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Maintenance Manual

Model 9600 and 9700 *Swing-Reach*® Lift Truck With *The ACR System*™



Model	Serial Numbers
9600	960-09-00001 and Up
9700	970-09-00001 and Up

1089040B
Replaces 1089040A

Re-Issued: 15 Jun 2010
Issued: 01 Sep 2009

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This publication, 1089040B, applies to the Model 9600 and 9700 *Swing-Reach*® Lift Truck With *The ACR System*, Model 9600, S/N 960-09-00001 and up, Model 9700, S/N 970-09-00001 and up, 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.

For revision information, see "Page Revision Record" on page v.

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: dd/mmm/yyyy" 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, etc. Non-technical changes are not identifed with a change bar, however, affected pages are identifed with "Revised: dd/mmm/yyyy" in the footer.

Document Revision History

1089040A Original Issue . . . . . 01 Sep 2009
1089040B Re-issue . . . . . 15 Jun 2010
(technical changes identified by change bars)

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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
SWR-09-R003	Power Amplifier Cooling Fan Kit Available	21 Dec 2009
SWR-10-R001	TM S/W V2.2 and CM S/W V1.8	26 Jan 2010

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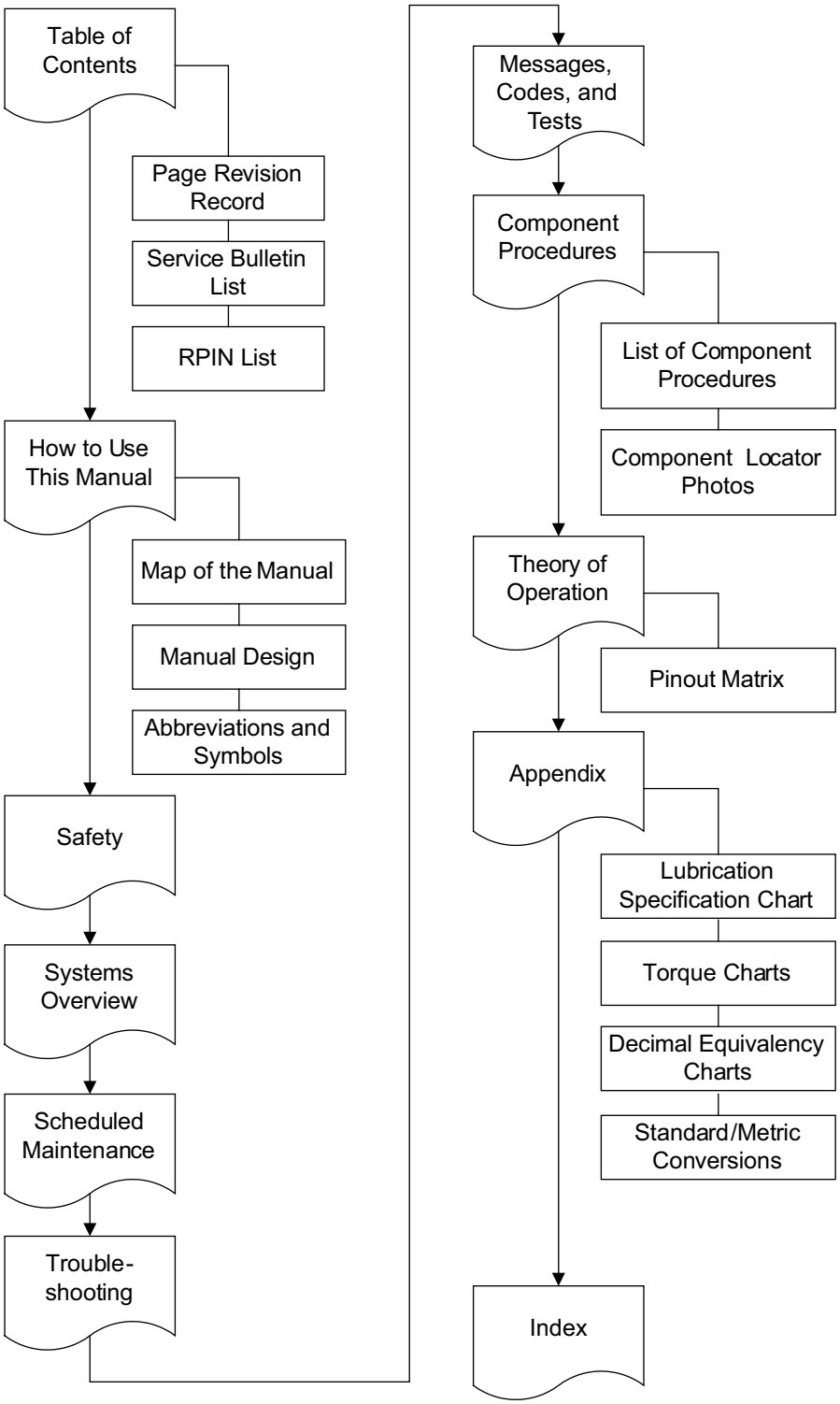
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Section 1. How to Use This Manual

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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:

- the name of the manual (Model 9600/9700 *Swing-Reach*® *Maintenance Manual*)
- the current section title (for example, this page *How to Use This Manual*)
- the current topic (for example, this page *Manual Design*)

This manual consists of the following sections:

- **Section 1: How to Use This Manual** explains the manual format and design as well as abbreviations and symbols used.
- **Section 2: Safety** explains warning and caution notes, general safety rules, and safety rules for batteries, static, jacking, and welding.
- **Section 3: Systems Overview** includes general lift truck specifications, installation, FlashWare, Modes of Operation, and configuration information.
- **Section 4: Scheduled Maintenance** outlines the recommended schedule of preventive services to keep the lift truck working most efficiently.
- **Section 5: Troubleshooting** guides the user from fault symptoms to specific checks and tests in order to isolate a bad component.
- **Section 6: Messages, Codes, and Tests** lists fault codes and firmware-based inputs and electrical tests designed to diagnose problems and repair the truck.
- **Section 7: Component Procedures** gives step-by-step procedures to remove, install, and adjust serviceable components. Components are grouped by truck system. To find a component procedure, you may use one of two methods:
  - Look up the component name in the **List of Component Procedures** on page 7-2.
  - Look up the component name in the **Index** (page I-1).
- **Section 8: Theory of Operation** explains signal flow within the electrical and hydraulic systems for various conditions of truck operation. This section also contains a detailed connection point table (Pinout Matrix) designed to assist in testing and troubleshooting the truck.
- **Appendix** contains reference information such as torque values, lubricants, and standard/metric conversions.
- **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
AH	hours on Load Handler
amp	Ampere or amplifier
ANSI	American National Standards Institute
API	American Petroleum Institute
approx.	approximately
assy	assembly
aux	auxiliary
AWG	American Wire Gauge
BSOC	Battery State-of-Charge
C	Celsius or Centigrade
CAN	Controller Area Network
CB	Counterbalance valve
CCW	Counterclockwise
cfg	configuration
CM	Carriage Manager
CMB	Carriage Manager Boot Block
cm	centimeter
COP	Computer Operating Properly
CS	Cold Storage
CV	Check Valve
CW	Clockwise
CYL	Cylinder
DC	Direct Current
DdManH	Deadman Pedal Hours
DFW	Distance From Wire
DGND	Digital Ground
diam.	diameter
Dir	Direction
DMM	Digital MultiMeter
DOT	US Department of Transportation
DVM	Digital Voltmeter
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
Elev. Ht.	Elevated Height
Emerg	Emergency
EOA	End-of-Aisle
EPO	Emergency Power Off
ESD	Electrostatic Discharge
ESDS	Electrostatic Discharge Sensitive
F	Fahrenheit
FF	Forks First
ft.	foot or feet
ft. lb.	foot pound(s)
FU	Fuse
GA	gauge
gal.	gallon or gallons
GM	Guidance Manager
gm	gram(s)
Gnd	ground
HA	Heading Angle or hours on Load Handler
HD	hours with Deadman switch activated
HL	hours lifting
HT	hours traveling
Ht	Height
HTR	Heater
IC	Integrated Circuit
in.	inch or inches
in. lb.	inch pound(s)
JP	jack and pin connector

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Term/Symbol	Definition
K	thousand
KH	hours with key switch ON
kg	kilogram(s)
km/cm^2	kilograms per square centimeter
km/h	kilometers per hour
kPa	kiloPascal(s)
l	liter(s)
lb.	pound or pounds
LPA	Lift Power Amplifier
LED	Light Emitting Diode
LiftH	Lift Hours
LH	Load Handler or Left-Hand
LHC	Load Handler Contactor
L/L	lift/lower
LHM	Load Handler Motor
LM	Lift Motor
LME	Lift Motor Encoder
LMT	Lift Motor Temperature sensor
LPA	Lift Power Amplifier
LPC	Lift Power Contactor
LR	LPA precharge resistor
LWR	Lower
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
NVM	Non-Volatile Memory
OACH	Overall Collapsed Height
OD	Operator Display
OSHA	Occupational Safety and Health Association
OTM	over-the-mast
oz.	ounce(s)
P	pump or lift contactor
PAL	Lift Power Amp Software
PALB	Lift Power Amp Boot Block
PALVCL	Lift Power Amp Vehicle Control Language
PAT	Traction Power Amp Software
PATB	Traction Power Amp Boot Block
PATVCL	Traction Power Amp Vehicle Control Language
pot	Potentiometer
Press	Pressure
Prop	Proportional
Prox	Proximity
psi	pounds per square inch
PWM	Pulse Width Modulation
P/N	Part Number
qt.	quart
qty.	quantity
RAM	Random Access Memory
RCH	Reach
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
STR	Steer Contactor
SWM	Supplier Wireless Module

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Abbreviations and Symbols

Term/Symbol	Definition
TA	Traction Power Amplifier
temp	temperature
TF	Tractor First
TM	Tractor Manager, Traction Motor, or Total distance traveled
TMB	Tractor Manager Boot Block
TME	Traction Motor Encoder
TMT	Traction Motor Temperature sensor
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
VR	variable resistor
wrt	with respect to
Xducer	Transducer
@	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 exists which, if not avoided, could result in death or serious injury.

⚠CAUTION

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

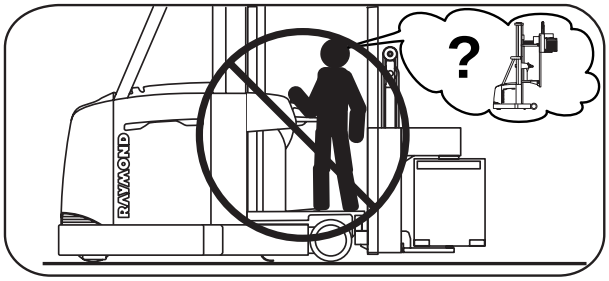
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General Safety

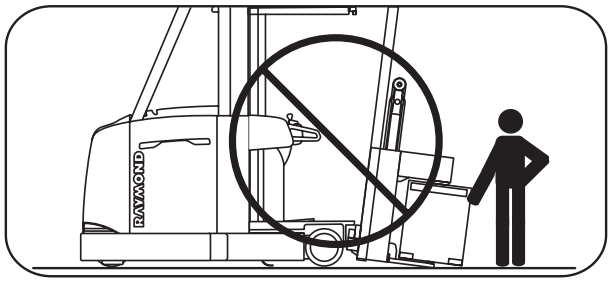
Do *not* operate or work on this lift truck unless you are trained, qualified, and authorized to do so, and you have read the Owner Manual and the Operator Manual.



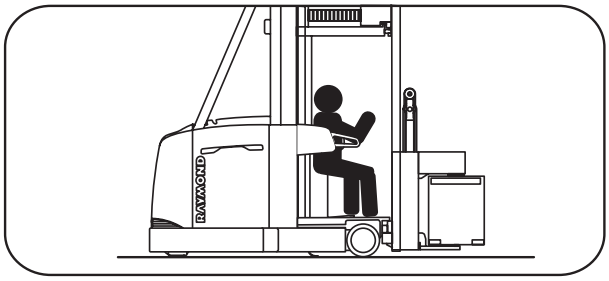
Know the lift truck's controls and what they do.



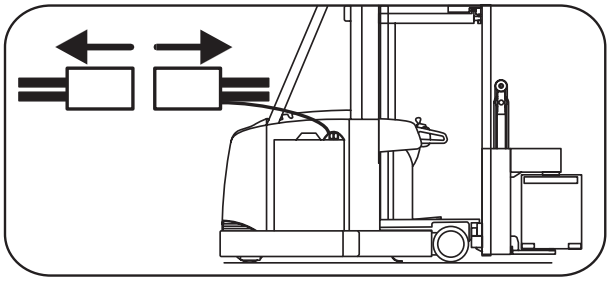
Do *not* operate this lift truck if it needs repair or if it is in any way unsafe.



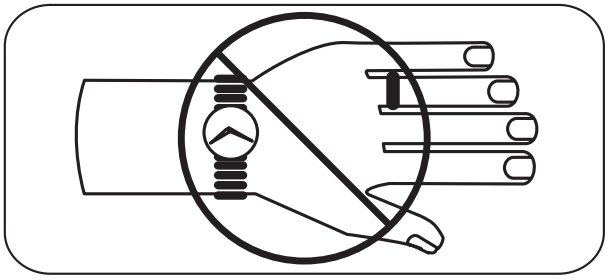
Operate this lift truck only from the operator's position.



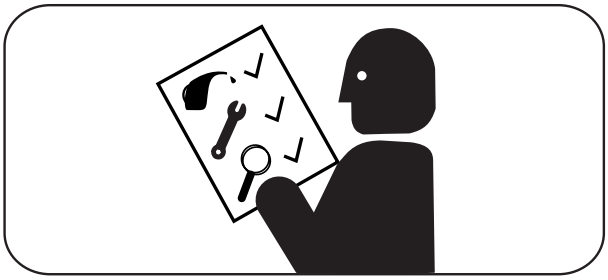
Before working on this lift truck, always turn the key switch to OFF and disconnect the lift truck's battery connector (unless this manual tells you otherwise).



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



Follow the scheduled lubrication, maintenance, and inspection steps.



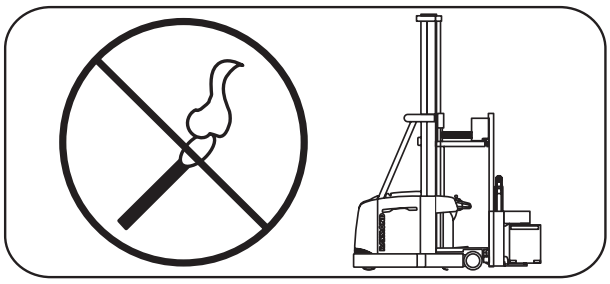
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General Safety

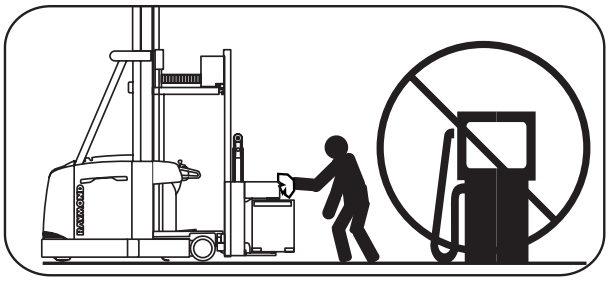
Follow exactly the safety and repair instructions in this manual. Do *not* take “shortcuts.”



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



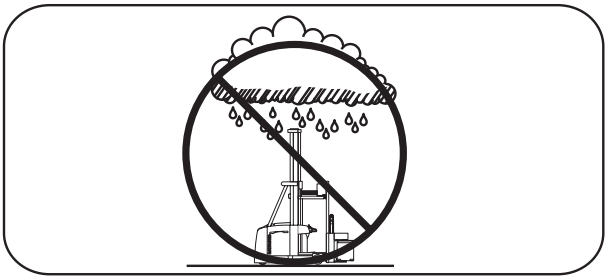
Do *not* use gasoline or other flammable liquids for cleaning parts.



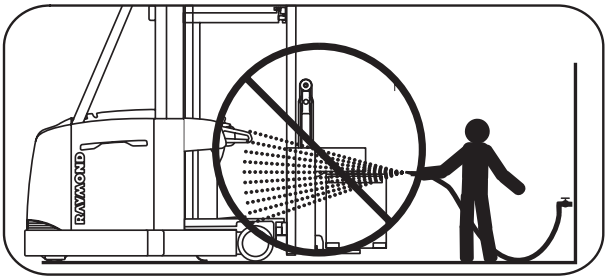
Clean up any hydraulic fluid, oil, or grease that has leaked or spilled on the floor.



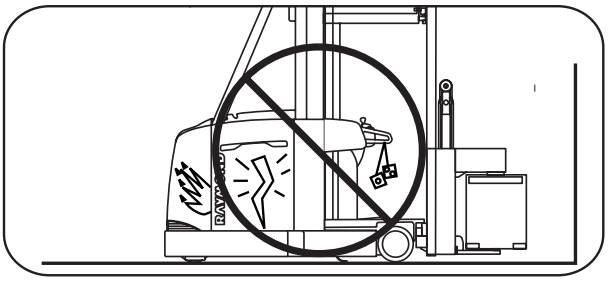
Always operate and park this lift truck indoors.



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.



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Battery Safety

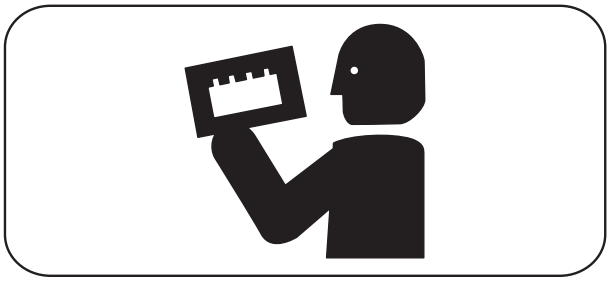
⚠ WARNING

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.

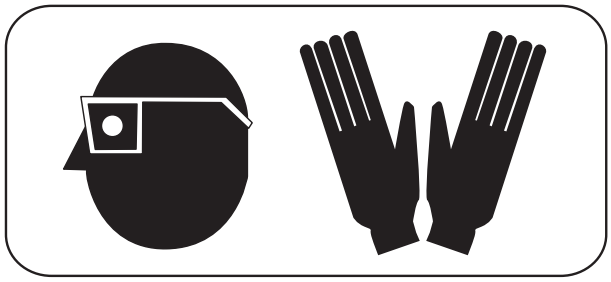
⚠CAUTION

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.

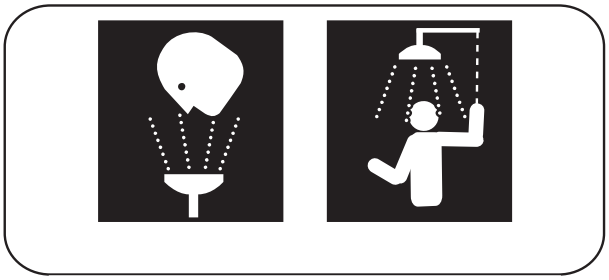
Read, understand, and follow procedures, recommendations, and specifications in the battery and battery charger manufacturer's manuals.



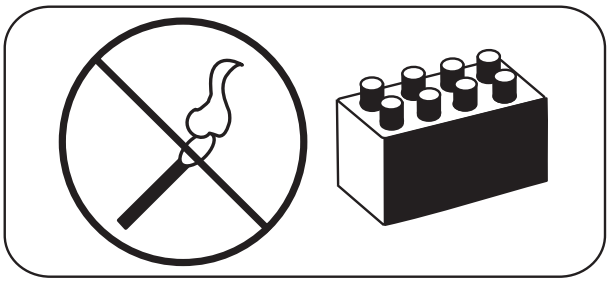
Wear personal protective equipment to protect eyes, face, and skin when checking, handling, or filling batteries. This equipment includes goggles or face shield, rubber gloves (with or without arm shields), and a rubber apron.



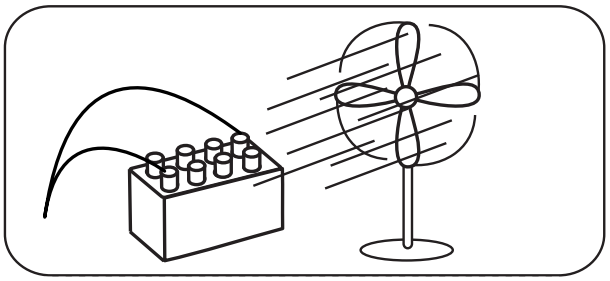
Make sure that a shower and eyewash station are nearby in case of an accident.



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



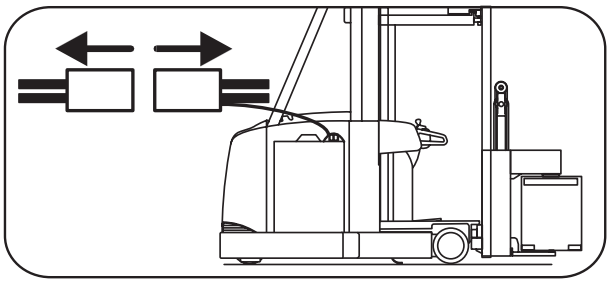
Keep the charging area well-ventilated to avoid hydrogen gas concentration.



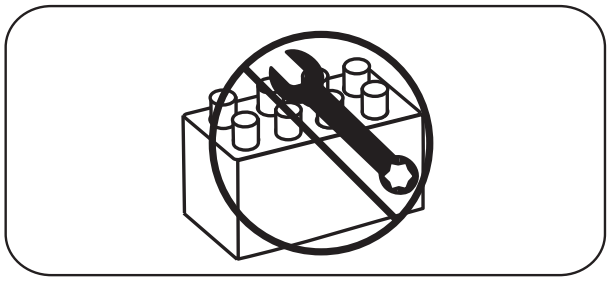
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Battery Safety

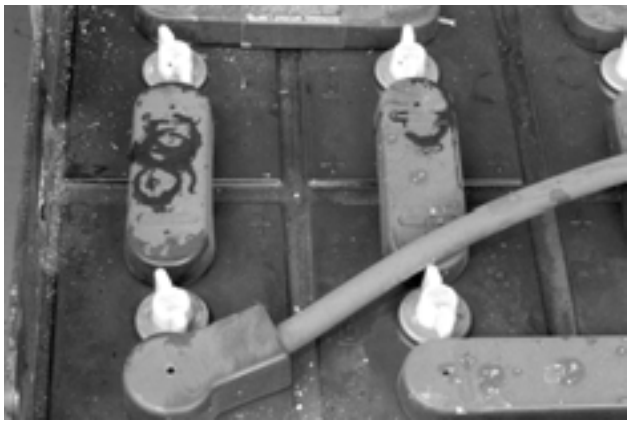
Turn the key switch OFF *before* disconnecting the battery from the lift truck at the battery connector. *Do not* break live circuits at the battery terminals. A spark often occurs at the point where a live circuit is broken.



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 the possibility of sparks.

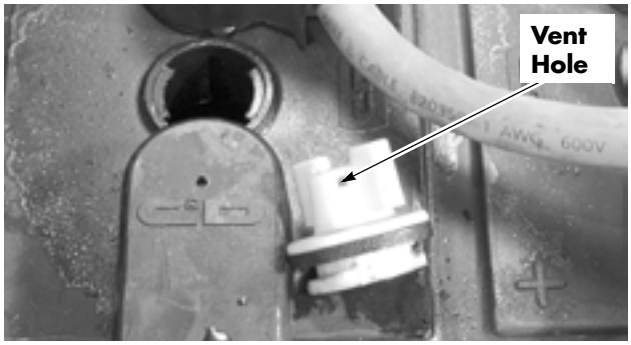


Keep plugs, terminals, cables, and receptacles in good condition to avoid shorts and sparks.



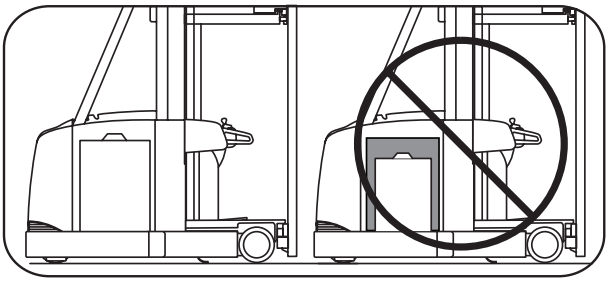
Keep filler plugs firmly in place at all times except when checking the electrolyte level, when adding water to the cells, or when checking the specific gravity.

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



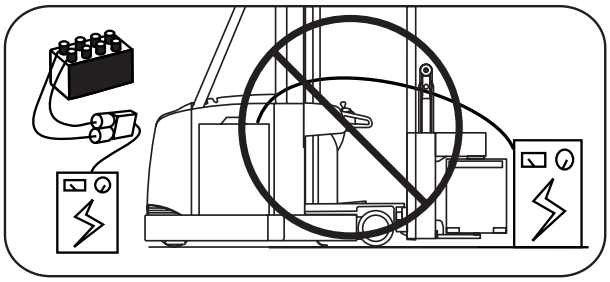
Do *not* permit cleaning solution, dirt, or any foreign matter to enter the cells.

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.



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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 on the lift truck. See Figure 2-1 and Figure 2-2. If you cannot use the ground jack, connect the ground clip to an unpainted, grounded surface on the lift truck frame.

Figure 2-1. ESD Ground Jack - Electrical Compartment

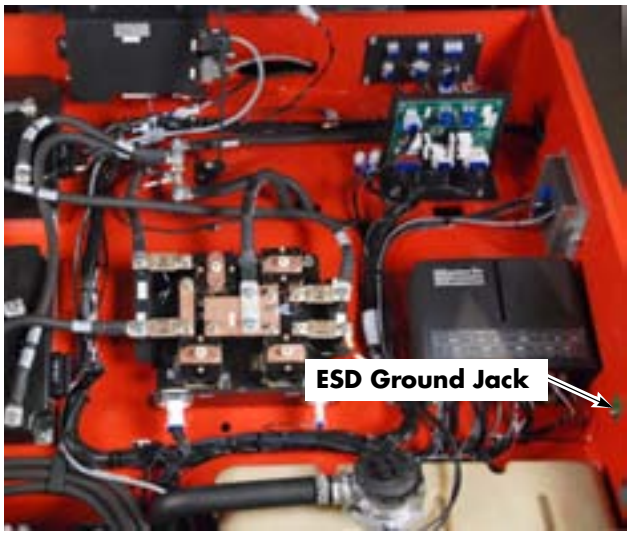


Figure 2-2. ESD Ground - Operator Compartment



- 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 2-3 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.

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Figure 2-3. 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 truck:

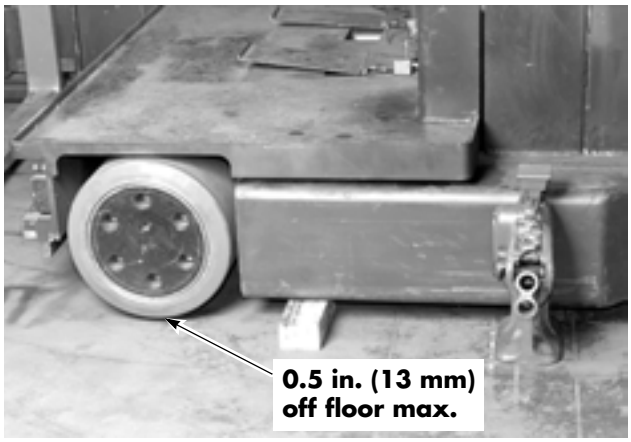
1. Lower the carriage and forks completely to the floor. Remove any load.
2. Place all controls in neutral.
3. Block the wheels to prevent movement of the vehicle.
4. Turn the key switch OFF and disconnect the battery connector.
5. If possible, stabilize the top of the mast with an overhead chain hoist.
6. Place the jack under the designated jacking points. See Figure 2-4 and Figure 2-5.

⚠ WARNING

Use extreme care when the lift truck is jacked up. Never block the lift truck between the carriage and the floor. 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.

7. *To jack the baseleg:* Place the jack in the designated jacking position. See Figure 2-4. Jack the lift truck up just high enough to raise the load wheel off the floor, no more than 0.5 in. (13 mm). Place a block under the baseleg as shown.

Figure 2-4. Jacking and Blocking Baseleg



8. *To jack the tractor*: Place the jack in the designated jacking position. Do *not* jack under the removable bumper. See Figure 2-5. Jack one side of the lift truck so that the drive tire is off the floor no more than 2 in. (50 mm). Block that side of the lift truck in place. Then jack up the other side of the lift truck in the same manner. Block that side in place.

Figure 2-5. Jacking and Blocking Tractor



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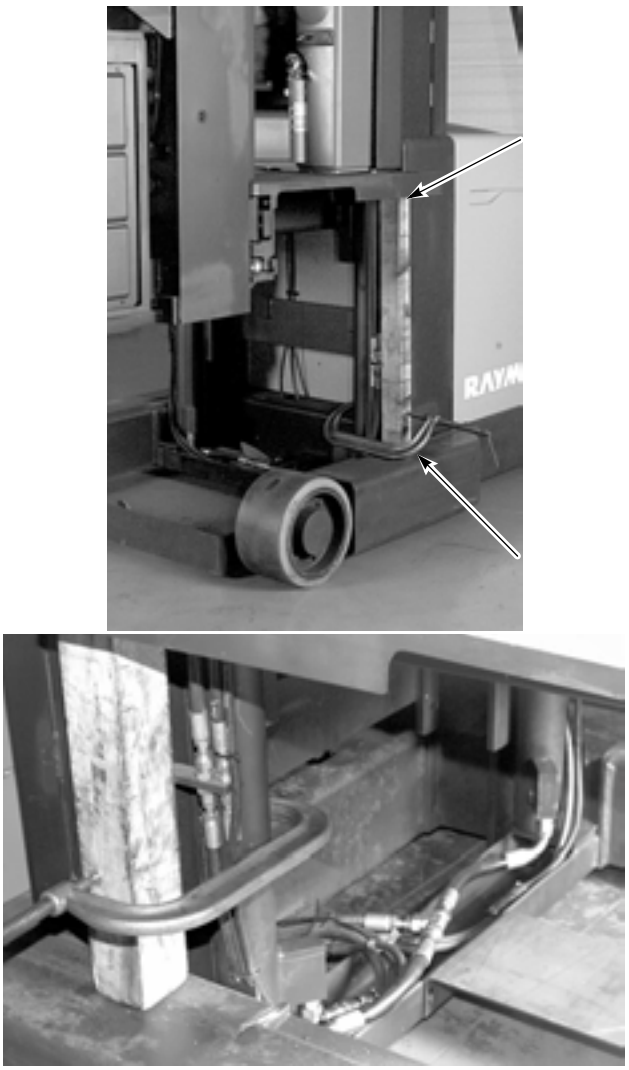
Blocking and Lifting Safety

Blocking the Carriage

⚠CAUTION

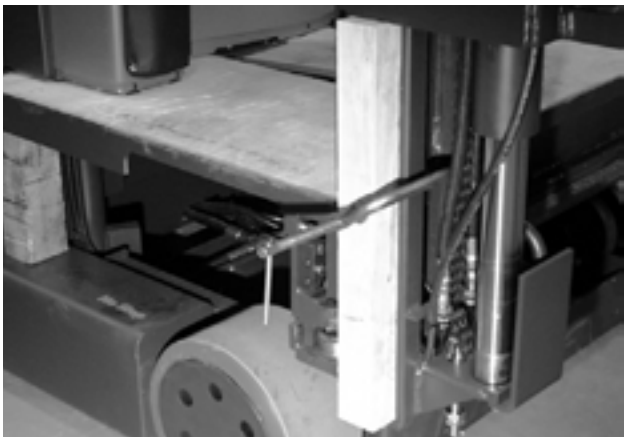
Do not block against the platform floor; use the edge of the platform. Do not block the carriage against the floor.

Figure 2-6. Blocking Carriage



Blocking Load Handler

Figure 2-7. Blocking Load Handler



Lifting Motors

Secure a hoist to the traction motor with 2 straps cross-wrapped as shown in Figure 2-8.

Figure 2-8. Lifting Traction Motor



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Welding Safety

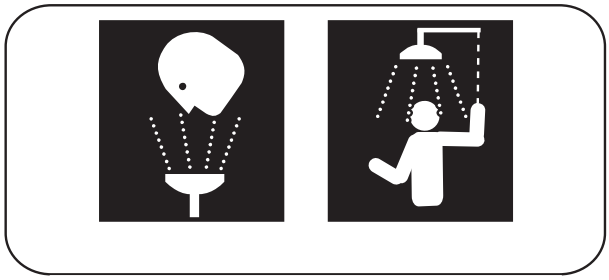
⚠ WARNING

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

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

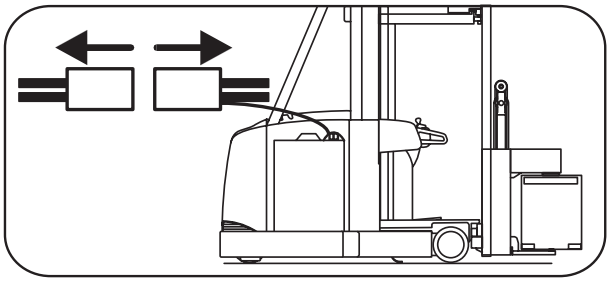
Before working on this lift truck, make sure:

- 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.



- Check for shorts to frame as described on page 5-3. If you detect 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.
- Do not weld near electrical components.
- If you must weld near the battery compartment, remove the battery from the lift truck.
- Disconnect all electrical circuit cards before welding. When you are finished welding, reconnect all circuit cards and do 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 9600/9700 Swing-Reach*® 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 local authorized Raymond dealer.

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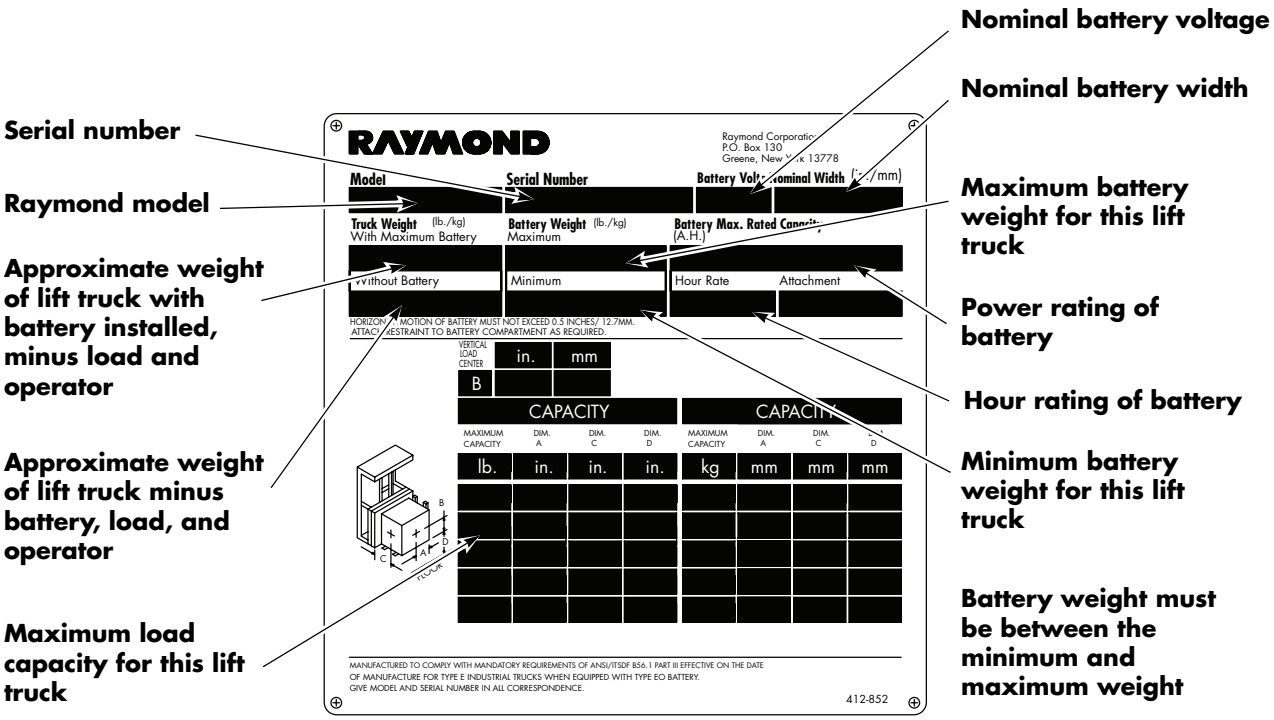
Lift Truck Specifications

This lift truck is rated for performance by load center, load weight, and load height with forks and/or platform elevated.

Review the specification plate located on the lift truck's left mast upright for detailed load capacity and load center information. See Figure 3-1.

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

Figure 3-1. Lift Truck Specification Plate



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Installation Instructions

Inspect the units as received for damage in transit. You should have the following:

- Mast assembly and diagonal support arms on a pair of skids
- Tractor assembly, with 2 battery gates, glass mast guard (if so equipped), side covers, and parts carton on a skid
- Full body harness and tether
- Cable clamps
- Miscellaneous hardware
- Lift Reference Prox switch and bracket

Equipment Required

In addition to normal tools, you should have the following available at the installation site:

- A hoist or crane with a capacity of 5 tons (4540 kg) for a Model 9600 mast, or 10 tons (9000 kg) for a Model 9700 mast. Ceiling clearance must be greater than the lift truck's collapsed height dimension. If erecting a Model 9700 mast by means of two lift trucks and a structural tubing lifting bar, the lift trucks should have a capacity of 8000 lbs. (3632 kg) each.
- A 3000 lb. (1362 kg) capacity lift truck for handling the tractor
- Hoist slings of suitable capacity
- Three lengths of heavy chain of suitable capacity
- Two wooden support blocks 3.5 in. (9 cm) wide by 2 in. (5 cm) high by 12 in. (30 cm) to 20 in. (51 cm) long for placement under baselegs

Assembly Procedure

⚠ WARNING

- **Perform this procedure with a minimum of two technicians.**
- ***Do not* permit observers to stand nearby.**
- ***Do not* allow distractions during setup of the lift truck.**
- **Wear gloves, safety glasses, steel-toed safety boots, and a safety helmet (hard hat).**
- **Place the mast and tractor skids in an open area where it is safe to work.**
- **Unassembled lift truck components are heavy, unstable, and difficult to handle. Use extreme caution when lifting and assembling the lift truck.**
- ***Do not* stand the mast up if the mini-mast is not centered side-to-side in the main carriage.**
- ***Do not* remove the steel banding securing the main carriage or the mini-mast, nor the wood stringers in the lower traverse rack, until the main mast is upright.**

1. Cut and discard the banding on the tractor. Carefully set aside the tractor side covers, glass mast guard (if so equipped), and parts carton. Remove forks from tractor skid.
2. Remove diagonal support arms from the mast skid.
3. Static straps might have been removed prior to shipment or might have been repositioned so as not to protrude below the mast. If they are not already installed, install two static straps at the base of the mast. Position static straps at a 45° angle to the floor.
4. Cut and discard the banding securing the mast to its skid(s). *Do not remove banding securing the mini-mast or the banding securing the carriage to the mast until the mast is standing upright.*

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5. Cut and discard the cable ties securing the over-the-mast hoses and cables. *Do not cut the cable ties securing the hose and cable slap pads to the hoses and cable on the outboard side of the cylinders.* These remain on the lift truck.
6. Use two lift trucks of suitable capacity to lift the mast off the skid(s). Remove and discard skid(s). Carefully lower mast to floor.
7. Model 9600: Attach two 5-ton hoist straps around the main mast and telescopic crossties.

NOTE: Model 9600 alternate method: Position the lifting truck as shown in Figure 3-2 and secure a heavy chain around the fork carriage of the lifting truck and the mast crosstie. Slowly and carefully raise the mast erect. See Figure 3-3. Lift very slowly at the point where the weight of the mast goes forward of the pivot point.

Figure 3-2. 9600 Mast Erection, Alternate Method

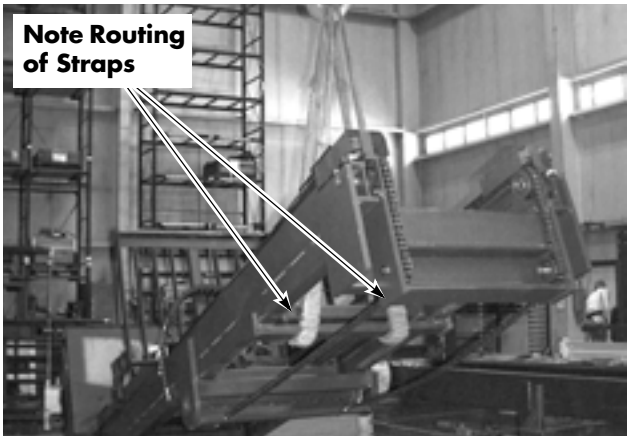


Figure 3-3. 9600 Mast Erection Using Lift Truck



8. Model 9700: Attach two 10-ton hoist straps around the second main mast and telescopic crossties. See Figure 3-4.

Figure 3-4. 9700 Mast Strapped to Hoist



⚠CAUTION

On a Model 9700 mast, *do not* wrap hoist strap around the uppermost crosstie, only the main mast and telescopic crossties.

NOTE: Model 9700 alternate method: Insert a length of suitable structural tubing through the 6 in. (15 cm) hole in the lifting flange. This flange is a part of the Model 9700 mast lower crosstie. See

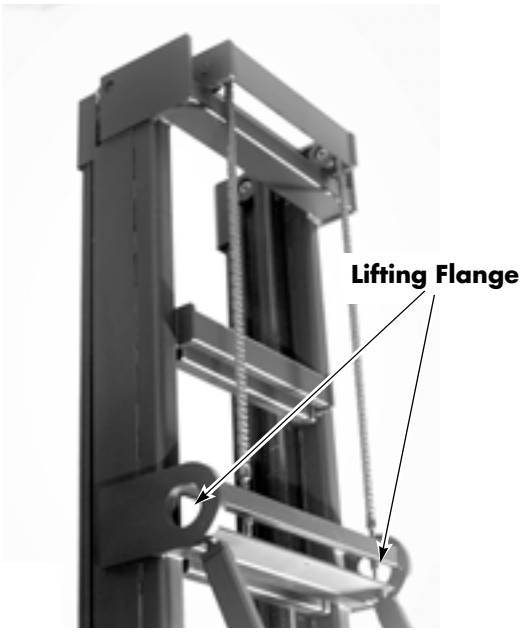
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Figure 3-5. If you are using two lift trucks to erect the mast, a 160 in. (407 cm) length is recommended for the tubing. See Table 3-1 for specifications on structural tubing.

Table 3-1. Structural Tubing Specifications

Structural Tubing Type	OD/ Size	Wall Thickness	ASTM
5 in. Round Type ERW	5 in.	0.5 in.	A500 Grade B or C
5 in. Round Schedule 160	5.6 in. nominal	0.62 in. nominal	A53 Type E Grade B
5 in. XXS Round		0.75 in. nominal	A53 Type A Grade A or B
Square	4x4 in.	0.5 in.	A500 Grade B or C

Figure 3-5. 9700 Mast Lifting Flange

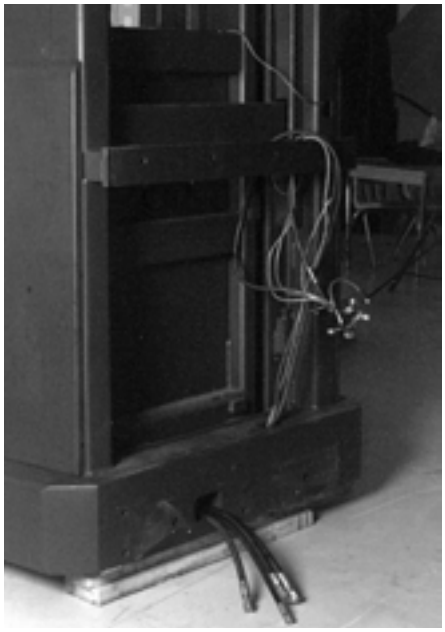


Attach and secure 10-ton hoist straps around the structural tubing on both sides of the mast.

If you are lifting the mast with lift trucks instead of a hoist, chain or clamp the structural tubing to the fork carriage of the lift trucks.

9. Raise the mast and carriage section erect and hold in a level position. Block the back edge of the mast with wooden blocks. See Figure 3-6.

Figure 3-6. Mast Blocked



10. Pull hydraulic hoses and wire guidance cable (if so equipped) out the hole near the left side of the base of the mast. Pull over-the-mast cables out the hole in the top of the base of the mast near the right side. Pull Model 9600 work light cable (if so equipped) out the cutout in the back of the mast approx. 4 ft. (1.2 m) from the floor on the right side.

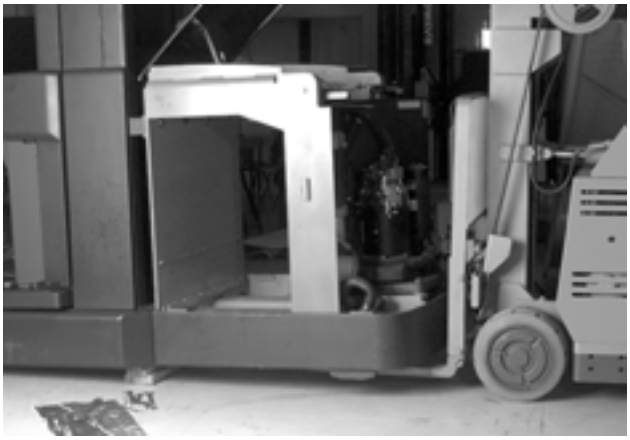
Figure 3-7. Pulling Hydraulic Hoses Through Mast



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11. Install Lift Reference Prox switch and bracket.
12. Using a lift truck, position the tractor in alignment with the mast. See Figure 3-8.

Figure 3-8. Mating Tractor to Mast



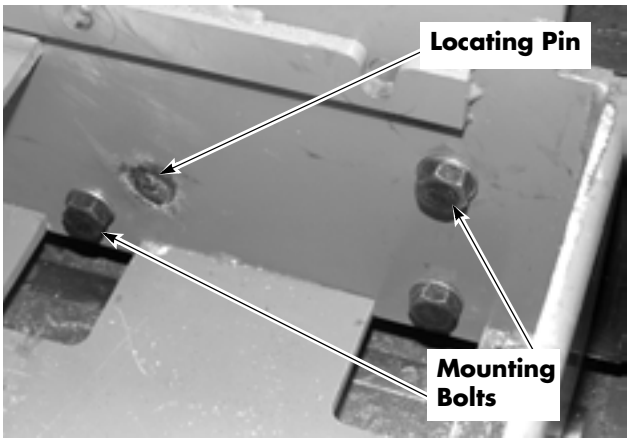
13. Connect the over-the-mast cable connectors to the correct tractor cable connectors at the mast-to-tractor cable connection panel. See Figure 3-9.

Figure 3-9. Mast to Tractor Cable Connections



14. Mate the tractor to the mast, engaging the locating pins in the tractor with the holes in the mast frame.
15. From the battery compartment, thread 4 mounting bolts and washers through the top of the tractor frame into the mast. Thread 7 mounting bolts and washers into the bottom of the tractor frame into the mast. Using a torque wrench, torque to 350 ft. lb. (475 Nm). See Figure 3-10.

Figure 3-10. Mast-Tractor Mounting Bolts, Lower



⚠CAUTION

Diagonal support arms weigh approx. 60 lb. (27 kg)

16. Install the diagonal support arms. Secure clevis pins with snap rings, flat side of the ring to the inside of the tractor. See Figure 3-11.

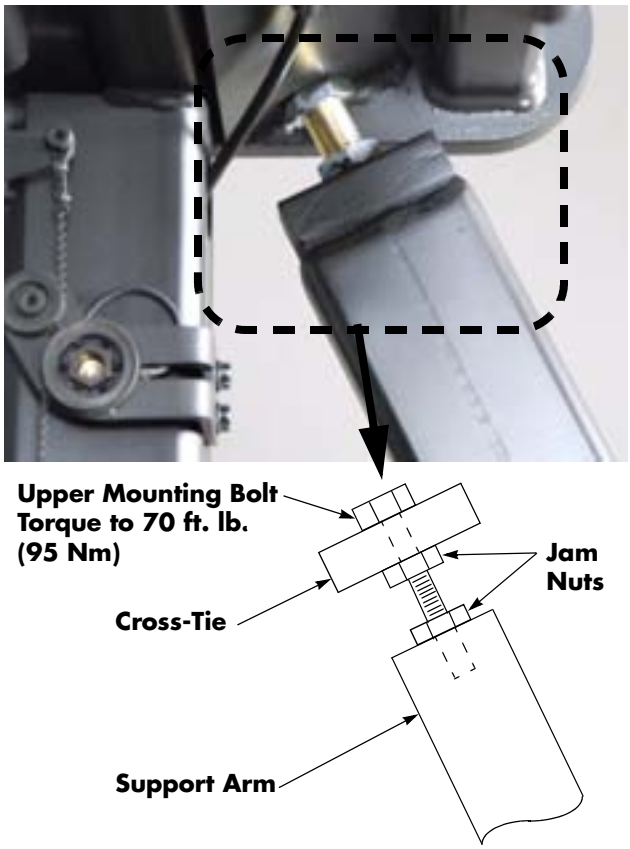
Figure 3-11. Support Arm Installation to Tractor



17. Apply thread-locking compound (P/N 990-571) to upper mounting bolt threads. Thread the upper mounting bolt, tighten, and torque to 70 ft. lb. (95 Nm). Tighten jam nuts against crosstie and support arm. See Figure 3-12.

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Figure 3-12. Support Arm Installation to Mast



18. Install the battery spacer, if used.
19. Remove hoist strap.
20. Cut and discard the steel banding securing the carriage to the mast. Remove the bolt securing the mini-mast. Cut and discard the cable ties and wooden stringers that center the mini-mast in the lower traverse rack. Remove the blocking between mini-mast and mini-mast lift cylinder.

⚠CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-8.

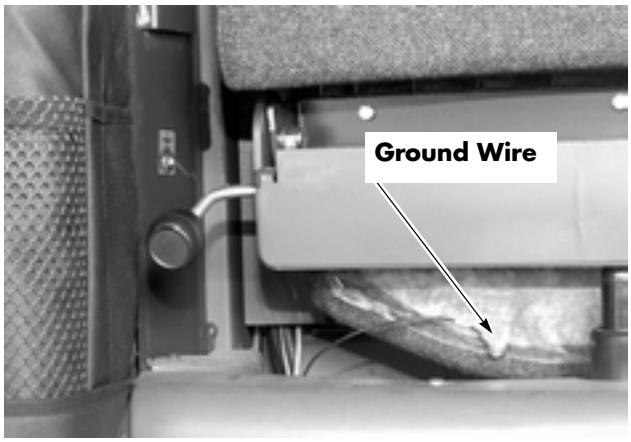
21. Feed the electrical cables, and cables for the travel light (if so equipped), end-of-aisle sensor (if so equipped), and wire guidance sensor (if so equipped) from the mast through the tractor opening and connect to the Tractor Manager and Wire Guidance Filter Card at JW1 (if so equipped). Connect standard cables to interconnection points.
22. Connect the hydraulic hoses at the bottom of the battery compartment. Make sure the O-ring is in place on the male fitting. See Figure 3-13.

Figure 3-13. Hydraulic Hose Connection



23. If they are not already in place, install battery rollers. Install a fully charged battery, using a suitable battery installation device. Install battery gates.
24. Make sure the ground wire to the bottom of the seat is installed. See Figure 3-14.

Figure 3-14. Operator Seat Ground Wire



25. Install the glass mast guard, if so equipped. Make sure brackets are installed with mounting screws on the tractor side of the glass, so that the glass lines up with the back of the operator compartment, without any "ledge" or "jog."

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This is important for the mounting of the Supplemental Operator Display.

26. Install the Supplemental Operator Display on the glass or mesh mast guard.
27. Remove plastic wrapping from control handles and arms.
28. Bleed the hydraulic system. See “Bleeding the Hydraulic System” on page 7-74.
29. Grease steering ring gear.
30. Grease the traverse racks and areas on the top and bottom of the carriage where the sliders ride.
31. Install the forks.
32. Install covers.
33. Run Wire Guidance Learn. Refer to page 3-34.
34. Perform Test O62 – Lower Sol [Lower Solenoid (SOL1)] (page 6-153).
35. Install optional equipment such as lights, fan, and so on. If so equipped, set Lift Limit with Bypass heights per customer requirements. See “Configuration and Truck Setup Options” on page 3-12.

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FlashWare

Overview

FlashWare is used on many different model trucks with different “Manager” configurations. The 9600/9700 uses the same “Vehicle Manager” for the Tractor and Carriage Manager. Unique software is loaded into the device and a harness/jumper configuration is used to identify the component. Refer to “Schematics” on page A-19.

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

- Update Vehicle (Tractor) Manager Software
- Clear Primary Memory (truck identification data from CM)
- Reset Factory Default Settings
- BSOC Calibration
- Clear Managers (Tractor and Carriage)
- View/Update Carriage Manager Software
- View/Install/Update Power Amp Software
- Update Carriage Manager Software
- Install Cleared (New) Manager

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

FlashWare can be installed on any IBM-compatible PC. The PC communicates with the truck software via a serial (9 pin) or USB port.

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.

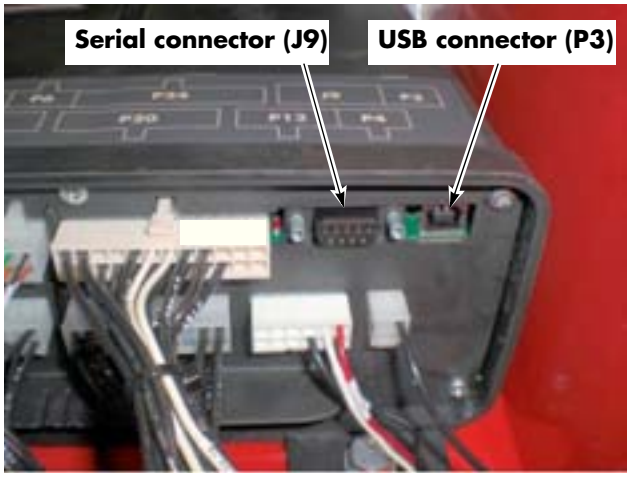
To install FlashWare on the PC, double-click the installation file and follow the instructions on the screen. The software package is a self-extracting executable file. Read the “Readme” file in the software package for the latest detailed installation instructions.

Connecting PC to Truck

There are two methods available to connect the PC to a manager:

- **USB to USB** - this method requires the correct drivers to be installed on the PC. Typically, this type of connection is much faster than a serial connection. With the key switch OFF, connect cable P/N 610-809/210 to a USB port on the PC and the P3 connector on the manager. See Figure 3-15.
- **Serial to Serial** - this method requires a surge protector (P/N 154-010-801) to be connected in series with the cable to protect the PC. With the key switch OFF, connect a standard 9-pin serial cable to a serial port on the PC and the J9 connector on the manager. See Figure 3-15.

Figure 3-15. Truck FlashWare Connections



Manager Connection

The Tractor Manager is the primary FlashWare connection point. However, when it is necessary to communicate with or clear a Carriage Manager, the PC must be connected directly to the Carriage Manager.

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Tractor Manager

Connect FlashWare to the Tractor Manager to:

- enable/disable options
- update TM, CM, LPA, and TPA software
- clear manager
- reset factory defaults
- install TM software into a blank manager

Carriage Manager

Connect FlashWare directly to the Carriage Manager to:

- install CM software into a blank manager
- clear CM

Starting FlashWare

1. With the key switch ON, double-click the FlashWare icon on the main desktop screen or navigate via Start > Programs > FlashWare. The truck opening screen appears. See Figure 3-16.

Figure 3-16. Truck Opening Screen



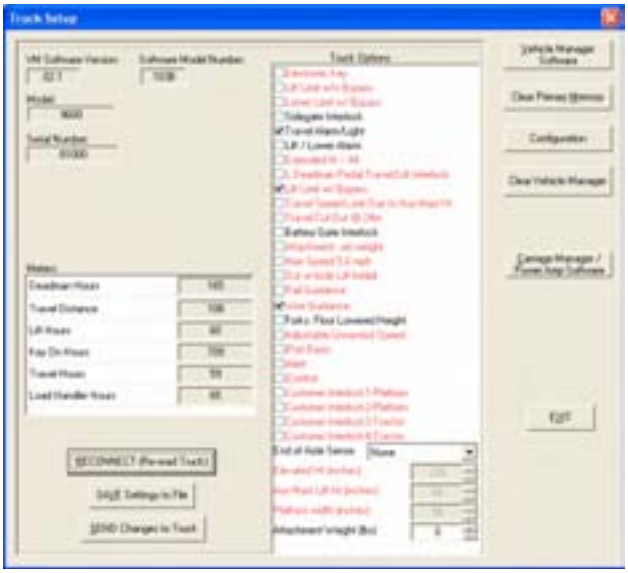
NOTE: When entering or using FlashWare, it is normal for Code 57 to display.

2. From the menu bar, click "Communications", then select the applicable connection type:
   - COMx (9-pin Serial)
   - COMx (USB)

NOTE: "x" numbers will vary depending on the computer configuration.

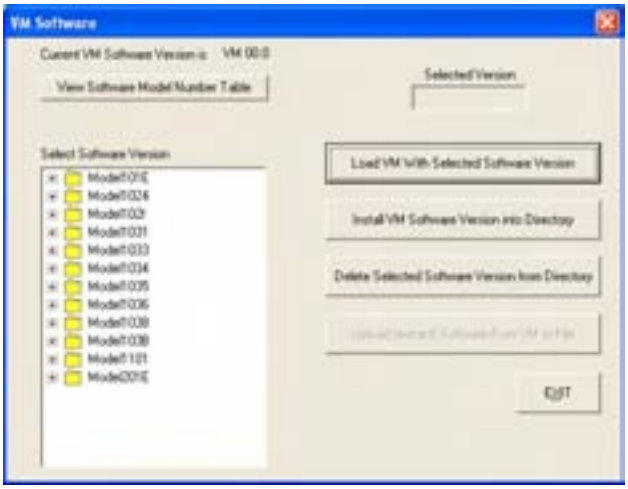
3. From the menu bar, click "Connect to Truck", then select "All Other Trucks". The Truck Setup screen is displayed.
   - If the PC is connected to a correctly functioning Tractor Manager, the Truck Setup screen is displayed.

Figure 3-17. Truck Setup Screen



   - If the PC is connected to a correctly functioning Carriage Manager or a blank manager, the VM Software screen is displayed. See Figure 3-18.

Figure 3-18. VM Software Screen



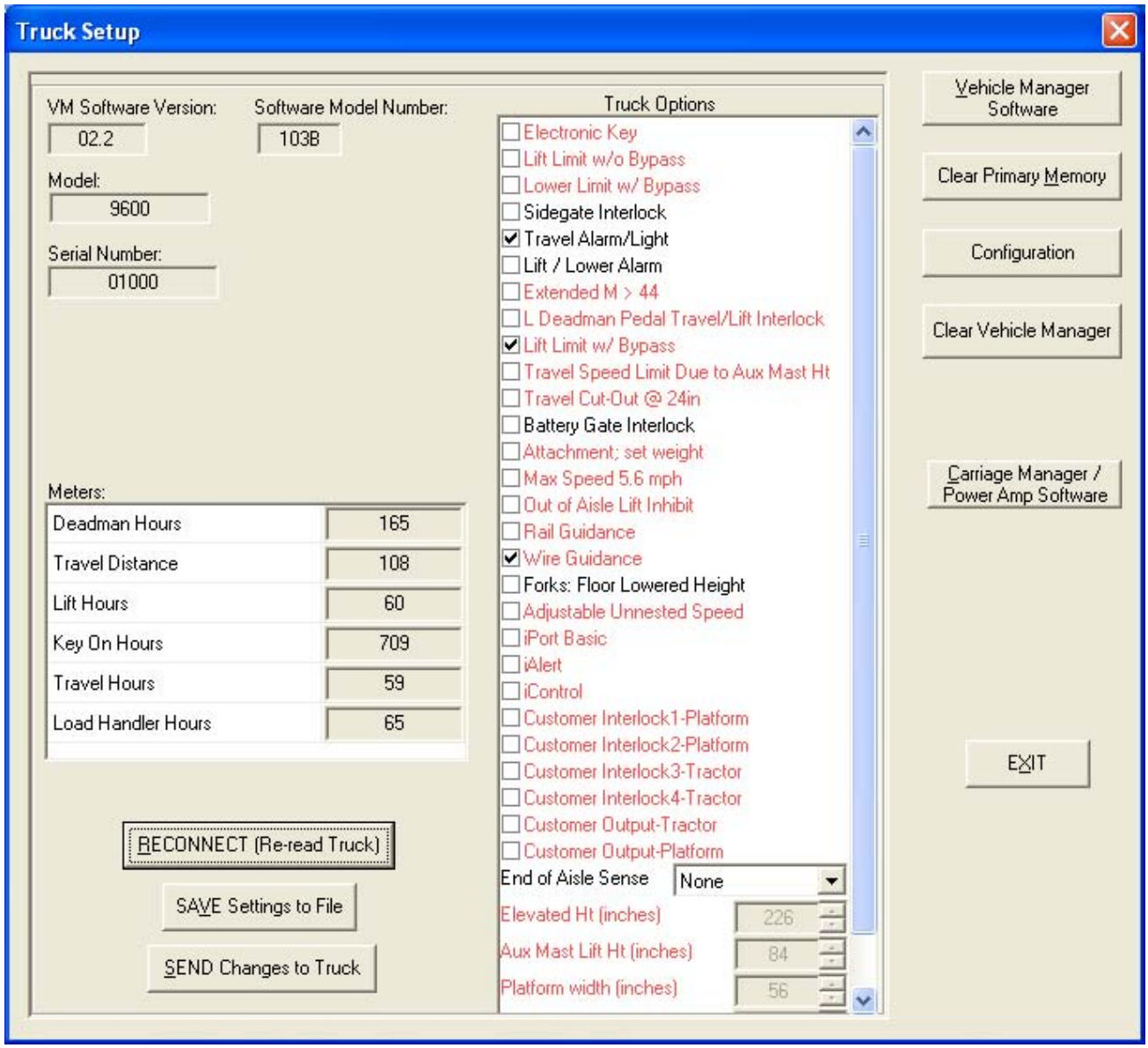
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Configuration and Truck Setup Options

The Truck Setup Screen allows you to:

- enable options that were added to the truck since shipment from the factory
- check the serial number, model number, software model number, Elevated Ht, Vehicle Manager version, and hour meters of the truck. See Figure 3-19.

Figure 3-19. Truck Setup Screen



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To Change an Option Setting:

The list box near the middle of the window shows the Truck Options.

Select the required check box. To disable an option, deselect the check box. See Figure 3-19. When the options are correctly configured, click the "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):

NOTE: Unless otherwise specified, all options require an authorization code.

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

Lift Limit w/o Bypass - limits lift height without a bypass switch.

Lower Limit w/Bypass - limits lower height and is equipped with a bypass switch.

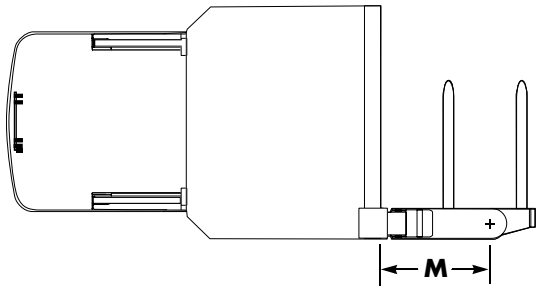
Sidegate Interlock - requires both sidegates to be lowered to allow travel and lift/lower functions. *Authorization Code not required.*

Travel Alarm/Light - allows the alarm or light to function when the lift truck is moving as configured. *Authorization Code not required.*

Lift/Lower Alarm - allows the alarm to function when the lift truck is lifting/lowering as configured. *Authorization Code not required.*

Extended M >44 - Refer to Figure 3-20. Used when dimension "**M**" exceeds 44 in. (112 cm).

Figure 3-20. Extended M Dimension



L Deadman Pedal Travel/Lift Interlock - used when the customer wants to have both deadman pedals depressed prior to allowing travel or lift/lower.

Lift Limit w/Bypass - limits lift at up to 4 programmable lift heights and is equipped with a bypass switch.

Travel Speed Limited due to Aux Mast Ht. - used to interrupt travel when the mini-mast is raised above the programmed height.

Travel Cut-Out @24 in. - used to interrupt travel when the vehicle's elevated height is above 24 in. (51 cm).

Battery Gate Interlock - used to interrupt travel until the battery gate is correctly installed. *Authorization Code not required.*

Attachment, set weight - used when an optional attachment has been installed.

Max Speed 5.6 mph - used to limit maximum travel speed to 5.6 mph (9.0 km/h).

Out-of-Aisle Lift Inhibit - used to interrupt main lift and limit travel speed when the truck is not located in a rail or wire guided aisle.

Rail Guidance - allows the rail guidance function to operate when the vehicle is correctly equipped.

Wire Guidance - allows the wire guidance function to operate when the vehicle is correctly equipped.

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Forks: Floor Lowered Height - used when truck has a floor lowered height to adjust the height display correctly. *Authorization Code not required.*

Adjustable Unnested Speed - used to select what speed [0, 0.5, or 1 mph (0, 0.8, or 1.6 km/h)] is allowed when the load handler is not nested.

iPort Basic - used to select *iPort* Basic.

iAlert - used to select *iAlert* as part of the *iPort* Premium package.

iControl - used to select *iControl* as part of the *iPort* Premium package.

Customer Interlock 1-Platform - used for optional inputs (see Table 3-2).

Customer Interlock 2-Platform - used for optional inputs (see Table 3-2).

Customer Interlock 3-Tractor - used for optional inputs (see Table 3-2).

Customer Interlock 4-Tractor - used for optional inputs (see Table 3-2).

Customer Output-Tractor - used for optional customer outputs (see "Configuration" on page 3-15).

Customer Output-Platform - used for optional customer outputs (see "Configuration" on page 3-15).

End of Aisle Sense - used to select the type of magnet system that has been installed into the floor for the End-of-Aisle system. *Authorization Code not required.*

Elevated Height (inches) - used to set the forks maximum elevated height.

Aux Mast Lift Ht (inches) - used to set the height of the Aux (mini) mast.

Platform Width (inches) - used to set the platform width.

Attachment Weight (lbs) - used to set the attachment weight after the *Attachment, set weight* option has been enabled.

Vehicle (Tractor) Manager Software

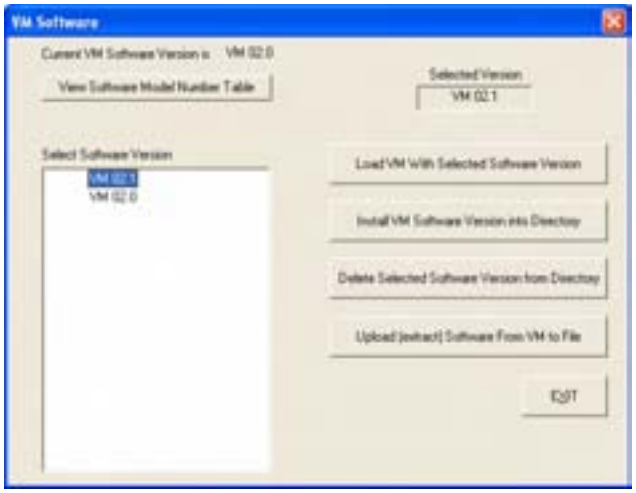
Tractor Manager software management can be performed in the VM Software dialog box:

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

NOTE: If installing a new or cleared manager, refer to "Install Cleared (New) Manager" on page 3-19.

1. Click the **Vehicle Manager Software** button on Truck Setup Screen.
2. Select the software version to load. See Figure 3-21.

Figure 3-21. VM Software Dialog Box



3. Click the **Load VM With Selected Software Version** button. The new software is then installed in the truck.
4. To display software versions in the truck, see "Version" under "Program Mode" on page 3-22.
5. Load updates to FlashWare and install software to the truck as needed to make sure a matching set of TM/CM software is installed.

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NOTE: Check the software model number table in FlashWare Help for the current matching set.

6. When the installation is complete, click **EXIT** to return to the Truck Setup screen.

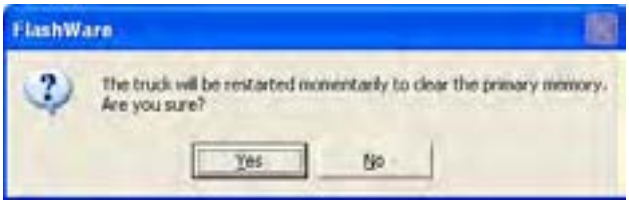
Clear Primary Memory

On this truck, the Clear Primary Memory feature removes truck specific information from the Carriage Manager.

NOTE: The Carriage Manager can be replaced without losing truck identity. A copy of the truck identity is stored in both the Tractor Manager 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 Carriage Manager and Tractor Manager must be installed.

1. Click the **Clear Primary Memory** on the Truck Setup screen.
2. After selecting this feature, the Clear Primary Memory dialog box appears. See Figure 3-22.

Figure 3-22. Clear Primary Memory Dialog Box



3. If **No** is selected, the action is cancelled. If **Yes** is selected, a new dialog box appears. See Figure 3-23. Click OK.

Figure 3-23. Remove Cleared Memory Dialog Box



CAUTION

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

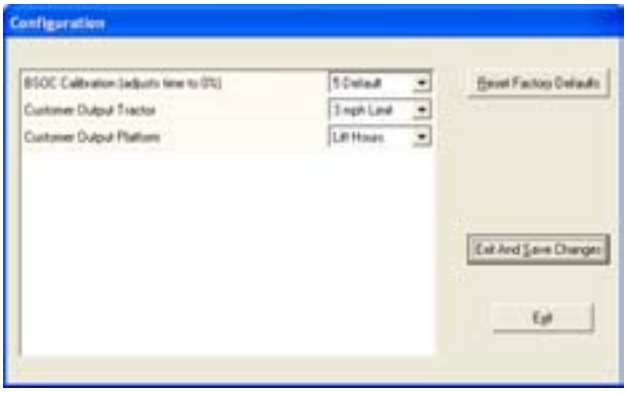
4. Remove the Carriage Manager.

Configuration

Truck configuration can be reviewed in the Configuration window.

Click **Configuration** on the main Truck Setup screen. See Figure 3-19. The Configuration dialog box appears. See Figure 3-24.

Figure 3-24. Configuration Dialog Box

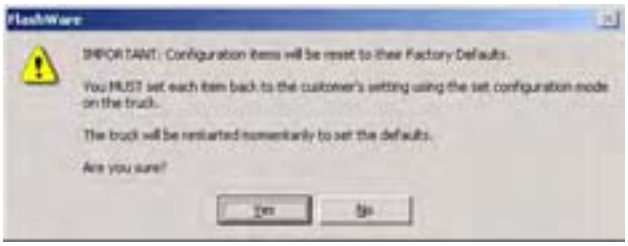


Reset Factory Defaults

Use this feature to reset vehicle configuration, including Superword and Password.

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

Figure 3-25. Configuration Reset Dialog Box



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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.

⚠CAUTION

If BSOC is lowered such that the battery is depleted to below Specific Gravity 1.120, the battery can be permanently damaged.

Customer Outputs - Tractor and Platform

This option controls the 48V output available at the Tractor and Platform Customer Output connectors (PCO1 and 2). Functionality is enabled by selecting one of the following Customer options.

- *None*
- *3 mph Limit* - activates an external device when travel speed is <3 mph in the tractor-first direction and at 0 mph. This setting is designed to activate an optional camera.
- *Lift Hours* - can be used to capture lift hours when using a wired third party warehouse management system. This setting records lift/lower hours.
- *Wire Guidance Status* - can be used to record when the system is in the auto or manual guidance mode.

Clear Vehicle Manager (Tractor Manager)

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

1. Click the **Clear Vehicle Manager** button on the right side of the Truck Setup screen. See Figure 3-19.
2. The Erase Vehicle Manager Software dialog box is displayed. See Figure 3-26.

Figure 3-26. Erase Vehicle Manager Software Dialog Box



3. Click **ERASE**. Memory is cleared and the manager can now be programmed as a Tractor Manager or a Carriage Manager.

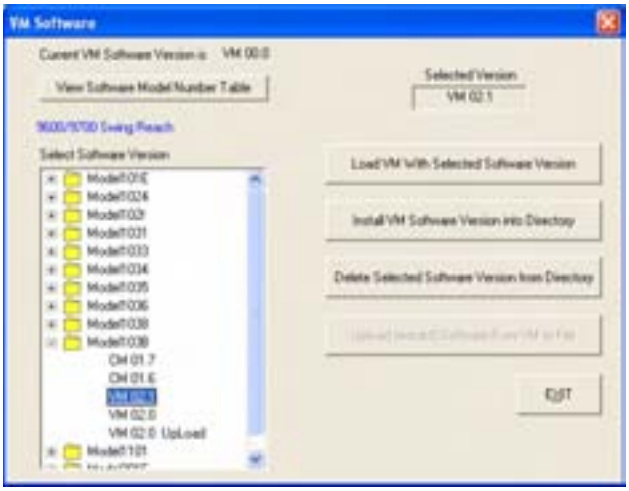
Clear Carriage Manager

NOTE: *To clear a Carriage Manager, it must first be programmed as a Tractor Manager.*

1. Connect directly to the Carriage Manager and start FlashWare. See "Starting FlashWare" on page 3-11.
2. At the VM Software screen, click to open the Model103B folder and select VM software to be loaded. See Figure 3-27.

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Figure 3-27. VM Software Screen - Folder Selection

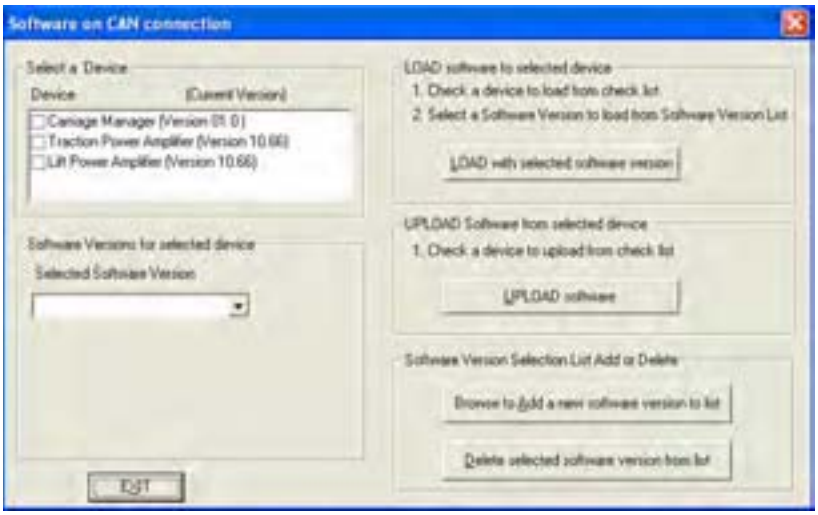


3. Click the **Load VM With Selected Software Version** button. When load is complete, the Truck Setup screen is displayed.
4. From the Truck Setup screen, select **Clear Vehicle Manager** and follow the prompts.

Carriage Manager/Power Amp Software

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

Figure 3-28. Software on CAN connection Screen



This feature is used to view/update Carriage Manager software and view/install/update Power Amplifier software.

NOTE: If installing a new or cleared manager, refer to "Install Cleared (New) Manager" on page 3-19.

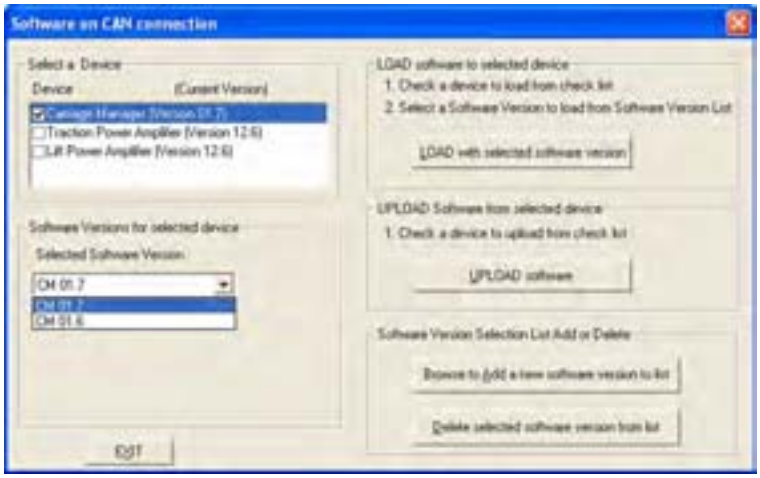
1. Click **Carriage Manager/Power Amp Software** button in the main Truck Setup screen.
2. When the Carriage Manager/Power Amp Screen appears, follow prompts on the screen to Load/Upload software. See Figure 3-28.

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Programming the Carriage Manager

Select Carriage Manager in the device window, then select desired software version in the software window. Click **LOAD with selected software version**. See Figure 3-29.

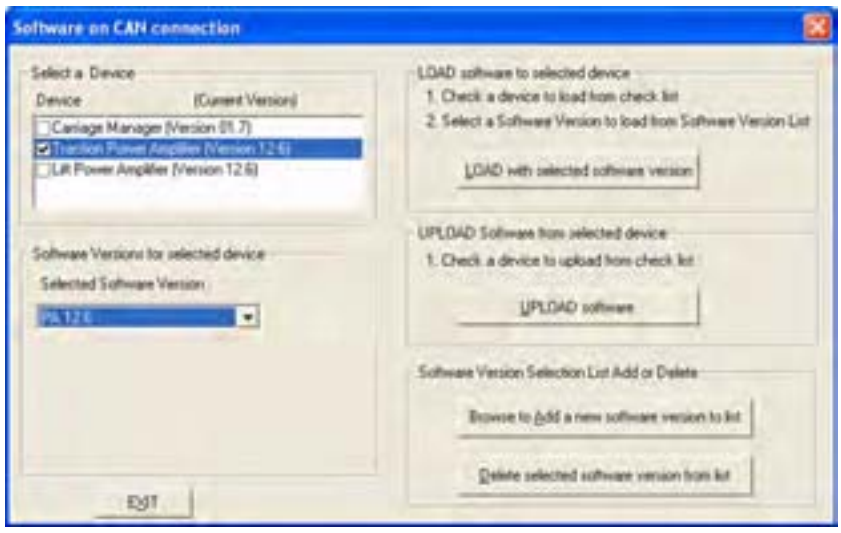
Figure 3-29. Carriage Manager Software Selection



Programming the Traction Power Amplifier

Select **Traction Power Amplifier** in the device window, then select desired software version in the software window. Click **LOAD with selected software version**. See Figure 3-29.

Figure 3-30. Traction Power Amplifier Software Selection

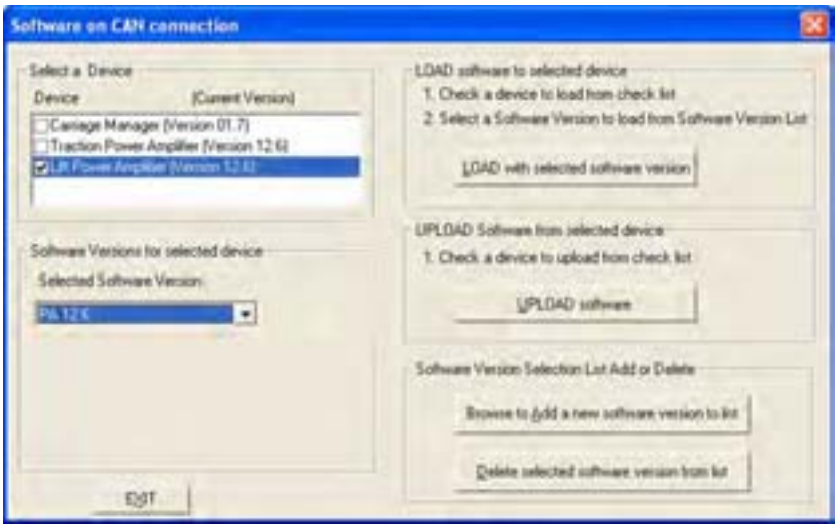


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Programming the Lift Power Amplifier

Select **Lift Power Amplifier** in the device window, then select desired software version in the software window. Click **LOAD with selected software version**. See Figure 3-29.

Figure 3-31. Lift Power Amplifier Software Selection



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.

Install Cleared (New) Manager

This feature is used to load Tractor Manager or Carriage Manager software in a cleared (new) manager.

1. Connect directly to the manager being installed and start FlashWare. See "Starting FlashWare" on page 3-11.

NOTE: If FlashWare cannot communicate with the manager, verify B+ and B– to the manager. Verify FlashWare program and cables are functioning properly by testing on another manager. If you are still unable to communicate with the manager, replace it.

2. At the VM Software screen, click to open the Model103B folder and select the correct software to be loaded.
3. Click the **Load VM With Selected Software Version** button. When load is complete, the Truck Setup screen is displayed.
4. Exit FlashWare. Cycle key switch and run Learn. See "Learn" on page 3-23.

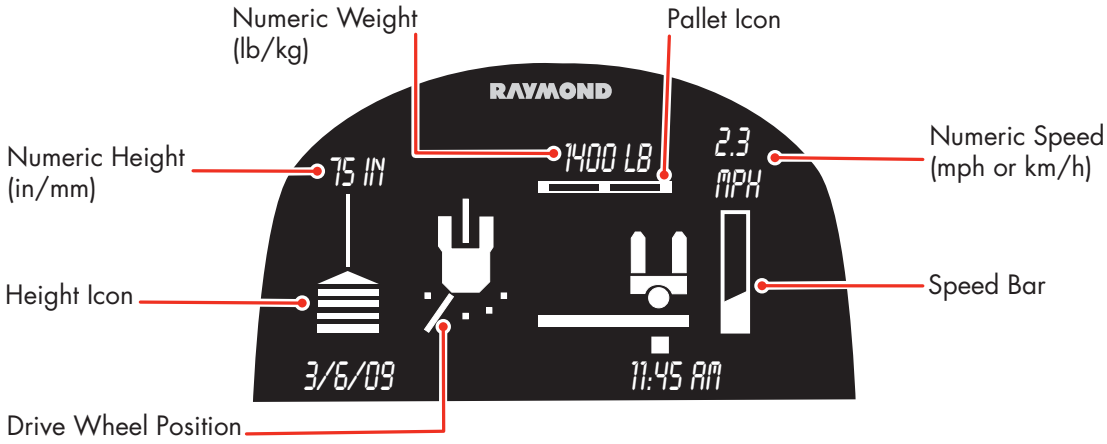
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Operator Displays

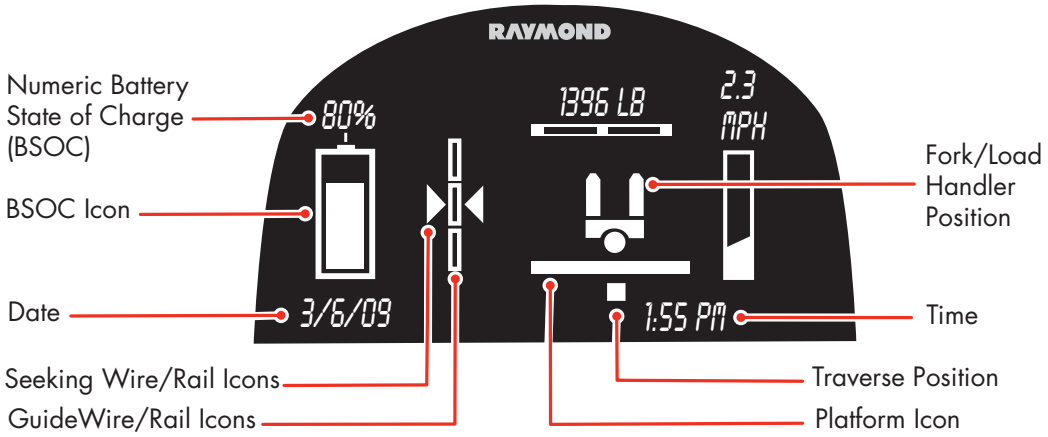
The lift truck has two Operator Displays. The Primary Operator Display is in the right control arm, as viewed by the operator when seated. See Figure 3-32. The Supplemental Display is located on the left side of the mast guard, as viewed by the operator when facing the tractor to drive standing up. See Figure 3-33.

Operator Display

Figure 3-32. Operator Display



Primary Display
Truck Lifting and Manual Steering Selected

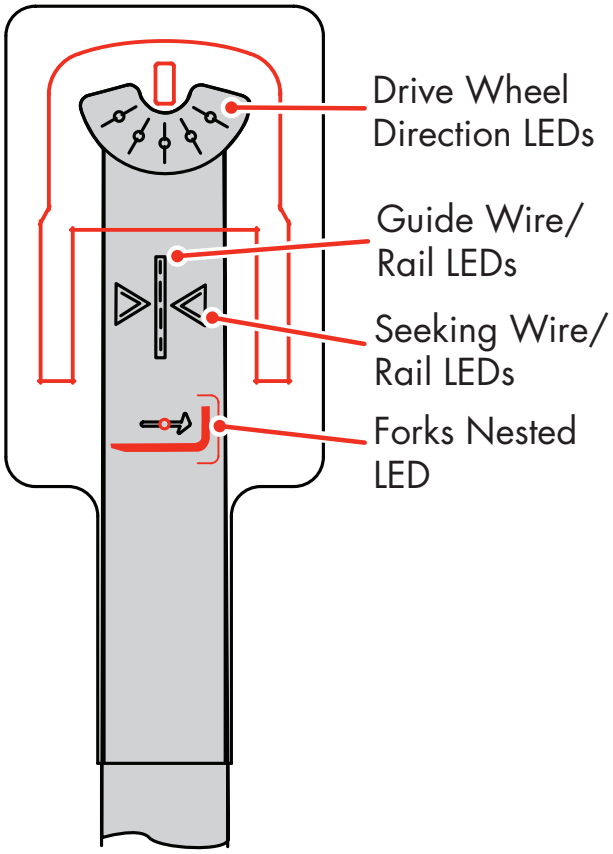


Primary Display
Truck Traveling and with Automatic Steering
(Wire Guided Mode) Selected

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Supplemental Display

Figure 3-33. Supplemental Display



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Modes of Operation

Overview of Modes

This lift truck has several modes of operation. The main distinction is between Run Mode and Program Mode. Run Mode is the normal working mode for the lift truck. Program Mode permits configuration, calibration, and diagnostic testing.

Run Mode

When you power the lift truck on normally, the on-board firmware performs a number of internal self-tests and enters the default mode of operation, Run Mode. Run Mode is the normal working mode. In Run Mode, the Operator Display shows the default display.

Program Mode

Use Program Mode for configuration, calibration, and diagnostic testing on the lift truck. You need a password in order to enter Program Mode. See "Passwords" on page 3-24.

Program Mode is divided into six categories:

- Serial #
- Version
- Hr Mtrs
- Config
- Learn *(Superword required)*
- Maint *(Superword required)*

When Program Mode is exited, the electronic key prompt is displayed (if enabled) or the truck performs Selftest and enters Run Mode.

Serial

The serial number displayed must match the serial number on the tractor and mast specification plates. This field cannot be changed from Program Mode.

Version

The version of software resident in the following devices is displayed:

- CM - Carriage Manager software
- CMB - Carriage Manager Boot Block***
- TM - Tractor Manager software
- TMB - Tractor Manager Boot Block***
- GM - Guidance Manager*
- PAT - Traction Power Amp software
- PATB - Traction Power Amp Boot Block***
- PATVCL - Traction Power Amp VCL**
- PAL - Lift Power Amp software
- PALB - Lift Power Amp Boot Block***
- PALVCL - Lift Power Amp VCL**

*Guidance Manager change requires firmware chip to be replaced to change version.

**VCL = Vehicle Control Language. This is Raymond specific software for the amp.

***Boot Block software cannot be changed in the field.

NOTE: When using FlashWare, the amp VCL file and software are located in the same file.

Hour Meters and Distance Indicator

The Operator Display shows the following accumulated totals:

- **KH**: Total hours the key switch has been turned ON
- **HD**: Total hours on deadman
- **HL**: Total hours spent lifting and lowering
- **TM**: Total distance traveled (miles or kilometers, depending on Units specified in Config)
- **HT**: Total hours spent traveling
- **HA**: Total hours on Load Handler

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Config

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

NOTE: Some items in Configure Mode appear only if Superword is entered and/or the option has been enabled.

For detailed description, see "Using Configure Mode" on page 3-26.

Learn

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

- Controls (travel, traverse, lift/lower, rotate)
- Load Handler (Ld Hndlr)
- Weight
- Guidance

To enter Learn Mode, you must enter the Superword.

For detailed description, see "Using Learn Mode" on page 3-33.

Maint

Maintenance Mode allows service technicians to check/test individual circuits within the system. Maintenance Mode is accessed through Program Mode after the Superword is entered. Refer to "Using Maintenance Mode" on page 3-37 to access Maintenance Mode.

NOTE: If the input/test does not appear in the Maintenance Mode menu for an option when you think it should, either that option is not enabled (via FlashWare) or the truck does not have the latest software.

NOTE: If you need to enter Maint several times to resolve a problem, it may save time if Superword is temporarily changed to a single digit code. Remember to re-enter the correct Superword when you are done.

⚠CAUTION

Disconnecting wires or connectors to integrated circuits with power ON can result in premature failure of those or other components. Always disconnect the battery before making or breaking any connections.

⚠ WARNING

During Maintenance Output Tests, always jack the drive tire off the floor and open the Emergency Lowering Valve.

Use extreme care when the truck is jacked up for any reason. Never block the lift truck between the carriage and the floor. 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. See "Jacking Safety" on page 2-10.

Follow all instructions contained in this manual for each test. If you are unsure how to conduct a test while in Maintenance Mode, do not proceed with the test.

Active Maintenance Mode

Active Maintenance Mode (ActMaint), when enabled in Config, permits testing of various systems on the truck. In Active Maintenance, all Analog and Digital inputs can be selected with the results displayed while operating the truck in Run Mode. Refer to "Using Active Maintenance Mode (ActMaint)" on page 3-39.

Passwords

Electronic Operator Key

Electronic Operator Key is a feature that allows the customer to assign up to 20 operator electronic keys (passwords). With Operator Key

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enabled, the operator is prompted to enter his/her electronic key when the key switch is turned ON. Truck operation is not allowed unless the correct electronic key *or Superword* is entered.

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.

We *strongly* recommend 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 Diagnostic Mode is limited to qualified 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 it necessary to reconfigure all variable settings.

Run Mode Tones

Tone 1. A single tone that indicates:

- A key on the Operator Keypad (Up/Down/Left/Right/Enter) is depressed
- Maximum steer request is reached

Tone 2. Two tones (high/low) that indicate the TPC and LPC contactors are disabled (opened). Travel, steering, and lift/lower are disabled and the brake is applied until the problem is corrected.

Tone 3. Three tones (high/medium/low) that indicate:

- A travel performance limitation - travel speed is limited to 1 mph (1.6 km/h). Lift, lower, steering, and horn functions operate normally.
- A traction system shutdown - travel is not allowed. Lift, lower, steering, and horn functions operate normally.
- A shutdown in the lift/lower system - lift and lower are not allowed. Travel, horn, and steering functions operate normally.
- Load Handler shutdown

Tone 4. A continuous tone with deadman pedal pressed and Auto/Manual switch in Manual indicates the truck is over the guide wire.

Tone 5. Tone ramps up then repeats, indicating the truck is seeking and aligning over the guide wire. The tone continues until the truck is locked on the guide wire or the Auto/Manual switch is changed to Manual.

Tone 6. Descending tone (bomb drop) that indicates an incorrect Password or Electronic Passkey was entered.

