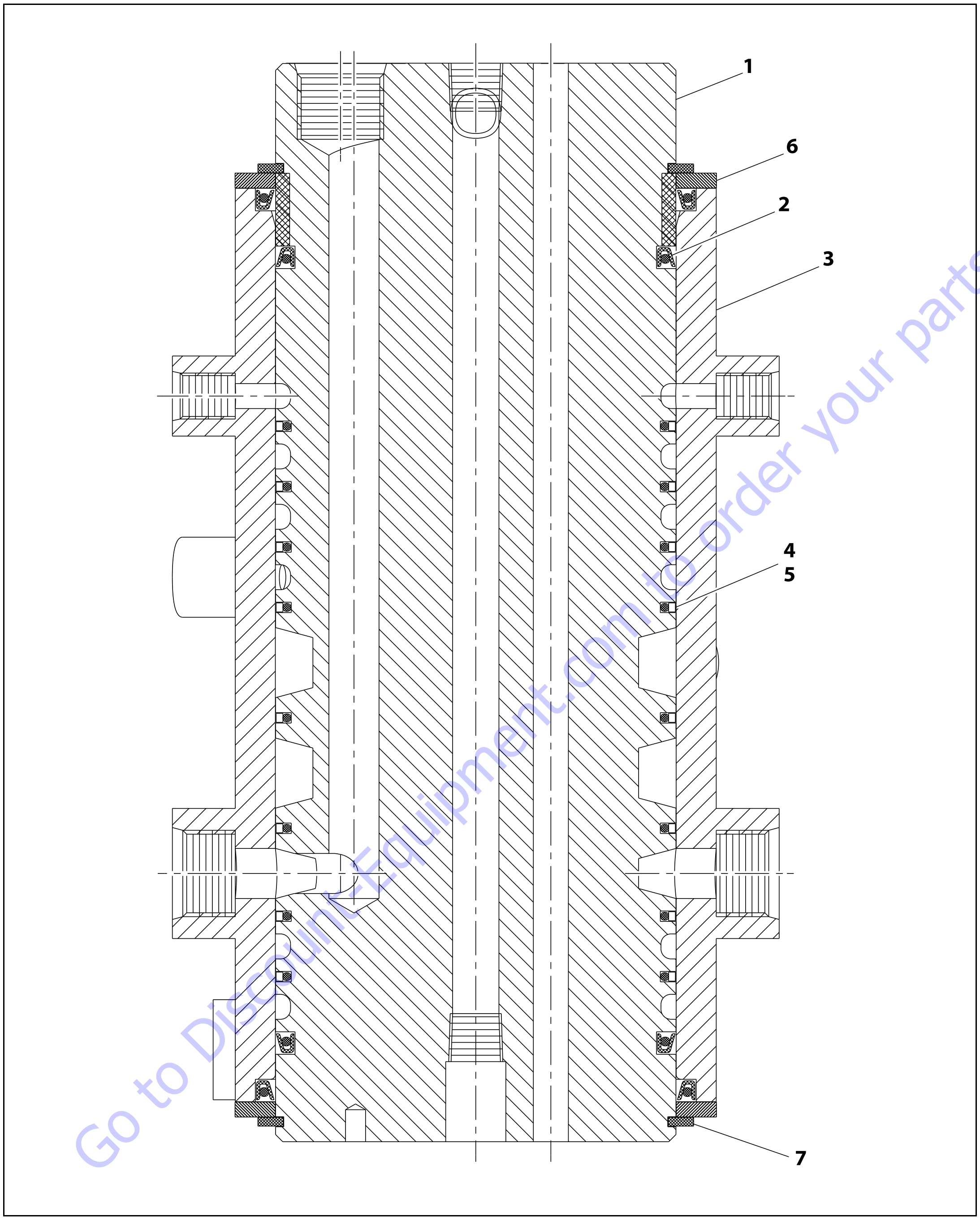


1. Center Body
2. Seal
3. Housing
4. O-ring
5. Cap Seal
6. Ring
7. Retaining Ring

Figure 3-57. Rotary Coupling Cutaway (Prior to SN 0300138447)

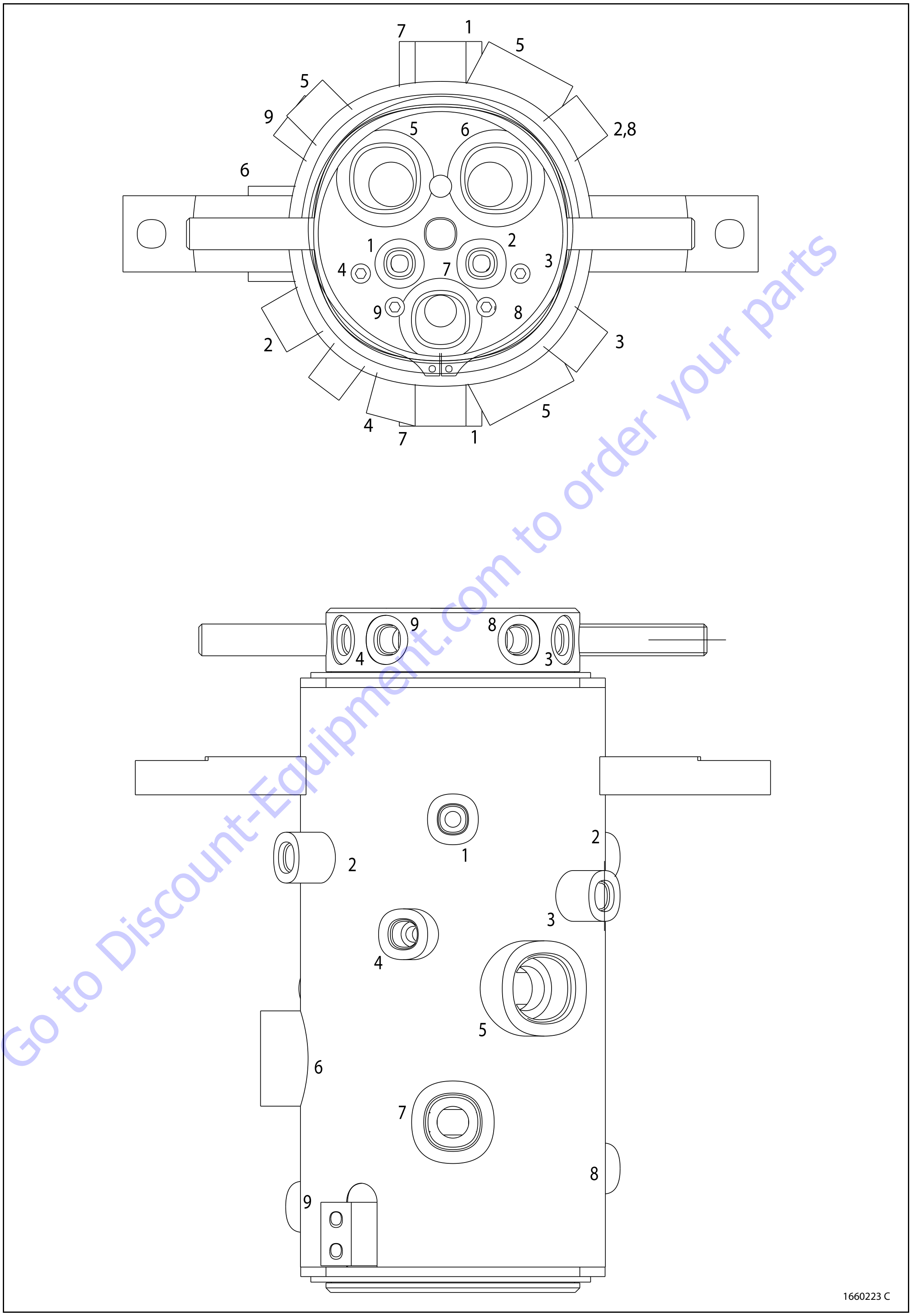
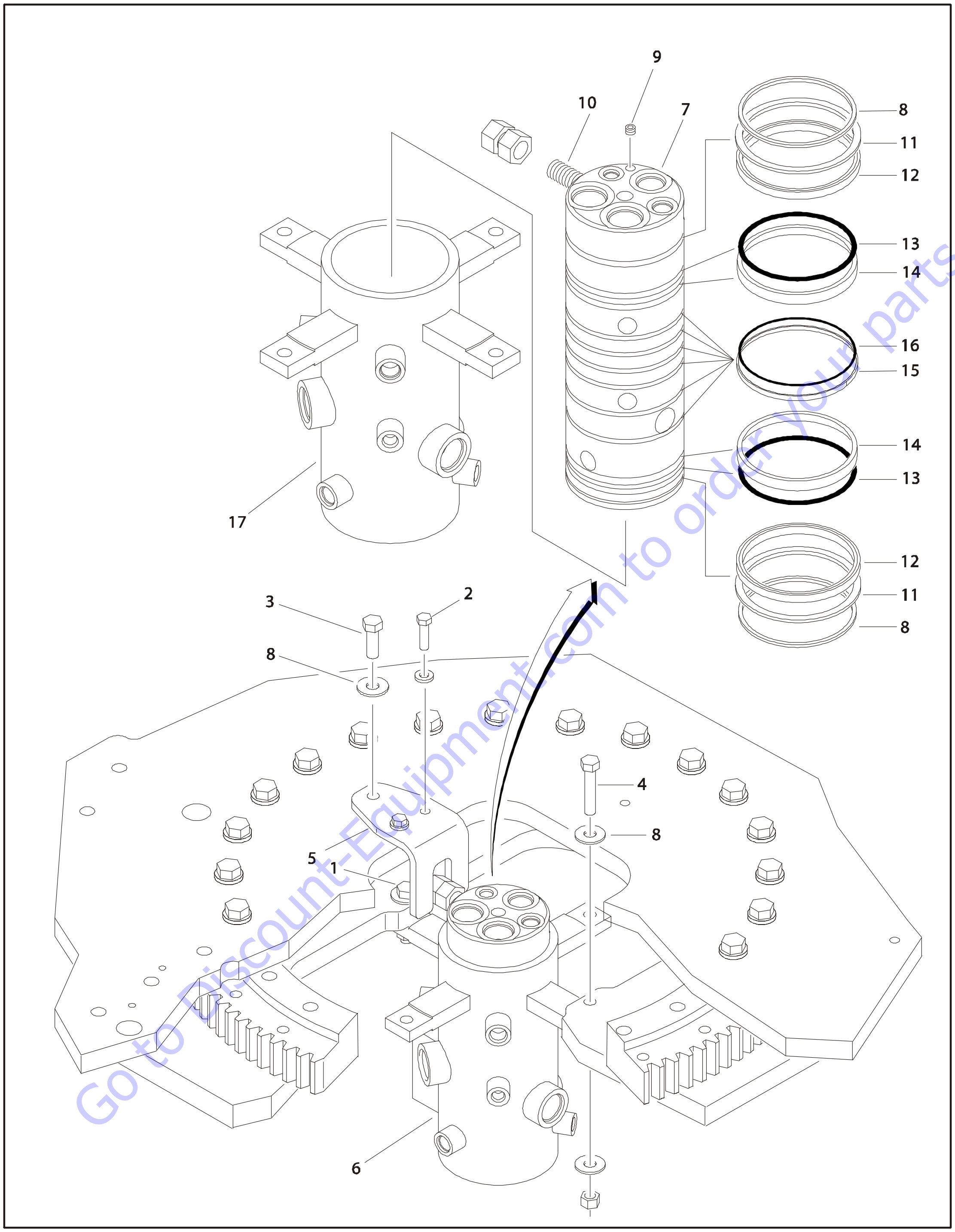


Figure 3-58. Rotary Coupling Port Location (9 Port) (Prior to SN 0300138447)



1. Loctite #242
2. Bolt
3. Bolt
4. Bolt
5. Bracket
6. Rotary Coupling
7. Spool
8. Retaining Ring
9. Plug
10. Torque Lug
11. Ring
12. Seal
13. O-ring
14. Bearing
15. Cap Seal
16. O-ring
17. Case

Figure 3-59. Rotary Coupling Installation (Prior to SN 0300138447)

3.20 ROTARY COUPLING (SN 0300138447 THROUGH 0300185827)

Use the following procedure to install the seal kit.

1. If not already removed, remove the axle oscillation valve from the cylinder barrel. The spool of the valve protrudes into the barrel and will damage the spool and seals if left in place.
2. Remove snap ring (7) from end.
3. Remove thrust ring (3) from the same end.
4. Remove center body (1) from housing (3).
5. Cut off old seals (2, 4, 5).
6. Remove proximity switch.
7. Assemble lip seals (2) in direction shown in Figure 3-56., Rotary Coupling Seal Installation (Prior to SN 0300138447).
8. Reassemble o-ring (4).
9. Heat cap seals (5) in hydraulic oil for 5 minutes at 300° F (149° C).
10. Assemble cap seals over o-rings.
11. Reinsert center body into housing (lube with hydraulic oil).
12. Replace thrust ring and snap ring.
13. Install proximity switch as shown in Figure 3-63.

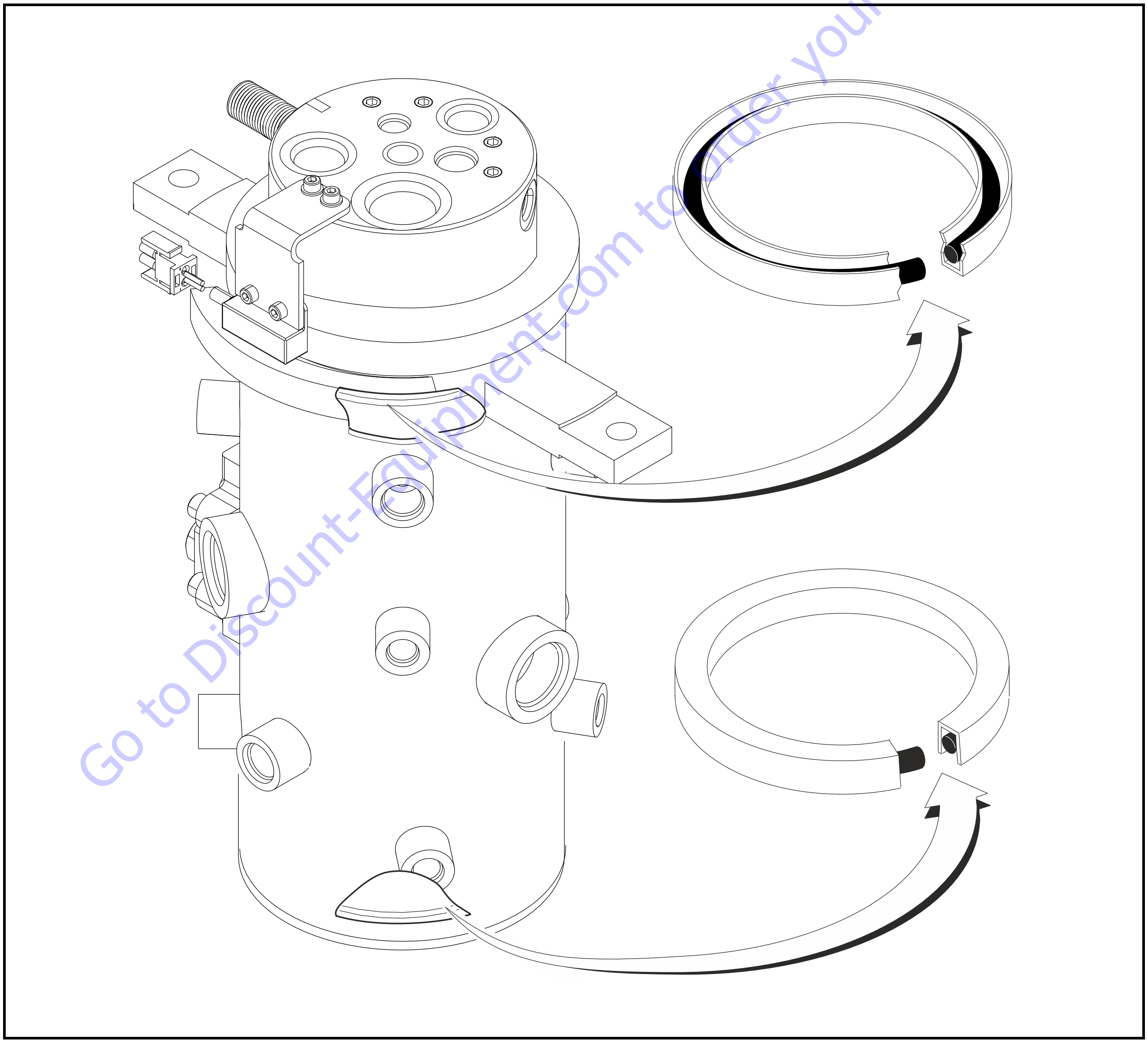
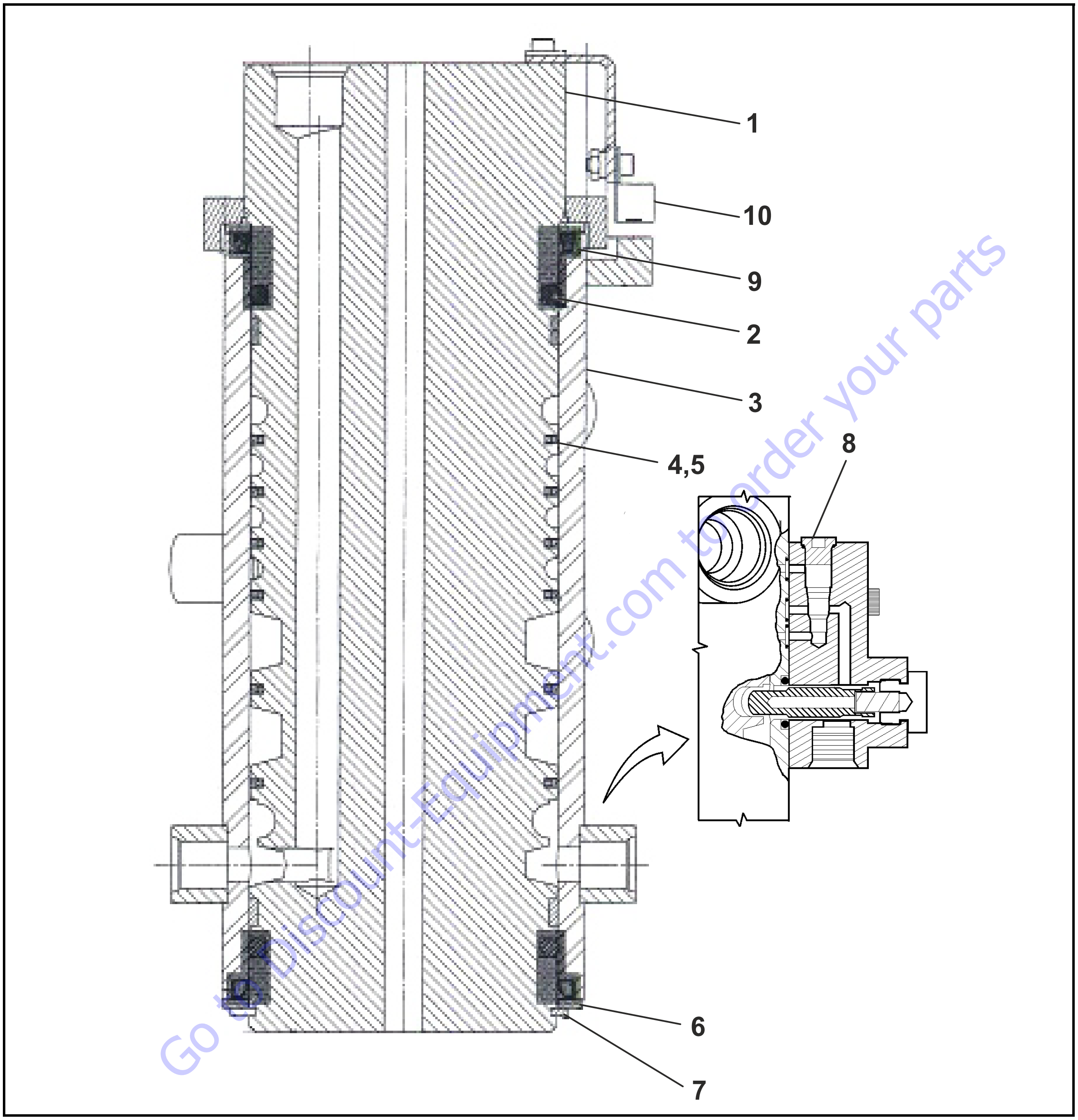


Figure 3-60. Rotary Coupling Seal Installation (SN 0300138447 through 0300185827)



1. Center Body
2. Seal
3. Housing
4. O-ring
5. Seal
6. Thrust Ring
7. Snap Ring
8. Valve Block (Axle Oscillation)
9. O-ring
10. Proximity Switch

Figure 3-61. Rotary Coupling Cutaway (SN 0300138447 through 0300185827)

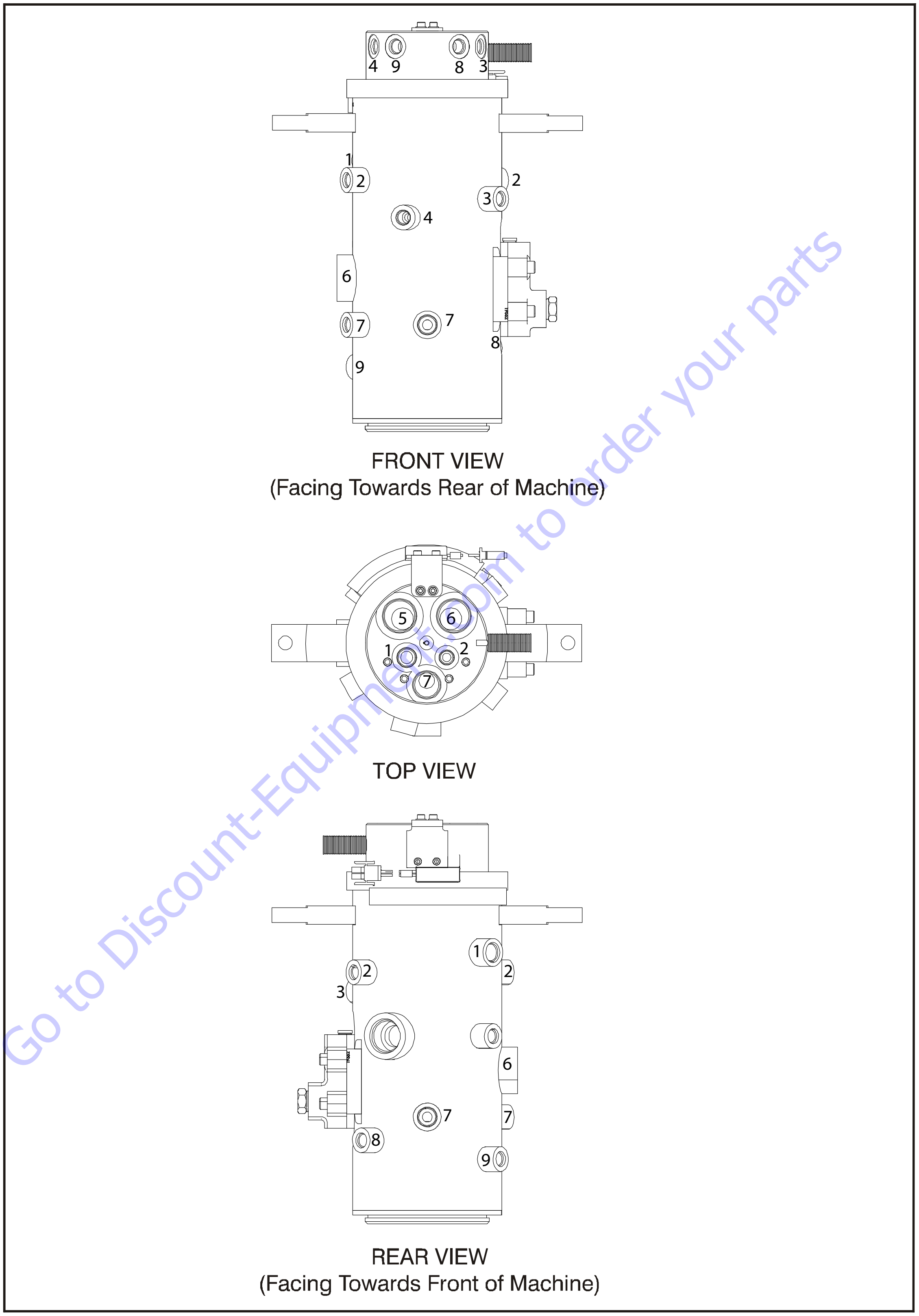
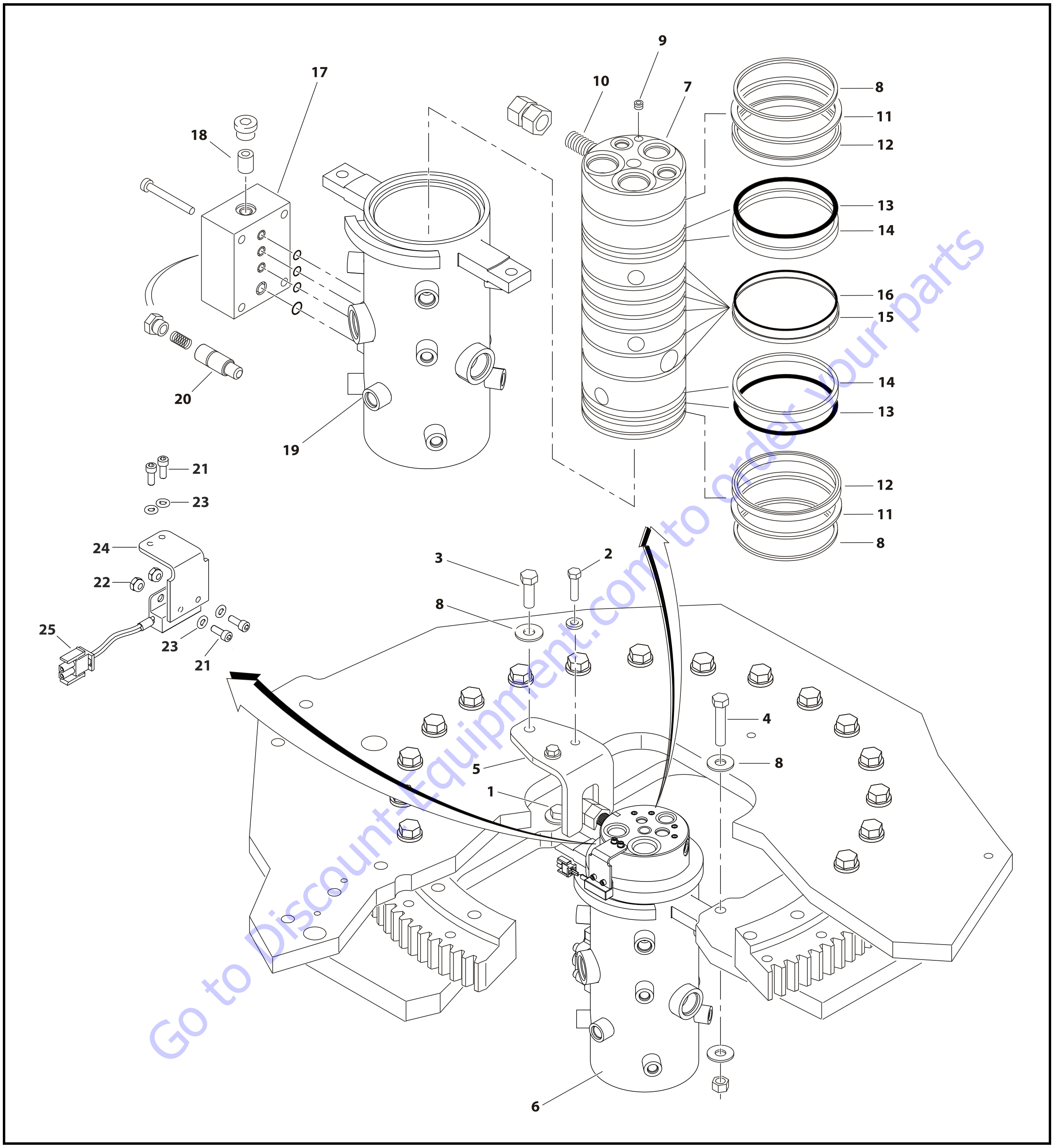


Figure 3-62. Rotary Coupling Port Location (9 Port) (SN 0300138447 through 0300185827)



1. JLG Threadlocker
2. Bolt
3. Bolt
4. Bolt
5. Bracket
6. Rotary Coupling
7. Spool
8. Retaining Ring
9. Plug
10. Torque Lug
11. Ring
12. Seal
13. O-ring
14. Bearing
15. Cap Seal
16. O-ring
17. Valve
18. Check Valve
19. Case
20. Plunger Valve
21. Bolt
22. Nut
23. Washer
24. Bracket
25. Proximity Switch

Figure 3-63. Rotary Coupling Installation (SN 0300138447 through 0300185827)

Table 3-9. Coupling Port Information Table (9 port) (Prior to SN 0300138447)

Port No.	Outlets	Port Size	Description	Operating Pressure PSI (Bar)	Proof Pressure PSI (Bar)
1	2	-6	Brake	250 (17)	375 (25.8)
2	2	-6	2 Speed	4500 (310)	6750 (465)
3	1	-6	Steer	2000 (138)	3000 (206.8)
4	1	-6	Steer	2000 (138)	3000 (206.8)
5	3	2-6, 1-16	Drive Reverse	4500(310)	6750(465)
6	1	-16	Drive Forward	4500 (310)	6750 (465)
7	2	-12	Drain	250 (17)	375 (26)
8	1	-6	Steer	2000 (138)	3000 (206.8)
9	1	-6	Steer	2000(138)	3000 (206.8)

Table 3-10. Coupling Port Information Table (9 port) (SN 0300138447 through 0300185827)

Port No.	Outlets	Port Size	Description	Operating Pressure PSI (Bar)	Proof Pressure PSI (Bar)
1	1	-8	Brake	450 (31)	675 (46.5)
2	2	-6	2 Speed	4500 (310)	6750 (465)
3	1	-6	Steer	2500 (172)	3750 (258.5)
4	1	-6	Steer	2500 (172)	3750 (258.5)
5	2	1-6, 1-16	Drive Reverse	4500(310)	6750(465)
6	1	-16	Drive Forward	4500 (310)	6750 (465)
7	3	2-8, 1-6	Drain	250 (17)	375 (26)
8	1	-6	Steer	2500 (172)	3750 (258.5)
9	1	-6	Steer	2500(172)	3750 (258.5)

3.21 TILT ALARM SWITCH

⚠ CAUTION

PERFORM TILT ALARM SWITCH LEVELING PROCEDURE A MINIMUM OF EVERY SIX MONTHS TO ENSURE PROPER OPERATION AND ADJUSTMENT OF SWITCH.

Manual Adjustment.

1. Park the machine on a flat, level surface. Ensure machine is level and tires are filled to rated pressure.

NOTE: *Ensure switch mounting bracket is level and securely attached.*

2. Level the base of the indicator by tightening the three flange nuts through approximately one quarter of its spring travel. DO NOT ADJUST THE "X" NUT DURING THE REMAINDER OF THE PROCEDURE.

3. With the electrical connections complete, using bubble level on top of indicator, slowly tighten or loosen the three flange nuts until indicator is level.

4. Individually push down on one corner at a time; there should be enough travel to cause the switch to trip. If the switch does not trip in all three tests, the flange nuts have been tightened too far. Loosen the "X" nut and repeat steps (2) through (4) LIMIT SWITCHES ADJUSTMENTS.

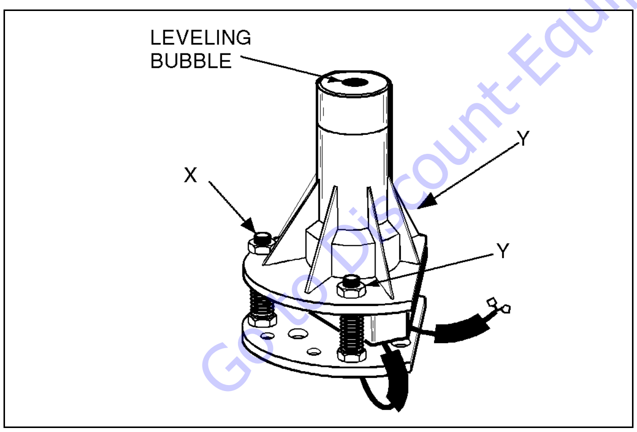


Figure 3-64. Tilt Switch Adjustment.

3.22 SPARK ARRESTER CLEANING INSTRUCTIONS

1. Remove the cleanout plug in the bottom of spark arrester (muffler).

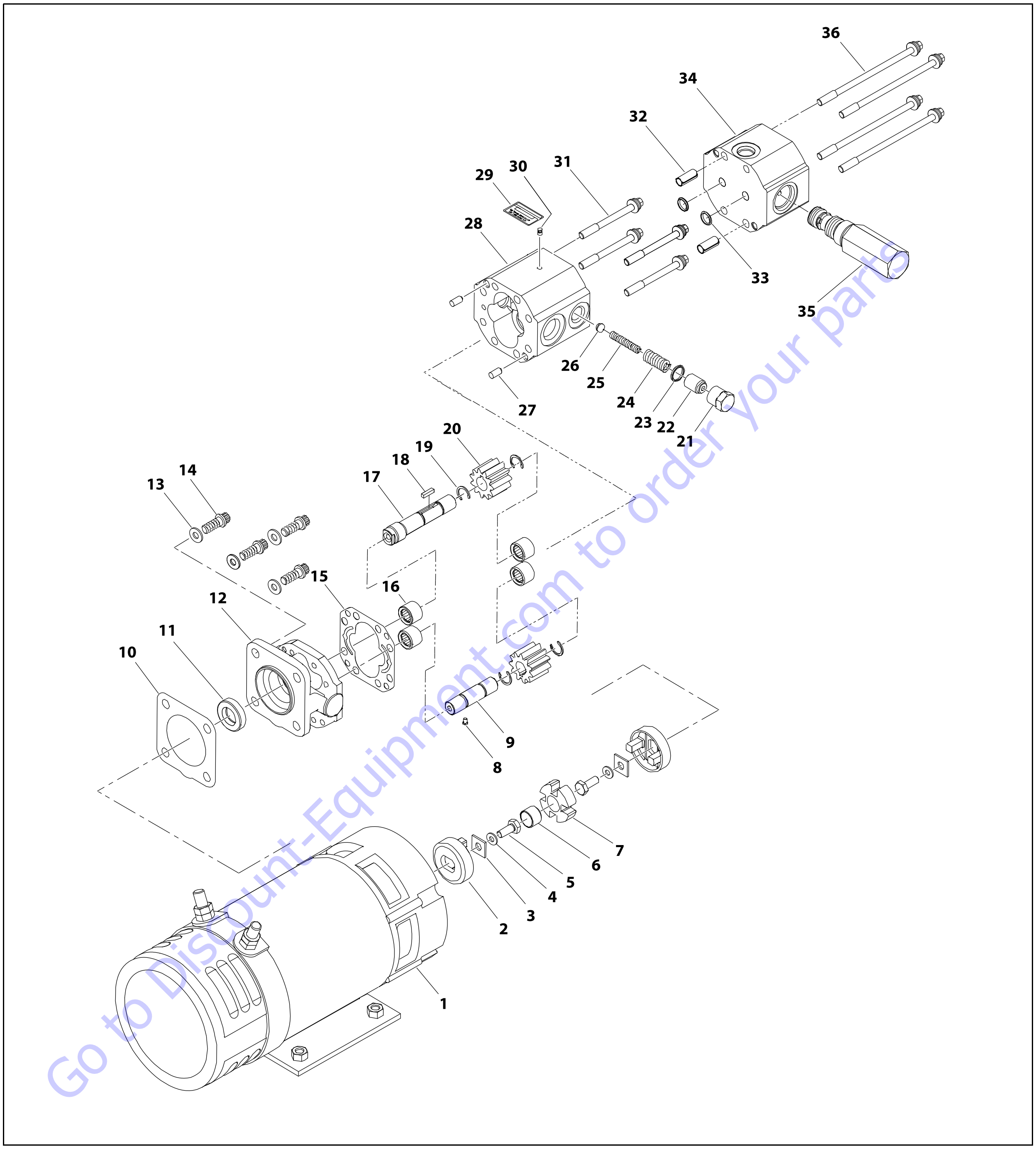
2. Without causing deformation (or any type of damage to the spark arrester) repeatedly tap on the arrester near the cleanout plug. This may be enough to begin drainage of the spark trap.

3. An industrial vacuum cleaner can do a complete job at this point.

   a. Or, IN A SAFE AREA, start the engine. Then alternate between low idle and high idle for two to three minutes.

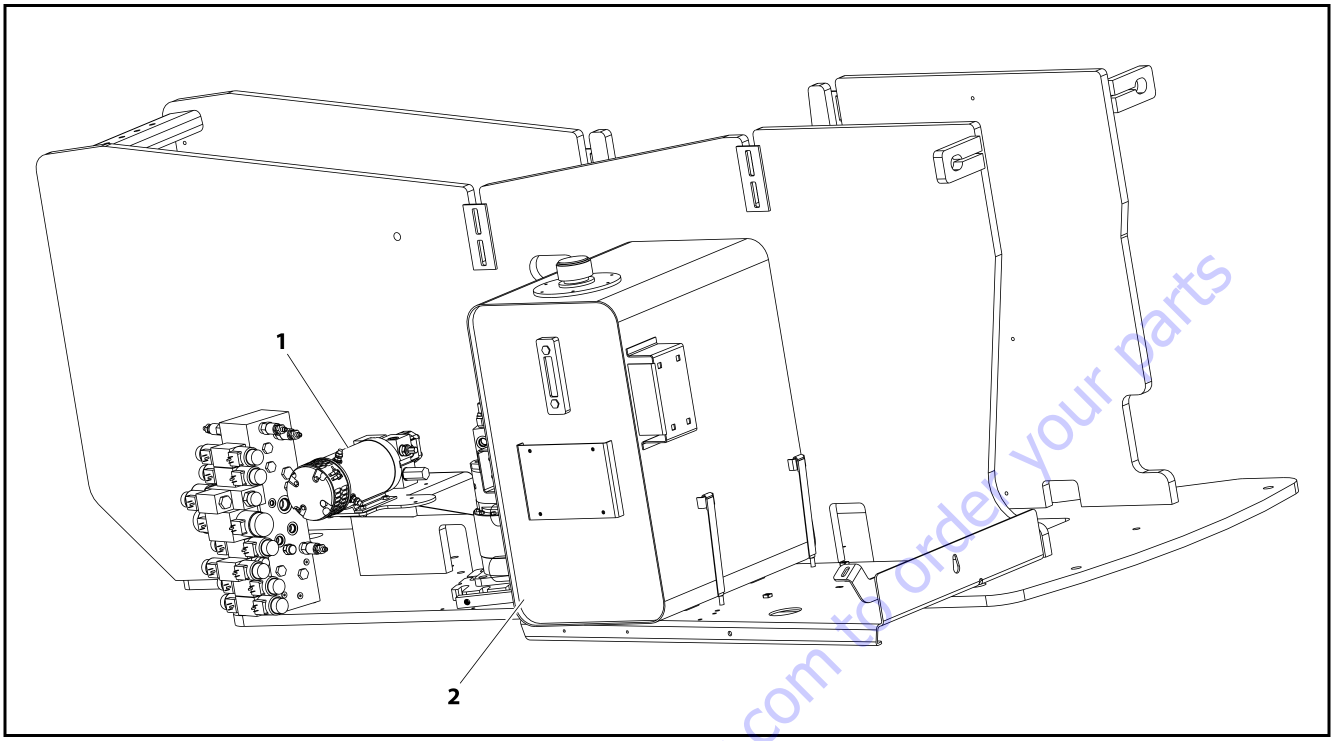
   b. Or, operate the engine as required by the application for two to three minutes.

4. Install the cleanout plug. (See Table 2-3. Preventive Maintenance and Inspection Schedule.)



1. DC Motor
2. Coupling Half
3. Washer
4. Lockwasher
5. Screw
6. Bushing
7. Spider
8. Pin
9. Idler Shaft
10. Mounting Gasket
11. Shaft Seal
12. Stator
13. Washer
14. Screw
15. Gasket Kit
16. Needle Bearing
17. Drive Shaft
18. Key
19. Retaining Ring
20. Gear
21. Hex Cap
22. Adjustment Screw
23. Gasket
24. Spring
25. Spring
26. Ball
27. Shear Pin
28. Gear Housing
29. I.D. Label
30. Plug
31. Screw
32. Dowel Bushing
33. O-ring
34. Valve Block
35. Logic Valve
36. Screw

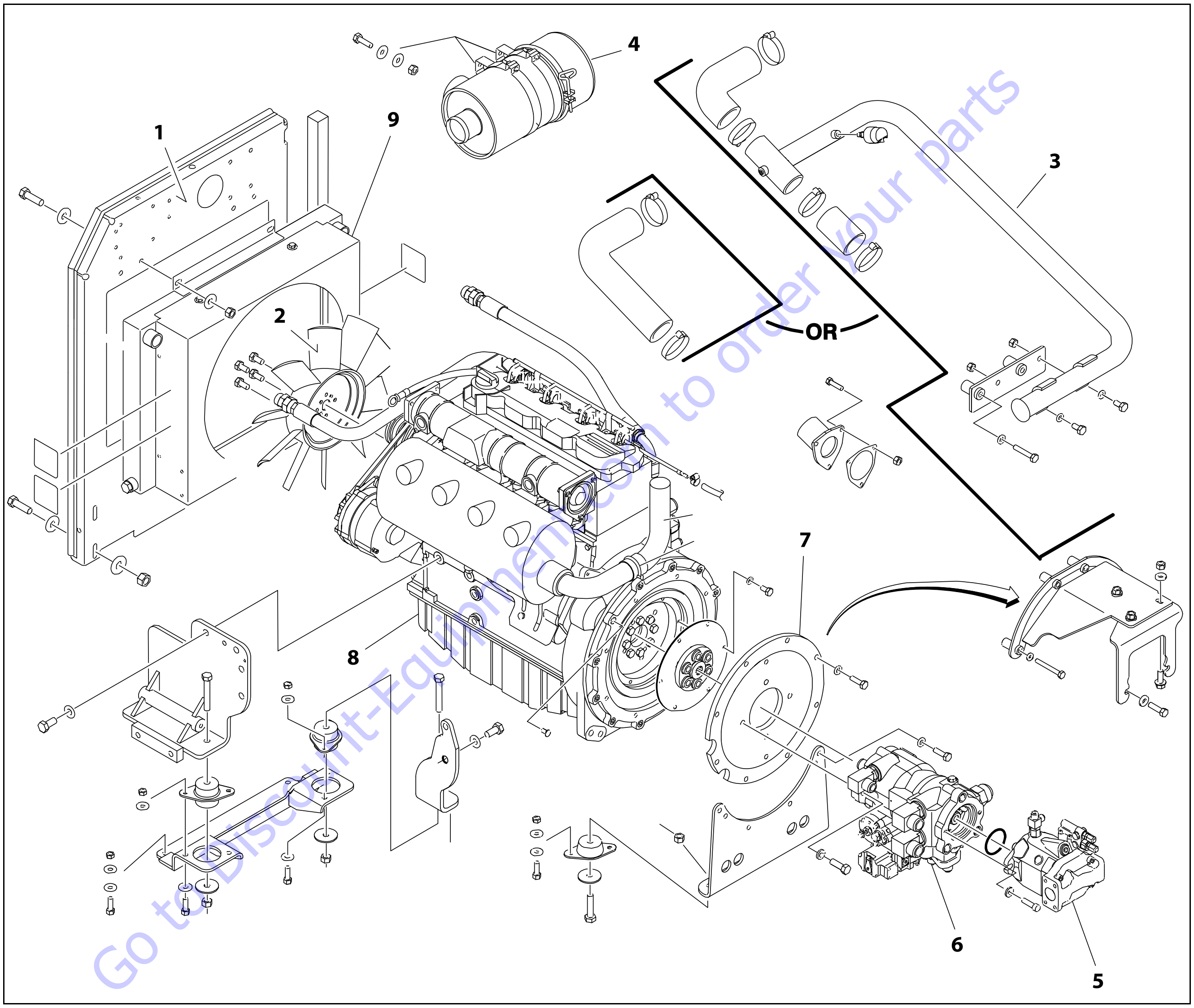
Figure 3-65. Auxiliary Pump



1. Auxiliary Pump 2. Hydraulic Tank

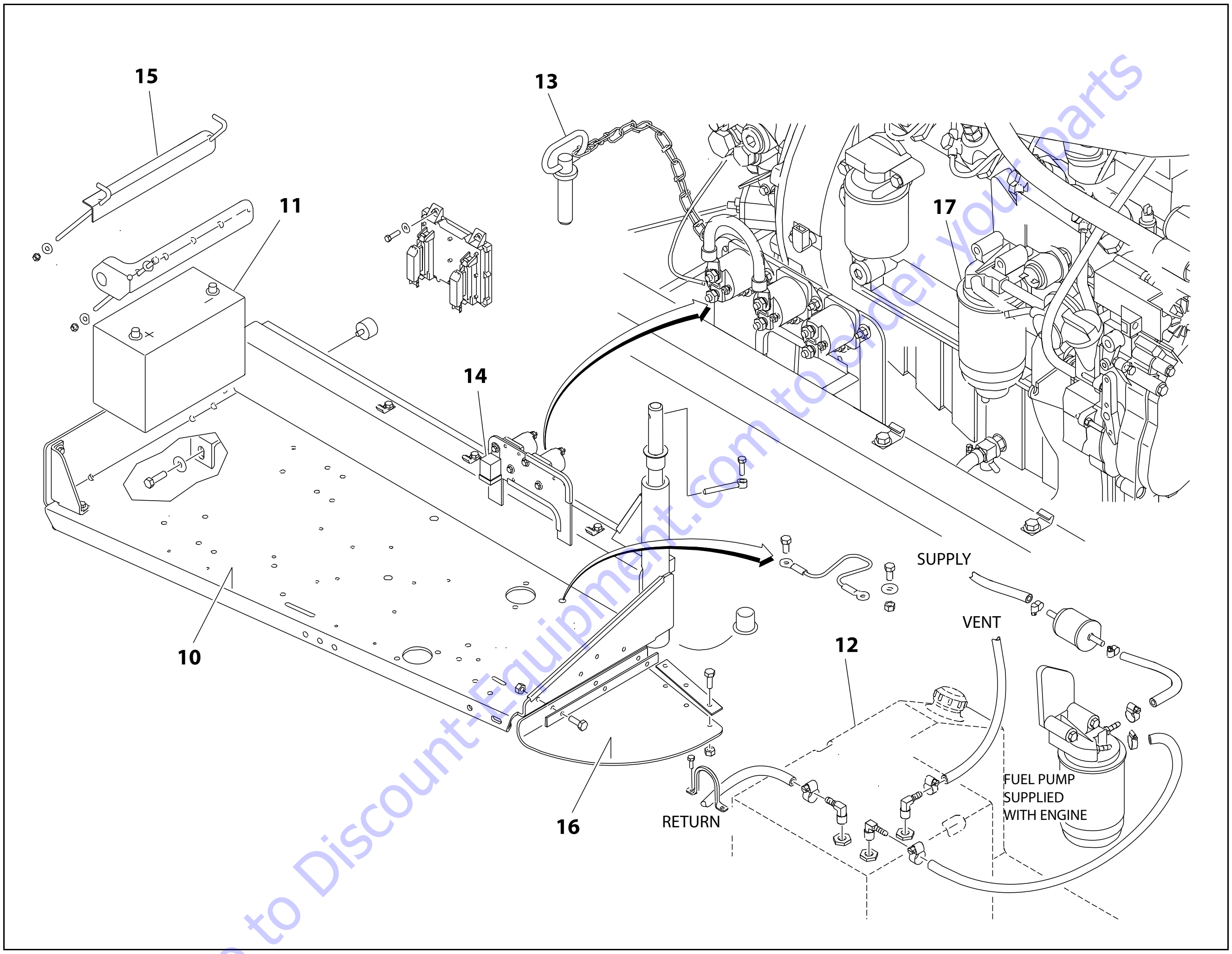
Figure 3-66. Auxiliary Pump Location

3.23 DEUTZ ENGINE



1. Radiator Mounting
2. Fan
3. Exhaust Tube
4. Air Cleaner
5. Gear Pump
6. Piston Pump
7. Pump Adapter Plate
8. Deutz ENgine
9. Oil Cooler

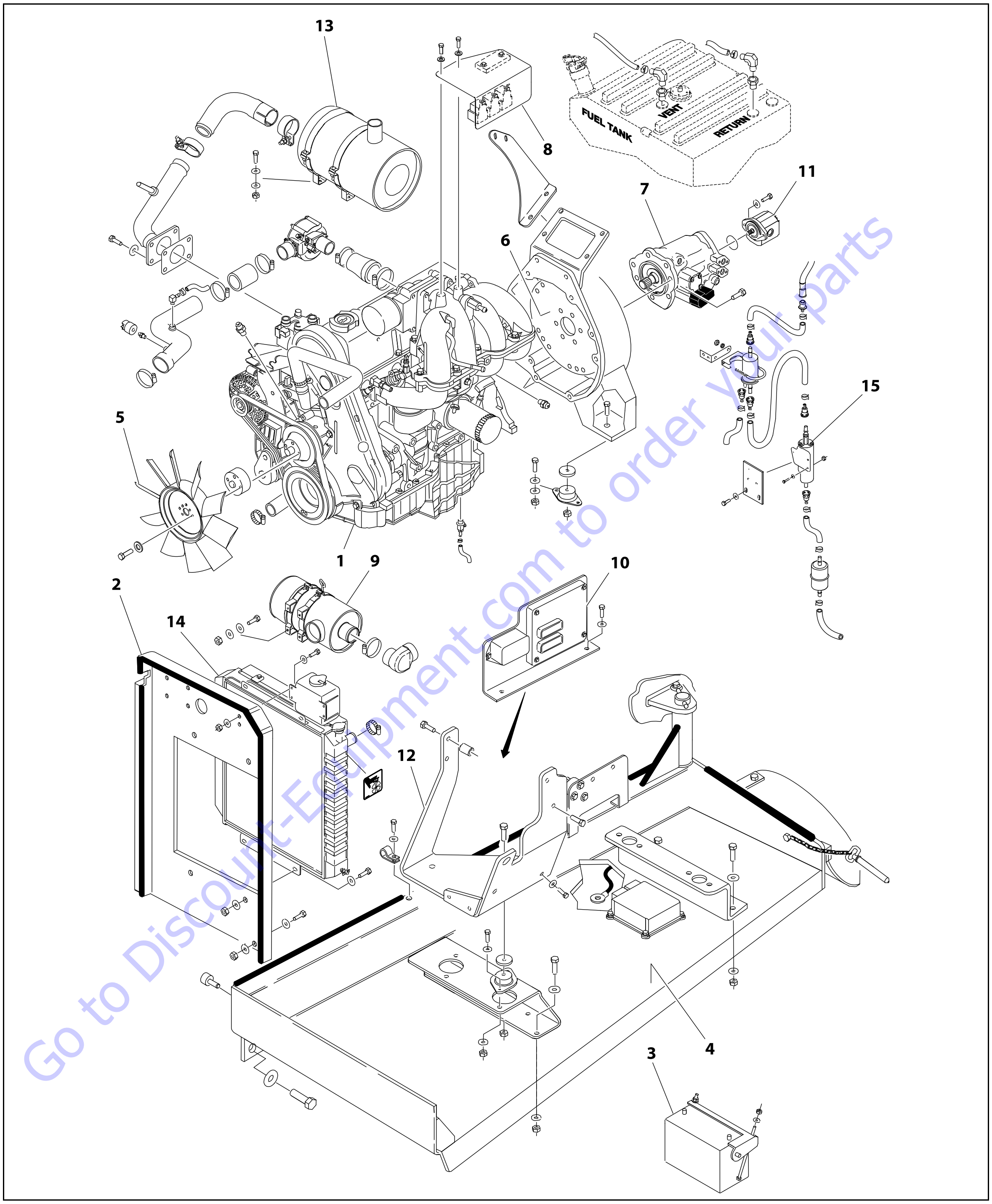
Figure 3-67. Deutz Engine Assembly (SN 0300077500 through 0300185827) - Sheet 1 of 2



10. Engine Tray
11. Battery
12. Fuel Tank
13. Hitch Pin
14. EGR Relay
15. Battery Hold-Down
16. Rubber Panel
17. Fuel Filter

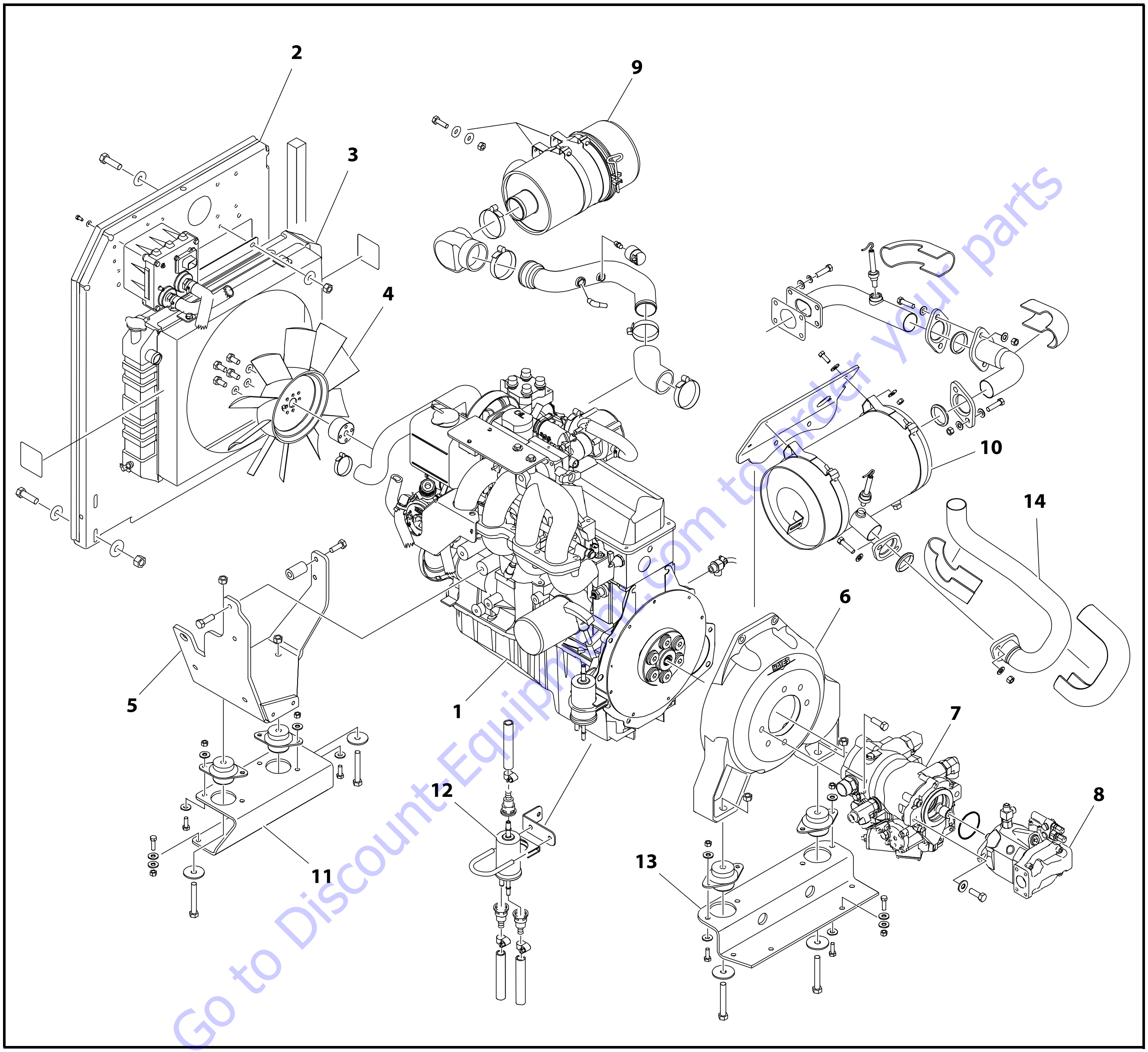
Figure 3-68. Deutz Engine Assembly (SN 0300077500 through 0300185827) - Sheet 2 of 2

3.24 FORD ENGINE



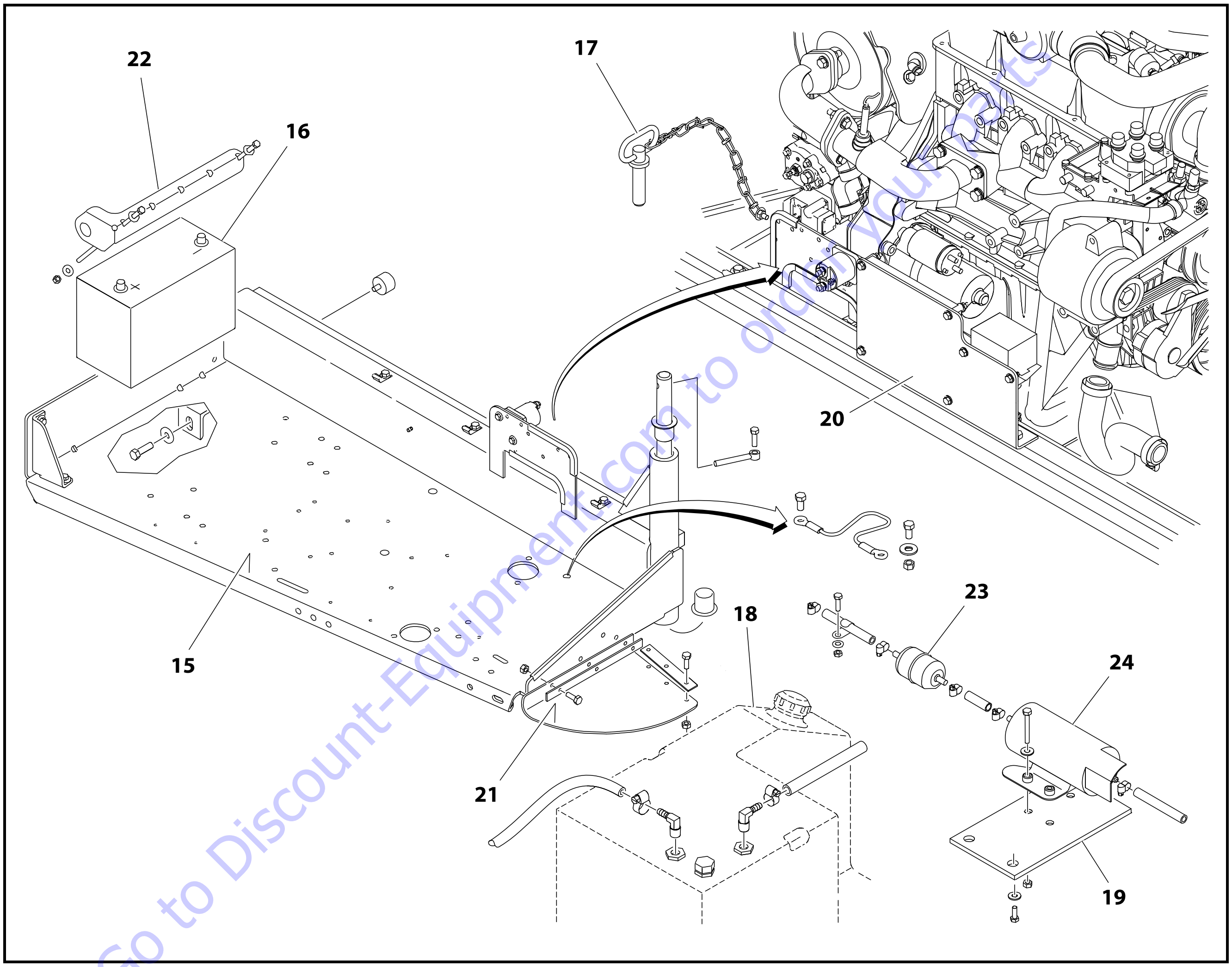
1. Ford LRG-425 Engine
2. Radiator Mount
3. Battery
4. Engine Tray
5. Fan
6. Pump Coupling
7. Piston Pump
8. Module Mount
9. Air Cleaner
10. EPM Module
11. Gear Pump
12. Engine Mount
13. Muffler
14. Radiator
15. Fuel Pump

Figure 3-69. Ford LRG-425 Engine Assembly (Prior to SN 0300077500)



1. Ford Engine
2. Radiator Mount
3. Radiator
4. Fan
5. Engine Mount
6. Coupling Pump
7. Piston Pump
8. Pump Assembly
9. Air Cleaner
10. Muffler
11. Engine Mount (Front)
12. Pressure Regulator and Filter
13. Engine Mount (Rear)
14. Exhaust Pipe

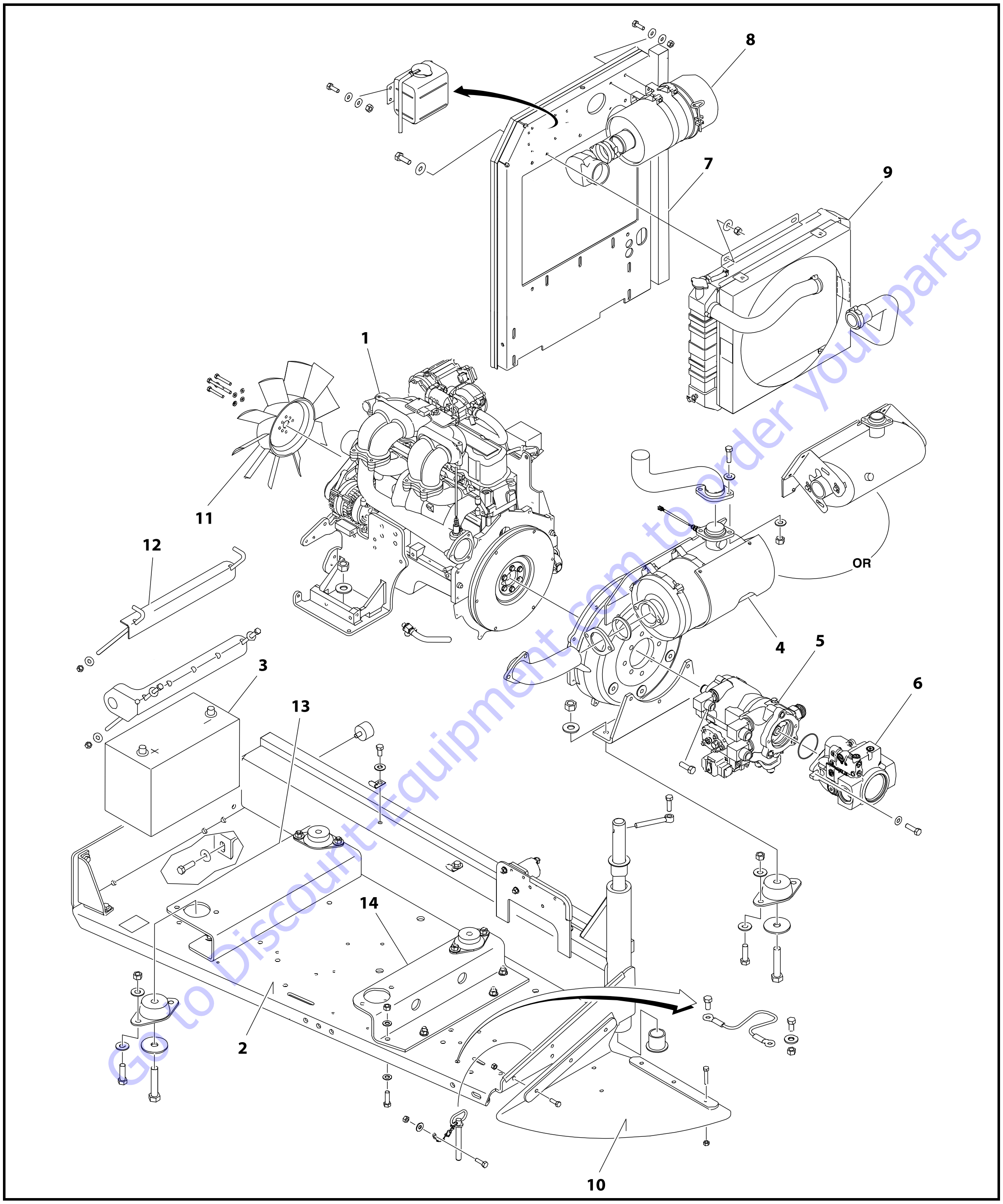
Figure 3-70. Ford Engine Assembly (SN 0300077500 through 0300185827) - Sheet 1 of 2



15.	Engine Tray	18.	Fuel Tank	21.	Rubber Panel	23.	Fuel Filter
16.	Battery	19.	Fuel Pump Mount	22.	Battery Hold-Down	24.	Fuel Pump
17.	Hitch Pin	20.	ECM Mount				

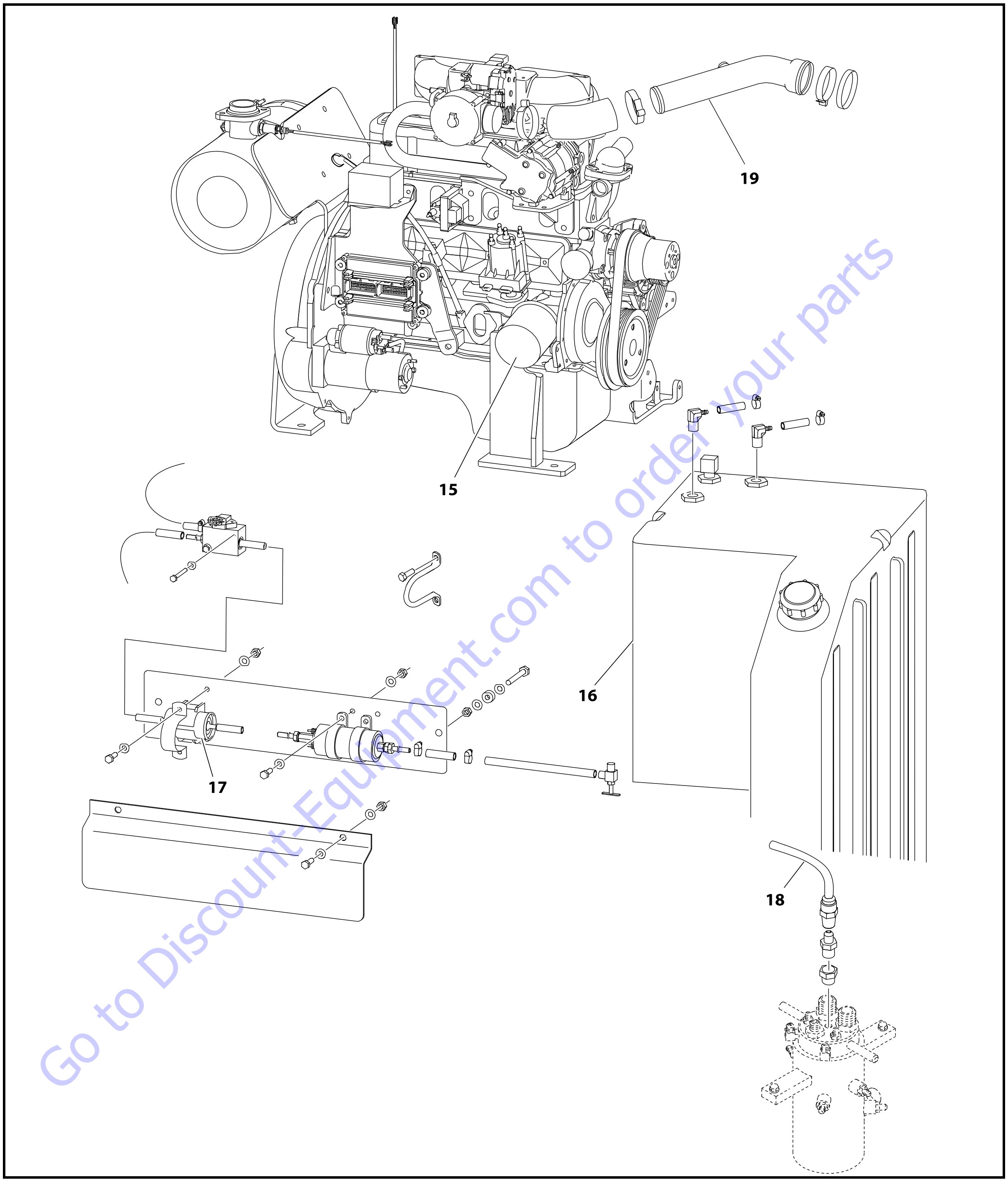
Figure 3-71. Ford Engine Assembly (SN 0300077500 through 0300185827) - Sheet 2 of 2

3.25 GM ENGINE



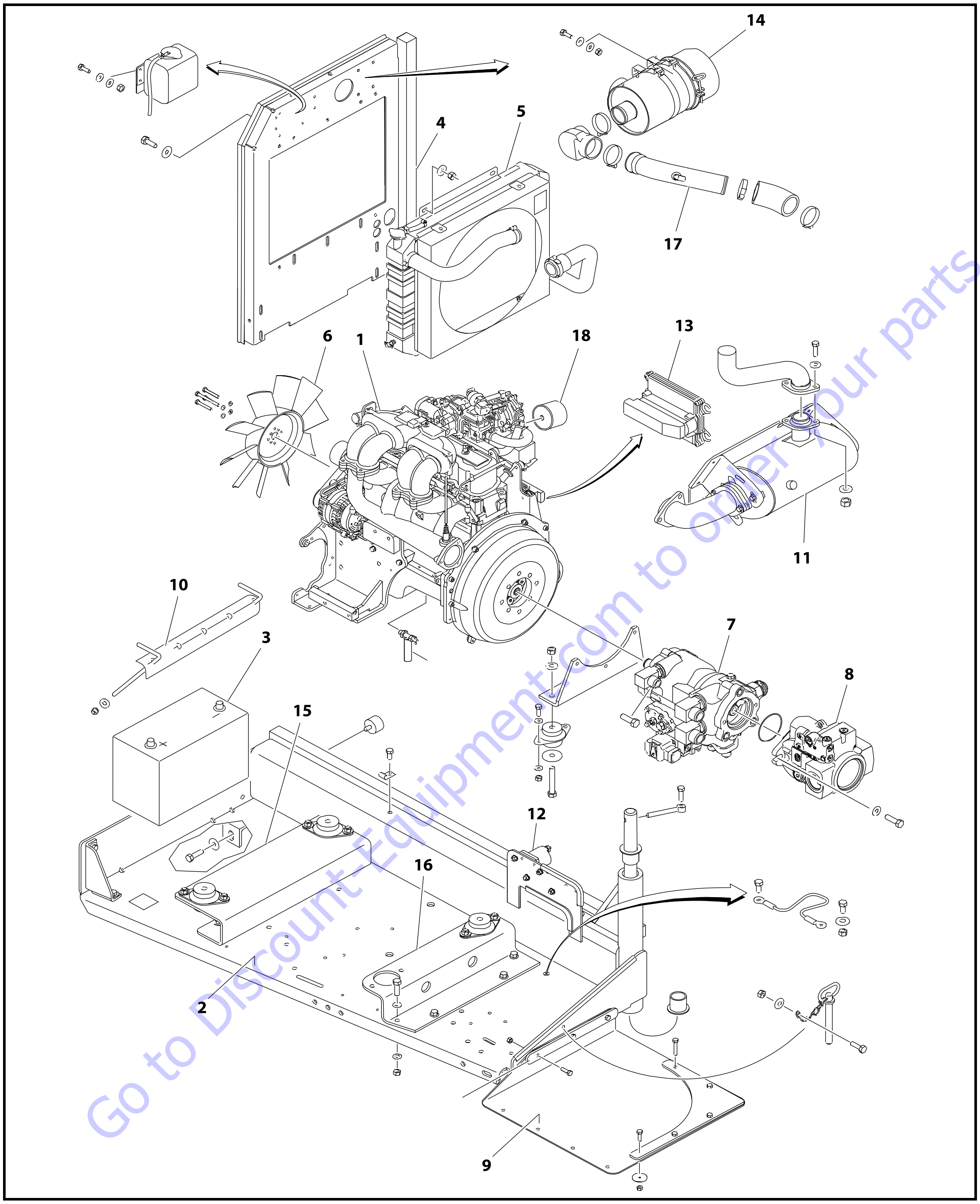
1. GM Engine
2. Engine Tray
3. Battery
4. Muffler
5. Piston Pump
6. Gear Pump
7. Radiator Mount
8. Air Cleaner
9. Radiator
10. Rubber Panel
11. Fan
12. Battery Hold-Down
13. Engine Mount (Front)
14. Engine Mount (Rear)

Figure 3-72. GM Engine Assembly (Prior to SN 0300140592) - Sheet 1 of 2



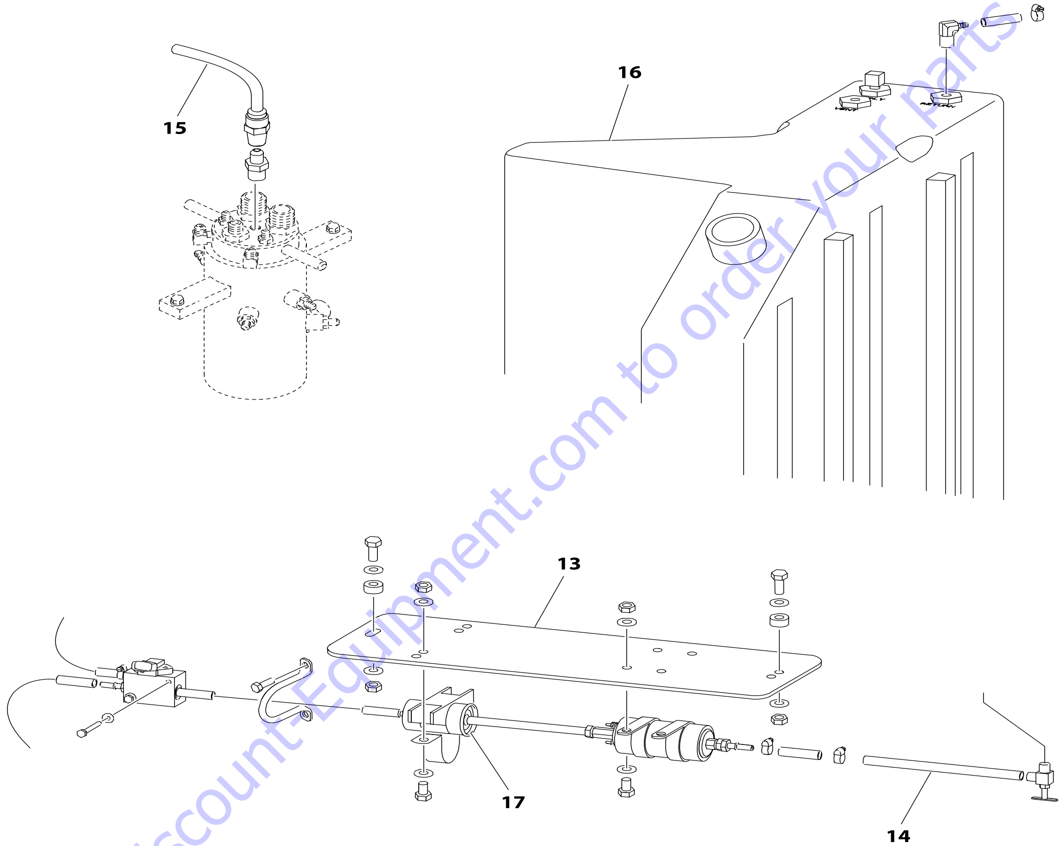
15. Oil Filter
16. Fuel Tank
17. Fuel Filter
18. LP Hose
19. Intake Tube

Figure 3-73. GM Engine Assembly (Prior to SN 0300140592) - Sheet 2 of 2



1. GM Engine
2. Engine Tray
3. Battery
4. Radiator Mount
5. Radiator
6. Fan
7. Piston Pump
8. Gear Pump
9. Rubber Panel
10. Battery Hold-Down
11. Muffler
12. Relay
13. Control Module (ECU)
14. Air Cleaner
15. Engine Mount (Front)
16. Engine Mount (Rear)
17. Intake Tube
18. Oil Filter

Figure 3-74. GM Engine Assembly (SN 0300140592 through 0300185827) - Sheet 1 of 2



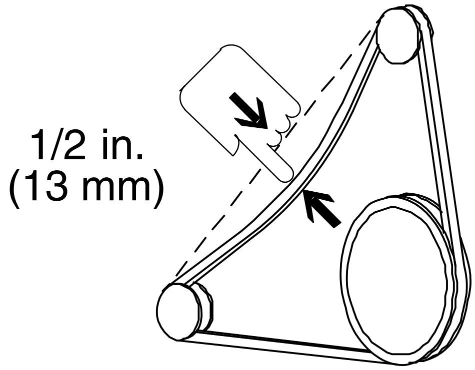
19. Fuel Filter Bracket
20. Tube (Fuel Line)
21. LP Hose
22. Fuel Tank
23. Fuel Filter

Figure 3-75. GM Engine Assembly (SN 0300140592 through 0300185827) - Sheet 2 of 2

3.26 GENERATOR

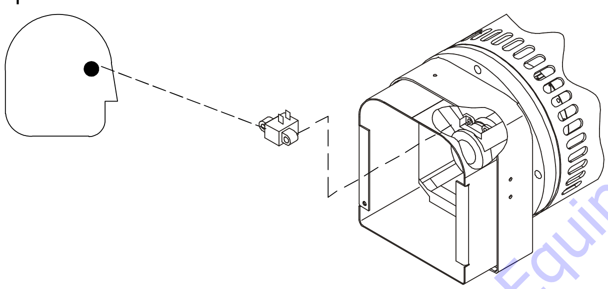
Every 250 hours

Every 250 hours of operation, check the drive belt for proper tension.

