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RAYMOND

Maintenance Manual

High-Level Orderpicker Lift Truck with *The ACR System*™



Models
5400, 5500, 5600

Serial Numbers
00100 and Up

1031794A **Issued: 1/27/06**

1031794B **Re-Issued: 7/14/06**

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This publication, 1031794B, applies to High-Level Orderpicker Models 5400, 5500, 5600, S/N 00100 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.

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 the revision date in the footer. These pages are also available on the Raymond iNet.
- Non-technical changes – These changes consist of typographical and grammatical corrections, paragraph renumbering, repagination, and so on. Non-technical changes are not identified with a change bar, however, affected pages are identified with the revision date in the footer.

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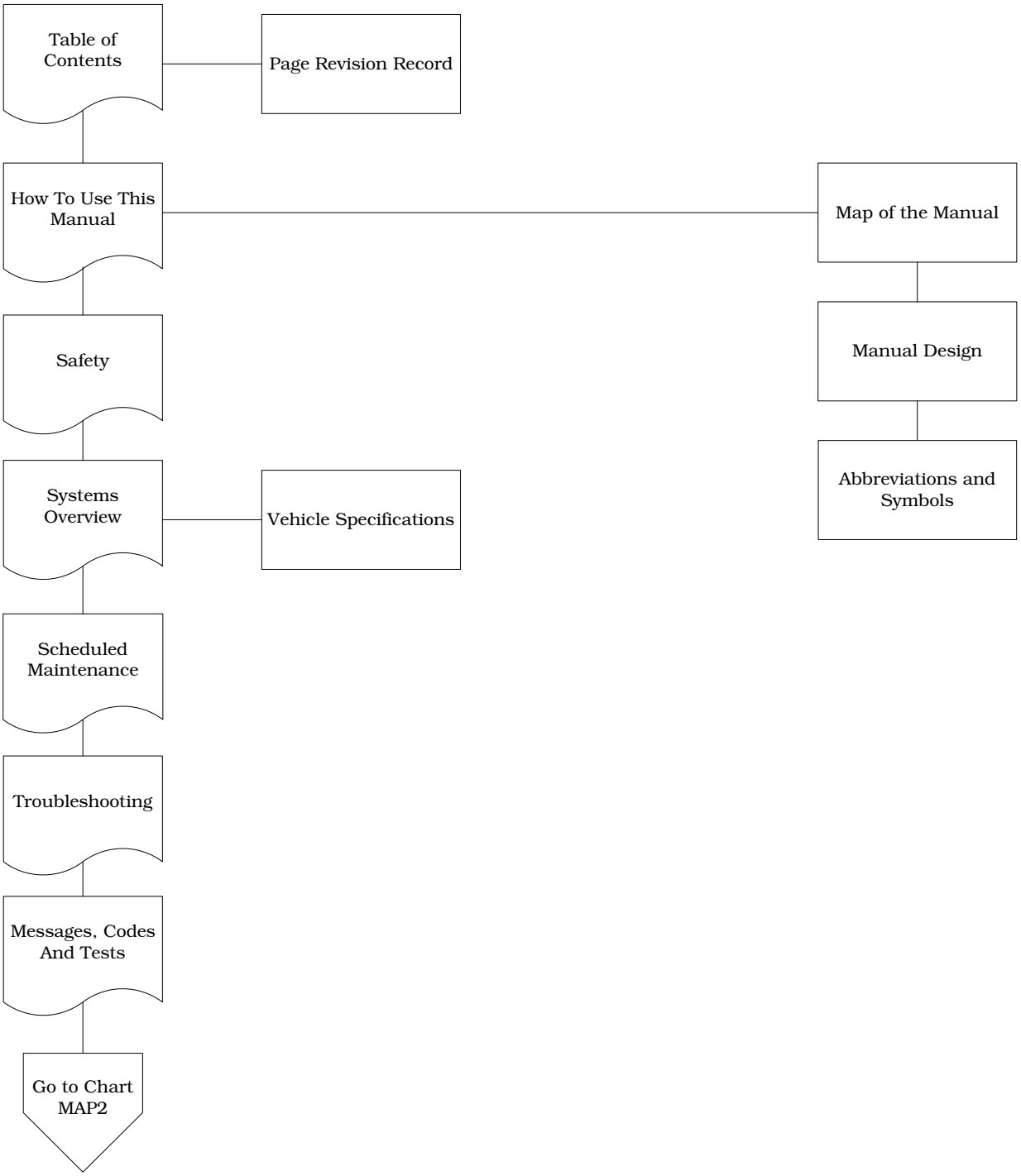
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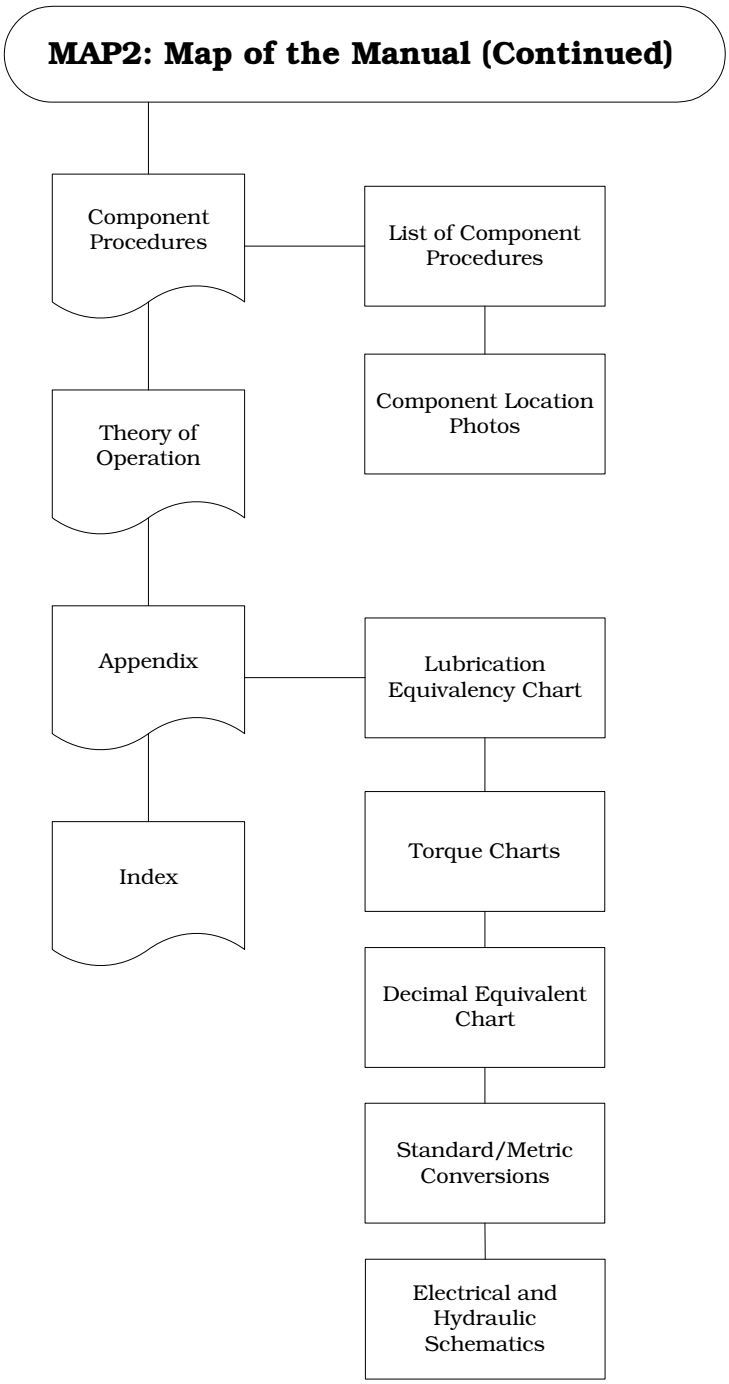
Section 1. How to Use This Manual

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Map of the Manual



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Manual Design

This manual is designed with the following objectives in mind:

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

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

- Name of the manual
(Model 5400, 5500, and 5600 Maintenance Manual)
- Current Section Title
(for example, this page; Section 1. How to Use This Manual)
- Current topic
(for example, this page; Manual Design)

This manual consists of the following sections:

- **How to Use This Manual** explains the manual format and design as well as abbreviations and symbols used.
- **Safety** explains warning and caution notes, general safety rules, and safety rules for batteries, static, jacking, and welding.
- **Systems Overview** includes general lift truck overview, programming instructions, and configuration menu.
- **Scheduled Maintenance** outlines the recommended schedule of preventive services to keep your lift truck working most efficiently.
- **Troubleshooting** is designed to take you from a symptom to a specific sequence of tests in order to isolate a failing component.
- **Messages, Codes and Tests** lists the electrical fault codes and procedures for running firmware electrical tests.
- **Component Procedures** gives step-by-step procedures for testing, removal, installation, and adjustment of individual truck components. Components are grouped by truck system.

  To find a component procedure, you may use one of three methods:

  - Look up the component name in the **List of Component Procedures**.
  - Find the component in the **Component Locator Photos**.
  - Look up the component name in the maintenance manual **Index**.
- **Theory of Operation** explains signal flow within the electrical and hydraulic systems for various conditions of lift truck operation. This section also contains a detailed connection point table (Pin-Out Matrix) designed to assist in testing and troubleshooting the truck.
- **Appendix** contains reference information such as torque values, lubricants, standard/metric conversions, and system schematics.
- **Index** lists subjects alphabetically.

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Abbreviations and Symbols

The following abbreviations, acronyms and symbols are used in this manual.

Term/Symbol	Definition
A	Ampere
AC	Alternating Current
Agnd	analog ground
amp	Ampere or amplifier
approx	approximately
Assy	assembly
aux	auxiliary
AWG	American Wire Gauge
BSOC	Battery State-of-Charge
BWI	brush wear indicator
CAN	Controller Area Network
CCC	Carriage Control Card
CCW	counterclockwise
CFP	Contactor Fuse Panel
cm	centimeter
COP	Computer Operating Program
CW	clockwise
CS	cold storage
DC	Direct Current
Dgnd	digital ground
DMM	Digital Multi Meter
DVM	Digital Voltmeter
EE	UL Electric Truck Type Certification Rating where electrical equipment is completely enclosed
EMF	ElectroMotive Force
EOA	End-of-Aisle
EPO	Emergency Power Off
EPROM	Erasable Programmable Read Only Memory
ESD	Electrostatic Discharge
ESDS	Electrostatic Discharge Sensitive
FF	Forks-first
fpm	feet per minute
FRC	Fuse/Relay Card
ft.	foot or feet
gal.	gallon or gallons
GM	Guidance Manager
gm	gram
Gnd	ground
HD	hours on deadman
Ht	height
Hgt/Wgt	Height/Weight
Hz	Hertz
in.	inch or inches
kg	kilogram(s)
kHz	kilohertz
km/h	kilometers per hour
kPa	kilo Pascal
lb.	pound or pounds
LED	Light Emitting Diode
L/H	Load Holding
L/L	Lift/Lower
LPA	Lift Power Amplifier
LPC	Lift Power Contactor
mA	milliampere
max	maximum
min	minute or minimum
mm	millimeter
MM	*Maintenance Minder*™
mph	miles per hour

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Abbreviations and Symbols

Term/Symbol	Definition
mS	millisecond or milliseconds
mV	millivolt or millivolts
mVAC	millivolts - alternating current
No.	number
NV	non-volatile
NVM	Non-Volatile Memory
N•m	newton meter
OACH	Overall Collapsed Height
OD	Operator Display
OI	Operator Interface
OSHA	Occupational Safety and Health Association
oz.	ounce
prox	proximity
pot	potentiometer
psi	pounds per square inch
PWM	Pulse Width Modulation
P/N	Part Number
RAM	Random Access Memory
rpm	Revolutions per Minute
SAE	Society of Automotive Engineers
sec.	second
SG	specific gravity
SOL	Solenoid
spec	specification
temp	Temperature
TF	Tractor-first
TPA	Traction Power Amplifier
TPC	Traction Power Contactor
TS	Traction Speed
T/S	troubleshoot
UL	Underwriters Laboratories, Inc.
V	Volt or Volts
VDC	Volts Direct Current
VM	Vehicle Manager
wrt	with respect to
Wt	Weight
w/	with
w/o	without
@	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

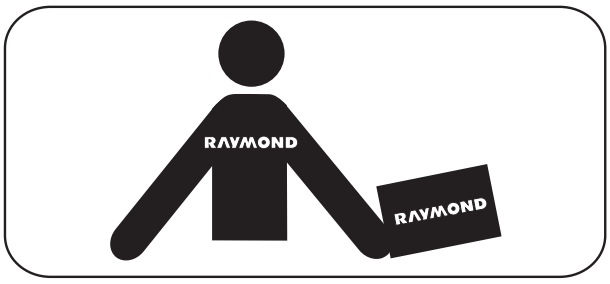
A Warning indicates a potentially hazardous situation that, if not avoided, could result in serious bodily injury or death.

⚠CAUTION

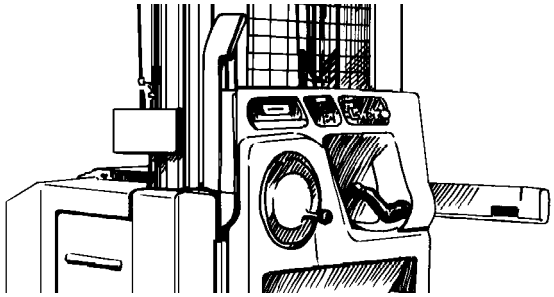
A Caution indicates a potentially hazardous situation that, if not avoided, could result in minor or moderate bodily injury or damage to the lift truck or nearby objects. It also can be used to alert personnel against unsafe practices.

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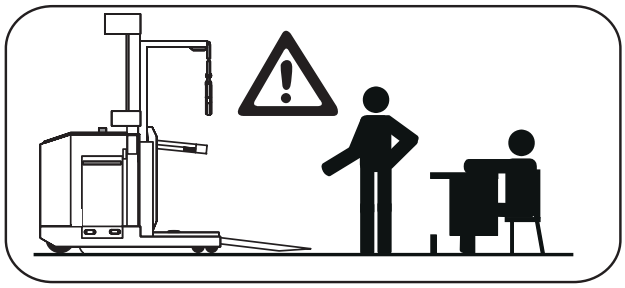
General Safety



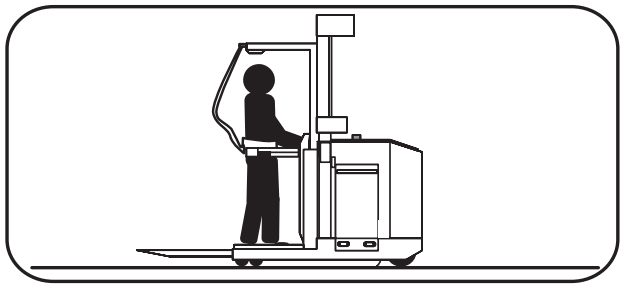
Do *not* operate or work on this truck unless you are trained, qualified and authorized to do so, and you have read both the Owner Manual and the Operator Manual.



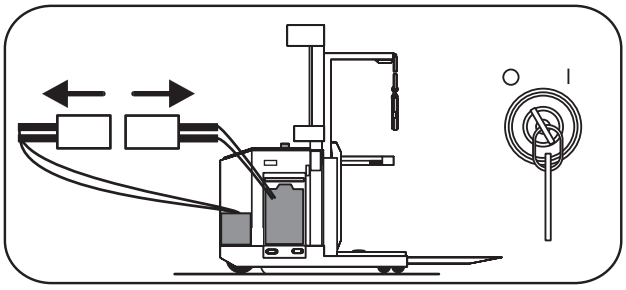
Know the truck's controls and what they do.



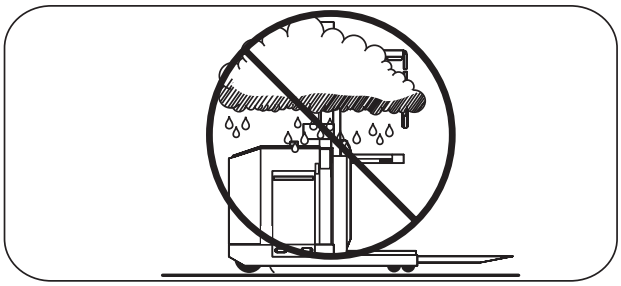
Do *not* operate this truck if it needs repair or if it is in any way unsafe.



Operate this truck only from the operator position. When elevated, make sure you wear a safety belt attached to a secured tether.



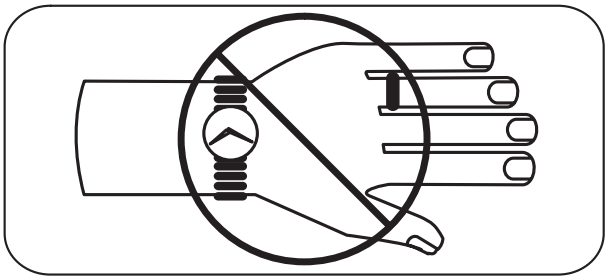
Before working on this truck, always turn the key switch OFF and disconnect the truck's battery connector (unless this manual tells you otherwise).



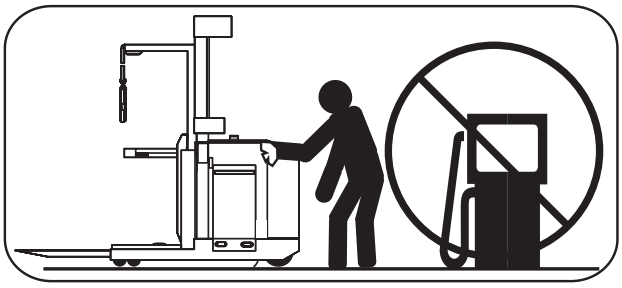
Always use and park this truck indoors.

Do *not* park a truck in a cold storage area overnight unless the truck is conditioned for cold storage.

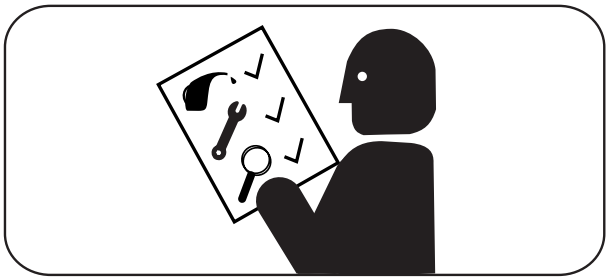
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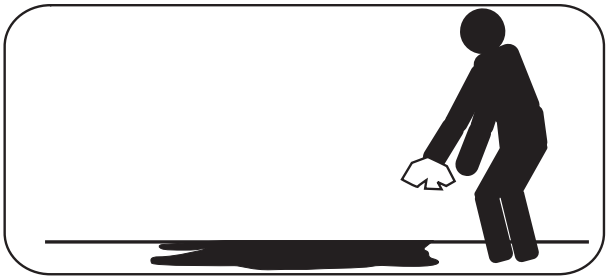
Do *not* wear watches, rings, or jewelry when working on this truck.



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



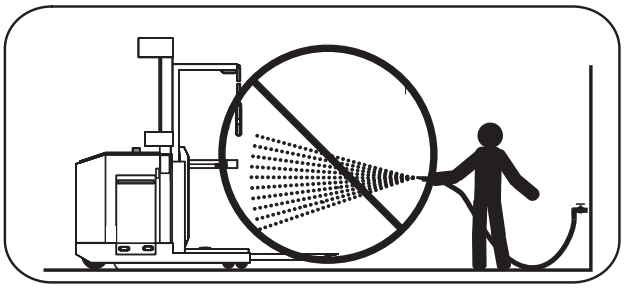
Follow the scheduled lubrication, maintenance, and inspection steps.



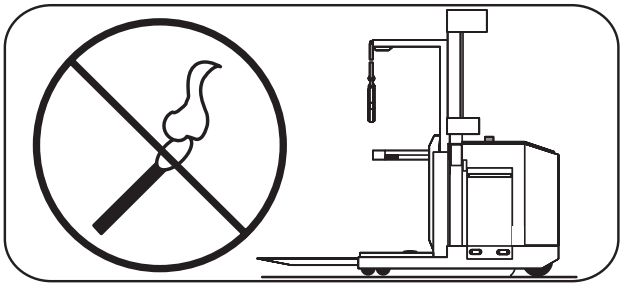
Clean up any hydraulic fluid, oil, or grease that has leaked or spilled on the floor.



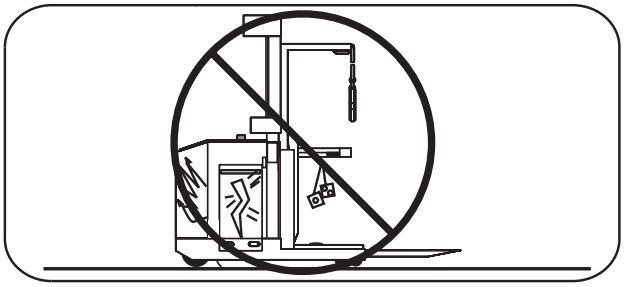
Follow exactly the safety and repair instructions in this manual. Do not take *shortcuts*.



Do *not* wash this truck with a hose.



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



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

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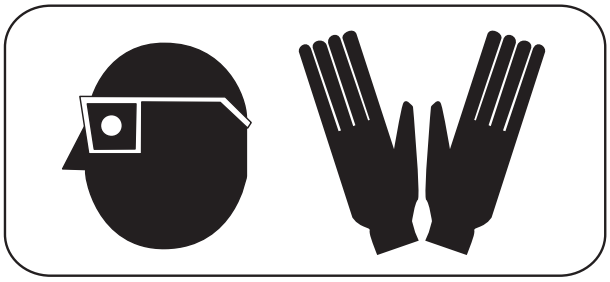
Battery Safety

⚠ WARNING

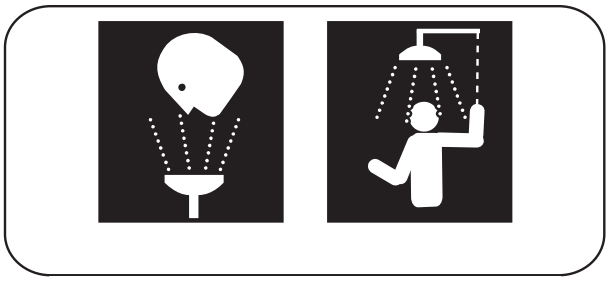
As a battery is charged, an explosive gas mixture forms within and around each cell. If the area is not correctly ventilated, this explosive gas can remain in or around the battery for several hours after charging. Make sure there are no open flames or sparks in the charging area. An open flame or spark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

⚠ WARNING

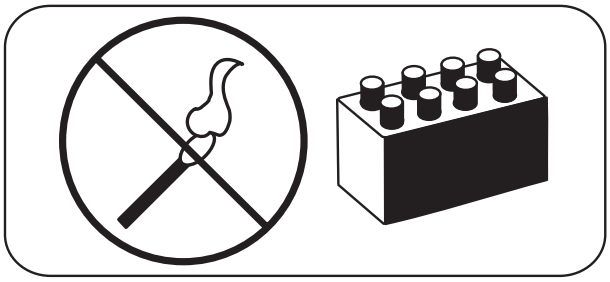
Battery electrolyte is a solution of sulfuric acid and water. Battery acid causes burns. Should any electrolyte come in contact with your clothing or skin, flush the area immediately with cold water. Should the solution get on your face or in your eyes, flush the area with cold water and get medical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



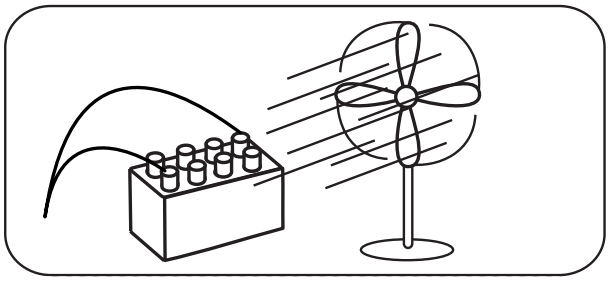
Wear personal protective equipment to protect eyes, face, and skin when checking, handling, or filling batteries. This equipment includes goggles or face shield, rubber gloves (with or without arm shields), and a rubber apron.



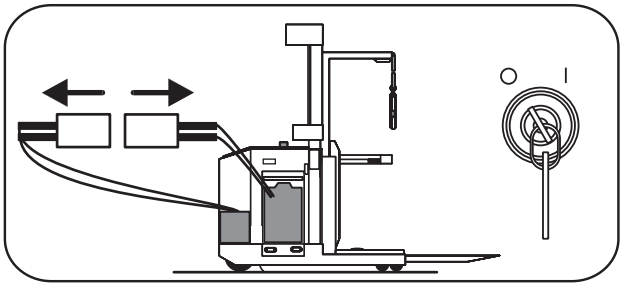
Make sure a shower and eyewash station are nearby in case there is an accident.



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



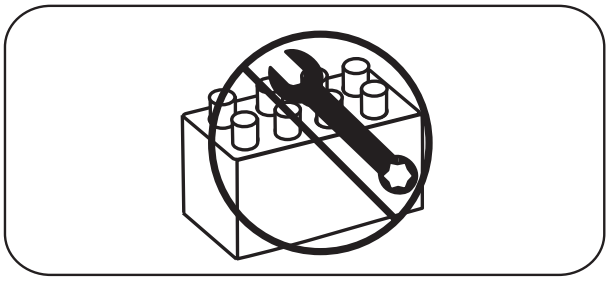
Keep the charging area well-ventilated to avoid hydrogen gas concentration.



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Battery Safety

Turn the key switch OFF *before* disconnecting the battery from the 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.

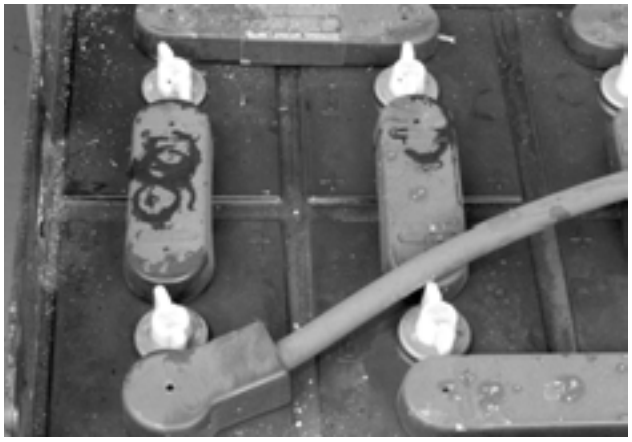


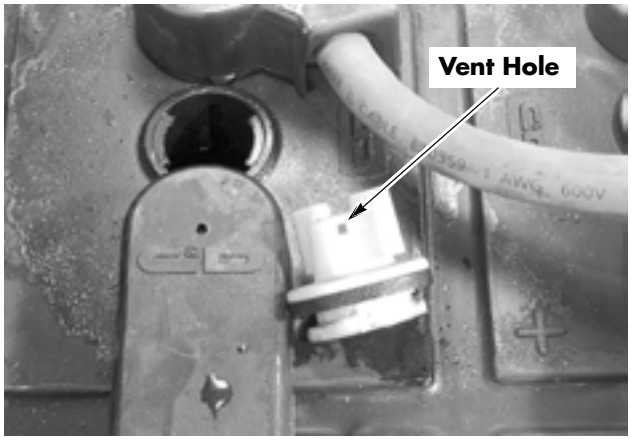
Do not lay tools or metal objects on top of the battery. A short circuit or explosion could result.

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

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

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



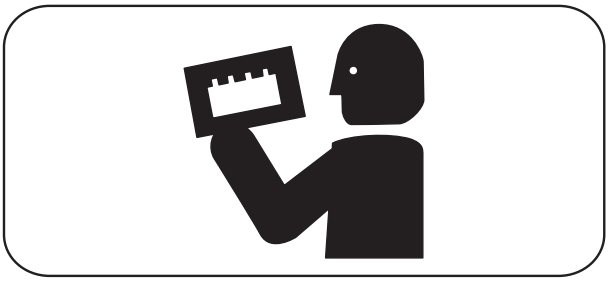


Make sure the vent holes in the filler plugs are open to allow the gas to escape from the cells.

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

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

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



Follow the charging procedures in the Battery Instruction Manual and in the Battery Charger Instruction Manual.

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Electrostatic Discharge 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 such as plastic bags, synthetic clothing, synthetic soles on shoes, and styrofoam coffee cups.

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.
- Connect the wrist strap plug to the ground jack on the lift truck. See Figure 2-1. If you cannot use the ground jack, connect the ground clip to an unpainted, grounded surface on the lift truck frame.
- Handle circuit boards by the edges only. Avoid touching the edge connectors.
- If you are removing or installing static-sensitive components, place them on a correctly grounded antistatic mat.
- To transport static sensitive components, including failed components being returned, place the components in an antistatic bag or box (available from your local authorized Raymond dealer).

The wrist strap and associated accessories must be tested monthly to verify they are working correctly. The wrist strap contains a one megohm resistor in the strap cord that acts as a fuse for personal protection. If the resistor is open, replace the strap.

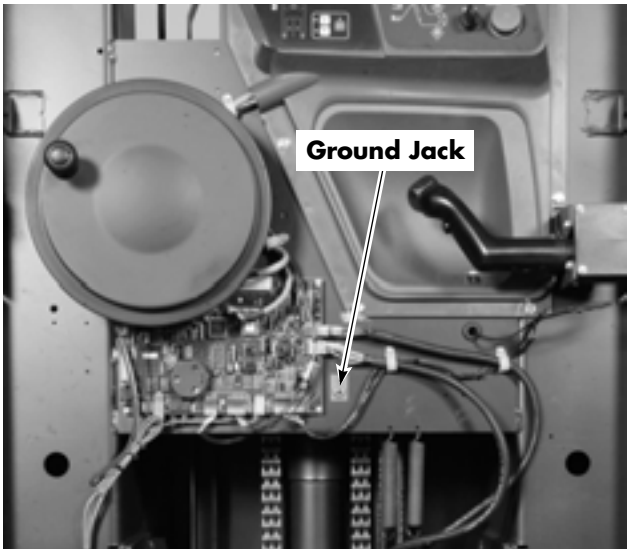


Figure 2-1. Ground Jack



Figure 2-2. Anti-Static Kit (P/N 1-187-059) with Wrist Strap and Mat

Figure 2-2 shows the components of the Raymond antistatic 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.

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

A wrist strap tester is available as P/N 1-187-060.

Contact your local authorized Raymond dealer for information.

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Jacking

Jacking Truck

When the truck is jacked up for any reason, take the necessary precautions listed here to ensure that the truck will not tip over.

- Lower the forks completely. Remove any load.
- Place all controls in neutral.
- Block the wheels to prevent movement of the vehicle.
- Turn the key switch OFF and disconnect the battery connector.
- Place the jack under the designated jacking points. See Figures 2-3 and 2-4.
- Always use solid blocks to support the vehicle. Never rely on jacks or chains to hold the vehicle.

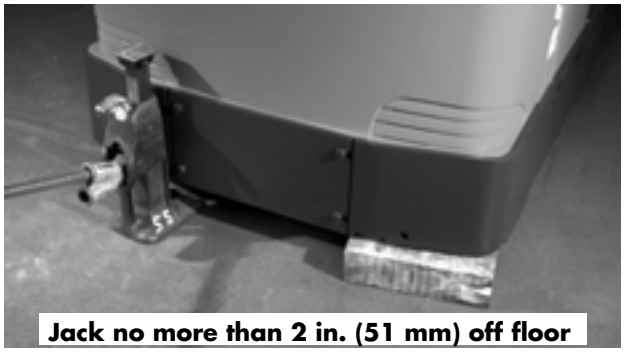


Figure 2-3. Jacking Drive Tire Off Floor

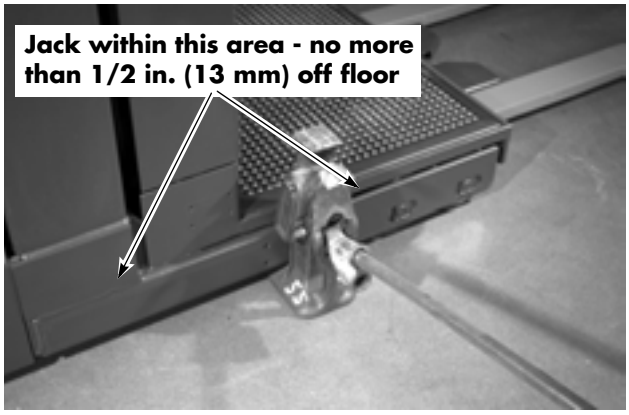


Figure 2-4. Jacking Side of Truck

⚠ WARNING

Attach a chain to the top of the mast and an overhead hoist to stabilize the mast if jacking more than described in this procedure.

Operator Platform

When it is necessary to perform a procedure with the operator platform elevated, place a safety stand between the carriage and baseleg as follows.

1. Use the lift knob and raise the operator platform until you have enough clearance to perform the procedure.
2. Place a safety stand or block between the carriage and a baseleg and carefully lower the operator platform onto the safety stand. See Figure 2-5.
3. Turn the key switch OFF and disconnect the battery connector.



Figure 2-5. Blocking Operator Platform

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Emergency Lower Valve

In the event that it is necessary to lower the carriage from the ground, do the following:

1. Remove tractor cover. The Emergency Lower Valve is located on the lift/lower manifold. See Figure 2-6.
2. Slowly turn the valve counterclockwise, allowing the operator platform to lower by its own weight.

NOTE: Leaving the valve open will prevent the operator platform from elevating.

3. Turn the valve clockwise to close. This will allow the operator platform to elevate when the main lift control is operated.

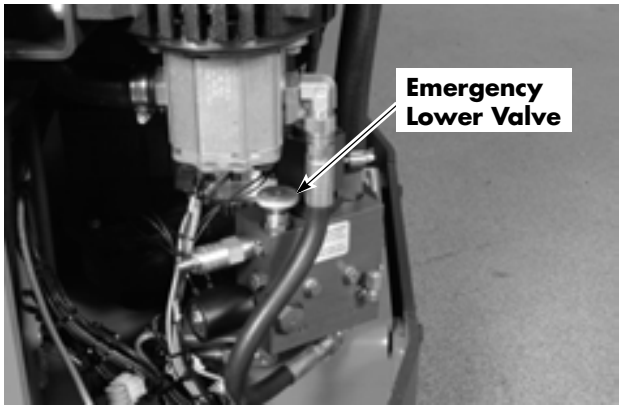


Figure 2-6. Emergency Lower Valve

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Tie-Down for Transport

Vertical Transport

To transport this lift truck in an over-the-road vehicle or rail car, follow these steps:

1. Lower operator platform and locate truck in center of transport vehicle.
2. Turn the key switch OFF and disconnect the battery connector.

NOTE: If guide rollers are present, place straps through guide rollers and secure to floor; skip to step 4.

3. If guide rollers (used for rail guidance) are not present:
   a. Install eye-bolts (3/4 in. [19 mm] thread size) in holes in the bumper. See Figure 2-7.
   b. Secure chain from eye-bolts to vehicle bed. See Figure 2-8.
4. Strap truck from bumper or guide roller to floor of transport vehicle.
5. Chock drive wheel to prevent tractor-first movement.
6. Place block between baseleg and platform, 7.5 in. (190.5 mm) from front edge of platform.
7. Position additional adjustable chain or strap perpendicular to forks over operator platform and attach it to vehicle bed. This will prevent tip-over during transportation. See Figure 2-8.

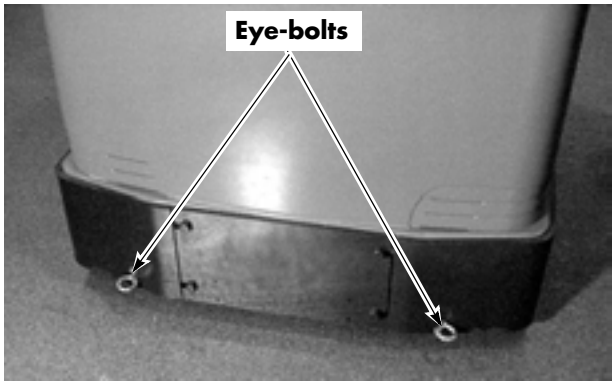


Figure 2-7. Eye-Bolts Installed for Transport

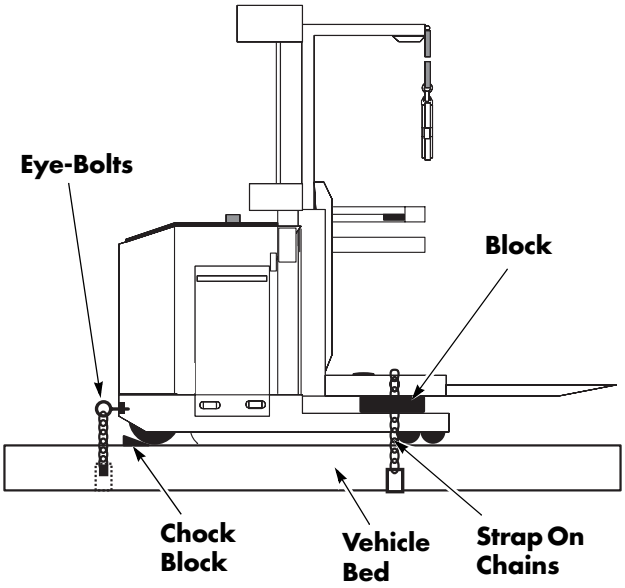


Figure 2-8. Tie-Down for Vertical Transport

Horizontal Transport

1. Remove forks from carriage.
2. Replace cap and screen in hydraulic reservoir with shipping cap and screws.
3. Band down carriage and battery rollers.
4. Remove dipstick, and plug drive unit.
5. Remove the bottom two bumper plate bolts (to be reinstalled after shipping).
6. Use two hoists in conjunction and lay truck on cradle.
7. Install long bolts through the holes in the bumper and secure to cradle.
8. Band truck to cradle.
9. Secure forks to cradle below mast.

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Towing

To tow this lift truck, follow these steps:

1. Lower the operator platform and remove any load.
2. Turn the key switch OFF and disconnect the battery connector.
3. Using a suitable towing vehicle, lift the tractor end of the truck until the drive tire is no more that 1 in. (25.4 mm) off the floor.
4. Tow the truck slowly in the tractor-first direction.

NOTE: If you must tow the truck flat on the ground, you must install the brake release bolts provided. See Figures 2-9 and 2-10.

Steering is disabled while you are towing, so you will need to manually turn the drive unit to steer.

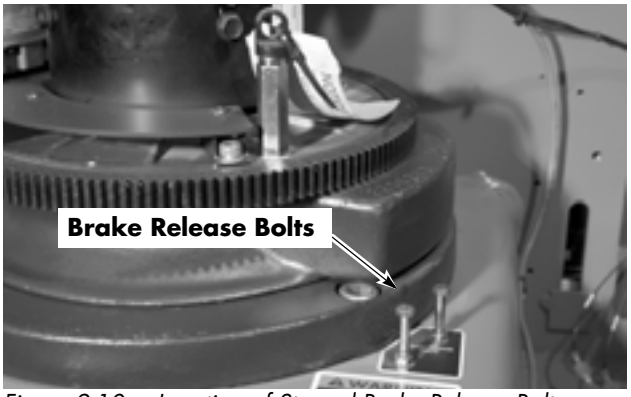


Figure 2-10. Location of Stowed Brake Release Bolts



Figure 2-9. Brake Release Bolt Installation

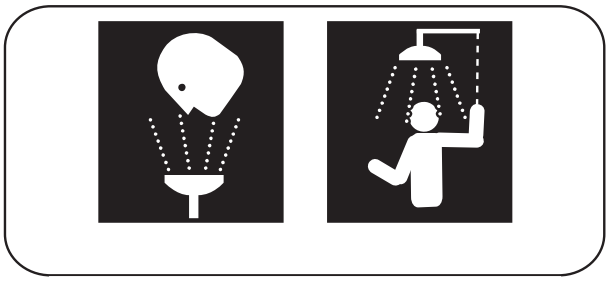
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Welding Safety

⚠ WARNING

Flame cutting or welding on painted surfaces may produce potentially harmful fumes, smoke, and vapors. Prior to performing flame cutting or welding operations, the coating must be removed in the vicinity where the operation(s) is performed.

Coating removal may be by mechanical methods, chemical methods, or a combination of methods. Perform flame cutting and/or welding operations only in well ventilated areas. Use local exhaust if necessary.



Before working on this truck, make sure that:

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

⚠CAUTION

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

- Check for any shorts to the frame. See Shorts to Frame Test on page 5-11. If any shorts are detected, remove them before you proceed with the welding operation.
- Clean the area to be welded.
- Protect all truck components from heat, weld spatter, and debris.
- Attach the ground cable as close to the weld area as possible.
- Do not perform any welding operation near the electrical components.
- If welding must be done near the battery compartment, remove the battery.
- When you are finished welding, perform all ground tests and electrical inspections before the vehicle is operated.

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Section 3. Systems Overview

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General System Data

Carriage

The carriage is the part of the truck that can be elevated and from where the lift truck is operated. The carriage includes the operator platform, the overhead guard, and the forks.

Chassis

The chassis is the basic frame of the lift truck that includes the tractor, baselegs, and mast.

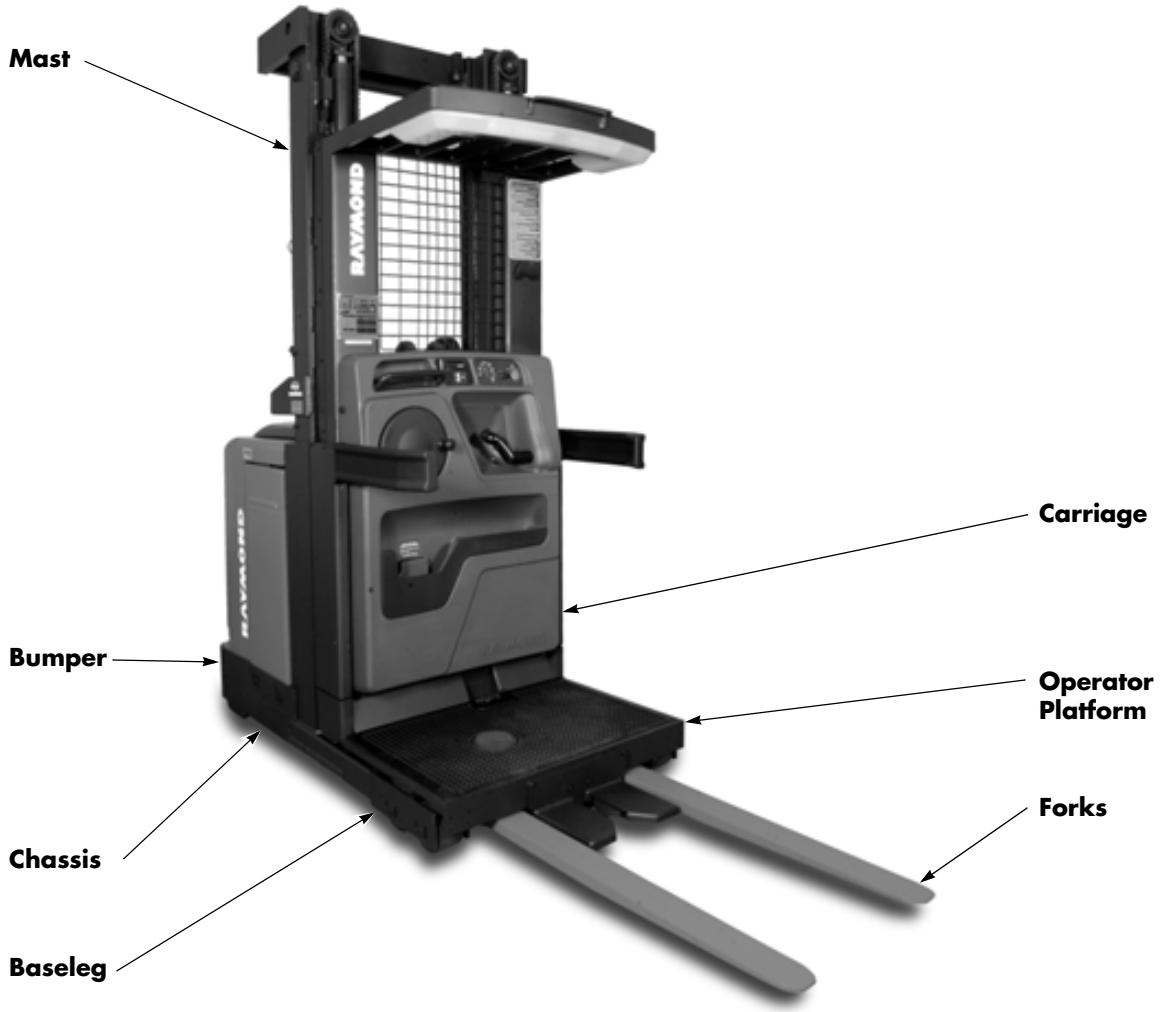


Figure 3-1. Model 5600

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Tractor

The tractor holds the majority of electrical and hydraulic components of the lift truck, including the battery, power section, pumps, and motors. For the location of specific components, see Component Locator Photos on page 7-3.

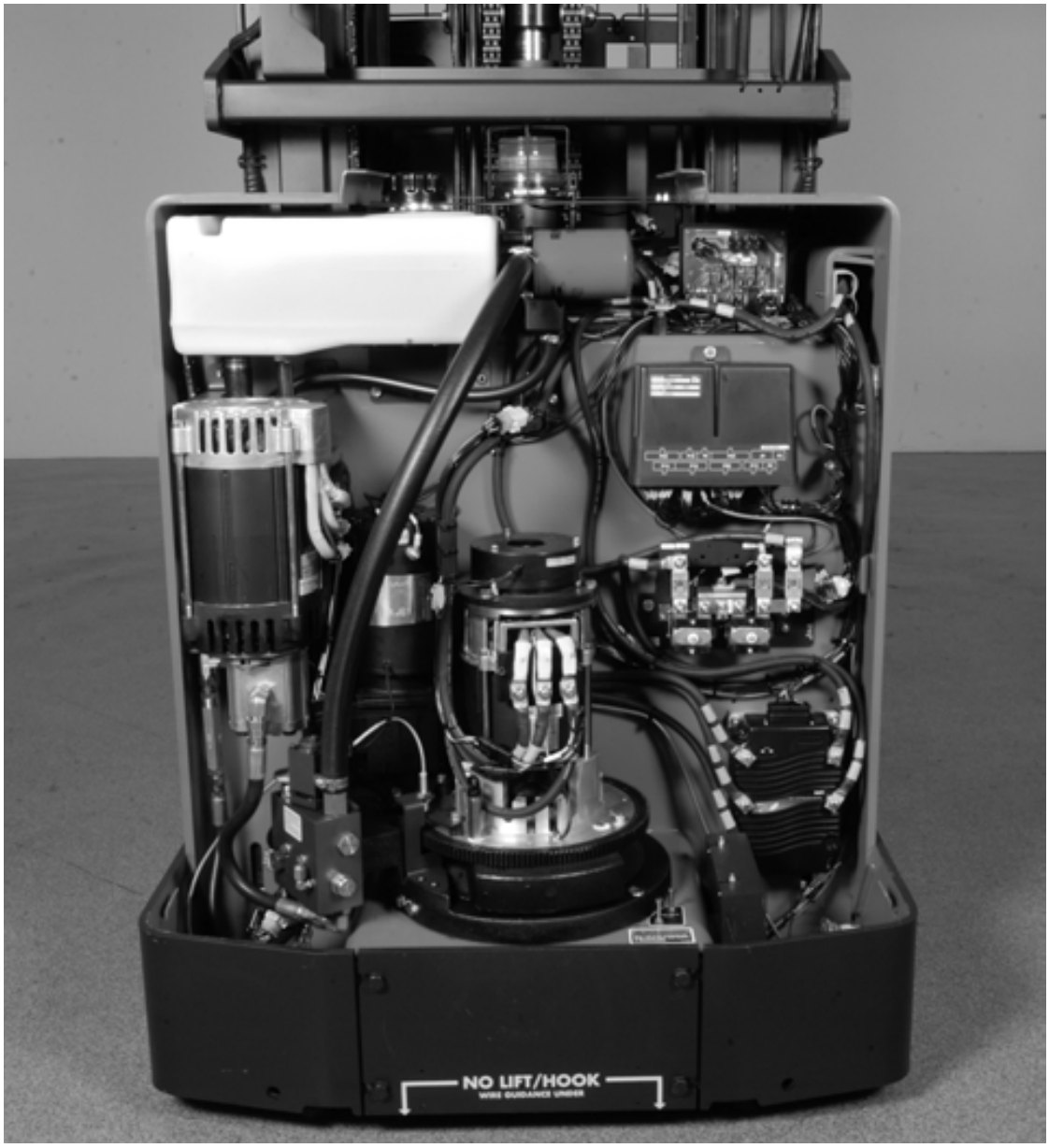


Figure 3-2. View Inside Tractor Compartment

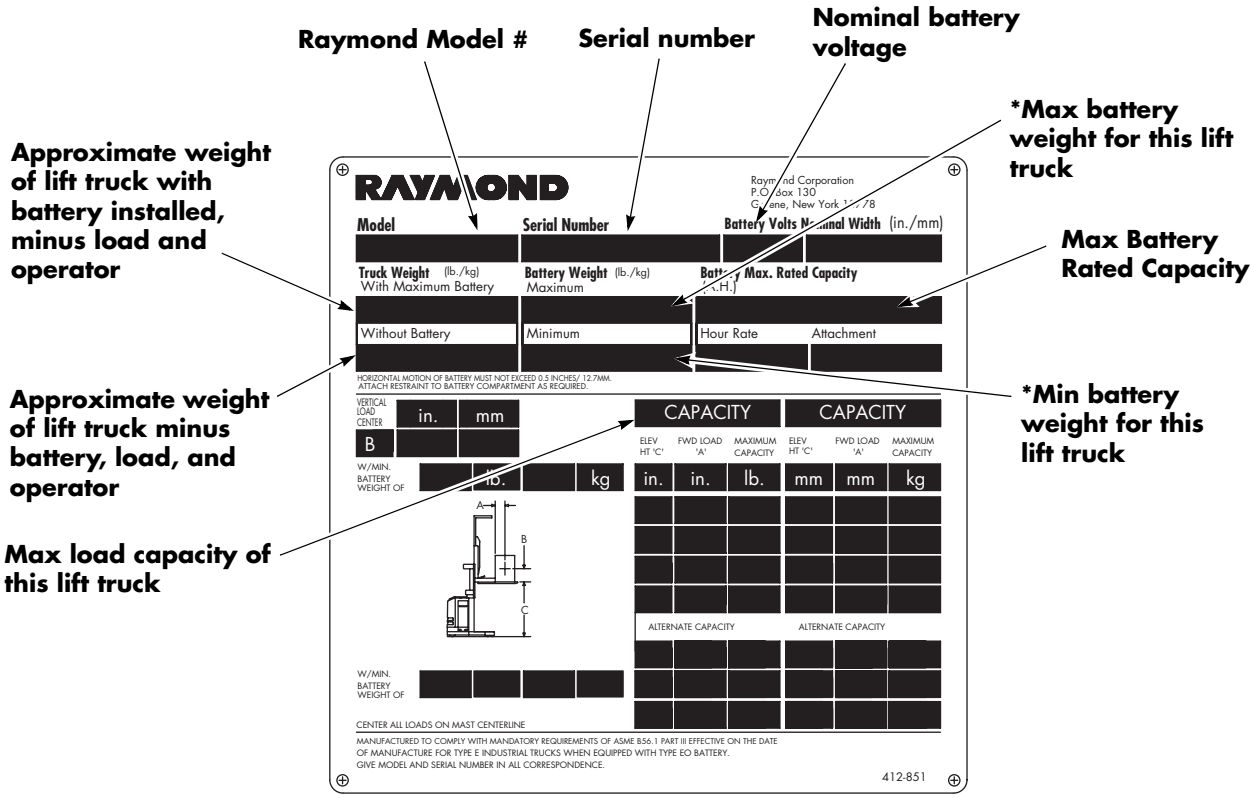
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Lift Truck Specifications

Specification Plate

This lift truck is rated for performance by load center and load weight. Review the specification plate for detailed load capacity and load center information. See Figure 3-3.

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



***Battery weight must be between the min and max weight.**

Figure 3-3. Lift Truck Specification Plate

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Installation

Installation procedures must be performed by a Raymond Certified Dealer Technician to ensure warranty coverage.

During installation, a visual and functional inspection must be performed.

Installation Procedure

NOTE: Two technicians are required for the installation/assembly of this truck.

⚠ WARNING

Place the mast, tractor, and pallets in an open area where it is safe to work.

- **The truck components are heavy, unstable, and difficult to handle. Use caution when lifting and assembling this truck.**
- **Personnel involved in the installation and assembly of this truck should wear gloves, safety glasses, steel toe boots, and a safety helmet.**
- **Do NOT remove the banding that secures the operator platform to the baselegs until the truck is upright.**

Uprighting a Cradled Vehicle

Two Hoist Method

This procedure requires two chain hoists of suitable weight capacity.

1. Position the cradled truck directly beneath and parallel to the chain hoist rail.
2. Attach one hoist to the upper crosstie of the mast.

NOTE: Place blocks between the crossties to avoid bending them.

3. Attach the second hoist to the baselegs.
4. Slowly raise each hoist until there is no slack in the chains.

⚠CAUTION

While performing step 5, make sure the hoist attached to the baselegs does not lift the cradle off the floor. Also, do not let the chain become slack as this will allow the truck to drop.

5. Continue to slowly lift the hoist attached to the mast until the center of gravity shifts, causing the weight of the truck to shift to the hoist attached to the baselegs.
6. Lower the truck with the hoist attached to the baselegs until it is standing upright on the floor.
7. Remove the chain from the baselegs.
8. Remove the chain from the upper crosstie of the mast and attach it to the upper cross-piece of the cradle.
9. Loosen and remove the nuts holding the wooden cradle cross-piece to the mast, then remove the wooden cross-piece.
10. Remove the bolts from the bottom cradle cross-piece attached to the truck's front bumper.
11. Lift the cradle up and away from the truck and lower it to the floor.
12. Carefully remove the strapping securing the operator platform to the baselegs.
13. Remove the shipping cap and screws on top of the hydraulic fluid reservoir. Install the breather cap and screen.
14. Check the fluid level of the hydraulic reservoir.
15. Remove the plug from the drive unit and install the dipstick.

Hoist and Lift Truck Method

This procedure requires a lift truck and a chain hoist of suitable weight capacity.

NOTE: Use this procedure when only one chain hoist is available.

1. Position the cradled truck directly beneath and parallel to the chain hoist rail.
2. Position the forks of the lift truck under the upper cross-piece of the cradle.

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3. Attach the chain hoist to the baselegs of the truck.
4. Slowly raise the hoist until there is no slack in the chain.

⚠CAUTION

While performing this procedure, make sure the hoist attached to the baselegs does not lift the cradle off the floor. Also, do not let the chain become slack as this will allow the truck to drop.

5. Raise the upper end of the cradle with the forks of the lift truck.
6. Continue to slowly lift the cradle until the center of gravity shifts, causing the weight of the truck to shift to the hoist.
7. Lower the truck with the hoist until it is standing upright on the floor.
8. Remove the chain from the baselegs and attach it to the upper cross-piece of the cradle.
9. Loosen and remove the nuts holding the wooden cradle cross-piece to the mast, then remove the wooden cross-piece.
10. Remove the bolts from the bottom cradle cross-piece attached to the truck's front bumper.
11. Lift the cradle up and away from the truck and lower it to the floor.
12. Carefully remove the strapping securing the operator platform to the baselegs.
13. Remove the shipping cap and screws on top of the hydraulic fluid reservoir. Install the breather cap and screen.
14. Check the fluid level of the hydraulic reservoir.
15. Remove the plug from the drive unit and install the dip stick.

Functional Inspection

Before a truck can be put into service, a Raymond Installation Report *must* be completed.

Vehicle Operation

Refer to the Owner and Operator Manuals for truck function information.

Warranty

The Installation Report activates the Raymond warranty on the truck. Failure to correctly complete the Installation Report can void the warranty on the truck.

Password/Superword Changes

Upon completion of truck installation, change the Password and Superword to the customer's specifications. See Changing Password or SuperWord on page 3-12.

Cold Storage Conditioning

If the truck is to be used in a Cold Storage (CS) application, it is equipped with CS option components when delivered from the factory. However, the fluid in the hydraulic reservoir *must* be changed.

Make sure the truck is in a clean area, away from any possible contaminating elements that could enter the hydraulic system.

1. Drain the hydraulic reservoir completely. Also drain fluid from the hydraulic lines and cylinders.

⚠CAUTION

Use of the wrong hydraulic fluid for a specific application can cause damage to hydraulic system components. Warranty claims will not be paid on component damage resulting from incorrect fluid use.

2. Fill the hydraulic reservoir with the correct fluid. See Lubrication Specification Chart on page A-2.
3. Operate all truck functions and check for hydraulic leaks.
4. Bleed the entire hydraulic system before placing the truck into service.
5. Check reservoir fluid level.

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Modes of Operation

This vehicle can operate in one of two modes of operation:

- Run Mode
- Program Mode

Run Mode

Run Mode is the normal operating mode for the vehicle. Run Mode is the only mode that normal vehicle travel is allowed. In this mode, the selectable display is shown on the Operator Display (OD). Run Mode will start automatically when Program Mode is exited or after SelfTest has passed.

Audible Alarm Description

Within Run Mode, various truck situations are identified using different audible tones and patterns. The following are the tones/patterns and possible cause for different operating conditions.

Run Mode Tones

Tone 1. A single tone that indicates:

- UP/DOWN (▲▼) buttons or 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

  A travel performance limitation will only allow the truck to travel at a maximum of 1 mph (1.6 km/h). Lift, lower, steering, and horn functions will operate normally.
- A traction system shutdown

  A traction system shutdown will not allow the truck to travel. Lift, lower, steering, and horn functions will operate normally.
- A shutdown in the lift system

  If a problem occurs in the lift system, lift is prevented. Travel, lower, horn, and steering functions will still be permitted.

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 indicates the truck is seeking and aligning over the guide wire. The tone will continue 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 will not repeat continuously. A fault code and associated message will scroll across the Operator's Display. The message will repeat continuously until the key switch is turned OFF.

Password Levels

Two password levels are used with this system:

- Password
- SuperWord

Password

Password allows access to Configure Mode only. Instructions for using **Config** are outlined on page 3-12.

SuperWord

SuperWord allows access to all program levels available. Only qualified service technicians should have access to SuperWord.

Instructions for entering or changing Password or SuperWord are described on page 3-8.

NOTE: It is *strongly* recommended that the SuperWord be changed from the factory default to something else during installation so access to programming is limited to qualified personnel. With that in mind, it is very important to remember the unique SuperWord code that was entered and saved. If the code is lost or forgotten, it is necessary for a technician to reset the truck to factory

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default settings. This would require the reconfiguration of all variable settings (Speed, Acceleration, Password, SuperWord, and so on).

Program Mode

Program Mode is divided into three categories:

- Configure (**Config**)
- Learn (**Learn**)
- Maintenance (**Maint**) - Static or Active

Configure Mode

The Configure Mode (**Config**) is used to adjust the vehicle's performance to specific customer requirements. To access **Config**, Password or SuperWord must be used. For a detailed description of Configure Mode, refer to page 3-12.

Learn Mode

The Learn Mode is used to calibrate:

- Throttle potentiometer (VR1) (Controls)
- Lift/lower potentiometer (VR2) (Controls)
- *intellispeed*™ sensor - height (optional)
- Pressure transducer - weight (optional)
- Wire guidance frequency and offset (optional)

A discussion of the Learn process for these items is included in this section.

NOTE: To access **Learn**, SuperWord must be used.

Maintenance Mode

The Maintenance Mode (**Maint**) is used to verify the operation of various circuits of the truck. In Maintenance Mode, individual circuits can be energized and cycled to aid in troubleshooting. Some tests can be performed under both active and static conditions to further aid in problem diagnosis.

Static Maintenance Mode

This mode allows one function at a time to be tested.

Active Maintenance Mode

This mode allows all input and analog tests to be active in Run Mode. Navigate through the OD using the Up/Down (▲▼) buttons, then enter Analog or Input by pressing the Enter (↵) button. You can now scroll through all input and output tests. There is no need to select items for Active Maintenance, and you are not limited to the number of items, they are all available. To return to the OD, navigate to **Quit** and press Enter (↵).

To access **Maint**, SuperWord must be used. For a detailed description of Maintenance Mode, refer to page 3-24.

Entering Program Mode

Program Mode can be entered by one of the following two methods.

Method 1

1. With key switch OFF, hold the horn button in and move the lift/lower control to full lift.
2. Turn the key switch to the ON position.
3. The OD will show all eight segments with a solid bar in each segment. See Figure 3-4.

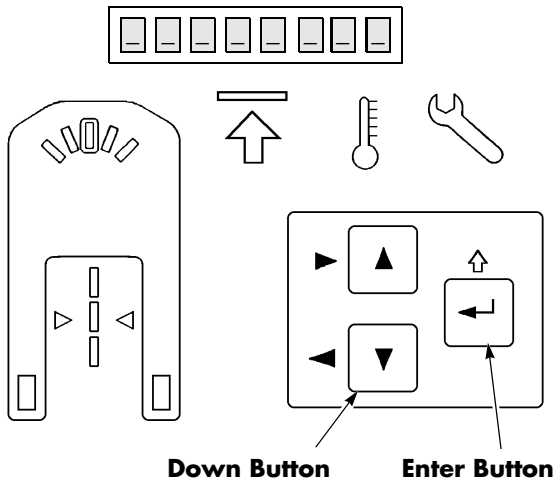


Figure 3-4. Operator Keypad and Display

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Method 2

1. With the key switch OFF, press and hold the Enter (↵) button and Down (▼) button at the same time. See Figure 3-4.
2. Turn the key switch to the ON position.
3. The OD will show all eight segments with a solid bar in each segment.

Entering Password or SuperWord

Refer to Figure 3-5.

1. Observe the OD. The flashing bar at the bottom of the left-most segment indicates the segment that is currently active.
2. Hold the Enter (↵) button down and press the Up (▲) button to move the cursor to the right. Hold the Enter (↵) button down and press the Down (▼) button to move the cursor to the left. Release the Enter (↵) button.
3. Once the segment that you want to change is selected:
   - Press the Up (▲) button to advance through the numbers then letters, (0!234.....XYZ).
   - Press the Down (▼) button to select letters then numbers, (ZYXWV.....432!0).

   Repeat steps 2 and 3 for all character positions in the Password or SuperWord.

NOTE: Initial factory set Password is 1. Initial factory set Superword is 2.

4. When the Password or SuperWord is displayed, press the Enter (↵) button once.

NOTE: If an invalid Password or SuperWord is entered, the following message will appear:

`Invalid password...`

To make a correction, repeat steps 2 thru 4.

NOTE: To reset the SuperWord to factory default, use FlashWare. See "Reset Factory Defaults" on page 3-31.

5. What menus can be accessed will depend on whether SuperWord or Password was entered. Refer to Table 3-1.

   Config is the first selection on the OD. If **Config** is the desired selection, press Enter (↵). If **Learn** or **Maint** is desired (available only if Program Mode is entered with SuperWord), use the Up/Down (▲▼) buttons to scroll to that menu, then press Enter (↵).

   To exit Program Mode, use the Up/Down (▲▼) buttons to scroll to **Quit**, then press Enter (↵).

NOTE: If the output tests are selected in **Maint**, the OD will remind the service technician to jack the truck so the drive tire is off the floor and to open the emergency lowering valve while in Maintenance Mode. When **Ready?** appears on the OD, press Enter (↵) to enter Maintenance Mode output tests.

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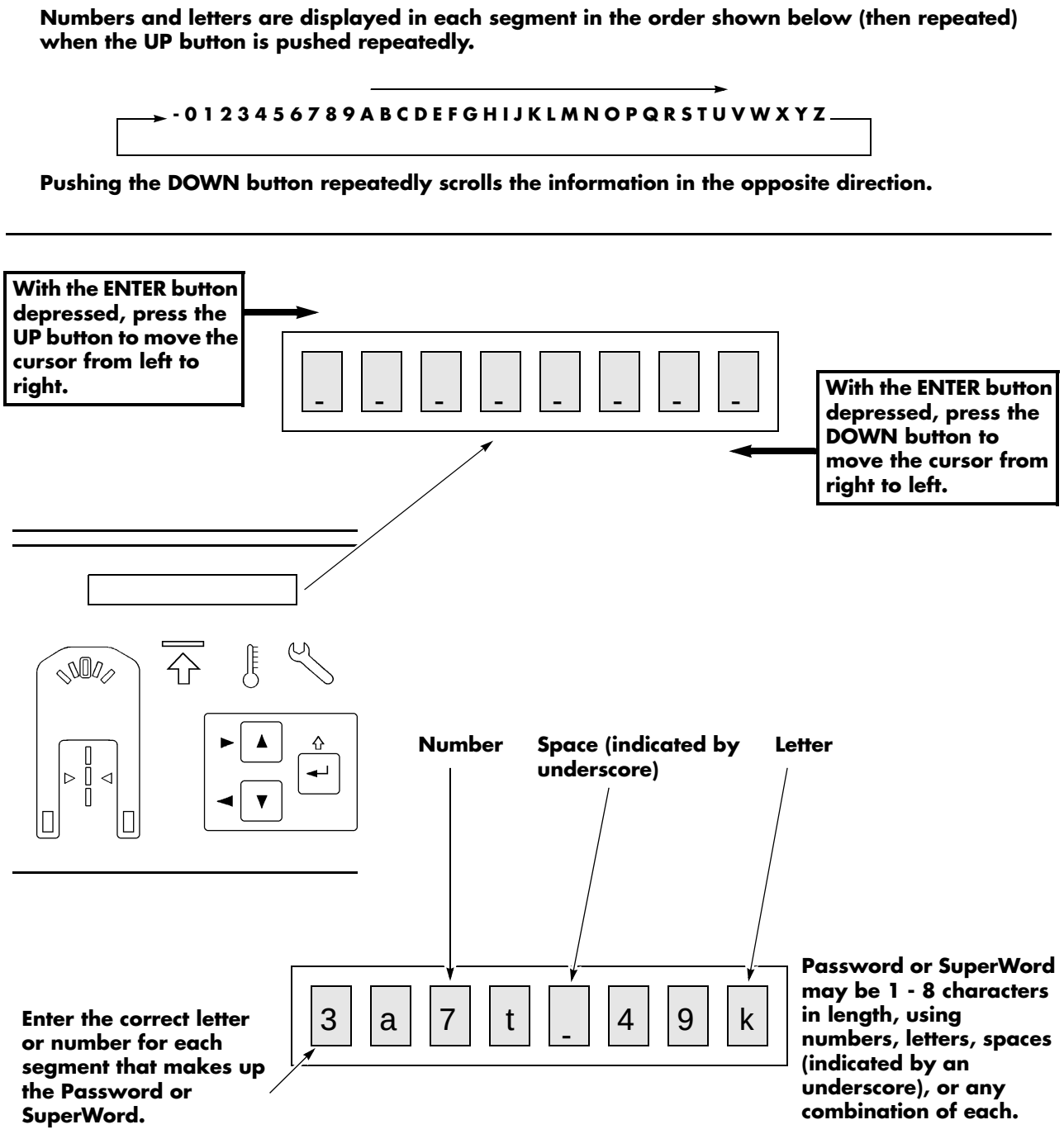


Figure 3-5. Operator Display for Program Mode (Example)

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Table 3-1. Program Mode Menu

PROGRAM MODE MENU – software version 2.0		
Menu	**Selection**	**Description**
Quit		Exits Program Mode
Config		Enter Configure Mode - Refer to Configure Mode and Table 3-2, Configure Mode Menu on page 3-13.
Learn (SuperWord only)		Learn Mode - See Learn Mode on page 3-19.
	Quit Lrn	Exits Learn Mode
	Controls	
	Hgt/Wgt	
	WireFreq	Displayed only if "Other" is selected in Configure Mode Menu
	Wg Offset	
	Steer	Only on rail guided vehicles equipped with auto-steer centering
Maint (SuperWord only)		Maintenance Mode - See Maintenance Mode on page 3-24.
	Analog Input	See Analog Input Tests on page 6-31.
	Output	See Input Tests on page 6-55.
	PA Reset	See Output Tests on page 6-91.
	EvtLog	See Power Amplifier Reset on page 3-25.
	Act Maint	See Event Log on page 3-25.
	Disable	See Active Maintenance Mode on page 3-24.
	Enable	
	Quit Mnt	Exits Maintenance Mode

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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 will appear in the submenu. To change the value, press the Up/Down (▲▼) button. When the desired value appears, press Enter (↵). This will select the item currently displayed and return to the main menu.

All possible truck configurations and options are listed in these instructions. Only the options associated with that particular truck is 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** will exit without saving changes.

Default Settings

NOTE: Once defaults have been 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 SuperWord

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 – software version 2.0 Can be entered with Password unless SuperWord is specified		
Menu	**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 3-12. Restore to Factory Defaults Do not restore to Factory Defaults **CAUTION:** The previous settings cannot be recalled once defaults have been reset (Reset? Y).
Speed	X.X mph	Set Max Speed 0.0 to 6.5 mph (0.0 to 10.46 km/h) (shown in increments of 0.1 mph). Default setting depends on model.
EOA Speed (optional) (SuperWord only)	1.0 mph (default)	Set End-of-Aisle Slowdown Speed (0.0 to Maximum Speed)
Accel	Hard Medium (default) Soft	Set Travel Acceleration
Coast	Long Medium (default) Short	Set Coast
Lift	Hard Medium (default) Soft	Set Lift/Lower Start/Stop Acceleration
LwrDecel (SuperWord only)	0 thru 9 (default = 5)	Set Lower Deceleration Speed. Set lowering speed below 24 in. (610 mm). Select from 0 (no lower deceleration) thru 9 (highest amount of deceleration)

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Table 3-2. Configure Mode Menu

CONFIGURE MODE MENU – software version 2.0 Can be entered with Password unless SuperWord is specified		
Menu	**Selection**	**Description**
BSOC (SuperWord only)	75 (default)	Battery State-of-Charge Reset Variable from 55 to 100 in increments of 1
ActMaint (optional) (SuperWord only)	Enable (default) Disable	Set Active Maintenance
Cut Out (SuperWord only)	20 (default)	Select Battery Cutout Voltage: 0 to 50 in increments of 1
24 Speed (optional) (SuperWord only)	2.5 mph (default)	Set the 24 in. (610 mm) mast switch speed from 0.5 to 2.5 mph (1.6 to 4 km/h)
L Bypass (optional) (SuperWord only)	Enable (default) Disable	Set Lift/Lower Bypass
LBPTrvCt (optional) (SuperWord only)	Enable (default) Disable	Set Lift Limit Bypass and Travel Cutout
LBPAlarm (optional) (SuperWord only)	Enable (default) Disable	Set Lift Limit Bypass Alarm
Units	English (default) Metric	Select English or Metric units of measure

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Table 3-2. Configure Mode Menu

CONFIGURE MODE MENU – software version 2.0 Can be entered with Password unless SuperWord is specified		
Menu	**Selection**	**Description**
WireFreq (optional) (SuperWord only)	5.2 kHz 6.25 kHz Other (default)	Select Wire Guidance Frequency
Guidance (optional) (SuperWord only)	Wire Rail	Select between Wire and Rail Guidance (will only appear if both options are installed on the truck)
GuideSet (optional) (SuperWord only)	Quit Gds HA SLOW 1.6 deg (default) HA STOP 3.0 deg (default) DFW SLOW 1.6 in (default) DFW STOP 3.0 in (default)	Set Heading Angle and Distance From Wire Exit Guideset 0.6 to 2.0° in 0.2° increments 2.0 to 4.0° in 0.2° increments 0.6 to 1.6 in. (1.5 to 4.0 cm) in 0.2 in. (5 cm) increments 1.6 to 3.0 in. (1.5 to 4.0 cm) in 0.2 in. (5 cm) increments
Acquire (optional) (SuperWord only)	1.0 mph (default)	Set Acquire Speed (tractor-first only) 1.0 to full speed in 0.1 mph (0.16 km/h) increments **Note:** Forks-first acquire speed is fixed at 1.0 mph.
FreeSpd (optional) (SuperWord only)	X.X mph (default = Max Speed)	Set Top Speed of truck when not in wire guidance mode 1.0 to full speed in 0.1 mph (0.16 km/h) increments
WrSnCrp (optional) (SuperWord only)	Enable Disable	Set Wire Sense Creep Speed 1.0 mph when enabled
WGAM	Enable Disable	Factory Use Only

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Entering Program Mode

Table 3-2. Configure Mode Menu

CONFIGURE MODE MENU – software version 2.0 Can be entered with Password unless SuperWord is specified		
Menu	**Selection**	**Description**
Elec Key (optional) (SuperWord only)	3_ _ _ _ _ _ _ (factory setting)	Enter New Electronic Key Display Current Elec Key
Password	!_ _ _ _ _ _ _ (factory setting)	Enter New Password Display Current Password
Superwrd (SuperWord only)	2_ _ _ _ _ _ _ (factory setting)	Enter New SuperWord Display Current SuperWord
Version		Display Software Version
	Quit Ver	Exit Version
	CCC XX.X	Software Version for Carriage Control Card
	VM XX.X	Software version for Vehicle Manager
	VMB X.X	Boot Code Software version for Vehicle Manager
	GM X.X	Software version for Guidance Manager
	PAT X.XX	Software version for Traction Power Amplifier
	PTB X.XX	Boot Code Software version for Traction Power Amplifier
	PAL X.XX	Software version for Lift Power Amplifier
	PLB X.XX	Boot Code Software version for Lift Power Amplifier
	Trac Mod	Traction Amplifier model number
	XXXXXXXX	(press ENTER to access)
	Trac S/N	Traction Amplifier serial number
	XXXXXXXX	(press ENTER to access)
	Lift Mod	Lift Amplifier model number
	XXXXXXXX	(press ENTER to access)
	Lift S/N	Lift Amplifier serial number
	XXXXXXXX	(press ENTER to access)
Serial #	XXXXX	Display the Serial Number Assigned to the Truck

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Table 3-2. Configure Mode Menu

CONFIGURE MODE MENU – software version 2.0 Can be entered with Password unless SuperWord is specified		
Menu	**Selection**	**Description**
Clock	Time	Set Time/Date
	HH:MM:SS	Set time of day (AM or PM)
	AM	
	PM	
	Date	
	MM/DD/YY	Set current date
	Quit Clk	Exit Clock
AlarmT (optional) (SuperWord only)		Set Alarm for Travel
	Quit	Exit
	Both (default)	On in Both directions
	Fork Ld?	Fork Lead On/Off
	Fork Trl?	Fork Trail On/Off
AlarmL (optional) (SuperWord only)		Set Alarm for Lift
	Quit	Exit
	Both (default)	On in Both directions
	Lift?	On/Off
	Lower?	On/Off
Mnt Mind		Setup for Maintenance Minder
	Quit MM	Quit Maintenance Minder Menu
	Enable	Turn on MM
	Setup	
	200 (default)	Hours on Deadman – 50 to 500 (in 50 hr increments)
	Msg Only	Message Only
	L Cutout	Lift Cut-Out and Message
	Reset	Update MM to the Current Interval
	Disable	Turn off Maintenance Minder
	Setup	Setup the Maintenance Minder Interval (See Maintenance Minder™ Tool on page 4-3.)
Auto Off		Set idle time for automatic shut-off
	Disable (default)	
	10 Min	
	5 Min	
	4 Min	
	3 Min	
	2 Min	
	1 Min	

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Table 3-2. Configure Mode Menu

CONFIGURE MODE MENU – software version 2.0 Can be entered with Password unless SuperWord is specified		
Menu	**Selection**	**Description**
UPRrefSW (optional) (SuperWord only)	XXX in.	Display Height of Upper Reference Switch [145 to 160 in. (3683 to 4064 mm)] CAUTION: If upper reference switch height is changed on an intellispeed truck, Learn height must be run.
Aux Mast	XXX in.	Set Aux Mast height in inches from 20-50. Default = 20

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Learn Mode

Learn Mode is used to calibrate the control circuits to the operator controls and the truck's external sensors, [such as throttle (VR1), lift/lower potentiometer (VR2), and the optional flow sensor used with the advanced *intellispeed*™ system].

After entering the SuperWord, **Config** is displayed on the OD (see Table 3-1 on page 3-11). Scroll Up/Down (▲▼) through the menu until **Learn** is displayed, then press Enter (↵). The alarm will beep, indicating that you are in Learn Mode.

Select the item you want to learn. Follow the instructions as they appear on the OD. **Learn** instructions will vary slightly between vehicles with different options. Instructions will repeat until they have been completed.

After the system is satisfied that the instructions on the OD have been followed, the alarm will beep and the next instruction will appear. This will continue until all required components are learned. After all steps have been satisfied, **Quit Lrn** is displayed, allowing **Learn** to be exited.

When to Run Learn

See Table 3-3 on page 3-20.

Learn Controls

Learn Controls is necessary on all trucks. During Learn Controls, the Vehicle Manager (VM) calibrates its control circuits to the output voltage from the Travel Potentiometer (VR1) and the Lift Potentiometer (VR2).

The VM measures and stores the neutral voltage value and the maximum forward and reverse voltage values from VR1. These values are used by the VM to determine direction and speed requested by the operator during Run Mode.

The VM also measures and stores the neutral and the maximum lift and lower voltage values from VR2. These values are used by the VM to determine if lift or lower is being requested and the percentage of full speed that is being requested.

Learn Hgt/Wgt

Learn Hgt/Wgt is only present if the *intellispeed* option is installed on the truck.

The VM interprets the height and weight inputs during Run. During Learn, the VM obtains a baseline for height and weight from where to calculate those parameters. The position of the upper and lower reference switches is part of the information that is installed into the trucks primary memory at the factory or as a result of a change with a Passkey.

When **Learn Hgt/Wgt** is performed, the carriage passes through both lower and upper reference switches. As hydraulic fluid flows through the Flow Sensor to move the carriage, the Flow Module produces two quadrature phased pulsed outputs to the VM. The VM counts and stores the number of pulses between the reference switches. The VM uses this information to determine the position of the carriage as the truck is operated during Run Mode.

The formula for calculating weight from the pressure transducer voltage is programmed into the VM, but it needs to know the reference voltage from where to start the calculation. It monitors and stores the voltage from the pressure transducer as the carriage is lifted between the reference switches during Learn. This value is used for the reference voltage for lifting an empty carriage.

After the carriage is lifted between the reference switches, the carriage will elevate about 12 in. and pause before lowering again. During this pause, the VM is storing the value that is produced from the pressure transducer when an empty carriage is elevated and stationary.

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Table 3-3. When to Run Learn

Component Repaired/Adjusted	Is Learn Required?		Portion of Learn to run
Vehicle Manager	Yes		Controls, Height, Weight, Steer
Upper Mast Switch	—	No	—
Lower Mast Switch	—	No	—
Carriage Control Card (CCC)	Yes	—	Controls
Carriage Control Card PROM	Yes	—	Controls
Steer Position Proximity Home Sensor	Yes	—	Learn Steer Zero or Learn
Deadman Switch (S2/S23)	—	No	—
Lift Potentiometer (VR2)	Yes	—	Controls
Guidance Manager	Yes	—	Frequency and Offset
Pressure Transducer	Yes	—	Height, Weight
Lift/Lower Solenoid	—	No	—
Load Holding Solenoid	—	No	—
Brake	—	No	—
Throttle Potentiometer (VR1)	Yes	—	Controls
Flow Sensor Module	Yes	—	Height, Weight
Filter Card	Yes	—	Frequency and Offset
Antenna Card	Yes	—	Frequency and Offset
Home Proximity Sensor	Yes	—	Steer

⚠CAUTION

Before Learning height and weight, the vehicle must be placed in an area where the platform is able to lift beyond the upper mast reference switch (156 in. [396 cm] plus the height of the carriage).

When **Hgt/Wgt** is selected, the following message appears:

```
Carriage will automatically lift/lower
between the reference switches
```

The operator is prompted as follows:

```
Step on deadman to start learn
```

This message will scroll continuously until the operator steps on the deadman pedal. After the operator steps on the deadman pedal, the carriage will immediately begin to lift. The display will continuously scroll the following message:

```
To abort, step off deadman
```

If all the parameters measured during **Learn** are within tolerance, the following message will appear:

```
Done learning
```

If, at any time during **Learn**, the operator steps off the deadman pedal or the measurements fall outside a tolerance, the following message appears:

```
Unable to learn...lower then press
enter to continue
```

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If the failure is not the result of stepping off the deadman, attempt to learn again. If repeated attempts to learn fail, run tests:

- Test A13 - Pressure Sensor Voltage (optional) (Page 6-38)
- Test I02 - Lower Mast Reference (24 in.) Switch (Page 6-58)
- Test I69 - Upper Mast Reference Switch (Page 6-82)
- Test I26 - Flow Sensor Count (Page 6-70) (use active maintenance)

Learning Wire Frequency

Trucks equipped with an optional wire guidance system can be configured as follows. Three selections are available under **WireFreq** in **Config.**

If **5.2 kHz** or **6.25 kHz** is selected, the Guidance Manager utilizes preset guide wire strength values and calculates only the wire guidance offsets (**Wg Offset** must be run).

NOTE: The **5.2 kHz** setting requires a guide wire output of 100 mA. The **6.25 kHz** setting requires a guide wire output of 225 mA. **Other** must be selected for all other guide wire outputs.

If **Other** is selected, the Guidance Manager is calibrated to the frequency and amplitude of the guide wire in order to correctly calculate wire guidance offsets. Both scenarios are discussed in the following paragraphs.

Learn Wirefreq:

WireFreq is visible in the **Learn** menu only if **Other** is selected under **WireFreq** in **Config**. **WireFreq** must be learned before **Wg Offset** is attempted. When **Other** is selected, the Guidance Manager (GM) must learn the frequency and strength of the AC current flowing through the guide wire. This is done as follows:

1. Verify that the line driver is adjusted to the correct frequency and amplitude.
2. Center the lift truck over the guide wire to within ±0.5 in. (±13 mm).
3. Select **WireFreq** from the **Learn** menu and press Enter (↵). The following message appears:

   `Center over wire, Then press enter`

   After Enter (↵) is pressed, the following message is displayed:

   `Learning wire frequency.`

NOTE: This process takes several seconds.

4. When the frequency and amplitude of the guide wire is learned, the following message is displayed:

   `Wirefreq`
5. Select **Quit Lrn** from the **Learn** menu and press Enter (↵) to exit Learn Mode. Cycle the key switch OFF, then ON. Re-enter Learn Mode prior to learning Wire Guidance Offsets.
6. If a valid frequency is not found, or if at any time during the learning process, the operator presses the Enter (↵) button, the following message is displayed:

   `Unable to learn. Press ENTER to continue.`
7. If repeated attempts to learn wire frequency fail, run the following tests:
   - Test A51 - Left Tractor Guidance Coil Voltage (Page 6-49)
   - Test A52 - Right Tractor Guidance Coil Voltage (Page 6-50)
   - Test A53 - Left Load Guidance Coil Voltage (Page 6-51)
   - Test A54 - Right Load Guidance Coil Voltage (Page 6-52)
   - Test A55 - Tractor Near Wire Coil Voltage (Page 6-53)
   - Test A56 - Load Near Wire Coil Voltage (Page 6-54)

Learn Wire Guidance Offsets

For wire guidance to function correctly, the GM must calibrate its internal guidance circuits to the voltage it receives from each guidance coil on the Antenna Card. The GM must also know the straight ahead position of the drive unit.

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These values are obtained while learning the wire guidance offsets as follows:

NOTE: The **Coast** value in **Config** *must* be set to **Long** and the truck driven in the tractor-first direction.

1. Center the truck over the guide wire as closely as possible.
2. Set the Auto/Manual switch to Auto to initiate **Learn**.
3. Drive the truck tractor-first on the guide wire for at least 60 ft. Allow truck to coast to a stop. This is done to allow the truck to center correctly to its neutral position. If the brake or plugging is applied, the drive unit may shift position.
4. After the truck has coasted to a stop, place the Auto/Manual switch in the Manual position. When the Auto/Manual switch changes state, the GM stores the voltage it measured from each guidance sensor coil. This voltage value is used to determine the wire guidance offsets and establish the scale factors required to determine Heading Angle (HA) and Distance From Wire (DFW) when in Run mode.
5. When the truck powered up, it auto centered, and reset the pulse counter for steering position. As the truck was traveling on the wire in step 3, the Feedback Encoder was keeping track of the deviation of the drive unit from the auto center position. When the Auto/Manual switch changed states in step 4, the GM also stored the number of Feedback Encoder pulses between the Auto Center position and the position that the drive unit was located when the Auto/Manual switch changed state. That is the value that the GM uses as straight ahead when determining how to position the drive unit to keep the truck centered over the wire (sensor coil voltages at the learned value) as the truck drives on the wire.

   If the truck was not centered over the wire when the Auto/Manual switch changed states in step 4, the GM would learn incorrect values (truck position) from the sensor coils. The GM would then attempt to keep the truck in a position other than centered over the wire. If the drive unit was not straight ahead, the GM would learn an incorrect angle and the truck may wander on the wire. Re-learn the wire guidance offsets as many times as necessary to make the truck track within 0.5 in. (13 mm) of the guide wire.
6. If the Learn procedure is completed correctly, the following message is displayed:

   `Done learning.`

   The truck should guide centered over the guide wire.

   If Enter (↵) is pressed during the Learn process, the session is aborted and the following message is displayed:

   `Unable to learn. Press ENTER to continue.`
7. Run Tests A51 thru A56.