The tones described do not repeat continuously. A fault code and associated message scroll across the Operator's Display. The message repeats continuously until the key switch is turned OFF.

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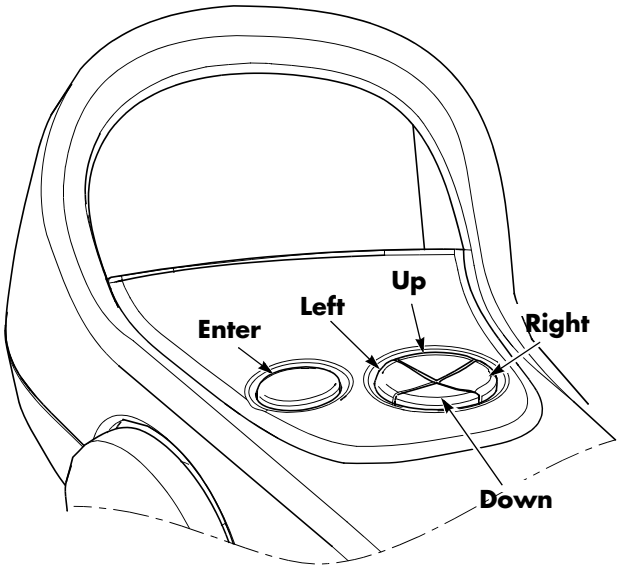
Using Program Mode

⚠ WARNING

By entering Program Mode, safety circuits associated with the *ACR System* are disabled. Follow all instructions in this manual for each test. If you are unsure how to conduct a test while in Program Mode, *STOP: do not proceed* with the test. Contact an authorized Raymond dealer.

To enter Program Mode, use the right button to obtain the cursor prompt. Using the **up/down** buttons to scroll to the desired number and the **left/right** buttons to move to a different character position, enter the Password or Superword, then press **Enter**.

Figure 3-34. Operator Display Control Buttons



Entering Electronic Operator Key, Password, or Superword

An Electronic Operator Key, Password, or Superword can be 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.*

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.
3. Once the character position is selected, use the **up/down** buttons to select the desired number, letter, or space. The character set wraps between "z" and "_" (space). To go quickly from the letter "z" to the number "0," press the down button twice.

   _0123456789ABCDEFGHIJKLMNOPQR STUVWXYZ
4. Repeat steps 2 and 3 for the remaining Electronic Operator Key, Password, or Superword characters.
5. When all characters in the Electronic Operator Key, Password, or Superword are entered, press the **Enter** button once.
6. If an invalid Electronic Operator Key, Password, or Superword is entered, a tone sounds and **Invalid Password** is displayed before returning to the password prompt screen.
7. If a mistake is made entering a character, repeat steps 2 thru 5.

   When a correct *Electronic Operator Key* is entered, the truck completes SelfTest and enters Run Mode.

   When the correct *Password or Superword* is entered, one of the following is displayed for 3 seconds:

   a. If Password is entered, the following is displayed:
      - Quit
      - Serial #
      - Version
      - Hr Meter
      - Config

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b. If Superword is entered, the following is displayed:
   - Quit
   - Serial #
   - Version
   - Hr Meter
   - Config
   - Learn
   - Maint

To exit Program Mode, select Quit and press **Enter**.

Using Configure Mode

Configure Mode can be accessed with Superword or Password, however some items in **Config** will only appear if Superword is entered.

Table 3-2 outlines all menus and submenus available in Config.

Quit Cfg is first displayed when **Config** is selected. Use the **Up/Down** buttons until the desired selection is displayed. Press **Enter**. This will take you into the submenu for that item.

Current values of configurable items or the ability to enable/disable an option appear in the submenu. To change the value, press the **Up/Down** button. When the desired value appears, press **Enter**.

All possible truck configurations and options are listed in these instructions. Only the options associated with that particular truck are displayed on the OD.

To save changes, select **Quit Cfg** from the **Config** menu and press **Enter**. Select **Save? Y** to save the changes made and exit **Config**.

To disregard changes made in **Config**, select **Save? N**. **Config** exits without saving changes.

Default Settings

NOTE: Once defaults are reset **(Reset? Y)**, the previous settings cannot be recalled.

To reinstate factory default settings:

1. Select **Defaults** from the main menu and press **Enter**. Select **Reset? Y**.
2. Select **Quit Cfg**.

Changing Password or Superwrd

Both Password and Superwrd can be changed to any combination of letters and/or numbers. Blank spaces are not allowed [spaces are represented by a down bar (_)].

If Program Mode is entered with a password, only **Password** can be changed. If Program Mode is entered with a superword, both **Password** and **Superwrd** be changed.

The minimum number of characters is one, the maximum is eight.

To change **Password** or **Superwrd**:

1. Enter **Config** using the current password or superword.
2. Select **Password** or **Superwrd** (as applicable) from the **Config** menu and press **Enter**.
3. Enter the new code using the **Up/Down** and **Enter** buttons.
4. When the new code is displayed, press **Enter**. The display returns to the main menu.

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Table 3-2. Configure Mode Menu

CONFIGURE MODE MENU **Can be entered with Password unless Superword is specified**			
Menu	**Item**	**Selection**	**Description**
Quit Cfg		Save? Y Save? N	Exits Configure Mode Save changes and leave Configure Mode Abandon changes and leave Configure Mode
Defaults		Reset? Y Reset? N (*default*)	Restore Factory Defaults - see "Default Settings" on page 3-26. Restore Factory Defaults Do not restore Factory Defaults **CAUTION:** The previous settings cannot be recalled once defaults are reset (Reset? Y).

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CONFIGURE MODE MENU **Can be entered with Password unless Superword is specified**			
Menu	**Item**	**Selection**	**Description**
Travel	Speed	Max Speed (*default*)	Set Max Travel Speed 0.0 or 1.0 to 6.0 mph (0.1 mph increments)
	T Accel	Hard Medium (*default*) Soft	Set Travel Acceleration
	Coast	Long Medium (*default*) Short	Set Coast
	Spd/Hgt-1	Height1 Speed1	Set Max Travel Speed above a given height Height 1 (1 in. increments) Speed 1 (0.1 mph increments)
	Spd/Hgt-2	Height2 Speed2	Set Max Travel Speed above a given height Height 2 (1 in. increments) Speed 2 (0.1 mph increments)
	OOA Spd (*Superword only*)	Max Speed (*default*)	Out-of-Aisle Speed: Set Max Travel Speed when truck is not located in a rail or wire guided aisle - enabled with FlashWare. 0.0 or 1.0 to 6.0 mph (0.1 mph increments)
	UnNestSp (*Superword only*)	1 mph (*default*)	Set Max Travel Speed when Load Handler is Unnested - enabled with FlashWare. 0 to 1.0 mph (0.5 mph increments)
	AlarmT (*Superword only*)	None Both (*default*) Fork Ld Fork Trl	Set Alarm for Traction - enabled with FlashWare. Choose one of following: Off On in both directions On when forks leading On when forks trailing
	EOASpeed	1.0 mph (*default*)	Set End-of-Aisle Speed - enabled with FlashWare. 0.0 or 1.0 to 6.0 mph (0.1 mph increments)
	AuxSpd/Ht (*Superword only*)	Max Speed Max Height	Set Max Travel Speed when mini-mast is above a given height - enabled with FlashWare. Speed (0.1 mph increments) Height (1 in. increments) **Note:** "Travel Speed Limited due to Aux Mast Ht" must be enabled in FlashWare.

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CONFIGURE MODE MENU **Can be entered with Password unless Superword is specified**			
Menu	**Item**	**Selection**	**Description**
Lift	LftAccel	Hard Medium (*default*) Soft	Set Lift/Lower Start/Stop Acceleration
	LwrDecel	2 (*default*)	Set Lower Deceleration Rate: 0-5 0 = quickest, 5 = slowest **Note:** This setting affects the height that decel begins.
	LftLimit (*Superword only*)	Enable	Enter a height between 0 and maximum elevated height. If option is enabled with FlashWare, lift is disabled above the configured height. Enable Height Disable
	Lft Byps (*Superword only*)	Disable Enable (*default*) Height1 - lowest Height2 Height3 Height4	Set Lift Bypass height - enabled with FlashWare. **Note:** Up to 4 different bypass heights can be programmed. The default is the maximum height programmed using FlashWare.
	AlarmL (*Superword only*)	None BOTH (*default*) Lift Lower	Set Alarm for Lift/lower - enabled with FlashWare. Off ON in both directions ON when lifting ON when lowering
	Lwr Byps (*Superword only*)	Disable Enable 10 inches	Set Lower Bypass Height - enabled with FlashWare. 0.0 to 48 in. (1 in. increments) **Note**: Setting the height to 0.0 is the same as not having a Lower Bypass
Ld Hndlr	LH Accel	Hard Medium (*default*) Soft	Set Load Handler Acceleration for Traverse and Rotate
	Trvse Sp (*Superword only*)	Slow (*default*) Medium Fast	Set Traverse Speed

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CONFIGURE MODE MENU **Can be entered with Password unless Superword is specified**			
Menu	**Item**	**Selection**	**Description**
BSOC (*Superword only*)	Reset	75 (*default*)	Battery State-of-Charge Reset Variable from 55 to 100 in increments of 1
	Cut Out	20 (*default*)	Select Battery Cutout Voltage Variable from 0 to 50 in increments of 1
Units		English (*default*) Metric	Select English or Metric units of measure.
Guidance	Type	Wire Rail None	Select between Wire, Rail Guidance, or None (only appears if the option is installed on the truck and enabled in FlashWare).
	Set Heading Angle and Distance From Wire		
	HA SLOW	1.6 deg (*default*)	0.6 to 2.0° in 0.2° increments
	HA STOP	3.0 deg (*default*)	2.0 to 4.0° in 0.2° increments
	DFW SLOW	1.6 in. (*default*)	0.6 to 1.6 in. in 0.2 in. increments
	DFW STOP	3.0 in (*default*)	1.6 to 3.0 in. in 0.2 in. increments
	AcquirSpd	1.0 mph (default)	Set Acquire Speed (tractor-first only) 1.0 to full speed in 0.1 mph increments **Note:** Forks-first acquire speed is fixed at 1.0 mph.
	FreeSpeed	Max Speed (*default*)	Set top speed of truck when not in wire guidance mode (Auto/Manual switch in Manual) and the wire is not sensed. 1.0 to max speed (0.1 mph increments)
	SensCreep	Enable (1.0 mph max) Disable	Set Sense Creep Speed. When enabled, Auto/Manual switch in Manual, and wire is sensed, truck soft plugs to 1 mph and remains speed limited until wire is no longer sensed or Auto/Manual switch is set to Auto.
Language		English (*default*) Spanish French	Set language for Error Messages - enabled with FlashWare
PassWord	Password	1 _ _ _ _ _ _ _ (*factory setting*)	Enter New Password Display Current Password
	Superwrd (*Superword only*)	2 _ _ _ _ _ _ _ (*factory setting*)	Enter New Superword Display Current Superword
	Elec Key	3_ _ _ _ _ _ _ (*factory setting*)	Enter New Electronic Keys (up to 20) - enabled with FlashWare Display Current Elec Key

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CONFIGURE MODE MENU **Can be entered with Password unless Superword is specified**			
Menu	**Item**	**Selection**	**Description**
Mnt Mind	Enab\Dis Reset Setup	Disable Enable 300 Hrs (*default*) Msg Only (*default*)	Set parameters for *Maintenance Minder* Turn *Maintenance Minder* ON/OFF Reset #hours (deadman) until next reminder Set #hours between reminders Choose between Lift CutOut or Message Only For more information, refer to "Maintenance Minder™ Tool" on page 4-3)
Clock	Time Date 24-Hour	HH:MM:SS –AM –PM MM/DD/YY Disable Enable	Set Time/Date Set time of day (AM or PM) Set date Turn 24 hour clock ON/OFF
Auto Off		Disable (*default*) 10 Min 5 Min 4 Min 3 Min 2 Min 1 Min	Set idle time for automatic shut-off. Truck turns off after the programmed setting with no activity while off the deadman.
ActMaint (*Superword only*)		Enable (*default*) Disable	Set Active Maintenance
Brighten		Up Down Default	Set brightness of Operator Display
CustInt1 (*Superword only*)	CI Speed CI Lift CI LH	0.0 mph (*default*) Enable Disable (*default*) Enable Disable (*default*)	Customer Interlock Input 1 - Platform: enabled with FlashWare 0.1 mph increments This option can disable lift and load handler functions, and also limit the truck's speed based on the state of the input to the CM.
CustInt2 (*Superword only*)	CI Speed CI Lift CI LH	0.0 mph (*default*) Enable Disable (*default*) Enable Disable (*default*)	Customer Interlock Input 2 - Platform: enabled with FlashWare 0.1 mph increments This option can disable lift and load handler functions, and also limit the truck's speed based on the state of the input to the CM.

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CONFIGURE MODE MENU **Can be entered with Password unless Superword is specified**			
Menu	**Item**	**Selection**	**Description**
CustInt3 (*Superword only*)	CI Speed CI Lift CI LH	 0.0 mph (*default*) Enable Disable (*default*) Enable Disable (*default*)	Customer Interlock Input 3 - Tractor: enabled with FlashWare 0.1 mph increments This option can disable lift and load handler functions, and also limit the truck's speed based on the state of the input to the TM.
CustInt4 (*Superword only*)	CI Speed CI Lift CI LH	 0.0 mph (*default*) Enable Disable (*default*) Enable Disable (*default*)	Customer Interlock Input 4 - Tractor: enabled with FlashWare 0.1 mph increments This option can disable lift and load handler functions, and also limit the truck's speed based on the state of the input to the TM.
iPort	Init Spd	 MAX SPEED (*default*)	Set max travel speed after key switched ON and before the 3rd party unit sends a speed request. 0.1 mph increments
	Err Spd	 MAX SPEED (*default*)	Set max travel speed after communication is lost with the 3rd party unit. 0.1 mph increments
iP Lim (*View only*)	TF MAX SPD	6.0 mph	Max TF travel speed setting
	FF MAX SPD	6.0 mph	Max FF travel speed setting
	Mast Vel DN	100%	Percentage of max lower speed setting
	Mast Vel UP	100%	Percentage of max lift speed setting
	T Accel	Medium	Travel acceleration profile setting
	L Accel	Hard	Lift acceleration profile setting

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Using Learn Mode

To place the lift truck in Learn Mode:

1. Enter Superword.
2. From the Program Mode Superword Level menu, use the **up/down** buttons to select **Learn**, then press the **Enter** button. The selected menu item is indicated by an arrow to the left of the selection.
3. The Learn Mode menu is displayed:
   - Controls
   - Ld Hndlr (Load Handler)
   - Weight
   - Wire Guidance
   - Rail Guidance

   Use the **up/down** and/or **left/right** buttons to select the category desired.

Learn Controls

With **Controls** selected at the Learn Mode menu, press **Enter**.

During Learn Controls, the Carriage Manager control circuits are calibrated to the output voltage of the Rotate (VR3) and Traverse/Reach (VR4) pots.

The Carriage Manager also communicates the status of the Travel (VR1) and Lift (VR2) pots to the Tractor Manager for calibration.

This determines the neutral position for the command pots. The maximum and minimum positions are calculated during Run Mode and adjusted as necessary to compensate for component wear.

Learn Ld Hndlr (Load Handler)

Use Learn Load Handler to determine the extreme positions of the Rotate Position Feedback (VR6) and Traverse Position Feedback (VR5) pots, and opening points for the proportional valves (SOL7 and SOL8) by the Carriage Manager.

⚠CAUTION

Make sure there is sufficient room for the Load Handler to traverse and rotate completely in both directions.

The fork carriage can be in any position at the start of Learn. However, for best results, start from the Load Handler nested right position.

With **LD Hndlr** selected at the Learn Mode menu, press **Enter**.

The Load Handler traverses and rotates with no control inputs once Learn is selected and both Deadman pedals are depressed.

The Load Handler first rotates clockwise to the stop, then counterclockwise to the stop. The Load Handler hits the stops harder than when in Run Mode. The Load Handler should then rotate clockwise and counterclockwise again, slowing down just before reaching the stops.

The Load Handler then traverses left to the stop, pause, then traverse right to the stop. The Load Handler hits the stops harder than when in Run Mode. The Load Handler should then traverse left and right again, slowing down just before reaching the stops.

Learn Weight

Learn Weight is used to calibrate the weight displayed. The Main Lift Pressure transducer is used with the main lift cylinders and the Mini Lift Pressure transducer is used with the mini-mast lift cylinder.

⚠CAUTION

Make sure there is sufficient lifting height to elevate both the main and mini-masts.

1. With **Weight** selected at the Learn Mode menu, press **Enter**. The following message should be displayed.

   Lift main mast at least 4 inches with the forks empty, then press Enter

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NOTE: If mast will not lift the required 4 in., check Lift Bypass (Lft Byps) setting in Configure mode (refer to Table 3-2 on page 3-27).

2. Elevate the truck as instructed.

   LEARNING
   PASSED

   should display.

3. **Lift mini mast at least 4 inches with the forks empty, then press Enter**

   should display.

4. Elevate the truck as instructed.

   LEARNING
   PASSED

   should display.

Learn Wire Guidance

The following information is for a correctly functioning wire guidance system. If problems are encountered while trying to perform these procedures, refer to "Bad Coil Values" on page 5-21.

Learn Guidance is a six step process:

1. Initial Learn Frequency and Signal Strength
2. Initial Learn Offset Between Antennas
3. Initial Learn Steer Zero Position
4. Final Learn Frequency and Signal Strength
5. Final Offset Between Antennas
6. Final Learn Steer Zero Position

Before performing the following procedures:

- Verify the line driver is adjusted to the correct frequency and amplitude.
- Center the truck over the guide wire within 0.5 in. (13 mm).

NOTE: It is easier to center the load antenna first, then center the tractor antenna.

- Place the truck in an area that allows tractor-first travel for upcoming steps.

With **Wire Guidance** selected at the Learn Mode menu, press **Enter**.

Step 1 - Initial Learn Frequency and Signal Strength

Step 1 learns the frequency and field strength of the floor signal. The guidance system actually "searches" for the frequency generated by the floor signal as well as the field strength.

```
Center on wire.  LLL

Press ENTER.    @LLL
LL=58 LN=103 LR=64
TL=71 TN=98 TR=65
```

When the **Enter** button is pressed, the numbers on the display change, indicating the system is switching between multiple frequencies and strengths. The Guidance Manager determines what frequency and field strength the floor signal is generating.

```
Busy learning wire..


LL= 58 LN=103 LR= 64
TL= 71 TN= 98 TR= 65
```

The numbers cycle from 1 to 199 until the system is able to calibrate itself to the floor signal. If the message **Learn wire failed, Press Enter to retry** is displayed, refer to "Bad Coil Values" on page 5-21.

Step 2 - Initial Learn Offset Between Antennas

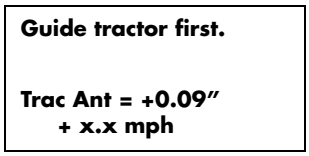
Step 2 learns the Offsets for the antennas. Following the screen message, **Must lock onto wire**, press the Auto/Manual switch to AUTO,

```
Must lock onto wire..
```

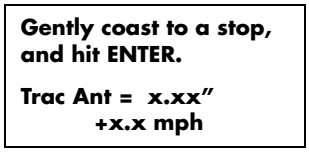
Guide Tractor First. is displayed. The display also shows **Trac Ant = +x.xx"** which is the distance from the wire as calculated by the

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Tractor Antenna. The display also shows **+x.x mph**. Drive tractor-first at 1.5 to 2 mph (2.4 to 3.2 km/h) for a distance of approx. 20 ft. (6m).

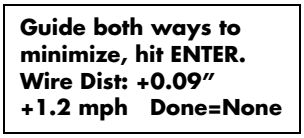


Gently coast to a stop, and hit ENTER is displayed. Return the throttle to neutral and allow the truck to coast to a stop. After the truck has come to a complete stop, press **Enter**. The Trac Ant value should be 0.00 ±0.40.



Step 3 - Initial Learn Steer Zero Position

Step 3 learns the Steer Zero Position. **Guide both ways to minimize, hit ENTER.** is displayed. The display also shows **Wire Dist: +x.xx"** and **+x.x mph**.



NOTE: While performing this portion of Learn, the truck must travel at least 1.5 mph (2.4 km/h) and not be aggressively accelerating. A rotating spinner in the upper right corner of the display indicates a valid Learn is in process.

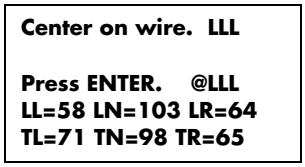
Travel in both directions a minimum of 100 ft. (30.5m) (shorter aisles require multiple runs) until the numbers for **Wire Dist** are consistently within ±0.25 in. in both directions. Press **Enter**. Learn Wire Guidance exits and the Learn Mode menu is displayed.

NOTE: If, after several attempts, the truck does not consistently track within ±0.25 in., press **Enter** to exit. Re-enter Guidance and repeat steps 1 thru 3.

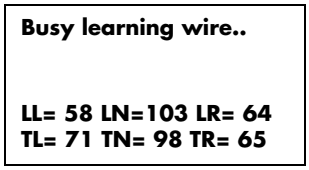
Step 4 - Final Learn Frequency and Signal Strength

Re-enter Wire Guidance Learn.

Step 4 learns the frequency and field strength of the floor signal.



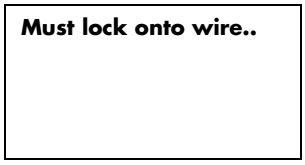
When the **Enter** button is pressed, the numbers on the display change, indicating the system is switching between multiple frequencies and strengths. The Guidance Manager determines what frequency and field strength the floor signal is generating.



The numbers cycle from 1 to 199 until the system is able to calibrate itself to the floor signal.

Step 5 - Final Learn Offset Between Antennas

Step 5 learns the Offsets for the antennas. Following the screen message **Must lock onto wire**, press the Auto/Manual switch to AUTO,



Guide Tractor First. is displayed. The display also shows **Trac Ant = +x.xx"** which is the distance from the wire as calculated by the Tractor Antenna. The display also shows **+x.x mph**. Drive tractor-first at 1.5 to 2 mph (2.4 to 3.2 km/h) for a distance of approx. 20 ft. (6m).

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Guide tractor first.

Trac Ant = +0.09"
+ x.x mph

Gently coast to a stop, and hit ENTER is displayed. Return the throttle to neutral and allow the truck to coast to a stop. After the truck has come to a complete stop, press **Enter**. The Trac Ant value should be 0.00 ±0.10.

Gently coast to a stop, and hit ENTER.

Trac Ant = x.xx"
+x.x mph

Step 6 - Final Learn Steer Zero Position

Step 6 learns the final Steer Zero Position. **Guide both ways to minimize, hit ENTER.** is displayed. The display also shows **Wire Dist: +x.xx"** and **+x.x mph**.

Guide both ways to minimize, hit ENTER.
Wire Dist: +0.09"
+1.2 mph Done=None

NOTE: While performing this portion of Learn, the truck must travel at least 1.5 mph (2.4 km/h) and not be aggressively accelerating. A rotating spinner in the upper right corner of the display indicates a valid Learn is in process.

Travel in both directions a minimum of 100 ft. (30.5m) (shorter aisles require multiple runs). The display indicates when it has successfully learned each direction by displaying **Fork**, **Trac** or **Both** (when both directions are learned).

Continue to drive the truck in both directions until **Done=Both** is displayed.

Learn Rail Guidance

Perform Learn Rail Guidance to adjust the center position of the drive unit so that the truck tracks straight while in the aisle.

1. Place the truck in an area where there is a straight line at least 20 ft. (6m) in length that can be used as a reference (such as wire guidance groove, yellow aisle marker, or rail).
2. Select *Manual* (ON) on the Auto/Manual switch. The truck is now in "seeking mode" and can be driven with manual steering.
3. Position the truck so that it drives parallel to the reference line. Make small corrections with the steer tiller until the truck tracks 10 ft. (3m) without deviating more than 1/2 in. (13 mm) from the straight line.
4. Manually activate and secure the rail switch to simulate the truck is in a rail guided aisle.
5. With **Rail Guidance** selected at the Learn Mode menu, press **Enter**. The display shows "Rail Offset: +/–X.X where X.X is a number between –5.0 and +5.0. This is the steer proximity offset from dead center in degrees. Rail Detect and Auto/Manual switch status is also displayed.

   Rail Offsets +X.X
   Rail Detect Sw: ON/OFF
   Auto/Manual Sw: ON/OFF

6. Select *Auto* on the Auto/Manual switch (OFF). The steer unit centers and manual steer is disabled.
7. Drive forward 10 ft. (3m). Measure deviation from the reference line. Deviation should be <1 in. (25.4 mm). If deviation is >1 in. (25.4 mm), proceed to the next step. If deviation is <1 in. (25.4 mm), proceed to step 11.
8. Drive the truck back to the original position.
9. Use the **up/down** buttons to adjust the value on the display. More negative numbers cause the truck to drive to the right when driven tractor-first. Changing the value by 0.1 corresponds to a deviation of approx. 0.25 in. (6 mm) over 10 ft. (3m).
10. Repeat steps 7 thru 9 until a deviation of 1 in. (25.4 mm) or less over 10 ft. (3m) is achieved.

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11. To save the value, press the **Enter** button. Select **Save? Y** and press **Enter**.
12. Learn Rail Guidance is complete.

Using Maintenance Mode

To place the lift truck in Maintenance Mode:

1. Enter Superword.
2. From the Program Mode Superword Level menu, use the **up/down** buttons to select **Maint**, then press the **Enter** button. The selected menu item is indicated by an arrow to the left of the selection.
3. The Maintenance Mode menu is displayed:
   - Analog
   - Input
   - Output
   - Wire Guidance
   - EvtLog
   - Quit Mnt

   Use the **up/down** buttons to select the category desired, then press the **Enter** button.

Analog (Inputs)

When Analog is selected, Analog inputs are displayed in numerical sequence. Use the **up/down** and **left/right** buttons to scroll to the desired input.

To display the selected input, press the **Enter** button. The Operator Display shows the input number and its status. To return to the Analog menu, press the **left** or **right** button.

Refer to "Analog Inputs" on page 6-35.

Input (Digital)

When Input is selected, Digital inputs are displayed in numerical sequence. Use the **up/down** buttons to scroll to the desired input.

To display the selected input, press the **Enter** button. The Operator Display shows the input number and its status. To return to the Input menu, press the **left** or **right** button.

Refer to "Digital Inputs" on page 6-35.

Output Tests

When Output is selected, Output Tests are displayed in numerical sequence. Use the **up/down** and **left/right** buttons to scroll to the desired test.

⚠ WARNING

When performing an output test, elevate the drive tire off the floor. See "Jacking Safety" on page 2-10. Open the Emergency Lowering Valve. See "Main Manifold" on page 7-70.

To "run" a selected test, press the **Enter** button. The Operator Display prompts you to jack the drive wheel off the floor and to open the Emergency Lowering Valve. The Operator Display shows the test number and its results. To return to the Output menu, press the **left** or **right** button.

Refer to "Output Tests" on page 6-36.

Wire Guidance

Wire Guidance Maintenance Mode can be used to examine system tracking (**Tracking Values**), view individual antenna coil inputs (**Coil Values**), and clear the EEPROM on the Guidance Manager card (**Clear WG EEPROM**). The system can function at several different frequencies and strengths. The Wire Guidance floor signal strength must be consistent throughout the warehouse. Refer to Publication PDSS-0051 for floor adjustment, troubleshooting, and additional information.

Tracking Values

Use Tracking Values to monitor the Wire Guidance calculated position and record Tractor First (TF) and Forks First (FF) position values. When centered over the wire, near-wire coil signal strength is typically about 100%.

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When the Auto/Manual switch transitions from Manual to Auto, the stored values are cleared. When the Auto/Manual switch transitions from Auto to Manual after tracking the wire, the following values are displayed (see Figure 3-35):

- Truck speed (**X.X**) in upper left corner
- Distance From the Wire (**DFW"**) in inches
- Heading Angle (**HA**) in degrees
- Near Wire signal as a percentage (**NW%**)

Figure 3-35. Wire Guidance Tracking Values



Term	Meaning
Now	Present calculated reading of coils
MaxT	Max. calculated reading of tractor coil pair
MinT	Min. calculated reading of tractor coil pair
MaxF	Max. calculated reading of fork coil pair
MinF	Min. calculated reading of fork coil pair

NOTE: Coil NW% can range from 0 to 199%.

When traveling TF, the NW% coil readings are from the tractor end antenna coils. When traveling FF, the NW% coil readings are from the load end antenna coils. The display alternates automatically, depending on direction of travel. Use the **Up/Down** buttons to obtain differences between the TF and FF tracking information when the truck is not over the guide wire and tracking.

Procedure: Enter Wire Guidance/Maintenance Mode/Tracking Values. Lock the truck onto the wire (if presently locked onto the wire, cycle the Auto/Man switch to clear existing values) and travel in both directions. Drive the truck the full length of the aisle. As the truck travels on the wire, minimum and maximum tracking values are automatically recorded. The following table lists acceptable values.

	DFW"	NW%
MaxT and MaxF	0.00 to +1.00	90 to 130%
MinT and MinF	0.00 to –1.00	70 to 110%

If the values displayed are not within these limits, re-Learn the Wire Guidance system and check again. See "Learn Wire Guidance" on page 3-34.

Coil Values

Use Coil Values to monitor what the Guidance Manager is sensing from the individual antenna coils for multiple frequencies. The readings can be used to aid in troubleshooting the system. The **Now**, **Min**, and **Max** coil strengths can be selected for display. When the truck is centered over the wire, the inner (near wire) coil signal strength is typically about 100%. Outer (left and right) coil signal strength is approx. 60% to 70%. These values are affected by truck position relative to the wire and wire depth in the floor. For more information, refer to "Wire Guidance Troubleshooting" on page 5-21.

Clear WG EEPROM

This is used to clear the EEPROM on the Guidance Manager card. When this occurs, learn Wire Guidance must be performed. See "Learn Wire Guidance" on page 3-34.

1. Select **Clear WG EEPROM** from Wire Guidance sub-menu.
2. **Reset? N** is displayed. Press the **right** button.
3. **Reset? Y** is displayed. Press **Enter**. The wire guidance EEPROM is cleared.

Evt Log

When Event Log is selected, the last twenty error codes recorded are displayed. Each entry shows the code and the date and time of occurrence.

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- Use the **up/down** buttons to switch between pages 1 and 2 of the log.
- Use the **left/right** buttons to exit the log back to the Maintenance Mode menu.
- If the log displays the message “Error Log is empty”, no error codes were recorded since the log was last cleared.
- To clear and reset the Event Log, select **Clear** and press **Enter**. On the Clear menu, select **Yes** with the **down** button, then press the **Enter** button. The log is cleared and the display returns to the Maintenance Mode menu.

Using Active Maintenance Mode (ActMaint)

Active Maintenance Mode allows inputs to be displayed while the truck is in Run mode.

ActMaint is enabled in Configure Mode. Refer to “Using Configure Mode” on page 3-26.

1. While in Run Mode (while time and date are displayed), use the **up/down** buttons to scroll to either Analog or Input and press **Enter**.
2. Use the **up/down** buttons to scroll to the desired item. Refer to “Analog Inputs” and “Digital Inputs” on page 6-35.

Graphics Database Download

Perform a graphics database download:

- if the Operator Display shows Code 57 and the truck is operational
- the Display Interface Card is replaced
- anytime the truck software is updated

To do this:

1. Turn the key switch OFF.
2. Press and hold the lift select button.
3. Step on and hold both deadman pedals.
4. Turn the key switch ON.
5. Press and release the lift select button three times.
6. The Operator Display then shows in large letters:

   Configuration Download in Progress
7. Wait for the download to complete (approx. 45 seconds to 1 minute). When the download has completed, the Operator Display shows:

   Configuration Download Complete
8. Step off both deadman pedals. Turn the key switch OFF.
9. Turn the key switch ON. The lift truck should go through normal SelfTest.

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RAYMOND

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Section 4. Scheduled Maintenance

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Scheduled Maintenance Guidelines

Following a regularly scheduled maintenance program:

- promotes maximum truck performance
- prolongs truck life
- reduces costly down time
- avoids unnecessary repairs

Scheduled maintenance includes:

- Lubrication
- Cleaning
- Inspection
- Service

Perform all of the scheduled checks and maintenance during the suggested intervals. The time intervals given in this guide are based on Deadman Hours (HD) under normal operating conditions.

When operating under Severe or Extreme conditions, perform these services more often as indicated in the following table.

Operating Conditions	Working Environment	Service Frequency
Light to Moderate	An eight hour shift 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 in chlorine or salt-sea air environments	100 hours

Hour Meters

To display the lift truck hour meters, turn the key switch OFF. Press and hold the horn button while turning the key switch ON. The Operator Display lists the accumulated totals in the following lift truck hour meters:

- **KH**: Total hours the key switch has been turned ON
- **HD**: Total hours on deadman
- **HL**: Total hours spent lifting and lowering
- **TM**: Total distance traveled (miles or kilometers, depending on Units specified in Config)
- **HT**: Total hours spent traveling
- **HA**: Total hours on Load Handler

To exit, press and release both deadman pedals.

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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 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"
- The audible alarm sounds a high pitch tone every 5 seconds.

Lift Cutout, when active, does 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.

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 "Overview of Modes" on page 3-22.

With Configuration Mode selected, use the **down** button to display the "Mnt Mind" item. Press the **right** button. With "Enab/Dis" 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.

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.

The first time the Setup menu is entered, the Factory default setting is displayed. Afterward, when the Setup menu is eneterd, the setting last used is displayed. Values from 50 to 500 deadman pedal hours are available. Use the **up/down** buttons to scroll to the desired time interval. With the selected value displayed, press the **Enter** button.

Next, select one of the following options:

- "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.

Use the **up/down** buttons to select the option you want, then press the **Enter** button. Exit Program Mode.

Resetting *Maintenance Minder*

If you want to reset the reminder prompt when *Maintenance Minder* is active and you have done 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 "Reset". Press the **Enter** button. Exit Program Mode.

Disabling

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

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With Configuration Mode selected, use the **down** button to display the “Mnt Mind” item. Press the **right** button. With “Enab/Dis” highlighted, press the **right** button. Use the **up** button to select “Disable.” Press the **Enter** button. Exit 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 cannot exit to the main menu until you have selected either **Restore** or **Save** and pressed the **Enter** button.

4. Use the **up/down** buttons to select Quit. Press the **Enter** button. The truck goes through reset, then enters Run Mode.

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Initial 90 Day/250 Deadman Hour (HD) Maintenance

Perform the following maintenance tasks 90 days or 250 HD after the truck was put into service, whichever comes first.	
Component	**Task**
Drive Unit	Break mounting bolts free and reapply thread-locking compound (P/N 990-544). Re-torque mounting bolts to 350 ft. lb. (475 Nm). Change fluid.
Hydraulic Tank	Change fluid and filter.
Power Amplifiers	Torque power cable terminal nuts to 11 ft. lb. (15 Nm).

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Every 180 days or 500 Deadman Hours (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.
Brakes	In an open area, measure stopping distance. Traveling to 2 to 3 mph (3.2 to 4.8 km/h) 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 approximately one and one-half truck lengths. Stopping distance depends on the load, floor, and tire condition. 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. (1.0 mm) max. See Figure 7-43 on page 7-36.
Contactor	Inspect contactor tips for burnt or pitted surfaces. Failure to replace the tips may prevent the contactor from opening or closing causing unscheduled downtime. With the key switch OFF and the battery disconnected, check the plunger for smooth operation with no binding. If binding occurs, the lift truck may malfunction or exhibit intermittent fault codes.
Control Handle(s)	Verify: • lift/lower function is smooth and controllable • travel function is smooth and responsive through full range of motion • rotate function is smooth and controllable • traverse function is smooth and responsive through full range of motion Check for play in the center position of all pots; repair/replace control handle if necessary. Verify function of all switches.
Deadman Pedals	Check for smooth operation with no binding through full range of pedal stroke. Test correct operation of the deadman switch by the pedal.
Drain Holes	Beneath deadman pedal and in battery compartment - make sure the drain holes are not blocked by any debris.
Drive Unit	Check fluid 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. See “Radial Ring Inspection” on page 7-32.
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 drive 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 tension so the cables just stay on the pulleys. Higher tension causes premature failure. Maximum spring tension is 5 to 7 lb. (2.2 to 3.2 kg).
Fans	Check for correct operation. Run Test O23 – Fans (page 6-133).

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Perform the following maintenance tasks every 180 days or 500 HD, whichever comes first.	
Component	**Task**
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 4-15.
Frame and Baseleg Checks	General 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, manifolds, mast-to-tractor mounting bolts). Tighten any loose hardware. Replace any broken or missing hardware. See "Component Specific Service/Torque Chart" on page A-4.
Horn	Check that horn sounds when activated. Check mounting bracket insulators.
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 pulleys spin freely and show no signs of wear.
Hydraulic Tank	Check fluid level.
Lift Chains	Check adjustment. See "Chain Maintenance" on page 4-14. Inspect for excessive stretch or wear (tool P/N 950-350/CG). Lubricate. See "Lubrication Specification Chart" on page A-2.
Lower Solenoid	Run Test O62 – Lower Sol [Lower Solenoid (SOL1)] (page 6-153).
Lubrication	Lubricate all grease points. See "Lubrication Points" on page 4-11.
Mast	Examine mast bearings. Inspect mast and carriage stops for tightness and wear. Inspect the outside of the main frame for wear. Inspect rails for abnormal wear, metal flakes, or shavings. Repair any grooves worn in the mast deeper than 1/8 in. (3 mm). *9600 Only* - Wipe old grease off mast uprights and apply new grease.
Mini-Mast	Traverse - Inspect the traverse rack and gears for wear. Check wear pad adjustment. Check traverse stop mounting bolt torque. Make sure traverse roller bearings are not binding or damaged. Make sure hose and cable guards are not damaged. Remove and clean Load Handler manifold filter. See "Load Handler Manifold" on page 7-71. Apply a thin coat of grease where the pucks contact the Mini-Mast lift cylinder.

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Every 180 days or 500 Deadman Hours (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. Verify the inside and outside nut are 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 - Visually 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. Find the shortest brush in the holder. Remove the brush and check overall dimension. See Table 7-6 on page 7-54. 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 the connections on the brush leads are tight. Check brush spring tension. Blow out the inside of the motor with compressed air. Check the cable lugs to make sure they are tight to the terminal studs. Verify both the inside and outside nut are torqued 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 carriage.
Power Amplifiers	Check torque on power amplifier connections.
Pump Coupling	Separate lift pump and motor. Apply Molybdenum Anti-Seize Compound (P/N 990-638) to the splines. See “Pump Maintenance” on page 7-68.
Safety Belt or Harness and Tether	Check for signs of wear, fraying, or damage. Check anchor points on overhead guard for damage.
Shorts to Frame	Check for electrical shorts to frame. See “Shorts to Frame Test” on page 5-3. Wipe compartments clean.
Side Gates and Barrier	Check for correct operation and/or damage.
Stability Pads	Check stability pad clearance to floor. Replace if clearance is >0.75 in. (19.05 mm).
Static Straps	Make sure static straps are not worn or broken. Clean debris from straps. Check resistance of resistor in standoff. EE Labeled lift trucks require a phosphor bronze static strap; do not use steel braided cable on EE labeled lift trucks.
Steering	Check that steering system function is smooth and responsive. Inspect the teeth on the steering gear and drive unit for wear. Check gap on Home Steering Proximity Sensor.
Switches	Check all switches for correct operation and adjust as needed.
Travel Alarm(s)	If epuipped, check for correct operation.
Ventilation Slots	Make sure ventilation slots in the tractor frame/cover are clear of obstructions and debris.
Warning Decals	Replace any illegible or damaged decals.
Warning Lights	Check for correct operation.
Wheels and Tires	Examine for bond failure, chunking, and excessive or uneven wear. Inspect load wheel bearings for binding or excessive play.

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Perform the following maintenance tasks every 180 days or 500 HD, whichever comes first.	
Component	**Task**
Wire Guidance	Check sensor assemblies for damage and mounting hardware for tightness. Verify the lift truck acquires and tracks the guide wire correctly. Verify the brake is applied when truck loses wire signal.

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Every 360 Days

Perform the following maintenance tasks every 360 days.	
Component	**Task**
Drive Unit	Change fluid.
Hydraulic Tank	Change hydraulic fluid and filter.
Pump Coupling	Separate load handler pump and motor. Apply Molybdenum Anti-Seize Compound (P/N 990-638) to the splines.

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Lubrication Points

Fluids

See "Lubrication Specification Chart" on page A-2.

Hydraulic Fluid

Reservoir capacity is 15 gal. (57 l), *not including* fluid in cylinders and hoses.

Drive Unit

Drive unit capacity is 7.12 qt. (6.75 l).

Lubrication Point Locator Photos

Figure 4-1. Lubrication Points, Fork Carriage Fittings

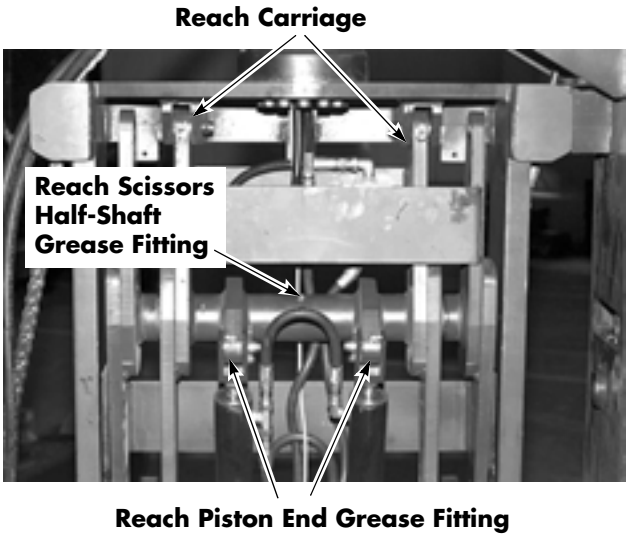
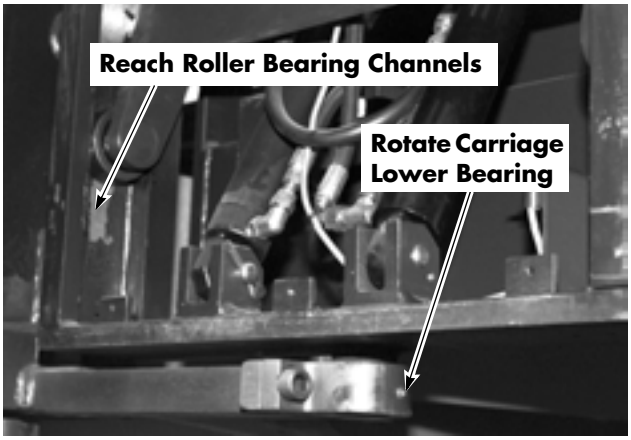


Figure 4-2. Lubrication Points, Fork Carriage Bearings



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Figure 4-3. Mini Mast and Load Handler

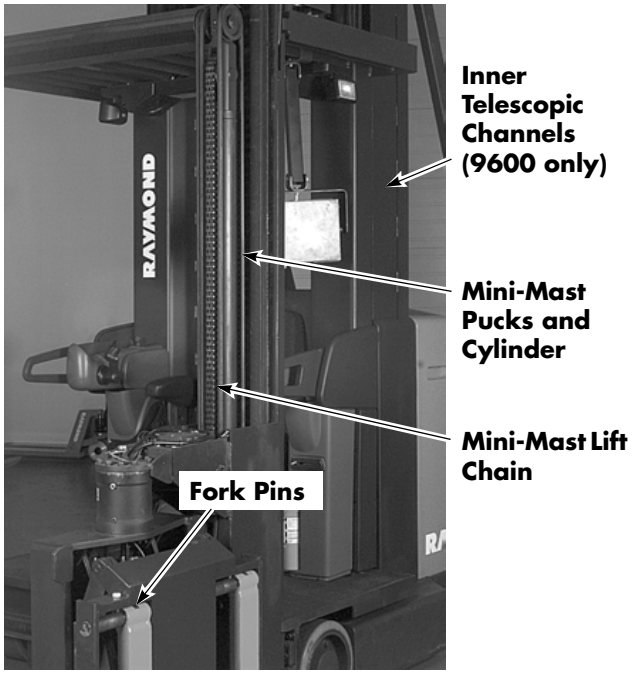


Figure 4-4. Traverse Rack

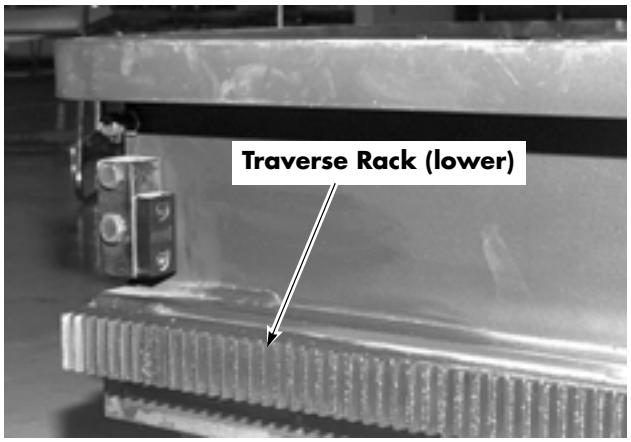


Figure 4-5. Lower Traverse Gears and Bearings

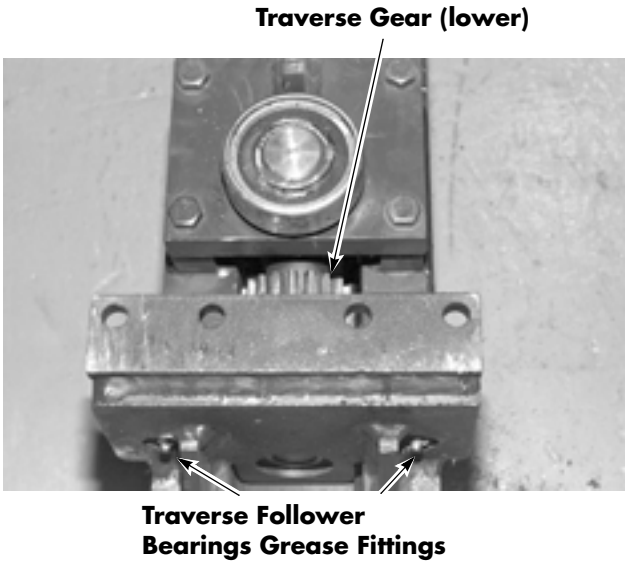
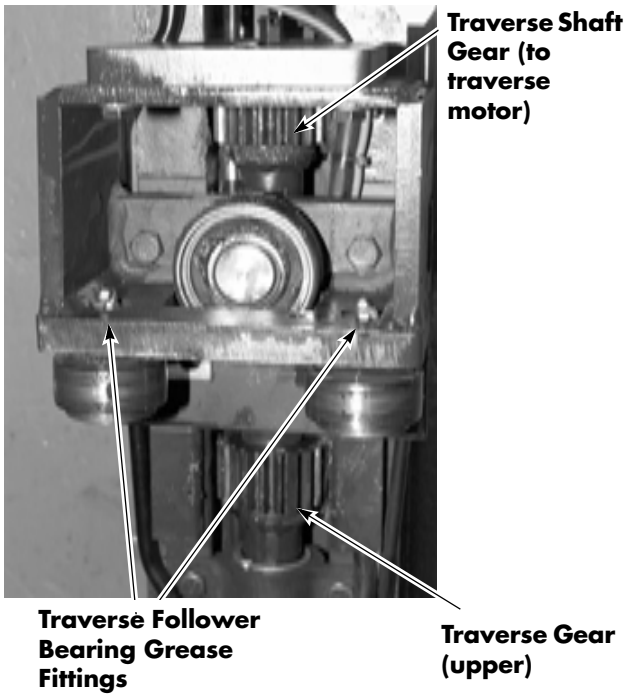
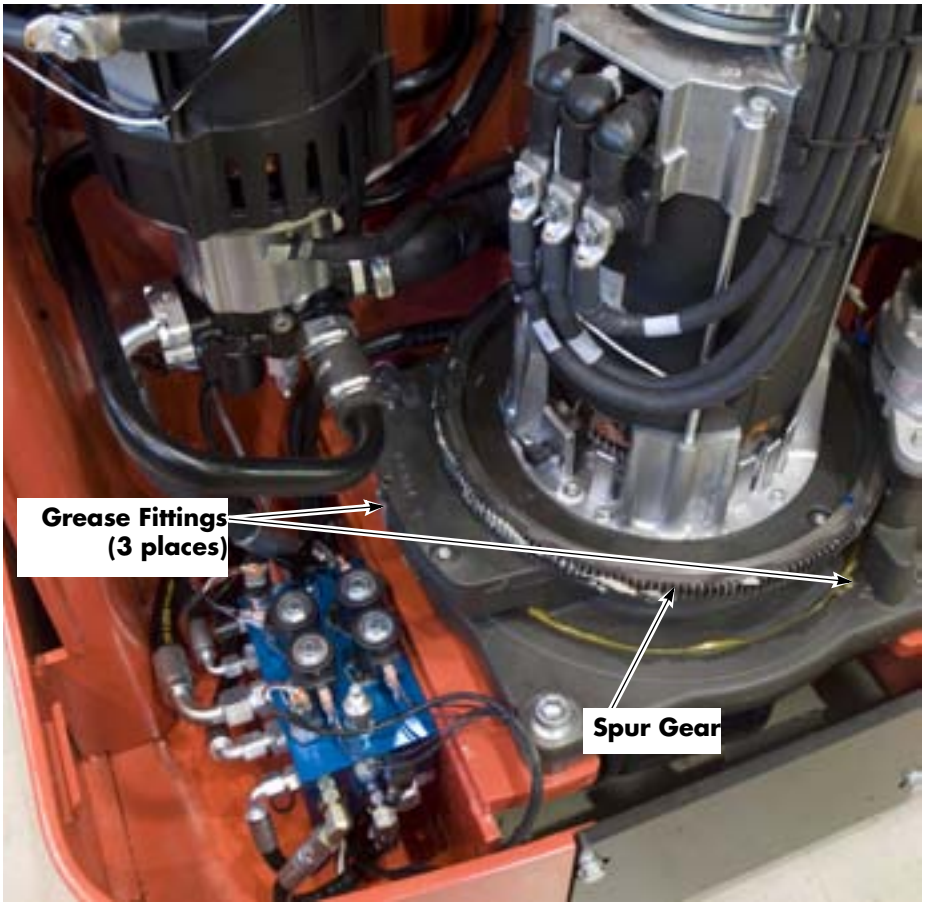


Figure 4-6. Upper Traverse Gears and Bearings



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Figure 4-7. Lubrication Points, Drive Unit



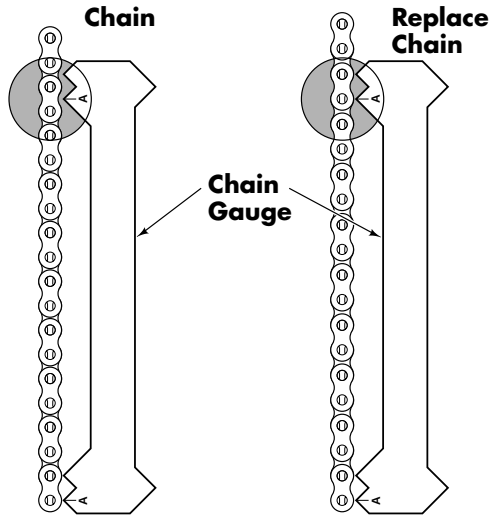
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Chain Maintenance

Inspection

Make sure chains are not damaged. Check the chain for wear using a Chain Gauge (P/N 950-350/CG). See Figure 4-8.

Figure 4-8. Chain Gauge



Problem	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 5/16 in. (8 mm) play is detected, replace the chain.
	Lack of oil	
Rust and Corrosion	Steam cleaning or degreasing new truck chains.	Oil chain frequently. Refer to Scheduled Maintenance.
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	Realign the chain on the pulleys.

Chain Adjustment

See "Main Lift Chains (9600)" on page 7-92, "Main Lift Chains (9700)" on page 7-94, and "Fork Height and Lift Chain Adjustment" on page 7-115.

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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

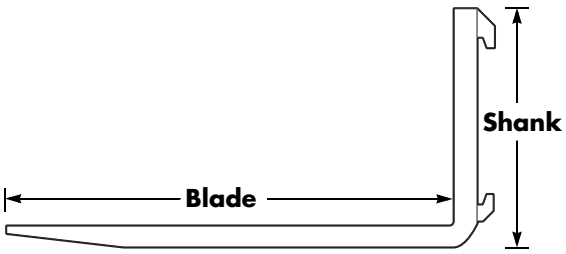
Pay special attention to the heel and welds attaching mounting components. If any damage is found, remove the fork from service.

Straightness of Blade and Shank

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

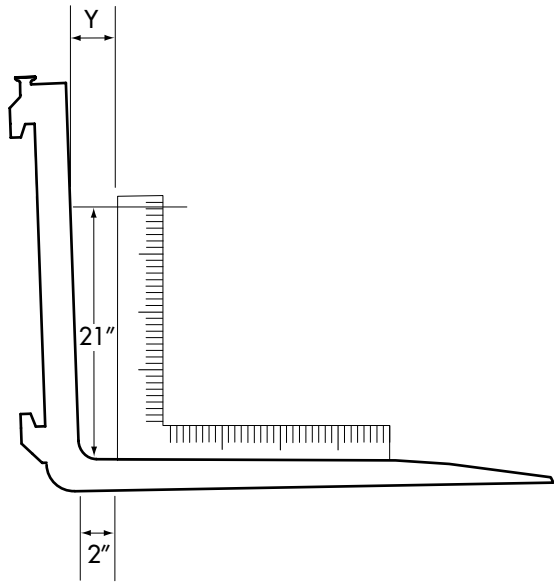
1. Measure the length of the blade and the height of the shank. See Figure 4-9.

Figure 4-9. 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 4-10.
4. At 21 in., measure the distance between the face of the shank and the framing square. See Figure 4-10.

Figure 4-10. Fork Measurement with Framing Square



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

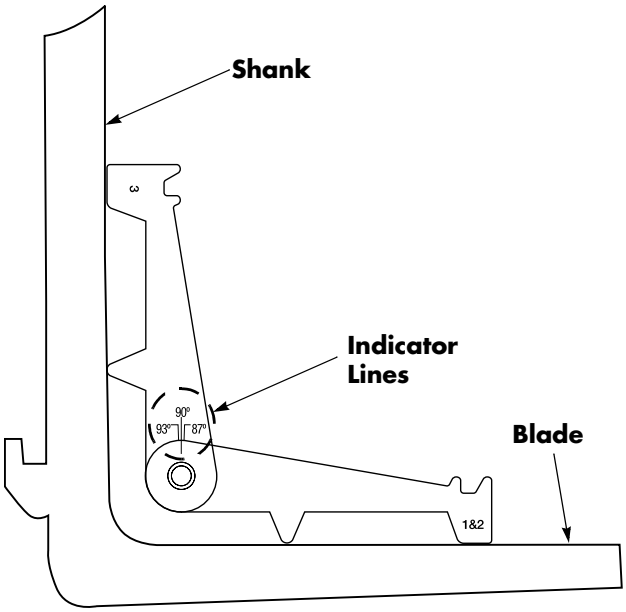
Fork Angle

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 4-11.
2. Now open and move the caliper so the two extruded points are touching the shank. See Figure 4-11.

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Figure 4-11. Fork Angle



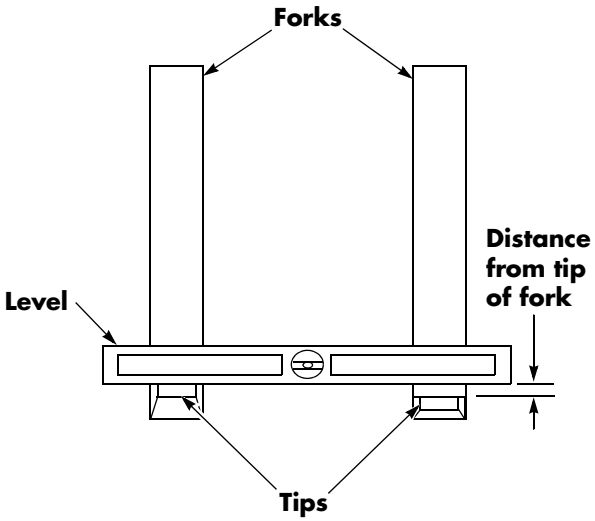
3. When all four extruded points are in contact with the fork, gently remove the caliper and note the reading on the indicator line, located right above the hinge pin. See Figure 4-11.
4. If the deviation is greater than 3° of the original angle, remove the fork from service.

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 4-9.
   - 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 4-12.
4. Raise one end of the level to make it level. See Figure 4-12.
5. Measure the distance from the tip of the fork. See Figure 4-12.

Figure 4-12. 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.

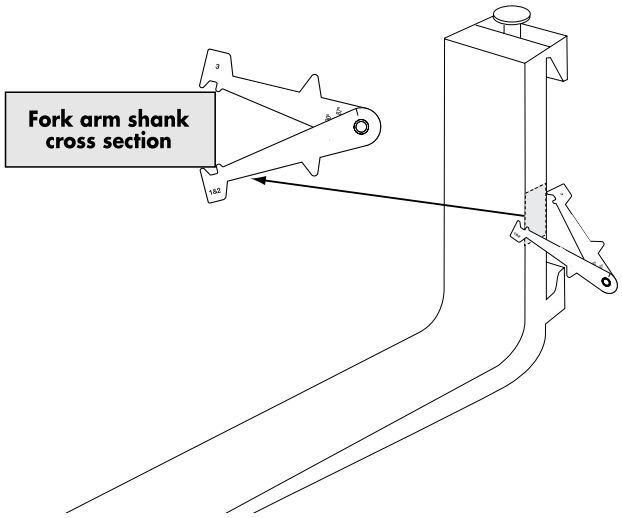
Wear

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 the caliper from the shank. See Figure 4-13.

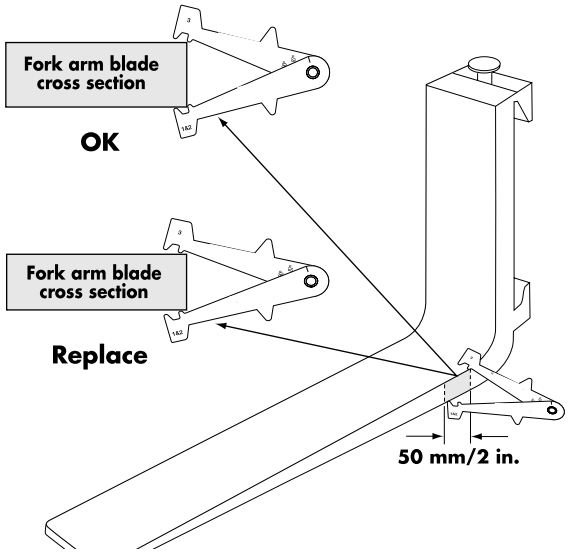
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Figure 4-13. Measuring Fork Shank



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 4-14.

Figure 4-14. 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

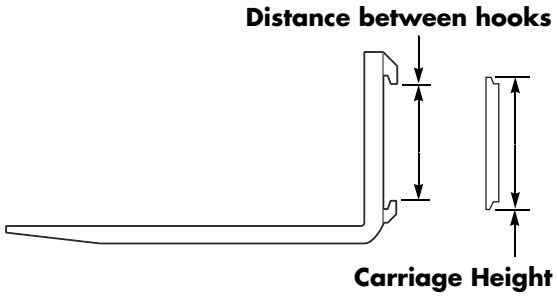
If there is greater than 10% wear of the fork arm, the fork has at least a 20% reduction in capacity.

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 4-15.

Figure 4-15. Determining Fork Mounting Class



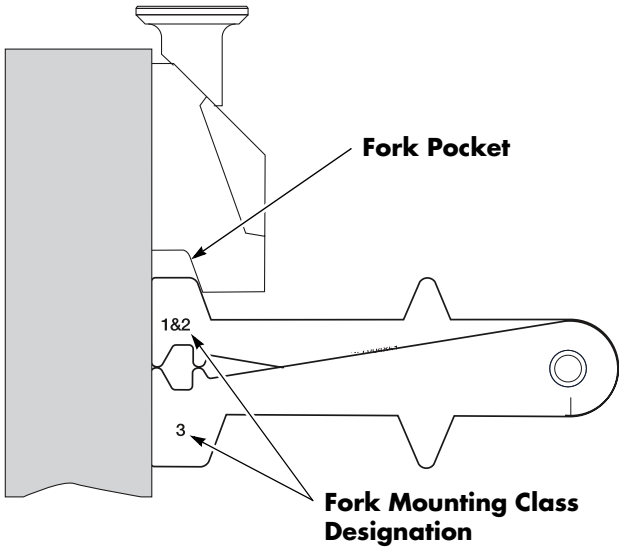
b. Compare this measurement to the table below.

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 4-16.
4. Slide the extruded edge up into the hook pocket. See Figure 4-16.
5. If the caliper's extruded edge *completely slides up into the fork pocket*, remove the fork from service. See Figure 4-16.

Figure 4-16. 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.

Use extreme care when the truck is jacked up for any reason. Never block the lift truck between the carriage and the floor. 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. See "Jacking Safety" on page 2-10.

Unless otherwise directed, disconnect the battery connector when you check electrical circuits 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

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- Bus bars
- Solenoids
- Contactors
- Terminal strips
- Switches
- Power panel insulation
- Circuit card mounts

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 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 truck, then continue with Step 4. Make sure the battery case does not touch the truck frame during the remaining tests.
4. With the battery disconnected (or removed and disconnected) from the 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.

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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 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 bad. 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 truck or the battery. If you previously removed the battery from the 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	100	Contactor/Fuse Panel	Power fuse for steering
FU2	500	Contactor/Fuse Panel	Power fuse for traction
FU3	675	Contactor/Fuse Panel	Power fuse for lift
FU4	200	Contactor/Fuse Panel	Power fuse for Load Handler Motor
FU5	15	Fuse/Relay Card	B+ Control fuse for Key switch and EPO
FU6	15	Fuse/Relay Card	B– Control fuse for Tractor and Carriage Manager
FU7	15/5	Fuse/Relay Card	B+ Control fuse for options
FU8	15/5	Fuse/Relay Card	B– Control fuse for options
FU11	70	Contactor/Fuse Panel	Power fuse for Aux option
F101	2	Light/Fan Package	Fans/Lights
F102	2		
F103	2		
F104	2		

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DC Motors

Types of DC Motors

There are two primary types of DC Motors:

- A series-wound motor has only two external connections because the armature and field windings are connected internally.

Figure 5-1. Series-Wound Motor Circuit



- A permanent magnet motor has two external connections. The field is produced by an internal magnet.

Figure 5-2. Permanent Magnet Motor Circuit



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

Inspection

Inspect 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 service.

Service

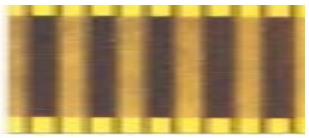
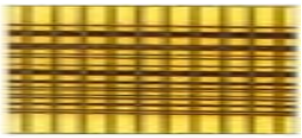
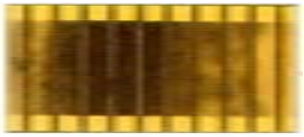
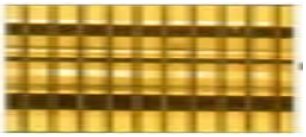
If the commutator requires service, you must remove the armature from the motor.

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

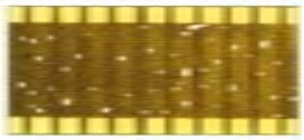
Servicing a motor for an abnormal commutator surface condition and high mica or mica undercutting requires special equipment at a motor rebuilding facility.

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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, however, machines having this 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.	
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.	

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Condition	Probable Cause	Commutator Surface
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, results 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 Figures 5-1 and 5-2 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
Load Handler	LHM-A1 to LHM-S1	<1 ohm
	LHM-A1 or LHM-S1 to Frame	>100,000 ohms
Steer	MSA1 to MSA2	<1 ohm
	MSA1 or MSA2 to Frame	>100,000 ohms

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.

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.

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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.

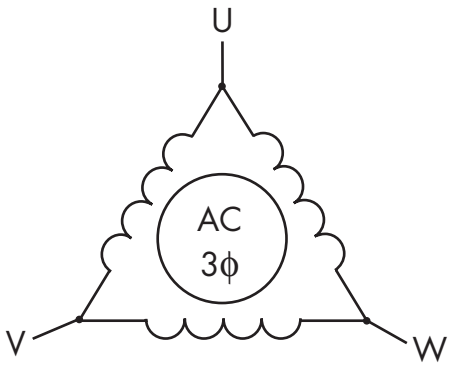
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AC Motors

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 5-3.

Figure 5-3. 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 reads 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 reads 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 the 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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Electrical Connector Locator Chart

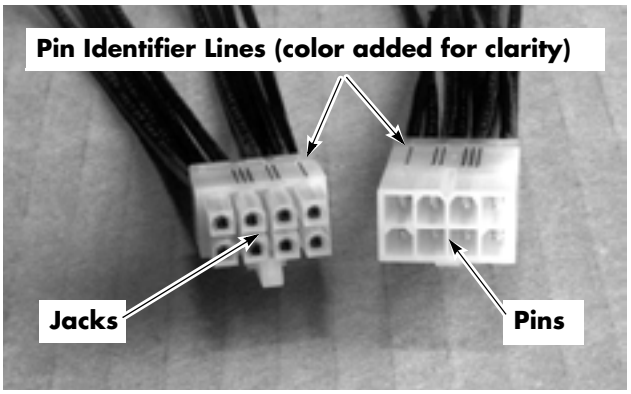
Terminology

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

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

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 5-4.

Figure 5-4. Molex Jack and Pin Connector



Use Table 5-3 (or the graphics beginning on page 5-15) to locate electrical connectors on the lift truck.

Table 5-3. Electrical Connector Locator Chart

Connector	Location	Function/Destination
J1	Near Tractor Manager	Lift/Lower pendant
JP1L	Under Platform	Wire guidance load sensor antenna
JP1T	Behind Front Bumper	Wire guidance tractor sensor antenna
JP2	Load Handler	Mini-mast height prox
JP3	Near Reach Scissors	Reach prox
JP4	Near Rotate Pot	Rotate pot
JP5	Turret - underside	Mini power supply
JP10	Top Tractor Cover	Warning/strobe light
JP12	Mast Crosstie	Travel light
JP18	Under Seat	OTM cable
JP19	Under seat - left side	
JP20	Right side of Seat	Load handler solenoid intermediate connector
JP21	Top of Mini-Mast	
JP27	Left Control Handle	Left-hand deadman
JP46	Main Manifold	Mini-Mast lift pressure transducer
JPA1	Supplemental Display	Supplemental Operator Display
JPA7	Drive Unit - right side	Home steer prox

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Electrical Connector Locator Chart

Connector	Location	Function/Destination
JPB–	Battery	B– cable
JPB+		B+ cable
JPBR	Top of Traction Motor	Brake coil
JPBSEN1	Above Main Manifold	Battery gate prox 1
JPBSEN2	Underneath Horn	Battery gate prox 2
JPC4	Carriage Manager	Refer to "Schematics" on page A-19.
JPC6		
JPC10		
JPC12		
JPC14		
JPC18		
JPC22		
JPC24		
JPD1	Display Interface Card	Display screen
JPD2		Menu switches
JPD3		CAN Bus+ power
JPD4		Horn (sounder)
JPD5		CAN baud rate
JPE1	Under Left Control Handle	Steer Encoder
JPE2		
JPE4	Steer Motor	Steer motor feedback encoder
JPE5	Tractor Bulkhead Panel	Main lift height encoder intermediate connector
JPE5A	Top of Mast	Main lift height encoder
JPF1	Fuse/Relay Card	Refer to "Schematics" on page A-19.
JPF2		
JPF3		
JPF4		
JPK2	Top of Mini-Mast	Traverse Feedback Pot
JPKP	Right Control Handle	Operator display control switches
JPL1	Left Control Handle	Left control handle inputs to CM
JPL2	Inside Left Control Handle	5V supply to VR3 and VR4
JPL19	Right side of Seat	Light/Fan harness intermediate connector

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Connector	Location	Function/Destination
JPLA1	Lift Power Amp	LPA connector
JPLA2	Near Lift Motor	Lift motor encoder
JPLA3		Lift motor temperature sensor
JPOM1	Top of Mini-Mast	Over the mini-mast cable
JPOM2	Turret - underside	
JPOM3	Top of Mini-Mast	
JPOM4	Turret - underside	
JPFAN1	Near Load Handler pump	Load handler cooling fan
JPFAN2	Top cover	Top cover cooling fan (optional)
JPFAN3		
JPR1	Right Control Handle	Right control handle
JPR2	Inside Right Control Handle	5V supply to VR1 and VR2
JPRDP	Supplier Wireless Module	*iWarehouse*
JPLHA1	Below Left Control Handle	Left control handle - intermediate connector
JPLHA2		Left control handle heater option - intermediate connector
JPRHA1	Below Right Control Handle	Right controls (handle, EPO, key switch) - intermediate connector
JPRHA2		Display, lights, and fan switches - intermediate connector
JPRHA3	Near Carriage Manager	Right control handle heater option - intermediate connector
JPS1	Contactor Panel	Contactor panel interface
JPS2		
JPS3	Tractor Bulkhead Panel	Slack Chain Switch 1
JPS4	Guidance Manager	Guidance Manager
JPS5	Tractor Bulkhead Panel	Slack Chain Switch 2
JPS6	Guidance Manager	Guidance Manager
JPS7	Behind Fuse/Relay Card	Top cover cooling fan (optional)
JPS8	Tractor Bulkhead Panel	Lift reference prox switch
JPS25		OTM cable
JPS26		
JPS27	Right side of Seat	Over the mini-mast cable
JPS44	Near Guidance Manager	Travel light - intermediate connector
JPS45		Travel alarm - intermediate connector

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Electrical Connector Locator Chart

Connector	Location	Function/Destination
JPS50	Main Manifold	Main lift pressure transducer
JPS54	Behind Fuse/Relay Card	Aisle detect sensors - intermediate connector
JPS55	Near Steer Motor	Rail guidance switch
JPT2	Tractor Manager	Refer to "Schematics" on page A-19.
JPT4		
JPT6		
JPT9		
JPT10		
JPT12		
JPT14		
JPT18		
JPT20		
JPT22		
JPT24		
JPTA1	Traction Power Amplifier	TPA connector
JPTA2	Traction Motor	Traction motor encoder
JPTA3		Traction motor temperature sensor
JPTA4	Harness above Traction Motor	Traction motor encoder/temp sensor intermediate connector
JPW1	Filter Card	Load sensor antenna connector
JPW2		Tractor sensor antenna connector
JPW7	Right Control Handle	Control handle heater, right side - optional
JPW8	Left Control Handle	Control handle heater, left side - optional
JPZ	Near Load Handler Fan	Load Handler Motor temperature sensor

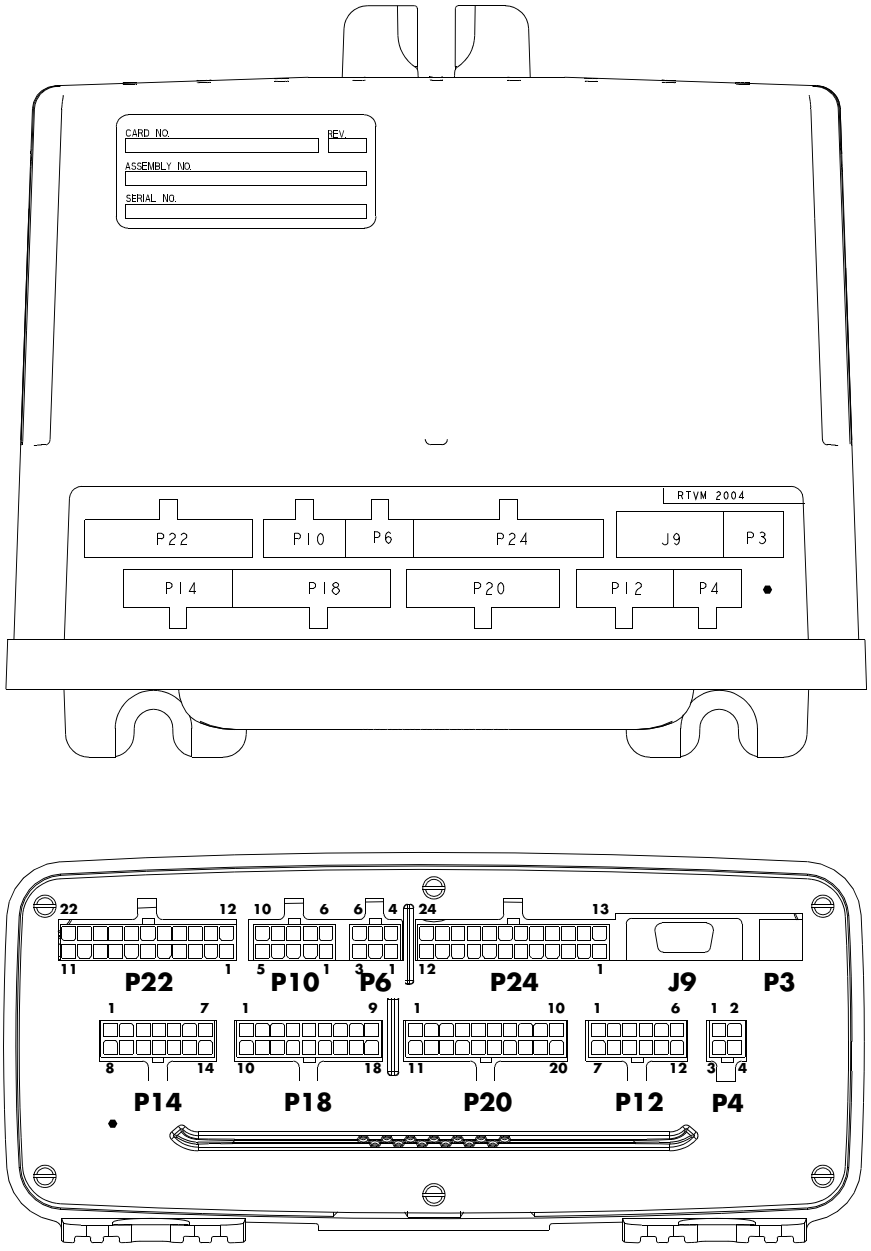
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Circuit Card Connectors

Refer to the following figures for circuit card connector and pin locations.

Tractor and Carriage Manager

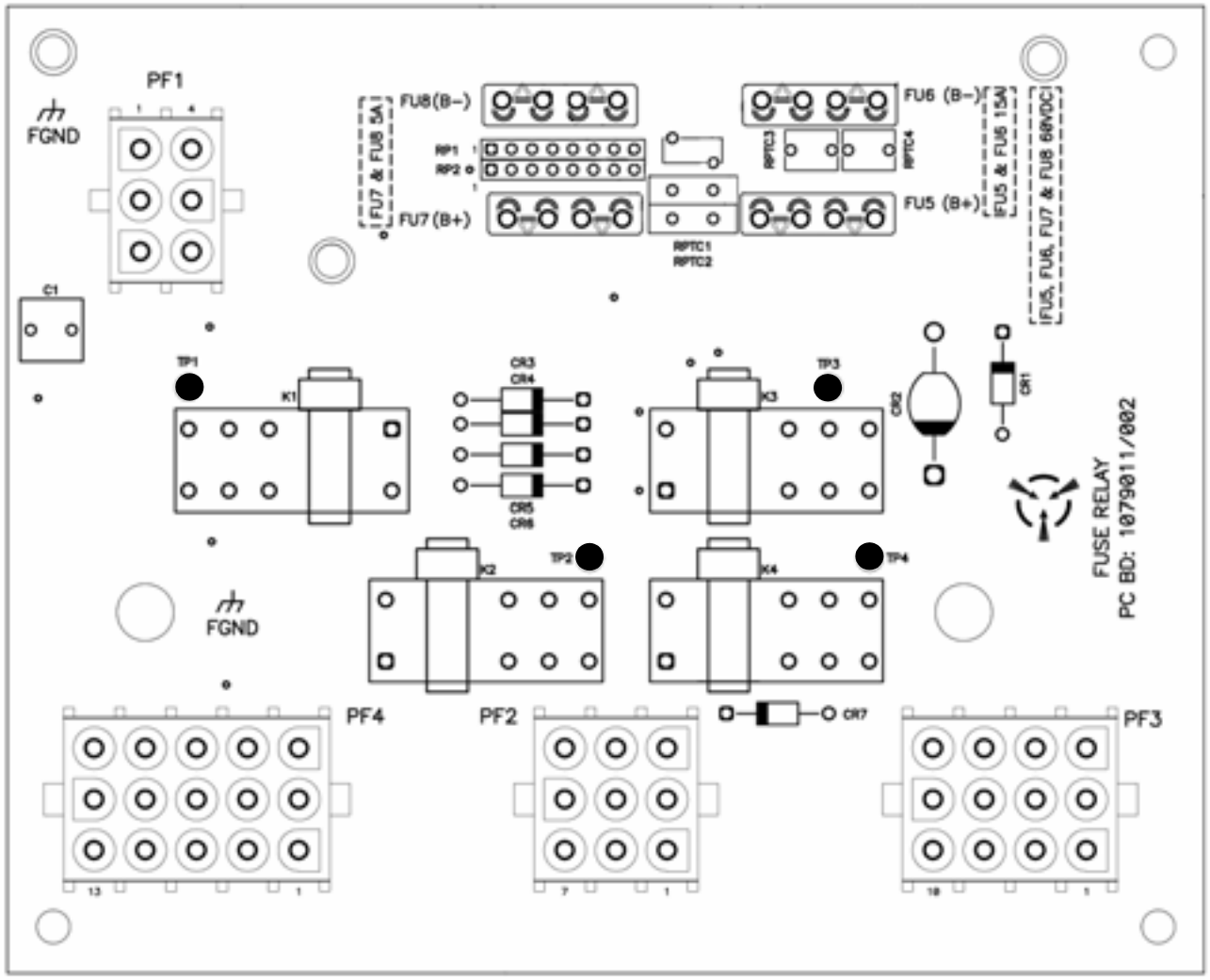
Figure 5-5. Tractor/Carriage Manager Connectors



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Fuse/Relay Card

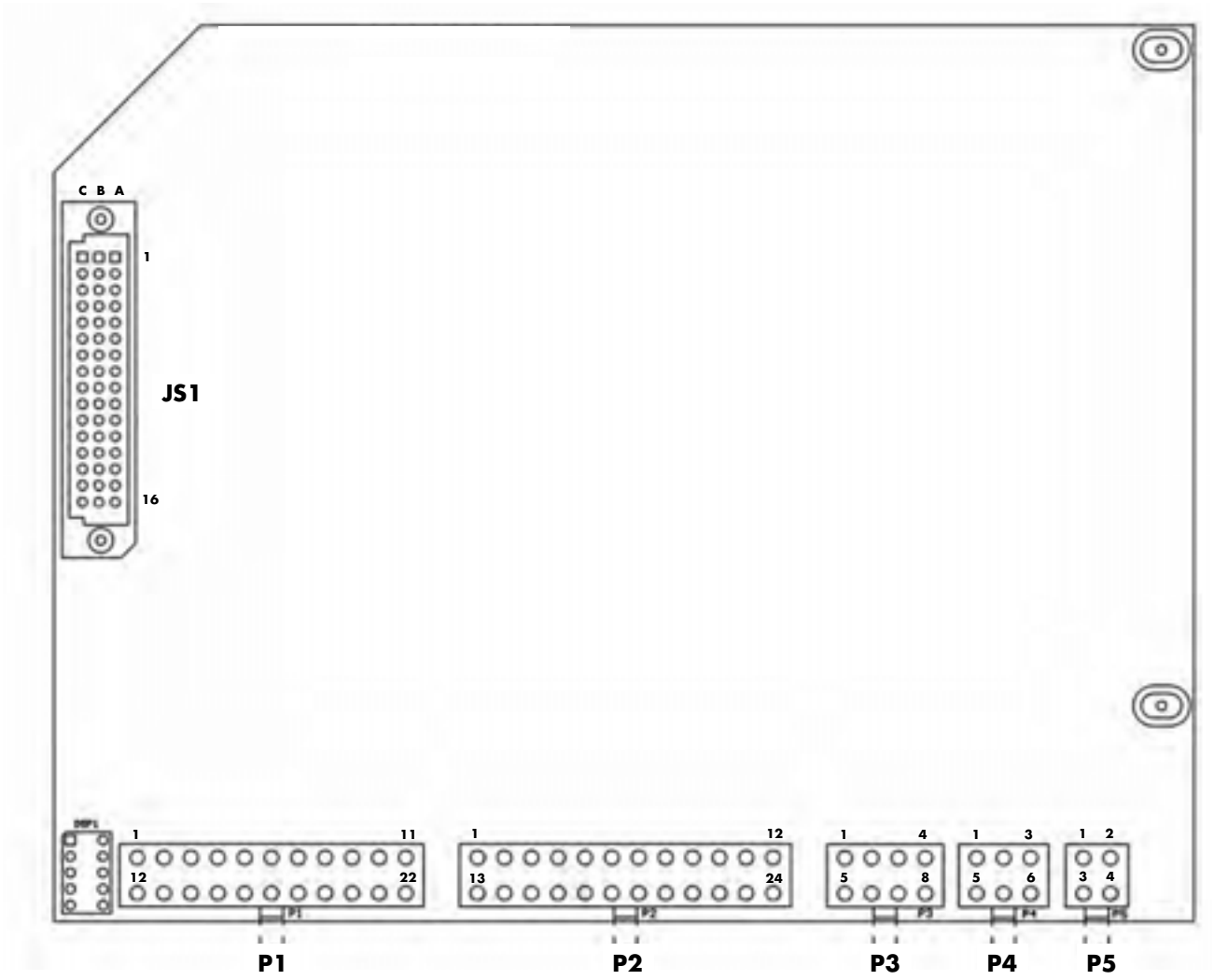
Figure 5-6. Fuse/Relay Card Connectors



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Guidance Manager

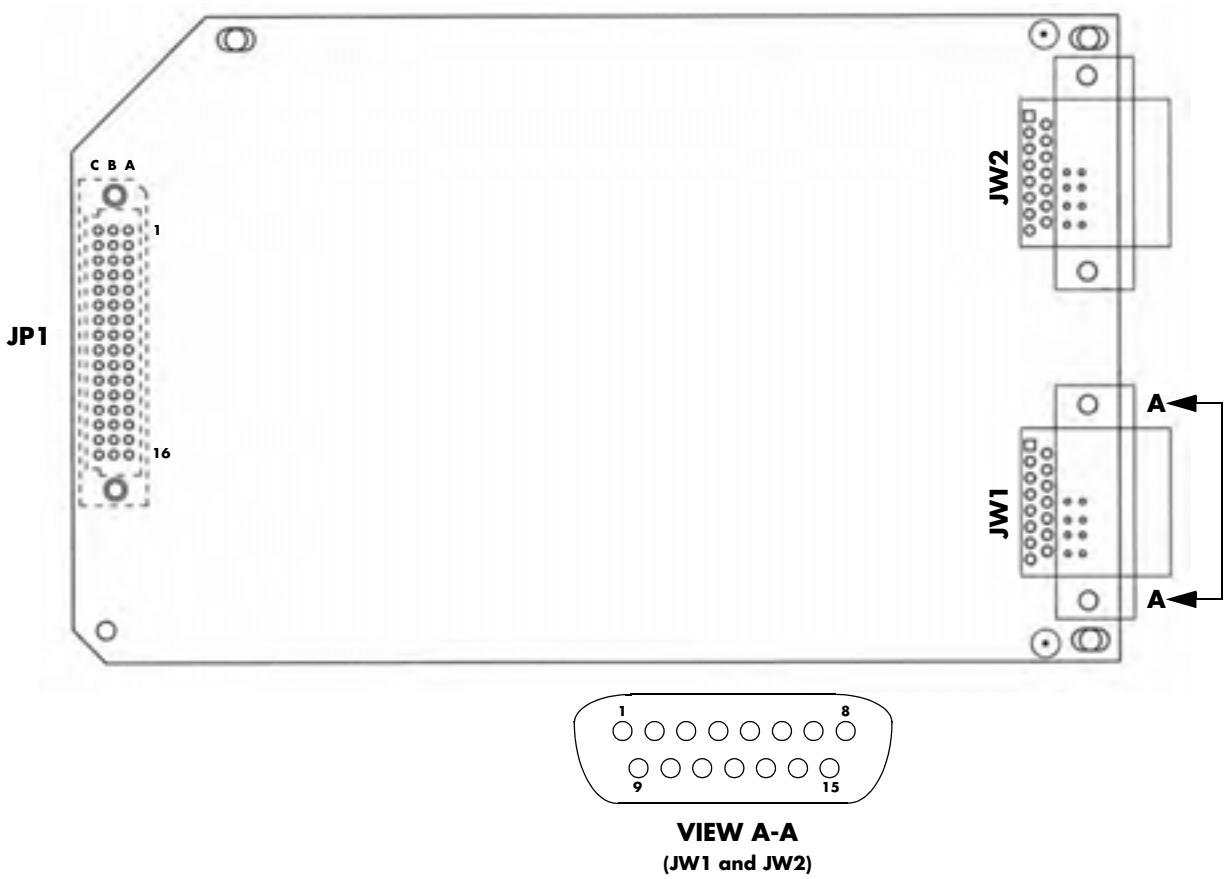
Figure 5-7. Guidance Manager Connectors



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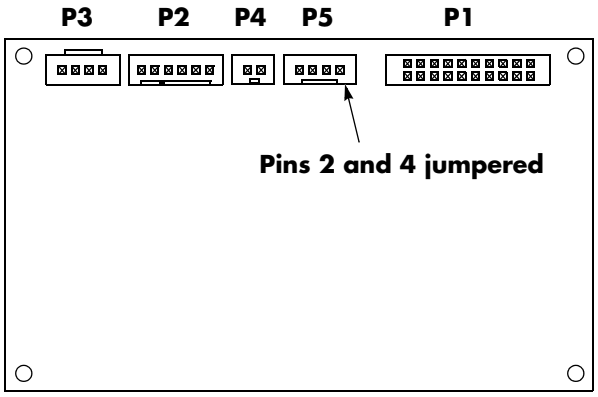
Wire Guidance Filter Card

Figure 5-8. Wire Guidance Filter Card connectors



Display Interface Card

Figure 5-9. Display Interface Card Connectors



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Troubleshooting Communication Error Codes (5x Series)

Troubleshooting Intermittent Communication Error Codes

If a Code 50, 51, 55, 56, 57, 59, 5A, 5E, 5G, or 5J is intermittently displayed, determine if there is a particular pattern that repeats itself. The following table lists possible causes and actions to perform.

Scenario	Action
Code is displayed while traveling	Check static straps. Refer to "Component Specific Service/ Torque Chart" on page A-4.
Code is displayed while lifting	Check over-the-mast cable.
Codes are randomly displayed	Refer to Shorts to Frame Test (page 5-3). Check static straps. Refer to "Component Specific Service/Torque Chart" on page A-4. Check wiring harness for loose connections in CAN Bus splices. Unplug and inspect associated CAN Bus jacks and pins.
Code is displayed while steering	Check cables and wiring to the Traction Motor. Cable ties should not be too tight. Make sure cable and wire insulation is not damaged.

If the above checks are performed and the code is still displayed, replace the Tractor Manager.

Troubleshooting Code 51

If Code 51 is displayed during SelfTest:

1. Check for correct jumper installation at the Carriage Manager between JPC22-22 and JPC24-4.
2. Check connections at JPC14-4 and JPC14-11.
3. Connect FlashWare directly to the Carriage Manager to verify manager is able to communicate. Refer to "Install Cleared (New) Manager" on page 3-19.

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Troubleshooting Code 57

Code 57 is displayed when the Display Interface Card is unable to communicate with the Tractor Manager. The appearance of this code (much larger scale numbers) differs from any other displayed code. Inputs and Output tests are not accessible when this code is displayed and a 5Q is registered in the error log.

NOTE: This code is displayed if the K2 relay tips are welded when the key switch is turned OFF.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Key ON/ DCV	JPT14-12	JPT14-1	Approx. 48V	Perform step 4	Perform step 2
2			TP4		Perform step 3	T/S OTM cable, key switch, fuse circuit, and wiring
3	DCV	TP1	JPT14-1		Perform step 1	T/S fuse circuit and wiring
4	Key ON/ DCV	JPC14-5	JPC14-2	Approx. 12V	Perform step 5	Unplug all connectors from CM except JC14 and check voltage again. If 12V is present, T/S the circuit that is pulling it down. If not OK, replace the CM.
5	Connect FlashWare to the truck and check TM software version. If a valid software version appears, the test is a success.				T/S Bus1 wiring from the TM to the Display Interface Card. Check jumper at JPD5.	Attempt to load a valid software version into the TM. If unable to load software, replace TM. If S/W load was successful, check for shorts to frame, static straps, and repair as necessary.

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Wire Guidance Troubleshooting

Intermittent Codes or Learn Problems

If Wire Guidance related codes are displayed intermittently or problems running Learn Wire Guidance occur, check for the following:

- bad radial rings
- dirty antennas
- worn load wheels or drive tire
- bad spur (steering) gear
- bad steer motor
- damaged cables
- bad line driver
- shorts to frame

Refer to Publication PDSS-0051 for floor related issues.

Bad Coil Values

If a Code 93, 94, 9J, or 9K is displayed or problems performing Step 1 of the Learn Wire Guidance process are encountered, perform the following procedure.

1. Verify line driver frequency/output.

NOTE: Most line drivers are equipped with a decal on the inside of the access door that identifies the frequency.

NOTE: Antenna signal strength can be influenced by several factors that are floor related and not truck related. If the value displayed varies at the same location (such as an expansion joint) every time, this may indicate a problem in the floor. For more information, refer to Publication PDSS-0051.

⚠CAUTION

If it is necessary to interrupt the floor signal, notify all personnel that may be using the guidepath.

2. Position the truck over the guidewire to within 0.5 in. (13 mm) of center (it is easier to center the load antenna first).
3. Enter Maint/Wire Guidance/Coil Values. Refer to "Coil Values" on page 3-38.

NOTE: If truck is locked on the wire when Coil Values is entered, cycle the Auto/Man switch.

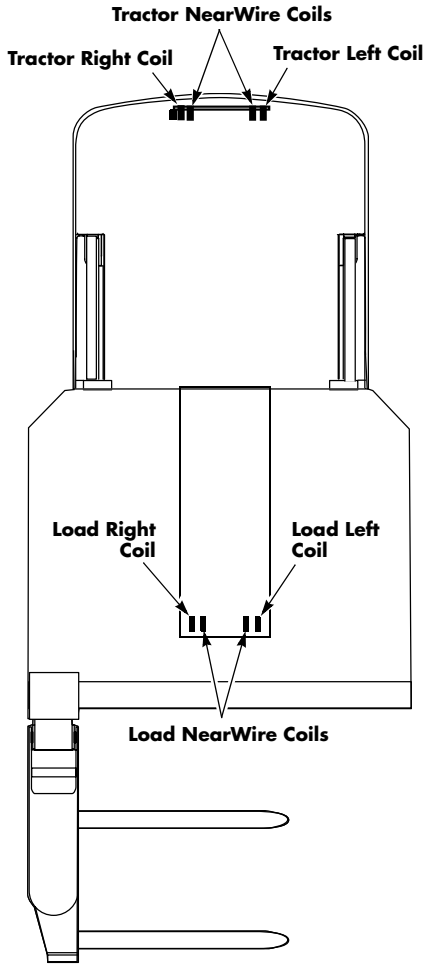
4. Using the **right** button, cycle to the frequency of the line driver determined in step1.
5. Observe coil readings. See Figures 5-10 and 5-11. If all are low (less than 10%), refer to Diagnosis and Repair. Figure 5-10 shows a good Load Antenna and a bad Tractor Antenna.