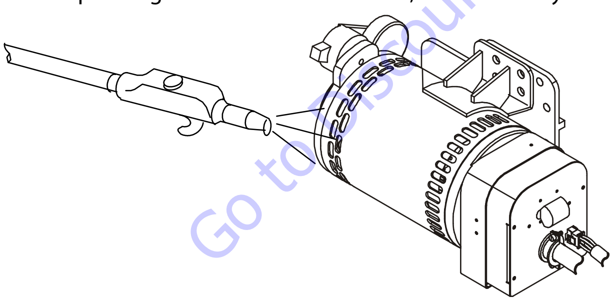


Every 500 hours

Every 500 hours of operation, service the generator brushes and slip rings. Hostile environments may require more frequent service.



Every 500 hours of service, blow out the inside of the generator. If operating in a hostile environment, clean monthly.

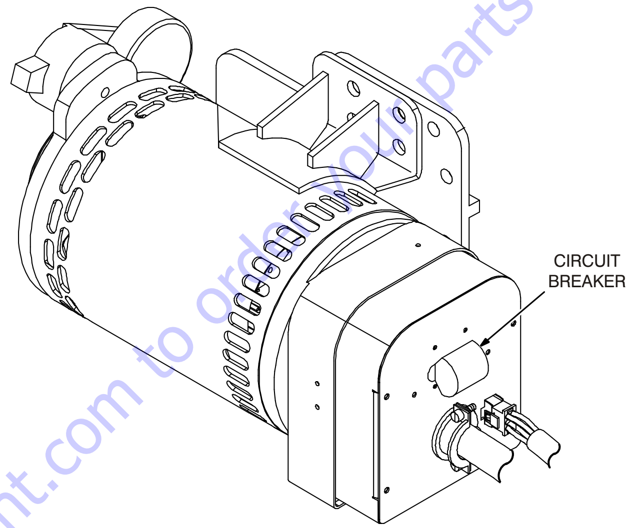


Overload Protection

⚠ CAUTION

STOP THE ENGINE WHENEVER CHECKING OR INSPECTING THE CIRCUIT BREAKER.

The circuit breaker protects the generator windings from overload. If the circuit breaker opens, generator output stops. If the circuit breaker continues to open, check for faulty equipment connected to the platform receptacles.



Inspecting Brushes, Replacing Brushes, and Cleaning Slip Rings

Refer to Figure 3-76., Inspecting Generator Brushes, Replacing Brushes, and Cleaning Slip Rings.

INSPECTING BRUSH POSITION

Inspect brush alignment with slip rings. View alignment through the air vents in the stator barrel. The brushes must ride completely on the slip rings.

INSPECTING BRUSHES

Remove the end panel. Inspect the wires. Remove the brush holder assembly. Pull the brushes from the holders.

Replace the brushes if damaged, or if the brush is at or near minimum length.

CLEANING SLIP RINGS

Visually inspect the slip rings. Under normal use, the rings turn dark brown.

If the slip rings are corroded or their surface is uneven, remove the belt to turn the shaft by hand for cleaning.

Clean the rings with 220 grit emery paper. Remove as little material as possible. If the rings are deeply pitted and do not clean up, consult generator factory service.

Reinstall the belt, brush holder assembly, and end panel.

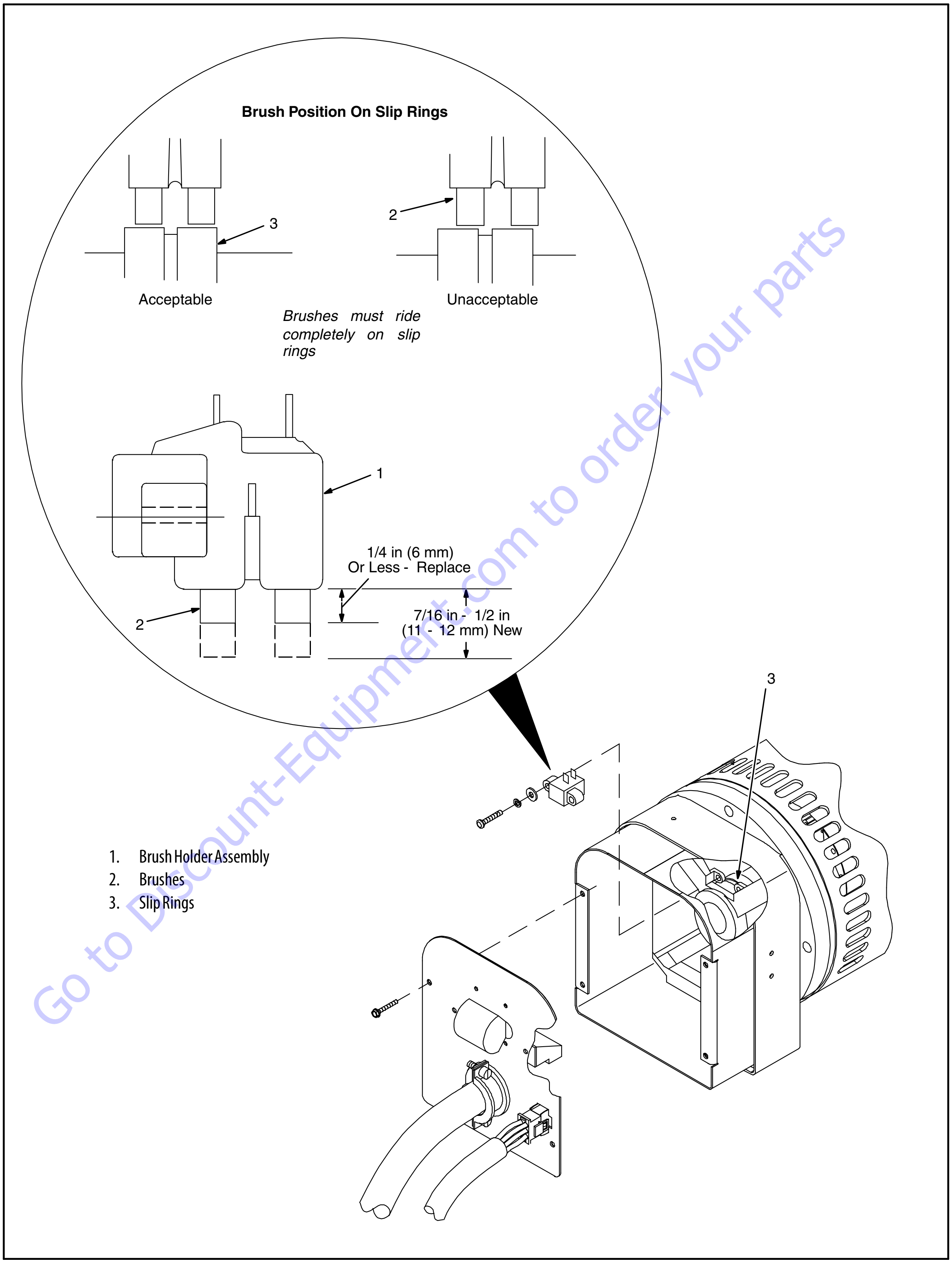


Figure 3-76. Inspecting Generator Brushes, Replacing Brushes, and Cleaning Slip Rings

Table 3-11. Troubleshooting

Trouble	Remedy
No generator output at platform AC receptacles.	Be sure generator control switch is turned on at platform.
	Check and secure electrical connections at platform, generator, and control box.
	Be sure all equipment is turned off when starting unit.
	Reset circuit breaker CB1.
	Check plug PLG3 connection and/or connections at receptacles RC3 and RC5.
	Be sure + 12 volts DC input voltage is being supplied to control box.
	Check slip rings, wiring to brushes, and brush position on slip rings. Install new brushes if necessary.
	Disconnect leads 12 and 13 from brushes, and check continuity across slip rings (nominal reading is 26 ohms). Replace generator if rotor is open.
	Disconnect stator weld leads 1, 2, and 3 from circuit breaker CB1 , and check continuity between leads. Replace generator if necessary.
	Disconnect plug PLG4 and check continuity between exciter leads 5 and 6. Replace generator if necessary.
	Check power board PC1 and connections, and replace if necessary.
	Check control board PC2 and connections, and replace if necessary.
Low generator output at platform AC receptacles.	Verify generator is running at 3600 rpm (60 Hz) or 3000 rpm (50 Hz).
	Check slip rings, wiring to brushes, and brush position on slip rings. Install new brushes if necessary.
	Disconnect leads 12 and 13 from brushes, and check continuity across slip rings nominal reading is 26 ohms). Replace generator if rotor is open.
	Disconnect stator weld leads 1, 2, and 3 from circuit breaker CB1, and check continuity between leads. Replace generator if necessary.
	Disconnect plug PLG4 and check continuity between exciter leads 5 and 6. Replace generator if necessary.
	Check power board PC1 and connections, and replace if necessary.
	Check control board PC2 and connections, and replace if necessary.
High generator output at platform AC receptacles.	Verify generator is running at 3600 rpm (60 Hz) or 3000 rpm (50 Hz).
	Check slip rings, wiring to brushes, and brush position on slip rings. Install new brushes if necessary.
	Check power board PC1 and connections, and replace if necessary.
	Check control board PC2 and connections, and replace if necessary.
Erratic generator output at platform AC receptacles.	Check and secure electrical connections at platform, generator, and control box.
	Verify generator is running at 3600 rpm (60 Hz) or 3000 rpm (50 Hz).
	Check slip rings, wiring to brushes, and brush position on slip rings. Install new brushes n necessary.
	Disconnect leads 12 and 13 from brushes, and check continuity across slip rings nominal reading is 26 ohms). Replace generator if rotor is open.
	Check power board PC1 and connections, and replace if necessary
	Check control board PC2 and connections, and replace if necessary

3.27 DUAL FUEL SYSTEM

CAUTION

IT IS POSSIBLE TO SWITCH FROM ONE FUEL SOURCE TO THE OTHER WITHOUT ALLOWING THE ENGINE TO STOP. EXTREME CARE MUST BE TAKEN AND THE FOLLOWING INSTRUCTIONS MUST BE FOLLOWED.

Changing from Gasoline to LP Gas

1. Start the engine from the ground control station.
2. Open the hand valve on the LP gas supply tank by turning counterclockwise.

CAUTION

BE SURE ALL GASOLINE IS EXHAUSTED BEFORE SWITCHING TO LP GAS.

3. While the engine is operating, place the two position LPG/Gasoline switch at the platform control station to the LP position. Allow the engine to operate without load until the engine regains smoothness.

Changing from LP Gas to Gasoline

1. With engine operating on LP under a no load condition, throw the LPG/Gasoline switch at the platform control station to the “Gasoline” position. Allow the engine to operate with no load until the engine regains smoothness
2. Close the hand valve on the LP gas supply tank by turning clockwise.

3.28 EFI ENGINE

Performing Diagnostics

1. Verify the complaint and determine if it is a deviation from normal operation.
2. Once the complaint has been verified, preliminary checks can be done. Conduct a thorough visual inspection, be alert for unusual sounds or odors, and gather diagnostic trouble code information.
3. Perform a system check that will verify the proper operation of the system in question and check for recent information updates.
4. If a diagnostic trouble code (DTC) is stored, contact a JLG distributor to make an effective repair.
5. If no DTC is stored, select the symptom from the symptom tables and follow the diagnostic path or suggestions to complete the repair.
6. After the repair has been made and validated for proper operation, the old part should be momentarily re-installed to verify that it was indeed the source of the problem.

If no matching symptom is available, analyze the complaint and develop a plan for diagnostics utilizing the wiring diagrams, technical assistance, and repair history.

Intermittent conditions may be resolved by using a check sheet to pinpoint the circuit or electrical system component. Some diagnostic charts contain Diagnostic Aids which give additional information about a system. Be sure to use all of the information that is available to you.

VISUAL/PHYSICAL ENGINE INSPECTION CHECK

Perform a careful visual and physical engine inspection before performing any diagnostic procedure. Perform all necessary repairs before proceeding with additional diagnosis, this can often lead to repairing a problem without performing unnecessary steps. Use the following guidelines when performing a visual/physical inspection check:

- Inspect engine for modifications or aftermarket equipment that can contribute to the symptom; verify that all electrical and mechanical loads or accessory equipment is "OFF" or disconnected before performing diagnosis.
- Inspect engine fluids for correct levels and evidence of leaks.
- Inspect vacuum hoses for damage, leaks, cracks, kinks, and improper routing, inspect intake manifold sealing surface for a possible vacuum leak.
- Inspect PCV valve for proper installation and operation.
- Inspect all wires and harnesses for proper connections and routing; bent or broken connector pins; burned, chafed, or pinched wires; and corrosion. Verify that harness grounds are clean and tight.
- Inspect engine control module (ECM), sensors, and actuators for physical damage.
- Inspect ECM grounds for cleanliness, tightness, and proper location.
- Inspect fuel system for adequate fuel level, and fuel quality (concerns such as proper octane, contamination, winter/summer blend).
- Inspect intake air system and air filter for restrictions.
- Inspect battery condition and starter current draw.

If no evidence of a problem is found after visual/physical engine check has been performed, proceed to MIL DTC retrieval procedure.

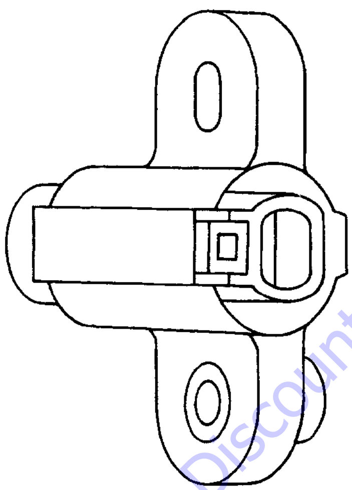
Engine Module and Sensors

CRANKSHAFT POSITION (CKP) SENSOR

The crankshaft position (CKP) sensor provides a signal used by the Engine Module to calculate the ignition sequence. The CKP sensor initiates the reference pulses which the Engine Module uses to calculate RPM and crankshaft position.

CAMSHAFT POSITION (CMP) SENSOR AND SIGNAL

The camshaft position (CMP) sensor sends a CMP signal to the Engine Module. The Engine Module uses this signal as a "sync pulse" to trigger the injectors in the proper sequence. The Engine Module uses the CMP signal to indicate the position of the #1 piston during its power stroke. The CMP uses a Hall Effect sensor to measure piston position. This allows the Engine Module to calculate true sequential fuel injection (SFI) mode of operation. If the Engine Module detects an incorrect CMP signal while the engine is running, DTC 53 will set. If the CMP signal is lost while the engine is running, the fuel injection system will shift to a calculated sequential fuel injection mode based on the last fuel injection pulse, and the engine will continue to nun. As long as the fault is present, the engine can be restarted. It will run in the previously established injection sequence.



ENGINE COOLANT TEMPERATURE (ECT) SENSOR

The engine coolant temperature (ECT) sensor is a g thermistor (a resistor which changes value based on temperature) mounted in the engine coolant stream. Low coolant temperature produces a high resistance of 100,000 ohms at -40°C (-40°F). High temperature causes a low resistance of 70 ohms at 130°C (266°F). The Engine Module supplies a 5-volt signal to the ECT sensor through resistors in the Engine Module and measures the voltage. The signal voltage will be high when the engine is cold and low when the engine is hot. By measuring the voltage, the Engine Module calculates the engine coolant temperature. Engine coolant temperature affects most of the systems that the Engine Module controls.

After engine start-up, the temperature should rise steadily to about 85°C (185°F). it then stabilizes when the thermostat opens. If the engine has not been run for several hours (overnight), the engine coolant temperature and intake air temperature displays should be close to each other. A fault in the engine coolant sensor circuit will set DTC 33 or DTC 43.

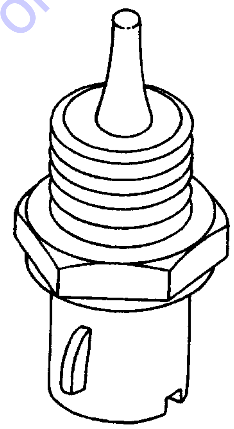


Table 3-12. ECM Diagnostic Trouble Codes

Diagnostic Trouble Code	Description
11	All Systems OK
12	Throttle Position (TP) Sensor Low Voltage
14	Manifold Absolute Pressure (MAP) Low Voltage
21	Overspeed
22	Throttle Position (TP) Sensor High Voltage
24	Manifold Absolute Pressure (MAP) High Voltage
31	Fuel Pump Low Voltage
32	Heated Oxygen Sensor (HO2S) Low Voltage
33	Engine Coolant Temperature (ECT) Sensor High Voltage
35	Intake Air Temperature (IAT) Sensor High Voltage
41	Fuel Pump High Voltage
42	Heated Oxygen Sensor (HO2S) High Voltage
43	Engine Coolant Temperature (ECT) Sensor Low Voltage
45	Intake Air Temperature (IAT) Sensor Low Voltage
51	Low Oil Pressure
52	Crankshaft Position (CKP) Sensor Extra/Missing Pulses
53	Camshaft Position Sensor (CMP) Sensor Illegal Pattern
54	Engine Control Module (ECM) Fault Illegal Operation
55	Engine Control Module (ECM) Fault Illegal Interruption
56	Engine Control Module (ECM) Fault COP (Computer Operating Properly) Failure
61	System Voltage Low
62	System Voltage High

Table 3-13. EPM Diagnostic Trouble Codes

Diagnostic Trouble Code	Description	Cause for Setting DTC
111	Closed Loop Multiplier High (LPG)	This fault sets if the Closed Loop multiplier exceeds the limits of normal operation and cannot correctly modify the fuel flow within its limits.
112	HO2S Open/Inactive (Bank 1)	This fault will set if HO2S 1 is cold, non-responsive, or inactive for 60 seconds or longer.
113	HO2S Open/Inactive (Bank 2)	This fault will set if HO2S 2 is cold, non-responsive, or inactive for 60 seconds or longer.
121	Closed Loop Multiplier High Bank 1 (Gasoline)	This fault sets if the Closed Loop multiplier exceeds the limits of normal operation. When the multi-plier cannot correctly modify the fuel flow within its limits, the limit is enforced. NOTE: If this DTC is set in conjunction with DTC 132, the HO2S sensors may be cross connected.
122	Closed Loop Multiplier Low Bank 1 (Gasoline)	This fault sets if the Closed Loop multiplier exceeds the limits of normal operation. When the multi-plier cannot correctly modify the fuel flow within its limits, it is limited at -35%. NOTE: If this DTC is set in conjunction with DTC 131, the HO2S sensors may be cross connected.
124	Closed Loop Multiplier Low (LPG)	This fault sets if the Closed Loop multiplier exceeds the limits of normal operation. When the multi-plier cannot correctly modify the fuel flow within its limits, it is limited at -35%. When this condition occurs, the EPM perceives the engine to be running rich.
125	Closed Loop Multiplier High (Natural Gas)	This fault sets if the Closed Loop multiplier exceeds the limits of normal operation. When the multi-plier cannot correctly modify the fuel flow within its limits, it is limited at 35%. When this fault occurs, it is because the EPM perceives the engine to be running lean.
126	Closed Loop Multiplier Low (Natural Gas)	This fault sets if the Closed Loop multiplier exceeds the limits of normal operation. When the multi-plier cannot correctly modify the fuel flow within its limits, it is limited at -35%. This occurs when the module perceives the engine to be running rich.
131	Closed Loop Multiplier High Bank 2 (Gasoline)	This fault sets if the Closed Loop multiplier exceeds the limits of normal operation. When the multi-plier cannot correctly modify the fuel flow within its limits, the limit is enforced.
132	Closed Loop Multiplier Low Bank 2 (Gasoline)	This fault sets if the Closed Loop multiplier exceeds the limits of normal operation. When the multi-plier cannot correctly modify the fuel flow within its limits, it is limited at -35%.
141	Adaptive Lean Fault (High Limit- Gasoline)	This fault sets if the Adaptive multiplier exceeds the limits of normal operation.
142	Adaptive Rich Fault (Low Limit Gasoline)	This fault sets if the Adaptive multiplier exceeds the limits of normal operation.
143	Adaptive Learn High (LPG)	This fault will set if the adaptive multiplier exceeds the limits of normal operation.
144	Adaptive Learn Low (LPG)	This fault will set if the adaptive multiplier exceeds the limits of normal operation.
145	Adaptive Learn High (Natural Gas)	This fault will set if the adaptive multiplier exceeds the limits of normal operation.
146	Adaptive Learn Low (Natural Gas)	This fault will set if the adaptive multiplier exceeds the limits of normal operation.
161	System Voltage Low	This fault will set if the EPM detects voltage less than 9.5 for 5 seconds or longer while the alternator should be charging. The adaptive learn is disabled due to the inability of the EPM to correctly time injector openings.
162	System Voltage High	This fault will set if the EPM detects voltage greater than 18 volts for 3 seconds at anytime the engine is cranking or running. The adaptive learn is disabled due to the inability of the EPM to correctly time the injector openings. The EPM will shut down with internal protection with more than 26 volts. A fuse will then blow in the harness.

Table 3-13. EPM Diagnostic Trouble Codes

Diagnostic Trouble Code	Description	Cause for Setting DTC
211	IAT High Voltage	This fault will set if the signal voltage is more than 4.95 volts anytime the engine is running. The EPM will use the default value for the IAT sensor in the event of this fault.
212	IAT Low Voltage	This fault will set if the signal voltage is less than 0.05 volts anytime the engine is cranking or running. The EPM will use a default value for the IAT sensor in the event
213	IAT Higher Than Expected 1	This fault will set if the Intake Air Temperature is greater than 200 °F and engine RPM is greater than 1000 and Power Derate 1 will be enforced. During this fault, maximum throttle position is 50% and the MIL light will flash twice per second.
214	IAT Higher Than Expected 2	This fault will set if the Intake Air Temperature is greater than 210 °F and engine RPM is greater than 1000. The MIL light will be on during this active fault and the engine will shut down.
215	Oil Pressure Low	This fault can be configured two different ways. It may use a normally closed switch or a normally open switch. If the switch is normally open, the fault will set if the circuit becomes grounded. If the switch is normally closed, the fault will set if the circuit becomes open. Go to the Fault page on Diagnostic Tool to determine how the input is configured. ("Open is OK" is normally open and "Ground is OK" is normally closed). The engine will shut down in the event of this fault to help prevent possible damage.
221	ECT High Voltage	This fault will set if the signal voltage is greater than 4.95 volts anytime the engine is running. The EPM will use a default value for the ECT sensor in the event of this fault.
222	ECT Low Voltage	This fault will set if the signal voltage is less than 0.05 volts anytime the engine is running. The EPM will use a default value for the ECT sensor in the event of this fault.
231	MAP High Pressure	This fault will set when the MAP reading is higher than it should be for the given TPS, and RPM. When the fault is set, the Adaptive Learn will be disabled for the remainder of the key on cycle and the MIL will be on. The engine will operate on a default MAP during this active fault.
232	MAP Low Voltage	This fault will set when the MAP reading is lower than the sensor should normally produce. When this fault is set the Adaptive learn will be disabled for the remainder of the key on cycle and the MIL will be on.
234	BP High Pressure	This fault sets in the event the BP value is out of the normal range.
235	BP Low Pressure	This fault sets in the event the BP value is out of the normal range.
242	Crank Sync Noise	The EPM must see a valid Crankshaft position signal while running. If no signal is present for 800 ms or longer, this fault will set.
243	Never Crank Synced At Start	The EPM must see a valid Crankshaft Position signal while cranking before it starts. If no signal is present within 4 cranking revs, this fault will set.
244	Camshaft Sensor Loss	The Camshaft Position Sensor is used to determine which cylinder to fire. This fault will set if the EPM does not detect a cam pulse when the RPM is greater than 1000. Normally the engine will run with this fault present. In some instances this fault may cause rough engine operation.
245	Camshaft Sensor Noise	This fault will set if the EPM detects erroneous pulses from the camshaft position sensor causing invalid cam re-sync.
253	Knock Sensor Open	This fault will set if the Knock Sensor input to the EPM is less than 0.2 volt while engine rpm is greater than 1500 and MAP is greater than 8 psia.
254	Excessive Knock Signal	This fault will set if the Knock Sensor input to the EPM is greater than 4.5 volts while MAP is less than 8 psia and knock spark retard is at maximum.

Table 3-13. EPM Diagnostic Trouble Codes

Diagnostic Trouble Code	Description	Cause for Setting DTC
311	Injector Driver #1 Open (2.5L)	This fault will set if the EPM detects low feedback voltage on the internal injector while the injector drive circuit is in the off-state and battery voltage is greater than 9 volts.
312	Injector Driver #1 Shorted (2.5L)	This fault will set if the EPM detects 10 injector firings with the internal driver sense voltage greater than 4 volts while the injector is in the on-state and battery voltage is less than 16 volts.
313	Injector Driver #2 Open (2.5L)	This fault will set if the EPM detects low feedback voltage on the internal injector while the injector drive circuit is in the off- state and battery voltage is greater than 9 volts.
314	Injector Driver #2 Shorted (2.5L)	This fault will set if the EPM detects 10 injector firings with the internal driver sense voltage greater than 4 volts while the injector is in the on-state and battery voltage is less than 16 volts.
315	Injector Driver #3 Open (2.5L)	This fault will set if the EPM detects low feedback voltage on the internal injector while the injector drive circuit is in the off-state and battery voltage is greater than 9 volts.
316	Injector Driver #3 Shorted (2.5L)	This fault will set if the EPM detects low feedback voltage on the internal injector while the injector drive circuit is in the off-state and battery voltage is greater than 9 volts.
321	Injector Driver #4 Open (2.5L)	This fault will set if the EPM detects 10 injector firings with the internal driver sense voltage greater than 4 volts while the injector is in the on-state and battery voltage is less than 16 volts.
322	Injector Driver #4 Shorted (2.5L)	This fault will set if the EPM detects 10 injector firings with the internal driver sense voltage greater than 4 volts while the injector is in the on-state and battery voltage is less than 16 volts.
351	Fuel Pump Loop Open or High Side Short To Ground	This fault will set if the EPM detects Fuel Pump high-side on-state voltage less than 4 volts while battery voltage is greater than 8 volts. When this fault occurs, the MIL light will illuminate and the engine will shut down.
352	Fuel Pump High Side Shorted To Power	This fault will set if the EPM detects Fuel Pump high-side voltage greater than 4 volts while the pump should be off and the battery voltage is less than 16 volts. When this fault occurs, the MIL light will illuminate and the engine will shut down.
411	Coil Driver #1 Open (2.5L)	This fault will set if the EPM detects 10 coil firings which require the adaptive dwell to be greater than allowed with the battery voltage above 11 volts.The purpose of this fault is to detect an open or high impedance circuit to the coil, or an open primary coil.
412	Coil Driver #1 Shorted (2.5L)	This fault will set if the EPM detects 10 coil firings in which the adaptive dwell is less allowed and battery voltage is less than 16 volts.The purpose of this fault is to detect a short to ground in the harness, or internally to the primary coil.
413	Coil Driver #2 Open (2.5L)	This fault will set if the EPM detects 10 coil firings which require the adaptive dwell to be greater than allowed with the battery voltage above 11 volts. The purpose of this fault is to detect an open or high impedance circuit to the coil, or an open primary coil.
414	Coil Driver #2 Shorted (2.5L)	This fault will set if the EPM detects 10 coil firings in which the adaptive dwell is less than allowed and battery voltage is less than 16 volts. The purpose of this fault is to detect a short to ground in the harness, or internally to the primary coil.
511	FPP1 High Voltage	This fault will set if voltage is over 4.8 volts at any operating condition while the key is on. If the voltage exceeds 4.8, then FPP1 is considered to be out of specifications. At this point the EPM does not have a valid signal, and must therefore enforce the low rev limit and Power Derate (level 1). When these are enforced the maximum throttle position is 50% and the maximum engine speed is 1600 RPM. The Low Rev Limit is enforced for the remainder of the key-on cycle. Rev limit is still enforced if the active fault is no longer present; the MIL light will flash at 2 Hz for the remainder of the key-on cycle. This is a reminder that the Low Rev Limit is still enforced.

Table 3-13. EPM Diagnostic Trouble Codes

Diagnostic Trouble Code	Description	Cause for Setting DTC
512	FPP1 Low Voltage	This fault will set if voltage is less than 0.2 volts at any operating condition while the key is on. If the voltage is less than 0.2, then FPP1 is considered to be out of specifications. At this point the EPM does not have a valid signal, and must therefore enforce the low rev limit and Power Derate (level-1). When these are enforced the maximum throttle position is 50% and the maximum engine speed is 1600 RPM. The low rev limit is enforced for the remainder of the key- on cycle. If the active fault is no longer present, the MIL light will flash at 2 Hz for the remainder of the key-on cycle. This is a reminder that the Low Rev Limit is still enforced.
513	FPP1 Higher Than IVS Limit	This fault will set if the IVS is at idle (open) and the FPP 1 voltage is greater than 1.2 volts. During this fault, Power Derate (level 2) and the Low Rev Limit are enforced. When these are enforced the maximum throttle position is 20% and the maximum engine speed is 1600 RPM. The Low Rev Limit and Power Derate are enforced for the remainder of the key-on cycle. If the active fault is no longer present, the MIL light will flash at 2 Hz for the remainder of the key-on cycle. This is a reminder that the Power Derate and Low Rev Limits are still enforced.
514	FPP1 Lower Than IVS Limit	This fault will set if the IVS is off-idle (closed) and the FPP 1 voltage is less than 0.6 volts. During this fault, Power Derate (level 2) and the Low Rev Limit are enforced. When these are enforced the maximum throttle position is 20% and the maximum engine speed is 1600 RPM. These are enforced for the remainder of the key-on cycle. If the active fault is no longer present, the MIL light will flash at 2 Hz for the remainder of the key-on cycle. This is a reminder that the Power Derate and Low Rev Limits are still enforced.
521	FPP2 High Voltage	This fault will set if signal voltage is over 4.8 volts at any operating condition while the key is on.If the voltage exceeds 4.8, then FPP2 is considered out of specification. At this point the EPM does not have a valid signal, and must therefore enforce the Low Rev Limit and Power Derate (level 1). When these are enforced the maximum throttle position is 50% and the maximum engine speed is 1600 RPM. The Low Rev Limit is enforced for the remainder of the key-on cycle. If the active fault is no longer present, the MIL light will flash at 2 Hz for the remainder of the key-on cycle. This is a reminder that the Low Rev Limit is still enforced.
522	FPP2 Low Voltage	This fault will set if signal voltage is less than 0.2 volts at any operating condition while the key is on. If the voltage is less than 0.2, then FPP2 is considered out of specification. At this point the EPM does not have a valid signal, and must therefore enforce the low rev limit and Power Derate (level 1). When these are enforced the maximum throttle position is 50% and the maximum engine speed is 1600 RPM. The low rev limit is enforced for the remainder of the key-on cycle. If the active fault is no longer present, the MIL light will flash at 2 Hz for the remainder of the key-on cycle. This is a reminder that the Low Rev Limit is still enforced.
531	TPS1 (Signal Voltage) High	This fault will set if voltage is above 4.8 volts at any operating condition while the engine is cranking or running. The engine will not start or run during this active fault.
532	TPS1 (Signal Voltage) Low	This fault will set if voltage is less than 0.2 volts at any operating condition while the engine is cranking or running. The engine will not start or run during this active fault.
533	TPS2 (Signal Voltage) High	This fault will set if voltage is above 4.8 volts at any operating condition while the engine is cranking or running. The engine will not start or run during this active fault. Throttle Position Sensor #2
534	TPS2 (Signal Voltage) Low	This fault will set if voltage is below 0.2 volts at any operating condition while the engine is cranking or running. The engine will not start or run during this active fault.
535	TPS1 Higher Than TPS2	This fault will set if TPS1 is 20% (or more) higher than TPS2. At this point the throttle is considered to be out of specification, or there is a problem with the TPS signal circuit. During this active fault, the MIL light will be on and the engine will shut down.

Table 3-13. EPM Diagnostic Trouble Codes

Diagnostic Trouble Code	Description	Cause for Setting DTC
536	TPS1 Lower Than TPS2	This fault will set if TPS1 is 20% (or more) lower than TPS2. At this point the throttle is considered to be out of specification, or there is a problem with the TPS signal circuit. During this active fault, the MIL light will be on and the engine will shut down.
537	Throttle Unable To Open	This fault will set if the throttle command is 20% or more than the actual throttle position. During this active fault the MIL light will be on and the engine will shut down.
538	Throttle Unable To Close	This fault will set if the throttle command is 20% less than the actual throttle position. During this active fault the MIL light will be on and the engine will shut down.
545	Governor Interlock Failure	This fault will set if Gov. 1, 2, or 3 are enabled and the EPM does not detect a ground from the brake switch input. During this active fault the MIL light will be on and Power Derate (level 1) and the Low Rev Limit will be enforced. When these are enforced the maximum throttle position is 50% and the maximum engine speed is 1600 RPM. The Low Rev Limit is enforced for the remainder of the key-on cycle. If the active fault is no longer present, the MIL light will flash at 2 Hz for the remainder of the key-on cycle. This is a reminder that the Low Rev Limit is still enforced.
551	Max Govern Speed Override	This fault will set anytime the engine RPM exceeds 4500 for 2 seconds or more continuously. This speed overrides any higher max governor speeds programmed by the user. This is to help prevent engine or equipment damage.
552	Fuel Rev Limit	This fault will set anytime engine RPM exceeds 4800 for 2 seconds or more continuously. When these conditions are met, the EPM shuts off the fuel injectors. This is to help prevent engine or equipment damage. NOTE: If any other DTCs are present, diagnose those first.
553	Spark Rev Limit	This fault will set anytime the engine RPM exceeds 4900 for 2 seconds or more continuously. When these conditions are met, the EPM will shut off spark to the engine. This is to help prevent engine or equipment damage. NOTE: If any other DTCs are present, diagnose those first.
611	COP Failure	Several different things can happen within the microprocessor that will cause this fault. The EPM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase. During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.
612	Invalid Interrupt	Several different things can happen within the microprocessor that will cause this fault. The EPM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase. During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.
613	A/D Loss	This fault should be erased after diagnosis by removing battery power. It will not self-erase. During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.
614	RTI 1 Loss	Several different things can happen within the microprocessor that will cause this fault. The EPM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase. During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

Table 3-13. EPM Diagnostic Trouble Codes

Diagnostic Trouble Code	Description	Cause for Setting DTC
615	Flash Checksum Invalid	Several different things can happen within the microprocessor that will cause this fault. The EPM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase. During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.
616	RAM failure	This fault will set if the EPM detects a problem accessing or writing information to RAM. This fault will not self erase and must be cleared manually.
631	External 5V Ref Lower Than Expected	This fault will set if the 5 Volt reference is below 4.6 volts.
632	External 5V Ref Higher Than Expected	This fault will set if the 5 Volt reference is above 5.4 volts.
655	RTI 2 Loss	Several different things can happen within the microprocessor that will cause this fault. The EPM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase. During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.
656	RTI 3 loss	Several different things can happen within the microprocessor that will cause this fault. The EPM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase. During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

ELECTRICALLY ERASABLE PROGRAMMABLE READ ONLY MEMORY (EEPROM)

The electrically erasable programmable read only memory (EEPROM) is a permanent memory chip that is located within the Engine Module. The EEPROM contains the pro-gram and the calibration information that the Engine Module needs to control engine operations.

If the Engine Module is replaced, the new Engine Module will need to be programmed. An IBM-compatible computer and software containing the correct program and calibration for the application are required to program the Engine Module.

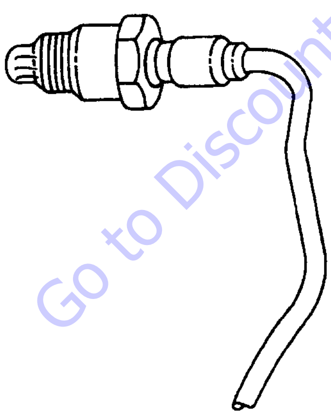
HEATED OXYGEN SENSOR

The heated oxygen sensor is mounted in the exhaust stream where it can monitor the oxygen content of the exhaust gas. The oxygen present in the exhaust gas reacts with the sensor to produce a voltage output. This voltage should constantly fluctuate from approximately 100 mV to 900 mV. The heated oxygen sensor voltage can be monitored on an IBM PC-compatible computer with diagnostic software. By monitoring the voltage out-put of the oxygen sensor, the Engine Module calculates the pulse width command for the injectors to produce the proper combustion chamber mixture.

Low HO2S voltage indicates a lean mixture which will result in a rich command to compensate.

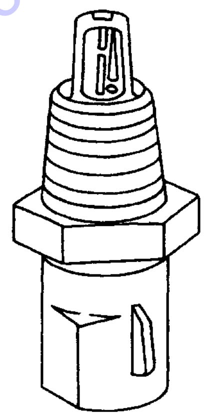
High HO2S voltage indicates a rich mixture which will result in a lean command to compensate.

A constant voltage below 200 mV for 10 consecutive seconds will set OTC 32. A constant voltage above 650 mV for 10 consecutive seconds will set OTC 42.



INTAKE AIR TEMPERATURE (IAT) SENSOR

The intake air temperature (IAT) sensor is a thermistor which changes its resistance based on the temperature of air entering the engine. Low temperature produces a high resistance of 100,000 ohms at -40°C (-40°F). High temperature causes a low resistance of 70 ohms at 130°C (266°F). The Engine Module supplies a 5-volt signal to the sensor through a resistor in the Engine Module and monitors the signal voltage. The signal voltage will be high when the incoming air is cold and low when the incoming air is hot. By measuring the voltage, the Engine Module calculates the incoming air temperature. The IAT sensor signal is used to adjust spark timing according to the incoming air density. An IBM PC-compatible computer with diagnostic soft-ware can be used to display the temperature of the air entering the engine. The temperature should read close to the ambient air temperature when the engine is cold, and rise as engine compartment temperature increases. If the engine has not been run for several hours (overnight), the IAT sensor temperature and engine coolant temperature should read close to each other. A failure in the IAT sensor circuit will set DTC 35 or DTC 45.



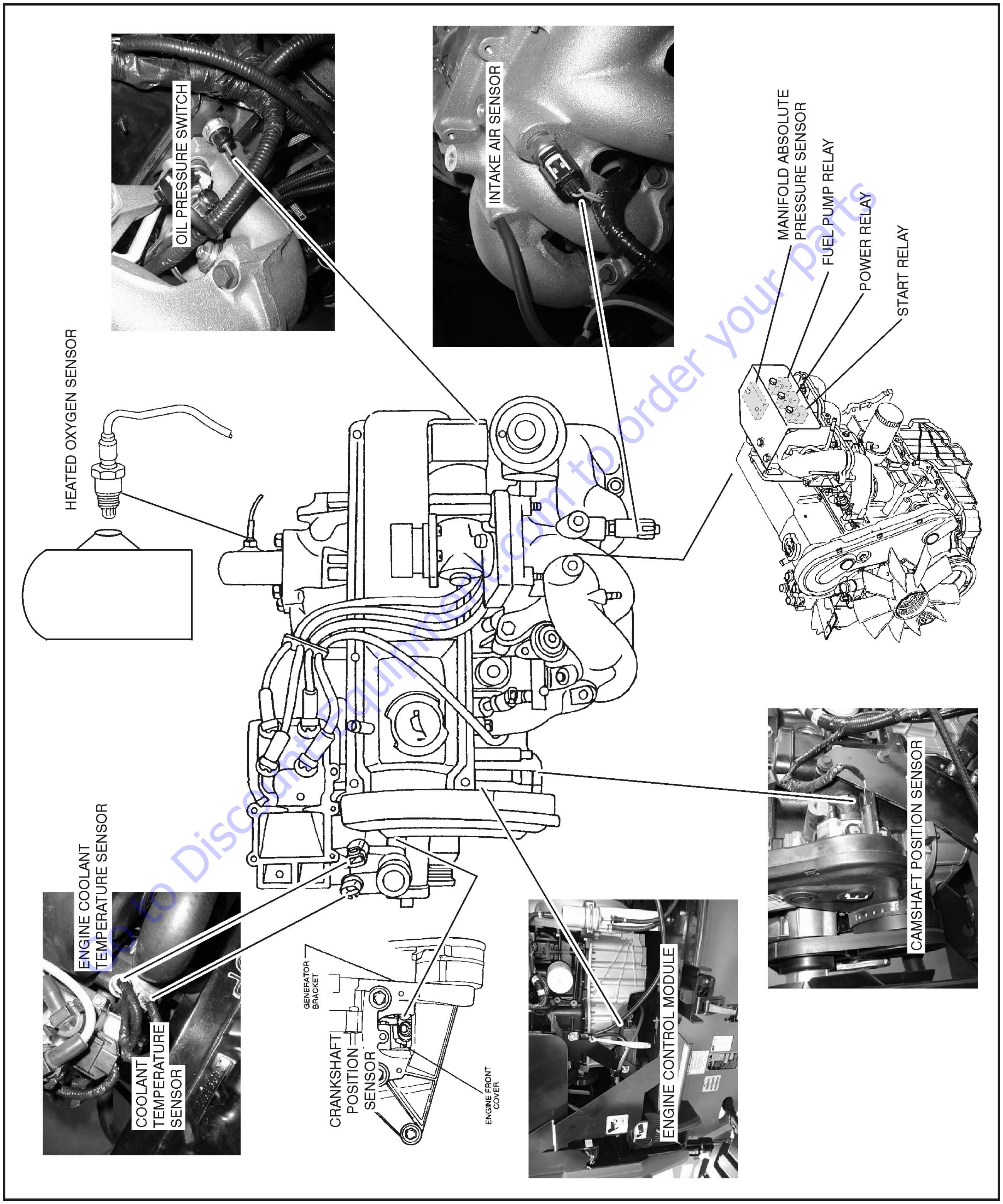


Figure 3-77. EFI Component Location

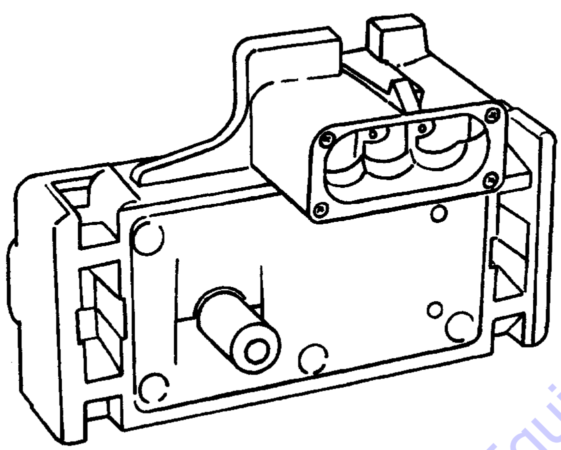
MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR

The manifold absolute pressure (MAP) sensor responds to changes in intake manifold pressure (vacuum). The MAP sensor signal voltage to the Engine Module varies from below 2 volts at idle (high vacuum) to above 4 volts with the ignition ON, engine not running or at wide-open throttle (low vacuum).

The MAP sensor is used to determine the following:

- Engine vacuum level for engine control purposes.
- Barometric pressure (BARO)

If the Engine Module detects a voltage that is significantly lower than the estimated MAP value for 2 or more consecutive seconds, DTC 14 will be set. A signal voltage significantly higher than the estimated MAP value for 2 or more consecutive seconds will set DTC 24.



ENGINE CONTROL MODULE (ECM)/ENGINE PERFORMANCE MODULE (EPM)

The engine will be controlled by one of two different Engine Modules. The Ford EFI engine was originally equipped with an ECM. The EPM was developed to replace the ECM and provide enhanced performance and durability. To see the physical difference between the ECM and EPM, refer to Figure 3-78., ECM/ EPM Identification.

The Engine Module controls the following:

- Fuel metering system
- Ignition timing
- On-board diagnostics for engine functions

The Engine Module constantly observes the information from various sensors. The Engine Module controls the systems that affect engine performance. The Engine Module performs the diagnostic function of the system. It can recognize operational problems, alert the operator through the Malfunction Indicator Lamp (MIL), and store diagnostic trouble codes (DTCs). DTCs identify the problem areas to aid the technician in making repairs.

The Engine Module supplies either 5 or 12 volts to power various sensors or switches. The power is supplied through resistances in the Engine Module which are so low in value that a test light will not light when connected to the circuit. In some cases, even an ordinary shop voltmeter will not give an accurate reading because its resistance is too low. Therefore, a digital voltmeter with at least 10 meg ohms input impedance is required to ensure accurate voltage readings. The Engine Module controls output circuits such as the fuel injectors, electronic governor, etc., by control ling the ground or the power feed circuit through transistors or other solid state devices.

The Engine Module is designed to maintain exhaust emission levels to government mandated standards while providing excellent operation and fuel efficiency. The Engine Module monitors numerous engine functions via electronic sensors such as the throttle position (TP) sensor and the heated oxygen sensor (HO2S).

ENGINE MODULE INPUTS/OUTPUTS

Inputs - Operating Conditions

- Engine Coolant Temperature
- Crankshaft Position
- Exhaust Oxygen Content
- Manifold Absolute Pressure
- Battery Voltage
- Throttle Position
- Fuel Pump Voltage
- Intake Air Temperature
- Camshaft Position

Outputs - System Controlled

- Fuel Control
- Idle Air Control
- Electric Fuel Pump
- Diagnostics:
  - Malfunction Indicator Lamp
  - Data Link Connector (DLC)

ENGINE MODULE SERVICE PRECAUTIONS

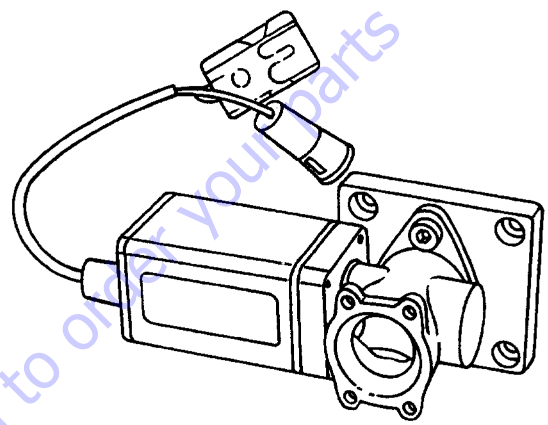
The Engine Module is designed to withstand normal current draws associated with engine operation. When servicing the Engine Module, observe the following guidelines:

- Do not overload any circuit.
- Do not probe wires for testing. This can cause a voltage drop that would be critical to the operation of the Engine Module.
- When testing for opens and shorts, do not ground or apply voltage to any of the Engine Module's circuits unless instructed to do so.
- When measuring voltages, use only a digital voltmeter with an input impedance of at least 10 megohms.
- Do not jump start with more than 12 volts. This could cause damage to the electronic components.
- Do not employ any non-standard practices such as charg-ing the battery with an arc welder.
- Take proper precautions to avoid static damage to the Engine Module. Refer to "Electrostatic Discharge Damage" for more information.

THROTTLE POSITION (TP) SENSOR

The throttle position (TP) sensor is a potentiometer connected to the throttle shaft on the throttle body which is built into the electronic governor. The Engine Module monitors the voltage on the signal line and calculates throttle position. As the throt-tle valve angle is changed, the TP sensor signal also changes. At a closed throttle position, the output of the TP sensor is low. As the throttle valve opens, the output increases so that at wide open throttle (WOT), the output voltage should be above 4 volts.

The Engine Module calculates fuel delivery based on throttle valve angle (operator demand). A broken or loose TP sensor may cause intermittent bursts of fuel from an injector and unstable idle because the Engine Module thinks the throttle is moving. A hard failure in the TP sensor 5-Volt reference or sig-nal circuits for greater than 2 consecutive seconds will set either a DTC 12 or DTC 22. A hard failure with the TP sensor ground circuit for more than two consecutive seconds may set DTC 22. If either DTC 12 or DTC 22 are set, the throttle will be forced to a 6% (idle) position.



USE OF CIRCUIT TESTING TOOLS

Do not use a test light to diagnose the engine electrical sys-tems unless specifically instructed by the diagnostic proce-dures. A test light can put an excessive load on an Engine Module circuit and result in component damage. For volt-age measurements, use only a digital voltmeter with an input impedance of at least 10 megohms.

ECM

EPM

Figure 3-78. ECM/EPM Identification

ELECTROSTATIC DISCHARGE DAMAGE

Electronic components used in the Engine Module are often designed to carry very low voltage. Electronic components are susceptible to damage caused by electrostatic discharge. Less than 100 volts of static electricity can cause damage to some electronic components. By comparison, It takes as much as 4000 volts for a person to feel the spark of a static discharge.

There are several ways for a person to become statically charged. The most common methods of charging are by friction and induction.

An example of charging by friction is a person sliding across a seat.

Charge by induction occurs when a person with well-insulated shoes stands near a highly charged object and momentarily touches ground. Charges of the same polarity are drained off, leaving the person highly charged with the opposite polarity. Static charges can cause damage, therefore it is important to-use care when handling and testing electronic components.

To prevent possible electrostatic discharge damage, follow these guidelines:

- Do not touch the Engine Module connector pins or soldered components on the Engine Module board.
- Do not open the replacement part package until the part is ready to be installed.
- Before removing the part from the package, ground the package to a known good ground on the equipment.
- If the part has been handled while sliding across a seat, while sitting down from a standing position, or while walking a distance, touch a known good ground before installing the part.

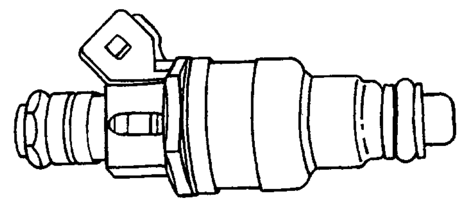
Fuel System

FUEL INJECTOR

The Electronic Fuel Injection (EFI) fuel injector is a solenoid-operated device controlled by the Engine Module. The Engine Module energizes the solenoid, which opens a valve to allow fuel delivery.

The fuel is injected under pressure in a conical spray pattern at the opening of the intake valve. Excess fuel not used by the injectors passes through the fuel pressure regulator before being returned to the fuel tank.

A fuel injector which is stuck partly open will cause a loss of fuel pressure after the engine is shut down, causing long crank times.



FUEL METERING SYSTEM COMPONENTS

The fuel metering system is made up of the following parts:

- The fuel injectors
- The fuel rail
- The fuel pressure regulator/filter assembly
- The electronic governor
- The Engine Module
- The crankshaft position (CKP) sensor
- The camshaft position (CMP) sensor
- The fuel pump
- The fuel pump relay

BASIC SYSTEM OPERATION

The fuel metering system starts with the fuel in the fuel tank. The fuel is drawn up to the fuel pump through a pre-filter. The electric fuel pump then delivers the fuel to the fuel rail through an inane fuel filter. The pump is designed to provide fuel at a pressure above the pressure needed by the injectors. A fuel pressure regulator in the fuel filter assembly keeps fuel available to the fuel injectors at a constant pressure. A return line delivers unused fuel back to the tank.

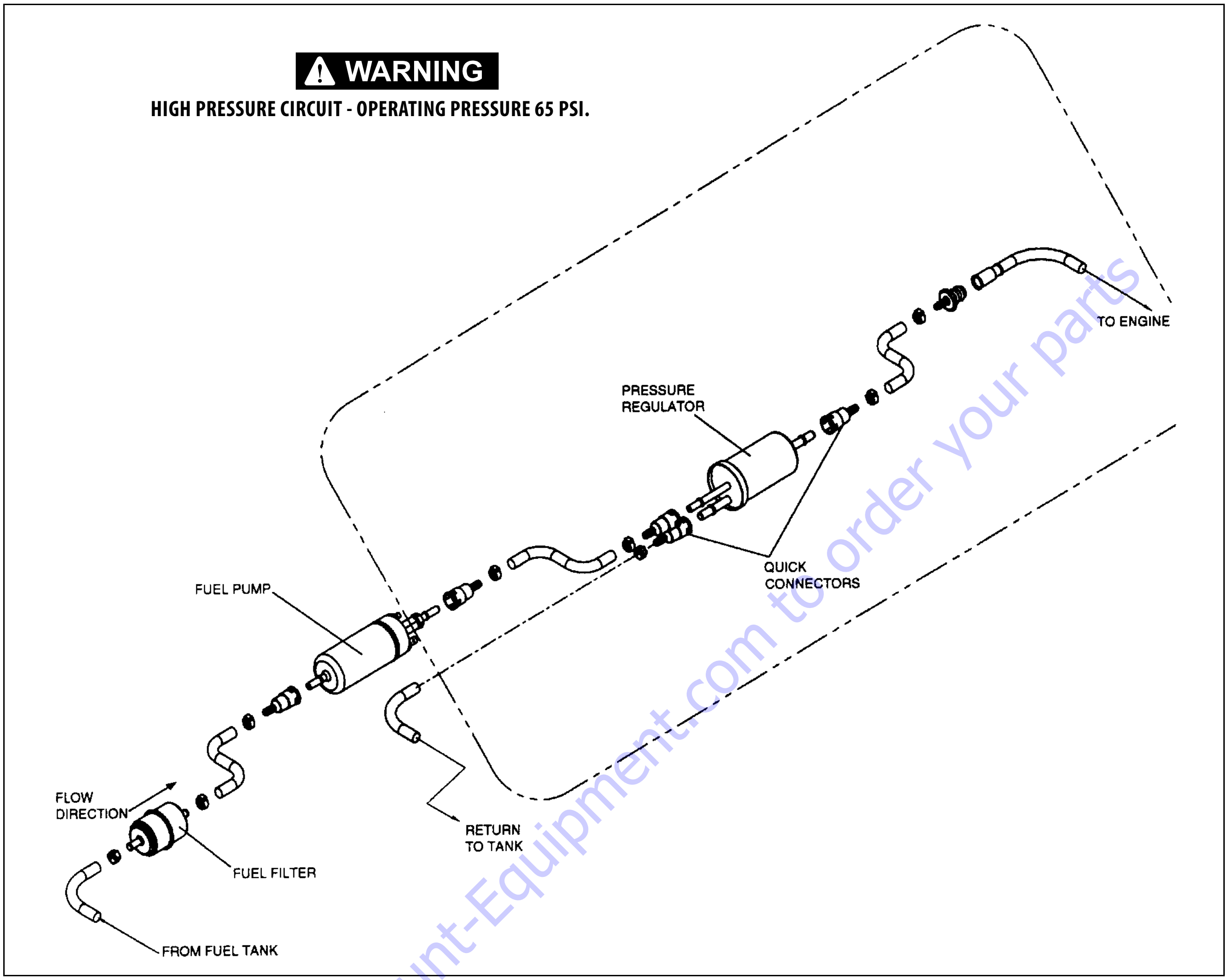


Figure 3-79. Typical Fuel System

FUEL METERING SYSTEM PURPOSE

The basic function of the air/fuel metering system is to control the air/fuel delivery to the engine. Fuel is delivered to the engine by individual fuel injectors mounted in the intake manifold near each intake valve.

The main control sensor is the heated oxygen sensor (H02S) located in the exhaust system. The H02S tells the Engine Module how much oxygen is in the exhaust gas. The Engine Module changes the air/fuel ratio to the engine by control-ling the amount of time that the fuel injector is "ON." The best mixture to minimize exhaust emissions is 14.7 parts of air to 1 part of gasoline by weight, which provides the most efficient combustion. Because of the constant measuring and adjusting of the air/fuel ratio, the fuel injection system is called a "closed loop" system.

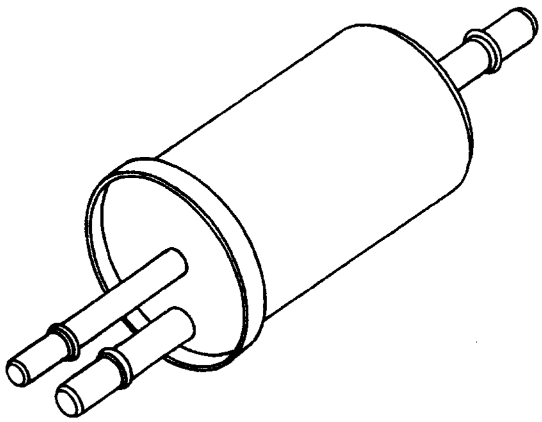
The Engine Module monitors signals from several sensors in order to determine the fuel needs of the engine. Fuel is delivered under one of several conditions called "modes." All modes are controlled by the Engine Module. Refer to "Open Loop and Closed Loop Operation" for more information.

FUEL PRESSURE REGULATOR

The fuel pressure regulator is a relief valve mounted in the fuel filter. It provides a constant fuel pressure of 441 kPa (64 psi).

If the pressure is too low, poor performance and a DTC 32 will set. If the pressure is too high, excessive odor and/or a DTC 42 will result.

When replacing the fuel filter, be sure to use an identical filter/regulator assembly. A standard fuel filter does not regulate pressure and could cause engine problems or component damage.



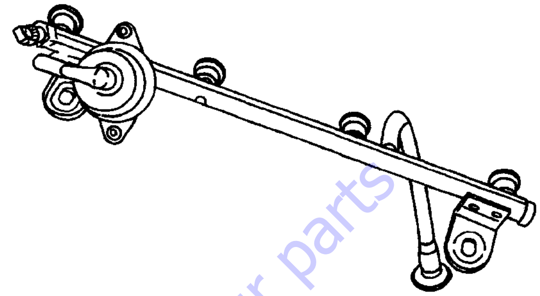
FUEL PUMP ELECTRICAL CIRCUIT

When the key is first turned "ON," the Engine Module energizes the fuel pump relay for two seconds to build up the fuel pressure quickly. If the engine is not started within two seconds, the Engine Module shuts the fuel pump off and waits until the engine is cranked. When the engine is cranked and crankshaft position signal has been detected by the Engine Module, the Engine Module supplies 12 volts to the fuel pump relay to energize the electric fuel pump.

An inoperative fuel pump will cause a "no-start" condition. A fuel pump which does not provide enough pressure will result in poor performance.

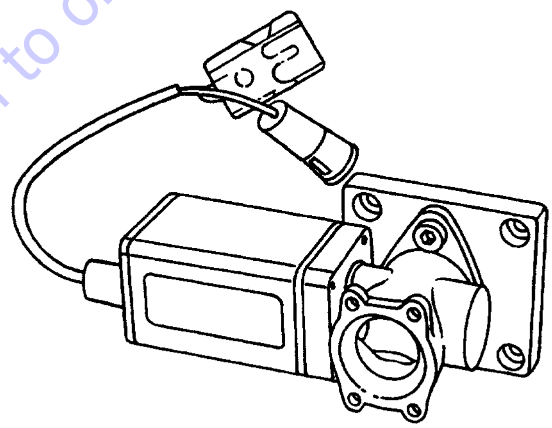
FUEL RAIL

The fuel rail is mounted to the top of the engine and distributes fuel to the individual injectors. Fuel is delivered to the fuel inlet tube of the fuel rail by the fuel lines.



ELECTRONIC GOVERNOR AND THROTTLE BODY

In the 2.5L EFI industrial engine, throttle control is achieved by using an electronic governor which is controlled by the Engine Module.



