An Oshkosh Corporation Company

Service & Maintenance Manual

Models
3394RT
4394RT

Prior to S/N 0200191606
excluding S/N's:
0200186972,
0200187002,
0200187013

3121133

October 6, 2008

ANSI

CE

An Oshkosh Corporation Company

SECTION A. INTRODUCTION - MAINTENANCE SAFETY PRECAUTIONS

A.A GENERAL

This section contains the general safety precautions which must be observed during maintenance of the aerial platform. It is of utmost importance that maintenance personnel pay strict attention to these warnings and precautions to avoid possible injury to themselves or others, or damage to the equipment. A maintenance program must be followed to ensure that the machine is safe to operate.

⚠ WARNING

MODIFICATION OF THE MACHINE WITHOUT APPROVAL BY JLG INDUSTRIES INC., IS A SAFETY VIOLATION.

The specific precautions to be observed during maintenance are inserted at the appropriate point in the manual. These precautions are, for the most part, those that apply when servicing hydraulic and larger machine component parts.

Your safety, and that of others, is the first consideration when engaging in the maintenance of equipment. Always be conscious of weight. Never attempt to move heavy parts without the aid of a mechanical device. Do not allow heavy objects to rest in an unstable position. When raising a portion of the equipment, ensure that adequate support is provided.

⚠ WARNING

SINCE THE MACHINE MANUFACTURER HAS NO DIRECT CONTROL OVER THE FIELD INSPECTION AND MAINTENANCE, SAFETY IN THIS AREA RESPONSIBILITY OF THE OWNER/OPERATOR.

A.B HYDRAULIC SYSTEM SAFETY

It should be noted that the machines hydraulic systems operate at extremely high potentially dangerous pressures. Every effort should be made to relieve any system pressure prior to disconnecting or removing any portion of the system.

Relieve system pressure by cycling the applicable control several times with the engine stopped and ignition on, to direct any line pressure back into the reservoir. Pressure feed lines to system components can then be disconnected with minimal fluid loss.

A.C MAINTENANCE

⚠ WARNING

FAILURE TO COMPLY WITH SAFETY PRECAUTIONS LISTED IN THIS SECTION MAY RESULT IN MACHINE DAMAGE, PERSONNEL INJURY OR DEATH AND IS A SAFETY VIOLATION.

- No smoking is mandatory. never refuel during electrical storms. ensure that fuel cap is closed and secure at all other times.
- Remove all rings, watches and jewelry when performing any maintenance.
- Do not wear long hair unrestrained, or loose-fitting clothing and neckties which are apt to become caught on or entangled in equipment.
- Observe and obey all warnings and cautions on machine and in service manual.
- Keep oil, grease, water, etc. wiped from standing surfaces and hand holds.
- Use caution when checking a hot, pressurized coolant system.
- Never work under an elevated sizzor until platform has been safely restrained from any movement by blocking or overhead sling, or boom safety prop has been engaged.
- Before making adjustments, lubricating or performing any other maintenance, shut off all power controls.
- Battery should always be disconnected during replacement of electrical components.
- Keep all support equipment and attachments stowed in their proper place.
- Use only approved, nonflammable cleaning solvents.

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1.1 SPECIFICATIONS

Table 1-1. Operating Specifications

Description	3394RT	4394RT
Maximum Occupants	6	
Maximum Workload (Capacity): Single Extension: Dual Extension: Extension Only:	 2250 lbs (1020 kg) 2000 lbs (905 kg) 500 lbs (230 kg)	 1500 lbs (680 kg) 1250 lbs (565 kg) 500 lbs (230 kg)
Maximum Travel Grade : 2 WD 4WD	 35% 45%	
Maximum Travel Grade :	3°	
Maximum Platform Height	33 ft	43 ft
Maximum Drive Speed 2 WD Maximum Drive Speed 4WD	3.0 mph (4.8 kph) 3.5 mph (5.6 kph)	3.0 mph (4.8 kph) 3.5 mph (5.6 kph)
LIft Up Speed (Stowed to Full Height)	29 - 31 sec	40 - 45 sec
Lift Down Speed (Full Height to Stowed)		
Maximum Wind Speed	28 mph (12.5 m/s)	
Maximum Horizontal Manual Side Force: Single Extension Dual Extension Single Extension (CE/AUS) Dual Extension (CE/AUS)	 335 lb force (1490 N) 300 lb force (1335 N) 90 lb force (400 N) 90 lb force (400 N)	 300 lb force (1335 N) 300 lb force (1335 N) 90 lb force (400 N) 90 lb force (400 N)
Maximum Tire Load	4400 lbs (1996 kg)	
Ground Bearing Pressure w/Standard tires	49 psi (3.45 kg/cm^2)	56 psi (3.94 kg/cm^2)
Leveling Jack Bearing Pressure	69 psi (4.9 kg/cm^2)	
Wheelbase	9.67 ft (2.95 m)	
Ground Clearance	12 in (30 cm)	
Maximum Hydraulic System Pressure	3000 psi (207 bar)	
Electrical System Voltage	12 Volt	
Inside Turning Radius	14 ft 5 in (4.39 m)	
Outside Turning Radius	20 ft 1 in (6.12 m)	
Gross Vehicle Weight w/ One Extension Note: Certain options or country standards increase weight.	11,910 lbs (5,402 kg)	15,300 lbs (6,940 kg)

1.2 CAPACITIES

Table 1-2. Capacities

Description	3394RT	4394RT
Fuel Tank	31.5 gal (119 l)	
Hydraulic Tank	40 gal (151 l)	

1.3 ENGINES

Table 1-3. Ford LRG-425 Specifications

Fuel	Gasoline
Oil Capacity	4.5 Quarts (4.25 L) w/Filter
Idle RPM	1000
Low RPM	1800
High RPM	2800
Alternator	40 Amp, Belt Drive
Battery	112 Amphour, 950 Cold Cranking Amps, 12 VDC
Fuel Consumption Low RPM High RPM	 3.45 GPH (13.06 lph) 4.60 GPH (17.41 lph)
Horsepower	54 @ 2400 RPM, full load
Cooling System	16 Quarts (15.14 L)
Spark Plug	AWSF-52-C
Spark Plug Gap	0.044 in. (1.117 mm)

Table 1-4. Deutz F3M2011 Specifications

Fuel	DIesel
Oil Capacity	8.5 Quarts (8 L) w/Filter
Low RPM	900
High RPM	2800
Alternator	95 Amp, Belt Drive
Battery	112 Amphour, 950 Cold Cranking Amps, 12 VDC
Fuel Consumption Low RPM High RPM	 1.3 GPH (4.9 lph) 1.6 GPH (6.0 lph)
Horsepower	48 @ 2800 RPM, full load

Table 1-5. GM 3.0L Specifications

Fuel	Gasoline or Gasoline/LP Gas
No. of Cylinders	4
BHP Gasoline LP	 83 hp @ 3000 rpm 75 hp @ 3000 rpm
Bore	4.0 in. (101.6 mm)
Stroke	3.6 in. (91.44 mm)
Displacement	181 cu.in. (3.0 L, 2966 cc)
Oil Capacity w/filter	4.5 qts. (4.25 L)
Minimum Oil Pressure at idle Hot	 6 psi (0.4 Bar) @ 1000 rpm 18 psi (1.2 Bar) @ 2000 rpm
Compression Ratio	9.2:1
Firing Order	1-3-4-2
Max. RPM	2800

1.4 TIRES

Table 1-6. Tire Specifications

Size	Ply Rating	Inflation Pressure	Wheel Nut Torque (Dry)
12 x 16.5 Pneumatic	10	90 psi (6 bar)	170 ft lbs (238 Nm)
12 x 16.5 Foam Filled	10	Foam Fill to 90 psi (6 bar)	170 ft lbs (238 Nm)
12 x 16.5 Pneumatic (Non-Marking)	10	90 psi (6 bar)	170 ft lbs (238 Nm)
12 x 16.5 Foam Filled (Non-Marking)	10	Foam Fill to 90 psi (6 bar)	170 ft lbs (238 Nm)
33/1550 x 16.5 Pneumatic	14	90 psi (6 bar)	170 ft lbs (238 Nm)
33/1550 x 16.5 Foam Filled	14	Foam Fill to 90 psi (6 bar)	170 ft lbs (238 Nm)
33/16LLx16.1 Foam Filled - Sand	10	Foam Fill to 50 psi (3.4 bar)	170 ft lbs (238 Nm)
31 x 15.50-15 Grass Master	10	60 psi (4 bar)	170 ft lbs (238 Nm)

1.5 MACHINE DIMENSIONS

Description	3394RT	4394RT
Machine Height (rails down)	61.75 in (1.6 m)	70.4 in (1.8 m)
Machine Width	7ft 10in (2.4 m)	
Machine Length	13 ft (4 m)	

1.6 PRESSURE SETTINGS

Table 1-7. Pressure Settings

Description	3394RT	4394RT
Main Relief	3000 psi (207 bar)	
Steer Relief	2800 psi (193 bar)	
Lift	2700 psi (186 bar)	
Leveling Jack Relief	2500 psi (172 bar)	

1.7 SERIAL NUMBER LOCATIONS

For machine identification, a serial number plate is affixed to the machine. The plate is located at the rear of the machine on the left side of the axle. In addition, should the serial number plate be damaged or missing, the machine serial number is stamped directly under the serial number plate.

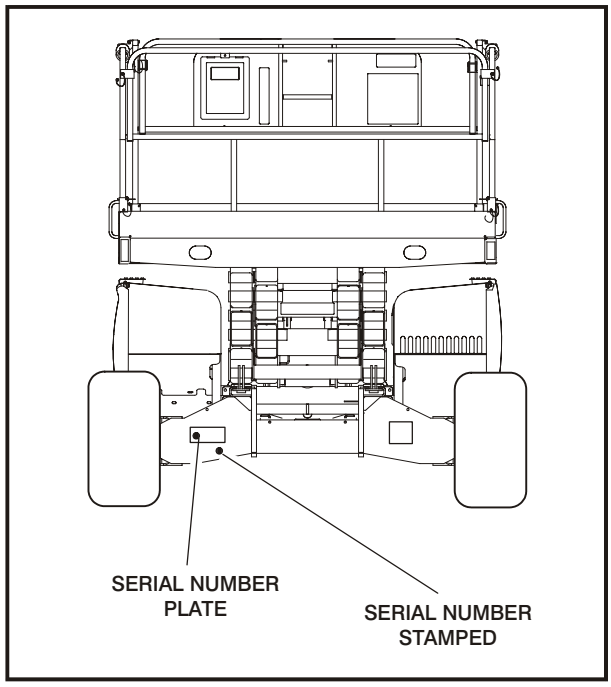


Figure 1-1. Serial Number Location

1.8 SENSORS

The machine is equipped with the following limit switches:

Elevation Switch/Rotary Position Sensor - High drive speed is cut out when platform is raised above the preset heights listed in Table 1-8, High Drive Cut-Out Height.

Table 1-8. High Drive Cut-Out Height

Model	Feet	Meters
3394RT	6-9	1.8 - 2.7
4394RT	7-10	2.1 - 3

Tilt Alarm - An alarm sounds and a warning light is illuminated when the machine is operated on a slope that exceeds the values in Table 1-9, Tilt Sensor Indicators. The lift and drive functions will cut out at these set heights.

NOTE: *Alarm only sounds when above elevation.*

If the machine is operated beyond the specified slope, with the platform completely lowered, only the warning light is illuminated.

Table 1-9. Tilt Sensor Indicators

Model	Front To Back	Side To Side
3394RT (ANSI, ANSI Export, Aus)	5° to full height	5° to 26 ft (8 m) 4° to 30 ft (9 m) 3° to 33 ft (10 m)
4394RT (ANSI, ANSI Export, Aus)	5° to full height	5° to 26 ft (8 m) 4° to 30 ft (9 m) 3° to 43 ft (13 m)
3394RT/4394RT (CSA)	3° to full height	3° to full height
3394RT/4394RT (CE)	5° to full height	3° to full height

1.9 CYLINDER SPECIFICATIONS

Table 1-10. Cylinder Specifications

Description	Bore	Stroke	Rod Dia
Lift Cylinder	4.5 in (11.4 cm)	83 in (211 cm)	3.5 in (8.9 cm)
Leveling Jack Cylinder	3 in (7.6 cm)	21.5 in (54.6 cm)	2 in (5 cm)
Lockout Cylinder (Oscillating Axle)	2.5 in (6.4 cm)	6.0 in (15.2 cm)	1.75 in (4.4 cm)
Power Deck Extension Cylinders	1.5 in (3.8 cm)	48 in (122 cm)	1 in (2.5 cm)
Steer Cylinder	2.5 in (6.4 cm)	4.6 in (11.2 cm)	1.75 in (4.4 cm)

1.10 MAJOR COMPONENT WEIGHTS

Table 1-11. Major Component Weights

Component	Weight
Fixed Platform	1070 lbs (485 kg)
Platform Extension	440 lbs (200 kg)
Arm Assembly- (Includes Lift Cylinder) 3394RT 4394RT	 3600 lbs (1633 kg) 4550 lbs (2064 kg)
Chassis with Pneumatic Tires 3394RT 4394RT	 6790 lbs (3080 kg) 9080 lbs (4119 kg)
Chassis with Foam Filled Tires 3394RT 4394RT	 7788 lbs (3533 kg) 9086 lbs (4121 kg)

1.11 CRITICAL STABILITY WEIGHTS

⚠ WARNING

DO NOT REPLACE ITEMS CRITICAL TO STABILITY WITH ITEMS OF DIFFERENT WEIGHT OR SPECIFICATION (FOR EXAMPLE: FILLED TIRES, ENGINE) DO NOT MODIFY UNIT IN ANY WAY TO AFFECT STABILITY.

Table 1-12. Critical Stability Weights

Component	Weight
Tires 12 x 16.5 Pneumatic 12 x16.5 Foam Filled 33/1550-16.5 Pneumatic 33/1550-16.5 Foam Filled 33/16LL x 16.1 Foam Filled - Sand	 132 lbs (60 kg) 352 lbs (160 kg) 162 lbs (73 kg) 410 lbs (186 kg) 426 lbs (193 kg)
Engine (Ford)	324 lbs (147 kg)
Engine (Deutz)	441 lbs (200 kg)
Engine (GM)	341 lbs (155 kg)

1.12 LUBRICATION SPECIFICATIONS

Table 1-13. Hydraulic Oil

HYDRAULIC SYSTEM OPERATING TEMPERATURE RANGE	SAE VISCOSITY GRADE
0°F to +23°F (-18°C to -5°C)	10W
0°F to +210°F (-18°C to +100°C)	10W-20,10W-30
+50°F to +210°F (+10°C to +100°C)	20W-20

NOTE: *Hydraulic oils must have anti-wear qualities at least to API Service Classification GL-3, and sufficient chemical stability for mobile hydraulic system service. JLG Industries recommends Mobilfluid 424 hydraulic oil, which has an SAE viscosity index of 152 .*

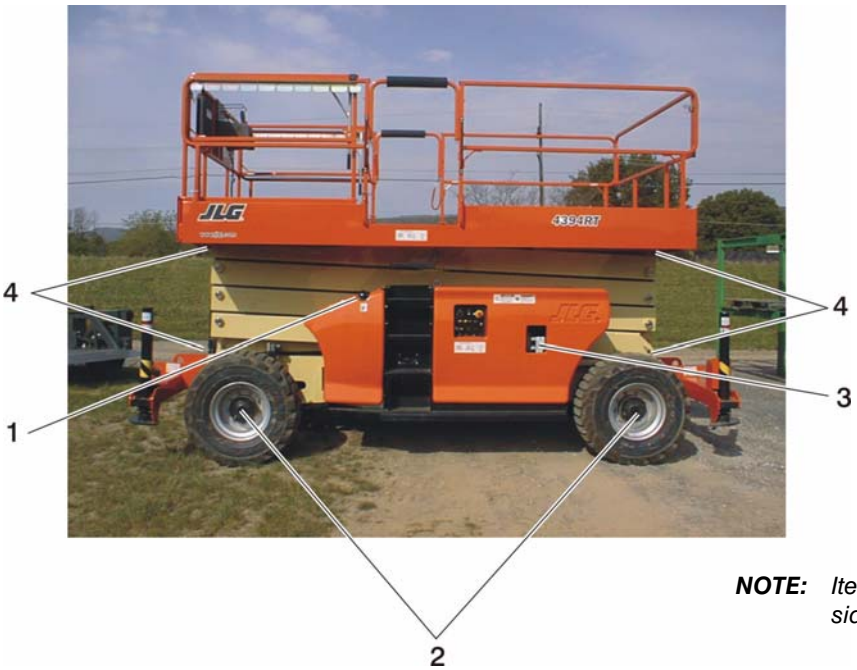
Table 1-14. Mobil DTE 13M Specs

ISO Viscosity Grade	#32
Specific Gravity	0.877
Pour Point, Max	-40°F (-40°C)
Flash Point, Min.	330°F (166°C)
Viscosity	
at 40° C	33cSt
at 100° C	6.6 cSt
at 100° F	169 SUS
at 210° F	48 SUS
cp at -20° F	6,200
Viscosity Index	140

Table 1-15. Mobil EAL 224H Specs

Type	Synthetic Biodegradable
ISO Viscosity Grade	32/46
Specific Gravity	0.922
Pour Point, Max	-25°F (-32°C)
Flash Point, Min.	428°F (220°C)
Operating Temp.	0°F to 180°F (-17°C to 162°C)
Viscosity	
at 40°C	37 cSt
at 100°C	8.4 cSt
Viscosity Index	213
NOTE: *Must be stored above 32°F (14°C)*	

1.13 OPERATOR MAINTENANCE



1. Fuel Tank
2. Drive Hubs
3. Hydraulic Oil Tank
4. Sliding Wear Pads
5. Oil Change w/Filter - Ford
6. Oil Change w/Filter - Deutz
7. Oil Change w/Filter - GM
8. Fuel Filter - Ford
9. Fuel Filter - Deutz
10. Fuel Filter (Gasoline) - GM
11. Air Filter
12. Electronic Pressure Regulator (LP Only)
13. Fuel Filter (Propane) - GM

NOTE: *Item #5 through #13 are on the opposite side of the machine and not shown.*

Figure 1-2. Operator Maintenance and Lubrication Diagram

⚠ WARNING

TO AVOID PERSONAL INJURY, USE SAFETY PROP FOR ALL MAINTENANCE REQUIRING PLATFORM TO BE ELEVATED.

NOTE: *Be sure to lubricate like items on each side.*

NOTE: *Recommended lubricating intervals are based on machine operations under normal conditions. For machines used in multi-shift operations and/or exposed to hostile environments or conditions, lubrication frequencies must be increased accordingly.*

Operate hydraulic functions through one complete cycle before checking hydraulic oil level in tank. Oil should be visible in ADD sight window on hydraulic tank. If oil is not visible, add oil until oil is visible in both ADD and FULL sight windows on tank. Do not overfill tank.

Any time the pump coupling is removed, coat splines of coupling with Texaco Code 1912 grease prior to assembly.

1. Fuel Tank

- Fuel - Diesel or Gasoline
- Capacity - 31.5 gal (119 l)

2. Drive Hub

- Lube Points - Fill Plugs (4)
- Lube - EPGL
- Interval - Every 2 years or 1200 hours

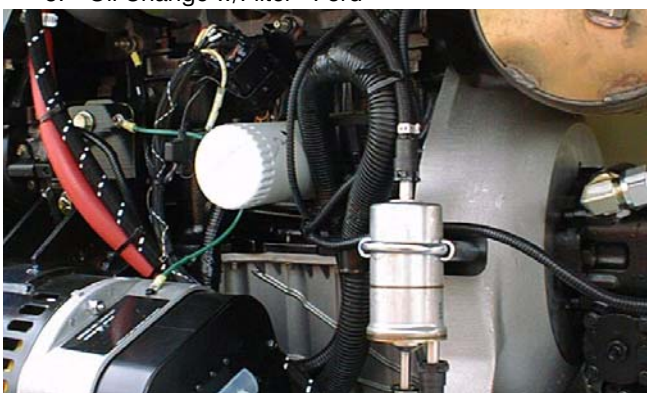
3. Hydraulic Oil

- Lube Point - Fill Cap/Fill Level
- Lube - HO
- Interval - Check oil every 10 hours of operation; change oil every 2 years or 1200 hours of operation.

4. Sliding Wear Pads

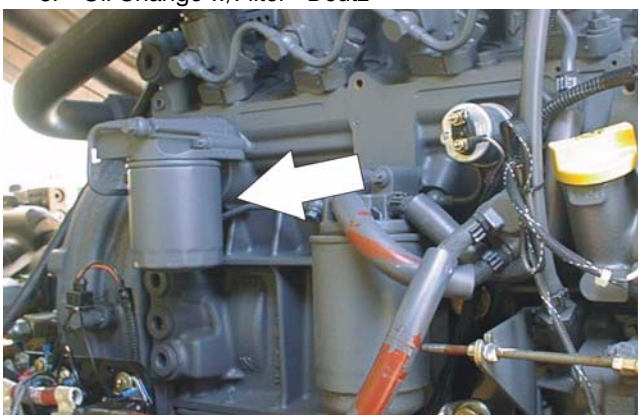
- Lube Points - 8 Sliding Wear Pads
- Lube - MPG
- Interval - Every month or 50 hours.

5. Oil Change w/Filter - Ford



- Lube Point(s) - Fill Cap/Spin-on Element (JLG P/N 7014501)
- Capacity - 4.5 qt. (4.25 L)
- Lube - EO
- Interval - 3 Months or 150 hours of operation
- Comments - Check level daily/Change in accordance with engine manual.

6. Oil Change w/Filter - Deutz

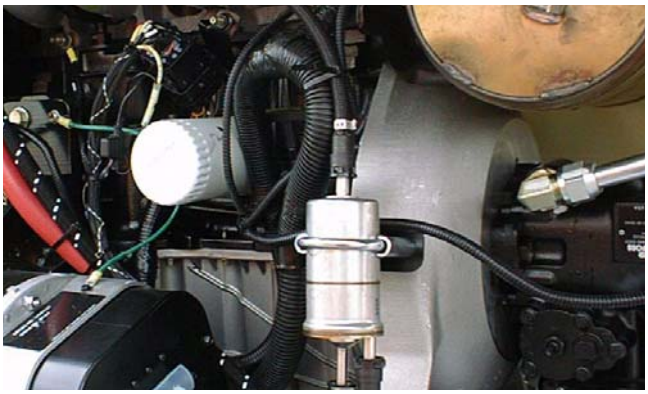


- Lube Point(s) - Fill Cap/Spin-on Element (JLG P/N 7016331)
- Capacity - 6.3 qt. (5.9 L) engine only
- Lube - EO
- Interval - Every Year or 600 hours of operation
- Comments - Check level daily/Change in accordance with engine manual.

7. Oil Change w/Filter - GM

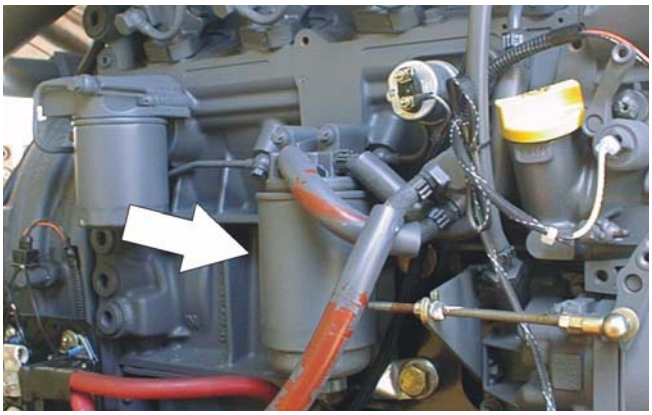
- Lube Point(s) - Fill Cap/Spin-on Element (JLG P/N 7027965)
- Capacity - 4.5 qt. (4.25 L) w/filter
- Lube - EO
- Interval - 3 Months or 150 hours of operation
- Comments - Check level daily/Change in accordance with engine manual.

8. Fuel Filter - Ford



- Lube Point(s) - Replaceable Element
- Interval - Every Year or 600 hours of operation

9. Fuel Filter - Deutz



- Lube Point(s) - Replaceable Element
- Interval - Every Year or 600 hours of operation

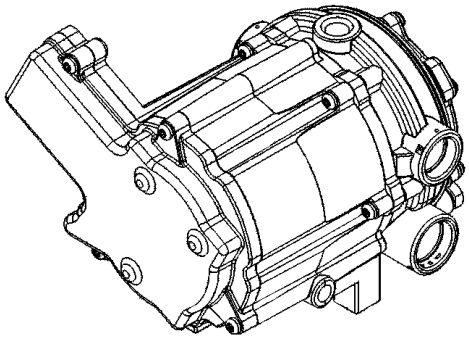
10. Fuel Filter (Gasoline) - GM

- Lube Point(s) - Replaceable Element
- Interval - Every 6 months or 300 hours of operation

11. Air Filter

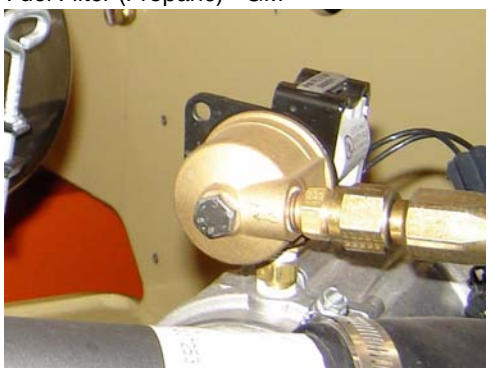
- Lube Point(s) - Replaceable Element
- Interval - Every 6 months or 300 hours of operation or as indicated by the condition indicator

12. Electronic Pressure Regulator (LP only)



- Interval - 3 Months or 150 hours of operation
- Comments - Drain oil build up. Refer to Draining Oil Build Up From The Propane Regulator

13. Fuel Filter (Propane) - GM



- Interval - 3 Months or 150 hours of operation
- Comments - Replace filter. Refer to Propane Fuel Filter Replacement

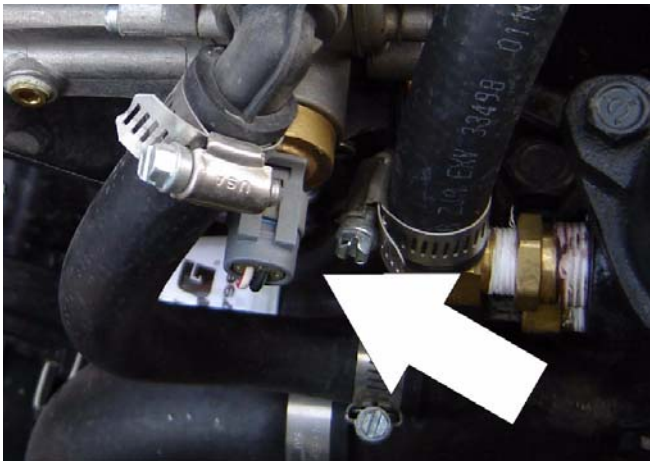
Draining Oil Build Up From The Propane Regulator

During the course of normal operation oils may build inside the primary and secondary chambers of the propane pressure regulator. These oils may be a result of poor fuel quality, contamination of the fuel supply chain, or regional variation in the make up of the fuel. If the build up of the oil is significant this can effect the operation of the fuel control system. Refer to Section 1.13, Operator Maintenance for maintenance intervals. More frequent draining may be required if the fuel supply has been contaminated.

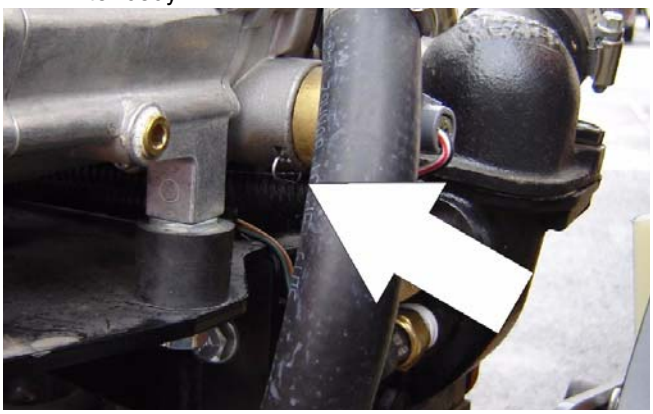
NOTICE

FOR BEST RESULTS WARM THE ENGINE TO OPERATING TEMPERATURE BEFORE DRAINING. THIS WILL ALLOW THE OILS TO FLOW FREELY FROM THE REGULATOR.

1. Move the equipment to a well ventilated area. Ensure there are no external ignition sources.
2. Start the engine and bring to operating temperature.
3. With the engine running, close the manual tank valve and run the engine out of fuel.
4. Push in the Emergency Switch once the engine stops.
5. Disconnect the electrical connection to the LPG fuel temperature sensor in the auxiliary fuel port of the EPR.



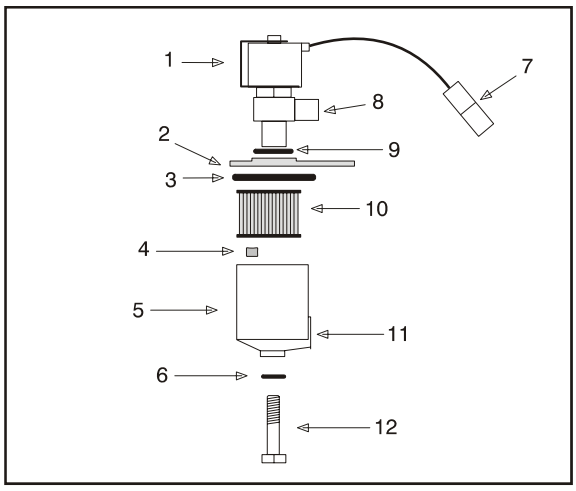
6. Remove the retainer clip for the LPG fuel temperature sensor and remove the sensor from the regulator body.



NOTE: *Have a small container ready to collect oil that will drain freely from the regulator at this point.*

7. Once all of the oil has been drained, reinstall the LPG fuel temperature sensor and reconnect the electrical connector.
8. Open the fuel tank manual valve.
9. Start the engine and verify all connections are secure.
10. Dispose of any drained oil per local regulations in a safe and proper fashion.

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 1-3. 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 retaining bolt and remove it.
4. Pull the filter housing from the Electric lock off assembly.
5. Locate Filter magnet and remove it.
6. Remove the filter from the housing.
7. Remove and discard the housing seal.
8. 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. 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. 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 retaining bolt 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.

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.

⚠ CAUTION

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

1.14 TORQUE CHARTS

VALUES FOR ZINC PLATED / YELLOW CHROMATE FASTENERS ONLY SAE GRADE 5 BOLTS & GRADE 2 NUTS								
SIZE	TPI	BOLT DIA	TENSILE STRESS AREA	CLAMP LOAD	TORQUE (DRY OR LOCTITE 263)	TORQUE (LUB)	TORQUE (LOCTITE 262)	TORQUE (LOCTITE) (242 OR 271)
		IN	SQ IN	LB	IN-LB [N.m]	IN-LB [N.m]	IN-LB [N.m]	IN-LB [N.m]
4	40	0.1120	0.00604	380	8 [.9]	6 [.7]		
	48	0.1120	0.00661	420	9 [1.0]	7 [.8]		
6	32	0.1380	0.00909	580	16 [1.8]	12 [1.4]		
	40	0.1380	0.01015	610	18 [2.0]	13 [1.5]		
8	32	0.1640	0.01400	900	30 [3.5]	22 [2.5]		
	36	0.1640	0.01474	940	31 [4]	23 [2.6]		
10	24	0.1900	0.01750	1120	43 [5]	32 [3.5]		
	32	0.1900	0.02000	1285	49 [5.5]	36 [4]		
1/4	20	0.2500	0.0318	2020	96 [11]	75 [9]		105 [12]
	28	0.2500	0.0364	2320	120 [14]	86 [10]		135 [15]
		IN	SQ IN	LB	FT-LB [N.m]	FT-LB [N.m]	FT-LB [N.m]	FT-LB [N.m]
5/16	18	0.3125	0.0524	3340	17 [23]	13 [18]	16 [22]	19 [26]
	24	0.3125	0.0580	3700	19 [26]	14 [19]	17 [23]	21 [29]
3/8	16	0.3750	0.0775	4940	30 [41]	23 [31]	28 [38]	35 [47]
	24	0.3750	0.0878	5600	35 [47]	25 [34]	32 [43]	40 [54]
7/16	14	0.4375	0.1063	6800	50 [68]	35 [47]	45 [61]	55 [75]
	20	0.4375	0.1187	7550	55 [75]	40 [54]	50 [68]	60 [81]
1/2	13	0.5000	0.1419	9050	75 [102]	55 [75]	68 [92]	85 [115]
	20	0.5000	0.1599	10700	90 [122]	65 [88]	80 [108]	100 [136]
9/16	12	0.5625	0.1820	11600	110 [149]	80 [108]	98 [133]	120 [163]
	18	0.5625	0.2030	12950	120 [163]	90 [122]	109 [148]	135 [183]
5/8	11	0.6250	0.2260	14400	150 [203]	110 [149]	135 [183]	165 [224]
	18	0.6250	0.2560	16300	170 [230]	130 [176]	153 [207]	190 [258]
3/4	10	0.7500	0.3340	21300	260 [353]	200 [271]	240 [325]	285 [386]
	16	0.7500	0.3730	23800	300 [407]	220 [298]	268 [363]	330 [447]
7/8	9	0.8750	0.4620	29400	430 [583]	320 [434]	386 [523]	475 [644]
	14	0.8750	0.5090	32400	470 [637]	350 [475]	425 [576]	520 [705]
1	8	1.0000	0.6060	38600	640 [868]	480 [651]	579 [785]	675 [915]
	12	1.0000	0.6630	42200	700 [949]	530 [719]	633 [858]	735 [997]
1 1/8	7	1.1250	0.7630	42300	800 [1085]	600 [813]	714 [968]	840 [1139]
	12	1.1250	0.8560	47500	880 [1193]	660 [895]	802 [1087]	925 [1254]
1 1/4	7	1.2500	0.9690	53800	1120 [1518]	840 [1139]	1009 [1368]	1175 [1593]
	12	1.2500	1.0730	59600	1240 [1681]	920 [1247]	1118 [1516]	1300 [1763]
1 3/8	6	1.3750	1.1550	64100	1460 [1979]	1100 [1491]	1322 [1792]	1525 [2068]
	12	1.3750	1.3150	73000	1680 [2278]	1260 [1708]	1506 [2042]	1750 [2373]
1 1/2	6	1.5000	1.4050	78000	1940 [2630]	1460 [1979]	1755 [2379]	2025 [2746]
	12	1.5000	1.5800	87700	2200 [2983]	1640 [2224]	1974 [2676]	2300 [3118]

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NOTE: THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS

SAE GRADE 5 SAE GRADE 8

Figure 1-4. Torque Chart (SAE Fasteners - Sheet 1 of 3)

VALUES FOR ZINC PLATED / YELLOW CHROMATE FASTENERS ONLY SAE GRADE 8 BOLTS & GRADE 8 NUTS, & SOCKET HEAD CAP SCREWS #6 THRU 1/4								
SIZE	TPI	BOLT DIA	TENSILE STRESS AREA	CLAMP LOAD	TORQUE (DRY OR LOCTITE 263)	TORQUE (LUB)	TORQUE (LOCTITE 262)	TORQUE (LOCTITE) (242 OR 271)
		IN	SQ IN	LB	IN-LB [N.m]	IN-LB [N.m]	IN-LB [N.m]	IN-LB [N.m]
4	40	0.1120	0.00604	540	12 [1.4]	9 [1.0]		
	48	0.1120	0.00661	600	13 [1.5]	10 [1.1]		
6	32	0.1380	0.00909	820	23 [2.6]	17 [1.9]		
	40	0.1380	0.01015	920	25 [2.8]	19 [2.2]		
8	32	0.1640	0.01400	1260	41 [4.5]	31 [3.5]		
	36	0.1640	0.01474	1320	43 [5]	32 [4]		
10	24	0.1900	0.01750	1580	60 [7]	45 [5]		
	32	0.1900	0.02000	1800	68 [8]	51 [6]		
1/4	20	0.2500	0.0318	2860	144 [16]	108 [12]		160 [18]
	28	0.2500	0.0364	3280	168 [19]	120 [14]		185 [21]
		IN	SQ IN	LB	FT-LB [N.m]	FT-LB [N.m]	FT-LB [N.m]	FT-LB [N.m]
5/16	18	0.3125	0.0524	4720	25 [34]	18 [24]	22 [30]	30 [41]
	24	0.3125	0.0580	5220	25 [34]	20 [27]	25 [34]	30 [41]
3/8	16	0.3750	0.0775	7000	45 [61]	35 [47]	40 [54]	50 [68]
	24	0.3750	0.0878	7900	50 [68]	35 [47]	45 [61]	55 [75]
7/16	14	0.4375	0.1063	9550	70 [95]	55 [75]	63 [85]	80 [108]
	20	0.4375	0.1187	10700	80 [108]	60 [81]	70 [95]	90 [122]
1/2	13	0.5000	0.1419	12750	110 [149]	80 [108]	96 [130]	120 [163]
	20	0.5000	0.1599	14400	120 [163]	90 [122]	108 [146]	135 [183]
9/16	12	0.5625	0.1820	16400	150 [203]	110 [149]	139 [188]	165 [224]
	18	0.5625	0.2030	18250	170 [230]	130 [176]	154 [209]	190 [258]
5/8	11	0.6250	0.2260	20350	220 [298]	170 [230]	180 [244]	240 [325]
	18	0.6250	0.2560	23000	240 [325]	180 [244]	204 [277]	265 [359]
3/4	10	0.7500	0.3340	30100	380 [515]	280 [380]	301 [408]	420 [569]
	16	0.7500	0.3730	33600	420 [569]	320 [434]	336 [456]	465 [630]
7/8	9	0.8750	0.4620	41600	600 [813]	460 [624]	485 [658]	660 [895]
	14	0.8750	0.5090	45800	660 [895]	500 [678]	534 [724]	725 [983]
1	8	1.0000	0.6060	51500	900 [1220]	680 [922]	687 [931]	990 [1342]
	12	1.0000	0.6630	59700	1000 [1356]	740 [1003]	796 [1079]	1100 [1491]
1 1/8	7	1.1250	0.7630	68700	1280 [1735]	960 [1302]	1030 [1396]	1400 [1898]
	12	1.1250	0.8560	77000	1440 [1952]	1080 [1464]	1155 [1607]	1575 [2135]
1 1/4	7	1.2500	0.9690	87200	1820 [2468]	1360 [1844]	1453 [1970]	2000 [2712]
	12	1.2500	1.0730	96600	2000 [2712]	1500 [2034]	1610 [2183]	2200 [2983]
1 3/8	6	1.3750	1.1550	104000	2380 [3227]	1780 [2413]	1907 [2586]	2625 [3559]
	12	1.3750	1.3150	118100	2720 [3688]	2040 [2765]	2165 [2935]	3000 [4067]
1 1/2	6	1.5000	1.4050	126500	3160 [4284]	2360 [3200]	2530 [3430]	3475 [4711]
	12	1.5000	1.5800	142200	3560 [4827]	2660 [3606]	2844 [3856]	3925 [5322]

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NOTE: THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS

SAE GRADE 5 SAE GRADE 8

Figure 1-5. Torque Chart (SAE Fasteners - Sheet 2 of 3))

JLG SPECIFICATION #4150701- MAGNA 565							
SOCKET HEAD CAP SCREWS 5/16 & ABOVE							
SIZE	TPI	BOLT DIA	TENSILE STRESS AREA	CLAMP LOAD	TORQUE	TORQUE (LOCTITE 262)	TORQUE (LOCTITE) (242 OR 271)
		IN	SQ IN	LB	IN-LB [N.m]	IN-LB [N.m]	IN-LB [N.m]
4	40	0.1120	0.00604				
	48	0.1120	0.00661				
6	32	0.1380	0.00909				
	40	0.1380	0.01015				
8	32	0.1640	0.01400				
	36	0.1640	0.01474				
10	24	0.1900	0.01750				
	32	0.1900	0.02000				
1/4	20	0.2500	0.0318	2860	108 [12]		160 [18]
	28	0.2500	0.0364	3280	120 [14]		185 [21]
		IN	SQ IN	LB	FT-LB [N.m]	FT-LB [N.m]	FT-LB [N.m]
5/16	18	0.3125	0.0524	4720	18 [24]	22 [30]	30 [41]
	24	0.3125	0.0580	5220	20 [27]	25 [34]	30 [41]
3/8	16	0.3750	0.0775	7000	35 [47]	40 [54]	50 [68]
	24	0.3750	0.0878	7900	35 [47]	45 [61]	55 [75]
7/16	14	0.4375	0.1063	9550	55 [75]	63 [85]	80 [108]
	20	0.4375	0.1187	10700	60 [81]	70 [95]	90 [122]
1/2	13	0.5000	0.1419	12750	80 [108]	96 [130]	120 [163]
	20	0.5000	0.1599	14400	90 [122]	108 [146]	135 [183]
9/16	12	0.5625	0.1820	16400	110 [149]	139 [188]	165 [224]
	18	0.5625	0.2030	18250	130 [176]	154 [209]	190 [258]
5/8	11	0.6250	0.2260	20350	170 [230]	180 [244]	240 [325]
	18	0.6250	0.2560	23000	180 [244]	204 [277]	265 [359]
3/4	10	0.7500	0.3340	30100	280 [380]	301 [408]	420 [569]
	16	0.7500	0.3730	33600	320 [434]	336 [456]	465 [630]
7/8	9	0.8750	0.4620	41600	460 [624]	485 [658]	660 [895]
	14	0.8750	0.5090	45800	500 [678]	534 [724]	725 [983]
1	8	1.0000	0.6060	51500	680 [922]	687 [931]	990 [1342]
	12	1.0000	0.6630	59700	740 [1003]	796 [1079]	1100 [1491]
1 1/8	7	1.1250	0.7630	68700	960 [1302]	1030 [1396]	1400 [1898]
	12	1.1250	0.8560	77000	1080 [1464]	1155 [1607]	1575 [2135]
1 1/4	7	1.2500	0.9690	87200	1360 [1844]	1453 [1970]	2000 [2712]
	12	1.2500	1.0730	96600	1500 [2034]	1610 [2183]	2200 [2983]
1 3/8	6	1.3750	1.1550	104000	1780 [2413]	1907 [2586]	2625 [3559]
	12	1.3750	1.3150	118100	2040 [2765]	2165 [2935]	3000 [4067]
1 1/2	6	1.5000	1.4050	126500	2360 [3200]	2530 [3430]	3475 [4711]
	12	1.5000	1.5800	142200	2660 [3606]	2844 [3856]	3925 [5322]

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NOTE: THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS

SAE GRADE 5 SAE GRADE 8

Figure 1-6. Torque Chart (SAE Fasteners - Sheet 3 of 3)

			VALUES FOR ZINC PLATED / YELLOW CHROMATE FASTENERS ONLY				
			CLASS 8.8 METRIC BOLTS CLASS 8 METRIC NUTS				
SIZE	PITCH	TENSILE STRESS AREA	CLAMP LOAD	TORQUE (DRY OR LOCTITE 263)	TORQUE (LUB)	TORQUE (LOCTITE 262)	TORQUE (LOCTITE) (242 OR 271)
		sq mm	KN	N.m	N.m	N.m	N.m
3	.5	5.03	2.19	1.3	1.0	1.2	1.4
3.5	.6	6.78	2.95	2.1	1.6	1.9	2.3
4	.7	8.78	3.82	3.1	2.3	2.8	3.4
5	.8	14.2	6.18	6.2	4.6	5.6	6.8
6	1	20.1	8.74	11	7.9	9.4	12
7	1	28.9	12.6	18	13	16	19
8	1.25	36.6	15.9	25	19	23	28
10	1.5	58.0	25.2	50	38	45	55
12	1.75	84.3	36.7	88	66	79	97
14	2	115	50.0	140	105	126	154
16	2	157	68.3	219	164	197	241
18	2.5	192	83.5	301	226	271	331
20	2.5	245	106.5	426	320	383	469
22	2.5	303	132.0	581	436	523	639
24	3	353	153.5	737	553	663	811
27	3	459	199.5	1080	810	970	1130
30	3.5	561	244.0	1460	1100	1320	1530
33	3.5	694	302.0	1990	1490	1790	2090
36	4	817	355.5	2560	1920	2300	2690
42	4.5	1120	487.0	4090	3070	3680	4290

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NOTE: THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS

METRIC CLASS 8.8 METRIC CLASS 10.9

Figure 1-7. Torque Chart (METRIC Fasteners - Sheet 1 of 3)

			VALUES FOR ZINC PLATED / YELLOW CHROMATE FASTENERS ONLY				
			CLASS 10.9 METRIC BOLTS CLASS 10 METRIC NUTS CLASS 12.9 SOCKET HEAD CAP SCREWS M3-M5				
SIZE	PITCH	TENSILE STRESS AREA	CLAMP LOAD	TORQUE (DRY OR LOCTITE 263)	TORQUE (LUB)	TORQUE (LOCTITE 262)	TORQUE (LOCTITE) (242 OR 271)
		sq mm	KN	N.m	N.m	N.m	N.m
3	.5	5.03	3.13	1.9	1.4	1.5	2.1
3.5	.6	6.78	4.22	3.0	2.2	2.4	3.3
4	.7	8.78	5.47	4.4	3.3	3.5	4.8
5	.8	14.2	8.85	8.9	6.6	7.1	9.7
6	1	20.1	12.5	15	11	12	17
7	1	28.9	18.0	25	19	20	28
8	1.25	36.6	22.8	37	27	29	40
10	1.5	58.0	36.1	72	54	58	79
12	1.75	84.3	52.5	126	95	101	139
14	2	115	71.6	200	150	160	220
16	2	157	97.8	313	235	250	344
18	2.5	192	119.5	430	323	344	473
20	2.5	245	152.5	610	458	488	671
22	2.5	303	189.0	832	624	665	915
24	3	353	220.0	1060	792	845	1170
27	3	459	286.0	1540	1160	1240	1690
30	3.5	561	349.5	2100	1570	1680	2310
33	3.5	694	432.5	2600	2140	2280	2860
36	4	817	509.0	3660	2750	2930	4020
42	4.5	1120	698.0	5860	4400	4690	6440

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NOTE: THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS

METRIC CLASS 8.8

METRIC CLASS 10.9

Figure 1-8. Torque Chart (METRIC Fasteners - Sheet 2 of 3))

			JLG SPECIFICATION #4150701- MAGNA 565 CLASS 12.9 SOCKET HEAD CAP SCREWS M6 AND ABOVE			
SIZE	PITCH	TENSILE STRESS AREA	CLAMP LOAD	TORQUE	TORQUE (LOCTITE 262)	TORQUE (LOCTITE) (242 OR 271)
		sq mm	KN	N.m	N.m	N.m
3	.5	5.03			1.5	2.1
3.5	.6	6.78			2.4	3.3
4	.7	8.78			3.5	4.8
5	.8	14.2			7.1	9.7
6	1	20.1	12.5	11	12	17
7	1	28.9	18.0	19	20	28
8	1.25	36.6	22.8	27	29	40
10	1.5	58.0	36.1	54	58	79
12	1.75	84.3	52.5	95	101	139
14	2	115	71.6	150	160	220
16	2	157	97.8	235	250	344
18	2.5	192	119.5	323	344	473
20	2.5	245	152.5	458	488	671
22	2.5	303	189.0	624	665	915
24	3	353	220.0	792	845	1170
27	3	459	286.0	1160	1240	1690
30	3.5	561	349.5	1570	1680	2310
33	3.5	694	432.5	2140	2280	2860
36	4	817	509.0	2750	2930	4020
42	4.5	1120	698.0	4400	4690	6440

NOTE: THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS

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Figure 1-9. Torque Chart (METRIC Fasteners - Sheet 3 of 3)

NOTES:

SECTION 2. GENERAL

2.1 MACHINE PREPARATION, INSPECTION, AND MAINTENANCE

General

This section provides the necessary information needed by those personnel that are responsible to place the machine in operation readiness and maintain its safe operating condition. For maximum service life and safe operation, ensure that all the necessary inspections and maintenance have been completed before placing the machine into service.

