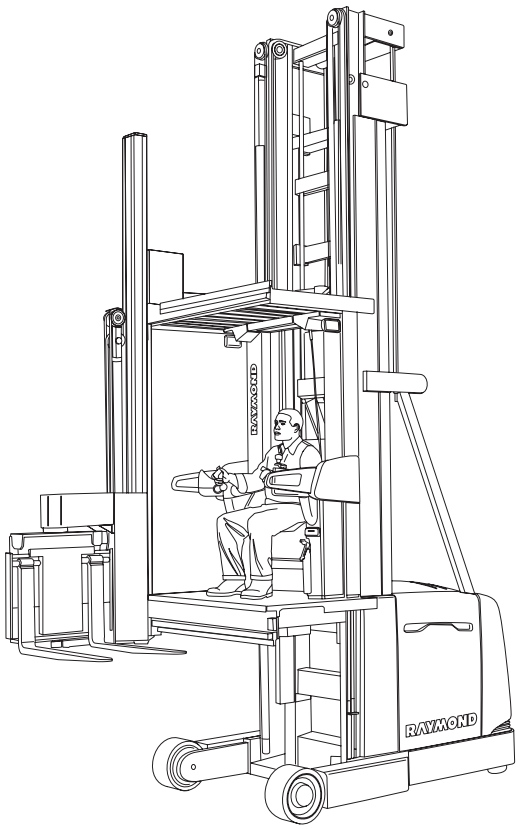
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Maintenance Manual

EAS*i Swing-Reach*® Lift Truck



Model	Serial Numbers
EAS*i Swing-Reach*® Truck	SA-98-00100 and up SB-98-00100 and up

Publication 1016335A — **Issued: 1 Mar 2008**

Replaces PDMM-0090 — **Issued: 1 May 2000**
Replaces PDSS-0077 — **Issued: 24 May 2002**

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This publication, 1016335A, applies to the EAS*i Swing-Reach*® lift truck, Model SA, S/N SA-98-00100 and up, Model SB, S/N SA-98-00100 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.

For revision information, see "Page Revision Page" on page iii.

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 Page

This page is a record of the latest revised pages in this manual. Whenever we revise a page, we update this section and include it in the revision. This lets you keep track of the latest revised pages for this manual.

Pages can be revised due to technical or non-technical changes.

- Technical changes are identified by a vertical line (change bar) in the left margin adjacent to the change. Pages affected by technical changes are identified with "*Page Revised dd mm yyyy*" in the footer.
- Non-technical changes consist of typographical/grammatical corrections, paragraph renumbering, repagination and so on. Non-technical changes are not identified with a change bar, but affected pages are identified with "*Page Revised dd mm yyyy*" in the footer.

Changed pages are posted on the Raymond iNet.

This manual replaces and supersedes the following prior manuals:

- PDMM-0090 Issued 1 May 2000
- PDSS-0077 Issued 24 May 2002

This manual applies to all serial numbers to date of publication for models SA and SB. It includes the following information:

- updated schematics
- pinout matrix (added)
- slack chain switches
- proportional auxiliary valve
- solid-state control handle repairs
- steer input encoder

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Page Revision Page

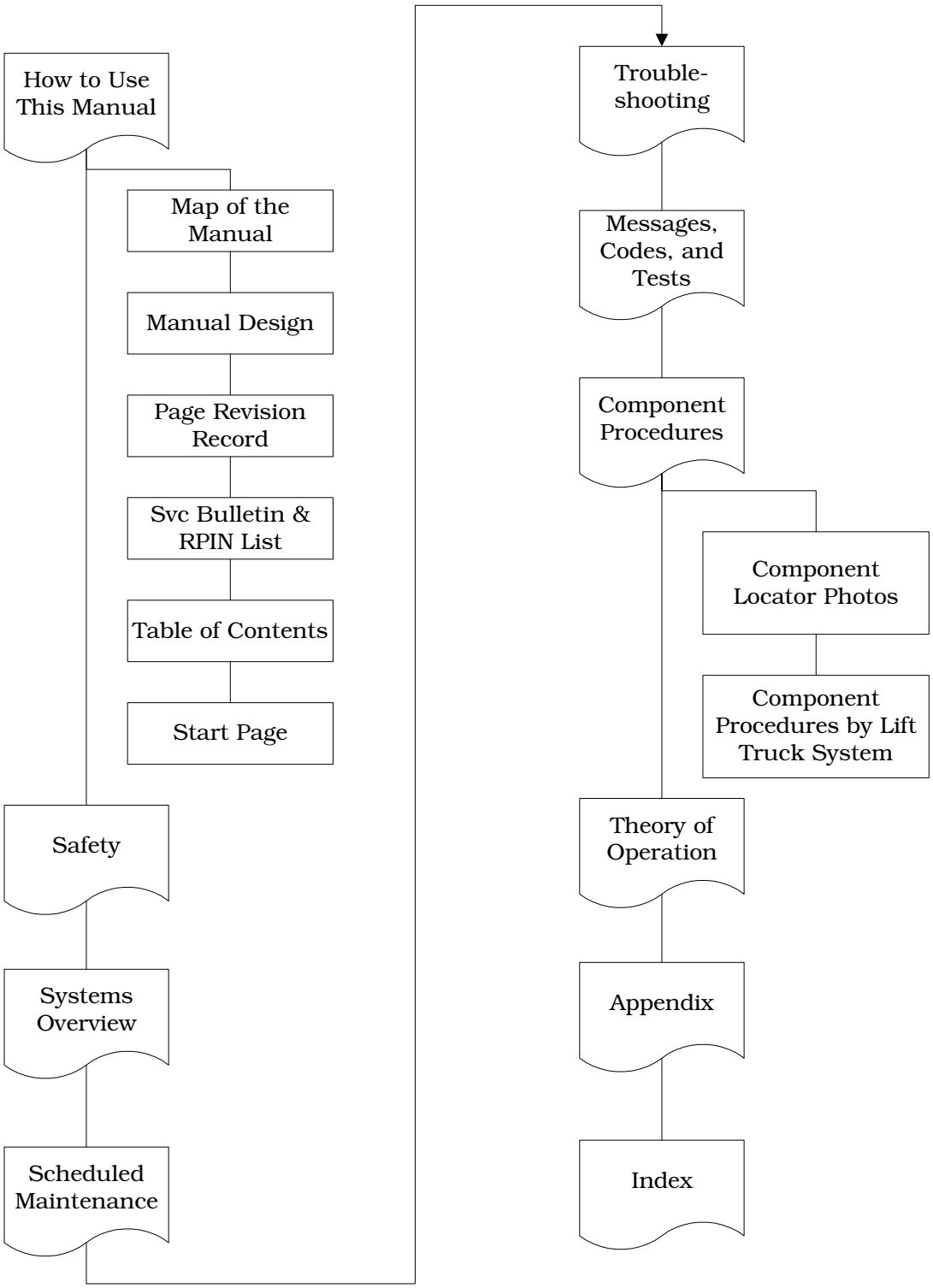
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Section 1. How to Use This Manual

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Map of the Manual



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Manual Design

The EASi *Swing-Reach*® Maintenance Manual is designed with the following objectives in mind:

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

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

- the name of the manual (EASi *Swing-Reach*® *Maintenance Manual*)
- the current Chapter Title (for example, this page *How to Use This Manual*)
- the current topic (for example, this page *Manual Design*)

We suggest you get in the habit of turning to the **START** page first when you use this manual.

The **START** page asks a few simple questions to guide you to the correct chapter.

- **How to Use This Manual** explains the manual format and design.
- **Safety** explains warning and caution notes, general safety rules and safety rules for batteries, static, jacking, and welding.
- **Systems Overview** includes truck specifications, a brief description of Modes of Operation, and instructions for installing the lift truck.
- **Scheduled Maintenance** outlines the recommended schedule of preventive services to keep your lift truck working most efficiently.
- **Troubleshooting** is a set of general troubleshooting guidelines, a troubleshooting task flow, and a set of troubleshooting tables for symptoms not accompanied by a fault code.
  - The **START TROUBLESHOOTING** chart (on page 5-29) is a general task flow.
  - Once you’re familiar with the symptoms listed, you could instead simply find the symptom from the **Troubleshooting Symptom Tables** (beginning on page 5-33.
  - When you complete a troubleshooting procedure, be sure to follow the steps in **End of Troubleshooting Chart END-1** (page 5-31).
- **Messages, Codes, and Tests** lists the electrical fault codes, details for modes of operation, and procedures for running firmware electrical tests.
- **Component Procedures** gives information for testing, removal, installation, and adjustment of individual truck components. Components are grouped by truck system.

  To find a component procedure, you could use one of two methods:
  - Look up the component name in the **Component Procedure by Lift Truck System** list (page 7-1).
  - Look up the component name in the maintenance manual **Index** (page I-1).
- **Theory of Operations** explains flow within hydraulic and electrical schematics for various conditions of truck operation. A pinout matrix chart lists functions and normal voltages of terminals and harness connector pins.
- **Appendix** contains reference information such as torque values, lubrication specifications, and system schematics.
- **Index** lists subjects alphabetically.

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Abbreviations, Acronyms, and Symbols

These abbreviations, acronyms, and symbols could be used in this manual.

Table 1-1. Abbreviations, Acronyms, and Symbols

Symbols	
@	at
©	copyright
°	degrees
°C	degrees Celsius
°F	degrees Fahrenheit
=	equals
>	greater than, above
<	less than, below
–	minus or negative
Ω	ohms
%	percent
±	plus or minus
+	plus or positive
®	registered trademark
™	trademark
¥	dynamic diagnostic mode

A	
A	ampere
A/D module	analog/digital input/output module
AGM	absorbed glass mat (battery type)
AGND	analog ground
AH	mini (aux) mast height manager
amp	ampere or amplifier
ANSI	American National Standards Institute
API	American Petroleum Institute
approx	approximately
aux	auxiliary
AWG	American Wire Gauge
B	
B+,B–	Battery Voltage
BSOC	Battery State-of-Charge
BWI	brush wear indicator
C	
C	capacitor; Celsius or Centigrade
CAN	controller area network
CCW	counterclockwise
CD	coil driver
cm	centimeter
CM	carriage manager
COP	computer operating program
CPU	central processing unit
CV	check valve
CW	clockwise
cyl	cylinder
C/S	cold storage
D	
DC	direct current
DFW	distance from guide wire
DGND	digital ground

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Abbreviations, Acronyms, and Symbols

diam.	diameter
DIRA	auxiliary direction A
DIRB	auxiliary direction B
DOT	US Department of Transportation
DTIC	Dealer Technician *intellidrive*® Configurator
DVM	digital voltmeter or multimeter
E	
EASi™	Ergonomically Advanced System with *intellidrive*® *control system*
E	UL Electric Truck Type Certification Rating with safeguards against inherent fire and electrical shock hazards
EE	UL Electric Truck Type Certification where electrical equipment is completely enclosed
EOA	end-of-aisle
EPO	emergency power off
EPROM	Erasable Programmable Read Only Memory
ESD	electrostatic discharge (static)
ESM	electric steer manager
F	
F	Fahrenheit
FILT	line filter
ft.	foot, feet
ft. lb.	foot-pounds of torque
FR	flow regulator
FU	fuse
G	
GA	gauge (of wire or sheet metal)
gal.	gallon or gallons
gm	gram
GND	ground
gpm	gallons per minute
gr	gram or grams
H	
H	horn
HA	heading angle (wire guidance)
HD	hours on deadman
HL	hours spent lifting
HM	height manager
ht.	height
htr or HTR	heater
Hz	Hertz
I	
il or IL	indicator light
in.	inch, inches
in. lb.	inch-pounds of torque
J	
JP	jack and pin connector
K	
K	relay
K	thousand
kg	kilograms
kg/cm^2	kilograms per square centimeter
KH	hours with key switch ON
km/h or km/hr	kilometers per hour
kPa	kilo Pascals
L	
l	liter

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L	Low Lift
lb.	pound, pounds
LED	light emitting diode
LH	load handler
L/H	load holding
L/L	lift/lower
LPC	lift power control contactor
LM	lift motor
LS	load shuttle
LV	lowering valve
M	
m	meter(s)
M	firmware chip
mA	milliampere
max	maximum
MD	drive motor
MH	main mast height manager
min	minute or minimum
mm	millimeter
MM, MntMind	Maintenance Minder
MP	lift pump motor
mph	miles per hour
MS	steer motor
MX	auxiliary lift pump motor
N	
N/A or n/a	not applicable or not available
N/C	normally closed
NLGI	National Lubricating Grease Institute
N•m, Nm	newton meter
N/O	normally open

O	
OACH	overall collapsed height
OD	Operator Display
ODI	Operator Display interface
OSHA	Occupational Safety and Health Association
OTM	over-the-mast
oz.	ounce
P	
P	pump of lift contactor
PC	personal computer, power contactor
PDD	power distribution diagram
pot	potentiometer
prox or PROX	proximity
psi	pounds per square inch
PT	pressure transducer
PWM	pulse width modulation
P/N	part number
Q	
Q	transistor
qt.	quart
R	
R	resistor
RAM	random access memory
rch or RCH	reach
REC	rectifier
reg.	regulator
REL	relief valve
Regen	regenerative braking

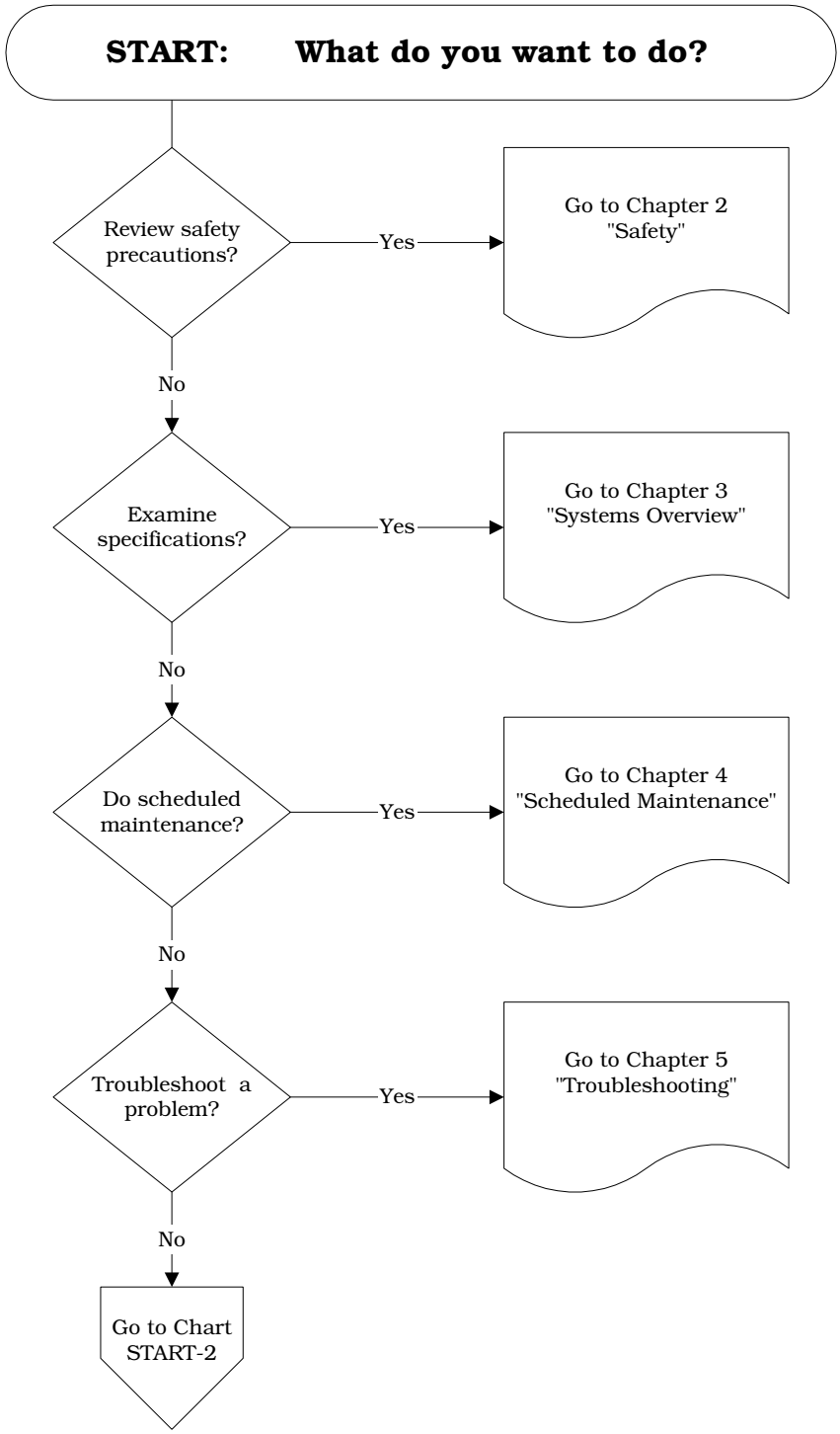
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Abbreviations, Acronyms, and Symbols

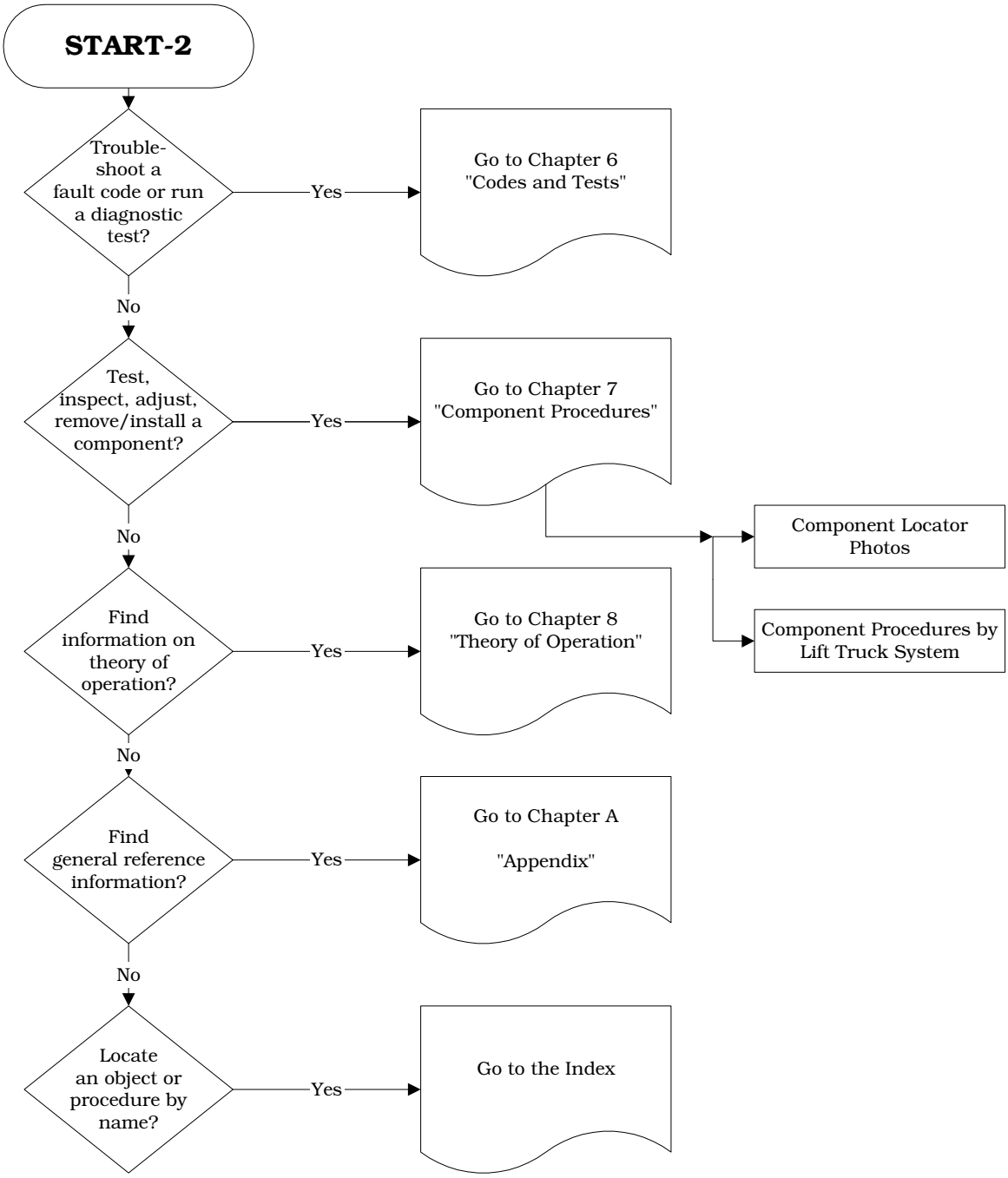
RF	radio frequency
ROM	read only memory
rot or ROT	rotate
RPIN	*Raymond* Product Improvement Notice
rpm	revolutions per minute
RSB	*Raymond* Service Bulletin
RV	relief valve
S	
S	switch
SAE	Society of Automotive Engineers
SG	specific gravity
SM	steer manager
SMART*i*	System Management and Recording Tool for *intellidrive*® control systems
S/N	serial number
SOD	supplemental Operator Display
SOL	solenoid
spec	specification
spl or SPL	splice
STR	steer contactor
SUP	suppressor
T	
T	two-stage (mast)
temp	temperature
TF	full free lift option on two-stage
TM	tractor manager; motor transistor; traction motor
TMI	traction miles
TN	two-stage with nominal free lift
TP	tie point, test point
TPC	traction power control contactor
TS	terminal strip or tractor speed
TT	triple telescopic (three-stage mast)
U	
UL	Underwriters' Laboratories, Inc.
UNC	unified coarse thread
UNF	unified fine thread
V	
V	volt or volts
VDC	volts direct current
ver.	version
VFC	vehicle function controller
VM	Vehicle Manager
VR	variable resistor (potentiometer)
W	
W	watt
WG	wire guidance
wrt	with respect to

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START Page



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Section 2. Safety

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Definitions

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

⚠ WARNING

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

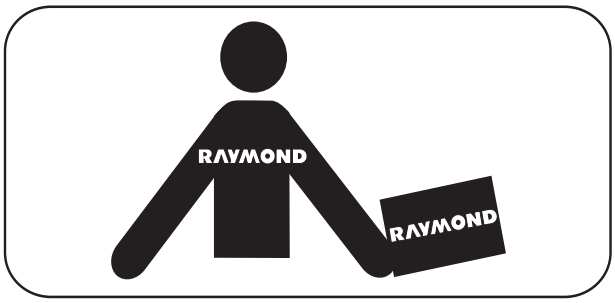
⚠CAUTION

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

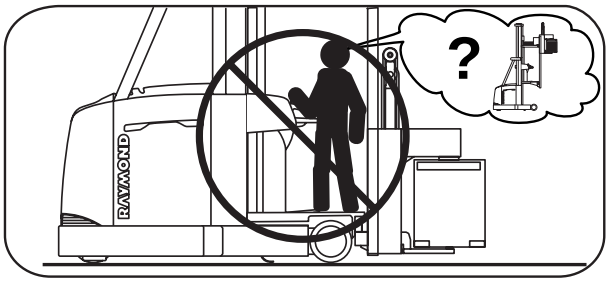
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General Safety

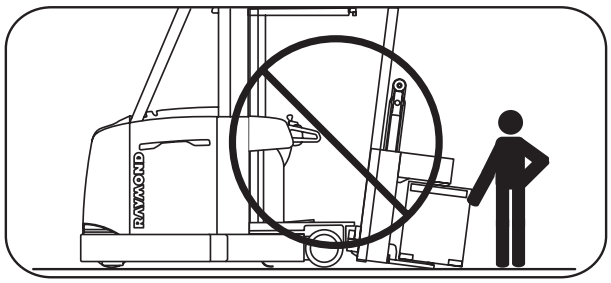
Do *not* operate or work on this lift truck unless you are trained, qualified, and authorized to do so, and have read the Owner/Operator Manual.



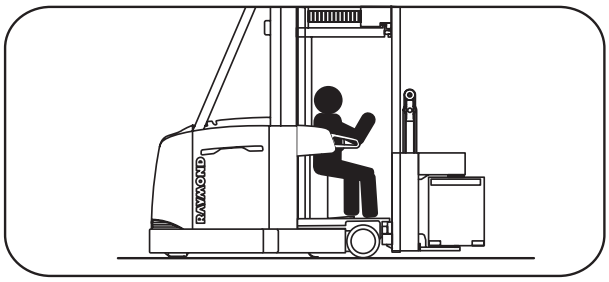
Know the lift truck's controls and what they do.



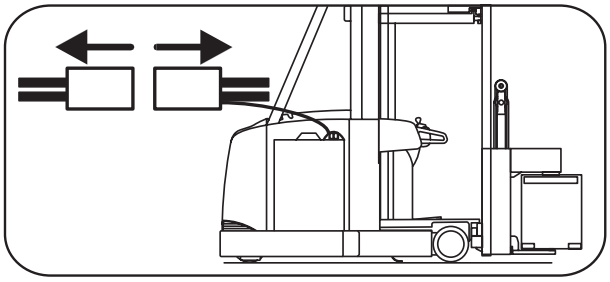
Do *not* operate this lift truck if it needs repair or if it is in any way unsafe.



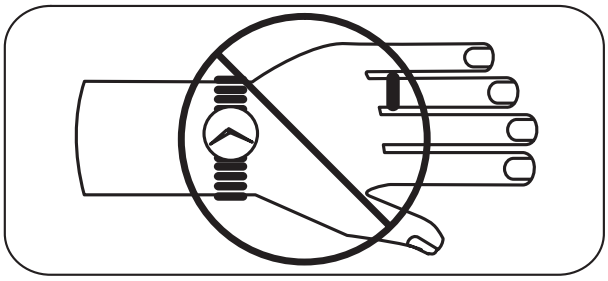
Operate this lift truck only from the operator's position.



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



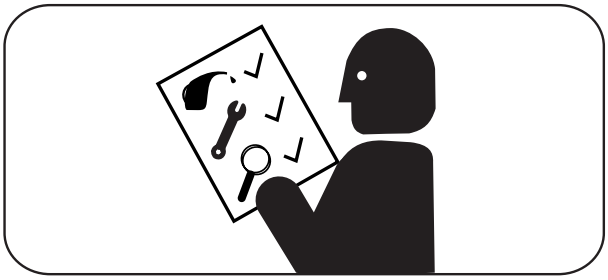
Do *not* wear watches, rings, or jewelry when working on the lift truck.



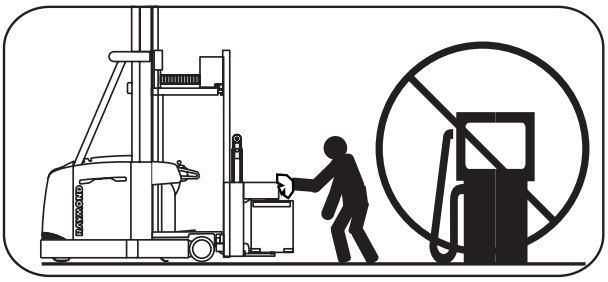
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General Safety

Follow the scheduled lubrication, maintenance, and inspection steps.



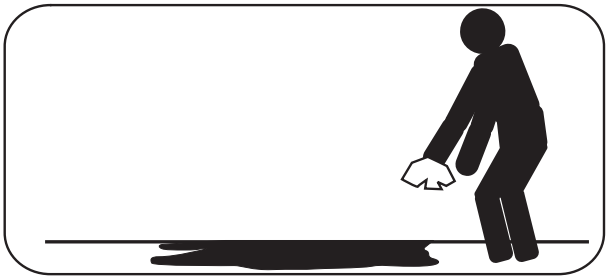
Do *not* use gasoline or other flammable liquids for cleaning parts.



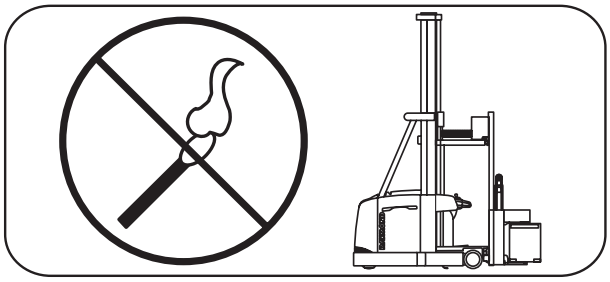
Follow exactly the safety and repair instructions in this manual. Do *not* take “shortcuts.”



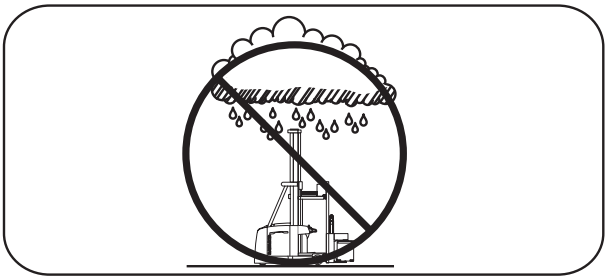
Clean up any hydraulic fluid, oil, or grease that has leaked or spilled on the floor.



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

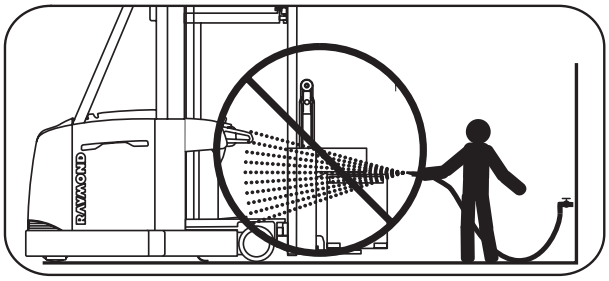


Always operate and park this lift truck indoors.

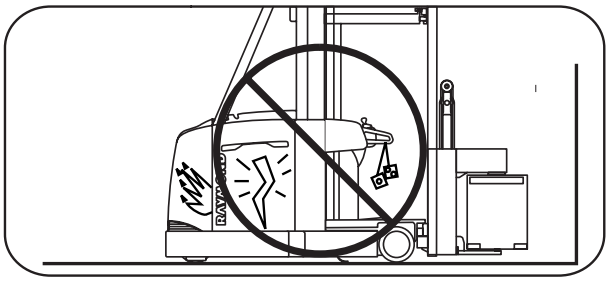


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Do *not* wash this lift truck with a hose.



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



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Battery Safety

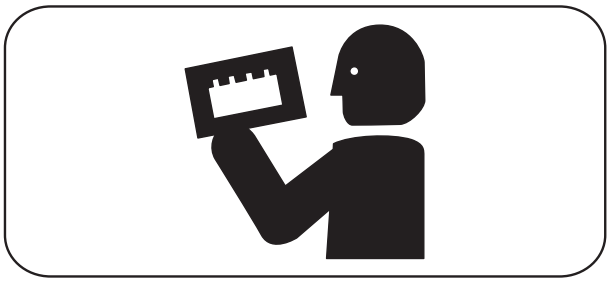
⚠ WARNING

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

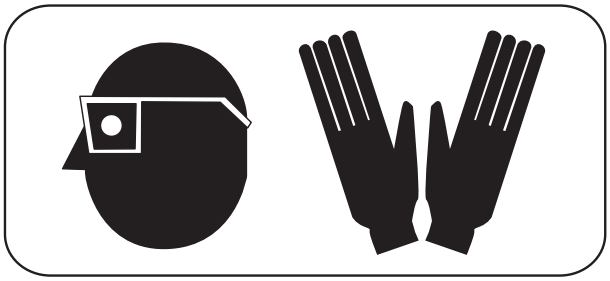
⚠CAUTION

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

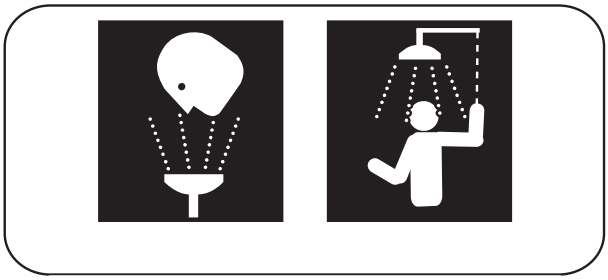
Read, understand, and follow procedures, recommendations, and specifications in the battery and battery charger manufacturer's manuals.



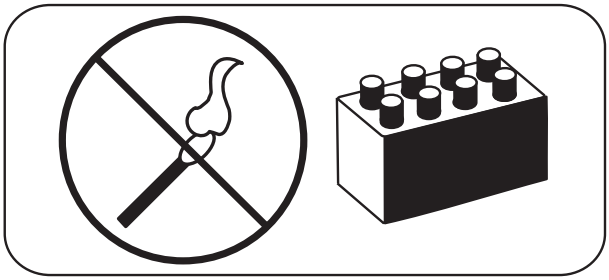
Wear personal protective equipment to protect eyes, face, and skin when checking, handling, or filling batteries. This equipment includes goggles or face shield, rubber gloves (with or without arm shields), and a rubber apron.



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

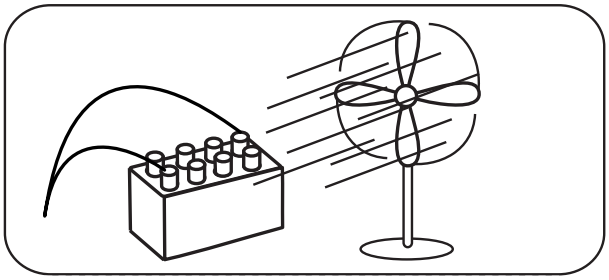


A battery gives off explosive gases. *Never* smoke, use an open flame, or use anything that gives off sparks near a battery.

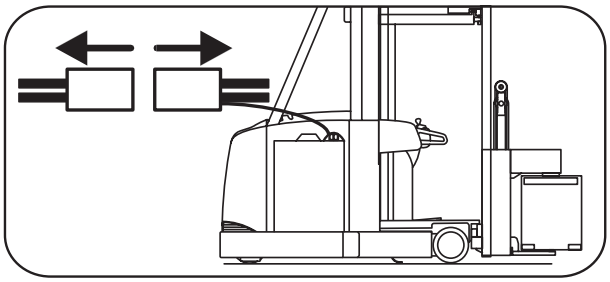


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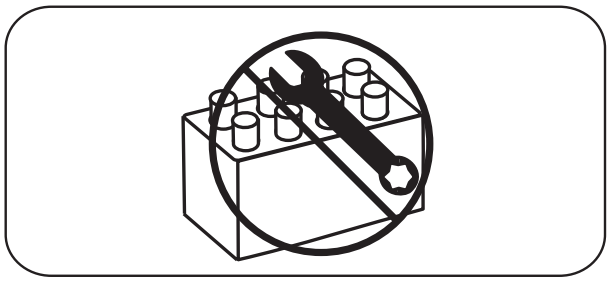
Keep the charging area well-ventilated to avoid hydrogen gas concentration.



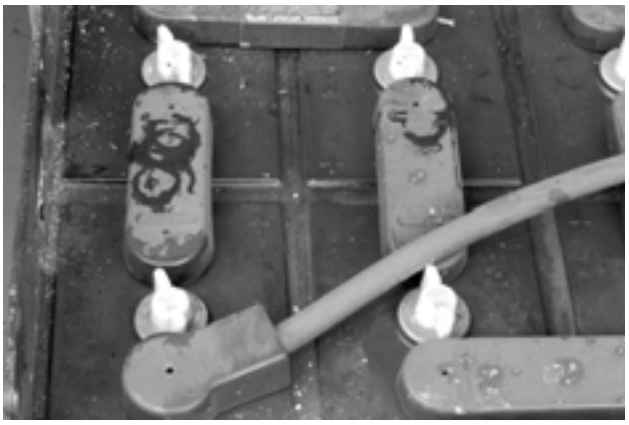
Turn the key switch OFF *before* disconnecting the battery from the lift truck at the battery connector. *Do not* break live circuits at the battery terminals. A spark often occurs at the point where a live circuit is broken.



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



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



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

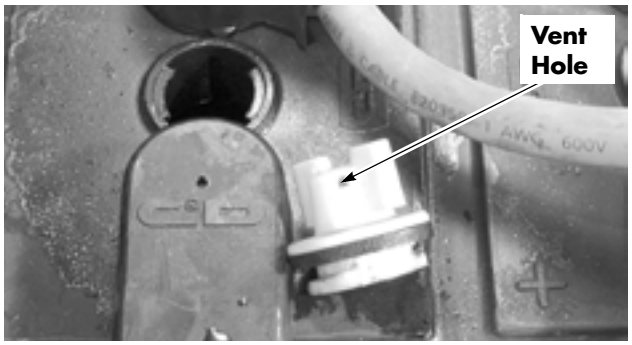


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Battery Safety

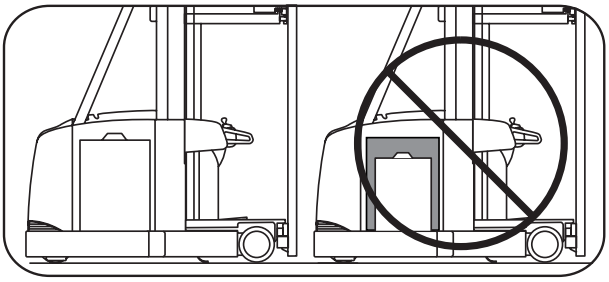
Keep filler plugs firmly in place at all times *except* when checking the electrolyte level, when adding water to the cells, or when checking the specific gravity.

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

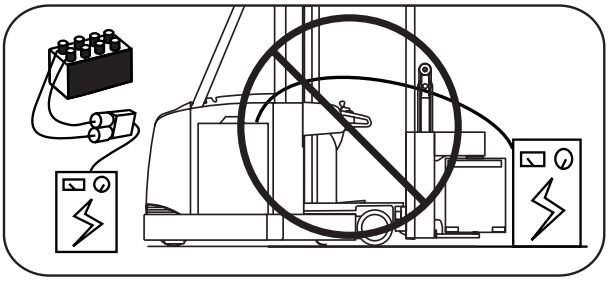


Do *not* permit cleaning solution, dirt, or any foreign matter to enter the cells.

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



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



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Static Precautions

The discharge of static electricity, called electrostatic discharge, can damage electronic circuit boards and devices used on the *Raymond* EASi *Swing-Reach*® truck.

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

Accumulated static can discharge through human skin to a circuit board or component by touching the parts. Static discharge is also possible through the air when a charged object is close to another surface at a different electrical potential. *Static discharge can occur without your seeing or feeling it.*

Whenever working on or near static-sensitive electronics, always use static discharge precautions.

1. Place a static discharge wrist strap around your wrist. Connect the ground lead to the wrist strap connector. The wrist strap must have a 1 megohm resistor to dissipate static charges slowly.
2. Connect the ground plug to the ESD ground jack on the lift truck. ESD ground jacks are located on the tractor frame near the lift motor, and under the seat, near the Carriage Manager. If you cannot use the ground jack, connect the ground clamp to an unpainted, grounded surface on the lift truck frame.

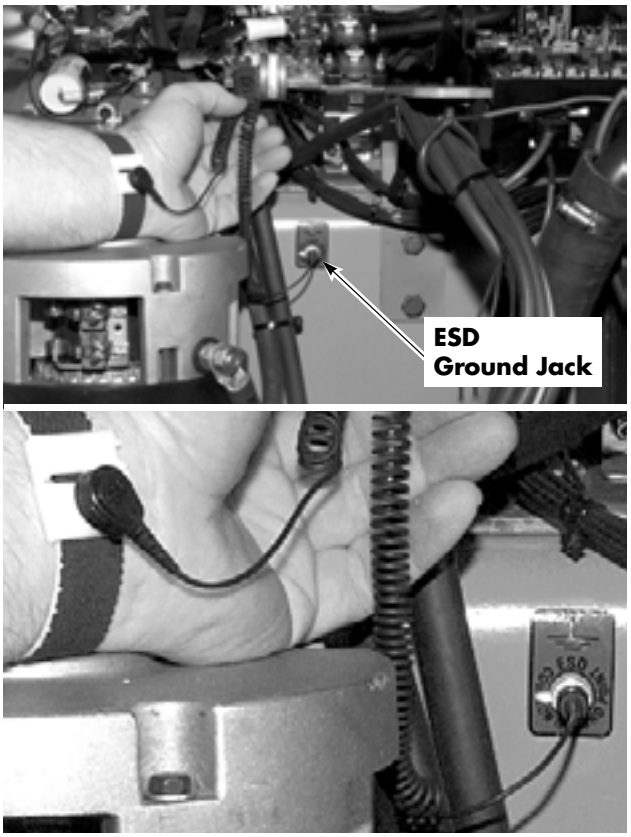


Figure 2-1. Anti-Static Wrist Strap and ESD Ground Jack, Tractor

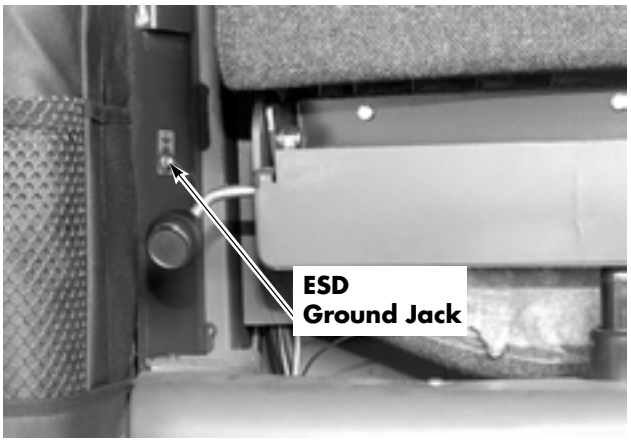


Figure 2-2. ESD Ground Jack, Operator Compartment

3. Handle circuit boards by edges only. Avoid touching edge connectors.
4. If you will be removing or installing static-sensitive components, place them on a correctly grounded static mat.

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5. To transport static-sensitive components, including failed components being returned, place the components in an antistatic bag or box (available from your Raymond dealer).

Test the wrist strap and associated accessories monthly to verify they are working correctly.

Figure 2-3 shows the components of the Raymond antistatic field service kit, part number 1-187-059. The kit includes a wrist strap, ground cord, and static-dissipative work surface (mat). Follow the instructions packaged with the kit.



Figure 2-3. Anti-Static Kit (1-187-059) with Wrist Strap and Mat

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

A wrist strap tester is available as part number 1-187-060/100.

Contact your local authorized Raymond dealer for information.

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Jacking Safety

Sometimes you might need to jack the lift truck off the floor to perform maintenance procedures. When doing so, observe the correct safety precautions:

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

⚠ WARNING

Use extreme care when the lift truck is jacked up. Never block the lift truck between the operator platform and the floor; this presents a tipping hazard. Keep hands and feet clear while jacking the lift truck. After the lift truck is jacked, place solid blocks or jack stands beneath it to support it. *Do not* rely on the jack alone to support the lift truck.

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

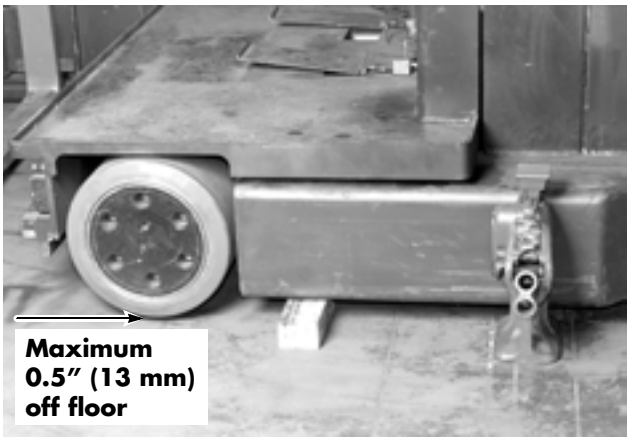


Figure 2-4. Jacking and Blocking Baseleg

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

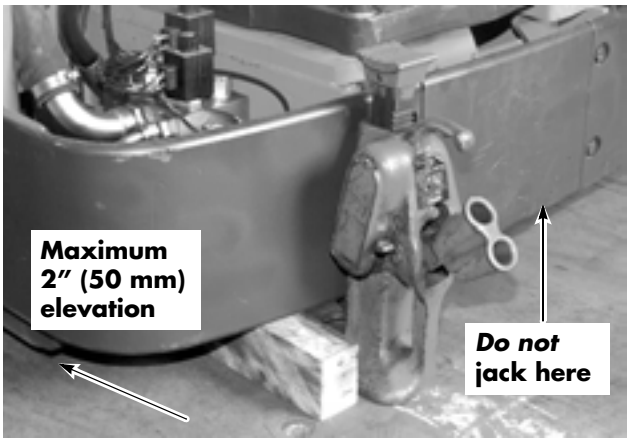


Figure 2-5. Jacking and Blocking Tractor

NOTE: After working on vehicle, test all controls and functions to assure correct operation.

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Blocking and Lifting Safety

Blocking the Platform

⚠CAUTION

Do *not* block against the platform floor, but use the edge of the platform. Do *not* block the carriage against the floor -- lowering the platform could tip the load wheels off the floor.

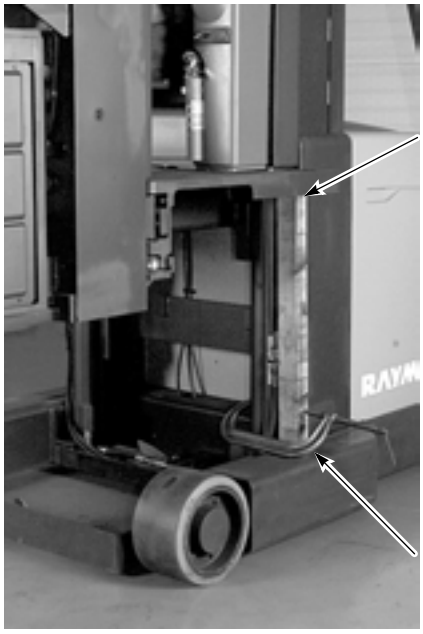


Figure 2-6. Blocking and Clamping Operator Platform



Figure 2-7. Blocking and Clamping Operator Platform

Blocking the Load Handler

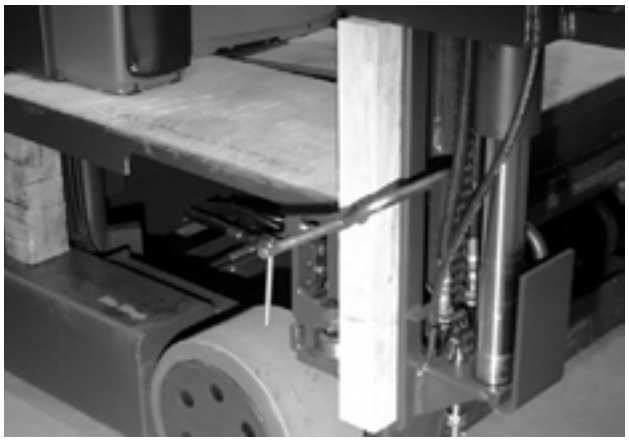


Figure 2-8. Blocking and Clamping Load Handler

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Lifting Motors

Secure a hoist to the drive motor, either by 4 hooks into the top of the motor casting, or with 2 straps cross-wrapped as shown in Figure 2-9.



Figure 2-9. Secure Hoist to Drive Motor

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Welding Safety

⚠CAUTION

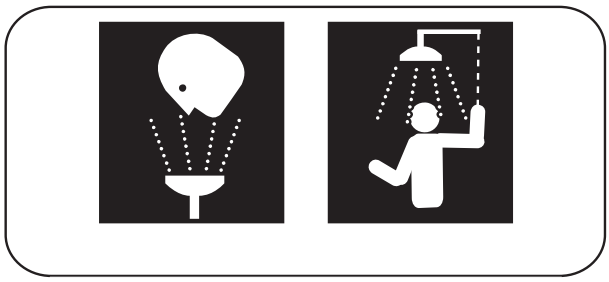
Flame cutting or welding on painted surfaces can produce potentially harmful fumes, smoke, and vapors. Before doing flame cutting or welding, remove the coating in the area where the operation(s) will occur.

⚠CAUTION

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

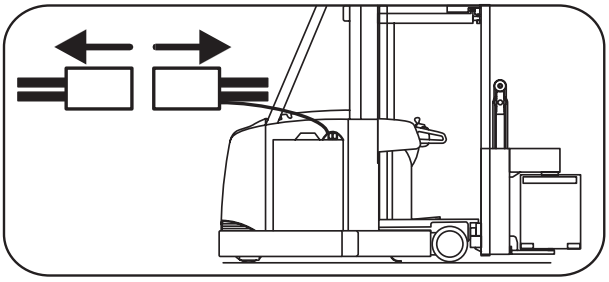
Before working on this lift truck, make sure that:

- 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. Discharge residual charge in the motor controller by pressing PC1, PC2, and P contactors closed simultaneously.



- Check for shorts to frame as described on page 5-4. If you detect any shorts, correct them before you weld.
- Clean the area to be welded.
- Protect all lift truck components from heat, weld spatter, and debris.
- Attach the ground cable as close to the weld area as possible.
- Do not weld near electrical components.
- If you must weld near the battery compartment, remove the battery from the lift truck.
- Disconnect all electrical circuit cards before welding. When you are finished welding, reconnect all circuit cards and do ground tests and electrical inspections before operating the lift truck.

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Section 3. Systems Overview

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Introduction

This manual provides information for maintenance and repair of the EAS*i* *Swing-Reach*® lift truck by Raymond.

This manual contains the most current and accurate procedures, drawings, and photographs available at the time of publication. Because *Raymond*® products are continually improved, your lift truck could differ slightly from that depicted here; some changes in parts, layout, or procedures might not be reflected in this manual.

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

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Lift Truck Specifications

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

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

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

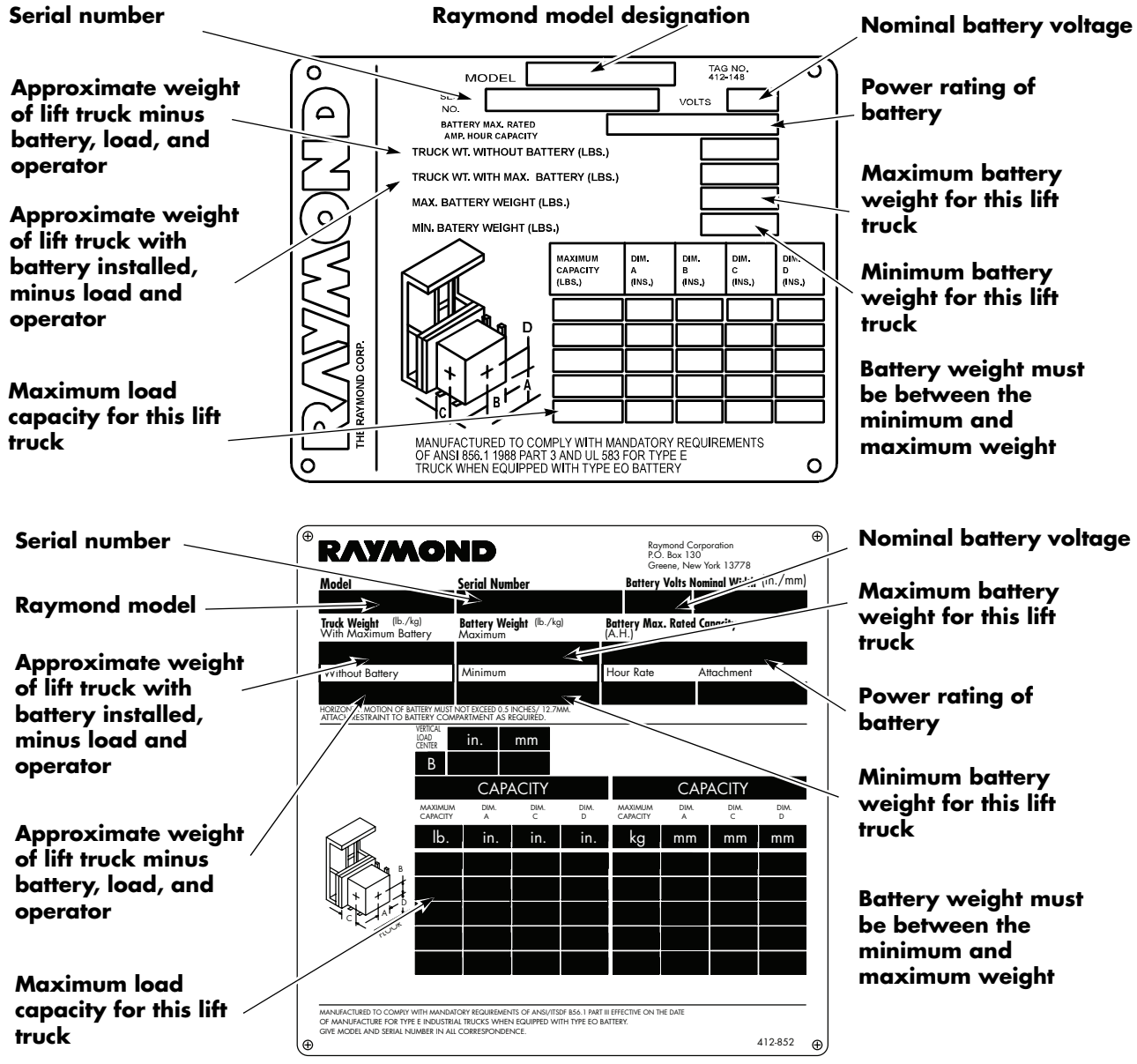


Figure 3-1. Lift Truck Specification Plate (early and later styles)

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General System Data

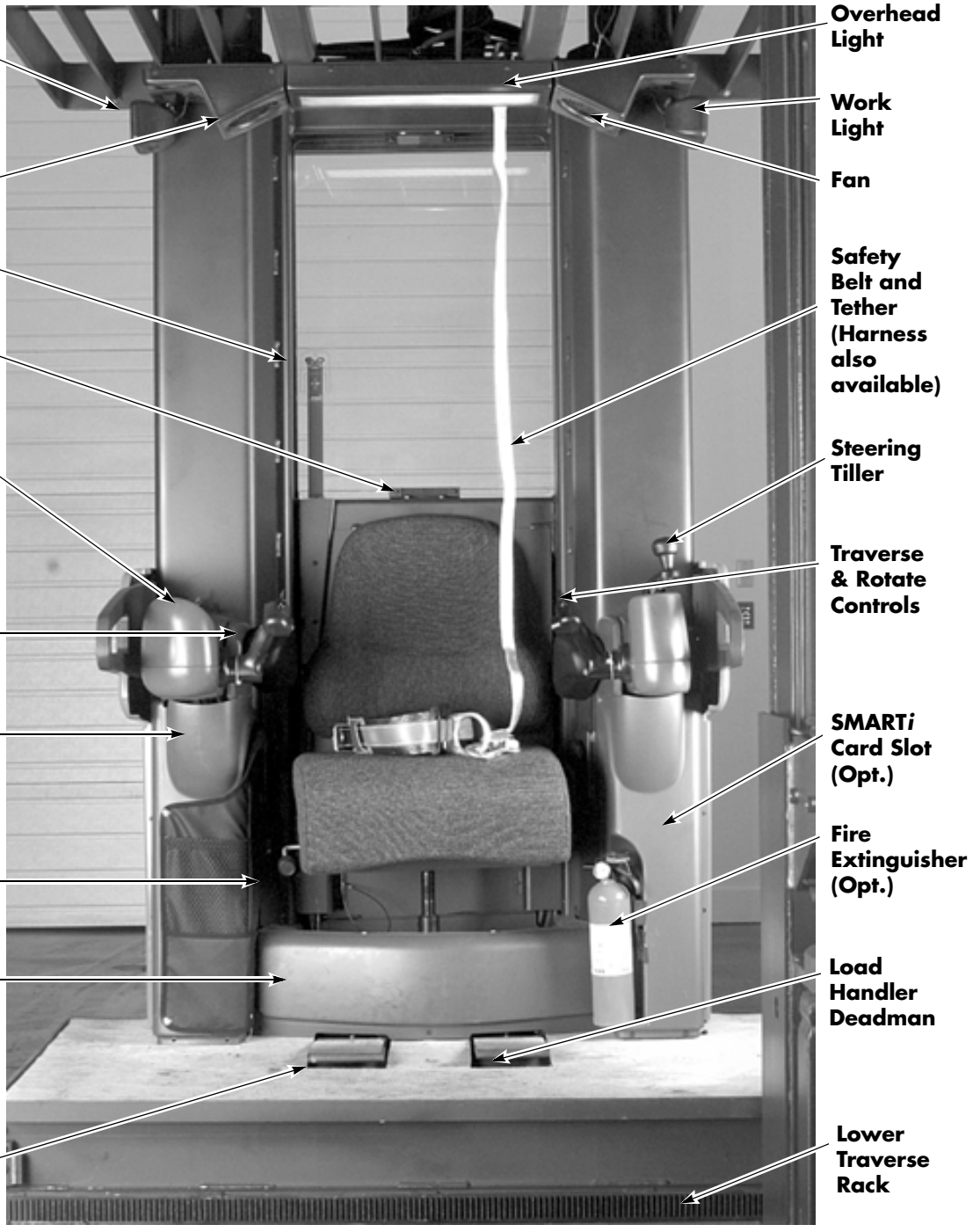


Figure 3-2. Operator Compartment

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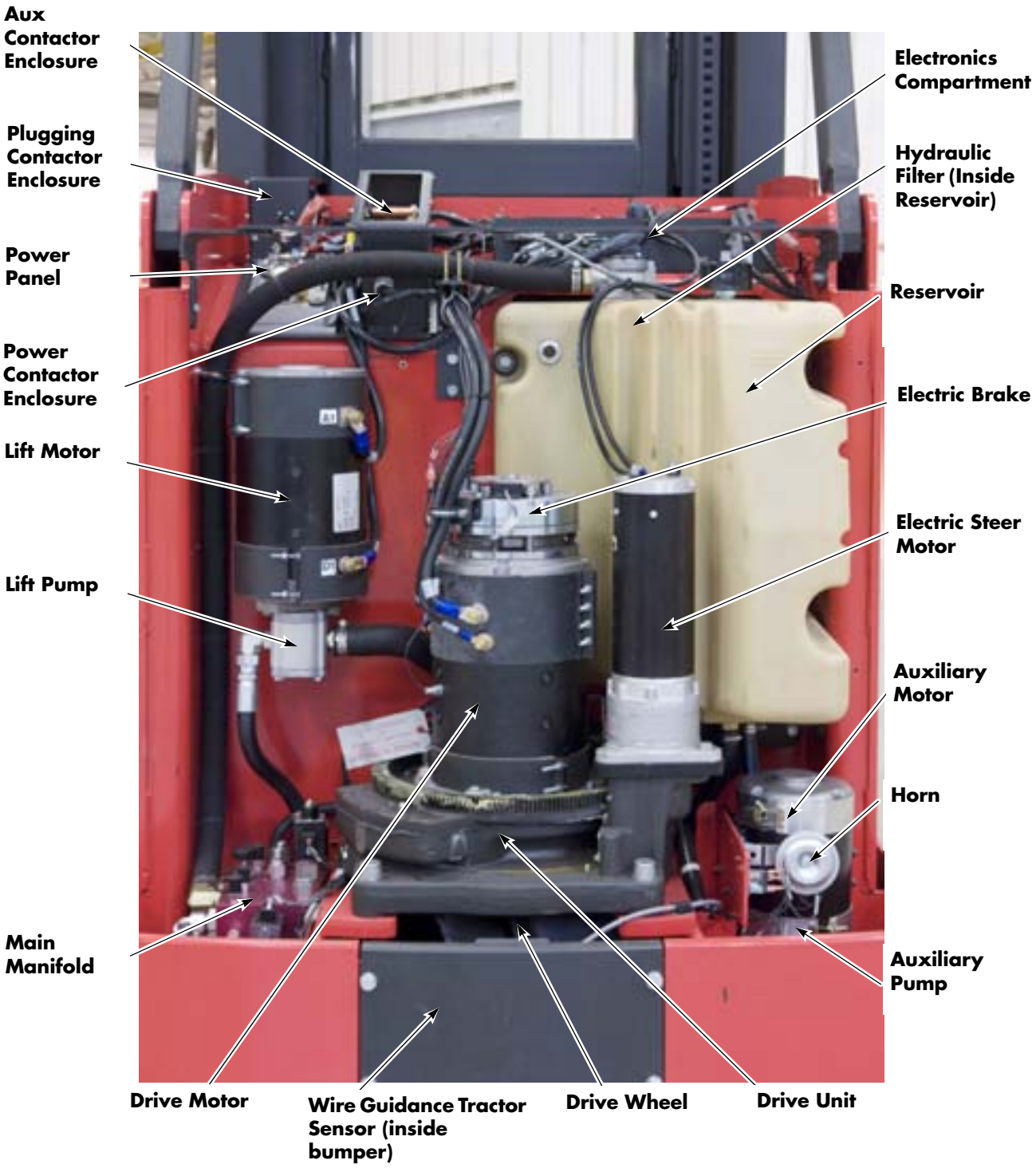


Figure 3-3. Tractor Components

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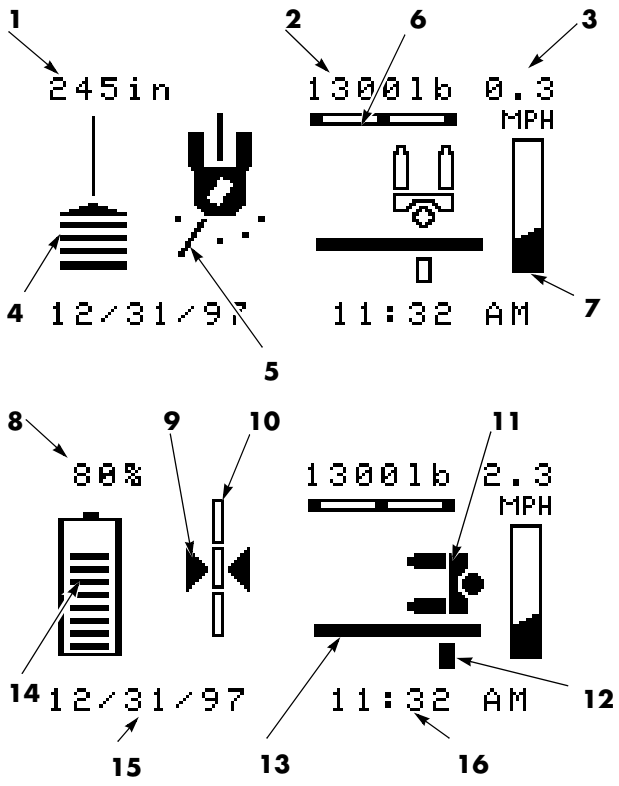
Operator Displays

The lift truck has two Operator Displays. The primary Operator Display is in the right control arm, as viewed by the operator when seated to drive. The Supplemental Operator Display (SOD) is located on the left side of the mast guard, as viewed by the operator when facing the tractor to drive standing up.

These displays inform you of specific conditions during lift truck operation.

NOTE: For detailed description of the elements of the Operator Displays, see the EASi *Swing-Reach*® Owner/Operator Manual PDDM-0131.

Operator Display

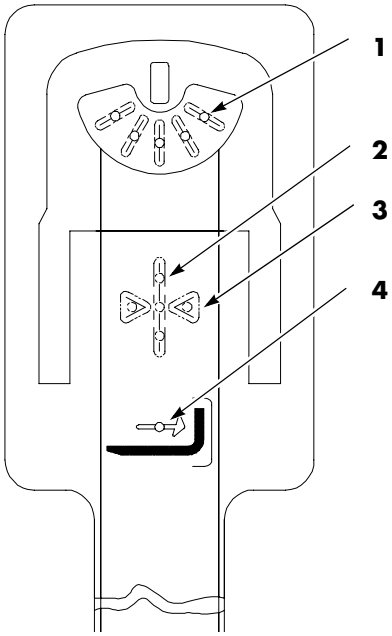


1. Numeric Height (in./cm)
2. Numeric Weight (lb./kg)
3. Numeric Speed (mph or km/hr)
4. Height Icon
5. Drive Wheel Position
6. Pallet Icon
7. Speed Bar
8. Numeric Battery State-of-Charge (BSOC)
9. Seeking wire/rail icons
10. Guide wire/rail icons
11. Fork/Load Handler position
12. Traverse Position
13. Platform icon
14. Battery State-of-Charge (BSOC) Icon
15. Date
16. Time

Figure 3-4. The Operator Display

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Supplemental Operator Display (SOD)



1. Drive Wheel Direction LED
2. Guide Wire/Rail LEDs
3. Seeking Wire/Rail LEDs
4. Forks Nested LED

Figure 3-5. Supplemental Operator Display (SOD)

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Modes of Operation

Overview of Modes

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

Run Mode

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

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

Program Mode

Use Program Mode for configuration, calibration, and maintenance testing on the truck. You need a password in order to enter Program Mode. See “Passwords.”

Program Mode is divided into three categories:

- Learn Mode
- Configure Mode
- Diagnostic Mode

Learn Mode

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

- Controls (travel, traverse, lift/lower, rotate)
- Carriage (traverse and rotate)
- Weight
- Steering (minimum power, rate, position)
- Wire Frequency (for non-standard wire guidance frequency)
- Wire guidance offsets (guide wire centering)

To enter Learn Mode, you must enter the Superword.

For detailed description, see “Using Learn Mode” on page 6-16.

Configure Mode

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

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

For detailed description, see “Using Configure Mode” on page 6-7.

Diagnostic Mode

Use Diagnostic Mode to test, cycle, and troubleshoot individual electrical circuits related to the *intellidrive*® and *intelliguide*™ systems. Static, dynamic, and active testing are permitted on some tests.

To enter Diagnostic Mode, you must enter the Superword.

For detailed description, see “Using Static Diagnostic Mode” on page 6-20, “Using Dynamic Diagnostic Mode” on page 6-22, and “Using Active Diagnostic Mode” on page 6-22.

Passwords

For detailed description of how to enter passwords, see “Entering an Electronic Operator Key, Password, or Superword” on page 6-6.

Password

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

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Superword

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

We *strongly* recommend that, during installation, you change the Superword from the factory default to a code known only to the dealer and/or owner so that access to Diagnostic Mode is limited to qualified personnel. Make sure to record the new Superword in a safe place. If this code is lost or forgotten, a technician will need to reset the truck to factory default settings. This will make necessary the reconfiguration of all variable settings.

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Installation Instructions

The Lift Truck Should Have

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

- Mast assembly and diagonal support arms on a pair of skids
- Tractor assembly, with 2 battery gates, glass mast guard (if so equipped), side covers, and parts carton on a skid
  - Safety belt and tether
  - Cable clamps
  - Miscellaneous hardware

You Should Have

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

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

Warning Notices

⚠ WARNING

- **Perform this procedure with a minimum of two technicians.**
- ***Do not* permit observers to stand nearby.**
- **Permit no distractions during setup of the lift truck.**
- **Anyone involved in the installation procedure should wear gloves, safety glasses, steel-toed safety boots, and a safety helmet (hard hat).**
- **Place the mast and tractor skids in an open area where it is safe to work.**
- **Unassembled lift truck components are heavy, unstable, and difficult to handle. A Series SB mast and carriage assembly can weigh as much as 13,810 lbs. (6270 kg). Use extreme caution when lifting and assembling the lift truck.**
- **Do *not* attempt to stand the mast up if the mini-mast is not centered side-to-side in the main carriage.**
- ***Do not* remove the steel banding securing the main carriage or the mini-mast, nor the wood stringers in the lower traverse rack, until the main mast is standing upright.**

Assembly Procedure

1. Read and follow all the warning notices on the preceding page.
2. Cut and discard the banding on the tractor. Carefully set aside the tractor side covers, glass mast guard (if so equipped), and parts carton. Remove forks from tractor skid.
3. Remove diagonal support arms from the mast skid.
4. Static straps might have been removed prior to shipment or might have been repositioned so as not to protrude below the mast. If they are not already installed,

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install two static straps at the base of the mast. Position static straps to point straight down towards the floor.

5. Cut and discard the banding securing the mast to its skid(s). *Do not remove banding securing the mini-mast or the banding securing the platform to the mast until the mast is standing upright.*
6. Cut and discard the cable ties securing the over-the-mast hoses and cables. *Do not cut the cable ties securing the hose and cable slap pads to the hoses and cable on the outboard side of the cylinders.* These remain on the lift truck.
7. Use two lift trucks of suitable capacity to lift the mast off the skid(s). Remove and discard skid(s). Carefully lower mast to floor.
8. Series SA: Attach two 5-ton hoist straps around the main mast and telescopic crossties.

   Series SA alternate method: Position the lifting truck as shown in Figure 3-6 and secure a heavy chain around the fork carriage of the lifting truck and the mast crosstie. Slowly and carefully raise the mast erect. See Figure 3-7. Lift very slowly at the point where the weight of the mast goes forward of the pivot point.



Figure 3-6. SA Mast erection, alternate method



Figure 3-7. SA Mast erection using lift truck

9. Series SB: Attach two 10-ton hoist straps around the second main mast and telescopic crossties. See Figure 3-8 on page 3-12.

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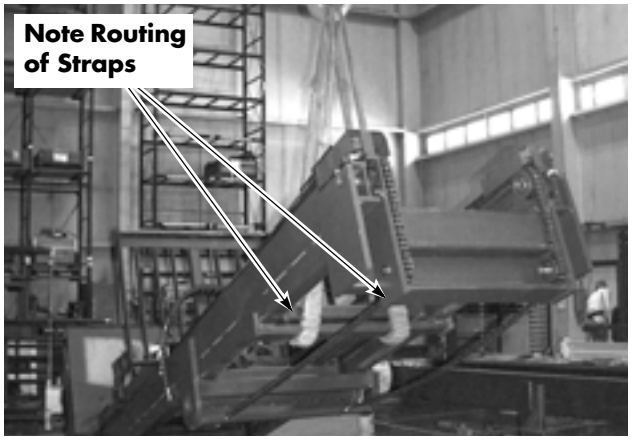


Figure 3-8. SB Mast Strapped to Hoist

⚠CAUTION

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

Series SB alternate method: Insert a length of suitable structural tubing through the 6 in. (15 cm) hole in the lifting flange. This flange is a part of the SB mast lower crosstie. See Figure 3-9 on page 3-13. If you are using two lift trucks to erect the mast, a 160 in. (407 cm) length is recommended for the tubing. See the table below for specifications on structural tubing.

Table 3-1. Structural Tubing Specifications

Structural Tubing Type	O.D./Size	Wall Thickness	ASTM
5 in. Round Mechanical Tubing Type ERW	5 in.	0.5 in.	A500 Grade B or C
5 in. Schedule 160 Round Pipe	5.6 in. nominal	0.62 in. nominal	A53 Type E Grade B
5 in. XXS Round Pipe	5.6 in. nominal	0.75 in. nominal	A53 Type A Grade A or B
Square Structural Tubing	4 in. x 4 in. square	0.5 in.	A500 Grade B or C

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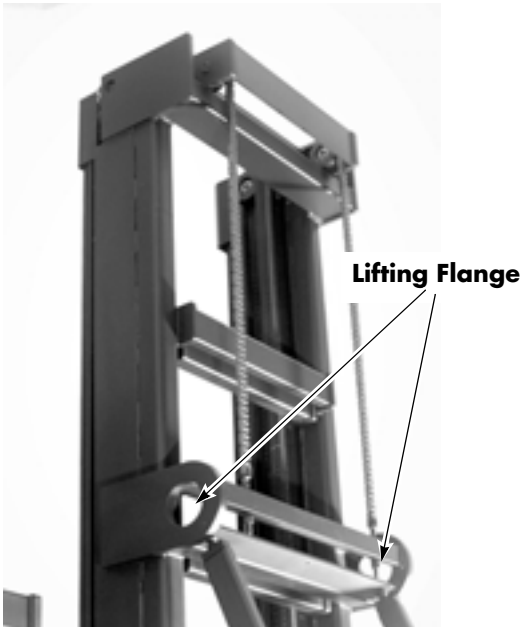


Figure 3-9. SB Mast Lifting Flange

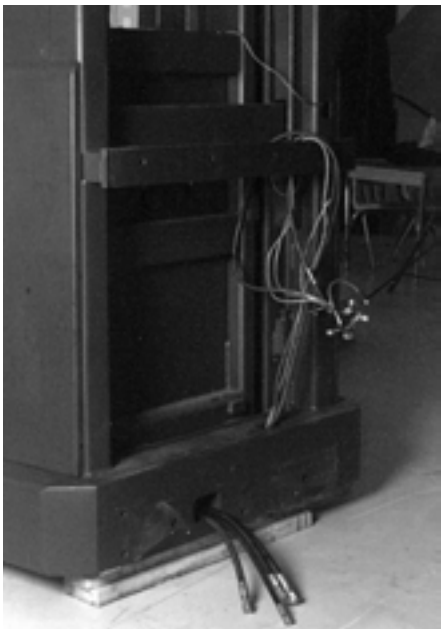


Figure 3-10. Mast Blocked

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

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

10. Raise the mast and carriage section erect and hold in a level position. Block the back edge of the mast with wooden blocks. See Figure 3-10.

11. Pull hydraulic hoses and wire guidance cable (if so equipped) out the hole near the left side of the base of the mast. Pull over-the-mast cables out the hole in the top of the base of the mast near the right side. Pull SA Height Manager cable and work light cable (if so equipped) out the cutout in the back of the mast about 4 feet (1.2 m) from the floor on the right side.



Figure 3-11. Pulling Hydraulic Hoses through Mast

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⚠CAUTION

Be cautious for possible sharp edges on cutouts.

12. Using a lift truck, position the tractor in alignment with the mast. See Figure 3-12.

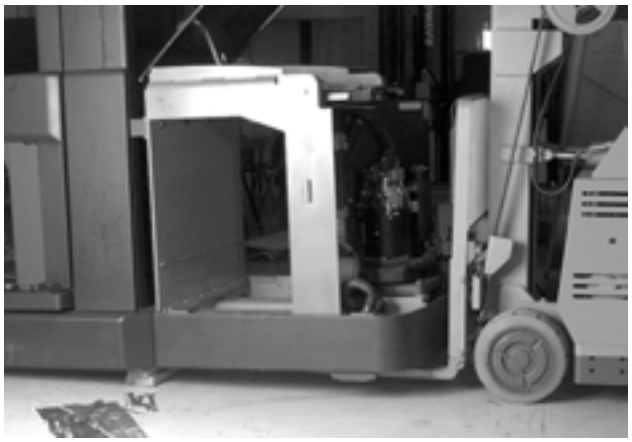


Figure 3-12. Mating tractor to mast

13. Mate the tractor to the mast, engaging the locating pins in the tractor with the holes in the mast frame.
14. From the battery compartment, thread 4 mounting bolts and washers through the top of the tractor frame into the mast. Thread 7 mounting bolts and washers into the bottom of the tractor frame into the mast. Using a torque wrench, torque to 350 ft. lb. (475 Nm). See Figure 3-13.

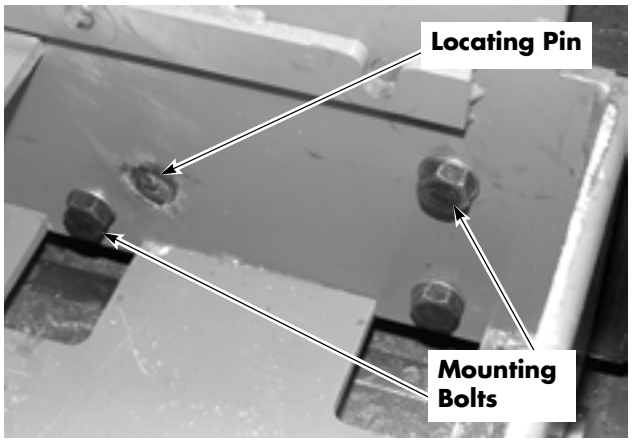


Figure 3-13. Mast-Tractor Mounting Bolts, Lower

⚠CAUTION

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

15. Install the diagonal support arms. Secure clevis pins with snap rings, flat side of the ring to the inside of the tractor. Apply thread-locking compound (P/N 990-571) to upper mounting bolt threads. Thread the upper mounting bolt, tighten, and torque to 70 ft. lb. (95 Nm). Tighten jam nuts against crosstie and support arm.



Figure 3-14. Support Arm Installation

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

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⚠CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-9.

19. Feed the over-the-mast electrical cables, and cables for Height Manager, travel light (if so equipped), end-of-aisle sensor (if so equipped), and wire guidance sensor (if so equipped) from the mast through the tractor opening and connect to the Tractor Manager at PS25, PS26, JH2 (SA), JPS44 (if so equipped), and PS6/PS28 (if so equipped), and Wire Guidance Filter Card at JW1 (if so equipped).
20. Connect line filter wire connectors JP39, JP49, and JP59 (or JP61 on trucks S/N SA > 03568, SB > 00855). Connect line filter wires to B+FILT_F1 and B+_F2 on filter FILT1 and to B+_F1 on filter FILT2.

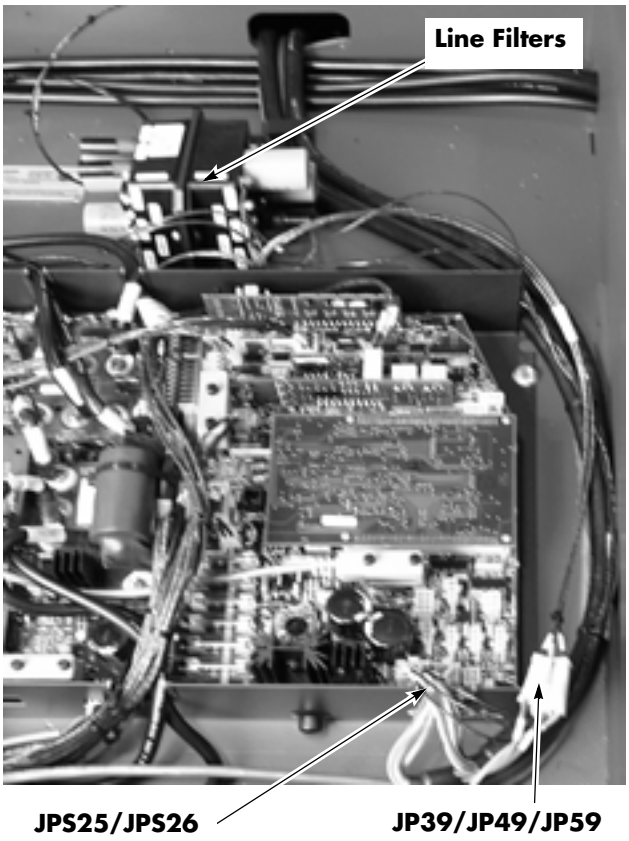


Figure 3-15. JS25 and JS26 Connection

21. Connect the hydraulic hoses at the bottom of the battery compartment. Make sure the O-ring is in place on the male fitting. See Figure 3-16.



Figure 3-16. Hydraulic Hose Connection

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22. If they are not already in place, install battery rollers. Install a fully charged battery, using a suitable battery installation device. Install battery gates.
23. Make sure the ground wire to the bottom of the seat is installed. See Figure 3-17.

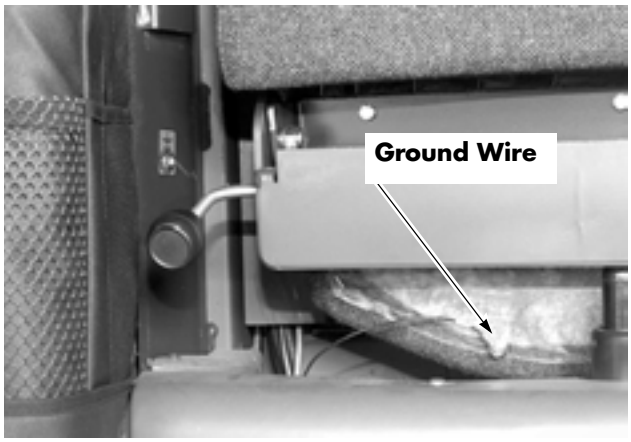


Figure 3-17. Operator Seat Ground Wire

24. Install the glass mast guard, if so equipped. Make sure brackets are installed with mounting screws on the tractor side of the glass, so that the glass lines up with the back of the operator compartment, without any “ledge” or “jog.” This is important for the mounting of the Supplemental Operator Display.
25. Install the Supplemental Operator Display on the glass or mesh mast guard.
26. Remove plastic wrapping from control handles and arms.
27. Bleed the hydraulic system. See “Bleeding the Hydraulic System” on page 7-124.
28. Grease the traverse racks and areas on the top and bottom of the platform where the sliders ride.
29. Install the forks.
30. Install the side covers.

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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 maximum truck life
- Reduces costly down time
- Prevents unnecessary repairs

Scheduled maintenance includes:

- Lubrication
- Cleaning
- Inspection
- Service

Table 4-1.

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

Do all of the scheduled checks and maintenance at the suggested intervals. The time intervals given in this guide are based on deadman hours under normal operating conditions. When operating under extreme or severe conditions, do these services more often as required to keep the unit in good operating condition.

See "Lubrication Specification Chart" on page A-1 in the Appendix for lubrication specifications. Refer to the manufacturer's supplements for components not listed on the following pages.

Hour Meters

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

- KH -- hours with key switch ON
- HD -- hours with deadman pedal depressed
- HL -- hours lifting
- TMI -- traction miles

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Initial 90 Day or 250 Deadman Hour Interval

Initial 90 Days or 250 Deadman Hours (HD)			
Item No. See "Scheduled Maintenance Points" beginning on page 4-17.	**Component**	**What to do**	**Refer to**
9	Drive Unit	Break free, reapply thread-locking compound (P/N 990-544), and retorque mounting bolts to 350 ft. lb. (475 Nm). Change fluid.	Page 7-64
16	Hydraulic Reservoir	Change fluid and filters.	Page A-1 Page 7-111

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Every 180 Days or 500 Deadman Hours

Every 180 Days or 500 Deadman Hours (HD)			
Item No. See "Scheduled Maintenance Points" beginning on page 4-17.	**Component**	**What to do**	**Refer to**
1	Aux Manifold Mesh Screen (SA S/N > 02999 and SB S/N > 00699)	Remove and clean.	
2	Battery	Compare the weight stamped on the battery in the lift truck against the minimum and maximum approved weights on the specification plate for the lift truck. Report any lift trucks that are operating with batteries under the minimum, or over the maximum approved weight. 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. Test for voltage leaks to frame.	Page 3-3 Page 4-19
3	Battery Connectors and Leads	Inspect all battery connectors and leads for damage and cuts in protective coatings. Shorts to the truck frame cause electronic component failure or intermittent electrical failures.	Page 7-86
4	Brake and Brake Pads	In a open area, measure stopping distance. Traveling at 2 to 3 mph (3.2 to 4.8 km/hr) empty, push the EPO switch; the empty lift truck should stop within 2 to 4 feet (0.6 to 1.2 m). During normal operation, with a rated load and traveling at top speed, the lift truck should stop within approximately one and one-half truck lengths. Stopping distance depends on the load, floor, and tire conditions. Look 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 brake pad surface. Measure minimum thickness of pad: 3/32 in. (2.3 mm). Inspect mounting hardware for tightness. Failure to keep brakes adjusted causes premature pad and rotor wear and excessive motor heat.	Page 7-71 Page 7-74

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Every 180 Days or 500 Deadman Hours (HD)			
Item No. See "Scheduled Maintenance Points" beginning on page 4-17.	**Component**	**What to do**	**Refer to**
5	Contactors	Inspect contactor tips for burnt or pitted surfaces. Darkened points do *not* indicate burning. Burning indicates a loss of contact point material. Silver alloy part of the point is usable contact material; copper backing is *not*. Replace the contact points if there is *not* enough contact point material to last until the next regular inspection. Failure to replace the tips can prevent contactors from opening or closing, causing unscheduled down time. Do *not* file contact points to remove discoloration or minor irregularities. This practice produces a surface more susceptible to sticking. With the key switch OFF and the battery disconnected, examine the plunger for smooth operation with no binding. If binding occurs, the lift truck could malfunction or display intermittent fault codes.	Page 7-8 through page 7-12
6	Control Handle Functions	Make sure travel function is smooth and responsive through full range of acceleration. Make sure lift/lower function is smooth and controllable. Make sure traverse/rotate functions are smooth and controllable. Test for play in the center position of lift or travel control; replace control handle if necessary. Make sure nylon insert is in the lift knob set screw hole. Test the function of all switches.	Page 7-49
7	Deadman Pedal	Check for smooth operation with no binding through full range of pedal stroke. Test correct activation of the deadman switch by the pedal. Adjust pedal height and switch gap as required.	Page 7-42

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Every 180 Days or 500 Deadman Hours

Every 180 Days or 500 Deadman Hours (HD)			
Item No. See "Scheduled Maintenance Points" beginning on page 4-17.	**Component**	**What to do**	**Refer to**
8	Drain Holes	Make sure the drain holes under the deadman pedal and in the battery compartment are free of any debris.	
9	Drive Unit	Examine fluid level. If low, check for leaks and refill. Inspect for leaks. Make sure O-ring is present on the dipstick. Use a dial indicator to check drive unit radial ring wear. Replace radial rings if play exceeds 0.089 in. (2.26 mm).	Page 7-64
10	Electrical Cables	Inspect all power cables for nicks or cuts. Give special attention to those cables that are not stationary, for example, cables to the drive motor. Replace any cable that is damaged or shows signs of excessive heat. Failure to do so will cause intermittent system shutdowns and/or electronic failures. Measure the length of the over-the-mast cable springs. Correct extended length of springs is 9 to 11 in. (228 to 280 mm). Higher tension will cause premature failure.	Page 5-3 Page 7-92
11	Forks	Check fork mounting surfaces for wear. Make sure fork positioning lock is working correctly. Examine for excessive wear, bends, cracks, welding arcs, excessive heat, or unauthorized modifications. Replace if found. Measure fork thickness (tool P/N 922-369).	Page 4-28
12	Frame, Tractor, and Mast	Examine all structural parts of lift mechanism. Visually examine tractor and mast members for cracks.	
	Hardware	Check bolt torque of major components (motors, pumps, brake, drive unit, manifolds, mast-to-tractor mounting bolts, overhead guard). Tighten any loose hardware. Replace any broken or missing hardware.	Page A-5 Page A-7 Page A-8
13	Height Sensing System	Check main height sensing rail for tightness and alignment.	
14	Horn	Make sure horn sounds correctly when activated. Examine mounting bracket insulators.	Figure 7-5 on page 7-5

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Every 180 Days or 500 Deadman Hours (HD)			
Item No. See "Scheduled Maintenance Points" beginning on page 4-17.	**Component**	**What to do**	**Refer to**
15	Hydraulic Hoses	Inspect for leaks, nicks, cuts, chafing, and bulges. Replace damaged or worn hoses immediately. Inspect fittings for leaks; repair immediately. Inspect over-the-mast hoses for correct tension. Make sure over-the-mast pulleys spin freely and show no signs of wear.	Page 5-27
16	Hydraulic Reservoir	Examine fluid level. If low, check for leaks and refill.	Page A-1
17	Lift Chains	Examine for too much stretch or wear (tool P/N 950-350/CG). Check adjustment. Lubricate.	Page 4-21 Page A-1
	Lubrication	Apply grease to all fittings on carriage and tractor. Apply small amount of grease to steering gear on drive unit.	Page 4-23 Page A-1
18	Mast	Wipe old grease off mast uprights and apply new grease. Adjust pucks (Series SA). Check adjustment of upper carriage slider rails (Series SA). Inspect slap pads (Series SB) for wear. 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 inch (3 mm).	Page A-1 Page 7-154, page 7-171 Page 7-155 Page 7-148
19	Motors, DC	Inspect brushes for excessive heat (discolored pigtails). Check brush length and evenness of wear. Check brush spring tension. Inspect brush rigging for damage or loose brush holders. Retorque terminal stud nuts. Replace power cables showing signs of excessive heat. Use compressed air (maximum 30 psi or 207 kPa) to clean the inside of the motor, impeller, and cooling fins. Check sensor wires for good connection and condition.	Page 4-11 Page 4-16 Page 4-11

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Every 180 Days or 500 Deadman Hours

Every 180 Days or 500 Deadman Hours (HD)			
Item No. See "Scheduled Maintenance Points" beginning on page 4-17.	**Component**	**What to do**	**Refer to**
20	Overhead Guard	Inspect guard for physical damage. If structurally damaged, replace the carriage.	
21 22	Pumps and Motors	Disassemble lift pump and motor, clean motor, inspect splines for wear. Apply molybdenum anti-seize compound (P/N 990-638) to splines. Disassemble aux pump and motor, clean motor, inspect coupling, if used, for wear. Apply molybdenum anti-seize compound (P/N 990-638) to coupling or spline.	Page 7-112 Page 7-81 Page 7-110 Page 7-78
23	Safety Belt (or Harness) and Tether	Check condition, including any signs of excessive wear, fraying, or damage.	
24	Shorts to Frame	Check for electrical shorts to frame.	Page 5-4
26	Stability Pads	Inspect stability pads for correct clearance: 0.31 to 0.56 in. (8 to 14 mm). Replace if clearance is greater than 0.75 in. (19 mm). Welding will be required.	
27	Static Straps	Make sure static straps are not worn or broken. Clean debris from straps. Measure resistance of resistor in standoff. If the resistance is less than 10K ohms or greater than 1.2 meg ohms, replace the resistor/insulator block or the whole static strap assembly **NOTE:** EE lift trucks require phosphor-bronze, not steel-braided straps.	
28	Steering	Inspect teeth on the steering gear and drive unit for wear. Make sure steering function is smooth and responsive, without binding or excess play. Check the gap on the steer home proximity sensor: 0.05 to 0.10 in. (1.3 to 2.5 mm).	Page 7-43
	Switches	Check all switches for correct operation and adjust as needed.	

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Every 180 Days or 500 Deadman Hours (HD)			
Item No. See "Scheduled Maintenance Points" beginning on page 4-17.	**Component**	**What to do**	**Refer to**
30	Traverse	Inspect the traverse rack and gears for wear. Check wear pad adjustment. Check traverse stop mounting bolt torque. Make sure traverse roller bearings are not binding or damaged. Make sure hose and cable guard are not damaged.	Page 7-161
31	Warning Decals	Replace any unreadable, damaged, or missing decals.	Page 7-35
32	Warning Lights	Check for correct operation.	
33	Wheels/Tires	Examine for bond failure, chunking, and excessive or uneven wear. Inspect load wheel bearings for binding or excessive play.	
34	Wire Guidance	Check sensor assemblies for damage and mounting hardware for tightness. Verify the lift truck acquires and tracks the guide wire correctly. Verify the lift truck brakes apply when truck loses wire signal.	Page 7-44

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Every 360 Days or 2000 Deadman Hours (HD)

Every 360 Days or 2000 Operating Hours			
Perform all 180-day/500-hour checks plus the following:			
Item No. See "Scheduled Maintenance Points" beginning on page 4-17.	**Component**	**What to do**	**Refer to**
9	Drive Unit	Change fluid.	Page 7-64
16	Hydraulic Reservoir	Change hydraulic fluid and filter.	Page A-1 Page 7-111

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Motor Maintenance

Motor Cleaning



Figure 4-1. Motor cleaning with compressed air

Periodic cleaning is essential to prevent overheating and electrical leakage (shorts). To clean a motor correctly:

1. Wear safety glasses or goggles to protect your eyes from dust and debris.
2. Using an OSHA approved air nozzle, use clean, dry, low pressure (30 psi or 207 kPa or 2.1 kg/cm^2) compressed air to blow carbon dust and other foreign matter from:
   - motor housing
   - brush holders
   - commutator
   - field and armature windings (if accessible)

⚠CAUTION

Never use a chemical solvent to clean a motor, as it can carry carbon dust to inaccessible areas and cause shorts within the motor.

⚠CAUTION

Cleaning a motor with solvents requires complete disassembly and drying, and must only be done by an authorized motor repair shop.

Motor Brushes

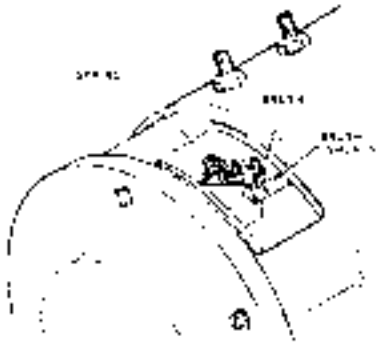


Figure 4-2. Motor Brush, Typical Location

Replacement

If one brush needs replacement, always replace the entire set of brushes.

Use only genuine Raymond-supplied 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 could enter the motor, causing premature wear and failure. Blowing out the motor with compressed air *does not* guarantee all the debris is removed.

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Motor Brush Spring Tension

Insufficient spring tension results 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 to OFF and disconnect the battery connector.
2. Remove any brush cover paneling.
3. Slide the brush up slightly in its holder.
4. Insert a paper strip between the brush face and the commutator.
5. Place a small leather loop around the coil spring for the brush. If the brush spring has a loop at the brush, hook the spring scale directly to the spring.
6. Attach a 5 lb. (2.27 kilogram) spring scale to the leather loop.
7. While gently pulling the scale outward, slowly pull the paper strip in the direction that the commutator normally rotates.
8. When the paper strip begins to move freely, the spring scale reads the brush spring tension.

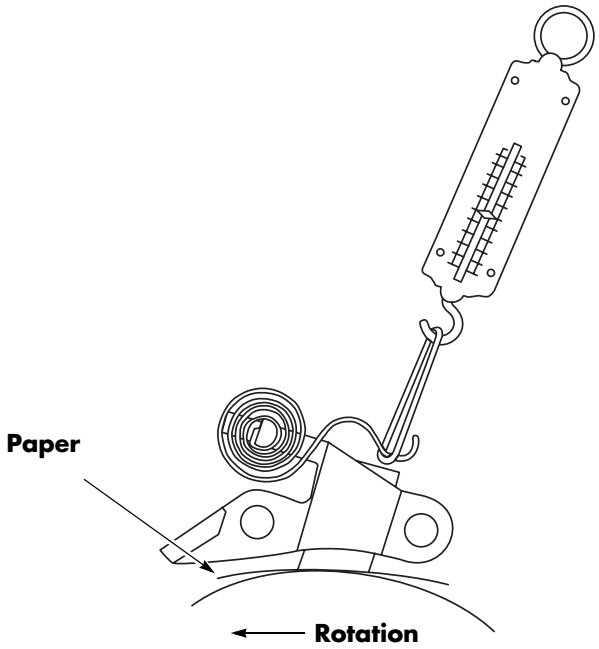


Figure 4-3. Motor Brush Spring Tension Inspection

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9. Refer to Table 4-2 for correct spring tension

Table 4-2. DC Motor Brush Specifications

Motor	SA/ SB	Raymond P/N	Manufacturer P/N	Brush Length				Brush Spring Tension			
				Minimum		Maximum		New		Worn	
				in.	mm	in.	mm	oz.	gr	oz.	gr
Drive	SA	570-400/500	FD	0.62	16	1.30	35	65	1820	40	1120
	SB	570-340/500	FF	0.62	16	1.30	35	65	1820	40	1120
Lift	SA	570-274/501	L89 L91 L93 L94 L95	0.62	16	1.30	35	65	1820	40	1120
	SA	570-274/200	MWB-4001A	0.68	17	1.53	39	40	1120	19	532
	SA	570-274/201	MWB-4001A	0.68	17	1.53	39	40	1120	19	532
	SB	570-341/500	203-01	0.62	16	1.30	35	65	1820	40	1120
Aux	SA/ SB	570-273/500	AJ	0.62	16	1.30	35	65	1820	40	1120
Steer	SA/ SB	838-010-037 /200	BA3644- 5316-7-10								

10. Repeat steps 3 through 9 for the remaining brushes.

Commutator

Inspection

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

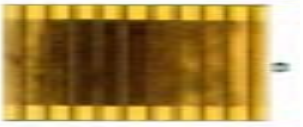
The commutator must be smooth and clean to provide maximum brush wear. When commutators are not correctly maintained, carbon dust can collect in the grooves between the segments. This can lead to a short circuit in the armature.

Good commutation is indicated by a dark brown polished commutator and an evenly polished brush wearing surface. See Table 4-3, “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.

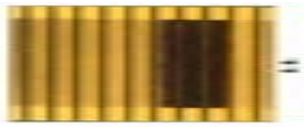
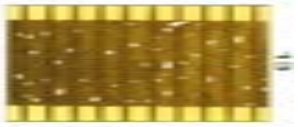
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Table 4-3. Commutator Surfaces

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, and so on. This is related to the winding design of the armature. Condition caused from split windings crossing in the same slot.	
Unsatisfactory Condition-Streaky Film With No Commutator Wear	Frequently due to under-loaded operation, machine grossly over-brushed or brush grade incorrect for particular machine application. Atmosphere and environmental conditions can contribute.	
Unsatisfactory Condition-Uneven Film	Patchy colors of varying densities and shape. Due to unclean operating conditions or incorrect physical condition of commutator.	
Unsatisfactory Condition-Film With Dark Areas	These areas can be isolated or regular. Commutator out of round. This can be caused by vibration or mechanical deficiencies in equipment operation, bearings, couplings, and so forth.	
Unsatisfactory Condition-Example of Poor Commutator Machining	Bars are low on entry and leaving edges giving rise to the brushes riding on the middle of the bars.	
Unsatisfactory Condition-Example of Poor Commutator Machining	Bars are low in the middle giving rise to the brushes riding on entry and leaving bar edges. This and the previous illustration indicate the need for better maintenance.	
Unsatisfactory Condition-Streaky Film With Commutator Wear	This is a further development of the third example. Brush grade, machine applications and working environment are all suspect. Earlier corrective action should have been taken.	

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Table 4-3. 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, bad coil, riser bars or equalizer connections.	
Unsatisfactory Condition-Brush Contact Mark	Storage of machines, for lengthy periods, with brushes in position. This can also result from operation of machine in prolonged stall conditions.	
Unsatisfactory Condition-Bar Edge Burning-Cause High Mica	Illustration shows high mica in every slot. Same effect can occur on one bar only. Similar conditions can be caused by a high or low bar.	
Unsatisfactory Condition-Small Bright Spots	Related to 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.	

High ridges between the brush travel paths indicate the commutator requires turning. High ridges could chip or damage the brushes. See “Servicing.”

High Mica

Most armatures have the mica undercut. If the armature on your motor does not, do not attempt to cut it. The decision to undercut or not is determined by the type and grade of brush used in that particular motor. The mica must be undercut to a depth equal to the width of the mica (usually 1/32 inch, but can vary in some motors). See Figure 4-4.

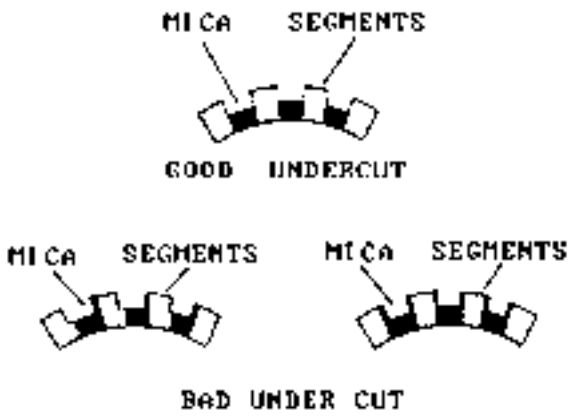


Figure 4-4. Mica Undercutting

Servicing

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

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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.

Terminal Nuts

Whenever you disconnect and reconnect any power leads to a motor, always tighten the motor cable securing nuts with a torque wrench to prevent overtightening them and damaging the motor. Use a second wrench on the stud terminal securing nut to avoid twisting the stud.

Torque stud terminal securing nuts to 140 to 160 in. lb. (15.8 to 18.1 Nm) and motor cable securing nuts to 100 to 120 in. lb. (11.3 to 13.6 Nm). Check these torques each time you check motor brushes.

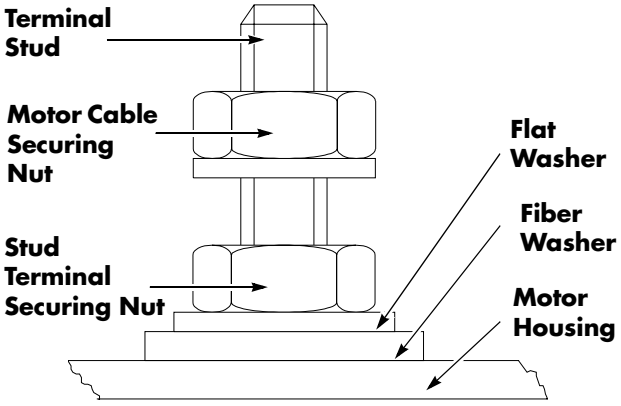


Figure 4-5. Motor Terminal Nuts

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Scheduled Maintenance Points

NOTE: Numbered arrows in photos on the following pages refer to Item No. in preceding scheduled maintenance charts.

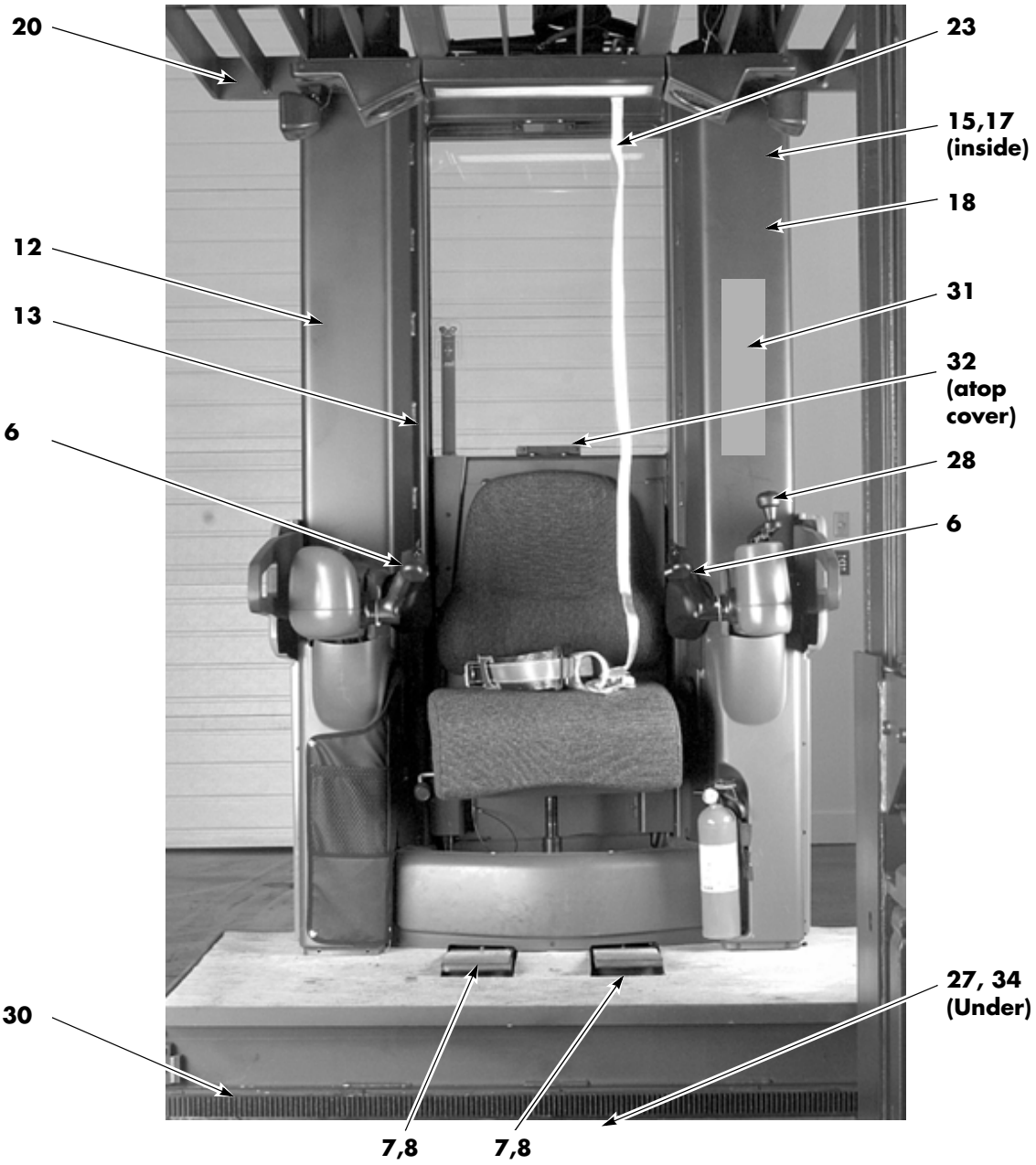


Figure 4-6. Scheduled Maintenance Points, Operator Compartment

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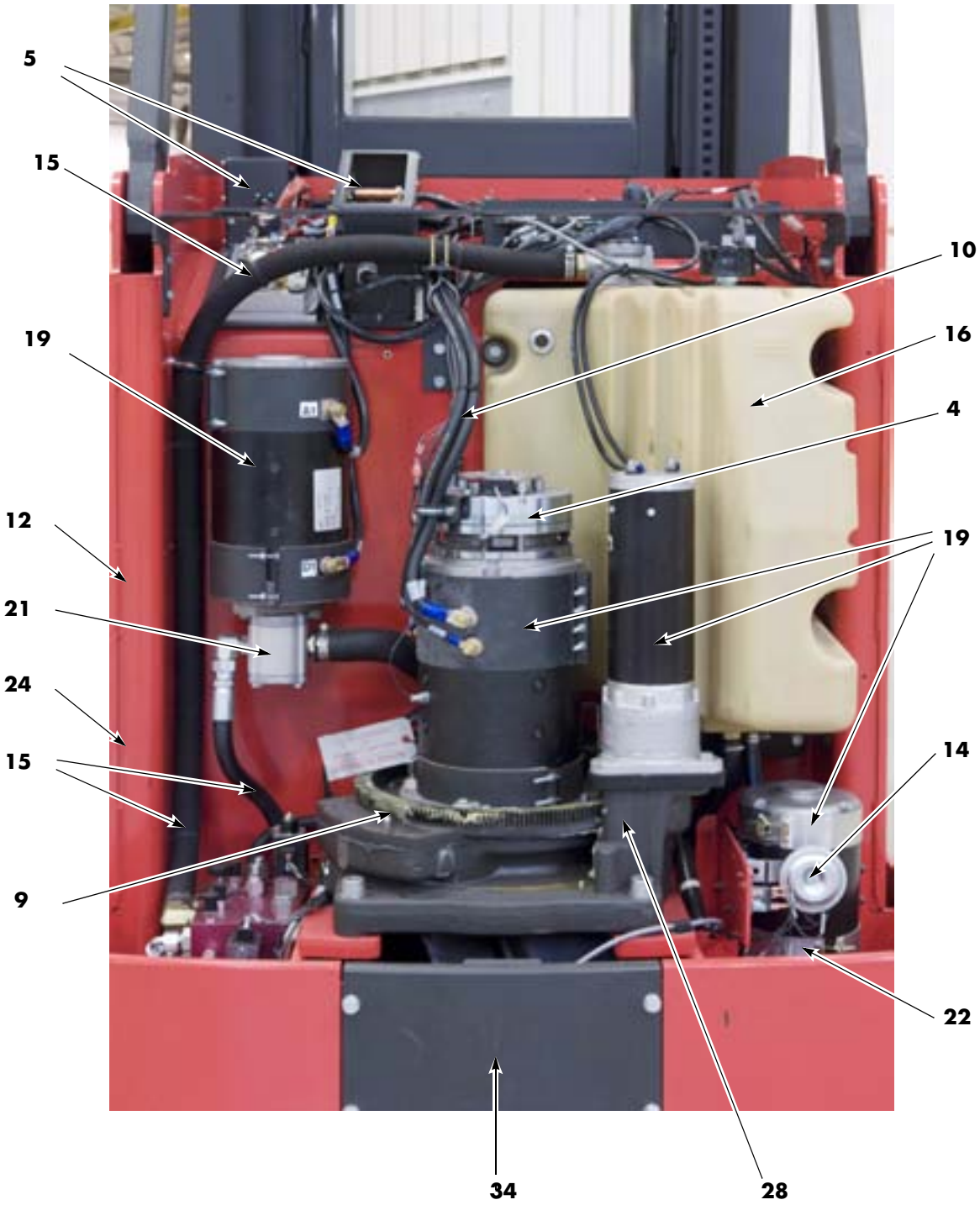


Figure 4-7. Scheduled Maintenance Points, Tractor

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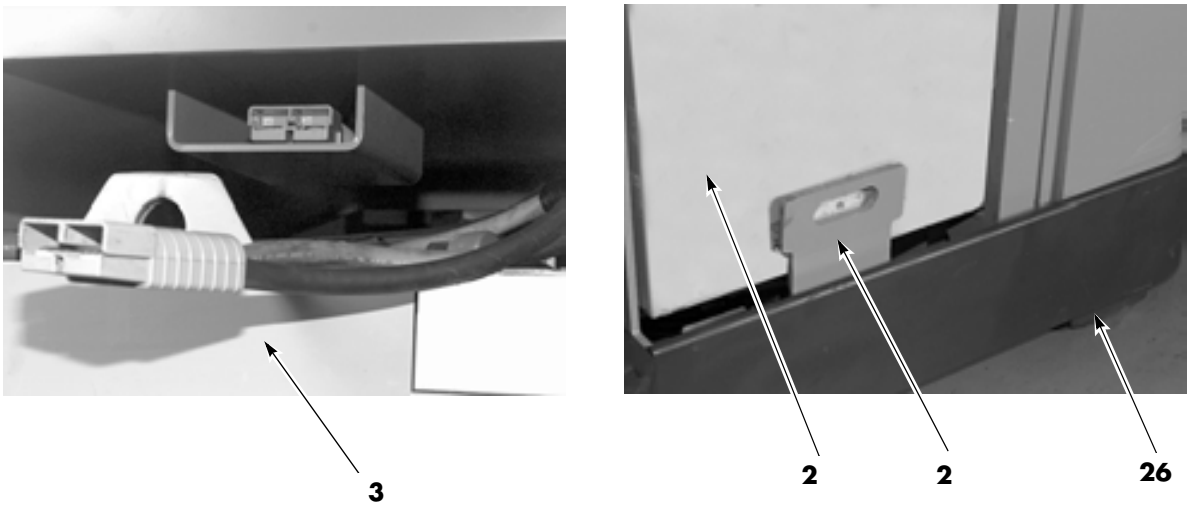


Figure 4-8. Scheduled Maintenance Points, Battery

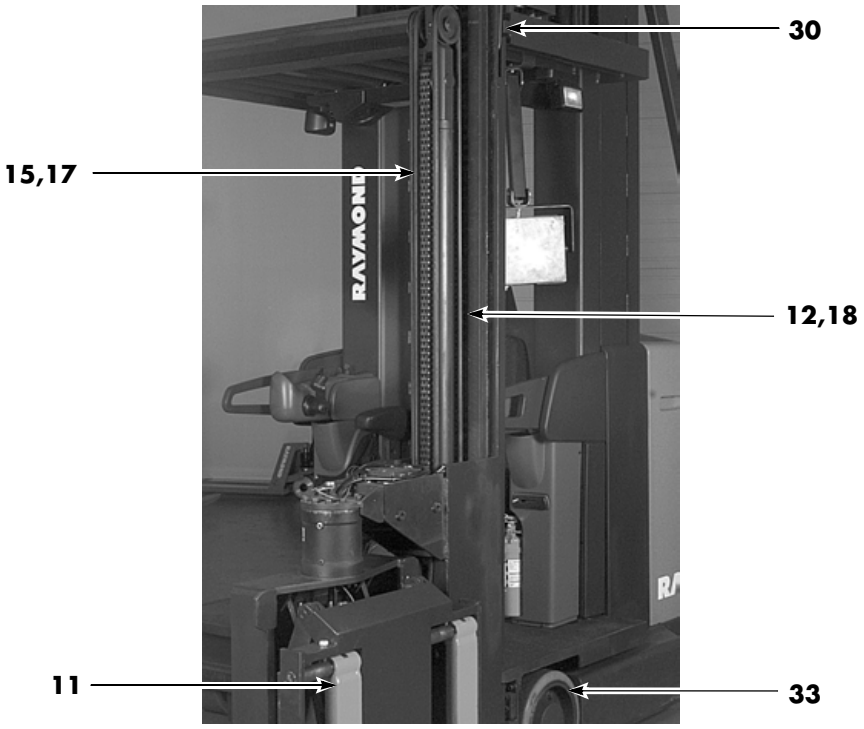


Figure 4-9. Scheduled Maintenance Points, Mini-Mast and Load Handler

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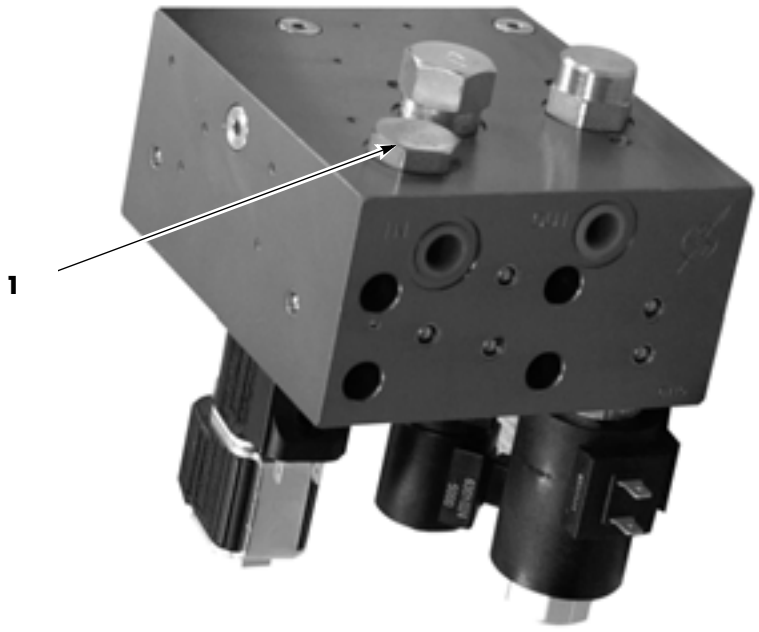


Figure 4-10. Scheduled Maintenance Points, Aux Manifold

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Chain Maintenance

Inspection

Make sure chains are not damaged. Check the chain for wear using a Chain Gauge (P/N 950-350/CG). See Figure 4-11.

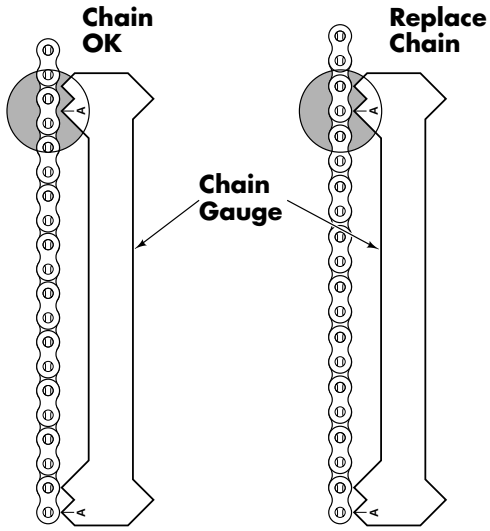


Figure 4-11. Chain Gauge

Problem	Cause	Maintenance Procedure
Chain Elongation	Wear Lack of oil	Use a chain gauge or lay the chain on a flat surface and push it together. Measure and mark a 12-inch (305 mm) length that has operated over the pulley sheave. Stretch the chain; if more than 5/16 inch (8 mm) play is detected, replace the chain.
Rust and corrosion	Steam cleaning or degreasing new truck chains.	Oil chain frequently. Refer to Scheduled Maintenance.
Cracked Plates	Infrequent Oiling	Replace the chain.
	Rust	
	Corrosion	
	Chain Fatigue	
Tight Joints	Bent pins or plates	Replace the chain.
	Rusty joints or peened plate edges	Replace the chain.
Chain side wear	Chain misalignment	Realign the chain on the pulleys.

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Lubrication

⚠CAUTION

Do not steam clean or degrease lift chains.

1. Apply oil to the chain using a narrow paint brush. See "Lubrication Specification Chart" on page A-1.
2. Make sure the exterior surface is covered to prevent rust and to make sure that the oil penetrates the chain joints to reduce wear.

Chain Adjustment

See "Fork Height and Lift Chain Adjustment" on page 4-30.

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Lubrication Points

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

1. Reach to fork carriage (left and right)
2. Reach scissors half-shaft
3. Reach piston end (2)
4. Reach mechanism roller bearing channels (4)
5. Fork pin
6. Mini-mast channels (3 surfaces, 2 sides)
7. Mini-mast lift chains
8. Mini-mast pucks and cylinder
9. Rotate carriage lower bearing
10. Traverse gear and rack (top and bottom)
11. Traverse follower bearings top and bottom (2 each)
12. Inner telescopic channels (left and right, both sides)
13. Main mast lift chain
14. Drive unit gear (to steer motor and prox): anti-seize compound (P/N 990-638)
15. Drive unit ball bearings (2 Zerks, left side and right rear)

Fluids

- Hydraulic Fluid

  Reservoir capacity is 15 gallons (57 liters), *not counting* fluid in cylinders and hoses.

  See Appendix for list of approved fluids.

- Drive Unit

  Drive unit capacity is 7.12 quarts (6.75 liters).

  See Appendix for list of approved lubricants.

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Lubrication Point Locator Photos

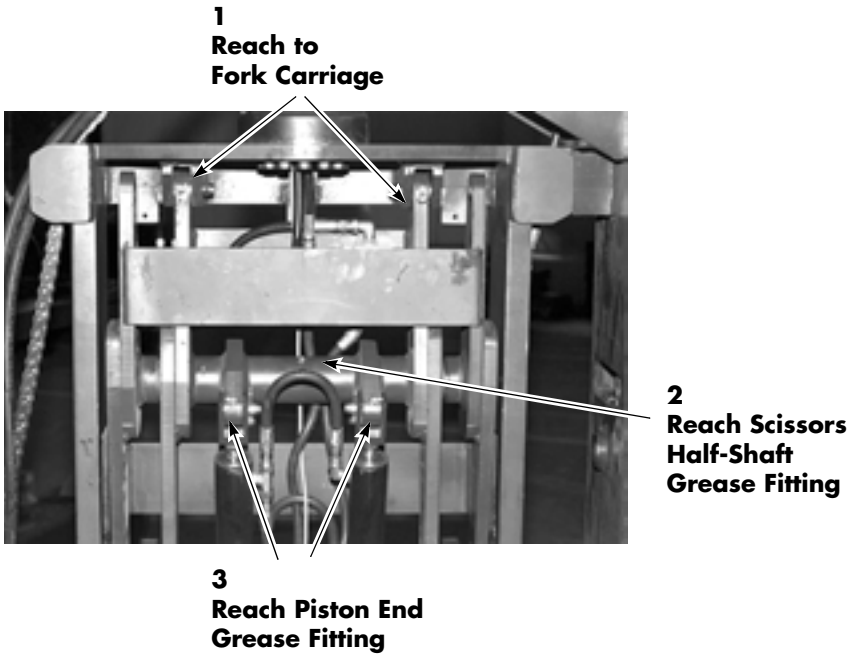


Figure 4-12. Lubrication Points, Fork Carriage

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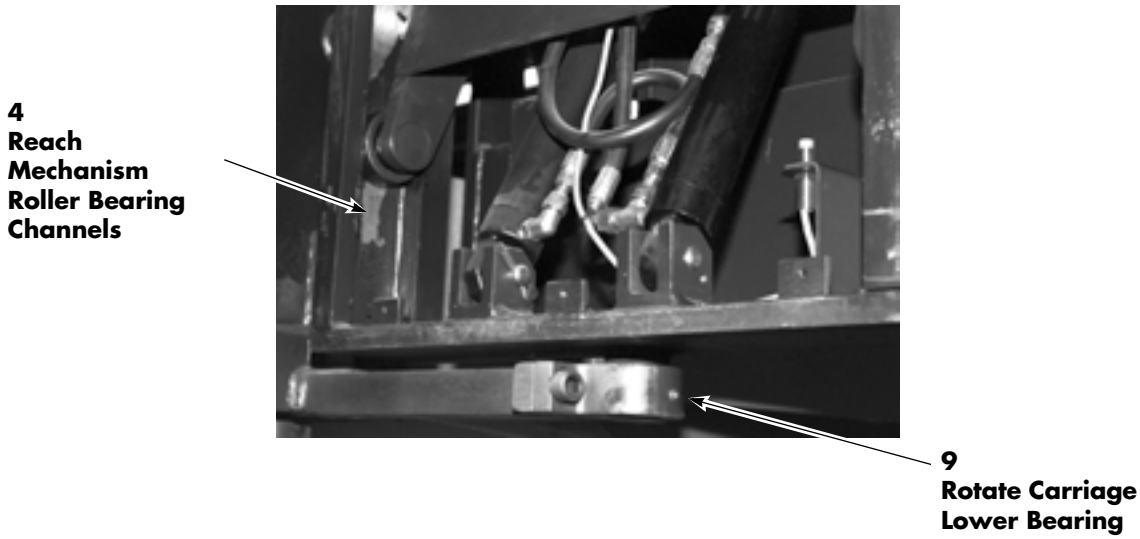


Figure 4-13. Lubrication Points, Fork Carriage

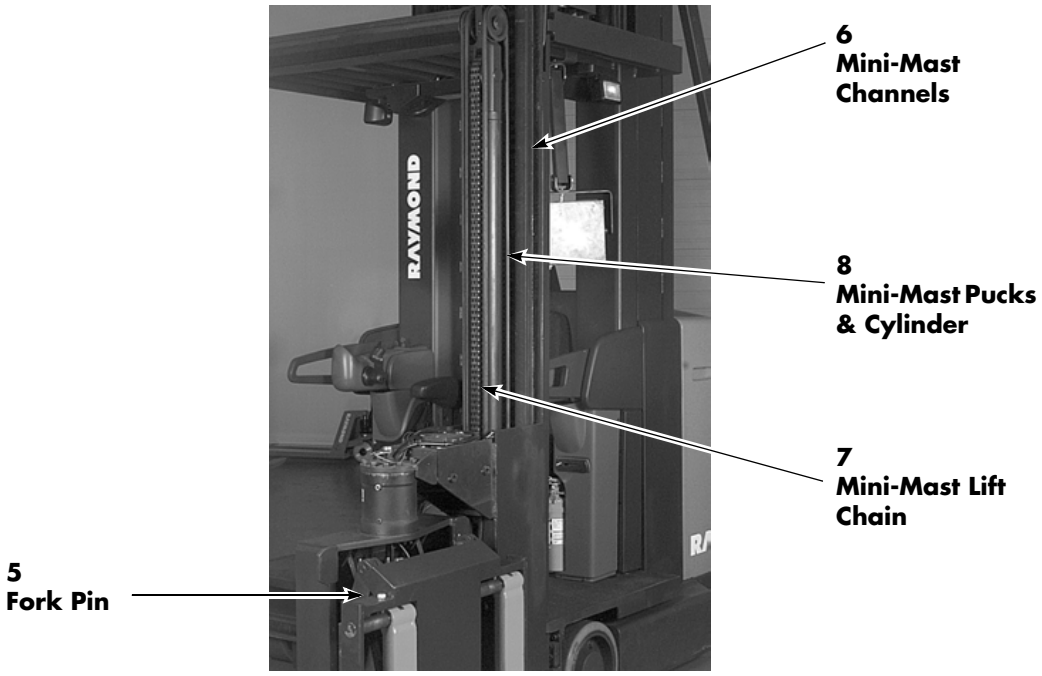


Figure 4-14. Lubrication Points, Mini-Mast and Load Handler

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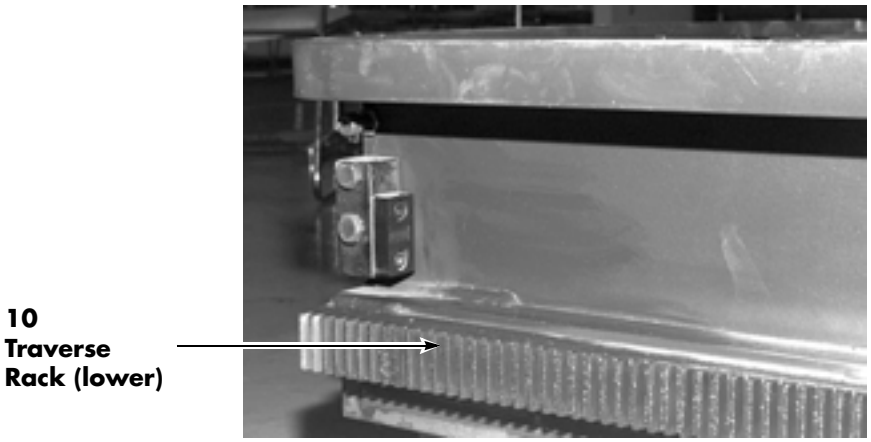


Figure 4-15. Lubrication Points

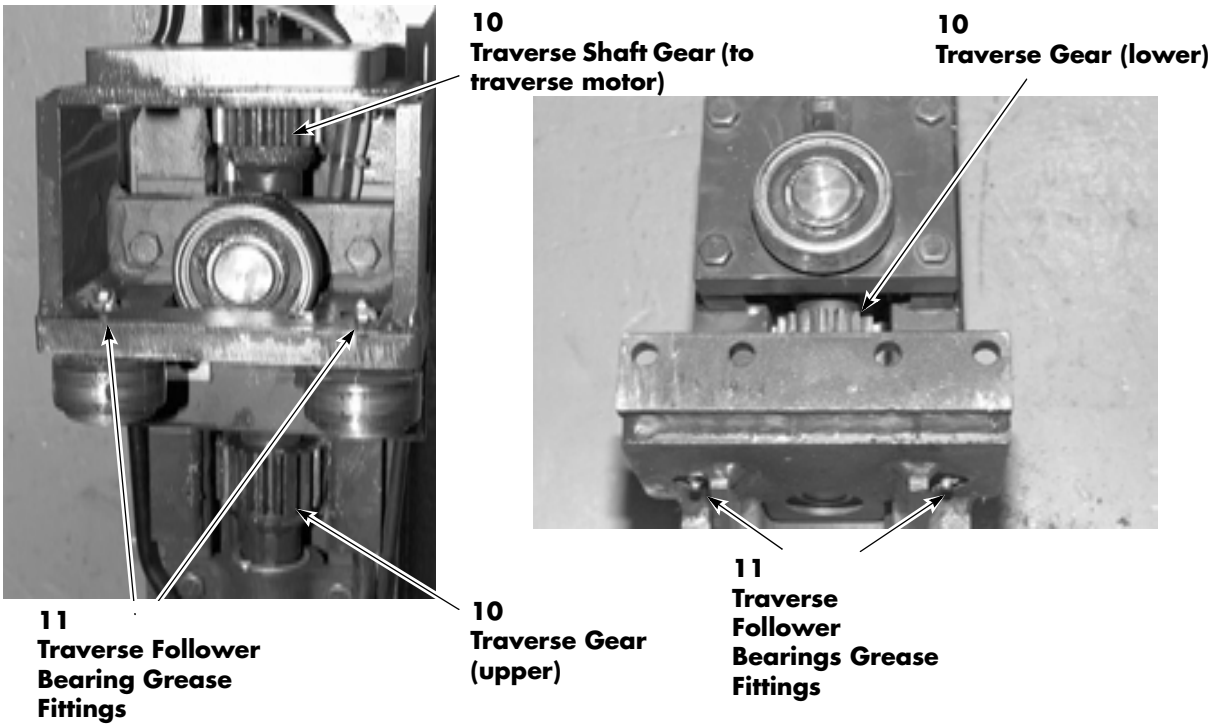


Figure 4-16. Lubrication Points

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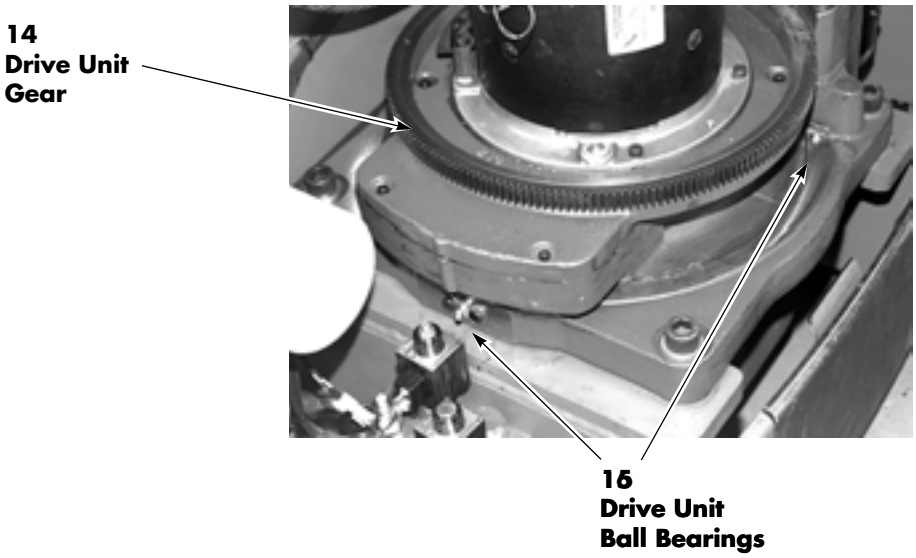


Figure 4-17. Lubrication Points

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Forks

Fork Inspection

General

- Check legibility of fork identification information, usually stamped on the edge of the fork. If not legible, re-stamp per instructions of fork supplier.
- Make sure the fork latch, if applicable, is working correctly. See Figure 4-18.

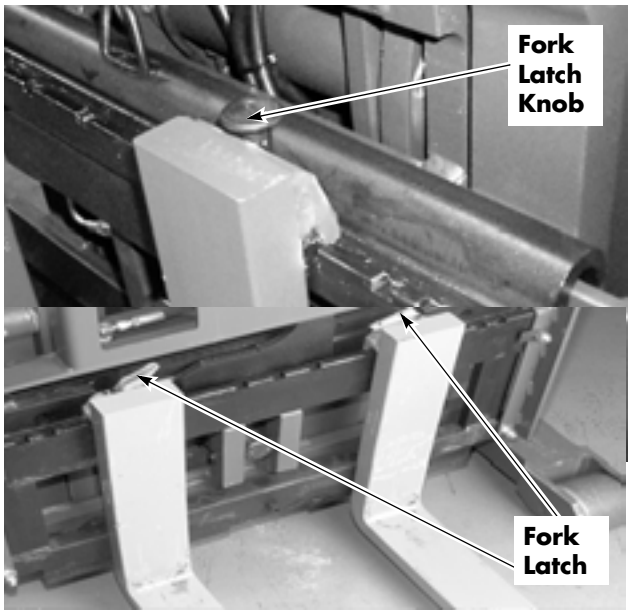


Figure 4-18. Fork Latch Types

- Visually inspect all fork surfaces for signs of damage, including, but not limited to: excessive wear, bends, cracks, welding arcs, excessive heat, or unauthorized modifications. If necessary, use a non-destructive crack detection process. Give special attention to the heel and mounting hooks. See Figure 4-19.

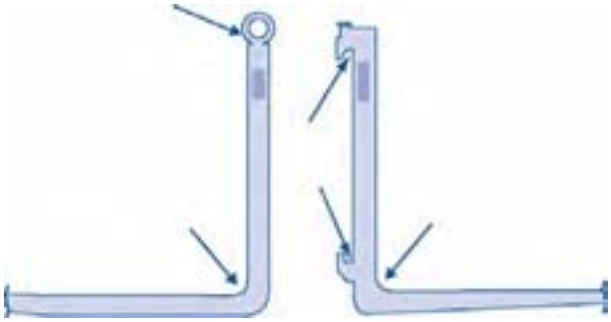


Figure 4-19. Fork Inspection for Cracks

⚠ WARNING

Remove from service immediately any fork that shows signs of damage.

Fork Thickness

Measure fork thickness, using a fork caliper (P/N 922-369), as follows.

NOTE: Use the fork caliper on forks up to 4 in. (100 mm) thick. Do not use it on forks where the shank is thicker than the blade.

1. Set the outer points of the caliper to the thickness of the vertical shank of the fork. See Figure 4-20.

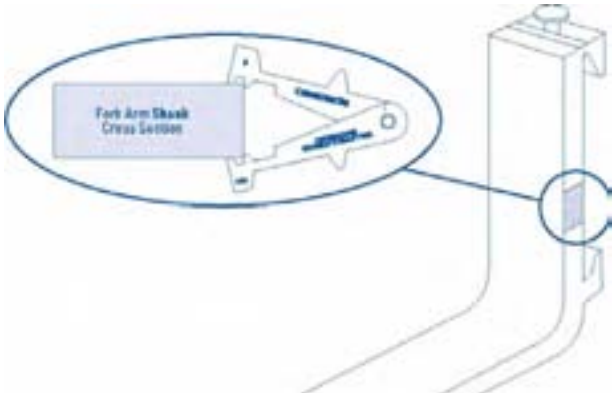


Figure 4-20. Measuring Fork Shank Thickness

2. Without changing the setting, measure the thickness of the fork blade 2 inches (51 mm) out from the heel. If the blade passes through the outer points but not

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the inner points of the caliper, it has less than 10% wear and can remain in service. If the inner points of the caliper pass over any part of the untapered base of the fork, replace the fork. See Figure 4-21.

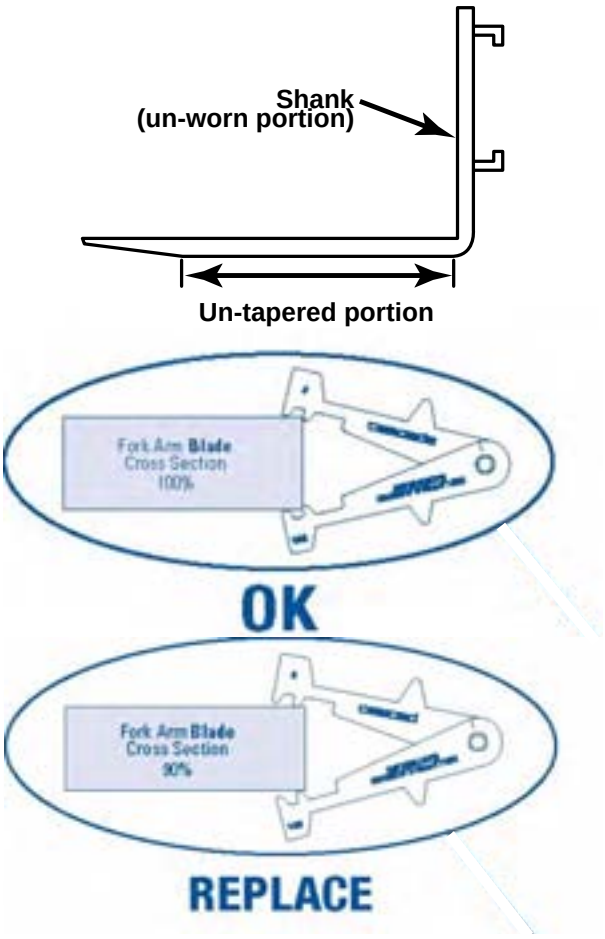


Figure 4-21. Measuring Fork Thickness

Fork Heel Angle

Measure fork heel angle, using a fork caliper (P/N 922-369), as follows:

1. Position the caliper in the heel of the fork so that all four points of the caliper touch the shank and blade, as shown in Figure 4-22.
2. Without changing the caliper setting, read the angle at the hinge of the caliper. If the angle is not between 87° and 93°, replace the fork.

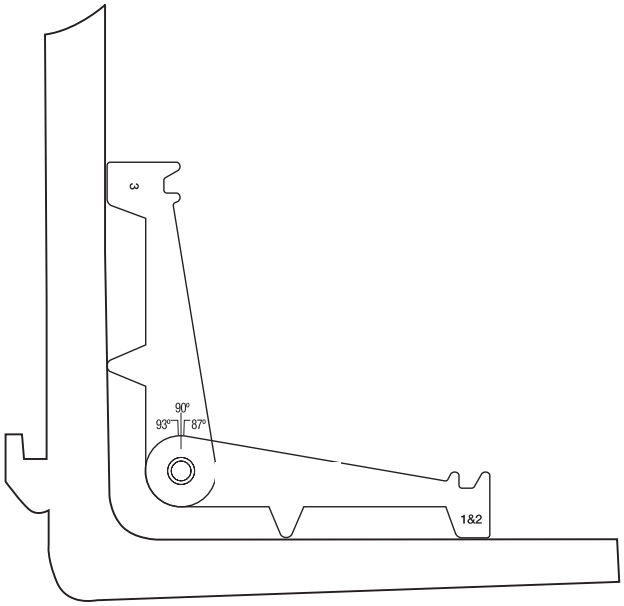


Figure 4-22. Measuring Fork Heel Angle

Fork Tip Alignment

Measure the difference in fork tip height between the pair of forks when the forks are mounted on the carriage and not resting on the floor. If the difference is more than 0.25 in. (6.3 mm) for a fork up to 42 in. (1067 mm) long, or more than 0.375 in. (9.5 mm) for a fork longer than 42 in. (1067 mm), check the fork angles and the carriage for deformation.

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Fork Straightness

Place a square on the blade 2 in. (51 mm) from the shank at the bottom. Measure the distance from the square to the shank at a point 21 in. (533 mm) up the shank. If the measurement (dimension Y in Figure 4-23) is not 2 ±3/32 in. (533 ± 2.5 mm), replace the fork.

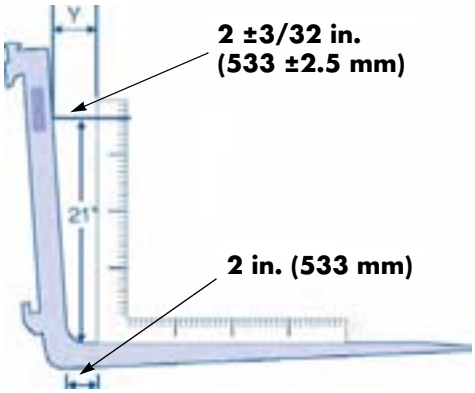


Figure 4-23. Measuring Fork Straightness

Fork Height and Lift Chain Adjustment

Adjust main lift chains in conjunction with the mini-mast lift chain.

1. Turn the key switch OFF and disconnect the battery connector.
2. Loosen the jam nut and the tensioning nut on the mini-mast lower chain anchor until the roller bearings rest on the bottom of the mast upright.

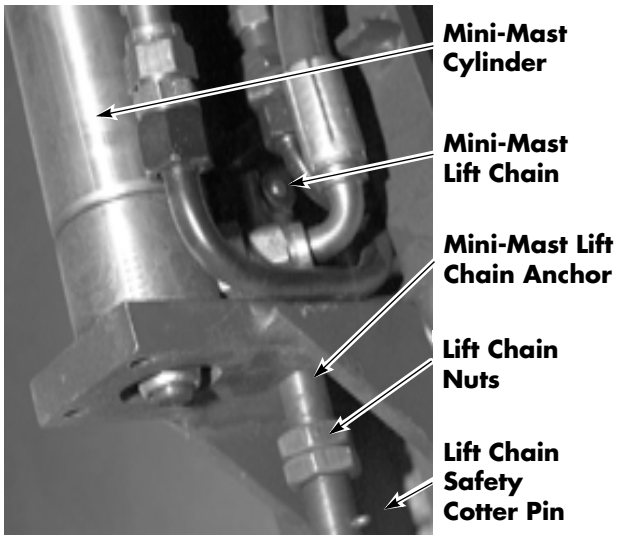


Figure 4-24. Mini-Mast Lift Chain Anchor

3. Tighten the tensioning nut until the fork carriage is raised 0.5 inch (12.7 mm) from the fully lowered position in step 2. Tighten the jam nut.
4. Loosen jam nuts on both main lift chains.
5. Adjust both main lift chains by tightening or loosening the tensioning nuts evenly to obtain a distance of 3 in. (76 mm) from the top of the fork to the floor, measured 4 in. (100 mm) in front of the fork heel.

NOTE: If the truck has the floor lowered height option, fork height adjustment is 2 in. (51 mm) from top of the fork to the floor, measured 4 in. (100 mm) in front of the fork heel.

6. Measure the distance from the top of the platform to the floor on both sides. Adjust main lift chains, if necessary, so the platform hangs evenly (level) on the chains.

NOTE: On Series SB, the distance from the top of the platform to the floor must not exceed the dimension in Table 4-4, to permit clearance between the top tele

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roller and the over-the-mast hose/cable pulley.

Table 4-4. SB Platform to Floor Distance

SB S/N Range	Platform to Floor Distance
< 01304	18.5 in. (470 mm)
> 01303	16 in. (406 mm)

7. Tighten jam nuts on both main lift chains.
8. Run "Test I09 ¥ – Mini-Mast Reference Point" on page 6-154. Run the test in Dynamic Diagnostic Mode and verify that the mini-mast height sensor can still recognize the mini-mast reference point, that is, can recognize that the forks are fully lowered.

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RAYMOND

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Section 5. Troubleshooting

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How to Use This Chapter

This chapter contains a set of general troubleshooting guidelines, a troubleshooting task flow, and a set of troubleshooting tables for symptoms not accompanied by a fault code.

Use the **START TROUBLESHOOTING Chart TS-1** on page 5-29 to guide you to the general flow of troubleshooting.

Use the **Symptom Tables** beginning on page 5-33 to identify possible causes of problems that are not accompanied by a fault code on the Operator Display.

Every time you complete a troubleshooting procedure, make sure to follow the steps in **End of Troubleshooting Chart END1** on page 5-31.

Another troubleshooting resource is the **Pinout Matrix** on page 8-43 in the Theory of Operation chapter. The pinout matrix chart lists functions and normal voltages of terminals and harness connector pins.

If the troubleshooting symptom charts do not isolate the problem, or if the symptoms are not consistent or repeatable, go to the **General Troubleshooting Chart GEN1** on page 5-30. This chart helps you approach the problem in a systematic and logical manner.

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Electrical Troubleshooting Guidelines

Many problems are caused by a faulty or dirty battery. Make sure the battery is clean. See "Battery Exterior Cleaning" on page 7-86. Check the electrolyte level and state-of-charge. See "Testing, Charging, and Maintenance" on page 7-87.

⚠ WARNING

Make sure to jack and block the lift truck whenever a troubleshooting procedure requires turning key switch S1 ON. This avoids accidents caused by unexpected lift truck travel. Opening the Emergency Lowering Valve prevents unexpected lifting.

⚠CAUTION

Unless otherwise directed, disconnect the battery connector when you check electrical circuits or components with an ohmmeter. Electrical current can damage the ohmmeter. Discharge residual charge in the motor controller by pressing PC1, PC2, and P contactors closed simultaneously.

- Save time and trouble by looking for simple causes first.
- For information on electrical connector location and function, see "Electrical Connector Locator Chart" on page 6-75.
- For diagrams showing electrical connector location on circuit cards, see "Circuit Card Connectors" on page 6-80.
- Use a digital multi-meter 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 correct function and scale are selected.
- Printed circuit boards have been conformal coated. You might need to 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.

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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 can 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 result in incorrect operation.

Shorts to frame can be 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, 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 12-volt test light to the battery case from battery B+, and then to the battery case from battery B–. If the light comes on 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. Your meter can be damaged if you proceed before correcting this condition.

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

   If the test light does not come on, continue to the next step.
3. With the battery disconnected from the lift truck, use a digital volt/ohm/ammeter on the Ampere function to measure the leakage current 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 scale. A reading of more than 0.001A (1 mA) shows a serious short. Do not continue until this condition is corrected. Your meter can 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 (0.2 mA), go to step 4. If the current is greater than 0.0002A (0.2 mA) and less than 0.001A (1 mA), remove the battery from the lift truck, then continue with step 4. Make sure the battery case does not touch the lift truck frame during the remaining tests.
4. With the battery disconnected (or removed and disconnected) from the lift truck, use a digital ohmmeter 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 shows a serious short. Do not continue until this condition is corrected. Your meter can be damaged if

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you proceed before correcting this condition.

a. To identify the cause of the short to frame, disconnect circuit components until the low resistance condition disappears. Do not reconnect components one at a time, but leave them disconnected until the low resistance reading disappears. Prevent disconnected terminals or connectors from touching lift truck frame or other conductive surfaces.

b. The most likely areas to examine are:

- Motors
- Heat sinks
- Power cables and tie points
- Power circuit components
- Control circuit components and terminals strips

c. Repair or replace the component causing the low resistance condition, then 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 bad; repair or replace as appropriate.

e. When, after all components are reconnected, and you repeat Step 4, you get readings greater than 1000 ohms, continue with the next step.

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

6. Use a volt/ohm/ammeter on the current function to measure leakage current to the lift truck frame from B+, B–, and all fuses and motor terminals. Begin measuring at the highest Ampere scale and work toward the lowest scale. If the current is less than 0.001A (1 mA), go to step 7. If the current is more than 0.001A (1 mA), 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 (1 mA). Do not reconnect components one at a time, but leave them disconnected until the leakage current reads less than 0.001A (1 mA). Prevent disconnected terminals or connectors from touching lift truck frame or other conductive surfaces.

b. The most likely areas to examine are:

- Motors
- Heat sinks
- Power cables and tie points
- Power circuit components
- Control circuit components and terminals strips

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 (1 mA) when reconnecting a component, that component or its wiring is bad. Repair/replace as appropriate.

7. When, after all components are reconnected, and you repeat Step 6, you get a reading less than 0.001A (1 mA) there is no short to frame condition with the lift truck or the battery. If you previously removed the battery from the lift truck, re-install the battery.

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Fuses

Test/Inspection

Examine for signs of overheating, discoloration, cracking, or other physical damage. To test a fuse, remove it from the lift truck or isolate it from the electrical circuit by removing all the connections from one side of the fuse. Use an ohmmeter set to Rx1 scale and measure the resistance across the fuse. The resistance must be less than 1 ohm.

Fuse Locator Chart

Table 5-1. Fuse Locator Chart

Fuse	Amps	Location	Function
FU1	15	Line Filter Module	Line Filter B+KEY (slow blow)
FU2	15	Line Filter Module	Line Filter B+F (slow blow)
FU4	150	Power Panel	Auxiliary Motor
FU5	350	Power Panel	Travel Power
FU6	450	Power Panel	Lift Power
FU8	70	Power Panel	Electrical Steer and Drive Motor Fields
FU11	15	Tractor Manager	B+ PCF
FU12	15	Tractor Manager	B– PCF
FU13	15	Tractor Manager	B– F
FU14	15	Tractor Manager	B+ F
FU15	6	Tractor Manager	B- F (Spare) (slow blow if second line filter assembly installed)
FU16	6	Tractor Manager	B+ F (Spare) (slow blow if second line filter assembly installed)
FU17	2	Tractor Manager	+12 VF
FU18	2	Under Operator Seat	Cold Storage Control Handle Heaters
FU19	2	Under Operator Seat	Cold Storage Control Handle Heaters
FU20	10	Near ESD Jack on Tractor	Cold Storage Electrical Compartment Heater
FU21	10	Near ESD Jack on Tractor	Cold Storage Electrical Compartment Heater
FU22	2	Under Operator Seat	Power Option (B+)
FU23	2	Under Operator Seat	Power Option (B–)
FU24	2	Tractor	Aux Power Amplifier Heater
FU25	1	In Fluorescent Light Assembly	Fluorescent Light
FU30	3	JH1/JK3 Cable (Oct 2006)	Circuit Card protection

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Fuse Locations

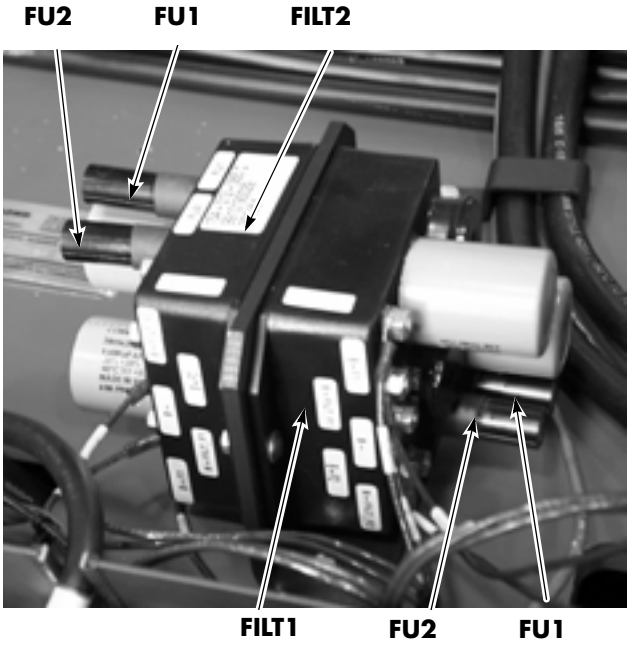


Figure 5-1. Line Filter Fuses

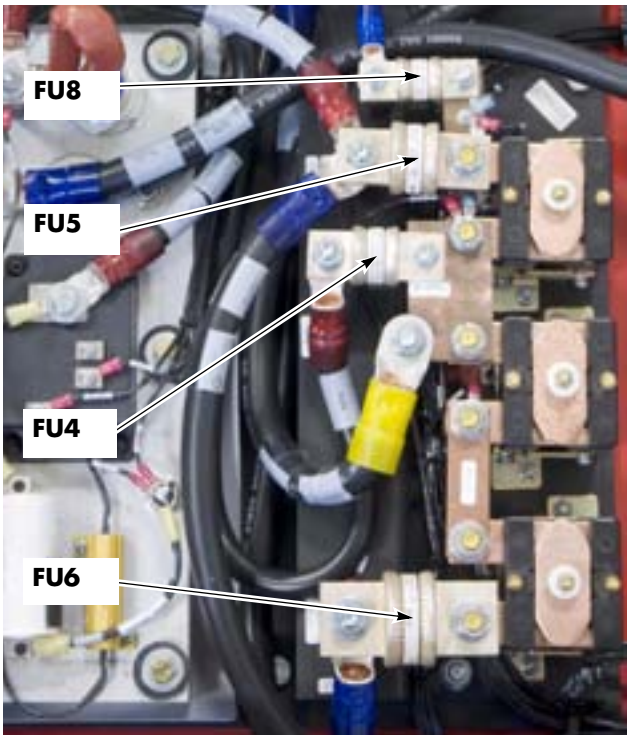


Figure 5-3. Power Panel Fuses (SA S/N > 02999, SB S/N > 00699

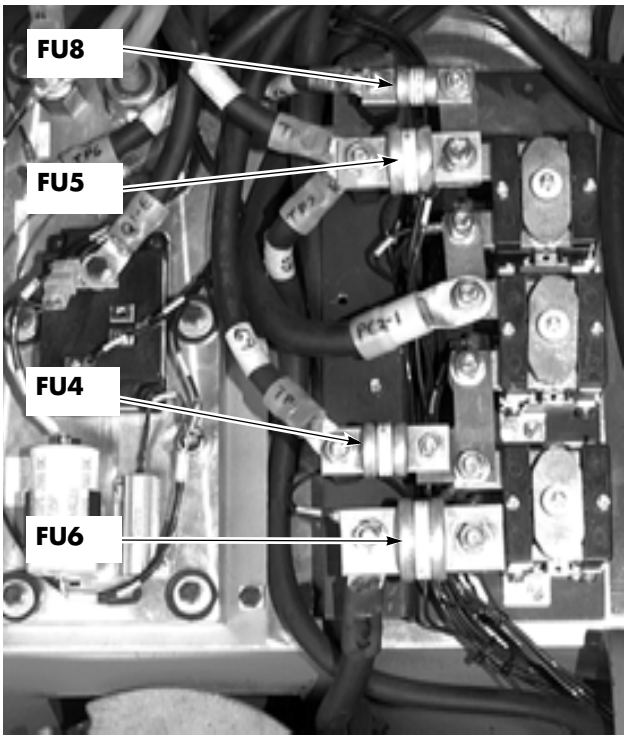


Figure 5-2. Power Panel Fuses (SA S/N < 03000, SB S/N < 00700

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Fuses

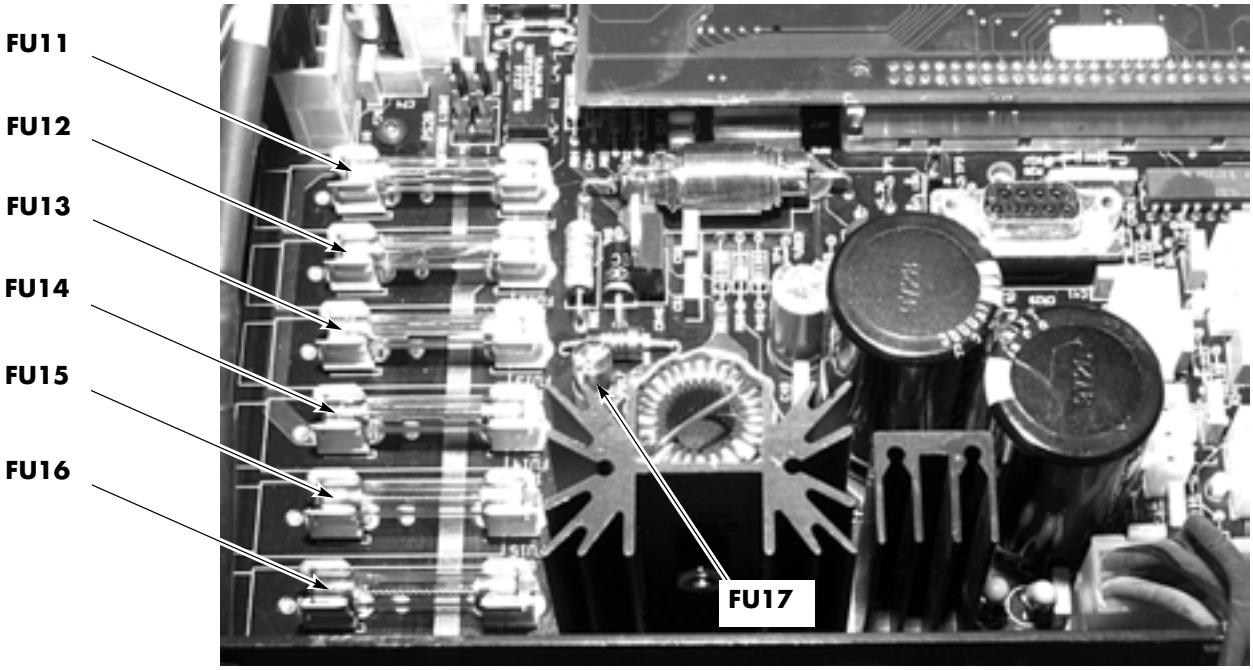


Figure 5-4. Tractor Manager Fuses

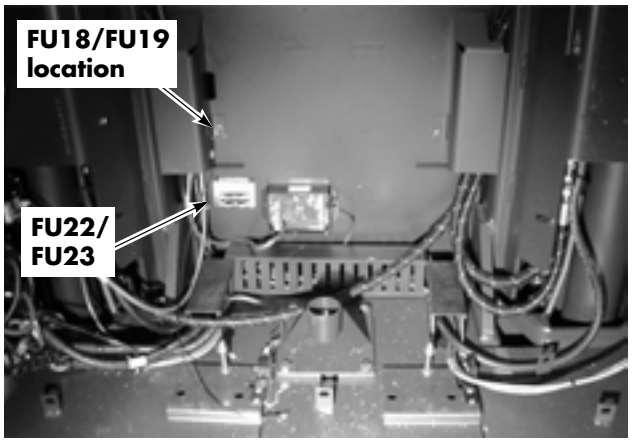


Figure 5-5. Cold Storage and Power Option Fuses, Platform (seat removed for clarity)

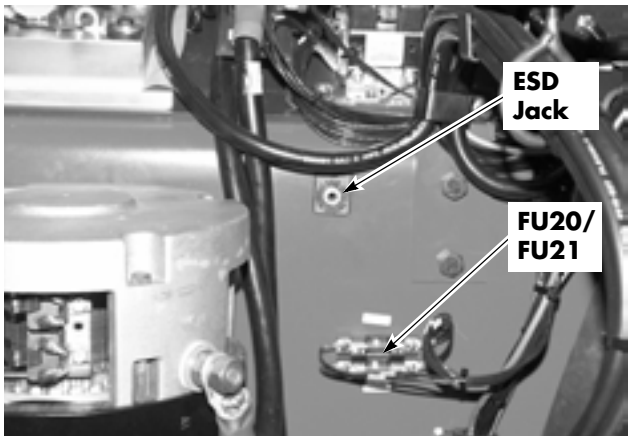


Figure 5-6. Cold Storage Fuses, Tractor

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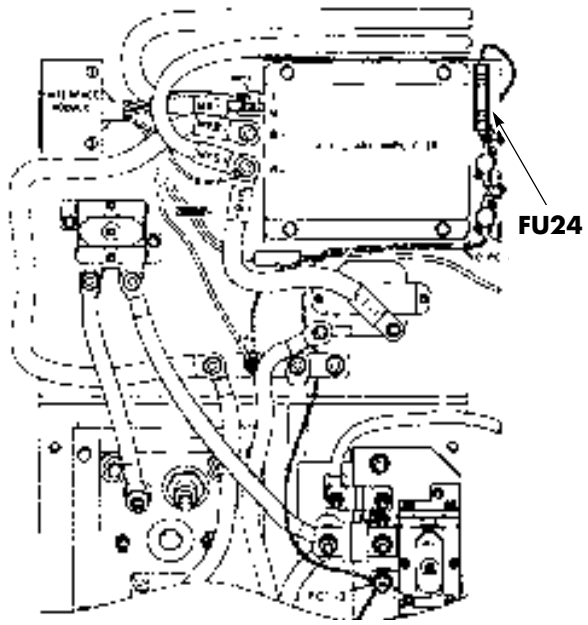


Figure 5-7. Cold Storage Fuse, Aux Power Amplifier

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Power Transistor (Q1)

NOTE: When Q1 fails open or shorted, test the power card before replacing Q1. See "Power Card" on page 5-14.

Testing Q1

1. Turn the key switch OFF and disconnect the battery connector.

⚠CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-9.

2. Lift the top cover. (See "Covers" on page 7-34.)
3. Disconnect the power cable from Q1-E to TP4. Also remove the snubber capacitor lead.
4. Disconnect Q1-B wire from Q1-B terminal.
5. Disconnect Q1-E wire from Q1-E terminal.
6. Set a digital voltmeter to the *diode test* function**.** Connect leads as shown in Table 5-2 and observe readings. If you do not obtain all the results shown in the table, the transistor is bad.

Table 5-2.

Positive Lead	Negative Lead	Meter Reading
Collector (Base Plate)	E (Emitter)	Open
E (Emitter)	Collector (Base Plate)	< 1.0
E (Emitter)	B (Base)	< 1.0
Collector	B (Base)	Open
B (Base)	E (Emitter)	< 1.0
B (Base)	Collector (Base Plate)	< 1.0

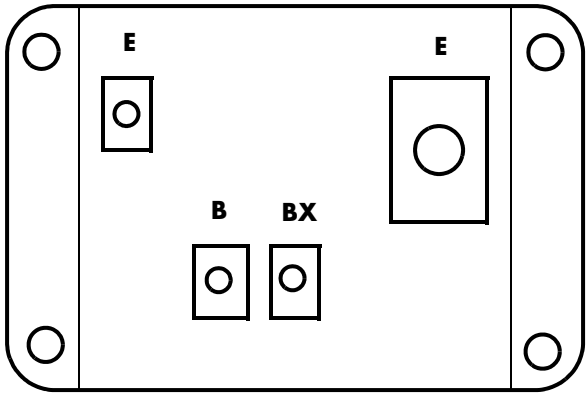


Figure 5-8. Q1 Power Transistor Connections

NOTE: Other bad components could have caused the power transistor to fail. *Before replacing the power transistor,* run Test O14 – Armature PWM Ramp (Page 6-213).

If Q1 fails during SelfTest, verify B– is being supplied to the power card from JPC1-1. If not, troubleshoot wiring from Q1-E to JPC1-1.

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Field Transistors TM1/TM2

Testing TM1/TM2

Set a digital voltmeter to the *diode test* function. Connect leads as shown in Table 5-3 and observe readings. If you do not obtain all the results shown in the table, the transistor is bad.

NOTE: *If either TM1 or TM2 fails the test, replace both transistors as a set.*

Table 5-3.

Positive Lead	Negative Lead	Meter Reading
C1	C2E1	Open
C1	B1 or G1	Open
C2E1	B1 or G1	Open
C2E1	B2 or G2	Open
C2E1	C1	< 1.0
C2E1	E2	Open
E2	C2E1	< 1.0
E2	B2 or G2	Open

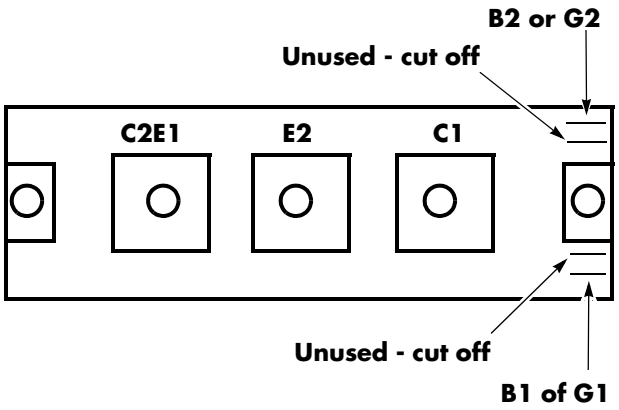


Figure 5-9. TM1/TM2 Field Transistor Connections

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Steering Transistors TM3/TM4

Testing TM3/TM4

Set a digital voltmeter to the *diode test* function. Connect leads as shown in Table 5-4 and observe readings. If you do not obtain all the results shown in the table, the transistor is bad.

NOTE: *If either TM3 or TM4 fails the test, replace both transistors as a set.*

Table 5-4.