The electronic governor consists of a throttle body, an electronically-actuated throttle plate, and a built-in throttle position (TP) sensor. There are two pigtails that exit the governor body. The 3-wire pigtail connects the TP sensor to the Engine Module. Refer to "Throttle Position (TP) Sensor" for more information.

The 2-wire pigtail carries the throttle signal from the Engine Module to the governor. Desired engine speeds are stored in the configuration program for each specific application, and can be changed with the Engine Module calibration software. When an engine speed is selected with the toggle switch, the Engine Module sends the appropriate signal to the governor. This is a pulse-width modulated (PWM) signal which cannot be read with conventional diagnostic tools such as a voltmeter. A 12-volt signal is pulsed on and off at a high rate of speed. The width of the "on" pulse determines the amount of throttle opening. The Engine Module sends a signal with the appropriate pulse width to the governor based on the operator's choice of switch settings.

The electronic governor also acts as an idle air control (IAC) valve. Changes in engine load are detected by the Engine Module by comparing manifold absolute pressure (MAP) with throttle position. When the Engine Module detects a change in engine load, it can adjust idle speed by changing the PWM signal to the governor.

OPEN LOOP AND CLOSED LOOP OPERATION

The Engine Module will operate in the following two modes:

- Open loop
- Closed loop

When the engine is first started, the system is in "open loop" operation. In open loop, the Engine Module ignores the signal from the heated oxygen sensor (HO2S). it uses a pre-programmed routine to calculate the air/fuel ratio based on inputs from the TP, ECT, and MAP sensors.

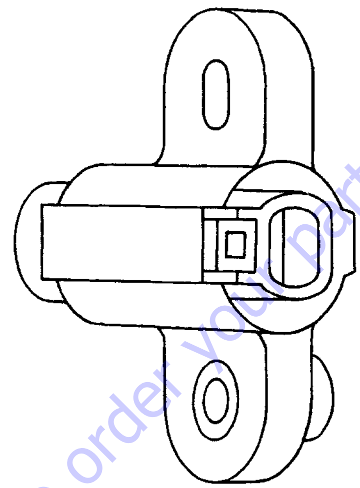
The system remains in open loop until the following conditions are met:

- The HO2S has a varying voltage output showing that it is hot enough to operate properly (this depends on temperature).
- The ECT has reached 160°F (71°C).
- Seven minutes has elapsed since starting the engine.

After these conditions are met, the engine is said to be operating in "closed loop." In closed loop, The Engine Module continuously adjusts the air/fuel ratio by responding to signals from the HO2S (except at wide-open throttle). When the HO2S reports a lean condition (low sensor signal voltage), the Engine Module responds by increasing the "on" time of the fuel injectors, thus enriching the mixture. When the HO2S reports a rich condition (high sensor signal Voltages the Engine Module responds by reducing the "on" time of the fuel injectors, thus leaning out the mixture.

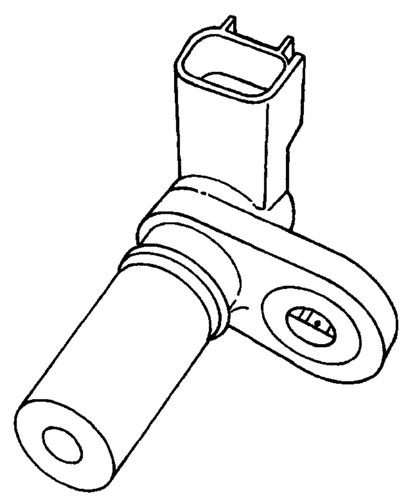
CAMSHAFT POSITION (CMP) SENSOR

The CMP sensor uses a variable reactor sensor to detect camshaft position. The CMP signal is created as piston #1 is a predetermined number of degrees after top dead center on the power stroke.



CRANKSHAFT POSITION (CKP) SENSOR

The crankshaft position (CKP) sensor provides a signal used by the engine control module (Engine Module) to calculate the ignition sequence. The sensor initiates the reference pulses which the Engine Module uses to calculate RPM and crankshaft position.



ELECTRONIC IGNITION

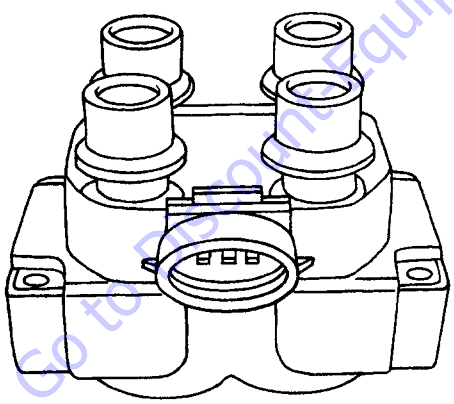
The electronic ignition system controls fuel combustion by providing a spark to ignite the compressed air/fuel w mixture at the correct time. To provide optimum engine performance, fuel economy, and control of exhaust emissions, the Engine Module controls the spark advance of the ignition system. Electronic ignition has the following advantages over a mechanical distributor system:

- No moving parts
- Less maintenance
- Remote mounting capability
- No mechanical load on the engine
- More coil cooldown time between firing events
- Elimination of mechanical timing adjustments
- Increased available ignition coil saturation time

IGNITION COIL

The electronic ignition system uses a coil pack with one ignition coil for each two cylinders in the engine. Each cylinder is paired with its opposing cylinder in the firing order, so that one cylinder on compression fires simultaneously with the opposing cylinder on exhaust. The spark that occurs in the cylinder on the exhaust stroke is referred to as a "waste spark."

The primary coils in the coil pack are triggered by the "Ignition Coil Feed #1" and "Ignition Coil Feed #2" Signals from the Engine Module.



ENGINE MODULE (ECM OR EPM)

The Engine Module is responsible for maintaining proper spark and fuel injection timing for all operating conditions. To provide optimum operation and emissions, the Engine Module monitors the input signals from the following components in order to calculate spark timing:

- Engine coolant temperature (ECT) sensor
- Intake air temperature (IAT) sensor
- Throttle position sensor
- Crankshaft position sensor

3.29 FORD LPG SYSTEM

NOTE: *+20° F (-6.6° C) is the low temperature limit for LP gas, for both starting and operation. This applies to all LP gas powered engines.*

Description

The LPG system starts at the tank. The liquid propane exits the tank, flows through the fuel lockoff solenoid, flows through the regulator (regulator converts the liquid to a vapor), flows through the megajector, flows through the mixer and into the engine.

Regulator

The regulator accepts LPG liquid at tank pressure (min = 30 psi; max = 312 psi [min = 207 kPa; max = 2151 kPa]) and reduces it to a regulator outlet pressure of 1.5 to 2.5 in. (3.8 to 6.3 cm) of H_2O at idle flow (approx. 750 RPM / no load). This regulator must have engine coolant flowing through it whenever the engine is running.

Megajector

The megajector is an electronic pressure regulator. This electronic regulator outputs a specific pressure needed at the mixer to maintain the desired air to fuel ratio. The megajector accepts LPG vapor at the regulator outlet pressure (1.5 to 2.5 in. (3.8 to 6.3 cm) of H_2O) and reduces it to a pressure value commanded by the EPM. The pressure command is sent by the EPM over the CAN link via the megajector harness. The megajector outlet pressure has units of in. of H_2O. The megajector outlet pressure is defined as the difference between the megajector outlet gas pressure and the balance line pressure (usually at or near barometric pressure depending on air intake restriction). The megajector outlet pressure can vary between -1.00 to -5.00 in. (-2.5 to -12.7 cm) of H_2O depending on the speed and load of the engine. The megajector must be mounted per the 2.5L 2004 Emission Installation Instructions. Torque mounting bolts to a maximum of 60 in.lbs. (7 Nm).

Mixer

The mixer accepts LPG vapor at the megajector outlet pressure (-1.00 to -5.00 in. (-2.5 to -12.7 cm) of H_2O) and mixes it with clean air. This mixture is then sucked into the engine via the actuator.

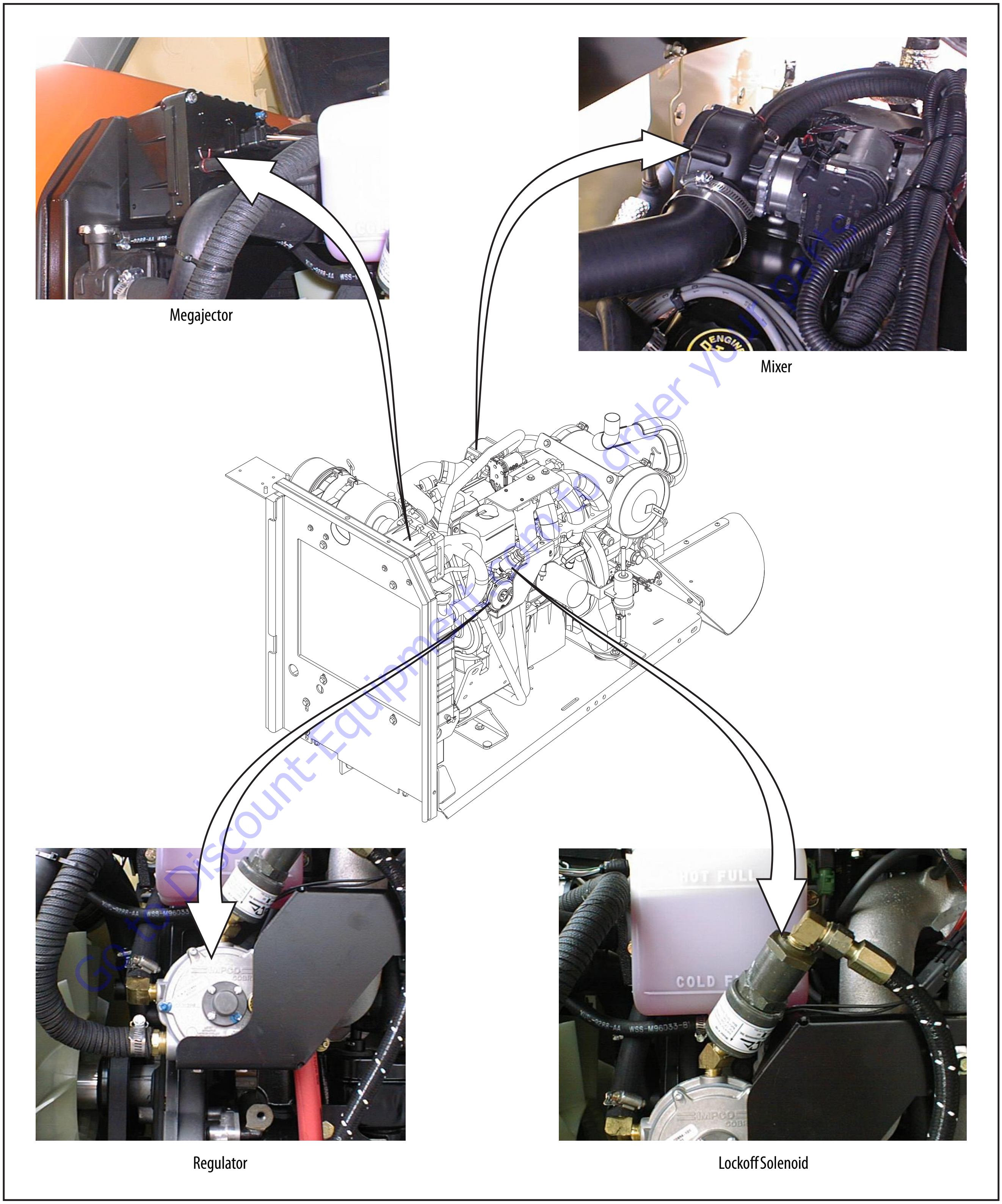


Figure 3-80. LPG System Components

Lockoff Solenoid

The lockoff solenoid is used to reduce the possibility of backfires. The EPM controls the opening and closing of the lockoff so that as a shutdown is commanded, the lockoff is closed, but the ignition system continues to operate to burn off unburned fuel in the manifold. This will cause longer than usual start times, because the manifold must fill up with fuel again before the engine will fire. This will also cause the engine to run for one to two seconds after ignition is turned off.

Megajector Diagnostic Code Descriptions

The following diagnostic codes are specific to the megajector. They will be displayed on the analyzer if the JLG Control System senses a fault dealing with the megajector. Refer to Section 6 - JLG Control System for more information concerning the Control System.

DTC 353 - Megajector delivery pressure higher than expected. This code will set if the difference between the Megajector actual pressure and the Megajector commanded pressure is greater than 4.00 in. (10.1 cm) of H_2O.

a. **Fuel Supply** - Check fuel supply pressure at the megajector inlet fitting. Fuel supply pressure on LPG applications should be between 3-5 in. (7.6-12.7 cm) H_2O.

b. **Lockoff Solenoid** - Check the lockoff to make sure it is sealing when closed. If it is not completely sealing, it could allow pressure creep in the fuel system.

c. **Reference Line** - Make sure the reference line is in place between the Megajector and the carburetor balance port. Make sure the hose is not kinked or restricted in any way and has no holes in it.

d. **Regulator** - Observe the regulator with the engine running to see if it is icing up. If it's icing up, refer to Engine Cooling System below.

e. **Engine Cooling System** - Make sure the engine cooling system is operating properly and there are no air locks in the system. Make sure the engine is operating at the proper temperature. Check the coolant hoses at the regulator and make sure they are both warm to verify proper coolant circulation.

If the fuel system is operating properly, the Megajector has an internal failure and must be replaced.

DTC 354 - Megajector delivery pressure lower than expected. This code will set if the difference between the Megajector actual pressure and the Megajector commanded pressure is less than -4.00 in. (10.1 cm) of H_2O.

a. **Fuel Supply** - Check fuel supply pressure at the megajector inlet fitting. Fuel supply pressure on LPG applications should be between 3-5 in. (7.6-12.7 cm) H_2O.

b. **Fuel System Hoses** - Make sure all fuel system hoses are in good condition. They should be clamped tight, free from kinks with no cuts, pinches, etc.

c. **Lockoff Solenoid** - Check the lock off to make sure it is opening properly. If it is not opening completely, it could cause low fuel pressure.

d. **Reference Line** - Make sure the reference line is in place between the Megajector and the carburetor balance port. Make sure the hose is not kinked or restricted in any way and has no holes in it.

e. **Regulator** - Observe the regulator with the engine running to see if it is icing up. If it's icing up, refer to Engine Cooling System below.

f. **Engine Cooling System** - Make sure the engine cooling system is operating properly and there are no air locks in the system. Make sure the engine is operating at the proper temperature. Check the coolant hoses at the regulator and make sure they are both warm to verify proper coolant circulation.

If the fuel system is operating properly, the Megajector has an internal failure and must be replaced.

DTC 355 - Megajector comm. lost. This codes will set if the communication (CAN link) between the Megajector and the EPM is not present.

a. **CAN Circuits** - Check CAN circuits for continuity and shorts to power or ground and for proper connections.

If the CAN circuits are ok and all wiring connections are good, the Megajector has an internal failure and must be replaced.

DTC 361 - Megajector voltage supply high.

a. **Voltage** - Check battery voltage. If the voltage at the battery is greater than 18 volts, either the charging system or the megajector is faulty.

DTC 362 - Megajector voltage supply low.

a. Voltage - Check battery voltage. If the voltage at the battery is less than 9.5 volts:

The battery is faulty

or

The charging system is faulty

or

The Megajector is faulty.

DTC 363 - Megajector Internal Actuator Fault Detection.

a. Connections - Check power, ground, and CAN circuits at the Megajector in addition to all electrical connections. Repair as necessary and retest.

b. Megajector - Megajector has an internal failure. Contact JLG Industries for further assistance.

DTC 364 - Megajector Internal Circuitry Fault Detection.

a. Connections - Check power, ground, and CAN circuits at the Megajector in addition to all electrical connections. Repair as necessary and retest.

b. Megajector - Megajector has an internal failure. Contact JLG Industries for further assistance.

DTC 365 - Megajector Internal Comm Fault Detection.

a. Connections - Check power, ground, and CAN circuits at the Megajector in addition to all electrical connections. Repair as necessary and retest.

b. Megajector - Megajector has an internal failure. Contact JLG Industries for further assistance.

3.30 ELECTRIC GOVERNOR INSTALLATION AND ADJUSTMENTS - FORD LRG425 ENGINE

General

These instructions presume no electrical test equipment other than a multimeter for making the electrical measurements called for on the following pages. If no suitable meter is available, an inexpensive but adequate meter, part number 22-188 is available from any local Radio Shack store.

Many “governor problems” turn out to be installation problems, particularly in first-time applications. Careful attention to the directions provided will go far toward a successful installation made in the least amount of time.

Quick-start Installations

If you are experienced in installing and adjusting Electric Governor, follow these steps. Otherwise, refer to the more detailed instructions starting with “MOUNTING-ACTUATOR”.

1. Mount Actuator rigidly to engine location which will permit a short, straight linkage to the carburetor or fuel valve. Avoid very hot areas.
2. Mount controller in a dry, fairly cool location. Accessibility for adjusting is required.
3. Wire per appropriate included schematic, using #16 wire.
4. Set up fuel linkage. This is critical, so review the section titled “LINKAGE”.
5. Hold linkage for safety, and start engine.
6. Adjust engine speed to desired valve using High Engine pot. Turn CW to increase, CCW to decrease speed.

Mounting-Actuator

The Actuator may be mounted in any attitude - there is no preferred orientation.

With no power applied, the Actuator is spring-loaded to the minimum fuel position. The Actuator output shaft rotates toward the maximum fuel position against this spring through electrical power from the controller. This rotation is CW (clockwise) on one side of the Actuator, and CCW (counterclockwise) on the other. If necessary, reverse the Actuator on its mounting plate so that the desired direction of rotation is on the desired side to match the fuel system direction of travel.

Before selecting the mounting location, consider the linkage that will be required to connect the Actuator output arm to the butterfly or fuel valve. Read the following section on linkages before deciding on a mounting location!

1. Mount Actuator rigidly to engine location which will permit a short, straight linkage to the carburetor or fuel valve. Avoid very hot areas.

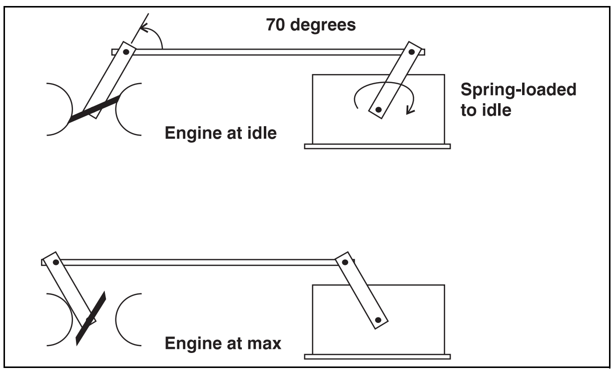
Linkage

1/4 in. -28 threaded rod and low friction rod-end bearings are recommended for linkage materials.

Keep the linkage as short and as straight as possible.

The linkage must not rub against the engine, brackets, hoses, etc. The linkage must be free of friction and lost motion or "slop".

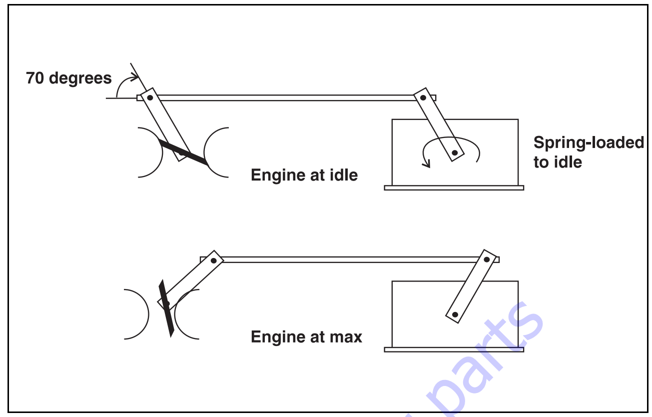
The following sketch indicates the proper linkage geometry for most installations.

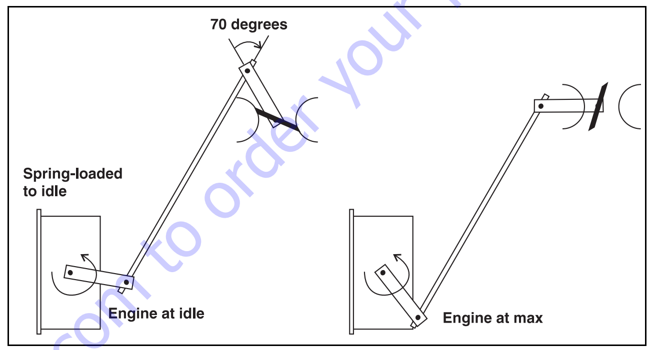


Note that the angle between the carburetor arm and the rod is 70 degrees with the engine at idle. This is highly desirable! Note also that the Actuator arm travels equally on either side of a 90 degree angle with the rod. This angular arrangement will give the proper mechanical gain for good stability and performance. It may be necessary to rotate the carburetor arm relative to the butterfly to achieve this. This can usually be done, and is usually worth the effort. Below are some workable installations, with good linkages. Remember, the Actuator can be turned 180 degrees on its mounting to "reverse" the spring-loaded direction. Also, the Actuator can be mounted in any attitude.

The needed travel of the carburetor determines how far out on the Actuator arm the rod is to be attached. In most cases, the carburetor should be moved from closed to above 10 degrees from full open as the Actuator is moved min. to max. THEN ALTER THE LENGTH OF THE ROD SLIGHTLY (PERHAPS.030"), SO THAT THE ACTUATOR IS JUST OFF ITS INTERNAL STOP, AND IS PULLING THE BUTTERFLY AGAINST ITS STOP. This insures that the carburetor can fully close to idle on load dumps, minimizing overspeeds.

Examine the system for springs, such as carburetor return springs. These should be removed. Some automotive carburetors (as opposed to industrial carburetors) contain internal springs for accelerator pumps, etc. These may make good governing difficult, or even impossible. For this, and other reasons, industrial carburetors are much to be preferred.





Move the linkage slowly through its travel, and look for any binding or unexplained forces. Correct any before going further.

Many "governing" problems are really caused by binding of the butterfly and its shaft in the carburetor. This is caused by loading due to vacuum under the butterfly and atmospheric pressure above when the engine is running. These forces cannot be felt when the engine is not running. Therefore, start the engine while carefully controlling the speed by hand, and feel for binding or airload forces. Needle bearings on the butterfly shaft are available on many industrial carburetors to deal with this problem. Any tendency on the butterfly stick must be corrected.

Mounting-Controller

Select a reasonably cool, dry, and vibration free location.

The rear cover will probably need to be removed during set-up in order to make adjustments for speed setting and gain. You may wish to defer final installation until this is done.

After completing these adjustments, replace cover. Mount so that water cannot pool on this cover. Always mount the controller with the strain relief down. This will prevent water from entering thru the cable, also place the vent hole in the bottom of the controller down.

Wiring

See wiring diagram for details of hook-up.

Use #16 wire minimum.

Keep all wiring to the Governor as short as is practical.

Go directly from the controller ground terminal (B of the 8 pin connector) by dedicated wire, to the battery “minus” terminal. If this cannot be done, for some reason, go by dedicated wire to a very good engine ground.

A properly functioning engine electrical system will supply 13.5 - 14.8 VDC when the engine is running. If wiring size is adequate, with good connections and proper grounds, you will get this reading between the wires terminals A & B of the 8 pin connector when the Governor is controlling engine speed. Verify this. Improper hook-up can damage electronics. Re-check wiring before applying power.

Power Distribution

8 PIN CONNECTOR

Pin:

- **a.** 12 VDC from the make before break oil pressure switch. This switch provides power to pin A when the ignition is on and the engine is not running (no oil pressure), or when the ignition is turned off when the engine is running (has oil pressure).
- **b.** Ground.
- **c.** Tach signal from the engine ignition system.
- **d.** Tach signal from the engine ignition system.
- **e.** Control signal to operate the Actuator.
- **f.** Control signal to operate the Actuator.
- **g.** Removes ground from the start lock out relay when the engine is running above the start lock out set point. A 20 turn pot is provided to adjust this set point. (usually around 500 RPM)
- **h.** Removes ground from the overspeed relay if this point is exceeded. A 20 turn pot is provided to adjust this set point.(usually around 5000 RPM)

4 PIN CONNECTOR

Pin:

- **a.** Input from the elevation limit switches to allow high engine to operate.
- **b.** Input from the high engine switch.
- **c.** Input for mid engine from one of the following: The engine low coolant temperature switch, platform footswitch, or a ground control directional switch.
- **d.** Provides ground to lockout start when the engine RPMS exceed the set point.

Check-Out and Initial Start-Up Procedures

Before proceeding, familiarize yourself with the locations of the various adjustment pots.

Adjustments:

High engine
Mid engine
Start lockout
Over speed lockout
Factory adjust
Gain

HIGH ENGINE:

This adjustment is made by turning the 1/8 in. brass screw clockwise (CW) to increase speed, and counterclockwise (CCW) to decrease speed. The adjustment range of the high engine pot is 25 turns, each turn will change engine speed by about 100 to 200 RPMS. This pot is protected by a slip clutch at each end and will not be harmed by moderate over-adjustment. However the governor will not function when the pot is past full travel. If you suspect that you may have over-adjusted the high engine pot, or have lost track of where you are, turn the pot 25 to 30 turns out (CCW), then turn in (CW) 10 turns. This will get you back into the range you should be in. Make the high engine adjustment first, then gain, then reset high engine.

GAIN:

This adjustment is made by turning the plastic screw clockwise (CW to increase governor sensitivity, counterclockwise (CCW) to decrease sensitivity. The adjustment range of the Factory pot is about 3/4 of a turn, AND OVERTURNING WILL BREAK THE INTERNAL STOPS, making further adjustments impossible. Too much gain will cause instability and the engine will pulsate, Not enough gain will make the engine slow to respond to load requirements, and at first appears to be a good setting when operating directional functions other than drive. The engine will accelerate right up to the set RPMS and stop at that point.The problem with this type of gain setting is that when a large load is applied (usually through drive) and then suddenly unloaded, the engine will be slow to respond in decreasing RPMS. This will cause the engine to over rev and then at times, will activate the over speed cutout and shut the engine off. The ideal gain setting will provide a compromise between quick response and good stability. This will usually show up as 1 to 3 engine pulsation’s before leveling out at the set RPMS when going from idle to high engine.

MID ENGINE:

This adjustment is made by turning the 1/8 in. brass screw clockwise (CW) to increase speed, and counterclockwise (CCW) to decrease speed. The adjustment range of the Mid engine pot is about 25 turns, each turn will change engine speed by about 100 to 200 RPMS. THE pot is protected by an slip clutch at each end and will not be harmed by moderate over adjustment. However, the governor will not function when the pot is past full travel. If you suspect that you have over adjusted the Mid engine pot, or have lost track of where you are, turn the pot 25 turns out (CCW), then turn in (CW), 15 turns. This will get you back into the range you should be in. Make all adjustments before setting the mid engine.

START LOCKOUT:

This adjustment is made by turning the 1/8 in. brass screw clockwise (CW) to increase speed and counterclockwise (CCW) to decrease speed. The adjustment range of the Start lockout pot is about 25 turns, each turn will change engine speed by about 100 to 200 RPMS. This pot is protected by a slip clutch at each end and will not be harmed by moderate over-adjustment. However, the governor will not function when the pot is past full travel. If you suspect that you may have over-adjusted the Start lockout pot, or have lost track of where you are, turn the pot to 25 to 30 turns in (CW), Then turn out (CCW) 8 1/2 turns. This will get you back into the range you should be in. Start lockout should normally not have to be adjusted. Normally startout should occur at around 500 RPM. If while cranking the engine seems to stop momentarily then reengages the starter, turn the adjustment in (CW) 1/4 to 1/2 turn at a time until the engine will crank with out locking out start. If the starter engages while the engine is running, check the idle RPMS before adjusting the governor. On the 800 series, this should be 1000 RPMS. Do not set the RPMS above 1100 RPMS as this will cause engine shut down problems that will be similar to dieseling.

OVER SPEED:

This adjustment is made by turning the 1/8 in. brass screw clockwise (CW) to increase speed, and counterclockwise (CCW) to decrease speed. The adjustment range of the over speed pot is about 25 turns, each turn will change engine speed about 100 to 200 RPMS. This pot is protected by a slip clutch at each end and will not be harmed by moderate over-adjustment. However the governor will not function when the pot is past full travel. If you suspect that you have over-adjusted the Over speed pot, or have lost track of where you are, turn the pot 25 turns in (CW), then turn out (CCW) 5 1/2 turns. This will get you back into the range you should be in. Over speed should normally not have to be adjusted. When adjusting Over speed make sure other adjustments have been made correct.

FACTORY:

This adjustment is made by turning the plastic screw clockwise (CW) to increase governor sensitivity, counterclockwise (CCW) to decrease sensitivity. The adjustment range of the Factory range of the pot is about 3/4 of a turn, AND OVER-TURNING WILL BREAK THE INTERNAL STOPS, making further adjustments impossible. The Factory setting normally will not have to be adjusted.

NOTE: *These settings are factory set, Start Lockout, Factory Adjust and Overspeed. They are conformally coated by P.G. and should not need to be reset.*

Assuming that the Actuator and Controller are mounted, the wiring is run and checked, and that the linkage is properly installed, proceed as follows:

1. Use multimeter to check battery voltage at battery terminals, and record. Now check voltage at the machine connection points for terminals A & B of the 8 pin connector on the E-331 (A is +, B is -). Voltage reading should be the same as at battery. If not, shut down, and correct wiring.
2. Hold the linkage back by hand, so as to control engine speed manually. Start engine, set vehicle controls to obtain High Engine speed, gradually release the linkage, and adjust the speed-set as needed to set the speed as desired. If engine speed surges, reduce Gain a little, as required (CCW).
3. Re-check voltage between terminal A & B as in step 2. Voltage reading should be between 13.5 - 14.6 VDC.
4. Carefully adjust Gain. You are looking for the best compromise between quick response and good stability. Make very small adjustments, then load and unload engine, or pull linkage back slightly and release. Usually, a good set-up is one that makes 1 to 3 small bounces and then steadies down after a large change. Too much Gain shows up as a rapid (bounce per second) instability, most commonly at light loads. Too little Gain shows up in large over-shoots on start-up or large load changes, and generally sluggish operation.
5. Make final adjustment to the High Engine Pot.
6. Set machine controls to obtain the mid-engine speed. Adjust the mid-engine pot as needed to obtain the speed desired.
7. The start lockout adjustment is factory set. If necessary, he starter lockout pot may be adjusted to obtain drop-out of the starter as the engine attains running speed. Normally this is around 500 RPM.

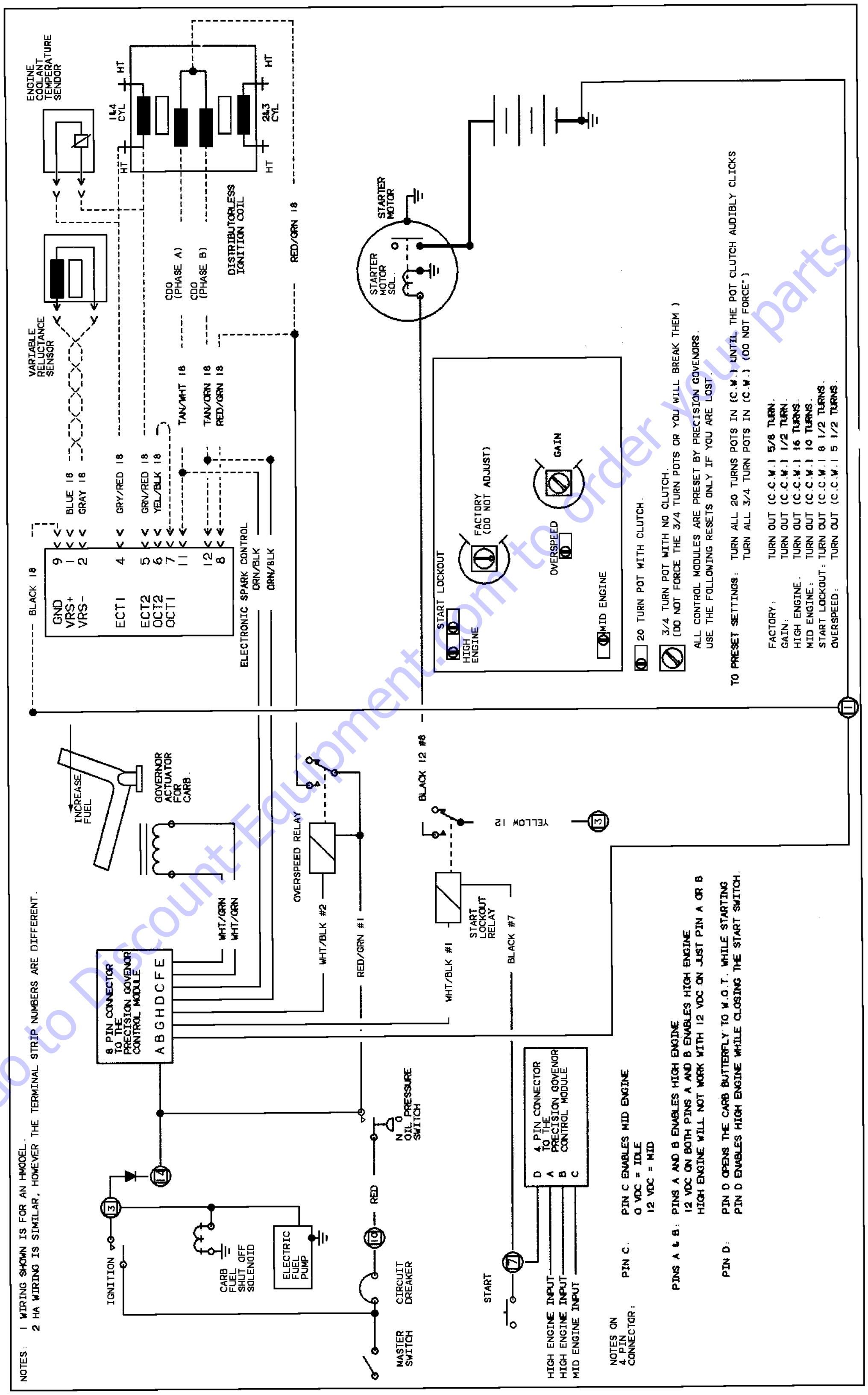
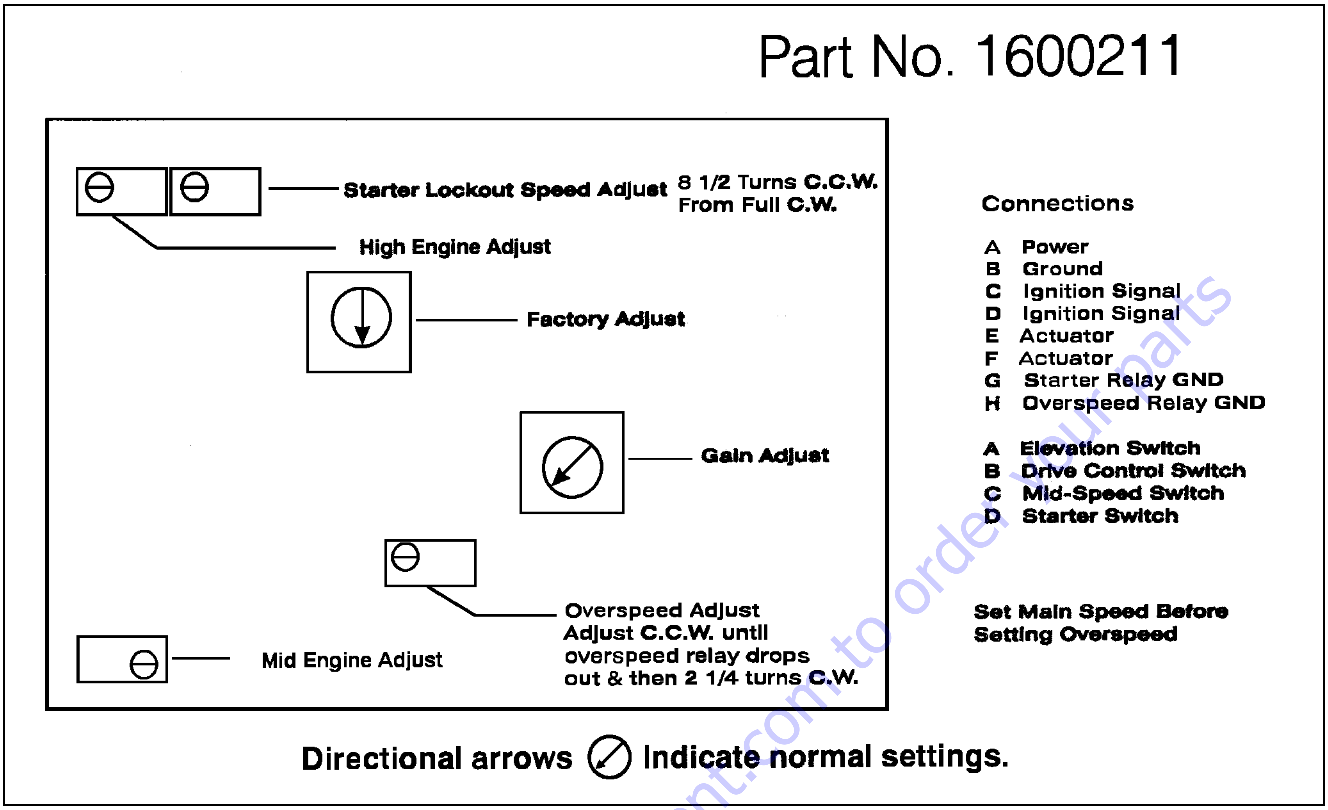


Figure 3-81. Check-Out and Initial Start-Up Procedures



8. The overspeed adjustment is factory set. If necessary, it may be readjusted to shut off ignition power at a different engine speed by means of the overspeed adjustment pot. The overspeed is simply to shut down an over revving engine.

NOTE: *Overspeed to be set at 4000 - 4500 RPM. This is not a function we test for correct settings. The High Engine speed must be set before setting the overspeed.*

9. Re-install the back cover on the E-331. Final mount the controller.

Troubleshooting

We will discuss Troubleshooting in two general categories:

- **Governor won't work.**
- **Governor works, but can't be set up to give satisfactory performance.**

There is, of course, some overlap between these categories. Read both sections and apply the fixes that seem appropriate.

NOTE: *During troubleshooting, be prepared to control the engine manually to prevent overspeeds, etc.*

- **Governor won't work.**

No reaction from Governor. Actuator output arm never moved, engine off or engine running. Can be caused by:

1. No power.
2. Incorrect linkage, preventing movement.
3. Incorrect electrical hook-up.
4. No speed signal to Governor.
5. Damaged Controller or Actuator.

(1.) No power - Use a multimeter to check for 12-15 VDC between terminals A & B on the controller. Check during engine off and engine running conditions. If voltage is absent or low, check for:

a. Wiring error.
b. Hook-up on wrong side of ballast resistor.
c. Low battery.
d. Bad voltage regulator.
e. Bad ground connection.
f. corroded terminals.
g. Undersized wiring.

(2.) Incorrect Linkage - Re-check linkage. The freedom of movement and lack of play are important.

(3.) Incorrect Electrical Hook-up - Re-check all wiring and connections to the Actuator and Controller against the supplied schematic.

(4.) No speed signal to Controller.

a. Check the voltage between terminals C and ground and D and ground of the 8 pin connector with the engine running. You should see 5 - 30 VDC.

b. The above checks do not guarantee a good speed signal, but their absence proves that there is a problem.

(5.) Incorrect Electrical Hook-up - If steps 1 - 4 above have not revealed the problem, the governor may have been damaged, either in shipping or during hook-up and test.

- **Governor reacts, but can't be set up to give proper performance.**

This kind of trouble usually falls into three main categories:

1. Actual Governor malfunction.
2. Governor installation problems and improper adjustment.
3. Governor not tuned or adjusted for engine/application.

NOTE: *Assure the engine is operating properly by running engine manually. The Governor will not control any poor running engine.*

(1.) Actual Governor Malfunction - The Governor was engine-tested for proper operation just prior to being shipped. Unless damaged in shipment or by improper handing, it should be serviceable. To check for proper operation proceed as follows:

a. Once again, disconnect fuel system linkage from Governor output arm and control engine manually.

b. Start engine, hold at a low speed, Governor arm should move to full-fuel position.

c. Increase engine speed carefully. At some engine speed, Governor arm should move to low-fuel position.

d. By carefully varying engine speed, you should be able to cause the Governor arm to pause momentarily near the middle of its travel. This engine speed is the speed for which the Governor is adjusted. If grossly incorrect, reset High Engine Pot.

e. With the engine running at low speed, move the Governor arm throughout its stroke by hand. You should feel a constant smooth force in the on direction. No binding or rubbing should be felt within the Governor.

If steps 1a. through 1e. can be accomplished as described, the Governor is probably OK. It recognizes underspeed, overspeed, onspeed and is not binding internally.

If the above steps cannot be accomplished satisfactorily, there is probably an actual Governor malfunction.

a. Governor is unable to move fuel system freely (not enough Actuator force available). If Governor doesn't move fuel system to on far enough to provide sufficient fuel but Governor arm moves far enough when disconnected look for:

1. Linkage binding or misadjusted.
2. Low voltage at Governor during operation.

NOTE: **Measure the voltage as discussed previously and observe voltage during operation. If Governor fails to move full on and voltage dips over 1 volt, check for undersize wire (should be #16 minimum).*

3. Excessive force at Governor during engine running, particularly on carburetor engines.

NOTE: **Carburetor butterfly valves are loaded by engine vacuum during running, which can add considerable force not present when engine isn't running.*

NOTE: **Springs in the system; carburetor return springs, acceleration pump springs, etc., are not usually needed and can cause governing problems.*

b. Governor is unstable at light-load or no-load. See "Linkage" for carbureted engines.

c. Governor experiences sudden, momentary spikes toward max. at random intervals, then recovers.

1. Look for loose wiring or momentary shorts in wiring. Noise or occasionally missing speed signal.

d. Speed seems to slowly wander (5-15 second periods) around at speed, particularly at higher loads. See item 2a. 3 concerning excessive on Governor.

(3.) Governor not tuned or adjusted for engine/application.

The basic adjustment to set sensitivity/stability is the Gain pot. A good starting point for many engines is full CCW, then CW 1/3 turn. (See "Governor adjustment" section). To increase stability, turn CCW. If satisfactory governing cannot be achieved with this one adjustment, the factory adjustment may be needed. Normal starting point for this adjustment is fully CCW, then CW 1/4 turn. (Before changing this pot, mark the original position).

NOTE: *If problems occurs with the Governor overshooting when a large load is released from the engine, such as driving up a hill and stopping. There is usually one of two things:*

a. Gain adjustment is to far CCW.

b. Mechanical preload between the carburetor and actuator is to large, this should be no greater than 1/2 to 1 ball diameter.

Automatic Choke Adjustment Procedure

(For all JLG 1.IL and 2.3L Ford carbureted engines)

1. At 70°F the choke plate should be open 1/3" (not touching the choke bore).
2. If the ambient temperature is not 7o°F, an additional adjustment is required:
   a. Loosen the three cover plate screws.
   b. Adjust the cover to open the choke plate 1/32".
   c. Readjust for ambient temperature by rotating the cover one (1) mark per 5°F from 70°. Rotate CCW (lean) if warmer than 70°, CW (rich) if colder than 70°.
      (If actual temperature is 80°, set at 1/32 in. and rotate two (2) marks CCW (lean) direction.)
   d. Tighten the three cover plate screws and check for free rotation (no sticking or binding) of the choke shaft.

3.31 DEUTZ EMR 2

The EMR2 consists of the sensors, the control unit and the actuator. Engine-side controls as well as the JLG Control System are connected by means of separate cable harnesses to the EMR control unit.

The sensors attached to the engine provide the electronics in the control unit with all the relevant physical parameters In accordance with the information of the current condition of the engine and the preconditions (throttle position etc.), the EMR2 controls an actuator that operates the control rod of the injection pump and thus doses the fuel quantity in accordance with the performance requirements.

The exact position of the regulating rod is reported back and, if necessary, is corrected, by means of the control rod travel sensor, situated together with the rotation magnets in a housing of the actuator.

The EMR2 is equipped with safety devices and measures in the hardware and software in order to ensure emergency running (Limp home) functions.

In order to switch the engine off, the EMR2 is switched in a de-energized fashion over the ignition switch. A strong spring in the actuator presses the control rod in the de-energized condition into the zero position. As a redundancy measure, an additional solenoid serves for switching off and this, independently of the actuator, also moves the control rod in the de-energized condition into the zero position.

After the programming, that is carried out over the ISO9141 interface, the EMR2 possesses a motor-specific data set and this is then fixedly assigned to the engine. Included in this are the various application cases as well as the customer's wishes regarding a particular scope of function.

Each EMR2 module is matched by serial number to the engine. Modules cannot be swapped between engines.

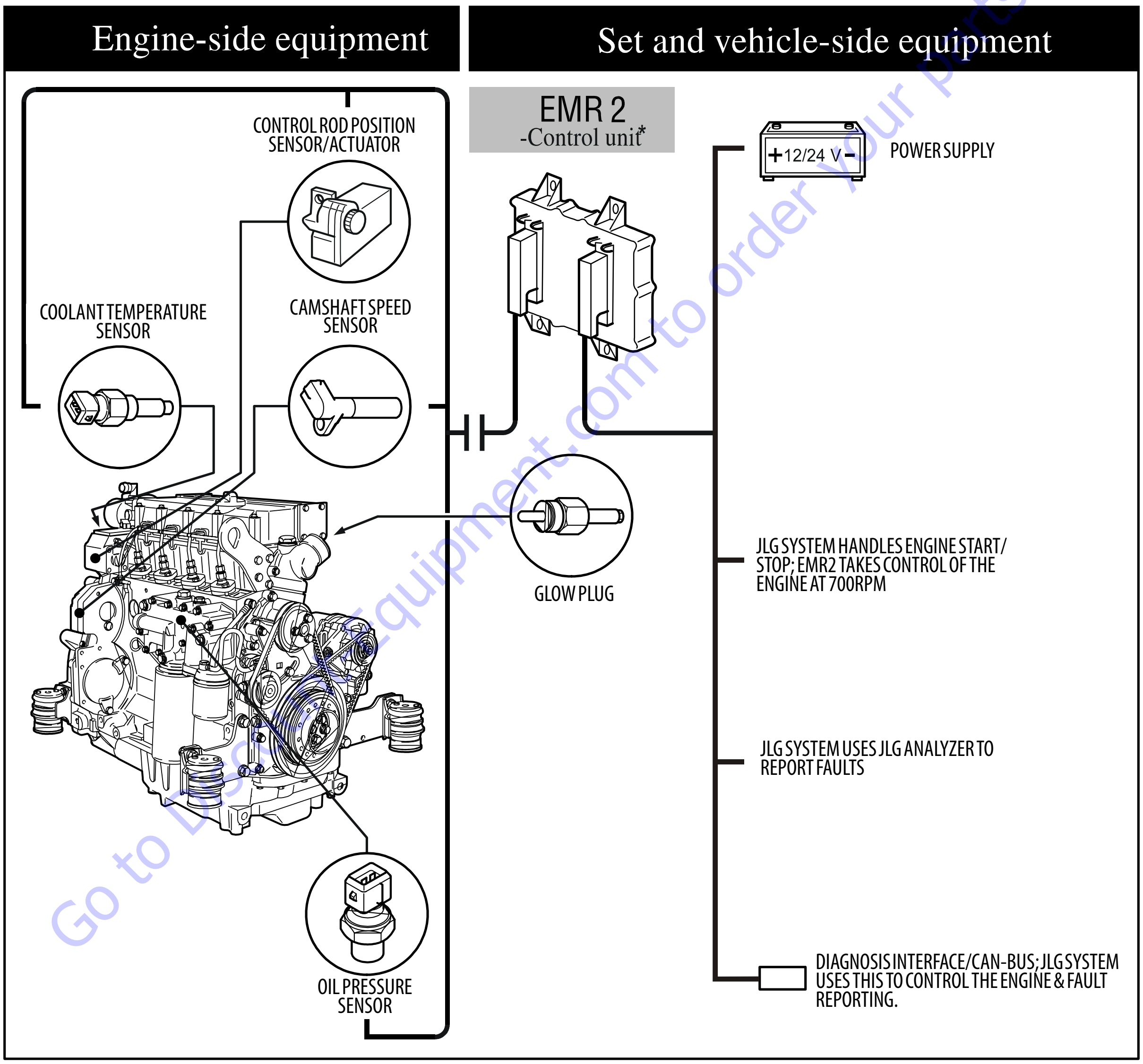


Figure 3-82. EMR 2 Engine Side Equipment

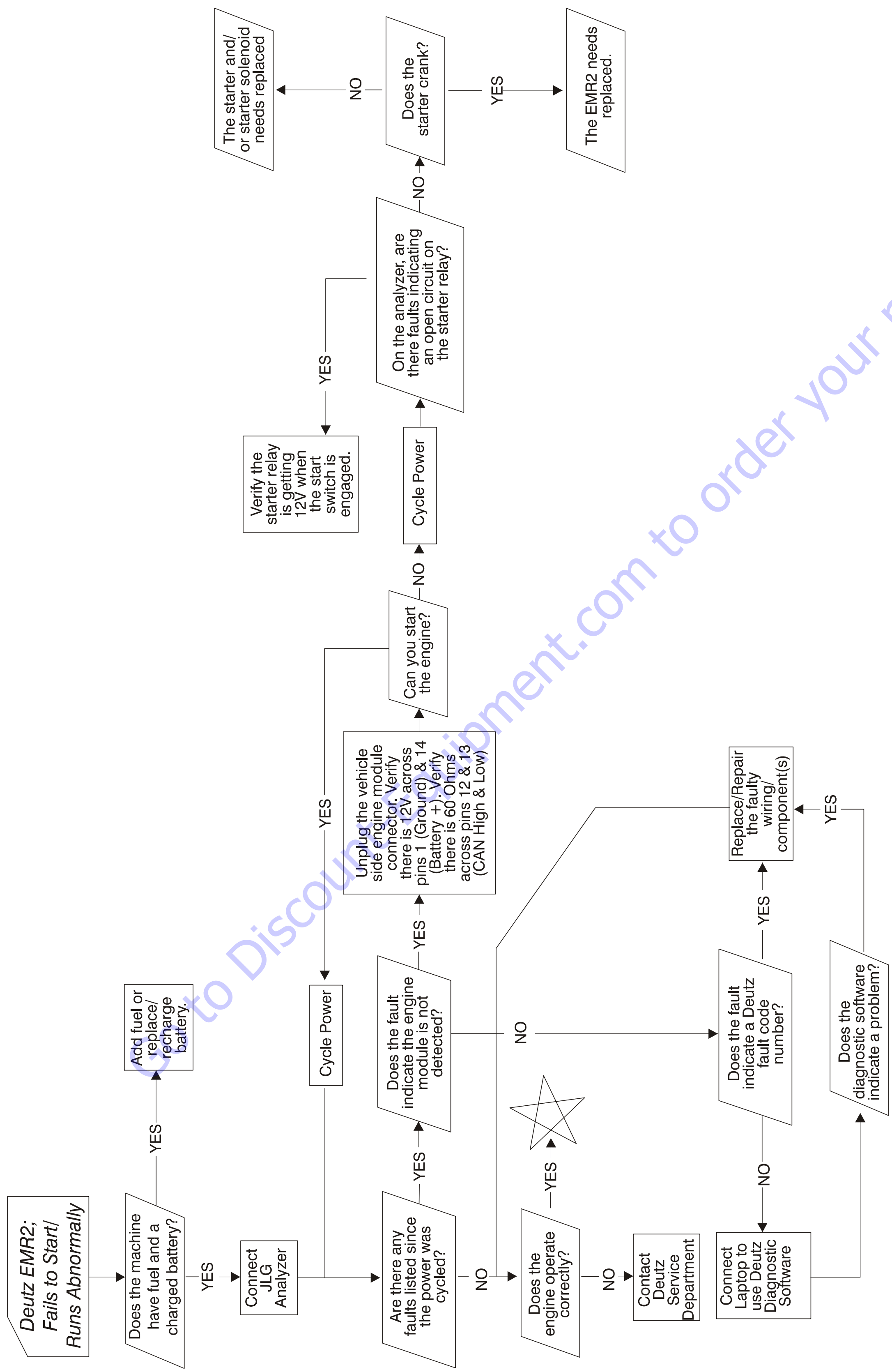


Figure 3-83. Deutz EMR 2 Troubleshooting Flow Chart

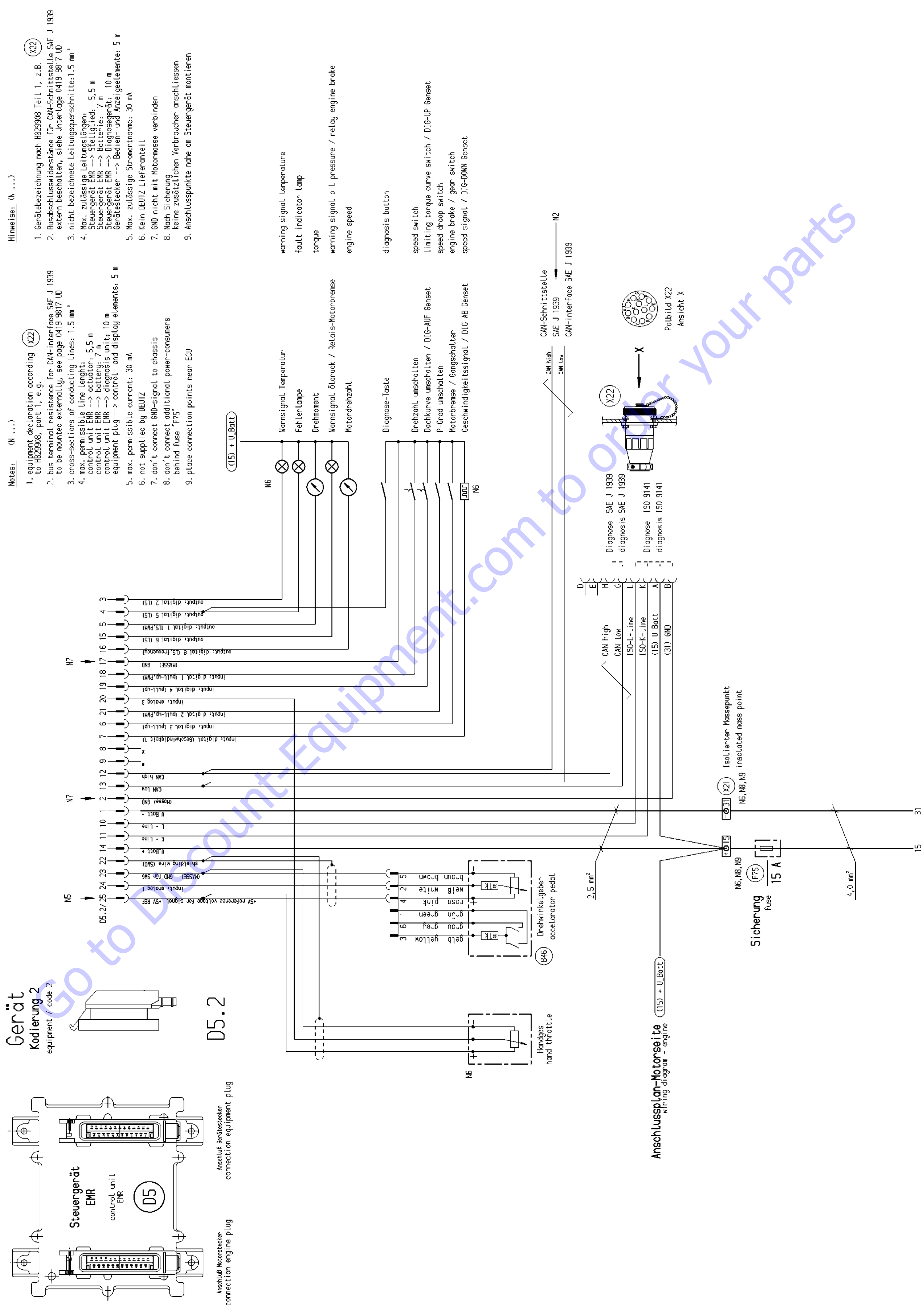


Figure 3-84. Deutz EMR 2 Vehicle Side Connection Diagram

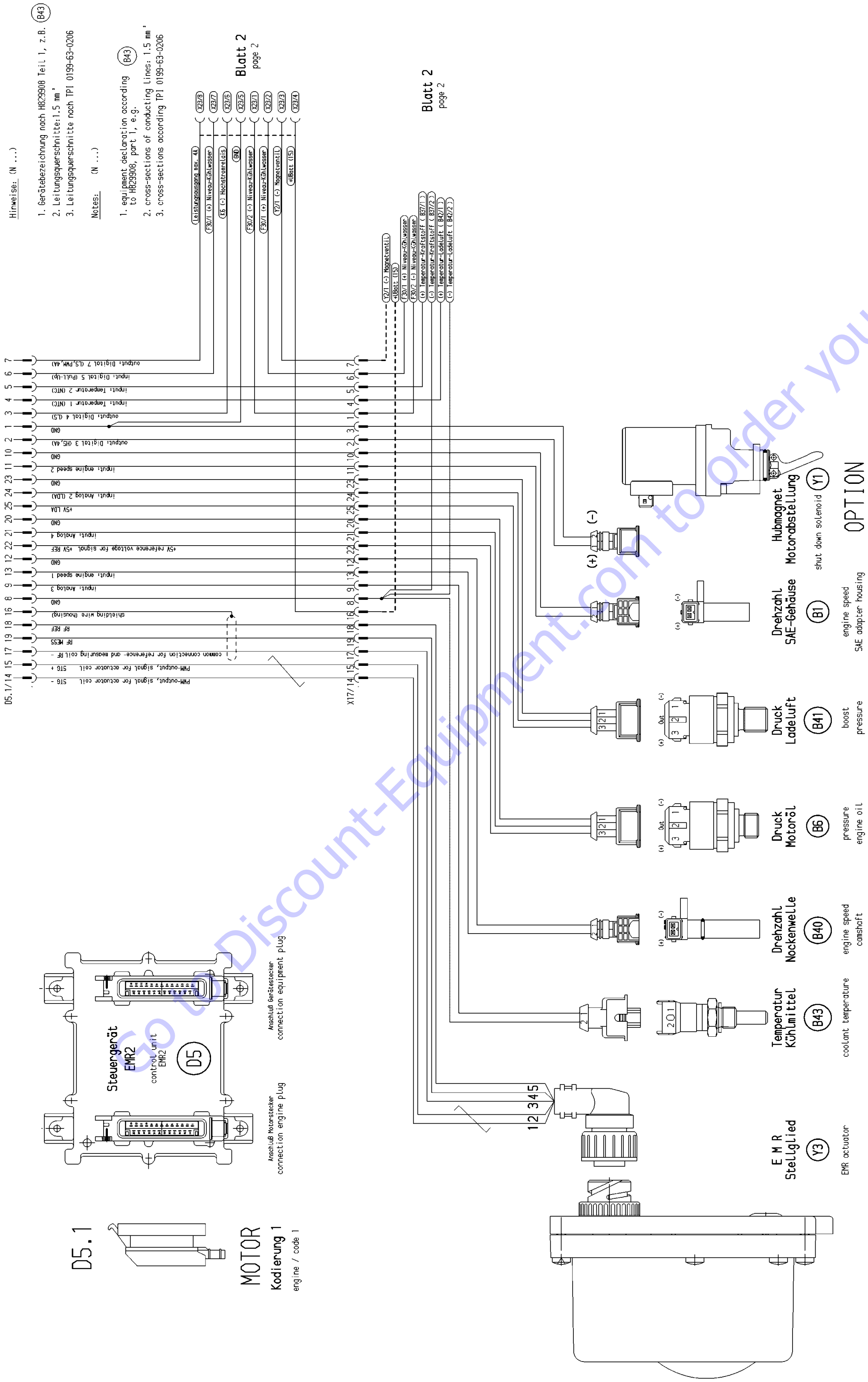


Figure 3-85. Deutz EMR 2 Engine Side Connection Diagram - Sheet 1 of 2

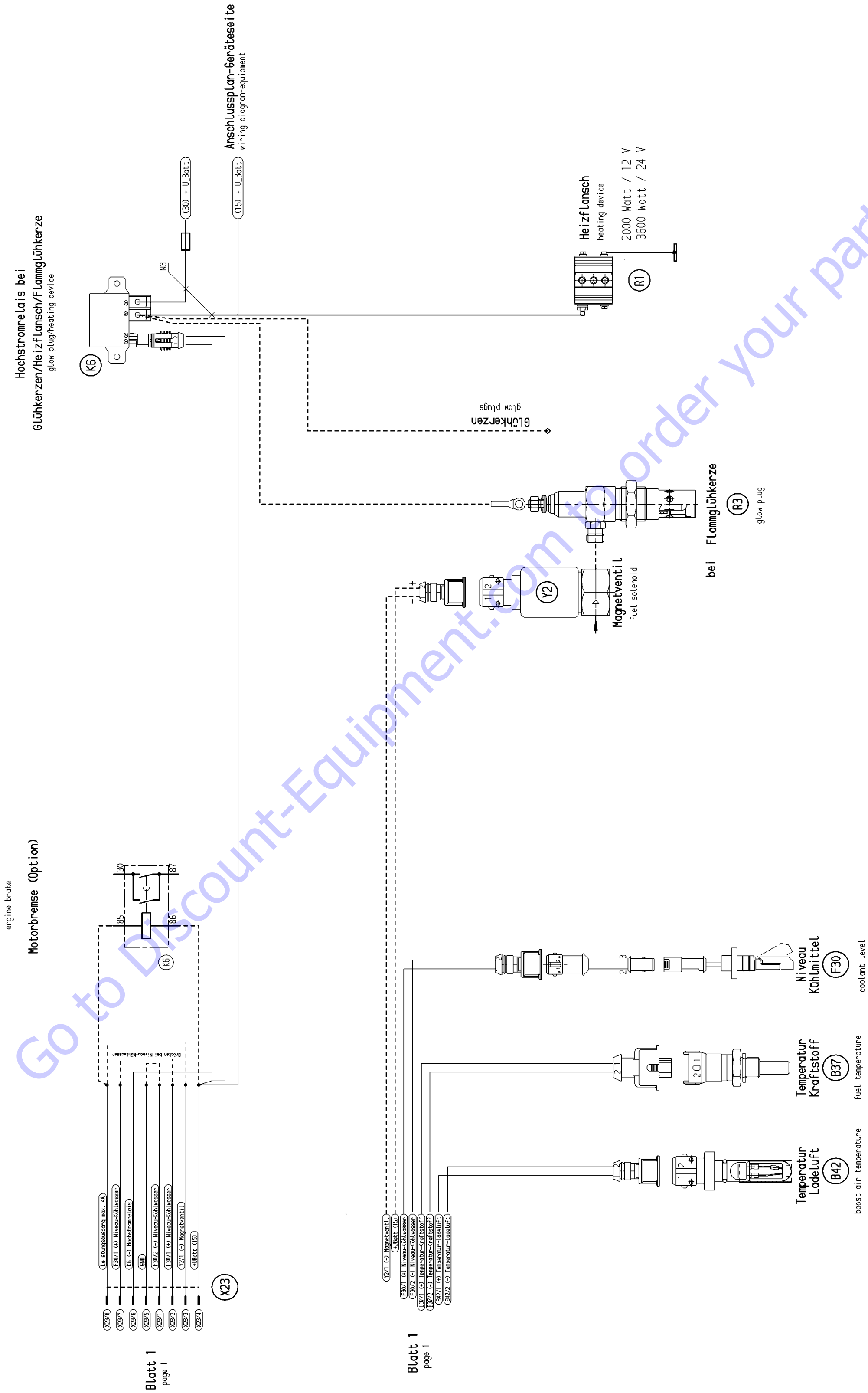
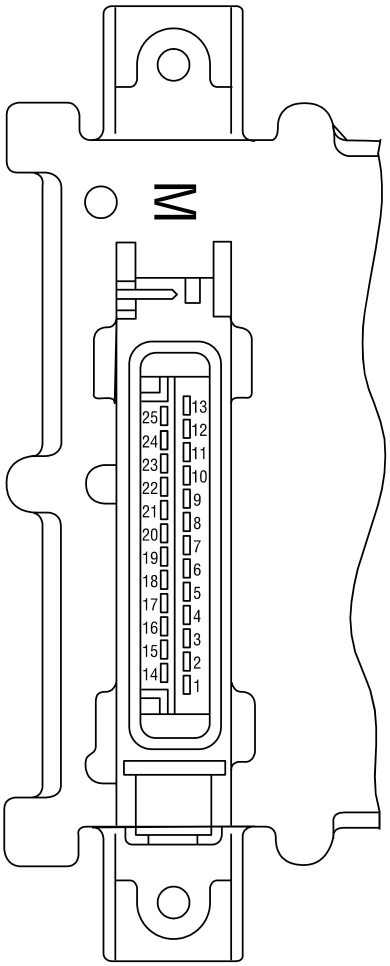


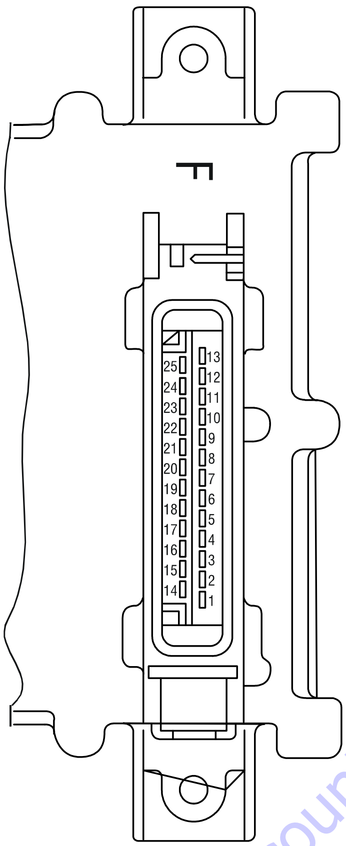
Figure 3-86. Deutz EMR 2 Engine Side Connection Diagram - Sheet 2 of 2



Pin No.	Designation	Description
1	Reserve	Reserve
2	Output: digital 3	Digital output for solenoid [1)]
3	Output: digital 4	For heating flange (optional)/ glow plug (optional)
4	Input (optional) Temp 1	Fuel temperature [2)]
5	Input (optional) Temp 2	Charge air temperature
6	Input (optional) DigIn 5	Coolant level / oil level
7	Output: PWM2/digital 6	
8	GND	Reference potential for analog signal at pin 9
9	Input: analog 7	Analog input for Coolant temperature sensor (NTC)
10	GND	Reference potential for analog signal at pin 11
11	Multi-function input: speed 2/DigIn 2	Digital input second engine speed (crankshaft) (optional) and speed signal (optional)
12	GND	Reference potential for analog signal at pin 13
13	Input: speed 1	Digital input first engine speed (camshaft)
14	STG -	PWM output, signal for actuator coil
15	STG +	PWM output, signal for actuator coil
16	Screen	Screening regulating rod travel sensor (for lines 17, 18, 19)
17	RF -	General connection for reference and measuring coil
18	RF REF	Analog input, reference signal of the reference coil
19	RF MESS	Analog input, measuring signal of the measuring coil
20	GND	Reference potential for signal at pin 21
21	Input: analog 4/digital 9	Analog input 4 (sensor signal oil pressure sensor) or digital input 9
22	+5 V REF	+5 V Reference voltage for signal at pin 21 (max. 15 mA)
23	GND	Reference potential for signal at pin 24
24	Input: analog 2/digital 7	Analog input 2 (sensor signal charge air) or digital input 7
25	+5 V LDA	+5 V Reference potential for signal at pin 24 (max. 15 mA)

1) For continuous power: < 4 A
2) Corresponds to special function"fuel temperature compensation at the EMR (0211 2571)

Figure 3-87. EMR 2 Engine Plug Pin Identification



Pin-No.	Designation	Description
1	U Batt -	Negative pole at battery (clamp 31)
2	GND	Reference potential for signal
3	Output: digital 2	PWM or digital output, various functions
4	Input / output: DigInOut	Fault lamp and diagnostic button
5	Output: PWM 1/Dig 1	PWM or digital output, various functions
6	Multi-function input: DigIn 3	Genset applications/gear shift/motor brake
7	Input: digital 10/velocity	Speed signal (tacho input)
8	NC	Not occupied
9	NC	Not occupied
10	L-line	Serial ISO 9141 interface
11	K-line	Serial ISO 9141 interface
12	CAN high	Interface for CAN-Bus
13	CAN low	Interface for CAN-Bus
14	U Batt +	Positive pole for battery (clamp 15)
15	Output: digital 5	Digital output, various functions
16	Output: digital 7/Frequency	Frequency, PWM or digital output, various functions
17	Ground	Reference potential for signal at pins 18, 19 and 21
18	Input: digital 1 / PWM 1	PWM 1 or digital input 1, various functions
19	Multi-function input: DigIn 4	Performance curve switching/genset applications
20	Multi-function input: digital 8 / analog 3	Hand hand throttle/genset applications, Digital (8) or analog input (3)
21	Input: digital 2 / PWM 2	PWM 2 or digital input 2, various functions
22	Screen	Screening (e.g. for lines hand throttle or PWG)
23	GND	Reference potential for signal at pin 24
24	Input: analog 1 / digital 6	Analog input 1 (pedal value sensor, PWG) or digital input 6
25	+5 V REF	+5 V Reference voltage for signal at pin 24

Figure 3-88. EMR 2 Vehicle Plug Pin Identification

Fault group	Fault no. (in SERDIA)	Fault locality/ Fault description	SPN	FMI	Cause	Remarks	Help
Zero error display	-	No faults	524287	31	No **active** faults present		
Revolutions / speed acquisition	01	Speed sensor 1	190	8	Sensor failure. Distance from gear too far. Additional fault impulses. Cable joint interrupted.	Governor in emergency operation (if sensor 2 available). Emergency switch-off (if sensor 2 not available or failed). Governor in emergency operation (with sensor 1) Emergency switch-off (if sensor 1 not available or failed).	Check distance. Check cable connection. Check sensor and replace if required.
	03	Speed sensor	84	8	Tacho failed. Additional fault impulses. Cable connection interrupted.	Governor in emergency operation.	Check cable connection and Tacho. Replace if required.
	04	Excess speed switch-off	190	0	Speed was/is in excess of limit.e.	Engine stop.	Check parameter (21). Check speed settings.
					Check PID setting. Check rods. Check actuator and replace if required. Check cable to actuator (impulse on incorrect speed). Check No. of teeth. For vehicles check for possible thrust mode.		
Sensors	07	Charge air pressure	102	2	Fault at corresponding sensor entry (e.g. short circuit or cable break).	With failure of the sensor, the associated monitoring function is de-activated.	Check sensor cable. Check sensor and replace if required. Check fault limits for sensor.
	08	Oil pressure	100	2			
	09	Coolant temperature	110	2			
	10	Charge air temperature	105	2			
	11	Fuel temperature	174	2			

NOTE: SID is equal to 512. To get SPN #, add 512 + number. For example, SID 254 would be 512+254 or an SPN of 766.