Preparation, Inspection, and Maintenance

It is important to establish and conform to a comprehensive inspection and preventive maintenance program. The following table outlines the periodic machine inspections and maintenance recommended by JLG Industries, Inc. Consult your national, regional, or local regulations for further requirements for aerial work platforms. The frequency of inspections and maintenance must be increased as environment, severity and frequency of usage requires.

Pre-Start Inspection

It is the User's or Operator's primary responsibility to perform a Pre-Start Inspection of the machine prior to use daily or at each change of operator. Reference the Operator's and Safety Manual for completion procedures for the Pre-Start Inspection. The Operator and Safety Manual must be read in its entirety and understood prior to performing the Pre-Start Inspection.

Pre-Delivery Inspection and Frequent Inspection

The Pre-Delivery Inspection and Frequent Inspection shall be performed by a qualified JLG equipment mechanic. JLG Industries, Inc. recognizes a qualified JLG equipment mechanic as a person who, by possession of a recognized degree, certificate, extensive knowledge, training, or experience, has successfully demonstrated the ability and proficiency to service, repair, and maintain the subject JLG product model.

The Pre-Delivery Inspection and Frequent Inspection procedures are performed in the same manner, but at different times. The Pre-Delivery Inspection shall be performed prior to each sale, lease, or rental delivery. The Frequent Inspection shall be accomplished for each machine in service for 3 months or 150 hours (whichever comes first); out of service for a period of more than 3 months; or when purchased used. The frequency of this inspection must be increased as environment, severity and frequency of usage requires.

Reference the JLG Pre-Delivery and Frequent Inspection Form and the Inspection and Preventative Maintenance Schedule for items requiring inspection during the performance of these inspections. Reference the appropriate areas of this manual for servicing and maintenance procedures.

Annual Machine Inspection

JLG recommends that an annual machine inspection be performed by a Factory-Certified Service Technician on an annual basis, no later than thirteen (13) months from the date of the prior Annual Machine Inspection. JLG Industries, Inc. recognizes a Factory-Certified Service Technician as a person who has successfully completed the JLG Service Training School for the subject JLG product model. Reference the machine Service and Maintenance Manual and appropriate JLG inspection form for performance of this inspection.

Reference the JLG Annual Machine Inspection Form and the Inspection and Preventative Maintenance Schedule for items requiring inspection during the performance of this inspection. Reference the appropriate areas of this manual for servicing and maintenance procedures.

For the purpose of receiving safety-related bulletins, it is important that JLG Industries, Inc. has updated ownership information for each machine. When performing each Annual Machine Inspection, notify JLG Industries, Inc. of the current machine ownership.

Preventative Maintenance

In conjunction with the specified inspections, maintenance shall be performed by a qualified JLG equipment mechanic. JLG Industries, Inc. recognizes a qualified JLG equipment mechanic as a person who, by possession of a recognized degree, certificate, extensive knowledge, training, or experience, has successfully demonstrated the ability and proficiency to service, repair, and maintain the subject JLG product model.

Reference the Preventative Maintenance Schedule and the appropriate areas of this manual for servicing and maintenance procedures. The frequency of service and maintenance must be increased as environment, severity and frequency of usage requires.

Table 2-1. Inspection and Maintenance

Type	Frequency	Primary Responsibility	Service Qualification	Reference
Pre-Start Inspection	Prior to use each day; or At each Operator change.	User or Operator	User or Operator	Operator and Safety Manual
Pre-Delivery Inspection	Prior to each sale, lease, or rental delivery.	Owner, Dealer, or User	Qualified JLG Mechanic	Service and Maintenance Manual and applicable JLG inspection form.
Frequent Inspection	In service for 3 months or 150 hours, whichever comes first; or Out of service for a period of more than 3 months; or Purchased used.	Owner, Dealer, or User	Qualified JLG Mechanic	Service and Maintenance Manual and applicable JLG inspection form.
Annual Machine Inspection	Annually, no later than 13 months from the date of the prior inspection.	Owner, Dealer, or User	Factory-Certified Service Technician or a Qualified JLG Mechanic	Service and Maintenance Manual and applicable JLG inspection form.
Preventative Maintenance	At intervals as specified in the Service and Maintenance Manual.	Owner, Dealer, or User	Qualified JLG Mechanic	Service and Maintenance Manual

2.2 SERVICE AND GUIDELINES

General

The following information is provided to assist you in the use and application of servicing and maintenance procedures contained in this book.

Safety and Workmanship

Your safety, and that of others, is the first consideration when engaging in the maintenance of equipment. Always be conscious of weight. Never attempt to move heavy parts without the aid of a mechanical device. Do not allow heavy objects to rest in an unstable position. When raising a portion of the equipment, ensure that adequate support is provided.

Cleanliness

1. The most important single item in preserving the long service life of a machine is to keep dirt and foreign materials out of the vital components. Precautions have been taken to safeguard against this. Shields, covers, seals, and filters are provided to keep air, fuel, and oil supplies clean; however, these items must be maintained on a scheduled basis in order to function properly.
2. At any time when air, fuel, or oil lines are disconnected, clear adjacent areas as well as the openings and fittings themselves. As soon as a line or component is disconnected, cap or cover all openings to prevent entry of foreign matter.
3. Clean and inspect all parts during servicing or maintenance, and assure that all passages and openings are unobstructed. Cover all parts to keep them clean. Be sure all parts are clean before they are installed. New parts should remain in their containers until they are ready to be used.

Components Removal and Installation

1. Use adjustable lifting devices, whenever possible, if mechanical assistance is required. All slings (chains, cables, etc.) should be parallel to each other and as near perpendicular as possible to top of part being lifted.
2. Should it be necessary to remove a component on an angle, keep in mind that the capacity of an eyebolt or similar bracket lessens, as the angle between the supporting structure and the component becomes less than 90°.
3. If a part resists removal, check to see whether all nuts, bolts, cables, brackets, wiring, etc., have been removed and that no adjacent parts are interfering.

Component Disassembly and Reassembly

When disassembling or reassembling a component, complete the procedural steps in sequence. Do not partially disassemble or assemble one part, then start on another. Always recheck your work to assure that nothing has been overlooked. Do not make any adjustments, other than those recommended, without obtaining proper approval.

Pressure-Fit Parts

When assembling pressure-fit parts, use an anti-seize or molybdenum disulfide base compound to lubricate the mating surface.

Bearings

1. When a bearing is removed, cover it to keep out dirt and abrasives. Clean bearings in nonflammable cleaning solvent and allow to drip dry. Compressed air can be used but do not spin the bearing.
2. Discard bearings if the races and balls (or rollers) are pitted, scored, or burned.
3. If bearing is found to be serviceable, apply a light coat of oil and wrap it in clean (waxed) paper. Do not unwrap reusable or new bearings until they are ready to install.
4. Lubricate new or used serviceable bearings before installation. When pressing a bearing into a retainer or bore, apply pressure to the outer race. If the bearing is to be installed on a shaft, apply pressure to the inner race.

Gaskets

Check that holes in gaskets align with openings in the mating parts. If it becomes necessary to hand-fabricate a gasket, use gasket material or stock of equivalent material and thickness. Be sure to cut holes in the right location, as blank gaskets can cause serious system damage.

Bolt Usage and Torque Application

1. Use bolts of proper length. A bolt which is too long will bottom before the head is tight against its related part. If a bolt is too short, there will not be enough thread area to engage and hold the part properly. When replacing bolts, use only those having the same specifications of the original, or one which is equivalent.
2. Unless specific torque requirements are given within the text, standard torque values should be used on heat-treated bolts, studs, and steel nuts, in accordance with recommended shop practices. (See Torque Chart Section 1.)

Hydraulic Lines and Electrical Wiring

Clearly mark or tag hydraulic lines and electrical wiring, as well as their receptacles, when disconnecting or removing them from the unit. This will assure that they are correctly reinstalled.

Hydraulic System

1. Keep the system clean. If evidence of metal or rubber particles are found in the hydraulic system, drain and flush the entire system.
2. Disassemble and reassemble parts on clean work surface. Clean all metal parts with non-flammable cleaning solvent. Lubricate components, as required, to aid assembly.

Lubrication

Service applicable components with the amount, type, and grade of lubricant recommended in this manual, at the specified intervals. When recommended lubricants are not available, consult your local supplier for an equivalent that meets or exceeds the specifications listed.

Battery

Clean battery, using a non-metallic brush and a solution of baking soda and water. Rinse with clean water. After cleaning, thoroughly dry battery and coat terminals with an anti corrosion compound.

Lubrication and Servicing

Components and assemblies requiring lubrication and servicing are shown in the Lubrication Chart in Section 1.

2.3 LUBRICATION AND INFORMATION

Hydraulic System

1. The primary enemy of a hydraulic system is contamination. Contaminants enter the system by various means, e.g., using inadequate hydraulic oil, allowing moisture, grease, filings, sealing components, sand, etc., to enter when performing maintenance, or by permitting the pump to cavitate due to insufficient system warm-up or leaks in the pump supply (suction) lines.

2. The design and manufacturing tolerances of the component working parts are very close, therefore, even the smallest amount of dirt or foreign matter entering a system can cause wear or damage to the components and generally results in faulty operation. Every precaution must be taken to keep hydraulic oil clean, including reserve oil in storage. Hydraulic system filters should be checked, cleaned, and/or replaced as necessary, at the specified intervals required in the Lubrication Chart in Section 1. Always examine filters for evidence of metal particles.

3. Cloudy oils indicate a high moisture content which permits organic growth, resulting in oxidation or corrosion. If this condition occurs, the system must be drained, flushed, and refilled with clean oil.

4. It is not advisable to mix oils of different brands or types, as they may not contain the same required additives or be of comparable viscosities. Good grade mineral oils, with viscosities suited to the ambient temperatures in which the machine is operating, are recommended for use.

NOTE: *Metal particles may appear in the oil or filters of new machines due to the wear-in of meshing components.*

Hydraulic Oil

1. Refer to Section 1 for recommendations for viscosity ranges.

2. JLG recommends Mobilfluid 424 hydraulic oil, which has an SAE viscosity of 10W-30 and a viscosity index of 152.

NOTE: *Start-up of hydraulic system with oil temperatures below -15°F (-26°C) is not recommended. If it is necessary to start the system in a sub-zero environment, it will be necessary to heat the oil with a low density, 100VAC heater to a minimum temperature of -15°F (-26°C).*

3. The only exception to the above is to drain and fill the system with Mobil DTE 13 oil or its equivalent. This will allow start up at temperatures down to -20°F (-29°C). However, use of this oil will give poor performance at temperatures above 120° (49°C). Systems using DTE 13 oil should not be operated at temperatures above 200°F (94°C) under any condition.

Changing Hydraulic Oil

1. Use of any of the recommended hydraulic oils eliminates the need for changing the oil on a regular basis. However, filter elements must be changed after the first 50 hours of operation and every 300 hours thereafter. If it is necessary to change the oil, use only those oils meeting or exceeding the specifications appearing in this manual. If unable to obtain the same type of oil supplied with the machine, consult local supplier for assistance in selecting the proper equivalent. Avoid mixing petroleum and synthetic base oils. JLG Industries recommends changing the hydraulic oil annually.

2. Use every precaution to keep the hydraulic oil clean. If the oil must be poured from the original container into another, be sure to clean all possible contaminants from the service container. Always clean the mesh element of the filter and replace the cartridge any time the system oil is changed.

3. While the unit is shut down, a good preventive maintenance measure is to make a thorough inspection of all hydraulic components, lines, fittings, etc., as well as a functional check of each system, before placing the machine back in service.

Lubrication Specifications

Specified lubricants, as recommended by the component manufacturers, are always the best choice, however, multi-purpose greases usually have the qualities which meet a variety of single purpose grease requirements. Should any question arise, regarding the use of greases in maintenance stock, consult your local supplier for evaluation. Refer to Section 1 for an explanation of the lubricant key designations appearing in the Lubrication Chart.

2.4 CYLINDER DRIFT TEST

Maximum acceptable cylinder drift is to be measured using the following methods.

Platform Drift

Measure the drift of the platform to the ground. Lower booms (if equipped) slightly elevated, upper boom fully extended with the rated load in the platform and power off. Maximum allowable drift is 2 in (5 cm) in 10 minutes. If the machine does not pass this test, proceed with the following.

Cylinder Drift

Table 2-2. Cylinder Drift

Cylinder Bore Diameter		Max. Acceptable Drift in 10 Minutes	
inches	mm	inches	mm
3	76.2	0.026	0.66
3.5	89	0.019	0.48
4	101.6	0.015	0.38
5	127	0.009	0.22
6	152.4	0.006	0.15
7	177.8	0.005	0.13

Drift is to be measured at the cylinder rod with a calibrated dial indicator. The cylinder oil must be at ambient temperature and temperature stabilized.

The cylinder must have the normal load, which is the normal platform load applied.

If the cylinder passes this test, it is acceptable.

NOTE: *This information is based on 6 drops per minute cylinder leakage.*

2.5 PINS AND COMPOSITE BEARING REPAIR GUIDELINES

Filament wound bearings.

1. Pinned joints should be disassembled and inspected if the following occurs:
   a. Excessive sloppiness in joints.
   b. Noise originating from the joint during operation.
2. Filament wound bearings should be replaced if any of the following is observed:
   a. Frayed or separated fibers on the liner surface.
   b. Cracked or damaged liner backing.
   c. Bearings that have moved or spun in their housing.
   d. Debris embedded in liner surface.
3. Pins should be replaced if any of the following is observed (pin should be properly cleaned prior to inspection):
   a. Detectable wear in the bearing area.
   b. Flaking, pealing, scoring, or scratches on the pin surface.
   c. Rusting of the pin in the bearing area.
4. Re-assembly of pinned joints using filament wound bearings.
   a. Housing should be blown out to remove all dirt and debris...bearings and bearing housings must be free of all contamination.
   b. Bearing / pins should be cleaned with a solvent to remove all grease and oil...filament wound bearing are a dry joint and should not be lubricated.
   c. Pins should be inspected to ensure it is free of burrs, nicks, and scratches which would damage the bearing during installation and operation.

2.6 PREVENTIVE MAINTENANCE AND INSPECTION SCHEDULE

The preventive maintenance and inspection checks are listed and defined in the following table. This table is divided into two basic parts, the “AREA” to be inspected and the “INTERVAL” at which the inspection is to take place. Under the “AREA” portion of the table, the various systems along with the components that make up that system are listed. The “INTERVAL” portion of the table is divided into five columns representing the various inspection time periods. The numbers listed within the interval column represent the applicable inspection code for which that component is to be checked.

The checks and services listed in this schedule are not intended to replace any local or regional regulations that may pertain to this type of equipment nor should the lists be considered as all inclusive. Variances in interval times may occur due to climate and/or conditions and depending on the location and use of the machine.

JLG Industries requires that a complete annual inspection be performed in accordance with the “Annual Machine Inspection Report” form. Forms are supplied with each new machine and are also available from JLG Customer Service. Form must be completed and returned to JLG Industries.

NOTICE

JLG INDUSTRIES REQUIRES THAT A COMPLETE ANNUAL INSPECTION BE PERFORMED IN ACCORDANCE WITH THE “ANNUAL MACHINE INSPECTION REPORT” FORM.

NOTE: *This machine requires periodic safety and maintenance inspections by a JLG Dealer. A decal located on the frame affords a place to record (stamp) inspection dates. Notify dealer if inspection is overdue.*

The inspection and maintenance code numbers are as follows:

1. Check for proper and secure installation.
2. Check for visible damage and legibility.
3. Check for proper fluid level.
4. Check for any structural damage; cracked or broken welds; bent or warped surfaces.
5. Check for leakage.
6. Check for presence of excessive dirt or foreign material.
7. Check for proper operation and freedom of movement.
8. Check for excessive wear or damage.
9. Check for proper tightness and adjustment.
10. Drain, clean and refill.
11. Check for proper operation while pump/motor is running.
12. Check for proper lubrication.
13. Check for evidence of scratches, nicks or rust and for straightness of rod.
14. Check for condition of element; replace as necessary.
15. Check for proper inflation.
16. Check Inspection Decal for current inspection stamp.

Table 2-3. Preventive Maintenance and Safety Inspection

AREA	INTERVAL				
	Daily	Weekly	300 Hours (6 months)	600 Hours (1 year)	1200 Hours (2 years)
PLATFORM					
1. Controller	1,11				
2. Switches	1,11				
3. Placards and Decals	1,2				
4. Control Tags	1,2				
5. Hoses and Cables		4,8			
6. Wear Pads			8		
7. Handrails and Chains	1,4				
CHASSIS					
1. Engine Oil	3	5			
2. Battery	3	5			
3. Air Cleaner	1	14			
4. Exhaust System	1		1,5		
5. Engine Mounts			1		
6. Hydraulic Pump	1	5			
7. Valves	1	5			
8. Hydraulic Filter (See Lubrication Chart)		5,14	14		
9. Hydraulic Hoses and Tubing	1	5			
10. Hydraulic Oil Tank*	3	5	4		
11. Hydraulic Tank Breather		6,14			
12. Fuel Tank	3,5		4		
13. Lift Cylinder	1,12	5,6,13	4		
14. Limit Switch	1,7				
15. Tilt Alarm Switch				1,7	
16. Placards and Decals	1,2				
17. Wheel and Tire Assemblies	1	8,9			
18. Drive Motors		1,5,6			
19. Drive Brakes		1,6	8		
20. Drive Torque Hubs		1,3,5,6			
21. Steer Cylinder	1	5,6,13	4		
22. Steer Components	1	4,6	8		
23. Wheel Bearings (2 Wheel Drive)			8	12	
24. Sizzor Arms	1,4				
25. Safety Props	1,4				
26. Sliding Wear Pads			8		
27. Pivot Pins/Bolts	1,4		7,8		
28. Switches, Ground Control	1,11				
29. Control Tags	1,2				

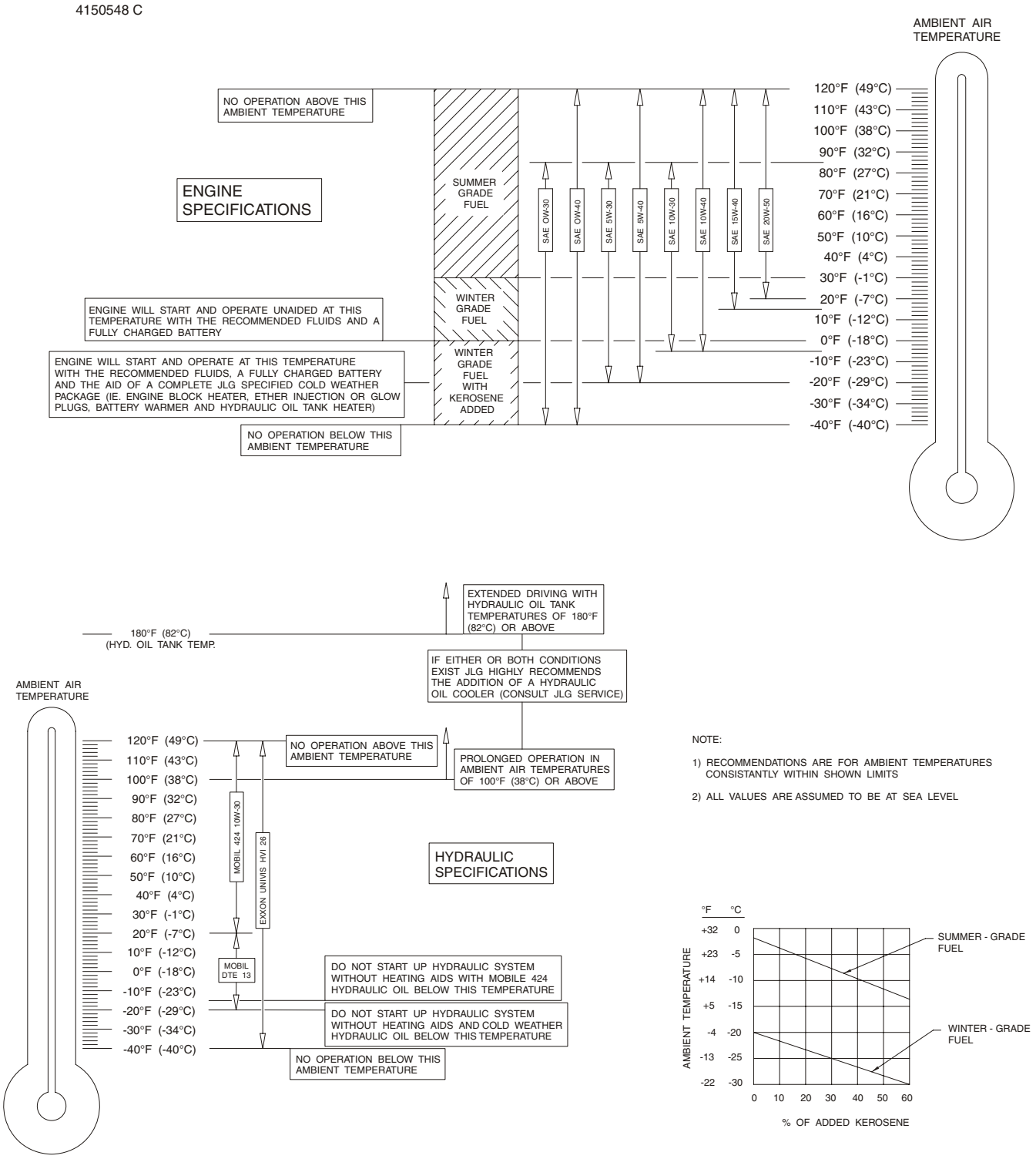


Figure 2-1. Engine Operating Temperature Specifications - Deutz

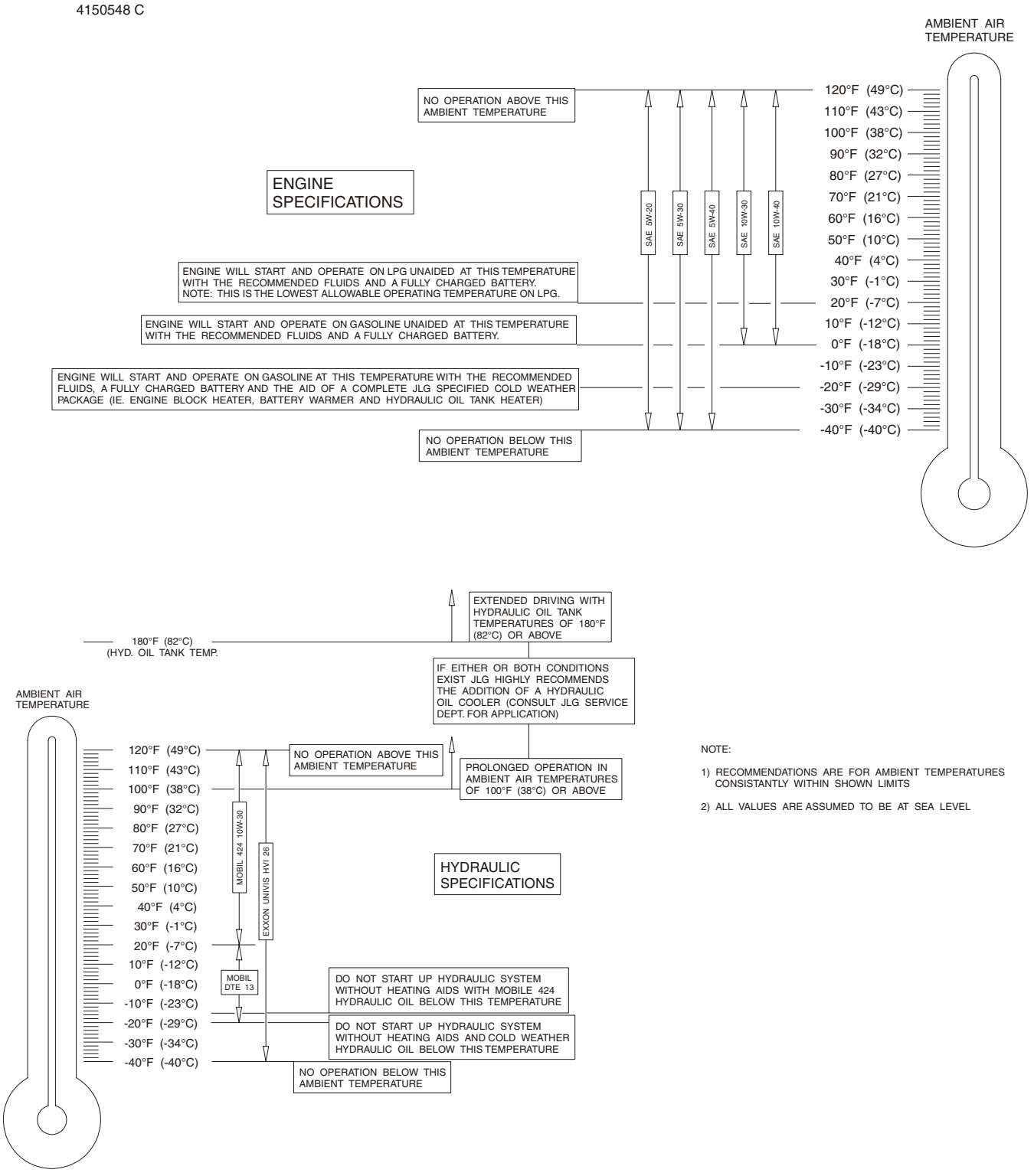


Figure 2-2. Engine Operating Temperature Specifications - Ford

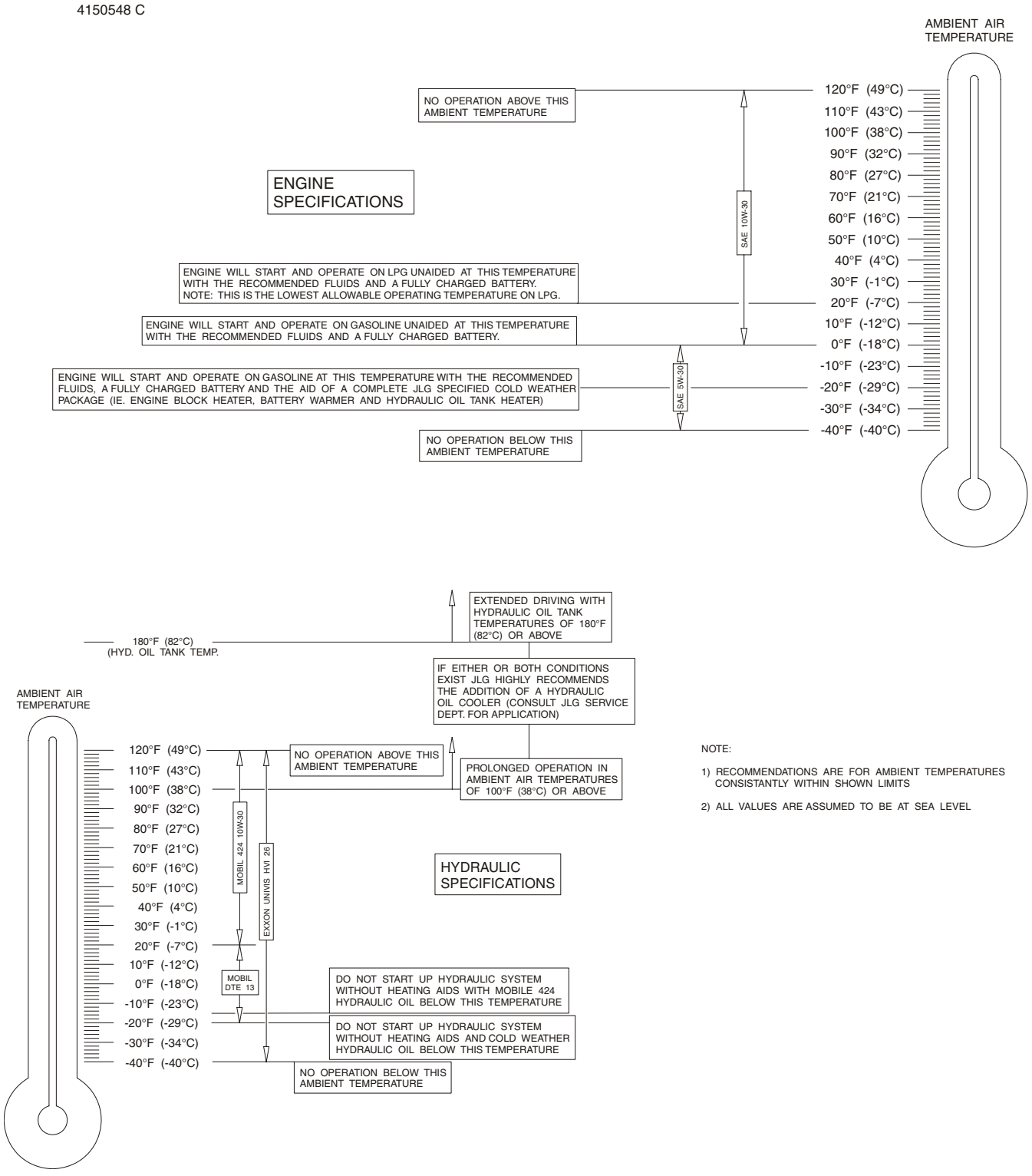


Figure 2-3. Engine Operating Temperature Specifications - GM

SECTION 3. CHASSIS & SCISSOR ARMS

3.1 OPERATING CHARACTERISTICS

Leveling Jacks

The machine may be equipped with auto leveling jacks. These leveling jacks are operated through one switch unlike the traditional four switch system. The leveling jacks are operated by a bang bang valve.

NOTE: *The engine speed will drop when the leveling jacks are in contact with the ground.*

1. Activate the leveling jack button located on the platform control box.
2. Extend the jacks by moving the joystick forward.

NOTE: *Once all four jacks make contact with the ground the system will go from set mode into level mode. At this point the engine will return to idle.*

3. The tilt indicator will go out once the machine is level.

NOTE: *If the machine is not level it will not lift. If you hit the end of stroke on any of the cylinders you cannot lift the machine.*

NOTE: *There is a limit switch on each cylinder that senses when the cylinder is fully retracted when all four are fully retracted, the stowed light in the platform control box will light.*

If you receive a 2/5 flash code through the system fault light at the platform control station the machine is unable to level. You must reposition and try again.

The jacks are operational (extend or retract) if the machine is in the stowed position. The proximity sensor and rotary sensor together must sense that the machine is stowed. A failure of either sensor will prevent the jacks from being activated.

Power Deck

The power deck is operated through a non proportional valve. This will not effect any other function when activated.

⚠ WARNING

BE SURE AND RETRACT ANY POWER DECK BEFORE LOWERING MACHINE.

Generator

When the generator switch is activated the engine RPM will speed up to 2000 RPM for a 60 Hz generator or 1700 RPM for a 50 Hz generator.

When a function is selected for operation, which requires a higher engine speed than the generator, the generator will automatically shut off during the operation of the function. Once the function has stopped, the generator will be active again.

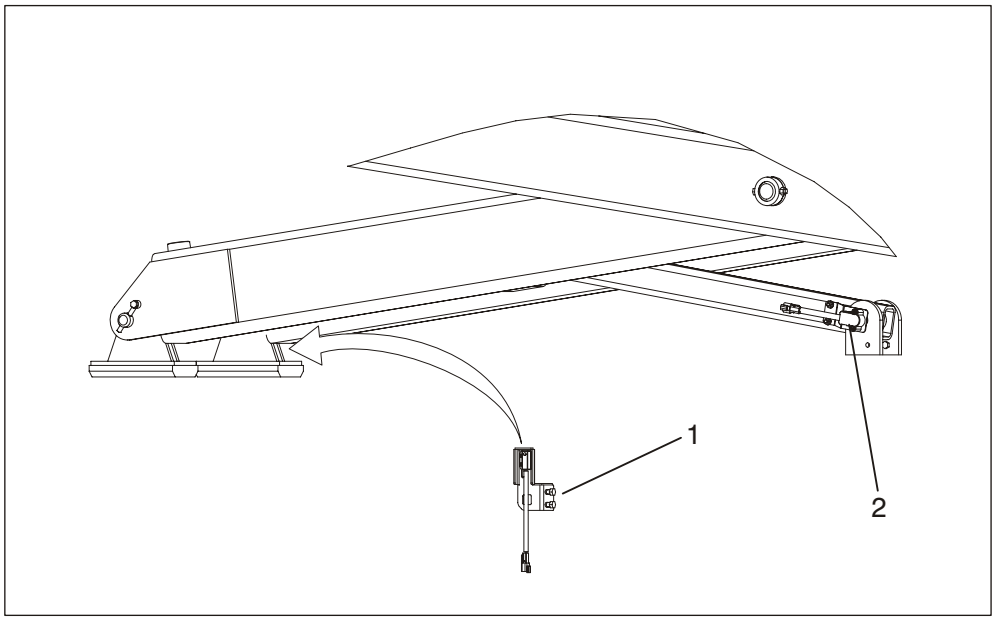
Lift

There is a flow control valve which controls both the lift up and lift down speeds.
Anytime you abruptly change lift directions, there is a three second delay between lift up and lift down.

Drive

If driving at high drive up a grade and you hit an 8° incline, the drive function will cut back to mid drive speed. The drive pump will shift back into high drive once the incline decreases to 5°. There will be a 2 second delay before the machine goes back into high drive.

3.2 CALIBRATIONS



1. Proximity Sensor
2. Rotary Angle Sensor

Figure 3-1. Limit Switch Location

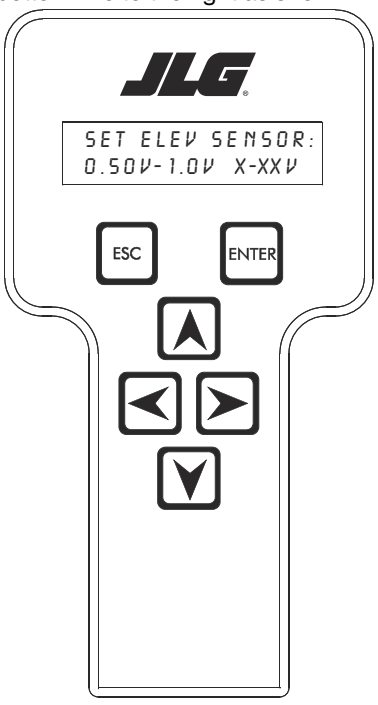
Elevation Sensor Calibration (Prior to Software P1.20)

NOTE: *Make sure your analyzer is in ACCESS LEVEL 1.*

When using the analyzer, under the DIAGNOSTIC menu the term referring to ROTARY & PROXIMITY sensors is ELEV SENSOR.

Use CALIBRATIONS menu for rotary switch adjustments.

1. When mounting, make sure the rotary switch is aligned with the bladed pin mounted on the center link as shown in Figure 3-1., Limit Switch Location. There must be a preload when installing the rotary switch on the bladed pin bracket.
2. There are (3) mounting screws that hold the switch onto the center link mounting lug, make sure they are snug, not loose, so you are able to rotate the rotary switch.
3. Make sure the deck is fully lowered. Plug in the analyzer and enter the service password (33271).
4. Go to CALIBRATIONS, then SET ELEV SENSOR and hit enter then right arrow.
5. The bottom line on the analyzer display will show the range of voltage the sensor must be within for proper calibration. the actual voltage is displayed on the bottom line to the right as shown.



6. Press the left arrow button and then enter.

NOTE: *Anytime the ground control board or if the rotary sensor is replaced the rotary sensor must be reset (zeroed out).*

When stowed, if angle sensor is within the range of CALIB (see below), the machine should be recalibrated.

If the gap ever increases beyond 5/16 in., the switch may cause intermittent operation.

7. Completely lower the platform. Using the analyzer press escape and scroll through DIAGNOSTICS and then go to ELEV SENSOR, press ENTER. Check to see that the following items are reading correctly.

   ANGLE SNSR 0.40 - X.XXV

   ZEROED 0.00V

   ELEV CUT

   CALIB 0.50v - 1.0v

8. Press ESCAPE until you arrive at DIAGNOSTICS, then scroll over to top level menu SET ELEV SENSOR, press ENTER. At this point press ENTER key. If everything tested properly the analyzer will read COMPLETE.

9. Now lift the machine up. Drive speed should be reduced to elevated speed at the following heights;

   3394RT - 6-9 ft (1.8 - 2.7m)

   4394RT - 7-10 ft (2.1 - 3m)

10. Press ESCAPE, remove analyzer and assure all hardware is tight.

NOTE: *If voltage is too low the analyzer will display SENSOR FAILURE. If the voltage is set too high the analyzer will read NOT STOWED. When calibration is attempted, once it is set within the proper limits, the analyzer will read COMPLETE.*

Elevation Sensor Calibration (Software P1.20 & Higher)

Using the Analyzer, in Access Level 1, go to MENU: CALIBRATION:

1. SET STOW ELEV;
   a. Completely lower platform to stowed position.
   b. Enter YES on the Analyzer.
   c. COMPLETE will show on the analyzer when calibrated.
2. SET 26FT ELEV (3394RT) or SET 30FT ELEV (4394RT);
   a. Raise platform to a height of 26 feet for the 3394RT or 30 feet for the 4394RT (measured deck to ground).
   b. Enter YES on the Analyzer.
   c. COMPLETE will show on the analyzer when calibrated.
3. SET 30FT ELEV (3394RT) or SET 36FT ELEV (4394RT);
   a. Raise platform to a height of 30 feet on the 3394RT or 36 feet for the 4394RT (measured deck to ground).
   b. Enter YES on the Analyzer.
   c. COMPLETE will show on the analyzer when calibrated.

NOTE: *Elevation Proximity Switch must be mounted and functioning properly to calibrate the Elevation Sensor.*

NOTICE

FOR MACHINE TO OPERATE TO CAPACITY, BE SURE TO CALIBRATE ELEVATION SENSOR AT ALL THREE POSITIONS.

Joystick Calibration (Software P1.20 & Higher)

Using the Analyzer, in Access Level 1, go to MENU: CALIBRATION: JOYSTICK and press ENTER.

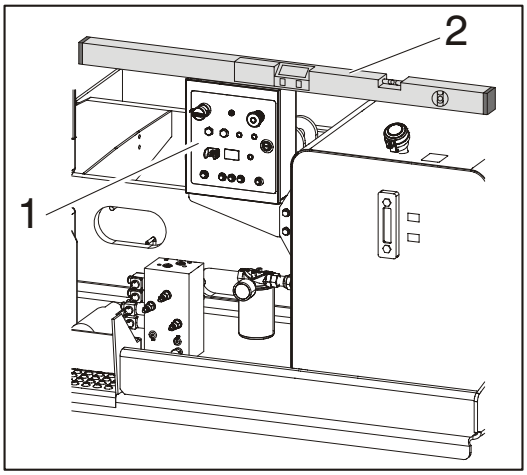
1. Following the analyzer screen prompts:
   a. Move the Joystick FORWARD and press ENTER.
   b. Allow Joystick to be in CENTER position and press ENTER.
   c. Move the Joytstick REVERSE and press ENTER.
2. CAL COMPLETE or CAL FAILED will display on the analyzer.
3. Possible reasons if calibration failed:
   a. The forward position must be a lower voltage than reverse position.
   b. The difference between center and forward & center and reverse must be atleast 1V.

Tilt Sensor Calibration:

1. Drive the machine onto a measured level surface (±0.5° for both x and y axis).
2. Using the Analyzer, go to MENU: CALIBRATION; TILT SENSOR. Press Enter. LEVEL VEHICLE will display. Press Enter again to calibrate.

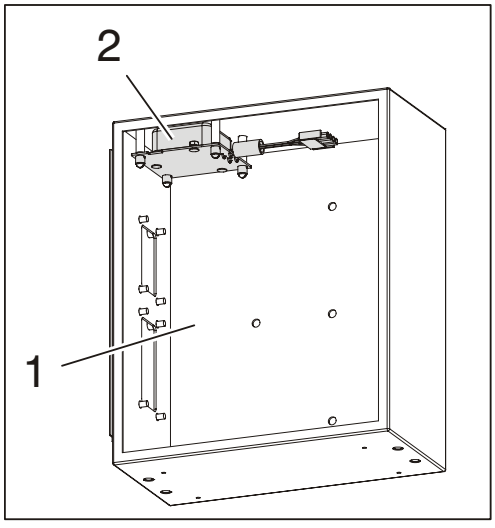
3. Both axis' raw angles need to be within ±5.0°, otherwise the machine is to unlevel and the software will prohibit calibration. Should this occur, attempt to dissect the three areas of error to find the primary contributor:

   a. Machine mounting and/or grade:
   With a digital level, measure the top of the Ground Control box for levelness. If unable to get a good reading, check the box's mounting surface for levelness.



1. Ground Control Box 2. Digital Level

   b. Tilt sensor mounting on machine or wedged crooked in control box:
   If the machine mounting/grade appears acceptable, open the Ground Control box carefully. Observe whether the tilt sensor is properly seated.



1. Ground Control Box 2. Tilt Sensor

   c. Tilt sensor has developed an offset shift:
   Remove the tilt sensor from the Ground Control box, but keep both the tilt sensor and Ground Control box electrically connected. Level one axis of the tilt sensor and observe the raw reading (should be within ±2.0°). Do the same for the other axis. If either axis is greater than ±2.0°, replace the tilt sensor.

Some possible reasons that the tilt sensor will not calibrate are:

   a. The surface the machine is sitting on is off level by a few degrees (flat doesn't imply level; parking lots are often not level).

   b. The tilt sensor has failed one or both of the channels (X axis and Y axis).

   c. Tilt sensor has moisture intrusion that has shifted its output.

   d. Water and/or corrosion in the box has corrupted electrical connections or caused a tilt sensor or ground control board failure (observe any cracks in the box).

   e. The Ground Control Box, as mounted on the machine, does not allow the tilt sensor to be level.

For the following troubleshooting steps, a bubble level (smaller is better) will be needed and the machine must be on a level surface:

1. On the Analyzer, go to Diagnostics/System and read the tilt angle. If either angle reports +20.0°, there is an electrical/electronic failure (tilt sensor, control board, electrical connections).

   a. Open the Ground Control Box.

   b. Disconnect the sensor and clean any corrosion off of the tilt sensor and control board connections.

   c. Reassemble and test. If fault persists, replace tilt sensor.

2. If the Analyzer displays angles other than +20.0°, attempt to calibrate. If machine will not calibrate, note the reason displayed on Analyzer:

   a. SENSOR FAILURE – tilt sensor internal frequency is out of range (replace sensor).

   b. NOT LEVEL - tilt sensor has either developed an offset or it is to unlevel as mounted on the machine.

3.3 LEVEL SENSOR AND ANALYZER CONNECTIONS

The level sensor is located at the ground control station. Using a screwdriver, open the ground control station and locate the level sensor as shown in Figure 3-2., Level Sensor and Analyzer Connections.

There are two analyzer connection ports. One in the ground control station and the other at the platform control station on the under side of the platform control box as shown in Figure 3-2., Level Sensor and Analyzer Connections.