Figure 5-10. Coil Readings - Bad Tractor Antenna



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Figure 5-11. Coil Locations



6. If one or more coil readings are low, turn the key switch OFF, disconnect the battery, and swap the JPW1 (Load) and JPW2 (Trac) connectors at the Filter Card.
   - If the problem follows the antenna and cable, troubleshoot the cable and antenna.
   - If the readings do not change, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect Antenna Cables at JPW1 and JPW2/DCV	JW1-15	JW1-14	10.5 to 13V	Perform step 2	Perform step 3
2		JW2-15	JW2-14		Replace Filter Card	Perform step 3
3	Remove Filter Card/ DCV	JA1-B1	JPS6-24 (Back probe connection)		Replace Filter Card. Recheck coil values. If correct results are still not obtained, replace GM	Replace the GM

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Troubleshooting Steering Fault Codes (G Series)

If Code G2, G3, or G4 is displayed *before* the truck is operated, refer to "Code Displayed After Deadman Pedal Is Depressed". If code is displayed *during* operation, refer to "Intermittent Steering Related Error Codes".

Code Displayed After Deadman Pedal Is Depressed

If a code is displayed after the deadman pedal is depressed, observe the reaction in the steering system and refer to the following table:

Scenario	Action
Truck steers and does not contact mechanical stops.	Refer to Input I25 – Str Encdr [Steer Motor Encoder] (page 6-84) and Input I39 – Neut Pulse [Neutral Pulses] (page 6-91). Run Test O44 – Steer Mtr [Steer Motor] (page 6-140).
Truck steers in one direction only and contacts mechanical stop.	Check home steer prox sensor adjustment. Refer to Input I24 – Str Home [Home Steer Proximity Sensor] (page 6-83) and Input I25 – Str Encdr [Steer Motor Encoder] (page 6-84). Run Test O44 – Steer Mtr [Steer Motor] (page 6-140).
No movement in steering. Mechanical issue, worn radial ring.	Run Test O44 – Steer Mtr [Steer Motor] (page 6-140).

Intermittent Steering Related Error Codes

If the truck has intermittent error codes, determine if there is a particular pattern that repeats itself. The following table lists possible causes and actions to perform.

Possible Cause	Action
Noise, shorts to frame	Refer to Shorts to Frame Test (page 5-3). Check static straps. Refer to "Component Specific Service/Torque Chart" on page A-4.
Calculated position of the drive unit bad	Check adjustment of home steer prox. Check home steer prox sensor sense rail for damage.
Large correction to steering prior to braking	Steer Motor Encoder, Steer Amplifier (SA), or TM may be bad. Check home steer prox adjustment.
Mechanical issue, worn radial ring	Refer to Input A37 - Str Curr [Steer Motor Current] (page 6-58) to determine if excessive current is required by the steer motor. Repair or replace as necessary.

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Hydraulic Troubleshooting Guidelines

⚠CAUTION

After elevating or reaching the carriage for troubleshooting, use blocks to secure the carriage. Never remove a block when it is supporting the mast.

Lower the carriage fully and retract the reach mechanism fully.

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

Whenever possible, keep the key switch OFF, the battery connector disconnected, and the Emergency Lowering Valve open.

Cap open hydraulic lines to prevent contamination.

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Symptom Tables: Hydraulic System

Load Handler Functions

Traverse - Erratic Operation

Possible Cause	Action
Bad Traverse Position Feedback Pot or wiring	Refer to Input A86 – Trv Posn [Traverse Position Feedback Pot (VR5)] (page 6-64).
Contamination in hydraulic system	Inspect mesh screen in Load Handler manifold, Traverse Solenoids 9A/B and CV4 for contamination. If found, flush and refill system.
Bad Traverse Directional Solenoid	Run Test O56 – Sol9A DirA [Traverse DIR A (SOL9A)] (page 6-147) and Test O57 – Sol9B DirB [Traverse DIR B (SOL9B)] (page 6-148).
Traverse Relief Valve	Check REL-3 pressure setting. Refer to "Traverse Pressure Adjustment" on page 7-78.
Bad Traverse PWM Solenoid	Run Test O58 – Traverse PWM [Traverse PWM (SOL7)] (page 6-149).
Mechanical binding in Rack assembly	Refer to "Shimming the Mini-Mast" on page 7-105.
Binding or excessive play in Traverse Motor	Replace Traverse Motor.

Traverse - Intermittent Operation

Possible Cause	Action
Bad Traverse Feedback Pot	Refer to Input A86 – Trv Posn [Traverse Position Feedback Pot (VR5)] (page 6-64).
Contamination in hydraulic system	Inspect mesh screen in Load Handler manifold, Traverse Solenoids 9A/B and CV4 for contamination. If found, flush and refill system.
Bad Traverse Directional Solenoid	Run Test O56 – Sol9A DirA [Traverse DIR A (SOL9A)] (page 6-147) and Test O57 – Sol9B DirB [Traverse DIR B (SOL9B)] (page 6-148).
Bad Traverse PWM Solenoid	Run Test O58 – Traverse PWM [Traverse PWM (SOL7)] (page 6-149).
Traverse Relief Valve	Check REL-3 pressure setting. Refer to "Traverse Pressure Adjustment" on page 7-78.
Binding or deformed Traverse Rack	Refer to "Shimming the Mini-Mast" on page 7-105.

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Possible Cause	Action
Binding Traverse Motor	Replace Traverse Motor.

Traverse - Noisy

Possible Cause	Action
Misaligned, damaged, or worn Rack assembly	Refer to "Shimming the Mini-Mast" on page 7-105.
Worn Traverse Shaft Gear	See "Traverse Gear Shaft" on page 7-110.
Worn Traverse Follower Bearings	Replace bearings. See "Traverse Gear Shaft" on page 7-110.

Traverse - Slow Operation

Possible Cause	Action
Contamination in hydraulic system	Inspect Traverse Solenoids 9A/B for contamination. If found, flush and refill system.
Incorrect Load Handler pressure relief setting	Adjust pressure. See "Load Handler Pressure Adjustment" on page 7-77.
Bad Load Handler Pump	Check pressure. See "Load Handler Pressure Adjustment" on page 7-77.
Bad Traverse Directional Solenoid	Replace or swap valves and see if symptoms change. If so, original solenoid valve is bad. See "Load Handler Manifold" on page 7-71.
Bad Traverse Pot	Refer to Input A85 – Trv Pot [Traverse/Reach Pot (VR4)] (page 6-63).
Mechanical binding in Traverse Rack or Motor	Refer to "Shimming the Mini-Mast" on page 7-105.
Traverse Relief Valve	Check REL-3 pressure setting. Refer to "Traverse Pressure Adjustment" on page 7-78.

Traverse - One Direction Only

Possible Cause	Action
Bad Traverse Directional Solenoid	Run Test O56 – Sol9A DirA [Traverse DIR A (SOL9A)] (page 6-147) and Test O57 – Sol9B DirB [Traverse DIR B (SOL9B)] (page 6-148).

Rotate - Erratic Operation

Possible Cause	Action
Bad Rotate Position Feedback Pot or wiring	Refer to Input A88 – Rot Posn [Rotate Position Feedback Pot (VR6)] (page 6-66).

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Possible Cause	Action
Contamination in hydraulic system	Inspect Rotate Direction Solenoids 10A/B for contamination. If found, flush and refill system.
Bad Reach Prox or wiring	Refer to Input I04 – Bypass S7 [Lift/Lower Inhibit Bypass Switch (S7)] (page 6-76). Tap lightly on the sensor to see if condition changes.
Bad Fork Control Solenoids	Run Test O53 – Sol10A DrA [Reach/Rotate DIR A (SOL10A)] (page 6-144) and Test O54 – Sol10B DrB [Reach/Rotate DIR B (SOL10B)] (page 6-145).
Bad Traverse PWM Solenoid	Run Test O58 – Traverse PWM [Traverse PWM (SOL7)] (page 6-149).
Bad Reach/Rotate PWM Solenoid	Run Test O55 – Rch/Rot PWM [Reach/Rotate PWM (SOL8)] (page 6-146).
Mechanical binding in Rotate Actuator	Check the Rotate Actuator and replace if necessary.
Incorrect or missing orifices in Rotate Actuator elbow fittings	Examine. Replace as necessary.

Rotate - Intermittent Operation

Possible Cause	Action
Bad Fork Control Solenoids	Run Test O53 – Sol10A DrA [Reach/Rotate DIR A (SOL10A)] (page 6-144) and Test O54 – Sol10B DrB [Reach/Rotate DIR B (SOL10B)] (page 6-145). Monitor current flow while tapping on coil body.
Bad Reach Prox or wiring	Refer to Input I04 – Bypass S7 [Lift/Lower Inhibit Bypass Switch (S7)] (page 6-76). Tap lightly on the sensor to see if condition changes.
Mechanical binding in Rotate Actuator	Replace Rotate Actuator.

Rotate - Slow Operation

Possible Cause	Action
Bad Load Handler Pump	Check pressure. See “Load Handler Pressure Adjustment” on page 7-77.
Contamination in hydraulic system	Inspect Fork Control Solenoids 10A/B for contamination. If found, flush and refill system.
Bad Fork Control Solenoid Valves	Replace or swap valves and see if symptoms change. If so, original solenoid valve is bad. See “Load Handler Manifold” on page 7-71.
Bad Traverse PWM Solenoid	Run Test O58 – Traverse PWM [Traverse PWM (SOL7)] (page 6-149).

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Possible Cause	Action
Incorrect Load Handler pressure relief setting. **Note:** Incorrect pressure relief would likely also affect reach and traverse functions.	Adjust pressure. See "Load Handler Pressure Adjustment" on page 7-77.
Mechanical binding in Load Handler	Replace parts as necessary.

Rotate - Noisy Operation

Possible Cause	Action
Worn, damaged, or misaligned Rotate Carriage Lower Bearing	Replace bearing.
Bad Rotate Actuator	Replace Rotate Actuator.

Rotate - One Direction Only

Possible Cause	Action
Bad Fork Control Solenoids	Run Test O53 – Sol10A DrA [Reach/Rotate DIR A (SOL10A)] (page 6-144) and Test O54 – Sol10B DrB [Reach/Rotate DIR B (SOL10B)] (page 6-145).
Mechanical binding or bad Rotate Actuator	Replace Rotate Actuator.

Reach - Erratic Operation

Possible Cause	Action
Bad Rotate Position Feedback Pot or wiring	Refer to Input A88 – Rot Posn [Rotate Position Feedback Pot (VR6)] (page 6-66).
Damaged or worn Reach Cylinder	Replace Reach Cylinder.
Worn Scissors Bearings or deformed Scissors Assembly	Replace bearings or repair/replace scissors assembly.
Bad Traverse PWM Solenoid	Run Test O58 – Traverse PWM [Traverse PWM (SOL7)] (page 6-149).
Bad Reach/Rotate PWM Solenoid	Run Test O55 – Rch/Rot PWM [Reach/Rotate PWM (SOL8)] (page 6-146).
Bad Reach Solenoid	Run Test O06 – Sol11Rch [Reach Select Solenoid (SOL11)] (page 6-128).
Bad Fork Control Solenoids	Run Test O53 – Sol10A DrA [Reach/Rotate DIR A (SOL10A)] (page 6-144) and Test O54 – Sol10B DrB [Reach/Rotate DIR B (SOL10B)] (page 6-145).

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Reach - Intermittent Operation

Possible Cause	Action
Bad Rotate Position Feedback Pot or wiring	Refer to Input A88 – Rot Posn [Rotate Position Feedback Pot (VR6)] (page 6-66)
Bad Reach Solenoid	Run Test O06 – Sol11Rch [Reach Select Solenoid (SOL11)] (page 6-128).
Bad Traverse PWM Solenoid	Run Test O58 – Traverse PWM [Traverse PWM (SOL7)] (page 6-149).
Bad Fork Control Solenoids	Run Test O53 – Sol10A DrA [Reach/Rotate DIR A (SOL10A)] (page 6-144) and Test O54 – Sol10B DrB [Reach/Rotate DIR B (SOL10B)] (page 6-145).
Bad Reach/Rotate PWM Solenoid	Run Test O55 – Rch/Rot PWM [Reach/Rotate PWM (SOL8)] (page 6-146).
Excessive play in the Reach Mechanism, due to mechanical wear/deformation	Repair/replace components as necessary.
Contamination in hydraulic system	Inspect Reach Solenoid SOL11 for contamination. If found, flush and refill system.

Reach - Noisy or Slow Operation

Possible Cause	Action
Worn Scissors Bearings or deformed Scissors Assembly	Replace bearings or repair/replace scissors assembly.
Contamination in hydraulic system	Inspect Reach Solenoid (SOL11) for contamination. If found, flush and refill system.
Damaged or worn Reach Cylinder	Replace Reach Cylinder.
Bad Reach/Rotate PWM Solenoid	Run Test O55 – Rch/Rot PWM [Reach/Rotate PWM (SOL8)] (page 6-146).
Bad Traverse PWM Solenoid	Run Test O58 – Traverse PWM [Traverse PWM (SOL7)] (page 6-149).
Bad Fork Control Solenoids	Run Test O53 – Sol10A DrA [Reach/Rotate DIR A (SOL10A)] (page 6-144) and Test O54 – Sol10B DrB [Reach/Rotate DIR B (SOL10B)] (page 6-145).
Bad Reach Solenoid Valve	Run Test O06 – Sol11Rch [Reach Select Solenoid (SOL11)] (page 6-128).

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Auto Traverse and Rotate and/or Auto Center Nest Does Not Function

Possible Cause	Action
Traverse and rotate do not function correctly independently.	Verify proper operation of the traverse and rotate. Verify the display shows the load handler in the nested position when it should.
Function being activated with rotate or traverse outside the allowable start positions. Allowable start positions may very slightly between trucks and platform widths.	Place the load handler in the nested position and retry.
Switch S5 not functioning correctly. Rotate will operate but no traverse. Traverse will only operate with the traverse command pot.	Refer to Input I110 – Attach S5 [Attachment (S5)].

Lift/Lower System

Slow Lift

Possible Cause	Action
Bad Lift Motor Encoder	Refer to Input I20 – Lift RPM [Lift Motor RPM] (page 6-80).
Incorrect lift pressure adjustment	Check and adjust lift pressure setting. See “Lift Pressure Adjustment” on page 7-76.
Bad Lift Pump	Check pressure. See “Lift Pressure Adjustment” on page 7-76.
Bad Lift Motor	Run Test O28 – Lift RPM [Ramp Lift Motor] (page 6-134).
Battery problems	Replace battery with fully-charged good battery.
Bad Flow Limiters	Replace the Flow Limiters. See “Flow Limiters” on page 7-84.
Contamination in hydraulic system	Inspect valves for contamination. If found, flush and refill system.
Bad Lower Solenoid	Run Test O11 – Sol1 Lwr [Lower Solenoid (SOL1)] (page 6-129).
LPA overtemperature	Refer to Input A19 - LA Temp [LPA Temp] (page 6-52).

Intermittent Lift

Possible Cause	Action
If problem occurs only with Main Mast, Main Lift Select Solenoid may be intermittent.	Run Test O52 – Sol4 ManSl [Main Lift Select (SOL4)] (page 6-143). Flex harness while running test to check for intermittent wires.
If problem occurs only with Mini-Mast, Mini Lift Select Solenoid may be intermittent.	Run Test O50 – Sol6 MinSl [Mini Lift Select (SOL6)] (page 6-141). Flex harness while running test to check for intermittent wires.

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Slow Lower

Possible Cause	Action
Bad Lift Motor Encoder	Refer to Input I20 – Lift RPM [Lift Motor RPM] (page 6-80).
Lower Solenoid may be intermittent/bad	Run Test O62 – Lower Sol [Lower Solenoid (SOL1)] (page 6-153).
If problem occurs only with Mini-Mast, Mini Load Hold Solenoid may be intermittent.	Run Test O43 – Sol5 MinLH [Mini Load Hold (SOL5)] (page 6-139). Flex harness while running test to check for intermittent wires.
If problem occurs only with Main Mast, Main Load Hold Solenoid may be intermittent.	Run Test O51 – Sol3 ManLH [Main Load Hold (SOL3)] (page 6-142). Flex harness while running test to check for intermittent wires.
Mechanical binding in Bearings or Telescopic	Adjust or replace bearings.
Bad Flow Limiter	Replace the Flow Control valves. See “Flow Limiters” on page 7-84.

Intermittent Lower

Possible Cause	Action
If problem occurs only with Main Mast, Main Load Hold Solenoid may be intermittent.	Run Test O51 – Sol3 ManLH [Main Load Hold (SOL3)] (page 6-142). Flex harness while running test to check for intermittent wires.
Mechanical binding in bearings or telescopic	Adjust or replace bearings.
If problem occurs only with Mini-Mast, Mini Load Hold Solenoid may be intermittent.	Run Test O43 – Sol5 MinLH [Mini Load Hold (SOL5)] (page 6-139). Flex harness while running test to check for intermittent wires.

Load Drifting/Settling

Possible Cause	Action
Leaking or contaminated Emergency Lower Valve	Make sure the handle is not bottoming out before the valve is seated. Inspect, clean, flush, or replace as needed.
Lower Solenoid may be intermittent/bad	Run Test O62 – Lower Sol [Lower Solenoid (SOL1)] (page 6-153).

Bouncing Lower

Possible Cause	Action
Air in lift cylinders	Bleed cylinders. See “Bleeding the Hydraulic System” on page 7-74.
Main Mast bearing pucks binding	Lubricate/adjust pucks as necessary. See “Main Mast Lateral Bearing Adjustment (9600)” on page 7-99.

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Symptom Tables: Travel Problems

Slow or Sluggish Acceleration or Travel

Possible Cause	Action
Configuration set to soft acceleration	In Config Mode, set Travel Accel to Medium or Hard. Refer to "Using Configure Mode" on page 3-26 and Table 3-2, "Configure Mode Menu," on page 3-27.
Note: Determine if problem is configuration settings, mechanical, or electrical:	In Config Mode, set Coast to Long. Drive and coast to a stop. Compare coasting distance with a normally operating lift truck, if possible. If coasting distance is short, problem is mechanical.
Mechanical:	
Binding Drive Unit	Check amp draw. Refer to Input A11 - Dr Curr [Traction Motor Current] (page 6-45).
Worn Load Wheel Bearings	Replace load wheel bearings.
Dragging brake	See "Brake" on page 7-36.
Electrical:	
Low battery	Install a fully charged battery.
Bad Traction Motor (might test OK with no load, but fail under load)	Run Test O29 – Traction RPM [Ramp Traction Motor] (page 6-135).
Speed is limited due to Traction Motor or TPA overtemperature or bad Temperature Sensor	Refer to Input A08 - Dr Mr Tmp [Traction Motor Temp] (page 6-42) and Input A10 - TA Temp [TPA Temp] (page 6-44).
Bad Traction Motor Encoder (TME)	Refer to Input I19 – Trac RPM [Traction Motor RPM] (page 6-79).
Throttle Pot problem	Refer to Input A04 – Thrtl Pot [Throttle Pot (VR1)] (page 6-40) and Input A22 – Thrtl % [Travel Request] (page 6-54).

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Uneven Travel Speed

Possible Cause	Action
Note: First determine if the problem is mechanical or electrical.	In Config Mode, set Coast to Long. Drive to 4 mph (6.5 km/h) and coast to a stop. If the lift truck deceleration is not smooth or lift truck drags as it coasts, the problem is mechanical.
Mechanical:	
Binding Drive Unit	Replace Drive Unit.
Electrical:	
Bad Traction Motor	Run Test O29 – Traction RPM [Ramp Traction Motor] (page 6-135).
Bad Throttle Pot	Refer to Input A04 – Thrtl Pot [Throttle Pot (VR1)] (page 6-40).
Bad Traction Motor Encoder (TME)	Refer to Input I19 – Trac RPM [Traction Motor RPM] (page 6-79).

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Symptom Tables: Electrical Problems

Motor Overheating

Possible Cause	Action
Fans	Run Test O23 – Fans (page 6-133).
Wrong motor for lift truck	Verify correct motor for lift truck.
Application exceeds designed workload -- short runs with plugging/acceleration or heavy-duty lifting cycles	Refer to service manager for evaluation.
Bad Battery	Check voltage, both open circuit and under load. Replace if necessary with fully-charged, good battery.
Corroded or damaged Battery Connector Tips	Inspect battery connector. See “Battery Connector/Cables” on page 7-40.
Incorrect BSOC Cutout value	Check battery specific gravity at cutout, after battery has stabilized. Compare to battery manufacturer specifications for discharged battery. Adjust BSOC Cutout as needed. Refer to Table 3-2, “Configure Mode Menu,” on page 3-27.
Heat stressed cables: Look for discolored terminals, drawn insulation, and hard spots and bulges.	Replace power cables.
Drive Motor Current problem	Refer to Input A11 - Dr Curr [Traction Motor Current] (page 6-45).
Binding Gearbox or Pump	Check gearbox or pump for binding. Clean, repair, or replace as necessary.
Dragging Brake	Check gap. See “Brake” on page 7-36.
Incorrectly adjusted steer centering on a rail guided lift truck	Run “Learn Rail Guidance” on page 3-36.

Motor Arcing (Load Handler Motor)

Possible Cause	Action
Worn Brushes or incorrect Brush Tension	Replace brushes and/or brush springs. See “Motor Brushes” on page 7-52 and “Motor Brush Spring Tension” on page 7-53.
Rough or pitted Motor Commutator	Refer to motor rebuild facility. Replace motor.

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BSOC Reset or Cutout Does Not Occur

Possible Cause	Action
Incorrect BSOC Cutout value	Check battery specific gravity at cutout, after battery has stabilized. Compare to battery manufacturer specifications for discharged battery. Adjust BSOC Cutout as needed. See "Setting Battery State-of-Charge Cutout" on page 5-10.

Scrambled or Intermittent Display

Possible Cause	Action
Loose Harness or Card Connectors	Reseat cards and harness connections.
Intermittent wires or connectors in harness	Test for continuity while flexing harness. If discontinuity is found, replace wiring harness.
Bad Display Module	Run Test O39 – Display Test [Cycle Display] (page 6-138).

Operator Display Dark or Inoperative, Truck Runs

Possible Cause	Action
Travel Speed Not Limited - Bad Operator Display Module or Display Interface Card	Check JPD1 connection. If OK, replace Display Module.
Travel Speed Limited - Bad Display Interface Card or wiring	Check wiring. If OK, replace Display Interface Card.

Display is Dark; Lift Truck is *not* Operational

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Key switch ON/DCV	JPC14-12	JPC14-1	Approx. 48V	Perform step 4	Perform step 2
2			TP4		Perform step 3	T/S battery, OTM cable, key switch, fuse circuit, and wiring
3	DCV	TP1	JPC14-1		Perform step 1	T/S OTM cable, fuse circuit, and wiring
4	Key switch ON/DCV	JPC14-5	JPC14-2	Approx. 12V	Perform step 5	Extract JC14-2 and unplug all connectors except JC14. Check again. If 12V is present, T/S the circuit that is pulling it down. If not OK, replace CM.
5		JPD3-3	JPD3-4		Replace Display Interface Card	T/S wiring

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RAYMOND

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Section 6. Messages, Codes, and Tests

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Messages and Codes Summary List

Messages

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Lift Cut-Out, Scheduled Maintenance Due 6-6
Lift Limited 6-6
Lift Speed Limited 6-6
Load Handler Overheated, Allow Time To Cool 6-7
Load Handler Stalled 6-7
Lower Disabled 6-7
Lower Sidegates To Resume Operation 6-8
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Messages and Codes

Message: Battery low, no lift

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Battery Low, No Lift Lift interrupt has occurred due to the battery state-of-charge.	If charging or changing the battery does not clear the message, refer to "Input A15 – BattVolt [Battery Voltage]" (page 6-49)	Charge/change battery.

Message: Check battery gates

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Check Battery Gates	"Input I87 – BG Lt S57 [Left Battery Gate Switch (S57)]" (page 6-101), "Input I88 – BG Rt S58 [Right Battery Gate Switch (S58)]" (page 6-102)	Check battery gates for correct installation. Cycle key switch to clear.

Message: Deadman?

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Deadman? Deadman switch(es) activated while truck is attempting to perform SelfTest *or* control handle inputs detected and deadman pedal(s) not depressed.	"Input I00 – Dman S23 [Carriage Deadman Switch (S23)]" (page 6-74), "Input I32 – Dman S2 [Brake Deadman Switch (S2)]" (page 6-86), "Input I02 – Lift S11 [Lift Reference Prox (S11)]" (page 6-75)	*Message displayed during SelfTest* - release deadman(s), resume operation. If message does not clear, refer to the inputs listed. *Message displayed after SelfTest* - depress deadman pedal(s). If message does not go away, refer to Inputs listed.

Message: EPO depressed

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
EPO Depressed EPO depressed. CM senses the EPO switch is open (IN).	"Input A41 - CM EPO [CM EPO Sense]" (page 6-60)	Lift EPO Button and cycle key switch to clear.

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Message: Learn timed out

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Learn Timed Out One or all deadman switches were open longer than 2.8 consecutive minutes during Learn Load Handler process.	"Input I00 – Dman S23 [Carriage Deadman Switch (S23)]" (page 6-74), "Input I32 – Dman S2 [Brake Deadman Switch (S2)]" (page 6-86), "Input I102 – LdDm S9 [Load Handler Deadman (S9)]" (page 6-105)	Restart Learn and step on both deadman pedals.

Message: Lift cut-out pending ... low battery

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Lift Cut-Out Pending ... Low Battery Battery low.	None	Message is displayed for five minutes, then lift is disabled. Change Battery.

Message: Lift cut-out, scheduled maintenance due

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Lift Cut-Out, Scheduled Maintenance Due Displayed when Mnt Mind is enabled in Configure Mode menu.	None	Reset or disable Mnt Mind in Configure Mode menu.

Message: Lift limited

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Lift Limited An option that inhibits lift in certain situations has been activated.	None	If truck is equipped with the Out-of-Aisle Lift Inhibit option, enter aisle to allow lift. If truck is equipped with the Lift Limit w/o Bypass option, lower the carriage below the height set in Config Mode to allow lift.

Message: Lift speed limited

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Lift Speed Limited LPA is not receiving encoder pulses.	"Input I20 – Lift RPM [Lift Motor RPM]" (page 6-80)	Cycle key switch to clear.

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Message: Load handler overheated, allow time to cool

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Load Handler Overheated, Allow Time To Cool The system has detected an over temperature condition exists.	"Input A65 - LH Mr Tmp [Load Handler Motor Temp]" (page 6-62), "Test O23 – Fans" (page 6-133)	Allow time for truck to cool.

Message: Load handler stalled

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Load Handler Stalled No change in Load Handler position detected when a traverse or rotate command is present.	**Traverse:** "Input A86 – Trv Posn [Traverse Position Feedback Pot (VR5)]" (page 6-64), "Test O56 – Sol9A DirA [Traverse DIR A (SOL9A)]" (page 6-147), "Test O57 – Sol9B DirB [Traverse DIR B (SOL9B)]" (page 6-148), "Test O58 – Traverse PWM [Traverse PWM (SOL7)]" (page 6-149) **Rotate:** "Input A88 – Rot Posn [Rotate Position Feedback Pot (VR6)]" (page 6-66), "Test O53 – Sol10A DrA [Reach/Rotate DIR A (SOL10A)]" (page 6-144), "Test O54 – Sol10B DrB [Reach/Rotate DIR B (SOL10B)]" (page 6-145), "Test O55 – Rch/Rot PWM [Reach/Rotate PWM (SOL8)]" (page 6-146)	Refer to applicable inputs/perform applicable tests.

Message: Lower disabled, use emergency lower valve to resume lowering

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Lower Disabled	"Test O62 – Lower Sol [Lower Solenoid (SOL1)]" (page 6-153)	Run test listed.

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Message: Lower sidegates to resume operation

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Lower Sidegates To Resume Operation One or both sidegates are raised while attempting to operate the truck. (Optional)	"Input I67 – SG Rt S60 [Right Sidegate Switch (S60)]" (page 6-96), "Input I83 – SG Lt S61 [Left Sidegate Switch (S61)]" (page 6-100)	Lower Sidegate(s) and resume operation.

Message: Mismatched software versions

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Mismatched Software Versions	None	Verify/install correct TM and CM software in FlashWare. Cycle key switch to clear.

Message: Overheated, allow time to cool

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Overheated, Allow Time To Cool Truck Overheated. The system has detected that an over-temperature condition exists.	"Input A08 - Dr Mr Tmp [Traction Motor Temp]" (page 6-42), "Input A09 - Lft Mr Tmp [Lift Motor Temp]" (page 6-43)	Allow time for truck to cool. If Traction Motor is overheated, traction is inhibited; if Lift motor is overheated, lift is inhibited.

Message: Press bypass switch to continue lifting

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Press Bypass Switch To Continue Lifting Calculated height of mast position has reached the point that lift interrupt should occur.	"Input I04 – Bypass S7 [Lift/Lower Inhibit Bypass Switch (S7)]" (page 6-76)	Activate bypass switch to continue to lift. Check height settings in Configure Mode.

Message: Press bypass switch to continue lowering

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Press Bypass Switch To Continue Lowering Calculated height of mast position has reached the point that lower interrupt should occur.	"Input I04 – Bypass S7 [Lift/Lower Inhibit Bypass Switch (S7)]" (page 6-76)	Activate bypass switch to continue to lower. Check height settings in Configure Mode.

Message: Reach not nested

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Reach Not Nested During Learn Load Handler, the Carriage Manager did not see the expected values for Reach Prox.	"Input I04 – Bypass S7 [Lift/Lower Inhibit Bypass Switch (S7)]" (page 6-76)	Verify the reach is fully retracted.

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Message: Release buttons

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Release Buttons The TM detects a Lift/Lower Pendant button(s) was depressed at Startup.	"Input A17 – Lift Pnd [Lift Pendant]" (page 6-50), "Input A18 – Lwer Pnd [Lower Pendant]" (page 6-51),	Cycle key switch to clear. **Note:** If message appears when the pendant is connected and no switches are depressed, the pendant is bad.

Message: Release bypass switch to continue lifting

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Release Bypass Switch to Continue Lifting Lift/lower bypass switch (S7) has been activated for an extended period of time or was depressed at Startup.	"Input I04 – Bypass S7 [Lift/Lower Inhibit Bypass Switch (S7)]" (page 6-76)	Release switch.

Message: Release lift select button to resume operation...Main lower is enabled

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Release Lift Select Button to Resume Operation...Main Lower is Enabled The TM detects the Lift Select Switch was depressed at Startup.	"Input I109 – LftSel S6 [Lift Select (S6)]" (page 6-112)	Release switch.

Message: Release lift to resume operation

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Release Lift To Resume Operation Control handle (VR2) was moved before deadman pedal was depressed at Startup.	"Input A05 – L/L Pot [Lift/Lower Pot (VR2)]" (page 6-41)	Release lift, step on deadman, resume operation. **Note:** After this message is displayed three times, "CODE 8F Inform Service" (page 6-25) is displayed.

Message: Release rotate to resume operation

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Release Rotate To Resume Operation Rotate pot (VR3) was moved before deadman pedal was depressed at Startup.	"Input A87 – Rot Pot [Rotate Command Pot (VR3)]" (page 6-65)	Release rotate pot, step on deadman, resume operation. **Note:** After this message is displayed three times, "CODE 8V Inform Service" (page 6-25) is displayed.

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Message: Release traction handle to resume operation

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Release Traction Handle To Resume Operation Control handle (VR1) was moved before deadman pedal was depressed.	"Input A04 – Thrtl Pot [Throttle Pot (VR1)]" (page 6-40)	Release throttle, step on deadman, resume travel. **Note:** After this message is displayed three times, "CODE 83 Inform Service" (page 6-24) is displayed.

Message: Release traverse handle to resume operation

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Release Traverse Handle To Resume Operation Traverse handle (VR4) was moved before deadman pedal was depressed at Startup.	"Input A85 – Trv Pot [Traverse/Reach Pot (VR4)]" (page 6-63)	Release Traverse handle, step on deadman, resume operation. **Note:** After this message is displayed three times, "CODE 8X Inform Service" (page 6-25) is displayed.

Message: Retract reach for full speed travel

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Retract Reach for Full Speed Travel Traverse handle (VR4) was moved before deadman pedal was depressed at Startup.	"Input I04 – Bypass S7 [Lift/Lower Inhibit Bypass Switch (S7)]" (page 6-76)	Retract forks to allow full speed travel.

Message: Rotate failed

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Rotate Failed During the Learn Load Handler process, the Carriage Manager did not see the expected values for Rotate.	"Input A88 – Rot Posn [Rotate Position Feedback Pot (VR6)]" (page 6-66), "Test O53 – Sol10A DrA [Reach/Rotate DIR A (SOL10A)]" (page 6-144), "Test O54 – Sol10B DrB [Reach/Rotate DIR B (SOL10B)]" (page 6-145), "Test O55 – Rch/Rot PWM [Reach/Rotate PWM (SOL8)]" (page 6-146)	During Learn, the values saved are the feedback pot voltages at both ends of the function and the current required by the proportional valves to make the functions begin to move and obtain the desired speeds.

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Message: Rotate and traverse failed

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Rotate and Traverse Failed During the Learn Load Handler process, the Carriage Manager did not see the expected values for both Rotate and Traverse.	**Traverse:** "Input A86 – Trv Posn [Traverse Position Feedback Pot (VR5)]" (page 6-64), "Test O56 – Sol9A DirA [Traverse DIR A (SOL9A)]" (page 6-147), "Test O57 – Sol9B DirB [Traverse DIR B (SOL9B)]" (page 6-148), "Test O58 – Traverse PWM [Traverse PWM (SOL7)]" (page 6-149) **Rotate:** "Input A88 – Rot Posn [Rotate Position Feedback Pot (VR6)]" (page 6-66), "Test O53 – Sol10A DrA [Reach/Rotate DIR A (SOL10A)]" (page 6-144), "Test O54 – Sol10B DrB [Reach/Rotate DIR B (SOL10B)]" (page 6-145), "Test O55 – Rch/Rot PWM [Reach/Rotate PWM (SOL8)]" (page 6-146)	During Learn, the values saved are the feedback pot voltages at both ends of the functions and the current required by the proportional valves to make the functions begin to move and obtain the desired speeds.

Message: Scheduled maintenance due

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Scheduled Maintenance Due Displayed when Mnt Mind is enabled in Configure Mode menu.	None	Reset or disable Mnt Mind in Configure Mode menu.

Message: Speed limited due to load handler

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Speed Limited Due To Load Handler Load handler is not nested.	"Input A86 – Trv Posn [Traverse Position Feedback Pot (VR5)]" (page 6-64), "Input A88 – Rot Posn [Rotate Position Feedback Pot (VR6)]" (page 6-66),	Return load handler to the nested position to allow full speed travel.

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Message: Speed limited due to unknown main height... lower main mast to floor then raise to cross reference switch

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Speed Limited Due To Unknown Main Height	"Input I02 – Lift S11 [Lift Reference Prox (S11)]" (page 6-75), "Input I26 – Main Ht Ct [Main Lift Height Encoder]" (page 6-85)	Refer to display. If message does not go away, refer to Inputs listed.

Message: Speed limited due to unknown mini height... completely lower mini mast, then lift to reset height

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Speed Limited Due To Unknown Mini Height	"Input I105 – Mini Ht Ct [Mini-Mast Height Count]" (page 6-108)	Refer to display. If message does not go away, refer to Input listed.

Message: Stalled, release control handle to resume operation

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Stalled, Release Control Handle To Resume Operation No encoder pulses are received by Power Amplifier.	**Travel speed limited** - "Input I19 – Trac RPM [Traction Motor RPM]" (page 6-79) **Lift speed limited** - "Input I20 – Lift RPM [Lift Motor RPM]" (page 6-80)	Travel speed or lift speed is limited when the corresponding power amp is not receiving encoder pulses. Cycle key switch OFF/ON to clear.

Message: Step on deadman

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Step on Deadman One or all of the deadman switches are open during the Learn Load Handler process.	"Input I00 – Dman S23 [Carriage Deadman Switch (S23)]" (page 6-74), "Input I32 – Dman S2 [Brake Deadman Switch (S2)]" (page 6-86), "Input I102 – LdDm S9 [Load Handler Deadman (S9)]" (page 6-105)	Depress both Deadman pedals for Learn to continue.

Message: Travel cut-out

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Travel Cut-Out "Travel Cut-Out @ 24in," option is enabled and fork height is above 24 in.	None	Lower forks below 24 in.

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Message: Traverse failed

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Traverse Failed During the Learn Load Handler process, the Carriage Manager did not see the expected values for Traverse.	"Input A86 – Trv Posn [Traverse Position Feedback Pot (VR5)]" (page 6-64), "Test O56 – Sol9A DirA [Traverse DIR A (SOL9A)]" (page 6-147), "Test O57 – Sol9B DirB [Traverse DIR B (SOL9B)]" (page 6-148), "Test O58 – Traverse PWM [Traverse PWM (SOL7)]" (page 6-149)	During Learn, the values saved are the feedback pot voltages at both ends of the function and the current required by the proportional valves to make the functions begin to move and obtain the desired speeds.

Message: Waiting for download command

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Waiting For Download Command Display Interface Card does not contain a valid Graphic Database Download.	None	Perform Graphics Database Download. Refer to "Graphics Database Download" on page 3-39. If unable to perform, check communications between TM and CM using FlashWare. If OK, replace Display Interface Card.

CODE 1H Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 1H: TPA Out-of-Range The TPA has reported its internal temperature is less than –40°F (–40°C) or greater than +203°F (+95°C).	"Input A10 - TA Temp [TPA Temp]" (page 6-44)	Cycle key switch to clear after TPA has cooled.

CODE 1K Platform Hung Lift Slowly

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 1K: Platform Hung Lift Slowly Slack chain switch has transitioned during operation.	"Input I45 – Slk Ch S50 [Slack Chain 1 Switch (S50)]" (page 6-92), "Input I46 – Slk Ch S51 [Slack Chain 2 Switch (S51)]" (page 6-93)	Lift platform if it is hung up to clear.

CODE 2A Overheated, Allow time to cool

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 2A: Traction Motor Approaching Overtemp The TPA senses the traction motor is approaching overtemperature.	"Input A08 - Dr Mr Tmp [Traction Motor Temp]" (page 6-42)	Travel speed is linearly de-rated starting at 284°F (140°C). Travel speed is limited to 1 mph at 311°F (155°C).

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CODE 2E Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 2E: Traction Motor Temp Sensor Out-of-Range The traction motor temperature sensor is open or shorted.	"Input A08 - Dr Mr Tmp [Traction Motor Temp]" (page 6-42)	Clears when reason for fault is corrected.

CODE 2G Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 2G: Phase Open on Traction Motor The TPA detects no current draw in one of the three phases of the motor.	"Test O29 – Traction RPM [Ramp Traction Motor]" (page 6-135)	Cycle key switch to clear.

CODE 2H Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 2H: Failure Detected in Traction Motor Speed Sensor	"Input I19 – Trac RPM [Traction Motor RPM]" (page 6-79)	If a single channel is bad, this code is displayed during Run. If one or both channels are bad at SelfTest, STALLED is displayed. Cycle key switch to clear.

CODE 2M Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 2M: TPA Pre-Charge Failed TPA failed to precharge correctly.	None	Check for B+ at TPA+. Cycle key switch to clear. If code does not clear, replace TPA. **Note:** The TM cannot cause this code.

CODE 2T Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 2T: TPA Current Calibration Error The TPA has sensed a current calibration error.	None	Cycle key switch to clear. If code does not clear, replace TPA. **Note:** The TM cannot cause this code.

CODE 2U Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 2U: TPA Overcurrent or Short Circuit The TPA has sensed current in excess of 450A.	"Test O29 – Traction RPM [Ramp Traction Motor]" (page 6-135)	Cycle key switch to clear. Check for shorted traction motor power cables. If code does not clear, replace TPA. **Note:** The TM cannot cause this code.

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CODE 2V Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 2V: TPA High DC BUS Voltage The TPA detects an overvoltage condition at the + terminal.	"Input A15 – BattVolt [Battery Voltage]" (page 6-49)	If the problem is intermittent and only occurs during plugging, it indicates a bad battery or possible loose connection in the power circuit connections for the traction system. Check all associated power cables for correct torque and contactor tips for excessive wear. If the error is a hard code, re-flash the TPA. If the code persists, replace the TPA. **Note:** The TM cannot cause this code.

CODE 2W Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 2W: TPA Internal Fault TPA internal circuitry has malfunctioned.	None	Cycle key switch to clear. Re-flash TPA. If code does not clear, replace TPA.

CODE 2X Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 2X: TPA Power Supply Out-of-Range The power supply output in the TPA is less than 4.5V, greater than 5.5V, or too much current is being drawn by an external component.	None	Cycle key switch to clear. Disconnect (+) wire to temperature and speed sensors. Cycle key switch. If code changes, troubleshoot wires and sensors. If not OK, replace TPA. **Note:** The TM cannot cause this code.

CODE 42 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 42: LPC Detected Closed When Commanded Open LPA detected an incorrect voltage at LPA+ during SelfTest.	"Test O02 – LPC Ctr [Lift Power Contactor]" (page 6-126)	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 TM cannot cause this code.

CODE 43 Inform Service

Code Title/Reason	Inputs/Tests 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 – LPC Ctr [Lift Power Contactor]" (page 6-126)	Cycle key switch to clear. Check contactor for mechanical binding. **Note:** The TM cannot cause this code.

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CODE 49 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 49: Load Handler Contactor Detected Closed When Commanded Open	"Input I112 – FU4 sense [FU4 Sense]" (page 6-115), "Test O03 – LHC Ctr [Load Handler Contactor]" (page 6-127)	Cycle key switch to clear.

CODE 4A Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 4A: Load Handler Contactor Detected Open When Commanded Closed	"Input I112 – FU4 sense [FU4 Sense]" (page 6-115), "Test O03 – LHC Ctr [Load Handler Contactor]" (page 6-127)	Cycle key switch to clear.

CODE 4B Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 4B: Steer Contactor Detected Closed At Start-Up	"Input I14 – FU1 Sense" (page 6-77), "Test O01 – STR Ctr [Steer Power Contactor]" (page 6-125)	Cycle key switch to clear. Check contactor for mechanical binding.

CODE 4C Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 4C: FU1 Sense Validation Steer contactor detected open when commanded closed.	"Input I14 – FU1 Sense" (page 6-77), "Test O01 – STR Ctr [Steer Power Contactor]" (page 6-125)	Check FU1, FU1 Sense line (JPT22-19). If FU1 opens during Run Mode, Code G4 is displayed. Cycle key switch to clear.

CODE 4F Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 4F: TPC Detected Closed When Commanded Open The TPA detects an incorrect voltage at the B+ terminal on the amplifier.	"Test O00 – TPC Ctr [Traction Power Contactor]" (page 6-124)	Cycle key switch to clear. Check contactor for mechanical binding.

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CODE 4G Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 4G: TPC Detected Open After Power-Up The TPA detects the TPC open after power-up.	"Test O00 – TPC Ctr [Traction Power Contactor]" (page 6-124)	Cycle key switch to clear.

CODE 4H Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 4H: TPA, TPC Contactor Coil or Coil Driver Open or Shorted	"Test O00 – TPC Ctr [Traction Power Contactor]" (page 6-124)	Cycle key switch to clear.

CODE 4K Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 4K: LPA, LPC Contactor Coil or Coil Driver Open or Shorted	"Test O02 – LPC Ctr [Lift Power Contactor]" (page 6-126)	Cycle key switch to clear.

CODE 50 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 50: No TM Communications Received by CM The Carriage Manager has not received correct communications from the TM.	"Input I23 – Can Bus [CAN Communication]" (page 6-81)	See "Troubleshooting Communication Error Codes (5x Series)" on page 5-19. Cycle key switch to clear.

CODE 51 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 51: No CM Communications Received by TM The Tractor Manager has not received correct communications from the CM.	Refer to "Troubleshooting Code 51" on page 5-19.	Cycle key switch to clear.

CODE 55 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 55: CAN Bus 1Transmission Buffer Error The Tractor Manager has detected a CAN transmission buffer error on CAN Bus 1.	"Input I23 – Can Bus [CAN Communication]" (page 6-81) If intermittent, refer to "Troubleshooting Communication Error Codes (5x Series)" on page 5-19.	Cycle key switch to clear.

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CODE 56 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 56: CAN Bus 1 Error Overflow CAN BUS error overflow detected by TM on CAN Bus 1.	"Input I23 – Can Bus [CAN Communication]" (page 6-81) If intermittent, refer to "Troubleshooting Communication Error Codes (5x Series)" on page 5-19.	Cycle key switch to clear.

CODE 57 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 57: No Communications Received by Display Interface Card	Refer to "Troubleshooting Code 57" on page 5-20.	Cycle key switch to clear. **Note:** This code is displayed when FlashWare is connected to truck.

CODE 59 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 59: CAN Bus 0 Transmission Buffer Error The Tractor Manager has detected a CAN transmission buffer error on CAN Bus 0.	"Input I23 – Can Bus [CAN Communication]" (page 6-81) If intermittent, refer to "Troubleshooting Communication Error Codes (5x Series)" on page 5-19.	Cycle key switch to clear.

CODE 5A Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 5A: CAN Bus 0 Error Overflow CAN BUS error overflow detected by TM on CAN Bus 0.	"Input I23 – Can Bus [CAN Communication]" (page 6-81) If intermittent, refer to "Troubleshooting Communication Error Codes (5x Series)" on page 5-19.	Cycle key switch to clear.

CODE 5E Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 5E: No Guidance Manager CAN Communications Received by TM	"Input I23 – Can Bus [CAN Communication]" (page 6-81) If intermittent, refer to "Troubleshooting Communication Error Codes (5x Series)" on page 5-19.	Travel disabled in AUTO mode. Travel allowed in MANUAL mode. Cycle key switch to clear.

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CODE 5G Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 5G: No Communications Received by TM from TPA The Tractor Manager has not received CAN communications from the TPA.	"Input I23 – Can Bus [CAN Communication]" (page 6-81) If intermittent, refer to "Troubleshooting Communication Error Codes (5x Series)" on page 5-19.	Cycle key switch to clear.

CODE 5J Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 5J: No communications Received by TM from LPA The Tractor Manager has not received CAN communications from the LPA.	"Input I23 – Can Bus [CAN Communication]" (page 6-81) If intermittent, refer to "Troubleshooting Communication Error Codes (5x Series)" on page 5-19.	Cycle key switch to clear.

CODE 5M Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 5M: TPA Start Timeout Occurs 1 minute after TPA is powered ON if TM does not send a message. This code is not likely to show on the truck display if there is truly a broken line between the TM and the TPA.	None	Re-Flash TPA software via FlashWare. If code does not clear, replace TPA.

CODE 5P Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 5P: LPA Start Timeout Occurs 1 minute after LPA is powered ON if TM does not send a message. This code is not likely to show on the truck display if there is truly a broken line between the TM and the LPA.	None	Re-Flash LPA software via FlashWare. If code does not clear, replace LPA.

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CODE 5Q Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 5Q: Display Interface Card Not Responding The TM is not receiving communication from the Display Interface Card. This code appears in the error log but not on the Operator Display.	Refer to "Troubleshooting Code 57" on page 5-20.	**Note:** Code 5Q is recorded in the error log. The Operator Display will most likely display Code 57.

CODE 64 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 64: Main Mast Height System Error While lifting or lowering at >500 rpm, no pulses or missing pulses are seen from the mast height encoder.	"Input I26 – Main Ht Ct [Main Lift Height Encoder]" (page 6-85)	Cycle key switch to clear.

CODE 65 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 65: Mini-Mast Height System Error While lifting or lowering at >300 rpm, no pulses or missing pulses are seen from the mini height prox switches or calculated height does not match.	"Input I105 – Mini Ht Ct [Mini-Mast Height Count]" (page 6-108)	Cycle key switch to clear.

CODE 67 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 67: Main Mast Count Error Calculated height does not match at main mast reference switch when lowering.	"Input I02 – Lift S11 [Lift Reference Prox (S11)]" (page 6-75), "Input I26 – Main Ht Ct [Main Lift Height Encoder]" (page 6-85)	Cycle key switch to clear.

CODE 6D Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 6D: Main Lift Pressure Sensor Out-of-Range The Tractor Manager has determined that the pressure sensor voltage is out-of-range.	"Input A13 – MainPres [Main Lift Pressure Sensor]" (page 6-47)	Cycle key switch to clear.

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CODE 6E Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 6E: Mini Lift Pressure Sensor Out-of-Range The Tractor Manager has determined that the pressure sensor voltage is out-of-range.	"Input A89 – MiniPres [Mini-Mast Pressure Sensor]" (page 6-67)	Cycle key switch to clear.

CODE 6F Overheated, Allow Time To Cool

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 6F: Lift Motor Overheated Lift motor temperature has exceeded 311°F (155°C).	"Input A09 - Lft Mr Tmp [Lift Motor Temp]" (page 6-43)	Allow time to cool. Cycle key switch to clear. **Note:** The TM cannot cause this code.

CODE 78 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 78: Lower Continues After Request is Removed	"Input A23 – L/L % [Lift/Lower Request]" (page 6-55), "Input I20 – Lift RPM [Lift Motor RPM]" (page 6-80), "Test O62 – Lower Sol [Lower Solenoid (SOL1)]" (page 6-153)	Cycle key switch to clear. **Note:** This code appears in the error log only.

CODE 79 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 79: Regen Lower Fault	"Input A23 – L/L % [Lift/Lower Request]" (page 6-55), "Input I20 – Lift RPM [Lift Motor RPM]" (page 6-80), "Test O62 – Lower Sol [Lower Solenoid (SOL1)]" (page 6-153)	Cycle key switch to clear. If code occurs after lift pump replacement, make sure correct pump was installed.

CODE 7E Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 7E: Lift Motor Temperature Sensor Out-of-Range Lift motor temperature sensor voltage is out-of-range.	"Input A09 - Lft Mr Tmp [Lift Motor Temp]" (page 6-43)	Cycle key switch to clear. **Note:** The TM cannot cause this code.

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CODE 7F Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 7F: LPA Temp Out-of-Range The LPA temperature is less than –40°F (–40°C) or greater than +203°F (+95°C).	"Input A19 - LA Temp [LPA Temp]" (page 6-52)	Cycle key switch to clear. **Note:** The TM cannot cause this code.

CODE 7G Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 7G: LPA Motor Phase Open The LPA detects no current draw in one of the three phases of the motor.	"Test O28 – Lift RPM [Ramp Lift Motor]" (page 6-134)	Cycle key switch to clear. **Note:** The TM cannot cause this code.

CODE 7H Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 7H: Lift Motor Speed Sensor Failure Detected The LPA detects incorrect pulses from the lift motor speed sensor.	"Input I20 – Lift RPM [Lift Motor RPM]" (page 6-80)	Cycle key switch to clear. **Note:** The TM cannot cause this code.

CODE 7M Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 7M: LPA Failed to Precharge The LPA failed to precharge.	"Test O03 – LHC Ctr [Load Handler Contactor]" (page 6-127)	Check for B+ at TPA+ or welded LHC tips. Cycle key switch to clear. If code will not clear, replace LPA. **Note:** The TM cannot cause this code.

CODE 7T Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 7T: LPA Current Sensor Fault Internal LPA circuitry detects a fault.	None	If cycling the key switch does not clear this code, replace the LPA. **Note:** The TM cannot cause this code.

CODE 7U Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 7U: LPA Overcurrent or Short Circuit The LPA senses current in excess of 650A.	"Test O28 – Lift RPM [Ramp Lift Motor]" (page 6-134)	Check for shorted lift motor power cables. Cycle key switch to clear. **Note:** The TM cannot cause this code.

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CODE 7V Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 7V: LPA High Voltage on DC BUS The LPA detects an overvoltage condition at the + terminal.	None	If the problem is intermittent and only occurs while lowering the main mast, it indicates a bad battery or possible loose connection in the power circuit connections for the lift/lower system. Check all associated power cables for correct torque and contactor tips for excessive wear. If the error is a hard code, re-flash the LPA. If the code persists, replace the LPA. **Note:** The TM cannot cause this code.

CODE 7W Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 7W: LPA Internal Fault Internal malfunction.	None	Cycle key switch to clear. Re-flash the LPA. If code does not clear, replace LPA. **Note:** The TM cannot cause this code.

CODE 7X Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 7X: LPA Power Supply Out-of-Range The power supply output in the LPA is less than 4.5V, greater than 5.5V, or too much current is being drawn by an external component.	None	Cycle key switch to clear. Disconnect (+) wire to LPA temperature and speed sensors. If code changes, troubleshoot wires and sensors. If code does not change, replace LPA. **Note:** The TM cannot cause this code.

CODE 80 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 80: Throttle Pot Voltage Out-of-Range VR1 voltage at pin JPC12-3 out-of-range.	"Input A04 – Thrtl Pot [Throttle Pot (VR1)]" (page 6-40)	Cycle key switch to clear.

CODE 81 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 81: Lift/Lower Pot Voltage Out-of-Range VR2 voltage at pin JPC12-2 out-of-range.	"Input A05 – L/L Pot [Lift/Lower Pot (VR2)]" (page 6-41)	Cycle key switch to clear.

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CODE 83 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 83: Throttle Pot Out-of-Neutral VR1 out of learned neutral value during SelfTest.	"Input A04 – Thrtl Pot [Throttle Pot (VR1)]" (page 6-40)	Cycle key switch to clear. Check throttle pot spring for excessive play. **Note:** This code is displayed if the Throttle is out-of-neutral and the "Release handle" message has scrolled three times.

CODE 84 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 84: Brake Inoperable - Not Applied The traction motor speed sensor indicated movement during Selftest.	"Test O30 – Brake" (page 6-136)	Make sure brake release bolts are removed from brake assembly. Cycle key switch to clear.

CODE 88 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 88: +5V Power Supply Out-of-Range Control handle +5V power supply located in Carriage Manager out-of-range.	"Input A26 - CM 5V PS [+5VDC Pot Supply]" (page 6-56)	Cycle key switch to clear.

CODE 8A Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 8A: Rotate Pot Voltage Out-of-Range VR3 voltage at JPC12-5 out-of-range.	"Input A87 – Rot Pot [Rotate Command Pot (VR3)]" (page 6-65)	Cycle key switch to clear.

CODE 8B Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 8B: Traverse Pot Voltage Out-of-Range VR4 voltage at JPC4-4 out-of-range.	"Input A85 – Trv Pot [Traverse/Reach Pot (VR4)]" (page 6-63)	Cycle key switch to clear.

CODE 8C Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 8C: Deadman Pedal Switch Error Signals do not agree from the Deadman pedals (S2 and S23).	"Input I00 – Dman S23 [Carriage Deadman Switch (S23)]" (page 6-74), "Input I32 – Dman S2 [Brake Deadman Switch (S2)]" (page 6-86)	Check for debris under deadman pedals. Cycle key switch to clear.

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CODE 8F Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 8F: Lift/Lower Pot Out-of-Neutral VR2 out of learned neutral value during SelfTest.	"Input A05 – L/L Pot [Lift/Lower Pot (VR2)]" (page 6-41)	Check lift/lower pot spring for excessive play. Cycle key switch to clear. **Note:** This code is displayed if the Lift pot is out-of-neutral and the "Release handle" message has scrolled three times.

CODE 8L Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 8L: Brake Feedback Current Out-of-Range The TM senses brake coil current is incorrect.	"Input A35 - BrkSense [Brake Voltage]" (page 6-57)	Cycle key switch to clear.

CODE 8M Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 8M: Mini Power Supply Voltage Out-of-Range Mini power supply voltage on load handler is <9.0 or >20.0V	"Test O63 – MiniPwrSup [Mini Power Supply]" (page 6-154), "Input A40 - MiniSply [Mini Power Supply]" (page 6-59)	Cycle key switch to clear.

CODE 8V Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 8V: Rotate Pot Out-of-Neutral VR3 out of learned neutral value during SelfTest.	"Input A87 – Rot Pot [Rotate Command Pot (VR3)]" (page 6-65)	Check rotate pot spring for excessive play. Cycle key switch to clear. **Note:** This code is displayed if the Rotate pot is out-of-neutral and the "Release handle" message has scrolled three times.

CODE 8X Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 8X: Traverse Pot Out-of-Neutral VR4 out of learned neutral value during SelfTest.	"Input A85 – Trv Pot [Traverse/Reach Pot (VR4)]" (page 6-63)	Check traverse pot spring for excessive play. Cycle key switch to clear. **Note:** This code is displayed if the Traverse pot is out of neutral and the "Release handle" message has scrolled three times.

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CODE 91 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 91: Drive Unit Turned >10° While On Wire	"Input I24 – Str Home [Home Steer Proximity Sensor]" (page 6-83), "Input I25 – Str Encdr [Steer Motor Encoder]" (page 6-84)	Cycle key switch to clear.

CODE 92 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 92: Tracking Limits Exceeded	None	Run Wire Guidance Learn. See "Learn Wire Guidance" on page 3-34. Cycle key switch to clear.

CODE 93 Lost TCP Lost Wire

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 93: Not Near Wire - Tractor Coil Pair	None	Refer to "Wire Guidance Troubleshooting" on page 5-21.

CODE 94 Lost LCP Lost Wire

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 94: Not Near Wire - Load Coil Pair	None	Refer to "Wire Guidance Troubleshooting" on page 5-21.

CODE 9A Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 9A: Bad WG Learn Procedure	None	Run Wire Guidance Learn. See "Learn Wire Guidance" on page 3-34.

CODE 9B Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 9B: Incorrect Firmware in Guidance Manager Version of firmware installed in Guidance Manager is not compatible with TM software.	None	Install correct TM software via FlashWare or correct firmware in Guidance Manager. Cycle key switch to clear.

CODE 9E Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 9E: Track and Hold Signal Failed The truck is moving on the wire and the guidance signals are not fluctuating.	Check for shorts to frame. Refer to "Shorts to Frame Test" on page 5-3.	Check static straps. AUTO/MAN switch to Manual. Cycle key switch to clear. Replace Guidance Manager.

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CODE 9F Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 9F: Filter Card Not Connected to Guidance Manager AUTO/MAN switch is switched to Auto and the Guidance Manager does not sense the Filter Card.	None	Cycle key switch to clear. Check connection between Filter Card and Guidance Manager. Replace Filter Card first, then Guidance Manager.

CODE 9G Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 9G: No Signal - Load Antenna	None	Cycle key switch to clear. Line driver output interrupted. Refer to "Wire Guidance Troubleshooting" on page 5-21.

CODE 9H Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 9H: No Signal - Tractor Antenna	None	Cycle key switch to clear. Line driver output interrupted. Refer to "Wire Guidance Troubleshooting" on page 5-21.

CODE 9J Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 9J: Load Antenna Input Too High	None	AUTO/MAN switch to Manual. Cycle key switch to clear.

CODE 9K Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code 9K: Tractor Antenna Input Too High	None	Refer to "Wire Guidance Troubleshooting" on page 5-21.

CODE A0 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code A0: Incorrect Software Incorrect Tractor Manager installed in truck or Flashed with incorrect software.	None	Travel, lift, and lower disabled. Cycle key switch to clear. If this code appears, upgrade the software in the truck using FlashWare.

CODE A2 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code A2: Software Compatibility Issue with TM and TPA	None	Upgrade software via FlashWare. Cycle key switch to clear.

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CODE A4 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code A4: Software Compatibility Issue with TM and LPA	None	Upgrade software via FlashWare. Cycle key switch to clear.

CODE AP Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code AP: TPA Software Fault	None	Cycle key switch to clear. If code does not clear, upgrade TPA software via FlashWare.

CODE AT Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code AT: LPA Software Fault	None	Cycle key switch to clear. If code does not clear, upgrade LPA software via FlashWare.

CODE AV Inform Service

Code Title/Reason	Inputs/Tests 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 pre-programmed TM and CM.

CODE B0 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code B0: Rotate Position Feedback Pot Out-of-Range	"Input A88 – Rot Posn [Rotate Position Feedback Pot (VR6)]" (page 6-66)	Cycle key switch to clear.

CODE B1 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code B1: Traverse Position Feedback Pot Out-of-Range	"Input A86 – Trv Posn [Traverse Position Feedback Pot (VR5)]" (page 6-64)	Cycle key switch to clear.

CODE FE Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code FE: Internal TM Circuit for BSOC Not Calibrated	None	Code is displayed for 30 seconds. Replace TM.

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CODE FG Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code FG: TM Power Supply Out-of-Range	"Input A14 - TM +12 [TM +12VDC Power Supply]" (page 6-48)	Cycle key switch to clear.

CODE FH Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code FH: Battery Voltage Out-of-Range Wrong voltage battery or voltage out-of-range.	"Input A15 – BattVolt [Battery Voltage]" (page 6-49)	Cycle key switch to clear.

CODE FK Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code FK: CM Power Supply Out-of-Range	"Input A12 - CM +12 [CM +12VDC Power Supply]" (page 6-46)	Cycle key switch to clear.

CODE FN Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code FN: Relays Did Not Open at Power Off	"Test O32 – Relay Tog [Toggle Relay Enable]" (page 6-137)	Cycle key switch to clear.

CODE FP Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code FP: TM In-Circuit Hardware Failure	None	If code is displayed at Startup, replace TM. If intermittent, check static straps and for shorts to frame. Refer to "Shorts to Frame" (page 5-2). Cycle key switch to clear.

CODE FT Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code FT: TM Internal Software Error	None	Cycle key switch to clear. If code does not clear, upgrade TM software via FlashWare.

CODE FX Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code FX: CM In-Circuit Hardware Failure	None	If code is displayed at Startup, replace CM. If intermittent, check static straps and for shorts to frame. Refer to "Shorts to Frame" (page 5-2). Cycle key switch to clear.

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CODE FY Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code FY: CM Internal Software Error	None	Cycle key switch to clear. If code does not clear, upgrade CM software via FlashWare.

CODE G0 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code G0: Steer Tiller Encoder 1 Bad	"Input I35 – Str Enc1 [Steering Encoder Channel E1]" (page 6-89)	Cycle key switch to clear.

CODE G2 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code G2: Auto Steer Center Failed 1. Home switch is >10° from the initial value saved during a successful Auto Steer Center. 2. Auto Steer Center time-out >2 seconds. 3. No encoder pulses sensed during Auto Steer Center.	Refer to "Troubleshooting Steering Fault Codes (G Series)" on page 5-23.	Step off, then back on the deadman pedal to allow travel again. Cycle key switch to clear.

CODE G3 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code G3: Home Prox Switch Not Functioning Correctly	Refer to "Troubleshooting Steering Fault Codes (G Series)" on page 5-23.	All steer indicator lights will flash. Cycle key switch to clear.

CODE G4 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code G4: Open Detected in Steer Control Circuit No neutral pulses detected when the truck is not moving and the deadman pedal is depressed.	Refer to "Troubleshooting Steering Fault Codes (G Series)" on page 5-23.	Step off, then back on the deadman pedal to allow travel again. Cycle key switch to clear.

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CODE G5 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code G5: Short Detected In Steer Power Circuit No command and steer motor encoder pulses detected.	"Input A37 - Str Curr [Steer Motor Current]" (page 6-58), "Input I25 – Str Encdr [Steer Motor Encoder]" (page 6-84), "Test O44 – Steer Mtr [Steer Motor]" (page 6-140)	Step off, then back on the deadman pedal to allow travel again. Cycle key switch to clear.

CODE G7 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code G7: Steer Tiller Encoder 2 Bad	"Input I36 – Str Enc2 [Steering Encoder Channel E2]" (page 6-90)	Cycle key switch to clear.

CODE GD Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code GD: No Steer Motor Encoder Pulses Seen No steer motor encoder pulses seen when requesting a steer correction, travel is >0.1 mph, or during Auto Steer Center.	"Input I25 – Str Encdr [Steer Motor Encoder]" (page 6-84)	Cycle key switch to clear.

CODE GE Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code GE: Both Steer Tiller Encoders Bad The connect detect circuit senses both steer tiller encoders are bad.	"Input I35 – Str Enc1 [Steering Encoder Channel E1]" (page 6-89), "Input I36 – Str Enc2 [Steering Encoder Channel E2]" (page 6-90)	Cycle key switch to clear.

CODE GF Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code GF: Wire Guidance Position Out-of-Range	None	Run Wire Guidance Learn. See “Learn Wire Guidance” on page 3-34. Cycle key switch to clear.

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CODE J2 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code J2: Aisle Exit Error Only one magnet was sensed when the aisle was exited.	"Input I72 – EOA1, Right [End-of-Aisle Sensor 1 (Right Side)]" (page 6-98), "Input I73 – EOA2, Left [End-of-Aisle Sensor 2 (Left Side)]" (page 6-99), "Input I117 – EOA1 Inner [Alternate Sensor 2]" (page 6-121), "Input I118 – EOA2 Outer [Alternate Sensor 1]" (page 6-122)	While out of the aisle, switch the AUTO/MAN switch to Manual. Turn the drive unit >10° and travel until the code clears. **Note:** Inputs displayed are dependant on EOA selection in FlashWare.

CODE J4 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code J4: End-of-Aisle Sensor Fault The connect/detect circuit senses one or both sensors are bad.	"Input I100 – EOA1 On [End-of-Aisle Connect Detect 1 (Right Side)]" (page 6-103), "Input I101 – EOA2 On [End-of-Aisle Connect Detect 2 (Left Side)]" (page 6-104)	Check sensor wiring. Cycle key switch to clear.

CODE T4 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code T4: Traverse Proportional Valve Solenoid Open	"Test O58 – Traverse PWM [Traverse PWM (SOL7)]" (page 6-149)	Cycle key switch to clear.

CODE T5 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code T5: Rotate/Reach Proportional Valve Solenoid Open	"Test O55 – Rch/Rot PWM [Reach/Rotate PWM (SOL8)]" (page 6-146)	Cycle key switch to clear.

CODE TE Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code TE: Load Handler Motor Temp Sensor Out-of-Range	"Input A65 - LH Mr Tmp [Load Handler Motor Temp]" (page 6-62)	Cycle key switch to clear.

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CODE TF Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code TF: Load Handler Motor Overtemp	"Input A65 - LH Mr Tmp [Load Handler Motor Temp]" (page 6-62), "Test O23 – Fans" (page 6-133)	Self-resetting after motor allowed to cool.

CODE X6 Inform Service

Code Title/Reason	Inputs/Tests to Run	Notes/Corrective Action
Code X6: EPO Mismatch Reading at JPT22-21 does not agree with reading at JPC22-21 regarding EPO position.	"Input A41 - CM EPO [CM EPO Sense]" (page 6-60) "Input A42 - TM EPO [TM EPO Sense]" (page 6-61)	Cycle key switch to clear.

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Analog Inputs

A Diagnosis and Repair table is provided for most inputs. If an input is not within the specified limits, refer to the Diagnosis and Repair table.

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

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 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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Input A04 – Thrtl Pot [Throttle Pot (VR1)]

The voltage the Carriage Manager (CM) reads from the throttle pot (VR1) is displayed.

NOTE: Run Learn after you replace, repair, or adjust the throttle pot. Refer to Learn Controls on page 3-33.

If a message to "Release Traction handle to resume operation" is displayed during SelfTest, check the handle for excessive play. The handle should not have movement that allows it to go beyond the values listed while in the neutral position.

Move the throttle pot from full Forks-First (FF) through neutral to full Tractor-First (TF), observing the Operator Display.

The input is good if the value displayed is within these limits:

Throttle Position	Voltage Displayed
Full FF	<4.4V
Neutral	2.25 to 2.75V
Full TF	>0.4

Voltage fluctuation indicates a bad cable or pot. If the displayed voltages are outside these limits or do not change in a smooth, linear fashion, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPR1/DCV	JR1-9	JR1-12	>4V	Perform step 2	T/S wiring
2	Disconnect JPR1 and JPC12/Ohms	JR1-11	JC12-3	0 Ohms	Perform step 3	T/S wiring
3	Disconnect JPC12. <1V should be displayed with A04 selected. If not, replace CM. If OK, connect a jumper (at the CM) between JC12-3 and JC12-1. The display should read >4 with A04 selected. If not, replace the CM. If the correct values are displayed, verify wiring to VR1. If OK, replace pot.					

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Input A05 – L/L Pot [Lift/Lower Pot (VR2)]

The voltage the CM reads from the lift/lower pot (VR2) is displayed.

NOTE: Run Learn after you replace, repair, or adjust the lift/lower pot. Refer to Learn Controls on page 3-33.

If message "Release Lift to resume operation" is displayed during SelfTest, check the handle for excessive play. The handle should not have movement that allows it to go beyond the values listed while in the neutral position.

Move the lift/lower pot from full lift through neutral to full lower, observing the Operator Display.

The input is good if the value displayed is within these limits:

Throttle Position	Voltage Displayed
Full Lift	>0.4
Neutral	2.25 to 2.75V
Full Lower	<4.4V

Voltage fluctuation indicates a bad cable or pot. If the voltage is outside these limits or does not change in a smooth, linear fashion, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPR1/DCV	JR1-9	JR1-13	>4V	Perform step 2	T/S wiring
2	Disconnect JPR1 and JPC12/Ohms	JR1-10	JC12-2	0 Ohms	Perform step 3	T/S wiring
3	Disconnect JPC12. <1V should be displayed with A05 selected. If not, replace CM. If OK, connect a jumper (at the CM) between JC12-2 and JC12-1. The display should read >4 with A05 selected. If not, replace the CM. If the correct values are displayed, verify wiring to VR2. If OK, replace pot.					

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Input A08 - Dr Mr Tmp [Traction Motor Temp]

Traction Motor temperature is displayed.

While operating, the TM continuously monitors traction motor temperature. If the temperature gets too high, performance is reduced until the motor cools down.

- Normal operation: ambient to 284°F (140°C)
- Travel speed reduced linearly between 285°F (141°C) and 310°F (154°C)
- Code 2A is displayed between 311°F (155°C) and 373°F (189°C) and speed is reduced to 1.0 mph
- Code 2E is displayed and travel is limited to 1.0 mph at 374°F (190°C)

With the lift truck at rest and at ambient temperature, compare the temperature displayed to the actual ambient temperature. If the temperatures are not within several degrees, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPTA3/ Ohms	JTA3-2	JTA3-1	<1200 ohms if Traction Motor is cool to the touch. >1200 ohms if hot to the touch	Perform step 2	Replace Traction Motor Temp Sensor
2	Disconnect JPTA1/ Ohms	JTA1-8 (on connector)	JTA1-7		Replace TPA	T/S Traction Motor Temp Sensor wires

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Input A09 - Lft Mr Tmp [Lift Motor Temp]

Lift Motor temperature is displayed.

While operating, the TM continuously monitors lift motor temperature. If the temperature gets too high, performance is reduced until the motor cools down.

- Normal operation: ambient to 310°F (154°C)
- Code 6F displayed at 311°F (155°C) and lift is disabled. Lower is allowed
- Code 7E displayed at 320°F (160°C) and lift continues to be disabled. Lower is allowed

With the lift truck at rest and at ambient temperature, compare the temperature displayed to the actual ambient temperature. If the temperatures are not within several degrees, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPLA3/ Ohms	JLA3-2	JLA3-1	<1200 ohms if Traction Motor is cool to the touch. >1200 ohms if hot to the touch	Perform step 2	Replace Traction Motor Temp Sensor
2	Disconnect JPLA1/ Ohms	JLA1-8	JLA1-7		Replace TPA	T/S Traction Motor Temp Sensor wires

NOTE: For extreme operating conditions where trucks are subjected to repetitive lift/lower cycles, short runs and/or repetitive plugging cycles without time for the amplifiers to cool, a cooling fan kit is available through the parts distribution center. Refer to the parts manual.

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Input A10 - TA Temp [TPA Temp]

Traction Power Amplifier (TPA) temperature is displayed.

While operating, the TPA continuously monitors its internal heatsink temperature. If the temperature gets too high, performance is reduced until the TPA cools down.

- Normal operation: ambient to 175°F (79°C)
- At 185°F (85°C), torque is linearly reduced by the TPA
- Code 1H is displayed when temperature exceeds 203°F (95°C) or falls below –40°F (–40°C)

As the truck is operated, the TPA temperature should increase evenly over time. If not, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Is TPA hot to touch?	N/A	N/A	Hot to touch	Perform step 2	If not hot, replace TPA
2	Allow time to cool			Not hot to touch/no code	Return to service	Replace TPA

NOTE: For extreme operating conditions where trucks are subjected to repetitive lift/lower cycles, short runs, and/or repetitive plugging cycles without time for the amplifiers to cool, a cooling fan kit is available through the Parts Distribution Center. Refer to the parts manual.

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Input A11 - Dr Curr [Traction Motor Current]

The current the TPA reads from one phase of the traction motor is displayed.

- Maximum current: 450A

The input is good if the value displayed is within these limits:

System Condition	Current Displayed
Static (at rest)	<20A
Travel at Full Speed	<150A

NOTE: Because Input A11 measures only one phase, the value displayed may not always reveal a current problem.

Check the current on each phase (U, V, and W) with a AC clamp-on ammeter.

- The current should ramp evenly as the truck accelerates and decelerates.
- Current should be approx. equal for each phase. Gross differences indicate a problem.

Diagnosis and Repair

If readings are not within specified limits, perform the following steps.

1. If any one phase differs significantly from the other two, check power cable continuity. Replace cables as necessary. Refer to Power Cable Terminals on page 7-52.
   - If power cable continuity is OK, troubleshoot the Traction Motor. Refer to 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 – Traction RPM [Ramp Traction Motor] (page 6-135).

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Input A12 - CM +12 [CM +12VDC Power Supply]

Output of the Carriage Manager's internal +12VDC power supply is displayed.

With the truck at rest, the value displayed should be 10.1 to 13.0V.

If the reading fluctuates by more than 0.8V in 10 seconds, refer to Diagnosis and Repair.

Diagnosis and Repair

Unplug all connectors supplying 12V from the CM. Measure 10.1 to 13VDC between JC24-13 and JC10-9. If not OK, replace the CM. If OK, plug in connectors one at a time. Troubleshoot the circuit that pulls the +12V down.

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Input A13 – MainPres [Main Lift Pressure Sensor]

Voltage from the main lift pressure sensor is displayed.

The input is good if the value displayed is within these limits:

Load Weight	Voltage Displayed
0 lb. (no load) - platform raised 4 in. (102 mm)	Approx. 2.2V

The voltage displayed should increase and decrease linearly as the load weight is increased or decreased. If it does not, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPT20-5	JPT24-10	10.5 to 13V	Perform step 2	Replace TM
2		JPS50-1	JPS50-3		Perform step 3	T/S harness
3	Attach pressure gauge to G1/DCV	JPS50-2		1V at 0 psi. 1V increase per 1000 psi	Perform step 4	Replace Pressure Transducer
4		JPT24-18	JPT24-10		Replace TM	T/S harness

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Input A14 - TM +12 [TM +12VDC Power Supply]

Output of the Tractor Manager's (TM) internal +12VDC power supply is displayed.

With the truck at rest, the value displayed should be 10.1 to 13.0V.

If the reading fluctuates by more than 0.8V in 10 seconds, refer to Diagnosis and Repair.

Diagnosis and Repair

Unplug all connectors supplying 12V from the TM. Measure 10.1 to 13VDC between JPT14-5 and TP4. If not OK, replace the TM. If OK, plug in connectors one at a time. Troubleshoot the circuit that pulls the +12V down.

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Input A15 – BattVolt [Battery Voltage]

The voltage the TM reads from BATTERY_ SENSE_IN at JPT24-24 is displayed.

NOTE: This voltage is used by the TM to calculate Battery State-of-Charge (BSOC).

The input is good if the value displayed is within these limits:

Nominal Battery Voltage	Voltage Displayed (while stationary)
48V	44 to 52V

If the voltage displayed is not within the correct range or the reading fluctuates by more than 0.8V in 10 seconds with the truck not moving or lifting, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	TP1	TP4	44 to 52V	Perform step 2	Check battery water level and specific gravity. Replace battery. T/S battery cables
2		JPF4-1			Perform step 3	T/S harness from TP1 to JPF4-1
3		JPF4-7			Perform step 4	Replace Fuse/Relay Card
4		JPT24-24			Replace TM	T/S harness from Fuse/Relay Card to TM

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Input A17 – Lift Pnd [Lift Pendant]

The voltage to the Lift Pendant from the Tractor Manager is displayed.

NOTE: The display should read approx. 5.0V with the pendant disconnected.

If the voltage reads approx. 5V, refer to Input A18. If the display reads <1V at startup, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV (pendant disconnected	J1-4	J1-9	Approx. 5V	Replace TM	Perform step 2
2	Extract JT12-5 from connector/DCV (pendant disconnected)	PT12-5	JPT12-12		T/S wiring	Replace TM

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Input A18 – Lwer Pnd [Lower Pendant]

The voltage to the Lower Pendant from the Tractor Manager is displayed.

NOTE: The display should read approx. 5.0V with the pendant disconnected.

If the voltage reads approx. 5V, refer to Input A17. If the display reads <1V at startup, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV (pendant disconnected	J1-3	J1-9	Approx. 5V	Replace TM	Perform step 2
2	Extract JT12-6 from connector/DCV (pendant disconnected)	PT12-6	JPT12-12		T/S wiring	Replace TM

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Input A19 - LA Temp [LPA Temp]

Lift Power Amplifier (LPA) temperature is displayed.

While operating, the LPA continuously monitors its internal heatsink temperature. If the temperature gets too high, performance is reduced until the LPA cools down.

- Normal operation: ambient to 175°F (79°C)
- At 185°F (85°C), speed is linearly reduced to 0 fpm at 239°F (115°C), when lift is disabled
- Code 7F is displayed when temperature exceeds 203°F (95°C) or falls below –40°F (–40°C)

As lift is operated, the LPA temperature should increase evenly over time. If not, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Is LPA hot to touch?	N/A	N/A	Hot to touch	Perform step 2	If not hot, replace LPA
2	Allow time to cool. Does code clear?			Not hot to touch/no code	Return to service	Replace LPA if code does not clear

NOTE: For extreme operating conditions where trucks are subjected to repetitive lift/lower cycles, short runs, and/or repetitive plugging cycles without time for the amplifiers to cool, a cooling fan kit is available through the Parts Distribution Center. Refer to the parts manual.

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Input A20 - Lft Curr [Lift Motor Current]

The current the LPA reads from one phase of the lift motor is displayed.

- Maximum current: 650A

The input is good if the value displayed is within these limits:

System Condition	Current Displayed
Static (at rest)	<20A
Full Lift	Approx. 460A

NOTE: Because Input A20 measures only one phase, the value displayed may not always reveal a current problem.

Check the current on each phase (U, V, and W) with a AC clamp-on ammeter.

- The current should ramp evenly as the truck lifts.
- Current should be approx. equal for each phase. Gross differences indicate a problem.

Diagnosis and Repair

If readings are not within specified limits, perform the following steps.

1. If any one phase differs significantly from the other two, check power cable continuity. Replace cables as necessary. Refer to Power Cable Terminals on page 7-52.
   - If power cable continuity is OK, troubleshoot the Lift Motor. Refer to AC Motors on page 5-9.
   - If all phases give high readings, the lift pump may be binding. Check lift pump.
2. The LPA may be bad. Run Test O28 – Lift RPM [Ramp Lift Motor] (page 6-134).

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Input A22 – Thrtl % [Travel Request]

The percentage of throttle request the TM sends to the TPA is displayed. This value is based on VR1 position as calculated by the TM.

NOTE: Run Learn after you replace, repair, or adjust the throttle pot. Refer to Learn Controls on page 3-33.

The input is good if the value displayed is within these limits:

Throttle Position	Percentage Displayed
Full TF	0 to +100
Neutral	0
Full FF	0 to –100

The values should change smoothly and evenly as the handle moves from Full Tractor-First to Full Forks-First. If these results are not observed, refer to Diagnosis and Repair.

Diagnosis and Repair

Refer to Input A04 – Thrtl Pot [Throttle Pot (VR1)] (page 6-40).

Compare Input A04 with Input A22. Maximum throw should show maximum values. If so, replace the TPA. If not, check traction system for speed limitations due to motor temperature, limit switches, or configured speed.

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Input A23 – L/L % [Lift/Lower Request]

The percentage of lift/lower request the TM sends to the LPA is displayed. This value is based on VR2 position as calculated by the TM.

NOTE: Run Learn after you replace, repair, or adjust the lift/lower pot. Refer to Learn Controls on page 3-33.

The input is good if the value displayed is within these limits:

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

The values should change smoothly and evenly as the pot is moved from Full Lower to Full Lift. If these results are not observed, refer to Diagnosis and Repair.

Diagnosis and Repair

Refer to Input A05 – L/L Pot [Lift/Lower Pot (VR2)] (page 6-41).

Compare Input A05 with Input A23. Maximum throw should show maximum values. If so, replace the LPA. If not, check lift system for limitations due to motor temperature or switches.

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Input A26 - CM 5V PS [+5VDC Pot Supply]

Output of the Carriage Manager's internal +5VDC power supply is displayed. This voltage is used for control handle pots.

With the truck at rest, the value displayed should be 5 ±0.25V.

If the reading fluctuates by more than 0.25V in 10 seconds, refer to Diagnosis and Repair.

Diagnosis and Repair

Disconnect JPC12 and JPC4. Measure 5 ±0.25VDC between PC12-1 and PC12-12. If not OK, replace the CM. If OK, plug in connectors, one at a time. Troubleshoot the circuit that pulls the +5V down.

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Input A35 - BrkSense [Brake Voltage]

The brake is activated by an internal TM coil driver. The voltage measured at JPT20-14 is displayed.

The input is good if the value displayed is within these limits:

State of Brake	Voltage Displayed
Deactivated	B+
Deadman Pedal Depressed/Travel Requested	7 to 11V for approx. 1 sec, increasing to 15 to 28V

If these results are not observed, refer to Diagnosis and Repair for Test O30 – Brake (Page 6-136).

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Input A37 - Str Curr [Steer Motor Current]

The current the steer motor is drawing is displayed.

The input is good if the value displayed is within these limits:

State of Motor	Current Displayed
At rest	<2A
Clockwise (CW) Steering	–30A to –50A
Counterclockwise (CCW) Steering	30A to 50A
Note: CW and CCW is drive unit direction. Open in wire at JPT6-3 equals –199A.	

If these results are not observed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPT6-3	JPT6-4	At rest: approx. 2.5V Steering CCW: <V at rest Steering CW: >V at rest	Replace TM	Replace Steer Amplifier

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Input A40 - MiniSply [Mini Power Supply]

Output of the Carriage Manager's internal power supply is displayed. This voltage is used to power the mini power supply located on the mini-mast.

With the truck at rest, the value displayed should be 8.5 to 11V.

The readings associated with this input vary depending on the load that is currently on connection JPC12-7. If the voltage displayed is not within the correct range, refer to Test O63 – MiniPwrSup [Mini Power Supply] (page 6-154).

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Input A41 - CM EPO [CM EPO Sense]

The status of the Emergency Power Off (EPO) switch (S21), as sensed by the CM, is displayed.

The input is good if the value displayed is within these limits:

State of Switch	Voltage Displayed
Up (closed)	B+
Down (open)	<0.5V

Code X6 is displayed when the truck cannot determine EPO switch status. If the above results are observed, refer to Input A42 - TM EPO [TM EPO Sense] (page 6-61).

If these results are not observed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPC22-21	JPC14-10	Switch closed: B+ Switch open: <0.5V	Replace CM	T/S wiring, switch, and connections

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Input A42 - TM EPO [TM EPO Sense]

The status of the Emergency Power Off (EPO) switch (S21), as sensed by the TM, is displayed.

The input is good if the value displayed is within these limits:

State of Switch	Voltage Displayed
Up (closed)	B+
Down (open)	<0.5V

If these results are observed, the TM EPO circuit from S21, the Over-the-Mast (OTM) cable, the Fuse/Relay Card, and the wiring to the TM are good.

Code X6 is displayed when the truck cannot determine EPO switch status. If the above results are observed, refer to Input A41 - CM EPO [CM EPO Sense] (page 6-60).

If these results are not observed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	With EPO switch raised, disconnect JPF4/Ohms	JF4-8	JF4-5	Approx. 0 ohms	Perform step 2	T/S OTM cable and connections
2	DCV	JPT22-21	TP4	Switch closed: B+ Switch open: <0.5V	Replace TM	T/S wiring and connections

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Input A65 - LH Mr Tmp [Load Handler Motor Temp]

Load Handler Motor (LHM) temperature is displayed.

While operating, the TM continuously monitors the load handler motor temperature. If the temperature gets too high, the fan circuit is activated by the TM. Fan activation should occur at 120°F (49°C).

- Normal operation: ambient to 259°F (126°C)
- Out-of-range code TE
- Code TF displayed at 260°F (127°C) and load handler functions are disabled

With the lift truck at rest and at ambient temperature, compare the temperature displayed to the actual ambient temperature. If the temperatures are not within several degrees, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
Run Test O23 – Fans (page 6-133) to verify fans are functional.						
1	JPZ disconnected/ Ohms	PZ-1	PZ-2	<1200 ohms if LHM is cool to the touch. >1200 ohms if hot to the touch	Perform step 2	Replace LHM Temp Sensor
2	JPT24 disconnected/ Ohms	JT24-23	JT24-11		Replace TM	T/S LHM Temp Sensor wires

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Input A85 – Trv Pot [Traverse/Reach Pot (VR4)]

The voltage the CM reads from the traverse/reach pot (VR4) is displayed.

NOTE: Run Learn after you replace, repair, or adjust the traverse/reach pot. Refer to Learn Controls on page 3-33.

If code 8X is displayed during SelfTest, check the handle for excessive play. The handle should not have movement that allows it to go beyond the values listed while in the neutral position.

Move the traverse/reach pot from full traverse right through neutral to full traverse left, observing the Operator Display.

The input is good if the value displayed is within these limits:

Position	Voltage Displayed
Traverse Right (handle pulled back)	<4.4V
Neutral	2.25 to 2.75V
Traverse Left (handle pushed forward)	>0.4

Voltage fluctuation indicates a bad cable or pot. If the voltage is outside these limits or does not change in a smooth, linear fashion, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPL1/DCV	JL1-9	JL1-12	>4V	Perform step 2	T/S wiring
2	Disconnect JPL1 and JPC4/Ohms	JL1-11	JC4-4	0 Ohms	Perform step 3	T/S wiring
3	Disconnect JPC4. <1V should be displayed with A85 selected. If not, replace CM. If OK, connect a jumper (at the CM) between JC4-2 and JC4-4. The display should read >4 with A85 selected. If not, replace the CM. If the correct values are displayed, verify wiring to VR4. If OK, replace pot.					

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Input A86 – Trv Posn [Traverse Position Feedback Pot (VR5)]

The voltage the CM reads from the traverse position feedback pot (VR5) is displayed.

NOTE: Run Learn after you replace, repair, or adjust the traverse position feedback pot. Refer to Learn Controls on page 3-33.

Traverse the mini-mast from full right to full left, observing the Operator Display.

The input is good if the value displayed is within these limits:

Mini-Mast Position	Voltage Displayed
Fully Left	>0.2V
Center	2.25 to 2.75V
Fully Right	<4.8V

Voltage fluctuation indicates a bad cable or pot. If the voltage is outside these limits or does not change in a smooth, linear fashion, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect VR5/DCV	JK2-1	JK2-3	Approx. 5V	Perform step 2	T/S wiring
2	Disconnect JPC24 and JPK-2/Ohms	JC24-18	JK2-2	0 ohms	Perform step 3	T/S wiring
3	Disconnect JPS27. <1V should be displayed with A86 selected. If not, replace CM. If OK, connect a jumper between JS27-14 and JPC4-1. The display should read >4 with A86 selected. If not, replace the CM. If the correct values are displayed, replace pot.					

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Input A87 – Rot Pot [Rotate Command Pot (VR3)]

The voltage the CM reads from the rotate command pot (VR3) is displayed.

NOTE: Run Learn after you replace, repair, or adjust the rotate pot. Refer to Learn Controls on page 3-33.

If code 8V is displayed during SelfTest, check the knob for excessive play. The knob should not have movement that allows it to go beyond the values listed while in the neutral position.

Move the rotate pot from full clockwise through neutral to full counterclockwise, observing the Operator Display.

The input is good if the value displayed is within these limits:

Rotate Position	Voltage Displayed
Full Clockwise	>0.4
Neutral	2.25 to 2.75V
Full Counterclockwise	<4.4V

Voltage fluctuation indicates a bad cable or pot. If the voltage is outside these limits or does not change in a smooth, linear fashion, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPL1/DCV	JL1-9	JL1-13	>4V	Perform step 2	T/S wiring
2	Disconnect JPL1 and JPC12/Ohms	JL1-10	JC12-5	0 ohms	Perform step 3	T/S wiring
3	Disconnect JPC12 and JPC4. >4V should be displayed with A87 selected. If not, replace CM. If OK, connect a jumper (at the CM) between PC12-5 and PC4-2. The display should read <1V with A87 selected. If not, replace the CM. If the correct values are displayed, verify wiring to VR3. If OK, replace pot.					

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Input A88 – Rot Posn [Rotate Position Feedback Pot (VR6)]

The voltage the CM reads from the rotate position feedback pot (VR6) is displayed.

NOTE: Run Learn after you replace, repair, or adjust the rotate position feedback pot. Refer to Learn Controls on page 3-33.

Rotate the load handler from full clockwise to full counterclockwise, observing the Operator Display.

The input is good if the value displayed is within these limits:

Rotate Position	Voltage Displayed
Full Clockwise	<4.5V
Straight Ahead	2.25 to 2.75V
Full Counterclockwise	>0.5V

Voltage fluctuation indicates a bad cable or pot. If the voltage is outside these limits or does not change in a smooth, linear fashion, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JP4/DCV	J4-1	J4-3	>4V	Perform step 2	T/S wiring
2	Disconnect JP4 and JPC24/Ohms	J4-2	JC24-15	0 Ohms	Perform step 3	T/S wiring
3	Disconnect JPS27 and JPC12. <1V should be displayed with A88 selected. If not, replace CM. If OK, connect a jumper (at the CM) between JC24-15 and JC12-1. The display should read >4 with A88 selected. If not, replace the CM. If the correct values are displayed, replace VR6.					

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Input A89 – MiniPres [Mini-Mast Pressure Sensor]

Voltage from the mini-mast pressure sensor is displayed.

The input is good if the value displayed is within these limits:

Load Weight	Voltage Displayed
0 lb. (no load) - Load Handler raised 4 in. (102 mm)	Approx. 1.5V

The voltage displayed should increase and decrease linearly as the load weight is increased or decreased. If it does not, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPT20-4	JPT20-6	10.5 to 13V	Perform step 2	Replace TM
2		JP46-1	JP46-3		Perform step 3	T/S harness
3	Attach pressure gauge to G1/DCV	JP46-2		1V at 0 psi. 1V increase per 1000 psi	Perform step 4	Replace Pressure Transducer
4		JPT24-19	JPT24-6		Replace TM	T/S harness

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Input A90 – TM B+Key

The voltage the TM is reading at JPT14-12 is displayed.

The input is good if the value displayed is within these limits:

Nominal Battery Voltage	Voltage Displayed
48V	44.0 to 52.0V

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Input A91 – CM B+Key

The voltage the CM is reading at JPC14-12 is displayed.

The input is good if the value displayed is within these limits:

Nominal Battery Voltage	Voltage Displayed
48V	44.0 to 52.0V

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Input A94 - Trv Curr [Traverse Solenoid (SOL7)]

The current the traverse solenoid (SOL7) is drawing, as read by the CM, is displayed in milliamps.