Figure 3-89. EMR2 Fault Codes - Sheet 1 of 5

Fault group	Fault no. (in SERDIA)	Fault locality/ Fault description	SPN	FMI	Cause	Remarks	Help
Functional fault warning	30	Oil pressure warning	100	1	Oil pressure below speed-dependent warning line characteristic	Fault message (disappears when oil pressure is again above recovery limit). After a delay time - fill limitation.	Check engine (oil level, oil pump). Check oil pressure sensor and cable. Check oil pressure warning line characteristic.
	31	Coolant temperature warning	110	0	Coolant temperature has exceeded warning level.	Fault message (disappears when coolant temperature again drops below recovery level). After a delay time - fill limitation.	Check coolant. Check coolant temperature sensor and cable.
	32	Charge air temperature warning	105	0	Charge air temperature has exceeded warning level.	Fault message (disappears when charge air temperature gain drops below recovery level). After a delay time - fill limitation.	Check charge air. Check charge air-temperature sensor and cable.
	34	Coolant level warning	111	1	Switch input “Low coolant level” is active.	Fault message.	Check coolant level. Check coolant level sensor and cable.
	35	Speed warning (with thrust mode operation).	SID 190	14	revolutions was/is above (top) revolution speed limit. “Thrust mode” function is active.		Check parameters. Check speed settings.
					Check PID setting. Check rods. Check actuator and replace if required. Check cable to actuator. Check speed sensor (impulses on incorrect speed). Check No. of teeth. For vehicles check for possible thrust mode.		
	36	Fuel temperature warning	174	0	Fuel-temperature has exceeded warning level.	Fault message (disappears when fuel temperature again drops below recovery level).	Check fuel. Check fuel temperature sensor and cable.

NOTE: SID is equal to 512. To get SPN #, add 512 + number. For example, SID 254 would be 512+254 or an SPN of 766.

Figure 3-90. EMR2 Fault Codes - Sheet 2 of 5

Fault group	Fault no. (in SERDIA)	Fault locality/ Fault description	SPN	FMI	Cause	Remarks	Help
Functional fault, switch-off	42	Charge air temperature switch-off	105	0	Charge air temperature has exceeded switch-off limit.	Emergency stop	Check charge air. Check charge air-temperature sensor and cable. Check switch-off limit.
	44	Coolant level switch-off	111	1	Switch input “Low coolant level” is active.	Emergency stop. Start lock.	Check coolant level. Check coolant level sensor and cable.
Actuator	50	Feedback	SID 24	12	Actuator not connected. Fault in actuator confirmation.	Emergency switch-off. Actuator cannot be operated.	Check actuator, replace if required. Check cable, check fault limits for “Confirmation”.
	52	Reference feedback	SID 24	13			Check actuator, replace if required. Check cable, check fault limits for “Rifeness confirmation”.
	53	Control travel difference	SID 23	7	Injection pump/actuator jammed or not connected. Difference between nominal/actual control travel is > 10 % of the overall control path.	Fault message (disappears when difference is < 10 %).	Check actuator/actuator rods / injection pump, replace if required. Check actuator cable.
	59	Auto calibration BOSCH-EDC pumps faulty operation	SID 23	13	No automatic actuator equalization possible. Incorrect input of the actuator reference values.	Engine stop / start lock. Governor cannot be taken into use. EDC actuator calibration required.	Check actuator and replaced if required. Check feedback cable. Check fault limits and reference values of the feedback. Program the fault limits for feedback, save values. Switch ignition off and on again.Check again. If faulty, inform DEUTZ-Service and carry out automatic equalization again. Set fault limits again.

NOTE: SID is equal to 512. To get SPN #, add 512 + number. For example, SID 254 would be 512+254 or an SPN of 766.

Figure 3-91. EMR2 Fault Codes - Sheet 3 of 5

Fault group	Fault no. (in SERDIA)	Fault locality/ Fault description	SPN	FMI	Cause	Remarks	Help
Hardware inputs/ outputs	60	Digital output 3 (Switch-off solenoid, pin M 2)	SID 51	2	Fault (short circuit / cable break) at digital output.	Driver level is switched off.	Check cable of digital output (cable break or short circuit).
	62	Digital output 6, pin M 7	SID 60	2		Fault message.	
	63	Excess voltage switch-off solenoid	SID 51	6			
	67	Error Hand Setp1	91	11			
	68	Error CAN Setp1	898	2			
Communi- cation	70	CAN-Bus controller	SID 231	12	CAN-controller for CAN-bus is faulty. Fault removal despite re-initialising continuously not possible	Application-dependent.	Check CAN connection, terminating resistor (see Chapter 12.4), Check control unit.
	71	CAN interface SAE J 1939	SID 231	9	Overflow in input buffer or a transmission cannot be placed on the bus.		
	74	Cable break, short circuit or bus-error	SID 231	14			Check CAN connection, cable connection. Check sensor and replace if required.
Memory	76	Parameter programming (write EEPROM)	SID 253	12	Fault in parameter programming in the governor fixed value memory.	Emergency switch-off. engine cannot be started.	Switch ignition off and on again. Check again. If faulty inform DEUTZ Service
	77	Cyclic program test	SID 240	12	Constant monitoring of program memory shows error (so-called “Flash-test”).		
	78	Cyclic RAM test	SID 254	2	Constant monitoring of working memory shows error.		Note values of parameters (3895 and 3896). Switch ignition off and on again. Check again. If faulty inform DEUTZ Service.

NOTE: SID is equal to 512. To get SPN #, add 512 + number. For example, SID 254 would be 512+254 or an SPN of 766.

Figure 3-92. EMR2 Fault Codes - Sheet 4 of 5

Fault group	Fault no. (in SERDIA)	Fault locality/ Fault description	SPN	FMI	Cause	Remarks	Help
Control unit hardware	80	Power supply (Actuator)	SID 254	2	Power supply for actuator not in the permissible range.	Fault message (disappears when power again in the normal range).	Switch ignition off and on again. Check again. If faulty inform DEUTZ Service.
	83	Reference voltage 1	SID 254	2	Reference voltage for actuator not in the permissible range.	Fault message (disappears when power again in the normal range). Auxiliary value 5 V	Check voltage supply. Switch ignition off and on again. Check again. If faulty inform DEUTZ Service.
	84	Reference voltage 2	SID 254	2			
	85	Reference voltage 4	SID 254	2			
	86	Internal temperature	171	12	Internal temperature for control unit not in permissible range.	Fault message (disappears when power again in the normal range).	Switch ignition off and on again. Check again. If faulty inform DEUTZ Service.
	87	Atmospheric pressure	108	12	Atmospheric pressure not in permissible range.	Fault message (disappears when power again in normal range). Atmospheric pressure monitoring function de-activated.	
Program logic	90	Parameter fault (EEPROM retrieval or checksum faulty).	SID 253	2	No data found or checksum of data is faulty (note: fault only occurs during setting of parameter / saving or reset.).	Engine cannot be started.	Check data for correct settings. Save parameters. Switch ignition off and on again. Check again. If faulty inform DEUTZ Service.
	93	Stack overflow	SID 240	2	Internal calculation fault (so-called "Stack overflow" fault).	Emergency switch-off. Engine cannot be started.	Note parameters (3897 and 3898). Switch ignition off and on again. Check again. If faulty inform DEUTZ Service.
	94	Internal fault	SID 254	2			

NOTE: SID is equal to 512. To get SPN #, add 512 + number. For example, SID 254 would be 512+254 or an SPN of 766.

Figure 3-93. EMR2 Fault Codes - Sheet 5 of 5

3.32 GM ENGINE GENERAL MAINTENANCE

Maintenance of the Drive Belt

The serpentine drive belt utilizes a spring loaded tensioner which keeps the belt properly adjusted. The drive belt is an integral part of the cooling and charging systems and should be inspected frequently.

When inspecting the belts check for:

- Cracks or breaks
- Chunking of the belt
- Splits
- Material hanging from the belt
- Glazing and hardening
- Damaged or improperly aligned pulleys
- Improperly performing tensioner

Check the belt tensioner by pressing down on the midway point of the longest stretch between pulleys. The belt should not depress beyond 1/2 in. (13mm). If the depression is more than allowable adjust the tension.

NOTICE

THE ENGINE MANUFACTURER DOES NOT RECOMMEND THE USE OF "BELT DRESSING" OR "ANTI SLIPPING AGENTS" ON THE DRIVE BELT.

Engine Electrical System Maintenance

The engine electrical system incorporates computers and microprocessors to control the engine ignition, fuel control, and emissions. Due to the sensitivity of the computers to good electrical connections periodic inspection of the electrical wiring is necessary. When inspecting the electrical system use the following:

- Check and clean the battery terminal connections and insure the connections are tight
- Check the battery for any cracks or damage to the case
- Check the Positive and Negative battery cables for any corrosion build up, rubbing or chafing, check connection on the chassis to insure they are tight
- Check the entire engine wire harness for rubbing chafing, cuts or damaged connections, repair if necessary
- Check all wire harness connectors to insure they are fully seated and locked
- Check ignition coil and spark plug cables for hardening, cracking, chafing, separation, split boot covers and proper fit
- Replace spark plugs at the proper intervals as prescribed in the engine manufacturer's manual
- Check to make sure all electrical components are fitted securely
- Check the ground and platform control stations to insure all warning indicator lights are functioning

Checking/Filling Engine Oil Level

NOTICE

AN OVERFILLED CRANKCASE (OIL LEVEL OVER THE SPECIFIED FULL MARK) CAN CAUSE AN OIL LEAK, A FLUCTUATION OR DROP IN THE OIL PRESSURE, AND ROCKER ARM "CLATTER" IN THE ENGINE.

NOTICE

CARE MUST BE TAKEN WHEN CHECKING THE ENGINE OIL LEVEL. OIL LEVEL MUST BE MAINTAINED BETWEEN THE "ADD" MARK AND "FULL" MARK ON THE DIPSTICK.

To ensure that you are not getting a false reading, make sure the following steps are taken to before check the oil level.

1. Stop the engine if in use.
2. Allow sufficient time (approximately 5 minutes) for the oil to drain back into the oil pan.
3. Remove the dipstick. Wipe with a clean cloth or paper towel and reinstall. Push the dipstick all the way into the dipstick tube.
4. Remove the dipstick and note the oil level.
5. Oil level must be between the "FULL" and "ADD" marks.

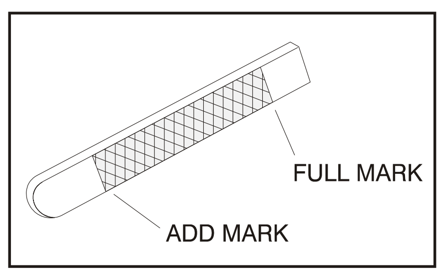


Figure 3-94. Engine Oil Dip Stick

6. If the oil level is below the "ADD" mark, proceed to Step 7 and 8 and reinstall the dipstick into the dipstick tube.
7. Remove the oil filter cap from the valve rocker arm cover.
8. Add the required amount of oil to bring the level up to but not over "FULL" mark on the dipstick.
9. Reinstall the oil fill cap to the valve rocker cover and wipe away any excess oil.

Changing The Engine Oil

NOTICE

WHEN CHANGING THE OIL, ALWAYS CHANGE THE OIL FILTER. CHANGE OIL WHEN THE ENGINE IS WARM FROM OPERATION AS THE OILS WILL FLOW FREELY AND CARRY AWAY MORE IMPURITIES.

To change the oil use the following steps:

1. Start the engine and run until it reaches normal operating temperature.
2. Stop the engine.
3. Remove the drain plug and allow the oil to drain.
4. Remove and discard the oil filter and its sealing ring.
5. Coat the sealing ring on the filter with clean engine oil and wipe the sealing surface on the filter mounting surface to remove any dust, dirt and debris. Tighten the filter securely (follow the filter manufacturers instructions). Do not over tighten.
6. Check the sealing ring on drain plug for any damage, replace if necessary, wipe the plug with a clean rag, and wipe the sealing surface on the pan and reinstall the pan plug. Do not over tighten.
7. Fill the crankcase with oil.
8. Start the engine and check for oil leaks.
9. Stop the engine and check the oil level to insure the oil level is at "FULL".
10. Dispose of the oil and filter in a safe manner.

Coolant Fill Procedure - Dual Fuel Engine

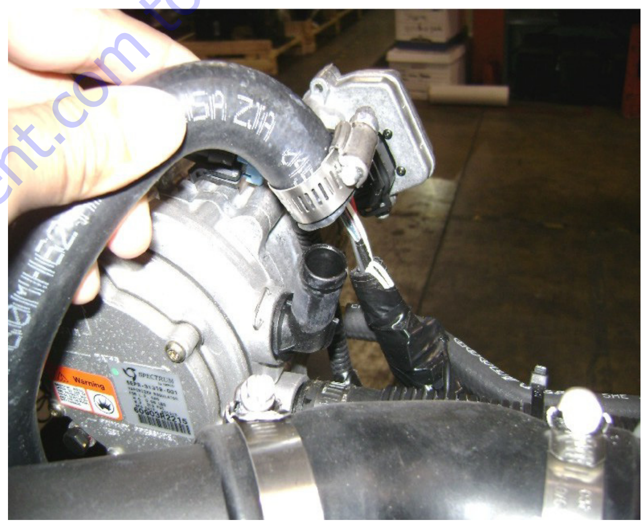
NOTICE

DAMAGE TO THE ENGINE COULD OCCUR IF NOT PROPERLY FILLED WITH COOLANT. LPG FUELED ENGINES ARE MOST PRONE TO CREATING AN AIR LOCK DURING A COOLANT FILL OPERATION DUE TO THE ELECTRONIC PRESSURE REGULATOR (EPR) BEING THE HIGHEST POINT IN THE COOLING SYSTEM. AN EPR THAT APPEARS TO HAVE FROST FORMING ON IT IS A SIGN THAT THE ENGINE COOLING SYSTEM CONTAINS AIR. THE APPEARANCE AND TEMPERATURE OF THE EPR SHOULD BE MONITORED DURING THE COOLANT FILL OPERATION. A WARM EPR IS AN INDICATION THAT THE COOLING SYSTEM IS PROPERLY FILLED AND FUNCTIONING.

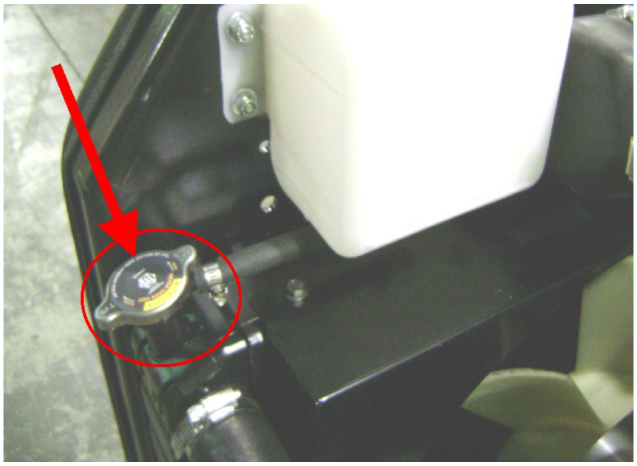
⚠ CAUTION

MAKE SURE ENGINE IS COOL BEFORE PERFORMING ANY MAINTENANCE WORK.

1. Loosen the worm gear clamp on the coolant line running into the EPR as shown below and remove the hose from the EPR. Place a rag under the hose to prevent coolant from running onto the engine/machine.



2. Remove the radiator cap. Fill the radiator with coolant until coolant starts to appear from the previously removed hose at the EPR. Reinstall the hose back onto the EPR and continue to fill radiator with coolant.



3. With the radiator cap still removed, start the engine and run until the thermostat opens. The thermostat opens at 170° F (77° C), which can be checked using the JLG handheld analyzer.

NOTICE

WHILE ENGINE IS RUNNING, AIR AND/OR STEAM MAY BE PRESENT COMING FROM THE RADIATOR. THIS IS NORMAL.

4. After running the engine for 5 minutes after it has reached operating temperature, shut the engine off and continue to step 5.

⚠ CAUTION

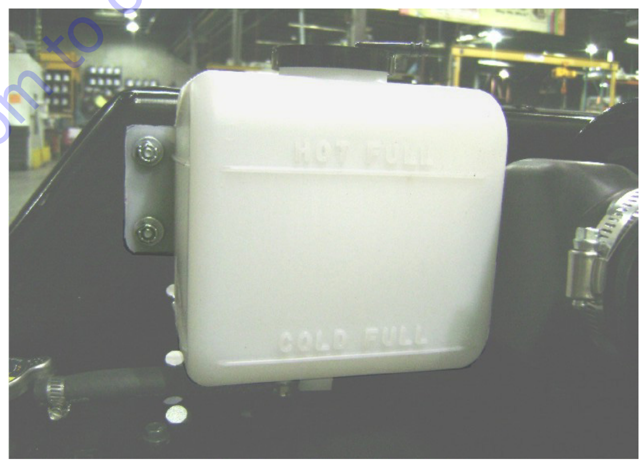
WITH THE ENGINE RUNNING OR WHEN SHUTTING OFF THE ENGINE, SOME HEATED COOLANT MAY SPILL OUT DUE TO AIR "BURPING" OUT OF THE SYSTEM WITH THE RADIATOR CAP OFF.

5. Next, verify that the 2 coolant hoses on the EPR are warm. If they are not warm repeat step 3 and 4, otherwise continue to step 6.

NOTICE

A PROPERLY PURGED COOLING SYSTEM WILL YIELD A WARM UPPER RADIATOR HOSE AND A WARM EPR HOSE. IF THE UPPER RADIATOR HOSE AND/OR EPR HOSE ARE NOT WARM TO THE TOUCH AFTER THE ENGINE HAS RUN FOR 5-8 MINUTES AFTER REACHING OPERATING TEMPERATURE, THE SYSTEM MAY STILL CONTAIN AIR. IT MAY BE NECESSARY TO REPEAT THE ABOVE STEPS.

6. Fill radiator with coolant as needed and install the radiator cap. Next, remove the cap off the coolant recovery bottle and fill just below the HOT FULL line and reinstall the caps.



3.33 GM ENGINE DUAL FUEL SYSTEM

NOTE: *+20° F (-6.6° C) is the low temperature limit for LP gas, for both starting and operation. This applies to all LP gas powered engines.*

The Dual Fuel system allows the operator to operate the vehicle on either gasoline or LPG by positioning a selector switch in the operator's platform. When the operator places the selector switch in the gasoline mode the gasoline fuel pump is energized. While in the gasoline mode the LPG fuel lock-off is isolated and will not energize. In addition the gasoline injector circuit is enabled and injector pulses are provided to each injector and the ECM calibration for gasoline is also enabled. When the operator selects the LPG mode the Low Pressure LPG lock-off is energized and fuel from the LPG tank flows to the Electronic Pressure Regulator (EPR). The EPR receives an electronic signal to position the secondary lever for the start or run positions and when the engine begins to crank the mixer air valve will rise and fuel will begin flowing to engine. During this mode the gasoline fuel pump is isolated and will not be activated. The primary components of the gasoline dual fuel system are the gasoline tank, electric fuel pump and filter, fuel supply line, injector rail and injectors and the fuel pressure regulator. The primary components of the LPG dual fuel system are the LPG fuel tank, in-fuel filter, LPG Low Pressure lock-off, Electronic Pressure Regulator (EPR) and the fuel mixer module. The LPG fuel system operates at pressures which range from 14.0 in. (355.60 mm) of water column up to 312 psi (21.5 bar).

Components which are shared by both systems include the Electronic Throttle Control and the ECM. The ECM contains a dual calibration; one controls the gasoline fuel system during gasoline operation and one controls the LPG fuel system during LPG operation.

Fuel Filter

Propane fuel like all other motor fuels is subject to contamination from outside sources. Refueling of the equipment's tank and removal of the tank from the equipment can inadvertently introduce dirt and other foreign matter into the fuel system. It is therefore necessary to filter the fuel prior to entering the fuel system components downstream of the tank. An inline fuel filter has been installed in the fuel system to remove the dirt and foreign matter from the fuel. The inline filter is replaceable as a unit only. Maintenance of the filter is critical to proper operation of the fuel system and should be replaced as Section 1. In severe operating condition more frequent replacement of the filter may be necessary.

Electric Lock Off

The Electric Lock Off device is an integrated assembly. When energized the solenoid opens the valve and allows the Propane fuel to flow through the device. The valve opens during cranking and run cycles of the engine. The lock off supply voltage is controlled by the engine control module (ECM).

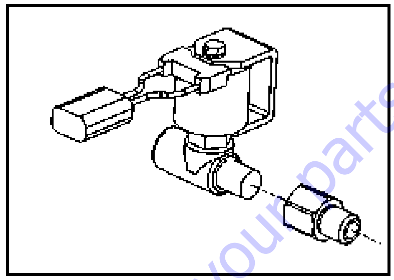
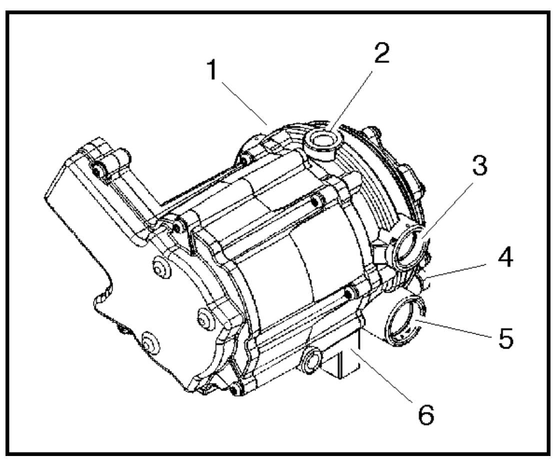


Figure 3-95. Electric Fuel Lock Off

EPR Assembly

The EPR assembly is a combination Low Pressure Regulator and a Voice Coil Assembly. The Voice coil is an electronic actuator which is controlled by an internal microprocessor. The microprocessor provides output data to the ECM and receives input data over a CAN BUS connection. The internal microprocessor receives electrical signals from the Fuel Pressure Sensor FPS and the Fuel Temperature Pressure FTP and communicates the data to the ECM. The ECM uses the FPS and FTP data to calculate the location of the secondary lever in the LPR and sends that data back to the EPR via the CAN BUS. The internal microprocessor in the EPR will then output a signal, which causes the voice coil to move and position the secondary lever to the correct location.



1. Pressure Regulator Section
2. Fuel Inlet
3. Coolant Passage
4. Primary Test Port
5. Secondary Test Port
6. Voice Coil Section

Figure 3-96. EPR Assembly

Low Pressure Regulator (LPR)

The LPR is a combination vaporizer, pressure regulating device. The LPR is a negative pressure, two stage regulator that is normally closed when the engine is not running. When the engine is cranking or running, a partial vacuum is created in the fuel line which connects the regulator to the mixer. This partial vacuum opens the regulator permitting fuel to flow to the mixer.

Propane fuel enters the primary port of the LPR and passes through the primary jet and into the primary/ exchanger chamber. As the propane passes through the heat exchanger the fuel expands and creates pressure inside the chamber. The pressure rises as the fuel expands when the pressure rises above 1.5 psi (10.34 kpa), sufficient pressure is exerted on the primary diaphragm to cause the diaphragm plate to pivot and press against the primary valve pin thus closing off the flow of fuel. This action causes the flow of fuel into the regulator to be regulated.

When the engine is cranking, sufficient vacuum will be introduced into the secondary chamber from the mixer drawing the secondary diaphragm down onto the spring loaded lever and opening the secondary valve allowing vaporized fuel to pass to the mixer. This mechanical action in conjunction with the EPR reactions causes the downward action on the secondary lever causing it to open wider allowing more fuel to flow to the mixer.

WARNING

THE VOICE COIL SECTION OF THE EPR ASSEMBLY IS AN EMISSIONS CONTROL DEVICE AND CANNOT BE REBUILT. IF THE COIL ASSEMBLY FAILS TO OPERATE PROPERLY, REPLACE IT WITH AN OEM REPLACEMENT PART ONLY.

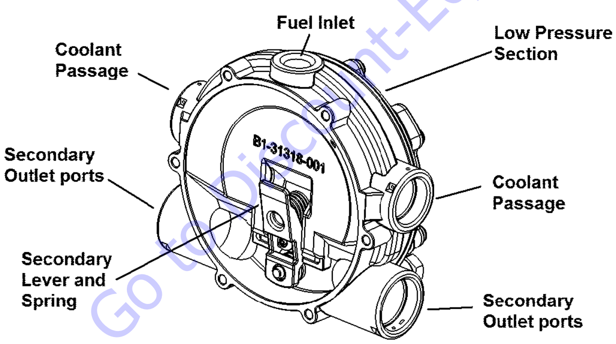


Figure 3-97. Low Pressure Regulators

Air Fuel Mixer

The air valve mixer is an air-fuel metering device and is completely self-contained. The mixer is an air valve design, utilizing a relatively constant pressure drop to draw fuel into the mixer from cranking to full load. The mixer is mounted in the air stream ahead of the throttle control device.

When the engine begins to crank, it draws in air with the air valve covering the inlet, negative pressure begins to build. This negative pressure signal is communicated to the top of the air valve chamber through 4 vacuum ports in the air valve assembly. A pressure/force imbalance begins to build across the air valve diaphragm between the air valve vacuum chamber and the atmospheric pressure below the diaphragm. The air valve vacuum spring is calibrated to generate from 4.0 in. (101.6 mm) of water column at start to as high as 14.0 in. (355.60 mm) of water column at full throttle. The vacuum being created is referred to as Air Valve Vacuum (AVV). As the air valve vacuum reaches 4.0 in. (101.6mm) of water column, the air valve begins to lift against the air valve spring. The amount of AVV generated is a direct result of the throttle position. At low engine speed the air valve vacuum is low and the air valve position is low thus creating a small venturi for the fuel to flow. As the engine speed increase the AVV increases and the air valve is lifted higher thus creating a much larger venturi. This air valve vacuum is communicated from the mixer venture to the LPR secondary chamber via the low pressure fuel supply hose. As the AVV increases in the secondary chamber the secondary diaphragm is drawn further down forcing the secondary valve lever to open wider.

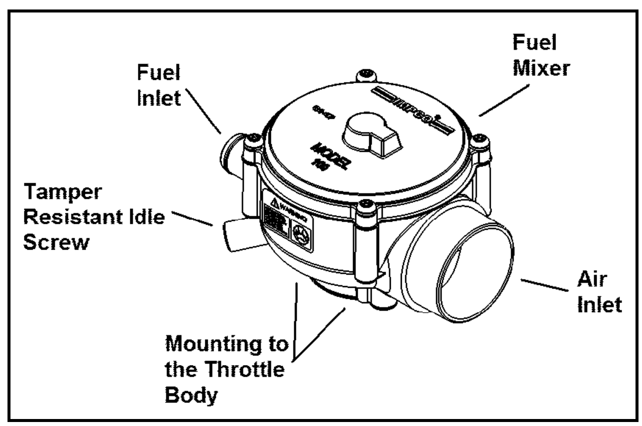


Figure 3-98. Air Fuel Mixer

Electronic Throttle Control (ETC)

Engine speed and load control is maintained by an ETC device. Speed and load control are determined by the ECM. Defaults programmed into the ECM software and throttle position sensors allow the ECM to maintain safe operating control over the engine. The Electronic Throttle Control device or "throttle body assembly" is connected to the intake manifold of the engine. The electronic throttle control device utilizes an electric motor connected to the throttle shaft. When the engine is running electrical signals are sent from the equipment controls to the engine ECM when the operator depresses an equipment function switch. The ECM then sends an electrical signal to the motor on the electronic throttle control to increase or decrease the angle of the throttle blade thus increasing or decreasing the air/fuel flow to the engine.

The electronic throttle control device also incorporates two internal Throttle Position Sensors (TPS) which provide output signals to the ECM as to the location of the throttle shaft and blade. The TPS information is used by the ECM to correct speed and load control as well as emission control.

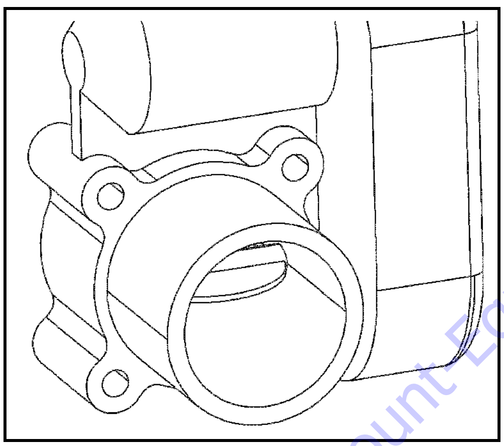


Figure 3-99. ETC throttle control device

Engine Control Module

To obtain maximum effect from the catalyst and accurate control of the air fuel ratio the emission certified engine is equipped with an onboard computer or Engine Control Unit (ECM). The ECM is a 32 bit controller which receives input data from sensors fitted to the engine and fuel system and then outputs various signals to control engine operation.

One specific function of the controller is to maintain "closed loop fuel control". Closed loop fuel control is accomplished when the exhaust gas oxygen sensor (HEGO) mounted in the exhaust system sends a voltage signal to the controller. The controller then calculates any correction that may need to be made to the air fuel ratio. The controller then outputs signals to the EPR to correct the amount of fuel being supplied to the mixer. At the same time the ECM may correct the throttle blade position to correct speed and load of the engine.

The controller also performs diagnostic functions on the fuel system and notifies the operator of malfunctions by turning on a Malfunction Indicator Light (MIL) mounted in the Ground Control Station and the Platform Control Station. Malfunctions in the system are identified by a Diagnostic Code number. In addition to notifying the operator of the malfunction in the system the controller also stores the information about the malfunction in its memory.

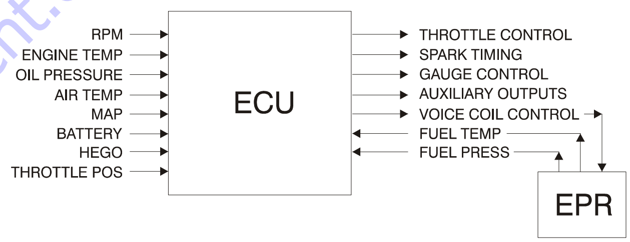


Figure 3-100. LPG Engine Control Unit (ECM)

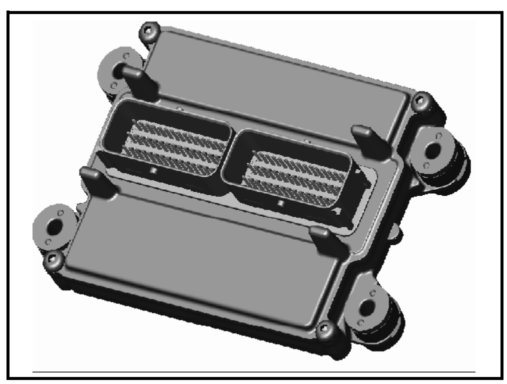


Figure 3-101. ECM Assembly

Heated Exhaust Gas Oxygen Sensor

There are two Heated Exhaust Gas Oxygen Sensors (HEGO). The first HEGO is mounted in the exhaust system downstream of the engine. It is used to measure the amount of oxygen present in the exhaust stream and communicate that to the ECM via an electrical signal. The amount of oxygen present in the exhaust stream indicates whether the fuel/air ratio is too rich or too lean. If the HEGO sensor signal indicates that the exhaust stream is too rich the ECM will decrease or lean the fuel mixture during engine operation, if the mixture is too lean the ECM will richen the mixture. The ECM continuously monitors the HEGO sensor output. If a rich or lean condition is present for an extended period of time, and the ECM cannot correct the condition, the ECM will set a diagnostic code and turn on the MIL light in control box.

The second HEGO is mounted in the exhaust system after the muffler. It measures the amount of oxygen in the exhaust system after the catalyst treatment has been completed in the muffler. If the ECM detects that the catalytic action in the muffler is not sufficient and fuel correction cannot correct the malfunction the MIL light is illuminated in the control box and a DTC code will stored in the computer.

NOTICE

THE HEATED EXHAUST GAS OXYGEN SENSOR IS AN EMISSION CONTROL DEVICE. IF THE HEGO FAILS TO OPERATE, REPLACE IT WITH AN OEM REPLACEMENT PART. THE HEGO SENSOR IS SENSITIVE TO SILICONE OR SILICONE BASED PRODUCTS AND CAN BECOME CONTAMINATED. AVOID USING SILICONE SEALERS OR HOSES TREATED WITH SILICONE LUBRICANTS IN THE AIR STREAM OR FUEL LINES.

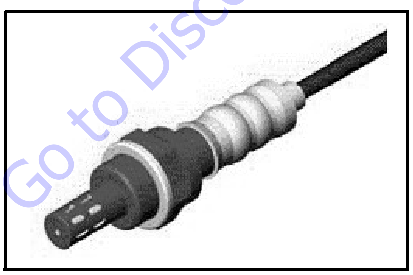


Figure 3-102. Heated Exhaust Gas Oxygen Sensor

Gasoline Multi Point Fuel Injection System (MPFI)

The primary components of the Gasoline Multi Point Fuel Injection (MPFI) fuel system are the fuel tank, electric fuel pump, fuel pressure and temperature sensor manifold, fuel filter and fuel rail.

Gasoline Fuel Pump

The Gasoline is stored as a liquid in the fuel tank and in drawn into the fuel system by an electric fuel pump. The fuel pump will receive a signal from the ECM to prime the fuel system for approximately 2 seconds prior to start. Priming of the fuel system provides for a quicker start, when the engine begins to crank.

Gasoline Pressure And Temperature Sensor Manifold

This engine is equipped with a fuel injector rail that does not have a pressure regulator or a return circuit to the fuel tank. Fuel pressure for this engine is regulated by the engine's ECM. The ECM receive fuel pressure and temperature feedback from the gasoline fuel sensor manifold and uses this information to control the ground side of the fuel pump. Fuel pressure is regulated by the ECM pulse width modulating (PWM) the fuel pump. The fuel pressure and temperature sensor manifold has a return or "bleed" circuit that connects back to the fuel tank. This circuit is used to bleed off any vapor that develops in the line and return a small amount of fuel to the tank. The fuel comes from the fuel tank and passes through the fuel pump. Fuel exits the fuel pump, passes through the filter and then enters the fuel pressure and temperature manifold assembly. Fuel flows through the feed circuit and is delivered to the fuel injector rail. Fuel that enters the bleed circuits through they bypass valve in the manifold is returned to the fuel tank.

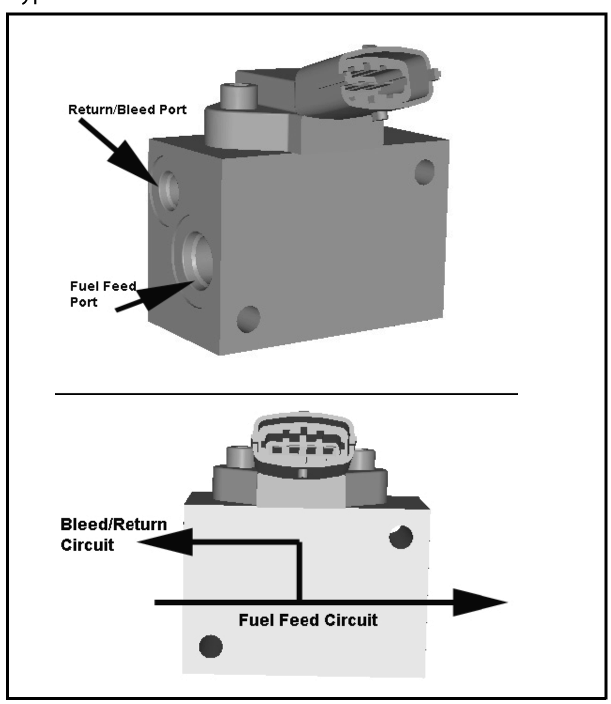


Figure 3-103. Gasoline Fuel Pressure and Temperature Manifold Assembly

Fuel Filter

After the fuel is drawn into the fuel pump, the fuel flows through the gasoline fuel filter. The fuel filter will trap small particles as the fuel passes through the filter to remove debris and prevents the fuel pressure and temperature manifold and fuel injectors from becoming damaged. Maintenance of the fuel filter is required as indicated in Section 1.

Fuel Injector Rail

Fuel flows from the fuel pressure and temperature manifold assembly to the fuel rails where the fuel is delivered to the fuel injectors. The fuel rail also contains a Schrader valve which is utilized to test the regulated pressure of the fuel system.

Fuel Injector

The fuel supply is maintained on the top of the injector from the injector rail. The injector is fed a "pulse" signal through the wire harness which causes the injector to open. During regular operating conditions the ECM controls the opening and duration of opening of the injector. During lower RPM operation the injector signals or "pulses" are less frequent then when the engine is operating at higher RPMs. The engine has been calibrated to deliver the precise amount of fuel for optimum performance and emission control.

3.34 GM ENGINE FUEL SYSTEM REPAIR

Propane Fuel System Pressure Relief

⚠ CAUTION

THE PROPANE FUEL SYSTEM OPERATES AT PRESSURES UP TO 312 PSI (21.5 BAR). TO MINIMIZE THE RISK OF FIRE AND PERSONAL INJURY, RELIEVE THE PROPANE FUEL SYSTEM PRESSURE (WHERE APPLICABLE) BEFORE SERVICING THE PROPANE FUEL SYSTEM COMPONENTS.

To relieve propane fuel system pressure:

1. Close the manual shut-off valve on the propane fuel tank.
2. Start and run the vehicle until the engine stalls.
3. Turn the ignition switch OFF.

NOTICE

RESIDUAL VAPOR PRESSURE WILL BE PRESENT IN THE FUEL SYSTEM. ENSURE THE WORK AREA IS WELL VENTILATED BEFORE DISCONNECTING ANY FUEL LINE.

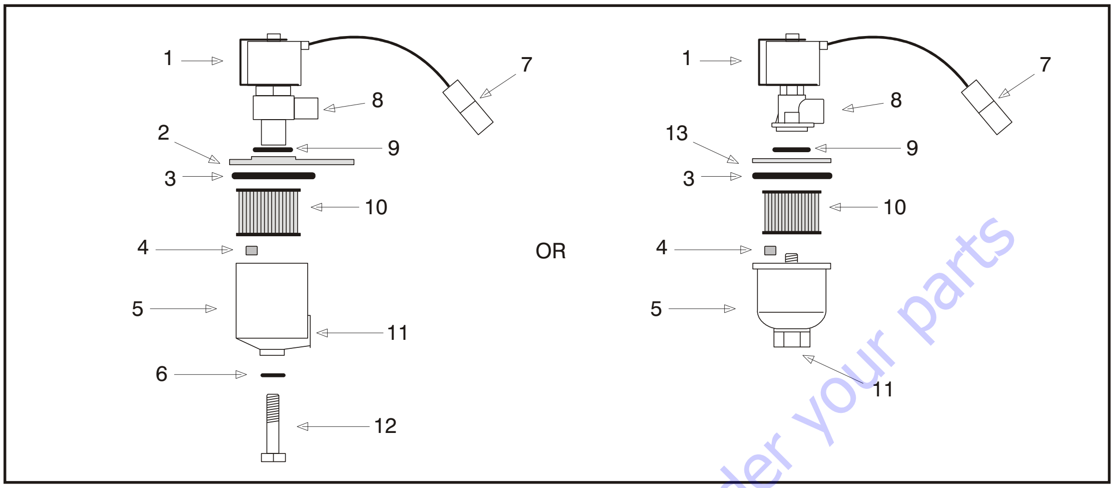
Propane Fuel System Leak Test

⚠ CAUTION

NEVER USE AN OPEN FLAME OF ANY TYPE TO CHECK FOR PROPANE FUEL SYSTEM LEAKS.

Always inspect the propane fuel system for leaks after performing service. Check for leaks at the fittings of the serviced or replaced component. Use a commercially available liquid leak detector or an electronic leak detector. When using both methods, use the electronic leak detector first to avoid contamination by the liquid leak detector.

Propane Fuel Filter Replacement



1. Electric Lock Off Solenoid
2. Mounting Plate
3. Housing Seal
4. Filter Magnet
5. Filter Housing
6. Seal
7. Electrical Connector
8. Fuel Outlet
9. O-ring
10. Filter
11. Fuel Inlet
12. Retaining Bolt

Figure 3-104. Filter Lock Assembly

REMOVAL

1. Relieve the propane fuel system pressure. Refer to Propane Fuel System Pressure Relief.
2. Disconnect the negative battery cable.
3. Slowly loosen the Filter housing and remove it.
4. Pull the filter housing from the Electric lock off assembly.
5. Remove the filter from the housing.
6. Locate Filter magnet and remove it.
7. Remove and discard the housing seal.
8. If equipped, remove and discard the retaining bolt seal.
9. Remove and discard mounting plate to lock off O-ring seal.

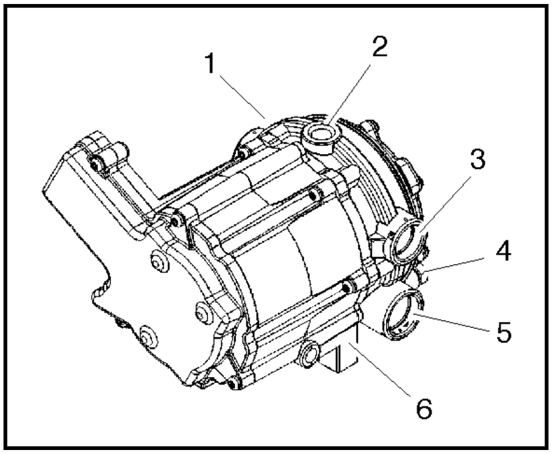
INSTALLATION

NOTICE

BE SURE TO REINSTALL THE FILTER MAGNET INTO THE HOUSING BEFORE INSTALLING NEW SEAL

1. Install the mounting plate to lock off O-ring seal.
2. If equipped, install the retaining bolt seal.
3. Install the housing seal.
4. Drop the magnet into the bottom of the filter housing.
5. Install the filter into the housing.
6. If equipped, install the retaining bolt into the filter housing.
7. Install the filter up to the bottom of the electric lock off.
8. Tighten the filter bowl retainer to 106 in lbs (12 Nm).
9. Open manual shut-off valve. Start the vehicle and leak check the propane fuel system at each serviced fitting. Refer to Propane Fuel System Leak Test.

Electronic Pressure Regulator (EPR) Assembly Replacement



1. Pressure Regulator Section
2. Fuel Inlet
3. Coolant Passage
4. Primary Test Port
5. Secondary Test Port
6. Voice Coil Section

Figure 3-105. EPR Assembly

The EPR assembly is a made up of two separate components. The Voice Coil Section is not serviceable and can only be replaced as an assembly. The pressure regulator section is serviceable and will be detailed in this section.

REMOVAL

1. Relieve the propane fuel system pressure. Refer to Propane Fuel System Pressure Relief.
2. Disconnect the negative battery cable.
3. Slowly remove the fuel inlet fitting at the Electric Lock Off.

NOTE: *Residual vapor pressure will be present in the fuel system.*

4. Disconnect the electrical connector to the Electric Lock off .
5. Remove the Electric Lock Off from the regulator.
6. Remove the lock pin from the vapor fitting on the regulator housing and remove the fitting and hose and retain the pin.
7. Remove the lock pin from the pressure sensor on the regulator housing and remove the Sensor and retain the pin.
8. Using a clamp pliers pinch off the hoses on the coolant lines to the regulator
9. Remove the lock pin from both the water fittings on the regulator housing and remove the fittings and hoses and retain the pin
10. Disconnect the EPR electrical connector
11. Remove the (3) three nuts from the EPR isolators and the EPR mounting bracket
12. Remove the EPR from the bracket
13. Remove the (3) three mounting isolators

INSTALLATION

NOTICE

DO NOT USE TEFLON TAPE ON ANY FUEL FITTING. USE A LIQUID PIPE THREAD SEALANT WHEN INSTALLING FITTINGS.

CHECK ALL THE O-RINGS ON THE VAPOR AND WATER FITTINGS FOR ANY DAMAGE REPLACE IF NECESSARY.

LUBE ALL THE O-RINGS WITH AN O-RING LUBE BEFORE INSTALLING.

1. Install the three (3) rubber isolators to the bottom of the EPR
2. Install the EPR assembly to the bracket and tighten the retaining nuts.

NOTE: *Do not over tighten the isolators and cause a separation of the isolators.*

3. Install the fuel temperature sensor into the regulator opening and lock in place with the locking pin, connect the electrical connector.
4. Insert the fuel vapor line and fitting into the regulator port and lock in place with the locking pin.
5. Install both the water hoses and fittings into the regulator and lock in place with the locking pin remove the clamp pliers from the hoses.
6. Install the electric lock off into the regulator inlet and tighten into proper location, connect the electrical connector.
7. Connect the fuel supply line and tighten until fully seated.
8. Connect the EPR electrical connector.
9. Open the manual valve.

10. Start the vehicle and leak check the propane fuel system at each serviced fitting Refer to Propane Fuel System Leak Test.

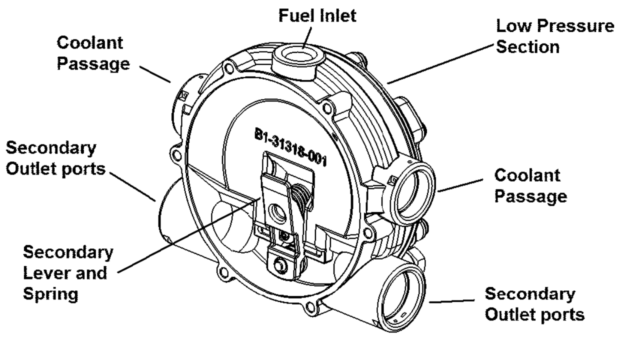


Figure 3-106. Pressure Regulator Section

PRESSURE REGULATOR SECTION REMOVAL

1. Remove the EPR refer to EPR Removal Procedure.
2. Remove the six (6) regulator to voice coil screws using the special tool and separate the regulator from the actuator.

NOTICE

DO NOT REMOVE THE SECONDARY DIAPHRAGM RETAINING PLATE AND DIAPHRAGM THIS WILL VOID THE WARRANTY OF THE ACTUATOR SECTION.

PRESSURE REGULATOR SECTION INSTALLATION

1. Install the regulator to the actuator section using the six (6) retaining screws and tighten 70 in lbs (8 Nm).
2. Install the EPR refer to EPR Installation.

Temperature Manifold Absolute Pressure (TMAP) Sensor

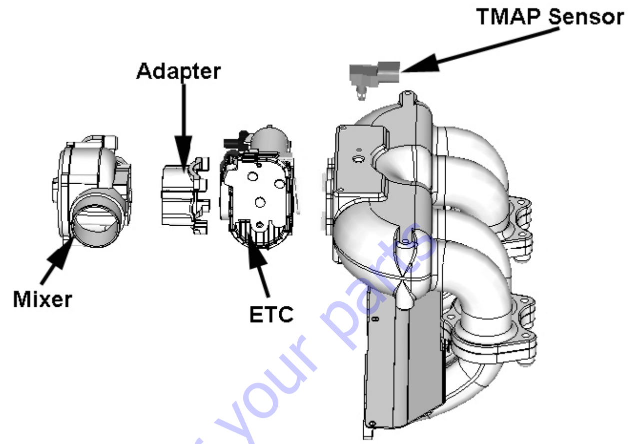


Figure 3-107. (TMAP) Sensor & Electronic Throttle Control (ETC)

REMOVAL

1. Disconnect the TMAP electrical connector.
2. Remove the two retaining bolts.
3. Remove the TMAP.

INSTALLATION

NOTE: *Apply a small amount of O-ring lubricant before installation.*

1. Install in the TMAP.
2. Tighten retaining bolts to 62 lb-in (7 Nm).
3. Start the vehicle and check for proper operation.

Electronic Throttle Control Replacement

See Figure 3-107.

REMOVAL

1. Disconnect the negative battery cable.
2. Remove the air intake duct.
3. Release the hose clamp on the vapor fuel line and remove the vapor hose.
4. Disconnect the TMAP electrical connector.
5. Disconnect the electronic throttle control connector.
6. Remove the manifold to throttle body adapter bolts and remove the throttle body mixer assembly.
7. Pull the throttle body assembly from the adapter.
8. Remove electronic throttle control device.
9. Remove the O-rings gasket and discard.

INSTALLATION

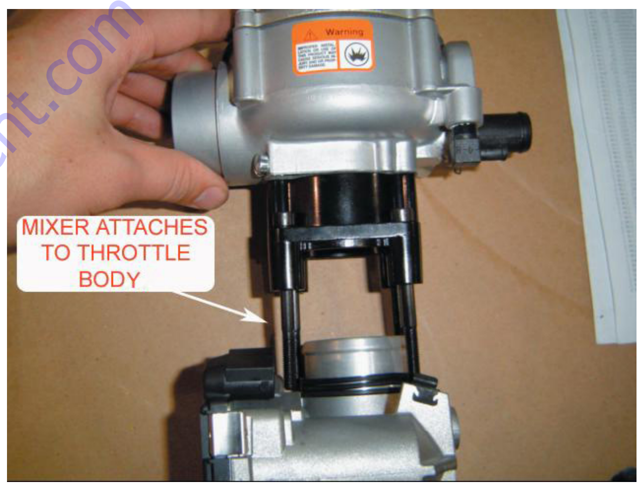
NOTICE

LIGHTLY LUBRICATE BOTH THROTTLE CONTROL DEVICE TO ADAPTER O-RINGS.

1. Install the o-ring on throttle body. Press it down to the bottom of the surface.

2. Install the two quad seals. Install one seal at a time to insure the seal does not roll. The seal must sit flat on the throttle body.

3. Attach mixer and throttle body together. The two parts do not bolt together; they will be secured when you mount it on the intake. Notice the orientation of the air inlet and throttle body cover.



4. Place gasket on intake manifold and attach mixer/throttle assembly to manifold.

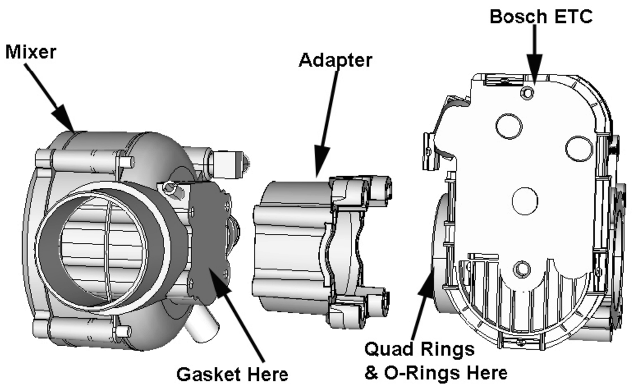


Figure 3-108. Mixer Assembly

Mixer Replacement

See Figure 3-108.

REMOVAL

1. Remove the Throttle control device Refer to Electronic Throttle Body Replacement.
2. Remove the four (4) bolts to the throttle control device to mixer adapter bolts.
3. Remove and discard the mixer to adapter gasket.

INSTALLATION

NOTICE

COVER THROTTLE BODY ADAPTER OPENING TO PREVENT DEBRIS FROM ENTERING ENGINE UNTIL REASSEMBLY.

1. Install Mixer to adapter gasket onto the mixer.
2. Install the mixer to the throttle control device to mixer adapter and secure with the 4 retaining screws. Tighten 80 lb-in (9 Nm)
3. Install Throttle body. Refer to Electronic Throttle Control Device Replacement.
4. Start the engine and leak check all fittings and connections.

Coolant Hose Replacement

REMOVAL

1. Drain the coolant.
2. Using hose clamp pliers, disconnect both hose clamps on each hose.
3. Remove the hose from each of the fittings.

INSTALLATION

NOTE: *Use hose material and lengths specified by JLG.*

1. Install the hose clamps to each hose and set the clamp back on each hose to make installation easier.
2. Fit the hose to the fittings.
3. Secure by positioning each of the clamps.

Vapor Hose Replacement

REMOVAL

1. Using hose clamp pliers disconnect both hose clamps.
2. Remove the vapor hose from each fitting.

INSTALLATION

NOTICE

THE VAPOR SUPPLY HOSE IS SPECIFICALLY DESIGNED, DO NOT USE HOSE MATERIAL OR LENGTH OTHER THAN JLG SPECIFIED PARTS.

1. Install hose clamps and set back on each hose.
2. Reinstall the vapor hose to each fitting.
3. Reset clamps.
4. Start engine and check for leaks.

Engine Control Module Replacement

REMOVAL

1. Disconnect Negative battery cable.
2. Remove controller from mounting bracket.
3. Push connector lock back to unlock connector.
4. Unplug controller and remove.

INSTALLATION

NOTICE

THE CONTROLLER IS CALIBRATED FOR EACH ENGINE VERIFY YOU HAVE THE CORRECT CONTROLLER

1. Plug connector into controller.
2. Push lock into place.
3. Mount controller into mounting bracket.
4. Reconnect the battery cable.
5. Start engine.
6. Check for any DTC codes and clear.
7. Verify engine is in closed loop and no warning lights are illuminated.

Heated Exhaust Gas Oxygen Sensor Replacement

REMOVAL

1. Disconnect Negative battery cable.
2. Disconnect the O2 sensor electrical connector.
3. Using an O2 Sensor socket, remove the O2 Sensor and discard.

INSTALLATION

NOTICE

BEFORE INSTALL THE O2 SENSOR LUBRICATE THREADS WITH ANTI-SEIZE COMPOUND GM P/N 5613695 OR EQUIVALENT. AVOID GETTING COMPOUND ON THE SENSOR TIP.

1. Install O2 sensor. Tighten to 30 lb-ft (41 Nm).
2. Start engine.
3. Check for any DTC codes and clear.
4. Verify engine is in closed loop and no warning lights are illuminated.

3.35 GM ENGINE LPG FUEL SYSTEM DIAGNOSIS

Fuel System Description

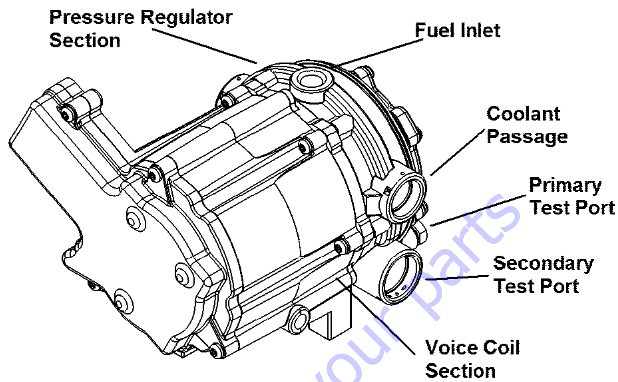


Figure 3-109. EPR Assembly

To maintain fuel and emission control on the LPG fuel system the Engine Control Units (ECM) relies on numerous engine sensor and output data from the Electronic Pressure Regulator (EPR). The ECM will then determine the target fuel calibration and command the EPR to reposition the voice coil to the proper position which, subsequently reposition the secondary lever in the pressure regulator to maintain proper control. The EPR and ECM will continue to communicate back and forth during normal operation.

In the event that the EPR fails to communicate or the Communications Area Network (CAN) cable fails to transmit data the regulator will operate in an open loop configuration. As the air valve vacuum in the mixer venturi is communicated to the secondary chamber of the regulator the secondary diaphragm will be drawn in a downwards motion. This downward motion will cause the secondary lever to open thus allowing more fuel to enter the mixer.

In the (LPR) the fuel is vaporized and the pressure reduced in two stages. The first stage reduces the pressure to approximately 1.0 to 3.0 psi (6.8 to 20.6 kPa). The second stage reduces the pressure to approximately negative 1.5 in. of water column.

The fuel is then drawn from the secondary chamber of the LPR by the vacuum generated by air flowing through the mixer. This vacuum signal is also used to generate lift for the mixer air valve. This vacuum signal is most commonly referred to as air valve vacuum. In the mixer, the fuel mixes with the air entering the engine. This air/ fuel mixture is then drawn into the engine for combustion.

Diagnostic Aids

This procedure is intended to diagnose a vehicle operating on LPG. If the vehicle will not continue to run on LPG, refer to Hard Start for preliminary checks. Before proceeding with this procedure, verify that the vehicle has a sufficient quantity of fuel and that liquid fuel is being delivered to the LPR. Also, ensure that the manual shut off valve on the LPG tank is fully opened and that the excess flow valve has not been activated.

Tools Required:

- 7/16 Open end wrench (for test port plugs)
- DVOM (GM J 39200, Fluke 88 or equivalent).
- 12 volt test light

Diagnostic Scan Tool

- Diagnostic Display tool.

Pressure Gauges

- IMPCO ITK-2 Test kit
- Water Column Gauge / Manometer (GM 7333-6 or equivalent).
- 0-10 PSI Gauge

Test Description

The numbers below refer to step numbers on the diagnostic table.

5. This step determines if the LPR requires replacement

6. This step determines if the problems are in the mechanical side of the Pressure Regulator or the Electronic Voice Coil

10. This step determines if the Mixer requires replacement

14. This step determines if the Lock Off requires replacement

17. This step determines if the Fuel Filter requires replacement.

Table 3-14. LPF Fuel System Diagnosis

STEP	ACTION	VALUE(S)	YES	NO
1	Were you referred to this procedure by a DTC diagnostic chart?	--	Go to Step 3	Go to Step 2
2	Perform the On Board Diagnostic (OBD) System Check. Are any DTCs present in the ECM?	--	Go to the applicable DTC Table	Go to Step 3
3	Verify that the LPG fuel tank has a minimum of 1/4 tank of fuel, that the manual valve is open and the tank quick connect is fully engaged Does the vehicle have fuel?	--	Go to Step 4	--
4	1. Connect a water column gauge or a manometer to the secondary test port of the low pressure regulator (LPR). 2. Start the engine and allow it to reach operating temperature. Does the engine start and run?	--	Go to Step 5	Go to Step 8
5	With the engine idling, observe the pressure reading for the LPR secondary pressure. Does the fuel pressure fluctuate rhythmically OUTSIDE the specified range?	-1.0 in. to -2.0 in. w.c	Go to Step 25	Go to Step 6
6	1. Disconnect the EPR electrical connectors. NOTE: This action will cause a DTC to be set by the ECM 2. With the engine idling observe the pressure reading on the secondary test port. Is the fuel pressure WITHIN the specified range?	-1.0 in. to -2.0 in. w.c	Go to Fuel Control System Diagnosis	Go to Step 7
7	1. Inspect the air intake stream between the mixer assembly and the throttle body for leaks. 2. Inspect the fuel hose connection between the LPR and mixer assembly for damage or leakage. 3. Inspect any vacuum hoses for leaks Was a problem found and corrected?	--	Go to Step 26	Go to Step 22
8	1. Connect a water column gauge or a manometer to the secondary test port of the low pressure regulator (LPR). 2. Crank the engine and observe the pressure reading for the LPR secondary pressure. Does the fuel pressure indicate a vacuum is present?	--	Go to Step 12	Go to Step 9
9	1. Remove Air induction hose to the mixer 2. Observe the air valve for movement while the engine is cranking. Note: Movement of the air valve will be minimal at cranking speeds. Does the air valve move when the engine is cranked?	--	Go to Step 11	Go to Step 10
10	1. Inspect the air intake stream to the mixer assembly and the throttle body for vacuum leaks. 2. Inspect the vacuum hoses from the mixer for proper connection and condition. Was a problem found and repaired?	--	Go to Step 26	Go to Step 24
11	Inspect the fuel hose connection between the LPR and the mixer assembly for damage or leakage. Was a problem found and repaired?	--	Go to Step 26	Go to Step 12
12	1. Connect a 0-10 psi gauge to the primary test port of the low pressure regulator (LPR). 2. Crank the engine and observe the pressure reading for the LPR primary pressure. Is the fuel pressure ABOVE the specified value?	1-3 PSI	Go to Step 22	Go to Step 13
13	1. Turn OFF the ignition. 2. Disconnect the LPL connector. 3. Install a test light between the pins of the LPL connector. 4. Crank the engine. The test light should illuminate. Does the test light illuminate?	--	Go to Step 14	Go to Step 16
14	Using a DVOM, check the resistance of the low pressure lock-off (LPL). Is the resistance within the specified range?	12W - 16W	Go to Step 15	Go to Step 23

Table 3-14. LPF Fuel System Diagnosis

STEP	ACTION	VALUE(S)	YES	NO
15	1. Turn the ignition OFF. 2. Close the manual shut-off valve on the LPG tank. CAUTION: When disconnecting LPG fuel lines, liquid LPG may be present. Perform this step in a well ventilated area. 3. Loosen the fuel inlet hose fitting at the inlet of the LPL. Was fuel present when the fitting was loosened?	--	Go to Step 23	Go to Step 17
16	1. Turn OFF the ignition. 2. Connect the test light to chassis ground and probe pin A of the LPL connector. 3. Crank the engine. The test light should illuminate. Does the test light illuminate?	--	Go to Step 20	Go to Step 21
17	1. Remove the LPG fuel filter / LPL. 2. Remove the filter from the LPL. 3. Empty the contents of the inlet side of the LPG fuel filter onto a clean surface. 4. Inspect the contents of the LPG fuel filter for an excessive amount of foreign material or water. If necessary, locate and repair the source of contamination. 5. Verify the LPG fuel filter is not restricted or plugged. Was a problem found?	--	Go to Step 19	Go to Step 18
18	The fuel supply system or hoses are plugged or restricted, locate and repair the problem. Is the action complete?	--	Go to Step 26	--
19	Replace the fuel filter. Refer to Fuel Filter Replacement. Is the action complete?	--	Go to Step 26	--
20	Repair the open in the lock-off ground circuit. Is the action complete?	--	Go to Step 26	--
21	Repair the open in the lock-off power circuit. Is the action complete?	--	Go to Step 26	--
22	Replace the low pressure regulator (LPR). Refer to Low Pressure Regulator Replacement. Is the action complete?	--	Go to Step 26	--
23	Replace the lock-off. Refer to Lock-off Replacement. Is the action complete?	--	Go to Step 26	--
24	Replace the mixer assembly. Refer to Fuel Mixer Replacement. Is the action complete?	--	Go to Step 26	--
25	The fuel supply system is operating normally, if a failure of the control solenoids is suspected. Refer to Fuel Control System Diagnosis. 1. Install the test plug in the LPR secondary chamber. 2. If you were sent to this routine by another diagnostic chart, return to the previous diagnostic procedure. Is the action complete?	--	System OK	--
26	1. Disconnect all test equipment 2. Install the primary and secondary test port plugs. 3. Start the engine. 4. Using SNOOP or equivalent, leak check the test port plugs. Is the action complete?	--	System OK	--

Table 3-15. Symptom Diagnosis

Checks	Action
Important Preliminary Checks	
Before Using This Section	Before using this section, you should have performed On Board Diagnostic Check and determined that: 1. The Control Module and MIL (Malfunction Indicator Lamp) are operating correctly. 2. There are no Diagnostic Trouble Codes (DTCs) stored, or a DTC exists but without a MIL. Several of the following symptom procedures call for a careful visual and physical check. The visual and physical checks are very important. The checks can lead to correcting a problem without further checks that may save valuable time.
LPG Fuel System Check	1. Verify the customer complaint. 2. Locate the correct symptom table. 3. Check the items indicated under that symptom. 4. Operate the vehicle under the conditions the symptom occurs. Verify HEGO switching between lean and rich. IMPORTANT! Normal HEGO switching indicates the LPG fuel system is in closed loop and operating correctly at that time.
Visual and Physical Checks	[2] Check all ECM system fuses and circuit breakers. [2] Check the ECM ground for being clean, tight and in its proper location. [2] Check the vacuum hoses for splits, kinks and proper connections. [2] Check thoroughly for any type of leak or restriction. [2] Check for air leaks at all the mounting areas of the intake manifold sealing surfaces. [2] Check for proper installation of the mixer module assembly. [2] Check for air leaks at the mixer assembly. [2] Check the ignition wires for the following conditions: - Cracking - Hardness - Proper routing - Carbon tracking [2] Check the wiring for the following items: - Proper connections, pinches or cuts. [2] The following symptom tables contain groups of possible causes for each symptom. The order of these procedures is not important. If the scan tool readings do not indicate the problems, then proceed in a logical order, easiest to check or most likely to cause first.
Intermittent	
DEFINITION: The problem may or may not turn ON the Malfunction Indicator Lamp (MIL) or store a Diagnostic Trouble Code (DTC).	
Preliminary Checks	[2] Refer to Important Preliminary Checks. [2] Do not use the DTC tables. If a fault is an intermittent, the use of the DTC tables may result in the replacement of good parts.
Faulty Electrical Connections or Wiring	[2] Faulty electrical connections or wiring can cause most intermittent problems. [2] Check the suspected circuit for the following conditions: - Faulty fuse or circuit breaker - Connectors poorly mated - Terminals not fully seated in the connector (backed out) - Terminals not properly formed or damaged - Terminal to wires poorly connected - Terminal tension insufficient. [2] Carefully remove all the connector terminals in the problem circuit in order to ensure the proper contact tension. If necessary, replace all the connector terminals in the problem circuit in order to ensure the proper contact tension. [2] Checking for poor terminal to wire connections requires removing the terminal from the connector body.
Operational Test	If a visual and physical check does not locate the cause of the problem, drive the vehicle with a scan tool. When the problem occurs, an abnormal voltage or scan reading indicates the problem may be in that circuit.