NOTE: *Ensure that the level sensor is installed with the bubble towards the top side of the lower control box.*

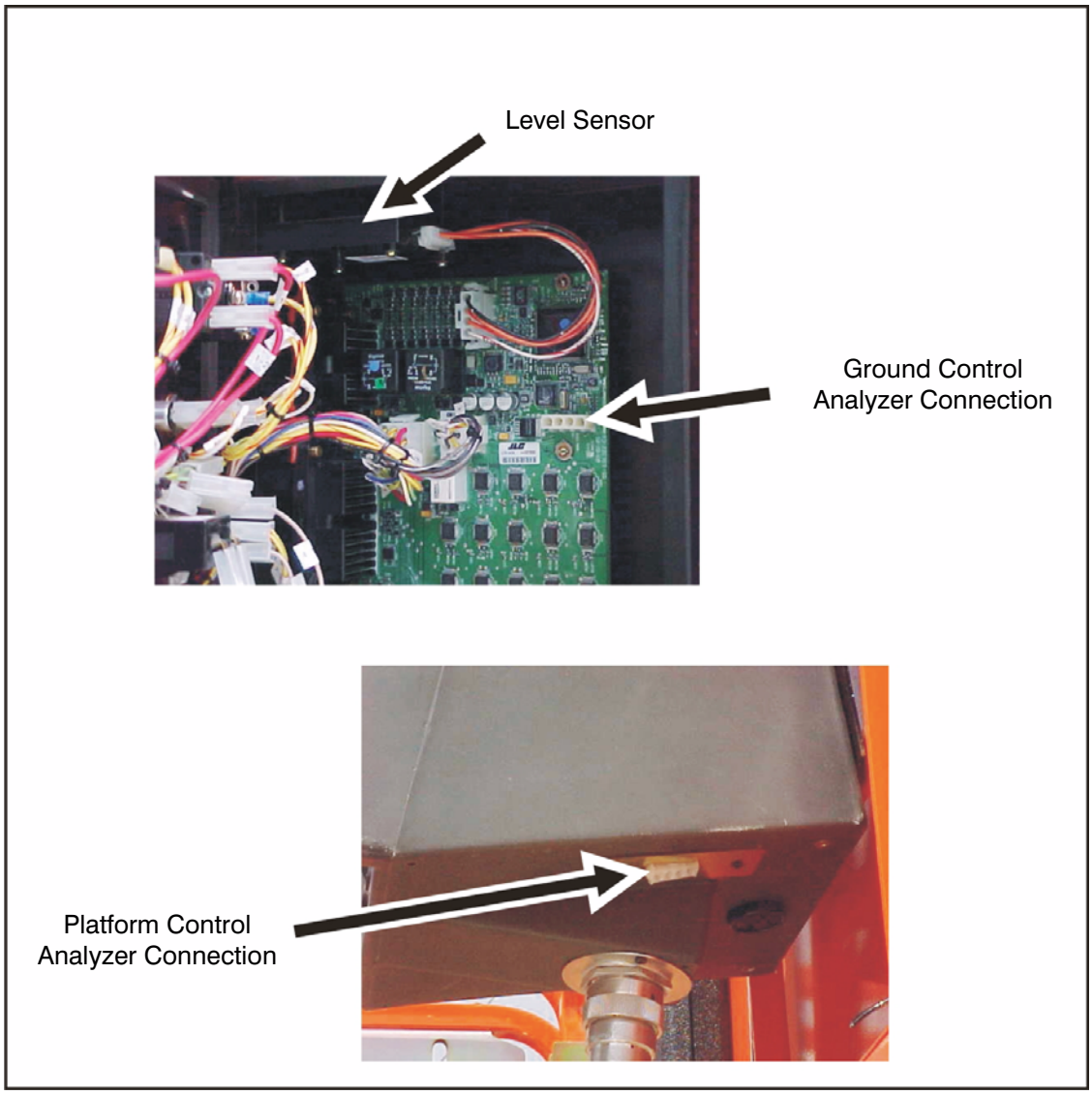
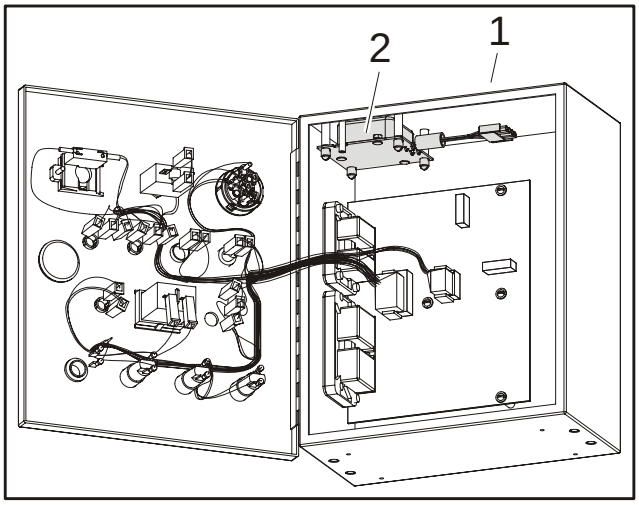


Figure 3-2. Level Sensor and Analyzer Connections

Tilt Sensor, JLG P/N 4000006:



1. Ground Control Box
2. Tilt Sensor (JLG P/N 4000006)

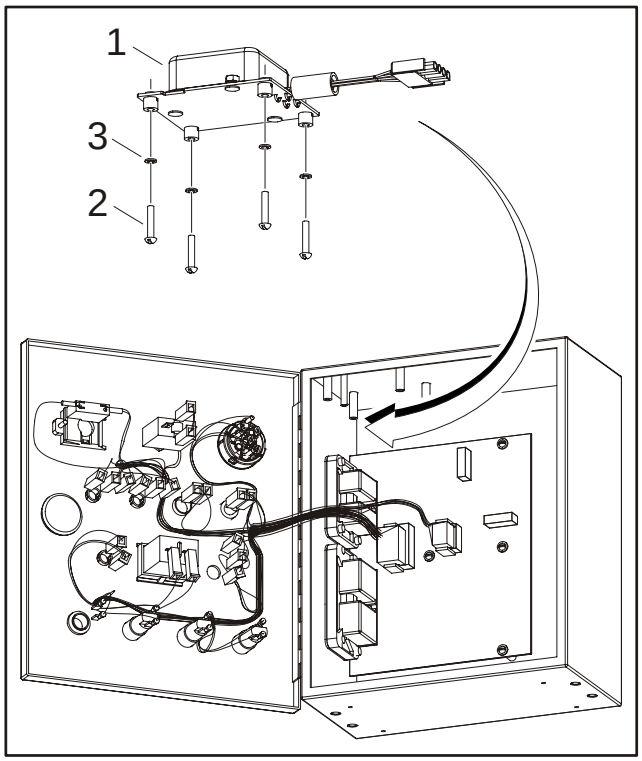
Figure 3-3. Tilt Sensor Location

Tilt Sensor Removal:

NOTE: *Refer to Figure 3-4., Tilt Sensor Removal for numbers in parenthesis.*

1. Disconnect the batteries.
2. Open the Ground Control Box to gain access to the Tilt Sensor Assembly.
3. Remove the four Screws (2) and Lockwashers (3) to remove the Tilt Sensor (1) from the Ground Control Box.

NOTE: *Follow the above procedures in reverse order when installing the tilt sensor assembly. After installing, be sure to calibrate the tilt sensor (refer to Section 3.2, Calibrations).*



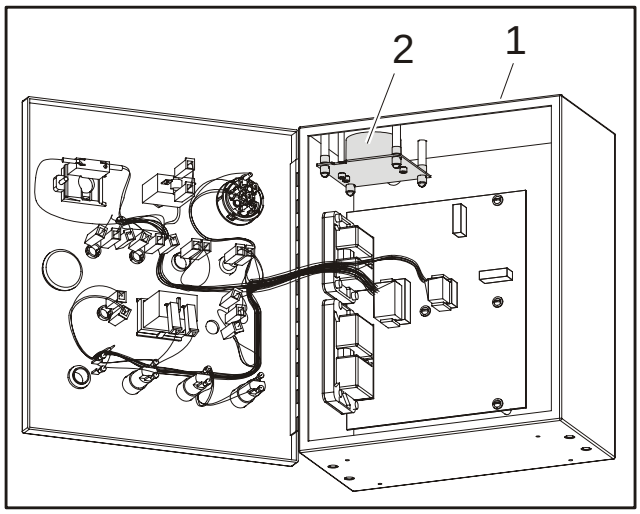
1. Tilt Sensor (JLG P/N 4000006)
2. Screw, 6-32 x 3/4
3. Lockwasher

Figure 3-4. Tilt Sensor Removal

Table 3-1. Tilt Sensor Harness Chart

Wire Color	Function	Connector Pin
Red	VCC	1
Black	Ground	4
Blue	PWMX	2
Yellow	PWMY	3

Tilt Sensor, JLG P/N 4000021:



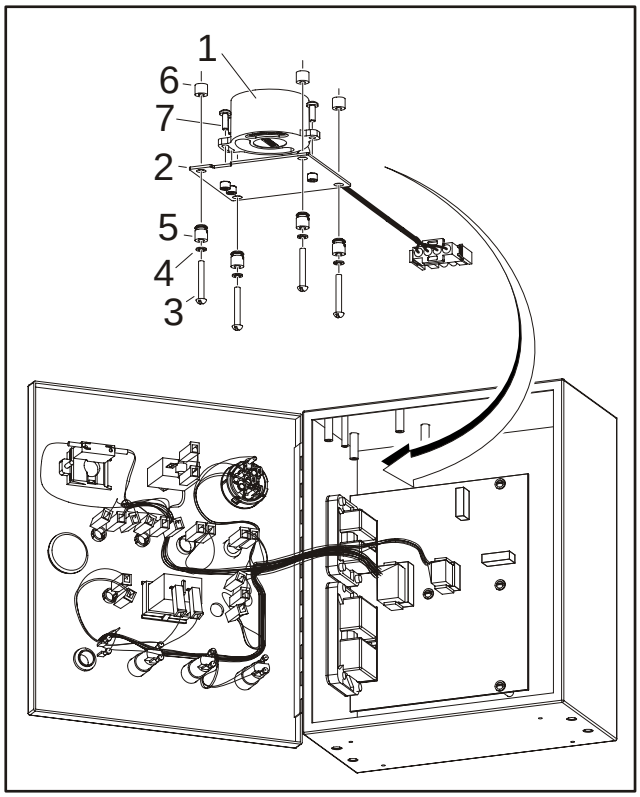
1. Ground Control Box
2. Tilt Sensor Assembly (JLG P/N 1810140)

Figure 3-5. Tilt Sensor Location

NOTE: *Refer to Figure 3-6., Tilt Sensor Removal for numbers in parenthesis.*

1. Disconnect the batteries.
2. Open the Ground Control Box to gain access to the Tilt Sensor Assembly.
3. Remove the four Screws (3), Lockwashers (4), Standoff Insulators (5), and Washers (6) to remove the Tilt Sensor (1) and Sensor Mount (2) from the Ground Control Box.
4. The Tilt Sensor (1) can be removed from the Sensor Mount (2) by removing the three Screws (7).

NOTE: *Follow the above procedures in reverse order when installing the tilt sensor assembly. After installing, be sure to calibrate the tilt sensor (refer to Section 3.2, Calibrations).*



1. Tilt Sensor (JLG P/N 4000021)
2. Sensor Mount
3. Screw, 6-32 x 1
4. Lockwasher
5. Standoff Insulator
6. Washer, 0.313 x 0.250 Nylon
7. Screw, M3.5 x 0.6 x 10

Figure 3-6. Tilt Sensor Removal

Table 3-2. Tilt Sensor Harness

Wire Color	Function	Connector Pin
Red	VCC	1
Green	PWMX	2
White	PWMY	3
Black	Ground	4

3.4 INTEGRATED TORQUE/DRIVE HUB

The Integrated Torque/Drive Hub is an axial piston-hydraulic motor with integrated, hydraulic released multi plate parking brake and a 2-stage planetary gearbox and a disconnect mechanism.

To insure an optimum balancing of loads, each planetary stage comprises of planet gears in sets. The externally toothed wheels are case-hardened.

The hydraulically released, wet running, multi plate brake, integrated in the hydraulic motor, is a parking brake. It is normally closed by spring force and released when pressurized by hydraulic oil.

NOTICE

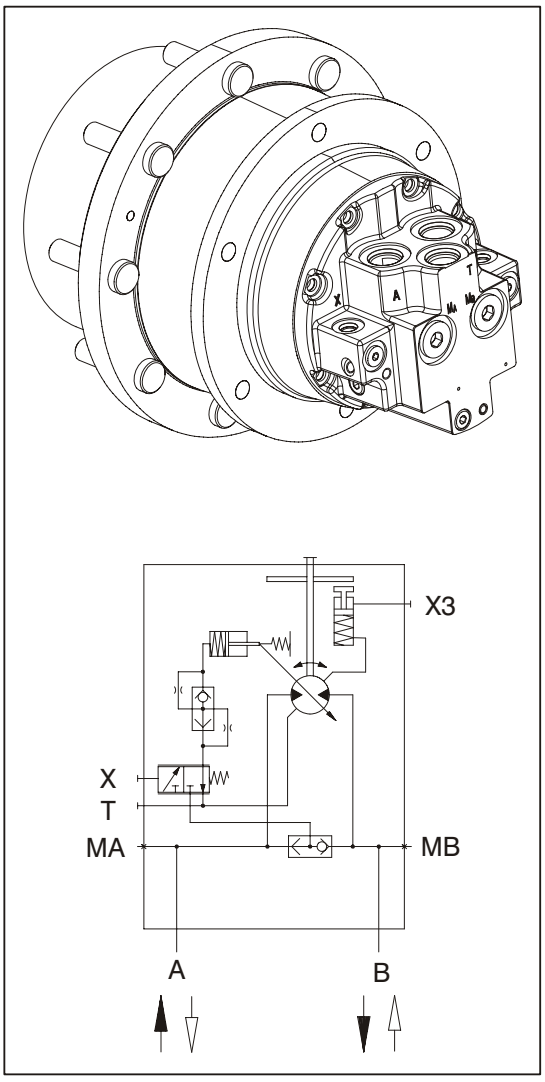
TORQUE HUB UNITS SHOULD ALWAYS BE ROLL AND LEAK TESTED BEFORE DISASSEMBLY AND AFTER ASSEMBLY TO MAKE SURE THAT THE UNIT'S GEARS AND SEALANTS ARE WORKING PROPERLY.

Roll Test

The purpose of a roll test is to determine if the unit's gears are rotating freely and properly. Gears should be able to be rotated by applying a constant force to the roll checker. If more drag is felt in the gears only at certain points, then the gears are not rolling freely and should be examined for proper installation or defects. Some gear packages roll with more difficulty than others. Do not be concerned if gears seem to roll hard as long as they roll with consistency.

Leak Test

The purpose of the leak test is to make sure the unit is air tight. The unit has a leak if the pressure gauge reading on the air checker starts to fall once the unit has been pressurized. Leaks will most likely occur at main seal or wherever o-rings or gaskets are located. The exact location of a leak can usually be detected by brushing a soap and water solution around the main seal and where o-rings or gaskets meet the exterior of the unit, then checking for air bubbles. If a leak is detected in a seal, o-ring, or gasket, the part must be replaced.

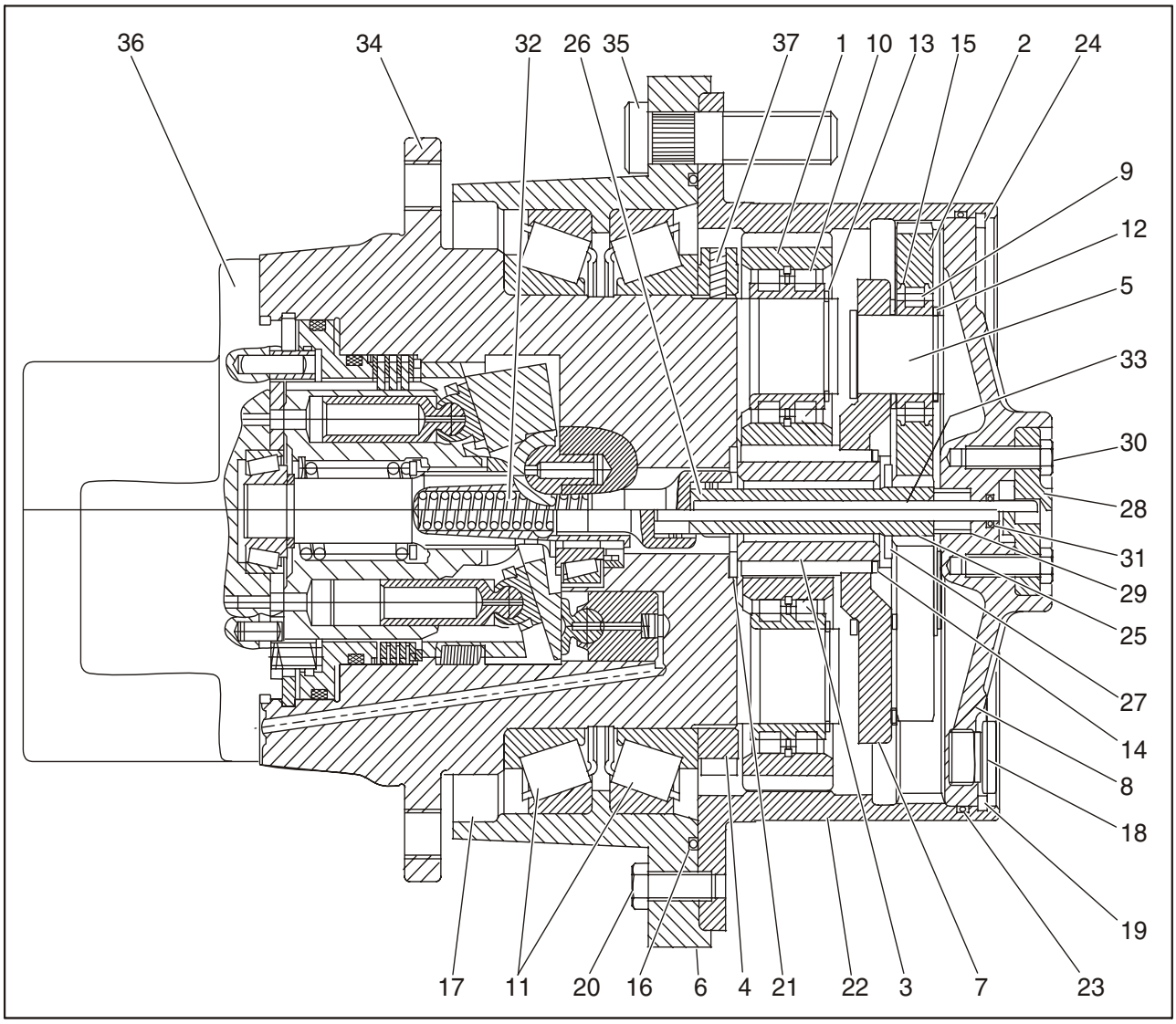


NOTE: *JLG P/N's: 2780263 (2WD), 2780262 (4WD)*

Figure 3-7. Integrated Torque/Drive Hub

Table 3-3. Torque/Drive Hub Specs

Gearbox	
Maximum Output Speed	30.25 rpm
Maximum Output Torque	4556.5 lb ft (6177.7 Nm)
Brake	
Static Brake Torque	88 lb ft (119.3 Nm)
Release Pressure	174 psi (12 bars)
Motor	
Maximum Displacement	28 CCM
Minimum Displacement	14.2 CCM
Switching Pressure	145 psi min - (1450 psi) max



1. Planet Gear
2. Planet Gear
3. Sun Gear
4. Shaft Nut
5. Planet Pin
6. Support Ring
7. Planet Carrier
8. Cover
9. Roller Bearing
10. Roller Bearing
11. Tapered Roller Bearing
12. Retaining Ring
13. Retaining Ring
14. Retaining Ring
15. Support Disk
16. O-Ring
17. Shaft Seal
18. Screw Plug
19. Seal Ring
20. Bolt
21. Thrust Washer
22. Gear, Ring Options
23. O-Ring
24. Retaining Ring
25. Sun Gear Shaft
26. Input Shaft
27. Thrust Washer
28. Cover
29. Sleeve
30. Bolt
31. O-Ring
32. Spring
33. Shift Rod
34. Brake Housing
35. Wheel Stud
36. Hydraulic Motor
37. Spring Sleeve Dowel

Figure 3-8. Drive Motor/Hub Assembly

Table 3-4. Gearbox Maintenance Schedule

After 150 motor operating hours	- First oil change
Weekly:	- Inspect visually - Check for unusual noise - Check oil level
Monthly:	- Check the tightness of all screws and bolts
Semi-annually:	- Check oil quality
Annually: (or after 1500 motor operating hours, whichever comes first)	- Change oil

Disconnect Mechanism

The disconnect mechanism on the torque/drive hub allows the machine to be towed. When activated, the mechanism disconnects the gear drive and motor.

Disengaging Procedure:

NOTICE

PRIOR TO DISENGAGING, THE MACHINE MUST BE ON LEVEL GROUND AND COMPLETELY SECURED FROM ANY MOVEMENT. ENSURE AREA SURROUNDING THE DISCONNECT IS CLEANED PRIOR TO OPERATION. MAKE SURE DIRT OR OTHER CONTAMINANTS DO NOT ENTER THE GEAR DRIVE.

⚠ WARNING

CHECK GEAR DRIVE TEMPERATURE PRIOR TO HANDLING. GEAR DRIVE MAY BE HOT AND CAUSE INJURY IF RECENTLY OPERATED.

For numbers in ( ), refer to Figure 3-8., Drive Motor/Hub Assembly.

1. Remove the 2 Bolts (30) from the Cover (28).
2. Remove the Cover.
3. Rotate Cover to show inside diameter.
4. Press Cover sufficiently against the Shift Rod (33) to insert the 2 Bolts at least 2-3 threads into the Cover. The Shift Rod is now subjected to the Spring (32) force.
5. Install the 2 Bolts (30) and tighten until they are flush with the Cover (28) with a torque wrench to 6.3 lb ft (8.5 Nm).

The Sun Gear Shaft (25) and Input Shaft (26) are now disconnected and the machine is ready to be towed.

NOTICE

THE MAXIMUM GEAR DRIVE TOWING SPEED OF 72 RPM MUST NOT BE EXCEEDED. ENGAGE GEAR DRIVE OR SECURE MACHINE WHEN MACHINE IS SEPARATED FROM THE TOWING VEHICLE.

Engaging Procedure:

NOTICE

PRIOR TO ENGAGING, THE MACHINE HAS TO BE ON LEVEL GROUND AND COMPLETELY SECURED FROM ANY MOVEMENT. ENSURE AREA SURROUNDING THE DISCONNECT IS CLEANED PRIOR TO OPERATION. MAKE SURE DIRT OR OTHER CONTAMINANTS DO NOT ENTER THE GEAR DRIVE.

⚠ WARNING

CHECK GEAR DRIVE TEMPERATURE PRIOR TO HANDLING. GEAR DRIVE MAY BE HOT AND CAUSE INJURY IF RECENTLY OPERATED.

⚠ WARNING

COVER (ITEM 28) IS UNDER SPRING FORCE.

For numbers in ( ), refer to Figure 3-8., Drive Motor/Hub Assembly.

1. Remove the 2 Bolts (30) from the Cover (28) evenly.
2. Remove the Cover.
3. Rotate the Cover 180° and assemble.
4. Tighten 2 Bolts (30) with a torque wrench to 6.3 lb ft (8.5 Nm).
5. Slightly pull the machine with the towing vehicle to allow the spline of the Sun Gear Shaft (25) to engage with the spline of the Input Shaft (26).

⚠ WARNING

DO NOT OPERATE THE MOTOR TO OBTAIN ENGAGEMENT.

6. Check again that all bolts are tight and that all components are returned to their original position.

The gear drive should now be reengaged and the machine can be disconnected from the towing vehicle.

Gearbox Disassembly

For numbers in parenthesis, refer to Figure 3-8., Drive Motor/Hub Assembly.

1. Remove Screw Plugs (18, 19) and drain oil into appropriate container.

2. Remove Snap Ring (24).

3. Remove the assembled Cover (8) with Shift Rod (33) and O-ring (23).

4. Remove Sun Gear Shaft (25).

5. Remove complete 1st planet stage.

6. Remove ring gear fastening Bolts (20), Ring Gear (22), and O-ring (16)..

7. Remove Snap Rings (13).

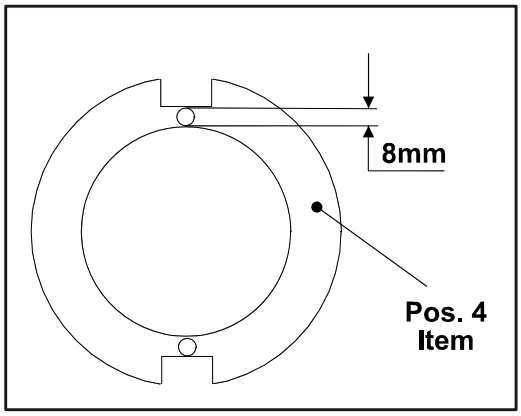
8. Pull Plane Gears (1).

9. Drill 2 holes into Shaft Nut (4) at 180° spacing according to Drilling Hole Sketch (step 10).

NOTICE

DO NOT DAMAGE THE BEARING CAGE OF TAPERED ROLLER BEARING. CAREFULLY REMOVE METAL CHIPS.

10. Drilling Hole Sketch



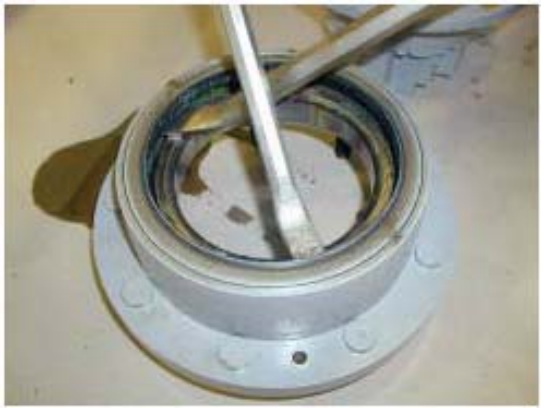
11. Split the Shaft Nut (4) in the area of the two drill holes by means of a chisel, and remove from Spindle (34).

NOTICE

DO NOT DAMAGE THE BEARING CAGE OF THE BEARING (11). DO NOT TURN THE SHAFT NUT; POSSIBILITY OF SPINDLE THREAD DAMAGE.

12. Remove the Support Ring (6) from the Spindle (34). Components stay in Supporting Ring (6).

13. Remove Radial Shaft Seal Ring (17).



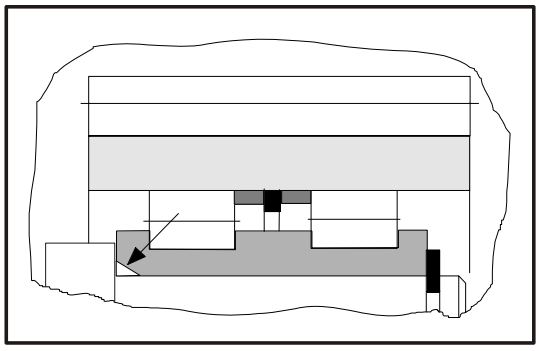
14. Disassembly of planet gears and sun gear (1st stage).
    a. Remove Snap Rings (12) and pull Planet Gears (2).
    b. Remove Support Disks (15).
    c. Remove Snap Ring (14) and lift off Planet Carrier (7).

15. Repair deformed threads on the Spindle (34) in the area of the ball detend with a thread file of 1.5mm pitch.

Gearbox Assembly

NOTE: *Clean all parts before assembling the gearbox.*

1. Make sure during assembly of the preassembled planet gears that the larger radius on the bearing bore is oriented towards the planet carrier.



2. Assembly of planet gears and sun gear (1st Stage).
    a. Fasten theSun Gear (3) with a new Snap Ring (14) to the Planet Carrier (7).
    b. Mount the Support Disks (15) and the planet gears with Bearing Assembly (2, 10) heated to approximately 189.5°F/70°C onto the planet bolts.

c. Secure the gears with new Snap Rings (12).

NOTE: *Heat* Supporting Ring (6) *up to approximately* 189.5°F/70°C in a heating furnace.

3. Insert outer rings into heated Supporting Ring (6). (check for proper axial seat)

4. Coat bore in Supporting Ring (6) with Loctite 573 for Radial Shaft Seal Ring (17).

5. Insert the bottom part of the double Tapered Roller Bearing (11).

6. Insert radial Shaft Seal Ring (17) into Supporting Ring (6) and fill mounting space between sealing lips with roller bearing grease.

NOTE: *Observe correct mounting position of sealing lip prior to installing the seal ring.*

7. Install preassembled supporting ring onto Spindle (34).

8. Heat upper ring with roller cage of double Tapered Roller Bearing (11) to approximately 189.5°F/70°C and mount onto Spindle (34). Allow cooling time of approximately 15 minutes before continuing assembly.

9. De-grease threads of Spindle (34) and Shaft Nut (4). Then evenly apply coat of Loctite 270 to Shaft Nut (4) threads.

10. Rotate the supporitng ring repeatedly in one direction only when setting the tapered roller bearing.
    a. Tighten Shaft Nut (4) by using an adequate device with a tightening torque of 627 lb-ft (850 Nm).
    b. The Loctite setting time equals 24 hours at ambient temperature of 68°F/20°C.

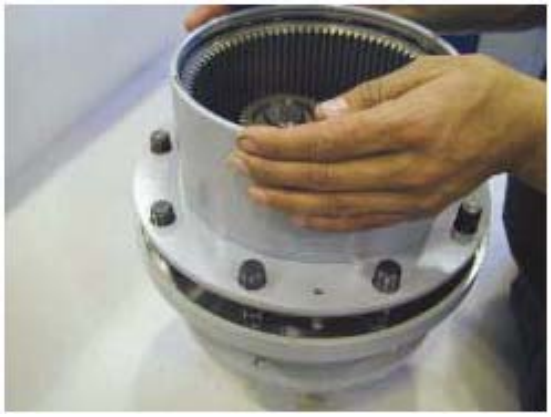
11. After proper bearing setting is completed, hammer ball with suitable punch, 1.1 - 1.3mm into the spindle thread. Retain ball in position with expanding plug.

12. Insert a new greased O-Ring (16) into the o-ring groove of the Supporting Ring (6).

13. Assembly of planet gear (Main Stage):

    a. Mount the planet gears with Bearing Assembly (1, 10), heated to approximately 189.5°F/70°C, onto the planet bolts of the Spindle (34) and secure the gears with new Snap Rings (13).

14. Install the Ring Gear (22).



15. Install the ring gear hex head bolts. Tighten bolts to proper torque of 15.5 ft-lbs (21 Nm).

16. Install completely pre-assembled 1st planet stage into the gear drive.

17. Install Sun Gear Shaft (25).

18. Check axial clearance:

    a. Determine clearance between contact face of Sun Gear (3) and Sun Gear Shaft (25). (Recommended clearance 1.0 -1.5mm)

19. Carefully insert a new greased O-ring (23) into the o-ring groove of Ring Gear (22).

20. Insert Shift Rod (33) into preassembled Cover (8).

21. Install preassembled Cover (8) into Ring Gear (22).

22. Install Snap Ring (24).

NOTE: *Prior to putting into operation fill the drive with new oil.*

23. Install Plugs (18) with new Seal Rings (19) into Cover (8).

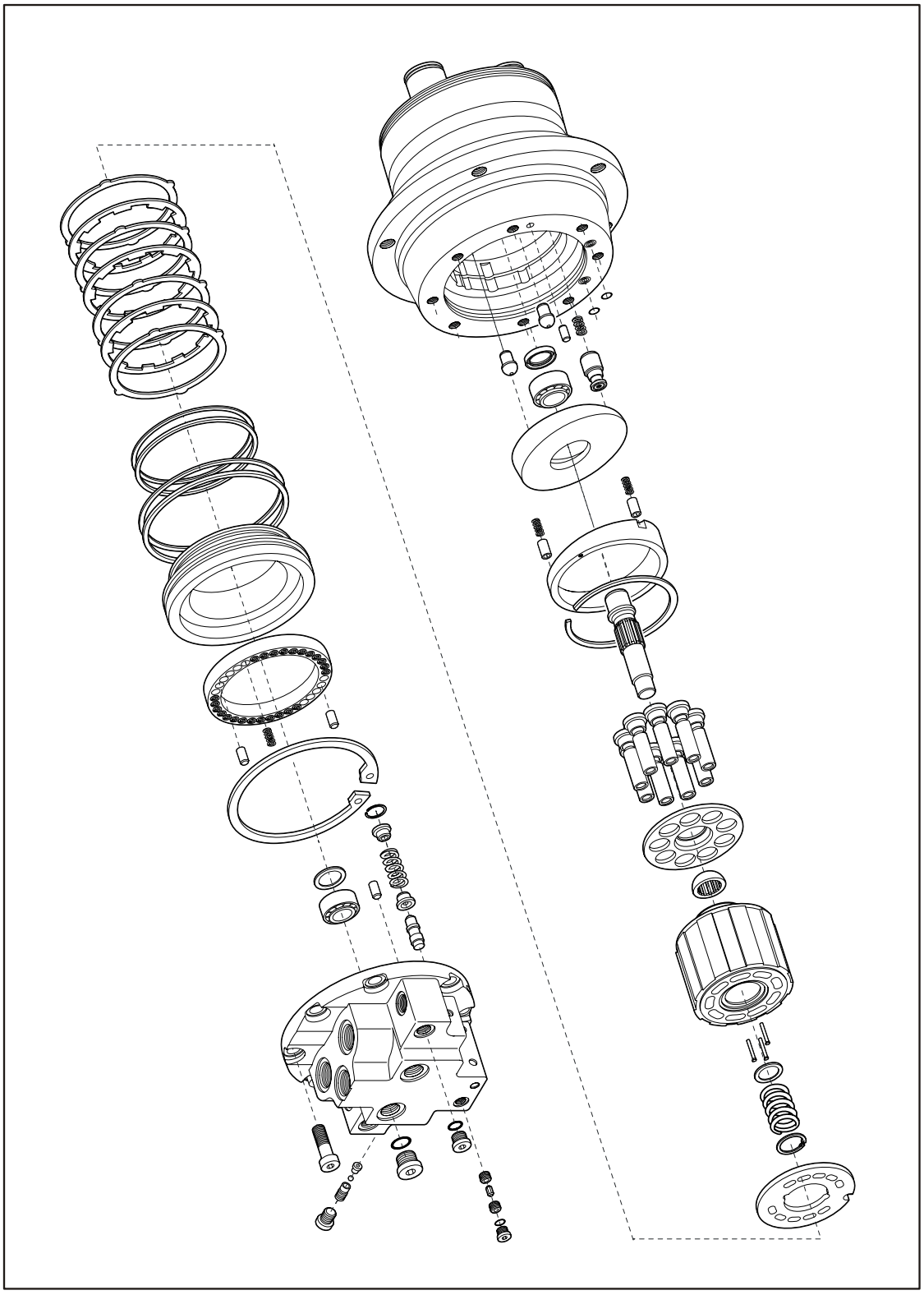
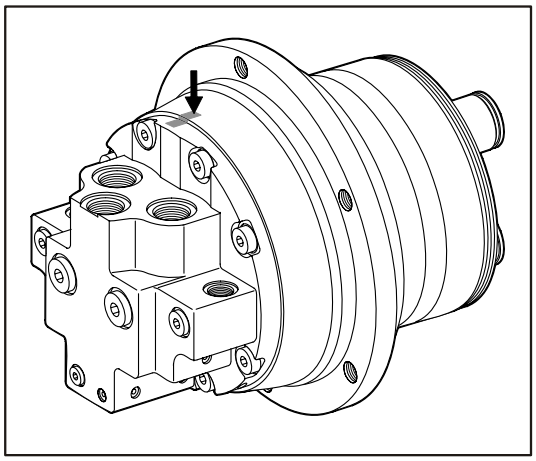


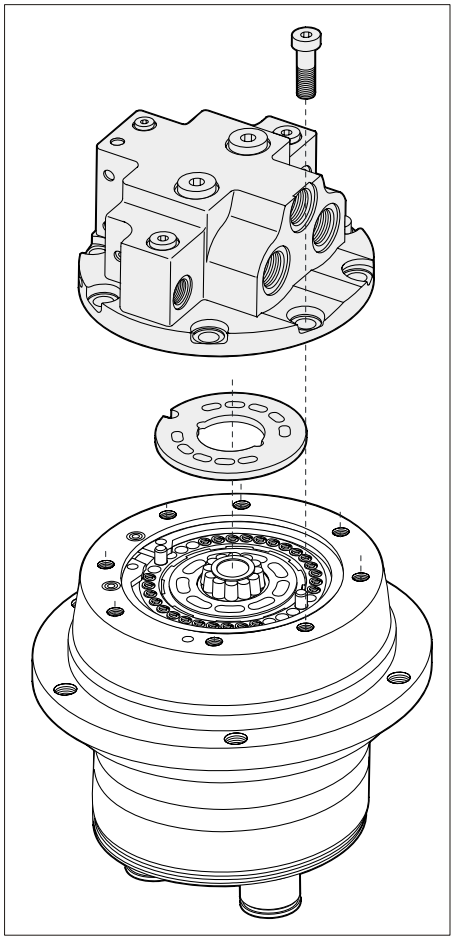
Figure 3-9. Drive Hub Assembly

Motor Disassembly

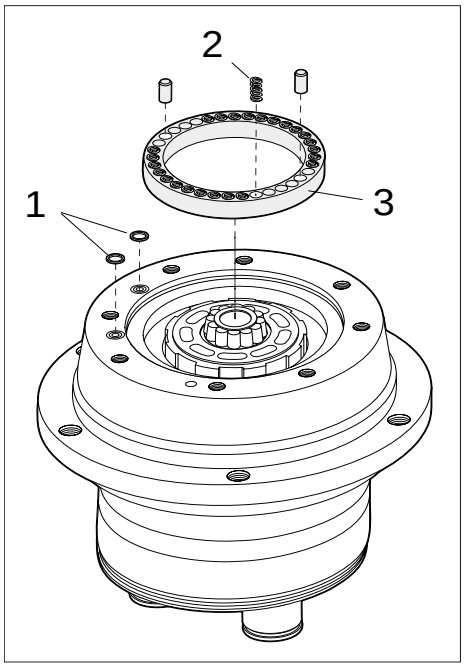
1. Mark port plate to the supporting axle.



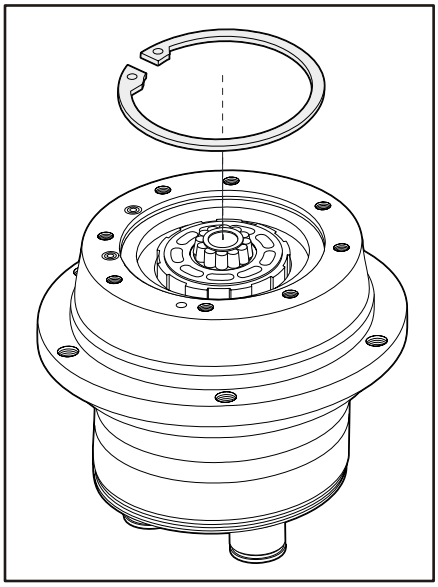
2. Remove port plate.



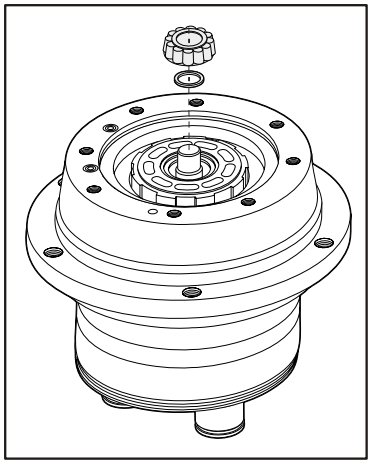
3. Disassemble guide ring:
   1. Seal Ring
   2. Pressure Springs (quantity = 26)
   3. Guide Ring



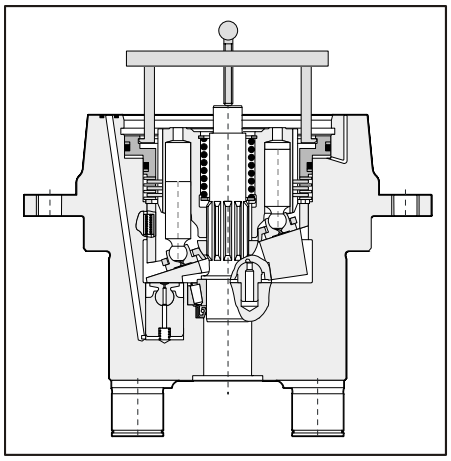
4. Disassemble retaining ring.



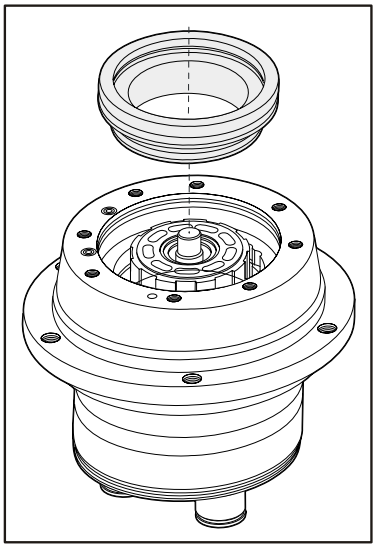
5. Disassemble bearing with synchronizing plate.



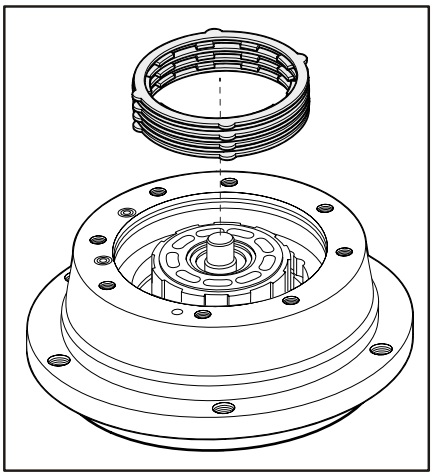
6. Press off pressure ring with extractor.



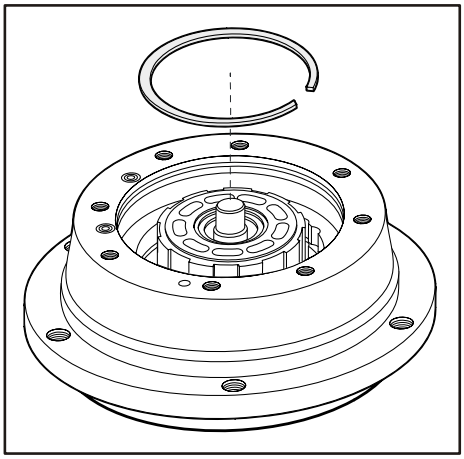
7. Remove pressure ring.



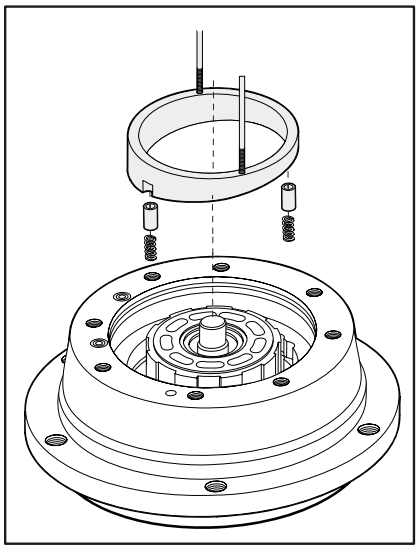
8. Disassemble lamination kit.



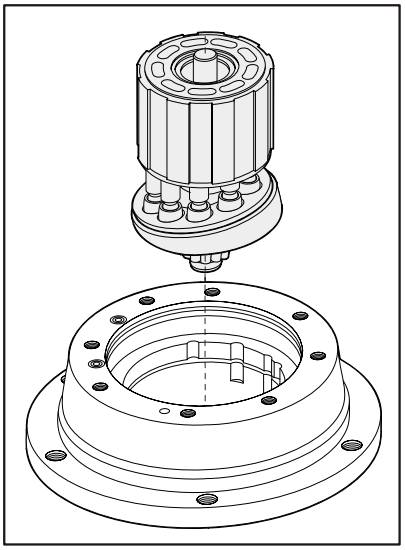
9. Disassemble Seeger snap ring.



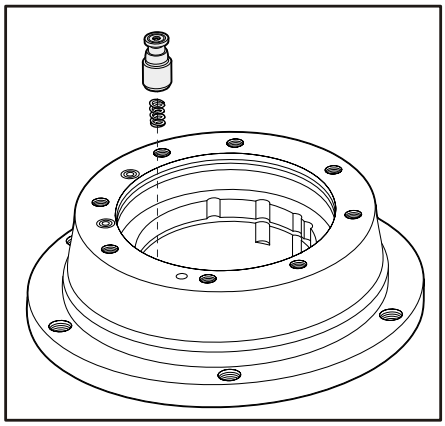
10. Disassemble cradle stop with 2 screws M4 x 75mm.



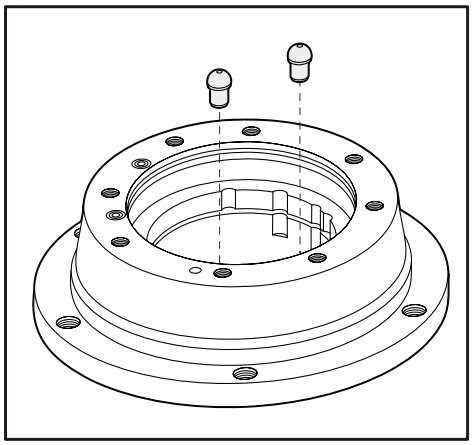
11. Disassemble rotary group completely with cradle.



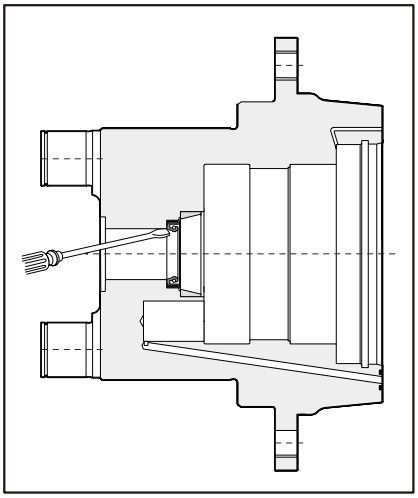
12. Disassemble control piston with spring.



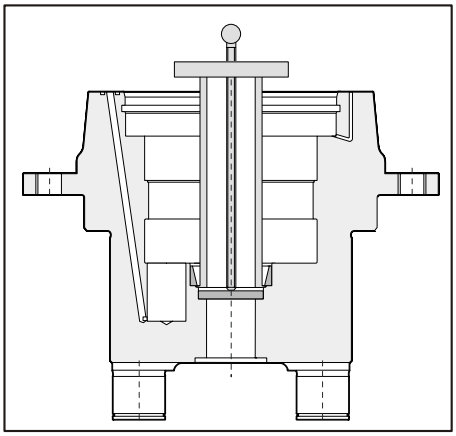
13. Pull out swivel balls.



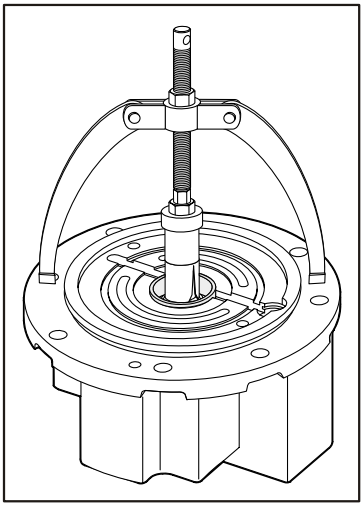
14. Disassemble shaft seal ring.



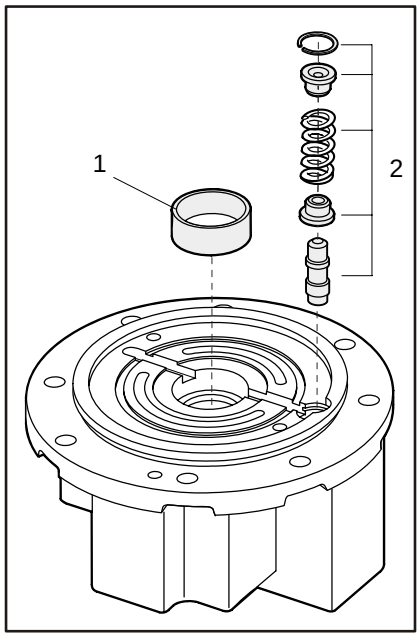
15. Insert disc. Pull off bearing ring with device. Remove disc.



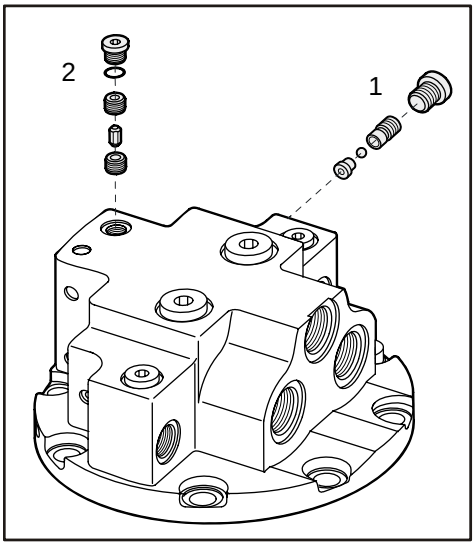
16. Disassemble bearing ring from port plate.



