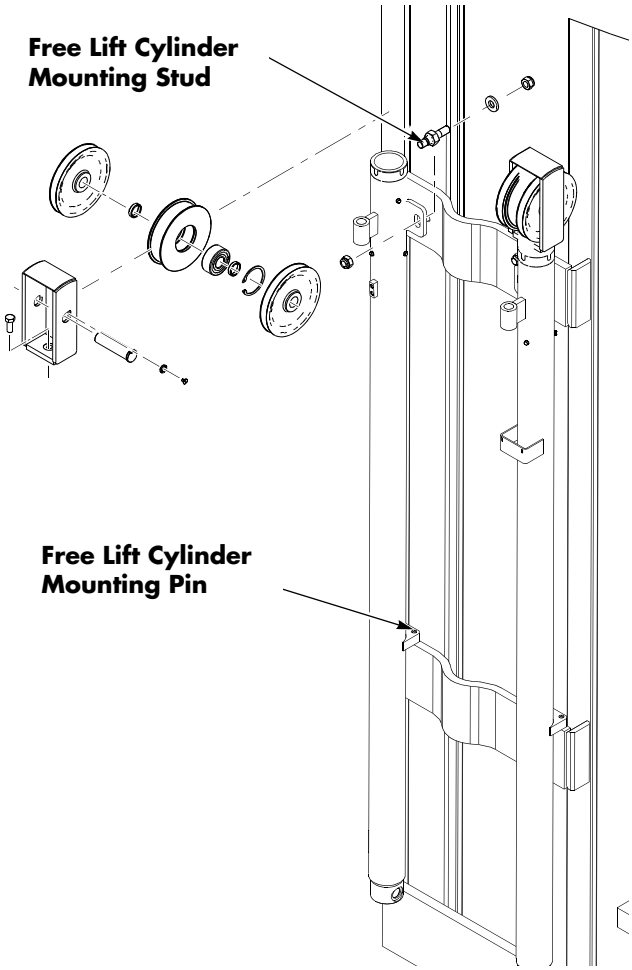
Figure 7-211. Hose Retaining Clamp, Left Free Lift Cylinder, Bottom



10. Feed hoses and cable through free lift cylinder pulleys.
11. Jack carriage up about 3 in. (7.5 cm) to provide slack in chains. Remove master links on free lift chains. Feed free lift chains through pulleys and drape over front of carriage.
12. Remove carriage stops at the top of the inner telescopic.
13. Rig lifting straps around the carriage. Using a hoist, carefully lift the carriage out of the inner telescopic and lower the carriage to the floor.
14. Disconnect and plug the hydraulic supply hose at the bottom of the free lift cylinders.
15. Disconnect the free lift crossover hose and cap both cylinders.
16. Remove the nylon locking nut from the mounting stud on the free lift cylinder. Lift each free lift cylinder off the mounting stud at the top and off the pin at the bottom. See Figure 7-212.

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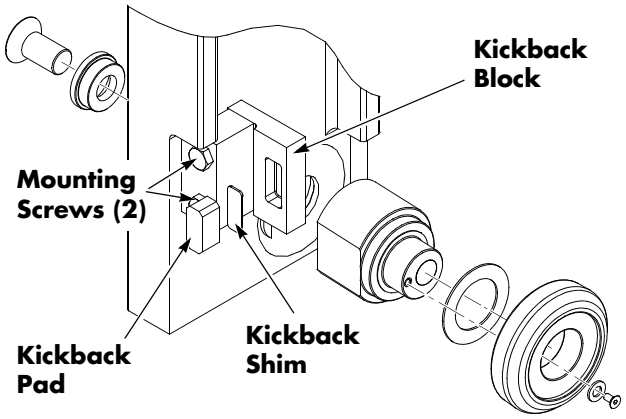
Figure 7-212. Free Lift Cylinder Mounting Stud and Pin



Main Lift Chain Removal

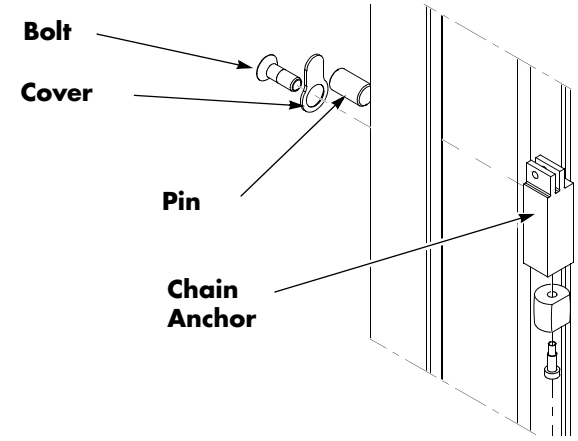
1. Rig a lifting strap of one hoist around the lower crosstie of the main frame (the one where the overhead guard attaches).
2. Rig a lifting strap of another hoist around the top crossties of both inner and outer telescopics. Using the hoist, raise the telescopics about 10 in. (25 cm).
3. Remove the kickback block, pads, and shims at the bottom of the inner telescopic. See Figure 7-213.

Figure 7-213. Inner Telescopic Kickback Block, Pad, Shims



4. Remove the chain anchor retaining nut from the chain anchor block at the bottom of the inner telescopic.
5. Remove the bolt and access cover to the upper chain anchor at the sides of main frame. See Figure 7-214.
6. Remove the chain anchor pin by using a slide hammer or by using a large socket (1 1/16 in.), an M8 x 50 mm bolt, and washers to act as a pulling device. See Figure 7-214 and Figure 7-146.

Figure 7-214. Main Lift Chain Upper Chain Anchor



7. Pull the chain anchor/mast stop out of the main frame.
8. Feed main lift chains from inside to outside over the chain sheave.

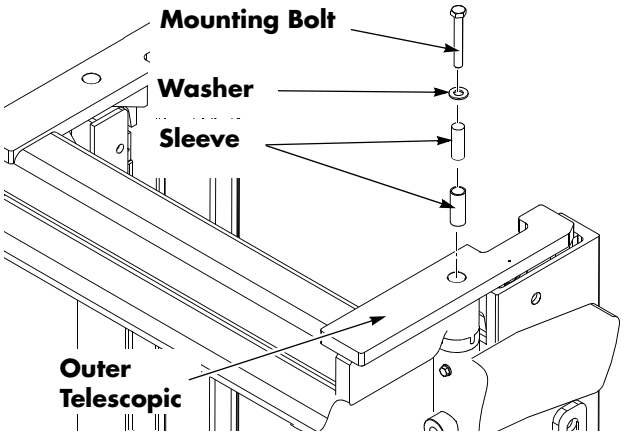
Separation of Telescopics

1. Using the hoists, carefully lower the mast to a horizontal position on jack stands.

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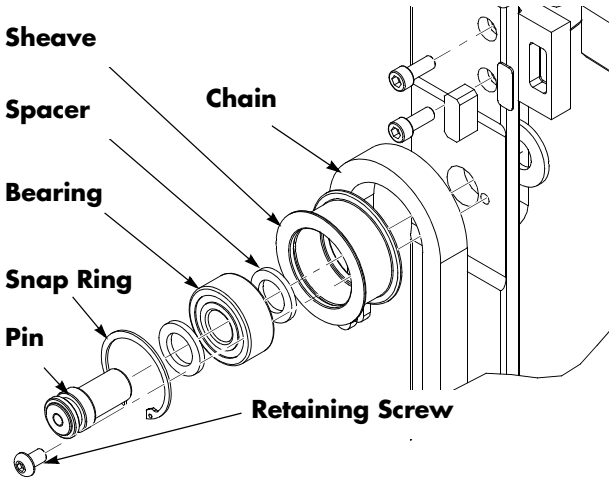
2. Loosen the L-bracket bolts holding the main lift cylinders to the telescopic.
3. Remove the top mounting bolt, washer, and sleeve holding the main lift cylinder to the outer telescopic. See Figure 7-215.

Figure 7-215. Main Lift Cylinder Mounting Hardware



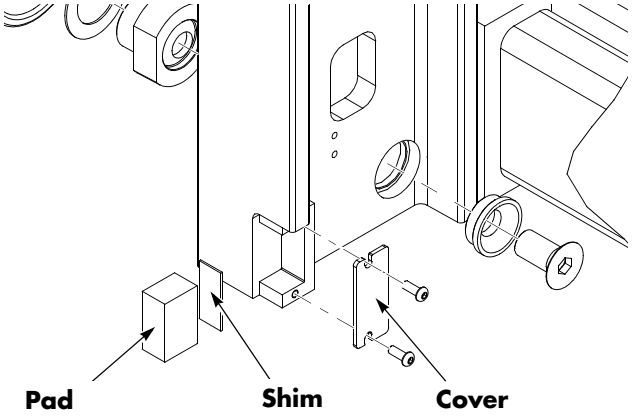
4. Remove main lift chain sheaves from top of outer telescopic. Sheaves attach with a pin and a retaining screw on the front. See Figure 7-216.

Figure 7-216. Main Lift Chain Sheave



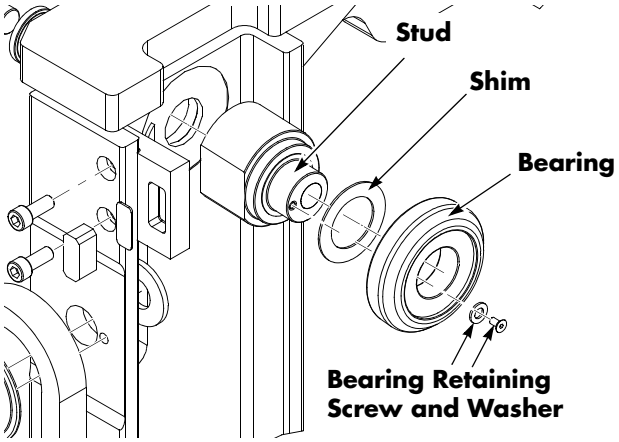
5. Remove anti-rattle pads and shims from bottom of outer telescopic. See Figure 7-217.

Figure 7-217. Outer Telescopic Lower Bearing and Anti-Rattle Pads



6. Using a suitable hoist, pull the inner telescopic halfway out of the outer telescopic.
7. Remove the upper roller bearings and shims from the top of the outer telescopic. See Figure 7-218.

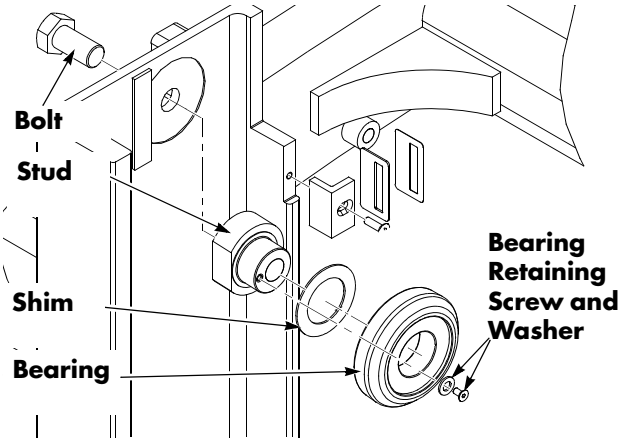
Figure 7-218. Outer Telescopic Upper Bearing



8. Remove the lower roller bearings and shims from the bottom of the inner telescopic. See Figure 7-213.
9. Using a suitable hoist, remove the inner telescopic from the outer telescopic.
10. Using a suitable hoist, pull the outer telescopic halfway out of the main frame.
11. Remove the upper roller bearings and shims from the main frame. See Figure 7-219.

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Figure 7-219. Main Frame Upper Bearing



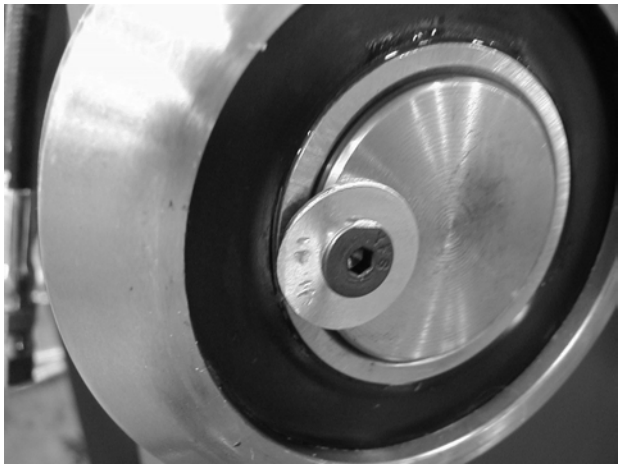
12. Remove the lower roller bearings and shims from the outer telescopic. See Figure 7-217.
13. Using a suitable hoist, remove the outer telescopic from the main frame.

Assembling and Shimming Outer Telescopic to Main Frame

Lower Bearings of Outer Telescopic

1. Begin the assembly with the main frame positioned horizontally on jack stands.
2. Attach the lower roller bearing to one side of the outer telescopic. Make sure the flat spot on the bearing outer stud is correctly positioned against the mast. This is important because the correct bearing alignment is canted with respect to the channel. See Figure 7-217.
3. Using a suitable hoist, insert the outer telescopic into the main frame as far as the crosstie.
4. Attach the lower roller bearing to the other side of the outer telescopic.
5. Using a pry bar, move the outer telescopic and bearing to one side.
6. Use spare shims as a gauge to determine the amount of shims required to cause the roller bearing to contact the main frame.
7. Remove both lower bearings. Install one half of the total shim thickness required to each roller bearing. Reinstall the bearings. Apply thread-locking compound (P/N 990-536) to the bearing mounting bolt and torque to 260 ft. lb. (352 Nm).
8. If the inner race of the bearing does not protrude past the end of the bearing stud when the bearing is fully seated, bend the flat washer to contact the bearing to prevent the bearing from walking on the stud shaft. See Figure 7-220.

Figure 7-220. Inner Race



9. Using the hoist, slide the outer telescopic the entire length of the main frame, checking for binding. The tightest spots are generally at the crossties. Add or remove shims as necessary to maintain a snug but free-running fit.

Upper Bearings of Main Frame

1. With the outer telescopic inserted halfway into the main frame, attach the upper roller bearing to one side of the main frame. Make sure the flat spot on the bearing outer stud is correctly positioned against the mast. See Figure 7-219.
2. Attach but do not tighten the upper roller bearing to the other side of the main frame.

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3. Use spare shims as a gauge to determine the amount of shims required to cause the roller bearing to contact the outer telescopic.
4. Remove both upper bearings. Install one half of the total shim thickness required to each roller bearing. Reinstall the bearings. Apply thread-locking compound (P/N 990-536) to the bearing mounting bolt and torque to 260 ft. lb. (352 Nm).
5. If the inner race of the bearing does not protrude past the end of the bearing stud when the bearing is fully seated, bend the flat washer to contact the bearing to prevent the bearing from walking on the stud shaft. See Figure 7-220.
6. Using the hoist, slide the outer telescopic the entire length of the main frame, checking for binding. Add or remove shims as necessary to maintain a snug but free-running fit.

Assembling and Shimming Inner Telescopic to Outer Telescopic

Lower Bearings of Inner Telescopic

1. Attach the lower roller bearing to one side of the inner telescopic. Make sure the flat spot on the bearing outer stud is correctly positioned against the mast. See Figure 7-213.
2. Using a suitable hoist, insert the inner telescopic into the outer telescopic as far as the crosstie.
3. Attach the lower roller bearing to the other side of the inner telescopic.
4. Using a pry bar, move the inner telescopic and bearing to one side.
5. Use spare shims as a gauge to determine the amount of shims required to cause the roller bearing to contact the outer tele.
6. Remove both lower bearings. Install one half of the total shim thickness required to each roller bearing. Reinstall the bearings. Apply thread-locking compound (P/N 990-536) to the bearing mounting bolt and torque to 260 ft. lb. (352 Nm).
7. If the inner race of the bearing does not protrude past the end of the bearing stud when the bearing is fully seated, bend the flat washer to contact the bearing to prevent the bearing from walking on the stud shaft. See Figure 7-220.
8. Using the hoist, slide the inner telescopic the entire length of the outer telescopic, checking for binding. Add or remove shims as necessary to maintain a snug but free-running fit.

Upper Bearings of Outer Telescopic

1. With the inner telescopic inserted halfway into the main frame, attach the upper roller bearing to one side of the outer telescopic. Make sure the flat spot on the bearing outer stud is correctly positioned against the mast. See Figure 7-213.
2. Attach but do not tighten the upper roller bearing to the other side of the outer telescopic.
3. Use spare shims as a gauge to determine the amount of shims required to cause the roller bearing to contact the inner telescopic.
4. Remove both upper bearings. Install one half of the total shim thickness required to each roller bearing. Reinstall the bearings. Apply thread-locking compound (P/N 990-536) to the bearing mounting bolt and torque to 260 ft. lb. (352 Nm).
5. If the inner race of the bearing does not protrude past the end of the bearing stud when the bearing is fully seated, bend the flat washer to contact the bearing to prevent the bearing from walking on the stud shaft. See Figure 7-219.
6. Using the hoist, slide the inner telescopic the entire length of the outer telescopic, checking for binding. Add or remove shims as necessary to maintain a snug but free-running fit.
7. Check the clearance gap of the bow pads between inner telescopic and outer telescopic. Shim as required to obtain a gap of 0.03 to 0.09 in. (0.8 to 2.3 mm).

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Main Lift Chain Installation

1. Install anti-rattle pads and shims at bottom of inner and outer telescopics. Shim so pads are snug against mast. See Figure 7-217 and Figure 7-213.
2. Install the main lift chain sheaves to the top of the outer telescopic. Sheaves install with a large pin and a retaining screw on the front. See Figure 7-216.
3. Install but do not tighten a new sleeve and collar, washer, and mounting bolt through the telescopic crosstie and into the cylinder housing of each main lift cylinder. See Figure 7-215.
4. Rig lifting straps around the upper crossties of all three mast sections.
5. Using a suitable hoist, raise the mast to a vertical position.
6. Rig a lifting strap of one hoist around the lower crosstie of the main frame (the one where the overhead guard attaches).
7. Rig a lifting strap of another hoist around the top crossties of both inner and outer telescopics. Using the hoist, lower the telescopics to about 10 in. (25 cm) from the floor.
8. Make sure the two holes in the upper chain anchor block are towards the outside. Feed the main lift chain from the outside to the inside over the chain sheave.
9. Feed the upper chain anchor block down between the main frame and outer telescopic until holes are aligned between block and main frame. Insert the chain anchor bolt (without the access cover) and lightly tighten the bolt to draw the chain anchor block to the main frame.
10. Thread a bolt into the hole in the chain anchor retaining pin. Insert the pin and drive it in. Remove the bolt from the pin.
11. Remove the chain anchor bolt. Apply thread-locking compound (P/N 990-544) to bolt threads. Install access cover and torque bolt to 130 ft. lb. (174 Nm).
12. Lower the telescopics into the main frame approx 3 in. (7.6 cm) from the floor.
13. Insert chain anchor bolts into chain anchor blocks. Lower the telescopics completely. Tighten the chain anchor nuts until the inner telescopic is 3/8 in. (9.5 mm) off the outer telescopic.

Shimming Carriage to Inner Telescopic

1. Drape the free lift chains forward over the carriage backrest. Rig lifting straps around the carriage.
2. Install the lower set of roller bearings, without shims, in the carriage.
3. Using a hoist, carefully lift the carriage and insert it into the inner telescopic until the bearings just enter the telescopic.
4. Using a pry bar, move the carriage bearings to one side.
5. Use spare shim(s) as a gauge to determine the amount of shims required to remove side play.
6. Remove the carriage from the inner telescopic far enough to expose the bearings being shimmed.
7. Remove the bearings being shimmed from the carriage. Install one half of the total shim thickness required to each roller bearing.
8. Using the hoist, reinsert the carriage into the inner telescopic. Check for tight areas while moving the carriage to the bottom of the inner telescopic.
9. Remove the carriage from the inner telescopic far enough to expose the bearings being shimmed.
10. Remove the bearings being shimmed from the carriage.

NOTE: You might need to remove the carriage several times to obtain the correct fit.

11. Install the center set of roller bearings, without shims, in the carriage.
12. Repeat steps 4 through 10 for the center set of bearings.
13. Install the upper set of roller bearings, without shims, in the carriage.

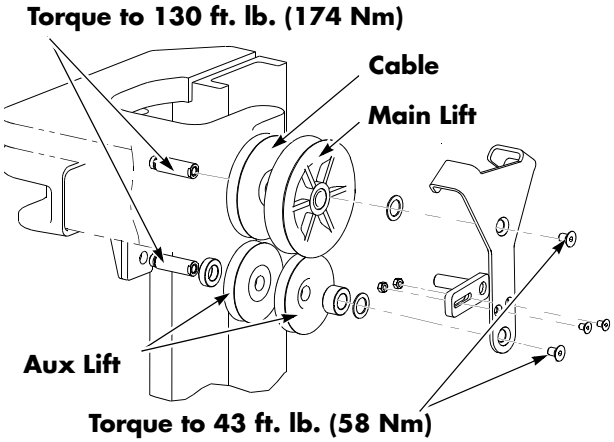
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14. Repeat steps 4 through 10 for the upper set of bearings.

Carriage, Free Lift Cylinder, and Hose/Cable Installation

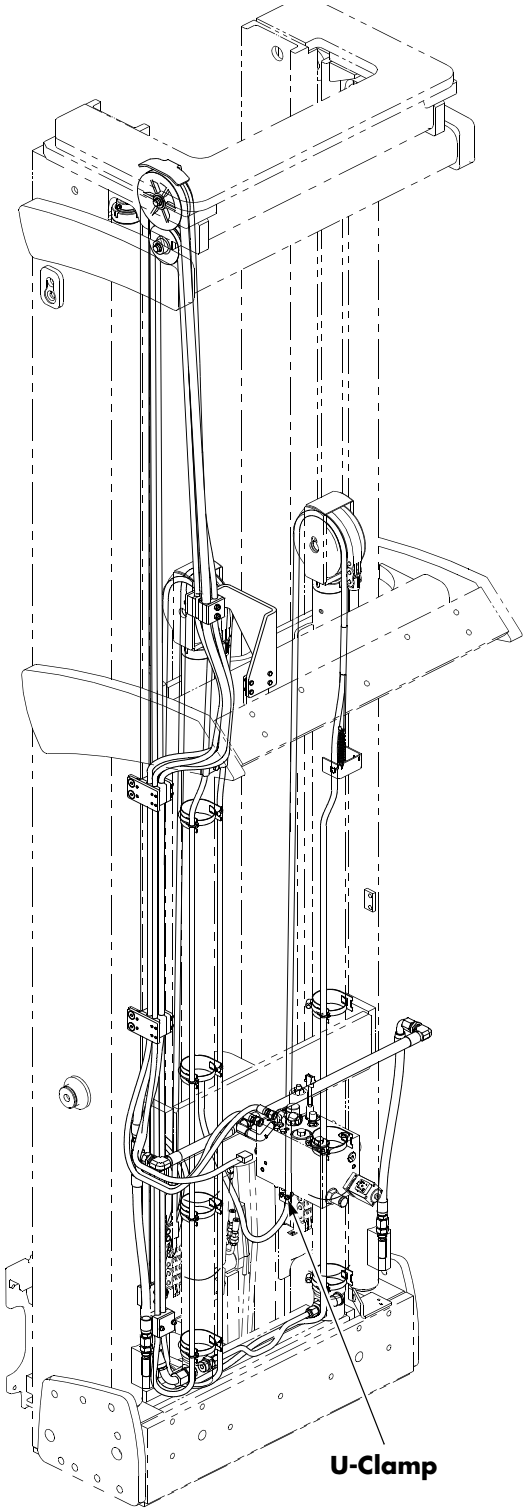
1. Drape the free lift chains forward over the carriage backrest. Rig lifting straps around the carriage. Using a hoist, carefully lift the carriage and insert it into the inner telescopic and lower the carriage to about 3 in. (7.6 cm) above the floor.
2. Route lift hose and cable around upper pulleys. See Figure 7-221.
3. Route auxiliary hoses around lower pulleys. See Figure 7-221.

Figure 7-221. Over-the-Mast Hose/Cable Pulleys



4. Install carriage stops at top of inner telescopic. Apply thread-locking compound (P/N 990-536) to mounting bolts and torque to 35 ft. lb. (47.5 Nm).
5. Lift each free lift cylinder into place over the mounting stud at the top and the pin at the bottom. See Figure 7-212.
6. Reference Figure 7-222 for the following steps that route the hoses/cable.