Table 3-15. Symptom Diagnosis

Checks	Action
Intermittent Malfunction Indicator Lamp (MIL)	The following components can cause intermittent MIL and no DTC(s): [2] A defective relay, Control Module driven solenoid, or a switch that can cause electrical system interference. Normally, the problem will occur when the faulty component is operating. [2] The improper installation of electrical devices, such as lights, 2-way radios, electric motors, etc. [2] The ignition secondary voltage shorted to a ground. [2] The Malfunction Indicator Lamp (MIL) circuit or the Diagnostic Test Terminal intermittently shorted to ground. [2] The Control Module grounds.
Loss of DTC Memory	To check for the loss of the DTC Memory: 1. Disconnect the TMAP sensor. 2. Idle the engine until the Malfunction Indicator Lamp illuminates. The ECM should store a TMAP DTC. The TMAP DTC should remain in the memory when the ignition is turned OFF. If the TMAP DTC does not store and remain, the ECM is faulty
Additional Checks	
No Start	
DEFINITION: The engine cranks OK[22] but does not start.	
Preliminary Checks	Refer to Important Preliminary Checks.
Control Module Checks	If a scan tool is available: [2] Check for proper communication with both the ECM [2] Check the fuse in the ECM battery power circuit. Refer to Engine Controls Schematics. [2] Check battery power, ignition power and ground circuits to the ECM. Refer to Engine Control Schematics. Verify voltage and/or continuity for each circuit.
Sensor Checks	[2] Check the TMAP sensor. [2] Check the Magnetic pickup sensor (RPM).
Fuel System Checks	**Important:** A closed LPG manual fuel shut off valve will create a no start condition. [2] Check for air intake system leakage between the mixer and the throttle body. [2] Verify proper operation of the low pressure lock-off solenoids. [2] Check the fuel system pressures. Refer to the LPG Fuel System Diagnosis. [2] Check for proper mixer air valve operation.
Ignition System Checks	Note: LPG being a gaseous fuel requires higher secondary ignition system voltages for the equivalent gasoline operating conditions. [2] Check for the proper ignition voltage output with J 26792 or the equivalent. [2] Verify that the spark plugs are correct for use with LPG (R42LTS) [2] Check the spark plugs for the following conditions: - Wet plugs - Cracks - Wear - Improper gap - Burned electrodes - Heavy deposits [2] Check for bare or shorted ignition wires. [2] Check for loose ignition coil connections at the coil.
Engine Mechanical Checks	**Important:** The LPG Fuel system works on a fumigation principle of fuel introduction and is more sensitive to intake manifold leakage than the gasoline fuel supply system. [2] Check for the following: - Vacuum leaks - Improper valve timing - Low compression - Bent pushrods - Worn rocker arms - Broken or weak valve springs - Worn camshaft lobes.

Table 3-15. Symptom Diagnosis

Checks	Action
Exhaust System Checks	[2] Check the exhaust system for a possible restriction: - Inspect the exhaust system for damaged or collapsed pipes - Inspect the muffler for signs of heat distress or for possible internal failure. [2] Check for possible plugged catalytic converter. Refer to Restricted Exhaust System Diagnosis
Hard Start	
DEFINITION: The engine cranks OK, but does not start for a long time. The engine does eventually run, or may start but immediately dies.	
Preliminary Checks	[2] Refer to Important Preliminary Checks. [2] Make sure the vehicle's operator is using the correct starting procedure.
Sensor Checks	[2] Check the Engine Coolant Temperature sensor with the scan tool. Compare the engine coolant temperature with the ambient air temperature on a cold engine. IF the coolant temperature reading is more than 5 degrees greater or less than the ambient air temperature on a cold engine, check for high resistance in the coolant sensor circuit. Refer to DTC 111 [2] Check the Crankshaft Position (CKP) sensor. [2] Check the Throttle position (TPS) sensor.
Fuel System Checks	Important: A closed LPG manual fuel shut off valve will create an extended crank OR no start condition. [2] Verify the excess flow valve in the LPG manual shut-off valve is not tripped. [2] Check mixer module assembly for proper installation and leakage. [2] Verify proper operation of the low pressure lock-off solenoids. [2] Verify proper operation of the EPR [2] Check for air intake system leakage between the mixer and the throttle body. [2] Check the fuel system pressures. Refer to the Fuel System Diagnosis.
Ignition System Checks	Note: LPG being a gaseous fuel requires higher secondary ignition system voltages for the equivalent gasoline operating conditions. [2] Check for the proper ignition voltage output with J 26792 or the equivalent. [2] Verify that the spark plugs are correct for use with LPG (R42LTS) [2] Check the spark plugs for the following conditions: - Wet plugs - Cracks - Wear - Improper gap - Burned electrodes - Heavy deposits [2] Check for bare or shorted ignition wires. [2] Check for moisture in the distributor cap if applicable. [2] Check for loose ignition coil connections. Important: 1. If the engine starts but then immediately stalls, Check the Crankshaft Position (CKP). 2. Check for improper gap, debris or faulty connections.
Engine Mechanical Checks	Important: The LPG Fuel system works on a fumigation principle of fuel introduction and is more sensitive to intake manifold leakage than the gasoline fuel supply system. [2] Check for the following: - Vacuum leaks - Improper valve timing - Low compression - Bent pushrods - Worn rocker arms - Broken or weak valve springs - Worn camshaft lobes. [2] Check the intake and exhaust manifolds for casting flash.
Exhaust System Checks	[2] Check the exhaust system for a possible restriction: - Inspect the exhaust system for damaged or collapsed pipes - Inspect the muffler for signs of heat distress or for possible internal failure. [2] Check for possible plugged catalytic converter. Refer to Restricted Exhaust System Diagnosis or Exhaust System in the GM Base Engine Service Manual

Table 3-15. Symptom Diagnosis

Checks	Action
Additional Checks	[2]
Cuts Out, Misses	
DEFINITION: A surging or jerking that follows engine speed, usually more pronounced as the engine load increases which is not normally felt above 1500 RPM. The exhaust has a steady spitting sound at idle, low speed, or hard acceleration for the fuel starvation that can cause the engine to cut-out.	
Preliminary Checks	[2] Refer to Important Preliminary Checks.
Ignition System Checks	[2] Start the engine. [2] Wet down the secondary ignition system with water from a spray bottle, and look/listen for arcing or misfiring as you apply water. [2] Check for proper ignition output voltage with spark tester J 26792. [2] Check for a cylinder misfire. [2] Verify that the spark plugs are correct for use with LPG (R42LTS) [2] Remove the spark plugs in these cylinders and check for the following conditions: [2] Insulation cracks [2] Wear [2] Improper gap [2] Burned electrodes [2] Heavy deposits [2] Visually/Physically inspect the secondary ignition for the following: [2] Ignition wires for arcing, cross-firing and proper routing [2] Ignition coils for cracks or carbon tracking
Engine Mechanical Checks	[2] Perform a cylinder compression check. [2] Check the engine for the following: - Improper valve timing - Bent pushrods - Worn rocker arms - Worn camshaft lobes. - Broken or weak valve springs. [2] Check the intake and exhaust manifold passages for casting flash.
Fuel System Checks	[2] Check the fuel system - plugged fuel filter, low fuel pressure, etc. Refer to LPG Fuel System Diagnosis. [2] Check the condition of the wiring to the low pressure lock-off solenoid.
Additional Check	Check for Electromagnetic Interference (EMI). [2] EMI on the reference circuit can cause a missing condition. [2] Monitoring the engine RPM with a scan tool can detect an EMI. [2] A sudden increase in the RPM with little change in the actual engine RPM, indicates EMI is present. [2] If the problem exists, check the routing of the secondary wires and the ground circuit.
Hesitation, Sag, Stumble	
DEFINITION: The vehicle has a momentary lack of response when depressing the accelerator. The condition can occur at any vehicle speed. The condition may cause the engine to stall if it's severe enough.	
Preliminary Checks	Refer to Important Preliminary Checks.
Fuel System Checks	[2] Check the fuel pressure. Refer to LPG Fuel System Diagnosis. [2] Check for low fuel pressure during a moderate or full throttle acceleration. If the fuel pressure drops below specification, there is possibly a faulty low pressure regulator or a restriction in the fuel system. [2] Check the Manifold Absolute Pressure (MAP) sensor response and accuracy. [2] Check LPL electrical connection [2] Check the mixer air valve for sticking or binding. [2] Check the mixer module assembly for proper installation and leakage. [2] Check the EPR electrical connections.

Table 3-15. Symptom Diagnosis

Checks	Action
Ignition System Checks	Note: LPG being a gaseous fuel requires higher secondary ignition system voltages for the equivalent gasoline operating conditions. If a problem is reported on LPG and not gasoline, do not discount the possibility of a LPG only ignition system failure and test the system accordingly. [2] Check for the proper ignition voltage output with J 26792 or the equivalent. [2] Verify that the spark plugs are correct for use with LPG (R42LTS) [2] Check for faulty spark plug wires [2] Check for fouled spark plugs.
Additional Check	[2] Check for manifold vacuum or air induction system leaks [2] Check the generator output voltage.
Backfire	
DEFINITION: The fuel ignites in the intake manifold, or in the exhaust system, making a loud popping noise.	
Preliminary Check	[2] Refer to Important Preliminary Checks.
Ignition System Checks	Important! LPG, being a gaseous fuel, requires higher secondary ignition system voltages for the equivalent gasoline operating conditions. The ignition system must be maintained in peak condition to prevent backfire. [2] Check for the proper ignition coil output voltage using the spark tester J26792 or the equivalent. [2] Check the spark plug wires by connecting an ohmmeter to the ends of each wire in question. If the meter reads over 30,000 ohms, replace the wires. [2] Check the connection at each ignition coil. [2] Check for deteriorated spark plug wire insulation. [2] Check the spark plugs. The correct spark plugs for LPG are (R42LTS) [2] Remove the plugs and inspect them for the following conditions: - Wet plugs - Cracks - Wear - Improper gap - Burned electrodes - Heavy deposits
Engine Mechanical Check	Important! The LPG Fuel system works on a fumigation principle of fuel introduction and is more sensitive to intake manifold leakage than a gasoline fuel supply system. [2] Check the engine for the following: - Improper valve timing - Engine compression - Manifold vacuum leaks - Intake manifold gaskets - Sticking or leaking valves - Exhaust system leakage [2] Check the intake and exhaust system for casting flash or other restrictions.
Fuel System Checks	[2] Perform a fuel system diagnosis. Refer to LPG Fuel System Diagnosis.
Lack of Power, Sluggishness, or Sponginess	
DEFINITION: The engine delivers less than expected power. There is little or no increase in speed when partially applying the accelerator pedal.	
Preliminary Checks	[2] Refer to Important Preliminary Checks. [2] Refer to the LPG Fuel system OBD System Check [2] Compare the customer's vehicle with a similar unit. Make sure the customer has an actual problem. Do not compare the power output of the vehicle operating on LPG to a vehicle operating on gasoline as the fuels do have different drive feel characteristics [2] Remove the air filter and check for dirt or restriction. [2] Check the vehicle transmission Refer to the OEM transmission diagnostics.

Table 3-15. Symptom Diagnosis

Checks	Action
Fuel System Checks	[2] Check for a restricted fuel filter, contaminated fuel, or improper fuel pressure. Refer to LPG Fuel System Diagnosis. [2] Check for the proper ignition output voltage with the spark tester J 26792 or the equivalent. [2] Check for proper installation of the mixer module assembly. [2] Check all air inlet ducts for condition and proper installation. [2] Check for fuel leaks between the LPR and the mixer. [2] Verify that the LPG tank manual shut-off valve is fully open. [2] Verify that liquid fuel (not vapor) is being delivered to the LPR.
Sensor Checks	[2] Check the Heated Exhaust Gas Oxygen Sensor (HEGO) for contamination and performance. Check for proper operation of the MAP sensor. [2] Check for proper operation of the TPS sensor.
Exhaust System Checks	[2] Check the exhaust system for a possible restriction: - Inspect the exhaust system for damaged or collapsed pipes - Inspect the muffler for signs of heat distress or for possible internal failure. - Check for possible plugged catalytic converter.
Engine Mechanical Check	Check the engine for the following: [2] Engine compression [2] Valve timing [2] Improper or worn camshaft. Refer to Engine Mechanical in the Service Manual.
Additional Check	[2] Check the ECM grounds for being clean, tight, and in their proper locations. [2] Check the generator output voltage. [2] If all procedures have been completed and no malfunction has been found, review and inspect the following items: [2] Visually and physically, inspect all electrical connections within the suspected circuit and/or systems. [2] Check the scan tool data.
Poor Fuel Economy	
DEFINITION: Fuel economy, as measured by refueling records, is noticeably lower than expected. Also, the economy is noticeably lower than it was on this vehicle at one time, as previously shown by an by refueling records.	
Preliminary Checks	[2] Refer to Important Preliminary Checks. [2] Check the air cleaner element (filter) for dirt or being plugged. [2] Visually (Physically) check the vacuum hoses for splits, kinks, and proper connections. [2] Check the operators driving habits for the following items: - Is there excessive idling or stop and go driving? - Are the tires at the correct air pressure? - Are excessively heavy loads being carried? - Is their often rapid acceleration? [2] Suggest to the owner to fill the fuel tank and to recheck the fuel economy. [2] Suggest that a different operator use the equipment and record the results.
Fuel System Checks	[2] Check the LPR fuel pressure. Refer to LPG Fuel System Diagnosis. [2] Check the fuel system for leakage.
Sensor Checks	[2] Check the Temperature Manifold Absolute Pressure (TMAP) sensor.
Ignition System Checks	[2] Verify that the spark plugs are correct for use with LPG (R42LTS) [2] Check the spark plugs. Remove the plugs and inspect them for the following conditions: - Wet plugs - Cracks - Wear - Improper gap - Burned electrodes - Heavy deposits [2] Check the ignition wires for the following items: - Cracking - Hardness - Proper connections
Cooling System Checks	[2] Check the engine thermostat for always being open or for the wrong heat range

Table 3-15. Symptom Diagnosis

Checks	Action
Additional Check	[2] Check the transmission shift pattern. Refer to the OEM Transmission Controls section the Service Manual. [2] Check for dragging brakes.
Rough, Unstable, or Incorrect Idle, Stalling	
DEFINITION: The engine runs unevenly at idle. If severe enough, the engine or vehicle may shake. The engine idle speed may vary in RPM. Either condition may be severe enough to stall the engine.	
Preliminary Check	Refer to Important Preliminary Checks.
Sensor Checks	[2]Check for silicon contamination from fuel or improperly used sealant. The sensor will have a white powdery coating. The sensor will result in a high but false signal voltage (rich exhaust indication). The ECM will reduce the amount of fuel delivered to the engine causing a severe drive-ability problem. [2]Check the Heated Exhaust Gas Oxygen Sensor (HEGO) performance: [2]Check the Temperature Manifold Absolute Pressure (TMAP) sensor response and accuracy.
Fuel System Checks	[2]Check for rich or lean symptom that causes the condition. Drive the vehicle at the speed of the complaint. Monitoring the oxygen sensors will help identify the problem. [2]Check for a sticking mixer air valve. [2]Verify proper operation of the EPR. [2]Perform a cylinder compression test. Refer to Engine Mechanical in the Service Manual. [2]Check the LPR fuel pressure. Refer to the LPG Fuel System Diagnosis. [2]Check mixer module assembly for proper installation and connection.
Ignition System Checks	[2]Check for the proper ignition output voltage using the spark tester J26792 or the equivalent. [2] Verify that the spark plugs are correct for use with LPG (R42LTS) [2]Check the spark plugs. Remove the plugs and inspect them for the following conditions: - Wet plugs - Cracks - Wear - Improper gap - Burned electrodes - Blistered insulators - Heavy deposits [2]Check the spark plug wires by connecting an ohmmeter to the ends of each wire in question. If the meter reads over 30,000 ohms, replace the wires.
Additional Checks	**Important:** The LPG Fuel system works on a fumigation principle of fuel introduction and is more sensitive to intake manifold leakage than the gasoline fuel supply system. [2]Check for vacuum leaks. Vacuum leaks can cause a higher than normal idle and low throttle angle control command. [2]Check the ECM grounds for being clean, tight, and in their proper locations. [2]Check the battery cables and ground straps. They should be clean and secure. Erratic voltage may cause all sensor readings to be skewed resulting in poor idle quality.
Engine Mechanical Check	[2] Check the engine for the following: - Broken motor mounts - Improper valve timing - Low compression - Bent pushrods - Worn rocker arms - Broken or weak valve springs - Worn camshaft lobes
Surges/Chuggles	
DEFINITION: The engine has a power variation under a steady throttle or cruise. The vehicle feels as if it speeds up and slows down with no change in the accelerator pedal.	
Preliminary Checks	Refer to Important Preliminary Checks.
Sensor Checks	[2] Check Heated Exhaust Gas Oxygen Sensor (HEGO) performance.

Table 3-15. Symptom Diagnosis

Checks	Action
Fuel System Checks	[2] Check for Rich or Lean symptom that causes the condition. Drive the vehicle at the speed of the complaint. Monitoring the oxygen sensors will help identify the problem. [2] Check the fuel pressure while the condition exists. Refer to LPG Fuel System Diagnosis. [2] Verify proper fuel control solenoid operation. [2] Verify that the LPG manual shut-off valve is fully open. [2] Check the in-line fuel filter for restrictions.
Ignition System Checks	[2] Check for the proper ignition output voltage using the spark tester J26792 or the equivalent. [2] Verify that the spark plugs are correct for use with LPG (R42LTS) [2] Check the spark plugs. Remove the plugs and inspect them for the following conditions: - Wet plugs - Cracks - Wear - Improper gap - Burned electrodes - Heavy deposits - Check the Crankshaft Position (CKP) sensor.
Additional Check	[2] Check the ECM grounds for being clean, tight, and in their proper locations. [2] Check the generator output voltage. [2] Check the vacuum hoses for kinks or leaks. [2] Check Transmission

Table 3-16. DTC to SPN/FMI Cross Reference Chart

DTC	Description	SPN Code	FMI Code
16	Crank Never Synced at Start	636	8
91	Fuel Pump Low Voltage	94	4
92	Fuel Pump High Voltage	94	3
107	MAP Low Voltage	106	4
108	MAP High Pressure	106	16
111	IAT Higher Than Expected 1	105	15
112	IAT Low Voltage	105	4
113	IAT High Voltage	105	3
116	ECT Higher Than Expected 1	110	15
117	ECT Low Voltage	110	4
118	ECT High Voltage	110	3
121	TPS 1 Lower Than TPS 2	51	1
122	TPS 1 Signal Voltage Low	51	4
123	TPS 1 Signal Voltage High	51	3
127	IAT Higher Than Expected 2	105	0
129	BP Low Pressure	108	1
134	EGO 1 Open/Inactive	724	10
154	EGO 2 Open/Inactive	520208	10
171	Adaptive Learn High Gasoline	520200	0
172	Adaptive Learn Low Gasoline	520200	1
182	Fuel Temp Gasoline Low Voltage	174	4
183	Fuel Temp Gasoline High Voltage	174	3
187	Fuel Temp LPG Low Voltage	520240	4
188	Fuel Temp LPG High Voltage	520240	3
217	ECT Higher Than Expected 2	110	0
219	Max Govern Speed Override	515	15
221	TPS 2 Signal Voltage Low	51	0
222	TPS 2 Signal Low Voltage	520251	4
223	TPS 2 Signal High Voltage	520251	3
261	Injector Driver 1 Open	651	5
262	Injector Driver 1 Shorted	651	6
264	Injector Driver 2 Open	652	5
265	Injector Driver 2 Shorted	652	6
267	Injector Driver 3 Open	653	5
268	Injector Driver 3 Shorted	653	6
270	Injector Driver 4 Open	654	5
271	Injector Driver 4 Shorted	654	6
336	Crank Sync Noise	636	2
337	Crank Loss	636	4
341	Cam Sync Noise	723	2
342	Cam Sensor Loss	723	4
420	Gasoline Cat Monitor	520211	10
524	Oil Pressure Low	100	1

Table 3-16. DTC to SPN/FMI Cross Reference Chart

DTC	Description	SPN Code	FMI Code
562	System Voltage Low	168	17
563	System Voltage High	168	15
601	Flash Checksum Invalid	628	13
604	RAM Failure	630	12
606	COP Failure	629	31
642	External 5V Reference Low	1079	4
643	External 5V Reference High	1079	3
685	Power Relay Open	1485	5
686	Power Relay Shorted	1485	4
687	Power Relay Short to Power	1485	3
1111	Fuel Rev Limit	515	16
1112	Spark Rev Limit	515	0
1151	Closed Loop Multiplier High LPG	520206	0
1152	Closed Loop Multiplier Low LPG	520206	1
1155	Closed Loop Multiplier High Gasoline	520204	0
1156	Closed Loop Multiplier Low Gasoline	520204	1
1161	Adaptive Learn High LPG	520202	0
1162	Adaptive Learn Low LPG	520202	1
1165	LPG Cat Monitor	520213	10
1171	LPG Pressure Higher Than Expected	520260	0
1172	LPG Pressure Lower Than Expected	520260	1
1173	EPR Comm Lost	520260	31
1174	EPR Voltage Supply High	520260	3
1175	EPR Voltage Supply Low	520260	4
1176	EPR Internal Actuator Fault	520260	12
1177	EPR Internal Circuitry Fault	520260	12
1178	EPR Internal Comm Fault	520260	12
1612	RTI 1 loss	629	31
1613	RTI 2 Loss	629	31
1614	RTI 3 Loss	629	31
1615	A/D Loss	629	31
1616	Invalid Interrupt	629	31
1625	Shutdown Request	1384	31
1626	CAN Tx Failure	639	12
1627	CAN Rx Failure	639	12
1628	CAN Address Conflict Failure	639	13
1629	Loss of TSC 1	639	31
2111	Unable to Reach Lower TPS	51	7
2112	Unable to Reach Higher TPS	51	
2135	TPS 1/2 Simultaneous Voltages	51	31
2229	BP Pressure High	108	0

3.36 AIR COMPRESSOR

Description

The compressor consists of a heavy duty rotary screw air compressor with integral inlet valve assembly, oil separation system, minimum pressure/discharge check valve and oil filter housing. The complete system incorporates compressor oil cooling system, hydraulic drive and valving.

Oil Injection

Lubricant is injected into the compressor air end unit and mixes directly with the air in the compression chamber, internal porting also injects oil into the bearings and seal area. The lubricant has three primary functions:

- Controls the rise of air temperature normally associated with the heat of compression.
- Seals the leakage paths between the rotors and the stator, and also between the rotors themselves.
- Acts as a lubricating film between the rotors allowing one rotor to directly drive the other which is an idler. It also lubricates the bearings and seal.

The screw compressor assembly is mounted inside the main casting and consists of a male and female rotor supported with anti-friction bearings suitably sized for long life.

Inlet Valve and Control Valving

The inlet valve and control solenoid valve assembly are mounted directly on top of the compressor module. On initial start-up the solenoid is energized and the inlet valve opens from pilot air being passed through the solenoid actuated valve. When final pressure is reached a pressure switch de-activates the solenoid and the inlet valve closes**.** At the same time the compressor pressure will relieve down to a low pressure (typically about 40 psig (2.75 bar)). Only the compressed air within the compressor module will reduce down to this lower pressure due to the operation of the discharge minimum pressure/check valve. This reduction in internal air pressure reduces the power requirement considerably during this unloaded state. The pressure switch located in the downstream air line senses air demand and upon reducing pressure in discharge line (ie. air being used) will re-activate the inlet valve and the compressor again starts to load and produce air.

The discharge air pressure switch will typically be set with a 30 psi (2.0 bar) differential pressure.

Air Filter Unit

The air filter is dry type replaceable element and is mounted directly on top of the inlet valve assembly. The element is easily replaced for service changeout - Refer to Maintenance Section.

Oil Reservoir and Primary Oil Separation

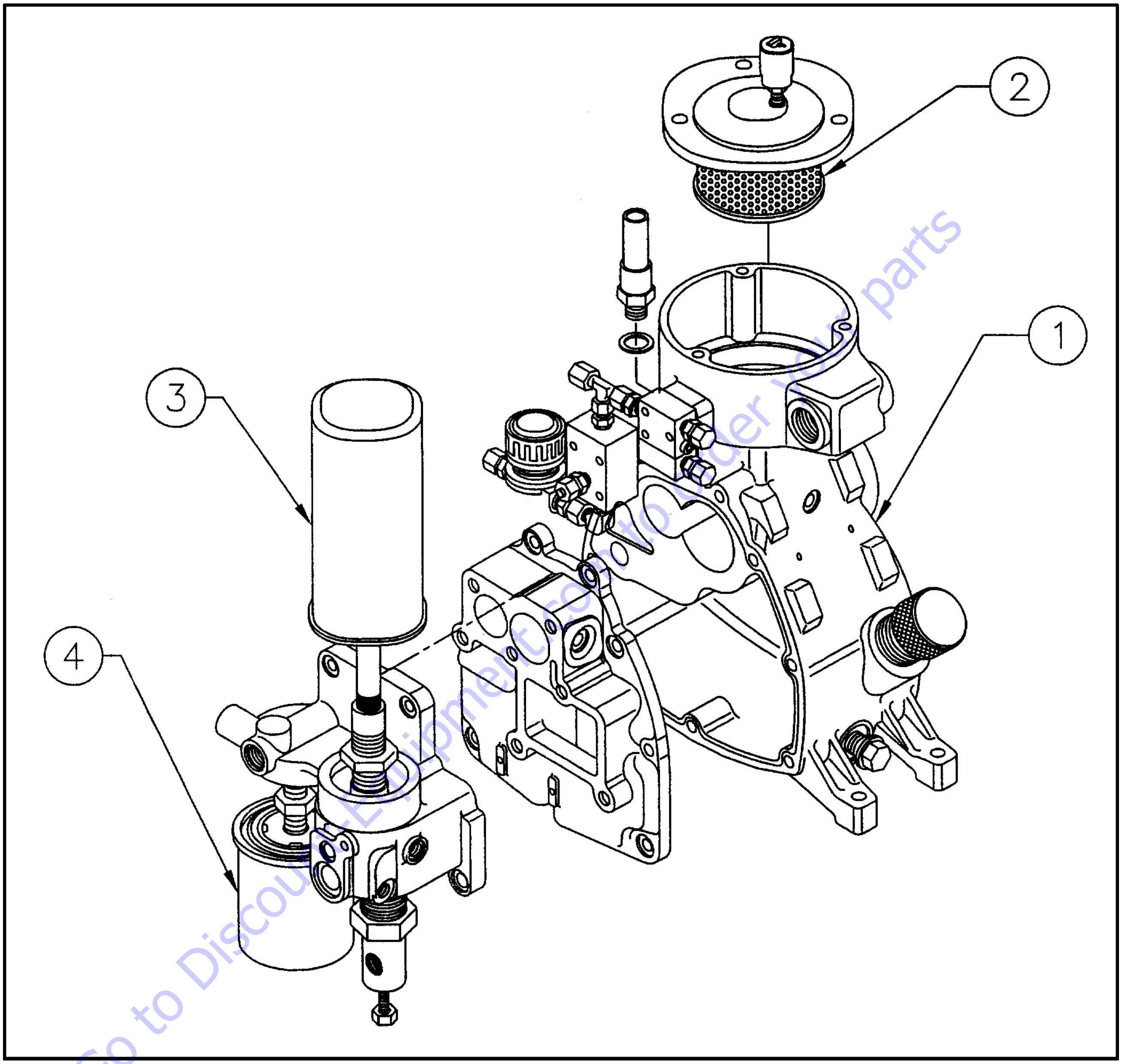
The main casting which contains the screw compressor is also the oil reservoir and primary oil separation unit. The initial (primary) oil separation is caused by both changes in velocity and direction. The main casting also contains the oil level/fill plug and oil drain connection. A separate oil reservoir is not required.

Secondary Spin-On Oil Coalescer/Separator

This spin-on element screws directly onto the filter support housing at the rear of the compressor module. The separator element (coalescer) recovers the finer particles of residual oil after pre-separation oil, which is collected in this element is scavenged back into the compressor unit. The oil return line passes through the Oil Sight Glass which indicates the amount of oil being deposited (scavenged) in the element. At start-up the sight glass most likely will be full for a short period which is due to drainage from the element when it is not in use, this should diminish fairly quickly and a lesser amount should be observed which indicates that the element is separating out oil deposited within the spin-on element.

Spin-On Oil Filter

Located on the filter support housing at the rear of the compressor. The filter incorporates a by-pass valve which will open to by-pass the filter during cold start-up when the oil is very viscous. It will also open if the filter element is plugged. Filter element rating is 10 Micron.



1. Compressor Assembly
2. Air Filter Element
3. Coalescer Spin-On Element
4. Oil Filter Element

Figure 3-110. Air Compressor

Minimum Pressure Valve/Check Valve Assembly

This combined valve located in the filter support housing has two functions.

The Minimum Pressure Valve - will maintain a pressure of approximately 65 psig (4.5 bar) in the compressor unit to ensure oil injection during load conditions and also to maintain effective oil separation. Once this internal pressure is exceeded it will allow air to discharge downstream to the service outlet.

The Discharge Check Valve - prevents air in service lines or downstream receiver from venting down through the compressor during unload (when the compressor automatically will unload to approximately 40 psig [2.75 bar] internally) and also during shutdown.

Hydraulic Drive System

Scope of supply may vary depending upon customer specifications.

Hydraulic pump, oil reservoir, return line oil filter and hoses to and from the completed packaged compressor are not furnished with the compressor. This is customer responsibility.

The packaged compressor unit will normally contain the hydraulic motor, hydraulic pressure relief valve, and on/off solenoid valve.

Input hydraulic oil pressure feed is connected to the bulkhead provided on the compressor package. Within the package the high pressure oil feeds to a manifold containing the pressure relief valve and directional solenoid valve. If a malfunction in the hydraulic motor/compressor assembly causes the hydraulic pressure to rise it will bypass to the return line to safeguard damage or potential injury.

The directional solenoid valve is normally activated by the on/off selector switch mounted in the instrument cluster on the package, this valve is also connected through the compressor safety circuits for over-temperature and over-pressure, if either condition occurs it will shut the unit down, by diverting oil back to tank. It is possible to add remote on/off switch in parallel with the instrument cluster to permit on/off operation from another location on the vehicle.

Hydraulic oil from the manifold is hosed directly to the hydraulic motor and the outlet from the motor passes to the return line connection on the package. Customer to provide both hydraulic feed and return lines.

The hydraulic motor powers the compressor through a belt drive system.

Compressor Cooling System

The package contains a cooler assembly powered by a 12 volt D.C. electric fan. Oil from the compressor sump passes through this cooler before being filtered for re-injection into the compressor. A thermostatic fan temperature switch activates the fan to come on/off to maintain the correct operating temperature for the compressor oil. This switch will activate the fan to come on at approximately 185°F (85°C) and will switch off again at approximately 165°F (74°C). The purpose of maintaining an elevated temperature during operation is to keep intake air moisture in suspension as it passes through the compressor. Thermal switch activation is affected by ambient conditions, load/unload cycles (or low oil level).

Initial Startup

The following procedure should be used to make the initial start-up of your compressor:

1. Position the compressor on a level surface so that the proper amounts of oil can be added if required.
2. Unit should be bolted down, do not rely on hoses to hold the module in position.
3. Check all hose connections are tight and wiring connections correct and tight.
4. Check compressor oil level, top up if necessary.
5. Switch instrument panel to OFF.
6. Ensure hydraulic oil to pump inlet. (Prime if necessary)
7. Engage hydraulic system and allow hydraulic oil to circulate back to tank. Check for leaks.
8. Service valve on compressor closed.
9. Switch the instrument panel switch to ON, this should very quickly pass oil to the hydraulic motor on the compressor and start producing air.
10. Check pressure and temperature gauges. Pressure switch may need adjustment to achieve desired operating pressure.
11. Partly open service valve to load compressor and allow to warm up. Monitor temperature gauge, the ideal operating temperature should be between 165°F and 190°F (74°C and 88°C) although it may be higher in high ambient conditions.
12. Cycle compressor on/off with service valve to ensure operation is OK
13. Close service valve then switch instrument switch to OFF.
14. Disengage hydraulic system.

15. Allow all air to vent to atmosphere, then check compressor oil level - top up if necessary. Check and correct any leaks, tighten any loose fittings, check drive belt tension.

Normal Startup Procedure

1. Check compressor oil level - top up if necessary.
2. Air service valve (beside the compressor) closed.
3. Start the engine.
4. Compressor switch (in the platform) ON - compressor should activate.
5. Allow the compressor to warm up for several minute before operating.

Normal Shutdown Procedure

1. Close service valve and allow compressor to unload and cool down (approx. 5 min.).
2. Position the compressor switch in the platform to OFF.
3. Shut down the engine.

Daily Operation

Before Starting:

1. Check compressor oil level.
2. Check for any leaks or loose bolts.
3. Check drive belt is tight.

After Starting:

1. Check pressure gauge for correct operating pressure.
2. Check for leaks.

General Maintenance

A good maintenance program is the key to long compressor life. Below is a program that when adhered to, should keep the compressor in top operating condition. However, it should be understood that these intervals are for normal operation in a good clean environment. More frequent inspections, oil changes and general maintenance should be carried out in dusty environments, high ambient temperatures or extended light load conditions.

⚠ WARNING

DO NOT REMOVE CAPS, PLUGS OR ANY COMPONENTS WHEN THE COMPRESSOR IS RUNNING OR PRESSURIZED. STOP THE COMPRESSOR AND RELIEVE ALL INTERNAL PRESSURE BEFORE DOING SO.

AFTER INITIAL 50 HOURS

1. Change oil filter (Since initial oil filter will have collected any foreign materials which have collected in manufacture).
2. Check belt tension and alignment (majority of belt stretch will occur during early operation hours, also be sure to check alignment).
3. Check compressor oil for water or emulsion.

EVERY 500 HOURS (OR 6 MONTHS)

1. Change compressor oil and filter.
2. Change air filter (shorter intervals may be required if dirty environment).
3. Check belt tension and alignment.
4. Blow out compressor cooler core.
5. Check all fittings and fastenings.
6. Test shutdown system.

EVERY 1000 HOURS (OR 1 YEAR)

1. Check safety circuit switches.
2. Check sump safety valve.
3. Replace spin-on coalescer (sooner if required).

Lubrication Guide

⚠ WARNING

IT IS IMPORTANT THAT THE COMPRESSOR OIL BE OF A RECOMMENDED TYPE AND THAT IT IS INSPECTED AND REPLACED TOGETHER WITH THE OIL AND AIR FILTERS, IN ACCORDANCE WITH THIS MANUAL.

The result of poorly maintained lubricant and/or filters may produce hazardous conditions resulting in ignition, which could cause a fire in the sump. Damage to equipment and serious bodily harm may result.

It is not possible to establish limits on all physical and chemical properties of lubricants which can affect their performance over a broad range of operating and environmental influences. The responsibility for recommending a suitable lubricant must rest with the user's lubricant supplier and their knowledge of the suitability of their lubricants in screw compressors, operating in the particular environment involved.

Table 3-17. Prime Lubricant Characteristics

Viscosity	160 - 210 SUS at 100°F (38°C) 47 SUS or greater at 210°F (99°C)
Flashpoint	400°F (204°C) minimum
Pour point	Must be at least 20°F (-7°C) lower than the lowest expected ambient operating temperature
Contain	Rust and Oxidation Inhibitors
Contain	Foam Suppressors

TYPES OF LUBRICANT TO BE CONSIDERED:

NOTE: *Factory Fill - A.T.F. – Dexron® III or equivalent.*

NOTICE

DO NOT MIX OILS OF DIFFERENT TYPES.

1. **Automatic Transmission Fluids (i.e., Dexron® III):** Are suitable for the majority of applications. They are commonly applied in heavy duty, high temperature conditions and also where temperatures are consistently below freezing (32°F [0°C]), down to approximately 0°F (-18°C).

   In light load and/or high humidity operating conditions A.T.F. can absorb moisture and may result in emulsification of the lubricant. If this occurs change lubricant immediately since the lubricating properties are breaking down. If this condition persists, consider changing to a different type of lubricant (consult supplier).

2. **Industrial Type Oils:** Should be of premium quality non-detergent mineral oil, viscosity grade SAE20 ISO 68). Industrial oils may be better for high humidity and/or low load factor, where condensed moisture and emulsification may occur. Water will separate and must be drained from the oil sump (daily if necessary In addition to the primary oil characteristics, good water separation is required.

   These lubricants should be applied where conditions above 32°F (0°C) prevail.

3. **Synthetic Lubricants:** In so far as know, all the elastomeric components and metals used in the compressor are fully compatible with Synthetic Hydrocarbon (SHC) and Diester Lubricants. However, the synthetic lubricant should not employ Viscosity Index Additives since, they could precipitate out and cause plugging. Viscosity ranges selected should be based on those outlined in Prime Characteristics and in close liaison with the lubricant supplier.

NOTICE

VARIOUS FACTORS CAN AFFECT "EXTENDED LIFE" LUBRICANTS, SUCH AS REACTIVE GASES OR VAPORS WHICH COULD BE INGESTED INTO THE COMPRESSOR AND MAY ADVERSELY AFFECT THESE LUBRICANTS. IT IS RECOMMENDED WITH THESE LUBRICANTS TO MAINTAIN OIL FILTER CHANGES AT RECOMMENDED INTERVALS AND PARTICIPATE IN AN OIL SAMPLING PROGRAM WITH THE LUBRICANT SUPPLIER.

Oil Filter Replacement

The compressor oil filter is a spin on, throw away type. Before attempting to remove the oil filter, ensure all air is relieved from the system.

NOTICE

USE ONLY ORIGINAL EQUIPMENT FILTERS, OTHER FILTERS MAY NOT HAVE CORRECT PRESSURE RATING OR EVEN DIFFERENT THREAD.

REMOVAL:

1. Remove old filter (use strap wrench if required) by turning Anti-Clockwise and discard as appropriate and in accordance with any pertinent regulations

2. Clean filter head with lint free wiper or cloth.

REPLACEMENT:

1. Apply a light film of oil to the seal surface on the new element.

2. Screw new element on, clockwise by hand until seal contacts filter head, then turn an additional 3/4 turn (by hand).

3. Run compressor and test for leaks.

Coalescer (Air/Oil Separator) Replacement

This is a spin-on, throw away type unit. Before attempting to change ensure all pressure is relieved from the system. Change in accordance with Maintenance Guidelines. If oil carryover into the service line occurs and the oil scavenge return line scavenge shows little or no oil return, then change the element. Verify receiver is not over full.

NOTICE

USE ONLY ORIGINAL EQUIPMENT COALESCER ELEMENT TO ENSURE PRESSURE RATING AND PERFORMANCE IS SATISFACTORY.

REMOVAL:

1. Remove old element (use strap wrench if required) by turning anti-clockwise and discard as appropriate and in accordance with any pertinent regulations.

REPLACEMENT:

1. Apply a light film of oil to the seal surface on the new element.
2. Screw element on clockwise until it seats on the head, rotate an additional 3/4 turn (by hand). Take care not to damage element.
3. Start up and check for leaks.

Air Filter Replacement

DO NOT replace with compressor in operation. If environment is dirty or dusty an earlier change out may be required. To ensure correct filtration use only original equipment filters.

REMOVAL:

1. Unscrew the wing nut on top of the air filter and remove filter cover.
2. Discard filter as appropriate and in accordance with any pertinent regulations.

REPLACEMENT:

1. Clean cover and any dirt inside filter housing taking extreme care that no dust/dirt particles reach the air intake of the compressor.
2. Fit new element inside housing.
3. Replace lid and tighten wing nut on top of air filter assembly.
4. Test run and functional test.

Belts - Tightening and Replacement

Correct tensioning and alignment is important for belt life, bearing life and power transmission.

Correct tensioning and alignment was provided at time of shipment from the factory. However, since maximum belt elongation will occur within the first 50 hours of operation (Of new belts), their tension should be checked several times during this period and corrected as required. The belts should thereafter be checked periodically in order to obtain maximum life and performance.

NOTE: *To avoid possible belt damage, never force belts over the sheaves. Oil spilled or splashed onto the belts in any quantity will cause slippage and severely reduce belt life - take care when filling compressor oil.*

REPLACING/TIGHTENING V-BELTS:

1. Loosen slightly the bolt at the base of the hydraulic motor mounting bracket. This will allow the hydraulic motor to be moved in or out to tighten or loosen the belts.
2. Back off adjusting bolt lock nut. Screw the adjusting bolt clockwise to tighten belt or anti clockwise to loosen belts.
3. After adjustments have been made, tighten base bolt to insure no further movement.

TENSION DATA

Deflection at center of belt span 0.25 in. (6.35 mm), with a force of 4 pounds (1.8 kg).

Pulley alignment is set at factory and shouldn't need to be adjusted, if it is found necessary to adjust the pulley alignment, this is done by loosening the four bolts that hold down the base plate to the frame and adjust per following instructions.

Ensure pulleys are aligned by using a long straight edge which will span both pulleys. Position the straight edge on the sides of the pulleys, if they are in-line there should be no gaps between the straight edge and the pulleys (for the full contact distance across each pulley side), adjust as necessary to get correct alignment and tension.

It may be necessary to repeat and check several times before both tension and alignment are satisfied.

Cooler Core Cleaning (Exterior)

Remove leaves, papers, etc. from outside face. Use compressed air and carefully blow through the core from the inside of the canopy (through fan assembly or remove fan assembly).

DO NOT use high pressure air or pressure washer.

NOTE: *Oil cooler core is aluminum, if this does at some point require internal cleaning, this is best done by a suitable equipped radiator shop. Internal cleaning is NOT a normal maintenance item if the oil is maintained in good condition.*

Adding/Changing Compressor Oil

Ensure all pressure is relieved from the system. Check oil level with unit level, otherwise a false oil level indication will occur.

1. Remove oil fill plug located on main compressor base casting.

NOTE: *This can be done without lifting canopy.)*

2. Carefully add lubricant and monitor oil level, allow time for oil to level out. A complete refill is approximately 5 1/4 quarts (5 liters). Correct oil level is minimum to bottom threads on oil fill port up until oil runs out of port. Overfill can only occur if unit is out of level.

3. Refit oil fill cap tightly by hand.

4. Run unit and recheck oil level after shutdown, allowing time for oil to settle.

Oil drain is provided with short drain hose. This can be routed to a more convenient location if required, dependent upon installation. Use only Schedule 80 pipe or suitably rated hose.

NOTE: *Fill cap has a vent release hole as a safety feature and to act as a "tell-tale". If air escapes while unscrewing the fill cap, then the system still has pressure. Re-tighten the cap and wait until all pressure is relieved.*

Pressure Adjustments

Before adjusting the pressure control system it is necessary to determine the rated full load pressure setting. These can be found in the Specification Section.

PRESSURE SWITCH LOCATION:

The pressure switch is located directly behind the cooling fan inside a black plastic box. Removing the one single screw from the bottom of the plastic cover allows the cover to be removed exposing the two adjustment screws at the top and also exposes the electrical terminations.

⚠ DANGER

ADJUSTMENTS SHOULD BE MADE WITH COMPRESSOR SWITCHED OFF SINCE ELECTRICAL TERMINALS INSIDE PRESSURE SWITCH WILL BE EXPOSED AND OPENING THE CANOPY EXPOSES BELT DRIVE SYSTEM.

PROCEDURE FOR SETTING:

1. Start compressor and allow to warm up. NOTE - Pressure reading on gauge with service valve closed. Switch off compressor.

2. Adjustment screws on pressure switch. Steel slotted screw (L.H. side upper) will adjust both cut-out and cut-in pressures together. Screw in clockwise to increase screw out counter clockwise to decrease. Plastic head slotted screw (R.H. side upper) will permit changes to cut-out pressure (higher pressure) without affecting cut-in pressure. (ie. changes differential pressure range) screw in clockwise to increase and counterclockwise to decrease upper pressure setting.

   Nominal differential setting 25 to 30 psi (1.7 to 2.0 Bar). This is to reduce load/unload cycle in cases where minimal air usage or leaks in hoses/connections may occur. The recovery period from unload to load is rapid with the screw compressor and this initial setting will suit most applications.

   It is suggest to make adjustments in% turn increments then close canopy, restart and check pressure. Re-adjust as necessary.

   When desired pressure is set, replace switch cover and close canopy for operation.

NOTICE

INCREASING AIR PRESSURE WILL INCREASE THE REQUIRED COMPRESSOR H.P. BE SURE THE HYDRAULIC POWER SUPPLY IS CAPABLE (HYDRAULIC PRESSURE) OTHERWISE THE COMPRESSOR MAY STALL OUT DURING OPERATION DUE TO INCREASED POWER REQUIREMENT.

Intake Control

The intake control consists of two main sub-assemblies:

1. **Inlet Valve Assembly:** The inlet valve opening/closing (load/unload) is controlled by admitting/exhausting pilot air pressure through the solenoid valve to the piston which is part of the inlet valve assembly. The inlet valve is not a routine maintenance item. Maintenance kits are available which include replacement seals, etc.

2. **Solenoid Valve:** Attaches directly to the inlet valve and responds to signals from the pressure switch to admit/vent pilot air pressure to the inlet valve to control load/unload. In the unlikely event of failure this item is to be replaced as a complete item.

Minimum Pressure Valve

Normally factory set to 65 psig (4.5 Bar). Provides two main functions:

1. **Maintains Minimum Pressure:** Prevents downstream air to pass until compressor system is up to minimum pressure valve setting which aids in maintaining good oil supply to the compressor and also is a requirement for good oil separation.

2. **Back Pressure Check Valve:** Allows for compressor to be unloaded to lower pressure than supply air line system and permits compressor air pressure to be totally relieved when stopped.

   This valve is <u>not</u> a routine maintenance item. Seals and replacement parts are available.

Compressor Thermal Valve

Controls compressor oil temperature and permits for rapid compressor oil warm up. Commences to pass oil through cooler at 160°F (71°C) and is fully open at 185°F (85°C).

Safety Shutdown Systems

Protection for over-pressure and/or over-temperature is provided. If either condition should occur the diverter valve should activate to divert hydraulic fluid back to tank and the compressor will stop, the reset on instrument panel will pop out and stay out until reset. Reason for shutdown should be investigated before pressing reset.

Periodically (every 6 months or every 500 hours) the shutdown system should be tested as follows: Compressor operating, close service valve and allow compressor to unload (2 minutes or more) then touch across button on gauge face to Bezel surrounding the respective gauge with coin or screwdriver. Reset button should pop out and compressor stop. Switch off compressor and press reset button to reactive shutdown system.

Troubleshooting

The information contained in the Troubleshooting Chart has been compiled from information gathered. It contains symptoms and usual causes for the most common types or problem. All available data concerning the trouble should be systematically analyzed before undertaking any repairs or component replacement.

A visual inspection is worth performing for almost all problems and may avoid unnecessary additional damage to the machine. The procedures which can be performed in the least amount of time and with the least amount of removal or disassembly of parts should be performed first.

⚠ WARNING

BEFORE WORKING ON ANY MACHINE, ENSURE IT IS SHUT DOWN AND ISOLATED, AIR PRESSURE RELIEVED, AND UNIT HAS COOLED DOWN.

Table 3-18. Air Compressor Troubleshooting

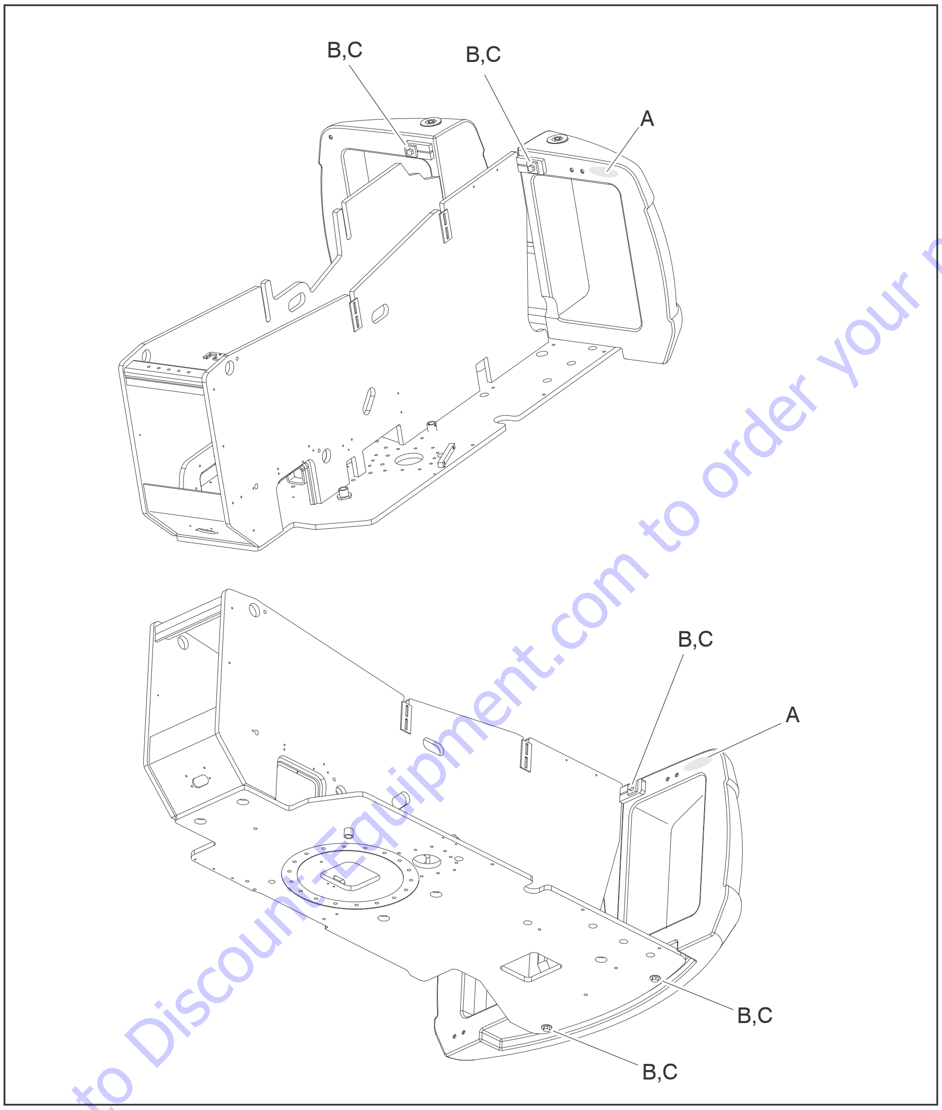
SYMPTOM	PROBABLE CAUSE	SOLUTION
1. Compressor shuts down with air demand	a. Compressor temperature; switch opening.	a. Low oil level-top up. Restricted cooling air intake- clean-reposition machine. Fan not operating-check ground-check fan switch.
	b. Plugged oil filter	b. Replace
	c. Dirty cooler core	c. Clean
	d. Contaminated cooler core	d. Remove and clean
	e. Hydraulic pressure & Flow incorrect	e. Adjust and reset
2. Compressor will not build up pressure	a. Air demand too great	a. Check for leaks and correct Too much air demand
	b. Air filter plugged	b. Check and replace
	c. Press. switch out of adjustment	c. Reset
	d. Defective pressure switch	d. Replace
	e. Motor does not speed up	e. Pressure switch Check hydraulic flow & pressure
	f. Belts slipping	f. Readjust/tighten
	g. Service valve wide open	g. Close
	h. Sol. valve stuck	h. Replace
	i. Leak in air pilot line	i. Check for leaks & correct
3. Compressor over pressures	a. Press. Regul. out of adjustment	a. Reset
	b. Defective press. switch	b. Replace
	c. Leak in air control line	c. Check and correct
	d. Inlet valve stuck	d. Free or replace
	e. Restriction in control line	e. Dirt or ice, clean/free up
	f. Sol. valve not energized/faulty	f. Check for power/replace
	g. Faulty gauge	g. Check with shop air/replace
	h. Defective safety valve	h. Replace
	i. Plugged coalescer	i. Replace
4. Insufficient air delivery	a. Plugged air filter	a. Replace
	b. Plugged coalescer	b. Replace
	c. Motor speed too low	c. Check hydraulic flow & pressure
	d. Inlet valve stuck	d. Free or replace
	f. Belts slipping	f. Readjust

Table 3-18. Air Compressor Troubleshooting

SYMPTOM	PROBABLE CAUSE	SOLUTION
5. Oil carryover	a. Oil level overfull	a. Drain to correct level
	b. Plugged oil scavenge line	b. Remove and clean
	c. Discharge pressure too low	c. Check minimum pressure valve
	d. Defective coalescer	d. Replace
6. Compressor overheating	a. Insufficient oil	a. Check level and top up
	b. Restricted cooling air flow	b. Reposition machine
	c. Fan not operating	c. Check ground connection; Check fan switch; Check air pressure switch; Check circuit breaker; Check for shorted wires; Check fan motor
	d. Plugged oil filter	d. Replace
	e. Cooler core plugged	e. Clean
	f. Pressure set too high	f. Readjust
	g. Contaminated cooler core	g. Remove and clean
	h. Running too fast	h. Check hydraulic flow & pressure
	i. Thermal Valve – element faulty	i. Replace
7. System retains pressure after shutdown	a. Solenoid valve stuck	a. Should be no power to solenoid valve Valve stuck. Replace Pressure switch faulty/replace
	b. Leak back from airline	b. Check minimum pressure valve for leak
8. Compressor stalls	a. Belts slipping	a. Readjust/tighten
	b. Insufficient hydraulic system pressure/flow. This can occur if another hydraulically activated component is used off same pump system. Activating the secondary component may drop hydraulic supply system pressure/flow and leave insufficient for compressor. NOTE - even a momentary drop in supply hydraulic supply pressure/ flow may initiate compressor blowdown to commence.	b. Check setting on supply pressure system relief valve. Check to ensure adequate pressure/ flow. Check if other systems activated off same supply.
	c. Pressure relief valve set too low	c. Check & reset
	d. Leak in seals on pressure relief valve	d. Remove & check seals or fit new valve cartridge
	e. Air pressure set too high for hydraulic system	e. Adjust pressure switch to reduce air pressure.
	f. Leak in solenoid valve cartridge (directional flow control valve) on manifold	f. Remove & check seals or fit new valve cartridge.
	g. Check over-pressure or over-temperature	

3.37 COUNTERWEIGHT

If the counterweight has been removed, ensure the retaining bolts are torqued to the proper value as shown in Figure 3-111., Counterweight.



A. Actual Weight Stamping

B. Apply JLG Threadlocker P/N 0100011 to Bolt Threads and to Threads in Counterweight.

C. Torque to 285 ft. lbs. (386 Nm). Typical Four Places.

Figure 3-111. Counterweight

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We sell worldwide for the brands: Genie, Terex, JLG, MultiQuip, Mikasa, Essick, Whiteman, Mayco, Toro Stone, Diamond Products, Generac Magnum, Airman, Haulotte, Barreto, Power Blanket, Nifty Lift, Atlas Copco, Chicago Pneumatic, Allmand, Miller Curber, Skyjack, Lull, Skytrak, Tsurumi, Husquvarna Target, , Stow, Wacker, Sakai, Mi-T- M, Sullair, Basic, Dynapac, MBW, Weber, Bartell, Bennar Newman, Haulotte, Ditch Runner, Menegotti, Morrison, Contec, Buddy, Crown, Edco, Wyco, Bomag, Laymor, Barreto, EZ Trench, Bil-Jax, F.S. Curtis, Gehl Pavers, Heli, Honda, ICS/PowerGrit, IHI, Partner, Imer, Clipper, MMD, Koshin, Rice, CH&E, General Equipment, ,AMida, Coleman, NAC, Gradall, Square Shooter, Kent, Stanley, Tamco, Toku, Hatz, Kohler, Robin, Wisconsin, Northrock, Oztec, Toker TK, Rol-Air, Small Line, Wanco, Yanmar

SECTION 4. BOOM & PLATFORM

4.1 PLATFORM

Platform/Support Removal

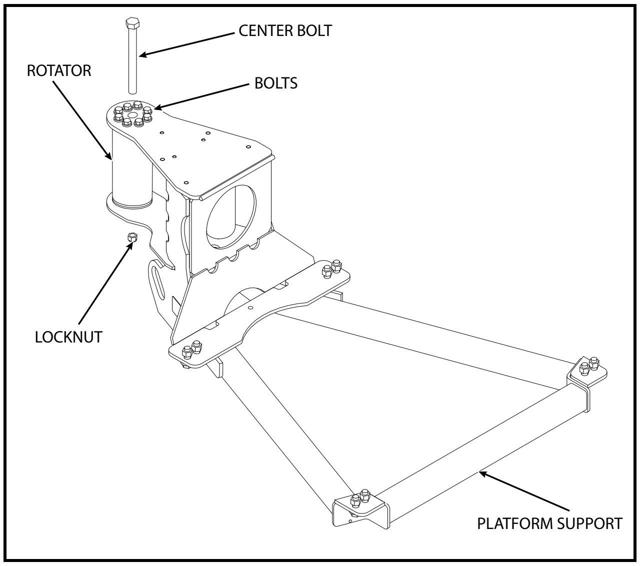
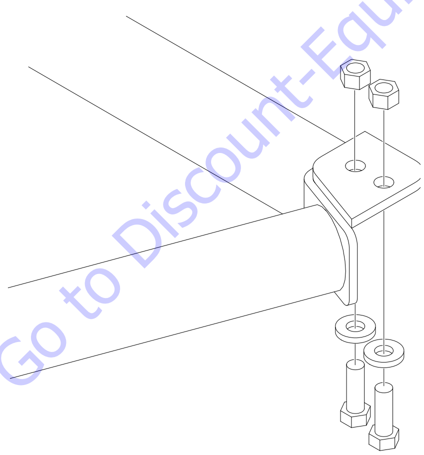


Figure 4-1. Location of Components Platform Support

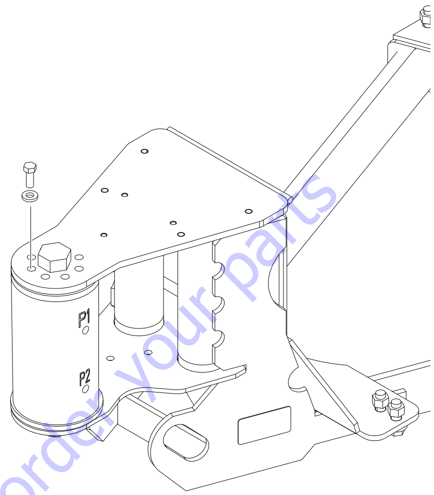
1. Disconnect electrical cable from control console.
2. Remove the bolts securing the platform to the platform support, then remove the platform.



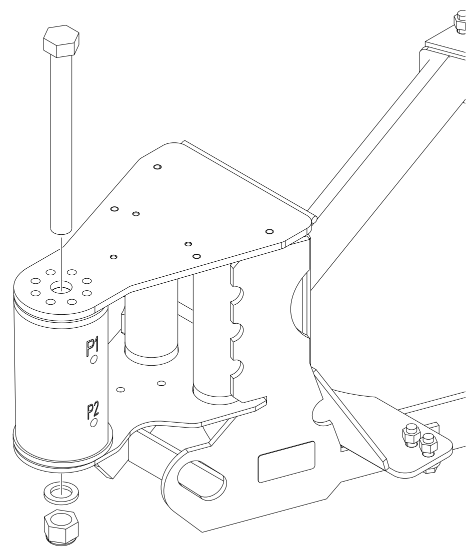
3. Using a suitable device, support the platform support.

NOTE: *The platform support weighs approximately 77 lbs. (35 kg).*

4. Remove the bolts and locknuts securing the support to the rotator.



5. Using a suitable brass drift and hammer, remove the center bolt and locknut.



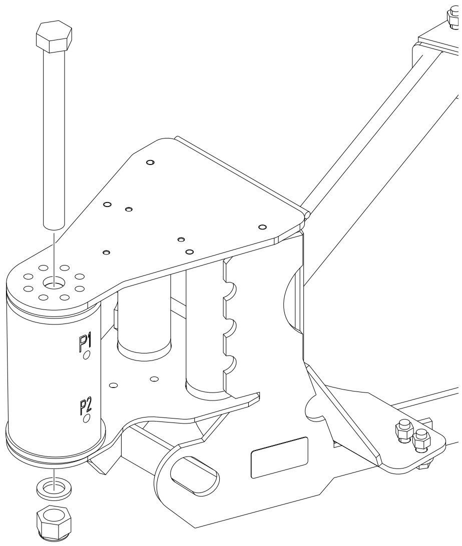
6. Remove the platform support from rotator.

Support Installation

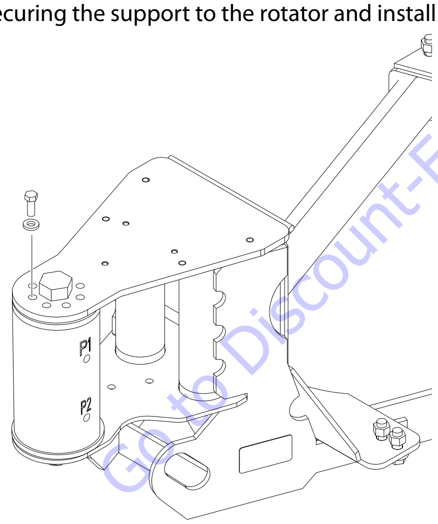
1. Using a suitable device, support the platform support and position it on the rotator.

NOTE: *The platform support weighs approximately 77 lbs. (35 kg).*

2. Install the rotator center bolt and locknut.

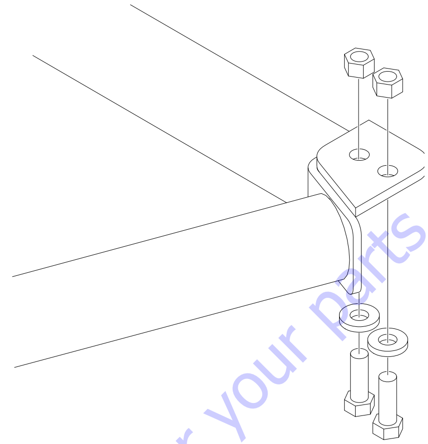


3. Apply JLG Threadlocker P/N 0100011 to the eight bolts securing the support to the rotator and install the bolts.

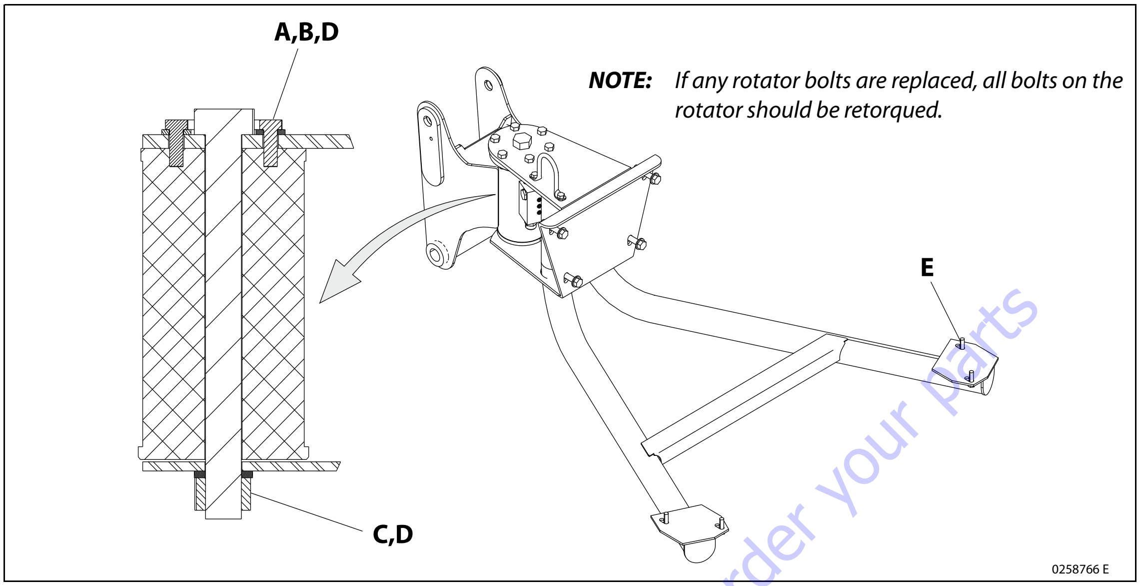


4. Torque the nut on the rotator center bolt and the retaining bolts. See Figure 4-2. & Figure 4-3.

5. Position the platform on the platform support and install the bolts securing the platform to the platform support. See Figure 4-2. & Figure 4-3.

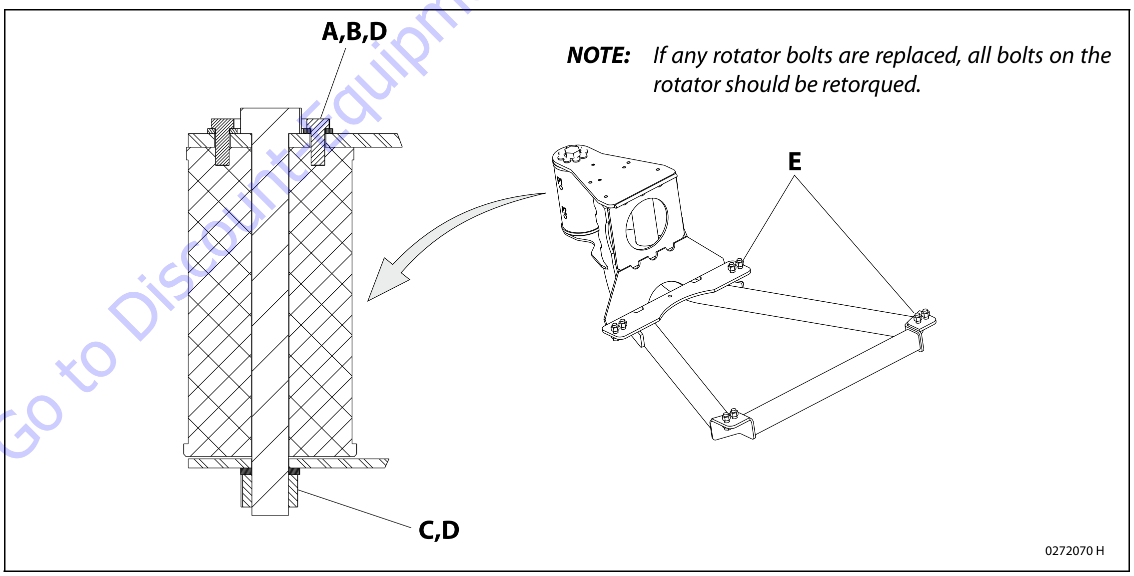


6. Connect the electrical harness to the platform control console.



A Torque to 85 ft. lbs. (116 Nm)
B JLG Threadlocker P/N 0100011
C Torque to 480 ft. lbs. (651 Nm)
D Check torque every 150 hours of operation
E Torque to 40 ft. lbs. (55 Nm)

Figure 4-2. Platform Support Torque Values (Prior to SN 0300130881)



A Torque to 40 ft. lbs. (55 Nm)
B JLG Threadlocker P/N 0100011
C Torque to 586 ft. lbs. (795 Nm)
D Check torque every 150 hours of operation
E Torque to 75 ft. lbs. (102 Nm)

Figure 4-3. Platform Support Torque Values (SN 0300130881 through 0300185827)

4.2 ROTATOR AND SLAVE CYLINDER

Removal

1. Tag and disconnect hydraulic lines to rotator and slave cylinder. Use suitable container to retain any residual hydraulic fluid. Cap hydraulic lines and ports.
2. Supporting the rotator, remove hardware from pin #1. Using a suitable brass drift and hammer remove pin #1 from the jib assembly.
3. Remove the hardware from pin #2. Using a suitable brass drift and hammer, remove pin #2 from the jib assembly and remove the rotator.
4. Telescope the fly section out approximately 20 in. (50.8 cm) to gain access to the slave leveling cylinder.
5. Supporting the slave cylinder, remove the hardware from pin #3. Using a suitable brass drift and hammer remove pin #3 from the jib assembly.
6. Remove the hardware from pin #4. Using a suitable brass drift and hammer remove pin #4 from the fly boom. Remove the slave cylinder.

Installation

1. Telescope the fly section out approximately 20 in. (50.8 cm) to gain access to the slave leveling cylinder.
2. Support the slave cylinder. Using a suitable brass drift and hammer, install pin #4 to the fly boom. Install hardware securing pin #4.
3. Using brass drift and hammer install pin #3 to jib assembly and install the slave cylinder. Install hardware securing pin #3.
4. Support the rotator. using a suitable brass drift and hammer, install pin #2 to the jib assembly. Install hardware securing pin #2.
5. Using brass drift and hammer install pin #1 to jib assembly and install the rotator. Install hardware securing pin #1.
6. Remove tag and reconnect the hydraulic lines to the rotator and the slave cylinder.