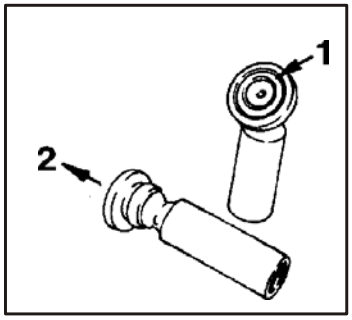
17. Remove bearing ring (1). Disassemble spool (2).



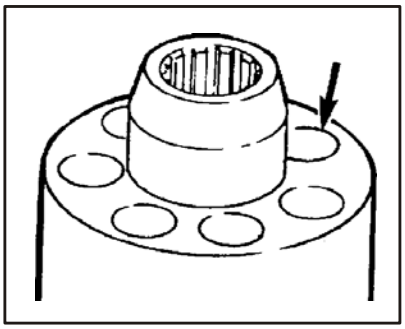
18. Disassemble shuttle valve (1). Disassemble throttle screw with throttle pin (2).



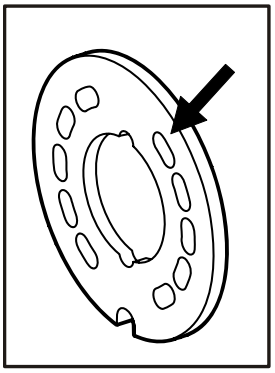
19. Check that there are no scratches or metal deposits on sliding surface (1), and there is no axial play (2), (Otherwise: Pistons must be replaced in sets).



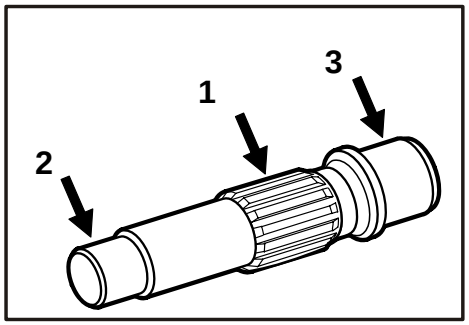
20. Check cylinder bores, splines.



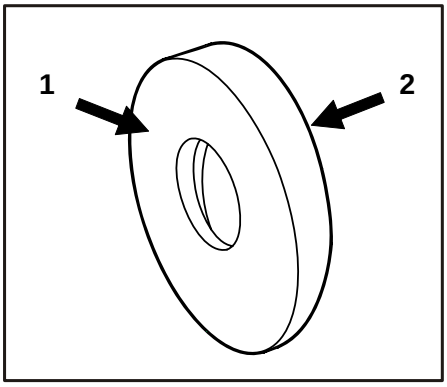
21. Check that cylinder track is free of scratches, there are no traces of wear and no embedded foreign particles. Make sure there are no scratches on the valve plate. (Replace ONLY in sets).



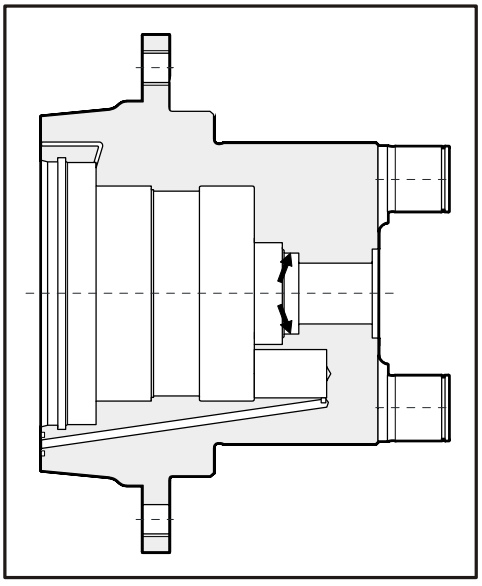
22. Check splines (1) for damage or fretting; running surfaces (2);groove cut by shaft seal (3).



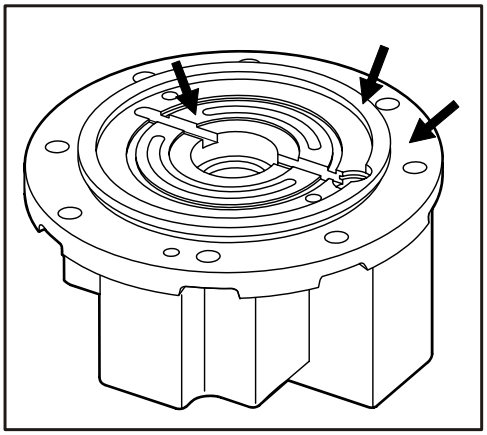
23. Check that sliding surface is free of grooves (1); cups are free of groove and there are no pittings (2).



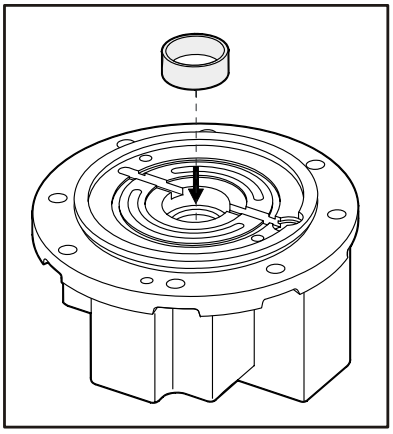
24. Make sure the seat of the shaft seal in the case has no damage.



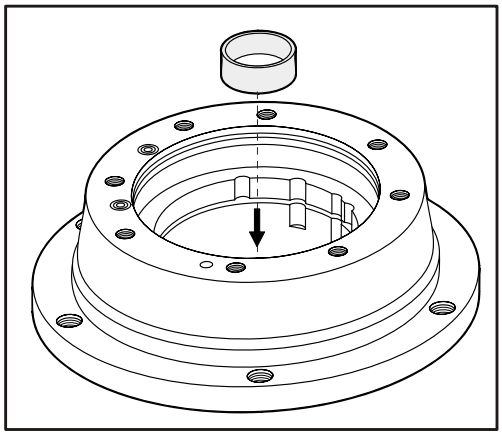
25. Make sure the sealing surfaces are damage free.



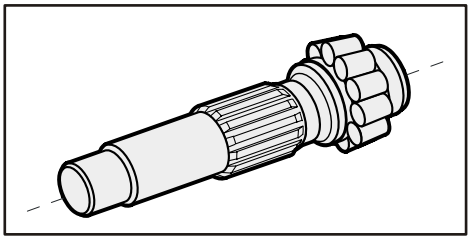
26. Press bearing ring in port plate (with tool).



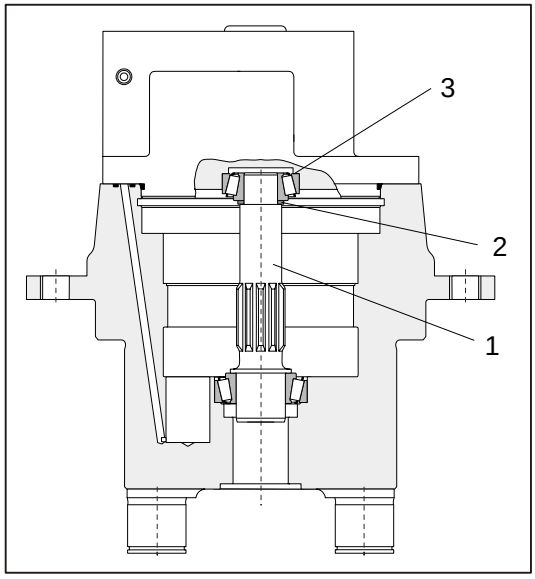
27. Press bearing ring in supporting axle (with tool).



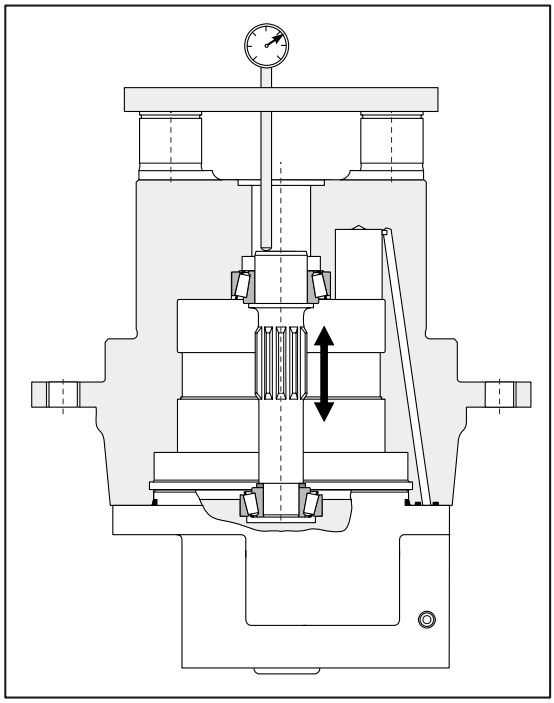
28. Press bearing on drive shaft.



29. Install shaft in supporting axle (1). Put in simulation ring (2). Mount bearing with port plate , fix with 2 screws (3)

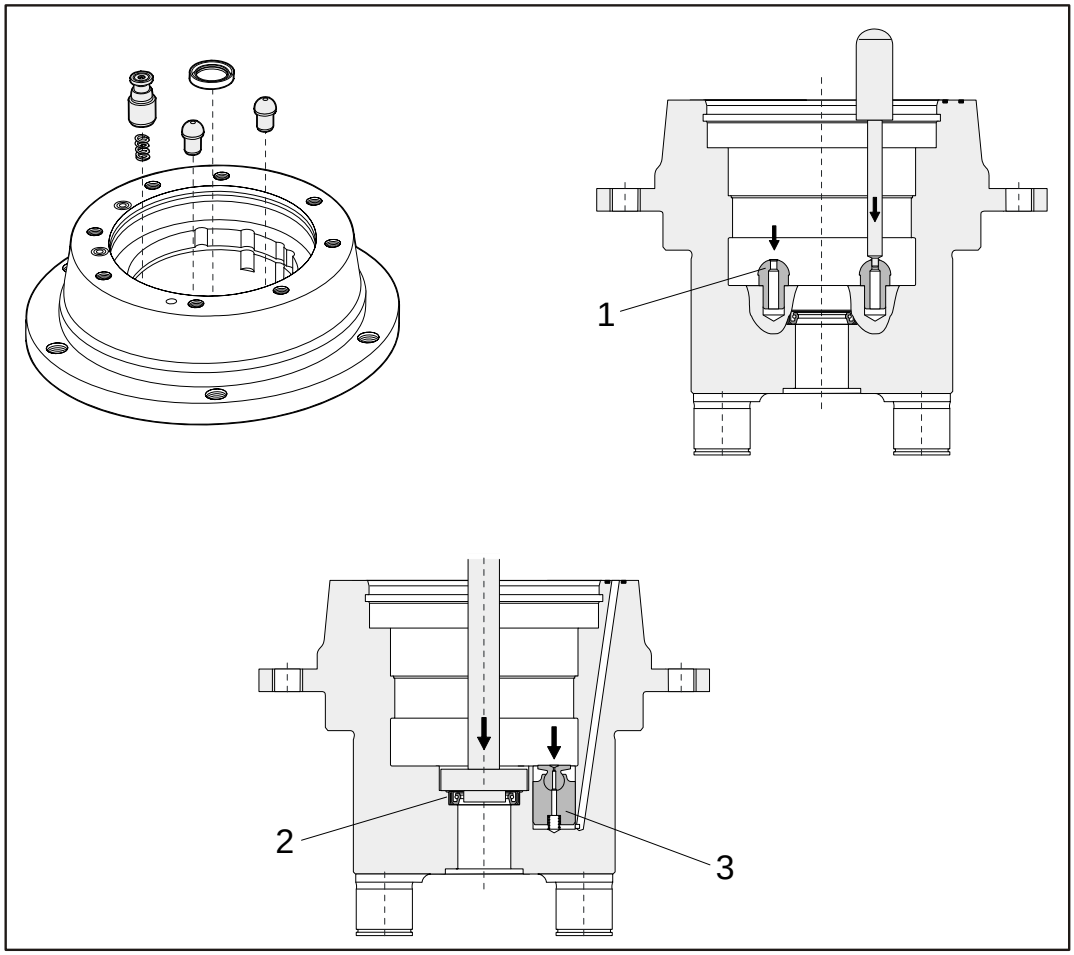


30. Place measuring device. Ascertain tolerance. Grip shaft with Seeger ring pincers and move up and down. [Simulation ring 1mm + tolerance + (bearing pretension 0.05 - 0.08) is resulting in thickness of the synchronizing disc]. Grind synchronizing disc to dimension.



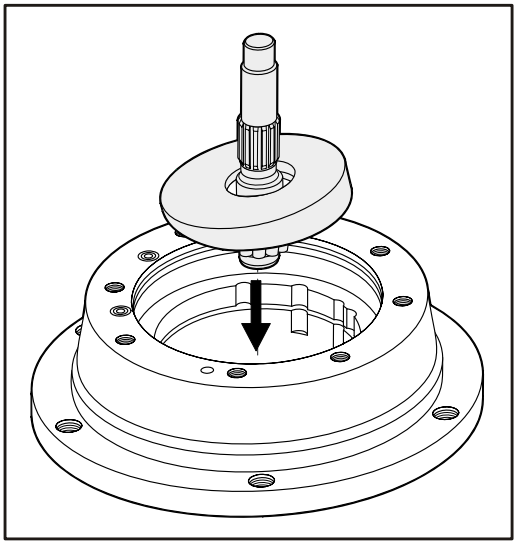
Motor Assembly

1. Press in swivel balls (with tool) (1). Insert shaft seal ring (with tool) (2). Insert control piston with spring (3).



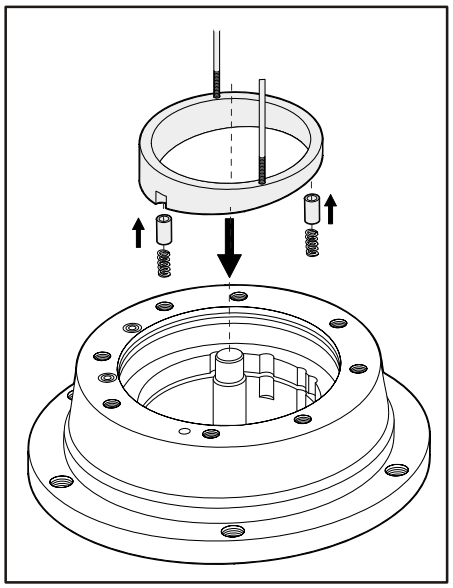
2. Install rotary group with cradle. Observe installation position of swivel balls.

NOTE: *Slightly grease swivel balls.*

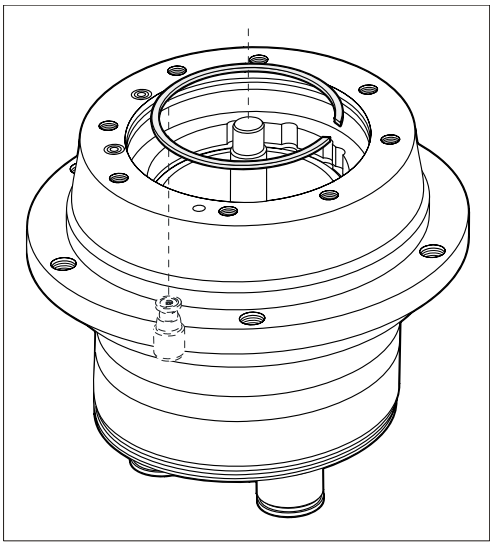


3. Mount sleeve and pressure ring in cradle stop. Insert cradle stop.

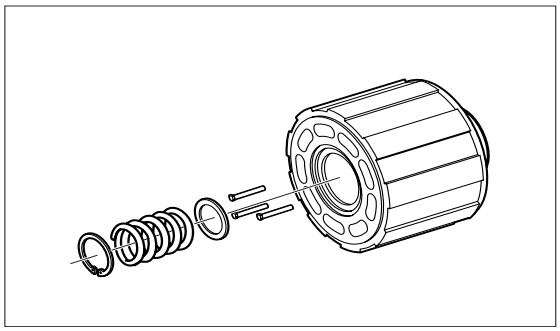
NOTE: *Stick with grease.*



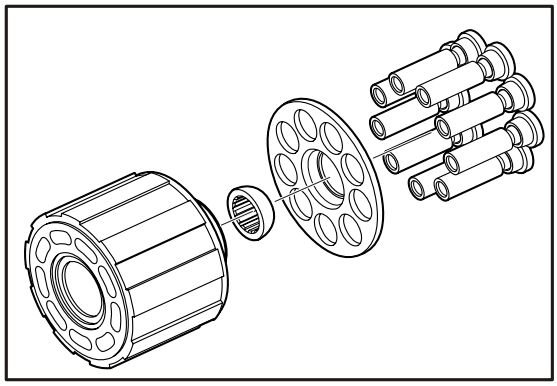
4. Mount Seeger snap ring. Opening of snap ring must be on the opposite side of the control piston.



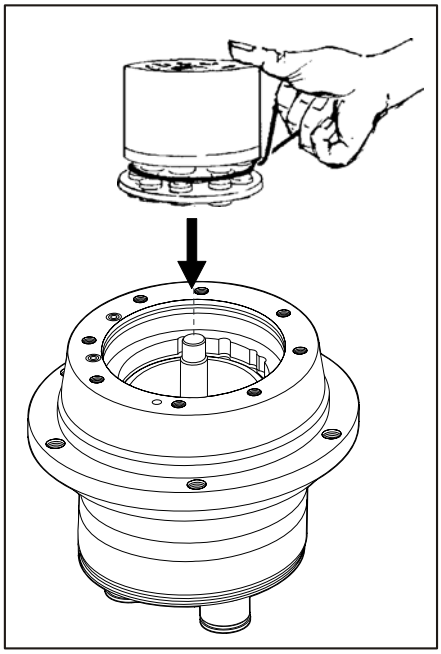
5. Fit pressure pins using an assembly aid. Pre-tension the spring using a suitable device.



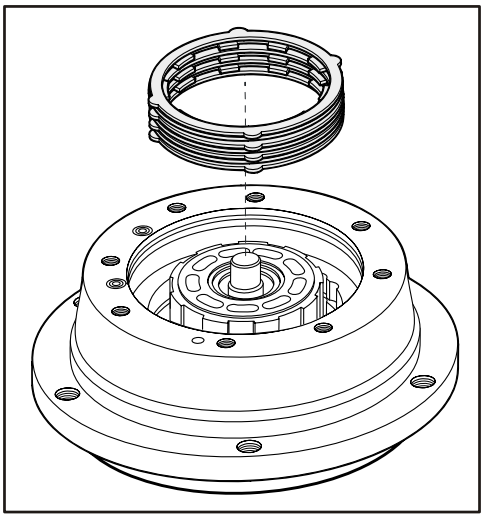
6. Assemble piston with retaining plate. Oil piston and slipper pad.



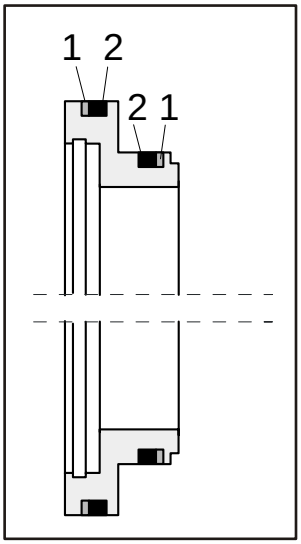
7. Assembly aid: Hold the pistons by using an o-ring.



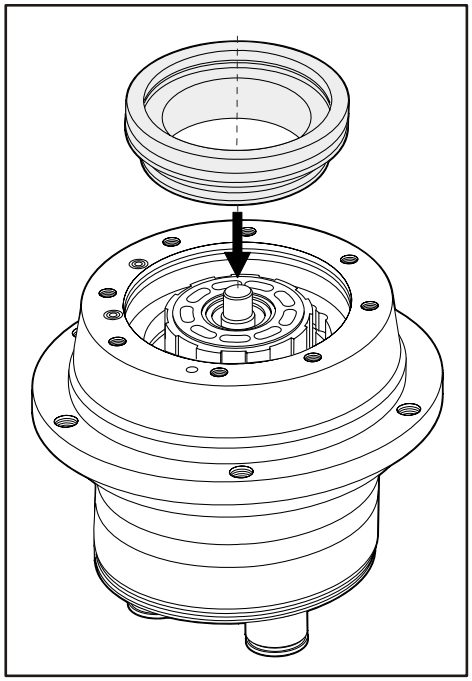
8. Install laminations in correct order.



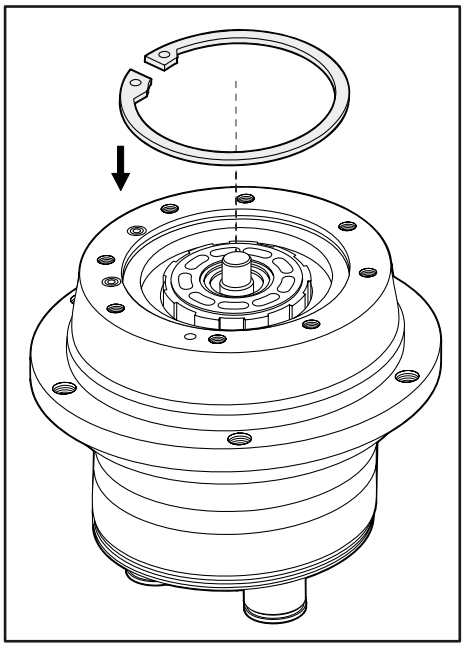
9. Mount support ring (1) and quad ring (2) in pressure ring. Be careful not to excessively extend the rings.



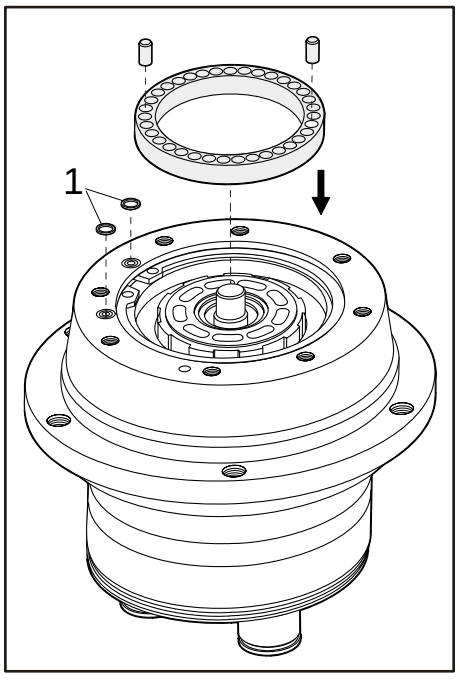
10. Grease seal rings, install in supporting axle.



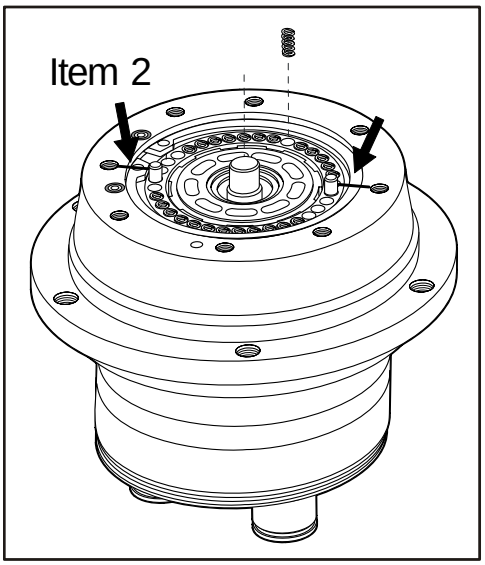
11. Mount retaining ring.



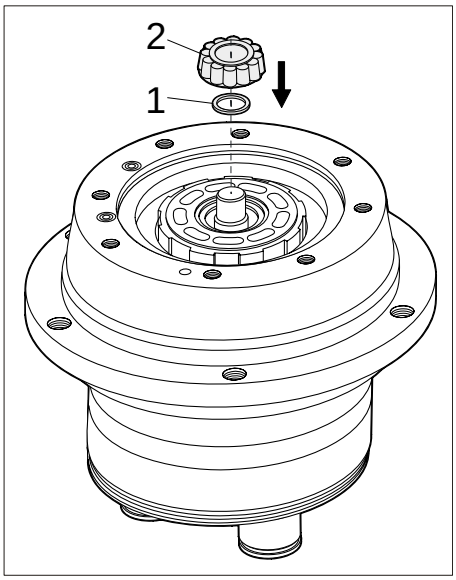
12. Mount seal rings (1). Insert and line-up guide ring.



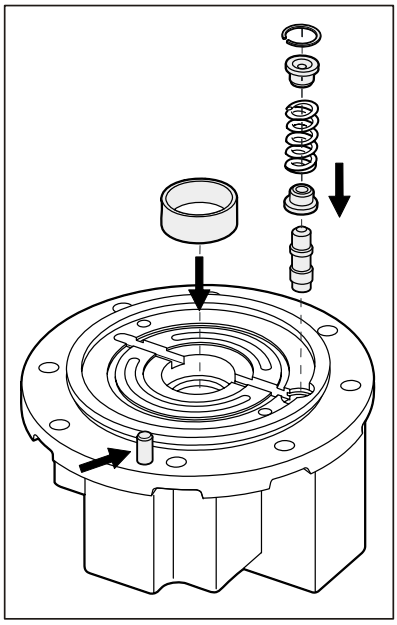
13. Align the two holes for fixation cylinder pin - port plate (item 2).



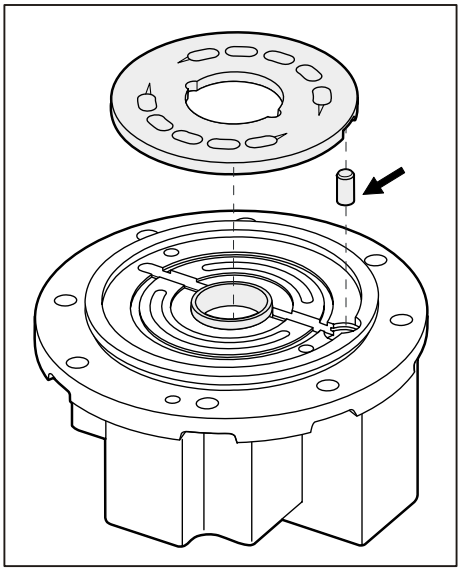
14. Mount synchronizing disc (1) and bearing (2).



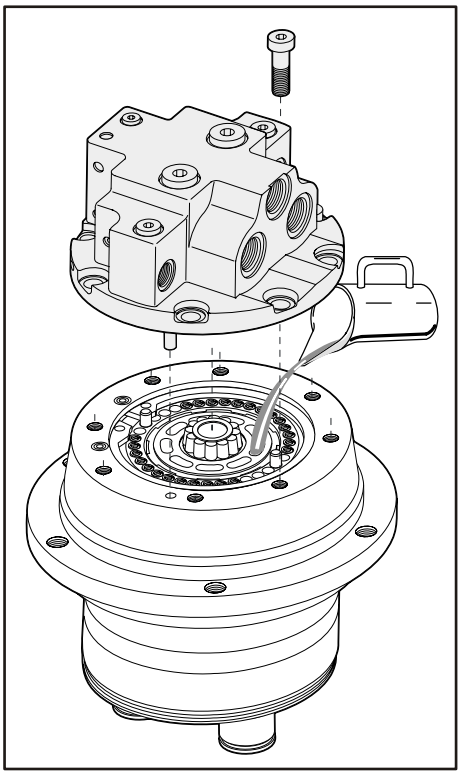
15. Mount bearing ring with device. Mount spool. Mount fixation pin.



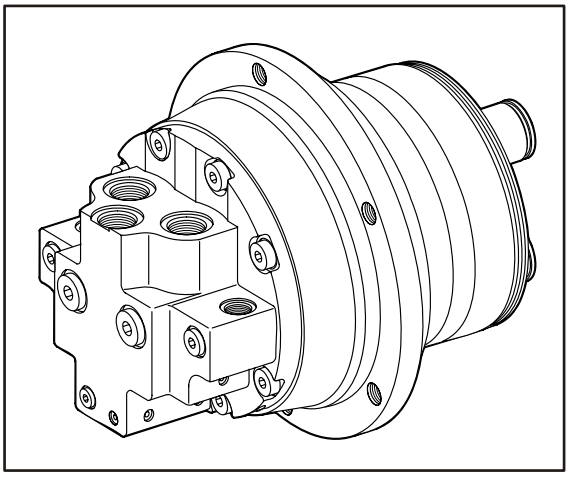
16. Fix control plate with grease at port plate.



17. Fill case with oil.



18. Mount and screw port plate on supporting axle.



3.5 DUAL FUEL/LPG SYSTEM

⚠ CAUTION

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

Changing From Gasoline to LP Gas

NOTE: Before climbing onto the platform, open hand valve on LP gas supply tank by turning valve counterclockwise.

19. Start engine from platform control station.
20. While engine is operating, place the dual fuel switch at platform control station to the LPG position. Allow engine to operate, without load, until engine begins to “stumble” from lack of gasoline. At this time the machine is allowing the LP fuel to be sent to the fuel regulator.

Changing From LP Gas to Gasoline

1. With engine operating on LP under a no-load condition, throw LPG/GASOLINE switch at platform control station to GASOLINE position.
2. If engine “stumbles” because of lack of gasoline, place switch to LPG position until engine regains smoothness, then return switch to GASOLINE position.
3. Close hand valve on LP gas supply by turning clockwise.

Using Liquid Petroleum (LP) Gas

⚠ WARNING

CLOSE FUEL VALVE ON TANK WHEN PARKING SIZZOR LIFT MORE THAN MOMENTARILY.

WHEN REFUELING LPG POWERED SIZZOR LIFTS, ALWAYS FOLLOW MANUFACTURERS SPECIFICATIONS AND/OR APPLICABLE REGULATIONS.

1. If machine is to be left overnight or longer, it must be parked outside or the LPG tank removed and stored outside.
2. LPG is extremely flammable. No smoking.
3. Only trained and authorized personnel are permitted to operate filling equipment.
4. Fill LPG tanks outdoors. Stay at least 50 ft (15 m) from buildings, motor vehicles, electrical equipment or other ignition sources. Stay at least 15 ft (5 m) from LPG storage tanks.
5. During transfer of LPG, metal components can become very cold. Always wear gloves when refilling or changing tanks to prevent “freeze burns” to skin.
6. Do not store LPG tanks near heat or open flame. For complete instructions on the storage of LPG fuels, refer to ANSI/NFPA 58 & 505 or applicable standards.

⚠ WARNING

DO NOT USE AN LPG TANK THAT IS DAMAGED. A DAMAGED TANK MUST BE REMOVED FROM SERVICE. FROST ON THE SURFACE OF A TANK, VALVES, OR FITTINGS INDICATES LEAKAGE. A STRONG ODOR OF LPG FUEL CAN INDICATE A LEAK.

3.6 FORD 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.

EFI Diagnostics

The EFI diagnostics are designed to assist in locating a faulty circuit or component. When a malfunction is detected by the Engine Control Module (ECM), a diagnostic trouble code (DTC) is set and will be displayed on the JLG Control System Analyzer. Refer to Section 6 - JLG Control System.

CLEARING TROUBLE CODES

To clear the trouble codes from the ECM, the electrical current running to the ECM must be shut off. To do this, disconnect the negative terminal from the battery for a period of approximately 15 minutes.

ECM and Sensors

CRANKSHAFT POSITION (CKP) SENSOR

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

CAMSHAFT POSITION (CMP) SENSOR AND SIGNAL

The camshaft position (CMP) sensor sends a CMP signal to the ECM. The ECM uses this signal as a "sync pulse" to trigger the injectors in the proper sequence. The ECM 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 ECM to calculate true sequential fuel injection (SFI) mode of operation. If the ECM 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

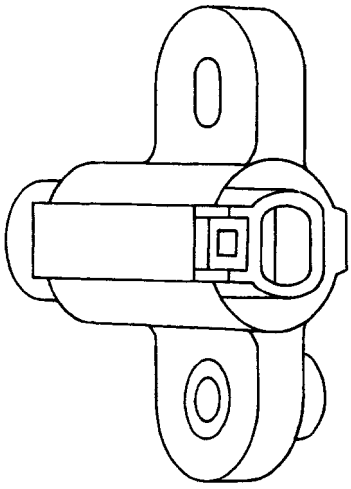


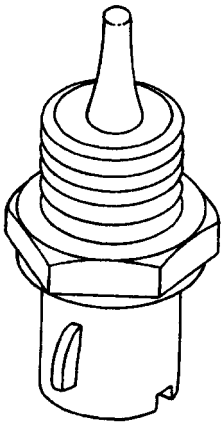
Table 3-5. ECM Diagnostic Trouble Codes

Diagnostic Trouble Code	Description
11	All Systems OK
12	Throttle Position (TP) Sensor Low Voltage
14	Manifold Absolute Pressure (MAP) Low Voltage
15	Under Minimum Map Sensor Temperature
21	Overspeed
22	Throttle Position (TP) Sensor High Voltage
23	Over maximum throttle
24	Manifold Absolute Pressure (MAP) High Voltage
25	Over Maximum Map Sensor Temperature
26	Over maximum initial Throttle Position Sensor 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

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 ECM supplies a 5-volt signal to the ECT sensor through resistors in the ECM 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 ECM calculates the engine coolant temperature. Engine coolant temperature affects most of the systems that the ECM 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.



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 ECM. The EEPROM contains the program and the calibration information that the ECM needs to control engine operations.
If the ECM is replaced, the new ECM 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 ECM.

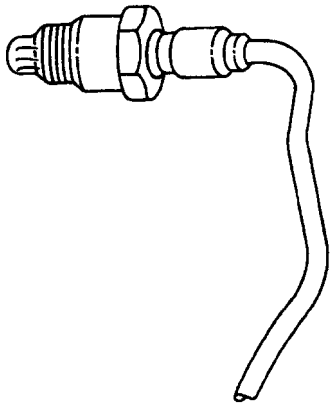
HEATED OXYGEN SENSOR

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 ECM 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.



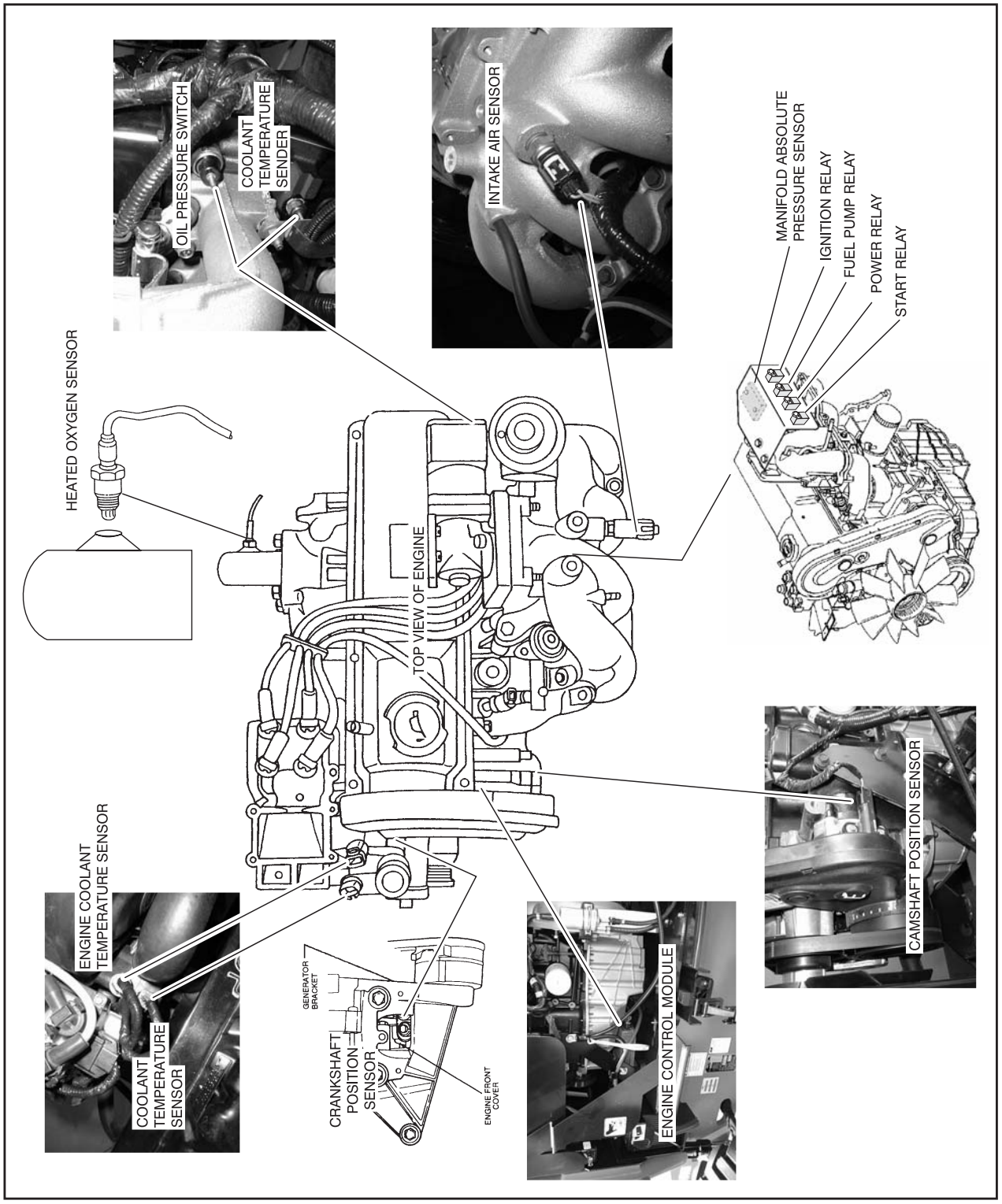
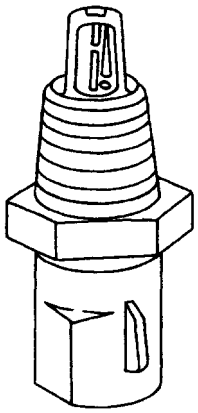


Figure 3-10. EFI Component Location

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 ECM supplies a 5-volt signal to the sensor through a resistor in the ECM 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 ECM 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.



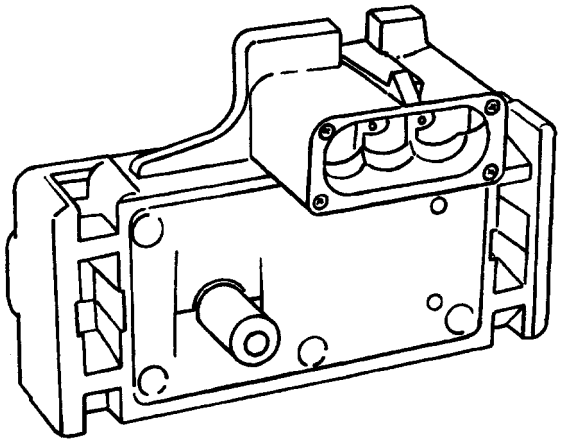
MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR

The manifold absolute pressure (MAP) sensor responds to changes in intake manifold pressure (vacuum). The MAP sensor signal voltage to the ECM 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 ECM 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)

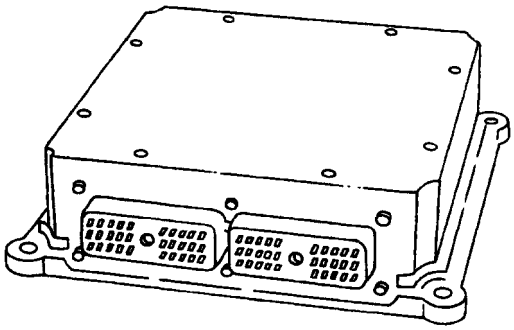
The ECM controls the following:

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

The ECM constantly observes the information from various sensors. The ECM controls the systems that affect engine performance. The ECM 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 ECM supplies either 5 or 12 volts to power various sensors or switches. The power is supplied through resistances in the ECM which are so huh 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 ECM 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 ECM is designed to maintain exhaust emission levels to government mandated standards while providing excellent operation and fuel efficiency. The ECM monitors numerous engine functions via electronic sensors such as the throttle position (TP) sensor and the heated oxygen sensor (HO2S).



ECM 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)

ECM SERVICE PRECAUTIONS

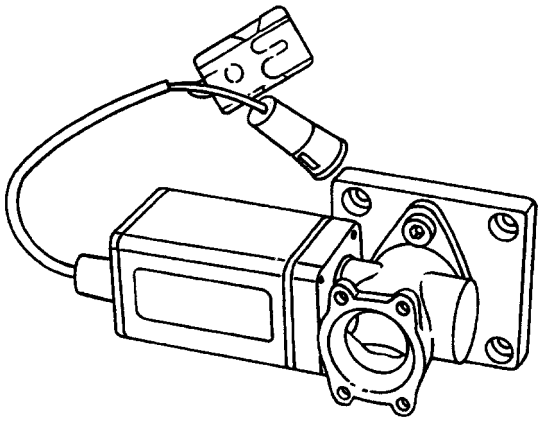
The ECM is designed to withstand normal current draws associated with engine operation. When servicing the ECM, observe the following guidelines:

- 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 ECM.
- When testing for opens and shorts, do not ground or apply voltage to any of the ECM'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 charging the battery with an arc welder.
- Take proper precautions to avoid static damage to the ECM. 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 ECM monitors the voltage on the signal line and calculates throttle position. As the throttle 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 ECM 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 ECM thinks the throttle is moving. A hard failure in the TP sensor 5-Volt reference or signal 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 systems unless specifically instructed by the diagnostic procedures. A test light can put an excessive load on an ECM circuit and result in component damage. For voltage measurements, use only a digital voltmeter with an input impedance of at least 10 megohms.

ELECTROSTATIC DISCHARGE DAMAGE

Electronic components used in the ECM 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 ECM connector pins or soldered components on the ECM 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.

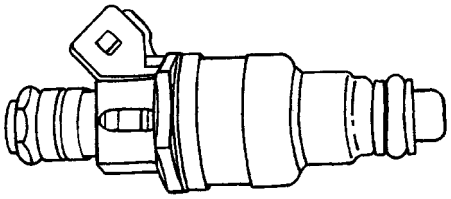
Fuel System

FUEL INJECTOR

The Electronic Fuel Injection (EFI) fuel injector is a solenoid-operated device controlled by the ECM. The ECM 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 ECM
- 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 prefilter. 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.

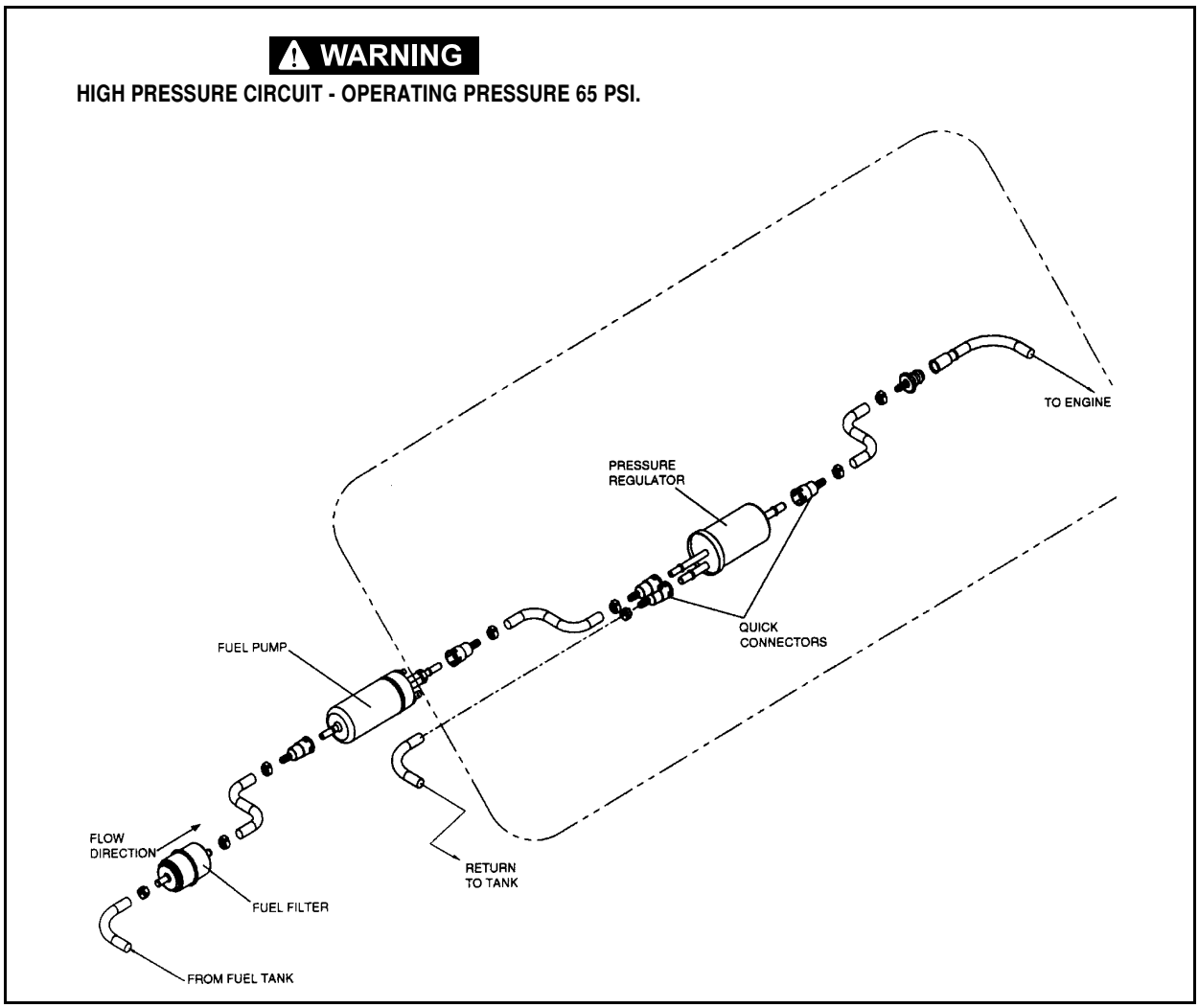


Figure 3-11. Typical Fuel System

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 ECM how much oxygen is in the exhaust gas. The ECM changes the air/fuel ratio to the engine by controlling 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.