Learn Steer Zero

This procedure removes the need to manually adjust the Home Proximity Switch to make the truck track centered over the wire.

1. Center the truck over the guide wire.
2. Select **Learn Steer Zero**.
3. Place the Auto/Manual Switch in Auto and drive the truck in both directions over the guide wire. Maintain a speed of greater than 1.2 mph for more than 2 seconds. Once a change in speed of less than 1 mph has been seen for 2 seconds the Steer Zero position for that travel direction is stored and there will be a Beep.
4. After both travel directions have been completed select **Quit Lrn** from the **Learn** menu and press Enter (↵) to exit Learn Mode. Cycle the key switch OFF, then ON. Test the truck operation.

Learn Auto Steer Center

Use this procedure on trucks with rail guidance and auto steer centering option. Adjust the center position of the drive unit so that the truck drives straight when in the aisle.

1. Place the truck in an area where there is a straight line at least 20 ft. in length, with

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wire guidance grooves, yellow aisle markers, or rails.

2. Depress the rail switch and secure it to simulate a rail.
3. Select Learn->Steer. the display will show “Str XXX” where XXX is a number between -50 and 50. This is the steer proximity offset from dead center in 10ths of degrees.
4. Step on the deadman pedal. Wait for the truck to self-center the drive unit.
5. Select manual on the auto/manual switch. The truck is now in “seeking mode” and can be driven with manual steering.
6. Position the truck so that it drives parallel to the reference line. Make small corrections in the steering wheel position until the truck can be driven 10 ft. without deviating from the line more than 1/2 in. without steering.
7. Drive back to the original position. Stop the truck. Select “Auto” on the Auto/Manual switch. The steer unit will center and manual steer is disabled.
8. Drive forward 10 ft. Measure the deviation of the truck from the reference line. The deviation should be less than one in. If more than one in. proceed to the next step. If it is less than one in. proceed to step 13.
9. Drive the truck back 10 ft. to the original position.
10. Use the Up/Down (▲▼) button arrows 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 one corresponds to a deviation of about 0.25 in. over 10 ft.
11. Repeat steps 9-11 until a deviation of one in. or less over ten ft. is achieved.
12. To save the value, press the enter button. The truck’s display will read “Save? N.” Press the Up/Down (▲▼) button arrows to display “Save? Y”, then press the Enter (↵) button.
13. Learn of steer center is complete.

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Maintenance Mode

Maintenance Mode allows service technicians to test individual circuits within the system. Maintenance Mode is accessed through Program Mode after the SuperWord is entered. Refer to page 3-8 for information on procedures for accessing Maintenance Mode.

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

General

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.

When removing a connector, do not pull on the wires to separate the connection.

All circuit cards are conformal coated. When testing circuit cards, make sure a good electrical connection is made between the board test point and the probe. This will eliminate false results.

⚠ WARNING

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

Use extreme care whenever the truck is jacked up for any reason. Never block the truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from beneath the vehicle while jacking. Use jack stands or solid blocks to support truck - do not rely on jacks. Refer to page 2-8.

By entering Static Maintenance Mode, the safety circuits associated with the system are disabled. Extra precautions must be exercised in Static Maintenance Mode. 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. Contact a certified *Raymond*® technician.

Static Maintenance Mode

In Static Maintenance Mode, the truck is inoperative. This mode allows the technician to test and operate individual circuits without operating the truck. All tests are available during static testing.

If Digital Outputs are selected from **Maint**, the OD will display:

```
Warning jack up the drive wheel, press
 enter when ready
```

Press Enter (↵) to start Maintenance Mode. The Up/Down (▲▼) buttons are used to turn the test ON/OFF.

Active Maintenance Mode

Active Maintenance Mode (Act Maint) permits testing of various systems on the lift truck. In Active Maintenance, all Analog and Digital tests can be selected with the results displayed while operating the truck in Run Mode. To enable a test for Active Maintenance, proceed as you

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would for Static Maintenance Mode. When the Analog or Digital test you want is displayed, press Enter (↵). An asterisk (*) will appear next to the test number indicating that this test is selected for Active Maintenance.

All tests can be selected. Individual tests can be turned OFF by going back to that test in **Maint** and pressing Enter (↵). The asterisk will disappear. The tests selected for Active Maintenance are stored in memory even if the key switch is turned OFF.

To select one of the Active Maintenance tests, press the deadman pedal and use the Up/Down (▲▼) buttons to select the test you want displayed while operating the truck. The test selected will remain on the display until another test or display selection is made.

Power Amplifier Reset

Power Amplifier Reset (PA Reset) returns the power amplifier back to its default baud rate of 125K. This feature is helpful when the power amplifier is to be returned to stock or installed on a different model truck.

Event Log

The Event Log (Evtlog) stores the last twenty error codes recorded on the lift truck. Entries are stored in order of occurrence, with the most recent error first.

To access the Event Log, use the Up/Down (▲▼) buttons to scroll to **Evtlog** and press Enter (↵).

If no errors are stored, **Empty** is displayed.

If errors have been logged, use the Up/Down (▲▼) buttons to scroll through the list.

To clear the log, use the Up/Down (▲▼) buttons to scroll to **Clr log**. Press Enter (↵). Scroll to **Clr yes** and press Enter (↵).

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FlashWare Program

Overview

The FlashWare program allows you to update software and view and configure options on your Model 5400, 5500, and 5600 through the following features:

- Vehicle Manager software
- Clear primary memory
- Reset factory default settings
- Power Amplifier Software

NOTE: For more detailed information with FlashWare, click on Help, the Help Topics from the menu bar.

Requirements

FlashWare can be installed on an IBM-compatible PC with Windows 98 or higher operating system. The PC communicates with the truck software through a 9-pin serial cable.

⚠CAUTION

We recommend using the surge protector (P/N 154-010-801) to protect your PC from possible electrostatic discharge or voltage surge.

Install FlashWare on PC

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

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

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

PC Connection to Truck

1. Turn the truck key switch OFF.
2. Connect the surge protector to an available com port on your computer.

⚠CAUTION

We recommend using a surge protector (P/N 154-010-801) to protect your PC from possible electrostatic discharge or voltage surge.

3. Connect a standard 9-pin serial cable to the surge protector.
4. Connect the cable to JPT-9 at the VM.
5. Turn the key switch ON.

Starting FlashWare

From Windows 98 or Higher

1. Make sure the truck key switch is ON.
2. Double-click the **FlashWare** icon on the main desktop screen or navigate via Start > Programs > FlashWare. The truck opening screen will appear. See Figure 3-6.



Figure 3-6. Truck Opening Screen

NOTE: When entering or using FlashWare, it is normal for the vehicle to display a Code 50.

3. From the menu bar, click Connect to Truck. The truck setup screen will appear on your PC screen. See Figure 3-7.

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Configuration and Truck Setup Options

The Truck Setup screen feature 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, OCAH, Elv Ht, and Vehicle Manager version of the truck. See Figure 3-7.

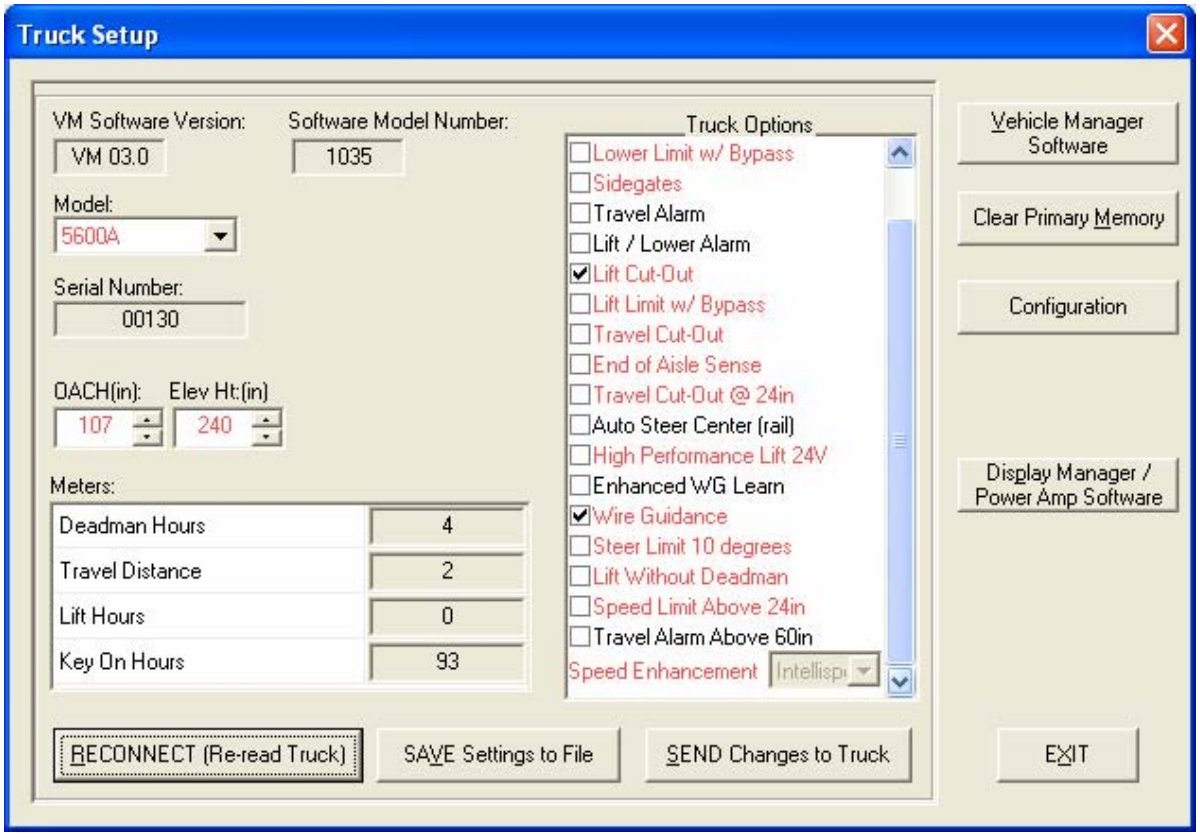


Figure 3-7. Typical Truck Setup Screen

To Change an Option Setting:

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

Place a check mark in the required option box. To disable an option, remove the check mark. See Figure 3-7.

Possible options include:

Truck Options:

Electric Key * Will require the operator to enter a code prior to operating the vehicle

Lift Limit * Will limit the vehicles lifting height based on placement of the switch.

Lower Limit w/Bypass * Will limit the vehicles lowering height and have a switch to depress to fully lower the vehicle.

Side Gates (Side Gate Power Disconnect) Will require that both side gates be lowered to allow travel and lift/lower function.

Travel Alarm Will allow the alarm to sound when the truck is moving as configured

Lift/Lower Alarm Will allow the alarm to sound when the truck is moving as configured

Lift Cut-Out (Deceleration) Will prevent the vehicle from hitting the stops at full speed lift.

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Lift Limit w/Bypass * Will limit the vehicles lifting height and have a switch to depress to fully lift the vehicle.

Aux Mast * Will allow the use of an auxiliary mast

Travel Cut-Out * Will Cut-Out vehicle travel at a pre-determined height based on switch placement, also may be used to interrupt travel on vehicles equipped with battery interlock switches.

End of Aisle Sense* Will allow the vehicles speed to be reduced while it approaches the end of a captive aisle.

Travel Cut-Out @ 24 inch Will Cut-Out vehicle travel at 24 in.

Auto Steer Center (rail) Will cause the vehicles drive unit steering position to be maintained straight ahead while guiding in an aisle

High Performance Lift 24V Is used to control the solenoid on the lift pump.

Enhanced WG Learn (Factory Use Only)

Wire Guidance Will allow wire guidance function to operate when vehicle is equipped with proper components.

Steer Limit 10 Degrees Will limit the steering angle to 10 degrees when the elevated height is above 150 in.

Lift Without Deadman * When installed will allow the operator to lift and lower without being on the deadman. (Requires Side Gates Power Disconnect)

Speed Limit Above 24 in. Will limit the vehicle speed when the elevated height is above 24 in. this speed will be set in Configure mode.

Travel Alarm Above 60 in. Will allow the alarm to sound when the truck is traveling when the elevated height is above 60 in.

Speed Enhancement

- **Intellispeed:** Intellispeed equipped vehicle
- **Stepped Up:** Vehicles equipped with a 120 in. and 180 in. speed limit switch as opposed to a 150 in. speed limit switch.

NOTE: * Some options 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. When the options are correctly configured, click SEND Changes to Truck button.

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To Review Vehicle Manager Software:

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

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

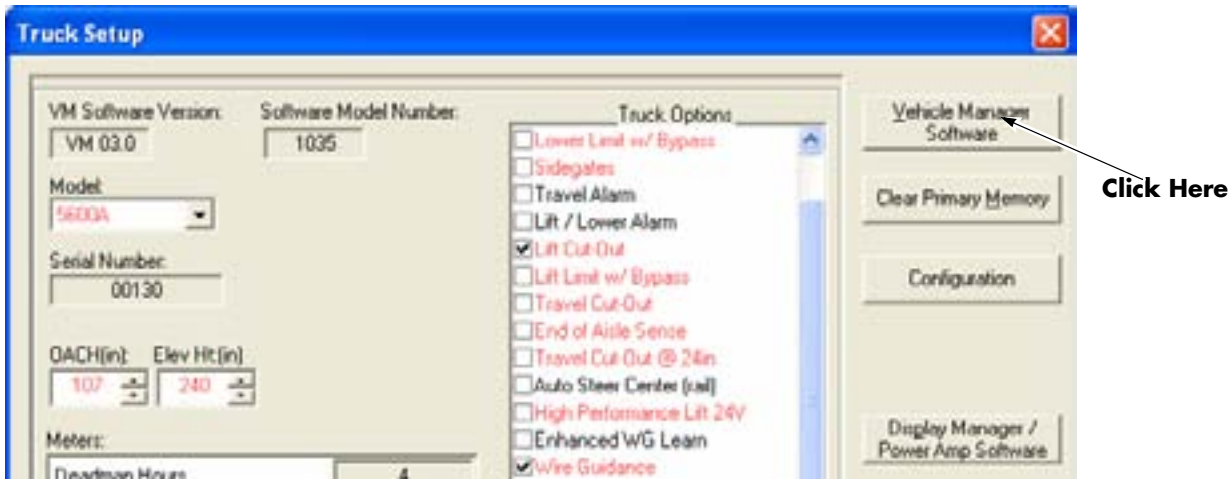


Figure 3-8. Truck Setup Screen

1. Click Vehicle Manager Software button on Truck Setup screen. See Figure 3-8.
2. Select Software version to load. See Figure 3-9.
3. Click the Load VM With Selected Software Version button. See Figure 3-9. The new software is then installed in the truck.
4. When installation is complete, click Exit to return to the main Truck Setup screen.

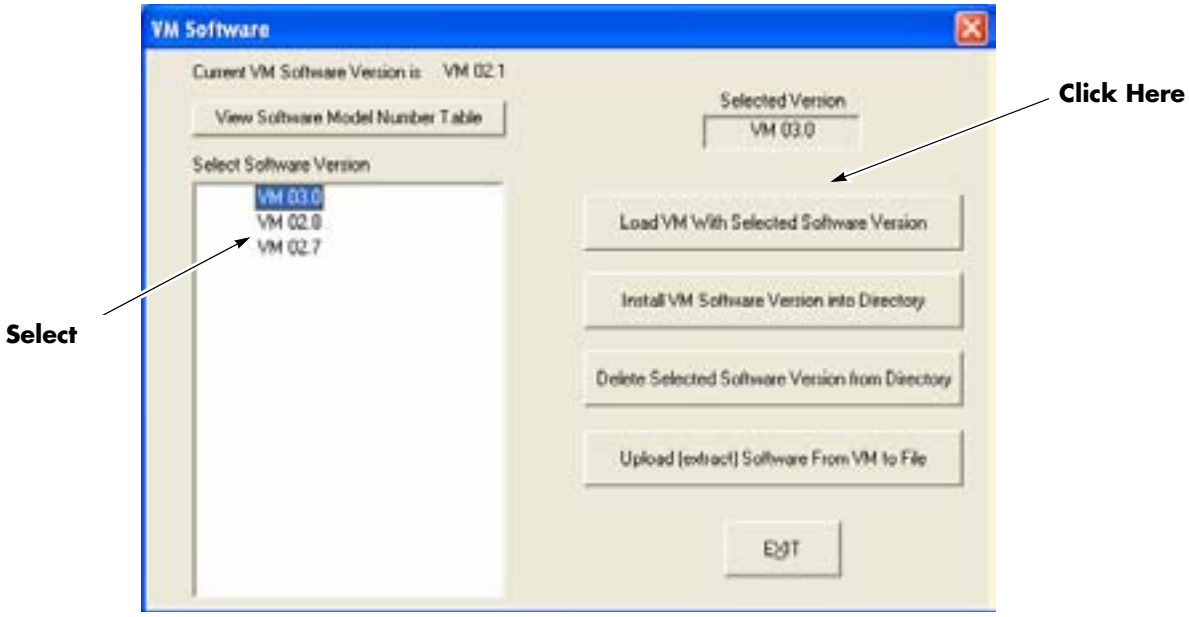


Figure 3-9. VM Software Screen

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To Clear Primary Memory:

The clear primary memory feature allows you to clear a carriage manager in a truck so it can be used in another truck.

1. Click on the Clear Primary Memory button.
2. After selecting this feature, the clear primary memory screen appears. See Figure 3-10.



Figure 3-10. Clear Primary Memory Screen

3. If you select **No**, the action is cancelled.
4. If you select **Yes**, a new prompt appears. See Figure 3-11. Click OK.



Figure 3-11. Remove Cleared Memory Screen

⚠CAUTION

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

5. Remove the carriage manager.

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To Review Configuration Settings:

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

Click Configuration on the main Truck Setup screen. See Figure 3-8. The Configuration screen will appear. See Figure 3-12.

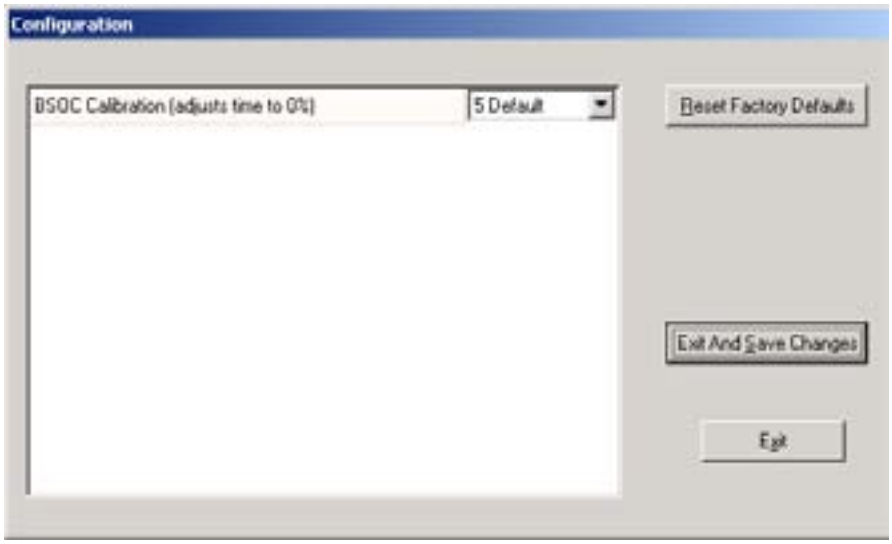


Figure 3-12. Configuration Screen

Reset Factory Defaults

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

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

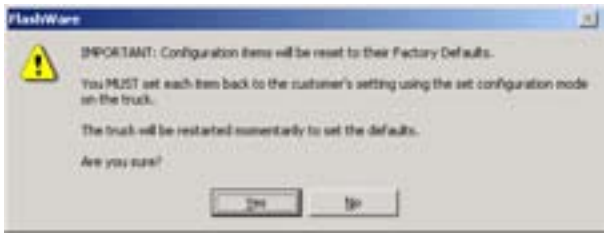


Figure 3-13. Configuration Reset Screen

BSOC Calibration

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

Making this number smaller (down to 1), will lower 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) will increase the average voltage considered as 0% BSOC, resulting in decreasing the time to reach 0% BSOC, by using less battery capacity.

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To Display Manager/Power Amp Software:

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

1. Click Display Manager/Power Amp Software button in the main Truck Setup screen.
2. When the Display Manager/Power amplifiers screen appears, follow prompts on the screen to Load/Upload software. See Figure 3-14.

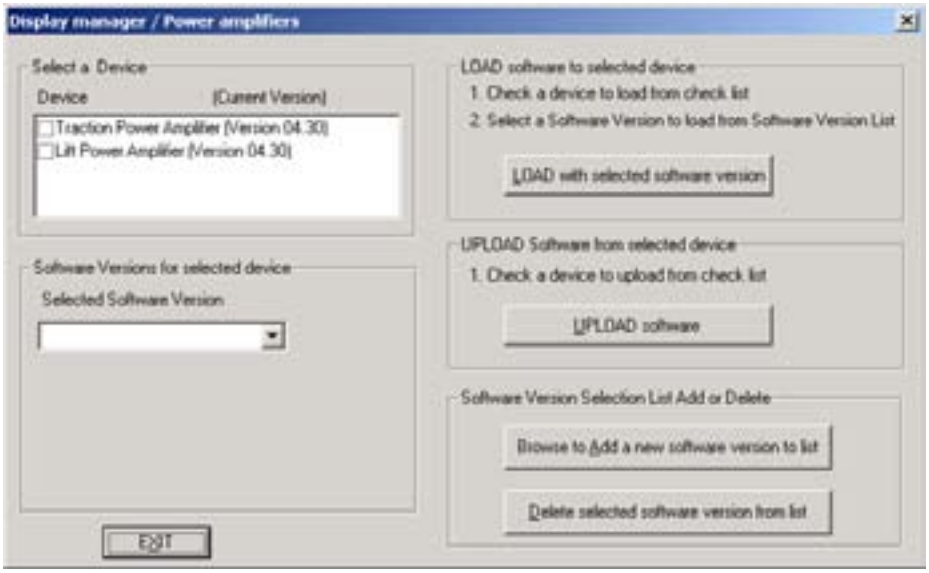


Figure 3-14. Display Manager/Power Amp Screen

Program the Traction Power Amplifier:

If initial attempts to reprogram the power amplifiers fail perform the following:

1. Turn the key switch OFF and unplug the battery.
2. If the truck is equipped with wire guidance disconnect all cables on the wire guidance manager except for the two sensor cables (JPW1 and JPW2).
3. Model 5500 and 5600: disconnect the lift power amplifier at JPLA.
4. Connect the PC and open Flashware.
5. Plug in the battery and turn the key switch ON. An error code will occur.
6. Load the software into the traction power amplifier. You may get the following messages while attempting to load new software.

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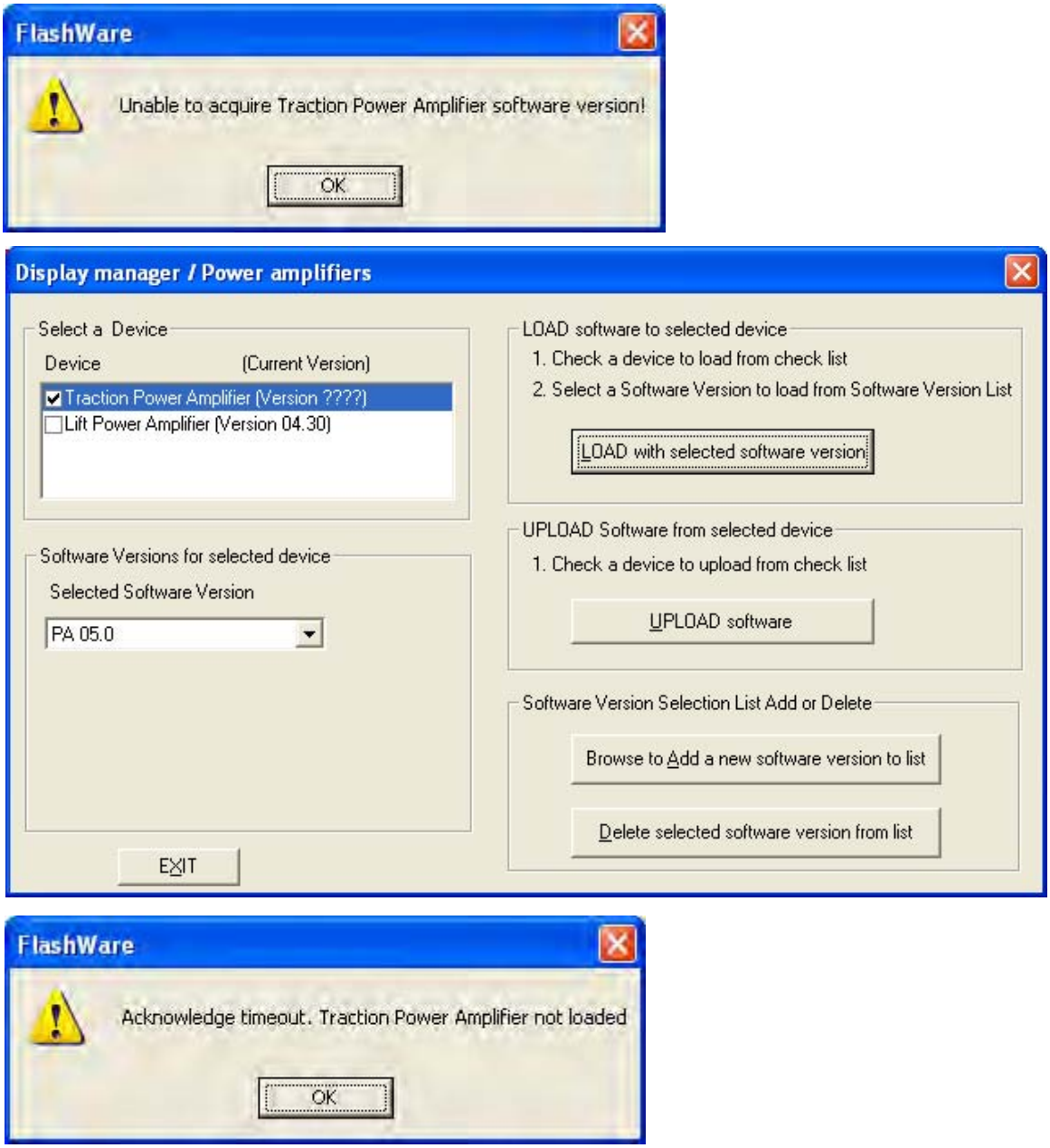


Figure 3-15: Traction Power Amplifier Program Messages

If you get these messages:

7. Disconnect the PC.
8. Turn the key switch to the OFF position, then to the ON position and wait 60 seconds.
9. Repeat step 8, but do not wait 60 seconds.
10. Connect the PC and verify the software version of the traction power amplifier.
    - If the requested software to be downloaded is listed under (Current Version) in Display Manager window, the download was a success.

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- If it shows Version ????, you must attempt to load the software again.

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

11. When completed, turn key switch OFF, unplug the battery and reconnect the Wire Guidance Manager. Reconnect the lift power amplifier (Model 5500 and 5600).

Program the Lift Power Amplifier:

1. Turn the key switch OFF and unplug the battery.
2. If the truck is equipped with wire guidance disconnect all cables on the wire guidance manager except for the two sensor cables (JPW1 and JPW2).
3. Disconnect the traction power amplifier at JPTA-1.
4. Connect the PC and open Flashware.
5. Plug in the battery and turn the key switch ON. An error code will occur.
6. Load the software into the lift power amplifier. You may get messages similar to those shown in Figure 3-15 while attempting to load new software. If you get a similar message, disconnect the PC.
7. Turn the key switch OFF, then ON and wait 60 seconds.
8. Repeat step 7, but do not wait 60 seconds.
9. Connect the PC and verify the software version of the traction power amplifier.
   - If the requested software to be downloaded is listed under (Current Version) in Display Manager window, the download was a success.
   - If it shows Version ????, you must attempt to load the software again.
10. Once completed, turn key switch OFF. Unplug the battery and reconnect the Wire Guidance manager, reconnect the traction power amplifier, reconnect battery, turn key switch ON and test truck operation.

RECONNECT (Re-read Truck):

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

SAVE Settings to File:

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

SEND Changes to Truck:

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

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Wire Guidance

Wire guidance is a means to automatically steer the truck while traveling in an aisle. It offers precise steering at full-speed travel in Very Narrow Aisle (VNA) applications.

A wire guidance system consists of two sub-systems.

- Warehouse-installed equipment includes a guide wire and line driver. The guide wire is installed in the floor and emits an Alternating Current (AC) signal at a specific frequency and amplitude generated from the line driver.
- Truck-installed equipment includes:
  - Two guidance sensors, tractor end and load end
  - Guidance Manager (GM)
  - Steer feedback encoder
  - Auto/Manual switch, on operator console
  - Associated cables and mounting brackets

  The truck must learn the amplitude and frequency of the guidance signal to correctly track the guide wire.

NOTE: This manual covers all truck-installed equipment. For information on warehouse-installed equipment, refer to PDSS-0051, Raymond Wire Guidance.

To operate wire guidance, refer to the Operator Manual.

Wire Guidance Setup

This procedure should not normally have to be performed. For the truck to guide correctly, the following must be true:

- for 5.2 kHz, the current through the guide wire must be 100 mA peak-to-peak ±10%
- for 6.25 kHz, the current through the guide wire must be 225 mA peak-to-peak ±10%

If the warehouse portion of the guidance system has a different line driver output, refer to Learn Wirefreq on page 3-21.

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Cold Storage

Cold storage is an option that enables truck operation in temperatures of –20°F (–28.86°C) to 40°F (4°C).

On cold storage trucks, the electrical panel on the tractor is completely enclosed to contain heat. Components added to the truck for cold storage are listed in the table below and shown on the electrical schematic. See Schematics on page A-11.

Heater Assemblies			
Components	**Location**		
	Carriage Control Card	**Control Handle**	**Deadman Pedal**
Heating elements	HTRC	HTRH	HTRDM
Thermostats	S81	S91	S80
Fuses	FU21 (10A)	None	FUDM (5A)

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Configuration Codes

The vehicle configuration code is included in the serial number of the truck. The configuration code allows you to easily determine performance and height.

Configuration Code Cross Reference			
Code	**Model #**	**Traction/Lift**	**Configuration**
A	5400	AC/DC	24V Hi-Pro
	5500	AC/AC	24V High Performance
	5600	AC/AC	36V High Performance
B	5400	AC/DC	24V Hi-Pro above 315 in.*
	5500	AC/AC	24V High Performance above 315 in.*
	5600	AC/AC	36V High Performance above 315 in.*
C	5400	AC/DC	24V
*At and below 315 in. uses the standard drive unit. Above 315 in. and in specific customer applications, use the heavy duty unit.			

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Storage

If the truck is going to be stored for any length of time, cover the truck with canvas or plastic.

If the truck is going to be stored for more than 30 days, jack and block the truck up off the floor.

⚠ WARNING

Use extreme care whenever the truck is jacked up for any reason. Never block the truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from beneath vehicle while jacking. Use jack stands or solid blocks to support truck. Do *Not* rely on the jack alone. See Jacking on page 2-8.

Warranty

The Raymond Corporation must be contacted by an authorized Raymond dealer for the correct warranty procedures.

Motors

The brushes in DC motors must be lifted away from the commutator surface. When preparing the truck for service, the surface must be inspected and polished, if necessary, using a rubber abrasive polish. Polishers are specifically made for polishing commutators. *do Not* use a stone.

Periodically rotate the motor shafts to coat the bearings with lubricant, reducing the possibility of oxidation and corrosion.

Hydraulic System

The hydraulic system will absorb moisture when left standing for a long time. Make sure the reservoir is full before storing. Before returning the truck to service, drain the reservoir and change the filter. Fill the reservoir with new hydraulic fluid. Operate the hydraulic systems slowly to allow internal components to be lubricated.

NOTE: If the truck is going to be stored for more than six months, spray hydraulic components with a silicone protectant. Do not let silicone protectant spray get on circuit cards.

Hydraulic Cylinders

Store the truck with the cylinder pistons retracted. Coat all exposed chrome surfaces of the piston with hydraulic fluid.

Lift Chains

Liberally coat all chains with oil to prevent rust and corrosion.

Electronics

Make sure all electronics stay dry.

Special Tools

Pin Extractor

Use the pin extractor (P/N 950-026) when removing wires from any connectors.

Ram Service Tools

Use these tools when repacking the side cylinders or center cylinder.

Tool	Part Number
Side Cylinder Service Guide	401-000-051
Side Cylinder Service Driver	401-000-050
Center Cylinder Service Guide	401-000-059
Center Cylinder Service Driver	401-000-058

Lift/Lower Pendant

The lift/lower pendant (P/N 114-020-848) is a tool that allows you to use the hydraulic system independent of the lift and lower pots. This pendant connects to the J1 connector located to the right of the VM in the main harness.

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Section 4. Scheduled Maintenance

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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 chart below.

Operating Conditions	Working Environment	Service Frequency
Normal	An eight hour day of basic material handling	180 days or 500 hours, whatever comes first
Severe	Extended operating hours or constant use	175 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 Sudden temperature changes such as going from freezer to room temperature Corrosive atmosphere such as in chlorine or salt-sea air environments	100 hours

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Maintenance Minder™ Tool

Maintenance Minder™ Tool is a feature that alerts the operator when the truck is due for scheduled maintenance.

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

- One of two messages scrolls on the Operator Display for at least 30 seconds following the **DAILY CHECKLIST** message:

  `Scheduled maintenance due`

  or

  `Lift cutout, scheduled maintenance due`
- A wrench icon flashes
- The audible alarm sounds the high-low tone for approximately 5 seconds

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

Enabling

Once installed in the configuration options, **MAINTENANCE MINDER** appears in the Configure Mode menu. The initial factory setting is **DISABLE**. To enable the feature, enter Configure Mode.

NOTE: For instructions on selecting Modes of Operation, see Modes of Operation on page 3-7.

With Configuration Mode selected, use the Up/Down (▲▼) button to scroll to display **MAINTENANCE MINDER**. Press the Enter (↵) button. When entered from a disabled state, *Maintenance Minder* offers a submenu with the options **QUIT MM** and **ENABLE**. Use the Up/Down (▲▼) button to select **ENABLE**. Press the Enter (↵) button.

Setting Time Interval and Action Option

The first time you enter the time interval menu, the Factory Suggested setting, followed by the letters **FS** is displayed. Subsequently, when you enter the time interval menu, the last used setting is displayed. Values from 50 to 500 hours, in increments of 50, are available. Use the Up/Down (▲▼) button to scroll to the desired time interval. With the desired value displayed, press the Enter (↵) button.

Use the Up/Down (▲▼) button to select the desired action option. Then press the Enter (↵) button.

- **MSG ONLY** causes the Operator Display to show **SCHEDULED MAINTENANCE DUE** when the scheduled maintenance time interval is exceeded.
- **L CUTOUT** 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 (▲▼) button to select **QUIT MM** from the submenu. If the status has changed, you are prompted to save changes. Press the Enter (↵) button.

NOTE: From the Config Menu, exit by selecting **QUIT CFG**. You will not be prompted again to save changes, but any changes saved when you **QUIT MM** are retained.

Changing Time Interval or Action Option

When *Maintenance Minder* is active, and you wish to change the time interval or action option, enter Configure Mode.

With Configuration Mode selected, use the Up/Down (▲▼) button to display the **MNT MIND** item. Press the Enter (↵) button. When entered from an enabled state, *Maintenance Minder* offers a submenu with the options **QUIT MM**,

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RESET, **DISABLE**, and **SETUP**. Use the Up/Down (▲▼) button to select **SETUP**, then press the Enter (↵) button. The current time interval is displayed (hours). Proceed as described under Setting Time Interval and Action Option.

Resetting *Maintenance Minder*

When *Maintenance Minder* is active, and, after you have performed scheduled maintenance, you wish to reset the reminder prompt, enter Configure Mode.

With Configuration Mode selected, use the Up/Down (▲▼) button to display the **MNT MIND** item. Press the Enter (↵) button. Use the Up/Down (▲▼) button to select **Reset**, then press the Enter (↵) button. Select **QUIT MM** and press the Enter (↵) button again. Save changes, as prompted.

Disabling

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

With Configuration Mode selected, use the Up/Down (▲▼) button to display the **MNT MIND** item. Press the Enter (↵) button. Use the Up/Down (▲▼) button to select **DISABLE**, then press the Enter (↵) button. Select **QUIT MM** and press the Enter (↵) button again. Save changes, as prompted.

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Initial 90 Day/250 Deadman Hours (HD) Maintenance

Perform the following maintenance tasks 90 days after the lift truck was put into service or at 250 HD, whichever comes first.	
Component	**What to do**
Drive Unit	Break mounting bolts free and reapply thread-locking compound (P/N 990-544). Re-torque mounting bolts to 130 ft. lb. (176 N•m). Change fluid.
Hydraulic Tank	Change hydraulic fluid and filter.
Power Amplifier(s)	Torque power amplifier terminal bolts - 100 in. lb. (11.3 N•m).

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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	**What to do**	**Refer to**
Battery	Check the weight stamped on the battery in the lift truck against the minimum and maximum allowable weights on the specification tag for the lift truck. Report any lift trucks that are running with batteries under the minimum or over the maximum allowable weight. Check for voltage leaks to frame. If cleaning does not remove voltage to frame, install a new battery. 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 inch (13 mm) free play in any direction.	Page 3-4 Page 5-11
Brakes	In an open area, measure stopping distance. Traveling to 2 to 3 mph (3.2 to 4.8 km/hr) empty, push the EPO switch; the empty lift truck should stop within 2 to 4 feet (0.6 to 1.2 m). During normal operation, with a rated load and traveling at top speed, the lift truck should stop within 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 and clean the pads and rotor. Use a file, if necessary, to clean the break pad surface. Measure minimum thickness of pad and steel backing plate 0.80 in. (20 mm). Measure for correct gap: 0.007 inch lower air gap 0.018 total air gap *Failure to keep brakes adjusted causes premature pad and rotor wear and excessive motor heat.*	
Contactors	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	Verify lift/lower function is smooth and controllable. Verify travel function is smooth and responsive through full range of acceleration. Check for play in the center position of lift or travel control; repair/replace control handle if necessary. Verify no codes on display. Verify function of all switches. Make sure nylon insert is in the lift knob set screw hole.	
Deadman Pedal	Check for smooth operation with no binding. Check for correct activation and deactivation 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 debris.	
Drive Unit	Inspect for leaks. Make sure O-ring is present on the dipstick. Examine for drive unit radial ring wear.	

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Perform the following maintenance tasks every 180 days or 500 HD, whichever comes first.		
Component	**What to do**	**Refer to**
Electrical Cables	Inspect all power cables for nicks or cuts. Give special attention to 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 will cause intermittent system shutdowns and/or electronic failures. Check the tension of the over-the-mast pulley cables. Set tension so the cables just stay on the pulleys. Higher tension will cause premature failure. Maximum spring tension is 5 to 7 in. lb. (0.57 to 0.79 N•m).	
Forks	Examine for excessive wear, bends, cracks, welding arcs, excessive heat, or unauthorized modifications. Replace if found.	
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.	Appendix
Horn	Check that horn sounds correctly 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. Inspect center cylinder chain anchors and springs. Inspect for excessive stretch or wear (tool P/N 950-350/CG). Lubricate.	Page 4-10 Page 7-94
Lubrication	Apply grease to all fittings on drive unit. Apply small amount of grease to steering gear on drive unit. Coat all chains with film of spray lubricant.	Page A-2
Mast	Wipe old grease off mast uprights and apply new grease. Inspect anti-rattle pads. Examine mast bearings. Inspect mast and carriage stops for tightness and wear. Inspect rails for abnormal wear, metal flakes or shavings. Repair any grooves worn in the mast deeper than 1/8 in. (3 mm).	Page 7-96

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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	**What to do**	**Refer to**
Motors	**AC** - Check the cable lugs to make sure they are tight to the terminal studs. Both the inside and outside nut must be torqued to the values listed page 7-66. Replace any cable that shows signs of excessive heat. Check sensor wires for sound connection and condition.	
	DC - Visually inspect brushes for excessive heat (discoloration of the pigtails). If excessive heat is evident, inspect the armature circuit for loose connections. Inspect and clean commutator. Check condition per photos on page 5-7. Find the shortest brush in the holder. Remove the brush and check overall dimension as per the chart on page 7-65. 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. Blow out impeller and cooling fins. Check the cable lugs to make sure they are tight to the terminal studs. Both the inside and outside nut must be torqued to the values listed on page 7-66. Replace any cable that shows signs of excessive heat. Check sensor wires for sound connection and condition.	
Overhead Guard	Inspect guard for physical damage. If structurally damaged, replace the carriage.	
Power Amplifier(s)	Torque power amplifier terminal bolts - 100 in. lb. (11.3 N•m).	
Shorts to Frame	Check for electrical shorts to frame.	Page 5-11
Static Straps	Make sure static straps are not worn or broken. Clean debris from straps. Check resistance of 1 megohm resistor in standoff. EE Labeled lift trucks require a phosphor bronze static strap; do not use steel braided cable on EE labeled lift trucks.	
Switches	Check all switches for correct operation and adjust as needed.	
Ventilation Slots	Make sure ventilation slots in the tractor frame are clear of obstructions and debris.	
Warning Decals	Replace any illegible or damaged decals.	
Warning Lights	Check for correct operation.	
Wheels/Tires	Examine for bond failure, chunking, and excessive or uneven wear. Inspect load wheel bearings for binding or excessive play. Inspect drive axle for excessive play.	
Wire Guidance	Check sensor assemblies for damage and mounting hardware for tightness. Verify the lift truck acquires and tracks the guide wire correctly.	

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Every 360 Days or 2000 Deadman Hours (HD)

Perform the following maintenance tasks every 360 days or 2000 HD, whichever comes first.		
Component	**What to do**	**Refer to**
Drive Unit	Change fluid.	Page A-2
Hydraulic Reservoir	Change fluid and filter.	Page A-2
Lift Pump	Separate lift pump and motor. Apply molybdenum anti-seize compound (P/N 990-638) to the splines.	Page 7-82

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Chain Maintenance

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

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Section 5. Troubleshooting

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Electrical Troubleshooting

General

⚠ WARNING

Block the lift truck so that the drive tire is off the floor whenever a troubleshooting procedure requires turning the key switch ON. This will prevent accidents caused by unexpected lift truck travel. Opening the Emergency Lowering Valve will prevent unexpected lifting.

⚠CAUTION

Unless otherwise directed, disconnect the battery connector when you check electrical circuits or components with an ohmmeter. Electrical current can damage an ohmmeter. Discharge residual charge in the motor controller by pressing the PC and P contactors closed simultaneously.

- Many problems are caused by a faulty or dirty battery. Make sure the battery is clean.
- Save time and trouble by looking for simple causes first.
- For information on electrical connector location and function, see “Electrical Connector Locations” on page 5-14.
- Use a Digital Multi Meter (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. Clean test points in order to obtain accurate readings.
- 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.

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Battery State-of-Charge

Battery State-of-Charge (BSOC) is an option that monitors and remembers the charge level of the battery connected to the truck and prevents excessive discharging of that battery. Operating a truck using a discharged battery can damage both the battery and the electrical components in the truck's electrical system.

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

If a different battery is detected, BSOC tests to determine the state-of-charge of the new battery as follows:

1. BSOC computes the difference between the charge of the battery that was connected to the truck and the charge of the new battery. A charge difference of a least 50% between the two batteries resets BSOC to show the state-of-charge of the new battery (for example - the displayed state-of-charge of the new battery minus the displayed state-of-charge of the old battery must equal or exceed 50%). This reset can be higher or lower than the old battery. Example - A battery in the truck is at 10% charge; the new battery is at 95%. With more than a 50% difference in the charge levels, BSOC will reset the OD to show the new battery's charge.
2. 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 Configure Mode using the Superword. The new battery must be equal to or greater than the configured percent of charge before the BSOC will change. Example - BSOC configured at 95. Plugging in a battery at anything below 95% charge will not change the OD. Older batteries may require a lower configured value for BSOC since older batteries may be unable to reach a higher percent charge. Therefore, older batteries may require BSOC configure to 85 before the OD will reset to show the charge of the new battery.

Either Step 1 or 2 will cause BSOC to reset.

The following examples describe installing a new battery where the OD does not reset. Assume the following:

- **Example 1:** BSOC is configured at 95, the battery connected is at a calculated 45% charge and the new battery is at a calculated 92% charge.

  Since the new battery charge has not changed by at least 50% and the state-of charge of the new battery is not greater than the BSOC reset configured value, the OD will continue to show the old battery's charge of 45% (even though the new battery is at 92%). The OD will remain at 45% until the charge of the new battery declines to 45%. The display will then resume its normal descent.
- **Example 2:** BSOC is configured at 95, the battery connected is at a calculated 65% charge and the new battery is at a calculated 20% charge.

  Again, the change in charge is not at least 50% and the new battery is not above the configured BSOC level. The OD will continue to show 65%, but then descends rapidly as the truck operates until the OD shows the original charge of 20%. Once the display shows 20% it resumes a normal descent.

NOTE: If the displayed BSOC is suspected to be inaccurate, check for Code FE.
See Code FE: Internal VM Circuit for BSOC Not Calibrated (Page 6-27).

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See Figure 5-1 for a graphic representation of the BSOC process.

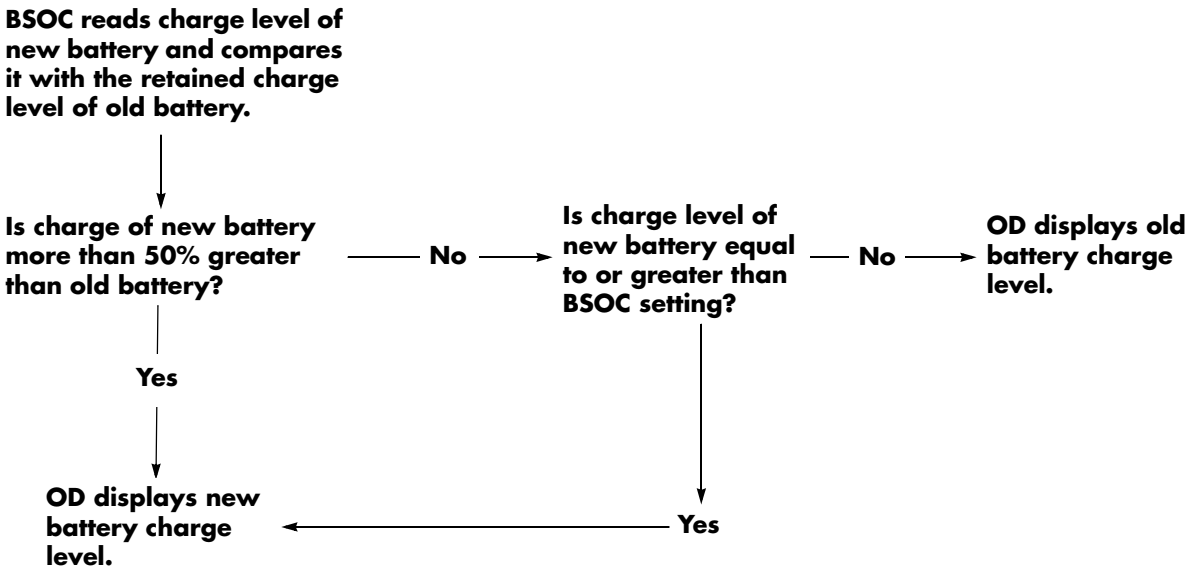


Figure 5-1. Battery State-of-Charge Process

Lift Cutout Adjustment

1. Run truck until lift cutout is activated.
2. Allow battery to set unused for two hours. Check SG and compare to manufacturer's recommendations.
3. Adjust cutout in **Config** until correct discharge is obtained.

NOTE: Additional BSOC adjustment is available using FlashWare. See "BSOC Calibration" on page 3-31.

Electrostatic Discharge

Electrostatic discharge can cause certain fault codes, such as FP or FT. Over time, electrostatic discharge can damage circuit cards. Static tends to be higher in environments with low relative humidity, such as freezers. See Electrostatic Discharge Precautions on page 2-7.

Make sure static straps are installed on the truck and work correctly.

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Fuses

Table 5-1 lists the fuses for a truck with all available options. Not all trucks will have all of the fuses listed.

Table 5-1. Fuses

Fuse	Function	Location	Amps
FU1	Power Fuse for Steer Power Amplifier	Contactor Panel	100
FU2	Power Fuse for Traction Power Amplifier		350
FU3	Power Fuse for Lift Power Amplifier - Model 5500, 5600		500
	Power Fuse for Lift Motor - Model 5400		350/Hi-Pro - 500
FU5	Control Fuse for Vehicle Manager B+	Fuse/Relay Card	15
FU6	Control Fuse for Vehicle Manager B–		15
FU7	Control Fuse for Aux Power B+		15/5
FU8	Control Fuse for Aux Power B–		15/5
FU9	Control Fuse for RF Terminal B+	Carriage Console Plate	2
FU10	Control Fuse for RF Terminal B–		2
FU21	Control Fuse for Cold Storage CCC Heater	CCC Heater Plate	10
FUDM	Control Fuse for Cold Storage Deadman Heater	Carriage Console Plate	5

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DC Motor Troubleshooting

Motor Types

Refer to Figure 5-2.

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

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

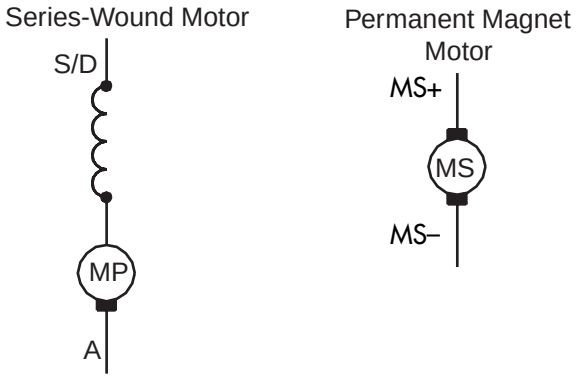


Figure 5-2. Motor Circuits

Inspection

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

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

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

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

Servicing

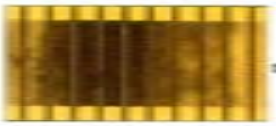
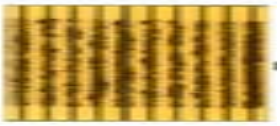
If the commutator requires service, you will need to remove the armature from the motor.

Do not use a stone to even out high and low spots on the commutator. Use only a suitable abrasive rubber polisher.

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

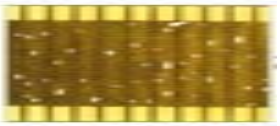
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Table 5-2. Commutator Surfaces

Condition	Probable Cause	Commutator Surface
Good Condition-Light Film	Uniform coloring indicates satisfactory operation of machine and brushes. Film color is largely an effect of thickness, therefore provided the film is uniform it is perfectly acceptable.	
Satisfactory Condition-Light and Dark Pattern	This is not a good condition but in our experience it is known that machines having this commutator pattern have operated with satisfactory results for long periods of time. This condition can appear in alternating bars as shown or every 3rd or 4th bar, etc. 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, etc.	
Unsatisfactory Condition-Example of Poor Commutator Machining	Bars are low on entry and leaving edges giving rise to the brushes riding on the middle of the bars.	
Unsatisfactory Condition-Example of Poor Commutator machining	Bars are low in the middle giving rise to the brushes riding on entry and leaving bar edges. This and the previous illustration indicate the need for better maintenance.	
Unsatisfactory Condition-Streaky Film With commutator Wear	This is a further development of the third example. Brush grade, machine applications and working environment are all suspect. Earlier corrective action should have been taken.	

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Table 5-2. Commutator Surfaces

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

Open Circuit Motor Test

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

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

Refer to Figure 5-2 on page 5-6 for the following procedure:

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

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

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

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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.

If the ohmmeter reads resistance of less than 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 normal (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 Motor Troubleshooting

AC motors used on this 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.

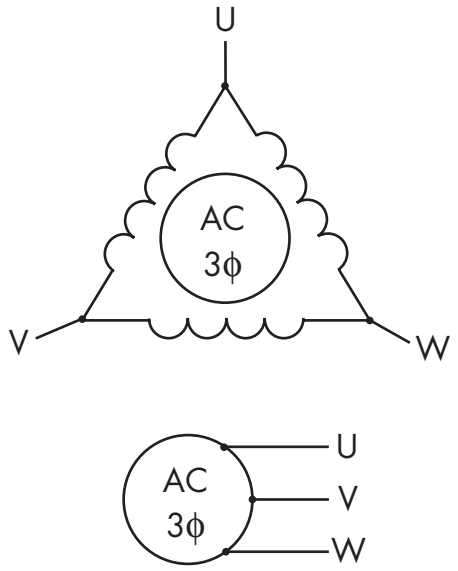


Figure 5-3. Drive Motor Circuits

Open Winding

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

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

Shorted Winding

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

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

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Shorts to Frame Test

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

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

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

Shorts to frame are caused by:

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

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

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

To test for shorts to frame:

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 light, 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 less than 0.0002A (0.2mA), go to Step 4. If the current is greater than 0.0002A (0.2mA) and less than 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 less than 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.

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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
- Heat sinks
- 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 less than 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 greater than 1000 ohms, continue with the next step.

5. Reconnect the battery connector and turn the key switch ON. If the battery was previously removed, make sure the battery case does not touch the lift truck frame.

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

6. Use a DVM set to the current function to measure current leakage to the truck frame from B+, B–, and all fuses and motor terminals. Begin measuring at the highest ampere scale and work toward the lowest. If the current is less than 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 less than 0.001A (1mA). Do not reconnect components one at a time, but leave them disconnected until the leakage current reads less than 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
- Heat sinks
- 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 defective. Repair or replace as appropriate.

7. When, after all components are reconnected, you get a reading less than 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.

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Wiring

Visually inspect all wiring and electrical components for:

- Loose connections or connectors
- Loose or broken terminals
- Damaged terminals, blocks, or strips
- Exposed wire at terminations, excessive strip gap
- Abrasions, scrapes, nicks in the wire, damage from overheating or burns, or other general insulation damage
- Broken wire strands and shorted conditions (especially those that are close to metal edges or surfaces)

During troubleshooting and repairs, it may be necessary to unplug a connector, move a harness, cut a cable tie, or remove the wire from a bracket. Note the location of the wire and all protective or securing attachments before moving the harness.

After repair, return or replace all protective and/or securing hardware to its original condition. Protective materials are necessary to provide reliable performance of the interconnect system.

Examine and maintain any added materials used to dress and protect the wire. This includes spiral wrap, brackets, cable ties, fasteners and flexible conduit.

Do not attach cable ties so tight that they pinch cable harnesses. Avoid attaching cables to hydraulic hoses that expand with pressure, pinching the attached electrical cables.

Use a DMM to check for wiring continuity.

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Electrical Connector Locations

Table 5-3. Connector Locations

Connector	Function or Routing	Location
FSUP	Connector on Fan Suppressor	Near Fan
HTR3	Connector for Deadman Heater	Near Deadman
J1	Connector for Lift/Lower Pendant	Near VM in Main Harness
JP1	Connector for Lights	Light Assembly
JP1L	Connector from Load Wire Guidance Antenna to Filter Card	Load Antenna
JP1T	Connector from Tractor Wire Guidance Antenna to Filter Card	Tractor Antenna
JP2	Connector for Lights	Light Assembly
JP10	Connector for Warning Light	Under Warning Light
JPA7	Connector for Home Sensor	Hydraulic Compartment
JPB–	(–) Battery Connector	Battery Connector
JPB+	(+) Battery Connector	
JPB1	Connector on Lift Motor Fan (EE only)	Near Lift Motor
JPBR	Connector for Brake	Near Brake Assembly
JPC1	Connector for Steering Encoder	Carriage Control Card
JPC2	Connector for Display Card	
JPC3	Connector for 60 in. Limit Switch	
JPC4	Connector for Lower Inhibit	
JPC5	Connector for Lights/Fans	
JPC6	Connector for Lift/Lower Bypass Switch	
JPC7	Connector for Deadman Switches	
JPC8	Connector for 24 in. Limit Switch	
JPC9	Connector for Control Handle	
JPC11	Connector for Over-the-Mast Cable #1	
JPC12	Connector for Spare Power	
JPC13	Connector for Sidegate Switches	
JPC14	Connector for Sidegate Switches	
JPC15	Connector for Light Display Card	
JPC16	Connector for Over-the-Mast Cable #2	
JPC17	Connector for Aux Card	
JPC18	Connector for Aux Card	

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Table 5-3. Connector Locations

Connector	Function or Routing	Location
JPC19	Connector for Aux Lift and Lower Switch	Aux Card
JPC20	Connector for Aux Limit Switch	
JPC21	Connector for Secondary Steer Input Encoder	Carriage Control Card
JPC23	Connector on Aux Card for Aux Deadman	Aux Card
JPE4	Connector for Steer Motor Encoder	Hydraulic Compartment
JPF1	B– Aux Power and B+ Power Amps Connector	Fuse/Relay Card
JPF2	B+ Key Switch Relays Connector	
JPF3	B– Connector	
JPF4	Key Switch, EPO, Battery Sense Connector	
JPLA1	Lift Amp Connector	Lift Amplifier
JPLA2	Lift Motor Encoder Connector	Near bottom of Lift Motor
JPLA3	Lift Motor Temperature Sensor Connector	
JPLA4	Lift Motor Encoder/Temperature Sensor Connector	Hydraulic Compartment
JPS1	Contactor Panel Interface Connector	Contactor Panel
JPS2	Wire Guidance Power Connector	Guidance Manager Card
JPS4	Wire Guidance Communications Connector	
JPS8	Connector for 120”/150” Limit Switch	Behind Fuse/Relay Card
JPS10	Connector for Lift Inhibit Switch	
JPS15	Connector for Travel Alarm	Near Lift Amp
JPS16	Connector for Travel Cutout Switch	Behind Fuse/Relay Card
JPS25	Connector for Over-the-Mast Cable #1	
JPS26	Connector for Over-the-Mast Cable #2	
JPS27	Connector for Over-the-Mast wires for optional equipment	Over-the-Mast wiring
JPS28	Connector for 180” Limit Switch	Behind Fuse/Relay Card
JPS50	Connector for Pressure Transducer A	Hydraulic Compartment
JPS51	Connector for Flow Module	
JPS52	Connector for Lift/Lower Alarm	Behind Fuse/Relay Card
JPS53	Connector for Rail Sense Switch	Near Horn Assembly
JPS54	Connector for Aisle Detect Sensor #1	Hydraulic Compartment
JPS55	Connector for Aisle Detect Sensor #2	
JPS57	Connector for Lift Cutout	Behind Fuse/Relay Card

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Electrical Connector Locations

Table 5-3. Connector Locations

Connector	Function or Routing	Location
JPSC1	Splice for CAN Bus	Below Battery Connector
JPSC2	Splice for CAN Bus	Behind Drive Motor
JPT2	USB Connector	Vehicle Manager
JPT4	Connector	
JPT6	Electric Steer Connector	
JPT9	Flashware Connector	
JPT10	CAN Digital Inputs and Outputs Connector	
JPT12	Lift Pendant Connector	
JPT14	B+, B–, CAN Communications Connector	
JPT18	Coil Drivers Connector	
JPT20	Proportional Coil Drivers Connector	
JPT22	Digital Inputs Connector	
JPT24	Analog Inputs Connector	
JPTA1	Traction Amp Connector	Traction Amplifier
JPTA2	Traction Motor Encoder Connector	Near Bottom of Drive Motor
JPTA3	Traction Motor Temperature Sensor Connector	
JPTA4	Traction Motor Encoder and Temperature Connector	Top of Drive Motor Power Cables
JPW1	Connector for Load Sensor	Filter Card
JPW2	Connector for Tractor Sensor	
JPY1	Connector for Flow Module	Flow Module
JPY2	Connector for Flow Sensor Temperature Sensor	
JPY6	Connector for Flow Sensor Channel 1	
JPY7	Connector for Flow Sensor Channel 2	

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Carriage Control Card Connectors

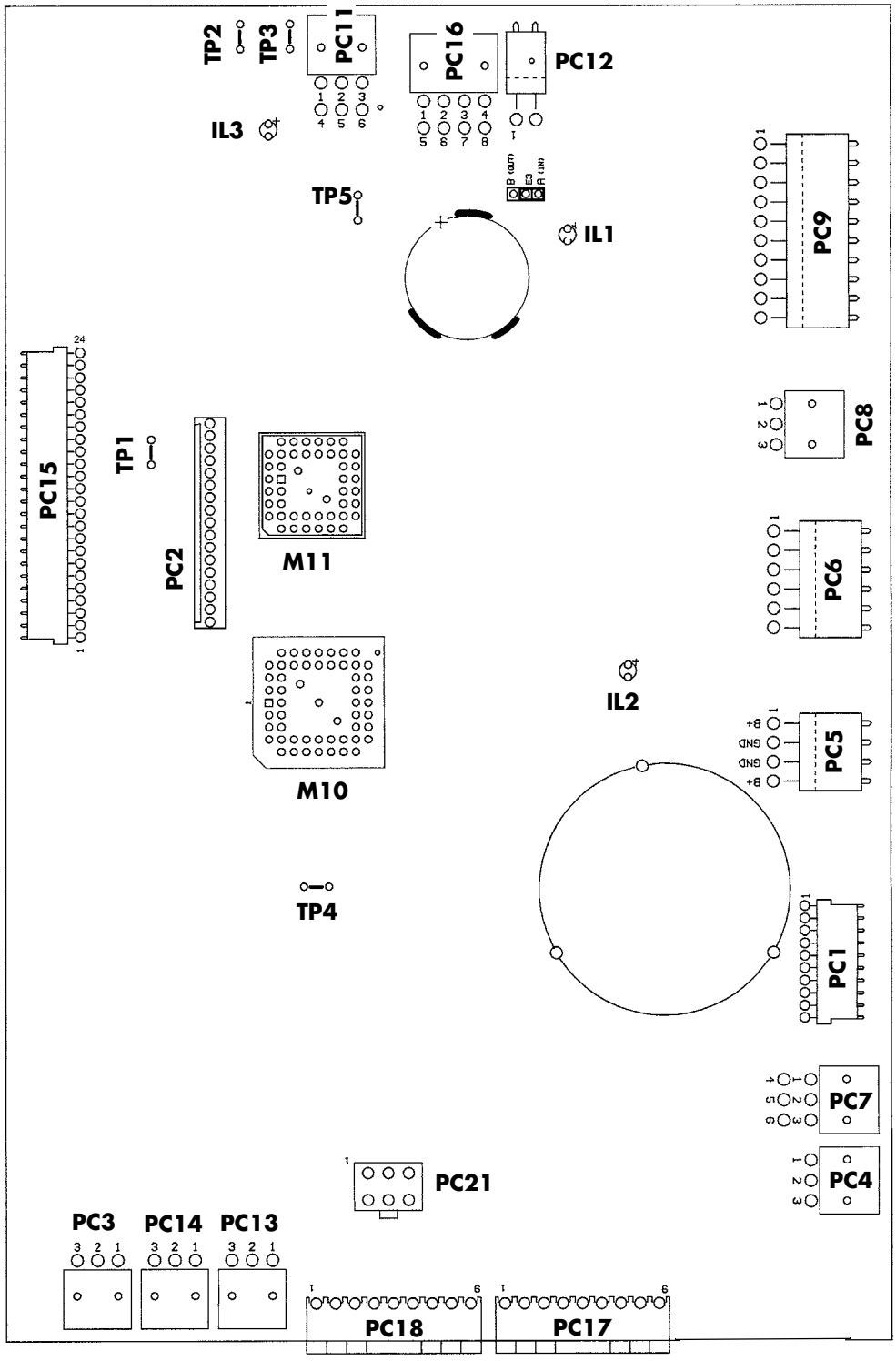


Figure 5-4. Carriage Control Card Connectors

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Vehicle Manager Connectors

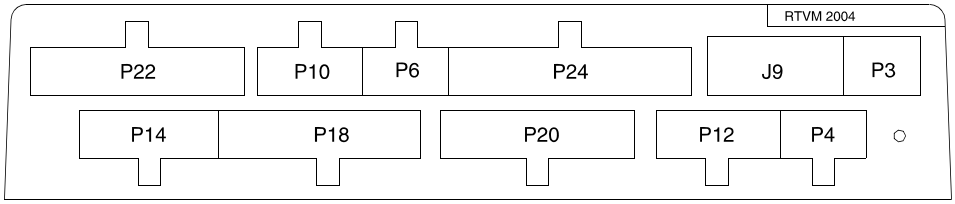


Figure 5-5. Vehicle Manager Connectors

Guidance Card Connectors

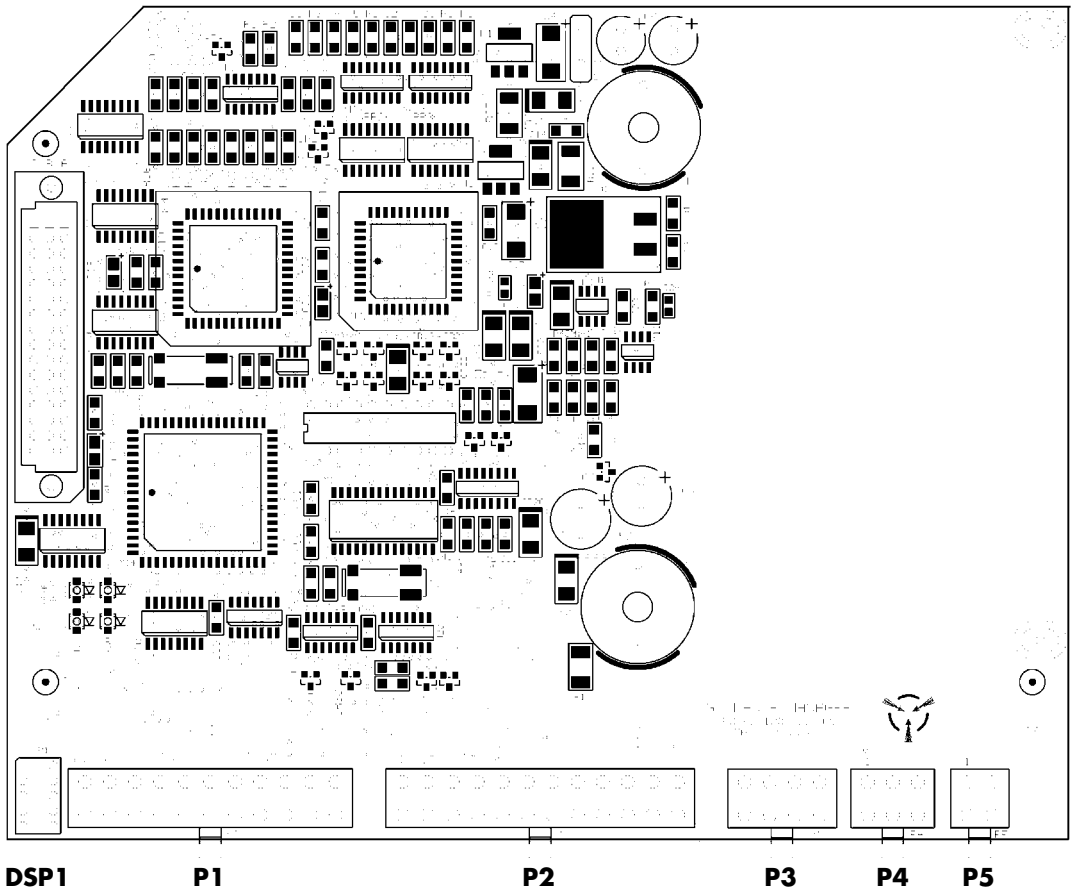


Figure 5-6. Guidance Card Connectors

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Filter Card Connectors

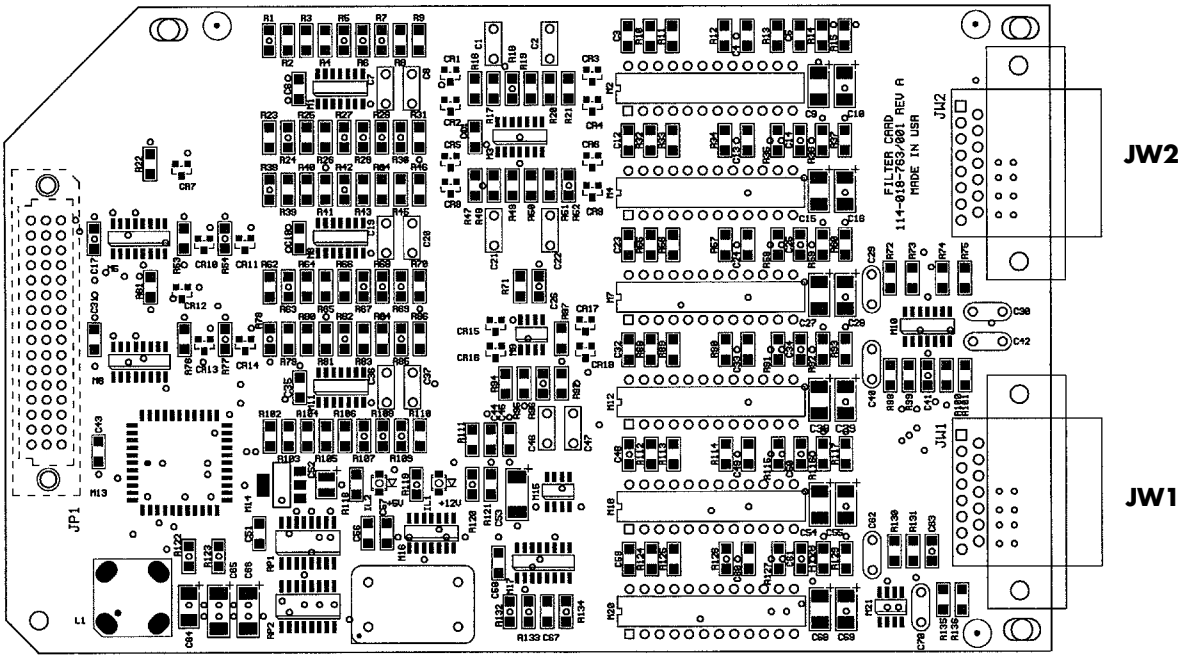


Figure 5-7. Filter Card Connectors

Fuse Relay Card

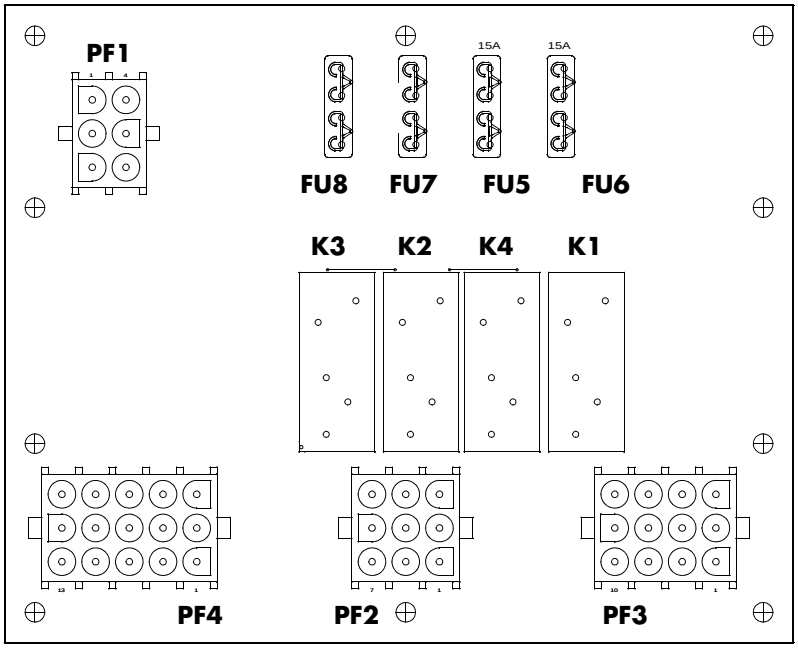


Figure 5-8. Filter Card Connectors

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Auxiliary Card Assembly

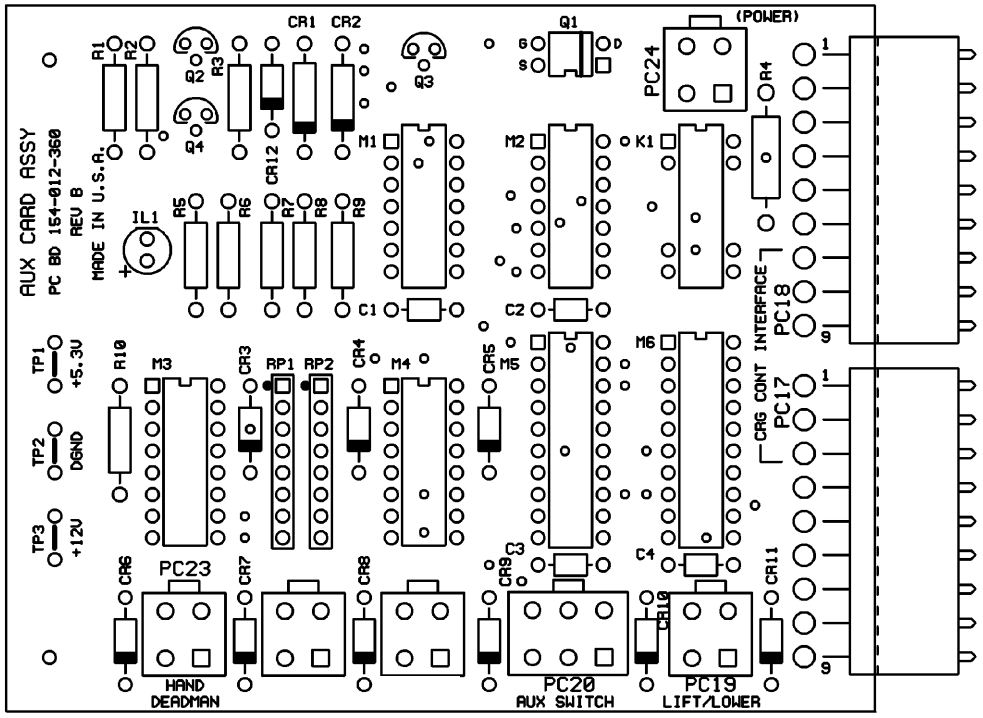


Figure 5-9. Auxiliary Card Connectors

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Drive Unit Troubleshooting

Refer to page 7-23 for standard drive unit repair procedures and page 7-42 for heavy duty drive unit repair procedures.

Symptom	Probable Cause	Required Action
Oil leaks	Damaged sealing rings	Replace sealing rings, bearing shims, and drive shaft bearings.
	Worn or damaged drive shaft	Replace sealing rings, bearing shims, drive shaft bearings, and drive shaft.
	Housing/cover joint	Reseal
	Worn or damaged housing	Replace drive unit.
Drive wheel wobbles	Worn or damaged drive shaft bearings	Replace sealing rings, bearing shims, and drive shaft bearings.
	Worn or damaged drive shaft	Replace sealing rings, bearing shims, drive shaft bearings, and drive shaft.
	Loose wheel mounting hardware	Inspect housing and drive shaft for damage; Re-torque mounting hardware.
Noise	Worn or damaged drive shaft bearing	Replace sealing rings, bearing shims, and drive shaft bearings.
	Worn or damaged pinion bearings	Replace pinion bearing and pinion shaft nut.
	Worn or damaged gear set (drive shaft is in good condition)	Replace sealing rings, bearing shims, drive shaft bearings, pinion bearings, pinion shaft nut, and gear set.
	Worn or damaged gear set (drive shaft is worn or damaged)	Replace sealing rings, bearing shims, drive shaft bearings, pinion bearings, pinion shaft nut, gear set, and drive shaft.
	Worn or damaged helical gear and pinion	Replace helical gear and pinion.
Steering binds	Inadequate bearing lubrication	Grease steering bearing.
	Worn or damaged steering bearing	Replace radial rings and ball bearings.

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Communication Error Code Troubleshooting

Intermittent Communication Codes

If possible, determine what the operator was doing when the codes were generated; driving, plugging, lifting, sounding horn, and so on.

Focus on these circuits for shorts to frame and external noise being generated that can interfere with the communication circuits. Determine where in the SelfTest Cycle the code is generated (for instance, when the drive motor is energized or when the horn was sounded).

Intermittent Codes During SelfTest

Make sure the key switch is turned OFF for at least 5 seconds before turning it back to the ON position. Test the key switch for high resistance. If nothing is found in the following steps, replace the key switch.

Test for shorts to frame. See Shorts to Frame Test on page 5-11.

If equipped with optional light/fan package, disconnect PC5. If code goes away, troubleshoot light/fan circuitry.

NOTE: The condition of the light/fan suppressor module cannot be checked with a DMM. If the suppressor module is suspected to be bad, replace it.

During Travel and/or Plugging

If truck is equipped with optional travel alarm, disconnect wires to the relay. If code goes away, troubleshoot travel alarm circuitry.

NOTE: The condition of the travel alarm suppressor module cannot be checked with a DMM. If the suppressor module is suspected to be bad, replace it.

Test and clean static straps.

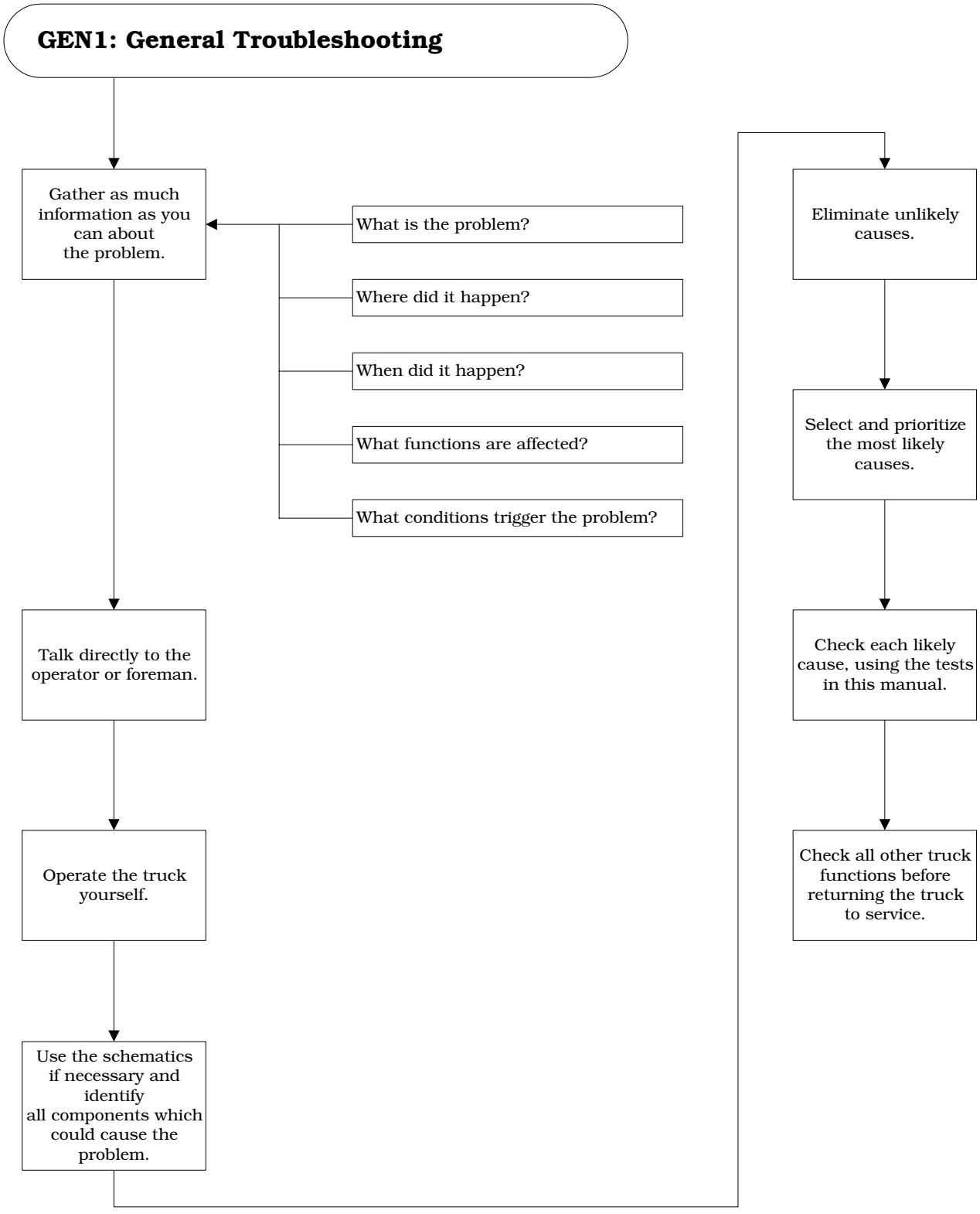
Test for shorts to frame. See Shorts to Frame Test on page 5-11.

Communication Code Every Time Key Is Turned ON

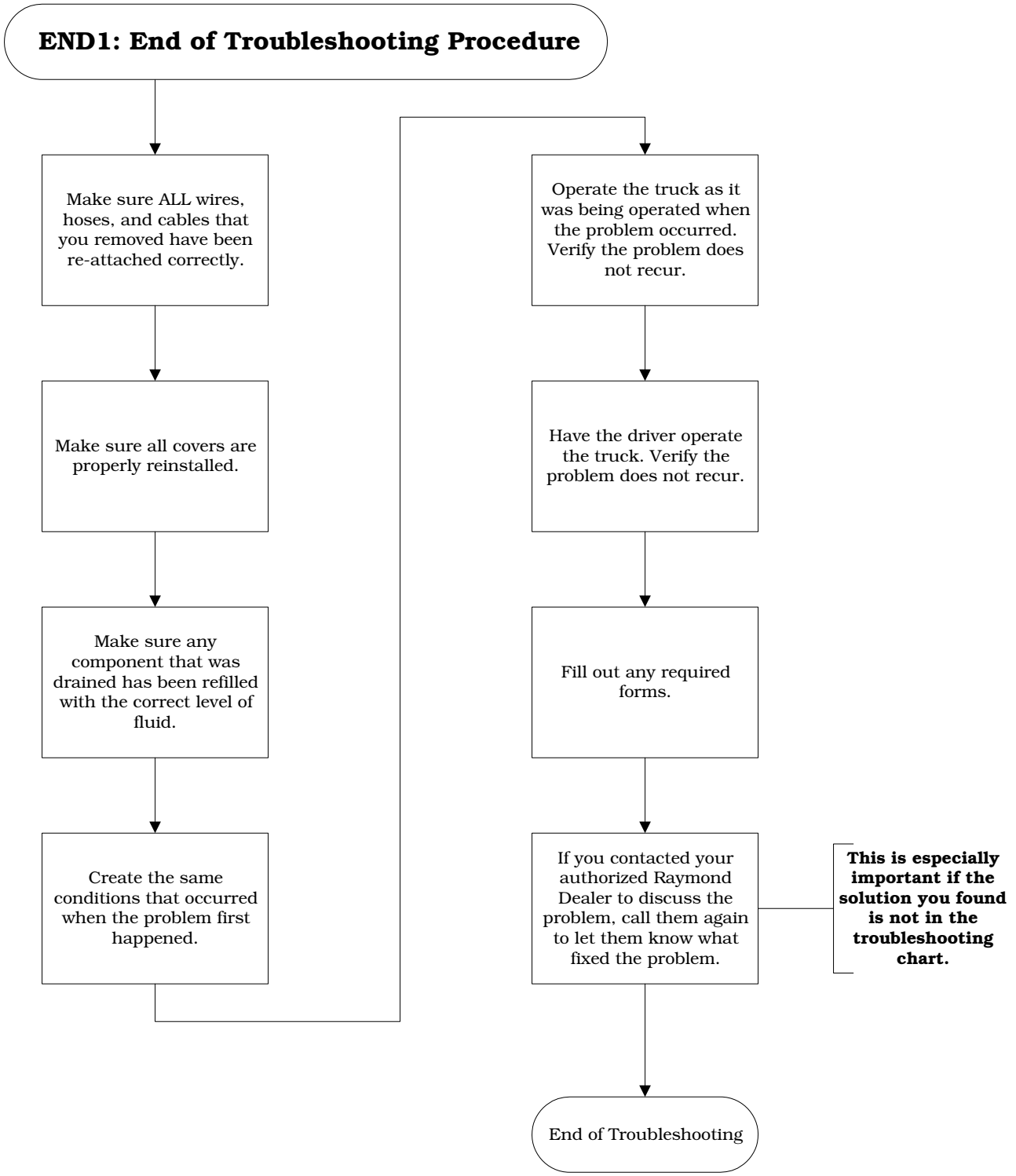
Troubleshoot per code on display using Test I23 - CAN Bus (Page 6-66).

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Troubleshooting Procedure



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Symptom Tables: Hydraulic Functions

NOTE: If it is determined that a component failed as a result of hydraulic fluid contamination, replace the failed component and flush, fill, and bleed the hydraulic system.

NOTE: Reference schematics on page A-11.

Intermittent Lift/Lower

Possible Cause	Action
Bad wiring	Check wiring harnesses between valves and VM.
Hydraulic contamination (can cause binding proportional valve or load holding solenoid)	Replace damaged component and flush, fill, and bleed the hydraulic system.

Lift Function

No Lift - Carriage: Lift motor does not run

Possible Cause	Action
Bad battery	Adjust lift cutout as necessary. Replace battery with fully charged battery.
Bad optional lift limit switch	Run Test I05 - Lift Inhibit Switch (optional) (Page 6-62) and Test I04 - Lift/Lower Inhibit Bypass (optional) (Page 6-61).