Positive Lead	Negative Lead	Meter Reading
C1	C2E1	Open
C1	B1 or G1	Open
C2E1	B1 or G1	Open
C2E1	B2 or G2	Open
C2E1	C1	< 1.0
C2E1	E2	Open
E2	C2E1	< 1.0
E2	B2 or G2	Open

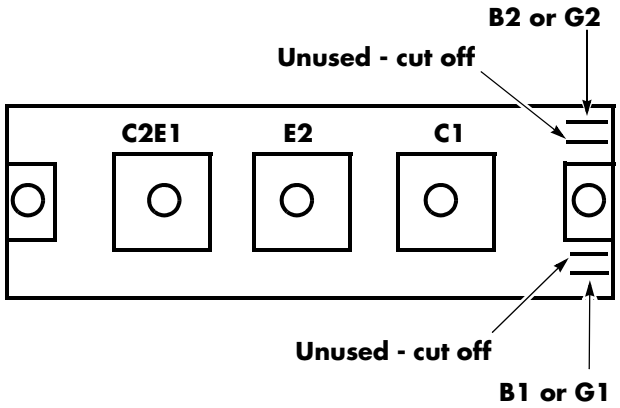


Figure 5-10. TM3/TM4 Steering Transistor Connections

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REC1

Testing

1. Turn the key switch OFF and disconnect the battery connector.

⚠CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-9.

2. Lift the top cover. (See "Covers" on page 7-34.)
3. Disconnect the lead from REC1 at TP5.
4. Set a digital voltmeter to the *diode test* function. Connect leads as shown in Table 5-5 and observe readings. If you do not obtain all the results shown in the table, the transistor is bad.

Table 5-5.

Positive Lead	Negative Lead	Meter Reading
TP6 (Body of REC1)	Lead removed from TP5	< 1.0
Lead removed from TP5	TP6 (Body of REC1)	Open

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Power Card

Test Q1 and REC 1. If they do not pass the tests, replace them. However, before replacing the power card or testing the replaced parts under power, test the power card using the following procedure:

1. Turn the key switch OFF and disconnect the battery connector.
2. Disconnect the cable harness to Q1 transistor at PC1.
3. Set a digital volt meter (DVM) to measure resistance on a scale of not less than 20 ohms. Connect the positive lead of the DVM to PC1 Pin 2. See Figure 5-11.

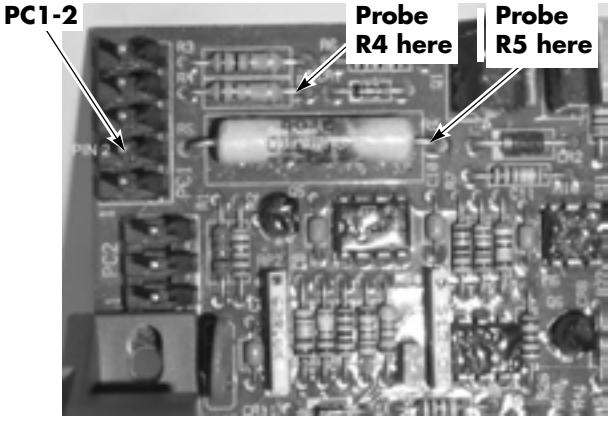


Figure 5-11. Power Card

4. Using the negative lead, probe R4 and R5 on the end farthest away from PC1. Both resistors should measure between 0.5 and 10 ohms. You may have to scrape conformal coating off the resistor leads to get good electrical contact. If the readings are not within tolerance, replace the power card.

NOTE: Resistor R5 may look burnt, bubbled, or otherwise discolored/damaged. This resistor is coated with a conformal coating that discolors when heated to normal resistor operating temperatures. If the value of the resistor is between 0.5 and 10 ohms, it is acceptable.

5. Reconnect PC1 to the Power Card and remove the base lead from Q1. Do *not* disconnect the emitter lead. Make sure that the emitter of Q1 (large bolt on top of device) is connected to battery negative (TP4 on most trucks).
6. Set meter to 20 volt DC scale. Connect the negative lead of the DVM to the emitter of Q1 (either small or large terminal). Connect the positive lead to the ring terminal removed from Q1 base. Make sure that neither the meter nor base lead contact any other points of the truck during the test.
7. Reconnect the battery connector and turn the key switch ON. Make sure the armature over-temperature light (red IL1 LED on the power card) is *not* lit before proceeding. If the LED is on, troubleshoot the main heatsink temperature circuit prior to proceeding.
8. Enter Maintenance Mode. Run Output Test O14. The voltage should ramp from 0.0 volts to approximately 1.5 to 2.0 volts. If the voltage does not ramp above 1.4 volts, replace the Power Card. If the voltage ramps above 3.0 volts, replace the Power Card.
9. Reconnect Q1 base lead and test the lift truck for correct operation.

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DC Motor Troubleshooting

Motor Types

Refer to Figure 5-12.

- A shunt-wound or series-wound drive motor has four external connections: two armature (A), and two field (S, E, or D).
- A series-wound lift motor has only two external connections because the armature (A) and field (S or D) windings are connected internally.
- A permanent magnet motor has two external connections. The field is produced by an internal permanent magnet.
- A compound auxiliary motor has both shunt and series field windings connected internally, resulting in only two external connections.

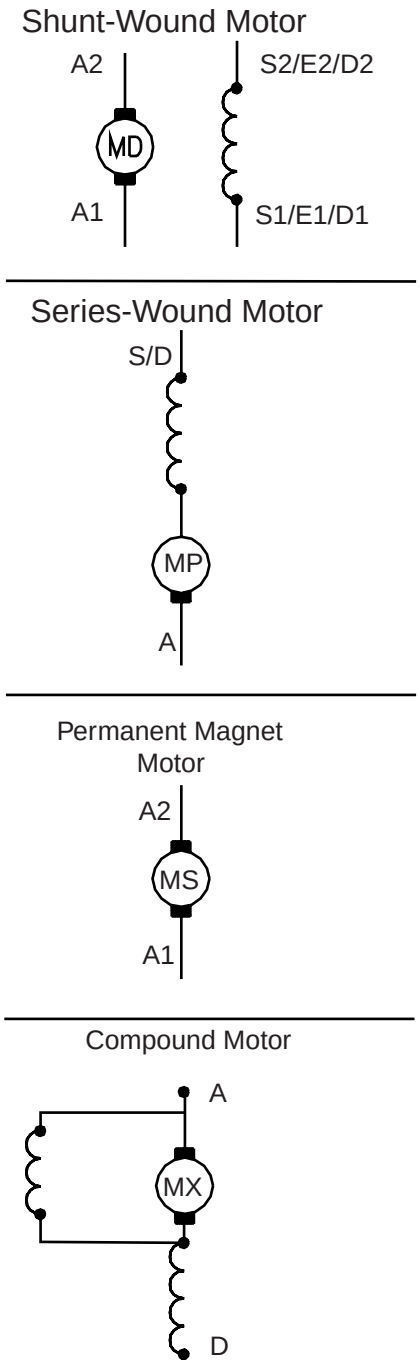


Figure 5-12. Motor Circuits

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Inspection

Each partial inspection of the motor should include the following:

1. Inspect the brushes for wear and for correct contact with the commutator. Record the level of wear on the brushes. This history gives you an indication of whether a brush must be changed or if it can wait until the next inspection. See the table on page 4-11 for correct brush length.

NOTE: Overloading a motor is ultimately reflected in commutator and brush wear; take this into account when considering brush replacement.

2. Check brushes for signs of overheating: discolored shunts or springs or cracked contact area.
3. Check brush spring tension. See "Motor Brush Spring Tension" on page 4-12.
4. Clean brushes and holders. Wipe the commutator with a dry, lint-free cloth. *Do not use* lubricants of any kind on or around the commutator.
5. Check 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. Be careful not to strip the threads or crush the insulating parts.
8. Check all the screws and bolts around the endbell 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.

Electric Motor Tests

Open Circuit Motor Test

An open circuit is one in which the electrical circuit within the motor has been 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 5-12 on page 5-15 for the following procedure:

1. Isolate the motor from the 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 measurements in Table 5-6:

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Table 5-6. Open Circuit Motor Test

Motor	Probe Points	Resistance
Drive Motor	S1 to S2 (shunt)	0.9 to 1.5 ohms
	S1 to S2 (series)	< 1 ohm
	A1 to A2	< 1 ohm
	A1 to S1; A1 to S2	> 100,000 ohms
	A2 to S1; A2 to S2	> 100,000 ohms
	A1 or A2 to Frame	> 100,000 ohms
Lift Motor	A to S	< 1 ohm
	A to Frame	> 100,000 ohms
Auxiliary Motor	A1 to A2	< 1 ohm
	A1 or A2 to Frame	> 100,000 ohms
Steer Motor	A1 to A2	< 1 ohm
	A1 or A2 to Frame	> 100,000 ohms

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

Grounded Motor Test

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

The ground could 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 in which the insulation on the field or armature has broken down at two or more points. The breakdown creates a low resistance path, permitting 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 could 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

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DC Motor Troubleshooting

These symptoms can be caused by problems other than the motor itself:

- brake too tight or dragging
- wheel bearings too tight
- faulty transmission
- binding in a related pump, hose, or solenoid valve
- load wheels not aligned correctly
- rail guided with drive tire not aligned correctly

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

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Troubleshooting Wiring Problems

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 is sometimes necessary to unplug a connector, move a harness, cut a cable tie, or remove the wire from a bracket. Note carefully 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 or protect the wire. This includes spiral wrap, brackets, cable ties, fasteners, flexible conduit, and so forth.

Do not attach cable ties so tight that they pinch or deform cable harnesses. Avoid attaching to hydraulic hoses, which expand with pressure, causing extra pinching of electrical cables.

Use a digital ohmmeter to check for wiring continuity.

For general instructions on repairing wiring problems, see “Wiring, General” on page 7-92.

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Troubleshooting Communication Fault Codes (50-series)

Fault codes numbered in the 50-series indicate communication problems among managers.

Enter Configure Mode and display versions. The Carriage Manager (CM) requests version information from the other managers and then sends this information to the display.

- If no versions are displayed (version is blank for AH and MH, 0 for all others), then the CM is not communicating.
- In general, if any versions are displayed, then the CM and the managers showing a version are working correctly.
- If all versions are present, then communication is being affected by loading, noise, terminations, and/or excessive errors causing re-send.
- If the fault code is intermittent, the cause could be a faulty cable or cable connection, card, or socket.
- If the fault code cannot be reset, and other version information is present in Configure Mode, then the receiving manager, as defined under the code title, probably needs replacing.

Before replacing any managers for a 50-series fault code, check the following:

1. Codes 50 and 53 can be caused by a mismatch between Tractor Manager VFC and/or Steer Manager hardware and firmware.
   a. VFC Cards starting with P/N 1002059/202 require Tractor Manager firmware version 4.00 or higher.
   b. Steer Manager cards starting with P/N 154-012-351/020 require Steer Manager firmware version 2.1 or higher.
2. Static discharge.
   a. Check condition of static straps on mast.
   b. Make sure the static cable on the operator seat is connected to frame.
3. Verify correct termination jumpers for the truck series.
   a. Series SA
      - E1 jumper on ESM in the OUT position. See drawing on page 7-83.
      - Jumper between JP5-1 and JP5-10 on Main Height Manager
      - Jumper between JP5-1 and JP5-10 on Mini Height Manager
   b. Series SB
      - E1 jumper on ESM in the IN position. See drawing on page 7-83.
      - Jumper between JP5-1 and JP5-10 on Mini Height Manager
4. Verify TM3/TM4 connections are secure. Verify correct connection of capacitor between SMB+ and SMB– on the ESM.
5. Verify condition of all bus+/bus– cables and connections, including over-the-mast cable.
6. Check Q1 snubber components (R2, REC2, C1) and connections. Make sure R2 is electrically isolated from the main heatsink and that the main heatsink is isolated from the lift truck frame.
7. Check for shorts to frame, including dirty battery. See “Shorts to Frame Test” on page 5-4.
8. Check for loose, worn, or chipped motor brushes or rough motor commutator.
9. Check condition of all motor cables, crimps, terminals, and connections.
10. Make sure no unapproved electrical devices have been connected to the lift truck electrical system.
11. Make sure that neither the horn nor light and fan package is shorted to truck frame.

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Troubleshooting Code 57 - Truck Will Not Operate

1. Connect a DVM to the BUS+ (positive lead) and BUS– (negative lead) wires. Correct voltage is approximately 5.3 volts. If voltage is higher, turn the key switch OFF and disconnect the battery connector. Check all communication wires for shorts to other wires and do not turn the key switch ON again until you find the short circuit.
2. Check the 12 volt power supply on the Carriage Manager. If voltage is low, disconnect, one at a time, all components from the CM that use 12 volts or 5 volts. When voltage returns to normal, troubleshoot the component and wiring last disconnected.
3. Disconnect the two over-the-mast BUS+/BUS– wires (JPC17-2 and JPC17-3) at the Carriage Manager. Turn the key switch ON.
   a. If the Fault Code changes to Code 50 on startup, then either the over-the-mast cable or a component connected to the Tractor Manager is affecting communications. Go to step 4.
   b. If Code 57 recurs, the Carriage Manager, Display Interface Card, or Mini-Mast Height Manager is affecting communications. Go to step 6.
4. Turn the key switch OFF. Reconnect the over-the-mast BUS+/BUS– wires. Disconnect connector the ESM cable at JPS17 at the Tractor Manager. Turn the key switch ON.
   a. If the fault code changes to Code 53 on startup, troubleshoot wiring to the ESM from PA2 to PS17. If wires are OK, replace the ESM.
   b. If Code 57 recurs, then the problem is with either the Tractor Manager or (SA only) the Main Mast Height Manager or its wiring.
5. SA only: If Code 57 occurred in the previous step, turn the key switch OFF. Disconnect the Main Mast Height Manager at JPH2 on the Tractor Manager. Turn the key switch ON.
   a. If Code 57 recurs, replace the Tractor Manager.
   b. If the fault code changes to Code 55, troubleshoot wiring to the HM from JH2 to J5. If wires are OK, replace the Height Manager.
6. Turn the key switch OFF. Disconnect the Mini-Mast Height Manager at connector JPH1 on the Carriage Manager. Turn the key switch ON.
   a. If Code 57 recurs, replace the Tractor Manager.
   b. If the fault code changes to Code 54, troubleshoot wiring to the HM from JH1 through JPK3 to J5. If wires are OK, replace the Height Manager.
7. If Code 57 remains on the Operator Display, disconnect the Operator Display Interface Card at connector JPC8 on the Tractor Manager.
   a. If the truck runs, troubleshoot wiring to the Interface Card from PC18 to J3. If wires are OK, replace the Display Interface Card.
   b. If the truck will not run, replace the Carriage Manager.

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Troubleshooting Code 50

1. Test the BUS+ and BUS– wires in the over-the-mast cable for continuity. See Table 5-7 for wire paths.

Table 5-7.

BUS Wire	At TM	Under Operator Seat	At CM
BUS+	JS25-3	JP18-7	JC17-3
BUS–	JS25-2	JP18-6	JC17-2

2. Check the 12 volt power supply on the Tractor Manager. If voltage is low, disconnect, one at a time, all components from the TM that use 12 volts or 5 volts. When voltage returns to normal, troubleshoot the component and wiring last disconnected.
3. If Code recurs, replace firmware in the VFC Card.
4. If Code 50 recurs, replace the VFC Card.
5. If Code 50 recurs, replace the Tractor Manager.

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Troubleshooting Height Manager Fault Codes

Table 5-8. Code 66 and 67 Tests and Adjustments in Recommended Order

Order to Check	Test or Adjustment	Codes Affected
1	Install firmware kit for CM ver. 4.01 or higher.	66
2	Make sure there are no unapproved electronic devices connected to the electrical system. Verify all approved devices are connected to the correct location and connections are tight.	67
3	Make sure the main mast lateral adjustments (SA pucks, SB bearings) are correct.	6C
4	Make sure the mini-mast height sensor seats well in its holder and does not bind. It should spring back when pushed in.	67
5	Inspect the mini-mast height sensing rail. Check for burrs and rough spots that could wear the sensor. Check to see if the lower reference tab is bent towards the platform; straighten by using a hammer and long punch from the platform side while holding a steel block against the fork side of the rail. Run Test I09 to verify the height sensor is completely in the reference area when the load handler is lowered completely. If not, adjust the main and load handler lift chains.	67
6	Check the adjustment of the main height sensing rail. Verify that the sensors stay centered over the holes the entire length of the rail.	6C
7	Check that the set screws on top of the mast that secure the upper telescopic mast bearing bosses are tight.	6C
8	Check for damage to the main mast height sensor wiring.	6C
9	Check for damage to the mini-mast height sensor wiring.	67
10	Check mast rollers for excessive fore-aft movement.	6C
11	Look for movement of the mini-mast when elevating or lowering the main mast. Look for movement of the main mast when elevating or lowering the mini-mast.	67, 6C
12	Run Test A04 to verify neutral position voltage on the lift/lower potentiometer.	68
13	Interview the operator and determine exactly what the operator was doing just prior to and at the time the code occurred.	64, 65, 6C
14	Inspect the plugging resistor for damage. Check mounting hardware and cable torques. Test the circuit for shorts to frame. Check connections for high resistance caused by corrosion.	67, 6C
15	Test all components in the Q1 snubber circuit. Verify all connections are tight.	67, 6C

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Troubleshooting Height Manager Fault Codes

Table 5-8. Code 66 and 67 Tests and Adjustments in Recommended Order

Order to Check	Test or Adjustment	Codes Affected
16	Test key switch for poor contacts. Measure voltage across key switch while cycling the switch several times. Voltage should be battery voltage when OFF and 0 volts when ON. If other voltage is seen, replace switch.	67, 6C
17	Check for shorts in mini-mast control circuit wiring. Check especially the rotate position feedback potentiometer and wiring, and the reach position proximity switch where the cable goes through the rotate actuator.	67
18	Inspect power cable terminal connectors for correct crimps and torques. Look for signs of excessive heat or other condition that could cause abnormally high resistance.	6C
19	Check connection torque on TM 1, 2, 3, and 4. Inspect the circuit board under the cable terminals where they attach to the printed circuit boards. Look for evidence of terminals contacting board traces connecting other circuits. The conformal coating near these other circuits must not be damaged or worn by the terminals.	6C
20	Test the light and fan circuit for shorts to frame. Disconnect connector JPC19 and operate the truck. If code does not recur, troubleshoot light and fan circuit.	67, 6C
21	Inspect and test static straps.	67, 6C
22	Inspect motor armatures and brushes for abnormal wear and discoloration caused by excessive heat or carbon deposits. Stone the commutator and seat the brushes if needed.	67, 6C
23	Watch to see if the operator frequently holds the lift request after either mast has contacted the stops. Watch to see if forks get hung up as the operator lowers the platform or load handler.	67, 6C
24	Test the horn for correct operation. A malfunctioning horn or horn suppressor can introduce electrical noise into the system. If Code 67 or 6C occurs when the horn is sounded, troubleshoot the horn and suppressor.	67, 6C
25	Observe the truck in operation. Look for extended periods of time (numerous lift/lower cycles) when the truck does not enter a reference area on main or mini-mast. Look for periods when the operator is feathering the lift for excessive time.	67, 6C
26	Monitor the battery condition throughout its usage cycle.	67, 6C

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Troubleshooting Steering Fault Codes (G-series)

You can use Learn Steering to assist in troubleshooting some G-series fault codes. During Learn Steering, different component failures will cause the system to react differently and can pinpoint the circuit that is not functioning correctly. Use the steps below *exactly* as described.

NOTE: After running each step, cycle the key switch OFF and ON, then run Learn Steering. If the Learn process fails, the system will not activate Learn Steer again until you cycle the key switch.

⚠ 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 Safety on page 2-11.

1. Jack the truck so the drive tire is off the floor.
2. Manually turn the drive unit to the straight ahead position.
3. Enter Program Mode. Reference page 6-6.
4. Run Learn Steering.
5. Observe the response of the steering system and select from the following symptoms to start troubleshooting the error.
   a. The drive unit turns to the left mechanical stop. Once against the stop, the sound created by the steering system is heard as current to the steer motor increases. Within 8 seconds, release the deadman pedal and press the **enter** button to abort Learn; failure to do so can cause damage to the steer transistors. This symptom indicates a failure in the Steer Feedback Encoder circuit. Refer to Diagnosis and Repair in Test I22 ¥ – Steer Position Feedback Encoder Count (Page 6-167).
   a. The drive unit turns quickly to the left mechanical stop. After contacting the stop, power to the steer transistors is removed very quickly and the system shuts down. This indicates a failure in the Steer Home Prox circuitry. Troubleshoot per Test I24 ¥ – Steer Home Proximity Sensor (Page 6-169).
   b. There is no movement in the drive unit but you can hear the steering system trying to turn the drive unit. Troubleshoot the steer motor and gearbox or the drive unit for binding.
   c. There is no movement or only a small amount of movement in the drive unit, and there is *not* a constant noise from the steering system. This indicates an open in at least one side of the steer motor power circuit. If there is an open in the half of the power circuit activated by T1 and T3 base leads, the drive unit moves just enough for the Home Prox to transition from *metal to no metal*. At this point the steering system shuts down and no other movements can be made. If there is an open in the half of the power circuit activated by T2 and T4 base leads, the drive unit moves just enough for the Home Prox to transition from *no metal to metal*. At this point the steer system shuts down and no other movements can be made. Troubleshoot per table Table 5-9.

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Table 5-9.

Fault Code G-series Diagnosis and Repair

Step	Action/ Meter Setting	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1	SelfTest Passed/ DCV	SMB+ on ESM	SMB– on ESM	B+	Do step 2.	Troubleshoot cables and connections.
2	Steer motor cables disconnected from ESM/Ohms	SMTR1	SMTR2	Circuit not open	Do step 3.	Troubleshoot cables and motor.
Prior to running steps 3 thru 6, connect a jumper wire (cable is not required) from TP4 (B–) to one of the steer motor terminals. Disconnect T1 thru T4 from TM3/TM4 at the ESM. After each step, a G-series code will be displayed. Cycle the key switch to reset the system for the next step to operate. The voltages at T1 thru T4 display only for a second or less on the meter and the system will shut down. *Run each step several times and watch the meter closely.*						
3	Steer Home Proximity Sensor *not over* metal/DCV	T1 at ESM	B–	Deadman released: <1V Deadman depressed: approx. 13.75V	Do step 4.	Replace ESM.
4		T3 at ESM			Do step 5.	
5	Steer Home Proximity Sensor *over* metal/DCV	T2 at ESM			Do step 6.	
6		T4 at ESM			Test wires to TM3/TM4 from ESM. Test TM3/TM4 See "Steering Transistors TM3/TM4" on page 5-12.	Replace ESM and test TM3/TM4.

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Hydraulic Troubleshooting Guidelines

⚠CAUTION

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

⚠CAUTION

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

Lower the carriage fully and retract the reach mechanism fully.

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

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

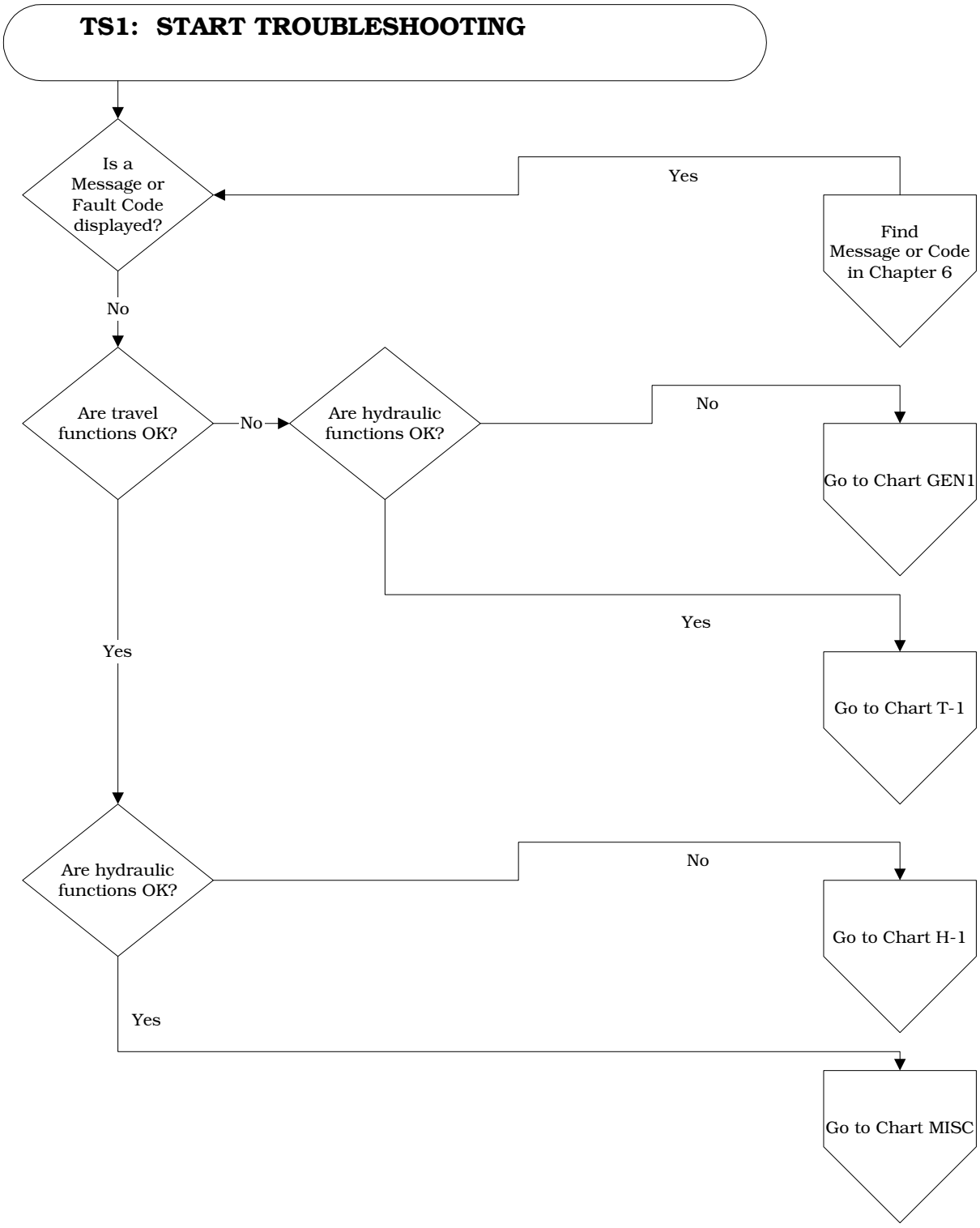
Cap open hydraulic lines to prevent contamination.

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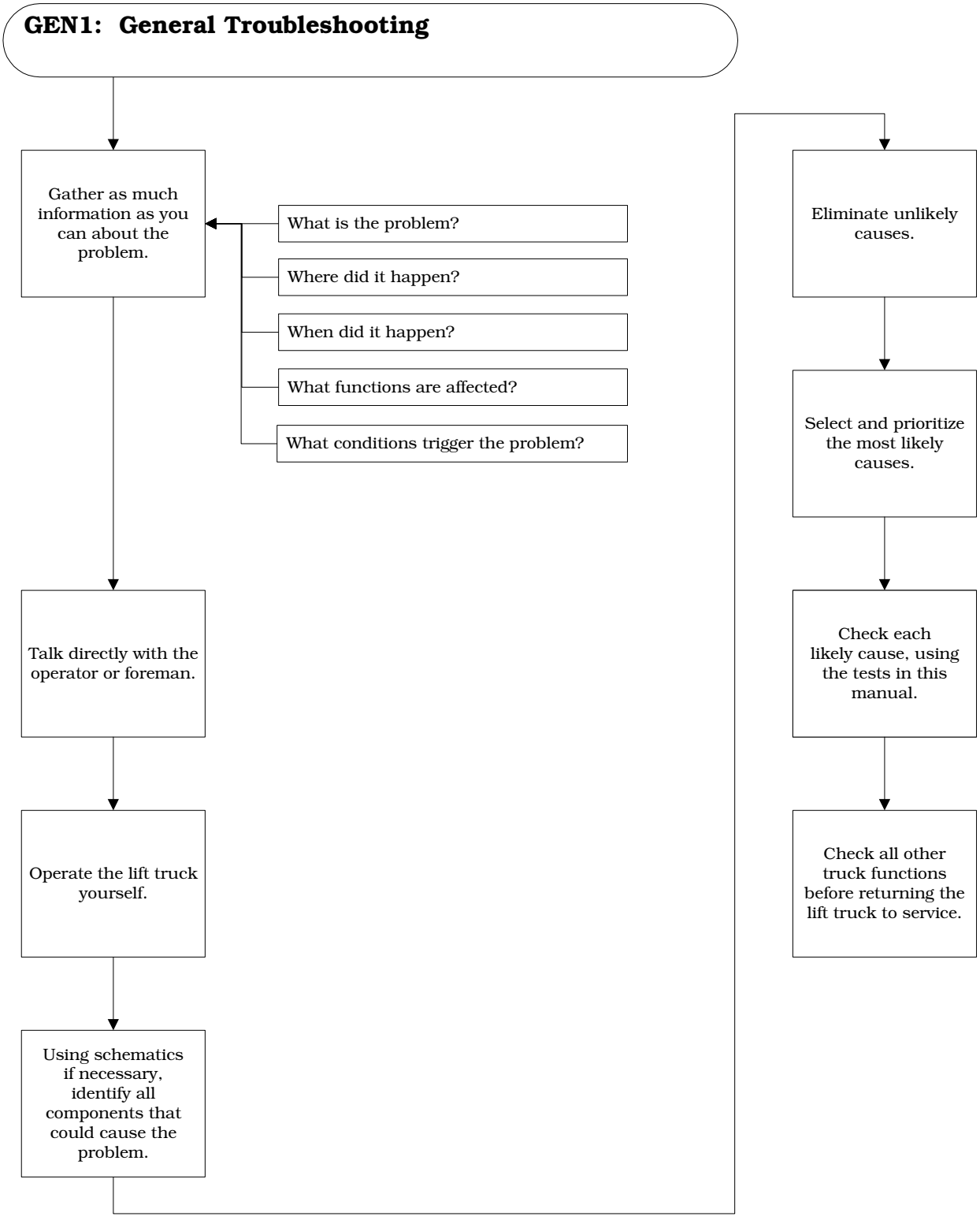
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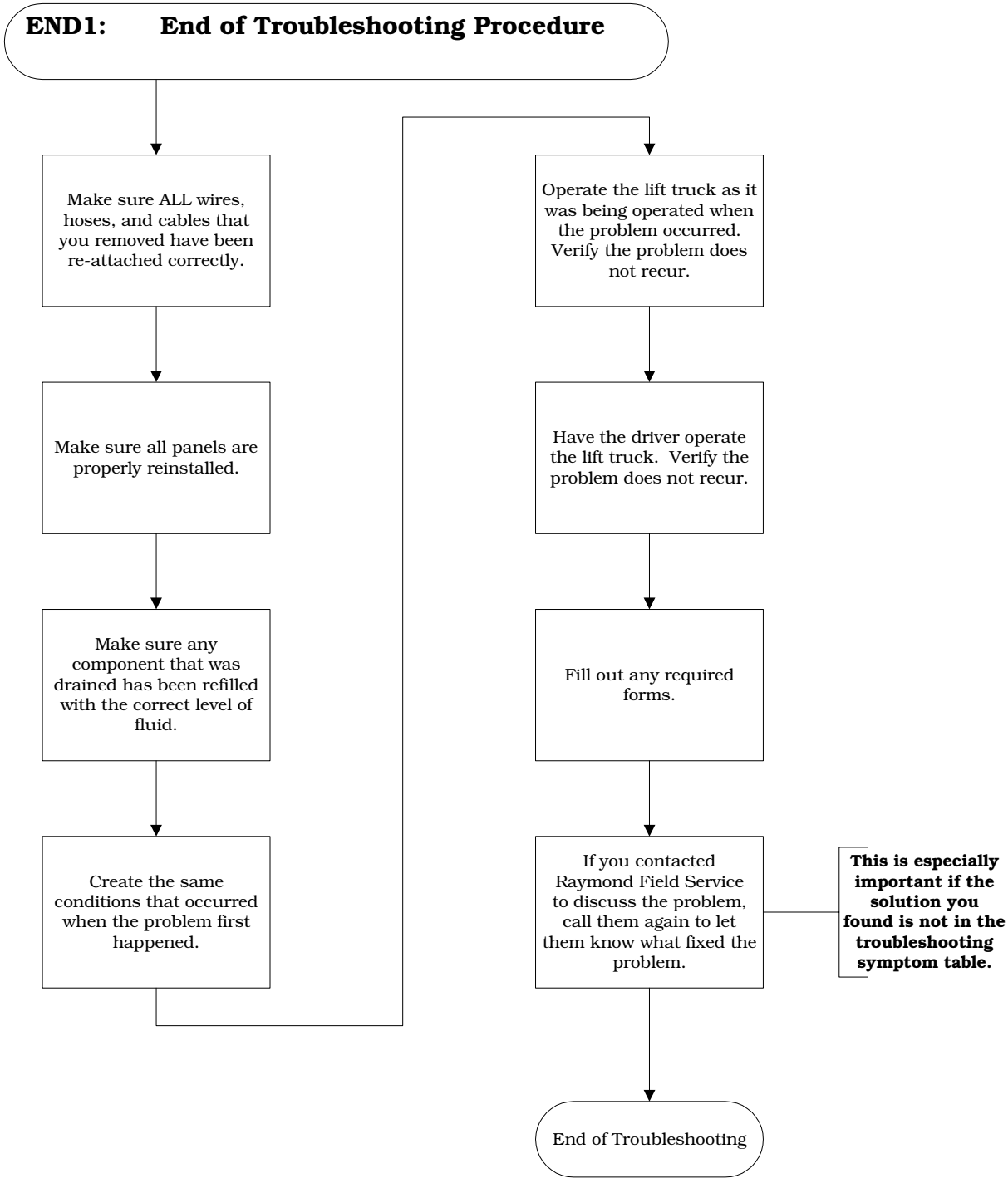
Troubleshooting Procedure



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Symptom Tables: Hydraulic Problems

Auxiliary Functions

Traverse

Traverse - Erratic Operation

Possible Cause	Action
Mechanical binding in rack assembly	Replace the traverse rack.
Binding or excessive play in Traverse Motor	Replace Traverse Motor. See "Traverse Motor" on page 7-114.
Bad Traverse Position Feedback Potentiometer or wiring	Run Test A26 ¥ – Traverse Position Feedback Pot (VR5) Voltage (Page 6-123).
Incorrectly "Learned" Controls and Carriage	Run Learn Controls and/or Carriage. See "Using Learn Mode" on page 6-16.
Bad Traverse Control Potentiometer or wiring	Run Test A06 – Traverse Control Potentiometer (VR4) Voltage (Page 6-102).
Bad Traverse Solenoid coil or driver	SA S/N < 03000, SB S/N < 00700: Run Test O19 – Load Handler Traverse Solenoid "A" (SOL34A) (Page 6-220) and Test O20 – Load Handler Traverse Solenoid "B" (SOL34B) (Page 6-222). SA S/N > 02999, SB S/N > 00699: Run Test O28 – Load Handler Traverse Solenoid "A" (SOL34A) (Page 6-237) and Test O29 – Load Handler Traverse Solenoid "B" (SOL34B) (Page 6-239).
Contamination in hydraulic system	Inspect Traverse Solenoids 34A/B or Traverse Flow Regulator for contamination. If found, flush and refill system. See "Hydraulic Fluid Replacement" on page 7-111.
Broken/weak springs in Solenoids 34A/B	Replace or swap valves and see if symptoms change. If so, original solenoid valve is bad. See "Traverse Solenoid (SOL34 A/B)" on page 7-114.
Clogged mesh screen in Auxiliary Manifold	SA S/N > 02999, SB S/N > 00699: Remove and clean mesh screen.
S/N SA < 01095, SB < 00307	Install new check valve P/N 520-336/008, new auxiliary relief valve P/N 520-242/001, and new priority flow regulator P/N 521-807/115.

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Traverse - Intermittent Operation

Possible Cause	Action
Bad Traverse Control Potentiometer (VR4)	Run Test A06 – Traverse Control Potentiometer (VR4) Voltage (Page 6-102).
Bad SOL34A or SOL34B or coil driver	SA S/N < 03000, SB S/N < 00700: Run Test O19 – Load Handler Traverse Solenoid "A" (SOL34A) (Page 6-220) and Test O20 – Load Handler Traverse Solenoid "B" (SOL34B) (Page 6-222). Monitor current flow while tapping on coil body. SA S/N > 02999, SB S/N > 00699: Run Test O28 – Load Handler Traverse Solenoid "A" (SOL34A) (Page 6-237) and Test O29 – Load Handler Traverse Solenoid "B" (SOL34B) (Page 6-239).
Binding or deformed traverse rack	Replace traverse rack.
Binding Traverse Motor	Replace Traverse Motor. See "Traverse Motor" on page 7-114.

Traverse - Noisy

Possible Cause	Action
Misaligned, damaged, or worn rack assembly	Check rack assembly and alignment to carriage. Replace rack if necessary.
Worn traverse shaft gear	See "Traverse Gear Shaft" on page 7-168.
Worn traverse follower bearings	Replace bearings. Reference "Traverse Gear Shaft" on page 7-168.

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Traverse - Slow Operation

Possible Cause	Action
Mechanical binding in traverse rack or motor	Replace as required.
Incorrectly "Learned" Controls	Run Learn Controls. See "Using Learn Mode" on page 6-16.
Bad Traverse Control Potentiometer	Run Test A06 – Traverse Control Potentiometer (VR4) Voltage (Page 6-102).
Bad Auxiliary Motor Controller	Run Test O25 – Aux Motor Control Enable (with Aux Control Card) (Page 6-231) and Test O26 – Aux Motor Controller PWM (with Aux Control Card) (Page 6-234).
Incorrect auxiliary pressure relief setting	Adjust pressure. See "Auxiliary System Pressure Adjustment" on page 7-127.
Incorrectly adjusted or bad Flow Regulator	Adjust regulator. Replace if traverse cannot be adjusted to spec. See "Flow Regulator Adjustment" on page 7-128.
Contamination in hydraulic system	Inspect Traverse Solenoids 34A/B or Traverse Flow Regulator for contamination. If found, flush and refill system. See "Hydraulic Fluid Replacement" on page 7-111.
Bad SOL34A/B valves	Replace or swap valves and see if symptoms change. If so, original solenoid valve is bad. See "Traverse Solenoid (SOL34 A/B)" on page 7-114.
Bad Auxiliary Pump	Check pressure. See "Auxiliary System Pressure Adjustment" on page 7-127.

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Rotate

Rotate - Erratic Operation

Possible Cause	Action
Mechanical binding in Rotate Actuator	Check the Rotate Actuator and replace if necessary. See “Rotate Actuator” on page 7-114.
Bad Rotate Position Feedback Potentiometer or wiring	Run Test A28 ¥ — Rotate Position Potentiometer (VR6) Voltage (Page 6-125).
Incorrectly “Learned” Controls	Run Learn Controls. “Using Learn Mode” on page 6-16.
Bad Rotate Control Potentiometer or wiring	Run Test A09 – Rotate Control Potentiometer (VR3) Voltage (Page 6-106).
Bad Fork Control Solenoid coil or driver	Run Test O21 – Fork Control Solenoid “B” (SOL35B) (Page 6-224) and Test O22 – Fork Control Solenoid “A” (SOL35A) (Page 6-226). See “Fork Control Solenoid (SOL35 A/B)” on page 7-111.
Contamination in hydraulic system	Inspect Fork Control Solenoids 35A/B for contamination. If found, flush and refill system. See “Hydraulic Fluid Replacement” on page 7-111.
Incorrect or missing orifices in Rotate Actuator elbow fittings	Examine, replace as necessary.
S/N SA < 01095, SB < 00307	Install new check valve P/N 520-336/008, new auxiliary relief valve P/N 520-242/001, and new priority flow regulator P/N 521-807/115.

Rotate - Intermittent Operation

Possible Cause	Action
Bad SOL35A or SOL35B or coil driver	Run Test O21 – Fork Control Solenoid “B” (SOL35B) (Page 6-224) and Test O22 – Fork Control Solenoid “A” (SOL35A) (Page 6-226). Monitor current flow while tapping on coil body.
Bad Reach Position Proximity Sensor (PROX2) or wiring	Run Test I10 ¥ – Reach Position Proximity Sensor (PROX2) (Page 6-155) in Active Diagnostic Mode. Tap lightly on the sensor to see if condition changes.
Mechanical binding in Rotate Actuator	Replace the Rotate Actuator. See “Rotate Actuator” on page 7-114.

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Rotate - Slow Operation

Possible Cause	Action
Mechanical binding in load handler	Replace parts as required.
Incorrectly "Learned" Controls	Run Learn Controls. See "Using Learn Mode" on page 6-16.
Bad Rotate Control Pot	Run Test A09 – Rotate Control Potentiometer (VR3) Voltage (Page 6-106).
Bad Auxiliary Motor Controller	Run Test O25 – Aux Motor Control Enable (with Aux Control Card) (Page 6-231) and Test O26 – Aux Motor Controller PWM (with Aux Control Card) (Page 6-234).
Incorrect auxiliary pressure relief setting **NOTE:** Incorrect pressure relief would likely also affect reach and traverse functions.	Adjust pressure. See "Auxiliary System Pressure Adjustment" on page 7-127.
Bad Solenoid 35A/B valves	Replace or swap valves and see if symptoms change. If so, original solenoid valve is bad. See "Fork Control Solenoid (SOL35 A/B)" on page 7-111.
Bad Auxiliary Pump	Check pressure. See "Auxiliary System Pressure Adjustment" on page 7-127.
Contamination in hydraulic system	Inspect Fork Control Solenoids 35A/B for contamination. If found, flush and refill system. See "Hydraulic Fluid Replacement" on page 7-111.

Rotate - Noisy Operation

Possible Cause	Action
Worn, damaged, or misaligned Rotate Carriage lower bearing	Replace bearing.
Bad Rotate Actuator	Replace Rotate Actuator. See "Rotate Actuator" on page 7-114.

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Rotate - One Direction Only

Possible Cause	Action
Mechanical binding or bad Rotate Actuator	Replace rotate actuator.
Bad SOL35A/B	Run Test O21 – Fork Control Solenoid "B" (SOL35B) (Page 6-224) and Test O22 – Fork Control Solenoid "A" (SOL35A) (Page 6-226).

Reach

Reach - Erratic Operation

Possible Cause	Action
Damaged or worn Reach Cylinder	Replace Reach Cylinder. See "Reach Cylinder" on page 7-113.
Bad Rotate Position Potentiometer or wiring	Run Test A28 ¥ — Rotate Position Potentiometer (VR6) Voltage (Page 6-125) in Active Diagnostic Mode.
Worn scissors bearings or deformed scissors assembly	Replace bearings or repair/replace scissors assembly.
Bad SOL33	Run Test O30 – Proportional Reach/Rotate Solenoid (SOL33) (Page 6-241).
Bad SOL35A/B	Run Test O21 – Fork Control Solenoid "B" (SOL35B) (Page 6-224) and Test O22 – Fork Control Solenoid "A" (SOL35A) (Page 6-226).

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Reach - Intermittent Operation

Possible Cause	Action
Bad Rotate Position Potentiometer or wiring	Run Test A28 ¥ — Rotate Position Potentiometer (VR6) Voltage (Page 6-125) in Active Diagnostic Mode.
Bad Reach Solenoid SOL36	Run Test O23 – Reach Solenoid (SOL36) (Page 6-228).
Excessive play in the reach mechanism, due to mechanical wear/deformation	Repair/replace components as necessary.
Contamination in hydraulic system	Inspect Reach Solenoid 36 for contamination. If found, flush and refill system. See "Hydraulic Fluid Replacement" on page 7-111.
Bad SOL33	Run Test O30 – Proportional Reach/Rotate Solenoid (SOL33) (Page 6-241).
Bad SOL35A/B	Run Test O21 – Fork Control Solenoid "B" (SOL35B) (Page 6-224) and Test O22 – Fork Control Solenoid "A" (SOL35A) (Page 6-226).

Reach - Noisy or Slow Operation

Possible Cause	Action
Damaged or worn Reach Cylinder	Replace Reach Cylinder. See "Reach Cylinder" on page 7-113.
Worn scissors bearings or deformed scissors assembly	Replace bearings or repair/replace scissors assembly.
Additional symptoms	See "Reach - Slow Operation" on page 5-40.

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Reach - Slow Operation

Possible Cause	Action
Contamination in hydraulic system	Inspect Reach Solenoid SOL36 for contamination. If found, flush and refill system. See "Hydraulic Fluid Replacement" on page 7-111.
Bad Solenoid 36 valve	Run Test O23 – Reach Solenoid (SOL36) (Page 6-228).
Bad Auxiliary Motor Controller or Auxiliary Motor	Run Test O25 – Aux Motor Control Enable (with Aux Control Card) (Page 6-231) and Test O26 – Aux Motor Controller PWM (with Aux Control Card) (Page 6-234).
Bad SOL33	Run Test O30 – Proportional Reach/Rotate Solenoid (SOL33) (Page 6-241).
Bad SOL35A/B	Run Test O21 – Fork Control Solenoid "B" (SOL35B) (Page 6-224) and Test O22 – Fork Control Solenoid "A" (SOL35A) (Page 6-226).

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Lift/Lower System

Lift Function

Slow Lift

Possible Cause	Action
Battery problems	Replace battery with fully-charged good battery.
Lift/Lower Potentiometer VR2	Run Test A04 – Lift/Lower Potentiometer (VR2) Voltage (Page 6-99).
Incorrect lift pressure adjustment	Check and adjust lift pressure setting. See "Lift Pressure Adjustment" on page 7-129.
Load Holding Solenoid SOL1 or SOL2 (would also cause load drift)	Main Lift: Run Test O06 – Toggle Main Load Holding Solenoid (SOL1) (Page 6-200). Mini Lift: Run Test O16 – Mini Load Holding Solenoid (SOL2) (Page 6-215).
Contamination in hydraulic system	Inspect solenoids for contamination. If found, flush and refill system. See "Hydraulic Fluid Replacement" on page 7-111.
Bad Lift/Lower SOL4	Run Test O12 – Lift/Lower Solenoid (SOL4) PWM Ramp (Page 6-209).
Bad Flow Control	Replace the Flow Control valves. See "Flow Control" on page 7-136.
Bad Lift Pump	Check pressure. See "Lift Pressure Adjustment" on page 7-129.
Bad Lift Motor	Test motor. See "DC Motor Troubleshooting" on page 5-15.

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Intermittent Lift

Possible Cause	Action
Lift/Lower Solenoid SOL4	Run Test O12 – Lift/Lower Solenoid (SOL4) PWM Ramp (Page 6-209). Follow procedure.
If problem occurs only with mini-mast, Lift Select Solenoid SOL3 could be intermittent.	Run Test O18 – Lift Select Solenoid (SOL3) (Page 6-218). Flex harness while running test to check for intermittent wires.
Intermittent Lift Select Switch	Run Test I02 – Lift Select Switch (S6) (Page 6-147).

Lower Function

Slow Lower

Possible Cause	Action
Lift/Lower Solenoid	Run Test O12 – Lift/Lower Solenoid (SOL4) PWM Ramp (Page 6-209). Follow test procedure.
Bad Flow Control	Replace the Flow Control valves. See “Flow Control” on page 7-136.
Load Holding Solenoid	Main Mast: Run Test O06 – Toggle Main Load Holding Solenoid (SOL1) (Page 6-200). Mini-Mast: Run Test O16 – Mini Load Holding Solenoid (SOL2) (Page 6-215).
Lift/Lower Potentiometer VR2	Run Test A04 – Lift/Lower Potentiometer (VR2) Voltage (Page 6-99). Follow procedure.
Mechanical binding in bearings or telescopic	Adjust or replace bearings.

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Intermittent Lower

Possible Cause	Action
Load Holding Solenoid	Main Mast: Run Test O06 – Toggle Main Load Holding Solenoid (SOL1) (Page 6-200). Mini-Mast: Run Test O16 – Mini Load Holding Solenoid (SOL2) (Page 6-215). Flex harness while running test to check for intermittent wires.
If problem occurs only with mini-mast, Lift Select Solenoid SOL3 could be intermittent.	Run Test O18 – Lift Select Solenoid (SOL3) (Page 6-218). Flex harness while running test to check for intermittent wires.
Intermittent Lift Select Switch	Run Test I02 – Lift Select Switch (S6) (Page 6-147).

Load Drifting/Settling

Possible Cause	Action
Leaking or contaminated Emergency Lower Valve	Inspect, clean, and flush, or replace as needed.
Leaking or contaminated Load Holding Solenoid SOL1 (Main) or SOL2 (Mini)	Main Lift: Run Test O06 – Toggle Main Load Holding Solenoid (SOL1) (Page 6-200). Mini Lift: Run Test O16 – Mini Load Holding Solenoid (SOL2) (Page 6-215).
If lift motor turns backwards as load settles, Load Holding Check Valve is leaking as well as Load Holding Solenoid SOL1 or SOL2.	Replace Load Holding Check Valve and Load Holding Solenoid SOL1 or SOL2.

Bouncy Lower

Possible Cause	Action
Faulty Proportional Lift/Lower Valve (SOL4)	Bleed and adjust the Lift/Lower Valve. See "Proportional Valve (SOL4) Adjustment" on page 7-126. If problem persists, replace Lift/Lower Valve. See "Lift/Lower Manifold Locations (later)" on page 7-115. See "Solenoids, General" on page 7-114. Then re-learn weight. See "Learn Weight" on page 6-18.

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Symptom Tables: Travel Problems

Slow or Sluggish Acceleration or Travel

Possible Cause	Action
Configuration set to soft acceleration	In Config Mode, set Travel Accel to Medium or Hard. See "Using Configure Mode" on page 6-7. See "Configure Mode Settings" on page 6-10.
NOTE: Determine if problem is configuration settings, mechanical, or electrical:	In Config Mode, set Coast to Long. Drive and coast to a stop. Compare coasting distance with a normally operating lift truck, if possible. If coasting distance is short, problem is mechanical.
Mechanical:	
Binding Drive Unit	Check amp draw.
Worn Load Wheel Bearings	Replace load wheel bearings.
Dragging brake	Adjust brake. See "Brake Adjustment" on page 7-74.
Electrical:	
Low battery	Install a fully charged battery.
Bad Drive Motor (might test OK with no load, but fail under load)	Run Test A01 – Armature Current Sense (Page 6-95), Test A14 – Field Current Sense (Page 6-111).
Speed is limited due to Drive Motor or Power Panel temperature or bad temperature sensor	Run Test A02 – Power Panel Temperature Sensor Voltage (Page 6-96) and Test A15 – Drive Motor Temperature Sensor (DT) (Page 6-112).
Bad Speed Feedback Proximity Sensor	Run Test I29 – Speed Feedback Proximity Sensor, Channel A (Page 6-174) and Test I30 – Speed Feedback Proximity Sensor, Channel B (Page 6-175). See "Speed Feedback Proximity Sensor" on page 7-64.
Bad plugging contactor or coil	Run Test O03 – Toggle the Plugging Contactor (Page 6-197).
Short circuit from traction heat sink to frame	See "Shorts to Frame Test" on page 5-4.
Throttle Potentiometer problem	Run Test A03 – Throttle Pot Voltage (VR1) (Page 6-98).

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Uneven Travel Speed

Possible Cause	Action
NOTE: First determine if the problem is mechanical or electrical.	In Config Mode, set Coast to Long. Drive to 4 mph (6.5 km/hr) and coast to a stop. If the lift truck deceleration is not smooth or lift truck drags as it coasts, the problem is mechanical.
Mechanical:	
Binding Drive Unit	Replace Drive Unit. See "Drive Unit" on page 7-64.
Electrical:	
Bad Drive Motor armature or field circuit	Run Test O13 – Field PWM Ramp (Page 6-211) and Test O14 – Armature PWM Ramp (Page 6-213). If OK, monitor motor voltage while driving. If voltage variations match unevenness in lift truck speed, there is a control problem with Run Mode.
Throttle Potentiometer problem	Run Test A03 – Throttle Pot Voltage (VR1) (Page 6-98) in Active Diagnostic Mode.
Problem with Speed Feedback Proximity Sensor	Run Test I05 – Speed Feedback Proximity Sensor (Page 6-150).

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Symptom Tables: Electrical Problems

Electrical Motors

Motor Overheating

Possible Cause	Action
Wrong motor for lift truck	Verify correct motor for lift truck.
Application exceeds designed workload -- short runs with plugging/acceleration or heavy-duty lifting cycles	Refer to service manager for evaluation.
Bad battery	Check voltage, both open circuit and under load. Replace if necessary with fully-charged good battery.
Corroded or damaged battery connector tips	Inspect battery connector. See “Battery Connector” on page 7-86.
Incorrect BSOC Cutout value	Check battery specific gravity at cutout, after battery has stabilized. Compare to battery manufacturer specifications for discharged battery. Adjust BSOC Cutout as needed. See “BSOC/Key Settings” on page 6-13.
Clogged motor vents	Check and clear motor vent openings.
Heat stressed cables: Look for discolored terminals, drawn insulation, and hard spots and bulges.	Replace power cables.
Plugging contactor not dropping out; worn or pitted plugging contactor tips	Inspect the plugging contactor tips. Replace tips as necessary. Test Plugging Contactor operation. Run Test O03 – Toggle the Plugging Contactor (Page 6-197).
Corroded plugging resistor	Inspect plugging resistor for corrosion. Replace as needed. See “Plugging Resistor” on page 7-64.
Incorrect use of deadman pedal instead of plugging to stop	Instruct operator in correct stopping procedures.
Drive Motor Armature Current problem	Run Test A01 – Armature Current Sense (Page 6-95). Follow procedure.
Worn, damaged, or bad brushes or springs	Inspect motor brushes. Check brush spring tension. See “Motor Brush Spring Tension” on page 4-12.

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Possible Cause	Action
Binding gearbox or pump	Check gearbox or pump for binding. Clean, repair, or replace as necessary.
Dragging brake	Adjust brake. See “Brake Adjustment” on page 7-74.
Incorrectly adjusted steer centering on a rail guided lift truck	See “Steer Home Proximity Sensor” on page 7-43.

Motor Arcing

Possible Cause	Action
Worn brushes or incorrect brush tension	Replace brushes and/or brush springs. See “Motor Brushes” on page 4-11. See “Motor Brush Spring Tension” on page 4-12.
Rough or pitted motor commutator	Refer to motor rebuild facility. Replace motor.

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BSOC Problems

BSOC Reset or Cutout Does Not Occur

Possible Cause	Action
Incorrect BSOC Cutout value	Check battery specific gravity at cutout, after battery has stabilized. Compare to battery manufacturer specifications for discharged battery. Adjust BSOC Cutout as needed. See "BSOC/Key Settings" on page 6-13. For an explanation of BSOC, see "Battery State-of-Charge Theory".

Battery State-of-Charge Theory

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

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

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

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

The criteria are determined in this way:

1. BSOC compares the charge of the battery that was connected to the lift truck with the replacement battery's charge. A charge difference of at least 50% between the two batteries resets BSOC to show the state-of-charge of the replacement battery, that is, the measured state-of-charge of the replacement battery minus the remembered state-of-charge of the old battery must equal or exceed 50%. This reset can be higher or lower than the old battery.
   a. *Example 1*: A battery in the lift truck is at 10% charge; the replacement battery is at 95%. With more than a 50% difference in the charge levels, BSOC resets the Operator Display to show the replacement battery's charge.
   b. *Example 2*: A battery in the lift truck is at 20% charge and lift cutout has not occurred. The replacement battery has a state-of-charge equal to 50%. Because the difference is only 30%, the display will remain at 20% until the replacement battery has discharged to 20%. Then the display will begin counting down.
   c. *Example 3*: A battery in the lift truck is at 20% charge and lift cutout has occurred. The replacement battery has a state-of-charge equal to 50%. Because the difference is only 30%, the display will remain at 20% and lift cutout will remain in effect until a battery with a charge of at least 70% and a state-of-charge exceeding the configured BSOC setting is installed in the lift truck.
2. BSOC looks at the configured reset point. BSOC reset is programmable from 55% to

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100% of total battery charge and can be changed by entering the Configure Mode using Superword. The replacement battery must be 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 Operator Display. Older batteries or applications providing inadequate charging time could require a lower configured value for BSOC since older batteries might be unable to reach a higher percent charge. Therefore, some batteries could require BSOC configured as low as 55% before lift cutout will reset and the Operator Display shows the charge of the replacement battery.

The following example describes installing a replacement battery when the Operator Display does not reset. Assume the following:

- BSOC configured at 95%, the battery connected is at 45% charge, and the replacement battery is at 92% charge.

Since the replacement battery charge has not changed by at least 50% and the state-of-charge of the replacement battery is not greater than the BSOC reset configured value, the Operator Display continues to show the old battery's charge of 45% (even though the replacement battery is at 92%). What occurs is that the Operator Display remains at 45% until the charge of the replacement battery declines to 45%. Then the display resumes its normal descent.

One final example. Assume the following:

- BSOC configured at 95%, the battery connected is at 65% charge, and the replacement battery is at 20% charge.

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

Setting Battery State-of-Charge Cutout

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

BSOC and Sealed or Maintenance-free Batteries

BSOC (Battery State-of-Charge) could give inaccurate readings when certain types of sealed or maintenance-free batteries are used. As a result, trucks using these batteries could generate low-voltage error codes and shut down before BSOC readings drop low enough to cut out lift or warn the operator to change the battery.

Gelled Electrolyte

Batteries that use the gelled electrolyte design demonstrate similar discharge characteristics to equivalent capacity flooded cell batteries. *The use of gelled electrolyte batteries does not require a change in BSOC setting.*

Absorbed Glass Mat (AGM)

Batteries that use either the AGM design or a combination of AGM and gelled electrolyte have significantly different discharge characteristics from equivalent capacity flooded cell batteries. Batteries using AGM design have a higher sustained voltage during discharge than an equivalent capacity flooded cell battery. To compensate for this difference, *set the BSOC lift*

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cut-out to 10% to 20% higher than that which would be used for a flooded cell battery in this application.

Mixed Types

On lift trucks where both AGM or AGM/gelled electrolyte batteries and flooded batteries are used, use the compensated BSOC setting. Although this results in “early” BSOC cut-out when using flooded cell batteries, this might be preferable to damage and/or warranty exclusion as a result of over-discharging the sealed or maintenance-free battery.

Operator Display Problems

Scrambled or Intermittent Display

Possible Cause	Action
Loose harness or card connectors	Reseat cards and harness connections.
Intermittent wires or connectors in harness	Test for continuity while flexing harness. If discontinuity is found, replace wiring harness.
Bad Operator Display Card or Operator Display Interface Card	Run Test O09 – Display Lights (Page 6-205). Follow procedure.

Operator Display Dark or Inoperative, Truck Runs

Possible Cause	Action
Bad Operator Display Card or Operator Display Interface Card	Run Test O09 – Display Lights (Page 6-205). Follow procedure.

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Display is Dark; Lift Truck is *not* Operational

Step	Check	If OK	If *not* OK
1	Check battery voltage between PC2-1 (+) and TP4 (–).	Go to step 2.	Check connection. Replace battery.
2	Check battery voltage between JPS14-12 and 13 (+) wrt JPS14-3 and 4 (–).	Go to step 3.	Troubleshoot wiring.
3	Remove and test FU13 and FU14.	Go to step 4.	Replace fuse(s). Check wiring for shorts.
4	Measure voltage at FU14 wrt FU13.	Go to step 5.	Replace Tractor Manager.
5	Measure voltage at JPS26-8 (+) wrt JPS25-6 (–).	Go to step 6.	Replace Tractor Manager.
6	Remove and test FU2 in Line Filter 1.	Go to step 7.	Replace fuse. Check wiring for shorts.
7	Measure voltage at B+FILT_F2 (+) wrt TP4 (–).	Go to step 8.	Replace line filter.
8	Measure voltage at JPC20-5 (+) wrt JPC17-6 (–).	Go to step 9.	Troubleshoot Over-the-Mast Cable.
9	Measure voltage at JPC15-1 (+) wrt JPC17-6 (–).	Go to step 10.	Replace the Carriage Manager.
10	Measure voltage at JPC15-5 (+) wrt JPC17-6 (–) with Key Switch ON	Go to step 11.	Troubleshoot wiring and Key Switch.
11	Measure voltage at JPC14-6 (+) wrt JPC14-1 (–).	Go to step 12.	Replace the Carriage Manager.
12	Measure Carriage Manager Power Supply voltages.		Troubleshoot using Diagnosis and Repair chart for Test A12. See "Test A12 – CM Power Supply" on page 6-110.

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Fuses Blow During SelfTest

Possible Cause	Action
Short circuit	Check circuit for shorts. Isolate circuits and components on the fuse. Disconnect circuits one at a time until the short is eliminated. Check motors, heatsinks, cables and harnesses for shorts.

Control Fuses Blow when Battery Connector is Plugged In

Possible Cause	Action
Short circuit	Isolate circuits supplied by B+ and B+F. Check for shorts from both sides of FU14 to Tractor Manager TP4. Disconnect circuits one at a time until the short is eliminated.

Control Fuse Blows When Key Switch is Turned ON

Possible Cause	Action
Short circuit in B+ KEY circuitry	Replace the fuse, depress the EPO knob, and cycle the key switch. If fuse holds, check for short circuit in EPO circuitry. If fuse blows, isolate and troubleshoot those circuits powered by B+KEY.
Short in TM or CM related circuit	Disconnect B+KEY at JP39-1 near the line filter. If fuse still blows, problem is Carriage Manager related; if not, Tractor Manager related. Reconnect JP39-1
Short in Tractor Manager related circuit	Disconnect circuits powered by B+KEY and check for shorts: Horn/Horn Suppressor Warning Light Power Card Carriage Manager
Short in Carriage Manager related circuit	Disconnect circuits powered by B+KEY and check for shorts.

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Line Filter Fuse Blows during Plugging and Lifting

Possible Cause	Action
Low battery	Check battery condition. Check BSOC cutout configuration setting. See "BSOC/Key Settings" on page 6-13.

Shorts to Frame

Possible Cause	Action
	See "Shorts to Frame Test" on page 5-4.

Voltage to Frame

Possible Cause	Action
	See "Shorts to Frame Test" on page 5-4.

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RAYMOND

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Section 6. Messages, Codes, and Tests

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Firmware Changes

Table 6-1 summarize version changes in the EASi *Swing-Reach*® lift truck Tractor Manager, Carriage Manager, and Steer Manager firmware. The table does not discuss details of engineering changes contained in these versions.

Table 6-1. Firmware Version Changes

Date	CM ver	TM ver	SM ver	Changes
	1.17	1.11		Slack Chain Support, Code 1K, Test I45
4 Mar 1999	1.19	1.11		Config menu item Regional Settings added; Tests A39, A40 added; Display Configuration download procedure changed
21 Jun 1999	1.22	1.12		Code AL added; Guidance Type set by FIC not Config; Config Version shows truck S/N
28 Feb 2000	1.23	1.13	01.1	Improve drive motor efficiency, load handler response
16 Jun 2000	1.25	1.15	01.2	Delete Tests A27, A34, A39, A40; improve Learn Steer function
9 Nov 2000	1.27	1.17	01.2	Improved EOA slowdown; Code J1 obsolete
15 May 2001	1.28	1.18	01.3	Learn weight algorithm changed; auto steer center recalibrate; decreased delay in slow L/L; Code 29 changes
14 Aug 2001	1.29	1.20	01.3	End-of-Aisle changes; SMART*i* correction; nuisance Code 53
1 Mar 2002	2.01	2.01	02.0	Code 29 changes; DmpVlv added to Config menu; 4-sensor End-of-Aisle support
31 Oct 2002	2.04	2.01	02.0	SA S/N < 03000, SB S/N < 00700 only: New Code 6C
12 Sep 2002	3.03	3.01	02.1	SA S/N > 02999, SB S/N > 00699 only: New SM/VFC microprocessor support
23 Sep 2002	3.04	3.01	02.1	SA S/N > 02999, SB S/N > 00699 only: Learn carriage improvements; default carriage width 56 in.
1 Apr 2003	3.05	3.03	02.1	SA S/N > 02999, SB > 00699 only: New Code 6C
23 Jul 2003	4.01	4.01	02.1	S/N All: Add Codes FX and FP
13 Nov 2003	4.02	4.01	02.2	Code B3 deleted; unnested travel speed option support
14 Jun 2004	4.03	4.02	02.2	New wire guidance config parameters FRMaxSpd and WrSnCrp
5 Mar 2007	4.05	4.04	02.6	Code 8C changed; Code 8F added

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Table 6-1. Firmware Version Changes

Date	CM ver	TM ver	SM ver	Changes
7 Jun 2007	4.08	4.05	02.6	Code 42; Config menu item Traverse added (must be set disabled on trucks with Aux Contactor

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Modes of Operation

Overview of Modes

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

Run Mode

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

The lift truck also enters Run Mode when it exits Program Mode.

Program Mode

Use Program Mode for configuration, calibration, and diagnostic testing on the lift truck. You need a password in order to enter Program Mode. See “Passwords.”

Program Mode is divided into three categories:

- Configure Mode
- Learn Mode
- Diagnostic Mode

Configure Mode

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

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

For detailed description, see page 6-7.

Learn Mode

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

- Controls (travel, traverse, lift/lower, rotate)
- Carriage (traverse and rotate)
- Weight
- Steering (minimum power, rate, position)
- Wire Frequency (for non-standard wire guidance frequency)
- Wire guidance offsets (guide wire centering)

To enter Learn Mode, you must enter the Superword.

For detailed description, see page 6-16.

Diagnostic Mode

Use Diagnostic Mode to test, cycle, and troubleshoot individual electrical circuits related to the *intellidrive*® and *intelliguide*™ systems. Diagnostic Mode is divided into three categories:

- Static
- Dynamic
- Active

To enter Diagnostic Mode, you must enter the Superword.

For detailed descriptions, see pages 6-20 through 6-22.

Passwords

Electronic Operator Key

Electronic Operator Key is a configurable software feature that permits the customer to set an operator electronic key or operator password. With Operator Key enabled, when the operator turns the key switch ON, the software prompts the operator to enter the

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electronic key. The lift truck does not enter Run Mode unless the correct electronic key is entered.

Password

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

Superword

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

We *strongly* recommend that, during installation, you change the Superword from the factory default to a code known only to the dealer and/or owner so that access to Diagnostic Mode is limited to qualified personnel. Make sure to record the new Superword in a safe place. If this code is lost or forgotten, a technician will need to reset the lift truck to factory default settings. This will make necessary the reconfiguration of all variable settings.

Run Mode Tones

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

1. A single tone (chirp) occurs when:
   - a key on the operator keypad (up/down/left/right/enter) is depressed
   - maximum steer request is reached
2. A double tone (high/low) means the system has detected a fault condition.
   - PC1 and PC2 contactors are de-energized (open). Travel, steering, lift/lower, and load handling functions are disabled and the brake is applied.
3. A triple tone (high/medium/low) means one of the following:
   - Travel performance limitation: The lift truck is limited to a maximum travel speed of 1 mph (1.6 km/hr). Lift, lower, load handler functions, steering, and horn are all enabled.
   - Traction system shutdown: The lift truck is disabled for travel. Lift, lower, load handler functions, steering, and horn are all enabled.
   - Lift system shutdown: The lift truck is not permitted to lift. Lower, travel, load handler functions, steering, and horn are all enabled.
   - Lower system shutdown. The lift truck is not permitted to lower. Travel, lift, load handler functions, steering, and horn are all enabled.
   - Load handler shutdown. The lift truck is not permitted to traverse, rotate, or reach. Travel, lift, lower, steering, and horn are all enabled.
4. Continuous tone with deadman pedal depressed and Auto/Manual switch in Manual means either:
   - the lift truck is over the guide wire
   - the lift truck is in contact with the guide rail (rail switch closed)
5. A tone that ramps up then repeats (“red alert”) indicates either:
   - the lift truck is seeking and aligning over the guide wire. The tone continues until the lift truck is locked onto the guide wire signal or the Auto/Manual switch is changed to Manual.
   - the lift truck is seeking the guide rail. The tone continues until the lift truck contacts the guide rail (rail switch closes) or the Auto/Manual switch is changed to Manual.
6. An “arcade” tone indicates:
   - An incorrect password or electronic key was entered.
7. CM ver. 1.29/TM ver. 1.20 and above: A triple tone (low/high/low) indicates wire guidance has detected a change in aisle position, normally as the truck passed over end-of-aisle sensor magnets.

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8. CM ver. 1.29/TM ver. 1.20 and above: A double tone (low/high or high/low) ("European style police siren") sounds when the lift truck is in the wire guided aisle with the Auto/Manual switch in Manual.

Entering Program Mode

You can use any of three methods for entering Program Mode:

First Method:

1. With the key switch OFF, press and hold the **horn** button with your right thumb and using your right index finger, move the **lift/lower** control to full lift.
2. With your other hand, turn the key switch ON.

Second Method:

1. With the key switch OFF, press and hold the **enter** and **down** buttons at the same time.
2. Turn the key switch ON.

Third Method:

1. With the lift truck in Run Mode, press and hold the **enter** button.
2. Press buttons in the following order: **up, down, down, down, up**. Then release the **enter** button.

You see a message and prompt on the Operator Display that says:

RESTRICTED MENU

ENTER PASSWORD

_ _ _ _ _ _ _ _

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

Entering an Electronic Operator Key, Password, or Superword

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

1. When the password prompt displays, an eight character field of underscores appears. Initially, the left-most character position is flashing, showing it is the currently selected position.
2. Use the **left/right** buttons to select a different character position.
3. Once you select the character position, use the **up/down** buttons to select the number, letter, or space you want. The character set wraps between "z" and "_" (space). In other words, to go quickly from the letter "z" to the number "0," press the **down** button twice.

   -0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ
4. Repeat steps 2 and 3 for the remaining characters in the Electronic Key, Password, or Superword.
5. When you have completed entering all the characters in the Electronic Key, Password, or Superword, press the **enter** button once.
6. If you enter an invalid Electronic Key, Password, or Superword, an "arcade" tone sounds and the following message appears for 3 seconds on the Operator Display before returning to the password prompt screen:

   PASSWORD ERROR

   TRY AGAIN
7. If you make a mistake while entering a character, repeat steps 2 through 5.

When you enter the correct Electronic Operator Key, the lift truck completes SelfTest and enters Run Mode.

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When you enter the correct Password or Superword, you see one of the following displays for 3 seconds:

1. If you entered the Password, you see:

   WELCOME TO THE
   CONFIGURATION MENU
   PASSWORD LEVEL

2. If you entered the Superword, you see:

   WELCOME TO THE
   CONFIGURATION MENU
   SUPERWORD LEVEL

   You then see the Program Mode Superword Level menu:

   >LEARN
   CONFIGURE
   DIAGNOSTICS
   QUIT

To change Password or Superword

1. Enter Configure Mode using the current Password or Superword. See "Using Configure Mode" on page 6-7. If Password is entered, Password is available for change, but Superword is not.
2. Scroll to the **BSOC/KEY SETTINGS** group.
3. Select **OPER KEY**, **PASSWORD**, or **SUPERWORD** and press the **enter** button. (If Password was entered in step 1 above, Password is available for change, but Superword is not.)
4. Enter the new password as described under "Entering an Electronic Operator Key, Password, or Superword".
5. With the new password displayed, press the **enter** button.
6. Save the new password as described under "To save new values" on page 6-8.

Using Configure Mode

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

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

"Configure Mode Settings" on page 6-10 lists all possible lift truck configurations and options. If your lift truck does not have one or more of the listed options, those options do not appear in the Operator Display.

To place the lift truck in Configure Mode

1. Enter Program Mode by one of the three methods described on page 6-6.
2. Enter Password or Superword.
3. If you entered the Superword, the Operator Display shows the Program Mode Superword Level menu:

   >LEARN
   CONFIGURE
   DIAGNOSTICS
   QUIT

   Select **CONFIGURE**; press the **enter** button. (The selected menu item is indicated by an arrow to the left of the selection.)

To configure an item

1. Configuration items are arranged in groups, which appear in the following order:
   - Travel Settings
   - Lift/Lower Settings
   - Guidance Settings
   - BSOC/Key Settings
   - Regional Settings (CM ver 1.19 and above)
   - Miscellaneous Settings
2. Within a group, items appear in two columns. Use the **up/down** and **left/right** buttons to move to item you want.
   a. For example, from the first screen displayed, with **SPEED** selected, to select **SPDHGT_2**, press **right-down**.
   b. From **SPEED**, to select **LIFT ACCEL**, press **right-right**. Notice that the **left/right** buttons scroll from one screen (group)

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to another as well as between columns on one screen.

3. To configure the selected item, press the **enter** button. Follow the directions on the Operator Display. Use **up/down** and **left/right** buttons to select among specified values or parameters. Use the **up/down** buttons to enter a numerical value.

   When you have entered the desired values, press the **enter** button. The Operator Display shows the group you last selected.

NOTE: Changes are not saved until you exit Configure Mode and reply **YES** to the prompt.

To configure additional items

- After configuring the first item, press the **enter** button. From the group menu, navigate to the next item as described under "To configure an item."

If you make a mistake

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

To save new values

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

1. Use the **left/right** buttons to scroll through the group menus to the **MISCELLANEOUS SETTINGS** group **QUIT** item. Press the **enter** button.
2. The Operator Display shows the Save Changes menu:

   SAVE CONFIGURATION CHANGES?

   YES NO
3. Use the **left/right** buttons to select **YES**. Press the **enter** button. Your new values are saved.
4. If you entered from Password Level, the Operator Display shows the Exit Configuration menu:

   EXIT CONFIGURATION MENU?

   YES NO

   Select **YES** and press the **enter** button. The lift truck enters Run Mode, beginning with SelfTest diagnostics.
5. If you entered via Superword Level, the Operator Display shows the Program Mode Superword Level menu:

   LEARN

   CONFIGURE

   DIAGNOSTICS

   QUIT

   Select **QUIT** and press the **enter** button. The Operator Display shows the Exit Superword menu:

   EXIT SUPERWORD LEVEL

   YES NO

   Select **YES** and press the **enter** button. The lift truck enters Run Mode.

If you change your mind about making changes

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

1. Use the **left/right** buttons to scroll through the group menus to the **MISCELLANEOUS SETTINGS** group **QUIT** item. Press the **enter** button.
2. The Operator Display shows the Save Changes menu:

   SAVE CONFIGURATION CHANGES?

   YES NO
3. Use the **left/right** buttons to select **NO**. Press the **enter** button. Your new values are discarded.
4. If you entered from Password Level, the Operator Display shows the Exit Configuration menu:

   EXIT CONFIGURATION MENU?

   YES NO

   Select **YES** and press the **enter** button. The lift truck enters Run Mode, beginning with SelfTest diagnostics.

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5. If you entered via Superword Level, the Operator Display shows the Program Mode Superword Level menu:

   LEARN

   CONFIGURE

   DIAGNOSTICS

   QUIT

   Select **QUIT** and press the **enter** button. The Operator Display shows the Exit Superword menu:

   EXIT SUPERWORD LEVEL

   YES NO

   Select **YES** and press the enter button. The lift truck enters Run Mode.

To reinstate factory default settings

1. From the **MISCELLANEOUS SETTINGS** group, select **DEFAULTS** and press the **enter** button. Use the **left/right** buttons to select **YES**. Press the **enter** button.
2. Use the **left/right** buttons to scroll through the group menus to the **MISCELLANEOUS** group **QUIT** item. Press the **enter** button.
3. The Operator Display shows the Save Changes menu:

   SAVE CONFIGURATION CHANGES?

   YES NO
4. Use the **left/right** buttons to select **YES**. Press the **enter** button. Factory default settings are restored for all items except:
   - Electronic Key
   - Superword
   - Password
   - Wire Guidance Frequency
5. If you entered from Password Level, the Operator Display shows the Exit Configuration menu:

   EXIT CONFIGURATION MENU?

   YES NO

   Select **YES** and press the **enter** button. The lift truck enters Run Mode, beginning with SelfTest diagnostics.
6. If you entered via Superword Level, the Operator Display shows the Program Mode Superword Level menu:

   LEARN

   CONFIGURE

   DIAGNOSTICS

   QUIT

   Select **QUIT** and press the **enter** button. The Operator Display shows the Exit Superword menu:

   EXIT SUPERWORD LEVEL

   YES NO

   Select **YES** and press the **enter** button. The lift truck enters Run Mode.

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Configure Mode Settings

Configure Mode Menu		
NOTE: * Indicates Factory Default Shaded items are available only from the Superword menu structure. The Operator Display indicates the selected menu item by an arrow to the left of the selection		
Travel Settings		
Item	**Values**	**Description**
Speed	6.0	Maximum Travel Speed SA/SB: 0.0 to 6.0 mph SA/SB: 0.0 to 9.6 km/hr
Coast	Long * Medium Short	Coast Distance
Accel	Hard * Medium Soft	Travel Acceleration
FRMaxSpd [CM ver. 4.03 and above]	6.0	Free Ranging Maximum Speed: maximum speed when Auto/Manual Switch is in Manual, cannot exceed configured travel speed, visible only with Wire Guidance option
SpdHgt_1	514	Speed Limit at Height 1 0 to maximum height
	6.0 (SA/SB)	Speed Limit at Height 1 0 to maximum travel speed
SpdHgt_2	514	Speed Limit at Height 2 0 to maximum height (must be greater than or equal to setting 1)
	6.0 (SA/SB)	Speed Limit at Height 2 0 to maximum travel speed (must be less than or equal to setting 1)
Alarm	Disable Forward Reverse * Both	Travel Alarm Enable
EOA	1.0	End-of-Aisle Speed 0.1 to maximum travel speed

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Configure Mode Menu		
NOTE: * Indicates Factory Default Shaded items are available only from Superword menu structure. The Operator Display indicates the selected menu item by an arrow to the left of the selection		
Lift/Lower		
Item	**Values**	**Description**
Accel	Hard * Medium Soft	Lift Acceleration
Lift Bypass	Disable * Enable	Lift Bypass Enable
Lift Alarm	Disable * Enable	Lift Alarm Enable
DmpValve [CM ver 2.01 and above]	* Off On	Dump Valve SOL 99 not present Dump Valve SOL 99 present
Lower Decel	0 1 2 3 4 * 5	Lower Deceleration
Lower Inhibit	* 0	Lower Inhibit Height 3 to 18 inches (76 to 457 mm)
Lower Bypass	Disable * Enable	Lower Bypass Enable
Lower Alarm	Disable * Enable	Lower Alarm Enable

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Configure Mode Menu		
NOTE: * Indicates Factory Default Shaded items are available only from Superword menu structure. The Operator Display indicates the selected menu item by an arrow to the left of the selection		
Guidance Settings		
Item	**Values**	**Description**
Type	* Wire Rail	Guidance Type [CM ver < 1.19; CM 1.19 and above must use DTIC program to change]
Freq	5.2 KHz 6.25 KHz Other	Wire Guidance Frequency
Acquire	* 3.0	Acquire Guidance Tractor First Speed 1.0 to 3.0 mph
WrSnCrp [CM ver 4.03 and above]	* Disable Enable	Wire Sense Creep: When enabled, Auto/Manual switch in Manual, and wire is sensed, truck soft plugs to 1 mph and remains speed limited until wire is no longer sensed or Auto/Manual switch set to Auto.
DFW Slow	* 1.6 in	Guidance Distance from Wire - Slow 0.6 to 1.6 inches (15 to 40 mm)
DFW Stop	* 3.0 in	Guidance Distance from Wire - Stop 1.2 to 3.0 inches (30 to 76 mm)
HA Slow	* 1.6 deg	Guidance Heading Angle - Slow 0.6 to 2.0 degrees
HA Stop	* 3.0 deg	Guidance Heading Angle - Stop 2.0 to 4.0 degrees

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Configure Mode Menu		
NOTE: * Indicates Factory Default Shaded items are available only from Superword menu structure. The Operator Display indicates the selected menu item by an arrow to the left of the selection		
BSOC/Key Settings		
Item	**Values**	**Description**
Cut Out	* 20	Battery State-of-Charge Lift Cutout Value CM ver. < 1.28: 0 to 50% CM ver. > 1.27: 0 to 80% **NOTE:** Factory default setting is not necessarily the correct one for any particular application. Set cutout value to match battery manufacturer's specification for a discharged battery, as determined by specific gravity. See "Battery State-of-Charge Theory" on page 5-48.
Reset	* 85	Reset Battery State-of-Charge Value 55 to 100% **NOTE:** Factory default setting is not necessarily the correct one for any particular application. Set cutout value to match battery manufacturer's specification for a discharged battery, as determined by specific gravity. See "Battery State-of-Charge Theory" on page 5-48.
LH Width [CM ver. 3.04 and above] [CM 4.07 and above requires Superword]	* 56	Load Handler Carriage Width 40 to 80 in. **NOTE:** This value is not backed up. You must re-enter this value if the Carriage Manager is replaced.
LH Accel	Hard * Medium Soft	Load Handler Acceleration
Oper Key	Yes * No	Operator Key Change Password Prompt for electronic operator key. **NOTE:** Make Operator Key, Password, and Superword all unique. If you make the Electronic Key and Password the same, the lift truck recognizes only the Password. If you make the Electronic Key and Superword the same, the lift truck recognizes only the Electronic Key. If you make the Password and Superword the same, the lift truck recognizes only the Password.
Password	Yes * No	Change Password Prompt for password change. See note under Oper Key.
Super	Yes * No	Enter New Superword Prompt for superword change. See note under Oper Key.

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Configure Mode Menu		
NOTE: * Indicates Factory Default Shaded items are available only from Superword menu structure. The Operator Display indicates the selected menu item by an arrow to the left of the selection		
Traverse	Low Med Hi Enable Disable	[CM ver 4.08+] Set traverse speed. On lift trucks without Aux Contactor, must be set to disable.
Clock	* Time Date Quit	Set Time and Date [CM ver < 1.19; CM ver > 1.18 this parameter appears on the “Regional Settings” menu.]

Configure Mode Menu		
NOTE: * Indicates Factory Default Shaded items are available only from Superword menu structure. The Operator Display indicates the selected menu item by an arrow to the left of the selection		
Regional Settings [CM ver 1.19 and above only]		
Item	**Values**	**Description**
Units	* English Metric	Display Units [CM ver < 1.19 this parameter appears on the “Miscellaneous Settings” Menu.]
Clock	* Time Date Quit	Set Time and Date [CM ver < 1.19 this parameter appears on the “BSOC/Key Settings” menu.]
Time Fmt	AM/PM 24 hr	12- or 24-hour time format
Date Fmt	mm/dd/yy dd/mm/yy yy/mm/dd	Date format

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Configure Mode Menu		
NOTE: * Indicates Factory Default Shaded items are available only from Superword menu structure. The Operator Display indicates the selected menu item by an arrow to the left of the selection		
Miscellaneous Settings		
Item	**Values**	**Description**
Default	Yes * No	Restore all settings to Factory Default
Inform		Who to Inform for Service (Enter Name)
Pers ID		Who to Call for Service (Enter Phone Number)
SMART*i*®	* Disable Enable	SMART*i*® System activation/deactivation
Mnt Mind	* Disable Enable	*Maintenance Minder*™ tool
	* Setup/Reset Quit	*Maintenance Minder* tool
	* 200	*Maintenance Minder* Interval 50 to 500 Hours
	* Lift Cutout Message Only	*Maintenance Minder* Action
Auto Off	* Disable Enable	*Auto Power Off*™ device
	10 5 4 3 2 * 1	*Auto Power Off* Minutes
Version	 CM x.yy TM x.yy ESA xx.y TS xx.y AH MH SN xxxxx	Display Software Version: Carriage Manager Tractor Manager Electric Steer Manager Tractor Speed on Tractor Manager Mini-Mast Height Manager Main Mast Height Manager Serial Number [CM ver 1.22 and above only]
Brighten	Increase/Decrease/ Default	Set brightness of Operator Display [only with Operator Display Interface Card EPROM version 2005 or higher]
Quit		Exits Configure Menu

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Using Learn Mode

To place the lift truck in Learn Mode:

1. Release right-hand deadman pedal.
2. Enter Program Mode.
3. Enter Superword.
4. From the Program Mode Superword Level menu, use the **up/down** buttons to select **LEARN**, then press the **enter** button. The selected menu item is indicated by an arrow to the left of the selection.
5. You see the following Learn Mode menu:

   LEARN MODE

QUIT	**FREQ [IF "OTHER"]**
CONTROLS	**WGOFFSET**
CARRIAGE	
WEIGHT	
STEER	

   Use the **up/down** and/or **left/right** buttons to select the category desired, then press the **enter** button.

Learn Controls

Use Learn Controls to determine the neutral position of:

- VR1 travel control
- VR2 lift/lower control
- VR3 rotate control
- VR4 traverse control

When you select Learn Controls, the Operator Display shows:

DONE LEARNING

It takes only a moment to learn the controls because the firmware reads the neutral position of the controls. For this reason, controls must be left in neutral when you select Learn Controls. If controls are not in neutral, Learn Controls learns incorrect values, resulting in incorrect operation.

Learn Carriage

NOTE: TM/CM firmware versions > 3.00: LHWidth must be correctly configured in order for Learn Carriage to work correctly.

TM/CM firmware versions < 3.00:

Use Learn Carriage to determine the extreme positions of:

- VR5 traverse position feedback pot
- VR6 rotate position feedback pot

⚠CAUTION

Make sure there is sufficient room to traverse completely in both directions and to rotate fully in both directions at the nested load handler endpoints.

NOTE: You must start this procedure from either fully traversed and fully rotated position.

1. From the Learn Mode menu, select **CARRIAGE** and press the enter button. The Operator Display prompts:

   STEP ON DEADMAN TO START TEST

2. Step on *both* deadman pedals. The Operator Display prompts:

   MOVE TRAVERSE TO MAXIMUM AND RELEASE CONTROLLER

3. Use the Traverse Control to traverse, at full speed and uninterrupted, *completely* to one side. The Operator Display prompts:

   NOW TO OPPOSITE MAXIMUM AND RELEASE CONTROLLER

4. Use the Traverse Control to traverse, at full speed and uninterrupted, *completely* to the other side of the lift truck.
5. The Operator Display now prompts:

   MOVE ROTATE TO MAXIMUM AND RELEASE CONTROLLER

6. Use the Rotate Control to rotate the forks, at full speed and uninterrupted,

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completely to one side. The Operator Display prompts:

NOW TO OPPOSITE MAXIMUM AND RELEASE CONTROLLER

7. Use the Rotate Control to rotate the forks at full speed and uninterrupted, *completely* in the opposite direction.
8. When Learn Carriage is complete, the Operator Display shows the Learn menu.

The lift truck firmware records the direction of the request and movement of the load handler. When the firmware senses that the control has been released to neutral, it assumes that the load handler is nested at an endpoint. For this reason, if you let go of the control before the traverse or rotate has completed (nested position), Learn Carriage learns incorrect values, resulting in incorrect operation.

TM/CM firmware versions > 3.00:

Use Learn Carriage to determine the extreme positions of:

- VR5 traverse position feedback pot
- VR6 rotate position feedback pot

⚠CAUTION

Make sure there is sufficient room to traverse completely in both directions and to rotate fully in both directions at the nested load handler endpoints.

The fork carriage can be in any position before this procedure. After the initial prompt to step on the deadman pedal, the Learn Carriage function runs automatically without further operator prompt. The procedure requires approximately five minutes to complete.

1. From the Learn Mode menu, select **CARRIAGE** and press the **enter** button. The Operator Display shows:

   LEARNING LOAD HANDLER. FORKS WILL ROTATE AND TRAVERSE AUTOMATICALLY.

   The Operator Display scrolls:

   STEP ON DEADMAN TO START TEST

2. Step on *both* deadman pedals. During the learning process, the Operator Display scrolls:

   LEARNING. TO ABORT, STEP OFF DEADMAN.

3. The Operator Display shows:

   TRAVERSE LEFT

   If the carriage is not already nested left, it traverses left to the nested position.
   If the carriage is already nested left, it pushes against the stop for several seconds.

4. The Operator Display shows:

   TRAVERSE RIGHT

   The carriage traverses fully right and pauses for several seconds.

5. The Operator Display shows:

   TRAVERSE LEFT

   The carriage traverses fully left and pauses for several seconds.

6. The carriage then traverses right and left several times without pausing, while the traverse speed is adjusted.
7. The Operator Display shows:

   ROTATE LEFT

   If the forks are not already nested left, the forks rotate counterclockwise to the nested position.

   If the forks are already nested left, the load handler pushes against the stop for several seconds.

8. The Operator Display shows:

   ROTATE RIGHT

   The forks rotate fully clockwise and pause for several seconds.

9. The Operator Display shows:

   ROTATE LEFT

   The forks rotate fully counterclockwise and pause for several seconds.

10. The forks then rotate clockwise and counterclockwise several times without pausing, while the rotate speed is adjusted.
11. When learning is complete, the Operator Display shows:

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DONE LEARNING

The display returns to the Learn Mode Menu

12. If any measurements fall outside reference limits, or if at any time the operator steps off the deadman pedal, the Operator Display shows one of the following actions as the failing operation:

TRAVERSE LEFT SLOW

TRAVERSE LEFT FAST

TRAVERSE RIGHT SLOW

TRAVERSE RIGHT FAST

ROTATE LEFT SLOW

ROTATE LEFT FAST

ROTATE RIGHT SLOW

ROTATE RIGHT FAST

The Operator Display also scrolls:

UNABLE TO LEARN...PRESS ENTER TO CONTINUE

After the operator presses the **enter** button, the display returns to the Learn Mode Menu.

Learn Weight

Learn Weight stores a series of pressure readings used to calculate the weight during actual use when the main or mini-mast is lifting, lowering, or at rest:

- Lifting mini-mast
- Lifting main mast
- Pressure with forks and platform each elevated 48 in. (1.22 m).
- Lowering main mast
- Lowering mini-mast

⚠CAUTION

Make sure more than sufficient lifting height for the platform to elevate to 48 in. (1.22 m) and the forks to 96 in. (2.44 m).

1. From the Learn Menu, select **WEIGHT** and press the **enter** button. The Operator Display scrolls the following message:

CARRIAGE WILL AUTOMATICALLY LIFT/LOWER AUX AND MAIN MAST

2. After this message completes scrolling, the Operator Display prompts:

STEP ON DEADMAN TO START TEST

3. Step on *both* deadman pedals. The lift motor/pump immediately begins to run.

NOTE: When learning weight, lift off can be delayed, in order to learn the PWM (pulse width modulation) rate required by the Lift/Lower (proportional) Valve to initiate lift off. This results in decreasing the movement of the lift/lower control knob needed to gain lift off during Run Mode.

4. During the learning process, the following message is shown on the Operator Display:

LEARNING...TO ABORT, STEP OFF DEADMAN

5. Learn Weight causes the follow actions by the lift truck:
   - The load handler elevates 48 in. (1.22 m) and pauses.
   - The operator platform then elevates 48 in. (1.22 m) and pauses.
   - The load handler lowers completely.
   - The operator platform lowers completely.
6. If all parameters measured during Learn Weight are within reference limits, learning is successful and the Operator Display shows:

DONE LEARNING

7. If any measurements fall outside reference limits, or if at any time the operator steps off the deadman pedal, the Operator Display shows:

UNABLE TO LEARN...KEY OFF/ON, LOWER THEN REDO LEARN

8. If repeated attempts to Learn Weight fail, run the following tests:
   - Test A05 ¥ – Pressure Transducer, Main (Page 6-101)
   - Test A25 ¥ – Pressure Transducer, Mini (Page 6-122)

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Learn Steering

Use Learn Steering to learn minimum power to turn the drive unit and to achieve a predetermined steering rate reference value.

⚠ WARNING

Before beginning Learn Steering, elevate the drive tire off the floor. See "Jacking Safety" on page 2-11.

1. From the Learn Menu, select **STEERING** and press the **enter** button. The Operator Display scrolls the following message:

   JACK UP DRIVE UNIT AND BLOCK VEHICLE. READY?

2. After the lift truck is jacked and blocked, press the **enter** button. The Operator Display prompts:

   STEP ON DEADMAN TO START TEST

3. Step on the *right side* deadman pedal. The drive unit turns in both directions. Minimum power for steering the drive unit is recorded.
4. During the learning process, the following message is shown on the Operator Display:

   LEARNING...TO ABORT, PRESS ENTER.

5. If all parameters measured during Learn Steering are within reference limits, learning is successful and the Operator Display shows:

   DONE LEARNING

6. If any measurements fall outside reference limits, or if at any time the operator steps off the deadman pedal, the Operator Display shows:

   UNABLE TO LEARN...PRESS ENTER TO CONTINUE

7. If repeated attempts to Learn Steering fail, run the following tests:
   - Test I22 ¥ – Steer Position Feedback Encoder Count (Page 6-167)
   - Test I24 ¥ – Steer Home Proximity Sensor (Page 6-169)

Learn Wire Frequency

Learn Wire Frequency is required only if the wire frequency is configured to **OTHER.**

1. Verify that the line driver is correctly adjusted to the correct frequency and current amplitude.
2. Center the lift truck over the guide wire within ±0.5 inch (±13 mm).
3. From the Learn Menu, select **WIREFREQ** and press the **enter** button. The Operator Display prompts:

   CENTER OVER WIRE, THEN PRESS ENTER.

4. After the lift truck is centered over the guide wire, press the **enter** button. The Operator Display prompts:

   LEARNING GUIDE WIRE, TO ABORT PRESS ENTER

5. Be patient: the learning process takes several seconds.
6. When the frequency and amplitude of the guide wire has been learned, the Operator Display shows:

   DONE LEARNING GUIDE WIRE

7. Exit Learn Mode. Cycle the key switch OFF, then ON. Re-enter Learn Mode prior to learning wire guidance offsets.
8. If no valid frequency is found, or if at any time during the learning process, you press the **enter** button, the Operator Display shows:

   UNABLE TO LEARN...PRESS ENTER TO CONTINUE

9. If repeated attempts to Learn Wire Frequency fail, run the following tests:
   - Test A16 – Right Tractor Guidance Coil Voltage (Page 6-113)
   - Test A17 – Left Tractor Guidance Coil Voltage (Page 6-114)
   - Test A18 – Right Load Guidance Coil Voltage (Page 6-115)
   - Test A19 – Left Load Guidance Coil Voltage (Page 6-116)
   - Test A20 – Tractor Near Wire Coil Voltage (Page 6-117)

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- Test A21 – Load Near Wire Coil Voltage (Page 6-118)

Learn Wire Guidance Offsets

Guide wire offsets can be learned only when the lift truck is guiding over a guide wire that has the appropriate frequency and amplitude. Learn wire guidance offsets in the *tractor-first direction only*.

1. Verify that the line driver is correctly adjusted to the correct frequency and current amplitude.
2. Center the lift truck over the guide wire within ±0.5 inch (±13 mm).
3. Prior to learning wire guidance offsets, enter Configure Mode.
   a. Set **TRAVEL SETTINGS - COAST** to "long."
   b. Set the following Guidance Settings:
      - **FREQ** = frequency of line driver
        Select 5.2 for 5.2 kHz @ 100 ma/p/p.
        Select 6.25 for 6.25 kHz @ 225 ma/p/p.
        Select "Other" for any other frequency or amplitude.
      - **ACQUIRE** = 3 mph
      - **DFW SLOW** = 1.6 inches
      - **DFW STOP** = 3.0 inches
      - **HA SLOW** = 1.6 degrees
      - **HA STOP** = 3 degrees
4. From the Learn Menu, select **WGOFFSET** and press the **enter** button. The Operator Display prompts:

   PRESS AUTO/MANUAL SWITCH TO AUTO
5. Move the switch to **AUTO**. The Operator Display shows:

   DRIVE ON WIRE UNTIL STRAIGHT, THEN COAST, PRESS AUTO/MANUAL SWITCH TO MANUAL WHEN STOPPED

   Drive tractor-first at full speed for a minimum of 50 feet (15.25 m). Return throttle control to neutral and permit the lift truck to coast to a stop. After stopping, step off both deadman pedals and set the Auto/Manual switch to **MANUAL**.
6. If learning completes successfully, the Operator Display shows:

   DONE LEARNING OFFSETS
7. If at any time during the learning process, the operator presses the enter button, the Operator Display shows:

   UNABLE TO LEARN...PRESS ENTER TO CONTINUE
8. If repeated attempts to Learn Wire Guidance Offsets fail, run the following tests:
   - Test A16 – Right Tractor Guidance Coil Voltage (Page 6-113)
   - Test A17 – Left Tractor Guidance Coil Voltage (Page 6-114)
   - Test A18 – Right Load Guidance Coil Voltage (Page 6-115)
   - Test A19 – Left Load Guidance Coil Voltage (Page 6-116)
   - Test A20 – Tractor Near Wire Coil Voltage (Page 6-117)
   - Test A21 – Load Near Wire Coil Voltage (Page 6-118)

Diagnostic Mode

Diagnostic Mode is divided into three categories:

- Static
- Dynamic
- Active

Using Static Diagnostic Mode

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

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⚠ WARNING

By entering static diagnostic mode, you are disabling the safety circuits associated with the intellidrive system. Therefore, you must take extra precautions while in static diagnostic mode. Follow all instructions in this manual for each test. If you are unsure how to conduct a test while in diagnostic mode, *stop: do not proceed* with the test. Contact an authorized Raymond dealer.

⚠ WARNING

While in static diagnostic mode: Elevate the drive tire off the floor. See "Jacking Safety" on page 2-11. Open the Emergency Lowering Valve. See "Emergency Lowering Valve" on page 7-110.

To place the lift truck in static diagnostic mode

1. Enter Program Mode.
2. Enter Superword.
3. From the Program Mode Superword Level menu, use the **up/down** buttons to select **DIAGNOSTICS**, then press the **enter** button. The selected menu item is indicated by an arrow to the left of the selection.
4. You see the following Diagnostic Mode menu:

   DIAGNOSTICS MENU

   >QUIT

   ANALOG

   INPUT

   OUTPUT

   History

   Clr Act M [only if tests are selected for active diagnostics]

   Use the **up/down** buttons to select the test category desired, then press the **enter** button.
5. If you select **OUTPUT** tests, the Operator Display prompts you to jack the drive wheel off the floor and to open the emergency lowering valve.
6. Within a test category, tests numbers are displayed, in numerical sequence, in columns of five. The Operator Display can show two columns of five tests at a time. Use the **up/down** and **left/right** buttons to move to the desired test.
   a. For example, to select Test A08, press **right-down-down-down-down**.
   b. From A00, to select A10, press **right-right**. Notice that the **left/right** buttons scroll from one screen to another as well as between columns on one screen.
   c. The **QUIT** option, to exit this test category, is the first selection in the list. If you are currently positioned nearer the bottom of the list, it might be faster to scroll to the bottom of the list and press the down button. The list "wraps" between the last and first entries in the list.
7. To start the selected test, press the **enter** button. The Operator Display shows the test number and its results. For Output tests, use the **up/down** buttons to toggle the switch setting. To return to the test menu, press the **left** or **right** button.
8. If you select **HISTORY**, you access the error code history log, which stores the last ten error codes recorded on the lift truck. The log is displayed as two pages of five codes each. Each entry shows the code and the date and time of occurrence.
   a. Use the **up/down** buttons to switch between page 1 and page 2 of the log.
   b. Use the **left/right** buttons to exit the log back to the Diagnostics Menu.
   c. If the log displays the message **"NO CODES RECORDED,"** no error codes have been recorded since the log was last reset.
   d. To clear and reset the error log, display the log and press the **enter** button. On the reset menu, select **YES** with the **left**

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button, then press the **enter** button. The log is cleared and the Diagnostics Menu reappears.

Using Dynamic Diagnostic Mode

Dynamic diagnostic mode permits testing of individual circuits while a selected function of the lift truck is enabled for operation.

Dynamic diagnostic mode differs from active diagnostic mode in that, in dynamic diagnostic mode, only one lift truck function is enabled; in active diagnostic mode, all lift truck functions are enabled.

Dynamic diagnostic mode also permits you to test and monitor a function without cycling the lift truck through SelfTest.

You can run some, but not all, tests in dynamic diagnostic mode. Those that you can run in dynamic diagnostic mode have a "yen" symbol (¥) following the test number.

To place the lift truck in dynamic diagnostic mode

1. Enter static diagnostic mode as described under "Using Static Diagnostic Mode" on page 6-20.
2. Select the desired test.
3. With the desired test selected, press the **up** and **enter** buttons simultaneously. A "yen" symbol (¥) appears next to the test number, indicating the function associated with that test is enabled.

NOTE: If the ¥ symbol does not appear, the selected test might not have a dynamic diagnostic mode. Check "Electrical Test Summary List" on page 6-89.

4. Operate the lift truck function while monitoring the Operator Display.
5. To place the lift truck back into static diagnostic mode, press the **down** and **enter** buttons simultaneously.
6. To return to the test menu, press the **left** or **right** button. This also returns the lift truck into static diagnostic mode.
7. You can run only one test at a time in dynamic diagnostic mode.

Using Active Diagnostic Mode

Active diagnostic mode permits testing circuits related to the *intellidrive*®, *intelliguide*™, and *intellispeed*™ systems while the lift truck is enabled for normal operation. You can use active diagnostic mode for all analog and digital input tests.

To enable a test for active diagnostic mode

Enter static diagnostic mode, select the test, and press the **enter** button. With the individual test displayed on the Operator Display, press the **enter** button again. An asterisk (*) appears next to the test number to show that this test is selected for active diagnostic mode.

You can select up to six tests at a time to run in active diagnostic mode. Tests selected for active diagnostics are stored in memory even if you turn the key switch OFF. Use the **left** or **right** button to return to the test category menu to select additional tests. To select an additional test from a different category, quit the first category to return to the Diagnostic Mode menu so you can select the other category.

To select one of the active diagnostic tests

Place the lift truck in Run Mode by selecting **QUIT** from the Program Mode Superword Level menu, or by turning the key switch OFF and ON. When SelfTest completes, depress the deadman pedals and use the **up/down** buttons to select the test you want to monitor while operating the lift truck. The test you select remains on the display until you select another test.

If you try to select more than six tests for active diagnostics, an error tone sounds. If six tests are already selected, you must clear one test before you can add another to the active diagnostics list.

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To clear a test from the active diagnostic list

Display the test in diagnostic mode and press the **enter** button. The asterisk (*) disappears on the display, indicating the test is no longer enabled for active diagnostics.

To clear all active diagnostic tests at once

Go to the Program Mode Superword Level menu. Use the **up/down** buttons to select **DIAGNOSTICS**, then press the **enter** button. From the Diagnostics Menu, select **CLRACTM** (This option appears in the menu only if one or more tests are selected for active diagnostics.) and press the **enter** button. Active diagnostics tests are cleared and the Diagnostics Menu reappears, with the **CLRACTM** option deleted.

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Graphics Database Download

If new Tractor Manager VFC firmware alters or replaces the graphics database for the Operator Display, you need to download the new graphics database from the Tractor Manager VFC Card to the Operator Display Interface Card.

You must also perform a graphics database download if the Operator Display shows Code 57 and the truck is operational.

To do this:

1. Turn the key switch OFF.
   a. Step on both deadman pedals.
   b. Press and hold the lift select button
   c. Turn the key switch ON.
   d. Press and release the lift select button.
2. If a graphics database was ever loaded previously into this card, the Operator Display could briefly show:

   DEADMAN?
3. The Operator Display then shows in large letters:

   CONFIGURATION DOWNLOAD IN PROGRESS
4. Wait for the download to complete (approximately 45 seconds to 1 minute). When the download has completed, the Operator Display shows in large letters:

   CODE 57. INFORM SERVICE.

   This is *not* an error.
5. Step off both deadman pedals. Turn the key switch OFF.
6. Turn the key switch ON. The lift truck should go through normal SelfTest.

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Messages and Codes

Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Display: ALIGNING		
Aligning Auto/Man switch is in Auto mode, the guide wire has been sensed, lift truck is trying to acquire the wire.	Test A16 – Right Tractor Guidance Coil Voltage (Page 6-113) Test A17 – Left Tractor Guidance Coil Voltage (Page 6-114) Test A18 – Right Load Guidance Coil Voltage (Page 6-115) Test A19 – Left Load Guidance Coil Voltage (Page 6-116) Test A20 – Tractor Near Wire Coil Voltage (Page 6-117) Test A21 – Load Near Wire Coil Voltage (Page 6-118)	To clear: Acquire the guide wire or switch the Auto/Manual switch to Manual.
Message Displayed: BATTERY LOW		
Battery low Battery voltage has been sensed below the BSOC cutout.		To clear: Change battery
Message Displayed: LIFT INHIBITED		
Lift inhibited As the carriage lifted, it activated the lift inhibit, with no bypass available.		To clear: Enter Configure Mode and enable the lift bypass switch (S7). See "Using Configure Mode" on page 6-8.
Message Displayed: Lift Stopped Due to Weight		
Lift stopped due to weight This code is generated by the CM when the voltage from the pressure transducers indicates weight greater than 3500 lbs. (1588 kg) for 3 seconds.	Test A05¥ – Pressure Transducer, Main (Page 6-101) Test A25¥ – Pressure Transducer, Mini (Page 6-122)	To clear: Reduce load weight. Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Displayed: LOAD HANDLER STALLED		
Load handler stalled The load handler is not traversing or rotating as requested.	Test A26 ¥ – Traverse Position Feedback Pot (VR5) Voltage (Page 6-123) Test A28 ¥ — Rotate Position Potentiometer (VR6) Voltage (Page 6-125) Test O19 – Load Handler Traverse Solenoid "A" (SOL34A) (Page 6-220) Test O20 – Load Handler Traverse Solenoid "B" (SOL34B) (Page 6-222) Test O21 – Fork Control Solenoid "B" (SOL35B) (Page 6-224) Test O22 – Fork Control Solenoid "A" (SOL35A) (Page 6-226) Test O28 – Load Handler Traverse Solenoid "A" (SOL34A) (Page 6-237) Test O29 – Load Handler Traverse Solenoid "B" (SOL34B) (Page 6-239) Test O30 – Proportional Reach/Rotate Solenoid (SOL33) (Page 6-241)	To clear: Move load handler.

Message Displayed: LOWER INHIBITED		
Lower inhibited As the carriage lowered, it activated the lower inhibit, with no bypass available.		To clear: Enter Configure Mode and enable the lift bypass switch (S7). See "Using Configure Mode" on page 6-8.

Message Displayed: LOWER SIDEGATE TO RESUME OPERATION		
Lower sidegate to resume operation Deadman pedal is detected down with the sidegate detected up when you attempt to travel or lift.	Test I14 – Sidegate Switches (S60,S61) (Page 6-159)	To clear: Lower the sidegates, then attempt to travel and lift/lower again.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: GUIDANCE NOT LEARNED		
Guidance not learned When the Auto/Manual switch was placed in the "Auto" position, the wire guidance parameters were out-of-range.		To clear: Learn Guidance. If message does not clear, replace Electric Steer Manager.
Message Displayed: MOVE LOAD HANDLER		
Move load handler The load handler is not traversing or rotating as requested. (This is the same as "Load Handler Stalled," except that the key switch has been cycled.)	Test A26 ¥ – Traverse Position Feedback Pot (VR5) Voltage (Page 6-123) Test A28 ¥ — Rotate Position Potentiometer (VR6) Voltage (Page 6-125) Test O19 – Load Handler Traverse Solenoid "A" (SOL34A) (Page 6-220) Test O20 – Load Handler Traverse Solenoid "B" (SOL34B) (Page 6-222) Test O21 – Fork Control Solenoid "B" (SOL35B) (Page 6-224) Test O22 – Fork Control Solenoid "A" (SOL35A) (Page 6-226) Test O28 – Load Handler Traverse Solenoid "A" (SOL34A) (Page 6-237) Test O29 – Load Handler Traverse Solenoid "B" (SOL34B) (Page 6-239) Test O30 – Proportional Reach/Rotate Solenoid (SOL33) (Page 6-241)	To clear: Move load handler.
Message Displayed: PLATFORM HUNG-UP, LIFT SLOWLY		
Platform hung-up Lift trucks SA S/N below 01193, SB S/N below 00309: Hydraulic pressure sensor psi readings have dropped below no-load threshold.	Test A05 ¥ – Pressure Transducer, Main (Page 6-101)	How to clear: Lift carriage and toggle key switch

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: SEEKING		
Seeking The Auto/Manual switch is in the Auto position. The guide wire has not been sensed.	Test I11 – Auto/Manual Switch (S4) (Page 6-156) Test A16 – Right Tractor Guidance Coil Voltage (Page 6-113) Test A17 – Left Tractor Guidance Coil Voltage (Page 6-114) Test A18 – Right Load Guidance Coil Voltage (Page 6-115) Test A19 – Left Load Guidance Coil Voltage (Page 6-116) Test A20 – Tractor Near Wire Coil Voltage (Page 6-117) Test A21 – Load Near Wire Coil Voltage (Page 6-118)	To clear: Acquire the guide wire or switch Auto/Manual switch to Manual mode.
Message Displayed: SPEED LIMITED DUE TO LOAD HANDLER		
Speed limited due to load handler The load handler is not "nested." Nested is the fork carriage position that permits unrestricted travel.	Test A26 ¥ – Traverse Position Feedback Pot (VR5) Voltage (Page 6-123) Test A28 ¥ — Rotate Position Potentiometer (VR6) Voltage (Page 6-125) Test I10 ¥ – Reach Position Proximity Sensor (PROX2) (Page 6-155)	To clear: Return the load handler to a nested position.
Message Displayed: SPEED LIMITED DUE TO STEER ANGLE		
Speed limited due to steer angle A speed limiting condition is in effect due to a combination of steering angle and height. 1. If the height is greater than 24 in. and the steering angle is greater than 10 degrees, then the maximum travel speed is limited to 1 mph. 2. If the height is greater than 150 in. and the steering angle is greater than 10 degrees, then travel is not permitted.	Test I00 ¥ – Main Mast Reference Point (Page 6-142) Test I15 ¥ – Main Mast Height Count (Page 6-160) Test I22 ¥ – Steer Position Feedback Encoder Count (Page 6-167)	To clear: Straighten the steering wheel to within 10 degrees of straight ahead or, lower the carriage down to a height that permits a greater speed.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: STEP ON DEADMAN		
Step on deadman The throttle was moved from neutral position, but the deadman was not depressed.	Test A03 – Throttle Pot Voltage (VR1) (Page 6-98)	To clear: Release throttle, step on deadman pedal, then move throttle.
Message Displayed: POWER PANEL OVERHEATED, ALLOW TIME TO COOL		
Code 1H – Power panel overheated The temperature reading from the temperature sensor HT to the Tractor Manager exceeded 215 degrees F (101 degrees C).	Test A02 – Power Panel Temperature Sensor Voltage (Page 6-96)	Check battery state-of-charge. Low battery charge combined with heavy activity can result in this code. To clear: Turn key switch OFF. Permit time for the power panel to cool.
Message Displayed: CODE 1K INFORM SERVICE		
Code 1K – Slack Chain Switch The operator attempted to lower the main platform more than 8 in. (20 cm) after a slack chain switch (S50, S51) was detected open.	Test I45 – Slack Chain Switches (Page 6-186)	To clear: Release lift control. Turn key switch OFF/ON. Lift to free platform. Check that hoses and cables were not unseated from pulleys.
Message Displayed: CODE 1L EMERGENCY OFF BUTTON PRESSED		
Code 1L – Emergency power off switch depressed The Carriage Manager or Tractor Manager detected the emergency power off switch is depressed.	Test I04 – Emergency Power Off (EPO) Switch (S21) (Page 6-149)	To clear: Turn key switch OFF, lift emergency off button, then turn key switch to ON to resume operation.
Message Displayed: PRESS BYPASS SWITCH TO RESUME OPERATION		
Code 1N – Lift inhibit As the carriage elevated, it exceeded the software configured lift limit.	Test I17 – Lift/Lower Inhibit Bypass Switch (S7) (Page 6-165)	To clear: Press lift/lower inhibit bypass switch (S7) to continue lifting.

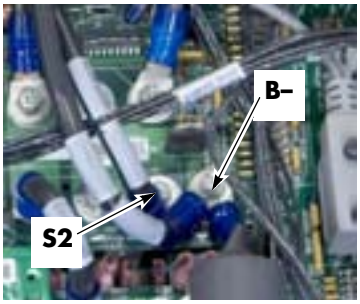
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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 20 INFORM SERVICE		
Code 20 – Power panel temperature sensor circuits not responding The input from the power panel temperature sensor (HT) does not agree with the power panel temperature limit input.	Test A02 – Power Panel Temperature Sensor Voltage (Page 6-96) Test I07 – Power Panel Temperature Limit (Page 6-152)	To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE 21 INFORM SERVICE		
Code 21 – Short detected in armature circuit During operation, CT1 on the Power Card sensed maximum armature current was exceeded, or Q1-C sense line did not see B+ when travel was requested.	Test A01 – Armature Current Sense (Page 6-95) Test A10 – Armature Transistor (Q1-C) Sense Voltage (Page 6-108)	If failures repeat, replace: • Traction heatsink components: insulator, C1, REC2, and R2 (if Q1 was found bad) • Plugging resistor and related wiring To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE 23 INFORM SERVICE		
Code 23 – Open detected in armature circuit During SelfTest, CT1 on the Power Card did not sense correct current levels through the Power Transistor (Q1).	Test A01 – Armature Current Sense (Page 6-95) Test A10 – Armature Transistor (Q1-C) Sense Voltage (Page 6-108) Test O11 – Armature Enable (Page 6-208) Test O14 – Armature PWM Ramp (Page 6-213)	Check: • Repeated Q1 failures can result from incorrect harness crimping between the Q1 heatsink and Power Card. • If Q1 fails during SelfTest, verify B– is being supplied to the power card from JPC1-1. If not, troubleshoot wiring from Q1-E to JPC1-1. • If Q1 has had repeated failures, replace traction heatsink components: insulator, C1, REC2, and R2.) • Check plugging resistor and related wiring To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 24 INFORM SERVICE		
Code 24 – Armature current sensor circuit not responding During operation, maximum current was exceeded and current limit input was not activated, or current limit input was active with low current.	Test A01 – Armature Current Sense (Page 6-95) Test I06 – Armature Current Limit Input (Page 6-151)	To clear: Cycle the key switch OFF/ON.

Message Displayed: CODE 25 INFORM SERVICE		
Code 25 – Short detected in field circuit Maximum field current was exceeded.	Test A14 – Field Current Sense (Page 6-111) Test O13 – Field PWM Ramp (Page 6-211)	To clear: Cycle the key switch OFF/ON.

Message Displayed: CODE 26 INFORM SERVICE		
Code 26 – Open detected in field circuit Current was not detected in the field circuit when it should be.	Test O13 – Field PWM Ramp (Page 6-211) Test O04 – Forward Enable Test (Forks-First) (Page 6-198) Test O05 – Reverse Enable Test (Tractor-First) (Page 6-199) Test A14 – Field Current Sense (Page 6-111)	To clear: Cycle the key switch OFF/ON. Check: This code can result from cables at the S2 power card connection shorting to the B– cables on the power card. Orient the connector at the S2 connection so that the bend at the lug faces away from the connections at B–. See photo. 

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 28 INFORM SERVICE		
Code 28 – Excessive acceleration The output voltage from the speed feedback proximity sensor exceeded the maximum allowable limit.	Test I05 – Speed Feedback Proximity Sensor (Page 6-150)	To clear: Cycle the key switch OFF/ON.

Message Displayed: CODE 29 INFORM SERVICE		
Code 29 – No movement detected when travel is requested This code is detected if all four of the following conditions occur at the same time for more than two seconds: 1. Speed request from throttle is greater than 25%. 2. Velocity from the speed feedback proximity sensor is zero. 3. The PWM command to the power card and transistor is greater than 50%. 4. No current limit detected from power card.	Test I05 – Speed Feedback Proximity Sensor (Page 6-150) Test I06 – Armature Current Limit Input (Page 6-151) Test O17 – Optional Alarm Test (Page 6-217)	To clear: Cycle the key switch OFF/ON, then request travel. The truck has limited power. If the error condition clears (speed feedback is seen), return the control handle to neutral to permit full speed.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 2A OVERHEATED. ALLOW TIME TO COOL.		
Code 2A – Drive motor overheated The Tractor Manager has detected the drive motor has overheated.	Test A15 – Drive Motor Temperature Sensor (DT) (Page 6-112)	Check the following: • Battery state of charge • Check battery specific gravity. • Configure Mode BSOC Cutout setting might be too low for this lift truck's application. • Drive motor brush condition • Power cable condition • Dragging brakes • Load wheel or drive unit binding • Correct operation of plugging contactor and plugging resistor R1 To clear: Turn key switch OFF and permit motor to cool.
Message Displayed: CODE 2B INFORM SERVICE		
Code 2B – Armature current sensed out-of-range The main transistor (Q1) current sensor analog input was detected out-of-range.	Test A01 – Armature Current Sense (Page 6-95)	To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE 2C TEMPERATURE OUT-OF-RANGE		
Code 2C – Power panel temperature sensor out-of-range Power panel temperature sensor analog input was detected out-of-range.	Test A02 – Power Panel Temperature Sensor Voltage (Page 6-96)	To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE 2D INFORM SERVICE		
Code 2D – Field current sensed out-of-range The analog input from the power card is not correct.	Test A14 – Field Current Sense (Page 6-111)	To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 2E TEMPERATURE OUT-OF-RANGE		
Code 2E – Drive motor temperature sensor out-of-range The drive motor temperature sensor analog input is not within programmed limits.	Test A15 – Drive Motor Temperature Sensor (DT) (Page 6-112)	To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE 2H INFORM SERVICE		
Code 2H – Failure detected in velocity feedback circuit The velocity feedback circuit is not communicating, inoperative, or not installed in the lift truck.	Test I05 – Speed Feedback Proximity Sensor (Page 6-150)	To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE 2J INFORM SERVICE		
Code 2J – Failure detected in plugging circuit The lift truck did not decelerate or did not decelerate fast enough when commanded to do so. The command to decelerate occurs when the deadman pedal is released or a speed-related limit occurs.	Test I05 – Speed Feedback Proximity Sensor (Page 6-150)	To clear: Cycle the key switch OFF/ON. Test drive motor for internal shorts to frame. If Code 2J recurs, replace TM, If Code 2J recurs, replace VFC.
Message Displayed: CODE 2K INFORM SERVICE		
Code 2K – Failure detected in brake drive circuit Either the brake is engaged and the drive voltage is less than 24 volts, or the brake is disengaged and the drive voltage is greater than 24 volts.	Test A37 – Brake Control Line Sense (Page 6-135) Test O08 – Toggle Brake (Page 6-203)	To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 42 INFORM SERVICE		
Code 42 – Lift (P) contactor detected closed when commanded open The P-sense line detects an incorrect voltage after the lift (P) contactor was commanded open.	Test O02 – Toggle the P (Lift) Contactor (Page 6-196) Test A08 – Lift Motor Sense Voltage (Page 6-104)	If excessive Code 42 or burning contactor tips occurs, verify correct battery usage, power cable connections, and lift cutout settings. If these are OK, replace the coil driver card for the appropriate contactor. Install firmware CM 4.08/TM 4.05/SM 02.6 or higher To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE 43 INFORM SERVICE		
Code 43 – Lift (P) contactor detected open when commanded closed The P sense line does not detect the correct voltage after the lift (P) contactor was commanded closed.	Test O02 – Toggle the P (Lift) Contactor (Page 6-196) Test A08 – Lift Motor Sense Voltage (Page 6-104)	To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE 44 INFORM SERVICE		
Code 44 – PC1 contactor detected closed when commanded open The Tractor Manager detected an incorrect voltage after the PC1 contactor was commanded open.	Test O00 – Toggle the PC1 (Travel PC) Contactor (Page 6-194) Test A07 – PC1 (Travel) Sense Voltage (Page 6-103)	If excessive Code 44 or burning contactor tips occurs, verify correct battery usage, power cable connections, and lift cutout settings. If these are OK, replace the coil driver card for the appropriate contactor. To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 45 INFORM SERVICE		
Code 45 – PC1 contactor detected open when commanded closed The PC1 sense line did not detect the correct voltage after the PC1 contactor was commanded closed.	Test O00 – Toggle the PC1 (Travel PC) Contactor (Page 6-194) Test A07 – PC1 (Travel) Sense Voltage (Page 6-103)	To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE 47 INFORM SERVICE		
Code 47 – PC2 contactor detected open when commanded closed The PC2 sense line did not detect the correct voltage after the PC2 contactor was commanded closed.	Test O01 – Toggle the PC2 (Lift PC) Contactor (Page 6-195) Test A35 – PC2 Sense Voltage (Page 6-133)	To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE 48 INFORM SERVICE		
Code 48 – PC2 contactor detected closed when commanded open The PC2 sense line detected incorrect voltage after the PC2 contactor was commanded open.	Test O01 – Toggle the PC2 (Lift PC) Contactor (Page 6-195) Test A35 – PC2 Sense Voltage (Page 6-133)	If excessive Code 48 or burning contactor tips occurs, verify correct battery usage, power cable connections, and lift cutout settings. If these are OK, replace the coil driver card. To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE 49 INFORM SERVICE		
Code 49 – AUX contactor detected closed when commanded open The AUX sense line detected incorrect voltage after the AUX contactor was commanded open.	Test O31 – Toggle the Aux (X) Contactor (Page 6-242) Test I62 ¥ – Aux Contactor Sense Line (Page 6-190)	To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE 4A INFORM SERVICE		
Code 4A – AUX contactor detected open when commanded closed The AUX sense line did not detect the correct voltage after the AUX contactor was commanded closed.	Test O31 – Toggle the Aux (X) Contactor (Page 6-242) Test I62 ¥ – Aux Contactor Sense Line (Page 6-190)	To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 50 INFORM SERVICE		
Code 50 – No Tractor Manager communication received by the Carriage Manager The Carriage Manager has not received a message over the bus+/bus– communication lines from the Tractor Manager.	Test A00 – TM Power Supply (Page 6-94)	• *See "Troubleshooting Communication Fault Codes (50-series)" on page 5-20.* • Check FU17 (12 volt 2 amp fuse). • Check for shorts to frame. • Replace CD3 card • Replace Tractor Manager with: • P/N 154-012-470/021 or higher - standard • P/N 154-012-470/022 or higher - EE-rated trucks To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE 51 INFORM SERVICE		
Code 51 – No Carriage Manager communications received by Tractor Manager The Tractor Manager has not received a message over the bus+/bus– communication lines from the Carriage Manager.		• *See "Troubleshooting Communication Fault Codes (50-series)" on page 5-20.* • Check for shorts to frame. • If Code 51 appeared after changing firmware, then the firmware could be faulty or the socket could have been damaged during installation. • Check the firmware socket for damage. If OK, reinstall the old firmware. • If Code 51 recurs, replace the Carriage Manager. To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 52 INFORM SERVICE		
Code 52 – No Carriage Manager communications received by Electric Steer Manager The Electric Steer Manager has not received a message over the bus+/bus– communication lines from the Carriage Manager.		• *See "Troubleshooting Communication Fault Codes (50-series)" on page 5-20.* • Check for shorts to frame. • Replace the Electric Steer Manager. To clear: Cycle the key switch OFF/ON.

Message Displayed: CODE 53 INFORM SERVICE		
Code 53 – No Electric Steer Manager communications received by Carriage Manager The Carriage Manager has not received a message over the bus+/bus– communication lines from the Electric Steer Manager.	Test A23 – Steer Manager Power Supply Voltage (Page 6-120)	• *See "Troubleshooting Communication Fault Codes (50-series)" on page 5-20.* • If Code 53 occurs when traveling, then the problem could be with either the drive motor or Q1 snubber circuitry. • Check for shorts to frame. To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 54 INFORM SERVICE		
Code 54 – No Mini Height Manager communications received by Carriage Manager The Carriage Manager has not received a message over the bus+/bus– communication lines from the Mini Height Manager.	None	• Swap the Main and Mini Height Managers. If the Fault Code at startup changes to a Code 55, replace the original Mini Height Manager. • *See "Troubleshooting Communication Fault Codes (50-series)" on page 5-20.* • Check for shorts to frame. • This code is not caused by a faulty CM. A faulty CM will result in a Code 57 or 51. To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE 55 INFORM SERVICE		
Code 55 – No Main Height Manager communications received by Carriage Manager The Carriage Manager has not received a message over the bus+/bus– communication lines from the Main Height Manager.	None	• *See "Troubleshooting Communication Fault Codes (50-series)" on page 5-20.* • Swap the Main and Mini Height Managers. If the Fault Code at startup changes to a Code 54, replace the original Main Height Manager. • Check for shorts to frame. • This code is not caused by a faulty CM. A faulty CM will result in a Code 57 or 51. To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 57 INFORM SERVICE		
Code 57 – No communications received by Display Manager The Operator Display Interface Card has not received a message over the bus+/bus– communication lines from any other manager.	Test O09 – Display Lights (Page 6-205)	If Code 57 appears when exiting Diagnostic Mode, verify that the firmware chip on the Operator Display Interface Card is at version 2005 or higher. If not, replace the Operator Display Interface Card. For chip location, see Figure 7-57 on page 7-31. This code can occur in two ways: • Truck operates with Code 57 displayed. • Check continuity of wiring harness from display interface to Carriage Manager JP3-JPC18. • If continuity is OK, replace the Operator Display Interface Card. See "Operator Display Interface Card" on page 7-81. • Truck does not operate with Code 57 displayed. • *See "Troubleshooting Communication Fault Codes (50-series)" on page 5-20.* • Check for shorts to frame. To clear: Cycle the key switch OFF/ON.

Message Displayed: CODE 59 INFORM SERVICE		
Code 59 – Carriage Manager transmit failure detected by Carriage Manager During power-up or run time, the Carriage Manager fails to transmit. This is reported by the Carriage Manager.	None	• Check for shorts to frame. • Replace the Carriage Manager. See "Carriage Manager" on page 7-79. To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 5B INFORM SERVICE		
Code 5B – Carriage Manager cannot receive message The Carriage Manager can not process the information fast enough. This situation could be the result of excessive message error recovery.		• Check for shorts to frame. • Replace the Carriage Manager firmware. Observe correct ESD precautions. • Replace the Carriage Manager. See "Carriage Manager" on page 7-79. To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE 5D INFORM SERVICE		
Code 5D – No SMART*i* system response The Carriage Manager has not received inputs from the SMART*i* card module.	None	Use a digital voltmeter to measure voltage between JC9-9 (+) and JC9-5 (–) and between JC9-9 (+) and JC9-8 (–). • If you measure between 10.8 and 13.0 volts, check the wiring harness between JC9 and the connector at the SMART*i* module for continuity. If the harness is good, replace the SMART*i* module. • If the voltage is not correct, replace the Carriage Manager. See "Carriage Manager" on page 7-79. To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 5E INFORM SERVICE		
Code 5E – Tractor Manager cannot receive message The Tractor Manager cannot process information.	None	• Check for shorts to frame. • Replace the Tractor Manager firmware. Observe correct ESD precautions. • Replace the Tractor Manager. See "Tractor Manager Card" on page 7-84. To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE 60 INFORM SERVICE		
Code 60 – Main Mast Height Manager transition error The Main Mast Height Manager has detected an incorrect transition from the height count inputs (2 are on or off at the same time).	Test I15 ¥ – Main Mast Height Count (Page 6-160)	To clear: Lower the carriage completely and let truck stand for 3 seconds. The height does reset to full lowered height as long as the weight is 0 lb. and the Height Manager sees the reference area.
Message Displayed: CODE 61 INFORM SERVICE		
Code 61 – Mini-Mast Height Manager transition error The Mini-Mast Height Manager has detected an incorrect transition from the height counts (2 are on or off at the same time).	Test I16 ¥ – Mini-Mast Height Count (Page 6-164)	To clear: *Method 1:* Lower mini-mast completely. Enter Program Mode by the First Method on page 6-6, run Test I09, then exit the test. **NOTE:** For this specific case, you must use the lift and horn control method for entering Diagnostic Mode. *Method 2:* • Lift fork carriage to maximum elevated height. • Turn key switch OFF, wait 2 seconds, then turn key switch ON. Lower fork carriage completely.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 62 INFORM SERVICE		
Code 62 – Main Mast Height initialization error The Main Mast Height Manager did not initialize the height to the value stored in non-volatile memory.	Test I00 ¥ – Main Mast Reference Point (Page 6-142) Test I15 ¥ – Main Mast Height Count (Page 6-160)	To clear: Lower the carriage completely and let truck stand for 3 seconds. The height does reset to full lowered height as long as the weight is 0 lb. and the Height Manager sees the reference area.
Message Displayed: CODE 63 INFORM SERVICE		
Code 63 – Mini-Mast Height initialization error The Mini-Mast Height Manager did not initialize the height to the value stored in non-volatile memory.	Test I09 ¥ – Mini-Mast Reference Point (Page 6-154) Test I16 ¥ – Mini-Mast Height Count (Page 6-164)	To clear: *Method 1:* Lower mini-mast completely. Enter Program Mode by the First Method on page 6-6, run Test I09, then exit the test. **NOTE:** For this specific case, you must use the lift and horn control method for entering Diagnostic Mode. *Method 2:* • Lift fork carriage to maximum elevated height. • Turn key switch OFF, wait 2 seconds, then turn key switch ON. Lower fork carriage completely.
Message Displayed: CODE 64 INFORM SERVICE		
Code 64 – Main Mast height change error as seen by CM The main height count attempted to go negative.	Test I15 ¥ – Main Mast Height Count (Page 6-160)	To clear: Lower the carriage completely and let truck stand for 3 seconds. The height does reset to full lowered height as long as the weight is 0 lb. and the Height Manager sees the reference area.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 65 INFORM SERVICE		
Code 65 – Mini-Mast height change error The mini height count attempted to go negative.	Test I16 ¥ – Mini-Mast Height Count (Page 6-164)	To clear: *Method 1:* Lower mini-mast completely. Enter Program Mode by the First Method on page 6-6, run Test I09, then exit the test. **NOTE:** For this specific case, you must use the lift and horn control method for entering Diagnostic Mode. *Method 2:* • Lift fork carriage to maximum elevated height. • Turn key switch OFF, wait 2 seconds, then turn key switch ON. Lower fork carriage completely.

Message Displayed: CODE 66 INFORM SERVICE		
Code 66 – Main Mast drastic height change error Main mast height changed more than 12 in. (300 mm) in 100 milli-seconds.		Update firmware to CM 4.01/TM4.01/SM 02.1 or higher.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 67 INFORM SERVICE		
Code 67 – Mini-Mast drastic height change error Mini-mast height changed more than 12 in. (300 mm) in 100 milli-seconds.	Test I09 ¥ – Mini-Mast Reference Point (Page 6-154) Test I16 ¥ – Mini-Mast Height Count (Page 6-164)	To clear: *Method 1:* Lower mini-mast completely. Enter Program Mode by the First Method on page 6-6, run Test I09, then exit the test. **NOTE:** For this specific case, you must use the lift and horn control method for entering Diagnostic Mode. *Method 2:* • Lift fork carriage to maximum elevated height. • Turn key switch OFF, wait 2 seconds, then turn key switch ON. • Lower fork carriage completely.
Message Displayed: CODE 68 INFORM SERVICE		
Code 68 – Main Mast lack of height change error The main height count did not change with a lift request.	Test I15 ¥ – Main Mast Height Count (Page 6-160)	To clear: Lower the carriage completely and let truck stand for 3 seconds. The height does reset to full lowered height as long as the weight is 0 lb. and the Height Manager sees the reference area.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 69 INFORM SERVICE		
Code 69 – Mini-Mast lack of height change error The Mini-Mast Height Manager did not change with a lift request.	Test I16 ¥ – Mini-Mast Height Count (Page 6-164)	To clear: *Method 1:* Lower mini-mast completely. Enter Program Mode by the First Method on page 6-6, run Test I09, then exit the test. **NOTE:** For this specific case, you must use the lift and horn control method for entering Diagnostic Mode. *Method 2:* • Lift fork carriage to maximum elevated height. • Turn key switch OFF, wait 2 seconds, then turn key switch ON. Lower fork carriage completely.
Message Displayed: CODE 6C INFORM SERVICE		
Code 6C – Main Mast drastic height change error as seen by MH Manager Main mast height changed more than 12 in. (300 mm) in 100 milli-seconds.	Test I00 ¥ – Main Mast Reference Point (Page 6-142) Test I15 ¥ – Main Mast Height Count (Page 6-160)	To clear: Lower the carriage completely and let truck stand for 3 seconds. The height does reset to full lowered height as long as the weight is 0 lb. and the Height Manager sees the reference area.
Message Displayed: CODE 6D INFORM SERVICE		
Code 6D – Main Mast Pressure Sensor out-of-range The Electric Steer Manager has determined that the hydraulic pressure in the main mast has exceeded the programmed limits.	Test A05 ¥ – Pressure Transducer, Main (Page 6-101)	To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 6E INFORM SERVICE		
Code 6E – Mini-Mast Pressure Sensor out-of-range The Electric Steer Manager has determined that the hydraulic pressure in the mini-mast has exceeded the programmed limits.	Test A25¥ – Pressure Transducer, Mini (Page 6-122)	To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE 70 INFORM SERVICE		
Code 70 – Auxiliary Motor Controller fault The auxiliary motor control card has indicated a fault.	Test I39¥ – Aux Fault Line (Page 6-181) Test O25 – Aux Motor Control Enable (with Aux Control Card) (Page 6-231) Test O26 – Aux Motor Controller PWM (with Aux Control Card) (Page 6-234)	To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE 80 INFORM SERVICE		
Code 80 – Throttle control reading out-of-range The throttle potentiometer voltage is out-of-range.	Test A03 – Throttle Pot Voltage (VR1) (Page 6-98)	To clear: Return the control pot to within its limits.
Message Displayed: CODE 81 INFORM SERVICE		
Code 81 – Lift/lower controller reading out-of-range The lift/lower potentiometer voltage out-of-range.	Test A04 – Lift/Lower Potentiometer (VR2) Voltage (Page 6-99)	To clear: Return the control pot to within its limits.
Message Displayed: CODE 8A INFORM SERVICE		
Code 8A – Rotate control reading out-of-range The rotate control potentiometer voltage is out-of-range.	Test A09 – Rotate Control Potentiometer (VR3) Voltage (Page 6-106)	To clear: Return the rotate pot to within its limits.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 8B INFORM SERVICE		
Code 8B – Traverse control reading out-of-range The traverse control potentiometer voltage is out-of-range.	Test A06 – Traverse Control Potentiometer (VR4) Voltage (Page 6-102)	To clear: Return the control pot to within its limits.
Message Displayed: CODE 8C INFORM SERVICE		
Code 8C – Travel deadman switches do not agree The Carriage Manager detected one of the deadman switches open and the other closed.	Test I03 – Brake Deadman Switch (S2) (Page 6-148) Test I31 – Carriage Deadman (S23) at the TM (Page 6-176) Test I40 – Carriage Deadman (S23) at the CM (Page 6-182)	To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE 8D INFORM SERVICE		
Code 8D – Plugging detector malfunction Either one of the following: Deadman pedal released, no drive current sensed, and the hardware circuit on the Tractor Manager is not trying to apply the brake or Deadman pedal is depressed, drive current is sensed, and the brake is not commanded to release.	Test O08 – Toggle Brake (Page 6-203)	To clear: Cycle the key switch OFF/ON. If Test O08 passes, replace the Tractor Manager.
Message Displayed: CODE 8E INFORM SERVICE		
Code 8E – Brake deadman signals do not agree The Tractor Manager has been told across bus+/bus– that the deadman switches have been depressed; but the Tractor Manager has not received the position input across brake control line.	Test I31 – Carriage Deadman (S23) at the TM (Page 6-176) Test I03 – Brake Deadman Switch (S2) (Page 6-148) Test I40 – Carriage Deadman (S23) at the CM (Page 6-182)	To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 8F - TRAVEL DEADMAN SWITCHES DO NOT AGREE		
Code 8F – Travel deadman switches do not agree CM 4.05 / TM 4.04 / DM 02.6: The Tractor Manager detected one of the deadman switches open and the other closed.	Test I03 – Brake Deadman Switch (S2) (Page 6-148) Test I31 – Carriage Deadman (S23) at the TM (Page 6-176) Test I40 – Carriage Deadman (S23) at the CM (Page 6-182)	To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE 91 WIRE LOST, STEP OFF/ON DEADMAN		
Code 91 – Drive unit turned > 10 degrees while guiding on wire While guiding on the wire, the drive unit has turned >10 degrees.	Test I22 ¥ – Steer Position Feedback Encoder Count (Page 6-167)	To clear: Step OFF/ON deadman pedal.
Message Displayed: CODE 92 WIRE LOST, STEP OFF/ON DEADMAN		
Code 92 – Tracking limits exceeded The lift truck has drifted beyond the configured HA stop or DFW stop values.	Test A16 – Right Tractor Guidance Coil Voltage (Page 6-113) Test A17 – Left Tractor Guidance Coil Voltage (Page 6-114) Test A18 – Right Load Guidance Coil Voltage (Page 6-115) Test A19 – Left Load Guidance Coil Voltage (Page 6-116) Test A20 – Tractor Near Wire Coil Voltage (Page 6-117) Test A21 – Load Near Wire Coil Voltage (Page 6-118)	To clear: Step OFF/ON deadman pedal.
Message Displayed: CODE 93 WIRE LOST, STEP OFF/ON DEADMAN		
Code 93 – Not near wire – tractor coil pair The guide wire is not being sensed by the tractor coil pair.	Test A20 – Tractor Near Wire Coil Voltage (Page 6-117)	To clear: Step OFF/ON deadman pedal.
Message Displayed: CODE 94 WIRE LOST, STEP OFF/ON DEADMAN		
Code 94 – Not near wire – load coil pair The guide wire is not being sensed by the load coil pair.	Test A21 – Load Near Wire Coil Voltage (Page 6-118)	To clear: Step OFF/ON deadman pedal.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 96 WIRE LOST, STEP OFF/ON DEADMAN		
Code 96 – Not near wire – both coil pairs The guide wire is not being sensed by either set of coil pairs.	Test A20 – Tractor Near Wire Coil Voltage (Page 6-117) Test A21 – Load Near Wire Coil Voltage (Page 6-118)	To clear: Step OFF/ON deadman pedal.
Message Displayed: CODE 9E INFORM SERVICE		
Code 9E – Track and hold voltage failed The lift truck is moving on the wire and the guidance coil voltages are not fluctuating at all.		• The Wire Guidance Filter Card could be malfunctioning. Replace the Filter Card. Refer to "Wire Guidance Filter Card" on page 7-85. Run Learn Mode. Re-run the test. • The Electric Steer Manager could be malfunctioning. Replace the Steer Manager. Refer to "Steer Manager" on page 7-83. Run Learn Mode. Re-run the test. To clear: Step OFF/ON deadman pedal.
Message Displayed: CODE 9F INFORM SERVICE		
Code 9F – Wire guidance board not installed The filter card is not connected to the Electric Steer Manager.	Test I23 – Wire Guidance Filter Card Status (Page 6-168)	To clear: Step OFF/ON deadman pedal.
Message Displayed: CODE 9G INFORM SERVICE		
Code 9G – No voltage – load antenna The voltage from the load antenna is not being received by the Electric Steer Manager.	Test A18 – Right Load Guidance Coil Voltage (Page 6-115) Test A19 – Left Load Guidance Coil Voltage (Page 6-116) Test A21 – Load Near Wire Coil Voltage (Page 6-118)	To clear: Step OFF/ON deadman pedal.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE 9H INFORM SERVICE		
Code 9H – No voltage – tractor antenna The voltage from the tractor antenna is not being received by the Electric Steer Manager.	Test A16 – Right Tractor Guidance Coil Voltage (Page 6-113) Test A17 – Left Tractor Guidance Coil Voltage (Page 6-114) Test A20 – Tractor Near Wire Coil Voltage (Page 6-117)	To clear: Step OFF/ON deadman pedal.
Message Displayed: CODE 9J INFORM SERVICE		
Code 9J – Load antenna voltage too high Near wire voltage is greater than 4.75 volts.	Test A21 – Load Near Wire Coil Voltage (Page 6-118)	To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE 9K INFORM SERVICE		
Code 9K – Tractor antenna voltage too high Near wire voltage is greater than 4.75 volts.	Test A20 – Tractor Near Wire Coil Voltage (Page 6-117)	To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE 9L INFORM SERVICE		
Code 9L – Voltage too high at both coil pairs The line driver might be out of adjustment.	Test A20 – Tractor Near Wire Coil Voltage (Page 6-117) Test A21 – Load Near Wire Coil Voltage (Page 6-118)	To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE A0 INFORM SERVICE		
Code A0 – Incorrect software The model number stored in the Carriage Manager does not match the lift truck type.	None	To clear: Cycle the key switch OFF/ON. If this does not clear the code, replace Carriage Manager firmware. If problem persists, replace Carriage Manager. See "Carriage Manager" on page 7-79.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE A1 INFORM SERVICE		
Code A1 – Carriage Manager not initialized The Carriage Manager distribution board has not been set up or the board has been damaged.	None	To clear: Cycle the key switch OFF/ON. If this does not clear the code, replace the Carriage Manager. See "Carriage Manager" on page 7-79.
Message Displayed: CODE AK INFORM SERVICE		
Code AK – Invalid RAM data The Carriage Manager checksum is bad and the Tractor Manager checksum is also bad.	None	To clear: Cycle the key switch OFF/ON. If this does not clear the code, replace the Carriage Manager with a correctly programmed Carriage Manager. See "Carriage Manager" on page 7-79.
Message Displayed: CODE AL INFORM SERVICE		
Code AL – Battery back-up memory problem The battery on the battery back-up SRAM chip on the Tractor Manager VFC Card is dead. The stored end-of-aisle state has been lost and has been re-initialized to "outside the aisle."	None	To clear: Replace the VFC Card. See "Tractor Manager VFC Card" on page 7-84.
Message Displayed: CODE B0 INFORM SERVICE		
Code B0 – Rotate position pot out-of- range The rotate position pot analog input was detected out-of-range.	Test A28 ¥ — Rotate Position Potentiometer (VR6) Voltage (Page 6-125)	To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE B1 INFORM SERVICE		
Code B1 – Traverse position pot out-of-range The traverse position pot analog input was detected out-of-range.	Test A26 ¥ – Traverse Position Feedback Pot (VR5) Voltage (Page 6-123)	To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE B3 INFORM SERVICE		
Code B3 – Traverse rate signal out-of-range The traverse rate analog input was detected out-of-range.		Update firmware to version CM 4.02/TM 4.01/ SM 02.2 or higher. To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE EC INFORM SERVICE		
Code EC – Tractor Manager operating system error Tractor manager PROM/Software failed/PROM or RAM has bad locations.	None	• This problem could be the result of static electricity and/or shorts to frame. Check static strap for correct installation, cleanliness, and wear. See “Shorts to Frame Test” on page 5-4. See “Static Straps” on page 7-139. • If problem persists, replace Tractor Manager VFC Card firmware. • Replace the Tractor Manager VFC Card. See “Tractor Manager VFC Card” on page 7-84. To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE EG INFORM SERVICE		
Code EG – Carriage Manager operating system error Carriage manager PROM/Software failed/PROM or RAM has bad locations.	None	• This problem could be the result of static electricity and/or shorts to frame. Check static strap for correct installation, cleanliness, and wear. See “Shorts to Frame Test” on page 5-4. See “Static Straps” on page 7-139. • Replace the Carriage Manager firmware. • Replace the Carriage Manager. See “Carriage Manager” on page 7-79. To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE F1 INFORM SERVICE		
Code F1 – Carriage Manager COP time-out An intermittent connection on either the Carriage Manager or a device connected to the Carriage Manager could cause this code.	None	• This problem could be the result of static electricity and/or shorts to frame. Check static strap for correct installation, cleanliness, and wear. See “Shorts to Frame Test” on page 5-4. See “Static Straps” on page 7-139. • Check for poor connections to the Carriage Manager. • Check the Carriage Manager PROM chip for correct seating. See “Firmware Replacement” on page 7-89. • Check for poor connections or faulty operation of potential electrical noise sources, such as line filters, lights, fans, backup or travel alarms. • If the problem persists, replace the Carriage Manager firmware. • If problem persists, replace Carriage Manager. See “Carriage Manager” on page 7-79. To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE F2 INFORM SERVICE		
Code F2 – Carriage Manager illegal OP-code An intermittent connection on either the Carriage Manager or a device connected to the Carriage Manager could cause this code.	None	• This problem could be the result of static electricity and/or shorts to frame. Check static strap for correct installation, cleanliness, and wear. See "Shorts to Frame Test" on page 5-4. See "Static Straps" on page 7-139. • Check for poor connections to the Carriage Manager. • Check the Carriage Manager PROM chip for correct seating. See "Firmware Replacement" on page 7-89. • Check for poor connections or faulty operation of potential electrical noise sources, such as line filters, lights, fans, backup or travel alarms. • If the problem persists, replace the Carriage Manager firmware. • If the problem persists, replace the Carriage Manager. See "Carriage Manager" on page 7-79. To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE F4 INFORM SERVICE		
Code F4 – Tractor Manager VFC COP time-out Internal fault	None	• This problem could be the result of static electricity and/or shorts to frame. Check static strap for correct installation, cleanliness, and wear. See "Shorts to Frame Test" on page 5-4. See "Static Straps" on page 7-139. • Check for poor connections to the Tractor Manager. • Check the Tractor Manager PROM chip for correct seating. See "Firmware Replacement" on page 7-89. • Check for poor connections or faulty operation of potential electrical noise sources, such as line filters, lights, fans, backup or travel alarms. • If the problem persists, replace the Tractor Manager firmware. • If the problem persists, replace the Tractor Manager VFC Card. See "Tractor Manager VFC Card" on page 7-84. To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE F5 INFORM SERVICE		
Code F5 – Tractor Manager VFC invalid OP-code Internal fault	None	• This problem could be the result of static electricity and/or shorts to frame. Check static strap for correct installation, cleanliness, and wear. See "Shorts to Frame Test" on page 5-4. See "Static Straps" on page 7-139. • Check for poor connections to the Tractor Manager. • Check the Tractor Manager PROM chip for correct seating. See "Firmware Replacement" on page 7-89. • Check for poor connections or faulty operation of potential electrical noise sources, such as line filters, lights, fans, backup or travel alarms. • If the problem persists, replace the Tractor Manager firmware. • If the problem persists, replace the Tractor Manager VFC Card. See "Tractor Manager VFC Card" on page 7-84. To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE F7 INFORM SERVICE		
Code F7 – Carriage Manager COP not enabled Internal fault	None	• This problem could be the result of static electricity and/or shorts to frame. Check static strap for correct installation, cleanliness, and wear. See “Shorts to Frame Test” on page 5-4. See “Static Straps” on page 7-139. • Check the Carriage Manager PROM chip for correct seating. See “Firmware Replacement” on page 7-89. • Check for poor connections to the Carriage Manager. • Check for poor connections or faulty operation of potential electrical noise sources, such as line filters, lights, fans, backup or travel alarms. • Replace the Carriage Manager firmware. To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE F8 INFORM SERVICE		
Code F8 – Tractor Manager COP not enabled The start up procedure detected either a Tractor Manager firmware or VFC malfunction. This check is run before the contactor test is started.	None	• This problem could be the result of static electricity and/or shorts to frame. Check static strap for correct installation, cleanliness, and wear. See "Shorts to Frame Test" on page 5-4. • Check the Tractor Manager VFC Card PROM chip for correct seating. See "Firmware Replacement" on page 7-89. • Check for poor connections to the Tractor Manager. • Check for poor connections or faulty operation of potential electrical noise sources, such as line filters, lights, fans, backup or travel alarms. • Replace the Tractor Manager VFC Card and firmware. See "Tractor Manager VFC Card" on page 7-84. To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE F9 INFORM SERVICE		
Code F9 – Electric Steer Manager COP time-out Internal failure	None	• This problem could be the result of static electricity and/or shorts to frame. Check static strap for correct installation, cleanliness, and wear. See “Shorts to Frame Test” on page 5-4. See “Static Straps” on page 7-139. • Check for poor connections to the Electric Steer Manager. • Check the Electric Steer Manager PROM chip for correct seating. See “Firmware Replacement” on page 7-89. • Check for poor connections or faulty operation of potential electrical noise sources, such as line filters, lights, fans, backup or travel alarms. • If the problem persists, replace the Electric Steer Manager firmware. See “Steer Manager Firmware” on page 7-83. • If the problem persists, replace the Electric Steer Manager. See “Steer Manager” on page 7-83. To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE FA INFORM SERVICE		
Code FA – Electric Steer Manager invalid OP-code Internal failure	None	• This problem could be the result of static electricity and/or shorts to frame. Check static strap for correct installation, cleanliness, and wear. See "Shorts to Frame Test" on page 5-4. See "Static Straps" on page 7-139. • Check for poor connections to the Electric Steer Manager. • Check the Electric Steer Manager PROM chip for correct seating. See "Firmware Replacement" on page 7-89. • Check for poor connections or faulty operation of potential electrical noise sources, such as line filters, lights, fans, backup or travel alarms. • If the problem persists, replace the Electric Steer Manager firmware. See "Steer Manager Firmware" on page 7-83. • If the problem persists, replace the Electric Steer Manager. See "Steer Manager" on page 7-83. To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE FB INFORM SERVICE		
Code FB – Electric Steer Manager ASIC, PROM, or CAN reset Internal failure	None	• This problem could be the result of static electricity and/or shorts to frame. Check static strap for correct installation, cleanliness, and wear. See “Shorts to Frame Test” on page 5-4. See “Static Straps” on page 7-139. • Check for poor connections to the Electric Steer Manager. • Check the Electric Steer Manager PROM chip for correct seating. See “Firmware Replacement” on page 7-89. • Check for poor connections or faulty operation of potential electrical noise sources, such as line filters, lights, fans, backup or travel alarms. • If the problem persists, replace the Electric Steer Manager firmware. See “Steer Manager Firmware” on page 7-83. • If the problem persists, replace the Electric Steer Manager. See “Steer Manager” on page 7-83. To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE FC INFORM SERVICE		
Code FC – Electric Steer Manager COP not enabled Internal failure	None	• This problem could be the result of static electricity and/or shorts to frame. Check static strap for correct installation, cleanliness, and wear. See "Shorts to Frame Test" on page 5-4. See "Static Straps" on page 7-139. • Check the Electric Steer Manager PROM chip for correct seating. See "Firmware Replacement" on page 7-89. • Check for poor connections to the Electric Steer Manager. • Check for poor connections or faulty operation of potential electrical noise sources, such as line filters, lights, fans, backup or travel alarms. • Replace the Electric Steer Manager firmware. To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE FE INFORM SERVICE		
Code FE – Uncalibrated Tractor Manager VFC The startup procedure detected that the Tractor Manager VFC was never calibrated at the factory.		• This problem could be the result of static electricity and/or shorts to frame. Check static strap for correct installation, cleanliness, and wear. See "Shorts to Frame Test" on page 5-4. • Check the Tractor Manager VFC Card PROM chip for correct seating. See "Firmware Replacement" on page 7-89. • Check for poor connections to the Tractor Manager VFC Card. • Check for poor connections or faulty operation of potential electrical noise sources, such as line filters, lights, fans, backup or travel alarms. • Replace the Tractor Manager VFC Card firmware. To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE FF INFORM SERVICE		
Code FF – Error Management Handling Error Internal Steer Manager fault	None	To clear: Cycle the key switch OFF/ON. If Code FF recurs, enter Configure Mode and display Version information. Verify Steer Manager and Carriage Manager software versions are compatible. If versions are compatible, replace the Steer Manager. See "Steer Manager" on page 7-83.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE FG INFORM SERVICE		
Code FG – Tractor Manager +12 volts power supply out-of-range The +12 volt sense analog input was detected out-of-range at the Tractor Manager.	Test A00 – TM Power Supply (Page 6-94)	To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE FH INFORM SERVICE		
Code FH – Battery voltage out-of-range Wrong battery voltage or battery voltage out-of-range	Test A11 – Battery Voltage (Page 6-109)	To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE FK INFORM SERVICE		
Code FK – Carriage Manager +12 volt power supply out-of-range The +12 volt sense analog input was detected out-of-range at the Carriage Manager.	Test A12 – CM Power Supply (Page 6-110)	To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE FL INFORM SERVICE		
Code FL – Error Management handling error Internal Carriage Manager fault	None	To clear: Cycle the key switch OFF/ON. If Code FL recurs, replace the Carriage Manager. See "Carriage Manager" on page 7-79.
Message Displayed: CODE FM INFORM SERVICE		
Code FM – Error Management handling error Internal Tractor Manager fault	None	To clear: Cycle the key switch OFF/ON. If Code FM recurs, enter Configure Mode and display Version information. Verify Tractor Manager and Carriage Manager software versions are compatible. If versions are compatible, replace the VFC Card. See "Tractor Manager VFC Card" on page 7-84.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE FN INFORM SERVICE		
Code FN – Carriage Manager +5 volt power supply out-of-range The +5 volt potentiometer supply sense was detected out-of-range at the Carriage Manager.	Test A44 – CM +5 V Potentiometer Power Supply (Page 6-139)	To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE FP INFORM SERVICE		
Code FP – Battery back-up RAM is corrupt Information in the battery backed-up RAM has been corrupted.	None	To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE FX INFORM SERVICE		
Code FX – Wrong CM detected FIC/DTIC configuration option "O" is set enabled, but no plug is connected at JPC26.	None	To clear: Reconfigure the truck to set option "O" off, or connect plug JPC26.
Message Displayed: CODE G0 INFORM SERVICE		
Code G0 – Manual steer error One channel from the steering encoder is intermittent.	Test I33 – Steering Encoder Channel B (Page 6-178) Test I34 – Steering Encoder Channel A (Page 6-179)	This code can be caused by a loose steering tiller. Check the adjustment of the steering tiller brake. See "Steering Tiller Brake Assembly" on page 7-44. To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE G1 INFORM SERVICE		
Code G1 - Electric steer power supply out-of-range +12 volts is not being sensed at the Electric Steer Manager.	Test A23 – Steer Manager Power Supply Voltage (Page 6-120)	To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE G2 INFORM SERVICE		
Code G2 – No steer position reference input or steer position encoder pulses detected without a steer command to turn No input was detected from the home sensor proximity switch to the Electric Steer Manager.	Test I24 ¥ – Steer Home Proximity Sensor (Page 6-169) Test I22 ¥ – Steer Position Feedback Encoder Count (Page 6-167)	See "Troubleshooting Steering Fault Codes (G-series)" on page 5-25. To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE G3 INFORM SERVICE		
Code G3 – No steer encoder signal or no home sensor input 1. No pulses are being sent from the steer position encoder to the Electric Steer Manager. 2. No home sensor proximity sensor input was received while trying to center. 3. There is an open circuit in the steer motor system.	Test I22 ¥ – Steer Position Feedback Encoder Count (Page 6-167) Test I24 ¥ – Steer Home Proximity Sensor (Page 6-169) Test A22 ¥ – Steer Motor Current (Page 6-119)	See "Troubleshooting Steering Fault Codes (G-series)" on page 5-25. To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE G4 INFORM SERVICE		
Code G4 – Open detected in steer control circuit No encoder pulses from steer feedback encoder and no current feedback.	Test I22 ¥ – Steer Position Feedback Encoder Count (Page 6-167)	See "Troubleshooting Steering Fault Codes (G-series)" on page 5-25. To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE G5 INFORM SERVICE		
Code G5 – Short detected in steer motor circuit Steer feedback encoder pulses were detected without steer command to turn.	Test A22 ¥ – Steer Motor Current (Page 6-119) Test I22 ¥ – Steer Position Feedback Encoder Count (Page 6-167)	See "Troubleshooting Steering Fault Codes (G-series)" on page 5-25. To clear: Cycle the key switch OFF/ON.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE G6 INFORM SERVICE		
Code G6 – Encoder - Steer Motor mismatch Drive unit turns opposite of commanded direction.	Test I22 ¥ – Steer Position Feedback Encoder Count (Page 6-167) Test I24 ¥ – Steer Home Proximity Sensor (Page 6-169)	See "Troubleshooting Steering Fault Codes (G-series)" on page 5-25. To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE G8 INFORM SERVICE		
Code G8 – Amplifier current out-of-range Current feedback out-of-range.	Test A22 ¥ – Steer Motor Current (Page 6-119)	See "Troubleshooting Steering Fault Codes (G-series)" on page 5-25. To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE G9 INFORM SERVICE		
Code G9 – No power to the steer motor when travel is requested No B+ to the Electric Steer Manager.	Test A24 – Steer Manager Battery Sense Voltage (Page 6-121)	See "Troubleshooting Steering Fault Codes (G-series)" on page 5-25. To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE GA INFORM SERVICE		
Code GA – Steering encoder card disconnected Connection to the steering encoder card, the steering request encoder itself, or the Carriage Manager is bad.	Test I41 – Steering Encoder Disconnect (Page 6-183) 1. Check connections at JPE1 and JPC16. 2. Check continuity of cable JE1-JC16.	See "Troubleshooting Steering Fault Codes (G-series)" on page 5-25. To clear: Cycle the key switch OFF/ON.
Message Displayed: CODE J2 INFORM SERVICE		
Code J2 – Aisle exit error Only one magnet was sensed when the guided aisle was entered or exited.	Test I25 – End-of-Aisle Sense, Left-Side Sensors (Page 6-170) Test I27 – End-of-Aisle Sense, Right-Side Sensors (Page 6-172)	To clear: While out of the guided aisle, turn the auto/manual switch to manual. Turn the drive unit to an angle greater than 10 degrees and travel greater than 1 mph.

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Code Title/Reason	Tests to Run	Notes/Corrective Action
Message Displayed: CODE J4 INFORM SERVICE		
Code J4 – Aisle sensor not present One of the aisle sensors is disconnected.	Test I25 – End-of-Aisle Sense, Left-Side Sensors (Page 6-170) Test I27 – End-of-Aisle Sense, Right-Side Sensors (Page 6-172)	To clear: Install or replace sensor.

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RAYMOND

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Electrical Connector Locator Chart

Terminology

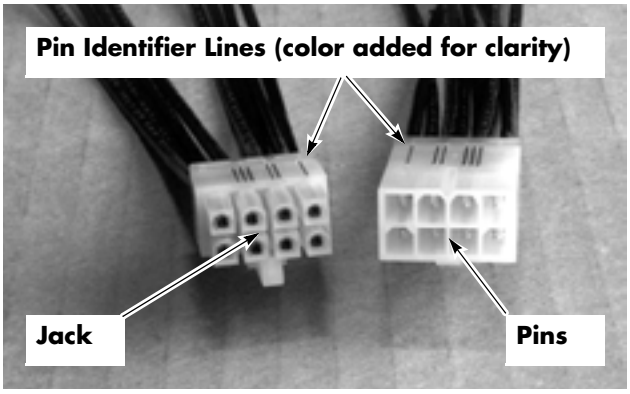


Figure 6-1. Molex Jack and Pin Connector

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

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

For example, connector JP1 is the mated main height sensor and main Height Manager connector. J1 represents the jack connections (in the cable). P1 represents the pin connections (on the Height Manager).

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

Use Table 6-1 (or the graphics beginning on page 6-80) to locate electrical connectors on the lift truck.

NOTE: Some connector names apply to more than one connector. For example, JP2.