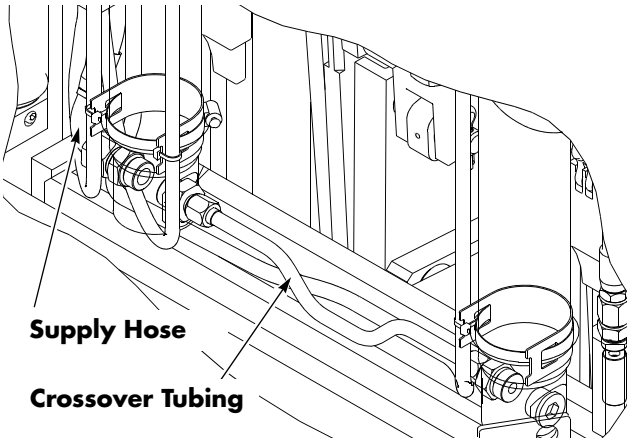
Figure 7-222. Over-the-Mast Hose and Cable Installation



7. Connect supply hose and crossover tubing to free lift cylinders. See Figure 7-223.

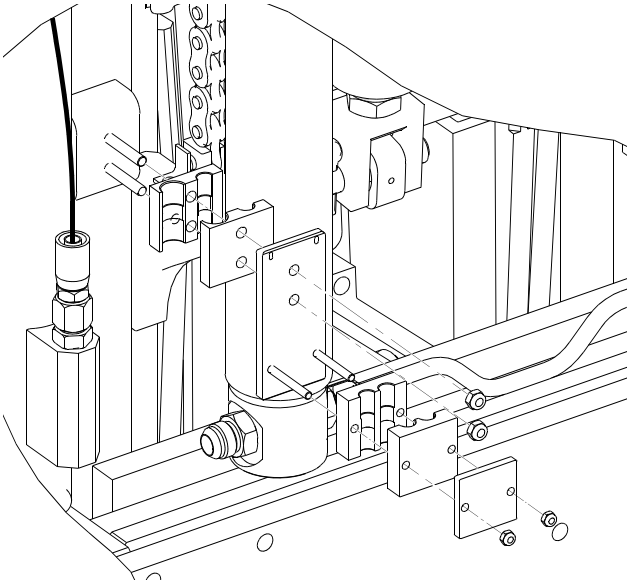
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Figure 7-223. Free Lift Cylinder Hose Connection



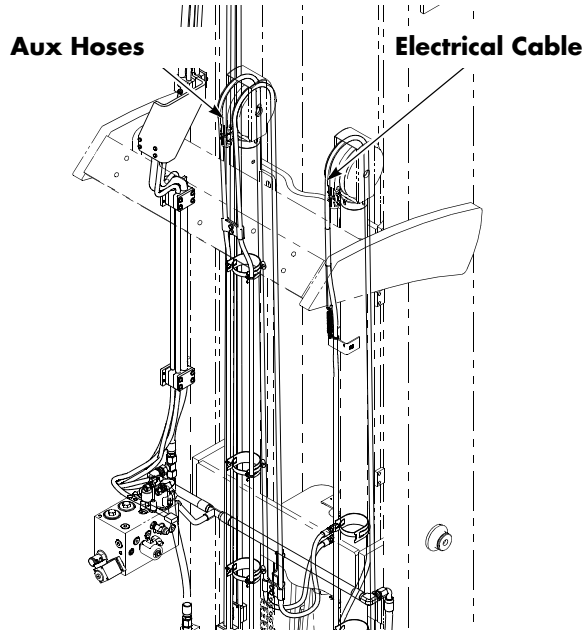
8. Attach and tighten the hose retainer bracket at the bottom of the free lift cylinder. See Figure 7-224.

Figure 7-224. Lower Hose/Cable Retainer, Free Lift Cylinder



9. Feed hydraulic hoses and electrical cable through the free lift pulleys, from tractor side to forks side. See Figure 7-225.

Figure 7-225. OTM Hoses and Cable at Free Lift Pulley



10. Attach and tighten the hose retaining clamp on the carriage near the bottom of the left side free lift cylinder. See Figure 7-211.
11. Replace cable ties on hose clamps on left side free lift cylinder.
12. Feed the over-the-mast (OTM) electrical cable through the U-clamp on the right side free lift cylinder. See Figure 7-222.
13. Attach and tighten the hose retaining clamp near top of the left side free lift cylinder. See Figure 7-209.
14. Feed the free lift chains over free lift pulleys, from forks side to tractor side. Install master links to attach the free lift chains to the chain anchor blocks.
15. Take slack out of hoses and cable.
16. Lower the carriage all the way to the floor.
17. Tighten the upper and lower hose clamps on the free cylinders.
18. With the auxiliary manifold removed from the carriage, connect auxiliary hydraulic hoses to the manifold, making sure to observe correct labeling.
19. Attach the manifold to the carriage. Apply thread-locking compound (P/N 990-536)

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to the mounting bolt threads and torque to 21 ft. lb. (29 Nm).

20. Connect the over-the-mast cable wires to the terminal block on the auxiliary manifold cover. Attach the manifold cover to the carriage. Apply thread-locking compound (P/N 990-536) to the mounting bolt threads and torque to 30 ft. lb. (42 Nm).

Mating Tractor to Mast

1. Position the tractor about 10 in. (25 cm) from the mast. Place blocks under the tractor near the mast to match the bolt hole height in tractor and mast.
2. With the mast secured by a hoist, use a lift truck to mate the tractor to the mast.
3. Apply thread-locking primer (P/N 990-666) to mast mounting bolt threads and hole threads. Permit to dry for several minutes.
4. Apply thread-locking compound (P/N 990-544) to threads of mast mounting bolts.
5. From the battery compartment, thread eight mounting bolts and washers through bottom of the tractor frame into the mast. Thread four mounting bolts and washers through the top of the tractor frame into the mast. Torque bolts to 165 ft. lb. (224 Nm).
6. Connect the main lift hose fitting at the left side of the tractor.
7. Route the auxiliary hoses and electrical cable through the tractor opening.
8. Connect auxiliary hoses A1 and A2 at the main manifold, observing labels.
9. Connect over-the-mast cable connector TS3 on the tractor deck. See Figure 7-169.
10. Feed the mast switch harness into the tractor near the lift pump. Connect connector JPS4.
11. Connect the ambient temperature sensor cable connector JPA on the tractor deck.
12. Connect the right side main lift hose to the fitting on the tractor bulkhead.
13. Secure a hoist strap around the overhead guard or position a lift truck with pallet under the overhead guard. Lift the guard into position at the lower crosstie of the main frame.
14. Apply thread-locking compound (P/N 990-536) to the mounting bolt threads. Install mounting bolts and torque to 130 ft. lb. (174 Nm).
15. Install the mast guard.
16. Using a suitable battery moving device, install the battery. Install battery gates.
17. Attach front covers and top cover.
18. Make sure all hoist straps and blocks are removed.
19. Reconnect the battery connector and turn the key switch ON.
20. Bleed the hydraulic system. See "Hydraulic System Bleeding" on page 7-74.
21. Test all lift truck functions.
22. Elevate the inner telescopic about 12 in. (30 cm). Torque the main cylinder top mounting bolts. Tighten main lift cylinder L-bracket mounting bolts to 55 ft. lb. (74.5 Nm).
23. Using a work basket and lift truck, grease the channels of all sections of the mast.

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Mast, Model 7640

Disassembly

Separation of Tractor and Mast

- **Do this procedure with a minimum of two technicians in a shop equipped with a suitable hoist.**
- **Do *not* permit observers to stand nearby.**
- **Wear gloves, safety glasses, steel-toed safety boots, and a safety helmet (hard hat).**

1. Lower and retract the fork carriage completely.
2. Turn the key switch OFF and disconnect the battery connector. Remove battery gates. Using a suitable battery removal device, remove the battery.
3. Remove the top cover and the left and right front covers.
4. Remove the mast guard.
5. Remove or disconnect any options mounted on the overhead guard. Secure a hoist strap around the overhead guard. Take the weight off the guard. Remove mounting bolts. Remove the guard.
6. Disconnect and cap the left end of the right side main lift hose at the tractor bulkhead fittings.
7. If so equipped, disconnect the ambient temperature sensor connector JPA and HTI connector JP13 on the tractor deck.
8. Disconnect the mast switch connector JPS4 (near the lift pump) and the encoder connector JPS11. Feed harness through tractor opening.
9. Disconnect over-the-mast cable connector TS3 on the tractor deck.
10. Disconnect and plug hydraulic hoses A1 and A2 at the main manifold, labeling as needed for correct reassembly. Feed hoses through opening in tractor bulkhead.

NOTE: Make sure the weight of the mast is fully supported by the hoist and the tractor is blocked where it meets the mast before loosening the mast mounting bolts.

11. Place blocks snugly under the tractor near the mast.
12. Attach a lifting strap around the top crossties of all three mast sections. Draw tight with hoist. Make sure the weight of the mast is supported by the hoist.
13. Remove the battery connector bracket to permit access to the top right mast mounting bolts.
14. Use an impact wrench to remove the mast mounting bolts inside the battery compartment; four on the top, eight on the bottom.
15. Using a lift truck, carefully separate the tractor about 6 in. (15 cm).
16. Reinstall mast mounting bolts and washers and tighten lightly (to prevent misplacing them).

Hose/Cable, Free Lift Cylinder, and Carriage Removal

1. Remove the auxiliary manifold cover from the carriage. See Figure 7-226.
2. Disconnect the wires of the over-the-mast cable from the terminal strip, labeling as needed for reconnection.
3. On the standard reach carriage, remove auxiliary manifold mounting screws to permit access to the over-the-mast hose fittings at the manifold.

NOTE: There may be shims between the manifold and carriage.

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Figure 7-226. Auxiliary Manifold Access

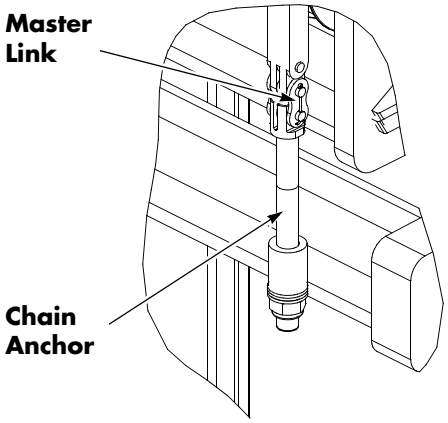


4. Disconnect and plug/cap the over-the-mast hoses and fittings at the auxiliary manifold. Label as needed to make sure correct reconnection.
5. Jack carriage up about 3 in. (7.6 cm) to provide slack in the free lift chains. Remove master links on free lift chains. Feed free lift chains through pulleys and drape over front of carriage.
6. Remove or loosen hose/cable retaining clamps on back of carriage.
7. Remove or loosen the upper clamp from left free lift cylinder.
8. Remove hose/cable ties from the free lift cylinders.
9. Separate and block the telescopics to provide slack in the OTM lift hose.
10. Remove the OTM hose/cable retainers from the bottom of the inner telescopic.
11. Disconnect and cap/plug the main lift hose at the left side free lift cylinder.
12. Remove the OTM hose/cable retainers from the mast crosstie and left main lift cylinder.
13. Remove the OTM hoses and cable from the mast.
14. Feed hoses and cable through free lift cylinder pulleys.
15. Remove connecting hose from free lift cylinders.
16. Remove top mounting hardware from each of the free lift cylinders. Lift each free lift cylinder off the mounting pin at the bottom and past the mounting pin at the top.
17. Remove carriage stops at the top of the inner telescopic.
18. Remove the forks.
19. Rig lifting straps around the carriage. Using a hoist, carefully lift the carriage out of the inner telescopic and lower the carriage to the floor.

Main Lift Chain Removal

1. Rig a lifting strap of one hoist around the lower crosstie of the main frame (the one where the overhead guard attaches).
2. Rig a lifting strap of another hoist around the top crossties of both inner and outer telescopics. Using the hoist, raise the telescopics about 10 in. (25 cm).
3. Remove master links from the upper (adjustable) chain anchors. See Figure 7-227.

Figure 7-227. Main Lift Chain Upper Chain Anchor



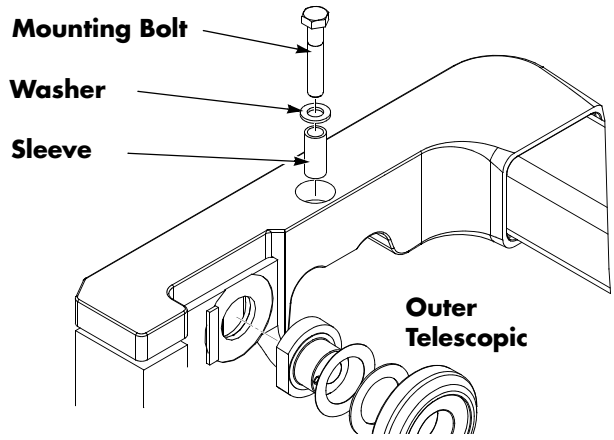
4. It will be easier to remove the lift chain if you separate telescopics first.

Separation of Telescopics

1. Using the hoists, carefully lower the mast to a horizontal position on jack stands.
2. Loosen the L-bracket bolts holding the main lift cylinders to the telescopic.
3. Remove the top mounting bolt, washer, and sleeve holding the main lift cylinder to the outer telescopic. See Figure 7-228.

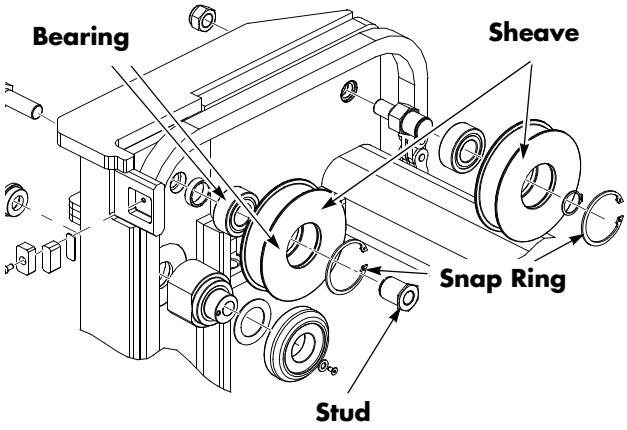
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Figure 7-228. Main Lift Cylinder Mounting Hardware



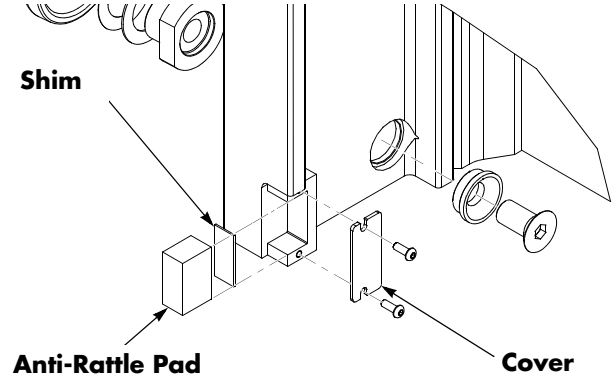
4. Remove main lift chain sheaves from top of outer telescopic. See Figure 7-229.

Figure 7-229. Main Lift Chain Sheave



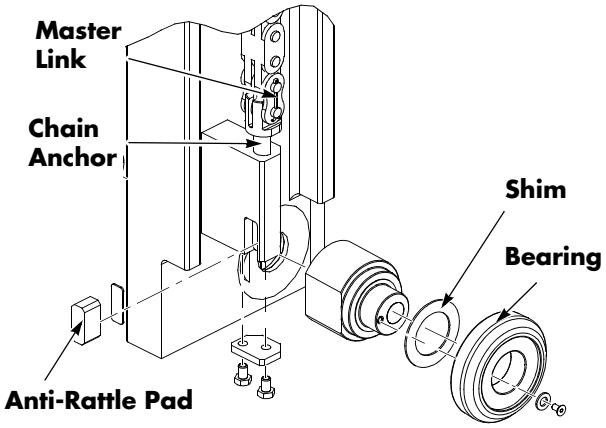
5. Remove anti-rattle pads and shims from bottom of outer telescopic. See Figure 7-230.

Figure 7-230. Outer Telescopic Lower Bearing and Anti-Rattle Pads



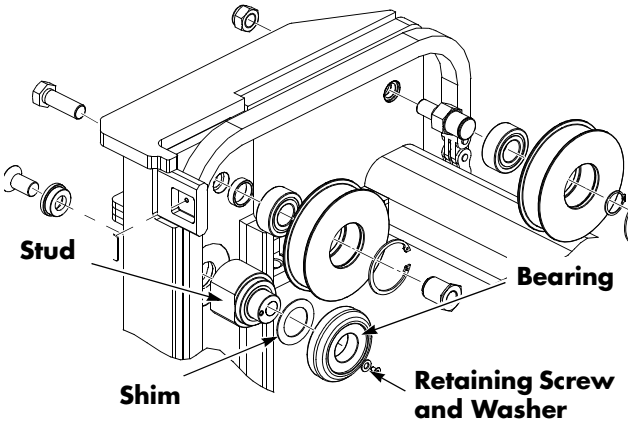
6. Remove anti-rattle pads and shims from bottom of inner telescopic. See Figure 7-231.

Figure 7-231. Main Lift Chain Lower Chain Anchor and Inner Telescopic Lower Roller Bearing



7. Using a suitable hoist, pull the inner telescopic halfway out of the outer telescopic. Keep tension on the main lift chains while pulling the inner telescopic.
8. Remove the main lift chains at the lower chain anchor. See Figure 7-231.
9. Remove the upper roller bearings and shims from the top of the outer telescopic. See Figure 7-232.

Figure 7-232. Outer Telescopic Upper Bearing

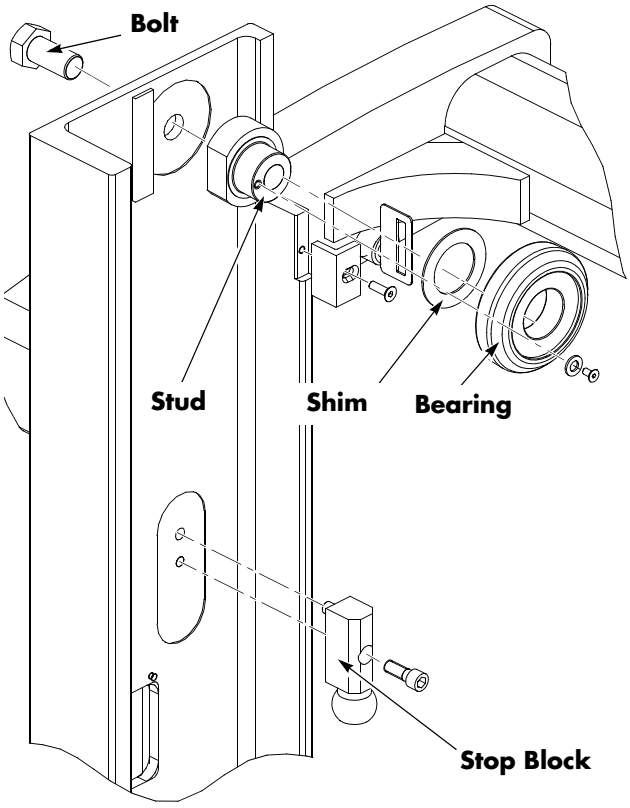


10. Remove the lower roller bearings and shims from the bottom of the inner telescopic. See Figure 7-231.
11. Using a suitable hoist, remove the inner telescopic from the outer telescopic.

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12. Using a suitable hoist, pull the outer telescopic halfway out of the main frame.
13. Disconnect the height encoder belt at the top of the outer telescopic. See "Height Encoder Belt" on page 7-140.
14. Remove the height encoder from the main frame.
15. Reconnect the encoder belt at the telescopic.
16. Remove the upper roller bearings and shims from the main frame. See Figure 7-233.

Figure 7-233. Main Frame Upper Bearing



17. Pull the telescopic until the lower stop access cutouts align with the stop blocks mounted to the main frame. Remove the stop blocks on the main frame. See Figure 7-233.
18. Remove the lower roller bearings and shims from the outer telescopic. See Figure 7-230.
19. Using a suitable hoist, remove the outer telescopic from the main frame.

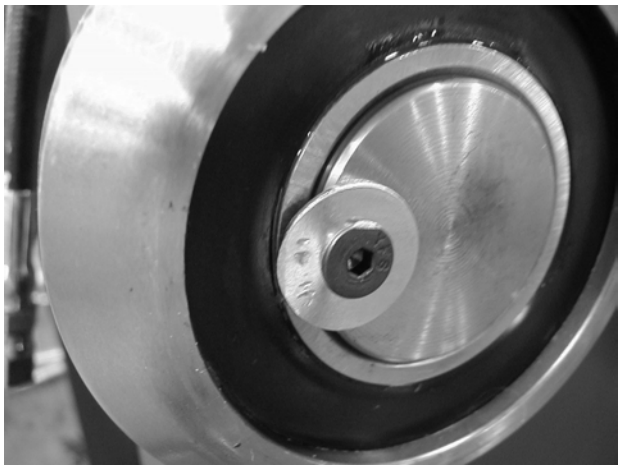
Assembling and Shimming Outer Telescopic to Main Frame

Lower Bearings of Outer Telescopic

1. Begin the assembly with the main frame positioned horizontally on jack stands.
2. Attach both ends of the height encoder belt to the mast.
3. Attach the lower roller bearing to one side of the outer telescopic. Make sure the flat spot on the bearing outer stud is correctly positioned against the mast. This is important because the correct bearing alignment is canted with respect to the channel. See Figure 7-230.
4. Using a suitable hoist, insert the outer telescopic into the main frame as far as the crosstie.
5. Attach the lower roller bearing to the other side of the outer telescopic.
6. Using a pry bar, move the outer telescopic and bearing to one side.
7. Use spare shims as a gauge to determine the amount of shims required to cause the roller bearing to contact the main frame.
8. Remove both lower bearings. Install one half of the total shim thickness required to each roller bearing. Reinstall the bearings. Apply thread-locking compound (P/N 990-536) to the bearing mounting bolt and torque to 260 ft. lb. (352 Nm).
9. If the inner race of the bearing does not protrude past the end of the bearing stud when the bearing is fully seated, bend the flat washer to contact the bearing to prevent the bearing from walking on the stud shaft. See Figure 7-234.

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Figure 7-234. Inner Race



10. Using the hoist, slide the outer telescopic the entire length of the main frame, checking for binding. The tightest spots will generally be at the crossties. Add or remove shims as necessary to maintain a snug but free-running fit.
11. Align mast stop cutouts on the outer telescopic with the stop locations on the main frame. Install mast stops on the main frame.

Upper Bearings of Main Frame

1. With the outer telescopic inserted halfway into the main frame, attach the upper roller bearing to one side of the main frame. Make sure the flat spot on the bearing outer stud is correctly positioned against the mast. See Figure 7-233.
2. Attach, but do not tighten, the upper roller bearing to the other side of the main frame.
3. Use spare shims as a gauge to determine the amount of shims required to cause the roller bearing to contact the outer telescopic.
4. Remove both upper bearings. Install one half of the total shim thickness required to each roller bearing. Reinstall the bearings. Apply thread-locking compound (P/N 990-536) to the bearing mounting bolt and torque to 260 ft. lb. (352 Nm).
5. If the inner race of the bearing does not protrude past the end of the bearing stud when the bearing is fully seated, bend the flat washer to contact the bearing to prevent the bearing from walking on the stud shaft. See Figure 7-234.
6. Using the hoist, slide the outer telescopic the entire length of the main frame, checking for binding. Add or remove shims as necessary to maintain a snug but free-running fit.
7. When the upper mast bearing shimming is complete, reinstall the height encoder.