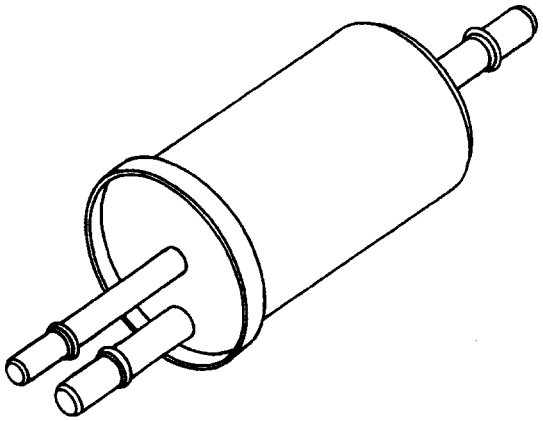
The ECM monitors signals from several sensors in order to determine the fuel needs of the engine. Fuel is delivered under one of several conditions called "modes." All modes are controlled by the ECM. Refer to "Open Loop and Closed Loop Operation" for more information.

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.



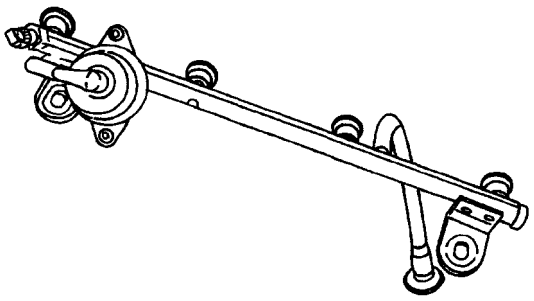
FUEL PUMP ELECTRICAL CIRCUIT

When the key is first turned "ON," the ECM 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 ECM 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 SECM, the ECM 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.

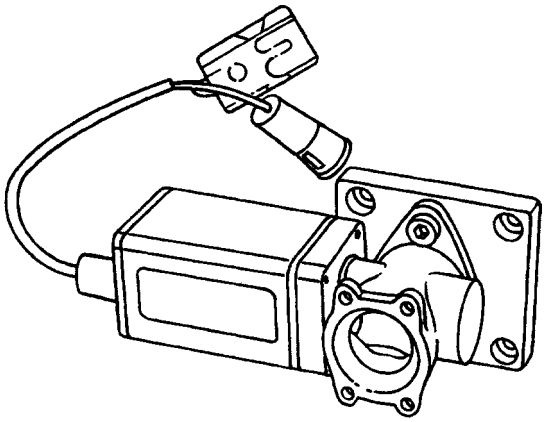
FUEL RAIL

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 control module (ECM).



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 ECM. Refer to "Throttle Position (TP) Sensor" for more information.

The 2-wire pigtail carries the throttle signal from the ECM to the governor. Desired engine speeds are stored in the configuration program for each specific application, and can be changed with the ECM calibration software. When an engine speed is selected with the toggle switch, the ECM 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 ECM 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 ECM by comparing manifold absolute pressure (MAP) with throttle position. When the ECM 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 ECM 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 ECM 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.

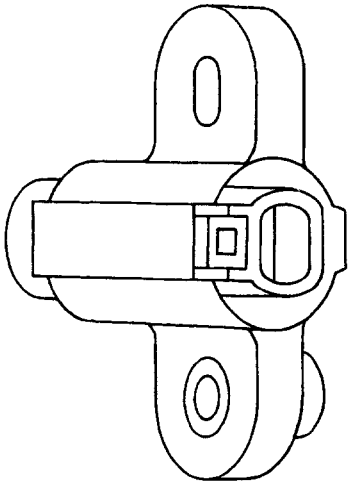
The system remains in open loop until the following conditions are met:

- 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 ECM 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 ECM 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 ECM responds by reducing the "on" time of the fuel injectors, thus leaning out the mixture.

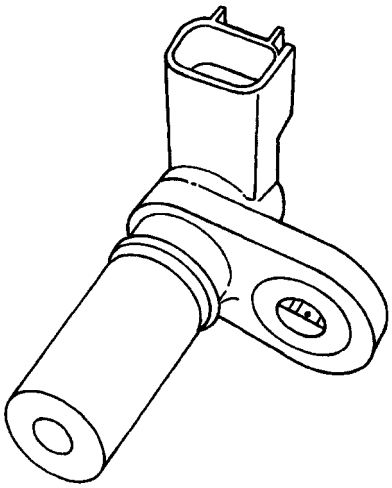
CAMSHAFT POSITION (CMP) SENSOR

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 (ECM) to calculate the ignition sequence. The sensor initiates the reference pulses which the ECM uses to calculate RPM and crankshaft position.



ELECTRONIC IGNITION

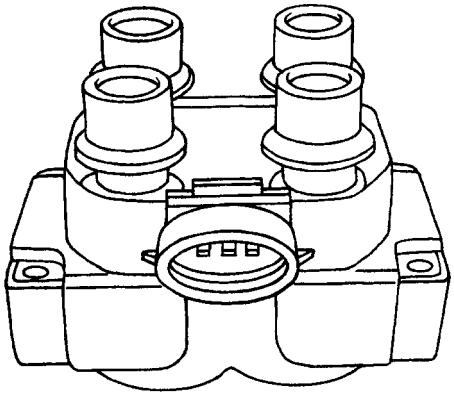
The electronic ignition system controls fuel combustion by providing a spark to ignite the compressed air/fuel w mixture at the correct time. To provide optimum engine performance, fuel economy, and control of exhaust emissions, the ECM controls the spark advance of the ignition system. Electronic ignition 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."

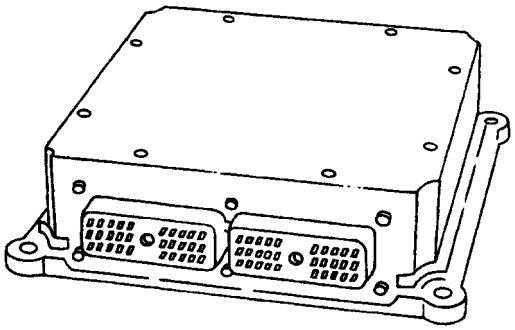
The primary coils in the coil pack are triggered by the "Ignition Coil Feed #1" and "Ignition Coil Feed #2" Signals from the ECM.



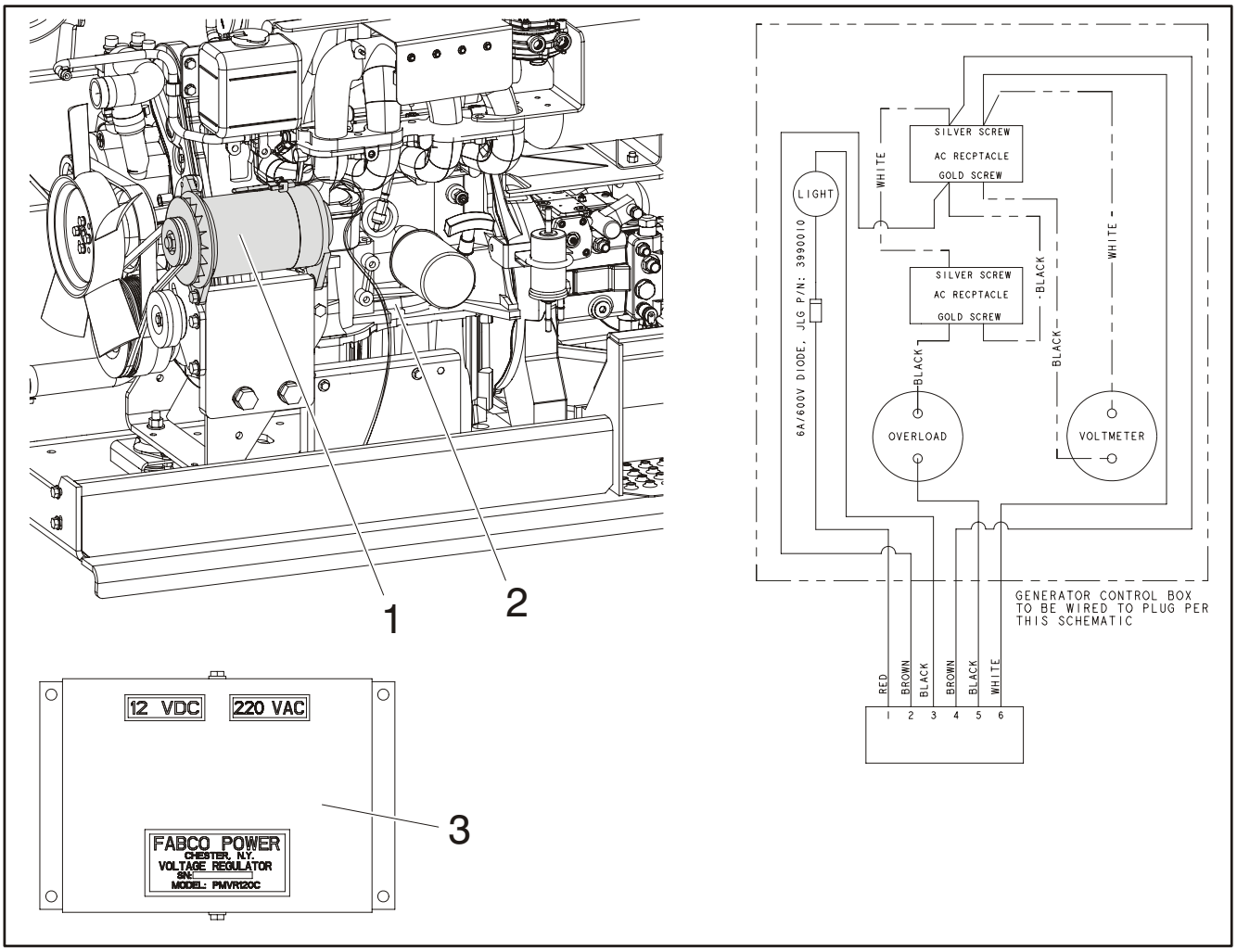
ENGINE CONTROL MODULE (ECM)

The ECM is responsible for maintaining proper spark and fuel injection timing for all operating conditions. To provide optimum operation and emissions, the ECM 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



3.7 GENERATOR - FORD ENGINE



1. Generator
2. Ford Engine
3. Voltage Regulator

Figure 3-12. Generator (Ford Engine)

Table 3-6. Generator Specifications

Description	220 Powermax
Voltage	220V
Continuous	2.5 KW
Peak	3.5 KW
Amps Peak	15 Amps

3.8 DEUTZ EMR 2 (S/N 0200138634 TO PRESENT)

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.

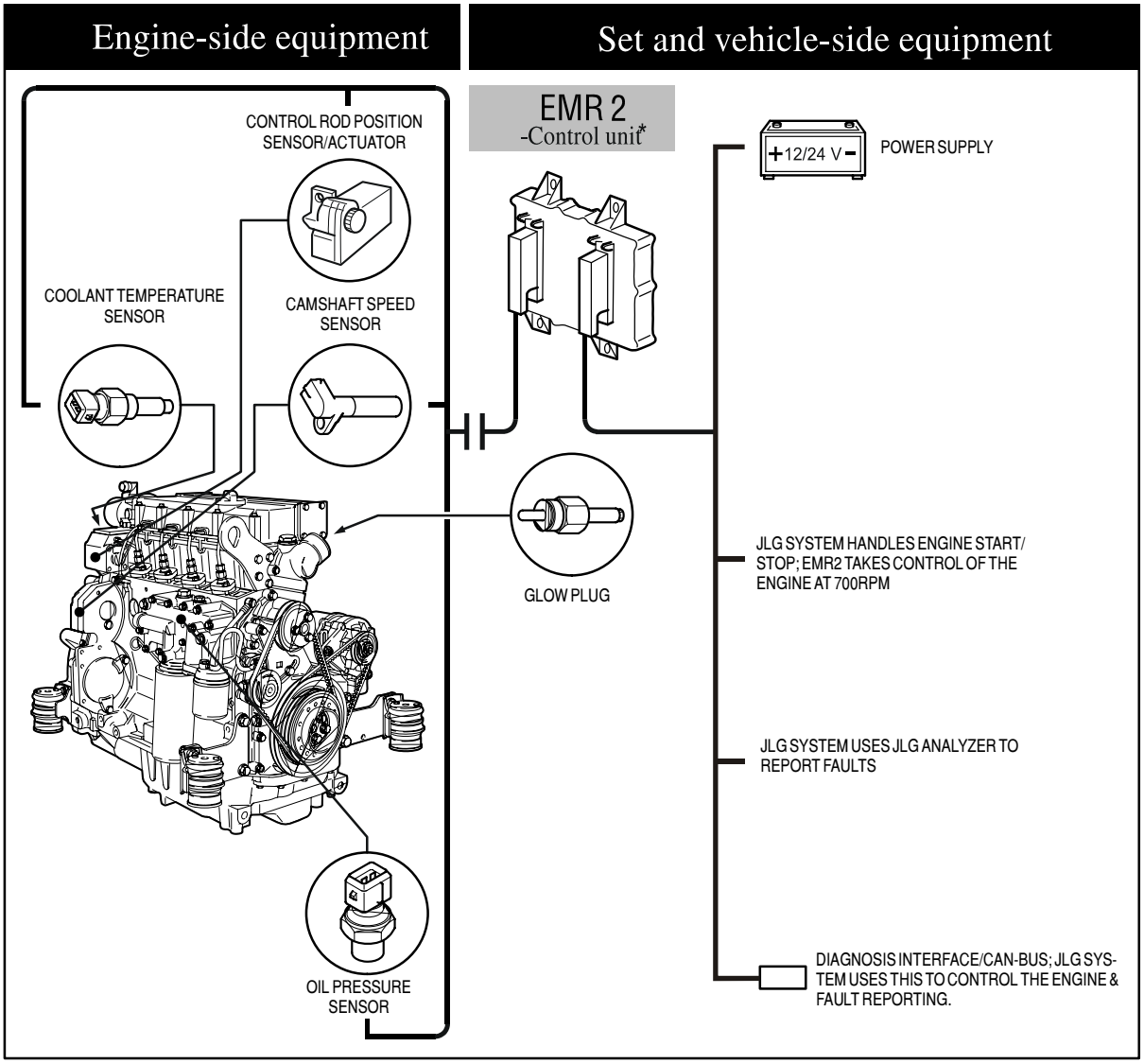


Figure 3-13. EMR 2 Engine Side Equipment

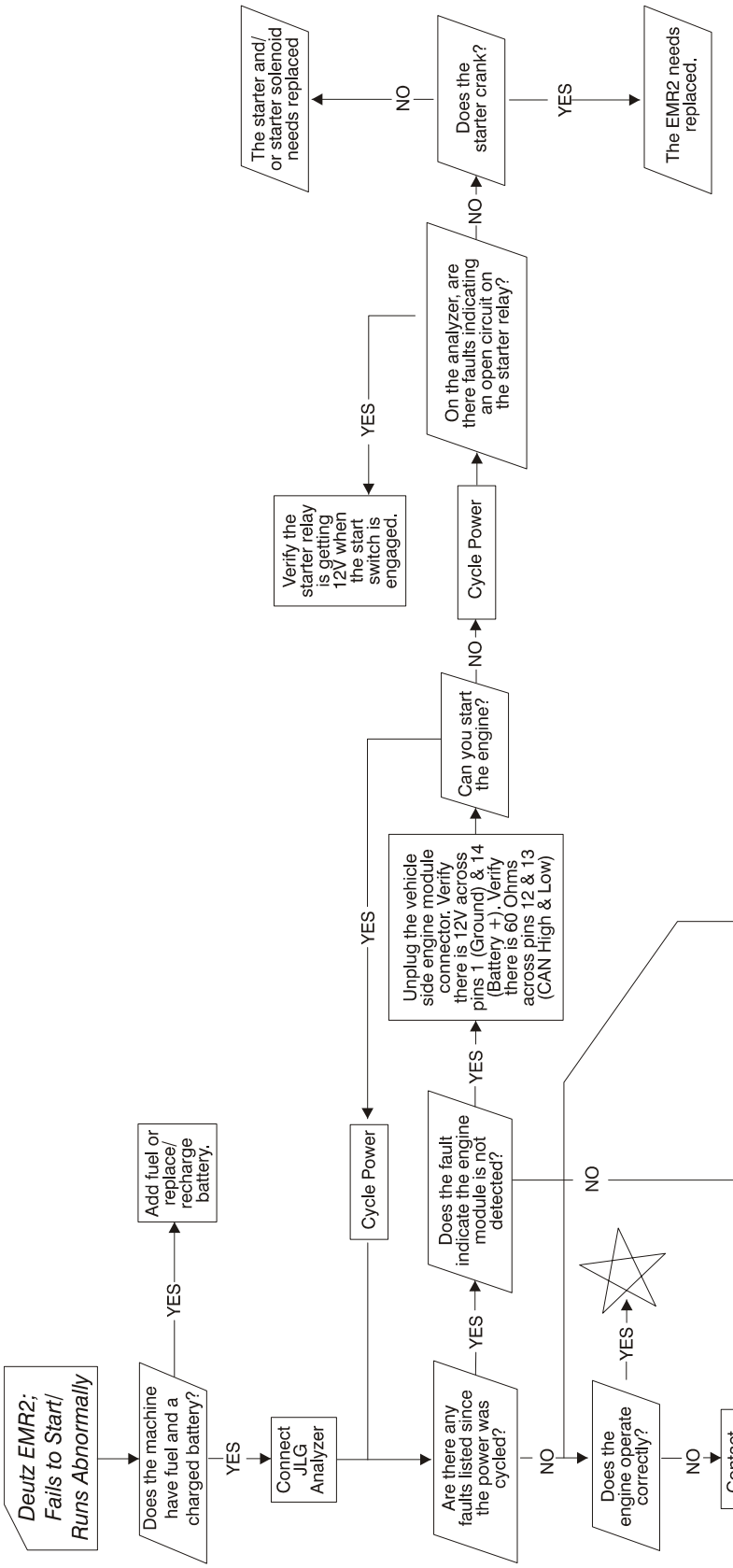


Figure 3-14. Deutz EMR 2 Troubleshooting Flow Chart

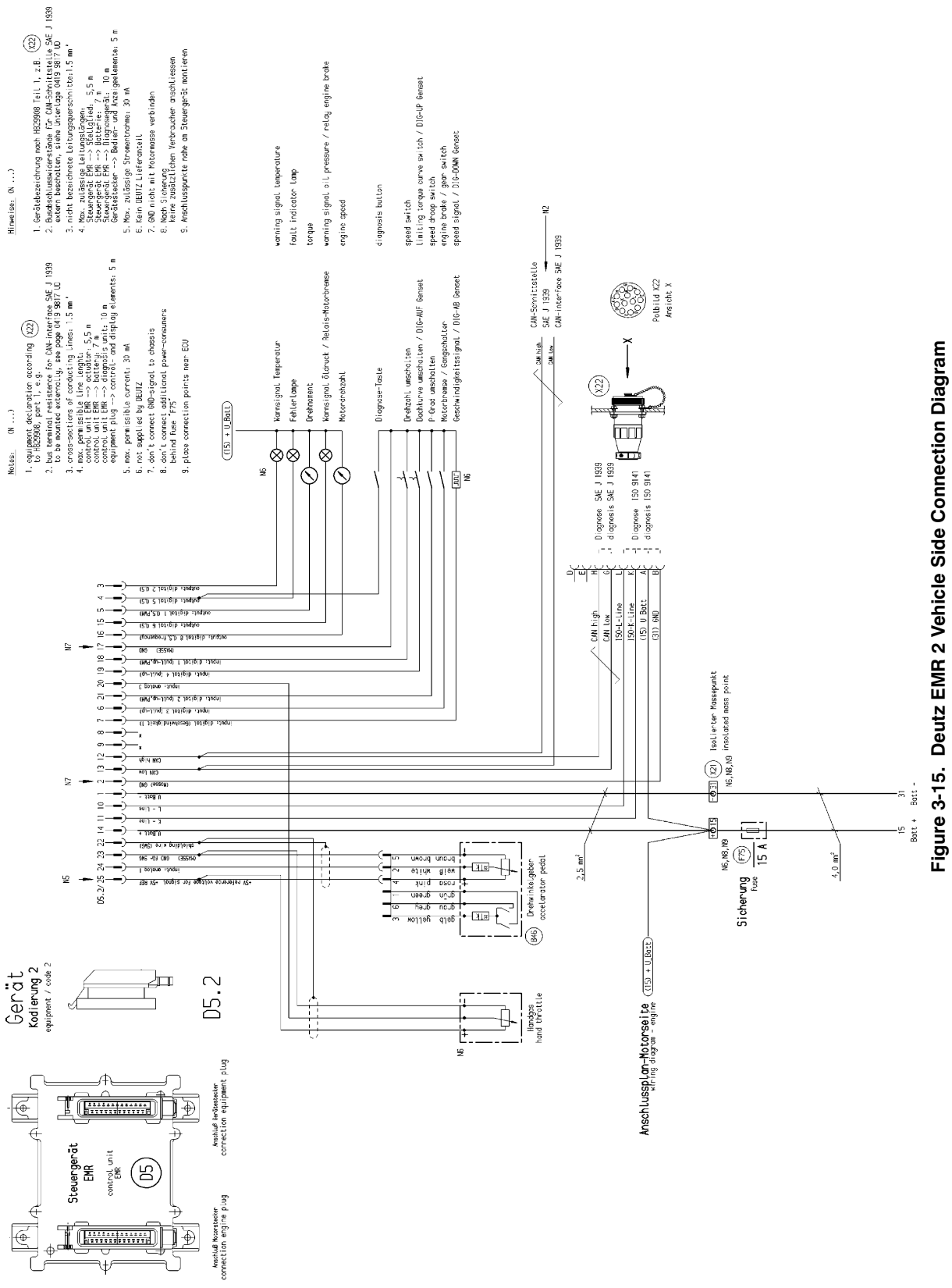


Figure 3-15. Deutz EMR 2 Vehicle Side Connection Diagram

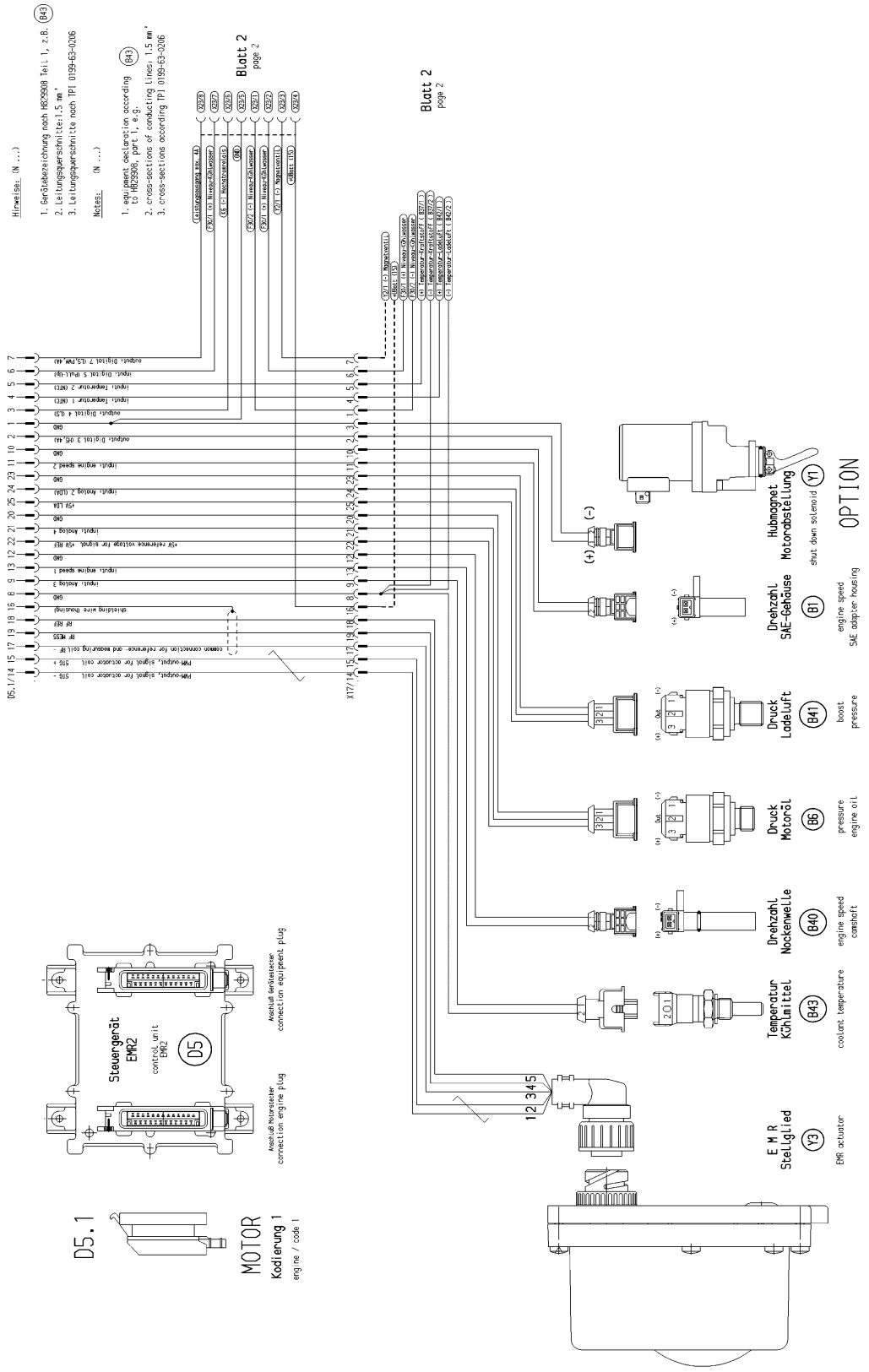


Figure 3-16. Deutz EMR 2 Engine Side Connection Diagram - Sheet 1 of 2

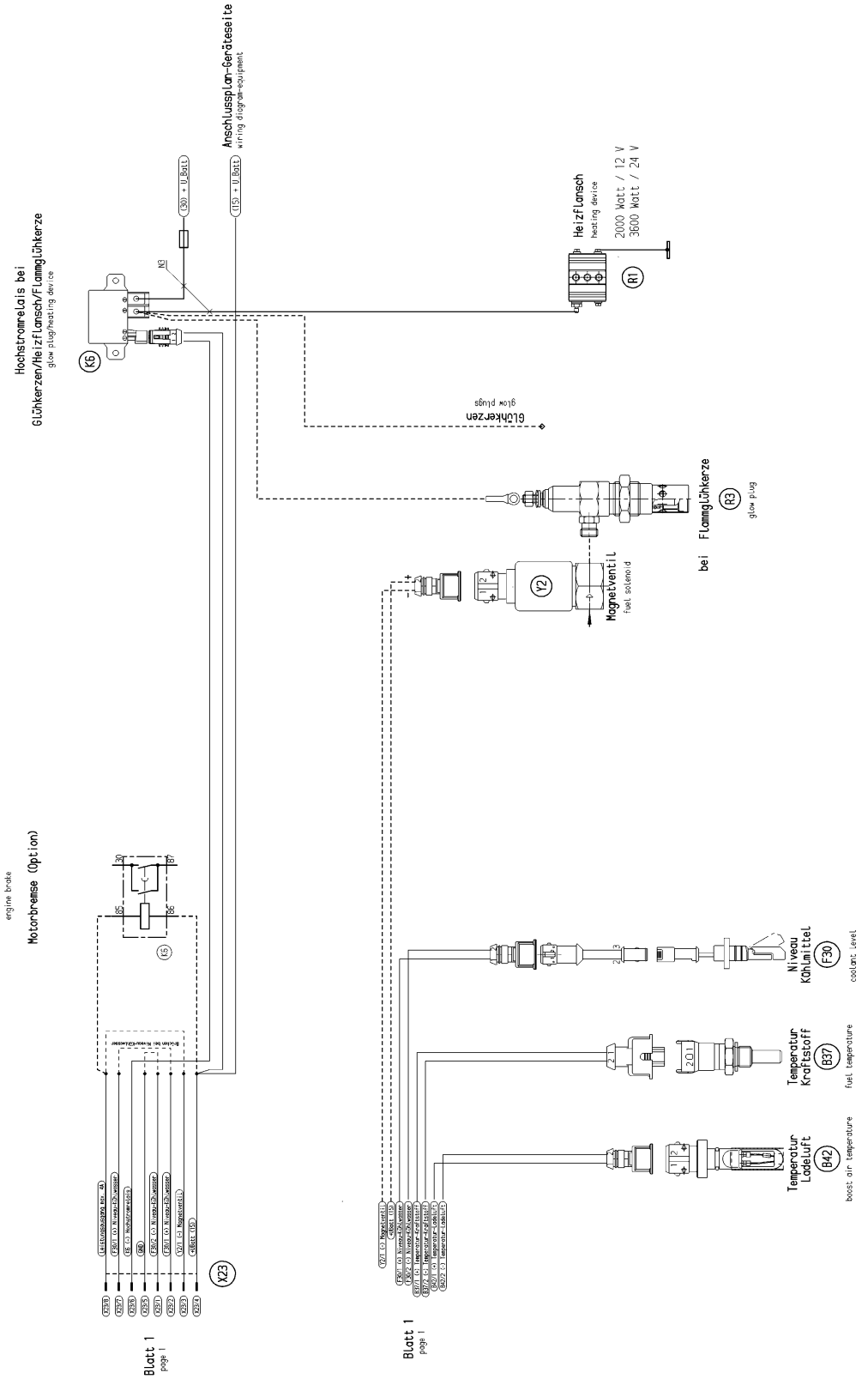
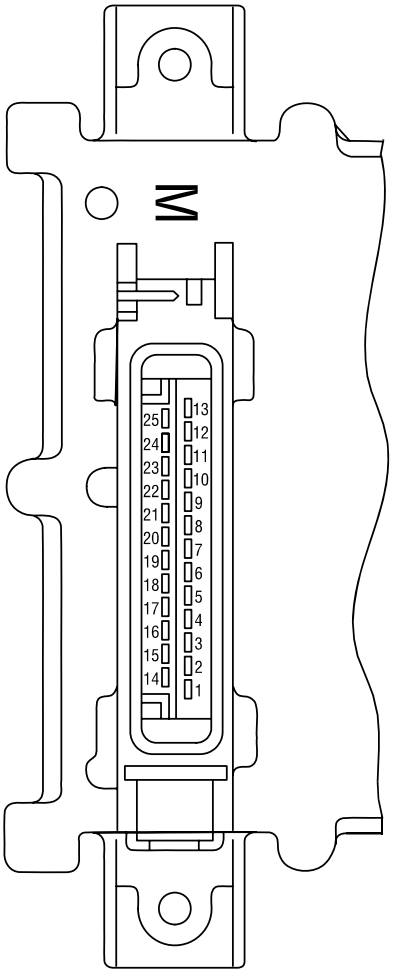


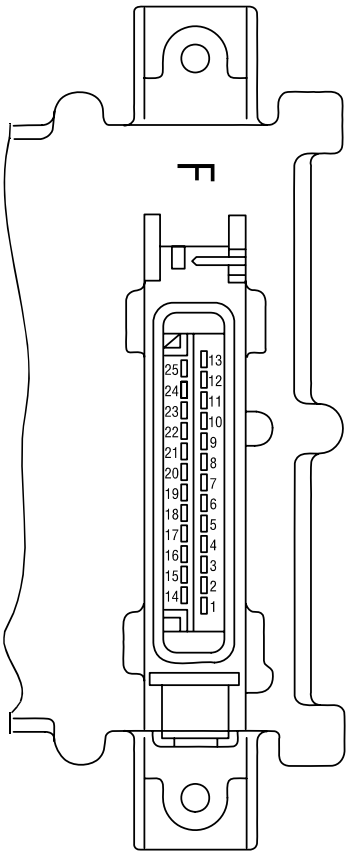
Figure 3-17. Deutz EMR 2 Engine Side Connection Diagram - Sheet 2 of 2



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 3-18. 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 3-19. 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 3-20. 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 3-21. 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 3-22. 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.

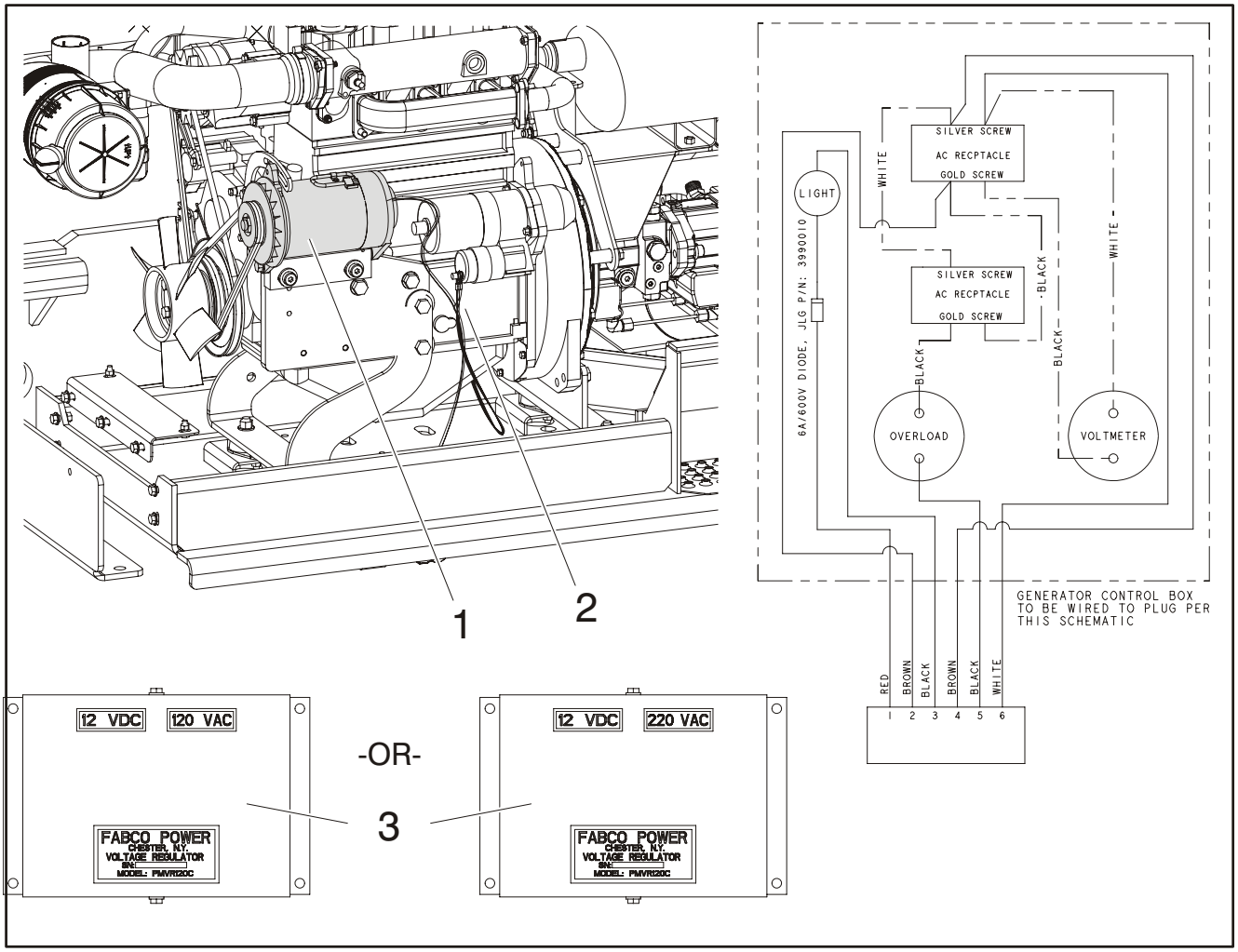
Figure 3-23. EMR2 Fault Codes - Sheet 4 of 5

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 3-24. EMR2 Fault Codes - Sheet 5 of 5

3.9 GENERATOR - DUETZ ENGINE



1. Generator (120V or 220V)
2. Deutz Engine
3. Voltage Regulator

Figure 3-25. Generator (Deutz Engine)

Table 3-7. Generator Specifications

Description	110 Bluemax	220 Powermax
Voltage	120V	220V
Continuous	3.5 KW	2.0 KW
Peak	4.5 KW	3.0 KW
Amps Peak	37 Amps	13 Amps

3.10 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 inch (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.

Belt Adjustment:

1. Remove existing belt and discard.
2. Install new belt (21mm X 1187mm).
3. Unload spring in belt tensioner.
4. Return alternator adjustment to original position and tighten bolt.
5. Release belt tensioner.
6. Check position of belt tensioner stop.
7. Readjust alternator position as necessary to allow correct positon of belt tensioner stop.

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

⚠ CAUTION

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.

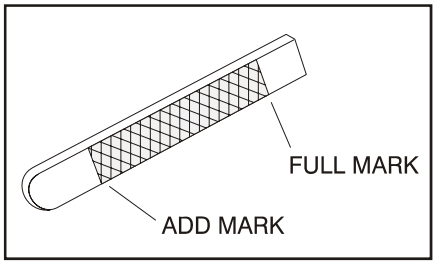


Figure 3-26. Engine Oil Dip Stick

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

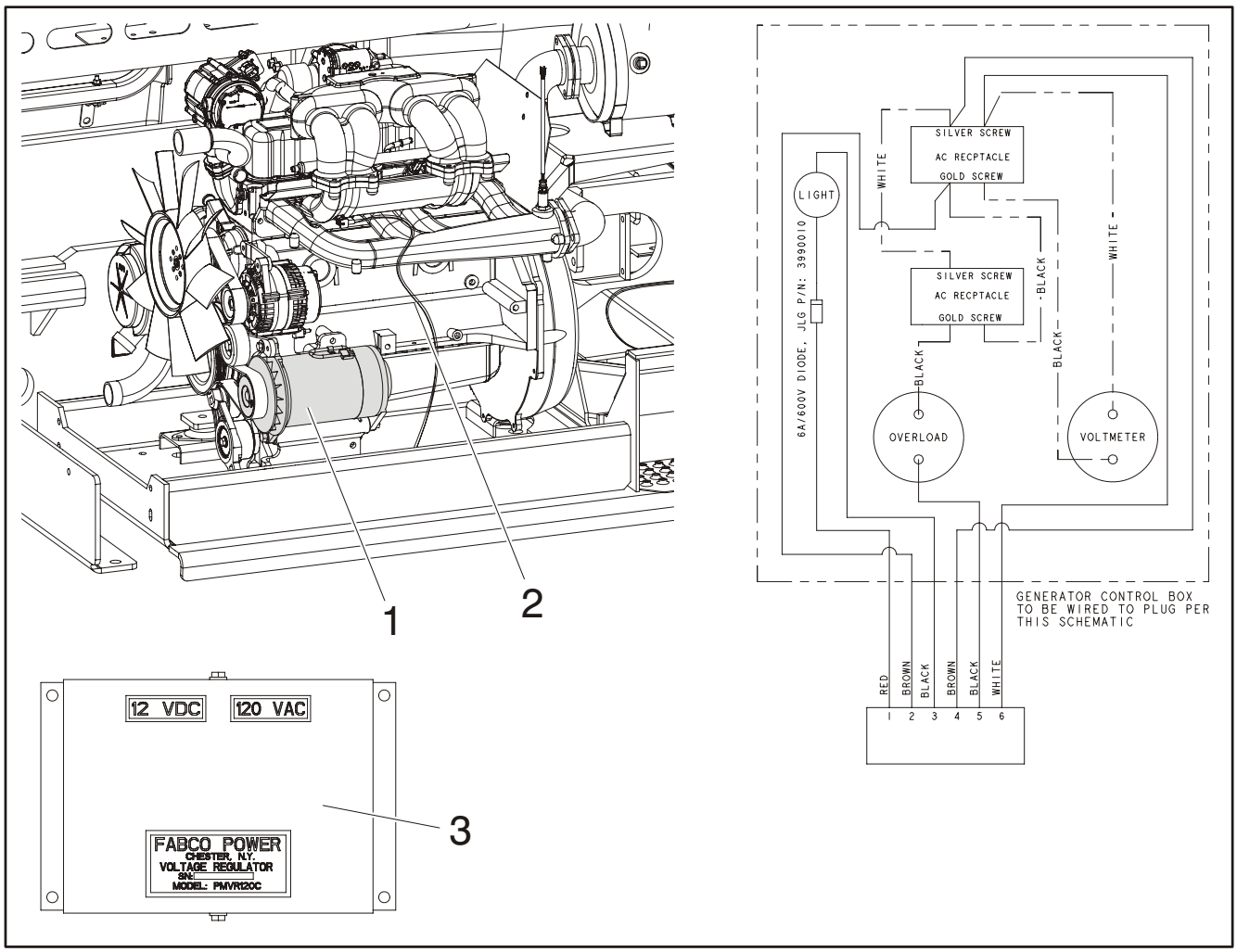
NOTICE

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.

3.11 GENERATOR - GM ENGINE



1. Generator 2. GM Engine 3. Voltage Regulator

Figure 3-27. Generator (GM Engine)

Table 3-8. Generator Specifications

Voltage	120V
Continuous	3.5 KW
Peak	4.5 KW
Amps Peak	37 Amps

3.12 GM ENGINE DUAL FUEL SYSTEM

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 inches (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).

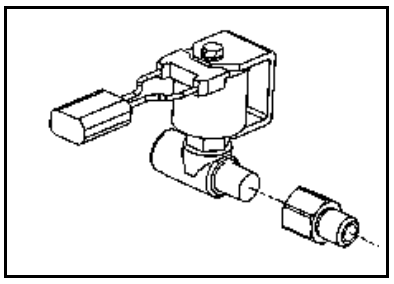
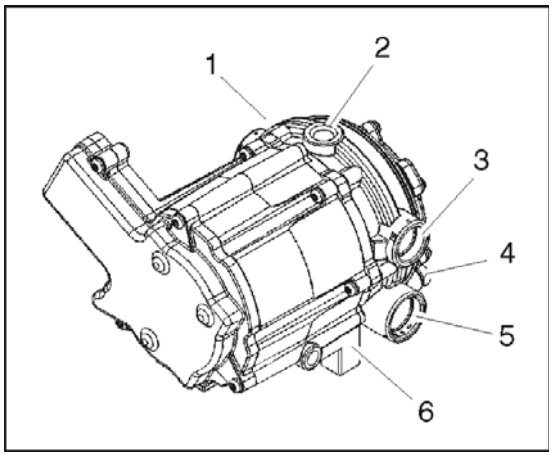


Figure 3-28. Electric Fuel Lock Off

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 3-29. 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.

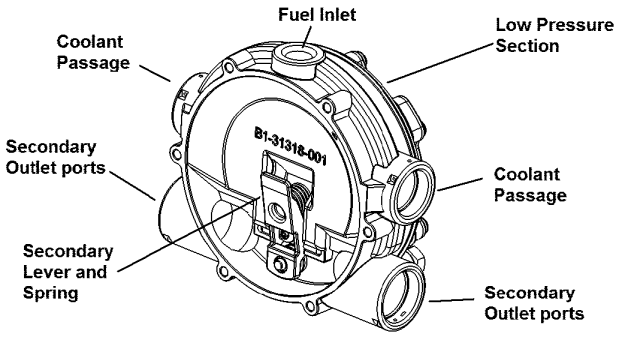


Figure 3-30. Low Pressure Regulators

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 inches (101.6 mm) of water column at start to as high as 14.0 inches (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 inches (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.

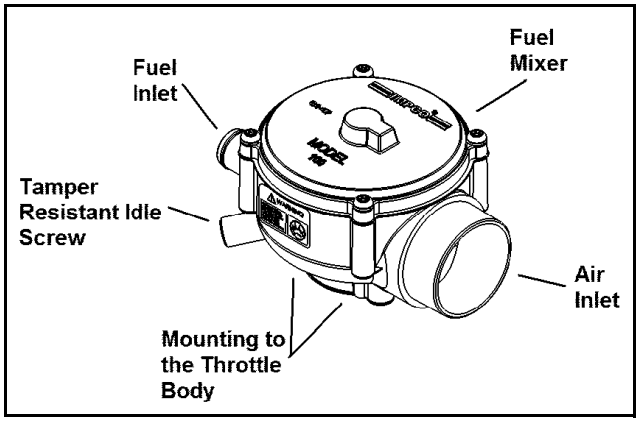


Figure 3-31. Air Fuel Mixer

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.

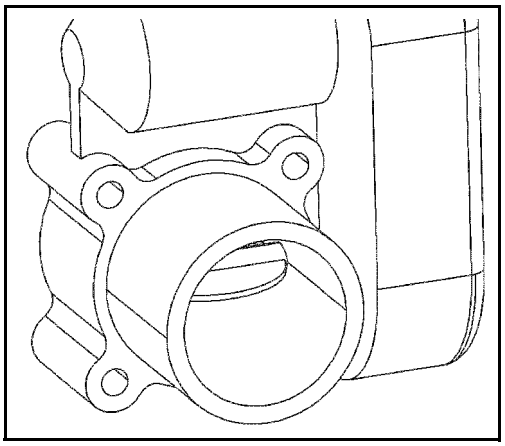


Figure 3-32. ETC throttle control device

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.

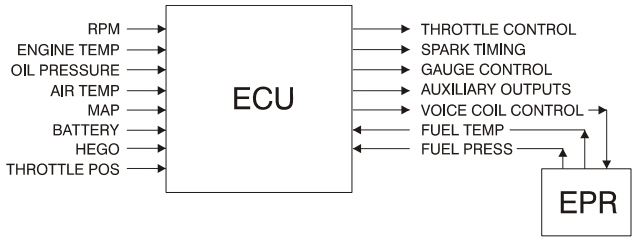


Figure 3-33. LPG Engine Control Unit (ECM)

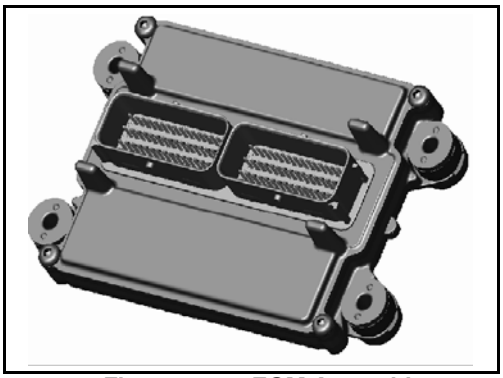


Figure 3-34. ECM Assembly

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.

⚠ CAUTION

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.

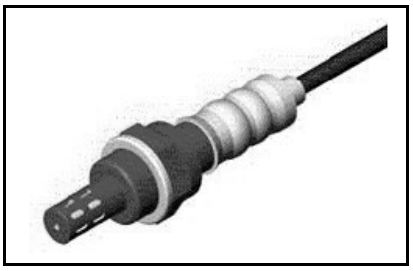


Figure 3-35. Heated Exhaust Gas Oxygen Sensor (HEGO)

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.