Table 6-1. Electrical Connector Locator Chart

Connector	Location	Function/Destination
AMPL	Aux Power Amplifier	Aux Power Amplifier to Aux Interface Module
DT	Drive Motor	Drive Motor Temperature Sensor to Tractor Manager JPS19
HSUP	Horn Suppressor Module	Horn Suppressor Module to Horn and Tractor Manager JPS19
JP1	Operator Display	Operator Display to Display Module
JP1	Main Mast Height Manager	Main Height Manager to Height Sensor
JP2	Traction Heatsink	Power Panel Temperature Sensor to Power Card JPC1
JP2	Mini-Mast Height Manager	Mini-Mast Height Manager to Height Sensor
JP2	Operator Display	Operator Display to operator keypad switches
JP3	Mini-Mast Height Manager	Mini-Mast Height Manager to Reach Position Proximity Sensor
JP3	Operator Display	Operator Display to Carriage Manager JPC18
JP4	Operator Display	Operator Display to Piezo Sounder (H2)
JP4	Mini-Mast Height Manager	Mini-Mast Height Manager to Rotate Position Potentiometer (VR6)

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Table 6-1. Electrical Connector Locator Chart

Connector	Location	Function/Destination
JP5	Mini-Mast Height Manager	Mini-Mast Height Manager to JPK3
JP5	Main Mast Height Manager	Main Mast Height Manager to Carriage Manager JPC7
JP10	Warning Light	Warning/Strobe Light to Tractor Manager JPS20
JP18	Under Operator Platform	Over-the-mast cable A from Tractor Manager JPS25 to Carriage Manager JPC17
JP19	Under Operator Platform	Over-the-mast cable B from Tractor Manager JPS26 to Carriage Manager JPC20
JP1L	Under Operator Platform	Wire Guidance Load Sensor to Filter Card JPW1
JP1T	Inside Tractor Bumper	Wire Guidance Tractor Sensor to Filter Card JPW2
JP20	Plugging Contactor Enclosure (EE only)	Plugging Contactor to coil wires (EE only)
JP25	Slack Chain Switch	Slack Chain Switches to JPS30 and JPS31 at Slack Chain CD3 Card
JP39	Line Filter	Line Filter 1 to Carriage Manager JP19 via JS26 bundle
JP49	Line Filter	Line Filter 1 to Carriage Manager JP19 via JS26 bundle
JP59	Line Filter	Line Filter 2 to Carriage Manager JP19 via JS26 bundle
JP60	Aux Contactor Box	Aux Contactor Interface Module to Aux Contactor (EE only)
JP61	Line Filter	Line Filter 1 and 2 to Carriage Manager JP19 via JS26 bundle
JPA1	Supplemental Display	Supplemental Operator Display to Carriage Manager JPC8
JPA2	Steer Manager	Steer Manager from Tractor Manager JPS17
JPA3	Steer Manager	Steer Manager to Wire Guidance Filter Card
JPA5	Steer Manager	Steer Manager to Main Pressure Transducer JP5
JPA6	Steer Manager	Steer Manager to Mini Pressure Transducer JP6
JPA7	Steer Manager	Steer Manager to Home Position Proximity Sensor
JPA8	Steer Manager	Steer Manager to Steer Position Feedback Encoder
JPB-	Battery	Battery negative cable
JPB+	Battery	Battery positive cable
JPC1	Power Card	Power Card from Q1 & Power Panel Temperature Sensor JP2
JPC7	Carriage Manager	Carriage Manager to SB Main Mast Height Manager JP5
JPC8	Carriage Manager	Carriage Manager to Supplemental Operator Display JPA1
JPC9	Carriage Manager	Carriage Manager from SMART*i* option
JPC10	Carriage Manager	Carriage Manager to Rotate (SOL35A/SOL35B) and Traverse (SOL34A/SOL34B) Solenoid coils

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Electrical Connector Locator Chart

Table 6-1. Electrical Connector Locator Chart

Connector	Location	Function/Destination
JPC12	Carriage Manager	Carriage Manager to JPK2 then to Traverse Position Potentiometer (VR5)
JPC14	Carriage Manager	Carriage Manager to Carriage Manager Power Supply JPP1
JPC15	Carriage Manager	Carriage Manager to Key Switch and EPO
JPC16	Carriage Manager	Carriage Manager to Steer Encoder Card JPE1
JPC17	Carriage Manager	Carriage Manager to over-the-mast cable JP18
JPC18	Carriage Manager	Carriage Manager to Operator Display JP3
JPC19	Carriage Manager	Carriage Manager to options (lights, fan and/or cold storage heater)
JPC20	Carriage Manager	Carriage Manager to over-the-mast cable JP19
JPC21	Carriage Manager	Carriage Manager from Sidegate Switches (S60 and S61)
JPC23	Carriage Manager	Carriage Manager from Left Control Handle JPL1
JPC24	Carriage Manager	Carriage Manager from Right Control Handle JPR1
JPC25	Carriage Manager	Carriage Manager to Deadman Switches (S2, S9, S23)
JPC26	Carriage Manager	Carriage Manager to Proportional Reach/Rotate (SOL33) Solenoid coil
JPCM1	Aux Contactor Interface Module	Aux Contactor Interface Module to Aux Contactor and to JPM1
JPE1	Steer Encoder Card	Steer Encoder Card to Carriage Manager JPC16
JPH1	Carriage Manager	Carriage Manager to JPK3 then to Mini-Mast Height Manager and Reach Solenoid (SOL36)
JPH2	Tractor Manager	Tractor Manager to SA Main Mast Height Manager JP5
JPK2	Traverse Position Pot	Traverse Position Potentiometer (VR5) to Carriage Manager JPC12
JPK3	Near Traverse Motor	From Mini-Mast Height Manager and Reach Solenoid (SOL36) to Carriage Manager JPH1
JPL1	Left Control Handle	Left Control Handle to Carriage Manager JPC23
JPL19	Under Seat or near Carriage Manager	From S40, S41, S42, S43 switches to terminal strip TS1 for lights and fan
JPM1	Auxiliary Control Card or Interface Module	Auxiliary Control Card to Tractor Manager at JPS4; or splice between Auxiliary Interface Module at JPM2 and Tractor Manager at JPS4
JPM2	Auxiliary Interface Module	Auxiliary Interface Module to Aux Power Amplifier and to splice JPM1
JPP1	Carriage Manager Power Supply Card	Carriage Manager Power Supply Card to Carriage Manager JPC14

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Table 6-1. Electrical Connector Locator Chart

Connector	Location	Function/Destination
JPR1	Right Control Handle	Right Control Handle to Carriage Manager JPC24
JPS1	Tractor Manager/Tractor Manager VFC	Tractor Manager/Tractor Manager VFC connection
JPS2	Tractor Manager/Tractor Manager VFC	Tractor Manager/Tractor Manager VFC connection
JPS3	Power Card/Tractor Manager	Power Card / Tractor Manager connection
JPS4	Tractor Manager	Tractor Manager to Auxiliary Control Card JPM1
JPS5	Power Card/Tractor Manager	Power Card / Tractor Manager connection
JPS6	Tractor Manager	Tractor Manager to Aisle Detect Sensor Option S46
JPS11	Tractor Manager/Coil Driver Card	Coil Driver Card to Tractor Manager
JPS12	Tractor Manager	Tractor Manager to Coil Driver 3 Card
JPS13	Tractor Manager	Tractor Manager to Rail Sense option S15
JPS14	Tractor Manager	Tractor Manager to sense lines, B+, B+ESTOP, B+PC1, B+PC1F, B-, and PC1 and Plugging Contactors
JPS15	Tractor Manager	Tractor Manager to Alarm and/or spare limit switch options
JPS16	Tractor Manager	Tractor Manager to Battery Gate Switch options
JPS17	Tractor Manager	Tractor Manager from Steer Manager at JPA2
JPS18	Tractor Manager	Tractor Manager to Speed Feedback Proximity Sensor or to connector SPS
JPS19	Tractor Manager	Tractor Manager to L/H and L/L Solenoid coils, Brake Contactor coil, Drive Motor Temperature Sensor, Horn, and Horn Suppressor Module
JPS20	Tractor Manager	Tractor Manager to Warning/Strobe Light JP10
JPS21	Tractor Manager	Tractor Manager to PC2 Contactor Coil Driver
JPS22	Tractor Manager	Tractor Manager to PC2 Contactor coil
JPS25	Tractor Manager	Tractor Manager to over-the-mast cable JP18
JPS26	Tractor Manager	Tractor Manager to over-the-mast cable JP19
JPS28	Tractor Manager	Tractor Manager to Aisle Detect Sensor option S47
JPS29	Coil Driver 3 Card on Tractor Manager	Coil driver 3 to Lift Select and Mini Load Holding Solenoid coils and P Contactor coil
JPS30	Slack Chain CD3 Card	Slack Chain CD3 Card to JP25 harness for S50
JPS31	Slack Chain CD3 Card	Slack Chain CD3 Card to JP25 harness for S51

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Electrical Connector Locator Chart

Table 6-1. Electrical Connector Locator Chart

Connector	Location	Function/Destination
JPS46	Tractor Manager	Splice between Tractor Manager and Aux Contactor/Aux Contactor Interface Module
JPW1	Wire Guidance Filter Card	Filter Card from Wire Guidance Load Sensor JP1L
JPW2	Wire Guidance Filter Card	Filter Card from Wire Guidance Tractor Sensor JP1T
JPW7	Right Control Handle Heater	Control Handle cold storage heater and switch S75 from FU18 and JPW8
JPW8	Left Control Handle Heater	Control Handle cold storage heater and switch S76 from FU19 and JPW7
JPY5	Main Pressure Transducer	Main Pressure Transducer to Steer Manager JPA5
JPY6	Mini Pressure Transducer	Mini Pressure Transducer to Steer Manager JPA6
SPS	Speed Feedback Proximity Sensor	Speed Feedback Proximity Sensor to Tractor Manager at JPS18

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Circuit Card Connectors

The following drawings identify location of connectors, LED indicator lights, and other major structures.

Power Card

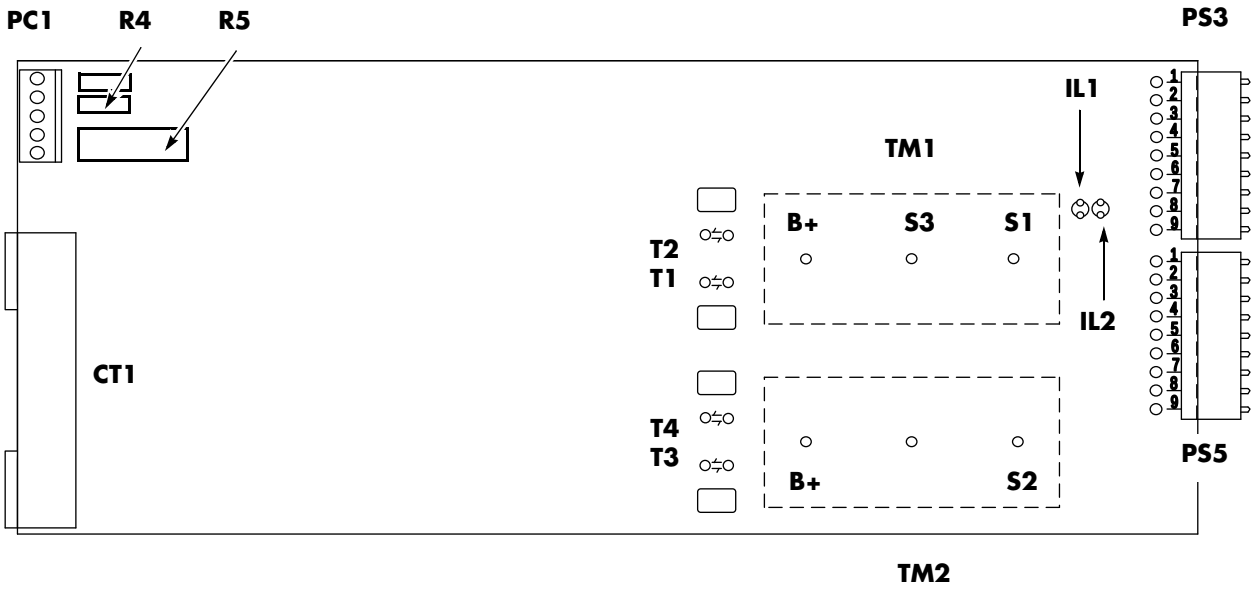


Figure 6-2. Power Card connectors

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Tractor Manager

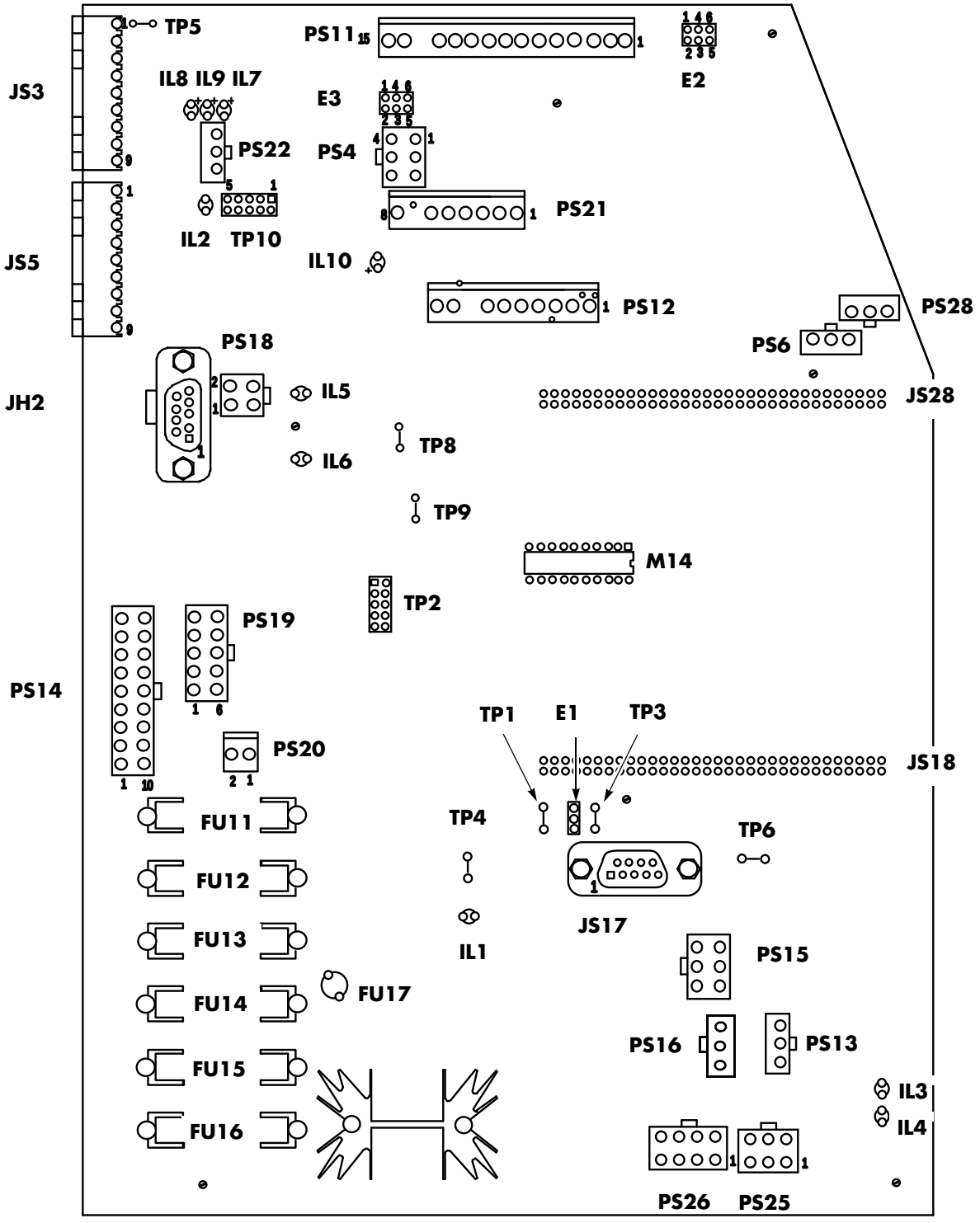


Figure 6-3. Tractor Manager connectors

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Tractor Manager Vehicle Function Controller

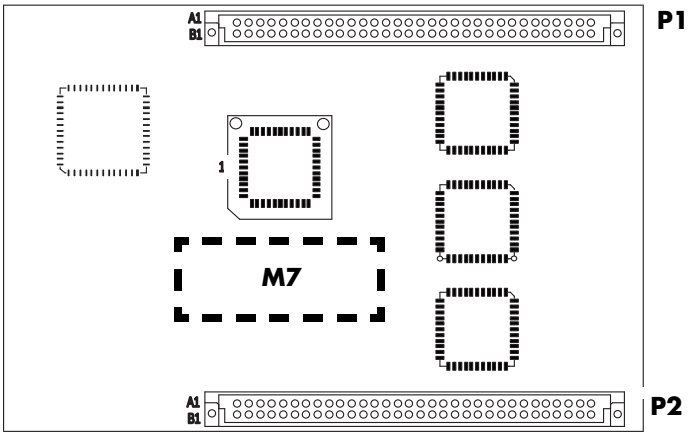


Figure 6-4. Tractor Manager VFC connectors

Carriage Manager Power Supply

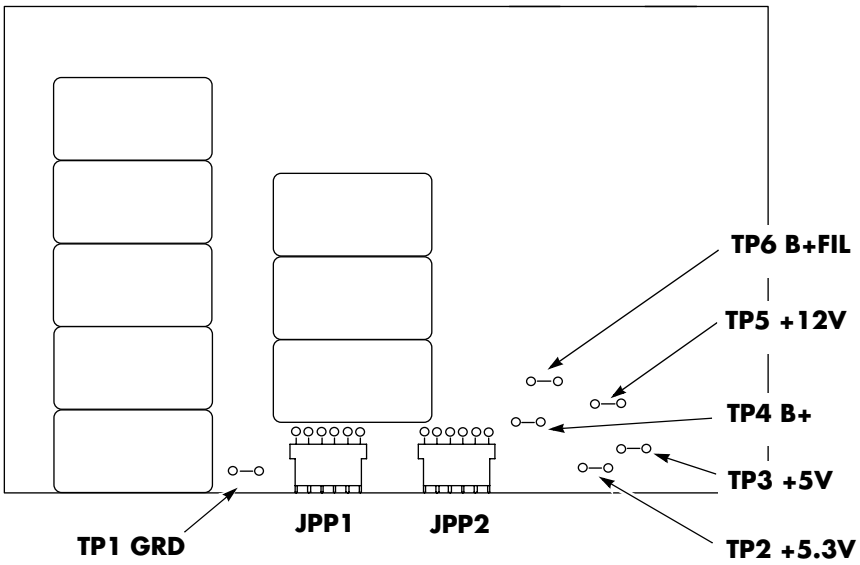


Figure 6-5. Carriage Manager Power Supply card connectors

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Carriage Manager (short)

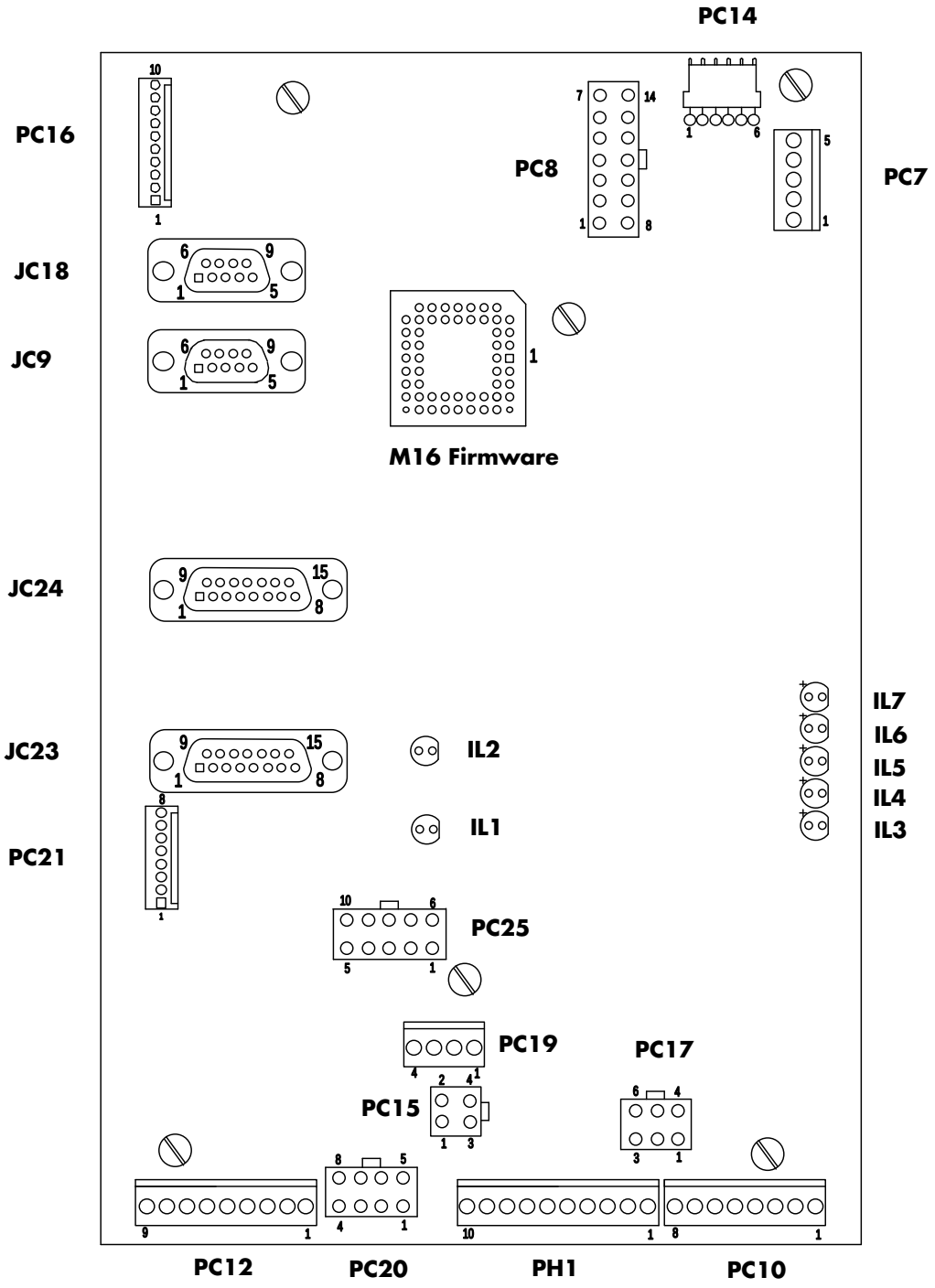


Figure 6-6. Carriage Manager connectors (P/N 154-012-504 shown)

NOTE: Carriage Manager circuit card P/N 154-012-504 requires CM firmware version 2.04 or below, or version 4.01 or above, and is used in lift trucks SA S/N < 03000 and in SB S/N < 00700.

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Carriage Manager (long)

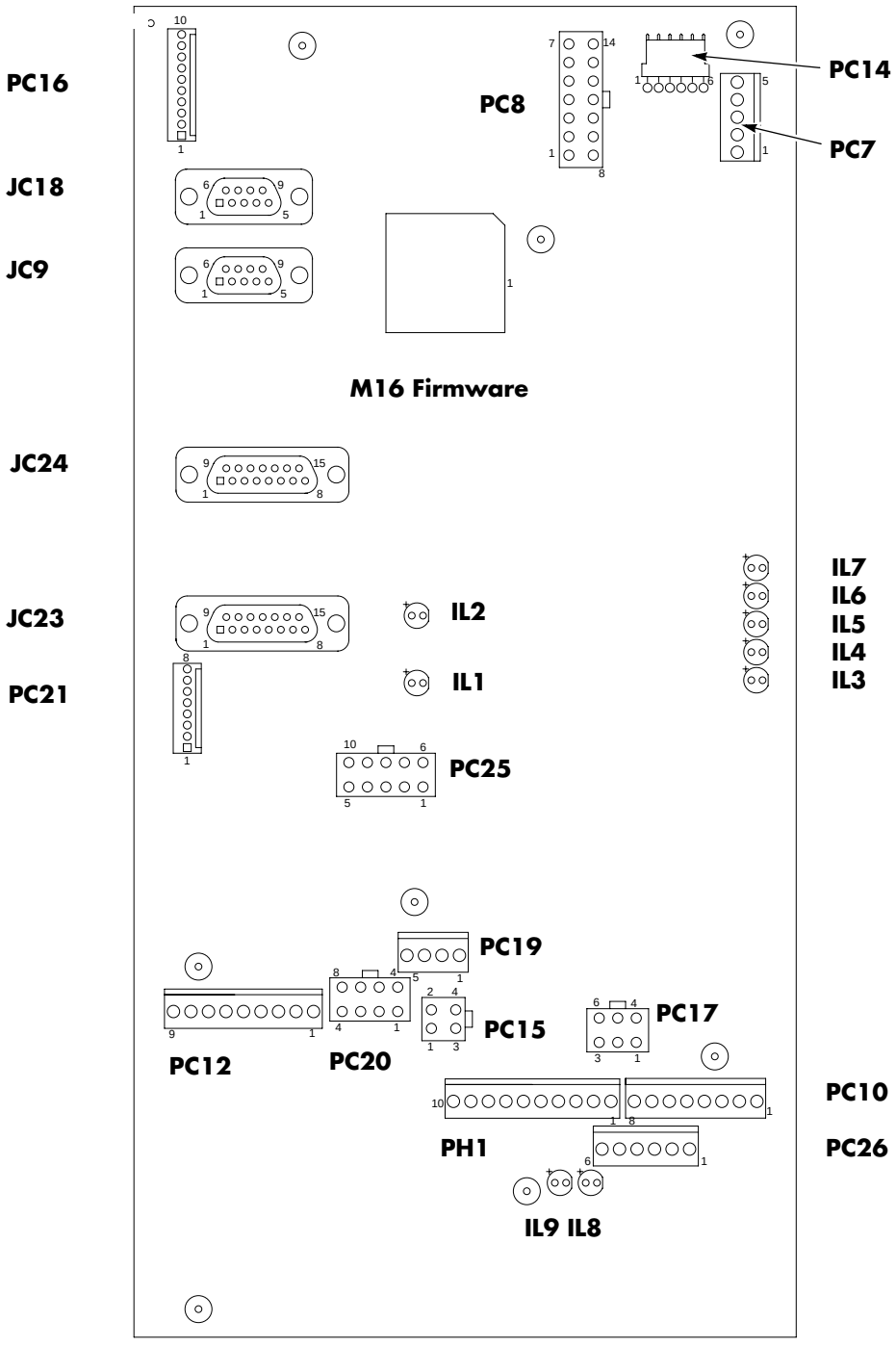


Figure 6-7. Carriage Manager connectors (P/N 1002608 shown)

NOTE: Carriage Manager circuit card P/N 1002608 requires CM firmware version 3.03 or higher, and is used in lift trucks SA S/N > 02999 and SB S/N > 00699.

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Steer Manager

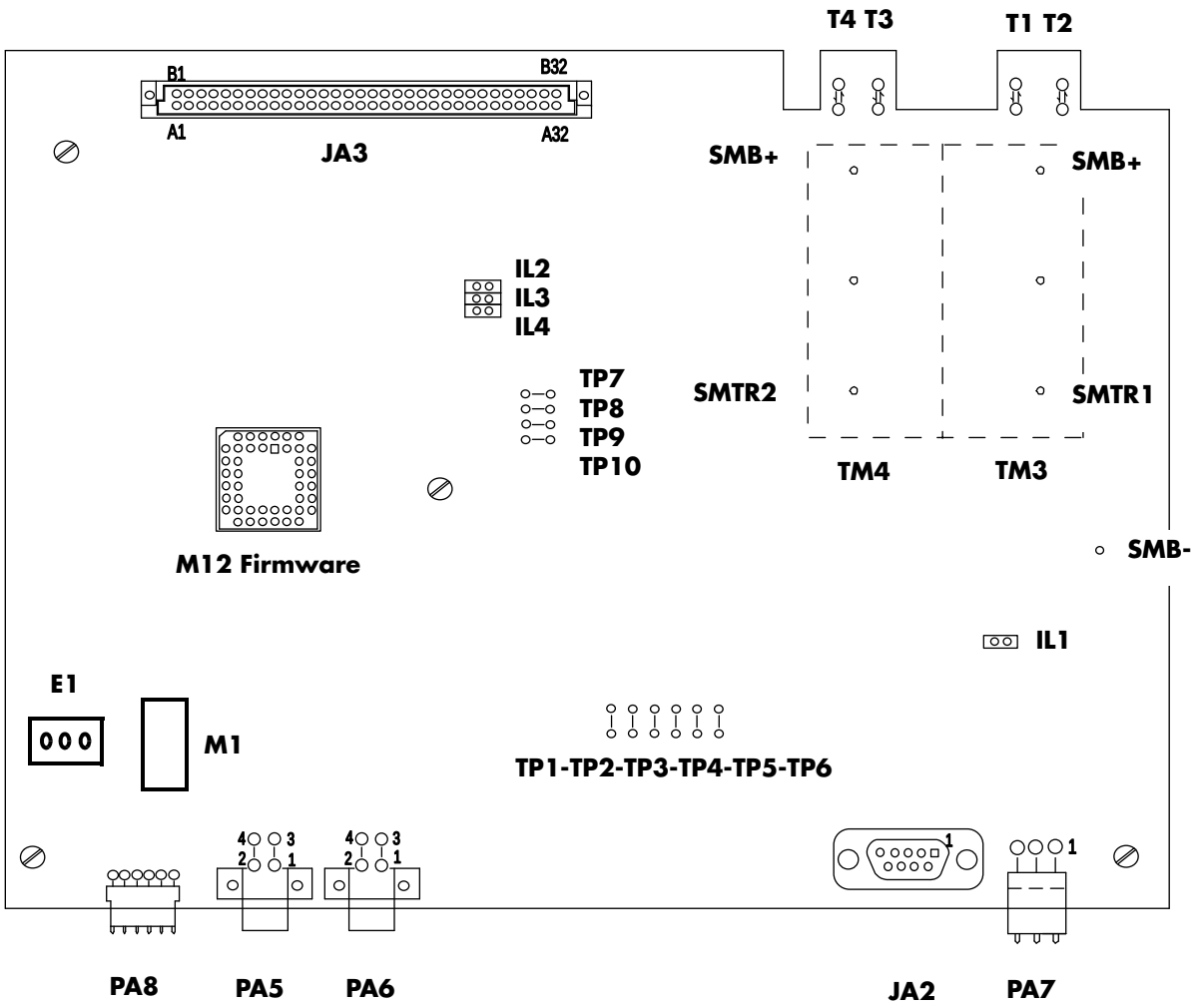


Figure 6-8. Steer Manager connectors

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Wire Guidance Filter Card

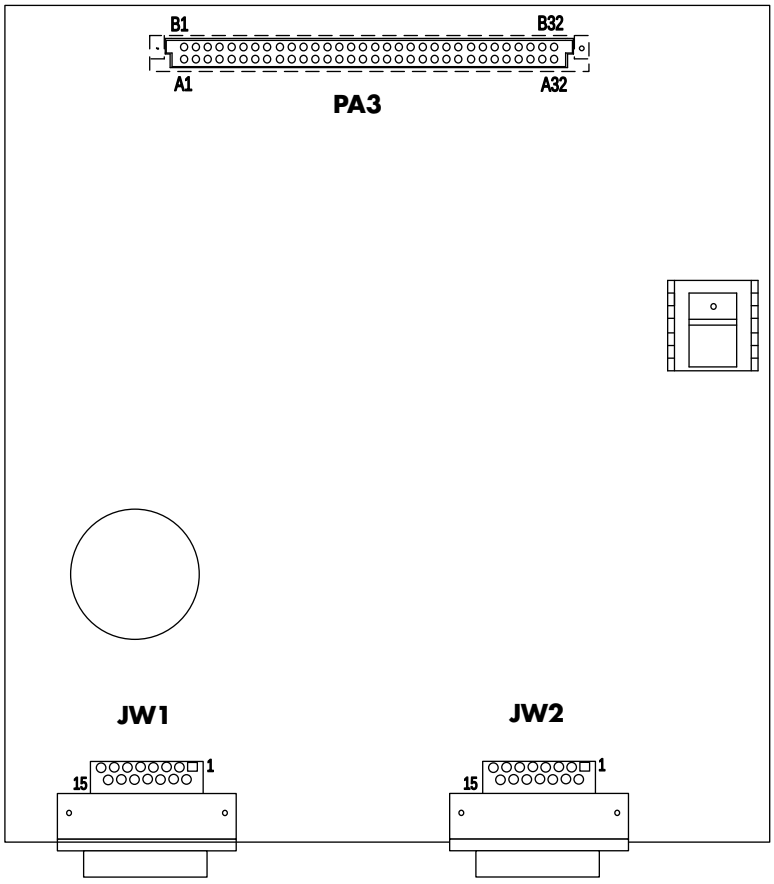


Figure 6-9. Wire Guidance Filter Card connectors

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Auxiliary Motor Controller Card

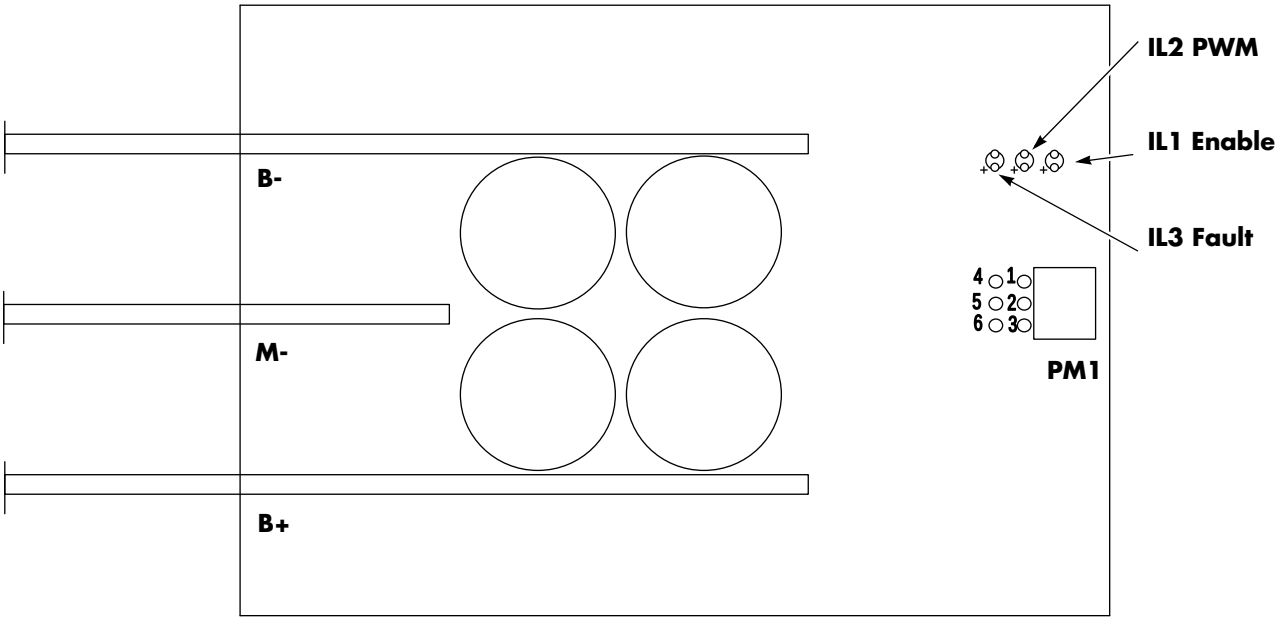


Figure 6-10. Auxiliary Controller Card connectors

Auxiliary Power Amplifier

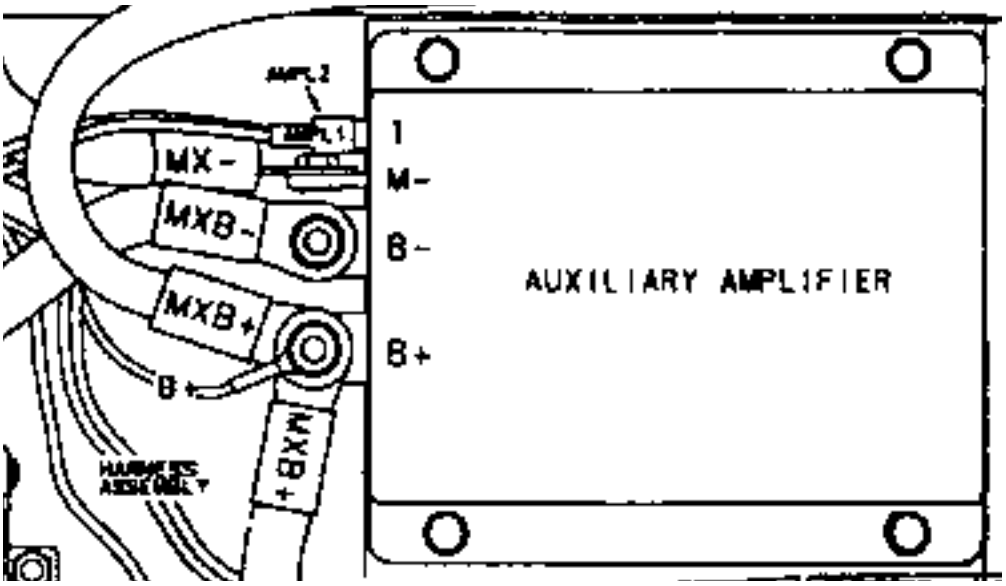


Figure 6-11. Auxiliary Power Amplifier

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Height Manager

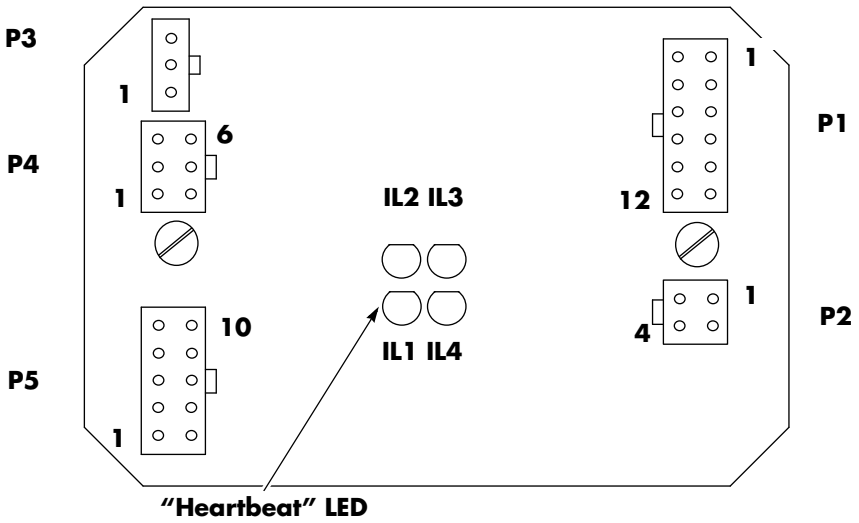


Figure 6-12. Height Manager connectors

Operator Display Interface Card

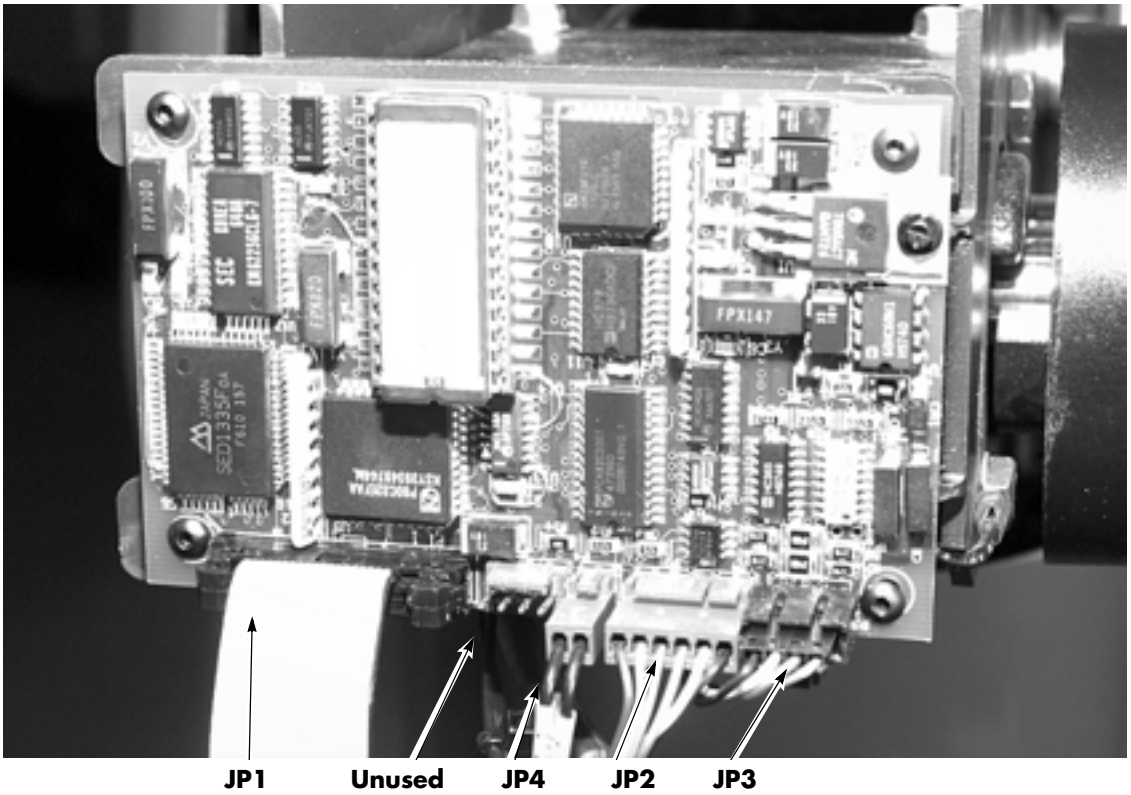


Figure 6-13. Operator Display Interface Card

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Electrical Test Summary List

NOTE: ¥ following test number indicates Dynamic Diagnostic Mode available for this test. Reference "Using Dynamic Diagnostic Mode" on page 6-22.

Analog Tests

Test A00 – TM Power Supply 6-94
Test A01 – Armature Current Sense 6-95
Test A02 – Power Panel Temperature Sensor Voltage 6-96
Test A03 – Throttle Pot Voltage (VR1) 6-98
Test A04 – Lift/Lower Potentiometer (VR2) Voltage 6-99
Test A05 ¥ – Pressure Transducer, Main 6-101
Test A06 – Traverse Control Potentiometer (VR4) Voltage 6-102
Test A07 – PC1 (Travel) Sense Voltage 6-103
Test A08 – Lift Motor Sense Voltage 6-104
Test A09 – Rotate Control Potentiometer (VR3) Voltage 6-106
Test A10 – Armature Transistor (Q1-C) Sense Voltage 6-108
Test A11 – Battery Voltage 6-109
Test A12 – CM Power Supply 6-110
Test A14 – Field Current Sense 6-111
Test A15 – Drive Motor Temperature Sensor (DT) 6-112
Test A16 – Right Tractor Guidance Coil Voltage 6-113
Test A17 – Left Tractor Guidance Coil Voltage 6-114
Test A18 – Right Load Guidance Coil Voltage 6-115
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Test A21 – Load Near Wire Coil Voltage 6-118
Test A22 ¥ – Steer Motor Current 6-119
Test A23 – Steer Manager Power Supply Voltage 6-120
Test A24 – Steer Manager Battery Sense Voltage 6-121
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Test A29 – Average Distance From Wire 6-127
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Test A31 – Average Heading Angle Magnitude 6-129
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Test A33 – Average Guide Wire Strength 6-131
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Digital Input Tests

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Test I02 – Lift Select Switch (S6) 6-147
Test I03 – Brake Deadman Switch (S2) 6-148
Test I04 – Emergency Power Off (EPO) Switch (S21) 6-149
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Test I06 – Armature Current Limit Input 6-151
Test I07 – Power Panel Temperature Limit 6-152
Test I08 – Rail Guidance Switch (S15) 6-153
Test I09 ¥ – Mini-Mast Reference Point 6-154
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Test I11 – Auto/Manual Switch (S4) 6-156
Test I12 – Plugging Detector 6-157
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Test I15 ¥ – Main Mast Height Count 6-160
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Test I23 – Wire Guidance Filter Card Status 6-168
Test I24 ¥ – Steer Home Proximity Sensor 6-169
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Test I29 – Speed Feedback Proximity Sensor, Channel A 6-174
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Test I33 – Steering Encoder Channel B 6-178
Test I34 – Steering Encoder Channel A 6-179
Test I35 – Steering Tiller Position 6-180
Test I39 ¥ – Aux Fault Line 6-181
Test I40 – Carriage Deadman (S23) at the CM 6-182
Test I41 – Steering Encoder Disconnect 6-183
Test I42 ¥ – EOA Sensor Connect Detect (optional) 6-184
Test I44 ¥ – Travel Cutout Switch (optional) 6-185
Test I45 – Slack Chain Switches 6-186
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Digital Output Tests

Test O00 – Toggle the PC1 (Travel PC) Contactor 6-194
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RAYMOND

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Analog Tests

A Diagnosis and Repair table is provided for most tests. If a test fails, refer to the Diagnosis and Repair table. This table provides a step-by-step approach to diagnosing a problem and the necessary corrective action. See the example below.

Example Diagnosis and Repair Table

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

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Test A00 – TM Power Supply

This test displays the voltage sensed from the Tractor Manager power supply.

A successful test proves that the Tractor Manager power supply is working correctly.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

The Operator Display shows the voltage that the Tractor Manager reads from its power supply.

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

Table 6-2.

Condition	Voltage Displayed
Truck at rest	10.8 to 13.0V

- If the reading fluctuates by more than 0.8 volts in 10 seconds, then the test is a failure.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	DCV scale	TP4 on TM	TP6 on TM	10.8 to 13V	Replace VFC.	Do step 2.
2.	PS17 disconnected	TP4 on TM	TP6 on TM	10.8 to 13V	Do step 3.	Do step 4.
3.	Disconnect each connector on the ESM using the 12 or 5.3V one at a time and check to see if 12V returns. / DCV scale	TP4 on TM	TP6 on TM	10.8 to 13V	Troubleshoot component and wires disconnected.	Replace ESM.
4.	Disconnect each connector and card on the TM using the 12 or 5.3V one at a time and check to see if 12V returns. / DCV scale	TP4 on TM	TP6 on TM	10.8 to 13V	Troubleshoot component and wires disconnected.	Replace TM.

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Test A01 – Armature Current Sense

This test displays the current that the Tractor Manager VFC reads from the current sensor (CT) on the power card.

The current sensor measures the current flowing through the drive motor armature. The Tractor Manager VFC constantly monitors this current.

The power card automatically limits the maximum current through the power transistor (Q1) to approximately 375 amps peak. The current limit value is preset at the factory and is not adjustable.

It is normal for the power card to go into current limit, particularly when accelerating. Whenever the power card is in current limit, the green LED (IL2) is on.

Run Test

NOTE: Run this test only if Test O14 passes.

For information on how to use maintenance mode, see “Diagnostic Mode” on page 6-4.

The Operator Display shows the current that the Tractor Manager reads from the current sensor.

At rest the test should read 0 amps.

With the drive motor running, the test should read between 0 and 375 amps.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Power Card disconnected from TM / DCV scale	B+	JS3-4	B+	Do step 2.	Replace TM.
2.	Run Test O14. / DCV scale	JPS3-4	B–	Ramps from approx. 6 to 9V	Do step 3.	Replace Power Card.
3.	Run Test O14. / DCV scale	JPS1-B2 (VFC)	B–	Ramps from approx. 2.4 to 3.7V	Replace VFC.	Replace TM.

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Test A02 – Power Panel Temperature Sensor Voltage

This test displays the voltage that the Tractor Manager VFC reads from the main power transistor (Q1) heatsink temperature sensor (HT).

While operating, the Tractor Manager VFC monitors the heatsink temperature. If the temperature exceeds 200°F (93°C), the travel speed is reduced until the heatsink cools down.

Run Test

NOTE: For information on how to use maintenance mode, see “Diagnostic Mode” on page 6-4.

You can also run this test in Active Diagnostic Mode.

HINT: In order to see a range of values, heat the truck up by driving it hard for 30 minutes while running this test. The heatsink cools quite rapidly, and you should see a significant change within 5 minutes.

The Operator Display shows the voltage that the Tractor Manager reads from the temperature sensor (HT).

The test is a success if the voltage displayed matches the truck condition in Table 6-3.

If the truck is truly overheating, determine the cause of the overheating condition. See “Troubleshooting.”

Table 6-3.

Truck Condition	Voltage at JPS5-7 (+) from JPS3-2 (-)	Resistance between JC1-3 and JC1-4
Rest (70°F/21°C)	4.0 ± 0.1V	2.1K ± 0.1K ohms
Normal Operation (-4°F/-20°C to 200°F/93°C)	2.7 to 5.8V	1.7K to 2.6K ohms
Overheated (200°F/93°C to 227°F/108°C)	5.8 to 7.0V	2.6K to 3.1K ohms
JP2 disconnected	7.0 to 12.0V	3.1K ohms to Open

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC1 at Power Card disconnected / Ohms scale	JC1-4	JC1-3	Approx. 2K ohms at 70°F (21°C)	Do step 2.	Troubleshoot wires and sensor.
2.	JPC1 at Power Card disconnected / DCV scale	PC1-4	PC1-3	OD: Approx. 11V; red overtemp LED on; Meter: Approx. 12V	Do step 3.	Replace Power Card.
3.	JPC1 at Power Card disconnected / DCV scale	JPS5-7	B–	Approx. 11V	Do step 4.	Replace Power Card.
4.	DCV scale	JPS5-7	B–	Approx. 3.8V at 70°F (21°C)	Replace TM.	Replace Power Card.

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Test A03 – Throttle Pot Voltage (VR1)

This test displays the voltage that the Carriage Manager reads from the throttle or travel potentiometer (VR1). A successful test proves that the throttle potentiometer and associated wiring from the pot through cable harness JPR1 to JPC24 is working correctly.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

Move the throttle control from full forward to full reverse, observing the Operator Display.

The Operator Display shows the voltage that the Carriage Manager reads from the throttle pot (VR1).

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

Table 6-4.

Throttle Control Position	Voltage Displayed
Full reverse	0.4 to 1.5V
Neutral	2.0 to 3.0V
Full forward	3.5 to 4.6V

While using this test, move the control handle slowly. Observe the reading on the Operator Display. The voltage should increase/decrease smoothly as you move the control throughout its range. If the reading is erratic, the potentiometer is bad.

Cycle the pot several times throughout its range. The voltages at the extremes and at neutral should be consistent.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC24 disconnected / DCV scale	JPC24-9	JPC24-12	5V	Do step 2.	Replace CM.
2.	JPC24 disconnected / DCV scale	JPC24-9	JPC24-11	5V	Do step 3.	Replace CM.
3.	DCV scale	JPC24-11	JPC24-12	Neutral: 2.0 to 3.0V; Full reverse: 0.4 to 1.5V; Full forward: 3.5 to 4.6V	Replace CM.	Test wires to handle; if OK, replace pot.

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Test A04 – Lift/Lower Potentiometer (VR2) Voltage

This test displays the voltage that the Carriage Manager reads from the lift/lower potentiometer (VR2). A successful test proves that the lift/lower potentiometer and associated wiring from the pot through cable harness JPR1 to JPC24 is working correctly.

Run Test

NOTE: For information on how to use maintenance mode, see “Diagnostic Mode” on page 6-4.

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

The Operator Display shows the voltage that the Carriage Manager reads from the lift/lower potentiometer (VR2).

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

Table 6-5.

Lift/Lower Potentiometer Position	Voltage Displayed
Full lift	0.4 to 1.5V
Neutral	2.0 to 3.0V
Full lower	3.5 to 4.6V

While using this test, move the control handle slowly. Observe the reading on the Operator Display. The voltage should increase/decrease smoothly as you move the pot throughout its range. If the reading is erratic, the potentiometer is bad.

Cycle the pot several times throughout its range. The voltages at the extremes and at neutral should be consistent.

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
Carbon Potentiometers						
1.	JPC24 disconnected / DCV scale	JPC24-15	JPC24-13	12V	Do step 2.	Replace CM.
2.	JPC24 disconnected / DCV scale	JPC24-15	JPC24-10	12V	Do step 3.	Replace CM.
3.	DCV scale	JPC24-10	JPC24-13	Neutral: 2.0 to 3.0V; Full Lift: 0.4 to 1.5V; Full Lower: 3.5 to 4.6V	Replace CM.	Test cable to control handle; if OK, replace pot.
Solid State Potentiometers						
1.	JPC24 disconnected / DCV scale	JPC24-9	JPC24-13	5V	Do step 2.	Replace CM.
2.	JPC24 disconnected / DCV scale	JPC24-9	JPC24-10	5V	Do step 3.	Replace CM.
3.	DCV scale	JPC24-10	JPC24-13	Neutral: 2.0 to 3.0V; Full Lift: 0.4 to 1.5V; Full Lower: 3.5 to 4.6V	Replace CM.	Test cable to control handle; if OK, replace pot.

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Test A05 ¥ – Pressure Transducer, Main

This test displays the voltage produced by the main lift pressure transducer (PT-A) on the main manifold and connected to the Electric Steer Manager at JPA5-2. A successful test proves that the pressure transducer and its associated wiring are working correctly.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

The Operator Display shows the voltage that the pressure transducer (PT-A) produces.

- Any reading greater than 4.8 volts or less than 1.0 volt on the Operator Display is a failure.
- Without a load on the forks, the Operator Display should show approximately 1.0 ± 0.1 volts.
- As the load on the forks increases, the voltage should increase. Each 1000 lbs. (454 kg) change in weight equals approximately 1.0 volt change on the Operator Display.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPA5 disconnected / DCV scale	PA5-1	PA5-3	Approximately 12V	Do step 2.	Replace ESM.
2.	JPA5 disconnected / DCV scale	PA5-1	PA5-2	Approximately 12V	Do step 3.	Replace ESM.
3.	No weight on forks	JPA5-1	JPA5-2	Fully lowered: Approx. 10.5V; Elevated 2 ft.: Approx. 0.5V less than voltage when fully lowered	Replace ESM.	Test wires to transducer; if OK, replace transducer.

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Test A06 – Traverse Control Potentiometer (VR4) Voltage

This test displays the voltage that the Carriage Manager reads from the traverse control potentiometer (VR4). A successful test proves that the traverse control potentiometer and associated wiring from the pot through cable harness JPL1 to JPC23 is working correctly.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

Move the traverse control from full speed left to full speed right, observing the Operator Display.

The Operator Display shows the voltage that the Carriage Manager reads from the traverse pot (VR4).

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

Table 6-6.

Traverse Control Position	Voltage Displayed
Full speed left	0.4 to 1.5V
Neutral	2.0 to 3.0V
Full speed right	3.5 to 4.6V

While using this test, move the control handle slowly. Observe the reading on the Operator Display. The voltage should increase/decrease smoothly as you move the pot throughout its range. If the reading is erratic, the potentiometer is bad.

Cycle the pot several times throughout its range. The voltages at the extremes and at neutral should be consistent.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC23 disconnected / DCV scale	JPC23-9	JPC23-12	5V	Do step 2.	Replace CM.
2.	JPC23 disconnected / DCV scale	JPC23-9	JPC23-11	5V	Do step 3.	Replace CM.
3.	DCV scale	JPC23-11	JPC23-12	Neutral: 2.0 to 3.0V; Full Left: 0.4 to 1.5V; Full Right: 3.5 to 4.6V	Replace CM.	Test cable to control handle; if OK, replace pot.

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Test A07 – PC1 (Travel) Sense Voltage

This test displays the voltage that the Tractor Manager VFC reads from the PC1 (Travel) sense line. The PC1 sense line goes from PC1-2 to the Tractor Manager at JPS14-6.

A successful test proves that the Tractor Manager VFC is correctly reading the battery voltage. It also proves that the PC1 contactor is closing correctly. It does *not* mean that the contactor tips on the PC1 contactor are good.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

The Operator Display shows the battery voltage that the Tractor Manager reads when the PC1 contactor tips are closed.

The test is a success if the voltage displayed, with the truck not moving or lifting, is as follows:

Table 6-7.

PC1 Contactor	Voltage Displayed
Closed	44.0 to 52.0V
Open	Less than 1V

- If the reading fluctuates by more than 0.5 volts in 10 seconds, then the test is a failure.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	PC1 tips closed / DCV scale	JPS14-6	TP4	B+	Replace the VFC and/or TM.	Do step 2.
2.	PC1 tips closed / DCV scale	PC1-1	TP4	B+	Test wire from PC1-1 to the TM.	Check PC1 contactor and tips. Test cables and connections back to battery.

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Test A08 – Lift Motor Sense Voltage

This test displays the voltage that the Tractor Manager VFC reads from the P Sense line. The P Sense line runs from TP3 at Fuse FU6 to the Tractor Manager at JPS14-7.

The P (pump) sense line (JPS14-7) monitors the voltage between the lift contactor and the lift motor. This voltage is used:

- to verify correct operation of the P contactor
- on trucks without SOL99 to monitor the rpm of the lift motor so that the load holding and lift/lower valves sequence correctly when going from full lift to full lower quickly
- on trucks without SOL99 to determine when the lift motor stops spinning by measuring its back EMF voltage.

Run Test

NOTE: For information on how to use maintenance mode, see “Diagnostic Mode” on page 6-4.

⚠ WARNING

Open the Emergency Lowering Valve before performing this test. This prevents the operator platform from lifting while the test is running.

1. The Operator Display shows the voltage that the Tractor Manager reads from the P sense line.

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

Table 6-8.

P Contactor Condition	Voltage Displayed
Open	< 1.0V
Closed	44.0 to 52.0V

   - If the reading fluctuates by more than 0.5 volts in 10 seconds, then the test is a failure.
2. Manually close the P contactor by pressing on the plunger. *Do not touch* the contactor tips themselves. The lift motor should start. (The carriage does not lift because the emergency lowering valve is open.)
3. Run the test in Active Diagnostic Mode. Battery voltage should be displayed when the contactor is closed. When the contactor is de-energized, the voltage should decrease rapidly as the lift motor speed decreases. Voltage should be less than 1 volt when the motor is stopped.

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Diagnosis and Repair Table

⚠CAUTION

The lift pump will run during this test. Open the emergency lowering valve to prevent lift.

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Run Test O02; push down PC2 contactor. / DCV scale	JPS14-7	B–	Test ON, tips closed: Approx. B+ minus 2V; Test OFF: 0V	Do step 2.	Troubleshoot wires, FU6, and contactor tips.
2.	Run Test O02; push down PC2 contactor. / DCV scale	JPS1-B3 (VFC)	B–	Test ON, tips closed: Approx. 4 to 6V; Test OFF: 0V	Replace VFC.	Replace TM.

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Test A09 – Rotate Control Potentiometer (VR3) Voltage

This test displays the voltage that the Carriage Manager reads from the rotate control potentiometer (VR3). A successful test proves that the rotate control potentiometer and associated wiring from the pot through cable harness JPL1 to JPC23 is working correctly.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

Move the rotate control potentiometer from full speed clockwise through neutral to full speed counterclockwise, observing the Operator Display.

The Operator Display shows the voltage that the Carriage Manager reads from the rotate control potentiometer (VR3).

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

Table 6-9.

Rotate Control Potentiometer Position	Voltage Displayed
Full speed clockwise	0.4 to 1.5V
Neutral	2.0 to 3.0V
Full speed counterclockwise	3.5 to 4.6V

While using this test, move the control handle slowly. Observe the reading on the Operator Display. The voltage should increase/decrease smoothly as you move the pot throughout its range. If the reading is erratic, the potentiometer is bad.

Cycle the pot several times throughout its range. The voltages at the extremes and at neutral should be consistent.

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
Carbon potentiometers						
1.	JPC23 disconnected / DCV scale	JPC23-15	JPC23-13	12V	Do step 2.	Replace CM.
2.	JPC23 disconnected / DCV scale	JPC23-15	JPC23-10	12V	Do step 3.	Replace CM.
3.	DCV scale	JPC23-10	JPC23-13	Neutral: 2 to 3V; Full CW: 0.4 to 1.5V; Full CCW: 3.5 to 4.6V	Replace CM.	Test cable to control handle; if OK, replace pot.
Solid State Potentiometers						
1.	JPC23 disconnected / DCV scale	JPC23-9	JPC23-13	5V	Do step 2.	Replace CM.
2.	JPC23 disconnected / DCV scale	JPC23-9	JPC23-10	5V	Do step 3.	Replace CM.
3.	DCV scale	JPC23-10	JPC23-13	Neutral: 2 to 3V; Full CW: 0.4 to 1.5V; Full CCW: 3.5 to 4.6V	Replace CM.	Test cable to control handle; if OK, replace pot.

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Test A10 – Armature Transistor (Q1-C) Sense Voltage

This test displays the voltage that the Tractor Manager VFC Card reads from the Q1C sense. The Q1 sense line runs from the collector of the Q1 transistor (TP6) to the Tractor Manager at JPS14-9.

Run Test

NOTE: Run this test only if Test O14 passes.

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

Table 6-10.

Truck Condition with PC1 Energized (In)	Voltage Displayed
Resting	44.0 to 52.0V
Full Speed	Toggles 0 to > 2.0V

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Run Test O14. / DCV scale	JPS14-9	B–	Test ON: ramp B+ to B+ minus 4V; Test OFF: Approx. 0.8V	Do step 2.	Troubleshoot wire to heatsink.
2.	Run Test O14. / DCV scale	JPS1-B4 (VFC)	B–	Test ON: ramp approx. 1.5 to 2.9V; Test OFF: Approx. 0.437V	Replace VFC.	Replace TM.

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Test A11 – Battery Voltage

This test displays the voltage that the Tractor Manager VFC reads from the battery sense line at JPS14-10 and JPS14-11 (B+PC1). The Tractor Manager uses this voltage to calculate battery state-of-charge.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

The Operator Display shows the voltage that the Tractor Manager reads from the battery sense line.

The test is a success if the voltage displayed, with the truck at rest with PC1 energized (IN) is between 44.0 and 52.0 volts.

If the reading fluctuates by more than 0.8 volts in 10 seconds, then the test is a failure.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	PC Closed / DCV scale	JPS14-10	B–	44 to 52V	Do step 2.	Troubleshoot wire and PC1 contactor and tips.
2.	PC Closed / DCV scale	JPS14-11	B–	44 to 52V	Do step 3.	Troubleshoot wire and PC1 contactor and tips.
3.	PC Closed / DCV scale	FU11-2	B–	44 to 52V	Do step 4.	Replace fuse.
4.	PC Closed / DCV scale	JPS1-A3 (VFC)	B–	Approx. 5.2V	Replace VFC.	Replace TM.

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Test A12 – CM Power Supply

This test displays the voltage sensed from the Carriage Manager power supply.

A successful test proves that the Carriage Manager power supply is working correctly.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

The Operator Display shows the voltage that the Carriage Manager reads from its power supply.

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

Table 6-11.

Condition	Voltage Displayed
Truck at rest with key switch ON	10.8 to 13.0V

- If the reading fluctuates by more than 0.8 volts in 10 seconds, then the test is a failure.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	DCV scale	JPC14-6	JPS14-1	48V	Do step 2.	Troubleshoot the 48V supply circuit.
2.	DCV scale	JPC14-4	JPS14-1	10.8 to 13V	Replace CM.	Do step 3.
3.	Disconnect from the CM all connectors that use 12 or 5V one at a time. Check voltage after each is disconnected. / DCV scale	JPC14-4	JPS14-1	10.8 to 13V	Troubleshoot wires and components that use the 12 or 5V in the connector that was pulling down the power supply.	Replace CM.

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Test A14 – Field Current Sense

This test displays the current that the Tractor Manager VFC reads from the field current shunt on the power card.

The current shunt measures the current flowing through Power Transistor modules TM1 and TM2 at the Power Card. The Tractor Manager VFC constantly monitors this current.

The Power Card automatically limits the maximum current through TM1 and TM2.

The Power Card current limit threshold is preset at the factory and is not adjustable.

Run Test

NOTE: Run this test only if Test O13 passes.

For information on how to use maintenance mode, see “Diagnostic Mode” on page 6-4.

The Operator Display shows the current that the Tractor Manager VFC reads from the current shunt on the power card.

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

Table 6-12.

Truck Condition	Current Displayed	Voltage JPS5-3 (+) to JPS3-2 (–)
Resting	0 A	1.0V
Full Speed	9 to 12 A	2 to 2.5V

- In active diagnostic mode, as the current increases through the fields, the voltage should increase. If you do not see this, then the test is a failure.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Run Test O13. / DCV scale	JPS5-3	JPS3-2	Ramps from approx. 0 to 4.7V	Do step 3.	Do step 2.
2.	Power Card disconnected from TM / DCV scale	B+	JS5-3	B+	Replace Power Card.	Do step 3.
3.	Run Test O13. / DCV scale	JPS1-A4 (VFC)	B–	Ramps from approx. 1 to 3V	Replace VFC.	Replace TM.

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Test A15 – Drive Motor Temperature Sensor (DT)

This test displays the voltage that the Tractor Manager VFC Card reads from the drive motor temperature sensor (DT) threaded into the drive motor housing.

While operating, the Tractor Manager VFC Card continually monitors the temperature of the drive motor. If the temperature exceeds 238°F/114°C, the maximum speed is reduced until the motor cools.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

Run this test in active diagnostic mode to see a range of voltage (temperature) values. Heat up the truck by driving it hard for approximately 10-15 minutes. As the motor heats, the voltage increases. Then stop. The motor cools rapidly and you can see significant changes within 10 minutes.

The Operator Display shows the voltage that the Tractor Manager VFC reads from the drive motor temperature sensor.

The test is a success if the voltage displayed matches the truck condition in Table 6-13. If the reading fluctuates by more than 0.2 volts in 10 seconds, then the test is a failure.

Table 6-13.

Truck Condition	Voltage Displayed	Resistance between DT-1 and DT-2
Rest (70°F/21°C)	3.1 ± 0.1V	2.1K ± 0.1K ohms
Normal Operation (-4°F/-20°C to 238°F/114°C)	2.7 to 4.3V	1.7K to 2.6K ohms
Overheated (238°F/114°C to 264°F/129°C)	4.3 to 4.6V	2.6K to 2.9K ohms
JPS19 disconnected	4.6 to 5.0V	2.9K ohms to Open

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPS19 disconnected / Ohms scale	JS19-6	JS19-7	2K +/- 5 ohms at 70°F/21°C	Replace TM.	Troubleshoot wires and sensor.
2.	If test still fails, replace VFC.					

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Test A16 – Right Tractor Guidance Coil Voltage

This test displays the voltage of the right guidance coil on the tractor end, as sensed by the Electric Steer Manager.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

Make sure that the truck is set to the correct frequency and is "learned." See "Using Learn Mode" on page 6-16.

The Operator Display shows the voltage that the Electric Steer Manager senses from the right tractor guidance coil.

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

Table 6-14.

Truck Condition	Voltage Displayed
Centered on wire	0.83 to 2.17V
Truck not near wire	< 0.5V

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Cable disconnected / Ohms scale	JW2-1 through JW2-8, JW2-14, JW2-15	J1T-1 through J1T-8, J1T8-14, J1T8-15	0 ohms	Do step 2.	Replace cable.
2.	JPW2 disconnected / DCV scale	PW2-15	PW2-14	Approx. 11.5V	Do step 4.	Do step 3.
3.	DCV scale	PA3-B1 (Filter Card)	PA3-B30 (Filter Card)	Approx. 11.5V	Replace Wire Guidance Filter Card.	Replace ESM.
4.	Bumper removed / mVAC scale	JPW2-1	B–	Centered: 32mV; 1.5 in. Left: 76mV; 1.5 in. Right: 15mV	Do step 5.	Replace tractor end Wire Guidance Sensor.
5.	Bumper removed / DCV scale	PA3-A8 (Filter Card)	B–	Centered: 1.1V; 1.5 in. Left: 2.8V; 1.5 in. Right: 0.6V	Replace ESM.	Replace Wire Guidance Filter Card.

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Test A17 – Left Tractor Guidance Coil Voltage

This test displays the voltage of the left guidance coil on the tractor end, as sensed by the Electric Steer Manager.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

Make sure that the truck is set to the correct frequency and is "learned." See "Using Learn Mode" on page 6-16.

The Operator Display shows the voltage that the Electric Steer Manager senses from the left tractor guidance coil.

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

Table 6-15.

Truck Condition	Voltage Displayed
Centered on wire	0.83 to 2.17V
Truck not near wire	< 0.5V

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Cable disconnected / Ohms scale	JW2-1 through JW2-8, JW2-14, JW2-15	J1T-1 through J1T-8, J1T8-14, J1T8-15	0 ohms	Do step 2.	Replace cable.
2.	JPW2 disconnected / DCV scale	PW2-15	PW2-14	Approx. 11.5V	Do step 4.	Do step 3.
3.	DCV scale	PA3-B1 (Filter Card)	PA3-B30 (Filter Card)	Approx. 11.5V	Replace Wire Guidance Filter Card.	Replace ESM.
4.	Bumper removed / mVAC scale	JPW2-3	B–	Centered: 32mV; 1.5 in. Left: 15mV; 1.5 in. Right: 76mV	Do step 5.	Replace tractor end Wire Guidance Sensor.
5.	Bumper removed / DCV scale	PA3-A3 (Filter Card)		Centered: 1.1V; 1.5 in. Left: 0.6V; 1.5 in. Right: 0.8V	Replace ESM.	Replace Wire Guidance Filter Card.

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Test A18 – Right Load Guidance Coil Voltage

This test displays the voltage of the right guidance coil on the load end, as sensed by the Electric Steer Manager.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

Make sure that the truck is set to the correct frequency and is "learned." See "Using Learn Mode" on page 6-16.

The Operator Display shows the voltage that the Electric Steer Manager senses from the right load guidance coil.

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

Table 6-16.

Truck Condition	Voltage Displayed
Centered on wire	0.83 to 2.17V
Truck not near wire	< 0.5V

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Cable disconnected / Ohms scale	JW1-1 through JW1-8, JW1-14, JW1-15	J1L-1 through J1L-8, J1L-14, J1L-15	0 ohms	Do step 2.	Replace cable.
2.	JPW1 disconnected / DCV scale	PW1-15	PW1-14	Approx. 11.5V	Do step 4.	Do step 3.
3.	DCV scale	PA3-B1 (Filter Card)	PA3-B30 (Filter Card)	Approx. 11.5V	Replace Wire Guidance Filter Card.	Replace ESM.
4.	Sensor removed / mVAC scale	JPW1-1	B–	Centered: 32mV; 1.5 in. Left: 76mV; 1.5 in. Right: 15mV	Do step 5.	Replace load end Wire Guidance Sensor.
5.	Sensor removed / DCV scale	PA3-A14 (Filter Card)	B–	Centered: 1.1V; 1.5 in. Left: 2.8V; 1.5 in. Right: 0.6V	Replace ESM.	Replace Wire Guidance Filter Card.

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Test A19 – Left Load Guidance Coil Voltage

This test displays the voltage of the left guidance coil on the load end, as sensed by the Electric Steer Manager.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

Make sure that the truck is set to the correct frequency and is "learned." See "Using Learn Mode" on page 6-16.

The Operator Display shows the voltage that the Electric Steer Manager senses from the left load guidance coil.

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

Table 6-17.

Truck Condition	Voltage Displayed
Centered on wire	0.83 to 2.17V
Truck not near wire	< 0.5V

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Cable disconnected / Ohms scale	JW1-1 through JW1-8, JW1-14, JW1-15	J1L-1 through J1L-8, J1L-14, J1L-15	0 ohms	Do step 2.	Replace Cable.
2.	JPW1 disconnected / DCV scale	PW1-15	PW1-14	Approx. 11.5V	Do step 4.	Do step 3.
3.	DCV scale	PA3-B1 (Filter Card)	PA3-B30 (Filter Card)	Approx. 11.5V	Replace Wire Guidance Filter Card.	Replace ESM.
4.	Sensor removed / mVAC scale	JPW1-3	B–	Centered: 32mV; 1.5 in. Left: 15mV; 1.5 in. Right: 76mV	Do step 5.	Replace load end Wire Guidance Sensor.
5.	Sensor removed / DCV scale	PA3-A4 (Filter Card)	B–	Centered: 1.1V; 1.5 in. Left: 0.6V; 1.5 in. Right: 2.8V	Replace ESM.	Replace Wire Guidance Filter Card.

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Test A20 – Tractor Near Wire Coil Voltage

This test displays the voltage of the near wire coil on the tractor end, as sensed by the Electric Steer Manager.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

Make sure that the truck is set to the correct frequency and is "learned." See "Using Learn Mode" on page 6-16.

The Operator Display shows the voltage that the Electric Steer Manager senses from the tractor near wire coil.

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

Table 6-18.

Truck Condition	Voltage Displayed
Centered on wire	1.44 to 3.01V
Truck not near wire	< 0.5V

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Cable disconnected / Ohms scale	JW2-1 through JW2-8, JW2-14, JW2-15	J1T-1 through J1T-8, J1T8-14, J1T8-15	0 ohms	Do step 2.	Replace cable.
2.	JPW2 disconnected / DCV scale	PW2-15	PW2-14	Approx. 11.5V	Do step 4.	Do step 3.
3.	DCV scale	PA3-B1 (Filter Card)	PA3-B30 (Filter Card)	Approx. 11.5V	Replace Wire Guidance Filter Card.	Replace ESM.
4.	Bumper removed / mVAC scale	JPW2-2	B–	Centered: 70mV; 1.5 in. Left: 100mV; 1.5 in. Right: 100mV	Do step 5.	Replace tractor end Wire Guidance Sensor.
5.	Bumper removed / DCV scale	PA3-A9 (Filter Card)	B–	Centered: 2.5V; 1.5 in. Left: 3.7V; 1.5 in. Right: 3.7V	Replace ESM.	Replace Wire Guidance Filter Card.

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Test A21 – Load Near Wire Coil Voltage

This test displays the voltage of the near wire coil on the load end, as sensed by the Electric Steer Manager.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

Make sure that the truck is set to the correct frequency and is "learned." See "Using Learn Mode" on page 6-16.

The Operator Display shows the voltage that the Electric Steer Manager senses from the tractor near wire coil.

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

Table 6-19.

Truck Condition	Voltage Displayed
Centered on wire	1.44 to 3.01V
Truck not near wire	< 0.5V

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Cable disconnected / Ohms scale	JW1-1 to 15	J1L-1 to 15	0 ohms	Do step 2.	Replace cable.
2.	JPW1 disconnected / DCV scale	PW1-15	PW1-14	Approx. 11.5V	Do step 4.	Do step 3.
3.	DCV scale	PA3-B1 (Filter Card)	PA3-B30 (Filter Card)	Approx. 11.5V	Replace Wire Guidance Filter Card.	Replace ESM.
4.	Sensor removed / mVAC scale	JPW1-2	B–	Centered: 70mV; 1.5 in. Left: 100mV; 1.5 in. Right: 100mV	Do step 5.	Replace load end Wire Guidance Sensor.
5.	Sensor removed / DCV scale	PA3-A9 (Filter Card)	B–	Centered: 2.5V; 1.5 in. Left: 3.7V; 1.5 in. Right: 3.7V	Replace ESM.	Replace Wire Guidance Filter Card.

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Test A22 ¥ – Steer Motor Current

This test displays the steer motor current as sensed by the Electric Steer Manager.

Run Test

NOTE: Run this test only if the steer motor is powered.

For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

The Operator Display shows the steer motor current that the Electric Steer Manager senses.

⚠CAUTION

Use extreme care whenever jacking the truck. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from beneath truck while jacking. Use jack stands or solid blocks to support truck. Do not rely on jacks.

1. Jack and block the truck so the drive tire is off the floor. See "Jacking Safety" on page 2-11.
2. Depress the right deadman pedal to enable steering.
3. The test is a success if the current displayed is between 10 and 35 Amps while the steering tiller is being turned.
4. If the readings are within reference limits, run this test with the drive tire on the floor. The average current should not exceed 50 Amps. This current value will vary depending on tire material.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Clamp-on amp meter	N/A	N/A	On jack: < 35 amps; On floor: < 50 amps	Replace ESM.	Check drive unit and steer gear box for binding. If OK, replace steer motor.

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Test A23 – Steer Manager Power Supply Voltage

This test displays the Steer Manager power supply voltage.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

The Operator Display shows the Steer Manager power supply voltage that the Steer Manager senses from JPA2-9.

The test is a success if the voltage displayed is between 10.8 and 13.0 volts.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPA2 disconnected / DCV scale	PA2-9	PA2-5	Approx. 12V	Do step 3.	Do step 2.
2.	JPS17 disconnected / DCV scale	JS17-9	JS17-5	Approx. 12V	Replace ESM cable.	Troubleshoot using Test A00.
3.	Disconnect all devices using 12V or 5V one at a time. / DCV scale	TP2 on ESM	B–	Check for return of 12V after disconnecting each device.	Troubleshoot circuit pulling down the 12V.	Replace the ESM.

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Test A24 – Steer Manager Battery Sense Voltage

This test displays the battery voltage sensed by the Steer Manager.

Run Test

NOTE: For information on how to use maintenance mode, see “Diagnostic Mode” on page 6-4.

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

Table 6-20.

PC1 Condition	Voltage Displayed
Closed	+44 to 52V
Open	< 0.25V

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	DCV scale	SMB+	SMB–	44VDC to 52VDC	Replace the ESM.	Troubleshoot SMB+ and SMB– cables.

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Test A25 ¥ – Pressure Transducer, Mini

This test displays the voltage produced from the mini pressure transducer (PT-B) at JPA6-2 on the Electric Steer Manager. A successful test proves that the pressure transducer and its associated wiring are working correctly.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

The Operator Display shows the voltage that the pressure transducer (PT-B) produces.

- Any reading greater than 4.8 volts or less than 1.03 volts on the Operator Display is a failure.
- Without a load on the forks, the Operator Display should show at least 1.03 volts.
- As the load on the forks increases, the voltage should increase. Each 1000 lbs. (454 kg) change in weight equals approximately 1.0 volt change on the Operator Display.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPA6 disconnected / DCV scale	JA6-1	JA6-3	Approx. 12 VDC	Do step 2.	Replace the ESM.
2.	DCV scale	JPY6-1	JPY6-3	Approx. 12 VDC	Do step 3.	Troubleshoot wires to ESM.
3.	DCV scale	JPA6-2	JPA6-3	No load on the forks: 1 to 1.5VDC. If < 1.0V, a code will be displayed. As weight is added to forks, voltage should increase 1V per 1000 lbs.	Replace ESM.	Troubleshoot wiring and connections between ESM and pressure transducer. If OK, replace pressure transducer.

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Test A26 ¥ – Traverse Position Feedback Pot (VR5) Voltage

This test displays the voltage that the Carriage Manager reads from the traverse position feedback potentiometer (VR5). A successful test proves that the traverse position feedback potentiometer and associated wiring from the pot through cable harness JPK2 to JPC12 is working correctly.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

Depress both deadman pedals. Move the traverse control from full one direction to full in the opposite direction, observing the Operator Display for voltage and the load handler for movement.

The Operator Display shows the voltage that the Carriage Manager reads from the traverse position potentiometer (VR5) as the load handler moves through its range.

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

Table 6-21.

Load Handler Position	Voltage Displayed	
	Short Carriage Manager (no PC26 connector)	Tall Carriage Manager (PC26 connector present)
Full left	0.4 to 1.9V	4.0 to 4.5V
Full right	4.0 to 4.5V	0.4 to 1.9V

While using this test, move the control handle slowly. Observe the reading on the Operator Display. The voltage should increase/decrease smoothly as you move the load handler throughout its range. If the reading is erratic, the potentiometer is bad.

Cycle the load handler several times throughout its range. The voltages should be consistent.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC12 disconnected / DCV scale	PC12-7	PC12-8	Approx. 12V	Do step 2.	Replace CM.
2.	JPK2 disconnected / DCV scale	JK2-1	JK2-3	Approx. 12V	Do step 3.	Repair/ replace wires.
3.	DCV scale	JPK2-2	JPK2-3	Full left: 3.9V; Full right: 0.49V	Do step 4.	Troubleshoot wires and pot.
4.	DCV scale	JPC12-1	JPC12-8	Full left: 3.9V; Full right: 0.49V	Replace CM.	Repair/ replace wires.

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Test A27 – Maximum Drive Unit Rotation

NOTE: This test is not useful for troubleshooting and was deleted in firmware CM ver. 1.25/TM ver. 1.15/SM ver. 1.2 and later.

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Test A28 ¥ – Rotate Position Potentiometer (VR6) Voltage

This test displays the voltage that the Carriage Manager reads from the rotate position potentiometer (VR6). A successful test proves that the rotate position potentiometer and associated wiring from the pot through cable harness JP4 are working correctly. It also proves that related circuitry in the height manager and wiring in cable harnesses from JP5 on the height manager through JPK3 atop the overhead guard to JPH1 on the Carriage Manager are all working correctly.

Run Test

NOTE: For information on how to use maintenance mode, see “Diagnostic Mode” on page 6-4.

Depress both deadman pedals. Move the rotate position pot from full counterclockwise to full clockwise, observing the Operator Display for voltage and the load handler for movement.

The Operator Display shows the voltage that the Carriage Manager reads from the rotate position pot (VR6) as the load handler is rotated throughout its range.

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

Table 6-22.

Rotate Position Pot Position	Voltage Displayed	
	Short Carriage Manager (no PC26 connector)	Tall Carriage Manager (PC26 connector present)
Full counter-clockwise	0.75 to 1.25V	3.75 to 4.25V
Full clockwise	3.75 to 4.25V	0.75 to 1.25V

While using this test, move the control handle slowly. Observe the reading on the Operator Display. The voltage should increase/decrease smoothly as you rotate the load handler throughout its range. If the reading is erratic, the potentiometer is bad.

Rotate the load handler several times throughout its range. The voltages at the extremes and at neutral should be consistent.

It is possible to pass this test and still have a noisy pot or a dead spot in the handle. If you still suspect a bad potentiometer, replace the potentiometer.

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JP4 disconnected / DCV scale	JP4-1	JP4-3	Approx. 5V	Do step 2.	Replace Mini Height Manager.
2.	DCV scale	JP4-2	JP4-3	Full CCW: 0.73V to 1.73V; Full CW: 3.84V to 4.84V	Do step 3.	Troubleshoot pot and cable to pot.
3.	DCV scale	JP5-3	JP4-3	Full CCW: 0.73V to 1.73V; Full CW: 3.7V to 4.84V	Do step 4.	Replace Mini Height Manager.
4.	DCV scale	JPH1-3	JPH1-8	Full CCW: 0.73V to 1.73V; Full CW: 3.7V to 4.84V	Replace CM.	Troubleshoot wires to Mini Height Manager.

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Test A29 – Average Distance From Wire

This test provides no useful information for troubleshooting.

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Test A30 – Peak Distance From Wire

This test provides no useful information for troubleshooting.

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Test A31 – Average Heading Angle Magnitude

This test provides no useful information for troubleshooting.

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Test A32 – Peak Heading Angle

This test provides no useful information for troubleshooting.

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Test A33 – Average Guide Wire Strength

This test provides no useful information for troubleshooting.

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Test A34 ¥ – Rotate Velocity

This test is used for internal software development and is not intended for field troubleshooting.

NOTE: This test was deleted in firmware CM ver. 1.25/TM ver. 1.15/SM ver. 1.2 and later.

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Test A35 – PC2 Sense Voltage

This test displays the voltage that the Tractor Manager VFC reads from the PC2 (lift) sense line. The PC2 sense line goes from the Tractor Manager at JPS14-8 to P-1 at the Pump Contactor.

A successful test proves that the Tractor Manager VFC is correctly reading the battery voltage. It also proves that the PC2 contactor is closing correctly. It does *not* mean that the contactor tips on the PC2 contactor are good.

Run Test

NOTE: For information on how to use maintenance mode, see “Diagnostic Mode” on page 6-4.

The Operator Display shows the battery voltage that the Tractor Manager reads when the PC2 contactor tips are closed.

The test is a success if the voltage displayed, with the truck not moving or lifting, is as follows:

Table 6-23.

PC2 Contactor	Voltage Displayed
Closed	+44 to +52V
Open	0V

- If the reading fluctuates by more than 0.5 volts in 10 seconds, then the test is a failure.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Run Test O01 / DCV scale	JPS14-8	B–	Test ON, tips closed: B+; Test OFF: approx. 0V	Replace TM.	Troubleshoot wires and contactor tips.
2.	If test still fails, replace the VFC.					

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Test A36 – Plugging Contactor Control Line Sense

This test displays the voltage that the Tractor Manager VFC reads from the plugging contactor control line at JPS14-16 on the Tractor Manager. A successful test proves that the Tractor Manager, Tractor Manager VFC, and the plugging contactor coil driver are functioning correctly to provide the correct voltage to the plugging contactor coil.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

The test is a success if the Operator Display shows a voltage toggling between battery voltage and less than one volt when the plugging contactor coil is energized.

If the plugging contactor coil driver is deenergized, the Operator Display shows battery voltage with no toggling.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Run Test O03.					

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Test A37 – Brake Control Line Sense

This test displays the voltage that the Tractor Manager VFC reads from the brake control line at JPS19-5. A successful test proves that the Tractor Manager, Tractor Manager VFC, and the brake coil driver are functioning correctly to provide the correct voltage to the brake coil.

Run Test

NOTE: For information on how to use maintenance mode, see “Diagnostic Mode” on page 6-4.

The test is a success if the Operator Display shows battery voltage when the brake is engaged, and less than 1.0 volt when the brake is released.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Run Test O08.					

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Test A39 – Lowering Speed

This test is not intended for field troubleshooting.

NOTE: This test was deleted in firmware CM ver. 1.25/TM ver. 1.15/SM ver. 1.2 and later.

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Test A40 – Learned Weight

This test presents no useful information for troubleshooting.

NOTE: This test was deleted in firmware CM ver. 1.25/TM ver. 1.15/SM ver. 1.2 and later.

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Test A43 ¥ – Traverse Velocity

This test provides no useful information for troubleshooting.

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Test A44 – CM +5 V Potentiometer Power Supply

This test displays the voltage sensed from an internal CM power supply that provides +5 volts to control potentiometers. This voltage is derived from the +12 volts supplied by the CM power supply. A successful test proves that the +5 volt CM potentiometer power supply is good.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

The Operator Display shows the voltage that the CM reads from its +5 volt potentiometer power supply.

This test is a success if the voltage is within these reference limits:

Condition	Operator Display
Lift truck at rest with key switch ON	+4.5 to +5.5V

- If the voltage displayed fluctuates by more than 0.5 volts in 10 seconds, the test is a failure.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Control handle harness disconnected at CM / DCV.	JPC12-5	JPC12-6	4.5 to 5.5VDC	Connect each connector one at a time, monitoring the 5V. Troubleshoot the handle that causes the 5V to change.	Replace CM.

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Digital Input Tests

A Diagnosis and Repair table is provided for most tests. If a test fails, refer to the Diagnosis and Repair table. This table provides a step-by-step approach to diagnosing a problem and the necessary corrective action. See the example below.

Example Diagnosis and Repair Table

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

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Test I00 ¥ – Main Mast Reference Point

This test monitors the state of the reference channel sensor of the optical head assembly used to determine height information from the main height sensing rail.

On Series SA, the main mast reference point is a point approximately 7 in. (178 mm) below the top of the main mast height sensing rail.

On Series SB, the main mast reference point is a point approximately 7 in. (178 mm) above the bottom of the main mast height sensing rail.

A successful test proves that the optical head, Main Mast Height Manager, and associated wiring and circuitry on the Carriage Manager are all functioning correctly.

Run Test

NOTE: Before running the test, make sure the sensor and rail are set up correctly. See "Main Mast Height Sensor" on page 7-99.

For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

The test is a success if the Operator Display matches the optical sensor position in and out of the reference zone on the height sensing rail, as shown in Table 6-24:

Table 6-24.

Reference Zone	Operator Display
In	Air
Out	Metal

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
Series SA						
1.	JP1 disconnected, measurement on HM / DCV scale	JP1-8	JP1-7	5.3V	Do step 2.	Replace HM.
2.	JP1 disconnected, measurement on HM / DCV scale	JP1-4	JP1-3	5.3V	Do step 3.	Replace HM.
3.	JP1 disconnected, measurement on HM / DCV scale	JP1-12	JP1-11	5.3V	Do step 4.	Replace HM.
4.	JP1 disconnected, measurement on HM / DCV scale	JP1-2	JP1-1	5.3V	Do step 5.	Replace HM.
5.	JP1 disconnected, measurement on HM / DCV scale	JP1-10	JP1-9	5.3V	Do step 6.	Replace HM.
6.	JP1 disconnected, measurement on HM / DCV scale	JP1-6	JP1-5	5.3V	Do step 7.	Replace HM.

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
7.	JP1 disconnected, reading at the connector / Diode Check scale	JP1-8	JP1-7	1V	Do step 8.	Repair/ replace wires. If wires OK, replace sensor assembly.
8.	JP1 disconnected, reading at the connector / Diode Check scale	JP1-4	JP1-3	1V	Do step 9.	Repair/ replace wires. If wires OK, replace sensor assembly.
9.	JP1 disconnected, reading at the connector / Diode Check scale	JP1-12	JP1-11	1V	Do step 10.	Repair/ replace wires. If wires OK, replace sensor assembly.
10.	DCV scale	JP1-2	JP1-1	Sensor over rail: 2V; Sensor over air: 5V	Do step 11.	Repair/ replace wires. If wires OK, replace sensor assembly.
11.	DCV scale	JP1-10	JP1-9	Sensor over rail: 2V; Sensor over air: 5V	Do step 12.	Repair/ replace wires. If wires OK, replace sensor assembly.
12.	DCV scale	JP1-6	JP1-5	Sensor over rail: 2V; Sensor over air: 5V	Replace CM.	Repair/ replace wires. If wires OK, replace sensor assembly.
Series SB						
1.	JP1 disconnected, measurement on HM / DCV scale	JP1-6	JP1-5	5.3V	Do step 2.	Replace HM.
2.	JP1 disconnected, measurement on HM / DCV scale	JP1-2	JP1-1	5.3V	Do step 3.	Replace HM.

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
3.	JP1 disconnected, measurement on HM / DCV scale	JP1-12	JP1-11	5.3V	Do step 4.	Replace HM.
4.	JP1 disconnected, measurement on HM / DCV scale	JP1-4	JP1-3	5.3V	Do step 5.	Replace HM.
5.	JP1 disconnected, measurement on HM / DCV scale	JP1-10	JP1-9	5.3V	Do step 6.	Replace HM.
6.	JP1 disconnected, measurement on HM / DCV scale	JP1-8	JP1-7	5.3V	Do step 7.	Replace HM.
7.	JP1 disconnected, reading at the connector / Diode Check scale	JP1-6	JP1-5	1V	Do step 8.	Repair/ replace wires. If wires OK, replace sensor assembly.
8.	JP1 disconnected, reading at the connector / Diode Check scale	JP1-2	JP1-1	1V	Do step 9.	Repair/ replace wires. If wires OK, replace sensor assembly.

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
9.	JP1 disconnected, reading at the connector / Diode Check scale	JP1-12	JP1-11	1V	Do step 10.	Repair/ replace wires. If wires OK, replace sensor assembly.
10.	DCV scale	JP1-4	JP1-3	Sensor over rail: 2V; Sensor over air: 5V	Do step 11.	Repair/ replace wires. If wires OK, replace sensor assembly.
11.	DCV scale	JP1-10	JP1-9	Sensor over rail: 2V; Sensor over air: 5V	Do step 12.	Repair/ replace wires. If wires OK, replace sensor assembly.
12.	DCV scale	JP1-8	JP1-7	Sensor over rail: 2V; Sensor over air: 5V	Replace CM.	Repair/ replace wires. If wires OK, replace sensor assembly.

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Test I01 – Load Handler Deadman Switch (S9)

This test monitors the state of the load handler deadman switch (S9). It shows what the Carriage Manager reads from the switch.

A successful test proves that the load handler deadman switch (S9) and its related wiring and circuitry in the Carriage Manager are all working correctly.

Switch S9 is closed when the left deadman pedal is depressed. No load handler operation can occur unless the left deadman pedal is depressed.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

The test is a success if the Operator Display matches the switch setting as shown in Table 6-25:

Table 6-25.

Load Handler (Left) Deadman Position	Operator Display
Released	Up
Depressed	Down

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC25 disconnected / DCV scale	JC25-7	JC25-9	10.5 to 13V	Do step 2.	Replace CM.
2.	DCV scale	JC25-8	JC25-9	S9 released: Approx. 5V; S9 depressed: 0V	Do step 3.	Replace CM.
3.	DCV scale	S9-1	S9-3	10.5 to 13V	Do step 4.	Repair/ replace wires.
4.	DCV scale	S9-1	S9-2	S9 open: 0V; S9 closed: 10.5 to 13V	Do step 5.	Replace switch.
5.	DCV scale	JPC25-8	JPC25-9	S9 open: 0V; S9 closed: 10.5 to 13V	Replace CM.	Repair/ replace wire.

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Test I02 – Lift Select Switch (S6)

This test monitors the state of the lift select switch (S6). It shows what the Carriage Manager reads from the switch.

A successful test proves that the lift select switch (S6) and its related wiring, through cable JL1 to PC23, and related circuitry in the Carriage Manager are all working correctly.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

The test is a success if the Operator Display matches the switch position as shown in Table 6-26:

Table 6-26.

Lift Select Button	Operator Display
Released	Out
Depressed	In

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC23 disconnected / DCV scale	JC23-1	JC23-6	5V	Do step 2.	Replace CM.
2.	JPC23 disconnected / Ohms scale	PC23-1	PC23-6	S6 open: open circuit; S6 closed: 0 ohms	Replace CM.	Replace the wires and or the switch.

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Test I03 – Brake Deadman Switch (S2)

This test monitors the state of the brake deadman switch (S2). It shows what the Carriage Manager reads from the switch.

A successful test proves that the brake deadman switch (S2) and its related wiring and circuitry in the Carriage Manager are all working correctly.

Switch S2 is closed when the right deadman pedal is depressed. The deadman input is routed to the Carriage Manager at JPC25-2. No travel or lift can occur unless both brake (S2) and carriage (S23) deadman inputs to the Carriage Manager and Tractor Manager agree.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

The test is a success if the Operator Display matches the switch position as shown in Table 6-27:

Table 6-27.

Right Deadman Position	Operator Display
Released	Up
Depressed	Down

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC25 disconnected / DCV scale	JC25-1	JC25-3	10.5 to 13V	Do step 2.	Replace CM.
2.	JPC25 disconnected / DCV scale	PC25-2	PC25-3	10.5 to 13V	Do step 3.	Replace CM.
3.	DCV scale	S2-1	S2-3	10.5 to 13V	Do step 4.	Repair/ replace wires.
4.	DCV scale	S2-1	S2-2	S2 depressed: 10.5 to 13V; S2 released: 0V	Do step 5.	Replace switch.
5.	DCV scale	JPC25-1	JPC25-2	S2 depressed: 10.5 to 13V; S2 released: 0V	Do step 6.	Repair/ replace wire.
6.	JPC17-4 disconnected / DCV scale	JPC20-1	PC17-4	S2 open: 0V; S2 closed: B+	Do step 7.	Replace CM.
7.	JPS25-4 disconnected / DCV scale	JPS26-1	JS25-4	S2 open: 0V; S2 closed: B+	Do step 8.	Troubleshoot over-the-mast cable.
8.	DCV scale	JPS25-4	JPS25-6	S2 open: 12V; S2 closed 0V	Do step 9.	Replace TM.
9.	DCV scale	JPS1-B6 (VFC)	JPS25-6	S2 open: 5.3V; S2 closed: 0V	Replace VFC.	Replace TM.

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Test I04 – Emergency Power Off (EPO) Switch (S21)

This test monitors the state of the Emergency Power Off switch (S21). It shows what the Carriage Manager and Tractor Manager read from the switch.

A successful test proves that the Emergency Power Off switch (S21) and its related wiring and circuitry in the Carriage Manager and Tractor Manager are all working correctly.

The Emergency Power Off Button electrically removes B+ from all contactors, solenoids, and brake release circuits, so that truck motion is stopped.

When the Emergency Power Off Button is OUT, the switch is closed; when the button is pressed, the switch is open.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

The test is a success if the Operator Display matches the switch position as shown in Table 6-28:

Table 6-28.

Emergency Off Button	Operator Display
Out	Out
In	In

- If the test passes, but you still get a Code 1L, go to Diagnosis and Repair.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Key ON, EPO Up / DCV scale	JPC15-3	B–	B+	Do step 2.	Troubleshoot wires and EPO switch.
2.	JPC20-1 disconnected / DCV scale	PC20-1	B–	B+	Do step 3.	Replace CM.
3.	JPS26-1 disconnected / DCV scale	JS26-1	B–	B+	Do step 4.	Replace over-the-mast cable.
4.	DCV scale	JPS2-A17 (VFC)	B–	5.3V	Replace VFC.	Replace TM.
5.	If code is still displayed, replace CM.					

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Test I05 – Speed Feedback Proximity Sensor

This test monitors the speed feedback proximity sensor on the drive motor.

The Tractor Manager uses the inputs from the speed feedback proximity sensor to determine the speed and direction of the drive motor.

The gap between the proximity rotor disc and the sensor is very important. If the gap is too great, the voltage generated is not enough for the Tractor Manager to sense. The gap between the disc and the sensor must be 0.06 ± 0.04 inch (1.5 ± 1.0 mm).

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

The count on the display should vary between 0 and 255.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	DCV scale	JPS18-3	B–	Approx. 12V	Do step 2.	Replace TM.
2.	DCV scale	SPS-3	B–	Approx. 12V	Do step 3.	Repair wire.
3.	DCV scale	SPS-1	B–	Ramps down from approx. 5V to approx. 4V when traveling	Do step 4.	Replace encoder.
4.	DCV scale	SPS-2	B–	Ramps down from approx. 5V to approx. 4V when traveling	Do step 5.	Replace encoder.
5.	DCV scale	JPS18-1	B–	Ramps down from approx. 5V to approx. 4V when traveling	Do step 6.	Repair wire.
6.	DCV scale	JPS18-2	B–	Ramps down from approx. 5V to approx. 4V when traveling	Replace TM. If problem not corrected, replace VFC.	Repair wire.

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Test I06 – Armature Current Limit Input

This test monitors the armature current limit signal from the Power Card.

The power card automatically limits the maximum current through the power transistor (Q1) to approximately 375 amps peak. The current limit value is preset at the factory and is not adjustable.

It is normal for the power card to go into current limit, particularly when accelerating. Whenever the power card is in current limit, the green LED (IL2) is on.

Related Messages, Codes, and Tests

- Code 21 – Short detected in armature circuit (Page 6-34)
- Code 24 – Armature current sensor circuit not responding (Page 6-35)
- Code 29 – No movement detected when travel is requested (Page 6-36)
- Test A01 – Armature Current Sense (Page 6-95)
- Test O14 – Armature PWM Ramp (Page 6-213)

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

1. With the truck stopped, the display should read "NO." If "YES" is displayed, the test is a failure.
2. In Active Diagnostic Mode, it is normal, while accelerating, for the display to change momentarily from "NO" to "YES." If you stall the drive motor during this test, the display changes to "YES" and continues to display "YES" while the drive motor is stalled.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Run Test O14. / DCV scale	JPS5-1	B–	> 10V, quickly drops to approx. 9V when current limit activates	Do step 3.	Do step 2.
2.	Power Card disconnected from TM/ DCV scale	JS5-1	B–	Key ON: 11V	Replace Power Card.	Replace TM.
3.	Run Test O14. / DCV scale	JPS2-B16 (VFC)	B–	Test ON: 5.3V drops to < 4V when current limit activates; Test OFF: Approx. 5.3v	Replace VFC.	Replace TM.

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Test I07 – Power Panel Temperature Limit

This test monitors the temperature limit input from the power card.

The temperature limit signal is activated by the Power Card whenever the power panel temperature exceeds 227°F/108°C. When this happens, the power card lights the red LED to indicate temperature has exceeded the permissible limit.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

1. Run Test A02 to determine the power panel temperature sensor's approximate temperature. Then run Test I07. When the sensor is below 227°F/108°C, the display should read **NO**. If **YES** is displayed, the test is a failure.
2. Turn the key switch OFF and disconnect the battery connector. Disconnect JP2 near the main power transistor (Q1) heatsink temperature sensor (HT). Reconnect the battery connector and turn the key switch ON. The display should show **YES**. If the display reads **NO**, the test is a failure.
3. Turn the key switch OFF and disconnect the battery connector. Reconnect JP2.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC1 disconnected at PC / Ohms scale	JC1-4	JC1-3	Approx. 2.1K at 70°F (21°C)	Do step 2.	Troubleshoot wires and sensor.
2.	DCV scale	JPS5-2	B–	JP2 disconnected: <5V; JP2 connected: 11V	Do step 4.	If voltage is present but does not change, do step 3.
3.	PC disconnected from TM / DCV scale	JS5-2	B–	Key ON: Approx. 11V	Replace PC.	Replace TM.
4.	DCV scale	JPS2-B23 (VFC)	B–	JP2 disconnected: 0V; JP2 connected: 5.3V	Replace VFC.	Replace TM.

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Test I08 – Rail Guidance Switch (S15)

This test monitors the state of the optional rail guidance switch (S15), as seen by the Tractor Manager VFC Card.

Run Test

NOTE: For information on how to use diagnostic mode, see “Diagnostic Mode” on page 6-4.

The test is a success if the switch position and the Operator Display match Table 6-29:

Table 6-29.

Guide Roller	Operator Display
Depressed	On
Released	Off

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPS13 disconnected / DCV scale	PS13-1	PS13-3	Approx. 11V	Do step 2.	Replace TM.
2.	JPS13 disconnected / Ohms scale	JS13-1	JS13-3	S15 open: open circuit; S15 closed: 0 ohms	Do step 3.	Repair/ replace switch and/ or wiring.
3.	DCV scale	JPS2-A24 (VFC)	B–	S15 closed: 0V; S15 open: 5.3V	Replace VFC.	Replace TM.

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Test I09 ¥ – Mini-Mast Reference Point

This test monitors the state of the mini-mast height sensor.

A successful test proves that the mini-mast height sensor and its cable, the mini-mast height manager, the cable from JP5 to JPK3 to JPH1, and Carriage Manager are all working correctly.

Run Test

NOTE: For information on how to use diagnostic mode, see “Diagnostic Mode” on page 6-4.

The test is a success if the Operator Display and fork location match Table 6-30

Table 6-30.

Operator Display	Fork Location
BELOW	Fully lowered
ABOVE	Elevated > 1.0 in. (25.4 mm)

If the test fails, verify the mini-mast lift chain adjustment.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JP2 disconnected / DCV scale	P2-1	P2-2, P2-3, P2-4	Approx. 10V	Do step 2.	Replace HM.
2.	DCV scale	JP2-1	JP2-2, JP2-3, JP2-4	Not over metal: Approx. 9V; Over metal: 3V	Replace HM and retest; if still not OK, replace CM.	Replace sensor assembly.

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Test I10 ¥ – Reach Position Proximity Sensor (PROX2)

This test monitors the state of the reach position proximity sensor (PROX2).

A successful test proves that the following are working correctly: reach position proximity sensor and its cable, and the mini height manager.

Run Test

NOTE: For information on how to use diagnostic mode, see “Diagnostic Mode” on page 6-4.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JP3 disconnected / DCV scale	JP3-1	JP3-3	Approx. 10V	Do step 2.	Replace HM.
2.	JP3 disconnected / DCV scale	JP3-2	JP3-3	4 to 5V	Replace proximity sensor.	Replace HM.

The test is a success if the Operator Display and reach carriage state match Table 6-31. *Do not* judge the proximity sensor by the illumination of the indicator LED on the sensor.

Table 6-31.

Operator Display	Proximity Sensor
OUT	Not over metal
IN	Over metal

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Test I11 – Auto/Manual Switch (S4)

This test displays the position of the auto/manual switch (S4). A successful test proves that the auto/manual switch, its associated wiring, and the cable harness JR1 to PC24 are all working correctly.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

The test is a success if the Operator Display and the position of the auto/manual switch match Table 6-32:

Table 6-32.

S4 Switch Position	Operator Display
O	Auto
|	Manual

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC24 disconnected / DCV scale	JC24-2	JC24-7	5V	Do step 2.	Replace CM.
2.	JPC24 disconnected / Ohms scale	PC24-2	PC24-7	S4 open: OL; S4 closed: 0 ohms	Replace CM.	Troubleshoot wiring and switch.

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Test I12 – Plugging Detector

This test provides no useful information for troubleshooting.

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Test I13 – Horn Switch (S3)

This test checks the input from the horn switch (S3) to the Carriage Manager at JPC24-1 and JPC24-6.

A successful test proves that the horn switch (S3) and its associated wiring, and Carriage Manager are all working correctly.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

Operate the horn switch several times while observing the Operator Display to determine if the switch is intermittent.

The test is a success if the horn switch position and the Operator Display match Table 6-33:

Table 6-33.

Horn Switch Position	Operator Display
Released	Off
Depressed	On

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC24 disconnected / Ohms scale	PC24-1	PC24-6	S3 open: OL; S3 closed: 0 ohms	Replace CM.	Troubleshoot switch and wires.

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Test I14 – Sidegate Switches (S60,S61)

This test verifies the state of the optional sidegate switches (S60 and S61) on trucks so equipped.

A successful test proves that both left and right sidegate switches, their associated wiring, and Carriage Manager are all working correctly.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

Since the software treats these switches as if they were in series, both sidegates must be down for the display to indicate **DOWN**.

The test is a success if the Operator Display and position of the sidegates matches Table 6-34:

Table 6-34.

Side Gate Position	Operator Display
One gate up	Up
Both gates up	Up
Both gates down	Down

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC21 disconnected / DCV scale	PC21-2	PC21-4	10.5 to 13V	Do step 2.	Replace CM.
2.	JPC21 disconnected / DCV scale	PC21-3	PC21-4	Approx. 5V	Do step 3.	Replace CM.
3.	JPC21 disconnected / DCV scale	PC21-7	PC21-8	10.5 to 13V	Do step 4.	Replace CM.
4.	JPC21 disconnected / DCV scale	PC21-5	PC21-8	Approx. 5V	Do step 5.	Replace CM.
5.	DCV scale	S60-1	S60-3	10.5 to 13V	Do step 6.	Repair/ replace wires.
6.	DCV scale	S60-1	S60-2	Closed: 10.5 to 13V; Open: 0V	Do step 7.	Replace switch.
7.	DCV scale	JPC21-2	JPC21-3	Closed: 10.5 to 13V; Open: 0V	Do step 8.	Repair/ replace wires.
8.	DCV scale	S61-1	S61-3	10.5 to 13V	Do step 9.	Repair/ replace wire.
9.	DCV scale	S61-1	S61-2	Depressed: 10.5 to 13V; Released: 0V	Do step 10.	Replace switch.
10.	DCV scale	JPC21-7	JPC21-5	Depressed: 10.5 to 13V; Released: 0V	Replace CM.	Repair/ replace wire.

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Test I15 ¥ – Main Mast Height Count

This test displays the height count from the Main Mast Height Manager. A successful test proves that the Main Mast Height Sensor is working correctly.

Run Test

NOTE: Before running the test, make sure the sensor and rail are set up correctly. See "Main Mast Height Sensor" on page 7-99.

The test is a success if the number displayed on the Operator Display increments when lifting and decrements when lowering.

NOTE: The numbers may or may not start at zero. The number displayed is not itself a direct measurement of height.

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
Series SA						
1.	JP1 disconnected, measurement on HM / DCV scale	JP1-8	JP1-7	5.3V	Do step 2.	Replace HM.
2.	JP1 disconnected, measurement on HM / DCV scale	JP1-4	JP1-3	5.3V	Do step 3.	Replace HM.
3.	JP1 disconnected, measurement on HM / DCV scale	JP1-12	JP1-11	5.3V	Do step 4.	Replace HM.
4.	JP1 disconnected, measurement on HM / DCV scale	JP1-2	JP1-1	5.3V	Do step 5.	Replace HM.
5.	JP1 disconnected, measurement on HM / DCV scale	JP1-10	JP1-9	5.3V	Do step 6.	Replace HM.
6.	JP1 disconnected, measurement on HM / DCV scale	JP1-6	JP1-5	5.3V	Do step 7.	Replace HM.
7.	JP1 disconnected, reading at the connector / Diode Check scale	JP1-8	JP1-7	1V	Do step 8.	Repair/ replace wires. If wires OK, replace sensor assembly.
8.	JP1 disconnected, reading at the connector / Diode Check scale	JP1-4	JP1-3	1V	Do step 9.	Repair/ replace wires. If wires OK, replace sensor assembly.
9.	JP1 disconnected, reading at the connector / Diode Check scale	JP1-12	JP1-11	1V	Do step 10.	Repair/ replace wires. If wires OK, replace sensor assembly.
10.	DCV scale	JP1-2	JP1-1	Sensor over rail: 2V; Sensor over air: 5V	Do step 11.	Repair/ replace wires. If wires OK, replace sensor assembly.

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
11.	DCV scale	JP1-10	JP1-9	Sensor over rail: 2V; Sensor over air: 5V	Do step 12.	Repair/ replace wires. If wires OK, replace sensor assembly.
12.	DCV scale	JP1-6	JP1-5	Sensor over rail: 2V; Sensor over air: 5V	Replace CM.	Repair/ replace wires. If wires OK, replace sensor assembly.
Series SB						
1.	JP1 disconnected, measurement on HM / DCV scale	JP1-6	JP1-5	5.3V	Do step 2.	Replace HM.
2.	JP1 disconnected, measurement on HM / DCV scale	JP1-2	JP1-1	5.3V	Do step 3.	Replace HM.
3.	JP1 disconnected, measurement on HM / DCV scale	JP1-12	JP1-11	5.3V	Do step 4.	Replace HM.
4.	JP1 disconnected, measurement on HM / DCV scale	JP1-4	JP1-3	5.3V	Do step 5.	Replace HM.
5.	JP1 disconnected, measurement on HM / DCV scale	JP1-10	JP1-9	5.3V	Do step 6.	Replace HM.
6.	JP1 disconnected, measurement on HM / DCV scale	JP1-8	JP1-7	5.3V	Do step 7.	Replace HM.
7.	JP1 disconnected, reading at the connector / Diode Check scale	JP1-6	JP1-5	1V	Do step 8.	Repair/ replace wires. If wires OK, replace sensor assembly.
8.	JP1 disconnected, reading at the connector / Diode Check scale	JP1-2	JP1-1	1V	Do step 9.	Repair/ replace wires. If wires OK, replace sensor assembly.

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
9.	JP1 disconnected, reading at the connector / Diode Check scale	JP1-12	JP1-11	1V	Do step 10.	Repair/ replace wires. If wires OK, replace sensor assembly.
10.	DCV scale	JP1-4	JP1-3	Sensor over rail: 2V; Sensor over air: 5V	Do step 11.	Repair/ replace wires. If wires OK, replace sensor assembly.
11.	DCV scale	JP1-10	JP1-9	Sensor over rail: 2V; Sensor over air: 5V	Do step 12.	Repair/ replace wires. If wires OK, replace sensor assembly.
12.	DCV scale	JP1-8	JP1-7	Sensor over rail: 2V; Sensor over air: 5V	Replace CM.	Repair/ replace wires. If wires OK, replace sensor assembly.

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Test I16 ¥ – Mini-Mast Height Count

This test displays the height count from the Mini-Mast Height Manager. A successful test proves that the mini-mast height proximity sensor and Mini-Mast Height Manager are working correctly.

Run Test

NOTE: For information on how to use diagnostic mode, see “Diagnostic Mode” on page 6-4.

The test is a success if the number displayed on the Operator Display increments when lifting and decrements when lowering.

NOTE: The numbers might or might not start at zero. The number displayed is not itself a direct measurement of height.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JP2 disconnected / DCV scale	P2-1	P2-2, P2-3, P2-4	Approx. 10V	Do step 2.	Replace HM.
2.	DCV scale	JP2-1	JP2-2, JP2-3, JP2-4	Not over metal: Approx. 9V; Over metal: 3V	Replace HM and retest; if still not OK, replace CM.	Replace sensor assembly.

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Test I17 – Lift/Lower Inhibit Bypass Switch (S7)

This test displays the position of the lift inhibit bypass switch (S7) on trucks so equipped. A successful test proves that the lift/lower inhibit bypass switch and the wiring to the Carriage Manager are all good.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

The test is a success if the Operator Display and the position of the Lift/Lower Inhibit Bypass Switch match Table 6-35:

Table 6-35.

S7 Switch Position	Operator Display
Released	Off
Depressed	On

- If you do not observe these results, and the truck is configured for this option, then the test is a failure.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC23 disconnected / DCV scale	JC23-2	JC23-7	Approx. 5V	Do step 2.	Replace CM.
2.	JPC23 disconnected / Ohms scale	PC23-2	PC23-7	S7 open: open circuit; S7 closed: 0 ohms	Replace CM.	Troubleshoot wires and switch.

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Test I21 – Steer Motor Current Limit

This test shows if the steer motor is in current limit. The Electric Steer Manager monitors current limit.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

The state of current limit is displayed on the Operator Display as follows:

Table 6-36.

Steer Motor in Current limit?	Operator Display
Yes	Yes
No	No

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	If test fails, run Test A22; if OK, replace the ESM.					

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Test I22 ¥ – Steer Position Feedback Encoder Count

This test displays the value that the Electric Steer Manager sees at JPA8 from the steer position feedback encoder.

A successful test proves that the steer position feedback encoder is working correctly and that the Electric Steer Manager reads the encoder correctly.

Run Test

NOTE: Before running test, make sure encoder has good connection with O-ring and gear is turning with drive unit.

The displayed value should change as you turn the steering encoder. The value wraps from 255 to 0.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	DCV scale	JPA8-3	JPA8-2	5.3V	Do step 2.	Replace ESM.
2.	DCV scale	B+	JPA8-5	B+	Do step 3.	Replace ESM.
3.	DCV scale	ENC-2	ENC-5	5.3VDC	Do step 4.	Repair/ replace wires from ESM to encoder.
4.	DCV scale	JPA8-3	ENC-3	Steering: Approx. 2.6V; No Steering: 5.3 or 0V	Do step 5.	Replace encoder.
5.	DCV scale	JPA8-3	ENC-1	Steering: Approx. 2.6V; No Steering: 5.3 or 0V	Do step 6.	Replace encoder.
6.	DCV scale	JPA8-3	JPA8-1	Steering: Approx. 2.6V; No Steering: 5.3 or 0V	Do step 7.	Repair/ replace wires from ESM to encoder.
7.	DCV scale	JPA8-3	JPA8-4	Steering: Approx. 2.6V; No Steering: 5.3 or 0V	Replace ESM.	Repair/ replace wires from ESM to encoder.

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Test I23 – Wire Guidance Filter Card Status

This test determines if the Electric Steer Manager recognizes that the Wire Guidance Filter Card is installed, on trucks so equipped.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

The test is a success if the filter card status and Operator Display match Table 6-36:

Table 6-37.

Filter Card	Operator Display
Installed	Yes
Not Installed	No

Diagnosis and Repair Table

NOTE: See Figure 6-9 on page 6-86 for Wire Guidance Filter Card pin locations.

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	DCV scale	B+	JPA3-B23 (Filter Card)	B+	Do step 2.	Replace ESM.
2.	DCV scale	B+	JPA3-B22 (Filter Card)	B+	Replace ESM.	Replace Wire Guidance Filter Card.

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Test I24 ¥ – Steer Home Proximity Sensor

This test displays what the Electric Steer Manager sees from the steer home proximity sensor.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

The Test is a success if you observe the following:

Table 6-38.

Steer Home Proximity Sensor	Operator Display
Over Metal	On
Away from Metal	Off

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	DCV scale	JPA7-3	JPA7-2	10.5 to 13V	Do step 2.	Replace ESM.
2.	DCV scale	JPA7-3	JPA7-1	Sensor over metal: Approx.10V; Not over metal: Approx. 0V	Replace ESM.	Adjust/ replace sensor.

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Test I25 – End-of-Aisle Sense, Left-Side Sensors

On trucks equipped with optional end-of-aisle sensors, this test displays what the Tractor Manager sees from end-of-aisle detect sensors S47A (left outboard) and S47B (left inboard), located on the left side (as you face the forks) of the wire guidance sensor bracket.

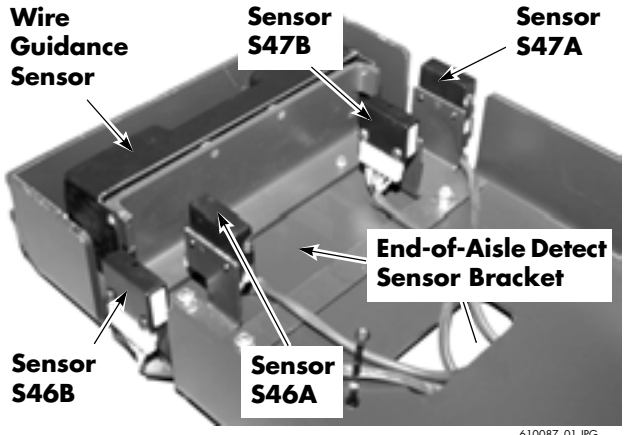


Figure 6-14. Wire Guidance Sensor Bracket (upside down)

Run Test

NOTE: For information on how to use diagnostic mode, see “Diagnostic Mode” on page 6-4.

You can run this test in either static diagnostic mode or active diagnostic mode.

Static diagnostic mode

1. Park the truck away from any floor magnets.
2. Obtain a magnet (P/N 591-552/002).
3. Select Test I25 in static diagnostic mode.
4. Have an observer watch the Operator Display. Pass the magnet under the sensor.
5. The Operator Display should change from **OFF** to **ON**.

Active diagnostic mode

1. Park the truck away from any floor magnets.
2. Select Test I25 for active diagnostic mode. Have this test on the Operator Display.
3. While observing the Operator Display, drive the truck so a sensor passes over a floor magnet.
4. The Operator Display should change from **OFF** to **ON**.

If the Operator Display does not change as described, then the test has failed.

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Diagnosis and Repair

⚠CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-9.

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPS28 disconnected / DCV scale	JPS28-2	JPS28-3	Approx. 11v	Do step 2.	Replace TM.
2.	JPS28 disconnected / DCV scale	JPS28-1	JPS28-3	Approx. 11v	Do step 3.	Replace TM.
3.	DCV scale	S47A-3	S47B-8	Approx. 11v	Do step 4.	Repair wiring to TM.
4.	DCV scale	S47B-3	S47A-8	Approx. 11v	Do step 5.	Repair wiring to other sensor.
5.	DCV scale	S47A-1	S47A-8	11V drops below 8V with magnet under S47A sensor.	Do step 6.	If no 12V, test wire to TM. If 12V doesn't drop, replace S47A.
6.	DCV scale	S47B-1	S47A-8	11V drops below 8V with magnet under S47B sensor.	Do step 7.	If no 12V, test wire to S47A. If 12V doesn't drop, replace S47B.
7.	DCV scale	JPS28-1	JPS28-3	11V drops below 8V with magnet under either sensor.	If trouble-shooting a Code J4, do step 9. If not, do step 8.	Test wire from TM to S47A-1.
8.	DCV scale	JS2-B20 (VFC)	B–	5.3V drops below 4.3V with magnet under either sensor.	Replace VFC.	Replace TM.
9.	DCV scale	JS2-A19 (VFC)	B–	JPS28 connected: 0V; JPS28 disconnected: 5.3V	Replace VFC.	Replace TM.

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Test I27 – End-of-Aisle Sense, Right-Side Sensors

On trucks equipped with optional end-of-aisle sensors, this test displays what the Tractor Manager sees from end-of-aisle detect sensors S46A (right inboard) and S46B right outboard), located on the right side (as you face the forks) of the wire guidance sensor bracket.

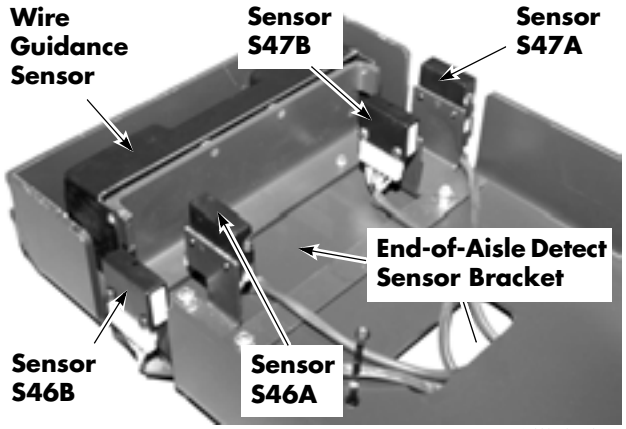


Figure 6-15. Wire Guidance Sensor Bracket (upside down)

Run Test

NOTE: For information on how to use diagnostic mode, see “Diagnostic Mode” on page 6-4.

Static diagnostic mode

1. Park the truck away from any floor magnets.
2. Obtain a magnet (P/N 591-552/002).
3. Select Test I27 in static diagnostic mode.
4. Have an observer watch the Operator Display. Pass the magnet under the sensor.
5. The Operator Display should change from **OFF** to **ON**.

Active diagnostic mode

1. Park the truck away from any floor magnets.
2. Select Test I27 for active diagnostic mode. Have this test on the Operator Display.
3. While observing the Operator Display, drive the truck so a sensor passes over a floor magnet.
4. The Operator Display should change from **OFF** to **ON**.

If the Operator Display does not change as described, then the test has failed.

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Diagnosis and Repair

⚠CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-9.

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPS6 disconnected / DCV scale	JPS6-2	JPS6-3	Approx. 11V	Do step 2.	Replace TM.
2.	JPS6 disconnected / DCV scale	JPS6-1	JPS6-3	Approx. 11V	Do step 3.	Replace TM.
3.	DCV scale	S46A-3	S46B-8	Approx. 11V	Do step 4.	Repair wiring to TM.
4.	DCV scale	S46B-3	S46A-8	Approx. 11V	Do step 5.	Repair wiring to other sensor.
5.	DCV scale	S46A-1	S46A-8	11V drops below 8V with magnet under S46A sensor.	Do step 6.	If no 12V, test wire to TM. If 12V doesn't drop, replace S46A.
6.	DCV scale	S46B-1	S46A-8	11V drops below 8V with magnet under S46B sensor.	Do step 7.	If no 12V, test wire to S46A. If 12V doesn't drop, replace S46B.
7.	DCV scale	JPS6-1	JPS6-3	11V drops below 8V with magnet under either sensor.	If trouble-shooting a code J4, do step 9. If not, do step 8.	Test wire from TM to S46A-1.
8.	DCV scale	JS2-B19 (VFC)	B–	5.3V drops below 4.3V with magnet under either sensor.	Replace VFC.	Replace TM.
9.	DCV scale	JS2-A19 (VFC)	B–	JPS6 connected: 0V; JPS6 disconnected: 5.3V	Replace VFC.	Replace TM.

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Test I29 – Speed Feedback Proximity Sensor, Channel A

This test monitors channel A of the speed feedback proximity sensor.

You should also run Test I30 in conjunction with this test.

The gap between the proximity rotor disc and the sensor is very important. The gap between the disc and the sensor must be between 0.06 and 0.10 in. (1.5 to 2.5 mm).

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

The test is a success if you observe the following results:

Table 6-39.

Speed Feedback Proximity Sensor Position	Operator Display
Over Metal	Off
Away from Metal	On

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	DCV scale	JPS18-3	B–	Approx. 12V	Do step 2.	Replace TM.
2.	DCV scale	SPS-3	B–	Approx. 12V	Do step 3.	Repair wire.
3.	DCV scale	SPS-1	B–	Ramps down from approx. 5V to approx. 4V when traveling	Do step 4.	Replace encoder.
4.	DCV scale	SPS-2	B–	Ramps down from approx. 5V to approx. 4V when traveling	Do step 5.	Replace encoder.
5.	DCV scale	JPS18-1	B–	Ramps down from approx. 5V to approx. 4V when traveling	Do step 6.	Repair wire.
6.	DCV scale	JPS18-2	B–	Ramps down from approx. 5V to approx. 4V when traveling	Replace TM. If problem not corrected, replace VFC.	Repair wire.

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Test I30 – Speed Feedback Proximity Sensor, Channel B

This test monitors channel B of the speed feedback proximity sensor.

You should also run Test I29 in conjunction with this test.

The gap between the proximity rotor disc and the sensor is very important. The gap between the disc and the sensor must be 0.06 ± 0.04 inch (1.5 ± 1.0 mm).

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

The test is a success if you observe the following results:

Table 6-40.

Speed Feedback Proximity Sensor Position	Operator Display
Over Metal	Off
Away from Metal	On

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	DCV scale	JPS18-3	B–	Approx. 12V	Do step 2.	Replace TM.
2.	DCV scale	SPS-3	B–	Approx. 12V	Do step 3.	Repair wire.
3.	DCV scale	SPS-1	B–	Ramps down from approx. 5V to approx. 4V when traveling	Do step 4.	Replace encoder.
4.	DCV scale	SPS-2	B–	Ramps down from approx. 5V to approx. 4V when traveling	Do step 5.	Replace encoder.
5.	DCV scale	JPS18-1	B–	Ramps down from approx. 5V to approx. 4V when traveling	Do step 6.	Repair wire.
6.	DCV scale	JPS18-2	B–	Ramps down from approx. 5V to approx. 4V when traveling	Replace TM. If problem not corrected, replace VFC.	Repair wire.

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Test I31 – Carriage Deadman (S23) at the TM

This test shows what the Tractor Manager reads from carriage deadman (right foot) switch S23. S23 is hardwired through the Carriage Manager to the Tractor Manager.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

The test is a success if the carriage deadman switch status matches the Operator Display as shown in Table 6-41:

Table 6-41.

Right Deadman	Operator Display
Up	Up
Down	Down

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC25 disconnected / DCV scale	PC25-4	PC25-6	10.5 to 13V	Do step 2.	Replace CM.
2.	DCV scale	S23-1	S23-3	10.5 to 13V	Do step 3.	Repair/ replace wires.
3.	DCV scale	S23-1	S23-2	Depressed: 10.5 to 13V; Released: 0V	Do step 4.	Replace switch.
4.	DCV scale	JPC25-4	JPC25-5	Depressed: 10.5 to 13V; Released: 0V	Do step 5.	Repair/ replace wire.
5.	JPC25 disconnected / DCV scale	PC25-5	PC25-6	Approx. 12V	Do step 6.	Replace CM.
6.	JPC17-5 disconnected / DCV scale	JPC20-6	PC17-5	S23 open: 0V; S23 closed: B+	Do step 7.	Replace CM.
7.	JPS25-5 disconnected / DCV scale	JPS26-6	JS25-5	S23 open: 0V; S23 closed: B+	Do step 8.	Troubleshoot over-the-mast cable.
8.	DCV scale	JPS25-5	JPS25-6	S23 open: 12V; S23 closed: 0V	Do step 9.	Replace TM.
9.	DCV scale	JPS2-A23 (VFC)	JPS25-6	S23 open: 5V; S23 closed: 0V	Replace VFC.	Replace TM.

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Test I32 – Brake Control Signal from CM to TM

This test displays the carriage deadman brake control input sent from the Carriage Manager to the Tractor Manager.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

The test is a success if the carriage deadman switch status matches the Operator Display as shown in Table 6-42:

Table 6-42.

Right Deadman	Operator Display
Up	Up
Down	Down

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC25 disconnected / DCV scale	JC25-1	JC25-3	10.5 to 13V	Do step 2.	Replace CM.
2.	JPC25 disconnected / DCV scale	PC25-2	PC25-3	10.5 to 13V	Do step 3.	Replace CM.
3.	DCV scale	S2-1	S2-3	10.5 to 13V	Do step 4.	Repair/ replace wires.
4.	DCV scale	S2-1	S2-2	S2 depressed: 10.5 to 13V; S2 released: 0V	Do step 5.	Replace switch.
5.	DCV scale	JPC25-1	JPC25-2	S2 depressed: 10.5 to 13V; S2 released: 0V	Do step 6.	Repair/ replace wire.
6.	JPC17-4 disconnected / DCV scale	JPC20-1	PC17-4	S2 open: 0V; S2 closed: B+	Do step 7.	Replace CM.
7.	JPS25-4 disconnected / DCV scale	JPS26-1	JS25-4	S2 open: 0V; S2 closed: B+	Do step 8.	Troubleshoot over-the-mast cable.
8.	DCV scale	JPS25-4	JPS25-6	S2 open: 12V; S2 closed 0V	Do step 9.	Replace TM.
9.	DCV scale	JPS1-B6 (VFC)	JPS25-6	S2 open: 5.3V; S2 closed: 0V	Replace VFC.	Replace TM.

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Test I33 – Steering Encoder Channel B

This test displays what the Carriage Manager reads from channel B of the steering encoder card assembly, located below the steering tiller in the left control arm.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

As you turn the steering tiller slowly, the Operator Display should toggle between **OFF** and **ON** as it shows pulses from channel A of the steering encoder.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC16 disconnected / DCV scale	JPC16-1	JPC16-2	5.3V	Do step 2.	Replace CM.
2.	JPC16 disconnected / DCV scale	JPC16-3	JPC16-2	5.3V	Do step 3.	Replace CM.
3.	JPC16 disconnected / DCV scale	JPC16-4	JPC16-2	5.3V	Do step 4.	Replace CM.
4.	DCV scale	JPC16-3	JPC16-2	Toggles between 5.3V and 0V as steering wheel is turned	Do step 5.	Test cable, if possible; then replace encoder.
5.	DCV scale	JPC16-4	JPC16-2	Toggles between 5.3V and 0V as steering wheel is turned	Replace CM.	Test cable, if possible; then replace encoder.

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Test I34 – Steering Encoder Channel A

This test displays what the Carriage Manager reads from channel A of the steering encoder card assembly, located below the steering tiller in the left control arm.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

As you turn the steering tiller slowly, the Operator Display should toggle between **OFF** and **ON** as it shows pulses from channel A of the steering encoder.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC16 disconnected / DCV scale	JPC16-1	JPC16-2	5.3V	Do step 2.	Replace CM.
2.	JPC16 disconnected / DCV scale	JPC16-3	JPC16-2	5.3V	Do step 3.	Replace CM.
3.	JPC16 disconnected / DCV scale	JPC16-4	JPC16-2	5.3V	Do step 4.	Replace CM.
4.	DCV scale	JPC16-3	JPC16-2	Toggles between 5.3V and 0V as steering wheel is turned	Do step 5.	Test cable, if possible; then replace encoder.
5.	DCV scale	JPC16-4	JPC16-2	Toggles between 5.3V and 0V as steering wheel is turned	Replace CM.	Test cable, if possible; then replace encoder.

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Test I35 – Steering Tiller Position

This test displays what the Carriage Manager reads for the position of the steering tiller.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

As the steering tiller is turned, the Operator Display shows a change in position value between 0 and 255, wrapping between 255 and 0.

As you rotate the tiller slowly clockwise, the value should decrease.

As you rotate the tiller slowly counterclockwise, the value should increase.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC16 disconnected / DCV scale	JPC16-1	JPC16-2	5.3V	Do step 2.	Replace CM.
2.	JPC16 disconnected / DCV scale	JPC16-3	JPC16-2	5.3V	Do step 3.	Replace CM.
3.	JPC16 disconnected / DCV scale	JPC16-4	JPC16-2	5.3V	Do step 4.	Replace CM.
4.	DCV scale	JPC16-3	JPC16-2	Toggles between 5.3V and 0V as steering wheel is turned	Do step 5.	Test cable, if possible; then replace encoder.
5.	DCV scale	JPC16-4	JPC16-2	Toggles between 5.3V and 0V as steering wheel is turned	Replace CM.	Test cable, if possible; then replace encoder.

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Test I39 ¥ – Aux Fault Line

NOTE: This test applies to lift trucks *without* an auxiliary contactor.

This test indicates whether an aux fault from the auxiliary control card or auxiliary power amplifier has been sensed by the Tractor Manager.

A successful test proves that the auxiliary fault sensing circuits on the auxiliary control card, auxiliary contactor interface module, or auxiliary power amplifier and the associated wiring and circuits on the Tractor Manager are all operating correctly.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

The test is a success if you observe the following:

Table 6-43.

Aux Fault Status	Operator Display
Absent	Off
Present	On

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
With Raymond Auxiliary Controller Card						
1	JPS4 disconnected / DCV scale	PS4-1	PS4-6	12V	Do step 2.	Replace TM.
2	JPM1 disconnected / DCV scale	JPM1-1	JPM1-6	12V	Do step 3.	Repair wires.
3	DCV scale	JPM1-4	JPM1-6	Fault: 0V; No fault: 6 to 12V	Do step 4.	Replace Aux Controller.
4	DCV scale	JPS4-4	B–	Fault: 0V; No fault: 6 to 12V	Do step 5.	Repair wires.
5	DCV scale	JS1-A6	B–	Fault: 5V; No fault: 0V	Replace VFC.	Replace TM.
With Auxiliary Motor Power Amplifier						
1	JPS4 disconnected / DCV scale	PS4-1	PS4-6	12V	Do step 2.	Replace TM.
2	JPCM1 disconnected / DCV scale	JPM2-4	JPM2-2	12V	Do step 3.	Repair wires.
3	DCV scale	JPM2-8	JPM2-2	Fault: 0V; No fault: 6 to 12V	Do step 4.	Replace Aux Interface Module.
4	DCV scale	JPS4-4	B–	Fault: 0V; No fault: 6 to 12V	Do step 5.	Repair wires.
5	DCV scale	JPS1-A6 (VFC)	B–	Fault: 5V; No fault: 0V	Replace VFC.	Replace TM.

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Test I40 – Carriage Deadman (S23) at the CM

This test monitors the state of the carriage deadman switch (S23). It shows what the Carriage Manager reads from the switch.

A successful test proves that the carriage deadman switch (S23) and its related wiring and the Carriage Manager are all working correctly.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

The test is a success if the Operator Display matches the switch position as shown in Table 6-44:

Table 6-44.

Right Deadman Position	Operator Display
Released	Up
Depressed	Down

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC25 disconnected / DCV scale	PC25-4	PC25-6	10.5 to 13V	Do step 2.	Replace CM.
2.	DCV scale	S23-1	S23-3	10.5 to 13V	Do step 3.	Repair/ replace wires.
3.	DCV scale	S23-1	S23-2	Depressed: 10.5 to 13V; Released: 0V	Do step 4.	Replace switch.
4.	DCV scale	JPC25-4	JPC25-5	Depressed: 10.5 to 13V; Released: 0V	Do step 5.	Repair/ replace wire.
5.	JPC25 disconnected / DCV scale	PC25-5	PC25-6	Approx. 12V	Do step 6.	Replace CM.
6.	JPC17-5 disconnected / DCV scale	JPC20-6	PC17-5	S23 open: 0V; S23 closed: B+	Do step 7.	Replace CM.
7.	JPS25-5 disconnected / DCV scale	JPS 26-6	JS 25-5	S23 open: 0V; S23 closed: B+	Do step 8.	Troubleshoot over-the-mast cable.
8.	DCV scale	JPS 25-5	JPS 25-6	S23 open: 12V; S23 closed: 0V	Do step 9.	Replace TM.
9.	DCV scale	JS2-A23 (VFC)	JPS 25-6	S23 open: 5V; S23 closed: 0V	Replace VFC.	Replace TM.

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Test I41 – Steering Encoder Disconnect

This test determines whether the Carriage Manager senses correct connection to the steering request encoder, located on the left control arm under the steering tiller.

A successful test indicates the steering request encoder is correctly installed and the related wiring and circuitry to the Carriage Manager is functionally correctly.

A successful test does *not* prove that the steering request encoder is functioning correctly.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

1. If the steering request encoder is correctly connected, the Operator Display should read **IN**.
2. Turn the key switch OFF and disconnect the battery connector. Disconnect JC16 from the Carriage Manager. Reconnect the battery connector and turn the key switch ON. Re-run Test I41. The Operator Display should read **OUT**.

If you do not obtain these results, the test is a failure.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	DCV scale	JPC16-1	JPC16-2	5.3V	Do step 2.	Replace CM.
2.	DCV scale	JPE1-1	JPE1-2	5.3V	Replace encoder.	Repair/ replace wires and/or connections.

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Test I42 ¥ – EOA Sensor Connect Detect (optional)

This test monitors the state of the optional end-of-aisle sensors that connect to JPS6 and JPS28. This test displays whether the Tractor Manager sees the sensors plugged into the harness.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

The test is a success if the Operator Display shows the following:

Table 6-45.

Sensor Status	Operator Display
All 4 sensors connected	On
Any sensor disconnected	Off

If you do not obtain these results, the test is a failure.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Run Test I25 and I27.					

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Test I44 ¥ – Travel Cutout Switch (optional)

This test monitors the state of the optional travel cutout switch that connects to JPS16. This test displays what the Tractor Manager sees from the switch if FIC option P is activated.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

The test is a success if the Operator Display shows the following:

Table 6-46.

Switch Position	Operator Display
Open	Above
Closed	Below

If you do not obtain these results, the test is a failure.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPS16 Disconnected /DCV scale	JPS16-2	JPS16-3	10.5 to 13.0V	Do step 2.	Replace TM.
2.	DCV scale	JPS16-1	JPS16-3	Switch open: 10.5 to 13.0V; Switch closed: 0V	Do step 3.	Troubleshoot switch and wiring.
3.	DCV scale	JPS2-A22 (VFC)	JPS16-3	Switch open: Approx. 5V; Switch closed: 0V	Replace VFC.	Replace TM.

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Test I45 – Slack Chain Switches

This test applies to lift trucks SA S/N > 01192 and SB S/N > 00308.

This test monitors the state of the slack chain switches (S50 and S51).

A successful test proves that the slack chain switches (S50 and S51) and associated wiring and circuitry on the CD3 and Tractor Manager cards are all working correctly.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

1. Elevate the operator platform and place a support block under the platform, but do not lower the platform yet.
2. Enter Test I45. The Operator Display should indicate **CLOSED**.
3. Using the Emergency Lower Valve, slowly lower the platform onto the support block until the main lift chains go slack. The Operator Display should indicate **OPEN**.
4. The test is a success if the Operator Display shows the following:

Table 6-47.

Condition	Operator Display
Chains taught	Closed
Chains slack	Open

- If you do not observe these results:
  - Check to be sure the switches are activating correctly. Adjust following the procedure for your specific model (see "Slack Chain Switch Adjustment" on page 7-106).
  - After adjustment, run Test I45 again. If you do not observe the correct results, follow the steps in "Diagnosis and Repair" to determine the cause of the test failure.

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	CD3 card disconnected / DCV scale	PS12-6	PS12-7	10.5 to 13V	Do step 2.	Replace TM.
2.	JPS30 disconnected / Ohms scale	PS30-1	PS30-3	Switch open: OL; Switch closed: 0 ohms	Do step 3.	Troubleshoot wiring; if OK, replace switch.
3.	JPS31 disconnected / Ohms scale	PS31-1	PS31-3	Switch open: OL; Switch closed: 0 ohms	Do step 4.	Troubleshoot wiring; if OK, replace switch.
4.	CD3 card disconnected / DCV scale	JPS12-4	JPS12-7	5.3V	Do step 5.	Replace TM.
5.	CD3 card disconnected / DCV scale	JPS12-5	JPS12-7	5.3V	Do step 6.	Replace TM.
6.	DCV scale	JPS12-6	JPS12-4	Switch closed: 12V; Switch open: 0V	Do step 7.	Replace CD3 Card.
7.	DCV scale	JPS12-6	JPS12-5	Switch closed: 12V; Switch open: 0V	Replace TM.	Replace CD3 Card.

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Test I46 – Lower Decel Switch (optional)

This test monitors the state of the optional lower decel switch that connects to JPS7. This test displays what the Tractor Manager is reading from the switch when FIC option W is activated.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

The test is a success if the Operator Display shows the following:

Table 6-48.

Switch Position	Operator Display
Open	Above
Closed	Below

If you do not obtain these results, the test is a failure.

Diagnosis and Repair Table

NOTE: Before doing steps below, verify switch is adjusted correctly and has been learned.

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPS7 disconnected / DCV scale	PS7-2	PS7-3	12V	Do step 2.	Replace TM.
2.	JPS7 disconnected / DCV scale	JPS7-2	JPS7-1	12V	Replace switch.	Replace TM.

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Test I61 – Aisle Status

This test displays the aisle status in the lift truck's memory.

The operator display shows either **IN** or **OUT**.

If the test result is incorrect, run Tests I25 and I27.

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Test I62 ¥ – Aux Contactor Sense Line

This test applies to lift trucks *with* an auxiliary contactor.

This test shows whether the aux sense line is correctly reporting the state of the auxiliary contactor tips at JPS4-4 on the Tractor Manager. A successful test proves that the Carriage Manager, Tractor Manager, VFC, contactor interface module, auxiliary contactor, and related wiring are all operating correctly.

Run Test

⚠ WARNING

The load handler could be enabled.
Keep clear of load handler during test.

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

The Operator Displays the state of the auxiliary contactor.

1. When the lift truck is operating correctly, with the traverse and rotate controls in the neutral position, the auxiliary contactor is de-energized and the Operator Display reads **OUT**.
2. When the lift truck is operating correctly, when either the traverse or rotate control is moved out of the neutral position, the auxiliary contactor energizes and the Operator Display reads **IN**. The auxiliary motor runs.

If you do not see these results, then the test is a failure.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Run Test O31. / DCV scale	JPCM1-9	JPCM1-3	Contactor closed: 48V; Contactor open: 0V	Do step 2.	Check for B+ to Aux Contactor. Verify contactor tips are not burnt and pitted.
2.	DCV scale	JPS4-4	JPS4-6	40 series code: 0V; No 40 series code: 6V	Do step 4.	Do step 3.
3.	DCV scale	JPCM1-10	JPCM1-3	40 series code: 0V; No 40 series code: 6V	Repair/ replace wires.	Replace Contactor Interface Module.
4.	Measure on VFC / DCV scale	JPS1-A6 (VFC)	JPS4-6	40 series code: 5.3V; No 40 series code: 0V	Replace VFC.	Replace TM.

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Test I63 ¥ – Lift Cutout Switch (optional)

This test monitors the state of the optional lift cutout switch that connects to JPS15-1 and JPS15-4. This test displays what the Tractor Manager reads from the switch when FIC option M is activated.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

The test is a success if the Operator Display shows the following:

Table 6-49.

Switch Position	Operator Display
Open	Above
Closed	Below

If you do not see these results, then the test is a failure.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPS15 disconnected /DCV scale	PS15-1	PS15-4	Approx. 11V	Do step 2.	Replace TM.
2.	DCV scale	JPS15-1	JPS15-4	Switch open: Approx. 11V; Switch closed: 0V	Do step 3.	Troubleshoot switch and wiring.
3.	DCV scale	JPS2-A18 VFC	JPS15-4	Switch open: Approx. 5V; Switch closed: 0V	Replace VFC.	Replace TM.

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Digital Output Tests

A Diagnosis and Repair table is provided for most tests. If a test fails, refer to the Diagnosis and Repair table. This table provides a step-by-step approach to diagnosing a problem and the necessary corrective action. See the example below.

Example Diagnosis and Repair Table

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

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Test O00 – Toggle the PC1 (Travel PC) Contactor

This test turns the PC1 contactor off and on, verifying its correct operation. A successful test proves that the PC1 contactor coil is functioning, as well as the wiring and related circuitry in the Tractor Manager VFC, Tractor Manager, and PC1 coil driver.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

The Operator Display shows the state commanded. Use the **Up** and **Down** buttons to toggle the PC1 contactor.

With the test **ON**, PC1 contactor current reading should be 0.6 amps. Turn the key switch OFF and disconnect the battery connector. Disconnect wire PC1-X. Connect a digital ammeter in series with PC1 coil, positive lead to wire X and negative lead to coil connection X. Reconnect the battery connector and turn the key switch ON. Run Test O00. If current is correct, but tips do not move, contactor could be bound. Replace contactor.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Inspect contactor for mechanical binding.	NA	NA	No binding	Do step 2.	Repair/ replace contactor.
2.	JPS14 disconnected / Ohms scale	JS14-5	JS14-18	Approx. 40 ohms	Do step 3.	Troubleshoot wires and coil.
3.	DCV scale	JPS14-5	B–	B+	Do step 4.	Replace TM.
4.	Test ON / DCV scale	JPS2-B14	B–	ON: 4V; OFF: 0V	Do step 5.	
5.	Test ON / DCV scale	JPS11-3	B–	ON: 4V; OFF: 0V	Do step 6.	Replace TM.
6.	Test ON / DCV scale	B+	JPS11-8	ON: Approx. 24V; OFF: < 2V	Do step 7.	Replace coil driver board.
7.	Test ON / DCV scale	B+	JPS14-18	ON: Approx. 24V; OFF: < 2V	Do step 2.	Replace TM.

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Test O01 – Toggle the PC2 (Lift PC) Contactor

This test turns the PC2 contactor off and on, verifying its correct operation. A successful test proves that the PC2 contactor coil is functioning, as well as the wiring and related circuitry in the Tractor Manager VFC, Tractor Manager, and PC2 coil driver.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

The Operator Display shows the state commanded. Use the **Up** and **Down** buttons to toggle the PC2 contactor.

With the test On, PC2 contactor current reading should be 0.6 amps. Turn the key switch OFF and disconnect the battery connector. Disconnect wire PC2-X. Connect a digital ammeter in series with PC2 coil, positive lead to wire X and negative lead to coil connection X. Reconnect the battery connector and turn the key switch ON. Run Test O01. If current is correct, but tips do not move, contactor could be bound. Replace contactor.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Inspect contactor for mechanical binding.	NA	NA	No binding	Do step 2.	Repair/ replace contactor.
2.	JPS22 and JPS19 disconnected / Ohms scale	JPS19-2	JPS22-1	40 ohms	Do step 3.	Troubleshoot wires and coil.
3.	DCV scale	JPS19-2	B–	B+	Do step 4.	Replace TM.
4.	Test ON / DCV scale	JPS2-B22 (VFC)	B–	ON: 4V; OFF: 0V	Do step 5.	Replace VFC.
5.	Test ON / DCV scale	JPS21-3	B–	4V	Do step 6.	Replace TM.
6.	Test ON / DCV scale	B+	JPS21-5	ON: 24V; OFF: < 2V	Do step 7.	Replace the PC2 CD card.
7.	Test On / DCV scale	B+	JPS22-1	ON: 24V; OFF: < 2V	Do step 2.	Replace TM.

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Test O02 – Toggle the P (Lift) Contactor

This test turns the P contactor off and on, verifying its correct operation. A successful test proves that the P contactor coil is functioning, as well as the wiring and related circuitry in the Tractor Manager VFC, Tractor Manager, and P coil driver on the CD 3 card.

Run Test

⚠ WARNING

Open the Emergency Lowering Valve before running this test.

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

The Operator Display shows the state commanded. Use the **Up** and **Down** buttons to toggle the P contactor.

With the Test **ON**, current readings for the lift contactor should be 1.2 amps and for SOL99 should be 1.7 amps. Turn the key switch OFF and disconnect the battery connector. Disconnect positive supply wire from the lift contactor coil or SOL 99. Connect a digital ammeter in series, positive lead to the wire and the negative lead to the coil connection. Reconnect the battery connector and turn the key switch ON. Run Test O02. If current is correct, but tips do not move, contactor could be bound. Replace contactor.

NOTE: The PC2 contactor opens before the P contactor closes.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Inspect contactor for mechanical binding.	NA	NA	No binding	Do step 2.	Repair/ replace contactor.
2.	JPS29 disconnected / Ohms scale	JPS29-2	JPS29-3	P contactor disconnected: 14 ohms; SOL99 disconnected: 19 ohms; Both connected: 8 ohms	Do step 3.	Troubleshoot wires and coils.
3.	DCV scale	JPS12-10	B–	B+	Do step 4.	Replace TM.
4.	Test ON / DCV scale	JPS1-A22 (VFC)	B–	ON: 5.3V; OFF: 0V	Do step 5.	Replace VFC.
5.	Test ON / DCV scale	JPS12-2	B–	4 to 7V	Do step 6.	Replace TM.
6.	Test ON / DCV scale	B+	JPS29-3	ON: 24V; OFF: 0V	Do step 2.	Replace the CD3 card.

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Test O03 – Toggle the Plugging Contactor

This test turns the plugging contactor off and on, verifying its correct operation. A successful test proves that the plugging contactor coil is functioning, as well as the wiring and related circuitry in the Tractor Manager VFC, Tractor Manager, and plugging coil driver.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

The Operator Display shows the state commanded. Use the **Up** and **Down** buttons to toggle the plugging contactor.

With the test **ON**, plugging contactor current reading should be 0.6 amps. Turn the key switch OFF and disconnect the battery connector. Disconnect wire X from plugging contactor. Connect a digital ammeter in series with plugging contactor coil, positive lead to wire X and negative lead to coil connection X. Reconnect the battery connector and turn the key switch ON. Run Test O03. If current is correct, but tips do not move, contactor could be bound. Replace contactor.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Inspect contactor for mechanical binding	N/A	N/A	No binding	Do step 2.	Repair/ replace contactor.
2.	JPS14 disconnected / Ohms scale	JPS14-14	JPS14-16	40 ohms	Do step 3.	Troubleshoot wiring and coil.
3.	Test ON / DCV scale	JPS14-14	B–	B+	Do step 4.	Replace TM.
4.	Test ON / DCV scale	JPS2-A15 (VFC)	B–	ON: 4V; OFF: 0V	Do step 5.	Replace VFC.
5.	Test ON / DCV scale	JPS11-1	B–	4 to 7V	Do step 6.	Replace TM.
6.	Test ON / DCV scale	B+	JPS11-6	ON: 24V; OFF: < 2V	Do step 7.	Replace coil driver card.
7.	Test ON / DCV scale	B+	JPS14-16	ON: 24V; OFF: < 2V	Do step 2.	Replace TM.

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Test O04 – Forward Enable Test (Forks-First)

This test verifies correct operation of the Tractor Manager's forward enable output.

This test toggles the Tractor Manager forward enable output on and off. The enable output "enables" the power card to pulse the power transistors (TM1 and TM2). If the Power Card is not enabled, it cannot pass pulses from the Tractor Manager on to the transistors.

A successful test proves that the related circuitry in the Tractor Manager and Tractor Manager VFC are all functioning correctly.

This test only checks that the forward enable output from the Tractor Manager is actually arriving at the input to the Power Card. To verify that the Power Card is correctly enabling its output, run Test O13 – Field Drive PWM Ramp.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

Connect a digital voltmeter between PS5-9 (+) and PS5-6 (–) on the Power Card.

Run the test. You should see:

Table 6-50.

Operator Display	Voltage PS5-9 (+) to PS5-6 (–)
Off	> 10.5V
On	< 1.0V

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	DCV scale	JPS5-6	B–	ON: > 10.5V; OFF: < 1V	Run Test O13.	Do step 2.
2.	Power Card removed from TM / DCV scale	JPS5-6	B–	ON: > 10.5V; OFF: < 1V	Replace PC.	Do step 3.
3.	DCV scale	JPS2-A11 (VFC)	B–	ON: <1V; OFF: Approx. 4V	Replace TM.	Replace VFC.

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Test O05 – Reverse Enable Test (Tractor-First)

This test verifies correct operation of the Tractor Manager's reverse enable output.

This test toggles the Tractor Manager reverse enable output on and off. The enable output "enables" the power card to pulse the power transistors (TM1 and TM2). If the Power Card is not enabled, it cannot pass pulses from the Tractor Manager on to the transistors.

A successful test proves that the related circuitry in the Tractor Manager and Tractor Manager VFC are all functioning correctly.

This test only checks that the reverse enable output from the Tractor Manager is actually arriving at the input to the Power Card. To verify that the Power Card is correctly enabling its output, run Test O13 – Field Drive PWM Ramp.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

Connect a digital voltmeter between PS5-9 (+) and PS5–5 on the Power Card.

Run the test. You should see:

Table 6-51.

Operator Display	Voltage PS5-9 (+) to PS5-5 (–)
Off	> 10.5V
On	< 1.0V

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Test ON / DCV scale	JPS5-5	B–	ON: > 10.5V; OFF: < 0V	Run Test O13.	Do step 2.
2.	Power Card disconnected from TM / DCV scale	JPS5-5	B–	ON:> 10.5V OFF: < 0V	Replace PC.	Do step 3.
3.	Test ON / DCV scale	JPS2-B11 (VFC)	B–	ON: <1V; OFF: Approx. 4V	Replace TM.	Replace the VFC.

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Test O06 – Toggle Main Load Holding Solenoid (SOL1)

This test turns the main load holding solenoid (SOL1) off and on, verifying its correct operation electrically.

A successful test proves that the main load holding solenoid coil, coil driver, and wiring and related circuitry in the Tractor Manager and Tractor Manager VFC are all functioning correctly. It does *not* prove that the solenoid valve is functioning correctly mechanically.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

⚠ WARNING

Open the Emergency Lowering Valve, lower the operator platform and load handler completely. The load handler fork carriage is still enabled for lift/lower, traverse, and rotate. Keep clear of forks.

1. Turn the key switch OFF and disconnect the battery connector.
2. Disconnect wire MAIN-1 at the main load holding solenoid.
3. Connect a digital ammeter in series with the load holding solenoid as follows:
   - Positive (+) to wire removed from solenoid.
   - Negative (–) to terminal MAIN-1.
4. Reconnect the battery connector and turn the key switch ON. Run Test O06. Use the **Up** and **Down** arrow keys to toggle the solenoid.

   The test is a success if you observe the following:

Table 6-52.

Operator Display	Off	On
Load Holding Solenoid	Closed	Open
Ammeter Reading	0.0 to 0.02 A	1.0 to 2.0 A

5. Turn the key switch OFF and disconnect the battery connector. Reconnect the wire to MAIN-1. Reconnect the battery connector and turn the key switch ON.

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPS19 disconnected / Ohms scale	JS19-2	JS19-3	Approx. 14 ohms	Do step 2.	Troubleshoot wires and coil.
2.	Test ON / DCV scale	JPS11-5	B–	Approx. 4 to 7V	Do step 4.	Do step 3.
3.	Test ON / DCV scale	JPS1-B22 (VFC)	B–	ON: 5.3V; OFF: 0V	Replace TM.	Replace VFC.
4.	Test ON / DCV scale	B+	JPS11-10	ON: Approx. 24V; OFF: < 2V	Do step 5.	Replace coil driver board.
5.	Test ON / DCV scale	B+	JPS19-3	ON: Approx. 24V; OFF: < 2V	Do step 1.	Replace TM.

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Test O07 – Toggle Horn

This test verifies correct operation of the horn.

A successful test proves that the horn, the K1 relay, and related wiring and circuitry in the Tractor Manager VFC and Tractor Manager are working correctly.

The horn beeps briefly after every successful Power On SelfTest completion. If the horn beeps, there is no need to run this test.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

Connect a digital voltmeter between H1 (+) and H2 (–) at the horn.

Toggle the horn by using the **Up** and **Down** arrow keys on the Operator Display.

The test is a success if you observe the following results:

Table 6-53.

Operator Display	Horn Status	Voltage Measured
Off	Off	0.0
On	Sounding	33 ± 4V

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	K1-3 and K1-4 disconnected / Ohms scale	K1-3 (on relay)	K1-4 (on relay)	Test ON: 0 ohms; OFF: open circuit	Troubleshoot horn and wires.	Do step 2.
2.	PC closed / DCV scale	JPS19-8	B–	B+	Do step 3.	Replace TM.
3.	Test ON / DCV scale	B+	JPS19-9	ON: 33V; OFF: < 2V	Troubleshoot wires and relay.	Do step 4.
4.	Test ON / DCV scale	JPS1-A23 (VFC)	B–	ON: 3.5V; OFF: 0V	Replace TM.	Replace VFC.

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Test O08 – Toggle Brake

This test toggles the brake coil off/on, verifying its correct operation electrically. A successful test proves that the brake coil, wiring, and related circuitry in the coil driver, Tractor Manager VFC, and Tractor Manager are functioning correctly.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

⚠CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-9.

1. Connect a digital voltmeter between JPS19-10 (+) and JPS19-5 (–) on the Tractor Manager.
2. Run Test O08. Use the deadman pedal and **Up** and **Down** arrow keys on the Operator Display to change the brake status as indicated in Table 6-54. The brake makes a noticeable "clunk" when it is applied.

Table 6-54.

Deadman Pedal	Operator Display	Brake Status	Meter Voltage
Up	On	Applied	0
Down	On	Released	48 ± 4
Up or Down	Off	Applied	0

   a. If the brake makes a noticeable "clunk" when the deadman pedal is depressed and the display shows **ON**, the brake could need adjustment. See "Brake Adjustment" on page 7-74.

   b. If there is no sound from the brake when the deadman pedal is depressed, and the display shows **ON**, the test is a failure.

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Diagnosis and Repair Table

NOTE: Verify jumpers on the TM are in the correct position.
Steps 4 and 5 will fail if the PC1 contact tips are not closed by hand.

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPS19 disconnected / Ohms scale	JS19-5	JS19-10	Approx. 22 ohms	Do step 2.	Troubleshoot wires and coil.
2.	DCV scale	JPS19-10	B–	B+	Do step 3.	Replace TM.
3.	DCV scale	JPS11-2	B–	ON: Approx. 10V; OFF: 0V	Do step 4.	Replace TM.
4.	Test ON, PC1 depressed / DCV scale	B+	JPS11-7	ON: B+; OFF: < 2V	Do step 5.	Replace coil driver card.
5.	Test ON, PC1 depressed / DCV scale	B+	JPS19-5	ON: B+; OFF: < 2V	Do step 1.	Replace TM.

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Test O09 – Display Lights

This test verifies the correct operation of the Operator Display.

A successful test proves that the display module, display interface card, and the cable from J3 to PC 18 are all working correctly, and that the Carriage Manager is communicating correctly.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

When you first enter the test, the Operator Display is blank except for "O09 – OFF" displayed in the lower left corner.

Press the UP key to turn the test ON.

The test displays a test pattern of vertical lines. The pattern appears to shift from side to side (lighted lines becoming dark, dark lines becoming light).

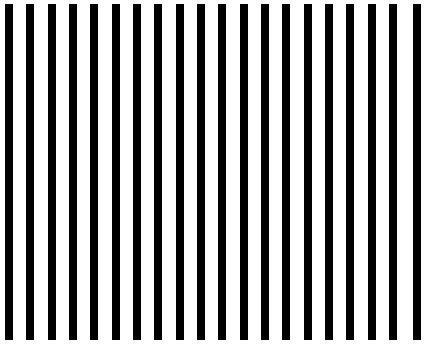


Figure 6-16. Operator Display Test Pattern

Press the DOWN key and the vertical lines become stationary.

If this pattern and shifting occurs, the test is a success.

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Diagnosis and Repair Table

NOTE: Verify that cable is connected to CM, display interface, and display module.

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JP3 disconnected / DCV	JP3-3	JP3-4	Approx. 12V	Do step 3.	Do step 2.
2.	JPC18 disconnected, measure at CM / DCV scale	JPC18-9	JPC18-8	Approx. 12V	Repair/ replace wires.	If truck will travel, replace CM. If no travel, run Test A12 CM Power Supply.
3.	JPC18 and JP3 disconnected/ Ohms scale	JPC18-6 and 7	JP3-1 and 2	0 ohms	Replace display interface.	Repair/ replace wires.
4.	If step 3 passes and the display interface does not fix problem, replace display module.					
5.	If display module does not fix problem, replace CM.					

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Test O10 – Audible Alarm Test

This test verifies the operation of the audible alarm, located in the right hand control arm.

A successful test proves that the alarm, display interface card, and related wiring are working correctly, and that the Carriage Manager is communicating correctly to the display interface card.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

The test generates a tone on the audible alarm located in the Operator Display. The tone ramps from a low pitch to a high pitch.

The test is a success if you obtain the following results:

Table 6-55.

Operator Display	Alarm
Ramp	Tone Ramps
Off	No Tone

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Test ON, wires disconnected from horn / DCV scale	H2-1	H2-2	1.8V	Replace alarm.	Test wires to display interface. If OK, replace display interface card.

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Test O11 – Armature Enable

This test verifies correct operation of the armature enable output from the Tractor Manager.

This test toggles the armature enable from the Tractor Manager ON and OFF. This enables the Power Card to pulse the power transistor (Q1). If the Power Card is not enabled, it cannot pass pulses from the Tractor Manager on to the transistor.

During normal operation, the armature enable is On whenever the Power Card is pulsing the Power Transistor (Q1).

A successful test proves that the wiring and related circuitry in the Tractor Manager are functioning correctly.

This test only checks that the enable output from the Tractor Manager is actually arriving at the input to the Power Card. You must run Test O14 – Armature PWM Ramp to verify that the Power Card is correctly enabling its output.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

⚠CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-9.

1. Connect a digital voltmeter between PS3-5 (+) and PS3-2 (–) on the Power Card.
2. Run Test O11 and use the **Up** and **Down** buttons to toggle the enable ON and OFF. Toggle the test at least twice.

The test is a success if the voltage measured and the Operator Display match Table 6-56:

Table 6-56.

Operator Display	Voltage PS3-5 to PS3-2
On	< 1.0
Off	> 10.5

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Power Card disconnected from TM / DCV scale	JS3-5	JS3-2	ON: 7V OFF: < 1.0V	Run Test O14.	Do step 2.
2.	Power Card disconnected from TM / DCV scale	JPS2-B10 (VFC)	B–	ON: 5.3V; OFF: 0V	Replace TM.	Replace VFC.

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Test O12 – Lift/Lower Solenoid (SOL4) PWM Ramp

This test ramps the lift/lower solenoid (SOL4) from full off to full on.

The proportional lift/lower solenoid is in the main lift/lower manifold. It opens and closes in response to a PWM voltage from the Tractor Manager. Varying the amount that the valve is open controls the rate of lifting/lowering.

A successful test proves that the proportional lift/lower solenoid coil, coil driver, and wiring and related circuitry in the Tractor Manager VFC and Tractor Manager are all functioning correctly.

It does *not* prove that the lift/lower solenoid valve itself is mechanically functional.

Run Test

NOTE: For information on how to use maintenance mode, see “Diagnostic Mode” on page 6-4.

⚠ WARNING

Open the Emergency Lowering Valve, lower the operator platform and load handler completely. The load handler fork carriage is still enabled for lift/lower, traverse, and rotate. Keep clear of forks.

⚠CAUTION

Use correct electrostatic discharge precautions. See “Static Precautions” on page 2-9.

1. Lift/Lower solenoid current reading should ramp from 0 to 4 amps on an SA and 0 to 1.2 amps on an SB.
2. Turn the key switch OFF and disconnect the battery connector. Disconnect wire SOL4-1.
3. Connect a digital ammeter in series with SOL4, positive lead to wire SOL4-1 and negative lead to coil connection SOL4-1.
4. Reconnect the battery connector and turn the key switch ON. Run Test O12. If current is correct, the solenoid could be bound. Replace solenoid. If current is not correct, the test has failed.

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Diagnosis and Repair Table

NOTE:

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPS19 disconnected/ Ohms scale	JPS19-2	JPS19-4	SA: Approx. 4 ohms; SB: Approx.16 ohms	Do step 2.	Troubleshoot wires and coil.
2.	Test ON / DCV scale	JPS2-A21 (VFC)	B–	ON: Ramp 0 to 2V; OFF: < 1V	Do step 3.	Replace VFC.
3.	Test ON / DCV scale	JPS11-4	B–	Ramp < 1V to 5.3V	Do step 4.	Replace TM.
4.	Test ON / DCV scale	B+	JPS11-9	ON: Ramp 47 to 28.5V; OFF: < 2V	Do step 5.	Replace coil driver card.
5.	Test ON / DCV scale	B+	JPS19-4	ON: Ramp 47 to 28.5V; OFF: < 2V	Do step 1.	Replace TM.

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Test O13 – Field PWM Ramp

This test verifies correct operation of the PWM (Pulse Width Modulation) to the power card and field windings.

A successful test proves that the drive motor field windings, transistors TM1/TM2, and related wiring and circuitry in the Tractor Manager, Tractor Manager VFC Cards, and Power Card are all functioning correctly.

This test generates an increasing PWM voltage to the power card. When the truck is operating normally, the Tractor Manager enables the power card and sends it a PWM voltage. The power card in turn pulses the power transistors. The forward (Test O04) and reverse (Test O05) outputs are also activated during this test, so that the power card can pulse the corresponding base leads of TM1/TM2.

Run Test

⚠ WARNING

During this test, the armature is not powered, so the truck should not move. If, however, there is a fault in the traction motor circuit, the traction motor could start. To prevent unexpected movement of the truck, elevate the drive tire off the floor before entering this test.

⚠ WARNING

Use extreme care whenever jacking the truck. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from beneath truck while jacking. Use jack stands or solid blocks to support truck. Do not rely on jacks.