Assembling and Shimming Inner Telescopic to Outer Telescopic

Lower Bearings of Inner Telescopic

1. Attach the lower roller bearing to one side of the inner telescopic. Make sure the flat spot on the bearing outer stud is correctly positioned against the mast. See Figure 7-231.
2. Using a suitable hoist, insert the inner telescopic into the outer telescopic as far as the crosstie.
3. Attach the lower roller bearing to the other side of the inner telescopic.
4. Using a pry bar, move the inner telescopic and bearing to one side.
5. Use spare shims as a gauge to determine the amount of shims required to cause the roller bearing to contact the outer tele.
6. Remove both lower bearings. Install one half of the total shim thickness required to each roller bearing. Reinstall the bearings. Apply thread-locking compound (P/N 990-536) to the bearing mounting bolt and torque to 260 ft. lb. (352 Nm).
7. If the inner race of the bearing does not protrude past the end of the bearing stud when the bearing is fully seated, bend the flat washer to contact the bearing to prevent the bearing from walking on the stud shaft. See Figure 7-234.

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8. Using the hoist, slide the inner telescopic the entire length of the outer telescopic, checking for binding. Add or remove shims as necessary to maintain a snug but free-running fit.
9. When the lower mast bearing shimming is complete, attach the main lift chains to the lower chain anchors. Keep tension on the chains as the inner telescopic is inserted into the outer telescopic.

Upper Bearings of Outer Telescopic

1. With the inner telescopic inserted halfway into the main frame, attach the upper roller bearing to one side of the outer telescopic. Make sure the flat spot on the bearing outer stud is correctly positioned against the mast. See Figure 7-232.
2. Attach, but do not tighten, the upper roller bearing to the other side of the outer telescopic.
3. Use spare shims as a gauge to determine the amount of shims required to cause the roller bearing to contact the inner telescopic.
4. Remove both upper bearings. Install one half of the total shim thickness required to each roller bearing. Reinstall the bearings. Apply thread-locking compound (P/N 990-536) to the bearing mounting bolt and torque to 260 ft. lb. (352 Nm).
5. If the inner race of the bearing does not protrude past the end of the bearing stud when the bearing is fully seated, bend the flat washer to contact the bearing to prevent the bearing from walking on the stud shaft. See Figure 7-234.
6. Using the hoist, slide the inner telescopic the entire length of the outer telescopic, checking for binding. Add or remove shims as necessary to maintain a snug but free-running fit.

Main Lift Chain Installation

1. Install anti-rattle pads and shims at bottom of inner and outer telescopics. Shim so pads are snug against mast. See Figure 7-230 and Figure 7-231.
2. Install the main lift chain sheaves to the top of the outer telescopic. See Figure 7-229.
3. Install a new sleeve and collar, washer, and mounting bolt through the telescopic crosstie and into the cylinder housing of each main lift cylinder. Apply thread-locking compound (P/N 1013829) to the threads of the bolt and leave a 0.12 in. (3 mm) gap between the bolt head and washer. See Figure 7-228.
4. Rig lifting straps around the upper crossties of all three mast sections.
5. Using a suitable hoist, raise the mast to a vertical position.
6. Rig a lifting strap of one hoist around the lower crosstie of the main frame (the one where the overhead guard attaches).
7. Lower the telescopics into the main frame approx 3 in. (7.5 cm) from the floor.
8. Insert chain anchor bolts into chain anchor blocks. Lower the telescopics completely. Tighten the chain anchor nuts until the inner telescopic is 3/8 in. (9.5 mm) off of the outer telescopic at the upper crossties.

Shimming Carriage to Inner Telescopic

1. Drape the free lift chains forward over the carriage backrest. Rig lifting straps around the carriage.
2. Install the lower set of roller bearings, without shims, in the carriage.
3. Using a hoist, carefully lift the carriage and insert it into the inner telescopic until the bearings just enter the telescopic.
4. Using a pry bar, move the carriage bearings to one side.
5. Use spare shim(s) as a gauge to determine the amount of shims required to remove side play.
6. Remove the carriage from the inner telescopic far enough to expose the bearings being shimmed.

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7. Remove the bearings being shimmed from the carriage. Install one half of the total shim thickness required to each roller bearing.
8. Using the hoist, reinsert the carriage into the inner telescopic. Check for tight areas while moving the carriage to the bottom of the inner telescopic.
9. Remove the carriage from the inner telescopic far enough to expose the bearings being shimmed.
10. Remove the bearings being shimmed from the carriage.

NOTE: The carriage may have to be removed several times to obtain the correct fit.

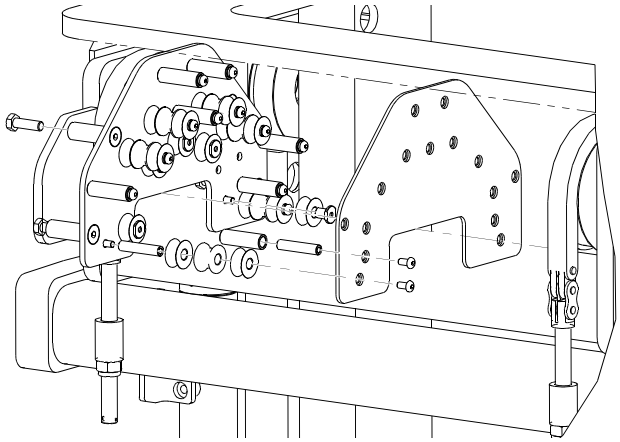
11. Install the center set of roller bearings, without shims, in the carriage.
12. Repeat steps 4 through 10 for the center set of bearings.
13. Install the upper set of roller bearings, without shims, in the carriage.
14. Repeat steps 4 through 10 for the upper set of bearings.

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Carriage, Free Lift Cylinder, and Hose/Cable Installation

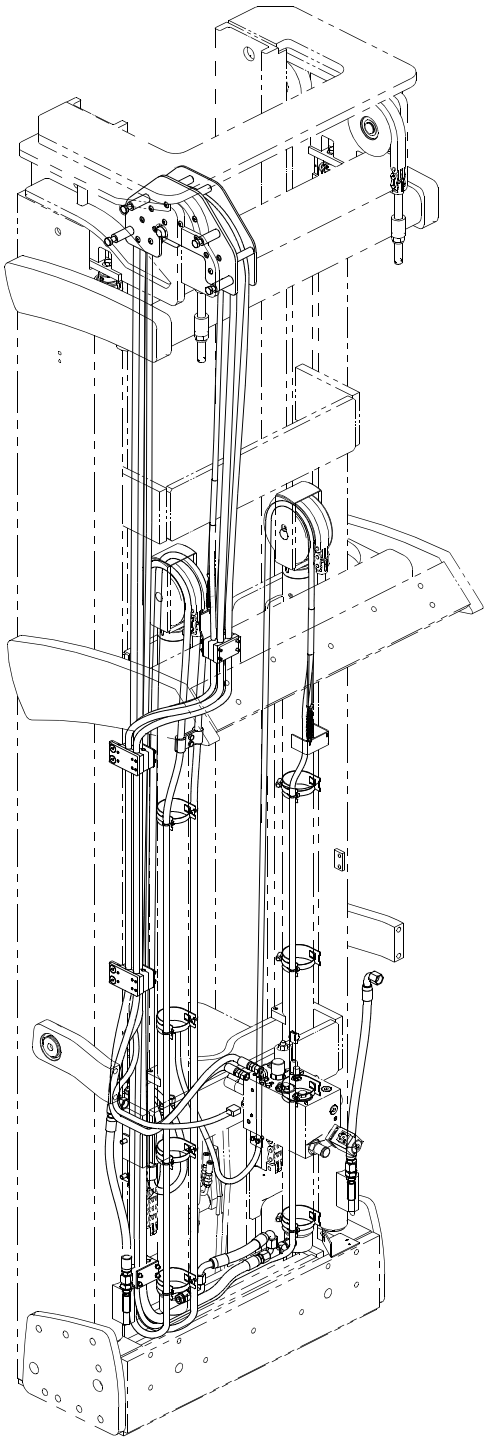
1. Drape the free lift chains forward over the carriage backrest. Rig lifting straps around the carriage. Using a hoist, carefully lift the carriage and insert it into the inner telescopic and lower the carriage to about 3 in. (7.5 cm) above the floor.
2. Attach the manifold block at the bottom of the mast between the main and free lift cylinders. Apply thread-locking compound (P/N 990-536) to bolt threads and torque to 15 ft. lb. (21 Nm).
3. Connect the tee tubing for the main lift cylinders.
4. Route cable and hoses around upper pulleys.

Figure 7-235. Over-the-Mast Hose/Cable Pulleys



5. Install carriage stops at top of inner telescopic. Apply thread-locking compound (P/N 990-536) to mounting bolts and torque to 35 ft. lb. (47.5 Nm).
6. Lift each free lift cylinder into place over the mounting pin at the bottom and the mounting pin at the top.
7. Attach the lift hose to the free lift cylinder.
8. Reference Figure 7-236 for the following steps that route the hoses/cable.

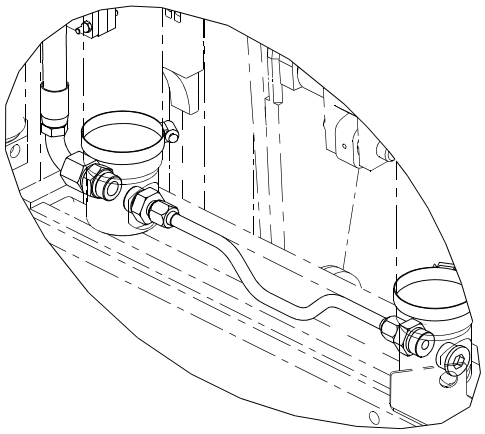
Figure 7-236. Over-the-Mast Hose and Cable Installation



9. Connect hose to free lift cylinders. See Figure 7-237.

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Figure 7-237. Free Lift Cylinder Hose Connection



10. Attach the OTM hoses to the reach manifold and the OTM cable to the carriage terminal strip.
11. Position the hoses and cable into their clamps at the back of the carriage and tighten. See Figure 7-238 and Figure 7-239.

Figure 7-238. Standard Carriage Hose Routing

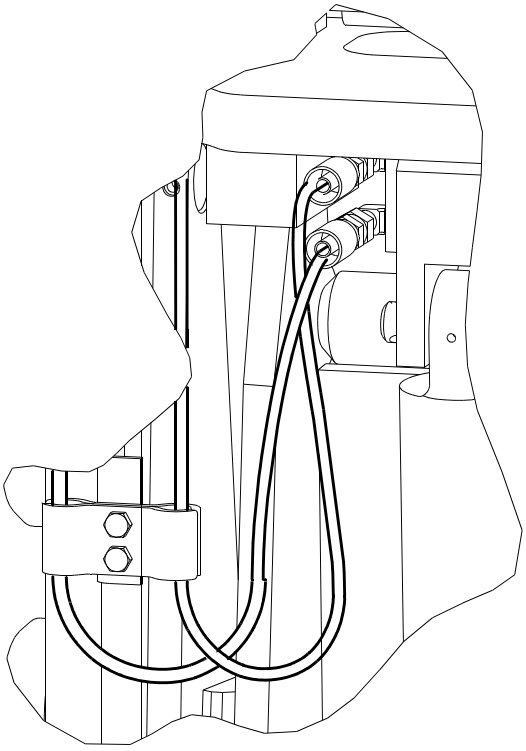
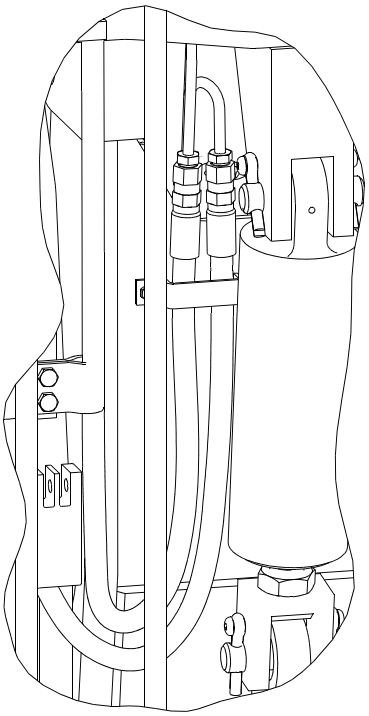


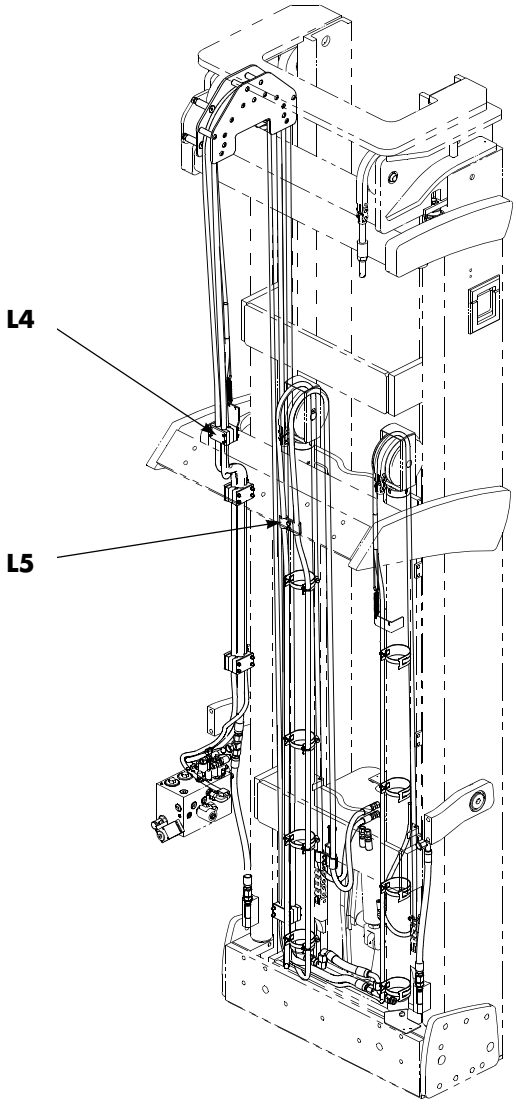
Figure 7-239. Deep-Reach® Carriage Hose Routing



12. Feed OTM hoses and cable through free lift cylinder pulleys. See *Deep-Reach*® Carriage Hose Routing.
13. Position hoses in the retaining clamp at the top of the left free lift cylinder. See Figure 7-240. Remove all slack.
14. Find the correct L5 value from Table 7-18. Measure and mark hoses above the clamp, using the L5 value. L5 equals the length the hoses are to be stretched over the free lift cylinder.
15. Reconnect the battery connector and turn the key switch ON.
16. Place block under carriage and lower carriage to relieve tension on hoses.
17. Pull down on the hoses until marks are flush with top of retainers.
18. Set the tension on the cable spring at the top of the right free lift cylinder by sliding the cable grip to produce a spring length of 1.75 ±0.12 in. (44.5 ±3.0 mm) across the coils.
19. Route hoses and cable down free lift cylinders. Remove slack. Fasten hoses and cable to cylinders with cable ties.

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Figure 7-240. Over-the-Mast Hose/Cable Retainer Locations (Model 7640)



20. Fasten the cable to the free lift cylinder connecting tube and position cable into retainers at the bottom of the inner telescopic.
21. Position hoses into the retainers at the bottom of the inner telescopic. Remove all slack and tighten the retainers.
22. Route and feed the hoses and cable through the pulley assembly at the top of the telescopic.
23. Feed the hoses and cable through the retainer at the main frame crosstie. See See Figure 7-240. Remove all slack.
24. Find the correct L4 values from Table 7-18. Measure and mark hoses above the retainer.
25. Block between the telescopics to provide slack in the hoses.
26. Pull down on the hoses until marks are flush with top of retainers.
27. Set the tension on the cable spring by sliding the cable grip to produce a spring length of 1.75 ±0.12 in. (44.5 ±3.0 mm) across the coils.
28. Feed cable and hoses through remaining retainers. Remove all slack and tighten.
29. Feed the free lift chains over free lift pulleys, from forks side to tractor side. Install master links to attach the free lift chains to the chain anchor blocks.

Table 7-18. Over-the-Mast Hose stretching values (Model 7640)

L4 (Lift and Aux Hoses)			**L5 (Aux Hoses)**		
OACH	in.	mm	OACH	in.	mm
142 to 147	2.75	69.9	142 to 158	1.50	38.1
148 to 154	3.00	76.2			
155 to 163	3.25	82.6	159 to 184	1.75	44.5
164 to 171	3.50	88.9			
172 to 180	3.75	95.3			
181 to 184	4.00	101.6			

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Mating Tractor to Mast

1. Position the tractor about 10 in. (25 cm) from the mast. Place blocks under the tractor near the mast to match the bolt hole height in tractor and mast.
2. With the mast secured by a hoist, use a lift truck to mate the tractor to the mast.
3. Apply thread-locking primer (P/N 990-666) to mast mounting bolt threads and hole threads. Permit to dry for several minutes.
4. Apply thread-locking compound (P/N 990-544) to threads of mast mounting bolts.
5. From the battery compartment, thread eight mounting bolts and washers through bottom of the tractor frame into the mast. Thread four mounting bolts and washers through the top of the tractor frame into the mast. Torque bolts to 165 ft. lb. (224 Nm).
6. Connect the main lift hose fitting at the left side of the tractor.
7. Install the battery connector bracket.
8. Connect auxiliary hoses A1 and A2 at the main manifold, observing labels.
9. Connect over-the-mast cable to TS3 (refer to Table 7-17 on page 7-152).
10. Feed the mast switch harness into the tractor, across the top of the deck to the right side near the lift pump. Connect connector JPS4.
11. Connect the ambient temperature sensor cable connector JPA on the tractor deck.
12. Connect HTI encoder to JP13 and JPS11.
13. Connect the right side main lift hose to the fitting on the tractor bulkhead.
14. Secure a hoist strap around the overhead guard or position a lift truck with pallet under the overhead guard. Lift the guard into position at the lower crosstie of the main frame.
15. Apply thread-locking compound (P/N 990-536) to the mounting bolt threads. Install mounting bolts and torque to 130 ft. lb. (174 Nm).
16. Install the mast guard.
17. Using a suitable battery moving device, install the battery. Install battery gates.
18. Attach front covers and top cover.
19. Make sure all hoist straps and blocks are removed.
20. Reconnect the battery connector and turn the key switch ON.
21. Bleed the hydraulic system. See "Hydraulic System Bleeding" on page 7-74.
22. Test all lift truck functions.
23. Apply thread-locking compound and tighten main lift cylinder L-bracket mounting bolts to 55 ft. lb. (74.5 Nm).
24. Using a work basket and lift truck, grease the channels of all sections of the mast.

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Section 8. Theory of Operation



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Traction System Functional Operation

Battery Connected

When the battery is connected, the truck has B+ and B– supplied to the following points:

- B+ to JPF4-3 and 4-4 through FU7 and to the normally open tips of K1 relay and JPF4-15.
- B+ to JPF4-1 and 4-2 through FU5 to the normally open tips of K2, K3, K4, and the key switch S1. JPF4-1 and JPF4-2 also supply the VM with BATTERY_SENSE_IN at JPC24-24. It is protected by a thermistor for overcurrent conditions caused by shorts in the wiring. This is used by the VM to make sure that battery voltage is within the requirements for the lift and traction amps prior to powering them up.
- B+ to the normally open tips of the Steer, Traction, and Lift contactors.
- B– is supplied to all points labeled B–, B–F, any sensor connection with a (–) negative label, and DGND.

Key Turned ON

When the key switch is turned ON, B+ is supplied to the following points:

- through the EPO switch to the coils of K1, K2, and K3.
- to JPC14-12 at the VM as B+ Key. This, internal to the VM, activates the power supply circuits that supply all 12V and 5V outputs from the VM and activates the microprocessor in the VM. The power supplies maintains a steady output as long as battery voltage remains above 17V. With the power supplies activated, 12V is supplied to the display. The display contains a microprocessor that requires firmware updates any time the VM is updated.
- The processor in the VM looks at BATTERY_SENSE_IN (JPC24-24) and verifies it is within the required parameters for the amps, 28 to 45V. If it is, there is an output from the processor to RELAY_ENABLE at JPC14-6 taking the relay coils for K1, K2, K3, and K4 to B– internal to the VM. The VM also uses this input to calculate BSOC and compares it to the last battery voltage in its memory. The VM then determines if the display requires updating.
- The tips of K1, K2, K3, and K4 close, supplying B+ to the following:
  - the Lift Power Amplifier (LPA) and the Traction Power Amplifier (TPA) pre-charge circuits from B+K3. B+K3 at JPT1-1 and JPL1-1 are used by the amplifiers to power their internal circuitry that includes power supplies. The power supplies provide 12V to the encoders and temperature sensors for the Traction Motor and the Lift Motor. When K3 is open, it supplies a path for the capacitors in the amplifiers pre-charge circuits to discharge to B–. Both pre-charge circuits have a thermistor in them (on the Fuse/Relay Card) to protect from overcurrent damage if there is an open in the motor power circuitry or contactors.
  - Reach, Tilt, Sideshift, Aux 1, Aux 2, L/L, L/H, and Dump solenoids, Nested Switch, Horn, and fans T, FW, FW2 and DU are supplied by B+K2.
  - connections for optional devices at JPF2-9 by B+K1.
  - B+ is supplied to the VM by B+K4 to be used internally.
- With all microprocessors powered up, SelfTest continues:
  - the VM checks to make sure its power supplies are within range.
  - the VM checks the BUS to make sure communications are functioning with all other devices (DISPLAY, LPA, and TPA).

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- the amplifiers check the pre-charge circuit voltages to make sure they are in range. If not, a message is sent over the BUS to the VM and a code is displayed.
- the VM asks the TPA and LPA for the status of the TPC and LPC contactors to make sure they are open. This is only checked during SelfTest. It is checked continuously after the truck has passed SelfTest and the VM has not commanded it to be closed.
- the VM verifies the Steer Contactor is open. This is only done during SelfTest.
- the VM commands the LPA and TPA over the BUS to close the LPC and TPC. The VM activates the circuitry to close the STR contactor. The LPC, TPC and STR contactors are checked to make sure power is supplied through the contactor tips to the motors circuits. The LPA and TPA report the state of the LPC and TPC over the BUS. They are monitored via the (+) connections on the amplifiers. When the contactor closes, the amplifiers see a higher voltage than seen from the pre-charge circuit. The VM monitors the STR contactor via JPC22-19.
- the VM verifies the EPO switch is closed.
- the software and configured parameters are checked in the LPA, TPA, Display, and VM to make sure they are within limits and correct.
- the amplifiers check to make sure there are no shorts in the power circuits.
- the VM checks to make sure the Deadman Switches are open.
- the VM checks to make sure the Steer Tiller Encoder is connected.
- the VM checks to make sure the lift potentiometer (VR2) and throttle potentiometer (VR1) are within 0.2V of the learned neutral position and are not outside the allowable minimum and maximum voltages. They are continuously monitored and messages are displayed if activated prior to closing the deadman switch.
- the TPA is commanded to activate the Traction Motor to make sure current is seen and there are no motor encoder inputs. This is to make sure the power circuits are functional and the brake is applying resistance to the Traction Motor.
- the VM checks the state of the control handle switches to make sure they are in the open position. They are continuously monitored and messages are displayed if activated prior to closing the Deadman Switch.
- the VM checks the information from the TPA and LPA to make sure the motor temperature sensor readings are within range and determines if speed limiting is required.
- the VM checks pressure transducer readings to make sure they are within range.
- the VM checks to make sure the Ambient Temperature Sensor is within the acceptable range.
- the VM checks its memory for all previously logged faults that have not been cleared.
- after SelfTest is complete, the LPC and TPC contactors remain energized for approximately 30 seconds. If no function requests are made by the operator, they open. The STR contactor opens as soon as the circuits are tested. The VM also monitors the temperature inputs from the TPA and LPA. Anytime one of the readings goes above 113°F (45°C), the VM turns on fans T, FW, FW2, and DU.

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Deadman Pedal Depressed

When one of the deadman pedals is depressed, the brake is released. The brake does not get applied until the truck is at a complete stop and the deadman switch is opened.

With the Deadman Switch closed, the VM tells the LPA and TPA it is closed and commands the LPC, TPC, and STR contactors to be closed. The VM now reacts to any request from control pots or switches for lift/lower, travel, and aux functions. When the Deadman Switch is opened again, the LPC and TPC remain energized for 30 seconds with no functions commanded and then open. The STR contactor remains energized for 3 seconds and then opens. One of the deadman switches then has to be closed again for the contactors to be energized.

With one of the deadman switches closed, the TPA continuously monitors the input from the Traction Motor encoder. If no travel request is seen from the control handle and inputs are seen from the sensor, the TPA powers the Traction Motor as required to keep the truck in the same position. This prevents unwanted movement on uneven surfaces, dock plates or ramps, or if placing a pallet in the rack system.