Slow Lift - Carriage: Lift motor runs

Possible Cause	Action
Bad battery	Adjust lift cutout as necessary. Replace battery with fully-charged battery. Test battery for bad cells. See Battery Procedures on page 7-62.
Emergency lowering valve not seated correctly	Make sure emergency lowering valve is closed. Check for contamination. If contamination is present, clean valve, flush, fill, and bleed the hydraulic system.
Bad proportional lift/lower valve	Inspect for binding. Run Test O12 - Proportional Solenoid PWM Ramp (Page 6-95).
Relief valve REL1 stuck open	Test system pressure. Check for contamination. If contamination is present, replace valve, flush, fill, and bleed the hydraulic system.
Plugged or malfunctioning flow control valve in lift cylinder	Check for contamination in hydraulic fluid. If contamination is present, inspect and clean the relief valve, replace the flow control valves, flush, fill, and bleed the hydraulic system.
Bad lift pump	Test system pressure.

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Possible Cause	Action
Binding in the mast	Inspect the mast and bearings for signs of binding.
Bad lift motor	**DC Lift Trucks:** Test lift motor. See DC Motor Troubleshooting on page 5-6. Check amp draw. **AC Lift Trucks:** Run Test O28 - Ramp Lift Motor (AC lift only) (Page 6-100).
Bad Lift Motor Encoder	Run Test I20 - Lift Motor RPM (AC lift only) (Page 6-65)

Unable to Pick Up a Load

Possible Cause	Action
Battery problems	Adjust lift cutout as necessary. Replace battery with fully-charged battery. Test battery for bad cells. See Battery Procedures on page 7-62.
Incorrect lift pressure adjustment	Check and adjust lift pressure setting.
Bad lift pump	Test system pressure.
Bad lift motor	**DC Lift Trucks:** Test lift motor. See DC Motor Troubleshooting on page 5-6. Check amp draw. **AC Lift Trucks:** Run Test O28 - Ramp Lift Motor (AC lift only) (Page 6-100).

Lower Function

Slow Lower

Possible Cause	Action
Binding proportional valve	Check valve operation. Run Test O12 - Proportional Solenoid PWM Ramp (Page 6-95).
Mechanical binding in bearings or telescopic	Adjust or replace bearings. If still slow, check shimming.
Plugged or malfunctioning flow control valve	Open Emergency Lower Valve. If still slow, remove and inspect flow control valves. Check for contamination in hydraulic fluid. If contamination is present, inspect and clean the relief valve, flush, fill, and bleed the hydraulic system. If no contamination is found, replace the flow control valves in the main lift cylinders.

Intermittent Lower

Possible Cause	Action
Bad load hold solenoid	Run Test O11 - Toggle Load Holding Solenoid (Page 6-94).
Binding proportional valve	Check valve operation. Run Test O12 - Proportional Solenoid PWM Ramp (Page 6-95).

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Possible Cause	Action
Plugged or malfunctioning flow control valve	Open Emergency Lower Valve. If still slow, remove and inspect. Check for contamination in hydraulic fluid. If contamination is present, inspect and clean the relief valve, flush, fill, and bleed the hydraulic system. If no contamination is found, replace the flow control valves in the main lift cylinders.

Load Drifting/Settling

Possible Cause	Action
Incorrect lift pressure adjustment	Check and adjust lift pressure setting.
Load holding solenoid	Run Test O11 - Toggle Load Holding Solenoid (Page 6-94). Check for contamination in hydraulic fluid. If contamination is present, inspect and clean the relief valve, flush, fill, and bleed the hydraulic system.
Load too large for lift truck capacity	Check load weight. Check lift pressure setting.
Emergency Lower Valve leaking	Replace valve.

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Symptom Tables: Travel Functions

Slow or Sluggish Acceleration

Possible Cause	Action
Dragging brake	Adjust brake.
Worn wheel bearings	Replace wheel bearings.
Debris in wheel axle	Remove debris.
Binding drive unit	Remove motor and check movement.

Slow Travel

Possible Cause	Action
Note: Determine if problem is mechanical or electrical.	
Mechanical:	
Dragging brake	Adjust brake.
Debris in wheel axle	Remove debris.
Binding drive unit	Remove motor and check movement.
Binding in control handle	Run Test A22 - Traction Throttle Request (Page 6-43) to determine if the controller is still seeing a 100% request.
Electrical:	
Bad mast speed limit switch (S10 or S11) or associated wiring	Run Test I02 - Lower Mast Reference (24 in.) Switch (Page 6-58), Test I69 - Upper Mast Reference Switch (Page 6-82), or Test I03 - 60 in. Limit Switch (Page 6-59).
Incorrect configuration	Reconfigure the lift truck.
Speed limited due to drive motor or power amplifier temperature (temperature icon illuminated)	Run Test A08 - Traction Motor Temperature (Page 6-34), Test A10 - Traction Power Amplifier Temperature (Page 6-36).
Bad encoder pulses from drive motor encoder	Run Test I19 - Traction Motor RPM (Page 6-64)

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Symptom Tables: Electrical Symptoms

NOTE: Reference schematics beginning on page A-11.

Electrical Motors

Motor Arcing

Possible Cause	Action
Worn brushes or incorrect brush tension	Replace brushes and brush springs.
Partially shorted motor armature or field	Clean motor.
Rough or pitted motor commutator	Replace motor.

Motor Overheating

Possible Cause	Action
Dragging brake	Adjust brake. See Brake on page 7-54.
Application exceeds designed workload -- short runs with plugging/acceleration or heavy-duty lifting cycles Using deadman pedal to stop all the time	Check with Dealer Service Manager to verify application.
Bad battery	Check voltage, both open circuit and under load. Replace if necessary with fully-charged good battery.
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.
Cable, terminal, or wiring problems. Look for discolored terminals, loose or damaged crimps	Replace wiring or cables as necessary. Check cable connection torque. See Terminal Hardware on page 7-66.
Worn, damaged, or bad brushes or springs	Inspect motor brushes. Check brush spring tension.
Binding gearbox or pump	Check gearbox or pump for binding. Clean, repair, or replace as necessary.
Hydraulic fluid viscosity too high or too low	Replace hydraulic fluid with correct fluid. See Lubrication Specification Chart on page A-2.
Pressure relief set too high	Adjust pressure relief.

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Operator Display Problems

Scrambled or Intermittent Display

Possible Cause	Action
Loose JPC15 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.
Electrical noise in motors	Check tightness of motor power cable connections (see page 7-66). Check motor brushes for arcing. Replace if necessary.
Bad key switch	Replace key switch.
Worn or missing static straps	Replace as necessary.

Dead Lift Truck

Display is Dark - No functions operate

Possible Cause	Action
No LEDs illuminated on circuit cards	Refer to Pin-Out Matrix on page 8-19 and Schematics on page A-11. Check for B+ at the following locations wrt TP4: • FU5 • JPF4-10 • JPC16-8 • JPC6-1 • JPC6-2 • JPC16-6 • JPF4-8 • JPF4-11 • JPT14-12 Check for B– at the following locations wrt TP1: • FU6 • JPF3-3, 4, 5, 6, 7, 8 and 12 • JPT14-1, 2, 8, 9 and 10 • JPC16-4 • JPT14-3 • JPC11-6 If all of the above locations have the correct voltages, refer to the Diagnosis and Repair table in Test A14 - VM +12V Power Supply (Page 6-39).

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Auto Steer Center Problem

Intermittent Truck Error Codes

Possible Cause	Action
Noise, shorts to frame	See “Shorts to Frame Test” on page 5-11.
Calculated position of the drive unit bad	Error Code G2 displayed, See “Message Displayed: CODE G2 Inform service” on page 6-28. Check adjustment of home prox sensor.
Large correction to steering prior to braking	Steer motor encoder, steering amp, or VM may be bad. Check home prox sensor adjustment
Mechanical issue, worn radial ring	Repair or replace as necessary.

Truck Codes After Deadman Pedal Depressed

Possible Cause	Action
Steering will move in both directions during auto center.	See “Test I25 - Steer Motor Encoder” on page 6-69.
Steering only in one direction,	Check home proximity sensor adjustment. See “Test I24 - Home Position Proximity Sensor” on page 6-68.
No movement in steering. Mechanical issue, worn radial ring.	Repair or replace as necessary.

Truck Codes Before Deadman Pedal Depressed

Possible Cause	Action
Low voltage measured between JPT6-6 and JPT6-4	Replace VM.
Fuse FU1 open	Replace fuse
High resistance measured between Steer Motor terminals.	Check brushes, replace motor.
Bad Steer Amplifier	Replace and Test.
Bad VM	Replace VM.

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Section 6. Messages, Codes and Tests

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Operator Display Messages

The Operator Display (OD) displays data received from the Carriage Control Card. See Figure 6-1. The displayed data includes:

- Time or calendar
- BSOC (Battery State-of-Charge)
- Hour meters (hours on deadman [HD], hours spent lifting [HL], total miles [TM])
- Status/Fault messages
- Weight of load (option)
- Fork Height (option)
- Maintenance required indicator
- Over-temperature indicator
- Lift-limit indicator (optional)
- Steering direction indicator
- Guidance indicator (optional)

The OD is not required for Run Mode or to pass SelfTest.

Steering Indicator Lights

The steering indicator lights are located on the Operator Display Console. The steer indicator lights show the operator the approximate position of the drive unit.

Wire Guidance LEDs

The wire guidance LEDs are located on the Operator Display Console. The LEDs consist of two green triangles and three yellow rectangles. The LEDs indicate when the wire guidance system is turned ON and the truck is locked on the guide wire.

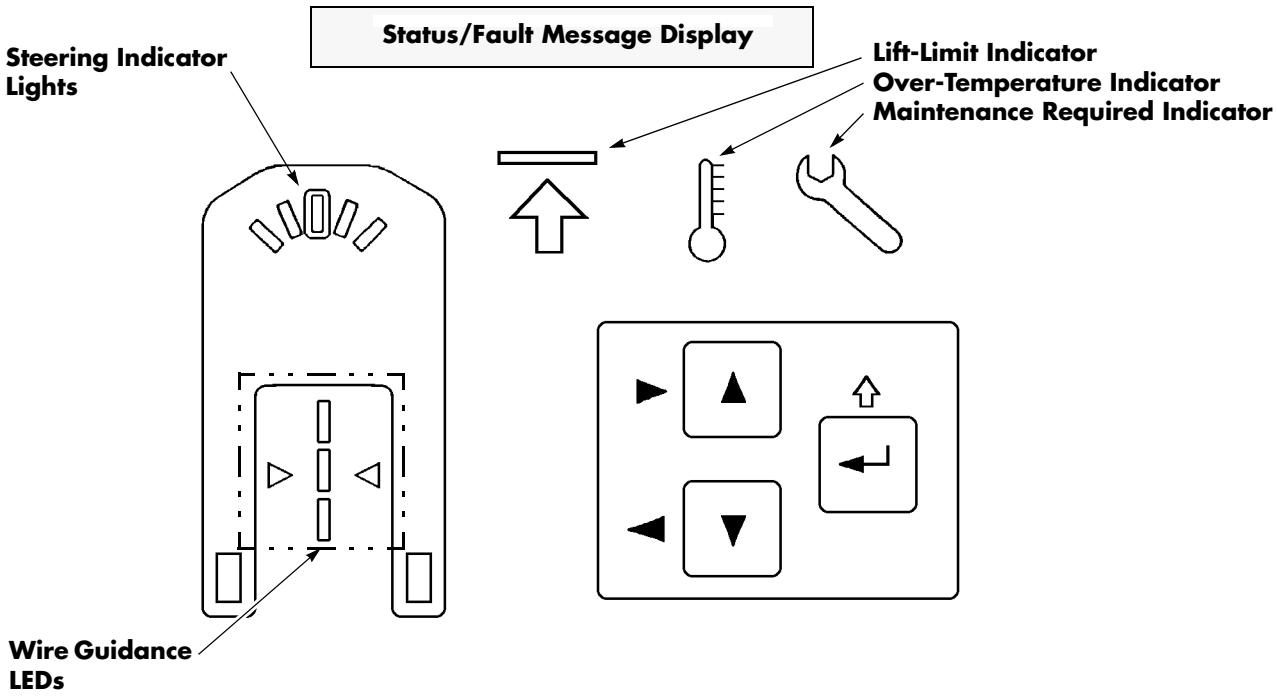


Figure 6-1. Operator Display Messages

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Messages and Codes Summary List

Messages

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Truck Travel Inhibited. 6-14

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Messages and Codes

Icon	Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: None			
	**LPA Approaching Overtemperature (temp icon only)** The VM senses the lift power amplifier temperature is approaching 185°F (85°C). Lift performance is limited.	Test A19 - Lift Power Amplifier Temperature (AC lift only) (Page 6-41)	Cycle key switch to clear after lift power amplifier has cooled.
Message Displayed: None			
	**TPA Approaching Overtemperature (temp icon only)** The VM senses the traction power amplifier temperature is approaching 185°F (85°C). Traction performance is limited.	Test A10 - Traction Power Amplifier Temperature (Page 6-36)	Cycle key switch to clear after traction power amplifier has cooled.
Message Displayed: Aligning			
	Aligning: Wire Is Sensed Truck Is Now Aligning The AUTO/MAN switch is in the Auto position. The guide wire is sensed. The truck is trying to acquire the wire.	None	None
Message Displayed: Seeking			
	Seeking: AUTO/MAN Switch Is In Auto The guide wire has not been sensed. The truck is trying to find the wire.	None	None

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Message Displayed: Speed limited due to steer angle

Icon	Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: Speed limited due to steer angle			
	Speed Limited Due To Steer Angle A speed limiting condition due to a combination of steering angle and height is in effect.	Test I02 - Lower Mast Reference (24 in.) Switch (Page 6-58) Test I03 - 60 in. Limit Switch (Page 6-59) Test I69 - Upper Mast Reference Switch (Page 6-82) Test I75 - 180 in. Limit Switch (optional) (Page 6-89)	Straighten the drive unit to within 10° of straight ahead or lower the carriage below the 24 in. lower mast reference switch. 1. If the operator platform height is between 24 in. (610 mm) and 60 in. (1520 mm) and the steering angle is >10°, max travel speed is limited to 2.5 mph (4km/h). 2. If the operator platform height is between 60 in. (1520 mm) and 150 in. (3810 mm) (w/*intellispeed*) or the upper reference switch (S10) (w/o *intellispeed*) and the steering angle is >10° then max travel speed is limited to 1 mph (1.6km/h). 3. If the height of the operator platform is greater than or equal to 50 in. (3810mm) (w/*intellispeed*) or the Upper Mast Reference Switch (S10) (w/o *intellispeed*) and steering is greater than 10°, then travel is *not* permitted.

Message Displayed: Lower sidegates to resume operation			
	Lower Side Gate While standing on the Deadman Pedal, a sidegate is detected UP when you attempt to travel or lift.	Test I67 - Sidegate Switches (optional) (Page 6-80)	Lower Sidegates to clear.

Message Displayed: Release control handle to resume operation			
	Control Handle Moved Before Deadman Pressed	Test A04 - Throttle Potentiometer Voltage (Page 6-32)	Release throttle, step on deadman, resume travel.

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Icon	Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: Guidance not learned			
	Guidance Not Learned When the AUTO/MAN Switch was placed in the Auto position, the wire guidance parameters were out-of-range.	None	Learn Guidance to clear.
Message Displayed: Lift cut-out pending ... low battery			
	**Battery Low**	None	Message is displayed for five minutes, then lift is disabled. Change Battery.
Message Displayed: Press bypass switch to continue lifting			
	**Press Bypass Switch to Continue Lifting** Lift inhibit switch (S24) is open.	Test I05 - Lift Inhibit Switch (optional) (Page 6-62)	Cycle key switch to clear.
Message Displayed: Release buttons			
	**Both Pendant Buttons Pressed Before Time-out** Both buttons are pressed at the same time. Must have at least a two second delay between pressing the first and second.	None	Allow more time between pressing buttons.
Message Displayed: EPO Depressed			
	**EPO Depressed** CCC or VM senses the EPO switch is open (IN).	Test I38 - EPO Switch (Page 6-73)	Lift EPO Button and cycle key switch to clear.
Message Displayed: FlashWare options incorrectly configured			
	**Incorrect FlashWare Options** FlashWare options incorrectly configured/ verify options are configured correctly in FlashWare.	Use FlashWare to set a valid configuration	Cycle key switch OFF/ON to clear
Message Displayed: Release aux buttons to resume operation			
	Aux Buttons Depressed Auxiliary deadman and auxiliary lift or lower switches are activated at start-up	Test I41 - Aux Mast Lift Switch S32 (Page 6-75) Test I42 - Aux Mast Lower Switch S33 (Page 6-76)	Cycle key switch OFF/ON to clear

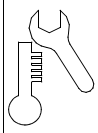
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Message Displayed: "Scheduled maintenance due."

Icon	Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: "Scheduled maintenance due."			
	**Scheduled Maintenance Reminder** This code occurs when configure mode Maintenance Minder has been set to request it be activated		Reset Mnt Mind in Configure mode
Message Displayed: "Lift cutout, Scheduled maintenance due."			
	**Scheduled Maintenance Reminder** This code occurs when configure mode Maintenance Minder has been set to request it be activated		Lift is disabled. Reset Mnt Mind in Configure mode
Message Displayed: "Battery low, no lift"			
	**Battery State-of-Charge** Lift interrupt has occurred due to the battery state-of-charge	If charging or changing the battery does not clear the message, run Test A15 - Battery Voltage (Page 6-40)	Lift is disabled. Battery needs to be charged or changed
Message Displayed: "Speed limited"			
	**TPA not receiving Motor RPM** This code is generated by the Traction Power Amplifier after not receiving encoder pulses.	Test I19 - Traction Motor RPM (Page 6-64)	Travel speed is limited. Cycle key switch OFF/ON to clear.
Message Displayed: "Press bypass switch to continue lifting"			
	**Switch (S24) Activated** Lift Inhibit Switch (S24) has been crossed.	Test I05 - Lift Inhibit Switch (optional) (Page 6-62)	Lift is disabled unless bypass switch is activated. Lower vehicle below lift inhibit switch
Message Displayed: "Stalled, release control handle to resume operation"			
	**Truck Stalled** No encoder pulses are received by Power Amplifier.	Travel speed limited. Test I19 - Traction Motor RPM (Page 6-64). Lift speed limited. Test I20 - Lift Motor RPM (AC lift only) (Page 6-65)	Travel speed or lift speed is limited depending on which amplifier is not receiving encoder pulses. Cycle key switch OFF/ON to clear.

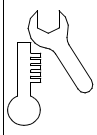
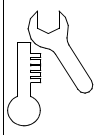
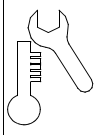
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Message Displayed: "Overheated, allow time to cool""

Icon	Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: "Overheated, allow time to cool""			
	**Truck Overheated** The system has detected that an over temperature condition exists.	This is the actual message: depending on what motor is over heated will determine if the Traction or Lift speed is reduced.	Allow time for truck to cool. Check truck Event Log to determine what motor or amp is causing the code.
Message Displayed: "Speed limited due to unknown height... lower to reference switch""			
	**Truck Speed Limited** Truck powered ON when above 24 inch limit switch	Test I02 - Lower Mast Reference (24 in.) Switch (Page 6-58)	Lower truck below 24 in. limit switch
Message Displayed: "Press bypass switch to continue lowering"			
	**Truck Lowering Inhibited** Lower Inhibit Switch (S25) has been crossed.	Test I74 - Lower Inhibit Switch (optional) (Page 6-88)	Lower is disabled unless bypass switch is activated. Lift above lower inhibit switch
Message Displayed: "Travel cutout"			
	**Truck Travel Inhibited** Truck has been elevated above travel cutout switch	Test I68 - Travel Cutout Switch (optional) (Page 6-81)	Travel is disabled. Lower vehicle below travel cutout switch
Message Displayed: "Release bypass switch"			
	**Truck Lift/Lower Inhibited** Will happen with either lift or lower bypass switch (S7) activated for an extended period of time.	Test I04 - Lift/Lower Inhibit Bypass (optional) (Page 6-61)	Release switch
Message Displayed: "Steer limited due to height""			
	**Truck Steering Inhibited** Truck is elevated above upper reference switch and a steering request of more than 10 degrees has been requested		Lower vehicle below upper reference switch

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Message Displayed: "Lift speed Limited"

Icon	Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: "Lift speed Limited"			
	**Truck Lift Speed Inhibited** This code is generated by the Lift Power Amplifier after not receiving encoder pulses	Test I20 - Lift Motor RPM (AC lift only) (Page 6-65)	Lift speed is limited. Cycle key switch OFF/ON to clear
Message Displayed: "Travel Interlock Activated""			
	**Truck Travel Inhibited** This will occur when truck is configured with lift limit w/bypass and configure mode is choosing to not allow travel when above the lift limit switch		Lower truck below lift limit switch
Message Displayed: ADF, PDF, AHA, PHA"			
	**Truck Travel Inhibited** WGAM has been left turned ON in Configure Mode		Turn off WGAM in Configure Mode
Message Displayed: CODE 1H Inform service			
	**Code 1H: TPA Out-of-Range** The traction power amplifier has reported its internal temperature is less than –40°F (–40°C) or greater than +203°F (+95°C).	Test A10 - Traction Power Amplifier Temperature (Page 6-36)	Cycle key switch to clear after traction power amplifier has cooled.
Message Displayed: CODE 2A Overheated Allow time to cool			
	**Code 2A: Traction Motor Approaching Overtemperature** The traction amplifier senses the traction motor is approaching overtemperature. Traction performance is limited.	Test A08 - Traction Motor Temperature (Page 6-34)	Travel speed is linearly derated starting at 266°F (130°C). Travel speed is limited to 1 mph at 300°F (149°C). Cycle key switch to clear after traction motor has cooled.
Message Displayed: CODE 2E Inform service			
	**Code 2E: Traction Motor Temp Sensor Out-of-Range** The traction motor temperature sensor is open or shorted.	Test A08 - Traction Motor Temperature (Page 6-34)	Travel is limited to 2.5 mph. Clears when reason for fault is corrected.

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Icon	Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 2G Inform service			
	**Code 2G: Phase Open on Traction Motor** The traction power amplifier has detected no current draw in one of the three phases of the motor.	Test O29 - Ramp Traction Motor (Page 6-101)	Travel is disabled. Cycle key switch to clear.
Message Displayed: CODE 2H Inform service			
	**Code 2H: Failure Detected in Traction Motor Speed Feedback Encoder**	Test I19 - Traction Motor RPM (Page 6-64)	Travel is limited to 1 mph. 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.
Message Displayed: CODE 2M Inform service			
	**Code 2M: TPA Pre-Charge Failed** Traction power amplifier failed to precharge correctly.	None	Travel is disabled. Check for B+ at TPA+. Cycle key switch to clear. If code will not clear, replace traction power amplifier. The VM cannot cause this code.
Message Displayed: CODE 2T Inform service			
	**Code 2T: TPA Current Calibration Error** The traction power amplifier has sensed a current calibration error.	None	Travel is limited to 2.5 mph. Cycle key switch to clear. If code will not clear, replace traction power amplifier. The VM cannot cause this code.
Message Displayed: CODE 2U Inform service			
	**Code 2U: TPA Overcurrent or Short Circuit** The traction power amplifier has sensed current in excess of 400A.	None	Travel is disabled. Cycle key switch to clear. Check for shorted traction motor power cables. If code will not clear, replace traction power amplifier. The VM cannot cause this code.

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Message Displayed: CODE 2V Inform service

Icon	Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 2V Inform service			
	**Code 2V: High DC BUS Voltage – TPA** The traction power amplifier has detected an overvoltage condition at the + terminal.	Test A15 - Battery Voltage (Page 6-40)	If voltage is OK, replace TPA. Cycle key switch to clear. The VM cannot cause this code.
Message Displayed: CODE 2W Inform service			
	**Code 2W: TPA Internal Fault** Traction power amplifier internal circuitry (not required for truck operation) has malfunctioned.	None	Cycle key switch to clear. Replace traction power amplifier.
Message Displayed: CODE 2X Inform service			
	**Code 2X: TPA Power Supply Out-of-Range** The power supply output in the traction power amplifier 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 temp and speed sensors. If OK, troubleshoot wires and sensors. If not OK, replace TPA. The VM cannot cause this code.
Message Displayed: CODE 2Y Inform service			
	**Code 2Y: Incorrect Traction Power Amplifier Installed**	None	Replace with correct power amp. Travel is limited to 2.5 mph.
Message Displayed: CODE 42 Inform service			
	**Code 42: LPC Detected Closed When Commanded Open** **AC Lift** - the lift power amplifier has detected an incorrect voltage at the B+ terminal on the amplifier. **DC Lift** - the VM has detected an incorrect voltage at JPT18-9.	Test O02 - Toggle the Lift Power Contactor (Page 6-93)	Cycle key switch to clear.
Message Displayed: CODE 43 Inform service			
	**Code 43: LPC Detected Open When Commanded Closed** **AC Lift** - the lift power amplifier has detected an incorrect voltage at the B+ terminal on the amplifier. **DC Lift** - the VM has detected an incorrect voltage at JPT18-9.	Test O02 - Toggle the Lift Power Contactor (Page 6-93)	Cycle key switch to clear.

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Icon	Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 4C Inform service			
	**Code 4C: FU1 Sense Validation** FU1 detected open by the VM. This is a sense lead validation. If fuse is bad during Run mode, another error code will detect it.	None	Check FU1, FU1 Sense line (JPT22-19). If FU1 opens during Run, Code G4 is displayed. Cycle key switch to clear.
Message Displayed: CODE 4F Inform service			
	**Code 4F: TPC Detected Closed When Commanded Open** The traction power amplifier has detected an incorrect voltage at the B+ terminal on the amplifier.	Test O00 - Toggle the Traction Power Contactor (Page 6-92)	Travel is disabled. DC Lift - lift is also disabled. Cycle key switch to clear.
Message Displayed: CODE 4G Inform service			
	**Code 4G: TPC Detected Open After Power-Up** The traction power amplifier has detected the TPC open after power-up.	Test O00 - Toggle the Traction Power Contactor (Page 6-92)	Travel is disabled. DC Lift - lift is also disabled. Cycle key switch to clear.
Message Displayed: CODE 4H Inform service			
	**Code 4H: TPA, TPC Contactor Coil or Coil Driver Open or Shorted**	Test O00 - Toggle the Traction Power Contactor (Page 6-92)	Cycle key switch to clear.
Message Displayed: CODE 4K Inform service			
	**Code 4K: LPA, LPC Contactor Coil or Coil Driver Open or Shorted** AC lift only.	Test O02 - Toggle the Lift Power Contactor (Page 6-93)	Lift is disabled. Cycle key switch to clear.
Message Displayed: CODE 50 Inform service			
	**Code 50: No VM Communications Received by CCC** The Carriage Control Card has not received correct communications from the VM. **Note:** This code is displayed during Flashware procedure.	Test I23 - CAN Bus (Page 6-66)	All functions disabled. See Communication Error Code Troubleshooting on page 5-22. Cycle key switch to clear.

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Message Displayed: CODE 51 Inform service

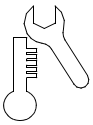
Icon	Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 51 Inform service			
	**Code 51: No CCC Communications Received by VM** The VM has not received correct communications from the CCC.	Test I23 - CAN Bus (Page 6-66)	All functions disabled. See Communication Error Code Troubleshooting on page 5-22. Cycle key switch to clear.
Message Displayed: CODE 59 Inform service			
	**Code 59: CAN Transmission Buffer Error** The VM has detected a CAN transmission buffer error.	Test I23 - CAN Bus (Page 6-66)	All functions disabled. See Communication Error Code Troubleshooting on page 5-22. Cycle key switch to clear.
Message Displayed: CODE 5A Inform service			
	**Code 5A: CAN BUS Error Overflow** CAN BUS error overflow detected by VM.	Test I23 - CAN Bus (Page 6-66)	All functions disabled. See Communication Error Code Troubleshooting on page 5-22. Cycle key switch to clear.
Message Displayed: CODE 5E Inform service			
	**Code 5E: No Guidance Manager CAN Communications Received by the VM**	Test I23 - CAN Bus (Page 6-66)	Travel disabled in AUTO mode. Travel allowed in MANUAL mode. Cycle key switch to clear.
Message Displayed: CODE 5G Inform service			
	**Code 5G: No Communications Received by VM from TPA** The VM has not received CAN communications from the traction power amplifier.	Test I23 - CAN Bus (Page 6-66)	Travel is disabled. Cycle key switch to clear.
Message Displayed: CODE 5J Inform service			
	**Code 5J: No communications Received by VM from LPA** **AC Lift only** - The VM has not received CAN communications from the lift power amplifier.	Test I23 - CAN Bus (Page 6-66)	Lift is disabled. Cycle key switch to clear.

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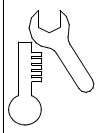
Icon	Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 61 Inform service			
	**Code 61: 24 in. Limit Switch Not Sensed** Too much time has passed without crossing 24 in. limit switch while lift request is above a certain threshold.	Test O12 - Proportional Solenoid PWM Ramp (Page 6-95) Test I02 - Lower Mast Reference (24 in.) Switch (Page 6-58)	Travel is limited to 2.5 mph. Make sure Emergency Lower Valve is closed. Cycle key switch to clear.
Message Displayed: CODE 63 Inform service			
	**Code 63: Upper and Lower Reference Switches Do Not Agree** The VM has sensed that the positions of the upper (S10) and the lower (S11) reference switches were out of sequence.	Test I02 - Lower Mast Reference (24 in.) Switch (Page 6-58) Test I69 - Upper Mast Reference Switch (Page 6-82)	Travel is limited to 1 mph. Cycle key switch to clear.
Message Displayed: CODE 64 Inform service			
	**Code 64: No Flow Sensor Pulses When Lift/Lower Requested** No pulses were seen from the flow sensor when lifting past one of the two mast reference switches (24 and 150 in.). (***intellispeed* only**)	Test I02 - Lower Mast Reference (24 in.) Switch (Page 6-58) Test I26 - Flow Sensor Count (Page 6-70) Test I69 - Upper Mast Reference Switch (Page 6-82)	Travel is limited to 1 mph. Lift or lower past one of the mast reference switches. Cycle key switch to clear.
Message Displayed: CODE 66 Inform service			
	**Code 66: Calculated Height Does Not Match at Upper Reference Switch (150 in.)** *intellispeed* count and calculated height of the upper reference switch (S10) are out of tolerance. (*intellispeed* only)	Test I26 - Flow Sensor Count (Page 6-70) Test I69 - Upper Mast Reference Switch (Page 6-82)	Travel is limited to 1 mph. Cycle key switch to clear.
Message Displayed: CODE 67 Inform service			
	**Code 67: Calculated Height Does Not Match at Lower Reference Switch (24 in.)** *intellispeed* count and calculated height of the lower reference switch (S11) are out of tolerance. (*intellispeed* only)	Test I02 - Lower Mast Reference (24 in.) Switch (Page 6-58) Test I26 - Flow Sensor Count (Page 6-70)	Travel is limited to 1 mph. Cycle key switch to clear.

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Message Displayed: CODE 6D Inform service

Icon	Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 6D Inform service			
	**Code 6D: Lift Pressure Sensor Out-of-Range** The VM has determined that the pressure sensor voltage has exceeded the programmed limits. (*intellispeed* only)	Test A13 - Pressure Sensor Voltage (optional) (Page 6-38)	Code is displayed for five seconds. Display will then change to "----". Cycle key switch to clear.
Message Displayed: CODE 6F Overheated Allow time to cool			
	**Code 6F: Lift Motor Overheated AC Lift only** - Lift motor temperature has exceeded 300°F (149°C).	Test A09 - Lift Motor Temperature (Page 6-35)	Lift is disabled. Allow time to cool. Cycle key switch to clear.
Message Displayed: CODE 6K Inform service			
	**Code 6K: 60 in. Switch Does Not Agree with Lower Mast Reference** The 60 in. switch (S28) is out of sequence with the lower reference switch (S11). (non-*intellispeed* only	Test I02 - Lower Mast Reference (24 in.) Switch (Page 6-58) Test I03 - 60 in. Limit Switch (Page 6-59)	Travel is limited to 2.5 mph. Lower, then lift past the first mast limit switch (S11), then cycle key switch to clear.
Message Displayed: CODE 6M Inform service			
	**Code 6M: 60 in. and/or 24 in. Switch Disconnected** The system detected that the 60 in. (S28) and/or the 24 in. (S11) switch are disconnected.	Test I02 - Lower Mast Reference (24 in.) Switch (Page 6-58) Test I03 - 60 in. Limit Switch (Page 6-59)	Lower, then lift past the lower reference switch (S11). Cycle key switch to clear.
Message Displayed: CODE 6N Inform service			
	**Code 6N: Flow Sensor Temperature Out-of-Range** The VM has sensed that the voltage is out-of-range. (*intellispeed* only)	None	Cycle key switch to clear. Only shown during Learn. Learn values will still be stored.
Message Displayed: CODE 6P Inform service			
	**Code 6P: 60 in. Limit Switch Out-of-Sequence with Upper Reference Switch** The system senses that the 60 in. limit switch and the upper reference switch are out of sequence. (*non-intellispeed* only)	Test I03 - 60 in. Limit Switch (Page 6-59) Test I69 - Upper Mast Reference Switch (Page 6-82)	Travel limited to 1 mph. Cycle key switch to clear.

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Icon	Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 7E Inform service			
	**Code 7E: Lift Motor Temperature Sensor Out-of-Range** Lift motor temperature sensor voltage is out-of-range.	Test A09 - Lift Motor Temperature (Page 6-35)	Lift performance is disabled by power amplifier. Cycle key switch to clear.
Message Displayed: CODE 7F Inform service			
	**Code 7F: LPA Temp Out-of-Range** The lift power amplifier has reported its internal temperature is less than –40°F (–40°C) or greater than +203°F (+95°C).	Test A19 - Lift Power Amplifier Temperature (AC lift only) (Page 6-41)	Lift is disabled. Cycle key switch to clear.
Message Displayed: CODE 7G Inform service			
	**Code 7G: LPA Motor Phase Open** The lift power amplifier has detected no current draw in one of the three phases of the motor.	Test O28 - Ramp Lift Motor (AC lift only) (Page 6-100)	Lift is disabled. Cycle key switch to clear.
Message Displayed: CODE 7H Inform service			
	**Code 7H: Failure Detected in Lift Motor Feedback Encoder** The lift power amplifier has detected incorrect pulses from the lift motor encoder.	Test I20 - Lift Motor RPM (AC lift only) (Page 6-65)	Lift is limited to approx. 10 feet per minute. Cycle key switch to clear.
Message Displayed: CODE 7M Inform service			
	**Code 7M: LPA Failed to Precharge** The lift power amplifier failed to precharge.	None	Lift is disabled. If cycling the key switch does not clear this code, the amplifier must be replaced. The VM cannot cause this code.
Message Displayed: CODE 7T Inform service			
	**Code 7T: LPA Current Sensor Fault** Internal lift power amplifier circuitry that measures current has detected a fault.	None.	Lift is limited to 60% of maximum request. If cycling the key switch does not clear this code, the amplifier must be replaced. The VM cannot cause this code.

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Message Displayed: CODE 7U Inform service

Icon	Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 7U Inform service			
	**Code 7U: LPA Overcurrent or Short Circuit** The lift power amplifier has sensed current in excess of 500A.	None	Lift is disabled. Cycle key switch to clear. The VM cannot cause this code.
Message Displayed: CODE 7V Inform service			
	**Code 7V: LPA High Voltage on DC BUS** The lift power amplifier has detected that the voltage at the + terminal is overvoltage.	None	Lift is disabled. Test voltage at LPA+. If OK, replace LPA. Cycle key switch to clear. The VM cannot cause this code.
Message Displayed: CODE 7W Inform service			
	**Code 7W: LPA Internal Fault** Internal coil driver sensed open or shorted.	None	Cycle key switch to clear. If code will not clear, replace lift power amplifier. The VM cannot cause this code.
Message Displayed: CODE 7X Inform service			
	**Code 7X: LPA Power Supply Out-of-Range** The power supply output in the lift power amplifier 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 temp and speed sensors. If OK, troubleshoot wires and sensors. If code will not clear, replace lift power amplifier. The VM cannot cause this code.
Message Displayed: CODE 7Y Inform service			
	**Code 7Y: Incorrect Lift Power Amplifier Installed** (AC lift only)	None	Replace with correct power amp.
Message Displayed: CODE 80 Inform service			
	**Code 80: Throttle Potentiometer (VR1) Voltage Out-of-Range**	Test A04 - Throttle Potentiometer Voltage (Page 6-32)	Travel is disabled. Cycle key switch to clear.

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Icon	Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 81 Inform service			
	**Code 81: Lift/Lower Potentiometer (VR2) Voltage Out-of-Range**	Test A05 - Lift/Lower Potentiometer Voltage (Page 6-33)	Lift is disabled. Cycle key switch to clear.
Message Displayed: CODE 83 Inform service			
	**Code 83: Throttle Potentiometer (VR1) Out-of-Neutral** Throttle potentiometer (VR1) out of learned neutral value.	Test A04 - Throttle Potentiometer Voltage (Page 6-32)	Travel is disabled. Cycle key switch to clear.
Message Displayed: CODE 84 Inform service			
	**Code 84: Brake Inoperable; Not Applied** The drive motor bearing encoder indicated movement during Selftest.	Test O30 - Toggle Brake Solenoid (Page 6-102)	Travel disabled at startup. Make sure brake release bolts are removed from brake assembly. Cycle key switch to clear.
Message Displayed: CODE 8C Inform service			
	**Code 8C: Deadman Switches Do Not Agree** Deadman switches S2 and S23 do not agree or the steering encoder is disconnected.	Test I00 - Carriage Deadman (Page 6-56) Test I01 - Brake Deadman Switch (S2) (Page 6-57)	Travel, lift, lower, and brake disabled. Cycle key switch to clear.
Message Displayed: CODE 8F Inform service			
	**Code 8F: Lift/Lower Potentiometer Out-of-Neutral** Lift/Lower potentiometer (VR2) out of learned neutral value.	Test A05 - Lift/Lower Potentiometer Voltage (Page 6-33)	Lift and lower disabled. Cycle key switch to clear.
Message Displayed: CODE 8L Inform service			
	**Code 8L: Electric Brake Feedback** The VM senses the brake coil current is incorrect.	Test A35 - Brake (Page 6-46)	Travel limited to 1 mph. Cycle key switch to clear.
Message Displayed: CODE 91 Inform service			
	**Code 91: Drive Unit Turned >10° while Guiding on Wire**	Test I25 - Steer Motor Encoder (Page 6-69)	Truck plugs to 0 mph. Auto/Man switch to Manual. Cycle key switch to clear.

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Message Displayed: CODE 92 Inform service

Icon	Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 92 Inform service			
	**Code 92: Tracking Limits Exceeded**	Test A51 - Left Tractor Guidance Coil Voltage (Page 6-49) Test A52 - Right Tractor Guidance Coil Voltage (Page 6-50) Test A53 - Left Load Guidance Coil Voltage (Page 6-51) Test A54 - Right Load Guidance Coil Voltage (Page 6-52)	Truck plugs to 0 mph. Auto/Man switch to Manual. Cycle key switch to clear.
Message Displayed: CODE 93 Lost TCP Lost Wire			
	**Code 93: Not Near Wire; Tractor Coil Pair**	Test A51 - Left Tractor Guidance Coil Voltage (Page 6-49) Test A52 - Right Tractor Guidance Coil Voltage (Page 6-50) Test A55 - Tractor Near Wire Coil Voltage (Page 6-53)	Truck plugs to 0 mph. Auto/Man switch to Manual. Cycle key switch to clear.
Message Displayed: CODE 94 Lost LCP Lost Wire			
	**Code 94: Not Near Wire; Load Coil Pair**	Test A53 - Left Load Guidance Coil Voltage (Page 6-51) Test A54 - Right Load Guidance Coil Voltage (Page 6-52) Test A56 - Load Near Wire Coil Voltage (Page 6-54)	Truck plugs to 0 mph. Auto/Man switch to Manual. Cycle key switch to clear.

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Icon	Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 9E Inform service			
	**Code 9E: Track And Hold Signal Failed** The truck is moving on the wire and the guidance signals are not fluctuating at all.	Test A51 - Left Tractor Guidance Coil Voltage (Page 6-49) Test A52 - Right Tractor Guidance Coil Voltage (Page 6-50) Test A53 - Left Load Guidance Coil Voltage (Page 6-51) Test A54 - Right Load Guidance Coil Voltage (Page 6-52)	Truck plugs to 0 mph. Auto/Man switch to Manual. Cycle key switch OFF/ON to clear.
Message Displayed: CODE 9F Inform service			
	**Code 9F: Filter Card Not Connected to Guidance Manager** When the auto/man switch is switched to auto and the guidance manager does not sense the filter card.	Check connection between filter card and guidance manager. Replace filter card first then guidance manager.	Hard plug to 0 mph. Cycle key switch OFF/ON to clear.
Message Displayed: CODE 9G Inform service			
	**Code 9G: No Input; Load Antenna** The signal from the load antenna is not being received by the Guidance Manager.	Test A53 - Left Load Guidance Coil Voltage (Page 6-51) Test A54 - Right Load Guidance Coil Voltage (Page 6-52)	Truck plugs to 0 mph. Auto/Man switch to Manual. Cycle key switch OFF/ON to clear.
Message Displayed: CODE 9H Inform service			
	**Code 9H: No Input; Tractor Antenna** The signal from the tractor antenna is not being received by the Guidance Manager.	Test A51 - Left Tractor Guidance Coil Voltage (Page 6-49) Test A52 - Right Tractor Guidance Coil Voltage (Page 6-50)	Truck plugs to 0 mph. Auto/Man switch to Manual. Cycle key switch OFF/ON to clear.
Message Displayed: CODE 9J Inform service			
	**Code 9J: Load Antenna Input Too High**	Test A53 - Left Load Guidance Coil Voltage (Page 6-51) Test A54 - Right Load Guidance Coil Voltage (Page 6-52)	Truck plugs to 0 mph. Auto/Man switch to Manual. Cycle key switch to clear.
Message Displayed: CODE 9K Inform service			

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Message Displayed: CODE A0 Inform service

Icon	Code Title/Reason	Tests to Run	Notes/Corrective Action
	**Code 9K: Tractor Antenna Input Too High**	Test A51 - Left Tractor Guidance Coil Voltage (Page 6-49) Test A52 - Right Tractor Guidance Coil Voltage (Page 6-50)	Truck plugs to 0 mph. Auto/Man switch to Manual. Cycle key switch to clear.

Message Displayed: CODE A0 Inform service			
	**Code A0: Incorrect Software** Incorrect VM 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.

Message Displayed: CODE A2 Inform service			
	**Code A2: Software Compatibility Issue with VM and TPA**	None	Travel disabled. Cycle key switch to clear. If this code appears, upgrade the software in the truck using Flashware.

Message Displayed: CODE A4 Inform service			
	**Code A4: Software Compatibility Issue with VM and LPA** AC lift only.	None	Lift disabled. Cycle key switch to clear. If this code appears, upgrade the software in the truck using Flashware.

Message Displayed: CODE AL Inform service			
	**Code AL: VM Battery Backed Up RAM Failed**	None	Travel, lift, and lower disabled. Cycle key switch to clear. If code will not clear, replace VM.

Message Displayed: CODE AP Inform service			
	**Code AP: TPA Software Fault**	None	Travel disabled. Cycle key switch to clear. If code will not clear, Flash traction power amplifier with latest software.

Message Displayed: CODE AT Inform service

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Icon	Code Title/Reason	Tests to Run	Notes/Corrective Action
	**Code AT: LPA Software Fault** AC lift only.	None	Lift disabled. Cycle key switch to clear. If code will not clear, Flash lift power amplifier with latest software.
Message Displayed: CODE FE Inform service			
	**Code FE: Internal VM Circuit for BSOC Not Calibrated**	None	Code is displayed for 30 seconds. Replace VM.
Message Displayed: CODE FG Inform service			
	**Code FG: +5V Reference Voltage and +12V Power Supply Failure**	Test A14 - VM +12V Power Supply (Page 6-39)	Travel, lift, and lower disabled. Brake will engage. Cycle key switch to clear.
Message Displayed: CODE FH Inform service			
	**Code FH: Battery Voltage Out-of-Range** Wrong voltage battery or voltage out-of-range.	Test A15 - Battery Voltage (Page 6-40)	Travel, lift, and lower disabled. Brake will remain engaged. Cycle key switch to clear.
Message Displayed: CODE FN Inform service			
	**Code FN: Relays Did Not Open at Power Off**	Test O32 - Toggle Relays (Page 6-103)	Travel, lift, and lower disabled. Brake will engage. Cycle key switch to clear.
Message Displayed: CODE FP Inform service			
	**Code FP: VM In-Circuit Hardware Failure**	None	Travel, lift, and lower disabled. Brake will remain engaged. Cycle key switch to clear. Replace VM.
Message Displayed: CODE FT Inform service			

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Message Displayed: CODE G0 Inform service

Icon	Code Title/Reason	Tests to Run	Notes/Corrective Action
	**Code FT: VM Internal Software Error**	None	Travel, lift, and lower disabled. Brake will remain engaged. Cycle key switch to clear. If code will not clear, Flash VM with latest software.

Message Displayed: CODE G0 Inform service			
	**Code G0: Steer Tiller Encoder 1 is Intermittent or Failed** Determined by channel A and/or B not functioning correctly when compared with Steer Tiller Encoder 2.	Test I35 - Steer Tiller Encoder 1 (Page 6-71)	Coasts to 2.5 mph. Travel limited to 2.5 mph. Cycle key switch to clear.

Message Displayed: CODE G2 Inform service			
	**Code G2: Auto Steer Center Failed** 1. Home switch is more than 10 degrees from the initial value saved during a successful auto steer center. 2. Auto steer center time-out - greater than 2 seconds. 3. No encoder pulses sensed during auto steer center.	See “Auto Steer Center Problem” on page 5-31.	Moderate plug to 0.0 mph. Step off then back on the deadman pedal to allow travel again. Max travel speed limited to 1.0 mph. Cycle key switch OFF/ON to clear.

Message Displayed: CODE G3 Inform service			
	**Code G3: Home Prox Switch Not Functioning Correctly**	See “Auto Steer Center Problem” on page 5-31.	All steer indicator lights will flash. Travel speed limited to 1.0 mph. Cycle key switch OFF/ON to clear.

Message Displayed: CODE G4 Inform service			
	**Code G4: Open Detected in Steer Control Circuit** No neutral pulses detected when the truck is not moving and operator is on the deadman pedal.	See “Auto Steer Center Problem” on page 5-31.	Aggressive plug to 0.0 mph. Step off then back on the deadman pedal to allow travel again. Max travel speed set to 1.0 mph. Cycle key switch OFF/ON to clear.

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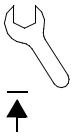
Icon	Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE G5 Inform service			
	**Code G5: Short Detected in Steer Power Circuit** Steer motor encoder pulses or command detected and no steer tiller encoder pulses detected.	Test A37 - Steer Power Amplifier Current (Page 6-47) Test I25 - Steer Motor Encoder (Page 6-69)	Moderate plug to 0.0 mph. Step off then back on the deadman pedal to allow travel again. Max travel speed set to 1.0 mph. Cycle key switch OFF/ON to clear.
Message Displayed: CODE G7 Inform service			
	**Code G7: Steer Tiller Encoder 2 is Intermittent or Failed** Determined by the connect detect circuit for the CD Supply and Gnd connections or by channel A and/or B not functioning correctly when compared with Steer Tiller Encoder 1.	Test I36 - Steer Tiller Encoder 2 (Page 6-72)	Coasts to 2.5 mph. Travel limited to 2.5 mph. Cycle key switch to clear.
Message Displayed: CODE GD Inform service			
	**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.	Test I25 - Steer Motor Encoder (Page 6-69)	Truck plugs to 0 mph. Travel limited to 1 mph. More steer tiller rotations required to turn drive unit. Cycle key switch to clear.
Message Displayed: CODE GE Inform service			
	**Code GE: Both Steer Tiller Encoders Failed** Determined by the connect detect circuit.	Test I35 - Steer Tiller Encoder 1 (Page 6-71) Test I36 - Steer Tiller Encoder 2 (Page 6-72)	Truck plugs to 0 mph. Travel limited to 1 mph. Cycle key switch to clear.
Message Displayed: CODE J2 Inform service			
	**Code J2: Aisle Exit Error** Only one magnet was sensed when the guided aisle was exited.	Test I72 - End-of-Aisle Sensor 2 (optional) (Page 6-84) Test I73 - End-of-Aisle Sensor 1 (optional) (Page 6-86)	Plugs to stop, speed is limited to 1 mph. While out of the aisle, switch the AUTO/MAN switch to manual. Turn the drive unit >10° and travel until the code clears.
Message Displayed: CODE J4 Inform service			

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Message Displayed: CODE X3 Inform service

Icon	Code Title/Reason	Tests to Run	Notes/Corrective Action
	**Code J4: Aisle Sensor Error**	Test I72 - End-of-Aisle Sensor 2 (optional) (Page 6-84) Test I73 - End-of-Aisle Sensor 1 (optional) (Page 6-86)	Travel limited to 1 mph.

Message Displayed: CODE X3 Inform service			
	**Code X3: 180 in. Limit Switch Mismatch** The 180 in. Switch (S100) is out of sequence with a standard mast switch.	Test I75 - 180 in. Limit Switch (optional) (Page 6-89)	Travel limited to 1.0 mph. Cycle key switch OFF/ON to clear.

Message Displayed: CODE X4 Inform service			
	**Code X4: Lift Cutout Switch Mismatch** Lift Cutout Switch (S124) mismatch with standard mast switch.	Test I76 - Lift Cutout Switch (optional) (Page 6-90)	Cycle key switch OFF/ON to clear. *Up arrow icon flashes and message lift cutout - max ht reached*

Message Displayed: CODE X5 Inform service			
	**Code X5: Lift Inhibit Switch Mismatch** Lift Inhibit Switch (S24) mismatch with standard mast switch.	Test I05 - Lift Inhibit Switch (optional) (Page 6-62)	Cycle key switch OFF/ON to clear.

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Analog Input Tests

A Diagnosis and Repair table is provided for most tests. If a test fails, refer to the Diagnosis and Repair table. Through the process of elimination, these tables provide the technician with a step-by-step approach to diagnosing a problem and the necessary corrective action. See the table below.

Example Diagnosis and Repair Table

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
This is the order that the testing must be performed.	This column identifies the action(s) required (if any) before testing the circuit. If no instructions are given, all circuits must be connected. **Note: If something was disconnected in the prior step, reconnect it before performing the next step.** This column also identifies the required setting on the meter for this step.	Connection point for the Positive (+) meter lead.	Connection point for the Negative (–) meter lead.	The reading required to consider the step a success.	The next action to be performed if the Expected Results are met.	The next action to be performed if the Expected Results are not met.

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Test A04 - Throttle Potentiometer Voltage

This test displays the voltage the CCC produces based on input from the throttle potentiometer (VR1).

NOTE: Learn must be run whenever the throttle assembly is replaced, repaired, or adjusted. See Learn Controls on page 3-19.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

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

Throttle Position	Voltage Displayed
Full forward position Tractor-first (TF)	0.30 to 1.21V
Neutral position	1.23 to 1.83V
Full reverse position Forks-first (FF)	1.85 to 2.80V

If the voltage reading is outside these limits or does not change in a smooth linear fashion, the test has failed. Any voltage fluctuation indicates a bad cable or VR1.

The voltage reading should decrease when the throttle is moved from the reverse to the forward position. If these results are not observed, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPC9 disconnected/ DCV	PC9-8	PC9-7	5.3V	Perform step 2	Replace CCC
2			PC9-9		Perform step 3	
3	DCV	JPC9-9	JPC9-7	Neutral: 1.23-1.83V FF: increase TF: decrease	Replace CCC	Replace pot (VR1)

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Test A05 - Lift/Lower Potentiometer Voltage

This test displays the voltage the CCC produces based on input from the lift/lower pot (VR2).

NOTE: Run this test if the voltage output by the lift/lower potentiometer (pot) exhibits problems.

NOTE: Learn must be run when the lift/lower pot is replaced, repaired, or adjusted. See Learn Controls on page 3-19.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

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

Lift/Lower Control Position	Voltage Displayed
Full lift position	0.15 to 0.95V
Neutral position	0.97 to 1.46V
Full lower position	1.48 to 2.40V

If the voltage reading is outside these limits or does not change in a smooth linear fashion, the test has failed. Any voltage fluctuation indicates a bad cable or VR2.

The voltage reading should decrease when the lift/lower knob is moved from lower to lift. If these results are not observed, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPC9 disconnected/DCV	PC9-5	PC9-4	5.3V	Perform step 2	Replace CCC
2			PC9-6		Perform step 3	
3	DCV	JPC9-6	JPC9-4	Neutral: 0.97-1.46V Lower: increase Lift: decrease	Replace CCC	Replace pot (VR2)

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Test A08 - Traction Motor Temperature

This test displays the temperature of the traction motor.

Limits

- Normal operation: ambient to 258°F (125°C)
- Between 266°F (130°C) and 300°F (149°C), speed is linearly reduced to 1.0 mph.
- Temperature icon lights at 275°F (135°C)
- Fault Code 2A and travel disabled at 300°F (149°C)

While operating, the VM continually monitors the temperature of the drive motor. If the temperature gets too high, performance is reduced until the motor cools down.

Use Active Maintenance to see the actual temperature from the temperature sensor. Heat the truck up by driving it hard for approximately 30 minutes. As the motor heats, the temperature will increase.

For information on how to use Maintenance Mode, refer to page 3-24.

Run test:

1. With the lift truck at rest and at ambient temperature, compare the temperatures obtained from those obtained using Maintenance Mode to the ambient temperature.
2. If the temperatures are not within several degrees, the test has failed.
3. If the lift truck is not at ambient temperature, use the diagnosis and repair chart to isolate the cause.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPTA1 disconnected/ Ohms	JTA1-8	JTA1-7	<1200 Ohms if motor is cool >1200 Ohms if motor is hot	Replace TPA	Perform Step 2
2	JPTA3 disconnected/ Ohms	JTA3-2	JTA3-1		T/S traction motor temp sensor	Replace traction motor temp sensor

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Test A09 - Lift Motor Temperature

This test displays the temperature of the AC lift motor.

Limits

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

For information on using Maintenance Mode, refer to page 3-24.

Run test:

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

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPLA1 disconnected/ Ohms	JLA1-8	JLA1-7	<1200 Ohms if motor is cool >1200 Ohms if motor is hot	Replace LPA	Perform Step 2
2	JPLA3 disconnected/ Ohms	JLA3-2	JLA3-1		T/S lift motor temp sensor	Replace lift motor temp sensor

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Test A10 - Traction Power Amplifier Temperature

This test displays the temperature of the Traction Power Amplifier (TPA).

Limits

- Normal operation: ambient to 175°F (79°C)
- Starting at 176°F (80°C), speed is linearly reduced by the Traction Power Amplifier to 0.0 mph at 239°F (115°C), when traction is disabled.
- Temperature icon lights at 185°F (85°C)
- Fault Code 1H at 203°F (95°C)

For information on using Maintenance Mode, refer to page 3-24.

Run test:

The Operator Display shows the heatsink temperature that the traction power amplifier reads.

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

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Is TPA heatsink 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

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Test A11 - Traction Motor Current

This test displays the current in the traction motor power circuits.

Limits:

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

For information on using Maintenance Mode, refer to page 3-24.

NOTE: This test shows best results in Active Maintenance.

Run test:

The Operator Display shows the current that the traction power amplifier reads from the drive motor.

System Condition	Current Displayed
Static at Rest	<20A
Travel at Full Speed	<150A

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

Diagnosis and Repair

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

Check individual phase currents with a clamping ammeter. The current should ramp evenly as the truck accelerates and decelerates. Phase currents must be approximately equal. Gross differences indicate a problem.

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

1. If any one phase differs significantly from the other two, check power cable continuity. Replace cables as necessary. See Terminal Hardware on page 7-66.
   - If power cable continuity is OK, troubleshoot the drive motor. See AC Motor Troubleshooting on page 5-10.
   - If all phases give high readings, the drive unit may be binding. Check drive unit.
2. The power amplifier may be bad. Run Test O29 - Ramp Traction Motor (Page 6-101).

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Test A13 - Pressure Sensor Voltage (optional)

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

For information on using Maintenance Mode, refer to page 3-24.

Limits

The operator display shows the voltage present with various load weights.

Load Weight	Voltage
0 (no load)	approx. 1.0V
3000 lbs.	approx. 3.0V

If the weight sensor is disconnected at the vehicle manager, the operator display shows 0V.

Run test:

The voltage shown on the operator display should increase and decrease in a linear fashion as the load weight is either increased or decreased. If it does not, the test has failed. If the weight display is inaccurate, the test has failed.

Diagnosis and Repair

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

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Test A14 - VM +12V Power Supply

This test displays the output of the internal +12V power supply of the Vehicle Manager.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

The display should read 10.8-13V. If the voltage fluctuates more than 0.8V in 10 seconds, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Remove wire from JPT14-5/DCV	PT14-5 (VM side)	TP4	10.5 to 13V	Step 2	Step 4
2	JPC11 disconnected/DCV	JPT14-5			Step 3	Replace mast cable
3	Disconnect all wires supplying 12 or 5.3V from the connectors at the CCC. Disconnect JPC15 and JPC2/DCV				Plug in wires and connectors one at a time. Troubleshoot the circuit that pulls down the 12V.	Replace CCC
4	Disconnect all wires supplying 12V from the connectors at the VM/DCV					Replace the VM

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Test A15 - Battery Voltage

This test displays the voltage the VM is reading from the battery sense line.

A successful test proves the VM is correctly reading BATTERY_SENSE_IN at JPT24-24.

NOTE: This voltage is used by the VM to calculate the battery state-of-charge.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

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

PC must be closed.	
Nominal Battery Voltage	**Voltage Displayed**
24V	22.0 to 26.0V
36V	33.0 to 39.0V

If the reading fluctuates by more than 0.8V in 10 seconds with the truck not moving or lifting, the test has failed.

NOTE: If FH Code occurs, verify that the model number viewed in FlashWare matches the vehicle model before replacing the VM,

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	TP1	TP4	24V truck: 16 to 32V 36V truck: 28 to 44V	Perform Step 2	Check battery voltage/ specific gravity. T/S battery cables.
2		JPF4-1			Perform Step 3	T/S harness TP1 to TP4.
3		JPF4-7			Perform Step 4	Replace Fuse Relay Card.
4		JPT24-24			Replace VM	T/S harness from Fuse Relay Card to VM.

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Test A19 - Lift Power Amplifier Temperature (AC lift only)

This test displays the temperature of the Lift Power Amplifier (LPA) heatsink.

Limits

- Normal operation: ambient to 175°F (79°C)
- Starting at 176°F (80°C), speed is linearly reduced to 0 fpm at 239°F (115°C), when lift is disabled
- Temperature icon illuminates at 185°F (85°C)
- Fault Code 7F at 203°F (95°C)

For information on using Maintenance Mode, refer to page 3-24.

Run test:

The Operator Display shows the heatsink temperature that the lift power amplifier reads.

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

Diagnosis and Repair

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

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Test A20 - Lift Motor Current (AC lift only)

This test displays the lift motor current through the lift power amplifier.

⚠ WARNING

The lift carriage and forks will move during this test.

⚠ CAUTION

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

Limits

- 0 to 500A lifting
- Maximum current 675A

For information on using Maintenance Mode, refer to page 3-24.

Run test:

The Operator Display shows the current that the lift power amplifier reads from one phase of the lift motor.

NOTE: Because only one phase is measured, a current problem may not be revealed.

Diagnosis and Repair

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

Check individual phase currents with a clamping ammeter. The current should ramp evenly as the truck accelerates and decelerates. Phase currents must be approximately equal. Gross differences indicate a problem.

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

1. If any one phase differs significantly from the other two, check power cable continuity. Replace cables as necessary. See Terminal Hardware on page 7-66.
   - If power cable continuity is OK, troubleshoot the drive motor. See AC Motor Troubleshooting on page 5-10.
   - If all phases give high readings, the lift pump may be binding.
2. The power amplifier may be bad. Run Test O28 - Ramp Lift Motor (AC lift only) (Page 6-100).

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Test A22 - Traction Throttle Request

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

For information on using Maintenance Mode, refer to page 3-24.

Run test:

NOTE: Run Learn after you replace, repair, or adjust the throttle assembly. See Learn Controls on page 3-19.

The Operator Display shows the percentage of throttle request that the VM reads from the control handle throttle potentiometer (VR1) and sends to the traction power amplifier.

Acceptable values are:

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

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

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

NOTE: Any speed limiting conditions will result in less than 100 shown on display.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Run Test A04 - Throttle Potentiometer Voltage (Page 6-32)	N/A	N/A	Test should pass. Compare Test A04 results with the results from A22. Max throw should show max values.	Replace the TPA	Check traction system for speed limits due to motor temperature, limit switches, or configured speed.

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Test A23 - Lift Request

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

For information on using Maintenance Mode, refer to page 3-24.

Run test:

NOTE: Run the Learn after you replace, repair, or adjust the lift/lower potentiometer (VR2). See Learn Controls on page 3-19.

The Operator Display shows the percentage of lift request that the VM reads from the lift potentiometer (VR2).

Acceptable values are:

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

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

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

NOTE: Any lift limiting conditions will result in less than 100% shown on display.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Run Test A05 - Lift/Lower Potentiometer Voltage (Page 6-33)	N/A	N/A	Test should pass. Compare Test A05 results with the results from A23. Max throw should show max values.	Replace the LPA	Check lift system for limits due to motor temperature or switches.

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Test A34 - Lift/Lower Current

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

For information on using Maintenance Mode, refer to page 3-24.

Run test:

Acceptable values are:

State	Current
Neutral	Approx. 0.15A
Full Lower	Approx. 1.3A

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

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPT18 and JPF2 disconnected/ Ohms	JPF2-5	JPC18-1	Approx 28 ohms	Perform Step 2	T/S wires and coil
2	DCV	JPT18-1	B–	B+	Replace VM	T/S Fuse Relay Card

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Test A35 - Brake

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

For information on using Maintenance Mode, refer to page 3-24.

NOTE: This test can only be run in Active Maintenance.

Run test:

When the test is run, observe the following results:

State of Brake	Display
Brake deactivated	B+
Deadman Pedal Depressed/Travel Requested	Approx. 12V (36V trucks) Approx. 0V (24V trucks)

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

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPT20 and JPF2 disconnected/ Ohms	JT20-14	JF2-2	Approx. 13 ohms	Perform Step 2	T/S wires and coil
2	DCV	JP20-14	TP4	Brake de-energized: B+ Brake energized: 36V truck = approx. 12V 24V truck = 0V	Inspect brake assembly for binding	If no B+, T/S Fuse Relay Card. If voltage does not drop when energized, replace VM

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Test A37 - Steer Power Amplifier Current

This test displays the current that the steer motor is drawing.

For information on using Maintenance Mode, refer to page 3-24.

Run Test:

You should see:

State of Motor	Display
At rest	<2A
Clockwise (CW) Steering	–30 to –50A
Counterclockwise (CCW) Steering	30 to 50A
NOTE: CW and CCW is drive unit direction.	

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

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPT6-3	TP4	at rest: approx. 2.5V Steering CCW: <V at rest Steering CW: >V at rest	Replace VM	Replace Steer Amplifier

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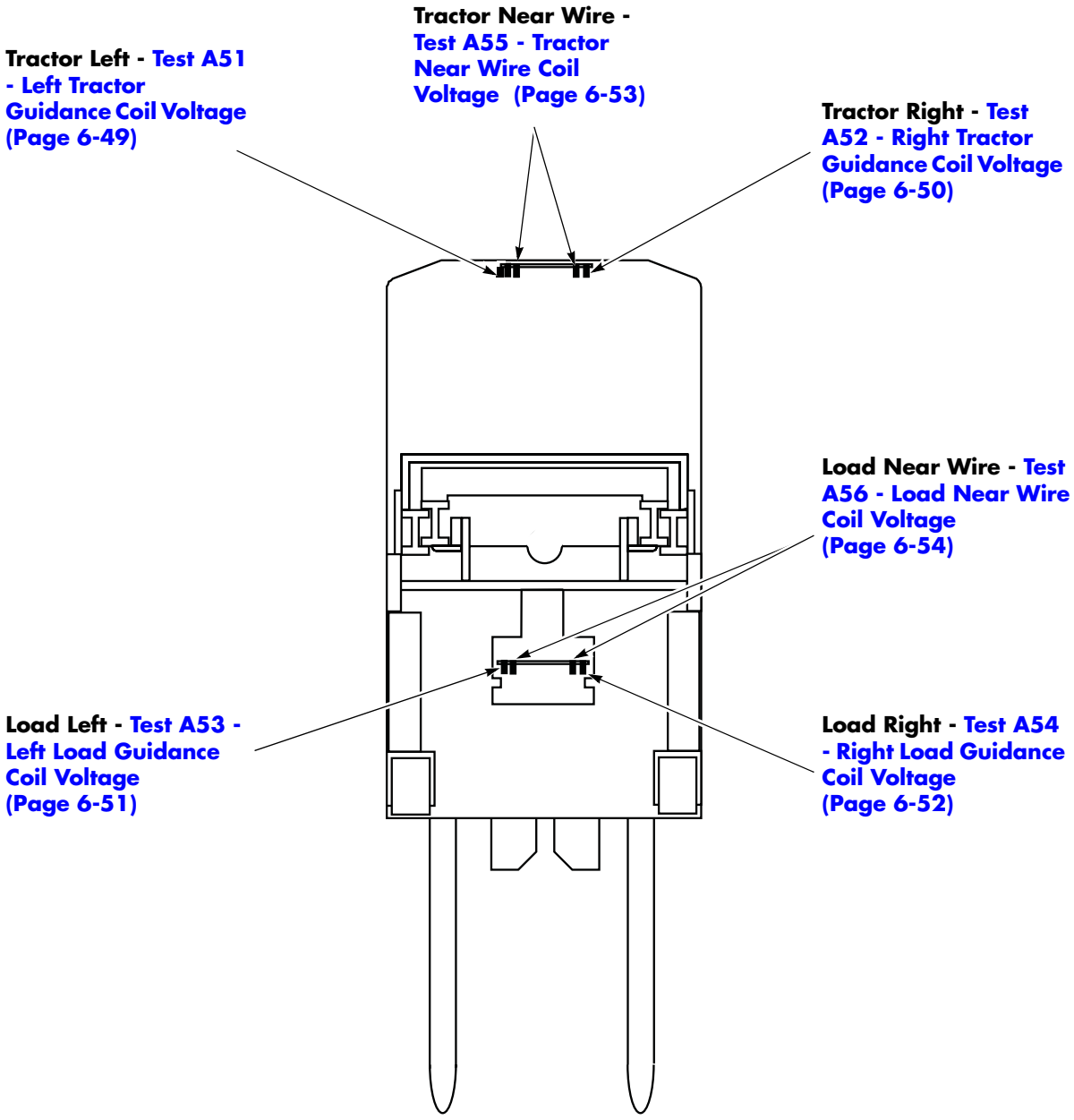


Figure 6-2. Location of Wire Guidance Coils and Related Tests

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Test A51 - Left Tractor Guidance Coil Voltage

This test displays the percentage of the left tractor guidance coil voltage sensed by the Guidance Manager.

Refer to Figure 6-2 on page 6-48 to determine what coil this test checks.

Make sure the truck is set to the correct frequency. If the frequency used is not standard, it must first be Learned. See Learn Wirefreq on page 3-21.

Test line driver output. Refer to Raymond Publication PDSS-0051.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

NOTE: This test must be run with the truck on the wire.

The test is a success if the percentage displayed is between 40 and 60%.

If the reading is outside these limits, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Cable dis-connected/ Ohms	JW2-1, 2, 3, 5, 6, 7, 8, 14, 15	J1T-1, 2, 3, 5, 6, 7, 8, 14, 15	0 Ohms	Perform Step 2	Replace cable
2	JPW2 dis-connected/ DCV	PW2-15	PW2-14	Approx 11.5V	Perform Step 4	Perform Step 3
3	Filter Card removed/ DCV	JP1-B1 (Filter Card connection on Steer Card)	JP1-A13 (Filter Card connection on Steer Card)		Replace Filter Card	Replace Steer Controller Card
4	Bumper removed/ mVAC	JPW2-3	B–	Centered: 32mV 1.5 in. left: 15mV 1.5 in. right: 76mV	Perform step 5	Replace Antenna Card
5	Bumper removed/ DCV	JP1-A15		Centered: 1.1V 1.5 in. left: 0.6V 1.5 in. right: 2.8V	Replace Steer Controller Card	Replace Filter Card

NOTE: Steps 4 and 5 are approximate readings. Floor settings will cause them to vary. If a similar change in values is seen, the test has passed.

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Test A52 - Right Tractor Guidance Coil Voltage

This test displays the percentage of the right tractor guidance coil voltage sensed by the Guidance Manager.

Refer to Figure 6-2 on page 6-48 to determine what coil this test checks.

Make sure the truck is set to the correct frequency. If the frequency used is not standard, it must first be Learned. See Learn Wirefreq on page 3-21.

Test line driver output. Refer to Raymond Publication PDSS-0051.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

NOTE: This test must be run with the truck on the wire.

The test is a success if the voltage percentage displayed is between 40 and 60%.

If the reading is outside these limits, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Cable dis-connected/ Ohms	JW2-1, 2, 3, 5, 6, 7, 8, 14, 15	J1T-1, 2, 3, 5, 6, 7, 8, 14, 15	0 Ohms	Perform Step 2	Replace cable
2	JPW2 dis-connected/ DCV	PW2-15	PW2-14	Approx 11.5V	Perform Step 4	Perform Step 3
3	Filter Card removed/ DCV	JP1-B1 (Filter Card connection on Steer Card)	JP1-A13 (Filter Card connection on Steer Card)		Replace Filter Card	Replace Steer Controller Card
4	Bumper removed/ mVAC	JPW2-1	B–	Centered: 32mV 1.5 in. left: 15mV 1.5 in. right: 76mV	Perform step 5	Replace Antenna Card
5	Bumper removed/ DCV	JP1-A16 (Filter Card)		Centered: 1.1V 1.5 in. left: 0.6V 1.5 in. right: 2.8V	Replace Steer Controller Card	Replace Filter Card

NOTE: Steps 4 and 5 are approximate readings. Floor settings will cause them to vary. If a similar change in values is seen, the test has passed.

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Test A53 - Left Load Guidance Coil Voltage

This test displays the percentage of the left load guidance coil voltage sensed by the Guidance Manager.

Refer to Figure 6-2 on page 6-48 to determine what coil this test checks.

Make sure the truck is set to the correct frequency. If the frequency used is not standard, it must first be Learned. See Learn Wirefreq on page 3-21.

Test line driver output. Refer to Raymond Publication PDSS-0051.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

NOTE: This test must be run with the truck on the wire.

The test is a success if the voltage percentage displayed is between 40 and 60%.

If the reading is outside these limits, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Cable dis-connected/ Ohms	JW2-1, 2, 3, 5, 6, 7, 8, 14, 15	J1L-1, 2, 3, 5, 6, 7, 8, 14, 15	0 Ohms	Perform Step 2	Replace cable
2	JPW1 dis-connected/ DCV	PW1-15	PW1-14	Approx 11.5V	Perform Step 4	Perform Step 3
3	Filter Card removed/ DCV	JP1-B1 (Filter Card connection on Steer Card)	JP1-A13 (Filter Card connection on Steer Card)		Replace Filter Card	Replace Steer Controller Card
4	Bumper removed/ mVAC	JPW1-3	B–	Centered: 32mV 1.5 in. left: 15mV 1.5 in. right: 76mV	Perform step 5	Replace Antenna Card
5	Bumper removed/ DCV	JP1-A7 (Filter Card)		Centered: 1.1V 1.5 in. left: 0.6V 1.5 in. right: 2.8V	Replace Steer Controller Card	Replace Filter Card

NOTE: Steps 4 and 5 are approximate readings. Floor settings will cause them to vary. If a similar change in values is seen, the test has passed.

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Test A54 - Right Load Guidance Coil Voltage

This test displays the percentage of the right load guidance coil voltage sensed by the Guidance Manager.

Refer to Figure 6-2 on page 6-48 to determine what coil this test checks.

Make sure the truck is set to the correct frequency. If the frequency used is not standard, it must first be Learned. See Learn Wirefreq on page 3-21.

Test line driver output. Refer to Raymond Publication PDSS-0051.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

NOTE: This test must be run with the truck on the wire.

The test is a success if the voltage percentage displayed is between 40 and 60%.

If the reading is outside these limits, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Cable dis-connected/ Ohms	JW1-1, 2, 3, 5, 6, 7, 8, 14, 15	J1L-1, 2, 3, 5, 6, 7, 8, 14, 15	0 Ohms	Perform Step 2	Replace cable
2	JPW1 dis-connected/ DCV	PW1-15	PW1-14	Approx 11.5V	Perform Step 4	Perform Step 3
3	Filter Card removed/ DCV	JP1-B1 (Filter Card)	JP1-A13 (Filter Card)		Replace Filter Card	Replace Steer Controller Card
4	Bumper removed/ mVAC	JPW1-1	B–	Centered: 32mV 1.5 in. left: 15mV 1.5 in. right: 76mV	Perform step 5	Replace Antenna Card
5	Bumper removed/ DCV	JP1-A15		Centered: 1.1V 1.5 in. left: 0.6V 1.5 in. right: 100mV	Replace Steer Controller Card	Replace Filter Card

NOTE: Steps 4 and 5 are approximate readings. Floor settings will cause them to vary. If a similar change in values is seen, the test has passed.

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Test A55 - Tractor Near Wire Coil Voltage

This test displays the percentage of the tractor near wire guidance coil voltage sensed by the Guidance Manager.

Refer to Figure 6-2 on page 6-48 to determine what coil this test checks.

Make sure the truck is set to the correct frequency. If the frequency used is not standard, it must first be Learned. See Learn Wirefreq on page 3-21.

Test line driver output. Refer to Raymond Publication PDSS-0051.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

NOTE: This test must be run with the truck on the wire.

The test is a success if the percentage displayed is between 90 and 110%.

If the reading is outside these limits, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPW2 and JP1T dis-connected/ Ohms	JW2-1, 2, 3, 5, 6, 7, 8, 14, 15	J1T-1, 2, 3, 5, 6, 7, 8, 14, 15	0 Ohms	Perform Step 2	Replace cable
2	JPW2 dis-connected/ DCV	PW2-15	PW2-14	Approx 11.5V	Perform Step 4	Perform Step 3
3	Filter Card removed/ DCV	JP1-B1 (Filter Card connection on Steer Card)	JP1-A13 (Filter Card connection on Steer Card)		Replace Filter Card	Replace Steer Controller Card
4	Bumper removed/ mVAC	JPW2-2	B–	Centered: 70mV 1.5 in. left: 100mV 1.5 in. right: 100mV	Perform step 5	Replace Antenna Card
5	Bumper removed/ DCV	JP1-A15 (Filter Card)		Centered: 2.5V 1.5 in. left: 3.7V 1.5 in. right: 3.7V	Replace Steer Controller Card	Replace Filter Card

NOTE: Steps 4 and 5 are approximate readings. Floor settings will cause them to vary. If a similar change in values is seen, the test has passed.

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Test A56 - Load Near Wire Coil Voltage

This test displays the percentage of the load near wire guidance coil voltage sensed by the Guidance Manager.

Refer to Figure 6-2 on page 6-48 to determine what coil this test checks.

Make sure the truck is set to the correct frequency. If the frequency used is not standard, it must first be Learned. See Learn Wirefreq on page 3-21.

Test line driver output. Refer to Raymond Publication PDSS-0051.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

NOTE: This test must be run with the truck on the wire.

The test is a success if the voltage percentage displayed is between 90 and 110%.

If the reading is outside these limits, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPW1 and JP1L dis-connected/ Ohms	JW1-1, 2, 3, 5, 6, 7, 8, 14, 15	J1L-1, 2, 3, 5, 6, 7, 8, 14, 15	0 Ohms	Perform Step 2	Replace cable
2	JPW1 dis-connected/ DCV	PW1-15	PW1-14	Approx 11.5V	Perform Step 4	Perform Step 3
3	Filter Card removed/ DCV	JP1-B1 (Filter Card connection on Steer Card)	JP1-A13 (Filter Card connection on Steer Card)		Replace Filter Card	Replace Steer Controller Card
4	Bumper removed/ mVAC	JPW1-2	B–	Centered: 70mV 1.5 in. left: 100mV 1.5 in. right: 100mV	Perform step 5	Replace Antenna Card
5	Bumper removed/ DCV	JP1-A6 (Filter Card)		Centered: 2.5V 1.5 in. left: 3.7V 1.5 in. right: 3.7V	Replace Steer Controller Card	Replace Filter Card

NOTE: Steps 4 and 5 are approximate readings. Floor settings will cause them to vary. If a similar change in values is seen, the test has passed.

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Input Tests

A Diagnosis and Repair table is provided for most tests. If a test fails, refer to the Diagnosis and Repair table. Through the process of elimination, these tables provide the technician with a step-by-step approach to diagnosing a problem and the necessary corrective action. See the table below.

Example Diagnosis and Repair Table

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
This is the order that the testing must be performed.	This column identifies the action(s) required (if any) before testing the circuit. If no instructions are given, all circuits must be connected. **Note: If something was disconnected in the prior step, reconnect it before performing the next step.** This column also identifies the required setting on the meter for this step.	Connection point for the Positive (+) meter lead.	Connection point for the Negative (–) meter lead.	The reading required to consider the step a success.	The next action to be performed if the Expected Results are met.	The next action to be performed if the Expected Results are not met.

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Test I00 - Carriage Deadman

This test shows what the VM is reading from S23. The switch is hard wired through the CCC to the VM.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

The state of the switch is displayed:

Deadman Pedal	Operator Display
Up	**Up**
Down	**Down**

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

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPC7 dis-connected/ DCV	PC7-5	PC7-6	10.7 to 13V	Perform Step 2	Replace CCC
2	DCV	JPC7-5	S23-3		Perform Step 3	Repair/replace wire
3		S23-1			Perform Step 4	
4			S23-2	Pedal down: 10.7 to 13V Pedal up: 0V	Perform Step 5	Adjust/replace S23
5		JPC7-5	JPC7-4		Perform Step 6	Repair/replace wires
6		B+	JPC11-4	Pedal down: B+ Pedal up: 0V	Perform Step 7	Replace CCC
7			JPS25-4		Perform Step 8	Repair/replace over-the-mast cable
8			JPT22-7		Replace VM	Repair/replace cable

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Test I01 - Brake Deadman Switch (S2)

This test shows what the VM is reading from S2. The switch is hard wired through the CCC to the VM.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

The state of the switch is displayed:

Deadman Pedal	Operator Display
Up	**Up**
Down	**Down**

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

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPC7 dis-connected/ DCV	PC7-2	PC7-3	10.7 to 13V	Perform Step 2	Replace CCC
2	DCV	JPC7-2	S2-3		Perform Step 3	Repair/replace wire
3		S2-1			Perform Step 4	
4			S2-2	Pedal down: 10.7 to 13V Pedal up: 0V	Perform Step 5	Adjust/replace S2
5		JPC7-2	JPC7-1		Perform Step 6	Repair/replace wires
6		JPC11-5	B–	Pedal down: 0V Pedal up: 10V	Perform Step 7	Replace CCC
7		JPS25-5			Perform Step 8	Replace over-the-mast cable
8		JPT22-8			Replace VM	

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Test I02 - Lower Mast Reference (24 in.) Switch

This test monitors the state of the lower mast reference switch (S11). This test displays what the CCC is reading from the switch.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

When the test is run, observe the following results:

Carriage Height	Switch Actuator	Operator Display
Below 24 in. (61 cm)	Depressed	**Belw**
Above 24 in. (61 cm)	Released	**Abve**

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

Use Active Maintenance to check that the display indicates the lower mast reference switch is **Belw** at all positions below 24 in. (61 cm). Check that the display indicates the 24 in. (61 cm) switch is **Abve** at all positions above 24 in. (61 cm).

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPC8 dis-connected /DCV	PC8-2	PC8-3	6 to 13V	Perform Step 2	Replace CCC
2	DCV	JPC8-2	S11-3		Perform Step 3	Repair/replace wires
3		S11-1			Perform step 4	
4			S11-2	S11 Closed (below): 6-13V Open (above): 0V	Perform step 5	Adjust/replace S11
5		JPC8-2	JPC8-1		Replace CCC	Repair/replace wires

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Test I03 - 60 in. Limit Switch

Using this test, the state of the 60 in. limit switch (S28) can be monitored. This test displays what the CCC is reading from the switch.

NOTE: This switch is not used with the *intellispeed* option.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

When the test is run, observe the following results:

Carriage Height	Switch	Operator Display
Below 60 in.	Depressed	**Belw**
Above 60 in.	Extended	**Abve**

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

Using Active Maintenance, check that the display indicates the 60 in. switch is **Belw** at all positions below 60 in. Check that the display indicates **Abve** for all positions above the 60 in. switch.

Trucks without S28 require a jumper (P/N 114-008-958/002) between JPC3-3 and JPC3-1.

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Test I03 - 60 in. Limit Switch

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPC3 disconnected /DCV	PC3-2	PC3-3	6 to 13V	Perform Step 2	Replace CCC
2	DCV	JPC3-2	S28-3		Perform Step 3	Repair/replace wires
3		S28-1			Perform step 4	
4			S28-2	S28 Closed (below): 6-13V Open (above): 0V	Perform step 5	
5		JPC3-2	JPC3-1		Replace CCC	

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Test I04 - Lift/Lower Inhibit Bypass (optional)

Using this test, the state of the lift inhibit bypass switch (S7) can be tested. This test displays what the CCC is reading from the switch. This test will only be visible on trucks equipped with the Lift/Lower inhibit bypass option.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

When the test is run, observe the following results.

Lift Inhibit Switch (S7)	Operator Display
Up	**Out**
Depressed	**In**

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

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPC6 dis-connected/ Ohms	JC6-6	JC6-5	Released: open circuit Depressed: 0 ohms	Verify option is turned ON. Replace CCC	Repair/replace wires and/or switch S7

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Test I05 - Lift Inhibit Switch (optional)

Using this test, the state of the lift inhibit switch (S24) can be monitored. This test displays what the VM is reading from the switch. This test will only work on trucks equipped with the lift inhibit option.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

When the test is run, observe the following results:

Operator Carriage	Operator Display
Below Switch (closed)	**Belw**
Above Switch (open)	**Abve**

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

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	Pull pin from JPT20-10. Backprobe connection.	JPT24-3	10.7 to 13V	Perform Step 2	Replace VM
2		JPT20-10	S24-1		Perform Step 3	Repair/replace harness
3		S24-3			Perform Step 4	
4			S24-2	S24 Closed: 10.7 to 13V Open: approx. 0V	Perform Step 5	Adjust or replace S24
5		JPT20-10	JPT22-2		Verify option is turned ON. Replace VM	Repair/replace harness

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Test I15 - Horn Switch

This test checks the input from the horn switch (S3) to the CCC at JPC9-3 and JPC9-4.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

When the test is run, observe the following results:

Horn Switch Position	Operator Display
Out	**Out**
Depressed	**In**

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

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPC9-3	JPC9-4	S3 Closed: < 0.6V Open: Approx. 5.35V	Replace CCC	Repair/replace wires and/or switch S3

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Test I19 - Traction Motor RPM

This test displays the output from the speed encoder on the traction motor as seen by the traction power amplifier.

⚠CAUTION

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

For information on using Maintenance Mode, refer to page 3-24.

This test shows best results in Active Maintenance.

Run Test:

NOTE: The Operator Display shows rpm as measured by the traction power amplifier. The RPM reading should show a linear increase to maximum RPM.

You should see:

Truck Type	Maximum RPM
Standard Duty	5532
Heavy Duty	4424

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPTA1-26	JPTA1-7	4.5 to 5.5V	Perform Step 2	Replace TPA
2		JPTA2-1			Perform Step 3	Troubleshoot/replace harness
3			JPTA2-4		Perform Step 4	
4		JPTA1-31	JPTA1-7	Stationary: >3.5V or <0.5V Running: approx. 2V	Perform Step 5	Perform Step 6
5		JPTA1-32			Replace TPA	Perform Step 7
6		JPTA2-3			Repair/replace harness	Replace traction motor speed encoder
7		JPTA2-2				

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Test I20 - Lift Motor RPM (AC lift only)

This test displays the input from the speed encoder on the lift motor as seen by the lift power amplifier.

⚠CAUTION

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

For information on using Maintenance Mode, refer to page 3-24.

This test shows best results in Active Maintenance.

Run test:

NOTE: The Operator Display shows rpm as measured by the lift power amplifier. The RPM reading should show a linear increase to maximum RPM.

During lift, 2400 rpm max must be displayed.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPLA1-26	JPLA1-7	4.5 to 5.5V	Perform Step 2	Replace LPA
2		JPLA2-1			Perform Step 3	Troubleshoot/replace harness
3			JPLA2-4		Perform Step 4	
4		JPLA1-31	JPLA1-7	Stationary: >3.5V or <0.5V Running: approx. 2V	Perform Step 5	Perform Step 6
5		JPLA1-32			Replace LPA	Perform Step 7
6		JPLA2-3			Repair/replace harness	Replace lift motor speed encoder
7		JPLA2-2				

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Test I23 - CAN Bus

This test verifies the VM is communicating with the Traction Power Amplifier, Lift Power Amplifier, and Guidance Manager.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

NOTE: To enter test, press and hold UP *and* DOWN buttons *and* turn key switch ON.