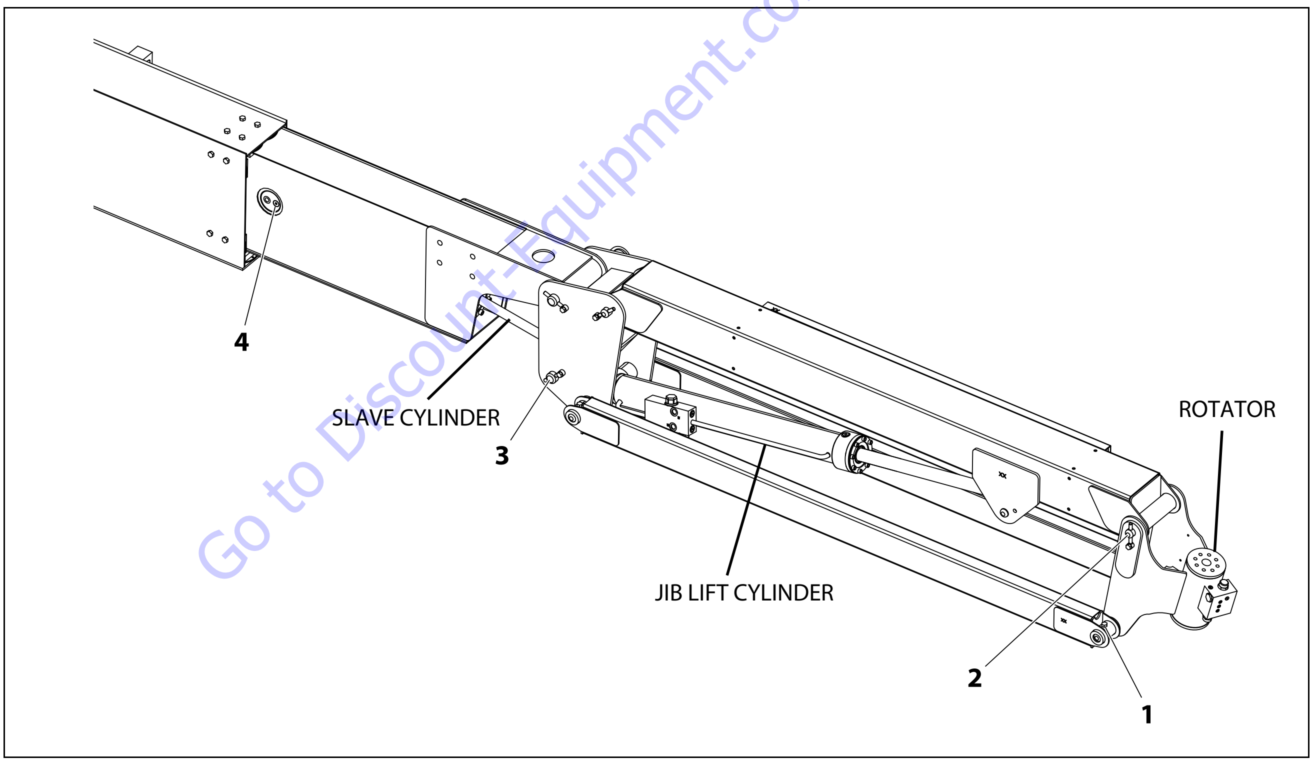


Figure 4-4. Location of Components - Rotator and Slave Cylinder

4.3 MAIN BOOM POWERTRACK

Removal

1. Disconnect wiring harness connectors located in tower upright.

NOTICE

HYDRAULIC LINES AND PORTS SHOULD BE CAPPED IMMEDIATELY AFTER DISCONNECTING LINES TO AVOID ENTRY OF CONTAMINANTS INTO SYSTEM.

2. Tag and disconnect hydraulic lines from connectors at boom assembly. Use suitable container to retain any residual hydraulic fluid. Cap hydraulic lines and ports.
3. Remove hydraulic lines and electrical cables from powertrack.
4. Using suitable lifting device, adequately support powertrack weight along entire length.
5. Remove bolt #1 securing the push tube on the fly boom section.
6. Remove bolt #2 securing the push tube on the base boom section.
7. With powertrack supported and using all applicable safety precautions, remove bolts #3, and #4 securing rail to the base boom section. Remove powertrack from boom section.

Installation

1. Using suitable lifting device, adequately support the powertrack weight along entire length.
2. With powertrack supported and using all applicable safety precautions, install bolts #3 securing rail to the base boom.
3. Install bolts #2 securing the push tube on the base boom section.
4. Install bolts #1 securing the push tube on the fly boom section.
5. Install bolts #4 securing rail to push tube.
6. Remove tag and reconnect all hydraulic lines and electrical cable from powertrack.
7. Reconnect dual capacity indicator limit switch from side of boom section.
8. Remove tag and reconnect hydraulic lines from connectors at boom assembly.

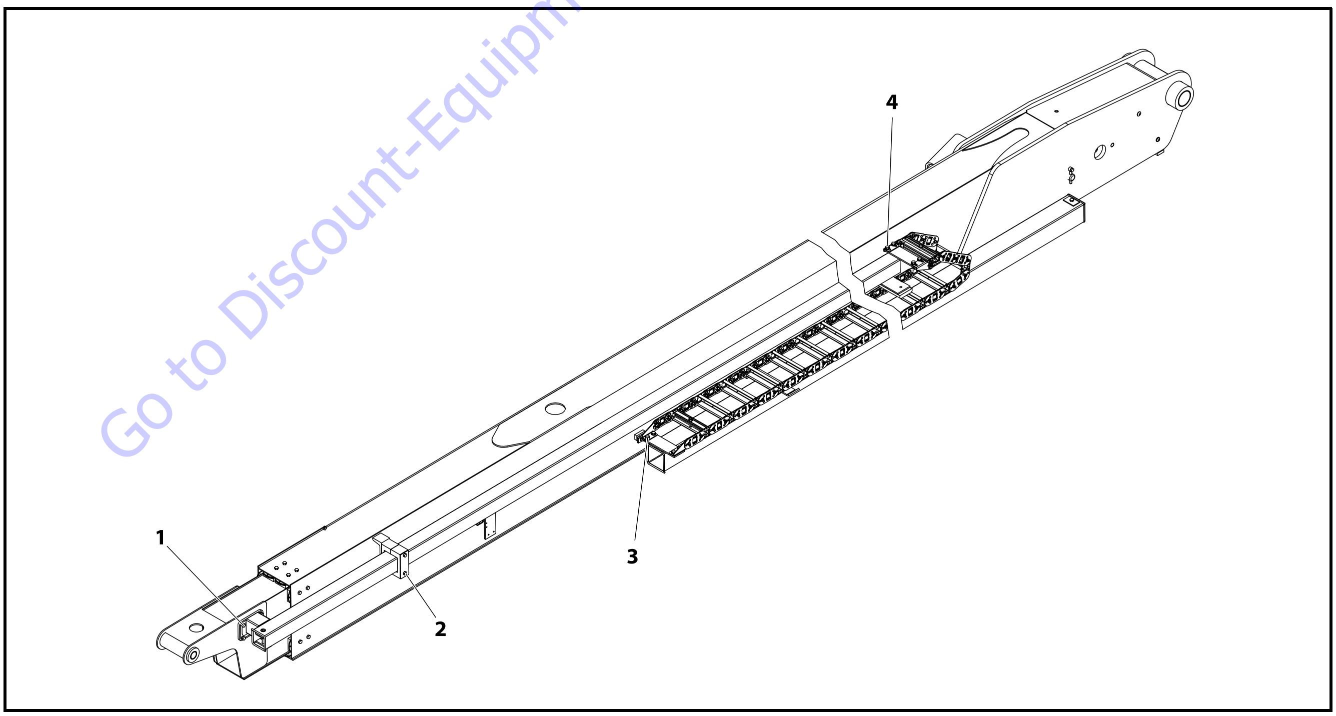
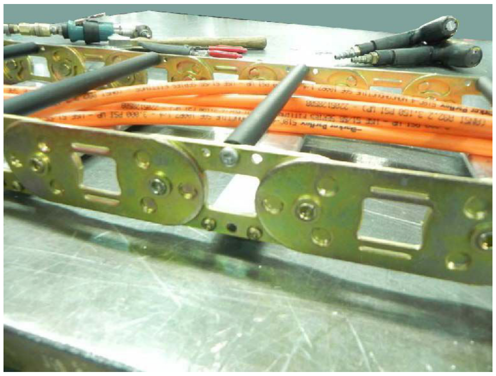


Figure 4-5. Boom Power Track Components

4.4 POWERTRACK MAINTENANCE

Flat Bar Removal

NOTE: *Hoses shown in the powertrack are for example only. Actual hose and cable arrangements will be different.*



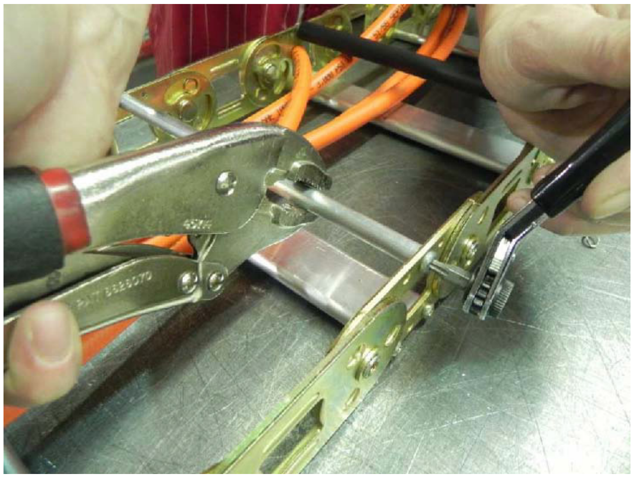
1. Use a small 1/4 in. ratchet and a T-20 Torx bit. Remove the 8-32 x 0.500 screws from both sides (If the track also has a flat bar on the inside of the track instead of round bar/poly, perform the same step to remove it.).

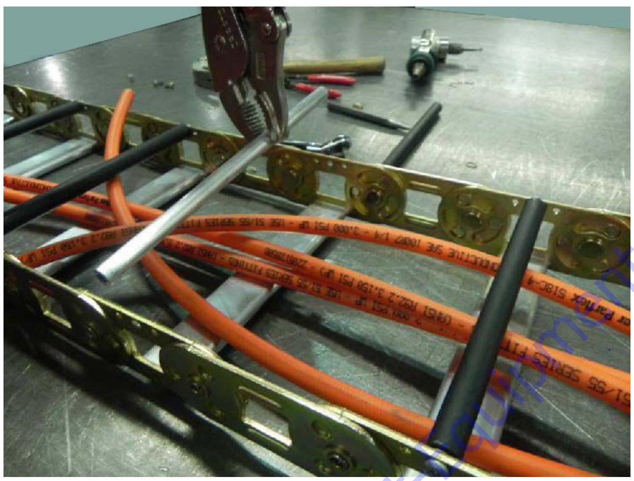
Round Bar/Poly Bar Removal

1. Use a small 1/4 in. ratchet with a T-25 Torx bit. Remove the 10-24 x 0.812 screw. (If the bar spins then grip the bar and poly tightly with a vise-grip).

2. Lift up one end of the bar and slide the poly roller off.

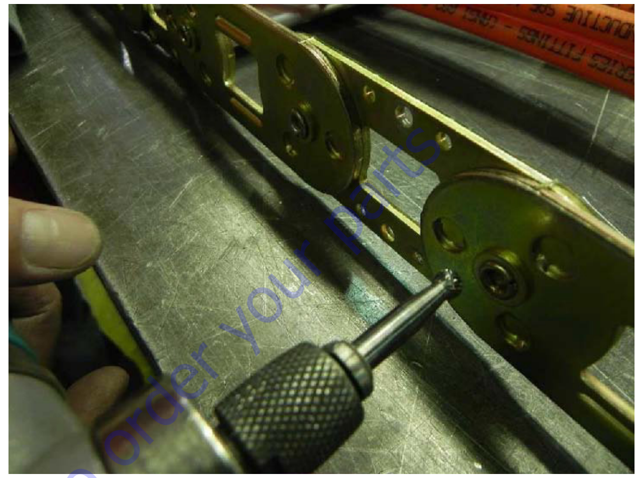
3. While gripping the bar tightly, remove the other 10-24 x 0.812 screw.



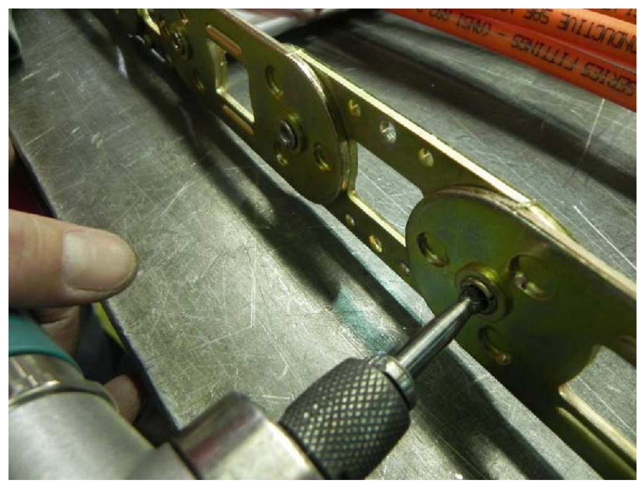


Removing and Installing Links

1. To remove the links, the rivets holding the links together must be removed. The following will show one way this can be done. Use a right angle die grinder with a 1/4 in. ball double cut bur.

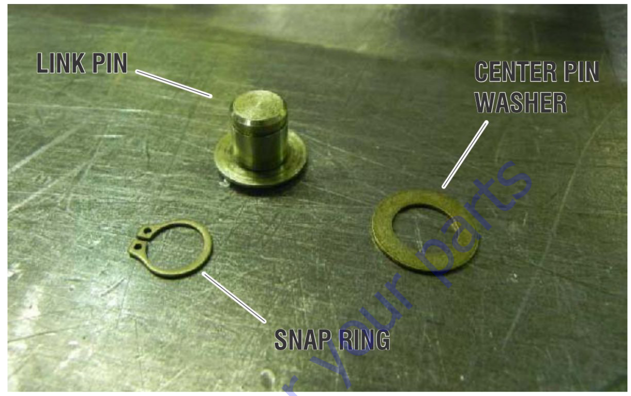


2. Insert the tool into the rolled over end of the rivet as shown. Grind out the middle of the rivet until the rolled over part of the rivet falls off. Repeat this step for all rivets that must be removed.

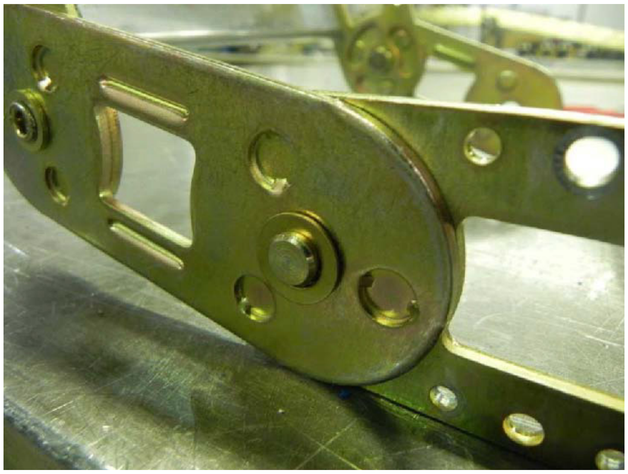


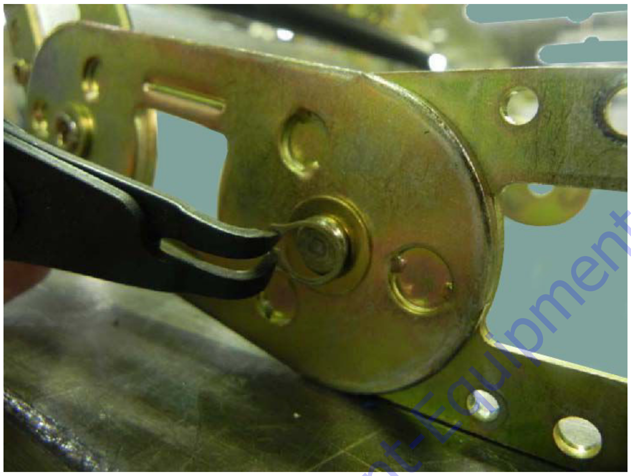
3. After grinding, it is sometimes necessary to use a center punch to punch out the rivet from the link.

4. To install new links, extend the upper moving end over the lower part of the track so the new connection point is in the curved part of the track. This will allow the round half-shears to be rotated in a way they will fit into the peanut-shaped cut-outs.

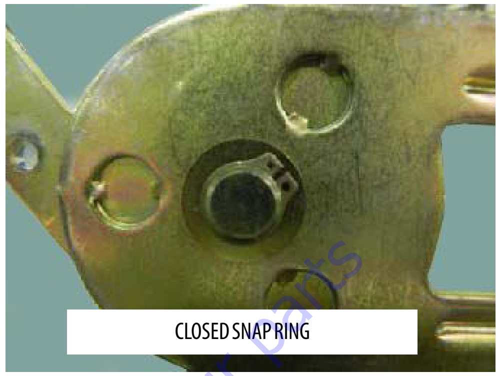


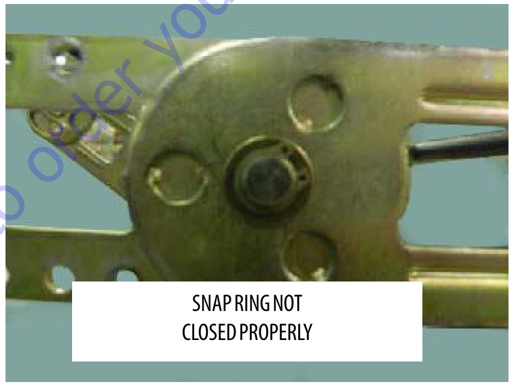
5. Install the pin into the center hole, then slide the washer over the pin. Install the snap ring into the groove in the pin.



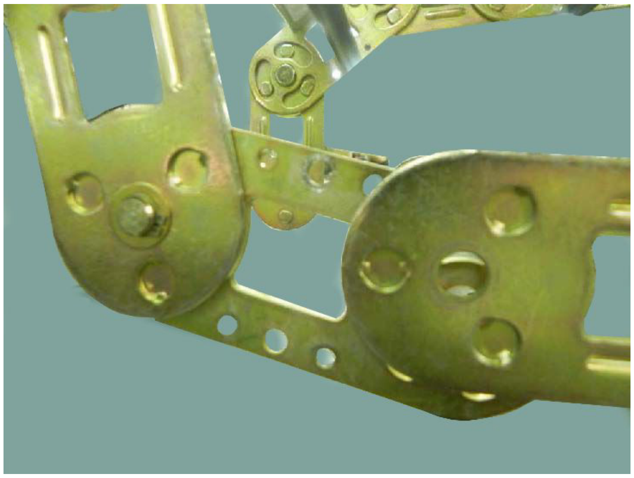


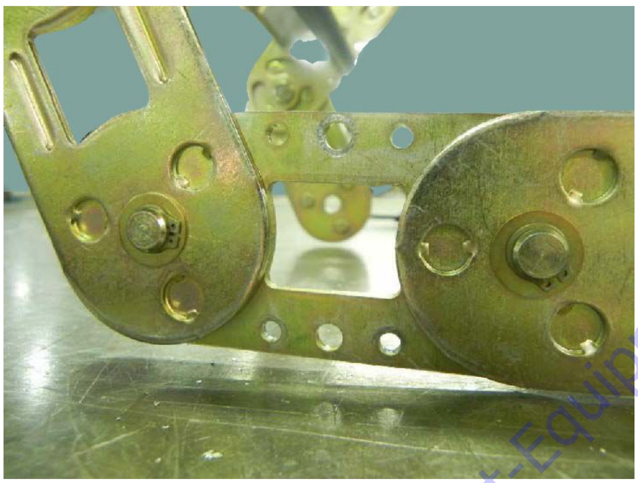
NOTE: *When installing snap rings make sure they are seated in the pin groove and closed properly.*





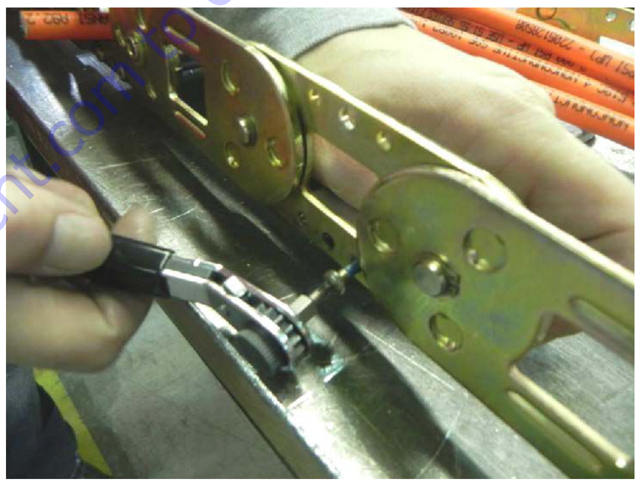
6. Install more pins, washers, and snap rings into all the links where a rivet was removed.





Installing a New Flat Bar

1. While holding the flat bar, install new 8-32 x 0.500 self threading torx screws into both holes on each side of track.



NOTE: *Maximum tightening torque for the 8-32 screw is 18-20 in. lbs. (2-2.2 Nm).*

Installing a New Round Bar/Poly Roller

1. While tightly holding the round bar, install the new 10-24 x 0.812 self threading torx screw. Next lift up the other end and slide a new poly roller on. Install another 10-24 x 0.812 screw on the other side.

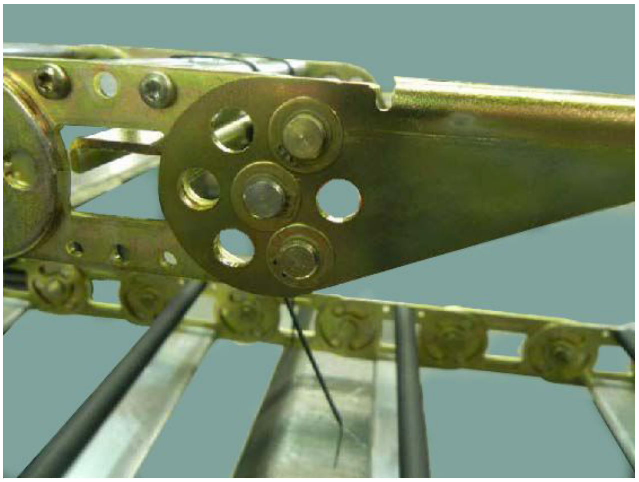
NOTE: *Maximum tightening torque for the 10-24 screw is 45-50 in. lbs. (5-5.6 Nm.).*

Replacing a Fixed End Bracket

1. Remove the bracket by removing the center pin, washer, and snap ring. Install a new bracket then reinstall the pin, washer, and new snap ring. After installing the new bracket make sure that it rotates correctly.

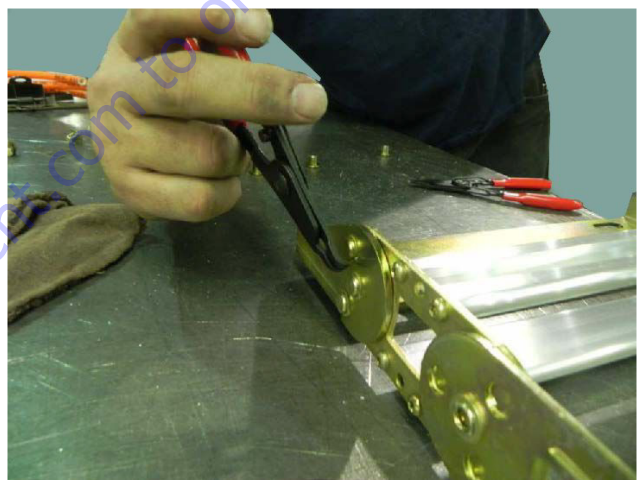
Replacing a Moving End Bracket

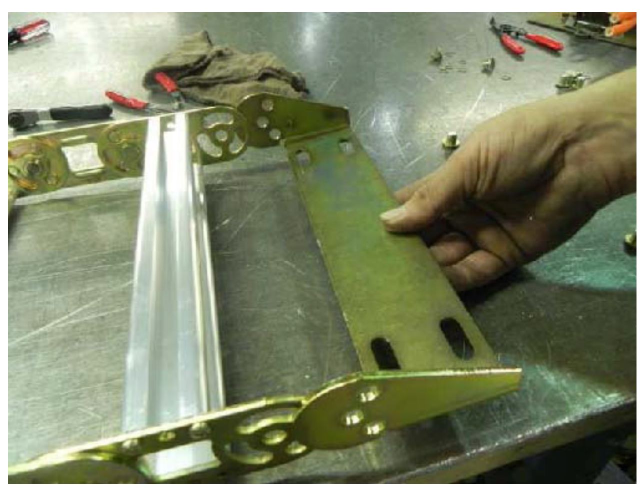
1. Remove bracket by removing all pins, washers, and snap rings. Replace with a new bracket and reinstall the pins, washers, and new snap rings. After installing a new bracket make sure that it rotates correctly.



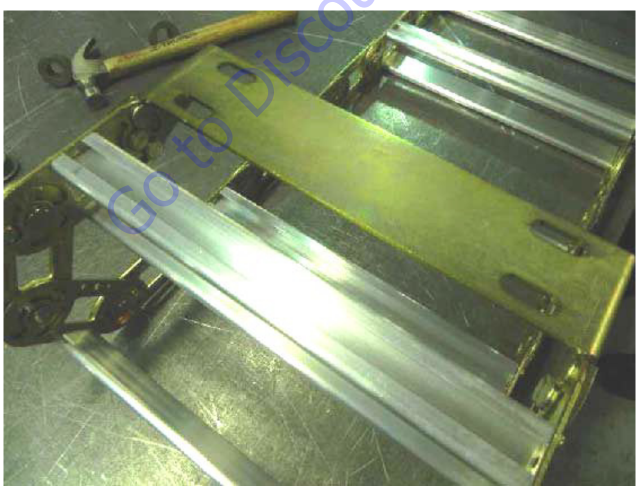
Replacing a One Piece Bracket

1. Remove all pins, washers, and snap rings and slide the bracket off of the links.





2. To install a new bracket, slide the bracket over the links and reinstall the pins, washers, and new snap rings. After installing the new bracket make sure that it rotates correctly.



4.5 BOOM CLEANLINESS GUIDELINES

The following are guidelines for internal boom cleanliness for machines that are used in excessively dirty environments.

1. JLG recommends the use of the JLG Hostile Environment Package if available to keep the internal portions of a boom cleaner and to help prevent dirt and debris from entering the boom. This package reduces the amount of contamination which can enter the boom but does not eliminate the need for more frequent inspections and maintenance when used in these types of environments.

2. JLG recommends that you follow all guidelines for servicing your equipment in accordance with the instructions outlined in the JLG Service & Maintenance Manual for your machine. Periodic maintenance and inspection is vital to the proper operation of the machine. The frequency of service and maintenance must be increased as environment, severity and frequency of usage requires.

3. Debris and foreign matter inside of the boom can cause premature failure of components and should be removed. Methods to remove debris should always be done using all applicable safety precautions outlined in the JLG Service & Maintenance Manuals.

4. The first attempt to remove debris from inside the boom must be to utilize pressurized air to blow the debris toward the nearest exiting point from the boom. Make sure that all debris is removed before operating the machine.

5. If pressurized air cannot dislodge the debris, then water with mild solvents applied via a pressure washer can be used. Again the method is to wash the debris toward the nearest exiting point from the boom. Make sure that all debris is removed, that no “puddling” of water has occurred, and that the boom internal components are dry prior to operating the machine. Make sure you comply with all federal and local laws for disposing of the wash water and debris.

6. If neither pressurized air nor washing of the boom dislodges and removes the debris, then disassemble the boom in accordance to the instructions outlined in the JLG Service & Maintenance Manual to remove the debris.

4.6 MAIN BOOM ASSEMBLY

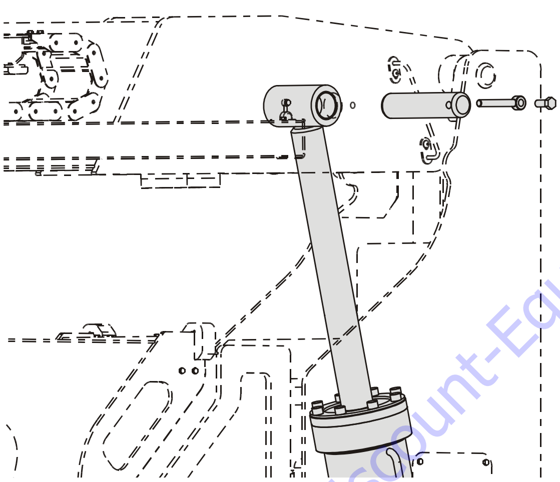
Removal

1. Using a suitable lifting equipment, adequately support boom assembly weight along entire length.

NOTICE

HYDRAULIC LINES AND PORTS SHOULD BE CAPPED IMMEDIATELY AFTER DISCONNECTING LINES TO AVOID ENTRY OF CONTAMINANTS INTO SYSTEM.

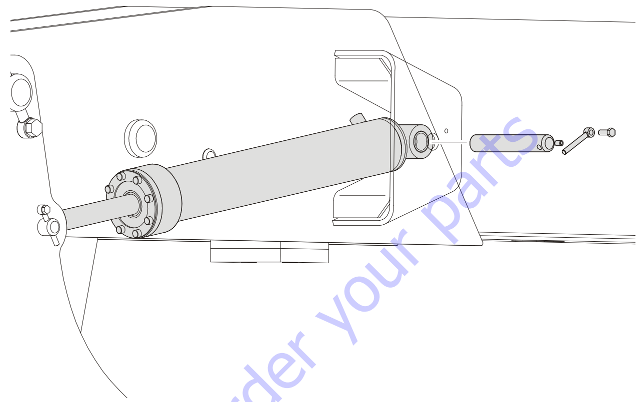
2. Tag and disconnect hydraulic lines from telescope cylinder. Use suitable container to retain any residual hydraulic fluid. Cap hydraulic lines and ports.
3. Remove hardware securing the main lift cylinder rod end to the base boom section.
4. Using a suitable brass drift and hammer, remove the main lift cylinder pin from base boom. Retract the main lift cylinder by using the auxiliary power switch.



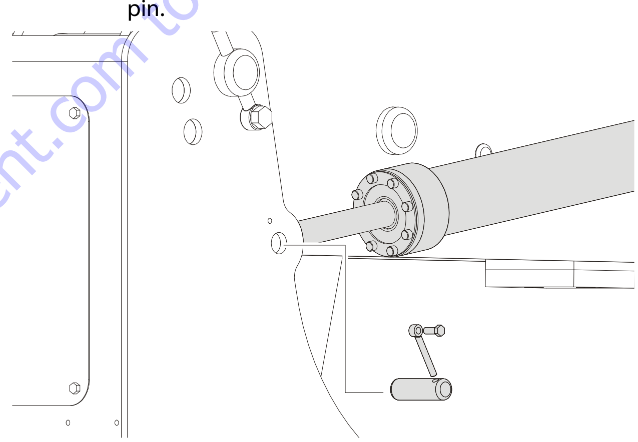
5. Remove the Master Cylinder as follows:
   - **a.** Using an adequate supporting device, support the master cylinder so it doesn't fall when the retaining pins are removed.

NOTE: *The master cylinder weighs approximately 58.5 lbs. (26.5 kg).*

   - **b.** Tag and disconnect hydraulic lines from Master Cylinder. Use a suitable container to collect any residual hydraulic fluid. Cap hydraulic lines and ports.
   - **c.** Remove the bolt and keeper pin securing the master cylinder barrel end pin to the base boom section. Next, install a 3/8-16 UNC threaded lifting eye into the threaded hole of the pin and pull pin out.

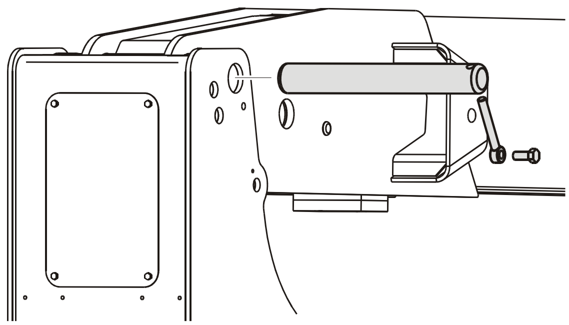


   - **d.** Remove the bolt and keeper pin securing the master cylinder rod end pin to the upright. Remove the pin.



NOTE: *When installing the master cylinder rod end pin, insert the keeper hardware pin to prevent the pin from inserting too far.*

6. Remove hardware securing the boom pivot pin to the upright. Using a suitable brass drift and hammer, remove the pivot pin from upright.



7. Using all applicable safety precautions, carefully lift boom assembly clear of upright and lower to ground or suitably supported work surface.

NOTE: *The main boom alone weighs approximately 2226 lbs. (1010 kg). Including the slave cylinder, rotator, and platform support the assembly weighs approximately 3185 lbs. (1445 kg).*

Disassembly

1. Remove hardware securing telescope cylinder to after end of the base boom section.
2. Remove hardware which secures the wear pads to the base boom section; remove the wear pads from the top, sides and bottom of the base boom section.
3. Using overhead crane or suitable lifting device, remove fly boom assembly from base section.
4. Remove hardware from the telescope cylinder pin. Using a suitable brass drift and hammer remove the cylinder pin from fly boom section.
5. Pull the telescope cylinder partially from after end of the fly boom section; secure the cylinder with a suitable sling and lifting device at approximately the center of gravity.
6. Carefully remove the telescope cylinder and place telescope cylinder on a suitable trestle.

NOTE: *The Main Boom Telescope Cylinder can be removed without the main boom disassembly by disconnecting hydraulic lines, top attaching pin of main lift cylinder and telescope cylinders as directed above, and pulling out the telescope cylinder from the rear, thru the access plate opening of the upright.*

7. Remove hardware which secures the wear pads to the after end of fly boom section; remove the wear pads from the top, sides and bottom of the fly boom section.

Inspection

NOTE: *When inspecting pins and bearings Refer to Section 2, Pins and Composite Bearing Repair Guidelines.*

1. Inspect main boom pivot pin for wear, scoring, tapering and ovality, or other damage. Replace pins as necessary.
2. Inspect telescope cylinder attach point for scoring, tapering and ovality. Replace pins as necessary.
3. Inspect upper lift cylinder attach pin for wear, scoring, tapering and ovality, or other damage. Ensure pin surfaces are protected prior to installation. Replace pins as necessary.
4. Inspect inner diameter of boom pivot bearing for scoring, distortion, wear, or other damage. Replace bearing as necessary. (See Section 5, Cylinder Repair for bearing replacement).
5. Inspect all wear pads for excessive wear, or other damage. Replace pads when worn as specified in Figure 4-12., Location and Thickness of Wear Pads.
6. Inspect all threaded components for damage such as stretching, thread deformation, or twisting. Replace as necessary.
7. Inspect structural units of boom assembly for bending, cracking, separation of welds, or other damage. Replace boom sections as necessary.

Assembly

NOTE: *When installing fly section wear pads, install same number and thickness of shims as were removed during disassembly.*

1. Measure inside dimensions of the base section to determine the number of shims required for proper fit.
2. Install side, top and bottom wear pads to the aft end of fly section; shim evenly to the measurements of the inside of base boom section.

NOTICE

WHEN ASSEMBLING BOOM SECTIONS, ENSURE THAT THE BOOM SLIDING TRAJECTORIES HAVE BEEN CLEARED OF CHAINS, TOOLS, AND OTHER OBSTRUCTIONS.

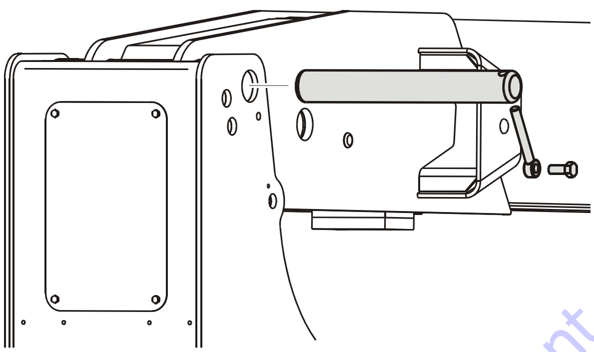
3. Secure the sling and lifting device at the telescope cylinder's approximate center of gravity, and lift the cylinder to the aft end of the fly boom section.
4. Slide telescope cylinder into the aft end of fly boom section. Align attachment holes in fly boom section with hole in rod end of telescope cylinder.
5. Install telescope cylinder pin and secure with mounting hardware.
6. Secure the sling and lifting device at the fly boom assembly approximate center of gravity.
7. Slide fly boom assembly into the base boom section. Shim boom, if necessary, for a total of 1/32 in. (0.8 mm) clearance.
8. Install wear pads into the forward position of the base boom section. Shim boom, if necessary, for a total of 1/32 in. (0.8 mm) clearance.
9. Align the cylinder with the slots at aft end of base boom section, then secure cylinder with mounting hardware.

Installation

1. Using all applicable safety precautions, carefully lift boom assembly to align the pivot holes in the boom with those of the upright.

NOTE: *The main boom alone weighs approximately 2226 lbs. (1010 kg). Including the slave cylinder, rotator, and platform support the assembly weighs approximately 3185 lbs. (1445 kg).*

2. Using a suitable brass drift and hammer, install the pivot pin into the upright. Install the bolt and keeper pin securing the boom pivot pin to the upright.

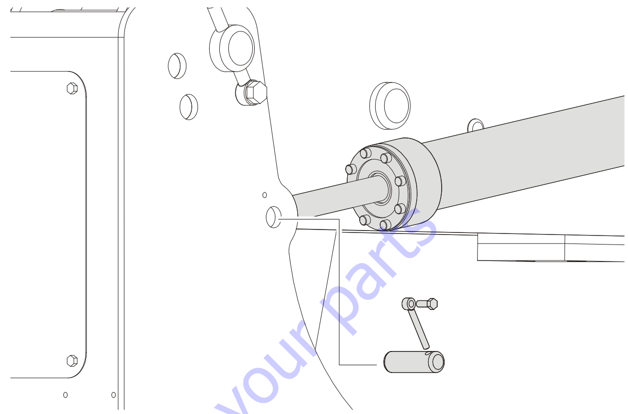


3. Install the Master Cylinder as follows:

   a. Using an adequate supporting device, align the master cylinder with the mounting holes on the boom and upright.

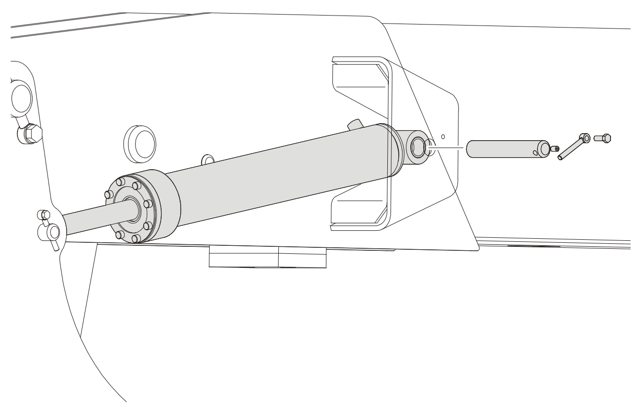
NOTE: *The master cylinder weighs approximately 58.5 lbs. (26.5 kg).*

   b. Install the master cylinder rod end pin. Install the bolt and keeper pin securing the master cylinder rod end pin to the upright.



NOTE: *When installing the master cylinder rod end pin, insert the keeper hardware pin to prevent the pin from inserting too far.*

   c. Install the barrel end retaining pin. Install the bolt and keeper pin securing the master cylinder barrel end pin to the base boom section.



   d. Connect hydraulic lines to the master cylinder as tagged during removal.

4.7 UPRIGHT

Removal

NOTICE

HYDRAULIC LINES AND PORTS SHOULD BE CAPPED IMMEDIATELY AFTER DISCONNECTING LINES TO AVOID ENTRY OF CONTAMINANTS INTO SYSTEM.

1. Remove the main boom.
2. Tag and disconnect hydraulic lines to main boom lift cylinder. Use a suitable container to collect any residual hydraulic fluid. Cap hydraulic lines and ports.
3. Remove mounting hardware from main boom lift cylinder barrel end. Using a suitable brass drift and hammer, remove pin #1 from upright and remove main boom lift cylinder.
4. Disconnect wiring harness to horizontal limit switch.
5. Upright Level Cylinder Removal.
    a. Using a suitable lifting device, support the upright.
    b. Remove mounting hardware securing hose bracket in upright, and remove the hose bracket.
    c. Remove mounting hardware from the upright level cylinder. Using a suitable brass drift and hammer, remove pin #3 from upright.
    d. Remove Upright Level Cylinder from upright.

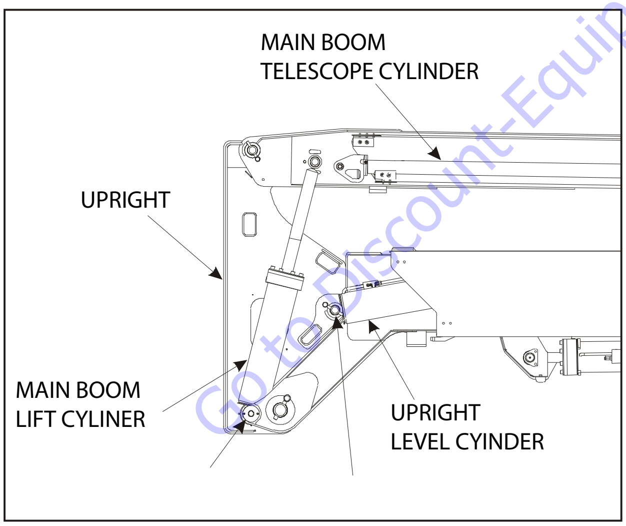


Figure 4-6. Location of Components - Upright

6. Remove mounting hardware from the Upright Pivot Pin using a suitable brass drift and hammer. Remove pin # 4 from tower boom assembly.

Upright Level Cylinder Removal

1. With upright removed, override tower telescope limit switch and extend the tower boom to gain access to the upright level cylinder barrel end attach pin.
2. Tag and disconnect hydraulic lines to the upright lift cylinder. Use a suitable container to collect any residual hydraulic fluid. Cap hydraulic lines and ports.
3. Using an overhead crane or suitable lifting device, support the upright lift cylinder, remove mounting hardware from the barrel end of the upright lift cylinder and remove the pin.
4. Carefully remove the upright lift cylinder and place on a suitable work surface.

Installation

NOTE: *Steps 1 through 4 are only necessary if the upright level cylinder is to be removed.*

1. Using a suitable lifting device, carefully install the upright lift cylinder into place in the tower boom.
2. Install the pin and mounting hardware at the barrel end of the upright lift cylinder.
3. Connect the hydraulic lines to the upright lift cylinder as tagged during removal.
4. Override the tower telescope limit switch and retract the tower boom.
5. Using an adequate lifting device, install the upright into position. Install pin #4 into the tower boom assembly and secure it in place with the mounting hardware.
6. Connect the Upright Level Cylinder as follows:
    a. Align the holes in the cylinder and upright for pin #3, and install the pin into the upright and connect the upright level cylinder to the upright. Install the mounting hardware securing the pin.
    b. Install the hose bracket and secure in place with the mounting hardware.
7. Connect the wiring harness to horizontal limit switch.
8. Align the holes in the main boom lift cylinder and upright for pin #1 and install the pin. Secure the pin in place with the mounting hardware.
9. Connect the hydraulic lines to the main boom lift cylinder as tagged during removal.
10. Install the main boom. Refer to Section 4.7, Main Boom Assembly.

4.8 TOWER BOOM ASSEMBLY

Removal

NOTICE

HYDRAULIC LINES AND PORTS SHOULD BE CAPPED IMMEDIATELY AFTER DISCONNECTING LINES TO AVOID ENTRY OF CONTAMINANTS INTO SYSTEM.

1. Remove the main boom assembly. Refer to Section 4.6, Main Boom Assembly.
2. Remove the upright. Refer to Section 4.7, Upright.
3. Using an overhead crane or suitable lifting device, support the entire Tower Boom Assembly and separately support the tower lift cylinder.
4. Remove mounting hardware from tower lift cylinder rod end. With a brass drift and hammer, remove the tower lift cylinder pin #1 disconnecting the tower lift cylinder.
5. Remove mounting hardware from the tower boom pivot pin. Using a suitable brass drift and hammer, remove pin #2 from turntable assembly.
6. Using all applicable safety precautions, carefully lift the Tower Boom Assembly clear of turntable and lower to ground or a suitable supported work surface.
7. Remove mounting hardware from upright leveling cylinder rod end. Using a suitable brass drift and hammer, remove the upright cylinder pin #3, disconnecting the upright cylinder from tower boom. Remove with suitable lifting device.

Inspection

NOTE: *Refer to Section 2, Pins and Composite Bearing Repair Guidelines.*

1. Inspect tower boom pivot pin for wear scoring, tapering, and ovality, or other damage. Replace pins as necessary.
2. Inspect tower boom pivot attach points for scoring, tapering, and ovality, or other damage. Replace pins as necessary.
3. Inspect inner diameter of tower boom pivot bearings for scoring, distortion, wear, or other damage.
4. Inspect lift cylinder attach pin for wear, scoring, tapering, and ovality, or other damage. Ensure pin surfaces are protected prior to installation. Replace pins as necessary.
5. Inspect inner diameter of upright attach point bearings for scoring, distortion, wear, or other damage. Replace bearing as necessary. (See Section 5 Cylinder Repair for Bearing Replacement).
6. Inspect all threaded components for damage such as stretching, thread deformation, or twisting. Replace as necessary.
7. Inspect structural units of tower boom assembly for bending, cracking, separation of welds, or other damage. Replace boom sections as necessary.

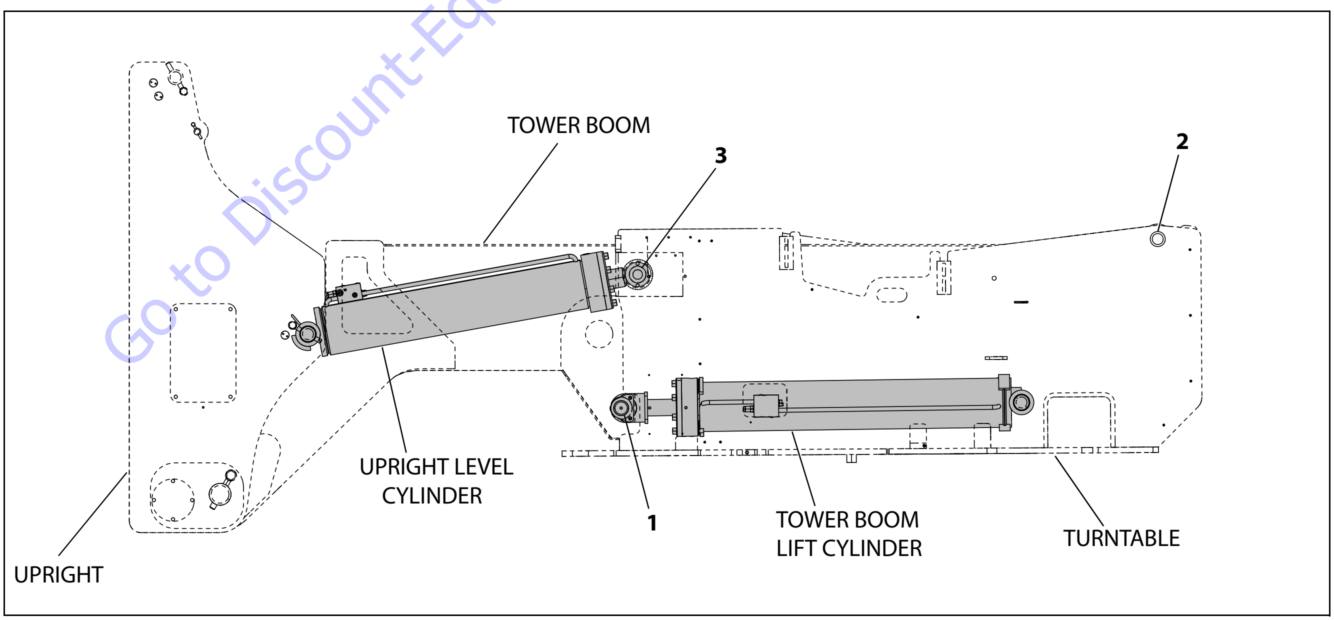


Figure 4-7. Tower Boom Removal

Installation

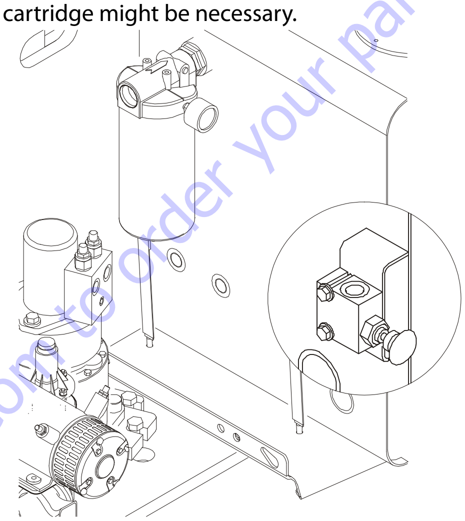
1. Using a suitable lifting device, position the tower boom such as to align upright leveling cylinder with attach holes in tower boom. Using a soft head mallet, install the cylinder pin into tower boom and secure with mounting hardware.
2. Using a suitable lifting device, position boom assembly on turntable so that the pivot holes in both boom and turntable are aligned.
3. Install boom pivot pin, ensuring that location of hole in pin is aligned with attach point on turntable.
4. If necessary, gently tap pin into position with soft headed mallet. Secure pin mounting hardware.
5. Connect all wiring connectors to the correct connectors.
6. Connect all hydraulic lines of boom assembly.
7. Using all applicable safety precautions, operate lifting device in order to position tower boom lift cylinder so that holes in the cylinder rod end and boom structure are aligned. Insert the lift cylinder pin, ensuring that location of hole in pin is aligned with attach point on boom.
8. Install the main boom assembly. Refer to Section 4.6, Main Boom Assembly.
9. Install the upright. Refer to Section 4.7, Upright.
10. Using all applicable safety precautions, operate from the lower controls and raise boom fully, noting the performance. Lower the boom, noting the performance.

Tower Out of Sync

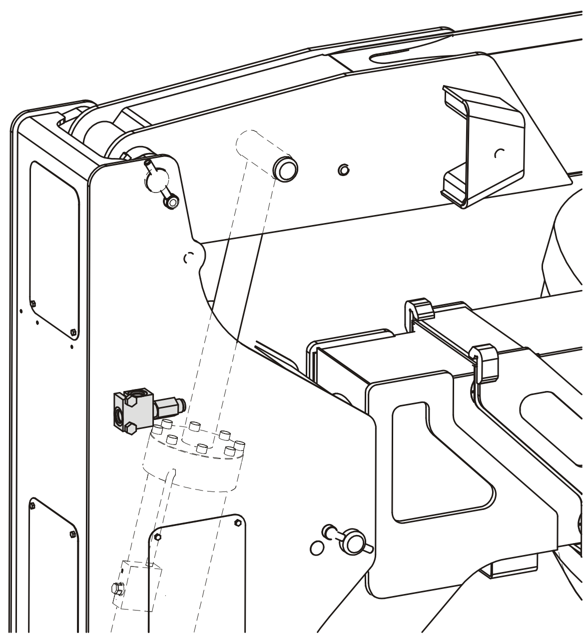
Tower is out of sync backwards, upright leaning toward the platform.

When towering down the upright cylinder bottoms out before the lower lift. Problems that could cause this are:

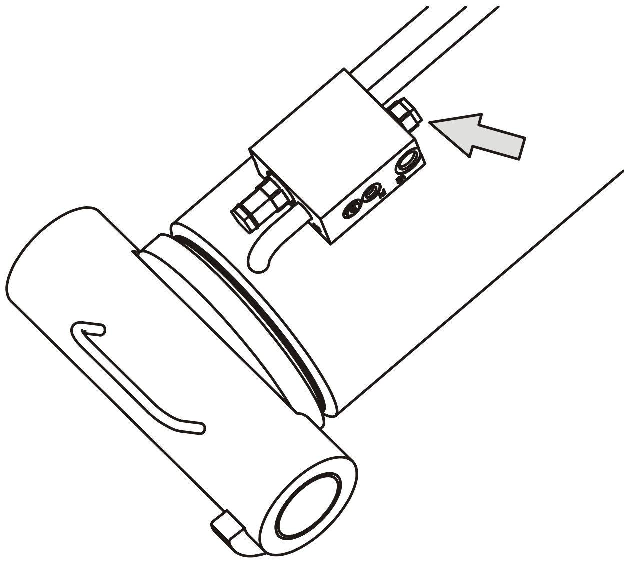
1. The releveling valve (red knob on the oil tank P/N: 4640866), this is a poppet valve that could be leaking fluid out of the closed loop. Manually opening the valve and flushing it can eliminate any contaminate on the seat. The seat could also be damaged, so replacing the cartridge might be necessary.



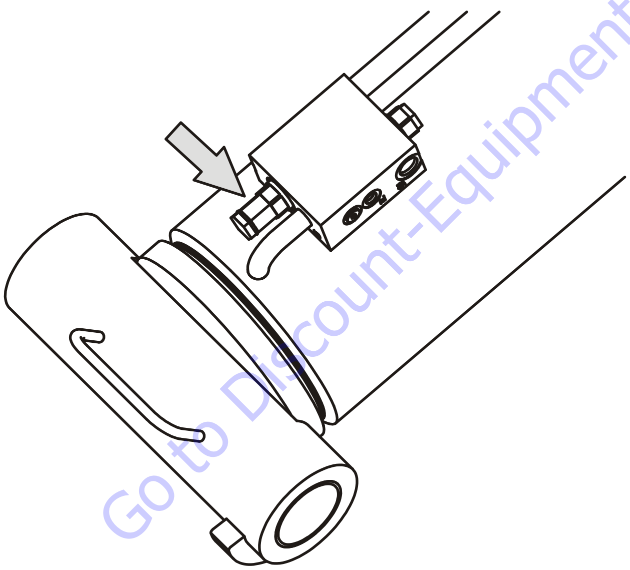
2. A relief valve is located in the upright (P/N: 4640929). This relief valve could be leaking backwards out of the loop. Replace the cartridge. They are pre-set.



3. The counterbalance valve in the piston end of the upright level cylinder. There could be a leak path from the valve port to the pilot port. Replace the counterbalance valve.



4. The counterbalance valve in the rod end of the lower lift cylinder. There could be a leak path from the valve port to the pilot port. Replace the counterbalance valve.

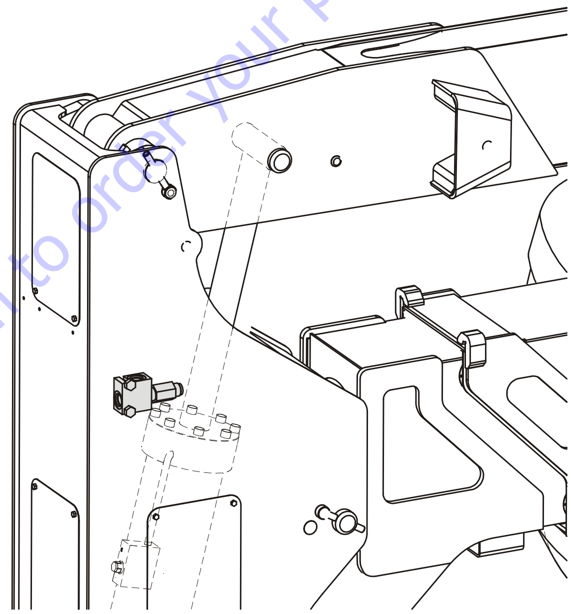


5. The packing on either the upright or lower cylinder can cause this. Do cylinder tests to determine if either cylinder needs new packing.

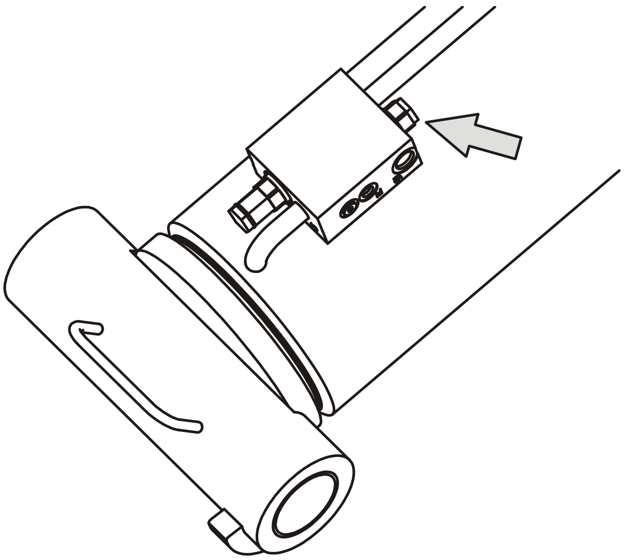
Tower is out of sync forwards, upright leaning toward the steer axle.

When towering down, the lower lift cylinder bottoms out before the upright level cylinder. This is caused by too much oil between the two cylinders. Problems that could cause this are:

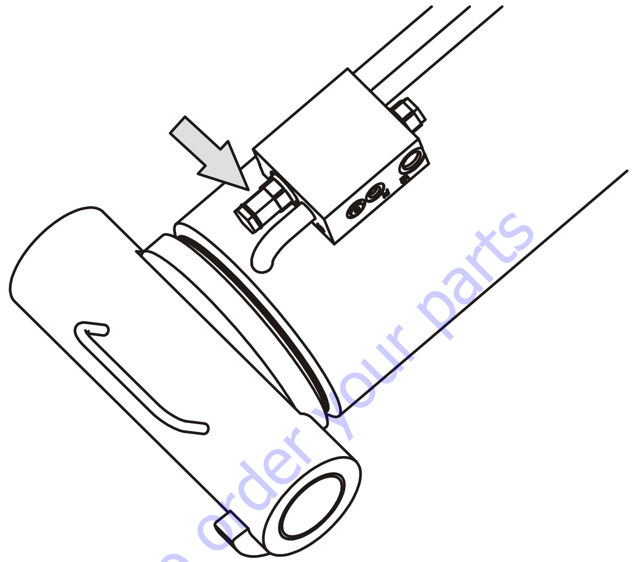
1. The relief valve located in the upright (P/N: 4640929). If this valve is set too low or has contaminate in it causing it to leak prematurely, when lifting down oil can pass through it causing the volume to grow between the cylinders. Flush the valve out and reinstall it, or replace the cartridge. The cartridge pressure is pre-set so no adjustment can be made.



2. The counterbalance valve in the piston end of the upright level cylinder. There could be a leak path from the pilot port to the valve port. Replace the counterbalance valve.



3. The counterbalance valve in the rod end of the lower lift cylinder. There could be a leak path from the pilot port to the valve port. Replace the counterbalance valve.



4. The packing on the lower lift cylinder can cause this. Do a cylinder test to check this out. Refer to Section 2.4, Cylinder Drift Test.

4.9 ARTICULATING JIB BOOM

Removal

1. For platform/support removal see platform/support removal diagram.
2. Position the articulating jib boom level with the ground.
3. Remove mounting hardware from slave cylinder pin #1. Using a suitable brass drift and hammer, remove the cylinder pin from articulating jib boom.
4. Remove mounting hardware from articulating jib boom pivot pin #2. Using a suitable brass drift and hammer, remove the pivot pin from boom assembly.

Disassembly

1. Remove mounting hardware from articulating jib boom pivot pins #3 and #4. Using a suitable brass drift and hammer, remove the pins from articulating jib boom pivot weldment.
2. Remove mounting hardware from rotator support pins #5 and #6. Using a suitable brass drift and hammer, remove the pins from rotator support.
3. Remove mounting hardware from lift cylinder pin #7. Using a suitable brass drift and hammer, remove the cylinder pin from articulating jib boom.

Inspection

NOTE: *When inspecting pins and bearings Refer to Section 2 - Pins and Composite Bearing Repair Guidelines.*

1. Inspect articulating fly boom pivot pin for wear, scoring, tapering and ovality, or other damage. Replace pins as necessary.
2. Inspect articulating fly boom pivot attach points for scoring, tapering and ovality, or other damage. Replace pins as necessary.
3. Inspect inner diameter of articulating fly boom pivot bearings for scoring, distortion, wear, or other damage. Replace bearings as necessary.
4. Inspect lift cylinder attach pin for wear, scoring, tapering and ovality, or other damage. Ensure pin surfaces are protected prior to installation. Replace pins as necessary.
5. Inspect inner diameter of rotator attach point bearings for scoring, distortion, wear, or other damage.
6. Inspect all threaded components for damage such as stretching, thread deformation, or twisting. Replace as necessary.
7. Inspect structural units of articulating jib boom assembly for bending, cracking, separation of welds, or other damage. Replace boom sections as necessary.

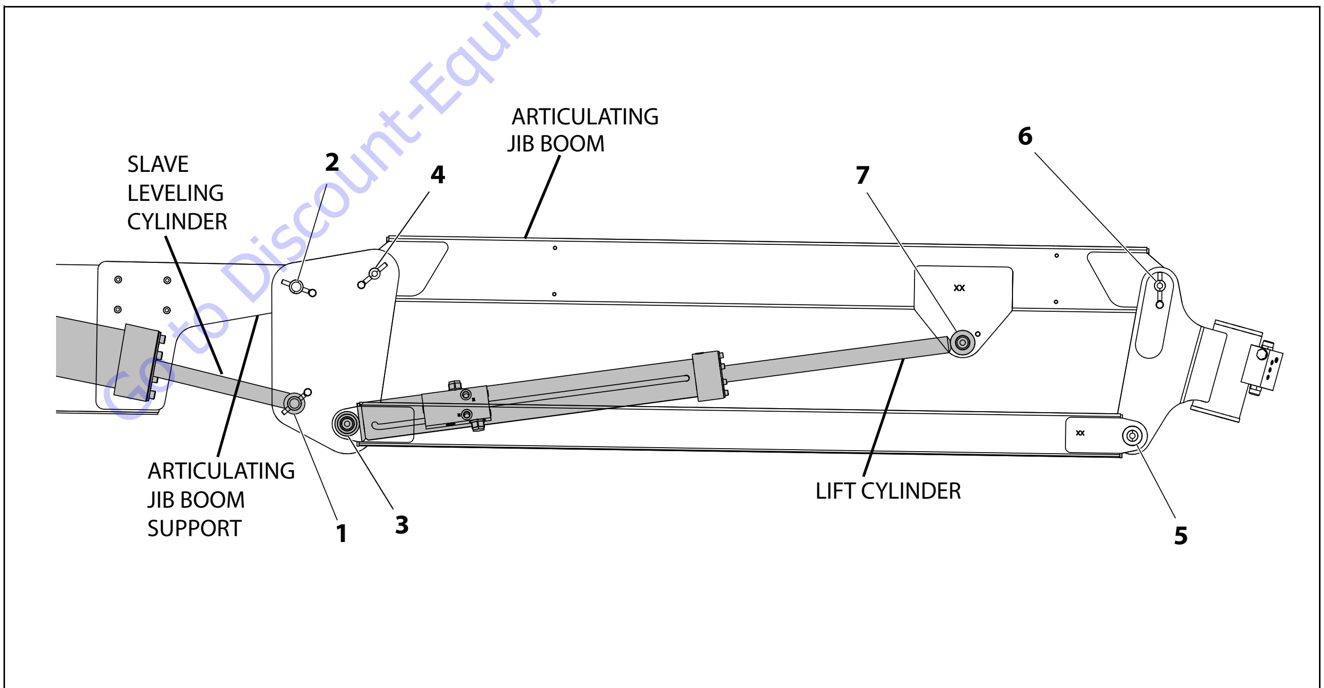


Figure 4-8. Location of Components - Articulating Jib

Assembly

1. Align lift cylinder with attach holes in articulating jib boom. Using a soft head mallet, install cylinder pin #7 into articulating jib boom and secure with mounting hardware.
2. Align rotator support with attach hole in articulating jib boom. Using a soft head mallet, install rotator support pin #6 into articulating jib boom and secure with mounting hardware.
3. Align bottom tubes with attach holes in rotator support. Using a soft head mallet, install rotator support pin #5 into articulating jib boom and secure with mounting hardware.
4. Align articulating jib boom with attach hole in articulating jib boom pivot weldment. Using a soft head mallet, install rotator support pin #4 into articulating jib boom and secure with mounting hardware.
5. Align bottom tubes with attach holes in articulating jib boom pivot weldment. Using a soft head mallet, install rotator support pin #3 into articulating jib boom pivot weldment and secure with mounting hardware.

Installation

1. Align articulating jib boom pivot weldment with attach holes in fly boom assembly. Using a soft head mallet, install pivot pin #2 into fly boom assembly and secure with mounting hardware.
2. Align the slave leveling cylinder with attach holes in articulating jib boom pivot weldment. Using a soft head mallet, install slave leveling cylinder pin #1 into articulating jib boom pivot weldment and secure with mounting hardware.

4.10 LIMIT SWITCHES ADJUSTMENT

Main Boom Horizontal Limit Switch

1. Place machine on level surface.
2. Raise main boom to 10 degrees above horizontal. The main angle limit switch should activate before this point.
3. Lower main boom until limit switch resets. This should be 1 degree above to 4 degrees below horizontal (See Figure 4-9. for adjustments).

NOTE: *Angle indicator should be placed approx. 2 ft. from the main boom pivot pin and the attach point on the main boom. Tower angle switch must be reset before main boom angle switch can be activated.*

Tower Boom Horizontal Limit Switch

1. Place machine on level surface.
2. Raise Tower Boom to 13 degrees above horizontal. The tower angle limit switch should activate at this point.
3. Lower the tower boom until the limit switch resets. This should be 2 to 7 degrees below where the switch was activated.