Electric Steering

NOTE: This information is based on a truck that is not programmed for Reverse Steering. If programmed for Reverse Steering, the VM reverses the CW and CCW commands to the Steer Amplifier. It also looks for feedback from the Steer Motor Encoder in the opposite direction.

On trucks with electric steering, when the VM closes the STR contactor, the VM begins to monitor the inputs from the Steer Amplifier, Steer Tiller Encoder, and the Steer Motor Encoder. The VM is looking for a current draw on the 12V lines that power the two Steer Tiller Encoder channels. With no steer requests from the Steer Tiller Encoder, the VM looks for an input from the Steer Amplifier on JPC6-1, NEUTRAL_PULSE. This feedback from the Steer Amplifier informs the VM that the Amplifier is connected and powered up. The NEUTRAL_PULSE is created by the VM sending a very low steering command over the CCW and CW wires to the Steer Amplifier. These commands are alternated back and forth between CCW and CW. This creates a toggling high/low input on the NEUTRAL_PULSE line that changes about 10 times a second. When a steer command is present, this input does not toggle as fast and the VM ignores it. When the operator turns the steering wheel, a set of square wave voltages (chopped DC voltage) is sent to the VM on Channels A_1, B_1, A_2, and B_2. The VM looks at the square waves as sets. A_1 and B_1 are one set and A_2 and B_2 are another set. Based on which channel of the set is seen first, A or B, the VM determines the direction the operator has requested the drive unit to turn. The VM determines the requested speed by the amount of time between the square waves. Less off time between them means a faster rotation was requested. Two sets are used so the VM can compare them and verify the encoder is functioning correctly. Once this information is processed, the VM sends out a chopped DC voltage to the Steer Amplifier over CCW_PWM or CW_PWM. CCW_PWM is a request for the drive unit to be turned in the counterclockwise direction and CW_PWM is a command to turn in the clockwise direction. Based on the off time between the square waves, the Steer Amplifier determines the speed of rotation requested and sends the appropriate voltage to the Steer Motor. Direction of Steer Motor/Drive Unit rotation is controlled by the side of the Steer Motor that has positive voltage applied to it, MS-A1 or MS-A2. The VM then monitors the inputs from the Steer Motor Encoder to determine the direction and speed the motor is turning and compares it to the request. The VM also monitors the Steer Motor current from the Steer Amplifier on JPC6-3, STEER_CURRENT. Current limit for the Steer Motor is approx 100 amps and is controlled by the Steer Amplifier. The VM uses this input when checking the steering system for shorts or opens in the power circuit. The VM also monitors the input from the END OF STEER ROTATION SWITCH (S11), mounted next to the drive unit. This is a proximity switch that is turned ON and OFF by a metal ring mounted to the drive unit. As the drive unit nears the end of its rotation, the metal ring is no longer under

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the proximity switch and the switch opens prior to hitting the drive unit's mechanical stop. When the input to the VM goes high at JPC22-22 STEER_LIMIT, the VM no longer sends out a steer command in that direction. It only sends out commands when there is a request in the opposite direction from the operator. This prevents the steering system from being held in current limit.

Travel Request

With one of the Deadman Switches (DS1 or DS2) closed, the VM constantly sends an RPM request that causes the TPA to maintain the speed requested by the operator. With the control handle in neutral, the request is always at 0 RPM. When the VM sees a change in the learned neutral voltage from the VR1 at JPC12-3, it first checks for any inputs that activate a speed limit condition. If none are seen, it calculates the direction and percent of full speed requested based on the learned values. A message is sent to the TPA over the BUS as a command to travel in the appropriate direction at the RPM to obtain the requested speed. The TPA then determines the correct sequence to energize the motor leads (U, V, and W) to move the truck in the correct direction. The TPA also determines the required amount of DC voltage to send through the motor leads based on the acceleration parameters programmed and the requested RPM. The TPA then monitors the feedback from the Traction Motor encoder to adjust the voltage to the Traction Motor to maintain the requested RPM and direction. Any conditions that prevent the TPA from maintaining these requests are sent over the BUS to the VM. The VM tells the Display over the BUS to display a message informing the operator. The VM also invokes any system shut down or limitations based on the information from the TPA.

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Cold Storage

On trucks with the Cold Storage option, the VM looks at the Ambient Temperature Sensor mounted on the overhead guard. If the temperature indicates the truck is parked inside the freezer, the VM does not turn off the RELAY_ENABLE circuit when the key switch is opened. When the key is turned OFF, K1, K2, and K3 all open because they are powered from the key switch. The K4 coil and tips receive power directly from the battery through FU5. When the tips are closed, K4 supplies B+ to internal circuitry of the VM. This is only used on trucks equipped with the optional Cold Storage package. The VM uses the input from the K4 tips to keep its circuitry powered up. This is done so the VM can keep the circuitry activated for the control handle heater. The display is shut down and no other functions are operable until the key is turned ON and the truck is powered up.

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Hydraulic System Functional Operation

System Components

Main Lift/Aux Pump (P1)

Pump P1 is a positive displacement gear pump that rotates clockwise from the shaft end. P1 is used for all lift and aux functions.

Main Lift System

The main lift system consists of four single acting hydraulic cylinders. Hydraulic fluid flows from the main manifold through a tee-fitting in the tractor, through fittings in the left and right front of the tractor bulkhead. The right side hose feeds the right side main lift cylinder. The left side divides again at a tee-fitting, supplying both the left side main lift cylinder and the free lift cylinders. At the bottom of the free lift cylinders, another tee-fitting divides the flow between left and right free lift cylinders. A flow limiter is installed at one of the free lift and one or both of the main lift cylinders.

When the operator requests lift, the entire lift system is pressurized. Since the carriage weighs less than the carriage plus telescopic, the free lift cylinders extend first, elevating the carriage. When they reach the limit of their travel, the main lift cylinders extend, elevating the telescopics.

Reach/Retract Cylinder

The reach/retract cylinder is a double-acting hydraulic cylinder used for extending and retracting the forks from the mast.

Sideshift Cylinder

The sideshift cylinder is a double-acting hydraulic cylinder used to shift the load left and right with respect to the mast.

Tilt Cylinder

The tilt cylinder is a double-acting hydraulic cylinder used to tilt the forks up and down.

Load Holding Valve (SOL1)

The load holding valve is a normally closed solenoid valve used to hold the carriage in an elevated position. It incorporates an override to allow lowering the carriage manually.

Proportional Lower Valve (SOL2)

The proportional lower valve is a pressure compensated flow control solenoid valve used to lower the carriage. As the voltage to the valve increases, the flow through the valve increases, regardless of the pressure.

Proportional Relief (SOL3/Dump)

SOL3 is a proportional solenoid used as a system relief. In addition, SOL3 is used to divert hydraulic fluid from Pump P1 back to the reservoir after a lift is stopped and the pump is still spinning. It also acts as a valve to port excess hydraulic fluid back to the reservoir from the auxiliary functions.

SOL5B/SOL5T

SOL5 is a directional solenoid valve providing directional control to the reach, tilt, and sideshift functions. De-energized, flow is blocked to the aux functions and directed to the reservoir. When SOL5B is energized, flow is directed to port A2 for tilt up, sideshift right, or reach. When SOL5T is energized, flow is directed to port A1 for tilt down, sideshift left, or retract.

Reach/Retract Solenoid (R/R SOL)

R/R SOL is a normally closed solenoid valve used to block (de-energized) or allow (energized) fluid flow to and from the reach cylinders.

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Sideshift Solenoid (S/S SOL)

S/S SOL is a normally closed solenoid valve used to block (de-energized) or allow (energized) fluid flow to and from the sideshift cylinder.

Tilt Solenoid (TILT SOL)

TILT SOL is a normally closed solenoid valve used to block (de-energized) or allow (energized) fluid flow to and from the tilt cylinder.

Flow Limiter Valve

Flow limiter valves are used to limit the maximum lower speed of the forks. A check valve forces restricted flow through the valve during lower, but allows free flow during lift.

Aux Relief Valve (REL2)

REL2 is a relief valve used to protect auxiliary system components against excessive pressure. It is factory-adjusted to 2000 psi (13790 kPa). A manual adjustment knob can be turned clockwise to increase the relief pressure, or counterclockwise to decrease the relief pressure.

Hydraulic Filter

The hydraulic system has two filters in the main manifold. Their purpose is to filter impurities from the hydraulic system. They filter all hydraulic fluid on the return to the reservoir. There is no internal bypass.

Lift Motor (LM)

The Lift Motor is a brushless, three-phase internally delta connected variable-speed AC motor.

Lift Motor Encoder

The Lift Motor encoder is a two-channel encoder. Its purpose is to tell the lift power amplifier the motor speed for motor speed regulation during lift and auxiliary functions.

Lift Motor Temperature Sensor

The Lift Motor Temperature Sensor is mounted internally in the Lift Motor. Its purpose is to tell the lift power amplifier the temperature of the lift motor.

Load Shuttle (LS-1)

The load shuttles are 2-input, pressure activated, 2-position valves. In each shuttle, the higher of the input pressures passes through the valve at the pressure out port. The output port provides flow used to operate pressure-activated devices such as piloted relief or metering valves. The load shuttles provide pressure feedback to the pilot line of the PODS valve to allow it to position itself for correct auxiliary and lift function operation.

Priority On Demand Spool (PODS)

This is a pilot operated spring return valve that divides flow between the lift and auxiliary functions as requested. It also provides a path to the reservoir for excess hydraulic fluid from P1.

Theory of Lift/Aux Functions

Lift

Lift speed varies directly with Lift Motor rpm. The voltage supplied to the Lift Motor is proportional to the amount of lift request from VR2 (faster lift = higher motor voltage). Maximum lift speed for a given weight load is governed by software.

Weight is calculated from inputs to the VM from the pressure transducer. Weight of the empty carriage and telescopic is calculated during Learn Mode.

Prior to requesting a lift, all valves are in the de-energized state.

When VR2 is moved to request lift, a voltage is sent to the VM at JPC12-2. The VM sees a voltage different from the “learned” neutral voltage, and sends a request to the lift power

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amplifier via BUS+/BUS– (JPC14-11 and JPC14-4 through the Operator Display to JPL1-22 and JPL1-14).

The LPA internally supplies B- to the Lift Contactor Coil (LPC) at JPL1-2, that closes the normally open contactor tips.

The LPC is energized either by depressing one of the Deadman Switches (DS1 or DS2), or rotating the lift pot (VR2) out of neutral to the lift position.

When the LPC is energized, the contactor tips close, allowing B+ to be supplied to the LPA, that supplies voltage to the Lift Motor to make it rotate.

The PODS valve (POD-1) receives pressure at port 4, placing pressure on the pilot line of the valve. This pressure moves the spool in the valve to allow flow out port 2 to CV-1, the de-energized Load Holding Solenoid (SOL1), through the flow limiters in the base of the lift cylinders, and into the lift cylinders, producing lift.

When the lift knob is returned to neutral, the Lift Motor is ramped down. SOL3 is opened to relieve any pressure spikes in the system.

Lower

Variable lowering is accomplished via the Proportional Lower Solenoid (SOL2). Lowering speed is not a function of weight on the forks. An increasing voltage increases the flow through the valve regardless of the pressure in the system.

When VR2 is moved to request Lower. A voltage is sent to the VM at JPC12-2. The VM sees a voltage different from the “learned” neutral voltage.

The VM energizes internal coil drivers for SOL1 at JPC18-10. SOL2 opens proportionally to the requested rate of lower via a signal from the VM at JPC20-16.

The VM energizes internal coil drivers for SOL1 at JPC18-10. SOL2 opens proportionally to the requested rate of lower via a signal from the VM at JPC20-16.

Auxiliary Functions

Tilt

Fork tilt allows the operator to raise or lower the tips of the forks. Standard fork tilt is 5° up and 2° down.

When the deadman pedal is depressed, the VM sends a command over BUS+/BUS- lines to the LPA to energize the LPC.

The LPA internally supplies B- to the LPC coil at JPL1-2, that closes the normally open contactor tips.

The Tilt Up Switch (S6) is depressed, completing a circuit between JPC12-5 and JPC12-12 at the VM.

The VM energizes the following solenoids via internal coil drivers:

- SOL3 (Dump) at JPC20-12
- SOL5B at JPC20-20
- TILT SOL at JPC18-15

Pump P1 rotates at a speed predetermined in software. Flow is ported to the PODS valve at port 3 and out at port 4. Fluid then flows through SOL5B or SOL5T, depending on the direction of the function requested. SOL5 is a proportional solenoid, but the VM sends a fixed voltage to it, regulating the speed of the requested function. If more oil than is needed flows to SOL5, back pressure is present at port 4, which is also the pilot line for the PODS valve. This shifts the spool of the PODS valve and sends the excess oil to SOL3 via port 2. SOL3 opens to allow the excess oil to flow back to the filter and reservoir. After leaving SOL5, the oil flows to the LS-1. The LS-1 ports oil back to the PODS valve at port 1 to help regulate the flow to the auxiliary function. From LS-1, the fluid flows to the Tilt Solenoid (TILT SOL) on the carriage. The TILT SOL allows fluid flow to the requested function.

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NOTE: LS-1 also supplies a pilot pressure to REL2 to open the auxiliary relief if pressure gets too high.

Fluid flows through the energized TILT SOL and then to the tilt cylinder.

Reach/Retract

Reach extends the forks away from the mast assembly. Retract moves the forks inward towards the mast assembly. The reach/retract function can be configured to have single speed reach/retract or two speed reach/retract. Single speed moves at the speed of high-speed.

To use two speed reach, depress S5 after depressing S4. Doing this switches from low speed to high-speed reach. For high speed retract, depress S4 then S5.

High-speed or single-speed reach/retract

When one of the deadman pedals is depressed, the VM sends a command over BUS+/BUS– lines to the LPA to energize the LPC.

The LPA internally supplies B- to the LPC at JPL1-2, that closes the normally open contactor tips.

When the Reach Switch (S4) or the Retract Switch (S5) is depressed, a circuit is completed to the VM.

On lift trucks with two speed selected, the VM activates high speed when the other switch is also depressed.

NOTE: To change the speed of the reach (high speed versus low speed), the VM adjusts the voltage to SOL5 to regulate the valve for more or less flow.

The VM energizes the following solenoids via internal coil drivers:

- SOL3 (Dump) at JPC20-12
- SOL5B at JPC20-20
- REACH SOL at JPC18-12

Pump P1 rotates at a speed predetermined in software. Flow is ported to the PODS valve at port 3 and out at port 4. Fluid then flows through SOL5B or SOL5T, depending on the direction of the function requested. SOL5 is a proportional solenoid, but the VM sends a fixed voltage to it, regulating the speed of the requested function. If more oil flows to SOL5 than is needed, back pressure is present at port 4, which is also the pilot line for the PODS valve. This shifts the spool of the PODS valve and sends the excess oil to SOL3 via port 2. SOL3 is opened to allow the excess oil to flow back to the filter and reservoir. After leaving SOL5, the oil flows to the LS-1. The LS-1 ports oil back to the PODS valve (at port 1) to help regulate the flow to the auxiliary function. From LS-1, the fluid flows to the reach solenoid on the carriage. The Reach/Retract Solenoid allows fluid flow to the requested function.

NOTE: LS-1 also supplies a pilot pressure to REL2 to open the auxiliary relief if pressure gets too high.

Fluid flows through the energized Reach/Retract Solenoid and then to the reach cylinders.

Sideshift

Sideshift allows the operator to move the fork carriage to the left or right relative to the mast. The amount of sideshift is 2 or 4 in. (5 or 10 cm) depending on the baseleg opening.

When one of the deadman pedals is depressed, the VM sends a command over BUS+/BUS– lines to the LPA to energize the LPC.

The LPA internally supplies B– to the LPC at JPL1-2, that closes the normally open contactor tips.

When the Sideshift Right Switch (S9) is depressed, a circuit is completed between JPC12-9 and JPC12-12 at the VM.

The VM energizes the following solenoids via internal coil drivers:

- SOL3 (Dump) at JPC20-12
- SOL5B at JPC20-20

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- SIDESHIFT SOL at JPC18-14

Pump P1 rotates at a speed predetermined in software. Flow is ported to the PODS valve at port 3 and out at port 4. Fluid then flows through SOL5B or SOL5T, depending on the direction of the function requested. SOL5 is a proportional solenoid, but the VM sends a fixed voltage to it, regulating the speed of the requested function. If more oil flows to SOL5 than is needed, back pressure is present at port 4, which is also the pilot line for the PODS valve. This shifts the spool of the PODS valve and sends the excess oil to SOL3 via port 2. SOL3 is opened to allow the excess oil to flow back to the filter and reservoir. After leaving SOL5, the oil flows to the LS-1. The LS-1 ports oil back to the PODS valve (at port 1) to help regulate the flow to the auxiliary function. From LS-1, the fluid flows to the Sideshift Solenoid on the carriage. The Sideshift Solenoid allows fluid flow to the requested function.

NOTE: LS-1 also supplies a pilot pressure to REL2 to open the auxiliary relief if pressure gets too high.

Lift while using Aux Functions

The LPC is energized by depressing the Deadman Switch (S2).

The LPA internally supplies B– to the LPC at JPL1-2, that closes the normally open contactor tips.

When the LPC coil is energized, the contactor tips close, allowing B+ to be supplied to the LPA, suppling voltage to the Lift Motor.

When VR2 is moved to request lift, a voltage is sent to the VM at JPC12-2. The VM sees a voltage different from the “learned” neutral voltage, and sends a request to the LPA via BUS+/BUS– (JPC14-11 and JPC14-4 to JPL1-22 and JPL1-14).

The voltage supplied to the Lift Motor is proportional to the amount of lift requested from VR2 (faster lift = higher motor voltage).

NOTE: The Lift Motor/pump is variable speed.

In order to operate reach or retract, S4 or S5 is used to send an input to the VM at JPC12-4 or JPC12-11.

When the request to lift and reach is made, the VM energizes the following solenoids via internal coil drivers:

- SOL3 (Dump) at JPC20-12
- SOL5T at JPC20-18 or SOL5B at JPC20-20, depending on the direction of the function chosen
- One of the following:
  REACH SOL at JPC18-12
  SIDESHIFT SOL at JPC18-14
  TILT SOL at JPC18-15

As Pump P1 begins to rotate, fluid flows into the PODS valve at port 3. The PODS valve is used to bias flow between lift and aux. Port 3 is connected to port 4. With pressure at port 4, the pilot line works to move the spool to its second position.

With the valve in its second position, fluid flows to Check Valve 1 (CV1). Fluid flows through CV1 and the de-energized SOL1. From there, fluid passes through the free flow portion of the flow limiters (located in the base of the lift cylinders) and into the lift cylinders.

SOL3 (Dump) is used as a proportional relief to limit system pressure to a safe level. With this valve: 0V = 3500 psi (24132 kPa). The pressure relief is set by the VM and firmware at approx 2V, which equals 3200 (22063 kPa) psi.

The PODS valve also meters fluid to the requested aux function. As the metered flow enters SOL5B or SOL5T (depending on the direction of function requested), the voltage applied to the valve by the VM causes it to open.

SOL5 is a proportional solenoid. The VM sends a fixed voltage to it to open it a specific amount, depending on the function requested.

The load shuttle sends pressure to the pilot line of the PODS valve to allow the valve to correctly divide the fluid between lift and auxiliary.

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Hydraulic System Functional Operation

When using auxiliary functions only (no lift), the speed of the motor is approx 400 rpm. If slow lift is used along with an aux function, the motor/pump speed may increase due to the need for more fluid to the functions.

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Electric Brake

Overview

The Model 7600/7620/7640 lift truck uses an electric brake. With the brake coil de-energized, the brake is in a “normally applied” state due to spring pressure. With the brake coil energized, the brake is held in a released state due to magnetic force.

The brake assembly of coil, armature plate, base plate, and pads slides up and down on three shoulder bolts threaded into the end bell of the Traction Motor. The armature plate and base plate are spaced apart by three hollow total air gap adjusters (spacers). The total gap is adjusted by the amount the adjuster is threaded into the coil body. Once this gap is set, it is held in place by three locking bolts that thread through the coil and the total air gap adjusters.

When the brake is electrically released, the assembly slides down the shoulder bolts and rests on the lower air gap adjusters. The lower air gap adjusters are threaded pedestals that are set so as to divide the total air gap evenly between the rotor and the top and bottom brake pads.

Brake Release

When the deadman pedal is depressed, the brake coil is energized. The current flow creates a magnetic field that draws the armature plate against the coil body, compressing the brake coil springs. The brake assembly of coil body, armature plate, base plate, and pads lowers by the amount of the lower air gap. Half of the total air gap (minus a 0.007 in. shim) is between the rotor and the pads on the base plate. The remainder of the total air gap is between the rotor and the pads on the armature plate. The rotor, attached to the Traction Motor shaft, is free to rotate.

Brake Application

If the lift truck is traveling when the deadman pedal is released, the VM causes the lift truck to plug to a stop. When the VM senses the lift truck has stopped, it de-energizes the brake coil. The magnetic field holding the brake released now collapses. The springs in the brake coil push the armature plate and pads down on the top of the rotor. Upward pressure of the springs against the coil body causes the base plate and pads to be pulled up against the bottom of the rotor. The brake pads prevent the rotor, and the Traction Motor shaft from rotating.

Brake Release Screws

Two brake release screws are stored in the brake coil body. These screws are not used when removing the entire brake assembly from the Traction Motor, but are used when disassembling the brake itself. The brake release bolts are threaded through the coil. The screws press on the base plate, overcoming the spring pressure and separating the base plate and coil body. The three locking bolts, total air gap adjusters, and rotor can now be removed.

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Pinout Matrix

The pinout matrix table lists functions and normal voltages of terminals and harness connector pins. The matrix columns have the following meanings:

- **Item #**: sequential number to aid in reference.
- **Connection**: the actual wire numbers or component abbreviations on the electrical schematic.
- **Function Description**: brief definition of the signal carried on the wire.
- **Theory of Operation**:
  - A detailed description of the signal carried on the wire. If the signal is variable, it indicates the state of a related component that causes the signal to vary.
  - Identifies possible causes for lack of correct signal.
- **Normal Level**: the approximate voltage that you should see on that wire for the state indicated. Unless otherwise indicated, voltages are measured with respect to (wrt) B– at TP4.
- **Signal Source**: the device or connection that supplies the signal directly to the wire.
- **Signal User**: the device or connection to which the wire directly delivers the signal.