The Operator Display shows:

- **V** if Vehicle Manager is communicating with the Carriage Control Card
- **T** if the Traction Power Amplifier is communicating with the Carriage Control Card
- **L** if the Lift Power Amplifier is communicating with the Carriage Control Card (AC lift only)
- **W** if the Guidance Manager is communicating with the Carriage Control Card (Wire Guidance only)

NOTE: Wait at least 60 seconds after test shows on the display for letters to be displayed.

If **V**, **T**, **L**, or **W** are not displayed, the test has failed.

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Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
If letter V is missing:						
1	DCV	JPTA1-1	B–	B+	Perform Step 2	T/S B+ from K3 Relay
2	JPT14 and JPSC1 disconnected/ Ohms	JPT14-11	JPSC1-2	0 ohms	Replace VM	Repair/replace harness
3		JPT14-4	JPSC1-1			
If letter L is missing (AC Lift only):						
1	DCV	JPLA1-1	B– (on amp)	B+	Perform Step 2	T/S B+ from K3 Relay
2	JPLA1 and JPSC2 disconnected/ Ohms	JPLA1-23	JPSC2-2	0 ohms	Replace Lift Amplifier	Repair/replace harness
3		JPLA1-35	JPSC2-1			
If letter T is missing:						
1	DCV	JPTA1-1	B– (on amp)	B+	Perform Step 2	T/S B+ from K3 Relay
2	JPTA1 and JPSC1 disconnected/ Ohms	JPTA1-23	JPSC1-2	0 ohms	Replace Traction Amplifier	Repair/replace harness
3		JPTA1-35	JPSC1-1			
If letter W is missing (Wire Guidance only):						
1	DCV	JPS2-11	JPS2-24	B+	Perform Step 4	Perform Step 2
2		JPT20-19	TP4		Perform Step 3	Replace VM
3		TP1	JPF3-9		Perform Step 1	Replace Fuse/Relay Card
4	Disconnect JPW1 and 2 and Filter Card at Guidance Manager	N/A	N/A	**W** shows on display	T/S wires and Antenna Cards. If OK, replace Filter Card	Replace Guidance Manager
If no letters are displayed:						
1	JPLA1, JPTA1, JPT14, JPS4 and JPC11 disconnected/ Ohms	JT14-11	JT14-4	Open	Perform Step 2	Repair/replace shorted Bus +/– cable
2			JTA1-23, JLA1-23, JS4-6, JC11-3	0 Ohms	Perform Step 3	Repair/replace harness
3	One at a time, disconnect all devices on Bus	N/A	N/A	Letters for the other devices come back on display	Replace disconnected component	Replace CCC

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Test I24 - Home Position Proximity Sensor

This test displays what the VM sees from the Home Proximity Sensor.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

When the test is run, observe the following results:

Home Proximity Sensor	Operator Display	Red LED on Sensor
Over metal	**On**	ON
Away from metal	**Off**	OFF

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

NOTE: If the test fails in Active Maintenance, pass a screwdriver or metal ruler under the sensor to activate it. If the test passes, adjust the switch. See Home Proximity Sensor Adjustment on page 7-11.

Diagnosis and Repair

Step	Action/Meter Setting	(+) Lead	(–) Lead	ExpectedResults	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 VM
3		JPA7-3	JPA7-1	Sensor over metal: approx. 10V Sensor not over metal: approx. 6V	Perform Step 4	Adjust/replace sensor
4		JPT22-3	JPT20-9		Replace VM	Replace/replace harness

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Test I25 - Steer Motor Encoder

This test displays the counts from the steer motor encoder.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

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.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) 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 VM	
6		JPT20-7		10.5 to 13V	Repair/replace harness	Replace VM

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Test I26 - Flow Sensor Count

NOTE: This test applies to trucks equipped with the *intellispeed*™ option.

This test displays the flow sensor pulses that the VM reads. A successful test proves the VM is correctly reading pulses from the flow sensor.

For information on using Maintenance Mode, refer to page 3-24. This test must be run from Active Maintenance.

Run test:

A three digit number is displayed representing the number of flow pulses counted. When the count exceeds 255, it starts over at 0. If the count goes below 0, it starts over at 255.

Place test in Active Maintenance. The count should increase during lift and decrease during lower. If these results are not observed, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	Ohms	JPY7-1	J21-A	0 Ohms	Perform Step 2	Repair/replace wires
2		JPY7-2	J21-B		Perform Step 3	
3		JPY6-1	J22-A		Perform Step 4	
4		JPY6-2	J22-B		Perform Step 5	
5	JPY1 dis-connected/ DCV	JPT20-2	JPY24-11	12V	Perform Step 6	Replace VM
6		JPY1-5	JPY1-3		Perform Step 7	Repair/replace wires
7	DCV	JPY7-1	JPY7-3	2.6V	Perform Step 8	Replace cable and sensor
8		JPY6-1	JPY6-3		Perform Step 9	
9	Lift or Lower/ mVAC	JPY7-2	JPY7-3	At rest: <2mV Lift/Lower: Ramps from approx 0 to between 200 and 300mV as speed increases	Perform Step 10	Clean flow sensor turbine
10		JPY6-2	JPY6-3		Perform Step 11	
11	Lift or Lower/ DCV	JPY1-1	B–	At rest: 0 to 5V Lift/Lower: approx 2.8V	Perform Step 12	Replace cable and sensor
12		JPY1-2			Perform Step 13	
13		JPT24-13			Perform Step 14	Repair/replace wires
14		JPT22-14			Replace VM	

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Test I35 - Steer Tiller Encoder 1

This test displays the value that the CCC sees from the Steer Tiller Encoder at JPC1. A successful test proves the CCC is reading the encoder correctly.

The VM uses the input from the CCC to determine the rate and direction of steering. The displayed number will vary between 0 and 255. The value has little correlation to the actual steering angle. The displayed value should change as the drive unit is steered.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

If the number displayed does not vary or the count only changes from 0 to 1 or 0 to 255, the test has failed.

Diagnosis and Repair

Step	Action/Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPC1at CCC/DCV	PC1-1	PC1-2	5.3V	Perform Step 2	Replace CCC
2		PC1-3 (CHB)	JPA8-2		Perform Step 3	
3		PC1-4 (CHA)	JPA8-5		Perform Step 4	
4	DCV	JPC1-3 (CHB) JPC1-4 (CHA)	JPC1-2	Approx. 5.3V or 0V when the tiller is stationary. Between 0 and 5V when tiller is moving.	Replace CCC	Replace steer tiller encoder

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Test I36 - Steer Tiller Encoder 2

This test displays the value that the CCC sees from the Steer Tiller Encoder at JPC21. A successful test proves the CCC is reading the encoder correctly.

The VM uses the input from the CCC to determine the rate and direction of steering. The displayed number will vary between 0 and 255. The value has little correlation to the actual steering angle. The displayed value should change as the drive unit is steered.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

If the number displayed does not vary or the count only changes from 0 to 1 or 0 to 255, the test has failed.

Diagnosis and Repair

Step	Action/Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPC21 at CCC/DCV	PC21-1	PC1-2	5.3V	Perform Step 2	Replace CCC
2		PC21-3 (CHB-E2)	JPA8-2		Perform Step 3	
3		PC21-4 (CHA-E2)	JPA8-5		Perform Step 4	
4	DCV	JPC21-3 (CHB-E2) JPC21-4 (CHA-E2)	JPC21-2	Approx. 5.3V or 0V when the tiller is stationary. Between 0 and 5V when tiller is moving.	Replace CCC	Replace steer tiller encoder

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Test I38 - EPO Switch

This test monitors the state of the Emergency Power Off (EPO) switch. A successful test proves the CCC is correctly reading the EPO switch.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

When the test is run, observe the following results:

Emergency Off Button	Operator Display
Out	**Out**
In	**In**

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

NOTE: After activating the EPO switch, cycle the key switch OFF/ON.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPC6-4	B–	B+	Perform Step 2	Replace CCC
2		JPC6-3			Perform Step 3	Repair/replace wires or switch
3		JPC16-1			Perform Step 4	Replace CCC
4		JPF4-5			Perform Step 5	Replace over-the-mast cable
5		JPF4-6			Perform Step 6	Replace Fuse Relay Card
6		JPT22-21			Replace VM	Repair or replace wire from Fuse Relay Card

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Test I39 - Neutral Pulses

This test displays the neutral pulses seen by the VM from the Steer Power Amplifier.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

You should see:

Off Deadman	On Deadman
ON	Quickly toggles between ON and OFF

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

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPT6-6	JPT6-4	10.5 to 13V	Perform Step 2	Replace VM
2		JPT6-1		Deadman pedal up: >4V	Replace VM	Repair wiring or replace Steer Power Amplifier

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Test I41 - Aux Mast Lift Switch S32

This test monitors the state of the auxiliary lift switch (S32). This switch causes the auxiliary mast to lift. This test displays what the CCC is reading from the switch.

NOTE: S31 (Aux left-hand deadman pedal) must also be depressed during this test.

Run test:

You should see:

Aus Mast Lift Switch	Operator Display
Out	**OFF**
Depressed	**On**

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

Diagnosis and Repair

Step	Action/Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPC19 disconnected /DCV	B+	PC19-3	B+	Perform Step 3	Perform Step 2
2	Aux Card disconnected /DCV		PC18-3		Replace Aux Card	Replace CCC
3	JPC19 disconnected /DCV	PC19-3	PC19-1	6 to 13V	Perform Step 7	Perform Step 4
4	Aux Card disconnected /DCV	JC18-8	JC18-1	B+	Perform Step 5	Replace CCC
5		JC18-5	JC18-3	5.3V	Perform Step 6	
6		JC18-7		12V	Replace Aux Card, then CCC	
7	JPC19 connected, S31 and S32 activated /DCV	B+	PC19-1	B+	Replace CCC	Repair/Replace Wires or Switch

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Test I42 - Aux Mast Lower Switch S33

This test monitors the state of the auxiliary lower switch (S33). This switch causes the auxiliary mast to lower. This test displays what the CCC is reading from the switch.

NOTE: S31 (Aux left-hand deadman pedal) must also be depressed during this test.

Run test:

You should see:

Aus Mast Lower Switch	Operator Display
Out	**OFF**
Depressed	**On**

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

Diagnosis and Repair

Step	Action/Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPC19 disconnected /DCV	B+	PC19-3	B+	Perform Step 3	Perform Step 2
2	Aux Card disconnected /DCV		PC18-3		Replace Aux Card	Replace CCC
3	JPC19 disconnected /DCV	PC19-3	PC19-2	6 to 13V	Perform Step 7	Perform Step 4
4	Aux Card disconnected /DCV	JC18-8	JC18-1	B+	Perform Step 5	Replace CCC
5		JC18-5	JC18-3	5.3V	Perform Step 6	
6		JC18-7		12V	Replace Aux Card, then CCC	
7	JPC19 connected, S31 and S33 activated /DCV	B+	PC19-2	B+	Replace CCC	Repair/Replace Wires or Switch

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Test I44 - Aux Mast Lift Ref Switch S34

This test monitors the state of the auxiliary lift Reference switch (S34). This switch causes the auxiliary mast to lift. This test displays what the CCC is reading from the switch.

NOTE: S31 (Aux left-hand deadman pedal) must also be depressed during this test.

Run test:

You should see:

Aus Mast Lift Ref Switch	Operator Display
Switch Activated	**Belw**
Switch Not Activated	**Abve**

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

Diagnosis and Repair

Step	Action/Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPC20 disconnected /DCV	PC20-2	PC20-3	6 to 13V	Perform Step 5	Perform Step 2
2	Aux Card disconnected /DCV	JC18-8	JC18-1	B+	Perform Step 3	Replace CCC
3		JC18-5	JC18-3	5.3V	Perform Step 4	
4		JC18-7		12V	Replace Aux Card, then CCC	
5	DCV	JPC20-2	JPC20-2	S34 Closed: 6-12V Open: <1.5V	Replace CCC	Repair/Replace Wires or Switch

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Test I65 - Rail Guidance Switch (optional)

NOTE: This test applies to trucks equipped with rail guidance.

Using this test, the state of the rail guidance switch (S15) can be verified.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

When the test is run, observe the following results:

Rail Guidance Switch (S15)	Operator Display
Depressed	**In**
Released	**Out**

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

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	Pull pin from JPT18-4. Backprobe connection.	JPT24-5	10.5 to 13V	Perform Step 2	Replace VM
2		JPT18-4	S15-1		Perform Step 3	Repair/replace harness
3		S15-3			Perform Step 4	
4			S15-2	S15 Closed: 10.7 to 13V Open: <1V	Perform Step 5	Adjust or replace S15
5		JPT18-4	JPT22-22		Replace VM	Repair/replace harness

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Test I66 - Auto/Manual Switch (optional)

This test displays the position of the AUTO/MANUAL switch (S4). A successful test proves the CCC is correctly reading the AUTO/MANUAL switch.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

When the test is run, observe the following results:

Switch Position	Operator Display
O (open)	**Auto**
| (closed)	**Manu**

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

NOTE: If the wire between the AUTO/MANUAL switch and the CCC becomes disconnected, the system defaults to AUTO.

Operation of the AUTO/MANUAL switch and CCC can also be checked by observing the green triangles on the display. The green triangles should illuminate when the switch is in AUTO and extinguish when the switch is in MANUAL.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPC9 dis-connected/ Ohms	JC9-1	JC9-2	Auto: open circuit Manual: 0 ohms	Verify option is turned ON. Replace CCC	Troubleshoot wires and switch

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Test I67 - Sidegate Switches (optional)

Use this test to test the state of the sidegate switches (S60, S61). This test displays what the CCC is reading from the switch. This test will only work on trucks equipped with the sidegate switch option.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

The state of the sidegate switch is displayed. Both sidegates must be down for the display to change states.

Sidegates	Operator Display
One sidegate up	**Up**
Both sidegates up	**Up**
Both sidegates down	**Down**

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

Diagnosis and Repair

Step	Action/Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
Right Sidegate - Switch S60						
1	JPC14 disconnected/ DCV	PC14-2	PC14-3	10.7 to 13V	Perform Step 2	Replace CCC
2	DCV	JPC14-2	S60-3		Perform Step 3	Repair/replace harness
3		S60-1			Perform Step 4	
4			S60-2	S60 Closed: 6 to 12V Open: 1V	Perform Step 5	Adjust or replace S60
5		JPC14-2	JPC14-1		Replace CCC	Repair/replace harness
Left Sidegate - Switch S61						
1	JPC13 disconnected/ DCV	PC13-2	PC13-3	10.7 to 13V	Perform Step 2	Replace CCC
2	DCV	JPC13-2	S61-3		Perform Step 3	Repair/replace harness
3		S61-1			Perform Step 4	
4			S61-2	S61 Closed: 10.7 to 13V Open: <1V	Perform Step 5	Adjust or replace S61
5		JPC13-2	JPC13-1		Replace CCC	Repair/replace harness

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Test I68 - Travel Cutout Switch (optional)

This test monitors the state of the travel cutout switch (S27). This test displays what the VM is reading from the switch.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

When the test is run, observe the following results.

Carriage Position wrt S27	**Operator Display**
Below	**Belw**
Above	**Abve**

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

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	Pull pin from JPT20-6. Backprobe connection.	JPT24-6	10.5 to 13V	Perform Step 2	Replace VM
2		JPT20-6	S27-1		Perform Step 3	Repair/replace harness
3		S27-3			Perform Step 4	
4			S27-2	S27 Closed: 6 to 12V Open: <1.5V	Perform Step 5	Adjust or replace S27
5		JPT20-6	JPT22-6		Replace VM	Repair/replace harness

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Test I69 - Upper Mast Reference Switch

This test monitors the state of the upper mast reference switch (S10). This test shows what the VM is reading from the upper mast reference switch at JPT20-1 wrt JPT22-1. A successful test proves the VM is correctly reading the upper mast reference switch.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

When the test is run, observe the following results:

Carriage Height	Switch Actuator	Operator Display
Below Upper Reference Switch	Depressed	**Belw**
Above Upper Reference Switch	Released	**Abve**

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

Use Active Maintenance to check that the display indicates the upper reference switch is closed at all positions below the upper reference switch. Check that the display indicates the upper reference switch is not closed at all positions above upper reference switch.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	Pull pin from JPT20-1. Backprobe connection.	JPF3-8 (Fuse Relay Card)	10.5 to 13V	Perform Step 2	Replace VM
2		JPT20-1	S10-1		Perform Step 3	Repair/replace harness
3		S10-3			Perform Step 4	
4			S10-2	S10 Closed: 10.5 to 13V Open: <1V	Perform Step 5	Adjust or replace S10
5		JPT20-1	JPT22-1		Replace VM	Repair/replace harness

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Test I70 - Pressure Switch (optional)

NOTE: This test applies to 24V trucks equipped with HiPro (*except trucks with EE option*).

This test checks the input from the pressure switch (PRESS SW1) to the VM at JPT22-5 and JPT18-5.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

When the test is run, observe the following results:

Weight	Switch Position	Operator Display
Greater than 1000 lb.	Open	**Off**
Less than 1000 lb.	Closed	**On**

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

NOTE: If the test fails in Active Maintenance, make sure the pressure switch is set per Pressure Switch Adjustment on page 7-83.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPT22 and JPT18 disconnected /Ohms	JPT22-5	JPT18-5	With forks elevated 1 ft. (304.8 mm) 0 lbs. on forks: <1 ohm 1000 lbs. (453.6 Kg) on forks: >2 megohms	Replace VM	Test wires, adjust/ replace pressure switch (see Pressure Switch Adjustment on page 7-83).

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Test I72 - End-of-Aisle Sensor 2 (optional)

NOTE: This test applies to trucks equipped with End-of-Aisle Detect.

This test displays what the VM sees from Aisle Detect Sensor 2. Sensor 2 (S47A and B) is located on the left side of the Antenna Card bracket as you stand on the platform facing the tractor.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

You have two choices when running this test:

Statically: If this test is to be run statically, park the truck away from any magnets in the floor. Obtain a magnet (P/N 591-552/002) and pass the magnet under the sensor. Remember that this is a transitional state.

The sensor will revert to its original position even if the magnet remains under the sensor. It may be helpful if two people are available for this test. When a magnet is placed under the sensor, the OD will show **On** briefly. Even if the magnet remains under the sensor, the display will change back to **Off**.

Active Maintenance: To run this test in Active Maintenance, position the truck away from any floor magnets. Select this test for Active Maintenance. Have this test on the operator display. While observing the display, drive the truck so the sensor passes over a floor magnet. The OD will show **On** briefly. Even if the magnet remains under the sensor, the display will change back to **Off**.

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

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Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	Pull pin JPT10-7. Backprobe connection	JPT24-9	Approx. 10.5V	Perform Step 2	Replace VM
2		JPT10-7		Approx. 7.9V	Perform Step 3	T/S harness for opens and shorts. If OK, replace sensor S47A or S47B
3		S47B-5	S47B-8	Approx. 4V	Perform Step 4	If <4V, replace S47A or S47B
4		S47A-6			Perform Step 5	If <4V, repair/replace harness from S47B-5 to S47A-6
5		JPT10-7	JPT24-9	Approx. 7.9V	Perform Step 6	If approx. 10.5V, replace sensor S47A
6		JPT10-8		S47A or S47B Closed (sees magnet): 3.7V Open (no magnet): approx 7.8V	Replace VM	T/S harness for opens and shorts. If OK, replace bad sensor

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Test I73 - End-of-Aisle Sensor 1 (optional)

NOTE: This test applies to trucks equipped with End-of-Aisle Detect or Auto Steer Center.

This test displays what the VM sees from Aisle Detect Sensor 1. Sensor 1 (S46A and B) is located on the right side of the Antenna Card bracket as you stand on the platform facing the tractor.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

You have two choices when running this test:

Statically: If this test is to be run statically, park the truck away from any magnets in the floor. Obtain a magnet (P/N 591-552/002) and pass the magnet under the sensor. Remember that this is a transitional state.

The sensor will revert to its original position even if the magnet remains under the sensor. It may be helpful if two people are available for this test. When a magnet is placed under the sensor, the OD will show **On** briefly. Even if the magnet remains under the sensor, the display will change back to **Off**.

Active Maintenance: To run this test in Active Maintenance, position the truck away from any floor magnets. Select this test for Active Maintenance. Have this test on the operator display. While observing the display, drive the truck so the sensor passes over a floor magnet. The OD will show **On** briefly. Even if the magnet remains under the sensor, the display will change back to **Off**.

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

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Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	Pull pin JPT10-6. Backprobe connection	JPT24-8	Approx. 10.5V	Perform Step 2	Replace VM
2		JPT10-6		Approx. 7.9V	Perform Step 3	T/S harness for opens and shorts. If OK, replace sensor S46A or S46B
3		S46B-5	S46B-8	Approx. 4V	Perform Step 4	If <4V, replace S46B
4		S46A-6			Perform Step 5	If <4V, repair/ replace harness from S46B-5 to S46A-6
5		JPT10-6	JPT24-8	Approx. 7.9V	Perform Step 6	If approx. 10.5V, replace sensor S46A
6		JPT10-2		S46A or S46B Closed (sees magnet): 3.7V Open (no magnet): approx 7.8V	Replace VM	T/S harness for opens and shorts. If OK, replace bad sensor

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Test I74 - Lower Inhibit Switch (optional)

This test monitors the state of the lower inhibit switch (S25). This test displays what the CCC is reading from the switch.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

The state of the lower inhibit switch (S25) is displayed.

Carriage Position (wrt S25)	**Operator Display**
Below	**Belw**
Above	**Abve**

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

Using Active Maintenance, check that the display indicates the carriage is **Belw** at all positions below the lower inhibit switch. Check that the display indicates **Abve** for all positions above the lower inhibit switch.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPC4 dis-connected /DCV	PC4-2	PC4-3	10.7 to 13V	Perform Step 2	Replace CCC
2	DCV	JPC4-2	S25-3		Perform Step 3	Repair/replace harness
3		S25-1			Perform Step 4	
4			S25-2	S25 Closed: 10.5 to 13V Open: 0V	Perform Step 5	Adjust or replace S25
5		JPC4-2	JPC4-1		Replace CCC	Repair/replace harness

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Test I75 - 180 in. Limit Switch (optional)

This test monitors the state of the 180 in. limit switch (S100). This test displays what the CCC is reading from the switch.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

The state of the 180 in. limit switch (S100) is displayed.

Carriage Position (wrt S100)	**Operator Display**
Below	**Belw**
Above	**Abve**

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

Using Active Maintenance, check that the display indicates the carriage is **Belw** at all positions below the lower inhibit switch. Check that the display indicates **Abve** for all positions above the lower inhibit switch.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	Pull pin from JPT24-1. Backprobe connection.	JPT24-7	10.5 to 13V	Perform Step 2	Replace VM
2		JPT24-1	S100-1		Perform Step 3	Repair/replace harness
3		S100-3		10.7 to 13V	Perform Step 4	
4			S100-2	S100 Closed: 10.7 to 13V Open: <1V	Perform Step 5	Adjust or replace S100
5		JPT24-1	JPT22-4		Replace VM	Repair/replace harness

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Test I76 - Lift Cutout Switch (optional)

This test monitors the state of the lift cutout switch (S124). This test displays what the CCC is reading from the switch.

For information on using Maintenance Mode, refer to page 3-24.

Run test:

The state of the lift cutout switch (S124) is displayed.

Carriage Position (wrt S124)	**Operator Display**
Below	**Belw**
Above	**Abve**

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

Using Active Maintenance, check that the display indicates the carriage is **Belw** at all positions below the lower inhibit switch. Check that the display indicates **Abve** for all positions above the lower inhibit switch.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	Pull pin from JPT20-8. Backprobe connection.	JPT18-7	10.5 to 13V	Perform Step 2	Replace VM
2		JPT20-8	S124-1	10.7 to 13V	Perform Step 3	Repair/replace harness
3		S124-3			Perform Step 4	
4			S124-2	S124 Closed: 10.5 to 13V Open: <1V	Perform Step 5	Adjust or replace S124
5		JPT20-8	JPT4-3		Replace VM	Repair/replace harness

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Output Tests

A Diagnosis and Repair table is provided for most tests. If a test fails, refer to the Diagnosis and Repair table. Through the process of elimination, these tables provide the technician with a step-by-step approach to diagnosing a problem and the necessary corrective action. See the table below.

Example Diagnosis and Repair Table

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
This is the order that the testing must be performed.	This column identifies the action(s) required (if any) before testing the circuit. If no instructions are given, all circuits must be connected. **Note: If something was disconnected in the prior step, reconnect it before performing the next step.** This column also identifies the required setting on the meter for this step.	Connection point for the Positive (+) meter lead.	Connection point for the Negative (–) meter lead.	The reading required to consider the step a success.	The next action to be performed if the Expected Results are met.	The next action to be performed if the Expected Results are not met.

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Test O00 - Toggle the Traction Power Contactor

This test toggles the TPC ON and OFF.

For information on how to use Maintenance Mode, refer to page 3-24.

Run test:

PC Contactor	Operator Display
Closed	**In**
Open	**Out**

The test is a success if the TPC contactor tracks the **In/Out** shown on the display. If these results are not observed, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPTA1 disconnected /Ohms	JPTA1-6	JPTA1-13	Approx. 38 ohms	Perform Step 2	T/S wires and coil
2	DCV	JPTA1-13	TP4	B+	Perform Step 3	Replace Traction Power Amplifier
3		B+	JPTA1-6	Test ON: B+ Test OFF: 0V	Test contactor for binding	

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Test O02 - Toggle the Lift Power Contactor

This test toggles the LPC ON and OFF.

For information on how to use Maintenance Mode, refer to 3-24.

⚠ WARNING

Open the emergency lowering valve before using this test.

Run test:

LPC Contactor	Operator Display
Closed	**In**
Open	**Out**

The test is a success if the LPC contactor tracks the **In/Out** shown on the display. If these results are not observed, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
AC Lift						
1	JPLA1 disconnected /Ohms	JPLA1-6	JPLA1-13	Approx. 38 ohms	Perform Step 2	T/S wires and coil
2	DCV	JPLA1-13	TP4	B+	Perform Step 3	Replace Lift Power Amplifier
3		B+	JPLA1-6	Test ON: B+ Test OFF: 0V	Test contactor for binding	
DC Lift						
1	JPT18 and JPF2 disconnected /Ohms	JPT18-9	JPF2-1	Approx. 38 ohms	Perform Step 2	T/S wires and coil
2	DCV		TP4	Contactor Energized: approx. 12V De-energized: B+	Test contactor for mechanical binding	If B+ is not present, T/S JPF2-1 on Relay Fuse Card. If voltage does not change when test is toggled, replace VM

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Test O11 - Toggle Load Holding Solenoid

This test turns the Load Holding (L/H) Solenoid (SOL1) ON and OFF.

⚠ WARNING

Make sure the operator platform is fully lowered before performing this test.

Turning the Load Holding Solenoid ON during this test will cause the operator platform to lower because the proportional lift/lower valve is open in Maintenance Mode.

For information on how to use Maintenance Mode, refer to 3-24.

Run test:

1. Lower the operator platform to the floor.
2. Disconnect wire from Load Holding solenoid L/H-1.
3. Connect an ammeter in series with the L/H solenoid as follows:
   - (–) lead to terminal of L/H-1
   - (+) lead to wire removed from L/H-1

L/H Solenoid	Ammeter Reading	Operator Display
Open	0.5 to 1.0A	**On**
Closed	0.0 to 0.02A	**Off**

If these results are not observed, the test has failed. Reconnect wire to L/H-1.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPT18 and JPF2 disconnected/ Ohms	JPT18-10	JPF2-5	Approx. 38 ohms	Perform Step 2	T/S wires and coil
2	DCV	JPF2-5	TP4	B+	Replace VM	T/S relays and Fuse Relay Card

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Test O12 - Proportional Solenoid PWM Ramp

This test ramps the proportional Lift/Lower (L/L) solenoid from 0% to 90%.

A successful test proves the wiring, related circuitry in the VM, and proportional L/L solenoid coil driver are all functioning correctly. It also proves the harness is electrically functional. It does not prove the L/L solenoid itself is mechanically functional.

Ramping the proportional L/L solenoid should not allow the operator platform to lower, since the Load Holding (L/H) valve must be closed. If there is a fault in the L/H circuit or a fault in L/H solenoid itself, the operator platform may lower. To guard against unexpected motion of the operator platform, fully lower the operator platform before entering this test.

For information on how to use Maintenance Mode, refer to 3-24.

Run test:

1. Turn key switch OFF.
2. Loosen the screw that secures the 90° connector to the L/L solenoid. Unplug the connector from the solenoid. Remove the cover to expose the connector terminals. Reconnect the connector.
3. Connect the (–) lead of a DVM to L/L-2 and the (+) lead to L/L-1.
4. Turn key switch ON and run this test.

Voltmeter Reading	Operator Display
0 to 24V	**Ramp (15% increments)**
0 to 1V	**0%**

The percentage shown on the display will start at 0%. Use the Up (▲) button to increase the percentage up to 90% in 15% increments.

If voltage ramps proportionally, the wiring and related circuitry are functional. (It does not prove the L/L solenoid itself is mechanically functional.)

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

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPT20 dis-connected/ Ohms	JPT20-16	JPT20-15	Approx 25 ohms	Perform Step 2	T/S wires and coil
2	DCV	JPT20-15	B–	B+	Perform Step 3	Replace VM
3	Test ON /DCV	JPT20-16		24V truck: ramp B+ to 0V 36V truck: ramp B+ to 12V	Check valve for mechanical binding or contamination	

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Test O18 - Toggle Horn

This test toggles the horn ON and OFF.

For information on how to use Maintenance Mode, refer to page 3-24.

Run test:

The horn should sound when test is activated. If these results are not observed, the test has failed.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	H2	TP4	B+	Perform Step 2	T/S wires and Fuse Relay Card
2		TP1	H1	Horn OFF: <0.5V Horn ON: B+	Replace horn	Perform Step 3
3			JPT18-16		T/S wires to horn	Replace VM

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Test O19 - Audible Alarm

Using this test, the operation of the audible alarm in the CCC can be verified.

A successful test proves the audible alarm is functioning.

For information on how to use Maintenance Mode, refer to page 3-24.

Run test:

Alarm	Operator Display
Sounding	**Ramp**
OFF	**Off**

This test will generate a sound on the audible alarm in the CCC.

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

Diagnosis and Repair

Replace Carriage Control Card.

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Test O20 - Travel Alarm (optional)

This test verifies the operation of the travel alarm.

A successful test proves the wiring and related circuitry in the VM are functioning correctly.

For information on how to use Maintenance Mode, refer to 3-24.

NOTE: In order to test the output portion of the Vehicle Manager, a device that will cause a load in the circuit is required. The load holding coil on the hydraulic manifold can be used for testing purposes. Remove the load holding coil and carefully connect wires into the circuit. Use extreme caution and make sure that the wires do not short to any components.

Run test:

Connect a voltmeter at JPT20-17 wrt JPT18-18.

Voltage Output	Operator Display
0.0 to 1.0V	**Off**
22.0V	**On**

When the display shows ON, the optional device must be activated.

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

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	AL+	AL–	Approx. 22V	Replace alarm	Perform Step 2
2			TP4	B+	Perform Step 3	Test wire to AL+
3		JPT18-18		24V truck: approx. 2V 36V truck: approx. 14V	Repair/replace wire to AL–	Replace VM
4	Connect Load Holding Coil/DCV	JPT20-17	JPT18-18	Approx. 22V	Replace alarm	Replace VM

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Test O25 - Toggle 2 Stage Select Solenoid (optional)

This test toggles the solenoid OFF and ON, verifying its correct operation electrically.

NOTE: This test does *not* prove that the solenoid valve is mechanically functional.

A successful test proves that the solenoid coil, coil driver, wiring and related circuitry in the VM are functioning correctly.

For information on how to use Maintenance Mode, refer to page 3-24.

Run test:

1. Turn the key switch OFF and disconnect the battery connector.
2. Disconnect the wire from the solenoid coil at SOL-1.
3. Connect a digital ammeter in series with the solenoid: (–) lead to SOL-1, (+) lead to the wire removed from SOL-1.
4. Reconnect the battery connector and turn the key switch ON. Run test and observe the following results.

Ammeter Reading	Operator Display
0.0 to 0.02A	**Off**
1.0 to 2.0A	**On**

   If the above results are not observed, the test has failed.
5. Turn the key switch OFF and disconnect the battery connector. Remove the ammeter from the circuit and reconnect the wire.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPT18 and JPF2 disconnected/ Ohms	JPF2-5	JPC18-1	Approx 28 ohms	Perform Step 2	T/S wires and coil
2	DCV	JPT18-1	B–	B+	Replace VM	T/S Fuse Relay Card

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Test O28 - Ramp Lift Motor (AC lift only)

This test ramps the lift motor by gradually increasing the command to the lift power amplifier via the CAN bus. This test verifies that the lift power amplifier can drive the lift motor.

⚠CAUTION

Running this test for an extended period of time can cause damage the motor, power amplifier, or wiring.

⚠ WARNING

Open the emergency lowering valve before performing this test. See "Emergency Lower Valve" on page 2-9.

For information on how to use Maintenance Mode, refer to page 3-24.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) 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 Lift Amplifier	If current does not ramp to one or two phases, test cables to motor. If OK, replace motor. If phases are low or unequal, replace the Lift Amplifier. If phases are equal and high but motor runs slow, check for binding. If not binding, replace lift motor.

Run test:

The requested rpm is displayed. Use the Up (▲) button to increase the rpm in increments of 25, from a minimum of 775 rpm to a maximum of 1500 rpm.

NOTE: To prevent lift pump damage due to very low rpm, the minimum lift motor speed request is 775 rpm.

When the maximum requested rpm is reached, press Down (▼) to reset the request to 0. Press the Enter (↵) button to exit the test.

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Test O29 - Ramp Traction Motor

This test ramps the traction motor by gradually increasing the command to the traction power amplifier via the CAN bus. This test verifies that the traction power amplifier can generate current and drive the traction motor.

⚠CAUTION

Running this test for an extended period of time can cause damage to the traction motor, power amplifier, or wiring.

⚠ WARNING

The traction motor will rotate during this test. Jack the drive wheel off the floor. Use extreme care whenever the truck is jacked up for any reason. Never block the truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from beneath vehicle while jacking. Use jack stands or solid blocks to support truck. DO NOT rely on the jack alone. See Jacking on page 2-8.

For information on how to use Maintenance Mode, refer to page 3-24.

Run test:

Step on the deadman pedal and run test.

The requested rpm is displayed. Use the Up (▲) button to increase the rpm in increments of 25, from 0 to a maximum of 1500 rpm.

When the maximum requested rpm is reached, press Down (▼) to reset the request to 0. Press the Enter (↵) button to exit the test.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) 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 Traction Amplifier	If current does not ramp to one or two phases, test cables to motor. If OK, replace motor. If phases are low or unequal, replace the Traction Amplifier. If phases are equal and high but motor runs slow, check for binding. If not binding, replace drive motor.

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Test O30 - Toggle Brake Solenoid

This test checks for correct brake coil operation.

For information on how to use Maintenance Mode, refer to page 3-24.

Run test:

Observe the following results:

Display	Brake
Up	Applied
Down	Released

NOTE: Deadman pedal must be depressed while performing this test. Use Enter button to cycle the test.

If these results are not observed, the test has failed.
If this test passes, check brake adjustment. See "Brake Adjustment" on page 7-54.

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPT20 and JPF2 disconnected/ Ohms	JT20-14	JF2-2	Approx. 13 ohms	Perform Step 2	T/S wires and coil
2	DCV	JP20-14	TP4	Brake de-energized: B+ Brake energized: 36V truck = approx. 12V 24V truck = 0V	Inspect brake assembly for binding	If no B+, T/S Fuse Relay Card. If voltage does not drop when energized, replace VM

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Test O32 - Toggle Relays

This test toggles the relays ON and OFF.

For information on how to use Maintenance Mode, refer to page 3-24.

Run test:

NOTE: Running this test requires cycling the key switch and re-entering Maintenance Mode. Error codes will appear on the OD while running this test.

Run test and observe the following results

ON	OFF
Tips closed	Tips open

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

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPF4 disconnected/ Ohms	JPF4-13	JPF4-5	Approx 1.6 M ohm	Perform Step 2	Check K1, K2, K3 relay coils. If OK, replace Fuse Relay Card
2			JPF4-10	Approx 1.7 K ohm	Perform Step 3	Check K4 relay coils. if OK, replace Fuse Relay Card
3	DCV		TP4	B+	Perform Step 4	Replace Fuse Relay Card
4		JPT14-6			Replace VM	T/S wiring from Fuse Relay Card

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Test O39 - Display Lights

This test verifies all the lights operate correctly on the Operator Display.

For information on how to use Maintenance Mode, refer to 3-24.

Run test:

When the test is turned ON, 13 LEDs on the display should light. See Figure 6-3. If all the LED's do not light, the test has failed.

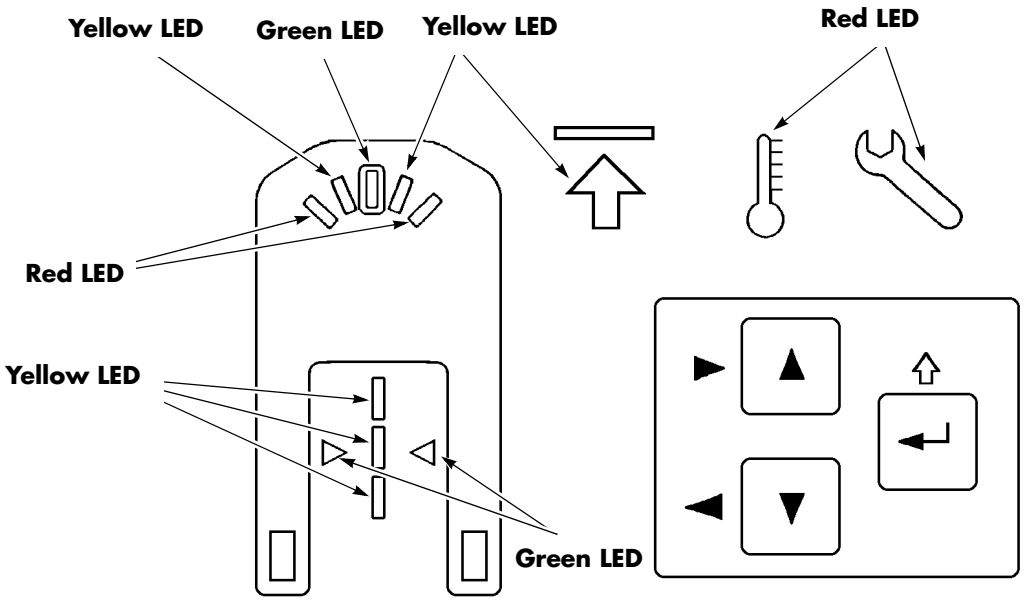


Figure 6-3. Operator Display LED Identification

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	JPD15-16	JPD15-15	Approx. 5.3V	Display not illuminated, Perform Step 3	Perform Step 2
2		JPC15-16	JPC15-15		Display not illuminated, Replace display	Replace CCC
3	Disconnect JPC15 from CCC and Display /Ohms	JC15-1 thru JC15-24	JD15-1 thru JD15-24	Continuity	Replace display	Display not illuminated, repair/replace cable

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Test O40 - Lift/Lower Alarm (optional)

This test toggles the Lift/Lower Alarm ON and OFF.

For information on how to use Maintenance Mode, refer to page 3-24.

NOTE: In order to test the output portion of the Vehicle Manager, a device that will cause a load in the circuit is required. The load holding coil on the hydraulic manifold can be used for testing purposes. Remove the load holding coil and carefully connect wires into the circuit. Use extreme caution and make sure that the wires do not short to any components.

Run test:

Use the ENTER button to toggle the test ON and OFF. The operator display shows ON or OFF.

Connect a voltmeter at JPT20-17 wrt JPT20-18.

Voltage Output	Operator Display
0.0 to 1.0V	**Off**
22.0V	**On**

Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	DCV	Lift/Lower Alarm +	Lift/Lower Alarm –	Approx. 22V	Replace alarm	Perform Step 2
2			TP4	B+	Perform Step 3	Test wire to Lift/Lower Alarm +
3	Disconnect JPT20/Ohms	JPT20-18	Lift/Lower Alarm –	0 Ohms	Perform Step 4	Repair/replace wire
4	Connect Load Holding Coil/DCV	JPT20-17	JPT20-18	Approx. 22V	Replace alarm	Replace VM

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Test O41 - Aux Select Solenoid (optional)

This test toggles the Aux Select Solenoid OFF and ON, verifying its correct operation electrically.

A successful test proves that the Aux Select Solenoid coil, coil driver, wiring, and related circuitry in the VM are functioning correctly.

NOTE: This test does *not* prove that the Aux Select Solenoid valve is mechanically functional.

For information on how to use Maintenance Mode, refer to page 3-24.

Run test:

1. Turn the key switch OFF and disconnect the battery connector.
2. Disconnect the wire from the Aux Select Solenoid coil at AUX SEL SOL-X.
3. Connect a digital ammeter in series with the Aux Select Solenoid: (–) lead to AUX SEL SOL-X terminal, (+) lead to the removed wire.
4. Reconnect the battery connector and turn the key switch ON. Run test and observe the following results.

Ammeter Reading	Operator Display
0.0 to 0.02A	**Off**
1.0 to 2.0A	**On**

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

5. Turn the key switch OFF and disconnect the battery connector. Remove the ammeter from the circuit and reconnect the wire.

Diagnosis and Repair TBD

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPT18 and JPF2 disconnected /Ohms	JPT18-15	JPF2-3	Approx. 38 ohms	Perform Step 2	T/S wires and coil
2	DCV	JPF2-3	TP4	B+	Replace VM	T/S relays and Fuse Relay Card

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Test O42 - Main Select Solenoid (optional)

This test toggles the Main Select Solenoid OFF and ON, verifying its correct operation electrically.

A successful test proves that the Main Select Solenoid coil, coil driver, wiring, and related circuitry in the VM are functioning correctly.

NOTE: This test does *not* prove that the Main Select Solenoid valve is mechanically functional.

For information on how to use Maintenance Mode, refer to page 3-24.

Run test:

1. Turn the key switch OFF and disconnect the battery connector.
2. Disconnect the wire from the Main Select Solenoid coil at MAIN SEL SOL-X.
3. Connect a digital ammeter in series with the Main Select Solenoid: (–) lead to MAIN SEL SOL-X terminal, (+) lead to the removed wire.
4. Reconnect the battery connector and turn the key switch ON. Run test and observe the following results.

Ammeter Reading	Operator Display
0.0 to 0.02A	**Off**
1.0 to 2.0A	**On**

   If the above results are not observed, the test has failed.
5. Turn the key switch OFF and disconnect the battery connector. Remove the ammeter from the circuit and reconnect the wire.

Diagnosis and Repair TBD

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPT18 and JPF2 disconnected /Ohms	JPT18-14	JPF2-3	Approx. 38 ohms	Perform Step 2	T/S wires and coil
2	DCV	JPF2-3	TP4	B+	Replace VM	T/S relays and Fuse Relay Card

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Test O43 - Aux Load Hold Solenoid (optional)

This test toggles the Aux Load Hold Solenoid OFF and ON, verifying its correct operation electrically.

A successful test proves that the Aux Load Hold Solenoid coil, coil driver, wiring, and related circuitry in the VM are functioning correctly.

NOTE: This test does *not* prove that the Aux Load Hold Solenoid valve is mechanically functional.

For information on how to use Maintenance Mode, refer to page 3-24.

Run test:

1. Turn the key switch OFF and disconnect the battery connector.
2. Disconnect the wire from the Aux Load Hold Solenoid coil at AUX L/H SOL-X.
3. Connect a digital ammeter in series with the Aux Load Hold Solenoid: (–) lead to AUX L/H SOL-X terminal, (+) lead to the removed wire.
4. Reconnect the battery connector and turn the key switch ON. Run test and observe the following results.

Ammeter Reading	Operator Display
0.0 to 0.02A	**Off**
1.0 to 2.0A	**On**

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

5. Turn the key switch OFF and disconnect the battery connector. Remove the ammeter from the circuit and reconnect the wire.

Diagnosis and Repair TBD

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	JPT18 and JPF2 disconnected /Ohms	JPT18-12	JPF2-3	Approx. 38 ohms	Perform Step 2	T/S wires and coil
2	DCV	JPF2-3	TP4	B+	Replace VM	T/S relays and Fuse Relay Card

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Component Locator Photos

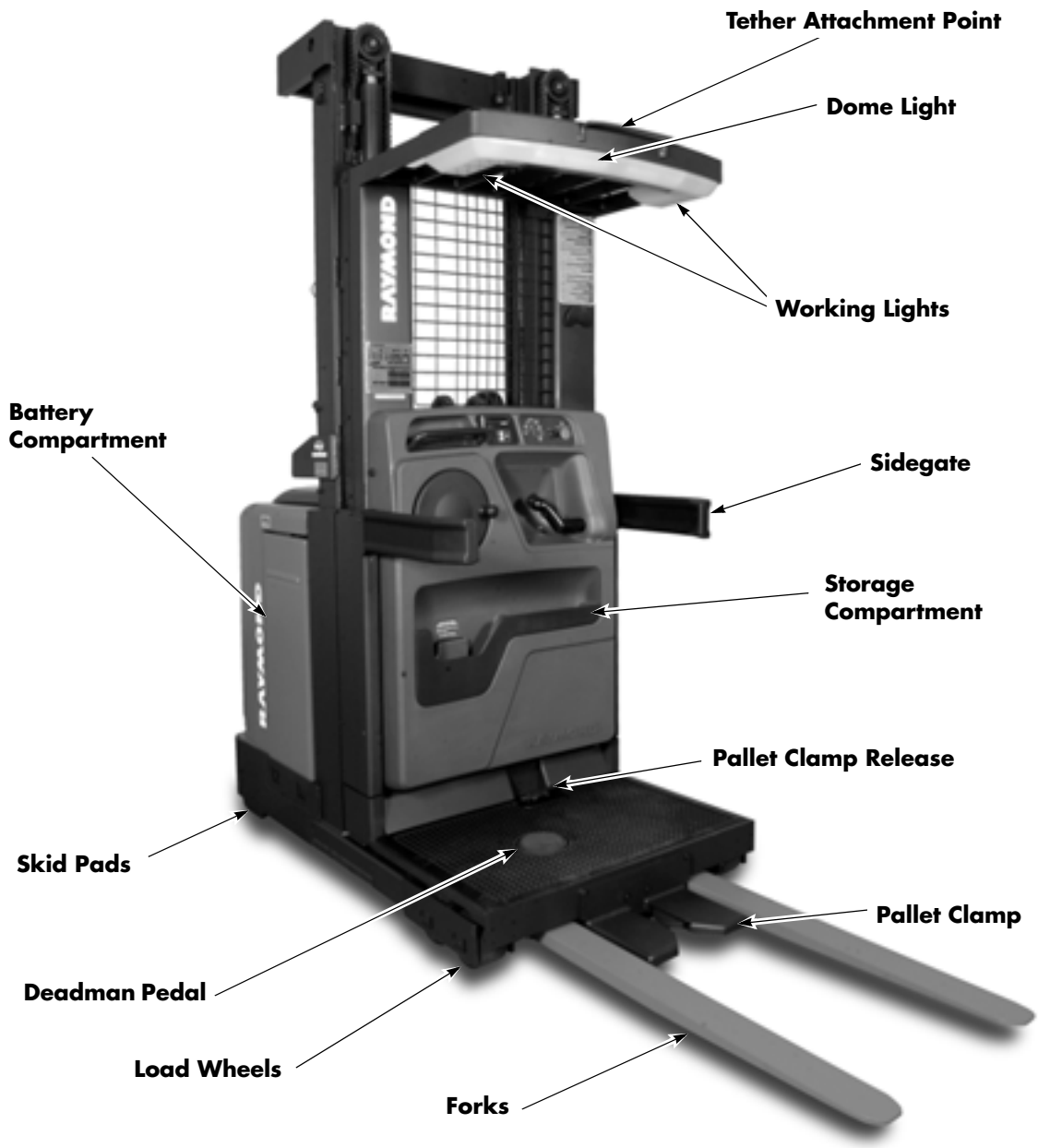


Figure 7-1. Model 5600 - Overall View

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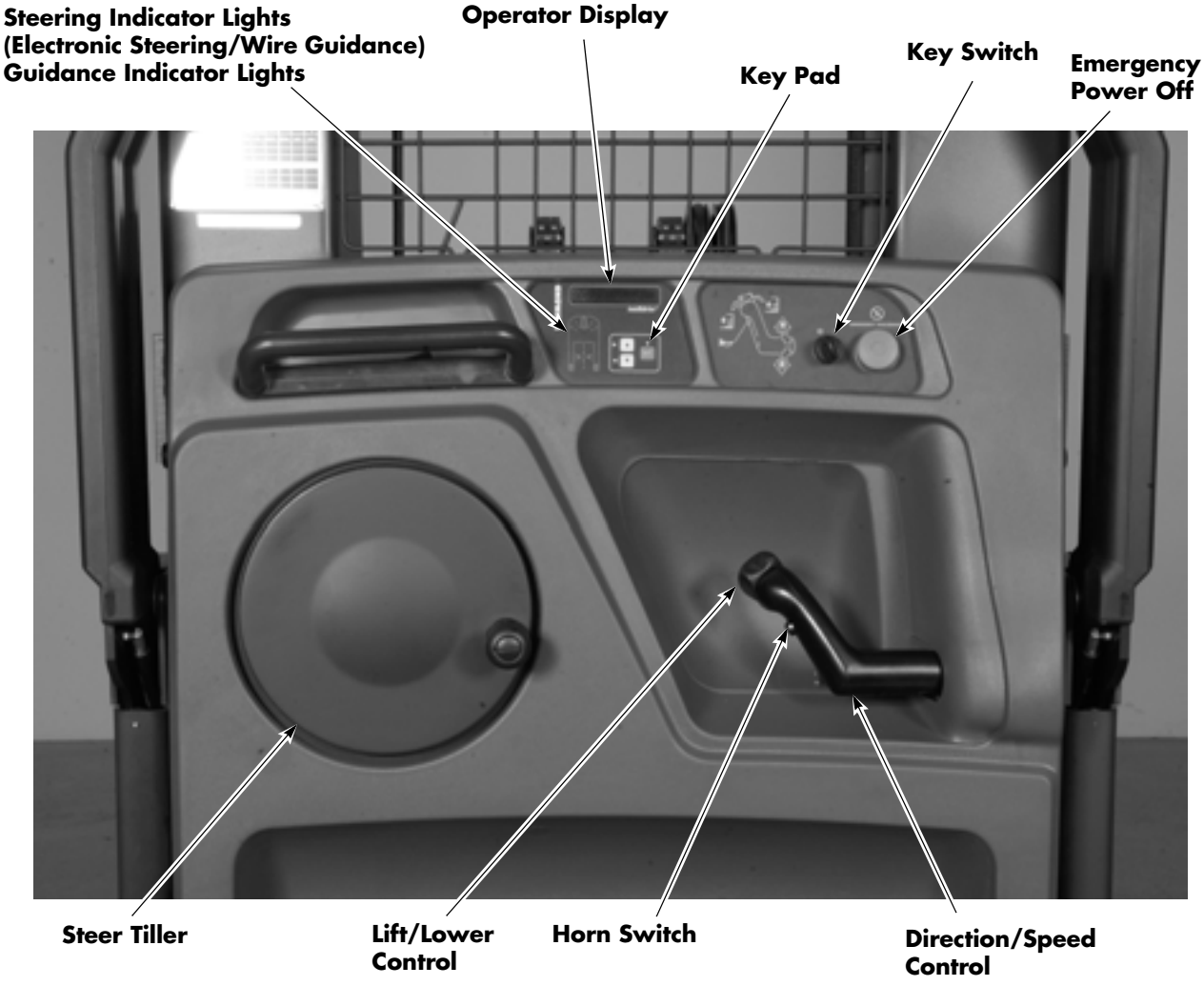


Figure 7-2. Operator Console

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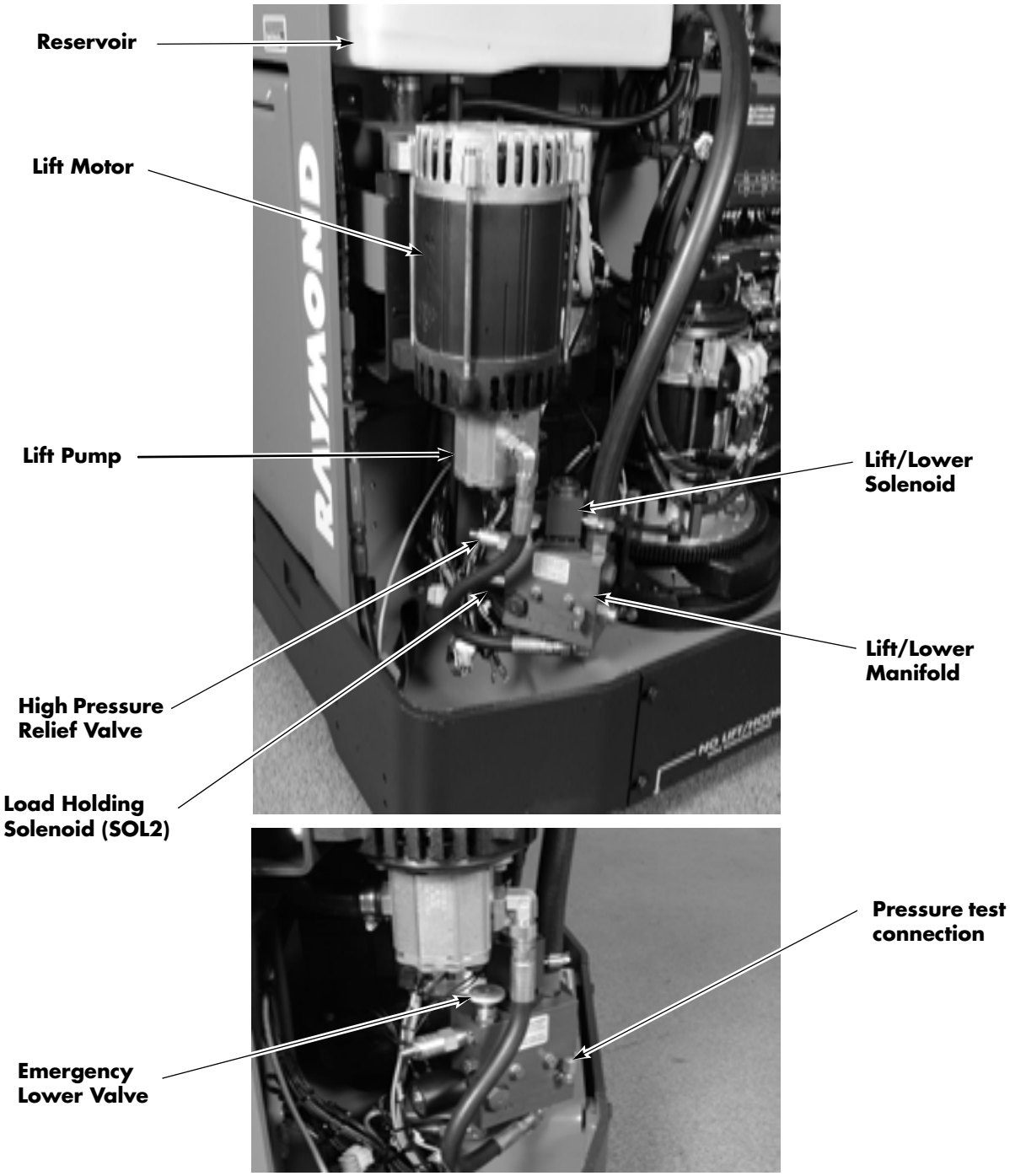


Figure 7-3. Hydraulic Compartment Components

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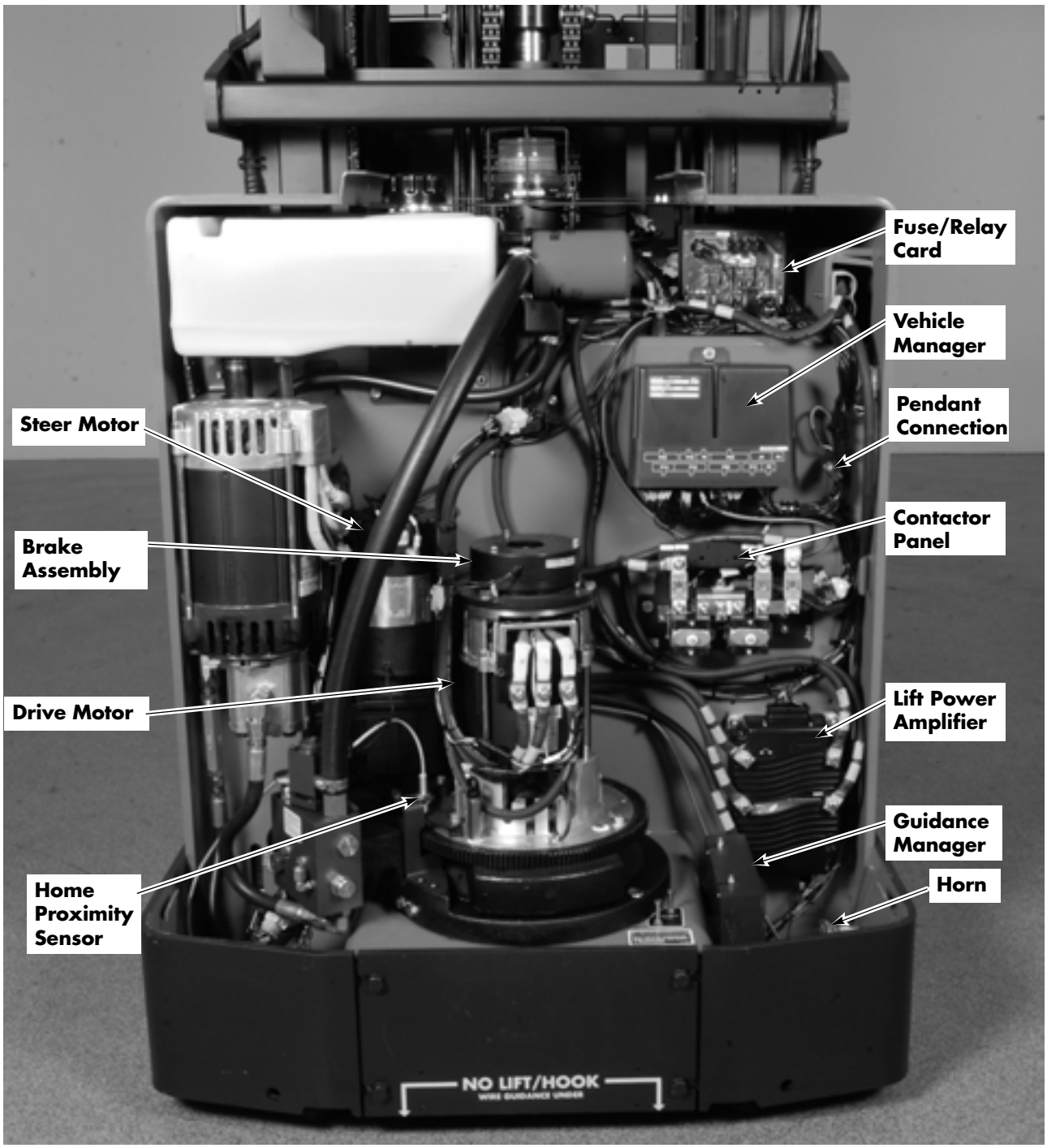


Figure 7-4. Electrical Compartment Components

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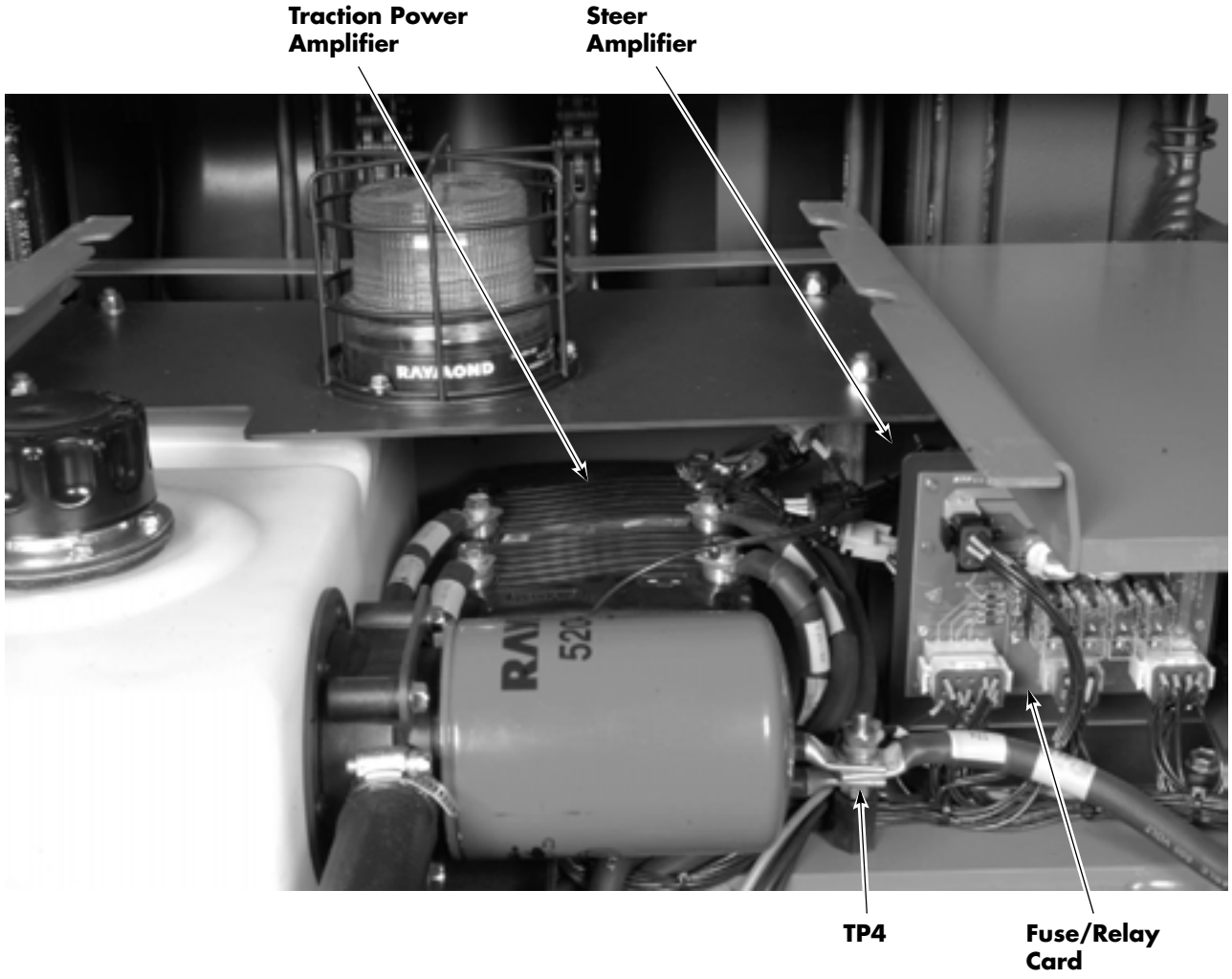


Figure 7-5. Electrical Compartment Components (located on Upper Deck of Power Section)

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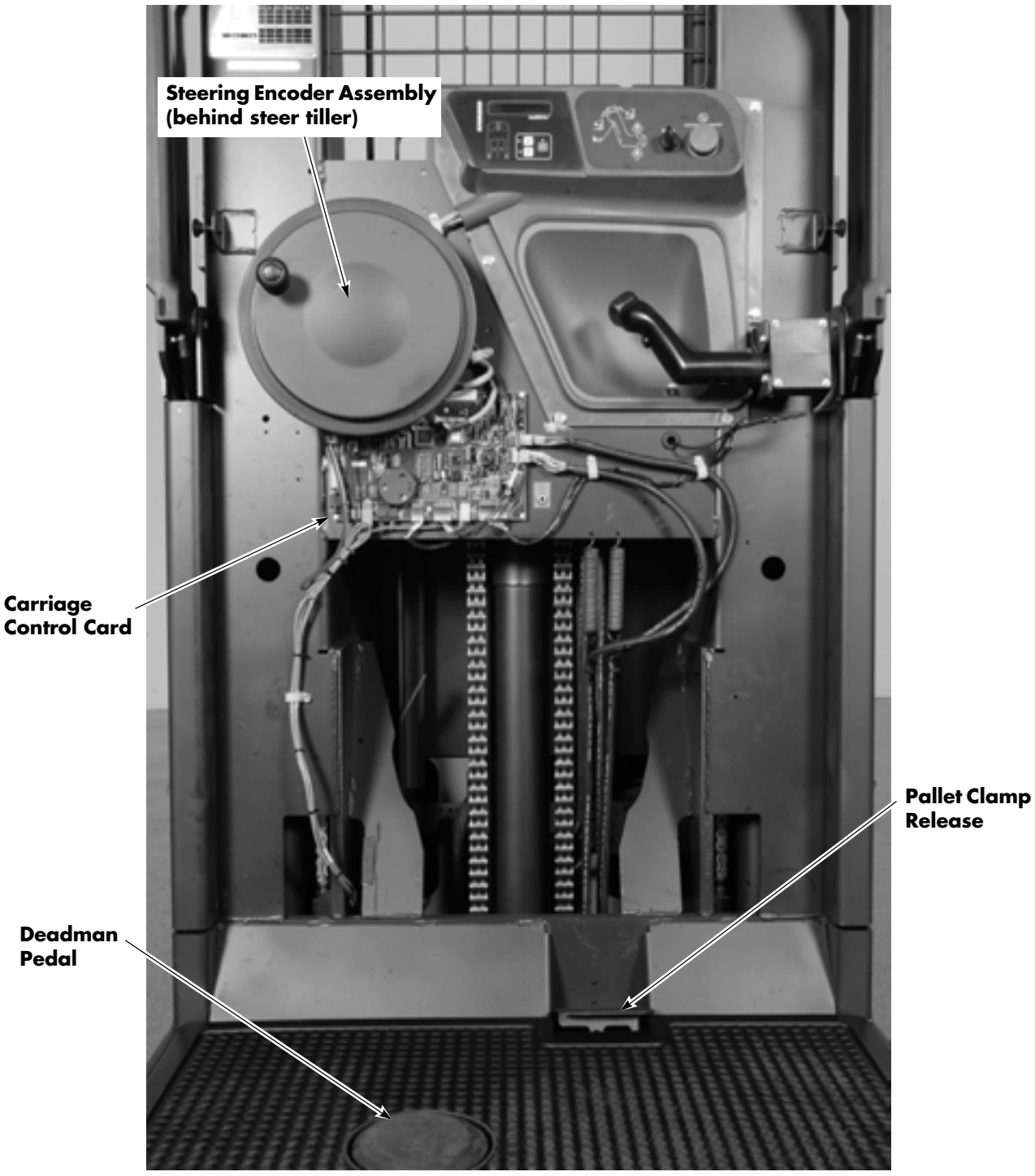


Figure 7-6. Platform Components

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Steering and Controls

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Steer Motor/Gearbox

Encoder Bearing Replacement

NOTE: Replace the shaft seal, the B side bearing, and the brushes while the motor is apart.

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the steer motor/gearbox.
3. Remove the B side end bell and brush retainers. See Figure 7-7.
4. Remove the A side end bell bolts and pull the end bell and rotor from the motor housing. Push the wires and rubber grommet out of the housing slot.
5. Loosen the two phillips head screws that are used with the small clips to retain the bearing in the A side end bell.
6. Remove the A side end bell from the rotor.
7. Use a press to remove the old bearing.

⚠CAUTION

New encoder bearings are mounted like regular bearings except induction heaters must not be used because they demagnetize the encoder. Also, care must be taken against ESD. See page 2-7.

NOTE: When pressing a bearing onto a shaft, press on the inner race, never the outer race.

8. Press on the new bearing and reassemble the motor, Place a small amount of good quality grease between the new bearing and the shaft seal. Take care to not damage the pinion gear in the end of the motor shaft.
9. Torque the bolts holding the motor to the gear reducer to approximately 85 in. lbs. (9.9 N•m).

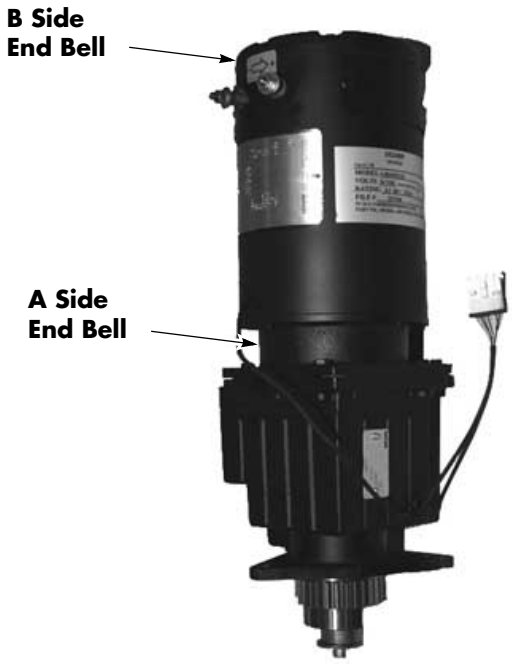


Figure 7-7. Steer Motor and Gearbox

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Home Proximity Sensor Adjustment

1. Turn the key switch OFF and disconnect the battery connector.
2. Loosen the two lock nuts securing the sensor to the bracket. See Figure 7-8.



Figure 7-8. Home Proximity Sensor

3. Adjust the vertical gap between the sensor and the sensor rail to 0.060 +0.010/ –0.040 in. (1.5 +0.254/–1.016 mm). Tighten the lock nuts.
4. Reconnect the battery connector and turn the key switch ON.
5. Center the drive wheel. The sensor must be located horizontally just over the end of the sensor rail.

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Control Handle

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Disconnect JPC9 and remove the Control Handle from the truck.

NOTE: Observe orientation of switches/potentiometers (pot) and routing of cables/wires as the handle is disassembled to make reassembly easier.

⚠CAUTION

Observe correct ESD precautions. See Electrostatic Discharge Precautions on page 2-7.

Before disassembly, determine what components require replacement:

- Lift/Lower Pot, Spring, and/or Horn Switch
- Travel Pot
- Travel Spring and/or Pinion
- Lift/Lower Knob

Disassembly

1. Remove the two 3/32 socket head nylon set screws in the lift/lower knob (thumb lever). If stripped, use a small 1/8 in. (3.2mm) blade flat screwdriver and carefully back out the set screw.
2. Loosen the two metal set screws in the lift/lower knob two full turns and remove the lift/lower knob.

NOTE: Carefully slide the two fiber washers, lift/lower spring, and third fiber washer off of the lift pot shaft. See Figure 7-9.

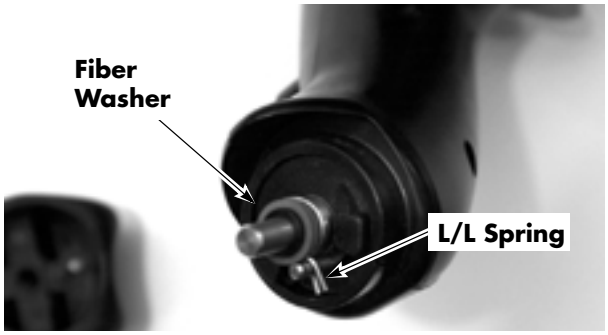


Figure 7-9. Spacer Washer and L/L Spring Removal

3. Remove the three 3 mm socket head cap screws from the handle assembly. See Figures 7-10 and 7-11. Separate the cover from the handle.

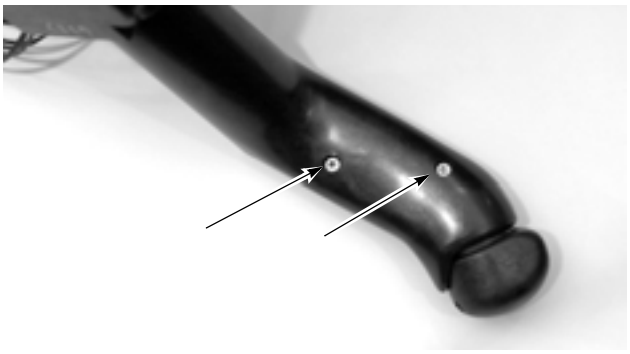


Figure 7-10. Cover Retaining Screws - Bottom



Figure 7-11. Cover Retaining Screw - Top

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Lift/Lower Potentiometer and Spring Replacement

NOTE: Before sliding the potentiometer (pot) bracket off the pot shaft, identify what slot in the pot bracket is used to hold the pot anti-rotate tab. The anti-rotate tab must be located in the slot furthest from the pin in the pot bracket.

1. Remove the lift/lower pot and bracket from the cover. See Figure 7-12.

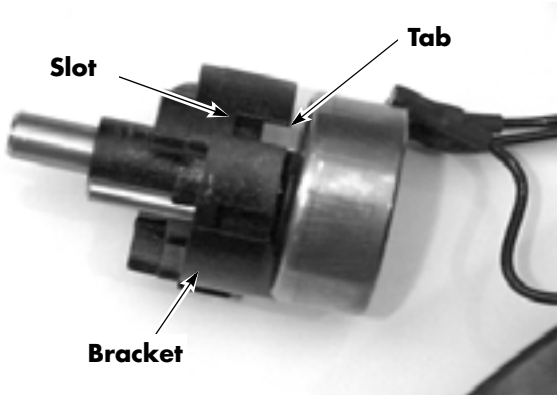


Figure 7-12. Anti-Rotate Tab

NOTE: The button, pin, and spring can easily slide apart. Identify the correct position of these components before disassembly.

2. If replacing the pot, carefully remove heat shrink tubing from the terminals. Identify the wires so they can be installed in the same location on the new pot.
3. Carefully unsolder the harness wires from the lift/lower pot.
4. Carefully solder harness wires to the correct terminals on the new lift/lower pot. Refer to Hand Soldering Procedures on page 7-17.
5. Slide lift/lower pot bracket onto the shaft. Make sure the anti-rotation tab is inserted into the correct slot on the bracket. See Figure 7-12.
6. Press the lift/lower pot and bracket into the handle cover. Make sure the key on the bracket engages the keyway in the handle cover.

Horn Switch Replacement

1. Disconnect the horn switch connector. See Figure 7-13.

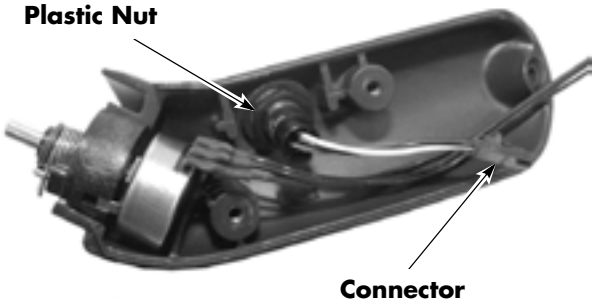


Figure 7-13. Horn Switch Removal

2. Remove plastic nut and internal tooth washer securing horn switch.
3. Install new horn switch assembly into the handle cover. Install internal tooth washer and plastic nut.

Assembly

1. Make sure all wires are routed correctly. Tuck the common ground wire into handle between the bottom of the potentiometer and the screw boss to prevent the wire from being pinched or interfering with the horn button.
2. Install the cover onto the handle assembly with the three socket head cap screws. Torque to 15-20 in. lb. (1.7-2.25 N•m).
3. Install a fiber washer and lift/lower spring (lightly greased with P/N 990-635) on the lift/lower pot shaft. Install the spring with the tangs straddling the pot bracket pin. See Figure 7-9.

NOTE: Replace the spring if the tangs are not parallel. *Do not* bend the spring.

4. Install the two remaining fiber washers.
5. Install the lift/lower knob. See "Lift/Lower Knob Installation/Adjustment" on page 7-16.

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Travel Pot (VR1) Replacement

1. Remove the four hex head cap screws from the front of the travel pot enclosure and remove cover. See Figure 7-14.

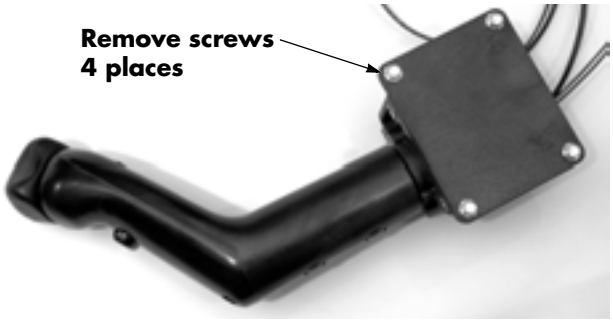


Figure 7-14. Travel Pot Cover Removal

2. Remove the two pan head machine screws from the back of the enclosure. Carefully pull the travel pot/bracket assembly from the enclosure. See Figures 7-15 and 7-16.

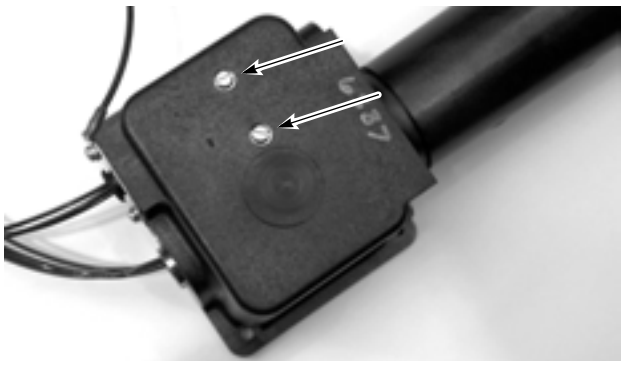


Figure 7-15. Travel Pot Bracket Screws

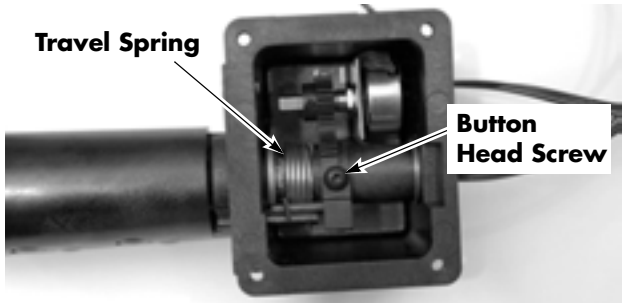


Figure 7-16. Travel Pot Enclosure (Cover Removed)

3. Loosen the set screw on the gear two full turns and slide the gear off the shaft. See Figure 7-17.
4. Remove retaining nut and lock washer from pot and separate from the bracket. See Figure 7-17.

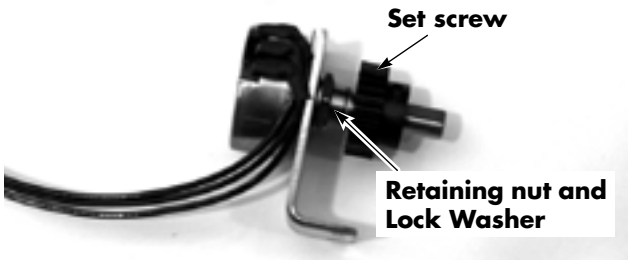


Figure 7-17. Travel Pot/Bracket Disassembly

5. Carefully remove heat shrink tubing from the terminals and identify the wires so they can be installed in the same location on the new pot.
6. Carefully unsolder the harness wires.
7. Slide 3/8 in. (9.5 mm) long shrink sleeving over previously sleeved wires.
8. Solder all electrical components to the harness. See "Hand Soldering Procedures" on page 7-17.
9. Shrink sleeving as necessary.
10. Assemble pot and bracket and install retaining nut and lock washer. When installing the travel pot into the bracket, leave the mounting nut finger tight. See Figure 7-17.
11. Install the gear on the pot shaft, aligning the set screw with the flat portion of the shaft.
12. Install the travel pot/bracket assembly into the enclosure. Engage the travel pot gear with the shaft gear (there is one large tooth that is used to align the gears). Tighten the pot gear set screw and torque to 3 to 4 in. lb. (0.3 to 0.4 N•m).

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⚠CAUTION

It is very easy to over torque and ruin the gear.

13. Tighten the two pan head machine screws on the back of the enclosure while moving the handle to ensure there is no binding. See Figure 7-15.
14. Install the handle in the truck.
15. Adjust the travel pot. Run Test A04 - Throttle Potentiometer Voltage (Page 6-32) and adjust the travel pot voltages to the values given.
16. Tighten the retaining nut.
17. Install the cover on the travel pot enclosure with the four hex head cap screws. See Figure 7-14.
18. Run Learn. See "Learn Mode" on page 3-19.

Travel Spring and Pinion

Disassembly

1. Remove the four hex head cap screws from the front of the travel pot enclosure and remove cover. See Figure 7-14.
2. Use a pin removal tool and pull pins 3 thru 6 from JC-9. These wires pass through the shaft to the lift/lower pot and horn switch.

NOTE: The washer and shims can easily slip off the shaft gear. Observe the correct position of these components before disassembling them.

3. Remove the button head screw from the shaft gear and slide shaft out of enclosure. See Figure 7-16.
4. Carefully rotate the shaft gear assembly to disengage the spring tangs from the pin. Remove the shaft gear assembly from the enclosure.

Assembly

1. Slide the shaft gear assembly back into enclosure. Engage the travel pot gear with the shaft gear (there is one large tooth that is used to align the gears).
   a. Make sure the spring tangs straddle the pin (tangs must be parallel). If the spirol pins were replaced, make sure they are installed such that when the spring is installed, the spring sits on an even edge of the pin and not on the gap.

NOTE: Replace the spring if the tangs are not parallel. *Do not* bend the spring.

   b. Make sure the washer and shims are correctly aligned to allow the handle shaft to slide easily through the enclosure. See Figure 7-18.

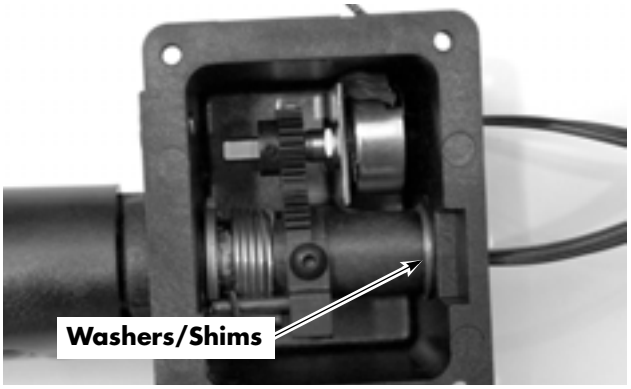


Figure 7-18. Travel Pot/Bracket Assembly Installation

2. Route the lift/lower pot and horn wires through the enclosure. Carefully slide the shaft through the enclosure, passing through the shaft gear assembly, washer, and shims.
3. Align the screw hole in the handle shaft with the hole in the shaft gear. Apply thread-locking compound (P/N 990-412) to the threads in the shaft and on the button head screw. Install the screw and torque to 8 to 12 in. lb. (0.9 to 1.3 N•m).
4. Reinstall the wire pins into the connector.

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5. Inspect the tab on the plate ground to ensure that it is in contact with the bronze handle shaft bushing. See Figure 7-19.

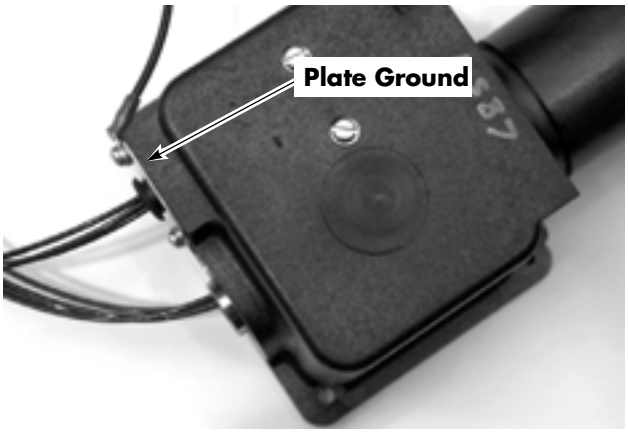


Figure 7-19. Plate Ground

6. Install the cover on the travel pot enclosure with the four hex head cap screws. See Figure 7-14.

Lift/Lower Knob Installation/Adjustment

1. Rotate the lift/lower potentiometer shaft fully counterclockwise.
2. Install the lift knob on the potentiometer shaft. The pin on the knob must fit between the tangs of the potentiometer return spring.
3. Rotate the lift/lower knob fully counterclockwise and tighten the metal set screws to 6 to 8 in. lb. (0.7 to 0.9 N•m).
4. Check the potentiometer for correct operation and spring return to neutral. Correct any binding.
5. Install and tighten two nylon set screws on top of the metal set screws.
6. Verify the potentiometer reference voltages. Refer to Test A05 - Lift/Lower Potentiometer Voltage on page 6-33.
7. Run Learn. See “Learn Mode” on page 3-19.

Cleaning and Inspection

⚠CAUTION

When cleaning plastic parts, use a dry rag or a cleaner that is safe on plastics. Most chemicals can damage plastic.

While performing a repair on the Control Handle, clean and inspect the parts listed in Table 7-1.

Table 7-1. Control Handle Checks

Part	Check for:
Horn button assembly	Cracks or deformation
Lift/lower pot bracket	Cracks, deformation, loose dowel pin, over round or oversized shaft hole
Travel pot gear	Cracks, gear deformation, stripped threads
Travel shaft gear assembly	Cracks, gear deformation, or loose spirol pin
Travel pot enclosure	Cracks, loose spirol pin, stripped threads, deformation or indents on external stops
Handle halves	Cracks, damage or deformation/indents on external stops
Lift/lower knob	Cracks, deformation, stripped threads, loose dowel pin
Plate ground	Check for continuity between the control handle shaft and the truck frame
Other hardware	Stripped threads. All screw threads must be cleaned.