The input is good if the value displayed is within these limits:

State	Current Displayed (mA)
Neutral	0 to 4
Traverse Requested	up to 650

If these results are not observed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC20/Ohms	JC20-20	JC20-17	Approx. 30 ohms	Perform step 2	T/S wiring, connections, and solenoid coil
2	DCV	SOL7-1	JPC14-1	B+	Perform step 3	T/S wiring, connections, and Fuse/Relay Card
3		JC20-20		Ramp from B+ (OFF) to approx. 31V (ON)	Check SOL7 for mechanical binding.	T/S B+K2. If OK, replace CM

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Input A95 - Rot Curr [Rotate Solenoid (SOL8)]

The current the rotate solenoid (SOL8) is drawing, as read by the CM, is displayed in milliamps.

The input is good if the value displayed is within these limits:

State	Current Displayed (mA)
Neutral	0 to 4
Traverse Requested	up to 550

If these results are not observed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC20/Ohms	JC20-16	JC20-13	Approx. 30 ohms	Perform step 2	T/S wiring, connections, and solenoid coil
2	DCV	SOL8-1	JPC14-1	B+	Perform step 3	T/S wiring, connections, and Fuse/Relay Card
3		JPC20-16		Ramp from B+ (OFF) to approx. 32V (ON)	Check SOL8 for mechanical binding.	T/S B+K2. If OK, replace CM

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Digital Inputs

A Diagnosis and Repair table is provided for most inputs. If an input is not within the specified limits, refer to the Diagnosis and Repair table.

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

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 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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Input I00 – Dman S23 [Carriage Deadman Switch (S23)]

The status of the Carriage Deadman Switch (S23), as seen by the CM, is displayed.

The input is good if these values are displayed:

Pedal Position	Value Displayed
Up	Off
Down	On

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect S23/DCV	S23-1	S23-3	Approx. 12V	Perform step 2	T/S wiring
2	DCV	JPC22-7	JPC22-11	Pedal Up: Approx. 5V Pedal Down: <1V	Replace CM	T/S switch, wiring, and connections

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Input I02 – Lift S11 [Lift Reference Prox (S11)]

The status of the Lift Reference Prox (S11), as seen by the TM, is displayed.

The display should indicate S11 is below (Belw) when near the mast crosstie and above (Abve) when the telescopic is raised above the switch.

Verify clearance between the switch and telescopic is 0.19 ±0.06 in. (4.8 ±1.5 mm).

The input is good if these values are displayed:

Switch State	Value Displayed
Near metal	Belw
Away from metal	Abve

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPS8/DCV	PS8-1	PS8-3	Approx. 12V	Perform step 2	T/S wiring
2	DCV	JPT22-7	JPF3-11	Above: Approx. 5V Below: <1V	Replace TM	T/S switch, wiring, and connections

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Input I04 – Bypass S7 [Lift/Lower Inhibit Bypass Switch (S7)]

The status of the Lift/Lower Inhibit Bypass Switch (S7), as seen by the CM, is displayed.

The input is good if these values are displayed:

Switch State	Value Displayed
Closed	In
Open	Out

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC12 and JPC4/Ohms	JC12-8	JC4-2	Switch depressed: 0 ohms	Replace CM	T/S switch, wiring, and connections

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Input I14 – FU1 Sense

The absence or presence of B+ to the load side of the STR contactor is displayed.

The input is good if these values are displayed:

STR State	Value Displayed
Open	<4V*
Closed	B+
*Allow approx. 7 minutes for voltage to drop below 4V after STR contactor opens.	

If these values are not displayed, refer to Diagnosis and Repair.

Code 4B - If >4V is displayed with the contactor open, check for shorts to frame. Remove the sense wire from JPT22-19. If the voltage goes away, locate the cause of the short. If the voltage remains >4V with the sense lead disconnected, replace the TM.

Code 4C - Check FU1 and the STR contactor tips.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	STR Contactor pushed in	JPT22-19	TP4	B+	Replace TM	T/S wiring, connections, and contactor

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Input I15 – Horn S3 [Horn Switch (S3)]

The status of the Horn Switch (S3), as seen by the CM, is displayed.

The input is good if these values are displayed:

Switch State	Value Displayed
Out	Out
Depressed	In

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC12/Ohms	JC12-10	JC12-12	Switch depressed: 0 ohms Switch not depressed: open	Replace CM	T/S switch, wiring, and connections

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Input I19 – Trac RPM [Traction Motor RPM]

The output from the Traction Motor Encoder (TME), as seen by the TPA, is displayed.

The Display shows rpm as measured by the TPA. The RPM reading should show a linear increase to maximum RPM.

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPTA4/DCV	JPTA1-26	JPTA1-7	4.5 to 5.5V	Perform step 2	Replace TPA
2	DCV	JPTA2-1			Perform step 3	T/S harness
3			JPTA2-4		Perform step 4	
4		JPTA1-31	JPTA1-7	Stationary: >3.5V or <0.5V Running: Approx. 2V	Replace TPA	T/S wiring. If OK, replace TME
5		JPTA1-32				

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Input I20 – Lift RPM [Lift Motor RPM]

The output from the Lift Motor Encoder (LME), as seen by the LPA, is displayed.

The Display shows rpm as measured by the LPA. The RPM reading should show a linear increase to maximum RPM.

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPLA2/DCV	JPLA1-26	JPLA1-7	4.5 to 5.5V	Perform step 2	Replace LPA
2	DCV	JPLA2-1			Perform step 3	T/S harness
3			JPLA2-4		Perform step 4	
4		JPLA1-32	JPLA1-7	Stationary: >3.5V or <0.5V Running: Approx. 2V	Perform step 5	T/S wire connections. If OK, replace LME
5		JPLA1-31			Replace LPA	

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Input I23 – Can Bus [CAN Communication]

Verification that the TM is communicating with the CM, TPA, LPA, Display Interface Card, and GM is displayed.

The information below is for a truck that displays a code during SelfTest. If the code is displayed after a successful SelfTest, refer to "Troubleshooting Communication Error Codes (5x Series)" on page 5-19.

The input is good if these values (letters) are displayed:

- **C** - CM is communicating with the TM
- **D -** Display Interface Card is communicating with the TM
- **L** - LPA is communicating with the TM
- **T** - TPA is communicating with the TM
- **W** - Guidance Manager is communicating with the TM (wire guidance only).

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
L is missing						
1	DCV	JPLA1-1	B– (on amp)	B+	Perform step 2	T/S B+ from K2 Relay
2	JPLA1 and JPT14 disconnected /Ohms	JLA1-35	JT14-4	0 ohms	Perform step 3	Repair/replace harness
3		JLA1-23	JT14-11		Replace LPA	
T is missing						
1	DCV	JPTA1-1	B– (on amp)	B+	Perform step 2	T/S B+ from K2 Relay
2	JPTA1 and JPT14 disconnected /Ohms	JTA1-35	JT14-4	0 ohms	Perform step 3	Repair/replace harness
3		JTA1-23	JT14-11		Replace TPA	

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Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
W is missing						
1	DCV	JPS6-11	JPS6-24	B+	Perform step 2	T/S B+ from K2 Relay
2	JPS4 and JPT14 disconnected /Ohms	PS4-5	JT14-4	0 ohms	Perform step 3	Repair/replace harness
3		PS4-6	JT14-11		Perform step 4	
4	Disconnect JPW1 and JPW2. If the "**W**" appears with the cables disconnected, troubleshoot wiring and antenna coils to determine which sensor/cable is dragging the GM down. If the "**W**" still does not display, inspect the GM firmware for correct installation. See "Guidance Manager Firmware Replacement" on page 7-56. If correctly installed, replace GM.					

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Input I24 – Str Home [Home Steer Proximity Sensor]

The state of the Home Steer Proximity Sensor, as seen by the TM, is displayed.

The input is good if these values are displayed:

Steer Prox	Value Displayed	LED (on sensor)
Over metal	On	On
Not over metal	Off	Off

If these values are not displayed, refer to Diagnosis and Repair.

NOTE: If the input is bad, pass a screwdriver or metal ruler under the sensor to activate it. If this produces desired results, adjust switch gap to 0.19 ±0.06 in. (4.8 ±1.5 mm).

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPA7-3	JPA7-2	10.5 to 13V	Perform step 3	Perform step 2
2		JPT20-9	JPT22-11		Replace/replace harness	Replace TM
3		JPA7-1	JPA7-2	Sensor over metal: <1V	Perform Step 4	Adjust/replace sensor
4		JPT22-3	JPT20-11	Sensor not over metal: Approx. 5V	Replace TM	Repair/replace harness

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Input I25 – Str Encdr [Steer Motor Encoder]

The Steer Motor feedback Encoder input (counts) to the TM is displayed.

A three digit number is displayed, representing the number of steer motor encoder counts. When the count exceeds 255, it starts over at 0. If the count goes below 0, it starts over at 255.

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPE4-1	JPE4-4	10.5 to 13V	Perform step 2	Perform step 6
2		JPE4-3		Stationary: >4V or <0.5V Turning: Approx. 2.5V	Perform step 3	Replace Steer Motor Encoder
3		JPE4-2			Perform step 4	
4		JPT22-9	JPT10-9		Perform step 5	Repair/replace harness
5		JPT22-10			Replace TM	
6		JPT20-7		10.5 to 13V	Repair/replace harness	Replace TM

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Input I26 – Main Ht Ct [Main Lift Height Encoder]

The Main Lift Height Encoder input to the TM is displayed.

A three digit number is displayed, representing the number of pulses counted. The count should increase during lower and decrease during lift. When the count exceeds 255, it starts over at 0. If the count goes below 0, it starts over at 255.

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPE5A-1	JPE5A-4	10.5 to 13V	Perform step 2	Repair/replace wiring
2		JPE5A-3 (Channel A)	JPE5A-4	Not lifting or lowering main mast: Approx. 5 or <1V Lifting or lowering main mast: Approx. 2.3V	Perform step 3	Replace Height Encoder
3		JPE5A-2 (Channel B)			Perform step 4	
4		JPT22-5 (Channel A)	JPT10-4		Perform step 5	Repair/replace wiring
5		JPT22-12 (Channel B)			Replace TM	

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Input I32 – Dman S2 [Brake Deadman Switch (S2)]

The state of the Brake Deadman Switch (S2), as seen by the TM (via over-the-mast cable), is displayed.

The input is good if these values are displayed:

Pedal Position	Value Displayed
Up	Up
Down	Down

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect S2/DCV	S2-1 at cable	S2-3 at cable	10.1 to 13V	Perform step 2	Perform step 4
2	Disconnect S2/DCV	S2-2 at cable		Approx. 4.5V	Perform step 3	Perform step 5
3	DCV	JPT22-8	JPT14-3	Deadman up: approx. 5V Deadman down: <1V	Replace TM	Replace S2
4	Disconnect S2/Ohms	S2-1 at cable	JPT14-5	Approx. 1 ohm	Perform step 5	Repair/replace wiring
5		S2-3 at cable	JPT14-3		Perform step 6	
6		S2-2 at cable	JPT22-8		Perform step 3	

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Input I33 – Str Enc1On [Steering Encoder Connect Detect 1]

Verification that the E1 channel of the Steering Encoder is connected is displayed.

The input is good if these values are displayed:

Steering Encoder	Value Displayed
Connected	Yes
Not Connected	No

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPC10-7	JPC18-5	JPE1 connected: Approx. 10V JPE1 disconnected: Approx. 12V	Replace CM	Check wiring. If OK, replace steering encoder

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Input I34 – Str Enc2On [Steering Encoder Connect Detect 2]

Verification that the E2 channel of the Steering Encoder is connected is displayed.

The input is good if these values are displayed:

Steering Encoder	Value Displayed
Connected	Yes
Not Connected	No

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPC10-6	JPC18-6	JPE2 connected: approx. 10V JPE2 disconnected: approx. 12V	Replace CM	Check wiring. If OK, replace steering encoder

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Input I35 – Str Enc1 [Steering Encoder Channel E1]

The input from the Steering Encoder Channel E1 to the CM is displayed.

The TM uses the input from the CM to determine the rate and direction of steering request. The number displayed varies between 0 and 255. The displayed value should change as the steer tiller rotates.

If the number displayed does not vary or only changes from 0 to 1 or 0 to 255, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPC10-7	JPC18-5	Approx. 9V	Perform step 2	Disconnect JPE1 and JPE2. If voltage goes to 12V, check wiring. If OK, replace steering encoder
2		JPC22-12 (Ch B)		Tiller stationary: approx. 0 or 4.75V Tiller moving: approx. 2.5V	Perform step 3	Check wiring. If OK, replace steering encoder
3		JPC22-5 (Ch A)			Replace CM	Check wiring. If OK, replace steering encoder

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Input I36 – Str Enc2 [Steering Encoder Channel E2]

The input from the Steering Encoder Channel E2 to the CM is displayed.

The TM uses the input from the CM to determine the rate and direction of steering request. The number displayed varies between 0 and 255. The displayed value should change as the steer tiller rotates.

If the number displayed does not vary or only changes from 0 to 1 or 0 to 255, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPC10-6	JPC18-6	Approx. 9V	Perform step 2	Disconnect JPE1 and JPE2. If voltage goes to 12V, check wiring. If OK, replace steering encoder
2		JPC22-14 (Ch B)		Tiller stationary: approx. 0 or 4.75V Tiller moving: approx. 2.5V	Perform step 3	Check wiring. If OK, replace steering encoder
3		JPC22-13 (Ch A)			Replace CM	Check wiring. If OK, replace steering encoder.

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Input I39 – Neut Pulse [Neutral Pulses]

The neutral pulses seen by the TM from the Steer Amplifier (SA) are displayed.

Run Test O44 – Steer Mtr [Steer Motor] (page 6-140) to check the power portion of the steering system.

The input is good if these values are displayed:

Deadman	Value Displayed
Off	Steady ON or OFF
ON	Quickly toggles between ON and OFF

NOTE: ON/OFF continues to toggle after deadman is released until STR contactor opens.

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPT6-6	JPT6-4	10.5 to 13V	Perform step 2	Replace TM
2		JPT6-1		Deadman pedal down: approx. 2.5V	Replace TM	Repair wiring/ replace SA

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Input I45 – Slk Ch S50 [Slack Chain 1 Switch (S50)]

The state of the Slack Chain Switch 1 (S50 located on seated operator left side), as seen by the TM, is displayed.

The input is good if these values are displayed:

Switch	Value Displayed
Activated	In
Deactivated	Out

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Check lift chain tension. Make sure the switch is activated and both main cylinder lift chains are at the same tension. Inspect the compression spring washers. Refer to "Main Lift Chains (9600)" on page 7-92 or "Main Lift Chains (9700)" on page 7-94. Also, the main lift cylinders may require bleeding. See "Bleeding the Hydraulic System" on page 7-74.

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPT22 and JPF3/Ohms	JT22-1	JF3-10	0 Ohms	Perform step 2	Repair/replace wiring/switch
2		PT22-1	PF3-10	Approx. 5V	Replace TM	Check wiring and Fuse/Relay Card. Make sure JPF3-10 is at B–

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Input I46 – Slk Ch S51 [Slack Chain 2 Switch (S51)]

The state of the Slack Chain Switch 2 (S51 located on seated operator right side), as seen by the TM, is displayed.

The input is good if these values are displayed:

Switch	Value Displayed
Activated	In
Deactivated	Out

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Check lift chain tension. Make sure the switch is activated and both main cylinder lift chains are at the same tension. Inspect the compression spring washers. Refer to "Main Lift Chains (9600)" on page 7-92 or "Main Lift Chains (9700)" on page 7-94. Also, the main lift cylinders may require bleeding. See "Bleeding the Hydraulic System" on page 7-74.

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPT22 and JPT4/Ohms	JT22-2	JT4-2	0 Ohms	Replace TM	Repair/replace wiring/switch

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Input I65 – Rail Sense [Rail Guidance Switch (S15)]

The state of the optional Rail Guidance Switch (S15), as seen by the TM, is displayed.

The input is good if these values are displayed:

Switch	Value Displayed
Depressed	In
Released	Out

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPT22 and JPT24/Ohms	JT22-4	JT24-5	Switch depressed: 0 Ohms Switch released: Open	Replace TM	Repair/replace wiring/switch

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Input I66 – Auto/Man [Auto/Manual Switch (S4)]

The state of the optional Auto/Manual Switch (S4), as seen by the CM, is displayed.

The input is good if these values are displayed:

Switch	Value Displayed
O (open)	Auto
|(closed)	Manu

If these values are not displayed, refer to Diagnosis and Repair.

NOTE: If the wire between the AUTO/MANUAL switch and the CM is disconnected, the system defaults to AUTO.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC12/Ohms	JC12-11	JC12-12	Auto: open circuit Manual: 0 ohms	Replace CM	T/S wiring and switch

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Input I67 – SG Rt S60 [Right Sidegate Switch (S60)]

The state of the optional Sidegate Right Switch (S60), as seen by the CM, is displayed.

The input is good if these values are displayed:

Sidegate	Value Displayed
Up	Up
Down	Down

If these values are not displayed, refer to Diagnosis and Repair.

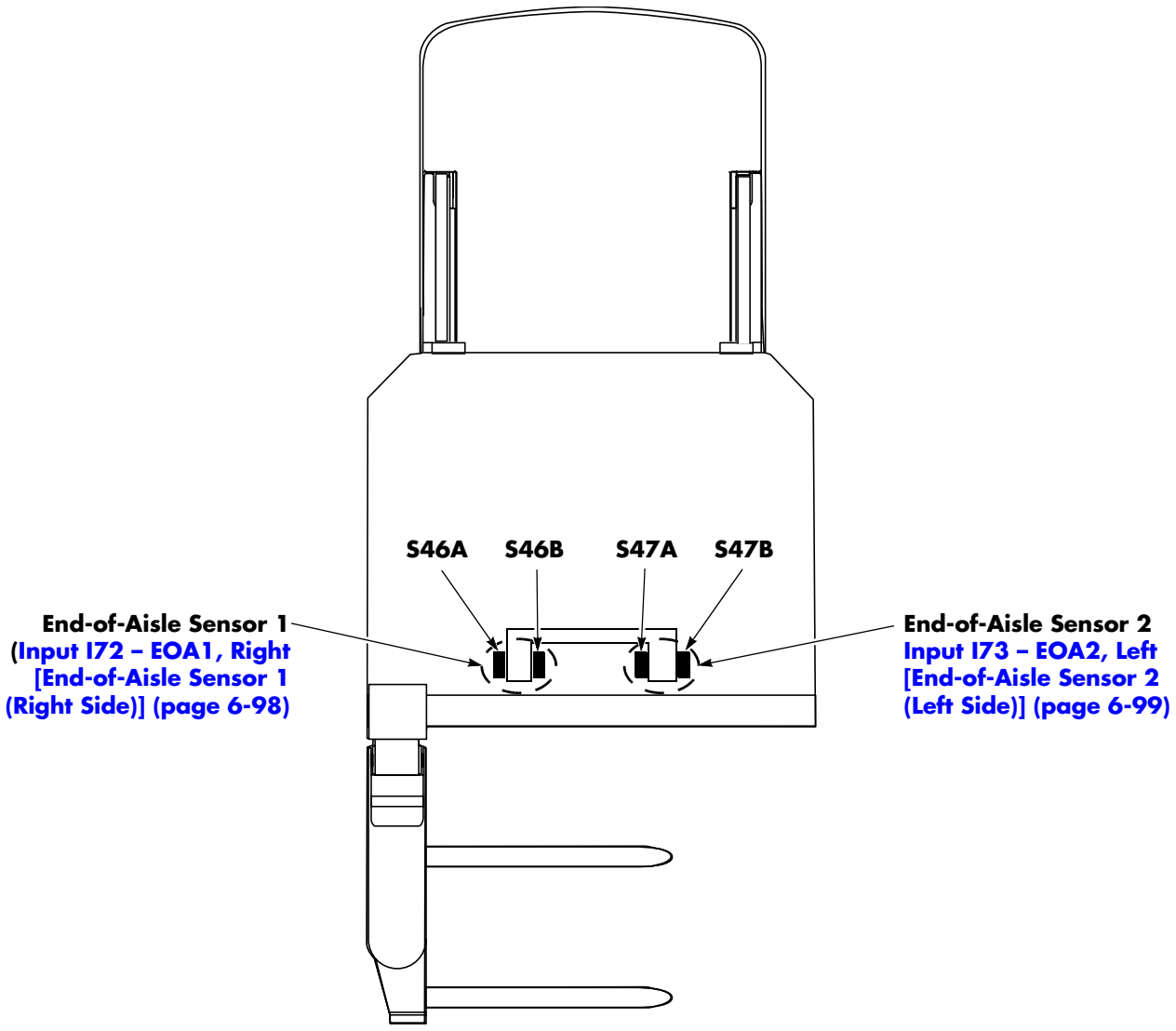
Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect S60/DCV	S60-1	S60-3	Approx. 12V	Perform step 2	T/S wiring
2	DCV	JPC22-4	JPC18-7	Sidegate up: 5V Sidegate down: <1V	Replace CM	T/S switch, wiring, and connections

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Raymond EOA Sensor Location

Figure 6-1. Location of Raymond End-of-Aisle Sensors and Related Inputs



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Input I72 – EOA1, Right [End-of-Aisle Sensor 1 (Right Side)]

The input from the optional End-of-Aisle Sensor 1 (S46A and B), as seen by the TM is displayed (refer to Figure 6-1 on page 6-97).

NOTE: This input is displayed when Raymond EOA is selected in FlashWare.

While observing the display, drive the truck so the sensor passes over a floor magnet. The display should change from “OFF” to “ON”,

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPT10/DCV	PT10-6	PT24-8	Approx. 12V	Perform step 2	Replace TM
2	DCV	JPT10-6 (Backprobe)	JPT24-8 (Backprobe)	Approx. 8V	Perform step 3	T/S harness for opens and shorts. If OK, replace sensor S46A or S46B
3	Disconnect JPT12 and JPT24/DCV	PT12-10	PT24-8	Approx. 5V	Perform step 4	Replace TM
4	DCV	JPT12-10 (Backprobe)	JPT24-8 (Backprobe)	S46A or S46B Closed (sees magnet): <1V Open (no magnet): Approx. 5V	Replace TM	T/S harness for opens or shorts. If OK, replace bad sensor

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Input I73 – EOA2, Left [End-of-Aisle Sensor 2 (Left Side)]

The input from the optional End-of-Aisle Sensor 2 (S47A and B), as seen by the TM is displayed (refer to Figure 6-1 on page 6-97).

NOTE: This input is displayed when Raymond EOA is selected in FlashWare.

While observing the display, drive the truck so the sensor passes over a floor magnet. The display should change from “OFF” to “ON”,

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPT10/DCV	PT10-7	PT24-9	Approx. 12V	Perform step 2	Replace TM
2	DCV	JPT10-7 (Backprobe)	JPT24-9 (Backprobe)	Approx. 8V	Perform step 3	T/S harness for opens and shorts. If OK, replace sensor S47A or S47B
3	Disconnect JPT10 and JPT24/DCV	PT24-17	PT24-9	Approx. 5V	Perform step 4	Replace TM
4	DCV	JPT24-17 (Backprobe)	JPT24-9 (Backprobe)	S47A or S47B Closed (sees magnet): <1V Open (no magnet): Approx. 5V	Replace TM	T/S harness for opens or shorts. If OK, replace bad sensor

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Input I83 – SG Lt S61 [Left Sidegate Switch (S61)]

The state of the optional Sidegate Left Switch (S61), as seen by the CM, is displayed.

The input is good if these values are displayed:

Sidegate	Value Displayed
Up	Up
Down	Down

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect S61/DCV	S61-1	S61-3	Approx. 12V	Perform step 2	T/S wiring
2	DCV	JPC22-6	JPC24-10	Sidegate up: 5V Sidegate down: <1V	Replace CM	T/S switch, wiring, and connections

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Input I87 – BG Lt S57 [Left Battery Gate Switch (S57)]

The state of the optional Left Battery Gate Switch (S57), as seen by the TM, is displayed.

The input is good if these values are displayed:

Battery Gate	Value Displayed
Removed	Out
Installed	In

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Check for correct switch clearance. The sensor should extend 0.23 in. (5.8 mm) beyond the switch mounting plate.

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPBSEN1/DCV	PBSEN1-2	PBSEN1-3	Approx. 12V	Perform step 2	T/S wiring
2	DCV	JPT22-6	JPT18-5	Gate removed: 5V Gate installed: <1V	Replace TM	T/S switch, wiring, and connections

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Input I88 – BG Rt S58 [Right Battery Gate Switch (S58)]

The state of the optional Right Battery Gate Switch (S58), as seen by the TM, is displayed.

The input is good if these values are displayed:

Battery Gate	Value Displayed
Removed	Out
Installed	In

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Check for correct switch clearance. The sensor should extend 0.23 in. (5.8 mm) beyond the switch mounting plate.

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPBSEN2/DCV	PBSEN2-2	PBSEN2-3	Approx. 12V	Perform step 2	T/S wiring
2	DCV	JPT24-20	JPT18-5	Gate removed: 5V Gate installed: <1V	Replace TM	T/S switch, wiring, and connections

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Input I100 – EOA1 On [End-of-Aisle Connect Detect 1 (Right Side)]

Verification that the Sensor 1 End-of-Aisle switches (S46A and B) are connected is displayed.

NOTE: S46A and B are located on the right side of the Antenna Card bracket as you stand on the platform facing the tractor.

The input is good if these values are displayed:

Sensor 1 Switches	Value Displayed
Connected	Yes
Not Connected	No

If these values are not displayed, refer to Input I72 – EOA1, Right [End-of-Aisle Sensor 1 (Right Side)] (page 6-98) Diagnosis and Repair.

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Input I101 – EOA2 On [End-of-Aisle Connect Detect 2 (Left Side)]

Verification that the Sensor 2 End-of-Aisle switches (S47A and B) are connected is displayed.

NOTE: S47A and B are located on the left side of the Antenna Card bracket as you stand on the platform facing the tractor.

The input is good if these values are displayed:

Sensor 2 Switches	Value Displayed
Connected	Yes
Not Connected	No

If these values are not displayed, refer to Input I73 – EOA2, Left [End-of-Aisle Sensor 2 (Left Side)] (page 6-99) Diagnosis and Repair.

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Input I102 – LdDm S9 [Load Handler Deadman (S9)]

The state of the Load Handler Deadman Switch (S9), as seen by the CM, is displayed.

The input is good if these values are displayed:

Switch	Value Displayed
Open	Off
Closed	On

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect S9/DCV	S9-1	S9-3	Approx. 12V	Perform step 2	T/S wiring
2	DCV	JPC22-2	JPC10-9	Pedal up: 5V Pedal down: <1V	Replace CM	T/S switch, wiring, and connections

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Input I103 – LeftHndDM [Left Hand Deadman (S26)]

The state of the optional Left Hand Deadman Switch (S26), as seen by the CM, is displayed.

The input is good if these values are displayed:

Switch	Value Displayed
Open	Off
Closed	On

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPC12-6	JPC4-2	Switch open: 5V Switch closed: <1V	Replace CM	T/S switch, wiring and connections

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Input I104 – ReachProx [Reach Proximity Sensor]

The state of the Reach Proximity Sensor, as seen by the CM, is displayed.

The input is good if these values are displayed:

Reach Prox	Value Displayed	LED (on sensor)
Over metal	On	On
Away from metal	Off	Off

If these values are not displayed, refer to Diagnosis and Repair.

NOTE: If the input is bad, pass a screwdriver or metal ruler under the sensor to activate it. If this produces desired results, adjust the switch gap to 0.09 ±0.03 in. (2.3 ±0.7 mm).

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JP3/DCV	JPC12-7	JPC10-4	8.5 to 11V	Perform step 2	T/S wiring. If OK, run Test O63 – MiniPwrSup [Mini Power Supply] (page 6-154)
2	Disconnect all wires/DCV	JPC22-1		Sensor over metal: approx. <1V Sensor not over metal: approx. 5V	Replace CM	T/S wiring. If OK, replace sensor

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Input I105 – Mini Ht Ct [Mini-Mast Height Count]

The mini-mast height count, calculated by the TM, is displayed. The displayed height should increase during lift and decrease during lower.

The mini-mast height count is determined by the height proximity sensor inputs. When the mini-mast is fully lowered, Height Prox A ("Input I106 – Mini Sw A [Mini-Mast Height Prox A]"), Height Prox B ("Input I107 – Mini Sw B [Mini-Mast Height Prox B]"), and Height Prox C ("Input I108 – Mini Sw C [Mini-Mast Height Prox C]") are all ON. While lifting or lowering, if all three inputs are present at the same time, a fault code occurs. Also, if one of the inputs does not change state while lifting or lowering, a fault code occurs.

Navigate to the input menu and scroll until I06, I07, and I08 are all displayed. Observe the status of each input while lifting or lowering.

If one of the inputs remains ON, it may indicate a shorted mast cable or wiring. If one of the three inputs does not change from ON to OFF while lifting/lowering, refer to the input for the switch that is not changing state.

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Input I106 – Mini Sw A [Mini-Mast Height Prox A]

The state of the Prox A channel of the mini-mast height proximity sensor, as seen by the CM, is displayed.

The input is good if these values are displayed:

Reach Prox	Value Displayed
Over metal	On
Not over metal	Off

The value displayed should change as the mini-mast is raised and lowered. If these results are not observed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JP5-3	JPC10-4	Approx. 5V	Perform step 2	Run Test O63 – MiniPwrSup [Mini Power Supply] (page 6-154)
2		JP2-1			Perform step 3	T/S wiring
3	JP2 and JPC22 disconnected/ Ohms	JC22-9	P2-2	0 Ohms	Perform step 4	
4	DCV	JPC22-9	JPC10-4	Near metal: 0.6V Not near metal: approx. 3.2V	Replace CM	Replace mini-mast Height Prox Sensor

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Input I107 – Mini Sw B [Mini-Mast Height Prox B]

The state of the Prox B channel of the mini-mast height proximity sensor, as seen by the CM, is displayed.

The input is good if these values are displayed:

Reach Prox	Value Displayed
Over metal	On
Away from metal	Off

The value displayed should change as the mini-mast is raised and lowered. If these results are not observed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JP5-3	JPC10-4	Approx. 5V	Perform step 2	Run Test O63 – MiniPwrSup [Mini Power Supply] (page 6-154)
2		JP2-1			Perform step 3	T/S wiring
3	JP2 and JPC22 disconnected /Ohms	JC22-10	P2-3	0 Ohms	Perform step 4	
4	DCV	JPC22-10	JPC10-4	Near metal: 0.6V Not near metal: approx. 3.2V	Replace CM	Replace mini-mast Height Prox Sensor

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Input I108 – Mini Sw C [Mini-Mast Height Prox C]

The state of the Prox C channel of the mini-mast height proximity sensor, as seen by the CM, is displayed.

The input is good if these values are displayed:

Reach Prox	Value Displayed
Over metal	On
Away from metal	Off

The value displayed should change as the mini-mast is raised and lowered. If these results are not observed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JP5-3	JPC10-4	Approx. 5V	Perform step 2	Run Test O63 – MiniPwrSup [Mini Power Supply] (page 6-154)
2		JP2-1			Perform step 3	T/S wiring
3	JP2 and JPC22 disconnected /Ohms	JC24-20	P2-4	0 Ohms	Perform step 4	
4	DCV	JPC24-20	JPC10-4	Near metal: 0.6V Not near metal: approx. 3.2V	Replace CM	Replace mini-mast Height Prox Sensor

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Input I109 – LftSel S6 [Lift Select (S6)]

The state of the Lift Select Switch (S6), as seen by the CM, is displayed.

The input is good if these values are displayed:

Switch Position	Value Displayed
Out	Off
Depressed	On

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPC12 and JPC4 disconnected/Ohms	JC12-4	JC4-2	Depressed: 0 ohms Not depressed: open	Replace CM	T/S switch, wiring, and connections

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Input I110 – Attach S5 [Attachment (S5)]

The state of the optional Attachment Switch (S5), as seen by the CM, is displayed.

The input is good if these values are displayed:

Switch Position	Value Displayed
Out	Off
Depressed	On

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPC12/Ohms	JC12-9	JPC12-12	Depressed: 0 ohms Not depressed: open	Replace CM	T/S switch, wiring, and connections

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Input I111 – In Aisle

This test displays the End-of-Aisle status in the truck's memory.

The display shows either **IN** or **OUT**.

If these values are not displayed, refer to Input I72 – EOA1, Right [End-of-Aisle Sensor 1 (Right Side)] (page 6-98) or Input I117 – EOA1 Inner [Alternate Sensor 2] (page 6-121) and Input I73 – EOA2, Left [End-of-Aisle Sensor 2 (Left Side)] (page 6-99) or Input I118 – EOA2 Outer [Alternate Sensor 1] (page 6-122).

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Input I112 – FU4 sense [FU4 Sense]

The absence or presence of B+ to the load side of the Load Handler Contactor (LHC) is displayed.

NOTE: Manually activate the contactor to see the transition.

The input is good if these values are displayed:

STR State	Value Displayed
Open	Out
Closed	In

If these values are not displayed, refer to Diagnosis and Repair.

Code 49 - If >4V is displayed with the contactor open, check for shorts to frame. Remove the sense wire from JPT22-20. If the voltage goes away, locate the cause of the short. If the voltage remains >4V with the sense lead disconnected, replace the TM.

Code 4A - Check FU4 and the LHC contactor tips.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	LPC and LHC Contactor pushed in	JPT22-20	TP4	B+	Replace TM	T/S wiring, connections, and contactor

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Input I113 – CustomIn1 [Custom Input 1 (CM)]

This option must be enabled in FlashWare. It is designed to support "Custom" inputs. This input displays the status of the associated circuit to the CM.

NOTE: Refer to the attached device manufacturer's documentation for specific troubleshooting information regarding that device.

Refer to Table 3-2, "Configure Mode Menu," on page 3-27.

The input is good if these values are displayed:

JPC10-8 to JPC24-8	Value Displayed
0 ohms	On
Open	OUT

If these results are not observed, refer to Diagnosis and Repair.

Diagnosis and Repair

Carefully complete the circuit between JPC10-8 and JPC24-8. If "ON" is displayed, troubleshoot the attached device and associated wiring. If "ON" *is not* displayed, replace the CM.

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Input I114 – CustomIn2 [Custom Input 2 (CM)]

This option must be enabled in FlashWare. It is designed to support "Custom" inputs. This input displays the status of the associated circuit to the CM.

NOTE: Refer to the attached device manufacturer's documentation for specific troubleshooting information regarding that device.

Refer to Table 3-2, "Configure Mode Menu," on page 3-27.

The input is good if these values are displayed:

JPC10-2 to JPC24-9	Value Displayed
0 ohms	ON
Open	OUT

If these results are not observed, refer to Diagnosis and Repair.

Diagnosis and Repair

Carefully complete the circuit between JPC10-2 and JPC24-9. If "ON" is displayed, troubleshoot the attached device and associated wiring. If "ON" *is not* displayed, replace the CM.

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Input I115 – CustomIn3 [Custom Input 3 (TM)]

This option must be enabled in FlashWare. It is designed to support "Custom" inputs. This input displays the status of the associated circuit to the TM.

NOTE: Refer to the attached device manufacturer's documentation for specific troubleshooting information regarding that device.

Refer to Table 3-2, "Configure Mode Menu," on page 3-27.

The input is good if these values are displayed:

JPT10-8 to JPT24-3	Value Displayed
0 ohms	ON
Open	OUT

If these results are not observed, refer to Diagnosis and Repair.

Diagnosis and Repair

Carefully complete the circuit between JPT10-8 and JPT24-3. If "ON" is displayed, troubleshoot the attached device and associated wiring. If "ON" *is not* displayed, replace the TM.

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Input I116 – CustomIn4 [Custom Input 4 (TM)]

This option must be enabled in FlashWare. It is designed to support "Custom" inputs. This input displays the status of the associated circuit to the TM.

NOTE: Refer to the attached device manufacturer's documentation for specific troubleshooting information regarding that device.

Refer to Table 3-2, "Configure Mode Menu," on page 3-27.

The input is good if these values are displayed:

JPT10-2 to JPT24-7	Value Displayed
0 ohms	ON
Open	OUT

If these results are not observed, refer to Diagnosis and Repair.

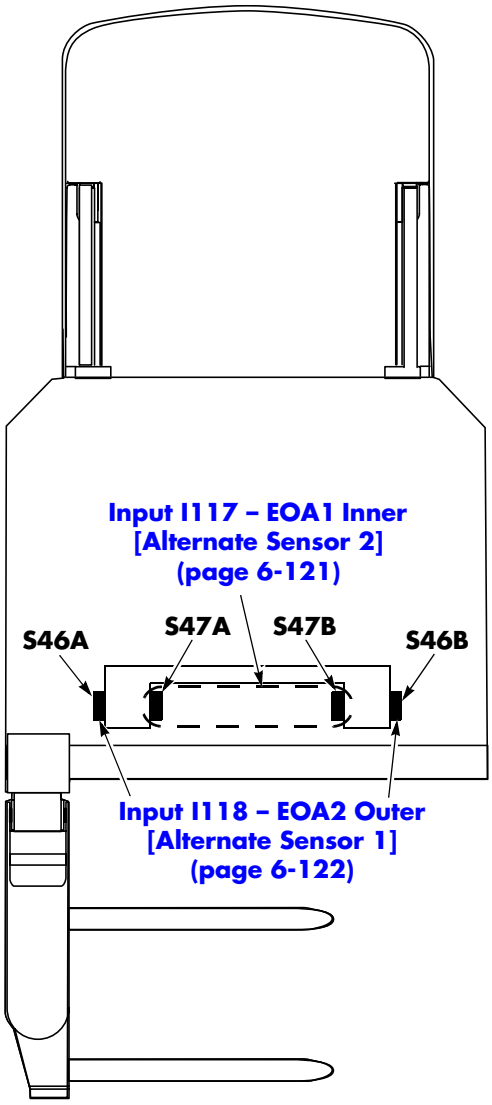
Diagnosis and Repair

Carefully complete the circuit between JPT10-2 and JPT24-7. If "ON" is displayed, troubleshoot the attached device and associated wiring. If "ON" *is not* displayed, replace the TM.

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Alternate EOA Sensor Location

Figure 6-2. Location of Alternate End-of-Aisle Sensors and Related Inputs



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Input I117 – EOA1 Inner [Alternate Sensor 2]

The input from the optional End-of-Aisle Sensor 2 (S47A and B), as seen by the TM is displayed (refer to Figure 6-2 on page 6-120).

NOTE: This input is displayed when Alternate EOA is selected in FlashWare.

While observing the display, drive the truck so the sensor passes over a floor magnet. “On” should display briefly,

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPT10/DCV	PT10-7	PT24-9	Approx. 12V	Perform step 2	Replace TM
2	DCV	JPT10-7 (Backprobe)	JPT24-9 (Backprobe)	Approx. 8V	Perform step 3	T/S harness for opens and shorts. If OK, replace sensor S47A or S47B
3	Disconnect JPT10 and JPT24/DCV	PT24-17	PT24-9	Approx. 5V	Perform step 4	Replace TM
4	DCV	JPT24-17 (Backprobe)	JPT24-9 (Backprobe)	S47A or S47B Closed (sees magnet): <1V Open (no magnet): Approx. 5V	Replace TM	T/S harness for opens or shorts. If OK, replace bad sensor

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Input I118 – EOA2 Outer [Alternate Sensor 1]

The input from the optional End-of-Aisle Sensor 1 (S46A and B), as seen by the TM is displayed (refer to Figure 6-2 on page 6-120).

NOTE: This input is displayed when Alternate EOA is selected in FlashWare.

While observing the display, drive the truck so the sensor passes over a floor magnet. “On” should display briefly,

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPT10/DCV	PT10-6	PT24-8	Approx. 12V	Perform step 2	Replace TM
2	DCV	JPT10-6 (Backprobe)	JPT24-8 (Backprobe)	Approx. 8V	Perform step 3	T/S harness for opens and shorts. If OK, replace sensor S46A or S46B
3	Disconnect JPT12 and JPT24/DCV	PT12-10	PT24-8	Approx. 5V	Perform step 4	Replace TM
4	DCV	JPT12-10 (Backprobe)	JPT24-8 (Backprobe)	S46A or S46B Closed (sees magnet): <1V Open (no magnet): Approx. 5V	Replace TM	T/S harness for opens or shorts. If OK, replace bad sensor

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Output Tests

A Diagnosis and Repair table is provided for most Output Tests. If a test result is not within the specified limits, refer to the Diagnosis and Repair table.

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

NOTE: Performing Output Tests can cause error codes to display (and be recorded in the error log). Before the truck is returned to service, cycle the key switch and clear the error log.

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 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 O00 – TPC Ctr [Traction Power Contactor]

This test toggles the Traction Power Contactor (TPC) ON and OFF.

Run Test

NOTE: For information on how to use maintenance mode, see “Maint” on page 3-23.

NOTE: The TPC is controlled by the TPA.

These values should display:

TPC	Value Displayed
Closed	On
Open	Off

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Check TPC for mechanical binding.

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPTA1/Ohms	JTA1-6	JTA1-13	Approx. 41 ohms	Perform step 2	T/S wiring and coil
2	DCV	JPTA1-13	TP4	B+	Perform step 3	Replace TPA
3		B+	JPTA1-6	Test ON: 24, then 18V Test OFF: <1V	Perform step 1	

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Test O01 – STR Ctr [Steer Power Contactor]

This test toggles the Steer Power Contactor (STR) ON and OFF.

Run Test

NOTE: For information on how to use maintenance mode, see “Maint” on page 3-23.

NOTE: The STR is controlled by the TM.

These values should display:

STR	Value Displayed
Closed	On
Open	Off

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Check STR for mechanical binding.

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPT18 and JPF2/Ohms	JF2-1	JT18-11	Approx. 48 ohms	Perform step 2	T/S wires and coil
2	DCV	JPF2-1	TP4	B+	Perform step 3	T/S relays and Fuse/Relay Card
3		JPT22-19	JPT14-10	Contactor closed: 24V Contactor open: <1V	Replace TM	T/S FU1 Sense wire

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Test O02 – LPC Ctr [Lift Power Contactor]

This test toggles the Lift Power Contactor (LPC) ON and OFF.

Run Test

NOTE: For information on how to use maintenance mode, see “Maint” on page 3-23.

NOTE: The LPC is controlled by the LPA.

These values should display:

LPC	Value Displayed
Closed	On
Open	Off

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Check LPC for mechanical binding.

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPLA1/Ohms	JLA1-6	JLA1-13	Approx. 41 ohms	Perform step 2	T/S wires and coil
2	DCV	JPLA1-13	TP4	B+	Perform step 3	Replace LPA
3		B+	JPLA1-6	Test ON: 24, then 18V Test OFF: <1V	Perform step 1	

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Test O03 – LHC Ctr [Load Handler Contactor]

This test toggles the Load Handler Contactor (LHC) ON and OFF.

Run Test

NOTE: For information on how to use maintenance mode, see “Maint” on page 3-23.

NOTE: The LHC is controlled by the TM.

These values should display:

LHC	Value Displayed
Closed	On
Open	Off

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Check LHC for mechanical binding.

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPF2 and JPT18/Ohms	JF2-1	JT18-1	Approx. 18 ohms	Perform step 2	T/S wires and coil
2	DCV	JPF2-1	TP4	B+	Replace TM	T/S relays and Fuse/Relay Card
3		JPT22-20	JPT14-10	Contactor closed: 24V Contactor open: <1V	Replace TM	T/S FU4 Sense wire

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Test O06 – Sol11Rch [Reach Select Solenoid (SOL11)]

This test toggles the Reach Select Solenoid (SOL11) ON and OFF.

Run Test

NOTE: For information on how to use maintenance mode, see "Maint" on page 3-23.

1. Disconnect wire from SOL11-2.
2. Connect an ammeter as follows:
   - (–) lead to SOL11-2
   - (+) lead to wire removed from SOL11-2

These values should display:

SOL11	Ammeter Reading	Value Displayed
Open	0.85 to 1.35	On
Closed	0 to 0.02	Off

If these values are not displayed, reconnect wire to SOL11-2 and refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC18 and JPC12/Ohms	JC12-7	JC18-17	Approx. 10 ohms	Perform step 2	T/S wires and coil
2	DCV	JPC12-7	JPC10-4	Approx. 10V	Replace CM	Refer to Input A40 - MiniSply [Mini Power Supply] (page 6-59)

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Test O11 – Sol1 Lwr [Lower Solenoid (SOL1)]

This test toggles the Lower Solenoid (SOL1) ON and OFF.

Run Test

NOTE: For information on how to use maintenance mode, see “Maint” on page 3-23.

1. Disconnect wire from SOL1-1.
2. Connect an ammeter as follows:
   - (–) lead to SOL1-1
   - (+) lead to wire removed from SOL1-1

These values should display:

SOL11	Ammeter Reading	Value Displayed
Open	0.5 to 1.0	On
Closed	0 to 0.02	Off

If these values are not displayed, reconnect wire to SOL1-1 and refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC18 and JPF2/Ohms	JT18-9	JF2-3	Approx. 30 ohms	Perform step 2	T/S wires and coil
2	DCV	JPF2-3	TP4	B+	Replace TM	T/S relays and Fuse/Relay Card

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Test O18 – Horn

This test toggles the Horn ON and OFF.

Run Test

NOTE: For information on how to use maintenance mode, see “Maint” on page 3-23.

The horn should sound when the test is activated and these values should display:

Horn	Value Displayed
Off	Off
Sounds	On

If the horn does not sound and/or these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Verify continuity between JPT18-6 and HRN-NEG					
2	Verify continuity between JPT18-6 and HRN-IN					
3	DCV	HRN-POS	TP4	B+	Perform step 2	T/S wiring and Fuse/Relay Card
4		TP1	HRN-NEG	Horn OFF: <0.5V Horn ON: B+	Replace Horn	Perform step 3
5			JPT18-16		T/S wiring to horn	Replace TM

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Test O19 – Disp Alarm [Display Interface Card Horn]

This test verifies operation of the Display Interface Card Horn (H2).

Run Test

NOTE: For information on how to use maintenance mode, see “Maint” on page 3-23.

The horn should sound when the test is activated and these values should display:

Alarm	Value Displayed
Sounding	Ramp
Off	Off

If the horn does not sound and/or these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPD4-1	JPD4-2	Off: <1V Ramp: 7 to 9V	Check wiring to H2. If OK, replace H2	Replace Display Interface Card

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Test O20 – Trav Alarm [Travel Alarm]

This test verifies operation of the optional Travel Alarm.

Run Test

NOTE: For information on how to use maintenance mode, see “Maint” on page 3-23.

The alarm should sound when the test is activated and these values should display:

Alarm	Value Displayed
Off	Off
Sounding	On

If the alarm does not sound and/or these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect AL+/DCV	AL+	TP4	B+	Perform step 2	T/S wiring and Fuse/Relay Card
2	Disconnect AL–/Ohms	AL–	JPT18-18	0 ohms	Perform step 3	T/S wiring
3	DCV	JPT18-18	TP4	Test ON: <1V Test OFF: B+	Replace alarm	Replace TM

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Test O23 – Fans

This test verifies operation of the cooling fans.

NOTE: All fans are controlled by the TM at JPT18-17.

Run Test

NOTE: For information on how to use maintenance mode, see “Maint” on page 3-23.

These values should display:

Fan	Value Displayed
Running	ON
Not Running	OFF

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPFAN1/DCV	JFAN1-1	TP4	B+	Perform step 2	T/S wiring and Fuse/Relay Card
2	Disconnect JPFAN1/Ohms	JFAN1-2	JPT18-17	0 ohms	Perform step 3	T/S wiring
3	DCV	JPT18-17	TP4	Test ON: <1V Test OFF: B+	Replace Fan	Replace TM

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Test O28 – Lift RPM [Ramp Lift Motor]

This test ramps the lift motor by gradually increasing the command to the LPA via the CAN bus. This test verifies that the LPA can drive the lift motor.

⚠CAUTION

Running this test for an extended period of time can cause damage to the motor, power amplifier, or wiring.

⚠ WARNING

Check for overhead obstructions before performing this test. Make sure the Emergency Lowering Valve is open.

Run Test

NOTE: For information on how to use maintenance mode, see “Maint” on page 3-23.

The requested percent of ON-time is displayed. Use the **Up** button to increase the rpm in increments of 25, from 775 to 1500.

Press **Down** to reset the request to 0. Press the **Enter** button to exit the test.

If these values are not displayed, refer to Diagnosis and Repair.

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 to one or two phases, test cables to lift motor. If OK, replace lift motor. If phases are low or unequal, replace the LPA. Check for binding in pump and mast. If not binding, replace lift motor.

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Test O29 – Traction RPM [Ramp Traction Motor]

This test ramps the traction motor by gradually increasing the command to the TPA via the CAN bus. This test verifies that the TPA can drive the Traction motor.

⚠CAUTION

Running this test for an extended period of time can cause damage to the motor, power amplifier, or wiring.

⚠ WARNING

Make sure drive tire is jacked off floor to prevent unwanted travel.

Run Test

NOTE: For information on how to use maintenance mode, see “Maint” on page 3-23.

The requested percent of ON-time is displayed. Use the **Up** button to increase the rpm in increments of 25, from 0 to 1500.

Press **Down** to reset the request to 0. Press the **Enter** button to exit the test.

If these values are not displayed, refer to Diagnosis and Repair.

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 to 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, check for binding in drive unit. If not binding, replace traction motor.

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Test O30 – Brake

This test checks for correct brake coil operation.

Run Test

NOTE: For information on how to use maintenance mode, see “Maint” on page 3-23.

NOTE: Depress the Deadman pedal while performing this test. Use **Enter** button to cycle the test.

These values should display:

Brake	Value Displayed
Released	Up
Applied	Down

If these values are not displayed, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPT20 and JPF2/Ohms	JT20-14	JF2-2	Approx. 13 ohms	Perform step 2	T/S wiring and coil
2	DCV	JPT20-14	TP4	Brake de-energized: B+ Brake energized: approx. 13.4V **Note:** When first turned ON, reading may be slightly higher	Inspect brake for binding	If no B+, T/S Fuse/Relay Card. If voltage does not drop when energized, replace TM

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Test O32 – Relay Tog [Toggle Relay Enable]

This test toggles the K1, K2, K3, and K4 relays, located on the Fuse/Relay Card, ON and OFF.

Run Test

NOTE: For information on how to use maintenance mode, see "Maint" on page 3-23.

Cycle the key switch and re-enter Maintenance Mode to perform this test. Error codes are displayed during this test.

NOTE: Test points located on the Fuse/Relay Card are connected to the output side of the relay tips. Refer to "Fuse/Relay Card" on page 5-16.

The following table gives the expected value at each relay test point during the test. If Code FN is displayed, refer to the "Key OFF" values.

<table>
<tr><th rowspan="2">Relay</th><th rowspan="2">(+) Lead (on Fuse/Relay Card)</th><th rowspan="2">(–) Lead</th><th colspan="3">Expected Values</th></tr>
<tr><th>Toggled ON</th><th>Toggled OFF</th><th>Key OFF</th></tr>
<tr><td>K1</td><td>TP1</td><td rowspan="4">TP4</td><td rowspan="4">B+</td><td><1V</td><td rowspan="4"><1V</td></tr>
<tr><td>K2</td><td>TP2</td><td>See Note</td></tr>
<tr><td>K3</td><td>TP3</td><td rowspan="2"><1V</td></tr>
<tr><td>K4</td><td>TP4</td></tr>
<tr><td colspan="6">Note: This voltage will vary depending on truck options. With JPF2 disconnected, this value should be <1V during test.</td></tr>
</table>

- If the expected values are not present at either K1, K2, or K3, switch the bad relay with K4 and repeat the test.
- If the expected value is not present for all relays, refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPT14-6	TP4	B+	Replace TM	T/S wiring and Fuse/Relay Card

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Test O39 – Display Test [Cycle Display]

This test illuminates all Operator Display segments.

Run Test

NOTE: For information on how to use maintenance mode, see “Maint” on page 3-23.

Vertical lines are displayed in two stages to test all segments.

Any blank segments are an indication that the display module is bad.

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Test O43 – Sol5 MinLH [Mini Load Hold (SOL5)]

This test toggles the Mini-Mast Load Holding Solenoid (SOL5) ON and OFF.

Run Test

NOTE: For information on how to use maintenance mode, see “Maint” on page 3-23.

1. Disconnect wire from Mini-Mast Load Holding Solenoid SOL5-1.
2. Connect an ammeter as follows:
   - (–) lead to SOL5-1
   - (+) lead to wire removed from SOL5-1

These values should display:

SOL5	Ammeter Reading	Value Displayed
Open	0.5 to 1.0	On
Closed	0 to 0.02	Off

If these values are not displayed, reconnect wire to SOL5-1 and refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC18 and JPF2/Ohms	JT18-12	JF2-3	Approx. 40 ohms	Perform step 2	T/S wiring and coil
2	DCV	JPF2-3	TP4	B+	Replace TM	T/S Relays and Fuse/Relay Card

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Test O44 – Steer Mtr [Steer Motor]

This test ramps the steer motor by gradually increasing the command to the Steer Amplifier (SA). This test verifies the SA can generate current and invoke steering in both the CW and CCW direction.

Values displayed range from –50 to +50, in increments of 5, and are an approximate percentage of a full steer command. A negative value steers to the left, positive to the right. To prevent damage, this test limits steer current to 80A.

⚠CAUTION

Running this test for an extended period of time can cause damage to the steer motor, steer amplifier, or wiring.

⚠CAUTION

The drive unit moves CW and/or CCW during this test. Jack the drive wheel off the floor. Use extreme care when the truck is jacked up for any reason. Never block the lift truck between the operator platform and the floor. 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. **See "Jacking Safety" on page 2-10.**

Run Test

NOTE: For information on how to use maintenance mode, see "Maint" on page 3-23.

Depress the brake deadman.

The requested percent of ON-time is displayed. Use the **Up** or **Down** buttons to increase/decrease the steer request in increments of 5%, from 0 to 50% (CW) and 0 to –50% (CCW).

If the steer motor does not rotate in both directions when commanded, the test has failed. Refer to Diagnosis and Repair.

Press **Enter** to exit the test.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect cables from Steer Motor/ Ohms	MSA1	MSA2	<0.5 Ohms	Perform step 2	Check Brushes. Replace Steer Motor if necessary
2	Motor cables removed to prevent movement/ DCV	JPT6-5	JPT6-4	While changing the value from 5 to 50, voltage should ramp from approx. 10.75 to 8V	Perform step 3	Replace TM
3		JPT6-2			Replace SA	

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Test O50 – Sol6 MinSl [Mini Lift Select (SOL6)]

This test toggles the Mini Lift Select Solenoid (SOL6) ON and OFF.

Run Test

NOTE: For information on how to use maintenance mode, see “Maint” on page 3-23.

1. Disconnect wire from Mini Lift Select Solenoid SOL6-1.
2. Connect an ammeter as follows:
   - (–) lead to SOL6-1
   - (+) lead to wire removed from SOL6-1

These values should display:

SOL6	Ammeter Reading	Value Displayed
Open	0.5 to 1.0	On
Closed	0 to 0.02	Off

If these values are not displayed, reconnect wire to SOL6-1 and refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPT18 and JPF2/Ohms	JT18-14	JF2-3	Approx. 40 ohms	Perform step 2	T/S wiring and coil
2	DCV	JPF2-3	TP4	B+	Replace TM	T/S Relays and Fuse/Relay Card

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Test O51 – Sol3 ManLH [Main Load Hold (SOL3)]

This test toggles the Main Load Holding Solenoid (SOL3) ON and OFF.

Run Test

NOTE: For information on how to use maintenance mode, see "Maint" on page 3-23.

1. Disconnect wire from Main Load Holding Solenoid SOL3-1.
2. Connect an ammeter as follows:
   - (–) lead to SOL3-1
   - (+) lead to wire removed from SOL3-1

These values should display:

SOL3	Ammeter Reading	Value Displayed
Open	0.5 to 1.0	On
Closed	0 to 0.02	Off

If these values are not displayed, reconnect wire to SOL3-1 and refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPT18 and JPF2/Ohms	JT18-10	JF2-3	Approx. 40 ohms	Perform step 2	T/S wiring and coil
2	DCV	JPF2-3	TP4	B+	Replace TM	T/S Relays and Fuse/Relay Card

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Test O52 – Sol4 ManSl [Main Lift Select (SOL4)]

This test toggles the Main Lift Select Solenoid (SOL4) ON and OFF.

Run Test

NOTE: For information on how to use maintenance mode, see “Maint” on page 3-23.

1. Disconnect wire from Main Lift Select Solenoid SOL4-1.
2. Connect an ammeter as follows:
   - (–) lead to SOL4-1
   - (+) lead to wire removed from SOL4-1

These values should display:

SOL4	Ammeter Reading	Value Displayed
Open	0.5 to 1.0	On
Closed	0 to 0.02	Off

If these values are not displayed, reconnect wire to SOL4-1 and refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPT18 and JPF2/Ohms	JT18-15	JF2-3	Approx. 40 ohms	Perform step 2	T/S wiring and coil
2	DCV	JPF2-3	TP4	B+	Replace TM	T/S Relays and Fuse/Relay Card

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Test O53 – Sol10A DrA [Reach/Rotate DIR A (SOL10A)]

This test toggles the Reach/Rotate Direction A Solenoid (SOL10A) ON and OFF.

Run Test

NOTE: For information on how to use maintenance mode, see “Maint” on page 3-23.

1. Disconnect wire from Reach/Rotate Direction A Solenoid SOL10A-1.
2. Connect an ammeter as follows:
   - (–) lead to SOL10A-1
   - (+) lead to wire removed from SOL10A-1

These values should display:

SOL10A	Ammeter Reading	Value Displayed
Open	0.5 to 1.0	On
Closed	0 to 0.02	Off

If these values are not displayed, reconnect wire to SOL10A-1 and refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC14 and JPC18/Ohms	JC18-11	JC14-14	Approx. 39 ohms	Perform step 2	T/S wiring and coil
2	DCV	Backprobe JPC14-14	Backprobe JPC14-10	B+	Replace CM	Perform step 3
3		Backprobe JPC14-13			Perform step 1	T/S OTM cable to Fuse/Relay Card

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Test O54 – Sol10B DrB [Reach/Rotate DIR B (SOL10B)]

This test toggles the Reach/Rotate Direction B Solenoid (SOL10B) ON and OFF.

Run Test

NOTE: For information on how to use maintenance mode, see “Maint” on page 3-23.

1. Disconnect wire from Reach/Rotate Direction B Solenoid SOL10B-1.
2. Connect an ammeter as follows:
   - (–) lead to SOL10B-1
   - (+) lead to wire removed from SOL10B-1

These values should display:

SOL10B	Ammeter Reading	Value Displayed
Open	0.5 to 1.0	On
Closed	0 to 0.02	Off

If these values are not displayed, reconnect wire to SOL10B-1 and refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC14 and JPC18/Ohms	JC18-12	JC14-14	Approx. 39 ohms	Perform step 2	T/S wiring and coil
2	DCV	Backprobe JPC14-14	Backprobe JPC14-10	B+	Replace CM	Perform step 3
3		Backprobe JPC14-13			Perform step 1	T/S OTM cable to Fuse/Relay Card

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Test O55 – Rch/Rot PWM [Reach/Rotate PWM (SOL8)]

This test toggles the Reach/Rotate PWM Solenoid (SOL8) ON and OFF.

Run Test

NOTE: For information on how to use maintenance mode, see “Maint” on page 3-23.

1. Disconnect wire from Reach/Rotate PWM Solenoid SOL8-1.
2. Connect an ammeter as follows:
   - (–) lead to SOL8-1
   - (+) lead to wire removed from SOL8-1

These values should display:

ON-Time (percent)	Reading (mA)
0P	0
15P	120
30P	240
45P	360
60P	480
75P	600
90P	720

If these values are not displayed, reconnect wire to SOL8-1 and refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC20/Ohms	JC20-13	JC20-16	Approx. 22 ohms	Perform step 2	T/S wiring and coil
2	DCV	Backprobe JPC20-13	Backprobe JPC14-10	B+	Replace CM	Perform step 3
3		Backprobe JPC14-13			Perform step 1	T/S OTM cable to Fuse/Relay Card

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Test O56 – Sol9A DirA [Traverse DIR A (SOL9A)]

This test toggles the Traverse Direction A Solenoid (SOL9A) ON and OFF.

Run Test

NOTE: For information on how to use maintenance mode, see “Maint” on page 3-23.

1. Disconnect wire from Traverse Direction A Solenoid SOL9A-1.
2. Connect an ammeter as follows:
   - (–) lead to SOL9A-1
   - (+) lead to wire removed from SOL9A-1

These values should display:

SOL9A	Ammeter Reading	Value Displayed
Open	0.5 to 1.5	On
Closed	0 to 0.02	Off

If these values are not displayed, reconnect wire to SOL9A-1 and refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC14 and JPC18/Ohms	JC18-14	JC14-14	Approx. 39 ohms	Perform step 2	T/S wiring and coil
2	DCV	Backprobe JPC14-14	Backprobe JPC14-10	B+	Replace CM	Perform step 3
3		Backprobe JPC14-13			Perform step 1	T/S OTM cable to Fuse/Relay Card

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Test O57 – Sol9B DirB [Traverse DIR B (SOL9B)]

This test toggles the Traverse Direction B Solenoid (SOL9B) ON and OFF.

Run Test

NOTE: For information on how to use maintenance mode, see “Maint” on page 3-23.

1. Disconnect wire from Traverse Direction B Solenoid SOL9B-1.
2. Connect an ammeter as follows:
   - (–) lead to SOL9B-1
   - (+) lead to wire removed from SOL9B-1

These values should display:

SOL9A	Ammeter Reading	Value Displayed
Open	0.5 to 1.5	On
Closed	0 to 0.02	Off

If these values are not displayed, reconnect wire to SOL9B-1 and refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC14 and JPC18/Ohms	JC18-15	JC14-14	Approx. 39 ohms	Perform step 2	T/S wiring and coil
2	DCV	Backprobe JPC14-14	Backprobe JPC14-10	B+	Replace CM	Perform step 3
3		Backprobe JPC14-13			Perform step 1	T/S OTM cable to Fuse/Relay Card

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Test O58 – Traverse PWM [Traverse PWM (SOL7)]

This test toggles the Traverse PWM Solenoid (SOL7) ON and OFF.

Run Test

NOTE: For information on how to use maintenance mode, see “Maint” on page 3-23.

1. Disconnect wire from Traverse PWM Solenoid SOL7-1.
2. Connect an ammeter as follows:
   - (–) lead to SOL7-1
   - (+) lead to wire removed from SOL7-1

These values should display:

ON-Time (percent)	Reading (mA)
0P	0
15P	120
30P	240
45P	360
60P	480
75P	600
90P	720

If these values are not displayed, reconnect wire to SOL7-1 and refer to Diagnosis and Repair.

Diagnosis and Repair

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC20/Ohms	JC20-17	JC20-20	Approx. 22 ohms	Perform step 2	T/S wiring and coil
2	DCV	Backprobe JPC20-17	Backprobe JPC14-10	B+	Replace CM	Perform step 3
3		Backprobe JPC14-13			Perform step 1	T/S OTM cable to Fuse/Relay Card

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Test O59 – SuppDisp [Supplemental Display]

This test illuminates the Supplemental Display LEDs.

Run Test

NOTE: For information on how to use maintenance mode, see “Maint” on page 3-23.

All LEDs should illuminate when test is activated.

Diagnosis and Repair

If the LEDs do not illuminate, troubleshoot wiring and connections to the display.

If all connections and wiring are good, replace the display.

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Test O60 – Custom Out 1C

Reserved for custom option.

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Test O61 – Custom Out 2T

Reserved for custom option.

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Test O62 – Lower Sol [Lower Solenoid (SOL1)]

This test checks for correct lower solenoid operation.

NOTE: The Mini-Mast Load Holding solenoid (SOL5) is activated during this test.

Run Test

NOTE: For information on how to use maintenance mode, see “Maint” on page 3-23.

Lift mini-mast 12 in. (30 cm) above floor and press **Enter** per operator display.

If the solenoid is working correctly (less than 2 in. (5 cm) of drop after 5 seconds), “Passed” is displayed.

If the solenoid is not working correctly (more than 2 in. (5 cm) of drop after 5 seconds), “Failed. Lower solenoid is not working properly” is displayed. Refer to Diagnosis and Repair.

Diagnosis and Repair

Disconnect a wire to SOL1 and repeat test. If test passes, perform Test O11 – Sol1 Lwr [Lower Solenoid (SOL1)] (page 6-129).

NOTE: The lift system must be bled if the SOL1 valve body is replaced.

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Test O63 – MiniPwrSup [Mini Power Supply]

This test verifies the output of the CM to the Mini Power Supply.

⚠CAUTION

Toggling this test ON before correct setup is performed results in component damage.

NOTE: Because Input A40 values vary with the load, this test can help identify bad components/connections in the circuit.

Before running this test, verify all connectors associated with the mini power supply are latched. Check jacks and pins for correct seating.

Perform the following preliminary checks before running the test.

Preliminary Checks

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC12 and JPC10/Ohms	JC12-7	JC10-4	Approx. 430 ohms	Setup and run test	Perform step 2
2	Disconnect JP5 at mini power supply/ Ohms	Pin 1 at Mini Power Supply	Pin 2 at Mini Power Supply		T/S wiring from CM to Mini Power Supply	Replace Mini Power Supply

Test Setup

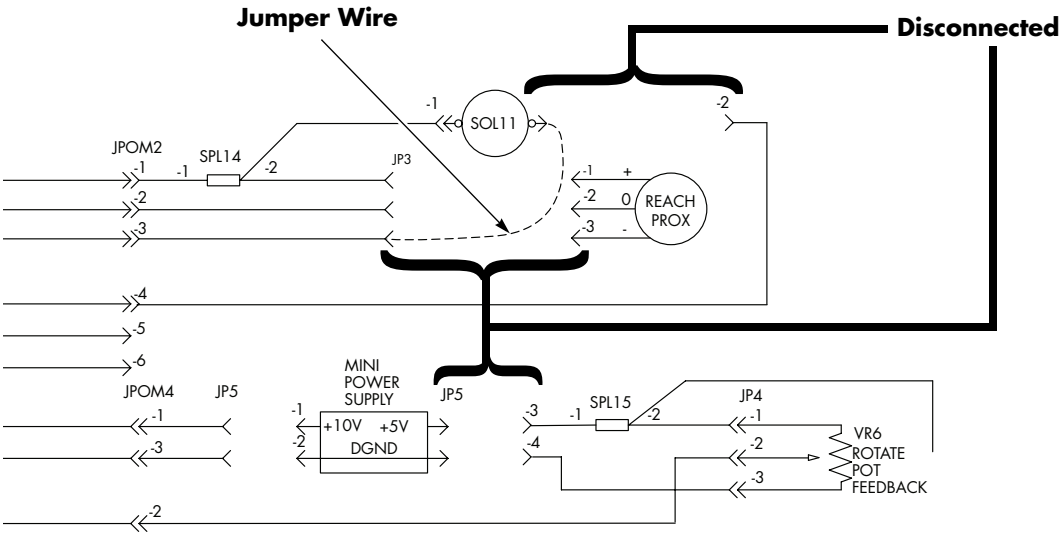
⚠CAUTION

Use extreme caution to prevent shorted circuits.

Disconnect JP3 and JP5. Remove the wire at SOL11-2 (leave disconnected until instructed to re-connect). Install a jumper wire from SOL11-2 to J3-3. See Figure 6-3.

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Figure 6-3. Test Setup Schematic Diagram



Verify Connections

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Disconnect JPC12 and JPC10/Ohms	JC12-7	JC10-4	Approx. 10 ohms	Run test	T/S wiring and coil

Run Test

NOTE: This test times out after 30 seconds.

1. Connect a meter to J3-1 and J3-3. Observe the meter reading and the value shown on the Operator Display.
2. Toggle the test ON and observe the values.

   5 to 15V should be observed on both the meter and Operator Display. If not, check for B+ at JPC14-7;

   - If B+ *is* present, replace CM.
   - If B+ *is not* present, troubleshoot OTM cable to the Fuse/Relay card.

NOTE: A 1 to 2V difference between the displayed value and the meter reading is acceptable.

3. If 5 to 15V is observed, remove the jumper and connect all disconnected cables *except* J3 (Reach Prox).
4. Re-key the truck and run Test O06 – Sol11Rch [Reach Select Solenoid (SOL11)] (page 6-128).
5. If Test O06 passes, troubleshoot Reach Prox wiring. If OK, replace Reach Prox.

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Section 7. Component Procedures

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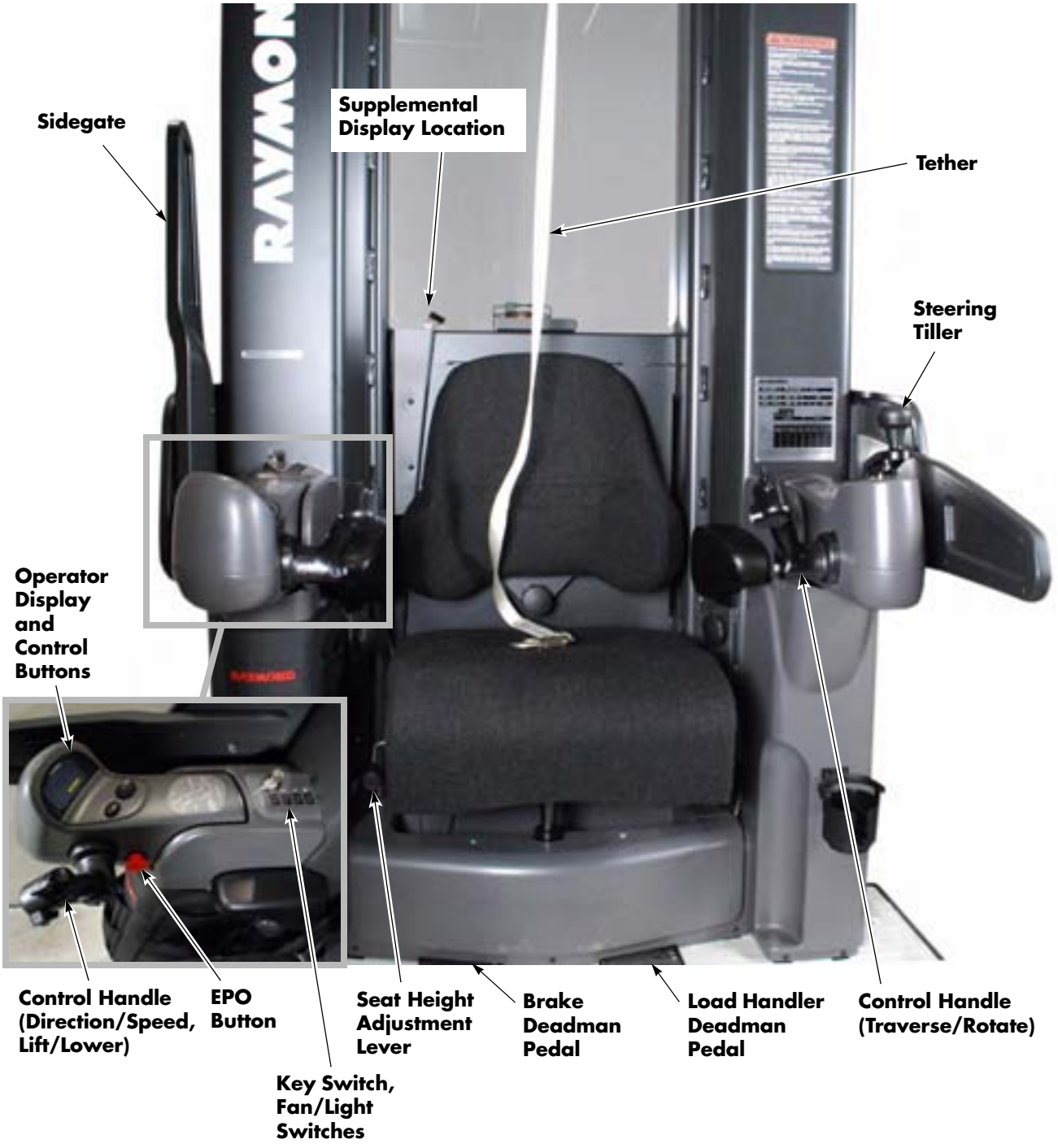
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Component Locator Photos

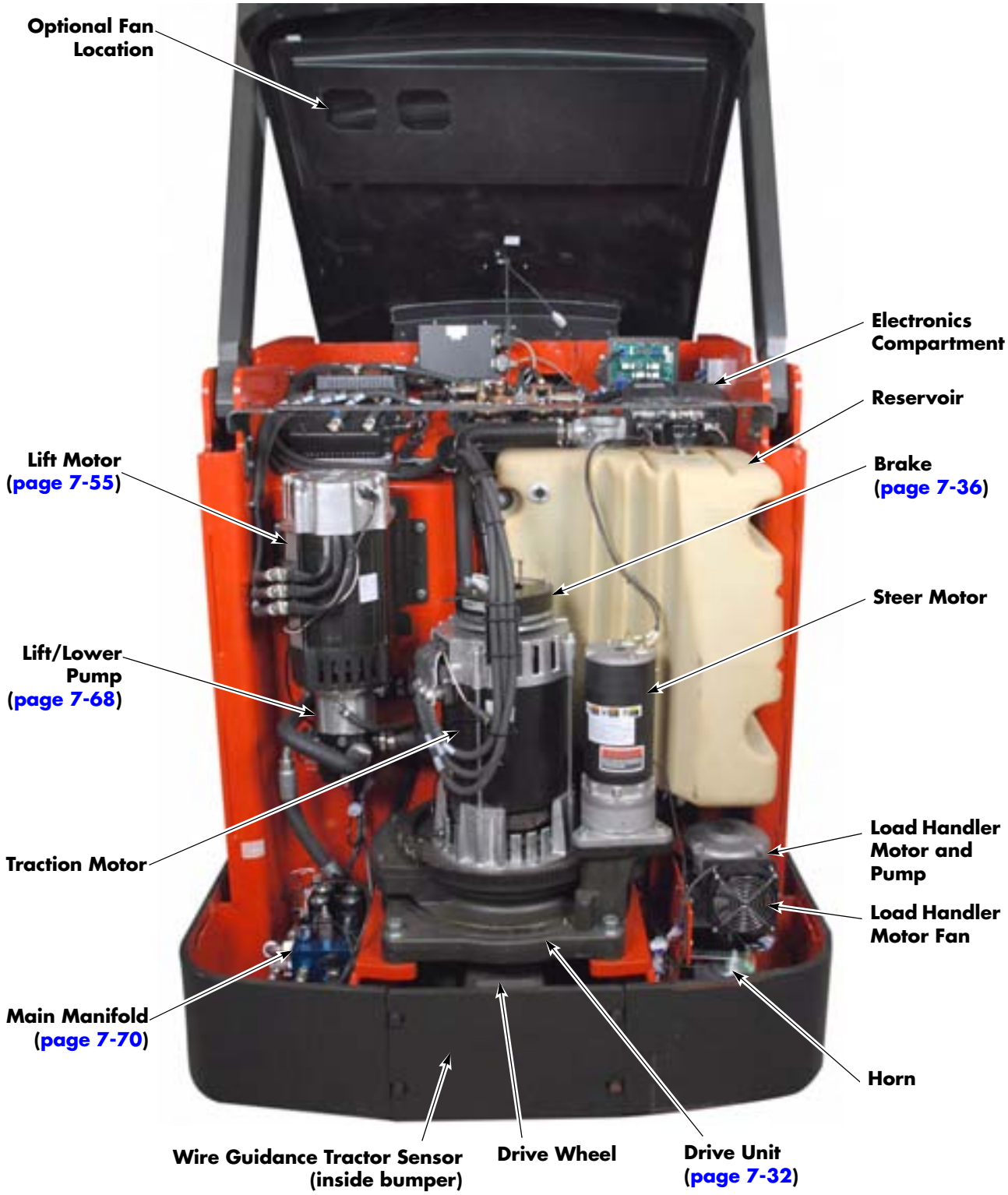
Figure 7-1. Operator Compartment



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Component Locator Photos

Figure 7-2. Tractor Components



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Figure 7-3. Electrical Compartment

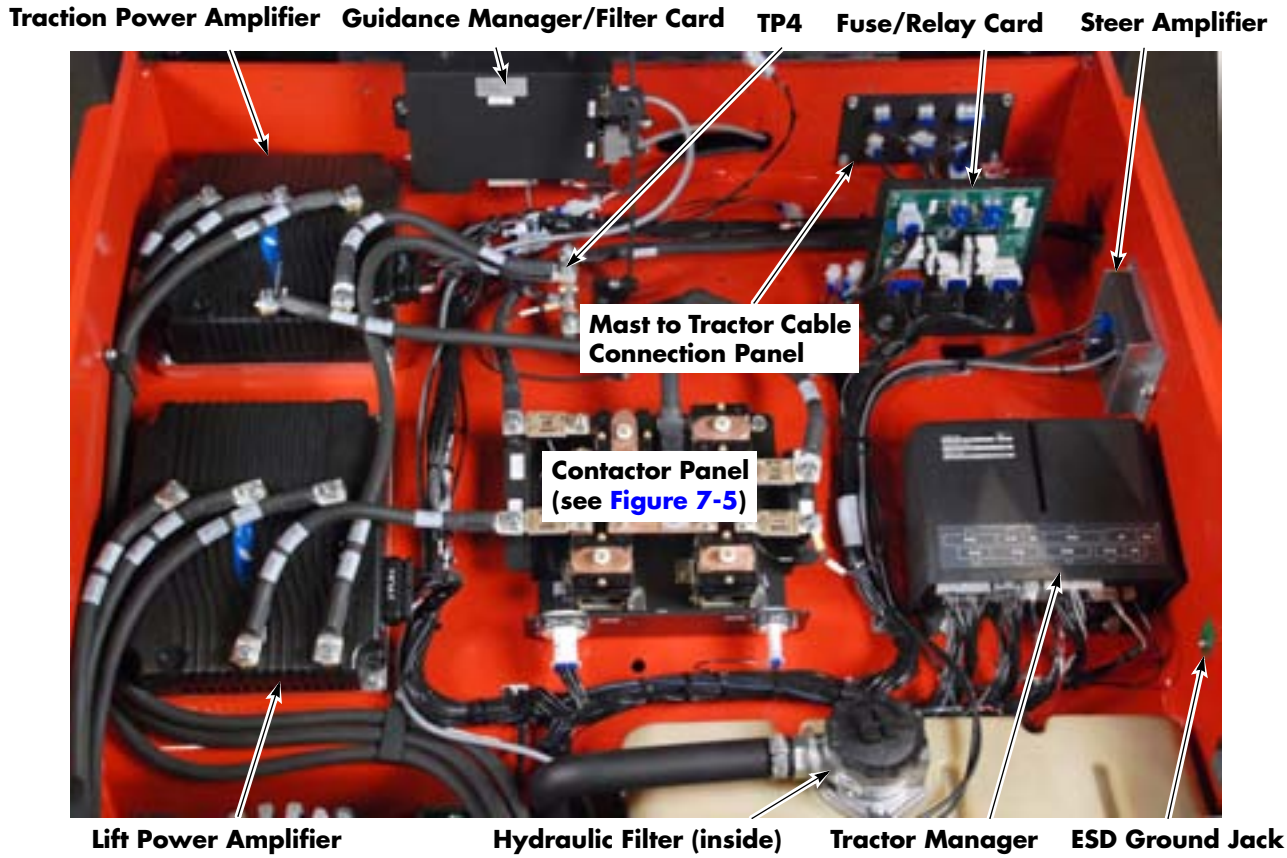
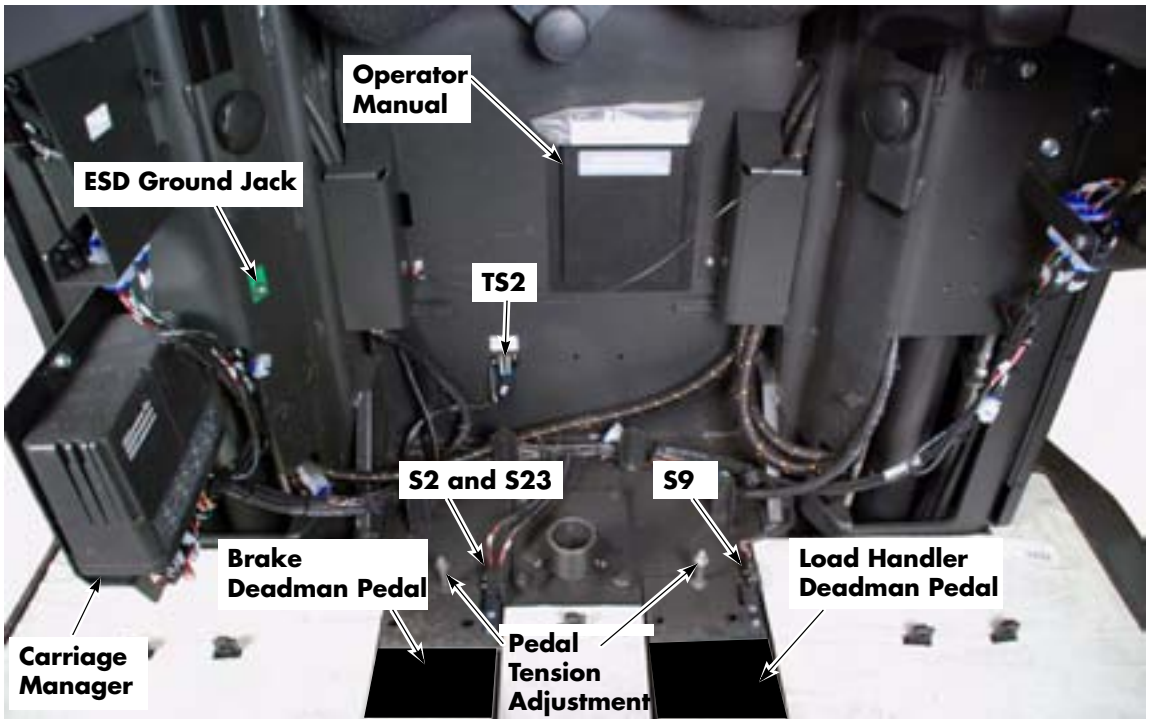


Figure 7-4. Operator Compartment - Seat and Covers Removed



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Component Locator Photos

Figure 7-5. Contactor Panel

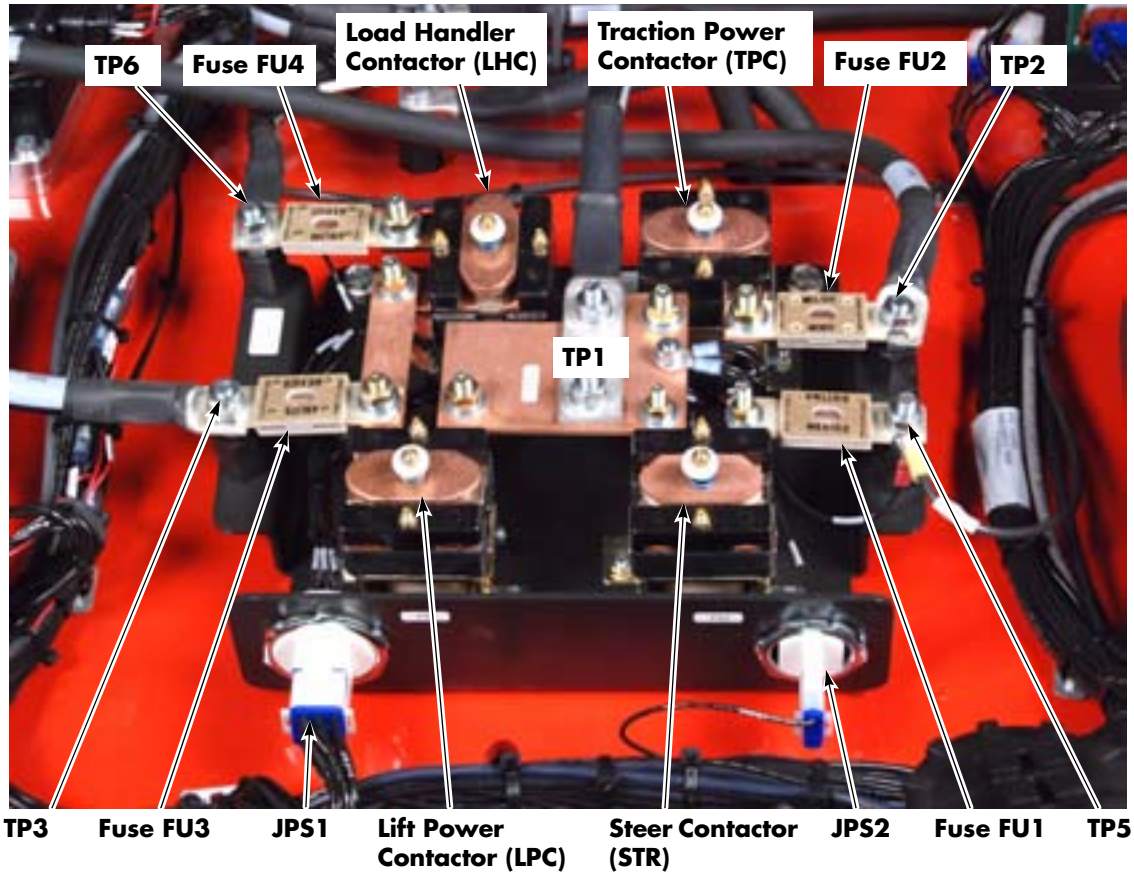
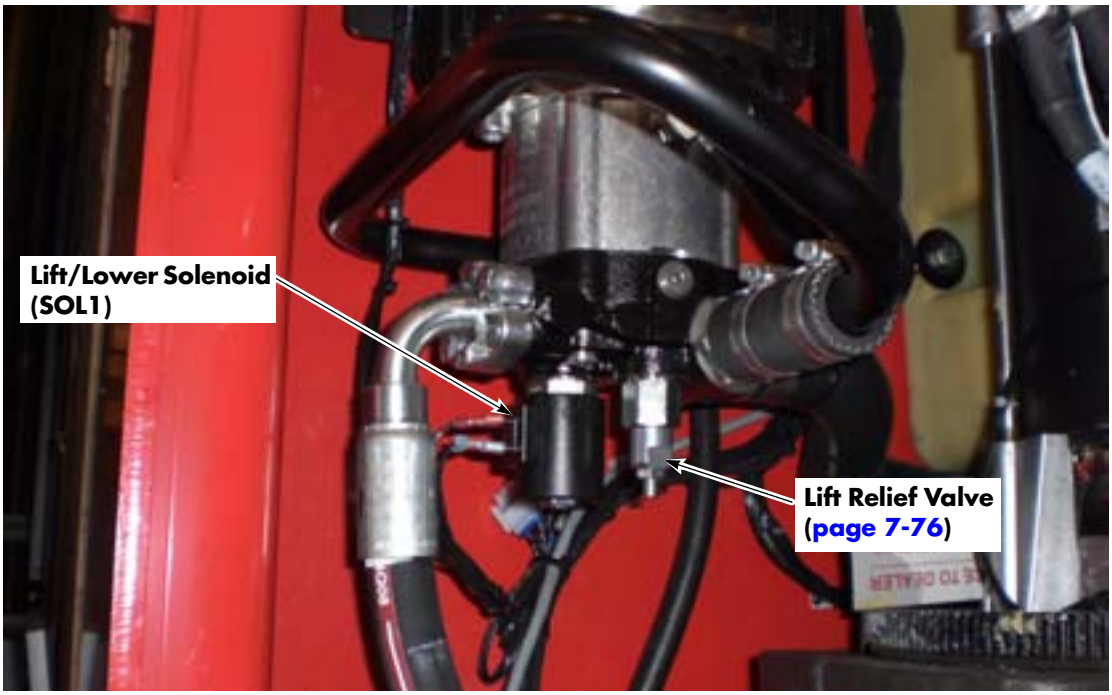


Figure 7-6. Lift Pump Components



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Figure 7-7. Load Handler Manifold

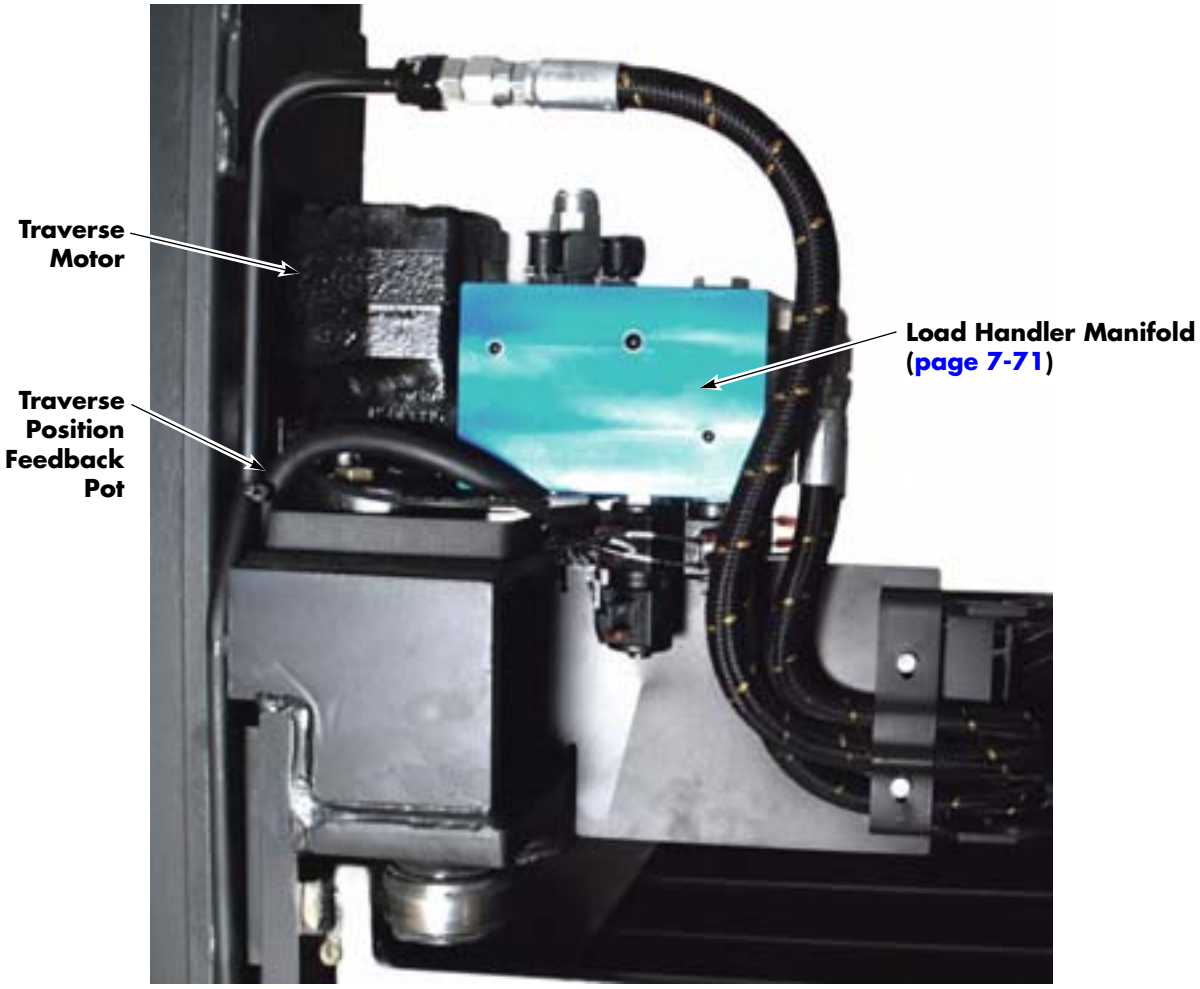
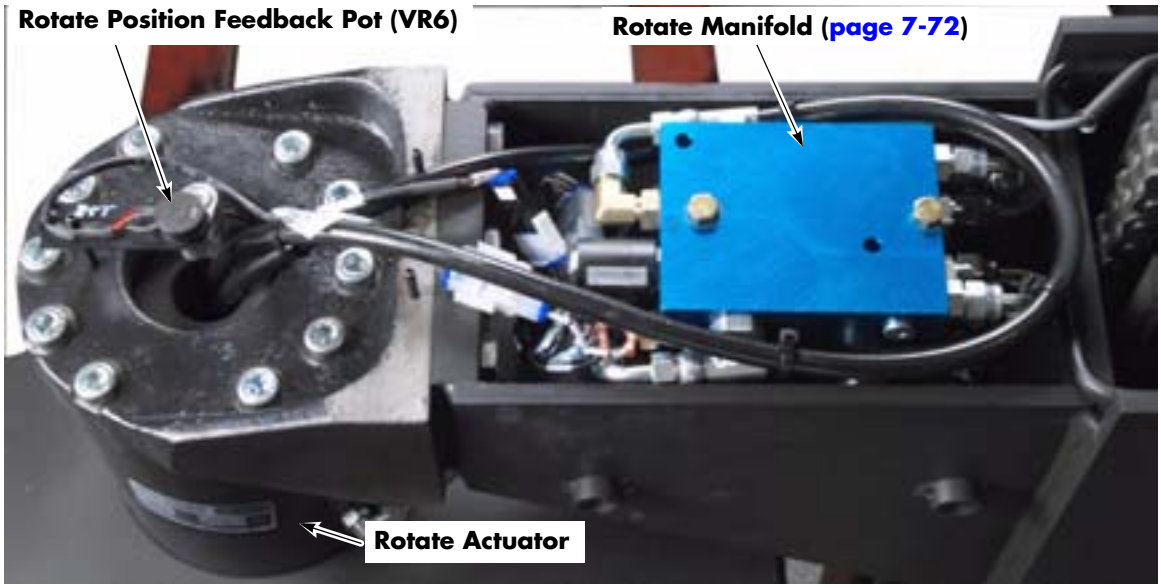


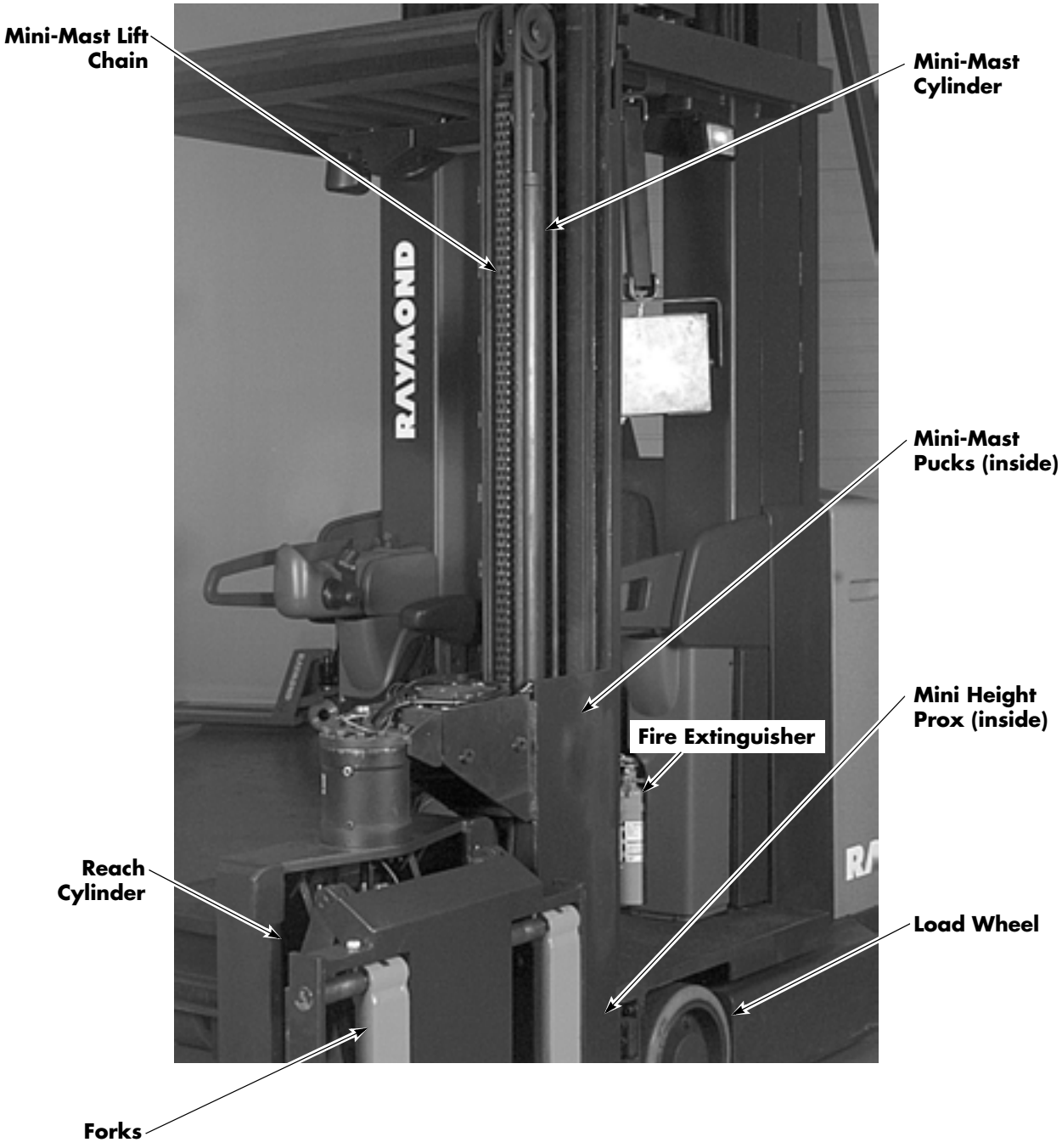
Figure 7-8. Load Handler Turret



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Component Locator Photos

Figure 7-9. Mini Mast and Load Handler



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Figure 7-10. Steering Input Encoder.