Table 8-1. Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Signal Source	Signal User
1	JPC3-1 thru 4		USB Communication Port - Not Used			
2	JPC6-1	NEUTRAL_ PULSE	This input tells the VM that the Steer Amplifier is connected and functioning.	Deadman Up: 4.6VDC; CCW steer: 4.5VDC; CW steer: 0.0VDC; No steering: voltage varies	VM	Steer Amplifier
3	JPC6-2	CW_PWM	This is a control voltage used to rotate the drive unit in the CW direction. The average DC value varies depending on the amount and speed of steering requested.	At rest: 11.5VDC; CCW steer: 11.6VDC; CW steer fast: 5VDC; CW steer slow: 9VDC;	VM	Steer Amplifier

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Item	Connection	Function Description	Theory of Operations	Normal Level	Signal Source	Signal User
4	JPC6-3	STEER_ CURRENT	Analog voltage which varies with the steer motor current and is sent from the Steer Amplifier to the VM. This voltage is used by the VM to establish current reading for opens or shorts in the steer system.	Steering CW: 1.8VDC; At rest: 2.5VDC; Steering CCW: 3.2VDC	Steer Amplifier	VM
5	JPC6-4	DGND	Reference for the control circuits in the Steer Amplifier. If missing, the steer amplifier does not power up.	<0.5VDC wrt B–	VM	Steer Amplifier
6	JPC6-5	CCW_PWM	This is a chopped voltage used to rotate the drive unit in the CCW direction. The average DC value varies depending on the amount and speed of steering requested.	Steering CW: 11.6VDC; At rest: 11.5VDC; Steering CCW: 9V slow 5V fast	VM	Steer Amplifier
7	JPC6-6	+12VP	Operating voltage from the VM for the control circuits in the steer amplifier. If this is missing, the steering is inoperable.	+10.7 to 13VDC	VM	Steer Amplifier
8	JPC9		FlashWare Connection			
9	JPC10-1 & 2		Not Used			
10	JPC10-3	THERM_EN	Voltage from the VM to the *ThermaKit* Control Card to control the heater in the control handle.	ON: <0.5VDC; OFF: >10.5VDC	VM	Control Handle Heater
11	JPC10-4		Not Used			
12	JPC10-5	BUS_E–	Carries negative component of the digital communications between the VM and the optional Warehouse Management Module (WMM). If missing, the VM cannot communicate. Troubleshoot using resistance checks. No useful information can be gained by measuring the voltage on this wire.	2.53VDC	VM	WMM
13	JPC10-6	+12V_EN1	Used as a connect detect to verify the Steer Tiller Encoder is connected to the VM.	Encoder connected: 9.0VDC; Disconnected: +10.7 to 13VDC	VM	Steer Tiller Encoder
14	JPC10-7	+12V_EN2	Used as a connect detect to verify the Steer Tiller Encoder is connected to the VM.	Encoder connected: 9.0VDC; Disconnected: +10.7 to 13VDC	VM	Steer Tiller Encoder

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Signal Source	Signal User
15	JPC10-8	ON DEADMAN (DS2)	Input to the VM from the Deadman Switch (DS2). Used by the VM to determine whether to ignore or comply with operational requests.	Released: >+4VDC; Depressed: <0.5VDC	DS2	VM
16	JPC10-9	DGND	Reference for the Steer Motor Encoder.	<0.5VDC wrt B–	VM	Steer Motor Encoder
17	JPC10-10	BUS_E+	Carries positive component of the digital communications between the VM and the optional WMM. If missing, the WMM cannot communicate. Troubleshoot using resistance checks. No useful information can be gained by measuring the voltage on this wire.	2.53VDC	VM	WMM
18	JPC12-1	+5VP	+5VDC supply to the solid state potentiometers and switches in the control handle. If this is less than 4.75, the handle will not function correctly. Measure wrt DGND JPC12-12.	4.9VDC	VM	Control Handle
19	JPC12-2	LIFT	Input to the VM from the wiper of the lift control. Measure wrt DGND JPC12-12.	Neutral: 1.0V; Full Forward: 1.84VDC; Full Reverse: 0.30VDC	VR2	VM
20	JPC12-3	P_THROTTLE	Input to the VM from the wiper of the throttle control. Measure wrt DGND JPC12-12.	Neutral: 1.2VDC; Full Forward: 1.9VDC; Full Reverse: 0.45VDC	VR1	VM
21	JPC12-4	REACH	Input to the VM from the reach switch (S4). **Note:** When other aux function switches are activated, reading can change by as much as 0.5V.	S4 open: >4.0VDC; S4 closed: <0.5VDC	S4	VM
22	JPC12-5	TILT UP	Input to the VM from the tilt up button (S6). **Note:** When other aux function switches are activated, reading can change by as much as 0.5V.	S6 open: >4.0VDC; S6 closed: <0.5VDC	S6	VM
23	JPC12-6	TILT DOWN	Input to the VM from the tilt down button (S7). **Note:** When other aux function switches are activated, reading can change by as much as 0.5V.	S7 open: >4.0VDC; S7 closed: <0.5VDC	S7	VM
24	JPC12-7	H_HTR	DC supply to handle heater (HTR6).	OFF: <0.5VDC; ON: 7.5 to 8.5VDC	VM	Control Handle

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Item	Connection	Function Description	Theory of Operations	Normal Level	Signal Source	Signal User
25	JPC12-8	SSHIFT_LEFT	Input to the VM from the sideshift left button (S8). **Note:** When other aux function switches are activated, reading can change by as much as 0.5V.	S8 open: >4.0VDC; S8 closed: <0.5VDC	S8	VM
26	JPC12-9	SSHIFT_RIGHT	Input to the VM from the sideshift right button (S9). **Note:** When other aux function switches are activated, reading can change by as much as 0.5V.	S9 open: >4.0VDC; S9 closed: <0.5VDC	S9	VM
27	JPC12-10	P_HORN	Input to the VM from the horn switch (S3). **Note:** When other aux function switches are activated, reading can change by as much as 0.5V.	S9 open: >4.0VDC; S3 closed: <0.5VDC	S3	VM
28	JPC12-11	RETRACT	Input to the VM from the retract switch (S5). **Note:** When other aux function switches are activated, reading can change by as much as 0.5V.	S5 open: >4.0VDC; S5 closed: <0.5VDC	S5	VM
29	JPC12-12	DGND	Reference for all switches and potentiometers in the control handle. If this voltage is not <0.5VDC wrt TP4 on the power panel, then intermittent handle codes may appear.	<0.5VDC wrt B–	VM	Control Handle
30	JPC14-1	B–F	Connects B–F on the VM to TP4 (B–) through FU6 on the Fuse/Relay Card.	<0.5VDC wrt B–	Fuse/Relay Card	VM
31	JPC14-2	DGND	Connects DGND and AGND on the VM to TP4(B–) through FU6 on the Fuse/Relay Card. This is the reference for all circuits on the truck that are referenced to either DGND or AGND.	<0.5VDC wrt B–	Fuse/Relay Card	VM
32	JPC14-3	DGND	Reference for the control circuits in the TPC, LPC, and Operator Display.	<0.5VDC wrt B–	VM	TPC,LPC and Display
33	JPC14-4	BUS_E– BUS_I–	Carries negative component of the digital communications between the VM and the TPA, LPA, and the Operator Display. If missing, the LPA and Operator Display cannot communicate with the VM. Troubleshoot using resistance checks in Test I23. No useful information can be gained by measuring the voltage on this wire.	2.24VDC	VM	TPA, LPA, and Display
34	JPC14-5	+12VP	Operating voltage from the VM to the Operator Display.	+10.5 to 13VDC	VM	Display
35	JPC14-6	RELAY_ ENABLE	Control path for K1, K2, K3, and K4 on the Fuse/Relay Card. After S1 is closed, all relays are energized simultaneously during SelfTest if the voltage at Battery_Sense_In is at an acceptable level.	Relays OFF: B+; Relays ON: <3.0VDC	VM	K1, K2, K3, and K4

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Signal Source	Signal User
36	JPC14-7	B+K4	B+ provided to the VM when K4 tips are closed. This voltage is used to power the heaters in cold storage trucks. If the ambient temp sensor detects the room temp to be <40°F, the VM keeps this circuit alive to power the heaters, even with the key switch turned OFF.	K4 tips closed: B+; K4 tips open: 0.2V	K4 tips	Cold Storage Package heater
37	JPC14-8	B–F	Connects DGND and AGND on the VM to TP4 (B–) through FU6 on the Fuse/Relay Card. This is the reference for all circuits on the truck that are referenced to either DGND or AGND.	<0.5VDC wrt B–	Fuse/Relay Card	VM
38	JPC14-9	B–F	Connects DGND and AGND on the VM to TP4 (B–) through FU6 on the Fuse/Relay Card. This is the reference for all circuits on the truck that are referenced to either DGND or AGND.	<0.5VDC wrt B–	Fuse/Relay Card	VM
39	JPC14-10	DGND	Connects DGND and AGND on the VM to TP4 (B–) through FU6 on the Fuse/Relay Card. This is the reference for all circuits on the truck that are referenced to either DGND or AGND.	<0.5VDC wrt B–	Fuse/Relay Card	VM
40	JPC14-11	BUS_I+	Carries the positive component of the digital communications between the VM and the TPA, LPA, and the Operator Display. If missing, the VM cannot communicate. Troubleshoot using resistance checks in Test I23. No useful information can be gained by measuring the voltage on this wire.	2.8VDC	VM	TPA, LPA, & Display
41	JPC14-12	B+KEY	B+ that is switched by Key Switch (S1) and used to power functions on the VM that are initiated after S1 is closed, and are not affected by the EPO. This includes the VM power supplies and the operation of the microprocessor.	S1 closed: B+; S1 open: 0.3VDC	S1	VM
42	JPC14-13	B+K2	B+ provided to the VM when K2 tips are closed. This voltage is used to power the hydraulic solenoids on the tractor and on the carriage. They are de-energized when the EPO is open.	K2 tips closed: B+; K2 tips open: 0.3VDC	K2 tips	Hydraulic Solenoids
43	JPC14-14	B+K2	B+ provided to the VM when K2 tips are closed. This voltage is used to power the hydraulic solenoids on the tractor and on the carriage. They are de-energized when the EPO is open.	K2 tips closed: B+; K2 tips open: 0.3VDC	K2 tips	Hydraulic Solenoids
44	JPC18-1 thru JPC18-4		Not Used			

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Item	Connection	Function Description	Theory of Operations	Normal Level	Signal Source	Signal User
45	JPC18-5	DGND	Reference for channel 1 of the Steer Tiller Encoder at JPC14-10 and JPC14-2.	<0.5VDC wrt B–	VM	Steer Tiller Encoder
46	JPC18-6	DGND	Reference for channel 2 of the Steer Tiller Encoder at JPC14-10 and JPC14-2.	<0.5VDC wrt B–	VM	Steer Tiller Encoder
47	JPC18-7	DGND	Reference for the deadman switches (DS1 and DS2).	<0.5VDC wrt B–	VM	DS1 & DS2
48	JPC18-8 & 9		Not Used			
49	JPC18-10	L/H	Control path for the load holding solenoid SOL1 that is switched to B– by the VM to energize the L/H solenoid coil (lowering).	De-energized (K2 tips closed): B+; Energized: 13.3VDC	VM	L/H SOL1
50	JPC18-11	STR CONTACTOR	Control path for the steer contactor that is switched to B– by the VM to energize the coil.	De-energized (K2 tips closed): B+; Energized: 13.4VDC	VM	STR Contactor
51	JPC18-12	REACH	Control path for Reach solenoid coil.	De-energized (K2 tips closed): B+; Energized: 13.2VDC	VM	Reach Solenoid
52	JPC18-13		Not Used			
53	JPC18-14	SIDESHIFT	Control path for Sideshift solenoid coil.	De-energized (K2 tips closed): B+; Energized: 13.1VDC	VM	Sideshift Solenoid
54	JPC18-15	TILT	Control path for Tilt solenoid coil.	De-energized (K2 tips closed): B+; Energized: 13.1VDC	VM	Tilt Solenoid
55	JPC18-16	HORN	Control path for the horn coil that is switched to B– by the VM to energize the coil.	De-energized (K2 tips closed): B+; Energized: 0.02 VDC	VM	Horn
56	JPC18-17	FAN	Control path for the amplifier and motor compartment fans that are controlled together by the VM.	De-energized (K2 tips closed): B+; Energized: 0.09VDC	VM	Fans
57	JPC20-1	+12VP	+12VDC supply for 1st Speed Limiting Switch (S12).	+10.7 to 13VDC	VM	S12

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Signal Source	Signal User
58	JPC20-2	+12VP	Not Used	+10.7 to 13VDC	VM	n/a
59	JPC20-3	+12VP	+12VDC supply for optional High Speed Travel Switch (S25).	+10.7 to 13VDC	VM	S25
60	JPC20-4	+12VP	+12VDC supply for the pressure transducer.	+10.7 to 13VDC	VM	Pressure Transducer
61	JPC20-5		Not Used			
62	JPC20-6	+12VP	+12VDC supply for the optional Lift Cutout Switch (S27).	+10.7 to 13VDC	VM	S27
63	JPC20-7	+12VP	+12VDC supply for the Steer Motor Encoder.	+10.7 to 13VDC	VM	Steer Motor Encoder
64	JPC20-8		Not Used			
65	JPC20-9	+12VP	+12VDC supply to the Steer Limit Switch (S11).	+10.7 to 13VDC	VM	S11
66	JPC20-10 & 11		Not Used			
67	JPC20-12	DUMP	Control path for SOL3, a combination proportional relief and dump valve. This is used both as a variable system relief and to dump oil back to the reservoir when lift is no longer requested and the Lift Motor/pump is slowing down. This permits immediate lower without waiting for the pump to stop turning.	De-energized: B+; When lift request stops: 12VDC for 1 to 2 seconds; Aux functions energized: 24VDC	VM	SOL3
68	JPC20-13	B+DUMP	B+ from the K2 tips to SOL3.	B+	VM	SOL3
69	JPC20-14	BRAKE	Control path for the electrically released brake on the Traction Motor.	Brake fully on: B+; Brake released: 0VDC at first, then 9VDC	VM	Brake
70	JPC20-15	B+L/L	B+ supplied to SOL2 from K2 tips when K2 is energized.	B+	VM	SOL2
71	JPC20-16	L/L	Control path for the Lift/Lower Solenoid SOL2. Voltage present during lower depends on the lower request from VR2.	De-energized: B+; No lower: 37.6VDC varies proportionally to Full lower: 18.8VDC	VM	SOL2
72	JPC20-17	B+AUX1	B+ supply for SOL5T solenoid.	B+	VM	SOL5T

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Item	Connection	Function Description	Theory of Operations	Normal Level	Signal Source	Signal User
73	JPC20-18	AUX1	Control path for one of the directional solenoids (SOL5T) for the aux functions sideshift left, tilt down, and retract.	De-energized: B+; Energized: Sideshift Left: 20VDC; Tilt Down: 17.5V; Retract High: 20VDC; Retract Low: 24VDC	VM	SOL5T
74	JPC20-19	B+AUX2	B+ supply for SOL5B solenoid.	B+	VM	SOL5B
75	JPC20-20	AUX2	Control path for one of the directional solenoids (SOL5B) for the aux functions sideshift right, tilt up, and reach.	De-energized: B+; Energized: Sideshift Right: 20VDC; Tilt Up: 18.0V; Reach High: 20VDC; Reach Low: 24VDC	VM	SOL5B
76	JPC22-1	SPEED_LIMIT_1	Used by the VM to determine when the telescopic is unnested. Speed is reduced at this point to the value set in Configure Mode.	Telescopics nested: <0.5VDC; Telescopics unnested: >4VDC	S12	VM
77	JPC22-2 & 3		Not Used			
78	JPC22-4	HS TRAVEL SW	Used by the VM to determine when the carriage is above S25.	Open: 5VDC; Closed: 0VDC	S25	VM
79	JPC22-5	CHANNEL_A_1	Channel_A_1 is one part of the steering request from the Steer Tiller Encoder on electric steer trucks when the steering tiller is moved. It is a square wave signal (0VDC & 4.5VDC) identical to Channel_B_1 but different phase. The VM uses the phase relationship of the two channels to determine the direction and speed of the steering request. When the tiller is stationary, the voltage can be either high or low.	Either >4.5VDC or <0.5VDC when tiller stationary. DC value when turning handle approx 2.5VDC.	Steer Tiller Encoder	VM
80	JPC22-6	LIFT CUTOUT SW	Used by the VM to determine when the carriage is above S27.	Open: 5VDC; Closed: 0VDC	S27	VM
81	JPC22-7		Not Used			
82	JPC22-8	ON DEADMAN	Input to the VM from the Deadman Switch (DS1). Used by the VM to determine whether to ignore or comply with operational requests.	Released: >+4VDC; Depressed: <0.5VDC	DS1	VM

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Signal Source	Signal User
83	JPC22-9	CHANNEL_A_4	Channel_A_4 is one part of the steering position feedback from the Steer Motor Encoder when the drive unit is rotated. It is a square wave signal (0VDC & 4.5VDC) identical to Channel_B_4 but different phase. The VM uses the phase relationship of the two channels to determine that the direction and speed of the steering response is the same as that requested. When the drive unit is stationary, the voltage can be either high or low.	Not turning: either 0VDC or 4.5VDC; Turning either direction: 1.8VDC	Steer Motor Encoder	VM
84	JPC22-10	CHANNEL_B_4	Channel_B_4 is one part of the steering position feedback from the Steer Motor Encoder when the drive unit is rotated. It is a square wave signal (0VDC & 4.5VDC) identical to Channel_A_4 but different phase. The VM uses the phase relationship of the two channels to determine that the direction and speed of the steering response is the same as that requested. When the drive unit is stationary, the voltage can be either high or low.	Not turning: either 0VDC or 4.5VDC; Turning either direction: 1.8VDC	Steer Motor Encoder	VM
85	JPC22-11	DGND	Reference for Steer Limit Switch (S11).	<0.5VDC wrt B–	VM	S11
86	JPC22-12	CHANNEL_B_1	Channel_B_1 is one part of the steering request from the Steer Tiller Encoder on electric steer trucks when the steering tiller is moved. It is a square wave signal (0VDC & 4.5VDC) identical to Channel_A_1 but different phase. The VM uses the phase relationship of the two channels to determine the direction and speed of the steering request. When the tiller is stationary, the voltage can be either high or low.	Not turning: either >4.5VDC or <0.5VDC; Turning either direction: approx 2.5VDC.	Steer Tiller Encoder	VM
87	JPC22-13	CHANNEL_A_2	Channel_A_2 is one part of the steering request from the Steer Tiller Encoder on electric steer trucks when the steering tiller is moved. It is a square wave signal (0VDC & 4.5VDC) identical to Channel_B_2 but different phase. The VM uses the phase relationship of the two channels to determine the direction and speed of the steering request. When the tiller is stationary, the voltage can be either high or low.	Not turning: either >4.5VDC or <0.5VDC; Turning either direction: approx 2.5VDC.	Steer Tiller Encoder	VM

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Item	Connection	Function Description	Theory of Operations	Normal Level	Signal Source	Signal User
88	JPC22-14	CHANNEL_B_2	Channel_B_2 is one part of the steering request from the Steer Tiller Encoder on electric steer trucks when the steering tiller is moved. It is a square wave signal (0VDC & 4.5VDC) identical to Channel_A_2 but different phase. The VM uses the phase relationship of the two channels to determine the direction and speed of the steering request. When the tiller is stationary, the voltage can be either high or low.	Not turning: either >4.5VDC or <0.5VDC; Turning either direction: approx 2.5VDC.	Steer Tiller Encoder	VM
89	JPC22-15 thru 17		Not Used			
90	JPC22-18	NESTED SWITCH	Control path for the optional Nested Switch (S14) on the carriage. Voltage will be B+ when the carriage is nested & K2 tips closed and 0VDC when the carriage is not nested. The VM reduces travel speed to the configured value (0 to 3.5mph [0 to 5.76 km/hr]) when the switch is open.	K2 tips Closed (carriage nested): B+; Open (unnested): 0VDC	K2 tips	VM
91	JPC22-19	FU1_SENSE	B+ when there is not an open between B+ and STR2. This voltage is used by the VM to determine the state of FU1 and the STR contactor tips.	Closed: B+; Open: Voltage drops slowly to 0VDC	STR2	VM
92	JPC22-20		Not Used			
93	JPC22-21	EPO_SENSE	Sense wire used by the VM to determine when the EPO is open.	EPO closed: B+; Open: 0VDC	EPO	VM
94	JPC22-22	STEER_LIMIT	The Steer Limit Switch (S11) stops drive unit rotation when closed. This switch is closed just before the hard stops are reached for both CW and CCW rotation.	Open (metal): 4 to 7VDC; Closed (air): 0.7VDC	S11	VM
95	JPC24-1 thru 5		Not Used			
96	JPC24-6	DGND	Reference for the pressure transducer.	<0.5VDC wrt B–	VM	Pressure Transducer
97	JPC24-7 thru 10		Not Used			
98	JPC24-11	DGND	Reference for the ambient temperature sensor.	<0.5VDC wrt B–	Ambient Temp Sensor	VM
99	JPC24-12 thru 17		Not Used			

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Signal Source	Signal User
100	JPC24-18	PRESSURE	Analog DC voltage that varies directly as the pressure varies.	No load: 1.0VDC; 1000lb. (454 kg) out of free lift: 1.8VDC; 2500 lb. (1134 kg): 2.5VDC	Pressure Transducer	VM
101	JPC24-19 thru 22		Not Used			
102	JPC24-23	ROOM_TEMP	Input to the VM from the ambient temperature sensor. This is used to tell the optional heaters when to turn ON.	73°F (22.8°C): 3VDC	Ambient Temp Sensor	VM
103	JPC24-24	BATTERY_ SENSE _IN	Used by the VM to determine the correct battery has been connected. It accepts any voltage between 28VDC and 45VDC. If the correct battery is sensed, Relay_Enable is energized during start-up. After start-up, this voltage is used to determine BSOC.	B+ (Drops no voltage)	B+ at JPF4-1	VM
104	JPF1-1	B–	B– for FU8, B– 15A fuse for optional Aux power.	<0.5VDC wrt B–	Power Panel TP4	Optional Aux Power
105	JPF1-2	B–	B– for FU8, B– 15A fuse for optional Aux power.	<0.5VDC wrt B–	Power Panel TP4	Optional Aux Power
106	JPF1-3	B+F or B–F	Provides either B+ or B– to the lift power amplifier pre-charge circuit, depending on the state of relay K3.	K3 De-energized: Voltage drops slowly to 0; Energized: B+	FU5 to B+ FU6 to B–	LPA
107	JPF1-4	B–F	B–F from FU8 to power the optional WMM.	<0.5VDC wrt B–	FU8 to B–	Aux Power, WMM
108	JPF1-5	B+F or B–F	Provides B+ or B– to the TPA pre-charge circuit, depending on the state of relay K3.	K3 De-energized: B–; Energized: B+	FU5 to B+ FU6 to B–	TPA
109	JPF1-6	B+F OR B–F	Provides B+F or B–F to the B+K3 on the Lift (JPL1-1) and the Traction (JPT1-1) Power Amplifiers.	K3 De-energized: B–; Energized: B+	FU5 to B+ FU6 to B–	LPA, TPA
110	JPF2-1	B+K2	B+K2 to power TPC, LPC, and STR contactors.	K2 Energized: B+	K2 tips	TPC, LPC, and STR Contactors
111	JPF2-2	B+K2	B+K2 to power the horn.	K2 Energized: B+	K2 tips	Horn
112	JPF2-3	B+K2	B+K2 to power the compartment fans.	K2 Energized: B+	K2 tips	Fans

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Item	Connection	Function Description	Theory of Operations	Normal Level	Signal Source	Signal User
113	JPF2-4	B+K4	B+K4 to the VM.	K2 Energized: B+	K4 tips	VM
114	JPF2-5	B+K2	B+K2 to power SOL1.	K2 Energized: B+	K2 tips	L/H SOL1
115	JPF2-6	B+K2	B+K2 to the VM.	K2 Energized: B+	K2 tips	VM
116	JPF2-7	B+K2	B+K2 to the VM.	K2 Energized: B+	K2 tips	VM
117	JPF2-8	B+K2	B+K2 to the reach, sideshift, and tilt solenoids, and Nested Switch (S14).	K2 Energized: B+	K2 tips	Carriage Functions
118	JPF2-9	B+K1	B+ to TS1.	K2 Energized: B+	K1	TS1
119	JPF3-1	B–	B– for FU6 (15A), that provides B– to the VM.	<0.5VDC wrt B–	Power Panel TP4	VM
120	JPF3-2	B–	B– for FU6 (15A), that provides B– to the VM.	<0.5VDC wrt B–	Power Panel TP4	VM
121	JPF3-3	B–F	B–F for DGND on the VM.	<0.5VDC wrt B–	FU6	VM
122	JPF3-4	B–F	B–F for DGND on the VM.	<0.5VDC wrt B–	FU6	VM
123	JPF3-5	B–F	B–F for the VM.	<0.5VDC wrt B–	FU6	VM
124	JPF3-6	B–F	B–F for the VM	<0.5VDC wrt B–	FU6	VM
125	JPF3-7	B–F	B–F for the VM.	<0.5VDC wrt B–	FU6	VM
126	JPF3-8	B–F	B–F for S12, 1st Speed Limiting Switch on mast.	<0.5VDC wrt B–	FU6	S12
127	JPF4-1	B+	B+ from TP1 to FU5, to supply K2, K3, and K4 relay tips; K4 relay coil; and key switch (S1). This also supplies Battery_Sense_In on the VM.	B+	TP1	FU5 & VM
128	JPF4-2	B+	B+ from TP1 to FU5, to supply K2, K3, and K4 relay tips; K4 relay coil; and Key Switch (S1). This also supplies Battery_Sense_In on the VM.	B+	TP1	FU5 & VM
129	JPF4-3	B+	B+ from TP1 to FU7 to supply auxiliary power option and Warehouse Management Module.	B+	1	FU7 and Aux Power
130	JPF4-4	B+	B+ from TP1 to FU7 to supply auxiliary power option.	B+	TP1	FU7 and Aux Power