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Hand Soldering Procedures

When hand soldering is performed on solid state potentiometers, the following is recommended:

- Flux - rosin base
- Solder - 60/40 rosin core or equivalent
- Solder Iron - 55 watt max.
- Tip Size - 0.118 in. (3 mm) dia. x 1.182 in. (30 mm) long screwdriver
- Tip Temperature - 500°F (260°C) max.
- Terminal Contact Time - 6 seconds max.

NOTE: Apply light soldering iron pressure on the terminal. Make sure the tip is clean. A dirty tip does not transfer heat well, therefore requiring longer dwell time and greater tip pressure.

⚠CAUTION

Contact contamination can occur if cleaning solvent is allowed to enter switches or potentiometers.

After soldering, clean terminals with a brush dampened with an alcohol based cleaner (P/N 990-600/FOF). Make sure cleaner does not seep into the electrical component.

NOTE: Components damaged due to solvent saturation *will not* be covered under warranty.

Installation

1. Install control handle on truck. Connect JPC9.
2. Connect the ground wire to the truck frame.
3. Reconnect the battery connector and turn the key switch ON.
4. Perform Learn Controls and test truck operation before returning to service. See "Learn Mode" on page 3-19.

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Deadman Pedal

Switch Replacement

There are two deadman switches (S2 and S23).

Trucks S/N 00100 thru 00133

1. Raise operator platform high enough (at least 3 ft. [91.44 cm]) to access bottom of deadman pedal from under platform.
2. Block operator platform with a 4 in. x 4 in. (100 x 100 mm) wooden block.
3. Turn the key switch OFF and disconnect the battery connector.
4. Remove snap ring from bottom of deadman pedal post. See Figure 7-20.
5. While holding the two return springs in place, lift pedal straight up.

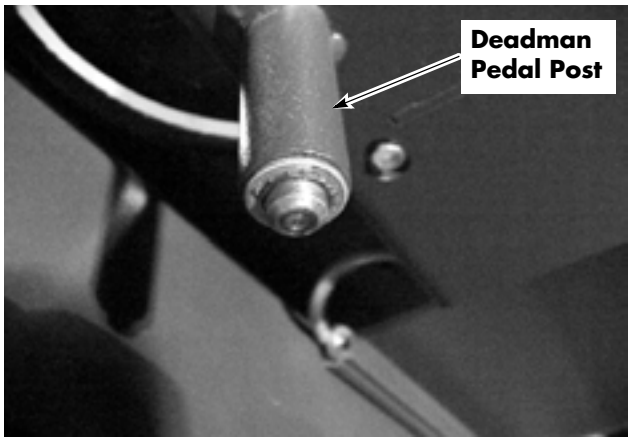


Figure 7-20. Deadman Pedal Post Under Platform

6. Remove two screws mounting deadman switch to bracket.
7. Disconnect wires from deadman switch(es). Note location and mark if necessary for recognition later.
8. Replace bad switch(es). See Figure 7-21.

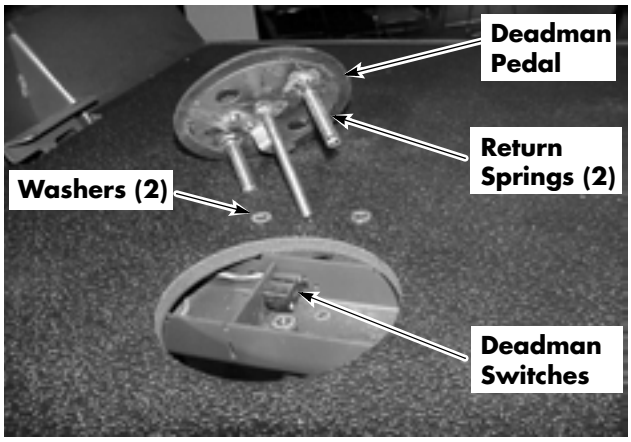


Figure 7-21. Deadman Pedal Components

9. Reconnect wires.
10. Align washers with holes.
11. While holding the two return springs in place, install pedal assembly. See Figure 7-21.
12. Install snap ring on bottom of deadman pedal post.
13. Reconnect the battery connector and turn the key switch ON. Test truck operation before returning to service.

Trucks S/N 00134 and Higher

1. Raise operator platform high enough (at least 3 feet [91.44 cm]) to access bottom of deadman pedal from under platform.
2. Block operator platform with a 4 in. x 4 in. (100 x 100 mm) wooden block.
3. Turn the key switch OFF and disconnect the battery connector.

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4. Remove the three lock nuts and washers that secure the deadman pedal assembly to the operator platform. See Figure 7-22.

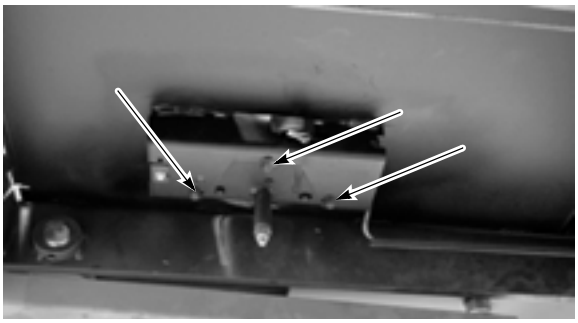


Figure 7-22. Deadman Lock Nuts and Washers

5. Remove the two screws mounting the deadman switch(es) to the bracket.
6. Disconnect wires from switch(es). Note location and mark if necessary for recondition later.
7. Replace bad switch(es).
8. Reconnect wires.
9. Align pedal assembly with holes in platform.
10. Install washer and lock nut on bottom of each deadman pedal assembly post. See Figure 7-22.
11. Reconnect the battery connector and turn the key switch ON. Test truck operation before returning to service.

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Emergency Power Off Switch

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove operator console cover.
3. Disconnect wires EPO-1 and EPO-2 from back of EPO switch. See Figure 7-23.

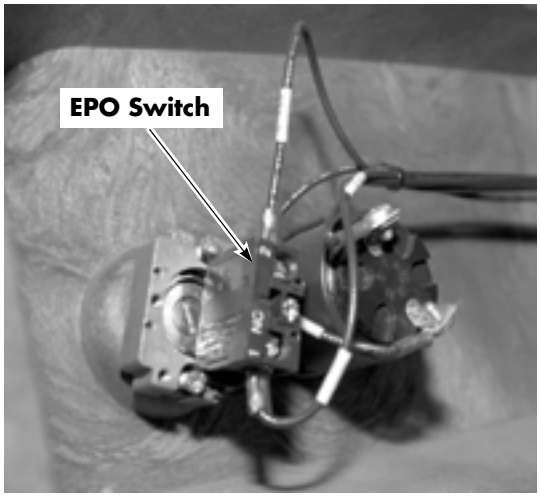


Figure 7-23. EPO Switch

4. Loosen two screws on backside of EPO switch.
5. Hold lower half of switch, push in and rotate top half 90° counterclockwise to unlock halves of EPO switch.

NOTE: The switch may be hard to turn.

6. Lift top half of EPO switch from bezel.

Installation

1. Insert lower portion of EPO switch in its hole in bezel.
2. Slide upper half of EPO switch over lower half until it is seated. Rotate top half 90° clockwise to lock.
3. Tighten screws on backside of EPO switch.
4. Re-connect wires.
5. Install operator console cover.
6. Reconnect the battery connector and turn the key switch ON. Test truck operation before returning truck to service.

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Drive and Brake

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Drive Motor

Refer to AC Motor Service on page 7-68 for drive motor temperature sensor and encoder bearing replacement procedures.

Removal/Installation

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove brake assembly including the rotor hub nut and rotor hub. See Figure 7-24. Note the number of spacers used.



Figure 7-24. Drive Motor

3. Identify and remove power cables from drive motor.
4. Remove the drive motor retaining screws.
5. Remove the drive motor.
6. For reassembly, reverse steps 1 thru 5 noting the following:
   - Clean motor mounting flange and drive unit. Install a new gasket.
   - Clean screws. Apply thread-locking compound (P/N 990-536) to screws and torque equally to 13 ft. lb. (18 N•m).
   - Torque the power cable nuts to 18 ft. lb. (24.4 N•m). See Terminal Hardware on page 7-66.
   - Check brake adjustment. See Brake Adjustment on page 7-54.
7. If the pinion on the drive motor needs to be installed:
   a. Clean threads using thread-locking compound primer (P/N 990-533).
   b. Install key and gear.
   c. Apply thread-locking compound (P/N 990-462) to threads.
   d. Torque nut to 85 ft. lb. (115 N•m).

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Drive Unit - Standard

Pivot Ring Inspection

The fit of pivot ring bearings in the drive unit is such that some play is expected. However, as the rings wear, the play may increase. If the play is permitted to become extreme, it will become quite noticeable in the drive unit.

If worn rings are suspected as the cause of excessive play in the drive unit, inspect the drive housing to determine if the bearing radial rings must be replaced:

1. Jack the tractor of the truck up just enough to permit the drive tire to clear the floor.

⚠ WARNING

Use extreme care whenever the truck is jacked up. Keep hands and feet clear from vehicle while jacking the truck. After the truck is jacked, place solid blocks beneath it to support it. Do *not* rely on the jack alone to support the truck.

2. Place a magnetic base dial indicator on the deck plate and position the indicator point on top of the drive unit top cover.
3. Adjust the dial indicator to zero then lower the truck to the floor.
4. Note the new indicator reading. If the reading is 0.089 in. (2.26 mm) or less the radial rings do *not* have to be replaced. If the reading exceeds 0.089 in. (2.26 mm) the rings must be replaced. If the reading is between 0.055 and 0.089 in. (1.4 and 2.26 mm) the bearing rings must be checked during future scheduled maintenance visits.

Drive Unit Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the bumper gate. See Figure 7-25.

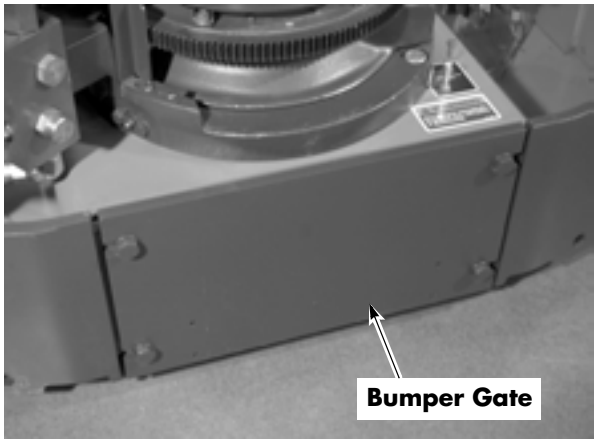


Figure 7-25. Removing Drive Unit

3. If the truck is wire guided, remove the sensor mounted on the backside of the bumper gate.
4. If the drive tire is to be removed, loosen the lug nuts.
5. Remove the proximity sensor and associated hardware on the drive unit casting.
6. Remove drive motor. See Drive Motor on page 7-22.

NOTE: If the drive unit is the only item requiring service, separating the brake assembly from the drive motor is not necessary.

⚠ WARNING

Use extreme care whenever the truck is jacked up for any reason. Never block the truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from beneath vehicle while jacking. Use jack stands or solid blocks to support truck. DO NOT rely on the jack alone. See Jacking on page 2-8.

7. Jack and block the tractor so the drive tire is off the floor.
8. Drain oil from drive unit.
9. Unbolt the lift/lower manifold from the drive unit casting.

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10. Remove the steering motor/gear reducer assembly.
11. Remove cap screws holding the drive unit assembly to the tractor.
12. Lift drive unit out of tractor frame using a suitable lifting device.
13. Clean the outside of the drive unit thoroughly and drain any remaining oil from the drive unit by removing the drain plug.



Figure 7-26. Inspect Housing for Hub Wear

14. Visually inspect the outside of the housing for damage, wear, or cracks. Pay particular attention to the area where hub wear may be evident.

Pivot Ring Disassembly

1. Remove the bearing filler plug screws using a 1/2 in. socket. See Figure 7-27.



Figure 7-27. Bearing Filler Plug Screws Removal

2. Remove the bearing filler plug with grease fitting.
3. Remove the steel balls through the bearing filler plug hole. To work the steel balls forward, insert a putty knife between the pivot ring and the housing. See Figure 7-28. Use care to prevent damaging the radial rings. Move the pivot ring slightly from side to side while working the putty knife toward the bearing filler plug hole.

NOTE: If the pivot ring will not spin or even turn, it is an indication of damaged radial rings and/or excessive wear to the channel in the housing. If this is the case, replace the entire drive unit. No further disassembly is necessary.



Figure 7-28. Remove Steel Ball Bearings

4. After removing all the steel balls, remove the pivot ring by lifting it off, toward the drive end of the housing. See Figure 7-29.



Figure 7-29. Pivot Ring Removal

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5. Use a screwdriver to remove the radial rings and thrust ring from the pivot ring. See Figure 7-30.



Figure 7-30. Radial and Thrust Ring Removal

⚠CAUTION

Due to normal or excessive wear, the edges of the radial rings could be very sharp.

6. Use a mallet and a punch to remove the spherical bearing and brass bushing from the pivot ring. See Figure 7-31.



Figure 7-31. Spherical Bearing and Brass Bushing Removal

7. Remove the grease fittings using a punch and a mallet. See Figure 7-32.



Figure 7-32. Grease Fitting Removal

8. Use a punch and mallet to remove the two roll pins that are used to hold the radial rings in position. See Figure 7-33. Inspect the roll pins. If they are worn, replace with new roll pins when reassembling the pivot ring.



Figure 7-33. Roll Pin Removal

9. Clean the grease from the radial ring channel in the pivot ring. Inspect the channels for wear. If there is excessive wear, replace the pivot ring.

Drive Unit Housing Disassembly

Excessive housing wear in the channel, pivot ring, or hub areas are signs of a damaged housing. If this occurs, replace the entire drive unit. No further disassembly is necessary.

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Radial Ring Removal

1. Use a screwdriver to remove the radial rings from the housing. See Figure 7-34.



Figure 7-34. Radial Ring Removal from Housing

⚠CAUTION

Due to normal or excessive wear, the edges of the radial rings could be very sharp.

2. Clean the grease from the radial ring channel in the housing. Inspect the channel for uneven wear. See Figure 7-35. If there is excessive wear, no further disassembly is necessary. The housing must be replaced.



Figure 7-35. Inspect Housing Channel

Axle Shaft and Bevel Gear Removal

1. Loosen the set screw locking the clamp nut using a 4 or 5 mm Allen socket and a breaker bar. See Figure 7-36. You may need to use an Allen wrench if access is limited.



Figure 7-36. Loosen Clamp Nut Set Screw

2. Use a screwdriver in the clamp nut slot to turn the clamp nut off. See Figure 7-37.

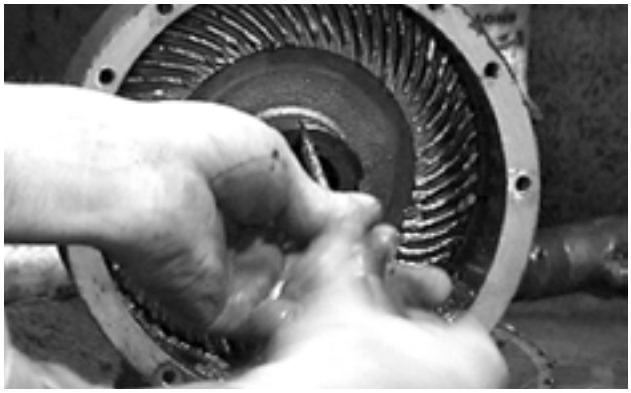


Figure 7-37. Turn Clamp Nut Off

3. Remove the axle from the housing using a large mallet. See Figure 7-38.

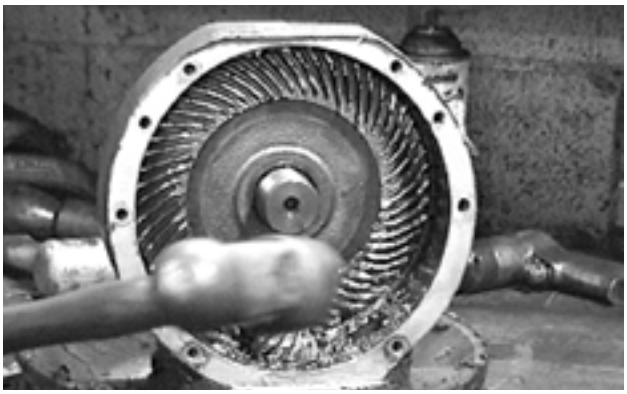


Figure 7-38. Remove Axle from Housing

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4. The bevel gear can now be lifted from the housing. In cases where severe chipping is present, you may need a mallet to knock the bevel gear loose. See Figure 7-39.



Figure 7-39. Lift Out Bevel Gear

Spiral Gear and Helical Gear Removal

1. Turn the drive unit housing over to remove the clamp nut from the spiral gear. Loosen the set screw locking the clamp nut using a 4 or 5 mm Allen wrench. See Figure 7-40.



Figure 7-40. Remove Clamp Nut Set Screw

2. Use a screwdriver in the clamp nut slot to turn the clamp nut off. Inspect the clamp nut for damage. See Figure 7-41.



Figure 7-41. Remove Clamp Nut

3. Use a brass drift punch and mallet to drive the spiral pinion gear shaft through the housing. The brass drift punch will prevent damage to the threads on the end of the spiral shaft. See Figure 7-42.

NOTE: It may be necessary to remove the spiral pinion gear with a press or pressing device equivalent.



Figure 7-42. Remove Spiral Pinion

4. Lift the helical gear and spacer from the housing. See Figure 7-43.

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Figure 7-43. Lift Helical Gear from Housing

5. Inspect the helical gear and the spiral gear for damage or wear.

NOTE: The bevel gear and spiral gear are a matched set. Their alignment is critical. Do not replace them separately.

6. Lift the bearing the spiral shaft goes through from the housing to remove it. See Figure 7-44.



Figure 7-44. Lift Bearing from Housing

Bearing Cup and Shim Removal

NOTE: The bearing cups and cones are usually damaged during removal. They must be replaced as sets.

1. Use the mallet and a long punch to drive the spiral gear bearing cup from the housing. Take care not to damage the shims. Save the shims for reference in reassembly. See Figure 7-45.



Figure 7-45. Spiral Gear Bearing Cup Removal

2. Use the mallet and a punch to drive the helical gear bearing cup from the housing. See Figure 7-46.



Figure 7-46. Helical Gear Bearing Cup Removal

3. Remove the axle shaft bearing cup from the housing using the punch and mallet. See Figure 7-47.

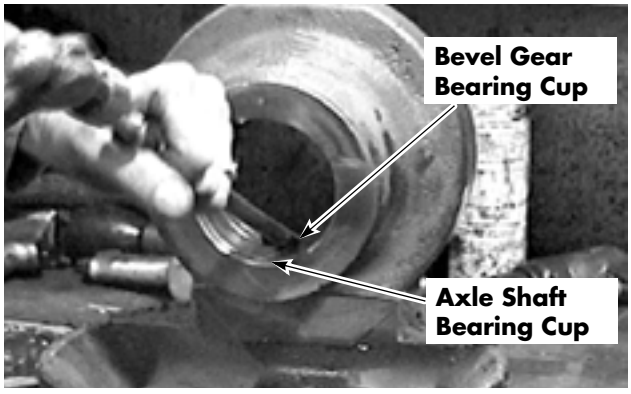


Figure 7-47. Axle Shaft and Bevel Gear Bearing Cup Removal

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4. Use the mallet and a punch to drive the bevel gear bearing cup from the housing. Take care not to damage the shims. Save the shims for reference in reassembly.
5. Visually inspect the housing bores and sealing surfaces for damage or wear.

Spur Gear Removal

Check the spur gear for damage or wear. If the spur gear is damaged, use a drift punch and mallet to remove it from the housing. See Figure 7-48.



Figure 7-48. Spur Gear Removal

Housing Cleaning and Inspection

Thoroughly degrease the housing. Visually inspect the entire housing again for excessive damage, cracks, or wear.

Axle Shaft Disassembly

⚠CAUTION

Always watch for pinch points when using a press or pressing tools.

1. Place a bearing puller clamp between the axle seal and beneath the axle bearing cone.
2. Press the bearing from the axle using a bearing press and a 6 in. tube. See Figure 7-49.



Figure 7-49. Bearing Removal

3. Lift the axle seal from the axle. See Figure 7-50.



Figure 7-50. Lift Seal Removal

4. Inspect the axle for damage or wear. See Figure 7-51.



Figure 7-51. Axle Inspection

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Bevel Gear Disassembly

⚠CAUTION

Always watch for pinch points when using a press or pressing tools.

1. Place the bearing puller clamp on the bevel gear beneath the bearing. See Figure 7-52.



Figure 7-52. Puller Clamp on Bevel Gear

2. Press the bearing from the bevel gear using a bearing press and an 8 in. tube. See Figure 7-53.



Figure 7-53. Press Bearing from Bevel Gear

Spiral Gear Disassembly

1. Place a bearing puller clamp beneath the bearing cone on the spiral gear. See Figure 7-54.



Figure 7-54. Puller Clamp on Spiral Gear

2. Press the bearing from the spiral gear using a bearing press. See Figure 7-55.



Figure 7-55. Pressing Bearing from Spiral Gear

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Assembly Procedures

CAUTION

Safety glasses are required.

Prepare the housing for assembly by running a tap through all bolt and screw holes. Cleaning the threads ensures there is no damage. It also enables you to determine the correct tooling to use in the assembly process.

Before beginning assembly of the drive unit, record the bearing seat data stamped on the housing. Record the setting distance information stamped on the bevel and spiral gears. This data is used in the formula to determine shim thickness later on.

Gear Set Assembly

1. Press the bearing cone on the bevel gear until it is seated. Place the matching bearing cup on the bearing cone for measuring purposes. See Figure 7-56.



Figure 7-56. Press Bearing on Bevel Gear

2. Press the bearing cone on the spiral gear until it is seated. Place the matching bearing cup on the bearing cone for measuring purposes. See Figure 7-57.

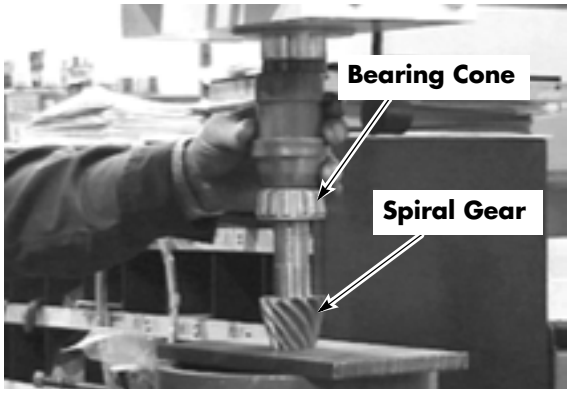


Figure 7-57. Press Bearing onto Spiral Gear

CAUTION

Always watch for pinch points when using a press or pressing tools.

3. Use a bearing zero offset tool and the formulas on page 7-31 to determine the shim thickness that is required to assemble the gear set in the housing.

Calculate Shim Formulas

Spiral pinion gear shim calculation:

- A = Dimension A (See Figure 7-58.) stamped on housing (4.438)
- B = Number (See Figure 7-59.) etched on gear (S/D 2.378)
- C = Zero Offset (See Figure 7-60.)

  Use a dial indicator to determine the zero offset. Turn the spiral gear as if seating the bearings. Record the data from the dial indicator to use in the formula.
- D = Plug Height (2.025)
- E = B + C + D
- F = A - E

  F = Shim thickness required

This calculation is used to determine the shim amount behind the bearing cup in the main housing. The shim(s) positions the spiral gear for correct backlash.

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Figure 7-58. Record Bearing Seat Data from Housing



Figure 7-59. Record Bearing Seat Data from Spiral Gear

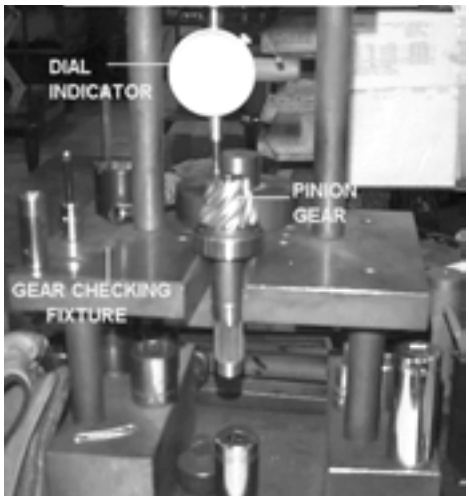


Figure 7-60. Check Zero Offset of Spiral Gear

Bevel gear shim calculation:

- G = Dimension B (See Figure 7-61.) stamped on housing (2.506)
- H = Number (See Figure 7-62.) etched on gear (S/D 0.541)
- J = Zero Offset (See Figure 7-63.)

  Use a dial indicator to determine the zero offset. Turn the bevel gear as if seating the bearings. Record the data from the dial indicator to use in the formula.
- K = Plug height (1.875)
- L = H + J + K
- M = G - L

  M = Shim thickness required

This calculation is used to determine the shim amount behind the bearing cup in the main housing. The shim(s) positions the bevel gear for correct backlash.



Figure 7-61. Record Bearing Seat Data from Housing

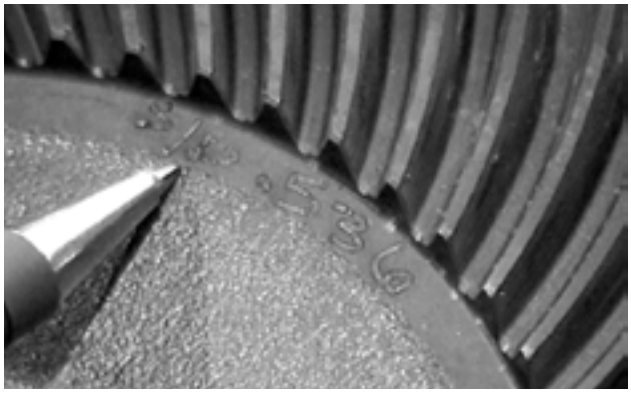


Figure 7-62. Record Bearing Seat Data from Bevel Gear

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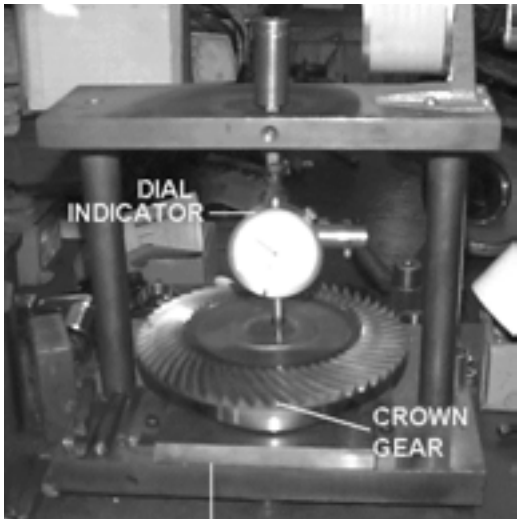


Figure 7-63. Check Zero Offset of Bevel Gear

Housing Bearing Cup and Shim Assembly

1. Place the spiral gear shims in the housing, then place the bearing cup in the housing. See Figure 7-64.



Figure 7-64. Spiral Gear Bearing Cup Installation

2. Install the bearing cup into the housing bore. See Figure 7-65.



Figure 7-65. Drive In Bearing Cup

3. Place the bevel gear shim in the housing, followed by the bearing cup. Use a press or mallet to press the bearing cup into the housing bore. See Figure 7-66.

NOTE: Make sure to wipe away any chips or excess metal pieces resulting from driving the race to seat it.



Figure 7-66. Bevel Gear Bearing Cup Installation

4. Place the drive axle bearing cup in the housing. Use a mallet or press to seat the axle bearing cup in the housing. See Figure 7-67.

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Figure 7-67. Axle Bearing Cup Installation

5. Turn the drive unit housing over. Install the helical bearing cup in the housing. Use a press or mallet to seat the bearing cup in the housing. See Figure 7-68.



Figure 7-68. Helical Bearing Cup Installation

Helical Gear/Spiral Pinion Gear Assembly

NOTE: The pinion shaft and bevel gear are a matched set. Their alignment is critical. Do not replace them separately.

⚠ WARNING

Bearing can become extremely hot. Use gloves to protect hands from burns.

1. Preheat the bearing cone with a bearing heater. See Figure 7-69.



Figure 7-69. Preheat Bearing Cone

NOTE: Steps 2 thru 5 need to be completed before the bearing cools to provide a correct installation.

2. Install the heated bearing cone in the bearing cup in the housing.
3. Place the spacer over the bearing cone, then place the helical gear into the housing.



Figure 7-70. Install Helical Gear

4. Install the spiral pinion gear shaft up through the helical gear. Push up until the spiral gear bearing is seated against its race. See Figure 7-71.

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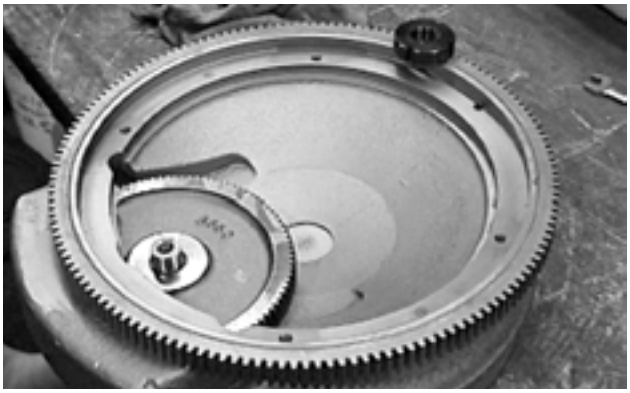


Figure 7-71. Spiral Pinion Gear Installation

5. Place the clamp nut on the end of the spiral pinion gear shaft and hand tighten until the bearing cools. See Figure 7-72.

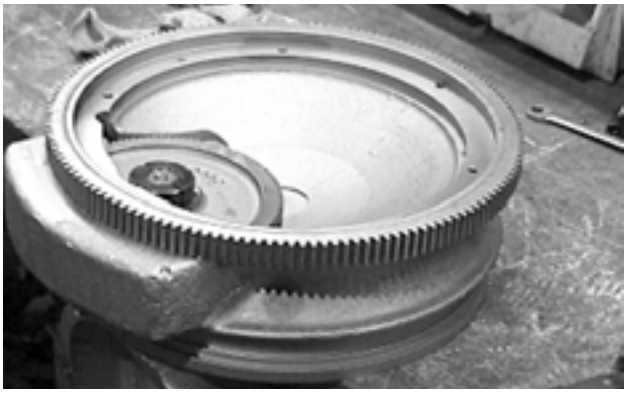


Figure 7-72. Install Clamp Nut

6. When the bearing has cooled, spin the helical gear to check for end play. Remove any end play in the bearings between the helical gear and the spiral gear using a nut driver tool (P/N 761-870/T04) and a wedge. Slowly tighten the clamp nut on the end of the spiral gear until there is no end play between the gears. Use a spin and tighten method to tighten clamp nut as the bearings are seating in the races. See Figure 7-73.

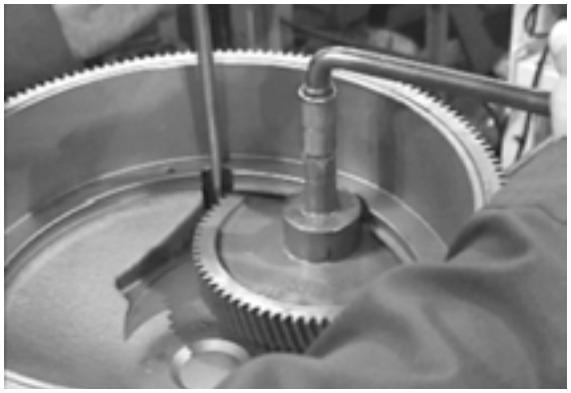


Figure 7-73. Removing End Play

7. Tighten the clamp nut the distance of a spanner nut space to preload the gears.
8. Back the nut off, then hand tighten.
9. Apply thread-locking compound (P/N 990-544) to the set screw in the clamp nut. Torque the set screw to 140 in. lbs. (15.8 N•m). See Figure 7-74.



Figure 7-74. Applying Locking Compound to Set Screw

10. Spin the helical gear to make sure there is no end play or that the bearings are not too tight.

Axle Assembly

1. Lubricate the oil seal. Place the seal over the axle shaft with the spring side toward the oil.

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Figure 7-75. Axle Seal Installation

2. Place the axle bearing cone over the axle shaft. Press the bearing cone on the axle shaft until it is seated. See Figure 7-76.

⚠CAUTION

Always watch for pinch points when using a press or pressing tools.



Figure 7-76. Axle Bearing Cone Installation

3. Apply a thin layer of gasket compound to the housing to seal the axle seal. See Figure 7-77.



Figure 7-77. Apply Gasket Compound to Sealing Surface

4. Place the bevel gear into the housing. See Figure 7-78.

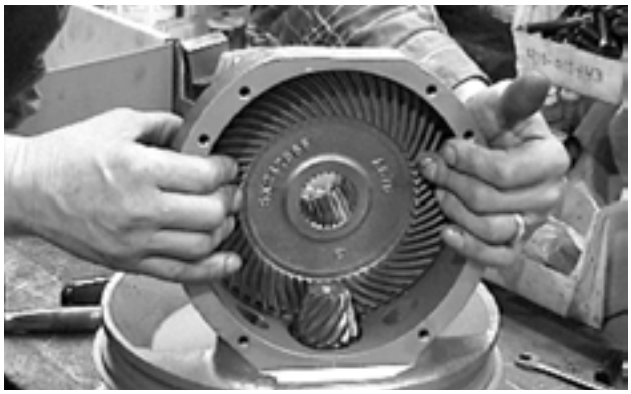


Figure 7-78. Bevel Gear Installation

5. Place a seal pressing ring (P/N 828-004-901) beneath the axle seal. Install the axle shaft through the bevel gear. See Figure 7-79.

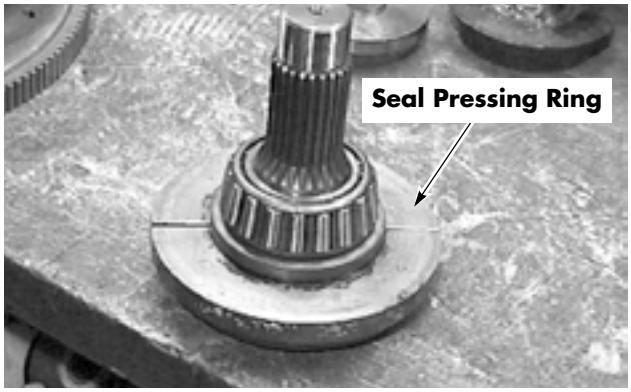


Figure 7-79. Axle Seal Pressing Ring

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6. Press the axle into the housing until the seal is fully installed. See Figure 7-80.

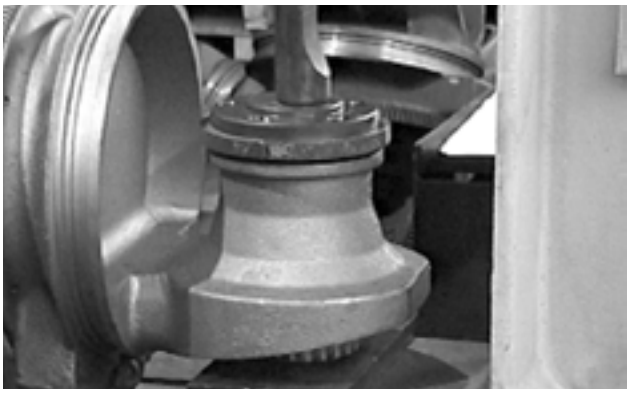


Figure 7-80. Press Axle into Housing

⚠CAUTION

Always watch for pinch points when using a press or pressing tools.

7. Remove the seal pressing ring.
8. Apply thread-locking compound (P/N 990-544) to the threads of the axle.
9. Install the clamp nut. Hold the axle to keep it from turning as the clamp nut is tightened.
10. Use clamp nut tool P/N 761-870/T07 and torque the clamp nut to 18 ft. lbs. (24 N•m). See Figure 7-81.



Figure 7-81. Tighten Clamp Nut to Seat Bearings

11. Rotate the axle and tighten the clamp nut. Repeat this step six times to make sure the bearing cones are seated into the cups.
12. Loosen the clamp nut, then retighten to 5 ft. lbs. (7 N•m) using the rotate, tightening process until the clamp nut does not turn any further.
13. Apply thread-locking compound (P/N 990-544) to the set screw in the clamp nut. See Figure 7-82. Torque the set screw to 140 in. lbs. (15.8 N•m).

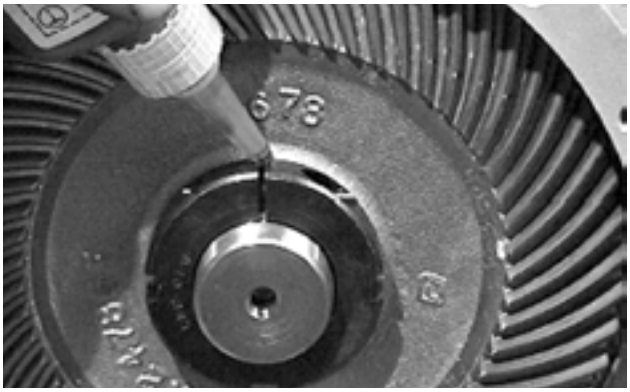


Figure 7-82. Applying Locking Compound to Set Screw

Measuring Backlash

NOTE: Backlash tolerance is critical to the performance of the drive unit. Incorrectly adjusted units will experience premature failure.

1. Place a gear locking tool on the helical gear and secure. See Figure 7-83.

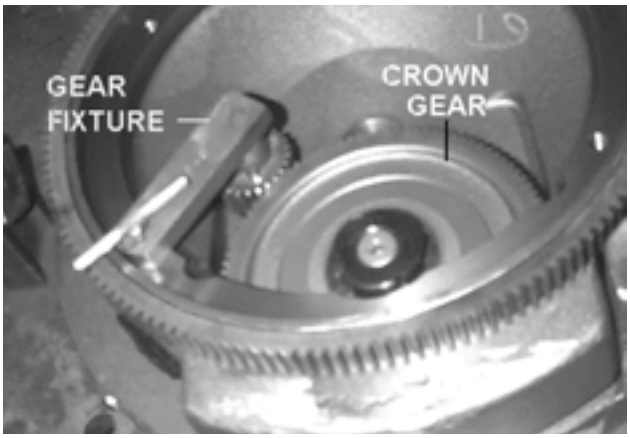


Figure 7-83. Gear Locking Tool

2. Position the probe of the dial indicator at the heel of the bevel gear tooth. Position

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the dial indicator probe perpendicular to the gear tooth surface.

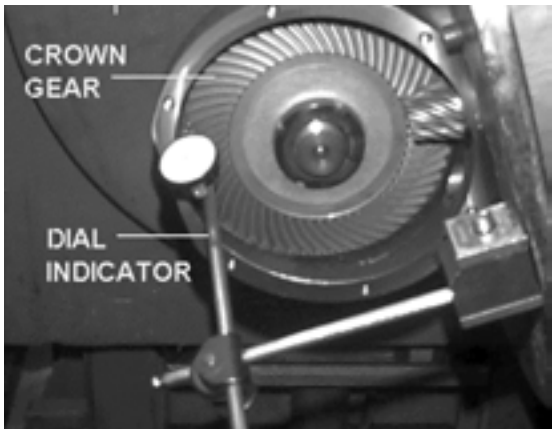


Figure 7-84. Dial Indicator Position

3. Zero the indicator. Clasp the bottom of the gear and rotate it. Read the backlash measurement on the dial indicator. **Total backlash tolerance is between 0.004 and 0.006 in.**

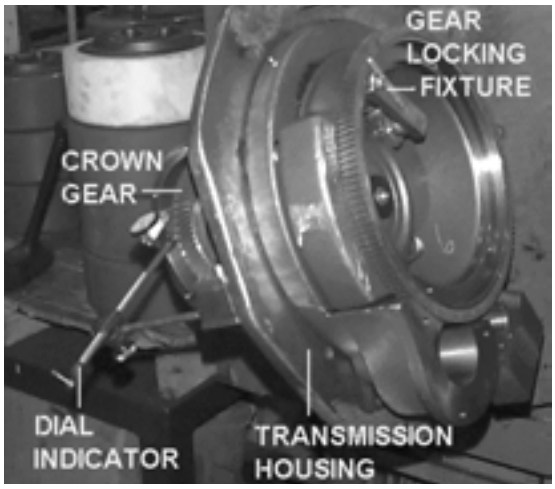


Figure 7-85. Measure Backlash

4. If the tolerance is not within the acceptable limits, calculate any necessary adjustments to the shims. Remove the clamp nut, axle assembly, and bevel gear. Install the correct amount of shims, and repeat Steps 3 and 4 of "Housing Bearing Cup and Shim Assembly" procedure on page 7-33.

Repeat steps 1 thru 3 of this procedure until the backlash is between 0.004 and 0.006.

5. When backlash is within the acceptable range, install the pivot ring.

Pivot Ring Assembly

1. Place a light coating of thread-locking compound (P/N 990-544) in the hole on the pivot ring assembly.
2. Line up the grease fitting hole with the grease fitting port. See Figure 7-86.



Figure 7-86. Spherical Bearing Alignment

3. Install the spherical bearing using a mallet or press. See Figure 7-87.



Figure 7-87. Install Spherical Bearing

4. Install the grease fitting in the pivot ring assembly using a grease fitting driver and a mallet or press. See Figure 7-88.

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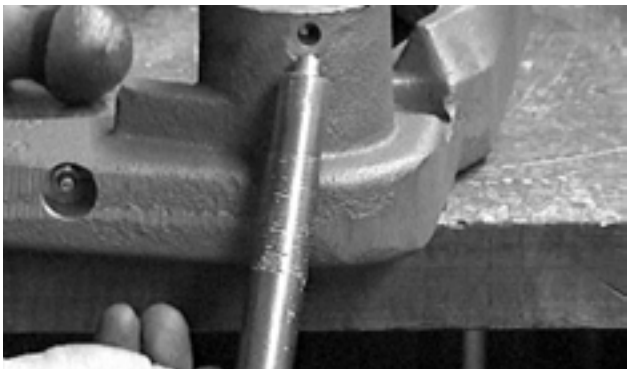


Figure 7-88. Grease Fitting Installation

5. On the inside of the pivot ring, make sure the roll pins are installed and in good condition on either side of the bearing filler plug hole. If they are missing or damaged, install new roll pins. See Figure 7-89.

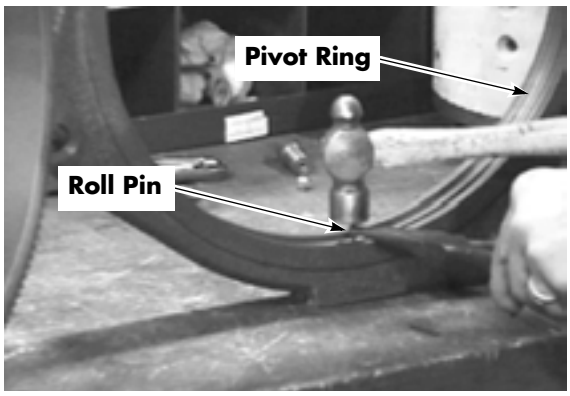


Figure 7-89. Roll Pin Installation

6. Install the radial rings so that the gap aligns with the bearing hole. Install the flat radial ring on the inside flat surface of the pivot ring. Then install the chamfered radial rings to the pivot ring. The chamfered edges will face the steel balls. The ends of the radial ring are against the roll pins. See Figure 7-90.

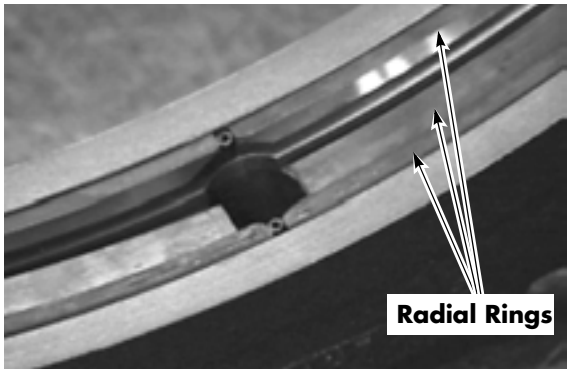


Figure 7-90. Radial Ring Installation

7. Install the brass bushing using a mallet or press. See Figure 7-91.



Figure 7-91. Brass Bushing Installation

Drive Unit Assembly

1. Install the radial rings on the housing. Stagger the ends of the rings around the housing so the gaps are not aligned. The beveled edges will face the steel balls. See Figure 7-92.

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Figure 7-92. Radial Ring Installation on Housing

2. Install the pivot ring assembly to the housing. The spherical bearing should face the spur gear. See Figure 7-93.



Figure 7-93. Pivot Ring Installation

3. Place one steel ball at a time into the pivot ring filler hole. Use a screwdriver to direct the steel balls first to one side then the other. See Figure 7-94.

NOTE: Count the steel balls as they are inserted in the pivot ring assembly for correct pivot ring operation. The drive unit requires 65 balls. Too many balls will cause binding and too few balls will cause excessive motion.



Figure 7-94. Ball Bearing Installation

4. Place the bearing filler plug in the filler hole. The grease fitting should face the spur gear.



Figure 7-95. Bearing Filler Plug Installation

⚠CAUTION

Excessive thread-locking compound will damage the ball bearings and pivot ring. Use thread-locking compound sparingly.

5. Apply thread-locking compound (P/N 990-536) sparingly to the filler plug bolts. Install the bolts and flat washers on each side of the grease fitting. Tighten to 20 ft. lbs. (27 N•m). See Figure 7-96.

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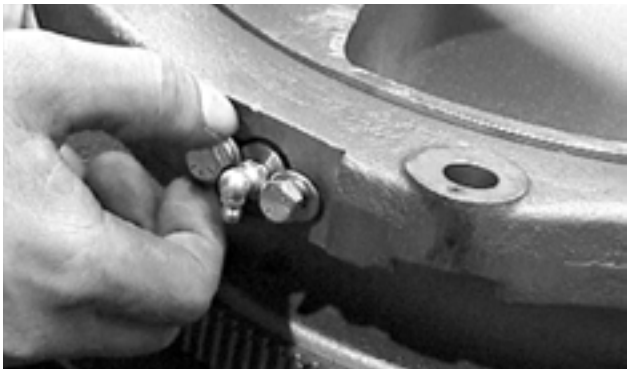


Figure 7-96. Filler Plug Bolt Installation

6. Grease and then test the pivot ring. Check to see that it spins freely.

Housing Cover Installation

1. Clean the cover mating surface. Apply gasket compound (P/N 990-443) to the surface where the cover contacts the housing. See Figure 7-97.

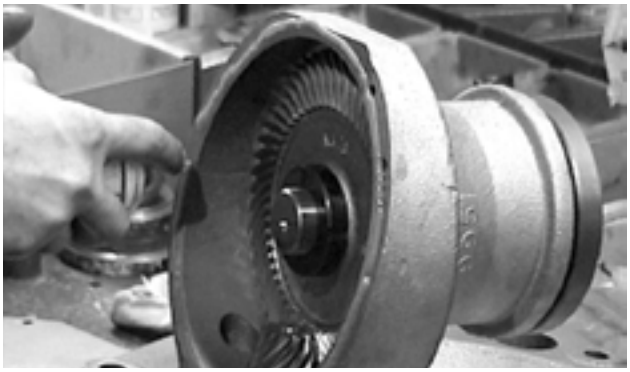


Figure 7-97. Apply Gasket Compound

2. Install the cover bolts. Torque to 20 ft. lbs. (27 N•m). See Figure 7-98.



Figure 7-98. Tighten Cover Bolts

3. Apply thread-locking compound (P/N 990-626) to the drain plug.
4. Install the drain plug in the cover plate. Torque to 15 ft. lbs. (20 N•m).

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Drive Unit - Heavy Duty

Pivot Ring Inspection

The fit of pivot ring bearings in the drive unit is such that some play is expected. However, as the radial rings wear, the play may increase. If the play is permitted to become extreme, it will become quite noticeable in the drive unit.

If worn rings are suspected as the cause of excessive play in the drive unit, inspect the drive housing to determine if the bearing radial rings must be replaced:

1. Jack the tractor of the truck up just enough to permit the drive tire to clear the floor.

⚠ WARNING

Use extreme care whenever the truck is jacked up. Keep hands and feet clear from vehicle while jacking the truck. After the truck is jacked, place solid blocks beneath it to support it. Do *not* rely on the jack alone to support the truck.

2. Place a magnetic base dial indicator on the deck plate and position the indicator point on top of the drive unit top cover.
3. Adjust the dial indicator to zero then lower the truck to the floor.
4. Note the new indicator reading. If the reading is 0.089 in. (2.26 mm) or less the radial rings do *not* have to be replaced. If the reading exceeds 0.089 in. (2.26 mm) the rings must be replaced. If the reading is between 0.055 and 0.089 in. (1.4 and 2.26 mm) the bearing rings must be checked during future scheduled maintenance visits.

Drive Unit Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the bumper gate. See Figure 7-99.

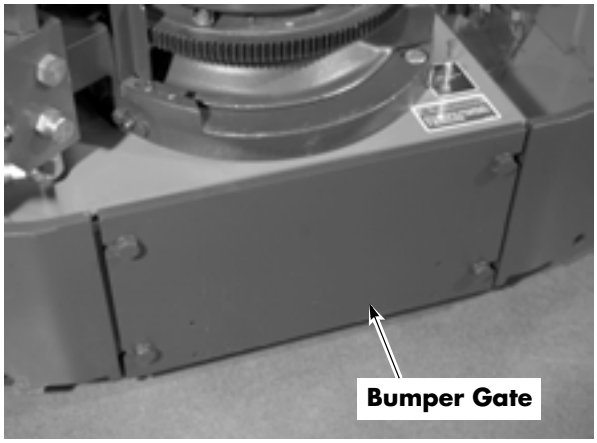


Figure 7-99. Removing Drive Unit

3. If the truck is wire guided, remove the sensor mounted on the backside of the bumper gate.
4. If the drive tire is to be removed, loosen the lug nuts.
5. Remove the proximity sensor and associated hardware on the drive unit casting.
6. Remove drive motor. See Drive Motor on page 7-22.

NOTE: If the drive unit is the only item requiring service, separating the brake assembly from the drive motor is not necessary.

⚠ WARNING

Use extreme care whenever the truck is jacked up for any reason. Never block the truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from beneath vehicle while jacking. Use jack stands or solid blocks to support truck. DO NOT rely on the jack alone. See Jacking on page 2-8.

7. Jack and block the tractor so the drive tire is off the floor.
8. Drain oil from drive unit.
9. Unbolt the lift/lower manifold from the drive unit casting.

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10. Remove the steering motor/gear reducer assembly.
11. Remove cap screws holding the drive unit assembly to the tractor.
12. Lift drive unit out of tractor frame using a suitable lifting device.
13. Clean the outside of the drive unit thoroughly and drain any remaining oil from the drive unit by removing the drain plug.
14. Visually inspect the outside of the housing for damage, wear or cracks.

Pivot Ring Disassembly

1. On the pivot ring, remove the grease fitting and the bearing filler plug. Inspect the bearing filler plug hole for uneven wear. See Figure 7-100.

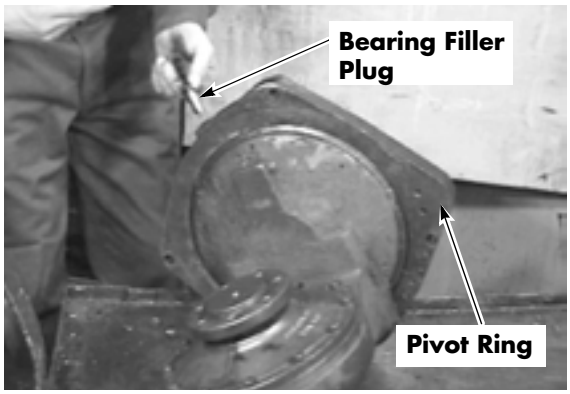


Figure 7-100. Grease Fitting and Filler Plug Removal

2. Turn the pivot ring to remove the steel balls through the bearing filler plug hole. See Figure 7-101.

NOTE: If the pivot ring will not spin or even turn, it is an indication of damaged radial rings and/or excessive wear to the channel in housing. If this is the case, replace the entire drive unit. No further disassembly is necessary.

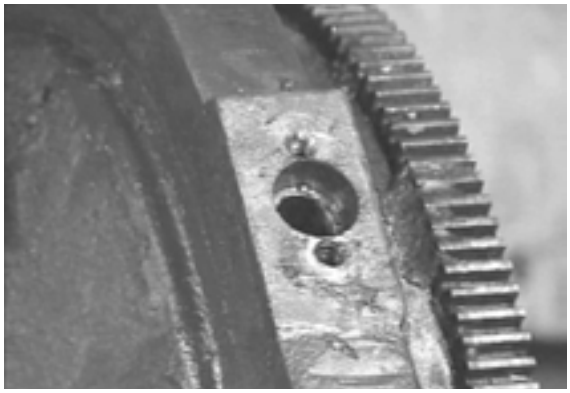


Figure 7-101. Remove Steel Ball Bearings

3. After removing all the steel balls, remove the pivot ring by working it off toward drive end of the housing. See Figure 7-102.



Figure 7-102. Pivot Ring Removal

4. Remove the radial rings from the channel in the housing and inside the pivot ring. See Figure 7-103.

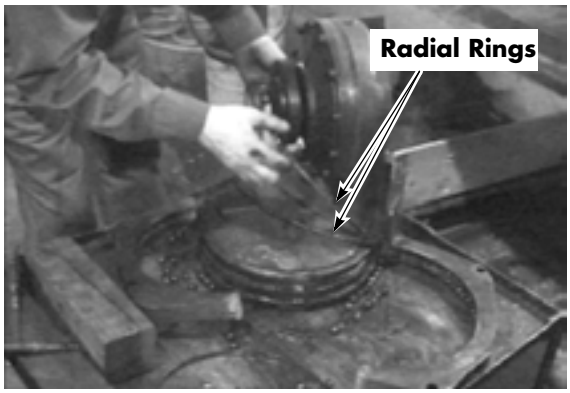


Figure 7-103. Radial Ring Removal

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5. Remove the roll pins and grease fittings from the pivot ring to ensure thorough cleaning.

⚠CAUTION

Due to normal or excessive wear, the edges of the radial rings could be very sharp.

6. Clean the grease from the radial ring channel in the housing. Inspect the channel for uneven wear. Also clean and inspect the inside of the pivot ring.

Main Cover and Output Shaft Disassembly

1. Visually inspect the housing around the main cover for wear outside the cover bolts.

NOTE: Excessive housing wear outside the cover bolts can make them difficult to remove. If this occurs, replace the entire drive unit. No further disassembly is necessary.

2. Remove the main cover bolts.
3. Using a mallet, knock the flanged output shaft to break the seal on the main cover.
4. Remove the main cover and output shaft assembly. See Figure 7-104.

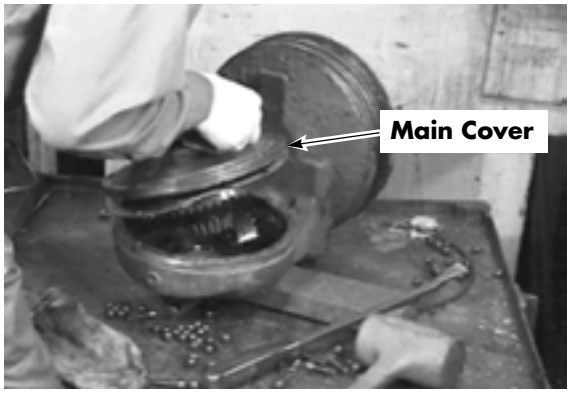


Figure 7-104. Cover and Output Shaft Removal

5. A press and 8 in. x 6 in. tube are required to remove the bearing cup on the end of the output shaft.

⚠CAUTION

Always watch for pinch points when using a press or pressing tools.

Safety glasses are required after this point in disassembly.

6. Place the main cover assembly, gear side down, on the tube under press. Press the output shaft down slightly to create a space between the bevel gear and the output bearing spacer. See Figure 7-105.

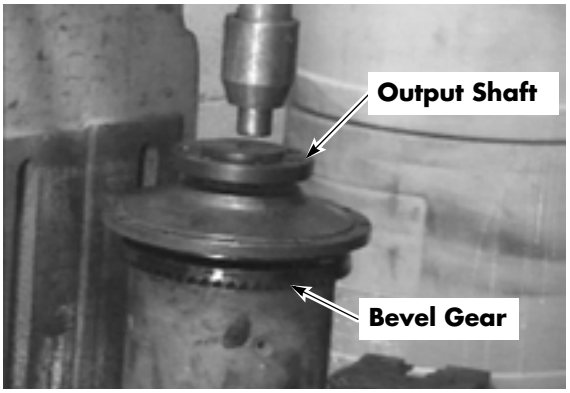


Figure 7-105. Press Down Output Shaft

7. Tighten a bearing puller clamp under the lip of the output bearing spacer, being careful not to catch the exterior retaining ring. See Figure 7-106.



Figure 7-106. Bearing Puller Clamp Installation

8. Place the main cover assembly, gear side up, on a 12 in. x 6 in. tube so the bearing puller clamp is resting on the tube. Press

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out the flanged output shaft and the output bearing spacer.

9. Remove the exterior retaining ring.
10. To remove the bevel gear, support the main cover assembly on an 8 in. x 6 in. tube under press. Press the output shaft down through the bevel gear. The bearing cone is removed at the same time. See Figure 7-107.

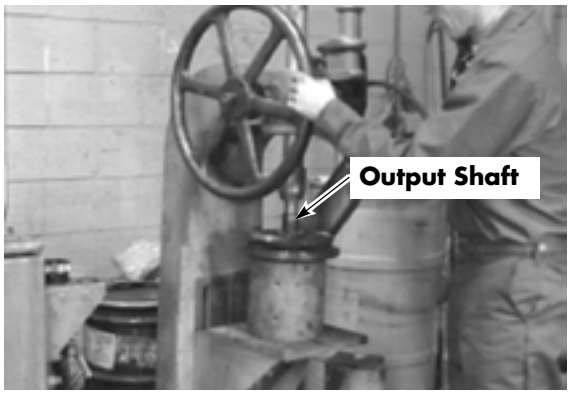


Figure 7-107. Bevel Gear Removal

11. Remove the bearing cup from the main cover with a race driver and pry bars.
12. Remove the lip seal from the main cover. See Figure 7-108.

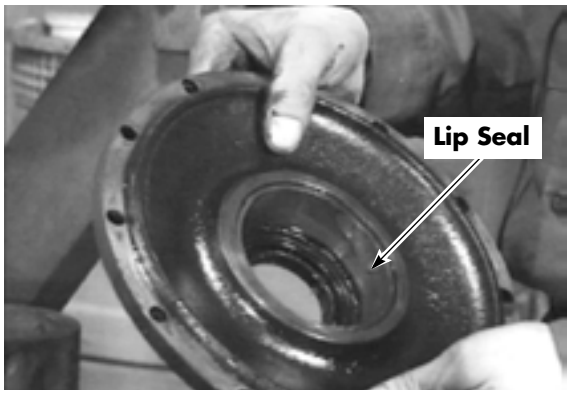


Figure 7-108. Bearing Cup and Lip Seal Removal

13. Remove the output shaft bearing cone in the base of the housing using two pry bars. Insert the pry bars under the bottom edge of the cone on opposite sides. Apply even pressure on both tools to lift the cone out. See Figure 7-109.

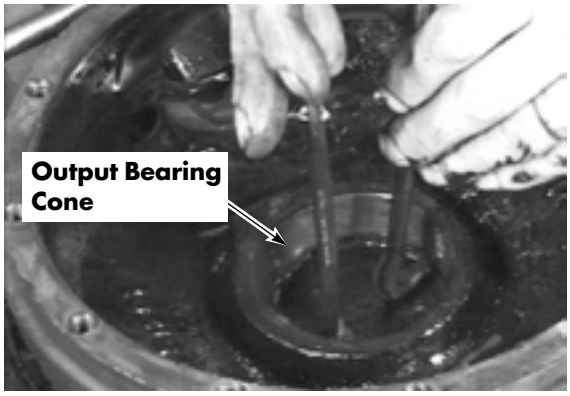


Figure 7-109. Output Shaft Bearing Cone Removal

14. Remove the shims from the housing bore. Save shims for reference only, as they are usually damaged when removing the bearing cone.
15. Remove the cover shims. Save the shims for reference only.

Spiral Pinion Disassembly

NOTE: The spiral pinion and bevel gear are a matched set. Their alignment is critical. Do not replace them separately.

1. Loosen the set screw on the clamp nut on the spiral pinion gear shaft. Using Tool 761-870/T03, remove the clamp nut. See Figure 7-110.

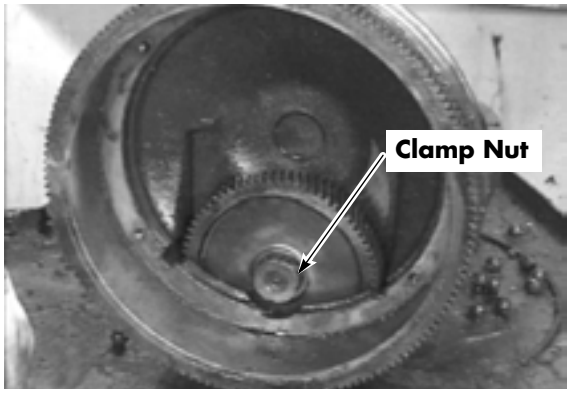


Figure 7-110. Clamp Nut Removal

2. Using a brass punch and hammer, drive the spiral pinion gear shaft out of the housing. See Figure 7-111.

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NOTE: You may need to remove the spiral pinion with a press or pressing device equivalent.



Figure 7-111. Spiral Pinion Removal

3. Remove the helical gear and the bearing cone from the housing.
4. Drive out the bearing cup. Inspect the bearing cup and housing bores for wear. See Figure 7-112.

NOTE: The bearing cups and cones are usually damaged during removal. They must be replaced as sets.

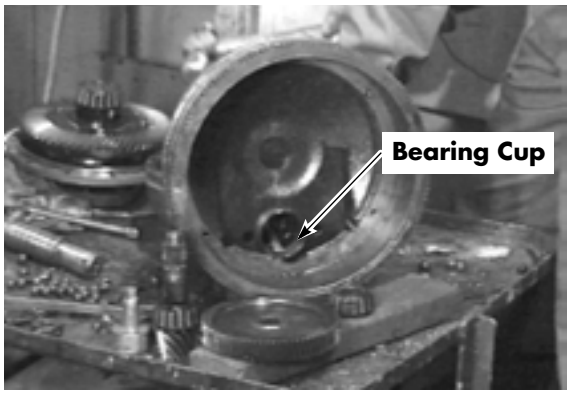


Figure 7-112. Bearing Cup Removal

Thoroughly wash the housing and visually inspect the entire housing again for excessive damage, wear, or cracks.

Assembly Procedures

CAUTION

Safety glasses are required.

Prepare the housing for assembly by running a tap through all bolt and screw holes. Cleaning the threads also ensures that there is no damage.

Spiral Pinion Assembly

1. Using a press or mallet, install the bearing cup into the housing bore. See Figure 7-113.



Figure 7-113. Bearing Cup Installation

2. Install the second bearing cup into the housing bore on the opposite side.

CAUTION

Always watch for pinch points when using a press or pressing tools.

3. Press the bearing cone onto the spiral pinion gear shaft until it is seated. See Figure 7-114.

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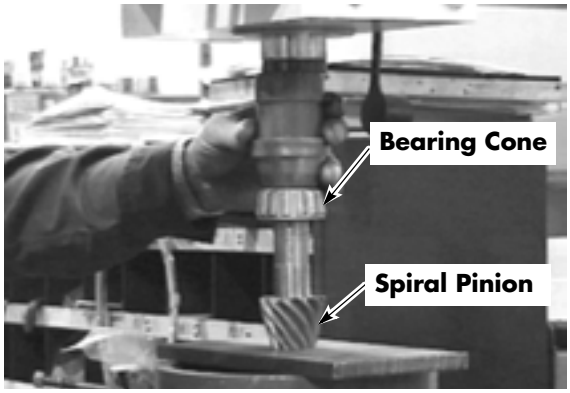


Figure 7-114. Pressing Bearing onto Spiral Pinion

Main Cover and Output Shaft Assembly

1. Before installing the output shaft lip seal, apply a thin layer of sealing adhesive around the seal surface of the main housing. Install the lip seal, spring side down, in the housing. See Figure 7-115.

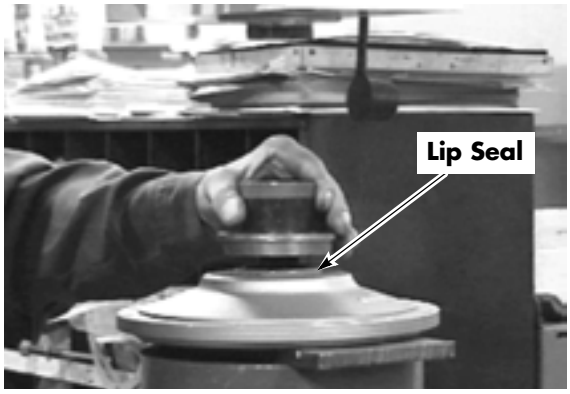


Figure 7-115. Press Lip Seal

2. Press the lip seal into the housing until it is just below flush with the housing surface.
3. Press the output bearing cup into the main cover until it is seated. Place the bearing cone into the bearing cup. See Figure 7-116.

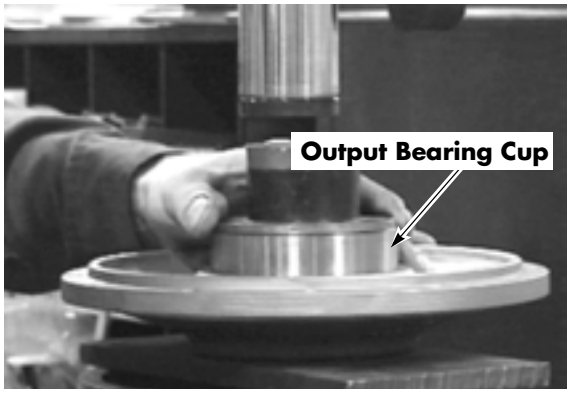


Figure 7-116. Pressing Output Bearing Cup

4. Push down on the bearing and turn to seat bearing into the cup.
5. Using dial indicators, measure dimension D from the edge of the bearing cone to the main cover flange surface. See Figure 7-117.



Figure 7-117. Bearing Cone to Flange Measurement

6. The reading on the two dial indicators should be the same. If they are different, repeat steps 4 and 5 until the readings are identical. Record final reading as dimension D on flange surface. This is required during final assembly.
7. Remove the bearing cone in preparation for installing the flanged output bearing shaft.
8. Use a light oil on the surface of the lip seal and inside the bearing cup.
9. Place the main cover down over the output shaft, flange side up. Place the bearing

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cone down over the output shaft. See Figure 7-118.

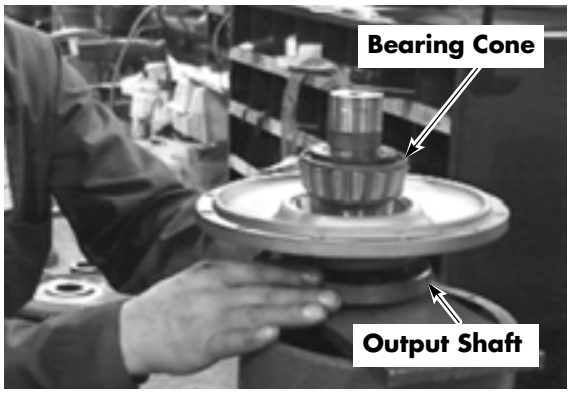


Figure 7-118. Install Main Cover and Bearing Cone

10. Press the bearing cone onto the output shaft. See Figure 7-119.



Figure 7-119. Pressing Bearing Cone

11. Place the bevel gear down over the output shaft, teeth side up. Press the bevel gear down, seating the bearing cone into the bearing cup. See Figure 7-120.

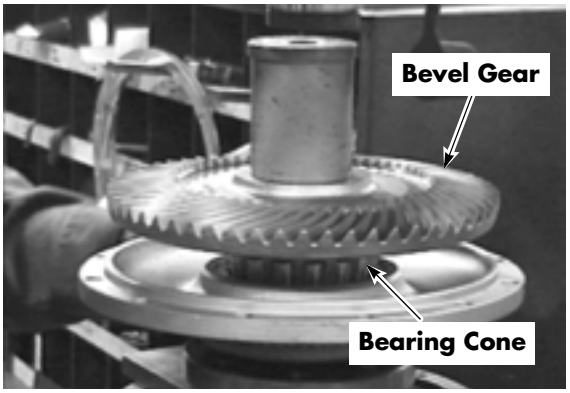


Figure 7-120. Pressing On Bevel Gear

12. Install the external retaining ring on the output shaft. Pull up on the bevel gear to make sure the external retaining ring is installed securely.
13. Place the output bearing spacer, with the recessed area down, over the output shaft. Place the bearing cone on top of the output shaft. See Figure 7-121.

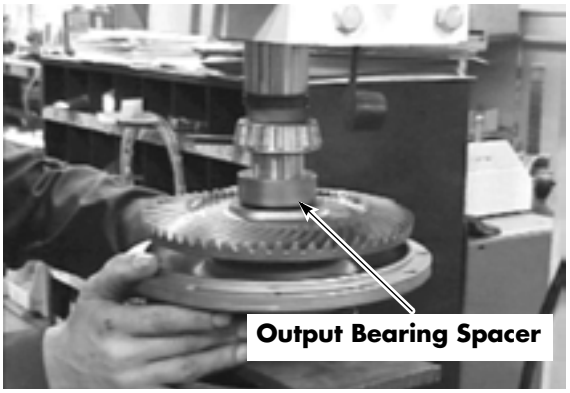


Figure 7-121. Pressing Down Bearing Cone

14. Press the bearing cone down until it is fully seated against the spacer and snap ring.
15. Press the bearing cone into place. At the same time, pull the gear sideways to eliminate any backlash in the spline area. See Figure 7-122.

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Figure 7-122. Eliminate Backlash

16. Place bearing cup onto bearing and rotate cup while applying downward pressure to seat the bearing. See Figure 7-122.
17. Using dial indicator(s), check that the bearing is correctly seated. The readings on the two dial indicators should be the same. If they are different, repeat steps 15 and 16 until the readings are identical. See Figure 7-123.



Figure 7-123. Bearing Cup to Flange Measurement

18. Record final readings as Dimension E. This is required during final assembly.

Helical Gear Assembly

NOTE: The pinion shaft and bevel gear are a matched set. Their alignment is critical. Do not replace them separately.

⚠ WARNING

Bearing can become extremely hot. Use gloves to protect hands from burns.

1. Preheat the bearing cone with a bearing heater. Install the heated bearing cone in the bearing cup in the housing.

NOTE: Steps 2 thru 4 need to be completed before the bearing cools.

2. Place the helical gear into the housing.
3. Install the spiral pinion gear shaft up through the helical gear.
4. Put the clamp nut on the end of the spiral pinion gear shaft and hand tighten until the bearing cools. See Figure 7-124.

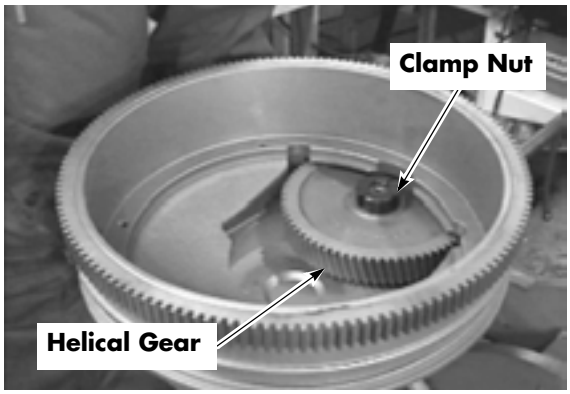


Figure 7-124. Helical Gear and Pinion Installation

5. While the bearing cone is cooling, calculate the formula for determining the required shim thickness.

Calculate Shim Formulas

- A = Dimension A stamped on housing (2.102/2.108)
- B = Dimension B stamped on housing (3.409/3.412)
- C = Number etched on back of gear (nominal 1.812)
- D = Distance from bearing to flange surface (see Figure 7-125)
- E = Distance from bearing cup to flange surface (see Figure 7-126)

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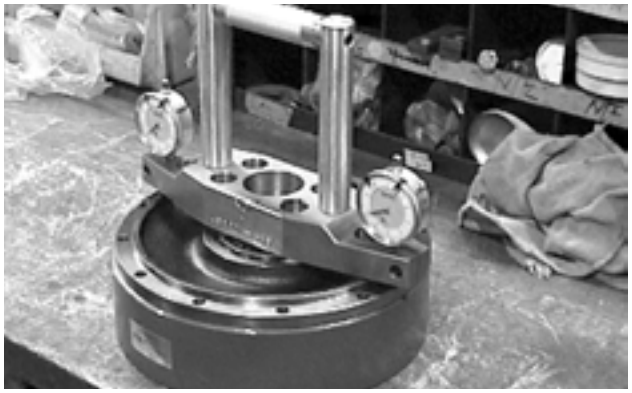


Figure 7-125. Bearing Cone to Flange Measurement



Figure 7-126. Bearing Cup to Flange Measurement

S1 = (B - A - E + D + C)

S1 = Shim amount behind bearing cup in main housing to position gear for correct backlash (S1).

S2 = E + S1 - B - 0.006 preload

S2 = Shim amount between cover plate face to set preload of bearings for output shaft (S2).

Installing and Testing Shims

1. Remove any end play in the bearings between the helical gear and the spiral gear using lock nut wrench (P/N 761-870/T03). Wedge the helical gear and tighten the clamp nut until there is no end play between the gears. See Figure 7-127.

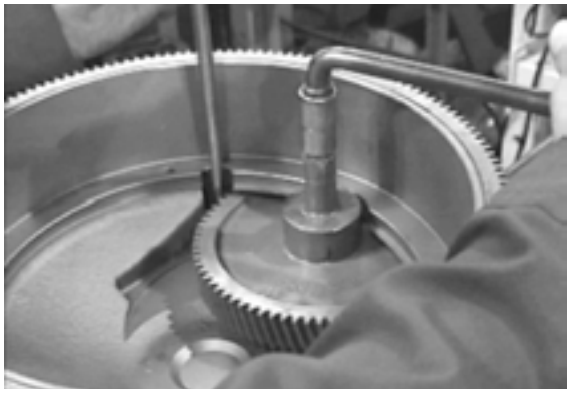


Figure 7-127. Removing End Play

2. Preload the helical gear for 0.000 to 0.002.
3. Remove any oil from the clamp nut. Apply thread-locking compound (P/N 990-544) to the threads in the clamp nut. Tighten the set screw in the clamp nut to 140 in. lbs. (15.8 N•m).
4. Spin the helical gear to ensure the bearings are not too tight.
5. One tooth on the spiral gear is etched or marked with an X. With a marker, mark that tooth surface for the purpose of lining up the spiral and bevel gears to check backlash. One tooth on the matching bevel gear is also marked. Mark that tooth surface also. See Figure 7-128.



Figure 7-128. Marking Spiral and Bevel Gears

6. Place the predetermined shims into the housing bore for the bearing cup. Install the bearing cup into the housing bore over the shims. See Figure 7-129.
7. Install the cover shims. See Figure 7-129.

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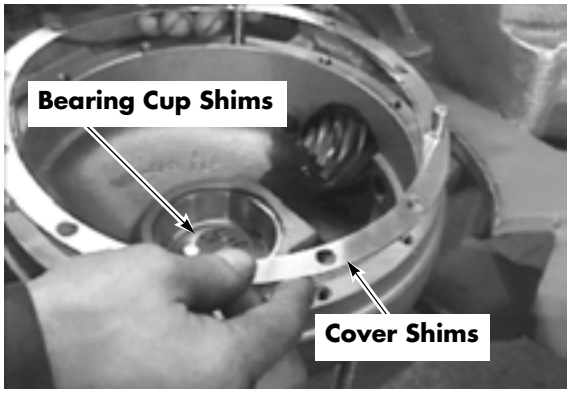


Figure 7-129. Cover Shims Installation

8. Place the main cover assembly over the shims, making sure to line up the marked teeth on both the spiral and bevel gears. See Figure 7-130.

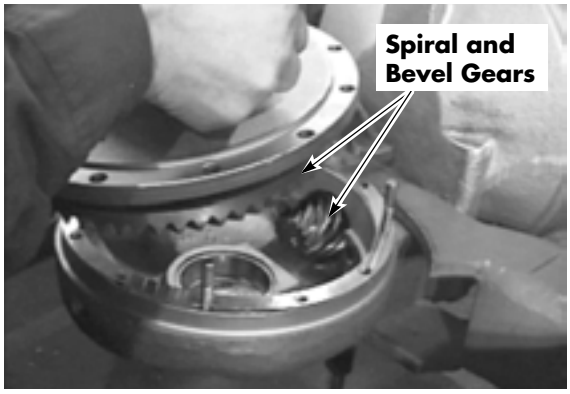


Figure 7-130. Lining Up Spiral and Bevel Gears

9. Install four housing cover bolts, evenly spaced, and tighten to 40 ft. lbs. (54 N•m).

Measuring Backlash

⚠CAUTION

Backlash tolerance is critical to the performance of the drive unit. Incorrectly adjusted units will experience premature failure.

1. Wedge the helical gear, then slightly turn the output shaft to determine backlash. Backlash reading on the dial indicator must be between 0.004 and 0.006 in. See Figure 7-131.

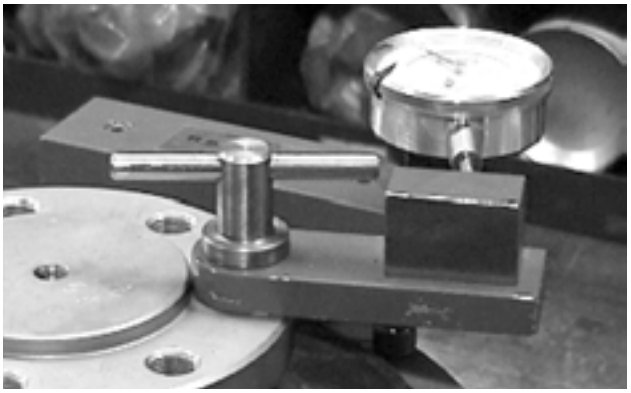


Figure 7-131. Measuring Backlash

2. Calculate any necessary adjustments to the shims. Remove the main cover assembly and the bearing cup, and adjust the shims.

   Repeat Steps 6 thru 9 in "Installing and Testing Shims" until backlash is between 0.004 and 0.006 in.

3. When backlash is within acceptable range, remove the main cover assembly and the cover shims.

Main Cover Installation

1. Clean the cover mating surface on the housing, then apply thread-locking compound (P/N 990-411) sparingly.
2. Install the cover shims and the main cover assembly. Install the main cover bolts and torque to 40 ft. lbs. (54 N•m).

⚠CAUTION

Safety glasses are required.

Pivot Ring Assembly

1. On the inside of the pivot ring, make sure the roll pins are installed and in good condition on either side of the bearing filler plug hole. If they are missing or damaged, install new roll pins. See Figure 7-132.

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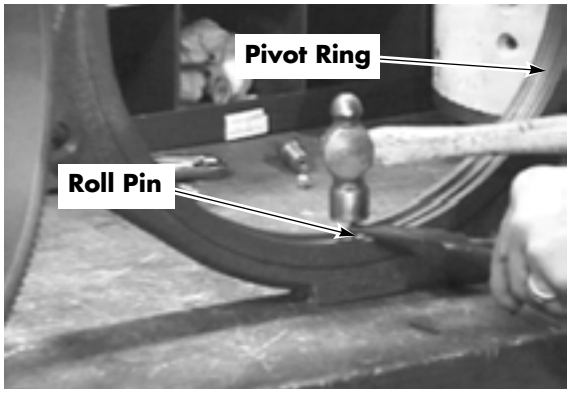


Figure 7-132. Roll Pin Installation

2. Install the grease fitting on the outside of the pivot ring.
3. Screw in the grease fitting in the bearing filler plug.
4. Using radial rings, install the flat radial ring on the inside flat surface of the pivot ring. Place the ends of the chamfered radial rings against the roll pins to install them in the pivot ring. See Figure 7-133.

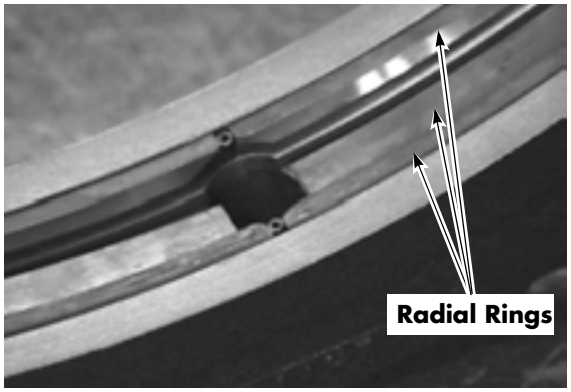


Figure 7-133. Radial Ring Installation

5. On the housing, install the radial rings. See Figure 7-134.

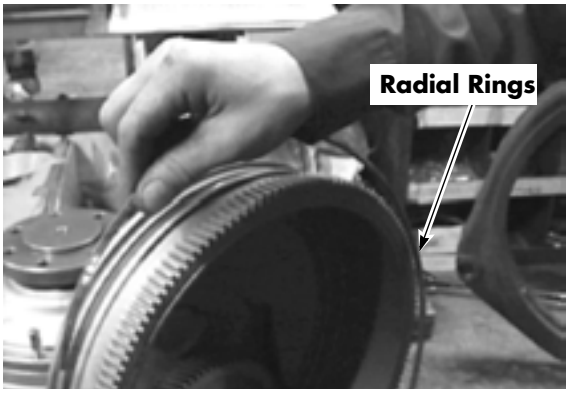


Figure 7-134. Outer Radial Ring Installation

6. Lift the drive end of housing and slide the pivot ring over the housing, being careful not to jar the radial rings out of place. Slide the pivot ring into place just behind the steering ring gear.
7. Make sure that the pivot ring bearing filler plug hole is on top, in preparation for installing the steel balls.
8. Put one ball at a time into the pivot ring filler hole. Use a screwdriver to direct the steel balls first to one side then the other. Continue until all 70 balls are installed. See Figure 7-135.



Figure 7-135. Install Ball Bearings

9. Fit the bearing filler plug with the grease fitting pointing toward the steering ring gear. See Figure 7-136.

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Figure 7-136. Bearing Filler Plug Installation

⚠CAUTION

Excessive thread-locking compound will damage the ball bearings and pivot ring. Use thread-locking compound sparingly.

10. Apply thread-locking compound (P/N 990-536) sparingly to the filler plug bolts. Install the bolts and washers on either side of the bearing filler plug and tighten to 20 ft. lbs. (27 N•m).
11. Grease and then test the pivot ring, checking to see that it spins freely.

Radial Ring Inspection

The fit of radial ring bearings in the drive unit is such that some play is expected. However, as the radial rings wear, the play may increase. If the play is permitted to become extreme, it will become quite noticeable in the drive unit.

If worn rings are suspected as the cause of excessive play in the drive unit, inspect the drive housing to determine if the bearing radial rings must be replaced:

1. Jack the tractor of the truck up just enough to permit the drive tire to clear the floor.

⚠ WARNING

Use extreme care whenever the truck is jacked up. Keep hands and feet clear from vehicle while jacking the truck. After the truck is jacked, place solid blocks beneath it to support it. Do *Not* rely on the jack alone to support the truck.

2. Place a magnetic base dial indicator on the deck plate and position the indicator point on top of the drive unit top cover.
3. Adjust the dial indicator to zero then lower the truck to the floor.
4. Note the new indicator reading. If the reading is 0.060 in. (1.5 mm) or less the radial rings do *not* have to be replaced. If the reading exceeds 0.060 in. (1.5 mm) the rings must be replaced. If the reading is between 0.050 and 0.060 in. (1.27 and 1.5 mm) the bearing rings must be checked during future scheduled maintenance visits.

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Brake

The brake assembly is mounted on top of the drive motor. The brake is spring applied and electrically released. The brake can be manually released by installing the brake release bolts. See Figure 7-137.

⚠ WARNING

When brake release bolts are used, make sure they are removed before the truck is returned to service. If the bolts are not removed, the brake will not work correctly.

Brake Adjustment

Inspect the brake gap inspections on a regular schedule.

⚠ WARNING

Use extreme care whenever the truck is jacked up for any reason. Never block the truck between the telescopic and the floor. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from beneath vehicle while jacking. Use jack stands or solid blocks to support truck. DO NOT rely on the jack alone. See Jacking on page 2-8.

1. Jack and block the tractor so the drive tire is off the floor.
2. With the brake de-energized (fully applied), use a feeler gauge to measure the total gap. See Figure 7-137.
3. Take measurements at three equally-spaced locations around the armature disk. The total gap must be 0.010 to 0.015 in. (0.25 to 0.38 mm). The gap must be uniform all the way around the armature disk. Brake wear is indicated if the total gap is greater than 0.015 in. (0.38 mm).

NOTE: Different thickness shims and spacers are available to maintain correct brake gap.