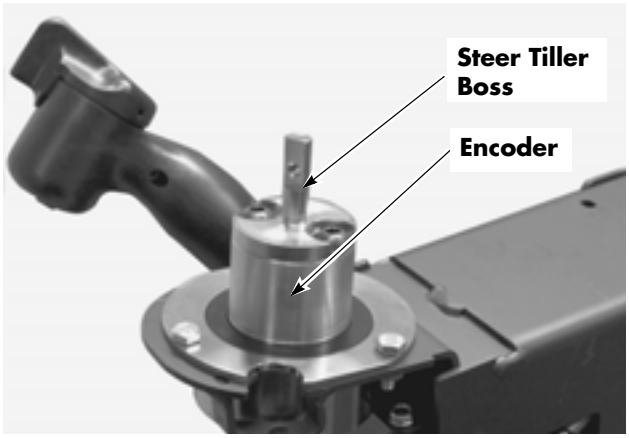


Figure 7-11. Wire Guidance Sensor, Tractor Side

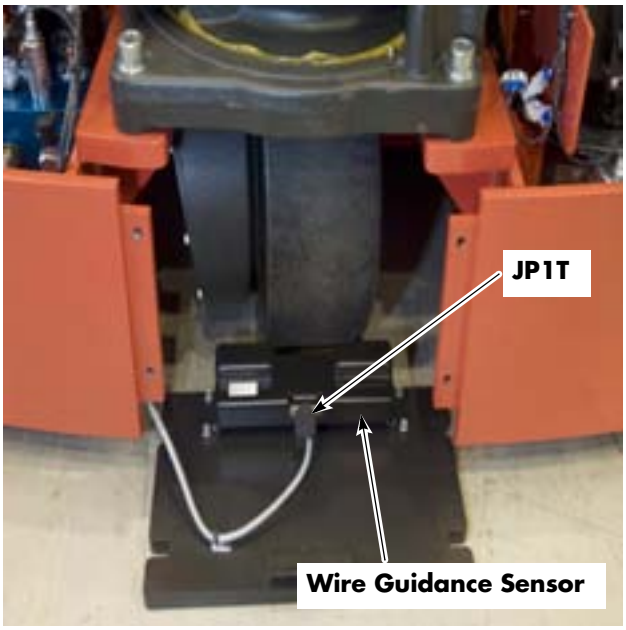


Figure 7-12. Wire Guidance and End-of-Aisle Sensors, Load Side

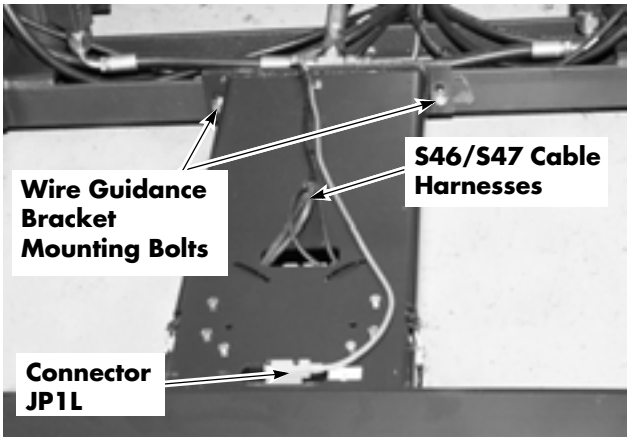


Figure 7-13. Wire Guidance and End-of-Aisle Sensor Bracket, swiveled

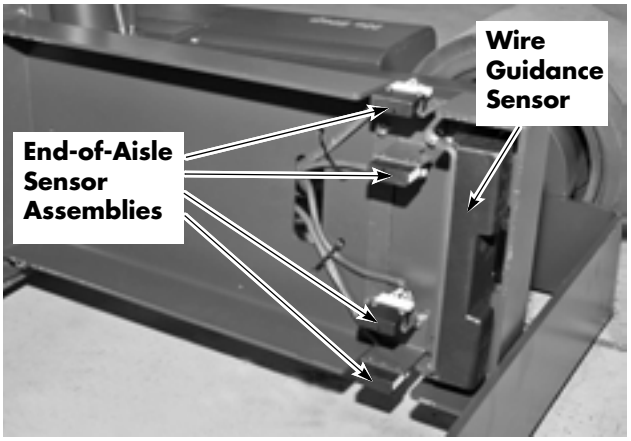


Figure 7-14. Wire Guidance Sensor and End-of-Aisle Detect Sensors

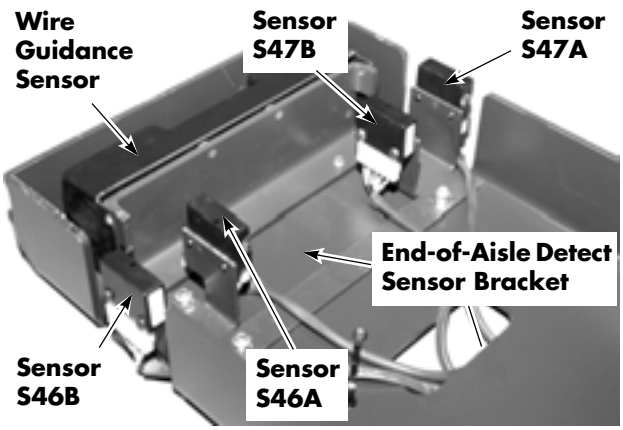
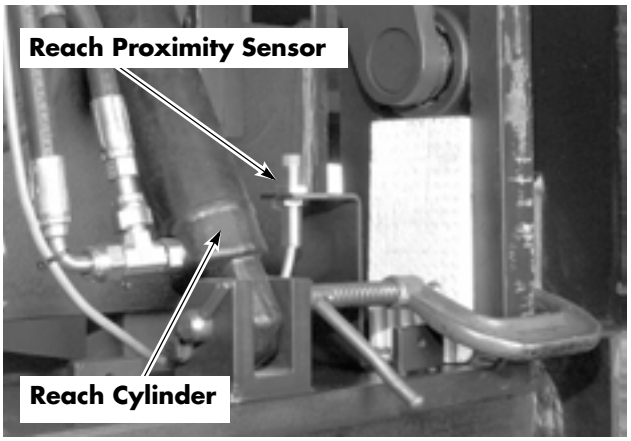


Figure 7-15. Reach Proximity Sensor



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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
Anti-static Field Kit	All	1-187-059	ESD protection
Anti-static Wrist Straps		1-187-058/001	
Anti-static Wrist Strap Tester		1-187-060/100	
Crimp Tool		1069861	Crimp power cable lugs
Chain Gauge		950-350/CG	Lift chain inspection
Chip Extraction Tool		950-032	Guidance Manager firmware replacement
Connector Unlatching		950-042	Separate AMP connectors
Fork Wear Caliper		922-369	Fork inspection
End Cap	9700	1090761/001	Main Lift Cylinder end cap removal/installation
End Cap	9600	1090761/005	Main Lift Cylinder end cap removal/installation
End Cap	All	1090761/008	Mini-Mast Lift Cylinder end cap removal/installation
Lift/Lower Pendant		114-020-848	Lift and lower platform for service. Refer to "Lift/Lower Pendant" on page 7-13.
Pin Extraction		950-003	AMP connector pin extraction (Control handle)
Pin Extraction	CS trucks	950-004	CS handle heater pin extraction
Pin Extraction	All	950-009	AMP connector pin extraction
Pin Extraction		950-026	MOLEX connector pin extraction
Surge Protector		154-010-801	ESD/voltage surge protection for serial type FlashWare connections
USB-to-USB Cable		610-809/210	FlashWare connection to truck

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Lift/Lower Pendant

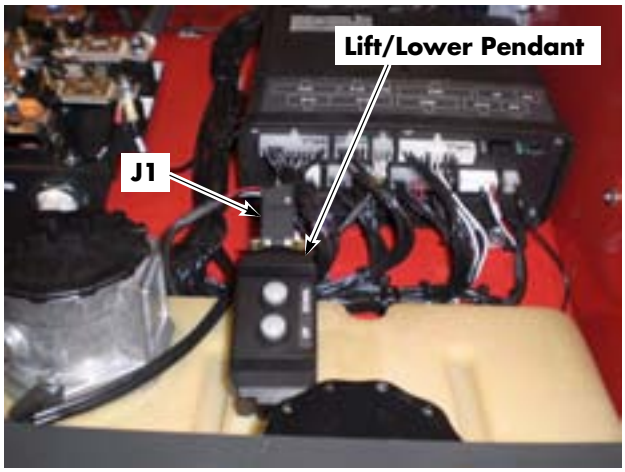
The lift/lower pendant (P/N 114-020-848) is a maintenance tool that allows the technician to lift and lower the platform when servicing the truck.

- When the pendant is used:
  - Travel is disabled and remains disabled until the truck is re-keyed or Program Mode is entered.
  - Load Handler functions are disabled and remain disabled until the truck is re-keyed.
  - Main and Mini lift and lower requests from the handle are ignored and remain ignored until the truck is re-keyed.
- Pendant is functional only when the deadman pedals are up.
- The pendant is disabled when in Maintenance and Learn Modes.

Operation

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove rear tractor cover and open top tractor cover.
3. Connect the pendant to J1 (near the Tractor Manager).

Figure 7-16. Lift/Lower Pendant Connection



4. Close top tractor cover.
5. Reconnect the battery connector and turn the key switch ON.
6. Press and hold the button for desired direction (lift or lower).
7. After 2 seconds, press the opposite button to initiate motion.

NOTE: There must be a delay of at least 2 seconds and no more than 5 seconds from the time the first button is pressed to when the second button is pressed.

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Decals and Plates

Replace any missing decals. Remove and replace any decals that are damaged.

Removal

1. Use a sharp edge to peel the decal from the surface. Use care not to scratch or damage the paint on the truck.
2. Clean the surface thoroughly and permit to dry before attaching new decals. Touch up paint as required.

Installation

1. Peel off the backing and place the decal into position.
2. Press the decal into place. Avoid wrinkling.
3. If the decal does not have a protective sheet over the surface, smooth the decal into place using clean fingers. Make sure all edges are secured to the surface.
4. If the decal has a protective sheet over the surface, rub over the protective sheet with a firm, straight plastic edge to remove any air bubbles and wrinkles. Then peel off the protective sheet.

Location

Refer to Table 7-2, Figure 7-17, Figure 7-18, and Figure 7-19 to locate decals on the truck.

Table 7-2. Decal Location Chart

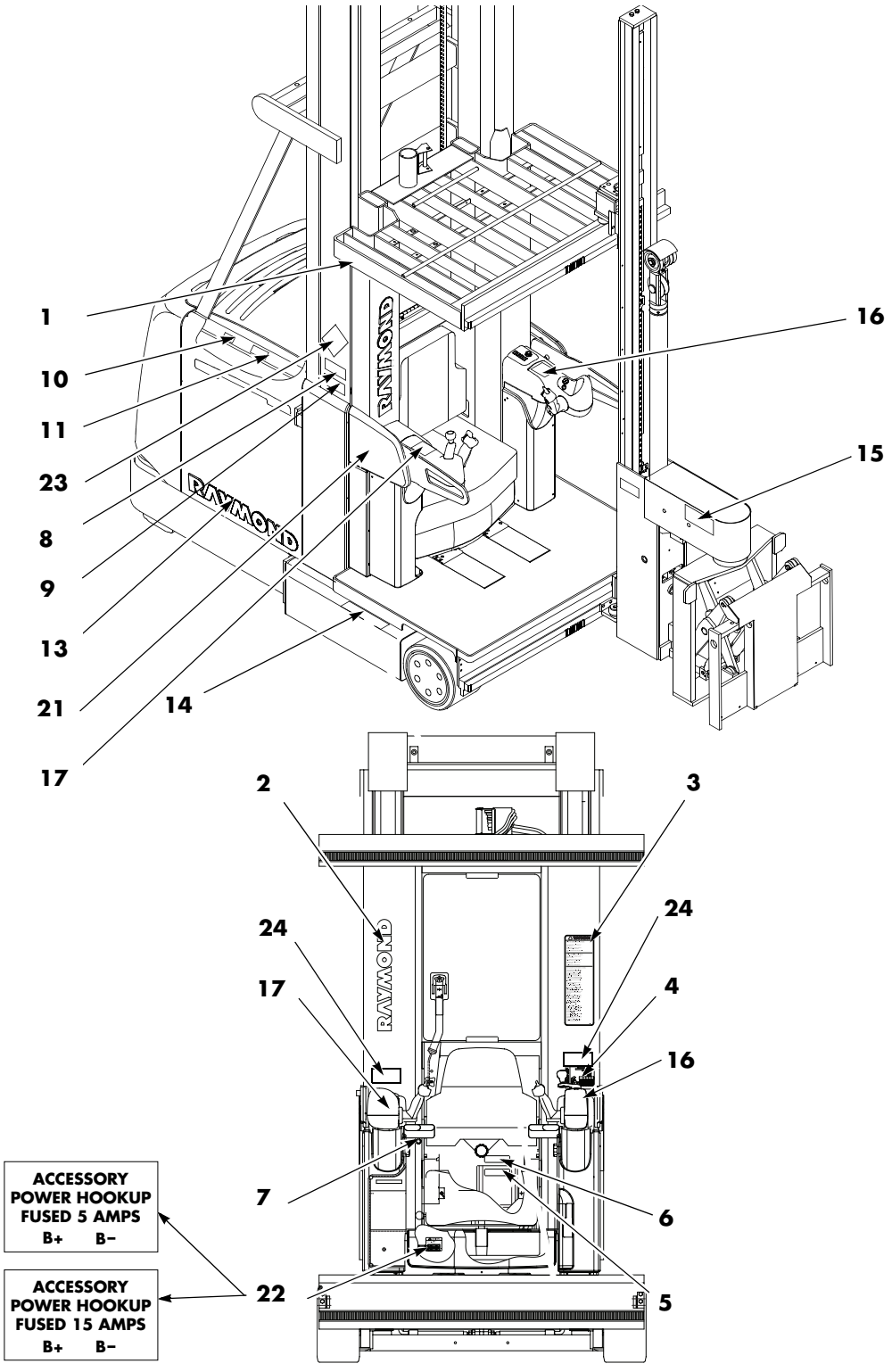
Identifier	Description	Location
1	*Overhead Guard ANSI/ASME conformance*	Overhead guard, right side
2	Raymond	Operator platform, right side
3	*Main Operator Warning Decal*	
4	Specification Plate (not a decal)	
5	Operator Manual	Under seat
6	Replacement Operator Manual	
7	ESD Jack	Operator platform, right side of seat
8	Performance	Mast, right side
9	Identification Plate (not a decal)	
10	*Charger Warning*	Tractor frame, above battery compartment
11	*Battery Warning*	
12	*Emergency Lower Valve*	Tractor frame, near main manifold
13	Raymond (2)	Side covers (each side)
14	*No Step (2)*	Top of baselegs (each side)
15	*Swinging Forks. Keep Clear* (Qty. 2)	Sides of load handler turret
16	Left Control Handle controls	Top of left control arm
17	Right Control Handle controls	Top of right control arm
18	ESD Jack	Tractor electrical compartment, right side

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Identifier	Description	Location
19	*Emergency Lower Decal*	Tractor cover, lower left corner, rear
20	*Drive Unit Warning*	Bottom of steer motor, next to drive unit
21	ACR Regen (Qty. 2)	Sidegates (each side)
22	*Aux Power*	Operator Platform, right side of seat, behind underseat tray
23	EE Rating	Mast, right side
24	Alternate Spec Plate	Operator platform, right side, below #2
Items in *italics* are warning decals.		

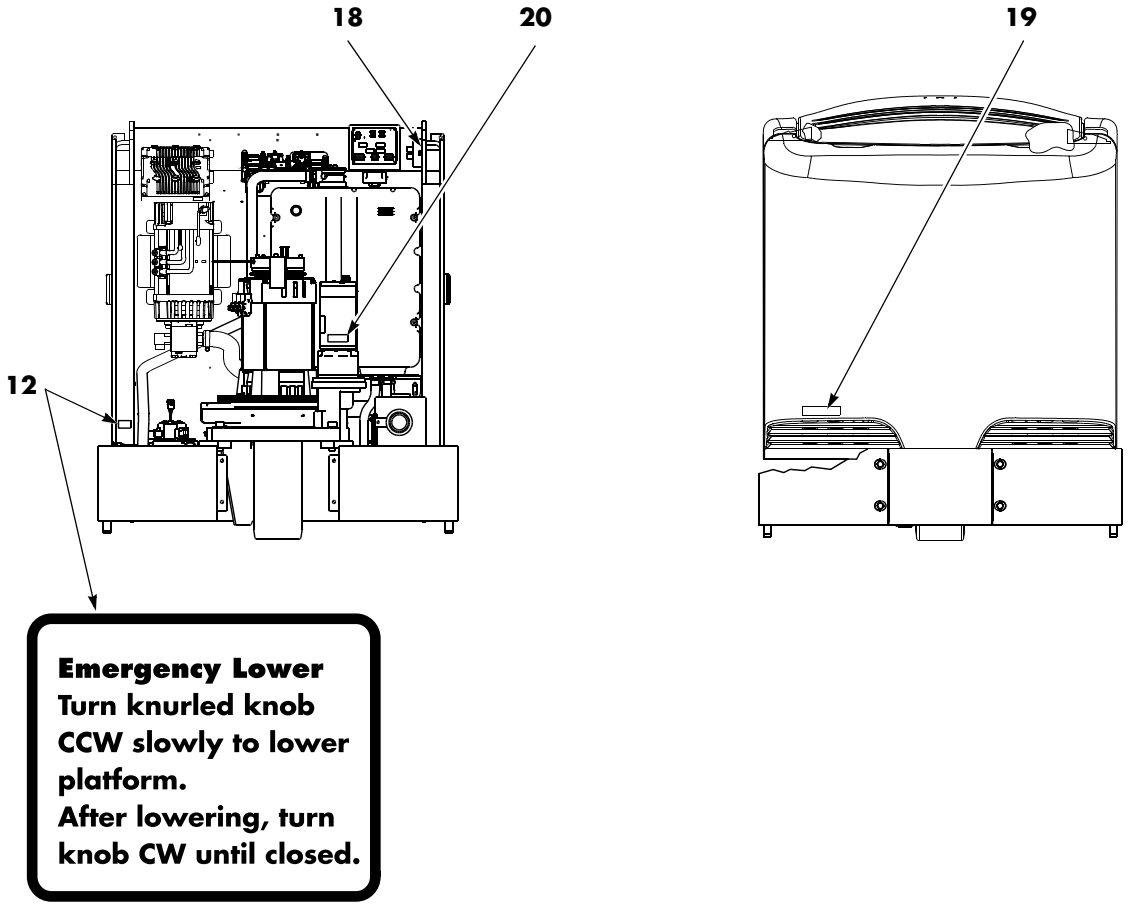
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Figure 7-17. Decal Locations



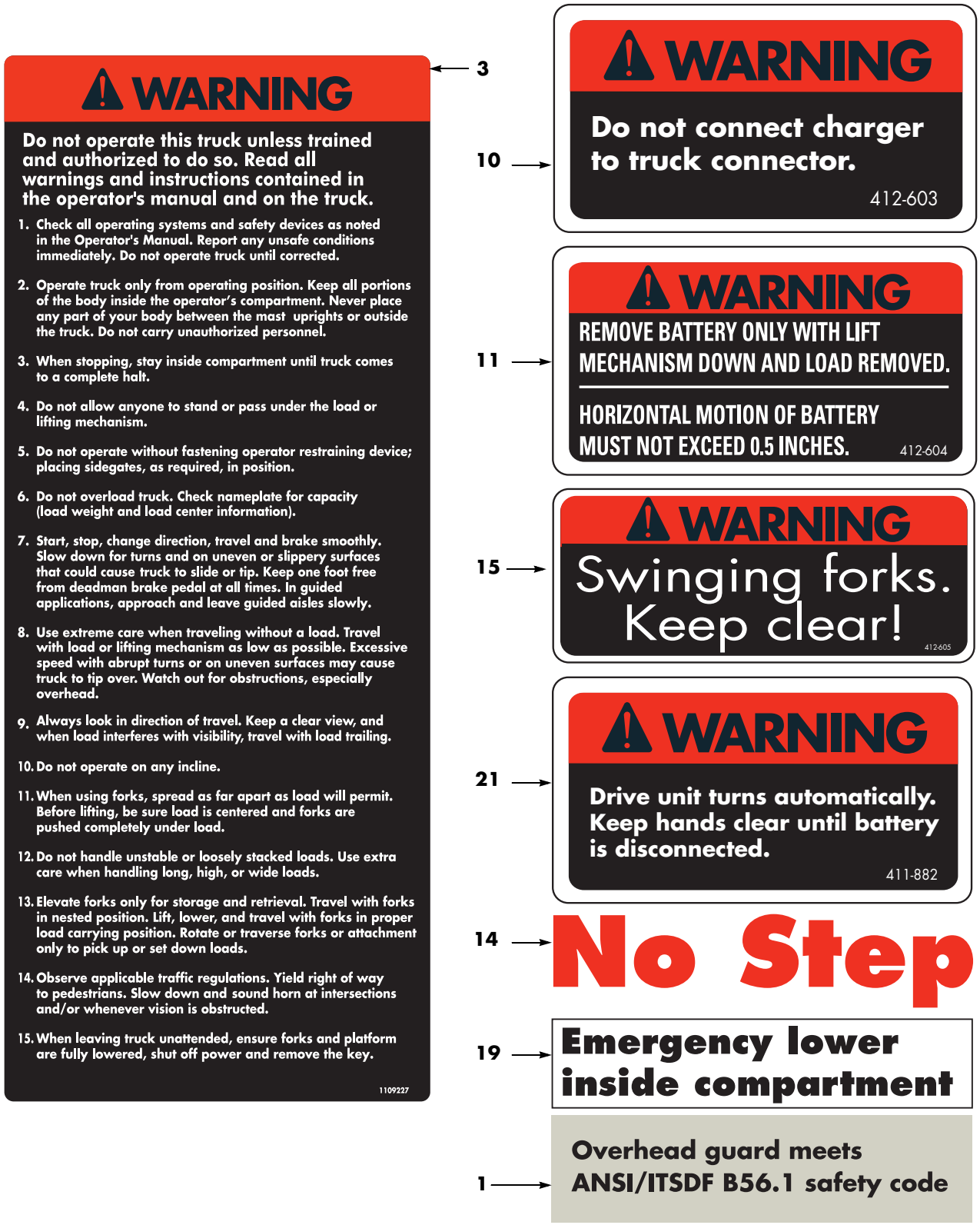
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Figure 7-18. Warning Decals



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Figure 7-19. Warning Decals Continued



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Steering and Controls

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Steer Motor

Removal

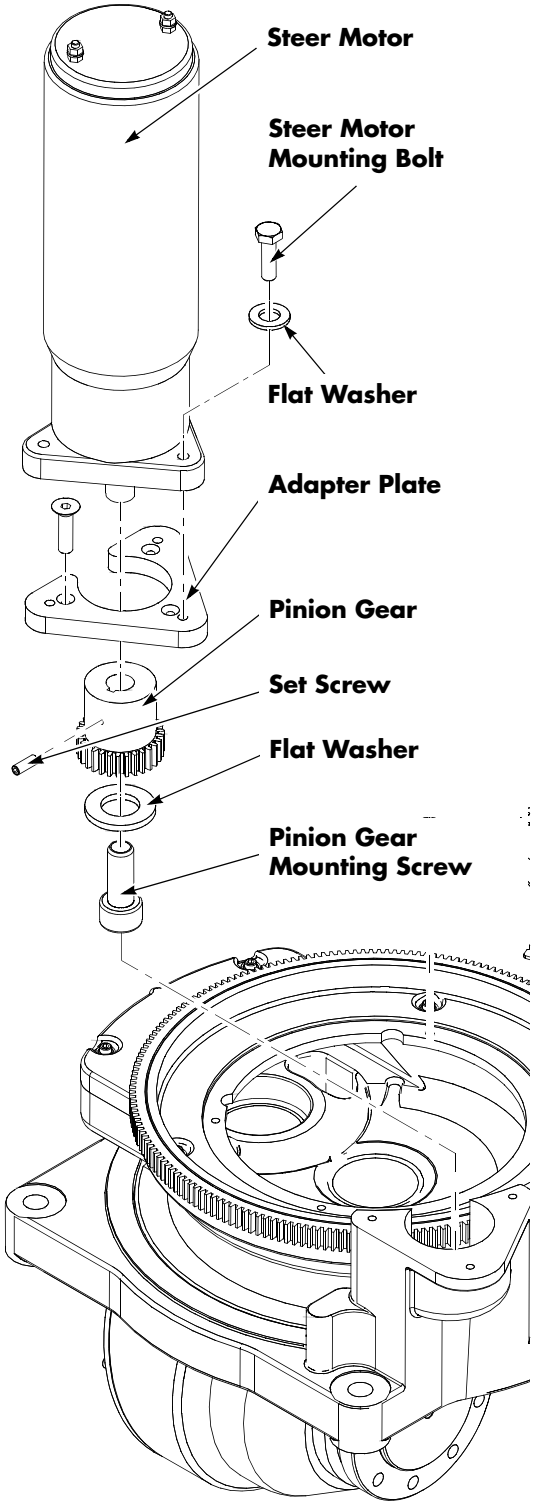
1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the tractor cover.
3. Remove the steer motor power cables. Use two wrenches to avoid twisting the motor stud.
4. Remove three steer motor mounting bolts. See Figure 7-20.

⚠CAUTION

The steer motor and gear reducer weigh approx. 54 lb. (24 kg).

5. Lift the steer motor and gear reducer up and out of the drive unit.

Figure 7-20. Electric Steer Motor



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Pinion Gear Replacement

1. Remove the set screw.
2. Remove the pinion gear mounting screw and flat washer. See Figure 7-20 on page 7-20.
3. Remove the pinion gear from the shaft.

NOTE: Install the pinion gear with the gear teeth *towards the end of the motor shaft*.

4. Using a brass-faced hammer, drive the pinion gear onto the motor shaft, aligning the keyways on the gear and shaft.
5. Apply thread-locking compound (P/N 990-536) to the pinion gear mounting screw and install. Torque to 20 ft. lb. (27 Nm).
6. Apply thread-locking compound (P/N 990-536) to set screw and install.

Installation

1. Apply molybdenum anti-seize compound (P/N 990-638) to the pinion gear teeth.
2. Install steer motor, meshing the pinion gear with the drive unit ring gear.
3. Apply thread-locking compound (P/N 990-536) to the steer motor mounting bolts and install. Torque to 30 ft. lb. (42 Nm).
4. Apply drive unit warning decal P/N 411-882.
5. Connect the power cables. Use a second wrench on the stud terminal securing nut to avoid twisting the motor stud.
6. Attach the tractor cover.
7. Reconnect the battery connector and turn the key switch ON.
8. Enter Learn Mode and perform Learn Guidance. See “Learn Wire Guidance” on page 3-34.
9. Test the steering function for smooth and correct operation.

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Control Handle Assembly

Disassembly

1. Remove the control handle and gear case from the control arm.
2. Loosen the set screws securing the thumb control. Remove the thumb control.
3. Remove the outboard screw securing the knob positioner to the handle shell.
4. Remove cable ties on wiring harness.
5. Remove 2 screws from inside handle hub. Remove 2 screws in handle shell. Separate the halves of the handle shell. The hub is part of the outboard half of the handle. See Figure 7-21.

Figure 7-21. Control Handle Disassembly

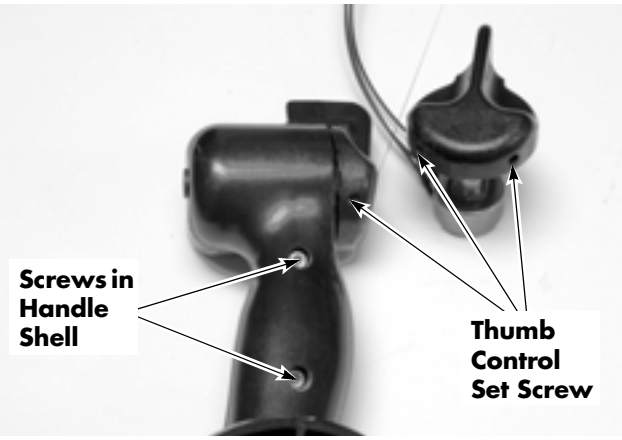


Figure 7-22. Control Handle Halves



Reassembly

1. Mate the halves of the handle shell, starting at the hub.
2. Apply thread-locking compound (P/N 990-403) to the handle shell screws and fasten the shell together.
3. Attach cable ties to harness where previously removed.
4. Attach the spring and knob positioner over the VR2/VR3 potentiometer shaft. Apply a thin coat of lubricant (P/N 990-635) to the spring. Set the metal pin on the knob positioner between the spring ears, and engage the locating tab on the pot body in the opening in the plastic housing. See Figure 7-23.

Figure 7-23. Control Handle Thumb Control

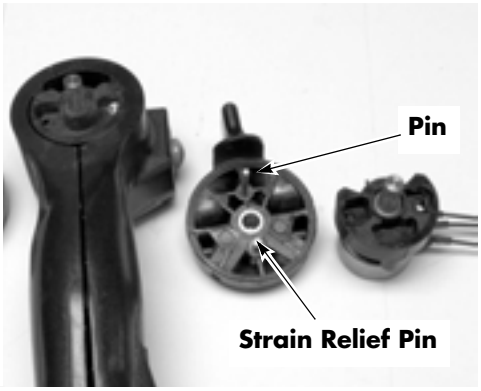
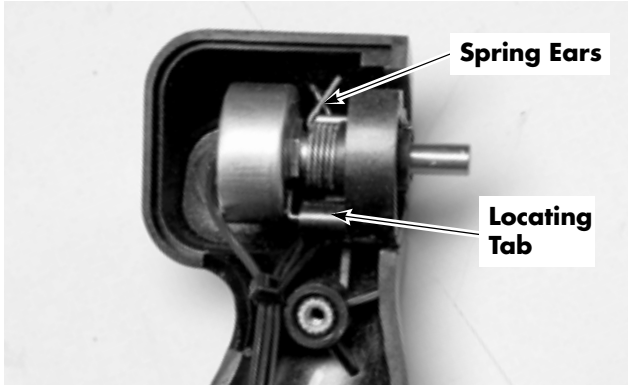


Figure 7-24. Control Handle Thumb Control, side view



5. Apply thread-locking compound (P/N 990-403) to the knob positioner screws. Secure the potentiometer and knob positioner in the handle.
6. Install the control handle and gear case in the control arm.

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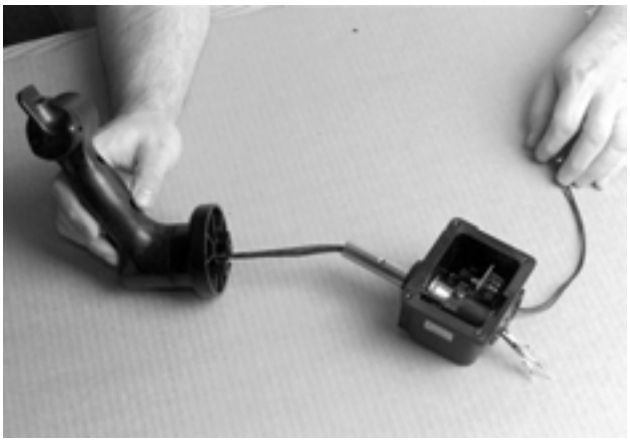
7. Adjust the potentiometer. See "Adjusting VR2 or VR3."
8. Run Learn Mode for "Controls." See "Learn Controls" on page 3-33.

Control Handle Return Spring

Removal

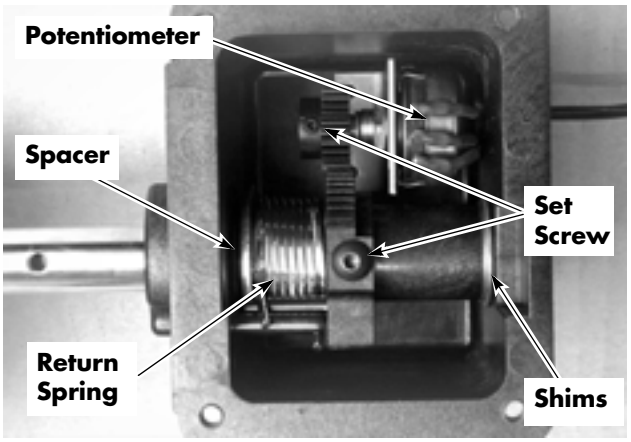
1. Remove the control handle and gear case from the control arm.
2. Open the gear case.
3. Using pin extractor P/N 950-003, extract all pins from PL1 (left) or PR1 (right) except pins 9, 11, and 12, labeling if necessary to make sure correct reconnection later. Also extract pins PL2-2 (left) or PR2-2 (right).
4. Separate wires and pull control handle off the shaft and the wires out of the shaft. See Figure 7-25.

Figure 7-25. Control Handle Gear Case Removal



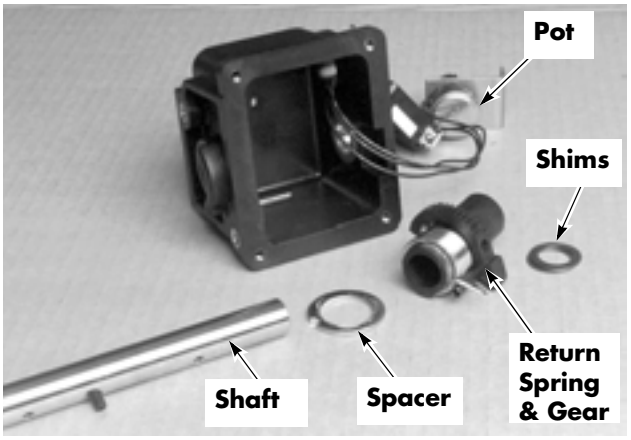
5. Remove the potentiometer assembly mounting screws and remove the potentiometer assembly from the case. See Figure 7-26.

Figure 7-26. Control Handle Gear Box Components



6. Remove the set screw securing the gear to the shaft. Pull the shaft out.
7. Remove the gear and spring assembly. Note and retain the shims on the inside end of the shaft. Remove and retain the spacer on the front of the gear. See Figure 7-27.

Figure 7-27. Control Handle Return Spring and Associated Components



8. Use needle nosed pliers to remove the spring from the gear.

Installation

1. Coat the inside of the new spring lightly with lithium grease (P/N 990-635).
2. Use needle nosed pliers to attach the new spring. Do not bend the spring ears.
3. Reinstall the spacer on the gear and spring assembly. Insert the gear and spring assembly in the case and insert the metal shaft part way.

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4. Install shims at the inside end of the gear and seat the shaft completely.
5. Make sure the control handle mounting set screw on the shaft points down.
6. Apply thread-locking compound (P/N 990-403) to the gear set screw. Fasten the gear and spring assembly to the shaft.
7. Mesh the potentiometer pinion gear with the control handle shaft gear, making sure the set screw on the pinion gear points up. Apply thread-locking compound to the potentiometer mounting screws and fasten.
8. Feed control handle wires through the shaft and reinsert pins.
9. Adjust the VR1 or VR4 potentiometer to electrically center the control. See "Adjustment" on page 7-25.
10. Reassemble the gear case.
11. Install the control handle and gear case in the control arm.
12. Run Learn Mode for "Controls." See "Learn Controls" on page 3-33.

Travel (VR1) and Traverse (VR4) Pots

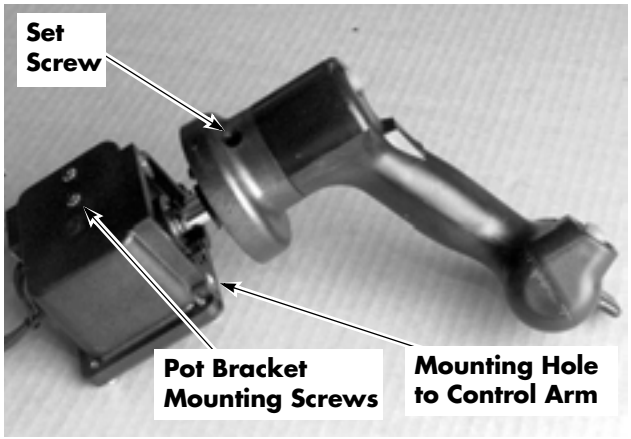
The travel pot (VR1) is located in the right-hand control handle. Service procedures are the same for the traverse pot (VR4), located in the left-hand control handle.

NOTE: Photos in this section show views of both left- and right-hand control handles.

Removal

1. Remove the control handle and gear case from the control arm.
2. Open the gear case.
3. Cut the cable tie on the wiring.
4. From the outside of the case, remove two screws and lock washers securing the potentiometer bracket. See Figure 7-28.

Figure 7-28. VR1/VR4 Pot Bracket Mounting Screws



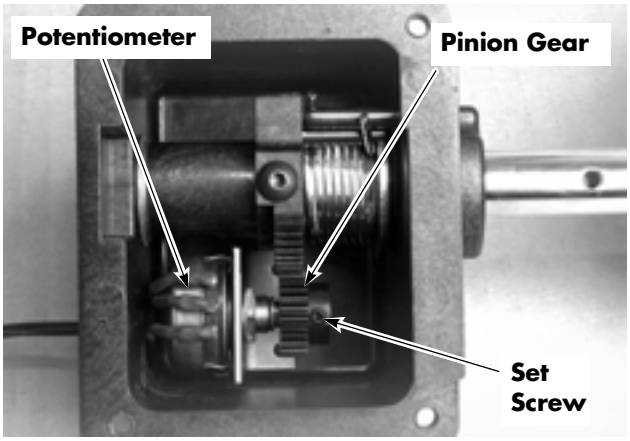
5. Remove the potentiometer assembly from the case.
6. Remove heat shrink and unsolder wire connections. Label wires as needed for correct reinstallation. See "Soldering Procedures" on page 7-42.
7. Loosen set screw and remove pinion gear. See Figure 7-29.
8. Remove the potentiometer from the mounting bracket, noting its orientation.

Installation

1. Attach the new pot to the mounting bracket in the same orientation as the original.
2. Slip heat shrink tubing over the wires, attach and solder wires to the potentiometer, and shrink the tubing over the connections. Bend terminals carefully so they are parallel with the pot body. See Figure 7-29. See "Soldering Procedures" on page 7-42.

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Figure 7-29. Control Handle Gear Case Components



3. Attach the pinion gear to the pot, aligning the flats and securing with the set screw.
4. Position the pot assembly in the case, meshing the gears and making sure that the set screw faces up. Attach the pot assembly to the case with two screws through the case. Turn the control handle shaft to make sure that the gears mesh correctly and potentiometer turns smoothly. If the gears are correctly meshed, but the movement binds, loosen the potentiometer assembly mounting screws and gently pry the potentiometer away from the control handle shaft as needed. Tighten the mounting screws.
5. Adjust the potentiometer on its bracket to electrically center the control. See “Adjustment” on page 7-25.
6. Reassemble the gear case.
7. Attach a cable tie on the wiring where previously removed.
8. Install the control handle and gear case in the control arm.
9. Run Learn Mode for Controls. See “Learn Controls” on page 3-33.

Adjustment

1. Remove the gear case.
2. Make sure the control handle is in the neutral position.
3. Reconnect the handle assembly connector to the truck harness connector (JPL1 or JPR1).
4. Refer to Input A04 – Thrtl Pot [Throttle Pot (VR1)] (page 6-40) or Input A85 – Trv Pot [Traverse/Reach Pot (VR4)] (page 6-63).
5. Loosen the jam nut until it is just snug.
6. Rotate the pot on the bracket until input voltage is 2.5V.
7. Tighten the jam nut and check the voltage again.
8. Install the control handle and gear case in the control arm.
9. After re-assembly, run Learn for Controls. See “Learn Controls” on page 3-33.

Lift/Lower (VR2) and Rotate (VR3) Pots

The lift/lower pot (VR2), is located in the right-hand control handle. Service procedures are the same for the rotate pot (VR3), in the left-hand control handle.

NOTE: Photos in this section show views of both left- and right-hand control handles.

Removal

1. Remove the control handle and gear case from the control arm.
2. Separate the control handle halves. See “Disassembly” on page 7-22.
3. Remove two screws securing the knob positioner. Remove the positioner, spring, and spacers from the potentiometer shaft. See Figure 7-23.
4. Cut the cable tie. Remove shrink wrap and unsolder wires on potentiometer. See “Soldering Procedures” on page 7-42. Label the wires as needed for correct reinstallation.

Installation

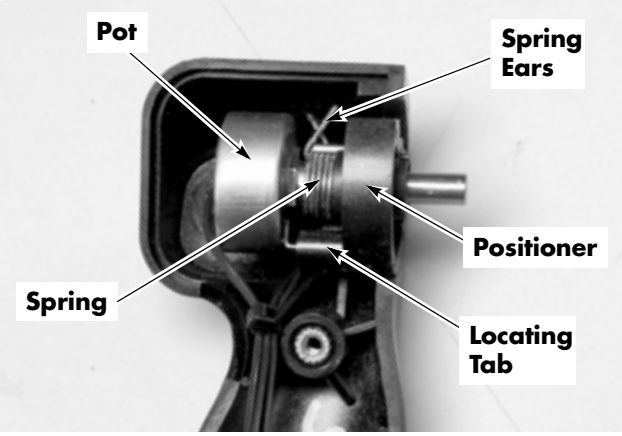
1. Slip heat shrink tubing over the wires, attach and solder wires to the potentiometer, and shrink the tubing over the connections. See “Soldering Procedures” on page 7-42. Bend terminals

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carefully so they are parallel with the pot body.

2. Attach cable tie where previously removed.
3. Attach the spring, knob positioner, and spacers over the potentiometer shaft. Apply a thin coat of lubricant (P/N 990-635) to the spring. Set the metal pin on the knob positioner between the springs ears, and engage the locating tab on the pot body in the opening in the plastic housing. See Figure 7-30.

Figure 7-30. Control Handle and Thumb Control

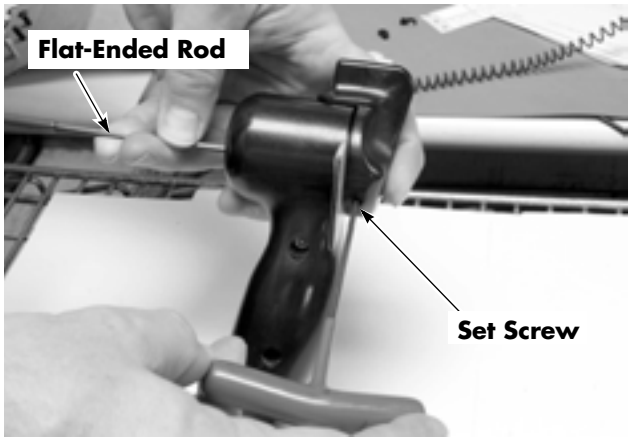


4. Make sure the pot shaft turns freely.
5. Apply thread-locking compound (P/N 990-403) to one knob positioner screw. Secure the potentiometer and knob positioner in the handle shell with one screw.
6. Adjust the potentiometer. See "Adjustment" on page 7-26.
7. Bundle wires and route them in the handle shell, making sure they are not pinched by the handle shell.
8. Reassemble the control handle halves. See "Reassembly" on page 7-22.
9. Install the control handle and gear case to the control arm.
10. Run Learn Mode for Controls. See "Learn Controls" on page 3-33.

Adjustment

1. Reconnect the handle assembly connector to the truck harness connector (JPL1 or JPR1).
2. Refer to Input A05 – L/L Pot [Lift/Lower Pot (VR2)] (page 6-41) or Input A87 – Rot Pot [Rotate Command Pot (VR3)] (page 6-65).
3. Adjust the pot until the input voltage is 2.5V.
4. Install the spacer and knob on the pot shaft.
5. Insert a flat-ended rod into the hole in the control handle and apply light pressure to press the potentiometer and return spring against the positioner. See Figure 7-31.

Figure 7-31. Attaching Thumb Control



6. Install the set screws securing the knob to the potentiometer shaft.
7. Verify the center voltage again.
8. Test the knob to make sure it does not bind.
9. Install a plug (P/N 1-085-106/001) in the hole.

Control Handle Switches

The Horn Switch (S3) and optional Auto-Manual Switch (S4) are located on the right-hand control handle. See Figure 7-32.

The Lift Select Switch (S6) and optional Lift/Lower Inhibit Bypass Switch (S7) are located on the left-hand control handle. See Figure 7-33.

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Figure 7-32. Right Control Handle Switches (S3/S4)

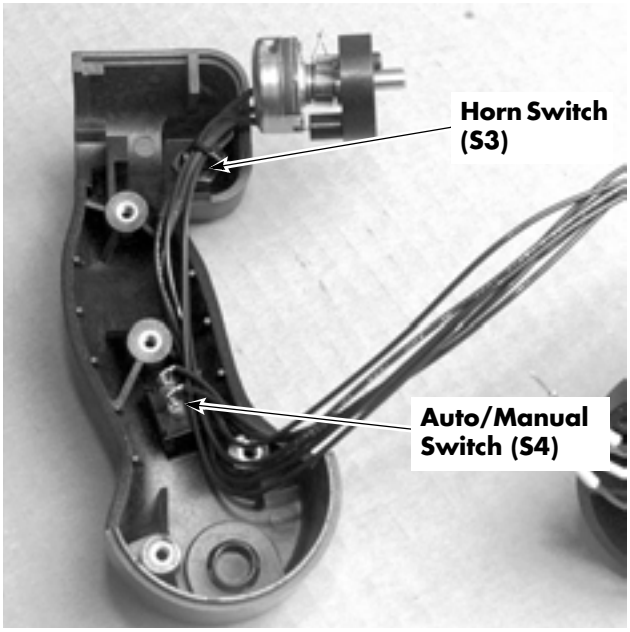
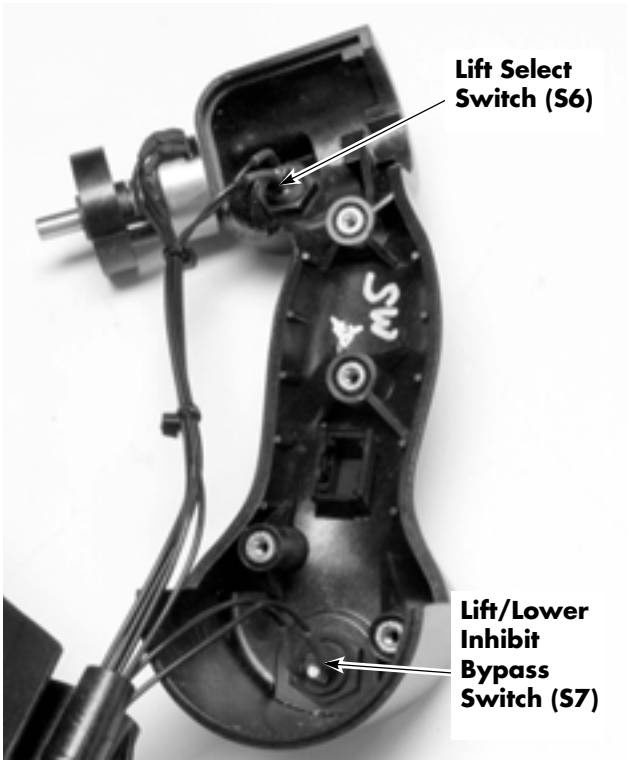


Figure 7-33. Left Control Handle Switches (S6/S7)



Removal

1. Remove the control handle and gear case from the control arm.
2. Separate the control handle halves. See "Disassembly" on page 7-22.
3. If replacing horn switch or lift select switch, remove two screws securing the knob positioner for the VR2/VR3 pot. Remove the pot assembly to gain access to the switch behind it.
4. Remove the switch from the handle shell. See Figure 7-32 or Figure 7-33. Remove heat shrink tubing and unsolder wires from switch, noting their position. See "Soldering Procedures" on page 7-42.

Installation

1. Slip heat shrink tubing over the wires, solder wires to the switch, and shrink the tubing over the connections. See "Soldering Procedures" on page 7-42.
2. Reinstall the switch in the handle.
3. If neither horn (S3) nor lift select switch (S6) was replaced, skip to step 7.
4. Reinstall the VR2/VR3 potentiometer assembly in the handle.
5. Apply thread-locking compound (P/N 990-403) to one knob positioner screw. Secure the pot and knob positioner in the handle shell with one screw.
6. Adjust the potentiometer. See "Adjustment" on page 7-26.
7. Bundle wires and route them in the handle shell, making sure they are not pinched by the handle shell.
8. Reassemble the control handle halves. See "Reassembly" on page 7-22.
9. Install the control handle and gear case in the control arm.

Cold Storage Heater Replacement

1. Remove the control handle and gear case from the control arm.
2. Open the gear case.
3. Remove the heat shields.
4. The heater has two wires. Remove one wire from the thermostat; it could be soldered or attached by a terminal. Remove the

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other wire by extracting the pin from connector PW7 (right) or PW8 (left), using P/N 950-003 pin extractor or equivalent.

5. Attach one of the replacement heater wires to the thermostat; it can be soldered or attached by a terminal.
6. Feed the other wire through the opening in the ground plate. Attach a new pin terminal and insert into connector PW7 (right) or PW8 (left).
7. Reattach the ground plate.
8. Reinstall the heat shields as they were before removal.
9. Seal the opening around the ground plate with cold storage silicone sealant.
10. Install the control handle and gear case in the control arm.

Cold Storage Thermostat Replacement

1. Remove the control handle and gear case from the control arm.
2. Open the gear case.
3. Remove the control handle shaft and gear. See “Removal” on page 7-23.
4. Disconnect the terminal from the heater wire.
5. Remove the nuts securing the thermostat.
6. Secure the new thermostat in place with mounting nuts.
7. Reconnect the terminal from the heater wire.
8. Reattach the control handle shaft and gear. See “Installation” on page 7-23.
9. Reassemble the gear case.
10. Install the control handle and gear case in the control arm.

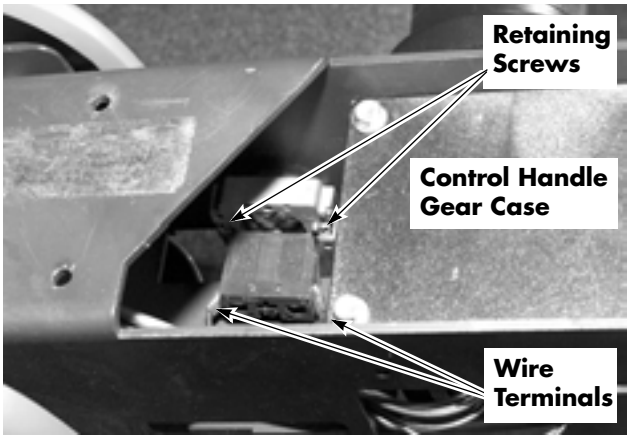
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EPO Switch

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove both top and bottom covers from the right control arm.
3. Remove the wires to EPO switch, labeling as necessary for later installation.
4. Loosen the retaining screws on the back of the switch body. (Insert screwdriver through access slot in control arm.)
5. Hold switch body firmly while twisting knob counterclockwise to disengage the knob from the body.
6. Remove both halves of the switch.

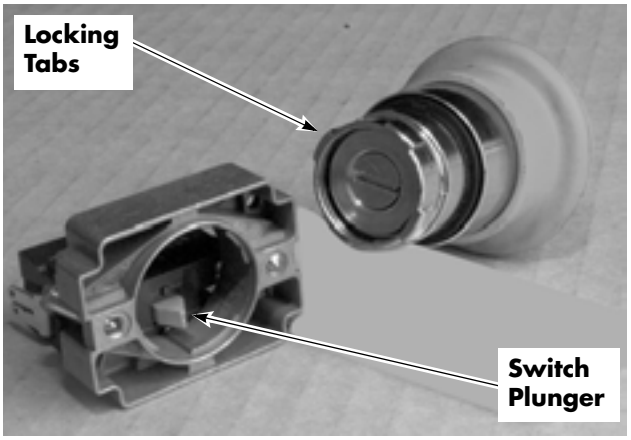
Figure 7-34. EPO Switch in Right Control Arm



Installation

1. Insert the knob through the mounting hole.
2. Mate the switch back to the knob shaft.
3. While holding the switch body firmly, press and twist the knob clockwise to engage the switch halves.
4. Tighten the retaining screws on the switch body.
5. Attach wires to the switch.
6. Reinstall the upper and lower control arm covers.
7. Reconnect the battery connector and turn the key switch ON.
8. Test operation of EPO switch. Switch should operate freely without binding. When switch is pushed IN, travel, lift, and auxiliary functions should be disabled.

Figure 7-35. EPO Switch Body and Knob



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RAYMOND

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Drive and Brake

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Drive Unit

Radial Ring Inspection

If a worn radial ring is suspected to be the cause of play in the drive unit, perform the following steps to determine if the rings should be replaced.

⚠ WARNING

Use extreme care when the lift truck is jacked up. Never block the lift truck between the operator platform and the floor; this presents a tipping hazard. 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. **See "Jacking Safety" on page 2-10.**

1. Jack the rear of the truck up until the drive tire clears 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, try to align it with a feature on the truck (such as a grease fitting). This helps 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), replace the radial rings.

Figure 7-36. Dial Indicator Placement



Axle Seal and Bearing

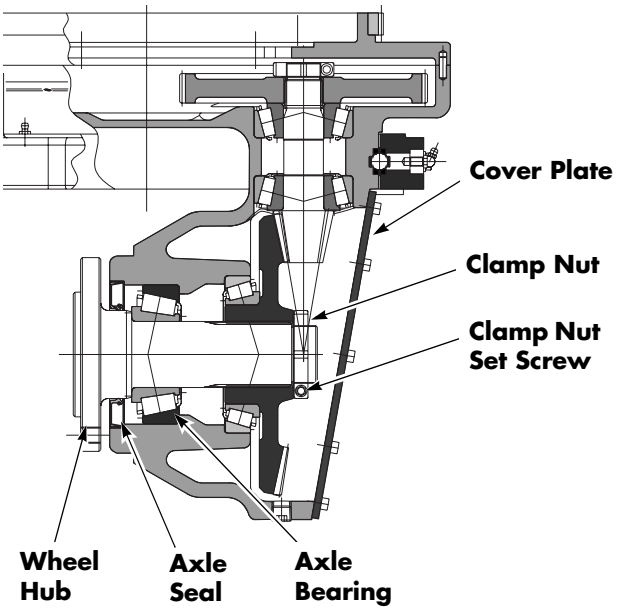
Removal

1. Remove the drive wheel.
2. Reconnect the battery connector and turn the key switch ON. Turn the steering tiller completely clockwise (to the right). The drive unit cover plate now faces the tractor bumper. Turn the key switch OFF and disconnect the battery connector.
3. Place a drain pan under the drive unit. Remove the drain plug and drain the drive unit. Drive unit capacity is 7.1 quarts (6.75 liters).
4. Apply gasket sealant (P/N 990-520) to the drain plug and reinstall drain plug.

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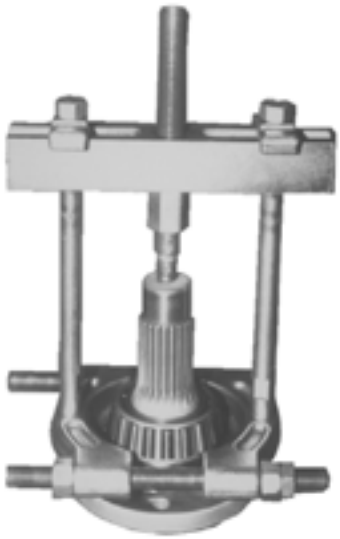
5. Remove the cover plate from the drive unit housing.

Figure 7-37. Drive Unit Axle Seal and Bearing



6. Remove the set screw in the clamp nut securing the axle to the bevel gear.
7. Remove the axle clamp nut.
8. Using a brass drift, drive the axle out of the bevel gear. (The bevel gear could come loose when the axle is removed.)
9. Use a bearing puller to remove the bearing cone from the axle. Inspect the bearing for wear, pitting, or damage. Replace if necessary.

Figure 7-38. Axle Bearing removal with puller



10. Remove the old axle seal. Inspect the axle for nicks, burrs, damage, and wear. Replace if necessary.
11. If you are replacing the axle bearing, drive the bearing cup out of the drive unit housing, working from the cover plate side of the drive unit.

Installation

1. If you are replacing the axle bearing, place the new bearing cup in the housing.
2. Lubricate the lip of the new axle seal and place seal onto axle.
3. Place the bearing cone onto the axle.
4. Using a bearing press, press the bearing onto the axle. See Figure 7-39 and Figure 7-40.

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Figure 7-39. Pressing Axle Bearing

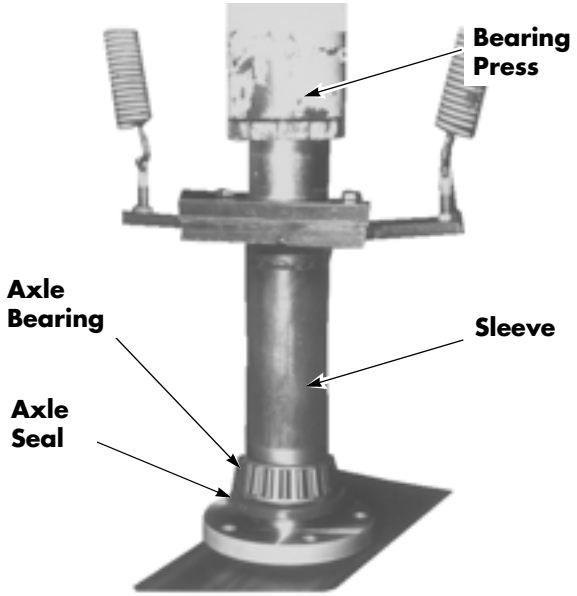
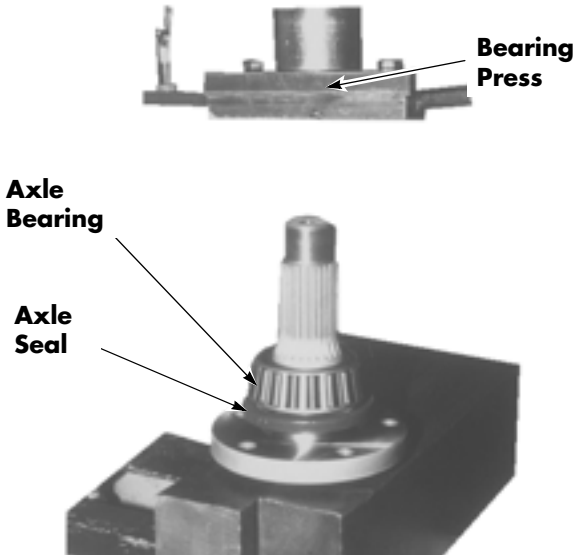
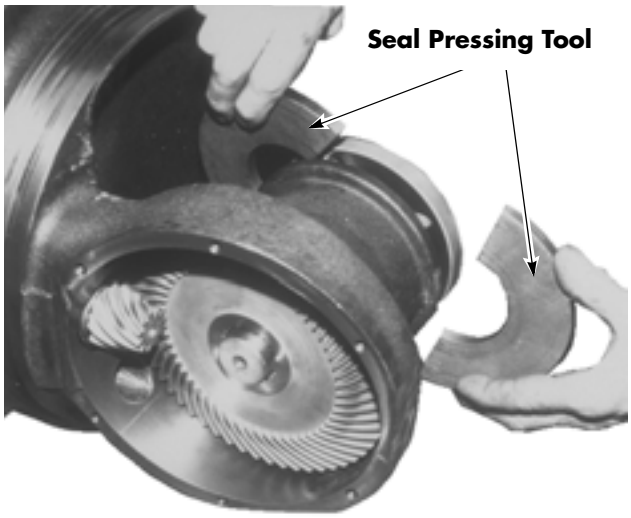


Figure 7-40. Pressing Axle Bearing, Complete



5. Insert the axle shaft into the drive unit housing, lining up the spline between axle shaft and bevel gear. Make sure the bevel gear and pinion gear are correctly mated.
6. Insert a seal pressing tool between the seal and the wheel flange of the axle. See Figure 7-41.

Figure 7-41. Axle Seal Pressing Tool



7. Using a brass hammer, drive the axle seal into the housing. The seal must be flush with the housing.
8. Push the axle out of the housing just enough to remove the seal pressing tool.
9. Push the axle back in until bearing cone and cup make contact.
10. Apply thread-locking compound (P/N 990-544) to the axle clamp nut. Install clamp nut and tighten to 18 ft. lb. (24 Nm) while rotating the wheel flange to seat the bearings.
11. Loosen the axle nut until hand tight.
12. Retighten the axle clamp nut to 40 in. lb. (4.5 Nm) in steps, rotating the axle a full turn between steps, until 40 in. lb. (4.5 Nm) torque no longer turns the nut. This could require as many as six turns. You should feel no end play in the axle.
13. Make sure the clamp nut set screw is marked grade 12.9 in the face of the screw head. Apply thread-locking compound (P/N 990-536) to the threads of the clamp nut set screw. Install the set screw and torque to 140 in. lb. (15.8 Nm).

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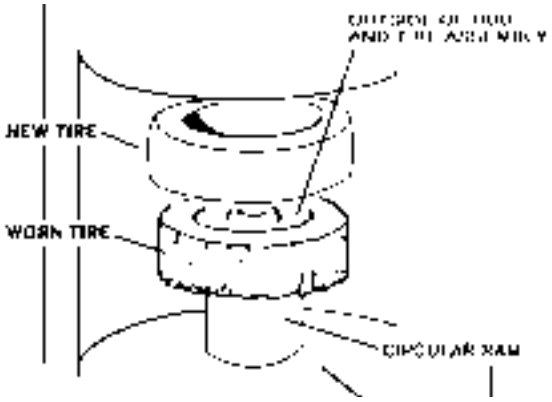
Drive Tire Pressing

⚠CAUTION

Misalignment of the tire and hub while the tire is being pressed onto the hub can cause damage to the hub. For this reason, chamfers have been provided on the outside edge of the hub and on the end of the inside diameter of the tire's metal insert. The chamfers help to center the hub and tire during the pressing operation and reduce the possibility of misalignment. To prevent damage, install the hub on the circular ram with its chamfered side up.

1. Check the inside surface of the metal insert on the new tire. Remove any scaling or rust with sandpaper. Clean the inside of the metal insert and lubricate it with a soap solution.
2. Place a circular ram on the press table. See Figure 7-42. The length of the ram must be longer than the width of the old tire to permit complete removal of the old tire. The outside diameter of the ram must be small enough to fit loosely in the insert of the tire but must be large enough to rest squarely on the flat surface on the outer edge of the hub.

Figure 7-42. Drive Tire Installation with Press



3. If the outside edge of the hub is not flush with the edge of the metal insert in the old tire, measure how far the hub is recessed inside the tire. Place the new tire in the same position the old tire was installed on the hub. You can use a spacer (slightly smaller in diameter than the inside diameter of the tire insert and the same thickness as the depth of the recess) to obtain the correct amount of recession.
4. Position the hub assembly with the old tire on the top of the circular ram so the outside of the wheel is positioned upward. The outside edge of the hub has a chamfer to help guide the new tire onto the wheel. The chamfered edge must always be the leading edge when you press a tire onto the hub.
5. Center the hub assembly on top of the ram and make sure that they mate squarely.
6. Apply grease to the inside of the tire rim.
7. Position the new tire with its chamfered insert facing the hub. Align the new tire and the hub so that they are concentric.
8. Begin pressing the new tire onto the hub and the old tire off the wheel. Run the press slowly for the first few inches of travel, because this is the critical stage of the operation. If the tire begins to cock to one side, stop the press and realign the tire. A sharp jar with a soft-headed mallet will usually realign the tire on the hub.
9. If the new tire does not press on with a minimum of 5 tons (68,947 kPa) pressure, try pressing a different new tire. If the tire still does not press on, replace the hub and tire assembly.
10. Release the press. Remove the wheel, tire assembly, and the old tire from the press table. Wipe off any grease. Inspect the wheel and tire assembly.

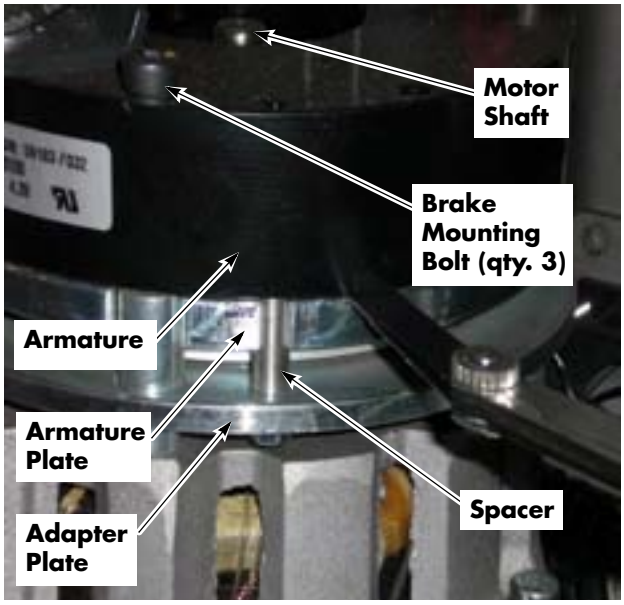
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Brake

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 7-43. If air gap exceeds 0.040 in. (1 mm), replace the brake pads. See "Pad Replacement".

Figure 7-43. 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. Raise tractor compartment top cover and remove rear cover.
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 7-43.
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 7-44.

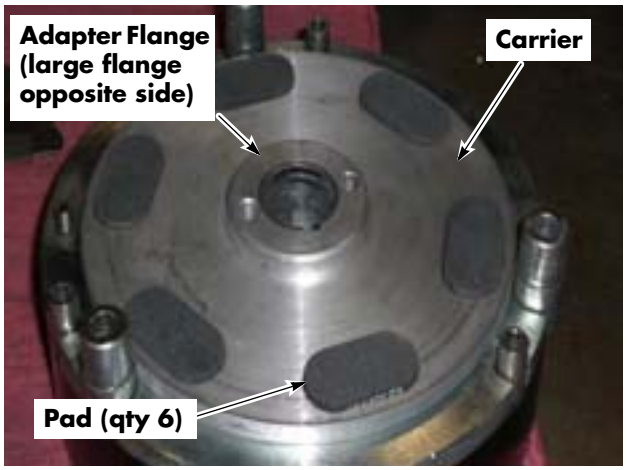
Figure 7-44. Adapter Plate Removal



3. Remove adapter plate. Inspect spacers and replace if damaged.
4. Remove old pads from carrier and install new pads. See Figure 7-45.

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Figure 7-45. 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 15 ft. lb. (20.3 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 120 ft. lb. (163 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/h).

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RAYMOND

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Electrical Components

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Battery Procedures

⚠CAUTION

Before working on the battery, review "Battery Safety" on page 2-5. Batteries for this lift truck weigh between 2900 and 3700 lb. (1317 to 1680 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

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.

NOTE: Some degreasers and parts cleaners 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.

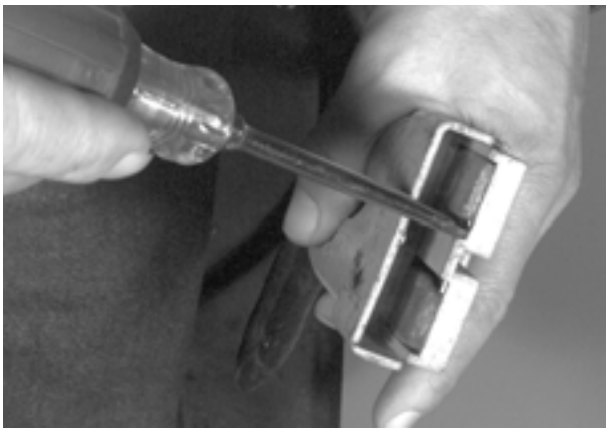
NOTE: When replacing battery cable ends, remove only one end at a time from the connector, to avoid the cable ends touching and causing a short circuit. DO NOT allow the metal cable end to touch the battery. Use insulated tools and avoid contact with battery case or cable ends.

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 7-46 and Figure 7-47.

Figure 7-46. Battery Cable and Connector



Figure 7-47. Battery Cable Removal from Connector



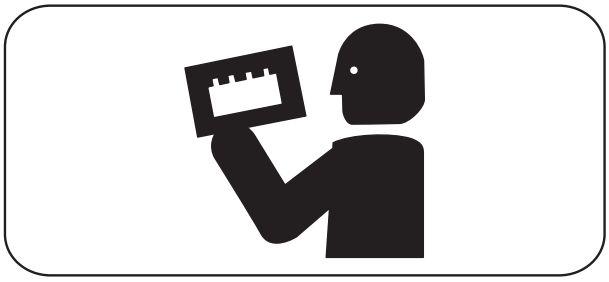
2. Do not attempt to repair battery cables by crimping new terminals. Replace the cable.

Battery Exterior Cleaning

1. Read, understand, and follow procedures, recommendations and specifications in the

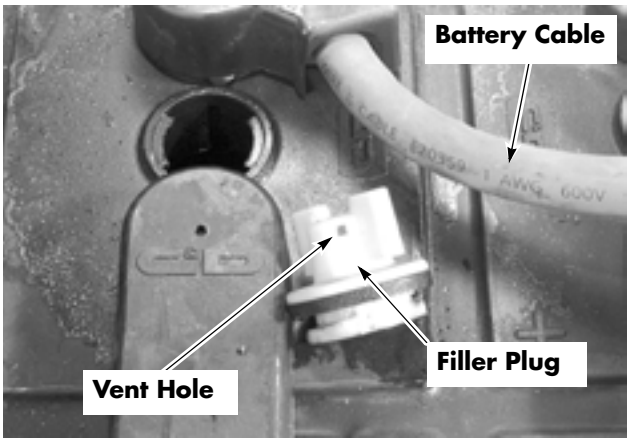
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battery and battery charger manufacturer's manuals.



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 7-48. 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.

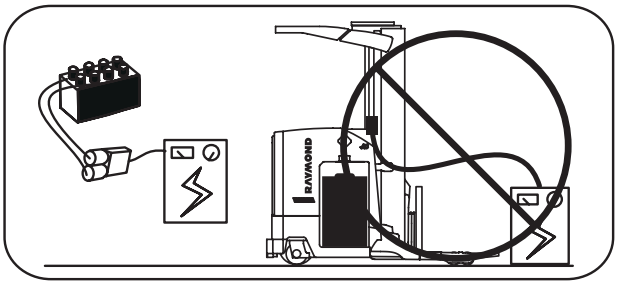
NOTE: DO NOT clean the top of the battery with the soda solution while it is installed in the lift truck. Water can seep into the electrical components and cause serious damage.

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.

NOTE: *Never* plug the battery charger into the lift truck. This severely damages 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 and 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 2-8.

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 cable ties 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:

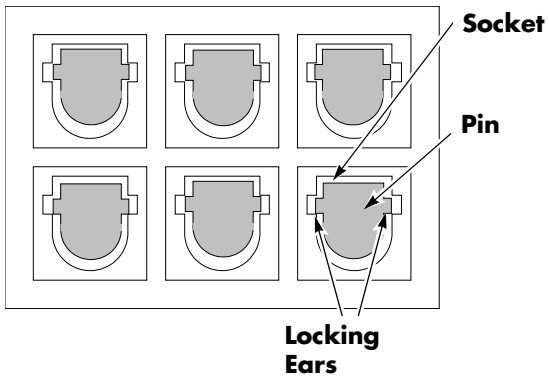
- Make sure the soldering tip is clean. A dirty tip does not transfer heat well and encourages long dwell time and greater pressure. Apply light pressure on the terminal.
- Flux: rosin base
- Solder: 60/40 rosin core or equivalent
- Solder Iron: 15-25 watt "pencil-type" maximum
- Tip Size: 3 mm (0.118 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 5-4 on page 5-11. 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 7-49.

Figure 7-49. Molex Connector, end view



Pin Extraction

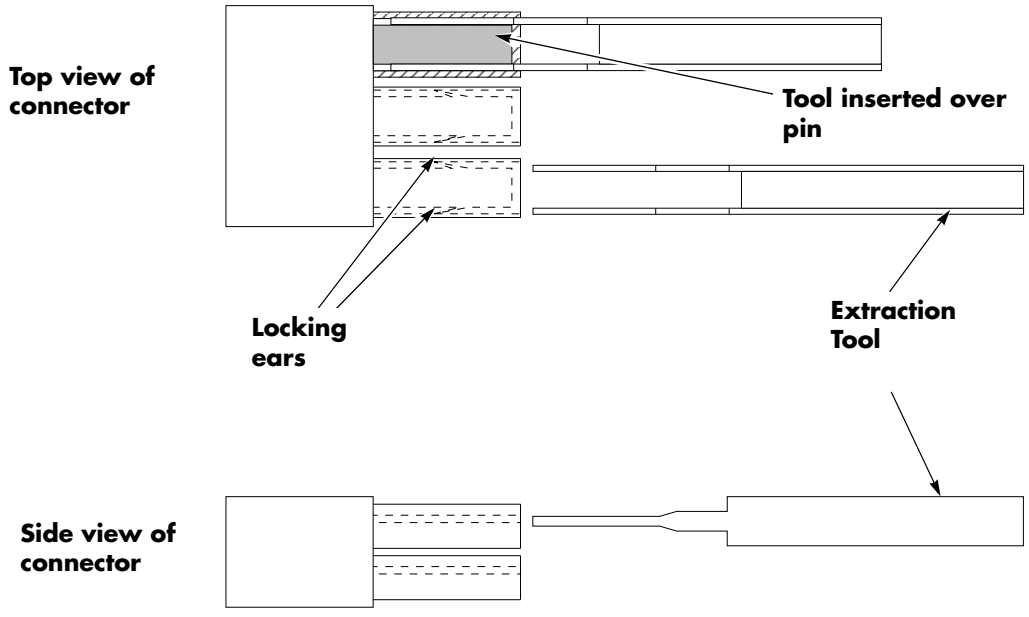
To remove a pin from a Molex connector, use pin extraction tool P/N 950-026.

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 7-50.

Figure 7-50. Pin Extraction

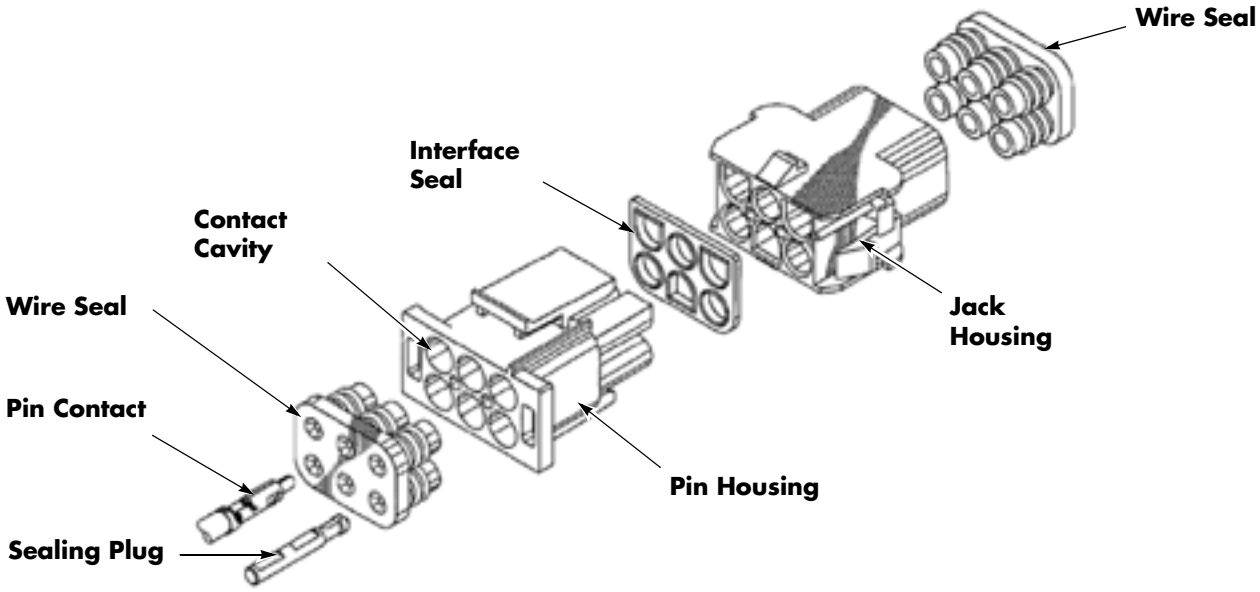


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AMP Water-Resistant Connectors

AMP connectors provide water-resistant connection by the use of seals between wires and connectors and between the mating connector halves. See Figure 7-51.

Figure 7-51. AMP Water-Resistant Connector



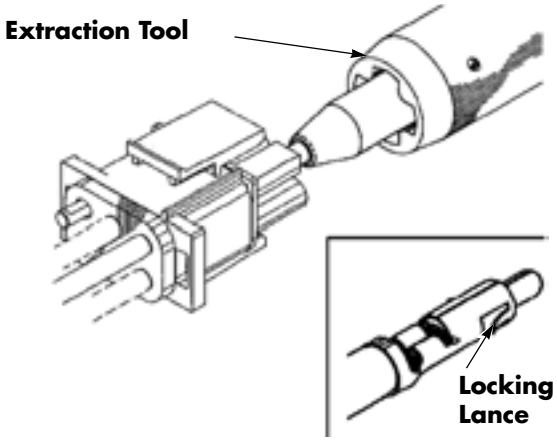
To maintain the integrity of water-resistant seals, use the following procedures when working with AMP connectors.

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 7-52.

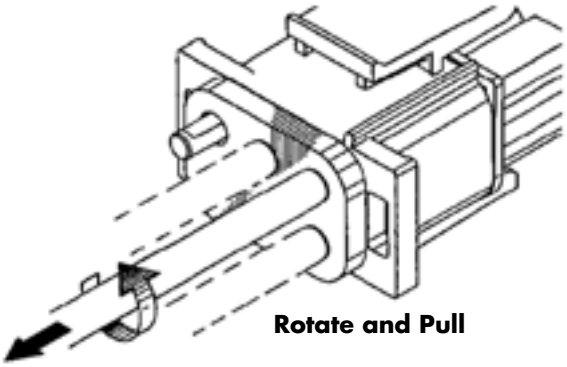
Figure 7-52. AMP Pin Extraction



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 7-53.

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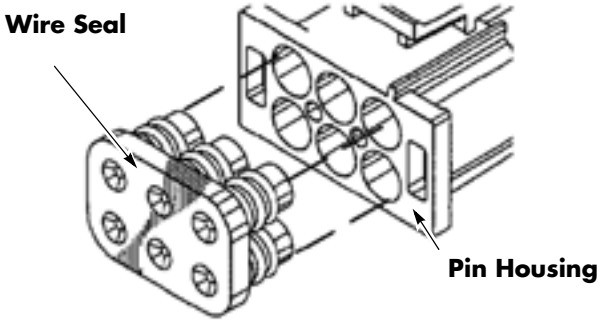
Figure 7-53. Removing Wire



Pin Insertion

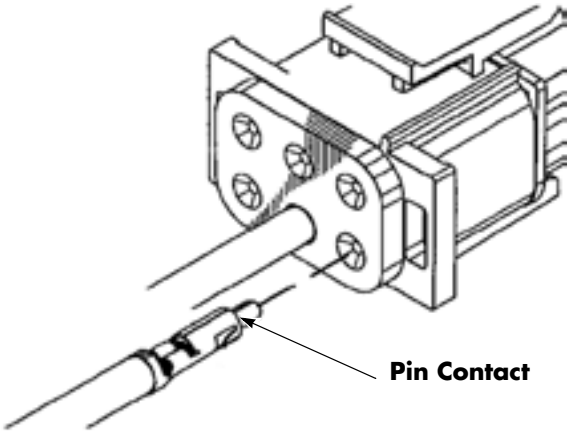
1. Make sure the connector has a wire seal attached to the connector back. See Figure 7-54.

Figure 7-54. 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 7-55.

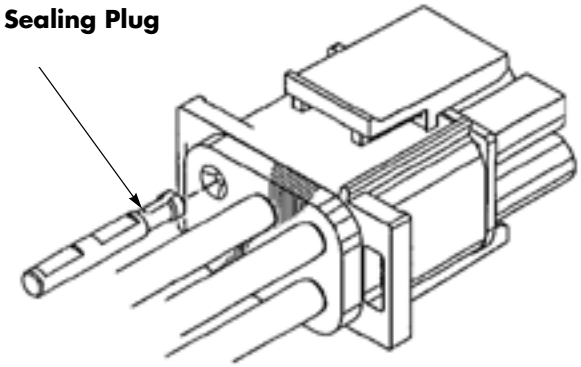
Figure 7-55. Wire Insertion



Seals

1. Use a wire seal at the back (wire end) of each connector half. See Figure 7-54.
2. Plug unused pin positions with sealing plugs. See Figure 7-56.

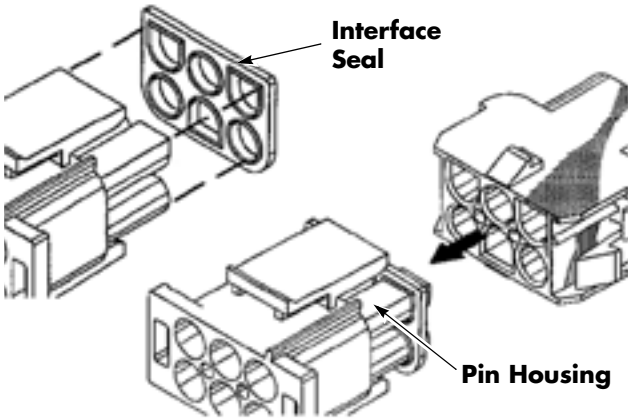
Figure 7-56. Sealing Plug



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 7-57.

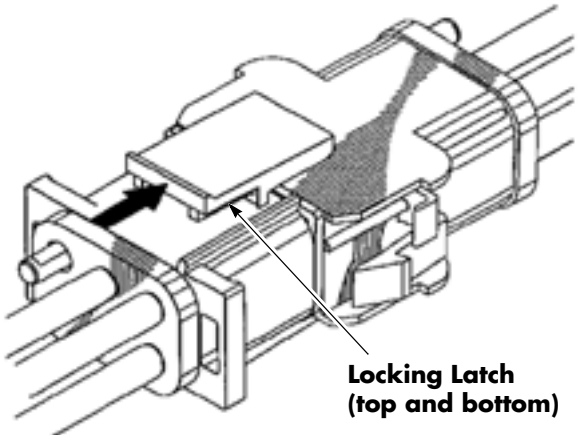
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Figure 7-57. Interface Seal



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 7-58.

Figure 7-58. Latching AMP Connector

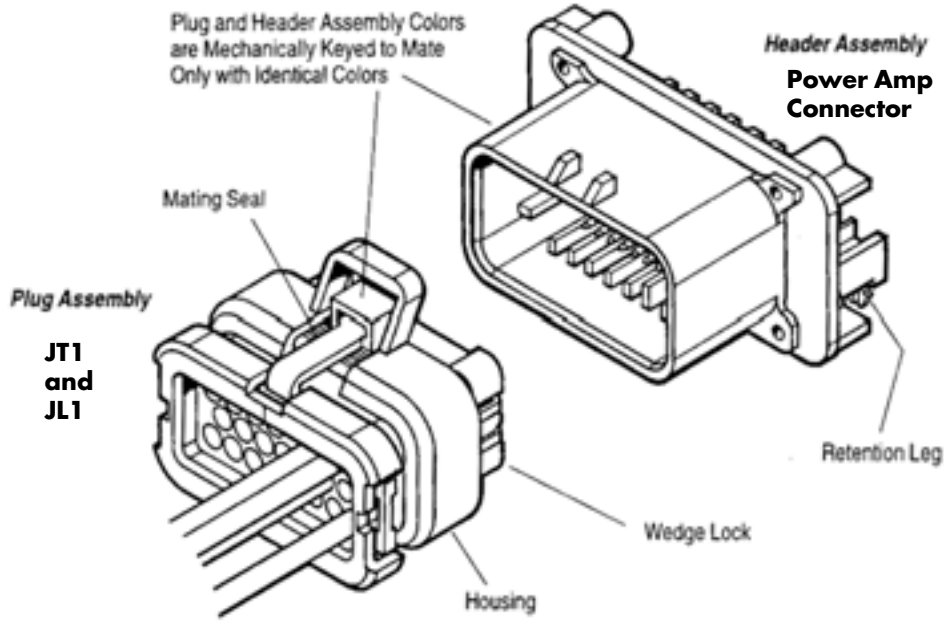


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AMP Harness/Power Amp Connector

Connector Components

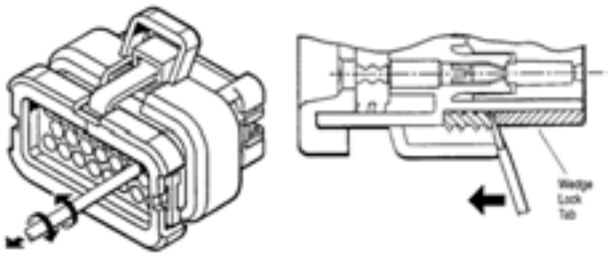
Figure 7-59. Power Amp Connector Components



Disassembly (Contact Removal)

1. Insert a 4.8 mm screwdriver blade between the mating seal and one of the red wedge lock tabs. See Figure 7-60.
2. Pry open the wedge lock to the open position.
3. While rotating the wire back and forth over a half turn (1/4 turn in each direction), gently pull the wire until the contact is removed.