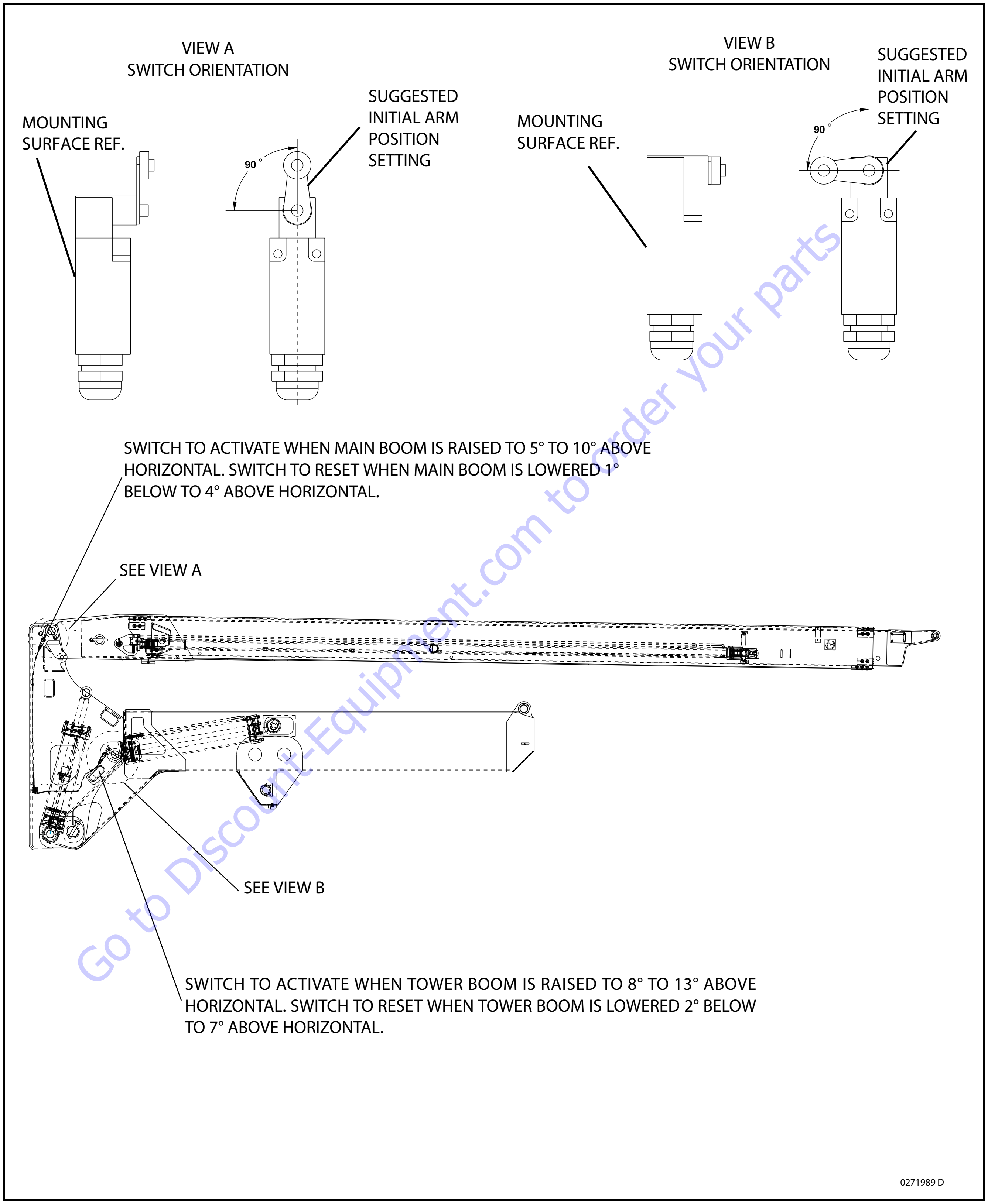


Figure 4-9. Boom Valve and Limit Switches Location - Sheet 1 of 2

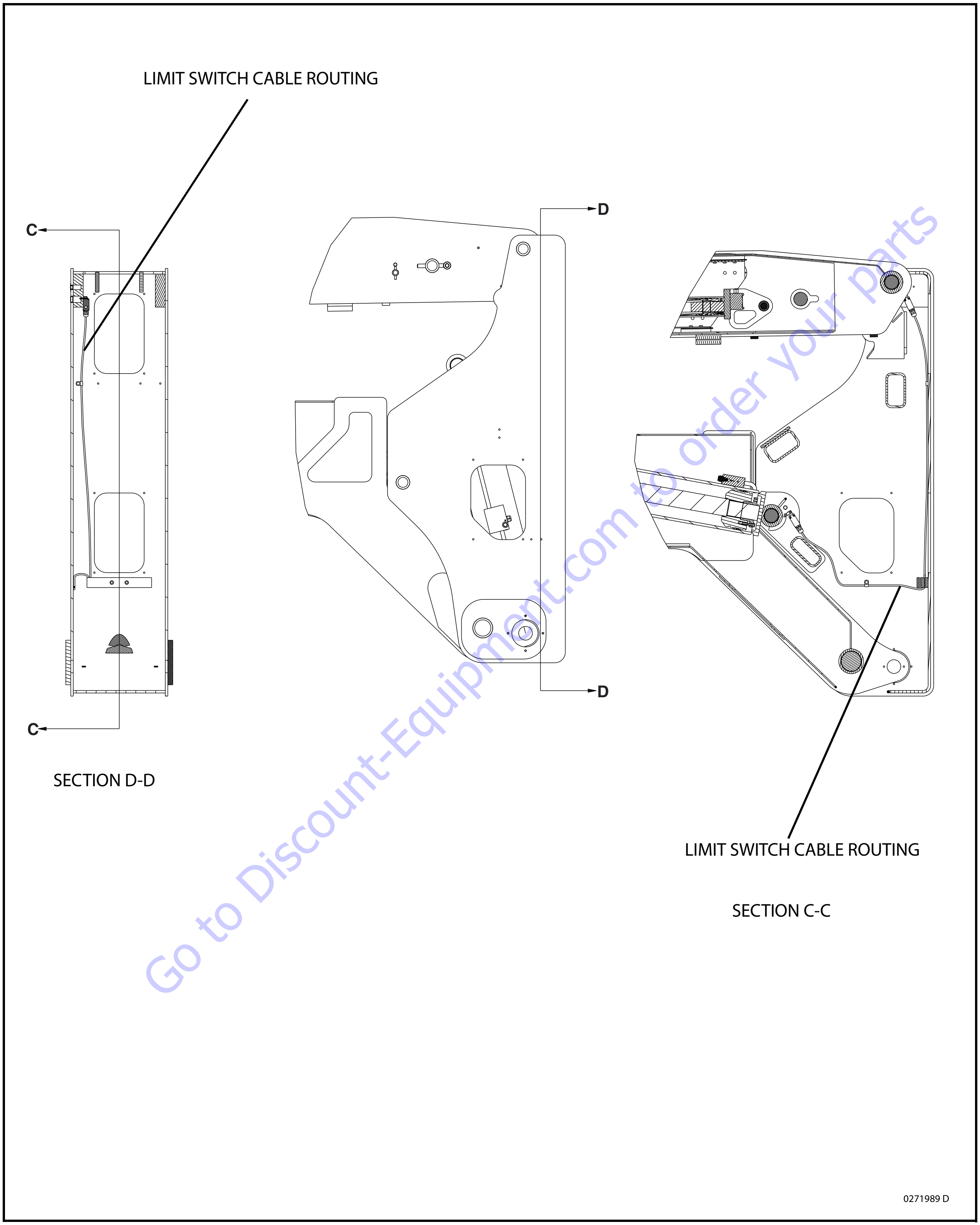


Figure 4-10. Boom Valve and Limit Switches Location - Sheet 2 of 2

4.11 PLATFORM

Platform Sections Replacement

The platform is made up of five sections: floor, right side, left side, back (console box mounting) and gate. The sections are secured with huck magna grip fastener and collars. Replace damaged platform sections as follows:

1. Support the huck collar with a sledge hammer or other suitable support.
2. Using a hammer and chisel, remove the collar from the fastener as shown in the diagram below.

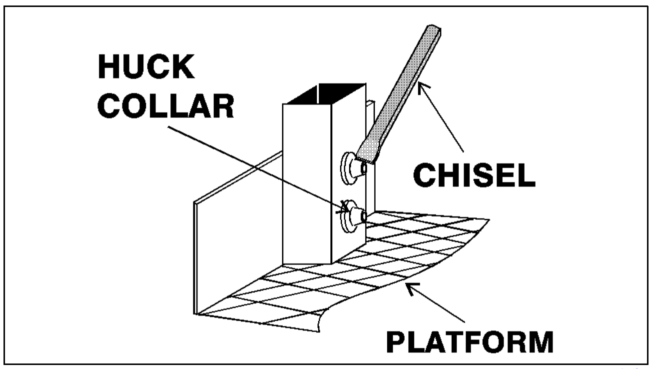


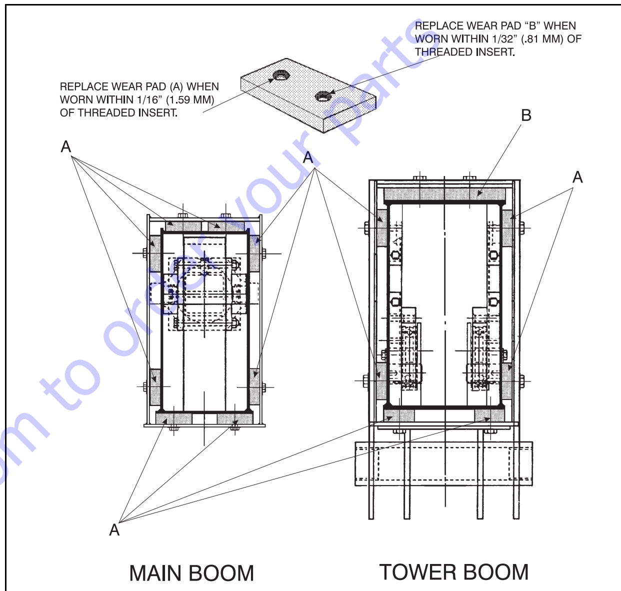
Figure 4-11. Platform Section Replacement

3. When installing new section of platform replace fasteners with 1/4 x 20 NC x 2 1/4" grade 5 bolts, flatwashers and locknuts.
4. When installing a new gate to platform, replace rivets with 1/4 x 20 NC x 2" grade 5 bolts, flatwashers and locknuts.

4.12 WEAR PADS

Tower Boom

1. Shim up wear pads until 1/32 in. (0.79 mm) clearance to adjacent surface.
2. Replace wear pads when worn to within 1/16 in. (1.59 mm) of threaded insert.



WEAR PADS		
PAD NUMBER	THICKNESS OF NEW PAD	REPLACE WHEN WORN TO
A	5/8	9/16
B	3/4	5/8

Figure 4-12. Location and Thickness of Wear Pads

NOTE: *Wear pads are made of polyethylene; these pads are intended to slide on polyurethane painted surfaces.*

3. When adjusting wear pads, removing or adding shims, bolt length must also be changed.
   - **a.** When adding shims, longer bolts must be used to ensure proper thread engagement in insert.
   - **b.** When shims are removed, shorter bolts must be used so bolt does not protrude from insert and come into contact with boom surface.

Main Boom

1. Shim up wear pads to within 1/32 in. (0.79 mm) clearance between wear pad and adjacent surface.
2. Replace wear pads when worn within 1/16 in. (1.59 mm) and 1/8 in. (3.18 mm) - B, C, D of threaded insert. See Figure 4-12., Location and Thickness of Wear Pads.
3. Adjusting wear pads, removing or adding shims, bolt length must also be changed.
   - **a.** When adding shims, longer bolts must be used to ensure proper thread engagement in insert.
   - **b.** When shims are removed, shorter bolts must be used so bolt does not protrude from insert and Sheaves and wire rope must be replaced as sets.

4.13 ROTATOR - HELAC (PRIOR TO SN 0300130881)

Disassembly

1. Place actuator on a clean workbench.
2. Remove all hydraulic fittings.
3. Using a suitable hammer and chisel remove the portion of end cap securing setscrew.

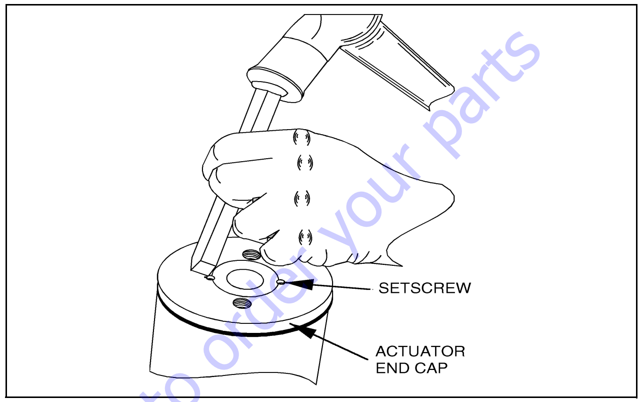


Figure 4-13. Removing Portion of End Cap

4. Using a torch, apply heat to the setscrews on the bottom of actuator.

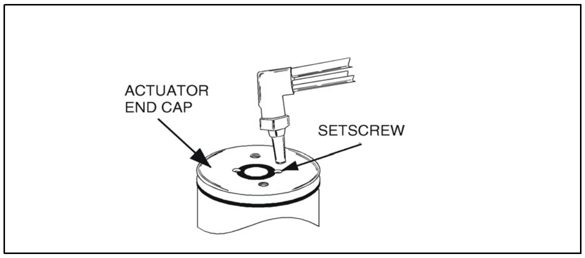


Figure 4-14. Heating Setscrews

5. Remove the two (2) setscrews (4) from bottom of the actuator (1). Discard setscrew.

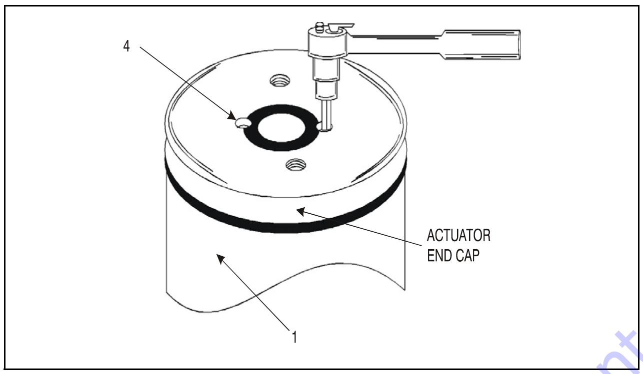


Figure 4-15. Removing Setscrew

6. Place two (2) 3/8"x16 NC bolts in threaded holes in bottom of the actuator. Using a suitable bar, unscrew the end cap (5). Remove the end cap from actuator (1).

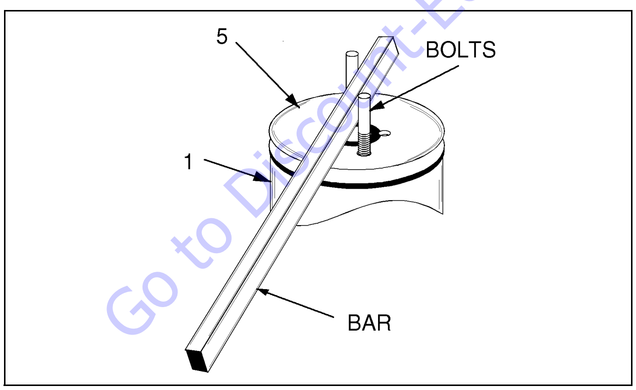


Figure 4-16. Removing End Cap

7. Remove the shaft (2) from piston sleeve (3) and the actuator housing (1).

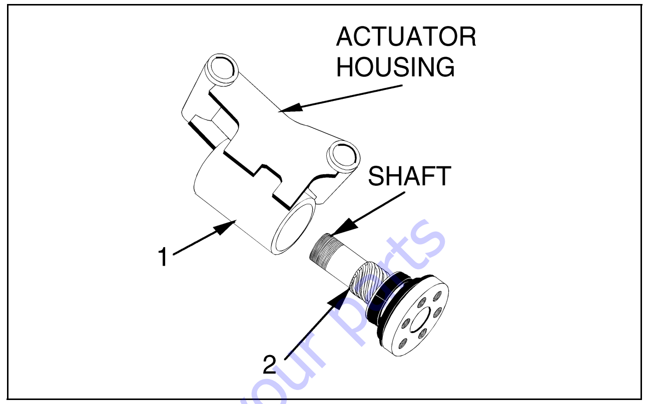


Figure 4-17. Removing Shaft from Housing

8. Remove piston sleeve (3) from housing (1).

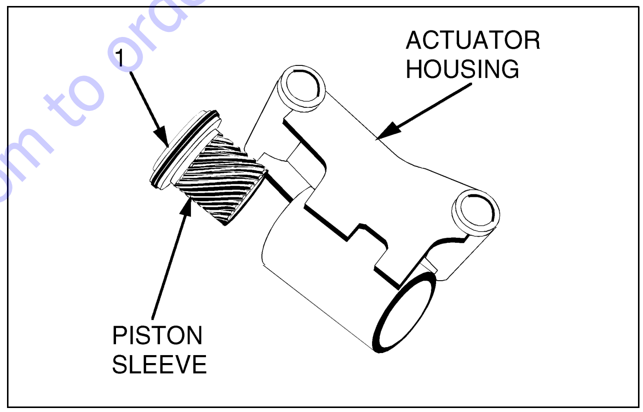


Figure 4-18. Removing Sleeve from Housing

9. Remove all seals and bearings from grooves. Discard seals.

Inspection

1. Clean all parts thoroughly.

2. Closely inspect all parts for excessive wear, cracks and chips. Replace parts as necessary.

NOTE: *A small amount of wear in the spline teeth will have little effect on the actuator strength. New spline sets are manufactured with a backlash of about 0.005 in. per mating set. After long service, a backlash of about 0.015 per set may still be acceptable in most cases, depending on the required accuracy of the application.*

3. Check the ring gear for wear and weld damage to the pins.

4. Inspect the cylinder bore for wear and scratches.

Assembly

NOTE: *Lubricate all seals and o-rings with clean hydraulic oil prior to assembly.*

1. Install piston seal (7) and rod seal (6) on the piston sleeve (3).

NOTE: *Apply a coat of grease to the thrust ring before sliding onto the shaft.*

2. Install new seal (8), thrust ring (10) and bearing (9) on shaft (2).

NOTE: *Apply a coat of grease to the thrust ring before sliding onto the end cap.*

3. Install new seals (11), backup ring (12), cap bearing (13), bearing packing (14) and thrust ring (10) on end cap (5).
4. Place the actuator in the vertical position, install the piston sleeve (3) in timed relation to the housing (1).

NOTICE

DO NOT MISALIGN THE SLEEVE TOO MUCH ANY ONE WAY, AS IT WILL MARK THE CYLINDER BORE.

NOTE: *The timing marks (the small punch marks on the face of each gear), must be aligned for proper shaft orientation (See Actuator Timing).*

5. Install the shaft (2) into housing (1) by aligning the proper punched timing marks. (See Actuator Timing Figure 4-19.)
6. Temporarily tape the threaded portion of the shaft will help installation past the shaft seals (masking tape).
7. The end cap (5) is torqued to 40-50 ft. lbs. (54 - 68 Nm), such that the actuator begins rotation at approximately 100 psi (6.895 bar) pressure.
8. The end cap must be secured against the shaft by installing axial setscrews (4).

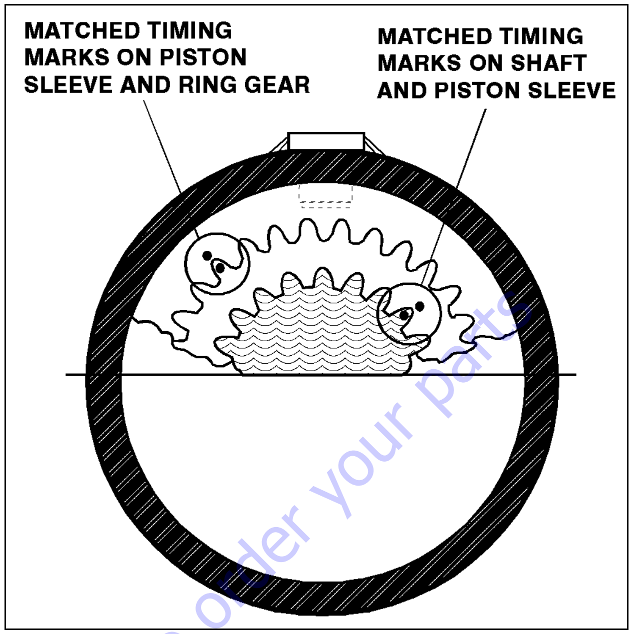
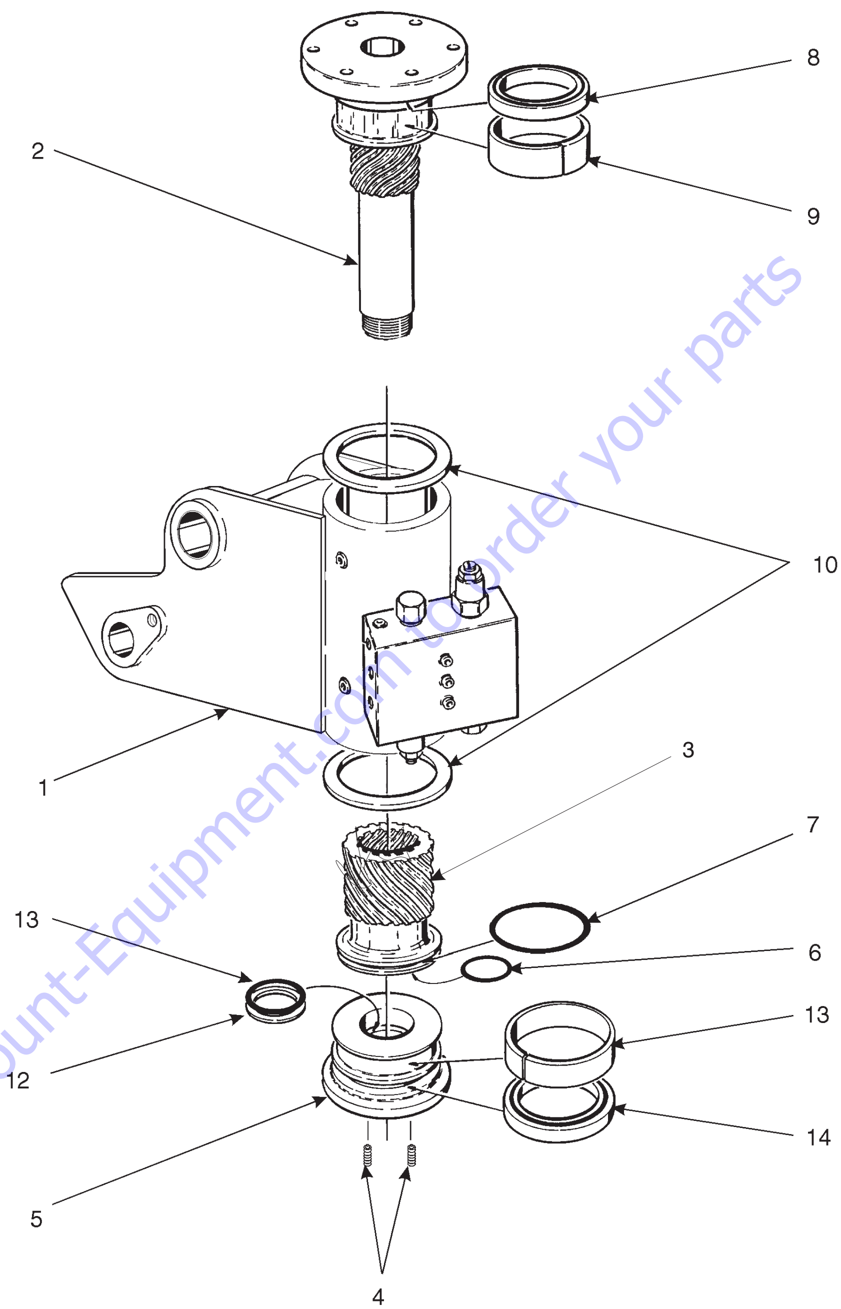


Figure 4-19. Actuator Timing



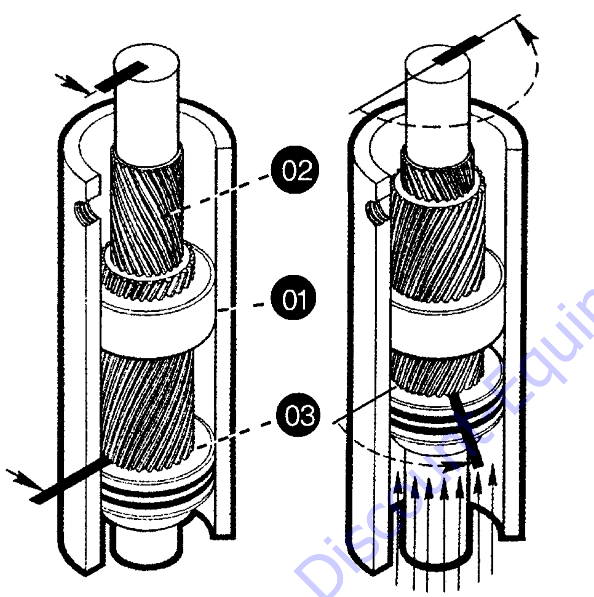
1. Housing/Ring Gear Assembly
2. Shaft
3. Piston/Sleeve Assembly
4. Set Screws
5. Cap, End
6. Seal, Rod
7. Seal, Piston
8. Packing, Bearing
9. Bearing, Shaft
10. Thrust Ring
11. Seal, Cap
12. Ring, Back-up
13. Bearing, Cap
14. packing

Figure 4-20. Rotator Assembly (HELAC)

4.14 ROTATOR ASSEMBLY (SN 0300130881 THROUGH 0300185827)

Theory of Operation

The L20 Series rotary actuator is a simple mechanism that uses the sliding spline operating concept to convert linear piston motion into powerful shaft rotation. Each actuator is composed of a housing with integrated gear teeth (01) and only two moving parts: the central shaft with integrated bearing tube and mounting flange (02), and the annular piston sleeve (03). Helical spline teeth machined on the shaft engage matching splines on the in- side diameter of the piston. The outside diameter of the piston carries a second set of splines, of opposite hand, which engage with matching splines in the housing. As hydraulic pressure is applied, the piston is displaced axially within the housing similar to the operation of a hydraulic cylinder while the splines cause the shaft to rotate. When the control valve is closed, oil is trapped inside the actuator, preventing piston movement and locking the shaft in position.



Bars indicate starting positions of piston and shaft. Arrows indicate direction they will rotate. The housing with integral ring gear remains stationary.

As fluid pressure is applied, the piston is displaced axially while the helical gearing causes the piston and shaft to rotate simultaneously. The double helix design compounds rotation: shaft rotation is about twice that of the piston.

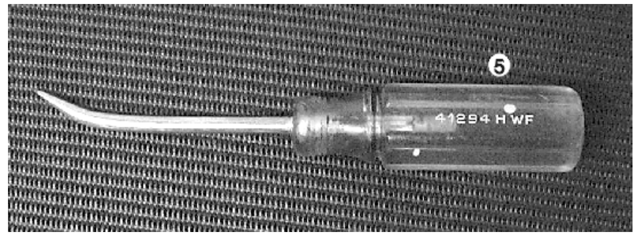
The shaft is supported radially by the large upper radial bearing and the lower radial bearing. Axially, the shaft is separated from the housing by the upper and lower thrust washers. The end cap is adjusted for axial clearance and locked in position by set screws or pins.

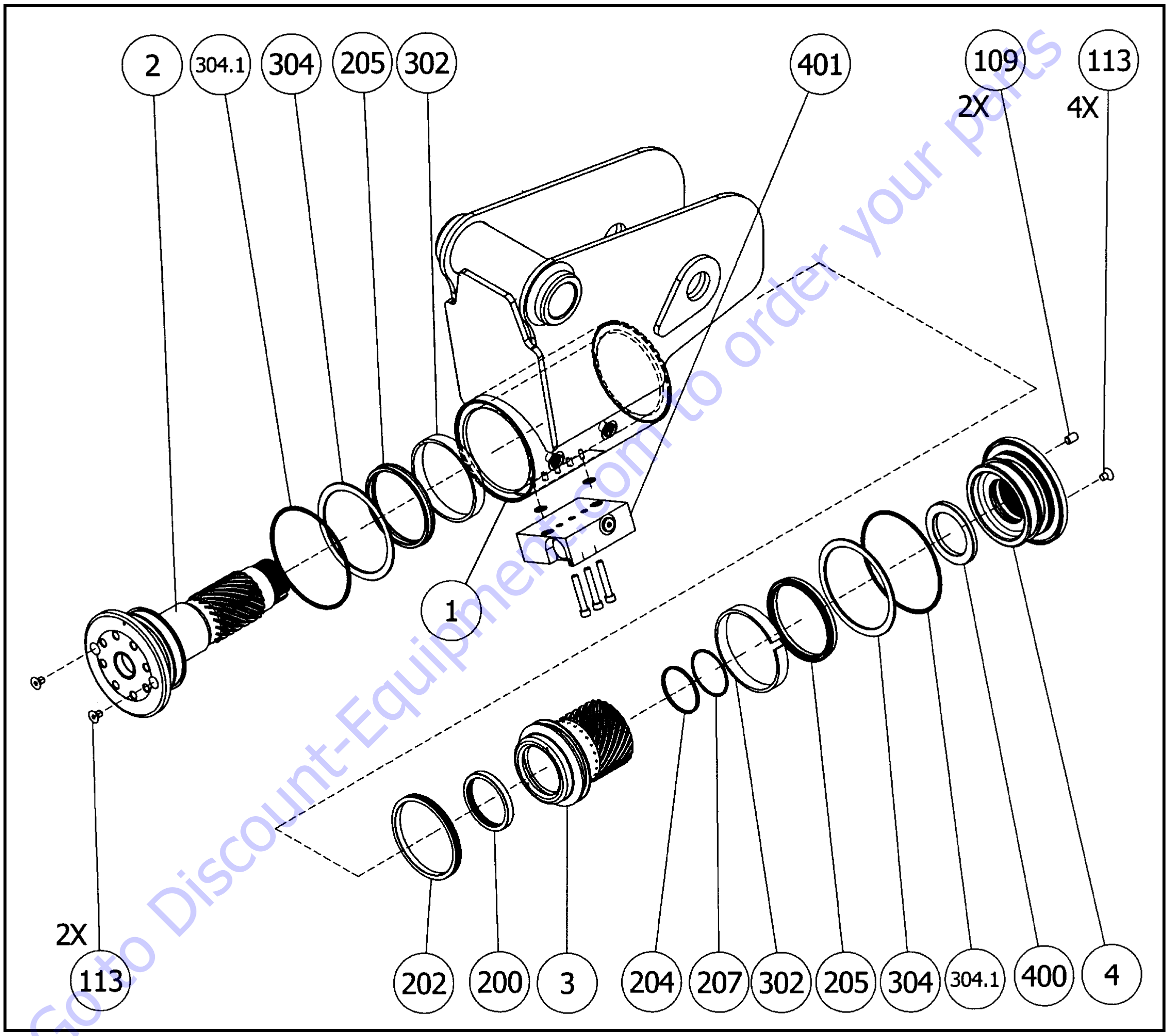
Required Tools

Upon assembly and disassembly of the actuator there are basic tools required. The tools and their intended functions are as follows:

1. Flashlight - helps examine timing marks, component failure and overall condition.
2. Felt Marker - match mark the timing marks and outline troubled areas.
3. Allen wrench - removal of port plugs and set screws.
4. Box knife - removal of seals.
5. Seal tool - assembly and disassembly of seals and wear guides.
6. Pry bar - removal of end cap and manual rotation of shaft.
7. Rubber mallet- removal and installation of shaft and piston sleeve assembly.
8. Nylon drift - installation of piston sleeve.
9. End cap dowel pins - removal and installation of end cap (sold with Helac seal kit).

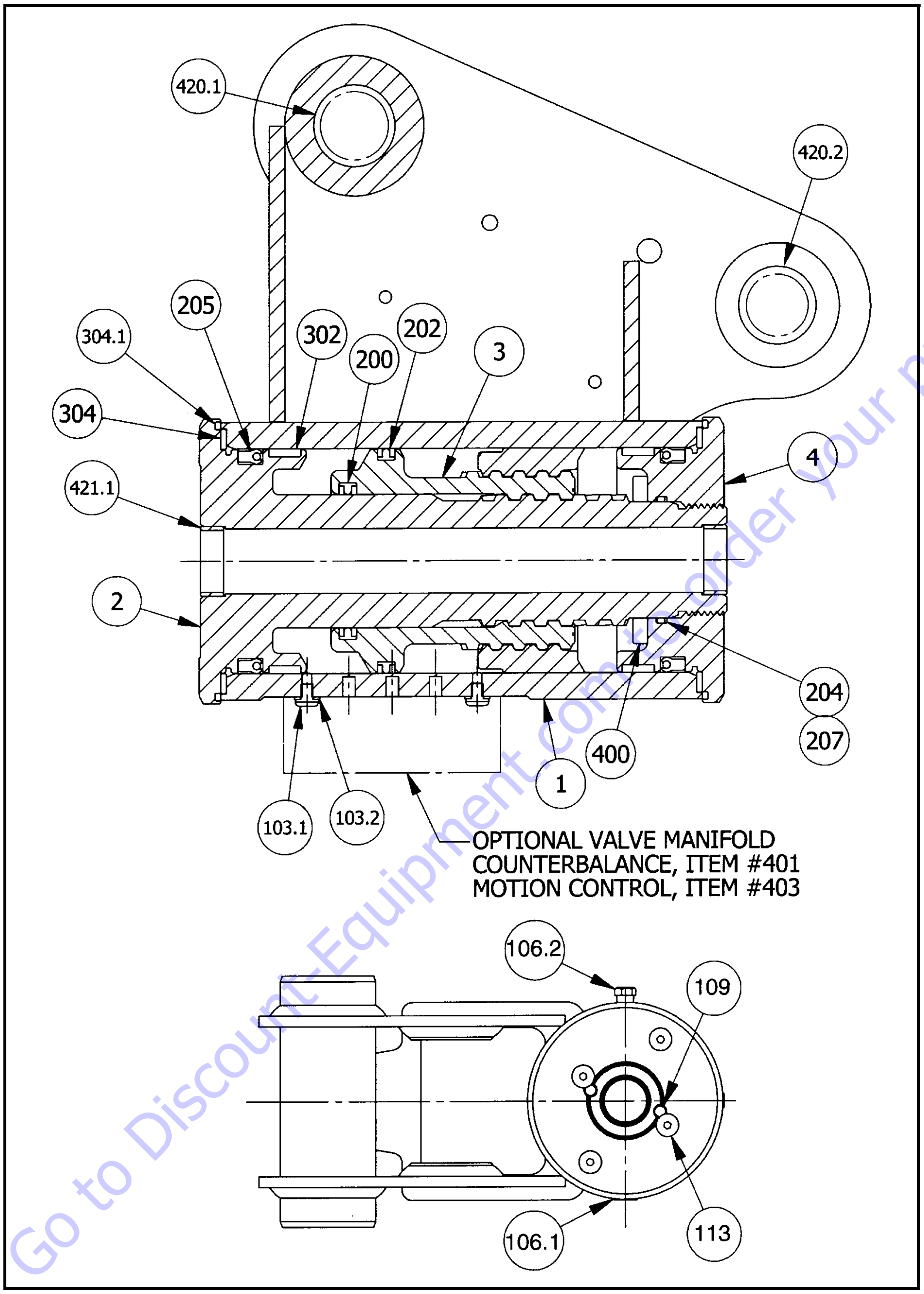
The seal tool is merely a customized standard flat head screwdriver. To make this tool you will need to heat the flat end with a torch. Secure the heated end of the screwdriver in a vice and physically bend the heated end to a slight radius. Once the radius is achieved round off all sharp edges of the heated end by using a grinder. There may be some slight modifications for your own personal preference.





PARTS	HARDWARE	SEALS	BEARINGS	ACCESSORIES
1. Housing	103.1. Screw	200. T-Seal	302. Wear Guide	400. Stop Tube
2. Shaft	103.2. Washer	202. T-Seal	304. Thrust Washer	420.1 Bushing
3. Piston Sleeve	106.1. Port Plug	204. O-ring		420.2 Bushing
4. End Cap	106.2. Port Plug	205. Cup Seal		421.1 Bushing
	109. Lock Pin	207. Backup Ring		
	113. Capscrew	304.1. Wiper Seal		

Figure 4-21. Rotator - Exploded View (SN 0300130881 through 0300185827)

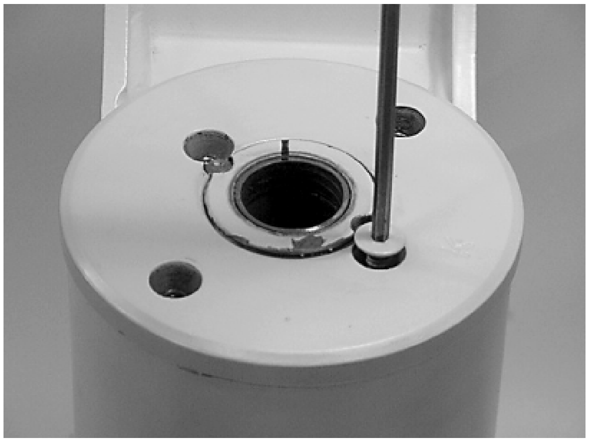


PARTS	HARDWARE	SEALS	BEARINGS	ACCESSORIES
1. Housing	103.1. Screw	200. T-Seal	302. Wear Guide	400. Stop Tube
2. Shaft	103.2. Washer	202. T-Seal	304. Thrust Washer	420.1 Bushing
3. Piston Sleeve	106.1. Port Plug	204. O-ring		420.2 Bushing
4. End Cap	106.2. Port Plug	205. Cup Seal		421.1 Bushing
	109. Lock Pin	207. Backup Ring		
	113. Capscrew	304.1. Wiper Seal		

Figure 4-22. Rotator- Assembly Drawing (SN 0300130881 through 0300185827)

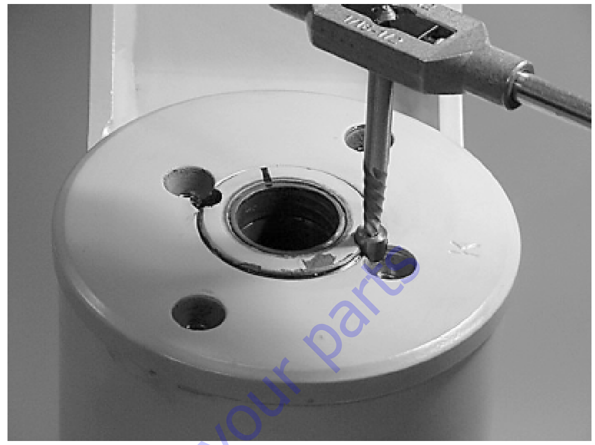
Disassembly

1. Remove the capscrews (113) over end cap lock pins (109).



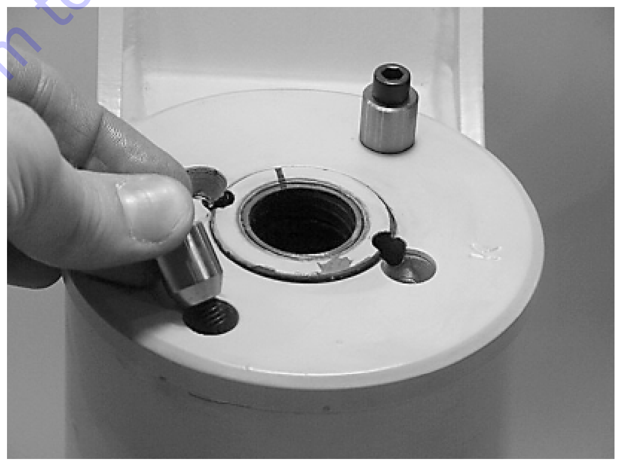
2. Using a 1/8 in. (3.18 mm) drill bit, drill a hole in the center of each lock pin to a depth of approximately 3/16" (4.76mm).

3. Remove the lock pins using an "Easy Out" (a size #2 is shown).



If the pin will not come out with the "Easy Out", use 5/16 in. drill bit to a depth of 1/2 in. (12.7 mm) to drill out the entire pin.

4. Install the end cap (4) removal tools provided with the Helac seal kit.

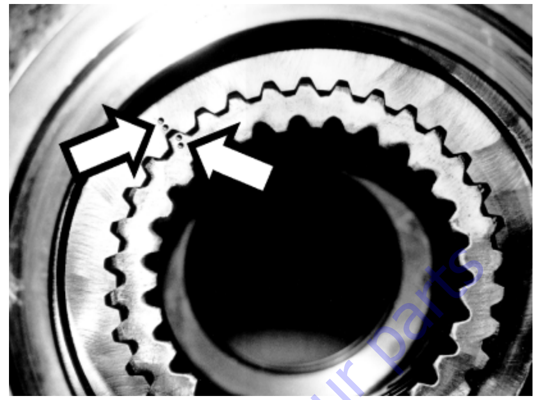


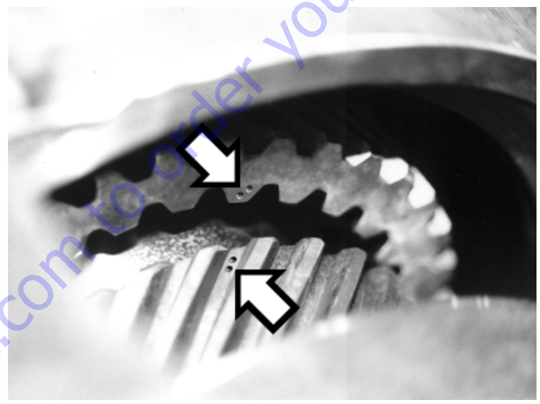
5. Using a metal bar, or something similar, unscrew the end cap (4) by turning it counterclockwise.

6. Remove the end cap (4) and set aside for later inspection.

7. Remove the stop tube if included. The stop tube is an available option to limit the rotation of the actuator.

8. Every actuator has timing marks for proper engagement.



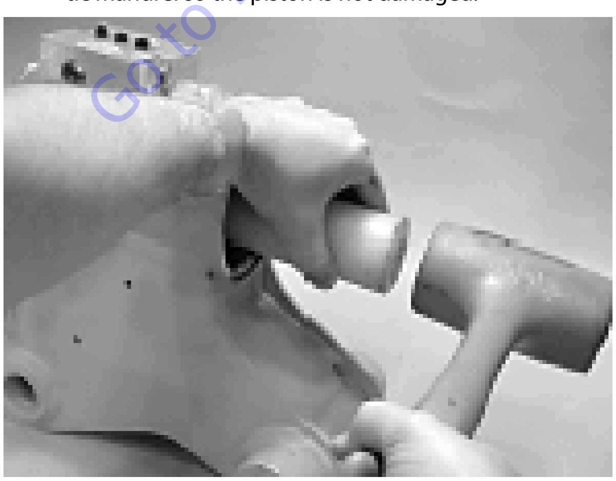


9. Prior to removing the shaft, (2), use a felt marker to clearly indicate the timing marks between shaft and piston. This will greatly simplify timing during assembly.

10. Remove the shaft (2). It may be necessary to strike the threaded end of the shaft with a rubber mallet.

11. Before removing the piston (3), mark the housing (1) ring gear in relation to the piston O.D. gear. There should now be timing marks on the housing (1) ring gear, the piston (3) and the shaft (2).

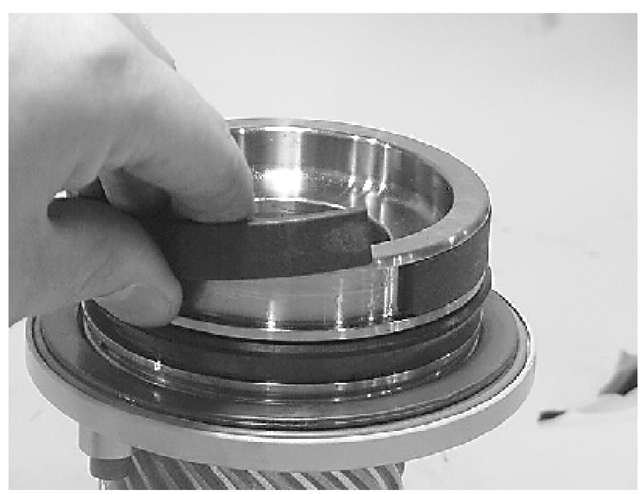
12. To remove the piston (3) use a rubber mallet and a plastic mandrel so the piston is not damaged.



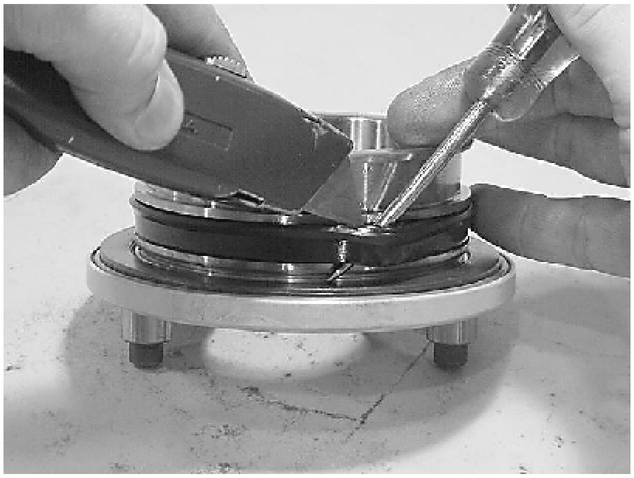
13. At the point when the piston gear teeth come out of engagement with the housing gear teeth, mark the piston and housing with a marker as shown.

14. Remove the o-ring (204) and backup ring (207) from end cap (4) and set aside for inspection.

15. Remove the wear guides (302) from the end cap (4) and shaft (2).



16. To remove the main pressure seals (205), it is easiest to cut them using a sharp razor blade being careful not to damage the seal groove.



17. Remove the thrust washers (304), from the end cap (4) and shaft (2).

18. Remove the wiper seal (304.1) from its groove in the end cap (4) and shaft (2).

19. Remove the piston O.D. seal (202).

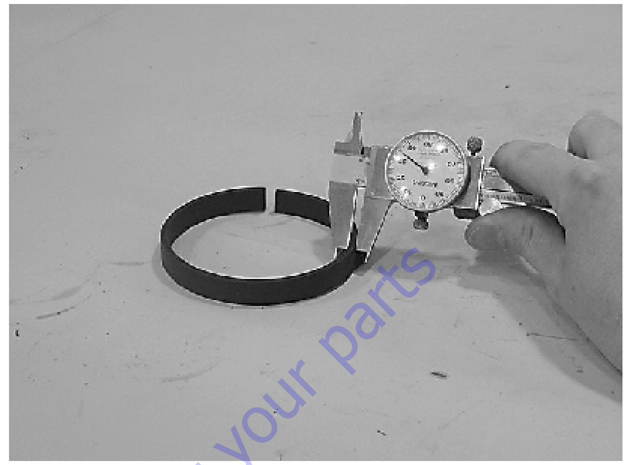
20. Remove the piston I.D. seal (200). You may now proceed to the inspection process.

Inspection

1. Clean all parts in a solvent tank and dry with compressed air prior to inspecting. Carefully inspect all critical areas for any surface finish abnormalities: Seal grooves, bearing grooves, thrust surfaces, rod surface, housing bore and gear teeth.

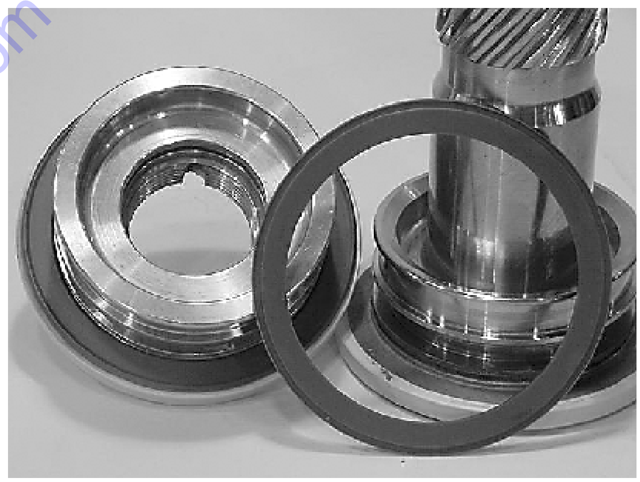
2. Inspect the thrust washers (304) for rough or worn edges and surfaces. Measure it's thickness to make sure it is within specifications (Not less than 0.092" or 2.34 mm).

3. Inspect the wear guide condition and measure thickness (not less than 0.123" or 3.12 mm).

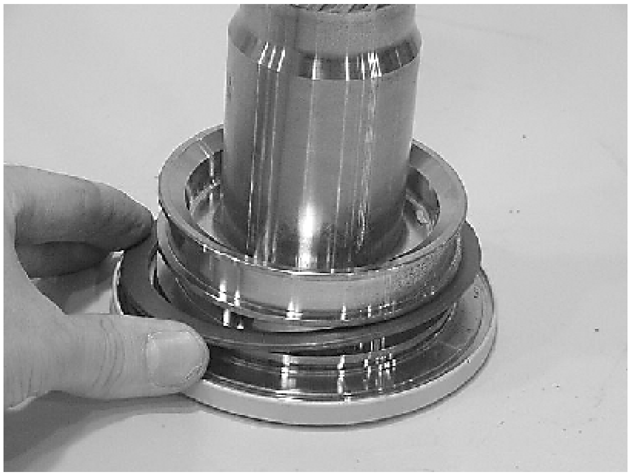


Assembly

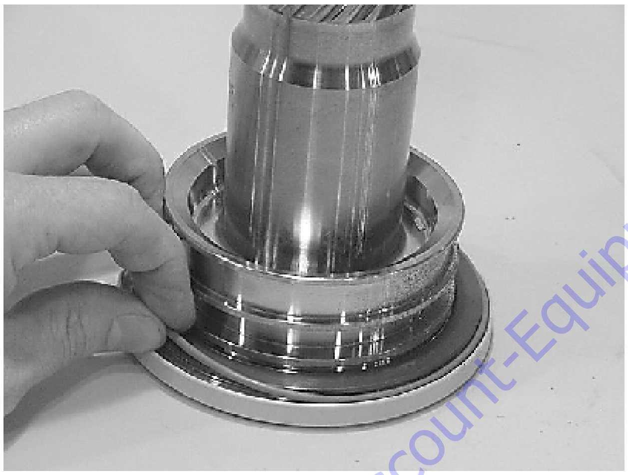
1. Gather all the components and tools into one location prior to re-assembly. Use the cut away drawing to reference the seal orientations.



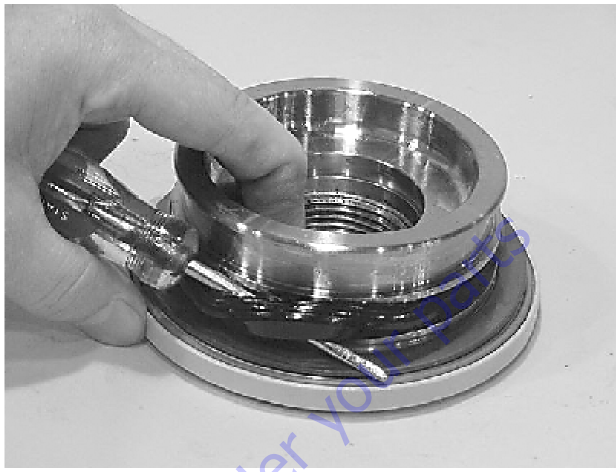
2. Install the thrust washer (304) onto shaft (2) and end cap (4).



3. Install the wiper seal (304.1/green 0-ring) into it's groove on the shaft (2) and end cap (4) around the outside edge of the thrust washer (304).



4. Using a seal tool install the main pressure seal (205) onto shaft (2) and end cap (4). Use the seal tool in a circular motion.



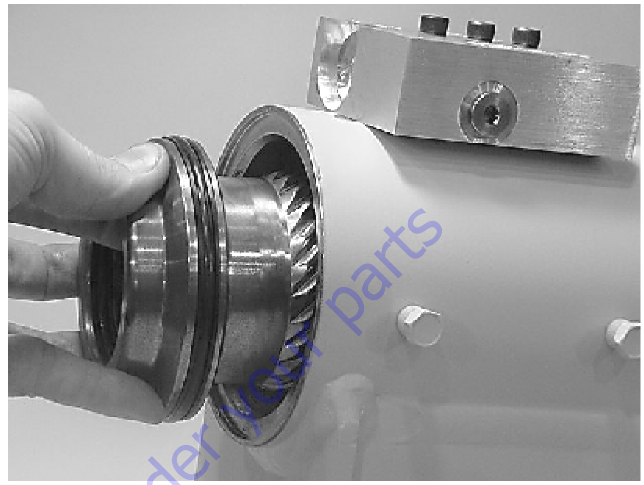
5. Install the wear guide (302) on the end cap (4) and shaft (2).

6. Install the inner T-seal (200) into the piston (3) using a circular motion. Install the outer T-seal (202) by stretching it around the groove in a circular motion. Each T-seal has 2 backup rings (see drawing for orientation).

Beginning with the inner seal (200) insert one end of b/u ring in the lower groove and feed the rest in using a circular motion. Make sure the wedged ends overlap correctly.

Repeat this step for the outer seal (202).

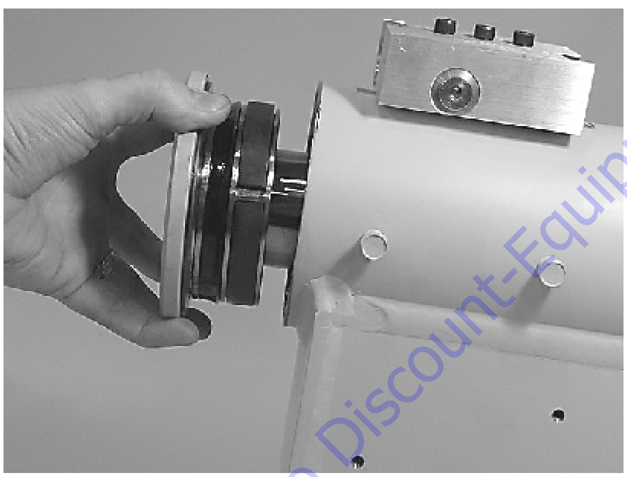
7. Insert the piston (3) into the housing (1) as shown, until the outer piston seal (202) is touching inside the housing bore.



8. Looking from the angle shown, rotate the piston (3) until the marks you put on the piston and the housing (1) during disassembly line up as shown. Using a rubber mallet, tap the piston into the housing up to the point where the gear teeth meet.

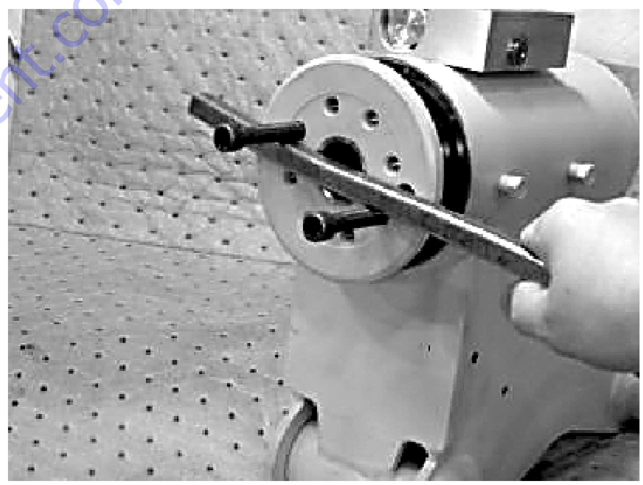
9. Looking from the opposite end of the housing (1) you can see if your timing marks are lining up. When they do, tap the piston (3) in until the gear teeth mesh together. Tap the piston into the housing the rest of the way until it bottoms out.

10. Install the shaft (2) into the piston (3). Be careful not to damage the seals. Do not engage the piston gear teeth yet.



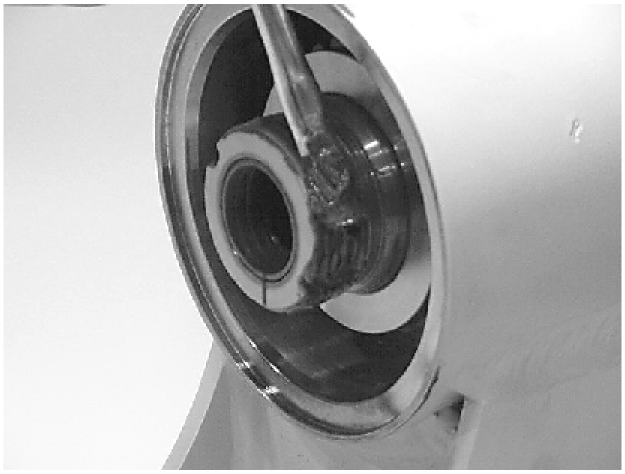
11. Looking from the view shown, use the existing timing marks to line up the gear teeth on the shaft (2) with the gear teeth on the inside of the piston (3). Now tap the flange end of the shaft with a rubber mallet until the gear teeth engage.

12. Install 2 bolts in the threaded holes in the flange. Using a bar, rotate the shaft in a clockwise direction until the wear guides are seated inside the housing bore.



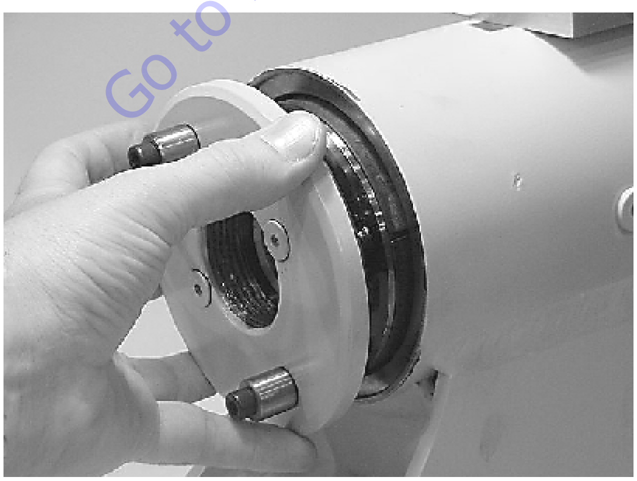
13. Install the stop tube onto the shaft end. Stop tube is an available option to limit the rotation of an actuator.

14. Coat the threads on the end of the shaft with anti-seize grease to prevent galling.



15. Install the 0-ring (204) and backup ring (207) into the inner seal groove on the end cap (4).

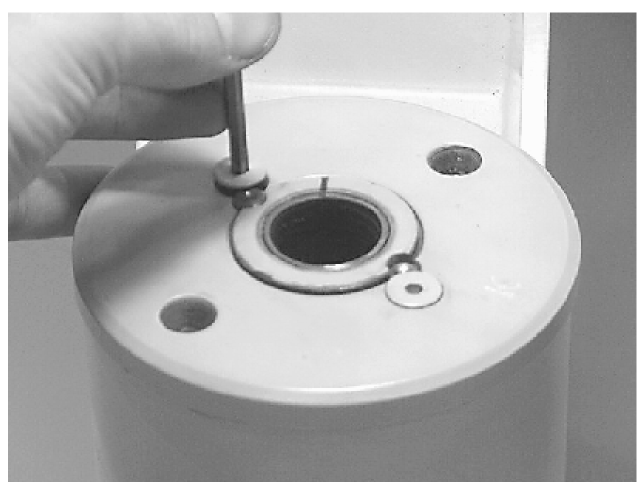
16. Thread the end cap (4) onto the shaft (2) end. Make sure the wear guide stays in place on the end cap as it is threaded into the housing (1).



17. Tighten the end cap (4). In most cases the original holes for the lock pins will line up.

18. Place the lock pins (109) provided in the Helac seal kit in the holes with the dimple side up. Then, using a punch, tap the lock pins to the bottom of the hole.

19. Insert the set screws (113) over the lock pins. Tighten them to 25 in. lbs. (2.825 Nm).



Installing Counterbalance Valve

Refer to Figure 4-23., Rotator Counterbalance Valve.

1. Make sure the surface of the actuator is clean, free of any contamination and foreign debris including old Loctite.
2. Make sure the new valve has the O-rings in the counterbores of the valve to seal it to the actuator housing.
3. The bolts that come with the valve are grade 8 bolts. New bolts should be installed with a new valve. Loctite #242 should be applied to the shank of the three bolts at the time of installation.
4. Torque the 1/4 - in. bolts 110 to 120 in. pounds (12.4 to 13.5 Nm). Do not torque over 125 in. pounds (14.1 Nm). Torque the 5/16 in. bolts 140 in. lbs. (15.8 Nm). Do not torque over 145 in. lbs. (16.3 Nm).

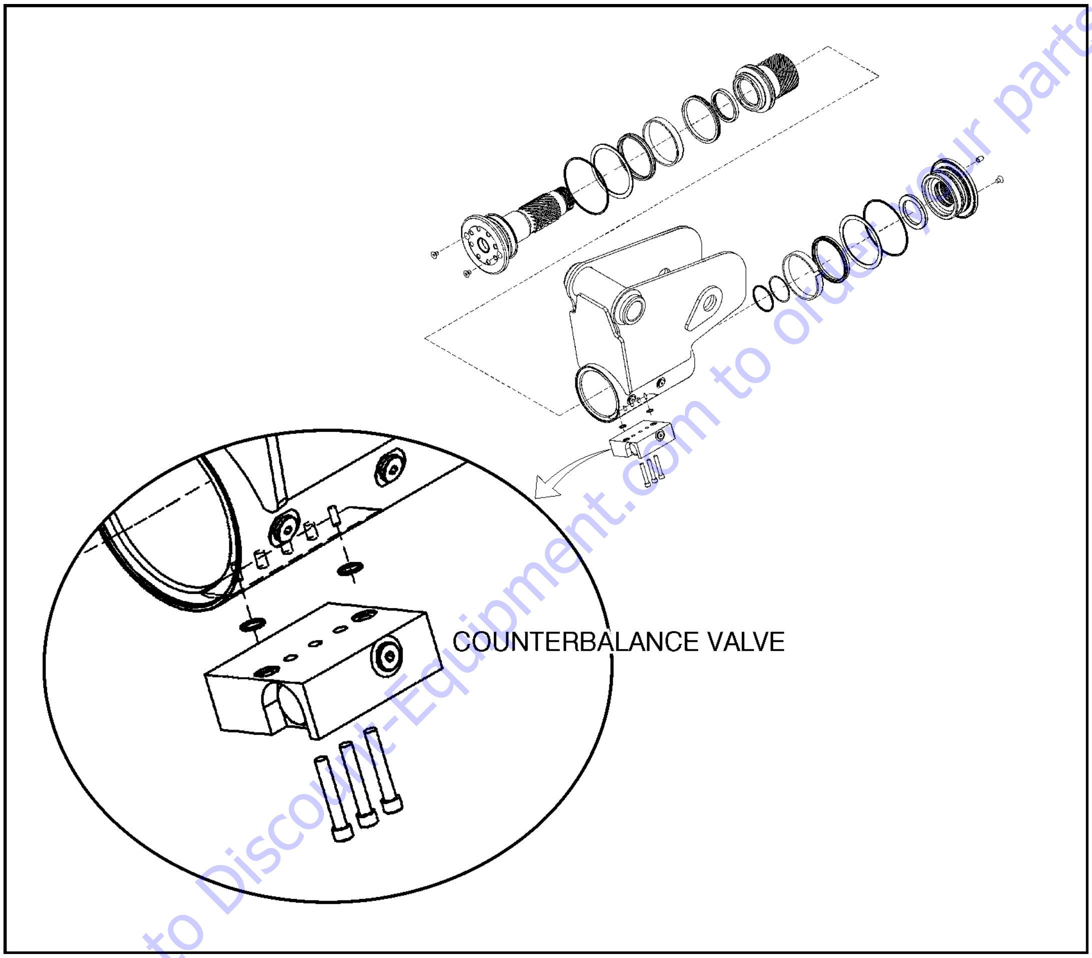


Figure 4-23. Rotator Counterbalance Valve

Testing the Actuator

If the equipment is available, the actuator should be tested on a hydraulic test bench. The breakaway pressure — the pressure at which the shaft begins to rotate — should be approximately 400 psi (28 bar). Cycle the actuator at least 25 times at 3000 psi (210 bar) pressure. After the 25 rotations, increase the pressure to 4500 psi (315 bar) to check for leaks and cracks. Perform the test again at the end of the rotation in the opposite direction.

TESTING THE ACTUATOR FOR INTERNAL LEAKAGE

If the actuator is equipped with a counterbalance valve, plug the valve ports. Connect the hydraulic lines to the housing ports. Bleed all air from the actuator (see Installation and Bleeding) Rotate the shaft to the end of rotation at 3000 psi (210 bar) and maintain pressure. Remove the hydraulic line from the non-pressurized side.

Continuous oil flow from the open housing port indicates internal leakage across the piston. Replace the line and rotate the shaft to the end of rotation in the opposite direction. Repeat the test procedure outlined above for the other port. If there is an internal leak, disassemble, inspect and repair.

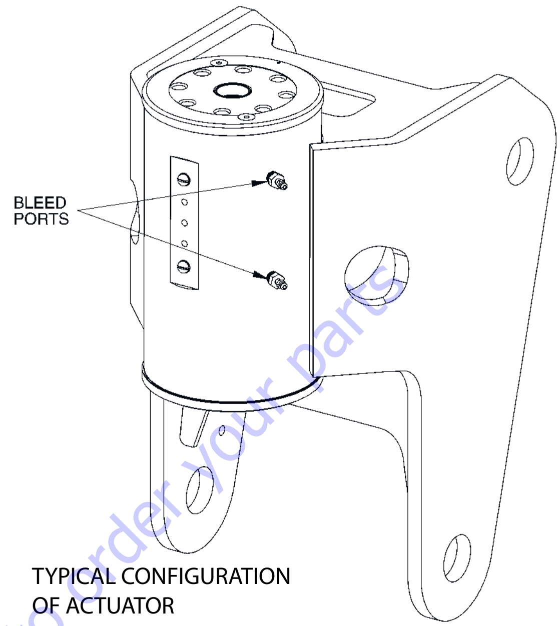
Installation and Bleeding

After installation of the actuator on the equipment, it is important that all safety devices such as tie rods or safety cables are properly reattached.

To purge air from the hydraulic lines, connect them together to create a closed loop and pump hydraulic fluid through them. Review the hydraulic schematic to determine which hydraulic lines to connect. The linear feet and inside diameter of the hydraulic supply lines together with pump capacity will determine the amount of pumping time required to fully purge the hydraulic system.

Bleeding may be necessary if excessive backlash is exhibited after the actuator is connected to the hydraulic system. The following steps are recommended when a minimum of two gallons (8 liters) is purged.

1. Connect a 3/16 in. inside diameter x 5/16 in. outside diameter x 5 foot clear, vinyl drain tube to each of the two bleed nipples. Secure them with hose clamps. Place the vinyl tubes in a clean 5-gallon container to collect the purged oil. The oil can be returned to the reservoir after this procedure is completed.



TYPICAL CONFIGURATION
OF ACTUATOR

2. With an operator in the platform, open both bleed nipples 1/4 turn. Hydraulically rotate the platform to the end of rotation (either clockwise or counterclockwise), and maintain hydraulic pressure. Oil with small air bubbles will be seen flowing through the tubes. Allow a 1/2 gallon of fluid to be purged from the actuator.

3. Keep the fittings open and rotate the platform in the opposite direction to the end position. Maintain hydraulic pressure until an additional 1/4 gallon of fluid is pumped into the container.

4. Repeat steps 2 & 3. After the last 1/2 gallon is purged, close both bleed nipples before rotating away from the end position.

Troubleshooting

Table 4-1. Troubleshooting

Problem	Cause	Solution
1. Shaft rotates slowly or not at all	a. Insufficient torque output	a. Verify correct operating pressure. Do not exceed OEM's pressure specifications. Load may be above maximum capacity of the actuator.
	b. Low rate of fluid flow	b. Inspect ports for obstructions and hydraulic lines for restrictions and leaks.
	c. Control or counterbalance valve has internal leak	c. Disconnect hydraulic lines and bypass valve. Leave valve ports open and operate the actuator through housing ports (do not exceed OEM's operating pressure). The valve must be replaced if a steady flow of fluid is seen coming from the valve ports.
	d. Piston and/or shaft seal leak	d. Remove the plug and the housing's valve ports. Operate the actuator through the housing ports. Conduct the internal leakage test as described in the Testing section on page 24 of this manual.
	e. Corrosion build-up on the thrust surfaces	e. Re-build the actuator. Remove all rust then polish. Replacement parts may be needed.
	f. Swollen seals and composite bearings caused by incompatible hydraulic fluid	f. Re-build the actuator. Use fluid that is compatible with seals and bearings.
2. Operation is erratic or not responsive	a. Air in actuator	a. Purge air from actuator. See bleeding procedures.
3. Shaft will not fully rotate	a. Twisted or chipped gear teeth	a. Check for gear binding. Actuator may not be able to be rebuilt and may need to be replaced. Damage could be a result of overload or shock.
	b. Port fittings are obstructing the piston	b. Check thread length of port fittings. Fittings should during stroke not reach inside the housing bore.
4. Selected position cannot be maintained	a. Control or counterbalance valve has internal leak	a. Disconnect hydraulic lines and bypass valve. Leave valve ports open and operate the actuator through housing ports (do not exceed OEM's operating pressure). The valve must be replaced if a steady flow of fluid is seen coming from the valve ports.
	b. Piston and/or shaft seal leak	b. Remove the plug and the housing's valve ports. Operate the actuator through the housing ports. Conduct the internal leakage test as described in the Testing section on page 24 of this manual.
	c. Air in actuator	c. Purge air from actuator. See bleeding procedures.

4.15 DRIVE CARD SETUP PROCEDURES

Lift, Swing, and Drive Cards

1. Center the input potentiometers. Power up the card, but do not start the engine. Place the common lead of a voltmeter on pin #6 and place the other lead on pin #8. Rotate the potentiometer, leaving the joystick in the center position, until the voltmeter reads 2.5 volts. Secure the set screw on the potentiometer. When the potentiometer is centered and the joystick is in the center position, LED #3 should not be illuminated.

2. Install test harness JLG P/N 4922012.

3. Set the minimum and maximum currents. The input potentiometer must be centered before continuing with this procedure. Power up the card, but do not start the engine. Place the current meter in series with the “A” output. Turn P3 counter clockwise until the adjustment potentiometer starts to click. This will set to maximum current to its lowest value. Move the joystick until LED #3 illuminates and hold the stick in this position. Adjust P4 until the meter equals the current setting range given in Table 4-2, Ramp Current Setting Range. Rotating the adjustment potentiometer clockwise will increase the current. This will set the minimum current setting for the “A” output. To set the maximum current for the “A” output, hold the joystick in its maximum position. Turn P3 clockwise until the meter reading equals the setting in Table 4-2, Ramp Current Setting Range. Follow the same procedure for the “B” output. Use P8 for the minimum current adjustment and P7 for the maximum current adjustment.