4. Add/remove shims as necessary to achieve the correct gap.

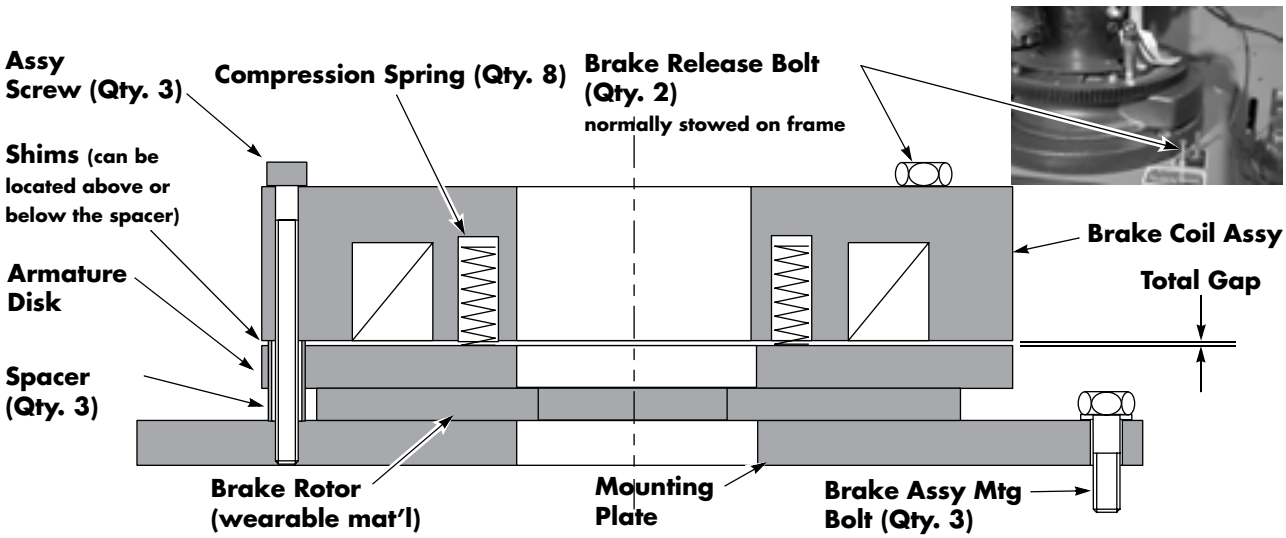


Figure 7-137. Brake Assembly Components

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Brake Rotor Replacement

Replace the rotor if worn to a thickness of 0.236 in. (6 mm) or less.

Removal/Disassembly

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the covers from the power section.
3. Disconnect the electrical cable to the brake assembly.
4. Remove the three screws that secure the brake to the drive unit.
5. Remove the cable support.
6. Lift the brake unit up and off the drive unit. Take the assembly to a workbench. You will need the brake release screws located on the tractor.
7. Insert the brake release screws into the brake assembly. Tighten the two brake release screws to release the brake completely.
8. Remove one of the three screws that hold the brake assembly together. Use care not to lose any shims that may be used.
9. Slide the rotor out of the assembly.

Assembly/Installation

1. Slide the new rotor into the assembly. The rotor is positioned between the armature disk and the brake mounting plate. See Figures 7-138 and 7-139.
2. Install the one assembly screw removed to replace the rotor. Make sure to install any spacers removed. Torque the three M6 screws that secure the coil to the assembly to 9 ft. lb. (12 N•m) with the threads lubricated.
3. Carefully center the rotor within the assembly and remove the brake release bolts.
4. Measure the total gap as shown below. The total gap must be between 0.010 in. (0.25 mm) and 0.015 in. (0.38 mm). If the gap is not within tolerance, add or remove shims and/or spacers as necessary. Different thickness shims and spacers are available.

⚠CAUTION

If the total gap exceeds 0.015 in. (0.38 mm), brake release problems will result particularly when the brake is hot and/or the battery is low.

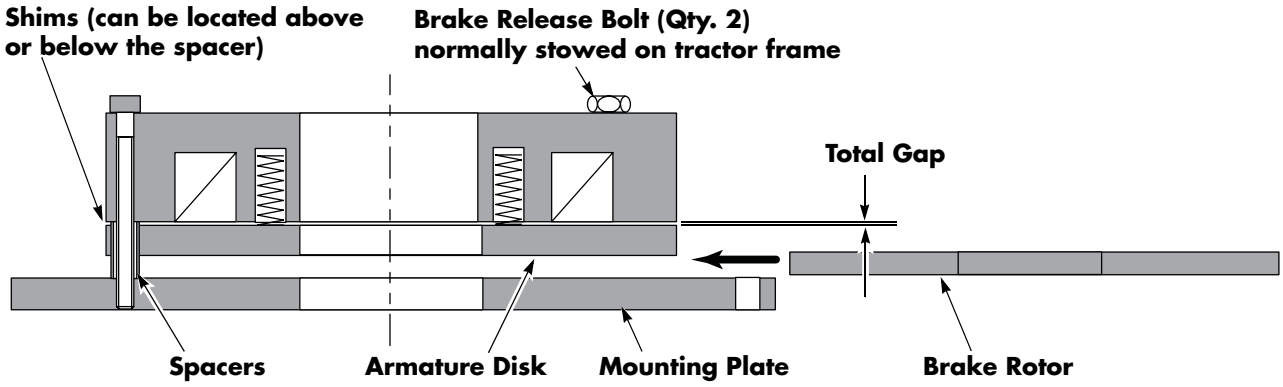


Figure 7-138. Installing Brake Rotor

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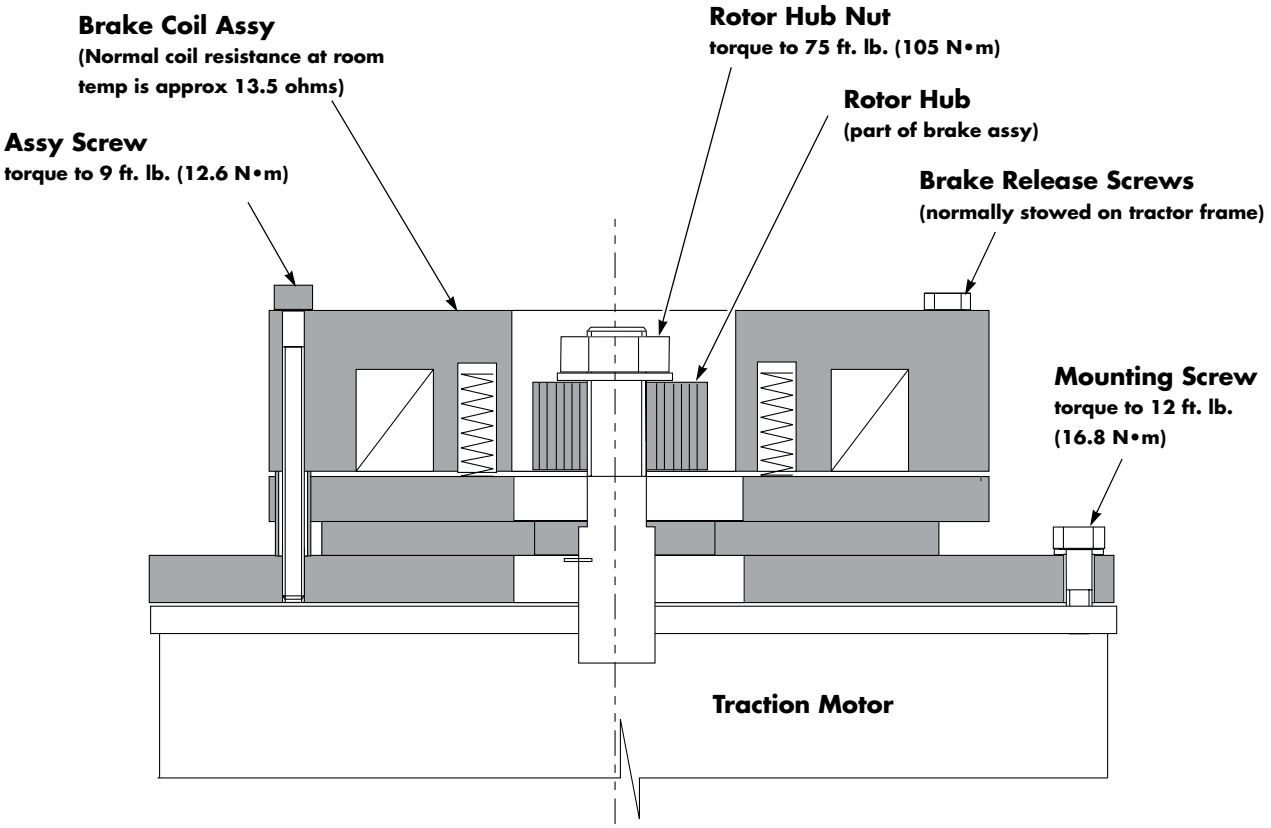


Figure 7-139. Brake Assembly - Section View

5. After the correct gap is achieved, torque the assembly screws as specified in step 2.
6. Inspect the splines on the rotor hub (on the drive motor). If the splines on the rotor hub have excessive wear, replace the hub before proceeding. Using a rotor hub with worn splines may cause rotor damage when the truck is driven.
7. Carefully install the brake assembly on the drive motor. It is critical that the splines on the rotor are not damaged during assembly.

⚠CAUTION

Damaging the splines on the brake rotor may cause brake failure.

8. Install the cable clamp that holds the power cables on the drive motor.
9. Secure the brake assembly to the drive motor. Apply thread-locking compound (P/N 990-462). Torque the three mounting screws to 12 ft. lb. (16.8 N•m).
10. Connect the brake to the truck electrical circuit.
11. If the rotor hub nut was removed, apply thread-locking compound (P/N 990-462) to threads on rotor hub nut. Install then torque the rotor hub nut holding the rotor hub to 25 ft. lb. (35 N•m).

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⚠ WARNING

Make sure the brake release bolts are removed before placing the truck back into service. If the brake release bolts are not removed, the brake will not work correctly.

12. Reconnect the battery connector and turn the key switch ON.

⚠ WARNING

If the brake does not work while performing the next step, the truck will not stop but will coast for approximately 30 ft. (9 m).

13. Test the brake. In an open area allowing for travel over a long distance, perform the following:
    a. Drive the truck approximately 2-3 mph (3.2-4.8 km/h).
    b. Push the EPO switch. The truck should stop within approximately 2 to 4 ft. (0.6 to 1.2 m).

⚠ WARNING

Stepping off the deadman pedal does not test the brake.

NOTE: During acceleration a slight rattle from the brake rotor is considered normal and does not affect brake durability or function.

14. Install covers.

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Drive Wheel

Removal

1. Turn steering wheel all the way to the right so you can access drive wheel mounting bolts.
2. Turn the key switch OFF and disconnect the battery connector.

⚠ WARNING

Use extreme care whenever the truck is jacked up. Never block the truck between the mast and the floor. Keep hands and feet clear from vehicle while jacking the truck. After the truck is jacked, place solid blocks beneath it to support it. DO NOT rely on the jack alone to support the truck. For details, see Jacking on page 2-8.

3. Jack and block truck under tractor frame.
4. Remove bumper plate.
5. Remove drive wheel mounting bolts.
6. Remove drive wheel.

Installation

1. Install drive wheel on drive wheel shaft.
2. Install drive wheel mounting bolts. Torque to 100 ft. lbs. (135 N•m).
3. Install bumper plate.
4. Remove block and lower tractor with jack.
5. Reconnect the battery connector and turn the key switch ON. Test operation before returning truck to service.

Drive Tire Replacement

⚠CAUTION

Any misalignment of the tire and hub while the tire is being pressed onto the hub can damage the hub. For this reason, chamfers are 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 operations and reduce the possibility of misalignment. To prevent damage, the hub must be installed on the circular ram with its chamfered side up.

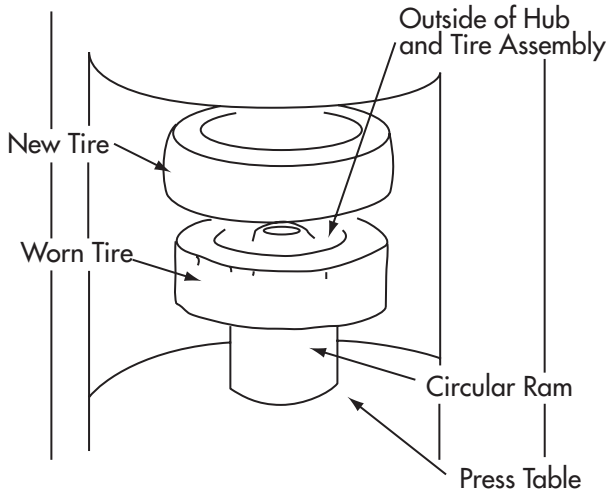


Figure 7-140. Drive Tire Installation

1. Check inside surface of metal insert on new tire. Use sandpaper to remove any scaling or rust. Clean inside of metal insert and lubricate it with a soap solution.
2. Place circular ram on the press table. See Figure 7-140. The length of ram must be longer than width of old tire to allow complete removal of old tire. The outside diameter of ram must be small enough to fit loosely in the insert of tire but must be large enough to rest squarely on flat surface on outer edge of hub.

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3. If outside edge of hub is not flush with edge of metal insert in old tire, measure how far hub is recessed inside tire. The new tire must be placed in the same position the old tire was installed on hub. You can use a spacer (slightly smaller in diameter than inside diameter of tire insert and same thickness as depth of recess) to obtain correct amount of recession.
4. Position hub assembly with old tire on top of circular ram so outside of wheel is positioned upward. The outside edge of hub has a chamfer to help guide new tire onto wheel. The chamfered edge must always be leading edge when a tire is pressed onto hub.
5. Center hub assembly on top of ram and make sure that they mate squarely.
6. Position new tire with its chamfered insert facing hub. Align new tire and hub so that they are concentric.
7. Begin pressing new tire onto hub and old tire off wheel. Run press slowly for the first few inches of travel, because this is the critical stage of the operation. If tire begins to cock to one side, stop press and realign tire. A sharp jar with soft-headed mallet will usually realign tire on hub.

NOTE: If new tire does not press on with a minimum of 5 tons (68,947 kPa) pressure, replace hub.

8. Release press. Remove wheel, tire assembly, and old tire from press table. Inspect wheel and tire assembly.

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Electrical Components

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Battery Procedures

⚠CAUTION

Before working on the battery, review Battery Safety, beginning on page 2-5. Batteries for this lift truck weigh between 920 and 2000 lb. (418 to 908 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.

NOTE: The distance from the floor to the top of the battery rollers is 12.25 in. (31.12 cm).

Battery Connector/Cables

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. See Figure 7-142.

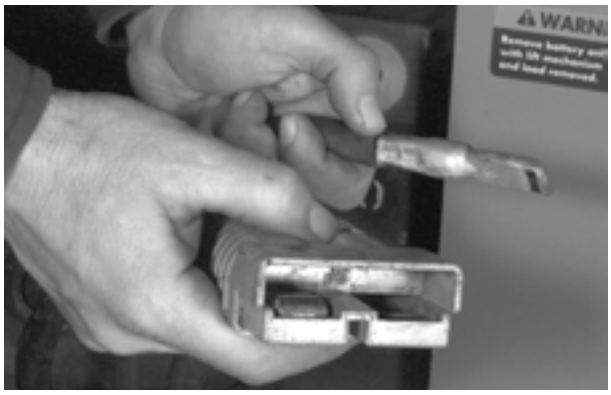


Figure 7-141. Battery Cable and Connector

⚠ WARNING

When replacing battery cable ends, remove only one end at a time from the connector to avoid the cable ends touching and causing a short circuit. Do *not* allow the metal cable end to touch the battery. Use insulated tools and avoid contact with battery case or cable ends.

1. To remove a cable from the connector, you must push this retainer down while pulling the battery cable towards the rear and out of the connector. See Figure 7-142.

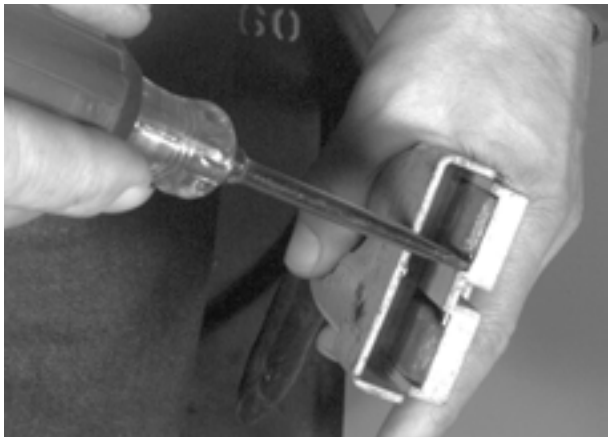


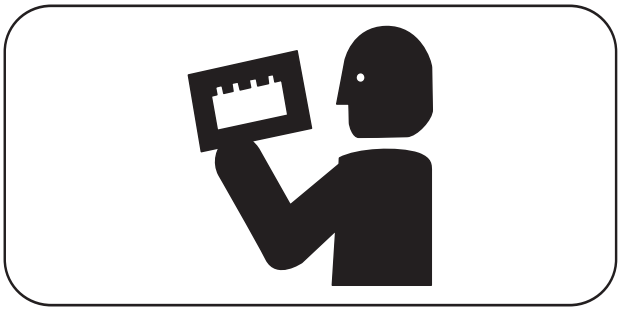
Figure 7-142. Removing Battery Cable from Connector

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 battery and battery charger manufacturer's manuals.

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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.

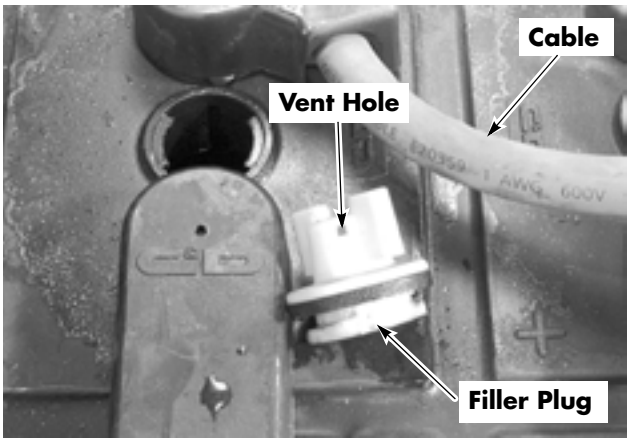


Figure 7-143. Battery Filler Plugs and Vent Holes

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.

⚠CAUTION

Do *not* clean the top of the battery with the soda solution while it is installed in the truck. Water can seep into the electrical compartments and cause serious damage.

6. Wash dirty batteries (or any that have had electrolyte spilled on them) with a solution of 1 lb. (0.45 kg) of baking soda added to 0.5 gal. (1.9 liters) of hot water.
7. Use a brush with flexible bristles to clean the entire top of the battery with the soda solution. Wait until all foaming stops, indicating that the battery exterior is neutralized.
8. Rinse the battery with clean water.
9. Dry the battery completely before reinstalling it.
10. Reinstall the battery in the lift truck, using a suitable battery-moving device. Reconnect the battery connector.

Testing, Charging, and Maintenance

For information on testing, charging, and maintaining your lift truck battery, consult the battery manufacturer's specifications and instruction manual.

⚠CAUTION

***Never* plug the battery charger into the lift truck. This will severely damage the lift truck's electrical system. Plug the charger *only* into the connector from the battery.**

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Motors

DC Motor Brushes

Inspection

Visually inspect the motor every 180 days or 250 hours of lift truck operation. See page 4-8. If the lift truck is operated in a severe or extreme environment or a rigorous duty cycle, inspect the motor more frequently. See "Maintenance Guidelines" on page 4-2.

Set up and rigidly adhere to a strict inspection schedule to obtain the maximum efficiency from the electrical equipment.

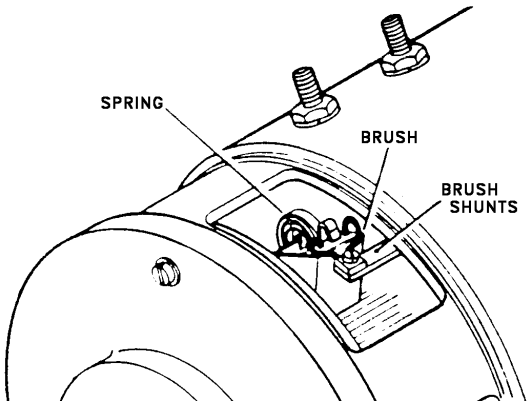


Figure 7-144. Motor Brush, Typical Location

1. Inspect the brushes for wear and for correct contact with the commutator. Record the level of wear on the brushes. This history will give you an indication of whether a brush must be changed or if it can wait until the next inspection. See the table on page 7-65 for correct brush length.

NOTE: Overloading a motor is ultimately reflected in motor commutator and brush wear: therefore, you must take this into account when considering brush replacement.

2. Check the brushes for signs of overheating: discolored shunts or springs or cracked contact area.
3. Check the brush spring tension. See "DC Motor Brush Spring Tension" on page 7-65.
4. Clean the brushes and holders. Wipe the commutator with a dry, lint-free cloth. *Do not* use lubricants of any kind on or around the commutator.
5. Check the brush holders for solid connection to the mounting support. Tighten any mounting screws as necessary.
6. Check the screws holding the brush cross connectors to the brush holder body.
7. Make sure the motor terminals are secured tightly to the motor frame. Use care not to strip the threads or crush the insulating parts.
8. Check all the screws and bolts around the end bell and frame for tightness.
9. 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

If one brush needs replacement, always replace the entire set of brushes.

Use only genuine *Raymond* replacement brushes. Using another type of brush could damage the commutator or cause excessive brush wear.

Do not use emery cloth or sandpaper to seat brushes. Grit may enter the motor, causing premature wear and failure. Blowing out the motor with compressed air will *not* guarantee all the debris is removed.

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DC Motor Brush Spring Tension

Insufficient brush spring tension can result in excessive arcing and reduced motor performance.

Excessive spring tension results in premature commutator wear.

A brush spring that does not apply tension evenly on the center of the brush causes uneven brush wear.

Inspection

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove covers as required for access to motor.
3. Remove any brush bands.
4. Slide the brush up slightly in its holder.
5. Insert a paper strip between the brush face and the commutator.
6. 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.
7. Attach a 5 lb. (2.27 kilogram) spring scale to the leather loop.

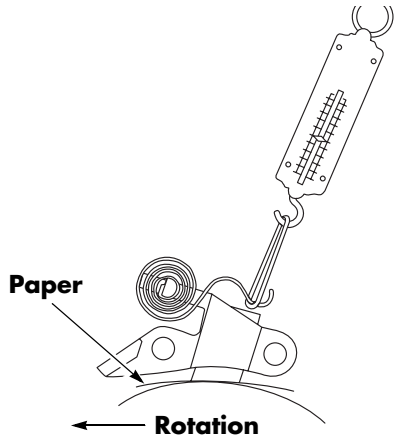


Figure 7-145. Motor Brush Spring Tension Inspection

8. While gently pulling the scale outward, slowly pull the paper strip in the direction that the commutator normally rotates.
9. When the paper strip begins to move freely, the spring scale will read the spring brush tension.
10. Refer to Table 7-2 for correct spring tension.
11. Repeat steps 4 through 9 for the remaining brushes.

Table 7-2. Minimum Brush Length

Motor	Raymond P/N	Brush Length				Brush Spring Tension			
		Minimum		Maximum		New		Worn	
		in.	mm	in.	mm	oz.	gr	oz.	gr
Lift	570-317/500 579-317	0.62	16	1.30	35	65	1820	40	1120
Steer	114-008-594/01	0.50	12.7	N/A					

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DC Motor Commutator

Inspection

Inspect the commutator for surface condition and high mica. See Figure 7-146.

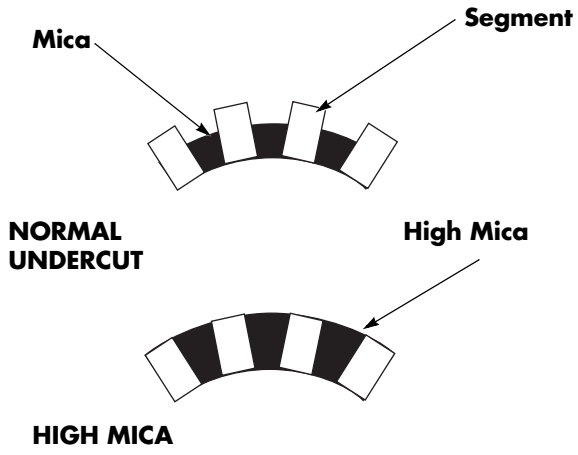


Figure 7-146. Mica Undercutting

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. Refer to Table 5-2, Commutator Surfaces, on page 5-7.

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

High ridges between the brush travel paths indicate the commutator requires turning. High ridges could chip or damage the brushes.

Terminal Hardware

⚠CAUTION

Do not attempt to repair power cable terminal lugs. If a power cable has worn or damaged lugs, replace the cable. Do not substitute other kinds of nuts for the flanged nuts. Failure to use correct cables, flanged nuts, and torque values can result in overheating and damage to components.

Whenever you disconnect and reconnect any power cables to a motor or power amplifier, always tighten the cable securing hardware with a torque wrench to prevent over-tightening them and damaging the motor or amplifier. On motors with stud terminal securing nuts, use a second wrench on the securing nut to avoid twisting the stud. Check these torques each time you check the motor.

Stud Size	Motor Cable Securing Nut	Stud Terminal Securing Nut
Traction Motor		
M10	12.5 to 18.4 ft. lb. (23.0 to 25.0 N•m)	10.7 to 11.0 ft. lb. (14.5 to 15.0 N•m)
Lift Motor		
M10	12.5 to 18.4 ft. lb. (23.0 to 25.0 N•m)	10.7 to 11.0 ft. lb. (14.5 to 15.0 N•m)
Lift Motor (brass nuts)		
M10	8.3 to 10.0 ft. lb. (11.2 to 13.6 N•m)	11.7 to 13.3 ft. lb. (15.8 to 18.1 N•m)
Steer Motor (brass nuts)		
M8	7.5 to 9.2 ft. lb. (10.2 to 12.5 N•m)	9.2 to 11.7 ft. lb. (12.5 to 15.9 N•m)
Traction Power Amplifier (bolt)		
N/A	100 in. lb. (11.3 N•m)	N/A

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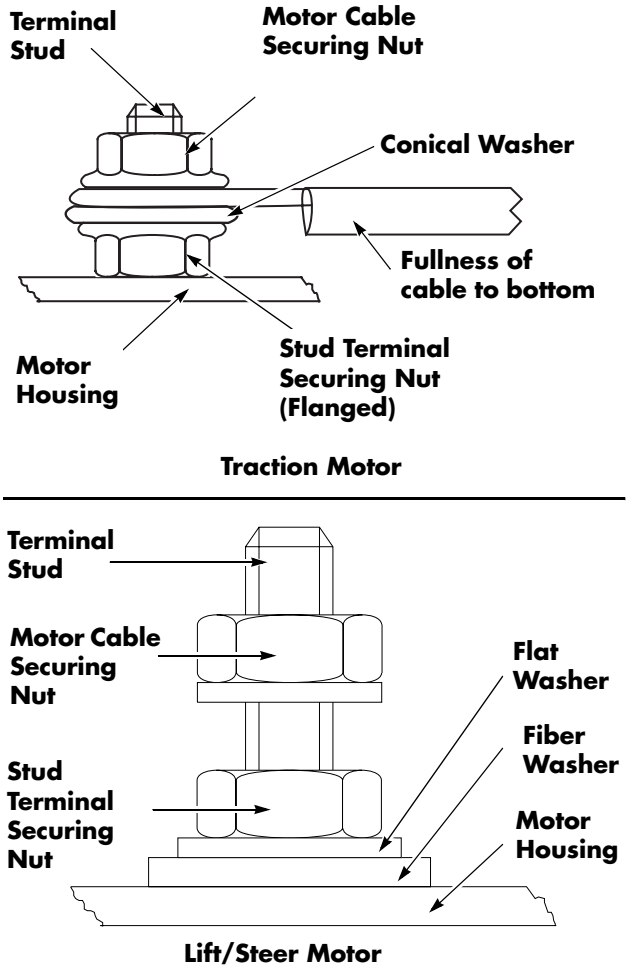


Figure 7-147. Terminal Nuts

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AC Motor Service

AC traction and lift motor Encoder Bearing Assembly and Temperature Sensor

AC Motor Temperature Sensor

Temperature sensors in the AC drive and lift motors are integral to the motor. When a motor temperature sensor fails, it can be replaced using the procedures below.

Drive Motor Replacement:

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the brake assembly including the rotor hub nut and rotor hub. Note the number of spacers used.
   - Disconnect the temperature sensor connector JPTA3.
   - Disconnect power cables making sure that you note locations for reassembly later.
   - Remove the terminal board.

⚠CAUTION

Use correct electrostatic discharge precautions. See "Electrostatic Discharge Precautions" on page 2-7.

3. Mark the position of the top end bell and bottom end bell relative to the stator, then remove the snap ring.
4. Remove the brake mounting motor flange. (Note: Use new flange mounting bolts when reassembling.)
5. Remove the four bolts that secure the top end bell to the bottom end bell.
6. Remove the top end bell using a puller. Use care that the encoder bearing remains in the bottom end bell to reduce the chance of damaging the bearing.
7. Install a new temperature sensor using the high temperature silicone (neutral curing) supplied with the temperature sensor. Mount the sensor close to the location of the original. Secure the cable with a cable tie to one of the power leads for stress relief.
8. Install the top end bell in the position that was previously marked. Verify correct stator installation and install snap ring.
9. Secure the top end bell to the bottom end bell using the four bolts previously removed.
10. Install the brake mounting motor flange with new mounting bolts.
11. Re-install the brake assembly including the rotor hub mount and rotor hub.
12. Check brake adjustment. See "Brake Adjustment" on page 7-54.
13. Install the terminal board, reconnect JPTA3, and power cables. Torque motor cable securing nuts to 18 ft. lb. (24 Nm).
14. Reconnect the battery connector and turn the key switch ON.

Lift Motor Replacement:

1. Turn the key switch OFF and disconnect the battery connector.

⚠CAUTION

Use correct electrostatic discharge precautions. See "Electrostatic Discharge Precautions" on page 2-7.

2. Disconnect the temperature sensor connector JPLA3.
3. Disconnect cables and motor harness connections, making sure that you note locations for reassembly later.
4. Separate the pump assembly from the lift pump motor and remove lift pump motor. See "Lift Pump and Motor" on page 7-82.
5. Remove the four bolts that secure the top end bell to the bottom end bell.
6. Remove the top end bell. Use care that the bearing remains in the bottom end bell to reduce the chance of damaging the bearing.
7. Install a new temperature sensor using the high temperature silicone (neutral curing)

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supplied with the temperature sensor. Mount the sensor close to the location of the original. Secure the cable with a cable tie to one of the power leads for stress relief.

8. Carefully press the top end bell to the stator. Do not pinch the cables or allow contact with the rotor. Verify correct stator installation.
9. Secure the top end bell to the bottom end bell using the four bolts previously removed.
10. Reinstall lift motor to the lift pump assembly.
11. Reconnect JPLA3, and power cables.
12. Reconnect the battery connector and turn the key switch ON.

AC Motor Bearing Encoder

Drive Motor Replacement:

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the brake assembly including the rotor hub nut and rotor hub. Note the number of spacers used.
   - Disconnect the temperature sensor connector JPTA3.
   - Disconnect the bearing encoder connector JPTA2.
   - Disconnect power cables making sure that you note locations for reassembly later.
   - Remove the terminal board.

⚠CAUTION

Use correct electrostatic discharge precautions. See "Electrostatic Discharge Precautions" on page 2-7.

3. Remove the steering position reference bracket.
4. Remove the drive motor. See "Drive Motor" on page 7-22.
5. Remove the nut that secures the pinion gear. Remove the gear and key using a suitable puller.
6. Mark the position of the top end bell and bottom end bell relative to the stator, then remove the snap ring.
7. Remove the brake mounting motor flange. (Note: Use new flange mounting bolts when reassembling.)
8. Remove the four bolts that secure the top end bell to the bottom end bell.
9. Remove the top end bell and bottom end bell using a puller.
10. Remove the clamps that secure the encoder bearing cable.
11. Remove the encoder bearing from the rotor using a suitable puller, pulling on the outer race only.
12. Remove the oil seal to allow pressing of the bottom end bell to the stator for later reassembly.
13. Make sure that the O-ring and wave washer are correctly positioned in the bottom bell bearing pocket.
14. Position the new encoder bearing in the bottom end bell with the cable oriented in the middle of the notch in the side of the bearing pocket.
15. Use an assembly bushing on the outer race and press the bearing into place. Do *not* press on the encoder part of the bearing.
16. Re-install encoder bearing cable clamps.
17. Install the top end bell in the position that was previously marked. Verify correct stator installation and install snap ring.
18. Carefully press the bottom end bell to the stator.
19. Secure the top end bell to the bottom end bell using the four bolts previously removed. Re-install oil seal.
20. Install key, pinion gear, and nut to the bottom of the drive motor. Re-install drive motor. See "Drive Motor" on page 7-22.
21. Install the brake mounting motor flange with new mounting bolts.

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22. Re-install the brake assembly including the rotor hub mount and rotor hub.
23. Check brake adjustment. See “Brake Adjustment” on page 7-54.
24. Install the terminal board, reconnect JPTA2, JPTA3, and power cables. Torque motor cable securing nuts to 18 ft. lb. (24 Nm).
25. Re-install steering position reference bracket and filler tube if previously removed.
26. Reconnect the battery connector and turn the key switch ON.

Lift Motor Replacement:

1. Turn the key switch OFF and disconnect the battery connector.

⚠CAUTION

Use correct electrostatic discharge precautions. See “Electrostatic Discharge Precautions” on page 2-7.

2. Disconnect the bearing encoder sensor connector JPLA2.
3. Disconnect connectors JPLA2, JPLA3, cables, and motor harness connections, making sure that you note locations for reassembly later.
4. Separate the pump assembly from the lift pump motor and remove lift pump motor. See “Lift Pump and Motor” on page 7-82.
5. Remove the four bolts that secure the top end bell to the bottom end bell.
6. Remove the top end bell using a suitable puller.
7. Remove the encoder bearing from the rotor, pulling on the outer race only.
8. Install the new encoder bearing by applying steady pressure to the inner ring.
9. Carefully press the top end bell to the stator. Do not pinch the cables or allow contact with the rotor. Verify correct stator installation.
10. Secure the top end bell to the bottom end bell using the four bolts previously removed.
11. Install lift motor and reconnect lift pump assembly. See “Lift Pump and Motor” on page 7-82.
12. Reconnect JPLA2, JPLA3, and power cables.
13. Reconnect the battery connector and turn the key switch ON.

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Power Amplifiers

NOTE: If the power amplifier being removed is to be returned to stock, a power amplifier reset must be performed. See page 3-25.

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Disconnect JT1 from the power amplifier.
3. Disconnect the power cables from the power amplifier.
4. Remove the four mounting screws.
5. Lift the power amplifier off the mounting plate.

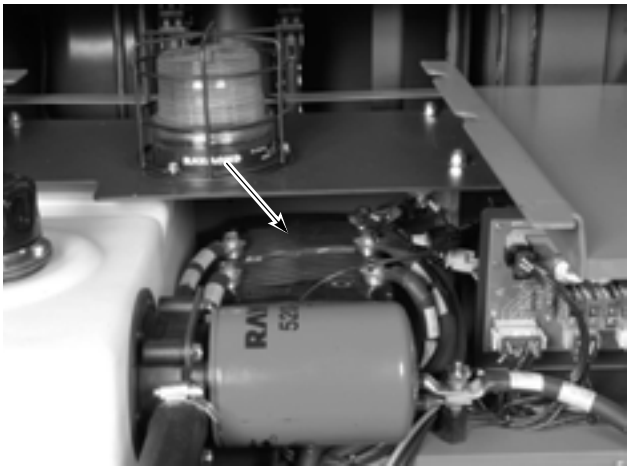


Figure 7-148. Traction Power Amplifier

Installation

1. Install new thermal conductive material (provided with new power amplifier) between the base of the power amplifier and the heatsink.
2. Position the power amplifier and install the four mounting screws.
3. Tighten the mounting screws to 7.4 ft. lb. (10 N•m).

⚠CAUTION

Do not attempt to repair power cable terminal lugs. If a power cable has worn or damaged lugs, replace the cable. Failure to use correct cables, bolts, and torque values can result in overheating and damage to components.

4. Reconnect the power cables to the correct terminals. Torque to 100 in. lb. (11.3 N•m).
5. Reconnect JT1.

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Carriage Control Card Replacement

⚠CAUTION

Observe proper ESD precautions. See Electrostatic Discharge Precautions on page 2-7.

The CCC has truck specific information programmed in the microprocessor. See Figure 7-149. This information includes Model Number, Serial Number (S/N), Date of Manufacture, Hour Meters, and a list of enabled Options. A backup copy of this information is also stored in the VM.

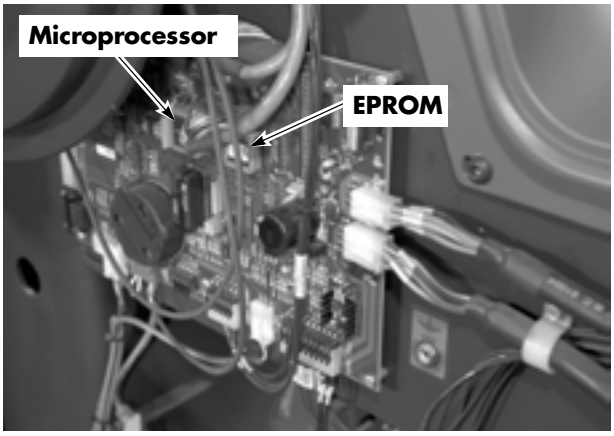


Figure 7-149. Carriage Control Card Chip Locations

If a blank CCC is installed, the information from the VM is uploaded into the CCC. A Pre-programmed CCC *must* be ordered and installed any time the Error Code corrective actions tells you to or if the CCC and VM are being replaced at the same time. Another way to retain the correct programming for the specific truck is to remove the microprocessor from the CCC being replaced and install it in the new CCC. See "EPROM/Microprocessor Removal/Replacement" on page 7-73. This can be done only if the error code being corrected does not instruct you to install a pre-programmed CCC. Some error codes indicate the possible corruption of the data stored in the microprocessor.

1. Correctly position the E3 jumpers, E3 jumper should be in the A (IN) position, E4 jumper should be in the B position.
2. On trucks without the 60 in. limit switch option, a jumper/resistor assembly must be installed at JPC3. Remove the assembly from the original CCC and install it on the new one.
3. Remove the EPROM from the original CCC and install it in the new card or install a new EPROM. See "EPROM/Microprocessor Removal/Replacement" on page 7-73.
4. Enter Configure Mode and verify the truck S/N stored in the CCC matches the S/N on the truck Specification Tag. If not, a new pre-programmed CCC must be obtained and installed prior to operating the truck.
5. Reset all of the information in the Configure Menu to the customer's specifications.
6. Run the complete Learn process.

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EPROM/Microprocessor Removal/Replacement

Removal

1. Turn the key switch OFF and disconnect the battery connector.

⚠CAUTION

Observe proper ESD precautions. See Electrostatic Discharge Precautions on page 2-7.

Failure to use approved EPROM Extraction Tool (P/N 950-032) may result in damage to the chip or socket.

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.
3. Insert the prongs of the extraction tool into the holes identified in step 2. Hold the tool straight up. See Figure 7-150.
4. Gently but firmly squeeze the jaws of the tool together. The prongs will retract, lifting and loosening the chip from its socket. *Do not rock or pull on the chip to release it.*



Figure 7-150. Chip Removal

Installation

1. Inspect the chip. Make sure there are no bent, broken or missing pins or other signs of physical damage. See Figure 7-151.

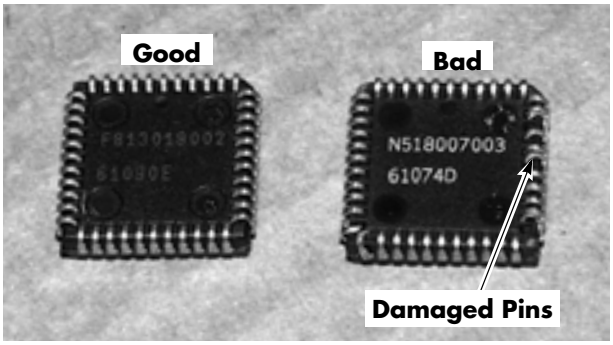


Figure 7-151. Chip Inspection

2. Notice the beveled corner and the arrow in the socket. Notice the beveled corner and the dot on the beveled edge of the chip.
3. Position the chip so the dot is aligned with the arrow on the socket and the beveled corner is aligned with the beveled corner of the socket.
4. Gently press the chip into the socket with your thumb. Make sure it is completely seated on all four edges. See Figures 7-152 and 7-153.

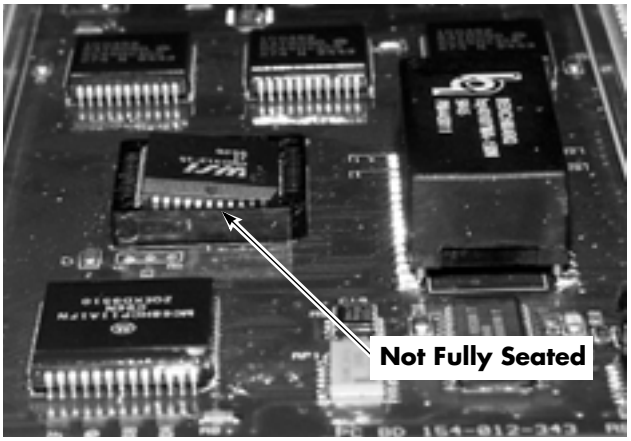


Figure 7-152. Chip Incorrectly Seated In Socket

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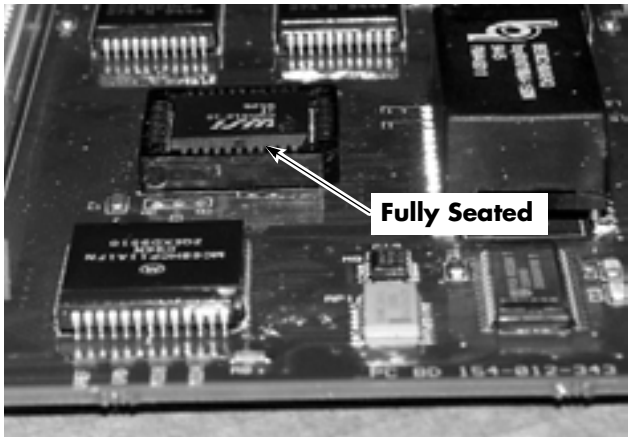


Figure 7-153. Chip Fully Seated In Socket

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Hydraulic Components

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Flow Sensor Service Notes

Servicing of the hydraulic flow sensor is limited to checking the turbine assembly inside the hydraulic flow sensor for cleanliness and freedom of movement.

NOTE: The flow sensor is electrically isolated from the truck chassis with insulating material and orange non-conductive hydraulic hose. Be careful that the connector plugs do not cause shorts between the body of the flow sensor and the truck chassis.

⚠CAUTION

The flow sensor must be electrically isolated. When servicing the flow sensor, make sure there is at least 2 megohm resistance between the body of the flow sensor and the truck chassis with JPY6 and JPY7 disconnected from the flow sensor pickups.

Make sure the connectors are reconnected to the correct pickup. Identify connector placement for correct reassembly. See Figure 7-154.

O-Ring Replacement

1. To ensure correct alignment during reassembly, use a pencil to mark the block and pickup on the small black nut, the large gold nut and the main block in a straight line.
2. Remove the assembly by unscrewing the large gold nut closest to the main block. Make sure the small black nut does not turn in relation to the large gold nut or the calibration of the pickup is altered.
3. Remove the bad O-ring and install a new one.
4. Install the pickup back into the main block and tighten the large gold nut. Make sure the marks made in step 1 are aligned.
5. Run Test I26 - Flow Sensor Count (Page 6-70) to make sure the pickup functions correctly.

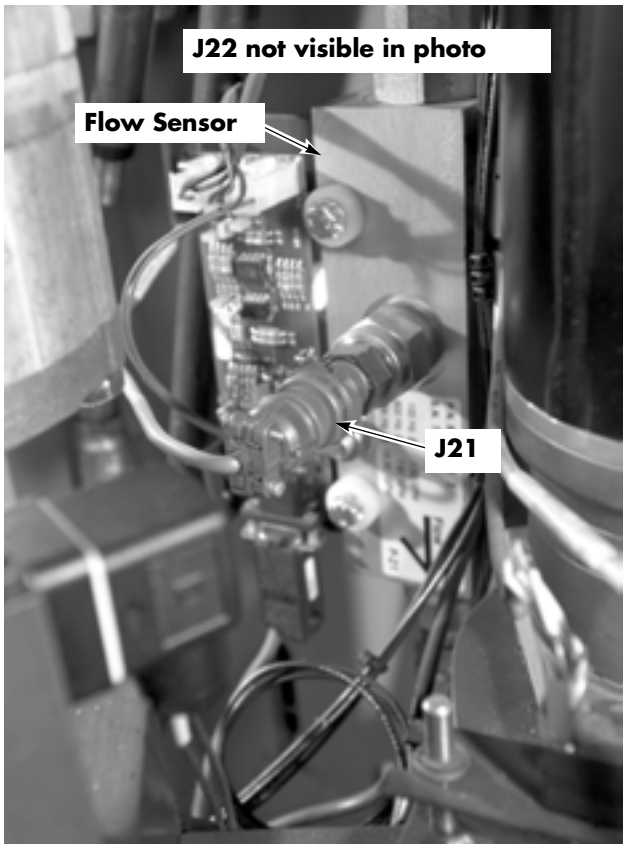


Figure 7-154. Flow Sensor

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Disassembly

Disassemble of the flow sensor in a clean area to prevent contamination from entering the turbine section of the flow sensor.

1. Remove the retaining ring from the inlet port. See Figure 7-155.



Figure 7-155. Retaining Ring Removal

2. Using a soft object (eraser end of a pencil will do), carefully push the turbine assembly out of the sensor body from the outlet end. See Figures 7-156 and 7-157.



Figure 7-156. Removing Turbine Assembly

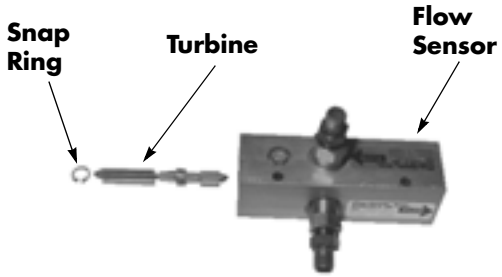


Figure 7-157. Turbine Assembly Removed

3. With the turbine assembly removed, inspect the turbine blades for damage and/or for debris that may have become entangled around the turbine. If the turbine is damaged, the entire assembly must be replaced.
4. Wash the turbine assembly in clean mineral spirits (or equivalent) and shake dry.

⚠CAUTION

Do not use compressed air to dry the turbine. Compressed air may over-speed the turbine, damaging the bearing surfaces.

5. With the longer section of the turbine assembly pointed up, compress the turbine shaft and spin the turbine using your fingers. The turbine should spin freely for several seconds without chattering. If the turbine does not spin freely, the entire flow sensor assembly must be replaced.

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Assembly

1. Reinstall the turbine assembly in the body of the sensor so that one of the vanes of the straightening section is between two stake marks located in the turbine bore. See Figure 7-158.

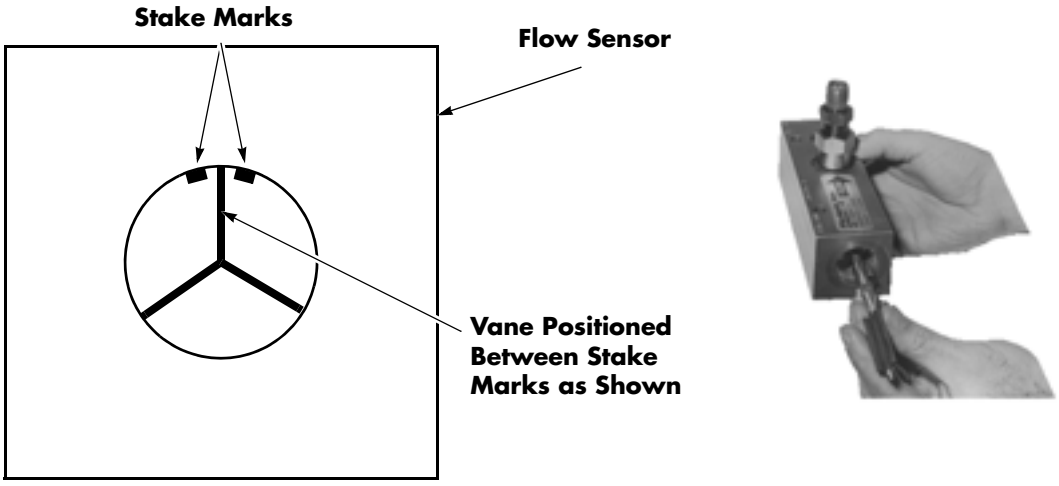


Figure 7-158. Reinstalling Turbine Assembly in Flow Sensor

2. Using the pencil eraser, depress the turbine assembly and reinstall the inlet snap ring.
3. Reinstall the flow sensor in the truck.
4. Bleed the hydraulic system and refill the reservoir. Check for leaks.
5. Run Learn. See Learn Hgt/Wgt on page 3-19.

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High Pressure Relief Valve Adjustment

1. Install a calibrated pressure gauge (3000 psi/20,682 kPa) in the test port. See Figure 7-159.
2. Back-out high pressure relief.
3. Check to see that the Emergency Lower Valve is closed.
4. Place a rated load on the forks plus 200 lb. (90.7 kg).
5. Start the lift system and turn the pressure relief screw clockwise until the platform starts to lift. Note the pressure required when the platform starts to elevate. Continue lifting until the third stage of the mast starts lifting. Record the pressure reading.
6. Lower platform and remove weight.
7. Chain mast sections together and lift or lift against the stops.
8. Adjust the pressure relief valve to a pressure 100 to 300 psi (689.4 to 2068 kPa) greater than the values recorded in step 5.
9. After the adjustment is complete, tighten the relief valve lock nut.
10. Check the lift system for correct operation.

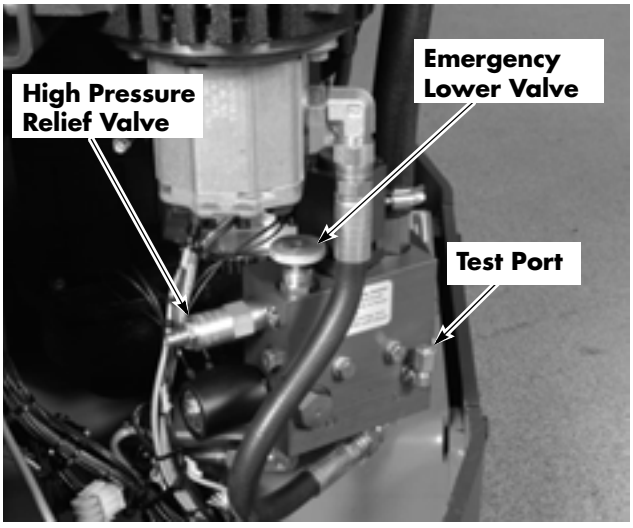


Figure 7-159. High Pressure Relief Valve Adjustment

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Lift/Lower and Load Holding Valves

Use this procedure when it is necessary to remove and install a lift/lower or load holding valve.

⚠CAUTION

When servicing hydraulic components, keep the work area clean. Contaminants can cause damage to hydraulic system.

1. Make sure the operator platform is completely lowered.
2. Turn the key switch OFF and disconnect the battery connector.
3. Remove the valve.
4. Inspect the sealing surface for contaminants. Clean the surface as necessary.
5. Lubricate O-rings with clean hydraulic fluid.
6. Install valve. See Figure 7-160.

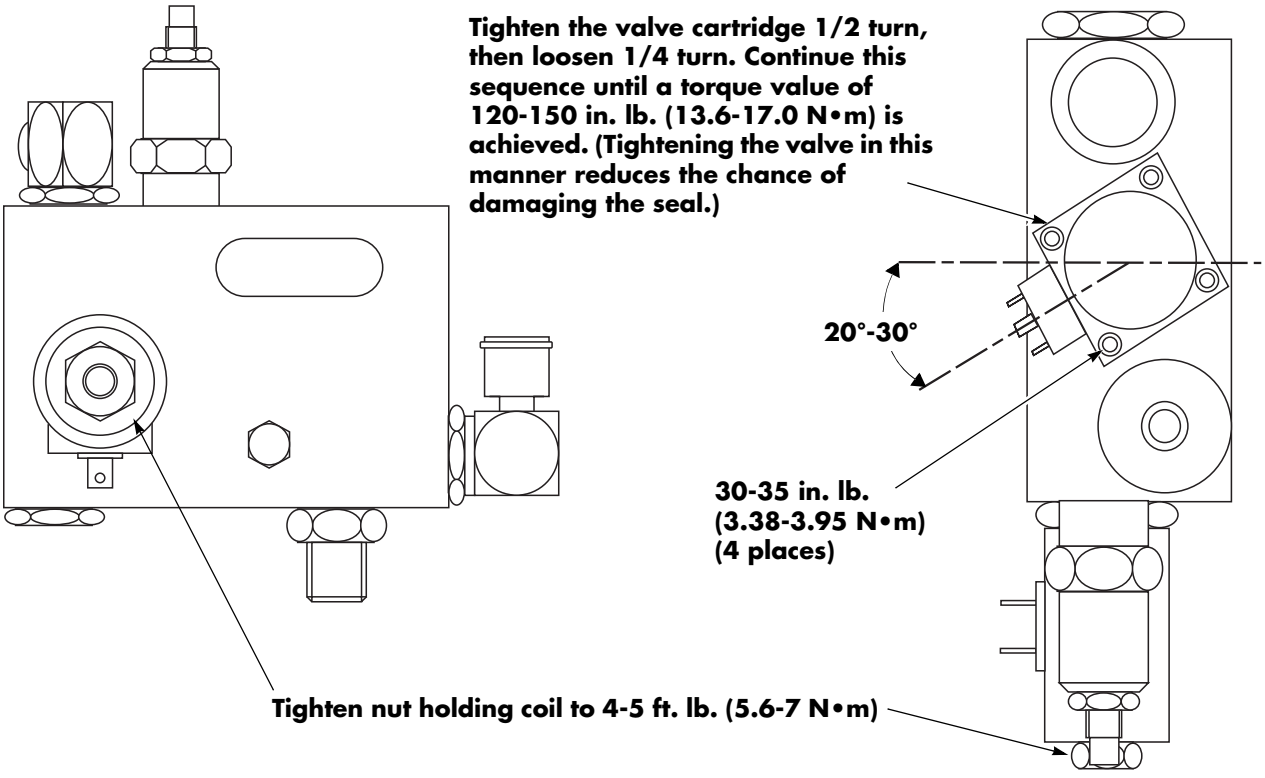


Figure 7-160. Lift/Lower and Load Holding Valve Installation

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Bleeding Lift Cylinders

Bleed the lift cylinders after maintenance or when operation indicates that air has entered the system (such as a bouncing operator platform).

Side Lift Cylinders

NOTE: For trucks with an OACH of less than 95 in. (241 cm), see Figure 7-161.

1. For trucks with an OACH above 95 in. (241 cm), elevate the operator platform approx 3 in. (7.6 cm).
2. Loosen, *do not remove*, the bleed screw near the top of the side cylinder just enough to bleed the air from the cylinder.

⚠CAUTION

The bleed screw should only be loosened enough to allow the air to escape.

3. When only oil flows from the cylinder, tighten the bleed screw. Repeat the process on the other cylinder.

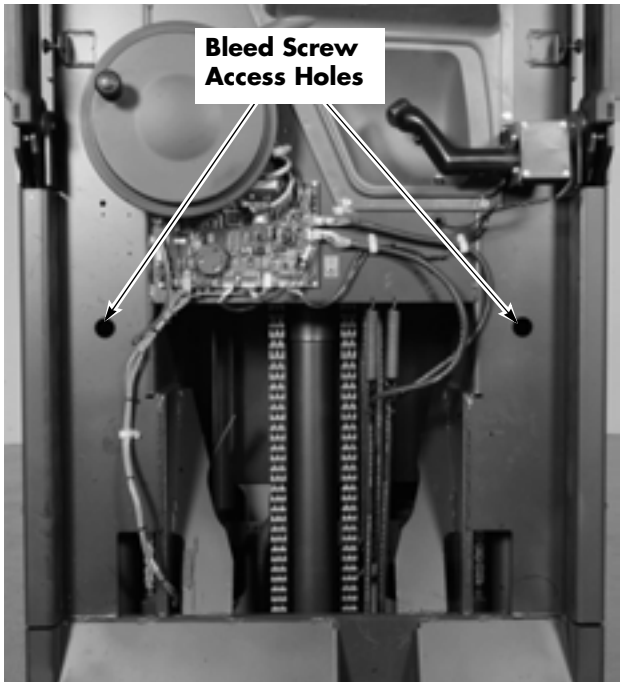


Figure 7-161. Bleed Screw Access - trucks with OACH of less than 95 in. (241 cm)

Center Cylinder

To bleed the center cylinder:

1. Elevate the operator platform enough to extend the center cylinder approx 3 in. (7.6 cm).
2. Carefully loosen *(do not remove)* the bleed screw located on the left side of the center cylinder.
3. When only oil flows from the cylinder, tighten the bleed screw.

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Lift Pump and Motor

For 36V trucks, refer to "AC Motor Service" on page 7-68 for drive motor temperature sensor and encoder bearing replacement procedures.

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Clamp suction hose closed. See Figure 7-162.
3. Remove two mounting bolts securing the lift pump to the lift motor.
4. Carefully separate the pump from the motor, taking care not to damage the toothed spline.
5. Remove the hydraulic fittings from the lift pump.

Installation

1. Attach the hydraulic fittings to the pump.
2. Apply molybdenum anti-seize compound (P/N 990-638) to the mating surfaces of the lift motor spline and pump.
3. Apply thread-locking compound (P/N 990-536) to the lift pump mounting bolts.
4. Carefully mate the lift pump spline to the lift motor and attach the lift pump to the lift motor with the two mounting bolts.
5. Unclamp the suction hose and add hydraulic fluid to the reservoir if necessary.
6. Reconnect the battery connector and turn the key switch ON.
7. Adjust high pressure relief valve. See page 7-79.
8. Bleed the hydraulic system.
9. Test the lift function for smooth and correct operation.
10. Check the lift pump for leaks.

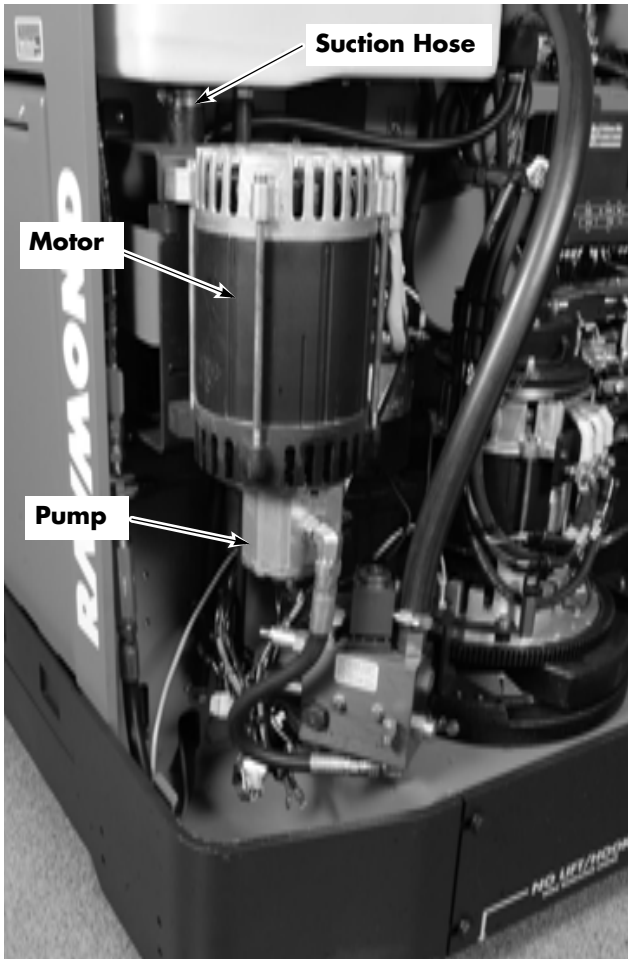


Figure 7-162. Lift Pump and Motor

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Pressure Switch Adjustment

This procedure applies to all 24V non-*intellispeed* lift trucks equipped with the High Performance Lift (Hi-Pro) option *(except EE rated trucks)*.

1. Disconnect JPT18 and JPT22 at the Vehicle Manager.
2. Connect a meter across terminals JPT22-5 and JPT18-5.
3. Raise the operator platform approximately 2 ft. (610 mm) with a 1000 lb. (454 kg) load on the forks.
4. Adjust the screw on the back of the switch until the switch just opens.
5. Turn the screw until the switch just closes.
6. Adjust the screw until the switch re-opens.

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Side Lift Cylinder

NOTE: A mirror will enable you to see the snap ring at the bottom of each cylinder housing in the side lift cylinder procedures.

Remove

1. Elevate the carriage just enough to access the tubing connected to the bottom of the side lift cylinder but not far enough to extend the side cylinder. Block the carriage.
2. Remove the tubing from the bottom block on the cylinder that is to be removed and cap both the tubing and the fitting to the side lift cylinder.

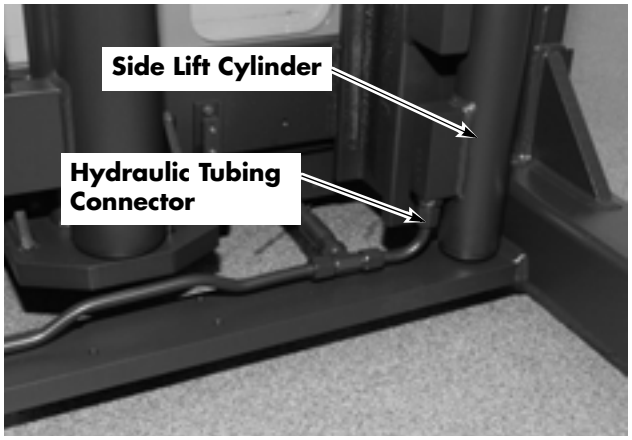


Figure 7-163. Hydraulic Connection, Side Cylinder, Bottom

3. Unblock and lower the carriage to the floor.
4. Remove the bolt in the top of the side lift cylinder that connects it to the bracket on the mast.
5. Elevate the carriage until it clears the cylinder assembly enough to allow cylinder removal.
6. Block the carriage.
7. Remove the snap ring from the bottom of the cylinder. See Figure 7-164.

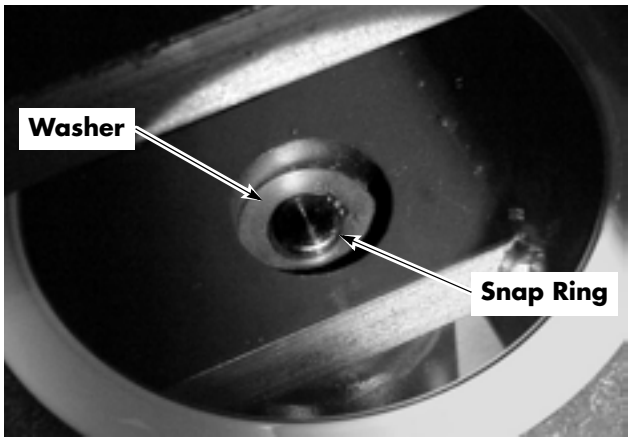


Figure 7-164. Bottom View of Housing (Using Mirror)

8. Remove the bolt that attaches the cylinder housing to the main frame of the truck. See Figure 7-165.

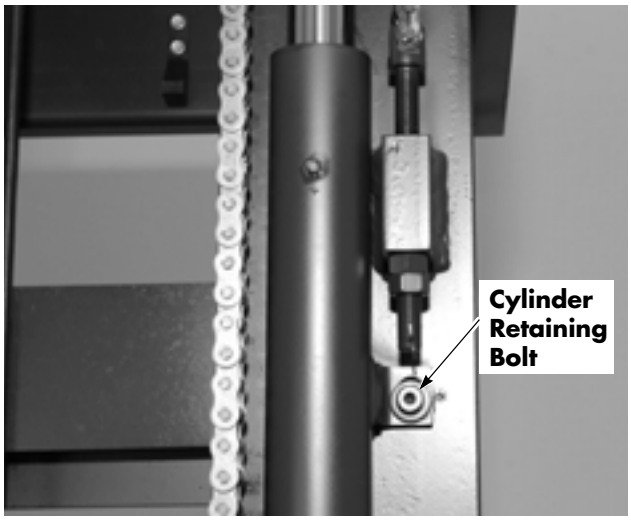


Figure 7-165. Side Cylinder

9. Remove the side lift cylinder from the truck.

Installation

1. Install the cylinder in the truck.
2. Install the bolt that attaches the cylinder housing to the main frame of the truck.
3. Install the snap ring on the bottom of the cylinder housing.

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4. Unblock and lower the carriage enough to collapse the other outer cylinder but still have access to the fitting at the bottom of the cylinder.
5. Block the carriage. Connect the tubing to the bottom of the cylinder.
6. Unblock and lower the carriage to the floor. Install the bolt in the top of the side lift cylinder that connects it to the bracket on the mast.
7. Bleed the hydraulic system. See Bleeding Lift Cylinders on page 7-81.
8. Lift and lower the carriage completely to check lift function.

Cushion Service

1. Remove cylinder from truck. See Side Lift Cylinder on page 7-84.
2. Remove snap ring and wiper. See Figure 7-166.

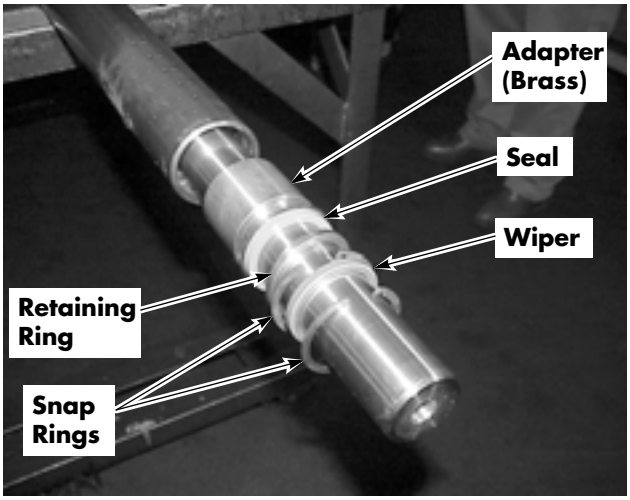


Figure 7-166. Piston Removal

3. Remove snap ring in cylinder housing.
4. Pull piston until piston stop pushes retaining ring, packing, and adapter out of cylinder. See Figure 7-166.
5. Pull piston out of housing. Place piston on cushioned stand. Do not damage piston surface.
6. Push cushion into piston at base of piston.

⚠ WARNING

The cushion is under extreme pressure. Keep pressure on the cushion when removing the items in the next step. Failure to do so could cause injury from projectile parts.

7. Remove snap ring and retaining ring. See Figure 7-167.

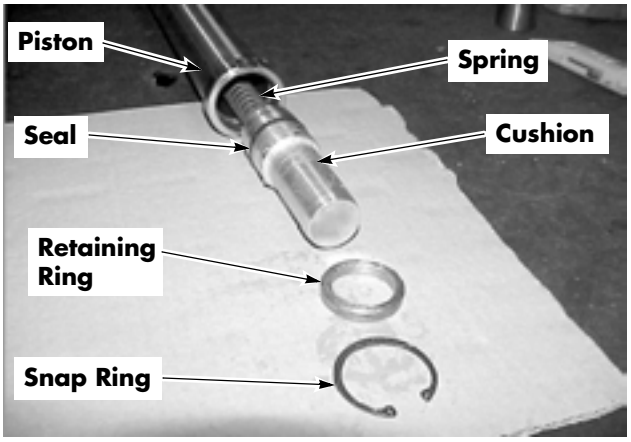


Figure 7-167. Cushion, Removed

8. Release pressure on cushion and pull cushion out of piston. See Figure 7-167.
9. Remove spring.
10. Remove seal from cushion.

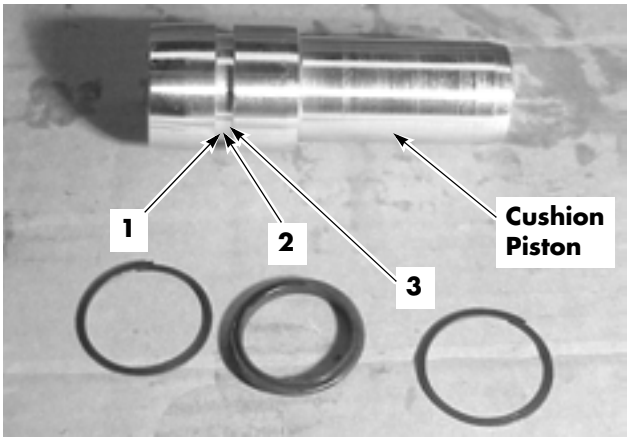


Figure 7-168. Cushion Piston Seal Kit, Shown In Order of Installation

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⚠CAUTION

Do not separate piston from piston plug unless necessary. If disassembly is required, use a strap wrench only. Do not damage piston surface.

NOTE: When repacking the cylinder, replace all packings. See Parts Catalog for packing kits.

11. Install seal kit on cushion piston. See Figure 7-168.

Tip: Twisting the fiber rings prior to installation helps them retain their "memory." See Figure 7-169.

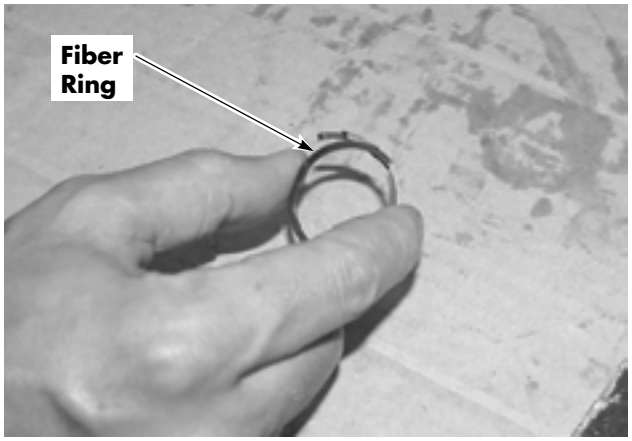


Figure 7-169. Twisting Fiber Rings

12. Install spring. Make sure it is fully seated in cushion piston.
13. Install cushion piston.
14. Install retaining ring and snap ring.
15. Install cylinder in truck. See Side Lift Cylinder on page 7-84.

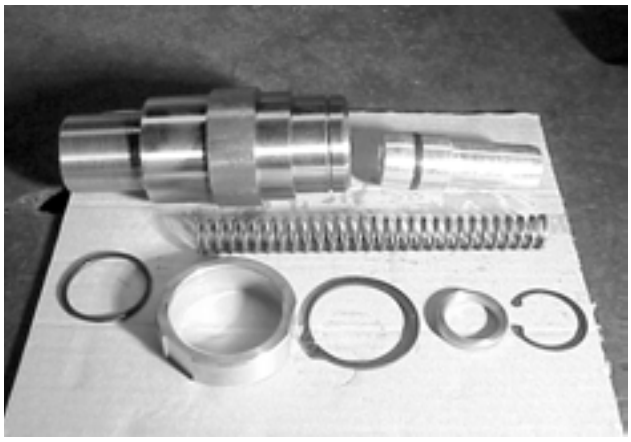


Figure 7-170. Cushion Assembly

Cleaning

1. Flush inside of housing.
2. Wipe piston with clean kerosene or suitable industrial solvent.
3. Inspect all surfaces for galling or heavy scratches. Remove minor damage with a fine emery cloth.
4. Inspect all parts: replace as necessary.

Seal Repacking

1. Remove cylinder. See Side Lift Cylinder on page 7-84.

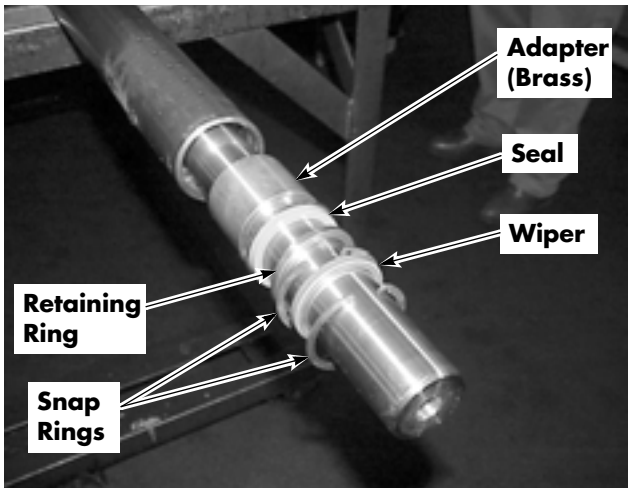


Figure 7-171. Packing Components on Side Cylinder

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⚠CAUTION

Do not damage chrome plating on piston.

2. Remove snap rings, seals, retaining ring and brass adapter. See Figure 7-171.
3. Dip all packings in clean hydraulic fluid.
4. Lubricate inside of cylinder housing with hydraulic fluid.

NOTE: To prevent damage to packings at the top of the cylinder, use the following tools:

- Service driver, P/N 401-000-050
- Service guide, P/N 401-000-051

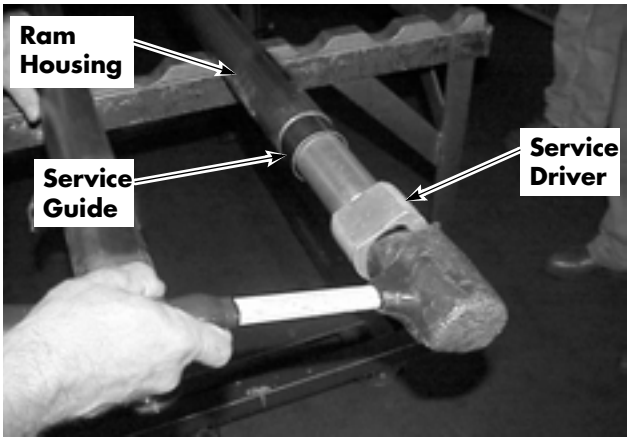


Figure 7-172. Using Cylinder Service Tools

5. Slide brass adapter on piston.
6. Install piston assembly into housing.
7. Install service guide. See Figure 7-172.
8. Dip seal in oil and slide over piston, back first.
9. Drive seal into assembly with driver. See Figure 7-172.
10. Remove service guide.
11. Install packing backup ring.
12. Install snap ring.
13. Install wiper.
14. Install snap ring.
15. Install cylinder. See Side Lift Cylinder on page 7-84.

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Center Lift Cylinder

Removal

1. Remove carriage. See Carriage on page 7-92.

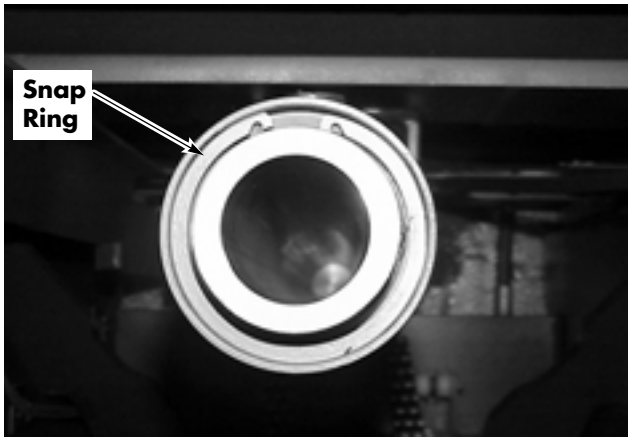


Figure 7-173. Center Cylinder, Bottom View

2. Remove snap ring and washer from bottom of center cylinder. See Figure 7-173.
3. Remove and cap hydraulic hoses.
4. Remove U-shaped bracket.
5. Remove center cylinder.

Installation

1. Install center cylinder. Make sure the bushing is on the mounting bolt.
2. Install washer and snap ring to bolt under center cylinder. See Figure 7-173.
3. Install U-shaped bracket.
4. Install carriage. See Carriage on page 7-92.
5. Install end cap on center cylinder.
6. Connect power and test lift function before returning truck to service.

Service of Cylinder with Cushions

Cushion Replacement

Refer to Figure 7-174 on page 7-89 for the following steps.

1. Remove retaining ring and top bearing .

NOTE: When the retaining ring is removed, a spring behind the top bearing may push the bearing out of the housing.

2. Remove the spring and pressure ring .
3. Remove the three Torx screws located about 6 in. from the top of the housing.
4. Remove piston from cylinder housing.
5. Remove the cushion assembly.
6. Coat the threads of the new cushion assembly with thread-locking compound primer (P/N 990-533) and apply thread-locking compound (P/N 990-571).
7. Assemble the new cushion assembly to piston rod.
8. Re-install piston assembly in cylinder housing.
9. Re-install the three Torx screws.
10. Lightly oil a new seal and install in pressure ring. Check to make sure the small orifice in the pressure ring is not obstructed.
11. Install spring.
12. Remove the bad parts from the top bearing.
13. Lightly oil new seal, O-ring, backup ring and wiper and install into the top bearing.
14. Install the top bearing.
15. Install the retaining ring.

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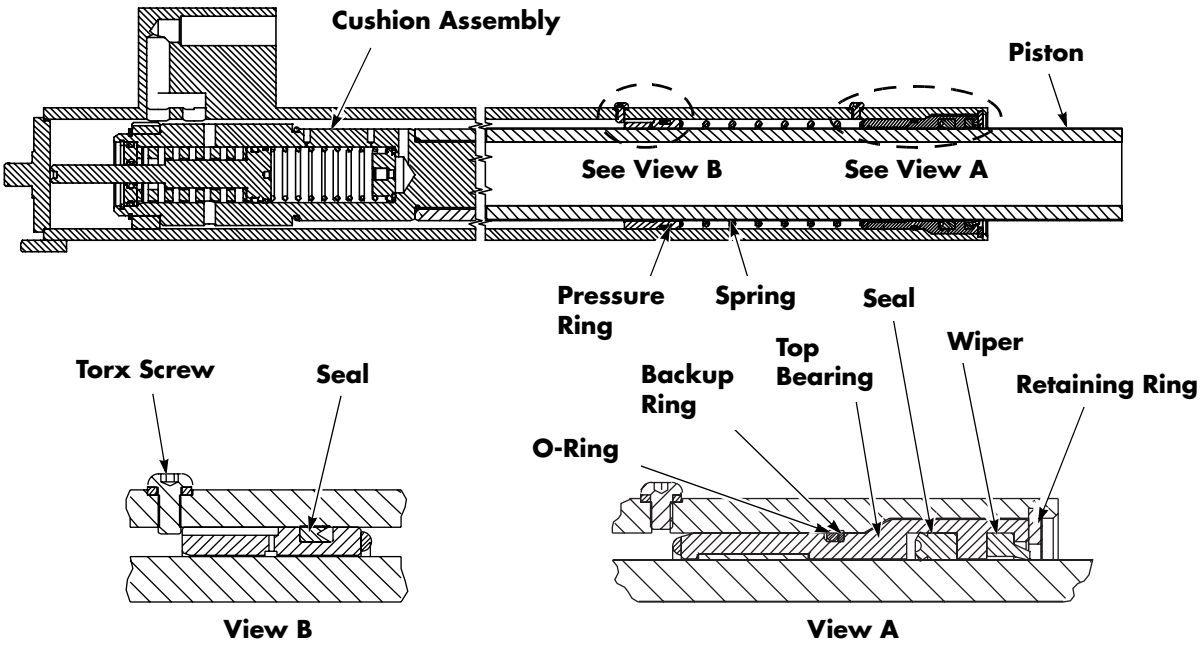


Figure 7-174. Center Lift Cylinder, Three-Stage with Cushions

Seal Replacement

Refer to Figure 7-174 for the following steps.

1. Remove retaining ring and top bearing.

NOTE: When the retaining ring is removed, a spring behind the top bearing may push the bearing out of the housing.

2. Remove the spring and pressure ring.
3. Check to make sure the small orifice in the pressure ring is not obstructed.
4. Lightly oil a new seal and install in pressure ring.
5. Remove the bad parts from the top bearing.
6. Lightly oil new seal, O-ring, backup ring and wiper and install into the top bearing.
7. Install the top bearing.
8. Install the retaining ring.

Installation

1. Reverse the removal procedure.
2. Install cylinder. See Side Lift Cylinder on page 7-84.
3. Reconnect the battery connector and turn the key switch ON.
4. Bleed hydraulic system after reassembly. See Bleeding Lift Cylinders on page 7-81. Check for leaks.
5. Test all vehicle functions.

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RAYMOND

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Mast Section

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Carriage

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove operator console cover.
3. Remove electrical over-the-mast cable from bottom pulley on carriage. See Figure 7-175.
4. Disconnect cable tension spring from carriage. See Figure 7-175.

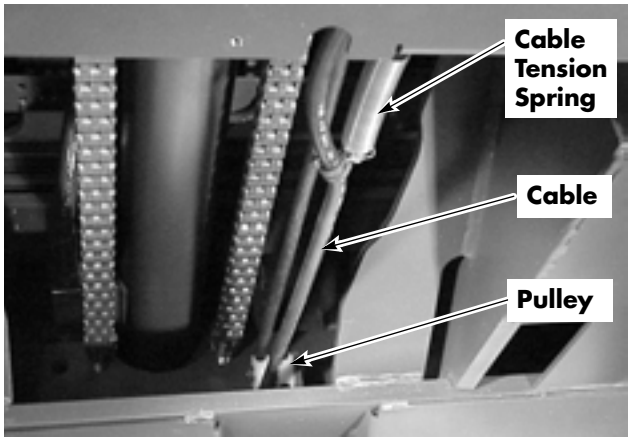


Figure 7-175. Electrical Over-the-Mast Cable

5. Disconnect JPC8 and JPC9 from carriage manager and cut cable tie from tractor side.

⚠CAUTION

Do not place hands between the masts before blocking the carriage.

6. Feed cable through carriage to tractor.
7. Use 90° snap ring pliers to remove snap ring holding chain rocker assembly to center cylinder. See Figure 7-176.

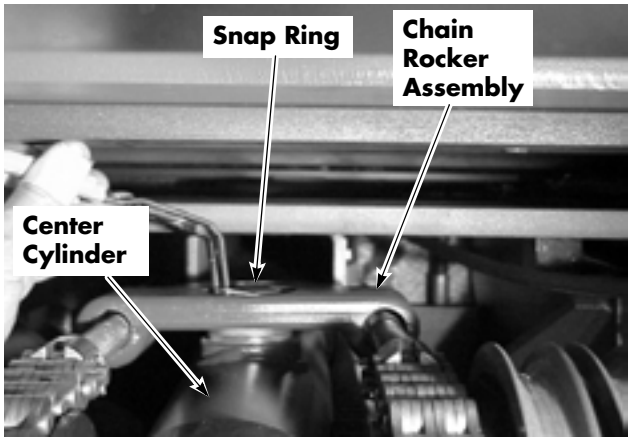


Figure 7-176. Center Cylinder, Top View

8. Attach a suitable hoist to carriage and lift approximately 1 ft. (30.5 cm).
9. Remove rocker assembly, its associated hardware and chain from center cylinder. Place chain on operator platform.
10. Remove end cap from center cylinder.
11. Remove carriage stops (2) from inner telescopic and pound in locator pins until carriage can clear the telescopic. See Figure 7-177 and Figure 7-178.

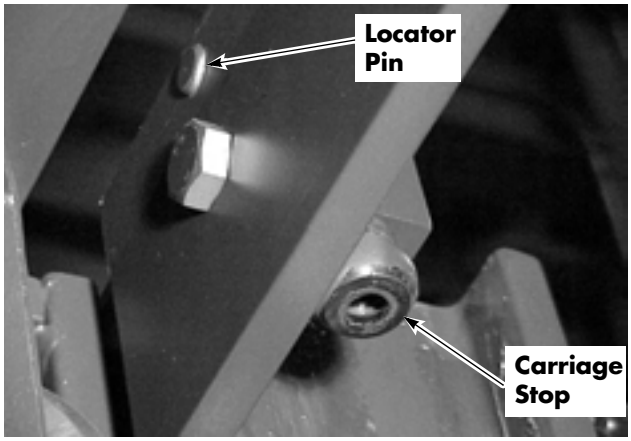


Figure 7-177. Inner Telescopic, Top Corner

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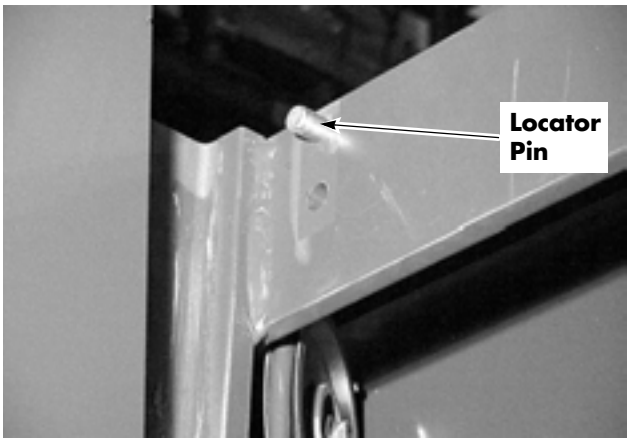


Figure 7-178. Inner Telescopic, Top Corner, Stops Removed

12. Remove operator platform.

Installation

1. With a suitable hoist, lower bottom bearings on carriage into channel on inner telescopic.
2. Make sure there are sufficient shims to prevent side play. See Mast Bearing Shimming on page 7-96.
3. Make sure the two switches (S36 and S37) at bottom of carriage are riding on their switch rail correctly. See Figure 7-179.