Figure 7-60. AMP Connector (JT1 or JL1)



Contact Insertion

The axial concentricity of the crimped contact shall fall into an area defined by a 2 mm diameter cylinder whose center is the centerline of the contact front end. See Figure 7-61.

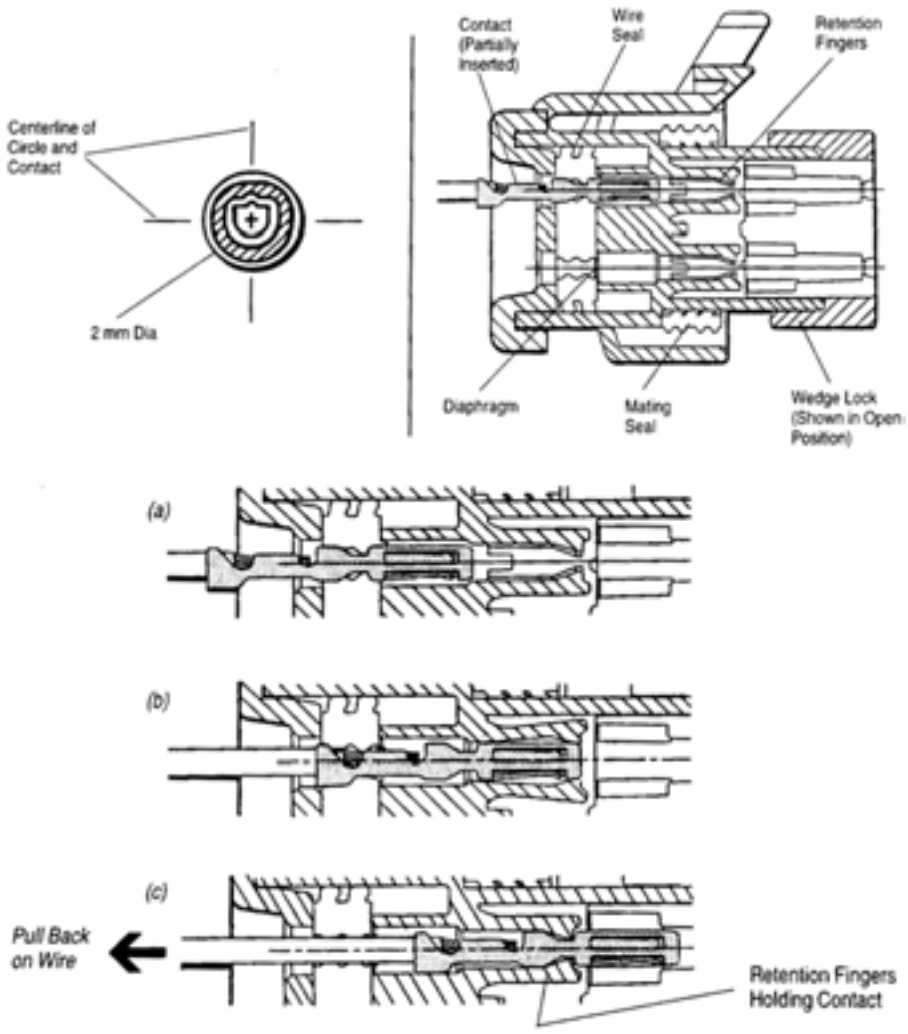
Assembly

Make sure the wedge lock is open.

1. To insert a contact, push it straight into the appropriate circuit cavity as far as it will go. See Figure 7-61 (a) and (b).
2. Pull back on the contact wire with a force of 1 or 2 lb. to make sure the retention fingers are holding the contact. See Figure 7-61 (c).

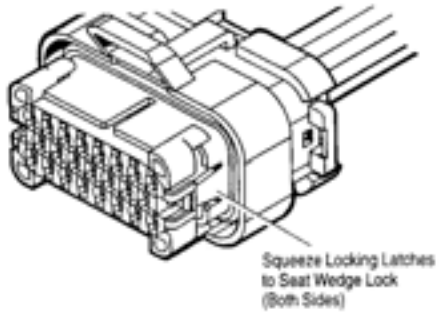
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Figure 7-61. Contact Insertion



3. After all contacts are inserted, close the wedge lock to its locked position. Release the locking latches by squeezing them inward. See Figure 7-62.

Figure 7-62. Wedge Lock Latches



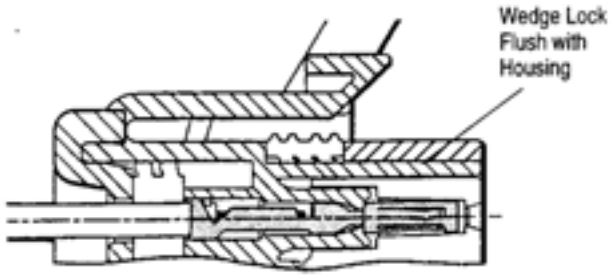
⚠CAUTION

Be very careful when putting the wedge lock in the locked position. Forcing the wedge lock can cause damage to the connector. Make sure the wedge lock is aligned correctly. If resistance is felt, slightly adjust the wedge lock until it slides in freely.

4. Slide the wedge lock into the housing until it is flush with the housing. See Figure 7-63.

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Figure 7-63. Wedge Lock Flush With Housing



Testing

Do not pierce wire insulation with a sharp point while troubleshooting.

The wedge lock has slotted openings in the forward (mating) end. These slots accommodate circuit test tabs that are approx. 3.3 by 0.6 mm, that prevent damage to the receptacle. For circuit testing in the field, use a flat probe such as a pocket knife blade. Do not use a probe with a sharp point.

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Power Cables

Check power cables for:

- evidence of overheating
- burned spots in the cable
- nicks in the insulation
- damaged or overheated terminal lugs
- damaged mounting hardware or brackets

Replace damaged cables or mounting hardware as necessary.

Power cables are marked on the terminal lug with the location where they belong. If the marking is missing or is not readable, remark the cable with the correct information.

NOTE: Terminal lugs may be replaced in the field using the appropriate crimping tools. Crimping tool, lugs, and heat-shrink are available through the Parts Distribution Center. Failure to use correct cables, terminal hardware, and torque values can result in overheating and damage to components.

Power Cable Repair

Traditional lug crimping techniques for power cables on DC motors may not meet the higher current requirements of AC motors. Use Manual Crimp Tool (P/N 1069861) when crimping power cables for all AC motors. This tool may also be used to repair power cables for DC motors.

1. Remove the bad cable(s).
2. Using the removed cable(s) for reference, cut an appropriate amount of replacement cable of the same gauge.
3. Set the adjustment screw on the manual crimp tool head to match the cable gauge.
4. Strip the cable jacket to fit the terminal to be crimped. Refer to Table 7-3 and Table 7-4.

Table 7-3. Cable Jacket Strip Length - Short Barrels

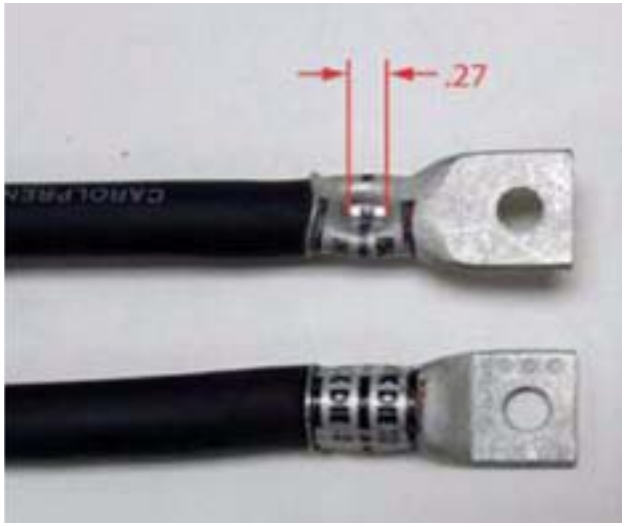
AWG	Lug P/N	Strip Length
1/0	1002215/001-004	11/16 in. (17 mm)
2/0	1002215/005-008	13/16 in. (21 mm)
3/0	1002215/009-012	1 in. (25 mm)
4/0	1002215/013-015	1-1/16 in. (27 mm)

Table 7-4. Cable Jacket Strip Length - Long Barrels

AWG	Lug P/N	Strip Length
1/0	1002217/001-003	1-9/16 in. (40 mm)
2/0	1002217/004-006	
3/0	1002217/007-009	
4/0	1002217/010-011	1-11/16 in. (43 mm)

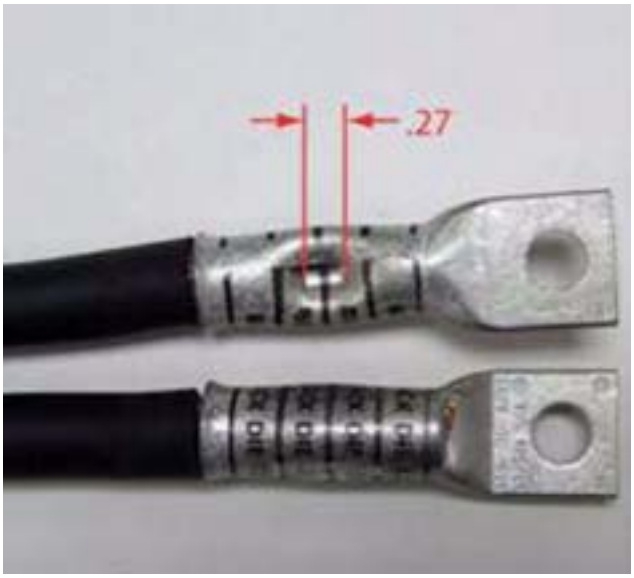
5. Insert cable into terminal.
6. Place cable and terminal into tool die and crimp. Refer to pictures below for what completed crimps should look like.

Figure 7-64. Short Barrel Terminal



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Figure 7-65. Long Barrel Terminals



7. Apply heat-shrink tubing (P/N 611-035) to the terminal after crimping.
   a. For short barrels, use 1.75 in. (45 mm) of tubing. Apply 1 in. (25 mm) over the jacket extending 0.75 in. (19 mm) over the barrel.
   b. For long barrels, use 2.5 in. (64 mm) of tubing. Apply 1 in. (25 mm) over the jacket extending 1.5 in. (38 mm) over the barrel.

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Motors

General

Power Cable Terminals

Table 7-5. Power Cable Terminal Torques

Location/Stud Size/Type	Torque
Traction Motor	*Top Nut:* 204 to 221 in. lb. (23 to 25 Nm) *Bottom Nut:* 128 to 133 in. lb. (14.5 to 15 Nm)
Lift Motor	
Load Handler Motor	*Top Nut:* 100 to 120 in. lb. (11.2 to 13.6 Nm) *Bottom Nut:* 140 to 160 in. lb. (15.8 to 18.1 Nm)
Steer Motor	17 in. lb. (1.9 Nm)
Power Amplifiers	95 to 104 in. lb. (10.7 to 11.8 Nm)
Contactor - M6 steel	50 in. lb. (5.6 Nm)
Contactor - M8 steel	180 in. lb. (20.3 Nm)
Contactor - M8 brass/copper	70 in. lb. (7.8 Nm)

DC Motor Troubleshooting

See “DC Motors” on page 5-5.

AC Motor Troubleshooting

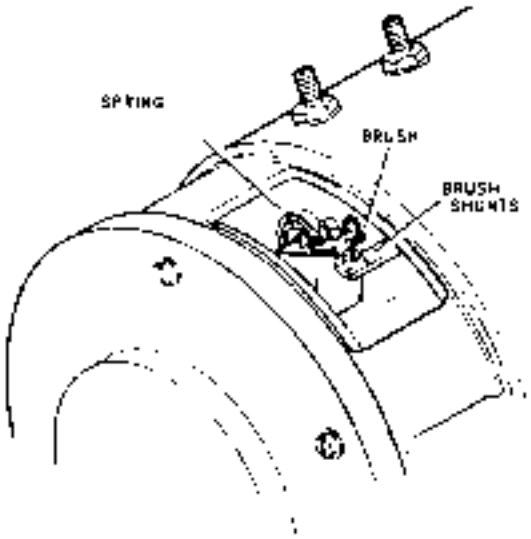
See “AC Motors” on page 5-9.

DC Motor Service

Motor Brushes

Inspection

Figure 7-66. Motor Brush Location



Conduct a partial inspection of the motor during scheduled maintenance. If the truck is operated in a severe or caustic environment or is used in an extended duty cycle application, inspect the motor more frequently.

Set up and rigidly adhere to a strict inspection schedule to obtain the maximum efficiency from the electrical equipment.

Each partial inspection of the motor must include:

1. Inspect the brushes for wear and for correct contact with the commutator. Record the level of wear on the brushes. This history provides an indication of whether a brush must be changed or if it can wait until the next inspection. Refer to Table 7-6 on page 7-54 for acceptable brush length.

NOTE: Overloading a unit is ultimately reflected in the motor and brush wear; therefore, you must take this into account when considering brush replacement.

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2. Check brush spring tension. Refer to "Motor Brush Spring Tension".
3. Clean brushes and holders. Wipe the commutator with a dry, lint-free cloth. Do not use lubricants of any kind on or around the commutator.
4. Check brush holders for a solid connection to the mounting support. Tighten the mounting screws as necessary.
5. Check the cap screws that hold the brush cross-connectors to the brush holder body.
6. Make sure the motor terminals are secured tightly to the motor frame. Use care not to strip the threads or crush the insulating parts. See "Power Cable Terminals" on page 7-52.
7. Check all the cap screws around the frame for tightness.
8. Keep the outside frame of the motor clean and free from dirt. Maintain a free air passage around the motor to permit heat radiation.

Replacement

NOTE: If one brush needs replacement, always replace the entire set of brushes.

Use only genuine *Raymond* brushes. Using another type of brush could cause damage to the commutator or cause excessive brush wear and will void your warranty.

If the end of the brush is not already contoured to fit the commutator, seat the brush to the commutator:

NOTE: If the motor commutator is not accessible, form the brush contour using a brush seating stone.

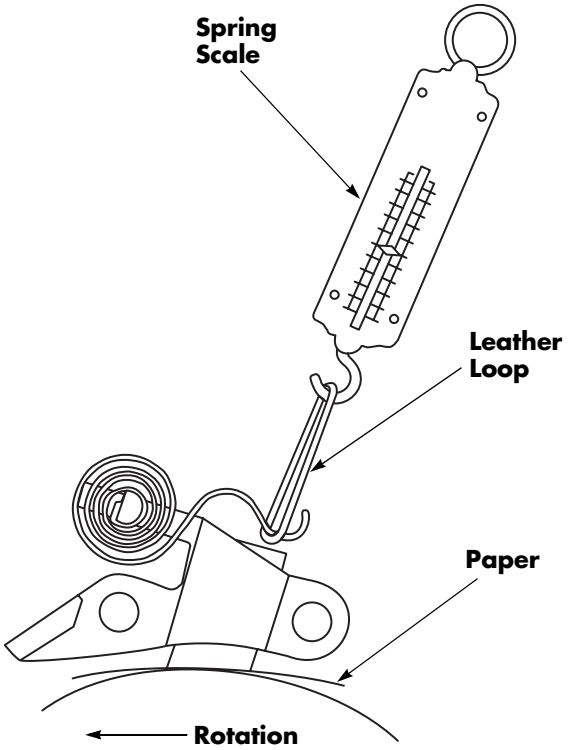
1. Move the motor brush springs out of your way.
2. Wrap a piece of 00 sandpaper around the commutator. *Do not* use emery cloth to seat brushes.
3. Move the brushes back down into their holders. Rotate the armature until the face of the brushes are contoured to match the curve of the commutator.
4. Remove the sandpaper.
5. Blow any dust out of the motor with clean, compressed air at a maximum of 30 psi (207 kPa).

Motor Brush Spring Tension

Inspection

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the operator compartment covers.
3. Slide the brush up slightly in its holder.
4. Insert a paper strip between the brush face and the commutator. See Figure 7-67.

Figure 7-67. Motor Brush Spring Tension Inspection



5. Place a small leather loop around the coil spring for the brush. If the brush spring has a loop at the brush, hook the spring scale directly to the spring.
6. Attach a 5 lb. (2.27 kilogram) spring scale to the leather loop.

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7. While gently pulling the scale outward, slowly pull the paper strip in the direction that the commutator normally rotates.
8. When the paper strip begins to move freely, the spring scale will read the spring brush tension.
9. Refer to Table 7-6 for correct spring tension.

Table 7-6. Minimum Brush Length and Spring Tension

Motor	Min. Brush Length	Spring Tension
Load Handler	0.62 in. (15.7 mm)	40 to 65 oz. (1134 to 1842 grams)
Steer	0.50 in. (13 mm)	32 to 40 oz. (907 to 1134 grams)

10. Repeat steps 3 thru 9 for the remaining brushes.

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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 new temperature sensor with high temperature silicone P/N 1062808/95. 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.

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Guidance Manager Firmware Replacement

Use circuit chip extraction tool P/N 950-032. See Figure 7-68.

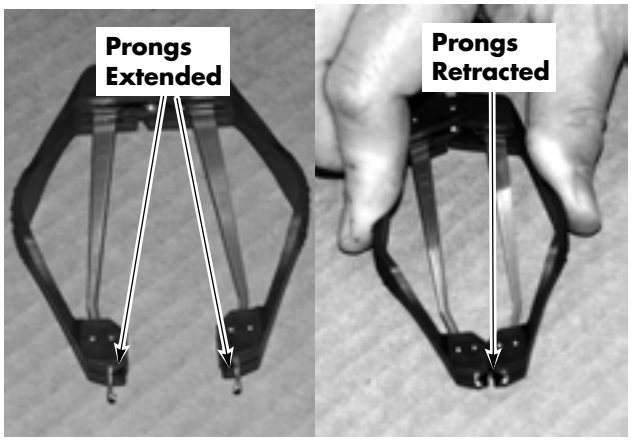
⚠CAUTION

Failure to use an approved circuit chip removal tool can result in damage to the chip or socket.

⚠CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-8.

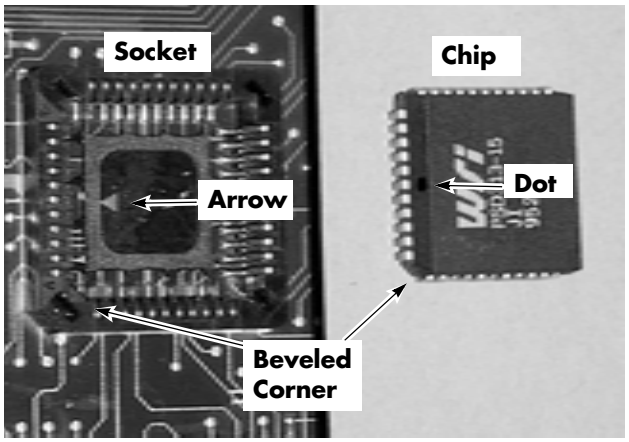
Figure 7-68. Chip Extraction Tool P/N 950-032



Removal

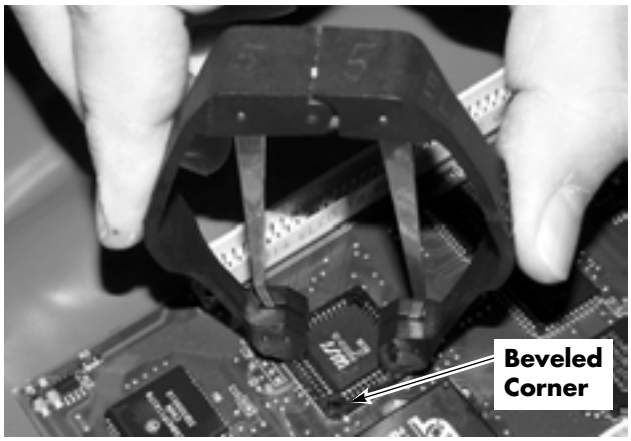
1. Turn the key switch OFF and disconnect the battery connector.
2. Look at the circuit chip's socket on the circuit board. Of the four slots in the corners of the socket, two diagonally opposite slots open into the chip cavity. These holes receive the prongs of the removal tool.

Figure 7-69. Firmware Socket and Chip



3. Insert the prongs of the extraction tool into the holes identified in the previous step. Hold the tool perpendicular (straight up) to the socket. See Figure 7-70.

Figure 7-70. Firmware Chip Removal



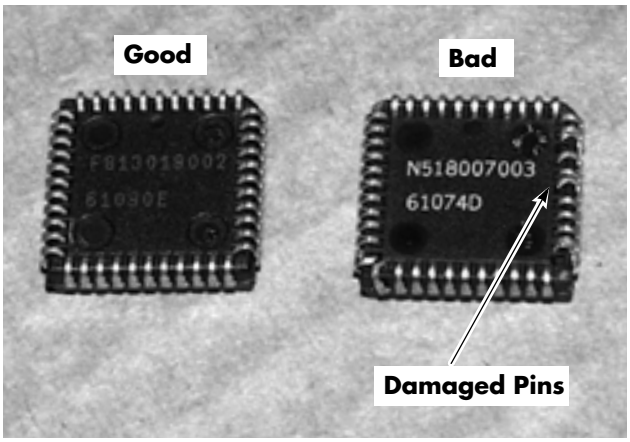
4. Gently but firmly squeeze the jaws of the tool together. The prongs retract, lifting and loosening the chip from its socket. *Do not rock or pull on the chip to release it.*

Chip Installation

1. Inspect the chip to make sure there are no bent, broken, or missing pins or other sign of physical damage. See Figure 7-71.

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Figure 7-71. Firmware Chip Inspection



2. Notice the beveled corner and the arrow in the chip socket. Notice the beveled corner and the dot on the beveled edge of the chip. See Figure 7-69 on page 7-56.
3. Orient the chip so the dot on the chip matches the arrow on the socket and the beveled corner of the chip matches the beveled corner of the socket.
4. With your thumb, gently press the chip into the socket. Make sure it is completely seated on all four edges. See Figure 7-72 and Figure 7-73.

Figure 7-72. Firmware Chip Incorrectly Seated in Socket

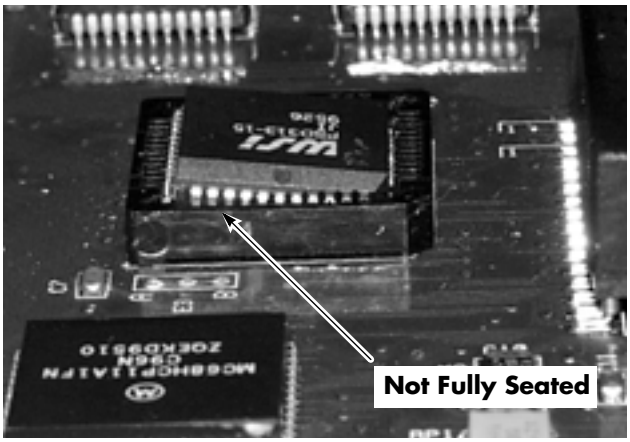
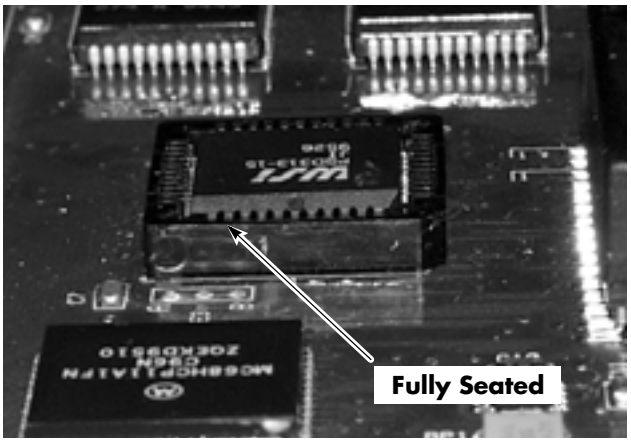


Figure 7-73. Firmware Chip Fully Seated in Socket



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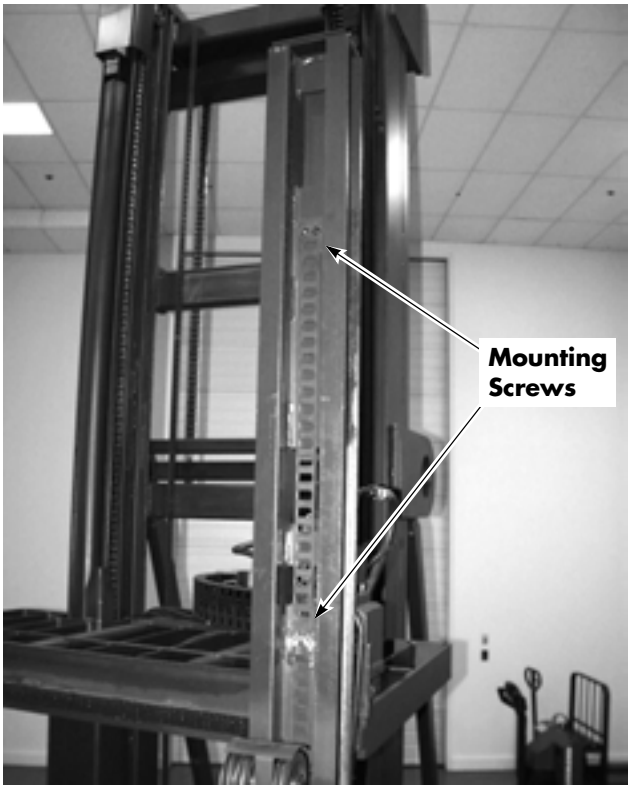
Mini-Mast Height Proximity Sensor

Procedures for removing and installing the mini-mast height sensor depend on the height of the mini-mast. If you have the 118 in. (300 cm) mini-mast, the sensor is accessible by removing a section of the height sensing rail. If you have the 84 in. (213 cm) mini-mast, you must partially disassemble the load handler and remove it from the mast. Both procedures are described below.

Removal [118 in./300 cm mini-mast]

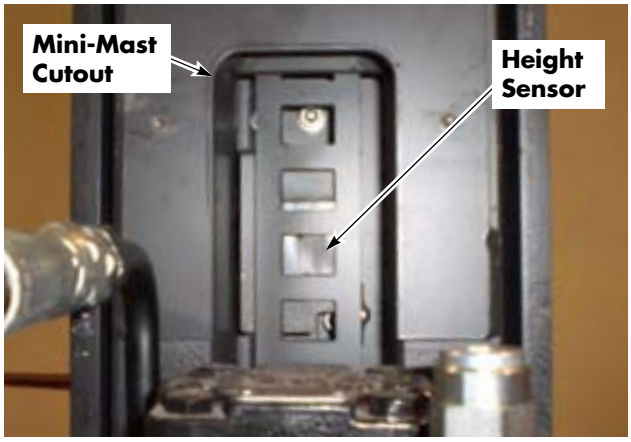
1. Remove the load handler turret cover and traverse motor cover.
2. Turn the key switch OFF and disconnect the battery connector.
3. Working from a ladder or work platform, remove the top-most section of the mini-mast height sensing rail. See Figure 7-74.

Figure 7-74. Mini-Mast Height Sensing Rail (118 in.)



4. Reconnect the battery connector and turn the key switch ON.
5. Elevate the load handler to position the mini-mast height sensor assembly within the cutout window in the mast, located in front of the traverse hydraulic motor. See Figure 7-75.

Figure 7-75. Mini-Mast Height Sensor (viewed from operator's side of mini-mast)



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6. Turn the key switch OFF and disconnect the battery connector.
7. Working from a ladder or work platform, remove the height sensor cable harness from the height manager card at connector JP2 under the turret. Remove cable ties on the cable harness, noting their location for reinstallation. Using the appropriate tool, remove the pins from the J2 connector. Attach a 6 ft. (2 m) length of 18 gauge wire to these pins and tape them together securely to aid in routing the new harness cable. Secure the other end of the wire to the turret.
8. Remove the three bolts holding the sensor bracket to the mini-mast. See Figure 7-79 on page 7-61 for a clear view of the location. Pull the wiring harness through the metal tubing until the attached wire appears. Remove wire and tape it to the replacement sensor assembly cable.
9. Remove the fender washer securing the sensor housing in the mounting bracket. Remove the sensor housing and wave spring. Remove the sensor from the housing. See Figure 7-80 on page 7-61 and Figure 7-81 on page 7-62.

Installation [118 in./300 cm mini-mast]

1. Check the height sensor assembly as noted in "Checking the Height Sensor Assembly" on page 7-62.
2. Working from a work platform or ladder, attach the new height sensor assembly to the load handler with three mounting bolts. Pull the wire and harness through the metal tubing. If the code sleeve on the cable interferes with insertion of the cable into the tubing, remove the code sleeve and remove all traces of adhesive with solvent.
3. Insert wires in the J2 connector. Connect the harness to the height manager card at connector JP2. Attach cable ties in their original locations on the hydraulic metal tubing and in the turret. Use care not to pinch the wires too tightly.
4. Reconnect the battery connector and turn the key switch ON.

⚠CAUTION

Use care to avoid damaging the sensor assembly when lowering load handler on mini-mast.

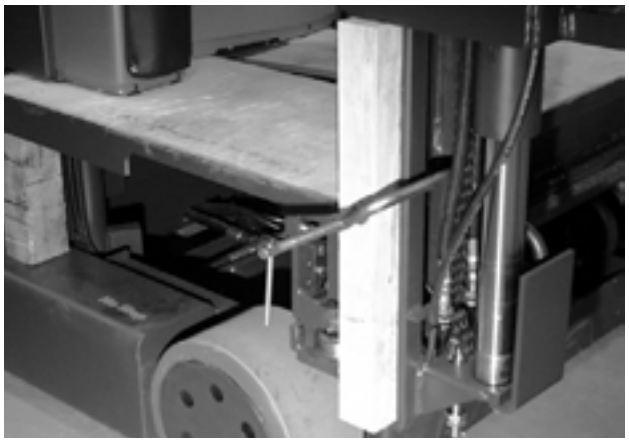
5. Insert a section of 1.5 in. (38 mm) wide strap steel at least 12 in. (30.5 cm) down the mini-mast to act as a "shoehorn" to guide the sensor past the cutout in the rail and the traverse position feedback pot. *Failure to guide the sensor results in damage to sensor and feedback pot!* Remove the strap steel when the sensor has engaged the rail.
6. Replace the top-most section of the height sensing rail previously removed.
7. Install the load handler turret cover and traverse motor cover.
8. Test the mini-mast lift and lower functions.

Removal [84 in./213 cm mini-mast]

1. Remove the load handler turret cover and traverse motor cover.
2. Retract the forks into their fully nested position. Rotate load handler so forks face straight ahead. Traverse the load handler completely to the left.
3. Turn the key switch OFF and disconnect the battery connector.
4. Remove the forks to keep the load handler balanced during this procedure.
5. Reconnect the battery connector and turn the key switch ON.
6. Elevate the load handler approx. 12 in. (300 mm). Block and clamp a wooden block in the mini-mast channel. See Figure 7-76.

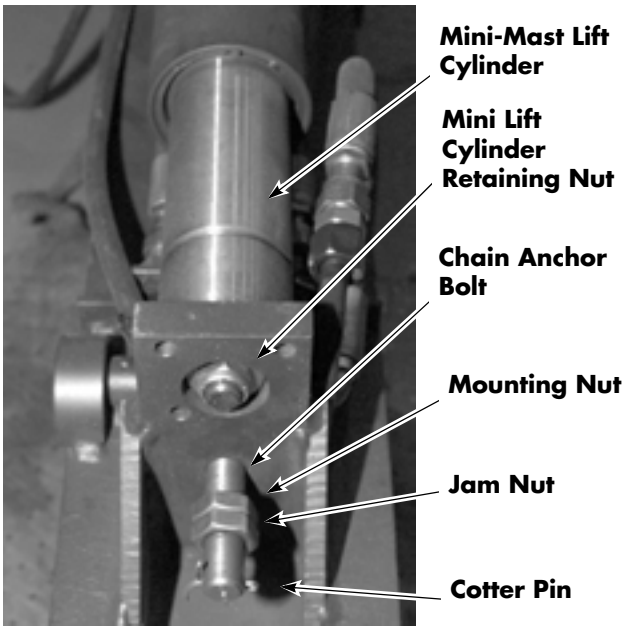
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Figure 7-76. Load Handler Blocked



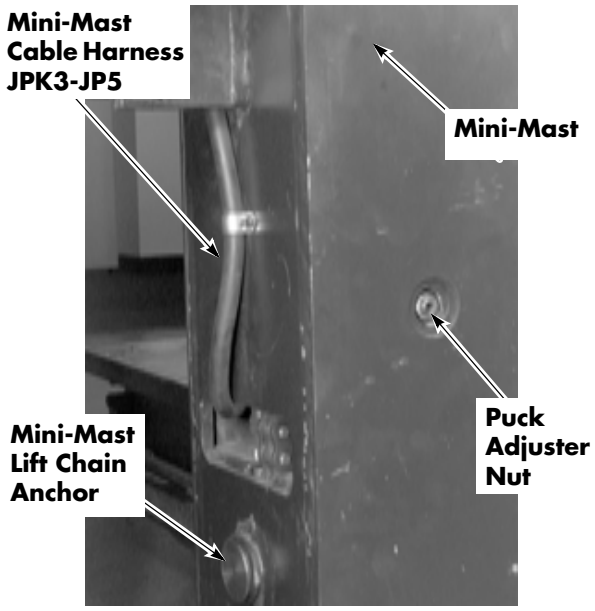
7. Lower the load handler onto the blocks. Let lift chain, hoses, and cable go slack.
8. Turn the key switch OFF and disconnect the battery connector.
9. Remove the power supply cable harness from connector JP5 under the turret. Remove cable ties on the cable harness, noting their location for reinstallation. Using the appropriate tool, remove the pins from the J5 connector. Attach a 6 ft. (2 m) length of 18 gauge wire to these pins and tape them together securely to aid in routing the new harness cable. Secure the other end of the wire to the turret.
10. Use cables ties to temporarily attach the over-the-mast electrical cable to one of the hydraulic hoses in the turret. This keeps tension on the electrical cable inside the load handler.
11. Remove the load handler pulley bracket cover. Remove the hoses and cable from the pulleys, laying them carefully to the side of the mini-mast.
12. Using a hoist or other suitable lifting device, support the load handler carriage with straps.
13. Remove the lift chain anchor at the bottom of the mini-mast by removing jam nut, hex nut, and cotter pin. Lift the chain over the pulley and lay it carefully over the actuator. To pass the chain anchor through the pulley, twist the lift cylinder 90° with a large screwdriver in the pulley eye. Then twist the cylinder back into its normal position. See Figure 7-77.

Figure 7-77. Mini-Mast Chain Anchor



14. Remove the pulley bracket assembly from the mini-mast cylinder by removing the mounting bolt in the end of the cylinder.
15. Loosen mini-mast puck adjuster lock nuts and back out the adjusting screws completely. See Figure 7-78.

Figure 7-78. Mini-Mast Puck Adjusters



16. Using the hoist, slowly and carefully lift the load handler up the mini-mast to within 12 in. (300 mm) of the top plate.

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Make sure cable, hoses, and chain do not bind or catch on the load handler.

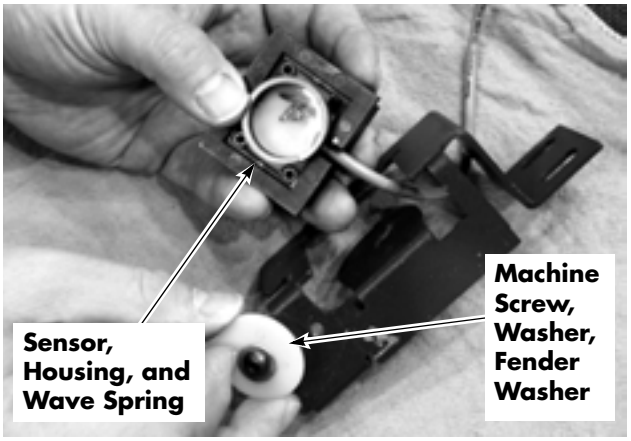
17. Working from a work platform or ladder, remove the stop plate on the top of the mini-mast. Cut the cable ties securing sensor to hydraulic tubing, noting their location for later installation.
18. Using the hoist, continue lifting the load handler past the cylinder until the sensor is visible above the mini-mast.
19. Working from a work platform or ladder, remove the three bolts holding the sensor bracket to the mini-mast. Pull the wiring harness through the metal tubing until the attached wire appears. Remove wire and tape it to the replacement sensor assembly cable.

Figure 7-79. Mini-Mast Height Sensor Location



20. Remove the fender washer securing the sensor housing in the mounting bracket. Remove the sensor housing and wave spring. Remove the sensor from the housing. See Figure 7-80 this page and Figure 7-81 on page 7-62.

Figure 7-80. Mini-Mast Height Sensor, Detached from Mast



NOTE: You should take advantage of the opportunity to inspect the mini-mast cylinder pucks. Replace as required. See "Mini-Mast Pucks" on page 7-113.

Inspect load handler bearings.

21. Clean the mini-mast cylinder. Apply a clean coating of grease where the pucks contact the cylinder.

Installation [84 in./213 cm mini-mast]

1. Check the height sensor assembly as noted in "Checking the Height Sensor Assembly" on page 7-62.
2. Working from a work platform or ladder, attach the new height sensor to the load handler. Pull the wire and harness through the metal tubing. Connect the sensor harness to the height manager card at connector JP2. Attach cable ties in their original locations on the tubing and in the turret.
3. Make sure the mini-mast cylinder puck adjuster lock nuts are loosened and the adjuster screws backed out completely.
4. Insert a section of 1.5 in. (38 mm) wide strap steel at least 12 in. (30.5 cm) down the mini-mast to act as a "shoehorn" to guide the sensor past the cutout in the rail and the traverse position feedback pot. Remove the strap steel when the sensor has engaged the rail.

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⚠CAUTION

Failure to guide the sensor results in damage to sensor and feedback pot.

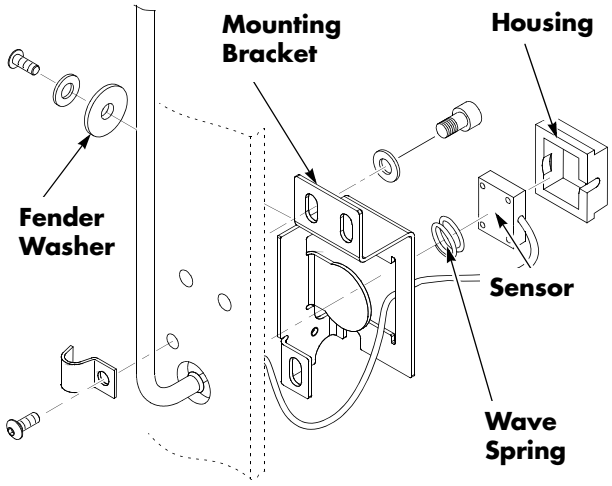
5. Using the hoist, slowly lower the load handler until it rests on the blocks. Make sure cable, hoses, and chain do not bind or catch on the load handler.
6. Apply thread-locking compound (P/N 990-536) to the mini-mast stop plate mounting screws and install the stop plate. Torque to 70 ft. lb. (95 Nm).
7. Apply thread-locking compound (P/N 990-536) to the pulley bracket assembly mounting bolt and install the bracket assembly on the end of the mini-mast cylinder. Torque to 90 ft. lb. (122 Nm).
8. Using a large screwdriver, twist the mini-mast cylinder 90° and feed the mini-mast lift chain anchor through the lift chain pulley. Once the chain hangs freely, twist the cylinder back to its normal position. Feed the lift chain and attach the chain anchor to the mini-mast.
9. Loop over-the-mast hoses and electrical cable over their pulleys and reattach the pulley bracket cover.
10. Reconnect the battery connector and turn the key switch ON.
11. Slowly raise the load handler to remove slack in over-the-mast hoses and cable. Remove blocks and lower the load handler completely. Remove the temporary cable tie securing the electrical cable to the turret. Attach the load handler turret cover and traverse motor cover.
12. Reinstall the forks. Check and adjust the fork height. See “Fork Height and Lift Chain Adjustment” on page 7-115.
13. Adjust the mini-mast cylinder pucks. See “Mini-Mast Pucks” on page 7-113.

Checking the Height Sensor Assembly

Check the following before reinstalling the Mini-Mast Height Sensor Assembly:

1. Make sure the sensor is fully seated in the sensor housing.
2. Check for compression of the wave spring when the sensor housing is at rest in the mounting bracket. The sensor housing should be fully extended from the bracket and the wave spring should be slightly compressed. If not, bend the circular tab on the back of the mounting bracket toward the sensor until the wave spring is slightly compressed.
3. Insert the sensor in the sensor housing. Insert the sensor housing, housing side out, with the wave spring on the inside, into the mounting bracket. To prevent the sensor assembly from sliding out of the bracket, secure it with the screw, washer, and fender washer in the threaded hole in the edge of the bracket.

Figure 7-81. Mini-Mast Height Sensor components



4. Replace the sensor assembly if the cable is cut, chafed, or otherwise damaged.

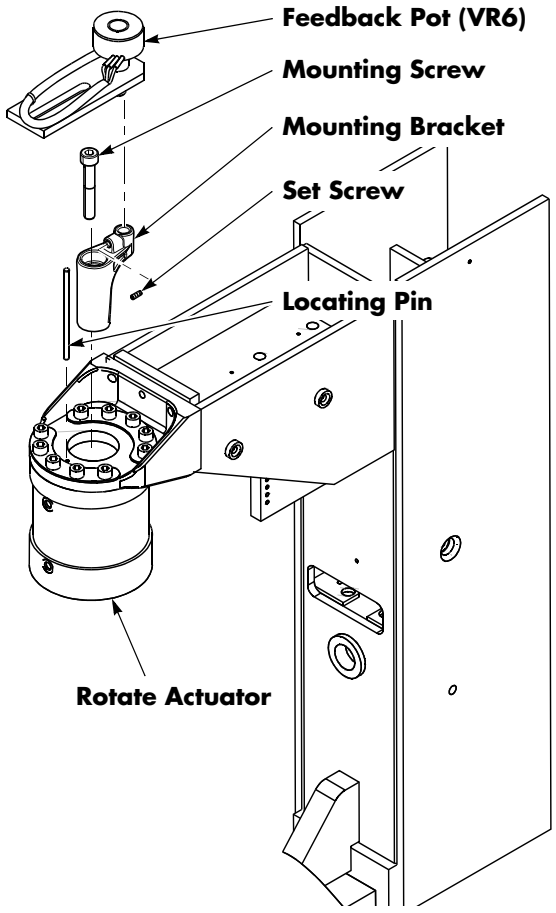
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Rotate Position Feedback Pot (VR6)

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the load handler turret cover.
3. Cut cable ties on the potentiometer cable, noting their location for later installation.
4. Disconnect the cable harness at JP4 under the turret.
5. Loosen the set screw in the bracket and remove the potentiometer. See Figure 7-82.

Figure 7-82. Rotate Position Feedback Pot



Installation

1. Position the potentiometer assembly over the locating pin and mounting bracket. Adjust the bracket on the actuator plate so the potentiometer is centered. Tighten the set screw.
2. Route the cable harness and install new cable ties.
3. Connect JP4 under the turret.
4. Reconnect the battery connector and turn the key switch ON.
5. Adjust the potentiometer. See "Adjustment".
6. Run Learn for load handler. See "Learn Ld Hndlr (Load Handler)" on page 3-33.
7. Install the load handler turret cover.

Adjustment

If the pot mounting bracket is not adjusted correctly, lift truck travel speed may be limited. To adjust the bracket:

1. Rotate the forks so they point straight ahead.
2. Adjust the potentiometer mounting bracket so it is centered fore-aft inside the rotate actuator.
3. Place a combination square against the flat sides of the mounting bracket.
4. Adjust the bracket left or right until it is centered in the mounting plate.
5. Refer to "Input A88 – Rot Posn [Rotate Position Feedback Pot (VR6)]" on page 6-66 and set the potentiometer voltage at 2.5V with the forks straight ahead.
6. Run Learn for load handler. See "Learn Ld Hndlr (Load Handler)" on page 3-33.

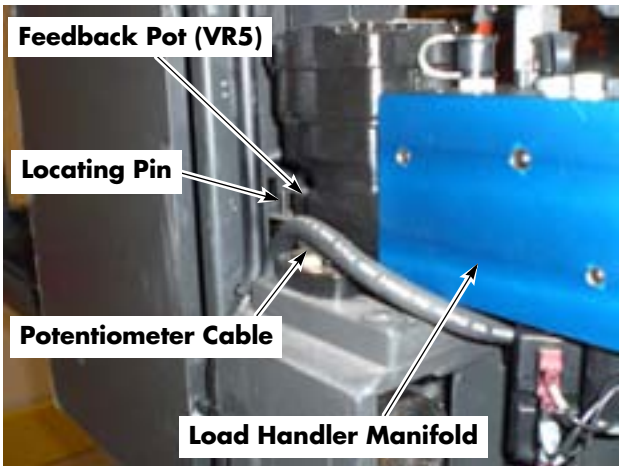
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Traverse Position Feedback Pot (VR5)

Removal

1. Traverse the mini-mast so it is centered side-to-side. Lower the operator carriage and load handler completely.
2. Use a work platform, ladder, or other suitable device to gain access to the Load Handler manifold on top of the overhead guard.
3. Remove the cover over the manifold and traverse motor. See Figure 7-83.

Figure 7-83. Traverse Position Feedback Pot



4. Traverse very slowly until the set screw on the pot shaft is accessible.
5. Turn the key switch OFF and disconnect the battery connector.
6. Loosen the set screw holding the pot shaft. Cut the cable tie.
7. Disconnect the pot wiring harness at JPK2.
8. Lift the pot assembly off the locating pin.

Installation

1. On the new potentiometer assembly, make sure the pot is turned so the terminals are at approx. a 45° angle from the slot in the mounting plate. If not, cut cable tie, loosen nut, align pot, tighten nut, and install a new cable tie.
2. *Correct routing of the cable is important.* Do not attach to hoses or other cables with cable ties. Do not wrap the cable around other hoses or cables such that the cable would tug on the pot.
3. Reconnect the wiring harness at connector JPK2.
4. Reconnect the battery connector and turn the key switch ON.
5. Refer to "Input A86 – Trv Posn [Traverse Position Feedback Pot (VR5)]" on page 6-64 and set the potentiometer voltage at 2.5V.
6. Position the pot over the locating pin. Make sure the wires of the pot are not touching, rubbing, or pressing on the locator pin. Tighten the set screw holding the pot shaft.
7. Refer to "Input A86 – Trv Posn [Traverse Position Feedback Pot (VR5)]" on page 6-64 and verify voltages are correct for full left and full right traverse.
8. Install the cover over the manifold and traverse motor.
9. Run Learn for load handler. See "Learn Ld Hndlr (Load Handler)" on page 3-33.

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Slack Chain Switch Adjustment

A slack chain switch is mounted on each of the main lift chain upper chain anchors.

Figure 7-84. Slack Chain Switch (9600)

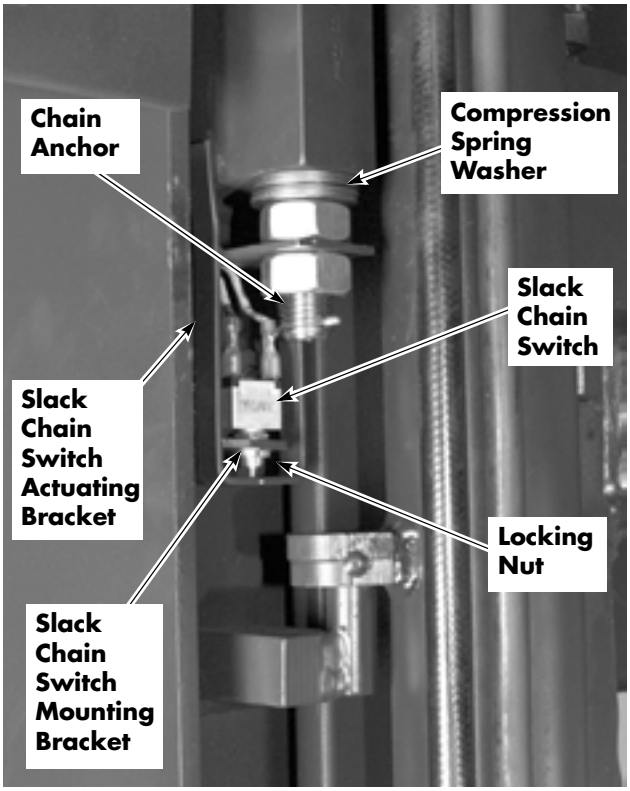
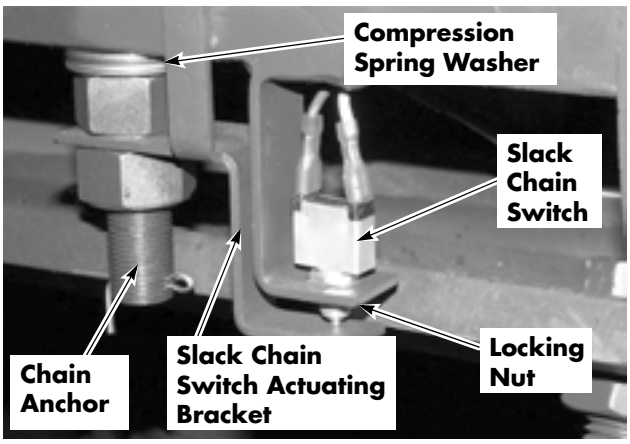


Figure 7-85. Slack Chain Switch (9700) Detail



1. Verify the switch is firmly in the normally closed position.
2. To adjust the switch, lower the raised platform onto a block.

⚠CAUTION

***Do not* block against the platform floor, use the edge of the platform. *Do not* block the carriage against the floor — lowering the platform could tip the load wheels off the floor.**

3. Continue to hold the lower control for at least 5 seconds.
4. *Model 9600*: Adjust the switch mounting bracket up or down so that the switch is open.
5. *Model 9700*: Turn the locking nut on the shaft of the switch to adjust the switch on the mounting bracket. Continue turning the locking nut until the switch is open.

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Cold Storage Conditioning

NOTE: Conversion for cold storage operation requires prior Raymond approval via Form S207.

Model 9600/9700 lift trucks to be operated in a cold storage environment require the following:

Components

NOTE: Do *not* add any additive to this hydraulic fluid.

- 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.

Grease carriage fittings and coat battery roller shafts with all-weather grease (P/N 1012992).

Corrosion Inhibitor Coating

Coat or spray bare metal surfaces listed below with Corrosion Inhibitor Coating (P/N 990-644):

- Main and mini lift chain pulleys and shafts
- Main and mini lift chain anchors and threaded pins
- Drive unit dipstick

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Hydraulic Components

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Lift/Lower Pump

The lift/lower pump assembly includes an integral manifold. The lift/lower solenoid (SOL1) and lift pressure relief valve (REL-1) are located on this manifold. Refer to "Manifold Port Torque Specifications" on page 7-73 when replacing these components.

⚠CAUTION

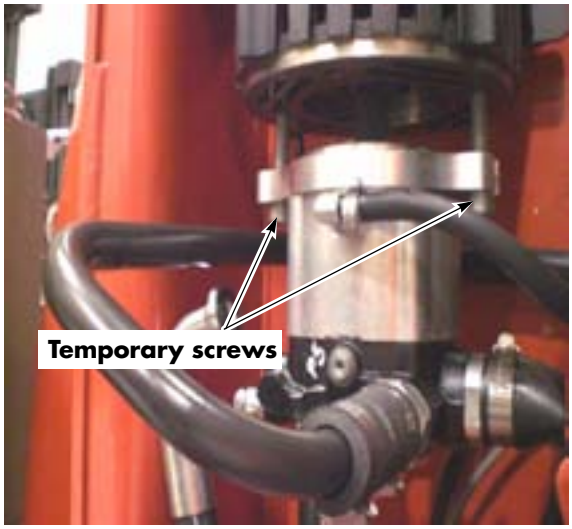
Fill the lift/lower pump completely with oil (prime) before operation.

Pump Maintenance

Lubricate the pump spline shaft every 180 days or 500 Deadman Hours. It is not necessary to completely remove the pump.

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove pressure hose from side of pump.
3. Remove return line (metal tubing) mounting hardware as necessary to allow pump to be lowered. Loosen one hose clamp and remove the second clamp.
4. Remove pump mounting screws and temporarily install longer screws (M12 x 60 mm shown). Install screws to just catch on a few threads of motor holes. See Figure 7-86.

Figure 7-86. Pump Maintenance



5. Drop pump onto screw heads to provide access to spline.
6. Clean, inspect, and lubricate spline shaft with molybdenum anti-seize compound (P/N 990-638).
7. Reassemble. Apply thread-locking compound (P/N 990-536) to mounting bolts and torque to 55 ft. lb. (75 Nm).
8. Open Emergency Lower Valve. Lift for 10 seconds to purge any air, then close valve. Re-key and lift to clear height errors.
9. Bleed hydraulic system. Refer to "Bleeding the Hydraulic System" on page 7-74.

Removal

1. Remove filter cap and allow oil to drain out of filter.
2. Clamp suction hose and disconnect from pump.
3. Clamp case drain hose and disconnect from pump.
4. Disconnect return line tube assembly from pump.
5. Loosen jam nut on manifold inlet fitting, P2. Remove pressure hose from pump.
6. Disconnect wires at SOL1.
7. Remove pump from truck.

Installation

1. Make sure the pump is filled with oil before installation.
   a. Hold pump with suction inlet facing up.
   b. Depress check valve to inspect cavity. Cavity should be completely filled with oil.
   c. Add oil if cavity is not completely filled.
2. Lubricate spline shaft with molybdenum anti-seize compound (P/N 990-638).
3. Install pump. Apply thread-locking compound (P/N 990-536) to mounting bolts and torque to 55 ft. lb. (75 Nm).
4. Connect all hoses. Connect SOL1 coil wires.
5. Open Emergency Lower Valve.

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6. Reconnect the battery connector and turn the key switch ON.
7. Request lift for 10 seconds.

NOTE: The first rotation of the lift motor and pump should be in the lifting direction. *Do not attempt to lower.* Code 64 or 67 is displayed during lift (truck sees motor rpm with no change in lift height). Lift rpm is limited.

8. Close Emergency Lower Valve.
9. Request lift. Continue lifting until system fills and mast elevates. Oil level in reservoir can be observed going down. Elevate both main and mini lift cylinders.
10. Bleed the main and mini lift cylinders. Refer to "Bleeding the Hydraulic System" on page 7-74.
11. Lower carriage and re-key to clear code.
12. Lift carriage and load handler to clear height error.
13. Check and fill reservoir.
14. Check lift pressure and adjust if necessary. Refer to "Lift Pressure Adjustment" on page 7-76.
15. Run Test O62 – Lower Sol [Lower Solenoid (SOL1)] (Page 6-153).

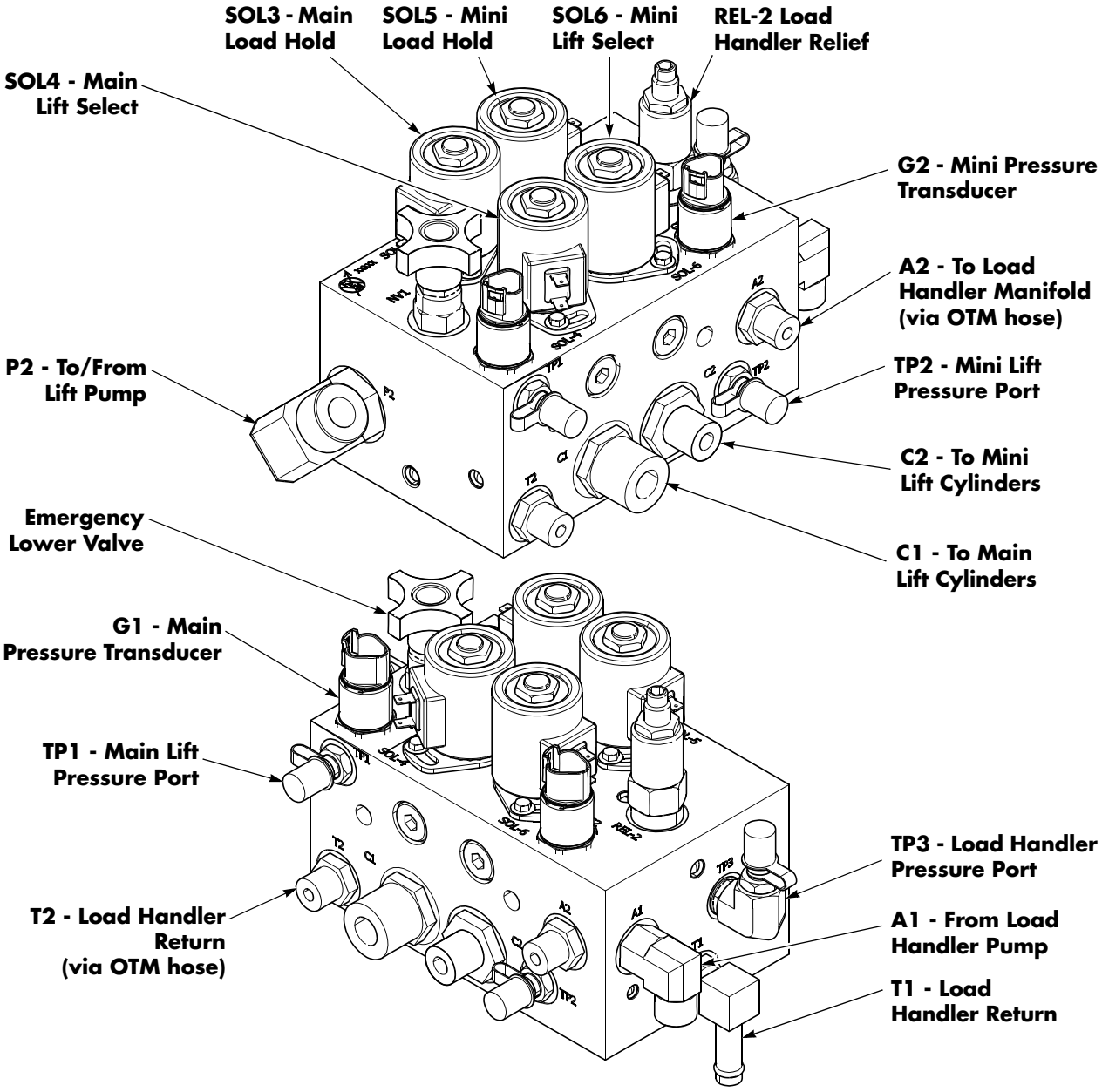
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Manifolds

Main Manifold

The main manifold, located in the tractor compartment on the lower left, controls main and mini-mast lift/lower functions and provides hydraulic fluid to the load handler manifold. It also contains a pressure relief valve for the load handler. See Figure 7-87. Refer to "Manifold Port Torque Specifications" on page 7-73 when replacing components on this manifold.

Figure 7-87. Main Manifold and Solenoids

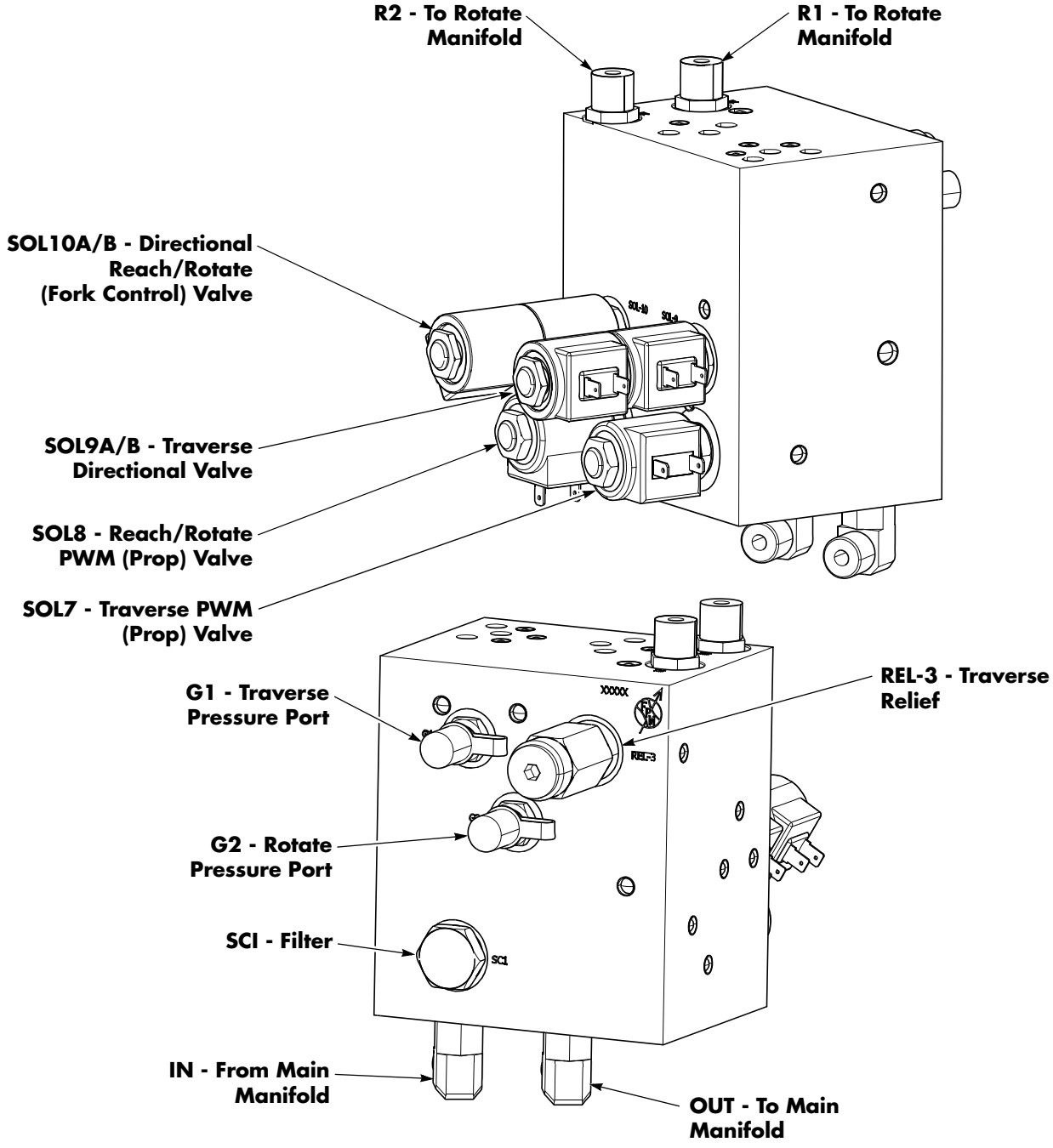


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Load Handler Manifold

The Load Handler (LH) manifold, located above the overhead guard, controls the traverse function and provides hydraulic fluid to the rotate manifold. Refer to "Manifold Port Torque Specifications" on page 7-73 when replacing components on this manifold.

Figure 7-88. Load Handler Manifold

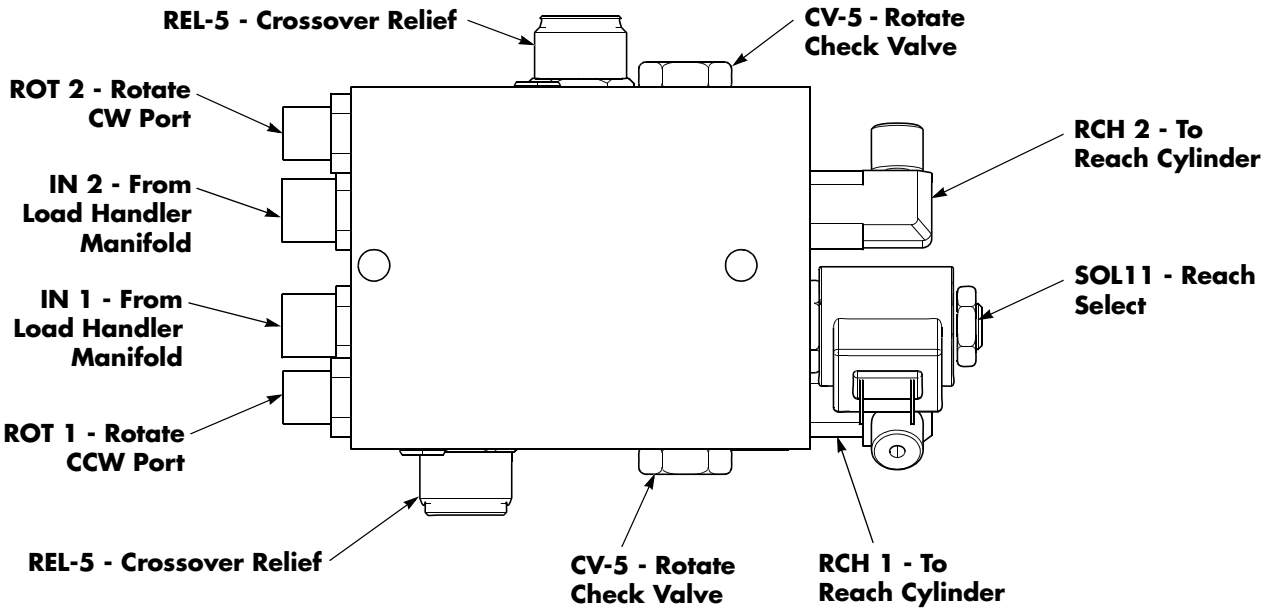


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Rotate Manifold

The rotate manifold, located on the load handler, controls the rotate/reach functions. Refer to "Manifold Port Torque Specifications" on page 7-73 when replacing components on this manifold.

Figure 7-89. Rotate Manifold



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Manifold Port Torque Specifications

Solenoid/ Fitting/Attachment	Manifold	Torque ft. lb. (Nm)
A1 - from LH Pump	Main	35 (47.5)
A2 - to LH Manifold	Main	
C1 - to Main Lift Cyl	Main	75 (101.5)
C2 - to Mini Lift Cyl	Main	
CV-1 - Check Valve	Pump	103 (140)
CV-2 - Check Valve	Pump	73 (99)
CV-3 - Check Valve	Pump	11 (15)
CV-5 - Rotate Chk Valve	Rotate	20 (27)
G1 - Main Press Xducer	Main	11 (15)
G1 - Traverse Press Port	LH	25 (34)
G2 - Mini Press Xducer	Main	11 (15)
G2 - Rotate Press Port	LH	25 (34)
IN - from Main Manifold	LH	
IN 1 & IN 2 - from LH Manifold	Rotate	
NV1 - Emerg Lwr Valve	Main	20 (27)
OUT - to Main Manifold	LH	25 (34)
P1 - to/from Main Manifold	Pump	30 (41)
P2 - to/from Lift Pump	Main	75 (101.5)
RCH 1 & 2 - to Rch Cyl	Rotate	25 (34)
REL-1 - Lift Press Relief	Pump	35 (47)
REL-2 - LH Press Relief	Main	25 (34)
REL-3 - Traverse Press Relief	LH	20 (27)
REL-5 - Rotate Press Relief	Rotate	
ROT 1 - to Rotate Actuator (CCW)	Rotate	25 (34)
ROT 2 - to Rotate Actuator (CW)	Rotate	
R1 & R2 - to/from Rotate Manifold	LH	

Solenoid/ Fitting/Attachment	Manifold	Torque ft. lb. (Nm)
SCI - Filter	LH	25 (34)
SOL1 - Lift/Lower Select	Pump	35 (47.5)
SOL3 - Main Load Hold	Main	35 (47.5) coil nut: 5 (6.8)
SOL4 - Main Lift Select		
SOL5 - Mini Load Hold		
SOL6 - Mini Lift Select		
SOL7 - Traverse Prop Valve	LH	20 (27) coil nut: 5 (6.8)
SOL8 - Rch/Rotate Prop Valve		
SOL9A/B - Traverse Dir		
SOL10A/B - Rotate Dir		
SOL11 - Rch Select	Rotate	
T1 - LH Return	Main	35 (47.5)
T2 - LH Return (via OTM hose)	Main	
TP1 - Main Lift Press Port	Main	25 (34)
TP2 - Mini Lift Press Port	Main	
TP3 - LH Press Port	Main	

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Bleeding the Hydraulic System

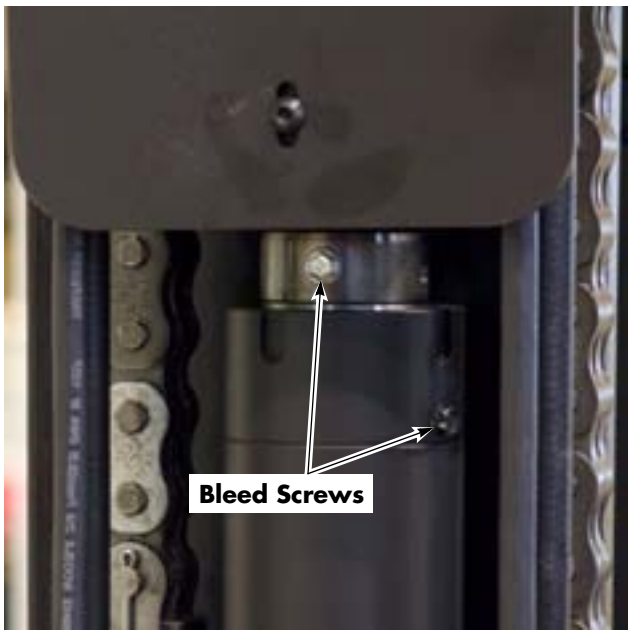
Bleed the hydraulic system to remove any trapped air whenever you:

- Change a hydraulic hose
- Disconnect a hydraulic fitting
- Remove a hydraulic cylinder
- Remove a hydraulic pump
- Remove the hydraulic reservoir
- Notice that the load is bouncing

Main Lift Cylinders

NOTE: Model 9600 and 9700 Main Lift cylinders have two bleed screws: one located in the cylinder cap and one located on the piston plug. See Figure 7-90.

Figure 7-90. Bleed Screw Locations



1. Elevate the carriage 6 to 12 in. (150 to 300 mm) above the floor.
2. One at a time, slowly loosen but *do not remove* the bleed screws. Allow all air in the cylinder to escape. Hold a shop rag close to and beneath the bleed screw to keep hydraulic fluid from spraying out. When fluid starts flowing from the bleed screw hole, retighten the bleed screw. Repeat this for the other lift cylinder.
3. Lower the carriage to the floor.

Mini-Mast Lift Cylinder

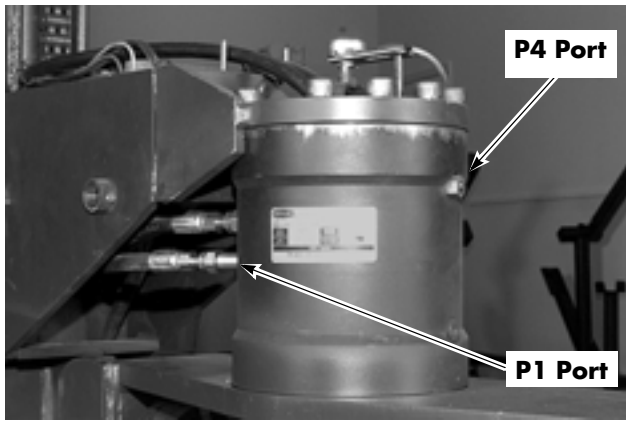
1. Elevate the load handler until the forks are 6 to 12 in. (150 to 300 mm) above the floor.
2. Slowly loosen but *do not remove* the bleed screw on the mini-mast cylinder. Allow all air in the cylinder to escape. Hold a shop rag close to and beneath the bleed screw to keep hydraulic fluid from spraying out. When fluid starts flowing from the bleed screw hole, retighten the bleed screw.
3. Lower the load handler to the floor.

Load Handler

1. Cycle traverse and rotate.
2. Rotate the forks fully clockwise.
3. Slowly loosen but *do not remove* the fitting in Port P1 (the lower fitting on the back, facing the tractor) of the rotate actuator.
4. Move the rotate control to rotate the forks clockwise until all the air is forced out of the P1 port. See Figure 7-91.
5. Release the rotate control, then tighten the fitting in the P1 port.
6. Rotate the forks fully counterclockwise. Slowly loosen but *do not remove* the fitting in the P4 Port (the top fitting on the front, facing the forks) of the rotate actuator. See Figure 7-91.

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Figure 7-91. Bleeding Auxiliary System



7. Move the rotate control to rotate the forks counterclockwise until all the air is forced out of the P4 port.
8. Release the rotate control and tighten the fitting in the P4 port.
9. Thoroughly clean up any spilled hydraulic fluid.

NOTE: No bleeding procedure is required for traverse, as cycling both to the left and right automatically purges the air from the system.

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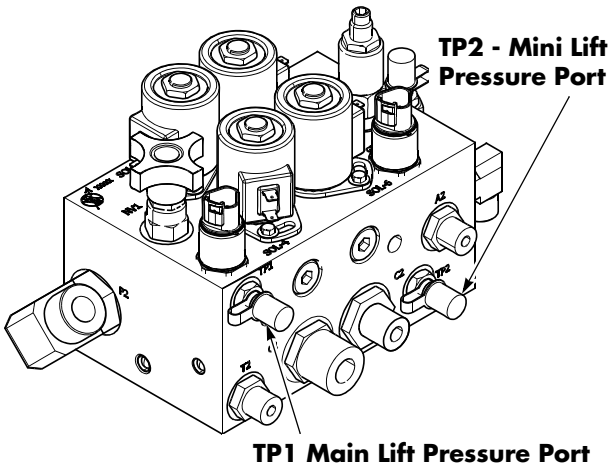
Lift Pressure Adjustment

The Lift Pressure Relief Valve (REL-1) limits system pressure for lift functions. Perform the following steps to adjust Lift system pressure.

1. Lower the carriage and load handler completely.
2. Turn the key switch OFF and disconnect the battery connector.
3. Remove the tractor cover.
4. *Model 9600* - Connect a pressure gauge capable of reading 5000 psi (351 kg/cm^2) to the *Main Lift Pressure Port* (TP1) on the main manifold. Refer to Figure 7-92.

   Model 9700 - Connect a pressure gauge capable of reading 5000 psi (351 kg/cm2) to the *Mini Lift Pressure Port* (TP2) on the main manifold. Refer to Figure 7-92.

Figure 7-92. Main Manifold Pressure Ports



5. Loosen the lock nut and back out the adjustment screw on the Lift Pressure Relief Valve (REL-1) located on the lift pump.
6. Reconnect the battery connector and turn the key switch ON.
7. Place a rated load plus 200 lb. (90 kg) on the forks.
8. *Model 9600* - while requesting *main lift*, turn the adjusting screw in until the load begins to elevate. Note the pressure required for lift.

   Model 9700 - while requesting *mini-mast lift*, turn the adjusting screw in until the load begins to elevate. Note the pressure required for lift.
9. Adjust REL-1 until lift pressure is 100 to 300 psi (7 to 21 kg/cm^2) *above* the value recorded in step 7. This can be done by elevating the main mast against the mechanical stops (*loaded or unloaded*).
10. When the pressure is correct, tighten the lock nut on the valve.
11. Check both main and mini mast for correct operation
12. Lower the load handler completely. Turn the key switch OFF and disconnect the battery connector.
13. Remove the pressure gauge.
14. Install the tractor cover.

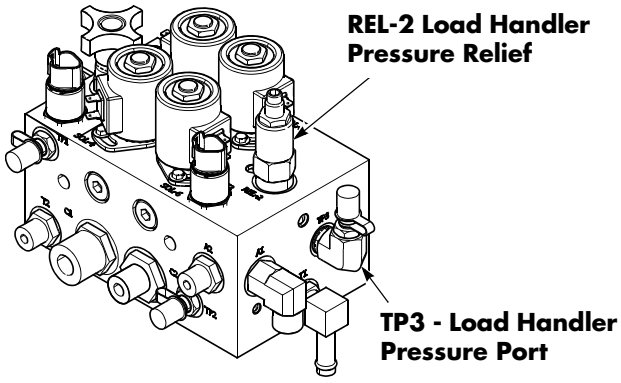
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Load Handler Pressure Adjustment

The Load Handler Pressure Relief Valve (REL-2) limits system pressure for the rotate, reach, and retract functions. Perform the following steps to adjust Load Handler system pressure.

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the tractor cover.
3. Connect a pressure gauge capable of measuring 3000 psi (211 kg/cm^2) to TP3 on the main manifold. Refer to Figure 7-93.

Figure 7-93. Load Handler Pressure Adjustment



4. Loosen the lock nut on the load handler pressure relief valve (REL-2) on the main manifold. See Figure 7-93.
5. Reconnect the battery connector and turn the key switch ON.
6. Rotate the load handler completely CW or CCW. While requesting rotate against the stop, observe pressure. Pressure should be 1500 psi (105.4 kg/cm^2).
7. Adjust REL-2 for the correct pressure while rotating against the stop.

NOTE: If request exceeds 5 seconds against the stop, the system will shut down.

8. When the pressure is correct, tighten the lock nut on the valve.
9. Turn the key switch OFF and disconnect the battery connector.
10. Remove the pressure gauge.
11. Install the tractor cover.

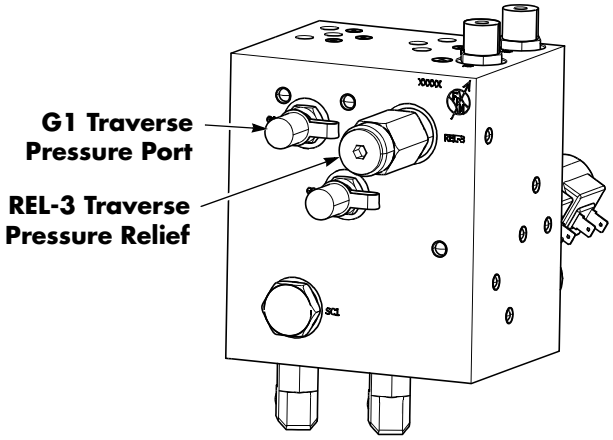
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Traverse Pressure Adjustment

The Traverse Pressure Relief Valve (REL-3) limits system pressure for the traverse function. Perform the following steps to adjust traverse pressure.

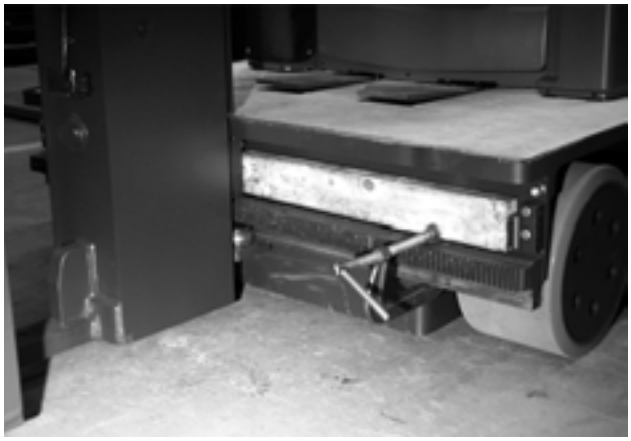
1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the manifold cover located at the top of the mini-mast.
3. Connect a pressure gauge capable of measuring 3000 psi (211 kg/cm^2) to G1 on the load handler manifold. Refer to Figure 7-94.

Figure 7-94. Traverse Pressure Adjustment



4. Clamp a block of wood against the traverse rack stop. See Figure 7-95.

Figure 7-95. Blocking Traverse Rack



5. Reconnect the battery connector and turn the key switch ON.
6. Move the traverse control so the load handler is traversed against the wood block. Keep the load handler pressing against the block. Pressure should be 1100 psi (77.3 kg/cm^2). If OK, proceed to step 13. If not OK, proceed as follows.
7. Turn the key switch OFF and disconnect the battery connector.
8. Remove the cap from the top of REL-3 to expose internal spring tension adjuster.

NOTE: Cap must be re-installed before system pressure can be tested.

9. Use a socket head wrench to adjust pressure. Turning CW increases pressure; CCW decreases pressure.

NOTE: 1/4 turn equals approx. 100 psi (7 kg/cm^2).

10. Re-install cap removed in step 8.
11. Reconnect the battery connector and turn the key switch ON.
12. Repeat steps 6 thru 11 until pressure is 1100 psi (77.3 kg/cm^2).
13. Turn the key switch OFF and disconnect the battery connector.
14. Remove the pressure gauge. Remove the clamp and wood block.
15. Install the manifold cover.

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Main Lift Cylinders (9700)

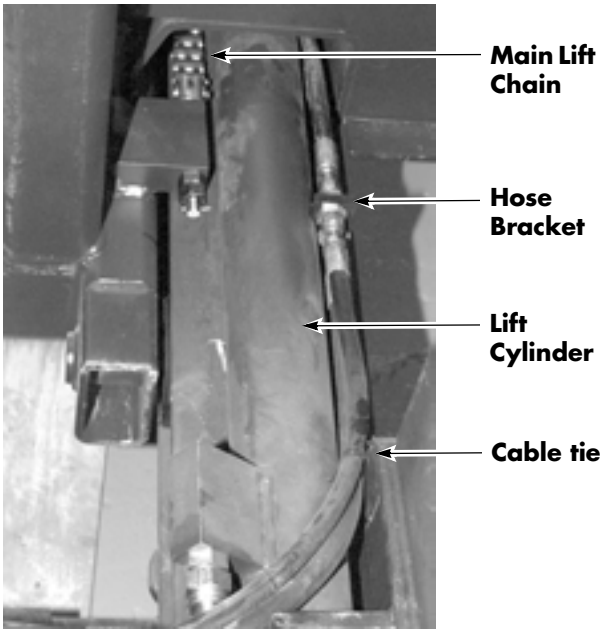
Removal

⚠CAUTION

Perform this procedure with two or more technicians. *Do not* attempt this procedure without a suitable hoist or crane and a work platform. Main lift cylinders weigh 350 lb. (159 kg) each.

1. Cut the cable ties on the two hose and cable slap pads on each cylinder to be removed.
2. Elevate the carriage approx. 3 ft. (1 m). Block and clamp between edge of carriage and baseleg. See "Blocking the Carriage" and Figure 2-6 on page 2-11.
3. Turn the key switch OFF and disconnect the battery connector.
4. Remove the left side over-the-mast hose pulleys.
5. Remove the nuts securing the upper end of the cylinder.
6. Remove the tractor cover. Use the emergency lowering valve to lower the cylinder. Make sure to close the valve when the cylinder is lowered. See "Main Manifold" on page 7-70.
7. Remove the lower cylinder retaining nut.
8. Loosen the left side over-the-mast hose bracket under the carriage. See Figure 7-96.

Figure 7-96. Hose Bracket Under carriage



9. Remove the hydraulic fittings at the bottom of the cylinder.
10. Wrap a lifting strap around the lift cylinder below the locating eye.

NOTE: To prevent the strap from slipping, place a hose clamp above and below the strap. Make sure the clamps are tight.

11. Carefully lift the cylinder from its locating pin. Guide the cylinder past the hydraulic fittings on the carriage.
12. Attach a nut to the mounting stud on the bottom of the cylinder to protect the threads.

Installation

1. Wrap a lifting strap around the lift cylinder below the locating eye.

NOTE: To prevent the strap from slipping, place a hose clamp above and below the strap. Make sure the clamps are tight.

2. Attach the strap to a suitable hoist or other lifting device.
3. Remove the nut protecting the threads on the mounting stud on the bottom of the cylinder.

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4. Carefully lift and lower the cylinder into position. One technician guides the cylinder past the hydraulic fittings inside the cutout near the carriage. One technician guides the cylinder locating eye onto the pin on the mast.
5. Attach the hydraulic fittings at the bottom of the cylinder.
6. Secure the left side over-the-mast hose brackets under the carriage.
7. Clean and apply thread-locking compound (P/N 990-536) to the threads of the cylinder mounting stud. Install the nut and torque to 50 ft. lb. (67.7 Nm).
8. Reconnect the battery connector and turn the key switch ON. *Slowly* and carefully extend the piston using the lift function. Continue to elevate the piston until the piston engages the telescopic.
9. Clean and apply thread-locking compound (P/N 990-536) to the threads of the top mounting stud. Install the nut and torque to 50 ft. lb. (67.7 Nm).
10. Attach the left side over-the-mast hose pulleys and route hoses over the pulleys.
11. Remove blocking beneath the carriage. Lower the carriage completely.
12. Install hose and cable slap pads.
13. Bleed the hydraulic system. See “Bleeding the Hydraulic System” on page 7-74.
14. Check hydraulic fluid level and refill as needed.
15. Shim cylinders as required. Refer to “Main Lift Cylinder Shimming” on page 7-83.

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Main Lift Cylinders (9600)

Removal

⚠CAUTION

Perform this procedure with two or more technicians. *Do not* attempt this procedure without a suitable hoist or crane and a work platform. Main lift cylinders weigh up to 225 lb. (102 kg) each.

1. Locate the truck in an area where the carriage can be elevated above the housing of the lift cylinder.

NOTE: You remove the lift cylinder below the carriage. You need to lift the carriage above the cylinder housing in order to remove the cylinder. If you do not elevate the bottom of the carriage near the top of the cylinder housing, you cannot remove the cylinder assembly.

2. Remove the tractor cover.
3. Remove the cover from the lift chain/hose pulleys (if present) at the top of the telescopics on the cylinder to be removed.
4. Elevate the carriage approx. 12 in. (300 mm).
5. Block and clamp between edge of carriage and baseleg. See "Blocking the Carriage" and Figure 2-6 on page 2-11.
6. Using the emergency lowering valve, lower the carriage onto the supports so the hoses become just slack enough to remove them from the pulleys. See Figure 7-87 on page 7-70.
7. Close the emergency lowering valve. Turn the key switch OFF and disconnect the battery connector.
8. Remove the hoses from the pulleys.
9. Remove the bolt securing the pulleys.
10. Remove the nut and washer holding the piston to the telescopic.
11. Reinstall the pulleys and hoses.
12. Reconnect the battery connector and turn the key switch ON.
13. Elevate the carriage until the crosstie of the telescopic is approx. 7 in. (180 mm) above the main frame crosstie.
14. Place a 4x6 in. (100x150 mm) hardwood block between the telescopic and main frame crossties.
15. *Slowly* lower the carriage until the telescopic crosstie rests on the hardwood block. This prevents the carriage and telescopic from lowering.
16. Turn the key switch OFF and disconnect the battery connector.
17. Wrap a chain around the telescopic and main frame crossties, near the block inserted in step 14. Make sure the ends of the chain are secure!
18. To collapse the lift cylinder, open the emergency lowering valve. When the piston is completely down, close the emergency lowering valve. At this point the carriage and telescopic are supported by the wooden block. The chain serves as a safety backup.
19. Disconnect, then cap, the main supply hose from the bottom of the lift cylinder.
20. Using a 15/16 in. box wrench, remove the nut and washer from the bottom of the lift cylinder.
21. Wrap a lifting strap around the lift cylinder below the locating eye.

NOTE: To prevent the strap from slipping, place a hose clamp above and below the strap. Make sure the clamps are tight.

22. Attach the strap to a suitable hoist or other lifting device.
23. Carefully elevate the lift cylinder enough to release the pin that secures the cylinder housing to the main frame. This pin is located on the cylinder housing near the chain anchor.
24. Carefully swing the bottom of the lift cylinder out between the load wheels and slowly lower the lift cylinder to the floor.
25. Thread the nut on the lower cylinder stud to prevent damage to the stud threads.

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Installation

1. Wrap the cylinder strap around the top third of the lift cylinder.
2. To prevent the strap from slipping, place a hose clamp above and below the strap. Make sure the clamps are tight.
3. Feed a hoist block through the carriage channel and attach a hoist strap to the cylinder.
4. Using the hoist, carefully elevate the lift cylinder. Guide the cylinder so that the pin on the side of the cylinder, near the top, mates with the block on the mast main frame. The stud on the bottom of the cylinder must go through the hole in the support channel between the baselegs.
5. Clean and apply thread-locking compound (P/N 990-536) to the threads of the cylinder mounting stud. Install the nut and torque to 50 ft. lb. (67.7 Nm).
6. Remove the hose clamps and strap.
7. Attach the hydraulic supply hose to the cylinder.
8. Reconnect the battery connector and turn the key switch ON. *Slowly* and carefully extend the piston using the lift function. Continue to elevate the piston until the piston engages the telescopic.
9. *Slowly* raise the carriage enough to permit removal of the safety chain and wooden block. Turn the key switch OFF and disconnect the battery connector. Remove the chain and block.
10. Using the emergency lowering valve, lower the carriage onto blocks to permit the hoses to become slack enough to be removed from the pulleys.
11. Remove the hoses from the pulleys.
12. Remove pulleys.
13. Clean and apply thread-locking compound (P/N 990-536) to the threads of the top mounting stud. Install the nut and torque to 50 ft. lb. (67.7 Nm).
14. Reinstall the pulleys and hoses. Clean and apply thread-locking compound (P/N 990-536) to the threads of the pulley screw.
15. Bleed the hydraulic system. See “Bleeding the Hydraulic System” on page 7-74.
16. Reinstall covers.
17. Shim cylinders as required. Refer to “Main Lift Cylinder Shimming” on page 7-83.

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Main Lift Cylinder Shimming

Check

Main lift cylinders may require shimming after installation. Perform the following steps to determine if shimming is necessary.

1. Position the forks in the straight ahead position.
2. Position the load handler in the center of the carriage.
3. Raise the carriage to the full elevated height. If carriage sways left or right, note the direction it sways.
4. Shim the side that the carriage sways toward using the following procedure.

Shim Installation Procedure

Install up to two thin shims [0.059 in. thick (P/N 1093258/001)] or one thick shim [0.119 in. thick (P/N 1093258/002)] maximum at the top of the piston using the following procedure.

1. Elevate the telescopic slightly and block the telescopic.
2. Turn the key switch OFF and disconnect the battery connector.
3. Open the emergency lowering valve and let the pistons settle. Install the shim(s) between the shoulder of the piston ram(s) and the retaining block(s) at the top of the mast.
4. Secure shim(s) with a M6 x 12 hex head cap screw (P/N 5-001-001) to the mast retaining block.
5. Reconnect the battery connector and turn the key switch ON.
6. Close the emergency lowering valve. Raise the carriage until the piston engages the retaining blocks at the top of the mast. Make sure the cylinder stops hit evenly.
7. Readjust the lift chains. Refer to “Main Lift Chains (9600)” on page 7-92 or “Main Lift Chains (9700)” on page 7-94.
8. Lower the carriage at full lowering speed and make sure that the carriage does not sway when it bottoms. If the carriage sways unacceptably, check the adjustment of the main lift chains to make sure they are adjusted evenly.

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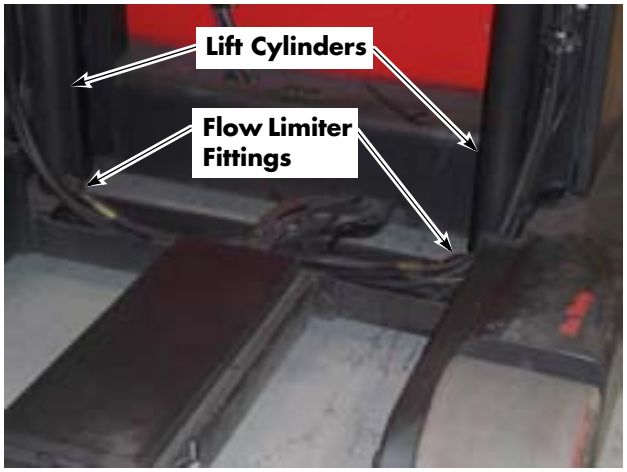
Flow Limiters

Main Mast

Removal

1. Elevate the carriage approx. 3 ft. (1 m). Block and clamp between edge of carriage and baseleg. See "Blocking the Carriage" and Figure 2-6 on page 2-11.
2. Turn the key switch OFF and disconnect the battery connector.
3. Place a drain pan beneath the main lift cylinder hydraulic fitting.
4. Remove the hydraulic hose. Remove the flow limiter fitting.