NOTE: *Run Test O04 and O05 before running this test.*

1. Jack and block the truck so the drive tire is off the floor. See warning above.
2. Connect a digital voltmeter from MD-E2 (negative) to MD-E1 (positive).

⚠CAUTION

Do not run this test for an extended period of time, as it could damage the power card or field wiring assembly.

3. Run Test O13.
4. You should see the voltmeter ramp from 0.0 to approximately -45.0 ±3.0 volts, then ramp from 0.0 to approximately +45.0 ±3.0 volts, then repeat until the test is stopped. It does not matter whether the test ramps + or – first, only that it ramps in alternating polarity.
5. If you do *not* observe the bipolar ramping described in Step 4, the test is a failure. Proceed to Diagnosis and Repair.

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	StepPassed	Step Failed
1.	DCV scale	TM1 B+	Power Card B–	B+	Do step 2.	Test cable and Fuse 8.
2.	T1, 2, 3, 4 base wires disconnected. Jumper from P4 to MDS2 / DCV scale	T1	B–	ON: Toggle from 14 to 0V every 15 sec.; OFF: 0V	Do step 3.	Do step 6.
3.	T1, 2, 3, 4 base wires disconnected. Jumper from TP4 to MDS2 / DCV scale	T2	B–	ON: Ramps 0 to approx. 15V every 15 sec.; OFF: Approx. 0V	Do step 4.	Do step 6.
4.	T1, 2, 3, 4 base wires disconnected. Jumper from TP4 to MDS2 / DCV scale	T3	B–	ON: Toggle from 0 to 14V every 15 sec.; OFF: 0V	Do step 5.	Do step 6.
5.	T1, 2, 3, 4 base wires disconnected. Jumper from TP4 to MDS2 / DCV scale	T4	B–	ON: Ramps 0 to approx. 15V every 15 sec.; OFF: Approx. 0V	Do step 8.	Do step 6.
6.	TM disconnected from Power Card / DCV scale	JPS1-A15 (VFC)	B–	OFF: 4V; ON: Ramps 4 to 0V	Do step 7.	Replace VFC.
7.	TM disconnected from Power card / DCV scale	B+	JS5-8	OFF: 44V; ON: Ramps 44 to 43V	Do step 8, then replace the PC.	Replace TM.
8.	Test TM1/TM2	N/A	N/A	See “Field Transistors TM1/TM2” on page 5-11.	Do step 9.	Replace TM1 and TM2 and do step 9.
9.	Test motor field and cable.	N/A	N/A	See “Electric Motor Tests” on page 5-16.	Do step 2.	Repair/ replace cables or motor.

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Test O14 – Armature PWM Ramp

This test verifies correct operation of the PWM (Pulse Width Modulation) to the power card and the power transistor (Q1).

A successful test proves that the drive motor armature windings, power transistor (Q1), and related wiring and circuitry in the Tractor Manager, Tractor Manager VFC, and Power Card are all functioning correctly.

This test generates an increasing PWM voltage to the power card. The chopper enable is also activated during this test, so that the power card can pulse the base of Q1.

Run Test

NOTE: *Before running this test, run Test O11.*

⚠ WARNING

During this test, the field is not powered, so the truck should not move. If, however, there is a fault in the traction motor circuit, the traction motor could start. To prevent unexpected movement of the truck, elevate the drive tire off the floor before entering this test.

⚠ WARNING

Use extreme care whenever jacking the truck. Use a suitable hoist to stabilize the mast. Keep hands and feet clear from beneath truck while jacking. Use jack stands or solid blocks to support truck. Do not rely on jacks.

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

1. Jack and block the truck so the drive tire is off the floor. See warning above.

⚠ CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-9.

2. Connect a digital voltmeter between TP6 (+) and TP4 (–) on the power panel.

⚠ CAUTION

Do not run this test for an extended period of time, as it could damage the power card or armature transistor (Q1).

3. Run Test O14. The Operator Display shows **OFF**. Press the **Down** key. The PC contactors de-energize and the display should still indicate **OFF**.
4. You should see the results shown in Table 6-57. Press the **Up** key to start the ramp cycle.

Table 6-57.

Operator Display	Voltmeter Reading
Off	0.0V
Ramp	Ramp from B+ to B+ minus 6V.

NOTE: B+ = 48 ± 4 volts.

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Q1 base wire disconnected / DCV scale	Q1 base wire	B–	ON: ramp 0 to 2V; OFF: 0V	Test Q1, REC1, and Power Card. See page 5-10, page 5-13, and page 5-14,	Do step 2.
2.	Q1 base wire disconnected / DCV scale	JPC1-2 at power card	B–	ON: ramp 0 to 2V; OFF: 0V	Test wire to Q1-B.	Do step 3.
3.	TM disconnected from power card / DCV scale	B+	JS3-3	ON: ramp 36 to 40V; OFF: 0V	Replace Power Card.	Do step 4.
4.	TM disconnected from power card / DCV scale	JS2-B18 (VFC)	B–	ON: ramp 0 to 1.2V; OFF: 0V	Replace TM.	Replace VFC.

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Test O16 – Mini Load Holding Solenoid (SOL2)

This test turns the mini (or aux) load holding solenoid (MINI-L/H or SOL2) off and on, verifying its correct operation electrically.

A successful test proves that the mini load holding solenoid coil, coil driver, and wiring and related circuitry in the Tractor Manager VFC, and Tractor Manager are all functioning correctly. It does *not* prove that the mini load holding solenoid valve is mechanically functional.

Run Test

NOTE: For information on how to use maintenance mode, see “Diagnostic Mode” on page 6-4.

1. Turn the key switch OFF and disconnect the battery connector.
2. Disconnect the wire from the mini load holding solenoid coil at L/H-1.
3. Connect a digital ammeter in series with SOL2, negative lead (–) to L/H-1, positive lead (+) to wire removed from L/H-1.

⚠ WARNING

Lower the operator carriage and load handler completely to the floor. The fork carriage is still enabled for lift/lower, traverse, and rotate. Keep clear of forks!

⚠ WARNING

If the load handler is elevated, it should be blocked in place, because the lift select solenoid SOL3 is normally closed. If there is a failure in the lift select circuit permitting SOL3 to open, toggling the mini load holding solenoid SOL2 results in the load handler lowering.

4. Reconnect the battery connector and turn the key switch ON. Run Test O16.

   The test is a success if you observe the following results:

Table 6-58.

Operator Display	Ammeter Reading
Off	0.0 to 0.02 A
On	1.0 to 2.0A

5. Turn the key switch OFF and disconnect the battery connector. Remove the ammeter from the circuit and reconnect the wire to L/H-1.

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPS29 disconnected / Ohms scale	JS29-2	JS29-4	14 ohms	Do step 2.	Troubleshoot wires and coil.
2.	Test ON / DCV scale	JPS12-3	B–	OFF: 0V; ON: 5.5V	Do step 4.	Do step 3.
3.	Test ON / DCV scale	JPS2-A26 (VFC)	B–	OFF: 0V; ON: 5.3V	Replace TM.	Replace VFC.
4.	Test ON / DCV scale	B+	JPS29-4	ON: 23V; OFF: < 1V	Run test again.	Replace coil driver card.

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Test O17 – Optional Alarm Test

This test verifies the operation of the optional alarm circuit.

It does *not* verify the correct operation of the device connected to the optional alarm circuit, or wiring to the device.

Devices attached to the optional alarm circuit could be travel alarms, lights, and so forth.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

1. Turn the key switch OFF and disconnect the battery connector. Disconnect the wires at the optional device.
2. Connect a digital voltmeter between AL+ and AL–.
3. Run Test O17.

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

Table 6-59.

Operator Display	Voltage
Off	0.0 to 1.0V
On	44 to 52V

4. Turn the key switch OFF and disconnect the battery connector. Reconnect JPS15.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Test ON / DCV scale	AL+	AL-	48V	Replace alarm.	Do step 2.
2.	PC closed / DCV scale	AL+	B–	48V	Do step 3.	Test wire to AL+.
3.	PC closed / DCV scale	B+	K2-4	48V	Do step 4.	Test wire to K2-4.
4.	K2, K3, K4 unplugged, Test ON / Ohms scale	K2-3	K2-4	ON: 0 ohms; OFF: open circuit	Do step 5.	Do step 6.
5.	Ohms scale	K2-3	AL-	0 ohms	Do step 1.	Repair/ replace wire.
6.	PC closed / DCV scale	JPS15-5	B–	B+	Do step 7.	Replace TM.
7.	DCV scale	B+	JPS15-6	ON: B+; OFF: Approx. 1.5V	Replace K2.	Do step 8.
8.	DCV scale	JPS1-A8 (VFC)	B–	ON: 5.3V; OFF: 0V	Replace TM.	Replace VFC.

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Test O18 – Lift Select Solenoid (SOL3)

This test turns the lift select solenoid (LIFTSEL or SOL3) off and on, verifying its correct operation electrically.

A successful test proves that the lift select solenoid coil, coil driver, and wiring and related circuitry in the Tractor Manager VFC, and Tractor Manager are all functioning correctly. It does *not* prove that the lift select solenoid valve is mechanically functional.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

⚠CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-9.

1. Turn the key switch OFF and disconnect the battery connector.
2. Disconnect the wire from the lift select solenoid coil SOL3 at LIFTSEL-1.
3. Connect a digital ammeter in series with SOL3, negative lead (-) to LIFTSEL-1, positive lead (+) to wire removed from LIFTSEL-1.

⚠ WARNING

Lower the operator carriage and load handler completely to the floor. The fork carriage is still enabled for lift/lower, traverse, and rotate. Keep clear of forks!

4. Reconnect the battery connector and turn the key switch ON. Run Test O18.

   The test is a success if you observe the following results:

Table 6-60.

Operator Display	Ammeter Reading
Off	0.0 to 0.02 A
On	1.0 to 2.0 A

5. Turn the key switch OFF and disconnect the battery connector. Remove the ammeter from the circuit and reconnect the wire to LIFTSEL-1.

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPS29 disconnected / Ohms scale	JS29-1	JS29-2	14 ohms	Do step 2.	Troubleshoot the solenoid coil, wires, and associated connections.
2.	DCV scale	JPS12-1	B–	ON: 5.5V; OFF: 0V	Do step 4.	Do step 3.
3.	DCV scale	JPS1-B21 (VFC)	B–	ON: 5.3V; OFF: 0V	Replace TM.	Replace VFC.
4.	DCV scale	B+	JPS29-1	ON: 24V; OFF: 0V	Run test again.	Replace coil driver card.

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Test O19 – Load Handler Traverse Solenoid "A" (SOL34A)

This test applies to lift trucks without an auxiliary contactor.

This test turns the load handler traverse solenoid "A" (SOL34A) on and off, verifying its correct operation electrically.

A successful test proves that the load handler traverse solenoid "A" (SOL34A) coil and wiring and related circuitry in the Carriage Manager are functioning correctly.

It does *not* prove that the load handler traverse solenoid "A" valve is mechanically functional.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

⚠CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-9.

1. Turn the key switch OFF and disconnect the battery connector.
2. Disconnect wire SOL34A-1 from the load handler traverse solenoid "A."
3. Connect a digital ammeter in series with SOL34A, positive lead (+) to SOL34A-1, negative lead (–) to wire removed from SOL34A-1.

⚠ WARNING

The fork carriage is enabled for lift/lower, traverse, and rotate. Keep clear of forks!

4. Reconnect the battery connector and turn the key switch ON. Step on both deadman pedals. Run Test O19.

   The test is a success if you observe the following results:

Table 6-61.

Operator Display	Ammeter Reading
Off	0.0 to 0.02 A
On	0.5 to 1.0 A

5. Turn the key switch OFF and disconnect the battery connector. Remove the ammeter from the circuit and reconnect the wire to SOL34A-1.

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC10 disconnected / Ohms scale	JC10-5	JC10-6	Approx. 40 ohms	Do step 2.	Troubleshoot the solenoid coil, wires, and associated connections.
2.	JPC10 disconnected / DCV scale	PC10-5	JPC20-4	48V	Do step 3.	Replace CM.
3.	Test ON / DCV scale	JPC10-5	JPC10-6	ON: 24V; OFF: 0V	If there are no other causes of restricted movement found, replace the solenoid valve.	Replace CM.

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Test O20 – Load Handler Traverse Solenoid "B" (SOL34B)

This test applies to lift trucks without an auxiliary contactor.

This test turns the load handler traverse solenoid "B" (SOL34B) on and off, verifying its correct operation electrically.

A successful test proves that the load handler traverse solenoid "B" (SOL34B) coil and wiring and related circuitry in the Carriage Manager are functioning correctly.

It does *not* prove that the load handler traverse solenoid "B" valve is mechanically functional.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

⚠CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-9.

1. Turn the key switch OFF and disconnect the battery connector.
2. Disconnect wire SOL34B-1 from the load handler traverse solenoid "B."
3. Connect a digital ammeter in series with SOL34B, positive lead (+) to SOL34B-1, negative lead (–) to wire removed from SOL34B-1.

⚠ WARNING

The fork carriage is enabled for lift/lower, traverse, and rotate. Keep clear of forks!

4. Reconnect the battery connector and turn the key switch ON. Step on both deadman pedals. Run Test O20.

   The test is a success if you observe the following results:

Table 6-62.

Operator Display	Ammeter Reading
Off	0.0 to 0.02 A
On	0.5 to 1.0 A

5. Turn the key switch OFF and disconnect the battery connector. Remove the ammeter from the circuit and reconnect the wire to SOL34B-1.

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC10 disconnected / Ohms scale	JC10-7	JC10-8	Approx. 40 ohms	Do step 2.	Troubleshoot the solenoid coil, wires, and associated connections.
2.	JPC10 disconnected / DCV scale	PC10-7	JPC20-4	48V	Do step 3.	Replace CM.
3.	Test ON / DCV scale	JPC10-7	JPC10-8	ON: 24V; OFF: 0V	If there are no other causes of restricted movement found, replace the solenoid valve.	Replace CM.

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Test O21 – Fork Control Solenoid "B" (SOL35B)

This test turns the fork control solenoid "B" (SOL35B) on and off, verifying its correct operation electrically.

A successful test proves that the fork control solenoid "B" (SOL35B) coil and wiring and related circuitry in the Carriage Manager are functioning correctly.

It does *not* prove that the fork control solenoid "B" valve is mechanically functional.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

⚠CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-9.

1. Turn the key switch OFF and disconnect the battery connector.
2. Disconnect wire SOL35B-1 from the fork control solenoid "B."
3. Connect a digital ammeter in series with SOL35B, positive lead (+) to SOL35B-1, negative lead (–) to wire removed from SOL35B-1.

⚠ WARNING

The fork carriage is enabled for lift/lower, traverse, and rotate. Keep clear of forks!

4. Reconnect the battery connector and turn the key switch ON. Step on both deadman pedals. Run Test O21.

   The test is a success if you observe the following results:

Table 6-63.

Operator Display	Ammeter Reading
Off	0.0 to 0.02 A
On	0.5 to 1.0 A

5. Turn the key switch OFF and disconnect the battery connector. Remove the ammeter from the circuit and reconnect the wire to SOL35B-1.

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC10 disconnected / Ohms scale	JC10-1	JC10-2	40 ohms	Do step 2.	Troubleshoot the solenoid coil, wires, and associated connections.
2.	JPC10 disconnected / DCV scale	PC10-1	JP20-4	48V	Do step 3.	Replace CM.
3.	Test ON / DCV scale	JPC10-1	JPC10-2	ON: 24V; OFF: 0V	If there are no other causes of restricted movement found, replace the solenoid valve.	Replace CM.

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Test O22 – Fork Control Solenoid "A" (SOL35A)

This test turns the fork control solenoid "A" (SOL35A) on and off, verifying its correct operation electrically.

A successful test proves that the fork control solenoid "A" (SOL35A) coil and wiring and related circuitry in the Carriage Manager are functioning correctly.

It does *not* prove that the fork control solenoid "A" valve is mechanically functional.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

⚠CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-9.

1. Turn the key switch OFF and disconnect the battery connector.
2. Disconnect wire SOL35A-1 from the fork control solenoid "A."
3. Connect a digital ammeter in series with SOL35A, positive lead (+) to SOL35A-1, negative lead (–) to wire removed from SOL35A-1.

⚠ WARNING

The fork carriage is enabled for lift/lower, traverse, and rotate. Keep clear of forks!

4. Reconnect the battery connector and turn the key switch ON. Step on both deadman pedals. Run Test O22.

   The test is a success if you observe the following results:

Table 6-64.

Operator Display	Ammeter Reading
Off	0.0 to 0.02 A
On	0.5 to 1.0 A

5. Turn the key switch OFF and disconnect the battery connector. Remove the ammeter from the circuit and reconnect the wire to SOL35A-1.

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC10 disconnected / Ohms scale	JC10-3	JC10-4	40 ohms	Do step 2.	Troubleshoot solenoid coil, wires, and associated connections.
2.	JPC10 disconnected / DCV scale	PC10-3	JPC20-4	48V	Do step 2.	Replace CM.
3.	Test ON / DCV scale	JPC10-3	JPC10-4	ON: 24V; OFF: 0V	If there are no other causes of restricted movement found, replace the solenoid valve.	Replace CM.

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Test O23 – Reach Solenoid (SOL36)

This test turns the reach solenoid (SOL36) on and off, verifying its correct operation electrically.

A successful test proves that the reach solenoid (SOL36) coil and wiring and related circuitry in the Carriage Manager are functioning correctly.

It does *not* prove that SOL36 valve is mechanically functional.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

⚠CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-9.

1. Turn the key switch OFF and disconnect the battery connector.
2. Disconnect wire SOL36-1 from the reach solenoid.
3. Connect a digital ammeter in series with SOL36, positive lead (+) to SOL36-1, negative lead (–) to wire removed from SOL36-1.

⚠ WARNING

The fork carriage is enabled for lift/lower, traverse, and rotate. Keep clear of forks!

4. Reconnect the battery connector and turn the key switch ON. Run Test O23.

   The test is a success if you observe the following results:

Table 6-65.

Operator Display	Ammeter Reading
Off	0.0 to 0.02 A
On	0.5 to 1.0 A

5. Turn the key switch OFF and disconnect the battery connector. Remove the ammeter from the circuit and reconnect the wire to SOL36-1.

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPH1 disconnected / Ohms scale	JH1-1	JH1-2	40 ohms	Do step 2.	Troubleshoot solenoid coil, wires, and associated connections.
2.	JPH1 disconnected / DCV scale	PH1-1	PH1-8	48V	Do step 3.	Replace CM.
3.	Test ON / DCV scale	JPH1-1	JPH1-2	ON: 24V; OFF: 0V	If there are no other causes of restricted movement found, replace the solenoid valve.	Replace CM.

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Test O24 – Test Supplemental Display

This test verifies the correct operation of the supplemental display.

A successful test proves that the supplementary display card, cable harness, and related circuitry in the Carriage Manager are all functioning correctly.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

When the test is turned ON, the LEDs should cycle on then off, one at a time. The entire test should take approximately 5 seconds.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPA1 disconnected / DCV scale	JA1-1	B–	10.8 to 13V	Do step 3.	Do step 2.
2.	JPC8 disconnected / DCV scale	JPC8-1	B–	10.8 to 13V	Repair/ replace wire.	Replace CM.
3.	JPA1 and JPC8 disconnected / Ohms scale	JPA1-2 thru JPA1-12	JPC8-2 thru JPC8-12	0 ohms	Replace supplemental operator display.	Repair/ replace wires.

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Test O25 – Aux Motor Control Enable (with Aux Control Card)

This version of Test O26 applies to lift trucks using a single auxiliary motor controller (card) instead of an auxiliary power amplifier and an auxiliary interface module (card).

This test verifies that the Tractor Manager is correctly enabling the auxiliary motor controller, permitting it to pass the PWM voltage to the transistors controlling the auxiliary motor.

A successful test proves that the Tractor Manager, Tractor Manager VFC Card, and related circuitry on the auxiliary motor controller are all functioning correctly.

Run Test

NOTE: For information on how to use maintenance mode, see “Diagnostic Mode” on page 6-4.

The test is a success if you observe the following:

Table 6-66.

Operator Display	Aux Enable LED IL1
On	Lit (On)
Off	Unlit (Off)

NOTE: If the aux enable is left on for more than two minutes, the aux fault LED IL3 should come on. If this does not occur, run Test I39.

PWM LED IL2 should be lit during this test.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Test ON / DCV scale	JPS4-5	JPS4-6	ON: > 10V; OFF: < 1V	Do step 3.	Do step 2.
2.	Test ON / DCV scale	JPS1-B8 (VFC)	B–	ON: 5V; OFF: 0V	Replace TM.	Replace VFC.
3.	Test ON / DCV scale	JM1-5	JM1-6	ON: > 10V; OFF: < 1V	Verify MXB+ and MXB– to the Aux Control Card. If OK, replace Aux Control Card.	Repair/ replace wires.

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Test O25 – Aux Power Amplifier Enable (with Interface Module)

This version of Test O25 applies to lift trucks using an auxiliary power amplifier and an auxiliary interface module (card) instead of a single auxiliary motor controller (card).

This test verifies that the Tractor Manager is correctly enabling the auxiliary interface module, permitting it to pass a voltage to the auxiliary power amplifier controlling the auxiliary motor.

A successful test proves that the Tractor Manager and Tractor Manager VFC Card are both functioning correctly. It does *not* prove that the auxiliary power amplifier or auxiliary interface module are working correctly.

Run Test

NOTE: For information on how to use maintenance mode, see “Diagnostic Mode” on page 6-4.

Connect a digital voltmeter between JPM2-7 (+) and JPM2-2 (–) on the auxiliary power amplifier.

Run the test. The test is a success if you observe the following:

Table 6-67.

Operator Display	Voltage
On	> 10.0V
Off	< 1.0V

If you do not observe these results, the test is a failure.

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	DCV scale	JPM2-5	JPM2-2	B+	Do step 2.	Repair/ replace wires.
2.	DCV scale	JPM2-1	JPM2-2	B+	Do step 3.	Replace Aux Interface Module.
3.	DCV scale	AMPL-1	JPM2-2	B+	Do step 4.	Repair/ replace wires.
4.	DCV scale	M- Aux Power Amp	B+ Aux Power Amp	B+	Do step 5.	Repair/ replace wires.
5.	DCV scale	JPS4-5	JPM2-2	ON: > 10V; OFF: < 1V	Do step 8.	Do step 7.
6.	DCV scale	JPS1-B8 (VFC)	B–	ON: 5V; OFF: 0V	Replace TM.	Replace VFC.
7.	DCV scale	JPM2-7	JPM2-2	ON: > 10V; OFF: < 1V	Do step 9.	Repair/ replace wires.
8.	DCV scale	JPM2-6	JPM2-2	ON: ramp from 0 to 5V; OFF: < 1V	Do step 10.	Replace Aux Interface Module.
9.	DCV scale	AMPL-3	JPM2-2	ON: ramp from 0 to 5V; OFF: < 1V	Replace Aux Power Amplifier.	Repair/ replace wires.
10.	DCV scale	JPM2-5	JPM2-2	B+	Do step 2.	Repair/ replace wires.

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Test O26 – Aux Motor Controller PWM (with Aux Control Card)

This version of Test O26 applies to lift trucks using a single auxiliary motor controller (card) instead of an auxiliary power amplifier and an auxiliary interface module (card).

This test verifies that the Tractor Manager is correctly providing the auxiliary controller with a ramped PWM voltage to operate the auxiliary motor.

A successful test proves that the Tractor Manager, Tractor Manager VFC Card, the wiring from the Tractor Manager to the auxiliary controller, and related circuitry on the auxiliary controller are functioning correctly.

A successful test does *not* prove that the auxiliary motor and pump are functioning correctly.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

1. Connect a digital voltmeter across the power terminals of the auxiliary motor.
2. Step on the right side (travel) deadman pedal. Run Test O26 and observe the meter. Toggle the test with the **Up** button.

The test is a success if you observe the following:

Table 6-68.

Operator Display	Voltage
Off	0V
Ramp	Ramps up from 0 to approximately 30V

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Test ON / DCV scale	JPS4-2	JPS4-6	Ramps from < 1 to 11V	Do step 2.	Replace TM. If still not OK, replace VFC.
2.	Test ON / DCV scale	JM1-2	JM1-6	Ramps from < 1 to 11V	Run Test O25.	Repair replace wire(s).

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Test O26 – Aux Power Amplifier PWM (with Interface Module)

This version of Test O26 applies to lift trucks using an auxiliary power amplifier and an auxiliary interface module (card) instead of a single auxiliary motor controller (card).

This test verifies that the Tractor Manager is correctly providing the auxiliary power amplifier with a ramped PWM voltage to operate the auxiliary motor.

A successful test proves that the Tractor Manager, Tractor Manager VFC Card, the wiring from the Tractor Manager to the Interface Module, and the Aux Power Amplifier are all functioning correctly.

A successful test does *not* prove that the auxiliary motor and pump are functioning correctly.

Run Test

NOTE: For information on how to use maintenance mode, see "Diagnostic Mode" on page 6-4.

1. Connect a digital voltmeter across the power terminals of the auxiliary motor.
2. Step on the right side (travel) deadman pedal. Run Test O26 and observe the meter. Toggle the test with the **Up** button.
3. The test is a success if you observe the following:

Table 6-69.

Operator Display	Voltage
Off	0V
Ramp	Ramps up from 0 to approximately 30V

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	Test ON / DCV scale	JPS4-2	JPS4-6	Ramps from <1 to 11V	Do step 2.	Replace TM. If still not OK, replace VFC.
2.	Test ON / DCV scale	JM1-2	JM1-6	Ramps from < 1 to 11V	Run Test O25.	Repair replace wire(s).

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Test O27 – Unused

This test is not used on Series SA/SB.

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Test O28 – Load Handler Traverse Solenoid "A" (SOL34A)

This test applies to lift trucks with an auxiliary contactor.

This test turns the load handler traverse proportional valve "A" on and off, verifying its correct operation electrically.

A successful test proves that the SOL34A coil driver circuitry in the Carriage Manager and the wiring to SOL34A from the Carriage Manager are operating correctly electrically.

It does not prove that SOL34A is operating correctly mechanically.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

⚠CAUTION

Use correct precautions against electrostatic discharge. See "Static Precautions" on page 2-9.

1. Turn the key switch OFF and disconnect the battery connector.
2. Disconnect wire SOL34A-2 from the load handler traverse solenoid "A."
3. Connect a digital ammeter in series with SOL34A, positive lead (+) to SOL34A-2, negative lead (–) to wire removed from SOL34A-2.
4. Reconnect the battery connector and turn the key switch ON. Step on both deadman pedals. Run Test O28.

   The test is a success if you observe the following results:

Operator Display	Ammeter Reading
Off	0.0 to 0.02 A
On	0.5 to 1.0 A

5. Turn the key switch OFF and disconnect the battery connector. Remove the ammeter from the circuit and reconnect the wire to SOL34A-2.

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC10 disconnected / Ohms	JC10-5	JC10-6	40 ohms	Do step 2.	Troubleshoot solenoid coil, wires, and associated connections.
2.	JPC10 disconnected / DCV	PC10-5	JPC20-4	48V	Do step 3.	Replace CM.
3.	Test ON / DCV	JPC10-5	JPC10-6	Ramp between 0 and 22V	If there are no other causes or restricted movement found, replace the solenoid valve.	Replace CM.

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Test O29 – Load Handler Traverse Solenoid "B" (SOL34B)

This test applies to lift trucks with an auxiliary contactor.

This test turns the load handler traverse proportional valve "B" on and off, verifying its correct operation electrically.

A successful test proves that the SOL34B coil driver circuitry in the Carriage Manager and the wiring to SOL34B from the Carriage Manager are operating correctly electrically.

It does not prove that SOL34B is operating correctly mechanically.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

⚠CAUTION

Use correct precautions against electrostatic discharge. See "Static Precautions" on page 2-9.

1. Turn the key switch OFF and disconnect the battery connector.
2. Disconnect wire SOL34B-2 from the load handler traverse solenoid "B."
3. Connect a digital ammeter in series with SOL34B, positive lead (+) to SOL34B-2, negative lead (–) to wire removed from SOL34B-2.
4. Reconnect the battery connector and turn the key switch ON. Step on both deadman pedals. Run Test O29.

   The test is a success if you observe the following results:

Operator Display	Ammeter Reading
Off	0.0 to 0.02 A
On	0.5 to 1.0 A

5. Turn the key switch OFF and disconnect the battery connector. Remove the ammeter from the circuit and reconnect the wire to SOL34B-2.

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC10 disconnected / Ohms scale	JC10-7	JC10-8	40 ohms	Do step 2.	Troubleshoot solenoid coil, wires, and associated connections.
2.	JPC10 disconnected	PC10-7	JPC20-4	48V	Do step 3.	Replace CM.
3.	Test ON / DCV scale	JPC10-7	JPC10-8	Ramp between 0 and 22V	If there are no other causes of restricted movement found, replace the solenoid valve.	Replace CM.

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Test O30 – Proportional Reach/Rotate Solenoid (SOL33)

This test applies to lift trucks with an auxiliary contactor.

This test turns the proportional reach/rotate solenoid (SOL33) on and off to verify its correct operation.

A successful test proves that the SOL33 coil driver circuitry in the Carriage Manager and the wiring to SOL33 from the Carriage Manager are operating correctly electrically.

It does not prove that SOL33 is operating correctly mechanically.

Run Test

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

1. Turn the key switch OFF and disconnect the battery connector.
2. Disconnect wire SOL33-2 from the proportional reach/rotate solenoid.
3. Connect a digital ammeter in series with SOL33, positive lead (+) to SOL33-2, negative lead (–) to wire removed from SOL33-2.
4. Reconnect the battery connector and turn the key switch ON. Step on both deadman pedals. Run Test O30.

   The test is a success if you observe the following results:

Operator Display	Ammeter Reading
Off	0.0 to 0.02 A
On	1.0 to 1.5 A

5. Turn the key switch OFF and disconnect the battery connector. Remove the ammeter from the circuit and reconnect the wire to SOL33-2.

Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPC26 disconnected / Ohms scale	JC26 -2	JC26-4	20 ohms	Do step 2.	Troubleshoot solenoid coil, wires, and associated connectors.
2.	JPC26 disconnected / DCV scale	PC26-2	JPC20-4	48V	Do step 3.	Replace CM.
3.	Test ON / DCV scale	JPC26-2	JPC26-4	Ramp between 0 and 22V	If there are no other causes of restricted movement found, replace the solenoid valve.	Replace CM.

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Test O31 – Toggle the Aux (X) Contactor

This test applies to lift trucks with an auxiliary contactor.

This test turns the auxiliary contactor coil on and off to verify its correct operation.

A successful test proves that the auxiliary contactor coil, related wiring and circuitry in the Carriage Manager, Tractor Manager, and contactor interface module are operating correctly.

Run Test

⚠ WARNING

Keep clear of load handler fork carriage during test.

NOTE: For information on how to use diagnostic mode, see "Diagnostic Mode" on page 6-4.

1. With the test On, Aux Contactor Coil current reading should be 1 amp.
2. Turn the key switch OFF and disconnect the battery connector. Disconnect wire X from the contactor coil.
3. Connect a digital ammeter in series, positive lead to coil connection and negative lead to wire X.
4. Reconnect the battery connector and turn the key switch ON.
5. Run Test O31.

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Diagnosis and Repair Table

Step	Action/ Meter Scale	(+) Lead	(–) Lead	Expected Results	Step Passed	Step Failed
1.	JPCM1 disconnected / Ohms scale	JPCM1-6	JPCM1-4	20 ohms	Do step 2.	Troubleshoot wires and coil.
2.	JPS4 disconnected / DCV scale	PS4-5	PS4-6	OFF: < 0.5V; ON: 9 to 13V	Do step 4.	Do step 3.
3.	JPS4 disconnected / DCV scale	JPS1-B8 (VFC)	JPS4-6	OFF: < 0.5V; ON: 5.3V	Replace TM.	Replace VFC.
4.	DCV scale	JPCM1-2	JPCM1-3	OFF: < 0.5V; ON: 9 to 13V	Do step 5.	Repair wires.
5.	JPS4 disconnected / DCV scale	JPS4-1	JPS4-6	12V	Do step 6.	Replace TM.
6.	DCV scale	JPCM1-1	JPCM1-3	12V	Do step 7.	Repair wires.
7.	DCV scale	JPCM1-6	JPCM1-3	B+	Do step 8.	Troubleshoot wires to JPS46-1.
8.	DCV scale	JPCM1-6	JPCM1-4	OFF: < 0.5V; ON: 20V	Verify contactor is not binding, then return to do step 1.	Replace Contactor Interface Module.

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Component Locator Photos

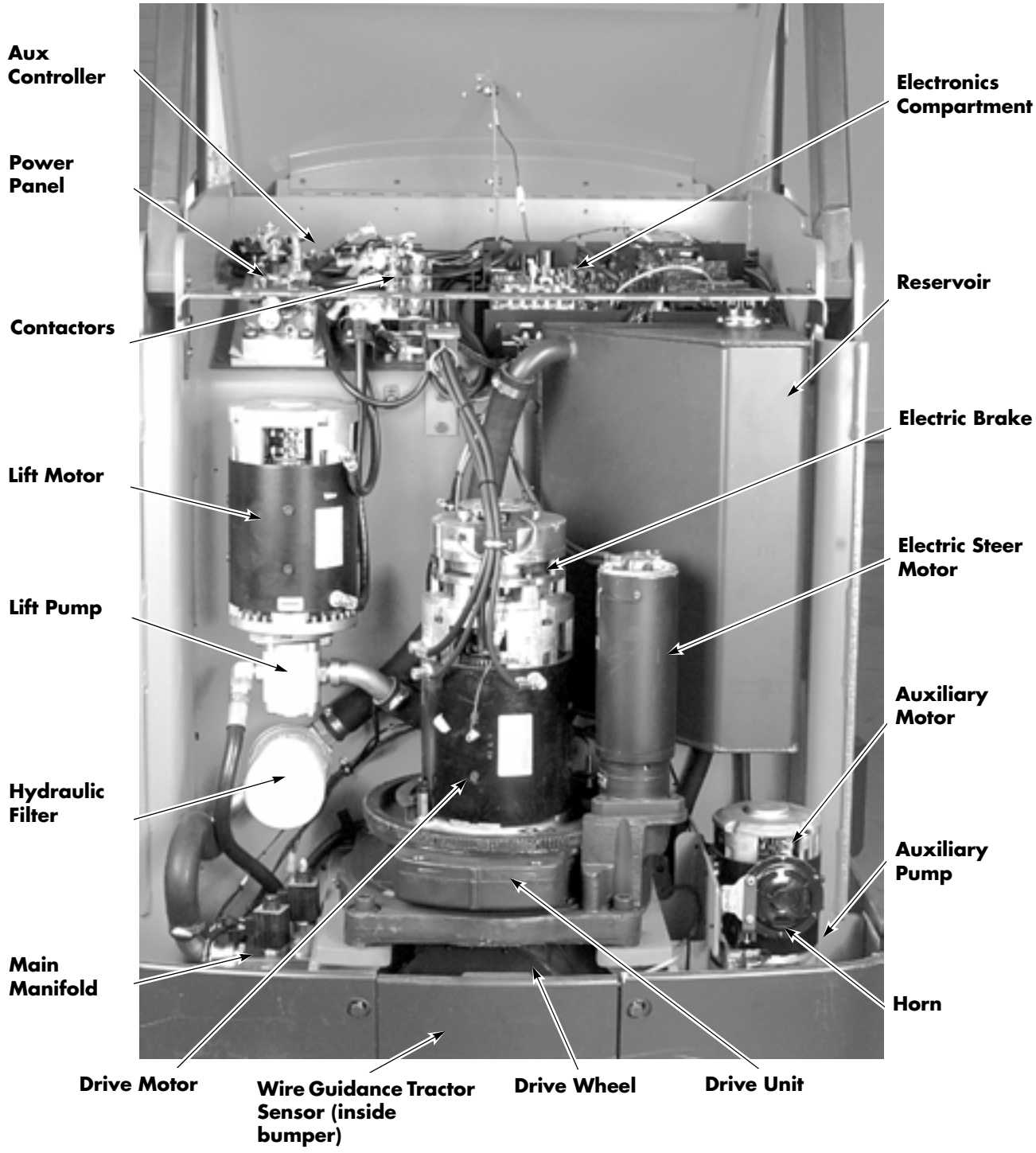


Figure 7-1. Tractor Components (SA S/N < 03817 and SB S/N < 00942)

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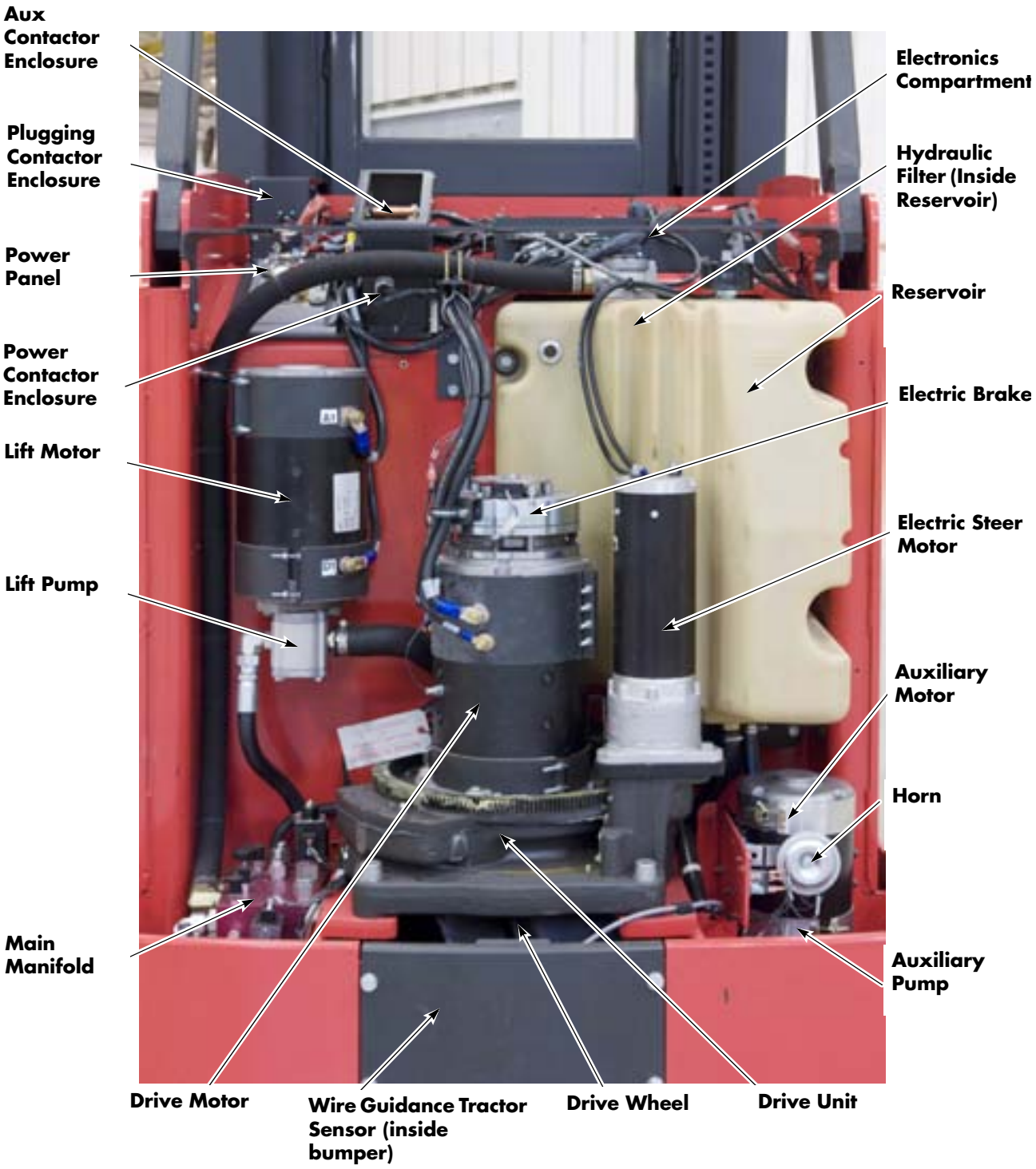


Figure 7-2. Tractor Components (SA S/N 03787 and > 03817, SB S/N > 00942, EE-rated truck shown)

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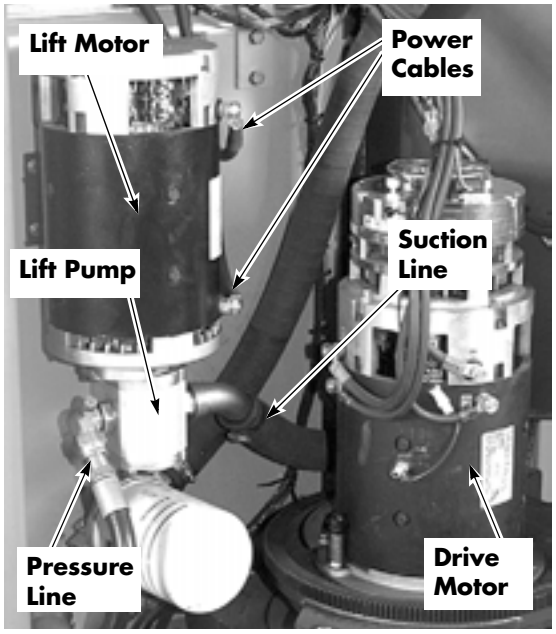


Figure 7-3. Lift Motor and Pump (SA S/N < 03817 and SB S/N < 00942 shown)

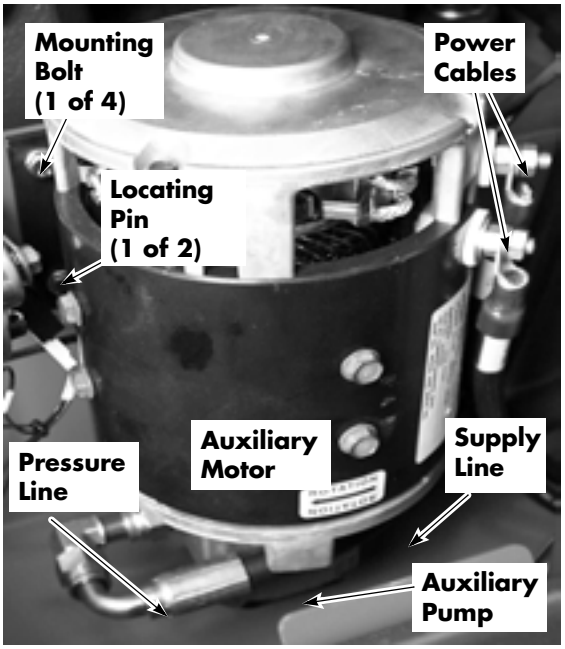


Figure 7-5. Auxiliary Motor and Pump (Early Trucks SA S/N < 01095 and SB S/N < 00307)

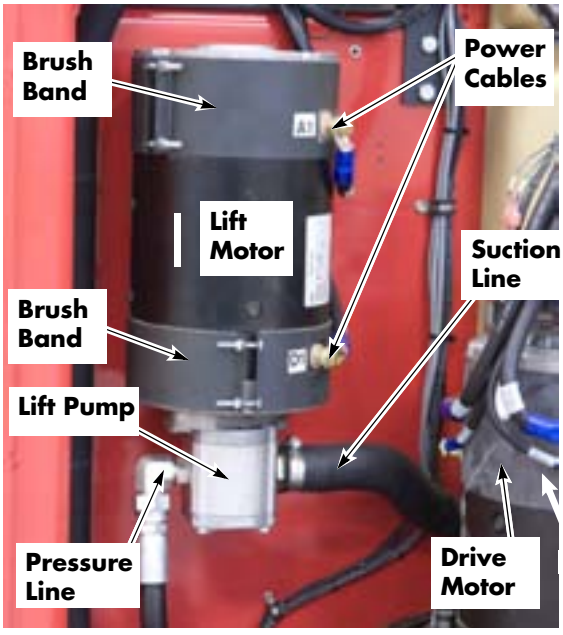


Figure 7-4. Lift Motor and Pump (SA S/N > 03816 and SB S/N > 00941 EE-rated truck shown)

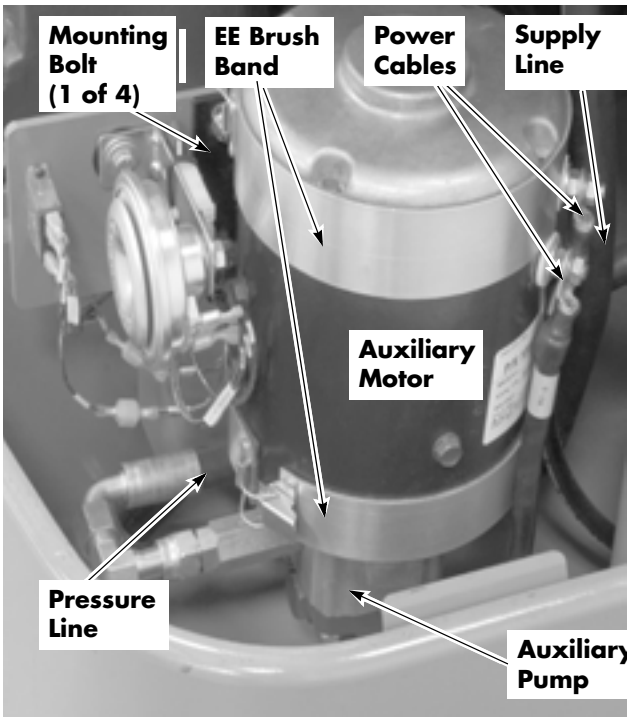


Figure 7-6. Auxiliary Motor and Pump (SA S/N > 01094 and SB S/N > 00306 EE-rated truck shown)

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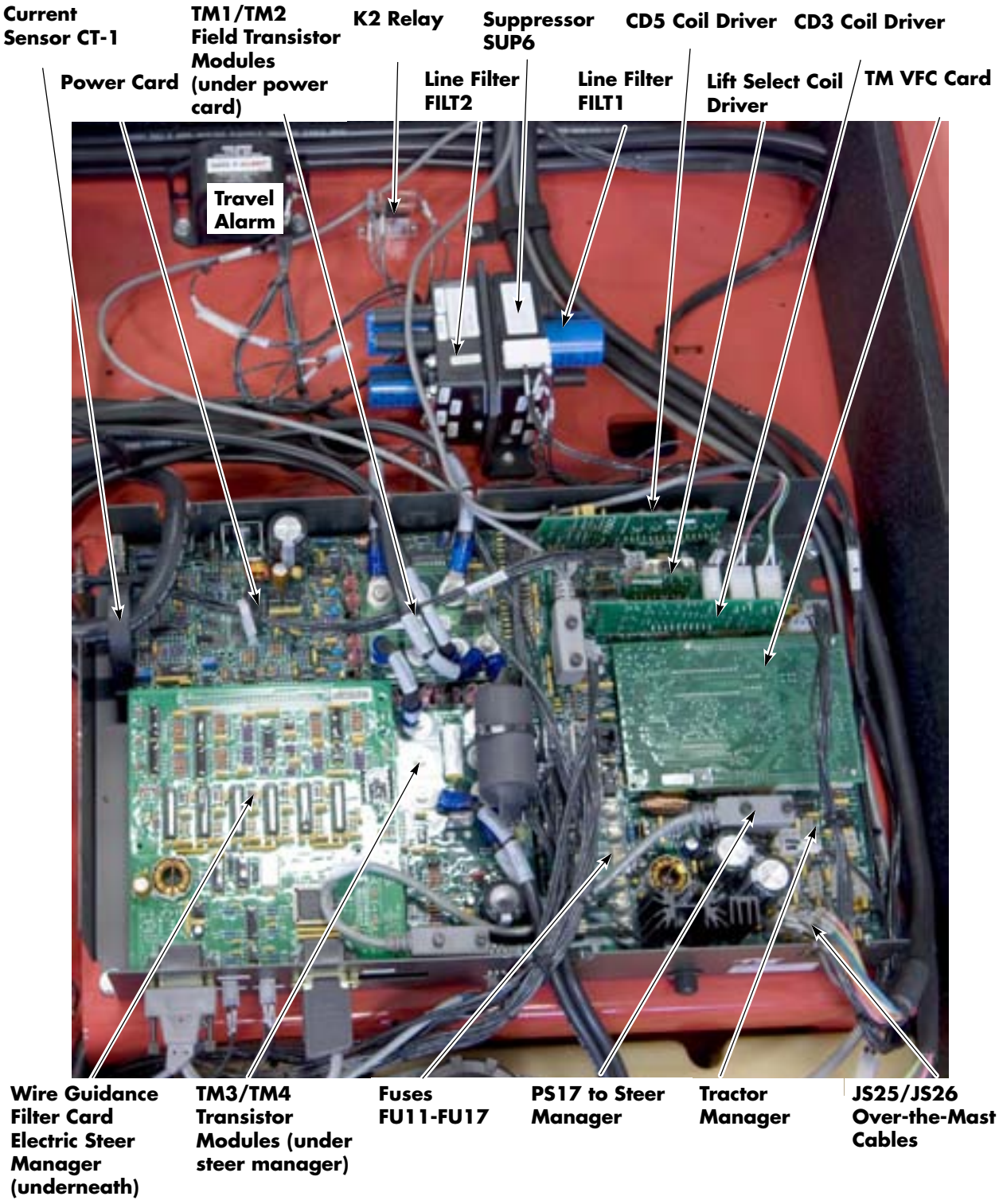


Figure 7-7. Electronics Compartment

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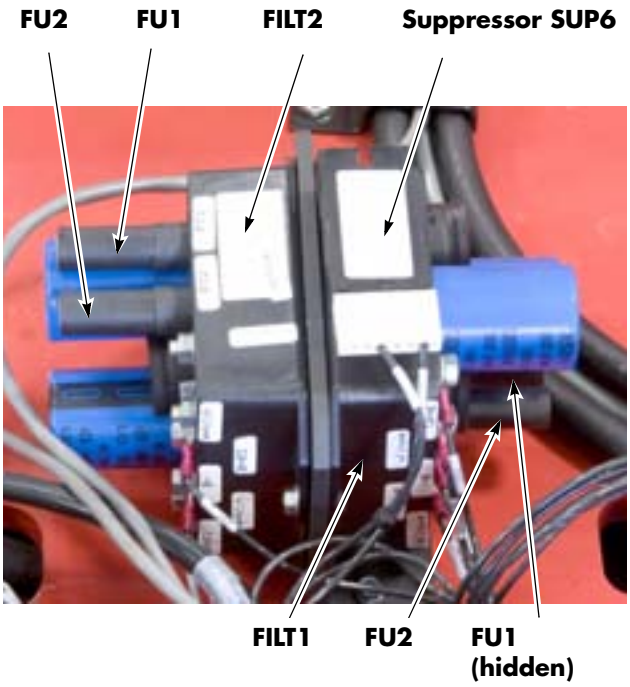


Figure 7-8. Line Filter Assembly

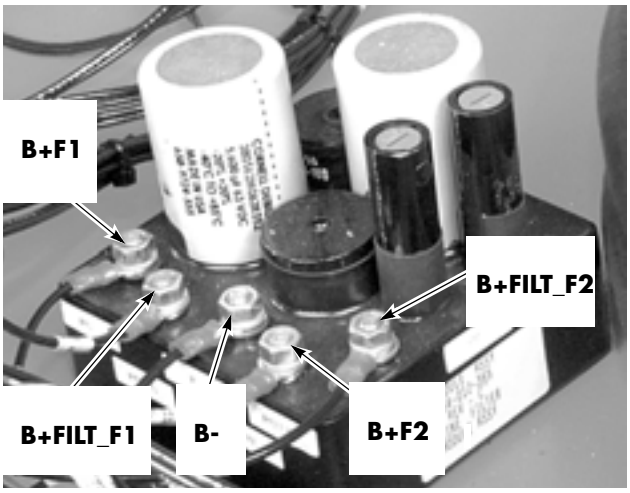


Figure 7-9. Line Filter Terminals (single filter shown)

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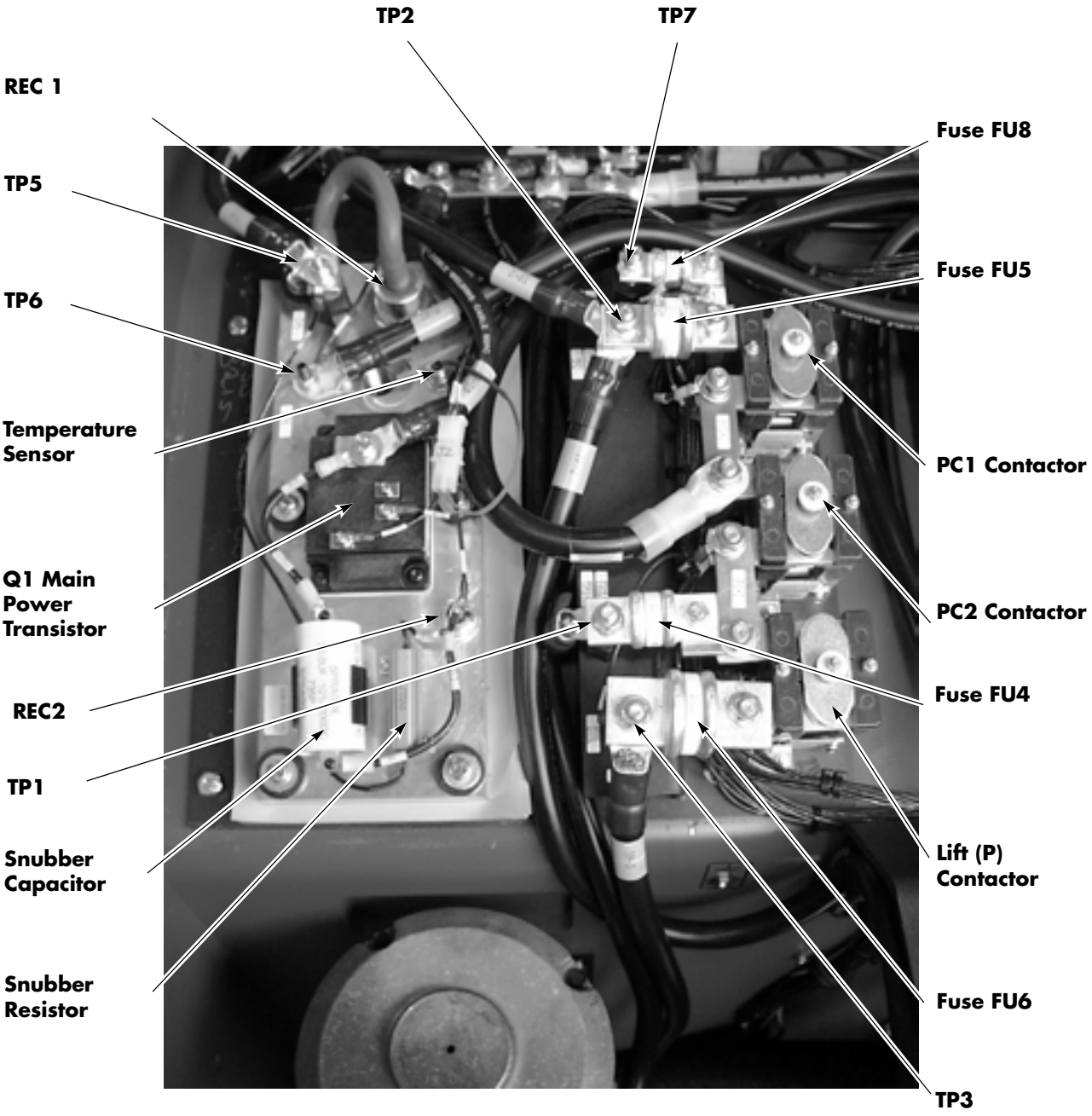


Figure 7-10. Power Panel (SA S/N < 03000 and SB S/N < 00700)

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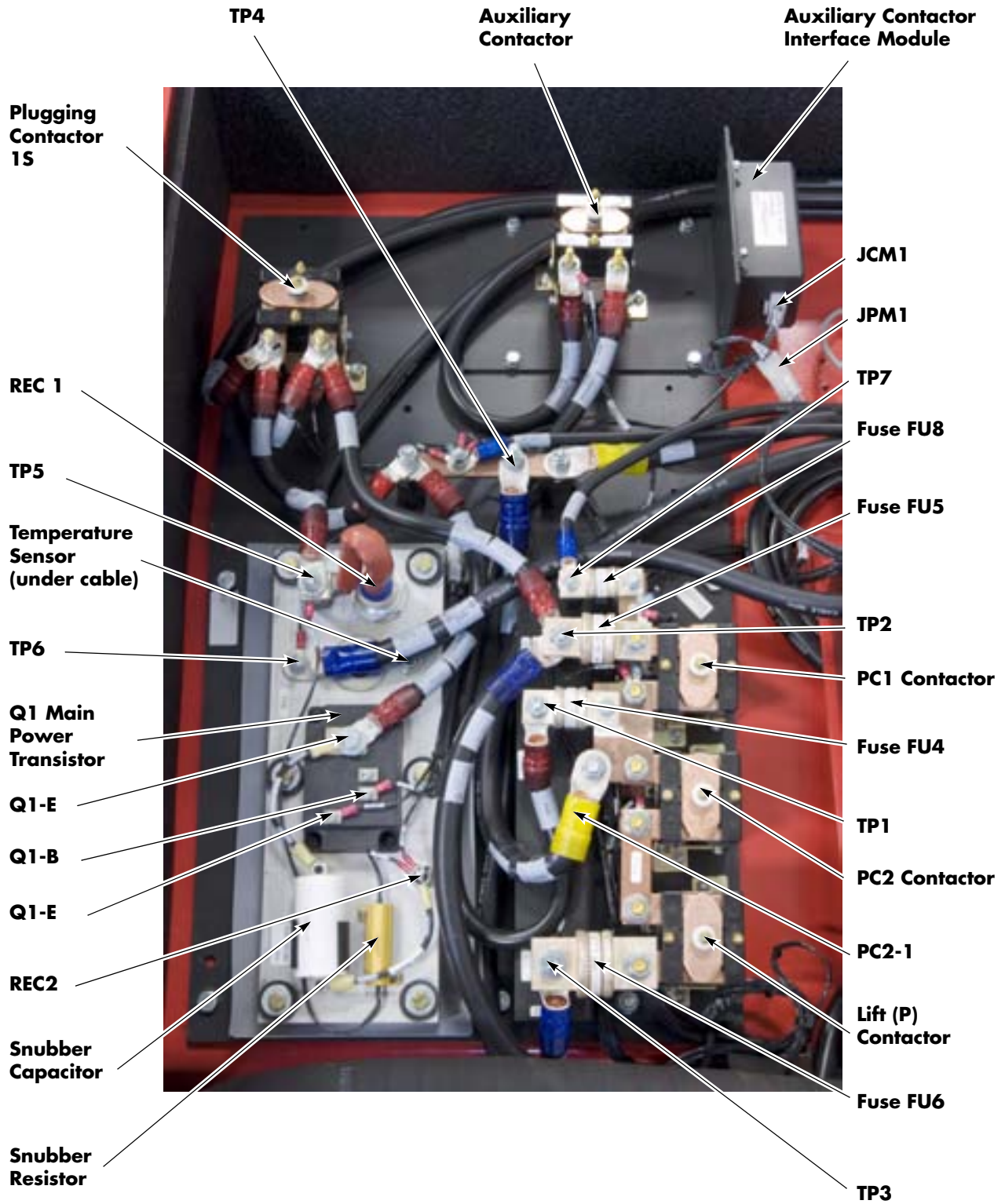


Figure 7-11. Power Panel (SA S/N > 02999 and SB S/N > 00699)

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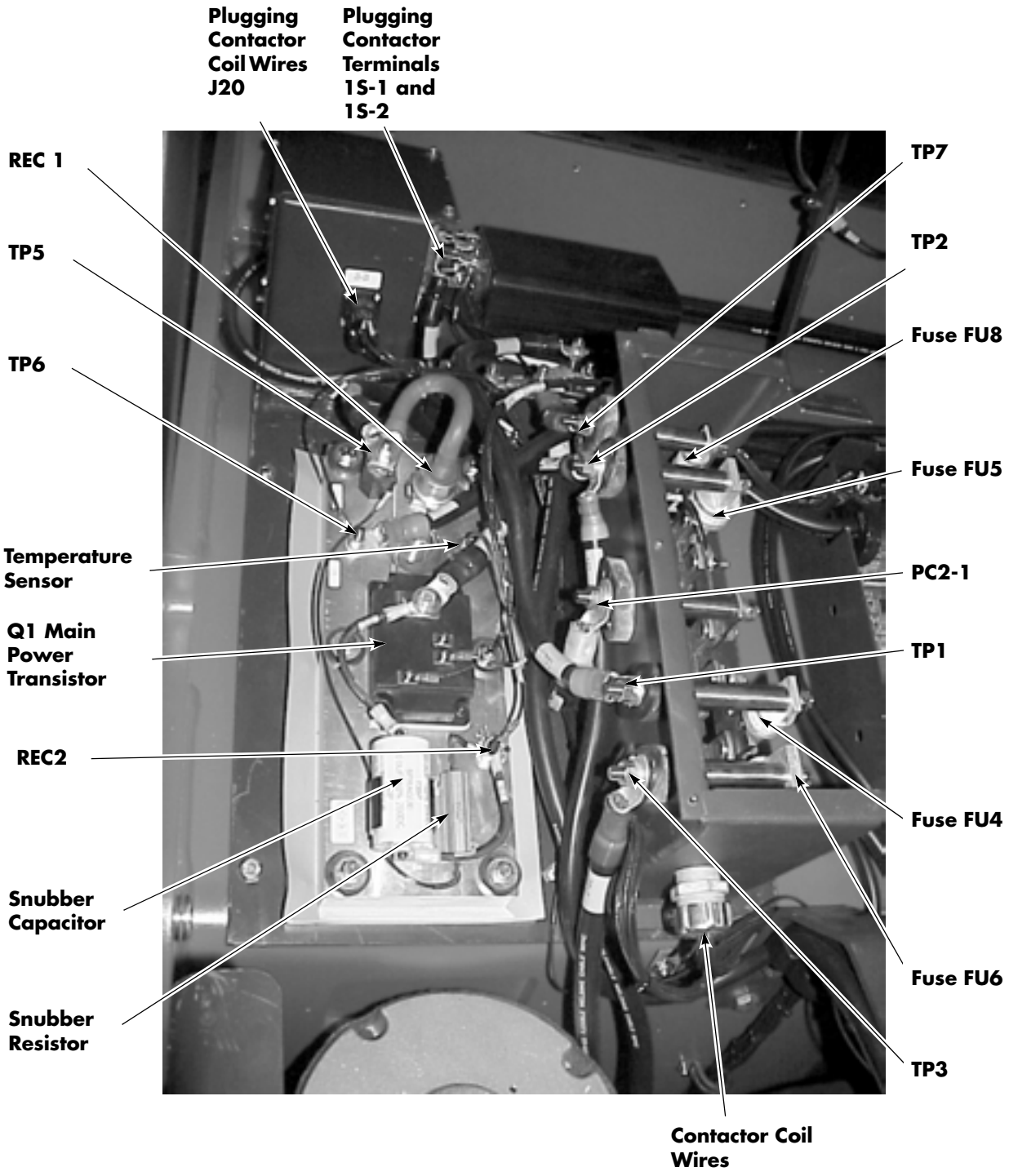


Figure 7-12. Power Panel, EE-rated lift truck (SA S/N < 03000, SB S/N < 00700) (main contactor enclosure cover removed for clarity)

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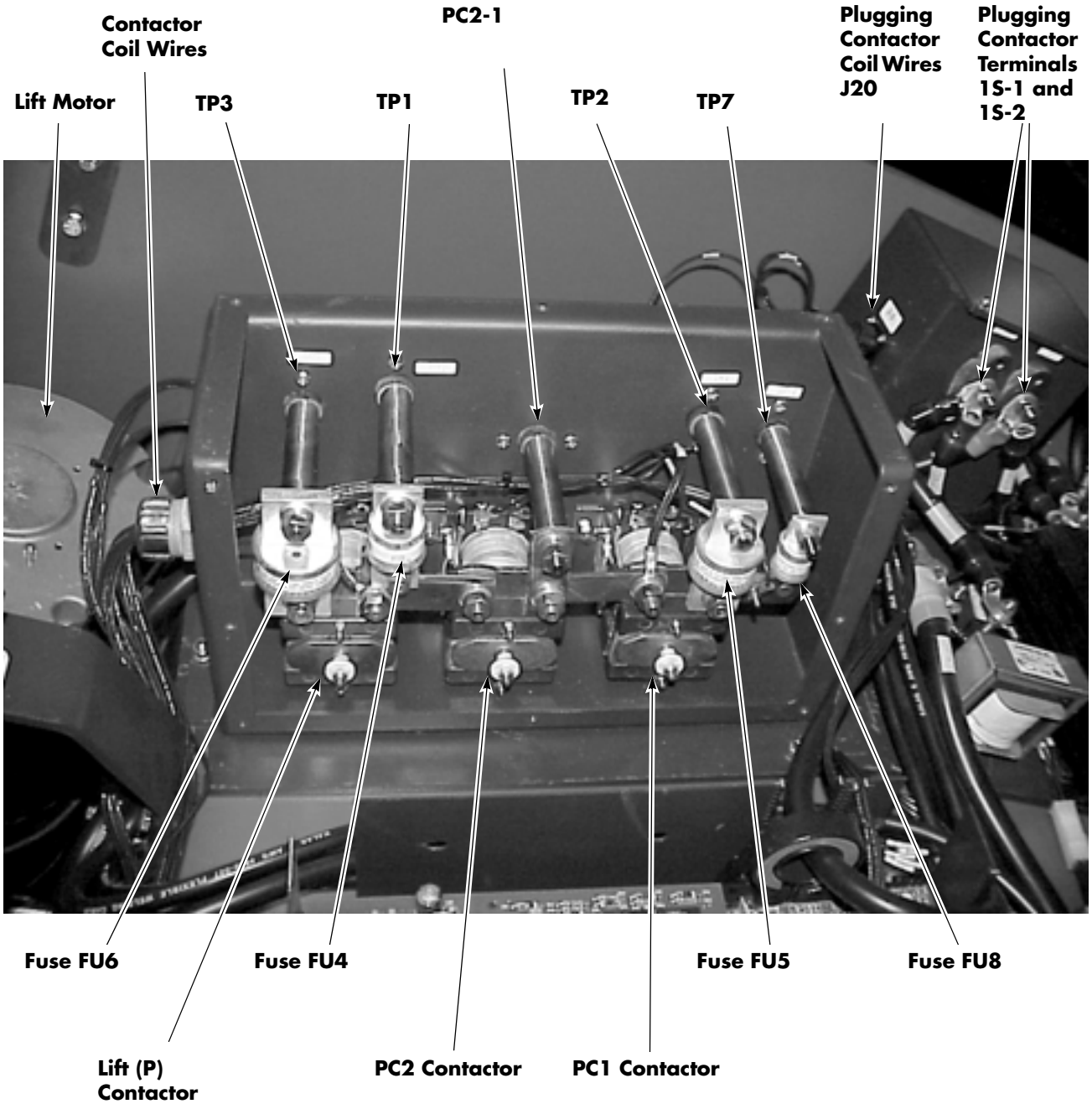


Figure 7-13. Contactors, EE-rated lift truck (early trucks) (main contactor enclosure cover removed for clarity)

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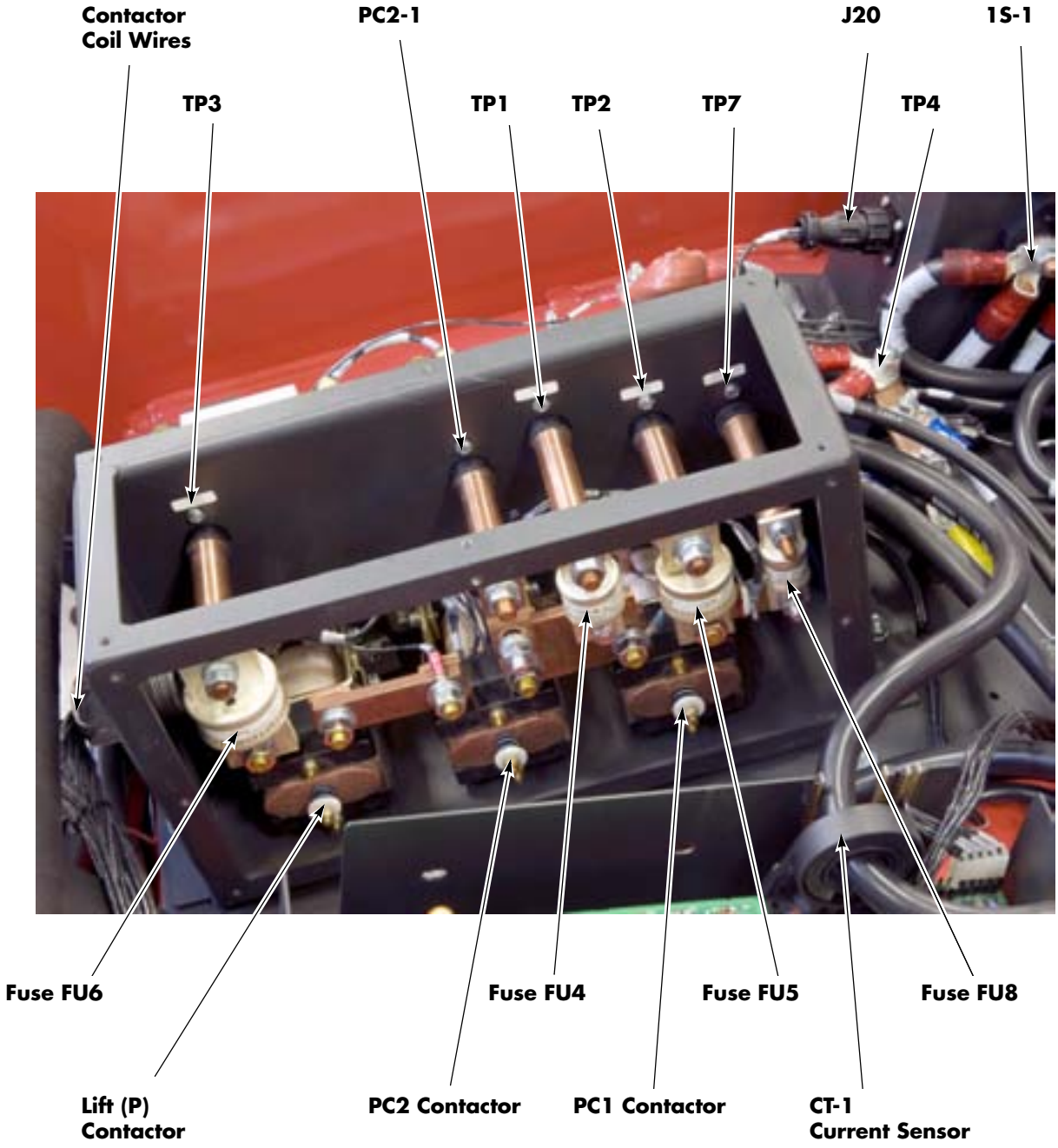


Figure 7-14. Contactors, EE-rated lift truck (later trucks) (main contactor enclosure cover removed for clarity)

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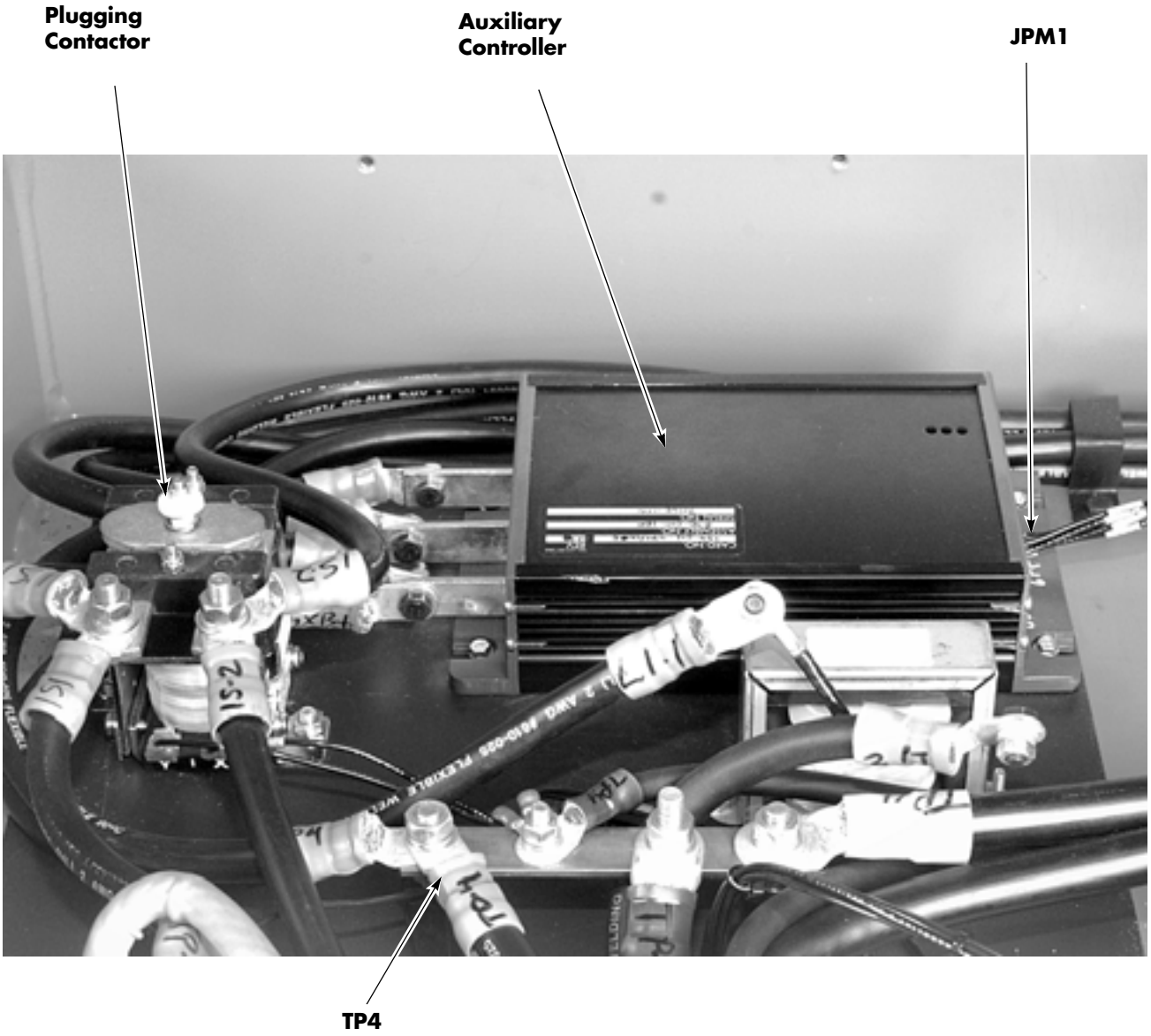


Figure 7-15. Auxiliary Motor Control Card (SA S/N < 00200, SB S/N < 00125)

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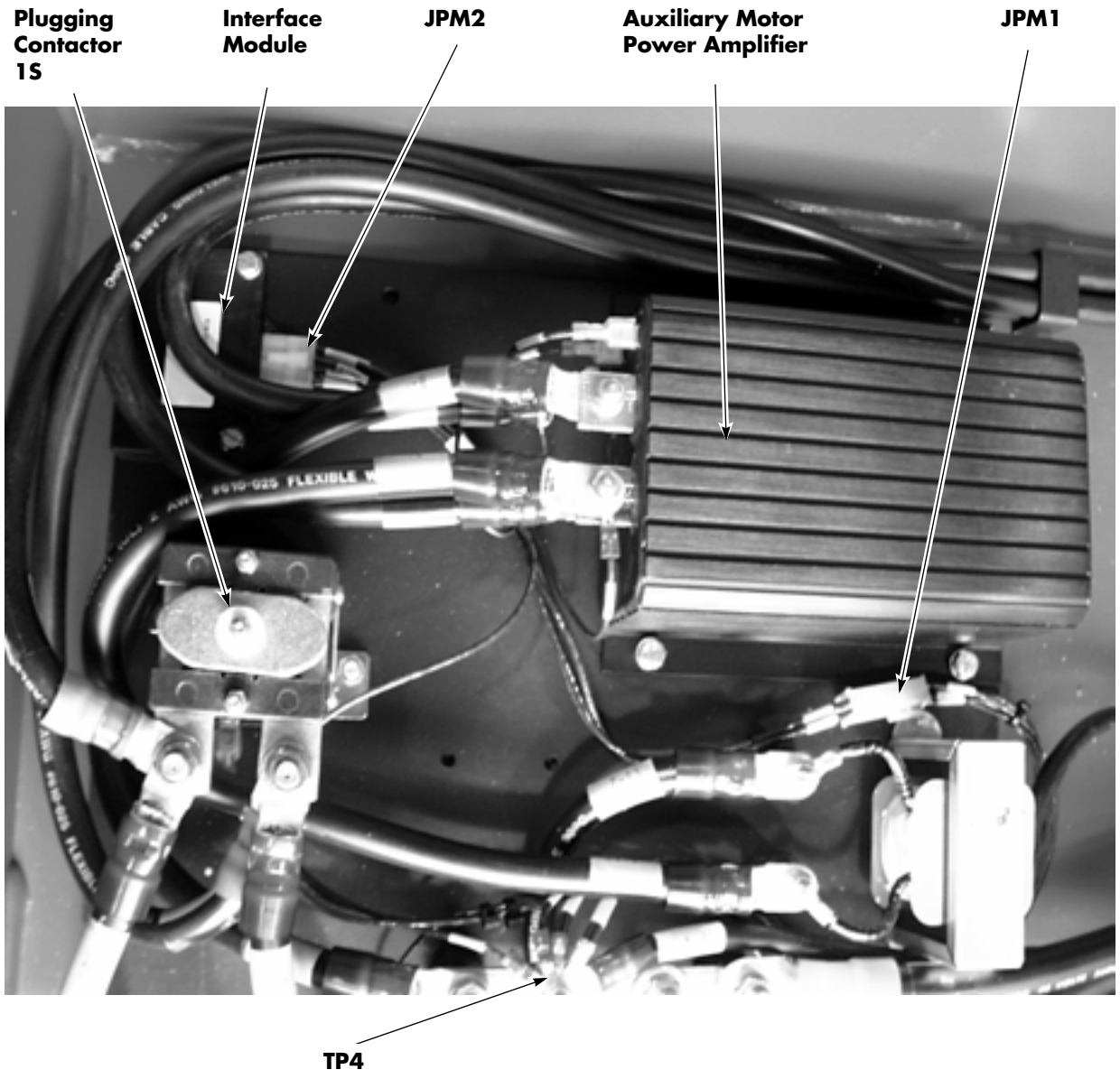


Figure 7-16. Auxiliary Motor Power Amplifier and Interface Module (SA S/N 00200 to 02999, SB S/N 00125 to 00699)

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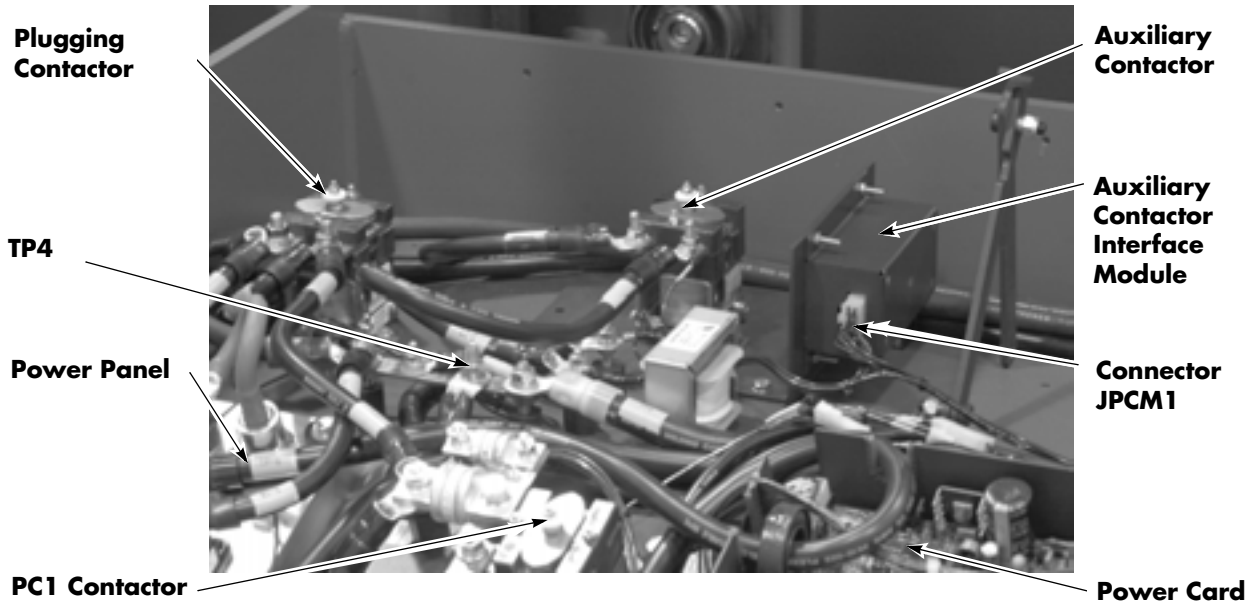


Figure 7-17. Auxiliary Contactor and Interface Module (SA S/N > 02999 and SB S/N > 00699)

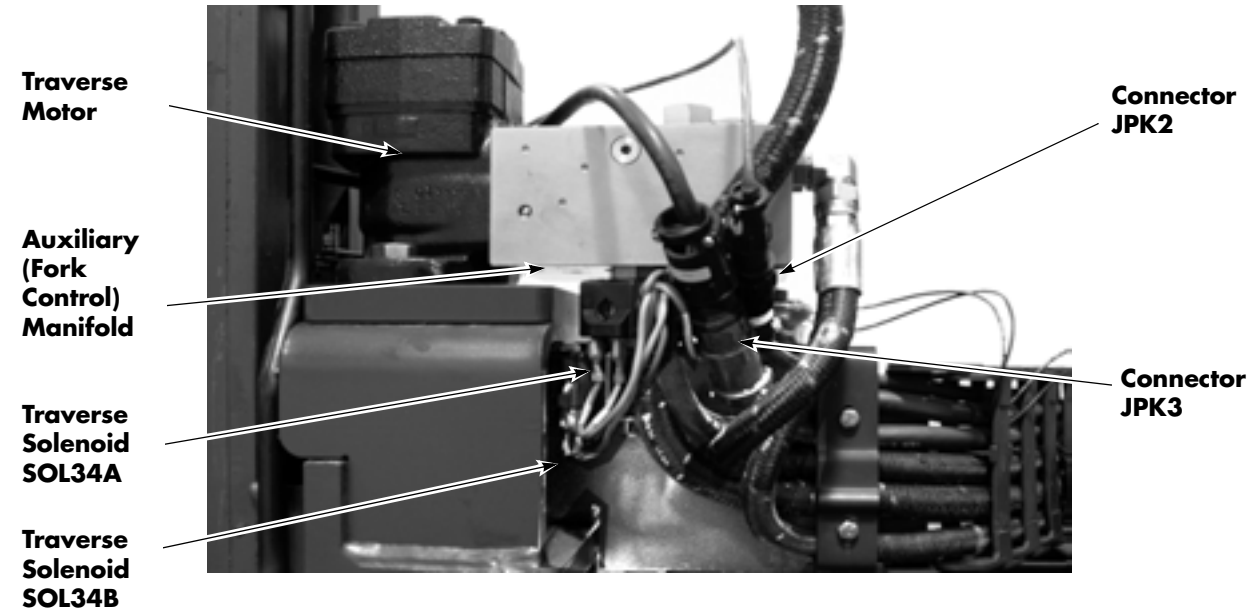


Figure 7-18. Auxiliary (Fork Control) Manifold, left side (SA S/N > 02999 and SB S/N > 00699)

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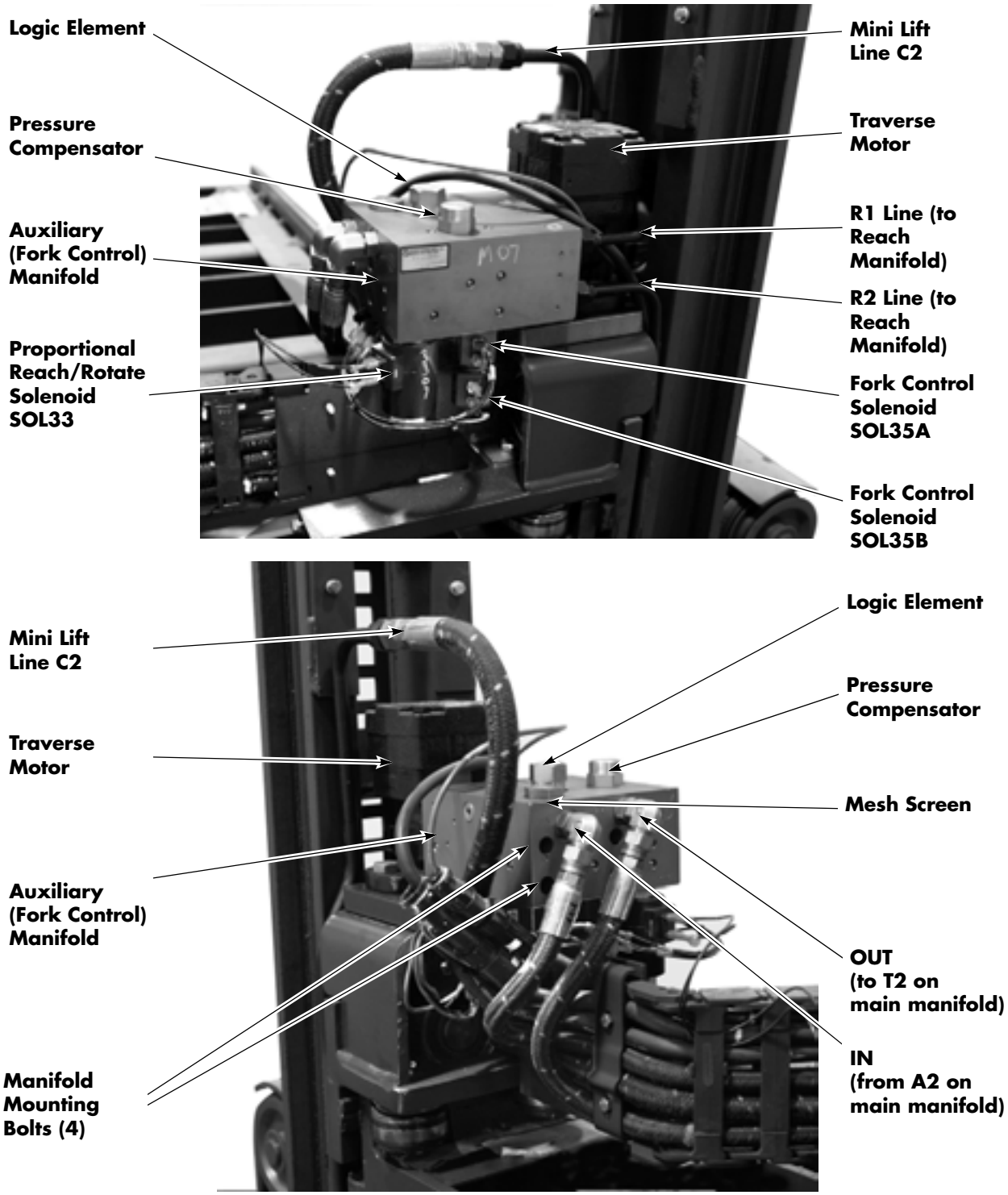


Figure 7-19. Auxiliary (Fork Control) Manifold (SA S/N > 02999 and SB S/N > 00699)

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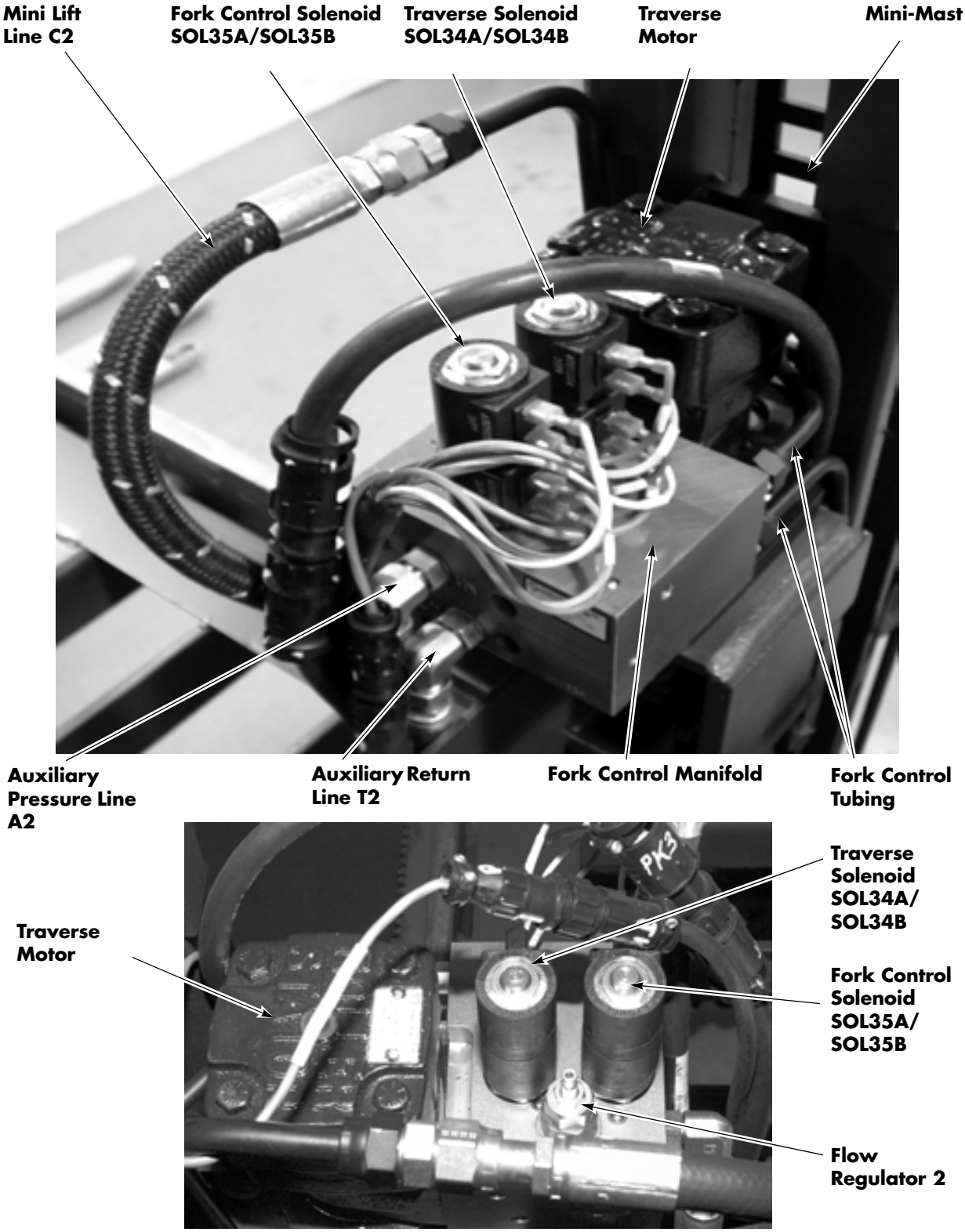


Figure 7-20. Auxiliary (Fork Control) Manifold (SA S/N < 03000 and SB S/N < 00700)

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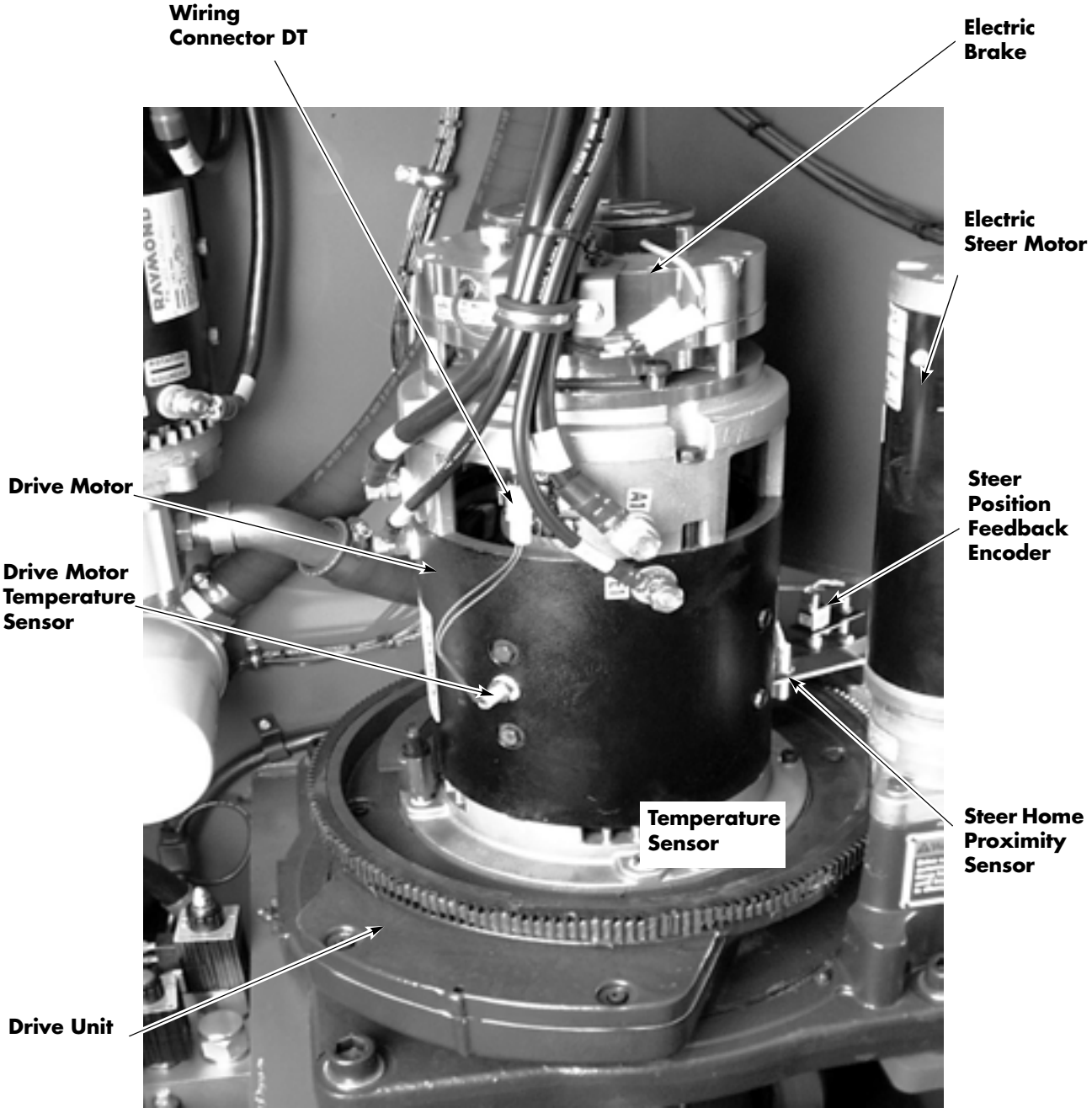


Figure 7-21. Drive and Steer Components

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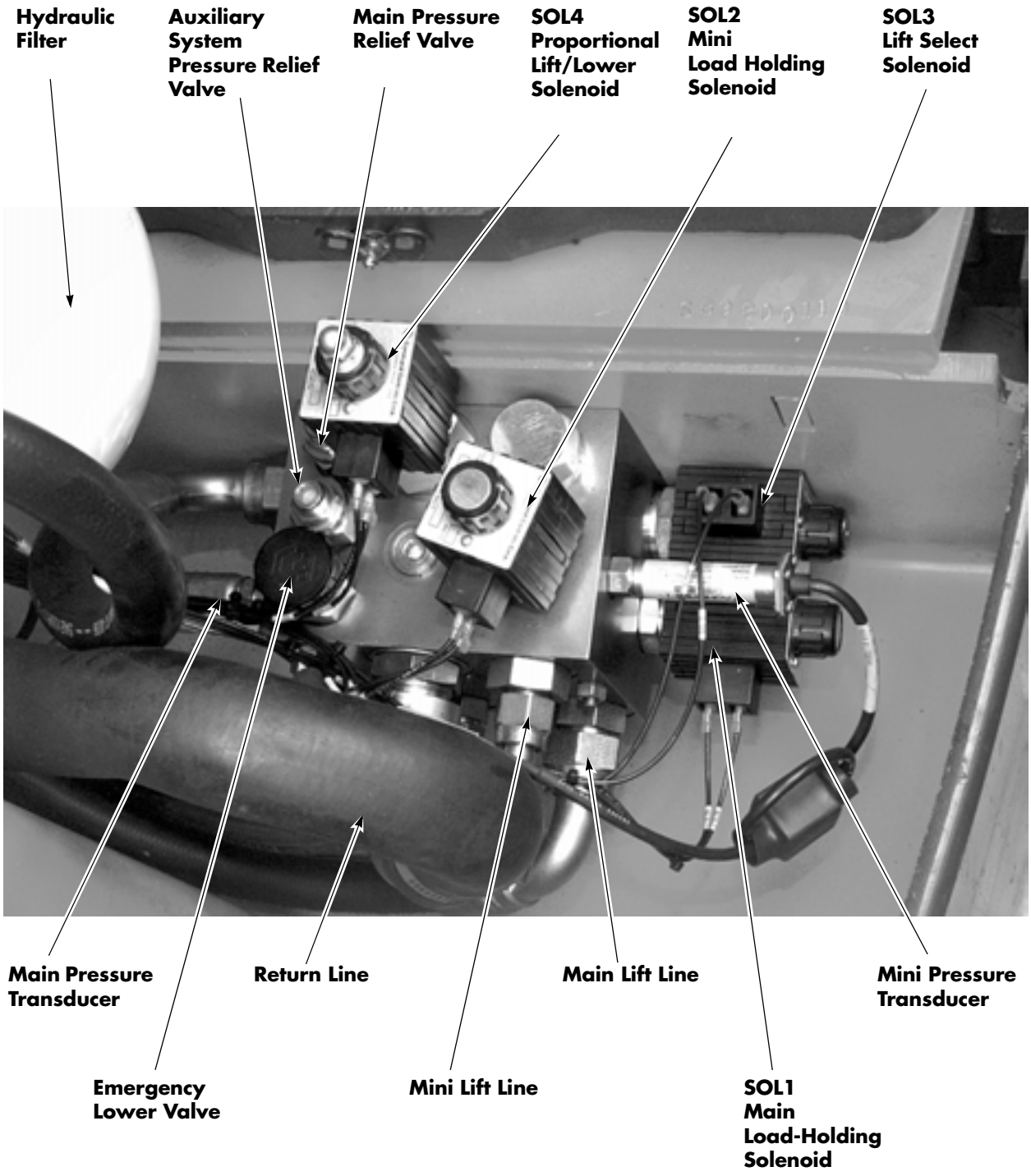


Figure 7-22. Main Manifold Components (SA S/N < 03218 except 03202, SB S/N < 00762 except 00757)

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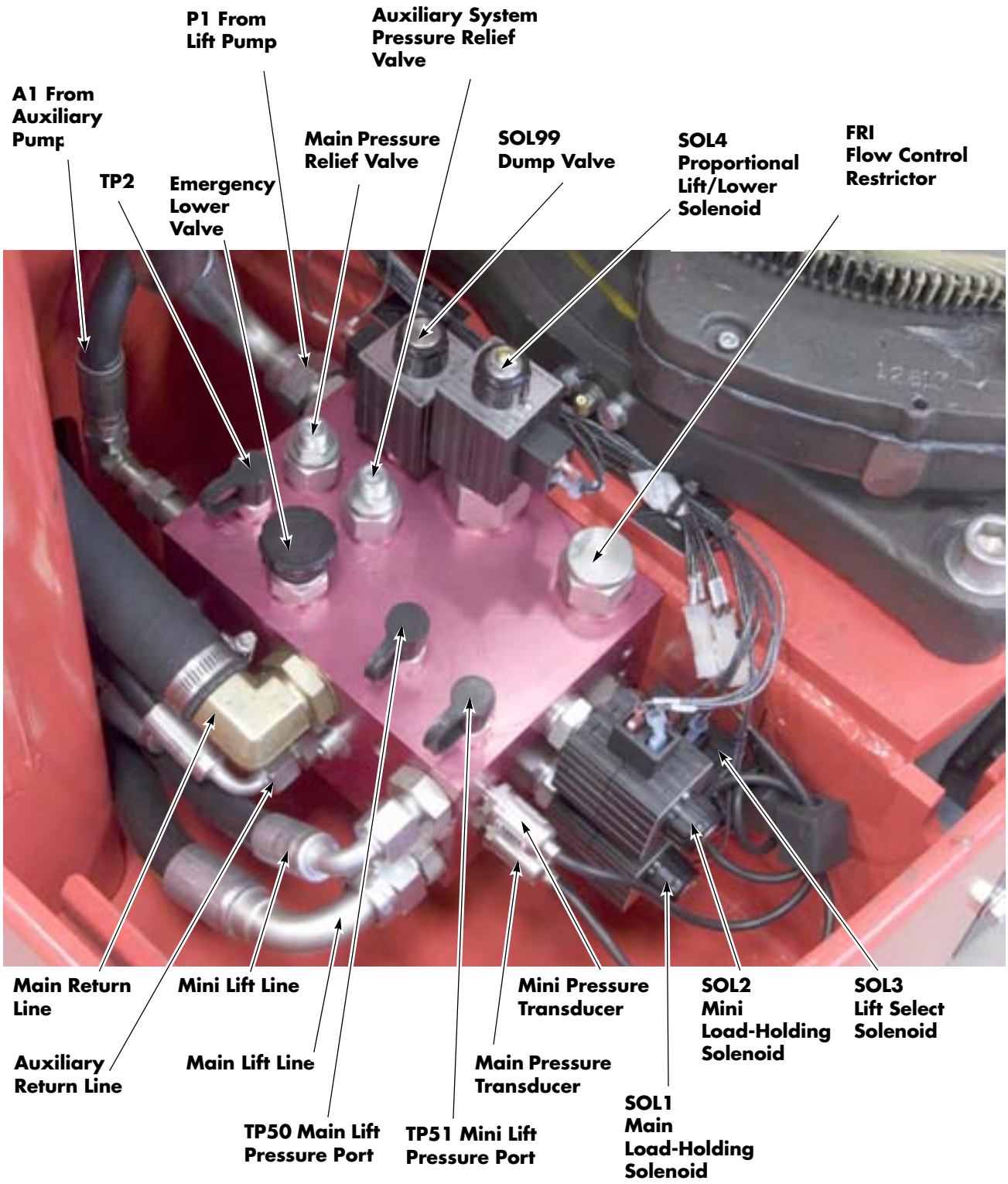


Figure 7-23. Main Manifold Components (SA S/N 03202, > 03217, SB S/N 00757, > 00761)

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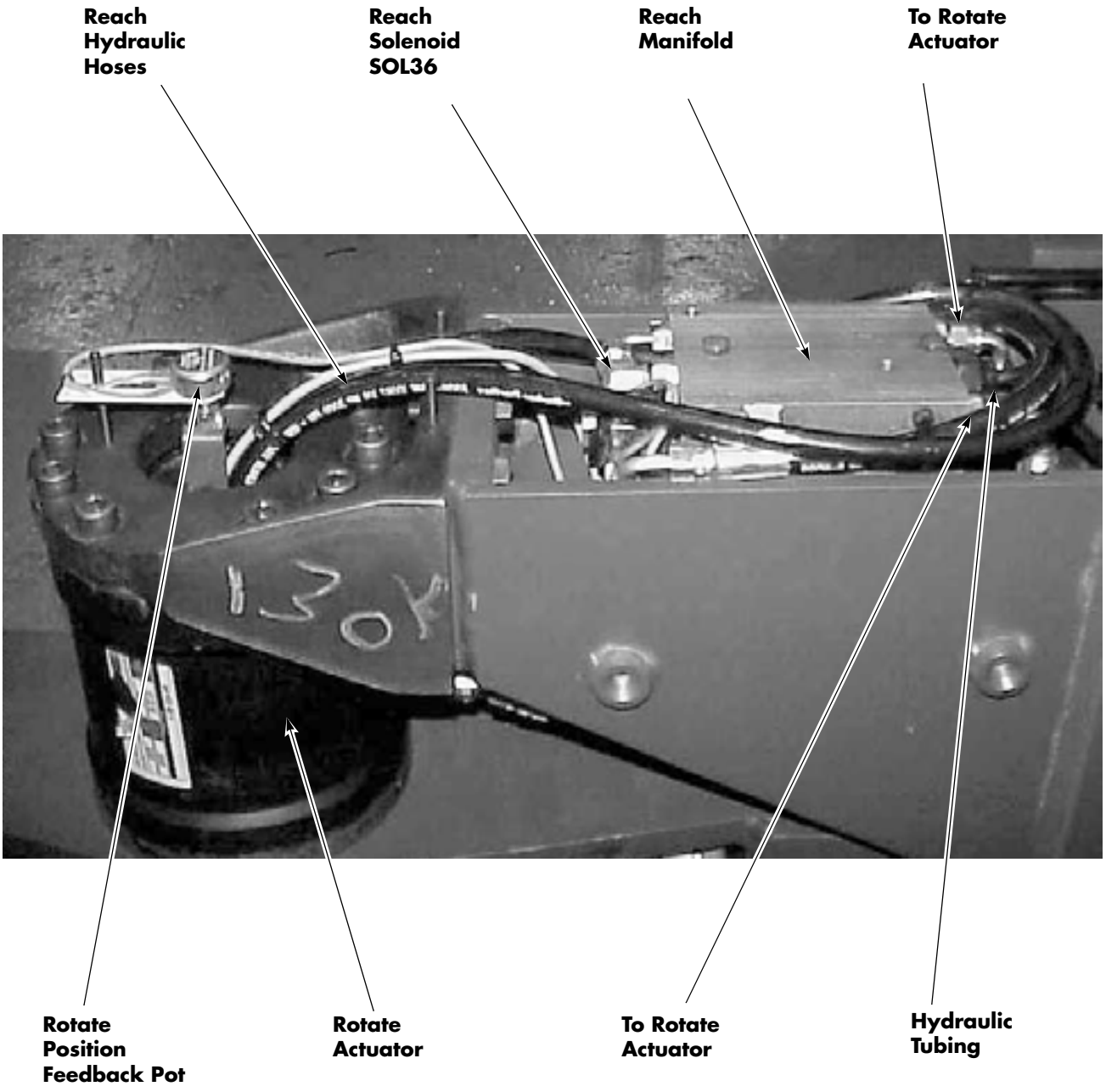


Figure 7-24. Load Handler Turret

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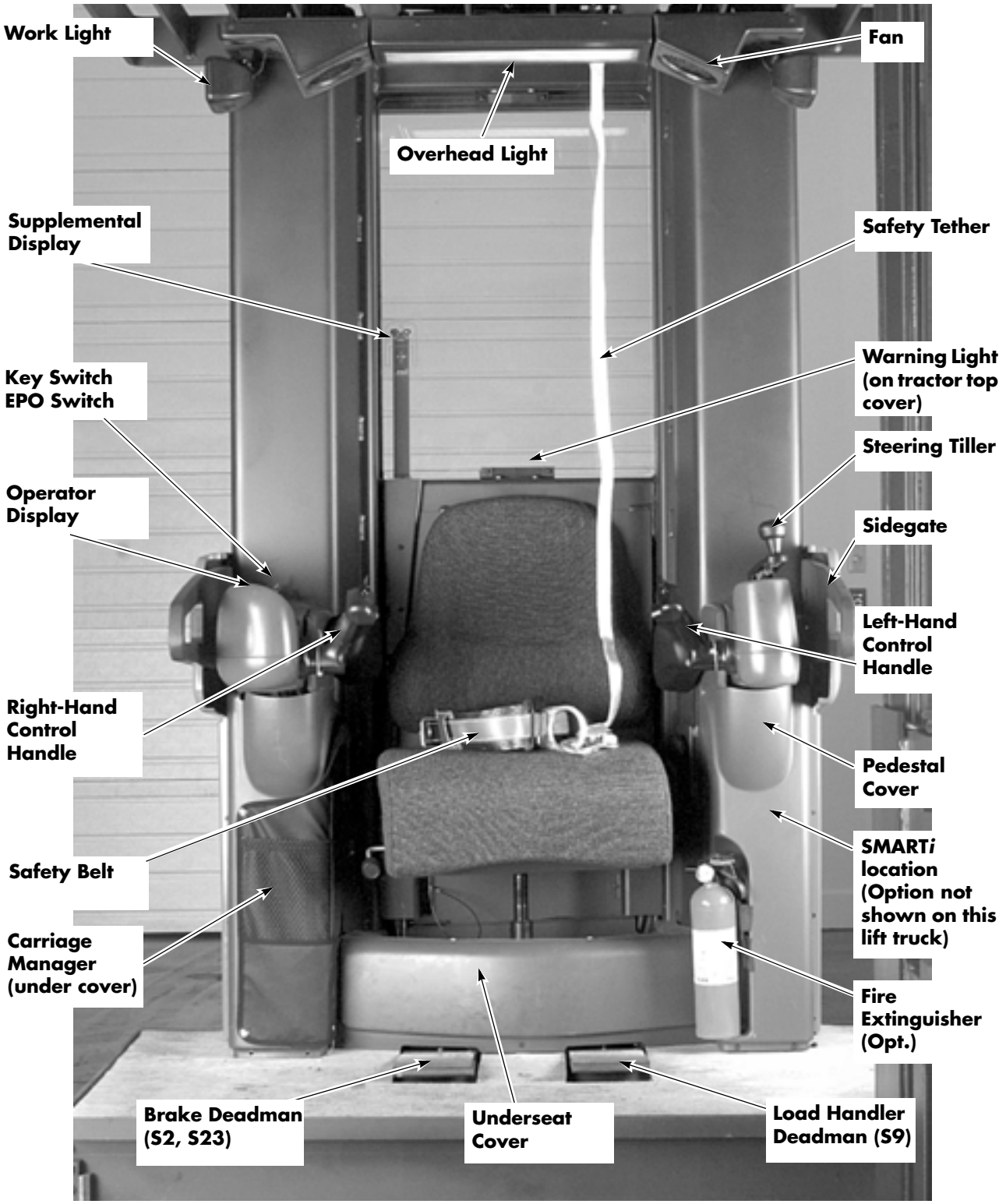


Figure 7-25. Operator Compartment

https://truckmanualshub.com/

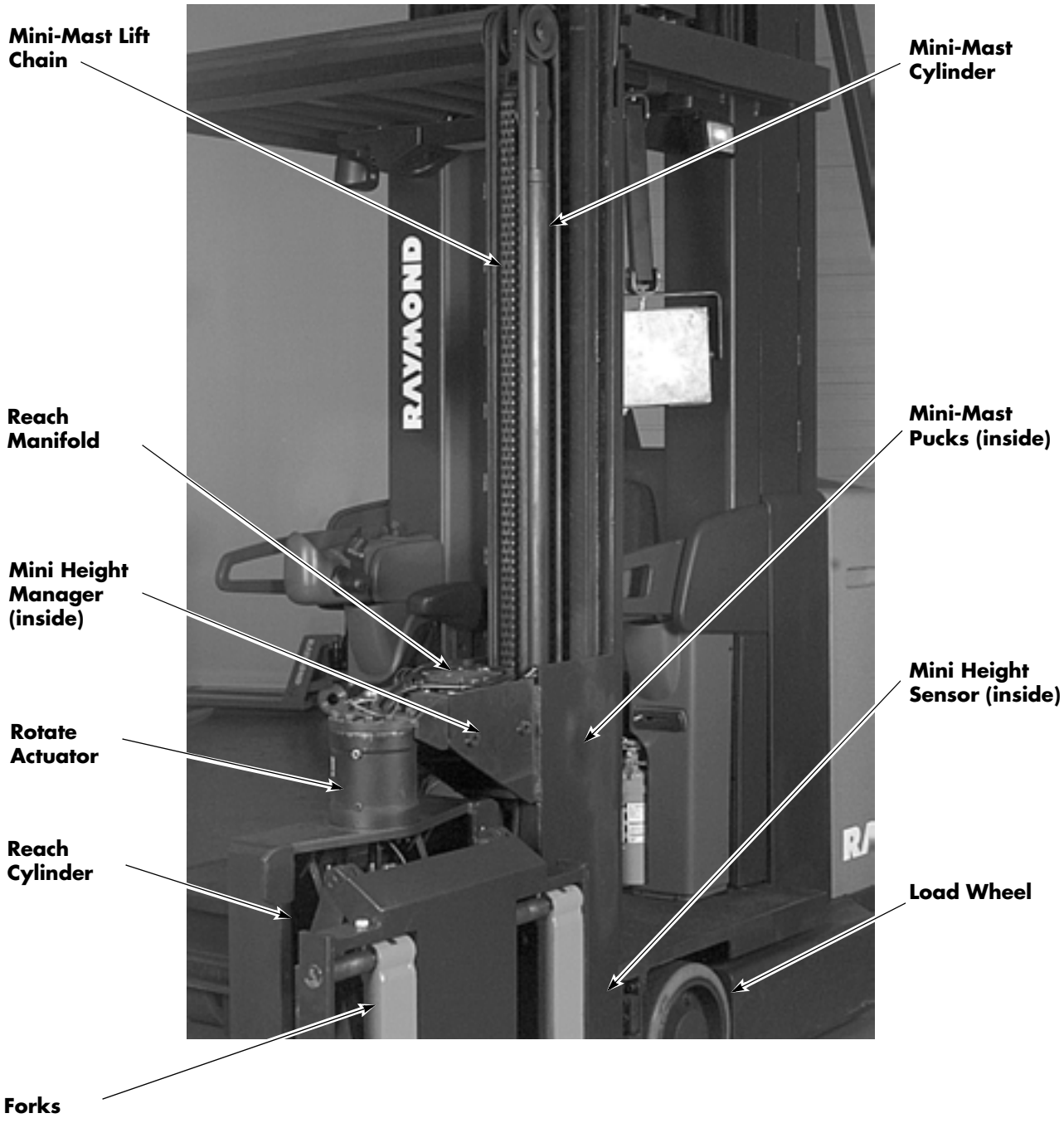


Figure 7-26. Mini-Mast and Load Handler

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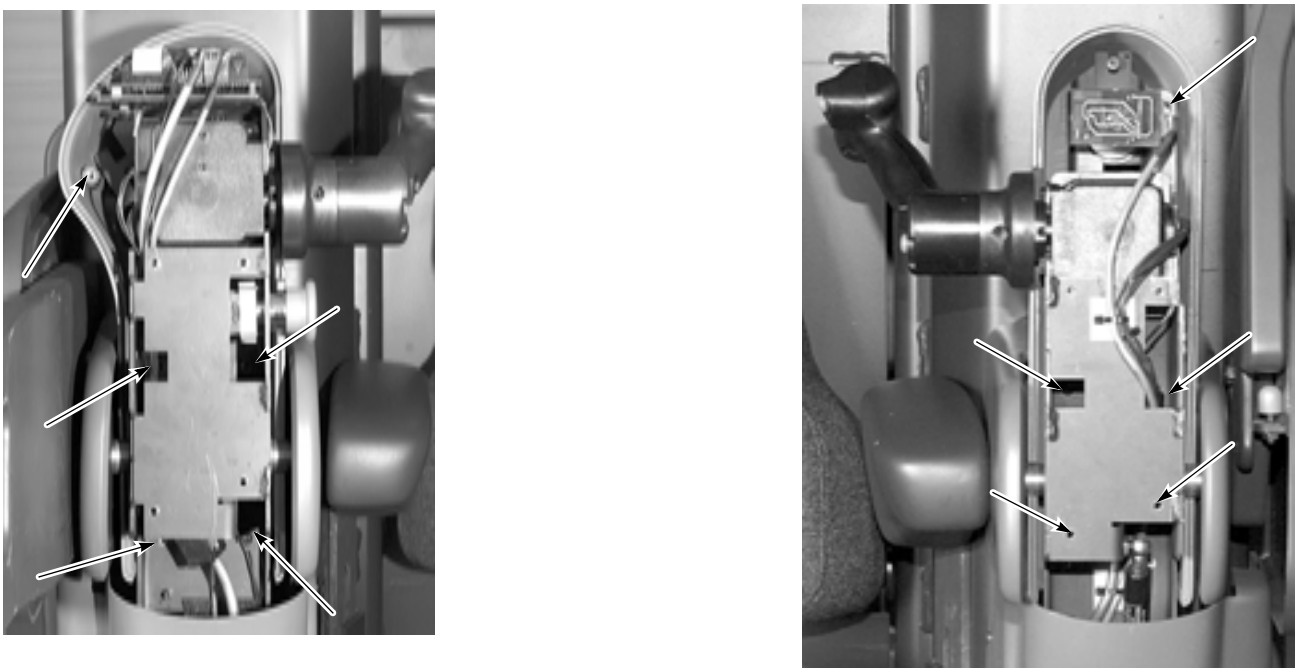


Figure 7-27. Right and Left Upper Control Arm Covers and Mounting Screw Locations (viewed from bottom)

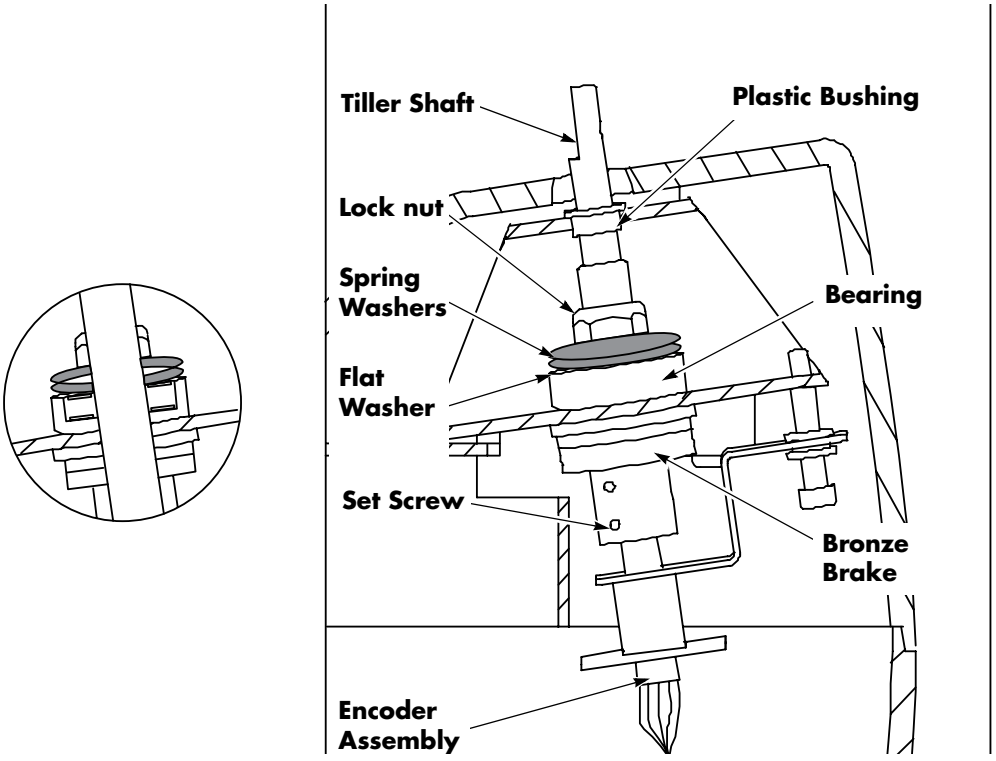


Figure 7-28. Steering Tiller Brake Assembly. Factory production of this style ceased 7 Sep 2005 at SA S/N 05011, SB S/N 01060 and was replaced by a Steering Input Encoder

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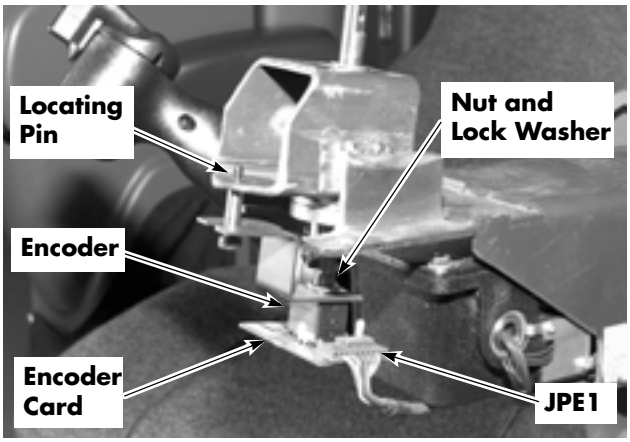


Figure 7-29. Steer Encoder Card Assembly.
Factory production of this style ceased 7 Sep 2005 at SA S/N 05011, SB S/N 01060 and was replaced by a Steering Input Encoder.

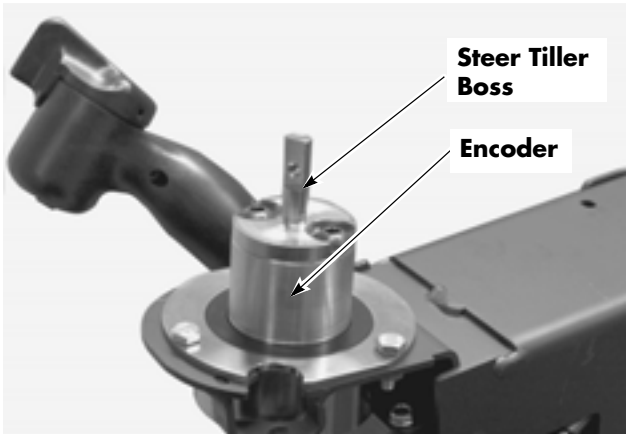


Figure 7-30. Steering Input Encoder.
Introduced in factory production 7 Sep 2005 at SA S/N 05011, SB S/N 01060.

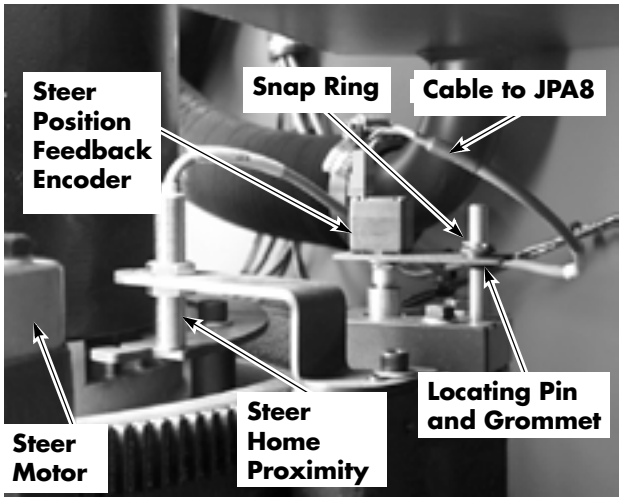


Figure 7-31. Steer Position Feedback Encoder Location

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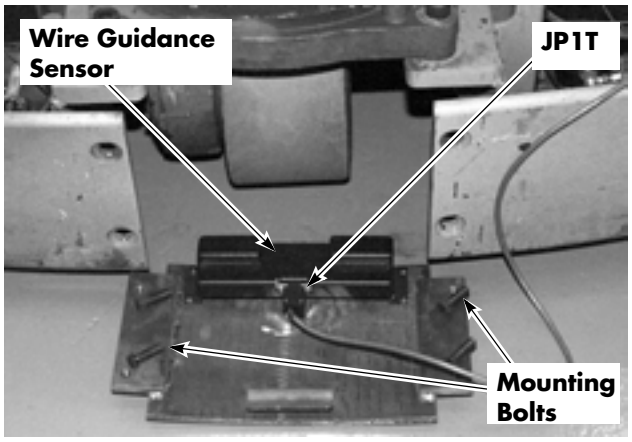


Figure 7-32. Wire Guidance Sensor, Tractor Side

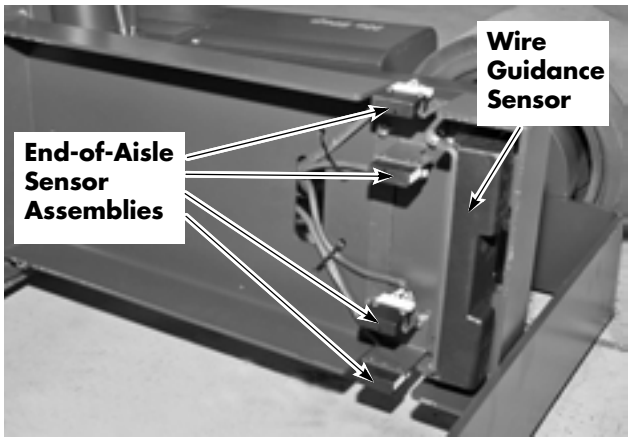


Figure 7-35. Wire Guidance and End-of-Aisle Sensor Bracket, swiveled

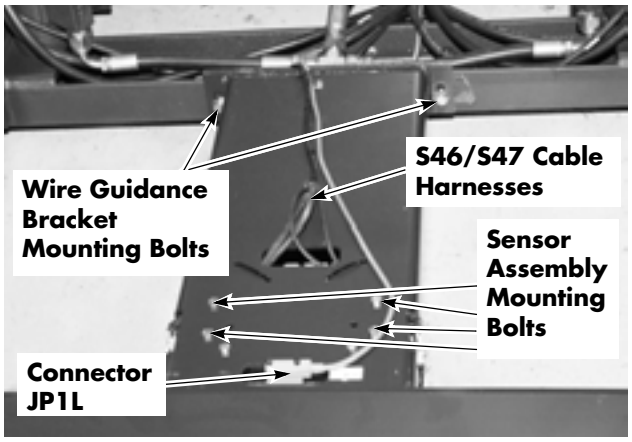


Figure 7-33. Wire Guidance and End-of-Aisle Sensors, Load Side

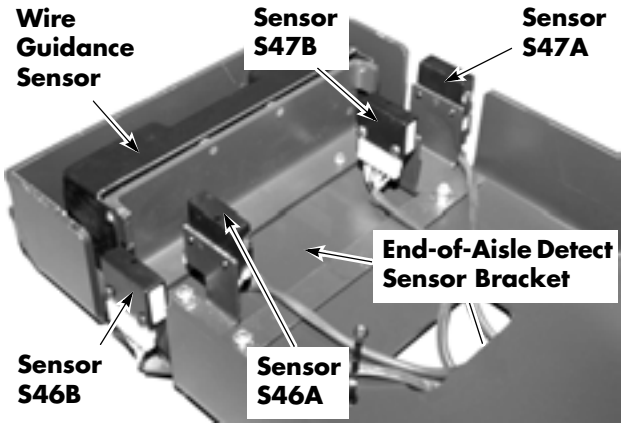


Figure 7-36. Wire Guidance Sensor and End-of-Aisle Detect Sensors

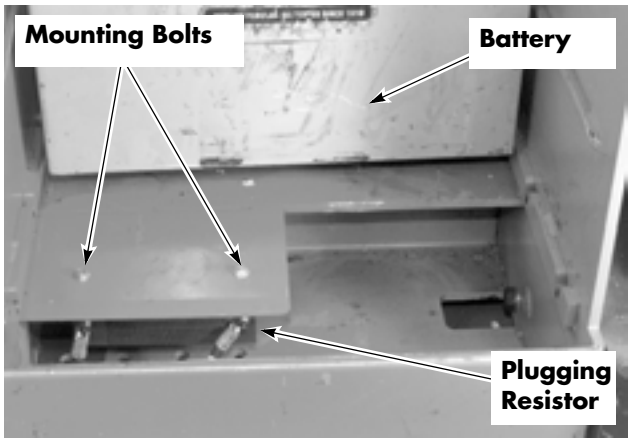


Figure 7-34. Plugging Resistor Location

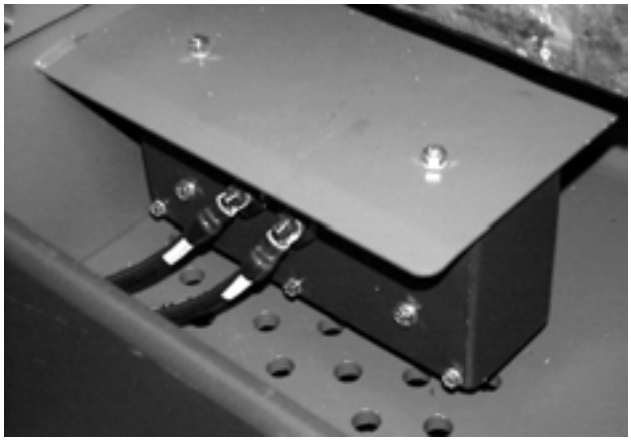


Figure 7-37. Plugging Resistor, EE Enclosure

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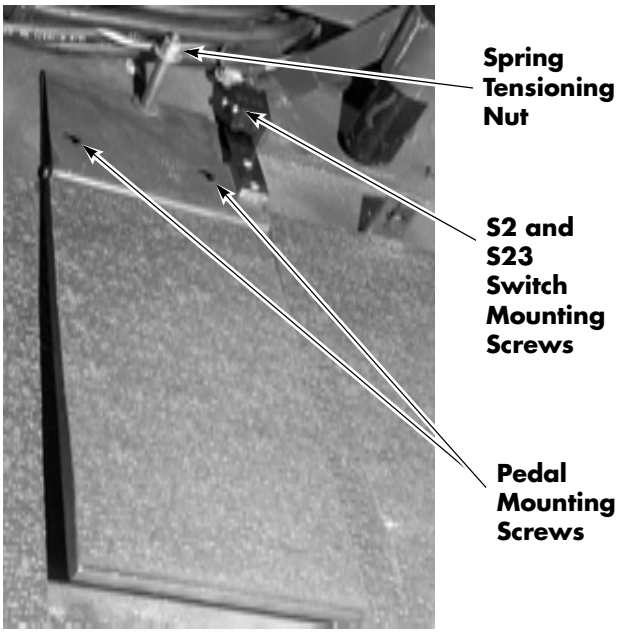


Figure 7-38. Deadman Switch(es) and Pedal (Right Pedal and Switches S2, S23 shown, Left Pedal and Switch S9 similar)

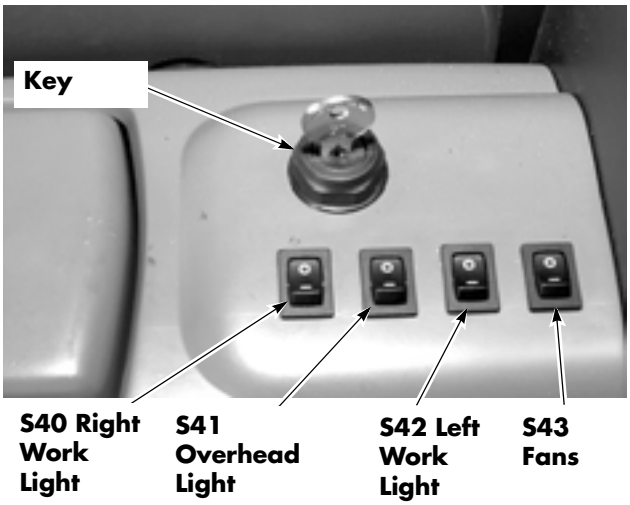


Figure 7-39. Lights and Fans Switches (S40-S43)

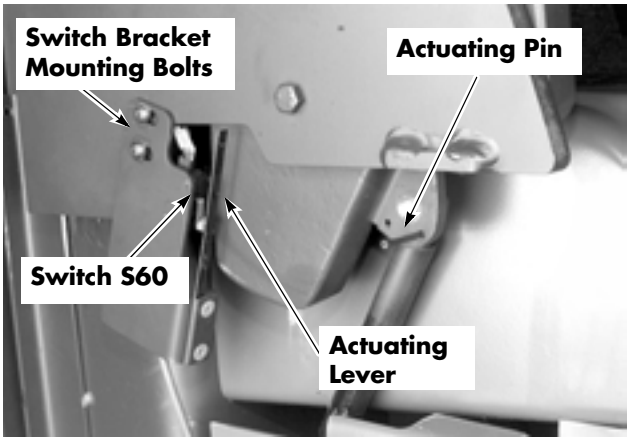


Figure 7-40. Sidegate Switch Bracket (right side shown)

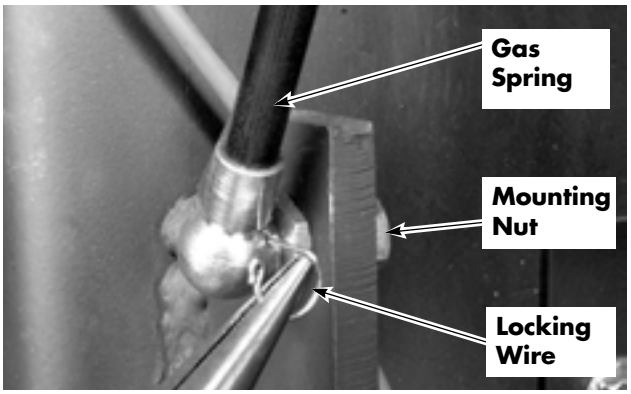


Figure 7-41. Sidegate Gas Spring, Locking Wire

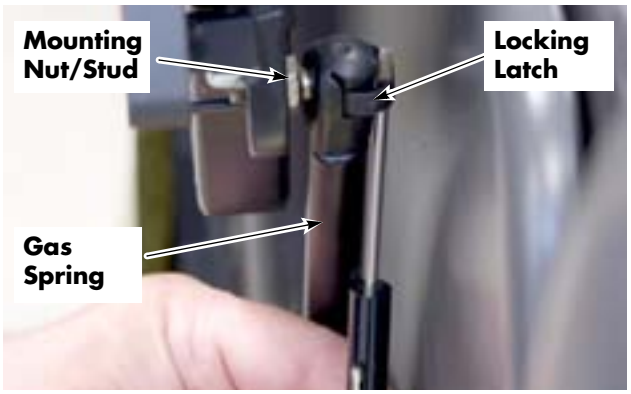


Figure 7-42. Sidegate Gas Spring, Locking Latch

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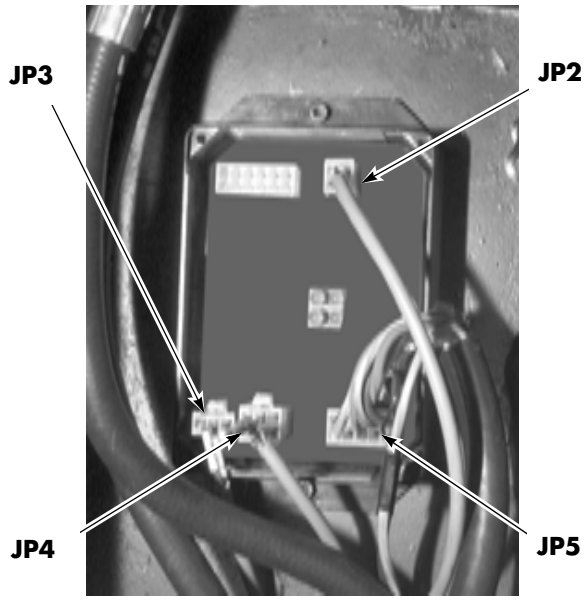


Figure 7-43. Height Manager, Mini

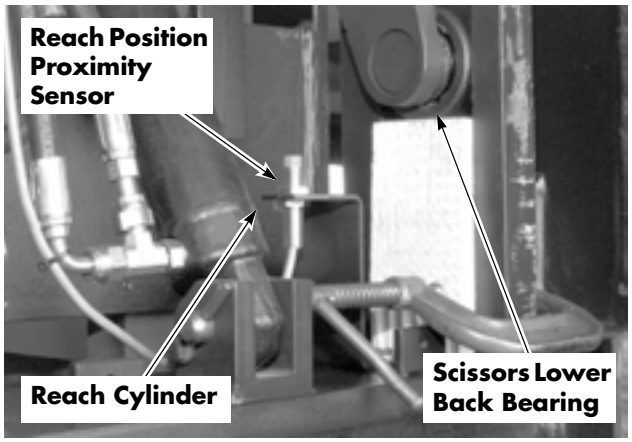


Figure 7-44. Reach Position Proximity Sensor

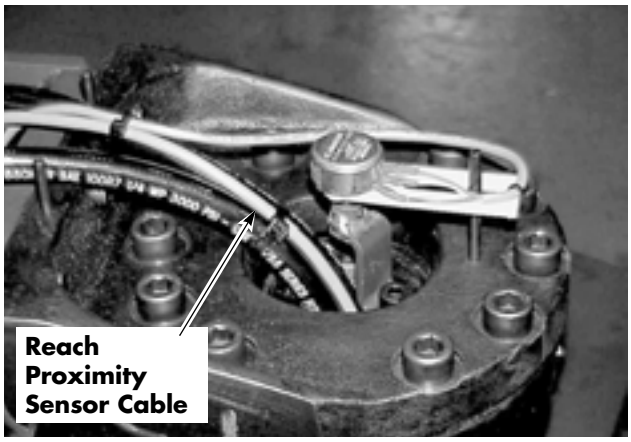


Figure 7-45. Reach Position Proximity Sensor Cable

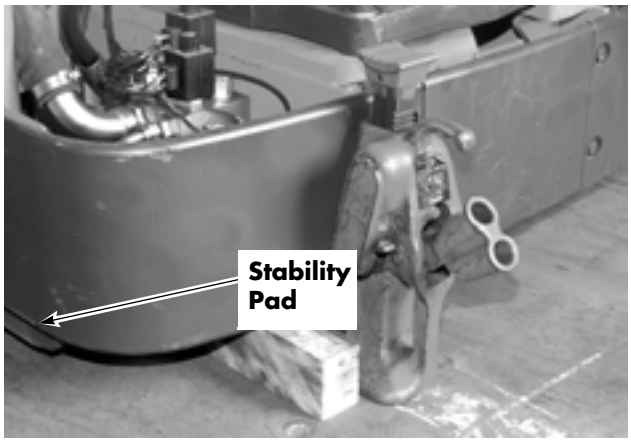


Figure 7-46. Stability Pad Location (one each side)

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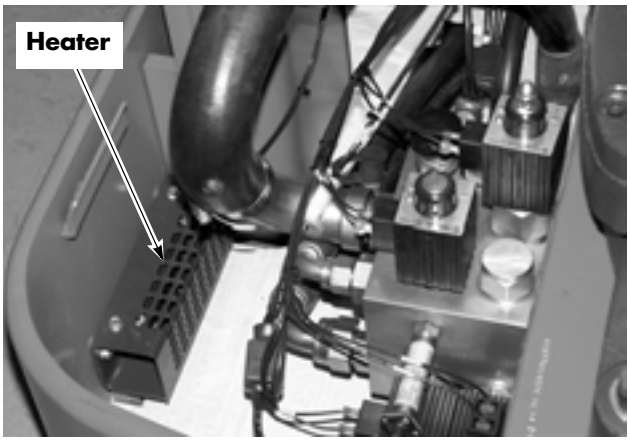


Figure 7-47. Cold Storage Heater, Tractor



Figure 7-48. Cold Storage Heater, Tractor

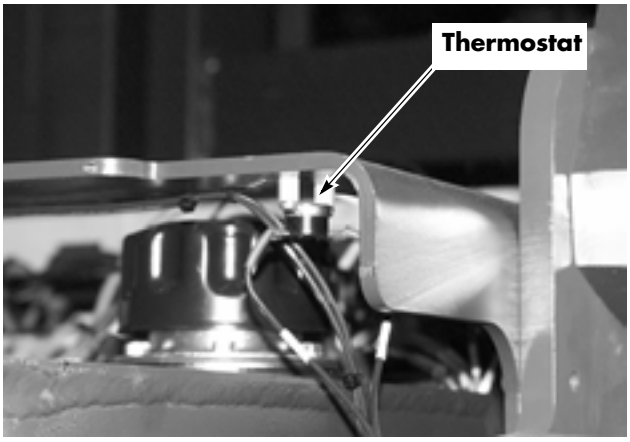


Figure 7-49. Cold Storage Thermostat, Tractor (1 of 2)

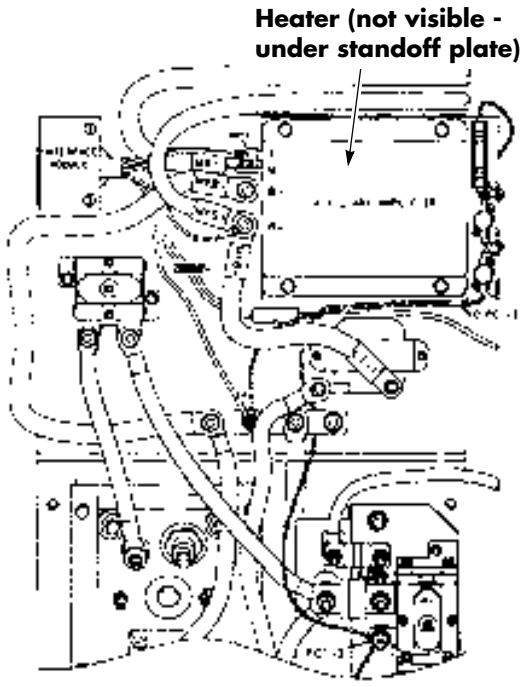


Figure 7-50. Aux Power Amplifier Heater Location

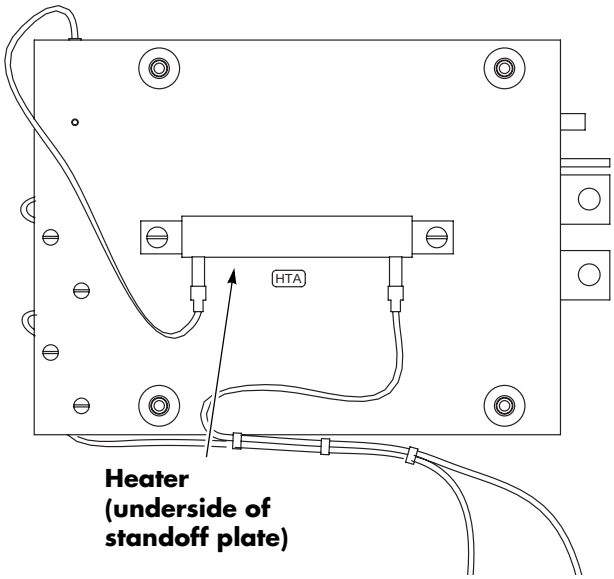


Figure 7-51. Aux Power Amplifier Heater mounting

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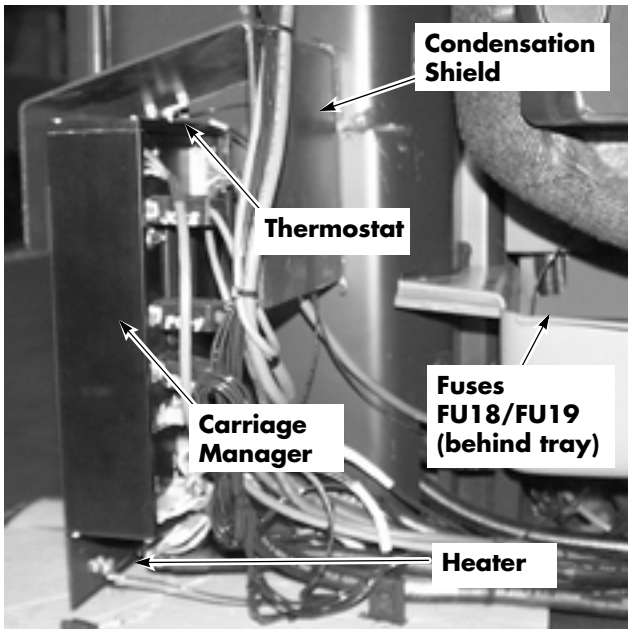


Figure 7-52. Cold Storage Components, Carriage Manager

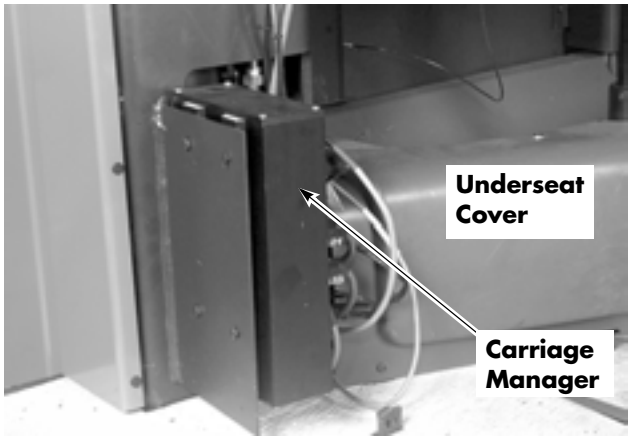


Figure 7-53. Carriage Manager Location

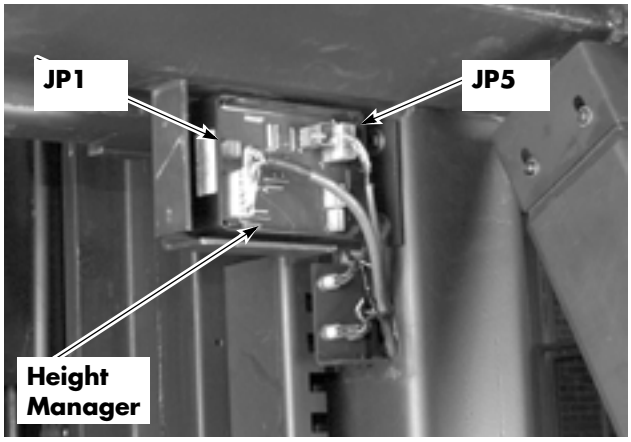


Figure 7-54. Main Mast Height Manager and Sensor (Series SA shown)

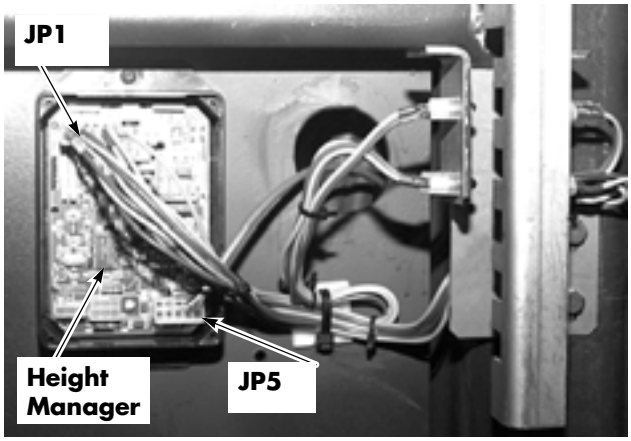


Figure 7-55. Main Height Manager and Sensor, Early Series SB

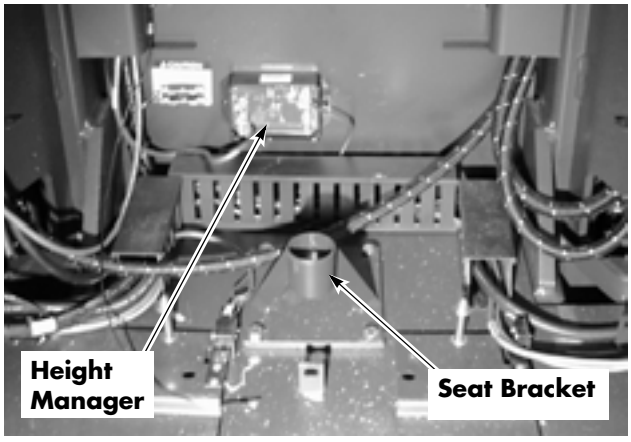


Figure 7-56. Main Height Manager, Later Series SB (seat removed for clarity)

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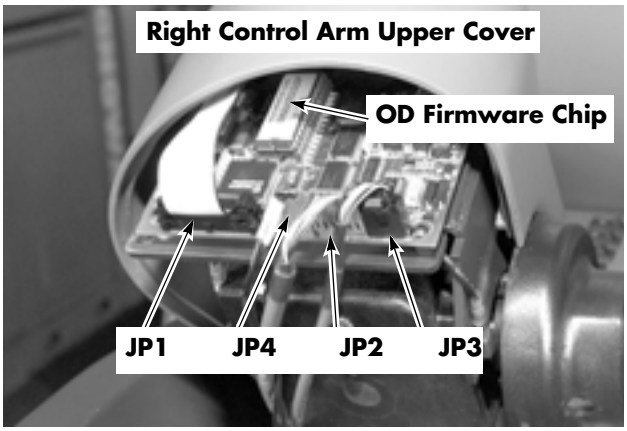


Figure 7-57. Operator Display Interface Card



Figure 7-58. Static Strap Location

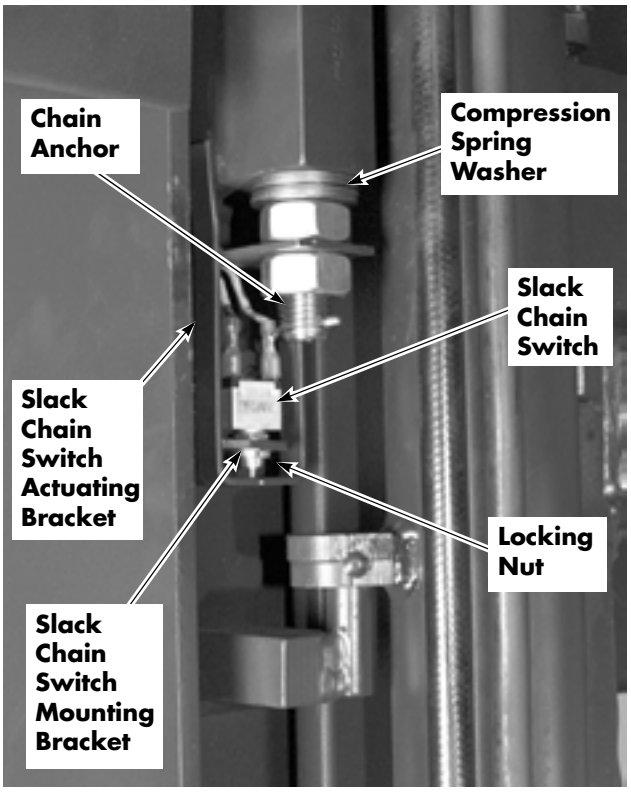


Figure 7-59. Slack Chain Switch (SA)

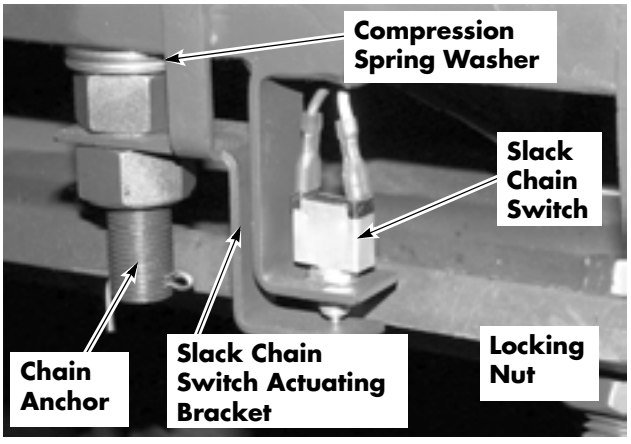


Figure 7-60. Slack Chain Switch (SB) Detail (early trucks)

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RAYMOND

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Covers and Finish

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Covers Component Procedures Summary

Table 7-1. Covers Component Procedures Summary

Component	Procedure /Photo or Drawing	Thread-Locking Compound/ Torque Values	Helpful Hints
Covers	Locator Photos: page 7-24	P/N 990-536	Install top cover before installing side covers. Top cover: Make sure prop rod is locked by pushing the pivot point toward the forks end.
Decals	Locator Photos: page 7-35		

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Decals and Plates

Replace any missing decals. Remove and replace any decals that are damaged.

Removal

1. Use a sharp edge to peel the decal from the surface. Use care not to scratch or damage the paint on the truck.
2. Clean the surface thoroughly and permit to dry before attaching new decals. Touch up paint as required.

Installation

1. Peel off the backing and place the decal into position.
2. Press the decal into place. Avoid wrinkling.
3. If the decal does not have a protective sheet over the surface, smooth the decal into place using clean fingers. Make sure all edges are secured to the surface.
4. If the decal has a protective sheet over the surface, rub over the protective sheet with a firm, straight plastic edge to remove any air bubbles and wrinkles. Then peel off the protective sheet.

Location

Refer to Table 7-2, Figure 7-61, Figure 7-62, and Figure 7-62 to locate decals on the truck.

Items in italics are safety decals.

Items in bold are required by OSHA.

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Table 7-2. Decal Location Chart

Decal Locations		
Identifier	**Description**	**Location**
1	**Overhead Guard ANSI/ASME conformance**	Overhead guard, right side
2	Raymond	Operator platform, right side
3	*Main Operator Warning Decal*	Operator platform, left side
4	**Specification Plate (not a decal)**	Operator platform, left side
5	Operator Manual	Under seat
6	Replacement Operator Manual	Under seat
7	ESD Jack	Operator platform, right side of seat
8	Performance	Mast, right side
9	**Identification Plate (not a decal)**	Mast, right side
10	*Charger Warning*	Tractor frame, above battery compartment
11	*Battery Warning*	Tractor frame, above battery compartment
12	*Emergency Lower Valve*	Tractor cover, lower left corner, rear
13	Raymond (2)	Side covers (each side)
14	*No Step (2)*	Top of baselegs (each side)
15	***Swinging Forks. Keep Clear (2)***	Sides of load handler turret
16	**Left Control Handle controls**	Top of left control arm
17	**Right Control Handle controls**	Top of right control arm
18	ESD Jack	Tractor frame, near lift motor
19	Lubrication	SA S/N < 03218 except 03202, and SB S/N < 00762 except 00757: Upper right corner of reservoir SA S/N 03202, > 03217 and SB S/N 00757, > 00761 Tractor frame, near lift motor
20	Patents	SA S/N < 03218 except 03202, and SB S/N < 00762 except 00757: Reservoir, upper right corner, left of #19 SA S/N 03202, > 03217 and SB S/N 00757, > 00761 Tractor frame, near lift motor, under #19
21	*Drive Unit Warning*	Bottom of steer motor, next to drive unit
22	Brake Release Bolts	Top of drive unit cable standoff bracket
23	*Aux Power*	Operator Platform, right side of seat, behind underseat tray

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Table 7-2. Decal Location Chart

Decal Locations		
Identifier	**Description**	**Location**
24	**EE Rating**	Mast, right side
25	**Alternate Spec Plate**	SA S/N < 03218 except 03202, and SB S/N < 00762 except 00757: Operator platform, left side, above # 4 SA S/N 03202, > 03217 and SB S/N 00757, > 00761: Operator platform, right side, below #2

NOTE: Items in *italics* are safety decals.
Items in **bold** are required by OSHA

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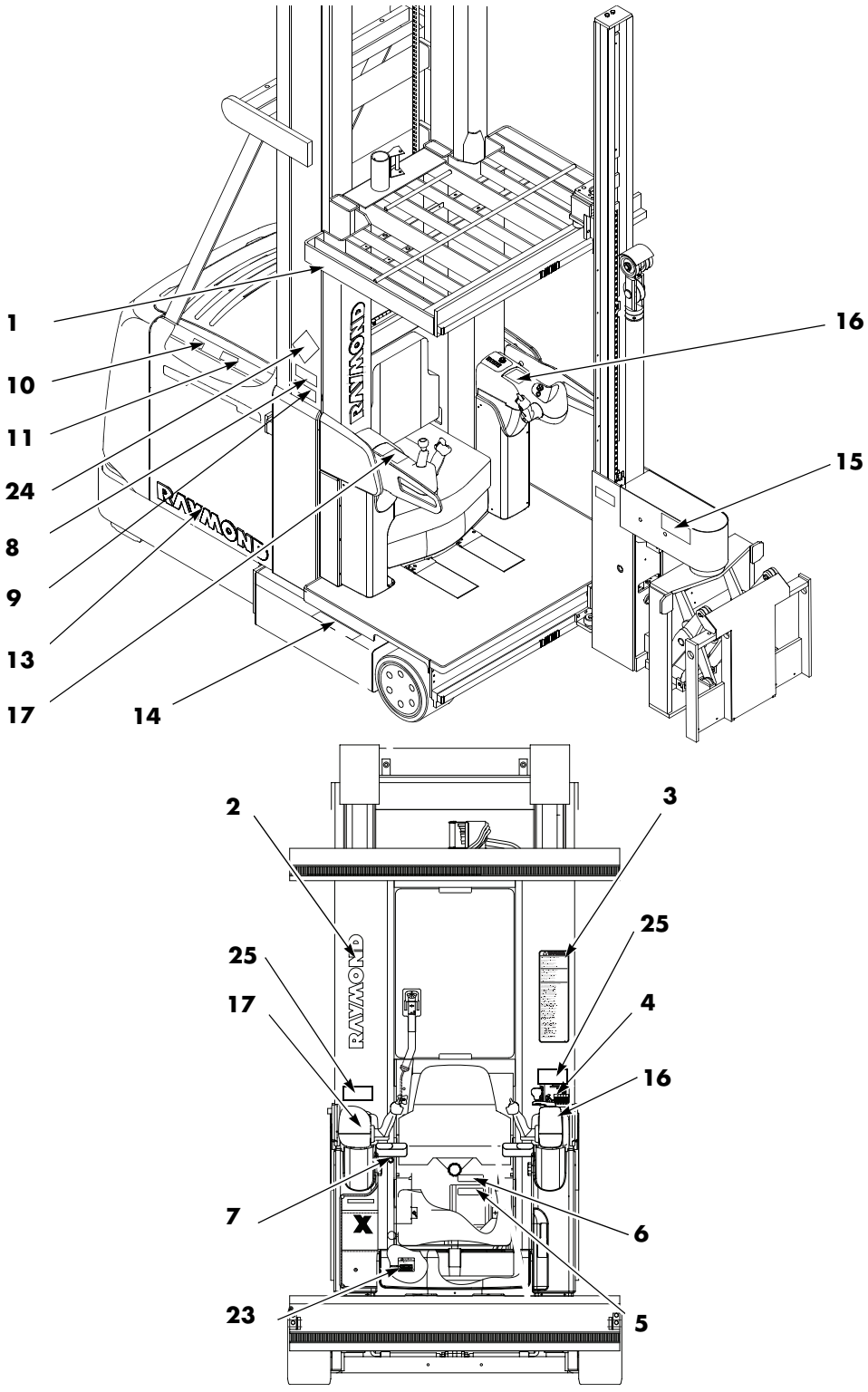
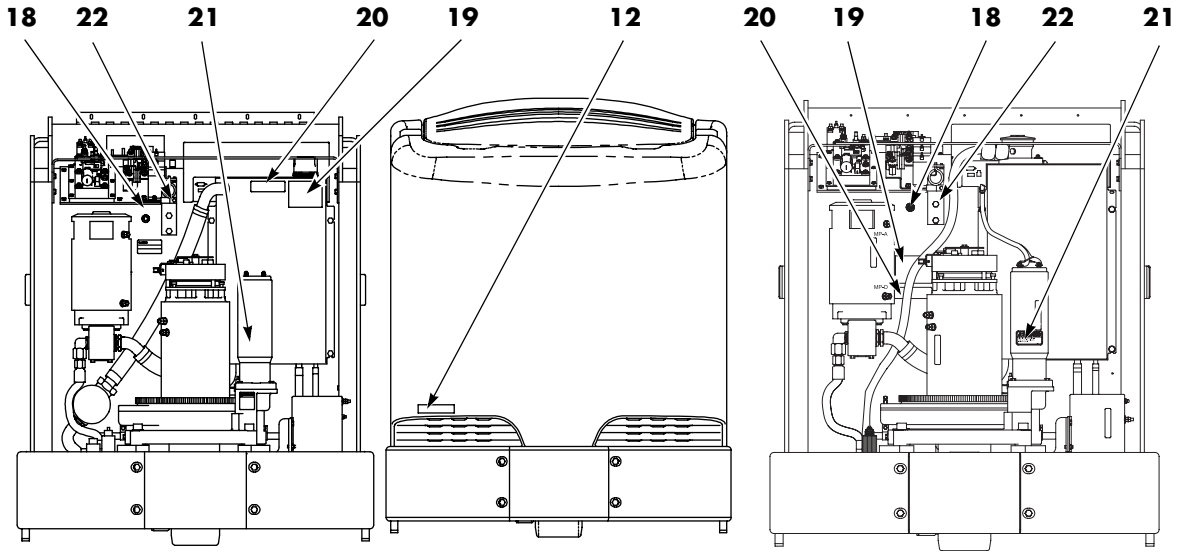


Figure 7-61. Decal Locations

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SA S/N < 03218
except 03202
SB S/N < 00762
except 00757

SA S/N 03202, > 03217
SB S/N 00757, > 00761

23 →

CAUTION

Power on terminals when battery is plugged in.