4. Set the ramp up and the ramp down times. Step 2 must be performed before continuing with procedure. Power up the card, but do not start the engine. Place the current meter in series with the “A” output. Move the joystick from the center position to the extreme position. Watch the meter for the time it takes the output to go to from 0 current to maximum current. This is the ramp up time. Adjust P1 until this time matches the time given inTable 4-3, Ramp time Setting. Rotating the adjustment potentiometer clockwise will increase the ramp time. To set the ramp down time, hold the joystick in the extreme position. Release the joystick and watch the meter for the time it takes the output to go from the maximum current setting to 0 current. Adjust P2 until this time matches the time in Table 4-3, Ramp time Setting. Rotating the adjustment potentiometer clockwise will increase the ramp time. Follow the same procedure for the “B” output. Use P5 for the ramp up adjustment and P6 for the ramp down adjustment.

Flow Control Card

1. Set the input potentiometer. Power up the card, but do not start the engine. Place the common lead of a voltmeter on pin #15 and place the other lead on pin #8. Rotate the potentiometer and verify the input to the card is 3.8 volts when the input potentiometer is in its minimum position. Rotate the input potentiometer to its maximum position and verify the input to the card is 0 volts.

2. Set the minimum and maximum current settings. The input potentiometer must function properly before continuing with this procedure. Turn P3 counter clockwise until the adjustment pot starts clicking. Place a current meter in series with the “A” output. Rotate the input potentiometer to its minimum setting and operate the telescope function. Adjust P4 until the meter reading matches the setting in Table 4-2, Ramp Current Setting Range. This sets the minimum current setting for the card. Rotate the input potentiometer to its extreme position and operate the telescope function. Turn P3 clockwise until the meter reading matches the setting in Table 4-2, Ramp Current Setting Range. This sets the maximum current for the card.

3. Set the ramp up and the down times. Step 2 must be completed before continuing with this procedure. Power up the card, but do not start the engine. Place the current meter in series with the "A" output. Turn the input potentiometer to its extreme position and operate the telescope function. watch the meter for the time it takes the output to go from 0 current to maximum current. This is ramp up time. Adjust P1 until this time matches the time in Table 4-3, Ramp time Setting. Rotating the adjustment potentiometer clockwise will increase ramp time. To set the ramp down time, hold the telescope function switch and watch the time it takes the output to go from the maximum current down to 0 current. This is the ramp down time. Adjust P2 until this time matches the setting time in Table 4-3, Ramp time Setting. Rotating the adjustment potentiometer clockwise will increase the ramp time.

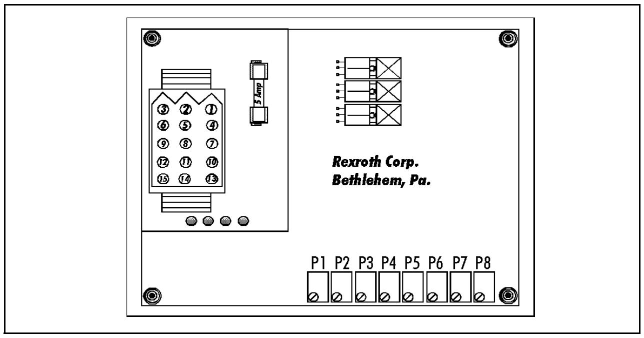


Figure 4-24. Control Card

Table 4-2. Ramp Current Setting Range.

FUNCTION	MINIMUM CURRENT	MAXIMUM CURRENT
MAIN LIFT UP	450 to 550 mA	1300 to 1500 mA
MAIN LIFT DOWN	450 to 550 mA	1700 to 2000 mA (Set 450 mA higher than Main lift)
SWING RIGHT	450 to 550 mA	1000 to 1300 mA
SWING LEFT	450 to 550 mA	1100 to 1300 mA (Set 100 mA higher than swing right)
FLOW CONTROL	750 to 850 mA	1100 to 1300MA (Set using Main Tele)
DRIVE FORWARD	20 to 60 mA	130 to 160 mA
DRIVE REVERSE	20 to 60 mA	130 to 160 mA

Table 4-3. Ramp time Setting.

FUNCTION	RAMP TIME
Lift Up	Ramp UpTime = 5:00 sec. Ramp Down Time = 3:00 sec.
Lift Down	Ramp Up Time =5:00 sec. Ramp Down Time =3:00 sec.
Swing Right	Ramp Up Time =7:00 sec. Ramp Down Time =3:00 sec.
Swing Left	Ramp Up Time =7:00 sec. Ramp Down Time =3:00 sec.
Drive Forward	Ramp Up Time =4:30 sec. Ramp Down Time = 2:30 sec.
Drive Reverse	Ramp Up Time = 4:30 sec. Ramp Down Time = 2:00 sec.
Flow Control	Ramp Up Time =3:00 sec. Ramp Down Time =0.00 sec.

4.16 FOOT SWITCH ADJUSTMENT

Adjust so that functions will operate when pedal is at center of travel. If switch operates within last 1/4 in. (6.35 mm) of travel, top or bottom, it should be adjusted.

4.17 UPRIGHT MONITORING SYSTEM

The UMS provides a visual and audible warning to the operator when the limits of the upright assembly alignment have been reached. In addition, the UMS will not allow the tower boom to be lowered when the upright assembly is misaligned in a direction oriented away from the work platform.

Re-Synchronizing Upright

A pull type control valve allows the operator to adjust the upright level cylinder if the upright is not 90° (vertical) relative to the chassis (Refer to Figure 4-26.). This valve is located in the tank compartment area.

Perform the following steps with the aid of an assistant:

1. Turn the key switch to the ground control position.
2. Start the engine.
3. Pull and hold the red relevel knob located next to the main control valve. Refer to Figure 4-25.
4. Raise the tower boom 6 feet (1.8 m).
5. Release the red relevel knob.
6. Lower the tower boom fully and continue to hold down the switch to Tower Down for an additional 20 seconds.
7. Repeat steps 3 thru 6 as necessary until the upright is 90° (vertical) relative to the chassis.

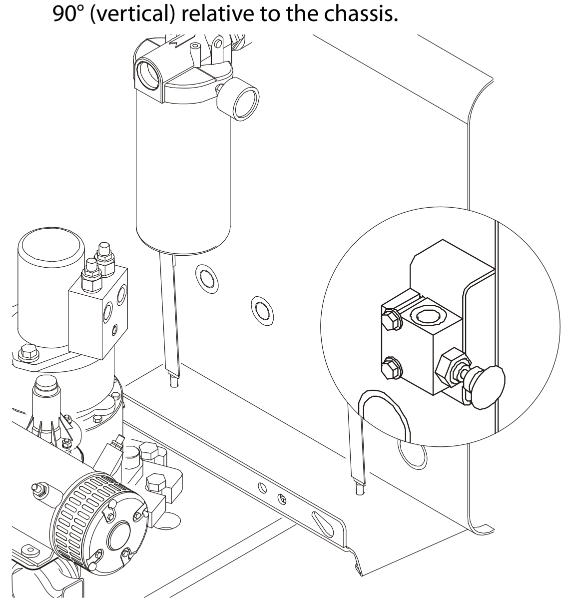


Figure 4-25. Releveling Valve

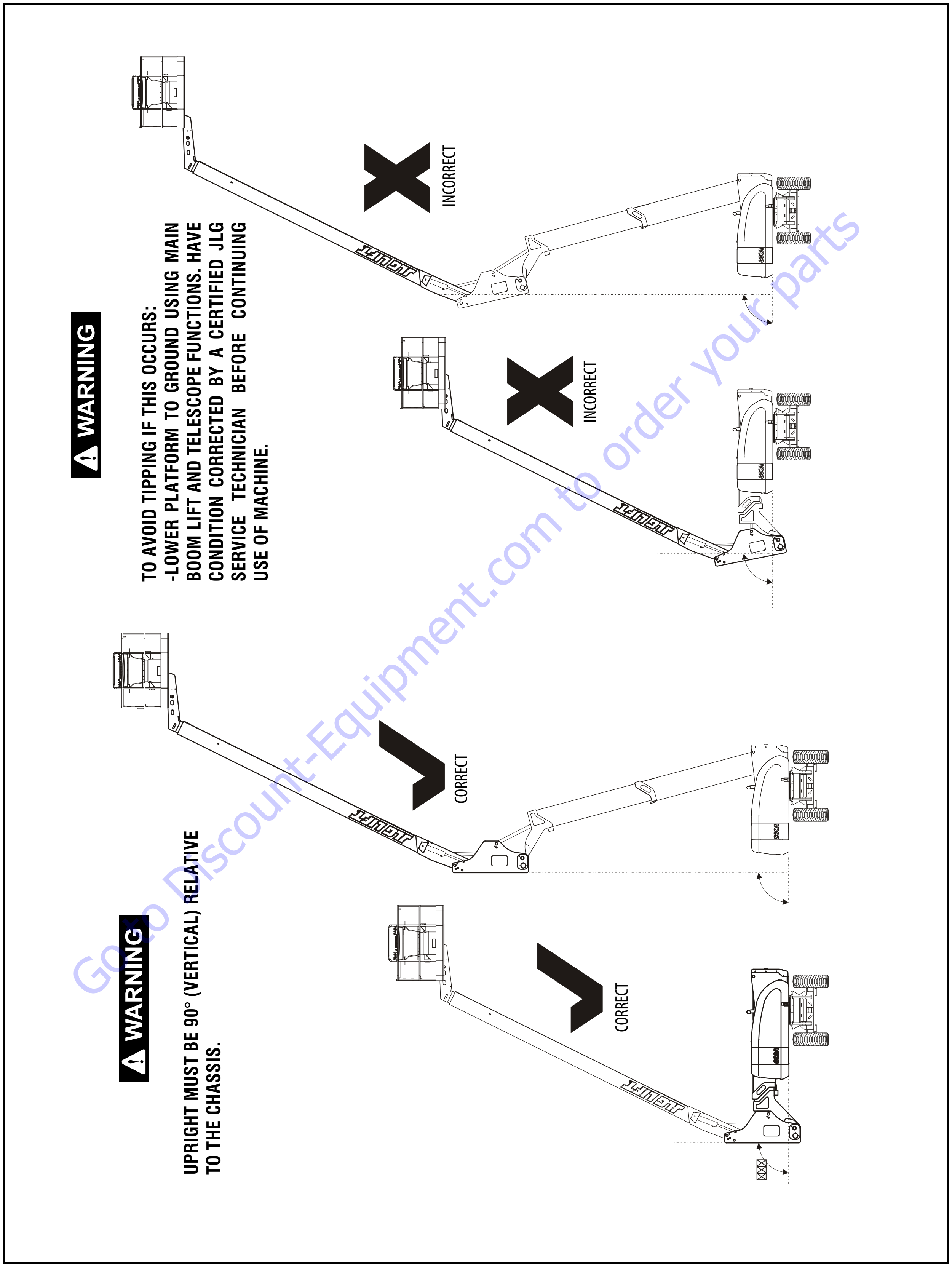


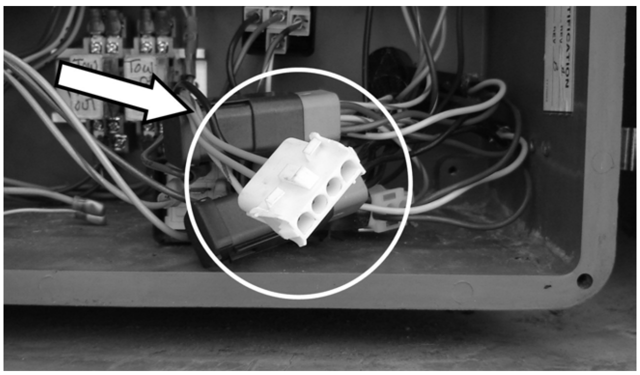
Figure 4-26. Boom Upright Positioning

Calibration - Pre ADE Machines

NOTICE

CALIBRATION OF THE UPRIGHT MONITORING SYSTEM REQUIRES THE MACHINE TO BE ON A FIRM AND LEVEL SURFACE WITH SUFFICIENT OVERHEAD CLEARANCE TO FULLY ELEVATE THE TOWER BOOM.

1. Refer to Section 6 for operating instructions and menu structures for the hand-held analyzer, #2901443.
2. Connect the hand-held analyzer at the ground control station using the four-pin analyzer connector shown below.



3. Pull out the emergency stop button at the ground control station and start the engine from the ground controls.

NOTE: *The boom malfunction indicator light at the ground controls will flash until the initial calibration is performed.*

4. To calibrate the Upright Monitoring System through the hand-held analyzer, you must be in access level 1. To advance to access level 1, scroll to the ACCESS LEVEL menu and press "ENTER" 

. Using the arrows on the keypad, enter the password "33271" and press "ENTER" 

.

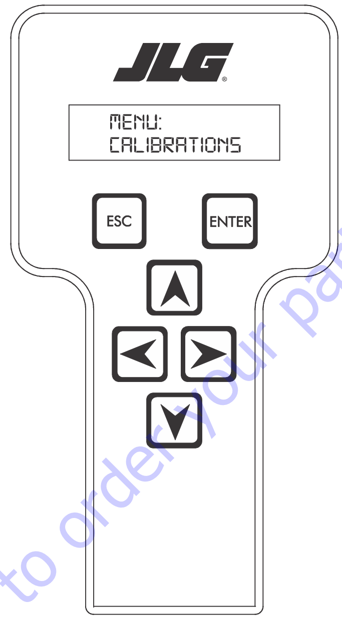
NOTE: *Repeat step #4 if the correct access level is not displayed.*

5. Calibrate the Upright Monitoring System (UMS) sensors by the following procedure:

NOTICE

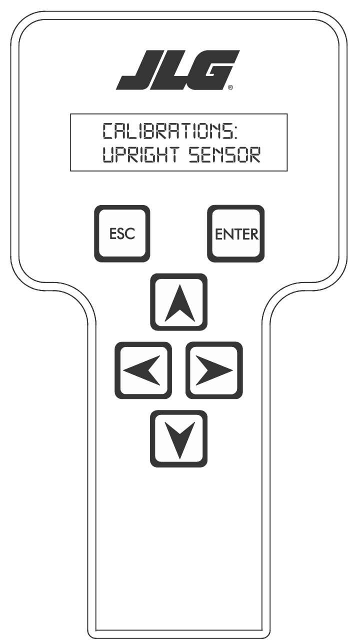
THE UPRIGHT SENSOR AND TURNTABLE SENSOR WILL BE CALIBRATED SIMULTANEOUSLY THROUGH THIS STEP.

a. In access level 1, scroll through the menu items until "CALIBRATIONS" is displayed on the second line of the analyzer screen as shown below.

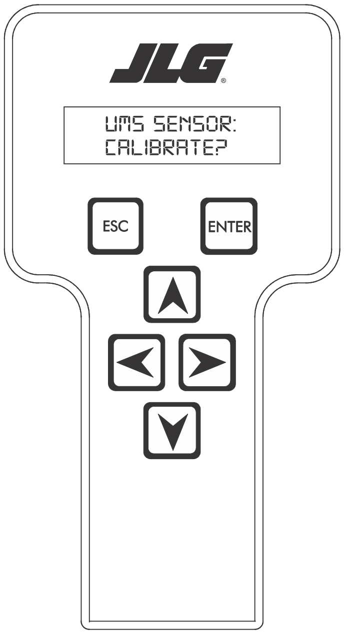


b. When "CALIBRATIONS" is displayed, press "ENTER" 

to advance to the next screen. The screen will display the following:

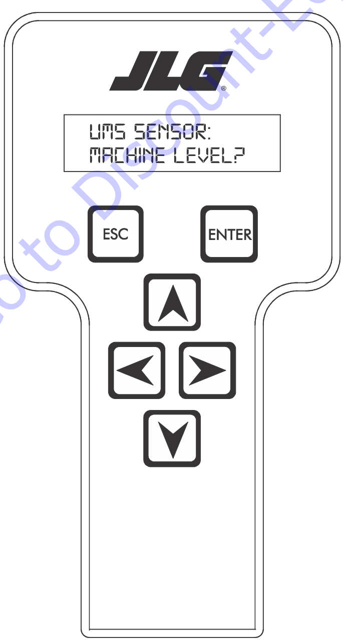


c. Press "ENTER" [ENTER], and the following screen will be displayed asking if you wish to calibrate the upright monitoring system.



NOTE: *By pressing the left or right arrow keys in this screen, you may view the output of the sensor.*

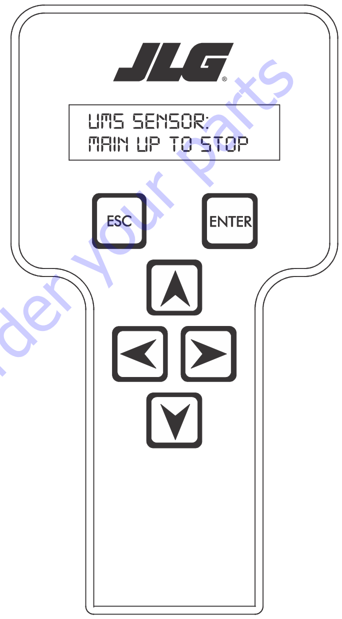
d. Press "ENTER" [ENTER] and the screen will display the following:



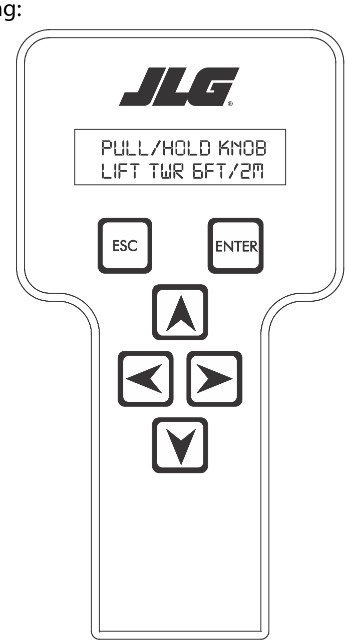
NOTICE

THE MACHINE MUST BE LEVEL FOR PROPER CALIBRATION.

e. Verify the machine is level and press "ENTER" [ENTER]. The screen will display the following, asking you to fully elevate the main boom.



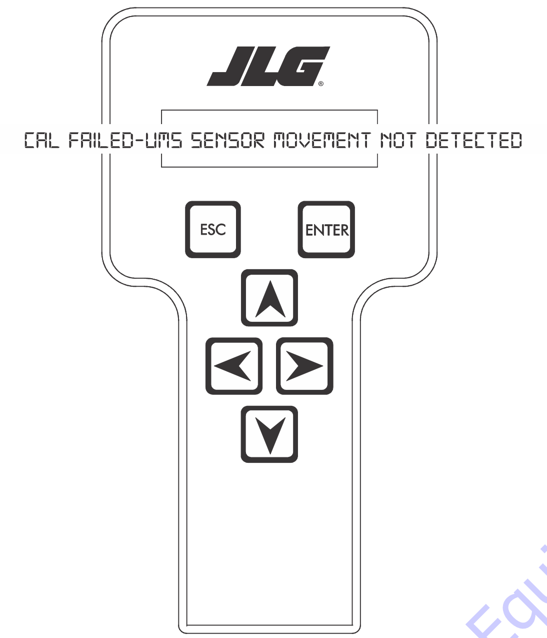
f. Start the machine and fully elevate the main boom. After the main boom has been fully elevated, press "ENTER" [ENTER]. The analyzer will display the following:



NOTE: *By pressing the left or right arrows in this screen, you may view the output of each sensor.*

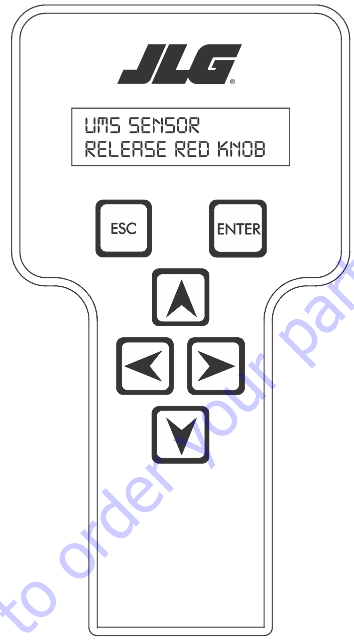
g. Pull and hold the red re-leveling knob on the hydraulic tank while lifting the tower boom. Raise the tower boom six (6) feet or two (2) meters. After elevating the tower the required distance, press "ENTER" .

If the UMS did not detect adequate sensor activity, the screen will display:

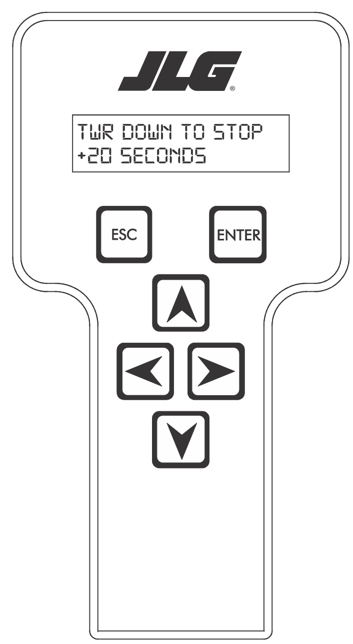


Should you get the above message, verify that the sensor is installed correctly and verify the sensor connection to the sensor harness is secure. Also, ensure the red knob is held fully open for the required time.

If the calibration is executing properly, you shall see the following display:



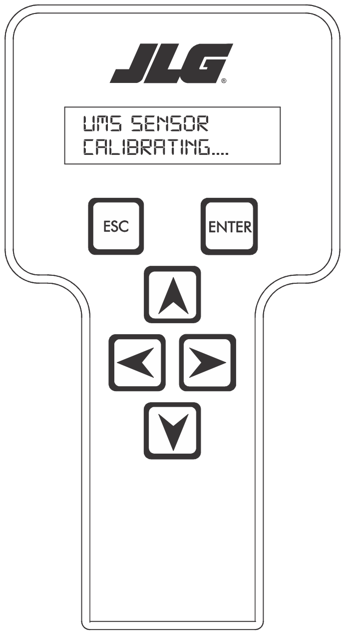
h. When viewing the above display, press "ENTER" . The screen will display the following:



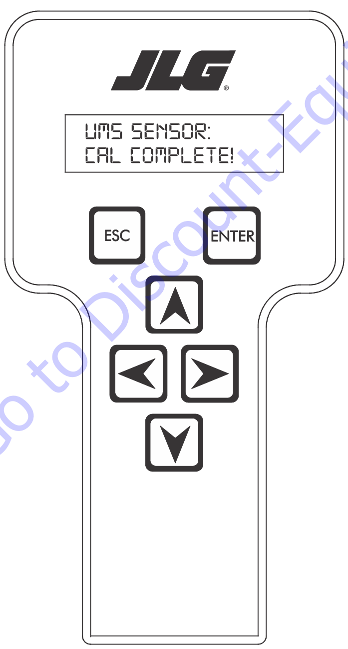
i. Lower the tower boom onto the boom stop. Continue to hold the tower boom down function for an additional twenty (20) seconds **WITHOUT RELEASING THE FUNCTION SWITCH**. The calibration must recognize continuous activation of the tower down function switch for the required time.
After the required activation time has passed,

release the function switch and press "ENTER" 

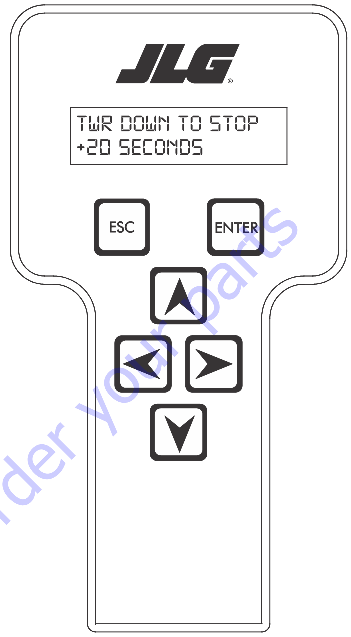
. The analyzer will display the following message:



If the calibration has been completed successfully, the screen will automatically change to:



j. If the calibration has *not* been completed successfully, the display will automatically change to:



Repeat step i until the calibration time requirement has been satisfied.

⚠ WARNING

DO NOT RAISE THE TOWER BOOM AGAIN DURING CALIBRATION.

k. To correctly complete the calibration process, fully retract and fully lower the boom. Once the machine is in the stowed position, turn off the machine and disconnect the analyzer.

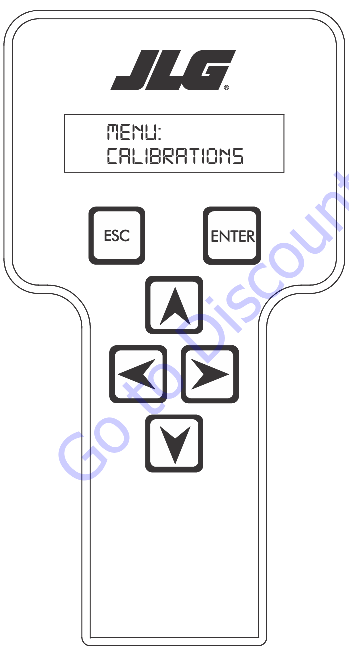
Calibration - ADE Equipped Machines

1. Connect the JLG Hand-held analyzer to the original analyzer connection in the ground box.

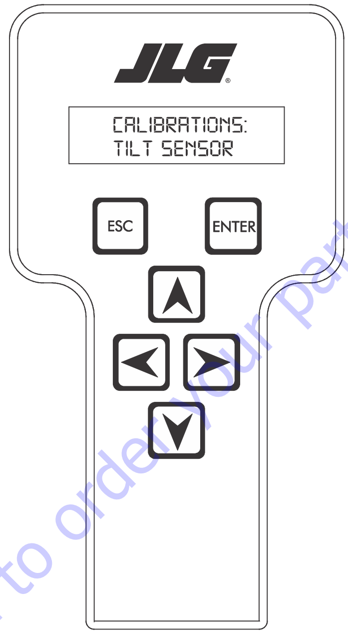
NOTICE

DO NOT CONNECT TO THE ANALYZER CONNECTION PORT INSTALLED WITH THE UPRIGHT MONITORING SYSTEM MODULE.

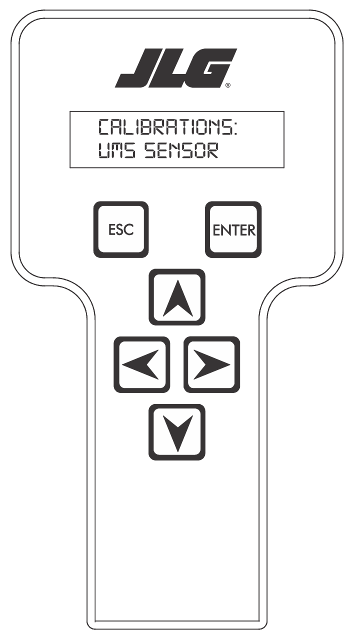
2. Pull out the emergency stop button at the ground control station and start the engine from the ground controls.
3. To calibrate the Upright Monitoring System through the hand-held analyzer, you must be in access level 1. To advance to access level 1, scroll to the ACCESS LEVEL menu and press "ENTER" [ENTER]. Using the arrows on the keypad, enter the password "33271" and press "ENTER" [ENTER].
4. Calibrate the upright monitoring system sensor by the following procedure:
   a. In access level 1, scroll through the menu items until "CALIBRATIONS" is displayed on the second line of the analyzer screen. The screen will display the following:



   b. After pressing 'ENTER" [ENTER] one of the following screens will be displayed:



Or:

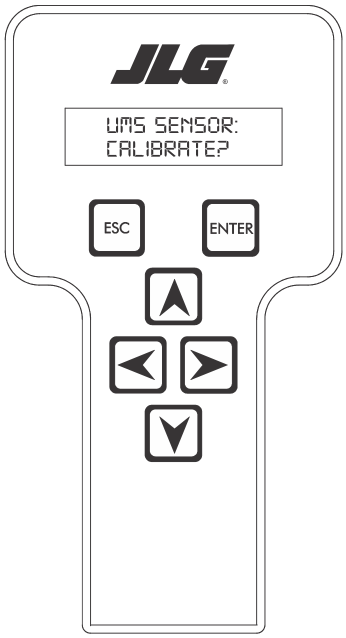


   c. Scroll left to right through the above menu items until "UMS SENSOR" sub menu appears on the bottom line of the analyzer display. Press the "ENTER" [ENTER] key.

NOTICE

IT IS NOT NECESSARY TO CALIBRATE THE TILT SENSOR IN THE GROUND CONTROL MODULE AT THIS TIME. HOWEVER, WHEN THE TILT SENSOR IN THE GROUND CONTROL MODULE IS RECALIBRATED, THE UPRIGHT MONITORING SYSTEM TILT SENSOR MUST BE RECALIBRATED AS WELL.

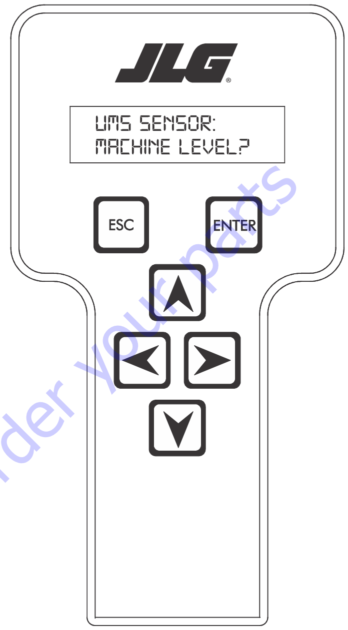
d. After selecting "UMS SENSOR", the following screen will appear:



NOTE: *By pressing the left or right arrow keys in this screen, you may view the output of the sensor.*

e. Press "ENTER" 

and the next screen will display the following, asking if the machine is on a level surface:

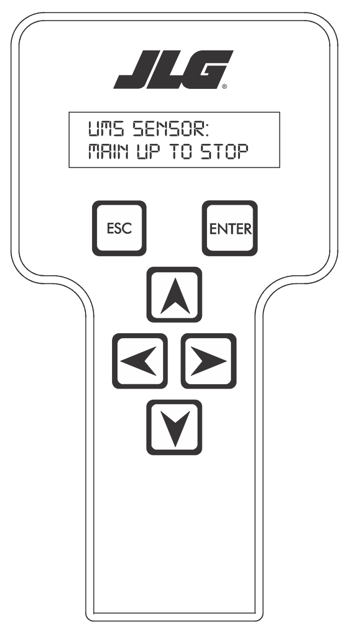


NOTICE

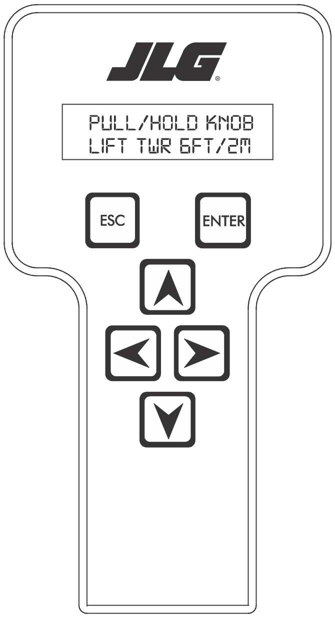
THE MACHINE MUST BE LEVEL FOR PROPER CALIBRATION.

f. Verify the machine is level and press "ENTER" 

. The screen will display the following, asking you to fully elevate the main boom:

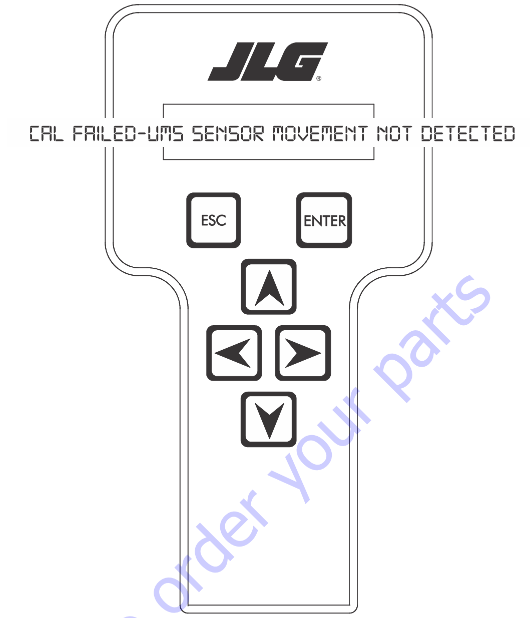


g. After the main boom has been fully elevated, press "ENTER" [ENTER]. The analyzer will display the following:



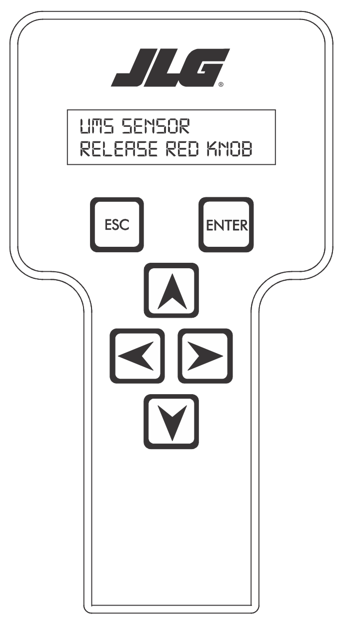
NOTE: *By pressing the left or right arrows in this screen, you may view the output of each sensor.*

h. With the aid of an assistant, pull and hold the red releveling knob on the hydraulic tank while lifting the tower boom. Raise the tower boom six (6) feet or two (2) meters. After elevating the tower the required distance, press "ENTER" [ENTER].
If the upright monitoring system did not detect adequate sensor activity, the screen will display:

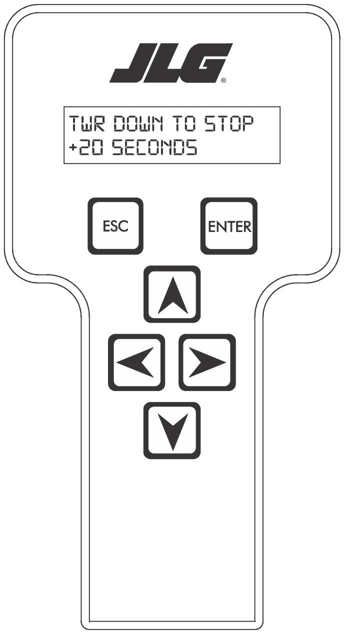


Should you get the above message, verify that the sensor is installed correctly and verify the sensor connection to the sensor harness is secure. Also, ensure the red knob is held fully open for the required time.

If the calibration is executing properly, you shall see the following display:

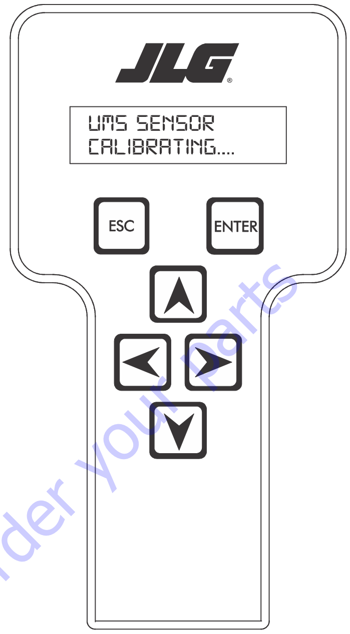


i. When viewing the above display, press "ENTER". The screen will display the following:

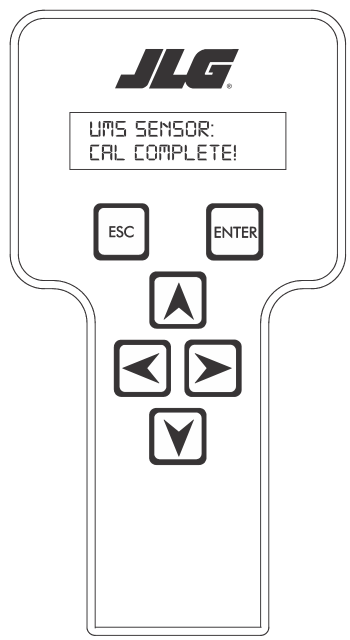


j. Lower the tower boom onto the boom stop. Continue to hold the tower boom down function for at least twenty (20) seconds **WITHOUT RELEASING THE FUNCTION SWITCH**. The calibration must recognize continuous activation of the tower down function switch for the required time.
After the required activation time has passed, release the function switch and press "ENTER".

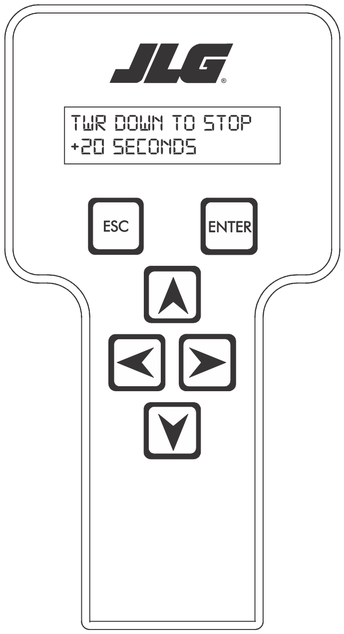
The analyzer will display the following message:



If the calibration has been completed successfully, the screen will automatically change to:



If the calibration has not been completed successfully, the display will automatically change to:



Repeat step j until the calibration time requirement has been satisfied.

⚠ WARNING

DO NOT RAISE THE TOWER BOOM AGAIN DURING CALIBRATION.

k. To correctly complete the calibration process, fully retract and fully lower the main boom. Once the machine is in the stowed position, turn off the machine and disconnect the analyzer.

Calibration Faults

CAL Failed-Chassis Not Level

In the event the turntable tilt switch input is logic low indicating that the machine is not level the UMS calibration screens shall display this fault.

CAL Failed-UMS Sensor Raw Output Out Of Range

The control system shall display a fault in the event the raw sensor output is greater then ±5° for the UMS sensor.

CAL Failed-Turntable Sensor Raw Output Out Of Range

The control system shall display a fault in the event the raw sensor output is greater then ±5° for the turntable sensor.

CAL Failed-Calibration Disrupted

If calibration is disrupted, the control system shall display this fault.

CAL Failed- UMS Sensor Movement Not Detected

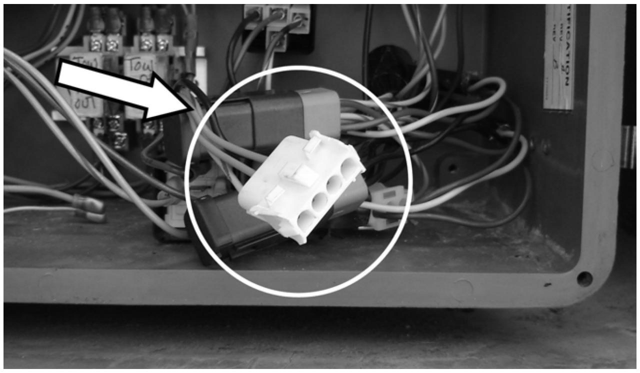
The UMS angle has not detected the required amount of movement during calibration.

Function Check

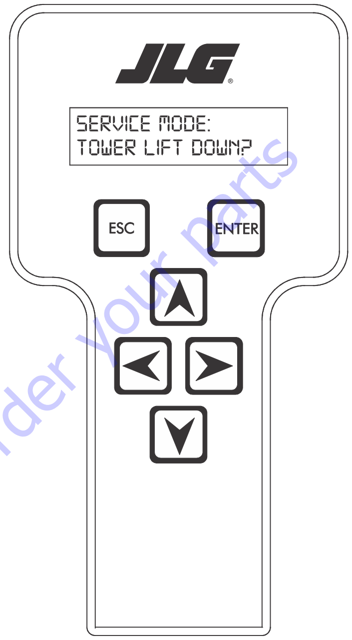
NOTICE

ON ADE EQUIPPED MACHINES, DO NOT CONNECT TO THE ANALYZER CONNECTION PORT INSTALLED WITH THE UPRIGHT MONITORING SYSTEM MODULE.

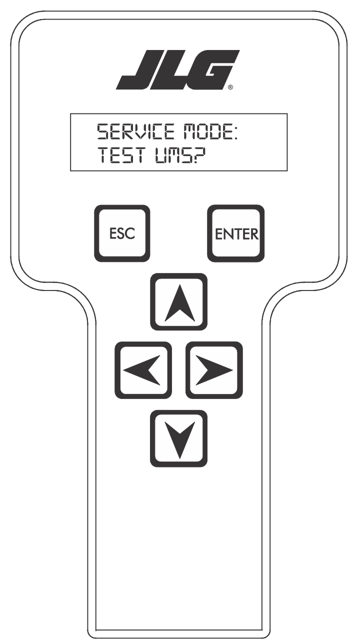
1. Connect the hand-held analyzer at the ground control station using the four-pin connector.



2. Pull out the emergency stop button at the ground control station and turn the key switch to ground controls. Start the engine.
3. Advance to access level 1 by scrolling to the ACCESS LEVEL menu and press "ENTER" . Using the arrows on the keypad, enter the password "33271" and press "ENTER" .
4. Scroll through the top level menu until SERVICE MODE appears. Press "ENTER" to select this menu item. After pressing "ENTER" one of the following screens will be displayed:

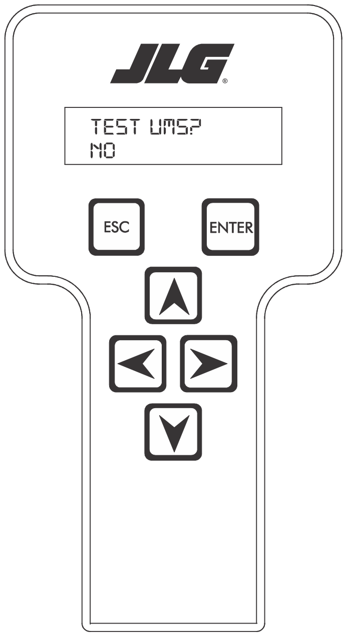


or

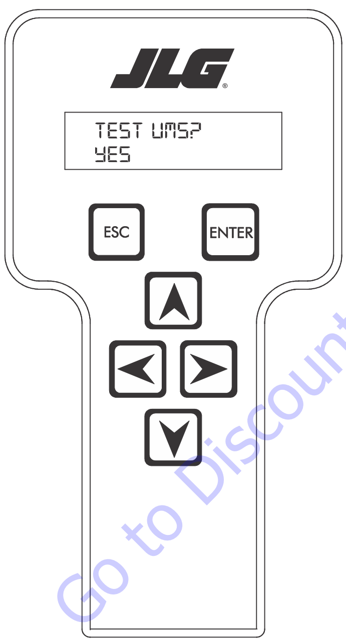


5. Scroll left to right through the above menu items until "TEST UMS?" sub menu appears on the bottom line of the analyzer display. Press the "ENTER" key.

6. The controller will now display the following:



or, by pressing the up and down arrow keys:



7. When the "YES" message is displayed, press the "ENTER" key to automatically perform a function test. Upon the function test, the system will activate the Upright Monitoring System, warning lights, and alarm. Verify that the alarm sounds, the boom malfunction indicator lights (platform and ground) are illuminated.

8. From the ground controls, raise the tower boom several feet. Verify that the tower boom will not lower.

9. To end the system test, press the Emergency Stop Switch (EMS) at the ground controls. Upon loss of power (pressing the EMS) to the system, the upright monitoring system will reset and all functionality will be restored to the machine.

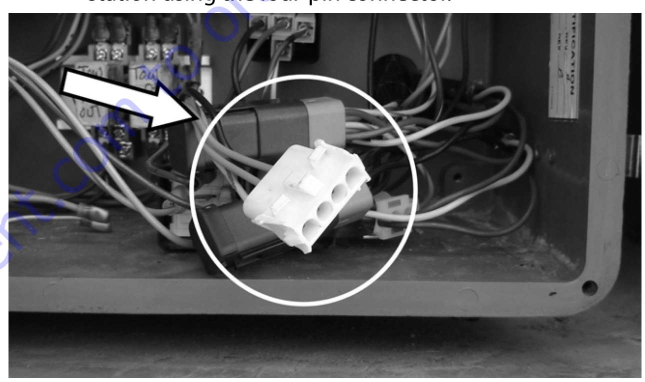
Service Mode/Tower Boom Retrieval

The UMS software incorporates a service mode to temporarily disengage the UMS and allow a tower lift down operation when the UMS has detected a backward stability concern.

NOTICE

ON ADE EQUIPPED MACHINES, DO NOT CONNECT TO THE ANALYZER CONNECTION PORT INSTALLED WITH THE UPRIGHT MONITORING SYSTEM MODULE.

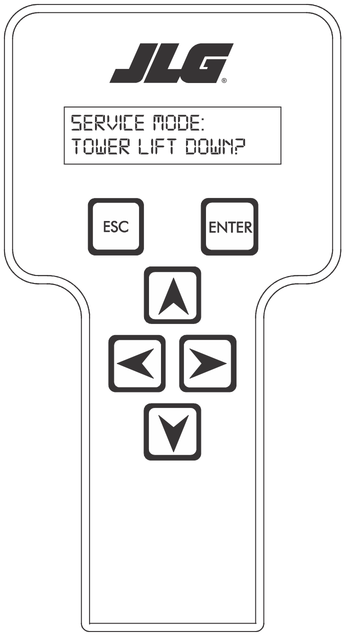
1. Connect the hand-held analyzer at the ground control station using the four-pin connector.



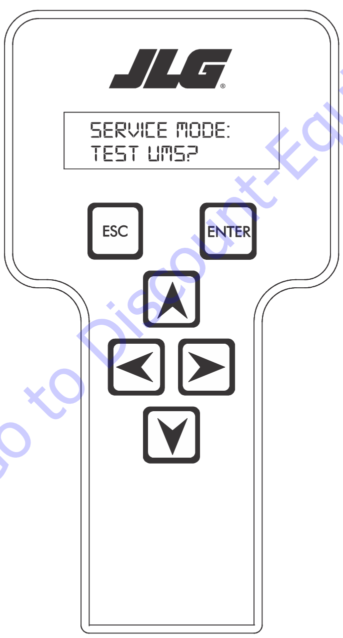
2. Pull out the emergency stop button at the ground control station and turn the key switch to ground controls. Start the engine.

3. Advance to access level 1 by scrolling to the ACCESS LEVEL menu and press "ENTER". Using the arrows on the keypad, enter the password "33271" and press "ENTER".

4. Scroll through the top level menu until SERVICE MODE appears. Press "ENTER" to select this menu item. After pressing "ENTER" one of the following screens will be displayed:

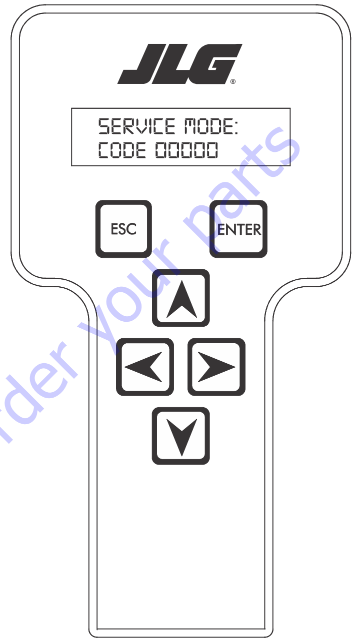


or

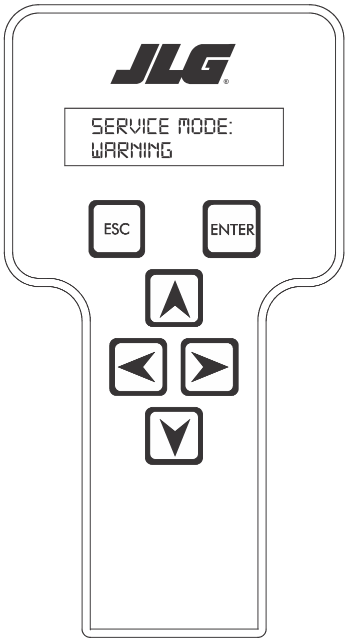


5. Scroll left to right through the above menu items until "TOWER LIFT DOWN?" sub menu appears on the bottom line of the analyzer display. Press the "ENTER" key.

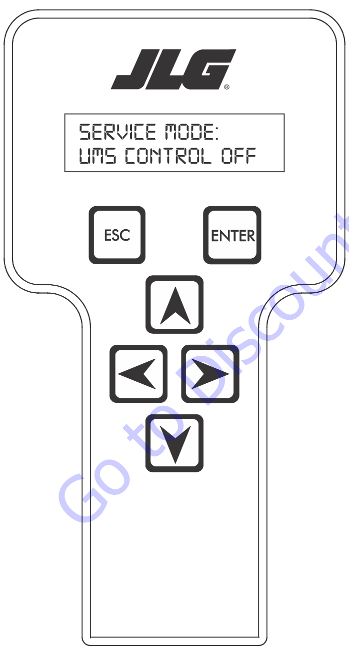
6. The controller will now display the following:



7. Enter the service code "**81075**" and press the "ENTER" key. The controller display will now display the following,

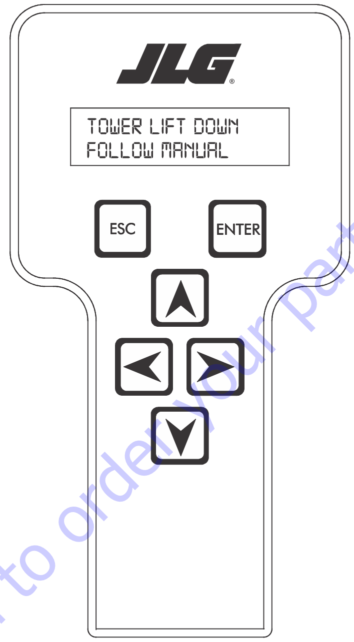


followed by:



The flashing and scrolling messages will repeat until the "ENTER" key is pressed.

8. When the "ENTER" key is pressed, the UMS will be disabled and the display will read:



9. Before using tower lift down adhere to the following:

- Make sure the main boom is fully retracted.
- Make sure the tower boom is fully retracted.
- Slowly lower the tower boom.

10. When the platform has been safely lowered to the ground, exit the service mode by pressing the Emergency Stop Switch (EMS) at the ground controls. Upon loss of power (pressing the EMS) to the system, the upright monitoring system will reset and all functionality will be restored to the machine.

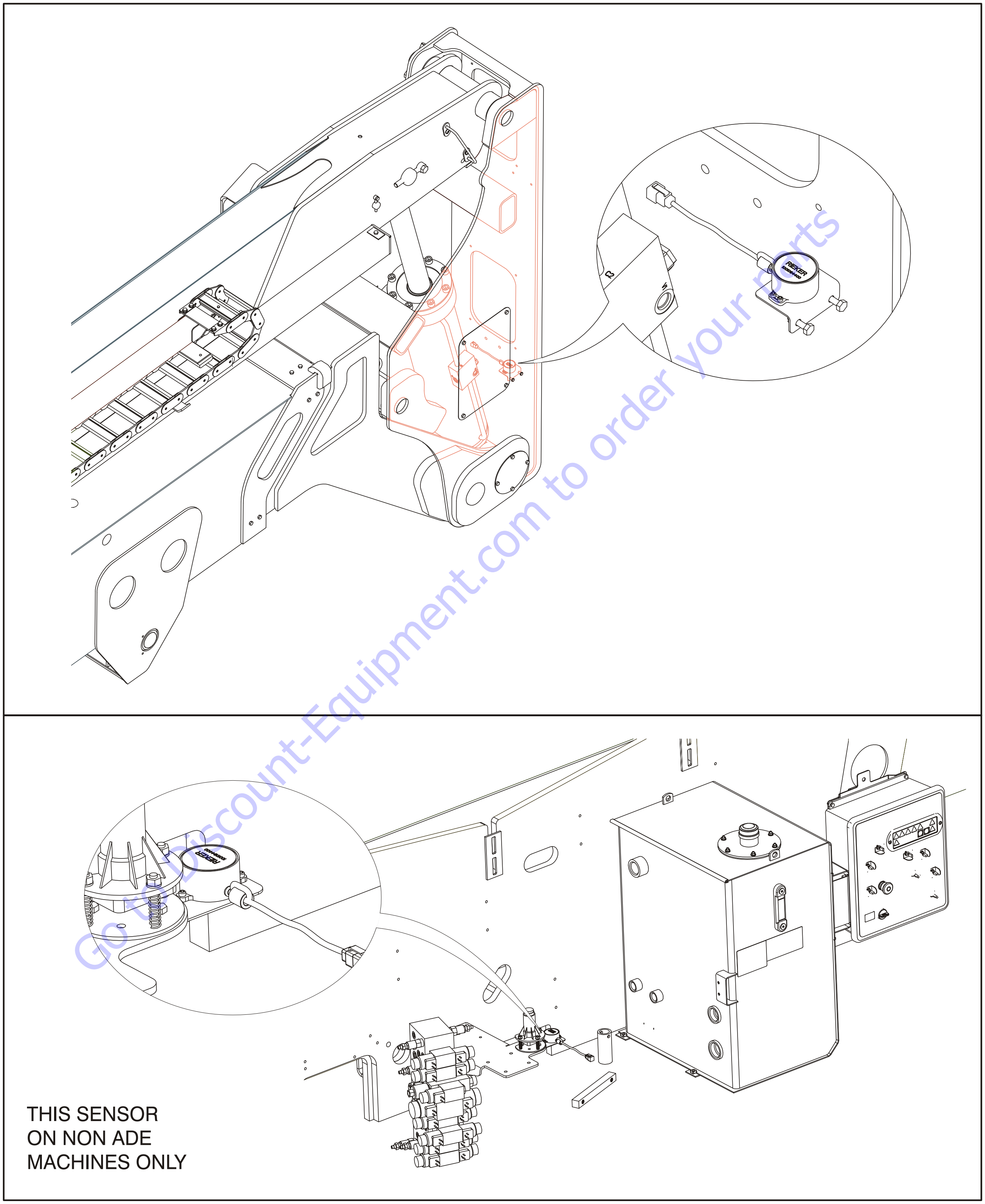


Figure 4-27. UMS Sensor Location

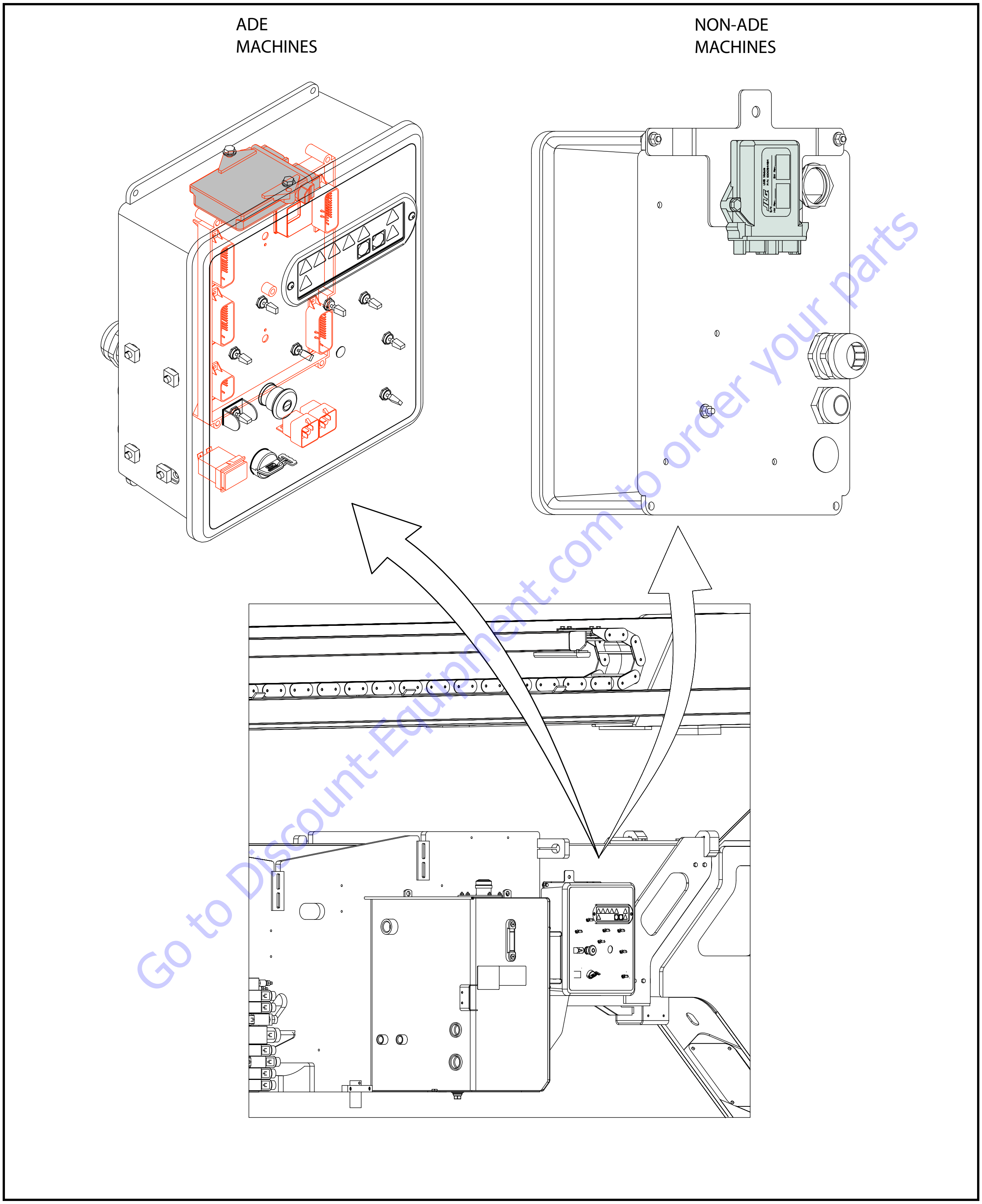


Figure 4-28. UMS Module Location

J1		J2	
1	IGN POWER (7-33V)	1	+5V ANALOG EXCITATION
2	GROUND	2	ANALOG INPUT 0
3	DIGITAL INPUT 0	3	ANALOG GROUND
4	DIGITAL INPUT 1	4	+5V ANALOG EXCITATION
5	DIGITAL INPUT 2	5	ANALOG INPUT 1
6	DIGITAL INPUT 3	6	ANALOG GROUND
7	DIGITAL OUTPUT 0 (PWM, IF)	7	ANALOG INPUT 2
8	DIGITAL OUTPUT 1 (PWM, IF)	8	ANALOG INPUT 3 (NOT POPULATED)
9	DIGITAL OUTPUT 2 (PWM, IF)	9	CANBUS HIGH
10	DIGITAL OUTPUT 3 (PWM, IF)	10	CANBUS LOW
11	DIGITAL OUTPUT 4 (PWM)	11	ANALYZER TRANSMIT
12	DIGITAL OUTPUT 5 (PWM)	12	ANALYZER RECEIVE

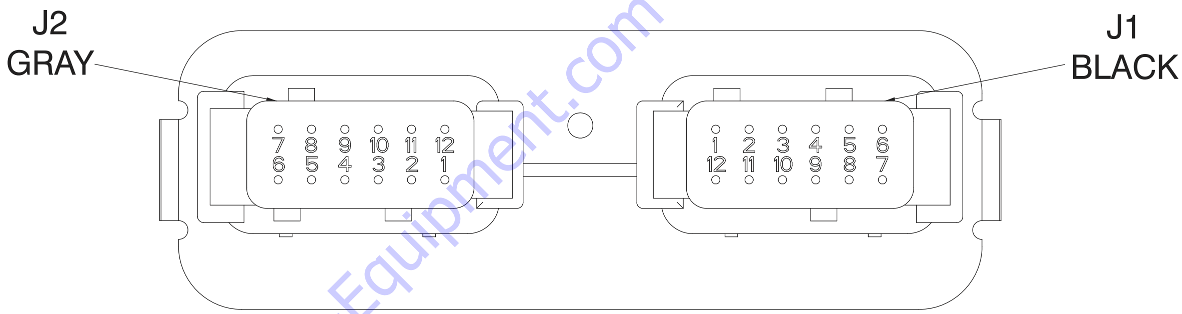


Figure 4-29. UMS Module Pin Identification

4.18 UMS TROUBLESHOOTING AND FAULT MESSAGES NON-ADE MACHINES

Tower Lift Down Permanently closed

2/2 FUNCTION LOCKED OUT - TOWER LIFT DOWN PERMANENTLY CLOSED.

The control system shall illuminate lamps and sound the alarm at startup for one second on and one second off. If the control system detects the TOWER LIFT DOWN, it shall report a fault. The TOWER LIFT DOWN function shall be locked out and activate the ground boom malfunction indicator lamp, upright tilted lamp and platform alarm continually until the condition is cleared.

Solution:

- Inspect switch and harness. Voltage (≈12V) should only be present on J1-3 of the UMS module when Tower Down switch is closed.

Backward Stability Concern Message

2/5 UMS SENSOR BACKWARD LIMIT REACHED.

When the upright angle relative to the turntable is higher than +2.5° (away from the work platform), tower lift down shall be disallowed immediately. Tower Lift Down shall be re-allowed when the upright angle relative to the turntable is less than 2.0°. If Tower Lift Down is disabled for more than 1.5 seconds, the ground boom malfunction indicator lamp, upright tilted lamp and platform alarm shall light/sound continually and a fault shall be raised. These conditions shall be latched along with Tower Lift Down until the upright angle is less than 2.0° for 2 seconds and the Tower Lift Down command is returned to neutral.

Solution:

- Inspect sensor mounting.
- Verify sensor calibration on level pad.
- Follow the corrective action listed on decal 1702265 located near the red knob of the machine.
- Inspect machine hydraulics.

Forward Stability Concern Message

2/5 UMS SENSOR FORWARD LIMIT REACHED.

When the upright angle relative to the turntable is less than –4.0° for longer than 1.5 seconds, the ground boom malfunction indicator lamp, the platform distress lamp, and platform alarm shall light/sound continually and a fault shall be raised. The light/alarm signal shall be removed only when the upright angle reaches values greater than –3.0° for 2 seconds.

Solution:

- Inspect sensor mounting.
- Verify sensor calibration on level pad.
- Tower lift down.
- Inspect machine hydraulics.

UMS Out of Usable Range Message

2/5 UMS SENSOR OUT OF USABLE RANGE

When both the Turntable tilt sensor and the UMS sensor read greater then ±10° in the same direction the UMS shall be disengaged until the condition no longer exists and a fault shall be raised.

Solution:

- Verify the message clears when operating the machine on grade less than 10°.
- Inspect sensor mounting.
- Verify sensor calibration on level pad.

Battery Voltage < 9.0 Volts

4/4 SYSTEM VOLTS LOW

Battery voltage is below 9V.

Solution:

- Inspect battery and alternator output.
- Inspect harness, looking closely for possible short circuits.

Battery Voltage > 16.0 Volts

4/4 SYSTEM VOLTS HIGH

Battery voltage is above 16V.

Solution:

- Inspect battery and alternator output.

UMS Sensor Not Calibrated Message

8/1 UMS SENSOR NOT CALIBRATED.

If the control system detects a sensor out of range condition or a not calibrated fault with the UMS angle sensor, the control system shall report a fault and disable Tower Lift Down and activate the ground boom malfunction indicator lamp, upright tilted lamp and platform alarm continually.

If the control system detects that either angle sensor has not been calibrated, the ground boom malfunction lamp will flash at a 3 Hz rate until the system is calibrated or disabled.

Solution:

- Calibrate sensor.

UMS Sensor Faulted

8/1 UMS SENSOR FAULTED

If the system detects that the UMS sensor frequency outside the 100Hz +/- 5Hz range or the duty cycle is outside 50% +/- 21% range the control system shall report a fault.

Solution:

- Inspect wire harness going to the sensor and UMS module.
- Inspect sensor mounting.
- Replace sensor.

Tower Lift Down Output Short to Ground or Open Circuit

8/1 TOWER LIFT DOWN OUTPUT SHORT TO GROUND OR OPEN CIRCUIT.

Short to Ground or open circuit has been detected on the Tower Lift Down output.

Solution:

- Inspect harness and valve.

Tower Lift Down Output Short to Battery

8/1 TOWER LIFT DOWN OUTPUT SHORT TO BATTERY

Short to battery has been detected on the Tower Lift Down output.

Solution:

- Inspect harness and valve.

Platform Indicator Output Short to Ground or Open Circuit

8/1 PLATFORM INDICATOR OUTPUT SHORT TO GROUND OR OPEN CIRCUIT.

Short to Ground or open circuit has been detected on the Platform Indicator output.

Solution:

- Inspect harness.

Platform Indicator Output Short to Battery

8/1 PLATFORM INDICATOR OUTPUT SHORT TO BATTERY.

Short to battery has been detected on the Platform Indicator output.

Solution:

- Inspect harness.

Ground Indicator Output Short to Ground

8/1 GROUND INDICATOR OUTPUT SHORT TO GROUND OR OPEN CIRCUIT.

Short to Ground or open circuit has been detected on the Ground Indicator output.

Solution:

- Inspect harness.

Ground Indicator Output Short to Battery

8/1 GROUND INDICATOR OUTPUT SHORT TO BATTERY.

Short to battery has been detected on the Ground Indicator Output.

Solution:

- Inspect harness.

Turntable Sensor Not Calibrated Message

8/1 TURNTABLE SENSOR NOT CALIBRATED.

If the control system detects that the Chassis Tilt sensor is not calibrated or there is an internal fault with the sensor, the control system shall disable Tower Lift Down and activate the ground boom malfunction indicator lamp, upright tilted lamp and platform alarm continually.

If the control system detects that either angle sensor has not been calibrated, the ground boom malfunction lamp will flash at a 3 Hz rate until the system is calibrated or disabled.

Solution:

- Calibrate sensor.

Turntable Sensor Faulted

8/1 TURNTABLE FAULTED

If the system detects that the Chassis tilt sensor frequency outside the 100Hz +/- 5Hz range or the duty cycle is outside 50% +/- 21% range the control system shall report a fault.

Solution:

- Inspect wire harness going to the sensor and UMS module.
- Inspect sensor mounting.
- Replace sensor.

EEPROM checksums failure

9/9 EEPROM FAILURE – CHECK ALL SETTINGS

A critical failure occurred with the EEPROM. Personalities, machine configuration digits, etc. may be reset to default values and should be checked.

Solution:

- Contact JLG if message is reoccurring.

4.19 UMS TROUBLESHOOTING AND FAULT MESSAGES-ADE MACHINES

Backward Stability Concern Message

2/5 UMS SENSOR BACKWARD LIMIT REACHED

When the upright angle relative to the turntable is higher than +2.5° (away from the work platform), tower lift down will be disallowed immediately. Tower Lift Down will be re-allowed when the upright angle relative to the turntable is less than 2.0°. If Tower Lift Down is disabled for more than 1.5 seconds, the ground boom malfunction indicator lamp, upright tilted lamp and platform alarm will light/sound continually and a fault shall be raised. These conditions will be latched along with Tower Lift Down until the upright angle is less than 2.0° for 2 seconds and the Tower Lift Down command is returned to neutral.

Solution:

- Inspect sensor mounting.
- Verify sensor calibration on level pad.
- Follow the corrective action listed on decal 1702265 located near the red knob of the machine.
- Inspect machine hydraulics.

Forward Stability Concern Message

2/5 UMS SENSOR FORWARD LIMIT REACHED

When the upright angle relative to the turntable is less than –4.0° for longer than 1.5 seconds, the ground control boom malfunction indicator lamp, the platform malfunction indicator lamp, and platform alarm will light/sound continually and a fault will be raised. The light/alarm signal will stop only when the upright angle reaches values greater than –3.0° for 2 seconds.

Solution:

- Inspect sensor mounting.
- Verify sensor calibration on level pad.
- Tower lift down.
- Inspect machine hydraulics.

Auto Detection Input Low Message

2/5 AUTO DETECTION INPUT LOW

If the UMS detects a valid ground module software version but digital input 2 is not tied high the UMS module shall report a fault.

Solution:

- Inspect wire harness, there should be 12 volts going into pin J1-5 (black connector) of UMS module.

UMS Sensor Communications lost

6/6 UMS SENSOR COMMUNICATIONS LOST

If the UMS detects a valid ground module software version but digital input 2 is not tied high the UMS module shall report a fault.

Solution:

- Inspect wire harness; CANbus communications are on pins J2-9 & J2-10 (gray connector) of the UMS module.
- Using access level 1 of the UMS module, under "DIAGNOSTICS" CAN, RX/SEC and TX/SEC should be values greater than 0. Also "BUS OFF:" and "BUS ERR:" should be 0 and "PASSIVE:" should be a low value.