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Signal Source	Signal User
131	JPF4-5	B+EPO	B+ supply from EPO to K1, K2, and K3. All functions associated with those functions are inoperable when the EPO is open. This also supplies voltage to EPO_Sense on the VM.	S1 and EPO closed: B+; Either open: 0.05VDC	EPO	K1, K2, & K3
132	JPF4-6	B+EPO	B+ to EPO_Sense on the VM. Tells the VM if the EPO is open or closed.	S1 and EPO closed: B+; Either open: 0.05VDC	EPO	VM EPO Sense
133	JPF4-7	BATTERY_ SENSE_IN	B+ to Battery_Sense_In on the VM.	B+	TP1	VM
134	JPF4-8	B+KEY	B+Key to supply all functions powered from Key Switch (S1).	S1 closed: B+	FU5	Various
135	JPF4-10	B+	B+ from FU5 to Key Switch (S1).	FU5 good: B+ FU5 open: 0VDC	FU5	Key switch S1
136	JPF4-11	B+KEY	B+ from Key Switch (S1) to the VM.	S1 closed: B+	S1	VM
137	JPF4-12	B+KEY	B+ from Key Switch (S1) to the EPO.	S1 closed: B+	S1	EPO
138	JPF4-13	RELAY_ ENABLE	Return path for relays K1, K2, K3, and K4.	Key ON & all relays De-energized: B+; Key OFF, or Key ON & any relay Energized: <1.5VDC	VM	K1, K2, K3, & K4
139	JPF4-14		Not Used			
140	JPF4-15	B+	B+ for battery connected to aux power.	B+	FU7	Optional Aux Power
141	JPL1-1	B+K3	B+ present when K3 is energized. This is used to power the control circuits of the LPA. It is also used by the LPA to produce +12VDC for the L Vel Sensor + and the internal circuits of the LPA. If voltage is not present, check K3 coil and tip circuit.	K3 Energized: B+	K3	LPA
142	JPL1-2	LPC CONTACTOR	Control path for the LPC Contactor. The lift power amplifier supplies B– to the contactor by way of the B– terminal.	LPC De-energized: B+; LPC Energized: 18VDC to 22VDC.	LPA	LPC Contactor
143	JPL1-3	L VEL SENSOR+	+12VDC supply to the Lift Motor encoder. This voltage is produced by the lift power amplifier B+K3.	+10.9 to 13VDC	LPA	Lift Encoder

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Item	Connection	Function Description	Theory of Operations	Normal Level	Signal Source	Signal User
144	JPL1-4	L VEL SENSOR–	Return path for the Lift Motor encoder. Returns through DGND JPL1-7 through the Operator Display to the VM.	<0.5VDC wrt B–	DGND on VM	Lift Encoder
145	JPL1-5	L VEL PHASE A	This square wave is generated whenever there is movement of the encoder in the Lift Motor. It is either high (>8VDC) or low (<1VDC). The frequency varies directly with the speed of the Lift Motor. Identical formation to L Vel Phase B, except for the phasing between the two. The LPA uses the quadrature phase relationship between Phases A and B to determine lift speed.	Motor Stationary: Either >8VDC or <1VDC; Turning: 4VDC to 6VDC.	Lift Encoder	LPA
146	JPL1-6	L VEL PHASE B	This square wave is generated whenever there is movement of the encoder in the Lift Motor. It is either high (>8VDC) or low (<1VDC). The frequency varies directly with the speed of the Lift Motor. Identical formation to L Vel Phase A, except for the phasing between the two. The LPA uses the quadrature phase relationship between Phases A and B to determine lift speed.	Motor Stationary: Either >8VDC or <1VDC; Turning: 4VDC to 6VDC.	Lift Encoder	LPA
147	JPL1-7	DGND	DGND from VM through the Operator Display to the LPA. If it is missing, the LPA and TPA do function.	<0.5VDC wrt B–	Display	LPA
148	JPL1-8	DGND B–	Provides DGND to the TPA from the LPA.	<0.5VDC wrt B–	LPA	TPA
149	JPL1-9 thru 13		Not Used			
150	JPL1-14	BUS_I–	Carries negative component of the digital communications between the Operator Display and the LPA and VM. If missing, the LPA and TPA cannot communicate with the Operator Display or VM. Troubleshoot using resistance checks in Test I23. No useful information can be gained by measuring the voltage on this wire.	2.2VDC	Display	LPA
151	JPL1-15	BUS_I–	Carries negative component of the digital communications between the LPA and the TPA. If missing, the TPA cannot communicate with the LPA, Display, or VM. Troubleshoot using resistance checks in Test I23. No useful information can be gained by measuring the voltage on this wire.	2.2VDC	LPA	TPA
152	JPL1-16	L TEMP+	Analog voltage that varies with the Lift Motor temperature. Used by the LPA to adjust motor performance when a motor overtemp condition exists.	75°F (24°C): approx 1.5VDC	LM Temp Sensor	LPA
153	JPL1-17	L TEMP–	Reference for the Lift Motor temperature sensor.	<0.5VDC wrt B–	DGND on VM	Temp Sensor

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Signal Source	Signal User
154			Not Used			
155	JPL1-22	BUS I+	Carries positive component of the digital communications between the LPA and the Operator Display and VM. If missing, the LPA and TPA cannot communicate with the Operator Display or VM. Troubleshoot using resistance checks in Test I23. No useful information can be gained by measuring the voltage on this wire.	2.94VDC	Display	LPA
156	JPL1-23	BUS I+	Carries the positive component of the digital communications between the LPA and the TPA. If missing, the TPA cannot communicate with the LPA, Display, or VM. Troubleshoot using resistance checks in Test I23. No useful information can be gained by measuring the voltage on this wire.	2.94VDC	LPA	TPA
157	JPT1-1	B+K3	B+ present when K3 is energized. Used to power control circuits of the TPA. Also used by the TPA to produce +12VDC for the T Vel Sensor+ and internal circuits of the TPA. If voltage is not present, check K3 coil and tip circuit.	K3 Energized: B+	K3	TPA
158	JPT1-2	TPC CONTACTOR	Control path for the TPC Contactor. The TPA supplies B– to the contactor by way of the B– terminal.	TPC De-energized: B+; TPC Energized: 18 to 22VDC.	TPA	TPC Contactor
159	JPT1-3	T VEL SENSOR+	+12VDC supply to the Traction Motor encoder. This voltage is produced by the traction power amp from B+K3.	+10.7 to 13VDC	TPA	Travel Encoder
160	JPT1-4	T VEL SENSOR–	Return path for the Traction Motor encoder. Returns through DGND JPT1-7 to the LPA, Operator Display, and to the VM.	<0.5VDC wrt B–	DGND on VM	Travel Encoder
161	JPT1-5	T VEL PHASE A	This is generated whenever there is movement of the Traction Motor. It is a square wave that is either high (>8VDC) or low (<1VDC). The frequency varies directly with the speed of the Traction Motor. Identical information to T Vel Phase B, except for the phasing between the two. The VM uses the quadrature phase relationship between Phases A and B to determine travel direction and speed.	Motor Stationary: Either >8VDC or <1VDC; Turning: 4VDC to 6VDC.	Travel Encoder	TPA

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Item	Connection	Function Description	Theory of Operations	Normal Level	Signal Source	Signal User
162	JPT1-6	T VEL PHASE B	This is generated whenever there is movement of the Traction Motor. It is a square wave that is either high (>8VDC) or low (<1VDC). The frequency varies directly with the speed of the Traction Motor. Identical information to T Vel Phase A, except for the phasing between the two. The VM uses the quadrature phase relationship between Phases A and B to determine travel direction and speed.	Motor Stationary: Either >8VDC or <1VDC; Turning: 4VDC to 6VDC.	Travel Encoder	TPA
163	JPT1-7	DGND	DGND for the TPA from the LPA.	<0.5VDC wrt B–	LPA	TPA
164	JPT1-8 thru 13		Not Used			
165	JPT1-14	BUS_I–	Carries negative component of the digital communications from the LPA and VM to the TPA. If missing, the TPA cannot communicate with the VM, LPA, or Display. Troubleshoot using resistance checks in Test I23. No useful information can be gained by measuring the voltage on this wire.	2.2VDC	LPA	TPA
166	JPT1-15		Not Used			
167	JPT1-16	T TEMP+	Analog voltage that varies with Traction Motor temperature. Used by the TPA to adjust motor performance when a motor overtemp condition exists.	75°F (24°C): approx 1.0VDC	Tracion Motor Temp Sensor	TPA
168	JPT1-17	T TEMP–	Reference for the Traction Motor Temp sensor.	<0.5VDC wrt B–	DGND on VM	Temp Sensor
169	JPT1-18 thru 21		Not Used			
170	JPT1-22	BUS_I+	Carries positive component of the digital communications from the LPA and VM to the TPA. If missing, the TPA cannot communicate with the VM, LPA, or Display. Troubleshoot using resistance checks in Test I23. No useful information can be gained by measuring the voltage on this wire.	2.93VDC	LPA	TPA
171	LPA (+)	LPA B+	B+ to the LPA used to pre-charge the amplifier and also to produce the AC phases U, V, and W when the LPC is closed to power the Lift Motor. The voltage present increases from 0VDC to B+ as the amplifier charges.	Fully charged or LPC Energized; B+	B+K3 and B+ from LPC	LPA
172	LPA B–	LPA B–	B– from TP4 on the Power Panel. It is used for the power circuits on the LPA. Without B– U, V, and W cannot be produced and the Lift Motor will not operate.	<0.5VDC wrt B–	TP4	LPA
173	LPA B+		Not Used			

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Signal Source	Signal User
174	TPA (+)	TPA B+	B+ to the TPA used to pre-charge the amplifier and also to produce the AC phases U, V, and W when the TPC is closed to power the Traction Motor. Voltage increases from 0VDC to B+ as the amplifier charges.	Fully charged or TPC Energized: B+	B+K3 and B+ from TPC	TPA
175	TPA B–	TPA B–	B– from TP4 on the Power Panel. It is used for the power circuits on the TPA. Without B– U, V, and W cannot be produced and the Traction Motor does not operate.	<0.5VDC wrt B–	TP4	TPA
176	TPA B+		Not Used			
177	U on LPA	LIFT MOTOR PHASE U	One of three phases from the LPA to the Lift Motor. This AC voltage is produced by LPA and is dependent on B+ at the (+) terminal and B– of the LPA. This AC voltage is measured between any two phases and varies from 0VAC at rest to about 24VAC on full lift request. When lift knob is initially moved to full lift, meter reading may show 120VAC before stabilizing at about 24VAC.	ACV between phases. Stationary: 0VAC; Full lift: 24VAC	LPA	Lift Motor
178	U on TPA	TRACTION MOTOR PHASE U	One of three phases from the TPA to the Traction Motor. This AC voltage is produced by TPA and is dependent on B+ at the (+) terminal and B– of the TPA. This AC voltage is measured between any two phases and varies from 0VAC at rest to about 24VAC on full acceleration. Stall condition produces about 4VAC.	ACV between phases. Stationary: 0VAC; Full travel: 24VAC; Stall: approx 4VAC	TPA	Traction Motor
179	V on LPA	LIFT MOTOR PHASE V	One of three phases from the LPA to the Lift Motor. This AC voltage is produced by LPA and is dependent on B+ at the (+) terminal and B– of the LPA. This AC voltage is measured between any two phases and varies from 0VAC at rest to about 24VAC on full lift request. When lift knob is initially moved to full lift, meter reading may show 120VAC before stabilizing at about 24VAC.	ACV between phases. Stationary: 0VAC; Full lift: 24VAC	LPA	Lift Motor
180	V on TPA	TRACTION MOTOR PHASE V	One of three phases from the TPA to the Traction Motor. This AC voltage is produced by TPA and is dependent on B+ at the (+) terminal and B– of the TPA. This AC voltage is measured between any two phases and varies from 0VAC at rest to about 24VAC on full acceleration. Stall condition produces about 4VAC.	ACV between phases. Stationary: 0VAC; Full travel: 24VAC; Stall: approx 4VAC	TPA	Traction Motor

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Item	Connection	Function Description	Theory of Operations	Normal Level	Signal Source	Signal User
181	W on LPA	LIFT MOTOR PHASE W	One of three phases from the LPA to the Lift Motor. This AC voltage is produced by LPA and is dependent on B+ at the (+) terminal and B– of the LPA. This AC voltage is measured between any two phases and varies from 0VAC at rest to about 24VAC on full lift request. When lift knob is initially moved to full lift, meter reading may show 120VAC before stabilizing at about 24VAC.	ACV between phases. Stationary: 0VAC; Full lift: 24VAC	LPA	Lift Motor
182	W on TPA	TRACTION MOTOR PHASE W	One of three phases from the TPA to the Traction Motor. This AC voltage is produced by TPA and is dependent on B+ at the (+) terminal and B– of the TPA. This AC voltage is measured between any two phases and varies from 0VAC at rest to about 24VAC on full acceleration. Stall condition produces about 4VAC.	ACV between phases. Stationary: 0VAC; Full travel: 24VAC; Stall: approx 4VAC	TPA	Traction Motor

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Section A. Appendix



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Lubrication Specification Chart

Table A-1. Lubrication Specification Chart

Approved **Raymond** Lubricants			
Where Used	**Type**	**Specification**	**Raymond Part Number**
Drive Unit Gear Case (all applications)	Gear Lubricant	75W-90 Synthetic Gear Oil API Service GL-5	990-655/001 (1 qt./0.9 liters) 990-655/003 (1 gal./3.8 liters)
Hydraulic Reservoir (Non-CS trucks) +50° to +120°F (+10° to +49°C)	Hydraulic Fluid	ISO VG 46	990-616/04 (1 qt./0.9 liter) 990-616/01 (1 gal./3.8 liters) 990-616/02 (2 gal./7.6 liters) 990-616/03 (5 gal./18.9 liters)
Hydraulic Reservoir (CS trucks - in and out of freezer) 0° to +50°F (–18° to +10°C)	Hydraulic Fluid	ISO VG 32	1017238 **Note:** Do *not* add any additives.
Hydraulic Reservoir (CS trucks - confined to freezer) –20° to 0°F (–29° to –18°C)	Hydraulic Fluid	MIL-H-5606E	990-618/TX1 (1 gal./3.8 liters) 990-618/01 (1 gal./3.8 liters)
Mast Uprights, Bearings, and so forth (all-weather) –20° to +120°F (–29° to +49°C)	Grease	NLGI 2	1012992
Lift Chains	Teflon Grease	Aerosol	990-652/001 (spray)

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Thread Adhesives, Sealants, and Lubricants

Table A-2. Thread Adhesives, Sealants, and Lubricants

Application	Raymond P/N	*Loctite** Number/Color
Thread-locking 1/4 in. and below	990-403	222/Purple
Thread-locking 1/4 to 3/4 in.	990-536	242/Blue
Thread-locking 1/4 to 3/4 in. contamination tolerant	990-462	243/Blue
Thread-locking 1 in. and under	990-544	271/Red
Thread-locking 1 in. and under, contamination tolerant	990-463	603/Green
Thread-locking 1 in. and over	990-571	277/Red
Thread-locking Cleaner	990-538	707
Thread-locking Primer	990-533	T747
Primerless Thread-locking 1 1/2 in. and below	1013829	2440
Hydraulic Sealant	990-552	569
RTV Silicone Sealant	990-659	5900/Black
		Other Manufacturer designation
Molybdenum Anti-Seize Compound (Molykote)	990-638	/Silver
Corrosion Inhibitor Coating	990-644	
Cold Storage Silicone Sealing Compound	990-445	
NOTE: **Loctite* is a registered trademark of the Loctite Corporation. Brand endorsement is not implied here, but listed only as a commonly identified product.		

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Component Specific Service/Torque Chart

Table A-3. Component Specific Service/Torque Chart

Component	Sub-Component(s)	Thread-Locking Compound P/N	Torque to:
Baseleg Apply anti-seize compound (P/N 990-638) to locating pins.	baseleg mounting bolts	990-544	165 ft. lb. (223 Nm)
	load wheel plate mtg bolts	990-536	50 ft. lb. (68 Nm)
Battery Gate Switches	Adjust the gap between the switch and target to 0.16 in. (4 mm) max.		
Deadman Pedal Assembly (DS1)	assembly to frame	990-536	15 ft. lb. (21 Nm)
Deadman Pedal Assembly (DS2)	assembly to frame	990-536	15 ft. lb. (21 Nm)
Drive Wheel	mounting bolts	n/a	170 ft. lb. (230 Nm)
EPO Switch	n/a	990-536	6 ft. lb. (8.6 Nm)
High Speed Travel Switch (S25)	Adjustment: Fully lower carriage and adjust gap between switch and rail from 0.10 to 0.22 in. (2.54 to 5.58 mm).		
Horn	bracket to frame	990-536	15 ft. lb. (21 Nm)
Hose, Over-the-Mast	pulley stud	1013289	130 ft. lb. (174 Nm)
Lift Cutout Switch (S27)	Adjustment: 1. Fully raise carriage and adjust gap between switch and rail from 0.10 to 0.25 in. (2.54 to 6.35 mm). 2. Align the vertical center line of the switch just below the bottom edge of the rail so the sensor LED is OFF.		
Lift Motor Apply anti-seize compound (P/N 990-638) to pump spline and mating surfaces.	lift pump mtg bolts	990-536	55 ft. lb. (72 Nm)
	motor mtg bolts to bracket		15 ft. lb. (21 Nm)
	bracket mtg bolts to deck		
	lift motor power cables	n/a	18 ft. lb. (24.4 Nm)
Lift Pump Apply anti-seize compound (P/N 990-638) to spline, mating surfaces.	P1 fitting		85 ft. lb. (115 Nm)
	input fitting		120 ft. lb. (163 Nm)
	lift pump mounting bolts	990-536	55 ft. lb. (72 Nm)
Manifold, Auxiliary (Reach/Tilt/Sideshift)	mounting bolts	990-536	21 ft. lb. (29 Nm)
Manifold, Main	Mounting bolts	990-536	21 ft. lb. (29 Nm)
Mast	mast to tractor	990-666 (primer) 990-544 (locker)	165 ft. lb. (224 Nm)

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Component	Sub-Component(s)	Thread-Locking Compound P/N	Torque to:
Power Amplifier, Lift	amplifier bolts to bracket		6 ft. lb. (8.6 Nm)
	bracket mtg bolts to deck		15 ft. lb. (21 Nm)
	power cables		11 ft. lb. (15 Nm)
Power Amplifier, Traction	amplifier bolts to bracket	n/a	6 ft. lb. (8.6 Nm)
	bracket mtg nuts to deck		15 ft. lb. (21 Nm)
	power cables		11 ft. lb. (15 Nm)
Proportional Valve	n/a		95 ft. lb. (129 Nm)
Pulleys, Over-the-Mast	pulley stud	1013289	130 ft. lb. (174 Nm)
Steer Limit Switch S11	switch bracket to drive unit	990-536	9 ft. lb. (12 Nm)
Speed Limiting Switch, First (S12)	Adjustment: 1. Lower carriage and adjust gap between switch and rail from 0.10 to 0.25 in. (2.54 to 6.35 mm). 2. Align the vertical center line of the switch just above the bottom edge of the rail so the sensor LED is ON.		
Steer Motor, Electric **Note:** *Apply anti-seize compound (P/N 990-638) to pinion gear. Orient pinion gear with shoulder toward mounting bolt.*	pinion gear set screw	1013829	45 ft. lb. (61 Nm)
	pinion gear mtg bolt		13 ft. lb. (17 Nm)
	motor mtg bolts		18 ft. lb. (24.4 Nm)
	flange mtg bolts	990-536	95 ft. lb. (129 Nm)
Stops, Carriage	n/a	990-536	35 ft. lb. (47.5 Nm)
Traction Motor *Apply anti-seize compound (P/N 990-638) to pinion gear. Orient pinion gear with shoulder toward mounting bolt.*	pinion gear nut	990-536	85 ft. lb. (115 Nm)
	mounting bolts		18 ft. lb. (24.4 Nm)
	power cables	n/a	
	steer limit sensing rail	990-536	9 ft. lb. (12 Nm)
Travel Light	n/a		23 ft. lb. (31 Nm)

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Torque Chart - Hydraulic Fittings

Table A-4. Torque Chart - Hydraulic Fittings

SAE Dash Size	Thread Size	JIC (37° Flare Thread)		SAE Straight Thread Steel Plugs			
				Hollow Hex Head Plug HP50N		Hex Head Plug P50N	
		ft. lb.	Nm	ft. lb.	Nm	ft. lb.	Nm
-2	5/16-24	3 ±1	4 ±1	3 ±0.5	4 ±0.6	7.5 ±0.5	10 ±0.6
-3	3/8-24	6 ±1	8 ±1	5 ±0.5	7 ±0.6	14 ±1	19 ±1
-4	7/16-20	12 ±1	16 ±1	11 ±1	15 ±1	18 ±1	24 ±1
-5	1/2-20	15 ±1	20 ±1	15 ±1	20 ±1	22 ±1	30 ±1
-6	9/16-18	21 ±1	28 ±1	18 ±1	24 ±1	27 ±2	37 ±3
-8	3/4-16	45 ±2	61 ±3	46 ±2	62 ±3	48 ±2	65 ±3
-10	7/8-14	60 ±5	81 ±7	75 ±5	102 ±7	90 ±5	122 ±7
-12	1 1/16-12	85 ±5	115 ±7	85 ±5	115 ±7	110 ±5	149 ±7
-14	1 3/16-12	105 ±5	142 ±7	130 ±6	176 ±8	145 ±6	197 ±8
-16	1 5/16-12	120 ±5	163 ±7	135 ±6	183 ±8	160 ±6	217 ±8
-20	1 5/8-12	170 ±10	230 ±14	225 ±12	305 ±16	225 ±12	305 ±16
-24	1 7/8-12	200 ±15	271 ±20	250 ±12	339 ±16	250 ±12	339 ±16
-32	2 1/2-12	270 ±20	366 ±27	325 ±15	441 ±20	325 ±15	441 ±20

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Torque Chart - Straight Thread Face Seal O-Rings

Table A-5. Torque Chart - Straight Thread Face Seal O-Rings

SAE Dash Size	Tube Size Thread Size	ft. lb.	Nm
-4	9/16-18	18 ±1	24 ±1
-6	11/16-18	27 ±2	37 ±3
-8	13/16-16	40 ±2	54 ±3
-10	1-14	63 ±3	85 ±4
-12	1 3/16-12	90 ±4	122 ±5
-14	1 5/16-32	95 ±6	129 ±8
-16	1 7/16-12	120 ±8	163 ±11
-20	1 11/16-12	140 ±8	190 ±11
-24	2-12	165 ±8	224 ±11
-32	2 1/2-12	360 ±10	488 ±14

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Torque Chart - Standard (Ferrous)

Table A-6. Torque Chart - Standard Ferrous

Grade Identification Marking	None					
Size	SAE Grade 2 Bolts Tightening Torque		SAE Grade 5 Bolts Tightening Torque		SAE Grade 8 Bolts Tightening Torque	
	Dry	Oiled	Dry	Oiled	Dry	Oiled
	in. lb.	in. lb.	in. lb.	in. lb.	in. lb.	in. lb.
4-40	5	4	8	6	12	9
4-48	6	5	9	7	13	10
6-32	10	8	16	12	23	17
8-32	19	14	30	22	41	31
8-36	20	15	31	23	43	32
10-24	27	21	43	32	60	45
10-32	31	23	49	36	68	51
1/4-20	66	49	96	75	144	108
1/4-28	78	56	120	86	168	120
	ft. lb.	ft. lb.	ft. lb.	ft. lb.	ft. lb.	ft. lb.
5/16-18	11	8	17	13	25	18
5/16-24	12	9	19	14	25	20
3/8-16	20	15	30	23	45	35
3/8-24	23	17	35	25	50	35
7/16-14	30	24	50	35	70	55
7/16-20	35	25	55	40	80	60
1/2-13	50	35	75	55	110	80
1/2-20	55	40	90	65	120	90
9/16-12	65	50	110	80	150	110
9/16-18	75	55	120	90	170	130
5/8-11	90	70	150	110	220	170
5/8-18	110	85	180	130	240	180

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Grade Identification Marking	None					
Size	SAE Grade 2 Bolts Tightening Torque		SAE Grade 5 Bolts Tightening Torque		SAE Grade 8 Bolts Tightening Torque	
	Dry	Oiled	Dry	Oiled	Dry	Oiled
	ft. lb.	ft. lb.	ft. lb.	ft. lb.	ft. lb.	ft. lb.
3/4-10	160	120	260	200	380	280
3/4-16	180	140	300	220	420	320
7/8-9	140	110	400	300	600	460
7/8-14	155	120	440	320	660	500
1-8	220	160	580	440	900	680
1-12	240	170	640	480	1000	740
1 1/8-7	300	220	800	600	1280	960
1 1/8-12	340	260	880	660	1440	1080
1 1/4-7	420	320	1120	840	1820	1360
1 1/4-12	460	360	1240	920	2000	1500
1 3/8-6	560	420	1460	1100	2380	1780
1 3/8-12	640	460	1680	1260	2720	2040
1 1/2-6	740	560	1940	1460	3160	2360
1 1/2-12	840	620	2200	1640	3560	2660

NOTE: Use “oiled” values for bolts with thread-locking compound.