2 Amp Max.

Figure 7-62. Safety Decals

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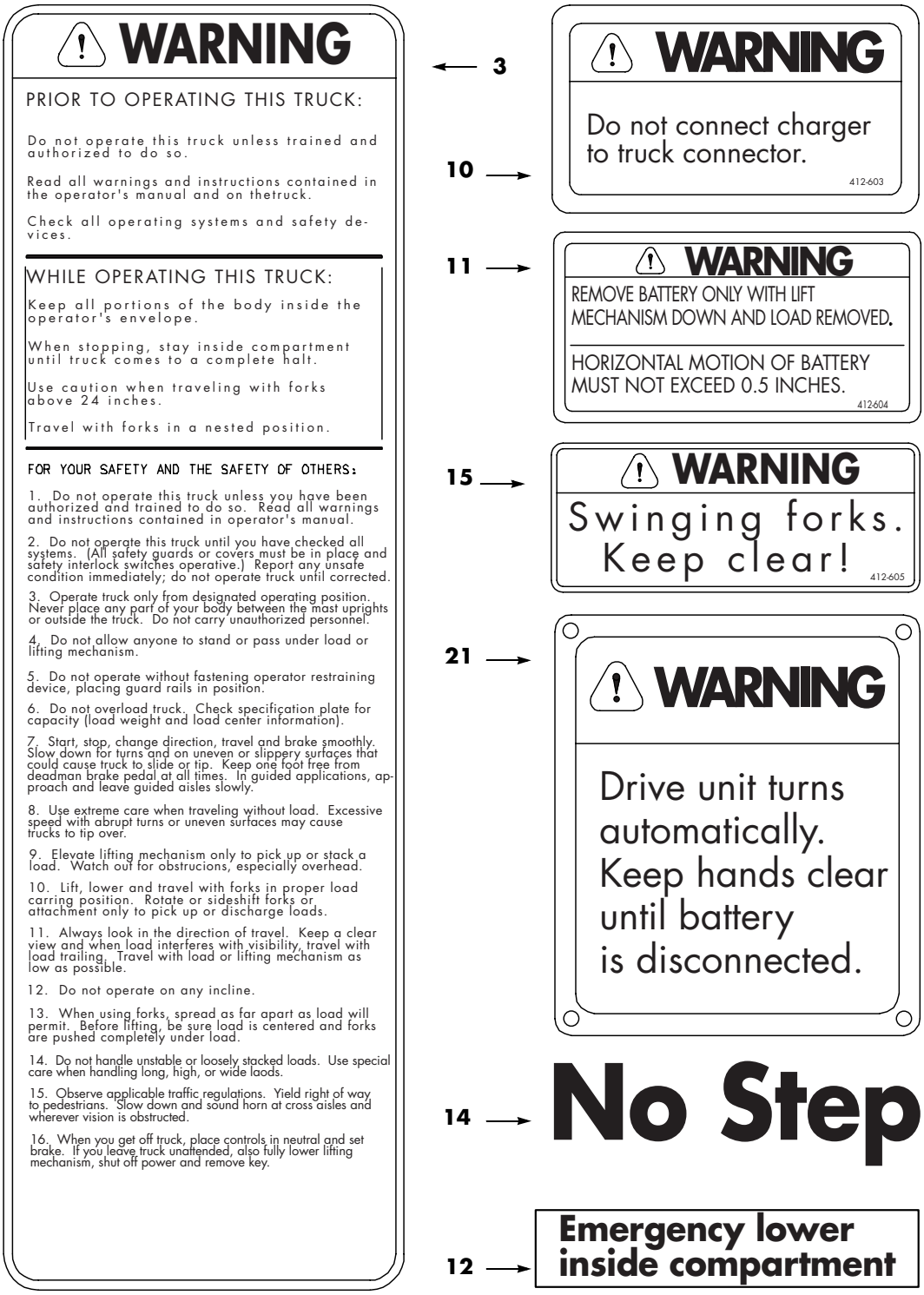


Figure 7-63. Safety Decals

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Steering and Controls

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Steering and Controls Component Procedures Summary

Table 7-3. Steering and Controls Component Procedures Summary

Component	Procedure /Photo or Drawing	Thread-Locking Compound/ Torque Values	Helpful Hints
Control Handle	Procedure: page 7-49		
Deadman Pedal and Switch	Locator Photo: Figure 7-38 on page 7-27	Pedal mounting screws: P/N 990-536	
Electric Steer Motor	Procedure: page 7-45		
End-of-Aisle Detect Sensors	Locator Photos: Figure 7-35 on page 7-26 and Figure 7-36 on page 7-26		Adjust sensor so bottom of sensor is 2 inches (50 mm) above the floor. Install EOA magnets 1/8 in. (3 mm) below the floor surface and cover with grout of RTV sealant. Locate floor magnets 4.5 in. (11.4 cm) from the aisle center line (rail guidance) or guide wire (wire guidance). Locate floor magnets at least 30 ft. (9.15 m) from the end of the rack.
EPO Switch	Procedure: page 7-62		
Gas Spring, Control Arm and Sidegate	Locator Photos: Figure 7-41 on page 7-27 and Figure 7-42 on page 7-27		
Key Switch	None		
Lights and Fans Switches	Locator Photo: Figure 7-39 on page 7-27		Push the switch up until it pops out of the cover. If necessary use a screwdriver to pry the switch out.

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Table 7-3. Steering and Controls Component Procedures Summary

Component	Procedure /Photo or Drawing	Thread-Locking Compound/ Torque Values	Helpful Hints
Operator Display	Locator Photos: Figure 7-25 on page 7-22 and Figure 7-57 on page 7-31 Interface Card Connectors: Figure 6-13 on page 6-88		**⚠CAUTION** **Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-9.** If new Tractor Manager VFC firmware altered or replaced the graphics database for the Operator Display, download the new graphics database from the Tractor Manager VFC Card to the Operator Display Interface Card. See "Graphics Database Download" on page 6-24.
Steer Encoder Card	Locator Photo: page 7-25	Set screw and locator pin bracket screw: P/N 990-536	Factory production on trucks prior to SA S/N 05011 and SB S/N 01060.
Steer Home Proximity Sensor	None		Adjust the vertical gap between the sensor and the sensor rail to 0.05 to 0.10 inch (1.3 to 2.5 mm). Center the drive wheel. Locate the sensor horizontally just past the end of the sensor rail. Run Learn Mode for Steering and Guidance. See "Learn Steering" on page 6-19. See "Learn Wire Guidance Offsets" on page 6-20.
Steer Motor Pinion Gear	Procedure: page 7-47		
Steer Position Feedback Encoder	Locator Photo: page 7-25	If installing a new O-ring, use a quick-drying temporary hose lubricant (P/N 1061054) to aid in installation.	Run Learn Mode for Steering and Guidance. See "Learn Steering" on page 6-19. See "Learn Wire Guidance Offsets" on page 6-20.
Steering Encoder Upgrade	Procedure: page 7-48		
Steering Input Encoder	Locator Photo: page 7-25	Socket head button screws mounting the steering tiller shaft boss to the encoder: P/N 990-536	Factory production on trucks beginning with SA S/N 05011 and SB S/N 01060. Mount the steering input encoder to the lower control arm bracket, using three nuts and bolts.

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Table 7-3. Steering and Controls Component Procedures Summary

Component	Procedure /Photo or Drawing	Thread-Locking Compound/ Torque Values	Helpful Hints
Steering Tiller Brake Assembly	Locator Photo: page 7-24	Tiller lock nut: 3 in. lb. (0.4 Nm) or until friction keeps tiller from wandering.	Make sure the spring washers are cupped with their *outer edges touching* each other.
Supplemental Operator Display	Locator Photo: page 7-22		
Wire Guidance Sensor	None	Bumper to tractor frame: 75 ft. lb. (101 Nm).	Adjust sensor so bottom of sensor is 2 inches (50 mm) above the floor. Run Learn Mode for Guidance. See "Learn Wire Guidance Offsets" on page 6-20.

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Electric Steer Motor

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the tractor cover.
3. Remove the steer motor power cables, labeling for later installation. Use two wrenches to avoid twisting the motor stud.
4. Remove three steer motor mounting bolts.

⚠CAUTION

The steer motor and gear reducer weigh approximately 54 lbs. (24 kg).

5. Lift the steer motor and gear reducer up and out of the drive unit.

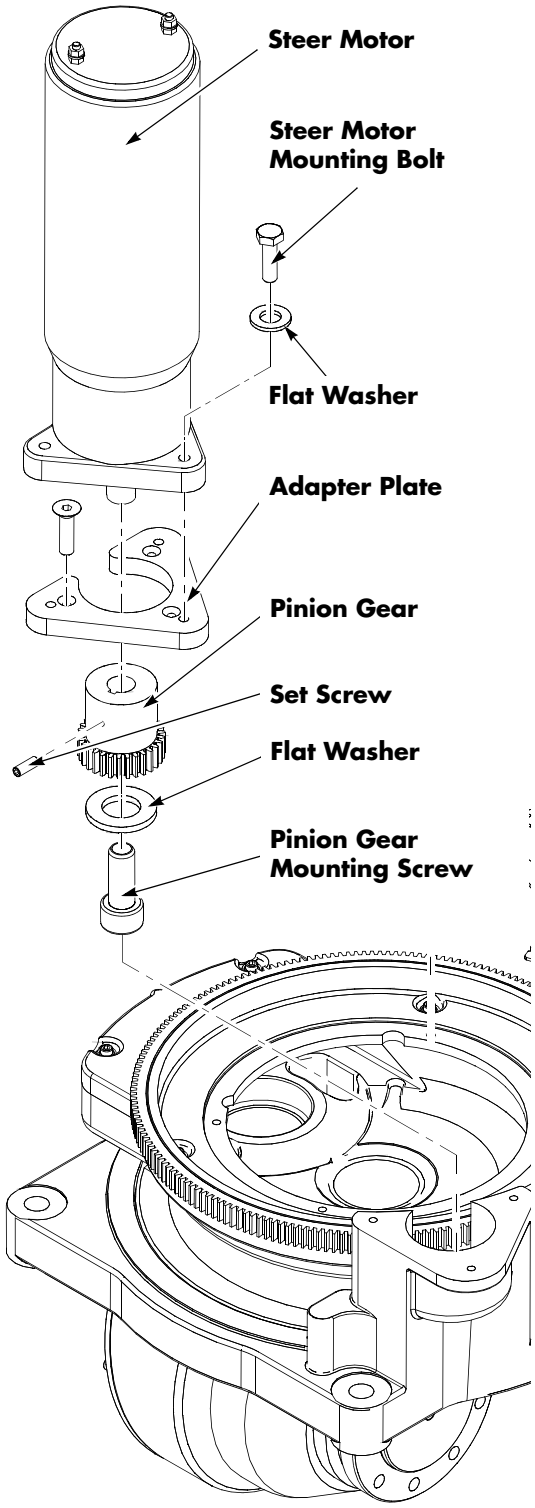


Figure 7-64. Electric Steer Motor

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Installation

NOTE: For lift trucks prior to S/N
SA 01895
SB 00483
If the steer motor has not been replaced previously, you will need to order an adapter plate, new style pinion gear, and associated hardware. See Parts Catalog for part numbers.

1. If the lift truck does not already have an adapter plate: Apply thread-locking compound (P/N 990-536) to M8x30 socket flat head screws. Mount adapter plate to mounting flange of drive unit. Torque screws to 21 ft. lb. (29 Nm).

⚠CAUTION

The steer motor and gear reducer weigh approximately 54 lbs. (24 kg).

2. Apply thread-locking compound (P/N 990-536) to the pinion gear mounting screw. Using screw and flat washer, mount gear to steer motor, with *gear teeth towards the end of the motor shaft*. Apply thread-locking compound (P/N 990-536) and install set screw.
3. Coat the pinion gear with molybdenum anti-seize compound (P/N 990-638).
4. Carefully lower the steer motor and gear reducer into position, meshing the steering pinion gear with the drive unit ring gear.
5. Apply thread-locking compound (P/N 990-536) to the M10 steer motor mounting bolts and install mounting bolts and washers. Torque to 30 ft. lb. (42 Nm).
6. Apply drive unit warning decal P/N 411-882 to the steer motor, 1 inch above the bottom of the main barrel, and centered horizontally.
7. Connect the power cables. Use a second wrench on the stud terminal securing nut to avoid twisting the motor stud.
8. Attach the tractor cover.
9. Reconnect the battery connector and turn the key switch ON.
10. Enter Learn Mode and perform Learn Steering. See “Learn Steering” on page 6-19.
11. Test the steering function for smooth and correct operation.

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Steer Motor Pinion Gear

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the tractor cover.

⚠CAUTION

The steer motor and gear reducer weigh approximately 54 lbs. (24 kg).

3. Remove the steer motor. See "Electric Steer Motor" on page 7-45.
4. Remove the set screw.
5. Remove the pinion gear mounting screw and flat washer. See Figure 7-64 on page 7-45.

Installation

⚠CAUTION

The steer motor and gear reducer weigh approximately 54 lbs. (24 kg).

1. Attach the pinion gear to the shaft, aligning the keyways on the gear and shaft.
2. Insert the key in the keyway.
3. Using a brass-faced hammer, drive the pinion gear to the drive shaft shoulder.
4. Apply thread-locking compound (P/N 990-536) to the pinion gear mounting screw. Using screw and flat washer, mount gear to steer motor, with gear teeth towards the end of the motor shaft.
5. Apply thread-locking compound (P/N 990-403) and install set screw.
6. Coat the pinion gear with molybdenum anti-seize compound (P/N 990-638).
7. Install the steer motor. See "Electric Steer Motor" on page 7-45.
8. Attach the tractor cover.
9. Reconnect the battery connector and turn the key switch ON.
10. Test the steering function for smooth and correct operation.

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Steering Encoder Upgrade

Use this procedure to upgrade a truck from the older style steering encoder card to the newer style steering input encoder. The newer style encoder was introduced with SA S/N 05011 and SB S/N 01060.

1. Turn the key switch OFF and disconnect the battery connector.

⚠CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-9.

2. Remove the set screw holding the steering tiller to the steering shaft. Remove the tiller.

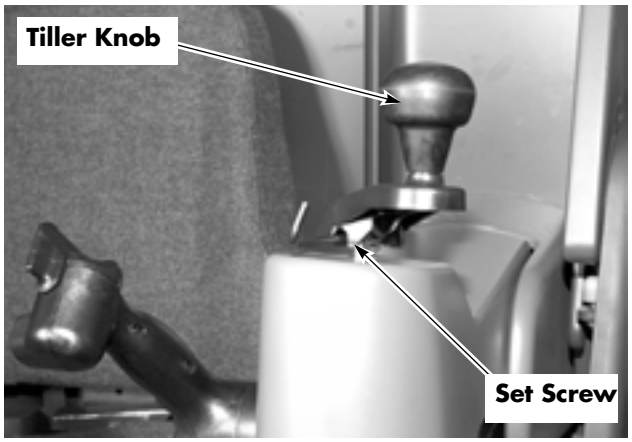


Figure 7-65. Steering Tiller removal

3. Remove both top and bottom left control arm covers.
4. Remove the rear control arm cover. It is fastened with 6 screws.
5. Disconnect the encoder cable at connector JPE1 on the encoder card.
6. Remove the control handle. See "Control Handle with Gear Case" on page 7-49.
7. Disconnect the gas spring at the top.
8. Remove the snap ring on the inboard side of the control arm pivot shaft. Remove the shaft and spacers.
9. From the old control arm bracket, remove the bumper stop, gas spring stud, and the pivot bushings. Discard the old control arm bracket.
10. Install pivot bushings, gas spring stud, and bumper stop in new control arm bracket.
11. Attach the new bracket to the rear bracket, using pivot shaft, spacers, shims (seven each side P/N 402-126), and snap rings.
12. Level the front control arm to the rear control arm.
13. Reconnect the gas spring.
14. Install the control handle. See "Control Handle with Gear Case" on page 7-49.
15. Install the new steering input encoder. See "Steering Input Encoder" on page 7-43.

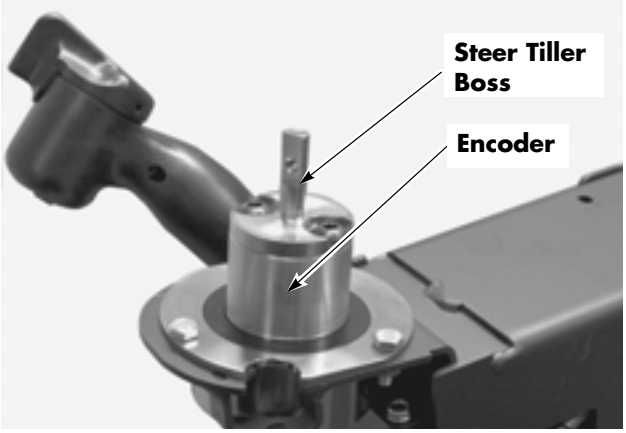


Figure 7-66. Steering Input Encoder.

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Control Handle

Control Handle with Gear Case

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove desired control arm covers.
3. Remove the screw securing the control handle to the shaft. Slide the handle out to gain access to the mounting bolts for the case. See Figure 7-67.

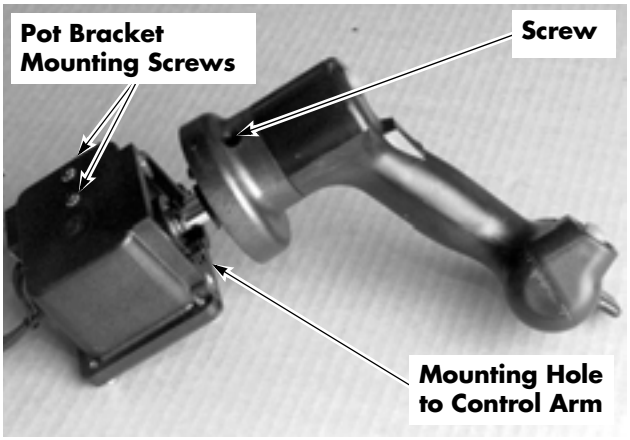


Figure 7-67. Control Handle Gear Case removal

4. Remove the bolts mounting the case to the control arm.
5. Remove the case from the control arm, disconnecting the ground wire and connector PL1 (left)/PR1 (right) and, if cold-storage equipped, PW7 (right)/PW8 (left).

Installation

1. Install the case in the control arm, reconnecting the ground wire and connector PL1 (left)/PR1 (right) and, if cold-storage equipped, PW7 (right)/PW8 (left).
2. Left control handle: Make sure the ground plate does not touch the truck frame.
3. Apply thread-locking compound (P/N 990-536) to the bolts mounting the case to the control arm and fasten.
4. Seat the handle on the shaft.

Non-solid state potentiometers only:
Apply thread-locking compound (P/N 990-403) to the screw securing the control handle to the shaft and fasten until flush with handle.

Solid state potentiometers only:
Insert the small socket head set screw (P/N 5-006-005) in the handle, as a positioner, only until the screw head is flush with the control handle. Installing it further into the handle will result in damage to the harness.

Apply thread-locking compound (P/N 990-412) to the button head screw (P/N 5-003-008) securing the control handle to the shaft and fasten.

NOTE: Some early solid state control handles had a different set screw configuration. Change those handles to match current production as shown in Figure 7-68.

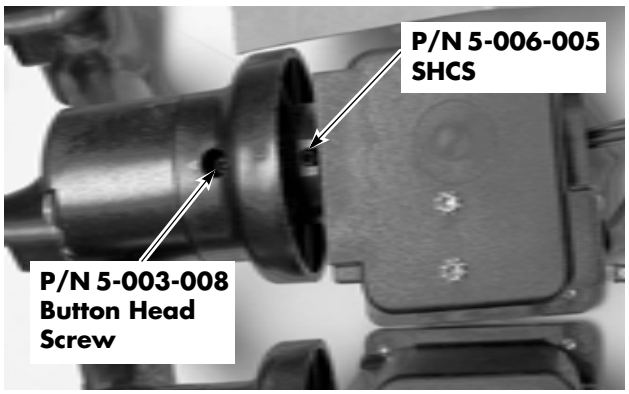


Figure 7-68. Solid State Control Handle mounting screws

5. Reinstall the control arm covers.

Gear Case

Disassembly

1. Remove the control handle and gear case from the control arm. See “Control Handle with Gear Case” on page 7-49.
2. Remove ground plate if necessary for easier access to wiring.
3. Remove four screws and cover from case.

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4. If cold-storage equipped, remove gasket-shaped heater and heat shields.

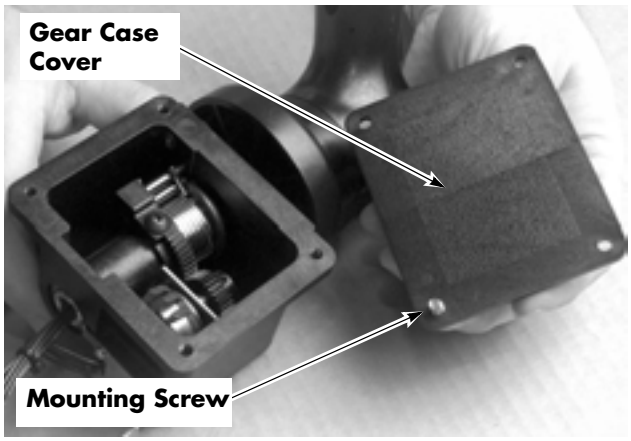


Figure 7-69. Control Handle Gear Case disassembly

Re-assembly

1. If cold-storage equipped, position the gasket-shaped heater and heat shields in the same position as they were before removal.
2. Attach the cover with four screws.
3. Reattach the ground plate if previously removed.
4. If cold-storage equipped, fill the opening around the ground plate with cold storage silicone sealant.
5. Install control handle and gear case in the control arm. See "Control Handle with Gear Case" on page 7-49.

Control Handle

Disassembly

1. Remove the control handle and gear case from the control arm. See "Control Handle with Gear Case" on page 7-49.
2. Remove two set screws securing the thumb control and remove the thumb control.
3. Remove the outboard screw securing the knob positioner to the handle shell.
4. Remove cable ties on wiring harness.
5. Remove 2 screws from inside handle hub. Remove 2 screws in handle shell. Separate the halves of the handle shell. The hub is part of the outboard half of the handle. See Figure 7-70 and Figure 7-71.

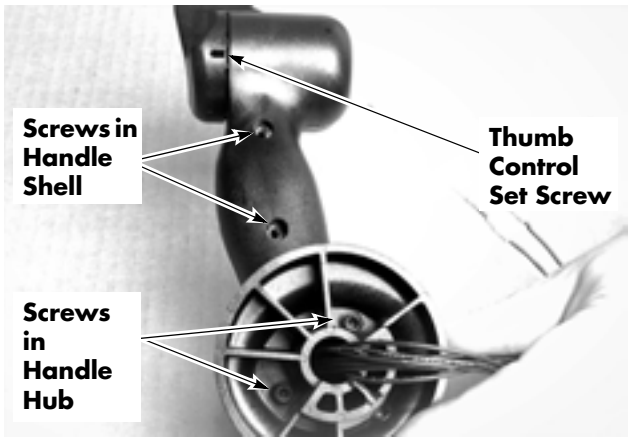


Figure 7-70. Control Handle disassembly (Non-Solid State)



Figure 7-71. Control Handle halves (Non-Solid State)

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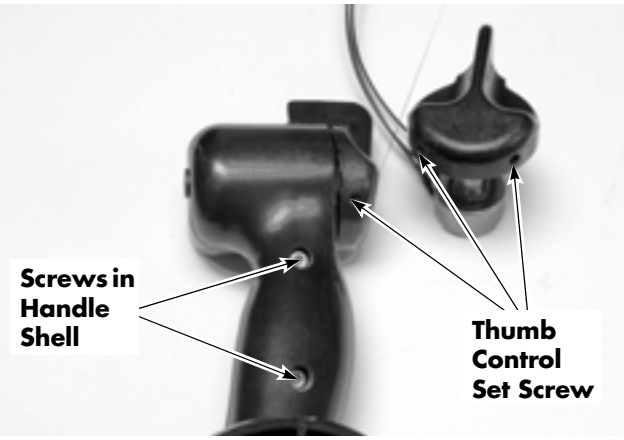


Figure 7-72. Control Handle disassembly (Solid State)



Figure 7-73. Control Handle halves - Solid State

Reassembly

All handles

1. Mate the halves of the handle shell, starting at the hub.
2. Apply thread-locking compound (P/N 990-403) to the handle shell screws and fasten the shell together.

Non-solid state handles only

3. Secure the VR2/VR3 knob positioner in the shell with the other screw, also applying thread-locking compound.
4. Turn the potentiometer so the flat on the shaft points down.
5. Attach the thumb control, mating the flats and engaging the pin between the spring ears. See Figure 7-74.

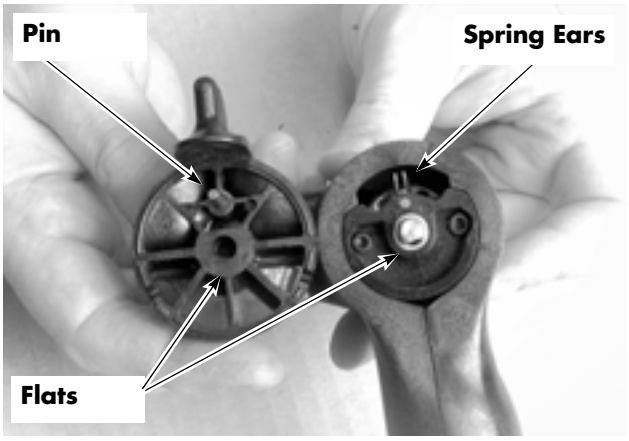


Figure 7-74. Control Handle Thumb Control, mating

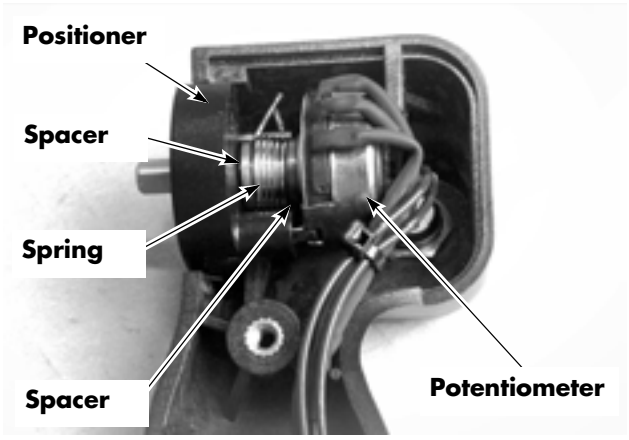


Figure 7-75. Control Handle Thumb Control, side view (Non-Solid State)

6. Apply thread-locking compound (P/N 990-403) to the thumb control set screws and fasten in place.

Solid State handles only

7. Attach cable ties to harness where previously removed.
8. Attach the spring and knob positioner over the VR2/VR3 potentiometer shaft. Apply a thin coat of lubricant (P/N 990-635) to the spring. Set the metal pin on the knob positioner between the spring ears, and

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engage the locating tab on the pot body in the opening in the plastic housing. See Figure 7-76.

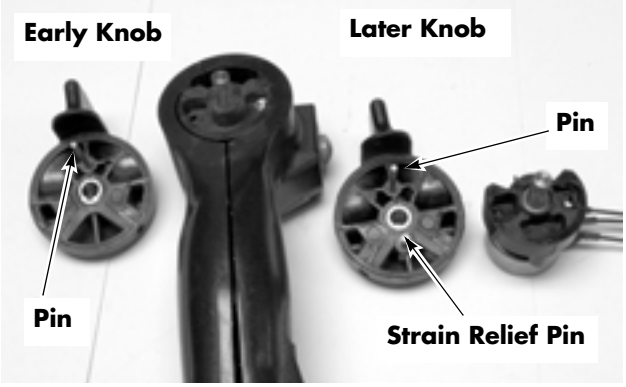


Figure 7-76. Control Handle Thumb Control, mating (Solid State)

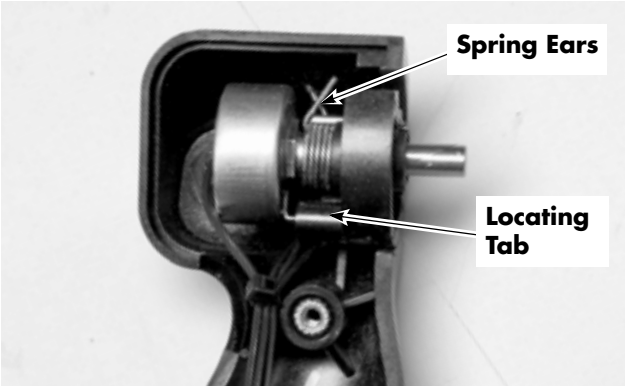


Figure 7-77. Control Handle Thumb Control, side view (Solid State)

9. Apply thread-locking compound (P/N 990-403) to the knob positioner screws. Secure the potentiometer and knob positioner in the handle.

All handles

10. Install the control handle and gear case in the control arm. See "Control Handle with Gear Case" on page 7-49.

Solid State handles only

11. Adjust the potentiometer. See "Adjusting VR2 or VR3."

All handles

12. Run Learn Mode for "Controls." See "Learn Controls" on page 6-16.

Control Handle Return Spring

Removal

1. Remove the control handle and gear case from the control arm. See "Control Handle with Gear Case" on page 7-49.
2. Open the gear case. See "Gear Case" on page 7-49.
3. Using a pin extractor AMP 91067-2 or equivalent, extract all pins from PL1 (left) or PR1 (right) except pins 9, 11, and 12, labeling if necessary to make sure correct reconnection later. On solid state handles, also extract pin PL2-2 (left) or PR2-2 (right).
4. Separate wires and pull control handle off the shaft and the wires out of the shaft. See Figure 7-78.

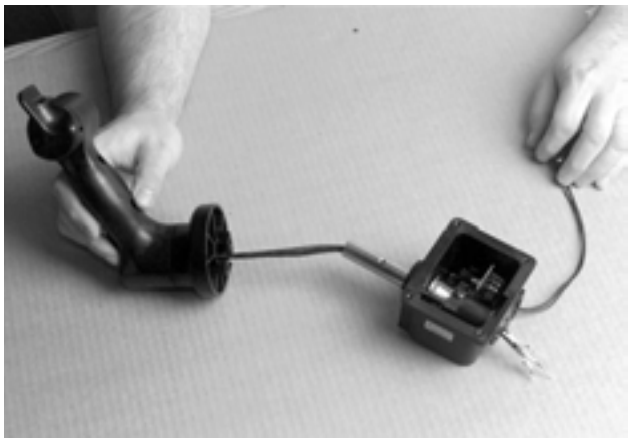


Figure 7-78. Control Handle, removing from Gear Case

5. Remove the potentiometer assembly mounting screws and remove the

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potentiometer assembly from the case. See Figure 7-79.

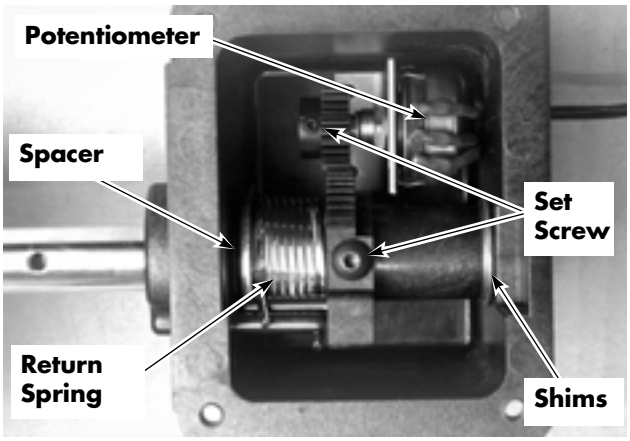


Figure 7-79. Control Handle Gear Box components

6. Remove the set screw securing the gear to the shaft. Pull the shaft out.
7. Remove the plastic gear and spring assembly. Note and retain the shims on the inside end of the shaft. Remove and retain the spacer on the front of the gear. See Figure 7-80.

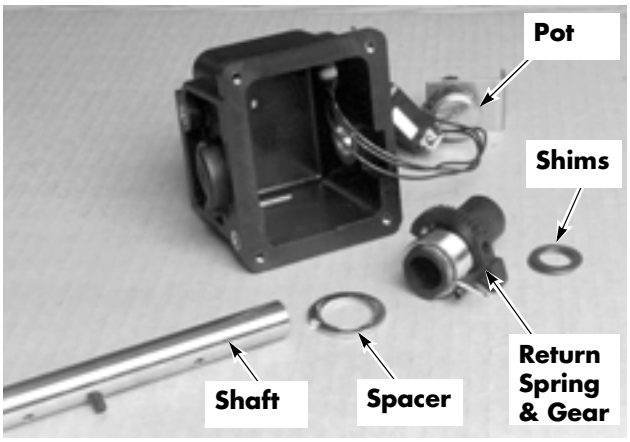


Figure 7-80. Control Handle Return Spring & related parts

8. Use needle-nosed pliers to remove the spring from the gear.

Installation

1. Coat the inside of the new spring lightly with lithium grease (P/N 990-635).
2. Use needle-nosed pliers to attach the new spring. Do not bend the spring ears.
3. Reinstall the spacer on the gear and spring assembly. Insert the gear and spring assembly in the case and insert the metal shaft part way.
4. Install shims at the inside end of the gear and seat the shaft completely.
5. Make sure the control handle mounting set screw on the shaft points down.
6. Apply thread-locking compound (P/N 990-403) to the gear set screw. Fasten the gear and spring assembly to the shaft.
7. Mesh the potentiometer pinion gear with the control handle shaft gear, making sure the set screw on the pinion gear points up. Apply thread-locking compound to the potentiometer mounting screws and fasten.
8. Feed control handle wires through the shaft. Reconnect wire pins to connector PL1 (left) or PR1 (right), observing correct connection. On solid state handles, also reconnect wire pin to PL2-2 (left) or PR2-2 (right).
9. Adjust the VR1 or VR4 potentiometer to electrically center the control. See “Adjusting VR1 or VR4” on page 7-55.
10. Reassemble the gear case. See “Gear Case” on page 7-49.
11. Install the control handle and gear case in the control arm. See “Control Handle with Gear Case” on page 7-49.
12. Run Learn Mode for “Controls.” See “Learn Controls” on page 6-16.

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Travel Potentiometer (VR1)

VR1, the travel potentiometer, also known as the throttle pot, travel control, or travel variable resistor, is located in the right-hand control handle. Service procedures are the same as for VR4, its mirror image, in the left-hand control handle. See "Traverse Potentiometer (VR4)" immediately below.

Traverse Potentiometer (VR4)

VR4, the traverse potentiometer, also known as the traverse control or traverse variable resistor, is located in the left-hand control handle.

NOTE: Photos in this section show views of both left- and right-hand control handles.

Removal

1. Remove the control handle and gear case from the control arm. See "Control Handle with Gear Case" on page 7-49.
2. Open the gear case. See "Gear Case" on page 7-49.
3. Cut the cable tie on the wiring.
4. From the outside of the case, remove two screws and lock washers securing the potentiometer bracket. See Figure 7-81.

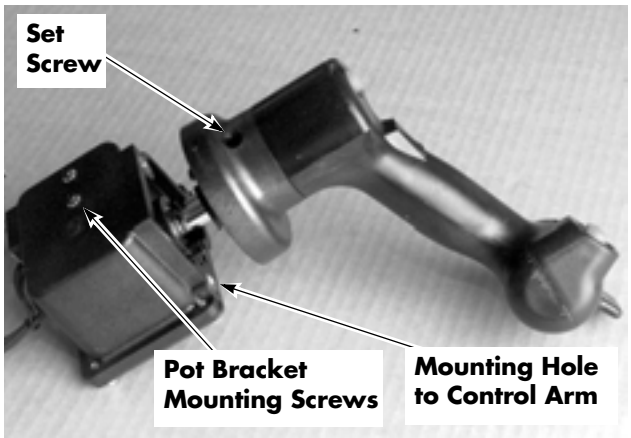


Figure 7-81. VR1/VR4 pot bracket mounting screws

5. Remove the potentiometer assembly from the case.
6. Remove heat shrink and unsolder wire connections. Label wires as needed for correct reinstallation. See "Soldering Procedures" on page 7-92 for cautions.
7. Remove the pinion gear from the potentiometer shaft by loosening the set screw. See Figure 7-82.
8. Remove the potentiometer from the mounting bracket, noting its orientation.

Installation

1. Attach the new potentiometer to the mounting bracket in the same orientation as the original.
2. Slip heat shrink tubing over the wires, attach and solder wires to the potentiometer, and shrink the tubing over the connections. Bend terminals carefully so they are parallel with the pot body. See Figure 7-82. See "Soldering Procedures" on page 7-92 for cautions.

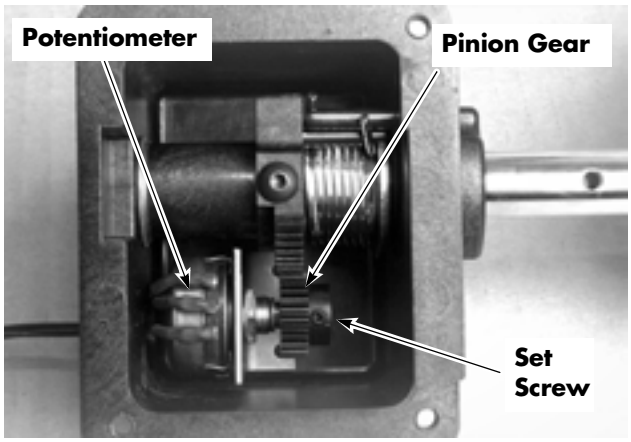


Figure 7-82. Control Handle Gear Case components

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3. Attach the pinion gear to the potentiometer, aligning the flats and securing with the set screw.

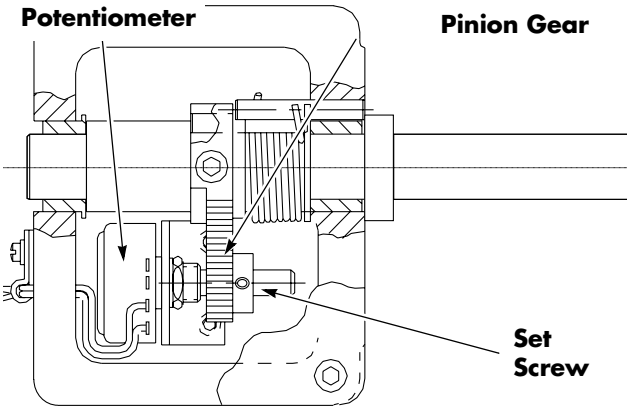


Figure 7-83. Control Handle Gear Case Components

4. Position the potentiometer assembly in the case, meshing the gears and making sure that the set screw faces up. Attach the potentiometer assembly to the case with two screws through the case. Turn the control handle shaft to make sure that the gears mesh correctly and potentiometer turns smoothly. If the gears are correctly meshed, but the movement binds, loosen the potentiometer assembly mounting screws and gently pry the potentiometer away from the control handle shaft as needed. Tighten the mounting screws.
5. Adjust the potentiometer on its bracket to electrically center the control. See "Adjusting VR1 or VR4" on page 7-55.
6. Reassemble the gear case. See "Gear Case" on page 7-49.
7. Attach a cable tie on the wiring where previously removed.
8. Install the control handle and gear case in the control arm. See "Control Handle with Gear Case" on page 7-49.
9. Run Learn Mode for Controls. See "Learn Controls" on page 6-16.

Adjusting VR1 or VR4

All potentiometers:

1. Remove the gear case from the truck in order to make this adjustment. See "Control Handle with Gear Case" on page 7-49. See "Gear Case" on page 7-49.
2. Make sure the control handle is in the neutral position.

Non-solid state potentiometers only:

3. With the key switch OFF and battery connector disconnected, measure resistance between PR1-11/PL1-11 (or the center terminal of the pot) and PR1-9/PL1-9 (one side terminal of the pot).
4. Loosen the jam nut until it is just snug and rotate the pot on the bracket until resistance measures approximately 1020 ohms.
5. Measure resistance between PR1-11/PL1-11 (or center terminal of the pot) and PR1-12/PL1-12 (the other side terminal of the pot).
6. Rotate the pot on the bracket until readings from steps 3 and 5 are within 5 ohms of each other.
7. Tighten the jam nut and check the resistance again.

Solid state potentiometers only:

8. Reconnect the handle assembly connector to the truck harness connector (JPL1 or JPR1).
9. Run Analog Test A03 (VR1) or A06 (VR4).
10. Loosen the jam nut until it is just snug.
11. Rotate the pot on the bracket until test voltage is 2.5 volts.
12. Tighten the jam nut and check the voltage again.

All potentiometers:

13. Install the control handle and gear case in the control arm. See "Control Handle with Gear Case" on page 7-49.

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14. After re-assembly, run Learn Mode for Controls. See "Learn Controls" on page 6-16.

Lift/Lower Potentiometer (VR2)

VR2, the lift/lower potentiometer, also known as the lift/lower control, or lift/lower variable resistor, is located in the right-hand control handle. Service procedures are the same as for VR3, its mirror image, in the left-hand control handle. See "Rotate Potentiometer (VR3)" immediately below.

Rotate Potentiometer (VR3)

VR3, the rotate potentiometer, also known as the rotate control or rotate variable resistor, is located in the left-hand control handle.

NOTE: Photos in this section show views of both left- and right-hand control handles.

Removal

1. Remove the control handle and gear case from the control arm. See "Control Handle with Gear Case" on page 7-49.
2. Separate the control handle halves. See "Control Handle" on page 7-50.
3. Remove two screws securing the knob positioner. Remove the positioner, spring, and spacers (spacers on non-solid state assemblies only) from the potentiometer shaft. See Figure 7-84 and Figure 7-85.

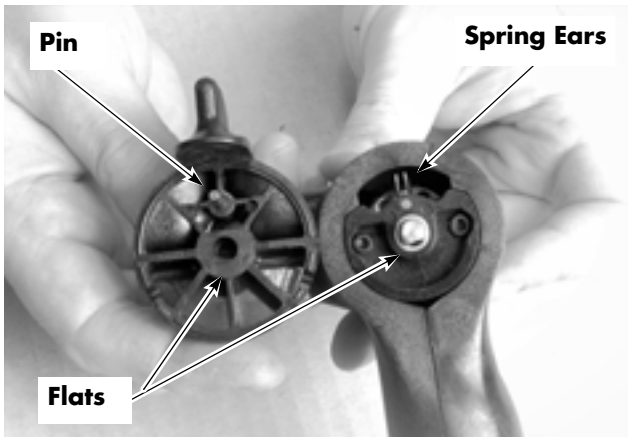


Figure 7-84. Control Handle and Thumb Control (Front View) (Non-Solid State "D"-shaft style)

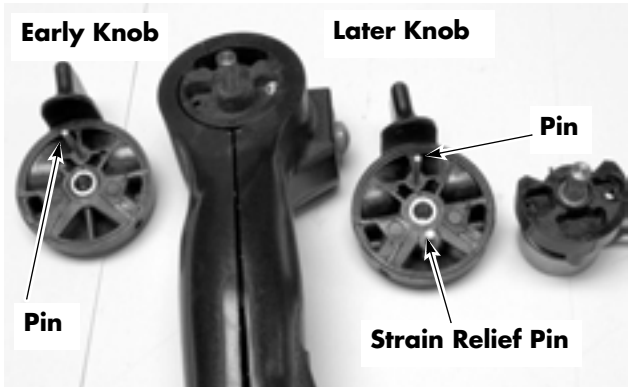


Figure 7-85. Control Handle and Thumb Control (Front View) (Solid State)

4. Cut the cable tie. Remove shrink wrap and unsolder wires on potentiometer. See "Soldering Procedures" on page 7-92 for cautions. Label the wires as needed for correct reinstallation.

Installation

1. Slip heat shrink tubing over the wires, attach and solder wires to the potentiometer, and shrink the tubing over the connections. See "Soldering Procedures" on page 7-92 for cautions. Bend terminals carefully so they are parallel with the pot body.

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2. Attach cable tie where previously removed.
3. Attach the spring, knob positioner, and spacers (spacers on non-solid state assemblies only) over the potentiometer shaft. Apply a thin coat of lubricant (P/N 990-635) to the spring. Set the metal pin on the knob positioner between the springs ears, and engage the locating tab on the pot body in the opening in the plastic housing. See Figure 7-86 or Figure 7-88.

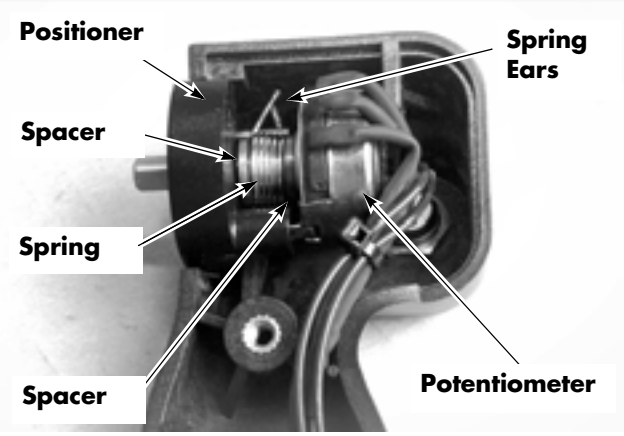


Figure 7-86. Control Handle and Thumb Control (Side View) (Non-Solid State)

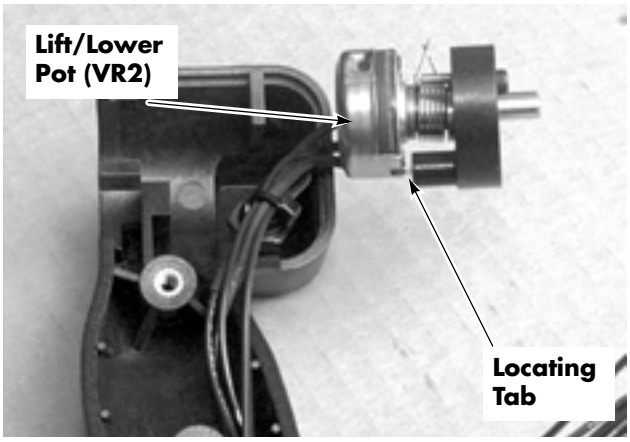


Figure 7-87. Control Handle and Thumb Control (side view) (Non-Solid State)

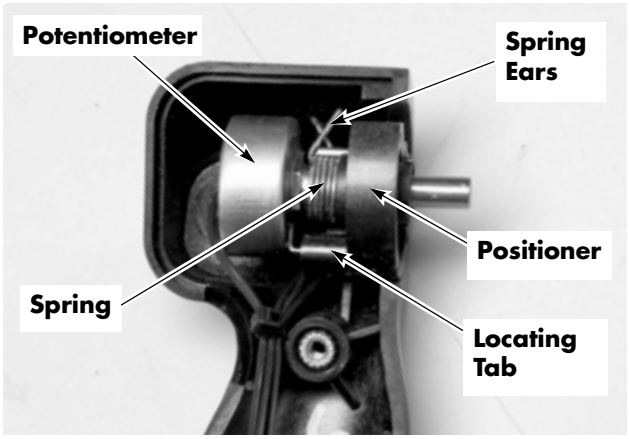


Figure 7-88. Control Handle and Thumb Control (side view) (Solid State)

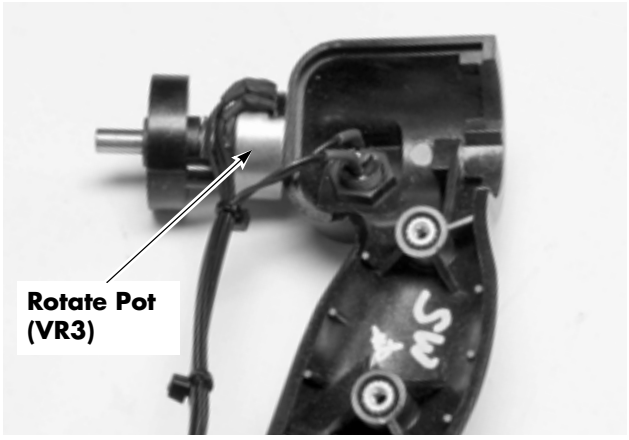


Figure 7-89. Control Handle and Thumb Control (side view) (Solid State)

4. Make sure the potentiometer shaft turns freely.
5. Apply thread-locking compound (P/N 990-403) to one knob positioner screw. Secure the potentiometer and knob positioner in the handle shell with one screw.
6. Adjust the potentiometer. See “Adjusting VR2 or VR3” on page 7-58..
7. Bundle wires and route them in the handle shell, making sure they will not be pinched by the handle shell.

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8. Reassemble the control handle halves. See "Control Handle" on page 7-50.
9. Install the control handle and gear case to the control arm. See "Control Handle with Gear Case" on page 7-49.
10. Run Learn Mode for Controls. See "Learn Controls" on page 6-16.

Adjusting VR2 or VR3

Non-solid state "D"-shaft potentiometers

There is no adjustment of non-solid state potentiometers with a "D"-shaft.

Non-solid state "O"-shaft potentiometers and solid-state potentiometers

1. Reconnect the handle assembly connector to the truck harness connector (JPL1 or JPR1).
2. Run Analog Test A04 (VR2) or A09 (VR3).
3. Adjust the potentiometer until the test voltage is 2.5 volts.
4. Install the knob on the potentiometer shaft. On solid state potentiometers, insert a feeler gauge between the knob and the shell. For older knobs with a single pin, use a 0.072 in. gauge. For newer knobs with two pins, use a 0.032 in. gauge. See Figure 7-90. On non-solid state "O"-shaft potentiometers, use no feeler gauge.

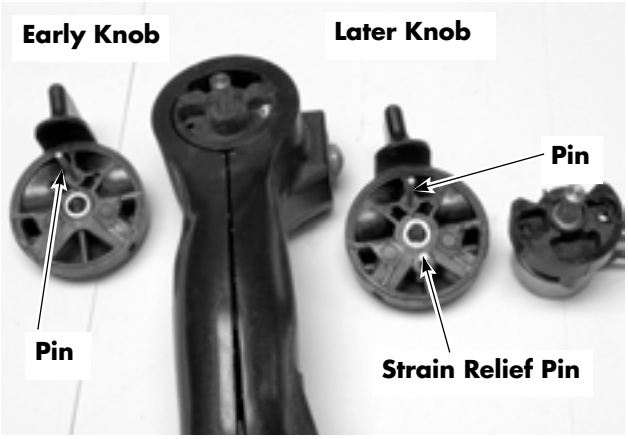


Figure 7-90. Solid state thumb control knobs and positioner

5. Insert a flat-ended rod into the hole in the control handle and apply light pressure to press the potentiometer and return spring against the positioner. See Figure 7-91 and Figure 7-92.

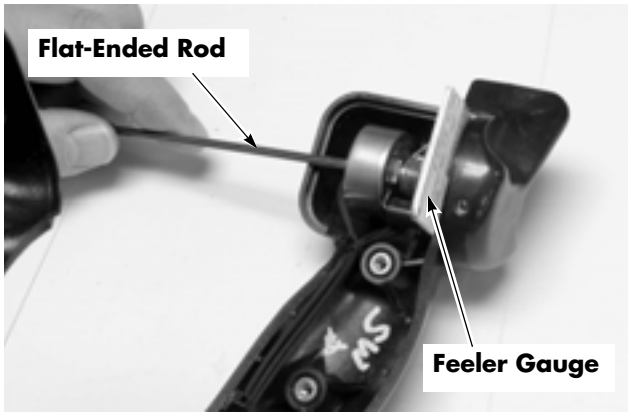


Figure 7-91. Attaching thumb control (handle half removed only for clarity)

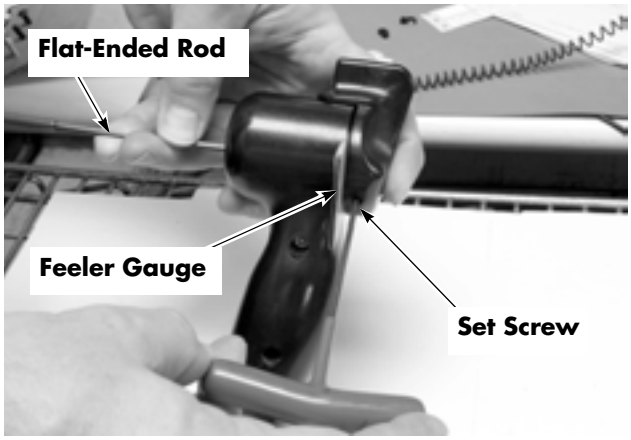


Figure 7-92. Attaching thumb control (note rod through hole)

6. Install the set screws securing the knob to the potentiometer shaft.
7. Verify the center voltage again.
8. Test the knob to make sure it does not bind.
9. Install a plug (P/N 1-085-106/001) in the hole.

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Control Handle Switches

The Horn Switch (S3) and optional Auto-Manual Switch (S4) are located on the right-hand control handle. See Figure 7-93.

The Lift Select Switch (S6) and optional Lift/Lower Inhibit Bypass Switch (S7) are located on the left-hand control handle. See Figure 7-94 on page 7-59.

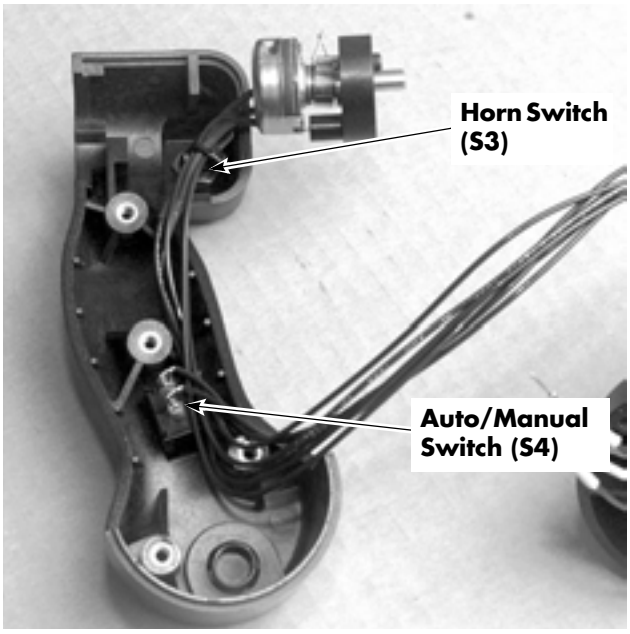


Figure 7-93. Right Control Handle Switches (S3/S4)

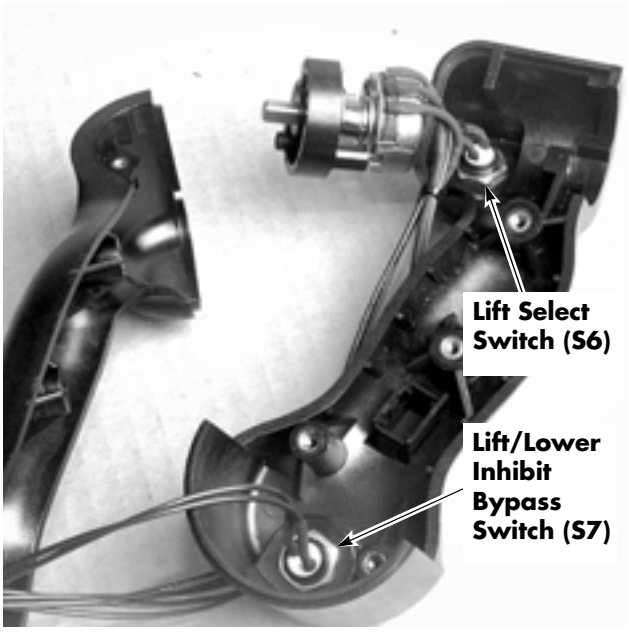


Figure 7-94. Left Control Handle Switches (S6/S7) (Non-Solid State)

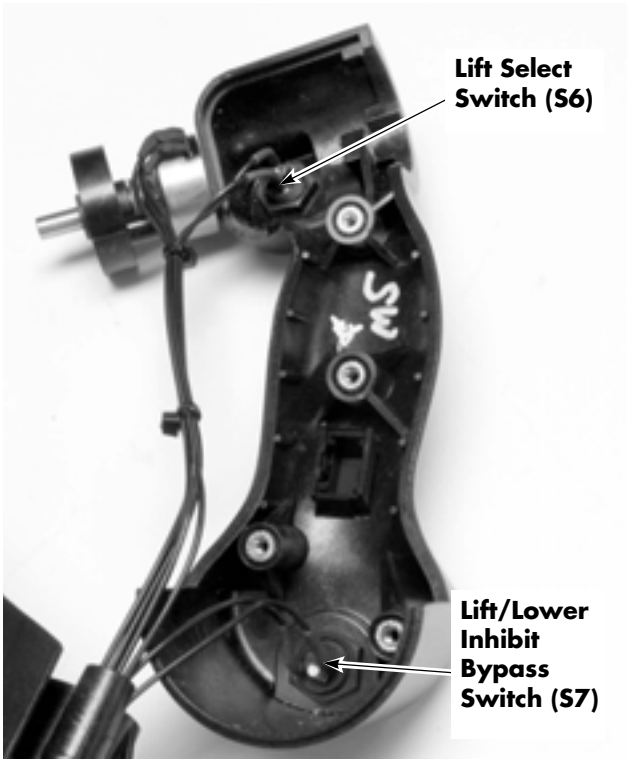


Figure 7-95. Lift Control Handle Switches (S6/S7) (Solid state)

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Removal

1. Remove the control handle and gear case from the control arm. See "Control Handle with Gear Case" on page 7-49.
2. Separate the control handle halves. See "Control Handle" on page 7-50.
3. If replacing horn switch or lift select switch, remove two screws securing the knob positioner for the VR2/VR3 potentiometer. Remove the potentiometer assembly to gain access to the switch behind it.
4. Remove the switch from the handle shell. See Figure 7-93, Figure 7-94, or Figure 7-95. Remove heat shrink tubing, unsolder wires from switch, noting their position to make sure correct installation. See "Soldering Procedures" on page 7-92 for cautions.

Installation

1. Slip heat shrink tubing over the wires, attach and solder wires to the switch, and shrink the tubing over the connections. See "Soldering Procedures" on page 7-92 for cautions.
2. Reinstall the switch in the handle.
3. If neither horn (S3) nor lift select switch (S6) was replaced, skip to step 7.
4. Reinstall the VR2/VR3 potentiometer assembly in the handle.
5. Apply thread-locking compound (P/N 990-403) to one knob positioner screw. Secure the potentiometer and knob positioner in the handle shell with one screw.
6. Adjust the potentiometer. See "Adjusting VR2 or VR3" on page 7-58.
7. Bundle wires and route them in the handle shell, making sure they will not be pinched by the handle shell.
8. Reassemble the control handle halves. See "Control Handle" on page 7-50.
9. Install the control handle and gear case in the control arm. See "Control Handle with Gear Case" on page 7-49.

Cold Storage Heater Replacement

1. Remove the control handle and gear case from the control arm. See "Control Handle with Gear Case" on page 7-49.
2. Open the gear case. See "Gear Case" on page 7-49.
3. Remove the heat shields.
4. The heater has two wires. Remove one wire from the thermostat; it could be soldered or attached by a terminal. Remove the other wire by extracting the pin from connector PW7 (right) or PW8 (left), using an AMP 305183 or equivalent pin extractor.
5. Attach one of the replacement heater wires to the thermostat; it could be soldered or attached by a terminal.
6. Feed the other wire through the opening in the ground plate. Attach a new pin terminal and insert into connector PW7 (right) or PW8 (left).
7. Reattach the ground plate.
8. Reinstall the heat shields as they were before removal.
9. Seal the opening around the ground plate with cold storage silicone sealant.
10. Install the control handle and gear case in the control arm. See "Control Handle with Gear Case" on page 7-49.

Cold Storage Thermostat Replacement

1. Remove the control handle and gear case from the control arm. See "Control Handle with Gear Case" on page 7-49.
2. Open the gear case. See "Gear Case" on page 7-49.
3. Remove the control handle shaft and gear. See "Control Handle Return Spring" on page 7-52.
4. Disconnect the terminal from the heater wire.
5. Remove the nuts securing the thermostat.

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6. Secure the new thermostat in place with mounting nuts.
7. Reconnect the terminal from the heater wire.
8. Reattach the control handle shaft and gear. See “Control Handle Return Spring” on page 7-52.
9. Reassemble the gear case. See “Gear Case” on page 7-49.
10. Install the control handle and gear case in the control arm. See “Control Handle with Gear Case” on page 7-49.

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EPO Switch

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove both top and bottom covers from the right control arm. Reference "Right and Left Upper Control Arm Covers and Mounting Screw Locations (viewed from bottom)" on page 7-24.
3. Remove the wires to EPO switch, labeling as necessary for later installation.
4. Loosen the retaining screws on the back of the switch body. (Insert screwdriver through access slot in control arm.)
5. Hold switch body firmly while twisting knob counterclockwise to disengage the knob from the body.
6. Remove both halves of the switch.

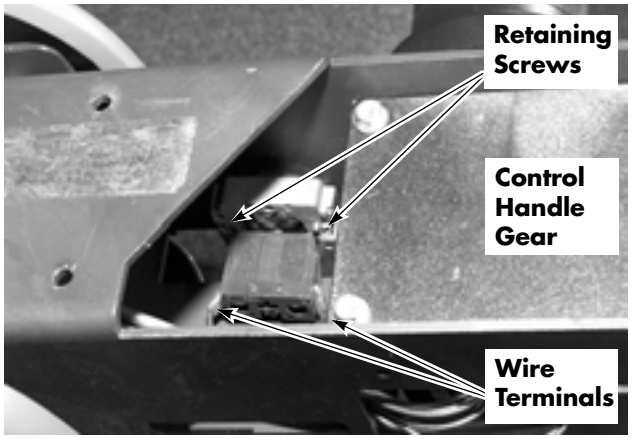


Figure 7-96. EPO Switch in Right Control Arm

Installation

1. Insert the knob through the mounting hole.
2. Mate the switch back to the knob shaft.
3. While holding the switch body firmly, press and twist the knob clockwise to engage the switch halves.
4. Tighten the retaining screws on the switch body.
5. Attach wires to the switch.
6. Reinstall the upper and lower control arm covers.
7. Reconnect the battery connector and turn the key switch ON.
8. Test operation of EPO switch. Switch should operate freely without binding. When switch is pushed IN, travel, lift, and auxiliary functions should be disabled.

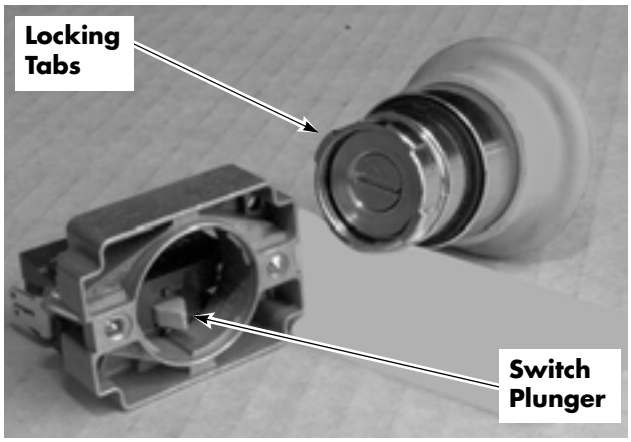


Figure 7-97. EPO Switch Body and Knob

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Drive and Brake

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Drive and Brake Component Procedures Summary

Table 7-4. Drive and Brake Component Procedures Summary

Component	Procedure /Photo or Drawing	Thread-Locking Compound/ Torque Values	Helpful Hints
Brake Adjustment	Procedure: page 7-74		
Brake Assembly	Procedure: page 7-69		
Brake Pads	Procedure: page 7-71		
Brake Rotor	Procedure: page 7-76		
Drive Unit	None	Drive unit mounting bolts: 350 ft. lb. (475 Nm) Drive wheel mounting bolts: 185 ft. lb. (251 Nm) Bumper bolts 75 ft. lb. (101 Nm)	Drive unit capacity is 7.1 quarts (6.75 liters).
Drive Unit Axle Seal and Bearing	Procedure: page 7-66		
Drive Wheel and Tire	Pressing Procedure: page 7-68		
Plugging Resistor	Locator Photos: Figure 7-34 and Figure 7-37 on page 7-26	Cover screws: P/N 990-536	**⚠CAUTION** ***Do not* roll the battery more than one-third of the way out of the battery compartment, or else the battery could tip out of the truck.**
Speed Feedback Proximity Sensor	None		Some early trucks require a new cable harness JPS18-SPS. Use shims as necessary to establish a gap of 0.06 +0.01/–0.04 inch (1.5 + 4.0/– 1.0 mm).

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Drive Unit Axle Seal and Bearing

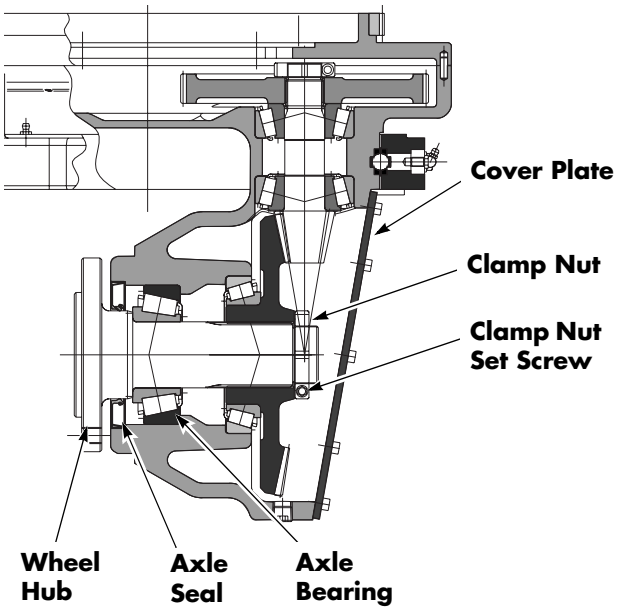


Figure 7-98. Drive Unit Axle Seal and Bearing

Removal

1. Remove the drive wheel.
2. Reconnect the battery connector and turn the key switch ON. Turn the steering tiller completely clockwise (to the right). The drive unit cover plate will now be facing the tractor bumper. Turn the key switch OFF and disconnect the battery connector.
3. Place a drain pan under the drive unit. Remove the drain plug and drain the drive unit. Drive unit capacity is 7.1 quarts (6.75 liters).
4. Apply gasket sealant (P/N 990-520) to the drain plug and reinstall drain plug.
5. Remove the cover plate from the drive unit housing.
6. Remove the set screw in the clamp nut securing the axle to the bevel gear.
7. Remove the axle clamp nut.
8. Using a brass drift, drive the axle out of the bevel gear. (The bevel gear could come loose when the axle is removed.)
9. Use a bearing puller to remove the bearing cone from the axle. Inspect the bearing for wear, pitting, or damage. Replace if necessary.

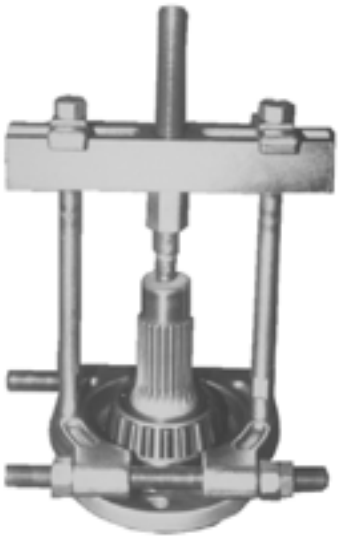


Figure 7-99. Axle Bearing removal with puller

10. Remove the old axle seal. Inspect the axle for nicks, burrs, damage, and wear. Replace if necessary.
11. If you will be replacing the axle bearing, drive the bearing cup out of the drive unit housing, working from the cover plate side of the drive unit.

Installation

1. If you are replacing the axle bearing, place the new bearing cup in the housing.
2. Lubricate the lip of the new axle seal and place seal onto axle.
3. Place the bearing cone onto the axle.

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4. Using a bearing press, press the bearing onto the axle. See Figure 7-100 and Figure 7-101.

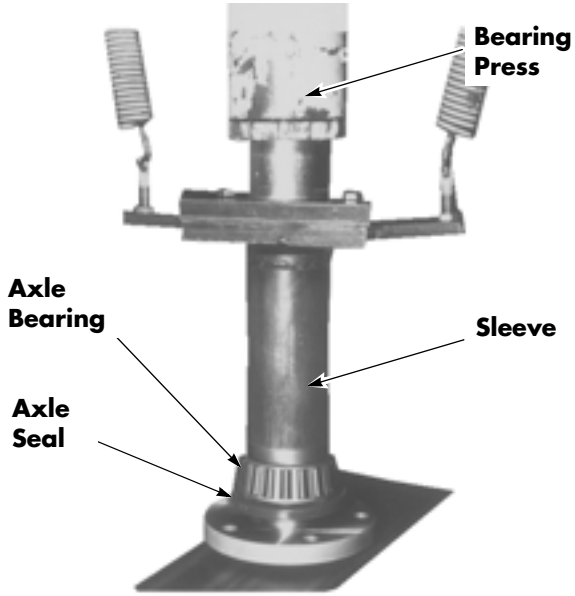


Figure 7-100. Pressing Axle Bearing

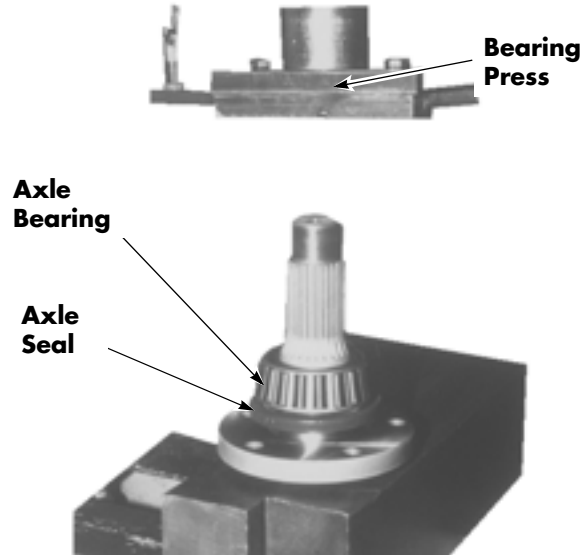


Figure 7-101. Pressing Axle Bearing, Complete

5. Insert the axle shaft into the drive unit housing, lining up the spline between axle shaft and bevel gear. Make sure the bevel gear and pinion gear are correctly mated.

6. Insert a seal pressing tool between the seal and the wheel flange of the axle. See Figure 7-102.

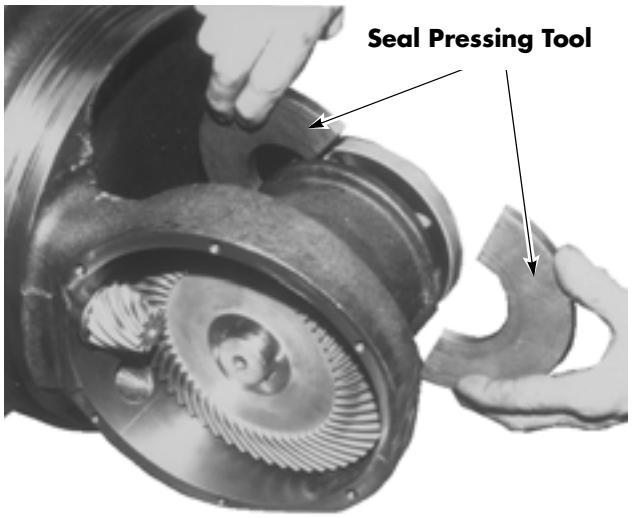


Figure 7-102. Axle Seal Pressing Tool

7. Using a brass hammer, drive the axle seal into the housing. The seal must be flush with the housing.
8. Push the axle out of the housing just enough to remove the seal pressing tool.
9. Push the axle back in until bearing cone and cup make contact.
10. Apply thread-locking compound (P/N 990-544) to the axle clamp nut. Install clamp nut and tighten to 18 ft. lb. (24 Nm) while rotating the wheel flange to seat the bearings.
11. Loosen the axle nut until hand tight.
12. Retighten the axle clamp nut to 40 in. lb. (4.5 Nm) in steps, rotating the axle a full turn between steps, until 40 in. lb. (4.5 Nm) torque no longer turns the nut. This could require as many as six turns. You should feel no end play in the axle.
13. Make sure the clamp nut set screw is marked grade 12.9 in the face of the screw head. Apply thread-locking compound (P/N 990-536) to the threads of the clamp nut set screw. Install the set screw and torque to 140 in. lb. (15.8 Nm).

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Drive Tire Pressing

⚠CAUTION

Any misalignment of the tire and hub while the tire is being pressed onto the hub can cause damage to the hub. For this reason, chamfers have been provided on the outside edge of the hub and on the end of the inside diameter of the tire's metal insert. The chamfers help to center the hub and tire during the pressing operation and reduce the possibility of misalignment. To prevent damage, install the hub on the circular ram with its chamfered side up.

1. Check the inside surface of the metal insert on the new tire. Remove any scaling or rust with sandpaper. Clean the inside of the metal insert and lubricate it with a soap solution.
2. Place a circular ram on the press table. See Figure 7-103. The length of the ram must be longer than the width of the old tire to permit complete removal of the old tire. The outside diameter of the ram must be small enough to fit loosely in the insert of the tire but must be large enough to rest squarely on the flat surface on the outer edge of the hub.

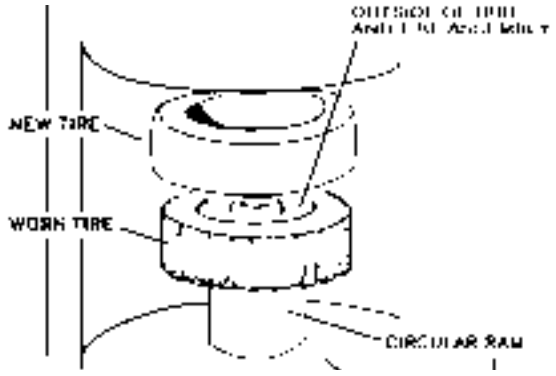


Figure 7-103. Drive Tire Installation with Press

3. If the outside edge of the hub is not flush with the edge of the metal insert in the old tire, measure how far the hub is recessed inside the tire. Place the new tire in the same position the old tire was installed on the hub. You can use a spacer (slightly smaller in diameter than the inside diameter of the tire insert and the same thickness as the depth of the recess) to obtain the correct amount of recession.
4. Position the hub assembly with the old tire on the top of the circular ram so the outside of the wheel is positioned upward. The outside edge of the hub has a chamfer to help guide the new tire onto the wheel. The chamfered edge must always be the leading edge when you press a tire onto the hub.
5. Center the hub assembly on top of the ram and make sure that they mate squarely.
6. Apply grease to the inside of the tire rim.
7. Position the new tire with its chamfered insert facing the hub. Align the new tire and the hub so that they are concentric.
8. Begin pressing the new tire onto the hub and the old tire off the wheel. Run the press slowly for the first few inches of travel, because this is the critical stage of the operation. If the tire begins to cock to one side, stop the press and realign the tire. A sharp jar with a soft-headed mallet will usually realign the tire on the hub.
9. If the new tire does not press on with a minimum of 5 tons (68,947 kPa) pressure, try pressing a different new tire. If the tire still does not press on, replace the hub and tire assembly.
10. Release the press. Remove the wheel, tire assembly, and the old tire from the press table. Wipe off any grease. Inspect the wheel and tire assembly.

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Brake Assembly

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the tractor cover.
3. Insert brake release bolts and tighten. This will retain the springs in the brake assembly.

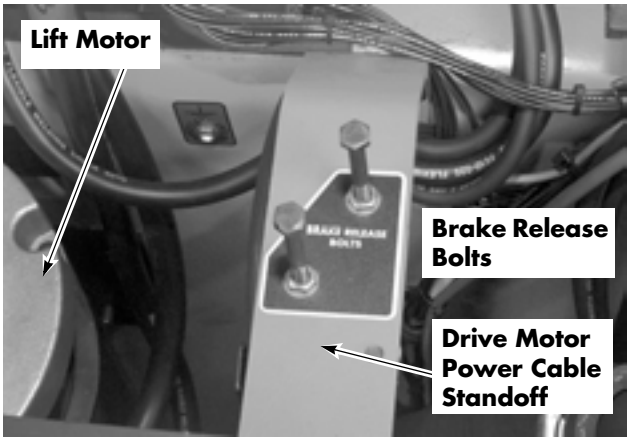


Figure 7-104. Brake Release Bolts storage location

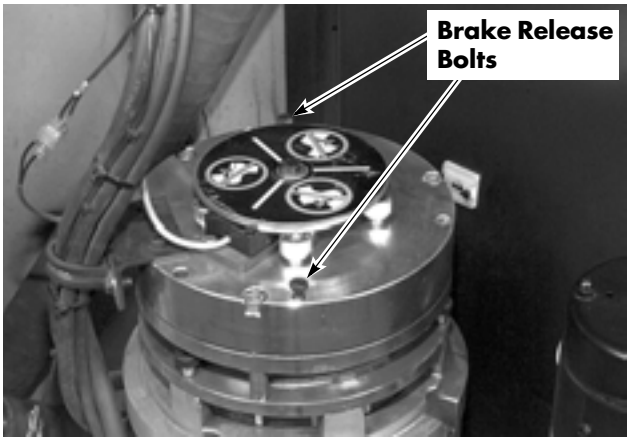


Figure 7-105. Brake Release Bolts

4. Remove the speed feedback proximity sensor assembly from the brake coil.
5. Disconnect the two brake coil harness terminals.
6. Remove the power cable strain relief from the top of the brake assembly.

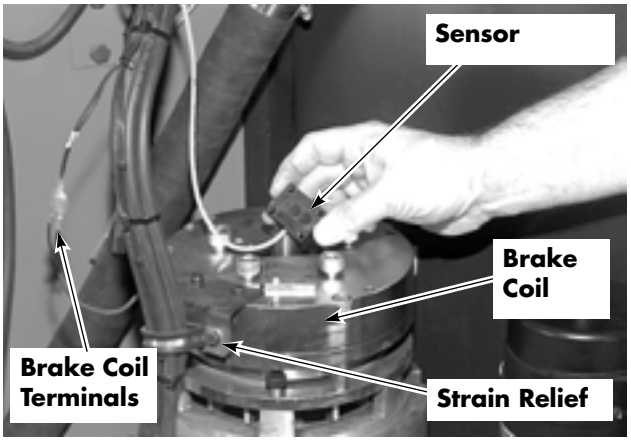


Figure 7-106. Speed Feedback Proximity Sensor Removal

7. Remove the snap ring and shims securing the brake to the drive motor shaft.

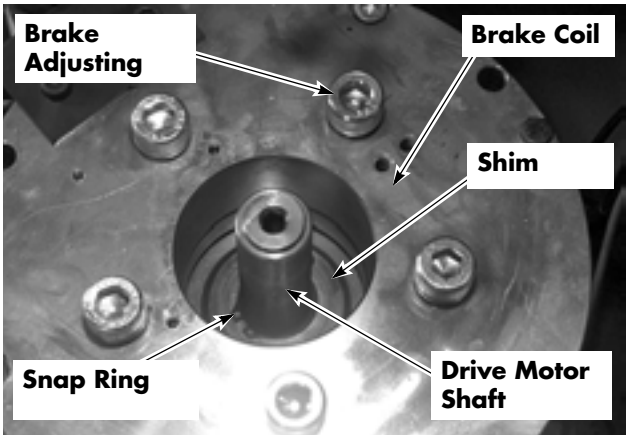


Figure 7-107. Snap Ring and Shim Removal

8. Remove three bolts securing the *lower* brake pad disc to the motor housing. Loosen the bolts part way and raise the

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brake assembly, then repeat the process until the bolts are entirely removed.

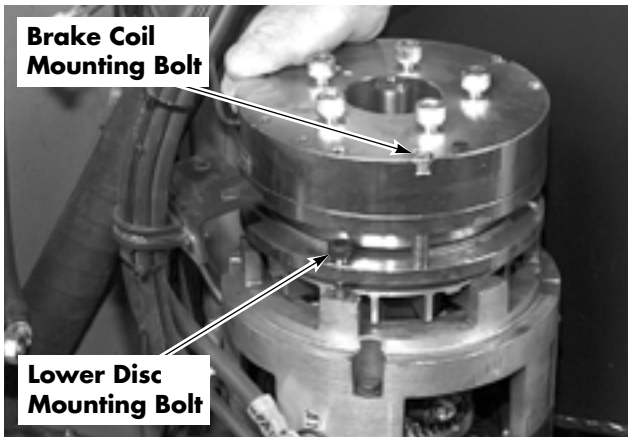


Figure 7-108. Lower Disc Mounting Bolt

9. Remove the brake assembly.

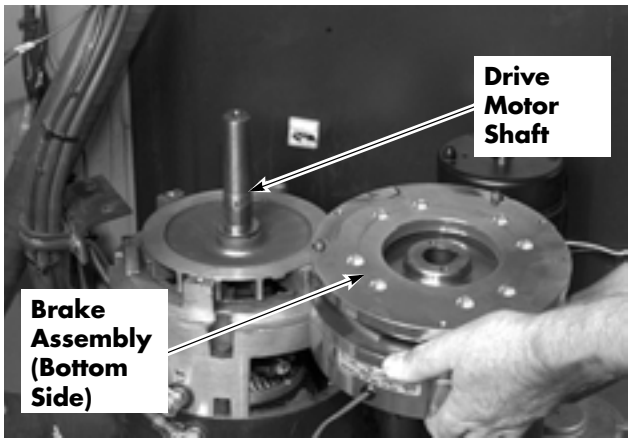


Figure 7-109. Brake Removed, Bottom Side Up

Installation

1. Install the brake assembly on the drive motor with three mounting bolts. Torque the mounting bolts to 12 ft. lb. (16 Nm).
2. Install the shim and snap ring securing the brake to the drive motor shaft.
3. Remove the brake release bolts.
4. Attach the speed feedback proximity sensor assembly.
5. Attach the speed sensor disc.
6. Attach the drive motor power cable strain relief at the top of the brake assembly.
7. Reconnect the brake coil wire terminals connectors.

⚠ WARNING

Make sure the brake release bolts are completely removed before operating the truck. If the bolts are not removed, the brake will not function!

8. Return brake release bolts to their storage holes in the cable standoff bracket.
9. Test and adjust the brake. See “Brake Adjustment” on page 7-74.

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Brake Pads

NOTE: Brake pads must be a minimum thickness of 3/32 in. (2.3 mm).

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove tractor cover.
3. Insert brake release bolts and tighten. This will retain springs in the brake assembly. (For brake release bolt storage location, see Figure 7-104 on page 7-69.)

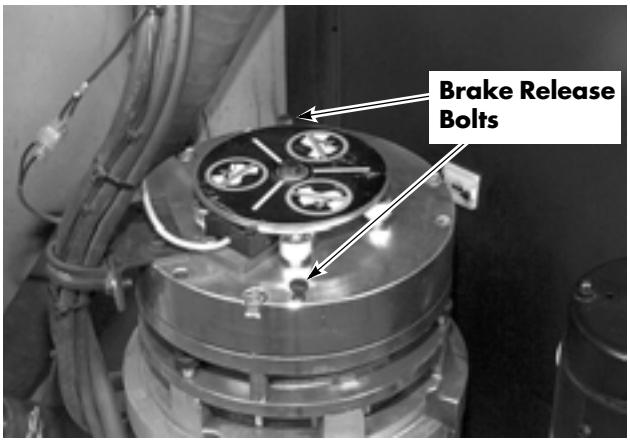


Figure 7-110. Brake Release Bolts

4. Remove the speed feedback proximity sensor assembly from the brake coil.

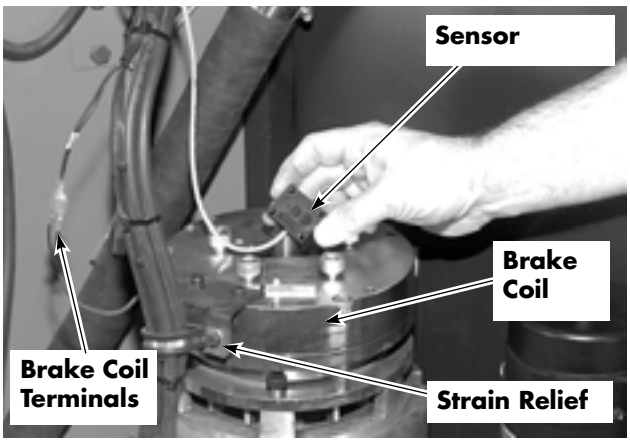


Figure 7-111. Sensor Assembly Removal from Brake Coil

5. Disconnect two brake coil harness terminals.
6. Remove the drive motor power cable strain relief from the top of the brake assembly.
7. Loosen five brake adjusting cap screws on the top of the top brake pad disc.

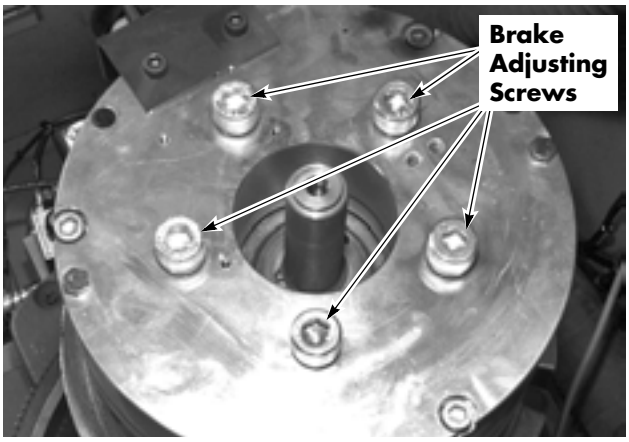


Figure 7-112. Brake Adjusting Cap Screws

8. Remove three brake coil mounting bolts, washers, and standoff studs, taking care not to drop standoffs into drive motor. See Figure 7-113.
9. Lift off the brake coil and upper brake pad disc.

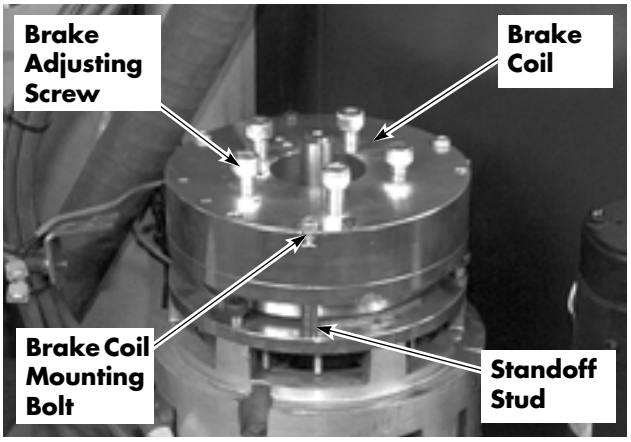


Figure 7-113. Brake Mounting Bolts and Adjusting Screws

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⚠CAUTION

Brake springs are under more than 200 lbs. (90 kg) compression. Use care when separating pad disc from coil.

10. Clamp the brake pad disc and coil with three evenly spaced C-clamps. Slowly, evenly, and carefully remove the brake release bolts. Slowly, evenly, and carefully loosen the C-clamps, releasing tension on the brake springs. Separate the brake pad disc from the coil.

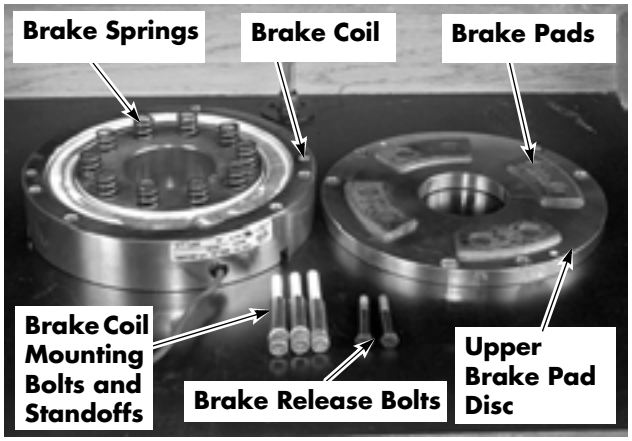


Figure 7-114. Brake Pad Disc and Coil Separation

11. On the truck, remove the snap ring, shim, and rotor.

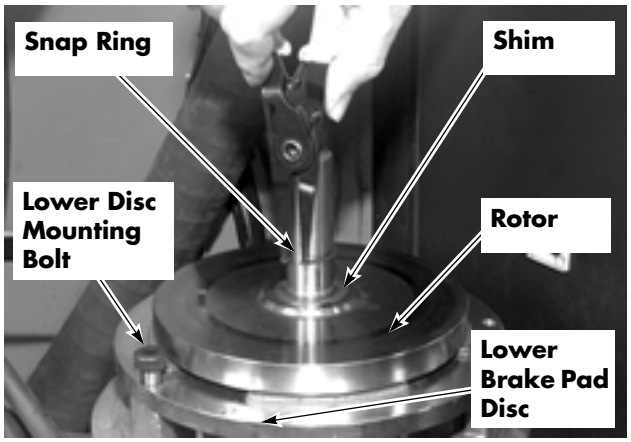


Figure 7-115. Snap Ring, Shim and Rotor Removal

12. Remove three bolts securing the lower brake pad disc. Remove the lower brake pad disc.

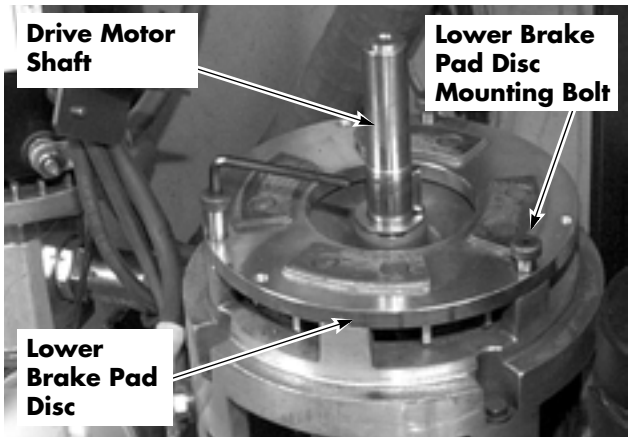


Figure 7-116. Lower Brake Pad Disc

Installation

1. Install the lower brake pad disc on the drive motor with three mounting bolts.
2. Align holes on the new brake pad disc with springs and holes on the brake coil. Compress the plate with three evenly spaced C-clamps and reinstall the brake release bolts. Remove the C-clamps.
3. Install the rotor, shim, and snap ring over the lower brake pad disc.
4. Attach the brake coil and upper brake pad disc assembly with 3 mounting bolts and standoffs.
5. Remove the brake release bolts.
6. Attach the speed sensor assembly.
7. Attach the speed sensor disc.
8. Reconnect the brake coil wire terminals connectors.

⚠ WARNING

Make sure you remove the brake release bolts completely before operating the truck. If the bolts are not removed, the brake will not function!

9. Return brake release bolts to their storage location on the drive motor power cable standoff. See Figure 7-104 on page 7-69.

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10. Test and adjust the brake. See "Brake Adjustment" on page 7-74.

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Brake Adjustment

⚠CAUTION

Incorrect clearance between the brake pads and rotor can cause the top or bottom brake pad to drag.

Rotor Gap Inspection

1. Do Test O08 - Toggle Brake Release.
2. Measure the smallest gap between the brake coil housing and the upper brake pad assembly around the entire assembly. The gap must measure 0.028 ± 0.009 in. (0.71 ± 0.22 mm).
3. Measure the gap in three evenly spaced locations around the brake. When comparing readings, make sure the difference between any two readings is less than 0.037 in. (0.94 mm).
4. If the gap is more than 0.037 in. (0.94 mm), adjust the gap as described below.

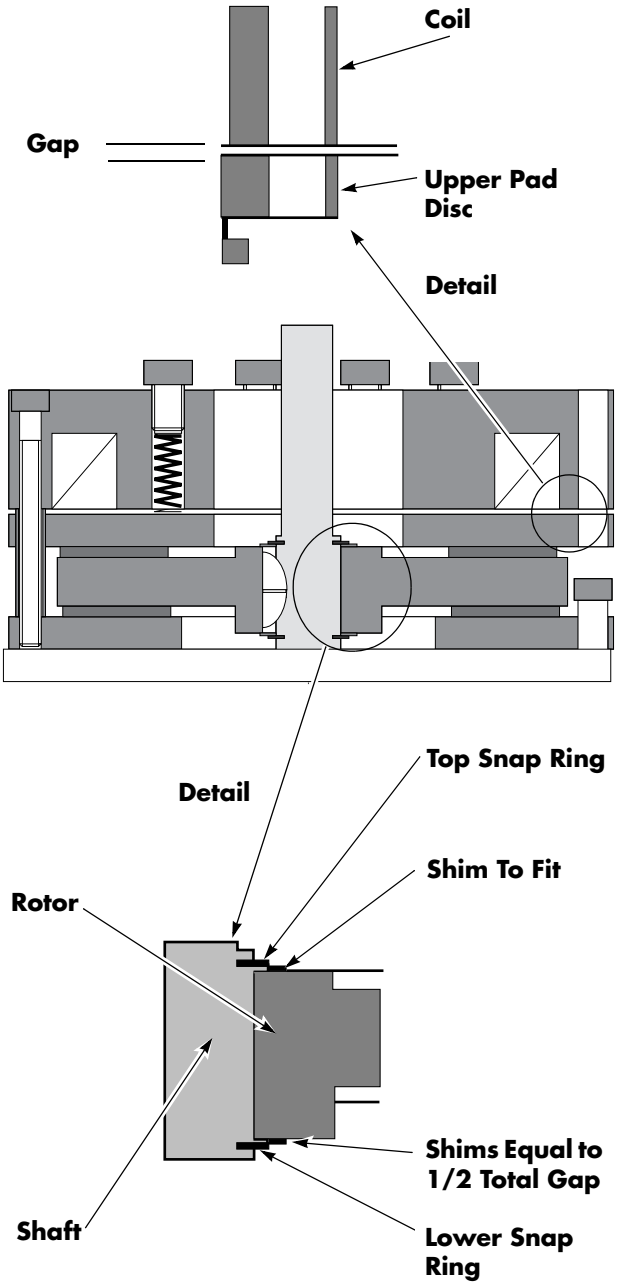


Figure 7-117. Brake Rotor Gap Adjustment

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Rotor Gap Adjustment

1. Remove the brake assembly. See "Brake Assembly" on page 7-69.
2. Remove the brake release bolts and return them to their storage location in the tractor compartment.
3. With the brake assembly off the truck, measure the smallest gap between the brake coil housing and the upper brake pad assembly around the entire assembly. The gap must measure 0.028 ± 0.009 in. (0.71 ± 0.22 mm).
4. Divide the gap measured in the last step by two.
5. Make sure the lower snap ring is installed correctly in the groove on the drive motor shaft, *with the flat side of the snap ring facing down*.
6. Remove the key from the drive motor shaft.
7. Place shims on top of the lower snap ring equal to the measurement in step 4 above. Use the smallest number of shims needed (use one 0.010 in. instead of two 0.005 in.). Use only shims which fit the motor shaft snugly. When using more than one shim, place the thickest shim next to the snap ring.
8. Temporarily place the brake assembly on the motor shaft, without the key.
9. Shim between the top surface of the rotor hub and the bottom of the top snap ring to eliminate any gap. When using more than one shim, place the thickest shim next to the snap ring. You should not be able to rotate the shims after the upper snap ring is installed.
10. Install the upper snap ring, with the flat side of the snap ring facing *up*.
11. Mount the brake assembly, torquing the three brake assembly mounting bolts to 12 ft. lb. (16 Nm).
12. Reconnect the brake coil wires. Reconnect the battery connector and turn the key switch ON. Run Output Test O08 to energize (release) the brake.
13. With the brake energized (released), the clearance between the rotor and top pad should be approximately the same as the clearance between the rotor and the bottom pad. Clearance of 0.002 in. to 0.021 in. (0.05 to 0.53 mm) are acceptable.

    If the top clearance is greater than the bottom clearance, relocate shims from the top to the bottom. If the bottom clearance is greater than the top clearance, relocate shims from the bottom to the top.
14. When the correct clearance is achieved, turn the truck OFF and disconnect the battery connector. Remove the brake assembly. Install the key in the drive motor shaft, then remount the brake assembly. Torque the three brake assembly mounting bolts to 12 ft. lb. (16 Nm).
15. Attach the speed feedback proximity sensor assembly.
16. Attach the speed sensor disc.
17. Reconnect the battery connector and turn the key switch ON.
18. Test the operation of the brake as described in the Scheduled Maintenance section.

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Brake Rotor

Removal

1. Remove the brake assembly. See Figure 7-104 on page 7-69.
2. With the brake assembly on a workbench, and the brake release bolts tightened, remove one and *only one* of the three bolts holding the brake assembly together. Retain spacer and any shims.
3. Slide the rotor out of the assembly.

Installation

1. Slide the new rotor into the assembly between the coil and the upper brake pad disc.
2. Install the brake assembly bolt previously removed, together with spacer and any shims. Torque to 9 ft. lb. (12 Nm).
3. Center the rotor within the assembly. Then remove the brake release bolts.
4. Adjust the brake gap. See “Brake Adjustment” on page 7-74. Follow all the steps indicated.
5. Test the operation of the brake as described in the Scheduled Maintenance section.

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Electrical Components

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Electrical Component Procedures Summary

Table 7-5. Electrical Component Procedures Summary

Component	Procedure / Photo or Drawing	Thread-Locking Compound/ Torque Values	Helpful Hints
Auxiliary Contactor Interface Module	Locator Photo: Figure 7-17 on page 7-15		After installation, run “Learn Carriage” and test lift truck auxiliary functions.
Auxiliary Interface Module	Locator Photo: Figure 7-16 on page 7-14		
Auxiliary Motor Control Card	Locator Photo: Figure 7-15 on page 7-13		Used on older trucks, no longer available, replaced by Auxiliary Power Amplifier and Auxiliary Interface Module on SA S/N < 03000 and SB S/N < 00700.
Auxiliary Power Amplifier	Procedure: page 7-107		Momentarily depress the PC1, PC2, and P contactor tips. This dissipates the charge in the auxiliary control circuit.
Auxiliary Pump and Motor	Locator Photos: Figure 7-5 and Figure 7-6 on page 7-5	Molybdenum anti-seize compound (P/N 990-638) to mating surfaces of the pump and motor coupling Aux pump mounting bolts: P/N 990-536 / 9 ft. lb. (12 Nm) Aux motor mounting bolts: 15 ft. lb. (20 Nm) Power cables: 100-120 in. lb. (11.2-13.6 Nm).	EE-rated trucks: A feeler gauge of 0.017 inch (0.43 mm) must *not* be able to fit between the brush band and the housing at any point around the motor. On power cables, use two wrenches to avoid twisting the motor studs.
Battery Procedures	Procedures: page 7-86		

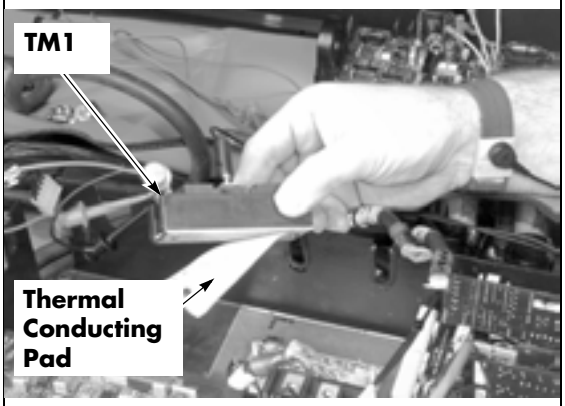
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Table 7-5. Electrical Component Procedures Summary

Component	Procedure / Photo or Drawing	Thread-Locking Compound/ Torque Values	Helpful Hints
Carriage Manager	Locator Photos: Figure 7-25 on page 7-22, Figure 7-53 on page 7-30 Card Connectors: Figure 6-6 on page 6-83, Figure 6-7 on page 6-84	CM assembly mounting bolts: P/N 990-536	Record configuration settings if possible before replacing CM; after replacing CM, reconfigure truck. See "Configure Mode Settings" on page 6-10. When using CM P/N 1002391/101 or 1002391/050, install firmware version 4.0 or higher.
Coil Driver Boards	Locator Photos: Figure 7-7 on page 7-6		
Cold Storage Components	Locator Photos: Figure 7-47, Figure 7-48, Figure 7-49, Figure 7-50, Figure 7-51 on page 7-29; Figure 7-52 on page 7-30		Aux Power Amplifier Heater and Thermostat present on SA S/N 00200 to 02999 and SB S/N 00125 to 00699.
Contactor Tip Replacement	None		Use all the new parts in the kit.
Contactors	None		
Drive Motor	None	Drive motor armature shaft lock nut: P/N 990-536/ 120 ft. lb. (163 Nm) Gasket sealing compound (P/N 990-520) on drive motor and drive unit mating surfaces Drive motor mounting bolts: 20 ft. lb. (27 Nm) Power cables: 100 to 120 in. lb. (11.2 to 13.6 Nm).	EE-rated trucks: A feeler gauge of 0.017 inch (0.43 mm) must *not* be able to fit between the brush band and the housing at any point around the motor. On power cables, use two wrenches to avoid twisting the motor studs.

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Table 7-5. Electrical Component Procedures Summary

Component	Procedure / Photo or Drawing	Thread-Locking Compound/ Torque Values	Helpful Hints
Drive Motor Temperature Sensor	Locator Photo: Figure 7-21 on page 7-18	Apply heatsink compound P/N 990-508 to sensor threads.	
Field Transistors (TM1/TM2)	Locator Photos: Figure 7-7 on page 7-6		**⚠CAUTION** **Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-9.** Install new thermal conducting pad between the transistors and the heatsink. 
Firmware Replacement	Procedure: page 7-89		
Fuses	Locator Chart and Photos: page 5-6		
Height Manager, Mini	Card Connectors: Figure 6-12 on page 6-88		HM is in load handler turret.
Height Manager, Main	Locator Photos: Figure 7-54, Figure 7-55, Figure 7-56 on page 7-30		*Series SA:* HM is at top of main mast. *Series SB early trucks:* HM is on back (tractor) side of operator platform. *Series SB later trucks:* HM is behind operator's seat.
Horn Assembly	None		

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Table 7-5. Electrical Component Procedures Summary

Component	Procedure / Photo or Drawing	Thread-Locking Compound/ Torque Values	Helpful Hints
Lift Motor	Locator Photos: Figure 7-3 and Figure 7-4 on page 7-5	Molybdenum anti-seize compound (P/N 990-638) to mating surfaces of the pump spline and motor coupling Lift pump and lift motor mounting bolts: P/N 990-536 / 21 ft. lb. (29 Nm) Power cables: 100 to 120 in. lb. (11.2 to 13.6 Nm)	Motor locating pins must be in lower holes in frame for Series SA and in upper holes for Series SB. EE-rated trucks: A feeler gauge of 0.017 inch (0.43 mm) must *not* be able to fit between the brush band and the housing at any point around the motor. On power cables, use two wrenches to avoid twisting the motor studs.
Line Filter	Locator Photos: Figure 7-8 and Figure 7-9 on page 7-7		
Main Mast Height Sensor	Procedure: page 7-99		
Mini-Mast Height Sensor	Procedure: page 7-93		
Motor Procedures	None		
Operator Display Interface Card	Locator Photo: Figure 7-57 on page 7-31 Card Connectors: Figure 6-13 on page 6-88		Download the Operator Display graphics. See “Graphics Database Download” on page 6-24.
Pin Extraction	Procedure: page 7-91		
Power Card	Locator Photos: Figure 7-7 on page 7-6 Card Connectors: Figure 6-2 on page 6-80		

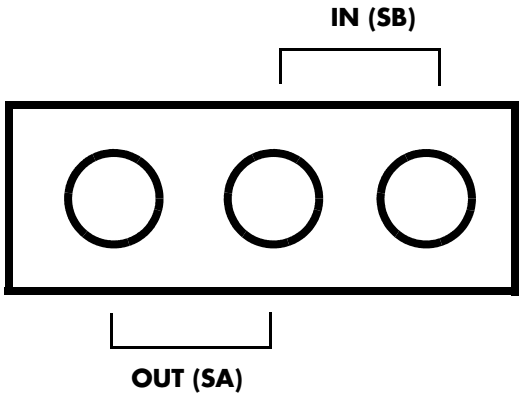
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Table 7-5. Electrical Component Procedures Summary

Component	Procedure / Photo or Drawing	Thread-Locking Compound/ Torque Values	Helpful Hints
Power Panel Heatsink Assembly	Locator Photos: Figure 7-10 on page 7-8, Figure 7-11 on page 7-9, Figure 7-12 on page 7-10		
Power Panel Temperature Sensor	Locator Photo: Figure 7-10 on page 7-8 and Figure 7-11 on page 7-9	Apply heatsink compound P/N 990-508 to sensor threads.	
Power Transistor (Q1)	Locator Photo: Figure 7-10 on page 7-8 and Figure 7-11 on page 7-9		Remove protective paper from new thermal conducting pad and attach pad to bottom of transistor.
Reach Position Proximity Sensor (PROX2)	Locator Photos: Figure 7-43 on page 7-28, Figure 7-44 and Figure 7-45 on page 7-28		Adjust the gap between the sensor and the carriage frame to 0.06 to 0.12 inches (1.5 to 3 mm).
REC1	Locator Photo: Figure 7-10 on page 7-8 and Figure 7-11 on page 7-9	Apply heatsink compound P/N 990-508 to threads.	
Rotate Position Feedback Potentiometer (VR6)	Procedure: page 7-102		
Sidegate Switch	Locator Photo: Figure 7-40 on page 7-27	Switch body screws: P/N 990-403 Switch bracket mounting bolts: P/N-990-536	

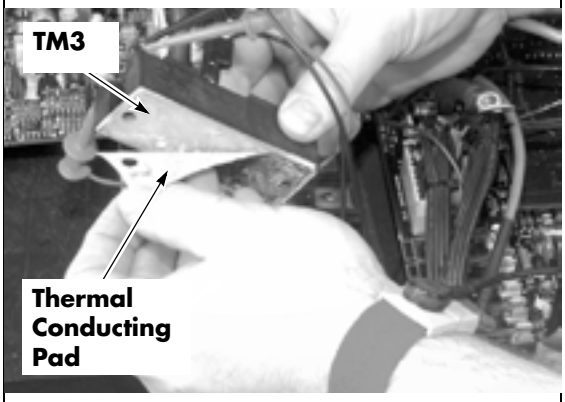
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Table 7-5. Electrical Component Procedures Summary

Component	Procedure / Photo or Drawing	Thread-Locking Compound/ Torque Values	Helpful Hints
Slack Chain Switch	Adjustment Procedure: page 7-106		
Steer Manager	Locator Photos: Figure 7-7 on page 7-6 Card Connectors: Figure 6-8 on page 6-85		SM P/N 154-012-351/020 or later requires SM firmware version 2.1 (P/N 073-312-002/021) or higher. Make sure the E1 jumper is plugged for the correct lift truck series. • Series SA = out • Series SB = in  *Figure 7-118. E1 Jumper Position* Run Learn Mode for Steering and Wire Guidance.
Steer Manager Firmware	Locator Drawing for M12 chip: Figure 6-8 on page 6-85		

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Table 7-5. Electrical Component Procedures Summary

Component	Procedure / Photo or Drawing	Thread-Locking Compound/ Torque Values	Helpful Hints
Steering Transistors (TM3/TM4)	Locator Photos: Figure 7-7 on page 7-6		**⚠CAUTION** **Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-9.** Install new thermal conducting pad between the transistors and the heatsink. 
Tractor Manager Card	Locator Photos: Figure 7-7 on page 7-6		Make sure jumpers are installed between pins 1 and 2, 3 and 4, 5 and 6 of shunt E2. Shunt E3 should have no jumpers installed. See Figure 6-3 on page 6-81.
Tractor Manager VFC Card	Locator Photos: Figure 7-7 on page 7-6		VFC P/N 1002059/202 and later requires TM firmware version 4.00 (P/N 073-312-001/400) or higher. If you install new Tractor Manager VFC firmware, download the new graphics database from the Tractor Manager VFC Card to the Operator Display Interface Card. See "Graphics Database Download" on page 6-24.
Tractor Speed Chip	Locator Drawing: Figure 6-3 on page 6-81		The Tractor Speed Chip is component M14 on the Tractor Manager Card, underneath the Tractor Manager VFC Card.
Traverse Position Feedback Potentiometer (VR5)	Procedure: page 7-104		

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Table 7-5. Electrical Component Procedures Summary

Component	Procedure / Photo or Drawing	Thread-Locking Compound/ Torque Values	Helpful Hints
Wire Guidance Filter Card	Locator Photos: Figure 7-7 on page 7-6		Run Learn Mode for wire guidance frequency and offsets as applicable.
Wiring, General	Procedures: See "Wiring, General" on page 7-92.		

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Battery Procedures

⚠CAUTION

Before working on the battery, review Battery Safety, beginning on page 2-6. Batteries for this truck weigh between 2900 and 3700 lbs. (1317 to 1680 kg). Use extreme care during replacement. Use a suitable battery moving device. Do not extend a battery more than 1/3 of its length outside the battery compartment without being attached to a battery moving device.

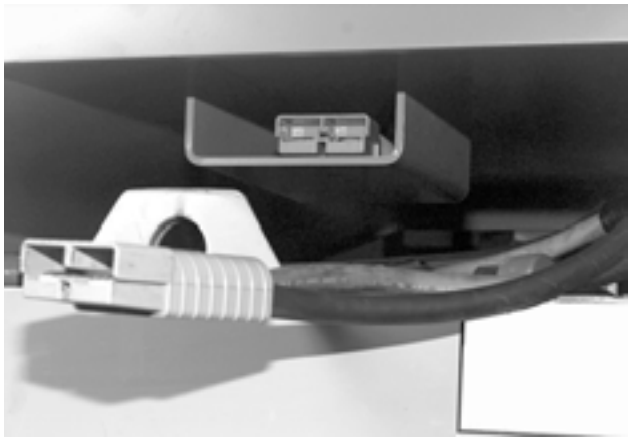


Figure 7-119. Battery Connector

Battery Connector

Inspection

1. Remove the right side cover.
2. Turn the key switch OFF and disconnect the battery connector.
3. Check the battery connector for damaged cables.
4. Check to see if battery cables are pulling out of the connector.
5. Check the cables at the battery terminals. Connections must be tight, with no corrosion.
6. Look inside the connector. Check internal contacts for damage, dirt, or corrosion. *Do not use a metal object to clean the connector.*

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.

To remove a cable from the connector, push this retainer down while pulling the battery cable towards the rear and out of the connector. See Figure 7-120 and Figure 7-121.

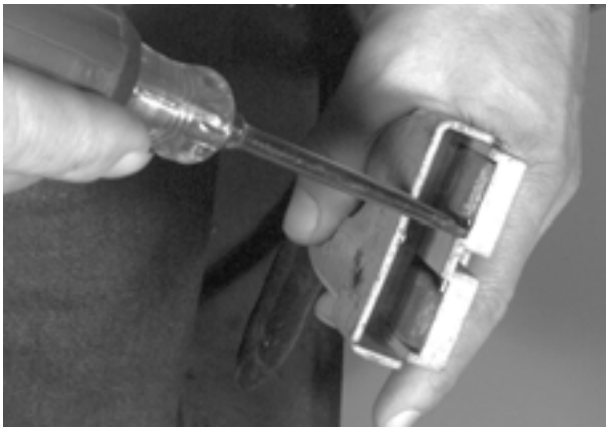


Figure 7-120. Battery Cable Removal from Connector



Figure 7-121. Battery Cable and Connector

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 2-6.
3. Turn the key switch OFF and disconnect the battery connector. Remove the battery from the 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.

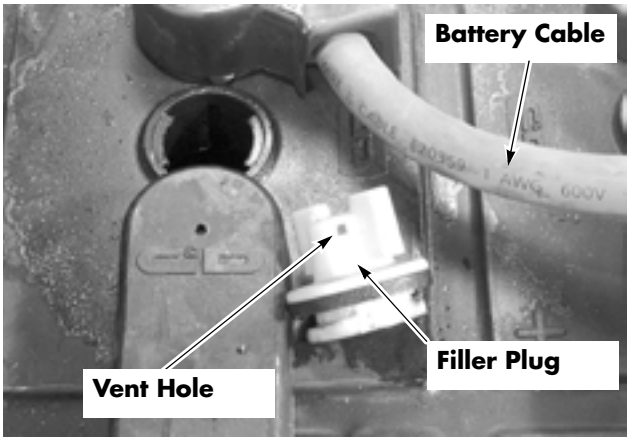


Figure 7-122. Battery Cable and Filler Plug

5. Keep the top of the battery clean and dry. Corrosion, dust, and moisture provide a conducting path to short-circuit cells or create grounds.

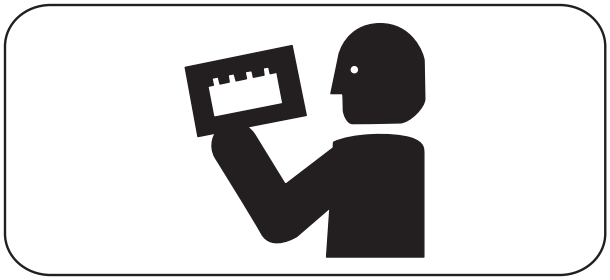
⚠CAUTION

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 components and cause serious damage.

6. Wash dirty batteries (or any that have had electrolyte spilled on them) with a solution of 1 lb. (0.45 kg) of baking soda added to 1/2 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 with compressed air (maximum 30 psi or 207 kPa or 2.1 kg/cm^2) before reinstalling it.
10. Apply a thin coat of petroleum jelly to the battery posts and cable terminals.
11. Reinstall the battery in the truck, using a suitable battery moving device. Reconnect the battery connector.

Testing, Charging, and Maintenance

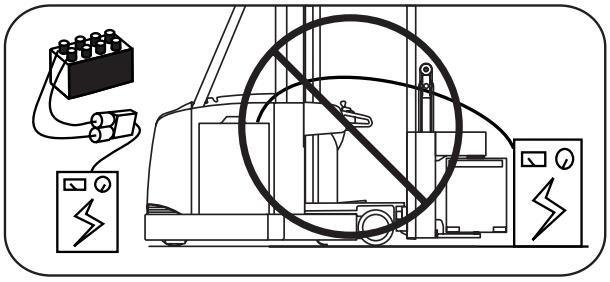
For information on testing, charging, and maintaining your lift truck battery, consult the battery manufacturer's specifications and instruction manual.



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⚠CAUTION

***Never* plug the battery charger into the truck. This will severely damage the truck's electrical system. Plug the charger *only* into the connector from the battery.**



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Firmware Replacement

General Instructions

1. Turn the key switch OFF and disconnect the battery connector.

⚠CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-9.

2. Follow all the instructions in Chapter 2, "Static Precautions," regarding the use of a static discharge wrist strap, static mats, and antistatic bags and boxes.
3. The only approved circuit chip extraction tool for this lift truck is P/N 950-032. See Figure 7-123.

⚠CAUTION

Failure to use an approved circuit chip removal tool could result in damage to the chip or socket.

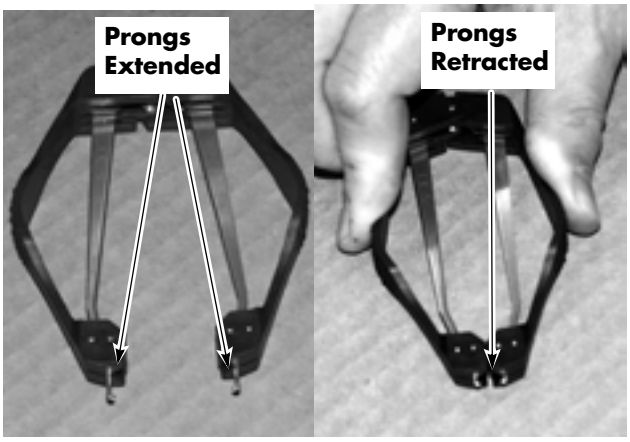


Figure 7-123. Chip Extraction tool P/N 950-032

Removal

1. Read the General Instructions in the preceding section.
2. Look at the circuit chip's socket on the circuit board. Of the four slots in the corners of the socket, two diagonally opposite slots open into the chip cavity. These holes receive the prongs of the removal tool.

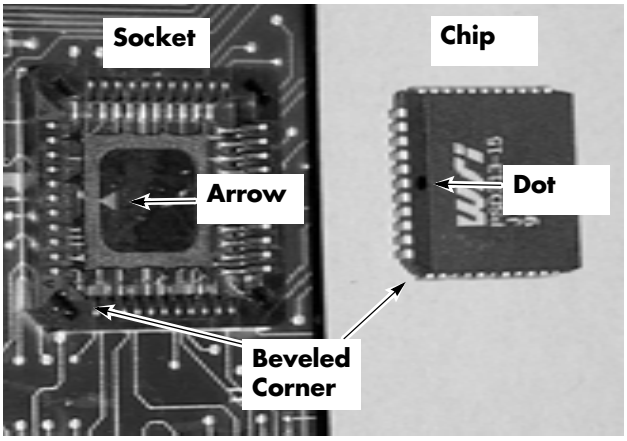


Figure 7-124. Firmware Socket and Chip

3. Insert the prongs of the extraction tool into the holes identified in the previous step.

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Hold the tool perpendicular (straight up) to the socket. See Figure 7-125.



Figure 7-125. Firmware Chip Removal

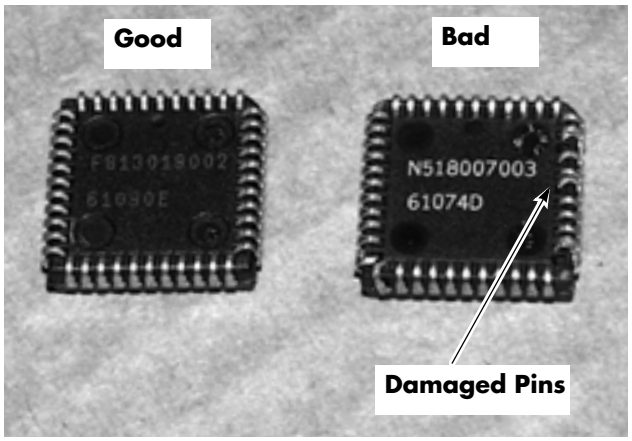


Figure 7-126. Firmware Chip inspection (chips upside down to reveal pins)

4. Gently but firmly squeeze the jaws of the tool together. The prongs retract, lifting and loosening the chip from its socket. (See Figure 7-123 on page 7-89 to see the lifting action of the retracting prongs.) *Do not rock or pull on the chip to release it.*

Chip Installation

1. Inspect the chip to make sure there are no bent, broken, or missing pins or other sign of physical damage. See Figure 7-126.
2. Notice the beveled corner and the arrow in the chip socket. Notice the beveled corner and the dot on the beveled edge of the chip. See Figure 7-124 on page 7-89.
3. Orient the chip so the dot on the chip matches the arrow on the socket and the beveled corner of the chip matches the beveled corner of the socket.
4. With your thumb, gently press the chip into the socket. Make sure it is completely seated on all four edges. See Figure 7-127 and Figure 7-128.

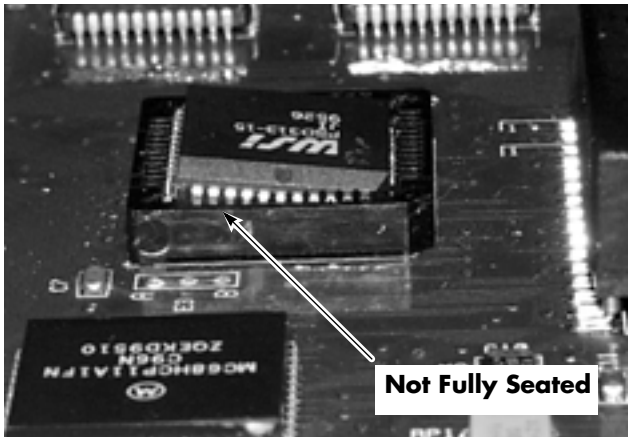


Figure 7-127. Firmware Chip incorrectly seated in socket

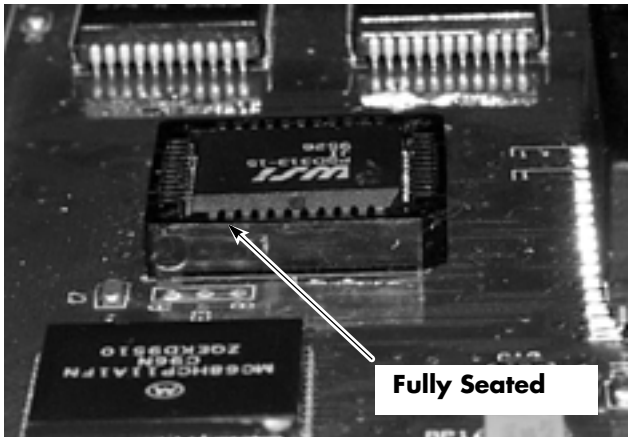


Figure 7-128. Firmware Chip fully seated in socket

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Pin Extraction

For pin orientation of Molex connectors, see page 6-75. Molex connectors have pins with locking ears that engage ridges in the plastic connector body. To remove a pin from a Molex connector, these locking ears must be depressed far enough to clear the ridge in the connector.

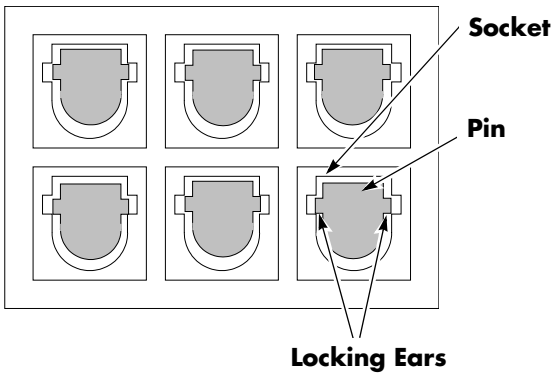


Figure 7-129. Molex Connector, end view

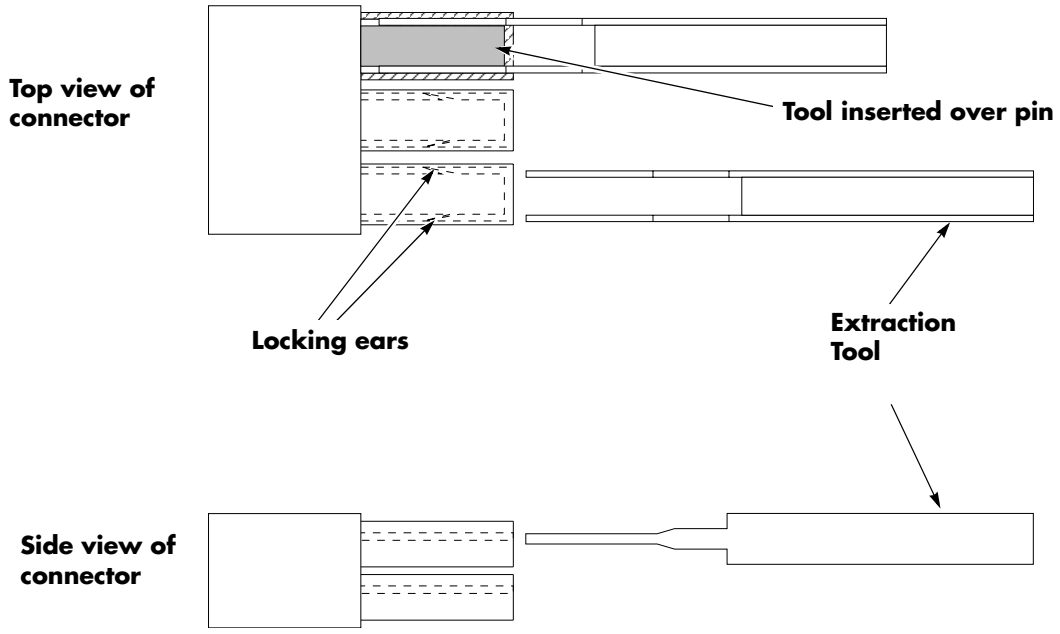


Figure 7-130. Pin Extraction

Removal

To remove a pin from a Molex connector, use pin extraction tool P/N 950-026.

1. Insert the extraction tool over the pin and push completely into the connector. This releases the locking ears on the pin.
2. Pull the wire and pin from the connector.

Insertion

To insert a pin into a Molex connector, insert the pin into the back side of the connector and push the wire in completely until it clicks. The locking ears have now engaged the connector.

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Wiring, General

Inspection

See "Troubleshooting Wiring Problems" on page 5-19.

Repair

Whenever working on the truck, use care around wiring harnesses.

⚠CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-9.

- Do not pull on wires.
- Carefully connect and disconnect all connections.
- Do not pry connectors apart with unspecified tools.

There must be a wire marker at each termination. If the marker is missing or unreadable, remark the wire to permit easier identification.

NOTE: It is normal to find unused connectors for uninstalled options that have had heat shrink applied over them and have been strapped to the harness.

When replacing wires, in some cases you will be able to tape or solder one end of a new wire to one end of the failed wire. Then you can pull the old wire out of the bundle and pull the new wire into the bundle, all at the same time. Make sure to disconnect the old wire from the new wire.

In other cases, it will be easier to secure a new wire with cable ties to the outside of the existing wire bundle. You can leave the failed wire in the bundle, or pull it by one end to remove it from the bundle.

When replacing wires, follow these guidelines:

- Use the appropriate tools to remove and insert terminations at each connector.
- Remove damaged terminations and discard. Never reuse a termination from a wire.
- Do not cut away a terminal lug and reuse the wire strands that were crimped into the original lug.
- When stripping wire, use new wire strands for new terminations. Make sure to use a new wire with extra length to permit for cutting and stripping of the ends to install new terminations.
- Use a new wire that is the same gauge (typically gauge 18 AWG), size, type, and color as the wire it is replacing.
- Use a hand stripper capable of stripping by wire gage number. Use care not to nick or cut any of the wire strands. Discard and replace a wire with damaged strands. Insert the wire strands the correct length into termination before crimping.

Soldering Procedures

To prevent damage from excessive heat when soldering small components in assemblies such as control handles, follow these guidelines:

- Flux: Rosin Base
- Solder: 60/40 Rosin Core or equivalent
- Solder Iron: 55 watt maximum
- Tip Size: 3 mm (0.118 in.) diameter x 30 mm (1.182 in.) long screwdriver point
- Tip Temperature: 500°F (260°C) maximum
- Terminal Contact Time: 6 seconds maximum

Make sure soldering tip is clean. A dirty tip does not transfer heat well and encourages long dwell time and greater pressure. Apply light pressure on the terminal.

After soldering, clean terminals with a brush dampened with an alcohol-based cleaner (P/N 990-600/FOF). Do not permit cleaner to seep into switches or potentiometers, or contact contamination could occur.

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Mini-Mast Height Sensor

Procedures for removing and installing the mini-mast height sensor depend on the height of the mini-mast. If you have the 118 in. (300 cm) mini-mast, the sensor is accessible by removing a section of the height sensing rail. If you have the 84 in. (213 cm) mini-mast, you must partially disassemble the load handler and remove it from the mast. Both procedures are described below.

Removal [118 in./300 cm mini-mast]

1. Remove the load handler turret cover and traverse motor cover.
2. Turn the key switch OFF and disconnect the battery connector.
3. Working from a ladder or work platform, remove the top-most section of the mini-mast height sensing rail. See Figure 7-131.

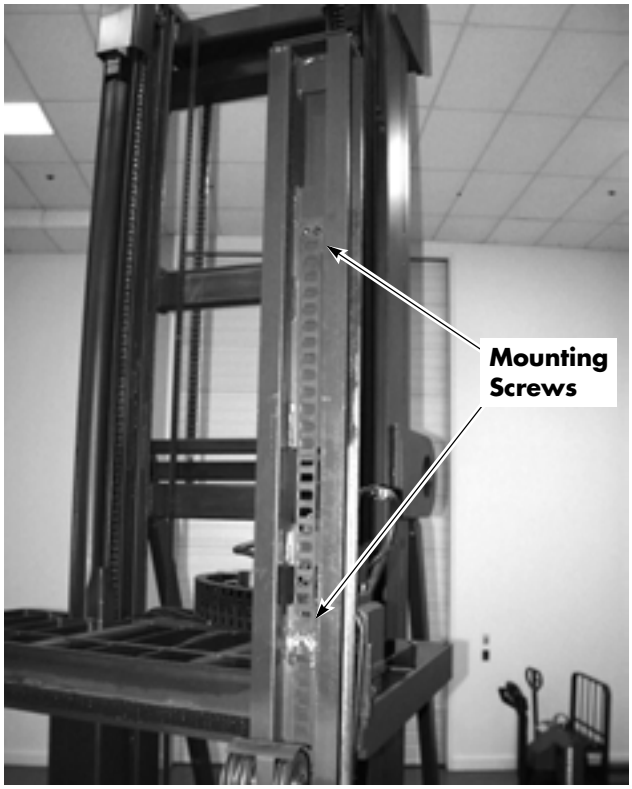


Figure 7-131. Mini-Mast Height Sensing Rail (118 in.)

4. Reconnect the battery connector and turn the key switch ON.
5. Elevate the load handler to position the mini-mast height sensor assembly within the cutout window in the mast, located in front of the traverse hydraulic motor. See Figure 7-132.

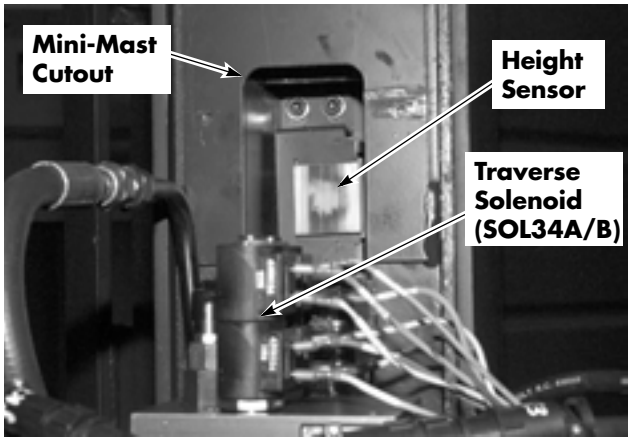


Figure 7-132. Mini-Mast Height Sensor (viewed from operator's side of mini-mast)

6. Turn the key switch OFF and disconnect the battery connector.
7. Working from a ladder or work platform, remove the height sensor cable harness from the height manager card at connector JP2 under the turret. Remove cable ties on the cable harness, noting their location for reinstallation. Using the appropriate tool, remove the pins from the J2 connector. Attach a 6 ft. (2 m) length of 18 gauge wire to these pins and tape them together securely to aid in routing the new harness cable. Secure the other end of the wire to the turret.
8. Remove the three bolts holding the sensor bracket to the mini-mast. See Figure 7-137 on page 7-96 for a clear view of the location. Pull the wiring harness through the metal tubing until the attached wire appears. Remove wire and tape it to the replacement sensor assembly cable.
9. Remove the fender washer securing the sensor housing in the mounting bracket. Remove the sensor housing and wave spring. Remove the sensor from the

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housing. See Figure 7-138 on page 7-96 and Figure 7-139 on page 7-98.

Installation [118 in./300 cm mini-mast]

1. Check the height sensor assembly as noted in "Checking the Height Sensor Assembly" on page 7-97.
2. Working from a work platform or ladder, attach the new height sensor assembly to the load handler with three mounting bolts. Pull the wire and harness through the metal tubing. If the code sleeve on the cable interferes with insertion of the cable into the tubing, remove the code sleeve and remove all traces of adhesive with solvent.
3. Insert wires in the J2 connector. Connect the harness to the height manager card at connector JP2. Attach cable ties in their original locations on the hydraulic metal tubing and in the turret, being careful not to pinch the wires too tightly.
4. Reconnect the battery connector and turn the key switch ON.

⚠CAUTION

Use care to avoid damaging the sensor assembly when lowering load handler on mini-mast.

5. Insert a section of 1.5 in. (38 mm) wide strap steel at least 12 in. (30.5 cm) down the mini-mast to act as a "shoehorn" to guide the sensor past the cutout in the rail and the traverse position feedback pot. *Failure to guide the sensor will result in damage to sensor and feedback pot!* Remove the strap steel when the sensor has engaged the rail.
6. Replace the top-most section of the height sensing rail previously removed.
7. Install the load handler turret cover and traverse motor cover.
8. Test the mini-mast lift and lower functions.

Removal [84 in./213 cm mini-mast]

1. Remove the load handler turret cover and traverse motor cover.
2. Retract the forks into their fully nested position. Rotate load handler so forks face straight ahead. Traverse the load handler completely to the left.
3. Turn the key switch OFF and disconnect the battery connector.
4. Remove the forks to keep the load handler balanced during this procedure.
5. Reconnect the battery connector and turn the key switch ON.
6. Elevate the load handler approximately 12 inches (300 mm). Block and clamp a wooden block in the mini-mast channel. See Figure 7-133.

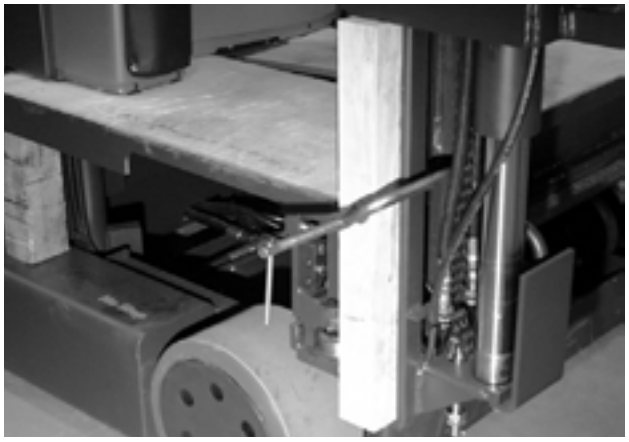


Figure 7-133. Load Handler Blocked

7. Lower the load handler onto the blocks. Let the lift chain, hoses, and cable go slack.
8. Turn the key switch OFF and disconnect the battery connector.
9. Remove the height sensor cable harness from the height manager card at connector JP2 under the turret. Remove cable ties on the cable harness, noting their location for reinstallation. Using the appropriate tool, remove the pins from the J2 connector. Attach a 6 ft. (2 m) length of 18 gauge wire to these pins and tape them together securely to aid in routing the new harness

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cable. Secure the other end of the wire to the turret.

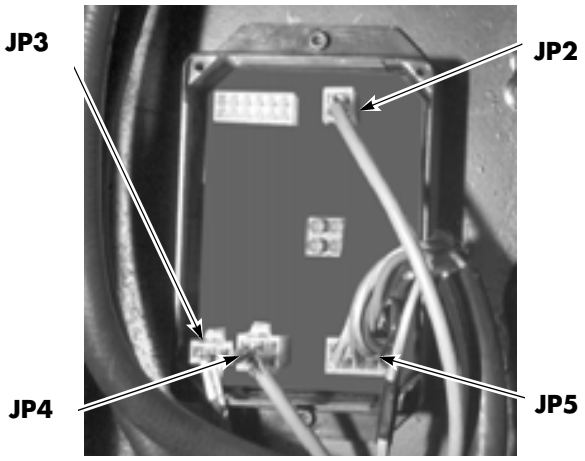


Figure 7-134. Height Manager, Mini-Mast

10. Use cables ties to temporarily attach the over-the-mast electrical cable to one of the hydraulic hoses in the turret. This keeps tension on the electrical cable inside the load handler.
11. Remove the load handler pulley bracket cover. Remove the hoses and cable from the pulleys, laying them carefully to the side of the mini-mast.
12. Using a hoist or other suitable lifting device, support the load handler carriage with straps.
13. Remove the lift chain anchor at the bottom of the mini-mast by removing jam nut, hex nut, and cotter pin. Lift the chain over the pulley and lay it carefully over the actuator. To pass the chain anchor through the pulley, twist the lift cylinder 90 degrees with a large screwdriver in the pulley eye. Then twist the cylinder back into its normal position. See Figure 7-135.

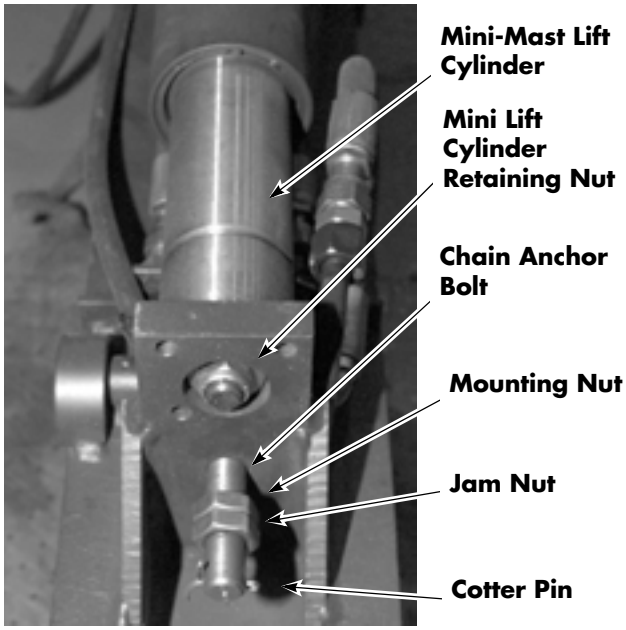


Figure 7-135. Mini-Mast Chain Anchor

14. Remove the pulley bracket assembly from the mini-mast cylinder by removing the mounting bolt in the end of the cylinder.

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15. Loosen mini-mast puck adjuster lock nuts and back out the adjusting screws completely. See Figure 7-136.

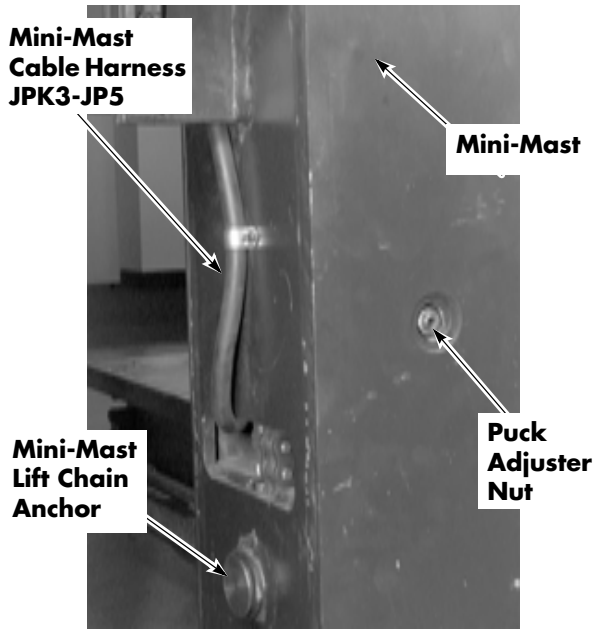


Figure 7-136. Mini-Mast Puck Adjusters

16. Using the hoist, slowly and carefully lift the load handler up the mini-mast to within 12 in. (300 mm) of the top plate. Make sure cable, hoses, and chain do not bind or catch on the load handler.
17. Working from a work platform or ladder, remove the stop plate on the top of the mini-mast. Cut the cable ties securing sensor to hydraulic tubing, noting their location for later installation.
18. Using the hoist, continue lifting the load handler past the cylinder until the sensor is visible above the mini-mast.
19. Working from a work platform or ladder, remove the three bolts holding the sensor bracket to the mini-mast. Pull the wiring harness through the metal tubing until the attached wire appears. Remove wire and tape it to the replacement sensor assembly cable.

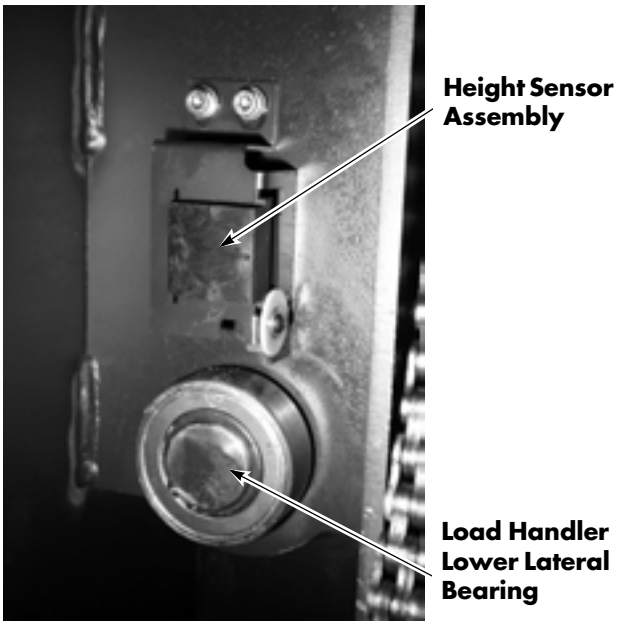


Figure 7-137. Mini-Mast Height Sensor Location

20. Remove the fender washer securing the sensor housing in the mounting bracket. Remove the sensor housing and wave spring. Remove the sensor from the housing. See Figure 7-138 this page and Figure 7-139 on page 7-98.

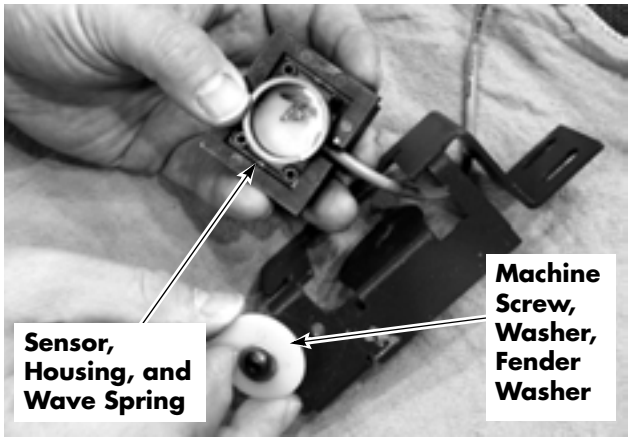


Figure 7-138. Mini-Mast Height Sensor, Detached from Mast

NOTE: You should take advantage of the opportunity to inspect the mini-mast

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cylinder pucks. Replace as required. See "Mini-Mast Pucks" on page 7-171.

This is also a good opportunity to inspect load handler upper bearings and to grease the load handler upper lateral bearing.

21. Working from ground level, clean the mini-mast cylinder of all grease and dirt. Apply a clean coating of grease where the pucks contact the cylinder.

Installation [84 in./213 cm mini-mast]

1. Check the height sensor assembly as noted in "Checking the Height Sensor Assembly" on page 7-97.
2. Working from a work platform or ladder, attach the new height sensor to the load handler with three mounting bolts. Pull the wire and harness through the metal tubing. Connect the sensor harness to the height manager card at connector JP2. Attach cable ties in their original locations on the hydraulic metal tubing and in the turret, being careful not to pinch the wires too tightly.
3. Make sure the mini-mast cylinder puck adjuster lock nuts are loosened and the adjuster screws backed out completely.

⚠CAUTION

Use care to avoid damaging the sensor assembly when lowering load handler on mini-mast.

4. Insert a section of 1.5 in. (38 mm) wide strap steel at least 12 in. (30.5 cm) down the mini-mast to act as a "shoehorn" to guide the sensor past the cutout in the rail and the traverse position feedback pot. *Failure to guide the sensor will result in damage to sensor and feedback pot!* Remove the strap steel when the sensor has engaged the rail.
5. Using the hoist, slowly lower the load handler until it rests on the blocks. Make sure cable, hoses, and chain do not bind or catch on the load handler.
6. Apply thread-locking compound (P/N 990-536) to the mini-mast stop plate mounting screws and install the stop plate. Torque to 70 ft. lb. (95 Nm).
7. Apply thread-locking compound (P/N 990-536) to the pulley bracket assembly mounting bolt and install the bracket assembly on the end of the mini-mast cylinder. Torque to 90 ft. lb. (122 Nm).
8. Using a large screwdriver, twist the mini-mast cylinder 90 degrees and feed the mini-mast lift chain anchor through the lift chain pulley. Once the chain hangs freely, twist the cylinder back into its normal position. Feed the lift chain and attach the chain anchor to the mini-mast.
9. Loop over-the-mast hoses and electrical cable over their pulleys and reattach the pulley bracket cover.
10. Reconnect the battery connector and turn the key switch ON.
11. Slowly raise the load handler to remove slack in over-the-mast hoses and cable. Remove blocks and lower the load handler completely. Remove the temporary cable tie securing the electrical cable to the turret. Attach the load handler turret cover and traverse motor cover.
12. Reinstall the forks. Check and adjust the fork height. See "Fork Height and Lift Chain Adjustment" on page 4-30.
13. Adjust the mini-mast cylinder pucks. See "Mini-Mast Pucks" on page 7-171.

Checking the Height Sensor Assembly

Make the following checks before reinstalling the Mini-Mast Height Sensor Assembly:

1. Check that the sensor is fully seated in the sensor housing.
2. Check for compression of the wave spring when the sensor housing is at rest in the mounting bracket. The sensor housing should be fully extended from the bracket and the wave spring should be slightly compressed. If this is not the case, bend the circular tab on the back of the

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mounting bracket toward the sensor until the wave spring is slightly compressed.

3. Insert the sensor in the sensor housing. Insert the sensor housing, housing side out, with the wave spring on the inside, into the mounting bracket. To prevent the sensor assembly from sliding out of the bracket, secure it with the screw, washer, and fender washer in the threaded hole in the edge of the bracket.

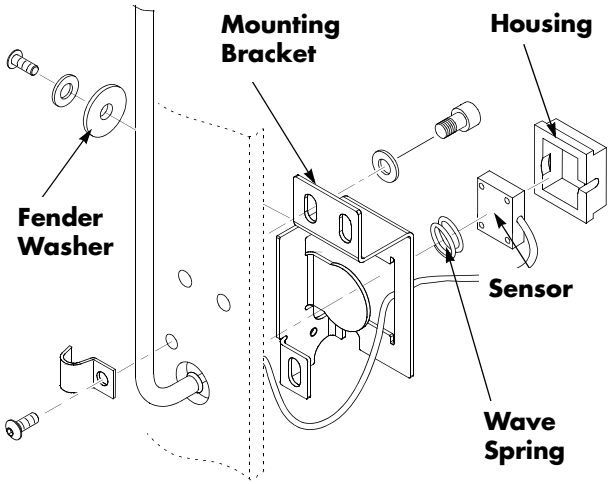


Figure 7-139. Mini-Mast Height Sensor components

4. Check that the sensor cable is not restricting the movement of the sensor housing in its mounting bracket.
5. To correct any restriction, cut the cable ties and reroute the cable, or replace the sensor assembly with one having the longer (59 in. or 15 cm) cable.
6. Replace the sensor assembly if the cable is cut, chafed or otherwise damaged.

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Main Mast Height Sensor

Removal

1. *Series SB only:* Elevate the operator carriage approximately 4 ft. (1.2 m) to expose the height sensor above the tractor bulkhead. Block and clamp the carriage securely.

NOTE: If a fault code prevents normal operation of the lift function, cycling the key switch ON/OFF/ON permits the lift function to operate intermittently to enable access to the main mast height sensor.

2. Turn the key switch OFF and disconnect the battery connector.
3. *Series SA only:* Use a ladder or work platform to access the main mast height sensor.

⚠CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-9.

4. Disconnect the height sensor cable harness connector JP1 at the height manager. Remove cable harness from the cable clamp on the carriage.
5. Apply protective tape over the sensor heads to protect them during removal.
6. Remove two height sensor bracket mounting bolts.
7. Carefully lower sensor assembly past the end of the height sensing rail.

Installation

1. *Series SB only:* Make sure the operator carriage is elevated approximately 4 ft. (1.2 m) to expose the mounting location above the tractor bulkhead, with the operator carriage blocked and clamped.
2. Make sure the key switch is OFF and the battery connector is disconnected.
3. Apply protective tape over the sensor heads to protect them during installation.
4. Carefully thread the sensor assembly behind the height sensing rail, starting from the bottom of the rail.

⚠CAUTION

Use correct electrostatic discharge precautions. See "Static Precautions" on page 2-9.

5. Install height sensor bracket on mast. Connect cable harness at connector JP1 at the main height manager. Secure cable harness in the cable clamp on the carriage.
6. Visually check centering of rail inside sensor assembly. If the sensor is not centered enough to avoid contact with the rail, adjust the height sensing rail as needed. If you cannot adjust the rail to perform satisfactorily, replace the rail.
7. Remove protective tape from sensor heads.
8. *Series SB only:* Remove blocking.
9. Reconnect the battery connector and turn the key switch ON.
10. Test main lift and lower (operator carriage) for correct operation.
11. If fork height adjustment is correct (see "Fork Height and Lift Chain Adjustment" on page 4-30), the Operator Display should show fork height as 3 in. (76 mm) with the operator platform and forks lowered completely. Adjust the sensor assembly in its slotted mounting holes if correction is necessary.

Adjustment (Series SB)

When the main mast height sensor is correctly adjusted, the distance between the center line of the sensor head and the tractor-most edge of the height count hole in the height rail is between 3/16 and 5/16 inch (4.75 to 7.9 mm). See Figure 7-140.

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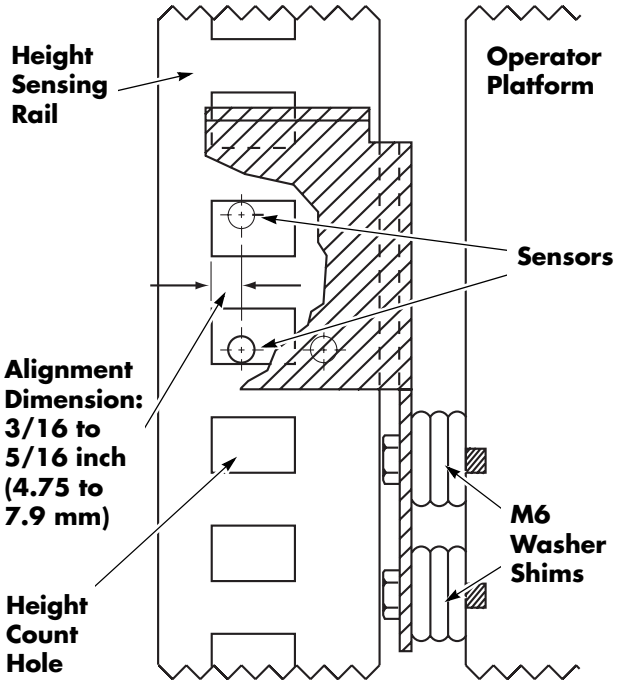


Figure 7-140. Series SB Main Height Sensor Adjustment

To adjust the sensor:

1. Adjust the main mast lateral bearings. See "Main Mast Lateral Adjustment (Series SB)" on page 7-150.
2. Elevate the operator carriage approximately 4 ft. (1.2 m) to expose the height sensor above the tractor bulkhead. Block and clamp the carriage securely.
3. Turn the key switch OFF and disconnect the battery connector.
4. Shim the sensor bracket to the platform with M6 flat washers to obtain the correct alignment.
5. Apply thread-locking compound (P/N 990-536) to the threads of the sensor assembly mounting bolts. Install mounting bolts and tighten.
6. Remove blocking. Reconnect the battery connector and turn the key switch ON.
7. Fully elevate and lower the operator platform while observing the position of the height sensor LEDs. They must track the holes of the rail for its full length as illustrated in Figure 7-140 on page 7-100.

   Repeat with a load nested to the left and with a load nested to the right.
8. Run Test I15 in dynamic diagnostic mode while observing the height information on the Operator Display. Make sure the height value increments and decrements correctly.

Adjustment (Series SA)

When the main mast height sensor is correctly adjusted, the distance between the edge of the height sensing rail and the main mast where the sensor assembly mounts is between 0.47 and 0.65 inch (12 to 16.5 mm). See Figure 7-141.

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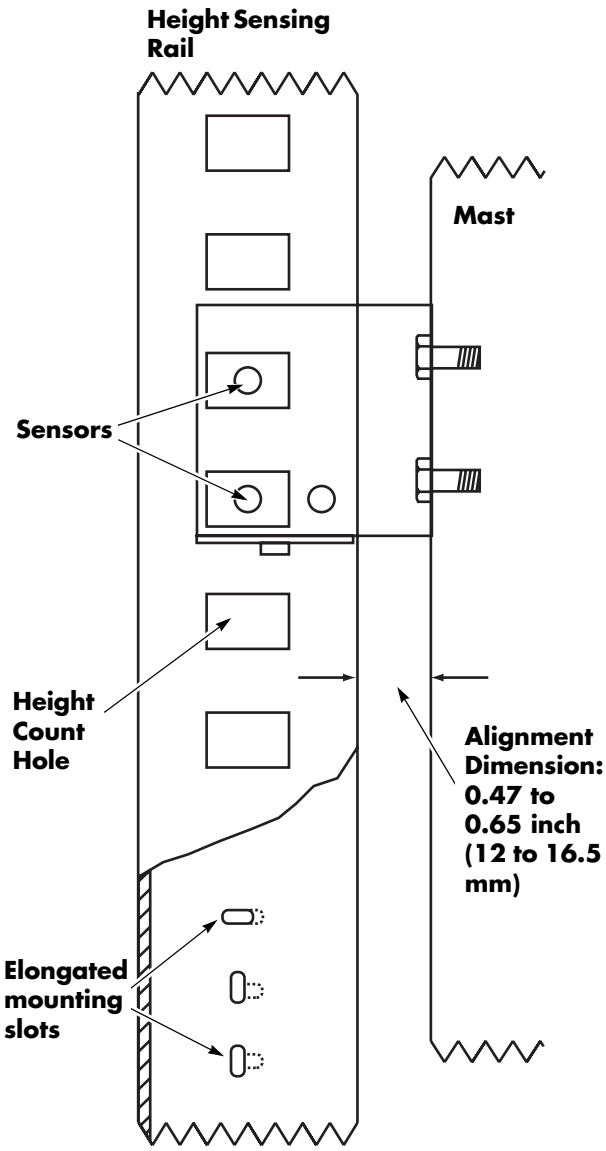


Figure 7-141. Series SA Main Height Sensor Adjustment

To adjust this dimension, adjust the height sensing rail.

Prior to adjusting the sensor, check for correct adjustment of mast pucks. See "Mast Pucks (SA)" on page 7-154.

1. Turn the key switch OFF and disconnect the battery connector.
2. Loosen the height rail mounting screws and adjust the height rail to obtain the correct adjustment throughout its length.
3. If there is insufficient horizontal movement to bring the rail into correct adjustment, horizontally elongate the mounting slots on the height rail.

   If you still cannot bring the rail into correct alignment, replace the height sensing rail. See "Main Height Sensing Rail (Series SA)" on page 7-156.
4. Apply thread-locking compound (P/N 990-536) to the threads of the height sensing rail mounting screws when retightening.
5. Reconnect the battery connector and turn the key switch ON.
6. Fully elevate and lower the operator platform while observing the position of the height sensor LEDs. They must track the holes of the rail for its full length as illustrated in Figure 7-141 on page 7-101.

   Repeat with a load nested to the left and with a load nested to the right.
7. Run Test I15 in dynamic diagnostic mode while observing the height information on the Operator Display. Make sure the height value increments and decrements correctly.

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Rotate Position Feedback Potentiometer (VR6)

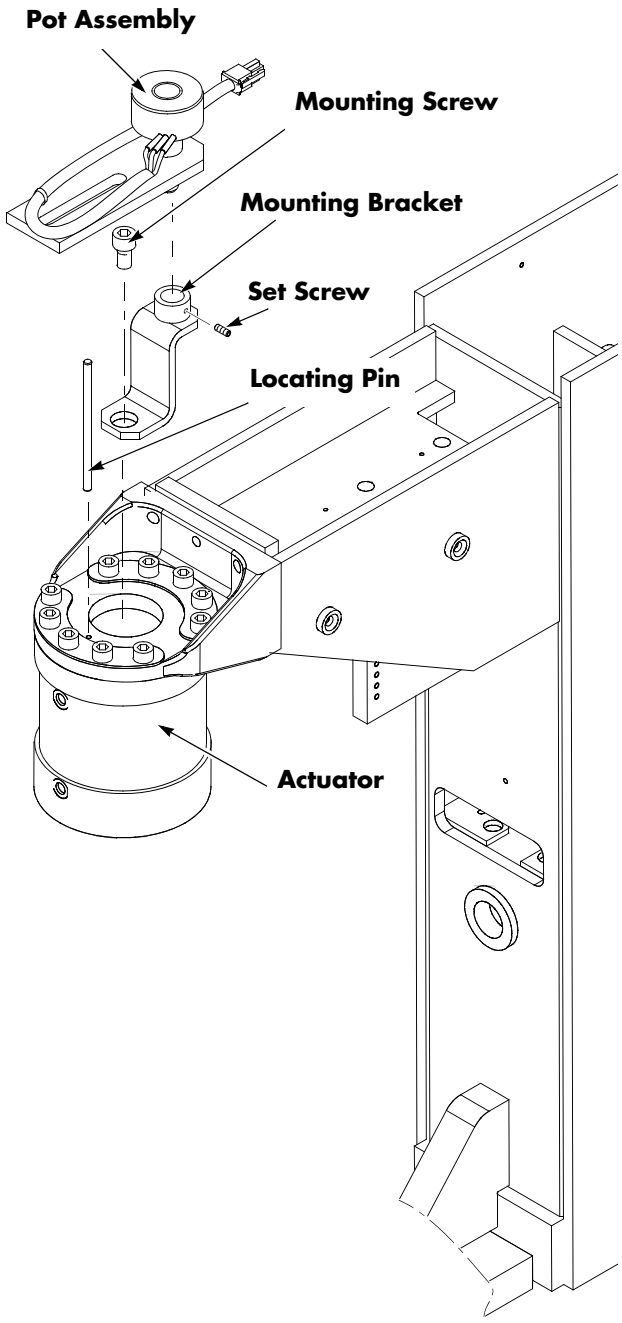


Figure 7-142. Rotate Position Feedback Pot, drawing

Removal

1. Rotate the forks approximately 45 degrees and elevate the load handler to a convenient working height approximately 3 feet (1 m) off the floor. Block and clamp the load handler to prevent it from lowering.
2. Turn the key switch OFF and disconnect the battery connector.
3. Remove the load handler turret cover.
4. Cut cable ties on the potentiometer cable, noting their location for later installation.
5. Disconnect the 6-wire cable harness at JP4 on the height manager board under the turret.
6. Loosen the set screw in the bracket and remove the potentiometer.
7. On trucks with S/N prior to SA 03843 and SB 00958, replace the bracket that mounts the potentiometer to the actuator.

Installation

1. Position the potentiometer assembly over the locating pin and mounting bracket. Adjust the potentiometer bracket on the actuator plate so the potentiometer is physically centered fore-aft and side-to-side. Tighten the set screw.
2. Route the cable harness and attach new cable ties. Take care not to pinch the wiring with the cable ties.
3. Connect the 6-wire cable harness at connector JP4 on the height manager board under the turret.
4. Remove clamp and blocking.
5. Reconnect the battery connector and turn the key switch ON.
6. Adjust the potentiometer. See "Adjustment" on page 7-103.
7. Run Learn Mode for Carriage.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-4.

8. Attach the load handler turret cover.

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Adjustment

If the potentiometer mounting bracket is not adjusted correctly, the lift truck could be limited to 1 mph even when the forks are nested in the center position and pointing straight ahead. To adjust the bracket:

1. Rotate the forks so they point straight ahead.
2. Adjust the potentiometer mounting bracket so it is centered fore-aft inside the rotate actuator.
3. Place a combination square against the flat sides of the mounting bracket.
4. Adjust the bracket left or right until it is centered in the mounting plate.
5. Run Test A28 and set the potentiometer voltage at 2.5 volts with the forks straight ahead.
6. Run Learn Carriage.

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Traverse Position Feedback Potentiometer (VR5)

Removal

1. Traverse the mini-mast so it is centered side-to-side. Lower the operator carriage and load handler completely.
2. Open the Emergency Lowering Valve on the main manifold in the tractor. (See "Emergency Lowering Valve" on page 7-110.)
3. Use a work platform, ladder, or other suitable device to gain access to the fork control manifold on top of the overhead guard.
4. Remove the cover over the manifold and traverse motor.

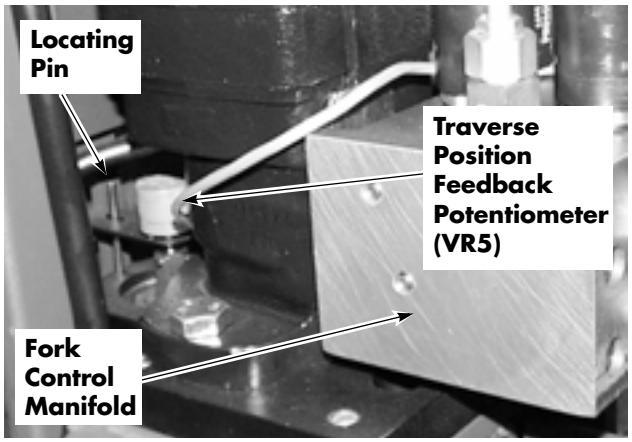


Figure 7-143. Traverse Position Feedback Potentiometer (motor removed for clarity)

5. Traverse very slowly until the set screw on the potentiometer shaft is accessible.
6. Turn the key switch OFF and disconnect the battery connector.
7. Loosen the set screw holding the potentiometer shaft. Cut the cable tie.
8. Disconnect the potentiometer wiring harness at connector JPK2.
9. Lift the potentiometer assembly off the locating pin.

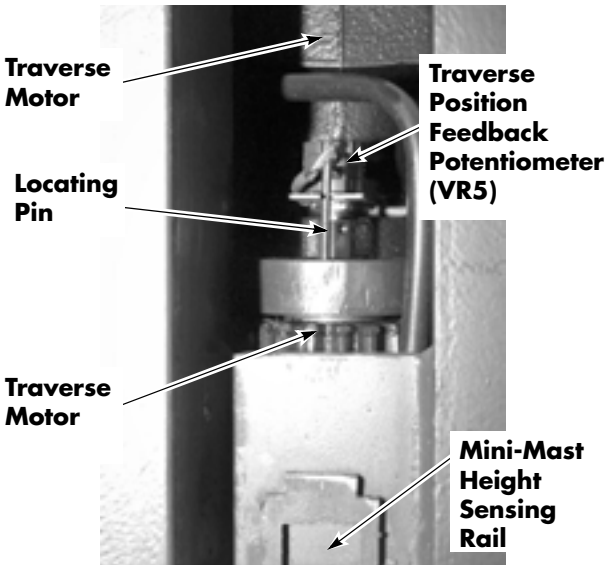


Figure 7-144. Traverse Position Feedback Potentiometer (Front view through Series SA mini-mast)

Installation

1. On the new potentiometer assembly, make sure the pot is turned so the terminals are at about a 45° angle to the slot in the positioning board. If not, cut cable tie, loosen nut, align pot, tighten nut, and install a new cable tie.
2. *Correct routing of the potentiometer cable is important.* With respect to a seated operator's view, route the cable from the right side of the pot across in front of the traverse motor, down the left side of the traverse motor, across behind the motor, around the manifold to connector JK2. Do not attach to hoses or other cables with cable ties. Do not wrap the cable around other hoses or cables such that the cable would tug on the pot. See Figure 7-145 and Figure 7-146.
3. Reconnect the potentiometer wiring harness at connector JPK2.
4. Before installing the potentiometer assembly, turn the pot shaft fully clockwise, then turn counterclockwise to half of the wiper's travel.