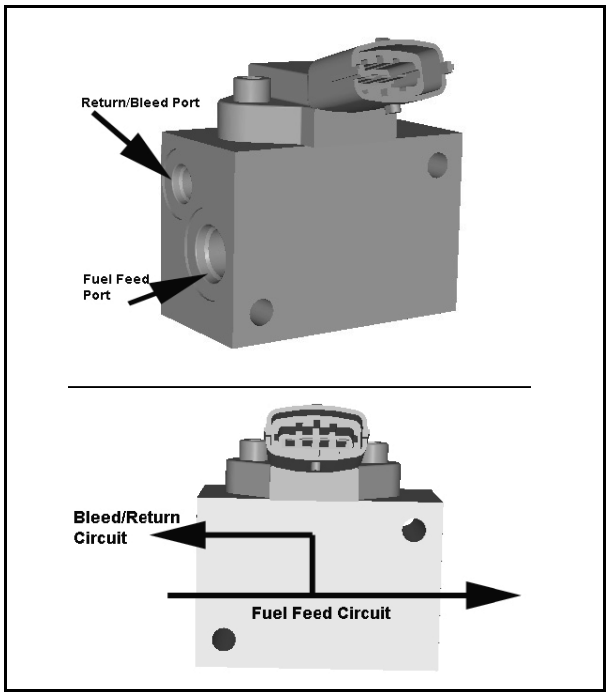


Figure 3-36. Gasoline Fuel Pressure and Temperature Manifold Assembly

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.

3.13 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.

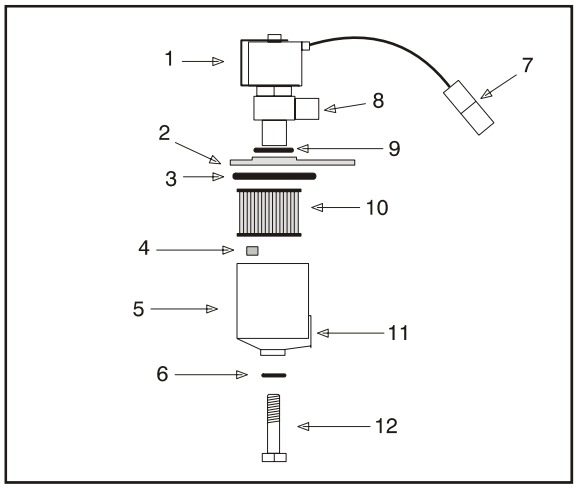
Propane Fuel System Leak Test

⚠ 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 3-37. 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 retaining bolt and remove it.
4. Pull the filter housing from the Electric lock off assembly.
5. Locate Filter magnet and remove it.
6. Remove the filter from the housing.
7. Remove and discard the housing seal.
8. Remove and discard the retaining bolt seal.
9. Remove and discard mounting plate to lock off O-ring seal.

INSTALLATION

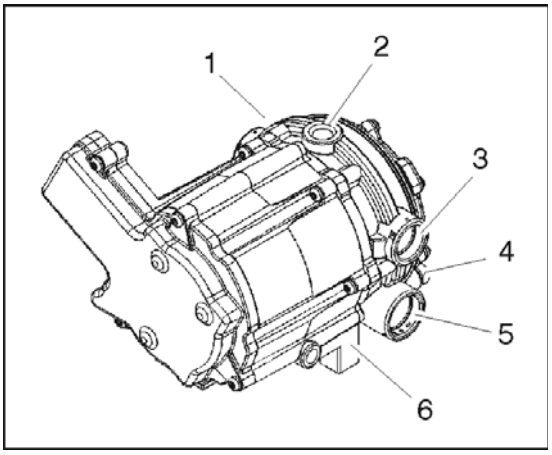
NOTICE

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. 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. 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 retaining bolt 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 3-38. 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.

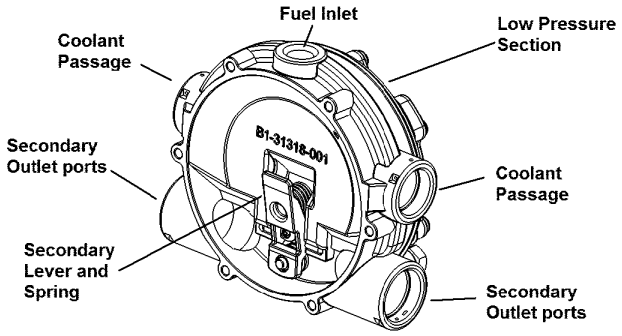


Figure 3-39. Pressure Regulator Section

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

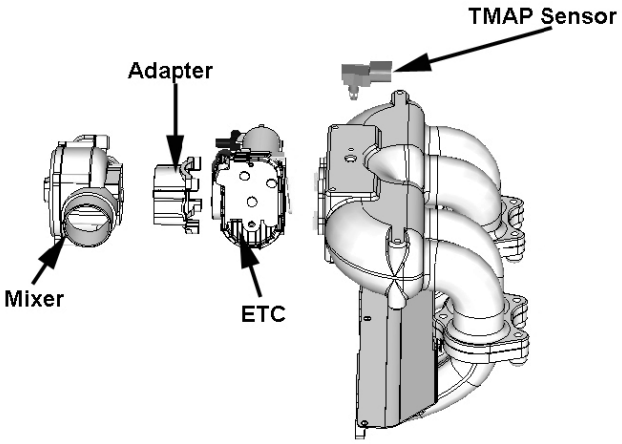


Figure 3-40. (TMAP) Sensor & Electronic Throttle Control (ETC)

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 3-40.

REMOVAL

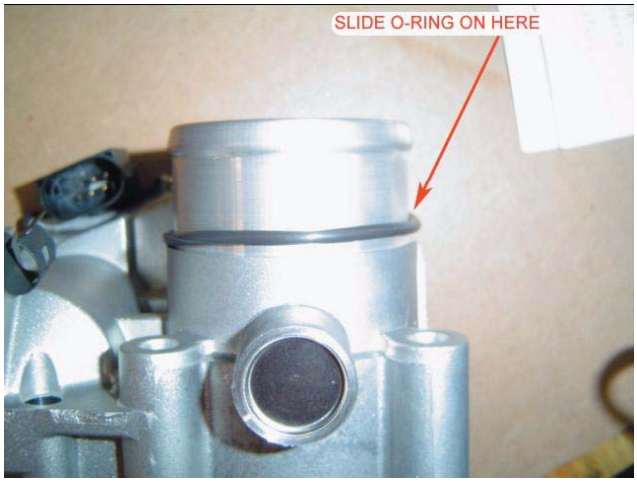
1. Disconnect the negative battery cable.
2. Remove the air intake duct.
3. Release the hose clamp on the vapor fuel line and remove the vapor hose.
4. Disconnect the TMAP electrical connector.
5. Disconnect the electronic throttle control connector.
6. Remove the manifold to throttle body adapter bolts 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

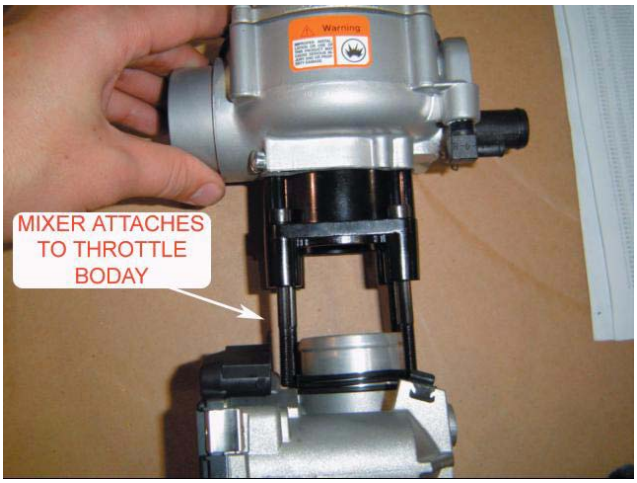
LIGHTLY LUBRICATE BOTH THROTTLE CONTROL DEVICE TO ADAPTER O-RINGS.

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.

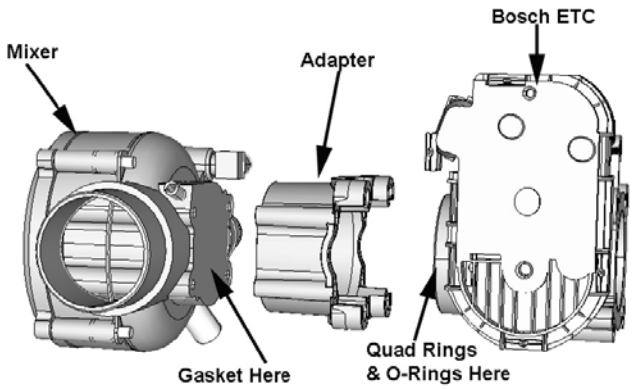


Figure 3-41. Mixer Assembly

Mixer Replacement

See Figure 3-41.

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.

3.14 GM ENGINE LPG FUEL SYSTEM DIAGNOSIS

Fuel System Description

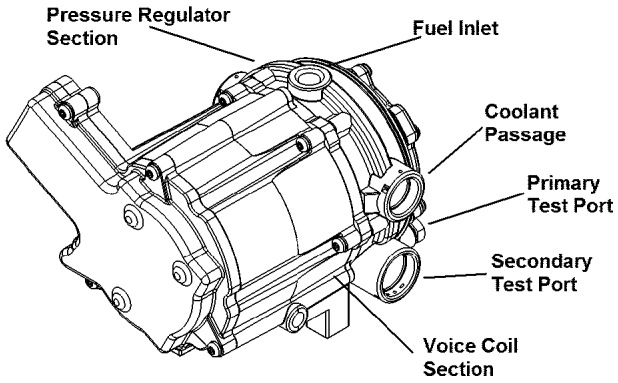


Figure 3-42. EPR Assembly

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" 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 3-9. 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?	--	Gotothe 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" to -2.0" 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" to -2.0" 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

Table 3-9. LPF Fuel System Diagnosis

STEP	ACTION	VALUE(S)	YES	NO
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?	12Ω - 16Ω	Go to Step 15	Go to Step 23
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	--

Table 3-9. LPF Fuel System Diagnosis

STEP	ACTION	VALUE(S)	YES	NO
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	--

3.15 JOYSTICK CONTROLLER

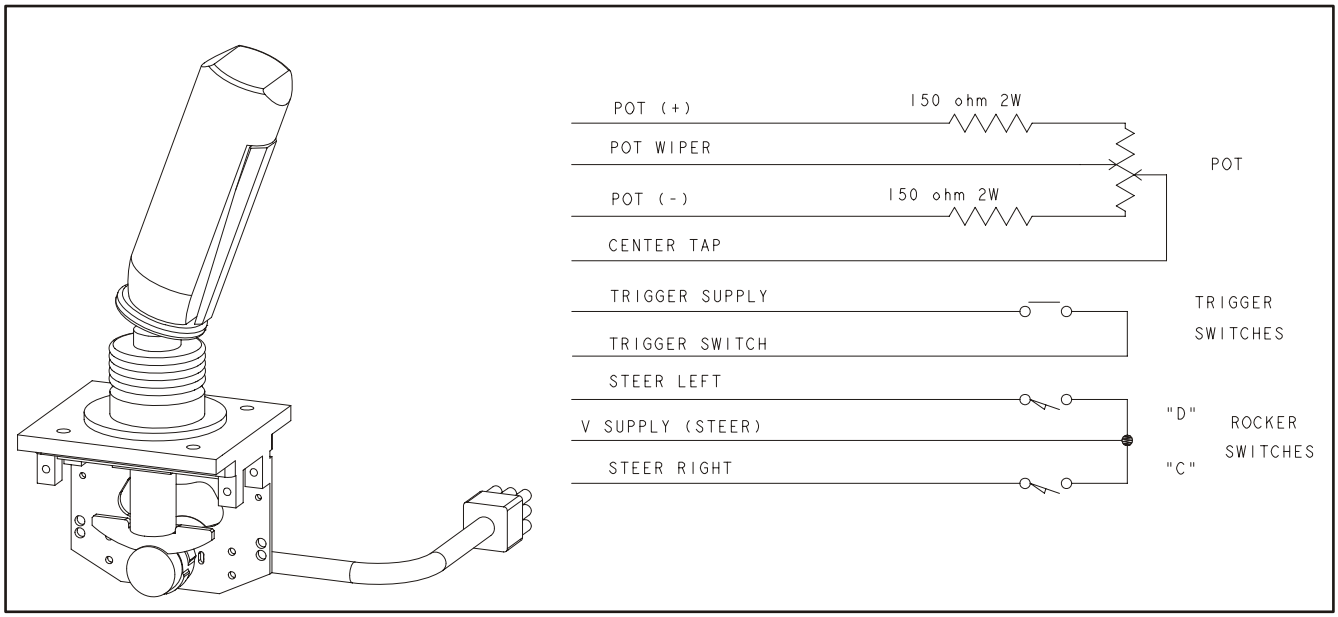


Figure 3-43. Joystick Controller - (JLG P/N 1600308)

Table 3-10. Joystick Specifications

Input Voltage	4.3V (±0.1V)
Centered Output Voltage	2.2V (±0.1V)
Full Positive (Rev) Deflection Output Voltage	4.0V (±0.1V)
Full Negative (Fwd) Output Voltage	0.4V (±0.1V)

Table 3-11. Joystick Plug Loading Chart

Terminal	Color	Function
1	Yellow	Steer Right
2	Green	Steer Left
3	Brown	Pot Wiper
4	Red	Handle Common
5	N/A	Not Connected
6	White/Red	Pot (+)
7	Violet	Trigger Switch
8	Blue	Trigger Supply
9	White/Black	Pot (-)

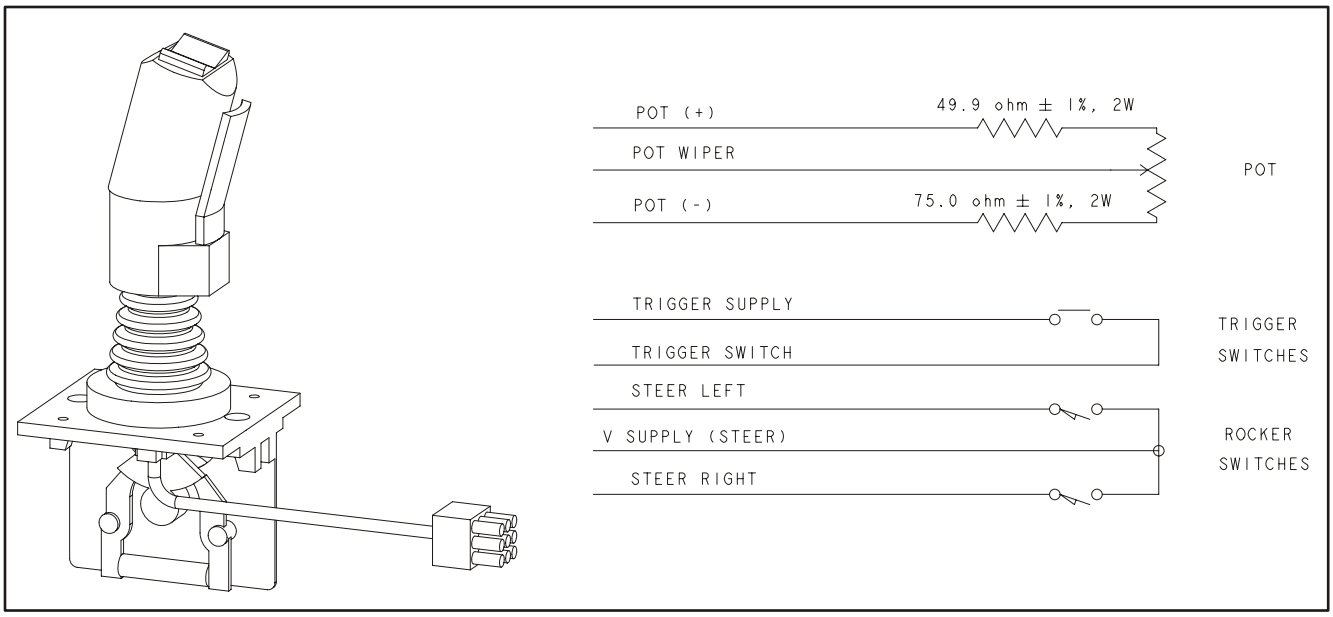


Figure 3-44. Joystick Controller - (JLG P/N 1600403)

Table 3-12. Joystick Specifications

Input Voltage	5V
Centered Output Voltage	4.25V to 2.60V
Reverse Voltage	4.60V to 4.80V
Forward Voltage	0.40V to 0.60V

Table 3-13. Joystick Plug Loading Chart

Terminal	Color	Function
1	Yellow	Steer Right
2	Green	Steer Left
3	Brown	Pot Wiper
4	Red	Handle Common
5	N/A	Not Connected
6	White/Red	Pot (+)
7	Violet	Trigger Switch
8	Blue	Trigger Supply
9	White/Black	Pot (-)

Table 3-14. 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	Check all ECM system fuses and circuit breakers. Check the ECM ground for being clean, tight and in its proper location. Check the vacuum hoses for splits, kinks and proper connections. Check thoroughly for any type of leak or restriction. Check for air leaks at all the mounting areas of the intake manifold sealing surfaces. Check for proper installation of the mixer module assembly. Check for air leaks at the mixer assembly. Check the ignition wires for the following conditions: - Cracking - Hardness - Proper routing - Carbon tracking Check the wiring for the following items: - Proper connections, pinches or cuts. 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	Refer to Important Preliminary Checks. 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	Faulty electrical connections or wiring can cause most intermittent problems. 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. 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. 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 3-14. Symptom Diagnosis

Checks	Action
Intermittent Malfunction Indicator Lamp (MIL)	The following components can cause intermittent MIL and no DTC(s): 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. The improper installation of electrical devices, such as lights, 2-way radios, electric motors, etc. The ignition secondary voltage shorted to a ground. The Malfunction Indicator Lamp (MIL) circuit or the Diagnostic Test Terminal intermittently shorted to ground. 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
No Start	
DEFINITION: The engine cranks OK but does not start.	
Preliminary Checks	Refer to Important Preliminary Checks.
Control Module Checks	If a scan tool is available: Check for proper communication with both the ECM Check the fuse in the ECM battery power circuit. Refer to Engine Controls Schematics. 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	Check the TMAP sensor. Check the Magnetic pickup sensor (RPM).
Fuel System Checks	**Important:** A closed LPG manual fuel shut off valve will create a no start condition. Check for air intake system leakage between the mixer and the throttle body. Verify proper operation of the low pressure lock-off solenoids. Check the fuel system pressures. Refer to the LPG Fuel System Diagnosis. 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. Check for the proper ignition voltage output with J 26792 or the equivalent. Verify that the spark plugs are correct for use with LPG (R42LTS) Check the spark plugs for the following conditions: - Wet plugs - Cracks - Wear - Improper gap - Burned electrodes - Heavy deposits Check for bare or shorted ignition wires. 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. 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 3-14. Symptom Diagnosis

Checks	Action
Exhaust System Checks	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. 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	Refer to Important Preliminary Checks. Make sure the vehicle' s operator is using the correct starting procedure.
Sensor Checks	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 Check the Crankshaft Position (CKP) sensor. 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. Verify the excess flow valve in the LPG manual shut-off valve is not tripped. Check mixer module assembly for proper installation and leakage. Verify proper operation of the low pressure lock-off solenoids. Verify proper operation of the EPR Check for air intake system leakage between the mixer and the throttle body. 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. Check for the proper ignition voltage output with J 26792 or the equivalent. Verify that the spark plugs are correct for use with LPG (R42LTS) Check the spark plugs for the following conditions: - Wet plugs - Cracks - Wear - Improper gap - Burned electrodes - Heavy deposits Check for bare or shorted ignition wires. Check for moisture in the distributor cap if applicable. 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. Check for the following: - Vacuum leaks - Improper valve timing - Low compression - Bent pushrods - Worn rocker arms - Broken or weak valve springs - Worn camshaft lobes. Check the intake and exhaust manifolds for casting flash.

Table 3-14. Symptom Diagnosis

Checks	Action
Exhaust System Checks	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. Refer to Restricted Exhaust System Diagnosis or Exhaust System in the GM Base Engine Service Manual
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	Refer to Important Preliminary Checks.
Ignition System Checks	Start the engine. Wet down the secondary ignition system with water from a spray bottle, and look/listen for arcing or misfiring as you apply water. Check for proper ignition output voltage with spark tester J 26792. Check for a cylinder misfire. Verify that the spark plugs are correct for use with LPG (R42LTS) Remove the spark plugs in these cylinders and check for the following conditions: Insulation cracks Wear Improper gap Burned electrodes Heavy deposits Visually/Physically inspect the secondary ignition for the following: Ignition wires for arcing, cross-firing and proper routing Ignition coils for cracks or carbon tracking
Engine Mechanical Checks	Perform a cylinder compression check. Check the engine for the following: - Improper valve timing - Bent pushrods - Worn rocker arms - Worn camshaft lobes. - Broken or weak valve springs. Check the intake and exhaust manifold passages for casting flash.
Fuel System Checks	Check the fuel system - plugged fuel filter, low fuel pressure, etc. Refer to LPG Fuel System Diagnosis. Check the condition of the wiring to the low pressure lock-off solenoid.
Additional Check	Check for Electromagnetic Interference (EMI). EMI on the reference circuit can cause a missing condition. Monitoring the engine RPM with a scan tool can detect an EMI. A sudden increase in the RPM with little change in the actual engine RPM, indicates EMI is present. 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	Check the fuel pressure. Refer to LPG Fuel System Diagnosis. 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. Check the Manifold Absolute Pressure (MAP) sensor response and accuracy. Check LPL electrical connection Check the mixer air valve for sticking or binding. Check the mixer module assembly for proper installation and leakage. Check the EPR electrical connections.

Table 3-14. 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. Check for the proper ignition voltage output with J 26792 or the equivalent. Verify that the spark plugs are correct for use with LPG (R42LTS) Check for faulty spark plug wires Check for fouled spark plugs.
Additional Check	Check for manifold vacuum or air induction system leaks 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	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.** Check for the proper ignition coil output voltage using the spark tester J26792 or the equivalent. 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. Check the connection at each ignition coil. Check for deteriorated spark plug wire insulation. Check the spark plugs. The correct spark plugs for LPG are (R42LTS) 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. Check the engine for the following: - Improper valve timing - Engine compression - Manifold vacuum leaks - Intake manifold gaskets - Sticking or leaking valves - Exhaust system leakage Check the intake and exhaust system for casting flash or other restrictions.
Fuel System Checks	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	Refer to Important Preliminary Checks. Refer to the LPG Fuel system OBD System Check 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 Remove the air filter and check for dirt or restriction. Check the vehicle transmission Refer to the OEM transmission diagnostics.

Table 3-14. Symptom Diagnosis

Checks	Action
Fuel System Checks	Check for a restricted fuel filter, contaminated fuel, or improper fuel pressure. Refer to LPG Fuel System Diagnosis. Check for the proper ignition output voltage with the spark tester J 26792 or the equivalent. Check for proper installation of the mixer module assembly. Check all air inlet ducts for condition and proper installation. Check for fuel leaks between the LPR and the mixer. Verify that the LPG tank manual shut-off valve is fully open. Verify that liquid fuel (not vapor) is being delivered to the LPR.
Sensor Checks	Check the Heated Exhaust Gas Oxygen Sensor (HEGO) for contamination and performance. Check for proper operation of the MAP sensor. Check for proper operation of the TPS sensor.
Exhaust System Checks	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: Engine compression Valve timing Improper or worn camshaft. Refer to Engine Mechanical in the Service Manual.
Additional Check	Check the ECM grounds for being clean, tight, and in their proper locations. Check the generator output voltage. If all procedures have been completed and no malfunction has been found, review and inspect the following items: Visually and physically, inspect all electrical connections within the suspected circuit and/or systems. 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	Refer to Important Preliminary Checks. Check the air cleaner element (filter) for dirt or being plugged. Visually (Physically) check the vacuum hoses for splits, kinks, and proper connections. 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? Suggest to the owner to fill the fuel tank and to recheck the fuel economy. Suggest that a different operator use the equipment and record the results.
Fuel System Checks	Check the LPR fuel pressure. Refer to LPG Fuel System Diagnosis. Check the fuel system for leakage.
Sensor Checks	Check the Temperature Manifold Absolute Pressure (TMAP) sensor.
Ignition System Checks	Verify that the spark plugs are correct for use with LPG (R42LTS) 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 ignition wires for the following items: - Cracking - Hardness - Proper connections

Table 3-14. Symptom Diagnosis

Checks	Action
Cooling System Checks	Check the engine thermostat for always being open or for the wrong heat range
Additional Check	Check the transmission shift pattern. Refer to the OEM Transmission Controls section the Service Manual. 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	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 driveability problem. Check the Heated Exhaust Gas Oxygen Sensor (HEGO) performance: Check the Temperature Manifold Absolute Pressure (TMAP) sensor response and accuracy.
Fuel System Checks	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. Check for a sticking mixer air valve. Verify proper operation of the EPR. Perform a cylinder compression test. Refer to Engine Mechanical in the Service Manual. Check the LPR fuel pressure. Refer to the LPG Fuel System Diagnosis. Check mixer module assembly for proper installation and connection.
Ignition System Checks	Check for the proper ignition output voltage using the spark tester J26792 or the equivalent. Verify that the spark plugs are correct for use with LPG (R42LTS) 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 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. Check for vacuum leaks. Vacuum leaks can cause a higher than normal idle and low throttle angle control command. Check the ECM grounds for being clean, tight, and in their proper locations. 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	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	Check Heated Exhaust Gas Oxygen Sensor (HEGO) performance.

Table 3-14. Symptom Diagnosis

Checks	Action
Fuel System Checks	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. Check the fuel pressure while the condition exists. Refer to LPG Fuel System Diagnosis. Verify proper fuel control solenoid operation. Verify that the LPG manual shut-off valve is fully open. Check the in-line fuel filter for restrictions.
Ignition System Checks	Check for the proper ignition output voltage using the spark tester J26792 or the equivalent. Verify that the spark plugs are correct for use with LPG (R42LTS) 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	Check the ECM grounds for being clean, tight, and in their proper locations. Check the generator output voltage. Check the vacuum hoses for kinks or leaks. Check Transmission

Table 3-15. 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 3-15. 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

NOTES:

SECTION 4. HYDRAULICS

4.1 CYLINDERS - THEORY OF OPERATION

Cylinders are of the double acting type. The steer system incorporates a double acting cylinder. A double acting cylinder is one that requires oil flow to operate the cylinder rod in both directions. Directing oil (by actuating the corresponding control valve to the piston side of the cylinder) forces the piston to travel toward the rod end of the barrel, extending the cylinder rod (piston attached to rod). When the oil flow is stopped, movement of the rod will stop. By directing oil to the rod side of the cylinder, the piston will be forced in the opposite direction and the cylinder rod will retract.

NOTE: *The lift cylinder is a single acting cylinder which takes hydraulic pressure to extend and gravity to retract.*

A holding valve is used in the Lift circuit to prevent retraction of the cylinder rod should a hydraulic line rupture or a leak develop between the cylinder and its related control valve.

4.2 VALVES - THEORY OF OPERATION

Solenoid Control Valves (Bang-Bang)

Control valves used are four-way three-position solenoid valves of the sliding spool design. When a circuit is activated and the control valve solenoid energizes, the spool is shifted and the corresponding work port opens to permit oil flow to the component in the selected circuit, with the opposite work port opening to reservoir. Once the circuit is deactivated (control returned to neutral), the valve spool returns to neutral (center) and oil flow is then directed through the valve body and returns to reservoir. A typical control valve consists of the valve body, sliding spool, and two solenoid assemblies. The spool is machine fitted in the bore of the valve body. Lands on the spool divide the bore into various chambers, which, when the spool is shifted, align with corresponding ports in the valve body open to common flow. At the same time other ports would be blocked to flow. The spool is spring-loaded to center position, therefore when the control is released, the spool automatically returns to neutral, prohibiting any flow through the circuit.

Relief Valves

Main relief valves are installed at various points within the hydraulic system to protect associated systems and components against excessive pressure. Excessive pressure can be developed when a cylinder reaches its limit of travel and the flow of pressurized fluid continues from the system control. The relief valve provides an alternate path for the continuing flow from the pump, thus preventing rupture of the cylinder, hydraulic line or fitting. Complete failure of the system pump is also avoided by relieving circuit pressure. The relief valve is installed in the circuit between the pump outlet (pressure line) and the cylinder of the circuit, generally as an integral part of the system valve bank. Relief pressures are set slightly higher than the load requirement, with the valve diverting excess pump delivery back to the reservoir when operating pressure of the component is reached.

Crossover Relief Valves

Crossover relief valves are used in circuits where the actuator requires an operating pressure lower than that supplied to the system. When the circuit is activated and the required pressure at the actuator is developed, the crossover relief diverts excess pump flow to the reservoir. Individual, integral relief's are provided for each side of the circuit.

4.3 COMPONENT FUNCTIONAL DESCRIPTION

Piston Hydraulic Pump

The Rexroth tandem piston pump is attached to and driven by the engine. The pump is a 28 cc piston pump that powers the drive motors.

Gear Hydraulic Pump

The Bosch rexroth gear pump is "piggy-backed" to the piston pump, and operates all machine functions except drive. The gear pump is a 14 cc pump which pumps 14.5 GPM.

Manual Descent Valve

The manual descent valve is located on top of the holding valve on the lift cylinder. The holding valve is a normally closed solenoid valve, and holds the platform in place when raised. When activated, the valve opens to permit lift down. The holding valve is connected to the manual descent valve, which is connected to a cable which, when pulled, manually opens the lift down port of the valve and allows the platform to be lowered in the event hydraulic power is lost.

4.4 CYLINDER CHECKING PROCEDURE

NOTE: *Cylinder check must be performed anytime a system component is replaced or when improper system operation is suspected.*

Cylinders Without Counterbalance Valves - Steer Cylinder

1. Using all applicable safety precautions, activate engine and fully extend cylinder to be checked. Shut down engine.
2. Carefully disconnect hydraulic hoses from retract port of cylinder. There will be some initial weeping of hydraulic fluid which can be caught in a suitable container. After the initial discharge, there should be no further drainage from the retract port.
3. Activate engine and extend cylinder.
4. If cylinder retract port leakage is less than 6-8 drops per minute, carefully reconnect hose to port and retract cylinder. If leakage continues at a rate of 6-8 drops per minute or more, cylinder repair must be made.
5. With cylinder fully retracted, shut down engine and carefully disconnect hydraulic hose from cylinder extend port.
6. Activate engine and retract cylinder. Check extend port for leakage.
7. If extend port leakage is less than 6-8 drops per minute, carefully reconnect hose to extend port, than activate cylinder through one complete cycle and check for leaks. If leakage continues at a rate of 6-8 drops per minute or more, cylinder repairs must be made.

Cylinders With Single Counterbalance Valve

NOTICE

OPERATE ALL FUNCTIONS FROM GROUND CONTROL STATION ONLY.

1. Using all applicable safety precautions, activate hydraulic system.
2. Shut down hydraulic system and allow machine to sit for 10-15 minutes. If machine is equipped with bang-bang or proportional control valves, turn ignition switch to on, move control switch or lever for applicable cylinder in each direction, then turn ignition switch to off. If machine is equipped with hydraulic control valves, move control lever for applicable cylinder in each direction. This is done to relieve pressure in the hydraulic lines. Carefully remove hydraulic hoses from appropriate cylinder port block.
3. There will be initial weeping of hydraulic fluid, which can be caught in a suitable container. After the initial discharge, there should be no further leakage from the ports. If leakage continues at a rate of 6-8 drops per minute or more, the counterbalance valve is defective and must be replaced.
4. To check piston seals, carefully remove the counterbalance valve from the retract port. After initial discharge, there should be no further leakage from the ports. If leakage occurs at a rate of 6-8 drops per minute or more, the piston seals are defective and must be replaced.
5. If no repairs are necessary or when repairs have been made, replace counterbalance valve and carefully connect hydraulic hoses to cylinder port block.
6. If used, remove lifting device from upright or remove prop from below main boom, activate hydraulic system and run cylinder through one complete cycle to check for leaks.

Oscillating Axle Lockout Test

NOTICE

LOCKOUT SYSTEM TEST MUST BE PERFORMED QUARTERLY, ANY TIME A SYSTEM COMPONENT IS REPLACED, OR WHEN IMPROPER SYSTEM OPERATION IS SUSPECTED.

NOTE: *Ensure platform is fully lowered prior to beginning lockout cylinder test.*

1. Place a 6 inch (15.2 cm) high block with ascension ramp in front of left front wheel.
2. From platform control station, select LOW drive speed.
3. Place DRIVE control switch to FORWARD position and carefully drive the machine up ascension ramp until left front wheel is on top of block.
4. Raise machine platform approximately 9 ft (2.7 m) on the 3394RT or 10 ft (3.1 m) on the 4394RT.
5. Place DRIVE control switch to REVERSE position and carefully drive the machine off the block and ramp.
6. Have an assistant check to see that the left front wheel remains locked in position off the ground.
7. Lower the machine platform; the lockout cylinder should then release and allow wheel to rest on the ground. It may be necessary to activate DRIVE to release cylinders.

8. Place the 6 inch (15.2 cm) high block with ascension ramp in front of right front wheel.
9. From platform control station, select LOW drive speed.
10. Place DRIVE control switch to FORWARD position and carefully drive the machine up ascension ramp until right front wheel is on top of block.
11. Raise machine platform approximately 9 ft (2.7 m) on the 3394RT or 10 ft (3.1 m) on the 4394RT.
12. Place DRIVE control switch to REVERSE position and carefully drive the machine off the block and ramp.
13. Have an assistant check to see that the right front wheel remains locked in position off the ground.
14. Lower the machine platform; the lockout cylinder should then release and allow wheel to rest on the ground. It may be necessary to activate DRIVE to release cylinders.
15. If the lockout cylinders do not function properly, have qualified personnel correct the malfunction prior to any further operation.

4.5 CYLINDER REPAIR

NOTE: *The following are general procedures that apply to all of the cylinders on this machine. Procedures that apply to a specific cylinder will be so noted.*

Disassembly

NOTICE

DISASSEMBLY OF THE CYLINDER SHOULD BE PERFORMED ON A CLEAN WORK SURFACE IN A DIRT FREE WORK AREA.

1. Connect a suitable auxiliary hydraulic power source to the cylinder port block fitting.

⚠ WARNING

DO NOT FULLY EXTEND CYLINDER TO THE END OF STROKE. RETRACT CYLINDER SLIGHTLY TO AVOID TRAPPING PRESSURE.

2. Operate the hydraulic power source and extend the cylinder. Shut down and disconnect the power source. Adequately support the cylinder rod, if applicable.
3. If applicable, remove the cartridge-type holding valve and fittings from the cylinder port block. Discard o-rings.

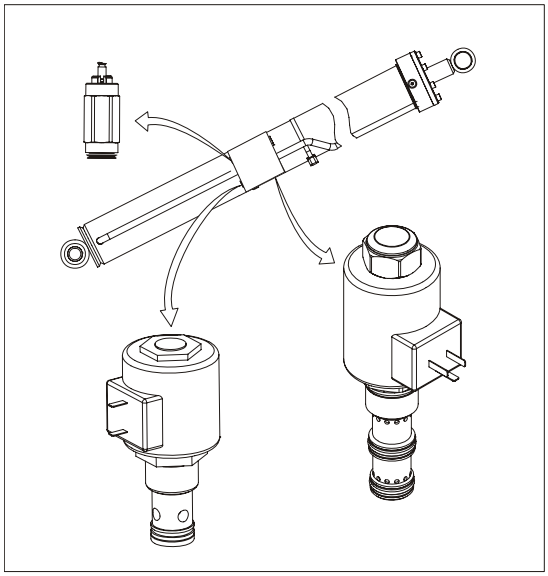


Figure 4-1. Lift Cylinder Holding Valve and Fitting Removal

4. Place the cylinder barrel into a suitable holding fixture.

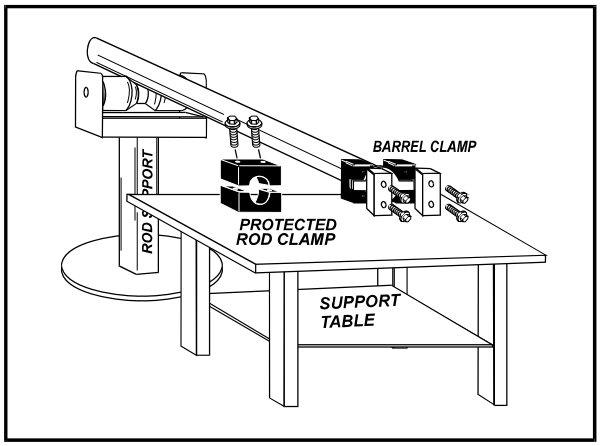


Figure 4-2. Cylinder Barrel Support

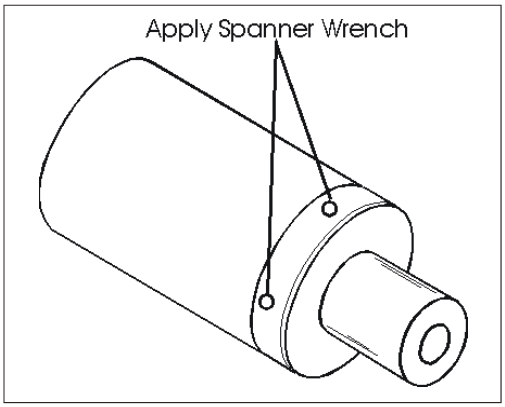
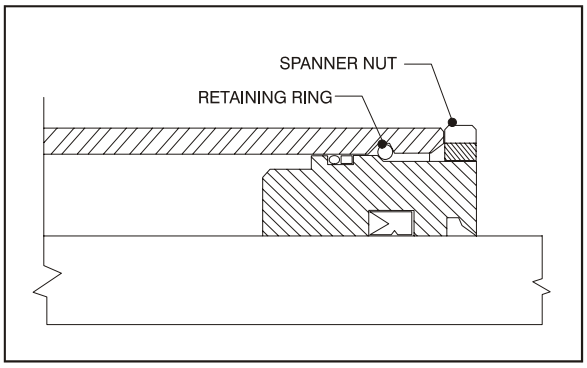


Figure 4-3. Lift Cylinder Cap Screw Removal

NOTE: *Steps 6 and 7 apply only to the steer cylinder.*

5. Using a spanner wrench, loosen the spanner nut retainer, and remove spanner nut from cylinder barrel.

6. Being careful not to mar the surface of the rod, use a punch or wooden dowel and hammer to drive the rod guide about one inch down into the cylinder bore. Using a screw driver, carefully push one end of the round retaining ring back towards the inside of the cylinder and then slip the screwdriver tip under that end. Pull the ring out of the groove toward the wall mouth. Once one end of the retaining ring is free from the groove, the remainder can be easily pried free using ones fingers or pliers.



7. Attach a suitable pulling device to the cylinder rod port block end or cylinder rod end, as applicable.

NOTICE

EXTREME CARE SHOULD BE TAKEN WHEN REMOVING THE CYLINDER ROD, HEAD, AND PISTON. AVOID PULLING THE ROD OFF-CENTER, WHICH COULD CAUSE DAMAGE TO THE PISTON AND CYLINDER BARREL SURFACES.

8. With the barrel clamped securely, apply pressure to the rod pulling device and carefully withdraw the complete rod assembly from the cylinder barrel.

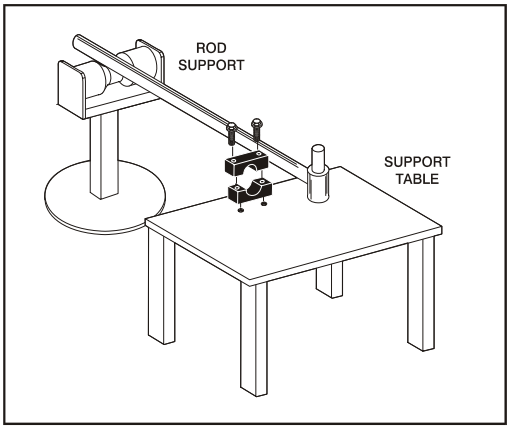


Figure 4-4. Cylinder Rod Support

9. Using suitable protection, clamp the cylinder rod in a vise or similar holding fixture as close to the piston as possible.

NOTE: *Step 11 applies only to the steer cylinder.*

10. Loosen and remove nut which attaches the piston to the rod, and remove the piston.

11. Loosen and remove the cap screw(s), if applicable, which attach the tapered bushing to the piston.

12. Insert the cap screw(s) in the threaded holes in the outer piece of the tapered bushing. Progressively tighten the cap screw(s) until the bushing is loose on the piston.

13. Remove the bushing from the piston.

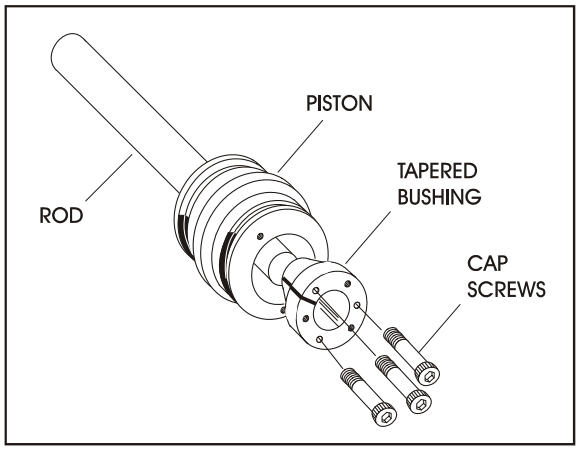


Figure 4-5. Tapered Bushing Removal

14. Screw the piston CCW, by hand, and remove the piston from cylinder rod.
15. Remove and discard the piston o-rings, seal rings, and backup rings.
16. Remove piston spacer, if applicable, from the rod.
17. Remove the rod from the holding fixture. Remove the cylinder head gland and retainer plate, if applicable. Discard the o-rings, back-up rings, rod seals, and wiper seals.

Cleaning and Inspection

1. Clean all parts thoroughly in an approved cleaning solvent.
2. Inspect the cylinder rod for scoring, tapering, ovality, or other damage. If necessary, dress rod with Scotch Brite or equivalent. Replace rod if necessary.
3. Inspect threaded portion of rod for excessive damage. Dress threads as necessary.
4. Inspect inner surface of cylinder barrel tube for scoring or other damage. Check inside diameter for tapering or ovality. Replace if necessary.
5. Inspect threaded portion of barrel for damage. Dress threads as necessary.
6. Inspect piston surface for damage and scoring and for distortion. Dress piston surface or replace piston as necessary.
7. Inspect threaded portion of piston for damage. Dress threads as necessary.
8. Inspect seal and o-ring grooves in piston for burrs and sharp edges. Dress applicable surfaces as necessary.
9. Inspect cylinder head inside diameter for scoring or other damage and for ovality and tapering. Replace as necessary.
10. Inspect threaded portion of head for damage. Dress threads as necessary.
11. Inspect seal and o-ring grooves in head for burrs and sharp edges. Dress applicable surfaces as necessary.
12. Inspect cylinder head outside diameter for scoring or other damage and ovality and tapering. Replace as necessary.
13. If applicable, inspect rod and barrel bearings for signs of correct excessive wear or damage. Replace as necessary.
    a. Thoroughly clean hole, (steel bushing) of burrs, dirt etc. to facilitate bearing installation.
    b. Inspect steel bushing for wear or other damage. If steel bushing is worn or damaged, rod/barrel must be replaced.
    c. Lubricate inside of steel bushing with WD40 prior to bearing installation.
    d. Using an arbor of the correct size, carefully press the bearing into steel bushing.

NOTE: *Install pin into the Gar-Max bearing dry. Lubrication is not required with nickel plated pins and bearings.*

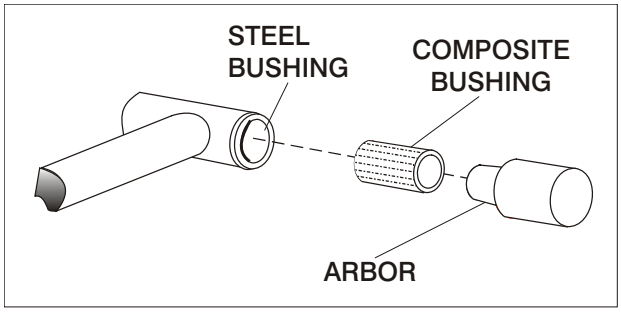


Figure 4-6. Bushing Installation

14. Inspect travel limiting collar or spacer for burrs and sharp edges. If necessary, dress inside diameter surface with Scotch Brite or equivalent.
15. If applicable, inspect port block fittings and holding valve. Replace as necessary.
16. Inspect the oil ports for blockage or the presence of dirt or other foreign material. Repair as necessary.
17. If applicable, inspect piston rings for cracks or other damage. Replace as necessary.

Assembly

NOTE: *Prior to cylinder assembly, ensure that the proper cylinder seal kit is used. See your JLG Parts Manual.*

Apply a light film of hydraulic oil to all components prior to assembly.

1. A special tool is used to install a new rod seal into the applicable cylinder head gland groove.

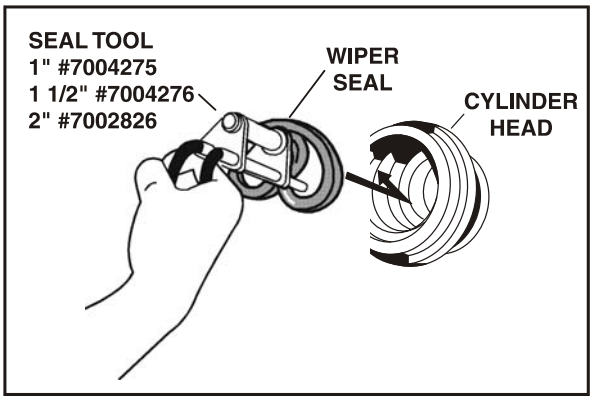


Figure 4-7. Rod Seal Installation

NOTICE

WHEN INSTALLING 'POLY-PAK' PISTON SEALS, ENSURE SEALS ARE INSTALLED PROPERLY. REFER TO WIPER SEAL INSTALLATION FOR CORRECT SEAL ORIENTATION. IMPROPER SEAL INSTALLATION COULD RESULT IN CYLINDER LEAKAGE AND IMPROPER CYLINDER OPERATION.

WHEN INSTALLING THE WIPER SEAL ON THE LOWER (TOWER) LIFT CYLINDER, APPLY LOCTITE #609 ON THE WIPER SEAL IN THREE EVENLY SPACED PLACES TO AID IN RETENTION OF THE SEAL.

2. Use a soft mallet to tap a new wiper seal into the applicable cylinder head gland groove. Install a new wear ring into the applicable cylinder head gland-groove.