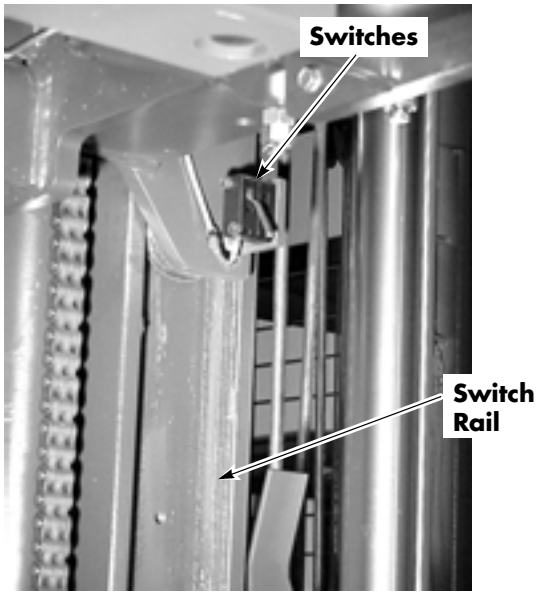


Figure 7-179. Underside of Carriage

4. Position platform 3 ft. (1 m) from floor.
5. Install rocker assembly, its associated hardware, and chain on center cylinder. See Figure 7-176.
6. Install end cap pulley on center cylinder.
7. Feed chains for center cylinder and over-the-mast cable.
8. Feed over-the-mast cable through back of carriage to carriage manager and connect to JPC8 and JPC9.
9. Use cable ties to secure electric cables to platform.
10. Install carriage stops at top of inner telescopic. See Figure 7-177.
11. Lower carriage and install cable on bottom pulley of carriage. Install cable retainer spring. See Figure 7-175.

NOTE: There is 5 1/2 in. (140 mm) from the top of the spring on the carriage to the center bolt in the cable clamp.

12. Install console cover.
13. Install mast guard.
14. Lift and lower platform fully, and check functions of lift system. Look for:
    - Hydraulic fluid leaks
    - Cables on pulleys
    - Switch actuation
    - Unusual bearing noise

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Center Cylinder Ride Spring Chain Anchors

Inspect the chain anchors and pivot rocker any time that the chains are lubricated and adjusted.

Inspection

1. Remove the operator compartment console cover and tractor cover.
2. Lift the operator platform just high enough to have the chain anchor/pivot rocker visible through the opening under the operator control panel.
3. Place blocking under the operator platform. Lower the platform onto the support.
4. Turn the key switch OFF and disconnect the battery connector. Open the emergency lower valve.

   The center cylinder will move down and the chains will go slack. If the center cylinder does not go down far enough to slacken the chains, push down on the top of the cylinder. This will allow the chain anchor to be visible for inspection. See Figure 7-180.

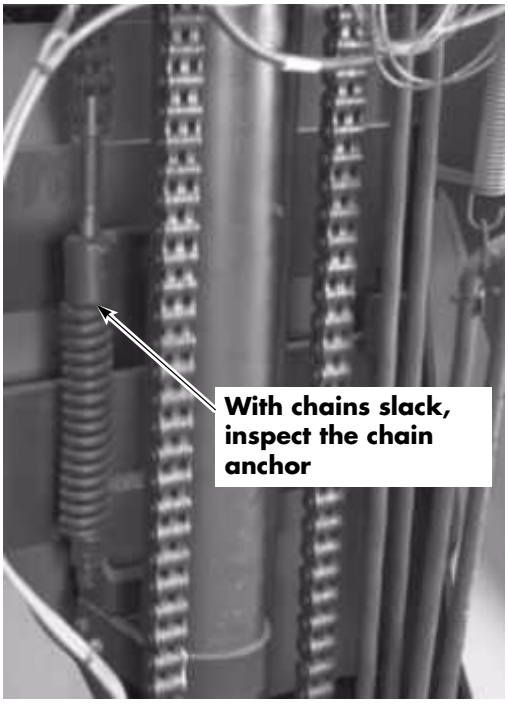


Figure 7-180: Chain Anchors

5. Inspect the chain anchor and pivot rocker for wear and replace if necessary.
6. Reconnect the battery connector and turn the key switch ON. Close the emergency lower valve.
7. Lift the platform *slowly* to take slack out of the chains and to clear the safety stand from beneath it.
8. Remove the stand and lower the platform.
9. Reinstall all covers.

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Forks

Removal

1. Raise operator platform high enough to reach bottom of forks.
2. Block operator platform.
3. Secure fork to hoist using a suitable strap or chain. See Figure 7-181.
4. Remove socket head cap screw from underneath fork at tractor end.

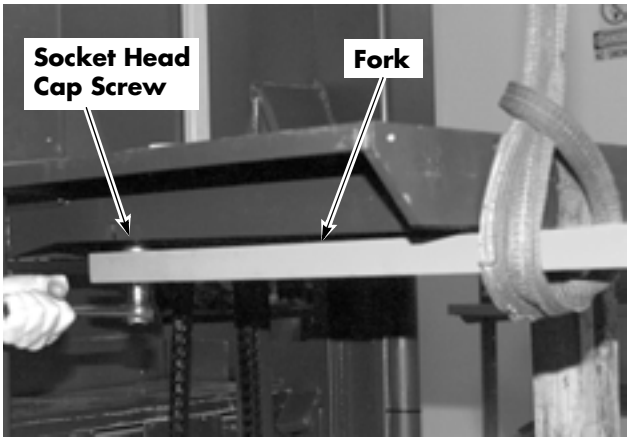


Figure 7-181. Fork Removal

5. Remove snap ring from pivot pin in mounting block of fork. See Figure 7-182.

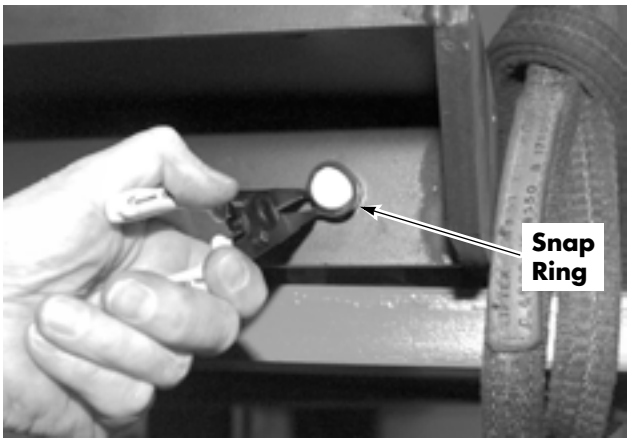


Figure 7-182. Snap Ring, Pivot Pin, and Mounting Block

⚠ WARNING

The fork will drop in step 6. It weighs approx 150 lb. (68 kg).

6. Drive out pivot pin. The fork, washers, or shim will drop.
7. Replace damaged fork.

Installation

1. Hold new fork in place underneath operator platform.
2. Install pivot pin through fork.

NOTE: Always use new snap rings when assembling components.

3. Install new snap ring in pivot pin.
4. Install correct amount of washers or shims at back side of fork to maintain a level fork. See Figure 7-183.

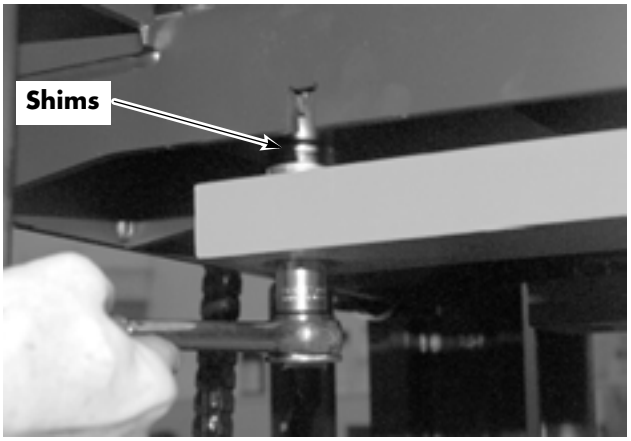


Figure 7-183. Installing Forks and Shims

5. Install socket head cap screw at tractor end of fork.
6. Remove block from operator platform.
7. Lower operator platform to floor and make sure forks are level. If forks are not level, add more shims to fork.

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Mast Bearing Shimming

Shimming a mast is done to ensure a smooth running unit that is not too tight or too loose. Total movement between the bearings and telescopics must be between 0.030 to 0.045 in. (0.76 to 1.14 mm).

If any marks are found within the telescopics or main frame where the rollers have been running, they must be removed with a sanding disk with 80 grit paper. Do not attempt to remove all marks, only the ridges.

A correctly adjusted mast must show no more than a 0.5 in. (13 mm) mark where the roller touches the respective telescopic or main frame. The assembly must be shimmed to the tightest spot on the assembly (as the rollers run up and down the rail). Small areas that are slightly higher than the rest of the web can be buffed to avoid shimming the major portion of the rail too loose. While shimming the mast, the telescopics and carriage must be loose enough to slide them in and out by hand. Shimming the assembly in an upright position can result in shimming that is too tight and could cause premature wear.

The shims used under each roller bearing come in the following sizes: thin, medium, and thick. When the truck is built, the factory typically installs a thick shim on each side. If the bearings are too loose, you should add shims to the bearing. If the roller bearings are shimmed too tight, causing wear along the I-beam or mast shaving, reduce the shim thickness. Although different combinations of shims may be used to obtain the correct adjustment, you should try to maintain equal shim thickness on each side of the mast main frame and telescopics. See Figure 7-184.

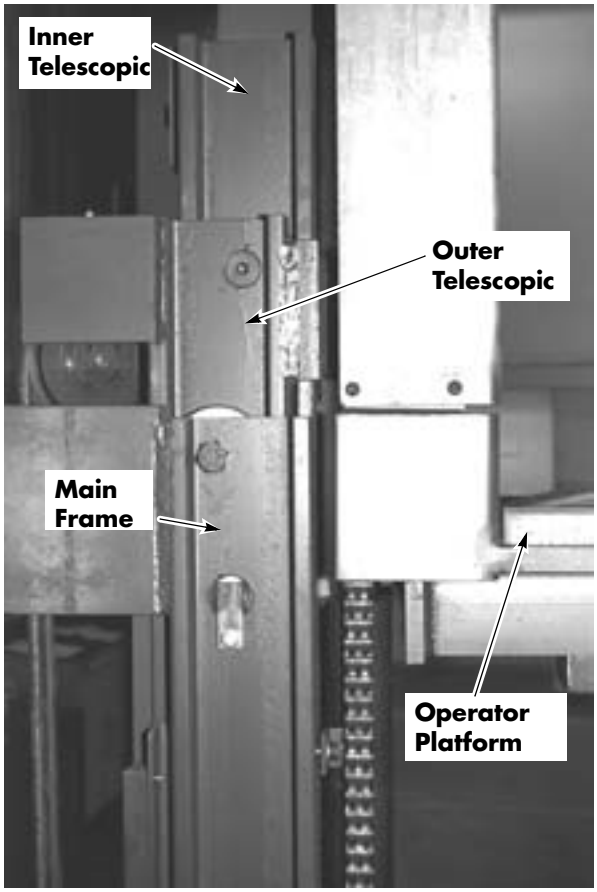


Figure 7-184. Staging of Mast Prior to Shimming Bearings

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Upper Mast Bearing Replacement

⚠ WARNING

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

1. Slightly elevate the carriage to gain access to the bearings.
2. Block the carriage before you attempt to remove the roller bearing. See Figure 7-185.



Figure 7-185. Blocking Carriage

   You may also use a lift hoist to pull the carriage upward to gain access to the roller bearing. Put a strap suitable to handle the weight of the carriage around the uppermost crosstie. Once the carriage is raised in place, block it into position.
3. Turn the key switch OFF and disconnect the battery connector.

⚠CAUTION

Do not damage the telescopic when prying with the screwdriver.

NOTE: For the upper mast bearings, wedge a screw driver between the roller bearing and the mast to prevent the bearing from falling.

NOTE: When removing the roller bearing, use caution not to let the bearing fall down into the mast assembly.

4. Remove the bolt securing the roller bearing to the respective mast or telescopic.

NOTE: If the bearings are worn or damaged, replace them.

5. Install the same number of shims under the bearing that were removed.
6. Make sure the roller bearing mounting bolts are clean before you install them.
7. Apply thread-locking compound (P/N 990-536) on the threads. Torque the bolts per Table 7-3.
8. Reconnect the battery connector and turn the key switch ON.
9. Lift the carriage and mast and unblock the mast.
10. Test the operation of the telescopics.
11. Return the truck to service.

Table 7-3. Mast Bearing Stud Retaining Bolt Torque Values

Location	*Torque
Main Frame	300 ft. lb. (406.7 N•m)
Outer Tele Upper	250 ft. lb. (339 N•m)
*After torquing, back bolt off 1/4 to 1/2 turn.	

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Mast Disassembly and Shimming

This section describes procedures for:

- Disassembling the three-stage mast
- Shimming main frame to outer telescopic
- Shimming outer telescopic to inner telescopic
- Shimming inner telescopic to carriage

Mast Disassembly

1. Remove the forks and mast guard.
2. Fully lower the carriage and make sure the pressure is out of the cylinders.
3. Turn the key switch OFF and disconnect the battery connector. Remove the battery.
4. Disconnect the over-the-mast cables and hoses inside the tractor compartment and plug the hoses. Disconnect the lift hose to the side cylinders inside the tractor compartment and plug. Disconnect all other cables that run from the tractor to the mast.
5. Secure the main carriage and telescopics so they cannot move.
6. Remove the tractor from the mast and block each securely.
7. Disconnect and remove the lift chains from the center lift cylinder. Remove the over-pulley-cables and hoses. Remove the center cylinder end cap assembly.
8. With a suitable hoist, carefully lay the mast assembly down and block securely in place. Remove the carriage stops from the inner telescopic.
9. Remove the main carriage by sliding it out the top of the inner telescopic. Set it aside for later reassembly.
10. Remove the lift chains, chain pulleys, hose pulleys, and cable pulleys.
11. Disconnect and remove the lift cylinders from the telescopics.
12. Attach the hoist to the inner telescopic.
13. Remove the upper roller bearing bosses and roller bearings from the outer telescopic.
14. Remove the telescopics and main frame stops.
15. Slide the inner telescopic out of the top of the outer telescopic. Attach the hoist to the outer telescopic.
16. Remove the upper roller bearing bosses and roller bearings from the main frame.
17. Slide the inner telescopic out of the top of the main frame.

Shimming Main Frame to Outer Telescopic

1. Install the mast roller bearings at the bottom of the outer telescopic.
2. Use a suitable lifting device and insert the outer telescopic into the main frame all the way to the bottom.
3. Using a pry bar, move the outer telescopic and roller bearing to one side.
4. Use spare shim(s) as a gauge to determine the amount required to move the roller bearings outward to make contact with the main frame.
5. Remove the outer telescopic from the main frame.
6. Remove the roller bearings from both roller bearing bosses at the bottom of the outer telescopic.
7. Install half of the total shim thickness required to each roller bearing boss at the bottom of the outer telescopic. (Applying one half of the total shim thickness to each side of the telescopic maintains the center line of the mast assembly.)
8. Reinstall the roller bearings. Torque the bolts per Table 7-3 on page 7-97.
9. Use a suitable lifting device and reinstall the outer telescopic into the main frame. Check for tightness while moving the outer telescopic to the bottom of the main frame. Add/remove shims as necessary to maintain a snug, but free-running, fit.

NOTE: If the outer telescopic hangs up, a pry bar may be used to move the telescopic.

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10. Assemble the two top main frame roller bearings and bosses without shims.
11. Install the roller bearing assemblies, attach with a retaining bolt, and snug up to the main frame.

NOTE: Failure to snug the assemblies to the main frame will result in the wrong amount of shims, since the studs are canted.

12. With the outer telescopic fully nested, use a pry bar and carefully move the outer telescopic to the opposite side. Using spare shims between the bearing and outer telescopic, determine the amount of shims required to remove side play.
13. Remove the roller bearing assemblies.
14. Install half of the total shim thickness to each roller bearing assembly.
15. Install the roller bearing assemblies and attach with the mounting bolts and tighten.
16. With the outer telescopic fully nested, use a pry bar to check for bearing tightness. If more shims can be inserted between the bearing and the outer telescopic, remove the roller bearing assembly and install the shim(s). Reinstall the bearing assembly.
17. Check for correct shimming by pulling the outer telescopic out and then pushing it in all the way. The outer telescopic should not hang up while moving it in and out. Torque the bearing stud retaining bolts per Table 7-3 on page 7-97.
18. Install the stops in the main frame.

Shimming Outer Telescopic to Inner Telescopic

1. Install the mast roller bearings at the bottom of the inner telescopic.
2. Use a suitable lifting device and insert the inner telescopic into the outer telescopic all the way to the bottom.
3. Use a pry bar and carefully move the inner telescopic and bearings to one side.
4. Use spare shim(s) as a gauge to determine the amount required to move the bearings outward to make contact with the outer telescopic.
5. Remove the inner telescopic from the outer telescopic.
6. Remove the bearings from both roller bosses at the bottom of the inner telescopic.
7. Install half the total shim thickness required to each roller boss at the bottom of the inner telescopic.
8. Reinstall the roller bearings. Torque the bolts per Table 7-3 on page 7-97.
9. Use a suitable lifting device and reinstall the inner telescopic into the outer telescopic. Check for tightness while moving the inner telescopic to the bottom of the outer telescopic.

NOTE: If the inner telescopic hangs up, a pry bar may be used to move the telescopic.

10. With the inner telescopic fully nested, use a pry bar to check for bearing tightness. If a thin shim can be inserted between the bearing and the outer telescopic, remove the inner telescopic and install the shim between the bearing and the roller boss. Torque the bearing stud retaining bolt per Table 7-3 on page 7-97. Leave the lifting device connected to the outer telescopic. *Do not apply excessive pressure to the bearings with the pry bar.*
11. Assemble the two roller bearings and bosses for the top inner telescopic without shims.
12. Insert the bearing/boss assemblies and attach with the retaining bolts. Draw the bearing bosses up snug to the outer telescopic.

NOTE: Failure to snug the assemblies to the main frame will result in the wrong amount of shims, since the studs are canted.

13. Use a pry bar and carefully move the inner telescopic to the other side. Using spare shims between the bearing and inner telescopic, determine the number of shims required to remove side play.
14. Remove the bearing/boss assemblies.

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15. Install half the total shim thickness to each bearing/boss assembly.
16. Install the bearing/boss assemblies into the outer telescopic/inner telescopic. Attach with a mounting bolt and tighten.
17. With the inner telescopic fully nested, use a pry bar to check for bearing tightness. If more shims can be inserted between the bearing and the inner telescopic, remove the bearing/boss assembly and install the shim(s). Reinstall the bearing/boss assembly. Torque the bearing stud retaining bolt per Table 7-3 on page 7-97.
18. Check for correct shimming by pulling the inner telescopic out and then pushing it in all the way. The inner telescopic should not hang up while moving it in and out.
19. Install the stops at the upper crosstie.
20. Install the outer lift cylinders.
21. Install the chain rollers and lift chains.
22. Install the center lift cylinders

Shimming Inner Telescopic to Carriage

1. Install the mast roller bearings on the carriage roller bosses.
2. Use a suitable lifting device and insert the carriage into the inner telescopic all the way to the bottom.

NOTE: The carriage may have to be removed several times to obtain the correct fit.

3. Using a pry bar, move the bottom carriage bearings to one side.
4. Use spare shim(s) as a gauge to determine the amount required to move the bearings outward to make contact with the inner telescopic.
5. Move the carriage to the top of the inner telescopic and repeat the process for the top set of bearings.
6. Remove the carriage from the inner telescopic.
7. Install half of the total shim thickness required to each roller boss.
8. Reinstall the roller bearings.
9. Use a suitable lifting device and reinstall the carriage into the inner telescopic. Check for tightness while moving the carriage to the bottom of the inner telescopic.
10. Use a pry bar to check for bearing tightness. If a thin shim can be inserted between the bearing and the inner telescopic, remove the carriage and install the shim between the bearing and the roller boss. *Do not apply excessive pressure to the bearings with the pry bar.*
11. Use a suitable lifting device and reinstall the carriage, checking for tightness. Make sure the carriage can be moved in and out by hand.
12. When the correct fit is obtained, measure the gap between the top of the platform and the inner telescopic on both sides. If the gap between the platform and the inner telescopic is not within 1/16 in. (1.59 mm) of each other, remove the platform.
13. Take shims from the top roller on the side that is farthest away and install them on the opposite side. Repeat this procedure until 1/16 in. (1.59 mm) is obtained. If all shims are on one side of the top rollers, remove shims from the bottom roller on the side that is farthest away and install them on the opposite side.
14. Repeat this procedure until the required clearance at the top of the platform is obtained.
15. Install the carriage and the carriage stops.
16. Install the pulleys for the over-mast-hoses and cables.
17. Secure the main carriage and telescopics in place so that they do not move while standing the assembly back up.
18. Install all the other items removed during the disassembly process after laying the assembly down.
19. Attach the hoist to the mast assembly and stand the mast back up. Install all the other items removed during the disassembly process prior to laying the assembly down.
20. Attach the tractor to the mast.

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21. Install the remaining components.
22. Connect the hoses and cables inside the tractor compartment.

⚠ WARNING

Make sure all mast stops are installed and securely tightened before operating the lift truck.

23. Reinstall the battery.
24. Reconnect the battery connector and turn the key switch ON.
25. Adjust the lift chains.
26. Install the forks and mast guard.
27. Check for correct operation.
28. Grease the channels.
29. Bleed the lift cylinders. See Bleeding Lift Cylinders on page 7-81.

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Section 8. Theory of Operation

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System Architecture

The following table identifies the various electronic components found on this truck and their function.

Ident	Component	Function
VM	Vehicle Manager	Controlling Manager for the truck. See Vehicle Manager on page 8-3.
TPA	Traction Power Amplifier	Powers the drive motor. See Traction Power Amplifier on page 8-4.
LPA	Lift Power Amplifier	Powers the lift motor on AC lift systems. See Lift Power Amplifier on page 8-4.
FRC	Fuse/Relay Card	Distributes B+/– throughout the truck. Houses the B+/– control fuses. See Fuse/Relay Card on page 8-5.
CCC	Carriage Control Card	Interfaces with operator and various components on carriage. See Carriage Control Card on page 8-3.
GM	Guidance Manager	Interfaces with the guidance coils and VM. See Guidance Manager on page 8-4.
	Filter Card	Located within GM. Filters and conditions the voltage from the guidance coils. See Filter Card on page 8-4.
	Antenna Cards	Receives and conditions the output from the guide wire. See Antenna Cards on page 8-4.
	Contactor/Fuse Panel	Contactors and power fuses are located on this panel.
	Auxiliary Card	Provides for the connection of the electrical devices required for the optional Auxiliary Mast. See Auxiliary Card on page 8-5.
	intellispeed® Module and Sensor	Processes inputs used for height calculation. See intellispeed® Module and Sensor on page 8-4.
	Operator Interface Card	Displays information and fault codes to operator. Also contains the push button entry keys. See Operator Interface Card on page 8-4.

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Systems Overview

The Orderpicker control system uses five "intelligent" devices working together to control the truck and respond to operator commands. These devices pass information to each other via the communications (CAN) Bus. The devices are:

- Vehicle Manager
- Carriage Control Card
- Traction Power Amplifier
- Lift Power Amplifier (AC Lift only)
- Guidance Manager (Wire Guidance Option only)

The system utilizes up to six other "non-intelligent" devices, depending on options. The following devices may also be installed on the truck:

- Filter Card (Wire Guidance Option only - located within GM)
- Antenna Cards (Wire Guidance Option only)
- Operator Interface Card
- Fuse/Relay Card
- Steering Amplifier
- *intellispeed*® Module

Intelligent Devices

Vehicle Manager

The Vehicle Manager (VM) controls the Orderpicker control system. It communicates with all other devices that are on the communications Bus. It receives, via the CAN Bus, all requests for travel and lift. The VM also receives information on the status of all carriage switches such as the Deadman, sidegate, and height switches. It also receives traction motor speed, direction, and temperature information from the Traction Power Amplifier (TPA): lift motor speed and temperature information from the Lift Power Amplifier (LPA). The VM determines allowable vehicle operation based on those inputs and operator requests. The VM and CCC share control of the brake release circuitry. The VM directly monitors and controls the steering system of the truck in both Auto and Manual modes of operation, but does not current limit the steering motor. The VM calculates and maintains the platform height count based on direct inputs from the *intellispeed*® Flow Module. The VM reduces the travel speed of the truck as necessary, based on the platform height and load weight as well as drive motor temperature. When in the guided mode, the VM receives information regarding the truck's position relative to the wire from the Guidance Manager (GM). During guided operation, the VM receives steering correction requests from the GM. It is the VM that slows or stops the truck as HA and DFW limits are reached or exceeded. The VM contains a power supply that provides a regulated +12V and +5V. It provides +12V to the CCC. The VM calculates the Battery State-of-Charge (BSOC) from the voltage measured at Battery Sense In.

Carriage Control Card

Although the Carriage Control Card (CCC) contains a microprocessor, a communications chip, and a firmware chip, it has very limited decision making ability and communicates only with the VM. The CCC and the VM share control of the brake release circuitry. The CCC functions primarily as an Input/Output (I/O) board for the devices connected to it, such as:

- deadman switches, sidegate switches, and lower limit switches
- steering tiller encoder
- travel and lift potentiometers

The CCC converts the voltages it reads from these inputs into a message that it sends to the VM that takes any action required. The CCC also drives the display and is the only manager that can put codes on the display. The only code that the CCC can actually precipitate is Code 50 (no VM communications received by the CCC). The VM commands all other codes, but must go to the CCC that causes the codes to be placed on the display. The CCC receives +12V from the VM. The CCC then regulates that voltage to +5.3V for the various devices that it powers.

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Traction Power Amplifier

The Traction Power Amplifier (TPA) communicates only with the VM, from where it receives all commands regarding travel direction and speed. The TPA monitors both the drive motor encoder and temperature sensor. It determines, based on the encoder feedback and the travel request, if the truck should be in travel, plugging, or regenerative braking, and determines if the performance has achieved the travel command from the VM. If it has not, the TPA adjusts the motor control voltage or sends a fault code to the VM, as appropriate. The TPA is solely responsible for controlling traction motor current. The TPA sends the traction motor temperature to the VM. The VM then alters the travel request if necessary depending on the traction motor temperature. The TPA monitors its internal temperature and limits current or travel speed as required by its internal programming. The TPA also checks the operation of the TPC, the charging of the amplifiers, and various internal operating parameters. It also sends fault codes to the VM if anything is operating incorrectly.

Lift Power Amplifier

The Lift Power Amplifier (LPA) is used on AC lift models only. The LPA only communicates with the VM, from where it receives all commands regarding lift speed. The LPA monitors both the lift motor encoder and temperature sensor. It determines from the encoder feedback if the motor has achieved the commanded speed request. The LPA is solely responsible for controlling lift motor current. It sends the lift motor temperature to the VM. The VM then determines if the motor must be shut down 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 the operation of the LPC, the charging of the amplifiers, and various internal operating parameters. It also sends fault codes to the VM if anything is operating incorrectly.

Guidance Manager

The Guidance Manager (GM) communicates with the VM 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 wire. It then reports the truck position along with a command for steering direction to the VM over the CAN Bus.

intellispeed® Module and Sensor

The *intellispeed*® module amplifies the inputs from the flow sensor and passes them on to the VM. The *intellispeed*® module also passes voltage from flow sensor temperature sensor to the VM for use during Learn.

Non-intelligent Devices

Filter Card

The Filter Card, attached both physically and electrically to the GM, provides voltages from the guide wire to the Guidance Card. The Filter Card contains circuitry that provides the GM with the guidance voltage levels required for correct operation of the guidance system. It is also connected electrically to the Antenna Cards that are located under the tractor and platform of the truck.

Antenna Cards

The two Antenna Cards are located along the center line of the truck. The Tractor Antenna Card is attached behind the center bumper plate in front of the drive tire. The Load End Antenna Card is located under the operator platform between the baselegs. The Antenna Cards contain circuitry that receives the signal from the floor wire and passes it to the Filter Card.

Operator Interface Card

The Operator Interface Card is mounted on the carriage and connected to the CCC. It contains the data entry push buttons and the character display that messages and codes are displayed

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on. It is driven by the CCC from where it receives all its inputs.

Fuse/Relay Card

The Fuse/Relay Card is a control power distribution board. It contains the B+ and B– control fuses and the K1 thru K4 relays. It provides B+ and B– to the VM, TPC, LPC, and CCC.

Steer Amplifier

The Steer Amplifier is an amplifier only. It takes a low level steering input from the VM and amplifies it to drive the steering motor. Steer motor current is limited by the Steer Amplifier. The Steer Amplifier also provides a steer motor current feedback voltage and a voltage called neutral pulse, which confirms amplifier operation, back to the VM.

Auxiliary Card

The Auxiliary Card acts as an interface between all switches for the optional aux mast and the Carriage Control Card.

Stored Value Locations

Value	Location
Primary Memory	The Primary Memory in this truck is stored in the CCC. There is a backup copy in the VM. If the CCC is blank or has garbled memory, the VM will send a copy up if the cards can communicate. If both cards are valid, but different, then the CCC will overwrite the VM.
Configure Mode Settings	Configure Mode settings are stored in both the CCC and the VM.
Learn Mode Values	Learn Mode values are stored in the VM.
Date and Time	Date and time are calculated and stored in the VM. There is no clock chip on the CCC.
Hour Meters	The hour meters (Hours Deadman, Hours Lifting, Key Hours, and Traction Miles) are stored in the CCC.

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Traction System

Deadman Pedal Depressed

When the Deadman Pedal is depressed, switches S2 (Brake Deadman) and S23 (Carriage Deadman) are closed. These switches are connected to the Carriage Control Card. The output of S2 is hard wired through the CCC and over the mast at JPC11-5 to JPT22-8 as an input to the VM processor. The Carriage Deadman voltage is not used by the CCC. It is only used by the VM. When S2 closes it switches Carriage Deadman voltage from a high state (>4.5VDC) to a low state (<0.7VDC). When the VM processor detects a low state at S2, it also needs to receive information that S23 is closed.

When S23 closes, it activates a circuit on the CCC that provides a high input (>4.5VDC) through the connect detect jumper (steering request encoder connector JPC1- 8 and 9) to the processor on the CCC. The purpose of this connect detect jumper is to ensure that the steering card is connected before the brake is released. When the processor receives that voltage, it performs two operations simultaneously. It sends a message over the communications bus telling the VM that the Brake Deadman is depressed. When the VM receives that message, it acknowledges to the CCC that the message was received. The CCC also activates a circuit on the CCC that switches the output Brake Deadman (JPC11-4) from a high state (>4.5VDC) to a low state (<0.7VDC). The output Brake Deadman is hard wired from the CCC at JPC11-4 to the VM at JPT22-7 through the over-the-mast cable.

To release the brake, the VM must know that all deadman switches are operational and that the steering encoder is connected. When the VM receives the communication message that S23 is closed, and detects low inputs at both JPT22-7 (Brake Deadman) and JPT22-8 (Carriage Deadman), it knows that all the required conditions are met. The VM then provides B– to JPT20-14 (Brake) that energizes the brake coil and releases the brake.

Travel

When the deadman is depressed, the brake is released. During Learn Mode, the VM learns the neutral position for the travel (VR1) and lift (VR2) potentiometers and stores those values in memory. During normal use, the VM learns the extreme values for full forward/reverse and full lift/lower. These values are also stored in memory in the VM. Refer to page 3-8 for a complete description of Learn Mode. The CCC is in constant communication with the VM through messages that report the status of the control potentiometers and carriage switches to the VM. When the VM receives the message, it compares the pot position information to the values that it stored when it learned the pots.

When the control handle is moved from neutral, the CCC detects a different voltage at JPC9-9 from VR1. The CCC updates the VR1 position value in the next message sent to the VM. When the VM receives the new position value, it compares that position value to the learned value for VR1 to determine the direction and magnitude of the travel request. The VM then looks at all speed limiting inputs such as motor temperature, height, weight, steering angle, and fault codes to determine if the requested speed is allowable. The VM then initiates a command for the appropriate direction and speed to the TPA over the communications Bus. The CCC is constantly monitoring the travel request at VR1 and updating the VR1 position value to the VM. The VM therefore, constantly updates the travel command to the TPA.

When the TPA receives a travel command from the VM, it produces a control output to the traction motor. All operational parameters that affect travel motor torque and speed are controlled exclusively by the TPA. It monitors motor current, voltage, and RPM, and from them, can determine motor performance. The TPA will alter its control output to the traction motor to match the motor performance to the travel command from the VM. As the travel request from the CCC to the VM changes, so does the travel command from the VM to the TPA that in turn, alters motor operation to track the travel request from the operator. The TPA also monitors drive motor temperature and the

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internal temperature of the amplifier and can alter travel based on the TPA temperature. The TPA sends motor temperature to the VM, and the VM alters the travel command based on drive motor temperature.

When the truck is moving and the travel control handle is moved to request the opposite direction, the same sequence of events takes place. The VM does not request plugging or regeneration: it just requests travel in the opposite direction at whatever speed the CCC communicated. The TPA, that calculates both direction and speed, determines whether the travel command from the VM must be met with a travel, a plug, or a regeneration control output to the drive motor.

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Steering System

This section contains a description of the steering system. For wire guided steering information, refer to page 8-13.

System Components

- **Steering Request Encoder** – a dual encoder located behind the steer wheel on the carriage converts the operator request into electronic pulses
- **Carriage Control Card** - converts the inputs from the steering request encoder into a message sent to the Vehicle Manager
- **Vehicle Manager** - the controlling manager of the steering system. Generates commands to the steer amplifier based on the message from the Carriage Control Card
- **Steer Amplifier** - amplifies the steering commands from the Vehicle Manager and drives the steer motor
- **Electric Steer Motor/Gear Reducer** - positions the drive unit
- **Steer Motor Encoder** - located inside the steer motor and used to determine if the motor is responding to the commands of the VM
- **Home Sensor Prox** - used by the steering system to position the drive unit straight ahead during Auto Steer Center

System Overview

The Steering Request Encoder is attached to the steer tiller on the carriage. The Steering Request Encoder is a dual encoder. It contains two encoders in a single package.

Each encoder produces two channels that are quadrature phased and are used by the CCC to produce a steering request (steering count) that is sent to the VM over the communications bus. The VM, in turn, sends steering commands for either clockwise or counterclockwise rotation to the Steer Amplifier. The Steer Amplifier drives the steering motor to obtain the movement that was requested from the tiller.

Both steering encoders in the dual encoder must be operational for full travel speed. If only one steering encoder is operational, travel speed is limited to 2.5 mph.

The VM monitors steer current (JPT6-3), the Steer Motor Encoder, and Neutral Pulse to determine that the steering system is operating correctly. The VM supplies +12VDC to the Steer Amplifier at JPT6-6 to power the circuits inside the Steer Amplifier. When the deadman is depressed, the VM energizes the TPC contactor, providing B+ to TP2 on the Steer Amplifier to power the steer motor.

Functional Description

The dual steering encoder is connected to the CCC at JPC1 (encoder 1) and JPC21 (encoder 2). Each encoder has a +5.3V supply, a DGND, two quadrature phased channels (CHA and CHB), and a jumper that is used as a connect detect to ensure that the steering encoder is connected to the CCC before normal operation of the truck is allowed by the VM.

When the tiller is moved, each encoder produces an output pair (CHA and CHB from encoder 1 and CHA-E2 and CHB-E2 from encoder 2). If the tiller is turned faster, the frequency of the output from the encoder increases. Each pair is converted into a positive or negative steering count that contains information on the direction and speed of the steering request from the tiller. This is sent over the communications bus to the VM. If either of the steering counts are missing, the VM will cause a steering code to be displayed;

- Code G0 if CHA/CHB is missing
- Code G7 if CHA-E2/ CHB-E2 is missing

When the VM receives the steering count from the CCC, it produces the appropriate steering command for the Steer Amplifier. This steering command is sent to the Steer Amplifier at JPT6-5 (CCW-PWM for CCW rotation) or JPT6-2 (CW-PWM for CW rotation). Although these commands are a PWM voltage, either can be

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measured as a DC voltage with a Digital Multi Meter. The voltage will vary from approx. 11VDC when the steering tiller is stationary, and decreases as the steer tiller is moved faster. A slow request is represented by a voltage of about 9VDC and a fast request is represented by a voltage of approx. 5VDC measured with respect to (wrt) B–. Because the VM is monitoring both the steer motor current and the output from the Steer Motor Encoder, it knows that the steer motor moves when requested.

When the steer motor is not moving, there is no input to the VM from either the steer motor current or the steer motor encoder. This situation can occur when driving in a straight line. The VM needs a way to ensure the steer system is operational. This is accomplished through the Neutral Pulse. When the Steer Amplifier has an input at the CW-PWM line, it drives the Neutral Pulse output low (<0.5VDC). When the Steer Amplifier has an input on the CCW-PWM, it drives the Neutral Pulse high (>4VDC). When the deadman is depressed and there is no input on either the CW-PWM or the CCW-PWM lines, the VM dithers the CW-PWM and CCW-PWM control lines, causing the Neutral Pulse line to toggle between high and low states. The VM detects the Neutral Pulse is toggling as the CW-PWM and CCW-PWM lines vary, thereby ensuring the VM that the steering system is operational.

The connect detect jumper for encoder 1 is JPC1-8 and 9 and is called BRKDMAN/ DEADMAN. If that jumper is open or JPC1 is disconnected, the hard wired voltage, BRAKE DEADMAN, from the CCC to the VM is interrupted and the VM will cause a Code 8C. If the jumper is intact and the encoder fails, the VM will lose steering encoder one and the VM will cause a Code G0.

The connect detect jumper for encoder 2 is JPC21-5 and 6 and is called CD SUPPLY/CD. This jumper connects a 5VDC supply to an input on the CCC processor. When the voltage is present, the CCC sends a message to the VM that the steering encoder is connected. If the voltage is not present, the message to the VM is that the encoder is not connected and the VM causes a Code G7. If the jumper is intact and encoder 2 fails, the CCC will send a count for encoder 1 and not encoder 2, to the VM, and the VM will still cause a Code G7. Either failure will cause the same code.

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Lift/Lower System

Emergency Lower

Provisions are made to lower the carriage from the ground. When the Emergency Lower Valve is opened, hydraulic fluid is allowed to pass through the emergency lower valve at a constant rate.

Variable Speed DC Lift with *intellispeed*®

NOTE: For trucks without *intellispeed*, all functions are the same excluding references to the flow sensor, *intellispeed* manager, and height counts.

The CCC is constantly monitoring the output voltage of VR2 and sending it to the VM over the BUS. The VM compares this voltage to the voltages stored during the Learn process. The VM checks the battery voltage (for lift cutout), all enabled options and switches that could prevent the activation of the lift system. When satisfied that no criteria are present to prevent lift, it then determines the requested percentage of full speed lift. It then activates the lift/lower proportional valve fully open and closes the lift pump contactor by taking the coils to B–.

Opening the lift/lower valve fully prevents sudden movement of the platform when the lift pump is first activated by allowing the fluid to return to the tank. As soon as the command to close the P contactor is activated, the VM looks at the P Sense input, verifying the contactor closed as commanded. It then slowly reduces the PWM output to the coil for the lift/lower proportional valve to match the percentage of full speed lift requested. As the lift/lower proportional valve closes, hydraulic fluid passes through the 5 psi check valve, the normally closed check valve in the load holding valve, through the flow sensor to the flow controls at the bottom of the lift cylinders. The flow control in the center cylinder allows unrestricted fluid flow to the center lift ram. The center ram elevates first because less pressure is required. Once the platform hits the stops on the inner telescopic, the pressure increases enough to start elevating the side cylinders. Oil flow spins the turbine in the flow sensor. As the turbine spins, the vanes pass by the magnetic pickups screwed into the flow sensor housing. This creates a series of high and low pulses (or counts) that go into the flow sensor module. The pickups are 90° out of phase. This allows the system to determine if the carriage is elevating or lowering, based on the direction the vanes are spinning. The flow sensor module passes these counts to the VM. The VM determines the direction of travel and the number of counts. The VM uses this information to calculate fork height, which it uses to determine speed reductions at elevated height.

When the VM first commands the activation of the lift system, it is looking for the feedback from the flow sensor. If the lift is commanded to activate and no counts from the flow sensor are present, the VM will flag an error condition and assume it is at maximum elevated height for speed limiting. Travel speed is reduced linearly by about 0.5 mph for every 18 in. from full speed down to 1 mph, between the lower reference switch and 240 inches. A low volume of fluid flow will not cause the turbine to spin. Because of this, if the lift system is feathered often, an error is registered. If the *intellispeed* option is not on the truck, the travel is reduced each time a mast limit switch is opened while elevating.

The VM monitors the P Sense line to determine the condition of the P contactor and verify the lift motor is spinning. When a lift request has finished (VR2 has either returned to neutral or through neutral to a lower request), the VM monitors the P Sense line for back ElectroMotive Force (EMF) from the motor to determine that the lift motor has stopped spinning. As long as the VM senses voltage on the P Sense line, it will provide voltage to the lift/lower proportional coil, keeping the valve open to allow the fluid from the pump to return to tank. This ensures the cylinders do not continue lifting after the request has ended. Once the lift motor has completely stopped spinning, the VM will remove voltage to the lift/lower coil, closing the lift/lower proportional valve.

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24V Trucks With Hi-Pro Option

24V trucks with the Hi-Pro Option have a two stage lift pump. This lift pump has a 2nd stage select solenoid on the bottom of the pump. This solenoid is activated whenever there is less than 1000 lb. (454 kg) on the forks. When activated, the fluid from the second pump is ported to the lift system to increase lift speed. The weight calculation is done with either a pressure transducer or a pressure switch (trucks without *intellispeed*®) located on the hydraulic manifold. The input from the pressure switch goes directly to the VM and activates a circuit to turn off the 2nd stage select solenoid. On trucks with the pressure transducer, the VM calculates the weight and turns off the solenoid when a reading of 1000 lb. (454 kg) or more is registered.

Variable Speed AC Lift with *intellispeed*

NOTE: For trucks without *intellispeed*, all functions are the same excluding references to the flow sensor, *intellispeed* manager, and height counts.

The CCC is constantly monitoring the output voltage of VR2 and sending it to the VM over the BUS. The VM compares this voltage to the voltages stored during the Learn process. The VM checks the battery voltage (for lift cutout), all enabled options, and all switches that could prevent the activation of the lift system.

When satisfied that no criteria are present to prevent lift, the VM then determines the requested percentage of full speed lift. It then sends an RPM command over the BUS to the Lift Power Amplifier. The LPA activates the LPC contactor by taking the coil to B– internally in the LPA. As soon as the command to close the P contactor is activated, the LPA looks at the (+) input from the LPC verifying the contactor closed as commanded. It then slowly increases the voltage output to the lift motor to match the RPM requested. As the voltage is increased to the lift motor, the motor and pump spin faster, increasing the output of oil to the lift system.

The LPA monitors the input from the bearing encoder in the lift motor and determines the RPM of the motor. It adjusts the output to the motor to maintain the requested RPM. The hydraulic fluid passes through the 5 psi check valve, the normally closed check valve in the load holding valve, through the flow sensor to the flow controls at the bottom of the lift cylinders. The flow control in the center cylinder allows unrestricted oil flow to the center lift ram. The center ram elevates first because less pressure is required. Once the platform hits the stops on the inner telescopic, the pressure increases enough to start elevating the side cylinders. As the lift cylinders start to elevate, the fluid flow starts to spin the turbine in the flow sensor once the volume is large enough**.** As the turbine spins, the vanes pass by the magnetic pickups screwed into the flow sensor housing. This creates a series of high and low pulses (or counts) that go into the flow sensor module. The pickups are 90° out of phase. This allows the system to determine if the carriage is elevating or lowering, based on the direction the vanes are spinning. The flow sensor module passes these counts to the VM. The VM determines the direction of travel and the number of counts. The VM uses this information to calculate the fork height that it uses to determine speed reductions at elevated height. When the VM first commands the activation of the lift system, it is looking for the feedback from the flow sensor. If the lift is commanded to activate and no counts from the flow sensor are present, the VM will flag an error condition and assume it is at maximum elevated height for speed limiting. Travel speed is reduced linearly, about 0.5 mph every 18 in., from full speed down to 1 mph, between 60 and 240 inches. A low volume of fluid flow will not cause the turbine to spin. Because of this, if the lift system is *feathered* often, an error is registered. If the *intellispeed* option is not on the truck, the travel is reduced each time a mast limit switch is opened.

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Variable Speed Lower Activation

The following is based on a lower request from a full speed lift situation.

VR2 passes through neutral to a full speed lower request. The CCC sends the voltage to the VM over the BUS. The VM recognizes the change and realizes full speed lower is required. All enabled options and switches that can prohibit lower are checked.

Once the VM is satisfied that lower can be allowed, it monitors the back EMF of the lift motor through the P Sense line. The VM monitors the P Sense line to determine the condition of the P contactor and verifies the lift motor is spinning. When a lift request has finished (VR2 has either returned to neutral or through neutral to a lower request), the VM monitors the P Sense line for back EMF from the motor to determine that the lift motor has stopped spinning. As long as the VM senses voltage on the P Sense line, it will provide voltage to the lift/lower proportional coil, keeping the valve open to allow the fluid from the pump to return to tank. This ensures the cylinders do not continue lifting after the request has ended.

Once the lift motor has completely stopped spinning, the VM removes voltage to the lift/lower coil, closing the lift/lower proportional valve. The Load Holding solenoid is activated by the VM, opening the valve. The VM then gradually opens the lift/lower solenoid to the percentage of requested lower. This allows the oil to flow from the side lift cylinders through the flow controls at the bottom of the cylinders, the 180 psi telescopic hang up valve, the flow sensor, the load holding valve, the lift/lower prop valve, the 100 psi platform hang up valve, the filter, and back to the reservoir. The telescopics will lower first due to the greater amount of pressure on the hydraulic fluid in the side cylinders. Once the telescopics fully lower, the center cylinder will begin to lower. Lowering causes the turbine in the flow sensor to spin in the opposite direction of lift and reverses the counts to the VM. The VM counts down, lowering the height count. If the forks get hung up while lowering, there is a 180 psi (1241 kPa) check valve in series with the side lift cylinders and a 100 psi (689 kPa) check valve in the manifold for the center cylinder. If the pressure on these valves is reduced below their rated pressure, the check valve will close, stopping the lower function. This keeps fluid from draining out of the cylinders and keeps the over pulley hoses, cables, and lift chains from falling off the pulleys.

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Wire Guidance System

This section contains a description of the wire guidance system. For manual steering information, refer to page 8-8.

System Components

- **Auto/Manual Switch (S4)** – located on the dashboard near the speed control handle. This switch is used by the operator to select manual steering or wire guided operation.
- **Carriage Control Card** - located behind the console cover and below the steer tiller assembly. It monitors the state of the Auto/Manual switch and advises the VM if it is open (Auto) or closed (Manual). Also operates the wire guidance icon LEDs on the Carriage Light Display card.
- **Vehicle Manager** - located in the tractor compartment. It is the controlling manager for the steering and travel systems. When it is advised that the Auto/Manual switch is in the Auto position, it uses the truck position information supplied by the Guidance Manager to provide steering control for the truck. The VM also provides direction and speed information to the Guidance Manager that enables it to provide correctly oriented steering commands for either forward or reverse directions of travel.
- **Steer Amplifier** - located at the rear wall on the top deck of the tractor compartment. It amplifies the steering commands from the VM and provides the high power drive necessary to control the steer motor.
- **Guidance Manager (GM)** - located on the right side of the drive tire wheel well housing in the tractor compartment. This assembly is 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 into DC voltages usable 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 the position of the truck relative to the guide wire using the voltages received from the Filter Card. The Guidance Card informs the VM of the necessary steering corrections to keep the truck over the wire, guidance system error codes, distance from wire, and heading angle information.
- **Antenna Cards** - there are two of these antenna assemblies. The Tractor Sensor is located behind the center bumper plate in front of the Drive Unit. The Load Sensor is located on a bracket between the baselegs beneath the operator platform. Each sensor card has 4 coils mounted on it. The center pair are the Nearwire 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 then 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 that are used by the VM to determine steer motor speed and direction of rotation. The VM then checks this information against the steering commands from the GM to verify correct operation.
- **Home Reference Prox Sensor** - used by the VM to determine “Home” or straight ahead position of the drive unit.
- **Guide Wire** - a wire that is buried in the facility floor that radiates a magnetic field when an AC current flows through it.

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System Overview

When the truck is in the wire guided mode, the truck steering functions the same way as when in the manual steering mode with one exception. Steering requests do not come from the CCC when in wire guided mode as they do in manual steering. In the wire guided mode, steering requests originate in the GM. To switch from manual steering to the wire guided mode, several events need to occur.

First, the CCC needs to detect that the Auto/Manual switch (S4) is open (Auto position). Next, the CCC needs to advise the VM that S4 is open. When the VM is advised that S4 is in the Auto position, 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 VM what direction and how far to steer the drive unit. During wire guided operation, the GM is constantly updating the VM with corrections since the trucks position relative to the guide wire is constantly changing. If the truck exceeds the deviation values for Distance from Wire or Heading Angle that are set in Configure, the GM will inform the VM to either slow or stop the truck depending on the magnitude of the deviation.

Functional Description

During normal manual steering operation, the CCC is in constant communication with the VM, updating the VM 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 VM 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 CCC detects that S4 is opened (Auto position), it advises the VM that S4 is open. The VM determines that the truck is ready for wire guided operation and transfers the steering control from the Steering Encoder to the GM.

The GM then tells the VM 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 Wire Sense Creep (WrSnCrp) option is enabled in Configure Mode, truck speed is limited to 1 mph 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 (on the Carriage Light Display card) will blink. Steering at this time will still be in manual control because the truck has not acquired the wire. The operator must be steering the truck toward the guide wire location to help the truck acquire the wire.

As either the tractor end or the load end center pair of sensor coils (Nearwire coils) approach the guide wire, they begin to detect the magnetic field around the guide wire. If the Nearwire coils do not detect this magnetic field for any reason, the truck will 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 was picked up by the 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 Nearwire coils get closer to the wire, the value of the DC voltage to the Guidance Card increases. When the Nearwire coils get close enough (to the wire), and the voltage is high enough, the Guidance Card tells the VM 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 VM ignores the steering request from the CCC and all the wire guidance icon LEDs on the Carriage Light Display Card will 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

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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 will switch from Aligning Mode to Locked on Wire or Guided Mode. At that time, all of the wire guidance icon LEDs on the Carriage Light Display Card will 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 VM to keep the truck centered over the guide wire. Also, using these values, the Guidance Card calculates the Heading Angle (HA - angle of the truck to the wire) and the Distance From Wire (DFW - how far the truck is from the wire) and issues the appropriate Slow or Stop commands to the VM when DFW or HA values set in Configure Mode are exceeded. See Table 3-2, “Configure Mode Menu,” on page 3-13.

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 VM. When the system is activated, the VM monitors the inputs from the sensors. When entering the aisle and both sensors cross a magnet in less than 24 in. (610 mm), the VM 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 be powered 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 within 10 in. of each other, the truck will plug 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 VM 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. When the sensors are activated by magnets that are more than 11 in. (279 mm) but less than 30 in. (762 mm) apart, the VM plugs the truck to a complete stop. The operator must then return the control handle to neutral and request travel again.

End-of-Aisle Configurations

Figure 8-1 shows the various EOA configurations possible within a system.

End-of-Aisle Magnet Installation Information

If there are consistent, repetitive problems with end-of-aisle operation, and the truck appears to be OK, the magnets may have been installed out of tolerance. Figure 8-2 and Figure 8-3 depict the correct location of the magnets.

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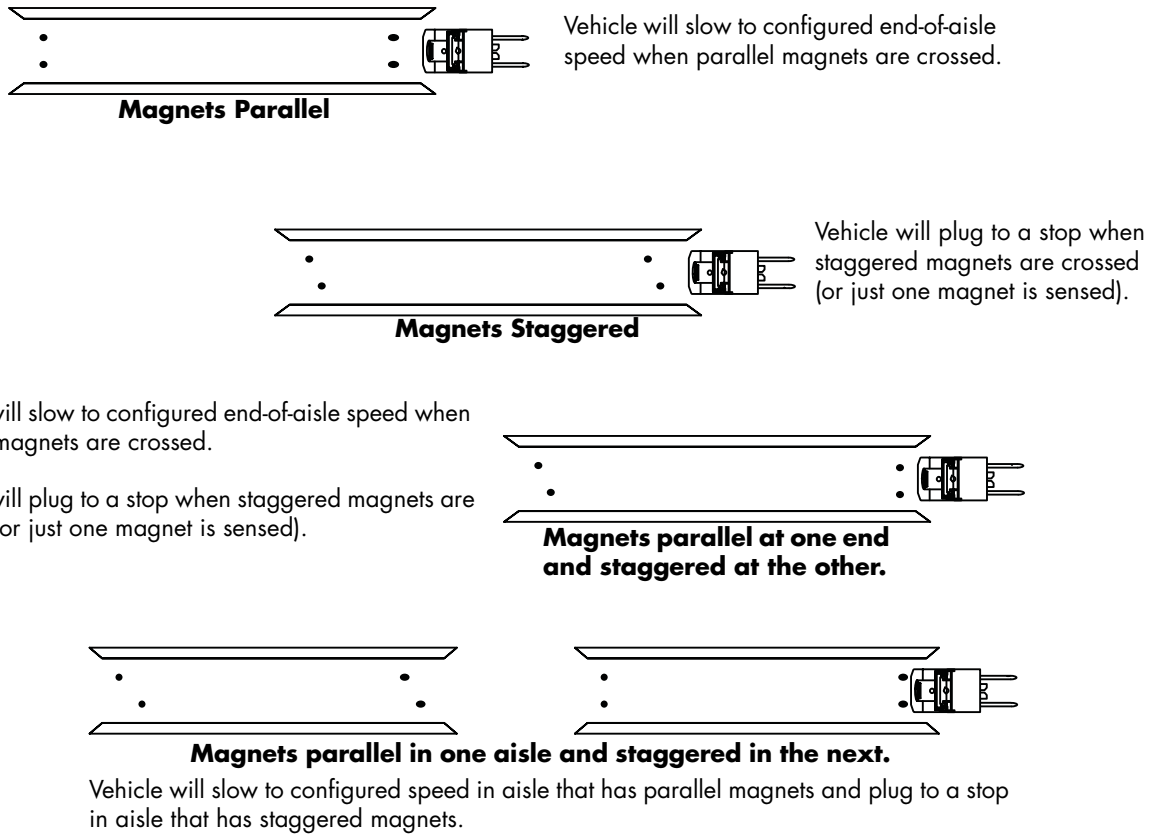
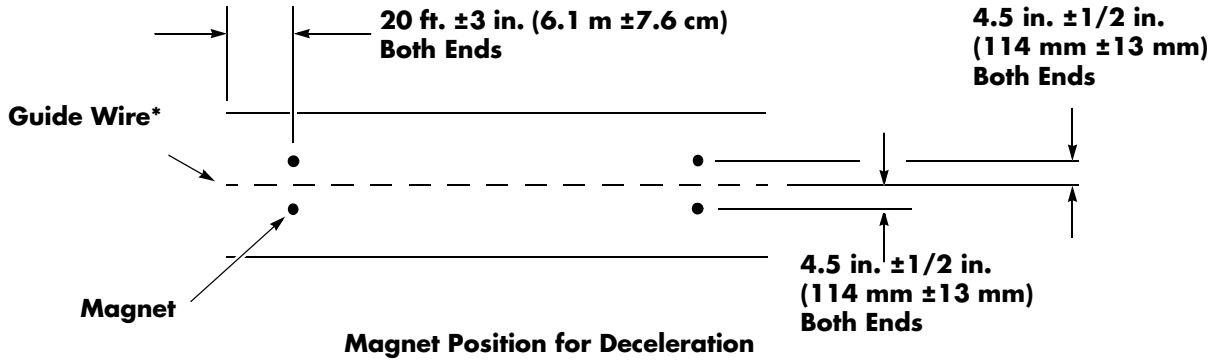


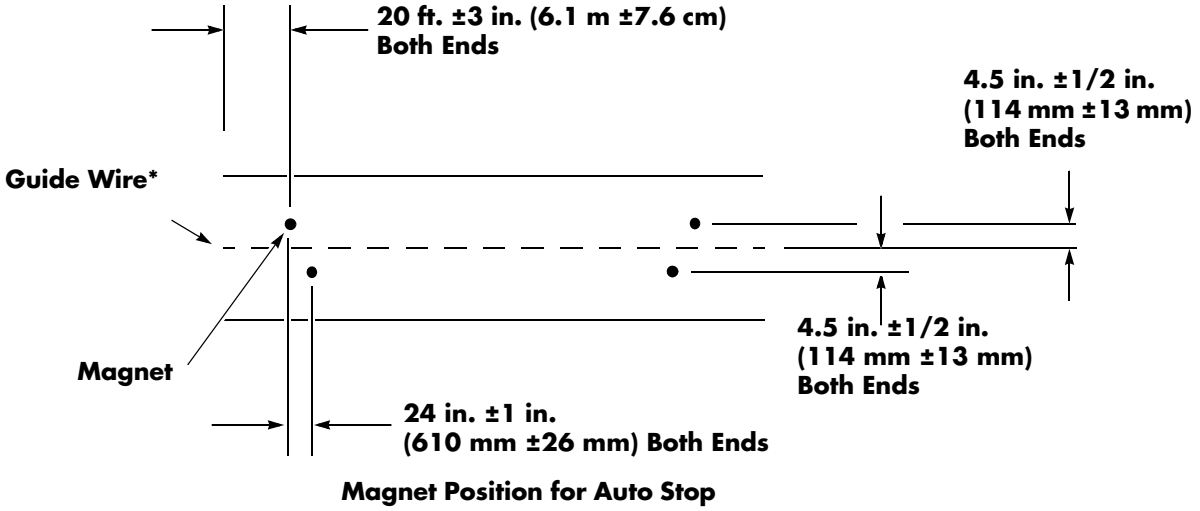
Figure 8-1. End-of-Aisle Configurations



*** In rail guided applications, use the center of the aisle as the reference point for the dimensions.**

Figure 8-2. End-of-Aisle Magnet Position (Deceleration)

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***In rail guided applications, use the center of the aisle as the reference point for the dimensions.**

Figure 8-3. End-of-Aisle Magnet Position (Auto Stop)

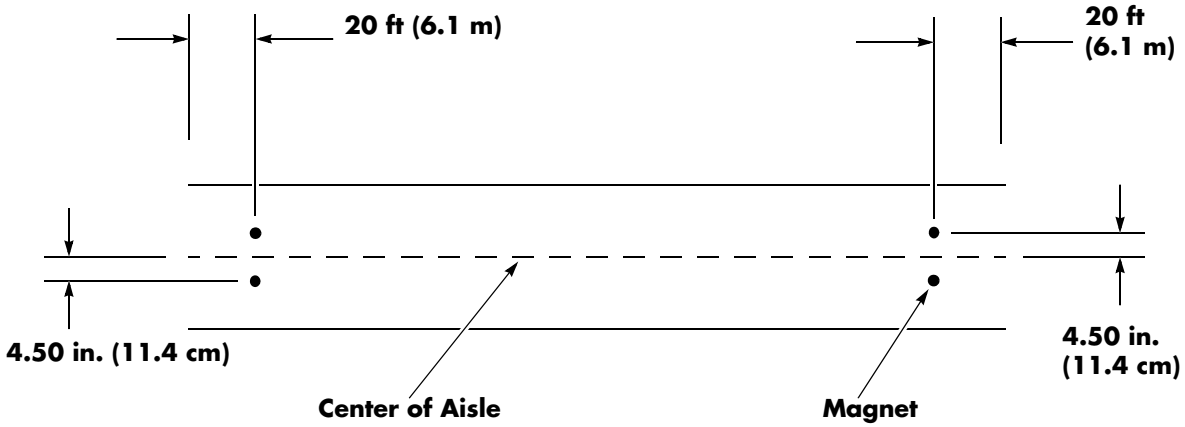


Figure 8-4. End of Aisle Magnet Location

End-of-Aisle Slow Down

With Wire Guidance

When the truck is locked on the guide wire, the VM will start looking for the input from the magnet sensors. When a set of magnets is crossed entering the aisle, the system functions as described in End-of-Aisle Control. If the magnets are crossed while exiting the aisle with the AUTO/MANUAL switch in the AUTO position, the truck will slow down or stop; whichever the system is configured for. If the AUTO/ MANUAL switch is moved to the MANUAL position prior to crossing the magnets, the system will not look for the magnets. Steering is reverted to the operator and normal operation is resumed. Once out of the aisle and the steering is turned more than 10° while traveling, the aisle state is reset to out-of-aisle.

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End-of-Aisle Slow Down

With auto steer center in a rail guided system WITH a rail switch installed on one guide roller assembly.

When the truck enters the rails, the switch mounted on the guide roller assembly is closed. When the switch is activated, a tone will sound and the truck is speed limited until the AUTO/MANUAl switch is placed in the AUTO position. When the switch is placed in the AUTO position, the drive unit auto steer centers and steering control is taken away from the operator. The speed restriction is removed and full speed travel is allowed. The VM then starts looking for floor magnet inputs. When exiting the aisle, if the magnets are crossed with the AUTO/MANUAL switch in the AUTO position, the truck will slow down or stop, depending on system configuration. If the AUTO/MANUAL switch is moved to the MANUAL position prior to crossing the magnets, the system will not look for the magnets. Steering is reverted to the operator and normal operation is resumed. An audible tone sounds until either the AUTO/MANUAL switch is turned back to AUTO or the rail switch on the guide roller opens. Once out of the aisle and the steering is turned more than 10° while traveling, the aisle state is reset to out-of-aisle.

With auto steer center in a rail guided system WITHOUT a rail switch installed on the guide roller assembly.

When the truck is in the aisle and the AUTO/MANUAL switch is in AUTO, the VM will start looking for the input from the magnet sensors. When a set of magnets is crossed entering the aisle, the system functions as described in “End-of-Aisle Control” on page 8-15 When exiting the aisle, if the magnets are crossed with the AUTO/MANUAL switch in either position, the truck will slow down or stop, depending on how the system is configured.

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Pin-Out Matrix

The pinout matrix chart lists functions and normal voltages of terminals and harness connector pins. The matrix columns have the following meanings:

- **Item**: sequential number to aid in reference.
- **Connection**: the actual wire numbers or component abbreviations on the electrical schematic.
- **Function Description**: brief definition of the signal carried on the wire.
- **Theory of Operation**:
  - A detailed description of the signal carried on the wire. If the signal can be variable, the state of a related component that will cause the signal to vary is indicated.
  - Identifies possible causes for lack of correct signal.
- **Normal Level**: the approximate voltage that must be seen on that wire for the state indicated. Unless otherwise indicated, voltages are measured with respect to (wrt) B– at TP4.
- **Signal Source**: the device or connection that supplies the signal directly to the wire.
- **Signal User**: the device or connection where the wire directly delivers the signal.

Item	Connection	Function Description	Theory of Operation	Normal Level	Signal Source	Signal User
1	JPC1-1	+5.3V	Supplies +5.3V to the Steering Request Encoder. It is dependent on the +12VP from the VM and JPC11-1.	>5V	CCC	Steering Request Encoder
2	JPC1-2	DGND	B– for the circuits of the Steering Request Encoder.	<0.3V wrt TP4	CCC	Steering Request Encoder
3	JPC1-3	CHB	One part of the steering request from the Steering Request Encoder when the steering tiller is moved. It is a square wave signal (0V and 5V) identical to CHA but different phase. The CCC uses the phase relationship of CHA/CHB to determine the direction and speed of the steering request.	0-5V nominal w/tiller moving: >4.5V or <0.5V w/tiller stationary	Steering Request Encoder	CCC
4	JPC1-4	CHA	One part of the steering request from the Steering Request Encoder when the steering tiller is moved. It is a square wave signal (0V and 5V) identical to CHB but different phase. The CCC uses the phase relationship of CHA/CHB to determine the direction and speed of the steering request.	0-5V nominal w/tiller moving: >4.5V or <0.5V w/tiller stationary	Steering Request Encoder	CCC

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Pin-Out Matrix

Item	Connection	Function Description	Theory of Operation	Normal Level	Signal Source	Signal User
5	JPC1-8	BRAKE DEADMAN	Output of the Brake Deadman switch (S2 at JPC7-1) that is looped back to the CCC at JPC1-9 and sent to the VM to inform the VM of the status of S2. If the Steering Request Encoder Cable becomes unplugged, the VM will not release the brake.	>5V w/pedal depressed: <0.5V w/pedal released	CCC	VM
6	JPC1-9	BRAKE DEADMAN	Receives output from JPC1-8 and sends the VM the status of S2. If the Steering Request Encoder Cable becomes unplugged, the VM will not release the brake.	>5V w/pedal depressed: <0.5V w/pedal released	CCC	VM
7	JPC2-1	DGND	B– for the Operator Interface Card.	<0.3V wrt TP4	Fuse/Relay Card	Operator Interface
8	JPC2-2	UP ARROW	The CCC monitors this input to determine when the up arrow on the Operator Interface is depressed.	>5V w/switch open; <0.5V w/switch closed	Operator Interface	CCC
9	JPC2-3	DN ARROW	The CCC monitors this input to determine when the down arrow on the Operator Interface is depressed.	>5V w/switch open; <0.5V w/switch closed	Operator Interface	CCC
10	JPC2-4	ETR/SHFT	The CCC monitors this input to determine when the Enter/Shift button on the Operator Interface is depressed.	>5V w/switch open; <0.5V w/switch closed	Operator Interface	CCC
11	JPC2-17		Not Usable			
12	JPC3-1	60" LIMIT Non-intellispeed trucks	The voltage on this line changes when the platform crosses S28 (60" Limit Switch). This change in voltage is used by the CCC to limit travel speed. S28 opens when the platform is above the 60 in. switch and speed is limited to 1 mph maximum. When the platform is below 60 in., S28 is closed and the speed is configurable from 0.5 to 2.5 mph.	<1V w/switch closed; >9V w/switch open	CCC	CCC
		Intellispeed Trucks	There is a jumper on the CCC at JPC3. Travel speed above S28 is determined by height. The truck will have full configured speed to 60 in.			
13	JPC3-2	6-12VF	12V supply to S28 (60" Limit Switch).	6-8.8V w/switch connected; >8.8V w/switch disconnected	VM	S28
14	JPC3-3	PGND	B– for S28 (60" Limit Switch).	<0.3V wrt TP4	VM	S28

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Item	Connection	Function Description	Theory of Operation	Normal Level	Signal Source	Signal User
15	JPC4-1	LOWER INHIBIT	Output from S25 used by the CCC to detect the location of the operator platform.	<1V w/platform below switch: approx. 10V with platform above switch	S25	CCC
16	JPC4-2	+12VF	12V supply to S25 (Lower Inhibit Switch).	10.8-13V w/key switch ON	VM	S25
17	JPC4-3	PGND	B– for S25.	<0.3V wrt TP4	VM	S25
18	JPC5-1	B+KEY	B+ that is switched by the key switch and powers the optional light and fan.	B+ w/key switch ON	CCC	Light and Fan package
19	JPC5-2	B–F	B– for the optional light and fan.	<0.3V wrt TP4	CCC	Light and Fan package
20	JPC5-3	B–F	B– for the CCC power option (Control Handle Heater).	<0.3V wrt TP4	CCC	Handle Heater
21	JPC5-4	B+KEY	B+ that is switched by the key switch and powers the CCC power option (Control Handle Heater).	B+ w/key switch ON	CCC	Handle Heater
22	JPC6-1	B+F	B+F to S1 (Key Switch). If B+ is not present, check for B+ at JPC16-3.	B+ wrt TP4 w/battery connected and FU5 good	Fuse/Relay Card	S1
23	JPC6-2	B+KEY	B+ switched by the key switch. If B+ is missing, check for B+ at JPC6-1.	B+ w/key switch ON and FU5 good	Fuse/Relay Card	All
24	JPC6-2	B+KEY	B+ for Security Start Switch Relay.	B+	CCC	K2 Relay for Security Start Switch
25	JPC6-3	B+ESTOP	B+ after going through S21 (ESTOP switch). If B+ is missing, the CCC will display EPO depressed. Check for B+ at JPC6-4.	B+ when ESTOP button is up (closed)	CCC	Fuse/ Relay Card
26	JPC6-4	B+KEY	B+ Key from JPC6-2 to supply B+ Estop when S21 is out (closed).	B+ from JPC6-1	S1	S21
27	JPC6-5	DGND	B– for S7.	<0.3V wrt TP4	VM	S7
28	JPC6-6	L/L INHIBIT BYPASS	Determines whether the CCC will allow lift or lower when either lift or lower limit is reached. When S7 is closed, lift/lower is prevented when the cutout switch is activated. When S7 is open, lift/lower is allowed.	>5V w/S7 closed (up); <0.5V w/S7 open (down)	CCC	CCC

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Pin-Out Matrix

Item	Connection	Function Description	Theory of Operation	Normal Level	Signal Source	Signal User
29	JPC7-1	CARRIAGE DEADMAN	The CCC monitors the voltage on this line to determine the state of S2. This signal is looped through the Steering Request Encoder at JPC1-8 and 9 and sent to the VM at JPT22-7.	>10V w/S2 up; <0.5V w/S2 down	CCC	VM and CCC
30	JPC7-2	+12VF	12V supply to S2 (Carriage Deadman Switch).	10.8-13V w/key switch ON	VM	S2
31	JPC7-3	DGND	B– for S2.	<0.3V wrt TP4	VM	S2
32	JPC7-4	BRAKE DEADMAN	The CCC monitors the state of S23 (Brake Deadman) directly. The VM detects the state of S23 at JPT22-8. The CCC and the VM communicate S23 status and must agree that it is depressed before the brake is released.	>4V up (released); <0.5V down (depressed)	CCC	VM and CCC
33	JPC7-5	+12VF	12V supply to S23 (Brake Deadman Switch).	10.8-13V w/key switch ON	VM	S23
34	JPC7-6	DGND	B– for S23.	<0.3V wrt TP4	VM	S23
35	JPC8-1	24 IN. LIMIT	The voltage on this line changes when the platform crosses S11. The change in voltage is used by the VM to reset the height counter and enable correct speed. S11 opens when the platform is above 24 in. and speed is determined by height. When the platform is below 24 in., S11 is closed and full speed is allowed.	<1V w/S11 closed; >9V w/S11 open	CCC	CCC
36	JPC8-2	6-12VF	12V supply to S11 (24 In. Limit Switch).	6-8.8V w/S11 connected: >9.0V w/S11 disconnected	VM	S11
37	JPC8-3	DGND	B– for S11.	<0.3V wrt TP4	VM	S11
38	JPC9-1	AUTO/MAN	The CCC monitors the state of the S4 (Auto/Manual Switch) to determine if the truck is in manual steering or Wire Guidance/Rail Guidance mode.	<1V in manual; >5V on wire/in rail	CCC	CCC
39	JPC9-2	DGND	B– for S4.	<0.3V wrt TP4	VM	S4
40	JPC9-3	HORN	This input is monitored by the CCC. When S3 (Horn Switch) is depressed, the CCC tells the VM to blow the horn.	>5V Open: <0.5V Closed	CCC	CCC
41	JPC9-4	DGND	B– for S3 and VR2 (Lift/Lower Pot). If missing, Code 81 is displayed.	<0.3V wrt TP4	VM	S3
42	JPC9-5	+5.3V	Supply voltage for VR2 (Lift/Lower Pot).	>5V	CCC	VR2

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Item	Connection	Function Description	Theory of Operation	Normal Level	Signal Source	Signal User
43	JPC9-6	L/L	Variable voltage from VR2 wiper. The CCC monitors this voltage and sends it to the VM. Voltage must be between 0.4 and 4.6V. If not, Code 81 is displayed.	1.3V Neutral: 0.4V Full Lift: 2.1V Full Lower	CCC	CCC
44	JPC9-7	DGND	B– for VR1.	<0.3V wrt TP4	VM	VR1
45	JPC9-8	+5.3V	Supply voltage for VR1 (Travel Pot).	>5V	CCC	VR1
46	JPC9-9	TRAVEL	Variable voltage from VR1 wiper. The CCC monitors this voltage and sends it to the VM. Voltage must be between 0.4 and 4.6V. If not, Code 80 is displayed.	1.3V Neutral; 0.8V Full Fwd: 2.6V Full Rev	CCC	CCC
47	JPC9-10	Not Used				
48	JPC11-1	+12VF	Supplies working voltage to the CCC.	10.8-13V w/key switch ON	VM	CCC
49	JPC11-2	BUS–	Carries the negative component of the digital communications between the CCC and the managers on the tractor side of the communications bus.	2.0V	CCC	LPA, TPA and VM
50	JPC11-3	BUS+	Carries the positive component of the digital communications between the CCC and the managers on the tractor side of the communications bus.	3.0V	CCC	LPA, TPA and VM
51	JPC11-4	BRAKE DEADMAN	Sent by the CCC to the VM to energize the brake when all other conditions are met. This output is sent when S2 is closed.	>6V with deadman up and brake applied; <0.5V with deadman down and brake released	CCC	VM
52	JPC11-5	CARRIAGE DEADMAN	Sent by the CCC to the VM to energize the brake when all other conditions are met. This output is sent when S23 is closed.	>6V with deadman up and brake applied; <0.5V with deadman down and brake released	CCC	VM
53	JPC11-6	DGND	Reference and negative for the circuits on the CCC. Although it eventually connects to B–, it is kept separate from the other grounds to help reduce the effects of noise on system operation.	<0.3V wrt TP4	VM	CCC
54	JPC12-2	B–F SPARE	B– for Security Start Switch Relay.	B–	CCC	K2 Relay for Security Start Switch

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Pin-Out Matrix

Item	Connection	Function Description	Theory of Operation	Normal Level	Signal Source	Signal User
55	JPC13-2	+12VF	12V supply to S61 (Left Sidegate Switch).	10.8-13V w/key switch ON	VM	CCC
56	JPC13-1	SIDEGATE LEFT	Output from S61 used by the CCC to detect the position of the left sidegate. The VM will prohibit travel if the sidegate is up or the switch is open.	10.8-13V w/key switch ON	VM	CCC
57	JPC13-3	PGND	B– for S61.	<0.3V wrt TP4	VM	CCC
58	JPC14-1	SIDEGATE RIGHT	Output from S60 used by the CCC to detect the position of the right sidegate. The VM will prohibit travel if the sidegate is up or the switch is open.	<1V with sidegate down: approx. 10V w/sidegate up	S60	CCC
59	JPC14-2	+12VF	12V supply to S60 (Right Sidegate Switch).	10.8-13V w/key switch ON	VM	S60
60	JPC14-3	PGND	B– for S60.	<0.3V wrt TP4	VM	CCC
61	JPC15-1	Not Used				
62	JPC15-15	DGND	B– for the Carriage Control Light Display Card.	<0.3V wrt TP4	VM	Light Display Card
63	JPC15-16	5.3V	Supply voltage for the Carriage Control Light Display Card.	>5V	CCC	Light Display Card
64	JPC15-24	Not Used				
65	JPC16-1	B+EPO	Present when both the Key Switch and EPO switch are closed. Supplies B+ Estop to the Fuse/Relay Card where it is used by the K1, K2, and K3 relays.	B+	CCC	Fuse/ Relay Card
66	JPC16-2	B–FUSEDS	B– for the Spare Power Connector (JPC12-2) on the CCC. Supplies B– for the optional lights, fan, and RF unit.	<0.3V wrt TP4	Fuse/Relay Card	CCC
67	JPC16-3	B+FUSEDS	B+ for the Spare Power Connector (JPC12-1) on the CCC. Supplies B+ for the optional lights, fan, and RF unit.	B+ wrt TP4 w/battery connected	Fuse/Relay Card (FU7)	CCC
68	JPC16-4	B–FUSED	B– for the CCC from the Fuse/Relay Card.	<0.3V wrt TP4	Fuse/Relay Card (FU6)	CCC
69	JPC16-5	B+EPO	B+EPO Spare.	B+	CCC	Spare
70	JPC16-6	B+KEY	B+ that is switched by the Key Switch (S1) and sent from the CCC to supply B+ Key to the Fuse/Relay Card.	B+ w/S1 closed	CCC	Fuse/ Relay Card
71	JPC16-7	B+FUSEDS	B+ Fused Spare.	B+	CCC	Spare
72	JPC16-8	B+FUSED	Main B+ supply to the CCC and is fused through FU5 on the Fuse/Relay Card.	B+ wrt TP4	Fuse/Relay Card	CCC

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Item	Connection	Function Description	Theory of Operation	Normal Level	Signal Source	Signal User
73	JPC21-1	+5.3V	Supplies +5.3V to the E2 Steering Request Encoder. It is dependent on the +12VP from the VM at JPC11-1.	>5V	CCC	E2 Steering Request Encoder
74	JPC21-2	DGND	B– for the circuits of the E2 Steering Request Encoder.	<0.3V wrt TP4	CCC	E2 Steering Request Encoder
75	JPC21-3	CHB–E2	One part of the steering request from the E2 Steering Request Encoder when the steering tiller is moved. It is a square wave signal (0V and 5V) identical to CHA-E2 but different phase. The CCC sends this information to the VM.	0-5V nominal w/tiller moving: >4.5V or <0.5V w/tiller stationary	E2 Steering Request Encoder	E2 Steering Request Encoder
76	JPC21-4	CHA-E2	One part of the steering request from the E2 Steering Request Encoder when the steering tiller is moved. It is a square wave signal (0V and 5V) identical to CHB-E2 but different phase. The CCC sends this information to the VM.	0-5V nominal w/tiller moving: >4.5V or <0.5V w/tiller stationary	E2 Steering Request Encoder	E2 Steering Request Encoder
77	JPC21-5	CD SUPPLY	5.3V output from the CCC power supply. This voltage is dependent on +12VP from the VM at JPC11-1. This voltage goes back to the CCC microprocessor to let the CCC know that JPC21 is connected. If not connected, Code G0 is displayed.	>4V	E2 Steering Request Encoder	CCC
78	JPC21-6	CD	+5.3V output from the CCC power supply. This voltage is dependent on +12VP from the VM at JPC11-1. This voltage goes back to the CCC microprocessor to let the CCC know that JPC21 is connected. If not connected, Code G0 is displayed.	>5V	E2 Steering Request Encoder	CCC
79	JPF1-1	B–	B– for FU8 (15A/5A) Fuse for optional Aux power.	<0.5V	TP4	Aux Power
80	JPF1-2	B–	B– for FU8 (15A/5A) Fuse for optional Aux power.	<0.5V	TP4	Aux Power
81	JPF1-3	Not Used				
82	JPF1-4	B–F	B–F from FU8 for optional Aux Power.	<0.5V	FU8 to B–	Aux Power
83	JPF1-5	Not Used				

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Pin-Out Matrix

Item	Connection	Function Description	Theory of Operation	Normal Level	Signal Source	Signal User
84	JPF1-6	B+F or B–F	Provides either B+F or B–F to B+K3 on the Lift and Travel Power Amplifiers. At Startup the K3 coil is energized, providing B+ to the pre-charge circuit and logic circuits in the power amplifiers. With the K3 coil de-energized, JPF1-6 is at B– to discharge the amplifier precharge circuits.	B– w/K3 De-energized; B+ w/K3 Energized	FU5 when K3 is energized; FU6 when K3 is de-energized	LPA and TPA
85	JPF2-1	B+K2	B+ that is present when the K2 relay tips close (DC lift only).	B+ w/K2 closed	Fuse/Relay Card	LPC Coil
86	JPF2-2	B+ K2	B+ K2 to power the horn.	B+ with K2 energized	K2 tips	Horn
87	JPF2-3	B+K2	B+ K2 when the K2 relay tips are closed.	B+	K2 tips	VM
88	JPF2-3	B+K2	B+ supplied to the Aux Mast solenoids.	B+	Fuse/Relay Card	Aux Mast Solenoids
89	JPF2-4	Not Used				
90	JPF2-5	B+K2	B+K2 to power Load Holding Solenoid.	B+ with K2 energized.	K2 tips	L/H Sol.
91	JPF2-6	B+K2	B+K2 when the K2 relay tips are closed.	B+	K2 tips	VM
92	JPF2-7	B+K2	B+K2 when the K2 relay tips are closed.	B+	K2 tips	VM
93	JPF2-8	N/A				
94	JPF2-8	B+K2	B+ supplied to the 2 Stage Select Solenoid.	B+	Fuse/Relay Card	2 Stage Select Sol.
95	JPF2-9	B+KEY	B+ Key for warning light when K1 tips are closed.	B+	CCC	Warning Light
96	JPF3-1	B–	B– for FU6 (15A) that provides B– to the Vehicle Manager.	<0.5V	TP4	VM
97	JPF3-2	B–	B– for FU6 (15A) that provides B– to the Vehicle Manager.	<0.5V	TP4	VM
98	JPF3-3	B–F	B–F for DGND on the VM.	<0.5V	FU6	VM
99	JPF3-4	B–F	B–F for DGND on the VM.	<0.5V	FU6	VM
100	JPF3-5	B–F	B–F for the VM.	<0.5V	FU6	VM
101	JPF3-6	B–F	B–F for the VM.	<0.5V	FU6	VM
102	JPF3-7	B–F	B–F for the VM.	<0.5V	FU6	VM
103	JPF3-8	B–F	B–F for S10 (150 or 120 In. Limit Switch) on the mast.	<0.5V	FU6	S10
104	JPF3-9	B–F	B–F for wire guidance.	<0.5V	Fuse/Relay Card	Guidance Manager

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Item	Connection	Function Description	Theory of Operation	Normal Level	Signal Source	Signal User
105	JPF3-11	B–F	B–F for the warning light.	<0.5V	FU6	Warning Light
106	JPF3-12	B–F	B–F for the CCC.	<0.5V	FU6	CCC
107	JPF4-1	B+	B+ from TP1 to FU5 (15A) to supply K2, K4 relay tips. This also supplies Battery_Sense_In on the VM.	B+	TP1	VM
108	JPF4-2	B+	B+ From TP1 to FU5 (15A) to supply K2, K4 relay tips. This also supplies Battery_Sense_In to the VM.	B+	TP1	FU5 and VM
109	JPF4-3	B+	B+ From TP1 to FU7 (15A/5A) to supply Aux power option.	B+	TP1	FU7 and Aux Power
110	JPF4-4	B+	B+ from TP1 to FU7 (15A/5A) to supply Aux power option.	B+	TP1	FU7 and Aux Power
111	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.	EPO Closed: B+: Open 0.05V	EPO	K1, K2, K3
112	JPF4-6	B+EPO	B+ to the EPO_Sense on the VM. Tells the VM if the EPO is open or closed.	EPO Closed: B+: Open 0.05V	EPO	VM, EPO Sense
113	JPF4-7	B+	B+ present when the battery is plugged in. It is supplied through a thermistor on the Relay Control Fuse Panel. This is used by the VM to determine that the correct battery is connected. It will accept between 28 and 45V (36V Battery) or 18 and 30V (24V Battery). 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	VM
114	JPF4-8	B+KEY	B+ Key from the CCC.	B+	CCC	VM and Warning Light
115	JPF4-10	B+	B+ Fused to the CCC.	B+	FU5	CCC
116	JPF4-11	B+KEY	B+ Key for VM.	B+	CCC	VM
117	JPF4-12	Not Used				

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Pin-Out Matrix

Item	Connection	Function Description	Theory of Operation	Normal Level	Signal Source	Signal User
118	JPF4-13	RELAY ENABLE	Return path for relays K1, K2, K3, and K4. This is dependant on Battery_Sense_In being between 28 and 45V (36V Battery)	B+ w/Key Switch ON and all relays de-energized: <0.5V w/Key Switch OFF *or* ON and any relay energized	VM	K1, K2, K3 and K4
119	JPF4-14	RELAY ENABLE	Return path for relays K1, K2, K3, and K4. This is dependant on Battery_Sense_In being between 18 and 30V (24V Battery)	B+ w/Key Switch ON and all relays de-energized: <0.5V w/Key Switch OFF *or* ON and any relay energized	VM	K1, K2, K3 and K4
120	JPF4-15	B+	B+ for battery connected Aux Power.	B+	FU7	Aux Power
121	JPLA1-1	B+K3	B+ present when K3 is energized. This is used to power the control circuits of the LPA.	B+ w/K3 energized	K3	LPC
122	JPLA1-7	DGND	Return path for the bearing encoder in the lift motor.	<0.5V	LPA	Lift Velocity Sensor
123	JPLA1-8	L TEMP+	Analog voltage that varies with the lift motor temperature. Used by the LPA to adjust motor performance.	75°F (24°C) approx. 1V	Lift Motor Temp. Sensor	Lift Motor
124	JPLA1-11	ID0	B+ present at the LPA with K3 tips energized. It is used as an identifier to determine correct connection.	B+ w/K3 energized	K3	LPA
125	JPLA1-11	ID0	ID0 on the LPA has B+ applied. This voltage tells the amplifier what amp it is.	B+	Fuse/Relay Card	LPA
126	JPLA1-12	ID1	Not Used by the Lift Power Amp.			
127	JPLA1-13	B+KB	B+ for the LPC. The LPA supplies B+ for the LPC.	B+	LPA	LPC
128	JPLA1-23	BUS+	Carries the positive component of digital communications between the LPA, VM, and CCC.	3.0V	CCC	LPA, VM, TPA
129	JPLA1-25	Not Used				
130	JPLA1-26	L VEL SENSOR +	5V supply to the bearing encoder on the lift motor. This voltage is produced by the Lift Power Amp from B+K3.	4.98V	LPA	Lift Velocity Sensor
131	JPLA1-28	Not Used				
132	JPLA1-29	Not Used				