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Torque Chart - Metric (Ferrous)

Table A-7. Torque Chart - Ferrous Metric

Ferrous Metric Bolts, Coarse Thread (Grade rating stamped on head of bolt)				
Diameter (in millimeters)	**Grade 8.8**		**Grade 10.9**	
	Torque (bolts oiled)		**Torque (bolts oiled)**	
	ft. lb.	**Nm**	**ft. lb.**	**Nm**
6	6	8.1	9	12.2
8	15	20.3	21	28.4
10	30	40.7	43	58.3
12	55	74.6	75	101.7
16	130	176.3	181	245.4
20	255	345.7	350	474.5
24	435	589.8	605	820.3
NOTE: Use “oiled” values for bolts with thread-locking compound.				

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Torque Chart - Standard (Brass)

Table A-8. Torque Chart - Standard Brass

Brass MS63 Standard Bolts, Coarse Thread		
Size	**Torque (bolts oiled)**	
	in. lb.	**Nm**
4-40	3.3	0.37
4-48	3.6	0.40
6-32	6.1	0.69
6-40	6.8	0.77
8-32	11	1.24
8-36	11	1.24
10-24	14	1.58
10-32	17	1.92
1/4-20	35	3.96
1/4-28	40	4.52
5/16-18	73	8.25
5/16-24	81	9.15
3/8-16	130	14.69
3/8-24	147	16.61
NOTE: Use “oiled” values for bolts with thread-locking compound.		

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Torque Chart - Metric (Brass)

Table A-9. Torque Chart - Brass Metric

Brass MS63 Metric Bolts, Coarse Thread		
Diameter (in millimeters)	**Torque (bolts oiled)**	
	in. lb.	**Nm**
3	4.4	0.5
3.5	7.0	0.79
4	10	1.1
5	19	2.1
6	34	3.8
8	79	9
10	150	17
NOTE: Use “oiled” values for bolts with thread-locking compound.		

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Decimal Equivalent Chart

Table A-10. Decimal Equivalent Chart

4ths	8ths	16ths	32nds	64ths	To 3 Places	To 2 Places	MM Equivalent
				1/64	.016	.02	.397
			1/32		.031	.03	.794
				3/64	.047	.05	1.191
		1/16			.062	.06	1.587
				5/64	.078	.08	1.984
			3/32		.094	.09	2.381
				7/64	.109	.11	2.778
	1/8				.125	.12	3.175
				9/64	.141	.14	3.572
			5/32		.156	.16	3.969
				11/64	.172	.17	4.366
		3/16			.188	.19	4.762
				13/64	.203	.20	5.159
			7/32		.219	.22	5.556
				15/64	.234	.23	5.593
1/4					.250	.25	6.350
				17/64	.266	.27	6.747
			9/32		.281	.28	7.144
				19/64	.297	.30	7.540
		5/16			.312	.31	7.937
				21/64	.328	.33	8.334
			11/32		.344	.34	8.731
				23/64	.359	.36	9.128
	3/8				.375	.38	9.525
				25/64	.391	.39	9.922
			13/32		.406	.41	10.319
				27/64	.422	.42	10.716
		7/16			.438	.44	11.112
				29/64	.453	.45	11.509
			15/32		.469	.47	11.906
				31/64	.484	.48	12.303
1/2					.500	.50	12.700
				33/64	.516	.52	13.097
			17/32		.531	.53	13.494
				35/64	.547	.55	13.891
		9/16			.562	.56	14.288
				37/64	.578	.58	14.684
			19/32		.594	.59	15.081

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Decimal Equivalent Chart

4ths	8ths	16ths	32nds	64ths	To 3 Places	To 2 Places	MM Equivalent
				39/64	.609	.61	15.478
	5/8				.625	.62	15.875
				41/64	.641	.64	16.272
			21/32		.665	.66	16.669
				43/64	.672	.67	17.065
		11/16			.688	.69	17.462
				45/64	.703	.70	17.859
			23/32		.719	.72	18.256
				47/64	.734	.73	18.653
3/4					.750	.75	19.050
				49/64	.766	.77	19.447
			25/32		.781	.78	19.844
				51/64	.797	.80	20.241
		13/16			.812	.81	20.637
				53/64	.828	.83	21.034
			27/32		.844	.84	21.431
				55/64	.859	.86	21.828
	7/8				.875	.88	22.225
				57/64	.891	.89	22.622
			29/32		.906	.91	23.019
				59/64	.922	.92	23.416
		15/16			.938	.94	23.812
				61/64	.953	.95	24.209
			31/32		.969	.97	24.606
				63/64	.984	.98	25.003
					1.000	1.00	25.400

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Standard/Metric Conversions

To Convert...	Multiply, Add, or Subtract...
Area	
Square Inches to Square Centimeters	Square Inches x 6.452
Square Centimeters to Square Inches	Square Centimeters x 0.155
Square Feet to Square Meters	Square Feet x 0.093
Square Meters to Square Feet	Square Meters x 10.753
Square Yards to Square Meters	Square Yards x 0.836
Square Meters to Square Yards	Square Meters x 1.196
Distance	
Inches to Millimeters	Inches x 25.4
Millimeters to Inches	Millimeters x 0.039
Inches to Centimeters	Inches x 2.54
Centimeters to Inches	Centimeters x 0.394
Feet to Meters	Feet x 0.305
Meters to Feet	Meters x 3.281
Yards to Meters	Yards x 0.914
Meters to Yards	Meters x 1.094
Miles to Kilometers	Miles x 1.609
Kilometers to Miles	Kilometers x 0.621
Mass	
Ounces to Grams	Ounces x 28.35
Grams to Ounces	Ounces x 0.035
Ounces to Kilograms	Ounces x 0.028
Kilograms to Ounces	Kilograms x 35.27
Pounds to Kilograms	Pounds x 0.454
Kilograms to Pounds	Kilograms x 2.2
Pressure	
Pounds per Square Inch (PSI) to kiloPascals	PSI x 6.894
kiloPascals to Pounds per Square Inch (PSI)	kiloPascals x 0.145
Speed	
Miles per hour to Kilometers per hour	Miles per hour x 1.609
Kilometers per hour to Miles per hour	Kilometers per hour x 0.6214
Temperature	
Fahrenheit to Celsius	(°F minus 32) x 0.555
Celsius to Fahrenheit	(°C x 1.8) plus 32
Torque	
Inch Pounds (in. lb.) to Newton Meters (Nm)	Inch Pounds x 0.113
Newton Meters (Nm) to Inch Pounds (in. lb.)	Newton Meters x 8.85
Foot Pounds (ft. lb.) to Newton Meters (Nm)	Foot Pounds x 1.3568
Newton Meters (Nm) to Foot Pounds (ft. lb.)	Newton Meters x 0.737
Volume	
Pints to Liters	Pints x 0.473
Liters to Pints	Liters x 2.113
Quarts to Liters	Quarts x 0.946
Liters to Quarts	Liters x 1.057
Gallons to Liters	Gallons x 3.785
Liters to Gallons	Liters x 0.26

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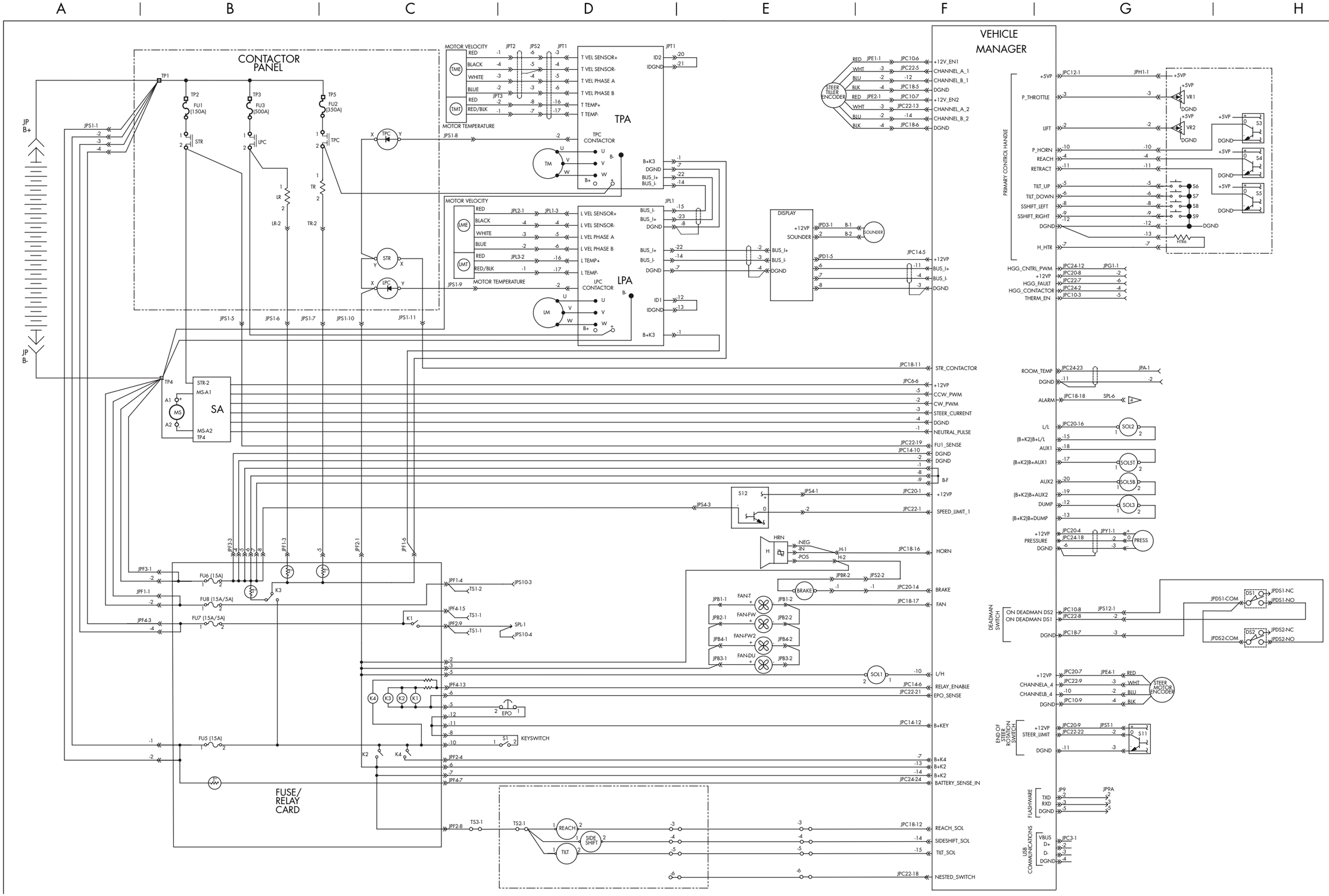
Schematics

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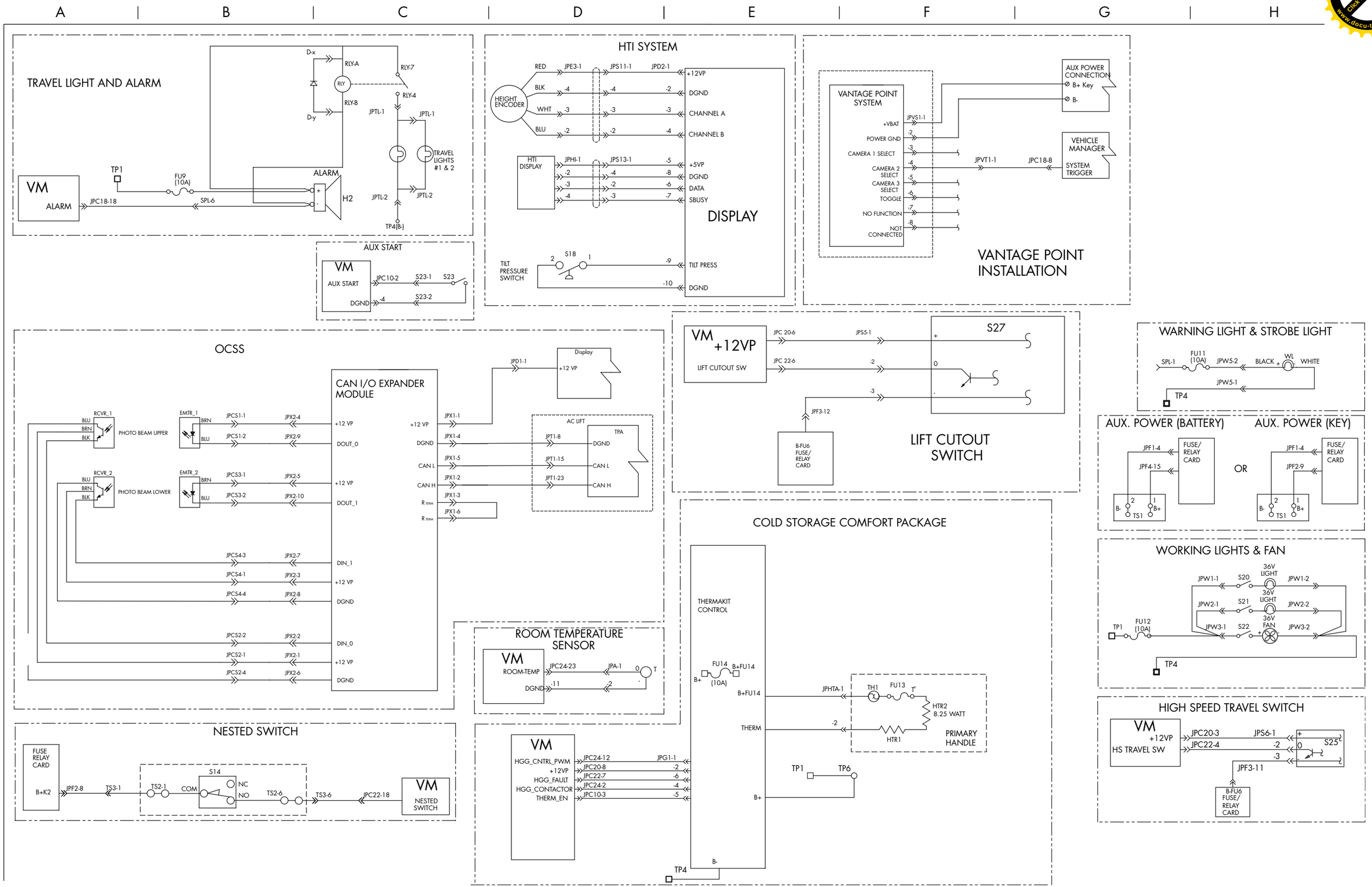
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Figure A-1. 7600/7620/7640 Electrical Schematic (Sheet 1 of 2)



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Figure A-2. 7600/7620/7640 Electrical Schematic - Optional Equipment (Sheet 2 of 3)



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Figure A-3. 7600/7620/7640 Electrical Schematic - Component Legend (Sheet 3 of 3)

LEGEND

IDENT.	SHEET	ZONE	DESCRIPTION
BRAKE	1,2	E5	ELECTRIC BRAKE
BW1	2	E2	CONNECTOR FOR BRUSH WEAR INDICATOR 1
BW2	2	E2	CONNECTOR FOR BRUSH WEAR INDICATOR 2
D	3	B2,C2	SUPPRESSOR DIODE
EPO	1,2	C6	EMERGENCY POWER OFF
FAN	3	H6	OPERATOR COOLING FAN
FAN-LM	2	E5	LIFT MOTOR COOLING FAN
FAN-T	1,2	E6	TRACTION AMPLIFIER COOLING FAN
FAN-FW	1,2	E6	DASH PLATE COOLING FAN
FAN-DU	1,2	E6	TRACTION MOTOR COOLING FAN
FAN-FW2	1,2	E6	SECOND DASH PLATE COOLING FAN
FU1	1,2	B3	POWER FUSE FOR STEER
FU2	1,2	C3	POWER FUSE FOR TRAVEL
FU3	1,2	B3	POWER FUSE FOR LIFT
FU5	1,2	B6	CONTROL FUSE FOR VEHICLE MANAGER B+ 15A
FU6	1,2	B5	CONTROL FUSE FOR VEHICLE MANAGER B- 15A
FU7	1,2	B6	CONTROL FUSE FOR AUX. POWER B+ 15A/5A
FU8	1,2	B5	CONTROL FUSE FOR AUX. POWER B- 15A/5A
FU9	3	B3	CONTROL FUSE FOR TRAVEL LIGHT & ALARM 10A
FU11	3	G4	CONTROL FUSE FOR WARNING LIGHT & STROBE 10A
FU12	3	G6	CONTROL FUSE FOR WORKING LIGHTS & FAN 10A
FU13	3	F5	THERMAL FUSE FOR CONTROL HANDLE HEATER (EXTERNAL)
FU14	3	E6	CONTROL FUSE FOR THERMAKIT 10A
H (HRN)	1,2	E5	HORN
H2	3	C3	TRAVEL ALARM
HEIGHT ENCODER	3	D2	ENCODER FOR HTI HEIGHT SENSING
HTI DISPLAY	3	D3	REMOTE DISPLAY FOR HTI
HTR1	3	F5	HEATER FOR CONTROL HANDLE (EXTERNAL LH)
HTR2	3	F5	HEATER FOR CONTROL HANDLE (EXTERNAL RH)
HTR6	1,2	G3	HEATER FOR PRIMARY CONTROL HANDLE (INTERNAL)
JPA	1,2	G4	CONNECTOR FOR ROOM TEMPERATURE SENSOR
JPB+	1,2	A3	BATTERY +
JPB-	1,2	A4	BATTERY -
JPB1	1,2	E5	CONNECTOR FOR FAN-T
JPB2	1,2	E5	CONNECTOR FOR FAN-FW
JPB3	1,2	E6	CONNECTOR FOR FAN-DU
JPB4	1,2	E6	CONNECTOR FOR FAN-FW2
JPB5	2	E6	CONNECTOR FOR FAN-LM
JPBR	1,2	E5	BRAKE CONNECTOR
JPC2	1,2	F7	USB CONNECTOR ON VM
JPC6	1	F4	ELECTRIC STEER CONNECTOR ON VM
JP9	1,2	F2	CONNECTOR ON VM FOR FLASHWARE
JP9A	1,2	F2	CONNECTOR FOR FLASHWARE
JPC10	1,2	E,F	CAN; DIGITAL INPUTS & OUTPUTS CONNECTOR ON VM
JPC10	3	C6, D6, E7	CAN; DIGITAL INPUTS & OUTPUTS CONNECTOR ON VM
JPC12	1,2	F2,F3	PRIMARY HANDLE CONNECTOR ON VM
JPC14	1,2	F	B+, B-, CAN COMMUNICATIONS CONNECTOR ON VM
JPC18	1,2	F	COIL DRIVERS CONNECTOR ON VM
JPC18	3	B5	COIL DRIVERS CONNECTOR ON VM
JPC20	1,2	F	PROPORTIONAL COIL DRIVERS ON VM
JPC20	3	G2-4,D6	PROPORTIONAL COIL DRIVERS ON VM
JPC22	1,2	F	DIGITAL INPUTS CONNECTOR ON VM
JPC22	3	D6,G2-4,H5	DIGITAL INPUTS CONNECTOR ON VM
JPC24	1,2	F	ANALOG INPUTS CONNECTOR ON VM
JPC24	3	D6,H5,E7	ANALOG INPUTS CONNECTOR ON VM
JPD1	1,2	E3	DISPLAY CONNECTOR
JPD2	3	E2-4	DISPLAY CONNECTOR FOR HTI
JPD3	1,2	E3	DISPLAY CONNECTOR FOR SOUNDER
JPDS1	1	G6	DEADMAN (DS1) SWITCH CONNECTOR
JPDS2	1	G6	DEADMAN (DS2) SWITCH CONNECTOR
JPE1	1	E2	STEER TILLER ENCODER 1 CONNECTOR
JPE2	1	E2	STEER TILLER ENCODER 2 CONNECTOR
JPE3	3	D2	CONNECTOR FOR HEIGHT ENCODER
JPE4	1	G6	STEER MOTOR ENCODER CONNECTOR
JPF1	1,2	B5, C5	B- AUX POWER, B+ POWER AMPS CONNECTOR ON FUSE/RELAY CARD
JPF1	3	A2,B2	B- AUX POWER, B+ POWER AMPS CONNECTOR ON FUSE/RELAY CARD
JPF2	1,2	C5,C6,C7	B+ KEY SWITCH RELAYS CONNECTOR ON FUSE/RELAY CARD
JPF2	3	B2	B+ KEY SWITCH RELAYS CONNECTOR ON FUSE/RELAY CARD
JPF3	1,2	B5	B- CONNECTOR ON FUSE/RELAY CARD
JPF3	3	G3,G4,H5,H6	B- CONNECTOR ON FUSE/RELAY CARD
JPF4	1,2	B6, C6,C7	KEY SWITCH, EPO, BATTERY SENSE CONNECTOR ON FUSE/RELAY CARD
JPF4	3	A2	KEY SWITCH, EPO, BATTERY SENSE CONNECTOR ON FUSE/RELAY CARD
JPG1	3	E6	THERMAKIT CONTROL CONNECTOR
JPG1	1,2	G3	THERMAKIT CONTROL CONNECTOR
JPHI	3	D3	CONNECTOR FOR HTI DISPLAY
JPH1	1,2	G2,G3	HANDLE CONNECTOR
JPHTA	3	F5	CONNECTOR FOR HANDLE EXTERNAL HEATER