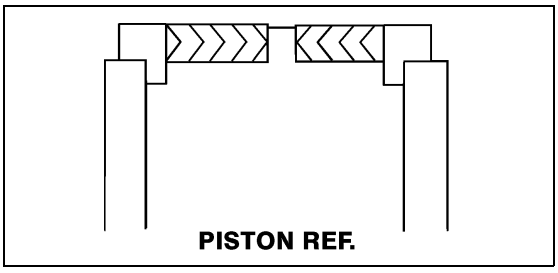


Figure 4-8. Poly-Pak Piston Seal Installation

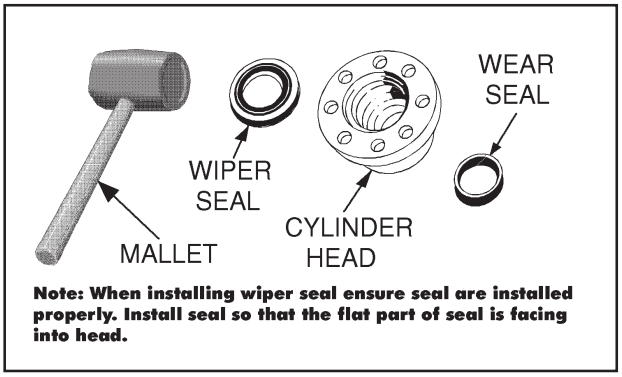


Figure 4-9. Wiper Seal Installation

3. Place a new "o"ring and back-up seal in the applicable outside diameter groove of the cylinder head.

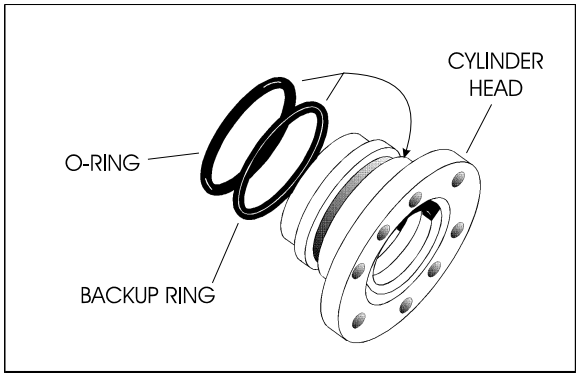


Figure 4-10. Installation of Head Seal Kit

4. Install washer ring onto rod, carefully install the head gland on the rod, ensuring that the wiper and rod seals are not damaged or dislodged. Push the head along the rod to the rod end, as applicable.
5. Carefully slide the piston spacer on the rod.
6. If applicable, correctly place new o-ring in the inner piston diameter groove. (The backup ring side facing the O-ring is grooved.)
7. If applicable, correctly place new seals and guide lock rings in the outer piston diameter groove. (A tube, with I.D. slightly larger than the O.D.of the piston is recommended to install the solid seal.)

NOTE: *The backup rings for the solid seal have a radius on one side. This side faces the solid seal.(See magnified insert in (See Figure 4-11.))The split of seals and backup rings are to be positioned so as not to be in alignment with each other.*

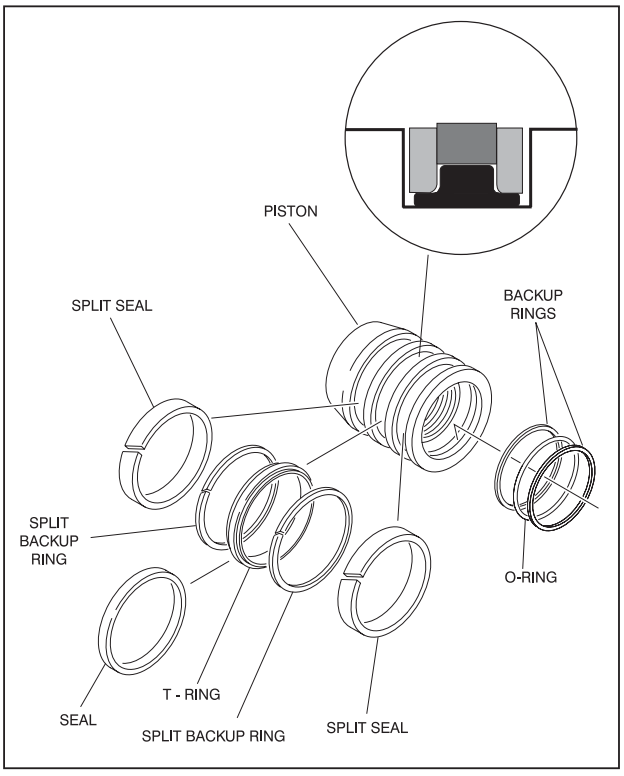


Figure 4-11. Piston Seal Kit Installation

1. Using suitable protection, clamp the cylinder rod in a vise or similar holding fixture as close to piston as possible.
2. Carefully thread the piston on the cylinder rod hand tight, ensuring that the o-ring and back-up rings are not damaged or dislodged.
3. Thread piston onto rod until it abuts the spacer end and install the tapered bushing.

NOTE: *When installing the tapered bushing, piston and mating end of rod must be free of oil.*

4. Assemble the tapered bushing loosely into the piston and insert JLG capscrews (not vendor capscrews) through the drilled holes in the bushing and into the tapped holes in the piston.

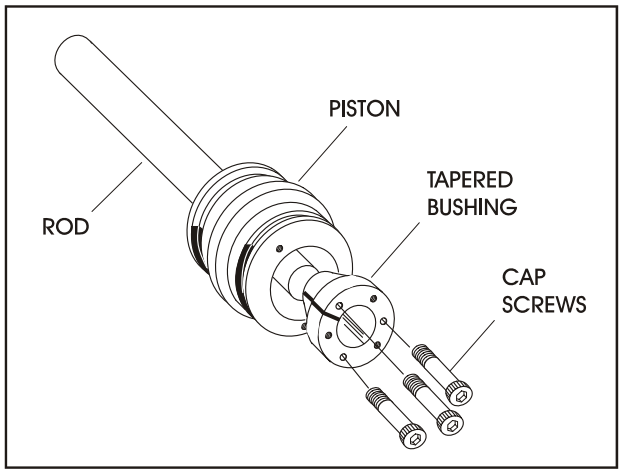


Figure 4-12. Tapered Bushing Installation

5. Tighten the capscrews evenly and progressively in rotation to the specified torque value.
6. After the screws have been torqued, tap the tapered bushing with a hammer (16 to 24 oz.) and brass shaft (approximately 3/4" in diameter) as follows;
   a. Place the shaft against the cylinder rod and in contact with the bushing in the spaces between the capscrews.
   b. Tap each space once; this means the tapered bushing is tapped 3 times as there are 3 spaces between the capscrews.

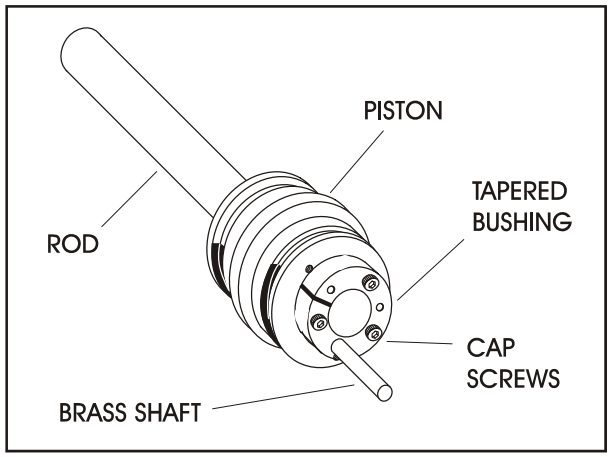


Figure 4-13. Seating the Tapered Bearing

7. Retorque the capscrews evenly and progressively in rotation to the specified torque value.
8. Remove the cylinder rod from the holding fixture.

9. Place new guide locks and seals in the applicable outside diameter grooves of the cylinder piston. (See Figure 4-11.)
10. Position the cylinder barrel in a suitable holding fixture.

NOTICE

EXTREME CARE SHOULD BE TAKEN WHEN INSTALLING THE CYLINDER ROD, HEAD, AND PISTON. AVOID PULLING THE ROD OFF-CENTER, WHICH COULD CAUSE DAMAGE TO THE PISTON AND CYLINDER BARREL SURFACES.

11. With barrel clamped securely, and while adequately supporting the rod, insert the piston end into the barrel cylinder. Ensure that the piston loading o-ring and seal ring are not damaged or dislodged.
12. Continue pushing the rod into the barrel until the cylinder head gland can be inserted into the barrel cylinder.
13. Secure the cylinder head gland using the washer ring and socket head bolts.

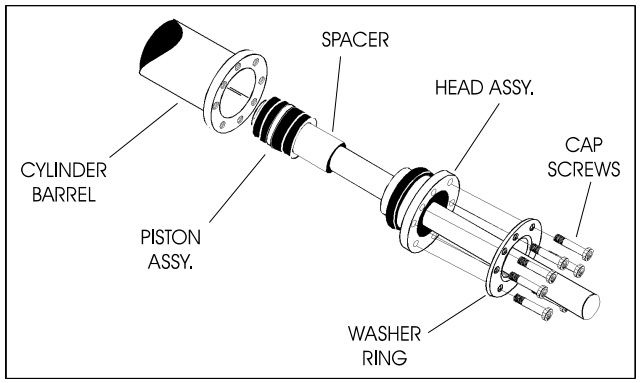


Figure 4-14. Rod Assembly Installation

14. After the cylinder has been reassembled, the rod should be pushed all the way in (fully retracted) prior to the reinstallation of any holding valve or valves.
15. If applicable, install the cartridge-type holding valve and fittings in the rod port block, using new o-rings as applicable. (See Table 4-2, Holding Valve Torque Specifications).

Table 4-1. Cylinder Piston Nut Torque Specifications

Description	Nut Torque Value	Setscrew torque Value
Lift Cylinder	400 ft lb (542 Nm)	100 in lb (12 Nm)
Lockout Cylinder	N/A	N/A
Steer Cylinder	N/A	N/A

Table 4-2. Holding Valve Torque Specifications

Description	Torque Value	
Sun - 7/8 hex M20 x 1.5 thds	30 - 35 ft lb	41 - 48 Nm
Sun - 1-1/8 hex 1 - 14 UNS thds	45 - 50 ft lb	61 - 68 Nm
Sun - 1-1/4 hex M36 x 2 thds	150 - 153 ft lb	204 - 207 Nm
Racine - 1-1/8 hex 1-1/16 - 12 thds	50 - 55 ft lb	68 - 75 Nm
Racine - 1-3/8 hex 1-3/16 - 12 thds	75 - 80 ft lb	102 - 109 Nm
Racine - 1-7/8 hex 1-5/8 - 12 thds	100 - 110 ft lb	136 - 149 Nm

16. Push the piston onto the rod until it abuts the spacer end and install the attaching nut.

⚠ WARNING

WHEN REBUILDING THE CYLINDERS, APPLY LOCTITE #242 TO PISTON NUT AND SETSCREW, THEN TORQUE PISTON NUT. REFER TO TABLE 4-1, CYLINDER PISTON NUT TORQUE SPECIFICATIONS

NOTE: *The Steer Cylinder uses snap rings to secure piston.*

17. Prior to setscrew installation spot drill rod before installing the setscrew(s) which secure the piston attaching nut to the diameter groove.
18. Remove the cylinder rod from the holding fixture.
19. Position the cylinder barrel in a suitable holding fixture.

NOTICE

EXTREME CARE SHOULD BE TAKEN WHEN INSTALLING THE CYLINDER ROD, HEAD, AND PISTON. AVOID PULLING THE ROD OFF-CENTER, WHICH COULD CAUSE DAMAGE TO THE PISTON AND CYLINDER BARREL SURFACES.

20. With barrel clamped securely, and while adequately supporting the rod, insert the piston end into the barrel cylinder. Ensure that the piston loading o-ring and seal ring are not damaged or dislodged.

21. Continue pushing the rod into the barrel until the cylinder head gland can be inserted into the barrel cylinder.

22. If applicable, secure the cylinder head retainer using a suitable chain wrench.

23. After the cylinder has been reassembled, the rod should be pushed all the way in (fully retracted) prior to the reinstallation of any holding valve or valves.

24. If applicable, install the cartridge-type holding valve and fittings in the port block using new o-rings as applicable. Refer to Table 4-2, Holding Valve Torque Specifications.

4.6 DRIVE PUMP START-UP PROCEDURE

NOTICE

THE FOLLOWING PROCEDURE SHOULD ALWAYS BE PERFORMED WHEN STARTING A NEW PUMP OR WHEN RESTARTING AN INSTALLATION IN WHICH EITHER THE PUMP OR MOTOR HAVE BEEN REMOVED FROM THE SYSTEM.

THE FOLLOWING PROCEDURE SHOULD ALWAYS BE PERFORMED WHEN STARTING A NEW PUMP OR WHEN RESTARTING AN INSTALLATION IN WHICH EITHER THE PUMP OR MOTOR HAVE BEEN REMOVED FROM THE SYSTEM.

THE FOLLOWING PROCEDURE MAY REQUIRE THE MACHINE TO BE DISABLED (WHEELS RAISED OFF THE GROUND, DRIVE FUNCTION DISCONNECTED, ETC.) WHILE PERFORMING THE PROCEDURE IN ORDER TO PREVENT INJURY TO TECHNICIAN AND OTHER PERSONNEL. TAKE NECESSARY SAFETY PRECAUTIONS BEFORE MOVING THE MACHINE.

Prior to installing pump and/or motor, inspect unit(s) for damage incurred during shipping and handling. Make certain all system components (reservoir, hoses, valves, fittings, heat exchanger, etc.) are clean prior to filling with hydraulic fluid.

Fill reservoir with recommended hydraulic fluid, which should be passed through a 10 micron (nominal, no bypass) filter prior to entering the reservoir. The use of contaminated fluid will cause damage to components, which may result in unexpected machine movement.

The inlet line leading from the reservoir to the pump should be filled prior to start-up. Check inlet line for properly tightened fittings and make sure it is free of restrictions and air leaks.

Be certain to fill pump and/or motor housing with clean hydraulic fluid prior to start-up. Fill housing by pouring filtered oil into upper case drain port.

Install a 0 to 500 psi (0 to 35 bar) pressure gauge in the charge pressure gauge port to monitor charge pressure during start-up.

It is recommended that the external control input signal electrical connections be disconnected at the pump control until after initial start-up. This will allow the pump to remain in its neutral position.

“Jog” or slowly rotate prime mover until charge pressure starts to rise. Start prime mover and run at the lowest possible RPM until charge pressure has been established. Excess air may be bled from high pressure lines through high pressure gauge ports.

⚠ WARNING

DO NOT START PRIME MOVER UNLESS PUMP IS IN NEUTRAL POSITION (0 DEGREES SWASHPLATE ANGLE). TAKE PRECAUTIONS TO PREVENT MACHINE MOVEMENT IN CASE PUMP IS ACTUATED DURING INITIAL START-UP.

Once charge pressure has been established, increase speed to normal operating RPM. Charge pressure should be approximately 220 psi (15.5 bar) minimum. If charge pressure is incorrect, shut down and determine cause for improper pressure.

⚠ WARNING

INADEQUATE CHARGE PRESSURE WILL AFFECT THE OPERATOR’S ABILITY TO CONTROL THE MACHINE.

Shut down prime mover and connect external control input signal. start prime mover, checking to be certain pump remains in neutral. with prime mover at normal operating speed, slowly check for forward and reverse machine operation.

Charge pressure should remain at 220 psi to 240 psi (15.5 bar to 16.9 bar) minimum during forward or reverse operation. Continue to cycle slowly between forward and reverse for at least five minutes.

Shut down prime mover, remove gauges, and plug ports. Check reservoir level and add fluid if necessary.

4.7 HYDRAULIC COMPONENT START-UP PROCEDURES AND RECOMMENDATIONS

From a hydrostatic component standpoint, the goal at system start up is to put into functional operation, the hydrostatic system in such a way as to preserve the designed life span of the system. The following start-up procedure should be adhered to whenever a new pump or motor is initially installed into a machine, or a system is restarted after either a pump or motor has been removed and/or replaced.

⚠ WARNING

THE FOLLOWING PROCEDURE MAY REQUIRE THE MACHINE TO BE DISABLED (WHEELS RAISED OFF THE GROUND, WORK FUNCTIONS DISCONNECTED, ETC.) WHILE PERFORMING THE PROCEDURE IN ORDER TO PREVENT INJURY. TAKE NECESSARY SAFETY PRECAUTIONS BEFORE MOVING THE VEHICLE/ MACHINE.

Prior to installing the pump and/or motor, inspect the unit(s) for damage that may have been incurred during shipping and handling. Make certain that all system components (reservoir, hoses, valves, fittings, heat exchanger, etc.) are clean prior to filling with fluid.

Fill the reservoir with recommended hydraulic fluid. This fluid should be passed through a 10 micron (nominal, no bypass) filter prior to entering the reservoir. The use of contaminated fluid will cause damage to the components, which may result in unexpected vehicle/machine movement.

NOTE: *If a pump or motor is being replaced due to internal damage, the remaining units (pump or motors) need to be inspected for damage and contamination, and the entire hydraulic system will need to be flushed and the fluid replaced. Failure to do so may cause considerable damage to the entire system.*

The inlet line leading from the reservoir to the pump must be filled prior to start-up. Check the inlet line for property tightened fittings and make sure it is free of restrictions and air leaks.

NOTE: *In most cases, the reservoir is above the pump inlet so that the pressure head created by the higher oil level helps to keep the inlet pressures within an acceptable range and prevent high vacuum levels. However, due to hose routing or low reservoir locations, there may be air trapped within this line. It is important to assure that the air is bled from this line. This can be accomplished by loosening the hose at the fitting closest the pump. When oil begins to flow, the line is full, the air has been purged, and the fitting can be retightened to its specified torque. If the tank needs to be pressurized in order to start the flow of oil, a vacuum reading should be taken at the inlet of the pump during operation in order to verify that the pump is not being asked to draw an inlet vacuum higher than it is capable of.*

Be certain to fill the pump and/or motor housing with clean hydraulic fluid prior to start up. Fill the housing by pouring filtered oil into the upper case drain port.

NOTE: *It is highly recommended to use the highest possible case drain port, this ensures that the housing contains as much oil as possible and offers the greatest amount of lubrication to the internal components.*

In initial start-up conditions, it may be convenient to fill the housing, just prior to installing the case drain line. Component, (especially motor), location may be such that access to the case drain port after installation is not realistic.

Make certain that the oil being used to fill the component housing is as clean as possible, and store the fill container in such a way as to prevent it from becoming contaminated.

Install a 60 bar (or 1000 psi) pressure gauge in the charge pressure gauge port in order to monitor the charge pressure during start-up.

It is recommended that the external control input signal, (electrical connections for EDC), be disconnected at the pump control until after initial start-up. This will ensure that the pump remains in its neutral position.

⚠ WARNING

DO NOT START THE ENGINE UNLESS PUMP IS IN THE NEUTRAL POSITION (0 DEGREES SWASHPLATE ANGLE). TAKE PRECAUTIONS TO PREVENT MACHINE MOVEMENT IN CASE PUMP IS ACTUATED DURING INITIAL START-UP.

"Jog" or slowly rotate the engine until charge pressure starts to rise. Start the engine and run at the lowest possible RPM until charge pressure has been established. Excess air should be bled from the system lines as close to the motors as possible.

NOTE: *With the engine on low idle, "crack", (loosen-don't remove), the system lines at the motor(s). Continue to run the engine at low idle and tighten the system lines as soon as oil is observed to leak from them. When oil is observed to "leak" at the motor the line is full, the air has been purged, and the system hoses should be retightened to their specified torque.*

Once charge pressure has been established, increase speed to normal operating RPM. Charge pressure should be as indicated in the pump model code. If charge pressure is inadequate, shut down and determine the cause for improper pressure.

⚠ WARNING

INADEQUATE CHARGE PRESSURE WILL AFFECT THE OPERATOR' S ABILITY TO CONTROL THE MACHINE.

Shut down the engine and connect the external control input signal. Also reconnect the machine function(s), if disconnected earlier. Start the engine, checking to be certain the pump remains in neutral. With the engine at normal operating RPM, slowly check for forward and reverse machine operation.

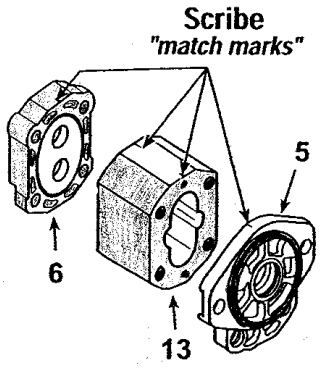
Charge pressure may slightly decrease during forward or reverse operation. Continue to cycle slowly between forward and reverse for at least five minutes.

Shut down engine, remove gauges, and plug ports. Check reservoir level and add filtered fluid if needed.

The machine is now ready for operation.

4.8 HYDRAULIC GEAR PUMP

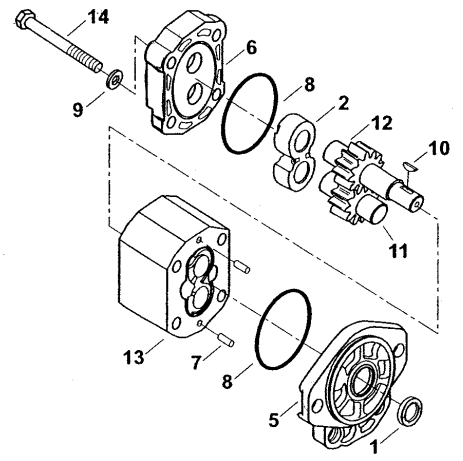
Overhaul pump only in a clean, dust free location, using clean tools and equipment. dirt and grit will damage the highly machined surfaces and will result in leakage or premature failure of the pump.



Before beginning disassembly, scribe "match marks" on the body (13) and covers (5 and 6) to insure that the pump will be reassembled in the same manner as it was shipped from the factory. If the body or rear cover is replaced during overhaul, scribe a match mark on the new part in the same location as on the part it replaced.

Pump Disassembly

1. Clean outside of pump with a good grade solvent and dry thoroughly.
2. On models with a splined drive shaft, proceed to step 3. On models with a keyed drive shaft, remove drive key (10) from drive shaft. Using a file or stone, remove burrs from shaft end of keyway.
3. Using light clamping pressure on the ears of the front cover, secure unit in vise with shaft side down; remove cap screws (14) and washers (9).
4. Separate rear cover (6) from the body (13). The static seal (8) may remain either with the body or the cover. In either case, remove the static seal and discard.
5. Lift out the rear bearing block (2), drive gear (12), and driven gear (11).



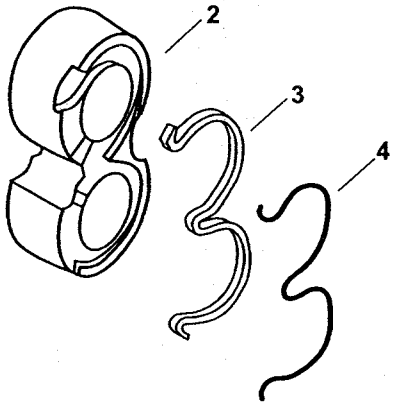
6. Separate body (13) from front cover (5). Dowel pins (7) and the front static seal (8) may remain with either the body (13) or the front cover (5). In either case, remove the static seal and discard.
7. usually the front bearing block (2) will remain in the body (13), so invert the body and lift out the bearing block.
8. Invert front cover (5) with shaft seal up. Remove the shaft seal (1) by prying it out with a large screwdriver.

NOTE: *During disassembly, take special note of the wear patterns on the bearing blocks (2) and body (13). Relate these patterns to the inlet and outlet sides of the pump. The large port whether in the body (13) or the rear cover (6) corresponds to the inlet side of the pump. The inlet side of the body can be identified by the gear contact pattern in the gear bore. The bearing block will have somewhat heavier wear patterns on the inlet side.*

Parts Inspection

1. Wash all part and dry thoroughly.
2. Inspect front and rear bearing block. replace if scoring or uneven wear is observed.

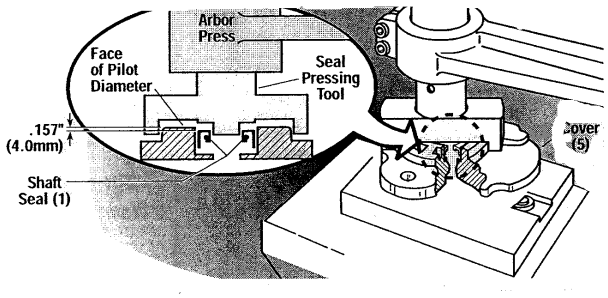
NOTE: *A somewhat heavier wear pattern is normal on the low pressure (inlet) side of the bearing blocks (2). However, there should be no heavy scoring in this area.*

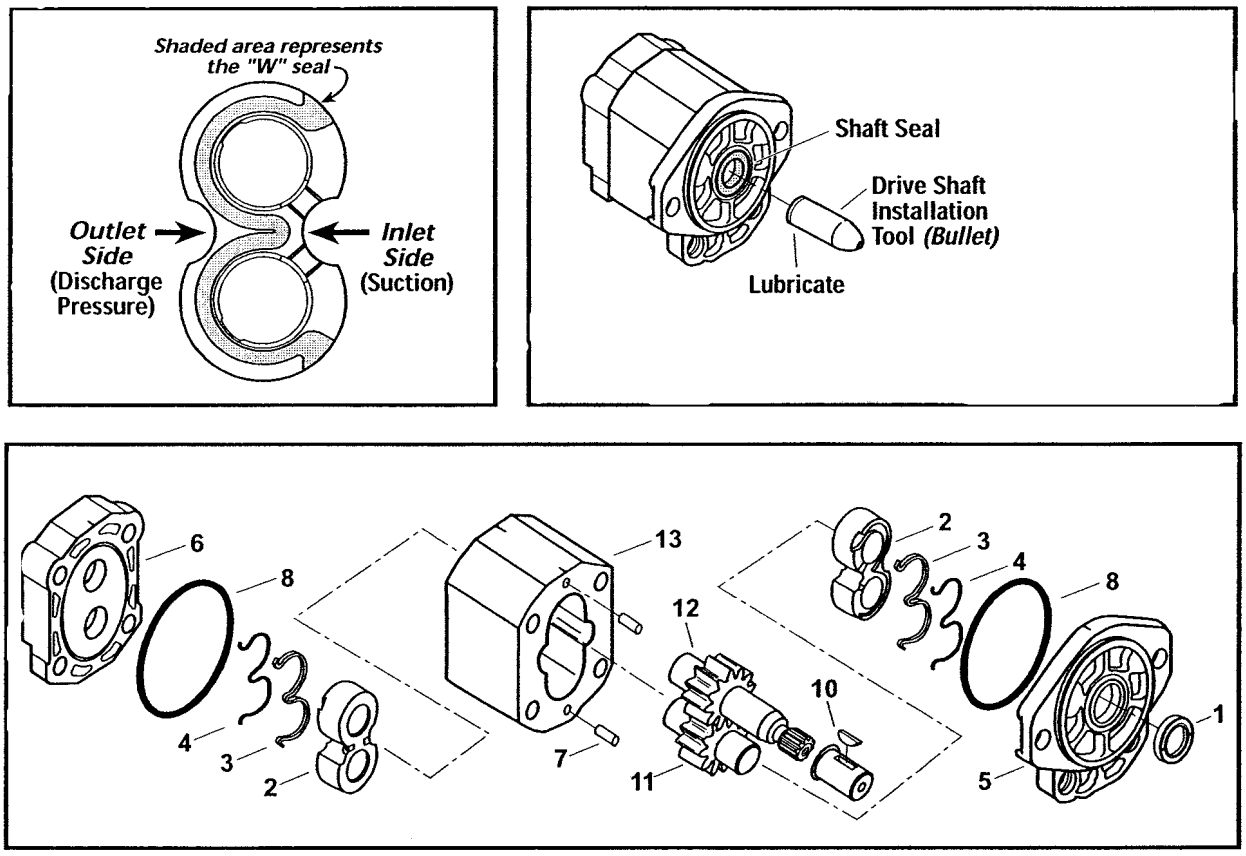


3. Remove anti extrusion seal (4) and pressure loading seal (3) from each bearing block and discard.
4. Inspect bushings in each bearing block (2). replace bearing block if bushings are heavily scored or burned.
5. Inspect gear journals and faces. Replace if faces or journals are scored or worn.
6. Inspect body for wear and scoring. If gear contact wear on low pressure side (inlet) exceeds 0.005 in. (.127mm) depth, replace body. If the body is usable, lightly wipe and remove burr's with suitable de-burring tool.

Pump Reassembly

1. Place the front cover (5) on a flat plate with the steal shaft seal bore up. Install new shaft seal (1). Press seal until it is 0.157 in (4.0mm) below front surface. Pack the area between the double lip of the seal with Lubriplate or and equivalent grease.





2. Clamp front cover into vise so that the ring groove is up. Apply a small amount of grease tot he seal groove and install a new seal ring (8) into the groove.

3. Apply lubriplate or equivalent to outer surface of drive shaft installation tool. Insert tool (bullet) into shaft seal from seal ring groove side of front cover.

4. Place a small amount of grease on the seal groove on the front bearing block (2). Install a new load seal and anti extrusion seal in the groove. Insert the bearing block into the body, making sure that the load seal (3) and anti extrusion seal (4) are positioned properly. ensure the outside of the "W" seal is exposed to the discharge pressure.

5. Apply a small amount of grease tot he dowel pins (7) and install them into the body (13).

6. Set the body (13) onto the front cover (5), matching the scribes marks on the body and front cover. The dowel pins (7) should go into the mating holes on the front cover (5).

7. Install drive gear (12), and driven gear (11).

8. Place a small amount of grease in seal groove on the rear bearing block (2). Install a new load seal and anti extrusion seal in groove. Insert the bearing block into the body, making sure that the load seal and anti extrusion seal are positioned properly. Ensure outside of the "W" seal is exposed to the discharge pressure.

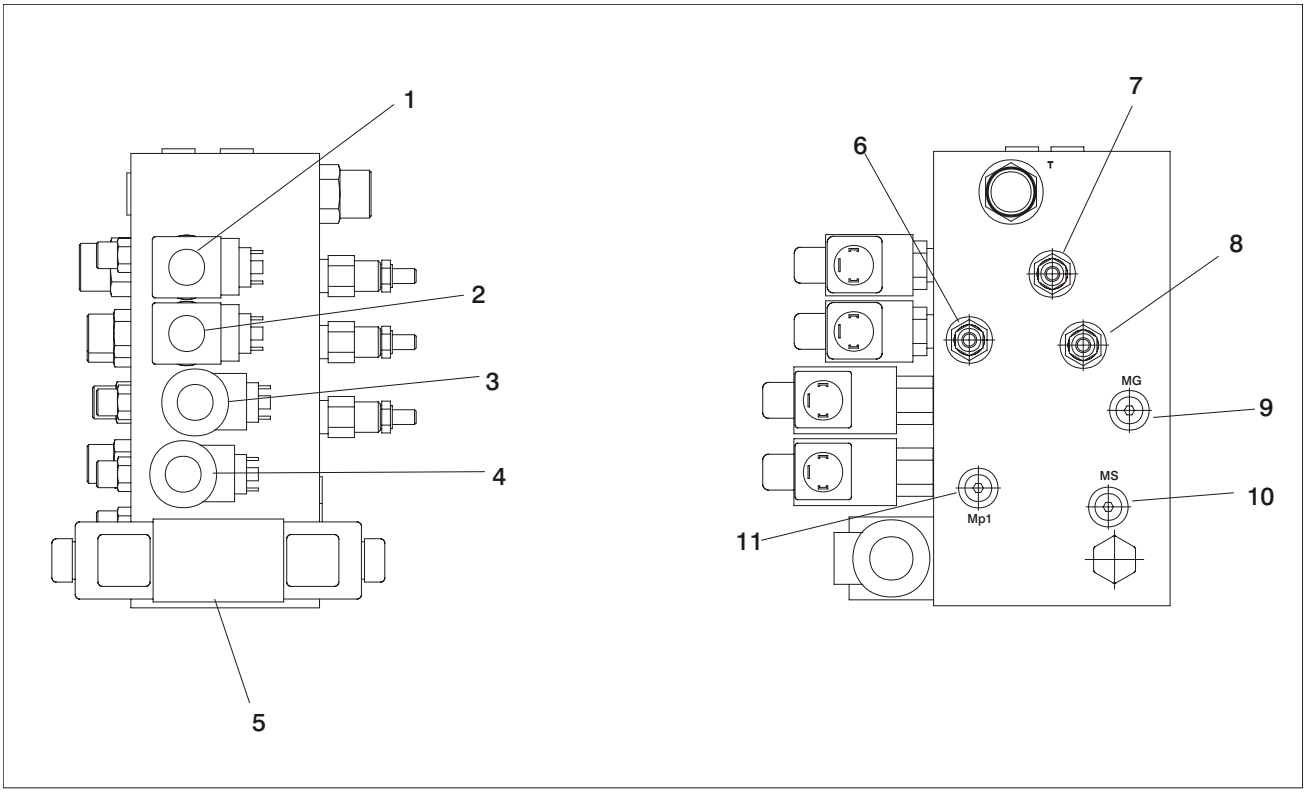
9. Apply a small amount of grease tot he seal groove in the rear cover (6) and install a new seal ring (8) into the groove. Set the rear cover (6) onto the body (13), matching the scribes marks on the body and rear cover.

10. Insert he cap screw (14) and washers (9); torque to 42-46 ft lb. (57-62 Nm).

11. On models equipped with keyed drive shaft, install drive key (10).

12. With an adjustable wrench, Check that the drive shaft turns without evidence of a mechanical bind.

4.9 MAIN VALVE



Valve	Ft-lb	Mn
1. Dump Valve	30 - 35	42 - 49
2. Lift Valve	25 - 30	35 - 42
3. Two Speed Valve	30 - 35	42 - 49
4. Brake Valve	30 - 35	42 - 49
5. Steer Valve	25 - 30	35 - 42
6. Lift Relief	30 - 35	42 - 49
7. Main Relief	25 - 30	35 - 42
8. Steer Relief	30 - 35	42 - 49
9. MG Port	N/A	N/A
10. MS Port	N/A	N/A
11. MP1 Port	N/A	N/A

Figure 4-15. Main Valve Torque Values

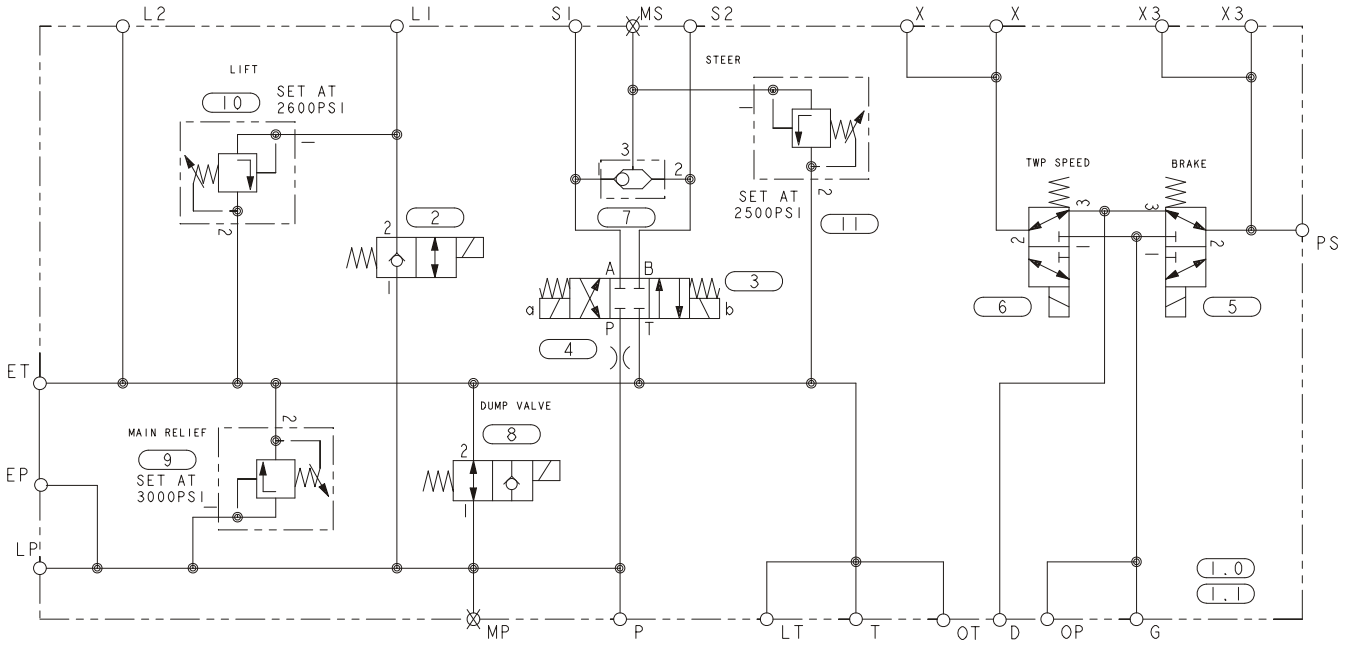


Figure 4-16. Main Valve Hydraulic Schematic

Pressure Setting Procedures

Cold temperatures have a significant impact on pressure readings. JLG Industries Inc. recommends operating the machine until the hydraulic system has warmed to normal operating temperatures prior to checking pressures. JLG Industries Inc. also recommends the use of a calibrated gauge. Pressure readings are acceptable if they are within ± 5% of specified pressures.

1. Install pressure gauge at the MP1 port.
2. Adjust both Steer Section Crossover Relief's all the way in.
3. Adjust Main Relief Cartridge out several turns.
4. Activate engine and allow hydraulic system to come up to operating temperature.
5. Bottom out Steer function. Adjust Main Relief to 3000 psi (207 bar).
6. Bottom out Steer Right and Steer Left functions and adjust each Steer Crossover Relief to 2800 psi (193 bar).
7. Bottom out Lift Up functions and adjust Lift Pressure to 2700 psi (186 bar).
8. De-energize Lift function, shut down motor, and disconnect pressure gauge.

4.10 DRIVE HEADER VALVE (2WD)

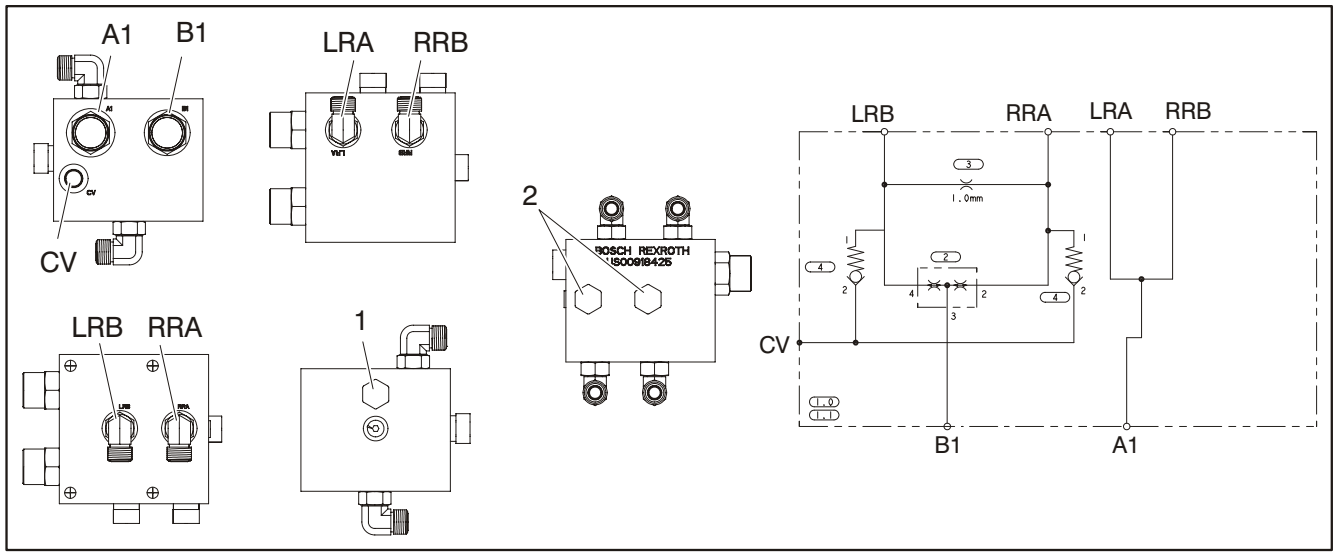


Figure 4-17. Drive Header Valve (2wd)

item #	Torque
1 (FSDH-XAN)	45 - 50 ft-lbs (61 - 68 Nm)
2 (CXAD-XCN)	25 - 30 ft-lbs (34 -41 Nm)

4.11 DRIVE HEADER VALVE (4WD)

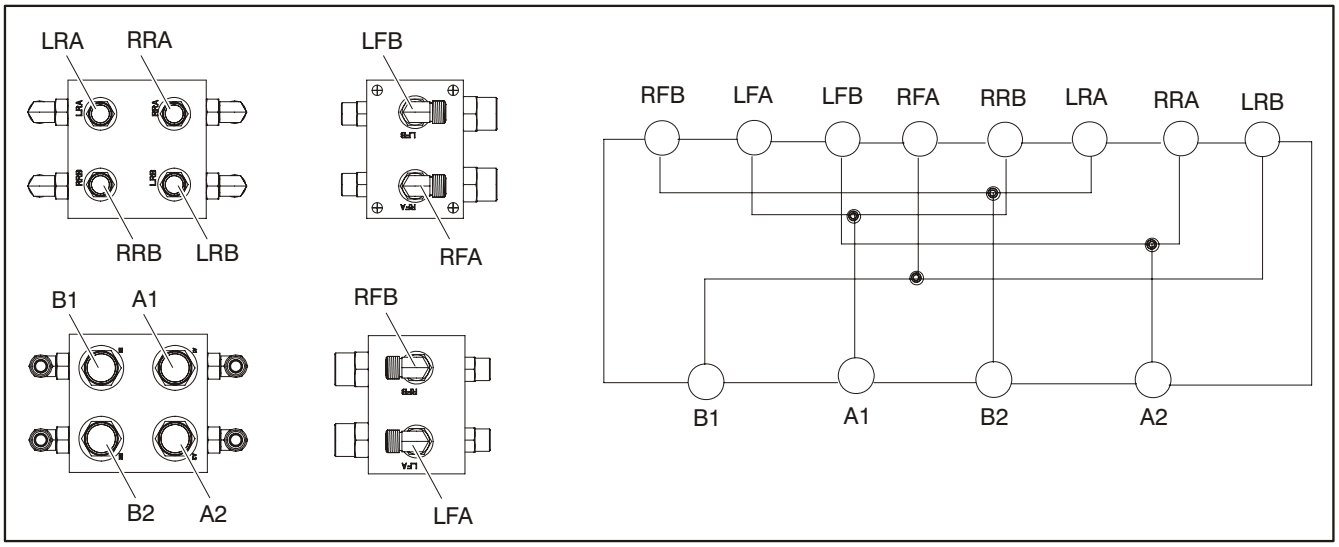


Figure 4-18. Drive Header Valve (4wd)

4.12 HEADER VALVES (4WD)

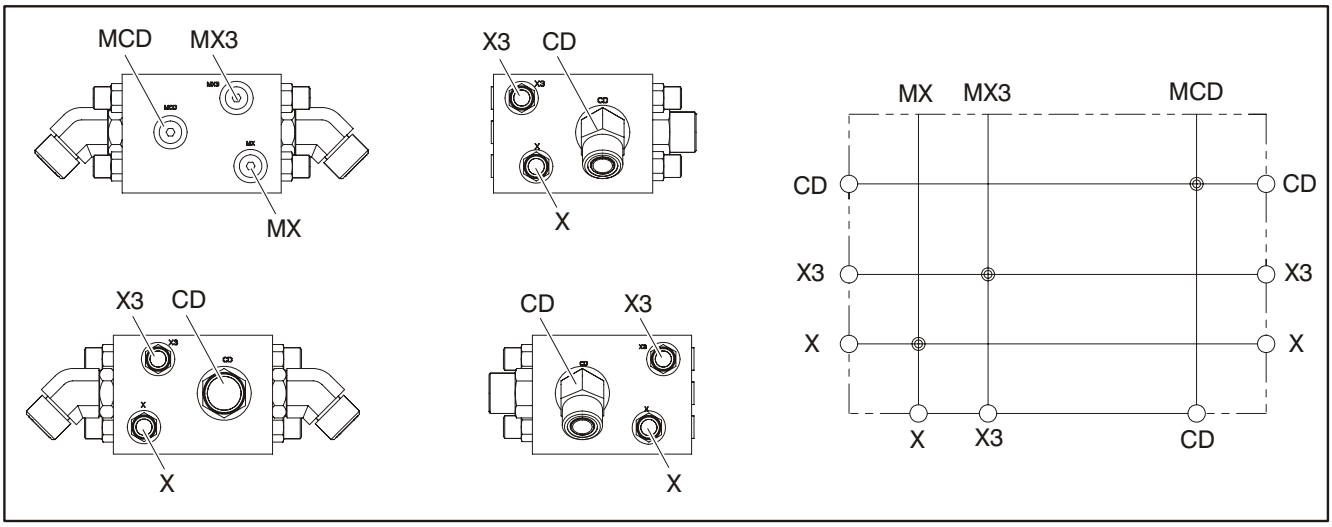


Figure 4-19. Header Valve (Fix)

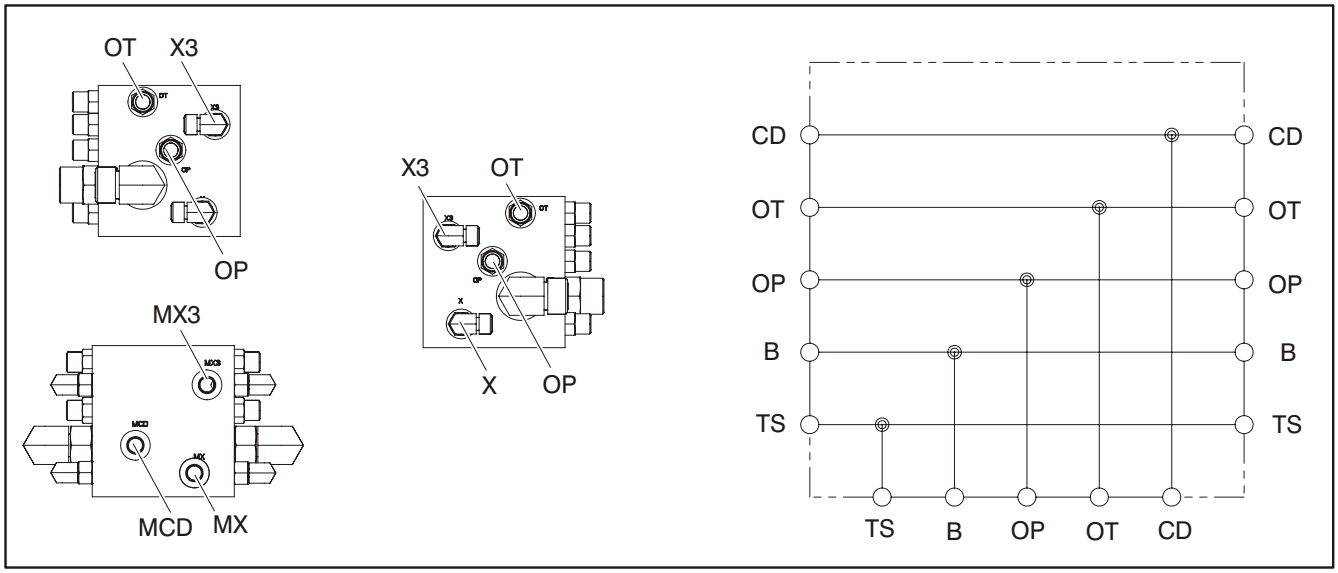


Figure 4-20. Header Valve (Osc)

4.13 DIRECTIONAL VALVE

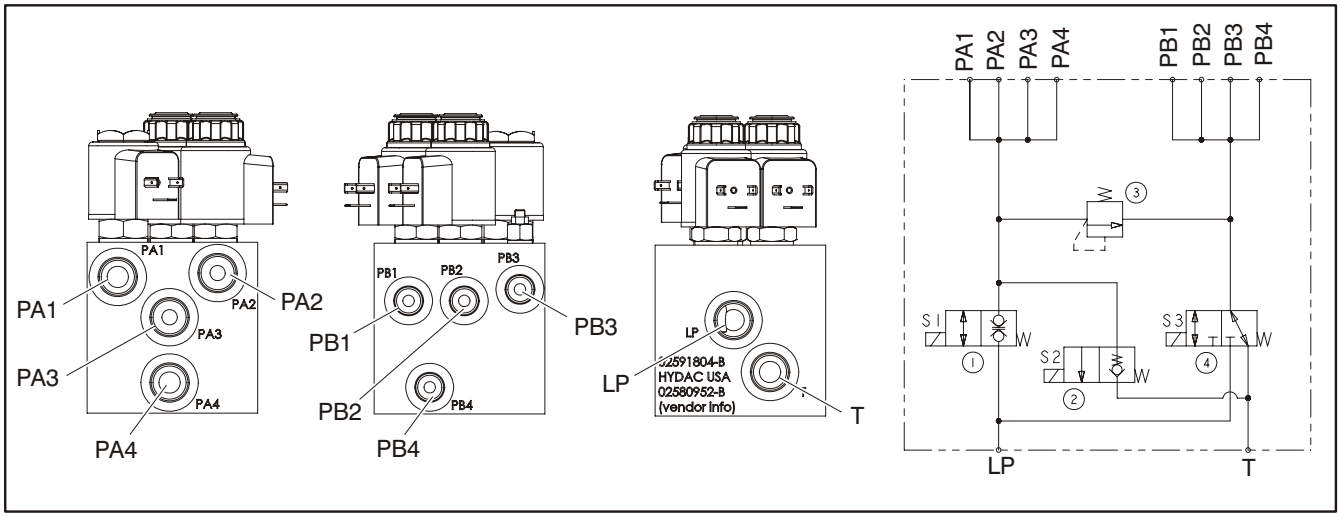


Figure 4-21. Directional Valve

item	Torque
PA1	40 ft-lbs (54 Nm)
PB1	23 ft-lbs (31 Nm)

Pressure Setting Procedure

Cold temperatures have a significant impact on pressure readings. JLG Industries Inc. recommends operating the machine until the hydraulic system has warmed to normal operating temperatures prior to checking pressures. JLG Industries Inc. also recommends the use of a calibrated gauge. Pressure readings are acceptable if they are within ± 5% of specified pressures.