Figure 7-97. Flow Limiters, Main Lift Cylinder



Installation

1. Insert the new flow limiter fitting.
2. Install the hydraulic fitting and hose.
3. Reconnect the battery connector and turn the key switch ON.
4. Lift the carriage, remove the blocking, then lower the carriage completely.
5. Bleed the lift system as necessary. See "Bleeding the Hydraulic System" on page 7-74.
6. Check hydraulic fluid level.

Mini-Mast

Removal

1. Elevate the load handler approx. 3 ft. (1 m). Block and clamp the load handler. See "Blocking Load Handler" and Figure 2-7 on page 2-11.
2. Turn the key switch OFF and disconnect the battery connector.
3. Place a drain pan beneath the mini-mast lift cylinder hydraulic fitting.
4. Remove the hydraulic hose. Remove the flow limiter fitting.

Figure 7-98. Flow Limiter, Mini-Mast Lift Cylinder



Installation

1. Insert the new flow limiter fitting.
2. Install the hydraulic fitting and hose.
3. Reconnect the battery connector and turn the key switch ON.

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4. Lift the load handler, remove the blocking, then lower the load handler completely.
5. Bleed the lift system as necessary. See "Bleeding the Hydraulic System" on page 7-74.
6. Check hydraulic fluid level.

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RAYMOND

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Mast, Chain, Hose, Cable

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Main Mast

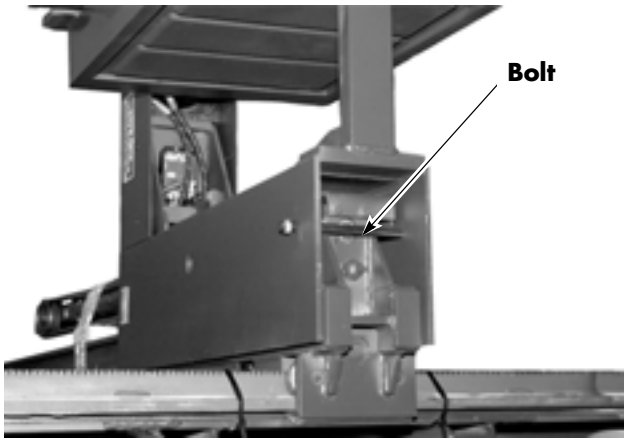
Separating Tractor and Mast

⚠ WARNING

Perform this procedure with a minimum of two technicians in a shop suitably equipped with a 10-ton hoist.

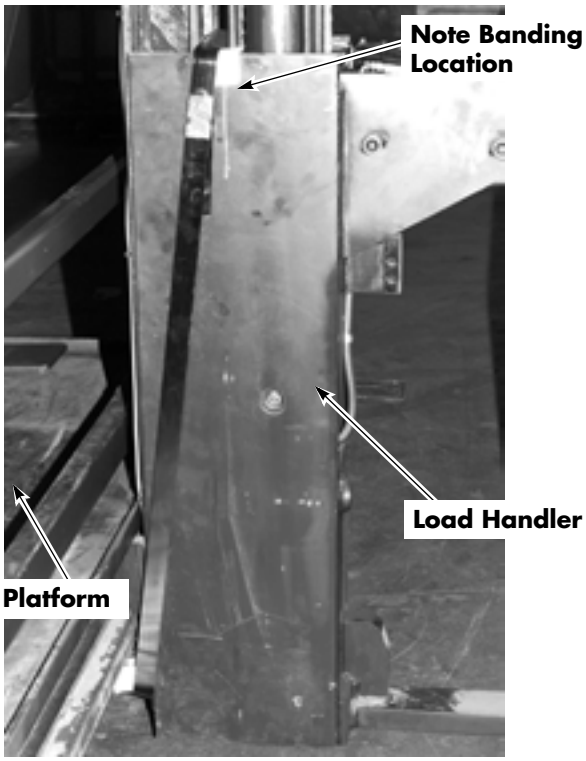
1. Retract and center the forks. Lower the load handler and operator platform completely.
2. Turn the key switch OFF and disconnect the battery connector. Using a suitable battery removal device, remove the battery. Remove battery rollers.
3. Remove the forks.
4. Secure the load handler:
   a. If there is a hole through the load handler near the bottom, insert a long bolt and nut so that the bolt secures the load handler. See Figure 7-99.

Figure 7-99. Load Handler Secured with Bolt



   b. If there is no hole through the load handler, use steel banding (1.25x0.031 in.) around the bottom of the mini-mast. See Figure 7-100.

Figure 7-100. Load Handler Secured to Mini-Mast



5. Insert 1x4 in. (2.5x10 cm) wood stringers cut to fit between lower traverse bearing and traverse stops on each side of the load handler. Secure with cable ties around the lower traverse rack.
6. Tape a 2x4x7 in. (5x10x18 cm) wood block between the mini-mast and the mini-mast lift cylinder at the midpoint of its height.
7. Disconnect four hydraulic hoses between the tractor and mast at the bottom of the battery compartment. Save the O-rings and cap/plug hose fittings.
8. Unplug all mast-to-tractor and wire guidance cable connections. Label for re-connection if necessary. See Figure 7-101.

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Figure 7-101. Mast to Tractor Cable Connections



9. *Model 9600:* Attach two straps from a 10-ton hoist around the main mast and telescopic crossties. See Figure 7-102.

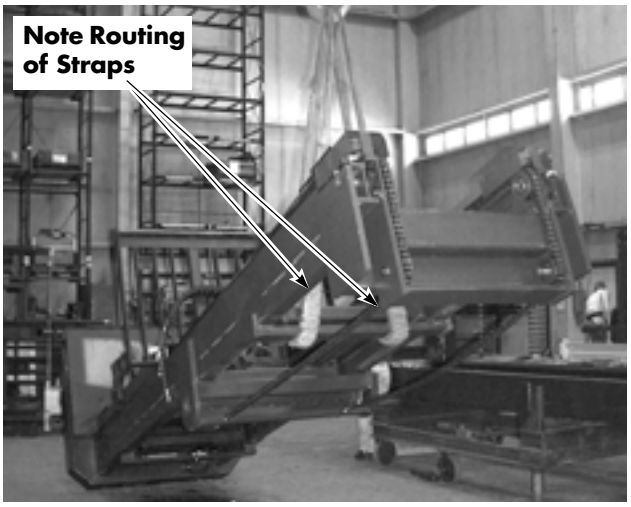
   Alternate method: Position the lifting truck as shown in Figure 3-3 on page 3-5 and secure a heavy chain around the fork carriage of the lifting truck and the mast crosstie.

10. *Model 9700:* Attach two straps from a 10-ton hoist around the second main mast and telescopic crossties. See Figure 7-102.

⚠CAUTION

On a Model 9700 mast, *do not* wrap hoist strap around the uppermost crosstie, only the main mast and telescopic crossties.

Figure 7-102. Mast Strapped to Hoist



Alternate method: Insert a length of suitable structural tubing (refer to Table 3-1 on page 3-6) through the 6 in. (15 cm) hole in the lifting flange. This flange is a part of the Model 9700 mast lower crosstie. See Figure 7-103. If you are using two lift trucks to lower the mast, a 160 in. (407 cm) length is recommended.

Attach and secure 10-ton hoist straps around the structural tubing on both sides of the mast.

If you are lowering the mast with lift trucks instead of a hoist, chain or clamp the structural tubing to the fork carriage of the lift trucks.

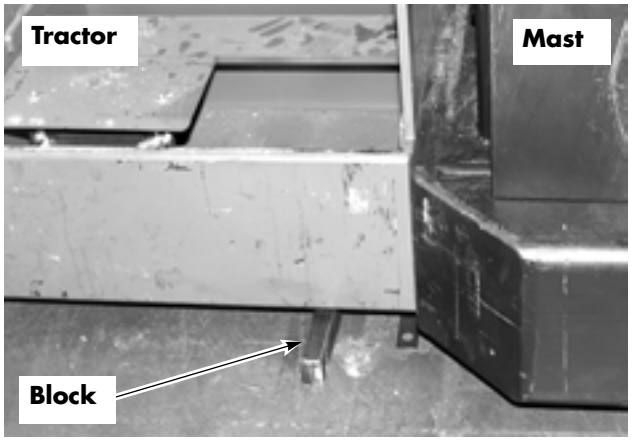
Figure 7-103. Model 9700 Mast Lifting Flange



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11. Block the tractor where it meets the mast.

Figure 7-104. Blocking Tractor At Mast



12. Loosen the diagonal support arm jam nuts and remove the upper mounting bolts.
13. Remove the snap ring from the support arm clevis pin.

⚠CAUTION

Each support arm weighs approx. 60 lbs. (27 kg).

14. Using a helper, remove the clevis pin while supporting the support arm. Remove the arm. Replace the clevis pin and snap ring (so as not to misplace them).

⚠ WARNING

Before loosening mast mounting bolts, make sure the weight of the mast is fully supported by the hoist (or lift trucks) and the tractor is blocked where it meets the mast.

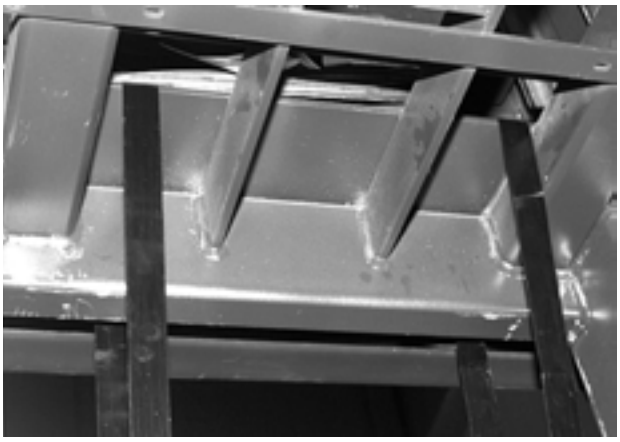
15. Remove eleven mounting bolts and washers (4 at top, 7 at bottom) joining the tractor and mast at the tractor front bulkhead inside the battery compartment.
16. Supporting the weight of the mast with the hoist (or lift trucks), separate the mast from the tractor.
17. Disconnect connector JPA1 at the Supplemental Operator Display. Remove glass or mesh mast guard. Package and seal guard and Display in protective cardboard.
18. Install steel banding around the overhead guard and bottom main frame crosstie as shown.
19. Protect removed electrical cable connectors with a plastic bag and cable tie.

Figure 7-105. Platform Strapped to Mast



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Figure 7-106. Overhead Guard Strapped to Mast



20. Tuck hydraulic hoses and electrical cables into the base of the main frame.

NOTE: Be careful of possible burrs on the edge of the opening in the frame.

Figure 7-107. Securing Hoses in Main Frame



21. Lower the upper end of the mast onto a suitable dolly or skid.
22. Using a 10-ton-capacity hoist, elevate the main frame at the platform and lower it unto a suitable dolly or skid.
23. To prevent over-the-mast hoses and cables from movement during transport, secure hoses and cables to main lift cylinders with cable ties at two or more points on each cylinder. Attach a “toe-tag” to the lift/lower control with a reminder to remove these cable ties at installation.
24. If the mast is placed on a skid, secure the mast tightly to the skid with steel banding around mast and inner telescopic crossties, at four places.
25. Reposition static straps so they do not protrude from the bottom of the mast during transport.
26. For tractor shipment, remove tractor side covers and tape them securely inside the battery compartment.
27. Securely tape the packaged mast guard and Supplemental Operator Display inside the battery compartment.
28. Install battery gates. Place the carton with the battery rollers in the battery compartment. Install steel banding around the bottom of the battery compartment, through the handles of the battery gates, and over the carton on both sides.
29. Immobilize control handles and steering tiller by wrapping with protective plastic tape.

Joining Tractor and Mast

See “Installation Instructions” on page 3-4.

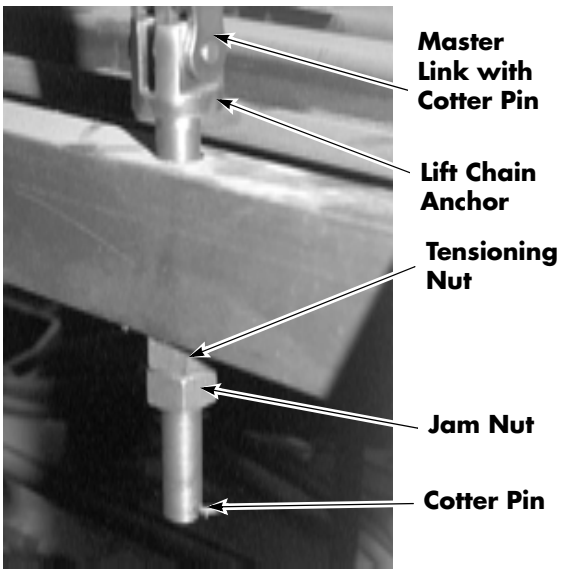
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Main Lift Chains (9600)

Removal

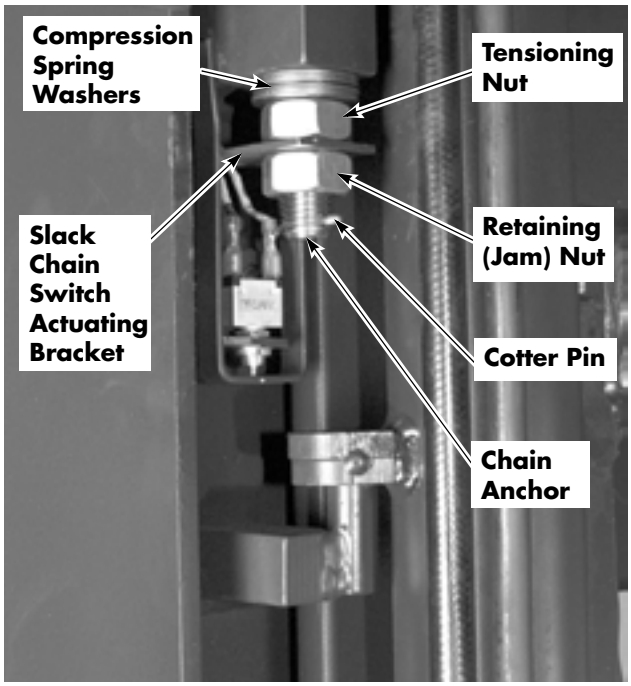
1. Center the load handler horizontally with forks straight ahead.
2. Loosen both upper chain anchor jam nuts before removing tension on lift chains.
3. Raise the platform 6 in. (150 mm).
4. Block and clamp the platform between the platform and baseleg (*not* the floor). Lower the platform onto the block to slacken the chains.
5. Turn the key switch OFF and disconnect the battery connector.
6. Measure and note the length of the exposed end of the upper chain anchor. This measurement is used to approximate correct chain tension during reassembly.
7. Remove the pedestal covers.
8. Remove chain from lower chain anchor block. Separate the chain from the lower chain anchor by removing the cotter pin and master link. See Figure 7-108.

Figure 7-108. Main Mast Lift Chain Anchor (lower)



9. At the top of the mast, remove the pulley cover.
10. Remove chain from upper chain anchor:
    a. Remove cotter pin, jam nut, and slack chain switch actuating bracket with switch. Remove tensioning nut and four compression spring washers.
    b. Pull the chain anchor out of the mast crosstie and pull the chain up and out over the chain pulley.

Figure 7-109. Slack Chain Switch Bracket (9600)



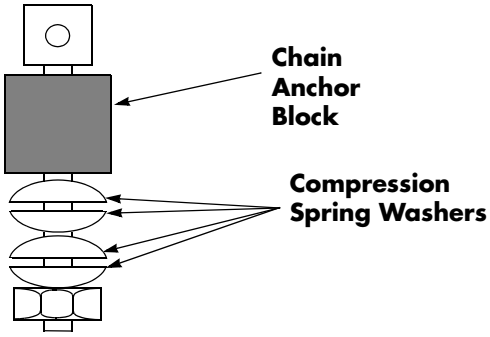
11. Repeat steps 8 thru 10 for the other lift chain.
12. Remove upper chain anchors from chains by removing cotter pins and master links.

Installation

1. Attach upper chain anchors to both lift chains with master links, securing each with a cotter pin.
2. Insert the anchor in the upper chain anchor block.
3. Attach tensioning and jam nuts. Install four compression spring washers between the chain anchor block and the tensioning nut. Then install the slack chain actuating bracket and switch between the tensioning nut and the retaining (jam) nut.

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Figure 7-110. Compression Spring Washer Orientation



NOTE: Make sure the compression spring washers are in the correct orientation so that they function correctly. See Figure 7-110. The compression spring washers compress fully when the chain is tight.

4. Attach the cotter pin. Adjust the tensioning and jam nuts to leave the same length of exposed thread as you measured in removal step 6.
5. Carefully feed the lift chain over the chain pulley and down the mast channel. Make sure the open side of the master link faces the forks.
6. At the pedestal access, attach the chain to the lower chain anchor with a master link, securing with a cotter pin.
7. Repeat steps 2 thru 6 for the other lift chain.
8. Reconnect the battery connector and turn the key switch ON.
9. Slowly and carefully request main lift until the slack is removed from the lift chains and the platform lifts slightly. Remove the blocking. Slowly and carefully lower the platform completely.
10. Adjust the lift chains as described under "Adjustment".

Adjustment

See "Fork Height and Lift Chain Adjustment" on page 7-115.

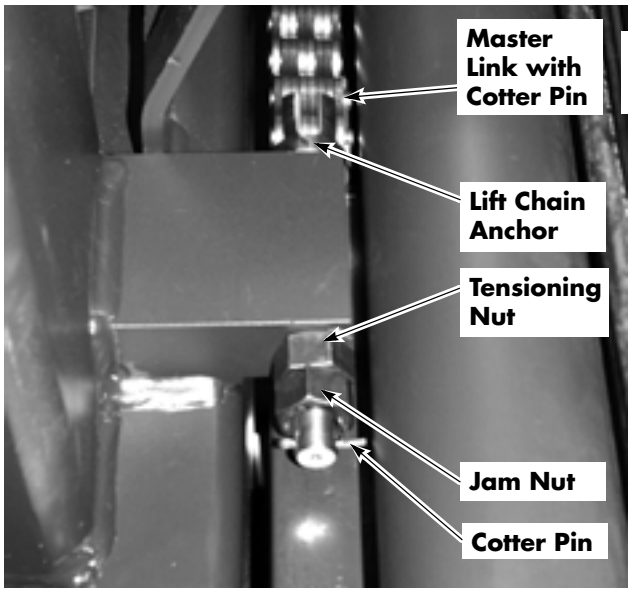
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Main Lift Chains (9700)

Removal

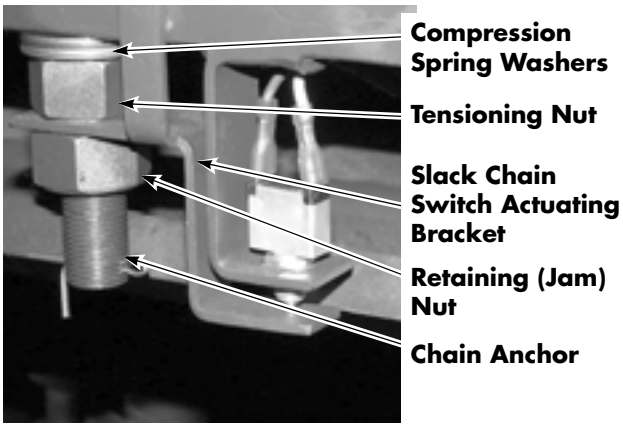
1. Center the load handler horizontally with forks straight ahead.
2. Loosen both upper chain anchor jam nuts before removing tension on lift chains.
3. Raise the platform 3 ft. (1 m) to permit access to the lower chain anchors.
4. Block and clamp the platform between the platform and baseleg (*not* the floor). Lower the platform onto the block to slacken the chains. See Figure 2-6 on page 2-11.
5. Turn the key switch OFF and disconnect the battery connector.
6. Measure and note the length of the exposed end of the upper chain anchor. Use this measurement to approximate correct chain tension during reassembly.
7. Remove safety cotter pin, jam nut, and tensioning nut from the lower chain anchor on each side. See Figure 7-111.

Figure 7-111. Lower Main Lift Chain Anchor



8. Working from a work platform, remove chain from upper chain anchor:
   a. Remove cotter pin, jam nut, and slack chain switch actuating bracket with switch. Remove tensioning nut and four compression spring washers. See Figure 7-112.
   b. Remove the chain anchor from the mast crosstie and pull the lift chain up and over the lift chain pulley.

Figure 7-112. Slack Chain Switch Bracket (9700)



9. Repeat step 8 for the other lift chain.
10. Remove chain anchors from chains by removing cotter pins and master links.

Installation

1. Attach chain anchors to both ends of the lift chains with master links, securing each with a cotter pin.
2. Add a large washer and nut to the upper lift chain anchor and attach a rope to the anchor. Tie the rope to the mast crosstie near the chain anchor bore.
3. Carefully feed the other end of the lift chain down the mast.
4. Underneath the platform, feed the chain anchor through the chain anchor block and secure with tensioning nut, jam nut, and cotter pin. See Figure 7-111.

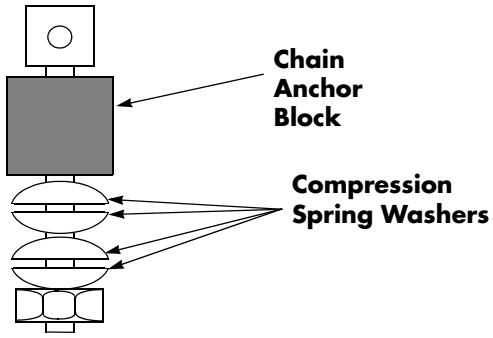
NOTE: Use the thinner jam nut on right side.

5. Repeat steps 2 thru 4 for the other lift chain.
6. On the right side, back the jam nut down against the cotter pin. Back the tensioning nut against the jam nut and tighten the nuts together.

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7. Measure the distance from the top of the tensioning nut to the bottom shoulder of the chain anchor.
8. On the left side, adjust the tensioning nut and jam nut so the distance between the top of the tensioning nut and the bottom shoulder of the chain anchor is 0.50 in. (12.7 mm) less than the distance you measured in step 7.
9. At the top of the mast, remove the rope, nut, and washer, and feed the chain anchor through the bore in the mast crosstie.
10. Attach tensioning and jam nuts. Install four compression spring washers between the chain anchor block and the tensioning nut. Then install the slack chain actuating bracket and switch between the tensioning nut and the retaining (jam) nut.

Figure 7-113. Compression Spring Orientation



NOTE: Make sure the compression spring washers are in the correct orientation so that they function correctly. See Figure 7-113. The compression spring washers compress fully when the chain is tight.

11. Attach the cotter pin. Leave the same length of exposed thread as you measured in removal step 6.
12. Reconnect the battery connector and turn the key switch ON.
13. Slowly and carefully request main lift until the slack is removed from the lift chains and the platform lifts slightly. Remove the blocking. Slowly and carefully lower the platform completely.
14. Adjust the lift chains as described under "Adjustment".

Adjustment

See "Fork Height and Lift Chain Adjustment" on page 7-115.

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Telescopic Removal and Mast Bearing Replacement (9700)

NOTE: To minimize rattle, rollers are available in widths between 5.406 in. (137.3 mm) and 5.562 in. (141.3 mm). Consult the Parts Manual. Measure the opening in the main frame and telescopic. Take measurements every foot of length to make sure you find the narrowest area. Using rollers that are too wide causes premature failure.

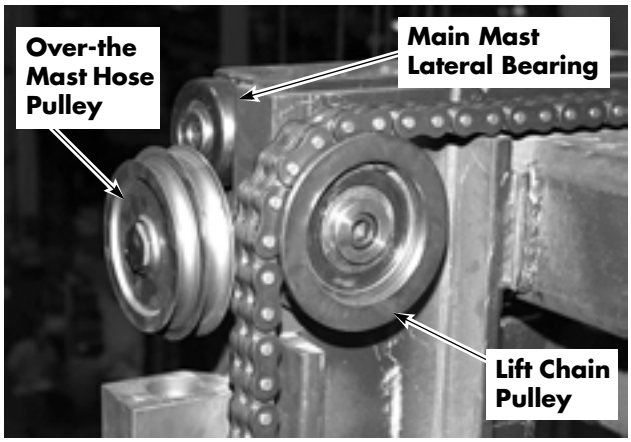
⚠ WARNING

Perform this procedure with a minimum of two technicians in a shop suitably equipped with a 10-ton hoist.

Removal

1. Remove the operator platform. See "Operator Platform" on page 7-100.
2. Remove Allen head bolt holding main mast lateral bearings (tip - mark the lateral bearing before removing it so that alignment is the same when reassembling), then remove bearings.
3. Remove fore-aft main mast bearings.
4. Remove nut attaching lift cylinder piston to the telescopic.
5. Wrap a 10-ton hoist strap twice around the upper telescopic crosstie.
6. Lift the telescopic about 4 ft. (1.2 m), block underneath, then change the position of the hoist strap to the second crosstie.
7. Lift the telescopic out of the main mast uprights and lower to the floor.

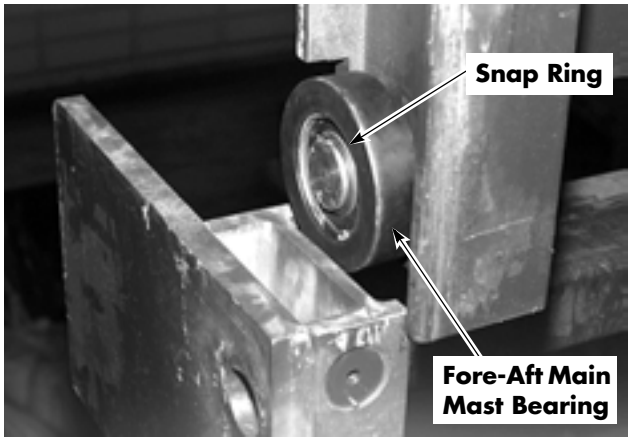
Figure 7-114. Main Mast Lateral Bearing (Right Side)



Bearing Replacement

1. Replace bearings by removing inner snap ring, then remove the bearing.
2. Place new bearing on bearing boss and install snap ring. See Figure 7-115.

Figure 7-115. Mast Bearing Replacement



Installation

1. Using a hoist as in steps 6 and 7 under "Removal," insert the telescopic in the main mast uprights. Slowly and carefully lower the telescopic onto the blocks.
2. Install fore-aft main mast bearing.
3. Install main mast lateral thrust bearing (could need some additional adjustment).
4. Move the hoist strap to the upper telescopic crosstie. Remove blocking, slowly lower the telescopic to the bottom. See Figure 7-115.

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5. Remove the hoist strap.
6. Reinstall the nut attaching the lift cylinder piston to the telescopic.
7. Install the operator platform.

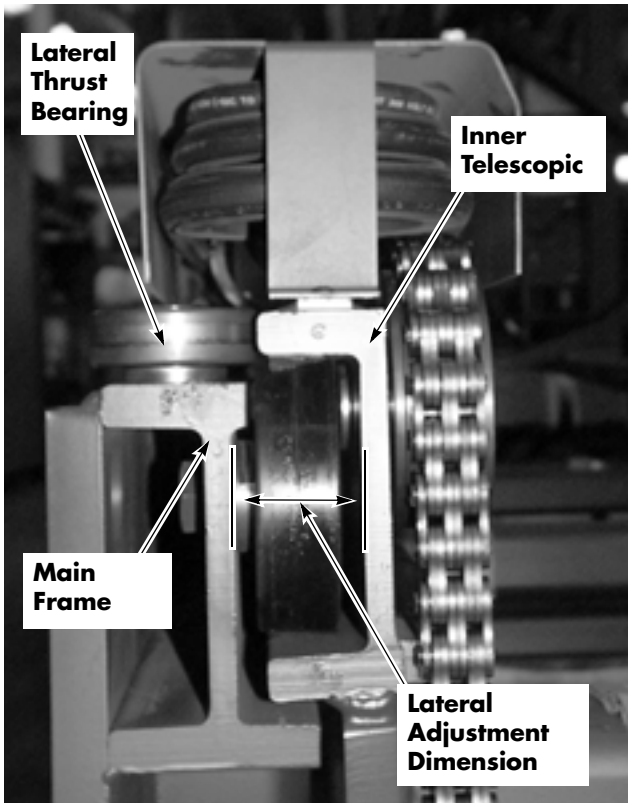
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Main Mast Lateral Bearing Adjustment (9700)

Adjustment

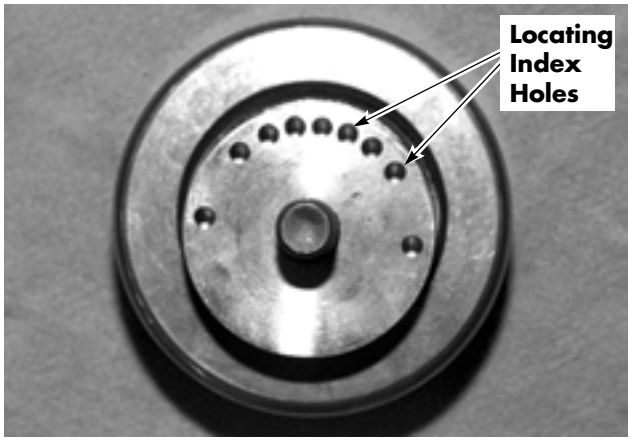
1. On both sides of the mast, measure the dimension between the inside of the main frame uprights and the outside of the inner telescopic.
2. Compare the dimensions to determine which way the telescopic needs adjustment.

Figure 7-116. Lateral Bearing Adjustment - 9700



3. Elevate the operator platform as required to gain access to the lateral thrust bearings on the main frame. Block and clamp the platform between the platform and baseleg (not the floor).
4. Turn the key switch OFF and disconnect the battery connector.
5. The lateral bearings are mounted on an eccentric. The bearing is positioned so a locating pin in the mast engages one of several adjustment holes. See Figure 7-117.

Figure 7-117. Lateral Thrust Bearing (Inside Surface)



6. Loosen or remove the bearing retaining bolt and remove the bearing.
7. Pry the carriage to the correct position.
8. Reposition the bearing on the locating pin offering the smallest clearance between bearing and main frame.
9. If the carriage is tight but not centered, loosen the bearings on one side before adjusting the bearings on the other side.
10. Torque all lateral bearing retaining bolts to 75 ft. lb. (102 Nm) with thread-locking compound P/N 990-536.
11. Remove blocking and clamps.
12. Reconnect the battery connector and turn the key switch ON.
13. When the bearings are adjusted correctly, only one upper and one lower bearing make contact with the main frame at a time.
14. Fully elevate the platform and check for binding between the main frame and telescopic. If both upper bearings or both lower bearings are making contact with the telescopic, the bearings are too tight. Loosen one bearing by one adjustment hole.

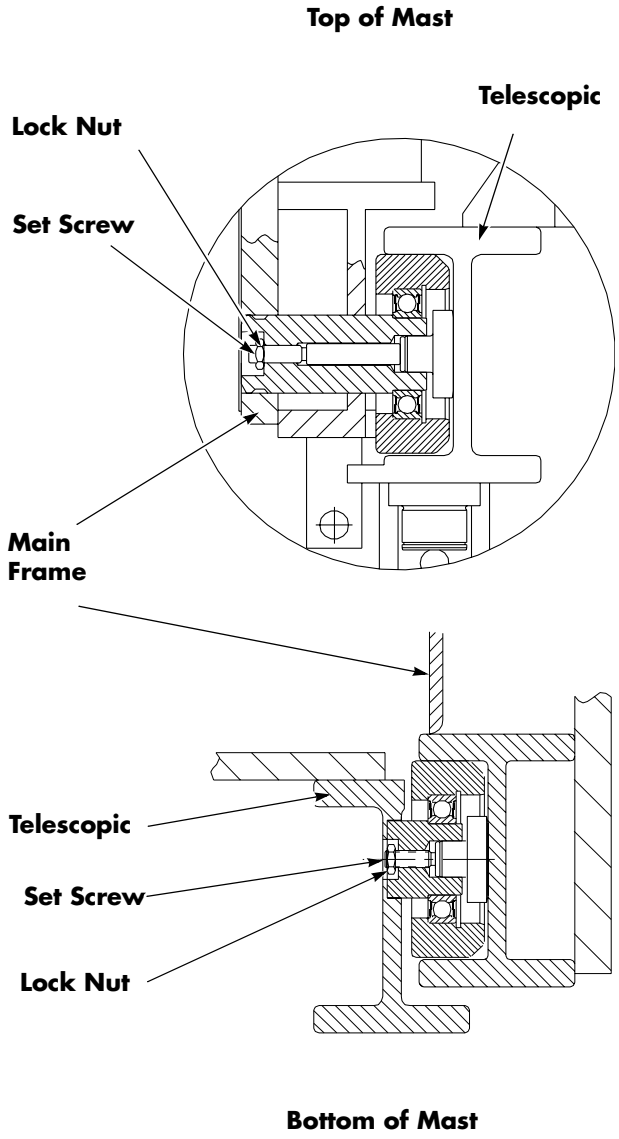
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Main Mast Lateral Bearing Adjustment (9600)

Adjustment

1. Loosen set screw lock nut. See Figure 7-118
2. Center the telescopic left to right within the main frame with the forks centered straight ahead. Turn the key switch OFF and disconnect the battery connector.
3. Tighten set screws equally to finish centering telescopic. If no adjustment remains, stop here. Replace the pucks. See "Telescopic Removal and Mast Puck/Bearing Replacement (9600)" on page 7-102.
4. Loosen set screw at top of mast, 1/4 turn on either side.
5. While holding set screw, tighten lock nut, both sides.
6. Apply thread-locking compound (P/N 990-536) to screw.
7. Tighten set screws at bottom of telescopic, then loosen 1/4 turn (both sides).
8. Tighten lock nut on either side after adjustment is done.

Figure 7-118. Lateral Bearing Adjustment - 9600



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Operator Platform

NOTE: *Read this entire procedure before beginning.*

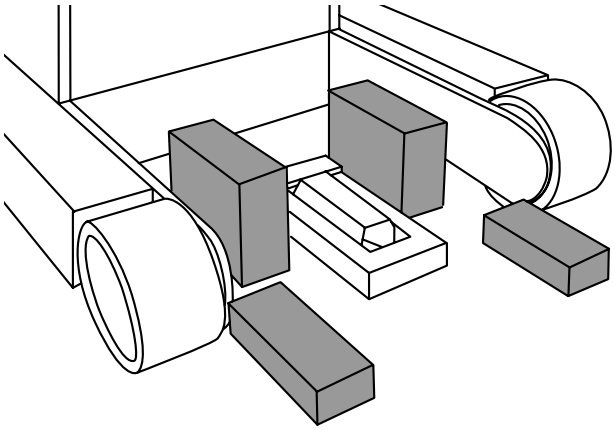
Removal

1. Elevate the carriage approx. 70 in. (1780 mm). Place adequate supports under the carriage to prevent it from lowering. Turn the key switch OFF and disconnect the battery connector.
2. Remove carriage stops from lower crosstie on inner telescopic by removing the bolts.
3. Reconnect the battery connector and turn the key switch ON. Remove supports. Lower the carriage.
4. Drive the truck a short distance to make sure that the drive unit is positioned straight ahead.
5. Enter Configure Mode. Record the current settings for Accel and Coast. Set:
   - Accel to “soft”
   - Coast to “long”

NOTE: See “Using Configure Mode” on page 3-26.

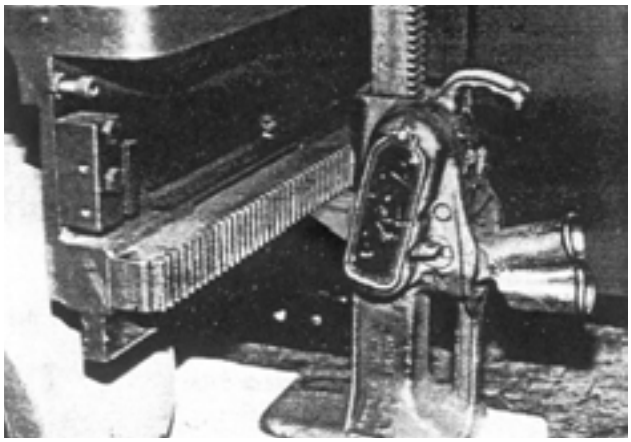
6. Center the mini-mast and position the forks straight ahead.
7. Slowly elevate the platform until fully elevated. Remove the mast sliders (9600 only).
8. Lower the platform.
9. Back adjustment screws out completely on all four carriage pucks.
10. Elevate the platform. Place blocks as shown in Figure 7-119.

Figure 7-119. Blocking Carriage



11. Lower the carriage onto the blocks. Continue to hold the lower control until the lift cylinders are fully collapsed.
12. Turn the key switch OFF and disconnect the battery connector.
13. Place one railroad jack on each side of the traverse rack as shown in Figure 7-120. This supports the front of the carriage.

Figure 7-120. Jacking Under Traverse Rack



14. Remove the pulley guards at the top of the telescopic. Remove the cables and hoses from the pulleys. Secure the hoses and cables to the overhead guard with cable ties.
15. Disconnect the lift chains at the connector links and secure to the overhead guard with cable ties.
16. Reconnect the battery connector and turn the key switch ON. *Slowly* elevate the telescopic section of the mast. Elevate the

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telescopic until the inner telescopic clears the carriage.

17. *Very slowly*, drive the tractor away from the carriage. *You can only move the tractor approx. 3 in. (76 mm) before the rollers on the carriage hit the lift cylinder housings.*

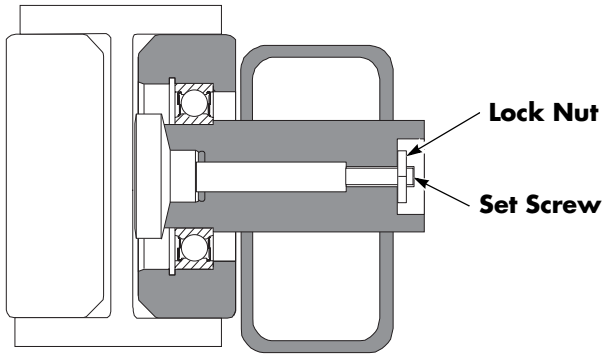
Installation

1. Reconnect the battery connector and turn the key switch ON. *Slowly*, move the tractor towards the carriage.
2. Once correctly positioned, lower the telescopic around the sliders/rollers on the carriage.
3. Install and adjust the lift chains. See "Main Lift Chains (9600)" on page 7-92.
4. Install and adjust the hoses and cables.
5. Perform lateral mast adjustment. See "Main Mast Lateral Bearing Adjustment (9600)" on page 7-99.
6. Add shims to the sliders until they do not enter the telescopic, then remove one shim. Apply thread-locking compound (P/N 990-536) to the slider bolts and fasten sliders with bolts.
7. Perform carriage lateral adjustment. Refer to "Lateral Adjustment".
8. Install the mechanical stops on the telescopic.
9. Elevate the platform enough to be able to bolt the stops removed in removal step 2. Block the carriage from dropping as in removal step 1.
10. Bolt the carriage stops to the lower crosstie of the inner telescopic. Apply thread-locking compound (P/N 990-536) to the bolts and torque to 75 ft. lb. (102 Nm).
11. Lower the main lift completely using the Emergency Lower Valve. Close the valve completely.
12. Enter Configure Mode and reset Accel and Coast parameters to the values recorded in removal step 5.
13. Test all lift truck functions.

Lateral Adjustment

1. Center the load handler with the forks straight ahead.
2. Elevate the carriage for access to bottom adjustments. Block and clamp the operator platform between the platform edge and baseleg.
3. Turn the key switch OFF and disconnect the battery connector.
4. Loosen set screw lock nut.
5. Using the set screws, center the carriage within the telescopic, and remove any side movement. If no adjustment remains, stop here. Replace the pucks. See "Telescopic Removal and Mast Puck/Bearing Replacement (9600)" on page 7-102.
6. Loosen each set screw 1/4 turn; lock in place.

Figure 7-121. Carriage Lateral Bearing Adjustment



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Telescopic Removal and Mast Puck/Bearing Replacement (9600)

Removal

1. Remove the operator platform. See "Operator Platform" on page 7-100.
2. Remove the mechanical stops from the telescopic.
3. Remove the retaining nut and washer at the top of each lift cylinder.
4. Carefully elevate the telescopic to its maximum elevated height.
5. Attach a hoist to the top crosstie of the telescopic with lifting straps. Take up slack to support the telescopic.
6. Remove the upper telescopic bearings and roller pins that are mounted in the main frame. Set screws hold the roller pins in place at the top of the main frame.
7. Remove the telescopic and replace all the pucks. While the telescopic is out, inspect all the bearings.
8. Replace worn or damaged components.

Installation

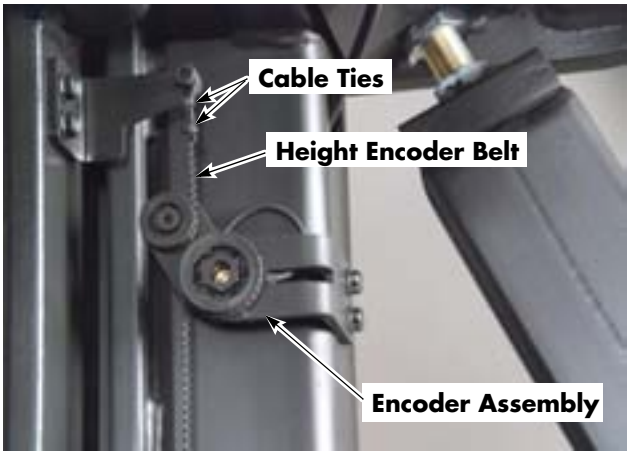
1. After replacing pucks and any other worn or damaged components, lower telescopic into main frame.
2. Install upper roller pins and bearings.
3. Apply thread-locking compound (P/N 990-536) to set screw and install. Make sure that roller pin is secured in place.
4. Lower telescopic onto lift cylinders. Install the washers and retaining nuts. *Do not* torque the retaining nuts tight.
5. Remove block and tackle.
6. Using the Emergency Lowering Valve, slowly lower the telescopic to a point where the carriage can still be inserted into the telescopic.
7. Install the operator platform. See "Operator Platform" on page 7-100.

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Height Encoder Belt Replacement

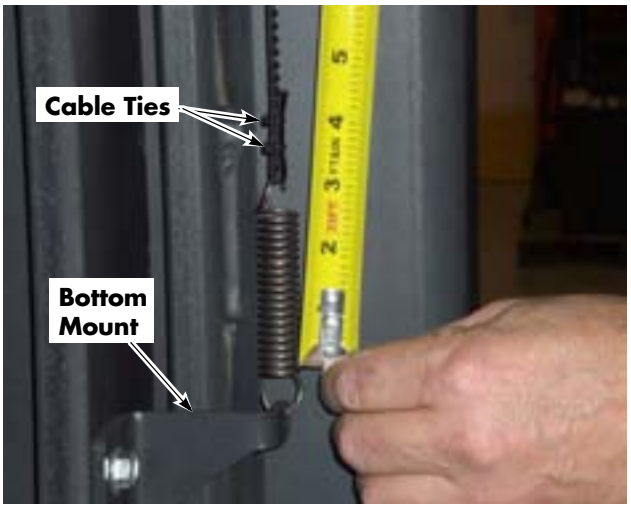
1. Turn the key switch OFF and disconnect the battery connector.
2. Loop the replacement belt around the shoulder bolt so that there is a 1.5 in. (38 mm) loop and secure belt with cable ties. See Figure 7-122.

Figure 7-122. Height Encoder Belt Routing



3. Route the belt through the encoder assembly and down through the mast. See Figure 7-122.
4. Raise and block the truck so the bottom spring mount is accessible. Insert spring into hook at bottom mount. See Figure 7-123. Loop the belt around the spring hook and draw taught until the spring body length is 2.5 in. (63.5 mm) and there is at least 1.5 in. (38 mm) of belt looped. Secure belt with cable ties as shown in Figure 7-123. Cut off excess belt material.

Figure 7-123. Height Encoder Belt Tension Spring



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Mini-Mast and Load Handler

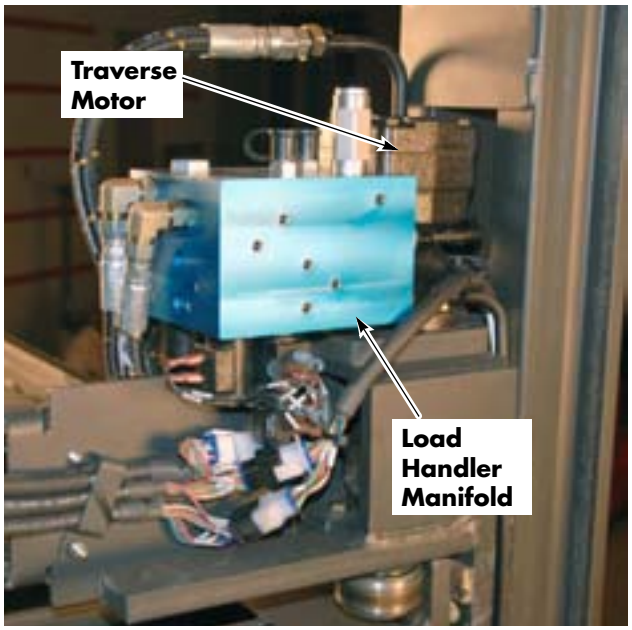
⚠ WARNING

Perform this procedure with a minimum of two technicians in a shop equipped with a 5-ton hoist.

Removal

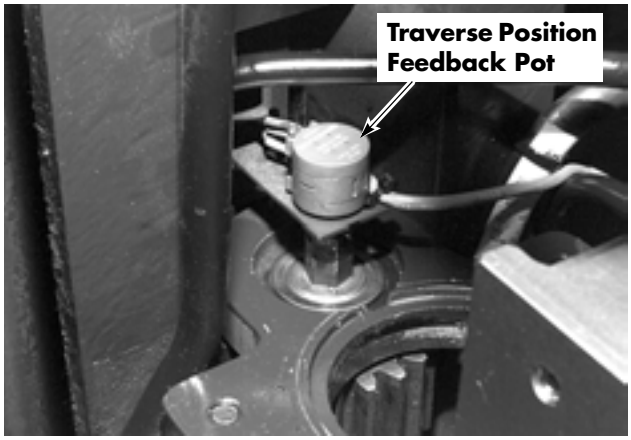
1. Traverse the load handler to the right, nest the forks, and lower the forks completely. Turn the key switch OFF and disconnect the battery connector.
2. Remove the forks.
3. Use a work platform, ladder, or other suitable device to gain access to components on top of the overhead guard. Remove the traverse motor cover.
4. Disconnect and label, if needed, the wires to SOL7, SOL8, SOL9A/B, and SOL10A/B on the Load Handler manifold. See Figure 7-124.

Figure 7-124. Load Handler Solenoids



5. Disconnect and cap the lift hydraulic hose from the tubing and plug the tubing.
6. Disconnect all hydraulic lines.
7. Remove bolts holding flexible hose/cable retainer bracket to the mini-mast. Remove bracket.
8. Remove the traverse motor mounting bolts.
9. Carefully lift the traverse motor and Load Handler manifold assembly up and out of the traverse shaft gear.
10. Remove the traverse position feedback pot assembly.

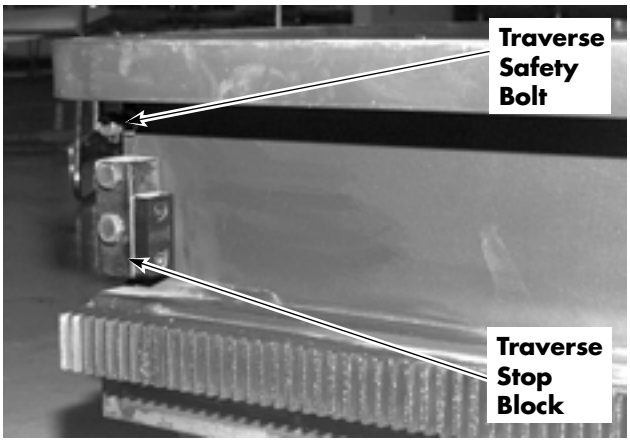
Figure 7-125. Traverse Position Feedback Pot



11. Attach a 5-ton hoist strap around the front of the fork carriage. Attach a second strap at the top of the mini-mast, under the stop plate.
12. Attach C-clamps to the mini-mast channel just above the top of the load handler. This prevents the load handler from being lifted up the mini-mast.
13. Remove the right side traverse stop block and safety bolt. See Figure 7-126.

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Figure 7-126. Traverse Stop Block and Safety Bolt



14. Using the hoist, take the weight off the traverse racks. Push the mini-mast past the rack stops until it is free of the rack.
15. Lower the mini-mast and load handler carefully to the floor.

Installation

1. Fasten C-clamps to the mini-mast to prevent movement of load handler.
2. Lift the mini-mast with a suitable hoist.
3. Install wear pads to left side, top, and bottom of mini-mast. For initial adjustment, insert 1 shim at the bottom and 3 at the top.
4. Mate and mesh the mini-mast gear to the traverse rack.
5. Install the traverse position feedback pot assembly to the traverse gear shaft. See Figure 7-125.
6. Install the traverse motor and manifold assembly. Install mounting bolts.
7. Reconnect all hydraulic lines removed for disassembly.
8. Reconnect wires to solenoids.
9. Install the traverse motor cover.
10. Install the safety bolt in the traverse rack. See Figure 7-126.
11. Install the traverse stop block. See Figure 7-126.
12. Test traverse operation and adjust mini-mast as necessary. See "Shimming the Mini-Mast".
13. Install the forks.

Shimming the Mini-Mast

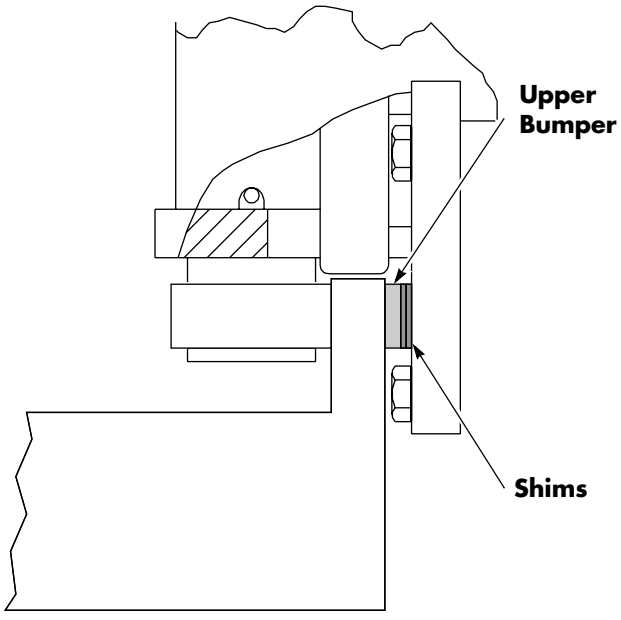
1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the traverse stop block from both sides of the carriage. See Figure 7-126.

⚠ WARNING

Make sure there is a safety stop bolt in each side of the carriage and that the bolts extend out far enough to prevent the mini-mast from traversing off the rack.

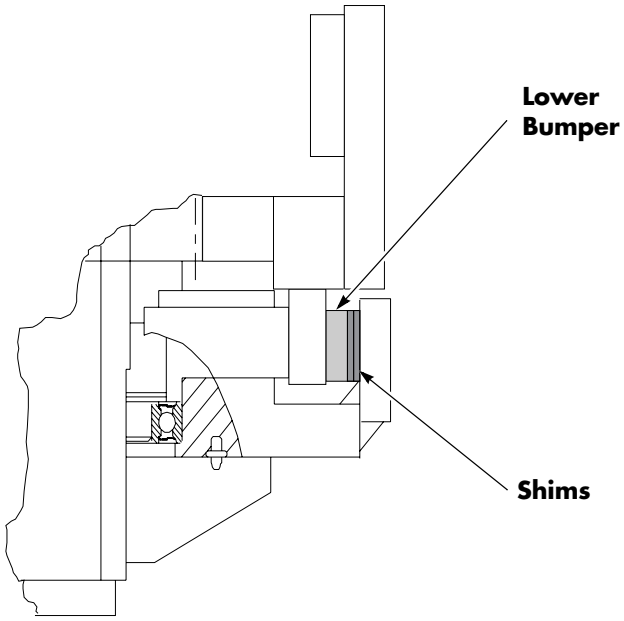
3. Reconnect the battery connector and turn the key switch ON. Slowly and carefully traverse the mini-mast to the right until it touches the safety stop bolt.
4. Turn the key switch OFF and disconnect the battery connector. Add or remove shims to the upper and lower bumper assemblies to obtain a gap equal to one thin shim.

Figure 7-127. Mini-Mast Shimming, Top



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Figure 7-128. Mini-Mast Shimming, Bottom



5. Reconnect the battery connector and turn the key switch ON. Slowly and carefully traverse the mini-mast to the left until it touches the safety stop bolt.
6. Turn the key switch OFF and disconnect the battery connector. Install the mast stop block on the right side.
7. Add or remove shims to the upper and lower bumper assemblies to obtain a gap equal to one thin shim.
8. Reconnect the battery connector and turn the key switch ON. Traverse the mini-mast to the center.
9. Turn the key switch OFF and disconnect the battery connector. Install the left side mast stop block.
10. Reconnect the battery connector and turn the key switch ON. Test traverse function in both directions for smooth operation.

Height Sensing Rail

Inspection

Check the height sensing rail for sharp edges or damage that may cause premature wear of the sensor housing. Grind the rail smooth or replace the damaged rail.

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Load Handler

⚠ WARNING

Perform these procedures with a minimum of two technicians in a shop equipped with a 5-ton hoist.

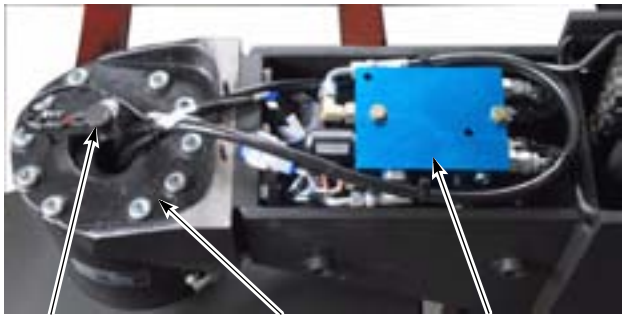
The load handler can be removed with the mini-mast attached to the truck or removed from the truck.

Mini-Mast Removed from Truck

Removal

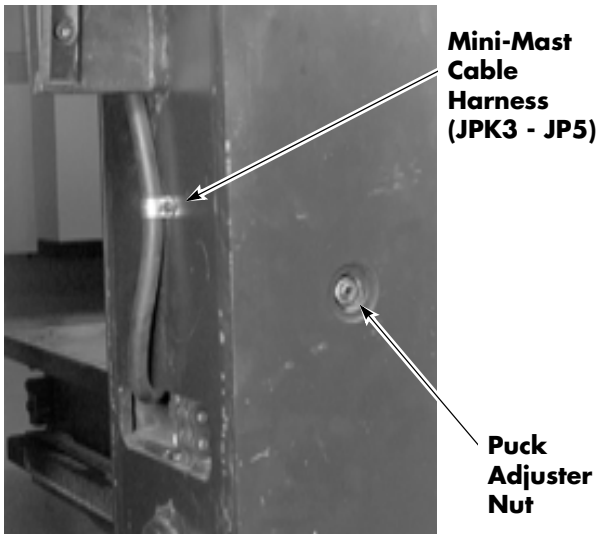
1. Remove the mini-mast and load handler from the operator platform. See "Mini-Mast and Load Handler" on page 7-104. Lay mini-mast down horizontally.
2. Attach hoist to load handler and position load handler approx. 12 in. (300 mm) from the bottom of the mini-mast. Secure the mini-mast from moving.
3. Disconnect JP5 at the mini power supply (under turret).
4. Disconnect the reach solenoid coil wires and label if necessary.

Figure 7-129. Load Handler Turret



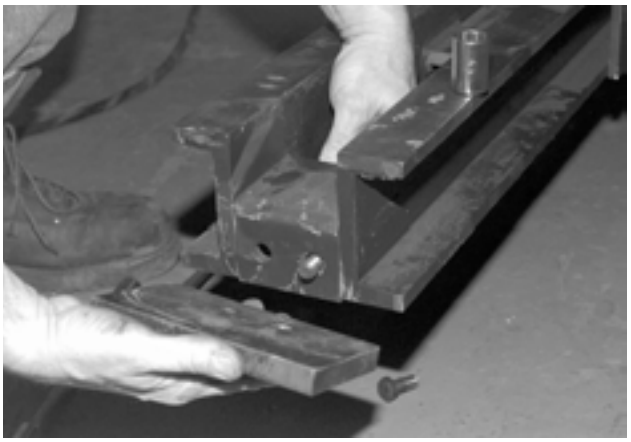
5. Remove the load handler electrical cable from the retaining clip on the load handler carriage. See Figure 7-130.
6. Loosen mini-mast puck adjuster lock nuts and back out the adjusting screws completely. See Figure 7-130.

Figure 7-130. Load Handler Electrical Cable



7. Remove the stop plate at the top of the mini-mast. See Figure 7-131.

Figure 7-131. Mini-Mast Top Stop Plate

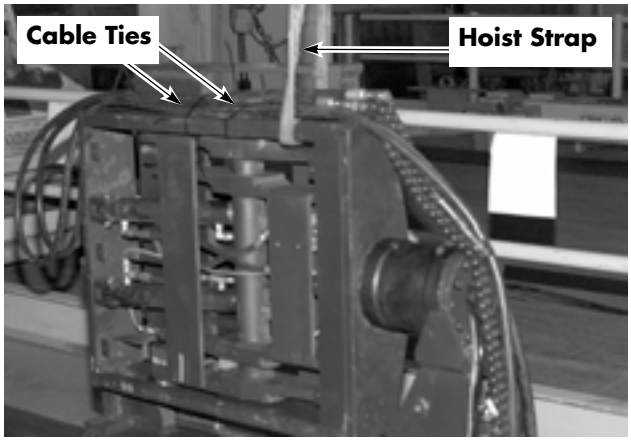


8. Disconnect the hydraulic hoses from fittings at the bottom of the cylinder.
9. Pull hydraulic hoses out through the top of the mini-mast.
10. Remove the lower chain anchor retaining nut near the bottom of the cylinder.
11. Pull the lift chain out through the top of the mini-mast.
12. Remove the rotate position feedback pot. See Figure 7-129.

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13. Feed the lift chain and hydraulic hoses forward over the actuator and down the side of the rotate carriage. Secure chain and hoses with cable ties. See Figure 7-132.

Figure 7-132. Load Handler Hoses and Chain Secured

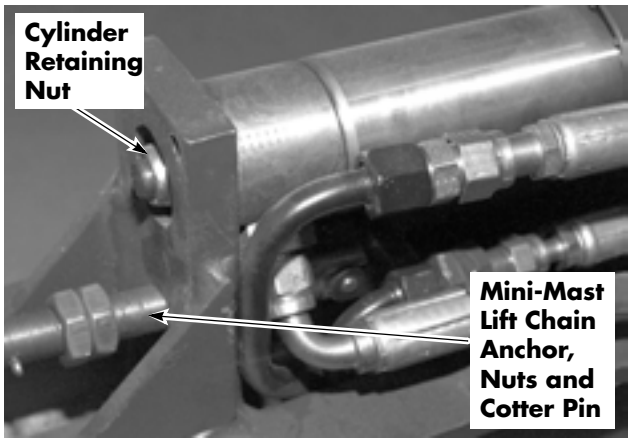


14. Block under the cylinder to prevent it from binding as the load handler is removed.
15. Using the hoist, slide the load handler up the mast, past the cylinder, and out the top end of the mini-mast. Lower carefully to the floor.

Installation

1. With the mini-mast laid down horizontally, place a block between the cylinder and mini-mast to prevent the cylinder from binding as the load handler is installed.
2. Attach a hoist to the load handler as shown. See Figure 7-132. Using the hoist, slide the load handler down the mini-mast and over the cylinder. Make sure the pucks engage the cylinder correctly.
3. Remove the cable ties securing the hoses, cable, and lift chain. Feed the hydraulic hoses and electrical cable over the pulley atop the cylinder, and back down through the load handler.
4. Feed the lift chain through the pulley atop the cylinder, then down through the load handler. Fasten the chain anchor to the mini-mast with retaining nut, jam nut, and cotter pin. See Figure 7-133.

Figure 7-133. Mini-Mast Lift Chain Anchor



5. Connect the hydraulic hoses to the fittings at the bottom of the cylinder.
6. Reinstall the rotate position feedback pot. See "Rotate Position Feedback Pot (VR6)" on page 7-63.
7. Install the stop plate at the top of the mini-mast. See Figure 7-131. Apply thread-locking compound (P/N 990-536) to the mounting bolts and torque to 70 ft. lb. (95 Nm).
8. Route the electrical cable.
9. Reconnect the reach solenoid coil wires. Reconnect JP5 at the mini power supply.
10. Adjust the mini-mast pucks. See "Mini-Mast Pucks" on page 7-113.

Mini-Mast Attached to Truck

Removal

1. Remove the load handler turret cover.
2. Retract the forks into their fully nested position. Rotate load handler so forks face straight ahead. Traverse the load handler completely to the left.
3. Turn the key switch OFF and disconnect the battery connector.
4. Remove the forks to keep the load handler balanced during this procedure.
5. Elevate the load handler approx. 12 in. (300 mm). Place blocks under the load handler carriage and lower the load

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handler onto the blocks. Let the lift chain, hoses, and cable go slack.

6. Remove the load handler pulley bracket cover. Remove the hoses and cable from the pulleys, laying them carefully to the side of the mini-mast.
7. Remove cable ties and disconnect the wires from the reach solenoid coil and JP5 at the mini power supply in the turret.
8. Disconnect hydraulic hoses at the bottom of the mini-mast.
9. Using a hoist or other suitable lifting device, support the load handler carriage with a strap. See Figure 7-134.

Figure 7-134. Strapping Load Handler Carriage



10. Remove the stop plate from the top of the mini-mast.
11. Remove the lift chain anchor at the bottom of the mini-mast. Lift the chain over the pulley and lay it carefully over the actuator. To pass the chain anchor through the pulley, twist the lift cylinder 90° with a large screwdriver in the pulley eye. Then twist the cylinder back into its normal position.
12. Remove the pulley bracket assembly from the mini-mast cylinder by removing the mounting bolt in the end of the cylinder.
13. Loosen mini-mast puck adjuster lock nuts and back out the adjusting screws completely.
14. Using the hoist, slowly lift the load handler out of the mini-mast and lower to the floor. Make sure cable, hoses, and chain do not bind or catch on the load handler.

Installation

1. Attach a hoist to the load handler as shown. See Figure 7-134. Lift the load handler into position. Slide the load handler down the mini-mast and over the cylinder. Make sure the pucks engage the cylinder correctly.
2. Feed the hydraulic hoses and electrical cable over the pulley atop the cylinder, and back down through the load handler.
3. Feed the lift chain through the pulley atop the cylinder, then down through the load handler. Fasten the chain anchor to the mini-mast with retaining nut, jam nut, and cotter pin. See Figure 7-133.
4. Connect the hydraulic hoses to the fittings at the bottom of the cylinder.
5. Reinstall the rotate position feedback pot. See “Rotate Position Feedback Pot (VR6)” on page 7-63.
6. Install the stop plate at the top of the mini-mast. See Figure 7-131. Apply thread-locking compound (P/N 990-536) to the mounting bolts and torque to 70 ft. lb. (95 Nm).
7. Route the electrical cable.
8. Reconnect the reach solenoid coil wires. Reconnect JP5 at the mini power supply.
9. Adjust the mini-mast pucks. See “Mini-Mast Pucks” on page 7-113.

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Traverse Gear Shaft

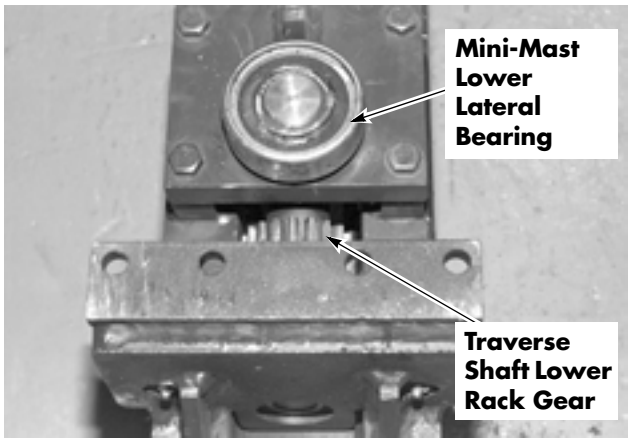
Removal

⚠ WARNING

Perform this procedure with a minimum of two technicians in a shop equipped with a 5-ton hoist.

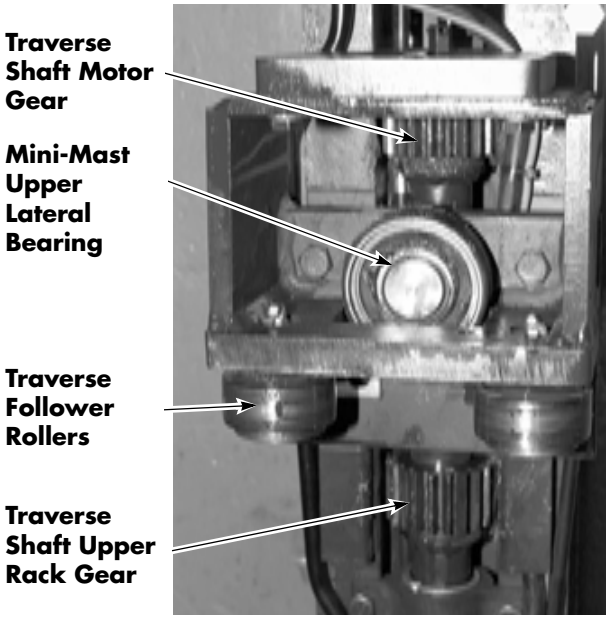
1. Remove the mini-mast and load handler. See "Mini-Mast and Load Handler" on page 7-104.
2. Stand the mini-mast and load handler erect and stabilize in place with the hoist.
3. Remove four bolts securing the mini-mast lower lateral bearing weldment and remove the bearing assembly. See Figure 7-135.

Figure 7-135. Traverse Gear Shaft and Lower Lateral Bearings



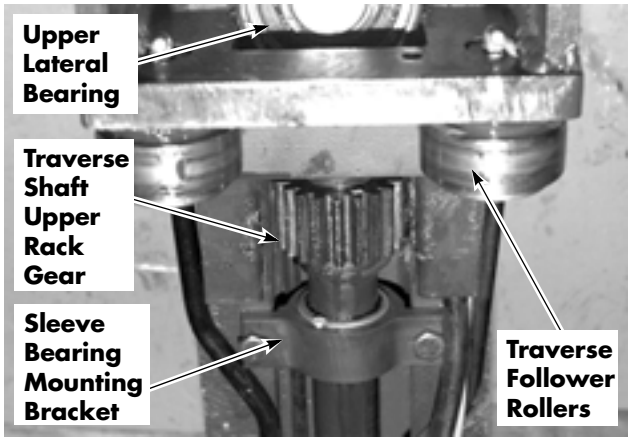
4. Remove four bolts holding the mini-mast upper lateral bearing weldment and remove the bearing assembly. See Figure 7-136.

Figure 7-136. Traverse Gear Shaft and Upper Lateral Bearing



5. Have your partner hold the gear shaft to prevent it from falling as you remove the two bolts securing the sleeve bearing mounting bracket. Remove the shaft and bearing bracket. See Figure 7-137.

Figure 7-137. Traverse Gear Shaft Removal



6. Remove the Traverse Position Feedback Pot adapter from the top of the shaft.

Installation

1. Install the sleeve bearing in the mounting bracket on the traverse gear shaft. See Figure 7-137.
2. Position the gear shaft in the mini-mast.

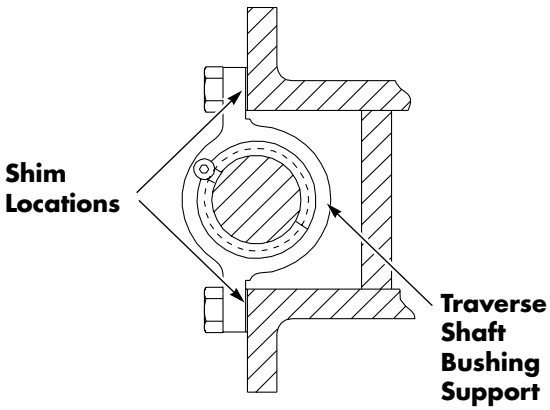
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3. Attach washer shims.
4. Pry between lower gear and mast weldment to seat shaft in lower bearing.
5. Attach the lower load bearing assembly, leaving a 3/16 in. gap between the load bearing and the top of the lower traverse gear.
6. Attach the upper bearing assembly.
7. Attach washers.
8. Attach the traverse gear shaft upper bearing plate to the bearing assembly. Make sure the plate does not bind on the gear. If binding occurs, add shims at the base of the shaft. Fasten plate with washers and bolts.
9. Center the traverse gear shaft in the mini-mast channel.
10. Torque the upper bearing housing bolts and lower bearing assembly bolts to 70 ft. lb. (95 Nm).
11. Screw the traverse potentiometer adapter onto the top of the shaft.
12. Install the mini-mast and load handler. See “Load Handler” on page 7-107.
13. Reinstall the rotate position feedback potentiometer. See “Rotate Position Feedback Pot (VR6)” on page 7-63.
14. Install the stop plate at the top of the mini-mast.
15. Route the electrical cable.
16. Reconnect the reach solenoid coil wires. Reconnect JP5 at the mini power supply.
17. Adjust the mini-mast pucks. See “Mini-Mast Pucks” on page 7-113.

Traverse Shaft Shimming

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the inspection cover on the tractor side of the mini-mast (facing the operator).
3. Remove two bolts securing the traverse bushing support.
4. Add or remove shims as needed so no loading occurs on the traverse shaft. See Figure 7-138.

Figure 7-138. Traverse Shaft Shimming



5. Apply thread-locking compound (P/N 990-536) to the bushing support mounting bolts and install. Torque to 43 ft. lb. (68 Nm).
6. Reinstall the inspection cover on the mini-mast.
7. Check the shimming of the mini-mast. See “Shimming the Mini-Mast” on page 7-105.
8. Reconnect the battery connector and turn the key switch ON.
9. Test the traverse function in both directions for smooth and correct operation.

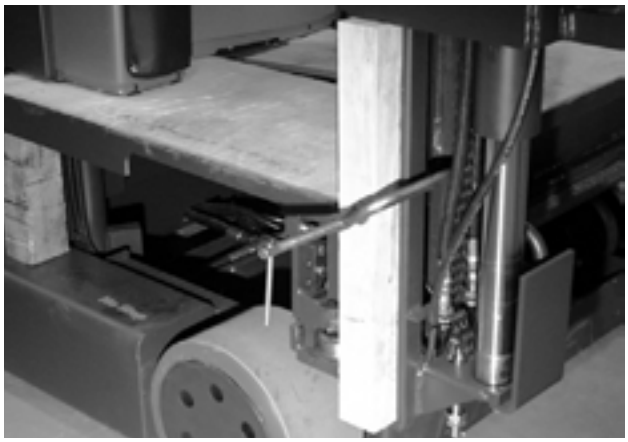
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Load Handler Lift Chain

Removal

1. Traverse the fork carriage to one side. Rotate the forks to the straight ahead position.
2. Elevate the operator platform approx. 12 in. (300 mm) to gain access to the mini-mast lower chain anchor nuts and cotter pin. Block and clamp the platform between the platform and baseleg (*not* the floor). See Figure 2-6 on page 2-11.
3. Install a temporary cable tie securing the electrical cable to the metal tubing. This prevents the cable tensioning spring from becoming disconnected in the load handler.
4. Elevate the load handler approx. two ft. (600 mm). Block and clamp a wooden block in the mini-mast channel. See Figure 7-139.

Figure 7-139. Blocking Load Handler



5. Lower the load handler until the mini-mast lift chain becomes slack.
6. Turn the key switch OFF and disconnect the battery connector.
7. Remove the master (connector) link from the lower chain anchor.
8. Pull the front chain anchor out of the mini-mast carriage frame. Remove the master (connecting) link.
9. Remove the chain from the pulley assembly.

Installation

1. Feed the new chain over the chain pulley. Pull it through the opening in the mini-mast carriage frame. Attach the chain to the chain anchor with a new master (connector) link. Insert the upper chain anchor in the opening in the frame.
2. Attach the other end of the lift chain to the bottom chain anchor with a new master (connector) link.
3. Reconnect the battery connector and turn the key switch ON.
4. Slowly elevate the load handler to remove slack. Elevate platform and remove clamps and blocking. Lower platform and load handler. Remove temporary cable tie.

Adjustment

See “Fork Height and Lift Chain Adjustment” on page 7-115.

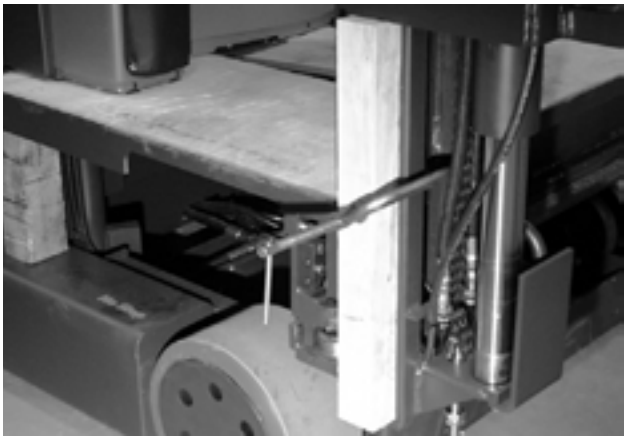
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Mini-Mast Pucks

Removal

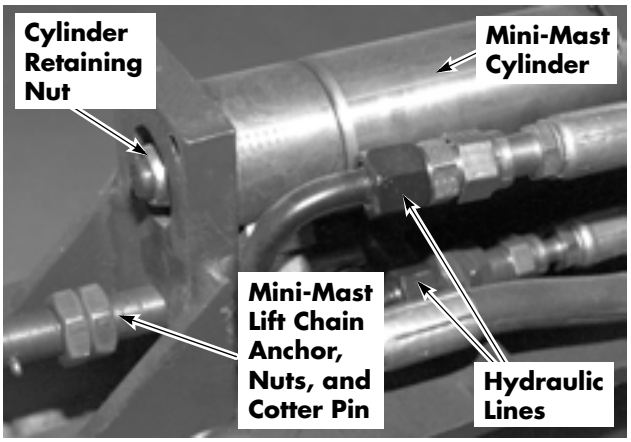
1. Remove the load handler turret cover.
2. Retract the forks into their fully nested position.
3. Elevate the load handler approx. two ft. (600 mm). Block and clamp a wooden block in the mini-mast channel. See Figure 7-139.

Figure 7-140. Blocking Load Handler



4. Turn the key switch OFF and disconnect the battery connector.
5. Remove the forks to keep the load handler balanced during this procedure.
6. Remove the load handler pulley bracket cover. Remove the hoses and cable from the pulleys.
7. Remove cable ties and disconnect electrical components in the load handler turret.
8. Disconnect two hydraulic hoses at the bottom of the mini-mast. See Figure 7-141.

Figure 7-141. Load Handler Lift Cylinder Connections



9. Using a hoist or other suitable lifting device, support the load handler carriage with straps.
10. Remove the lift chain anchor at the bottom of the mini-mast and lift the chain over the pulley. To pass the chain anchor through the pulley, twist the lift cylinder 90° with a large screwdriver in the pulley eye. Then twist the cylinder back into its normal position.
11. Loosen mini-mast puck adjuster lock nuts and back out the adjusting screws completely.
12. Using the hoist, slowly lift the load handler up the mini-mast past the cylinder to expose the cylinder pucks in the load handler.
13. Using a work platform or ladder, reach into the load handler to remove the nylon pucks and metal washers.
14. Clean the mini-mast cylinder of all grease and dirt. Apply a clean coating of grease where the pucks contact the cylinder.

Installation

1. Install new nylon pucks with metal washers between the puck and the carriage.
2. Make sure the mini-mast cylinder puck lock nuts are loosened and the adjuster screws backed out completely.
3. Using the hoist, slowly lower the load handler until it rests on the blocks.

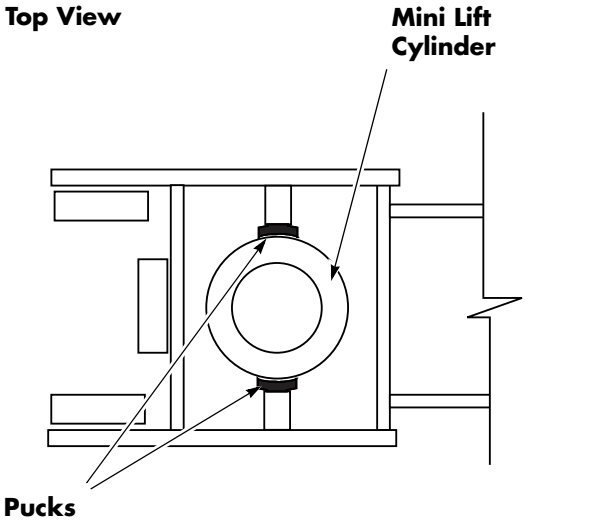
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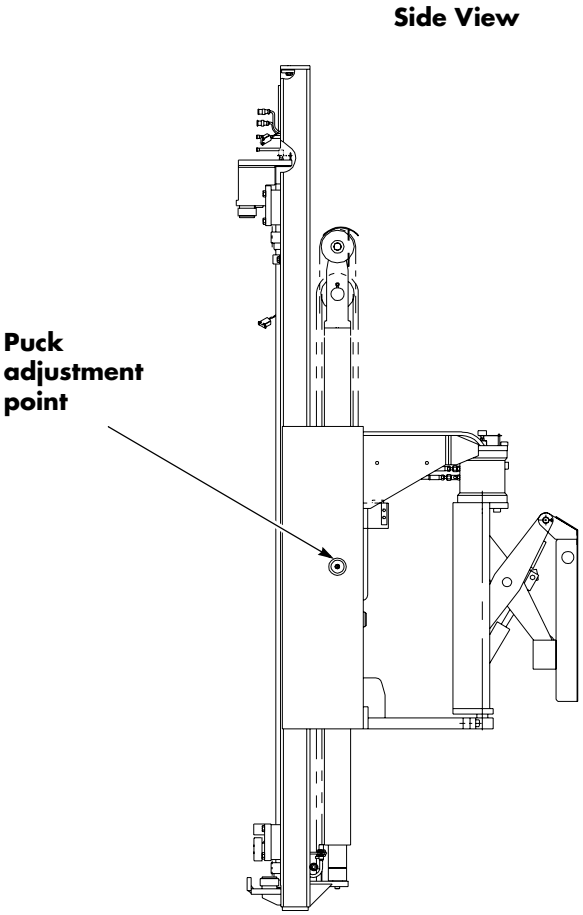
4. Using a large screwdriver, twist the mini-mast cylinder 90° and feed the mini-mast lift chain anchor through the lift chain pulley. Once the chain hangs freely, twist the cylinder back into its normal position. Feed the lift chain and attach the chain anchor to the mini-mast.
5. Reconnect the hydraulic hoses to the tubing fittings at the bottom of the mini-mast.
6. Route and connect the electrical cable to the turret at the reach solenoid and the height manager. Attach cable ties, being careful not to pinch the wires too tightly.
7. Loop hoses and electrical cable over their pulleys and reattach the pulley bracket cover.
8. Reconnect the battery connector and turn the key switch ON.
9. Slowly raise the load handler to remove slack in over-the-mast hoses and cable. Remove blocks and lower the load handler completely.
10. Check and adjust the fork height. See "Fork Height and Lift Chain Adjustment" on page 7-115.
11. Adjust the mini-mast cylinder pucks. See "Adjustment".
12. Bleed the hydraulic system. See "Bleeding the Hydraulic System" on page 7-74.

Adjustment

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the rotate turret cover.
3. Loosen the lock nuts securing the puck adjustment screws.
4. Center the mini-mast cylinder horizontally in relation to the mast channel, within 1/8 in. (3 mm).
5. Torque the puck adjusting screws equally to 30 in. lb. (3.4 Nm).
6. Tighten the puck adjusting screw lock nuts.
7. Test mini-mast lift and lower functions for smooth operation.

Figure 7-142. Mini-Mast Puck Adjustment





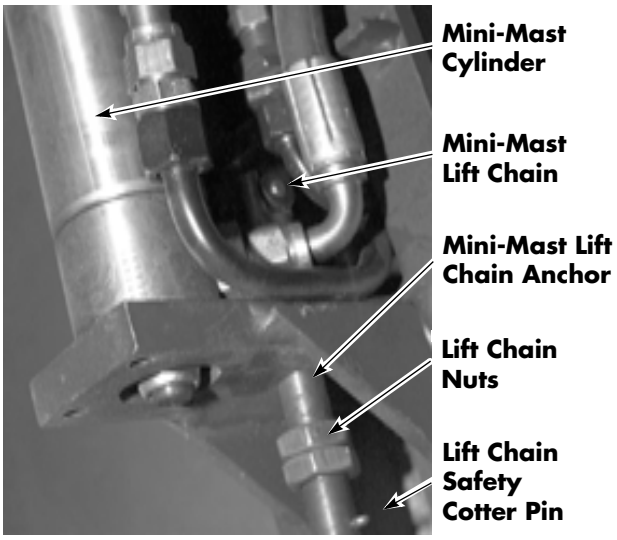
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Fork Height and Lift Chain Adjustment

Adjust main lift chains in conjunction with the mini-mast lift chain.

1. Turn the key switch OFF and disconnect the battery connector.
2. Loosen the jam nut and the tensioning nut on the mini-mast lower chain anchor until the roller bearings rest on the bottom of the mast upright.

Figure 7-143. Mini-Mast Lift Chain Anchor



3. Tighten the tensioning nut until the fork carriage is raised 0.5 in. (12.7 mm) from the fully lowered position in step 2. Tighten the jam nut.
4. Loosen jam nuts on both main lift chains.
5. Adjust both main lift chains by tightening or loosening the tensioning nuts evenly to obtain a distance of 3 in. (76 mm) from the top of the fork to the floor, measured 4 in. (100 mm) in front of the fork heel.

NOTE: If the truck has the floor lowered height option, fork height adjustment is 2 in. (51 mm) from top of the fork to the floor, measured 4 in. (100 mm) in front of the fork heel.

6. Measure the distance from the top of the platform to the floor on both sides. Adjust main lift chains, if necessary, so the platform hangs evenly (level) on the chains.

NOTE: The distance from the top of the platform to the floor must not exceed 16.5 in. (42 cm) to allow clearance between the top telescopic roller and the over-the-mast hose/cable pulley.

7. Tighten jam nuts on both main lift chains.
8. Refer to Input I105 – Mini Ht Ct [Mini-Mast Height Count] (page 6-108) to verify the mini-mast height sensor can still recognize that the forks are fully lowered.

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RAYMOND

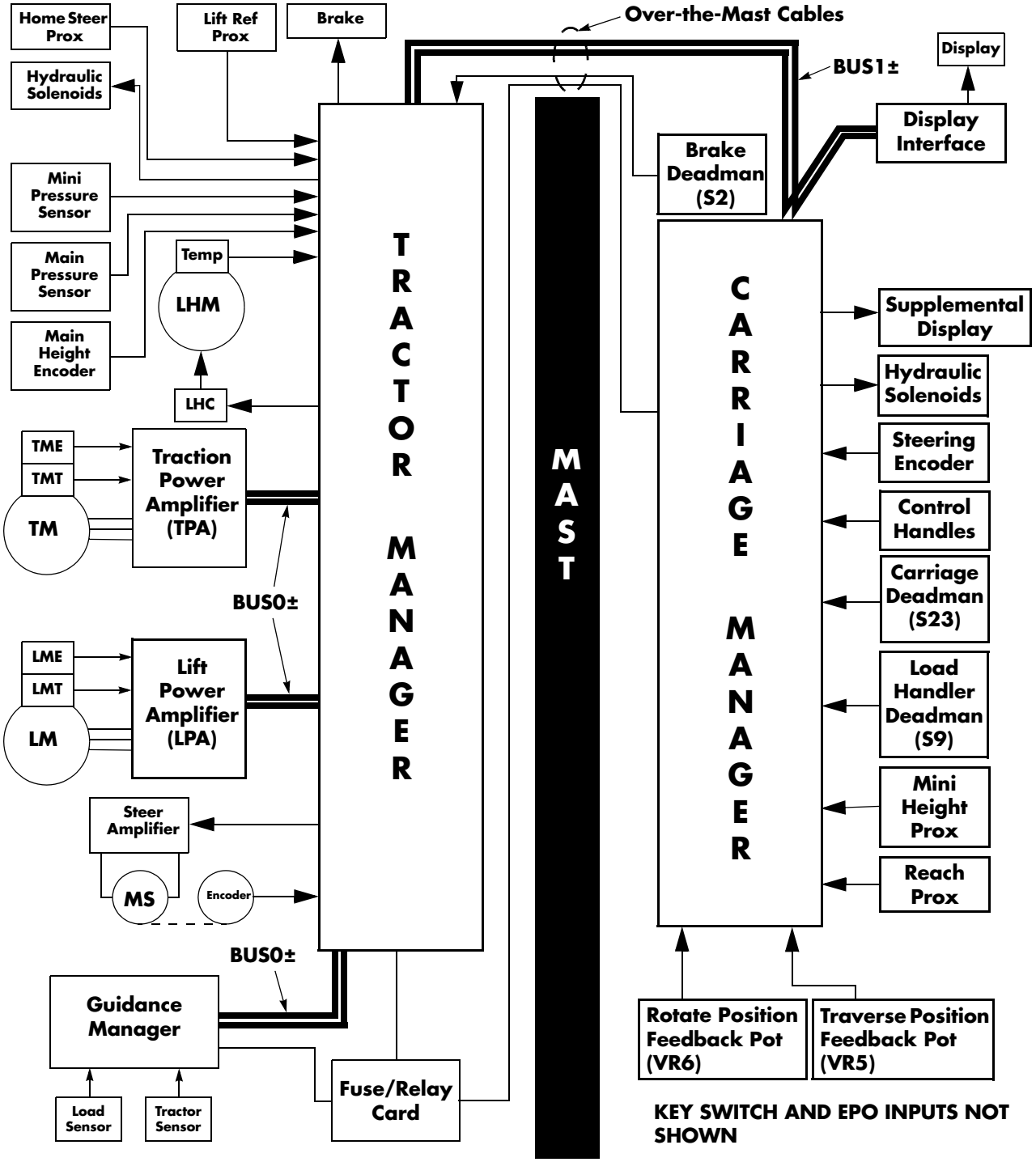
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Section 8. Theory of Operation

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System Architecture

Figure 8-1. System Architecture Diagram



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Communications Overview

Vehicle operation is accomplished via several input and feedback mechanisms. The system has two separate communication (BUS) lines which distribute appropriate information to multiple devices. See Figure 8-1 on page 8-2.

NOTE: The Tractor Manager is the main controller in the system. All communication is routed through the Tractor Manager.

- BUS0 provides communication between the Traction Power Amplifier, Lift Power Amplifier, Guidance Manager, and Tractor Manager.
- BUS1 provides communication between the Tractor Manager, Carriage Manager, and Display Interface Card.

NOTE: The Display Interface Card controls the Operator Display.

Tractor Manager

The Tractor Manager (TM) is the main controller in the system. It communicates with all other devices that are on the communication lines, BUS0 and BUS1. The TM receives information on the status of multiple devices such as the Deadman pedals, Mini Height Prox, Load Handler position and right hand control handle from the Carriage Manager. It also receives Traction Motor speed, direction, and temperature information from the Traction Power Amplifier (TPA) and Lift Motor speed, direction, and temperature information from the Lift Power Amplifier (LPA). The TM determines allowable vehicle operation based on those inputs and operator requests. The TM directly monitors and controls the steering system of the truck in both Auto and Manual modes of operation. The TM calculates and maintains the fork height count based on direct inputs from the Lift Reference Proximity switch, Height Encoder and Mini Height Prox. The TM will impose a deceleration of the lift/lower system as it approaches full elevation and also a reduction in lowering speed when approaching the bottom. The TM calculates load weight based on main and mini lift system pressures. The TM reduces travel speed as necessary, based on platform height, load weight, load handler position, and optional devices. When in the guided mode, the TM receives information regarding truck position relative to the guide wire from the Guidance Manager (GM). During guided operation, the TM receives steer correction requests from the GM. It is the TM that slows or stops the truck as Heading Angle (HA) and Distance From Wire (DFW) limits are reached or exceeded. The TM calculates the Battery State-of-Charge (BSOC) from the voltage measured at Battery Sense In. The TM controls the relay enable circuit that, when the circuit is completed, activates the relays on the Fuse/Relay Card, and provides B+ to all solenoid and contactor coils. The TM also controls the Operator Display and is the only manager that can display fault codes. A copy of the vehicle identity is stored in the TM.

Carriage Manager

The Carriage Manager (CM) is an input device for deadman switches, sidegate switches, Mini Height Prox, Steering Encoder, travel pot, lift pot, and optional devices. It communicates with the TM via BUS1. The CM controls operation of the traverse/reach and rotate functions. It also calculates Load Handler position. A copy of the vehicle identity is stored in the CM.

Traction Power Amplifier

The Traction Power Amplifier (TPA) communicates with the TM only via BUS0. It receives all commands regarding travel direction and speed. The TPA monitors both the Traction Motor Encoder (TME) and Traction Motor Temperature (TMT) sensor. It determines, based on encoder feedback and the travel request, how it should control the motor, and determines if the performance has satisfied the travel command from the TM. If it has not, the TPA adjusts the motor control voltage or sends a fault code to the TM, as appropriate. The TPA is solely responsible for controlling Traction Motor current. The TPA sends the Traction Motor temperature to the TM. The TM then alters the travel request if necessary, depending on Traction Motor temperature. The TPA monitors its internal temperature and limits current or travel speed as required by its

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internal programming. The TPA also checks the operation of the Traction Power Contactor (TPC), the pre-charging of the amplifier, and various internal operating parameters. It also sends fault codes to the TM if anything is operating incorrectly. A copy of the vehicle identity is stored in the TPA.

Lift Power Amplifier

The Lift Power Amplifier (LPA) communicates with the TM via BUS0 only. It receives all lift/lower speed commands. The LPA monitors both the Lift Motor Encoder (LME) and Lift Motor Temperature (LMT) sensors. It determines, from the encoder feedback and lift/lower request, if the motor has achieved the commanded speed request. The LPA solely controls Lift Motor current. It sends Lift Motor temperature to the TM. The TM determines if the motor must be limited due to motor temperature. The LPA monitors its internal temperature and limits current or lift speed as required by its internal programming. The LPA also checks operation of the Lift Power Contactor (LPC), the pre-charging of the amplifier, and various internal operating parameters. It also sends fault codes to the TM if anything is operating incorrectly.

Display Interface Card

The Display Interface Card is connected to the BUS1 communication line. The display has internal software (Graphics Database Download) that allows it to control the display module. A back-up copy is stored in the TM. The Display Interface Card communicates with the TM only. A jumper installed at JPD5 determines the baud rate for BUS communication. Correct placement of the jumper is required to avoid communication error codes. For jumper location, see "Display Interface Card" on page 5-18.