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Item	Connection	Function Description	Theory of Operation	Normal Level	Signal Source	Signal User
133	JPLA1-31	L VEL PHASE A	Generated when there is movement of the bearing encoder in the lift motor. 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 speed.	Motor Stationary: 4.06 or 0.03V Motor Turning: 2.3V	Lift Velocity Sensor	LPA
134	JPLA1-32	L VEL PHASE B	Generated when there is movement of the bearing encoder in the lift motor. 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 speed.	Motor Stationary: 4.06 or 0.03V Motor Turning: 2.3V	Lift Velocity Sensor	LPA
135	JPLA1-33	BUS–	The wire that carries the negative component of the digital communications between the LPA, VM, and the CCC.	2.3V	CCC	LPA, VM, TPA
136	JPS2-11	B+ESTOP	B+ Estop is present when both the key switch and EPO switch are closed. It is supplied to the Guidance Manager from B+K2 on the VM. If the key switch or EPO are open, K2 is de-energized.	B+ with S1 and EPO closed.	VM	Guidance Manager
137	JPS2-24	B–F	B– for the Guidance Manager. It is fused through FU6 on the Fuse/Relay Card.	<0.5V wrt TP4	Guidance Manager	VM
138	JPS4-6	BUS+	Carries the positive component of the digital communications between the VM and the Guidance Manager.	Not Usable	VM	Guidance Manager
139	JPT4-2	Not Used				
140	JPT4-3	LIFT CUTOUT	Voltage from S124 (Lift Cutout Switch) that indicates the open or closed state of the switch.	Open: 4.8V Closed: <0.3V	S124	VM
141	JPT6-1	NEUTRAL_PULSE	This input tells the VM that the Steer Power Amplifier is connected and functioning.	Deadman up: 4.8V; CCW steer: 0.2V; CW steer: 4.8V No steering: voltage varies	Steer Power Amplifier	VM
142	JPT6-2	CW_PWM	This is a control voltage used to rotate the drive unit in the CW direction. The average DC value will vary depending on the amount and speed of steering requested.	At rest: 11.9V CW fast: 4V CW slow: 11.8V	VM	Steer Power Amplifier

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Pin-Out Matrix

Item	Connection	Function Description	Theory of Operation	Normal Level	Signal Source	Signal User
143	JPT6-3	STEER_CURRENT	Analog voltage that varies with the steer motor current and is sent from the Steer Power Amplifier to the VM. This voltage is used by the VM to establish current reading for current limit.	Steering: CW: 2.9V At rest: 2.5V CCW: 2.1V	Steer Power Amplifier	VM
144	JPT6-4	DGND	Reference for the control circuits in the Steer Power Amplifier. If missing, the Steer Power Amplifier will not be powered up.	<0.5V	VM	Steer Power Amplifier
145	JPT6-5	CCW_PWM	This is a control voltage used to rotate the drive unit in the CCW direction. The average DC value will vary depending on the amount and speed of steering requested.	At rest: 11.9V CCW fast: 4V CCW slow: 11.8V	VM	Steer Power Amplifier
146	JPT6-6	+12VP	Operating voltage from the VM for the control circuits in the Steer Power Amplifier. If missing, steering is inoperable.	10.7-13V	VM	Steer Power Amplifier
147	JPT10-2	SENSOR 1	Voltage from the S46A and S46B aisle detect switches that indicates a transition over a Floor Magnet.	10.8-13V when magnet is not sensed; <1V for 0.1 sec. after magnet is sensed, then 10.8-13V	VM	S46A/B Aisle Detect Sensors
148	JPT10-6	+12VP	12V supply to S46A and S46B (Aisle Detect Sensors).	10.8-13V	VM	S46A and B
149	JPT10-7	+12VP	12V supply to S47A and S47B (Aisle Detect Sensors).	10.8-13V	VM	S47A and B
150	JPT10-8	SENSOR 2	Voltage from S47A and S47B (Aisle Detect Sensors) that indicates a transition over a floor magnet.	10.8-13V when magnet is not sensed; <1V for 0.1 sec. after magnet is sensed, then 10.8-13V	VM	S47A and B
151	JPT10-9	DGND	Reference for the steer motor encoder.	<0.5V	VM	Steer Motor Encoder
152	JPT12-5	LIFT	L/L Pendant TBD			
153	JPT12-6	LOWER	L/L Pendant TBD			
154	JPT12-12	DGND	L/L Pendant TBD			

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Item	Connection	Function Description	Theory of Operation	Normal Level	Signal Source	Signal User
155	JPT14-1	B–F	This connects B–F on the VM to TP4(B–) through FU6 on the Fuse/Relay Card. These B– provide the return for everything not using DGND or AGND as reference.	<0.5V	Fuse/Relay Card	VM
156	JPT14-2	DGND	This connects DGND on the VM to TP4 (B–) through FU6 on the Fuse/Relay Card. This is the reference for all circuits on the truck that reference DGND.	<0.5V	Fuse/Relay Card	VM
157	JPT14-3	DGND	This is the negative path for the 12V supply to the CCC. If this is not present, the CCC will not function. 5V is made from the 12V on the CCC.	<0.5V	VM	CCC
158	JPT14-4	BUS_I–	The wire that carries the negative component of the digital communications between the VM, TPA, LPA and CCC.	2.3V	VM	LPA, TPA and CCC
159	JPT14-5	+12VP	This is the positive path for the 12V supply to the CCC. If this is not present, the CCC will not function. 5V is made from the 12V on the CCC.	10.8-13V	VM	CCC
160	JPT14-6	RELAY_ENABLE	Control path for K1, K2, K3 and K4 on the Fuse/Relay Card. After S1 is closed, all relays are energized simultaneously during SelfTest if the voltage at Battery_Sense_In is between 28 and 45V (36V Battery) or 18 and 30V (24V Battery).	Relays OFF: B+ ON: <0.5V	VM	K1, K2, K3, K4
161	JPT14-7	B+K2	B+ provided to the VM when the K2 relay tips are closed. They are de-energized when the EPO is open. Note: Also used by the VM for Brake Coil Suppression.	B+	K2 Relay	VM, Brake Coil
162	JPT14-8	B–F	This connects B–F on the VM to TP4 (B–) through FU6 on the Fuse/Relay Card. These B– provide the return for everything not using DGND or AGND as reference.	<0.5V	Fuse/Relay Card	VM
163	JPT14-9	B–F	This connects B–F on the VM to TP4 (B–) through FU6 on the Fuse/Relay Card. These B– provide the return for everything not using DGND or AGND as reference.	<0.5V	Fuse/Relay Card	VM
164	JPT14-10	DGND	This connects DGND on the VM to TP4 (B–) through FU6 on the Fuse/Relay Card. This is the reference for all circuits on the truck that reference DGND.	<0.5V	Fuse/Relay Card	VM

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Item	Connection	Function Description	Theory of Operation	Normal Level	Signal Source	Signal User
165	JPT14-11	BUS_I+	The wire that carries the positive component of the digital communications between the VM, TPA, LPA and CCC.	3.0V	VM	LPA, TPA and CCC
166	JPT14-12	B+KEY	B+ that is switched by S1 (Key Switch) and used to power functions on the VM that are initiated after S1 is closed and are not affected by the EPO. This includes the VM power supplies. the operation of the microprocessor, and execution of the firmware.	S1 closed: B+ S1 open: 0.3V	S1	VM
167	JPT14-13	B+K2	B+ provided to the VM when the K2 relay tips are closed. They are de-energized when the EPO is open	B+	K2 relay	VM
168	JPT14-14	B+K2	B+ provided to the VM when the K2 relay tips are closed. They are de-energized when the EPO is open.	B+	K2 relay	VM
169	JPT18-1	2 STAGE SOL	Negative path for the 2nd Stage Select Solenoid 24V High Performance Lift.	<0.1V	Fuse/Relay Card	2 Stage Select Sol.
170	JPT18-4	+12VP	12V supply for S15 (Rail Sense Switch).	10.8-13V	S15	VM
171	JPT18-5	DGND	Negative path for the Pressure Switch 24V High Performance Lift.	<1V	Pressure Switch	VM
172	JPT18-6	HORN	Control path for the horn that is switched to B– by the VM.	B+ de-energized; <0V energized	VM	Horn
173	JPT18-7	DGND	Return path for S124 (Lift Cutout Switch).	<0.5V	S124	VM
174	JPT18-9	LIFT_ CONTACTOR	B– for the LPC coil (DC lift only).	24V Truck: B+ w/coil de-energized <1V w/coil energized 36V Truck: B+ w/coil de-energized 11-12V w/coil energized	VM	LPC Coil
175	JPT18-10	L/H	Control path for the load holding solenoid that is switched to B– by the VM to energize the L/H solenoid coil.	B+ de-energized: 12.7V energized	VM	L/H Sol.
176	JPT18-12	AUX L/H	Negative path for the Aux Mast L/H Solenoid.	<1V	Aux. L/H Sol.	VM
177	JPT18-15	AUX SEL	Negative path for the Aux Mast Select Solenoid.	<1V	Aux. Select solenoid	VM

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Item	Connection	Function Description	Theory of Operation	Normal Level	Signal Source	Signal User
178	JPT18-14	MAIN SEL	Negative path for the Aux Mast Main Select Solenoid.	<1V	Aux.Main Select Sol.	VM
179	JPT18-18	ALARM_TRAVEL	Return path for Travel Alarm.	B+ de-energized; <0V energized	Travel Alarm	VM
180	JPT20-1	+12VF	12V supply to S10 (120/150 In. Switch).	+10.7 -13V	VM	S10
181	JPT20-2	+12VP	12V supply for the Flow Sensor.	10.8-13V	Flow Sensor	VM
182	JPT20-3	Not Used				
183	JPT20-4	Not Used				
184	JPT20-5	+12VP	12V supply to the Pressure Transducer.	10.8-13V	VM	Pressure Trans-ducer
185	JPT20-6	+12VP	12V supply to S27 (Travel Cutout Switch).	10.8-13V	VM	S27
186	JPT20-7	+12VP	12V supply for the steer motor encoder.	10.8-13V	VM	Steer Motor Encoder
187	JPT20-8	+12VP	12V supply to S124 (Lift Cutout).	10.8-13V	S124	VM
188	JPT20-9	+12VP	12V supply to the Home Sensor Prox by the VM.	+10.7-13V	VM	Home Sensor Prox
189	JPT20-10	+12VP	12V supply to the S24 (Lift Inhibit Switch).	10.8-13V	S24	VM
190	JPT20-14	BRAKE	Control path for the electrically released brake on the drive motor.	B+ de-energized: 26V energized	VM	Brake
191	JPT20-15	B+L/L	B+ supplied to lift/lower solenoid when K2 tips are closed	B+	VM	L/L
192	JPT20-16	L/L	Control path for the lift/lower proportional solenoid.	De-energized: B+ Full Lift: 28V. Full Lower:11V Feather Lift: 34V Decel: 27.7V	VM	L/L
193	JPT20-17	B+ALARM	B+ supplied to the lift/lower alarm when K2 tips are closed.	B+	Alarm_Lift	VM
194	JPT20-18	ALARM_LIFT	Control path for the lift/lower alarm.	B+ de-energized: <0.0V energized	Alarm_Lift	VM

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Pin-Out Matrix

Item	Connection	Function Description	Theory of Operation	Normal Level	Signal Source	Signal User
195	JPT20-19	B+K2	B+ supplied to the Guidance Manager when the K2 tips are closed.	B+	VM	Guidance Manager
196	JPT22-1	120/150 IN. LIMIT	Input to the VM from S10.	Open: 4.8V Closed: <0.03V	S10	VM
197	JPT22-2	LIFT INHIB	Voltage from S24 that indicates the open/closed state of the switch.	Open: 4.8V Closed: <0.03V	S24	VM
198	JPT22-3	HOMESENSE	Voltage that the VM uses to determine on or off metal.	Off Metal: 5.2V On Metal: 0.03V	Home Sensor Prox	VM
199	JPT22-4	180_LIM	Voltage from S100 (180 In. Limit Switch) that indicates the open/closed state of the switch.	Open: 4.8V Closed: <0.03V	S100	VM
200	JPT22-5	PRESS_SW	5V supply for the Pressure Switch (PRESS SW1).	4.7V	VM	PRESS SW1
201	JPT22-6	TRVL CUTOUT	Voltage from S27 that indicates the open/closed state of the switch.	Open: 4.8V Closed: <0.03V	S27	VM
202	JPT22-7	BRAKE DEADMAN	Voltage from CCC to VM that indicates the open/closed state of switch S2.	6.1V released 0.1V depressed	S2	VM
203	JPT22-8	CARRIAGE DEADMAN	Voltage from CCC to VM that indicates the open/closed state of switch S23.	4.8V released, 0.1V depressed	S23	VM
204	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 signal identical to Channel B_4 but different phase. The VM uses the phase relationship of the two channels to determine that the direction and speed of the steering response is the same as that requested.	Not Turning: either 0V or 5V: Turning either direction: 2.4V	Steer Motor Encoder	VM
205	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 signal identical to Channel A_4 but different phase. The VM uses the phase relationship of the two channels to determine that the direction and speed of the steering response is the same as that requested.	Not Turning: either 0V or 5V: Turning either direction: 2.4V	Steer Motor Encoder	VM
206	JPT22-11	DGND	B– for the Home Sensor Prox.	<0.5V	Home Sensor Prox	VM
207	JPT22-12	Not Used				

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Item	Connection	Function Description	Theory of Operation	Normal Level	Signal Source	Signal User
208	JPT22-13	FLOW_A	Square waves generated whenever there is movement of the turbine in the flow sensor. The frequency varies directly with the speed of the turbine that is driven by fluid flowing through the sensor. The VM uses the quadrature phase relationship between Flow_A and_B to determine flow direction and speed to calculate carriage height.	Approx. 2.7V during lift at 1/3 speed or greater; >5V or <0.5V when stopped	Flow Sensor	VM
209	JPT22-14	FLOW_B	Square waves generated whenever there is movement of the turbine in the flow sensor. The frequency varies directly with the speed of the turbine that is driven by fluid flowing through the sensor. The VM uses the quadrature phase relationship between Flow_A and_B to determine flow direction and speed to calculate carriage height.	Approx. 2.7V during lift at 1/3 speed or greater; >5V or <0.5V when stopped	Flow Sensor	VM
210	JPT22-19	FU1_SENSE	B+ when there is not an open between battery positive and PC1. This voltage is used by the VM to determine the state of FU1 and the PC1 contactor tips.	Closed: B+ Open: voltage drops very slowly	PC1	VM
211	JPT22-20	FU3 SENSE	B+ when there is not an open between B+ and PC2. This voltage is used by the VM to determine the state of FU3 and the LPC contactor tips (DC lift only).	Closed: B+ Open: voltage drops slowly to 0V	PC2	VM
212	JPT22-21	EPO_SENSE	Sense wire used by the VM to determine when the EPO is open. This is used to initiate braking and display a message.	EPO closed: B+ EPO open: <0.5V	EPO	VM
213	JPT22-22	RAIL_SEN	Read by the VM to determine if the truck is in or out of the rail. The VM communicates truck position to the CCC, limiting 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: approx. 10V	S15	VM
214	JPT24-1	+12VF	12V supply for S100 (180 in. Limit Switch).	10.8-13V	S100	VM
215	JPT24-3	DGND	Return path for S24 (Lift Inhibit Switch).	<0.5V	S24 Switch	VM
216	JPT24-5	DGND	Return path for S15 (Rail Sense Switch).	<0.5V	S15 Switch	VM
217	JPT24-6	DGND	Return path for S27 (Travel Cutout Switch).	<0.5V	S27 Switch	VM
218	JPT24-7	DGND	Return path for S100 (180 In. Limit Switch).	<0.5V	S100	VM
219	JPT24-8	DGND	Return path for S46A and S46B (Aisle Detect Sensors).	<0.5V	S46A and S46B	VM

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Pin-Out Matrix

Item	Connection	Function Description	Theory of Operation	Normal Level	Signal Source	Signal User
220	JPT24-9	DGND	Return path for S47A and S47B (Aisle Detect Sensors).	<0.5V	S47A and S47B	VM
221	JPT24-10	DGND	Return path for Pressure Transducer A.	<0.5V	Pressure transducer	VM
222	JPT24-11	DGND	Return path for the Intellispeed Flow Sensor.	<0.5V	Flow Sensor	VM
223	JPT24-16	SLACK SW2	Input to the VM from S30 (Slack Chain Switch #2).	<1V closed: >9V open	Slack SW2	VM
224	JPT24-18	P/T_A	Analog DC voltage that varies directly with the weight on the carriage. Approx. 0.5V per 1000 lbs. It is necessary to have the VM supply approx. 12V as well as DGND in order for the transducer to function correctly.	1V with forks fully lowered	Pressure Transducer	VM
225	JPT24-19	FS_TEMP	Variable voltage that is representative of the temperature of the fluid in the lift system.	0.2-4.86V, approx. 3.2V @86°F	Flow Sensor	VM
226	JPT24-24	BATTERY_ SENSE_IN	B+ present when the battery is plugged in. It is supplied through a thermistor on the Relay Control Fuse Panel. This is used by the VM to determine that the correct battery is connected. It will accept between 28 and 45V (36V Battery) or 18 and 30V (24V Battery). If the correct battery is sensed, Relay Enable is energized during start-up. After start-up, this voltage is used to determine BSOC.	B+ (there should be no voltage drop)	TP1	VM
227	JPTA1-1	B+K3	B+ present when K3 is energized. This is used to power the control circuits of the TPA.	B+ w/K3 energized	K3	TPA
228	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: 14.7V	TPA	TPC
229	JPTA1-7	DGND	Return path for the bearing encoder in the traction motor.	<0.5V	Travel Velocity Sensor	TPA
230	JPTA1-8	T TEMP+	Analog voltage that varies with the drive motor temperature. Used by the TPA to adjust motor performance.	Approx. 1V @75°F (24°C)	Traction Motor Temp.Sensor	TPA
231	JPTA1-11	ID0	Not Used by the Traction Power Amp.			
232	JPTA1-12	ID1	B+ present at the TPA with K3 tips energized. It is used as an identifier to determine correct connection.	B+ w/K3 energized	K3	TPA

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Item	Connection	Function Description	Theory of Operation	Normal Level	Signal Source	Signal User
233	JPTA1-13	B+KB	B+ for the TPC. The TPA supplies B+ for the TPC.	B+	TPA	TPC
234	JPTA1-14	Not Used				
235	JPTA1-23	BUS+	The wire that carries the positive component of the digital communications between the TPA, the VM, and the CCC.	3V	CCC	TPA, LPA, VM
236	JPTA1-25	Not Used				
237	JPTA1-26	T VEL SENSOR +	5V supply to the bearing encoder on the traction motor. This voltage is produced by the traction power amp from B+K3.	4.95V	TPA	Travel Velocity Sensor
238	JPTA1-28	Not Used				
239	JPTA1-29	Not Used				
240	JPTA1-31	T VEL PHASE A	This is generated when there is movement of the bearing encoder in the drive motor. It is a square wave that is either high (>3V) or low (<1V). The frequency varies directly with the speed of the drive 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: 4.06 or 0.03V: Turning: 2.3V	Travel Velocity Sensor	TPA
241	JPTA1-32	T VEL PHASE B	This is generated when there is movement of the bearing encoder in the drive motor. It is a square wave that is either high (>3V) or low (<1V). The frequency varies directly with the speed of the drive 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: 4.06 or 0.03V: Turning: 2.3V	Travel Velocity Sensor	TPA
242	JPTA1-33	BUS–	The wire that carries the negative component of the digital communications between the TPA, VM, and the CCC.	2.3V	CCC	TPA, LPA, CCC
243	JS27-2	O.T.M. Cable	Spare over-the-mast wire for future option.	B–	VM	Option
244	LPA (+)	LPA +	B+ to the LPA used to produce the AC phases U,V, and W when the LPC is closed to power the lift motor.	B+ with LPC closed	LPC	LPA
245	LPA (–)	LPA B–	B– from TP4 on the power panel. It is used for the power circuits on the LPA. Without B–, U, V, and W cannot be produced and the lift motor will not turn.	<0.5V	TP4	LPA

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Pin-Out Matrix

Item	Connection	Function Description	Theory of Operation	Normal Level	Signal Source	Signal User
246	LPA (U)	Lift Motor Phase U	One of three phases from the LPA to the Lift Motor. This AC voltage is produced by the LPA and is dependent on B+ at the + terminal and B– on the LPA. This AC voltage is measured between any two phases and varies from 0VAC at rest to about 24VAC at full RPM.	VAC between two phases: Stationary: 0VAC Full Travel: 24VAC Stall: approx. 4VAC	LPA	Lift Motor
247	LPA (V)	Lift Motor Phase V	One of three phases from the LPA to the Lift Motor. This AC voltage is produced by the LPA and is dependent on B+ at the + terminal and B– on the LPA. This AC voltage is measured between any two phases and varies from 0VAC at rest to about 24VAC at full RPM.	VAC between two phases: Stationary: 0VAC Full Travel: 24VAC Stall: approx. 4VAC	LPA	Lift Motor
248	LPA (W)	Lift Motor Phase W	One of three phases from the LPA to the Lift Motor. This AC voltage is produced by the LPA and is dependent on B+ at the + terminal and B– on the LPA. This AC voltage is measured between any two phases and varies from 0VAC at rest to about 24VAC at full RPM.	VAC between two phases: Stationary: 0VAC Full Travel: 24VAC Stall: approx. 4VAC	LPA	Lift Motor
249	PC12-1	B+F (SPARE)	B+ power for optional Work Lights or RF Unit. Present when the battery is connected. It is fused through FU5 on the Fuse/Relay Card.	B+ wrt TP4 w/battery connected	Fuse/Relay Card	Work Lights and RF Unit
250	PC12-2	B–F (SPARE)	B– power for optional Work Lights or RF Unit. Present when the battery is connected. It is fused through FU6 on the Fuse/Relay Card.	<0.3V wrt TP4	Fuse/Relay Card	Work Lights and RF Unit
251	TPA (+)	TPA B+	B+ to the TPA used to produce the AC phases U, V and W when the TPC is closed to power the drive motor.	B+ w/TPC closed	B+ from TPC	TPA
252	TPA (B–)	TPA B–	B– from TP4 on the power panel. It is used for the power circuits on the TPA. Without B–, U, V and W cannot be produced and the drive motor will not turn.	<0.5V	TP4	TPA
253	TPA (U)	Traction Motor Phase U	One of three phases from the TPA to the traction motor. This AC voltage is produced by the TPA and is dependent on B+ at TPA (+) and B– at TPA (B–). This AC voltage is measured between any two phases and varies from 0VAC at rest to about 24VAC at full acceleration.	VAC between two phases: Stationary: 0VAC Full Travel: 24VAC Stall: approx. 4VAC	TPA	Drive Motor

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Item	Connection	Function Description	Theory of Operation	Normal Level	Signal Source	Signal User
254	TPA (V)	Traction Motor Phase V	One of three phases from the TPA to the traction motor. This AC voltage is produced by the TPA and is dependent on B+ at TPA (+) and B– at TPA (B–). This AC voltage is measured between any two phases and varies from 0VAC at rest to about 24VAC at full acceleration.	VAC between two phases: Stationary: 0VAC Full Travel: 24VAC Stall: approx. 4VAC	TPA	Drive Motor
255	TPA (W)	Traction Motor Phase W	One of three phases from the TPA to the traction motor. This AC voltage is produced by the TPA and is dependent on B+ at TPA (+) and B– at TPA (B–). This AC voltage is measured between any two phases and varies from 0VAC at rest to about 24VAC at full acceleration.	VAC between two phases: Stationary: 0VAC Full Travel: 24VAC Stall: approx. 4VAC	TPA	Drive Motor

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Section A. Appendix

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Lubrication Specification Chart

Approved Raymond Lubricants			
Where Used	**Type**	**Specification**	**Raymond Part Number**
Drive Unit Gear Case (all applications)	Gear Lubricant	75W-90 Synthetic Gear Oil API Service GL-5	990-655/001 (1 qt./0.9 liter) 990-655/003 (1 gal/3.8 liters)
Lift Chains	Oil	10W-30 Motor Oil API Service CE, CD, CC, SG, SF	990-603/04 (1 qt./0.9 liter) 990-603/03 (5 gal/18.9 liters)
Hydraulic Reservoir (Non-CS trucks) (+50°F to +120°F) (+10°C to +49°C)	Hydraulic Fluid	ISO 46 Anti-Wear Hydraulic Fluid	990-616/04 (1 qt./0.9 liter) 990-616/01 (1 gal/3.8 liters) 990-616/02 (2 gal/7.6 liters) 990-616/03 (5 gal/18.9 liters)
Hydraulic Reservoir (CS trucks) (-20°F to -0°F) (-29°C to -18°C) (confined to freezer)	Hydraulic Fluid	MIL-H-5606E	990-618/TX1 (1 gal/3.8 liters) 990-618/01 (1 gal/3.8 liters)
Hydraulic Reservoir (CS trucks) (-20°F to +70°F) (-29°C to +21°C) (in and out of freezer)	Hydraulic Fluid	ISO 32	990-617/01 (1 gal/3.8 liters) 990-617/03 (5 gal/18.9 liters)
Hydraulic Reservoir (high performance/ high temp conditions)	Hydraulic Fluid	ISO 46 Multi-Viscous Hydraulic Fluid	990-615/01 (1 gal/3.8 liters) 990-615/03 (5 gal/18.9 liters)
Mast Uprights, Bearings, (etc.)	Grease	NLGI Grade 2	1012992/01 (10 cartridges/case) 1012992/02 (5 gal/18.9 liters)
Mast Uprights, Bearings, (etc.) (CS trucks)	Grease w/Teflon	NLGI Grade 2	1012992/01 (10 cartridges/case) 1012992/02 (5 gal/18.9 liters)
Hydraulic Brake	Brake Fluid	SAE Standard J1705F Federal Motor Vehicle Standard No. 116, DOT-5	990-625/01 (1 gal/3.8 liters) 990-625/02 (1 qt./0.9 liter) 990-625/03 (1 pt./0.47 liter)

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Thread Adhesives, Sealants, and Lubricants

Application	Raymond P/N	*Loctite** Number/Color
Thread-locking 1/4 in. and below	990-403	222/Purple
Thread-locking 1/4 to 3/4 in. contamination tolerant	990-536	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/Primer	990-538	7075
Thread-locking Primer	990-533	T7471
Hydraulic Sealant, fittings up to 2 in.	990-552	569
Molybdenum Anti-Seize Compound (Molykote)	990-638	Silver
Gasket Cement	990-556	Permatex 300
Cover Plate Sealant	990-443	587/UltraBlue
Corrosion Inhibitor Coating	990-456/001	
Silicone Sealant (cold storage)	990-445	Dow Corning III

NOTE: * *Loctite* is a registered trademark of the Loctite Corporation. Brand endorsement is not implied here, but listed only as a commonly identified product.

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Component Specific Torque/Information Chart

Component	Sub-Component(s)	Thread-Locking Compound	Torque to:
Drive Wheels	mounting bolts	N/A	108 ft. lb. (146 N•m)
Hydraulic Steer Motor	sprocket set screws	P/N 990-536	N/A
Lift Cylinders	end caps	P/N 990-571	200 ft. lb. (271 N•m)
Power Amplifiers	mounting bolts	N/A	7.4 ft. lb. (10 N•m)
Power Amplifiers	power cables	N/A	100 in. lb. (11.3 N•m)
Solenoid Coils	securing nut	N/A	5 ft. lb. (7 N•m)
Solenoid Valves	N/A	N/A	60 ft. lb. (81 N•m)
Speed Feedback Sensor	mounting bolts	P/N 990-536	N/A
Steer Motor	impeller shroud mounting screws	P/N 990-536	N/A
	power cable securing nuts	N/A	45-55 in. lb. (5.0-6.2 N•m)
	mounting bolts (qty 4)	P/N 990-536	Reference Torque Chart - Standard (Ferrous) on page A-5.
Steer Reference (Home) Proximity Sensor	sensor mounting screws (qty 4)	P/N 990-536	N/A
	bracket mounting bolts (qty 2)	P/N 990-536	N/A
Tire Replacement	A minimum pressure of 5 tons (4536 kg) is required to press on a new tire. If the minimum pressure is not met, replace the hub.		

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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*
	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
3/4-10	160	120	260	200	380	280
3/4-16	180	140	300	220	420	320
7/8-9	140	110	400	300	600	460
7/8-14	155	120	440	320	660	500
1-8	220	160	580	440	900	680
1-12	240	170	640	480	1000	740
1 1/8-7	300	220	800	600	1280	960
1 1/8-12	340	260	880	660	1440	1080
1 1/4-7	420	320	1120	840	1820	1360
1 1/4-12	460	360	1240	920	2000	1500
1 3/8-6	560	420	1460	1100	2380	1780
1 3/8-12	640	460	1680	1260	2720	2040
1 1/2-6	740	560	1940	1460	3160	2360
1 1/2-12	840	620	2200	1640	3560	2660
Note: Use “oiled” values for bolts with thread-locking compound.						

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Torque Chart - Metric

Ferrous 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*)	
	N•m	ft. lb.	N•m	ft. lb.
6	8.6	6	12	9
8	21	15	29	21
10	42	30	68	43
12	72	55	101	75
16	174	130	245	181
20	340	255	475	350
24	580	435	820	605
Note: Use “oiled” values for bolts with thread-locking compound.				

Brass MS63 Metric Bolts, Coarse Thread		
Diameter (in millimeters)	Torque (with bolts oiled*)	
	N•m	in. lb.
3	0.5	4.4
3.5	0.79	7.0
4	1.2	10
5	2.2	19
6	3.9	34
8	9	79
10	17	150
Note: Use “oiled” values for bolts with thread-locking compound.		

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Torque Chart - Standard (Brass)

Brass MS63 Standard Bolts, Coarse Thread		
Size	**Torque (with bolts oiled*)**	
	N•m	**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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Decimal Equivalent Chart

4ths	8ths	16ths	32nds	64ths	To 3 Places	To 2 Places	MM Equivalent
				1/64	.016	.02	0.397
			1/32		.031	.03	0.794
				3/64	.047	.05	1.191
		1/16			.062	.06	1.587
				5/64	.078	.08	1.984
			3/32		.094	.09	2.381
				7/64	.109	.11	2.778
	1/8				.125	.12	3.175
				9/64	.141	.14	3.572
			5/32		.156	.16	3.969
				11/64	.172	.17	4.366
		3/16			.188	.19	4.762
				13/64	.203	.20	5.159
			7/32		.219	.22	5.556
				15/64	.234	.23	5.593
1/4					.250	.25	6.350
				17/64	.266	.27	6.747
			9/32		.281	.28	7.144
				19/64	.297	.30	7.540
		5/16			.312	.31	7.937
				21/64	.328	.33	8.334
			11/32		.344	.34	8.731
				23/64	.359	.36	9.128
	3/8				.375	.38	9.525
				25/64	.391	.39	9.922
			13/32		.406	.41	10.319
				27/64	.422	.42	10.716
		7/16			.438	.44	11.112
				29/64	.453	.45	11.509
			15/32		.469	.47	11.906
				31/64	.484	.48	12.303
1/2					.500	.50	12.700

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4ths	8ths	16ths	32nds	64ths	To 3 Places	To 2 Places	MM Equivalent
				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
		15/16			.938	.94	23.812
				61/64	.953	.95	24.209
			31/32		.969	.97	24.606
				63/64	.984	.98	25.003
					1.000	1.00	25.400

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Standard/Metric Conversions

To Convert...	Multiply, Add, or Subtract...
Area	
Square Inches to Square Centimeters	Square Inches x 6.452
Square Centimeters to Square Inches	Square Centimeters x 0.155
Square Feet to Square Meters	Square Feet x 0.093
Square Meters to Square Feet	Square Meters x 10.753
Square Yards to Square Meters	Square Yards x 0.836
Square Meters to Square Yards	Square Meters x 1.196
Distance	
Inches to Millimeters	Inches x 25.4
Millimeters to Inches	Millimeters x 0.039
Inches to Centimeters	Inches x 2.54
Centimeters to Inches	Centimeters x 0.394
Feet to Meters	Feet x 0.305
Meters to Feet	Meters x 3.281
Yards to Meters	Yards x 0.914
Meters to Yards	Meters x 1.094
Miles to Kilometers	Miles x 1.609
Kilometers to Miles	Kilometers x 0.621
Mass	
Ounces to Grams	Ounces x 28.35
Grams to Ounces	Ounces x 0.035
Ounces to Kilograms	Ounces x 0.028
Kilograms to Ounces	Kilograms x 35.27
Pounds to Kilograms	Pounds x 0.454
Kilograms to Pounds	Kilograms x 2.2
Pressure	
Pounds per Square Inch (PSI) to kiloPascals	PSI x 6.894
kiloPascals to Pounds per Square Inch (PSI)	kiloPascals x 0.145
Speed	
Miles per hour to Kilometers per hour	Miles per hour x 1.609
Kilometers per hour to Miles per hour	Kilometers per hour x 0.6214
Temperature	
Fahrenheit to Celsius	(°F minus 32) x 0.555
Celsius to Fahrenheit	(°C x 1.8) plus 32
Torque	
Inch Pounds (in. lbs.) to Newton Meters (N•m)	Inch Pounds x 0.113
Newton Meters (N•m) to Inch Pounds (in. lbs.)	Newton Meters x 8.85
Foot Pounds (ft. lbs.) to Newton Meters (N•m)	Foot Pounds x 1.3568
Newton Meters (N•m) to Foot Pounds (ft. lbs.)	Newton Meters x 0.737
Volume	
Pints to Liters	Pints x 0.473
Liters to Pints	Liters x 2.113
Quarts to Liters	Quarts x 0.946
Liters to Quarts	Liters x 1.057
Gallons to Liters	Gallons x 3.785
Liters to Gallons	Liters x 0.26

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Schematics

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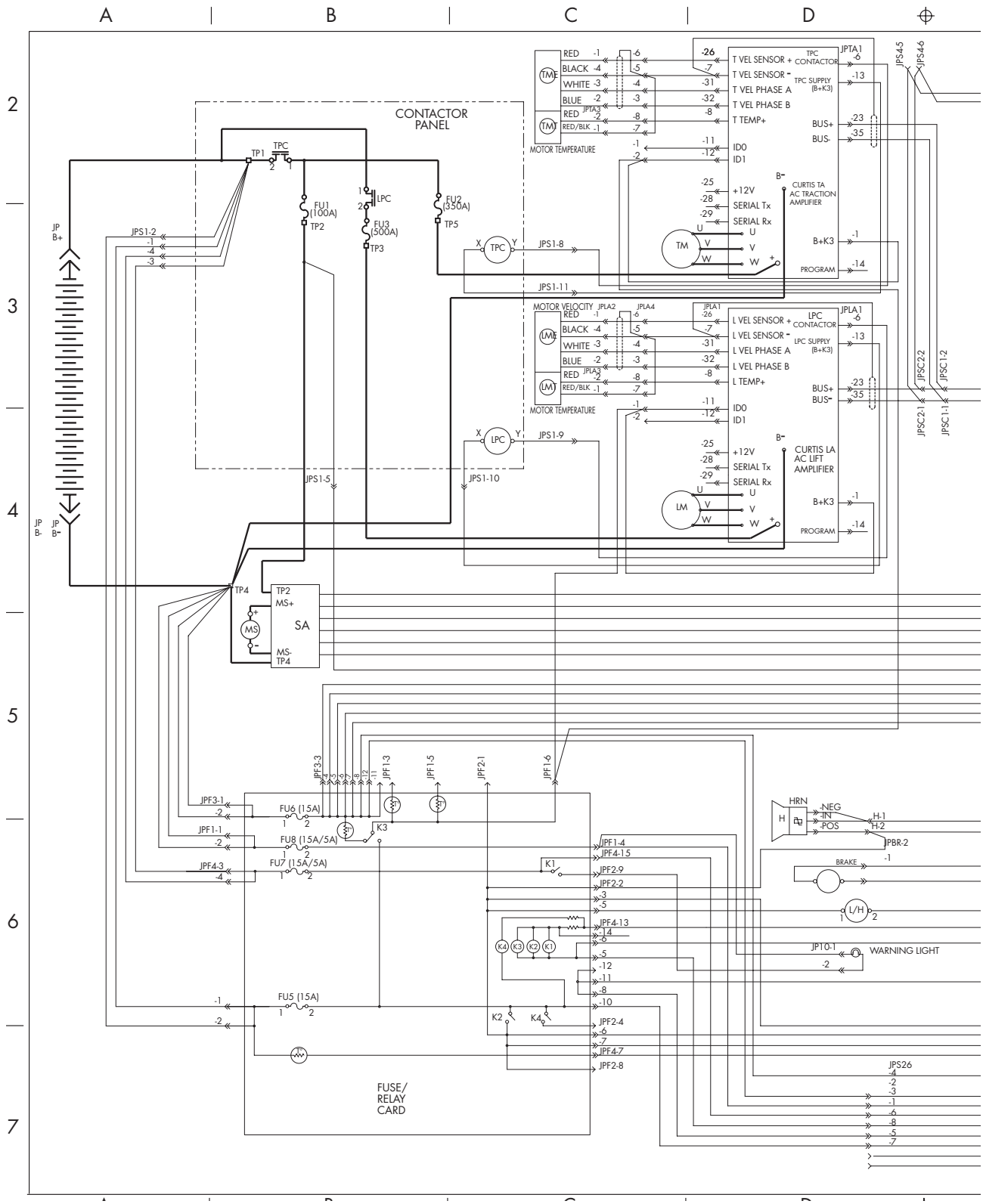
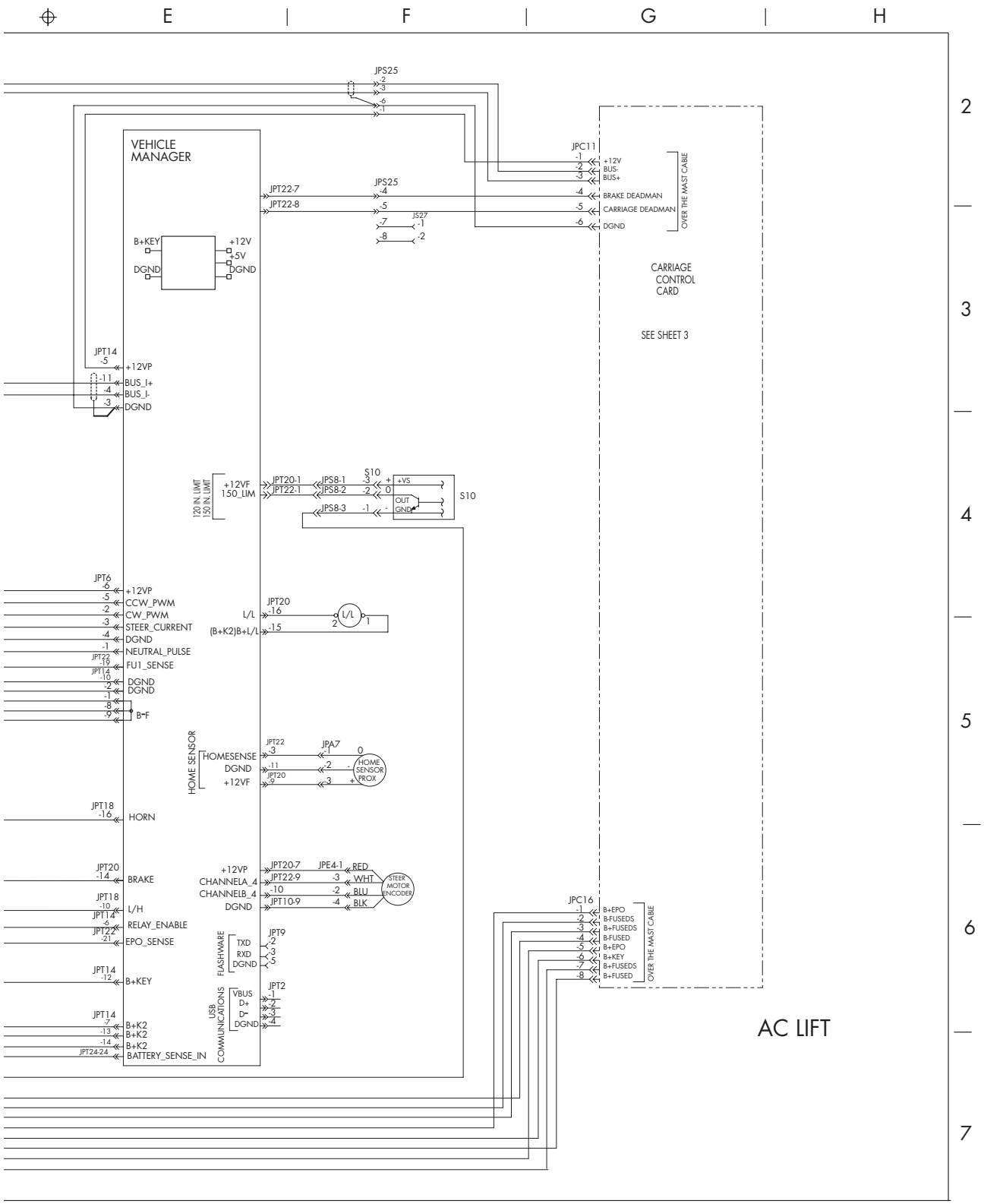


Figure A-1. Electrical Schematic Sheet 1 (AC Lift)

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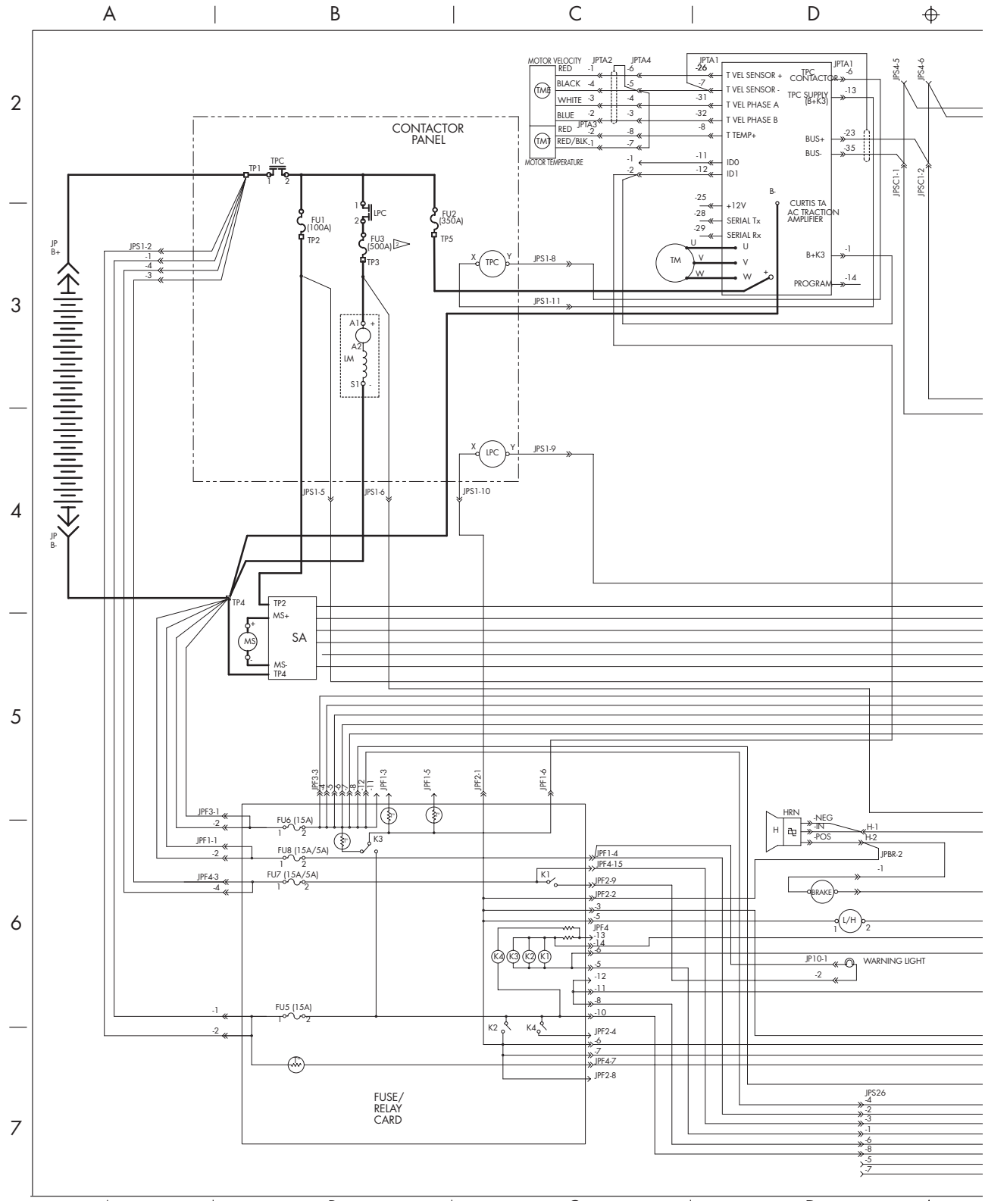
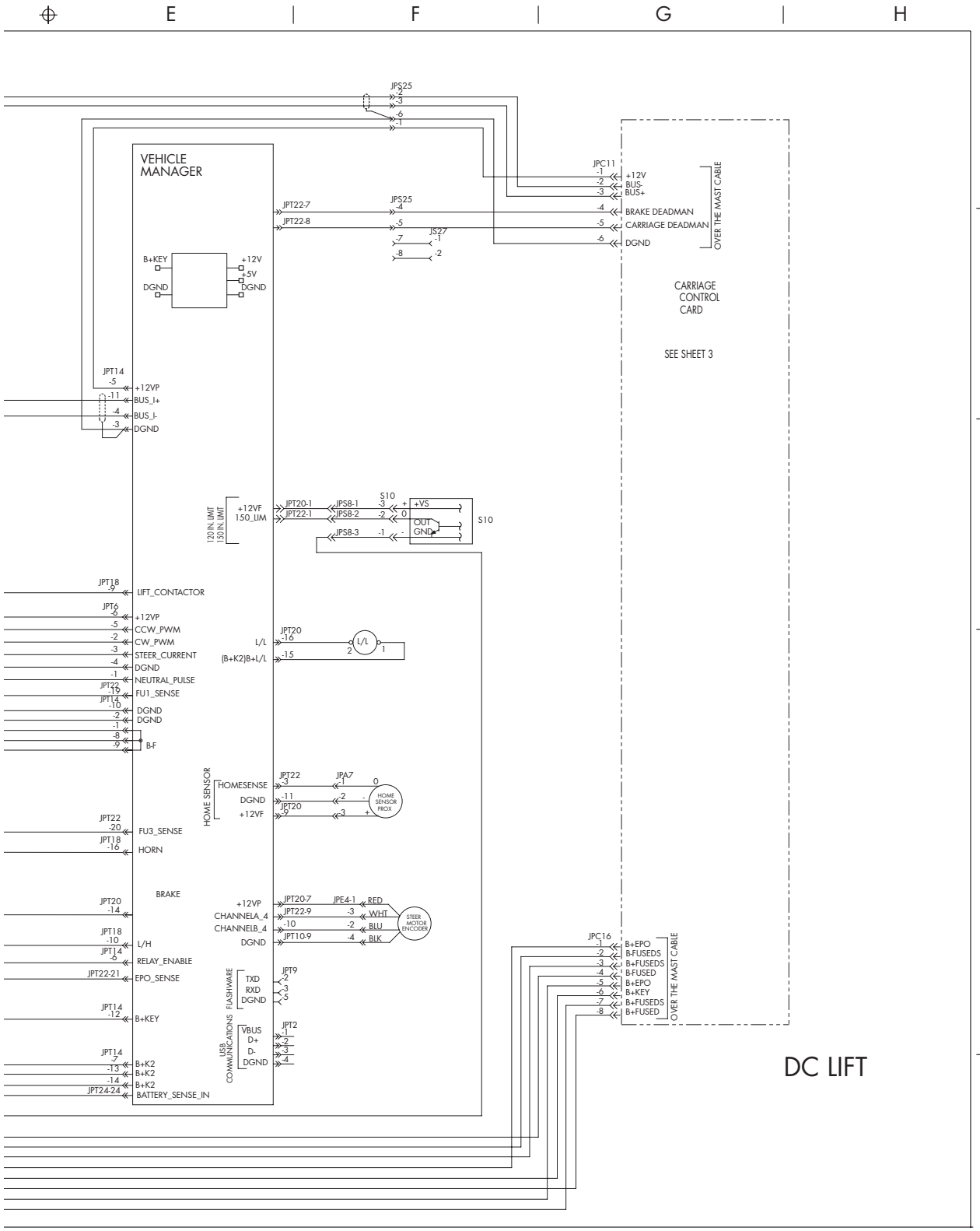


Figure A-2. Electrical Schematic Sheet 2 (DC Lift)

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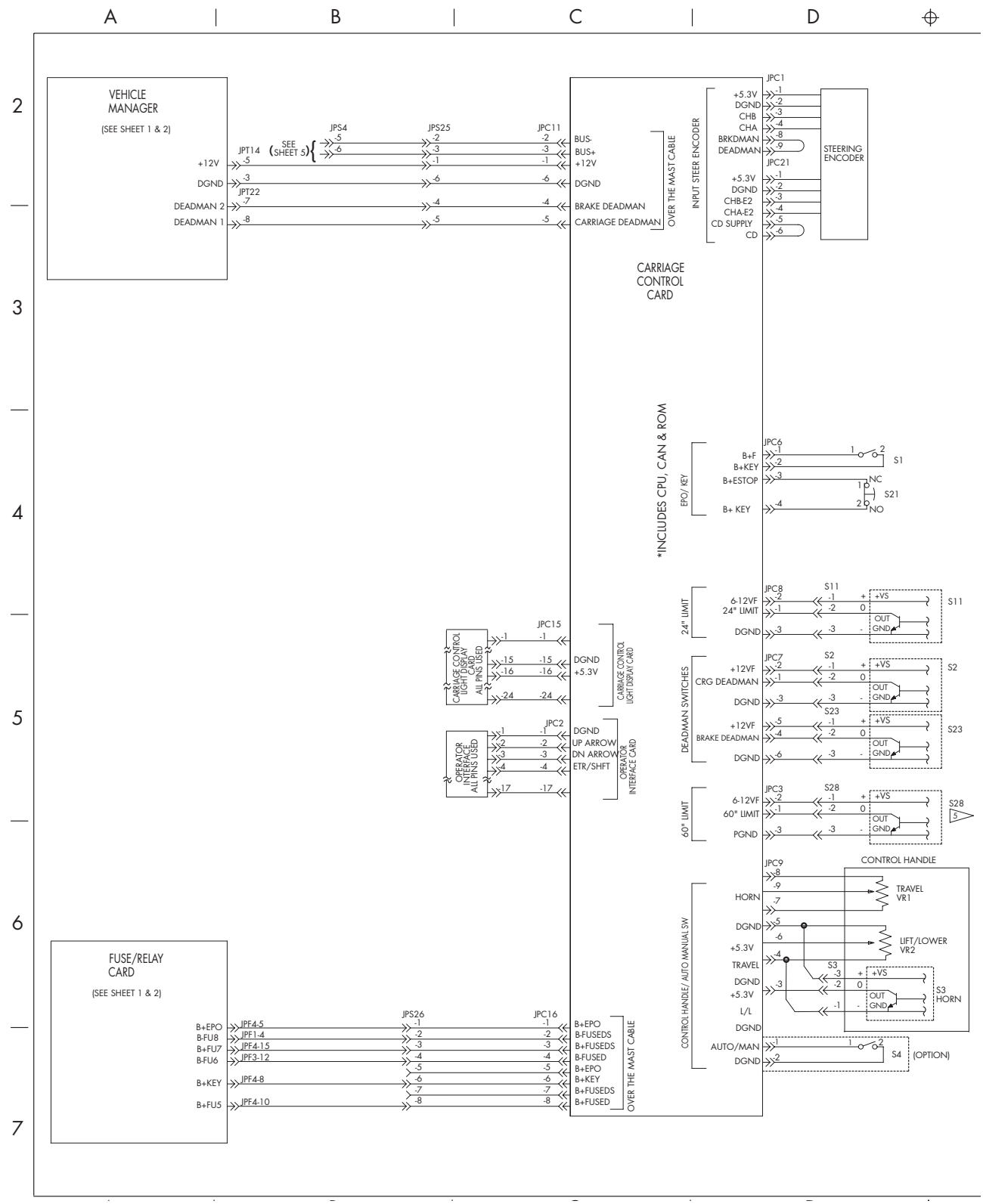


Figure A-3. Electrical Schematic Sheet 3

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RAYMOND

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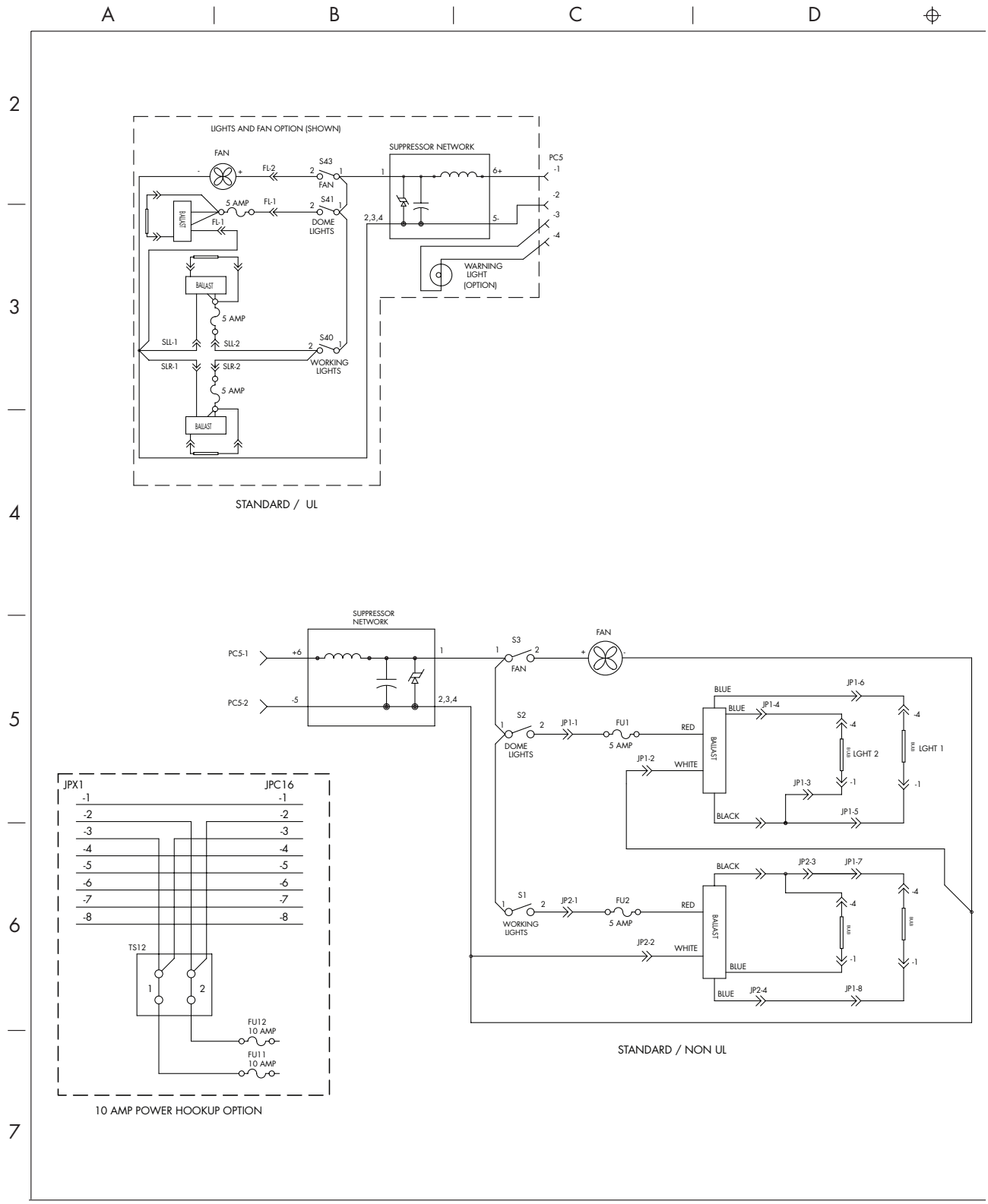
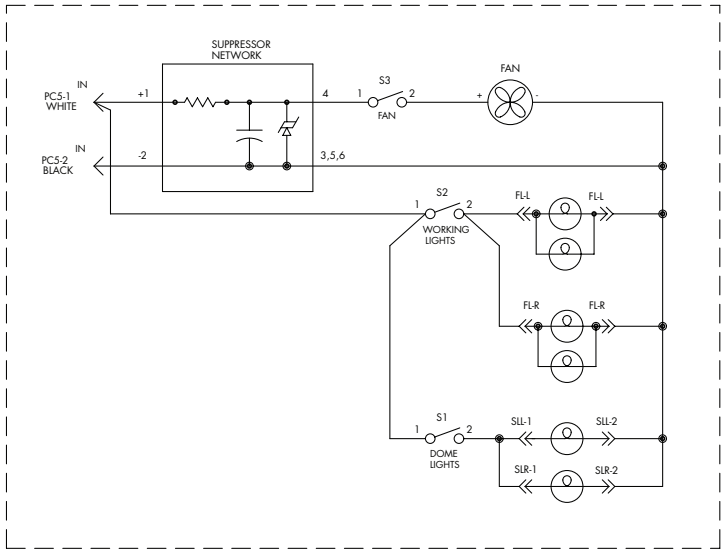
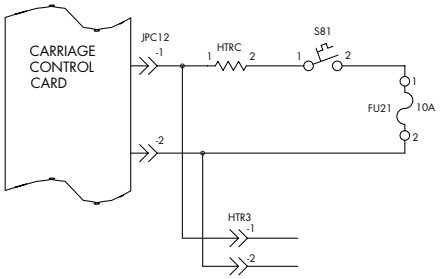


Figure A-4. Electrical Schematic Sheet 4

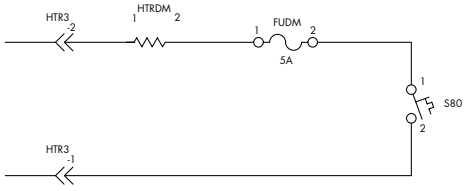
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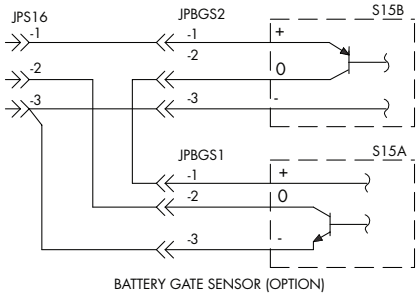
COLD STORAGE



COLD STORAGE OPTION
CARRIAGE CONTROL CARD HEATER



COLD STORAGE OPTION
DEADMAN HEATER



BATTERY GATE SENSOR (OPTION)

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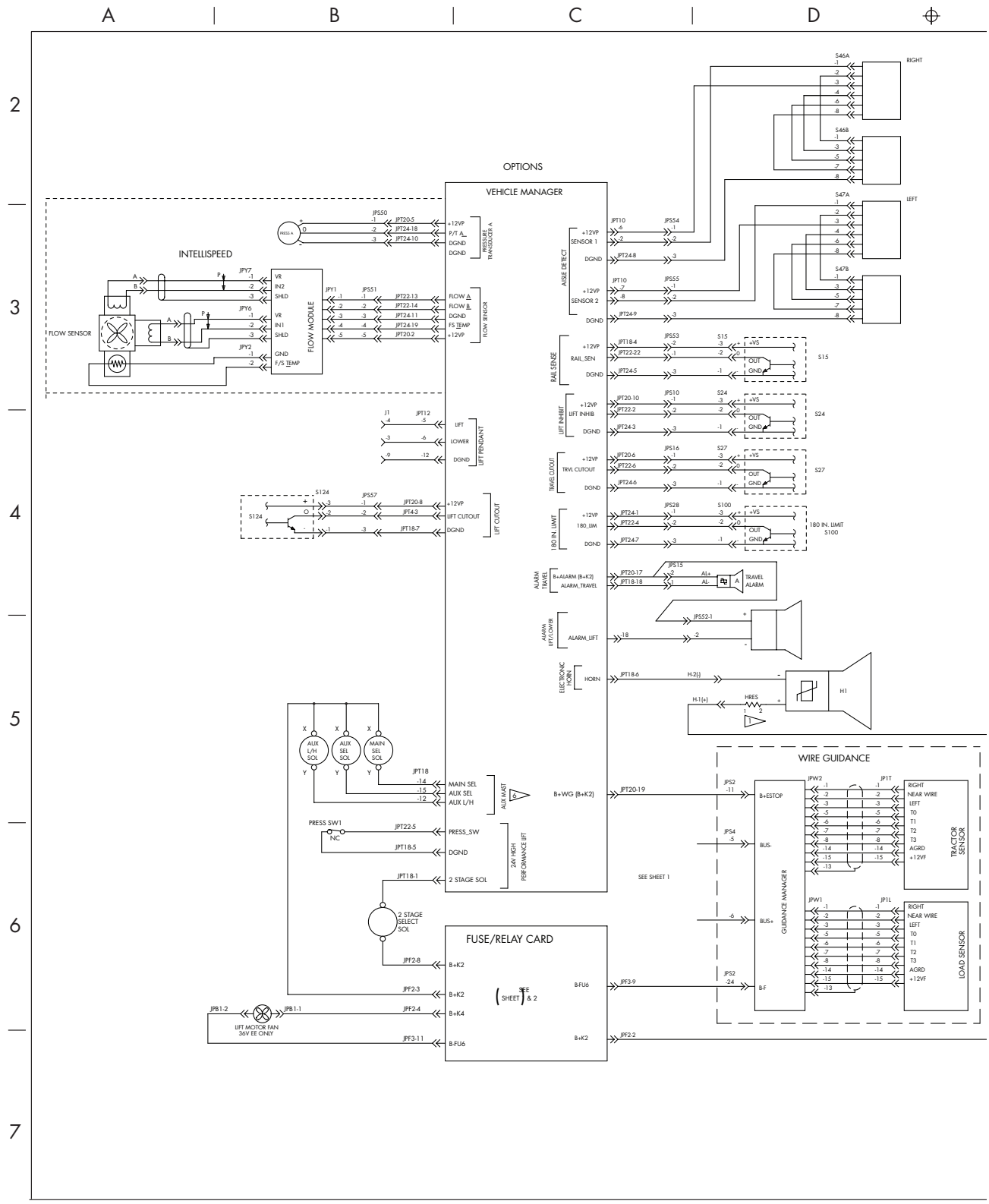
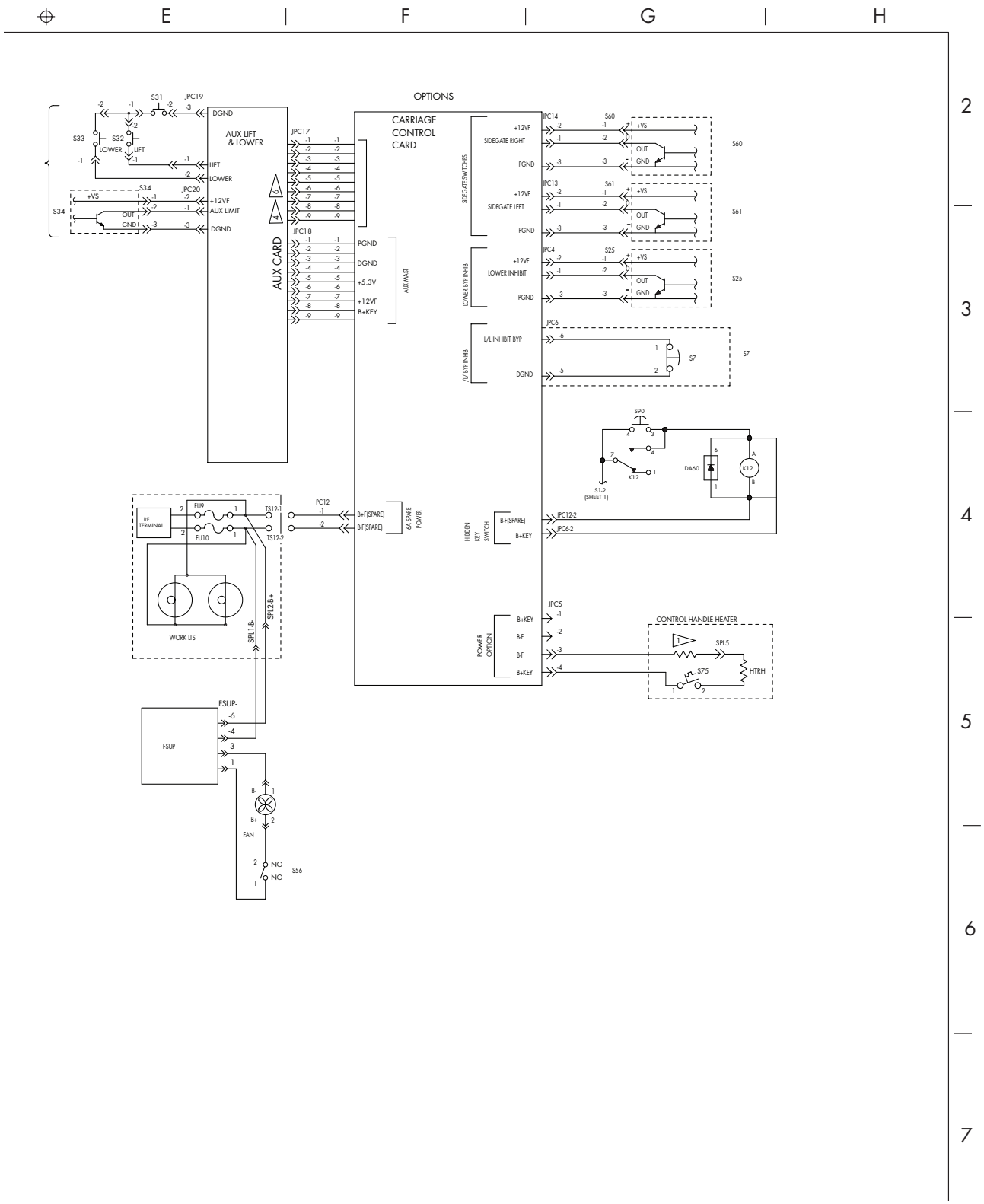


Figure A-5. Electrical Schematic Sheet 5

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A | B | C | D

2

3

4

5

6

7

NOTES:

1. 36V TRUCK ONLY.
2. 350A FUSE REPLACES 500A FUSE ON SINGLE STAGE LIFT PUMP TRUCKS.
3. SCHEMATIC SHOWS TRUCK SWITCHED OFF, DEADMAN SWITCHED OFF, AND CARRIAGE FULLY LOWERED.
4. AUSTRALIAN OPR ONLY.
5. 60 INCH LIMIT SWITCH NOT USED ON INTELLISPEED TRUCKS.
6. OPR W/AUX LIFT OPTION.
7. REFERENCE POWER DISTRIBUTION DIAGRAMS D20009008 AND D20009239.
8. CONNECTED TO JPF4-14 ON 24V TRUCKS WITH AC LIFT.

LEGEND

IDENT.	SHEET	ZONE	DESCRIPTION
2 STAGE SEL SOL	5	B6	TWO STAGE LIFT PUMP SOLENOID
AL-	5	D4	NEGATIVE SIDE OF ALARM
AL+	5	D4	POSITIVE SIDE OF ALARM
BRAKE	1,2	D6	ELECTRIC BRAKE
FSUP	5	F6	CONNECTOR ON FAN SUPPRESSOR
FU1	1,2	B3,C5	POWER FUSE FOR STEER
FU2	1,2	B3,C5	POWER FUSE FOR TRACTION
FU3	1,2	B3	POWER FUSE FOR LIFT
FU5	1,2	B6	CONTROL FUSE FOR VEHICLE MANAGER B+ 15A
FU6	1,2	B6	CONTROL FUSE FOR VEHICLE MANAGER B- 15A
FU7	1,2	B6	CONTROL FUSE FOR AUX. POWER B+ 15A/5A
FU8	1,2	B6	CONTROL FUSE FOR AUX. POWER B- 15A/5A
FU9	5	F4	CONTROL FUSE FOR RF TERMINAL B+ 2A
FU10	5	F4	CONTROL FUSE FOR RF TERMINAL B- 2A
FU21	4	H3	CONTROL FUSE FOR COLD STORAGE C.C.C. HEATER, 10A
FUDM	4	H5	CONTROL FUSE FOR COLD STORAGE DEADMAN HEATER, 5A
H1	5	E4	ELECTRONIC HORN
H (HRN)	1,2	D5	HORN
HRES	5	D4	ELECTRONIC HORN RESISTOR
HTR3	4	MULTI	CONNECTOR FOR DEADMAN HEATER
HTRC	4	G3	C.C.C. HEATER
HTRDM	4	G5	DEADMAN HEATER
HTRH	5	H5	CONTROL HANDLE HEATER
JP1L	5	E6	CONNECTOR FROM LOAD W.G. ANTENNA TO FILTER CARD
JP1T	5	E5	CONNECTOR FROM TRACTOR W.G. ANTENNA TO FILTER CARD
JP1	4	MULTI	CONNECTOR FOR LIGHTS
JP2	4	MULTI	CONNECTOR FOR LIGHTS
JP10	1,2	D6	CONNECTOR FOR WARNING LIGHT
JPA7	1,2	F5	CONNECTOR FOR HOME SENSOR
JPB-	1,2	A4	BATTERY CONNECTOR -
JPB+	1,2	A3	BATTERY CONNECTOR +
JPBR	1,2	D6	CONNECTOR FOR BRAKE
JPC1	3	F2	CONNECTOR ON C.C.C. FOR STEERING ENCODER
JPC2	3	E5	CONNECTOR ON C.C.C. FOR DISPLAY CARD
JPC3	3	F6	CONNECTOR ON C.C.C. FOR 60" LIMIT SWITCH
JPC4	5	H3	CONNECTOR ON C.C.C. FOR LOWER INHIBIT
JPC5	4,5	B5,C2	CONNECTOR ON C.C.C. FOR LIGHTS/FANS
JPC6	3,5	F4,G3	CONNECTOR ON C.C.C. FOR LIFT/LOWER BYPASS SWITCH
JPC7	3	F5	CONNECTOR ON C.C.C. FOR DEADMAN SWITCHES
JPC8	3	F5	CONNECTOR ON C.C.C. FOR 24" LIMIT SWITCH
JPC9	3	F6	CONNECTOR ON C.C.C. FOR CONTROL HANDLE
JPC11	1,2,3	G2,E3	CONNECTOR ON C.C.C. FOR OVER THE MAST CABLE #1
JPC12	4,5	G3,F4	CONNECTOR ON C.C.C. FOR SPARE POWER
JPC13	5	H3	CONNECTOR ON C.C.C. FOR SIDEGATE SWITCHES
JPC14	5	H3	CONNECTOR ON C.C.C. FOR SIDEGATE SWITCHES
JPC15	3	E5	CONNECTOR ON C.C.C. FOR LIGHT DISPLAY CARD
JPC16	1,2,3	G6,E6	CONNECTOR ON C.C.C. FOR OVER THE MAST CABLE #2
JPC17	5	F2	CONNECTOR ON C.C.C. FOR AUX CARD
JPC18	5	F3	CONNECTOR ON C.C.C. FOR AUX CARD
JPC19	5	F2	CONNECTOR ON AUX CARD FOR AUX LIFT & LOWER SWITCH
JPC20	5	F3	CONNECTOR ON AUX CARD FOR AUX LIMIT SWITCH
JPC21	3,5	G3,F3	CONNECTOR ON C.C.C FOR SECONDARY STEER INPUT ENCODER
JPC22	5	F4	CONNECTOR ON AUX CARD FOR AUX SLACK CHAIN
JPC23	5	F4	CONNECTOR ON AUX CARD FOR AUX DEADMAN
JPB1	5	B7	CONNECTOR FOR LIFT MOTOR FAN
FU11	4		CONTROL FUSE FOR AUX POWER B-10A
FU12	4		CONTROL FUSE FOR AUX POWER B-10A
JPX1	4		CONNECTOR FOR 10X AUX POWER

Figure A-6. Electrical Schematic Legend (1 of 2)

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E | F | G | H

2

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IDENT.	SHEET	ZONE	DESCRIPTION
JPE4	1,2	F6	CONNECTOR FOR STEER MOTOR ENCODER
JPF1	1,2,3	MULTI	B- AUX POWER, B+ POWER AMPS CONNECTOR ON FUSE/RELAY CARD
JPF2	1,2,5	MULTI	B+ KEY SWITCH RELAYS CONNECTOR ON FUSE/RELAY CARD
JPF3	1,2,3,5	MULTI	B- CONNECTOR ON FUSE/RELAY CARD
JPF4	1,2,3	MULTI	KEY SWITCH, EPO, BATTERY SENSE CONNECTOR ON FUSE/RELAY CARD
JPLA1	1	D3	LIFT AMP CONNECTOR
JPLA2	1	C3	LIFT MOTOR ENCODER CONNECTOR
JPLA3	1	C3	LIFT MOTOR TEMPERATURE SENSOR CONNECTOR
JPLA4	1	C3	CONNECTOR FOR LIFT MOTOR ENENCODER/TEMP SENSOR CONNECTOR
JPS1	1,2	MULTI	CONTACTOR PANEL INTERFACE CONNECTOR
JPS2	5	D5	CONNECTOR ON TRUCK TRACKER FOR POWER
JPS4	5	D5	
JPS8	1,2	F4	CONNECTOR FOR 120"/150" LIMIT SWITCH
JPS10	5	D3	CONNECTOR FOR LIFT INHIBIT SWITCH
JPS15	5	D4	CONNECTOR FOR TRAVEL ALARM
JPS16	5	D4	CONNECTOR FOR TRAVEL CUTOUT SWITCH
JPS25	1,2,3	F2E3	CONNECTOR FOR OVER THE MAST CABLE #1
JPS26	1,2,3	D7,E7	CONNECTOR FOR OVER THE MAST CABLE #2
JPS27	1,2	F3	CONNECTOR FOR SPARE OVER THE MAST WIRES
JPS28	5	D4	CONNECTOR FOR 180" LIMIT SWITCH
JPS50	5	B2	CONNECTOR FOR PRESSURE TRANSDUCER A
JPS51	5	B3	CONNECTOR FOR FLOW MODULE
JPS52	5	B3	CONNECTOR FOR LIFT/LOWER ALARM
JPS53	5	D3	CONNECTOR FOR RAIL SENSE SWITCH
JPS54	5	D2	CONNECTOR FOR AISLE DECTECT SENSOR 1
JPS55	5	D3	CONNECTOR FOR AISLE DETECT SENSOR 2
JPS57	5	B4	CONNECTOR FOR LIFT CUTOUT
JPS58	5	B5	CONNECTOR FOR SLACK CHAIN SWITCH
JPS59	5	B5	CONNECTOR FOR SLACK CHAIN SWITCH
JPSC1	1,2	D4,D3	SPLICE FOR CAN BUS
JPSC2	1	D4	SPLICE FOR CAN BUS
JPT2	1,2	F6	USB CONNECTOR ON VM
JPT4	5	C4	CONNECTOR ON VM
JPT6	1,2	E5	ELECTRIC STEER CONNECTOR ON VM
JPT9	1,2	F6	CONNECTOR ON VM FOR FLASHWARE
JPT10	1,2,5	MULTI	CAN, DIGITAL INPUTS AND OUTPUTS CONNECTOR ON VM
JPT12	5	D5	LIFT PENDANT CONNECTOR ON VM
JPT14	1,2,3	MULTI	B+, B-, CAN COMMUNICATIONS CONNECTOR ON VM
JPT18	1,2,5	MULTI	COIL DRIVERS CONNECTOR ON VM
JPT20	1,2,5	MULTI	PROPORTIONAL COIL DRIVERS CONNECTOR ON VM
JPT22	1,2,3,5	MULTI	DIGITAL INPUTS CONNECTOR ON VM
JPT24	1,2,5	MULTI	ANALOG INPUTS CONNECTOR ON VM
JPTA1	1,2	D2	TRACTION AMP CONNECTOR
JPTA2	1,2	C2	TRACTION MOTOR ENCODER CONNECTOR
JPTA3	1,2	C2	TRACTION MOTOR TEMPERATURE SENSOR CONNECTOR
JPTA4	1,2	C2	CONNECTOR FOR TRACTION MOTOR ENCODER AND TEMPERATURE
JPW1	5	D6	CONNECTOR ON FILTER CARD FOR LOAD SENSOR
JPW2	5	D5	CONNECTOR ON FILTER CARD FOR TRACTOR SENSOR
JPY1	5	B3	CONNECTOR ON FLOW MODULE
JPY2	5	B3	CONNECTOR ON FLOW MODULE TO FLOW SENSOR TEMPERATURE SENSOR
JPY6	5	B3	CONNECTOR ON FLOW MODULE TO FLOW SENSOR CHANNEL 1
JPY7	5	B3	CONNECTOR ON FLOW MODULE TO FLOW SENSOR CHANNEL 2
K1	1,2	C6	KEYSWITCH RELAY-OPTIONS
K2	1,2,5	C6,H4	KEYSWITCH RELAY-SOLENOIDS, ATTACHMENTS, HORN
K3	1,2	B6,C6	KEYSWITCH RELAY-POWER AMPS
K4	1,2	C6	KEYSWITCH RELAY-AUX. VM POWER
K12	5	H4	HIDDEN KEY SWITCH RELAY
L/H	1,2	D6	LOAD/HOLD SOLENIOD
L/L	1,2	F5	LIFT/LOWER SOLENOID
LA	1	D4	LIFT POWER AMPLIFIER

IDENT.	SHEET	ZONE	DESCRIPTION
LM	1,2	C4,B3	AC LIFT MOTOR OR DC LIFT MOTOR
LME	1	C3	LIFT MOTOR ENCODER
LMT	1	C4	LIFT MOTOR TEMPERATURE SENSOR
LPC	1,2	B3,C4	LIFT POWER CONTACTOR
MS	1,2	B5	STEER MOTOR
PRESS SW1	5	B6	PRESSURE SWITCH FOR 24V HI PERF LIFT
S1	3	F4	KEY SWITCH
S2	3	G5	DEADMAN SWITCH (BRAKE DEADMAN)
S3	3	F6	HORN SWITCH
S4	3	F6	AUTO/MANUAL SWITCH
S7	5	H4	LIFT/LOWER INHIBIT BYPASS SWITCH
S10	1,2	F4	150" LIMIT SWITCH OR 120" LIMIT SWITCH
S11	3	F5	24" LIMIT SWITCH
S15	5	D3	RAIL SENSE SWITCH
S21	3	F4	EPO SWITCH
S23	3	F5	DEADMAN SWITCH (CARRIAGE DEADMAN)
S24	5	D3	LIFT INHIBIT SWITCH
S25	5	H3	LOWER INHIBIT SWITCH
S27	5	D4	TRAVEL CUTOUT SWITCH
S28	3	F6	60" LIMIT SWITCH
S29	5	B4	SLACK CHAIN (MAIN #1)
S30	5	B4	SLACK CHAIN (MAIN #2)
S31	5	E2	AUX LIFT LEFTHAND DEADMAN
S32	5	E2	AUX LIFT
S33	5	E2	AUX LOWER
S34	5	E3	AUX LIFT LIMIT SWITCH #1/REARGATE #1
S36	5	E3	SLACK CHAIN CARRIAGE #1
S37	5	E4	SLACK CHAIN CARRIAGE #2
S40	4	B3	SWITCH FOR WORKING LIGHTS
S41	4	B3	SWITCH FOR DOME LIGHTS
S43	4	B2	SWITCH FOR FAN
S46A	5	D2	AISLE DETECT SENSOR 1
S46B	5	D2	AISLE DETECT SENSOR 1
S47A	5	D3	AISLE DETECT SENSOR 2
S47B	5	D3	AISLE DETECT SENSOR 2
S56	5	F6	SWITCH FOR FAN
S60	5	H2	SIDEGATE RIGHT SWITCH
S61	5	H3	SIDEGATE LEFT SWITCH
S75	5	H5	CONTROL HANDLE HEATER THERMOSTAT
S80	4	H5	DEADMAN HEATER THERMOSTAT
S81	4	H3	C.C.C. HEATER THERMOSTAT
S90	5	H4	SECURITY START SWITCH
S100	5	D4	180" LIMIT SWITCH
S124	5	B4	LIFT CUTOUT SWITCH
SA	1,2	B5	STEER POWER AMPLIFIER
TA	1,2	D2	TRACTION POWER AMPLIFIER
TM	1,2	C3	AC TRACTION MOTOR
TME	1,2	C2	TRACTION MOTOR ENCODER
TMT	1,2	C2	TRACTION MOTOR TEMPERATURE SENSOR
TP1	1,2	B2	TIE POINT ON B+
TP2	1,2	B3	TIE POINT ON STEER MOTOR FUSE
TP3	1,2	B3	TIE POINT ON LIFT MOTOR FUSE
TP4	1,2	B4	TIE POINT ON B-
TP5	1,2	B3	TIE POINT ON TRACTION MOTOR FUSE
TPC	1,2	B2,C3	TRACTION POWER CONTACTOR
TS12	5	F5	TERMINAL STRIP FOR SPARE POWER
VR1	3	F6	VARIABLE RESISTOR FOR THROTTLE
VR2	3	F6	VARIABLE RESISTOR FOR LIFT/LOWER

Figure A-6 (Cont.). Electrical Schematic Legend (2 of 2)

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VARIABLE LIFT SPEED

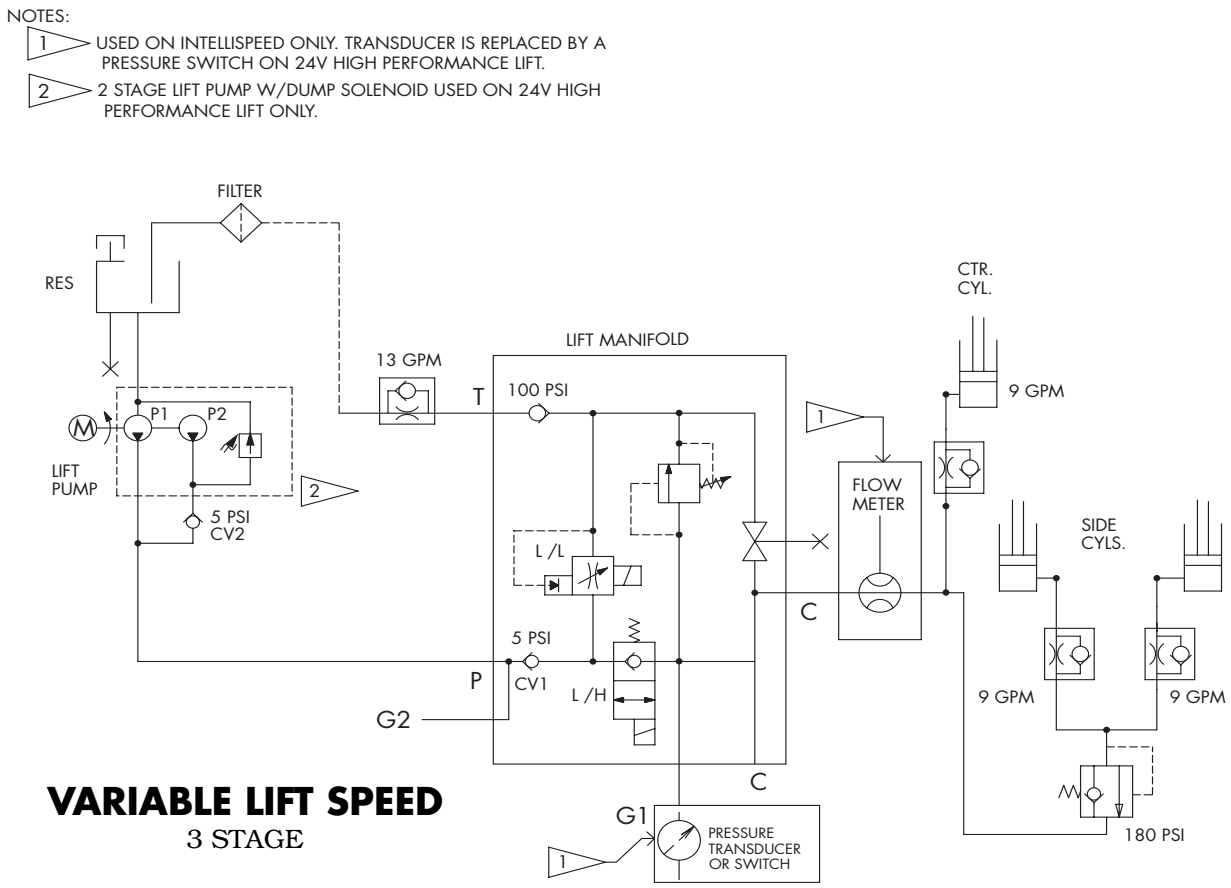


Figure A-7. Hydraulic Schematic

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