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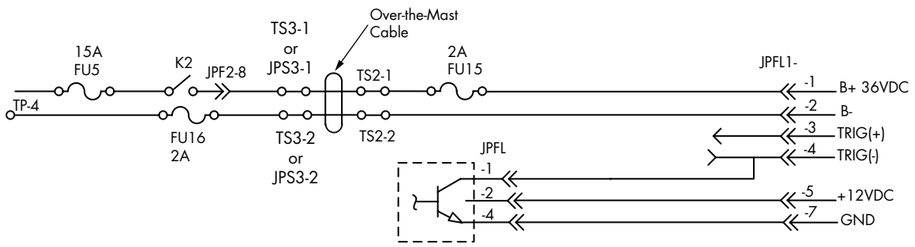
IDENT.	SHEET	ZONE	DESCRIPTION
JPL1	1	D3.D4	LIFT POWER AMP CONNECTOR
JPL2	1	D3	LIFT ENCODER CONNECTOR
JPL3	1	D3	LIFT MOTOR TEMPERATURE SENSOR CONNECTOR
JPS1	1,2	A3,B4,C5	CONTACTOR PANEL INTERFACE CONNECTOR
JPS2	1,2	D2,E5	DRIVE UNIT INTERFACE CONNECTOR
JPS4	1,2	D5, E5	MAST SWITCH 1 INTERFACE CONNECTOR
JPS6	3	H6	HIGH SPEED TRAVEL SWITCH INTERFACE CONNECTOR
JPS11	3	D2	HTI INTERFACE CONNECTOR
JPS12	1,2	G6	DEADMAN SWITCH CONNECTOR
JPS13	3	D3	HTI DISPLAY INTERFACE CONNECTOR
JPST	1	F6	STEER LIMIT CONNECTOR
JPTL	3	C2,C3	CONNECTOR FOR TRAVEL LIGHT
JPT1	1,2	D2	TRACTION AMP CONNECTOR
JPT2	1,2	D3	TRACTION ENCODER CONNECTOR
JPT3	1,2	C2	TRACTION TEMPERATURE SENSOR CONNECTOR
JPVS1	3	F2,F3	CONNECTOR FOR VISION SYSTEM
JPVT1	3	F2,F3	CONNECTOR FOR TRIGGER FOR VISION SYSTEM
JPW1	3	G5	CONNECTOR FOR WORKING LIGHT
JPW2	3	G5	CONNECTOR FOR WORKING LIGHT
JPW3	3	G5	CONNECTOR FOR OPERATOR FAN
JPW5	3	H4	CONNECTOR FOR WARNING LIGHT & STROBE
JPY1	1,2	G5	LIFT PRESSURE SENSOR CONNECTOR
JPZ	2	E4	LIFT MOTOR TEMPERATURE SENSOR CONNECTOR
K1	1,2	C6	KEYSWITCH RELAY-OPTIONS
K2	1,2	C6	KEYSWITCH RELAY-SOLENIODS, ATTACHMENTS, HORN
K3	1,2	B5, C6	KEYSWITCH RELAY, POWER AMPS
K4	1,2	C6	KEYSWITCH RELAY-HEATERS
LA	1	D3, D4	LIFT POWER AMPLIFIER
LIGHT	3	H5	WORK LIGHT
LM	1	D4	AC LIFT MOTOR
LME	1	C3	LIFT MOTOR ENCODER
LMT	1	C3	LIFT MOTOR TEMPERATURE SENSOR
LPC	1,2	B3, C3	LIFT POWER CONTACTOR
LR	1	B3	LIFT POWER AMP PRECHARGE RESISTOR
LR-2	1	B4	SPLICE FOR LIFT POWER AMP PRECHARGE RESISTOR
MS	1	B4	STEER MOTOR
PRESS	1,2	G5	LIFT PRESSURE SENSOR
REACH	1,2	D7	REACH SOLENOID
RLY	3	C2	RELAY FOR TRAVEL LIGHTS
S1	1,2	C6	KEY SWITCH
DS1	1,2	G6	DEADMAN SWITCH
DS2	1,2	G6	DEADMAN SWITCH
S3	1,2	G2	HANDLE HORN SWITCH
S4	1,2	G3	REACH SWITCH
S5	1,2	G3	RETRACT SWITCH
S6	1,2	G3	TILT UP SWITCH
S7	1,2	G3	TILT DOWN SWITCH
S8	1,2	G3	SHIFT LEFT SWITCH
S9	1,2	G3	SHIFT RIGHT SWITCH
S11	1	G6	STEER LIMIT SWITCH
S12	1,2	E5	1st SPEED LIMITING SWITCH
S14	3	B6,B7	NESTED SWITCH
S18	3	D3	TILT PRESSURE SWITCH
S20	3	H5	WORKING LIGHT SWITCH
S21	3	H5,H6	WORKING LIGHT SWITCH
S22	3	H6	OPERATOR COOLING FAN SWITCH
S23	3	C3	AUX START SWITCH
S25	3	H6	HIGH SPEED TRAVEL SWITCH
S27	3	E4, F4	LIFT CUTOUT SWITCH
SA	1	D4	STEER POWER AMPLIFIER
SIDESHIFT	1,2	D7	SIDE SHIFT SOLENOID
SOL1	1,2	E6	LOAD/HOLD SOLENOID
SOL2	1,2	G4	LIFT/LOWER PROPORTIONAL SOLENOID
SOL3	1	G5	PROPORTIONAL DUMP SOLENOID
SOL4	2	E6	SECOND STAGE PUMP SELECT SOLENOID
SOL5B	1,2	G5	SOLENOID FOR AUX. OIL DIRECTION CONTROL
SOL5T	1,2	G5	SOLENOID FOR AUX. OIL DIRECTION CONTROL
SOL8	2	G5	AUX. DUMP SOLENOID
SPL-1	1,2	C6	SPLICE FOR WARNING & STROBE LIGHT
SPL-1	3	G4	SPLICE FOR WARNING & STROBE LIGHT
SPL-2	2	B3	SPLICE FOR TRACTION RESISTOR
SPL-6	3	B3	SPLICE FOR TRAVEL LIGHT & ALARM

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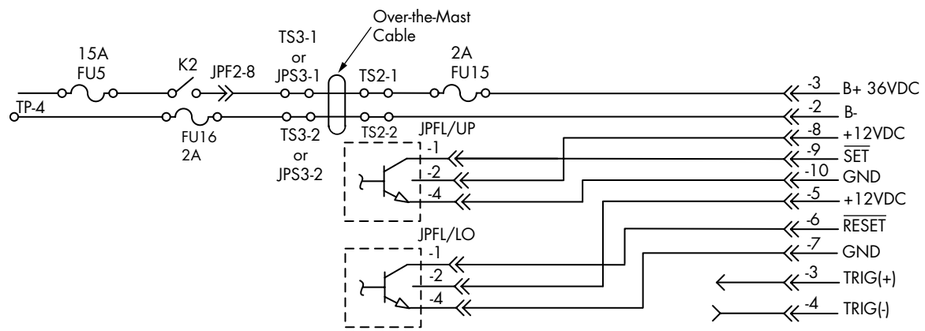
IDENT.	SHEET	ZONE	DESCRIPTION
STEER TILLER ENCODER	1	E2	STEER TILLER ENCODERS
STEER MOTOR ENCODER	1	G6	STEER POSITION FEEDBACK ENCODER
STR	1,2	C3	STEER POWER CONTACTOR
T	3	D6	AMBIENT TEMPERATURE SENSOR
TA	1,2	D2,D3	TRACTION POWER AMPLIFIER
TILT	1,2	D7	SOLENOID FOR TILT
TH1	3	E6,F6	THERMOSTAT FOR CONTROL HANDLE HEATER (EXTERNAL)
TM	1,2	D3	AC TRACTION MOTOR
TME	1,2	C2	TRACTION MOTOR ENCODER
TMT	1,2	C2	TRACTION MOTOR TEMPERATURE SENSOR
TP1	1,2	B2	TIE POINT ON B+
TP1	3	A3,E6,G5,G6	TIE POINT ON B+
TP2	1,2	B2,B3	TIE POINT ON AUXILIARY MOTOR FUSE
TP3	1	B2	TIE POINT ON LIFT MOTOR FUSE
TP4	1,2	B4	TIE POINT ON B-
TP4	3	G4,G6	TIE POINT ON B-
TP5	1,2	B2,B3	TIE POINT ON TRACTION MOTOR FUSE
TP6	3	E6	TIE POINT ON HEATED GLASS GUARD FUSE
TPC	1,2	C3	TRACTION POWER CONTACTOR
TR	1,2	B3	TRACTION POWER AMP. PRECHARGE RESISTOR
TR-2	1	B3	SPLICE FOR TRACTION POWER AMP. PRECHARGE RESISTOR
TS1	3	G5,H5	TERMINAL STRIP AUX POWER
TS2	1,2	C7, D7	TERMINAL STRIP CARRIAGE FUNCTIONS
TS2	3	B7	TERMINAL STRIP CARRIAGE FUNCTIONS
TS3	1,2	E7,C7	TERMINAL STRIP OVER THE MAST CABLE
TS3	2	A7,C7	TERMINAL STRIP NESTED SWITCH
VR1	1,2	G2	VARIABLE RESISTOR FOR PRIMARY CONTROL HANDLE THROTTLE
VR2	1,2	G3	VARIABLE RESISTOR FOR LIFT/LOWER
VR3	3	B4	VARIABLE RESISTOR FOR SECONDARY CONTROL HANDLE THROTTLE
VR4	1,2	G6	VARIABLE RESISTOR FOR DEADMAN SENSOR
WL	3	H4	WARNING LIGHT

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Figure A-4. Fork-Laser System Schematic



Model 7600 Fork-Laser Schematic



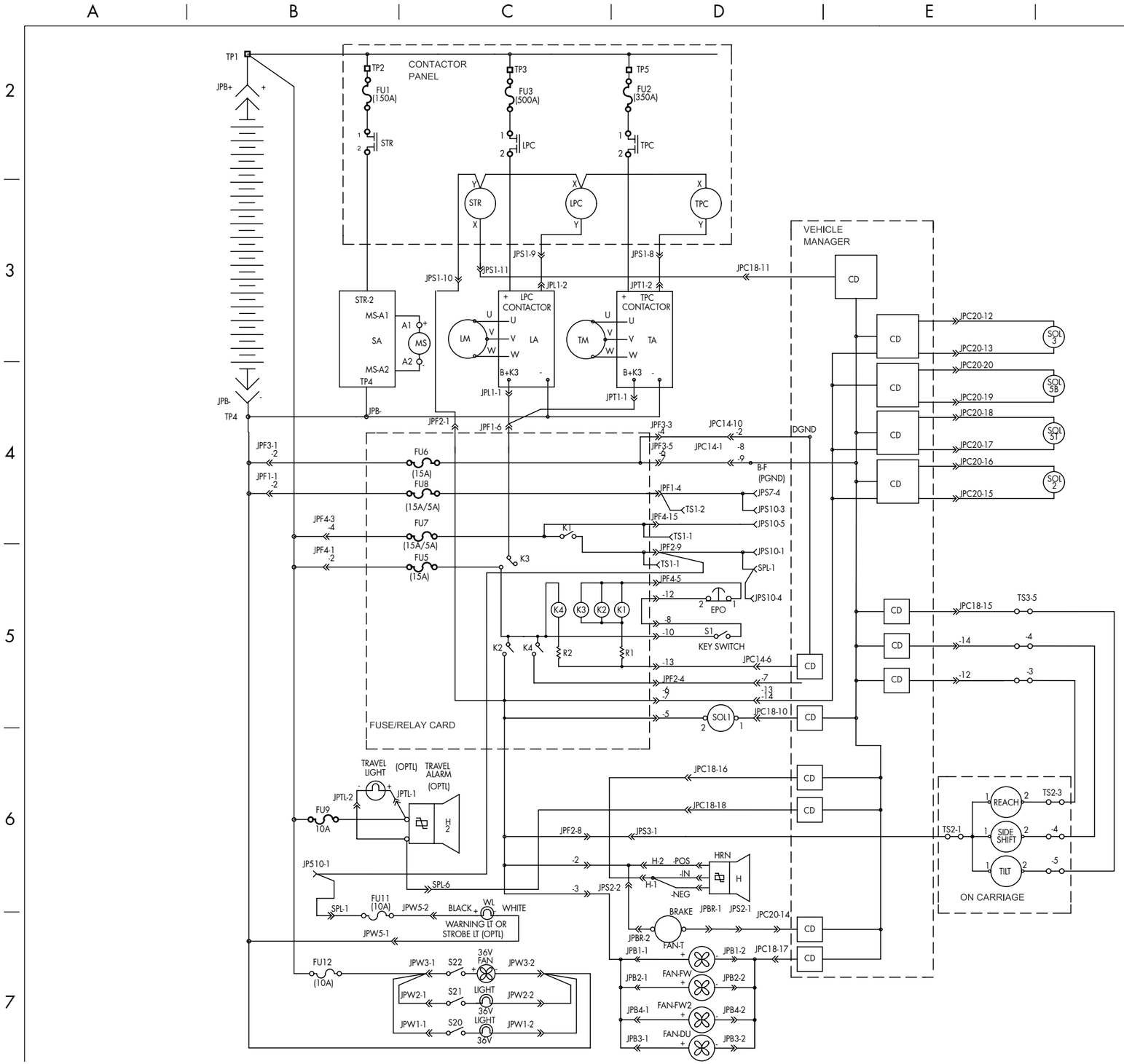
Model 7620/7640 Fork-Laser Schematic

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Figure A-5. Power Distribution Schematic

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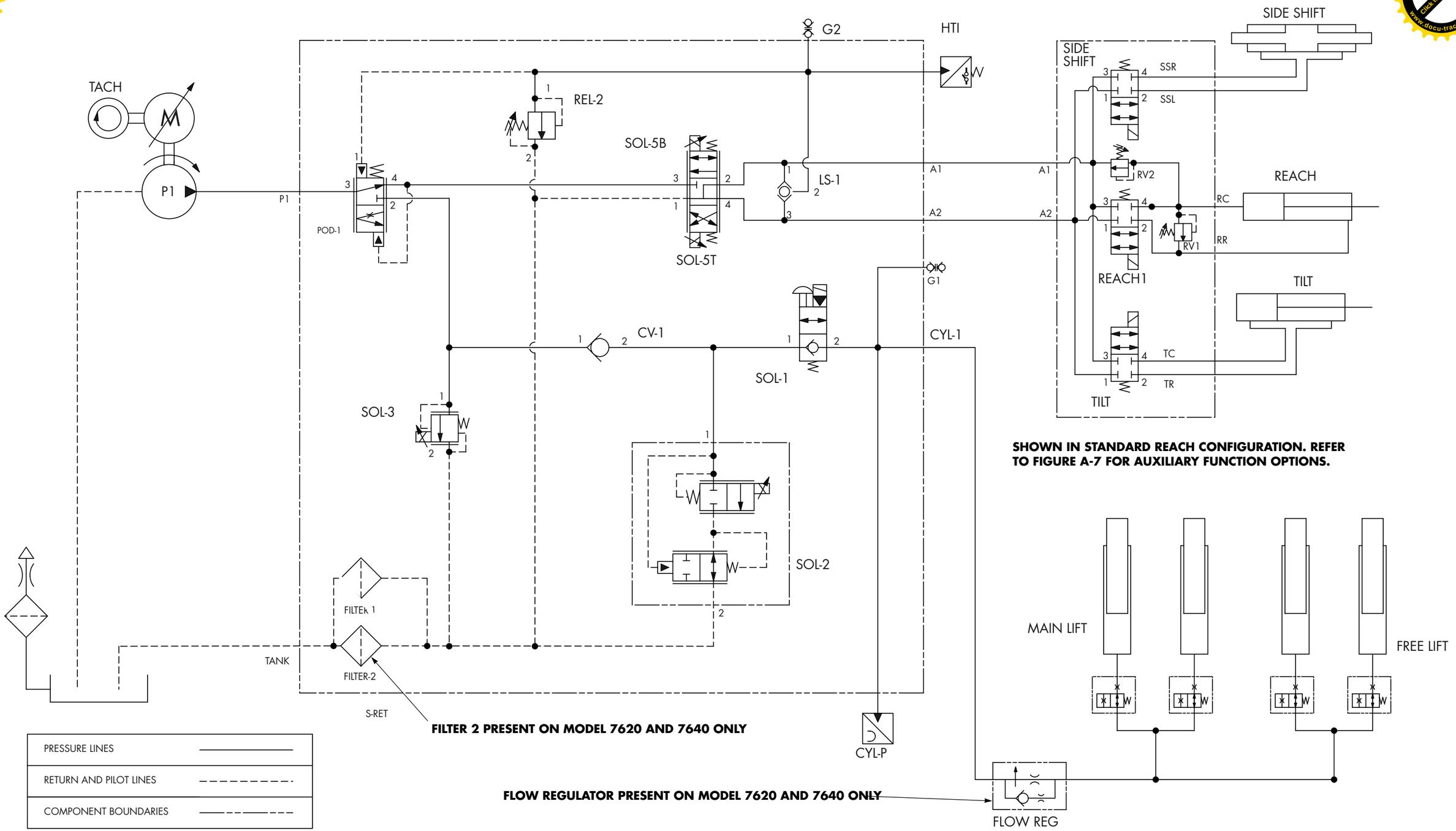
IDENT.	DESCRIPTION
BRAKE	ELECTRIC BRAKE
CD	EMERGENCY POWER OFF
EPO	COIL DRIVER CIRCUIT
FAN-FW2	SECOND DASH PLATE COOLING FAN
FAN-T	TRACTION AMPLIFIER COOLING FAN
FAN-FW	DASH PLATE COOLING FAN
FAN-DU	TRACTION MOTOR COOLING FAN
FU1	POWER FUSE FOR STEER
FU2	POWER FUSE FOR TRAVEL
FU3	POWER FUSE FOR LIFT
FU5	CONTROL FUSE FOR VEHICLE MANAGER B+ 15A
FU6	CONTROL FUSE FOR VEHICLE MANAGER B- 15A
FU7	CONTROL FUSE FOR AUX. POWER B+ 15A/5A
FU8	CONTROL FUSE FOR AUX. POWER B- 15A/5A
FU9	CONTROL FUSE FOR TRAVEL LIGHT & ALARM 10A
FU11	CONTROL FUSE FOR WARNING LIGHT & STROBE 10A
FU12	CONTROL FUSE FOR WORKING LIGHTS & FAN 10A
H (HRN)	HORN
H2	TRAVEL ALARM
JPB	BATTERY CONNECTOR
JPB1	CONNECTOR FOR FAN-T
JPB2	CONNECTOR FOR FAN-FW
JPB3	CONNECTOR FOR FAN-DU
JPB4	CONNECTOR FOR FAN-FW2
JPBR	BRAKE CONNECTOR
JPC14	B+, B-, CAN COMMUNICATIONS CONNECTOR ON VM
JPC18	COIL DRIVERS CONNECTOR ON VM
JPC20	PROPORTIONAL COIL DRIVERS ON VM
JPF1	B- AUX POWER, B+ POWER AMPS CONNECTOR ON FUSE/RELAY CARD
JPF2	B+ KEY SWITCH RELAYS CONNECTOR ON FUSE/RELAY CARD
JPF3	B- CONNECTOR ON FUSE/RELAY CARD
JPF4	KEY SWITCH, EPO, BATTERY SENSE CONNECTOR ON FUSE/RELAY CARD
JPL1	LIFT POWER AMP CONNECTOR
JPS1	CONTACTOR PANEL INTERFACE CONNECTOR
JPS2	DRIVE UNIT INTERFACE CONNECTOR
JPS7	EXTERNAL CAN COMMUNICATIONS INTERFACE CONNECTOR
JPT1	TRACTION AMP CONNECTOR
JPTL	CONNECTOR FOR TRAVEL LIGHT
JPW1	CONNECTOR FOR WORKING LIGHT
JPW2	CONNECTOR FOR WORKING LIGHT
JPW3	CONNECTOR FOR OPERATOR FAN
JPW5	CONNECTOR FOR WARNING LIGHT & STROBE
K1	KEYSWITCH RELAY-OPTIONS
K2	KEYSWITCH RELAY-SOLENIODS, ATTACHMENTS, HORN
K3	KEYSWITCH RELAY, POWER AMPS
K4	KEYSWITCH RELAY-HEATERS
LA	LIFT POWER AMPLIFIER
LM	AC LIFT MOTOR
LPC	LIFT POWER CONTACTOR
MS	STEER PUMP MOTOR
REACH	REACH SOLENOID
S1	KEY SWITCH
S20	WORKING LIGHT SWITCH
S21	WORKING LIGHT SWITCH
S22	OPERATOR COOLING FAN SWITCH
SA	AUX. MOTOR POWER AMPLIFIER
SIDESHIFT	SIDE SHIFT SOLENOID
SOL1	LOAD/HOLD SOLENOID
SOL2	LIFT/LOWER PROPORTIONAL SOLENOID
SOL3	PROPORTIONAL DUMP SOLENOID
SOL5B	SOLENOID FOR AUX. OIL DIRECTION CONTROL
SOL5T	SOLENOID FOR AUX. OIL DIRECTION CONTROL
SPL-1	SPLICE FOR WARNING & STROBE LIGHT
SPL-6	SPLICE FOR TRAVEL LIGHT & ALARM
STR	STEER POWER CONTACTOR
TA	TRACTION POWER AMPLIFIER
TILT	SOLENOID FOR TILT
TM	AC TRACTION MOTOR
TP1	TIE POINT ON B+
TP2	TIE POINT ON AUXILIARY MOTOR FUSE
TP3	TIE POINT ON LIFT MOTOR FUSE
TP4	TIE POINT ON B-
TP5	TIE POINT ON TRACTION MOTOR FUSE
TPC	TRACTION POWER CONTACTOR
TS1	TERMINAL STRIP AUX POWER
TS2	TERMINAL STRIP CARRIAGE FUNCTIONS
TS3	TERMINAL STRIP OVER THE MAST CABLE INTERFACE
WL	WARNING LIGHT

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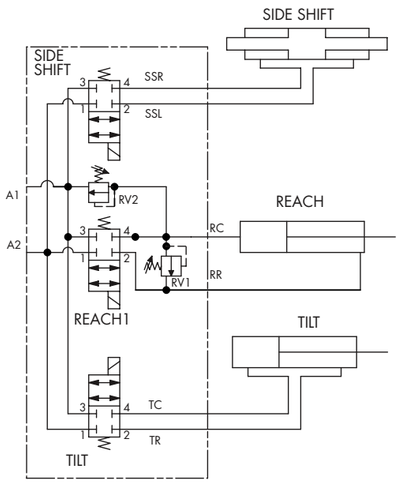
Figure A-6. 7600/7620/7640 Hydraulic Schematic (She of 2)



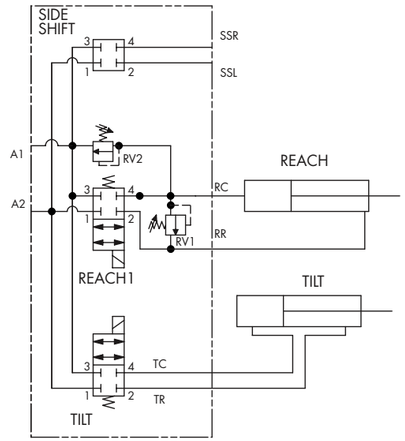
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Figure A-7. 7600/7620/7640 Hydraulic Schematic (Sheet 2 of 2)

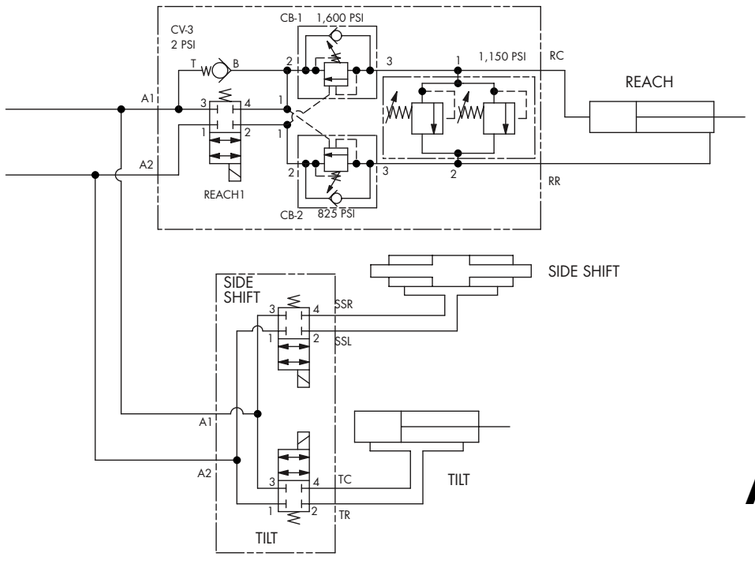
SINGLE REACH WITH TILT AND SIDE SHIFT



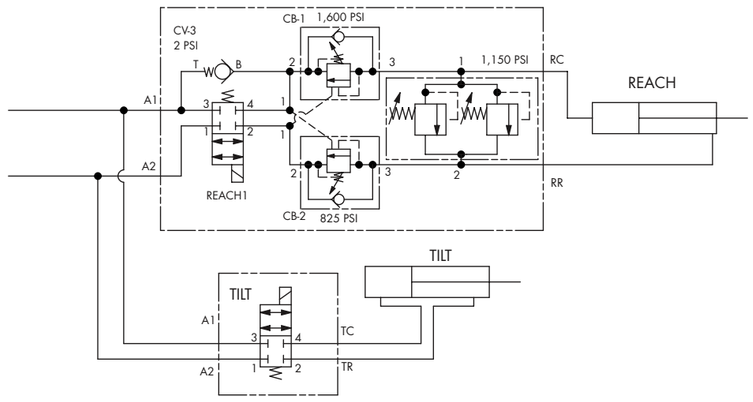
SINGLE REACH WITH TILT



DEEP REACH WITH TILT AND SIDE SHIFT



DEEP REACH WITH TILT



AUXILIARY FUNCTION OPTIONS

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