Guidance Manager

The Guidance Manager (GM) communicates with the TM only. The learned values for wire guidance are stored in the GM. It determines the position of the truck relative to the wire when in the guided mode. The GM uses inputs from the Filter Card to calculate the position of the truck relative to the guide wire. It then reports the truck position along with a command for steering direction to the TM via Bus0.

Systems Overview

Vehicle operation is accomplished via the following systems:

- Lift/Lower
- Traction
- Load Handler
- Steering/Guidance

Lift/Lower

The following components control the Lift/Lower system:

- **Tractor Manager** - determines the rate of lift or lower request sent to the LPA based on multiple inputs and controls the hydraulic solenoids to determine main or mini-mast movement. The TM calculates the height of the main and mini-mast to determine lift and lower deceleration points.
- **Lift Power Amplifier** - monitors and controls the LPC and Lift Motor so that varying lift and lower speeds are obtained.
- **Carriage Manager** - input for the pedal switches, lift/lower pot, lift select switch, and the Mini Height Prox switch.

Traction

The following components control the Traction system:

- **Tractor Manager** - determines the direction and rate request sent to the TPA based on multiple inputs.
- **Traction Power Amplifier** - monitors and controls the TPC and Traction Motor so that direction and speed requests are obtained.
- **Carriage Manager** - provides input for the pedal switches, travel pot, and calculates Load Handler position.

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Load Handler

The following components control the Load Handler system:

- **Carriage Manager** - activates solenoids to control rate and direction of traverse, rotate, and reach/retract, based on operator request and feedback pots. It also communicates Load Handler position to the TM.
- **Tractor Manager** - energizes the Load Handler Contactor (LHC) and updates the Operator Display.
- **Lift Power Amplifier** - monitors and controls the LPC so that B+ is supplied to the LHC.

Steering

The following components control the Steering system:

- **Tractor Manager** - determines direction and rate request sent to the Steer Power Amplifier (SA), based on multiple inputs. Calculates position using the Home Steer Prox and Steer Motor Encoder.
- **Carriage Manager** - calculates encoder requests and communicates them to the TM.

Wire Guidance

The following components control the Guidance system:

- **Auto/Manual Switch (S4)** – used by the operator to select manual or wire guided steering.
- **Carriage Manager** - monitors the state of the Auto/Manual switch and advises the TM if it is open (Auto) or closed (Manual).
- **Tractor Manager** - controlling manager for the steering and travel systems. When the Auto/Manual switch is in the Auto position, it uses truck position information supplied by the GM to provide steering control. The TM also provides direction and speed information to the GM that enables it to provide steering commands for forward or reverse travel.
- **Steer Power Amplifier (SA)** - amplifies the steering commands from the TM and controls the steer motor.
- **Guidance Manager (GM)** - comprised of two physically and electrically connected printed circuit cards:
  - **Filter Card** - conditions and amplifies the AC guidance voltages received from the Antenna Cards and converts them to DC voltages used by the Guidance Card. It also supplies digital signal conditioning inputs to the Antenna Cards as dictated by the frequency selection in Configure Mode and other program constraints.
  - **Guidance Card** - calculates truck position relative to the guide wire using the voltages received from the Filter Card. The Guidance Card informs the TM of the necessary steering corrections to keep the truck over the wire, guidance system error codes, DFW, and HA information.
- **Antenna Cards** - there are two Antenna Card assemblies. Each has 4 coils. The center pair are the Near Wire Coils and the outer coils are the Guidance Coils. These sensor coils have an AC voltage induced into them by the magnetic field being radiated from the guide wire. These AC voltages are amplified and sent to the Filter Card.
- **Steer Motor Encoder** - when the steer motor armature is rotating, the steer motor encoder produces a pair of quadrature phased square waves used by the TM to determine steer motor speed and direction of rotation. The TM checks this information against the steering commands from the GM to verify correct operation.
- **Home Steer Prox** - used by the TM to determine “Home” or straight ahead position of the drive unit.
- **Guide Wire** - a wire that is installed in the facility floor that radiates a magnetic field when an AC current flows through it.

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Functional Operation

SelfTest

During SelfTest, the Tractor Manager is communicating with all managers and amplifiers. It also looks at switch inputs/outputs and verifies truck identification. Upon completion of a successful SelfTest, the truck is operational.

TM SelfTest Sequence

- Checks the microprocessor to make sure it is enabled and all portions are functional
- Runs software checksum calculation
- Tests RAM
- Looks for correct battery voltage and calculates BSOC
- Checks truck-specific information (can be seen via FlashWare)
- Looks for a jumper at TMID0 (JPT24 pin 16 to pin 4) to determine that it has the correct software for the configured identity
- Establishes communication and checks for compatible software version in GM
- Establishes communication with the CM. Checks for compatible software and that the truck specific ID stored matches what it has stored
- Establishes communication with the LPA. Checks for compatible software
- Establishes communication with the TPA. Checks for compatible software and that the truck specific ID stored matches what it has stored
- Checks the EPO (S21) status
- Checks for compatible software version in TM
- Checks deadman switch (S2) for correct position
- Verifies travel (VR1) and lift/lower (VR2) control handle inputs are not out of neutral
- Verifies relays and contactors are not welded
- Activates the STR contactor and looks to see if FU1_Sense changes state
- Verifies the brake holds the vehicle with a small amount of current being applied to the drive motor
- Checks status of remaining inputs.
- Verifies the model number the software is written for matches the model number programmed in the truck

TPA SelfTest Sequence

- Checks the microprocessor to make sure it is enabled and all portions are functional
- Runs software checksum calculation
- Tests RAM
- Looks at JPTA1-12 to determine the configured identity
- Pre-charges the Amplifier's internal capacitors
- Activates the TPC and verifies its closure
- Backup copy of truck identity is communicated as needed
- Establishes communication with the TM
- Tests motor

LPA SelfTest Sequence

- Checks the microprocessor to make sure it is enabled and all portions are functional
- Runs software checksum calculation
- Tests RAM
- Looks at JPLA1-11 to determine the configured identity
- Pre-charges the Amplifier's internal capacitors
- Activates the LPC and verifies its closure
- Establishes communication with the TM
- Tests motor

CM SelfTest Sequence

- Checks the microprocessor to make sure it is enabled and all portions are functional
- Runs software checksum calculation
- Tests RAM

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- Checks EPROM
- Looks for a jumper at CMID1 (JPC22 pin 22 to JPC24 pin 4) to determine that it has the correct software for the configured identity
- Checks deadman switches (S9 and S23) for correct position
- Establishes communication with the TM
- Verifies traverse/reach (VR4) and rotate (VR3) control handle inputs are not out of neutral

GM SelfTest Sequence

- Checks the microprocessor to make sure it is enabled and all portions are functional
- Runs software checksum calculation
- Tests RAM
- Checks EPROM
- Establishes communication with the TM

Emergency Power Off

The CM and TM monitor the status of the Emergency Power Off (EPO) switch (S21). Both the CM and TM can generate an error code when an open in the circuit is detected.

Depressing the EPO directly removes the B+EPO voltage from the K1, K2, and K3 coils on the Fuse/Relay Card. With B+ to the coils interrupted, none of the relays activate and B+ is removed from the brake, contactor, solenoid coils, and power amplifiers.

Lift/Lower System

Main Lift/Lower

Lifting the main mast requires both right hand deadman pedal switches (S2 and S23) to be activated. The TM processes information received from the CM (via BUS1) regarding VR2 position to determine direction and rate of the request. To lift, the TM activates the Main Lift Select Solenoid (SOL4) through its internal coil driver. To lower, the TM activates the Main Load Hold (SOL3) and Lower Solenoid (SOL1). Speed is reduced as necessary based on fork height. During normal run, the truck decelerates near the fully extended or lowered position (refer to "Height Calculation" on page 8-10). Optional devices may cause additional restrictions or inhibit the function. See "Configuration and Truck Setup Options" on page 3-12.

Once the TM has determined the direction and rate requested, it communicates that to the LPA. The LPA controls the LPC, and the Lift Motor speed and direction for optimal performance. The LPA monitors Lift Motor current and imposes restrictions as necessary. The LPA sends temperature information to the TM which may impose restrictions.

Mini Lift/Lower

Lifting the mini-mast requires both right hand deadman pedal switches (S2 and S23), the left hand deadman switch (S9), and the Mini Lift Select switch (S6) to be activated. The TM processes the information received from the CM (via BUS1) regarding VR2 position to determine the direction and rate of the request. To lift, the TM activates the Mini Lift Select Solenoid (SOL6) through its internal coil driver. To lower, the TM activates the Mini Load Hold Solenoid (SOL5) and Lower Solenoid (SOL1). Speed is reduced as necessary based on fork height. During normal run, the truck decelerates near the fully extended or lowered position (refer to "Height Calculation" on page 8-10). Optional devices may cause additional restrictions or inhibit the function. See "Configuration and Truck Setup Options" on page 3-12.

Once the TM has determined the direction and rate requested, it communicates the speed requested to the LPA. The LPA controls the LPC, and the Lift Motor speed and direction for optimal performance. The LPA monitors Lift Motor current and imposes restrictions as necessary. The LPA sends temperature information to the TM which may impose restrictions.

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Traction System

Travel requires both right hand deadman pedal switches (S2 and S23) to be activated. The TM processes the information received from the CM (via BUS1) regarding VR1 position to determine the direction and rate of the request.

Load Handler position, vehicle height, and optional devices may cause additional restrictions or inhibit the function. See "Configuration and Truck Setup Options" on page 3-12.

Once the TM has determined the direction and rate requested, it communicates the speed requested to the TPA. The TPA controls the TPC, Traction Motor speed and direction for optimal performance. The TPA monitors Traction Motor current and imposes restrictions as necessary. The TPA sends temperature information to the TM which may impose restrictions.

Load Handler System

Load Handler operation requires both right hand deadman pedal switches (S2 and S23), and the left hand deadman switch (S9) to be activated.

Traverse/Reach

For Traverse/Reach, the CM processes a change in voltage at the Traverse/Reach pot (VR4). A command is sent to the TM (via BUS1) to energize the LHC. The CM activates the hydraulic solenoids that determine Traverse and Reach/Retract direction and speed. Traverse speed is determined by the position of VR4. Traverse position is calculated by input from the Traverse Feedback Pot (VR5). The mini-mast decelerates as it approaches the stops.

The rotate mechanism must be nested CW or CCW and the mini-mast must be at least half way across the platform before Traverse/Reach is allowed.

Rotate

For Rotate, the CM processes a change in the voltage at the Rotate pot (VR3). A command is sent to the TM (via BUS1) to energize the LHC. The CM activates the hydraulic solenoids that determine direction and speed. Rotate speed is determined by the position of VR3. Rotate position is calculated by input from the Rotate Position Feedback Pot (VR6). Rotation speed decelerates as it approaches the stops.

The reach mechanism must be fully nested before Rotate is allowed.

Auto Traverse and Rotate

The Auto Traverse and Rotate function is initiated by pressing the Attachment button located at the base of the traction control handle with both deadman pedals depressed and then activating the rotate control. Once initiated, the function remains active, even if the button is released. The speed of the load handler is continuously variable between fully stopped and the full configured speed, exactly the same as it is when operated manually. The function stops if the EPO is pushed, either deadman pedal is released, the rotate control knob is released, the reach mechanism moves out of its fully retracted position, or when the load handler reaches the nested state on the opposite side. The reach mechanism must be fully retracted for this function to be allowed.

Auto Center Nest

Auto Center Nest automatically centers traverse and rotate. Auto Center Nest is initiated the same way as Auto Traverse and Rotate. Once initiated, the Attachment button is pressed a second time. The Auto Center Nest function rotates the forks and traverses the turret to the centered positions. The reach mechanism must be fully retracted for this function to be allowed.

NOTE: Auto Traverse/Rotate and Auto Center Nest are not available if the truck has the "Extended M" or the "Attachment" option enabled.

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Steering

The Steering Encoder is attached to the steer tiller on the carriage. It contains two encoders in a single package.

Each encoder produces two quadrature phased channels that are sensed by the CM and sent to the TM via BUS1. The TM sends steer commands for either clockwise or counterclockwise rotation to the Steer Power Amplifier (SA). The SA drives the Steer Motor to obtain the movement requested from the tiller.

The TM monitors steer current, the Steer Motor Encoder, Steer Home Prox, and Neutral Pulse to determine that the steering system is operating correctly. When the deadman is depressed, the TM energizes the STR contactor, providing B+ to the SA to power the Steer Motor.

Guidance

Overview

When the truck is in the wire guided mode, steering functions the same way as when in manual steering mode with one exception. Steering requests do not come from the CM when in wire guided mode as they do in manual steering. In the wire guided mode, steering requests originate in the GM rather than from steering encoder. To switch from manual steering to the wire guided mode, several events must occur. First, the CM must detect the Auto/Manual switch (S4) is open (Auto position). Next, the CM must advise the TM that S4 is open. When the TM is advised that S4 is in the Auto position and aligning, it transfers steering control from the Steering Encoder to the GM. The GM calculates the position of the truck relative to the wire and advises the TM what direction and how far to steer the drive unit. During wire guided operation, the GM constantly updates the TM with corrections since the trucks position relative to the guide wire constantly changes. If the truck exceeds the deviation values for Distance from Wire (DFW - how far the truck is from the wire) or Heading Angle (HA - angle of the truck to the wire) that are set in Configure, the GM informs the TM to slow or stop the truck, depending on the magnitude of the deviation.

Functional Description

During normal manual steering operation, the CM is in constant communication with the TM, updating the TM with the status of the components connected to it such as switches, the control handle, and the Steering Encoder. Likewise, the GM is constantly attempting to calculate the position of the truck relative to the guide wire. The TM is constantly being updated as to the position of the drive unit relative to home position as well as travel speed and direction that it in turn communicates to the GM. When the CM detects that S4 is opened (Auto position), it advises the TM that S4 is open. The TM determines that the truck is ready for wire guided operation and informs the GM.

The GM then tells the TM to put the truck into Seeking Mode and try to acquire the wire. Travel speed is limited to 1 mph (1.6 km/h) in the forks-first direction and limited to the Acquire speed that is set in Configure Mode for tractor-first travel. If the Sense Creep Speed (SensCreep) option is enabled in Configure Mode, truck speed is limited to 1 mph (1.6 km/h) whenever S4 is detected closed (Manual position) and the GM reports that a guide wire is detected. During Seeking Mode, an audible tone is generated and the green LED triangles of the wire guidance icon blink. Steering at this time is still in manual control because the truck has not acquired the wire. The operator must steer the truck toward the guide wire location to help the truck acquire the wire.

As either the tractor or load end center pair of sensor coils (Near Wire coils) approach the guide wire, they begin to detect the magnetic field around the guide wire. If the Near Wire coils do not detect this magnetic field for any reason, the truck does not acquire the wire, even if the outer coils (Guidance coils) detect the magnetic field. The magnetic field around the guide wire causes an AC voltage to be induced into the sensor coils that is sent to the Filter Card (GM) for conditioning. The Filter Card removes any noise that is picked up by the

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antenna coils and also converts this AC voltage into a DC voltage to be used by the Guidance Card. As either the tractor end or the load end Near Wire coils get closer to the wire, the value of the DC voltage to the Guidance Card increases. When the Near Wire coils get close enough (to the wire), and the voltage is high enough, the Guidance Card tells the TM to release full control of issuing the steering commands to the Guidance Card.

When the Guidance Card takes over issuing steer commands, the truck is in an Aligning Mode. While in Aligning Mode, the TM ignores the steering request from the CM and all the wire guidance icon LEDs blink. The truck is now auto steering and no longer responds to operator steer tiller inputs. The Guidance Card also monitors the DC voltages from the Filter Card representing the AC voltages being picked up by the outer coils (Guidance Coils) on both the tractor end and the load end sensors as the truck begins to align over the wire. When the voltages that the truck detects from the load end and tractor end guidance coils begin to balance out and match the Learned Offset values for those coils, the Guidance Card switch from Aligning Mode to Locked on Wire or Guided Mode. At that time, all of the wire guidance icon LEDs illuminate solid and full travel speed is allowed in either direction.

The Guidance Card constantly monitors the voltages from each of the four guidance coils via the Filter Card. It compares the voltage from each coil to the value for each coil that was obtained through the Learn procedure. By comparing the actual values for all four guidance coils with the learned values stored in the memory, the Guidance Card can issue the appropriate steering commands to the TM to keep the truck centered over the guide wire. Also, using these values, the Guidance Card calculates the HA and the DFW and issues the appropriate Slow or Stop commands to the TM when DFW or HA values set in Configure Mode are exceeded. See Table 3-2 on page 3-27.

End-of-Aisle Control

The End-of-Aisle system consists of truck mounted components and magnets embedded in the floor inside of the aisle. The truck mounted hardware consists of four magnet sensors mounted between the baselegs under the operator's platform. They are connected directly to the TM. When the system is activated, the TM monitors the inputs from the sensors. When entering the aisle and both sensors cross a magnet in less than 24 in. (610 mm), the TM recognizes this as In-Aisle-State. This information is stored in Non Volatile Memory (NVM). NVM cannot be changed by a loss of power to the system. The only way to change it is by another input. This input can only be initiated by crossing another set of magnets or by traveling and turning the steering more than 10°. This allows the truck to power down inside the aisle and remember that it is in an In-Aisle-State when powered back up. System operation is not changed upon aisle entry. When the truck is exiting an aisle and each sensor is activated by magnets, the truck plugs to reduce speed until the speed is reached that is stored in the Configuration Menu. Once this speed is reached, travel speed is limited by the TM to the speed programmed in the Configuration Menu until the control handle is returned to neutral and travel is requested again. During the plugging sequence, the operator can override the plugging strength with a request for a more aggressive plug from the control handle.

Height Calculation

Main Height Sensing

The TM calculates main mast height that is calibrated when the mast telescopic transitions the Main Lift Ref Prox. This is done by using the Main Lift Height Encoder pulses. As the encoder is rotated, it produces two square wave voltages 90° out of phase with each other (quadrature phase) and are used to determine the rate, direction, and height of the platform. Lift decelerates as the platform approaches full elevated height. Lower decelerates as the platform approaches the fully lowered position. The calculated lift height is stored in the TM when the key is turned OFF. The TM combines the height of the main and mini-masts and updates the display with the actual height of

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the forks. If a height error is detected, lower decelerates when the Lift Reference Prox is crossed.

Mini Height Sensing

The TM calculates mini-mast height based on pulse counts communicated via BUS1 from the CM. The CM monitors the Mini Height Prox that detects the holes in the sensing rail as it passes over it. When fully lowered, all three channels are activated, indicating the mini lift is fully lowered. Lift decelerates as the Load Handler approaches full elevated height. Lower decelerates as the Load Handler approaches the fully lowered position. The TM combines the height of the main and mini-masts and updates the display with the actual height of the forks.

Weight Calculation

Main Weight Sensing

The TM calculates weight based on input from the pressure transducer at port G1 on the Main manifold.

Mini Weight Sensing

The TM calculates weight based on input from the pressure transducer at port G2 on the Main manifold.

Temperature Sensing

- **Tractor Manager** - calculates Load Handler Motor (LHM) temperature based on input from the LHM temperature sensor. The LHM cooling fan is activated when the motor temperature reaches 103°F (39.5°C).
- **Lift Power Amplifier** - monitors its internal heatsink temperature sensor and the Lift Motor temperature sensor. At 185°F (85°C), the LPA goes into thermal limiting. At 203°F (95°C), the LPA shuts down.
  - **Lift Motor** - At 311°F (155°C), the LPA disables lift. Lower is allowed.
- **Traction Power Amplifier** - monitors its internal heatsink temperature sensor and the Traction Motor temperature sensor. At 185°F (85°C), the TPA goes into thermal limiting. At 203°F (95°C), the TPA shuts down.
  - **Traction Motor** - At 311°F (155°C), the TPA linearly reduces travel speed. At 374°F (190°C), the TPA limits travel to 1.0 mph.

Options

Some available options can restrict normal truck operation. Refer to "Configuration and Truck Setup Options" on page 3-12 for additional information.

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Hydraulic Components

Main Hydraulic Manifold

The main hydraulic manifold, located in the tractor assembly, controls main and mini mast lift and lower. It also contains a relief valve used with the load handler. The following components are installed on the manifold:

SOL3 (Main Load Hold) - the main mast load holding solenoid. When activated, this solenoid allows fluid to exit the main lift cylinders for lowering.

SOL4 (Main Lift Select) - the main lift select solenoid. When activated, this solenoid allows fluid to enter the main lift cylinders for lifting.

SOL5 (Mini Load Hold) - the mini mast load holding solenoid. When activated, this solenoid allows fluid to exit the mini lift cylinder for lowering.

SOL6 (Mini Lift Select) - the mini lift select solenoid. When activated, this solenoid allows fluid to enter the mini lift cylinder for lifting.

Main Lift Press - used to determine weight on main mast. Voltage output varies, depending on hydraulic system pressure.

Mini Lift Press - used to determine weight on mini mast. Voltage output varies, depending on hydraulic system pressure.

Load Handler Relief - used to limit pressure in the rotate/reach circuit.

Lift Pump Manifold

The Lift Pump manifold, located at the bottom of the lift pump. controls fluid return to the hydraulic reservoir and pre-pressurization for optimal performance. The following components are installed on the manifold:

SOL1 - allows lowering of the main or mini lift. When activated, this solenoid allows fluid to return to the reservoir.

CV1 - used as a suction line to the pump and to correctly route return oil for lowering through CV2 to the hydraulic filter.

CV2 - used to prevent oil from flowing incorrectly during lift. During lower, routes oil through the hydraulic filter.

CV3 - used to allow pre-pressurization of the system to transition from a lift to lower command.

Lift Relief - used to limit pressure in the main and mini mast lift circuits.

Mini Mast Manifold

The Mini Mast manifold, located at the top of the Mini Mast, controls the rotate, traverse, and reach functions. Mounted into the valve body are the following components:

SOL7 (Traverse PWM) - proportional valve used to control traverse speed.

SOL8 (Rotate PWM) - proportional valve used to control reach and rotate speed. When activated, fluid is routed to the reach/rotate direction valve. If no current is present at the coil, the pilots open and allow oil to return to the tank.

SOL9A (Traverse Dir A) - valve used to route oil from the pump to port TR2 (Right).

SOL9B (Traverse Dir B) - valve used to route oil from the pump to port TR1 (Left).

SOL10A (Reach/Rotate Dir A) - valve used to route oil from the pump to port R1 (CW, Retract).

SOL10B (Reach/Rotate Dir B) - valve used to route oil from the pump to port R2 (CCW, Reach).

Rel 3 (Relief Valve 3) - used to limit pressure in the traverse circuit.

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Reach Manifold

The Reach manifold is located above the fork assembly. The following components are installed on the manifold:

SOL11 (Reach Select) - routes oil to the reach cylinders.

CB1, CB2 - used to retain oil in the rotate actuator until a rotate function is requested.

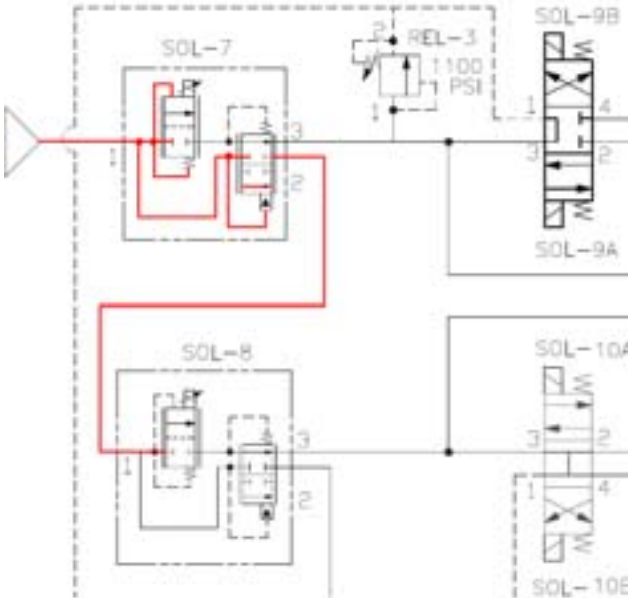
REL5 - used to limit system pressure in the rotate actuator even when the function is not activated.

Load Handler Proportional Valves (SOL7 Traverse PWM, SOL8 Rotate PWM)

The PWM Solenoids are physically one unit that performs two functions. One function allows oil that is not being used to flow through the valve with minimal resistance (Coil Not Activated). The other function controls the flow going to a load handler function (Coil Activated).

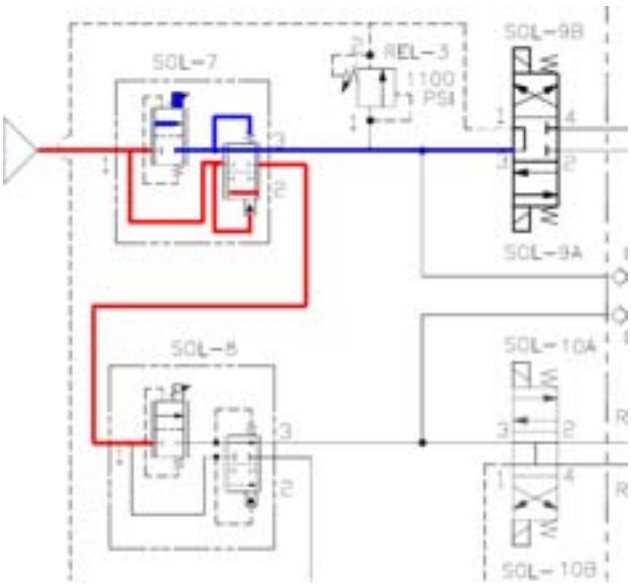
SOL7, SOL8 - Coil Not Activated

When the SOL7 coil is not activated and the Load Handler Motor is running, the pump output flows through the mesh screen to Port 1. The pressure increase causes the pilot line directly connected to Port 1 to shuttle and provide a path for fluid to flow through Port 2 to SOL8, Port 1. If SOL8 is not activated, the same scenario occurs at SOL8.



SOL7, SOL8 - Coil Activated

When SOL7 is activated, Solenoid 7 fluid passes through port 3 to the SOL9A DirA and SOL9B DirB valve. The greater the coil field strength, the more the valve opens, allowing more fluid to flow to the directional valve. The flow going to the directional valve activates the pilot line that deals with shuttling fluid between ports 2 and 3. The remaining pump output can shuttle SOL7 to provide fluid to SOL8.



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RAYMOND

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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 voltage carried on the wire.
- **Theory of Operation**:
  - A detailed description of the voltage carried on the wire. If the voltage is variable, it indicates the state of a related component that causes the voltage to vary.
  - Identifies possible causes for lack of correct voltage.
- **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.
- **Voltage Source**: the device or connection that supplies the signal directly to the wire.
- **Voltage User**: the device or connection that the wire directly delivers the signal to.

Table 8-1. Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
1	JPC2-1	VBUS	Used to communicate with USB type connection via FlashWare.	No useful voltages are measurable	CM	FlashWare
2	JPC2-2	D+	Positive Data Bus used for USB type connection via FlashWare.		CM	FlashWare
3	JPC2-3	D–	Negative Data Bus used for USB type connection via FlashWare.		CM	FlashWare
4	JPC4-1	+5V_POT	+5V for the Traverse Pot (VR4). This voltage is generated by a power supply on the CM. It is also jumpered in the Control Handle harness to supply the Rotate Pot (VR3).	4.75 to 5.25V	CM	VR3, VR4
5	JPC4-2	DGND	B– for the Lift Select switch (S6), Lift/Lower Inhibit Bypass switch (S7), Rotate Pot (VR3) and Traverse/Reach Pot (VR4).	Measure battery voltage to TP1 (B+) to verify connections. Then check for <0.3V wrt TP4.	CM	S6, S7, VR3, VR4

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
6	JPC4-4	TRAVERSE/ REACH CMD	Variable voltage input from the Traverse Pot (VR4). The CM monitors this voltage to determine the direction and speed of the traverse request when VR4 is rotated from its learned neutral position. The CM also uses this voltage to generate an error code if the voltage is not within its specified limits.	Neutral: 2.25 to 2.75V Left: 0.5 to 1.5V Right: 3.3 to 4.3V	VR4	CM
7	JPC6-2	LOW	Return path to the CM for the voltage used to operate the yellow LEDs of the triangular seeking wire/rail icon on the Supplemental (Supp) Display. The two triangular seeking wire/rail icon are OFF when the AUTO/MAN Switch (S4) is in the MAN position. They flash if no guide wire or rail is detected and S4 is in the AUTO position. They remain illuminated when the truck is determined to be locked on the guide wire or in the rail.	Illuminated: <1V Not illuminated: 12V	Supp Display	CM
8	JPC10-2	CUSTOM IN 2	Custom input to the CM. Used for special optional inputs. When used, the ability to disable lift and reduce travel speed is possible.	Open: >4V Closed: <1V	Optional Device	CM
9	JPC10-3	STR4	Return path to the CM for the voltage used to operate the first right of center yellow LED of the drive wheel direction icon on the Supplemental Display.	Illuminated: <1V Not illuminated: 12V	Supp Display	CM
10	JPC10-4	DGND	Return path for Mini Power Supply and Reach Prox.	Measure battery voltage to TP1 (B+) to verify connections. Then check for <0.3V wrt TP4.	CM	Mini Pwr Supply, Reach Prox
11	JPC10-6	+12V_SENSOR 1	+12V to the E2 portion of the Steering Encoder. It is also used as a detect to make sure that the encoder is connected.	Encoder Connected: 9V Disconnected: 10 to 13V	CM	Steering Encoder
12	JPC10-7	+12V_SENSOR 2	+12V to the E1 portion of the Steering Encoder. It is also used as a detect to make sure that the encoder is connected.		CM	Steering Encoder
13	JPC10-8	CUSTOM IN 1	Custom input to the CM used for special optional inputs. When used, the ability to disable lift and reduce travel speed is possible.	Open: >4V Closed: <1V	Opt. Devices	CM

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
14	JPC10-9	DGND	Return path for the Load Handler Deadman switch (S9).	Measure battery voltage to TP1 (B+) to verify connections. Then check for <0.3V wrt TP4.	CM	S9
15	JPC12-1	+5V_POT	+5V for the Travel Pot (VR1) and the Lift/Lower Pot (VR2). This voltage is generated by a power supply on the CM. It is also jumpered in the Control Handle harness to supply the Traverse Pot (VR5).	4.75 to 5.25V	CM	VR1, VR2, VR5
16	JPC12-2	LIFT/LOWER CMD	Input from the Lift/Lower Pot (VR2). The TM monitors this voltage to determines the direction and speed of the lift or lower request when VR2 is rotated from its learned neutral position. The TM also uses this voltage to generate an error code if the voltage is not within its specified limits.	Neutral: 2.25 to 2.75V Full Lift: 0.5 to 1.5V Full Lower: 3.3 to 4.3V	VR2	CM
17	JPC12-3	TRAVEL CMD	Input from the Travel Pot (VR1). The TM monitors this voltage to determines the direction and speed of the travel request when VR1 is rotated from its learned neutral position. The TM also uses this voltage to generate an error code if the voltage is not within its specified limits.	Neut: 2.25 to 2.75V Full TF: 0.5 to 1.5V Full FF: 3.3 to 4.3V	VR1	CM
18	JPC12-4	LIFT SELECT	Input from the Lift Select switch (S6) that determines whether the TM commands Main or Mini lift. With S6 open (not depressed) only Main lift or lower is commanded when the Lift/Lower Control Pot is rotated in the desired direction from its learned neutral position and with S6 closed (depressed) Mini lift/lower is commanded.	Open: >4V Closed: <1V	S6	CM
19	JPC12-5	ROTATE CMD	Input from the Rotate Command Pot (VR3). The CM monitors this voltage to determine the direction and speed of the rotate request when VR3 is rotated from its learned neutral position. The CM also uses this voltage to generate an error code if the voltage is not within its specified limits.	Neut: 2.25 to 2.75V Full CW: 0.5 to 1.5V Full CCW: 3.3 to 4.3V	VR3	CM
20	JPC12-7	+10V CARRIAGE	+10V for devices on the Mini-Mast. Regulated by circuitry in the CM. This voltage varies if the correct load is not present.	9 to 11V	CM	SOL11, Reach Prox, Mini Pwr Supply

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
21	JPC12-8	L/L_INH_BYPASS	Lift/Lower Inhibit Bypass switch (S7) input to the CM. The voltage on this line determines whether the TM allows lift or lower when the specified Lift or Lower Limit height is reached. When this option is installed, S7 operation may be enabled or disabled in Configure Mode. With S7 open (not depressed), Main Lift/Lower beyond the specified height limit is inhibited. With S6 closed (depressed), further lifting or lowering is allowed.	Open: >4V Closed: <1V	CM	S7
22	JPC12-9	ATTACHMENT	Attachment switch (S5) input to the CM.		S5	CM
23	JPC12-11	AUTO/MANUAL	AUTO/MAN switch (S4) input to the CM. Activates/deactivates guidance mode (wire or rail). Guidance Mode is activated when S4 is open and off when it is closed.		S4	CM
24	JPC12-12	DGND	B– for the Horn switch (S3), AUTO/MAN switch (S4), Attachment switch (S5), L/L Pot (VR2), and Travel Pot (VR1).	<0.5V	CM	S3, S4, S5, VR1, VR2
25	JPC14-2	DGND	B– for the Display Interface Card.	Measure B+ at TP1 to verify connections. Then check for <0.3V wrt TP4.	CM	Display Interface Card
26	JPC14-4	BUS1–	CAN Communication line between TM, CM, and Display Interface Card.	2.3V	Display Interface Card, CM, TM	Display Interface Card, CM, TM
27	JPC14-5	+12VD	+12V supply to Display Interface Card. Protected by an internal diode in the CM.	10.1 to 13V	CM	Display Interface Card
28	JPC14-7	B+K2	B+K2 supplied from the Over-the-Mast Cable and the Fuse/Relay Card when the TM has activated the K2 relay via the relay enable circuit. It provides B+ to SOL7, SOL8, SOL9A/B, and SOL10A/B. It also provides a return path for the suppressors to the coils.	K2 energized: B+	Fuse/Relay Card	SOL7, SOL8, SOL9A/B, SOL10A/B

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
29	JPC14-8	B– FU6	B– for the CM Power Supply and other internal circuits, and is distributed to other connection points for external circuit components.	Measure B+ at TP1 to verify connections. Then check for <0.5V wrt TP4.	Fuse/Relay Card	CM
30	JPC14-9	B– FU6	B– for the CM Power Supply and internal circuits. Also distributed to other connection points for external circuit components.		Fuse/Relay Card	CM
31	JPC14-10	B– FU6	B– for the CM Power Supply and internal circuits. Also distributed to other connection points for external circuit components.		Fuse/Relay Card	CM
32	JPC14-11	BUS1+	CAN Communication line between TM, CM, and Display Interface Card.	2.3V	Display Interface Card, CM, TM	Display Interface Card, CM, TM
33	JPC14-12	B+KEY	B+ to the CM power supply when the Key switch (S1) is closed. It is also routed to the over-the-mast cables and TM.	B+	S1	CM, TM
34	JPC14-13	B+K2	B+K2 supplied from the Over-the-Mast Cable and the Fuse/Relay Card when the TM has activated the K2 relay via the relay enable circuit. It provides B+ to SOL7, SOL8, SOL9A/B, SOL10A/B. It also provides a return path for the suppressors to the coils.	K2 energized: B+	Fuse/Relay Card	SOL7, SOL8, SOL9A/B, SOL10A/B
35	JPC14-14	B+K2	B+K2 supplied from the Over-the-Mast Cable and the Fuse/Relay Card when the TM has activated the K2 relay via the relay enable circuit. It provides B+ to SOL9A/B and SOL10A/B. It also provides a return path for the suppressors to the coils.	K2 energized: B+	Fuse/Relay Card	SOL9A/B, SOL10A/B
36	JPC18-3	+12VP	+12V supply to the LEDs on the Supplemental Display. Generated by a power supply on the CM. Present when the Key switch is ON.	10.1 to 13V	CM	Supp Display
37	JPC18-4	+12VP	+12V supply to the Carriage Deadman switch (S23).	10.1 to 13V	CM	S23
38	JPC18-5	DGND	B– for Steering Encoder 1.	Measure B+ at TP1 to verify connections. Then check for <0.5V wrt TP4.	CM	Steering Encoder
39	JPC18-6	DGND	B– for Steering Encoder 2.		CM	Steering Encoder
40	JPC18-7	DGND	B– for Sidegate Right switch (S60).		CM	S60

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
41	JPC18-8	WIRE SENSE	Return path to the CM for the voltage used to operate the 3 green LEDs that make up the guide wire/rail icon. The LEDs are OFF when the AUTO/MAN switch (S4) is in the MAN position. The LEDs flash if a guide wire is sensed when S4 is in the AUTO position. They remain illuminated when the truck is locked on the guide wire.	Illuminated: <1V Not illuminated: 12V	Supp Display	CM
42	JPC18-11	REACH/ROTATE DIR A	Output of the SOL10A Coil Driver in the CM. It provides the negative path to complete the circuit to energize SOL10A when the Rotate Command Pot (VR3) is rotated CW from its learned neutral position or a Reach function is requested.	De-energized: B+ Energized: Approx. 24V	CM	SOL10A
43	JPC18-12	REACH/ROTATE DIR B	Output of the SOL10B Coil Driver in the CM. It provides the negative path to complete the circuit to energize SOL10B when the Rotate Command Pot (VR3) is rotated CCW from its learned neutral position or a Reach function is requested.	De-energized: B+ Energized: Approx. 24V	CM	SOL10B
44	JPC18-14	TRAVERSE DIR A	Output of the SOL9A Coil Driver in the CM. It provides the negative path to complete the circuit to energize the SOL9A coil when the Traverse Command Pot (VR4) is rotated CW from its learned neutral position.	De-energized: B+ Energized: Approx. 24V	CM	SOL9A
45	JPC18-15	TRAVERSE DIR B	Output of the SOL9B Coil Driver in the CM. It provides the negative path to complete the circuit to energize the SOL9B coil when the Traverse Command Pot (VR4) is rotated CCW from its learned neutral position.	De-energized: B+ Energized: Approx. 24V	CM	SOL9B
46	JPC18-17	REACH SELECT SOL	Output of the SOL11 Coil Driver in the CM. It provides the negative path to the circuit to energize SOL11. This output is automatically present to permit reach/ retract operation during a traverse function when the CM has determined that Traverse Feedback Pot (VR5) voltage at JPC24-18 indicates that the mid-point of the platform width has been exceeded and that the forks are fully nested. Once the mid-point has been attained, a REACH SOL output can be energized by rotating the Traverse Command Pot (VR4) slightly out of its learned neutral position.	De-energized: 10V Energized: <1V	CM	SOL11

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
47	JPC18-18	STR5	Return path to the CM for the voltage used to operate the second right of center red LED of the drive wheel direction icon on the Supplemental Display.	Illuminated: <1V Not illuminated: 12V	Supp Display	CM
48	JPC20-5	+12VP	+12V for the optional Sidegate Right switch (S60). This voltage comes from the CM and is present whenever the Key switch (S1) is ON.	10.1 to 13V	CM	S60
49	JPC20-8	+12VP	+12V for the optional Sidegate Left switch (S61). This voltage comes from the CM and is present whenever the Key switch (S1) is ON.	10.1 to 13V	CM	S61
50	JPC20-12	LH NEST	Return path to the CM for the voltage used to operate the red LED of the forks nested icon. This LED is ON when the traverse and rotate mechanisms are in their fully nested positions and is OFF when either mechanism is not fully nested.	Illuminated: <1V Not illuminated: 12V	Supp Display	CM
51	JPC20-13	(B+K2) B+ROTATE	B+ supply from the Over-the-Mast cable and the Fuse/Relay Card when the TM has activated the K2 Relay via the relay enable circuit. It provides B+ to SOL8 and a return path for the suppressors to the coils.	K2 energized: B+	Fuse/Relay Card	SOL8
52	JPC20-15	B+K2	B+ for the custom Output to the CM used for special optional outputs.	K2 energized: B+	CM	Optional Device
53	JPC20-16	REACH/ROTATE PWM	PWM signal used to control rotate and reach speed, depending on the position of VR3. Rotate speed is variable. During decel, PWM is reduced to restrict fluid through the valve, thereby reducing rotate speed. This is also used with the reach command.	K2 energized: B+ Rotate slow: 39V fast: 32V	CM	SOL8
54	JPC20-17	(B+K2) B+TRAV	B+ from the Over-the-Mast Cable and the Fuse/Relay Card when the TM has activated the K2 relay via the relay enable circuit. It provides B+ to SOL7 and a return path for the suppressors to the coils.	K2 energized: B+	Fuse/Relay Card	SOL7
55	JPC20-20	TRAVERSE PWM	This PWM signal is used to control the traverse speed, depending on the position of VR4. Traverse speed is variable. During decel, PWM is reduced to restrict fluid through the valve, thereby reducing traverse speed.	K2 energized: B+ Traverse slow: 40V fast: 32V	CM	SOL7

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
56	JPC22-1	REACH PROX	Output voltage from the Reach Proximity Sensor. This is used to determine if the forks are reached or nested.	Forks nested: <1V Forks un-nested: >4V	Reach Prox	CM
57	JPC22-2	LOAD HANDLER DEADMAN	Input voltage to the CM from the Load Handler Deadman switch (S9). The CM uses this voltage to determine the state of S9. When S9 is detected closed (left deadman pedal depressed), the CM enables the use of the Mini-Mast and Load Handler functions. These functions are inhibited if S9 is detected open (left deadman pedal up).	Deadman Up: >4V Down: <1V	S9	CM
58	JPC22-4	SIDEGATE RIGHT	Input voltage to the CM from the optional Right Sidegate switch (S60). The CM uses this voltage to determine whether the sidegate is raised or lowered. S60 is closed when the right sidegate is down.	Sidegate Up: >4V Down: <1V	CM	S60
59	JPC22-5	CHA-E1	Part of the steering request when the encoder is rotated. It is a square wave signal identical to CHB-E1 but different phase. The TM uses the phase relationship of the two channels to determine whether CW or CCW steering is requested. The number of pulses is used to determine the total movement requested.	Moving: Approx. 2.5V Not Moving: <1V or 4.75V	Steering Encoder	CM
60	JPC22-6	SIDEGATE LEFT	Input voltage to the CM from the optional Left Sidegate switch (S61). The CM uses this voltage to determine whether the sidegate is raised or lowered. S61 is closed when the right sidegate down.	Sidegate Up: >4V Down: <1V	CM	S61
61	JPC22-7	CARRIAGE DEADMAN	Input voltage to the CM from the Carriage Deadman switch (S23). The CM uses this voltage to determine the state of S23. The TM and CM both use this information in conjunction with a travel request to release the brake; however, either cause the brake to apply when it detects a fault, regardless of deadman switch position.	Deadman Up: >4V Down: <1V	S23	CM
62	JPC22-9	HEIGHT PROX A	Input voltage to the CM from Channel A of the Mini Height Prox Sensor. It switches ON and OFF as it passes over the mini height sensing rail.	Not over metal: >1.7V Over metal: <0.7V	Mini Height Prox	CM
63	JPC22-10	HEIGHT PROX B	Input voltage to the CM from Channel B of the Mini Height Prox Sensor. It switches ON and OFF as it passes over the mini height sensing rail.	Not over metal: >1.7V Over metal: <0.7V	Mini Height Prox	CM

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
64	JPC22-11	DGND	B– for the Carriage Deadman switch (S23).	Measure B+ at TP1 to verify connections. Then check for <0.5V wrt TP4.	CM	S23
65	JPC22-12	CHB-E1	Part of the steering request when the encoder is rotated. It is a square wave signal identical to CHA-E1 but different phase. The TM uses the phase relationship of the two channels to determine whether CW or CCW steering is requested. The number of pulses is used to determine the total movement requested.	Moving: Approx. 2.5V Not Moving: <1V or 4.75V	Steering Encoder	CM
66	JPC22-13	CHA-E2	Part of the steering request when the encoder is rotated. It is a square wave signal identical to CHB-E2 but different phase. The TM uses the phase relationship of the two channels to determine whether CW or CCW steering is requested. The number of pulses is used to determine the total movement requested.	Moving: Approx. 2.5V Not Moving: <1V or 4.75V	Steering Encoder	CM
67	JPC22-14	CHB-E2	Part of the steering request when the encoder is rotated. It is a square wave signal identical to CHA-E2 but different phase. The TM uses the phase relationship of the two channels to determine whether CW or CCW steering is requested. The number of pulses is used to determine the total movement requested.	Moving: Approx. 2.5V Not Moving: <1V or 4.75V	Steering Encoder	CM
68	JPC22-21	B+EPO	B+ provided through the normally closed EPO Switch (S21), when the Key Switch (S1) is closed, to the Over-the-Mast cables, and to feed B+ to the K1, K2, and K3 relay coils. The status of the EPO switch is monitored by the CM and TM.	B+	S21	K1, K2, K3
69	JPC22-22	CMID1	Jumper used to identify module as the CM.	Approx. 5V	CM	CM
70	JPC24-2	STR1	Return path to the CM for the voltage used to operate the second left of center red LED of the drive wheel direction icon on the Supplemental Display.	Illuminated: <1V Not illuminated: 12V	Supp Display	CM

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
71	JPC24-4	DGND	B– for VMID1.	Measure B+ at TP1 to verify connections. Then check for <0.5V wrt TP4.	CM	CM
72	JPC24-6	DGND	B– for the Traverse Feedback Pot (VR5).		CM	VR5
73	JPC24-8	DGND	B– for CUSTOM IN P1.		CM	Custom In P1
74	JPC24-9	DGND	B– for CUSTOM IN P2.		CM	Custom In P2
75	JPC24-10	DGND	B– for the Sidegate Left switch (S61).		CM	S61
76	JPC24-12	STR3	Return path to the CM for the voltage used to operate the centered green LED of the drive wheel direction icon on the Supplemental Display.	Illuminated: <1V Not illuminated: 12V	Supp Display	CM
77	JPC24-13	+12VP	12V supply to Load Handler Deadman switch (S9).	10.1 to 13V	TM	S9
78	JPC24-14	STR2	Return path to the CM for the voltage used to operate the first left of center yellow LED of the drive wheel direction icon on the Supplemental Display.	Illuminated: <1V Not illuminated: 12V	Supp Display	CM
79	JPC24-15	ROTATE POT	Input to the CM from the Rotate Position Feedback Pot (VR6). The CM uses this voltage to determine the rotated position of the forks and the rate that they are moving during Learn.	Nested full right: 3.5 to 4.5V Centered: 2.25 to 2.75V Nested full left: 0.5 to 1.5V	VR6	CM
80	JPC24-18	TRAVERSE POT	Input to the CM from the Traverse Position Feedback Pot (VR5) via JPK-2. The CM uses this voltage to determine the position of the traverse assembly and the rate that it is moving during Learn.	Nested full right: 3.5 to 4.5V Centered: 2.25 to 2.75V Nested full left: 0.5 to 1.5V	VR5	CM
81	JPC24-20	HEIGHT PROX C	Input voltage to the CM from Channel C of the Mini Height Prox Sensor. It switches ON and OFF as it passes over the mini height sensing rail.	Not over metal: >1.7V Over metal: <0.7V	Mini Height Prox	CM
82	JPD5-2	CAN BAUD SELECT	Used to set up the Display Interface Card to the correct baud rate for the 9600/ 9700.	DGND	Display Interface Card	Display Interface Card

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
83	JPD5-4	DGND	B– for CAN Baud Select.	Measure B+ at TP1 to verify connections. Then check for <0.5V wrt TP4.	Display Interface Card	Display Interface Card
84	JPF1-1	B–	B– for FU8 (15A/5A) Fuse for optional Aux power.		TP4	Aux Power
85	JPF1-2	B–	B– for FU8 (15A/5A) Fuse for optional Aux power.		TP4	Aux Power
86	JPF1-3	B+F or B–F	B+K3 to the TPA. At Startup, the presence of B+ is used to identify the amp as the TPA and power the TPA logic circuits.	K3 de-energized: B– K3 energized: B+	FU5 when K3 is energized; FU6 when K3 is de-energized	TPA
87	JPF1-4	B–F	B–F from FU8 for Warning Light and optional Aux Power.	Measure B+ at TP1 to verify connections. Then check for <0.5V wrt TP4.	FU8 to B–	Warning Light and Aux Power
88	JPF1-5	B+F or B–F	B+K3 to the LPA. At Startup, the presence of B+ is used to identify the amp as the LPA and power the LPA logic circuits.	K3 de-energized: B– K3 energized: B+	FU5 when K3 is energized; FU6 when K3 is de-energized	LPA
89	JPF1-6		Not used.			
90	JPF2-1	B+K2	B+ supplied to the STR and LHC contactor coils when the K2 relay tips close.	K2 energized: B+	Fuse/Relay Card	STR and LHC Coils
91	JPF2-2	B+K2	B+ to the horn and the brake coil.	K2 energized: B+	K2 tips	Horn/ Brake Coil
92	JPF2-3	B+K2	B+ supplied to the hydraulic manifold solenoids.	K2 energized: B+	Fuse/Relay Card	SOL1, SOL3 thru SOL6
93	JPF2-4		Not Used.			
94	JPF2-5	B+K2	B+ to the GM, FAN1, FAN2, FAN3, and Travel Light/Alarm.	K2 energized: B+	K2 tips	GM, FANs 1 thru 3, Travel Light /Alarm
95	JPF2-6	B+K2	B+K2 to the TM when the K2 relay tips are closed.	B+	K2 tips	TM
96	JPF2-7	B+K2	B+K2 to the TM when the K2 relay tips are closed.	B+	K2 tips	TM

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
97	JPF2-8	B+K2	B+K2 to the Light and Fan Package and to the CM. The CM supplies B+ to SOL7, SOL8, SOL9A/B, and SOL10A/B.	B+	Fuse/Relay Card, OTM cable	Light/Fan Package, SOL7, SOL8, SOL9A/B, SOL10A/B
98	JPF2-9	B+K1	B+ for warning light and aux power with Key switch ON and K1 tips closed.	B+	Fuse/Relay Card	Warning Light and Aux Power with Key
99	JPF3-1	B–	B– for FU6 (15A) that provides B– to the TM.	Measure B+ at TP1 to verify connections. Then check for <0.5V wrt TP4.	TP4	TM
100	JPF3-2	B–	B– for FU6 (15A) that provides B– to the TM.		TP4	TM
101	JPF3-3	B–F	B– for the TM DGND circuits.		FU6	TM
102	JPF3-4	B–F	B– for the TM DGND circuits.		FU6	TM
103	JPF3-5	B–F	B– for the TM.		FU6	TM
104	JPF3-6	B–F	B– for the TM.		FU6	TM
105	JPF3-7	B–F	B– for the TM.		FU6	TM
106	JPF3-9	B–F	B– for GM.		Fuse/Relay Card	GM
107	JPF3-10	B–FU6	B– for the Slack Chain 1 switch (S50).		FU6	S50
108	JPF3-11	B–FU6	B– for the Lift Ref Prox switch (S11).		FU6	S11
109	JPF3-12	B–F	B– for the CM.		FU6	CM
110	JPF4-1	B+	B+ from TP1 to FU5 (15A) to supply B+ to all logic circuits and relay tips. This also supplies Battery_Sense_In on the TM.	B+	TP1	FU5, TM
111	JPF4-2	B+	B+ from TP1 to FU5 (15A) to supply B+ to all logic circuits and relay tips. This also supplies Battery_Sense_In to the TM.	B+	TP1	FU5, TM
112	JPF4-3	B+	B+ from TP1 to FU7 (15A/5A) to supply Aux power option.	B+	TP1	FU7, Aux Power
113	JPF4-4	B+	B+ from TP1 to FU7 (15A/5A) to supply Aux power option.	B+	TP1	FU7, Aux Power
114	JPF4-5	B+EPO	B+ supply from EPO to K1, K2, and K3. All functions associated with these relays are inoperable when the EPO is open.	Key switch ON and EPO Closed: B+ Open: <0.5V	EPO	K1, K2, K3
115	JPF4-6	B+EPO	B+ to the EPO_Sense on the TM. Tells the TM if the EPO is open or closed.		EPO	TM, EPO Sense

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
116	JPF4-7	B+	B+ present when the battery is plugged in. It is supplied through a thermistor on the Fuse/Relay Card. This is used by the TM to determine the correct battery is installed. It accepts between 37.3 and 58.7V. If the correct battery is sensed, Relay_Enable is energized during startup. After startup, this voltage is used to determine BSOC.	B+ (there should be no voltage drop)	TP1	TM
117	JPF4-8	B+KEY	B+Key from the Over-the-Mast cable and Key switch to the TM.	B+	S1	TM
118	JPF4-10	B+	B+ to the Key switch (S1).	B+	FU5	S1
119	JPF4-11	B+KEY	B+Key from the Over-the-Mast cable and Key switch to the TM.	B+	Fuse/Relay Card	TM
120	JPF4-13	RELAY ENABLE	Return path for relays K1, K2, K3, and K4. This is dependant on Battery_Sense_In being between 44 and 52V.	Key Switch ON and all relays de-energized: B+ Key Switch OFF or ON and any relay energized: Approx. 12V	TM	K1 thru K4
121	JPF4-14		Not used.			
122	JPF4-15	B+	B+ for battery connected Aux Power.	B+	FU7	Aux Power
123	JPLA1-1	B+K3	B+ to the LPA when K3 is energized.	K3 energized: B+	K3	LPA
124	JPLA1-6	LPC CONTACTOR	Control path for the LPC. The LPA supplies B– for the contactor by way of the B– terminal.	LPC de-energized: B+ energized: 26V	LPA	LPC
125	JPLA1-7	L VEL SENSOR–	B– for the Lift Motor Encoder (LME). It also provides B– to the Lift Motor Temp (LMT) sensor.	Measure B+ at TP1 to verify connections. Then check for <0.5V wrt TP4.	LME	LPA
126	JPLA1-8	L TEMP+	Input from the Lift Motor Temperature (LMT) sensor. Voltage will vary with lift motor temperature. Used by the LPA to adjust lift motor performance.	Approx. 1V @ 75°F (24°C)	LMT	LPA
127	JPLA1-11	ID0	B+ to the LPA when K3 tips energize. It is used as an identifier to determine correct connection.	K3 energized: B+	K3	LPA
128	JPLA1-13	LPC SUPPLY (B+K3)	B+ supply to the LPC from the LPA.	B+	LPA	LPC

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
129	JPLA1-23	BUS0+	Positive component of the digital communications between the TPA, LPA, TM, and GM.	2.3V	TM	TPA, LPA, TM, GM
130	JPLA1-26	L VEL SENSOR +	5V supply to the LME. This voltage is produced by the LPA from B+K3.	4.75 to 5.25V	LPA	LME
131	JPLA1-31	L VEL PHASE A	Input from the Lift Motor Encoder (LME). It is a square wave that is either high (>3V) or low (<1V). The frequency varies directly with motor speed. Identical to L VEL Phase B except for phase. The LPA uses the relationship between phases to determine lift and lower speed.	Motor Stopped: >3 or <1V Motor Turning: Approx. 2.3V	LME	LPA
132	JPLA1-32	L VEL PHASE B	Input from the Lift Motor Encoder (LME). It is a square wave that is either high (>3V) or low (<1V). The frequency varies directly with motor speed. Identical to L VEL Phase A except for phase. The LPA uses the relationship between phases to determine lift and lower speed.	Motor Stopped: >3 or <1V Motor Turning: Approx. 2.3V	LME	LPA
133	JPLA1-35	BUS0–	Negative component of the digital communications between the TPA, LPA, TM, and GM.	2.3V	TM	TPA, LPA, TM, GM
134	JPS4-5	BUS0–	Negative component of the digital communications between the TM and GM.	2.3V	TM	GM
135	JPS4-6	BUS0+	Positive component of the digital communications between the TM and GM.	2.3V	TM	GM
136	JPS6-24	B–F	B– to the GM. It is fused through FU6 on the Fuse/Relay Card.	Measure B+ at TP1 to verify connections. Then check for <0.5V wrt TP4.	GM	TM
137	JPT2-1	VBUS	Used to communicate with USB type connection via FlashWare.	No useful voltages are measurable	TM	FlashWare
138	JPT2-2	D+	Positive Data Bus used for USB type connection via FlashWare.		TM	FlashWare
139	JPT2-3	D–	Negative Data Bus used for USB type connection via FlashWare.		TM	FlashWare
140	JPT4-2	DGND	B– for the SLACK CHAIN 2 switch (S51).	Measure B+ at TP1 to verify connections. Then check for <0.5V wrt TP4.	TM	S51

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
141	JPT6-1	NEUTRAL_PULSE	Steer Amplifier (SA) input to the TM.	Deadman down: Approx. 2.5V CCW steer: <1V; CW steer: >4V No steering: voltage varies	SA	TM
142	JPT6-2	CW_PWM	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: 11.9V CW fast: 4V CW slow: 11.8V	TM	SA
143	JPT6-3	STEER_CURRENT	Analog voltage that varies with steer motor current and is sent from the Steer Amplifier (SA) to the TM. This voltage is used by the TM to establish current reading for current limit.	Steering CW: 2.9V At rest: 2.5V CCW: 2.1V	SA	TM
144	JPT6-4	DGND	B– for the control circuits in the Steer Amp (SA). If missing, the SA does not power up.	Measure B+ at TP1 to verify connections. Then check for <0.5V wrt TP4.	TM	SA
145	JPT6-5	CCW_PWM	Control 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.	At rest: 11.9V CCW fast: 4V CCW slow: 11.8V	TM	SA
146	JPT6-6	+12VP	Operating voltage from the TM for the control circuits in the Steer Amp (SA). If missing, steering is inoperable.	10.1 to 13V	TM	SA
147	JPT9-2	TXD	Transmit Data Bus used for Serial Type Communications via FlashWare.	No useful voltages are measurable	TM	FlashWare
148	JPT9-3	RXD	Receive Data Bus used for Serial Type Communications via FlashWare.		TM	FlashWare
149	JPT9-5	DGND	B– for Serial Type Communications via FlashWare.	Measure B+ at TP1 to verify connections. Then check for <0.5V wrt TP4.	TM	FlashWare
150	JPT10-1	+12VP	+12V supply for the Main Lift Height Encoder.	10.1 to 13V	TM	Main Lift Height Encoder

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
151	JPT10-2	CUSTOM IN 4	This is a custom input to the TM. Used for special optional inputs. The ability to disable lift and reduce travel speed is possible through this input.	Open: >4V Closed: <1V	Opt. Device	TM
152	JPT10-4	DGND	B– for the Main Lift Height Encoder.	Measure B+ at TP1 to verify connections. Then check for <0.5V wrt TP4.	TM	Main Lift Height Encoder
153	JPT10-5	BUS1–	Negative component of the digital communications between the TM, CM, and Display Interface Card.	2.3V	TM	TM, CM
154	JPT10-6	+12V_SENSOR 1	12V to the optional End-of-Aisle Sensor (S46A) at S46A-3. It is then routed through the switch module to S46A-4 to S46B-3 to power that switch module also. There is also a circuit detect to verify the end-of-aisle sensor is connected. This voltage is present when the Key switch (S1) is ON.	Sensor plugged in: Approx. 8V Sensor unplugged: 10 to 13V	TM	S46A/B
155	JPT10-7	+12V_SENSOR 2	12V to the optional End-of-Aisle Sensor (S47A) at S47A-3. It is then routed through the switch module to S47A-4 to S47B-3 to power that switch module also. There is also a circuit detect to verify the end-of-aisle sensor is connected. This voltage is present when the Key switch (S1) is ON.	Sensor plugged in: Approx. 8V Sensor unplugged: 10 to 13V	TM	S47A/B
156	JPT10-8	CUSTOM IN 3	This is a custom input to the TM. Used for special optional inputs. When this is used, the ability to disable lift and reduce travel speed is possible.	Open: >4V Closed: <1V	Opt. Device	TM
157	JPT10-9	DGND	B– for the Steer Motor Encoder.	Measure B+ at TP1 to verify connections. Then check for <0.5V wrt TP4.	TM	Steer Motor Encoder
158	JPT10-10	BUS1 +	Positive component of the digital communications between the TM and CM.	2.3V	TM	TM, CM
159	JPT12-5	LIFT	Lift/Lower Pendant connection to raise platform.	Lifting: <1V At rest: Approx. 5V	Pendant	TM

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
160	JPT12-6	LOWER	Lift/Lower Pendant connection to lower platform.	Lowering: <1V At rest: >4V	Pendant	TM
161	JPT12-10	SENSOR 1	Input voltage to the TM from aisle detect sensor S46A. It is generated by either S46A or B when one or both sensors detect a floor magnet. Sensor 1 is used along with Sensor 2 (JPT24-17) to determine if the truck is in or out of the aisle. This information is used to control travel speed based on truck location and position of the AUTO/MAN switch.	Magnet not sensed: >4V Magnet sensed: <1V	S46A/B	TM
162	JPT12-12	DGND	B– for Lift/Lower Pendant.	Measure B+ at TP1 to verify connections. Then check for <0.5V wrt TP4.	Pendant	TM
163	JPT14-1	B–F	This connects B–F on the TM to TP4 (B–) through FU6 on the Fuse/Relay Card. These B– provide the return for everything not using DGND or AGND as reference.		Fuse/Relay Card	TM
164	JPT14-2	DGND	This connects DGND on the TM to TP4 (B–) through FU6 on the Fuse/Relay Card. This is the reference for all circuits on the truck that reference DGND.		Fuse/Relay Card	TM
165	JPT14-3	DGND	B– for the Brake Deadman switch (S2). It is also used as a shield to the BUS communications.		TM	CM
166	JPT14-4	BUS0–	Negative component of the digital communications between the TM, TPA, LPA, and GM.	2.3V	TM	TPA, LPA, GM
167	JPT14-5	+12VP	+12V supply to the Brake Deadman switch (S2).	10.1 to 13V	TM	S2
168	JPT14-6	RELAY_ENABLE	Control path for K1, K2, K3, and K4 on the Fuse/Relay Card. When S1 closes, all relays are energized simultaneously during SelfTest if the voltage at BATTERY_SENSE_IN is between 44 and 52V.	Relays OFF: B+ ON: 12V	TM	K1, K2, K3, K4
169	JPT14-8	B–F	This connects B–F on the TM to TP4 (B–) through FU6 on the Fuse/Relay Card. These B– provide the return for everything not using DGND or AGND as reference.	Measure B+ at TP1 to verify connections. Then check for <0.5V wrt TP4.	Fuse/Relay Card	TM
170	JPT14-9	B–F	This connects B–F on the TM to TP4 (B–) through FU6 on the Fuse/Relay Card. These B– provide the return for everything not using DGND or AGND as reference.		Fuse/Relay Card	TM
171	JPT14-10	DGND	This connects DGND on the TM to TP4 (B–) through FU6 on the Fuse/Relay Card. This is the reference for all circuits on the truck that reference DGND.		Fuse/Relay Card	TM

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
172	JPT14-11	BUS0+	Positive component of the digital communications between the TM, TPA, LPA, and GM.	2.3V	TM	TPA, LA, GM
173	JPT14-12	B+KEY	B+ that is switched by the Key switch (S1) and is used to power functions on the TM that are initiated after S1 closes and are not affected by the EPO. This includes the TM power supplies, the operation of the microprocessor, and execution of the firmware.	S1 Closed: B+ Open: <0.5V	S1	TM
174	JPT14-13	B+K2	B+ provided to the TM when the K2 Relay tips are closed. They are de-energized when the EPO is open or key switch is OFF.	B+	K2 Relay	TM
175	JPT14-14	B+K2	B+ provided to the TM when the K2 Relay tips are closed. They are de-energized when the EPO is open or key switch is OFF.	B+	K2 Relay	TM
176	JPT18-1	LHC	Negative path for the Load Handler Contactor (LHC) coil.	Coil De-energized: B+ Coil Energized: Approx 24V	Fuse/Relay Card	LHC Contactor
177	JPT18-5	DGND	B– for Battery Gate Prox 1 and 2 (S57 and S58).	Measure B+ at TP1 to verify connections. Then check for <0.5V wrt TP4.	TM	S57, S58
178	JPT18-9	LOWER	Control path for the Lower solenoid (SOL1).	Coil De-energized: B+ Coil Energized: Approx 24V	TM	SOL1 Coil
179	JPT18-10	MAIN LOAD HOLD	Control path for the Main Load Hold solenoid (SOL3).		TM	SOL3 Coil
180	JPT18-11	STR	Negative path for the Steer Contactor Coil (STR).		TM	STR Contactor
181	JPT18-12	MINI LOAD HOLD	Control path for the Mini Load Hold solenoid (SOL5).		TM	SOL5 Coil
182	JPT18-14	MINI LIFT SELECT	Negative path for the Mini Lift Select solenoid (SOL6).		TM	SOL6 Coil
183	JPT18-15	MAIN LIFT SELECT	Negative path for the Main Lift Select solenoid (SOL4).		TM	SOL4 Coil
184	JPT18-16	HORN	Control path for the horn that is switched to B– by the TM.	De-energized: B+; Energized: <0.5V	TM	Horn

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
185	JPT18-17	FAN_CTRL	Control path for Fan1, Fan2, and Fan3, by the TM when the temperature reaches 100°F (37.7°C).	Fan OFF: B+ Fan ON: <0.5V	TM	FAN 1, FAN 2, FAN 3
186	JPT18-18	ALARM_TRAVEL	Return path for Travel Alarm and/or Travel Light.	De-energized: B+ Energized: <0.5V	TM	Travel Alarm, Travel Light
187	JPT20-1	+12VP	+12V supply to Lift Ref Prox (S11).	10.1 to 13V	TM	S11
188	JPT20-2	+12VP	+12V supply to Battery Gate Prox 1 and 2 (S57 and S58).	10.1 to 13V	TM	S57, S58
189	JPT20-4	+12VP	+12V supply to the Mini Lift Pressure Transducer.	10.1 to 13V	TM	Mini Lift Press. Transducer
190	JPT20-5	+12VP	+12V supply to the Main Lift Pressure Transducer.			
191	JPT20-7	+12VP	+12V supply for the Steer Motor Encoder.	10.1 to 13V	TM	Steer Motor Encoder
192	JPT20-9	+12VP	+12V supply to the Home Steer Prox.	10.1 to 13V	TM	Home Steer Prox
193	JPT20-14	BRAKE	Control path for the electrically released brake on the Traction Motor.	De-energized: B+ Energized: 26V	TM	Brake
194	JPT22-1	SLACK CHAIN 1	Input to the TM from Slack Chain Switch 1 (S50).	Open: >4V Closed: <1V	S50	TM
195	JPT22-2	SLACK CHAIN 2	Input to the TM from Slack Chain Switch 2 (S51).		S51	TM
196	JPT22-3	HOMESENSE	Voltage the TM uses to determine if Home Steer Prox is over metal.	Off Metal: >4V On Metal: <1V	Home Steer Prox	TM
197	JPT22-4	RAIL_SEN	Read by the TM to determine if the truck is in or out of the rail. The TM may limit travel speed based on truck location and position of the Auto/Man switch. When the truck is in the rail, S15 is closed.	Closed: <1V Open: >4V	S15	TM
198	JPT22-5	CHANNELA_5	Part of the height position feedback when the encoder is rotated. It is a square wave identical to Channel B_5 but different phase. The TM uses the phase relationship of the two channels to determine whether the platform is lifting or lowering. The number of pulses is used to determine the height.	At Rest: <1V or >4V Full lift/lower: Approx. 2.3V	Main Lift Height Encoder	TM

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
199	JPT22-6	BATTERY GATE LT	Input voltage to the TM from optional Battery Gate Prox 1 (S57). The prox switch is used to detect the left battery gate is correctly installed. Travel is inhibited when the switch does not detect a correctly installed gate.	Gate installed: <1V Not installed: Approx. >4V	S57	TM
200	JPT22-7	LIFT REF	Used by TM to determine when platform is above the Lift Ref Prox (S11).	Off Metal: >4V On Metal: <1V	S11	TM
201	JPT22-8	BRAKE DEADMAN	Input to TM from the Brake Deadman switch (S2).	Pedal Up: >4V Depressed: <1V	S2	TM
202	JPT22-9	CHANNELA_4	Part of the steering position feedback from the Steer Motor Encoder when the drive unit is rotated. It is a square wave identical to Channel B_4 but different phase. The TM 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.	Not Turning: <1V or >4V Turning either direction: Approx. 2.4V	Steer Motor Encoder	TM
203	JPT22-10	CHANNELB_4	Part of the steering position feedback from the Steer Motor Encoder when the drive unit is rotated. It is a square wave identical to Channel A_4 but different phase. The TM 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.	Not Turning: <1V or >4V Turning either direction: Approx. 2.4V	Steer Motor Encoder	TM
204	JPT22-11	DGND	B– for the Home Steer Prox.	Measure B+ at TP1 to verify connections. Then check for <0.5V wrt TP4.	TM	Home Steer Prox
205	JPT22-12	CHANNELB_5	Part of the height position feedback when the encoder is rotated. It is a square wave signal identical to Channel A_5 but different phase. The TM uses the phase relationship of the two channels to determine whether the main carriage on the truck is lifting or lowering. The number of pulses is used to determine the height.	At Rest: <1V or >4V Full lift/lower: Approx. 2.3V	TM	Main Lift Height Encoder
206	JPT22-19	FU1_SENSE	B+ when STR contactor closes. This voltage is used by the TM to determine the state of FU1 and the STR contactor tips.	Closed: B+ Open: voltage drops very slowly	STR	TM

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
207	JPT22-20	FU4_SENSE	B+ when there is not an open between B+ and PC2. This voltage is used by the TM to determine the state of FU4 and the LHC contactor tips.	LPC Closed: B+ Open: voltage drops slowly to <1V	LHC	TM
208	JPT22-21	EPO_SENSE	Sense wire used by the TM to determine when the EPO is open. This is used to initiate braking and display a message.	EPO closed and key switch ON: B+ EPO open: <0.5V	EPO	TM
209	JPT24-3	DGND	B– for Custom In T1.	Measure B+ at TP1 to verify connections. Then check for <0.5V wrt TP4.	TM	Custom In T1
210	JPT24-4	DGND	B– for TMID0.		TM	TM
211	JPT24-5	DGND	B– for the Rail Sense switch (S15).		S15	TM
212	JPT24-6	DGND	B– for Mini Lift Pressure Transducer.		Mini Lift Pressure Transducer	TM
213	JPT24-7	DGND	B– for Custom In T2.		TM	Custom In T2
214	JPT24-8	DGND	B– to the optional End-of-Aisle Sensor (S46B) at S46B-8. It is then routed through the switch module to S46B-7 to S46A-8.		TM	S46A/B
215	JPT24-9	DGND	B– to the optional End-of-Aisle Sensor (S47B) at S47B-8. It is then routed through the switch module to S46B-7 to S46A-8. It is connected on the TM through Fuse FU13 to JPS14-3 and 4, and on to TP4. There is no harness wiring connected at this point.		TM	S47A/B
216	JPT24-10	DGND	B– for the Main Lift Pressure transducer.	Measure B+ at TP1 to verify connections. Then check for <0.5V wrt TP4.	Main Lift Pressure transducer	TM
217	JPT24-11	DGND	B– for the Load Handler Motor Temp Sensor.		TM	TM
218	JPT24-16	VMIDO	Jumper used to identify module as the TM.	<0.5V	TM	TM
219	JPT24-17	SENSOR 2	Input voltage to the TM. It is generated by either S47A or S47B when one or both of them detect the presence of a floor magnet. SENSOR 2 is used along with SENSOR 1 (JPT12-10) to determine if the truck is in or out of the aisle. This information is used to control travel speed based on truck location and the position of the AUTO/MAN switch.	Magnet not sensed: >4V Magnet sensed: <1V	S47A/B	TM

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
220	JPT24-18	MAIN LIFT PRESS.	Analog DC voltage that varies directly with the weight on the carriage. Approx. 1V per 1000 lb. (453 kg). It is necessary to have the TM supply approx. 12V as well as DGND in order for the transducer to function correctly.	Forks Fully Lowered: 1V	Main Lift Pressure Transducer	TM
221	JPT24-19	MINI LIFT PRESS.	Analog DC voltage that varies directly with the weight on the mini-mast. Approx. 1V per 1000 lb. (453 kg). It is necessary to have the TM supply approx. 12V as well as DGND in order for the transducer to function correctly.	Forks Fully Lowered: 1V	Mini Lift Pressure Transducer	TM
222	JPT24-20	BATTERY GATE RT	Input voltage to the TM from the optional Battery Gate Prox 2 (S58). The proximity switch is used to detect the right battery gate is correctly installed. Travel is inhibited when the switch does not detect a correctly installed gate.	Gate installed: <1V Not installed: >4V	S58	TM
223	JPT24-23	LHM TEMP	Analog input that varies with Load Handler motor temperature. Used by the TM to control cooling fan (Fan1) operation.	Approx. 1V @ 75°F (24°C)	Load Handler Motor Temp Sensor	TM
224	JPT24-24	BATTERY_ SENSE_IN	B+ present when the battery is plugged in. It is supplied through a thermistor on the Fuse/Relay Card. This is used by the TM to determine the correct battery is installed. It accepts between 37.3 and 58.7V. If the correct battery is sensed, Relay_Enable is energized during Startup. After Startup, this voltage is used to determine BSOC.	B+ (there should be no voltage drop)	TP1	TM
225	JPTA1-1	B+K3	B+ present when K3 is energized. This is used to power the control circuits of the TPA.	Energized: B+	K3	TPA
226	JPTA1-6	TPC CONTACTOR	Control path for the TPC. The TPA supplies a path for B– for the contactor by way of the B– terminal.	TPC De-energized: B+ Energized: 26.4V	TPA	TPC
227	JPTA1-7	T VEL SENSOR–	B– for the Traction Motor Encoder (TME), Traction Motor Temperature (TMT) sensor, and TME cable shield.	Measure B+ at TP1 to verify connections. Then check for <0.5V wrt TP4.	TPA	TME and shield, TMT
228	JPTA1-8	T TEMP+	Input from Traction Motor Temperature (TMT) sensor that varies with motor temperature. Used by the TPA to adjust motor performance.	Approx. 1V @ 75°F (24°C)	TMT	TPA

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
229	JPTA1-12	ID1	B+ present at the TPA with K3 tips energized. It is used as an identifier to determine correct connection.	K3 energized: B+	K3	TPA
230	JPTA1-13	TPC SUPPLY (B+K3)	B+ for the TPC contactor coil. The TPA supplies B+ to the TPC contactor coil.	B+	TPA	TPC
231	JPTA1-23	BUS0+	Positive component of the digital communications between the TPA, LPA, TM, and GM.	2.3V	TM	TPA, LPA, TM, GM
232	JPTA1-26	T VEL SENSOR +	5V supply to the Traction Motor Encoder (TME). This voltage is produced by the TPA from B+K3.	4.75 to 5.25V	TPA	TME
233	JPTA1-31	T VEL PHASE A	Input signal from the TME. It is a square wave that is either high (>3V) or low (<1V). The frequency varies directly with the speed of the Traction Motor. Identical to T VEL Phase B, except for phase. The TPA uses the relationship between phase A and B to determine travel speed and direction.	Motor Stationary: >3V or <1V Turning: Approx. 2.3V	TME	TPA
234	JPTA1-32	T VEL PHASE B	Input signal from the TME. It is a square wave that is either high (>3V) or low (<1V). The frequency varies directly with the speed of the Traction Motor. Identical to T VEL Phase A, except for phase. The TPA uses the relationship between phase A and B to determine travel speed and direction.	Motor Stationary: >3V or <1V Turning: Approx. 2.3V	TME	TPA
235	JPTA1-35	BUS0–	Negative component of the digital communications between the TPA, LPA, TM, and GM.	2.3V	TM	TPA, LPA, TM, GM
236	JPW1-1	RIGHT	Input from the load antenna right wire sensor to the Filter Card.	Centered over wire: Approx. 32mVAC Right 1.5 in.: Approx. 15mVAC Left 1.5 in.: Approx. 75mVAC	Antenna	Filter Card
237	JPW1-2	NEAR WIRE	Input from the load antenna near wire sensor coil to the Filter Card.	Centered over wire: Approx. 70mVAC Either side 1.5 in.: Approx. 100mVAC	Antenna	Filter Card

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
238	JPW1-3	LEFT	Input from the load antenna left wire sensor to the Filter Card.	Centered over wire: Approx. 32mVAC Right 1.5 in.: Approx. 75mVAC Left 1.5 in.: Approx. 15mVAC	Antenna	Filter Card
239	JPW1-5	T0	Communication lines used by the GM to tell the Load Sensor what amplitude it should be looking for.	No useful voltages are measurable	GM	Antenna Card
240	JPW1-6	T1				
241	JPW1-7	T2				
242	JPW1-8	T3				
243	JPW1-13	SHIELD	Shield that helps reduce noise interference in the AC voltage from the Antenna Card. It must be connected to B– on the Filter Card connection only.	<0.5V wrt TP4 (B–)	Filter Card	Antenna Card
244	JPW1-14	AGRD	B– to the Load Sensor.	<0.5V wrt TP4 (B–)	Filter Card	Antenna Card
245	JPW1-15	12V	+12V supply for the Load Sensor from the GM power supply.	Key Switch ON: +10.1 to 13V	Filter Card	Antenna Card
246	JPW2-1	RIGHT	Input from the right Tractor Sensor to the Filter Card.	Centered over wire: Approx. 32mVAC Right 1.5 in.: Approx. 75mVAC Left 1.5 in.: Approx. 15mVAC	Antenna Card	Filter Card
247	JPW2-2	NEAR WIRE	Input from the tractor near wire sensor to the Filter Card.	Centered over wire: Approx. 70mVAC Either side 1.5 in.: Approx. 100mVAC	Antenna Card	Filter Card
248	JPW2-3	LEFT	Input from the left Tractor Sensor to the Filter Card.	Centered over wire: Approx. 32mVAC Right 1.5 in.: Approx. 15mVAC Left 1.5 in.: Approx. 75mVAC	Antenna Card	Filter Card

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
249	JPW2-5	T0	Communication lines used by the GM to tell the Tractor Sensors what amplitude it should be looking for.	No useful voltages are measurable	Filter Card	Antenna Card
250	JPW2-6	T1				
251	JPW2-7	T2				
252	JPW2-8	T3				
253	JPW2-13	SHIELD	Shield that helps reduces noise interference in the AC voltage from the Antenna Card. It must be connected to B– on the Filter Card connection only.	<0.5V wrt TP4 (B–)	Filter Card	Antenna Card
254	JPW2-14	AGRD	B– to the Tractor Sensor.			
255	JPW2-15	12V	+12V supply from the GM power supply for the Tractor Sensor.	Key Switch ON: +10.1 to 13V	Filter Card	Antenna Card

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Pinout Matrix

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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/Grade**	**Raymond Part Number**
Drive Unit Gear Case (all-weather) (-20°F to +120°F) (-29°C to +49°C)	Gear Lubricant	75W-90 Synthetic Gear Oil API Service Classification GL-5	990-655/001 (1 qt./0.9 liters) 990-655/003 (1 gal./3.8 liters)
Hydraulic Reservoir (Non-Cold Storage Trucks) (+50°F to +120°F) (+10°C 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 (In and Out of Freezer) (0°F to +50°F) (-18°C to +10°C)	Hydraulic Fluid	ISO VG 32	1017238
Hydraulic Reservoir (Confined to Freezer) (-20°F to 0°F) (-29°C 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°F to +120°F) (-29°C 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, Lubricants

Application	**Raymond P/N**	**Loctite* Number/Color**
Cold Storage silicone sealing compound	990-445	
Corrosion Inhibitor Coating	990-644	
Hydraulic Sealant	990-552	569
Molybdenum Anti-Seize Compound (Molykote)	990-638	
RTV Silicone Sealant	990-659	5900/Black
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
*Loctite is a registered trademark of the Loctite Corporation. Brand endorsement is not implied here, but listed only as a commonly identified product.		

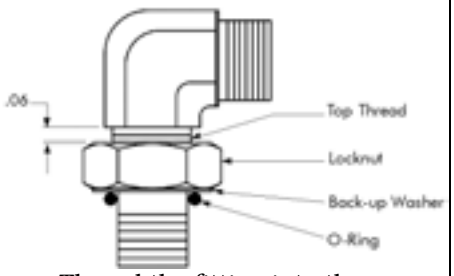
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Component Specific Service/Torque Chart

Table A-3. Component Specific Service/Torque Chart

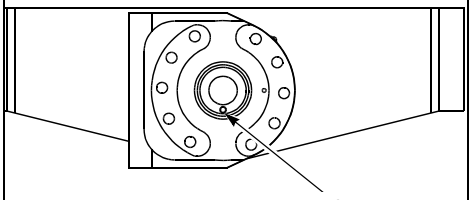
Component	Sub-Component(s)	Thread-Locking Compound/ Torque Values	Helpful Hints
Carriage Manager	CM mounting bolts:	P/N 990-536	Record configuration settings if possible before replacing CM; after replacing CM, reconfigure truck. See "Using Configure Mode" on page 3-26.
Deadman Pedal and Switch	Pedal mounting screws	P/N 990-536	
Drive Unit	Drive unit mtg. bolts: Drive wheel mtg. bolts: Bumper bolts:	350 ft. lb. (475 Nm) 185 ft. lb. (251 Nm) 75 ft. lb. (101 Nm)	Drive unit capacity is 7.1 quarts (6.75 liters).
End-of-Aisle Detect Sensors			Adjust sensor so bottom of sensor is 2 in. (50 mm) above the floor.
Guidance Manager			Run Learn for wire guidance after replacement. See "Learn Wire Guidance" on page 3-34.
Hydraulic Filter			Always remove canister with filter. Lubricate the inside of filter cap with hydraulic fluid, install the cap, and tighten to 60 in. lb. (6.8 Nm).
Hydraulic Fluid Replacement			Reservoir capacity is 15 gallons (57 liters), *not counting* fluid in cylinders and hoses. Fill to sight gauge.
Lift Motor	Pump spline and motor coupling Pump and motor mtg. bolts: Power cables:	Molybdenum anti-seize compound (P/N 990-638) P/N 990-536/ 21 ft. lb. (29 Nm) 100 to 120 in. lb. (11.2 to 13.6 Nm)	On power cables, use two wrenches to avoid twisting the motor studs.
Lift Reference Proximity Sensor			Adjust the gap between the switch and the telescopic to 0.19 ±0.06 in. (4.8 ±1.5 mm).

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Component	Sub-Component(s)	Thread-Locking Compound/ Torque Values	Helpful Hints
Load Handler Pump and Motor	Pump spline and motor Pump mounting bolts: Motor mounting bolts: Power cables:	Molybdenum anti-seize compound (P/N 990-638) 9 ft. lb. (12 Nm). 15 ft. lb. (20 Nm). 100 to 120 in. lb. (11.2 to 13.6 Nm)	EE-rated trucks: A feeler gauge of 0.017 in. (0.43 mm) must *not* be able to fit between the brush band and the housing at any point around the motor. On power cables, use two wrenches to avoid twisting the motor studs.
Operator Display Interface Card			Make sure jumper is plugged in at JPD5. Download the Operator Display graphics. See "Graphics Database Download" on page 3-39.
Pressure Transducers	O-rings:	Lubricate with hydraulic fluid. Tighten transducer to 11 ft. lb. (15 Nm).	Run Learn Mode for Weight. See "Learn Weight" on page 3-33.
Reach Cylinder			Attach fittings to cylinder as follows: • Replace O-ring as needed. • Back off the lock nut 1 to 2 threads short of the uppermost position on the fitting.  • Thread the fitting into the cylinder port until the O-ring contacts the surface. • Align the fitting for hose attachment by unthreading *no more than 360°*. • Tighten the lock nut. Adjust the reach extension (from fork carriage to load handler carriage) to the reach specification for the truck.
Reach Manifold	Manifold mtg. bolts: Valve torques:	P/N 990-536 See "Manifold Port Torque Specifications" on page 7-73.	

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Component Specific Service/Torque Chart

Component	Sub-Component(s)	Thread-Locking Compound/ Torque Values	Helpful Hints
Reach Position Proximity Sensor			Adjust the gap between the sensor and the carriage frame to 0.06 to 0.12 in. (1.5 to 3 mm).
Rotate Actuator	Mounting bolts:	100 ft. lb. (135 Nm)	Orient actuator in rotate carriage as shown.  **Mounting hole for Rotate Position Feedback Potentiometer Bracket**
Sidegate Switch	Switch body screws: Switch bracket mtg. bolts:	P/N 990-403 P/N-990-536	
Stability Pads			Inspect stability pads for correct clearance: 0.31 to 0.56 in. (8 to 14 mm). Replace if clearance is >0.75 in. (19 mm). Welding is required.
Static Straps			Make sure static straps are not worn or broken. Clean debris from straps. Measure resistance of resistor in standoff. If resistance is <10K ohms or >1.2 meg ohms, replace the resistor/insulator block or the whole static strap assembly. Install static straps at a 45° angle. EE trucks require phosphor-bronze straps.
Steer Home Proximity Sensor			Adjust the vertical gap between the sensor and the sensor rail to 0.15 to 0.19 in. (4 to 5 mm). Center the drive wheel. Locate the sensor horizontally just past the end of the sensor rail. See “Learn Wire Guidance” on page 3-34.
Steer Position Feedback Encoder			Run Learn for Guidance. See “Learn Wire Guidance” on page 3-34.
Steering Input Encoder	Socket head button screws mounting the steering tiller shaft boss to the encoder:	P/N 990-536	

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Component	Sub-Component(s)	Thread-Locking Compound/ Torque Values	Helpful Hints
Traction Motor	Armature shaft lock nut: Motor and drive unit mating surfaces: Motor mounting bolts: Power cables:	P/N 990-536/ 120 ft. lb. (163 Nm) P/N 990-520 (Gasket sealing compound) 20 ft. lb. (27 Nm) 100 to 120 in. lb. (11.2 to 13.6 Nm)	EE-rated trucks: A feeler gauge of 0.017 in. (0.43 mm) must *not* be able to fit between the brush band and the housing at any point around the motor. On power cables, use two wrenches to avoid twisting the motor studs.
Traverse Motor	Mounting bolts:	75 ft. lb. (102 Nm)	
Wire Guidance Filter Card			Run Learn for wire guidance after replacement. See “Learn Wire Guidance” on page 3-34.
Wire Guidance Sensor	Bumper to tractor frame:	75 ft. lb. (101 Nm)	Adjust sensor so bottom of sensor is 2 in. (50 mm) above the floor. Run Learn Mode for Guidance. See “Learn Wire Guidance” on page 3-34.

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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	
		Nm	ft. lb.	Nm	ft. lb.	Nm	ft. lb.
-2	5/16-24	4 ±1	3 ±1	4 ±0.6	3 ±0.5	10 ±0.6	7.5 ±0.5
-3	3/8-24	8 ±1	6 ±1	7 ±0.6	5 ±0.5	19 ±1	14 ±1
-4	7/16-20	16 ±1	12 ±1	15 ±1	11 ±1	24 ±1	18 ±1
-5	1/2-20	20 ±1	15 ±1	20 ±1	15 ±1	30 ±1	22 ±1
-6	9/16-18	28 ±1	21 ±1	24 ±1	18 ±1	37 ±3	27 ±2
-8	3/4-16	61 ±3	45 ±2	62 ±3	46 ±2	65 ±3	48 ±2
-10	7/8-14	81 ±7	60 ±5	102 ±7	75 ±5	122 ±7	90 ±5
-12	1 1/16-12	115 ±7	85 ±5	115 ±7	85 ±5	149 ±7	110 ±5
-14	1 3/16-12	142 ±7	105 ±5	176 ±8	130 ±6	197 ±8	145 ±6
-16	1 5/16-12	163 ±7	120 ±5	183 ±8	135 ±6	217 ±8	160 ±6
-20	1 5/8-12	230 ±14	170 ±10	305 ±16	225 ±12	305 ±16	225 ±12
-24	1 7/8-12	271 ±20	200 ±15	339 ±16	250 ±12	339 ±16	250 ±12
-32	2 1/2-12	366 ±27	270 ±20	441 ±20	325 ±15	441 ±20	325 ±15

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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	Nm	ft. lb.
-4	9/16-18	24 ±1	18 ±1
-6	11/16-18	37 ±3	27 ±2
-8	13/16-16	54 ±3	40 ±2
-10	1-14	85 ±4	63 ±3
-12	1 3/16-12	122 ±5	90 ±4
-14	1 5/16-32	129 ±8	95 ±6
-16	1 7/16-12	163 ±11	120 ±8
-20	1 11/16-12	190 ±11	140 ±8
-24	2-12	224 ±11	165 ±8
-32	2 1/2-12	488 ±14	360 ±10

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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

Note: Use “oiled” values for bolts with thread-locking compound.

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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
	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 - Standard (Brass)

Table A-7. Torque Chart - Standard (Brass)

Brass MS63 Standard Bolts, Coarse Thread		
Size	**Torque (with bolts oiled)**	
	Nm	**in. lb.**
4-40	0.37	3.3
4-48	0.40	3.6
6-32	0.69	6.1
6-40	0.77	6.8
8-32	1.24	11
8-36	1.24	11
10-24	1.58	14
10-32	1.92	17
1/4-20	3.96	35
1/4-28	4.52	40
5/16-18	8.25	73
5/16-24	9.15	81
3/8-16	14.69	130
3/8-24	16.61	147
Note: Use “oiled” values for bolts with thread-locking compound.		

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Torque Chart - Metric

Table A-8. Torque Chart - Metric (Ferrous Bolts, Coarse Thread)

Ferrous Metric Bolts, Coarse Thread (The grade rating is stamped on the head of the bolt.)				
Diameter (in millimeters)	**Grade 8.8**		**Grade 10.9**	
	Torque (with bolts oiled)		**Torque (with bolts oiled)**	
	Nm	**ft. lb.**	**Nm**	**ft. lb.**
6	8.1	6	12.2	9
8	20.3	15	28.4	21
10	40.7	30	58.3	43
12	74.6	55	101.7	75
16	176.3	130	245.4	181
20	345.7	255	474.5	350
24	589.8	435	820.3	605
Note: Use “oiled” values for bolts with thread-locking compound.				

Table A-9. Torque Chart - Metric (Brass Bolts, Coarse Thread)

Brass MS63 Metric Bolts, Coarse Thread		
Diameter (in millimeters)	**Torque (with bolts oiled)**	
	Nm	**in. lb.**
3	0.5	4.4
3.5	0.79	7.0
4	1.1	10
5	2.1	19
6	3.8	34
8	9	79
10	17	150
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

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4ths	8ths	16ths	32nds	64ths	To 3 Places	To 2 Places	MM Equivalent
				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
				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

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Decimal Equivalent Chart

4ths	8ths	16ths	32nds	64ths	To 3 Places	To 2 Places	MM Equivalent
		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

Table A-11. Standard/Metric Conversions

To Convert...	**Multiply...**
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
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
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
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
Ounces to grams	Ounces x 28.35

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Standard/Metric Conversions

To Convert...	**Multiply...**
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
Pounds per Square Inch (psi) to Kilopascals (kPa)	Pounds per Square Inch x 6.894
Kilopascals to Pounds per Square Inch	Kilopascals x 0.145
Pounds per Square Inch (psi) to Kilograms per square centimeter (kg/cm^2)	Pounds per Square Inch (psi) x 0.0704
Kilograms per square centimeter (kg/cm^2) to Pounds per Square Inch (psi)	Kilograms per square centimeter ($kg/cm^{2)}$ x 14.2
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
Fahrenheit to Celsius	(°F - 32) x 0.555
Celsius to Fahrenheit	(°C x 1.8) + 32

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1089040B

Printed by the Digital Print Center,

The Raymond Corporation, Greene, NY