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5. Reconnect the battery connector and turn the key switch ON.
6. Run Maintenance Test A26 and adjust the potentiometer until the voltage reads 2.50 volts. See "Test A26 ¥ – Traverse Position Feedback Pot (VR5) Voltage" on page 6-123.
7. Position the potentiometer assembly over the locating pin. Make sure the wires of the pot are not touching, rubbing, or pressing on the locator pin. Tighten the set screw holding the potentiometer shaft.
8. Run Maintenance Test A26 and verify voltages for full left and full right traverse.

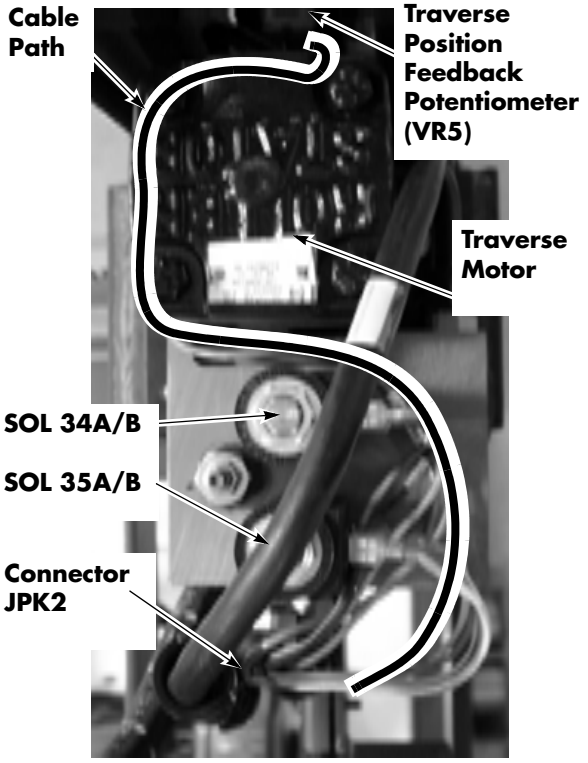


Figure 7-145. Traverse Position Feedback Pot cable path

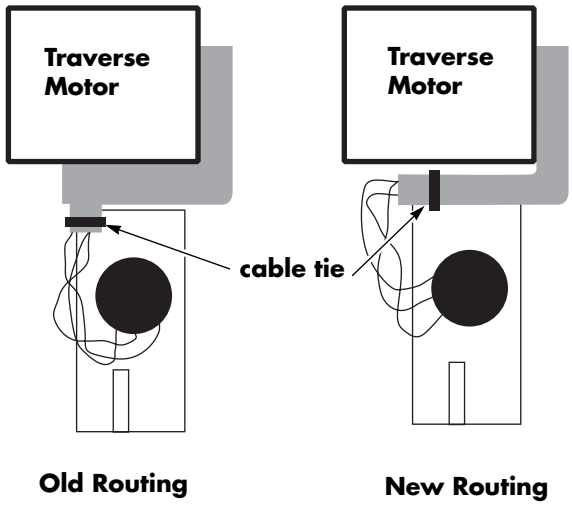


Figure 7-146. Wire routing

9. Attach the cover over the manifold and traverse motor.
10. Close the Emergency Lowering Valve on the main manifold in the tractor.
11. Run Learn Mode for Carriage.

NOTE: For instructions on selecting Modes of Operation, see "Modes of Operation" on page 6-4.

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Slack Chain Switch Adjustment

SA S/N > 01192 and SB S/N > 00308:
A slack chain switch is mounted on each of the main lift chain upper chain anchors.

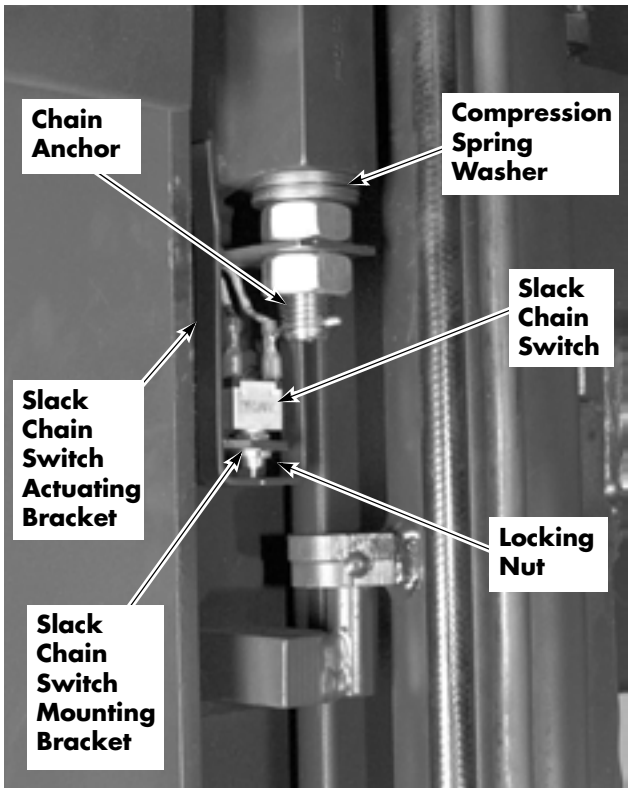


Figure 7-147. Slack Chain Switch (SA)

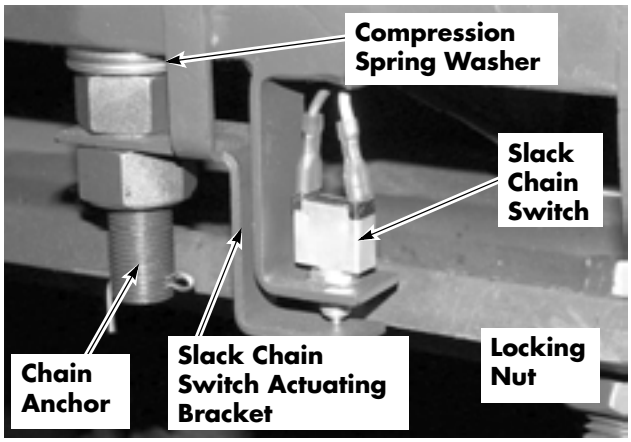


Figure 7-148. Slack Chain Switch (SB) Detail (early trucks)

1. Verify the switch is firmly in the normally closed position.
2. To adjust the switch, lower the raised platform onto a block.

⚠CAUTION

***Do not* block against the platform floor, use the edge of the platform. *Do not* block the carriage against the floor — lowering the platform could tip the load wheels off the floor.**

3. Continue to hold the lower control for at least 5 seconds.
4. *Series SA*: Adjust the switch mounting bracket up or down so that the switch is open.
5. *Series SB*: Turn the locking nut on the shaft of the switch to adjust the switch on the mounting bracket. Continue turning the locking nut until the switch is open.

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Aux Power Amplifier

The Auxiliary Power Amplifier and Aux Interface Module were introduced on lift trucks SA S/N 00470 through 02999 and on SB S/N 00185 through 00699.

The Auxiliary Power Amplifier and Aux Interface Module replace the Auxiliary Motor Control Card, which is no longer available, on older trucks.

To replace the Auxiliary Motor Control Card, order an Auxiliary Power Amplifier kit, P/N 838-910-AAK/STD (standard) or 838-910-AAK/CSK (cold storage), which includes the Amplifier, Interface Module, wiring harness, and mounting hardware. A separate kit for cold storage applications includes a heater, thermostats, and fuse.

The Auxiliary Power Amplifier requires Tractor Manager P/N 154-012-470/007 or higher. EE-rated trucks require P/N 154-012-470/008 or higher.

Upgrading

Use the following procedure to upgrade a lift truck previously equipped with an Auxiliary Motor Control Card.

1. Remove the Auxiliary Motor Control Card.
2. Cover electrical components on lift truck to prevent contamination from drilling waste.
3. Drill and tap mounting holes in main tractor heatsink for Auxiliary Power Amplifier and Interface Module.
4. Remove all filings.



Figure 7-149. Aux Power Amplifier upgrade

5. Attach Interface Module to main tractor heat sink using machine screws and flat washers.
6. Connect the PM1-JM2 wiring harness to Interface Module at JPM2 and to original harness assembly at JPM1.
7. Cold Storage only:
   a. Make sure heater HTA, thermostats S80 and S81, and fuse FU24 are attached to the standoff plate. The heater mounts to the underside of the standoff plate.
   b. Connect wire from thermostat to PC1-2, and wire from heater to TP-4.
8. Attach Auxiliary Power Amplifier. See “Installation” steps 1-3 below.
9. Install new Tractor Manager Card, if required.
10. Close tractor top cover. Reference “Covers” on page 7-34.
11. Reconnect the battery connector and turn the key switch ON.
12. Run “Learn Carriage” and test lift truck, including auxiliary functions.

Installation

1. Remove the three button-head hex screws on the side of the Auxiliary Power Amplifier and make sure the three

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potentiometers are adjusted *fully clockwise*. Reinstall the screws.

2. Attach Auxiliary Power Amplifier:
   a. Non-cold storage: Attach amplifier to main tractor heatsink with bolts and flat washers.
   b. Cold storage: Install bolts through washers, amplifier, standoff plate, and spacers into main tractor heatsink.
3. Connect power cables to pins on Auxiliary Power Amplifier: MXB– to B– pin, MX– to M– pin, MXB+ (two) to B+ pin.
4. Connect wires from Interface Module to Auxiliary Power Amplifier and bus bar: AMPL1 to pin #1, AMPL2 to pin#2, B+ to B+ pin, TP4 to ground (bus bar).
5. Lower top cover and install tractor and side covers.
6. Reconnect the battery connector and turn the key switch ON.
7. Run “Learn Carriage” and test lift truck, including auxiliary functions.

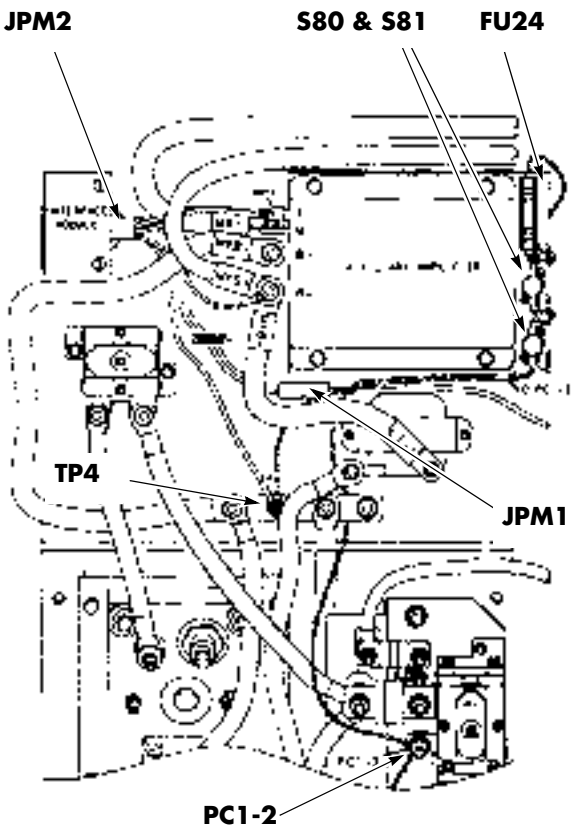


Figure 7-150. Aux Power Amplifier connections

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Hydraulic Components

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Hydraulic Component Procedures Summary

Table 7-6. Hydraulic Component Procedures Summary

Component	Procedure /Photo or Drawing	Thread-Locking Compound/ Torque Values	Helpful Hints
Auxiliary (Fork Control) Manifold Locations (early)	Photos: Figure 7-153 and Figure 7-154 on page 7-117		
Auxiliary (Fork Control) Manifold Locations (later)	Photos: Figure 7-155 on page 7-118 and Procedure: Figure 7-156 on page 7-119		
Auxiliary Pump and Motor	Locator Photos: Figure 7-1 on page 7-3 and Figure 7-2 on page 7-4	Mating surfaces of pump and motor adapter and coupling: molybdenum anti-seize compound (P/N 990-638) Pump mounting bolts: 9 ft. lb. (12 Nm). Motor mounting bolts: 15 ft. lb. (20 Nm).	
Auxiliary System Pressure Adjustment	Procedure: page 7-127		
Bleeding the Hydraulic System	Procedure: page 7-124		
Emergency Lowering Valve	Locator Drawings: Figure 7-151 on page 7-115 and Figure 7-152 on page 7-116		

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Table 7-6. Hydraulic Component Procedures Summary

Component	Procedure /Photo or Drawing	Thread-Locking Compound/ Torque Values	Helpful Hints
Flow Control	Procedure: page 7-136		
Flow Regulator	Locator Photo: Figure 7-154 on page 7-117 Adjustment Procedure: page 7-128	Torque: Table 7-9 on page 7-122	
Fork Control Solenoid (SOL35 A/B)	Locator Photos: Figure 7-153 on page 7-117, Figure 7-155 on page 7-118, and Figure 7-156 on page 7-119	Valve Torque: Table 7-8 and Table 7-9 on page 7-122	
Hydraulic Filter	Locator Photos: Figure 7-1 on page 7-3 and Figure 7-2 on page 7-4		On trucks with external filter, drain hydraulic fluid from the reservoir prior to replacing the filter. Reservoir capacity is 15 gallons (57 liters), *not counting* fluid in cylinders and hoses. On trucks with internal filter, lubricate the inside of filter cap with hydraulic fluid, install the cap, and tighten to 60 in. lb. (6.8 Nm).
Hydraulic Fluid Replacement	None		Reservoir capacity is 15 gallons (57 liters), *not counting* fluid in cylinders and hoses. Hydraulic fluid level. • SA S/N < 03218 except 03202; SB S/N < 00762 except 00757: Fluid level should be 1.5 to 2 inches (25.4 to 50.8 mm) below the top of the strainer in the filler neck of the reservoir. • SA S/N 03202, > 03217; SB S/N 00757, > 00761: Fill to sight gauge in reservoir.

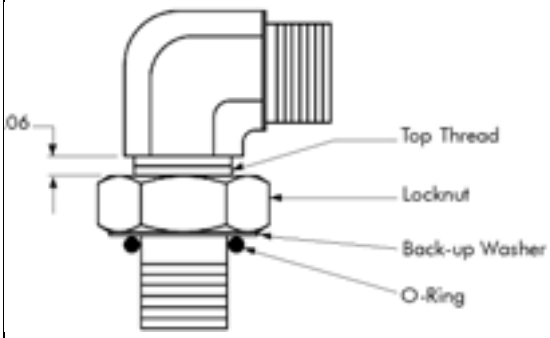
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Table 7-6. Hydraulic Component Procedures Summary

Component	Procedure /Photo or Drawing	Thread-Locking Compound/ Torque Values	Helpful Hints
Lift Pressure Adjustment	Procedure: page 7-129		
Lift Pump	Locator Photos: Figure 7-1 on page 7-3 and Figure 7-2 on page 7-4	Mating surfaces of lift motor spline and pump: Molybdenum anti-seize compound (P/N 990-638) Pump mounting bolts: thread-locking compound (P/N 990-536)	
Lift/Lower Manifold Locations (early)	Drawings: page 7-116		
Lift/Lower Manifold Locations (later)	Drawings: page 7-115		
Main Lift Cylinders (SA)	Procedure: page 7-134		
Main Lift Cylinders, SB	Procedure: page 7-131		
Manifold Solenoids, Fittings, Attachments	Table: page 7-121		
Pressure Transducers	Locator Photos: Figure 7-22 on page 7-19 and Figure 7-23 on page 7-20	Lubricate new O-ring with hydraulic fluid and install with the new transducer in the manifold. Tighten transducer to 11 ft. lb. (15 Nm).	Run Learn Mode for Weight. See “Learn Weight” on page 6-18.
Proportional Reach/Rotate Solenoid (SOL33)	Photo: Figure 7-155 on page 7-118 and Figure 7-156 on page 7-119	Torque: Table 7-9 on page 7-122	
Proportional Valve (SOL4) Adjustment	Procedure: page 7-126		

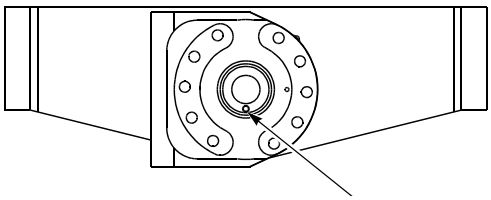
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Table 7-6. Hydraulic Component Procedures Summary

Component	Procedure /Photo or Drawing	Thread-Locking Compound/ Torque Values	Helpful Hints
Reach Cylinder	None		Attach fittings to cylinder as follows: • Replace O-ring as needed. • Back off the lock nut 0.06 (1/16th) inch (1.5 mm) (1 to 2 threads) short of the uppermost position on the fitting.  • Thread the fitting into the cylinder port until the O-ring contacts the surface. • Align the fitting for hose attachment by unthreading *no more than 360 degrees*. • Tighten the lock nut. Adjust the reach extension (from fork carriage to load handler carriage) to the reach specification for the truck.
Reach Manifold	Locator Photos: Figure 7-24 on page 7-21 and Figure 7-157 on page 7-120	Manifold mounting bolts: P/N 990-536 Valve torques: Table 7-10, "Reach Manifold Attachment Torques," on page 7-123.	
Reach Manifold Locations	Photo: Figure 7-156 on page 7-120		
Reach Solenoid	Locator Photos: Figure 7-24 on page 7-21 and Figure 7-157 on page 7-120	Table 7-10, "Reach Manifold Attachment Torques," on page 7-123	

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Table 7-6. Hydraulic Component Procedures Summary

Component	Procedure /Photo or Drawing	Thread-Locking Compound/ Torque Values	Helpful Hints
Rotate Actuator	Locator Photo: Figure 7-24 on page 7-21	Mounting bolts: 100 ft. lb. (135 Nm)	Orient actuator in rotate carriage as shown.  **Mounting hole for Rotate Position Feedback Potentiometer Bracket**
Solenoids, General	Tables: "Manifold Solenoids, Fittings, and Attachments" on page 7-121		
Traverse Motor	Locator Photos: Figure 7-18 on page 7-15, Figure 7-19 on page 7-16, and Figure 7-20 on page 7-17	Mounting bolts: 75 ft. lb. (102 Nm)	
Traverse Solenoid (SOL34 A/B)	Locator Photos: Figure 7-153 on page 7-117, Figure 7-155 on page 7-118, and Figure 7-156 on page 7-119	Torque: Table 7-8 and Table 7-9 on page 7-122	

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Lift/Lower Manifold Locations (later)

This manifold was introduced in new production on lift trucks with SA S/N 03202, > 03217 and SB S/N 00757, > 00761. Trucks SA S/N 03218 to 04010 and SB S/N 00762 to 01014 were manufactured with the lift pressure relief valve in the lift pump body.

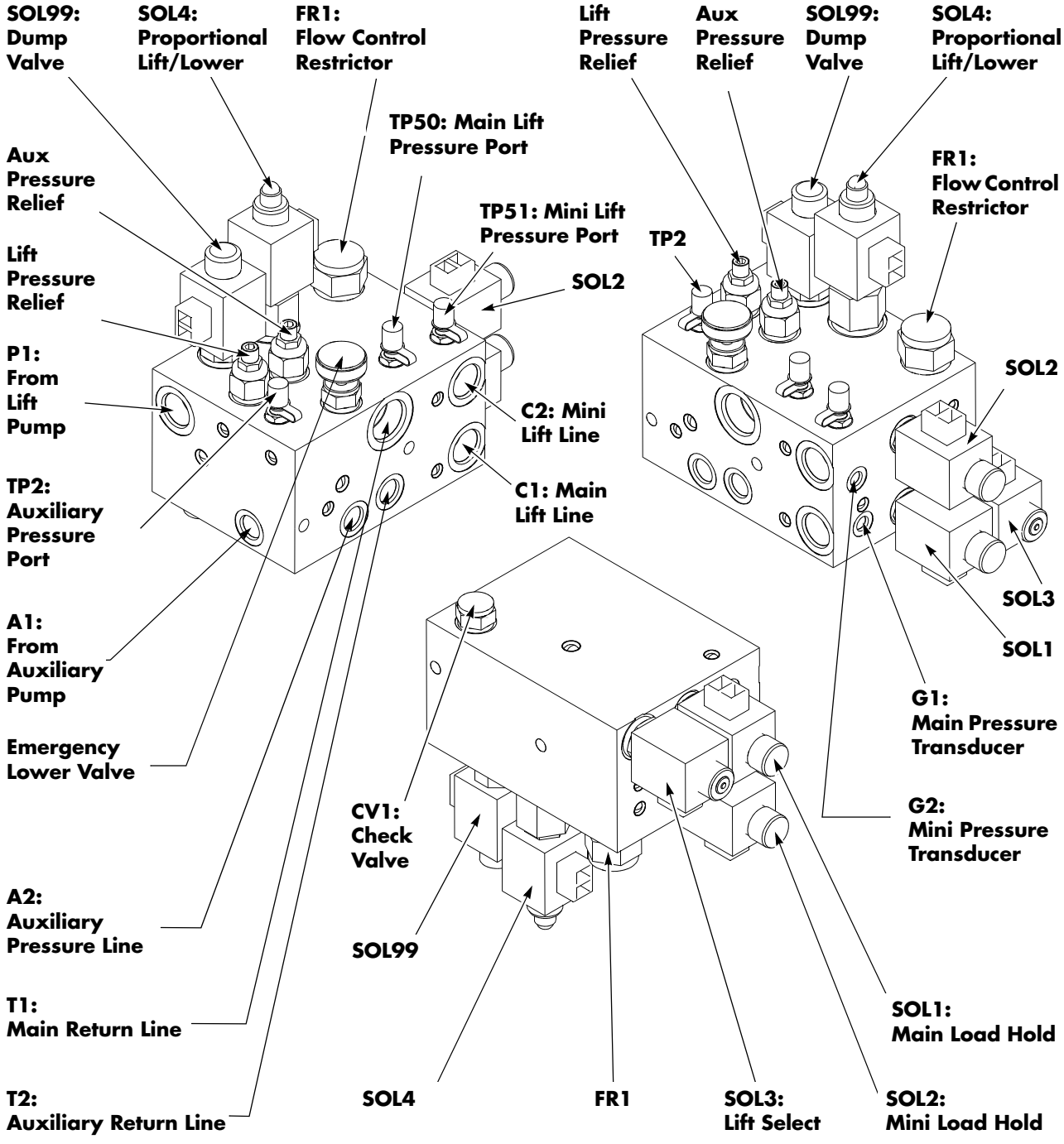


Figure 7-151. Lift/Lower Manifold and Solenoids (SA S/N 03202, > 03217 and SB S/N 00757, > 00761)

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Lift/Lower Manifold Locations (early)

This manifold was used in production on lift trucks SA S/N < 03218 except 03203, and SB S/N < 00762 except 00757.

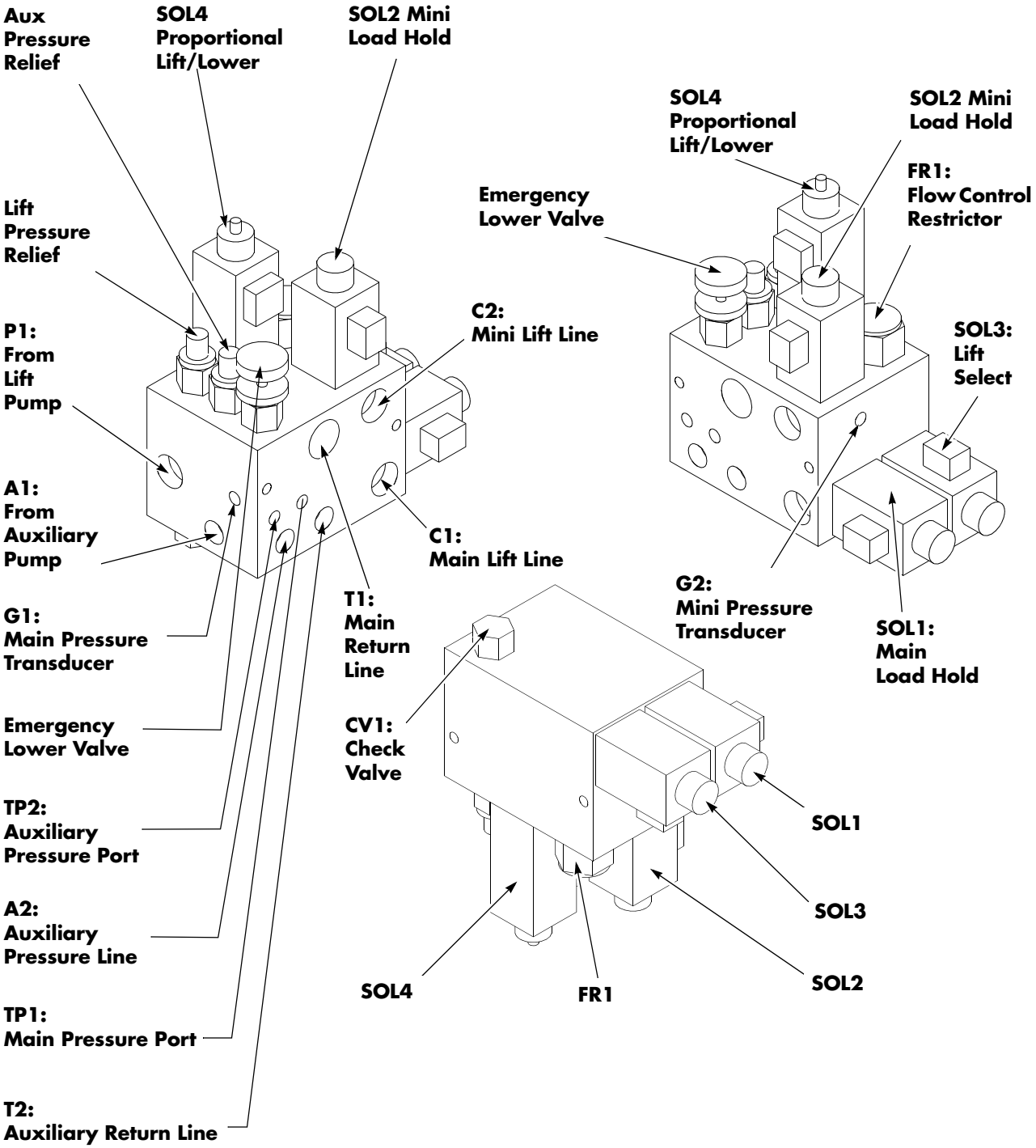


Figure 7-152. Lift/Lower Manifold and Solenoids (SA S/N < 03218 except 03202, SB S/N < 00762 except 00757

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Auxiliary (Fork Control) Manifold Locations (early)

This manifold is used on lift trucks SA S/N < 03000 and SB S/N < 00700.

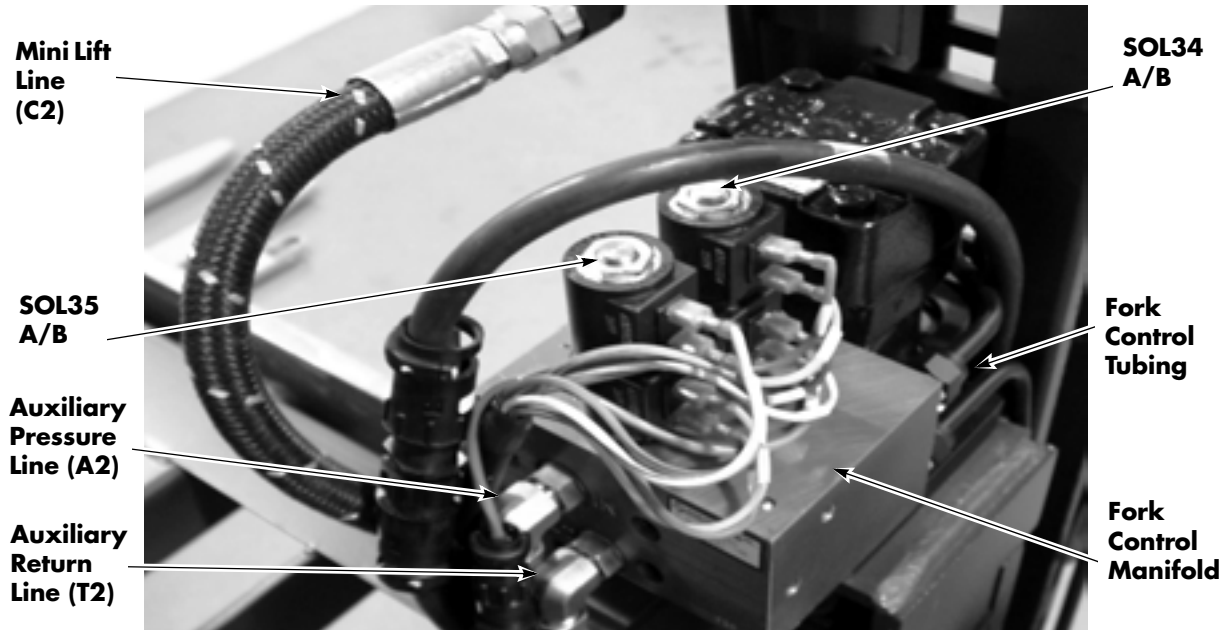


Figure 7-153. Fork Control Manifold and Solenoids

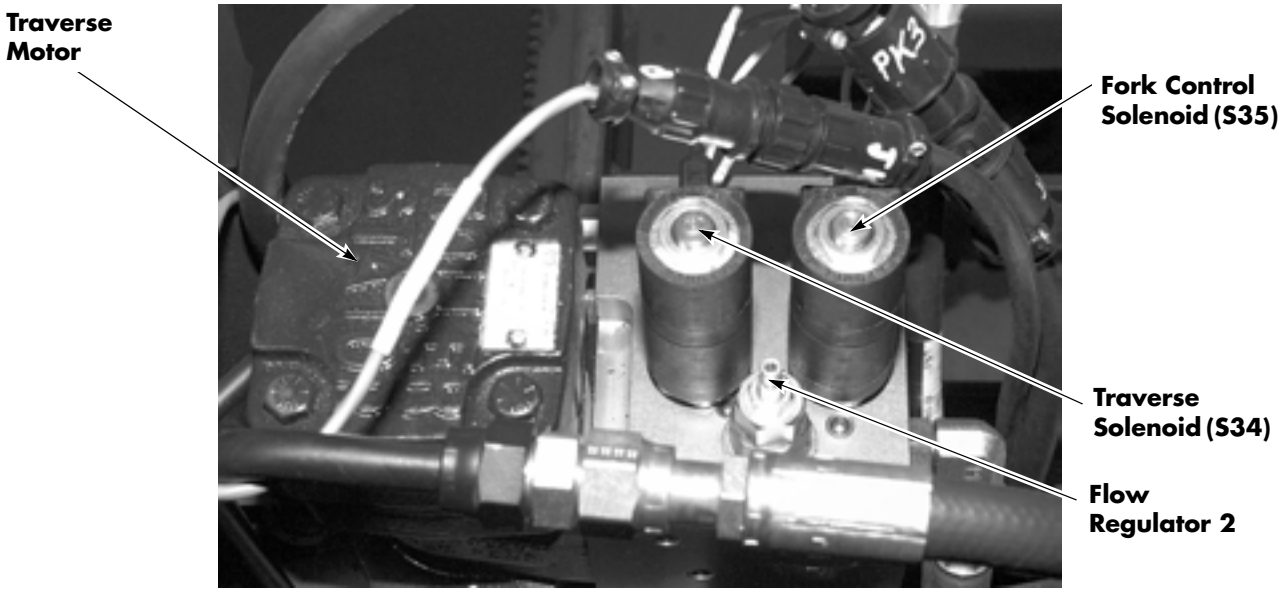


Figure 7-154. Flow Regulator

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Auxiliary (Fork Control) Manifold Locations (later)

This manifold is used on lift trucks SA S/N > 02999 and on SB S/N > 00699.

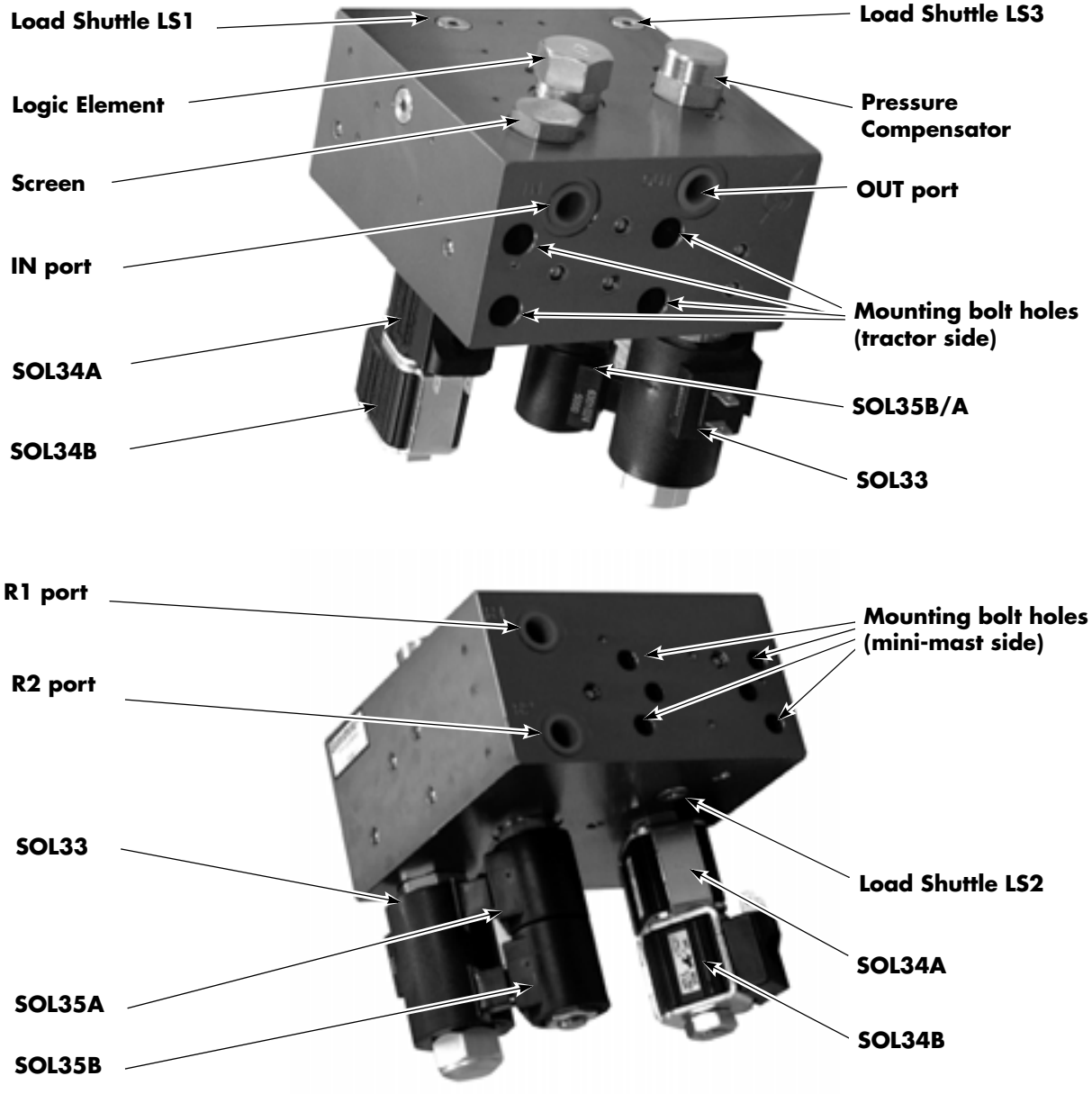


Figure 7-155. Auxiliary (Fork Control) Manifold locations (SA S/N > 02999, SB S/N > 00699)

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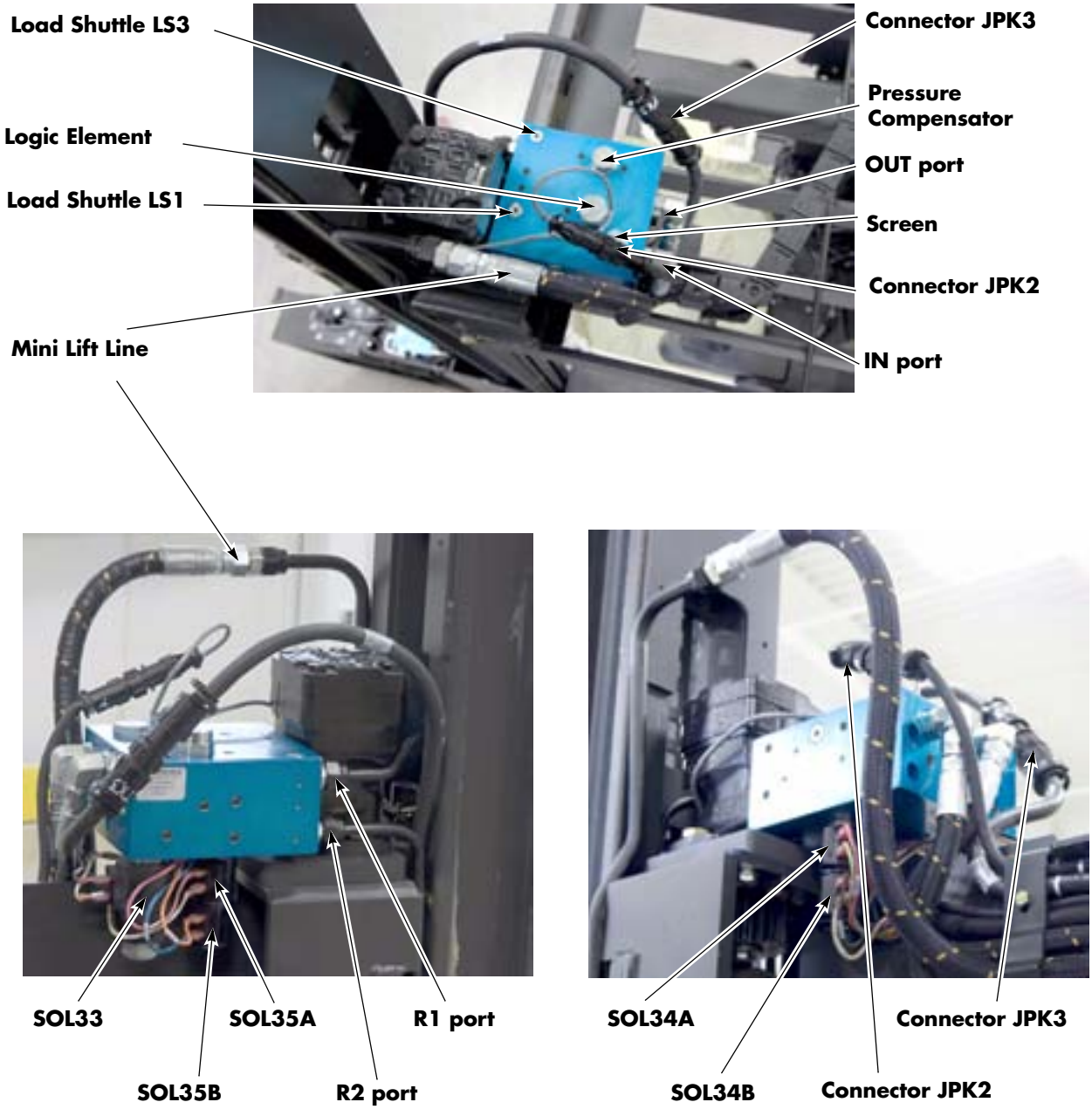


Figure 7-156. Auxiliary (Fork Control) Manifold (SA S/N > 02999, SB S/N > 00699)

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Reach Manifold Locations

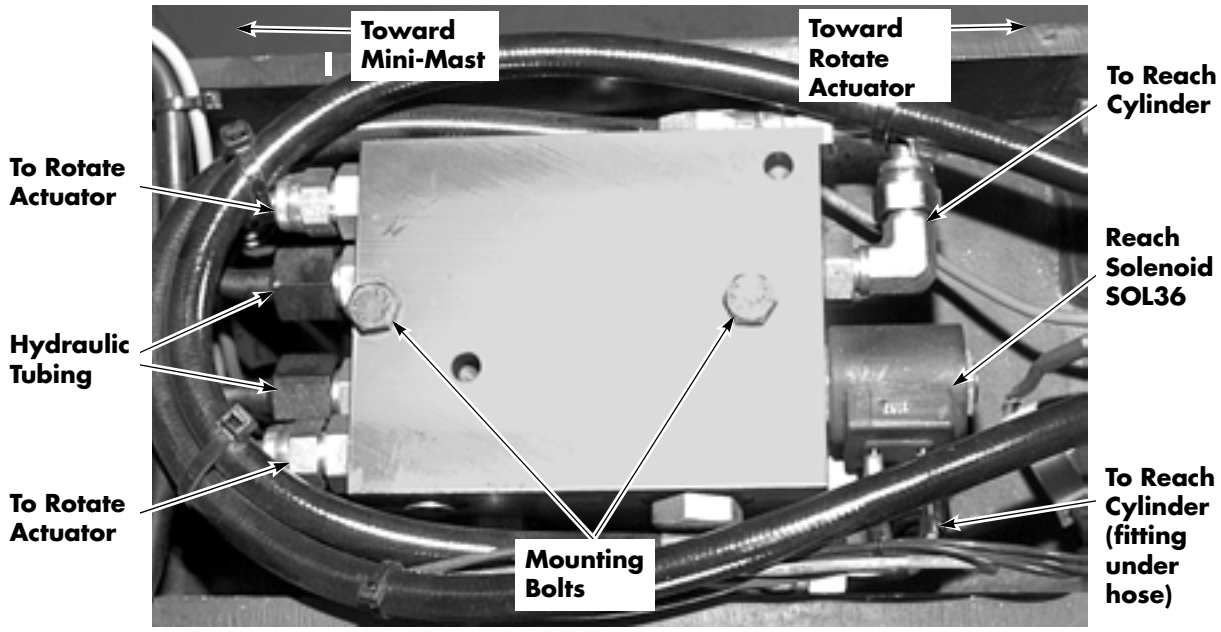


Figure 7-157. Reach Manifold

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Manifold Solenoids, Fittings, and Attachments

Table 7-7. Lift/Lower Manifold Attachment Torques

Solenoid / Fitting / Attachment	Valve / Fitting Torque (ft. lb.)	Valve / Fitting Torque (Nm)	Locking tab or bracket (Yes/No)	Coil Nut Torque (ft. lb.)	Coil Nut Torque (Nm)
SOL1 Main Load Holding	55	75	No	5	6.8
SOL2 Mini Load Holding	55	75	No	5	6.8
SOL3 Lift Select	85	115	No	5	6.8
SOL4 Proportional Lift/Lower	35 to 40	47 to 54	No	5	6.8
SOL99 Dump Valve	85	115	No	5	6.8
A1 From Aux Pump	46	62	n/a	n/a	n/a
A2 To Aux Pump	46	62	n/a	n/a	n/a
C1 Main Lift	85	115	n/a	n/a	n/a
C2 Mini Lift	85	115	n/a	n/a	n/a
CV1 Check Valve	55	75	n/a	n/a	n/a
Emergency Lower Valve	55	75	n/a	n/a	n/a
FR1 Flow Control Restrictor	70	95	n/a	n/a	n/a
G1 Main Pressure Transducer	11	15	n/a	n/a	n/a
G2 Mini Pressure Transducer	11	15	n/a	n/a	n/a
P1 From Lift Pump	85	115	n/a	n/a	n/a
T1 Main Return	135	183	n/a	n/a	n/a
T2 Aux Return	46	62	n/a	n/a	n/a
Lift Relief	60	81	No	n/a	n/a
Auxiliary Relief	60	81	No	n/a	n/a
TP1 Main Lift Pressure Port (early trucks)	11	15	n/a	n/a	n/a
TP2 Mini Lift Pressure Port (early trucks)	11	15	n/a	n/a	n/a
TP2 Auxiliary Pressure Port (later trucks)	11	15	n/a	n/a	n/a
TP50 Main Lift Pressure Port (later trucks)	11	15	n/a	n/a	n/a
TP51 Mini Lift Pressure Port (later trucks)	11	15	n/a	n/a	n/a

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Table 7-8. Auxiliary (Fork Control) Manifold Attachments Torques (SA S/N < 03000, SB < 00700)

Solenoid / Fitting / Attachment	Valve / Fitting Torque (ft. lb.)	Valve / Fitting Torque (Nm)	Locking tab or bracket (Yes/No)	Coil Nut Torque (ft. lb.)	Coil Nut Torque (Nm)
SOL34A/B Traverse	18	24	No	4	5.4
SOL35A/B Fork Control	18	24	No	4	5.4
C2 Port (R1/R2) SAE6	18	24	n/a	n/a	n/a
A2 Port (IN) SAE 6	18	24	n/a	n/a	n/a
T2 Port (OUT) SAE6	18	24	n/a	n/a	n/a
FR2 Flow Regulator	18	24	No	n/a	n/a

Table 7-9. Auxiliary (Fork Control) Manifold Attachment Torques (SA S/N > 02999, SB > 00699)

Solenoid / Fitting / Attachment	Valve / Fitting Torque (ft. lb.)	Valve / Fitting Torque (Nm)	Locking tab or bracket (Yes/No)	Coil Nut Torque (ft. lb.)	Coil Nut Torque (Nm)
SOL33 Proportional Reach/Rotate	25	34	No	10	13.5
SOL34A/B Traverse Control	20	27	No	4	5.4
SOL35A/B Fork Control	20	27	No	4	5.4
LS1 Load Shuttle	5	6.8	No	n/a	n/a
LS2 Load Shuttle	5	6.8	No	n/a	n/a
LS3 Load Shuttle	5	6.8	No	n/a	n/a
R1 Port	18	24	n/a	n/a	n/a
R2 Port	18	24	n/a	n/a	n/a
In Port	18	24	n/a	n/a	n/a
Out Port	18	24	n/a	n/a	n/a
Logic Element	37	50	No	n/a	n/a
Pressure Compensator	25	34	No	n/a	n/a

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Table 7-10. Reach Manifold Attachment Torques

Solenoid / Fitting / Attachment	Valve / Fitting Torque (ft. lb.)	Valve / Fitting Torque (Nm)	Locking tab or bracket (Yes/No)	Coil Nut Torque (ft. lb.)	Coil Nut Torque (Nm)
Check Valve	18	24	No	n/a	n/a
Relief Valve	18	24	n/a	n/a	n/a
SOL36 Reach	18	24	No	4	5.4
To Reach Cylinder	18	24	n/a	n/a	n/a
To Rotate Actuator	18	24	n/a	n/a	n/a
To Rotate Actuator	18	24	n/a	n/a	n/a
Tubing	18	24	n/a	n/a	n/a

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Bleeding the Hydraulic System

Bleed the hydraulic system to remove any trapped air whenever you:

- Change a hydraulic hose
- Disconnect a hydraulic fitting
- Remove a hydraulic cylinder
- Remove a hydraulic pump
- Remove the hydraulic reservoir
- Notice that the load is bouncing

1. Bleed the lift system as follows:
   a. Using main lift, elevate the platform until the forks are 6 to 12 inches (150 to 300 mm) above the floor.
   b. One at a time, slowly loosen but *do not remove* the Allen bleed screw(s).
   Model SA: Bleed the screw on the cylinder housing. It is not necessary to bleed the screw on the piston.
   Model SB: Bleed the screw on the piston and one of the screws on the cylinder cap. It is not necessary to bleed the screw on the housing.
   Permit any air in the cylinder to be expelled. Hold shop rag close to and beneath the bleed screw to keep hydraulic fluid from spraying out. When fluid starts flowing from the bleed screw hole, retighten the bleed screw. Repeat this for the other lift cylinder. See Figure 7-158.
   c. Lower the platform to the floor.

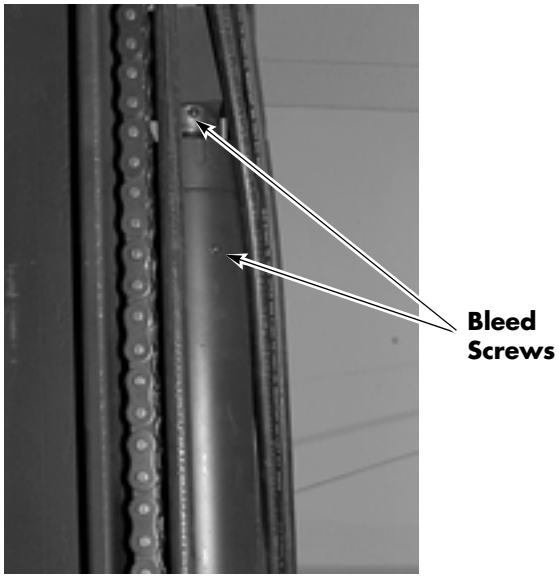


Figure 7-158. Bleed Screws, Main Lift Cylinder

   d. Using mini lift, elevate the load handler until the forks are 6 to 12 inches (150 to 300 mm) above the floor.
   e. Slowly loosen but *do not remove* the bleed screw on the mini-mast cylinder. Permit any air in the cylinder to escape. Retighten the bleed screw.
   f. Lower the load handler to the floor.

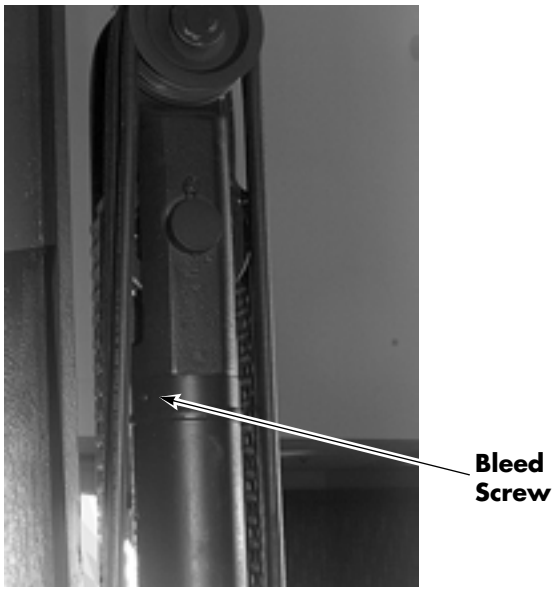


Figure 7-159. Bleed Screw, Mini Lift Cylinder

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2. Bleed the auxiliary system as follows:
   a. Run the auxiliary system. Cycle the traverse and rotate.
   b. Rotate the forks fully clockwise.
   c. Slowly loosen but *do not remove* the fitting in Port P1 (the lower fitting on the back, facing the tractor) of the rotate actuator.
   d. Move the rotate control to rotate the forks clockwise until all the air is forced out of the P1 port. See Figure 7-160.
   e. Release the rotate control, then tighten the fitting in the P1 port.
   f. Rotate the forks fully counterclockwise. Slowly loosen but *do not remove* the fitting in the P4 Port (the top fitting on the front, facing the forks) of the rotate actuator. See Figure 7-160.

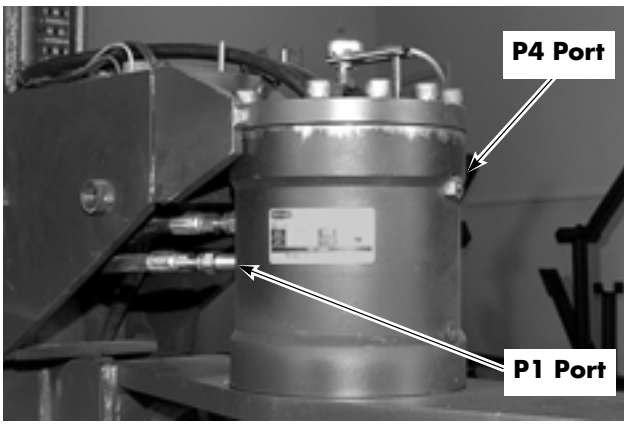


Figure 7-160. Bleeding Auxiliary System

   g. Move the rotate control to rotate the forks counterclockwise until all the air is forced out of the P4 port.
   h. Release the rotate control and tighten the fitting in the P4 port.
3. Thoroughly clean up any spilled hydraulic fluid.

NOTE: No bleeding procedure is required for traverse, as cycling both to the left and right automatically purges the air from the system.

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Proportional Valve (SOL4) Adjustment

If the carriage hesitates when being lowered, or cannot be feathered, adjust the SOL4 proportional lift/lower valve as follows:

1. Fully lower both the main and mini masts.
2. Remove the tractor cover.
3. Remove the acorn nut on the top of SOL4. Using a 1/16 inch hex head wrench, remove the set screw contained within the adjusting screw. *Do not loosen the lock nut.* Hold a magnet against the hex head wrench and remove the ball bearing in the hole under the set screw. See Figure 7-161.

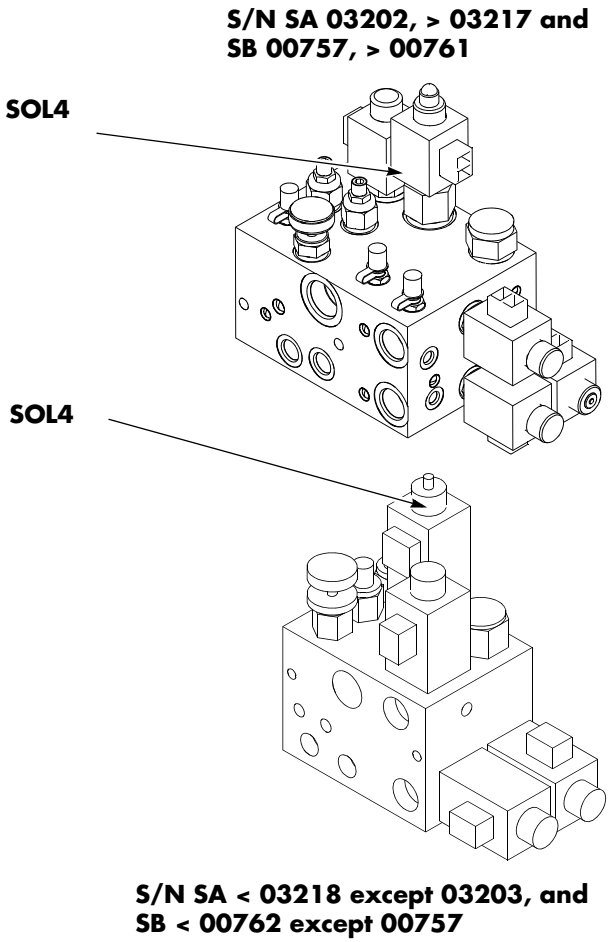


Figure 7-161. SOL4

4. Place shop rags around the exposed bleed hole.
5. Request full speed lower for 5 seconds. Do this repeatedly for at least 5 minutes, or until clear hydraulic fluid is flowing from the bleed hole with no air bubbles.
6. Replace the ball bearing and set screw.
7. Elevate the operator platform about 4 feet (1.2 meters).
8. Remove one wire from the SOL4 coil.
9. Loosen the lock nut on the proportional valve adjusting screw.
10. Request a full speed lower and hold.
11. Turn the adjusting screw until platform movement is *barely* noticeable.
12. Tighten the lock nut, making sure not to turn the adjusting screw.
13. Reinstall the acorn nut.
14. Reattach the SOL4 coil wire previously removed.
15. Lower the operator platform completely.
16. Enter Learn Mode. See “Using Learn Mode” on page 6-16.
17. Run “Learn Weight.” See “Learn Weight” on page 6-18.
18. Test the lift and lower functions for correct operation.
19. If the lower deceleration response has changed, adjust the “lower decel” setting in Config Mode. See “Using Configure Mode” on page 6-7. See “Lower Decel” on page 6-11.

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Auxiliary System Pressure Adjustment

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the tractor cover. See "Covers" on page 7-34.
3. Connect a pressure gauge capable of measuring 3000 psi (20,682 kPa or 211 kg/cm^2) to the auxiliary pressure test port on the main manifold. See Figure 7-162.
4. Loosen the lock nut on the auxiliary pressure relief valve on the main manifold. See Figure 7-162.

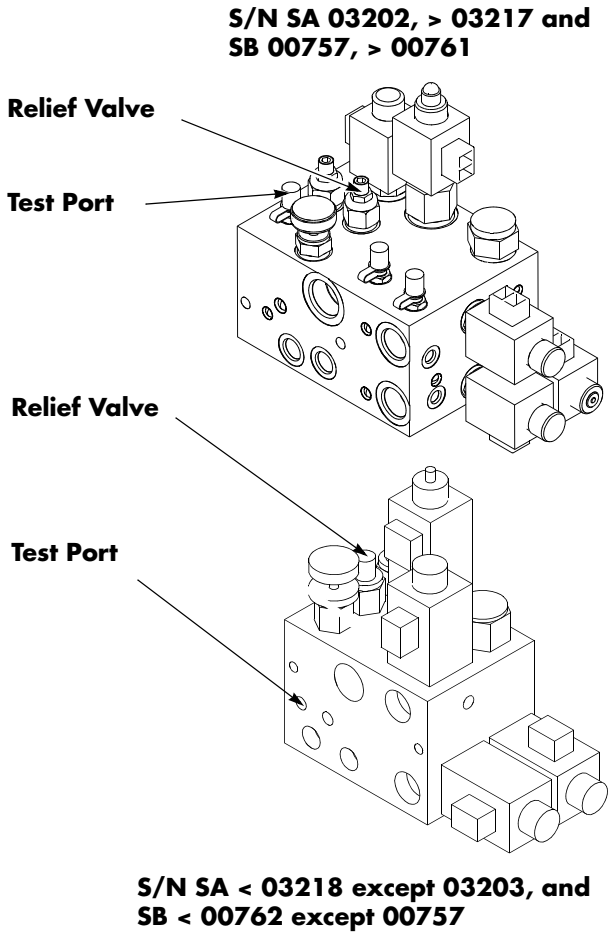


Figure 7-162. Auxiliary System Pressure Relief Valve and Test Port

5. Reconnect the battery connector and turn the key switch ON.
6. Clamp a block of wood against the traverse rack stop. See Figure 7-163.

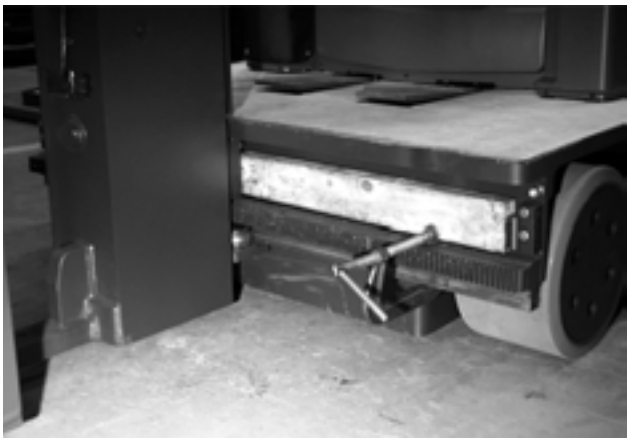


Figure 7-163. Blocking Traverse Rack

7. Move the traverse control so the load handler is traversed against the wood block. Keep the load handler pressing against the block. Pressure should be 1200 to 1300 psi (8272 to 8962 kPa or 84.5 to 91.5 kg/cm^2).
8. Using a hex head wrench, adjust the auxiliary pressure relief valve for the correct pressure when rotating against the block.
9. When the pressure is correct, tighten the lock nut on the valve.
10. Turn the key switch OFF and disconnect the battery connector.
11. Remove the pressure gauge from the auxiliary pressure test port. Remove the clamp and wood block.
12. Install the tractor cover.

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Flow Regulator Adjustment

1. Operate rotate and traverse simultaneously at their maximum speeds. The functions should begin and end at approximately the same time.
2. Adjust the flow regulator to obtain the best coordination between the functions:
   a. Loosen the locking nut on the adjustable flow regulator.
   b. Turn the adjustment screw in small increments, clockwise to increase rotate speed and decrease traverse speed.
   c. Test the functions separately and simultaneously, without a load. Adjust until rotate and traverse functions begin and end at approximately the same time.
3. Tighten the flow regulator locking nut.

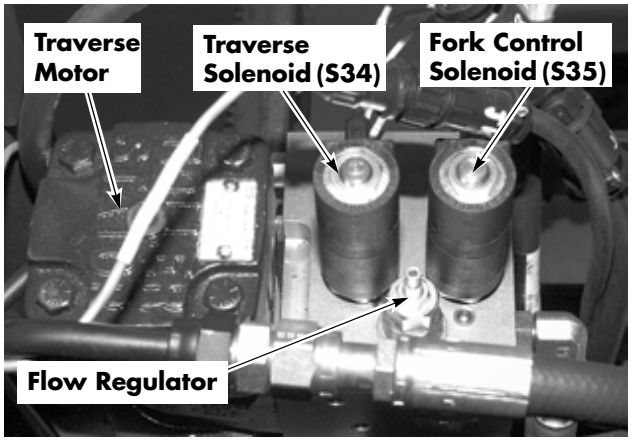


Figure 7-164. Flow Regulator

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Lift Pressure Adjustment

1. Lower the operator platform and load handler completely.
2. Turn the key switch OFF and disconnect the battery connector.
3. Remove the tractor cover. (See “Covers” on page 7-34.)
4. Connect a pressure gauge capable of reading 3000 psi (20,682 kPa or 211 kg/cm^2) to the pressure test port on the main manifold. See Figure 7-165 on page 7-130.
   a. *Model SA*: Connect to the main lift pressure test port (TP1 or TP50).
   b. *Model SB later trucks*: Connect to mini lift pressure test port (TP51).
   c. *Model SB early trucks*: Connect to main lift pressure test port (TP1). (There is no mini lift pressure test port on this manifold.)
5. Loosen the lock nut on the main lift pressure relief valve on the main manifold or lift pump. See Figure 7-165.

NOTE: Lift trucks SA S/N 03212 and 03218 to 04010, and SB S/N 00757 and 00762 to 01014 were manufactured with the relief valve in the lift pump.

6. Reconnect the battery connector and turn the key switch ON.
7. Place a maximum rated load plus 200 lbs. (90 kg) on the forks.
8. Request *main lift* (*Model SA*) or *mini lift* (*Model SB*) by moving the lift/lower control until the load begins to elevate. Note the pressure reading while lifting.
9. Lower the load completely and remove the load from the forks.
10. *Model SA later trucks*: Move the pressure gauge from the main lift pressure test port (TP50) to the mini lift pressure test port (TP51). See Figure 7-165.
11. Request *mini-mast lift* by pressing the lift select button while moving the lift/lower control. Lift the load handler completely until it is against its stop.
12. While continuing to lift against the stop, use a hex head wrench to adjust the main lift pressure relief valve until lift pressure is 200 to 300 psi (1378 to 2068 kPa or 14 to 21 kg/cm^2) *above* the value recorded in step 8 above.
13. When the pressure is correct, tighten the lock nut on the valve.
14. Lower the load handler completely. Turn the key switch OFF and disconnect the battery connector.
15. Remove the pressure gauge from the lift pressure test port.
16. Install the tractor cover.

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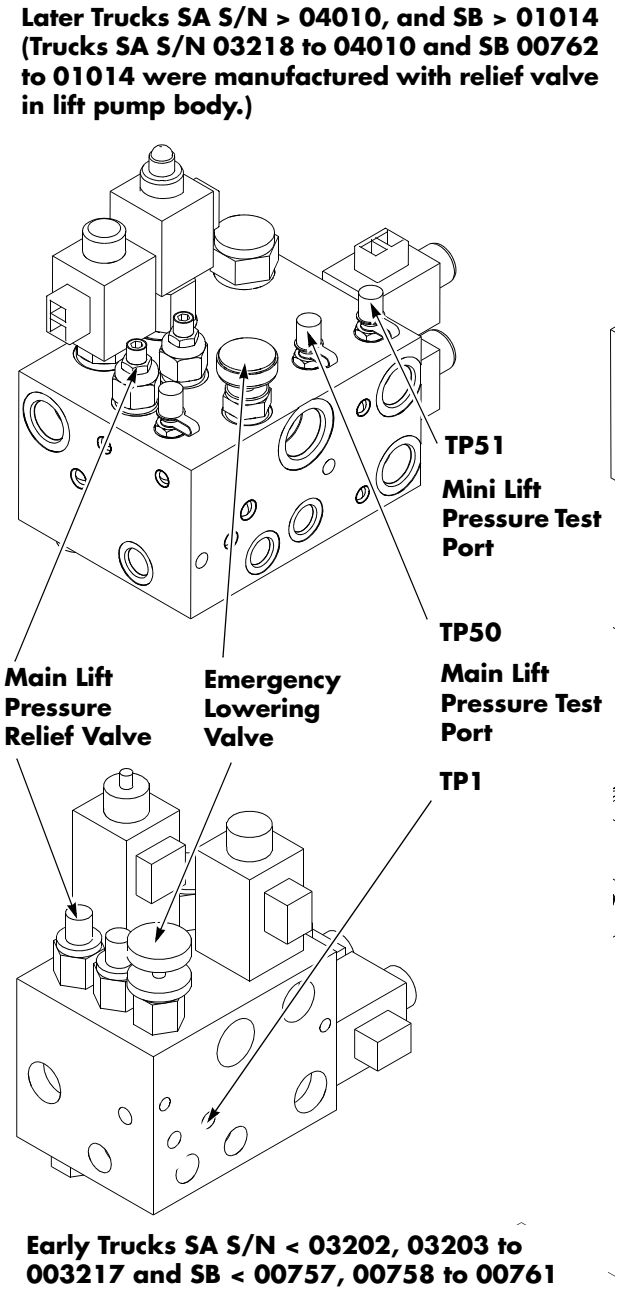


Figure 7-165. Lift Pressure Adjustment

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Main Lift Cylinders (Series SB)

Removal

⚠CAUTION

This procedure should be performed *only* with two or more technicians. *Do not* attempt this procedure without a suitable hoist or crane and a work platform. Main lift cylinders on a 203 inch OACH truck weigh 350 lb. (159 kg) each.

1. Cut the cable ties on the two hose and cable slap pads on each cylinder to be removed. See "Slap Pads, Hose and Cable (Series SB only)" on page 7-155.
2. Elevate the load handler about 3 ft. (1 m). Block and clamp between edge of carriage and baseleg. See "Blocking the Platform" and Figure 2-6 on page 2-12.
3. Turn the key switch OFF and disconnect the battery connector.
4. Remove the left side over-the-mast hose pulleys.
5. Remove the nuts securing the upper end of the cylinder.
6. Remove the tractor cover. See "Covers" on page 7-34. Use the emergency lowering valve to lower the cylinder. Make sure to close the valve when the cylinder is lowered. Reference Figure 7-22 on page 7-19 or Figure 7-23 on page 7-20.
7. Remove the lower cylinder retaining nut.
8. Loosen the left side over-the-mast hose bracket under the platform. See Figure 7-166.

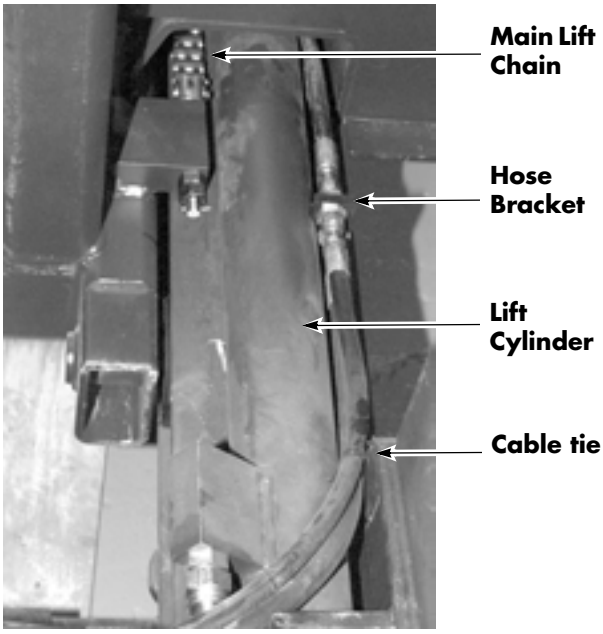


Figure 7-166. Hose Bracket Under Platform

9. Disconnect JP19 and JP18 and lay the cables over the baselegs. This protects the electrical cables from contamination with hydraulic fluid. See Figure 7-167.

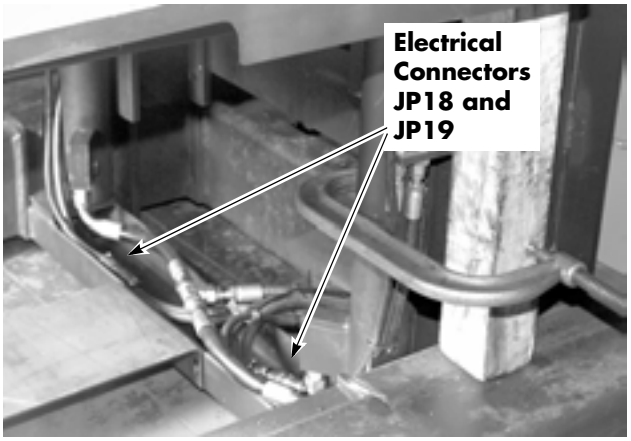


Figure 7-167. Connectors JP18 and JP19

10. Remove the hydraulic fittings at the bottom of the cylinder.
11. Attach a saddle clamp to the cylinder housing below the locating eye.
12. Attach a 1-ton hoist sling securely around the cylinder below the saddle clamp.

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13. Using a 1-ton capacity hoist, carefully lift the cylinder from its locating pin. Guide the cylinder past the hydraulic fittings on the platform.
14. Attach a nut to the mounting stud on the bottom of the cylinder to protect the threads.

Installation

1. Attach a saddle clamp to the cylinder housing below the locating eye.
2. Attach a 1-ton hoist sling securely around the cylinder below the saddle clamp.
3. Remove the nut protecting the threads on the mounting stud on the bottom of the cylinder.
4. Using a 1-ton capacity hoist, carefully lift and lower the cylinder into position. One technician guides the cylinder past the hydraulic fittings inside the cutout near the platform. One technician guides the cylinder locating eye onto the pin on the mast.
5. Attach the hydraulic fittings at the bottom of the cylinder.
6. Reconnect JP19 and JP18 under the platform.
7. Secure the left side over-the-mast hose brackets under the platform.
8. Install the lower cylinder retaining nut.
9. To raise the piston, open the emergency lowering valve. While one technician requests lift, the second technician controls lifting with the emergency lowering valve. Close the valve enough to raise the piston slowly to engage the retaining blocks at the top of the mast.
10. Install the nuts securing the upper end of the cylinder.
11. Attach the left side over-the-mast hose pulleys and route hoses over the pulleys.
12. Remove blocking beneath the platform. Lower the platform completely.
13. Install hose and cable slap pads. See “Slap Pads, Hose and Cable (Series SB only)” on page 7-155.
14. Bleed the hydraulic system. See “Bleeding the Hydraulic System” on page 7-124.
15. Check hydraulic fluid level and refill as needed.

Shimming

The following procedure could require two sizes of shims: P/N 771-043 (0.042 in.) and P/N 771-044 (0.075 in.). Use combinations on both cylinders to make the internal stops hit evenly at full elevated height. Use a maximum of 0.150 in. on each side.

Testing

To determine if main lift cylinders require shimming:

1. Rotate the fork carriage to the straight ahead position.
2. Traverse the load handler to the center of the platform.
3. Raise the platform to the full elevated height and note whether the platform sways to the right or to the left when it hits the stops.
4. If the platform sways, shim the side that the platform sways towards as follows.

Determine Shim Thickness

Determine the thickness required by temporarily adding shims under the cylinder housings, as described in the following steps.

1. Lower the platform as far as possible and still have access to the bottom of the lift cylinders.

⚠CAUTION

***Do not* block against the platform floor, but use the edge of the platform. *Do not* block the carriage against the floor — lowering the platform could tip the load wheels off the floor.**

2. Turn the key switch OFF and disconnect the battery connector.
3. Block and clamp between edge of carriage and baseleg. See Figure 2-6 on page 2-12.

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4. Loosen the lower cylinder retaining nut on the bottom of the cylinder that needs shimming.
5. Pry up the cylinder housing and insert a shim as far under the housing as possible without completely removing the cylinder retaining stud from the hole in the frame.
6. Remove blocking. Reconnect the battery connector and turn the key switch ON. Repeat the preceding procedure until the cylinder stops hit evenly at full elevated height. Note the thickness of shims required; do not exceed 0.150 in. of shims on either side.
7. Lower the platform and block as in step 3.
8. Remove the shims from under the cylinder housing. Install but do not tighten new lower cylinder retaining nuts. Make sure that the housing can float slightly.

Install Shims

Install shims at the top of the piston using the following procedure.

1. Elevate the telescopic slightly and block the telescopic as described earlier.
2. Turn the key switch OFF and disconnect the battery connector.
3. Remove the piston retaining nut at the top of the piston(s) where the shims will be installed.
4. Open the emergency lowering valve and let the pistons settle enough so that the shims can be installed around the piston upper retaining stud. Install the shims as described previously.
5. Reconnect the battery connector and turn the key switch ON.
6. To raise the piston, open the emergency lowering valve. While one technician requests lift, the second technician controls lifting with the emergency lowering valve. Close the valve enough to raise the piston slowly to engage the retaining blocks at the top of the mast.
7. Attach the nuts securing the upper end of the cylinder. Make sure that the cylinder assembly can float slightly.
8. Repeat the steps under "Testing" on page 7-132 to make sure that the cylinder stops hit evenly.
9. Readjust the lift chains. See "Main Lift Chains (Series SB)" on page 7-146.
10. Lower the platform at full lowering speed and make sure that the platform does not sway when it bottoms. If the platform sways unacceptably, check the adjustment of the main lift chains to make sure they are adjusted evenly.

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Main Lift Cylinders (Series SA)

Removal

⚠CAUTION

This procedure should be performed *only* with two or more technicians. *Do not* attempt this procedure without a suitable hoist or crane and a work platform. Main lift cylinders on a Series SA lift truck weigh up to 225 lb. (102 kg) each.

1. Locate the truck in an area where the operator platform can be elevated above the housing of the lift cylinder.

NOTE: You remove the lift cylinder below the platform. You need to lift the platform above the cylinder housing in order to remove the cylinder. If you do not elevate the bottom of the platform near the top of the cylinder housing, you cannot remove the cylinder assembly.

2. Remove the tractor cover. See “Covers” on page 7-34.
3. Remove the cover from the lift chain/hose pulleys (if present) at the top of the telescopics on the cylinder to be removed.
4. Elevate the platform approximately 12 in. (300 mm).
5. Block and clamp between edge of carriage and baseleg. See “Blocking the Platform” and Figure 2-6 on page 2-12.
6. Using the emergency lowering valve, lower the platform onto the supports so the hoses become just slack enough to remove them from the pulleys. See Figure 7-151 on page 7-115.
7. Close the emergency lowering valve. Turn the key switch OFF and disconnect the battery connector.
8. Remove the hoses from the pulleys.
9. Remove the bolt securing the pulleys.
10. Remove the nut and washer holding the piston to the telescopic.
11. Reinstall the pulleys and hoses.
12. Reconnect the battery connector and turn the key switch ON.
13. Elevate the carriage until the crosstie of the telescopic is approximately 7 in. (180 mm) above the main frame crosstie.
14. Place the 4 x 6 inch (100 mm x 150 mm) hardwood block between the telescopic and main frame crossties.
15. *Slowly* lower the carriage until the telescopic crosstie rests on the 4 x 6 inch hardwood block. This prevents the carriage and telescopic from lowering.
16. Turn the key switch OFF and disconnect the battery connector.
17. Wrap a chain around the telescopic and main frame crossties, near the block inserted in step 15. Make sure that the ends of the chain are secure.
18. To collapse the lift cylinder, open the emergency lowering valve. When the piston is completely down, close the emergency lowering valve. At this point the carriage and telescopic are supported by the wooden block. The chain serves as a safety backup.
19. Disconnect, then cap, the main supply hose from the bottom of the lift cylinder.
20. Using a 15/16 in. box wrench, remove the nut and washer from the bottom of the lift cylinder.
21. Wrap the cylinder strap around the top third of the lift cylinder.
22. To prevent the strap from slipping, place a “C” clamp above and below the strap. Make sure the clamps are tight.
23. Attach the cylinder strap to a suitable hoist or other lifting device.
24. Carefully elevate the lift cylinder enough to release the pin that secures the cylinder housing to the main frame. This pin is located on the cylinder housing near the chain anchor.

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25. Carefully swing the bottom of the lift cylinder out between the load wheels and slowly lower the lift cylinder to the floor.
26. Thread the nut on the lower cylinder stud to prevent damage to the stud threads.

Installation Procedure

1. Wrap the cylinder strap around the top third of the lift cylinder.
2. To prevent the strap from slipping, place a "C" clamp above and below the strap. Make sure the clamps are tight.
3. Feed a hoist block through the carriage channel and attach a hoist strap to the cylinder.
4. Using the hoist, carefully elevate the lift cylinder. Guide the cylinder so that the pin on the side of the cylinder, near the top, mates with the block on the mast main frame. The stud on the bottom of the cylinder must go through the hole in the support channel between the baselegs.
5. Install the washer and nut on the bottom of the lift cylinder. Tighten the nut on the bottom of the cylinder to permit the washer to float. *Do not* torque the nut tight.
6. Remove the "C" clamps and cylinder strap.
7. Attach the hydraulic supply hose to the cylinder.
8. Reconnect the battery connector and turn the key switch ON. *Slowly* and carefully extend the piston using the lift function. Continue to elevate the piston until the piston engages the telescopic.
9. *Slowly* raise the carriage enough to permit removal of the safety chain and wooden block. Turn the key switch OFF and disconnect the battery connector. Remove the chain and block.
10. Using the emergency lowering valve, lower the carriage onto blocks to permit the hoses to become slack enough to be removed from the pulleys.
11. Remove the hoses from the pulleys.
12. Remove pulleys.
13. Install the washer and tighten the nut on the top of the piston to permit the washer to float. *Do not* torque the nut tight.
14. Reinstall the pulleys and hoses. Clean and apply thread-locking compound (P/N 990-536) to the threads of the pulley screw.
15. Bleed the hydraulic system. See "Bleeding the Hydraulic System" on page 7-124.
16. Reinstall covers.

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Flow Control

Removal

1. Elevate the load handler about 3 ft. (1 m). Block and clamp between edge of carriage and baseleg. See "Blocking the Platform" and Figure 2-6 on page 2-12.
2. Turn the key switch OFF and disconnect the battery connector.
3. Place a drain pan beneath the main lift cylinder hydraulic fitting.
4. Remove the hydraulic hose. Remove the hydraulic fitting. The flow control should fall out.

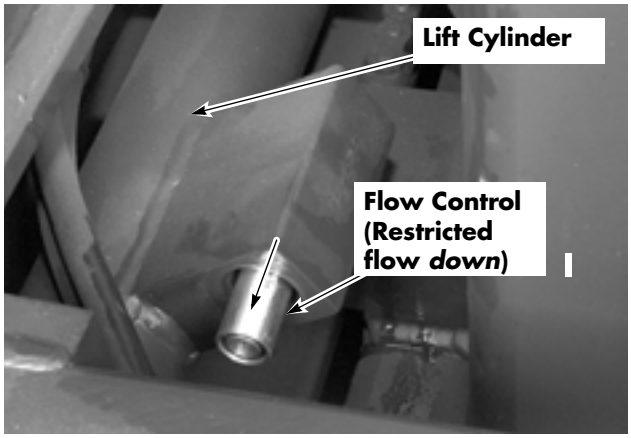


Figure 7-168. Flow Control, Main Lift Cylinder

Installation

1. Insert the new flow control, *making sure the restricted flow is in the down direction.*
2. Install the hydraulic fitting and hose.
3. Reconnect the battery connector and turn the key switch ON.
4. Lift the platform, remove the blocking, then lower the platform completely.
5. Bleed the lift system as necessary. See "Bleeding the Hydraulic System" on page 7-124.
6. Turn the key switch OFF and disconnect the battery connector.
7. Open or remove the rear tractor cover. See "Covers" on page 7-34.
8. Check the hydraulic fluid level. Correct fluid level is 1.5 to 2 in. (25.4 to 50.8 mm) below the top of the strainer in the filler neck of the reservoir or to the fill level in the sight gauge of the reservoir. See See "Hydraulic Fluid Replacement" on page 7-111.
9. Install the tractor cover.

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Mast, Chain, Hose, Cable

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Mast, Chain, Hose, Cable Component Procedures Summary

Table 7-11. Mast, Chain, Hose, Cable Component Procedures Summary

Component	Procedure /Photo or Drawing	Thread-Locking Compound/ Torque Values	Helpful Hints
Forks	Procedure: page 4-28		
Load Handler	Procedure: page 7-164		
Load Handler Lift Chain	Procedure: page 7-170		
Main Height Sensing Rail, SA	Procedure: page 7-156		
Main Height Sensing Rail, SB	Procedure: page 7-158		
Main Lift Chains, SA	Procedure: page 7-144		
Main Lift Chains, SB	Procedure: page 7-146		
Main Mast	Procedure: page 7-140		
Main Mast Lateral Adjustment, SA	Procedure: page 7-151		
Main Mast Lateral Adjustment, SB	Procedure: page 7-150		
Mast Pucks, SA	Procedure: page 7-154		
Mini-Mast and Load Handler	Procedure: page 7-160		
Mini-Mast Carriage Adjustment	Procedure: page 7-159		
Mini-Mast Pucks	Procedure: page 7-171		

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Table 7-11. Mast, Chain, Hose, Cable Component Procedures Summary

Component	Procedure /Photo or Drawing	Thread-Locking Compound/ Torque Values	Helpful Hints
Operator Platform	Procedure: page 7-152		
Rotate Carriage Lower Bearing	Locator Photo: page 4-25		
Slap Pads, Hose and Cable (SB)	Procedure: page 7-155		
Stability Pads	Locator Photo: page 7-28		Inspect stability pads for correct clearance: 0.31 to 0.56 in. (8 to 14 mm). Replace if clearance is greater than 0.75 in. (19 mm). Welding will be required.
Static Straps	Locator Photo: page 7-31		Make sure static straps are not worn or broken. Clean debris from straps. Measure resistance of resistor in standoff. If the resistance is less than 10K ohms or greater than 1.2 meg ohms, replace the resistor/insulator block or the whole static strap assembly EE lift trucks require phosphor-bronze, not steel-braided straps.
Telescopic Removal and Mast Bearing Replacement, SB	Procedure: page 7-148		
Traverse Gear Shaft	Procedure: page 7-168		

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Main Mast

Separating Tractor and Mast

⚠ WARNING

Do this procedure with a minimum of two technicians in a shop suitably equipped with a 10-ton hoist.

1. Retract and center the forks. Lower the load handler and operator platform completely.
2. Turn the key switch OFF and disconnect the battery connector. Using a suitable battery removal device, remove the battery. Remove battery rollers and place in a carton.
3. Remove the forks. Replace the fork bar, set screw, and locating pin.
4. Secure the load handler:
   a. If there is a hole through the load handler near the bottom, insert a long bolt and nut so that the bolt secures the load handler. See Figure 7-169.

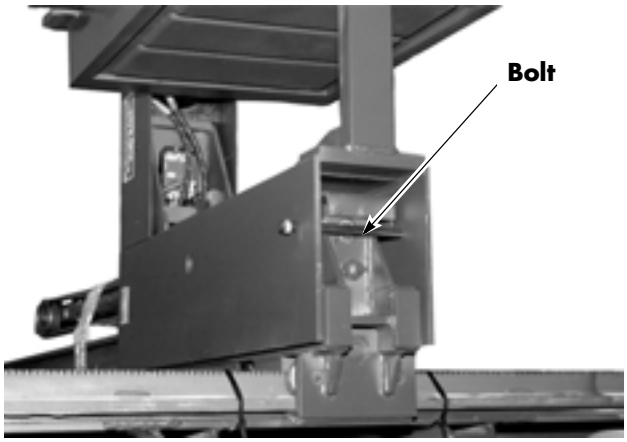


Figure 7-169. Load Handler Secured with Bolt

   b. If there is no hole through the load handler, use steel banding (1.25 x 0.031 in.) around the bottom of the mini-mast. See Figure 7-170.

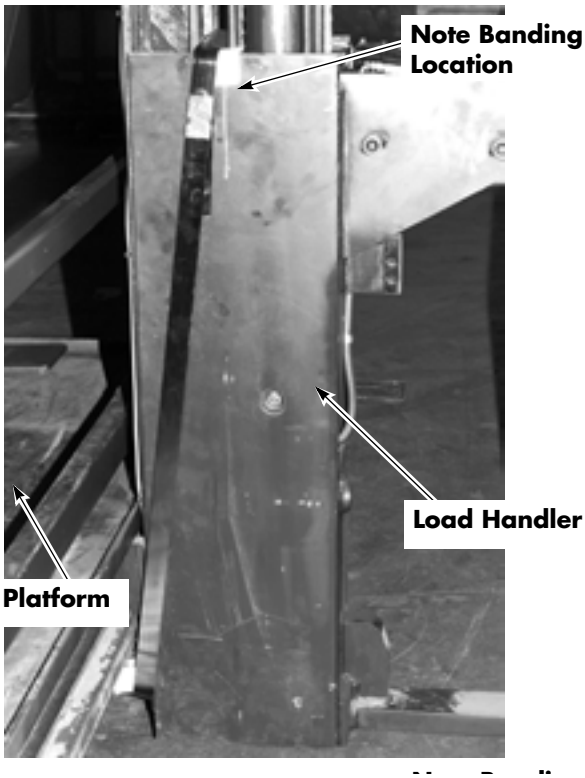


Figure 7-170. Load Handler Secured to Mini-Mast

5. Insert 1 x 4 in. (2.5 x 10 cm) wood stringers cut to fit between lower traverse bearing and traverse stops on each side of the load handler. Secure with cable ties around the lower traverse rack.
6. Tape a 2 x 4 x 7 in. (5 cm x 10 cm x 18 cm) wood block between the mini-mast and the mini-mast lift cylinder at the midpoint of its height.
7. Disconnect four hydraulic hoses between the tractor and mast at the bottom of the battery compartment. Save the O-rings and cap/plug hose fittings.
8. Disconnect connector(s) JP61 (later trucks) or JP39, JP49, and JP59 (earlier trucks). Disconnect wires from B+FILT_F1 and B+F2 on filter FILT1 and from B+F1 on filter FILT2, labeling if necessary for later installation. Disconnect over-the-mast cable connectors JPS25 and JPS26, Height Manager connector JPH2 (Series SA), travel light connector JPS44 (if

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so equipped), and end-of-aisle sensor connectors JPS6 and JPS28 (if so equipped) at the Tractor Manager and wire guidance connector JPW1 (if so equipped) at the Wire Guidance Filter Card. Thread the cables through the tractor opening and over the mast crosstie.

Reference Figure 6-3 on page 6-81, Figure 6-9 on page 6-86, and Figure 7-7 on page 7-6.

9. Series SA: Attach two straps from a 10-ton hoist around the main mast and telescopic crossties. See Figure 7-171 on page 7-141.

   Series SA alternate method: Position the lifting truck as shown in Figure 3-6 on page 3-11 and secure a heavy chain around the fork carriage of the lifting truck and the mast crosstie.

10. Series SB: Attach two straps from a10-ton hoist around the *second* main mast and telescopic crossties. See Figure 7-171.

⚠CAUTION

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

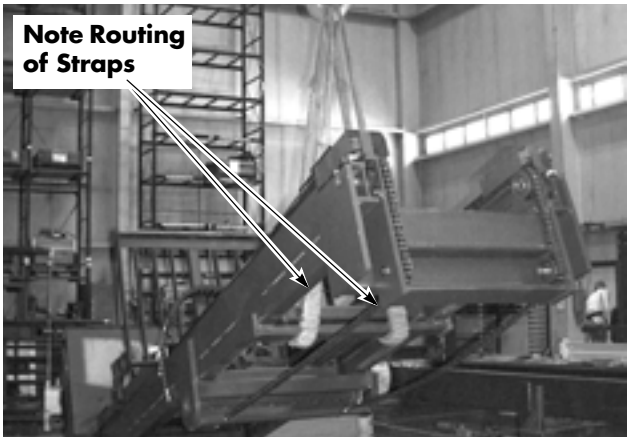


Figure 7-171. Mast Strapped to Hoist

Series SB alternate method: Insert a length of suitable structural tubing through the 6 in. (15 cm) hole in the lifting flange. This flange is a part of the SB mast lower crosstie. See Figure 7-172. If you are using two lift trucks to lower the mast, a 160 in. (407 cm) length is recommended for the tubing. See Table 3-1 on page 3-12 for specifications on structural tubing.

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

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

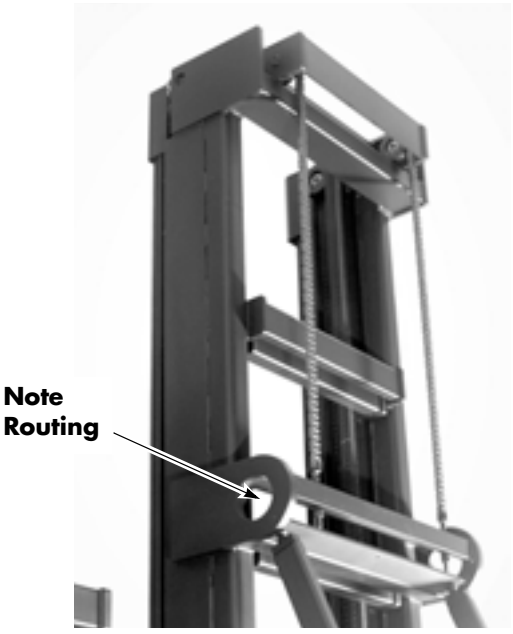


Figure 7-172. SB Mast Lifting Flange

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11. Block the tractor where it meets the mast.

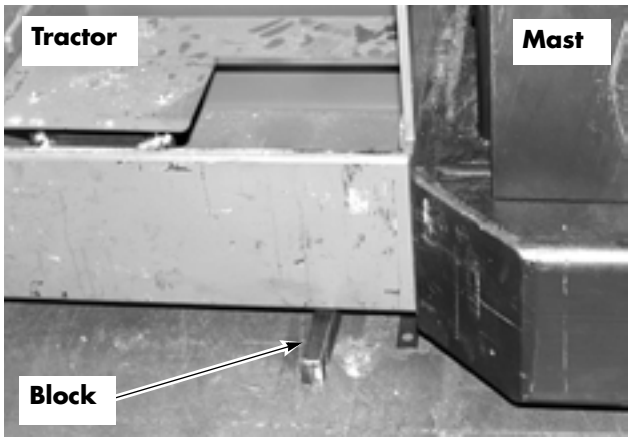


Figure 7-173. Blocking Tractor At Mast

12. Loosen the diagonal support arm jam nuts and remove the upper mounting bolts.
13. Remove the snap ring from the support arm clevis pin.

⚠CAUTION

Each support arm weighs approximately 60 lbs. (27 kg).

14. Using a helper, remove the clevis pin while supporting the support arm. Remove the arm. Replace the clevis pin and snap ring (so as not to misplace them).

⚠ WARNING

Before loosening mast mounting bolts, make sure the weight of the mast is fully supported by the hoist (or lift trucks) and the tractor is blocked where it meets the mast.

15. Remove eleven mounting bolts and washers (4 at top, 7 at bottom) joining the tractor and mast at the tractor front bulkhead inside the battery compartment.
16. Supporting the weight of the mast with the hoist (or lift trucks), separate the mast from the tractor.
17. Disconnect connector JPA1 at the Supplemental Operator Display. Remove glass or mesh mast guard. Package and seal guard and Display in protective cardboard.
18. Install steel banding around the overhead guard and bottom main frame crosstie as shown.
19. Protect removed electrical cable connectors with a plastic bag and cable tie.



Figure 7-174. Platform Strapped to Mast

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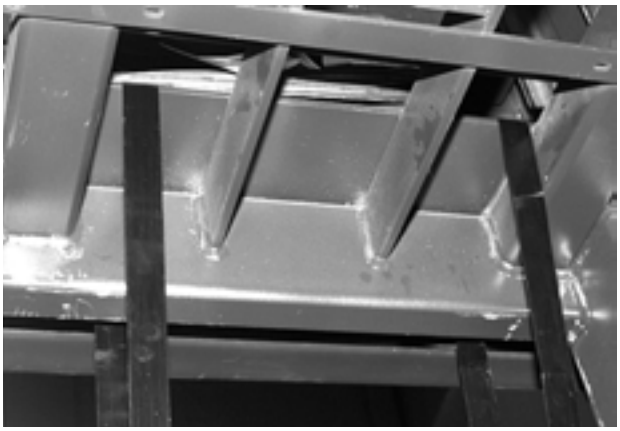


Figure 7-175. Overhead Guard Strapped to Mast

20. Tuck hydraulic hoses and electrical cables into the base of the main frame.

NOTE: Be careful of possible burrs on the edge of the opening in the frame.



Figure 7-176. Securing Hoses in Main Frame

21. Lower the upper end of the mast onto a suitable dolly or skid.
22. Using a 10-ton-capacity hoist, elevate the main frame at the platform and lower it unto a suitable dolly or skid.
23. To prevent over-the-mast hoses and cables from movement during transport, secure hoses and cables to main lift cylinders with cable ties at two or more points on each cylinder. Attach a “toe-tag” to the lift/lower control with a reminder to remove these cable ties at installation.
24. If the mast has been placed on a skid, secure the mast tightly to the skid with steel banding around mast and inner telescopic crossties, at four places.
25. Reposition static straps so they do not protrude from the bottom of the mast during transport.
26. For tractor shipment, remove tractor side covers and tape them securely inside the battery compartment.
27. Securely tape the packaged mast guard and Supplemental Operator Display inside the battery compartment.
28. Install battery gates. Place the carton with the battery rollers in the battery compartment. Install steel banding around the bottom of the battery compartment, through the handles of the battery gates, and over the carton on both sides.
29. Immobilize control handles and steering tiller by wrapping with protective plastic tape.

Joining Tractor and Mast

See “Installation Instructions” on page 3-10.

Make sure to read and follow all warnings and cautions in these instructions.

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Main Lift Chains (Series SA)

Removal

1. Center the load handler horizontally with forks straight ahead.
2. Loosen both upper chain anchor jam nuts before removing tension on lift chains.
3. Raise the platform 6 inches (150 mm).
4. Block and clamp the platform between the platform and baseleg (*not* the floor). Lower the platform onto the block to slacken the chains.
5. Turn the key switch OFF and disconnect the battery connector.
6. Measure and note the length of the exposed end of the upper chain anchor. You will use this measurement to approximate correct chain tension during reassembly.
7. Remove the pedestal covers.
8. Remove chain from lower chain anchor block. Separate the chain from the lower chain anchor by removing the cotter pin and master link. See Figure 7-177.

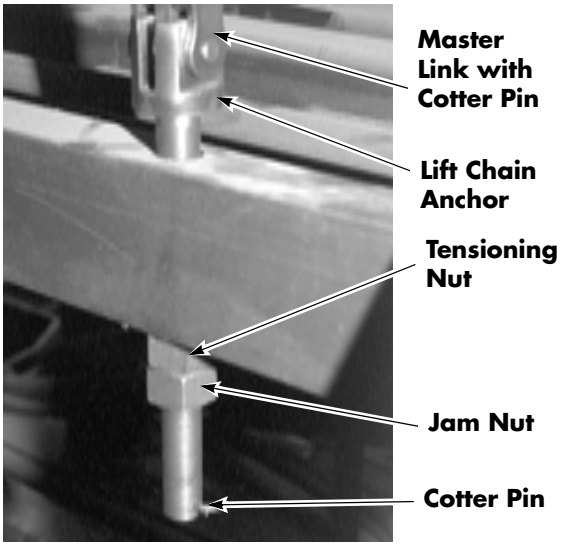


Figure 7-177. Main Mast Lift Chain Anchor (lower)

9. At the top of the mast, remove the pulley cover.
10. Remove chain from upper chain anchor:
    a. If equipped with slack chain switches, remove cotter pin, jam nut, and slack chain switch actuating bracket with switch. Remove tensioning nut and four compression spring washers.
    b. If not equipped with slack chain switches, remove the cotter pin, jam nut, and tensioning nut.
    c. All trucks: Pull the chain anchor out of the mast crosstie and pull the chain up and out over the chain pulley.

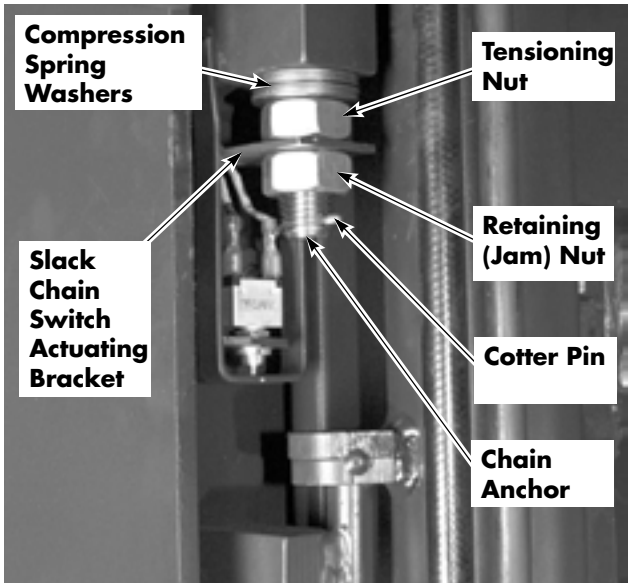


Figure 7-178. Slack Chain Switch Bracket (SA)

11. Repeat steps 8 through 10 for the other lift chain.
12. Remove upper chain anchors from chains by removing cotter pins and master links.

Installation

1. Attach upper chain anchors to both lift chains with master links, securing each with a cotter pin.
2. Insert the anchor in the upper chain anchor block.
3. Attach tensioning and jam nuts. If equipped with slack chain switches, install

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four compression spring washers between the chain anchor block and the tensioning nut. Then install the slack chain actuating bracket and switch between the tensioning nut and the retaining (jam) nut.

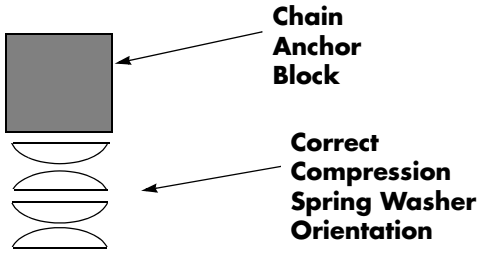


Figure 7-179. Compression Spring Orientation

NOTE: Make sure the compression spring washers are in the correct orientation so that they function correctly. See Figure 7-179. The compression spring washers compress fully when the chain is tight.

4. Attach the cotter pin. Adjust the tensioning and jam nuts to leave the same length of exposed thread as you measured in removal step 6.
5. Carefully feed the lift chain over the chain pulley down the mast channel. Make sure the open side of the master link faces the forks.
6. At the pedestal access, attach the chain to the lower chain anchor with a master link, securing with a cotter pin.
7. Repeat steps 2 through 6 for the other lift chain.
8. Reconnect the battery connector and turn the key switch ON.
9. Slowly and carefully request main lift until the slack is removed from the lift chains and the platform lifts slightly. Remove the blocking. Slowly and carefully lower the platform completely.
10. Adjust the lift chains as described under "Adjustment".

Adjustment

See "Fork Height and Lift Chain Adjustment" on page 4-30.

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Main Lift Chains (Series SB)

Removal

1. Center the load handler horizontally with forks straight ahead.
2. Loosen both upper chain anchor jam nuts before removing tension on lift chains.
3. Raise the platform 3 ft. (1 m) to permit access to the lower chain anchors.
4. Block and clamp the platform between the platform and baseleg (*not* the floor). Lower the platform onto the block to slacken the chains. See Figure 2-6 on page 2-12.
5. Turn the key switch OFF and disconnect the battery connector.
6. Measure and note the length of the exposed end of the upper chain anchor. You will use this measurement to approximate correct chain tension during reassembly.
7. Remove safety cotter pin, jam nut, and tensioning nut from the lower chain anchor on each side. See Figure 7-180.

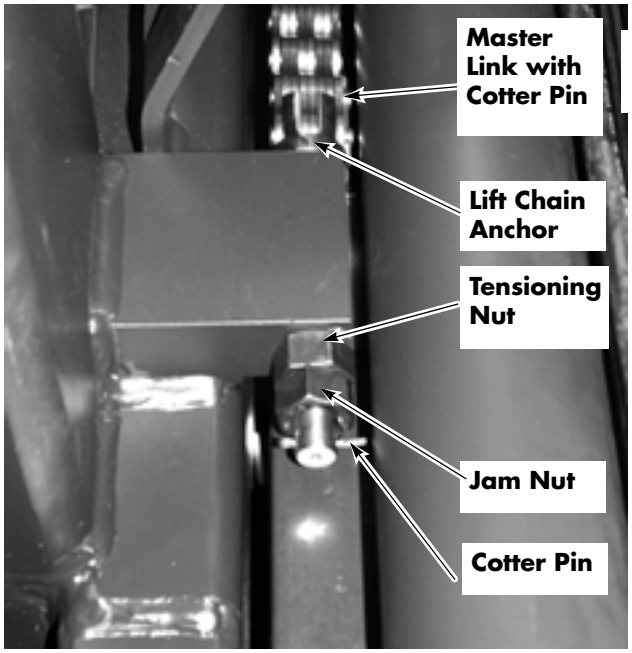


Figure 7-180. Main Lift Chain Lower Chain Anchor (left side shown)

8. Working from a work platform, remove chain from upper chain anchor:
   a. If equipped with slack chain switches, remove cotter pin, jam nut, and slack chain switch actuating bracket with switch. Remove tensioning nut and four compression spring washers. See Figure 7-181.
   b. If not equipped with slack chain switches, remove the cotter pin, jam nut, and tensioning nut.
   c. Remove the chain anchor from the mast crosstie and pull the lift chain up and over the lift chain pulley.

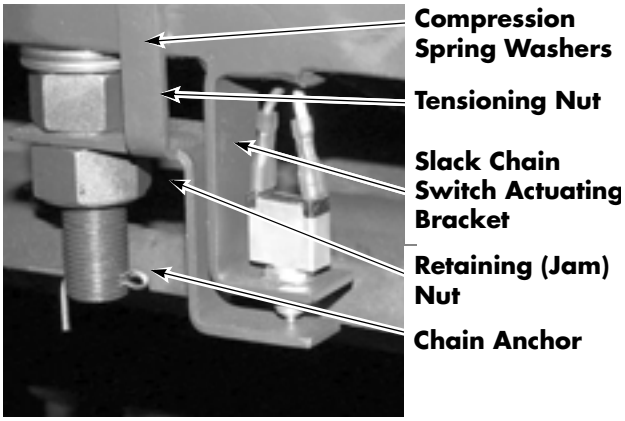


Figure 7-181. Slack Chain Switch Bracket (SB)

9. Repeat step 8 for the other lift chain.
10. Remove chain anchors from chains by removing cotter pins and master links.

Installation

1. Attach chain anchors to both ends of the lift chains with master links, securing each with a cotter pin.
2. Add a large washer and nut to the upper lift chain anchor and attach a rope to the anchor. Tie the rope to the mast crosstie near the chain anchor bore.
3. Carefully feed the other end of the lift chain down the mast.
4. Underneath the platform, feed the chain anchor through the chain anchor block and secure with tensioning nut, jam nut,

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and cotter pin. See Figure 7-180 on page 7-146.

NOTE: On the left side, use jam nut P/N 750-254. On the right side, use the thinner jam nut P/N 750-452.

5. Repeat steps 2 through 4 for the other lift chain.
6. On the right side, back the jam nut down against the cotter pin. Back the tensioning nut against the jam nut and tighten the nuts together.
7. Measure the distance from the top of the tensioning nut to the bottom shoulder of the chain anchor.
8. On the left side, adjust the tensioning nut and jam nut so the distance between the top of the tensioning nut and the bottom shoulder of the chain anchor is 0.50 in. (12.7 mm) less than the distance you measured in step 7.
9. At the top of the mast, remove the rope, nut, and washer, and feed the chain anchor through the bore in the mast crosstie.
10. Attach tensioning and jam nuts. If equipped with slack chain switches, install four compression spring washers between the chain anchor block and the tensioning nut. Then install the slack chain actuating bracket and switch between the tensioning nut and the retaining (jam) nut.

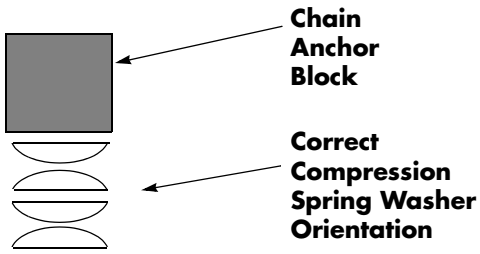


Figure 7-182. Compression Spring Orientation

NOTE: Make sure the compression spring washers are in the correct orientation so that they function correctly. See Figure 7-182. The compression spring washers compress fully when the chain is tight.

11. Attach the cotter pin. Leave the same length of exposed thread as you measured in removal step 6 above.
12. Reconnect the battery connector and turn the key switch ON.
13. Slowly and carefully request main lift until the slack is removed from the lift chains and the platform lifts slightly. Remove the blocking. Slowly and carefully lower the platform completely.
14. Adjust the lift chains as described under "Adjustment".

Adjustment

See "Fork Height and Lift Chain Adjustment" on page 4-30.

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Telescopic Removal and Mast Bearing Replacement (Series SB)

NOTE: To minimize rattle, rollers are available in widths between 5.406 in. (137.3 mm) and 5.562 in. (141.3 mm). Consult the Parts Catalog. Measure the opening in the main frame and telescopic. Take measurements every foot of length to make sure you find the narrowest area. Using rollers that are too wide causes premature failure.

⚠ WARNING

Do this procedure with a minimum of two technicians in a shop suitably equipped with a 10-ton hoist.

Removal

1. Remove the operator platform. See "Operator Platform (SA/SB)" on page 7-152.
2. Remove Allen head bolt holding main mast lateral bearings (tip - mark the lateral bearing before removing it so that alignment is the same when reassembling), then remove bearings.
3. Remove fore-aft main mast bearings.
4. Remove nut attaching lift cylinder piston to the telescopic.
5. Wrap a 10-ton hoist strap twice around the upper telescopic crosstie.
6. Lift the telescopic about 4 ft. (1.2 m), block underneath, then change the position of the hoist strap to the second crosstie.
7. Lift the telescopic out of the main mast uprights and lower to the floor.

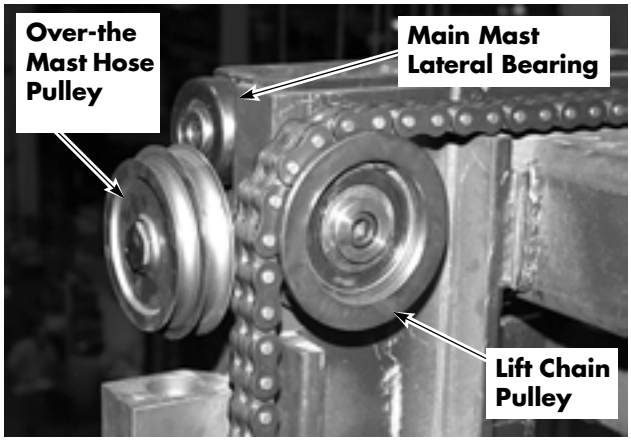


Figure 7-183. Main Mast Lateral Bearing (Right Side)

Bearing Replacement

1. Replace bearings by removing inner snap ring, then remove the bearing. Place new bearing on bearing boss and install snap ring. See Figure 7-184.

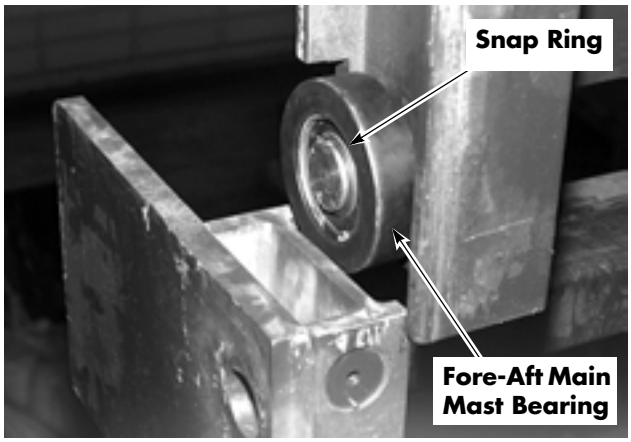


Figure 7-184. Mast Bearing Replacement

Installation

1. Using a hoist as in steps 6 and 7 under "Removal," insert the telescopic in the main mast uprights. Slowly and carefully lower the telescopic onto the blocks.
2. Install fore-aft main mast bearing.
3. Install main mast lateral thrust bearing (could need some additional adjustment).
4. Move the hoist strap to the upper telescopic crosstie. Remove blocking,

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slowly lower the telescopic to the bottom. See Figure 7-184.

5. Remove the hoist strap.
6. Reinstall the nut attaching the lift cylinder piston to the telescopic.
7. Install the operator platform.

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Main Mast Lateral Adjustment (Series SB)

Adjustment

1. On both sides of the mast, measure the dimension between the inside of the main frame uprights and the outside of the inner telescopic.
2. Compare the dimensions to determine which way the telescopic needs adjustment.

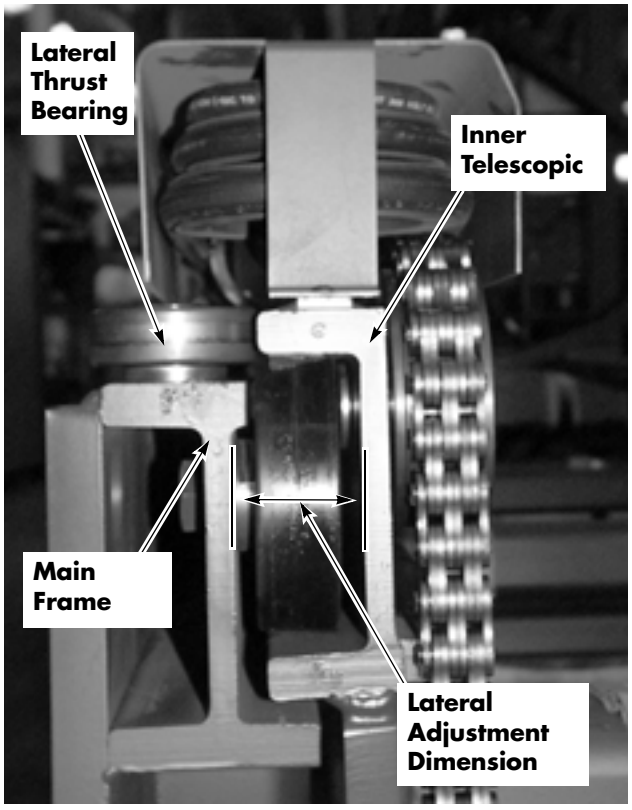


Figure 7-185. Main Mast Lateral Thrust Bearing (top view, left side)

3. Elevate the operator platform as required to gain access to the lateral thrust bearings on the main frame. Block and clamp the platform between the platform and baseleg (*not* the floor).
4. Turn the key switch OFF and disconnect the battery connector.
5. The lateral bearings are mounted on an eccentric. The bearing is positioned so a locating pin in the mast engages one of several adjustment holes.
See Figure 7-186.

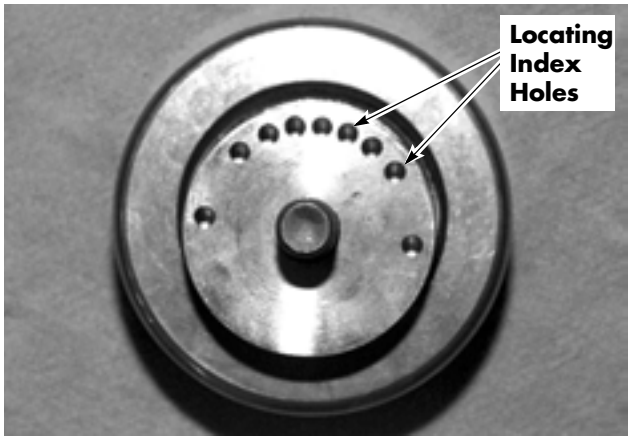


Figure 7-186. Lateral Thrust Bearing (Inside Surface)

6. Loosen or remove the bearing retaining bolt and remove the bearing.
7. Pry the carriage to the correct position.
8. Reposition the bearing on the locating pin offering the smallest clearance between bearing and main frame.
9. If the carriage is tight but not centered, you could need to loosen the bearings on one side before adjusting the bearings on the other side.
10. Torque all lateral bearing retaining bolts to 85 ft. lb. (115 Nm).
11. Remove blocking and clamps.
12. Reconnect the battery connector and turn the key switch ON.
13. When the bearings are adjusted correctly, only one upper and one lower bearing make contact with the main frame at a time.
14. Fully elevate the platform and check for binding between the main frame and telescopic. If both upper bearings or both lower bearings are making contact with the telescopic, the bearings are too tight. Loosen one bearing by one adjustment hole.

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Main Mast Lateral Adjustment (Series SA)

Adjustment

1. Loosen lock nut.
2. Center the telescopic left to right within the main frame with the forks centered straight ahead. Turn the key switch OFF and disconnect the battery connector.
3. Tighten adjusting screws equally to finish centering telescopic. If no adjustment remains, stop here. Replace the pucks. See "Mast Pucks (SA)" on page 7-154.
4. Loosen adjusting screw at top of mast, 1/4 turn on either side.
5. While holding adjusting screw, tighten lock nut, both sides.
6. Apply thread-locking compound (P/N 990-536) to screw.
7. Tighten adjusting screws at bottom of telescopic, then loosen 1/4 turn (both sides).
8. Tighten lock nut on either side after adjustment is done.
9. Check for correct adjustment of the main height sensing rail to the sensor. See "Main Mast Height Sensor" on page 7-99.

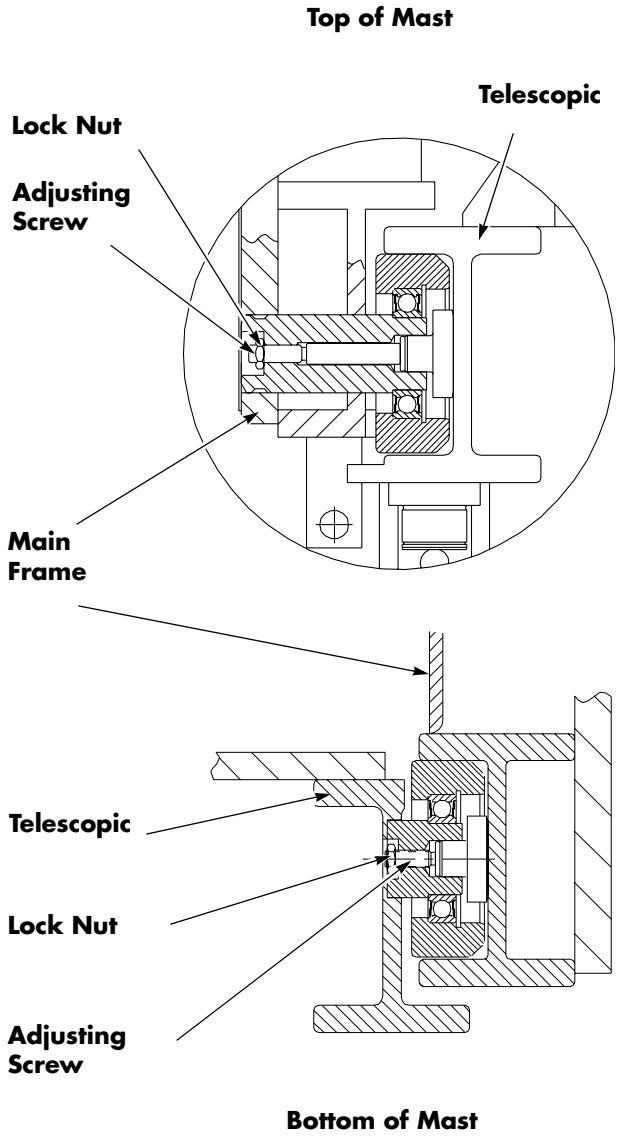


Figure 7-187. Mast Lateral Adjustment

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Operator Platform (SA/SB)

NOTE: *Read this entire procedure before beginning.*

Removal

1. Elevate the carriage approximately 70 in. (1780 mm). Place adequate supports under the carriage to prevent it from lowering. Turn the key switch OFF and disconnect the battery connector.
2. Remove carriage stops from lower crosstie on inner telescopic by removing the bolts.
3. Reconnect the battery connector and turn the key switch ON. Remove supports. Lower the carriage.
4. Drive the truck a short distance to make sure that the drive unit is positioned straight ahead.
5. Enter Configure Mode. Record the current settings for Accel and Coast. Set:
   - Accel to “soft”
   - Coast to “long”

NOTE: See “Using Configure Mode” on page 6-7.

6. Slowly elevate the platform until fully elevated. Remove the mast sliders.
7. On all four carriage pucks, back adjustment screws out completely.
8. Center the mini-mast and position the forks straight ahead.
9. Elevate the carriage enough to clear the flow control block. Place blocks as shown in Figure 7-188.

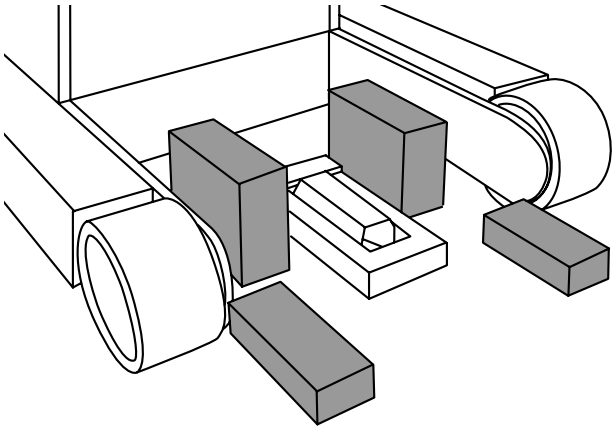


Figure 7-188. Blocking Carriage

10. Lower the carriage onto the blocks. Continue to hold the lower control until the lift cylinders are fully collapsed.
11. Turn the key switch OFF and disconnect the battery connector.
12. Place one railroad jack on each side of the traverse rack as shown in Figure 7-189. This supports the front of the carriage.

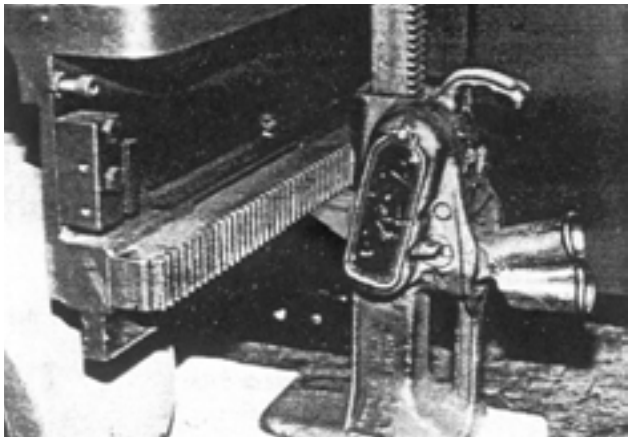


Figure 7-189. Jacking under Traverse Rack

13. Remove the pulley guards at the top of the telescopic. Remove the cables and hoses from the pulleys. Secure the hoses and cables to the overhead guard with cable ties.
14. Disconnect the lift chains at the connector links and secure to the overhead guard with cable ties.

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15. Reconnect the battery connector and turn the key switch ON. *Slowly* elevate the telescopic section of the mast. Elevate the telescopic until the inner telescopic clears the carriage.
16. *Very slowly*, drive the tractor away from the carriage. *You can only move the tractor approximately 3 in. (76 mm) before the rollers on the carriage hit the lift cylinder housings.*

Installation

1. Reconnect the battery connector and turn the key switch ON. *Slowly*, move the tractor towards the carriage.
2. Once correctly positioned, lower the telescopic around the sliders/rollers on the carriage.
3. Install and adjust the lift chains. See "Main Lift Chains (Series SA)" on page 7-144.
4. Install and adjust the hoses and cables.
5. Perform lateral mast adjustment. See "Main Mast Lateral Adjustment (Series SA)" on page 7-151.
6. Add shims to the sliders until they will not enter the telescopic, then remove one shim. Apply thread-locking compound (P/N 990-536) to the slider bolts and fasten sliders with bolts.
7. Perform operator platform lateral adjustment. See "Lateral Adjustment (SA)" on page 7-153.
8. Install the mechanical stops on the telescopic.
9. Elevate the main mast enough to be able to bolt the stops removed in removal step 2. Block the carriage from dropping as in removal step 1.
10. Bolt the carriage stops to the lower crosstie of the inner telescopic. Apply thread-locking compound (P/N 990-536) to the bolts and torque to 75 ft. lb. (102 Nm).
11. Lower the main lift completely using the Emergency Lower Valve. Close the valve completely.
12. Enter Configure Mode and reset Accel and Coast parameters to the values you found in Removal step 5.
13. Test all lift truck functions.

Lateral Adjustment (SA)

1. Center the load handler with the forks straight ahead.
2. Elevate the carriage for access to bottom adjustments. Block and clamp the operator platform between the platform edge and baseleg.
3. Turn the key switch OFF and disconnect the battery connector.
4. Loosen lock nut.
5. Using the set screws, center the carriage within the telescopic, and remove any side movement. If no adjustment remains, stop here. Replace the pucks. See "Mast Pucks (SA)" on page 7-154.
6. Loosen each set screw 1/4 turn; lock in place.

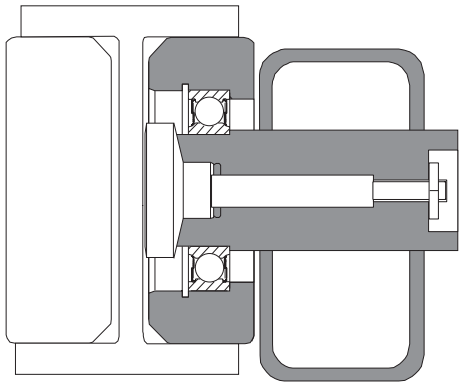


Figure 7-190. Operator Platform Lateral Adjustment (Series SA)

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Mast Pucks (SA)

Removal

1. Follow the procedure for removing the operator platform. See "Operator Platform (SA/SB)" on page 7-152.
2. Using an 8 mm Apex, remove the mechanical stops from the telescopic.
3. Remove the retaining nut and washer at the top of each lift cylinder.
4. Carefully elevate the telescopic to its maximum elevated height.
5. Attach a block and tackle to the top of the crosstie. Take up slack to support the telescopic.
6. Remove the upper telescopic bearings and roller pins that are mounted in the main frame. Set screws hold the roller pins in place at the top of the main frame.
7. Remove the telescopic and replace all the pucks. While the telescopic is out, inspect all the bearings.
8. Replace worn or damaged components.

Installation

1. After replacing pucks and any other worn or damaged components, lower telescopic into main frame.
2. Install upper roller pins and bearings.
3. Apply thread-locking compound (P/N 990-536) to set screw and install. Make sure that roller pin is secured in place.
4. Lower telescopic onto lift cylinders. Install the washers and retaining nuts. *Do not* torque the retaining nuts tight!
5. Remove block and tackle.
6. Using the Emergency Lowering Valve, slowly lower the telescopic to a point where the carriage can still be inserted into the telescopic.
7. Follow the procedure for installing the operator platform. See "Operator Platform (SA/SB)" on page 7-152.

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Slap Pads, Hose and Cable (Series SB only)

Series SB lift trucks could be equipped with slap pads designed to minimize the noise of over-the-mast hoses and cables striking the main lift cylinders during normal travel.



Figure 7-191. Hose and Cable Slap Pad Assembly

Removal

1. Turn the key switch OFF and disconnect the battery connector.
2. Using a suitable work platform, cut the cable ties securing the slap pads. The slap pads consist of two pieces each. Each cylinder has two pads, one located approximately 5.5 inches (14 cm) from the top of the cylinder, and the other approximately 93 inches (236 cm) from the floor.

Installation

1. Turn the key switch OFF and disconnect the battery connector.
2. Use a suitable work platform to access the slap pad locations on each cylinder. Install pad assemblies to the outboard hoses/cables at a height of 93 inches (236 cm) from the floor and 5.5 inches (14 cm) from the top of the cylinder. Install cable ties around cylinders and pads.

NOTE: Do not block cylinder bleed screws.

⚠CAUTION

Apply slap pads and cable ties to the *outboard side* hoses/cable only. The *inboard side* hoses/cables must be free to move with platform lift/lower.

3. Apply the shorter pad between the cylinder and hoses/cable. Apply the longer pad over the hoses/cable. Secure with a cable tie.

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Main Height Sensing Rail (Series SA)

Removal

1. Raise the telescopic to access the lower mounting screw and remove it.
2. Elevate the telescopic to access the remaining screws. Remove both the screws and the retainers as they clear the main frame. When reinstalling the rail, position the retainers as they were before they were removed.
3. Raise telescopic to full extension. Full extension might not be necessary, but will make removal easier.
4. Securely chain the crossties of telescopic and main frame so that the telescopic cannot move.
5. Turn the key switch OFF and disconnect the battery connector.
6. Slide the height sensing rail to the opposite side of the telescopic from where it was mounted, and slide it up and out of the mast.

Installation

1. While the telescopic is at the removal height in step 3 above, slide the new sensing rail into the mast at the same location from which the old one was removed. Make sure that each of the larger cutouts lines up with the mast crossties.
2. Slide the height-sensing rail over until it lines up with the mounting holes.
3. The retainers are designed with offset holes to permit the retainers to rotate to provide more adjustment of the rail.
4. Install the retainers and screws in the square cutouts in the back of the new rail. Start with the retainers in the same orientation as on the previous rail. If you need more adjustment, you can reverse the retainers later. Install the mounting screws snug, but do not tighten. You will tighten them after adjustment later. See step 8 below.



Figure 7-192. SA Height Sensing Rail retainers

5. Remove the chain from the mast crossties.
6. Reconnect the battery connector and turn the key switch ON.
7. When the new rail is mounted, fully lower the telescopic.
8. Measure the clearance between the height rail and the upright directly under the Main Height Sensor. The clearance should be 0.47 to 0.65 inch (12 to 16.5 mm) at the mounting points. Elevate the carriage fully and check the distance as the carriage moves.

   Repeat these measurements with a load nested to the left and with a load nested to the right. Adjust mast pucks as required. Reference "Mast Pucks (SA)" on page 7-154
9. Apply thread-locking compound (P/N 990-536) to the threads of the height sensing rail mounting screws when retightening. Adjust each mounting screw as necessary to maintain the clearance throughout the travel of the height rail.
10. Check that the Main Height Manager LEDs cycle correctly as you elevate and lower the platform throughout the full range.
    a. With the main mast fully lowered, only the red "heartbeat" LED1 should be blinking. One green LED (top left on SA, top right on SB) should be on solid. The

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other two green LEDs could be on or off depending on their position on the height rail.

b. As you elevate the load handler, two green LEDs should blink on and off and the green LED that was on solid in the previous step should be off solid when the sensor is outside the reference area.

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Main Height Sensor (Series SB)

When the main mast height sensor is correctly adjusted, the fore-aft distance between the center line of the sensor head and the tractor-most edge of the height count hole in the height rail is between 3/16 and 5/16 inch (4.75 to 7.9 mm). See Figure 7-193.

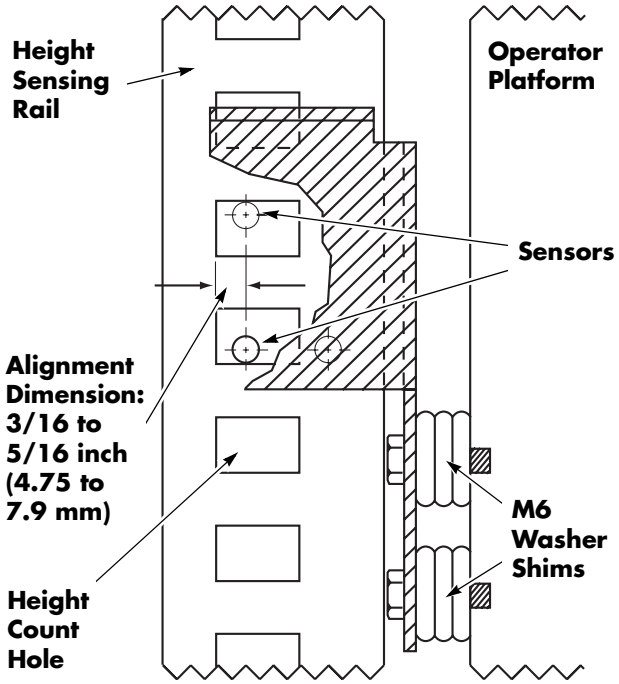


Figure 7-193. Series SB Main Height Sensor Adjustment

To adjust the sensor:

1. Elevate the operator carriage approximately 4 ft. (1.2 m) to expose the height sensor above the tractor bulkhead. Block and clamp the carriage securely.
2. Turn the key switch OFF and disconnect the battery connector.
3. Shim the sensor bracket to the platform with M6 flat washers to obtain the correct alignment.
4. Apply thread-locking compound (P/N 990-536) to the threads of the sensor assembly mounting bolts. Install mounting bolts and tighten.
5. Remove blocking. Reconnect the battery connector and turn the key switch ON.
6. Fully elevate and lower the operator platform while observing the height information on the Operator Display. Make sure the height value increases and decreases correctly. Repeat with a load nested to the left and with a load nested to the right.

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Mini-Mast Carriage Adjustment

Check the Mini Height Sensing Rail

1. Check the height rail for sharp edges or damage that would cause premature wear of the sensor housing. Grind the rail smooth or replace the damaged rail.
2. On mini-masts having a removable upper section of height rail, make sure that the transition between the sections is smooth, without a “step.”
3. If a “step” exists at the transition point, remove the upper rail section and grind material off the rail until the rail lies flat when mounted.
4. Straighten the end of the removable rail section if necessary.

Replacing the Mini Height Sensing Rail

1. Vertically, the new rail should mount the same as the rail that was removed.
2. The bottom edge of the height rail extends down 1.86 in. (47.2 mm) from the bottom edge of the lowest web plate on the mast weldment.
3. Horizontally, the rail should be centered in the opening. This should leave 0.5 in. (12.7 mm) margin on each side of the rail.
4. If the mini-mast has a removable upper section, mount the upper section and use that section to correctly position the new lower section for welding.

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Mini-Mast and Load Handler

⚠ WARNING

Do this procedure with a minimum of two technicians in a shop suitably equipped with a 5-ton hoist.

Removal

1. Traverse the load handler to the right, nest the forks, and lower the forks completely. Turn the key switch OFF and disconnect the battery connector.
2. Remove the forks.
3. Use a work platform, ladder, or other suitable device to gain access to components on top of the overhead guard. Remove the traverse motor cover.
4. Near the traverse motor, disconnect and label, if needed, the wires to fork control solenoid coils 33 (if so equipped), 34A/B, and 35A/B. See Figure 7-194 and Figure 7-195.

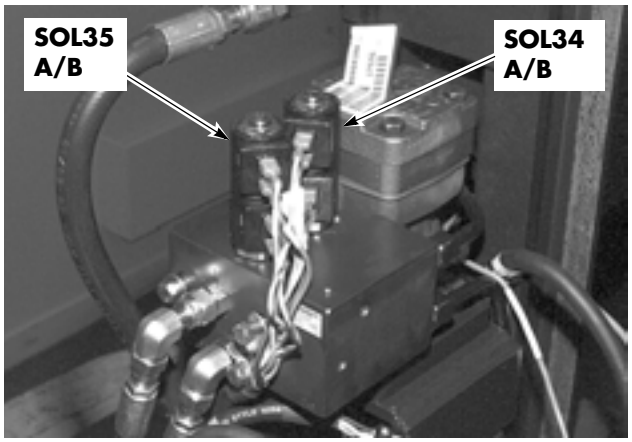


Figure 7-194. Fork Control Solenoids SOL34/35

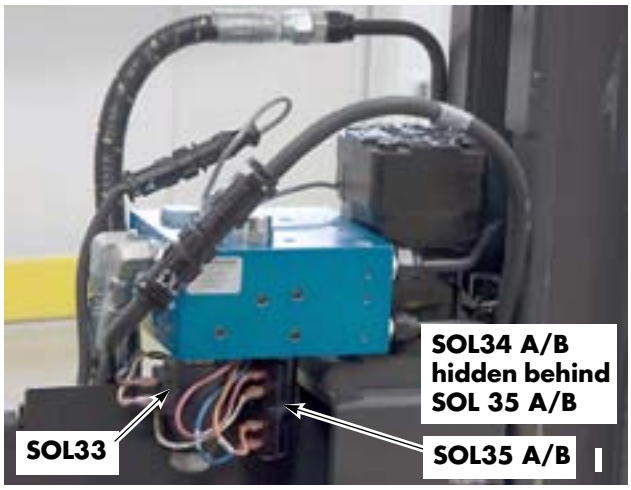


Figure 7-195. Fork Control Solenoids SOL33/34/35

5. Disconnect and label, if necessary, electrical connectors JPK2 and JPK3.
6. Disconnect and cap the lift function hydraulic hose from the tubing and plug the tubing. Use rags to absorb hydraulic fluid. See Figure 7-196.
7. Disconnect the two hydraulic hoses at fittings at the back of the fork control manifold. See Figure 7-196.

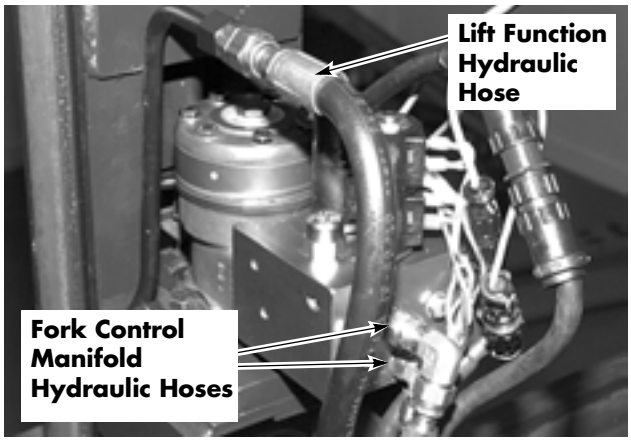


Figure 7-196. Fork Control Manifold Hydraulic Hoses

8. Disconnect two hydraulic tubings at the fork control manifold. See Figure 7-197 on page 1-161.
9. Remove the bolts holding the flexible hose/cable retainer bracket to the mini-mast. Remove the bracket.

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10. Remove two traverse motor mounting bolts. See Figure 7-197.
11. Carefully lift the traverse motor and fork control manifold assembly up and out of the traverse shaft gear.

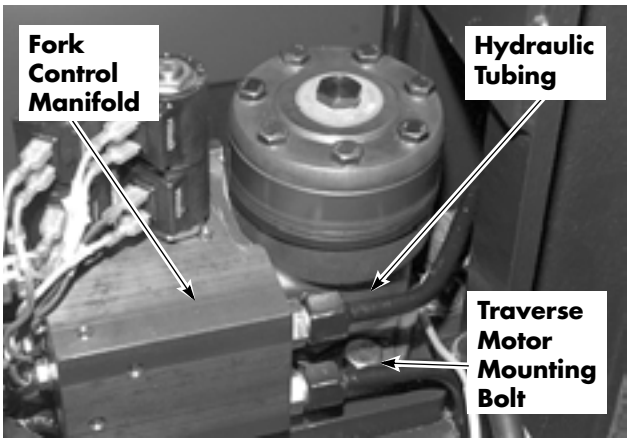


Figure 7-197. Hydraulic Tubing at Fork Control Manifold

12. Remove the traverse position feedback potentiometer assembly. See Figure 7-198.

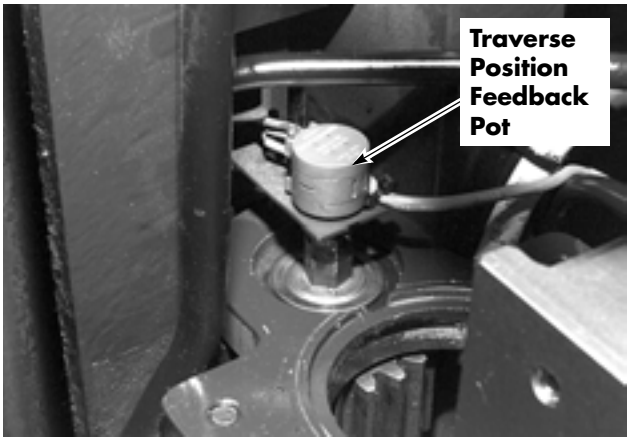


Figure 7-198. Traverse Position Feedback Pot (motor removed for clarity)

13. Attach a 5-ton hoist strap around the front of the fork carriage. Attach a second strap at the top of the mini-mast, under the stop plate.
14. Attach C-clamps to the mini-mast channel just above the top of the load handler. This prevents the load handler from being lifted up the mini-mast.
15. Remove the right side traverse stop block and safety bolt. See Figure 7-199.

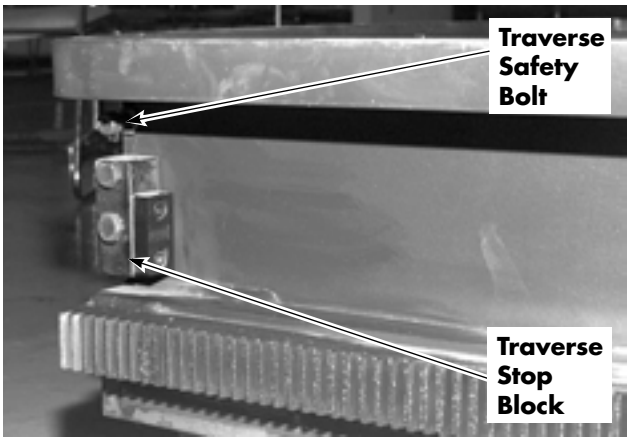


Figure 7-199. Traverse Stop Block and Safety Bolt

16. Using the hoist, take the weight off the traverse racks. Push the mini-mast past the rack stops until it is free of the rack.
17. Lower the mini-mast and load handler carefully to the floor.

Installation

1. Fasten C-clamps to the mini-mast to prevent movement of load handler
2. Using a hoist, lift the mini-mast.
3. Install wear pads to left side, top and bottom of mini-mast. For initial adjustment, insert 1 shim at the bottom and 3 at the top.
4. Mate and mesh the mini-mast gear to the traverse rack.
5. Install the traverse position feedback pot assembly to the traverse gear shaft. See Figure 7-198.
6. Install the traverse motor and fork control manifold assembly. Install mounting bolts.
7. Reinstall the flexible hose/cable retainer bracket.
8. Reconnect the hydraulic tubings at the fork control manifold. See Figure 7-197.
9. Reconnect the two hydraulic hoses at the back of the fork control manifold. See Figure 7-196.

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10. Reconnect the lift function hydraulic hose to the tubing.
11. Reconnect electrical connections JPK2 and JPK3.
12. Reconnect wires to fork control solenoid coils SOL33 (if so equipped), SOL34A/B, and SOL35A/B.
13. Install the traverse motor cover.
14. Install the safety bolt in the traverse rack. See Figure 7-199.
15. Install the traverse stop block. See Figure 7-199.
16. Test traverse operation and adjust mini-mast shimming as necessary. See "Shimming the Mini-Mast" on page 7-162.
17. Install the forks.

Shimming the Mini-Mast

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the traverse stop block from both sides of the carriage. See Figure 7-199.

⚠ WARNING

Make sure there is a safety stop bolt in each side of the carriage and that the bolts extends out far enough to prevent the mini-mast from traversing off the rack.

3. Reconnect the battery connector and turn the key switch ON. Slowly and carefully traverse the mini-mast to the right until it touches the safety stop bolt.
4. Turn the key switch OFF and disconnect the battery connector. Add or remove shims to the upper and lower bumper assemblies to obtain the tightest possible fit.

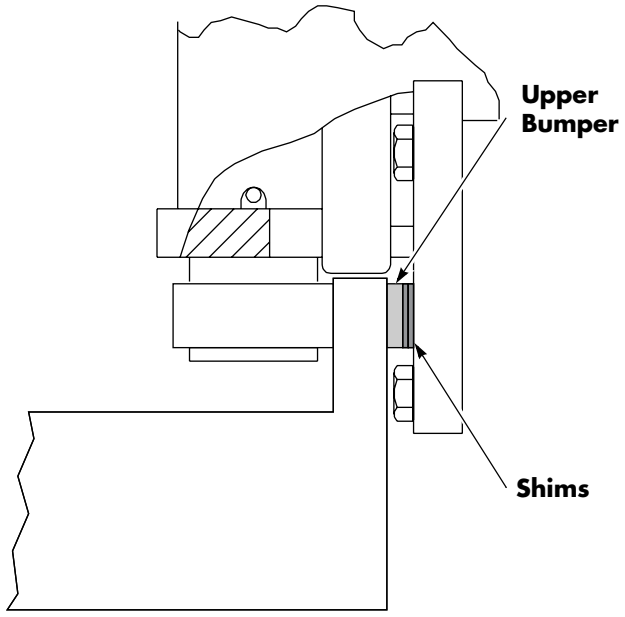


Figure 7-200. Mini-Mast Shimming, Top

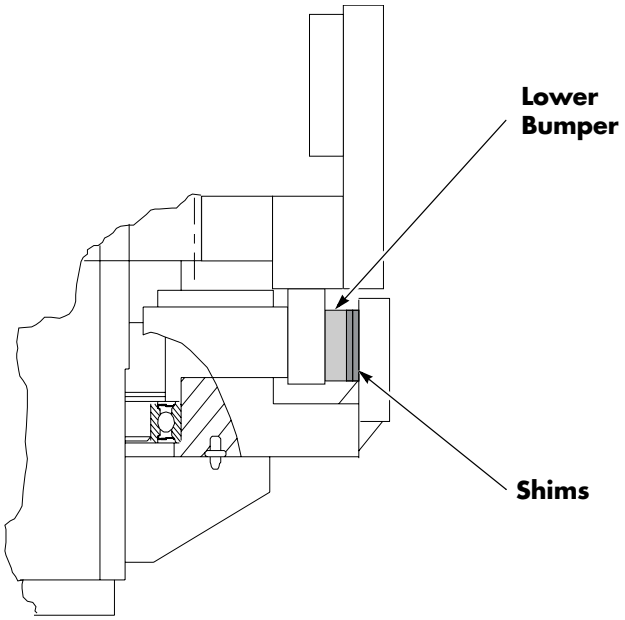


Figure 7-201. Mini-Mast Shimming, Bottom

5. Reconnect the battery connector and turn the key switch ON. Slowly and carefully traverse the mini-mast to the left until it touches the safety stop bolt.

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6. Turn the key switch OFF and disconnect the battery connector. Install the mast stop block on the right side.
7. Add or remove shims to the upper and lower bumper assemblies to obtain the tightest possible fit.
8. Reconnect the battery connector and turn the key switch ON. Traverse the mini-mast to the center.
9. Turn the key switch OFF and disconnect the battery connector. Install the left side mast stop block.
10. Reconnect the battery connector and turn the key switch ON. Test traverse function in both directions for smooth operation.

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Load Handler

⚠ WARNING

Do these procedures with a minimum of two technicians in a shop suitably equipped with a 5-ton hoist.

You can remove the load handler from the truck in either of two ways, depending on whether you also need to remove the mini-mast.

Removal after Mini-Mast Removal

1. Remove the mini-mast and load handler from the operator platform. See "Mini-Mast and Load Handler" on page 7-160. Lay mini-mast down horizontally.
2. Attach hoist to load handler and position load handler approximately 12 in. (300 mm) from the bottom of the mini-mast. Secure the mini-mast from moving.
3. Disconnect JP5 at the mini-mast height manager. See Figure 7-202.

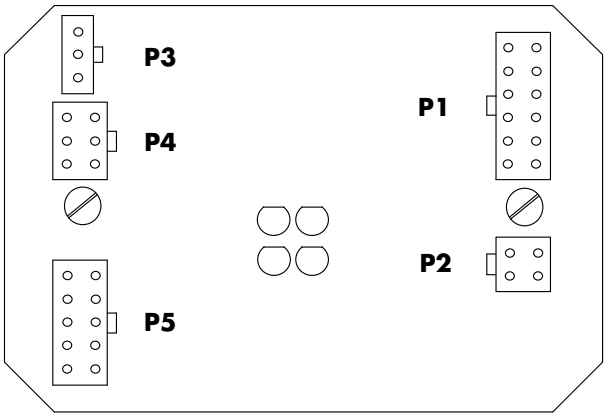


Figure 7-202. Height Manager Connectors

4. Disconnect the reach solenoid coil wires and label if necessary.

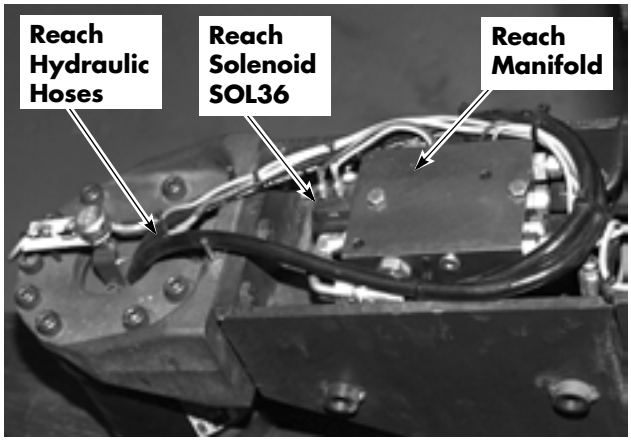


Figure 7-203. Load Handler Turret

5. Remove the load handler electrical cable from the retaining clip on the load handler carriage.
6. Loosen mini-mast puck adjuster lock nuts and back out the adjusting screws completely.

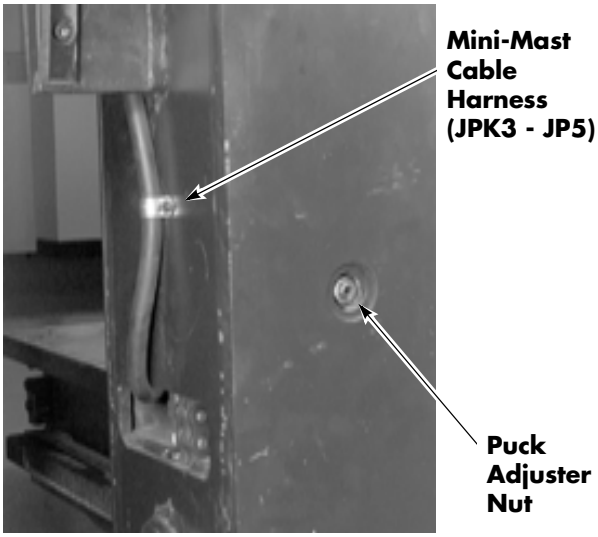


Figure 7-204. Load Handler Electrical Cable

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7. Remove the stop plate at the top of the mini-mast. See Figure 7-205.

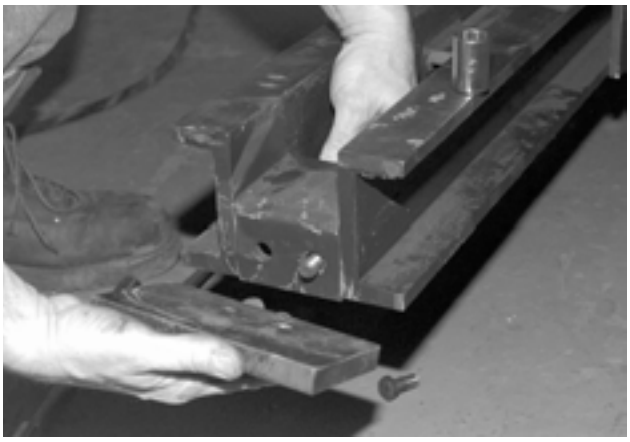


Figure 7-205. Mini-Mast Top Stop Plate

8. Disconnect the hydraulic hoses from fittings at the bottom of the cylinder.
9. Pull hydraulic hoses out through the top of the load handler.
10. Remove the lower chain anchor retaining nut near the bottom of the cylinder.
11. Pull the lift chain out through the top of the load handler.

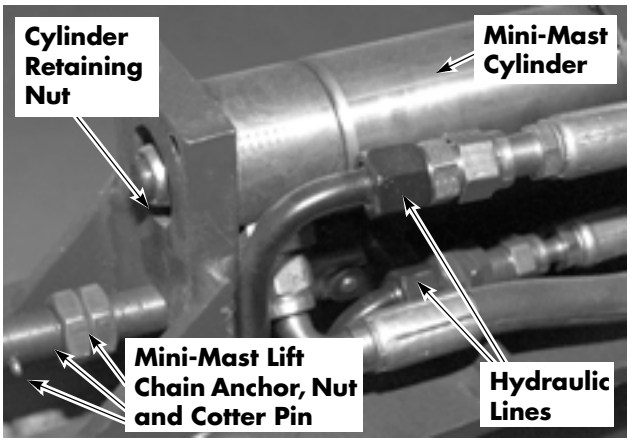


Figure 7-206. Load Handler Lift Cylinder Connections

12. Remove the rotate position feedback potentiometer assembly to prevent it from being damaged. See "Rotate Position Feedback Potentiometer (VR6)" on page 7-102.

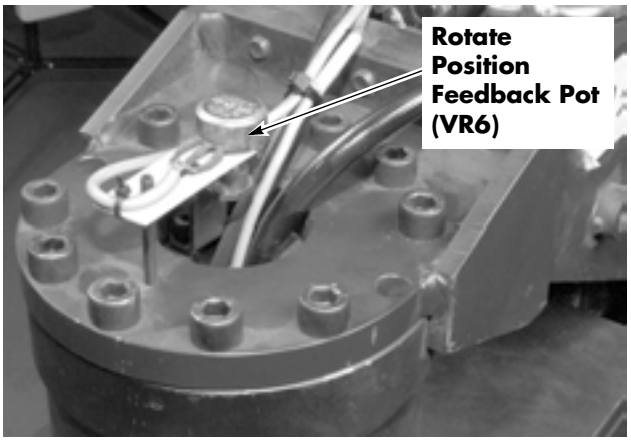


Figure 7-207. Rotate Position Feedback Pot (VR6)

13. Feed the lift chain and hydraulic hoses forward over the actuator and down the side of the rotate carriage. Secure chain and hoses with cable ties. See Figure 7-208.

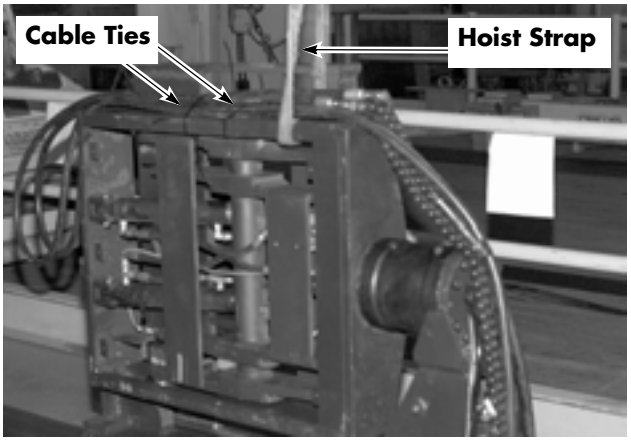


Figure 7-208. Load Handler Hoses and Chain Secured

14. Block under the cylinder to prevent it binding as the load handler is removed.
15. Using the hoist, slide the load handler up the mast, past the cylinder, and out the top end of the mini-mast. Lower carefully to the floor.

Removal from Mini-Mast on Truck

1. Remove the load handler turret cover.
2. Retract the forks into their fully nested position. Rotate load handler so forks face

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straight ahead. Traverse the load handler completely to the left.

3. Turn the key switch OFF and disconnect the battery connector.
4. Remove the forks to keep the load handler balanced during this procedure.
5. Elevate the load handler approximately 12 in. (300 mm). Place blocks under the load handler carriage and lower the load handler onto the blocks. Let the lift chain, hoses, and cable go slack.
6. Remove the load handler pulley bracket cover. Remove the hoses and cable from the pulleys, laying them carefully to the side of the mini-mast.
7. Remove cable ties and disconnect the wires from the reach solenoid coil and the mini-mast Height Manager in the load handler turret. Disconnect JP5 at the mini-mast Height Manager.
8. Disconnect two hydraulic hoses at the bottom of the mini-mast.
9. Using a hoist or other suitable lifting device, support the load handler carriage with straps as shown in Figure 7-208.
10. Remove the stop plate from the top of the mini-mast. See Figure 7-205 on page 7-165.
11. Remove the lift chain anchor at the bottom of the mini-mast by removing jam nut, hex nut, and cotter pin. Lift the chain over the pulley and lay it carefully over the actuator. To pass the chain anchor through the pulley, twist the lift cylinder 90 degrees with a large screwdriver in the pulley eye. Then twist the cylinder back into its normal position.
12. Remove the pulley bracket assembly from the mini-mast cylinder by removing the mounting bolt in the end of the cylinder.
13. Loosen mini-mast puck adjuster lock nuts and back out the adjusting screws completely.
14. Using the hoist, slowly lift the load handler out of the mini-mast and lower to the floor. Make sure cable, hoses, and chain do not bind or catch on the load handler.

Installation

1. With the mini-mast laid down horizontally, place a block between the cylinder and mini-mast to prevent the cylinder from binding as the load handler is installed.
2. Attach a hoist to the load handler as shown. See Figure 7-208 on page 7-165. Using the hoist, slide the load handler down the mini-mast and over the cylinder. Make sure the pucks engage the cylinder correctly.
3. Remove the cable ties securing the hoses, cable, and lift chain. Feed the hydraulic hoses and electrical cable over the pulley atop the cylinder, and back down through the load handler.
4. Feed the lift chain through the pulley atop the cylinder, then down through the load handler. Fasten the chain anchor to the mini-mast with retaining nut, jam nut, and cotter pin. See Figure 7-209.

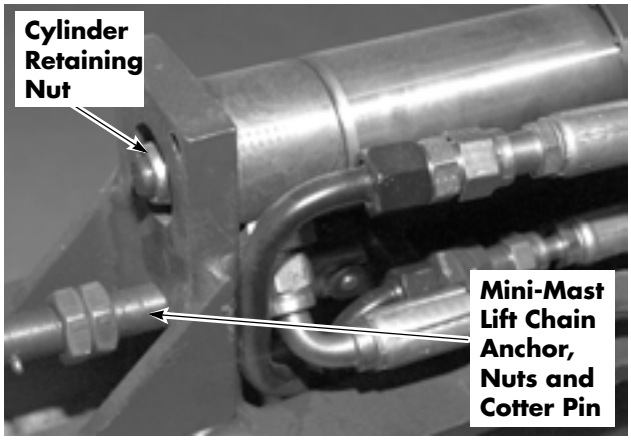


Figure 7-209. Mini-Mast Lift Chain Anchor

5. Connect the hydraulic hoses to the fittings at the bottom of the cylinder.
6. Reinstall the rotate position feedback potentiometer. See "Rotate Position Feedback Potentiometer (VR6)" on page 7-102.
7. Install the stop plate at the top of the mini-mast. See Figure 7-205. Apply thread-locking compound (P/N 990-536) to the mounting bolts and torque to 70 ft. lb. (95 Nm).
8. Route the electrical cable.

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9. Reconnect the reach solenoid coil wires. Reconnect JP5 at the mini-mast Height Manager.
10. Adjust the mini-mast pucks. See "Mini-Mast Pucks" on page 7-171.

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Traverse Gear Shaft

Removal

⚠ WARNING

Do this procedure with a minimum of two technicians in a shop suitably equipped with a 5-ton hoist.

1. Remove the mini-mast and load handler. See "Mini-Mast and Load Handler" on page 7-160.
2. Stand the mini-mast and load handler erect and stabilize in place with the hoist.
3. Remove four bolts securing the mini-mast lower lateral bearing weldment and remove the bearing assembly. See Figure 7-210.

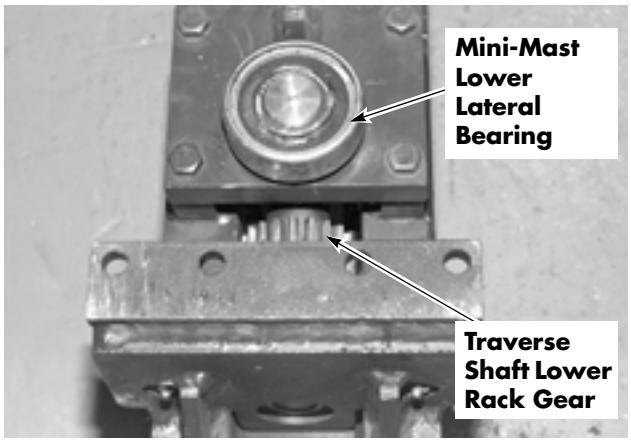


Figure 7-210. Traverse Gear Shaft and Lower Lateral Bearings

4. Remove four bolts holding the mini-mast upper lateral bearing weldment and remove the bearing assembly. See Figure 7-211.

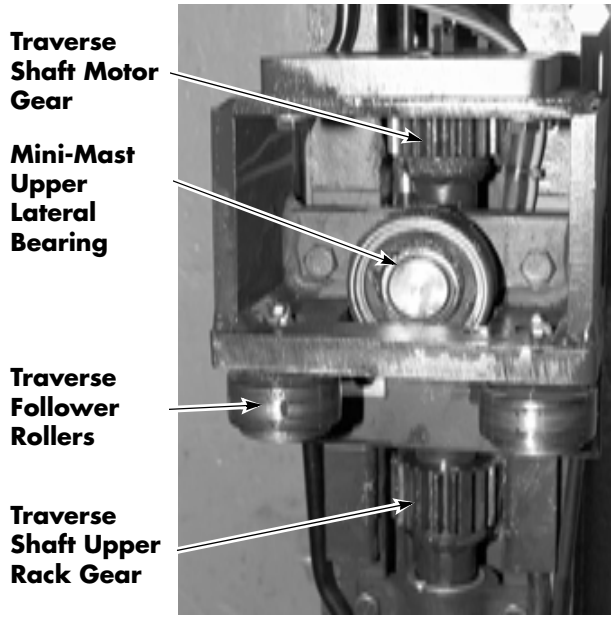


Figure 7-211. Traverse Gear Shaft and Upper Lateral Bearing

5. Have your partner hold the gear shaft to prevent it from falling as you remove the two bolts securing the sleeve bearing mounting bracket. Remove the shaft and bearing bracket. See Figure 7-212.

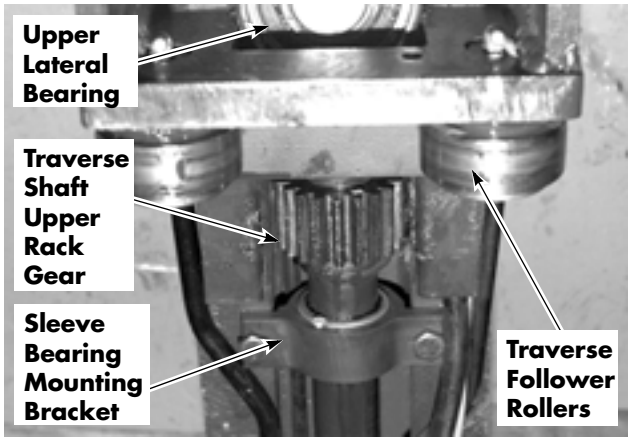


Figure 7-212. Traverse Gear Shaft, Removal

6. Remove the traverse position feedback potentiometer adapter from the top of the shaft.

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Installation

1. Install the sleeve bearing in the mounting bracket on the traverse gear shaft. See Figure 7-212.
2. Position the gear shaft in the mini-mast.
3. Attach washer shims.
4. Pry between lower gear and mast weldment to seat shaft in lower bearing.
5. Attach the lower load bearing assembly, leaving a 3/16 in. gap between the load bearing and the top of the lower traverse gear.
6. Attach the upper bearing assembly.
7. Attach washers.
8. Attach the traverse gear shaft upper bearing plate to the bearing assembly. Make sure the plate does not bind on the gear. If binding occurs, add shims at the base of the shaft. Fasten plate with washers and bolts.
9. Center the traverse gear shaft in the mini-mast channel.
10. Torque the upper bearing housing bolts and lower bearing assembly bolts to 70 ft. lb. (95 Nm).
11. Screw the traverse potentiometer adapter onto the top of the shaft.
12. Install the mini-mast and load handler. See “Load Handler” on page 7-164.
13. Reinstall the rotate position feedback potentiometer. See “Rotate Position Feedback Potentiometer (VR6)” on page 7-102.
14. Install the stop plate at the top of the mini-mast.
15. Route the electrical cable.
16. Reconnect the reach solenoid coil wires. Reconnect JP5 at the mini-mast Height Manager.
17. Adjust the mini-mast pucks. See “Mini-Mast Pucks” on page 7-171.

Traverse Shaft Shimming

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the inspection cover on the tractor side of the mini-mast (facing the operator).
3. Remove two bolts securing the traverse bushing support.
4. Add or remove shims as needed so no loading occurs on the traverse shaft. See Figure 7-213.

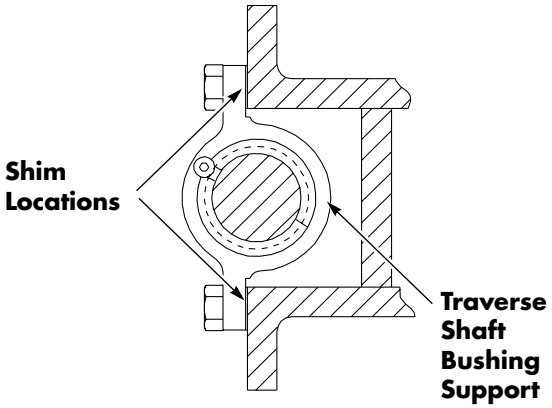


Figure 7-213. Traverse Shaft Shimming

5. Apply thread-locking compound (P/N 990-536) to the bushing support mounting bolts and install. Torque to 43 ft. lb. (68 Nm).
6. Reinstall the inspection cover on the mini-mast.
7. Check the shimming of the mini-mast. See “Shimming the Mini-Mast” on page 7-162.
8. Reconnect the battery connector and turn the key switch ON.
9. Test the traverse function in both directions for smooth and correct operation.

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Load Handler Lift Chain

Removal

1. Traverse the fork carriage to one side. Rotate the forks to the straight ahead position.
2. Elevate the operator platform approximately 12 inches (300 mm) to gain access to the mini-mast lower chain anchor nuts and cotter pin. Block and clamp the platform between the platform and baseleg (*not* the floor). See Figure 2-7 on page 2-12.
3. Install a temporary cable tie securing the electrical cable to the metal tubing. This prevents the cable tensioning spring from becoming disconnected in the load handler.
4. Elevate the load handler approximately two feet (600 mm). Block and clamp a wooden block in the mini-mast channel. See Figure 2-8 on page 2-12.

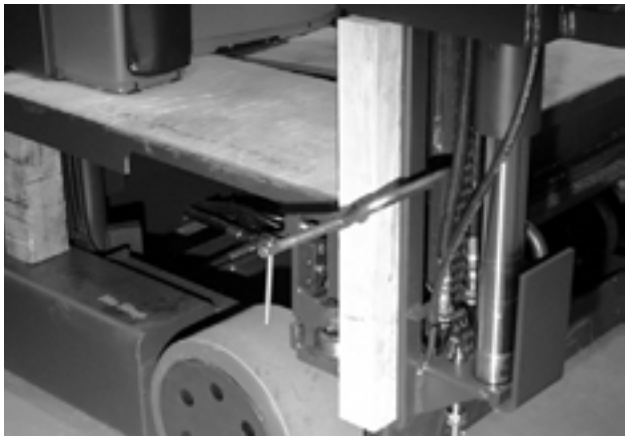


Figure 7-214. Blocking Load Handler

5. Lower the load handler until the mini-mast lift chain becomes slack.
6. Turn the key switch OFF and disconnect the battery connector.
7. Remove the master (connector) link from the lower chain anchor.
8. Pull the front chain anchor out of the mini-mast carriage frame. Remove the master (connecting) link.
9. Remove the chain from the pulley assembly.

Installation

1. Feed the new chain over the chain pulley. Pull it through the opening in the mini-mast carriage frame. Attach the chain to the chain anchor with a new master (connector) link. Insert the upper chain anchor in the opening in the frame.
2. Attach the other end of the lift chain to the bottom chain anchor with a new master (connector) link.
3. Reconnect the battery connector and turn the key switch ON.
4. Slowly elevate the load handler to remove slack. Elevate platform and remove clamps and blocking. Lower platform and load handler. Remove temporary cable tie.

Adjustment

See “Fork Height and Lift Chain Adjustment” on page 4-30.

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Mini-Mast Pucks

Removal

1. Remove the load handler turret cover.
2. Retract the forks into their fully nested position.
3. Elevate the load handler approximately two feet (600 mm). Block and clamp a wooden block in the mini-mast channel. See Figure 7-214.

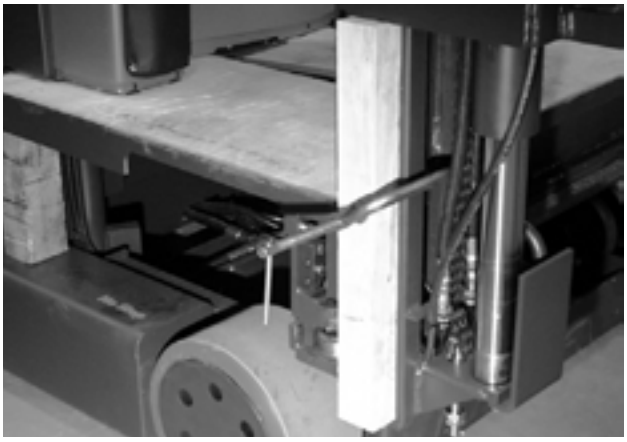


Figure 7-215. Blocking Load Handler

4. Turn the key switch OFF and disconnect the battery connector.
5. Remove the forks to keep the load handler balanced during this procedure.
6. Remove the load handler pulley bracket cover. Remove the hoses and cable from the pulleys.
7. Remove cable ties and electrical cable from the reach solenoid and the height manager in the load handler turret.
8. Disconnect two hydraulic hoses at the bottom of the mini-mast. See Figure 7-216.

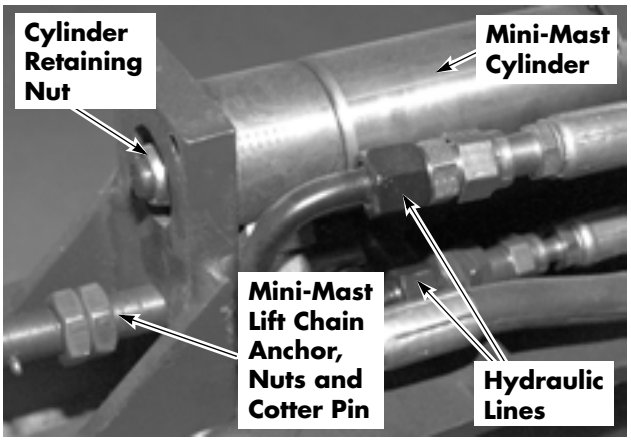


Figure 7-216. Load Handler Lift Cylinder Connections

9. Using a hoist or other suitable lifting device, support the load handler carriage with straps.
10. Remove the lift chain anchor at the bottom of the mini-mast and lift the chain over the pulley. To pass the chain anchor through the pulley, twist the lift cylinder 90 degrees with a large screwdriver in the pulley eye. Then twist the cylinder back into its normal position.
11. Loosen mini-mast puck adjuster lock nuts and back out the adjusting screws completely.
12. Using the hoist, slowly lift the load handler up the mini-mast past the cylinder to expose the cylinder pucks in the load handler.
13. Using a work platform or ladder, reach into the load handler to remove the nylon pucks and metal washers.
14. Clean the mini-mast cylinder of all grease and dirt. Apply a clean coating of grease where the pucks contact the cylinder.

Installation

1. Install new nylon pucks with metal washers between the puck and the carriage.
2. Make sure the mini-mast cylinder puck lock nuts are loosened and the adjuster screws backed out completely.

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3. Using the hoist, slowly lift the load handler until it rests on the blocks.
4. Using a large screwdriver, twist the mini-mast cylinder 90 degrees and feed the mini-mast lift chain anchor through the lift chain pulley. Once the chain hangs freely, twist the cylinder back into its normal position. Feed the lift chain and attach the chain anchor to the mini-mast.
5. Reconnect the hydraulic hoses to the tubing fittings at the bottom of the mini-mast.
6. Route and connect the electrical cable to the turret at the reach solenoid and the height manager. Attach cable ties, being careful not to pinch the wires too tightly.
7. Loop hoses and electrical cable over their pulleys and reattach the pulley bracket cover.
8. Reconnect the battery connector and turn the key switch ON.
9. Slowly raise the load handler to remove slack in over-the-mast hoses and cable. Remove blocks and lower the load handler completely.
10. Check and adjust the fork height. See "Fork Height and Lift Chain Adjustment" on page 4-30.
11. Adjust the mini-mast cylinder pucks. See "Adjustment."

Adjustment

1. Turn the key switch OFF and disconnect the battery connector.
2. Remove the rotate turret cover.
3. Loosen the lock nuts securing the puck adjustment screws.
4. Center the mini-mast cylinder horizontally in relation to the mast channel, within 1/8 inch (3 mm).
5. Torque the puck adjusting screws equally to 30 in. lb. (3.4 Nm).
6. Tighten the puck adjusting screw lock nuts.
7. Test mini-mast lift and lower functions for smooth operation.

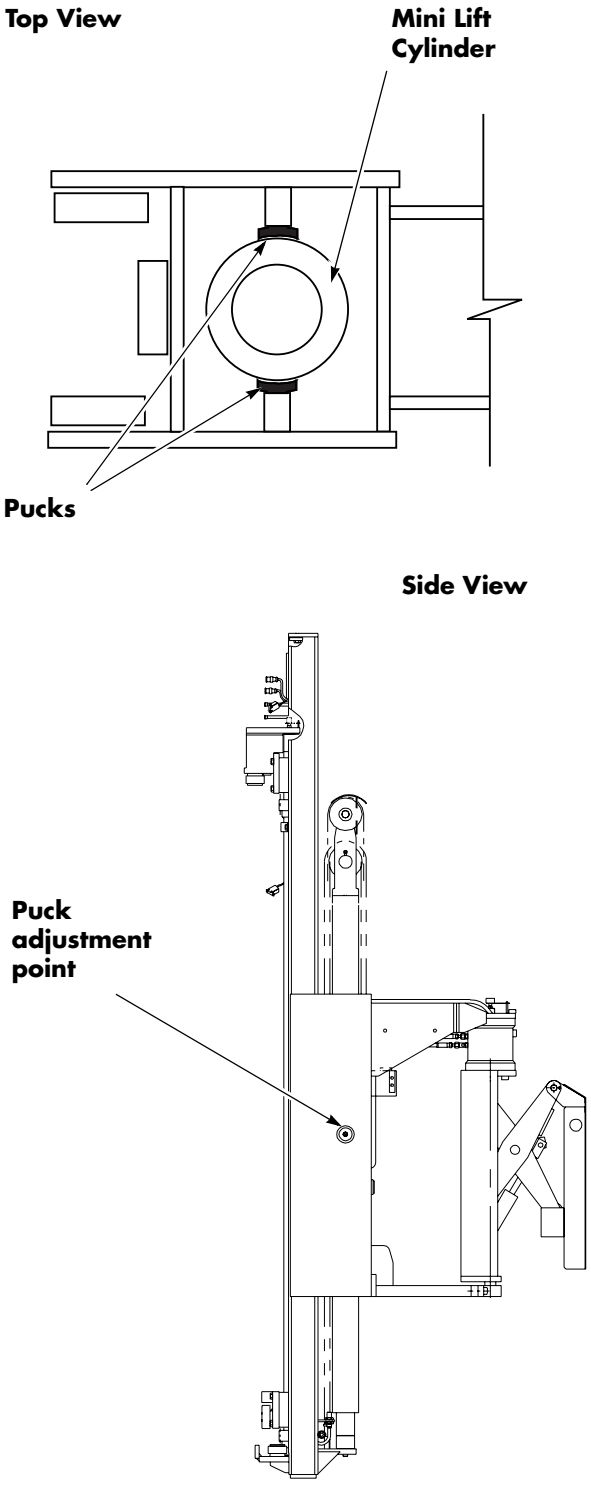


Figure 7-217. Mini-Mast Puck Adjustment

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Section 8. Theory of Operation

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System Architecture

Electronic Cards

Overview

This vehicle has six intelligent circuit cards that work together to:

- Respond to and monitor operator's requests
- Perform vehicle functions
- Monitor operating conditions of the truck
- Display this information to the operator.

An intelligent circuit card is connected to the communications bus. It contains a microprocessor that processes information to be transmitted or received.

Each intelligent circuit card has specific areas of responsibility.

These intelligent circuit cards are:

1. Carriage Manager (CM)
2. Tractor Manager (TM)
3. Electric Steer Manager (ESM)
4. Main Mast Height Manager (MH-Main)
5. Mini-Mast Height Manager (AH-Mini)
6. Operator Display (OD)

NOTE: Some trucks built prior to 2003 could have an optional seventh intelligent circuit card (SMART*i*®) installed at JC9.

Operation of the truck requires that five of the six intelligent circuit cards (TM, CM, ESM, MH-Main, and AH-Mini) work together to comply with operator requests, while maintaining safe control of the truck. The TM, CM, and ESM comply with requests only if all the vehicle's programmed safe operating conditions are met. To accomplish this, the intelligent circuit cards communicate and update each other on what is happening in each area of their responsibility. The communication scheme employed is a balanced two wire system (BUS+ and BUS–) called a Controlled Area Network (CAN).

The TM, CM, ESM, MH-Main, and AH-Mini, control the operation of the truck based on programmed design parameters, operator inputs, and system feedback sources. The Operator Display (OD) displays information about the truck's operating status to the operator.

This section also discusses the Power Card and Auxiliary Motor components.

Carriage Manager (CM)

The CM enclosure contains a Power Supply Card Assembly that receives battery voltage (TP4 on the power supply) from the Key Switch, and produces +12 volts (TP5), +5.3 volts (TP2), and +5 volts (TP3), with respect to ground (AGND at TP1). It also produces a B+ Filtered voltage (TP6) that is not used by the CM. The CM enclosure also contains a distribution board that contains all the necessary components for information distribution and processing.

The Carriage Manager (CM) processes all operational requests initiated by the operator. It directly controls the load handler functions (traverse, reach, and rotate). The CM monitors the status of all operator control handle potentiometer inputs, deadman switch (S2, S23 and S9) inputs, EPO switch (S21), and the optional sidegate switches (S60/S61).

Direct Inputs to the CM

- Key Switch (S1)
- EPO (S21)
- Sidegate (S60, S61) (optional)
- Steer Input Encoder
- Travel (VR1)
- Horn Input (S3)
- Brake Deadman (S2)
- Carriage Deadman (S23)
- Load Handler Deadman (S9)
- Lift/Lower (VR2)

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- Rotate (VR3)
- Traverse (VR4)
- Traverse Position (VR5)
- Lift Select Switch (S6)
- Guidance Auto/Manual Switch (S4) (optional)
- Lift/Lower Inhibit Bypass Switch (S7) (optional)
- Rotate Position (VR6) through the Mini-Mast Height Manager

Carriage Manager Functions

The Carriage Manager:

1. Stores the vehicle's primary memory, configuration parameters, hour meters, and all learned values with the exception of steering and guidance
2. Shares the monitoring of the EPO switch circuitry with the TM/VFC. Either the CM or TM/VFC can generate an error code when an open in the circuit is detected.
3. Shares control of the brake coil driver with the TM. The TM and the CM must agree on the position of the deadman switches in conjunction with a request for travel before the brake is released. Either the TM or CM can make the decision to apply the brake.
4. Sends all operator requests for truck operation to the TM (travel and lift/lower) and ESM (steering) over BUS+/BUS–
5. Sends or receives the following information to or from the Display Interface Card over BUS+/BUS–:
   - Speed, height, weight, BSOC, informational messages, status messages, and fault codes
   - Drive wheel and load handler position
   - Key pad inputs
   - Hour meters and Time and Date
   - Controls the sounding of the alarm (H2) by the Display Interface Card
6. Monitors the Steering Input Encoder output and connection
7. Receives Drive Unit position and hydraulic pressure information from the ESM over BUS+/BUS–
8. Receives travel speed, direction, Power Panel temperature (Q1 heatsink) and Drive Motor current and temperature information from the TM over BUS+/BUS–
9. Determines speed limiting restrictions and travel shutdown
10. Calculates main mast height and mini-mast height based on inputs from the Height Managers and determines lift and lower decel points. The Mini Height Manager connects to the Carriage Manager at JPH1 on both Models SA and SB. The Main Height Manager connects to the Carriage Manager at JPC7 on Model SB, and to the Tractor Manager at JPH2 on Model SA.
11. Operates the load handler solenoid control valves with internal coil driver circuitry
12. Interprets voltages from the Traverse (VR5) and Rotate (VR6) Position Feedback Potentiometers (during Learn) to calculate function speed and position and to determine their appropriate decel points
13. Determines if the reach mechanism is nested or not due to the status of the Reach Position Proximity Sensor as reported over BUS+/BUS– by the Mini Height Manager
14. Generates Time and Date information
15. Stores Password and Superword and permits entry to the Program Mode
16. Stores Error Code history
17. Provides a connection at JC9 for access by a laptop computer using the Dealer/ Technician I*intellidrive*® Control System Configuration Program (DTIC)
18. Provides power at PC19 for the optional light and fan package and/or other optional devices requiring 48-volt battery power (such as communication terminals, control handle heaters for cold storage)

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Carriage Manager LEDs

P/N 1002391/xxx

Original equipment on SA S/N > 02999 and SB S/N > 00699

- IL1 – Heartbeat: indicates that the computer is operating correctly when it is flashing ON and OFF approximately once a second
- IL2 – Status: not used
- IL3 – Traverse A: indicates an internal coil driver circuit for the Traverse Proportional Solenoid Valve A coil (SOL34A) has been activated by a PWM control voltage. Brightness varies depending on the amplitude of the control voltage.
- IL4 - Spare
- IL5 – Rotate A: indicates an internal coil driver circuit for the Rotate Solenoid Valve A coil (SOL35A) has been activated by a control voltage
- IL6 - Rotate B: indicates an internal coil driver circuit for the Rotate Solenoid Valve B coil (SOL35B) has been activated by a control voltage
- IL7 – Reach: indicates an internal coil driver circuit for the Reach Solenoid Valve coil (SOL36) has been activated by a control voltage
- IL8 - Traverse B: indicates an internal coil driver circuit for the Traverse Proportional Solenoid Valve B coil (SOL34B) has been activated by a PWM control voltage. Brightness varies depending on the amplitude of the control voltage.
- IL9 – Rotate PWM: indicates an internal coil driver circuit for the Rotate Proportional Solenoid Valve coil (SOL33) has been activated by a PWM control voltage. Brightness varies depending on the amplitude of the control voltage.

P/N 838-010-308/xxx

Original equipment on SA S/N < 03000 and SB S/N < 00700

NOTE: This CM, (P/N 838-010-308/xxx) is obsolete and has been replaced by P/N 1002391/xxx described previously.

- IL1 – Heartbeat: indicates that the computer is operating correctly when it is flashing ON and OFF approximately once a second
- IL2 – Status - Not used
- IL3 – Traverse A: indicates an internal coil driver circuit for the Traverse Solenoid Valve A coil (SOL34A) has been activated by a control voltage
- IL4 - Traverse B: indicates an internal coil driver circuit for the Traverse Solenoid Valve B coil (SOL34B) has been activated by a control voltage
- IL5 – Rotate A: indicates an internal coil driver circuit for the Rotate Solenoid Valve A coil (SOL35A) has been activated by a control voltage
- IL6 - Rotate B: indicates an internal coil driver circuit for the Rotate Solenoid Valve B coil (SOL35B) has been activated by a control voltage
- IL7 – Reach: indicates an internal coil driver circuit for the Reach Solenoid Valve coil (SOL36) has been activated by a control voltage

Tractor Manager

The Tractor Manager (TM) is an assembly of two boards: a Tractor Manager card and a Vehicle Function Controller (VFC). References to the Tractor Manager (TM) in this section refer to the Tractor Manager assembly TM/VFC.

The Tractor Manager card connects the VFC to all of its input sources and output users. The TM card contains all the jack (J) and pin (P) connectors for distribution of control voltages. It also contains a power supply that receives battery voltage (TP1 on the TM) from the Key Switch, and produces B+ Filtered (TP2), +12 volts (TP4), +5.3 volts (TP3), with respect to ground (AGND at TP6). These test points are accessible on the TM.

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The VFC is the information processing portion of the TM. It processes all the direct inputs from the TM as well as the communicated information (BUS+/BUS–) from the ESM and CM to control the traction, lift, and some auxiliary system components. It sends inputs of temperature, height, and steer position information to the CM to determine optimal drive system operation.

The VFC turns solenoids on and off by controlling coil drivers connected to the TM card.

The VFC contains a red LED (IL1) that indicates that the computer is operating when it is flashing ON and OFF approximately once a second.

Direct Inputs to the TM

- Vehicle travel speed (Speed Feedback Proximity Sensor)
- Drive motor temperature (DT)
- PC1 Contactor tip position (PC1 Sense)
- PC2 Contactor tip position (PC2 Sense)
- Q1 Collector voltage (Q1C Sense)
- P Contactor tip position (P Sense)
- Rail Sense Switch (S15) (optional)
- Battery Gate Proximity Switches (S57, S58) (Optional)
- Aisle Detect Switches (S46A & B and S47A & B) (Optional)

TM Inputs through Other Devices

- Armature current through the Power Card
- Armature current limit through the Power Card
- Field current through the Power Card
- Power Panel temperature through the Power Card
- Power Panel temperature limit through the Power Card
- Lift trucks *with* Auxiliary Contactor: AUX Contactor tip position (AUX Sense) through the Contactor Interface Module
- Carriage Deadman Switch through the Carriage Manager
- Brake Control Deadman Switch through the Carriage Manager
- [Models SA S/N > 01192 and SB S/N > 00308] Slack Chain Switches S50 and S51 through the coil driver card (CD3)

TM/VFC Functions

1. Controls the Plugging, P, PC1, and PC2 contactors through plug-in coil driver cards and monitors their status via sense line inputs
2. Lift trucks *with* Auxiliary Contactor: Controls the Auxiliary Contactor through the Contactor Interface Module when a Load Handler operation request is received from the CM
3. Lift trucks *without* Auxiliary Contactor: Provides the PWM voltage to control the speed of the Auxiliary Motor and Pump based on the Load Handler operation request received from the CM over BUS+/ BUS
4. Controls Lift/Lower system solenoid valves through plug-in coil driver cards
5. Controls the operation of Q1
6. Controls the operation of TM1 and TM2
7. Determines the required Drive Motor field and armature strengths based on the current system status compared to command requests from the CM. The TM/VFC also applies the required speed limiting and travel shutdowns as determined by the CM.
8. Controls the optional Travel/Lift/Lower Alarm Relay
9. Shares control of the brake coil driver with the CM. The TM and the CM must agree on the position of the deadman switches in conjunction with a request for travel before the brake is released. Either the TM or CM can make the decision to apply the brake.
10. [Models SA S/N > 01192 and SB S/N > 00308] Monitors the status of the Slack Chain Switches (S50 & S51) and sends it to the CM over BUS+/BUS–

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11. Monitors the status of the End-Of-Aisle Sensor Switches (S46A&B and S47A&B) and sends it to the CM over BUS+/BUS–

Tractor Manager Control Fuses

- B+PC1 (FU11) (15A)
- B-PC (FU12) (15A)
- B- (FU13) (15A)
- B+ (FU14) (15A)
- B- (FU15) spare (6A - slow blow)
- B+ (FU16) spare (6A - slow blow)
- +12 volts (FU17) (2A)

Tractor Manager Light-Emitting Diodes (LEDs)

- IL1 – GREEN: indicates that +12 volts is available from the power supply and that fuse FU17 is good
- IL2 – RED: indicates that the CHOPPER ENABLE is being sent to the power card
- IL3 - YELLOW: indicates that the Carriage Deadman Switch (S23) has been detected closed by the TM
- IL4 – YELLOW: indicates that a brake control voltage from the CM as a result of the Brake Deadman Switch (S2) closure has been detected by the TM
- IL5 – RED: indicates the Main Load Holding Solenoid Valve coil driver is activated
- IL6 – RED: indicates the Lift/Lower Proportional Solenoid Valve coil driver is activated
- IL7 – RED: indicates the Brake coil driver is activated
- IL8 – RED: indicates the Plugging Contactor coil driver is activated
- IL9 – RED: indicates the PC1 Contactor coil driver is activated
- IL10 – RED: indicates the PC2 Contactor coil driver is activated

Tractor Manager Jumper Connectors

- E1 is a BUS+/- termination connector. The two pin shunt jumper must be installed at the A (OUT) position. Pins 1 and 2 are jumpered together.
- E2 is a brake control connector. E2 provides the correct voltage to operate the brake coil when a six pin shunt jumper is installed. Pins 1 and 2 and pins 3 and 4 are jumpered together.
- E3 has no shunt jumper installed. Pins 5 and 6 are not used. E3 provides a hard wired connection to PC1F for the PC1 Contactor, Lift/Lower Proportional Solenoid Valve, and Main Load Holding Solenoid Valve coil suppression diodes.

Line Filter

Models SA and SB have two dual Line Filter assemblies.

Dual Line Filter 1 (FILT1) utilizes both filters. Filter F1 filters the B+KEY power from the CM to the TM. Filter F2 filters the B+F power from the TM to the CM. Each filter contains a 15-amp slow-blow fuse (FU1 and FU2).

Dual Line Filter 2 (FILT2) uses only one of its 2 filters. Filter F1 filters the B+ (Spare) power to the Light and Fan Package and other devices connected to JPC19. This filter also contains a 15-amp slow-blow fuse (FU1). On some lift trucks, a Suppressor Module (SUP6) is connected in series with the input terminal of this filter. The suppressor limits the in-rush current in the event a freshly charged battery is connected to the truck when the Key Switch has been left in the ON position *and* the lights and fans were also left turned ON.

Electric Steer Manager

The Electric Steer Manager (ESM) processes manual steering inputs and controls the position of the Drive Unit based on those inputs. There are two optional automatic guidance modes available: wire guided and rail.

If the truck is equipped with wire guidance, then the ESM uses the inputs from the Wire Guidance Sensors and the Filter Card to position the Drive Unit when operating on a Guide Wire with the Auto/Manual Switch (S4) in the Auto position.

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With rail guidance, the truck is equipped with roller wheel assemblies that contact guide rails installed in the aisles. A Rail Sense Switch (S15) is activated by a roller contacting the guide rail. When the Auto/Manual Switch (S4) is in the Auto position, closing the Rail Sense Switch causes the Drive Unit to center up on the Home Sensor Proximity Switch and be maintained there while operating in the rail guided aisle.

The ESM also sends the main and mini lift system pressures (used for weight calculation) to the CM over BUS+\BUS–.

The ESM contains a power supply that receives +12 volts (TP2 on the ESM) from the TM and produces +15 volts (TP4) and +5.3 volts (TP3) with respect to ground (DGND at TP1) for internal use. The ESM also receives battery voltage at SMB+ and SMB- and produces +9.1 volts (TP5) with respect to ground (battery (–) at TP6) for use as a battery sense voltage.

Direct Inputs to the ESM

- Steer Position Encoder
- Steer Home Proximity Sensor (PROX)
- Main Pressure Transducer
- Mini Pressure Transducer

ESM Inputs through Other Devices

- Optional wire guidance antenna coil voltages through the Load and Tractor Sensors and the Filter Card.

Electric Steer Manager Functions

1. Processes steer commands received from the CM over BUS+/BUS– or from the optional wire guidance system when activated
2. Controls Steering Transistor Modules TM3 and TM4 to control the amplitude and direction of current flow through the Steer Motor, which translates to the speed and direction of rotation of the Drive Unit
3. Processes the input from the Steer Feedback Encoder to determine direction, speed, and distance from the centered position. Reports this information to the CM over BUS+/BUS–.
4. Stores the steering and the wire guidance (if installed) learned values
5. Calculates Distance From Wire (DFW) and Heading Angle (HA) information based on inputs from the Filter Card and sends it to the CM over BUS+/BUS–
6. Activates the correct circuits on the Filter Card based on the frequency selection made in Configure Mode
7. Monitors travel speed and direction information sent over BUS+/BUS– by the TM
8. Monitors the Steer Home Proximity Sensor input for Drive Unit center reference
9. Processes the voltage inputs from the Main and Mini Pressure Transducers and sends the information to the CM over BUS+/BUS–

Electric Steer Manager Light Emitting Diodes (LEDs)

- IL1 – RED: “Heatbeat” LED indicates that the computer is operating when it is flashing ON and OFF approximately once a second.
- IL2 – GREEN: indicates when the ESM is sending a PWM voltage to TM3 or TM4
- IL3 – YELLOW: indicates when the ESM is sending CW DIRECTION ENABLE to TM3 or TM4
- IL4 – YELLOW: indicates when the ESM is sending CCW DIRECTION ENABLE to TM3 or TM4

Electric Steer Manager Jumper Connectors

- E1 is a BUS+/BUS– termination connector. The two pin shunt jumper must be installed at the B position (OUT) for a Model SA truck and at the A position (IN) for a Model SB truck. See Figure 7-118 on page 7-83.

Main Height Manager

The Main Height Manager (MH-Main) monitors the change in height of the main mast through the use of an Optical Sensing Head and a sensing rail. It receives +12 VF from the TM (Model SA) or +12_PROT from the CM (Model

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SB). An internal voltage regulator produces +5 volts from this +12 volt input.

The Optical Sensing Head uses frequency-modulated infrared light emitters to pass a beam through the holes in the sensing rail to opposing detectors as the rail passes through the sensing head. The making and breaking of these beams produce voltage pulses that are counted by the MH-Main. The physical positioning of these emitter/detector pairs enables MH-Main to determine if the carriage is being lifted or lowered.

Main Height Manager Functions

1. Monitors changes of height based on inputs from the Optical Sensing Head
2. Sends the incrementing or decrementing count changes to the CM over BUS+/BUS– where the fork height is calculated in inches
3. Informs the CM when the Optical Sensing Head is detected in the sensing rail reference area

Main Height Manager Light Emitting Diodes (LEDs)

- IL1 – RED: “Heartbeat” LED indicates that the computer is operating when it is flashing ON and OFF approximately once a second
- IL2 – GREEN: indicates input from sensor channel A
- IL3 – GREEN: indicates input from sensor channel B
- IL4 – GREEN: indicates input from sensor channel C

Mini Height Manager

The Mini Height Manager (AH-Mini) monitors the change in height of the mini-mast through the use of a Multi-Head Proximity Sensor (3 sensors) and a sensing rail. It receives +12_PROT from the CM. An internal voltage regulator produces +5 volts from this +12 volt input.

The Proximity Sensor detects the holes in the sensing rail as it passes over the rail. This produces voltage pulses that are counted by the AH-Mini. The physical orientation of the 3 sensors within the Proximity Sensor assembly enables the AH-Mini to determine if the forks are being lifted or lowered.

Direct Inputs to Mini Height Manager

- Rotate Position Feedback Potentiometer (VR6)
- Reach Position Proximity Sensor
- Multi-Head Proximity Sensor

Mini Height Manager Functions

1. Monitors changes of height based on input from the Proximity Sensor
2. Sends the incrementing or decrementing count changes to the CM over BUS+/BUS– where the fork height is calculated in inches
3. Informs the CM when the Proximity Sensor is detected in the sensing rail reference area
4. Produces the +5 volt supply for the Rotate Position Feedback Potentiometer (VR6) and serves as an intermediate connection point between VR6 and the CM
5. Serves as a connection point for the Reach Position Proximity Sensor (PROX2) to report its status to the CM over BUS+/BUS–

Mini Height Manager LEDs

- IL1 – RED: “Heartbeat” LED indicates that the computer is operating when it is flashing ON and OFF approximately once a second
- IL2 – GREEN: indicates input from sensor channel A
- IL3 – GREEN: indicates input from sensor channel B
- IL4 – GREEN: indicates input from sensor channel C

Power Card

The Power Card is connected directly to the TM and receives inputs from the TM to control the Drive Motor field transistors TM1 and TM2 that

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are mounted directly underneath the card. It also receives inputs from the TM to control the Drive Motor armature through transistor Q1. The Power Card provides feedback to the TM for armature and field current values.

Power Card Functions

1. Amplifies a PWM (Pulse Width Modulated) voltage from the TM to control Traction Transistor Modules TM1 and TM2 when the appropriate FWD or REV ENABLE voltage is present.
2. Amplifies a PWM (Pulse Width Modulated) voltage from the TM to control Power Transistor Q1 when the appropriate CHOPPER ENABLE voltage is present.
3. Places the truck in current limit when the Drive Motor armature current is detected by CT-1 to have reached the value required (approximately 350A) to activate internal circuitry and light the green LED (IL2).
4. Processes the voltage input from the Q1 heatsink Temperature Sensor (HT) and reports it to the TM. When this voltage indicates the Power Panel (heatsink) temperature has reached 227°F (108° C), the red LED (IL1) lights.
5. Utilizes the B– supplied at JPC1-1 (E – Drive) to ensure the Q1 Power Transistor is rapidly and adequately being turned OFF.

Power Card Light Emitting Diodes (LEDs)

- IL1 – RED: indicates that the heatsink (Power Panel) temperature is at the limit.
- IL2 – GREEN: indicates that the armature current is at the limit.

Auxiliary Motor Control Card

NOTE: Models SA S/N < 00200, SB S/N < 00125 only

The Auxiliary Motor Control Card receives commands from the TM to energize the Auxiliary Motor for traverse, rotate, and reach operations. The Auxiliary Motor Control Card pulses the Auxiliary Motor based on a PWM voltage from the TM.

Auxiliary Motor Control Light Emitting Diodes (LEDs)

- IL1 - indicates that the Auxiliary Motor Control Card is receiving the enable voltage
- IL2 - indicates the duty cycle of the PWM voltage
- IL3 - indicates that the Auxiliary Motor Control Card has detected a fault condition

Auxiliary Motor Power Amplifier

NOTE: Lift trucks SA S/N > 199, SB S/N > 00124 *and without* Auxiliary Contactor.

The Auxiliary Motor Power Amplifier receives commands from the TM to energize the Auxiliary Motor for traverse, rotate, and reach operations. The Auxiliary Motor Power Amplifier pulses the Auxiliary Motor based on a ramped voltage from the Auxiliary Interface Module, which is derived from the PWM voltage from the TM.

Auxiliary Contactor Interface Module

NOTE: Trucks *with* Auxiliary Contactor

The Auxiliary Contactor Interface Module receives a command (AUX ENABLE) from the TM to control the Auxiliary Contactor to power the Auxiliary Motor and Pump for traverse, rotate, and reach operations. It also conditions the voltage input at JPCM1-9 to provide a voltage output at JPCM1-10, which informs the TM of the status of the Auxiliary Contactor tips.

Control Devices

Rotate Potentiometer (VR3)

The CM monitors the voltage across the Rotate Potentiometer (VR3). When VR3 is moved, the CM detects the voltage change, then determines the direction (CW or CCW) and speed requested.

On lift trucks without an Auxiliary Contactor, the TM/VFC receives the speed request information and sends a PWM voltage proportional to the VR3 request to the Auxiliary

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Motor Controller or Interface Module/Amplifier to control the speed of the Auxiliary Motor and Pump.

On lift trucks with an Auxiliary Contactor, the TM/VFC receives the speed request information and sends a voltage (AUX ENABLE) to the Contactor Interface Module to energize the Auxiliary Contactor and apply power to the Auxiliary Motor and Pump.

The CM also sends a PWM control voltage to an internal coil driver circuit for the Rotate Proportional Solenoid Valve coil (SOL33). SOL33 controls the flow of hydraulic fluid being applied to the Rotate Motor through SOL35A or SOL35B, as requested by VR3.

Traverse Potentiometer (VR4)

The CM monitors the voltage across the Traverse Potentiometer (VR4). When VR4 is moved, the CM detects the voltage change, then determines the direction (right or left) and speed requested.

On lift trucks without an Auxiliary Contactor, the CM sends the speed request information over BUS+/BUS– to the TM/VFC. The TM/VFC sends a PWM voltage proportional to the VR4 request to the Auxiliary Motor Controller or Interface Module/Amplifier to control the speed of the Auxiliary Motor and Pump. The CM uses the direction information to control an internal coil driver circuit to energize the Traverse Solenoid Valve SOL34A or SOL34B (depending on the direction requested).

On lift trucks with an Auxiliary Contactor, the CM sends the speed request information over BUS+/BUS– to the TM/VFC. The TM/VFC receives the speed request information and sends a voltage (AUX ENABLE) to the Contactor Interface Module to energize the Auxiliary Contactor and apply power to the Auxiliary Motor and Pump. The CM uses the direction information to send a PWM voltage to an internal coil driver circuit for the Traverse Proportional Solenoid Valve coil SOL35A or SOL35B to control the flow of hydraulic fluid being applied to the Traverse Motor (depending on the direction requested).

Lift Select Switch (S6)

The CM monitors the state of the Lift Select Switch (S6) and sends this information over BUS+/BUS–. The TM VFC receives the message and energizes the Lift Select Solenoid (SOL3) to port hydraulic fluid to the mini-mast.

Load Handler Deadman (S9)

The CM monitors the state of the Load Handler Deadman Switch (S9). S9 must be detected depressed before the Mini-Mast is permitted to operate. S9 does not need to be depressed to permit operation of the main mast, nor to enable travel.

Traverse Position Feedback Potentiometer (VR5)

The CM processes the voltage input from the Traverse Position Feedback Potentiometer (VR5) to determine the position and movement of the traverse mechanism. It sends this information over BUS+/BUS– to the Operator Display. If the traverse mechanism is determined to be in an unnested position, the CM limits maximum travel speed and informs the TM/VFC over BUS+/BUS–. The CM also uses the position information to determine the traverse mechanism end-of-travel decel points and when to permit initiation of the reach function.

On lift trucks with an Auxiliary Contactor, the CM also processes the voltage input from VR5 to determine the speed of the traverse mechanism during the Carriage portion of Learn Mode. This information is used, in conjunction with the Platform Width setting in Configure Mode, to determine that the correct PWM voltages are applied to the internal coil driver circuits for the Traverse Proportional Solenoid Valve (SOL35A/B) coil to permit optimal Load Handler operation.

Rotate Position Feedback Potentiometer (VR6)

The CM processes the voltage input from the Rotate Position Feedback Potentiometer (VR6) to determine the position and movement of the

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rotate mechanism. It sends this information over BUS+/BUS– to the Operator Display. If the rotate mechanism is determined to be in an unnested position, the CM inhibits the reach function, and limits maximum travel speed. The CM also uses the position information to determine the rotate mechanism end-of-travel decel points.

On lift trucks with an Auxiliary Contactor, the CM also processes the voltage input from VR6 to determine the speed of the rotate mechanism during the Carriage portion of Learn Mode. This information is used to determine that the correct ROTATE PWM voltage is applied to the internal coil driver circuit for the Rotate Proportional Solenoid Valve (SOL33) coil to permit optimal Load Handler operation.

Auto/Man (S4) (Option)

The CM monitors the state of S4 and sends the information over BUS+/BUS–. The ESM uses this information to determine when to activate the guidance systems.

Lift Inhibit Bypass (S7) (Option)

The CM monitors the state of S7. Main lift is permitted beyond a programmed limit when S7 is closed. This switch input can be ENABLED or DISABLED in Configure Mode.

Reach Position Proximity Sensor (PROX2)

The CM monitors the status of Reach Position Proximity Sensor (PROX2) as reported by the Mini Height Manager over BUS+/BUS–. The CM uses the information to determine if the reach mechanism is unnested or fully retracted. If reach is determined to be unnested, the rotate function is inhibited, and the CM reduces maximum travel speed.

Travel Potentiometer (VR1)

The CM monitors the voltage input from the Travel Potentiometer (VR1). When VR1 is moved, the CM detects the change in voltage and determines direction and speed requested. The CM, after determining and imposing any speed restrictions, sends this information over BUS+/BUS– to the TM/VFC. The TM/VFC then supplies the Power Card with the appropriate direction information and PWM voltages for TM1, TM2 and Q1 to comply with the operator request for travel.

Lift/Lower Potentiometer (VR2)

The CM monitors the voltage input from the Lift/Lower Potentiometer (VR2). When VR2 is moved, the CM detects the voltage change, then determines which function (lift or lower) and the speed requested. The CM, after checking the status of the Lift Select Switch (S6) and the Load Handler Deadman Switch (S9), sends this information over BUS+/BUS– to the TM/VFC.

If Lift is requested, the TM/VFC applies the appropriate voltages to the coil drivers for the Lift Select Solenoid Valve (SOL3), Pump Contactor/Dump Solenoid Valve (SOL99) (Models SA S/N > 03217 and SB S/N > 00761), and the PWM voltage to the Lift/Lower Proportional Solenoid Valve (SOL4).

If Lower is requested, the TM/VFC applies the appropriate voltages to the coil drivers for the Lift Select Solenoid Valve (SOL3), Main (SOL1) or Mini (SOL2) Load Holding Solenoid Valve, and the PWM voltage to the Lift/Lower Proportional Solenoid Valve (SOL4).

Brake Deadman Switch (S2)

The CM monitors the status of the Brake Deadman Switch (S2) and sends this information over BUS+/BUS– to the TM/VFC. The CM also processes the S2 input and generates an output voltage, BRAKE CONTROL, to the TM/VFC through the over-the-mast cables at JPC17-4 to JPS25-4. The TM/VFC confirms agreement on the status of BRAKE CONTROL with the CM over BUS+/BUS–.

The TM/VFC and the CM must agree on the position of the Brake Deadman Switch (S2) and Carriage Deadman Switch (S23), in conjunction with a request for travel, before the brake is released.

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Carriage Deadman Switch (S23)

The CM monitors the status of the Carriage Deadman Switch (S23) and sends this information over BUS+/BUS– to the TM/VFC. The CM also processes the S23 input and generates an output voltage, CARRIAGE DEADMAN, to the TM/VFC through the over-the-mast cables at JPC17-5 to JPS25-5. The TM/VFC confirms agreement on the status of CARRIAGE DEADMAN with the CM over BUS+/BUS–.

The TM/VFC and the CM must agree on the position of the Brake Deadman Switch (S2) and Carriage Deadman Switch (S23), in conjunction with a request for travel, before the brake is released.

Horn Switch (S3)

The CM monitors the status of the Horn Switch (S3) and includes this information in the messages sent over BUS+/BUS–. The TM/VFC receives the message and enables the Horn Relay (K1) when S3 is depressed.

Emergency Power Off Switch (EPO) (S21)

The CM and the TM/VFC equally share the monitoring of the status of EPO SWITCH (S21) circuitry. Either the CM or TM/VFC can generate an error code when an open in the circuit is detected.

Depressing the EPO (S21) directly removes the B+ESTOP voltage from the PC1, PC2, and the P contactor coils, the Main and Auxiliary Load Holding, Lift Select, Traverse, Rotate, Reach, and the Proportional Lift/Lower Solenoid Valve coils. Removing B+ESTOP from the PC1 contactor coil removes PC1F from the BRAKE coil, causing the brake to apply and stop the truck.

[Models SA S/N > 03217 and SB S/N > 00761] B+ESTOP is also removed from the Dump Solenoid Valve (SOL99).

Sidegate Switches (S60 and S61) (Option)

The CM monitors the status of the optional Sidegate Switches (S60 and S61). These switches are Hall-effect devices that each supply a ground (DGND) input to the CM when the sidegates are in the down position. These inputs are electronically connected in series internally. If either input, S60 or S61, is detected open (sidegate raised), the CM generates a performance limiting message and prevents main lift and travel until both switch inputs are detected closed (sidegates down). The CM sends this information over BUS+/BUS– to the Operator Display which shows “Lower Sidegate to Resume Operation.”

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Traction System Functional Operation

Overview

Carriage Manager

The Carriage Manager (CM) monitors the Travel Deadman Switches (S2, S23) and the voltage from the Travel Potentiometer (VR1). When the CM detects the simultaneous closure of the Brake Deadman Switch (S2) and the Carriage Deadman Switch (S23):

- The CM sends a BRAKE CONTROL output voltage to the TM/VFC through the over-the-mast cables at JPC17-4 to JPS25-4.
- The TM/VFC confirms agreement on the status of BRAKE CONTROL with the CM over BUS+/BUS–.
- The CARRIAGE DEADMAN (S23) output voltage is detected by the CM and the TM/VFC via a hardwired connection through the CM and through the over-the-mast cables at JPC17-5 to JPS25-5.
- The TM/VFC confirms agreement on the status of CARRIAGE DEADMAN with the CM over BUS+/BUS–.

As Travel Potentiometer VR1 is rotated from its learned neutral position, the CM processes this input voltage change into speed and direction travel request information. This request for travel is then sent over BUS+/BUS– to the TM/VFC.

When the CM and TM/VFC have agreed that S2 and S23 were correctly activated (right deadman pedal depressed), and a travel request has been received by the TM/VFC, the TM/VFC sends a BRAKE CONTROL voltage to the brake coil driver to energize the brake coil and release the brake. Although both the CM and the TM/VFC must agree on the conditions required to release the brake, either one can make the decision to apply it.

The speed requested depends on how far the control handle is moved from the neutral position and on the maximum configured speed. The TM/VFC reports travel speed information from the Speed Feedback Proximity Sensor over BUS+/BUS– to the CM. The CM in turn sends it to the Operator Display for display in miles/kilometers per hour.

The CM processes information sent to it over BUS+/BUS– from the TM/VFC, ESM, and the Mini and Main Height Managers. This information includes:

- Travel direction and speed
- Traction Motor current
- Traction Motor temperature
- Power Panel (Q1 heatsink) temperature
- Height
- Weight
- Drive Unit position

The CM uses this information from these and other sources to:

- Update the Operator Display
- Generate messages and codes
- Impose speed limiting and performance limiting restrictions.

Tractor Manager

The Tractor Manager (TM) monitors the Travel Deadman Switches, travel speed, travel speed request, and Drive Motor operating parameters. The TM produces outputs to the Power Card based on the inputs received. When the TM detects both Deadman Switches (S2 and S23) closed and receives a travel request from the CM, it enables the brake coil driver to release the Drive Motor brake.

Connecting the Battery

When a correctly charged battery is connected to the lift truck and all fuses are good, battery positive is present at the following points (all with respect to TP4 (B–)):

1. B+ side of the PC1 Contactor tips (PC1-2)

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2. JPS14-12 and JPS14-13 (B+) on the Tractor Manager
3. FU14 on the Tractor Manager
4. FU16 on the Tractor Manager
5. JPS26-8 on the Tractor Manager to B+_F2 on Line Filter 1 through Fuse FU2 and JP19-9 to JPC20-5 on the Carriage Manager (B+F)
6. JPS26-3 on the Tractor Manager through the Current Limiting Suppressor (SUP6) to B+_F1 on Line Filter 2, through Fuse FU1, to JP19-7 and JPC20-7 on the Carriage Manager (B+F) (SPARE)
7. JPC15-1 on the Carriage Manager to S1-1 on the Key Switch
8. JPC19-1 on the Carriage Manager (B+F SPARE) to the optional light and fan package
9. JPC19-4 on the Carriage Manager (B+F SPARE) for power options and/or Control Handle and Carriage Manager Heaters (Cold Storage Option)
10. Cold Storage Tractor Heater, if so equipped, through PC1-2 and FU20
11. Cold Storage Auxiliary Power Amplifier Heater, if so equipped, through PC1-2 and FU24
12. PC2 Contactor tips (PC2-1), through FU4 and L1 to the Auxiliary Contactor tip (AUX-1). Some lift trucks do not have an L1 choke.

Turning the Key Switch (S1) ON

When the Key Switch is turned ON, power is distributed through the truck, and the intelligent circuit cards perform a SelfTest. This section describes where power is available at the moment the Key Switch is turned ON, then what happens during SelfTest, and finally where power is available once SelfTest is complete.

All of the voltages listed are with respect to TP4 (B–).

1. Turning the Key Switch (S1) ON supplies battery voltage from S1-2 to JPC15-4 (B+ Key) and through the EPO Switch (S21) JPC15-3 (B+ESTOP).
2. B+ KEY is at the following points on the truck:
   a. JPC14-6 on the Carriage Manager to JPP1-1 on the CM power supply
   b. JPC20-6 on the Carriage Manager to B+_F1 on Line Filter 1, through the Line Filter Fuse FU1 to JPS26-6 on the Tractor Manager
   c. JPS3-6 to the Power Card
   d. TP1 on the Tractor Manager (input to the TM power supply)
   e. JPS20-1 to the warning light
   f. JPS19-1 to the horn
   g. JPS19-8 as B+FIL (to the Horn Relay) from TP2 Pin 10 on the Tractor Manager.
3. B+ESTOP is at the following points on the truck:
   a. JPC10-1 to SOL35B
   b. JPC10-3 to SOL35A
   c. JPC10-5 to SOL34A
   d. JPC10-7 to SOL34B
   e. Lift trucks with Auxiliary Contactor: JPC26-2 to the Rotate/Reach Proportional Solenoid SOL33
   f. JPH1-1 through JPK3-6 to the Reach Select Solenoid SOL36
   g. JPC20-1 on the Carriage Manager through JP19-1 to JPS26-1 on the Tractor Manager
   h. JPS12-10 to the Coil Driver 3 Card (CD3)
   i. JPS29-2 on the Coil Driver 3 Card (CD3) (to the P Contactor coil and the Lift Select Solenoid and Mini Load Holding Solenoid Valves). Also the Dump Solenoid (SOL99) Valve on Models SA S/N 03202 and > 03217, and SB S/N 00757 and > 00761.
   j. JPS21-4 to the PC2 coil driver
   k. JPS19-2 on the Tractor Manager (to the PC2 Contactor coil, Main Load Holding

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Solenoid Valve, and the Lift/Lower Proportional Solenoid Valve)

l. JPS14-5 on the Tractor Manager (to the PC1 Contactor Coil)

m. JPS11-14 to the Coil Driver 5 Card

n. Lift trucks with Auxiliary Contactor: PS22-2 through JPS46-1 to the Auxiliary Contactor coil and JPMC1-6 at the Contactor Interface Module

o. PS43-1 (B+ESTOP) – not used

4. The Carriage Manager power supply card receives B+KEY (TP4) and produces the following voltages with respect to TP1 (AGND) (test points listed are on the Carriage Manager power supply):
   a. B+ Filtered (48-volts) (TP6) - not used on the Carriage Manager
   b. +12 volts (TP5) - Voltages measured between +10.5 to +13 volts are acceptable
   c. +5.3 volts (TP2) - Voltages measured between +4.47 to +5.83 volts are acceptable
   d. +5 volts (TP3) - Voltages measured between +4.5 to +5.5 volts are acceptable
5. +12 volts on the Carriage Manager could be shown as +12V, +12V_POT and +12V_PROT. All of these voltages are derived from the +12 volts produced by the CM Power Supply card. +12V_POT and +12V_PROT are diode-protected and actually measure approximately 0.7 volts lower than the +12V. These voltages are used internally and at the following points on the Carriage Manager:
   a. JPC23-15 left Control Handle connector for Rotate Potentiometer VR3
   b. JPC24-15 right Control Handle connector for Lift/Lower Potentiometer VR2
   c. JPC12-2 traverse connector on Carriage Manger P/N 1002608/xxx
   d. JPC12-7 through JPK2-1 to the Traverse Position Feedback Potentiometer VR5 on Carriage Manger P/N 1002608/xxx
   e. JPC25-1 to Brake Deadman Switch S2
   f. JPC25-4 to Carriage Deadman Switch S23
   g. JPC25-7 to Load Handler Deadman Switch S9
   h. JPC7-1 through JP5-9 to the main Height Manager for Models SB
   i. JPH1-9 through JPK3-5 and JP5-9 to the Mini Height Manager. The Height Manager supplies +12V_PROT to the Reach Position Proximity Sensor at JP4-1 and to the Multi-Head Proximity Sensor at JP2-1.
   j. JPC8-1 to the Supplemental Operator Display
   k. JPC18-9 to the Operator Display
   l. JPC9-9 to the SMART*i*®/RS232 connector
   m. JPC21-2 to the right Sidegate Switch (S60) (optional)
   n. JPC21-7 to the left Sidegate Switch (S61) (optional)
6. +5.3 volts is used internally on the Carriage Manager
7. +5 volts from the CM Power Supply is at the following points on Carriage Manger P/N 154-012-504/xxx:
   a. JPC12-7 to the Traverse Position Feedback Potentiometer VR5
   b. JPC24-9 to the Travel Potentiometer VR1
   c. JPC23-9 to the Traverse Potentiometer VR4
8. +5V _POT is derived from the CM Power Supply +12V and is used on Carriage Manger P/N 1002608/xxx at the following points:
   a. JPC12-7 Traverse Position Feedback Potentiometer connector
   b. JPC12-5 Traverse Position Feedback Potentiometer connector
   c. JPC24-9 right Control Handle connector
   d. JPC23-9 left Control Handle connector

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e. JPH1-10 Mini Height Manager connector

9. +5 volts at JP4-1 (Rotate Position Feedback Potentiometer connector) is generated internally on the Mini Height Manager and is derived from +12V_PROT.
10. ENCODER_VCC at the Steer Encoder connector JPC16-1 is approximately +5.3 volts. It is produced by CM circuitry powered by the +12V from the CM Power Supply card. This CM circuitry also provides "Connect Detection" for both the Steer Encoder and Steer Encoder Card by monitoring voltage change due to the open circuit present when no current is being drawn.
11. The Tractor Manager power supply receives B+KEY (TP1) and produces the following voltages (the test points listed are on the Tractor Manager):
    a. B+FIL (48-volts) (TP2 pin 10)
    b. +12VF (TP4)
    c. +5.3 volts (TP3, TP8, and TP2 pin 2) for internal use only
12. B+FIL is at the following points on the Tractor Manager:
    a. JPS19-8 to the Horn Relay K1
    b. JPS15-5 to the optional Alarm Relay K2
13. +12V is at TP2 pin 5 then through the 2A fuse, FU-17, becoming +12VF (TP4) and is at the following points on the Tractor Manager:
    a. JPS25-1 (no cable wiring connection to this point)
    b. JPS17-9 to the Electric Steer Manager
    c. JPS12-6 to the Coil Driver 3 (CD3) Card
    d. JPH2-9 to the Main Height Manager on Model SA
    e. JPS21-1 and JPS21-2 to the PC2 Contactor coil driver
    f. JPS4-1 through JPM1-1 to the Auxiliary Motor Control Card, Auxiliary Interface Module, or Contactor Interface Module
    g. JPS5-9 to the Power Card. The power card provides this voltage to the heatsink (Power Panel) Temperature Sensor (JPC1-4).
    h. JPS18-3 to the Speed Feedback Proximity Sensor
    i. JPS13-2 to the Rail Sense Switch (S15) connector (optional)
    j. JPS16-2 Battery Gate Switch (S57/S58) (optional)
    k. +VSENSOR1 and +VSENSOR2 at the Aisle Detect connectors JPS6-2 and JPS28-2 respectively is approximately +11 volts. It is produced by TM circuitry powered by the +12VF from the TM Power Supply. This TM circuitry also provides "Connect Detection" for both connection points by monitoring voltage change due to the open circuit present when no current is being drawn.
    l. JPS9-2 Steer Feedback Connector - not used
    m. JPS15-2 Alarm and Spare Limit Switch connector - no wiring connected
    n. Used internally on the Tractor Manager
14. The Electric Steer Manager receives +12VF from the Tractor Manager at JPA2-9. +12VF is at the following locations on the ESM:
    a. JPA7-3 to the Home Steer Proximity Sensor
    b. JPA6-1 to the Mini-Mast Pressure Transducer
    c. JPA5-1 to the Main Mast Pressure Transducer
    d. Used internally on the ESM
15. +15 volts is derived from +12VF and used internally on the ESM
16. +9.1 volts is derived from battery voltage at SMB+ and used internally to determine the battery voltage of the truck
17. +5.3V is derived from +12VF and is at the following locations on the ESM:
    a. JPA8-3 to the Steer Position Encoder
    b. Used internally on the ESM
18. The Filter Card receives +12VF from the ESM at JPA3-B1, B2, and B3, and

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supplies it to the Wire Guidance Sensor Assemblies at (JPW1-15 and JPW2-15) (optional).

Hour Meters

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

- KH -- hours with Key Switch ON
- HD -- hours with Deadman Pedal depressed
- HL -- hours lifting
- TMI -- traction miles

SelfTest

After the power supplies start producing the various voltages, the computers on the intelligent circuit cards perform a series of internal system tests. The SelfTest portion of power up checks the following for correct operation before the PC Contactor is energized.

CM SelfTest

The CM starts its checks by looking for correct hardware connections and voltage inputs from switches and pots. The CM commands the ESM and TM to start SelfTest.

The Carriage Manager:

- Checks the microprocessor to make sure it is enabled and all portions are functional
- Runs software checksum calculation
- Tests the RAM
- Checks the EPROM and restores information from the backup copy on the TM if necessary
- Checks to make sure the TM is responding over the BUS lines
- Checks the truck-specific information that can be seen using DTIC
- Checks the VFC card to make sure it is setup correctly for operation
- Checks to make sure the model number the software is written for matches the model number programmed in the truck
- Checks memory to see if the last time the truck was powered down was due to a COP time-out or microprocessor crash rather than key OFF
- Checks deadman switches for correct position
- Looks for the correct battery voltage and calculates BSO.
- Checks communications with the main and mini height managers.

CM completes its checks and waits for the ESM and TM to complete SelfTest and report back. CM generates a Code 50 if the TM does not respond and a Code 53 if the ESM does not respond.

TM SelfTest Sequence

The Tractor Manager:

- Checks the microprocessor to make sure it is enabled and all portions are functional
- Runs software checksum calculation
- Tests the RAM
- Checks EPROM
- Checks to see if the PC1 and PC2 sense line has a low reading
- Checks deadman switches for correct position
- Checks to see if the EPO line from the CM has a high reading
- Activates the coil driver to close the PC contactors and looks to see if the PC sense lines changed state.
- Checks to see if the P sense line has a low reading
- Checks memory to see if the prior shutdown was caused by a COP time-out rather than a key OFF
- Waits for a communication message from the CM to continue with SelfTest in order to synchronize CM and TM startup
- Checks for correct battery voltage

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- Checks to see if the P sense line has a low reading again
- Looks at the field current circuit to make sure there are no shorts
- Powers the field and looks at the field current circuit to make sure there is no open
- Looks at the power panel temperature circuits to make sure the readings are within limits
- Looks at Q1C Sense to make sure the main transistor is not shorted
- Turns on the main transistor and checks for open circuits
- Looks at Q1C Sense to make sure the main transistor is not shorted again
- Looks at the power panel temperature circuits to make sure the readings are within limits again
- Calculates power panel temperature and checks for overheating
- Looks at the drive motor temperature circuits to make sure the readings are within limits
- Calculates drive motor temperature and checks for overheating
- Checks the remaining input statuses. Sends a startup complete message over the BUS to CM along with a SelfTest PASS/FAIL status.

ESM SelfTest Sequence

The Electric Steer Manager:

- Checks the microprocessor to make sure it is enabled and all portions are functional
- Runs software checksum calculation
- Tests the RAM
- Checks EPROM
- Checks input status. Sends a "startup complete" message via the BUS to the CM along with a SelfTest PASS/FAIL status.

If a problem is detected, SelfTest stops at the point of the problem and display the appropriate fault code on the Operator Display.

Once the system SelfTest has been successfully completed, the Operator Display shows "Please complete daily check list." At this point the PC1, PC2, and Plug Contactor coils are energized, closing their respective tips. Battery voltage (B+) is now supplied to the following points with respect to TP4 (B–) on the Power Panel:

1. The collector of the Power Transistor (Q1)
2. B+ side of the Lift Pump (P) contactor tips, P-1
3. The cathode of REC1 and REC2
4. The anode of REC1 and REC2
5. PRB+ at the Power Card
6. SMB+ at the Electric Steer Manager
7. FU4 and TP1 on the Power Panel
8. MXB+ on the Auxiliary Motor Controller or B+ on the Auxiliary Power Amplifier
9. Lift trucks *without* Auxiliary Contactor: Auxiliary Motor terminals A and D
10. MX– on the Auxiliary Motor Controller or M– on the Auxiliary Power Amplifier
11. JPM2-5 on the Auxiliary Interface Module
12. Lift trucks *with* Auxiliary Contactor: AUX-1 on the Auxiliary Contactor

B+ voltage is also at the following locations on the Tractor Manager:

1. JPS14-6 (PC1 sense)
2. JPS14-10 and JPS14-11 (B+PC1)
3. JPS14-8 (PC2 sense)
4. JPS14-9 (Q1C sense)
5. FU11 (B+PC1 becoming B+PC1F after passing through the fuse)
6. JPS19-10 (as B+PC1F to the brake coil)
7. JPS11-12 and JPS11-13 (as B+PC1F to the Coil Driver 5 (CD5) Card)
8. JPS14-14 (as B+PC1F to the plugging contactor coil).

Closing Deadman Switches (S2 and S23)

Stepping on the right Deadman Pedal simultaneously activates Brake Deadman

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Switch S2 and Carriage Deadman Switch S23. This causes the following to occur:

1. S2 supplies a ground (DGND) to the CM at JPC25-2 (BRAKE DEADMAN).
2. The CM detects a change in voltage at JPC25-2 when S2 is activated and generates an output voltage at JPC17-4 (BRAKE CONTROL) to the TM/VFC at JPS25-4.
3. S23 supplies a ground (DGND) to the CM at JPC25-5 (CARRIAGE DEADMAN).
4. The CM detects a change in voltage at JPC25-5 when S23 is activated and checks to see if the S23 input matches the S2 input.
5. The CARRIAGE DEADMAN input from S23 is sent directly through the CM at JPC17-5 to the TM/VFC at JPS25-5.
6. The TM/VFC detects the changes in voltage at JPS25-4 and 5.
7. The CM and TM/VFC exchange information over BUS+/BUS–, confirming that they each agree on the status of both deadman switches.
8. If either the CM or TM/VFC fail to agree on the status of the Deadman Switches (S2 or S23), an error code (8C or 8F) is shown on the Operator Display.

Requesting Travel

With the Key Switch ON and the right Deadman Pedal depressed (S2 and S23 activated), moving the right Control Handle either toward the forks (FWD) or the tractor (REV) rotates the Travel Potentiometer (VR1) from its learned neutral position, causing the following to occur:

1. The VR1 output voltage to the CM at JPC24-11 (TRAVEL CMD) either increases (forks-first, FWD) or decreases (tractor-first, REV) from its learned neutral position.
2. The CM senses this increase or decrease in voltage and determines that a request for forks-first (FWD) or tractor-first (REV) travel has been made. The CM processes this voltage and sends the information over BUS+/BUS– to the TM/VFC.
3. The TM/VFC receives the travel request information and determines the actual speed and direction of truck movement. It does this by monitoring the feedback from the Speed Feedback Proximity Sensor at JPS18-1 and JPS18-2. Three conditions could exist:
   a. The truck is not moving (no pulses received from the Speed Feedback Proximity Sensor).
   b. The truck is moving in the same direction as the travel request.
   c. The truck is moving in the opposite direction as the travel request.
4. If the truck is not moving, then the TM/VFC takes the following actions:
   a. The TM/VFC enables the Power Card to begin control of the Drive Motor armature by sending a CHOPPER ENABLE command to the power card at JPS3-5.
   b. The TM/VFC sends a chopper pulse width modulation (CHOPPER PWM) command to the Power Card at JPS3-3. The width of the pulses varies proportionally to the speed request. Wider pulses result in faster speed. These wider pulses cause a longer on-time of the Power Transistor (Q1), thus delivering more power to the Drive Motor.
   c. The Power Card produces a PWM output to the base lead of Power Transistor Q1 at JPC1-2 (B DRIVE) to control the Drive Motor armature.
   d. When the Q1 transistor turns on during the positive portion of the PWM cycle, current flows from battery positive through the closed PC1 Contactor tips, through FU5, through the Drive Motor armature (creating a magnetic field), through Q1 from collector to emitter, and back to battery negative.
   e. When the Q1 transistor turns off (during the negative portion of the PWM cycle), the magnetic field that was created by the current flowing through the armature collapses back into the

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armature windings, producing a more positive voltage at A1 with respect to A2. This causes current to continue to flow out of the armature to TP6, then from TP6 to the anodes of REC1 and 2. REC1 turns on, permitting current to flow through REC1 to TP5, then through the closed PLUG contactor tips to TP2, and then back to A2 on the armature. REC2 turns on, permitting capacitor C1 to absorb the voltage spike across Q1 thus protecting Q1 from damage. When Q1 again turns on during the positive portion of the PWM cycle, capacitor C1 discharges through resistor R2, closed PLUG contactor tips to TP2, back through the Drive Motor armature and Q1 to Battery negative at TP4.

f. At the same time as the CHOPPER ENABLE voltage, the TM/VFC also sends a forks-first (F/F) or tractor-first (T/F) ENABLE voltage (depending on the direction of the travel request) to the Power Card at JPS5-6 or JPS5-5 respectively.

g. The TM/VFC sends a Field PWM command to the Power Card at JPS5-8. The width of the pulses varies proportionally to the torque required. Wider pulses result in more torque. These wider pulses cause a longer on-time of the transistors, thus delivering more power to the Drive Motor field.

h. The Power Card amplifies the ENABLE (F/F or T/F) and PWM voltages and applies them in correct sequence to the transistors in the TM1 and TM2 Transistor Modules. This produces current flow through the Drive Motor field and Drive Motor armature rotation in the desired direction.

i. When TM1 and TM2 are on, current flows from battery positive through the closed PC1 contactor tips, through FU8 to the power card at PRB+, through one transistor of a dual Transistor Module (TM), through the Drive Motor field winding, through one transistor of the other dual Transistor Module (TM), and back to battery negative. For travel in the opposite direction, current flows in the opposite direction through the field winding and through the other transistors in the dual Transistor Modules.

j. When both the CM and TM/VFC have agreed that both Deadman Switches (S2 and S23) are activated and that a travel request has been received by the TM/VFC from the CM, the TM/VFC supplies a PWM voltage (BRAKE CONTROL) at JPS11-2 to activate the brake coil driver.

k. When the brake coil driver is activated, it provides a path to ground for the brake coil from JPS19-5 (BRAKE), to the Coil Driver 5 (CD5) Card at JPS11-7 (BRAKE), through the coil driver to JPS11-11, through FU12 to B-PC at JPS14-1 and JPS14-2 to the B–Tie Point TP4. With the brake coil energized, the Drive Motor can rotate freely.

l. As the truck accelerates in the either the forks-first or tractor-first direction, the TM/VFC continues to monitor the Speed Feedback Proximity Sensor until actual truck speed and direction match requested truck speed and direction.

5. If the truck is moving in the *same direction* as the travel request, the TM/VFC takes the following actions:

   a. The TM/VFC monitors the pulses from the Speed Feedback Proximity Sensor and compares the requested speed and direction to the actual speed and direction.

   b. The TM/VFC generates an error signal based on the difference between the requested speed and the actual speed.

   c. The TM/VFC modifies the chopper PWM voltage and the field PWM voltage as necessary to increase or decrease truck speed to match the actual speed to the requested speed.

6. If the truck is moving in the *opposite direction* to the travel request, the TM/VFC takes the following actions:

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a. The TM/VFC monitors the pulses from the Speed Feedback Proximity Sensor and compares the requested speed and direction to the actual speed and direction.

b. The TM/VFC determines that plug mode is requested.

c. The TM VFC stops supplying the CHOPPER ENABLE and the CHOPPER PWM voltages to the Power Card.

d. The Power Card stops supplying the B DRIVE to the Q1 transistor.

e. When the Q1 transistor turns off, the magnetic field that was created by the current flowing through the armature collapses back into the armature windings, producing a more positive voltage at A1 with respect to A2. This causes current to continue to flow out of the armature to TP6, then from TP6 to the anodes of REC1 and 2. REC1 turns on, permitting current to flow through REC1 to TP5, then through the closed PLUG contactor tips to TP2, and then back to A2 on the armature. REC2 turns on, permitting capacitor C1 to absorb the voltage spike across Q1, protecting Q1 from damage.

f. The TM/VFC removes the PLUG CONTROL PWM voltage from the Coil Driver 5 (CD5) Card at JPS11-1. This deactivates the Plug Contactor coil driver, removing the ground path for the Plug Contactor coil JPS11-6. The Plug Contactor tips open and current flows through the Plugging Resistor (R1).

g. The TM/VFC removes the tractor-first or forks-first command at JPS5-5 or JPS5-6 and sends a forks-first or tractor-first command to the power card at JPS5-6 or JPS5-5. This causes the current flow in the Drive Motor field to be reversed.

h. With the Drive Motor field now energized in the opposite direction and the armature spinning in the original direction of travel, a voltage is produced in the armature that causes current to flow out of terminal A1 on the Drive Motor to TP6, then from TP6 to the anodes of REC1 and 2. REC1 turns on, permitting current to flow through REC1 to TP5, then through the Plugging Resistor (R1) to TP2, and then back to A2 on the armature.

i. This plugging current flow places a braking force on the Drive Motor armature, slowing it down. This results in the truck slowing down. The speed at which the truck slows down depends on the strength of the Drive Motor field. The field strength is proportional to the amplitude of the travel request input voltage from VR1. Plugging current continues to flow until the TM/VFC receives information from the Speed Feedback Proximity Sensor that travel speed has slowed to approximately 0.5 mph (0.8 km/hr) or the conditions initiating the plug have been satisfied.

j. When plugging is completed, the TM/VFC again supplies the PLUG CONTROL PWM voltage to the Coil Driver 5 (CD5) Card at JPS11-1. This activates the Plug Contactor coil driver and provides the ground path for the Plug Contactor coil at JPS11-6. The Plug Contactor tips close, bypassing the Plugging Resistor (R1).

k. If the right Control Handle (VR1) remains in the same direction that initiated the plug once the truck has slowed to approximately 0.5 mph (0.8 km/hr), the TM/VFC responds as described under “If the truck is not moving.”

l. Once the truck is moving after plugging is completed, the TM/VFC monitors the Speed Feedback Proximity Sensor until the actual truck speed and direction match the requested truck speed and direction.

7. If the right Deadman Pedal is released while the truck is moving, the truck quickly plugs to a stop regardless of the right Control Handle position. When the truck has stopped, the brake is applied.

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8. If one of the Travel Deadman Switches (S2 or S23) is detected to have changed state while the other did not, the truck plugs quickly to a stop regardless of the right Control Handle position, applies the brake, and the Operator Display shows a fault code.

Thermal Travel Speed Limits

Table 8-1. Thermal Travel Speed Limits

Power Panel Temperature	**SA Travel Speed Limit**	**SB Travel Speed Limit**
200°F (93.3°C) 1st threshold	5.75 mph (9.3 km/hr)	5.5 mph (8.9 km/hr)
207°F (97.2°C) 2nd threshold	5.5 mph (8.9 km/hr)	5.0 mph (8 km/hr)
214°F (101.1°C) 3rd threshold	5.0 mph (8 km/hr)	4.5 mph (7.2 km/hr)
227°F (108.3°C) Code 1H alarm		
NOTE: Taller SM trucks are more severely speed restricted		
Drive Motor Temperature	**SA Travel Speed Limit**	**SB Travel Speed Limit**
238°F (114.4°C) 1st threshold	5.75 mph (9.3 km/hr)	5.5 mph (8.9 km/hr)
246°F (118.9°C) 2ndt threshold	5.5 mph (8.9 km/hr)	5.0 mph (8 km/hr)
251°F (121.7°C) 3rd threshold	5.0 mph (8 km/hr)	4.5 mph (7.2 km/hr)
264°F (128.9°C) Code 2A alarm		
NOTE: Taller SM trucks are more severely speed restricted		

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Steering System Functional Operation

Electric Steering Components

Steering Tiller

On lift trucks manufactured prior to 10/1/2005, the Steering Tiller is connected, through a friction clutch assembly, to a shaft-style Steer Encoder located on the Steer Encoder Card. Trucks manufactured after that date have the Steering Tiller connected directly to a bearing-style Steer Encoder. Some older trucks could have the Steer Encoder Card and friction clutch assembly replaced by the newer bearing-style Steer Encoder.

Steer Encoder Card

On trucks manufactured prior to 10/1/2005, the Steer Encoder Card generates a steering request proportional to the speed and direction of the steering movement requested by the operator through the Steering Tiller. Trucks using the newer bearing-style Steer Encoder do not require an encoder card, but have the Steer Encoder directly connected to the CM and providing the same information.

Carriage Manager

The Carriage Manager determines that the Steer Encoder Card or the Steer Encoder is correctly connected between JPC16 and JPE1 and communicates the steering request to the ESM via BUS+/BUS–.

Tractor Manager

The Tractor Manager provides +12VF and a BUS+/BUS– connection at JPS17 to JPA2 on the Electric Steer Manager. When the Rail Guidance option is installed, it also reports the status of the Rail Sense Switch (S15) to the Carriage Manager.

Electric Steer Manager

The Electric Steer Manager receives steering information over BUS+/BUS– at JPA2 and determines the correct steering response, based on inputs from the Steer Position Encoder and the Steer Home Proximity Sensor. The Wire Guidance option components also connect to the Electric Steer Manager.

Electric Steer Motor

The Electric Steer Motor is a permanent magnet motor/gear reducer assembly. Both the direction and magnitude of current through the Steer Motor are controlled by the dual Steering Transistor Modules, TM3 and TM4, on the Electric Steer Manager.

Steer Position Feedback Encoder

The Steer Position Feedback Encoder is connected to the ESM at JPA8 and is located on the Drive Unit under the Hydraulic Reservoir. It is driven by the steering ring gear on the Drive Unit. It provides Drive Unit position information to the ESM.

Steer Home Proximity Sensor

The Steer Home Proximity Sensor is connected to the ESM at JPA7 and is also located under the Hydraulic Reservoir. It senses the metal plate (sensor rail) over which it is positioned. The transition from metal to no metal indicates straight ahead when everything is adjusted correctly.

Manual (Electric) Steering Operation

When the operator moves the Steering Tiller, the Steer Encoder produces two square wave voltages 90° out of phase with each other (quadrature phase). These voltages go to the Carriage Manager at JPC16–3 (CHB) and JPC16-4 (CHA) and are used by the Carriage

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Manager to determine the speed and direction of steering requested by the operator.

A communications message is sent over BUS+/BUS– to the Electric Steer Manager, telling the Electric Steer Manager how fast, for how long, and in which direction to rotate the drive unit. This message passes through the Tractor Manager to the Electric Steer Manager at JPA26 and JPA2. The Tractor Manager does nothing with these messages, but acts only as a part of the BUS+/BUS– communication.

The Electric Steer Manager processes this steering request and controls the appropriate transistors in the dual Transistor Modules, TM3 and TM4, to turn the Steer Motor in the direction and at the speed that the operator requested. The ESM also monitors the Steer Motor current through a shunt on the ESM.

As the Drive Unit begins to rotate, the Steer Position Feedback Encoder, which is driven by the steering ring gear on the Drive Unit, begins generating a pair of square wave voltages that are 90° out of phase with each other (quadrature phase). These voltages go to the Electric Steer Manager at JPA8-1 and JPA8-4, where they are used to determine the direction and rate of steering movement. If the actual movement does not match the steering command, then an error is posted and a fault code is generated and displayed on the Operator Display.

The Electric Steer Manager also looks for a transition from metal to no metal input from the Steer Home Proximity Sensor, indicating a straight ahead position, when centering the Drive Unit on power-up. If the transition is not detected, then a fault code results. The ESM also monitors the Steer Motor current and verifies it is within acceptable limits.

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Wire Guidance Option Functional Operation

Introduction

Wire Guidance is a means to steer the lift truck automatically while traveling down the aisle, permitting full speed travel in very narrow aisle (VNA) applications.

Wire Guidance Components and Terms

Line Driver

The Line Driver is a device installed in the warehouse that generates a magnetic field of a certain frequency and amplitude. Consult PDSS-0051 for information on the Raymond Line Driver.

Guide Wire

The Guide Wire is a wire connected to the Line Driver and installed in the floor of the warehouse. The Guide Wire radiates a magnetic field as dictated by the Line Driver, providing a path for the lift truck to follow.

Wire Guidance Sensor Assemblies

The truck has two Wire Guidance Sensor Assemblies. One is mounted behind the center plate of the tractor bumper (tractor end coils). The other is mounted between the load wheels under the steel sensor cover (load end coils). The sensor assemblies contain antenna coils to detect the magnetic field radiated by the Guide Wire and circuitry to filter and amplify the resulting voltages before sending them to the Filter Card.

Wire Guidance Filter Card

The Wire Guidance Filter Card is mounted on top and connected to the Electric Steer Manager (ESM). It provides additional filtering, amplification, and processing for the voltages from the Wire Guidance Sensor Assemblies.

Auto/Manual Switch

The Auto/Manual Switch is located on the inboard side of the right-hand Control Handle. When either the Wire Guidance or Rail Guidance options is installed, the operator can use the Auto/Manual Switch to choose either manual steering control or automatic (wire) guidance mode.

"Learning" Wire Frequency

If in Configure Mode, Wire Guidance Frequency is set to "Other," the lift truck must *learn* the frequency and amplitude of the guide wire in order to track the wire correctly. The truck automatically programs the Tractor Sensor, Load Sensor, and Filter Card circuitry for the correct frequency and amplitude values when the 5.2 kHz or 6.25 kHz choice is selected. When 5.2 kHz or 6.25 kHz is selected, the Line Driver must be set up correctly for 100 milliamps/peak-to-peak or 225 milliamps/peak to peak in order for the truck to track the wire correctly. "Other" must be selected if the Line Driver is set up for 5.2 kHz at 300 milliamps/ peak-to-peak, or some other frequency and amplitude. See "Learn Wire Frequency" on page 6-19.

"Learning" Wire Guidance Offsets

The lift truck must *learn* what voltages are present from the Wire Guidance Sensors when the lift truck is steering straight on the Guide Wire. See "Learn Wire Guidance Offsets" on page 6-19.

Heading Angle

Heading Angle (HA) is the angle between center line of the tractor and Load Sensor assemblies, and the Guide Wire in the direction the truck is pointed. The Electric Steer Manager (ESM) calculates this angle by comparing the voltages received from the Wire Guidance Sensors to the values obtained during Learn-Wire Guidance Offsets.

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If, while traveling in wire guidance mode, the heading angle exceeds the configured HA Slow value (default is 1.6°), the lift truck slows to 1 mph (1.6 km/hr).

If, while traveling in wire guidance mode, the heading angle exceeds the configured HA Stop value (default is 3.0°), the brake is applied to stop the lift truck.

The values for HA Slow and HA Stop can be set using Configure Mode, under the "Guidance Settings" menu. See "Configure Mode Settings" beginning on page 6-10.

Distance From Wire

Distance from Wire (DFW) is the distance from the center line of the tractor and Load Sensor assemblies to the Guide Wire. The Electric Steer Manager calculates this distance by comparing the voltages received from the Wire Guidance Sensors to the values obtained during Learn-Wire Guidance Offsets.

If, while traveling in wire guidance mode, the distance from wire exceeds the configured DFW Slow value (default is 1.6 inches or 40 mm), the lift truck slows to 1 mph (1.6 km/hr).

If, while traveling in wire guidance mode, the distance from wire exceeds the configured DFW Stop value (default is 3.0 inches or 76 mm), the brake is applied to stop the lift truck.

The values for DFW Slow and DFW Stop can be set using Configure Mode, under the "Guidance Settings" menu. See "Configure Mode Settings" beginning on page 6-10.

Wire Guidance Operation

The following discussion assumes that the output from the line driver is at the correct amplitude and frequency. It also assumes that the truck "Frequency" and "Wire Guidance Offset" were learned correctly with the truck centered over the wire.

When the truck is in the aligning (wire) guidance mode, voltages from the wire guidance components replace the input from the Steer Tiller. Commands for steering are generated by the ESM based on comparing information from the Wire Guidance Filter Card to the values obtained during Learn-Wire Guidance Offsets.

The Wire Guidance Sensors located at either end of the truck each contain four coils. The center coil pair in each sensor is used to detect the presence of a Guide Wire. Their output is used to generate a "nearwire" voltage. Without a "nearwire" voltage present, the truck does not acquire the wire, even if voltages are generated from the outer coil pairs. The outer coil pair in each sensor is used to determine truck position relative to the wire. They produce the right and left guide voltages for the tractor end and the load end.

At power up, the home position of the drive unit is found using the Steer Home Proximity Sensor.

When the "Learn Wire Frequency" process is used, the ESM learns the frequency and amplitude radiating from the Guide Wire. During the "Learn Wire Guidance Offsets" process, the ESM learns the voltages from the Wire Guidance Sensors that represent the position of the lift truck when centered over the Guide Wire.

The difference in Steer Feedback Encoder pulses between the home position, and the position of the drive unit when offsets is learned, is stored in memory and used to determine wire guidance zero position, or straight ahead.

Acquiring the Guide Wire

The process of steering the lift truck over the Guide Wire so the wire guidance system recognizes the wire is called "acquiring the Guide Wire."

It is possible to acquire the Guide Wire while driving in either the forks-first or tractor-first direction, but tractor-first is preferred for best results. When attempting to acquire the Guide Wire tractor-first, travel speed must be no greater than the configured acquire speed (maximum 3.0 mph (4.8 km/hr). When

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attempting to acquire the Guide Wire forks first, travel speed must be no greater than 1 mph (1.6 km/hr).

To begin acquiring the Guide Wire, place the Auto/Man Switch in the AUTO position. An audible alarm sounds and the two triangular "seeking wire" icons blink on the Operator Display and the Supplemental Operator Display. The Operator Display shows the word "seeking." (See Figure 8-1.)

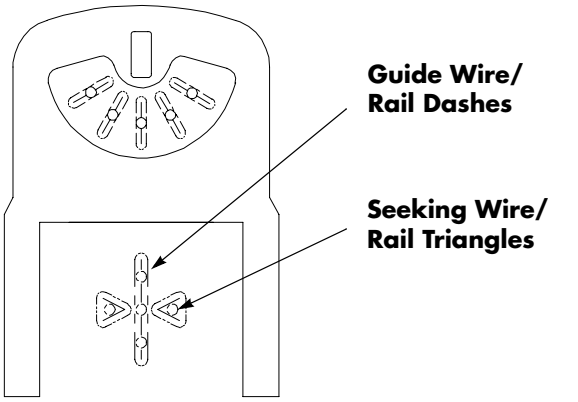


Figure 8-1. Guidance Indicators, Secondary Operator Display

When approaching the wire, the "nearwire" coils are used to sense the wire. When the wire is between the "nearwire" coils of one of the sensors, the alarm is silenced and the three dashed "guide wire" icons begin blinking on both displays. The Operator Display changes from "seeking" to "aligning." (See Figure 8-1.)

While "aligning," the lift truck steers automatically while traveling in a speed-limited condition until the wire is between the near wire coils of both the tractor and load end sensors.

When the lift truck is parallel to and centered on the Guide Wire, the word "aligning" disappears from the Operator Display, and the "seeking wire" icons and "guide wire" icons stop blinking and remain on. The wire guidance system is now locked onto the Guide Wire and the Electric Steer Manager controls steering. Travel at full configured speed is permitted.

Guided Mode

As the lift truck travels and drifts off-center, voltages from the Wire Guidance Sensor Coils on one side decrease, while voltages from the coils on the other side increase. These voltages are filtered and processed by the Wire Guidance Filter Card and passed through JPA3 to the Electric Steer Manager (ESM). The ESM calculates the distance from the wire (DFW) and heading angle (HA) from these voltages. The ESM supplies the appropriate control voltages to the Steering Transistor Modules, TM3 and TM4, to turn the Drive Unit in the opposite direction until the sensor coil voltages equal their "learned" values.

As the Drive Unit begins to rotate, the Steer Position Feedback Encoder shaft rotates and supplies to the ESM two square wave voltages 90° out of phase with each other (quadrature phase). From these voltages, the ESM determines that the Drive Unit is responding in the correct direction to the steering command. The ESM keeps a count of the pulses from the Steer Position Feedback Encoder and knows the position of the Drive Unit at any given time. When the Steer Home Proximity Sensor detects the Drive Unit at its center position, the ESM resets the pulse count.

If the lift truck is driven off the end of the Guide Wire while in guided mode, the alarm sounds, the truck quickly plugs to a stop, and the brake applies.

Table 8-2 summarizes wire guidance operation of the lift truck:

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Table 8-2.

Situation	**Effect**				
Auto/Man Switch Position	**Lift Truck Position**	**Can the operator steer manually?**	**Seeking Wire/ Rail Icons**	**Guide Wire/ Rail Icons**	**Alarm**
MANUAL	Not near wire or rail switch open	Yes	Off	Off	Off
	Over wire or rail switch closed	Yes	Off	Off	On steady
AUTO	Seeking: Not near wire or rail switch open	Yes	Blinking	Off	ON
	Aligning: near wire	No[1]	Blinking	Blinking	Off
	Guided: locked on wire or rail switch closed	No[2]	On steady	On steady	Off

1. Lift truck steers automatically to center itself over the wire
2. Lift truck steers automatically to maintain drive wheel straight ahead in rail guide

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Lift/Lower System Functional Operation

Overview

Electric Steer Manager

The Electric Steer Manager (ESM) reports the voltage of the Main and Mini-Mast Pressure Transducers. It sends this information over BUS+/BUS– to the CM for the generation of weight-related fault codes, operational restrictions, and information to be sent to the Operator Display.

Height Manager - Main Mast

An infrared Optical Sensor supplies inputs to the Main Height Manager. The Main Mast Height Manager sends information over BUS+/BUS– to the CM for the generation of height-related fault codes, operational restrictions, and information to be sent to the Operator Display (OD).

Height Manager - Mini-Mast

A Multi-Head Proximity Sensor supplies inputs to the Mini Height Manager. The Mini-Mast Height Manager sends information over BUS+/BUS– to the CM for the generation of height-related fault codes, operational restrictions, and information to be sent to the Operator Display.

Carriage Manager

The Carriage Manager (CM) uses information based on inputs from the Main Mast Height Manager and Mini-Mast Height Manager to limit speed due to height and to determine the lift/lower “decel” points for the Main and Mini-Mast when nearing their extremes of movement. The CM also uses information from the ESM or TM to stop lowering if the platform is hung up.

The Carriage Manager (CM) monitors the input from the Lift/Lower Potentiometer (VR2) and sends lift/lower requests to the TM over BUS+/BUS–.

The CM receives height count information from the Height Managers and calculates the values from the Height Managers with respect to the value of the reference point (fully lowered position). The CM then updates the OD height indication. The CM uses the information from the ESM to update the OD for weight indication.

Slack Chain Switch

When the slack chain switch is open or the pressure transducer senses no pressure, lift is limited to a maximum of 23.6 inches (600 mm) so that the operator can correct a hung-up platform and remove the slack in the chain. If the slack chain condition will not correct, the ability to lift will cease.

Main Lift

With the Key Switch ON and the right Deadman Pedal depressed, moving the Lift/Lower Control thumb control knob (VR2) on the right-hand Control Handle clockwise causes the following to occur:

1. The VR2 output voltage to the CM at JPC24-10 decreases to a voltage lower than when in the neutral position.
2. The CM, detecting this voltage decrease, determines that a request for lift has been made. It does this by comparing the input voltage with the learned voltage values for lift, lower, and neutral. The CM processes this voltage and sends a message over BUS+/BUS– to the TM/VFC.
3. The TM/VFC receives the message and supplies a PWM voltage (P CONTROL) to the Coil Driver 3 (CD3) Card at JPS12-2, enabling the P Contactor coil driver.
4. With the P Contactor coil driver energized, the P Contactor coil has a path to ground from JPS29-3, through the coil driver to JPS12-9, through FU12 to B-PC at JPS14-1 and JPS14-2. This energizes the P Contactor coil, closing the P contactor tips, and starting the lift pump motor. Models SA S/N > 03217 and

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SB S/N > 00761 have a Dump Solenoid Valve (SOL99) installed. The "Dmp Vlv" setting in Configure Mode must be set ON for trucks equipped with SOL99 and OFF for all others. The normally open SOL99 valve has its coil wired in parallel with the P Contactor coil. It is also energized (valve closed) by the P Contactor coil driver. With SOL99 coil energized (valve closed), the Lift Pump output is available to the lift system during a lifting function. When the lift request is removed, the P Contactor coil is de-energized, along with the SOL99 coil, returning the valve to its normally open state. This provides a path back to the Reservoir for the Lift Pump output, resulting in the rapid relief of pump pressure to the system, thereby reducing the transition delay between a lift to lower function.

5. The TM/VFC also supplies a PWM voltage to the Lift/Lower Proportional Solenoid Valve (SOL4) coil driver at JPS11-4, enabling the Lift/Lower Proportional Solenoid Valve coil driver.
6. With the Lift/Lower Proportional Solenoid Valve coil driver energized, SOL4 has a path to ground from JPS19-4, to the coil driver at JPS11-9, through the coil driver to JPS11-11, through FU-12 to B-PC at JPS14-1 and JPS14-2.
7. The Lift/Lower Proportional Solenoid Valve initially moves to the full open position, directing all hydraulic fluid flow back to the Hydraulic Reservoir. It then positions proportionally to the lift request voltage from VR2. The less the lift request voltage, the more open the Lift/Lower Proportional Solenoid Valve will be, permitting more fluid to return to the Reservoir, resulting in a slower lift rate. A faster lift rate requires a greater lift request voltage, which further closes the valve, and ports more hydraulic fluid to the Main Mast Lift Cylinders.
8. The hydraulic fluid flows through the Lift Select Solenoid Valve (SOL3) and the Main Load Holding Solenoid Valve (SOL1) to the Lift Cylinders.
9. The TM monitors the voltage at P Contactor tip P-2 through the P-SENSE line at JPS14-7. The TM/VFC uses this information to determine if the P Contactor tips are open or closed. On trucks not having the Dump Solenoid Valve (SOL99) installed (Models SA S/N < 03218 and SB S/N < 00762), when the lift request is removed (VR2 returned to the neutral position), the P Contactor coil is immediately de-energized, but the Lift/Lower Proportional Solenoid Valve (SOL4) is kept fully energized (open) until the Lift Motor stops turning. It does this because a spinning motor does not stop instantly. Due to the voltage (back EMF) produced in the Lift Motor as it spins to a stop, the P-SENSE line has some voltage on it. The TM/VFC monitors the P-SENSE line (JPS14-7) to determine when the Lift Motor has stopped turning (no more back EMF produced). At that point the TM/VFC turns off (closes) the Lift/Lower Proportional Solenoid Valve coil driver. If the Lift/Lower Proportional Solenoid Valve coil driver were de-energized at the same time as the P Contactor coil, the operator carriage would jump. Leaving the valve open until the motor stops diverts excess hydraulic fluid back to the Reservoir
10. The ESM reads the voltage from Pressure Transducer A at JPA5-2 and sends this information over BUS+/BUS– to the CM. The CM processes this information and sends it to the Operator Display to show weight in pounds or kilograms. The CM also uses this information to determine error codes and operational restrictions.
11. The CM determines the height and direction of carriage movement by summing the inputs from the Main Height Manager and the Mini Height Manager.

Main Lower

With the Key Switch ON and the right Deadman Pedal depressed (S2 and S23 closed), moving the Lift/Lower thumb control knob (VR2) on the right-hand Control Handle counterclockwise causes the following to occur:

1. The VR2 output voltage to the CM at JPC24-10 increases to a voltage higher than when in the neutral position.

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2. The CM, detecting this voltage increase, determines that a request for lower has been made. It does this by comparing the input voltage to the learned voltage values for lift, lower, and neutral. The CM processes this voltage and sends a message over BUS+/BUS– to the TM/VFC.
3. The TM/VFC receives the message and supplies a PWM voltage L/H CONTROL to the Coil Driver 5 (CD5) Card at JPS11-5, enabling Main Load Holding Solenoid Valve (SOL1) coil driver.
4. With the Main Load Holding Solenoid Valve coil driver energized, SOL1 has a path to ground from JPS19-3, to the coil driver at JPS11-10, through the coil driver to JPS11-15, through FU12 to B–PC at JPS14-1 and JPS14-2.
5. With the Main Load Holding Solenoid Valve coil now energized, hydraulic fluid can flow from the lift cylinders through the Main Load Holding Solenoid Valve (SOL1) to the Lift/Lower Proportional Solenoid Valve (SOL4) and the Load Holding Check Valve (CV1).
6. With the Lift/Lower Proportional Solenoid Valve coil driver energized, SOL4 has a path to ground from JPS19-4, to the coil driver at JPS11-9, through the coil driver to JPS11-11, through FU-12 to B–PC at JPS14-1 and JPS14-2.
7. The Lift/Lower Proportional Solenoid Valve is initially fully closed to prevent any fluid flow back to the Hydraulic Reservoir. It opens proportionally to the lower request voltage from VR2. The less the lower request voltage, the less open the Lift/Lower Proportional Solenoid Valve will be, permitting less fluid to return to the Reservoir. A faster lower rate requires a greater lower request voltage, which further opens the valve, permitting more hydraulic fluid to return to the Reservoir.
8. The hydraulic fluid can now continue its flow through the Lift/Lower Proportional Solenoid Valve and the Hydraulic Filter to the Reservoir.
9. The CM determines the height and direction of carriage movement by summing the inputs from the Main Height Manager.

Mini Lift

With the Key Switch ON and both Deadman Pedals depressed (S2, S23, and S9 closed), depressing the Lift Select Switch (S6) on the left-hand Control Handle, then moving the Lift/Lower Potentiometer (VR2) thumb control knob on the right-hand Control Handle clockwise causes the following to occur:

1. Depressing the Lift Select Switch (S6) applies a ground (DGND) input to the CM at JPC23-1.
2. The VR2 output voltage to the CM at JPC24-10 decreases to a voltage lower than when in the neutral position.
3. The CM detects the voltage decrease at JPC24-10, and determines that a request for lift has been made. It does this by comparing the input voltage to the learned voltage values for lift, lower, and neutral. The CM processes this voltage together with the input from S6, and sends a message to the TM/VFC over BUS+/BUS–.
4. The TM/VFC supplies a PWM voltage (P CONTROL) to the Coil Driver 3 (CD3) Card at JPS12-2, enabling the P Contactor coil driver.
5. With the P Contactor coil driver energized, the P Contactor coil has a path to ground from JPS29-3, through the coil driver to JPS12-9, through FU12 to B-PC at JPS14-1 and JPS14-2. This energizes the P Contactor coil, closing the P Contactor tips, and starting the Lift Motor. Models SA S/N > 03217 and SB S/N > 00761 have a Dump Solenoid Valve (SOL99) installed. The “Dmp Vlv” setting in Configure Mode must be turn ON for trucks equipped with SOL99 and OFF for all others. The normally open SOL99 valve has its coil wired in parallel with the P Contactor coil. It is therefore also energized (valve closed) by the P Contactor coil driver. With SOL99 coil energized (valve closed), the Lift Pump output is available to the lift system during a lifting function. When the lift request is removed, the P Contactor coil is

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de-energized, along with the SOL99 coil, returning the valve to its normally open state. This provides a path back to the Reservoir for the Lift Pump output, resulting in the rapid relief of pump pressure to the system, thereby reducing the transition delay between a lift to lower function.

6. The TM/VFC also supplies a PWM voltage to the Lift Select Solenoid Valve (SOL3) coil driver at JPS12-1, enabling the Lift Select Solenoid Valve coil driver.
7. With the Lift Select Solenoid Valve coil driver energized, SOL3 has a path to ground from JPS29-1, through the coil driver to FU12 to B-PC at JPS14-1 and JPS14-2.
8. TM/VFC also supplies a PWM voltage to the Lift/Lower Proportional Solenoid Valve (SOL4) coil driver at JPS11-4, enabling the Lift/Lower Proportional Solenoid Valve coil driver.
9. With the Lift/Lower Proportional Solenoid Valve coil driver energized, SOL4 has a path to ground from JPS19-4, to the coil driver at JPS11-9, through the coil driver to JPS11-11, through the coil driver to JPS11-15, through FU12 to B-PC at JPS14-1 and JPS14-2.
10. The Lift/Lower Proportional Solenoid Valve initially moves to the full open position, directing all fluid flow back to the Hydraulic Reservoir. It then positions proportionally to the lift request voltage from VR2. The less the lift request voltage, the more open the Lift/Lower Proportional Solenoid Valve will be, permitting more fluid to return to the Reservoir, resulting in a slower lift rate. A faster lift rate requires a greater lift request voltage. This further closes the valve, and ports more hydraulic fluid to the Mini-Mast Lift Cylinder.
11. The hydraulic fluid flows through the Lift Select Solenoid Valve (SOL3), the 9 gpm Flow Regulator (which diverts excess flow back to the Reservoir), the Mini Load Holding Solenoid Valve (SOL2), and to the Mini Lift Cylinder.
12. The TM monitors the voltage at P Contactor tip P-2 through the P-SENSE line at JPS14-7. The TM/VFC uses this information to determine if the P Contactor tips are open or closed. On trucks not having the Dump Solenoid Valve (SOL99) installed (Models SA S/N < 03218 and SB S/N < 00762), when the lift request is removed (VR2 returned to the neutral position), the P Contactor coil is immediately de-energized, but the Lift/Lower Proportional Solenoid Valve (SOL4) is kept fully energized (open) until the Lift Motor stops turning. It does this because a spinning motor does not stop instantly. Due to the voltage (back EMF) produced in the Lift Motor as it spins to a stop, the P-SENSE line has some voltage on it. The TM/VFC monitors the P-SENSE line (JPS14-7) to determine when the Lift Motor has stopped turning (no more back EMF produced). At that point the TM/VFC turns off (closes) the Lift/Lower Proportional Solenoid Valve coil driver. If the Lift/Lower Proportional Solenoid Valve were de-energized at the same time as the P Contactor coil, the forks would jump. Leaving the valve open until the motor stops diverts excess hydraulic fluid back to the Reservoir.
13. The ESM reads the voltage from Pressure Transducer B at JPA6-2 and sends this information over BUS+/BUS– to the CM. The CM processes this information and sends it to the Operator Display to show weight in pounds or kilograms. The CM also uses this information to determine error codes and operational restrictions.
14. The CM determines the height and direction of fork movement by summing the inputs from the Mini Height Manager.

Mini Lower

With the Key Switch ON and the both Deadman Pedals depressed (S2, S23, and S9 closed), depressing the Lift Select Switch (S6) on the left-hand Control Handle, then moving the Lift/Lower Potentiometer (VR2) thumb control knob on the right-hand Control Handle counterclockwise causes the following to occur:

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1. Depressing the Lift Select Switch (S6) applies a ground (DGND) input to the CM at JPC23-1.
2. The VR2 output voltage to the CM at JPC24-10 increases to a voltage higher than when in the neutral position.
3. The CM, detecting the voltage increase at JPC24-10, determines that a request for lower has been made. It does this by comparing the input voltage to the learned voltage values for lift, lower, and neutral. The CM processes this voltage, together with the input from S6, and sends a message over BUS+/BUS– to the TM/VFC.
4. The TM/VFC receives the message and supplies a PWM voltage Mini L/H CONTROL to the Coil Driver 3 (CD3) Card at JPS12-3, enabling Mini Load Holding Solenoid Valve (SOL2) coil driver.
5. With the Mini Load Holding Solenoid Valve coil driver energized, SOL2 has a path to ground from JPS29-4, through the coil driver to FU12, to B-PC at JPS14-1 and JPS14-2.
6. The TM/VFC also supplies a PWM voltage to the Lift Select Solenoid Valve (SOL3) coil driver at JPS12-1, enabling the Lift Select Solenoid Valve coil driver.
7. With the Lift Select Solenoid Valve coil driver energized, SOL3 has a path to ground from JPS29-1, through the coil driver to FU12, to B-PC at JPS14-1 and JPS14-2.
8. With the Mini Load Holding Solenoid Valve coil now energized, hydraulic fluid can flow from the Mini Lift Cylinder through the Mini Load Holding Solenoid Valve (SOL2) and the Lift Select Solenoid Valve (SOL3) to the Lift/Lower Proportional Solenoid Valve (SOL4) and the Load Holding Check Valve (CV1).
9. TM/VFC also supplies a PWM voltage to the Lift/Lower Proportional Solenoid Valve (SOL4) coil driver energized at JPS11-4, enabling the Lift/Lower Proportional Solenoid Valve coil driver.
10. With the Lift/Lower Proportional Solenoid Valve coil driver energized, SOL4 has a path to ground from JPS19-4, to the coil driver at JPS11-9, through the coil driver to JPS11-11, through the coil driver to JPS11-15, through FU12 to B-PC at JPS141 and JPS14-2.
11. The Lift/Lower Proportional Solenoid Valve is initially fully closed to prevent any fluid flow back to the Hydraulic Reservoir. It opens proportionally to the lower request voltage from VR2. The less the lower request voltage, the less open the Lift/Lower Proportional Solenoid Valve will be, permitting less fluid to return to the Reservoir. A faster lower rate requires a greater lower request voltage. This further opens the valve, permitting more hydraulic fluid to return to the Reservoir.
12. The hydraulic fluid can now continue its flow through the Lift/Lower Proportional Solenoid Valve and the Hydraulic Filter to the Reservoir.
13. The CM determines the height and direction of fork movement by summing the inputs from the Mini Height Manager.

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Auxiliary System Functional Operation

(Lift Trucks Without Auxiliary Contactor)

Traverse/Reach

With the Key Switch ON and both Deadman Pedals depressed (S2, S23, and S9 closed), rotating the Traverse Control Potentiometer (VR4) on the left-hand Control Handle toward the tractor (traverse right) or toward the forks (traverse left) causes the following to occur:

1. The Traverse Control Potentiometer (VR4) input voltage to the CM at JPC23-11 increases or decreases to a voltage higher or lower than its learned neutral position.
2. The CM, detecting this voltage change at JPC23-11, determines that a request for traverse right (higher voltage) or traverse left (lower voltage) has been made. It does this by comparing the input voltage to the learned voltage values for traverse left, right, and neutral. The CM processes this voltage and sends a message to the TM/VFC over BUS+/BUS–.
3. The TM/VFC receives the message from the CM and sends an AUX ENABLE voltage at JPS4-5 and an AUX PWM voltage at JPS4-2 to the Auxiliary Motor Controller or Auxiliary Interface Module.
4. The AUX ENABLE voltage input to the Auxiliary Motor Controller or the Auxiliary Interface Module at JPM1-5 or JPM2-7 respectively enables these components to process the AUX PWM voltage at JPM1-2 or JPM2-3 respectively. The AUX PWM voltage to the Auxiliary Motor Controller or the Auxiliary Interface Module is directly proportional to the VR4 input voltage. The farther VR4 is moved from neutral in either direction, the higher the AUX PWM voltage to the Auxiliary Motor Controller or the Auxiliary Interface Module.
   a. Lift trucks with Auxiliary Motor Controller: As the AUX PWM voltage increases to the Auxiliary Motor Controller, more power is provided to the Auxiliary Motor, causing it to turn faster, thus delivering more fluid.
   b. Lift trucks with Auxiliary Interface Module: When the AUX PWM voltage is delivered to the Auxiliary Interface Module, it is processed into a proportional DC voltage, which is then supplied at JPM2-6 to the Auxiliary Power Amplifier at AMPL-3. Increasing the AUX PWM voltage increases the DC voltage, which in turn causes the Auxiliary Power Amplifier to provide more power to the Auxiliary Motor. The motor turns faster, thus delivering more fluid.
5. At the same time that the TM/VFC is initiating Auxiliary Motor control, the CM supplies a control voltage to either the Traverse A Solenoid Valve (SOL34A) coil driver (right) or the Traverse B Solenoid Valve (SOL34B) coil driver (left), depending on the traverse direction requested. Coil drivers for the Traverse A and B Solenoid Valve are internal to the CM.
   a. With the Traverse A Solenoid Valve coil driver energized, SOL34A has a path to ground from JPC10-6 through the coil driver in the CM to B-PCF at JPC20-4, then through FU12 to B-PC at JPS14-1 and JPS14-2.
   b. With the Traverse B Solenoid Valve coil driver energized, SOL34B has a path to ground from JPC10-8 through the coil driver in the CM to B-PCF at JPC20-4, then through FU12 to B-PC at JPS14-1 and JPS14-2.
6. The hydraulic fluid flows from the Auxiliary Pump, through the Adjustable Flow Regulator (FR2) and the Traverse A or B Solenoid Valves to the Traverse Hydraulic Motor, back through the Traverse A or B Solenoid Valves to the Reservoir.
7. The Adjustable Flow Regulator (FR2) provides a flow adjustment to obtain optimum coordination between the

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traverse and rotate functions when operated together.

8. As the Mini-Mast traverses to the right or left, the CM monitors the input voltage from the Traverse Position Feedback Potentiometer (VR5) at JPC12-1. The CM compares the voltage from VR5 to the learned traverse values to determine the position of the Mini-Mast to:
   - Determine appropriate decel points at the traverse travel extremes
   - Determine nested center position
   - Send information to the Operator Display over BUS+/BUS–
   - Determine when to initiate the reach function
   - Impose operational restrictions
   - Generate error codes.
9. When the following conditions are true, the CM supplies a control voltage to the Reach Select Solenoid Valve (SOL36) coil driver and the Fork Control A Solenoid Valve (SOL35A) coil driver. Coil drivers for the Reach Select Solenoid Valve and the Fork Control A Solenoid Valve are internal to the CM.

   Conditions:
   - Traverse passes the midpoint of the carriage.
   - The rotate mechanism is fully nested (clockwise or counterclockwise) as determined by the feedback voltage from the Rotate Position Feedback Potentiometer (VR6).
   - The fork tips are pointing in the direction of load handler traverse.

   a. With the Reach Select Solenoid Valve (SOL36) coil driver energized, SOL36 has a path to ground through JPK3-1 to JPH1-2, through the coil driver in the CM to B-PC at JPC20-4, then through FU12 to B-PC at JPS14-1 and JPS14-2.

   b. With the Fork Control A Solenoid Valve (SOL35A) coil driver energized, SOL35A has a path to ground from JPS10-4, through the coil driver in the CM to B-PC at JPC20-4, then through FU12 to B-PC at JPS14-1 and JPS14-2.
10. Energizing the Reach Select Solenoid (SOL36) Valve coil and the Fork Control A Solenoid (SOL35A) Valve coil permits the forks to extend for load handling.
11. The CM also sends a message over BUS+/BUS– to the TM/VFC when the reach or rotate function is requested. The TM/VFC receives the message and increases the AUX PWM voltage to the Auxiliary Motor Controller or Auxiliary Interface Module to speed up the Auxiliary Motor so that traverse speed is not affected by the added fluid flow requirements due to reach or rotate operation.
12. As the Mini-Mast approaches the end of the traverse, as determined from the Traverse Position Feedback Potentiometer (VR5) voltage input, the CM sends a message over BUS+/BUS– to the TM/VFC. The TM/VFC receives the message and reduces the PWM voltage to the Auxiliary Motor Controller or Auxiliary Interface Module to slow down the Auxiliary Motor. This reduces the volume of hydraulic fluid being supplied from the pump, thereby slowing the traverse speed.
13. If the Mini-Mast is fully traversed to the left or right, with the forks rotated fully counterclockwise or clockwise and the forks extended, when traverse right or left is selected, the Reach Select Solenoid (SOL36) and Fork Control B Solenoid (SOL35B) valves are energized to retract the forks as the Mini-Mast begins to traverse in the opposite direction.

Rotate

With the Key Switch ON, both Deadman Pedals depressed (S2, S23, and S9 closed) and the forks detected fully retracted, moving the Rotate Control Potentiometer (VR3) thumb control knob on the left-hand Control Handle clockwise (CW) or counterclockwise (CCW)] causes the following to occur:

1. The Rotate Control Potentiometer (VR3) input voltage to the CM at JPC23-10

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increases or decreases to a voltage higher or lower than its learned neutral position.

2. The CM, detecting this voltage change at JPC23-10, determines that a request for rotate right (higher voltage) or rotate left (lower voltage) has been made. It does this by comparing the input voltage to the learned voltage values for rotate CW, CCW, and neutral. The CM processes this voltage and sends a message to the TM/VFC over BUS+/BUS–.
3. The TM/VFC receives the message from the CM and sends an AUX ENABLE voltage at JPS4-5 and an AUX PWM voltage at JPS4-2 to the to the Auxiliary Motor Controller or Auxiliary Interface Module.
4. The AUX ENABLE voltage input to the Auxiliary Motor Controller or the Auxiliary Interface Module at JPM1-5 or JPM2-7 respectively enables these components to process the AUX PWM voltage at JPM1-2 or JPM2-3 respectively. The AUX PWM voltage to the Auxiliary Motor Controller or the Auxiliary Interface Module is directly proportional to the VR3 input voltage. The farther VR3 is moved from neutral in either direction, the higher the AUX PWM voltage to the Auxiliary Motor Controller or the Auxiliary Interface Module.
   a. Lift trucks with Auxiliary Motor Controller: As the AUX PWM voltage increases to the Auxiliary Motor Controller, more power is provided to the Auxiliary Motor, causing it to turn faster, thus delivering more fluid.
   b. Lift trucks with Auxiliary Interface Module: When the AUX PWM voltage is delivered to the Auxiliary Interface Module, it is processed into a proportional DC voltage, which is then supplied at JPM2-6 to the Auxiliary Power Amplifier at AMPL-3. Increasing the AUX PWM voltage increases the DC voltage, which in turn causes the Auxiliary Power Amplifier to provide more power to the Auxiliary Motor. The motor turns faster, thus delivering more fluid.
5. At the same time that the TM/VFC is initiating Auxiliary Motor control, the CM supplies a control voltage to either the Fork Control A Solenoid Valve (SOL35A) coil driver (CW) or the Fork Control B Solenoid Valve (SOL35B) coil driver (CCW), depending on the rotate direction requested. Coil drivers for the Fork Control A and B Solenoid Valves are internal to the CM.
   a. With the Fork Control A Solenoid Valve coil driver energized, SOL35A has a path to ground from JPC10-4 through the coil driver in the CM to B–PCF at JPC20-4, then through FU12 to B–PC at JPS14-1 and JPS14-2.
   b. With the Fork Control B Solenoid Valve coil driver energized, SOL35B has a path to ground from JPC10-2 through the coil driver in the CM to B–PCF at JPC20-4, then through FU12 to B–PC at JPS14-1 and JPS14-2.
6. The hydraulic fluid flows from the Fork Control A Solenoid Valve (CW) or the Fork Control B Solenoid Valve (CCW), through the normally closed Reach Select Solenoid (SOL36) Valve to the Rotate Actuator.
7. The Reach Select Solenoid Valve coil is de-energized during a rotate function.
8. Hydraulic pressure on the pressure side of the Rotate Actuator causes the Counterbalance Check Valve on the return side to unseat. This permits fluid to flow from the Rotate Actuator through the return side Counterbalance Check Valve, back through the Fork Control A or B Solenoid Valve to the Reservoir.
9. The Rotate Position Feedback Potentiometer (VR6) is connected to and powered by the Mini Height Manager but the output voltage of VR6 is supplied directly to the CM at JPH1-3. The CM compares the voltage from VR6 to the learned rotate values to determine the position of the forks and to:
   - Determine appropriate decel points at the rotate travel extremes
   - Determine nested center position

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- Send information to the Operator Display over BUS+/BUS–
- Impose operational restrictions
- Generate error codes.

10. As the forks approach the end of their rotation, as determined by the voltage from the Rotate Position Feedback Potentiometer (VR6), the CM sends a message over BUS+/BUS– to the TM/VFC. The TM/VFC receives the message and reduces the PWM voltage to the Auxiliary Motor Controller or Auxiliary Interface Module to slow down the Auxiliary Motor. This reduces the volume of fluid being supplied from the pump, thereby slowing the rotate speed.
11. There are two Crossover Relief Valves installed in the Reach/Rotate Manifold. Their purpose is to equalize pressure spikes from either direction, CW or CCW, that can occur when the forks encounter sudden changes in resistance during operation or travel.

Auxiliary System Functional Operation

(Lift Trucks with Auxiliary Contactor)

Overview

On lift trucks with an Auxiliary Contactor, Proportional Solenoid Valves control the flow of hydraulic fluid to the auxiliary system components rather than using the Auxiliary Motor/Pump speed control method.

Hydraulic Controls

Mesh Screen

The Mesh Screen screws into the pressure input port on the Auxiliary Manifold on top of the Overhead Guard. It helps prevent contamination from entering the Auxiliary Manifold. It can easily be removed for cleaning.

Load Shuttles

There are 3 identical Load Shuttles in the Auxiliary Manifold. The Load Shuttles are 2-input, pressure-activated, 2-position valves. In each shuttle, the higher of the input pressures passes through the valve at the pressure out port. While the output port gives no usable flow, it can be used to operate pressure-activated devices such as other shuttles, piloted check valves, or piloted metering valves. In this application the Load Shuttles react to the pressure applied to the Reach, Rotate Actuator, and the Traverse Motor, and apply a pressure feedback to a pilot on the Logic Element in the Auxiliary Manifold.

Logic Element

The Logic Element is a metering valve that uses manifold pressure input from the supply side of the hydraulic circuit (Pilot A), pressure feedback from Load Shuttles in the load side of the circuit (Pilot B), and a calibrated spring to meter hydraulic fluid flow to the Traverse Motor, Rotate Actuator, and Reach Cylinders. Hydraulic fluid not needed for the selected function is returned back to the Reservoir.

Reach/Rotate Proportional Solenoid Valve (SOL33)

The Reach/Rotate Proportional Solenoid Valve (SOL33) controls the hydraulic fluid flow to the Rotate Actuator and Reach Cylinders. The Carriage Manager changes the position of the spool by changing the voltage to the Reach/Rotate Proportional Solenoid Valve coil. A coil driver in the Carriage Manager controls voltage to the coil, based on the request input voltages from the Rotate Control Potentiometer (VR3) and Traverse Control Potentiometer (VR4).

The Reach/Rotate Proportional Solenoid Valve also contains a Pressure Compensator. This pilot-operated metering valve has two pilot inputs, one from the manifold pressure input and one from the pressure line to the Fork Control Solenoid. As the pressure into the manifold or the pressure out to rotate/reach

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changes, the spool in the Pressure Compensator moves to keep a constant hydraulic fluid flow to the Rotate Actuator/ Reach Cylinder.

Fork Control Solenoid Valves (SOL35A/B)

This 2-position solenoid valve controls the direction of hydraulic fluid flow to the Rotate Actuator and the Reach Cylinders.

Traverse Solenoid Valves (SOL34A/B)

The Traverse Proportional Solenoid Valves (SOL34A/B) control the amount and direction of the hydraulic fluid flow to the Traverse Motor. The Carriage Manager changes the position of the spool by changing the voltage to the Traverse Proportional Solenoid Valve coil. A coil driver in the Carriage Manager controls voltage to the coil, based on the request input voltages from Traverse Control Potentiometer (VR4).

Traverse/Reach

With the Key Switch ON and both Deadman Pedals depressed (S2, S23, and S9 closed), rotating the Traverse Control Potentiometer (VR4) on the left Control Handle back toward the tractor (traverse right) or forward toward the forks (traverse left) causes the following to occur:

1. The Traverse Control Potentiometer (VR4) input voltage to the CM at JPC23-11 increases or decreases to a voltage higher or lower than its learned neutral position.
2. The CM, detecting this voltage change at JPC23-11, determines that a request for traverse right (higher voltage) or traverse left (lower voltage) has been made. It does this by comparing the input voltage to the learned voltage values for traverse left, right, and neutral. The CM processes this voltage and sends a message over BUS+/BUS– to the TM/VFC.
3. The TM/VFC receives the message from the CM and sends an AUX ENABLE voltage at JPS4-5 to the Contactor Interface Module (CIM).
4. The AUX ENABLE voltage input to the Contactor Interface Module at JPCM1-2 enables the internal Auxiliary Contactor coil driver, which provides a path to ground for the Auxiliary Contactor coil from JPCM1-3, through JPM1-6, JPS4-6, and through FU12 to B–PC at JPS14-1 and JPS14-2.
5. With the Auxiliary Contactor coil energized, its closed tips supply B+ to operate the Auxiliary Motor and Pump. Hydraulic fluid is now applied, through the Mesh Screen Filter, to the normally closed Traverse A and B Proportional Solenoid Valves (SOL34A/B), the normally closed Reach/Rotate Proportional Solenoid Valve (SOL33) and to the Logic Element on the Auxiliary Manifold. The Logic Element is initially closed. Increasing pressure at pilot input A causes the spool to move, which opens the valve, permitting the hydraulic fluid to return to the Reservoir.
6. At the same time that the TM/VFC is enabling the Auxiliary Contactor coil driver, the CM applies a PWM control voltage to either the Traverse A Proportional Solenoid Valve (SOL34A) coil driver (right) or the Traverse B Proportional Solenoid Valve (SOL34B) coil driver (left), depending on the traverse direction requested. The amount of PWM control voltage being applied to the coil drivers corresponds to the amount of input voltage (requested traverse speed) to the CM from the Traverse Control Potentiometer (VR4). Coil drivers for the Traverse A and B Proportional Solenoid Valves are internal to the CM.
   a. With the Traverse A Proportional Solenoid (SOL34A) Valve coil driver energized, SOL34A has a path to ground from JPC10-6 through the coil driver in the CM to B–PCF at JPC20-4, then through FU12 to B–PC at FU12 to B–PC at JPS14-1 and JPS14-2.
   b. With the Traverse B Proportional Solenoid (SOL34B) Valve coil driver energized, SOL34B has a path to ground from JPC10-8 through the coil driver in the CM, to B–PCF at JPC20-4,

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then through FU12 to B–PC at JPS14-1 and JPS14-2.

7. Hydraulic fluid is now able to flow through the Traverse A or B Proportional Solenoid Valves to the Traverse Hydraulic Motor, back through the Traverse A or B Proportional Solenoid Valves to the Reservoir.
8. As hydraulic fluid flows through SOL34A/B, Traverse Load Shuttle LS1 reacts to the pressure applied to the Traverse Motor. The highest pressure applied to LS1 is sent to Auxiliary Load Shuttle LS2. LS2 reacts to pressure from both the traverse system and the rotate/reach system. LS2 passes the highest pressure input to pilot B of the Logic Element.

   In this case, the pressure from the traverse system is the highest pressure input and is sent to pilot B of the Logic Element. The pressure at pilot B causes the Logic Element to close partially, limiting the flow to the Reservoir, and supplying more hydraulic fluid for the traverse function.
9. If the operator requests an increase in traverse speed, the CM detects the input voltage increase from VR4 and in turn increases the PWM control voltage to the Traverse A or B Proportional Solenoid Valve coil drivers. This further opens the Traverse A or B Proportional Solenoid Valves to permit more hydraulic fluid to flow to the Traverse Motor. Pressure at LS1 increases, which in turn increases the pressure at LS2, and finally at pilot input B on the Logic Element. The increase at pilot B causes the spool in the Logic Element to close more, further limiting the flow to the Reservoir, supplying more hydraulic fluid to the Traverse Motor.
10. As the Mini-Mast traverses to the right or left, the CM monitors the input voltage from the Traverse Position Potentiometer (VR5) at JPC12-1. The CM compares the voltage from VR5 to the learned traverse values to determine the position of the Mini-Mast to:
    - Determine appropriate decel points at the traverse travel extremes
    - Determine nested center
    - Send information to the Operator Display over BUS+/BUS–
    - Determine when to initiate the Reach function
    - Impose operational restrictions
    - Generate error codes.
11. The CM monitors both the input request voltage from the Traverse Control Potentiometer (VR4) and the feedback voltage from the Traverse Position Feedback Potentiometer (VR5). The speed of the traverse mechanism is based on these voltages. The Carriage Manager controls the opening and closing of the Traverse A or B Proportional Solenoid Valves (SOL34A/B).
12. When the following conditions are true, the CM initiates the reach function by supplying a PWM control voltage to the coil drivers for the Reach/Rotate Proportional Solenoid Valve (SOL33), the Fork Control A Solenoid Valve (SOL35A), and the Reach Select Solenoid Valve (SOL36). Coil drivers for the Reach/Rotate Proportional Solenoid Valve, Fork Control A Solenoid Valve, and Reach Select Solenoid Valve are internal to the CM.

    Conditions:
    - Traverse passes the midpoint of the carriage
    - The rotate mechanism is fully nested (clockwise or counterclockwise) as determined by the feedback voltage from the Rotate Position Feedback Potentiometer (VR6)
    - The fork tips are pointing in the direction of travel
13. With the Reach/Rotate Proportional Solenoid Valve coil driver energized, SOL33 has a path to ground from JPC26-4, through the coil driver in the CM to B–PCF at JPC20-4, then through FU12 to B–PCF at JPS14-1 and JPS14-2.

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14. With the Fork Control A Solenoid Valve coil driver energized, SOL35A has a path to ground from JPS10-4, through the coil driver in the CM to B–PCF at JPC20-4, then through FU12 to B–PCF at JPS14-1 and JPS14-2.
15. With the Reach Select Solenoid Valve coil driver energized, SOL36 has a path to ground from JPK3-1 and JPH1-2, through the coil driver in the CM to B–PCF at JPC20-4, then through FU12 to B– PCF at JPS14-1 and JPS14-2.
16. Hydraulic fluid flows through the Reach/Rotate Proportional Solenoid Valve (SOL33) and its internal pressure compensator, Fork Control A Solenoid Valve (SOL35A), and Reach Select Solenoid Valve (SOL36), permitting the forks to extend for load handling. Pressure on the reach line unseats the reach pilot check and permits hydraulic fluid to flow from the retract side of the Reach Cylinders through the check valve on the Reach Manifold, back through the Fork Control A Solenoid Valve to the Reservoir.
17. As pressure increases in the reach system, the Reach/Rotate Load Shuttle LS3 passes the highest pressure that it detects to the input of LS2. Auxiliary Load Shuttle LS2 now has pressure inputs from both LS1 and LS3. LS2 passes the highest pressure input to the Logic Element, which is then repositioned according to the pressure inputs at pilot A and pilot B. This process helps maintain a constant traverse and reach speed under changing pressure and flow requirements.
18. If the Mini-Mast is fully traversed to the left or right, with the forks rotated fully counterclockwise or clockwise and the forks extended, when traverse right or left is selected, the Reach/Rotate Proportional Solenoid Valve (SOL33), Reach Select Solenoid Valve (SOL36), and Fork Control B Solenoid Valve (SOL35B) are energized to retract the forks as the Mini-Mast begins to traverse in the opposite direction.

Rotate

With the Key Switch ON, both Deadman Pedals depressed (S2, S23, and S9 closed) and the forks detected fully retracted, moving the Rotate thumb control knob (VR3) on the left Control Handle clockwise (CW) or counterclockwise (CCW) causes the following to occur:

1. The Rotate Control Potentiometer (VR3) input voltage to the CM at JPC23-10 increases or decreases to a voltage higher or lower than its learned neutral position.
2. The CM, detecting this voltage change at JPC23-10, determines that a request for rotate right (higher voltage) or rotate left (lower voltage) has been made. It does this by comparing the input voltage to the learned voltage values for rotate CW, CCW, and neutral. The CM processes this voltage and sends a message to the TM/VFC over BUS+/BUS–.
3. The TM/VFC receives the message from the CM and sends an AUX ENABLE voltage at JPS4-5 to the Contactor Interface Module (CIM).
4. The AUX ENABLE voltage input to the Contactor Interface Module at JPCM1-2 enables the internal Auxiliary Contactor coil driver, which provides a path to ground for the Auxiliary Contactor coil from JPCM1-3, through JPM1-6, JPS4-6, and through FU12 to B-PC at JPS14-1 and JPS14-2.
5. With the Auxiliary Contactor coil energized, its closed tips supply B+ to operate the Auxiliary Motor and Pump. Hydraulic fluid is now applied, through the Mesh Screen Filter, to the normally closed Traverse A and B Proportional Solenoid Valves (SOL34A/B), the normally closed Reach/Rotate Proportional Solenoid Valve (SOL33), and to the Logic Element on the Auxiliary Manifold. The Logic Element is initially closed. As pressure increases at pilot input A, the spool moves, opening the valve and permitting the hydraulic fluid to return to the Reservoir.
6. At the same time that the TM/VFC is enabling the Auxiliary Contactor coil driver, the CM applies a PWM control

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voltage to the coil driver for either the Fork Control A Solenoid Valve (SOL35A) (CCW) or the Fork Control B Solenoid Valve (SOL35B) (CW), depending on the rotate direction requested. The CM also supplies a PWM control voltage to the coil driver for the Reach/Rotate Proportional Solenoid Valve (SOL33). The amount of PWM control voltage being applied to the SOL33 coil driver corresponds to the amount of input voltage (requested speed of rotation) to the CM from the Rotate Control Potentiometer (VR3). Coil drivers for the Fork Control A and B Solenoid Valves and the Reach/Rotate Proportional Solenoid Valve are internal to the CM.

a. With the Fork Control A Solenoid Valve coil driver energized (CCW rotation), SOL35A has a path to ground from JPC10-4, through the coil driver in the CM to B-PCF at JPC20-4, then through FU12 to B–PC at FU12, to B–PC at JPS14-1 and JPS14-2.

b. With the Fork Control B Solenoid Valve coil driver energized (CW rotation), SOL35B has a path to ground from JPC10-2, through the coil driver in the CM to B–PCF at JPC20-4, then through FU12 to B-PC at FU12, to B–PC at JPS14-1 and JPS14-2.

c. With the Reach/Rotate Proportional Solenoid Valve coil driver energized, SOL33 has a path to ground from JPC26-4, through the coil driver in the CM to B–PCF at JPC20-4, then through FU12 to B–PC at FU12, to B–PC at JPS14-1 and JPS14-2.

7. Hydraulic fluid is now able to flow through the Reach/Rotate Proportional Solenoid Valve and its internal pressure compensator, Fork Control A (CCW) or B (CW) Solenoid Valves, into the reach manifold at port IN2 (CW rotation) or port IN1 (CCW rotation), then through the de-energized Reach Select Solenoid Valve and Reach Manifold port ROT2 (CCW) or ROT1 (CW) to the Rotate Actuator.

8. Hydraulic pressure on the pressure side of the Rotate Actuator unseats the Crossover Check Valve on the return side, permitting fluid to flow from the Rotate Actuator through the return Crossover Check Valve, through the de-energized Reach Select Solenoid Valve and the port IN1 (CW) or IN2 (CCW) of the Reach Manifold, then through Fork Control B (CW) or A (CCW) Solenoid Valve to the Reservoir.

9. As hydraulic fluid flows through the Fork Control Solenoid Valve SOL35A/B, Reach/Rotate Load Shuttle LS3 reacts to the pressure applied to the Rotate Actuator. The highest pressure applied to LS3 is sent to the Auxiliary Load Shuttle LS2. LS2 reacts to pressure from both the traverse system and the reach/rotate system. LS2 passes the highest pressure input to pilot B of the Logic Element.

10. In this case, pressure from the rotate system is the highest pressure input and is sent to pilot input B of the Logic Element. The pressure at pilot B causes the Logic Element to close partially, limiting the flow to the Reservoir, supplying more hydraulic fluid for the rotate function.

11. If the operator requests an increase in rotate speed, the CM detects the input voltage increase from VR3 and in turn increases the PWM control voltage to the Reach/Rotate Proportional Solenoid Valve (SOL33) coil driver. This further opens the Reach/Rotate Proportional Solenoid Valve to permit more hydraulic fluid to flow to the Traverse Motor. The pressure at LS3 increases, which in turn increases the pressure at LS2, and finally at pilot input B on the Logic Element. The increase at pilot B causes the spool in the Logic Element to close more, further limiting the flow to the Reservoir, supplying more hydraulic fluid to the Rotate Actuator.

12. The pressure compensating valve portion of SOL33 moves in response to the pressures at the two pilot inputs and reduces pressure spikes to the Rotate Actuator under changing load conditions.

13. As the forks rotate, the CM monitors the input from the Rotate Position Feedback Potentiometer (VR6). The Rotate Position Feedback Potentiometer is connected to and powered by the Mini Height Manager,

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but the output voltage of VR6 is supplied directly to the CM at JPH1-3. The CM compares the voltage from VR6 to the learned rotate values to find the rotated position of the forks to:

- Determine appropriate decel points at the rotate travel extremes
- Send information to the Operator Display over BUS+/BUS–
- Determine if operation of the Reach function can be allowed
- Impose operational restrictions
- Generate error codes.

14. As the VR6 voltage approaches the learned value for the rotate stops, the CM gradually closes SOL33 to give a soft stop.
15. There are two Crossover Relief Valves installed in the Reach/Rotate Manifold. Their purpose is to equalize pressure spikes from either direction, CW or CCW, that can occur when the forks encounter sudden changes in resistance during operation.

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Pinout Matrix

The pinout matrix chart lists functions and normal voltages of terminals and harness connector pins. The matrix columns have the following meanings:

1. Item #: sequential number to aid in reference.
2. Connection: the actual wire numbers or component abbreviations on the electrical schematic.
3. Function Description: brief definition of the signal carried on the wire.
4. Theory of Operation:
   a. A detailed description of the signal carried on the wire. If the signal can be variable, it indicates the state of a related component that causes the signal to vary.
   b. Identifies possible causes for lack of correct signal.
5. Normal Level: the approximate voltage that you should see on that wire for the state indicated. Unless otherwise indicated, voltages are measured with respect to (wrt) B– at TP4.
6. Voltage Source: the device or connection that supplies the voltage directly to the wire.
7. Voltage User: the device or connection to which the wire directly delivers the voltage.

NOTE: Voltages are measured with respect to (wrt) TP6 (A-GND) on the Tractor Manager, unless otherwise noted.

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
1.	JP1-1	DA+	DA+ provides the operating voltage from the Main Height Manager to the Channel A detector in the Optical Head Sensor at JPN1-2.	Unblocked: Approx. +3.4VDC Blocked: Approx. +5VDC	Main Height Manager	Optical Head
2.	JP1-2	DA–	DA– is an input voltage to the Main Height Manager from the Channel A detector at JPN1-1. It is switched ON and OFF due to the infrared light from the Channel A emitter being interrupted by the passage of the Main Height Sensing Rail.	Unblocked: Approx. +1.5VDC Blocked: Approx. +0VDC	Optical Head	Main Height Manager
3.	JP1-3	EA–	EA– provides the return path for the current used to operate the Channel A emitter from the Main Height Manager through JPN2-3.	Approx. +2VDC	Optical Head	Main Height Manager
4.	JP1-4	EA+	EA+ provides the source path for the current used to operate the Channel A emitter from the Main Height Manager through JPN2-2.	Approx. +3VDC	Main Height Manager	Optical Head
5.	JP1-5	DB+	DB+ provides the operating voltage from the Main Height Manager to the Channel B detector in the Optical Head Sensor at JPN2-6.	Unblocked: Approx. +3.4VDC Blocked: Approx. +5VDC	Main Height Manager	Optical Head

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
6.	JP1-6	DB–	DB– is an input voltage to the Main Height Manager from the Channel B detector at JPN1-1. It is switched ON and OFF due to the infrared light from the Channel B emitter being interrupted by the passage of the Main Height Sensing Rail.	Unblocked: Approx. +1.5VDC Blocked: Approx. +0VDC	Optical Head	Main Height Manager
7.	JP1-7	EB–	EB– provides the return path for the current used to operate the Channel B emitter from the Main Height Manager through JPN1-3.	Approx. +2VDC	Optical Head	Main Height Manager
8.	JP1-8	EB+	EB+ provides the source path for the current used to operate the Channel B emitter from the Main Height Manager through JPN1-4.	Approx. +3VDC	Main Height Manager	Optical Head
9.	JP1-9	DC–	DC– is an input voltage to the Main Height Manager from the Channel C detector at JPN1-6. It is switched ON and OFF due to the infrared light from the Channel C emitter being interrupted by the passage of the Main Height Sensing Rail.	Unblocked: Approx. +1.5VDC Blocked: Approx. +0VDC	Optical Head	Main Height Manager
10.	JP1-10	DC+	DC+ provides the operating voltage from the Main Height Manager to the Channel C detector in the Optical Head Sensor at JPN1-5.	Unblocked: Approx. +3.4VDC Blocked: Approx. +5VDC	Main Height Manager	Optical Head
11.	JP1-11	EC–	EC– provides the return path for the current used to operate the Channel C emitter from the Main Height Manager through JPN2-5.	Approx. +2VDC	Optical Head	Main Height Manager
12.	JP1-12	EC+	EC+ provides the source path for the current used to operate the Channel C emitter to the Main Height Manager through JPN2-4.	Approx. +3VDC	Main Height Manager	Optical Head
13.	JP2-1	+12V_PROT	+12V_PROT (+12 Volts Protected) provides the working voltage for the Mini Height Proximity Sensor (HEIGHT PROX). It is supplied by the Carriage Manager via JPH1-9, JPK3-5, JP5-9, and through the Mini Height Manager. This voltage comes from the +12V output supplied by the Carriage Manager Power Supply and is present whenever the Key Switch (S1) is closed.	+10.8VDC to +13VDC	Carriage Manager	Mini Height Proximity Sensor (HEIGHT PROX)
14.	JP2-2	CHAN A	CHAN A is an input voltage to the Mini Height Manager from the Channel A sensor in the Mini Height Proximity Sensor (HEIGHT PROX). It is switched ON and OFF due to its passage over the Mini Height Sensing Rail. This input also causes a corresponding GREEN LED on the Mini Height Manager to turn ON and OFF.	Not over metal: >+ 7.0VDC Over Metal: <+ 1.7VDC	Mini Height Proximity Sensor (HEIGHT PROX)	Mini Height Manger

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
15.	JP2-3	CHAN B	CHAN B is an input voltage to the Mini Height Manager from the Channel B sensor in the Mini Height Proximity Sensor (HEIGHT PROX). It is switched ON and OFF due to its passage over the Mini Height Sensing Rail. This input also causes a corresponding GREEN LED on the Mini Height Manager to turn ON and OFF.	Not over metal: >+7.0VDC Over Metal: <+1.7VDC	Mini Height Proximity Sensor (HEIGHT PROX)	Mini Height Manager
16.	JP2-4	CHAN C	CHAN C is an input voltage to the Mini Height Manager from the Channel C sensor in the Mini Height Proximity Sensor (HEIGHT PROX). It is switched ON and OFF due to its passage over the Mini Height Sensing Rail. This input also causes a corresponding GREEN LED on the Mini Height Manager to turn ON and OFF.	Not over metal: >+7.0VDC Over Metal: <+1.7VDC	Mini Height Proximity Sensor (HEIGHT PROX)	Mini Height Manager
17.	JP2-6	DGND	DGND (Digital Ground) is the negative reference (B–) for the keypad switches. DGND is supplied from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND. B– supply to switches on the Key Pad.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for <+0.5VDC wrt TP4 (B– tie point).	Carriage Manager	Operator Display Interface Card
18.	JP2-1	SD1	SD1 is the UP button on the keypad switch assembly. It is switched to DGND when S100 is depressed, causing the Operator Display to scroll upwards.	SD1 depressed: < +1VDC SD1 not depressed: +4VDC	Up Switch (S100)	Operator Display Interface Card
19.	JP2-2	SD2	SD2 is the DOWN button on the keypad switch assembly. It is switched to DGND when S101 is depressed, causing the Operator Display to scroll downwards.	SD2 depressed: < +1VDC SD2 not depressed: +4VDC	Down Switch (S101)	Operator Display Interface Card
20.	JP2-3	SD3	SD3 is the RIGHT button on the keypad switch assembly. It is switched to DGND when S102 is depressed, causing the Operator Display to scroll to the right.	SD3 depressed: < +1VDC SD3 not depressed: +4VDC	Right Switch (S102)	Operator Display Interface Card
21.	JP2-4	SD4	SD4 is the LEFT button on the keypad switch assembly. It is switched to DGND when S103 is depressed, causing the Operator Display to scroll to the left.	SD4 depressed: < +1VDC SD4 not depressed: +4VDC	Left Switch (S103)	Operator Display Interface Card

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
22.	JP2-5	SD5	SD5 is the ENTER button on the keypad switch assembly. It is switched to DGND when S104 is depressed to activate the selected choice on the Operator Display menu.	SD5 depressed: < +1VDC SD5 not depressed: +4VDC	Enter Switch (S104)	Operator Display Interface Card
23.	JP3-1	+12V_PROT	+12V_PROT (+12 Volts Protected) provides the working voltage for the Reach Position Proximity Sensor (PROX2). It is supplied by the Carriage Manager via JPH1-9, JPK3-5, JP5-9, and through the Mini Height Manager. This voltage comes from the +12V output supplied by the Carriage Manager Power Supply and is present whenever the Key Switch (S1) is closed.	+10.8VDC to +13VDC	Carriage Manager	Reach Position Proximity Sensor (PROX2)
24.	JP3-2	PROX OUT	PROX OUT is an output voltage from the Mini Height Manager to the Reach Position Proximity Sensor (PROX2). This information is communicated to the Carriage Manager, which uses it to determine whether the forks are reached or nested.	Forks nested: <+1VDC Forks unnested: >+4VDC	Reach Position Proximity Sensor (PROX2)	Mini Height Manager
25.	JP3-3	DGND	DGND (Digital Ground) is the B– (ground) for the Reach Position Proximity Sensor (PROX2). DGND is supplied via JPH1-5 and 8, JPK3-5 and 4 through the Mini Height Manager from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND, then through the Carriage Manager to JPC17-6, over-the-mast cables to the Tractor Manager, through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for <+0.5VDC wrt TP4 (B– tie point).		
26.	JP4-1	+5	+5 comes to the Mini Height Manager from the +12V_PROT generated by the Carriage Manager Power Supply. It supplies the working voltage to the Rotate Position Feedback Potentiometer (VR6).	4.5VDC to 5.8VDC	Mini Height Manager	Rotate Position Feedback Potentiometer (VR6)
27.	JP4-2	ROTATE POS	ROTATE POS is an analog voltage input to the Carriage Manager from the Rotate Position Feedback Potentiometer (VR6) directly through the Mini Height Manager. The Carriage Manager uses this voltage to determine the rotated position of the forks and the rate at which they are moving during Learn.	Nested full right: Approx. +3.9VDC Centered: Approx. +2.4VDC Nested full left: Approx. +1.1VDC	Rotate Position Feedback Potentiometer (VR6)	Carriage Manager

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
28.	JP4-3	DGND	DGND (Digital Ground) is the B– (ground) for the Rotate Position Feedback Potentiometer (VR6). DGND is supplied via JPH1-5 and 8, JPK3-5 and 4 through the Mini Height Manager from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND, then through the Carriage Manager to JPC17-6, over-the-mast cables to the Tractor Manager, through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for <+0.5VDC wrt TP4 (B– tie point).	Carriage Manager	Rotate Position Feedback Potentiometer (VR6)
29.	JP4-4		Not connected			
30.	JP4-5	CONFIG1	CONFIG1 is a wiring harness jumper to DGND at JP4-6. With this jumper in place, the Carriage Manager is able to determine that communication from this location is coming from the Mini Height Manager.	Check for wiring harness continuity to JP4-6	Mini Height Manager	Carriage Manager
31.	JP4-6	CONFIG2	CONFIG2 is a wiring harness jumper from DGND to JP4-5. With this jumper in place, the Carriage Manager is able to determine that communication from this location is coming from the Mini Height Manager.	Check for wiring harness continuity to JP4-5	Mini Height Manager	Carriage Manager
32.	JP4-1	H2-1	H2-1 (JD1-1) is the positive voltage source for the PIEZO SOUNDER.	1.8VDC horn activated wrt H2-1	Operator Display Interface Card	PIEZO SOUNDER
33.	JP4-2	H2-2	H2-2 (JD1-2) is the negative reference (ground) for the PIEZO SOUNDER.	1.8VDC horn activated wrt H2-1	Operator Display Interface Card	PIEZO SOUNDER
34.	JP5-1	CAN LOAD 2	CAN LOAD 2 connects a resistor internal to the Height Manager from BUS+ to BUS– via a jumper in the wiring harness to JP5-10 (CAN LOAD 1). This resistor correctly terminates the tractor end of the communications bus on SA main HM only.	Check for continuity to JP5-10	Main Height Manager	Main Height Manager
35.	JP5-2	N/C	Not connected			
36.	JP5-3	ROTATE POS	ROTATE POS is an analog voltage input to the Carriage Manager from the Rotate Position Feedback Potentiometer (VR6) directly through the Mini Height Manager. The Carriage Manager uses this voltage to determine the rotated position of the forks and the rate at which they are moving during Learn.	Nested full right: Approx. +3.9VDC Centered: Approx. +2.4VDC Nested full left: Approx. +1.1VDC	Rotate Position Feedback Potentiometer (VR6)	Carriage Manager

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
37.	JP5-4	N/C	Not connected			
38.	JP5-5	DGND	DGND (Digital Ground) is the B– (ground) for the Height Manager.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for <+0.5VDC wrt TP4 (B– tie point).	Carriage Manager	Mini Height Manager, Rotate Position Feedback Potentiometer (VR6), and the Reach Position Proximity Sensor (PROX2)
39.	JP5-6	BUS+	This wire carries the positive component of the digital communications between the Height Manager and the other managers on the communications bus. Measuring voltage on this wire provides no usable information.	Not usable	All Managers on the BUS	All Managers on the BUS
40.	JP5-7	BUS–	This wire carries the negative component of the digital communications between the Height Manager and the other managers on the communications bus. Measuring voltage on this wire provides no usable information.	Not usable	All Managers on the BUS	All Managers on the BUS
41.	JP5-8	DGND	DGND (Digital Ground) is the B– (ground) the Mini Height Manager.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for <+0.5VDC wrt TP4 (B– tie point).	Carriage Manager	Mini Height Manager, Rotate Position Feedback Potentiometer (VR6) and the Reach Position Proximity Sensor (PROX2)
42.	JP5-9	+12V_PROT	+12V_PROT is supplied to the circuitry on the Height Manager from the 12 volt power supply on the Manager.	+10.8VDC to +13VDC	Tractor Manager	Main Height Manager
43.	JP5-10	CAN LOAD 1	CAN LOAD 1 connects a resistor internal to the Height Manager from BUS+ to BUS– via a jumper in the wiring harness to JP5-1 (CAN LOAD 2). This resistor correctly terminates the tractor end of the communications bus on SA main HM only.	Check for continuity to JP5-1.	Main Height Manager	Main Height Manager
44.	JPA2-1	N/C	Not connected			
45.	JPA2-2	N/C	Not connected			
46.	JPA2-3	N/C	Not connected			

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
47.	JPA2-4	N/C	Not connected			
48.	JPA2-5	DGND	DGND (Digital Ground) is the B– (ground) for the Electric Steer Manager. DGND is tied common to AGND through a molded cable assembly to JPS17-5, through the Tractor Manager, Fuse FU13, JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for <+0.5VDC wrt TP4 (B– tie point).	Tractor Manager	Electric Steer Manager
49.	JPA2-6	BUS+	This wire carries the positive component of the digital communications between the Electric Steer Manager and the other managers on the communications bus. Measuring voltage on this wire provides no usable information.	Not usable	All Managers on the BUS	All Managers on the BUS
50.	JPA2-7	BUS–	This wire carries the negative component of the digital communications between the Electric Steer Manager and the other managers on the communications bus. Measuring voltage on this wire provides no usable information.	Not usable	All Managers on the BUS	All Managers on the BUS
51.	JPA2-8	N/C	Not connected. Not used on this truck			
52.	JPA2-9	+12VF	+12VF is the working voltage for the Electric Steer Manager. It is supplied through a molded cable assembly to JPS17-5 from the 12 volt power supply on the Tractor Manager via Fuse FU17. This voltage is present when the Key Switch (S1) is closed.	+10.8VDC to +13VDC	Tractor Manager	Electric Steer Manager
53.	JPA5-1	+12VF	+12VF is the working voltage for the Main Pressure Transducer (PRESS MAIN). It is supplied through the Electric Steer Manager and JPY5-1 from the 12 volt power supply on the Tractor Manager via Fuse FU17. This voltage is present when the Key Switch (S1) is closed.	+10.8VDC to +13VDC	ESM/TM	Pressure Transducer A
54.	JPA5-2	P/T_A	P/T_A is an input voltage to the Electric Steer Manager via JPY5-2. This voltage varies directly with the weight on the forks and carriage platform when elevated. This information is communicated by the Electric Steer Manager to the Carriage Manager, which calculates the weight.	Approx. +1VDC with carriage platform fully lowered. Approx. 1 VDC increase per 1000 lbs. (454 kg)	Pressure Transducer A	Electric Steer Manager

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
55.	JPA5-3	AGND	AGND (Analog Ground) is supplied as the negative reference (B–) through the Electric Steer Manager and JPY5-3 for the Main Pressure Transducer (PRESS MAIN). It is connected on the Tractor Manager through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for <+0.5VDC wrt TP4 (B– tie point).	ESM/TM	Pressure Transducer A
56.	JPA5-4	AGND	No harness wiring connection. Not used on this truck.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for <+0.5VDC wrt TP4 (B– tie point).		
57.	JPA6-1	+12VF	+12VF is the working voltage for the Mini Pressure Transducer (PRESS MINI). It is supplied through the Electric Steer Manager and JPY6-1 from the 12 volt power supply on the Tractor Manager via Fuse FU17. This voltage is present when the Key Switch (S1) is closed.	+10.8VDC to +13VDC	ESM/TM	Pressure Transducer B
58.	JPA6-2	P/T_B	P/T_B is an input voltage to the Electric Steer Manager via JPY6-2. This voltage varies directly with the weight on the forks when elevated. This information is communicated by the Electric Steer Manager to the Carriage Manager, which calculates the weight for use in determining any speed management requirements, messages and/or codes.	Approx. +1VDC with carriage platform fully lowered Approx. 1 VDC increase per 1000 lbs (454 kg)	Pressure Transducer B	ESM
59.	JPA6-3	AGND	AGND (Analog Ground) is supplied as the negative reference (B–) through the Electric Steer Manager and JPY6-3 for the Mini Pressure Transducer (PRESS MINI). It is connected on the Tractor Manager through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for <+0.5VDC wrt TP4 (B– tie point).	ESM/TM	Pressure Transducer B

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
60.	JPA6-4	AGND	No harness wiring connection. Not used on this truck.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for <+0.5VDC wrt TP4 (B– tie point).		
61.	JPA7-1	HOME SENSE	HOMESENSE is an input voltage to the Electric Steer Manager from the Home Proximity Sensor (HOME SENSOR PROX). The Electric Steer Manager uses this voltage to determine when the Drive Unit is physically centered. The Electric Steer Manager resets the Steer Position Feedback Encoder count whenever this voltage indicates the Drive Unit centered position has been detected.	Not over metal: >+7VDC Over metal: <+ 2VDC	Steering Home Proximity Sensor (HOME SENSOR PROX)	Electric Steer Manager
62.	JPA7-2	AGND	AGND (Analog Ground) is the B– (ground) for the Steering Home Proximity Sensor (HOME SENSOR PROX). AGND is supplied through the Electric Steer Manager to JPA2-5, then through a molded cable assembly to JPS17-5, through the Tractor Manager, Fuse FU13, JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1 (B+) to verify connections. Then check for <+0.5VDC wrt TP4 (B– tie point).	Tractor Manager	Steering Home Proximity Sensor (HOME SENSOR PROX)
63.	JPA7-3	+12VF	+12VF is the working voltage for the Steering Home Proximity Sensor (HOME SENSOR PROX). It is supplied through the Electric Steer Manager to JPA2-9, then through a molded cable assembly to JPS17-9 from the 12 volt power supply on the Tractor Manager via fuse FU17. This voltage is present when the Key Switch (S1) is closed.	+10.8VDC to +13VDC	Tractor Manager	Steering Home Proximity Sensor (HOME SENSOR PROX)
64.	JPA8-1	STEER A	STEER A is a square wave voltage input to the Electric Steer Manager from the Steer Position Feedback Encoder. It has a 50% duty cycle and its frequency is directly proportional to the speed that the Drive Unit is being rotated. STEER A is identical to STEER B but they are 90 degrees out of phase with each other. The Electric Steer Manager uses the phase differential to determine the direction of Drive Unit rotation and uses the frequency to determine the speed at which the Drive Unit is rotating.	Voltage should vary between approx. > +3VDC to < +1VDC as encoder shaft is rotated slowly.	Steer Position Feedback Encoder	Electric Steer Manager

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
65.	JPA8-2	DGND	DGND (Digital Ground) is the B– (ground) for the Steer Position Feedback Encoder. DGND is supplied through the Electric Steer Manager to JPA2-5, where it is tied common to AGND, then through a molded cable assembly to JPS17-5, through the Tractor Manager, Fuse FU13, JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for <+0.5VDC wrt TP4 (B– tie point).	Tractor Manager	Steer Position Feedback Encoder
66.	JPA8-3	+5.3V	+5.3V provides the working voltage for the Steer Position Feedback Encoder. This voltage is generated on the Electric Steer Manager and comes from +12VF at JPA2-9 from the Tractor Manager via Fuse FU17. This voltage is present, lighting a green LED (IL1) on the Tractor Manager when the Key Switch (S1) is closed.	4.5VDC to 5.8VDC	Electric Steer Manager	Steer Position Feedback Encoder
67.	JPA8-4	STEER B	STEER B is a square wave voltage input to the Electric Steer Manager from the Steer Position Feedback Encoder. It has a 50% duty cycle and its frequency is directly proportional to the speed that the Drive Unit is being rotated. STEER B is identical to STEER A but they are 90 degrees out of phase with each other. The Electric Steer Manager uses the phase differential to determine the direction of Drive Unit rotation and uses the frequency to determine the speed at which the Drive Unit is rotating.	Voltage should vary between approx. > +3VDC to < +1VDC as encoder shaft is rotated slowly.	Steer Position Feedback Encoder	Electric Steer Manager
68.	JPA8-5	DGND	DGND (Digital Ground) is the negative reference (B–) for the shield around the cable to the Steer Position Feedback Encoder. The shield shunts currents generated by electrical noise and other undesirable sources to ground, thereby preventing them from interfering with the internal cable wiring. DGND is supplied through the Electric Steer Manager to JPA2-5, where it is tied common to AGND, then through a molded cable assembly to JPS17-5, through the Tractor Manager, Fuse FU13, JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for <+0.5VDC wrt TP4 (B– tie point).	Tractor Manager	Steer Position Feedback Encoder cable
69.	JPC7-1	+12V_PROT	+12V_PROT (+12 Volts Protected) provides the working voltage to operate the Main Height Manager. This voltage comes from the +12V output supplied by the Carriage Manager Power Supply and is present whenever the Key Switch (S1) is closed.	+10.8VDC to +13VDC	Carriage Manager	Main Height Manager

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
70.	JPC7-2	BUS+	This wire carries the positive component of the digital communications between the Main Height Manager and the other managers on the communications bus. Measuring voltage on this wire provides no usable information.	Not usable	All Managers on the BUS	All Managers on the BUS
71.	JPC7-3	BUS–	This wire carries the negative component of the digital communications between the Main Height Manager and the other managers on the communications bus. Measuring voltage on this wire provides no usable information.	Not usable	All Managers on the BUS	All Managers on the BUS
72.	JPC7-4	DGND	DGND (Digital Ground) is the B– (ground) for the Main Height Manager. DGND is supplied from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND, then through the Carriage Manager to JPC17-6, over-the-mast cables to the Tractor Manager, through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for <+0.5VDC wrt TP4 B– tie point).	Carriage Manager	Main Height Manager
73.	JPC7-5	N/C	Not connected			
74.	JPC8-1	+12V_PROT	+12V_PROT (+12 Volts Protected) provides the working voltage to operate the LED's on the Supplemental Operator Display (SOD). This voltage comes from the +12V output supplied by the Carriage Manager Power Supply and is present whenever the Key Switch (S1) is closed.	+10.8VDC to +13VDC	Carriage Manager	Supplemental Operator Display
75.	JPC8-2	W1	W1 provides the return path to the Carriage Manager for the voltage used to operate the top green LED of the guide wire/rail icon. The 3 green LEDs (W1, W2, and W3) that make up the guide wire/rail icon are OFF when the AUTO/MAN Switch (S4) is in the MAN position. They flash if a guide wire is sensed when (S4) is in the AUTO position. They stay lit when the truck is determined to be locked on the guide wire.	Approx. 0.6 to 1VDC less in the ON (lit) state than when in the OFF (dark) state	Supplemental Operator Display	Carriage Manager

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
76.	JPC8-3	W2	W2 provides the return path to the Carriage Manager for the voltage used to operate the center green LED of the guide wire/rail icon. The 3 green LEDs (W1, W2, and W3) that make up the guide wire/rail icon are OFF when the AUTO/MAN Switch (S4) is in the MAN position. They flash if a guide wire is sensed when (S4) is in the AUTO position. They stay lit when the truck is determined to be locked on the guide wire.	Approx. 0.6 to 1VDC less in the ON (lit) state than when in the OFF (dark) state	Supplemental Operator Display	Carriage Manager
77.	JPC8-4	W3	W3 provides the return path to the Carriage Manager for the voltage used to operate the bottom green LED of the guide wire/rail icon. The 3 green LEDs (W1, W2, and W3) that make up the guide wire/rail icon are OFF when the AUTO/MAN Switch (S4) is in the MAN position. They flash if a guide wire is sensed when (S4) is in the AUTO position. They stay lit when the truck is determined to be locked on the guide wire.	Approx. 0.6 to 1VDC less in the ON (lit) state than when in the OFF (dark) state	Supplemental Operator Display	Carriage Manager
78.	JPC8-5	L1	L1 provides the return path to the Carriage Manager for the voltage used to operate the right yellow LED of the triangular seeking wire/rail icon. L1 and L2 LEDs making up the two triangular seeking wire/rail icon are OFF when the AUTO/MAN Switch (S4) is in the MAN position. They flash if no guide wire or rail is detected and S4 is in the AUTO position. They stay lit when the truck is determined to be locked on the guide wire.	Approx. 0.6 to 1VDC less in the ON (lit) state than when in the OFF (dark) state	Supplemental Operator Display	Carriage Manager
79.	JPC8-6	L2	L2 provides the return path to the Carriage Manager for the voltage used to operate the right yellow LED of the triangular seeking wire/rail icon. L1 and L2 LED's making up the two triangular seeking wire/rail icon are OFF when the AUTO/MAN Switch (S4) is in the MAN position. They flash if no guide wire or rail is detected and S4 is in the AUTO position. They stay lit when the truck is determined to be locked on the guide wire.	Approx. 0.6 to 1VDC less in the ON (lit) state than when in the OFF (dark) state	Supplemental Operator Display	Carriage Manager
80.	JPC8-7	S1	S1 provides the return path to the Carriage Manager for the voltage used to operate the second left of center red LED of the drive wheel direction icon on the Supplemental Operator Display.	Approx. 0.6 to 1VDC less in the ON (lit) state than when in the OFF (dark) state	Supplemental Operator Display	Carriage Manager

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
81.	JPC8-8	S2	S2 provides the return path to the Carriage Manager for the voltage used to operate the first left of center yellow LED of the drive wheel direction icon on the Supplemental Operator Display.	Approx. 0.6 to 1VDC less in the ON (lit) state than when in the OFF (dark) state	Supplemental Operator Display	Carriage Manager
82.	JPC8-9	S3	S3 provides the return path to the Carriage Manager for the voltage used to operate the centered green LED of the drive wheel direction icon on the Supplemental Operator Display.	Approx. 0.6 to 1VDC less in the ON (lit) state than when in the OFF (dark) state	Supplemental Operator Display	Carriage Manager
83.	JPC8-10	S4	S4 provides the return path to the Carriage Manager for the voltage used to operate the first right of center yellow LED of the drive wheel direction icon on the Supplemental Operator Display.	Approx. 0.6 to 1VDC less in the ON (lit) state than when in the OFF (dark) state	Supplemental Operator Display	Carriage Manager
84.	JPC8-11	S5	S5 provides the return path to the Carriage Manager for the voltage used to operate the second right of center red LED of the drive wheel direction icon on the Supplemental Operator Display.	Approx. 0.6 to 1VDC less in the ON (lit) state than when in the OFF (dark) state	Supplemental Operator Display	
85.	JPC8-12	N1	N1 provides the return path to the Carriage Manager for the voltage used to operate the red LED of the forks nested icon. This LED is ON when the traverse and rotate mechanisms are in their fully nested positions and is OFF when either mechanism is not fully nested.	Approx. 0.6 to 1VDC less in the ON (lit) state than when in the OFF (dark) state	Supplemental Operator Display	Carriage Manager
86.	JPC8-14	DGND	DGND (Digital Ground) is the negative reference (B–) for the shield around the cable to the Supplemental Operator Display (SOD). The shield shunts currents generated by electrical noise and other undesirable sources to ground, thereby preventing them from interfering with the internal cable wiring. DGND is supplied from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for <+0.5VDC wrt TP4 (B– tie point).	Carriage Manager	Supplemental Operator Display
87.	JPC9-1	N/C	Not connected			
88.	JPC9-2	PRXD	Not used on this truck.	Not usable		
89.	JPC9-3	PTXD	Not used on this truck.	Not usable		

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
90.	JPC9-4	N/C	Not connected			
91.	JPC9-5	DGND	DGND (Digital Ground) is the B– (ground) for the circuits in the SMART*i*® module. DGND is supplied from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND, then through the Carriage Manager to JPC17-6, over-the-mast cables to the Tractor Manager, through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for <+0.5VDC wrt TP4 (B– tie point).	Carriage Manager	SMART*i* Module
92.	JPC9-6	BUS+	This wire carries the positive component of the digital communications between DTIC and the other managers on the communications bus. Measuring voltage on this wire provides no usable information.	Not usable	All Managers on the BUS	All Managers on the BUS
93.	JPC9-7	BUS–	This wire carries the negative component of the digital communications between DTIC and the other managers on the communications bus. Measuring voltage on this wire provides no usable information.	Not usable	All Managers on the BUS	All Managers on the BUS
94.	JPC9-8	DGND	DGND (Digital Ground) is the B– (ground) for the circuits in the SMART*i* module. DGND is supplied from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND, then through the Carriage Manager to JPC17-6, over-the-mast cables to the Tractor Manager, through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for <+0.5VDC wrt TP4 (B– tie point).	Carriage Manager	SMART*i* Module
95.	JPC9-9	+12V_PROT	+12V_PROT (+12 Volts Protected) provides the working voltage to operate the SMART*i* module. This voltage comes from the +12V output supplied by the Carriage Manager Power Supply.	10.5 to 13VDC	Carriage Manager	SMART*i* Module
96.	JPC10-1	B+ESTOP	B+ESTOP is B+ supplied through the normally closed EPO Switch (S21) when the Key Switch (S1) is closed, through the Carriage Manager, to power the Fork Control Solenoid Valve coil (SOL35B). It also provides a return path for the suppressor to this coil.	B+	EPO Switch (S21)	Fork Control Solenoid Valve (SOL35B)

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
97.	JPC10-2	ROTATE B	ROTATE B is the output of the Fork Control Solenoid Valve Coil Driver (SOL35B) in the Carriage Manager. It provides the negative path to complete the circuit to energize the SOL35B coil through the Fork Control Solenoid Valve Coil Driver to B– (ground) and light the red LED (IL6) on the Carriage Manager when the Rotate Command Potentiometer (VR3) is rotated (CCW) from its learned neutral position or a Retract function is requested.	Deenergized: B+ Energized: Approx. +24VDC	Carriage Manager	Fork Control Solenoid Valve (SOL35B)
98.	JPC10-3	B+ESTOP	B+ESTOP is B+ supplied through the normally closed EPO Switch (S21) when the Key Switch (S1) is closed, through the Carriage Manager, to power the Fork Control Solenoid Valve coil (SOL35A). It also provides a return path for the suppressor to this coil.	B+	EPO Switch (S21)	Fork Control Solenoid Valve (SOL35A)
99.	JPC10-4	ROTATE A	ROTATE A is the output of the Fork Control Solenoid Valve Coil Driver (SOL35A) in the Carriage Manager. It provides the negative path to complete the circuit to energize the SOL35A coil through the Fork Control Solenoid Valve Coil Driver to B– (ground) and light the red LED (IL5) on the Carriage Manager when the Rotate Command Potentiometer (VR3) is rotated (CW) from its learned neutral position or a Reach function is requested.	Deenergized: B+ Energized: Approx. +24VDC	Carriage Manager	Fork Control Solenoid Valve (SOL35A)
100.	JPC10-5	B+ESTOP	B+ESTOP is B+ supplied through the normally closed EPO Switch (S21) when the Key Switch (S1) is closed, through the Carriage Manager, to power the Traverse Proportional Solenoid Valve coil (SOL34A). It also provides a return path for the suppressor to this coil.	B+	EPO Switch (S21)	Traverse Proportional Solenoid Valve (SOL34A)
101.	JPC10-6	TRAVERSE A	TRAVERSE A is the output of the Proportional Traverse Solenoid Valve Coil Driver (SOL34A) in the Carriage Manager. It provides the negative path to complete the circuit to energize the SOL34A coil through the Proportional Traverse Solenoid Valve Coil Driver to B– (ground) on the Carriage Manager when the Traverse Command Potentiometer (VR4) is rotated (CW) from its learned neutral position.	Creep right: Approx. +35VDC Full right: Approx. +24VDC	Carriage Manager	Traverse Proportional Solenoid Valve (SOL34A)

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
102.	JPC10-7	B+ESTOP	B+ESTOP is B+ supplied through the normally closed EPO Switch (S21) when the Key Switch (S1) is closed, through the Carriage Manager, to power the Traverse Proportional Solenoid Valve coil (SOL34B). It also provides a return path for the suppressor to this coil.	B+	EPO Switch (S21)	Traverse Proportional Solenoid Valve (SOL34B)
103.	JPC10-8	TRAVERSE B	TRAVERSE B is the output of the Proportional Traverse Solenoid Valve Coil Driver (SOL34B) in the Carriage Manager. It provides the negative path to complete the circuit to energize the SOL34B coil through the Proportional Traverse Solenoid Valve Coil Driver to B– (ground) on the Carriage Manager when the Traverse Command Potentiometer (VR4) is rotated (CCW) from its learned neutral position.	Creep left: Approx. +32VDC Full left: Approx. +24VDC	Carriage Manager	Traverse Proportional Solenoid Valve (SOL34A)
104.	JPC12-1	TRAVERSE POSITION	TRAVERSE POSITION is an analog voltage input to the Carriage Manager from the Traverse Position Feedback Potentiometer (VR5) via JPK-2. The Carriage Manager uses this voltage to determine the position of the traverse assembly and the rate at which it is moving during Learn.	Nested full right: Approx. +9.7VDC Centered: Approx. +6.2VDC Nested full left: Approx. +2.8VDC	Traverse Position Feedback Potentiometer (VR5)	Carriage Manager
105.	JPC12-2	+12V_POT	+12_POT comes from the +12V output supplied by the Carriage Manager Power Supply and is present whenever the Key Switch (S1) is closed. There is no wiring connection to this point. Not used on this truck.	+10.8VDC to +13VDC	Carriage Manager	
106.	JPC12-3	MINI LIFT REF	No wiring connection to this point. Not used on this truck.			
107.	JPC12-5	+5V_POT	+5_POT comes from the +12V generated by the Carriage Manager Power Supply. There is no wiring connection to this point. Not used on this truck.	4.5VDC to 5.8 VDC	Carriage Manager	
108.	JPC12-6	DGND	DGND (Digital Ground) is B– (ground) supplied from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND, then through the Carriage Manager to JPC17-6, over-the-mast cables to the Tractor Manager, through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment. There is no wiring connection to this point. Not used on this truck.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Carriage Manager	

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
109.	JPC12-7	+12V_POT	+12_POT provides the working voltage to operate the Traverse Position Feedback Potentiometer (VR5). This voltage comes from the +12V output supplied by the Carriage Manager Power Supply and is present whenever the Key Switch (S1) is closed.	+10.8VDC to +13VDC	Carriage Manager	Traverse Position Feedback Potentiometer (VR5)
110.	JPC12-8	DGND	DGND (Digital Ground) is the B– (ground) for the Traverse Position Feedback Potentiometer (VR5) via JPK2-3 from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND, then through the Carriage Manager to JPC17-6, over-the-mast cables to the Tractor Manager, through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Carriage Manager	Traverse Position Feedback Potentiometer (VR5)
111.	JPC12-9	N/C	Not connected			
112.	JPC15-1	B+F	B+F is the B+ supply to the Key Switch (S1) and is present when the battery is plugged in. It is fused by FU14 and supplied through the Tractor Manager, JP61, line filter, over-the-mast cables, and Carriage Manager to the Key Switch.	B+	Carriage Manager and Tractor Manager	Key Switch (S1)
113.	JPC15-2	DGND	Not used on this truck.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).		
114.	JPC15-3	B+ESTOP	B+ESTOP originates at this point. It is B+ provided through the normally closed EPO Switch (S21) when the Key Switch (S1) is closed. B+ESTOP goes to all Carriage Manager B+ESTOP connections, over-the-mast cables, line filter, and through the Tractor Manager, where it is distributed to all the other B+ESTOP connections on the Tractor Manager.	B+	EPO Switch (S21)	Carriage Manager and Tractor Manager

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
115.	JPC15-4	B+KEY	B+KEY is B+ provided to the Carriage Manager Power Supply and all other B+KEY connections on the Carriage Manager when the Key Switch (S1) is closed. It is also supplied through the Carriage Manager, over-the-mast cables, line filter, JP61, and the Tractor Manager. B+KEY is distributed to all the other B+KEY connections on the Tractor Manager.	B+	Key Switch (S1)	Carriage Manager and Tractor Manager
116.	JPC16-1	ENCODER VCC	ENCODER VCC is a voltage derived from the +12V provided by the Carriage Manager Power Supply. It supplies the working voltage to the Steer Encoder circuitry. This voltage is monitored by the Carriage Manager and used to verify that the Steer Encoder circuits are connected at JPC16.	+4.75VDC to +5.75VDC with Key Switch (S1) closed	Carriage Manager	Steer Encoder
117.	JPC16-2	DGND	DGND (Digital Ground) is the negative reference (B–) for the Steer Encoder. DGND is supplied from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Carriage Manager	Steer Encoder
118.	JPC16-3	CHB	CHB is a square wave voltage input to the Carriage Manager. It has a 50% duty cycle. Its frequency is directly proportional to the speed that the Steering Tiller rotates. CHB is identical to CHA but 90 degrees out of phase. The Carriage Manager uses the phase differential to determine the requested steering direction and uses the frequency to determine the speed at which the Steer Motor is commanded to operate.	0VDC to +5.75VDC depending on speed of tiller rotation	Steer Encoder	Carriage Manager
119.	JPC16-4	CHA	CHA is a square wave voltage input to the Carriage Manager. It has a 50% duty cycle. Its frequency is directly proportional to the speed that the Steering Tiller rotates. CHA is identical to CHB but 90 degrees out of phase. The Carriage Manager uses the phase differential to determine the requested steering direction and uses the frequency to determine the speed at which the Steer Motor is commanded to operate.	0VDC to +5.75VDC depending on speed of tiller rotation	Steer Encoder	Carriage Manager
120.	JPC16-5	N/C	Not connected			
121.	JPC16-6	N/C	Not connected			
122.	JPC16-7	N/C	Not connected			

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
123.	JPC16-8	N/C	Not connected			
124.	JPC16-9	N/C	Not connected			
125.	JPC16-10	DGND	DGND (Digital Ground) is the negative reference (B–) for the shield around the cable to the Steer Encoder. The shield shunts currents generated by electrical noise and other undesirable sources to ground, thereby preventing them from interfering with the internal cable wiring. DGND is supplied from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Carriage Manager	Steer Encoder
126.	JPC17-1	N/C	Not connected			
127.	JPC17-2	BUS–	This wire carries the negative component of the digital communications between the Carriage Manager and the managers on the tractor side of the communications bus. Measuring voltage on this wire provides no usable information.	Not usable	All Managers on the BUS	All Managers on the BUS
128.	JPC17-3	BUS+	This wire carries the positive component of the digital communications between the Carriage Manager and the managers on the tractor side of the communications bus. Measuring voltage on this wire provides no usable information.	Not usable	All Managers on the BUS	All Managers on the BUS
129.	JPC17-4	BRAKE CONTROL	BRAKE CONTROL is an output voltage from the Tractor Manager sent over a mast cable to the Carriage Manager. It indicates the status of the Brake Deadman Switch (S2), which pulls the voltage low when closed. This change is seen on the Tractor Manager and the VFC communicates back to the Carriage Manager that it has received this input. The VFC and Carriage Manager both use this information, in conjunction with a travel request, to release the brake. Either causes the brake to apply when it detects a fault, regardless of the position of the deadman switches.	Deadman UP (Switch S2 open): > +9.5VDC Deadman DOWN (Switch S2 closed): < +1VDC	Carriage Manager	TM/VFC

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
130.	JPC17-5	CARRIAGE DEADMAN	CARRIAGE DEADMAN is an output voltage from the Tractor Manager sent over a mast cable to the Carriage Manager. It indicates the status of the Carriage Deadman switch (S23), which pulls the voltage low when closed. This change is seen on the Tractor Manager and the VFC communicates back to the Carriage Manager that it has received this input. The VFC and Carriage Manager both use this information, in conjunction with a travel request, to release the brake. Either causes the brake to apply when it detects a fault, regardless of the position of the deadman switches.	Deadman UP (Switch S23 open): > +9.5VDC Deadman DOWN (Switch S23 closed): < +1VDC	Carriage Deadman Switch (S23)	TM/VFC
131.	JPC17-6	AGND	AGND (Analog Ground) is the negative reference (B–) for the Carriage Manager Power Supply and other internal circuits, and is distributed to other connection points for external circuit components. Although it eventually connects to B–, it is kept separate from the other grounds to help reduce the effects of noise on system operation. It is connected on the Tractor Manager through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC TP4 (B– tie point).	Tractor Manager	Carriage Manager
132.	JPC18-1	_____ RESET	There is no wiring connected to this point. Not used on this truck.			
133.	JPC18-2	PRXD	There is no wiring connected to this point. Not used on this truck.			
134.	JPC18-3	PTXD	There is no wiring connected to this point. Not used on this truck.			
135.	JPC18-5	DGND	There is no wiring connected to this point. Not used on this truck.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).		
136.	JPC18-6	BUS+	This wire carries the positive component of the digital communications between the Operator Display Interface Card and the other managers on the communications bus. Measuring voltage on this wire provides no usable information.	Not usable	All Managers on the BUS	All Managers on the BUS

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
137.	JPC18-7	BUS–	This wire carries the negative component of the digital communications between the Operator Display Interface Card and the other managers on the communications bus. Measuring voltage on this wire provides no usable information.	Not usable	All Managers on the BUS	All Managers on the BUS
138.	JPC18-8	DGND	DGND (Digital Ground) is the negative reference (B–) for the Operator Display Interface Card. DGND is supplied from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Tractor Manager	S23
139.	JPC18-9	+12_PROT	+12V_PROT (+12 Volts Protected) provides the working voltage to operate the Operator Display Interface Card. This voltage comes from the +12V output supplied by the Carriage Manager Power Supply and is present whenever the Key Switch (S1) is closed.	+10.8VDC to +13VDC	Carriage Manager	Operator Display and Operator Display Interface Card
140.	JPC19-1	B+F (SPARE)	B+F (SPARE) is the B+ supply for the optional lights and fans and is present when the battery is plugged in. It is supplied from the Tractor Manager at JPS26-3 through JP61, current limit module (SUP6), line filter, and the over-the-mast cables to the Carriage Manager. It is fused through FU16 on the Tractor Manager to JPS12-10 & 13, and on to the B+ tie point at PC1-2 in the tractor electrical compartment.	B+	Tractor Manager	Work Lights and options
141.	JPC19-2	B–F (SPARE)	B–F (SPARE) is the B– (ground) for the optional RF Unit and for heaters on cold storage trucks and is present when the battery is plugged in. It is supplied from the Tractor Manager at JPS26-2 through the over-the-mast cables to the Carriage Manager. It is fused through FU15 on the Tractor Manager to JPS14-1 & 2, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC TP4 (B– tie point).	Tractor Manager	Optional Devices

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
142.	JPC19-3	B–F (SPARE)	B–F (SPARE) is the B– (ground) for the optional lights and fans and is present when the battery is plugged in. It is supplied from the Tractor Manager at JPS26-2 through the over-the-mast cables to the Carriage Manager. It is fused through FU15 on the Tractor Manager to JPS14-1 & 2, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC TP4 (B– tie point).	Tractor Manager	Work Lights and options
143.	JPC19-4	B+F (SPARE)	B+F (SPARE) is the B+ supply for the optional RF Unit and for heaters on cold storage trucks and is present when the battery is plugged in. It is supplied from the Tractor Manager at JPS26-3 through JP61, current limit module (SUP6), line filter, and the over-the-mast cables to the Carriage Manager. It is fused through FU16 on the Tractor Manager to JPS12-10 & 13, and on to the B+ tie point at PC1-2 in the tractor electrical compartment.	B+	Tractor Manager	Optional Devices
144.	JPC20-1	B+ESTOP	B+ESTOP is B+ provided through the normally closed EPO Switch (S21), when the Key Switch (S1) is closed, to all Carriage Manager B+ESTOP connections, over-the-mast cables, line filter, and through the Tractor Manager, where it is distributed to all the other B+ESTOP connections on the Tractor Manager.	B+	Carriage Manager	Tractor Manager
145.	JPC20-2	N/C	Not connected			
146.	JPC20-3	N/C	Not connected			
147.	JPC20-4	B–PCF	B–PCF is the B– (ground) for the Carriage Manager Coil Driver circuitry. It is fused through FU12 on the Tractor Manager to JPS14-1& 2, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Tractor Manager	Carriage Manager
148.	JPC20-5	B+F	B+F is the main B+ supply to the Carriage Manager and is present when the battery is plugged in. It is fused by FU14 and supplied through the Tractor Manager, JP61, line filter, over-the-mast cables, and Carriage Manager to the Key Switch (S1).	B+	Tractor Manager	Carriage Manager

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
149.	JPC20-6	B+KEY	B+KEY is B+ provided to the Tractor Manager when the Key Switch (S1) is closed. It is supplied through the Carriage Manager, over-the-mast cables, line filter, JP61, and the Tractor Manager, where it is distributed to all the other B+KEY connections on the Tractor Manager.	B+	Carriage Manager	Tractor Manager
150.	JPC20-7	B+F (SPARE)	B+F (SPARE) is the B+ supply for the Spare Power connector (JPC19) on the Carriage Manager when the battery is plugged in. It is supplied from the Tractor Manager at JPS26-3 through JP61, current limit module (SUP6), line filter, and the over-the-mast cables to the Carriage Manager. B+F (SPARE) provides B+ for optional lights, fan, RF Unit, and for heaters on cold storage trucks. It is fused through FU16 on the Tractor Manager to JPS12-10 & 13, and on to the B+ tie point at PC1-2 in the tractor electrical compartment.	B+	Tractor Manager	Lights, fan, & other options
151.	JPC20-8	B–F (SPARE)	B–F (SPARE) is the B– (ground) for the Spare Power connector (JPC19) on the Carriage Manager. It is supplied from the Tractor Manager at JPS26-2 through the over-the-mast cables to the Carriage Manager. B–F (SPARE) provides B– for optional lights, fan, RF Unit, and for heaters on cold storage trucks. It is fused through FU15 on the Tractor Manager to JPS14-1 & 2, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC TP4 (B– tie point).	Tractor Manager	Lights, fan, & other options
152.	JPC21-1	B+ESTOP	B+ESTOP is present at PC21-1 but there is no JC21-1 wiring connection. It is B+ provided through the normally closed EPO Switch (S21) when the Key Switch (S1) is closed.	B+	Carriage Manager	Carriage Manager
153.	JPC21-2	+12V PROT	+12V_PROT (+12 Volts Protected) provides the working voltage to operate the Hall Effect circuitry in optional right Sidegate Switch S60. This voltage comes from the +12V output supplied by the Carriage Manager Power Supply and is present whenever the Key Switch (S1) is closed.	+10.8VDC to +13VDC	Carriage Manager	Sidegate Switch (S60)
154.	JPC21-3	SIDEGATE 1	SIDEGATE 1 is an input voltage to the Carriage Manager from the optional right Sidegate Switch (S60). The Carriage Manager uses this voltage to determine whether the sidegate is raised or lowered. S60 is closed when the right sidegate down.	Sidegate UP: 5VDC Sidegate DOWN: 1VDC	Carriage Manager	Sidegate Switch (S60)

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
155.	JPC21-4	DGND	DGND (Digital Ground) is the B–(ground) for the optional right Sidegate Switch (S60). DGND is supplied from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND then through the Carriage Manager to JPC17-6, over-the-mast cables to the Tractor Manager, through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Carriage Manager	Sidegate Switch (S60)
156.	JPC21-5	SIDEGATE 2	SIDEGATE 2 is an input voltage to Carriage Manager from the optional left Sidegate Switch (S61). The Carriage Manager uses this voltage to determine whether the sidegate is raised or lowered. S61 is closed when the left sidegate is down.	Sidegate UP: 5VDC Sidegate DOWN: 1VDC	Sidegate Switch (S61)	Carriage Manager
157.	JPC21-6	DGND	No wiring connection at JC21-6.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Carriage Manager	
158.	JPC21-7	+12V PROT	+12V_PROT (+12 Volts Protected) provides the working voltage to operate the Hall Effect circuitry in the optional left Sidegate Switch S61. This voltage comes from the +12V output supplied by the Carriage Manager Power Supply and is present whenever the Key Switch (S1) is closed.	+10.8VDC to +13VDC	Carriage Manager	Sidegate Switch S61
159.	JPC21-8	DGND	DGND (Digital Ground) is the B– (ground) for the optional left Sidegate Switch (S61). DGND is supplied from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND, then through the Carriage Manager to JPC17-6, over-the-mast cables to the Tractor Manager, through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Carriage Manager	Sidegate Switch (S61)

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
160.	JPC23-1	LIFT SELECT	LIFT SELECT is an output voltage from the Carriage Manager to the Lift Select Switch (S6). It determines whether the Carriage Manager will command main or mini lift. With S6 open (not depressed) only main lift or lower is commanded when the lift/lower control potentiometer (VR2) is rotated in the desired direction from its learned neutral position. With S6 closed (depressed), mini lift/lower is commanded.	Not depressed: > +4VDC Depressed: < +1VDC	Carriage Manager	Lift Select Switch (S6)
161.	JPC23-2	L/ L_INH_BYPASS	L/L_INH_BYPASS is an output voltage from the Carriage Manager to the optional Lift/Lower Inhibit Bypass Switch (S7). The voltage on this line determines whether the Carriage Manager permits lift or lower when the specified Lift or Lower Limit height is reached. When this option is installed, S7 operation can be enabled or disabled in Configure Mode. With S7 open (not depressed), main lift or lower past the specified height limit is inhibited. With S7 closed (depressed), further lifting or lowering is permitted.	Not depressed: > +4VDC Depressed: < +1VDC	Carriage Manager	Lift/Lower Inhibit Bypass Switch (S7)
162.	JPC23-3	DIG IN	Not used on this truck.			
163.	JPC23-4	DIG IN	Not used on this truck.			
164.	JPC23-5	DGND	DGND (Digital Ground) is the negative reference (B–) for the shield around the cable to the left hand control handle. The shield shunts currents generated by electrical noise and other undesirable sources to ground, thereby preventing them from interfering with the internal cable wiring. DGND is supplied from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Carriage Manager	Carriage Manager
165.	JPC23-6	DGND	DGND (Digital Ground) is the B– (ground) for the Lift Select Switch (S6) circuit. DGND is supplied from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND, then through the Carriage Manager to JPC17-6, over-the-mast cables to the Tractor Manager, through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Carriage Manager	Lift Select Switch (S6)

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
166.	JPC23-7	DGND	DGND (Digital Ground) is the B– (ground) for the optional Lift/Lower Inhibit Bypass Switch (S7) circuit. DGND is supplied from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND, then through the Carriage Manager to JPC17-6, over-the-mast cables to the Tractor Manager, through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Lift/Lower Inhibit Bypass Switch (S7)	Carriage Manager
167.	JPC23-8	DGND	Not used on this truck.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).		
168.	JPC23-9	+5_POT	+5_POT is the supply voltage for the Traverse Control Potentiometer (VR4). This voltage comes from the +12V generated by the Carriage Manager Power Supply. On trucks having solid state potentiometers, it is also jumpered in the internal control handle harness to supply the Rotate Control Potentiometer (VR3).	4.5VDC to 5.8VDC	Carriage Manager	Traverse Control Potentiometer (VR4) and Rotate Control Potentiometer (VR3) on trucks with solid state pots.
169.	JPC23-10	ROTATE CMD	ROTATE CMD is a variable voltage input from the Rotate Control Potentiometer (VR3). The Carriage Manager monitors this voltage to determine the direction and speed of the rotate request when VR3 is rotated from its learned neutral position. The Carriage Manager also uses this voltage to generate an error code if the voltage is not within its specified limits.	Neutral: +2VDC to +3VDC Full CW: +0.4VDC to +1.5VDC Full CCW: +3.5VDC to +4.6VDC	Rotate Control Potentiometer (VR3)	Carriage Manager
170.	JPC23-11	TRAVERSE CMD	TRAVERSE CMD is a variable voltage input from the Traverse Control Potentiometer (VR4). The Carriage Manager monitors this voltage to determine the direction and speed of the traverse request when VR4 is rotated from its learned neutral position. The Carriage Manager also uses this voltage to generate an error code if the voltage is not within its specified limits.	Neutral: +2VDC to +3VDC Full Left: +0.4VDC to +1.5VDC Full Right: +3.5VDC to +4.6VDC	Traverse Control Potentiometer (VR4)	Carriage Manager

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
171.	JPC23-12	DGND	DGND (Digital Ground) is the negative reference (B–) for the Traverse Control Potentiometer (VR3). DGND is supplied from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Carriage Manager	Traverse Control Potentiometer (VR4)
172.	JPC23-13	AGND	AGND (Analog Ground) is the negative reference (B–) for the Rotate Control Potentiometer (VR3).	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Carriage Manager	Rotate Control Potentiometer (VR3)
173.	JPC23-15	+12_POT	+12_POT provides the working voltage to operate the Rotate Control Potentiometer (VR3) on trucks *not* having solid state potentiometers installed in the Control Handles. This voltage comes from the +12V output supplied by the Carriage Manager Power Supply and is present whenever the Key Switch (S1) is closed.	+10.8VDC to +13VDC	Carriage Manager	Rotate Control Potentiometer (VR3)
174.	JPC24-1	HORN	HORN is an output voltage from the Carriage Manager to the Horn Switch (S3) that determines whether the Carriage Manager will command the horn to be sounded.	Not depressed: > +4VDC Depressed: < +1VDC	Horn Switch (S3)	Carriage Manager
175.	JPC24-2	AUTO MANUAL	AUTO MANUAL is an output voltage from the Carriage Manager to the AUTO/MAN Switch (S4) that determines whether the Carriage Manager commands a guidance mode to be activated. The Guidance Mode can be either Wire or Rail. Guidance is commanded to activate when S4 is open and is OFF when S4 is closed.	Not depressed: > +4VDC Depressed: < +1VDC	AUTO/MAN Switch (S4)	Carriage Manager
176.	JPC24-3	DIG IN 1E	DIG IN 1E is an input for an undefined option. It is not used on this truck.			

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
177.	JPC24-5	DGND	DGND (Digital Ground) is the negative reference (B–) for the shield around the cable to the right-hand control handle. The shield shunts currents generated by electrical noise and other undesirable sources to ground, thereby preventing them from interfering with the internal cable wiring. DGND is supplied from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Carriage Manager	Carriage Manager
178.	JPC24-6	DGND	DGND (Digital Ground) is the negative reference (B–) for the Horn Switch (S3). DGND is supplied from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Carriage Manager	Horn Switch (S3)
179.	JPC24-7	DGND	DGND (Digital Ground) is the negative reference (B–) for the AUTO/MAN Switch (S4). DGND is supplied from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Carriage Manager	AUTO/MAN Switch (S4)
180.	JPC24-8	DGND	DGND (Digital Ground) is the negative reference (B–) for an undefined option. It is not used on this truck.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).		
181.	JPC24-9	+5_POT	+5_POT is the supply voltage for the Travel Potentiometer (VR1). This voltage comes from the +12V generated by the Carriage Manager Power Supply. On trucks with solid state potentiometers, it is also jumpered in the Control Handle harness to supply the Lift/Lower Potentiometer (VR2).	4.5VDC to 5.8VDC	Carriage Manager	Travel Potentiometer (VR1)and Lift/Lower Potentiometer (VR2) on trucks with solid state pots.

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
182.	JPC24-10	LIFT/LOWER CMD	LIFT/LOWER CMD is a variable voltage input from the Lift/Lower Potentiometer (VR2). The Carriage Manager monitors this voltage to determines the direction and speed of the lift or lower request when VR2 is rotated from its learned neutral position. The Carriage Manager also uses this voltage to generate an error code if the voltage is not within its specified limits.	Neutral: +2VDC to +3VDC Full lift: +0.4VDC to +1.5VDC Full lower: +3.5VDC to +4.6VDC	Lift/Lower Potentiometer (VR2)	Carriage Manager
183.	JPC24-11	TRAVEL CMD	TRAVEL CMD is a variable voltage input from the Travel Potentiometer (VR1). The Carriage Manager monitors this voltage to determines the direction and speed of the travel request when VR1 is rotated from its learned neutral position. The Carriage Manager also uses this voltage to generate an error code if the voltage is not within its specified limits.	Neutral: +2VDC to +3VDC Full reverse: +0.4VDC to +1.5VDC Full forward: +3.5VDC to +4.6VDC	Travel Potentiometer (VR1)	Carriage Manager
184.	JPC24-12	DGND	DGND (Digital Ground) is the negative reference (B–) for the Travel Potentiometer (VR1). DGND is supplied from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Carriage Manager	Travel Potentiometer (VR1)
185.	JPC24-13	AGND	AGND (Analog Ground) is the negative reference (B–) for the Lift/Lower Control Potentiometer (VR2).	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for <+0.5VDC wrt TP4 (B– tie point).	Carriage Manager	Lift/Lower Potentiometer (VR2)
186.	JPC24-14	DGND	Not used on this truck.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).		

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
187.	JPC24-15	+12_POT	+12_POT provides the working voltage to operate the Lift/Lower Control Potentiometer (VR2) on trucks *not* having solid state potentiometers. This voltage comes from the +12V output supplied by the Carriage Manager Power Supply and is present whenever the Key Switch (S1) is closed.	+10.8VDC to +13VDC	Carriage Manager	Lift/Lower Potentiometer (VR2)
188.	JPC25-1	+12V_PROT	+12V_PROT (+12 Volts Protected) provides the working voltage to operate the Hall effect circuitry in the Brake Deadman Switch (S2). This voltage comes from the +12V output supplied by the Carriage Manager Power Supply and is present whenever the Key Switch (S1) is closed.	+10.8VDC to +13VDC	Carriage Manager	Brake Deadman Switch (S2)
189.	JPC25-2	BRAKE DEADMAN	BRAKE DEADMAN is an output voltage from the Carriage Manager to the Brake Deadman Switch (S2). The Carriage Manager uses this voltage to determine the state of S2 and outputs a resultant B– (BRAKE CONTROL) at JPC17-4, over a mast cable, to the Tractor Manager/VFC. This VFC communicates back to the Carriage Manager that it has received this input. The VFC and Carriage Manager both use this information, in conjunction with a travel request, to release the brake. Either causes the brake to apply when it detects a fault, regardless of the position of the deadman switches.	Deadman UP (S2 open): >9.5VDC Deadman DOWN (S2 closed): <0.5VDC	Brake Deadman Switch (S2)	Carriage Manager
190.	JPC25-3	DGND	DGND (Digital Ground) is the B– (ground) for the Brake Deadman Switch (S2). DGND is supplied from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND, then through the Carriage Manager to JPC17-6, over-the-mast cables to the Tractor Manager, through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Carriage Manager	Brake Deadman Switch (S2)
191.	JPC25-4	+12V_PROT	+12V_PROT (+12 Volts Protected) provides the working voltage to operate the Hall effect circuitry in the Carriage Deadman Switch (S23). This voltage comes from the +12V output supplied by the Carriage Manager Power Supply and is present whenever the Key Switch (S1) is closed.	+10.8VDC to 13VDC	Carriage Manager	Carriage Deadman Switch (S23)

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
192.	JPC25-5	CARRIAGE DEADMAN	CARRIAGE DEADMAN is an output voltage from the Tractor Manager sent over a mast cable to the Carriage Manager. It indicates the status of the Carriage Deadman switch (S23), which pulls the voltage low when closed. This change is seen on the Tractor Manager and the VFC communicates back to the Carriage Manager that it has received this input. The VFC and Carriage Manager both use this information, in conjunction with a travel request, to release the brake. Either causes the brake to apply when it detects a fault, regardless of the position of the deadman switches.	Deadman UP (S23 open): >9.5VDC Deadman DOWN (S23 closed): <1.0VDC	Carriage Deadman Switch (S23)	Carriage Manager and Tractor Manager/ VFC
193.	JPC25-6	DGND	DGND (Digital Ground) is the B– (ground) for the Carriage Deadman Switch (S23). DGND is supplied from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND, then through the Carriage Manager to JPC17-6, over-the-mast cables to the Tractor Manager, through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Carriage Manager	Carriage Deadman Switch (S23)
194.	JPC25-7	+12V_PROT	+12V_PROT (+12 Volts Protected) provides the working voltage to operate the Hall effect circuitry in the Load Handler Deadman Switch (S9). This voltage comes from the +12V output supplied by the Carriage Manager Power Supply and is present whenever the Key Switch (S1) is closed.	+10.8VDC to +13VDC	Carriage Manager	Load Handler Deadman Switch (S9)
195.	JPC25-8	LOAD HANDLER DEADMAN	LOAD HANDLER DEADMAN is an output voltage from the Carriage Manager to the Load Handler Deadman Switch (S9). The Carriage Manager uses this voltage to determine the state of S9. When S9 is detected closed (left deadman pedal depressed), the Carriage Manager enables the Mini Mast and Load Handler functions. These functions are inhibited if S9 is detected open (left deadman pedal up).	Deadman UP (S9 open): >9.5VDC Deadman DOWN (S9 closed): <0.5VDC	Load Handler Deadman Switch (S9)	Carriage Manager

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
196.	JPC25-9	DGND	DGND (Digital Ground) is the B– (ground) for the Load Handler Deadman Switch (S9). DGND is supplied from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND, then through the Carriage Manager to JPC17-6, over-the-mast cables to the Tractor Manager, through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Carriage Manager	Load Handler Deadman Switch (S9)
197.	JPC26-1	B+ESTOP	B+ESTOP is B+ supplied through the normally closed EPO Switch (S21) when the Key Switch (S1) is closed. There is no harness wiring connected at this point. Not used on this truck.	B+	EPO Switch (S21)	Carriage Manager
198.	JPC26-2	B+ESTOP	B+ESTOP is B+ supplied through the normally closed EPO Switch (S21) when the Key Switch (S1) is closed, through the Carriage Manager, to power the Proportional Reach/Rotate Solenoid Valve coil (SOL33) coil. It also provides a return path for the suppressor to this coil.	B+	EPO Switch (S21)	Proportional Reach/ Rotate Solenoid Valve (SOL33)
199.	JPC26-3	SPARE_PWM _COIL	Not used on this truck.			
200.	JPC26-4	ROTATE_PW M_COIL	ROTATE_PWM_COIL is the output of the Proportional Reach/Rotate Solenoid Valve Coil Driver (SOL33) in the Carriage Manager. It provides the negative path to complete the circuit to energize the SOL33 coil through the Proportional Reach/Rotate Solenoid Valve Coil Driver to B– (ground). It also lights the red LED (IL9) on the Carriage Manager when the Rotate Command Potentiometer (VR3) is rotated from its learned neutral position. The brightness of IL9 varies with the amount of control voltage being applied to the S33 coil. The ROTATE_PWM_COIL output is automatically present to permit reach/retract operation during a traverse function when the Carriage Manager has determined that Traverse Feedback Potentiometer (VR5) voltage at JPC12-1 indicates that the mid-point of the platform width has been exceeded and that the forks are fully nested. Once the mid-point has been attained, a ROTATE_PWM_COIL output can also be energized by rotating the Traverse Command Potentiometer (VR4) slightly out of its learned neutral position to request a reach or retract function.	Creep CW: Approx. +5 or +6VDC > the starting voltage Full CW/ CCW: Approx. +10 or +12VDC < the starting voltage When reaching or retracting forks: Approx. +12 or +14VDC < the starting voltage	Carriage Manager	Proportional Reach/ Rotate Solenoid Valve (SOL33)

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
201.	JPC26-5	N/C	Not connected			
202.	JPC26-6	N/C	Not connected			
203.	JPH1-1	B+ESTOP	B+ESTOP is B+ supplied through the normally closed EPO Switch (S21) when the Key Switch (S1) is closed, through the Carriage Manager, to power the Reach Solenoid Valve coil (SOL36) via JPK3-6. It also provides a return path for the suppressor to this coil.	B+	EPO Switch (S21)	Reach Solenoid Valve coil (SOL36)
204.	JPH1-2	REACH SOL	REACH SOL is the output of the Reach Solenoid Valve Coil Driver in the Carriage Manager. It provides the negative path via JPK3-1 to complete the circuit to energize the Reach Solenoid Valve (SOL36) coil through the Reach Solenoid Valve Coil Driver to B– (ground). It also lights the red LED (IL7) on the Carriage Manager. This output is automatically present to permit reach/retract operation during a traverse function when the Carriage Manager has determined that Traverse Feedback Potentiometer (VR5) voltage at JPC12-1 indicates that the mid-point of the platform width has been exceeded and that the forks are fully nested. Once the mid-point has been attained, a REACH SOL output can be energized by rotating the Traverse Command Potentiometer (VR4) slightly out of its learned neutral position.	Deenergized: B+ Energized: Approx. +24VDC	Carriage Manager	Reach Solenoid Valve coil (SOL36)
205.	JPH1-3	ROTATE POS	ROTATE POS is an analog voltage input to the Carriage Manager from the Rotate Position Feedback Potentiometer (VR6) directly through the Mini Height Manager. The Carriage Manager uses this voltage to determine the rotated position of the forks and the rate at which they are moving during Learn.	Nested full right: Approx. +3.9VDC Centered: Approx. +2.4VDC Nested full left: Approx. +1.1VDC	Rotate Position Feedback Potentiometer (VR6)	Carriage Manager
206.	JPH1-5	DGND	DGND (Digital Ground) is the B– (ground) via JPK3-8 for the Mini Height Manager and the Rotate Position Feedback Potentiometer (VR6). DGND is supplied from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND, then through the Carriage Manager to JPC17-6, over-the-mast cables to the Tractor Manager, through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Carriage Manager	Mini Height Manager, Rotate Position Feedback Potentiometer (VR6,) and the Reach Position Proximity Sensor (PROX2)

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
207.	JPH1-6	BUS+	This wire carries the positive component of the digital communications between the Mini Height Manager via JPK3-7 and the other managers on the communications bus. Measuring voltage on this wire provides no usable information.	Not usable	All Managers on the BUS	All Managers on the BUS
208.	JPH1-7	BUS–	This wire carries the negative component of the digital communications between the Mini Height Manager via JPK3-3 and the other managers on the communications bus. Measuring voltage on this wire provides no usable information.	Not usable	All Managers on the BUS	All Managers on the BUS
209.	JPH1-8	DGND	DGND (Digital Ground) is the B– (ground) via JPK3-4 for the Mini Height Manager and the Rotate Position Feedback Potentiometer (VR6). DGND is supplied from the Carriage Manager Power Supply connector JPC14-1, where it is tied common to AGND, then through the Carriage Manager to JPC17-6, over-the-mast cables to the Tractor Manager, through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Carriage Manager	Mini Height Manager, Rotate Position Feedback Potentiometer (VR6), and the Reach Position Proximity Sensor (PROX2)
210.	JPH1-9	+12V_PROT	+12V_PROT (+12 Volts Protected) provides the working voltage via JPK3-5 to operate the Mini Height Manager, Mini Height Proximity Sensor (HEIGHT PROX), Rotate Position Feedback Potentiometer (VR6) and the Reach Position Proximity Sensor (PROX2). This voltage comes from the +12V output supplied by the Carriage Manager Power Supply and is present whenever the Key Switch (S1) is closed.	+10.8VDC to +13VDC	Carriage Manager	Mini Height Manager, Mini Mast Height Sensor (HEIGHT PROX), Rotate Position Feedback Potentiometer (VR6), and the Reach Position Proximity Sensor (PROX2).
211.	JPH1-10	+5V_POT	+5_POT comes from the +12V generated by the Carriage Manager Power Supply. There is no wiring connection to this point. Not used on this truck.	4.5VDC to 5.8VDC	Carriage Manager	
212.	JPH2-1	N/C	Not connected			
213.	JPH2-2	N/C	Not connected			
214.	JPH2-3	N/C	Not connected			
215.	JPH2-4	N/C	Not connected			

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
216.	JPH2-5	N/C	AGND is connected at PH2-5, but there is no wire connected at JH2-5.			
217.	JPH2-6	BUS+	This wire carries the positive component of the digital communications between the Main Height Manager on the SA and the other managers on the communications bus. Measuring voltage on this wire provides no usable information.	Not usable	All Managers on the BUS	All Managers on the BUS
218.	JPH2-7	BUS–	This wire carries the negative component of the digital communications between the Main Height Manager on the SA and the other managers on the communications bus. Measuring voltage on this wire provides no usable information.	Not usable	All Managers on the BUS	All Managers on the BUS
219.	JPH2-8	DGND	DGND is the negative reference (B–) for the Main Height Manager. It is connected to AGND (Analog Ground) on the Tractor Manager through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Tractor Manager	Main Height Manager
220.	JPH2-9	+12VF	+12VF is supplied to the circuitry on the Main Height Manager from the 12 volt power supply on the Tractor Manager via fuse FU17. This voltage is present when the Key Switch (S1) is closed.	+10.8 VDC to +13.0 VDC	Tractor Manager	Main Height Manager
221.	JPS3-1	N/C	No connection			
222.	JPS3-2	AGND	AGND (Analog Ground) is the negative reference (B–) for some of the circuits on the Power Card. It is connected on the Tractor Manager through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5 VDC wrt TP4 (B– tie point).	Tractor Manager	Power Card
223.	JPS3-3	CHOPPER PWM	CHOPPER PWM is a voltage generated when there is a request for travel. It is a varying voltage sent from the VFC, through the Tractor Manager to the Power Card. CHOPPER PWM controls the ON/OFF time of Q1 when CHOPPER ENABLE is present at JPS3-5. The DC value measured with a meter should vary from >10VDC at rest down to approx. 1VDC depending on speed request and speed limiting.	At rest: >10VDC At full speed: Approx. +5VDC	TM/VFC	Power Card

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
224.	JPS3-4	ARM CURRENT	ARM CURRENT is an analog voltage derived from the magnetic field around the cable routed through the Current Transformer (CT-1) on the Power Card when there is current flowing in the armature of the drive motor. This voltage varies directly with the amplitude of the drive motor armature current and is used by the Power Card to limit armature current. It is also sent from the Power Card through the Tractor Manager to the VFC. The VFC processes this voltage and compares it to the armature current limit input to determine error codes.	At rest: +5.7VDC to +6.3VDC Current limit is approx. +3VDC > voltage at rest.	Power Card	TM/VFC
225.	JPS3-5	CHOPPER ENABLE	CHOPPER ENABLE is a digital voltage generated when there is a request for travel. It is sent from the VFC through the Tractor Manager to the Power Card. It permits the Power Card to pulse Q1 when CHOPPER PWM (JPS3-3) is also present. If the CHOPPER ENABLE is missing, then Q1 can not be turned on, even if CHOPPER PWM is present.	Enabled: < +1VDC Not enabled: > +10.5VDC	TM/VFC	Power Card
226.	JPS3-6	B+KEY	B+KEY is battery positive supplied to the Power Card when the Key Switch (S1) is closed. It is used internally by the Power Card.	B+	Tractor Manager	Power Card
227.	JPS3-7	N/C	No connection	NA	NA	NA
228.	JPS3-8	N/C	No connection	NA	NA	NA
229.	JPS3-9	N/C	No connection	NA	NA	NA
230.	JPS4-1	+12VF	+12VF is supplied to the Contactor Interface Module from the 12 volt power supply on the Tractor Manager via Fuse FU17. This voltage is present when the Key Switch (S1) is closed.	+10.8 VDC to +13.0 VDC	Tractor Manager	Contactor Interface Module
231.	JPS4-2	AUX PWM	No connection on trucks equipped with Proportional Auxiliary functions (S/N SA > 02999 and SB > 00699).			
232.	JPS4-3	N/C	No connection			
233.	JPS4-4	AUX FAULT	AUX FAULT is a voltage provided to the TM/VFC from AUX-2 through the Contactor Interface Module when the Auxiliary Contactor tips are closed (Aux. Sense). It is used by the TM/VFC to verify the correct state of the Auxiliary Contactor and initiate Auxiliary Contactor fault codes.	Contactor open: 0VDC Contactor closed: 6VDC	Contactor Interface Module	TM/VFC

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
234.	JPS4-5	AUX ENABLE	AUX ENABLE is a control voltage sent from the VFC through the Tractor Manager to the Contactor Interface Module to operate an internal Coil Driver circuit to energize or de-energize the Auxiliary Contactor.	Deenergized: < +1VDC Energized: > +10VDC	Tractor Manager	Contactor Interface Module
235.	JPS4-6	PGND	PGND (Power Ground) is the B– return for the Auxiliary Contactor coil. It is switched by the internal Coil Driver in the Contactor Interface Module. It is connected on the Tractor Manager through Fuse FU12 to JPS14-1 & 2, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Tractor Manager	Contactor Interface Module
236.	JPS5-1	ARM CURRENT LIMIT	ARM CURRENT LIMIT is a digital voltage generated by the Power Card when the current flowing in the armature of the drive motor exceeds a preset value. This voltage is >10VDC when not in current limit. When current is limited by the Power Card, this voltage is < 5VDC, and the green LED IL2 on the Power Card is lit. The TM/VFC processes this voltage and compares this information to the armature current input and uses it to determine the error code.	Not limited: > +10VDC Limited: +5VDC	Power Card	TM/VFC
237.	JPS5-2	PP TEMP LIMIT	PP TEMP LIMIT is a digital voltage generated when the temperature of the power panel heatsink exceeds a preset value. This voltage is >10VDC when not in temperature limit. When temperature limit is exceeded this voltage is < 5VDC and the red LED IL1 on the Power Card is lit. The TM/VFC processes this voltage and compares this information to the PP TEMP input and uses it to determine the error code.	Not limited: > +10VDC Limited: <+5VDC Disconnected: Approx. +1.5VDC	Power Card	TM/VFC
238.	JPS5-3	FIELD CURRENT	FIELD CURRENT is a voltage generated due to current flowing in the field circuit of the drive motor. Field Current is an analog voltage derived from current shunt, RS1 on the Power Card. Its amplitude varies in direct proportion to the drive motor field current. It is used by the Power Card to determine when to limit field current. It is also sent from the Power Card to the TM/VFC, which processes this voltage and communicates this information to the Carriage Manager, which uses it in determining error codes.	At rest: +0.8VDC to +1.2VDC Current limit: > +3.5VDC	Power Card	TM/VFC
239.	JPS5-4	N/C	No connection			

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
240.	JPS5-5	TRACTOR FIRST	TRACTOR FIRST is a digital voltage generated when there is a request for reverse travel. This voltage, sent from the VFC through the Tractor Manager to the Power Card, enables the Power Card to pulse TM1 & TM2 for travel in the tractor-first (reverse) direction. If it is not present, the truck will not travel, even if FIELD PWM is present at JPS5-8.	Enabled: > +10.5VDC Not enabled: < +1VDC	TM/VFC	Power Card
241.	JPS5-6	FORKS FIRST	FORKS FIRST is a digital voltage generated when there is a request for forward travel. This voltage, sent from the VFC through the Tractor Manager to the Power Card, enables the Power Card to pulse TM1 & TM2 for travel in the forks-first (forward) direction. If FORKS FIRST is not present, the truck will not travel, even if FIELD PWM is present at JPS5-8.	Enabled: > +10.5VDC Not enabled: < +1VDC	TM/VFC	Power Card
242.	JPS5-7	PP TEMP	PP TEMP is a voltage generated whenever the truck is powered on. It is an analog voltage produced by the temperature sensor (HT) on the Traction Heatsink and conditioned by the Power Card. This voltage varies from approx. 4VDC to 6VDC as the heatsink temperature changes. The TM/VFC processes this voltage and communicates it to the Carriage Manager, which uses it to adjust truck travel speed in order to keep the power panel temperature within limits.	70 deg. F.: Approx. +4VDC Normal operating temp. range: +4VDC to +6VDC Disconnected: > +10VDC	Power Card	TM/VFC
243.	JPS5-8	FIELD PWM	FIELD PWM is a voltage generated whenever there is a request for travel. It is a chopped DC (PWM) voltage sent from the VFC, through the Tractor Manager to the Power Card. It controls the ON/OFF time of TM1 & TM2 when either tractor-first or forks-first enable voltage is present at JPS5-5 or 6.	During travel: +3VDC to +7VDC In current limit: > +11VDC	TM/VFC	Power Card
244.	JPS5-9	+12VF	+12VF is supplied to some circuitry on the Power Card and other components connected to the Power Card from the 12 volt power supply on the Tractor Manager via Fuse FU17. This voltage is present when the Key Switch (S1) is closed.	+10.8VDC to +13VDC	Tractor Manager	Power Card

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
245.	JPS6-1	SENSOR1	SENSOR1 is an input voltage to the TM/VFC. It is generated by either S46A or S46B when one or both sensors detect the presence of a floor magnet. SENSOR1 is used along with SENSOR2 (JPS28-1) to determine if the truck is in or out of the aisle. This information is communicated to the Carriage Manager, which controls travel speed based on truck location and the position of the AUTO/MAN switch.	Magnet not sensed: +10.8VDC to +13VDC Magnet sensed: < +1VDC	End-of-Aisle Sensors (S46A/B)	TM/VFC
246.	JPS6-2	+VSENSOR1	+VSENSOR1 supplies working voltage to the optional End-of-Aisle Sensor (S46A) at S46A-3. It is then routed through the switch module to S46A-4 to S46B-3 to power that switch module also. S46A and S46B comprise SENSOR1. +VSENSOR is generated by a separate 12 volt regulator on the Tractor Manager that is powered by +12VF Fuse FU17. This voltage is present when the Key Switch (S1) is closed.	Approx. +8VDC	Tractor Manager	End-of-Aisle Sensors (S46A/B)
247.	JPS6-3	AGND	AGND (Analog Ground) supplies a negative reference (B–) for to the optional End-of-Aisle Sensor (S46B) at S46B-8. It is then routed through the switch module to S46B-7 to S46A-8. It is connected on the Tractor Manager through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment. There is no harness wiring connected at this point.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Tractor Manager	End-of-Aisle Sensors (S46A/B)
248.	JPS11-1	PLUG CONTROL	PLUG CONTROL is a chopped (PWM) control voltage sent from the VFC through the Tractor Manager to the Coil Driver Card (CD5) to control the plugging contactor Coil Driver. This voltage is present whenever there is no request for plugging and the PLUG Contactor coil is energized.	Coil deenergized: < +1VDC Energized: Approx. +5VDC to +9VDC	TM/VFC	Coil Driver Card (CD5)
249.	JPS11-2	BRAKE CONTROL	BRAKE CONTROL is a voltage sent from the VFC through the Tractor Manager to the Coil Driver Card (CD5) to control the operation of the brake when the TM/VFC and the Carriage Manager both agree to release it. This voltage is determined by the battery voltage of the truck as set by the position of the shunt jumper on either E2 or E3 on the Tractor Manager. For 48 volt operation, the shunt jumper is located at E2.	Coil deenergized: < +1VDC Energized: > +9VDC	TM/VFC	Coil Driver Card (CD5)

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
250.	JPS11-3	PC1 CONTROL	PC1 CONTROL is a chopped (PWM) control voltage sent from the VFC through the Tractor Manager to the Coil Driver Card (CD5) to control the PC1 Contactor Coil Driver. This voltage is present whenever there is a requirement for the PC1 Contactor coil to be energized.	Coil deenergized: < +1VDC Energized: > +10VDC for approx. 1 second then dropping to between +5VDC and +8VDC	TM/VFC	Coil Driver Card (CD5)
251.	JPS11-4	L/L CONTROL	L/L CONTROL is a chopped (PWM) control voltage sent from the VFC through the Tractor Manager to the Coil Driver Card (CD5) to control the Lift/Lower Solenoid Coil Driver. The DC value of this voltage is determined by the position of the Lift/Lower Control Potentiometer (VR2). This voltage is present whenever there is a request for main or mini lift/lower functions.	No request: Approx. +0.4VDC Slow lift: Approx. +2.0VDC Max lift: Approx. +0.5VDC Slow lower: Approx. +1.8VDC Full lower: Approx. +5.0VDC In Decel: Approx. +1.8VDC	TM/VFC	Coil Driver Card (CD5)
252.	JPS11-5	L/H CONTROL	L/H CONTROL is a chopped (PWM) control voltage sent from the VFC through the Tractor Manager to the Coil Driver Card (CD5) to control the Main Load Holding Solenoid Coil Driver. This voltage is present whenever there is a request for main mast lower.	Coil deenergized: < +1VDC Energized: Approx. +5VDC to +8VDC	TM/VFC	Coil Driver Card (CD5)
253.	JPS11-6	PLUG CNTR	PLUG CNTR is the output of the plugging Coil Driver (CD5) and is connected through the Tractor Manager to the PLUG Contactor coil, terminal Y at JPS14-16. It provides the negative path to complete the circuit to energize the PLUG Contactor coil through the plugging Coil Driver (CD5) to B– (ground) when PLUG CONTROL is present at JPS11-1.	Coil deenergized: B+ Coil energized: Approx. +24VDC	TM/VFC	Plug Contactor Coil

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
254.	JPS11-7	BRAKE	BRAKE is the output of the brake Coil Driver (CD5) and is connected through the Tractor Manager to the brake coil, terminal Y at JPS19-5. It provides the negative path to complete the circuit to energize the brake coil through the brake Coil Driver (CD5) to B– (ground) when BRAKE CONTROL is present at JPS11-2. The voltage across the brake coil is determined by the battery voltage of the truck, as set by the position of the shunt jumper on either E2 or E3 on the Tractor Manager. For 48 volt operation, the shunt jumper is located at E2.	Brake coil deenergized: B+ Energized: < +1VDC	TM/VFC	Brake
255.	JPS11-8	PC1 CNTR	PC1 CNTR is the output of the PC1 Coil Driver (CD5) and is connected through the Tractor Manager to the PC1 Contactor coil, terminal Y at JPS14-18. It provides the negative path to complete the circuit to energize the PC1 Contactor coil through the PC1 Coil Driver (CD5) to B– (ground) when PLUG CONTROL is present at JPS11-3.	Contactor deenergized: B+ Energized: Approx. +24VDC	TM/VFC	PC1 Contactor Coil
256.	JPS11-9	L/L SOL	L/L SOL is the output of the Lift/Lower Solenoid Coil Driver (CD5) and is connected through the Tractor Manager to the lift/lower solenoid coil, terminal 2 at JPS19-4. It provides the negative path to complete the circuit to energize the Lift/ Lower Solenoid coil through the L/L Solenoid Coil Driver (CD5) to B– (ground) when L/L Control is present at JPS11-4. The DC value of this voltage is determined by the value of the L/L CONTROL voltage being applied at JPS11-4.	Voltage reading varies with battery condition and collapsed height. Creep lift: Approx. 35VDC Full lift: Approx. 42VDC Creep lower: Approx. 45VDC Full lower: Approx. 28VDC	TM/VFC	Lift/Lower Solenoid Coil
257.	JPS11-10	L/H SOL	L/H SOL is the output of the Main Load Holding Solenoid Coil Driver (CD5) and is connected through the Tractor Manager to the Main Load Holding Solenoid coil, terminal 2 at JPS19-3. It provides the negative path to complete the circuit to energize the Main L/H Sol coil through the Main L/H Sol Coil Driver (CD5) to B– (ground) when L/H CONTROL is present at JPS11-5.	Deenergized: B+ Energized: Approx. +24VDC	TM/VFC	Main Load Holding Solenoid (SOL1) Coil

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
258.	JPS11-11	PGND	PGND (Power Ground) is the B– return for the brake and PLUG Contactor coils. It is switched by the Coil Drivers on the Coil Driver Card. It is connected on the Tractor Manager through Fuse FU12 to JPS14-1 & 2, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Tractor Manager	Coil Drivers on Coil Driver Card (CD5)
259.	JPS11-12	B+PC1F	JPS11-12 is connected to pin 1 on the E3 jumper connector. On models SA and SB there is no shunt jumper installed on E3, but E3-1 is hardwired to E3-2 to provide a complete path for the brake and plugging coil suppressors.	B+	Tractor Manager	Brake and Plug Coil Suppressors on the Coil Driver Card (CD5)
260.	JPS11-13	B+PC1F	JPS11-13 is the keyed position for the CD5 card. There is physically no pin present on JPS11 in this location.			
261.	JPS11-14	B+ESTOP	B+ESTOP is B+ provided through the normally closed EPO Switch (S21) when the Key Switch (S1) is closed. It powers those circuits that must be energized before the PC1 contactor is energized. When the EPO Switch (S21) contacts are opened, it removes this power, thereby shutting down most truck functions.	B+	EPO Switch, Carriage Manager, and Tractor Manager	Coil Driver Card (CD5)
262.	JPS11-15	PGND	PGND (Power Ground) is the B– return for the Lift/Lower and Main Load Holding Solenoids and the PC1 Contactor coil. It is switched by the Coil Drivers on the Coil Driver Card. It is connected on the Tractor Manager through Fuse FU12 to JPS14-1 & 2, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Tractor Manager	Coil Driver Card (CD5)
263.	JPS12-1	LIFT SEL CONT	LIFT SEL CONT (Lift Select Control) is a PWM voltage sent from the TM/VFC, through the Tractor Manager to the Coil Driver Card (CD3) to control the Lift Select Solenoid Coil Driver whenever the Lift Select Switch (S6) is closed.	Coil deenergized (S6 open): < +1VDC Energized (S6 closed): Approx. +5VDC to +8VDC	TM/VFC	Coil Driver Card (CD3)

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
264.	JPS12-2	P CONTROL	P CONTROL (Pump Control) is a PWM voltage sent from the TM/VFC, through the Tractor Manager to the Coil Driver Card (CD3) to control the P Contactor and the Dump Valve Solenoid coils whenever the Lift/Lower Control Potentiometer (VR2) is moved in a CW direction outside its learned neutral value (lift requested).	Coil deenergized (no lift requested): < +1VDC Energized (lift requested): Approx. +5VDC to +8VDC	TM/VFC	Coil Driver Card (CD3)
265.	JPS12-3	MINI L/H CONTROL	MINI L/H CONTROL (Mini Load Hold Control) is a PWM voltage sent from the TM/VFC, through the Tractor Manager to the Coil Driver Card (CD3) to control the Mini L/H Solenoid coil whenever the Lift/Lower Control Potentiometer (VR2) is moved in a CCW direction outside its learned neutral value (lower requested).	No lower requested: < +1VDC Lower requested: Approx. +5VDC to +8VDC	TM/VFC	Coil Driver Card (CD3)
266.	JPS12-4	SLKCHN1	SLKCHN1 is a digital voltage output of the TM to the Coil Driver Card (CD3) that indicates the status of Slack Chain Switch 1 (S50).	S50 closed: < +1VDC S50 open: Approx. +5VDC	Coil Driver Card (CD3)	Tractor Manager
267.	JPS12-5	SLKCHN2	SLKCHN2 is a digital voltage output of the TM to the Coil Driver Card (CD3) that indicates the status of Slack Chain Switch 2 (S51).	S51 closed: < +1VDC S51 open: Approx. +5VDC	Coil Driver Card (CD3)	Tractor Manager
268.	JPS12-6	+12VF	+12VF is supplied to the circuitry on the Coil Driver Card (CD3) from the 12 volt power supply on the Tractor Manager via Fuse FU17. This voltage is present when the Key Switch (S1) is closed.	+10.8 VDC to +13.0 VDC	Tractor Manager	Coil Driver Card (CD3)
269.	JPS12-7	AGND	AGND (Analog Ground) is the negative reference (B–) for the slack chain circuitry on the Coil Driver Card (CD3). It is connected on the Tractor Manager through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Tractor Manager	Coil Driver Card (CD3)
270.	JPS12-8	N/C	Not connected			

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
271.	JPS12-9	PGND	PGND (Power Ground) is the B– return for the Lift Select (SOL3), Mini Load Holding (SOL2), and Dump Valve (SOL99) solenoids and the PUMP Contactor coil. It is switched by the Coil Drivers on the Coil Driver Card. It is connected on the Tractor Manager through Fuse FU12 to JPS14-1 & 2, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Tractor Manager	Coil Driver Card CD3
272.	JPS12-10	B+ESTOP	B+ESTOP is B+ provided through the normally closed EPO Switch (S21) when the Key Switch (S1) is closed, through the Carriage Manager, over-the-mast cables, and through the Tractor Manager to the Coil Driver Card (CD3). It supplies the B+ path for the Lift Select (SOL3), P, Dump Valve (SOL99), and Mini L/H Solenoid (SOL2) coils, as well as their suppressor circuits, and operating voltage for LEDs IL1, IL2, and IL3.	B+	EPO Switch, Carriage Manager, and Tractor Manager	Coil Driver Card CD3
273.	JPS13-1	+12VF	+12VF from the Tractor Manager via Fuse FU17. This voltage is present when the Key Switch (S1) is closed. There is no harness wiring connected at this point.	+10.8VDC to +13VDC	Tractor Manager	Optional Rail Guidance Switch (S15)
274.	JPS13-2	RAIL_SEN	RAIL_SEN is an input voltage to the Tractor Manager/VFC from Rail Sense Switch (S15) when the truck is equipped for operation in rail guided aisles. RAIL_SEN is switched to AGND by a spring loaded guide roller wheel when it contacts the aisle guide rail. This closure is communicated by the TM/VFC to the Carriage Manager, and an alarm is sounded to indicate the truck has entered an aisle.	Switch S15 open: +10.8VDC to +13VDC Switch S15 closed: < +1VDC	Rail Guidance Switch (S15)	TM/VFC
275.	JPS13-3	AGND	AGND supplies a negative reference (B–) for the optional Rail Sense Switch (S15). It is connected on the Tractor Manager through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC TP4 (B– tie point).	Tractor Manager	Optional Rail Guidance Switch (S15)

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
276.	JPS14-1	B–PC	B–PC is one of the two B– lines that provide a return path (ground) through FU12 for circuits powered by B+PC, and through FU15 for circuits powered by B+SPARE to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	B–	Tractor Manager
277.	JPS14-2	B–PC	B–PC is one of the two B– lines that provide a return path (ground) through FU12 for circuits powered by B+PC, and through FU15 for circuits powered by B+SPARE to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	B–	Tractor Manager
278.	JPS14-3	B–	B– is one of the two B– lines that provide an Analog Ground (AGND) return path through FU13 for circuits powered by +12VF on the Tractor Manager and +12V on the Carriage Manager to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	B–	Tractor Manager
279.	JPS14-4	B–	B– is one of the two B– lines that provide an Analog Ground (AGND) return path through FU13 for circuits powered by +12VF on the Tractor Manager and +12V on the Carriage Manager to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	B–	Tractor Manager
280.	JPS14-5	B+ESTOP	B+ESTOP is B+ provided through the normally closed EPO Switch (S21) when the Key Switch (S1) is closed, through the Carriage Manager, over-the-mast cables, and through the Tractor Manager to the PC1 Contactor coil at PC1-X.	B+	EPO Switch, Carriage Manager, and Tractor Manager	PC1 Contactor Coil

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
281.	JPS14-6	PC1 SENSE	PC1 SENSE is B+ provided to the TM/VFC when the PC1 Contactor tips are closed. It is used by the TM/VFC to verify the correct state of the PC1 Contactor and initiate PC1 fault codes.	PC1 tips closed: B+ from PC1-1 PC1 tips open: Approx. < 0.5VDC	PC1 Contactor	TM/VFC
282.	JPS14-7	P SENSE	P SENSE is B+ provided through FU6 at tie point TP3 to the TM/VFC when the Pump Contactor tips are closed. The TM/VFC uses this voltage to determine the state of the P Contactor tips to verify they are in the correct state and to initiate P contactor fault codes. On trucks with no dump valve (SOL99), it is also used to detect when the lift motor stops rotating after the Pump Contactor tips are opened after a lift function. This information is used for correct sequencing of the L/L and L/H Solenoid Valves.	P tips closed: B+ from P-2 P tips open: Approx. < 0.5VDC	Pump Contactor and Lift Motor	TM/VFC
283.	JPS14-8	PC2 SENSE	PC2 SENSE is B+ provided to the TM/VFC when the PC2 Contactor tips are closed. It is used by the TM/VFC to verify the correct state of the PC2 Contactor and to initiate PC2 fault codes.	PC2 tips closed: Measure B+ from P-1 PC2 tips open: Approx. +5VDC	PC2 Contactor	TM/VFC
284.	JPS14-9	Q1C SENSE	Q1C SENSE monitors the voltage at the collector of the main transistor Q1. This voltage is supplied through the drive motor armature circuit. It is used by the TM/VFC to verify the correct operation of Q1. When the PC1 tips are closed and there is no travel request, the voltage should be B+. As the speed of the drive motor increases, the voltage at Q1-C decreases.	Measure B+ from Q1-C or JPS14-9 to TP6 on Tractor Manager with PC tips closed. Creed speed: Approx. +42VDC Full speed: Approx. +20VDC	Drive Motor armature circuit	TM/VFC
285.	JPS14-10	B+PC1	B+PC1 is B+ to the Tractor Manager when the PC1 Contactor tips are closed. This voltage supplies FU11 and supplies the brake and PLUG Contactor as B+PC1F.	B+	PC1-1	All B+PC1F
286.	JPS14-11	B+PC1	B+PC1 is B+ to the Tractor Manager when the PC1 Contactor tips are closed. This voltage supplies FU11 and supplies the brake and PLUG Contactor as B+PC1F.	B+	PC1-1	All B+PC1F

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
287.	JPS14-12	B+	B+ from PC1-2 is present when the battery is plugged in. It is fused by FU14 and then supplied as B+F through the Tractor Manager, line filter, over-the-mast cables, and Carriage Manager to the Key Switch (S1). It is also fused by FU16 and then supplied as B+SPARE through the Tractor Manager, Suppressor 6, JP61, line filter, over-the-mast cables, and Carriage Manager to power lights and fans and other optional items at JPC19.	B+	PC1-2	Tractor Manager
288.	JPS14-13	B+	B+ from PC1-2 is present when the battery is plugged in. It is fused by FU14 and then supplied as B+F through the Tractor Manager, Suppressor 6, line filter, over-the-mast cables, and Carriage Manager to the Key Switch (S1). It is also fused by FU16 and then supplied as B+SPARE through the Tractor Manager, Suppressor 6, JP61, line filter, over-the-mast cables, and Carriage Manager to power lights and fans and other optional items at JPC19.	B+	PC1-2	Tractor Manager
289.	JPS14-14	B+PC1F	B+PC1F is B+ supplied to the Plug Contactor coil at (PLUG-X) through Fuse FU11 whenever the PC1 Contactor tips are closed.	B+	FU11	Plug Contactor Coil
290.	JPS14-16	PLUG CNTR	PLUG CNTR is the negative path (B–) for the Plug Contactor coil. It is connected through the Tractor Manager to the Coil Driver Card (CD5) at JPS11-6 (PLUG CNTR). PLUG CNTR is switched to B– through the Coil Driver Card (CD5). The red LED IL8 on the Tractor Manager is lit when there is an input applied to JPS11-1 (PLUG CONTROL).	Deenergized: B+ Energized: Approx. +24VDC	Coil Driver Card (CD5)	Plug Contactor Coil
291.	JPS14-18	PC1 CNTR	PC1 CNTR is the negative path (B–) for the PC1 Contactor coil. It is connected through the Tractor Manager to the Coil Driver Card (CD5) at JPS11-8 (PC1 CNTR). PC1 CNTR is switched to B– through the Coil Driver Card (CD5). The red LED IL9 on the Tractor Manager is lit when there is an input applied to JPS11-3 (PC1 CONTROL).	Deenergized: B+ Energized: Approx. +24VDC	Coil Driver Card (CD5)	PC1 Contactor Coil
292.	JPS15-1	SPARE INP. LIMIT	SPARE INP. LIMIT is an input point available for an undetermined spare limit switch.	Approx. +11VDC	Tractor Manager	
293.	JPS15-2	+12VF	+12VF from the Tractor Manager via Fuse FU17. This voltage is present when the Key Switch (S1) is closed.	+10.8VDC to +13VDC	Tractor Manager	

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
294.	JPS15-3	AGND	AGND (Analog Ground) is available as a negative reference (B–) for an undetermined spare limit switch. It is connected on the Tractor Manager through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC TP4 (B– tie point).	Tractor Manager	
295.	JPS15-4	PGND	PGND (Power Ground) is connected on the Tractor Manager through Fuse FU12 to JPS14-1 & 2, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC TP4 (B– tie point).	Tractor Manager	
296.	JPS15-5	ALARM (24V)	ALARM (24V) is from B+FIL and is the B+ supply voltage to the optional Alarm Relay coil (K2). This is a filtered B+ voltage provided by the Tractor Manager power supply.	B+ when the Key Switch (S1) is closed.	Tractor Manager	Optional Alarm Relay (K2)
297.	JPS15-6	ALARM ENABLE	ALARM ENABLE is the negative path (B–) for the optional Alarm Relay coil (K2). It is switched to B– by the VFC Card through a Coil Driver internal to the Tractor Manager. This control voltage is present when Travel/Lift/Lower are functioning and the option is activated.	Relay coil deenergized: B+ Energized: 11VDC to 14VDC	Tractor Manager	Optional Alarm Relay (K2)
298.	JPS16-1	+12VF	+12VF is supplied to the optional switch(es) from the 12 volt power supply on the Tractor Manager via Fuse FU17 when the Key Switch (S1) is closed.	+10.8VDC to +13VDC	Tractor Manager	Optional Travel Cut-Out Device(s), for example: Battery Gate Switches (S57/S58)
299.	JPS16-2	INPUT	INPUT is an input voltage to the Tractor Manager/VFC from the optional travel cut-out device(s), for example battery gate switch(es). One proximity switch or two proximity switches wired in series can be used to detect that the metal battery gate(s) are correctly installed. Travel is inhibited when the switch(es) do not detect the presence of metal.	Battery gate out: +10.8VDC to +13VDC Battery gates in: < 1.0VDC	Optional Switch(es)	TM/VFC and Carriage Manager

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
300.	JPS16-3	AGND	AGND supplies a negative reference (B–) for the optional travel cut-out device(s). It is connected on the Tractor Manager through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC TP4 (B– tie point).	Tractor Manager	Optional Travel Cut-Out Device(s)
301.	JPS17-1	_____ RESET	Not used			
302.	JPS17-2	PRXD	Not used			
303.	JPS17-3	PTXD	Not used			
304.	JPS17-4	N/C	+12VF from the Tractor Manager via Fuse FU17. This voltage is present when the Key Switch (S1) is closed. The voltage at this point is not used on the Steer Manager.	+10.8VDC to 13VDC with Key Switch (S1) closed	Tractor Manager	None
305.	JPS17-5	AGND	AGND (Analog Ground) is the negative reference (B–) for some of the circuits on the Steer Manager. It is connected on the Tractor Manager through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-3 (B+) to verify connections. Then check for < +0.5VDC TP4 (B– tie point).	Tractor Manager	Electric Steer Manager
306.	JPS17-6	BUS+	This wire carries the positive component of the digital communications between the ESM and the other managers on the communications bus. Measuring voltage on this wire provides no usable information.	Not usable	All Managers on the BUS	All Managers on the BUS
307.	JPS17-7	BUS–	This wire carries the negative component of the digital communications between the ESM and the other managers on the communications bus. Measuring voltage on this wire provides no usable information.	Not usable	All Managers on the BUS	All Managers on the BUS
308.	JPS17-8	PGND	Not used on the Steer Manager.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC TP4 (B– tie point).		

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
309.	JPS17-9	+12VF	+12VF is supplied to some circuitry on the ESM and other components connected to the ESM from the12 volt power supply on the Tractor Manager via Fuse FU17. This voltage is present, lighting a green LED (IL1), when the Key Switch (S1) is closed.	+10.8VDC to +13VDC	Tractor Manager	Electric Steer Manager
310.	JPS-18-1	CHAN B IN	CHAN B IN is generated whenever there is movement of the sensor disc over the Speed Feedback Proximity Sensor. It is a square wave voltage generated by the Speed Feedback Proximity Sensor when it detects the metal spokes in the sensor disc. This voltage is high (> 7VDC) when not sensing metal and low (< 1VDC) when sensing metal. The frequency of the voltage varies directly with the speed of the drive motor. CHAN B IN is an identical input at CHAN A IN. The TM/VFC calculates the quadrature phase relationship (travel direction) between the Channel A & B inputs and their frequency (speed) and communicates this information to the Carriage and Steer Managers.	> +5VDC when drive motor is turning	Speed Feedback Proximity Sensor	TM/VFC
311.	JPS18-2	CHAN A IN	CHAN A IN is generated whenever there is movement of the sensor disc over the Speed Feedback Proximity Sensor. It is a square wave voltage generated by the Speed Feedback Proximity Sensor when it detects the metal spokes in the sensor disc. This voltage is high (> 7VDC) when not sensing metal and low (< 1VDC) when sensing metal. The frequency of the voltage varies directly with the speed of the Drive Motor. CHAN A IN is an identical input at CHAN B IN. The TM/VFC calculates the quadrature phase relationship (travel direction) between the Channel A & B inputs and their frequency (speed) and communicates this information to the Carriage and Steer Managers.	> +5VDC when drive motor is turning	Speed Feedback Proximity Sensor	TM/VFC
312.	JPS18-3	+12VF	+12VF is supplied to the Speed Feedback Proximity Sensor from the 12 volt power supply on the Tractor Manager via Fuse FU17. This voltage is present when the Key Switch (S1) is closed.	+10.8VDC to +13VDC	Tractor Manager	Speed Feedback Proximity Sensor
313.	JPS19-1	B+KEY	B+KEY is B+ provided to the Horn Suppressor connector HSUP-2 via the horn wiring harness splice H-1(+). It is supplied from the Key Switch (S1) through the Carriage Manager, over-the-mast cables, line filter, JP61, and the Tractor Manager.	B+	Key Switch, Carriage Manager, and Tractor Manager	Horn

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
314.	JPS19-2	B+ESTOP	B+ESTOP is B+ provided through the normally closed EPO Switch (S21) when Key Switch (S1) is closed, through the Carriage Manager, over-the-mast cables, and through the Tractor Manager to the Main L/H Solenoid, the L/L Solenoid, and PC2 Solenoid, when both the Key Switch (S1) and the EPO Switch (S21) are closed.	B+	EPO Switch, Carriage Manager, and Tractor Manager	Main L/H (SOL1), L/L (SOL4), and PC2 Solenoid coils
315.	JPS19-3	MAIN L/H SOL	MAIN L/H SOL is the negative path for the Main Load Holding Solenoid (SOL1). It is connected through the Tractor Manager to L/H Solenoid at JP11-10 and is switched to B– (ground) through the L/H Solenoid Coil Driver (CD5). It lights the red LED IL5 on the Tractor Manager when L/H Control is present at JPS11-5.	Deenergized: B+ Energized: Approx. +24VDC	Coil Driver Card	Main L/H Sol (SOL1)
316.	JPS19-4	L/L SOL	L/L SOL is the negative path for the Lift/Lower Proportional Solenoid Valve. It is connected through the Tractor Manager to L/L Solenoid (SOL4) at JP11-9 and is switched to B– (ground) through the L/L Solenoid Coil Driver (CD5). It lights the red LED IL6 on the Tractor Manager when L/L Control is present at JPS11-4. The brightness of IL6 varies with the amount of control voltage being applied to the L/L Solenoid coil.	Voltage reading varies with battery condition and collapsed height. Creep lift: Approx. 35VDC Full lift: Approx. 42VDC Creep lower: Approx. 45VDC Full lower: Approx. 28VDC	Coil Driver Card	L/L Solenoid Coil (SOL4)
317.	JPS19-5	BRAKE	BRAKE is the negative path (B–) for the electric brake. BRAKE is connected through the Tractor Manager to brake at JPS11-7, to the Coil Driver Card. It is switched to B– through the brake Coil Driver (CD5) to B– (ground). It lights the red LED IL7 on the Tractor Manager when BRAKE CONTROL is present at JPS11-2. The voltage across the brake coil is determined by the battery voltage of the truck, as set by the position of the shunt jumper on either E2 or E3 on the Tractor Manager. For 48 volt operation, the shunt jumper is located at E2.	Brake coil deenergized: B+ Brake coil energized: < +1VDC	Coil Driver Card	Brake

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
318.	JPS19-6	TRAC TEMP SENSOR	TRAC TEMP SENSOR is an analog DC voltage that varies as temperature changes the resistance of the Drive Motor Temperature Sensor.	70 deg. F.: Approx. +3VDC Overheating: Approx. +4.4VDC Open circuit: > +9VDC	Tractor Manager	TM/VFC
319.	JPS19-7	PGND	PGND (Power Ground) is the B– return for the Drive Motor Temperature Sensor. It is connected on the Tractor Manager through Fuse FU12 to JPS14-1 & 2, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC TP4 (B– tie point).	Tractor Manager	Drive Motor Temperature Sensor
320.	JPS19-8	B+FIL	B+FIL is the B+ supply voltage to the Horn Relay coil. This is a filtered B+ voltage provided by the Tractor Manager power supply.	Slightly < B+ when the Key Switch (S1) is closed	Tractor Manager	Horn Relay
321.	JPS19-9	HORN ENABLE	HORN ENABLE is the negative path (B–) for the Horn Relay coil. Horn Relay is switched to B– through a Coil Driver internal to the Tractor Manager by a voltage supplied from the VFC Card. This voltage is present when the Carriage Manager communicates to the VFC that the Horn Switch (S3) is activated.	ON: 33VDC OFF: <2VDC wrt B+	Tractor Manager	Horn Relay
322.	JPS19-10	B+PC1F	B+PC1F is B+ is supplied to the brake coil at (BR-X) through Fuse FU11 whenever the PC1 Contactor tips are closed.	B+	FU11	Brake
323.	JPS20-1	B+KEY	B+KEY is B+ supplied to the Warning Light when the Key Switch (S1) is closed.	B+	Tractor Manager	Warning Light
324.	JPS20-2	PGND	PGND (Power Ground) is the B– return for the Warning Light. It is connected on the Tractor Manager through Fuse FU12 to JPS14-1 & 2, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC TP4 (B– tie point).	Tractor Manager	Warning Light
325.	JPS21-1	+12VF	+12VF is supplied to the circuitry on the PC2 Coil Driver Card (CD1) from the 12 volt power supply on the Tractor Manager via Fuse FU17. This voltage is present when the Key Switch (S1) is closed.	+10.8 VDC to +13.0 VDC	Tractor Manager	PC2 Coil Driver Card

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
326.	JPS21-2	+12VF	+12VF is supplied to the circuitry on the PC2 Coil Driver Card (CD1) from the 12 volt power supply on the Tractor Manager via Fuse FU17. This voltage is present when the Key Switch (S1) is closed.	+10.8 VDC to +13.0 VDC	Tractor Manager	PC2 Coil Driver Card
327.	JPS21-3	PC2 CONTROL	PC2 CONTROL is a chopped (PWM) control voltage sent from the VFC through the Tractor Manager to the Coil Driver Card (CD1) to control the PC2 contactor Coil Driver. This voltage is generated by the VFC card whenever B+Key is present and no error conditions exist to prevent the contactor from closing.	Coil deenergized: < +1VDC Energized: > +10VDC for approx. 1 second then dropping to between +5VDC and +8VDC	TM/VFC	PC2 Coil Driver Card
328.	JPS21-4	B+ESTOP	B+ESTOP is B+ provided through the normally closed EPO Switch (S21) when Key Switch (S1) is closed, through the Carriage Manager, over-the-mast cables, and through the Tractor Manager to the PC Coil Driver Card (CD1). It supplies the B+ path for the PC2 Contactor coil suppressor circuit.		EPO Switch, Carriage Manager and Tractor Manager	PC2 Coil Driver Card
329.	JPS21-5	PC2 CNTR	PC2 CNTR is the negative path (B–) for the PC2 contactor coil. It is connected through the Tractor Manager and JPS22-1 to the PC2 Contactor coil at PC2-Y. It is switched to B– through the Coil Driver Card (CD1), lighting the red LED IL10 on the Tractor Manager when there is an input applied to JPS21-3 (PC2 CONTROL).	Deenergized: B+ Energized: Approx. +24VDC	Coil Driver Card (CD1)	PC2 Contactor Coil
330.	JPS21-6	PGND	PGND (Power Ground) is the B– return for the PC2 Coil Driver Card. It is switched by the Coil Driver on the Coil Driver Card (CD1). It is connected on the Tractor Manager through Fuse FU12 to JPS14-1 & 2 and on to the B– tie point at TP4 in the tractor electrical compartment.	Deenergized: B+ Energized: Approx. +24VDC	Tractor Manager	PC2 Contactor Coil
331.	JPS21-7	N/C	Not connected			
332.	JPS21-8	N/C	Not connected			
333.	JPS22-1	PC2 CNTR	PC2 CNTR is the negative path (B–) for the PC2 contactor coil. It is connected through the Tractor Manager to the Coil Driver Card (CD1) at JPS21-5 (PC2 CNTR). PC2 CNTR is switched to B– through the Coil Driver Card (CD1), lighting the red LED IL10 on the Tractor Manager when there is an input applied to JPS21-3 (PC2 CONTROL).	Deenergized: B+ Energized: Approx. +24VDC	Coil Driver Card (CD1)	PC2 Contactor Coil

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
334.	JPS22-2	B+ESTOP	B+ESTOP is B+ provided through the normally closed EPO Switch (S21) when Key Switch (S1) is closed, through the Carriage Manager, over-the-mast cables, and through the Tractor Manager to JPS46-1 to the Auxiliary Contactor coil at Aux-Y and the Contactor Interface Module at JPCM1-6.	B+	EPO Switch, Carriage Manager, and Tractor Manager	Auxiliary Contactor Coil
335.	JPS22-3	N/C	No Connection			
336.	JPS25-1	+12VF	No mast cable wire is connected to this point.	NC	NC	NC
337.	JPS25-2	BUS–	BUS– is the wire carrying the negative component of the digital communications between the Carriage Manager and the other managers on the tractor side of the communications bus.	Not usable	All Managers on the BUS	All Managers on the BUS
338.	JPS25-3	BUS+	BUS+ is the wire carrying the positive component of the digital communications between the Carriage Manager and the other managers on the tractor side of the communications bus.	Not usable	All Managers on the BUS	All Managers on the BUS
339.	JPS25-4	BRAKE CONTROL	BRAKE CONTROL is an output voltage from the Tractor Manager sent over a mast cable to the Carriage Manager. It indicates the status of the Brake Deadman Switch (S2), which pulls the voltage low when closed. This change is seen on the Tractor Manager, and the VFC communicates back to the Carriage Manager that it has received this input. The VFC and Carriage Manager both use this information, in conjunction with a travel request, to release the brake. Either causes the brake to apply when it detects a fault, regardless of the position of the deadman switches.	Deadman UP: >9.5VDC Deadman DOWN: <0.5VDC	Tractor Manager	TM/VFC
340.	JPS25-5	CARRIAGE DEADMAN	CARRIAGE DEADMAN is an output voltage from the Tractor Manager sent over a mast cable to the Carriage Manager. It indicates the status of the Carriage Deadman switch (S23), which pulls the voltage low when closed. This change is seen on the Tractor Manager, and the VFC communicates back to the Carriage Manager that it has received this input. The VFC and Carriage Manager both use this information, in conjunction with a travel request, to release the brake. Either causes the brake to apply when it detects a fault, regardless of the position of the deadman switches.	Deadman UP: >9.5VDC Deadman DOWN: <1VDC	Tractor Manager	TM/VFC

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
341.	JPS25-6	AGND	AGND (Analog Ground) is the negative reference (B–) for some of the circuits on the Carriage Manager. It is connected on the Tractor Manager through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-3 (B+) to verify connections. Then check for < +0.5VDC TP4 (B– tie point).	Tractor Manager	Carriage Manager
342.	JPS26-1	B+ESTOP	B+ESTOP is B+ provided through the normally closed EPO Switch (S21) when the Key Switch (S1) is closed, through the Carriage Manager, over-the-mast cables, line filter, and through the Tractor Manager, where it is distributed to all the other B+ESTOP connections on the Tractor Manager.	B+	EPO Switch and Carriage Manager	Tractor Manager
343.	JPS26-2	B–F (SPARE)	B–F (SPARE) is the B– (ground) for the Spare Power connector (JPC19) on the Carriage Manager. It supplies B– for optional lights, fan, RF unit, and for heaters on cold storage trucks. It is fused through FU15 on the Tractor Manager to JPS14-1& 2, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC TP4 (B– tie point).	Tractor Manager	Lights, fan, and so forth
344.	JPS26-3	B+F (SPARE)	B+F (SPARE) is the B+ supply for the Spare Power connector (JPC19) on the Carriage Manager when the battery is plugged in. It provides B+ for optional lights, fan, RF unit, and for heaters on cold storage trucks. It is fused through FU16 on the Tractor Manager to JPS14-12 & 13, and on to the B+ tie point at PC1-2 in the tractor electrical compartment.	B+	Tractor Manager	Lights, fan, and so forth
345.	JPS26-4	B–F	B–F is the B– (ground) for the Carriage Manager Coil Driver circuitry. It is fused through FU12 on the Tractor Manager to JPS14-1 & 2, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC TP4 (B– tie point).	Tractor Manager	Carriage Manager

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
346.	JPS26-6	B+KEY	B+KEY is B+ provided to the Tractor Manager when the Key Switch (S1) is closed. It is supplied from the Key Switch through the Carriage Manager, over-the-mast cables, line filter, JP61, and the Tractor Manager, where it is distributed to all the other B+KEY connections on the Tractor Manager.	B+	Carriage Manager	Tractor Manager
347.	JPS26-8	B+F	B+F is the main B+ supply to the Carriage Manager and is present when the battery is plugged in. It is fused by FU14 and supplied through the Tractor Manager, JP61, line filter, over-the-mast cables, and Carriage Manager to the Key Switch (S1).	B+	Tractor Manager	Carriage Manager
348.	JPS28-1	SENSOR2	SENSOR2 is an input voltage to the TM/VFC. It is generated by either S47A or S47B when one or both of them detect the presence of a floor magnet. SENSOR2 is used along with SENSOR1 (JPS6-1) to determine if the truck is in or out of the aisle. This information is communicated to the Carriage Manager, which controls travel speed based on truck location and the position of the AUTO/MAN switch.	Magnet not sensed: +10.8VDC to +13VDC Magnet sensed: < +1VDC for 0.1sec, then return to +10.8VDC to +13VDC.	End-of-Aisle Sensor (S47A/B)	TM/VFC
349.	JPS28-2	+VSENSOR2	+VSENSOR2 supplies working voltage to the optional End-of-Aisle Sensor (S47A) at S47A-3. It is then routed through the switch module to S47A-4 to S47B-3 to power that switch module also. S47A and S47B comprise SENSOR2. +VSENSOR is generated by a separate 12 volt regulator on the Tractor Manager that is powered by +12VF Fuse FU17. This voltage is present when the Key Switch (S1) is closed.	Approx. +8VDC	Tractor Manager	TM/VFC
350.	JPS28-3	AGND	AGND (Analog Ground) supplies a negative reference (B–) to the optional End-of-Aisle Sensor (S47B) at S47B-8. It is then routed through the switch module to S46B-7 to S46A-8. It is connected on the Tractor Manager through Fuse FU13 to JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment. There is no harness wiring connected at this point.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC TP4 (B– tie point).	Tractor Manager	End-of-Aisle Sensor (S47A/B)
351.	JPS29-1	LIFT SEL	LIFT SEL is the negative path for the Lift Select Solenoid (SOL3). It is switched to B– (ground) through the Lift Select Solenoid Coil Driver (CD3). The red LED IL1 on the CD3 Coil Driver Card is lit when LIFT SEL CONT is present at JPS12-1.	Deenergized: B+ Energized: Approx. +24VDC	Coil Driver Card (CD3)	Lift Select Solenoid (SOL3)

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
352.	JPS29-2	B+ESTOP	B+ESTOP is B+ provided through the normally closed EPO Switch (S21) when the Key Switch (S1) is closed, through the Carriage Manager, over-the-mast cables and through the Tractor Manager to the Coil Driver Card (CD3). It supplies the B+ path for the Lift Select (SOL3), P, Dump Valve (SOL99), and Mini L/H Solenoid (SOL2) coils, as well as their suppressor circuits and operating voltage for LEDs IL1, IL2, and IL3.	B+	Tractor Manager	
353.	JPS29-3	P	P is the negative path for the Pump Contactor (P) and the Dump Valve Solenoid (SOL99). It is switched to B– (ground) through the Pump Contactor (P) and the Dump Valve Solenoid (SOL99) Coil Driver (CD3). The red LED IL2 on the CD3 Coil Driver Card is lit when P CONTROL is present at JPS12-2.	Deenergized: B+ Energized: Approx. +24VDC	Coil Driver Card (CD3)	Pump Contactor (P) and the Dump Valve Solenoid (SOL99)
354.	JPS29-4	MINI L/H	MINI L/H is the negative path for the Mini Load Holding Solenoid (SOL2). It is switched to B– (ground) through the Mini Load Holding Solenoid Coil Driver (CD3). The red LED IL3 on the CD3 Coil Driver Card is lit when MINI L/H CONTROL is present at JPS12-3.	Deenergized: B+ Energized: Approx. +24VDC	Coil Driver Card (CD3)	Mini Load Holding Solenoid (SOL2)
355.	JPW1-1	RIGHT	RIGHT is a conditioned and amplified analog voltage input to the Wire Guidance Filter Card from the right sensor coil on the Load End Wire Guidance Sensor at JPT2-1. After being processed by the Filter Card, it is sent to the Electric Steer Manager, which uses it, in conjunction with the other wire guidance analog signal channels, to provide steering commands to keep the truck centered on the wire.	Measured with Oscilloscope Centered: 32 mVAC Left 1.5 in.: 76 mVAC Right 1.5 in.: 15 mVAC	Load End Wire Guidance Sensor	Wire Guidance Filter Card
356.	JPW1-2	NEAR WIRE	NEAR WIRE is a conditioned and amplified analog voltage input to the Wire Guidance Filter Card from the center pair of sensor coils on the Load End Wire Guidance Sensor at JPT2-2. After being processed by the Filter Card, it is sent to the Electric Steer Manager, which uses it to determine the presence of a guide wire and the direction of approach.	Measured with Oscilloscope Centered: 70 mVAC Left 1.5 in.: 100 mVAC Right 1.5 in.: 100 mVAC	Load End Wire Guidance Sensor	Wire Guidance Filter Card

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
357.	JPW1-3	LEFT	LEFT is a conditioned and amplified analog voltage input to the Wire Guidance Filter Card from the right sensor coil on the Load End Wire Guidance Sensor at JPT2-3. After being processed by the Filter Card, it is sent to the Electric Steer Manager, which uses it, in conjunction with the other wire guidance analog signal channels, to provide steering commands to keep the truck centered on the wire.	Measured with Oscilloscope Centered: 32 mVAC Left 1.5 in.: 15 mVAC Right 1.5 in.: 76 mVAC	Load End Wire Guidance Sensor	Wire Guidance Filter Card
358.	JPW1-5	L0	L0 is the least significant bit (LSB) of a 4 bit binary code input to the Load End Wire Guidance Sensor at JP1L-5. Together with the L1, L2, and L3 inputs, it is used to select the correct gain parameter for the wire guidance analog signal channels.	HIGH: > +7VDC LOW: < +1VDC	Wire Guidance Filter Card	Load End Wire Guidance Sensor
359.	JPW1-6	L1	L1 is the second bit of a 4 bit binary code input to the Load End Wire Guidance Sensor at JP1L-6. Together with the L0, L2, and L3 inputs, it is used to select the correct gain parameter for the wire guidance analog signal channels.	HIGH: > +7VDC LOW: < +1VDC	Wire Guidance Filter Card	Load End Wire Guidance Sensor
360.	JPW1-7	L2	L2 is the third bit of a 4 bit binary code input to the Load End Wire Guidance Sensor at JP1L-7. Together with the L0, L1, and L3 inputs, it is used to select the correct gain parameter for the wire guidance analog signal channels.	HIGH: > +7VDC LOW: < +1VDC	Wire Guidance Filter Card	Load End Wire Guidance Sensor
361.	JPW1-8	L3	L3 is the most significant bit (MSB) of a 4 bit binary code input to the Load End Wire Guidance Sensor at JP1L-8. Together with the L0, L1, and L2 inputs, it is used to select the correct gain parameter for the wire guidance analog signal channels.	HIGH: > +7VDC LOW: < +1VDC	Wire Guidance Filter Card	Load End Wire Guidance Sensor
362.	JPW1-13	AGND	AGND (Analog Ground) is the negative reference (B–) for the shield around the cable to the Load End Wire Guidance Sensor. The shield shunts currents generated by electrical noise and other undesirable sources to ground, thereby preventing them from interfering with the internal cable wiring. AGND is supplied through the Wire Guidance Filter Card, Electric Steer Manager to JPA2-5, where it is tied common to AGND, then through a molded cable assembly to JPS17-5, through the Tractor Manager, Fuse FU13, JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Tractor Manager	Load End Wire Guidance Sensor

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
363.	JPW1-14	AGND	AGND (Analog Ground) is the B– (ground) for the Load End Wire Guidance Sensor at JP1L-14. AGND is supplied through the Wire Guidance Filter Card, Electric Steer Manager to JPA2-5, then through a molded cable assembly to JPS17-5, through the Tractor Manager, Fuse FU13, JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Tractor Manager	Load End Wire Guidance Sensor
364.	JPW1-15	+12VF	+12VF is the working voltage for the Load End Wire Guidance Sensor at JP1L-15. It is supplied through the Wire Guidance Filter Card, Electric Steer Manager to JPA2-9, then through a molded cable assembly to JPS17-9 from the 12 volt power supply on the Tractor Manager via Fuse FU17. This voltage is present when the Key Switch (S1) is closed.	+10.8VDC to +13VDC	Tractor Manager	Load End Wire Guidance Sensor
365.	JPW2-1	RIGHT	RIGHT is a conditioned and amplified analog voltage input to the Wire Guidance Filter Card from the right sensor coil on the Tractor Wire Guidance Sensor at JPT1-1. After being processed by the Filter Card, it is sent to the Electric Steer Manager, which uses it, in conjunction with the other wire guidance analog signal channels, to provide steering commands to keep the truck centered on the wire.	Measured with Oscilloscope Centered: 32 mVAC Left 1.5 in.: 76 mVAC Right 1.5 in.: 15 mVAC	Tractor Wire Guidance Sensor	Wire Guidance Filter Card
366.	JPW2-2	NEAR WIRE	NEAR WIRE is a conditioned and amplified analog voltage input to the Wire Guidance Filter Card from the center pair of sensor coils on the Tractor Wire Guidance Sensor at JPT1-2. After being processed by the Filter Card, it is sent to the Electric Steer Manager, which uses it to determine the presence of a guide wire and the direction of approach.	Measured with Oscilloscope Centered: 70 mVAC Left 1.5 in.: 100 mVAC Right 1.5 in.: 100 mVAC	Tractor Wire Guidance Sensor	Wire Guidance Filter Card
367.	JPW2-3	LEFT	LEFT is a conditioned and amplified analog voltage input to the Wire Guidance Filter Card from the right sensor coil on the Tractor Wire Guidance Sensor at JPT1-3. After being processed by the Filter Card, it is sent to the Electric Steer Manager, which uses it, in conjunction with the other wire guidance analog signal channels, to provide steering commands to keep the truck centered on the wire.	Measured with Oscilloscope Centered: 32 mVAC Left 1.5 in.: 15 mVAC Right 1.5 in.: 76 mVAC	Tractor Wire Guidance Sensor	Wire Guidance Filter Card

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
368.	JPW2-5	T0	T0 is the least significant bit (LSB) of a 4 bit binary code input to the Tractor Wire Guidance Sensor at JPT1-5. Together with the T1, T2, and T3 inputs, it is used to select the correct gain parameter for the wire guidance analog signal channels.	HIGH: > +7VDC LOW: < +1VDC	Wire Guidance Filter Card	Tractor Wire Guidance Sensor
369.	JPW2-6	T1	T1 is the second bit of a 4 bit binary code input to the Tractor Wire Guidance Sensor at JPT1-6. Together with the T0, T2, and T3 inputs, it is used to select the correct gain parameter for the wire guidance analog signal channels.	HIGH: > +7VDC LOW: < +1VDC	Wire Guidance Filter Card	Tractor Wire Guidance Sensor
370.	JPW2-7	T2	T2 is the third bit of a 4 bit binary code input to the Tractor Wire Guidance Sensor at JPT1-7. Together with the T0, T1, and T3 inputs, it is used to select the correct gain parameter for the wire guidance analog signal channels.	HIGH: > +7VDC LOW: < +1VDC	Wire Guidance Filter Card	Tractor Wire Guidance Sensor
371.	JPW2-8	T3	T3 is the most significant bit (MSB) of a 4 bit binary code input to the Tractor Wire Guidance Sensor at JPT1-8. Together with the T0, T1, and T2 inputs, it is used to select the correct gain parameter for the wire guidance analog signal channels.	HIGH: > +7VDC LOW: < +1VDC	Wire Guidance Filter Card	Tractor Wire Guidance Sensor
372.	JPW2-13	AGND	AGND (Analog Ground) is the negative reference (B–) for the shield around the cable to the Tractor Wire Guidance Sensor. The shield shunts currents generated by electrical noise and other undesirable sources to ground, thereby preventing them from interfering with the internal cable wiring. AGND is supplied through the Wire Guidance Filter Card, Electric Steer Manager to JPA2-5, where it is tied common to AGND, then through a molded cable assembly to JPS17-5, through the Tractor Manager, Fuse FU13, JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for <+0.5VDC wrt TP4 (B– tie point).	Tractor Manager	Tractor Wire Guidance Sensor
373.	JPW2-14	AGND	AGND (Analog Ground) is the B– (ground) for the Tractor Wire Guidance Sensor at JP1T-14. AGND is supplied through the Wire Guidance Filter Card, Electric Steer Manager to JPA2-5, then through a molded cable assembly to JPS17-5, through the Tractor Manager, Fuse FU13, JPS14-3 & 4, and on to the B– tie point at TP4 in the tractor electrical compartment.	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5 VDC wrt TP4 (B– tie point).	Tractor Manager	Tractor Wire Guidance Sensor

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Pinout Matrix

Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
374.	JPW2-15	+12VF	+12VF is the working voltage for the Tractor Wire Guidance Sensor at JP1T-15. It is supplied through the Wire Guidance Filter Card, Electric Steer Manager to JPA2-9, then through a molded cable assembly to JPS17-9 from the 12 volt power supply on the Tractor Manager via Fuse FU17. This voltage is present when the Key Switch (S1) is closed.	+10.8VDC to +13VDC	Tractor Manager	Tractor Wire Guidance Sensor
375.	JPX1-2	OPTION INPUT	There is no wiring connection to this point.			
376.	JPX1-3	DGND	Not used	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	Carriage Manager	
377.	SMB–	SMB–	SMB– is B– (ground) supplied to the Electric Steer Manager from the B– tie point at TP4 in the tractor electrical compartment. It is routed through the Electric Steer Manager to provide B– to the Steer Motor (MS) Control Transistor Modules (TM3 and TM4).	Measure battery voltage to PC1-2 (B+) to verify connections. Then check for < +0.5VDC wrt TP4 (B– tie point).	TP4 (B– tie point)	Steer Motor (MS)
378.	SMB+	SMB+	SMB+ is B+ provided to the Electric Steer Manager through Fuse FU8 from TP7 (tie point) in the tractor electrical compartment when the PC1 Contactor tips are closed. It is routed through the Electric Steer Manager to supply the steer motor control Transistor Modules (TM3 and TM4).	PC1 Contactor tips closed: B+	FU8	Steer Motor (MS)
379.	SMTR1	SMTR1	SMTR1 is an output voltage to the steer motor (MS) from the steer motor control Transistor Modules (TM3 and TM4). The amplitude of this voltage depends on the speed of the steering request and its polarity depends on the direction requested.	At rest: Approx. +14VDC Steering CW: Approx. +2.7VDC Steering CCW: Approx. +9VDC	TM3 on Electric Steer Manager	Steer Motor (MS)

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Item	Connection	Function Description	Theory of Operations	Normal Level	Voltage Source	Voltage User
380.	SMTR2	SMTR2	SMTR2 is an output voltage to the steer motor (MS) from the steer motor control Transistor Modules (TM3 and TM4). The amplitude of this voltage depends on the speed of the steering request and its polarity depends on the direction requested.	At rest: Approx. +14VDC Steering CW: Approx. +2.7VDC Steering CCW: Approx. +9VDC	TM4 on Electric Steer Manager	Steer Motor (MS)

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Section A. Appendix

Lubrication Specification Chart

Table A-1. Lubrication Specification Chart

Approved Lubricants			
Where Used	**Type**	**Specification/Grade**	**Part Number**
Drive Unit Gear Case (all-weather) (-20°F to +120°F) (-29°C to +49°C)	Gear Lubricant	75W-90 Synthetic Gear Oil API Service Classification GL-5	990-655/001 (1 qt./0.9 liters) 990-655/003 (1 gal./3.8 liters)
Hydraulic Reservoir (Non-Cold Storage Trucks) (+50°F to +120°F) (+10°C to +49°C)	Hydraulic Fluid	ISO VG 46	990-616/04 (1 qt./0.9 liter) 990-616/01 (1 gal./3.8 liters) 990-616/02 (2 gal./7.6 liters) 990-616/03 (5 gal./18.9 liters)
Hydraulic Reservoir (In and Out of Freezer) (0°F to +50°F) (-18°C to +10°C)	Hydraulic Fluid	ISO VG 32	1017238
Hydraulic Reservoir (Confined to Freezer) (-20°F to 0°F) (-29°C to -18°C)	Hydraulic Fluid	MIL-H-5606E	990-618/TX1 (1 gal./3.8 liters) 990-618/01 (1 gal./3.8 liters)
Mast Uprights, Bearings, etc. (all-weather) (-20°F to +120°F) (-29°C to +49°C)	Grease	NLGI 2	1012992
Lift Chains	Teflon Grease	Aerosol	990-652/001 (spray)
Hydraulic Brake	Brake Fluid	SAE Standard J1705F Federal Motor Vehicle Standard No. 116, DOT-5	990-625/01 (1 gal./3.785 liters) 990-625/02 (1 qt./0.9 liter) 990-625/03 (1 pint/0.47 liter)

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Thread Adhesives, Sealants, and Lubricants

Table A-2. Thread Adhesives, Sealants, Lubricants

Application	**Raymond P/N**	***Loctite**** **Number/Color**
Thread-locking 1/4 in. and below	990-403	222/Purple
Thread-locking 1/4 to 3/4 in.	990-536	242/Blue
Thread-locking 1/4 to 3/4 in. contamination tolerant	990-462	243/Blue
Thread-locking 1 in. and under	990-544	271/Red
Thread-locking 1 in. and under, contamination tolerant	990-463	603/Green
Thread-locking 1 in. and over	990-571	277/Red
Thread-locking Cleaner	990-538	707
Thread-locking Primer	990-533	T747
Hydraulic Sealant	990-552	569
RTV Silicone Sealant	990-659	5900/Black
		Other Manufacturer designation
Molybdenum Anti-Seize Compound (Molykote)	990-638	/Silver
Corrosion Inhibitor Coating	990-644	
Cold Storage silicone sealing compound	990-445	

NOTE: * *Loctite* is a registered trademark of the Loctite Corporation. Brand endorsement is not implied here, but listed only as a commonly identified product.

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Torque Chart - Hydraulic Fittings

Table A-3. Torque Chart - Hydraulic Fittings

SAE Dash Size	Thread Size	JIC (37° Flare Thread)		SAE Straight Thread Steel Plugs			
				Hollow Hex Head Plug HP50N		Hex Head Plug P50N	
		Nm	ft. lb.	Nm	ft. lb.	Nm	ft. lb.
-2	5/16-24	4 ± 1	3 ± 1	4 ± 0.6	3 ± 0.5	10 ± 0.6	7.5 ± 0.5
-3	3/8-24	8 ± 1	6 ± 1	7 ± 0.6	5 ± 0.5	19 ± 1	14 ± 1
-4	7/16-20	16 ± 1	12 ± 1	15 ± 1	11 ± 1	24 ± 1	18 ± 1
-5	1/2-20	20 ± 1	15 ± 1	20 ± 1	15 ± 1	30 ± 1	22 ± 1
-6	9/16-18	28 ± 1	21 ± 1	24 ± 1	18 ± 1	37 ± 3	27 ± 2
-8	3/4-16	61 ± 3	45 ± 2	62 ± 3	46 ± 2	65 ± 3	48 ± 2
-10	7/8-14	81 ± 7	60 ± 5	102 ± 7	75 ± 5	122 ± 7	90 ± 5
-12	1 1/16-12	115 ± 7	85 ± 5	115 ± 7	85 ± 5	149 ± 7	110 ± 5
-14	1 3/16-12	142 ± 7	105 ± 5	176 ± 8	130 ± 6	197 ± 8	145 ± 6
-16	1 5/16-12	163 ± 7	120 ± 5	183 ± 8	135 ± 6	217 ± 8	160 ± 6
-20	1 5/8-12	230 ± 14	170 ± 10	305 ± 16	225 ± 12	305 ± 16	225 ± 12
-24	1 7/8-12	271 ± 20	200 ± 15	339 ± 16	250 ± 12	339 ± 16	250 ± 12
-32	2 1/2-12	366 ± 27	270 ± 20	441 ± 20	325 ± 15	441 ± 20	325 ± 15

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Torque Chart - Straight Thread Face Seal O-Rings

Table A-4. Torque Chart - Straight Thread Face Seal O-Rings

SAE Dash Size	Tube Size Thread Size	Nm	ft. lb.
-4	9/16-18	24 ± 1	18 ± 1
-6	11/16-18	37 ± 3	27 ± 2
-8	13/16-16	54 ± 3	40 ± 2
-10	1-14	85 ± 4	63 ± 3
-12	1 3/16-12	122 ± 5	90 ± 4
-14	1 5/16-32	129 ± 8	95 ± 6
-16	1 7/16-12	163 ± 11	120 ± 8
-20	1 11/16-12	190 ± 11	140 ± 8
-24	2-12	224 ± 11	165 ± 8
-32	2 1/2-12	488 ± 14	360 ± 10

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Torque Chart - Standard (Ferrous)

Table A-5. Torque Chart - Standard Ferrous

Grade Identification Marking	**None**					
Size	**SAE Grade 2 Bolts Tightening Torque**		**SAE Grade 5 Bolts Tightening Torque**		**SAE Grade 8 Bolts Tightening Torque**	
	Dry	**Oiled***	**Dry**	**Oiled***	**Dry**	**Oiled***
	in. lb.	**in. lb.**	**in. lb.**	**in. lb.**	**in. lb.**	**in. lb.**
4-40	5	4	8	6	12	9
4-48	6	5	9	7	13	10
6-32	10	8	16	12	23	17
8-32	19	14	30	22	41	31
8-36	20	15	31	23	43	32
10-24	27	21	43	32	60	45
10-32	31	23	49	36	68	51
1/4-20	66	49	96	75	144	108
1/4-28	78	56	120	86	168	120
	ft. lb.	**ft. lb.**	**ft. lb.**	**ft. lb.**	**ft. lb.**	**ft. lb.**
5/16-18	11	8	17	13	25	18
5/16-24	12	9	19	14	25	20
3/8-16	20	15	30	23	45	35
3/8-24	23	17	35	25	50	35
7/16-14	30	24	50	35	70	55
7/16-20	35	25	55	40	80	60
1/2-13	50	35	75	55	110	80
1/2-20	55	40	90	65	120	90
9/16-12	65	50	110	80	150	110
9/16-18	75	55	120	90	170	130
5/8-11	90	70	150	110	220	170
5/8-18	110	85	180	130	240	180

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Table A-5. Torque Chart - Standard Ferrous

Grade Identification Marking	**None**					
Size	**SAE Grade 2 Bolts Tightening Torque**		**SAE Grade 5 Bolts Tightening Torque**		**SAE Grade 8 Bolts Tightening Torque**	
	Dry	**Oiled***	**Dry**	**Oiled***	**Dry**	**Oiled***
	ft. lb.	**ft. lb.**	**ft. lb.**	**ft. lb.**	**ft. lb.**	**ft. lb.**
3/4-10	160	120	260	200	380	280
3/4-16	180	140	300	220	420	320
7/8-9	140	110	400	300	600	460
7/8-14	155	120	440	320	660	500
1-8	220	160	580	440	900	680
1-12	240	170	640	480	1000	740
1 1/8-7	300	220	800	600	1280	960
1 1/8-12	340	260	880	660	1440	1080
1 1/4-7	420	320	1120	840	1820	1360
1 1/4-12	460	360	1240	920	2000	1500
1 3/8-6	560	420	1460	1100	2380	1780
1 3/8-12	640	460	1680	1260	2720	2040
1 1/2-6	740	560	1940	1460	3160	2360
1 1/2-12	840	620	2200	1640	3560	2660

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Torque Chart - Standard (Brass)

Table A-6. Torque Chart - Standard (Brass)

Brass MS63 Standard Bolts, Coarse Thread		
Size	**Torque (with bolts oiled*)**	
	Nm	**in. lb.**
4-40	0.37	3.3
4-48	0.40	3.6
6-32	0.69	6.1
6-40	0.77	6.8
8-32	1.24	11
8-36	1.24	11
10-24	1.58	14
10-32	1.92	17
1/4-20	3.96	35
1/4-28	4.52	40
5/16-18	8.25	73
5/16-24	9.15	81
3/8-16	14.69	130
3/8-24	16.61	147

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Torque Chart - Metric

Table A-7. Torque Chart - Metric (Ferrous Bolts, Coarse Thread)

Ferrous Metric Bolts, Coarse Thread (The grade rating is stamped on the head of the bolt.)				
Diameter (in millimeters)	**Grade 8.8**		**Grade 10.9**	
	Torque (with bolts oiled*)		**Torque (with bolts oiled*)**	
	Nm	**ft. lb.**	**Nm**	**ft. lb.**
6	8.1	6	12.2	9
8	20.3	15	28.4	21
10	40.7	30	58.3	43
12	74.6	55	101.7	75
16	176.3	130	245.4	181
20	345.7	255	474.5	350
24	589.8	435	820.3	605

Table A-8. Torque Chart - Metric (Brass Bolts, Coarse Thread)

Brass MS63 Metric Bolts, Coarse Thread		
Diameter (in millimeters)	**Torque (with bolts oiled*)**	
	Nm	**in. lb.**
3	0.5	4.4
3.5	0.79	7.0
4	1.1	10
5	2.1	19
6	3.8	34
8	9	79
10	17	150

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Decimal Equivalent Chart

Table A-9. Decimal Equivalent Chart

4ths	8ths	16ths	32nds	64ths	To 3 Places	To 2 Places	MM Equivalent
				1/64	.016	.02	.397
			1/32		.031	.03	.794
				3/64	.047	.05	1.191
		1/16			.062	.06	1.587
				5/64	.078	.08	1.984
			3/32		.094	.09	2.381
				7/64	.109	.11	2.778
	1/8				.125	.12	3.175
				9/64	.141	.14	3.572
			5/32		.156	.16	3.969
				11/64	.172	.17	4.366
		3/16			.188	.19	4.762
				13/64	.203	.20	5.159
			7/32		.219	.22	5.556
				15/64	.234	.23	5.593
1/4					.250	.25	6.350
				17/64	.266	.27	6.747
			9/32		.281	.28	7.144
				19/64	.297	.30	7.540
		5/16			.312	.31	7.937
				21/64	.328	.33	8.334
			11/32		.344	.34	8.731
				23/64	.359	.36	9.128
	3/8				.375	.38	9.525
				25/64	.391	.39	9.922
			13/32		.406	.41	10.319
				27/64	.422	.42	10.716
		7/16			.438	.44	11.112

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Table A-9. Decimal Equivalent Chart

4ths	8ths	16ths	32nds	64ths	To 3 Places	To 2 Places	MM Equivalent
				29/64	.453	.45	11.509
			15/32		.469	.47	11.906
				31/64	.484	.48	12.303
1/2					.500	.50	12.700
				33/64	.516	.52	13.097
			17/32		.531	.53	13.494
				35/64	.547	.55	13.891
		9/16			.562	.56	14.288
				37/64	.578	.58	14.684
			19/32		.594	.59	15.081
				39/64	.609	.61	15.478
	5/8				.625	.62	15.875
				41/64	.641	.64	16.272
			21/32		.665	.66	16.669
				43/64	.672	.67	17.065
		11/16			.688	.69	17.462
				45/64	.703	.70	17.859
			23/32		.719	.72	18.256
				47/64	.734	.73	18.653
3/4					.750	.75	19.050
				49/64	.766	.77	19.447
			25/32		.781	.78	19.844
				51/64	.797	.80	20.241
		13/16			.812	.81	20.637
				53/64	.828	.83	21.034
			27/32		.844	.84	21.431
				55/64	.859	.86	21.828
	7/8				.875	.88	22.225
				57/64	.891	.89	22.622
			29/32		.906	.91	23.019

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Decimal Equivalent Chart

Table A-9. Decimal Equivalent Chart

4ths	8ths	16ths	32nds	64ths	To 3 Places	To 2 Places	MM Equivalent
				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

Table A-10. Standard/Metric Conversions

To Convert...	Multiply...
Inches to Millimeters	Inches x 25.4
Millimeters to Inches	Millimeters x 0.039
Inches to Centimeters	Inches x 2.54
Centimeters to Inches	Centimeters x 0.394
Feet to Meters	Feet x 0.305
Meters to Feet	Meters x 3.281
Yards to Meters	Yards x 0.914
Meters to Yards	Meters x 1.094
Miles to Kilometers	Miles x 1.609
Kilometers to Miles	Kilometers x 0.621
Square Inches to Square Centimeters	Square Inches x 6.452
Square Centimeters to Square Inches	Square Centimeters x 0.155
Square Feet to Square Meters	Square Feet x 0.093
Square Meters to Square Feet	Square Meters x 10.753
Square Yards to Square Meters	Square Yards x 0.836
Square Meters to Square Yards	Square Meters x 1.196
Pints to Liters	Pints x 0.473
Liters to Pints	Liters x 2.113
Quarts to Liters	Quarts x 0.946
Liters to Quarts	Liters x 1.057
Gallons to Liters	Gallons x 3.785
Liters to Gallons	Liters x 0.26
Miles per hour to kilometers per hour	Miles per hour x 1.609
Kilometers per hour to miles per hour	Kilometers per hour x 0.6214
Ounces to grams	Ounces x 28.35

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Standard/Metric Conversions

Table A-10. Standard/Metric Conversions

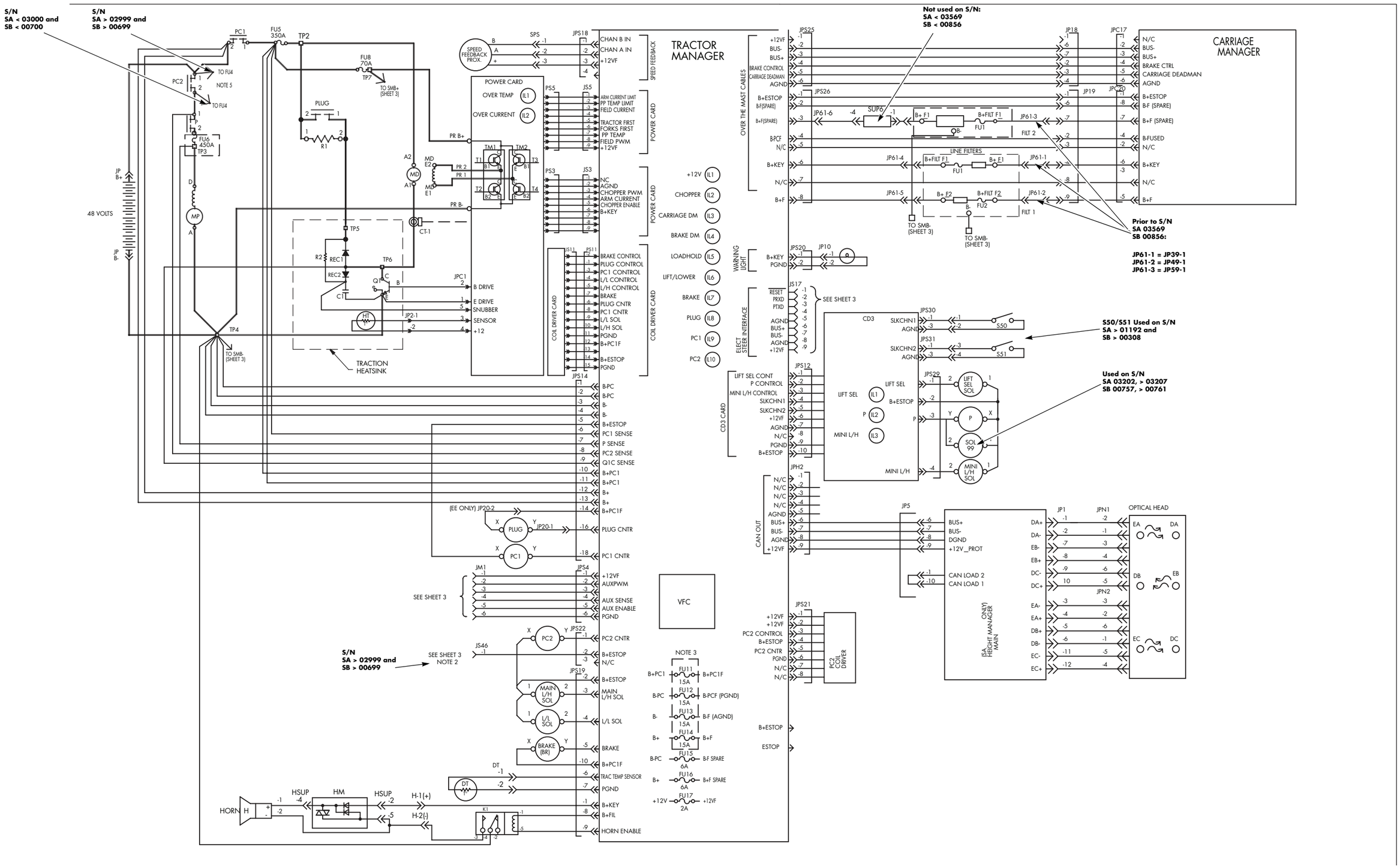
To Convert...	**Multiply...**
Grams to ounces	Ounces x 0.035
Ounces to kilograms	Ounces x 0.028
Kilograms to ounces	Kilograms x 35.27
Pounds to Kilograms	Pounds x 0.454
Kilograms to pounds	Kilograms x 2.2
Pounds per Square Inch (psi) to Kilopascals (kPa)	Pounds per Square Inch x 6.894
Kilopascals to Pounds per Square Inch	Kilopascals x 0.145
Pounds per Square Inch (psi) to Kilograms per square centimeter (kg/cm^2)	Pounds per Square Inch (psi) x 0.0704
Kilograms per square centimeter (kg/cm^2) to Pounds per Square Inch (psi)	Kilograms per square centimeter ($kg/cm^{2)}$ x 14.2
Inch Pounds (in. lb.) to Newton Meters (Nm)	Inch Pounds x 0.113
Newton Meters (Nm) to Inch Pounds (in. lb.)	Newton Meters x 8.85
Foot Pounds (ft. lb.) to Newton Meters (Nm)	Foot Pounds x 1.3568
Newton Meters (Nm) to Foot Pounds (ft. lb.)	Newton Meters x 0.737
Fahrenheit to Celsius	(°F - 32) x 0.555
Celsius to Fahrenheit	(°C x 1.8) + 32

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Schematics

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Tractor Manager

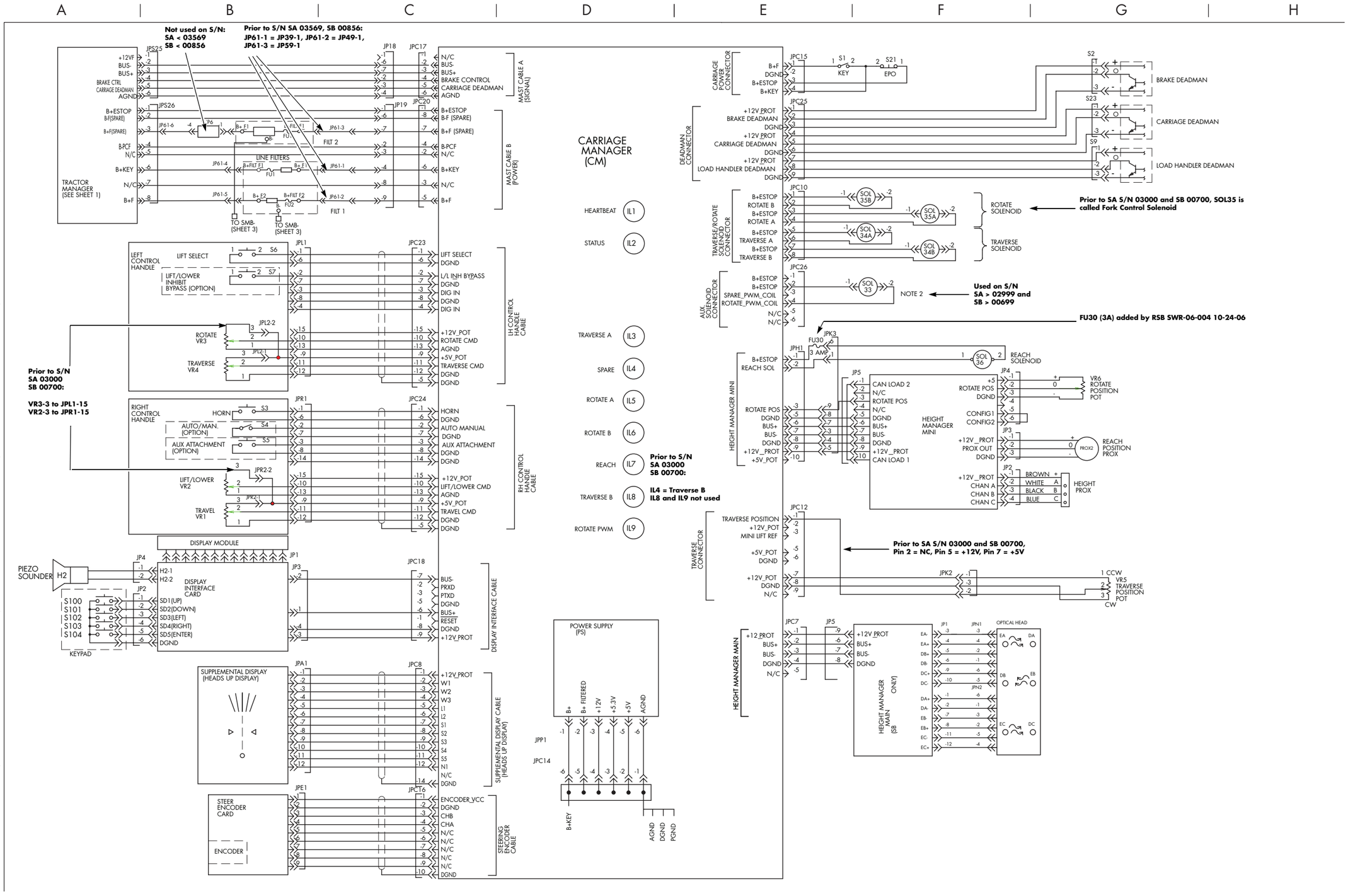


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Figure A-1. Tractor Manager (Elec. Schematic, Sheet 1 of 7)

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Carriage Manager

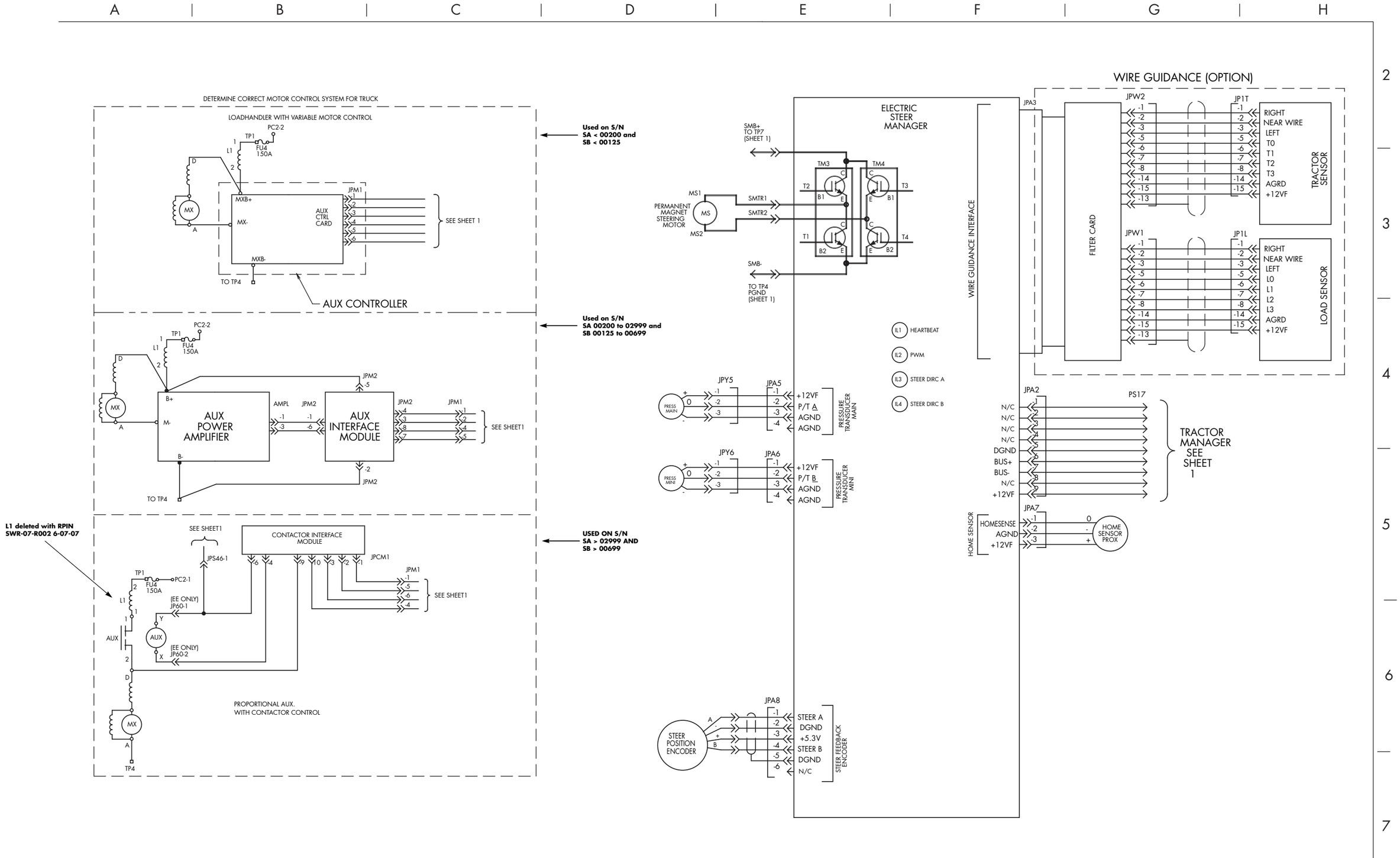


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Figure A-2. Carriage Manager (Elec. Schematic, Sheet 2 of 7)

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Auxiliary Motor Control and Electric Steer Manager

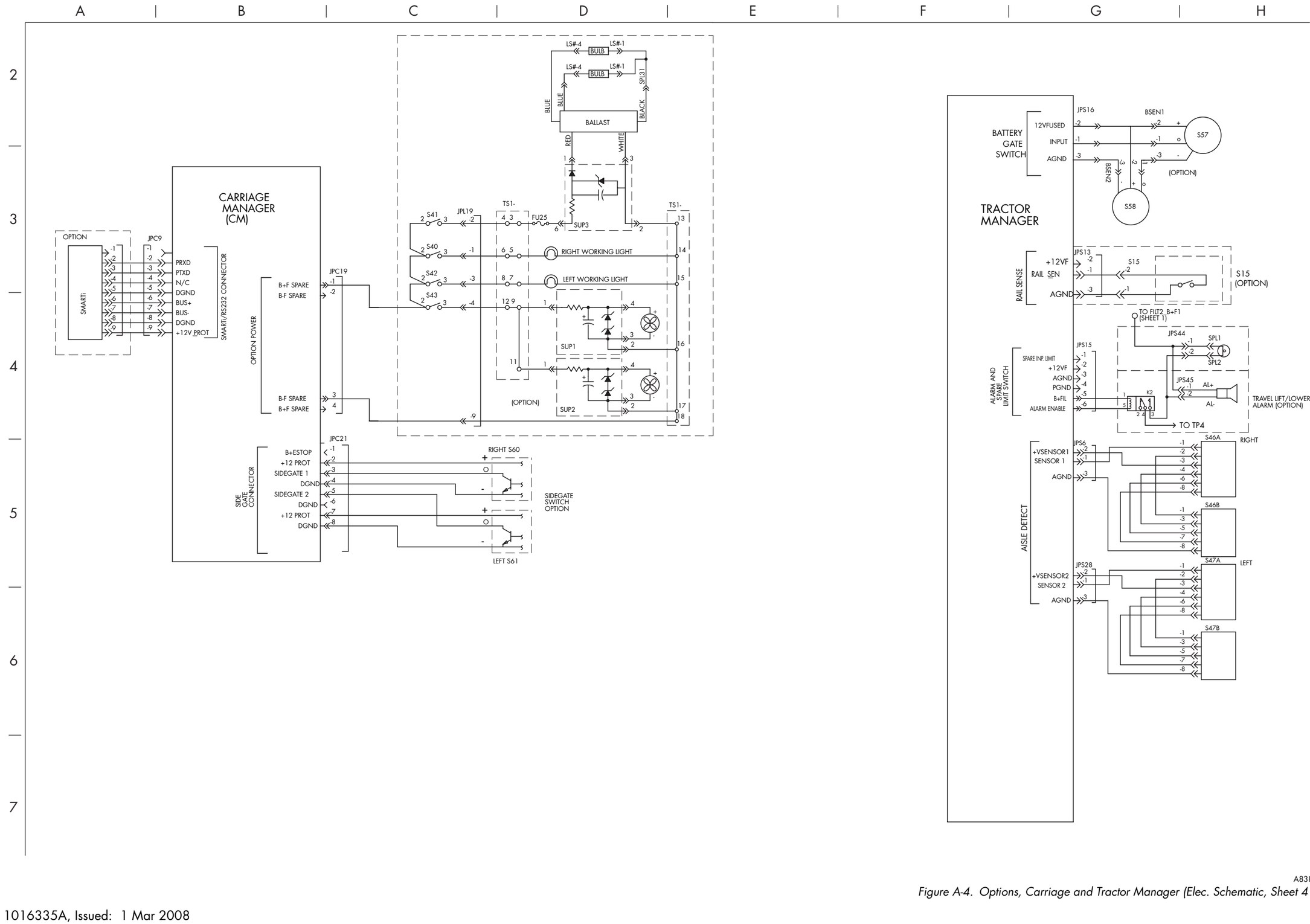


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Figure A-3. Auxiliary Motor Control and Electric Steer Manager (Elec. Schematic, Sheet 3 of 7)

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Options, Carriage and Tractor Manager

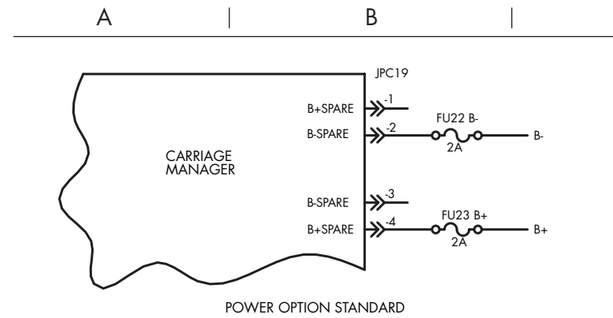


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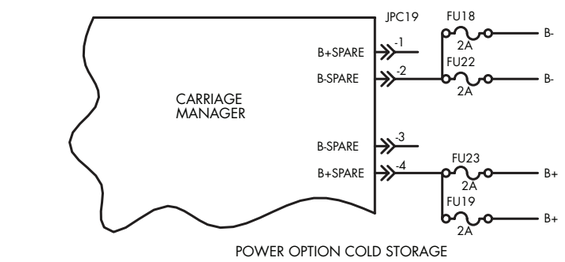
Figure A-4. Options, Carriage and Tractor Manager (Elec. Schematic, Sheet 4 of 7)

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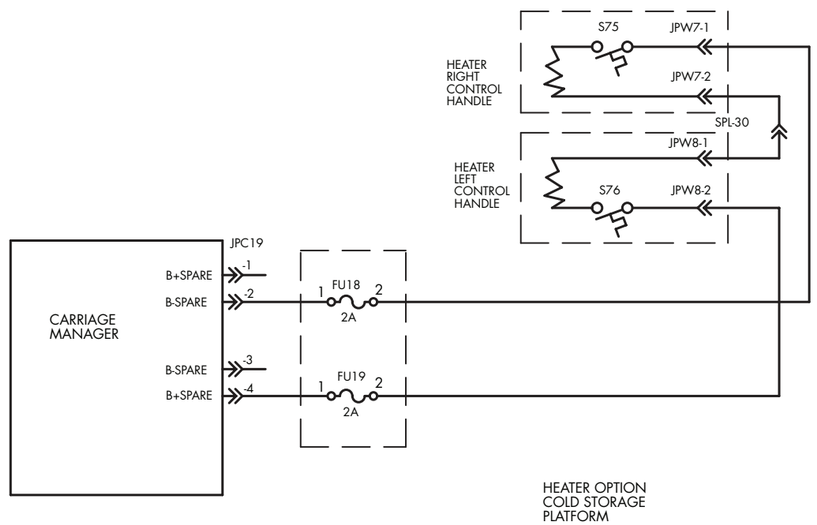
Options, Power and Cold Storage



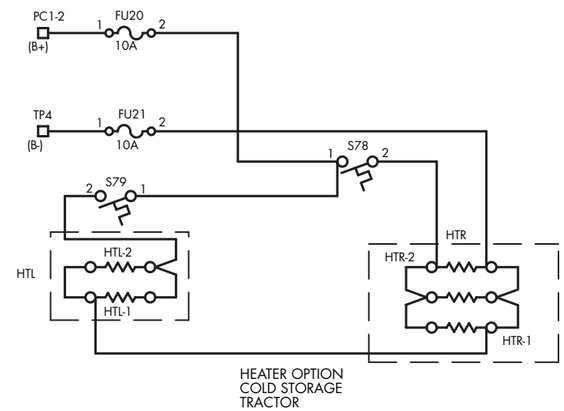
POWER OPTION STANDARD



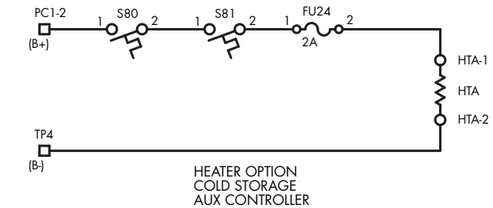
POWER OPTION COLD STORAGE



HEATER OPTION COLD STORAGE PLATFORM



HEATER OPTION COLD STORAGE TRACTOR



HEATER OPTION COLD STORAGE AUX CONTROLLER

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Figure A-5. Options, Power and Cold Storage (Elec. Schematic, Sheet 5 of 7)

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Legend (1 of 2)

IDENT.	SHEET	ZONE	DESCRIPTION
AL+	4	D4	POSITIVE SIDE OF TRAVEL, LIFT/LOWER ALARM
AL-	4	D4	NEGATIVE SIDE OF TRAVEL, LIFT/LOWER ALARM
AMPL	3	B4	CONNECTOR FROM AUX AMPLIFIER TO AUX INTERFACE MODULE
AUX	3	A6	AUX CONTACTOR
BR	1	C7	BRAKE SOLENOID
BSEN1	4	D2	CONNECTOR ON S57
BSEN2	4	C3	CONNECTOR ON S58
C1	1	B4	Q1 SNUBBER CAP
CD3	1	E4	
CM	4	E2	CARRIAGE MANAGER
CT-1	1	C3	ARMATURE CURRENT SENSOR
DT	1	C7	DRIVE MOTOR TEMPERATURE SENSOR
FILT1	1,2	E3,B3	LINE FILTER
FILT2	1,2	E3,B3	LINE FILTER
FU1	1,2	E3,B3	FILT2 FUSE, 15A
FU1	1,2	E3,B3	FILT1 FUSE, 15A
FU2	1,2	F3,B3	FILT1 FUSE, 15A
FU4	3	B3,B4,B5	AUX MOTOR FUSE, 150A
FU5	1	B2	TRAVEL POWER FUSE, 350A
FU6	1	B3	LIFT POWER FUSE, 450A
FU8	1	B2	ELECTRIC STEERING & TRACTION FIELD POWER FUSE, 70A
FU11	1	D6	CONTROL FUSE FOR B+PC1F ON TM, 15A
FU12	1	D6	CONTROL FUSE FOR B-PCF ON TM, 15A
FU13	1	D6	CONTROL FUSE FOR B-F ON TM, 15A
FU14	1	D7	CONTROL FUSE FOR B+F ON TM, 15A
FU15	1	D7	CONTROL FUSE FOR B-F (SPARE) ON TM, 6A
FU16	1	D7	CONTROL FUSE FOR B+F (SPARE) ON TM, 6A
FU17	1	D7	CONTROL FUSE FOR +12VF ON TM, 2A
FU18	5	B3,B5	CONTROL FUSE FOR COLD STORAGE CARRIAGE, 2A
FU19	5	B4,B6	CONTROL FUSE FOR COLD STORAGE CARRIAGE, 2A
FU20	5	G2	CONTROL FUSE FOR COLD STORAGE TRACTOR, 10A
FU21	5	G2	CONTROL FUSE FOR COLD STORAGE TRACTOR, 10A
FU22	5	B2,B3	CONTROL FUSE FOR POWER OPTIONS (RF TERMINAL ETC.), 2A
FU23	5	B3,B4	CONTROL FUSE FOR POWER OPTIONS (RF TERMINAL ETC.), 2A
FU24	5	G5	CONTROL FUSE FOR COLD STORAGE AUX, 2A
FU25	4	D3	OVERHEAD LIGHT FUSE, 1A
H	1	B7	HORN
H2	2	A5	PIEZO SOUNDER
H-1(+)	1	C7	SPLICE ON HORN HARNESS
H-2(-)	1	C7	SPLICE ON HORN HARNESS
HSP	3	G5	HOME SENSOR PROX.
HT	1	B4	TRACTION HEATSINK THERMISTOR
HTA	5	H5	HEATER FOR AUX CONTROLLER (COLD STORAGE OPTION)
HTC	5	B5	HEATER FOR CM COLD STORAGE OPTION
HTL	5	F3	HEATER FOR LEFT SIDE OF TRACTOR COLD STORAGE OPTION
HTR	5	H3	HEATER FOR RIGHT SIDE OF TRACTOR COLD STORAGE OPTION
HM	1	B7	HORN SUPPRESSOR MODULE
H2	2	B5	DISPLAY PIEZO SOUNDER
HSUP	1	B7	CONNECTOR ON HORN SUPPRESSOR MODULE
IL1	2	D3	CM HEARTBEAT
IL1	1	D3	12V TM
IL1	1	E4	CD3 CARD LIFT SELECT SOLENOID
IL1	3	E4	SM HEARTBEAT
IL1	1	C2	OVER TEMP-POWER CARD
IL2	1	D3	TM CHOPPER ENABLE
IL2	1	C2	OVER CURRENT-POWER CARD
IL2	1	E4	CD3 CARD PUMP CONTACTOR
IL2	2	D3	CM STATUS
IL2	3	E4	STEER PWM
IL3	1	D3	TM CARRIAGE DEADMAN
IL3	1	E4	CD3 CARD MINI LOADHOLD SOLENOID
IL3	2	D4	CM TRAVERSE A SOLENOID
IL3	3	E4	STEER DIRC A
IL4	1	D3	TM BRAKE DEADMAN
IL4	2	D4	CM TRAVERSE B SOLENOID
IL4	3	E4	STEER DIRC B
IL5	1	D4	TM LOADHOLD MAIN
IL5	2	D4	CM ROTATE A SOLENOID
IL6	1	D4	TM LIFT/LOWER SOLENOID
IL6	2	D4	CM ROTATE B SOLENOID
IL7	1	D4	TM TRACTION BRAKE
IL7	2	D5	CM REACH SOLENOID
IL8	1	D4	TM PLUG CONTACTOR
IL8	2	D5	CM TRAVERSE
IL9	1	D4	TM PC1 CONTACTOR
IL9	2	D5	CM ROTATE PWM
IL10	1	D4	TM PC2 CONTACTOR
JP1	2	B5	CONNECTOR ON DISPLAY FOR DISPLAY MODULE
JP1	2	F6	OPTICAL HEAD CONNECTOR ON MAIN MAST HEIGHT MANAGER
JP1L	3	G3	CONNECTOR FROM LOAD W.G. ANTENNA TO FILTER CARD
JP1T	3	G2	CONNECTOR FROM TRACTOR W.G. ANTENNA TO FILTER CARD
JP2	1	C4	POWER PANEL TEMPERATURE SENSOR
JP2	2	F5	INDUCTIVE PROX CONNECTOR ON MINI MAST HEIGHT MANAGER
JP2	2	B6	CONNECTOR ON DISPLAY INTERFACE CARD
JP3	2	F4	PROX 2 CONNECTOR ON HEIGHT MANAGER (MINI)
JP3	2	B5	CONNECTOR ON DISPLAY INTERFACE CARD TO CM
JP4	2	F4	ROTATE POSITION POT CONNECTOR ON HEIGHT MANAGER (MINI)
JP4	2	B5	CONNECTOR ON DISPLAY INTERFACE CARD
JP5	2	E4	HEIGHT MANAGER INTERFACE CONNECTOR (MINI)
JP5	1,2	E5,E6	HEIGHT MANAGER INTERFACE CONNECTOR (MAIN)
JP10	1	E3	CONNECTOR ON STROBE LIGHT
JP18	1,2	F2,C2	INTERMEDIATE OVER MAST CABLE A
JP19	1,2	F2,C3	INTERMEDIATE OVER MAST CABLE B
JP20	1	C5	CONNECTOR TO PLUG CONTACTOR (EE ONLY)
JP25	4		CONNECTOR FOR SLACKCHAIN SWITCHES
JP39			REPLACED BY JP61-1
JP49			REPLACED BY JP61-2
JP59			REPLACED BY JP61-3
JP60	3	A6	CONNECTOR TO AUX. CONTACTOR (EE ONLY)
JP61	1,2	E3,F3	CONNECTOR TO FILT1 AND FILT2
JPA1	2	B6	CONNECTOR ON SUPPLEMENTAL DISPLAY
JPA2	3	F4	CONNECTOR FROM STEER MANAGER TO TRACTOR MANAGER
JPA3	3	F2	CONNECTOR FROM STEER MANAGER TO W.G. FILTER CARD
JPA5	3	E4	CONNECTOR FROM PRESSURE TRANSDUCER MAIN TO STEER MANAGER
JPA6	3	E4	CONNECTOR FROM PRESSURE TRANSDUCER MINI TO STEER MANAGER
JPA7	3	F5	CONNECTOR FROM HOME PROX SENSOR TO STEER MANAGER
JPA8	3	E6	CONNECTOR FROM STEER POSITION FEEDBACK ENCODER TO STEER MANAGER
JPB-	1	A4	B- BATTERY CONNECTOR
JPB+	1	A3	B+ BATTERY CONNECTOR
JPC1	1	C4	CONNECTOR ON POWER CARD FOR Q1
JPC7	2	E5	CONNECTOR ON CM FOR MAIN MAST HEIGHT MANAGER
JPC8	2	C6	CONNECTOR ON CM FOR SUPPLEMENTAL DISPLAY
JPC9	4	E3	CONNECTOR ON CM FOR SMARTi OPTION
JPC10	2	E3	CONNECTOR FOR CARRIAGE SOLENOIDS
JPC12	2	E5	CONNECTOR ON CM FOR TRAVERSE POSITION POT
JPC14	2	D6	CONNECTOR ON CM FOR POWER SUPPLY CARD
JPC15	2	E2	CONNECTOR ON CM FOR KEY SWITCH AND EPO
JPC16	2	C7	CONNECTOR ON CM FOR STEER ENCODER CARD
JPC17	1,2	F2,C2	CONNECTOR ON CM FOR MAST CABLE A
JPC18	2	C5	CONNECTOR ON CM FOR DISPLAY INTERFACE CARD
JPC19	4,5	F3,B2,B5	CONNECTOR ON CM FOR OPTIONS POWER
JPC20	1,2	F2,C2	CONNECTOR ON CM FOR MAST CABLE B
JPC21	4	F4	CONNECTOR ON CM FOR SIDEGATE SWITCHES
JPC23	2	C3	CONNECTOR ON CM FOR LEFT CONTROL HANDLE
JPC24	2	C4	CONNECTOR ON CM FOR RIGHT CONTROL HANDLE
JPC25	2	E2	CONNECTOR ON CM FOR DEADMAN INPUT SWITCHES
JPC26	2	E3	CONNECTOR ON CM FOR AUX. SOLENOID
JPCM1	3	C5	CONNECTOR ON CONTACTOR INTERFACE MODULE
JPE1	2	B7	CONNECTOR ON STEER ENCODER CARD
JPH1	2	E4	CONNECTOR ON CM FOR MINI MAST HEIGHT MANAGER
JPH2	1	E5	CONNECTOR ON TM FOR MAIN HEIGHT MANAGER
JPK2	2	F5	CONNECTOR ON TRAVERSE POSITION FEEDBACK POT
JPK3	2	E4	CONNECTOR ON MINI OVER-MAST CABLE
JPL1	2	B3	CONNECTOR ON LEFT CONTROL HANDLE
JPL19	4	G2	CONNECTOR ON LIGHT & FANS HARNESS
JPM1	1,3	C5,C3,C4,C6	CONNECTOR ON AUX CTRL CARD
JPM2	3	C4	CONNECTOR ON AUX INTERFACE MODULE
JPP1	2	D6	CONNECTOR ON CM POWER SUPPLY
JPR1	2	B4	CONNECTOR ON RIGHT CONTROL HANDLE
JPS4	1	D5	CONNECTOR ON TM FOR AUX MOTOR CONTROL
JPS6	4	G5	CONNECTOR ON TM FOR AISLE DETECT
JPS12	1,4	E4,C6	CONNECTOR ON TM FOR CD3 CARD
JPS13	4	C3	CONNECTOR ON TM FOR RAIL SENSE
JPS14	1	D4	CONNECTOR ON TM FOR CONTACTOR ASSY
JPS15	4	C4	CONNECTOR ON TM TO ALARM AND SPARE LIMIT SWITCH
JPS16	4	C2	CONNECTOR ON TM FOR BATTERY GATE SWITCH
JPS18	1	D2	CONNECTOR ON TM FOR SPEED FEEDBACK PROX.
JPS19	1	D6	CONNECTOR ON TM FOR SOLENOIDS
JPS20	1	E3	CONNECTOR ON TM FOR WARNING LIGHT
JPS21	1	E6	CONNECTOR ON TM FOR PC2 COIL DRIVER
JPS22	1	D6	CONNECTOR ON TM FOR PC2
JPS25	1,2	E2,B2	CONNECTOR ON TM FOR MAST CABLE A
JPS26	1,2	E2,B2	CONNECTOR ON TM FOR MAST CABLE B
JPS28	4	G5	CONNECTOR ON TM FOR AISLE DETECT
JPS29	1	E4	CONNECTOR ON CD3 CARD FOR SOLENOIDS
JPS30	4	D6	CONNECTOR ON CD3 TO SLACK CHAIN SWITCH OPTION
JPS31	4	D6	CONNECTOR ON CD3 TO SLACK CHAIN SWITCH OPTION
JPS44	4	D4	CONNECTOR ON OPTIONS HARNESS
JPS45	4	D4	CONNECTOR ON OPTIONS HARNESS
JPS46	1,3	C6,B5	CONNECTOR FOR POWER TO CONTACTOR INTERFACE MODULE
JS3	1	D3	CONNECTOR ON TM TO POWER CARD
JS5	1	D2	CONNECTOR ON TM TO POWER CARD
JS11	1	D4	CONNECTOR ON COIL DRIVERS TO TM
JS17	1	E4	CONNECTOR ON TM TO SM

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Figure A-6. Legend (1 of 2) (Elec. Schematic, Sheet 6 of 7)

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Legend (2 of 2)

IDENT.	SHEET	ZONE	DESCRIPTION
JPW1	3	G3	CONNECTOR ON WG FILTER CARD FOR LOAD SENSOR
JPW2	3	G2	CONNECTOR ON WG FILTER CARD FOR TRACTOR SENSOR
JPW7	5	D5	CONNECTOR ON RIGHT CONTROL HANDLE HEATER
JPW8	5	D5	CONNECTOR ON LEFT CONTROL HANDLE HEATER
JPY5	3	D4	CONNECTOR ON PRESSURE TRANSDUCER MAIN
JPY6	3	D5	CONNECTOR ON PRESSURE TRANSDUCER MINI
K1	1	C7	HORN RELAY
K2	4	D4	ALARM RELAY OPTION
L1	3	A4,A6,B3	AUX INDUCTOR
LIFT SEL	1	F4	MAIN/MINI LIFT SELECT SOLENOID
L/L SOL	1	C6	LIFT/LOWER SOLENOID (PROPORTIONAL)
MAIN L/H	1	C6	MAIN LIFT LOADHOLD SOLENOID
MD-A1	1	C3	DRIVE MOTOR TERMINAL (ARMATURE)
MD-A2	1	C3	DRIVE MOTOR TERMINAL (ARMATURE)
MD-E1	1	C3	DRIVE MOTOR TERMINAL (FIELD)
MD-E2	1	C3	DRIVE MOTOR TERMINAL (FIELD)
MINI L/H	1	F5	MINI LIFT LOADHOLD SOLENOID
MP	1	B3	PUMP MOTOR
MS	3	D3	STEER MOTOR
MX	3	A4,A6,B3	AUX PUMP MOTOR
MX-	1	B6	AUX MOTOR ARMATURE CONNECTION TO AUX MOTOR CONTROLLER
MXB-	2	B6	AUX MOTOR CONTROLLER B-
MXB+	2	B6	AUX MOTOR CONTROLLER B+
P	1	B3,F5	LIFT PUMP CONTACTOR
PC1	1,5	C5,B2,F2,F4	POWER DISCONNECT CONTACTOR FOR TRACTION/STEERING SYSTEM
PC2	1	A3,C6	POWER DISCONNECT CONTACTOR FOR LIFT/AUX SYSTEM
PC2	3	B3,B4,B5	POWER DISCONNECT CONTACTOR FOR LIFT/AUX SYSTEM
PLUG	1	B3,C5	PLUGGING CONTACTOR
PRESS MAIN	3	D4	MAIN MAST PRESSURE TRANSDUCER
PRESS MINI	3	D5	AUX MAST PRESSURE TRANSDUCER
PROX2	2	G4	REACH POSITION PROXIMITY SENSOR
PR1	1	C3	CONNECTOR FROM POWER CARD TO DRIVE MOTOR FIELD
PR2	1	C3	CONNECTOR FROM POWER CARD TO DRIVE MOTOR FIELD
PRB-	1	C3	CONNECTOR FROM POWER CARD TO TP4
PRB+	1	C3	CONNECTOR FROM POWER CARD TO TP7
PS3	1	D3	CONNECTOR FROM POWER CARD TO TM
PS5	1	D2	CONNECTOR FROM POWER CARD TO TM
PS11	1	D4	CONNECTOR FROM TM TO COIL DRIVERS
PS17	3	G5	CONNECTOR ON TM TO SM
Q1	1	B3	MAIN TRANSISTOR (TRACTION ARMATURE)
R1	1	B3	PLUGGING RESISTOR
R2	1	B4	Q1 SNUBBER RESISTOR
REC1	1	B4	FREEWHEEL DIODE
REC2	1	B4	SNUBBER DIODE-Q1
S1	2	E2	KEYSWITCH
S2	2	G2	BRAKE DEADMAN
S3	2	B4	HORN SWITCH
S4	2	B4	AUTO/MANUAL SWITCH
S5	2	B4	UNDEFINED OPTION SWITCH
S6	2	B3	LIFT SELECT SWITCH
S7	2	B3	LIFT/LOWER INHIBIT BYPASS SWITCH
S9	2	G3	LOAD HANDLER DEADMAN SWITCH
S15	4	C3	RAIL SENSE SWITCH
S21	2	F2	EPO SWITCH
S23	2	G2	CARRIAGE DEADMAN SWITCH
S40	4	F2	RIGHT WORKING LIGHT SWITCH
S41	4	F2	OVERHEAD LIGHT SWITCH
S42	4	F3	LEFT WORKING LIGHT SWITCH
S43	4	F3	FAN SWITCH
S46A	4	D4	AISLE DETECT SENSOR 1
S46B	4	D5	
S47A	4	D5	AISLE DETECT SENSOR 2
S47B	4	D6	
S50	4	E6	SLACKCHAIN SWITCH #1
S51	4	E6	SLACKCHAIN SWITCH #2
S57	4	D2	BATTERY GATE SENSE SWITCH
S58	4	C3	BATTERY GATE SENSE SWITCH
S60	4	G4	RIGHT SIDEGATE SWITCH
S61	4	G4	LEFT SIDEGATE SWITCH
S75	5	C4	RIGHT CONTROL HANDLE THERMOSTAT (COLD STORAGE OPTION)
S76	5	C5	LEFT CONTROL HANDLE THERMOSTAT (COLD STORAGE OPTION)
S77	5	A6	CM ENCLOSURE HEATER THERMOSTAT (COLD STORAGE OPTION)
S78	5	G3	TRACTOR, RIGHT, THERMOSTAT (COLD STORAGE OPTION)
S79	5	F3	TRACTOR, LEFT, THERMOSTAT (COLD STORAGE OPTION)
S80	5	G4	AUX CONTROLLER THERMOSTAT (COLD STORAGE OPTION)
S81	5	G4	AUX CONTROLLER THERMOSTAT (COLD STORAGE OPTION)
S100	2	A5	DISPLAY INTERFACE SWITCH #1
S101	2	A5	DISPLAY INTERFACE SWITCH #2
S102	2	A6	DISPLAY INTERFACE SWITCH #3
S103	2	A6	DISPLAY INTERFACE SWITCH #4
S104	2	A6	DISPLAY INTERFACE SWITCH #5

IDENT.	SHEET	ZONE	DESCRIPTION
SFP	1	C2	SPEED FEEDBACK PROX.
SM	4	E6	STEER MANAGER
SMB-	1,3	B4,E4	B- TO STEERING POWER COMPONENTS
SMB-	2	B3	B- TO STEERING POWER COMPONENTS
SMB+	1,3	B2,D2	B+ TO STEERING POWER COMPONENTS
SMTR1	3	E3	STEER MOTOR TO ELECTRIC STEER MANAGER
SMTR2	3	E3	STEER MOTOR TO ELECTRIC STEER MANAGER
SOL33	2	F3	PROPORTIONAL ROTATE SOLENOID
SOL34A	2	F3	TRAVERSE A SOLENOID
SOL34B	2	F3	TRAVERSE B SOLENOID
SOL35A	2	F3	ROTATE A SOLENOID
SOL35B	2	F3	ROTATE B SOLENOID
SOL36	2	F4	REACH SOLENOID
SPE	3	D6	STEER POSITION ENCODER
SPL1	4	D4	CONNECTOR ON OPTIONS HARNESS
SPL2	4	D4	CONNECTOR ON OPTIONS HARNESS
SPL30	5	D5	SPLICE ON COLD STORAGE HARNESS
SPL31	4	G2	SPLICE ON LIGHT AND FAN
SPS	1	C2	INTERIM CONNECTOR TO SPEED FEEDBACK PROX
SUP1	4	G3	SUPPRESSOR ON FAN
SUP2	4	G3	SUPPRESSOR ON FAN
SUP	4	G3	SUPPRESSOR
SUP6	1,2	E2,B2	SUPPRESSOR ON TRACTOR FOR B+F(SPARE)
TM	1	D2	TRACTOR MANAGER
TM1	1	C3	H-BRIDGE TRANSISTOR FOR DRIVE MOTOR (FIELD)
TM2	1	C3	H-BRIDGE TRANSISTOR FOR DRIVE MOTOR (FIELD)
TM3	3	E3	H-BRIDGE TRANSISTOR FOR STEER MOTOR
TM4	3	E3	H-BRIDGE TRANSISTOR FOR STEER MOTOR
TP1	3	A5,B4,B3	TIE POINT ON FU4
TP2	1	B2	TIE POINT ON FU5
TP3	1	B3	TIE POINT ON FU6
TP4	1	B4	TIE POINT ON B-
TP4	3	B4,B5	TIE POINT ON B-
TP4	4	D4	TIE POINT ON B-
TP4	5	F2,F5	TIE POINT ON B-
TP5	1	B3	TIE POINT ON REC1
TP6	1	C4	TIE POINT ON REC2
TP7	1	B2	TIE POINT ON FU8
TS1	4	G2,H2	TERMINAL STRIP ON LIGHTS & FANS HARNESS
VFC	1	D6	VEHICLE FUNCTION CONTROLLER
VR1	2	B5	VARIABLE RESISTOR FOR TRAVEL
VR2	2	B5	VARIABLE RESISTOR FOR LIFT/LOWER
VR3	2	B4	VARIABLE RESISTOR FOR ROTATE
VR4	2	B4	VARIABLE RESISTOR FOR TRAVERSE
VR5	2	G5	VARIABLE RESISTOR FOR TRAVERSE POSITION FEEDBACK
VR6	2	G4	VARIABLE RESISTOR FOR ROTATE POSITION FEEDBACK
WG	3	G2	WIRE GUIDANCE

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Figure A-7. Legend (2 of 2) (Elec. Schematic, Sheet 7 of 7)

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Lift/Aux System and Main/Aux Cylinders

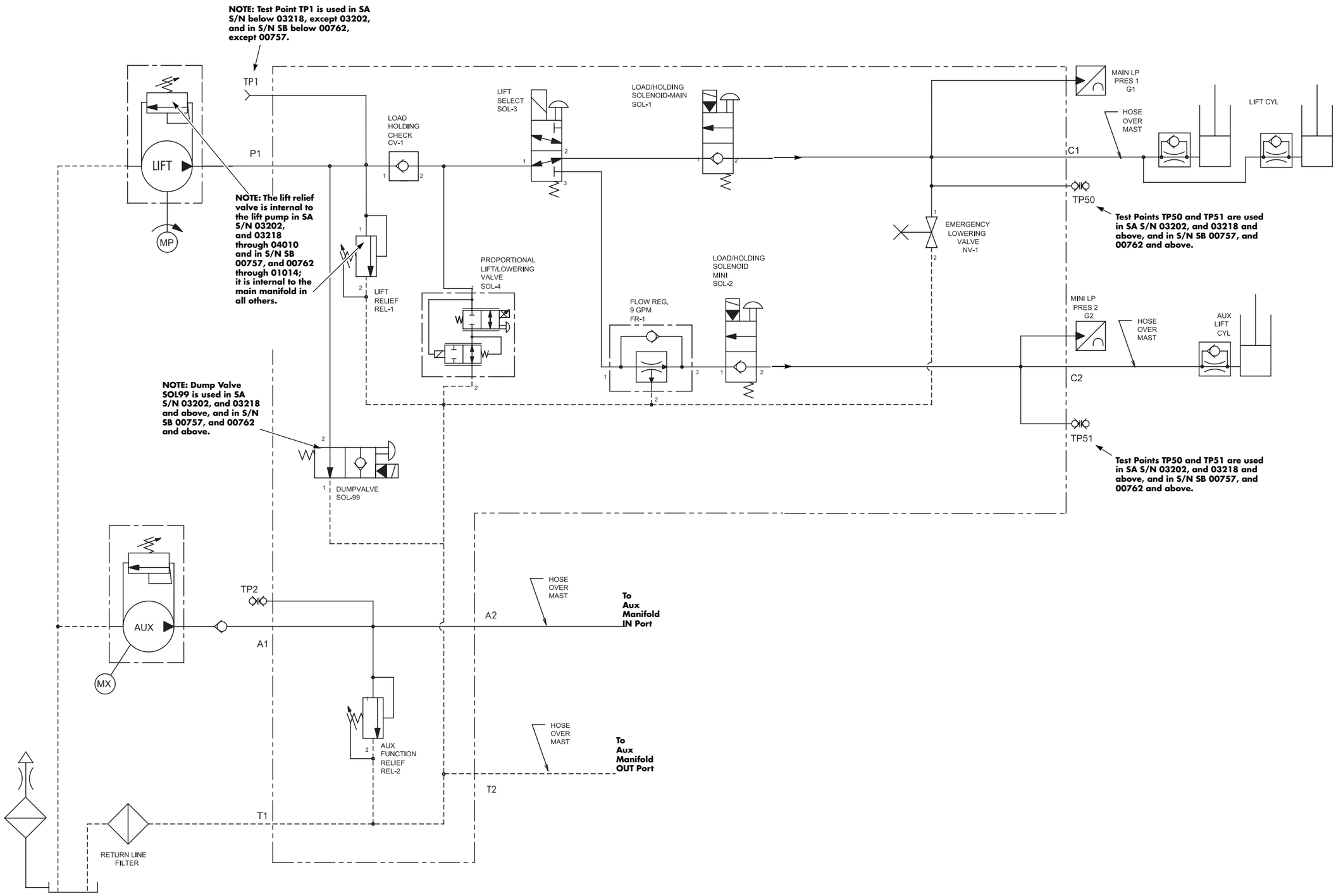


Figure A-8. Lift/Aux System and Main/Aux Cylinders (Hyd. Schematic, Sheet 1 of 3)

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Aux and Reach/Rotate Manifolds (late)

NOTE: Applies to SA S/N 03202, and > 03217, and to SB S/N 00757, and > 00761.

For all other S/N, see page A-24.

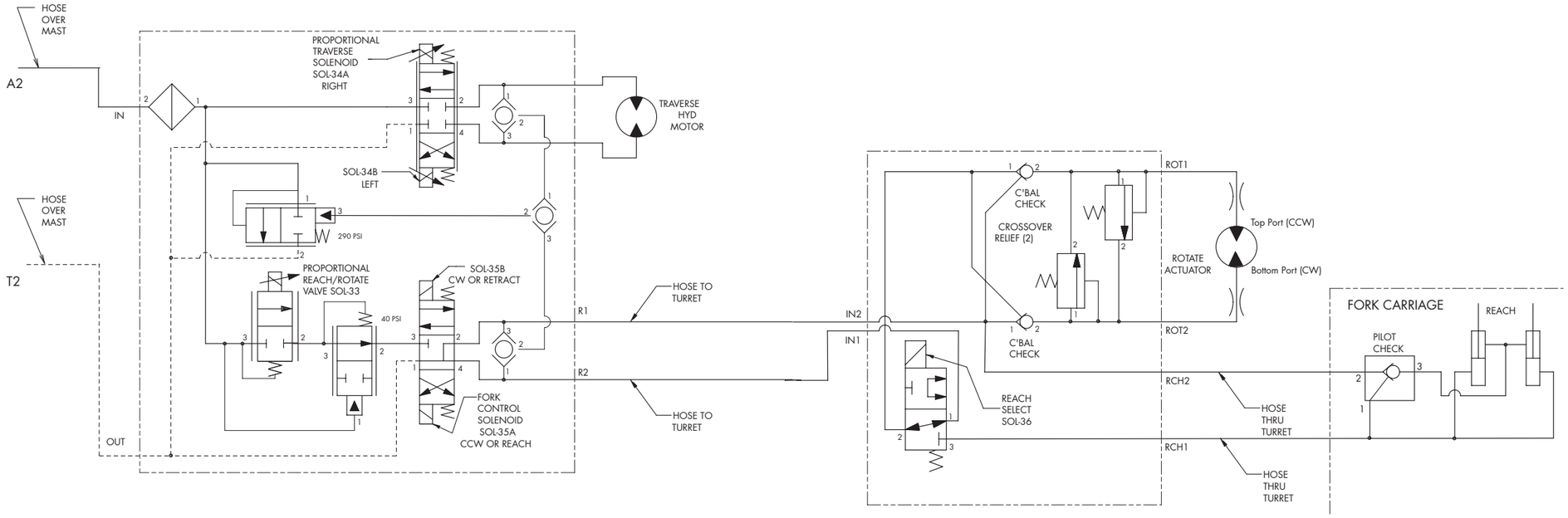


Figure A-9. Aux and Reach/Rotate Manifolds (late) (Hyd. Schematic, Sheet 2 of 3)

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Aux and Reach/Rotate Manifolds (early)

NOTE: Applies to SA S/N < 003218, except 03202, and to SB S/N < 00762, except 00757.

For all other S/N, see page A-23.

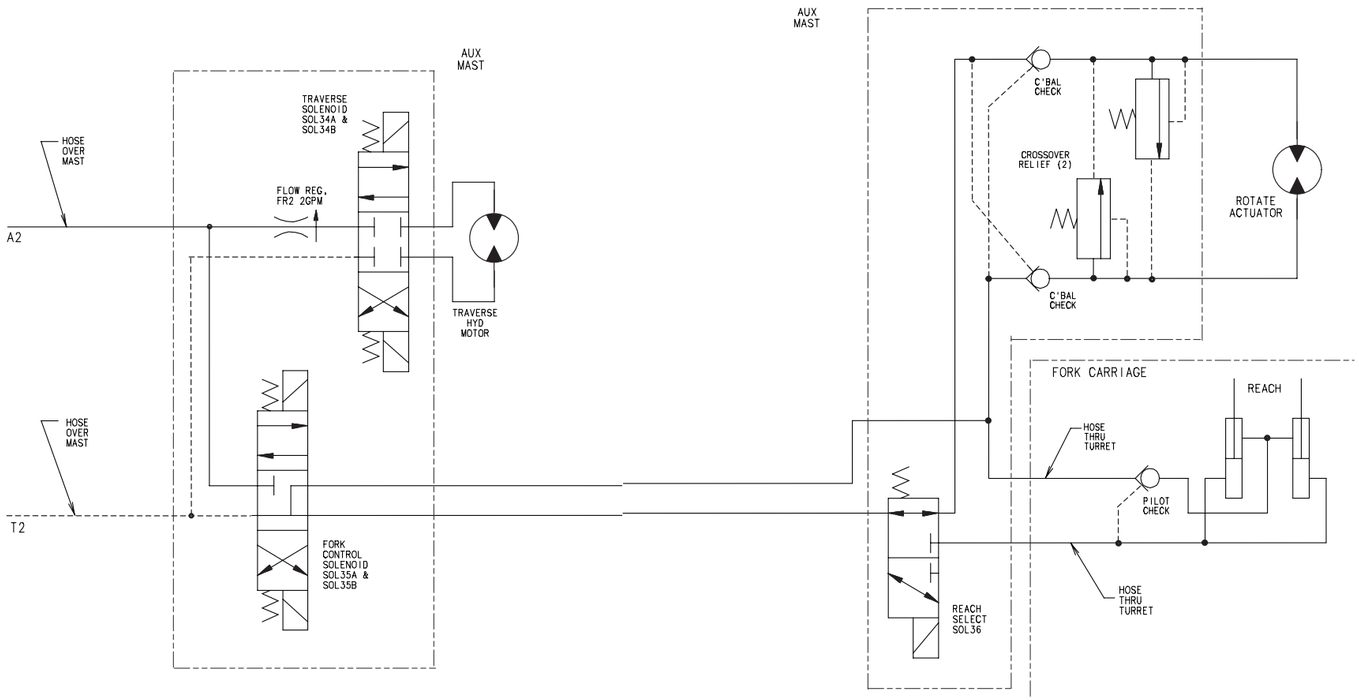


Figure A-10. Aux and Reach/Rotate Manifolds (early) (Hyd. Schematic, Sheet 3 of 3)

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