1. Activate engine and allow hydraulic system to come up to operating temperature.
2. Install pressure gauge at quick connect on main valve (M1).
3. Energize and bottom ut the leveling jack function. Adjust relief to 2800 psi (193 bar).
4. De-energize jack function and shut down engine. Remove pressure gauge.

4.14 POWER DECK SANDWICH VALVE

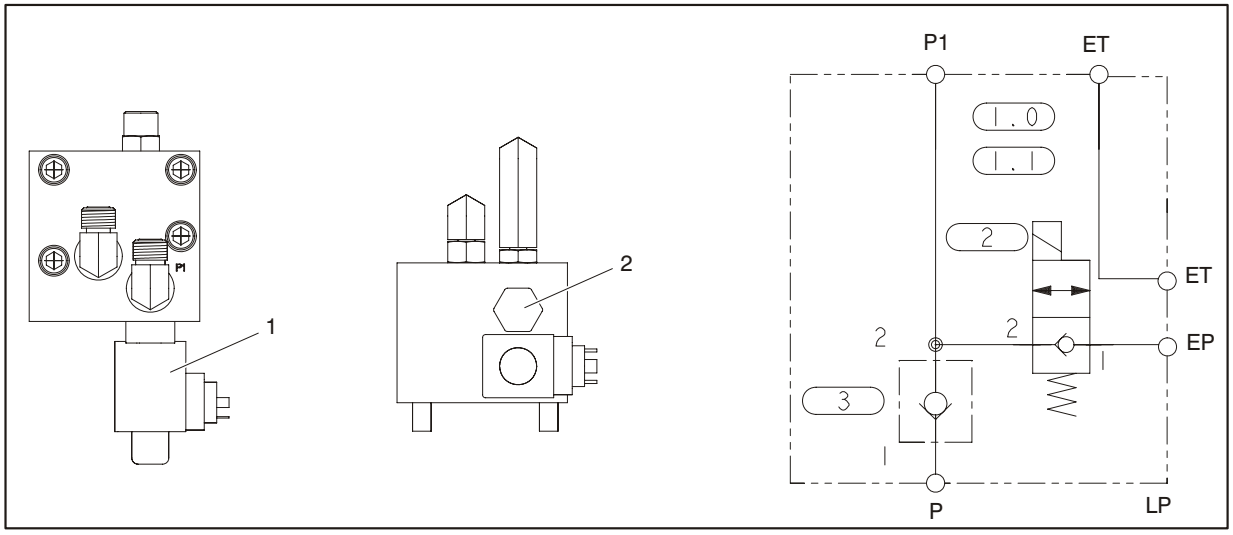


Figure 4-22. Power Deck Sandwich Valve (Dual Deck Extension Only)

item #	Torque
1	30 - 35 ft-lbs (41 - 47 Nm)
2	25 - 30 ft-lbs (34 - 41 Nm)

4.15 POWER DECK MANIFOLD VALVE

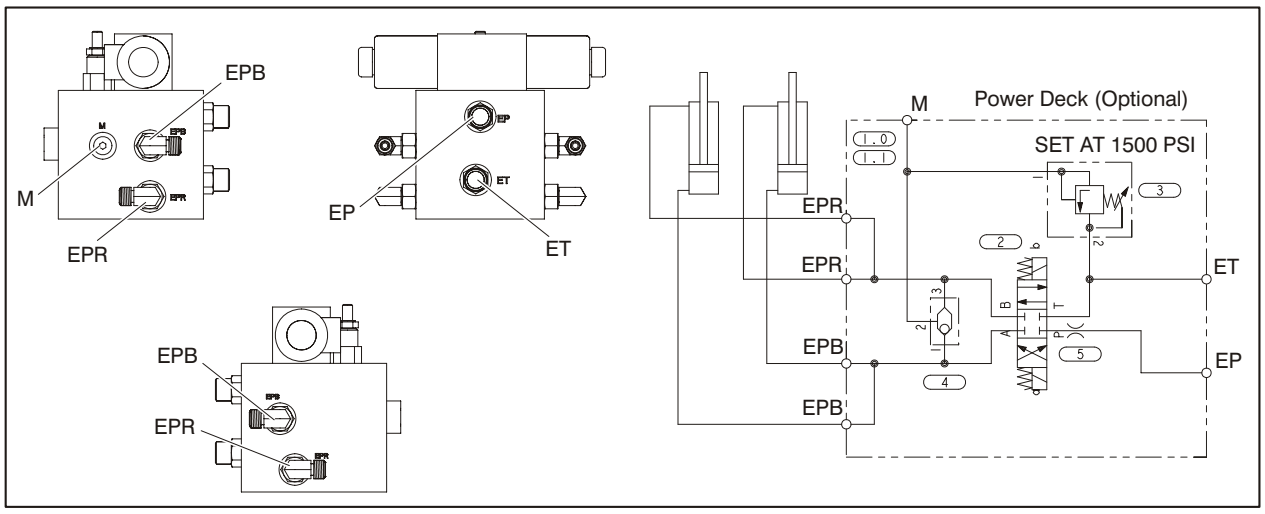


Figure 4-23. Power Deck Manifold Valve

Port(s)	Torque
EP, ET	24 ft-lbs (32.5 Nm)
EPR, EPB	32 ft-lbs (43.4 Nm)

NOTE: *Power Deck Manifold Valve is located on the underside of the platform. Dual extension decks are equipped with two Manifold Valves. Single extension decks have only one Manifold Valve.*

4.16 HYDRAULIC PUMP

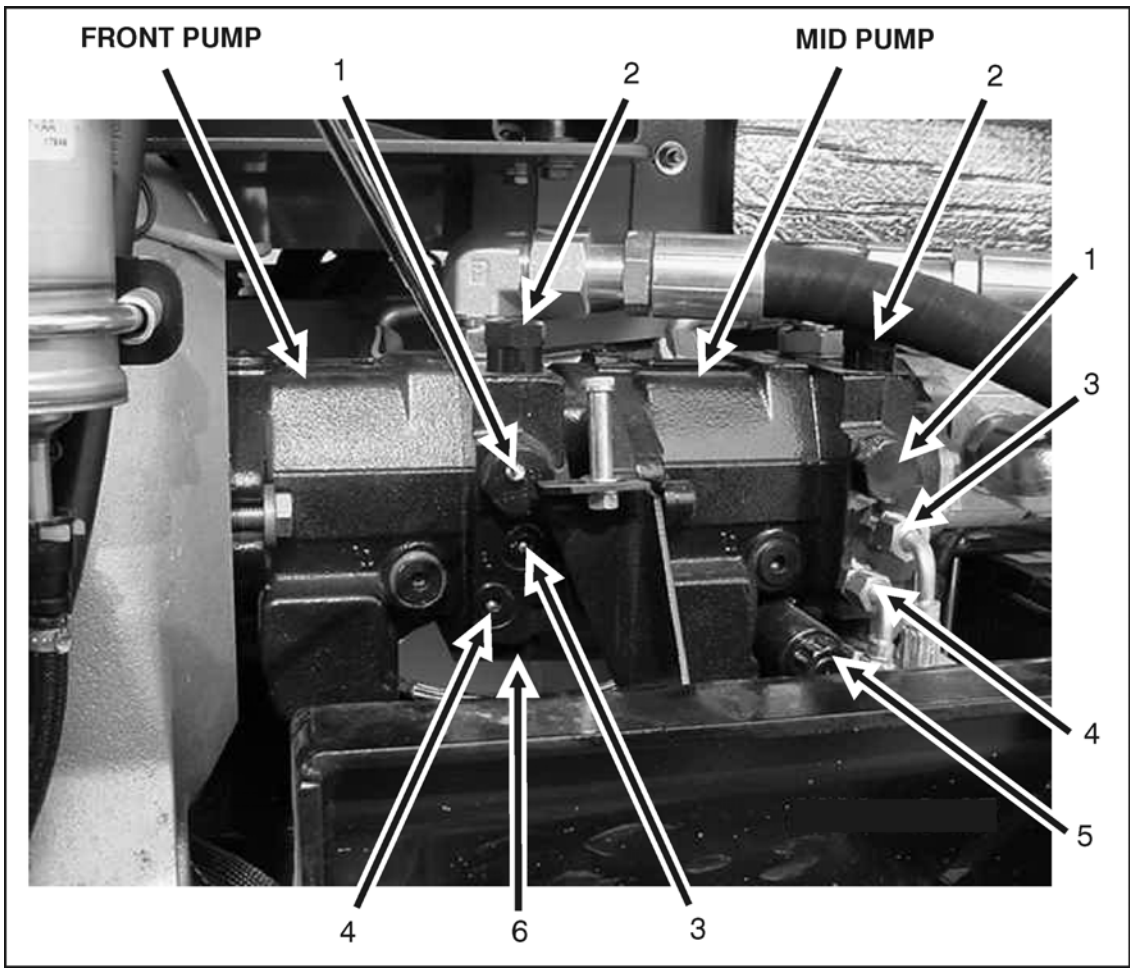
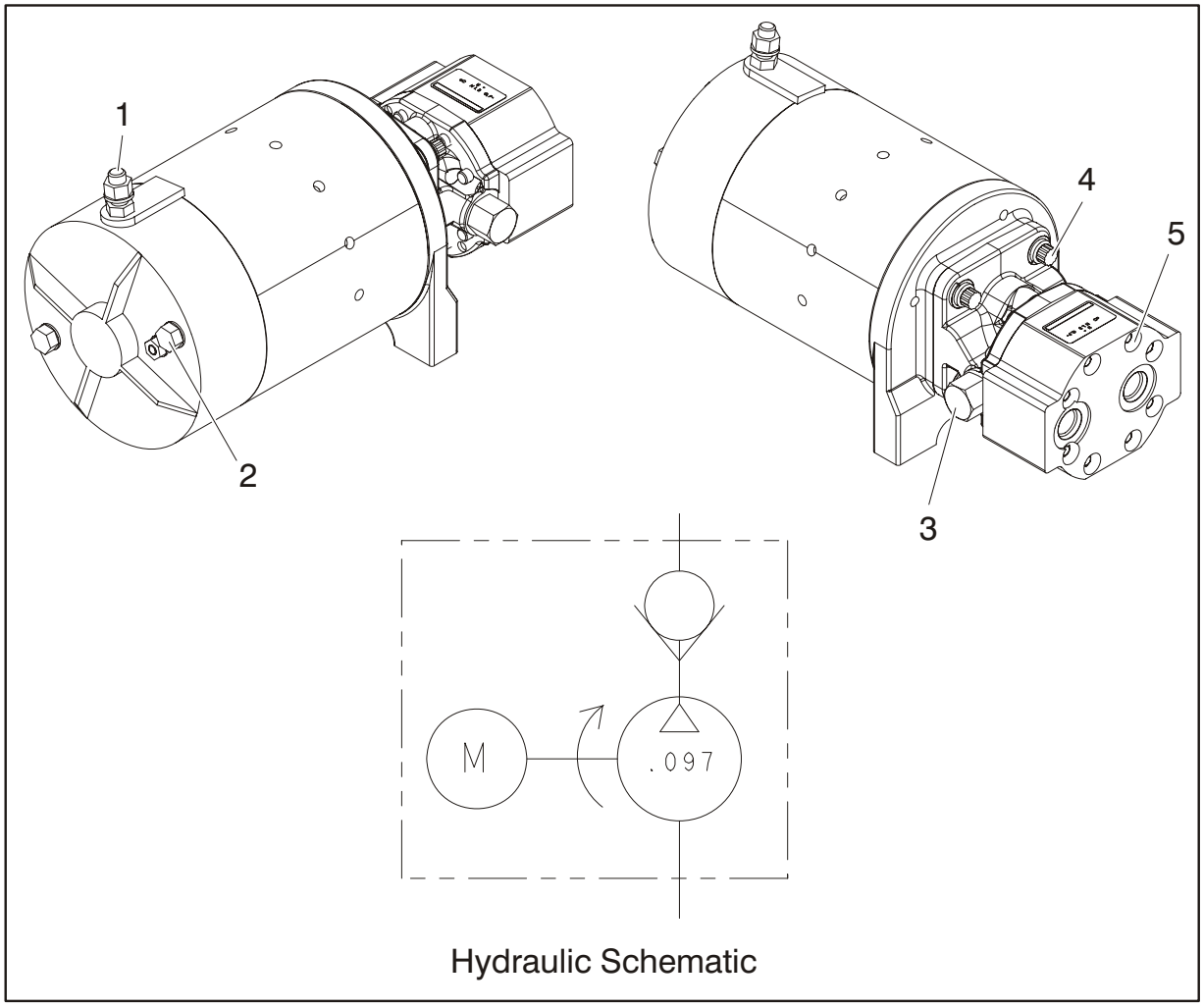


Figure 4-24. Pump Pressure Locations

Table 4-3. Pump Pressure

Item #	Name	Pressure
1	Charge Pump Relief	320 psi (22 bar)
2	Cross Relief Pressure	3000 psi (207 bar)
3	G Port	4800 psi (331 bar)
4	PS Port	4800 psi (331 bar)
5	Coil	N/A
6	Cross Relief Pressure	N/A

Auxiliary Pump Motor

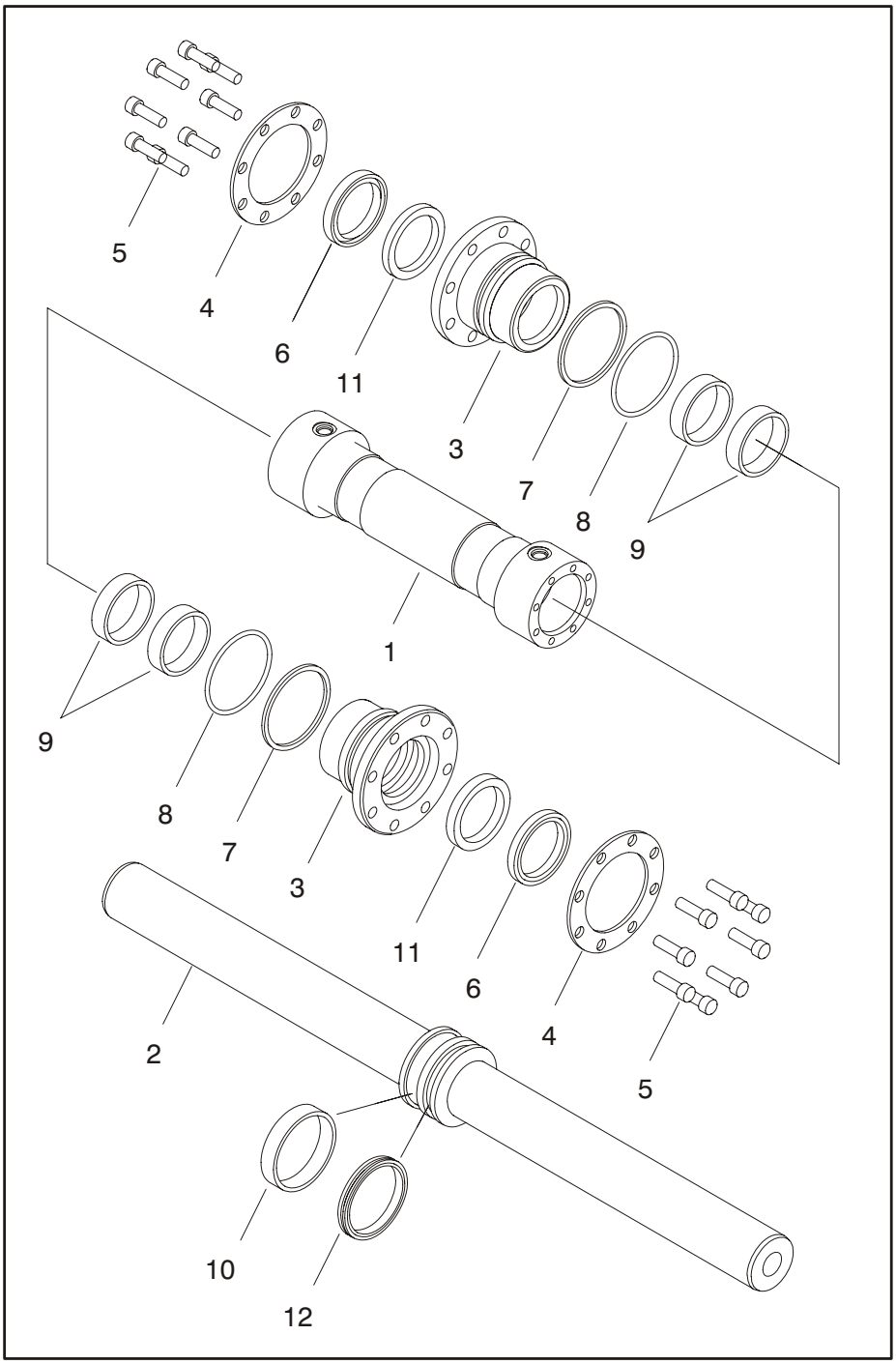


1. UNF -2A Terminal - Torque: 84 in-lbs (9.5 Nm)
2. 2x Torque: 96 - 120 in-lbs (11 - 14 Nm)
3. Check Valve Cap Torque: 144 - 180 in-lbs (16 - 20 Nm)
4. 4x Torque: 180 - 216 in-lbs (20 - 24 Nm)
5. 8x Torque: 114 - 150 in-lbs (13 - 17 Nm)

Figure 4-25. Auxiliary Pump Motor

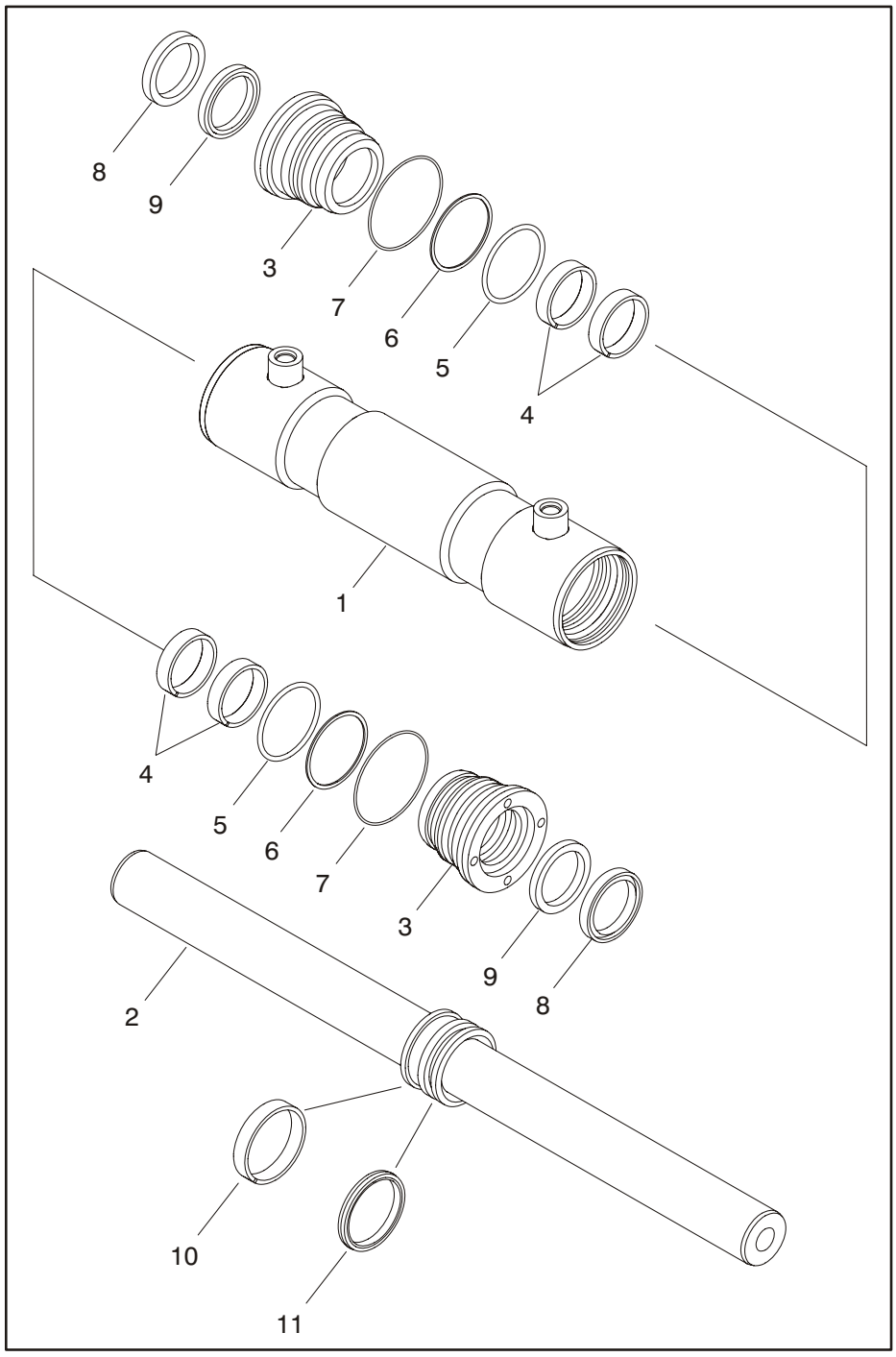
- Displacement: 0.097 CU. IN/REV (1.59 CC/REV)
- Delivers 1.2 min. GPM (4.5 min Liters/Min) at 1500 psi (103.4 bar) and 165 Amps maximum at 12VDC

4.17 CYLINDER ASSEMBLIES



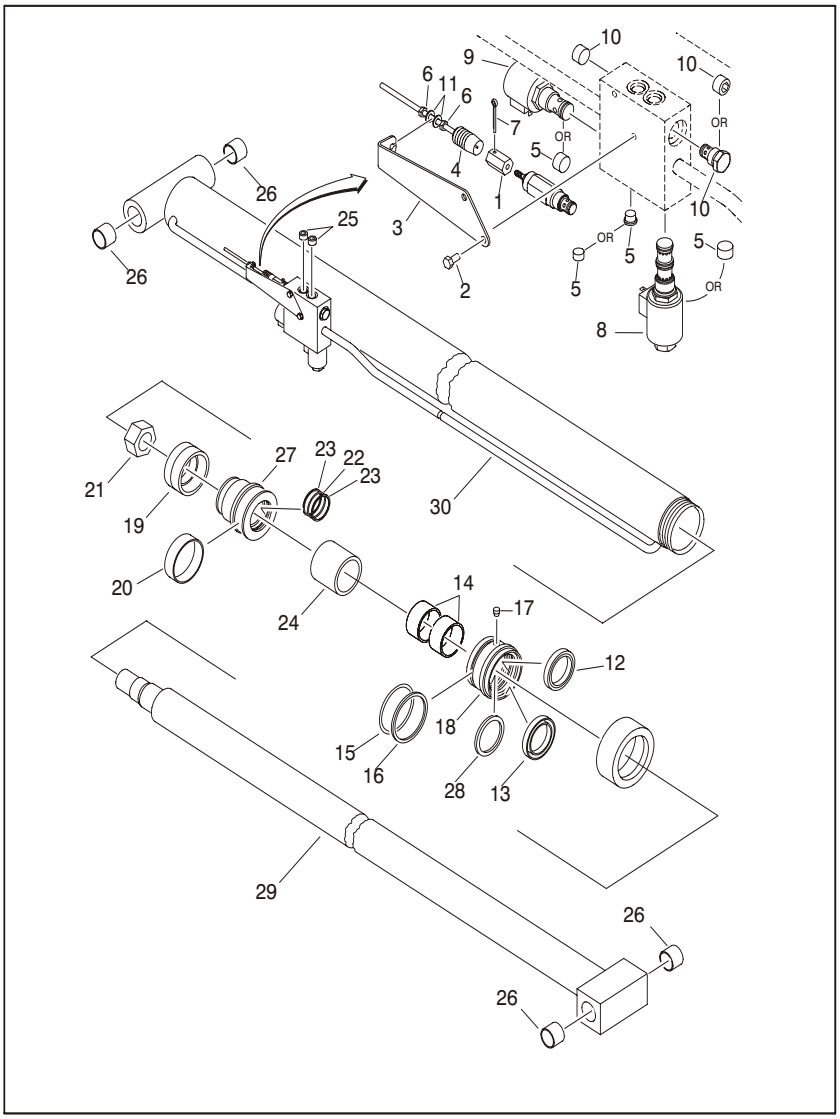
1. Barrel
2. Rod
3. Cap
4. Ring, Washer
5. Socket Head Bolt
6. Wiper
7. Ring, Back-Up
8. O-Ring
9. Ring, Wear
10. Ring, Wear
11. Seal
12. T-Seal

Figure 4-26. Steer Cylinder - Prior to S/N 137518



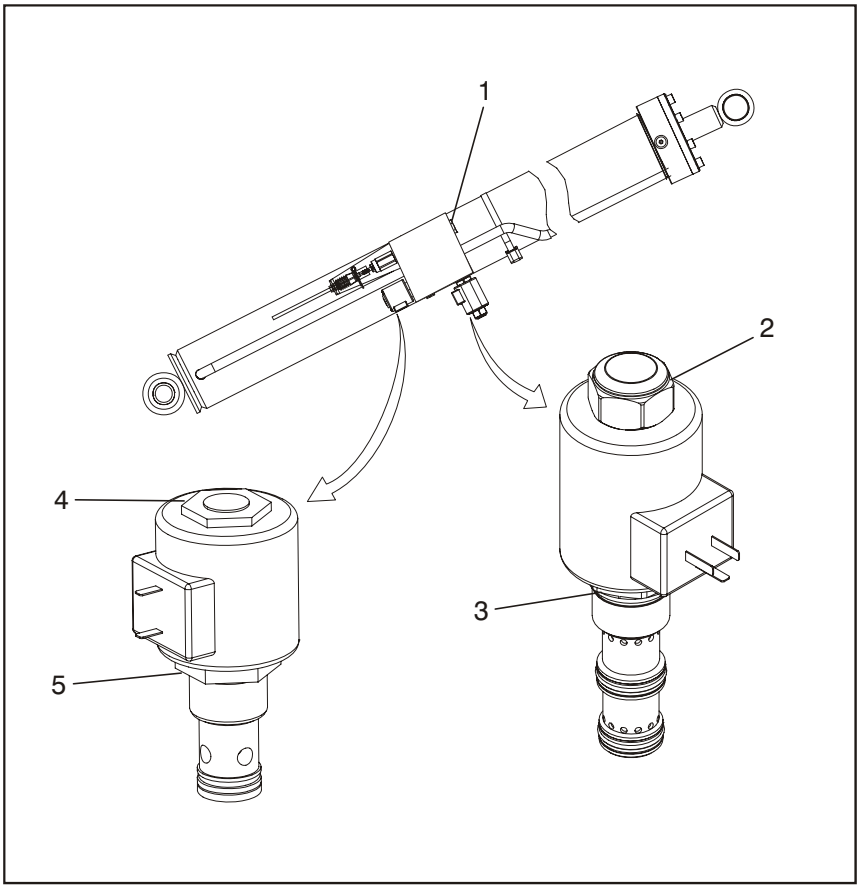
1. Barrel Weldment
2. Rod Weldment
3. Cylinder Head
4. Wear Ring
5. O-ring
6. Back-up Ring
7. O-ring
8. Wiper
9. Seal
10. Wear Ring
11. T-Seal

Figure 4-27. Steer Cylinder - S/N 137518 to Present



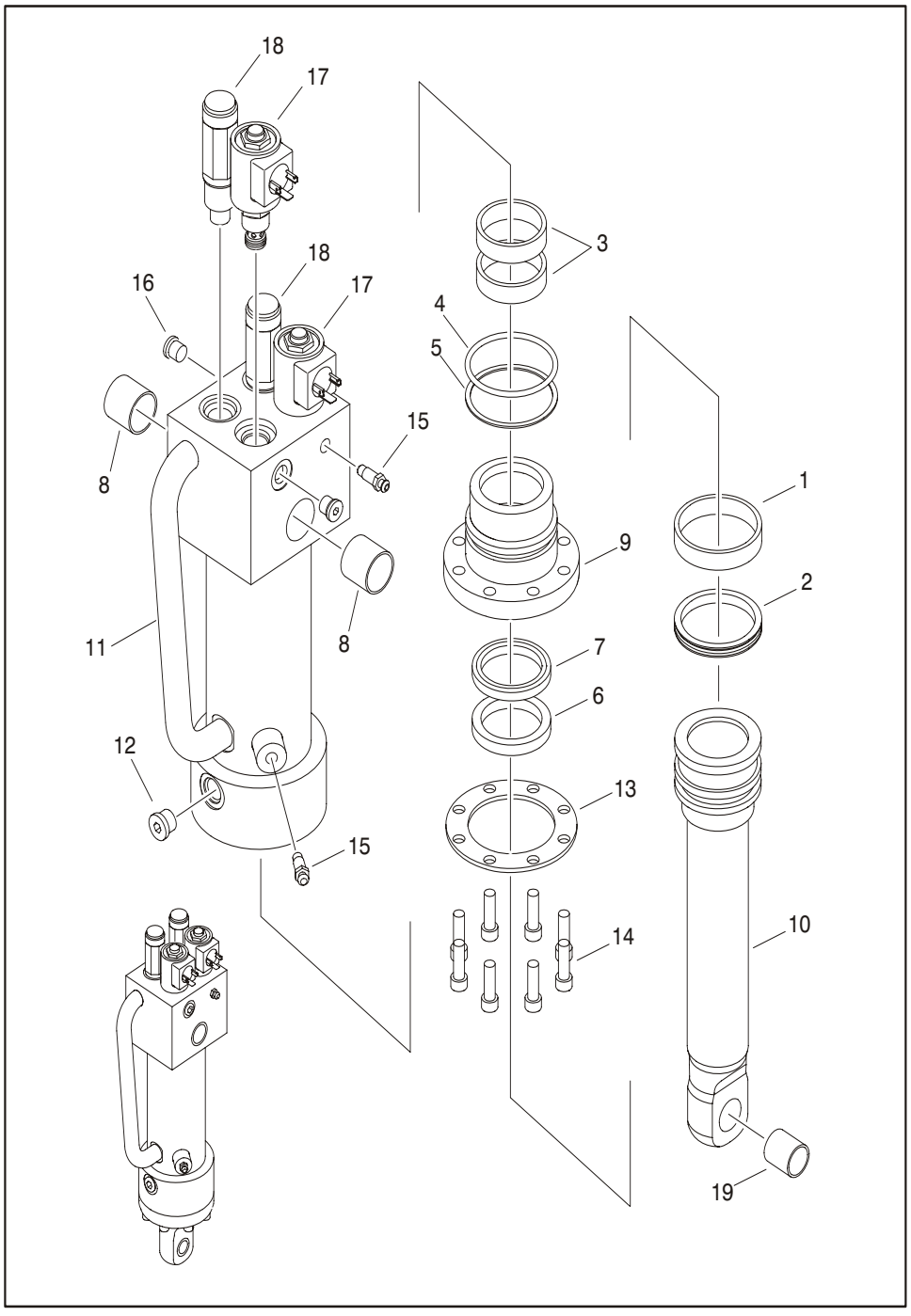
1. Cable Adapter	11. Flat Washer	21. Nut
2. Bolt	12. Wiper	22. Seal
3. Bracket	13. Seal	23. Ring, Back-Up
4. Manual Descent Cable	14. Ring, Wear	24. Spacer
5. Plug, O-Ring	15. Seal	25. Plug, O-Ring
6. Jam Nut	16. Ring, Back-Up	26. Bushing
7. Cotter Pin	17. Setscrew	27. Piston
8. Cartridge, Lift Holding Solenoid	18. Head	28. Seal
9. Cartridge, Lift Holding Solenoid	19. Seal	29. Rod
10. Cartridge, Check	20. Ring, Wear	30. Barrel

Figure 4-28. Lift Cylinder



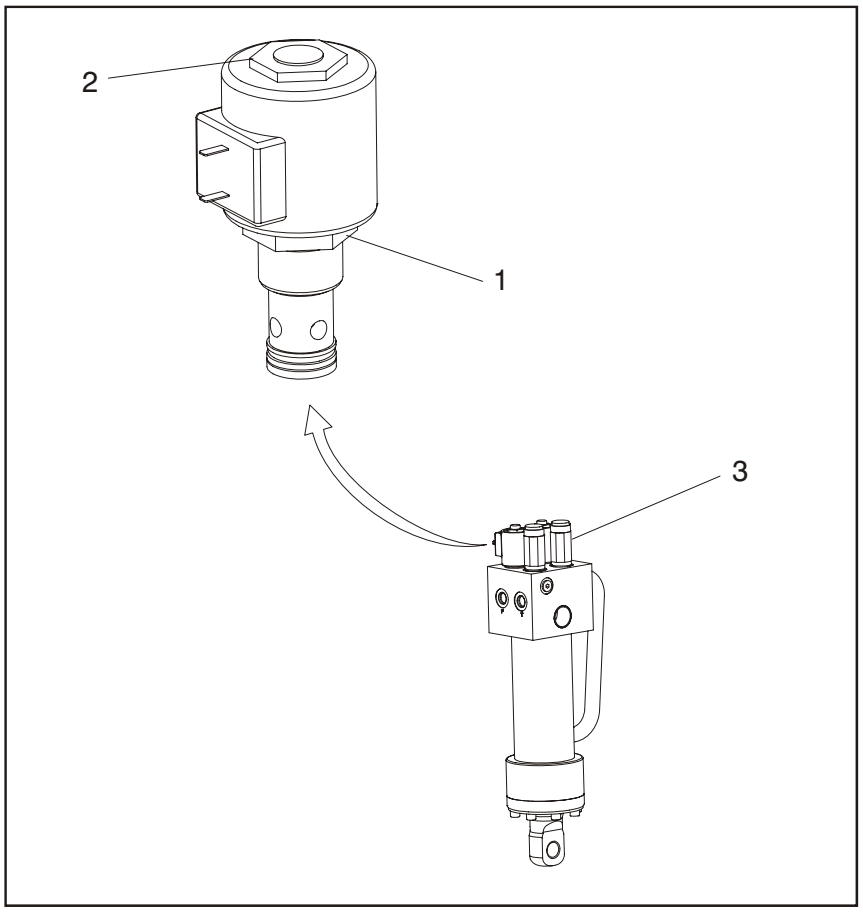
Item	Ft-Lbs	Nm
1	25	35
2	10 - 12	14 - 17
3	35	49
4	5	7
5	30	42

Figure 4-29. Lift Cylinder Valve Cartridge Torque Values



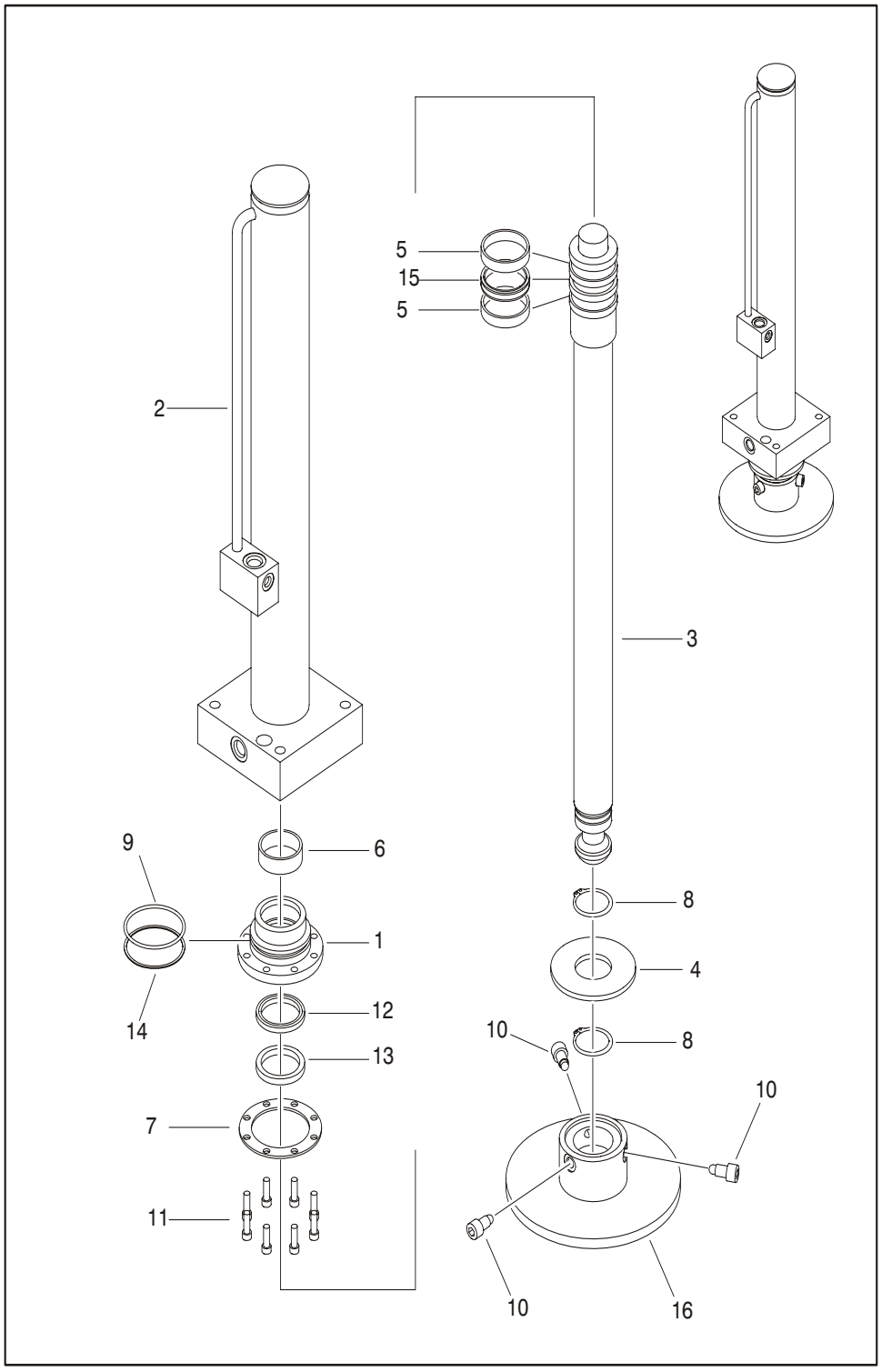
1. Ring, Wear
2. T-Seal
3. Ring, Wear
4. O-Ring
5. Ring, Back-Up
6. Seal, WIper
7. Polyseal
8. Bushing
9. Head
10. Rod
11. Barrel
12. Plug, O-Ring
13. Ring, Washer
14. Capscrew
15. Bleeder
16. Plug, O-Ring
17. Solenoid
18. Relief Valve
19. Bearing

Figure 4-30. Oscillating Axle Cylinder



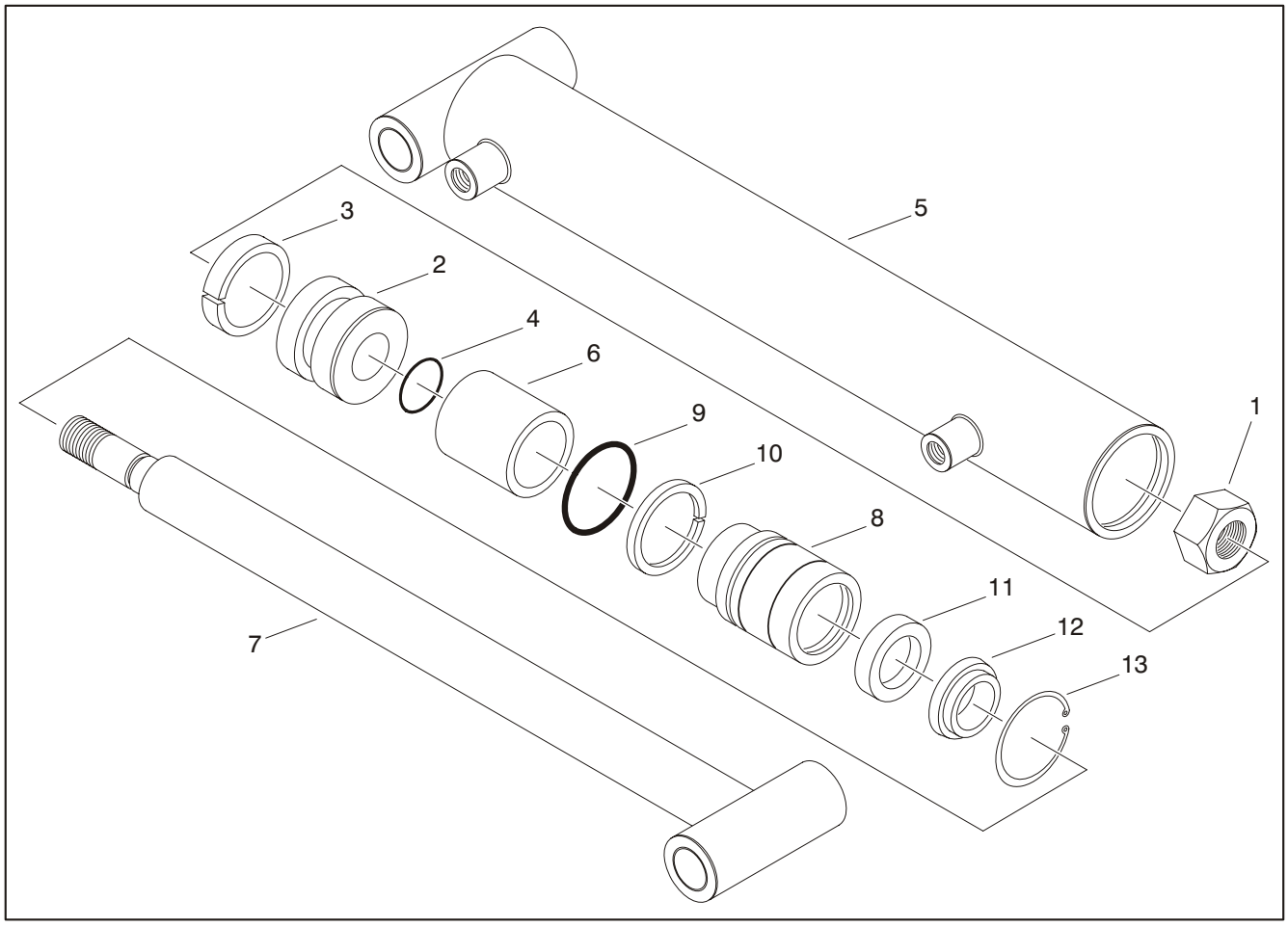
Item #	Ft-Lbs	Nm
1	18.5 - 22	25 - 30
2	3 - 4.5	4.2 - 6.3
3	20 - 25	28 - 35

Figure 4-31. Oscillating Axle Valve Cartridge Torque Values



1. Head
2. Barrel
3. Rod
4. Jack Plate
5. Ring, Lock
6. Ring, Wear
7. Ring, Washer
8. Ring, Retaining
9. O-Ring
10. Screw
11. Capscrew
12. Seal
13. WIper
14. Ring, Back-Up
15. T-Seal
16. Jack Pad

Figure 4-32. Leveling Jack Cylinder



1. Locknut
2. Piston
3. Seal
4. O-Ring
5. Barrel
6. Spacer Tube
7. Head
8. Rod
9. O-Ring
10. Back-up Ring
11. Seal
12. Wiper Ring
13. Retaining Ring

Figure 4-33. Deck Extension Cylinder

Oscillating Axle Bleeding Procedure

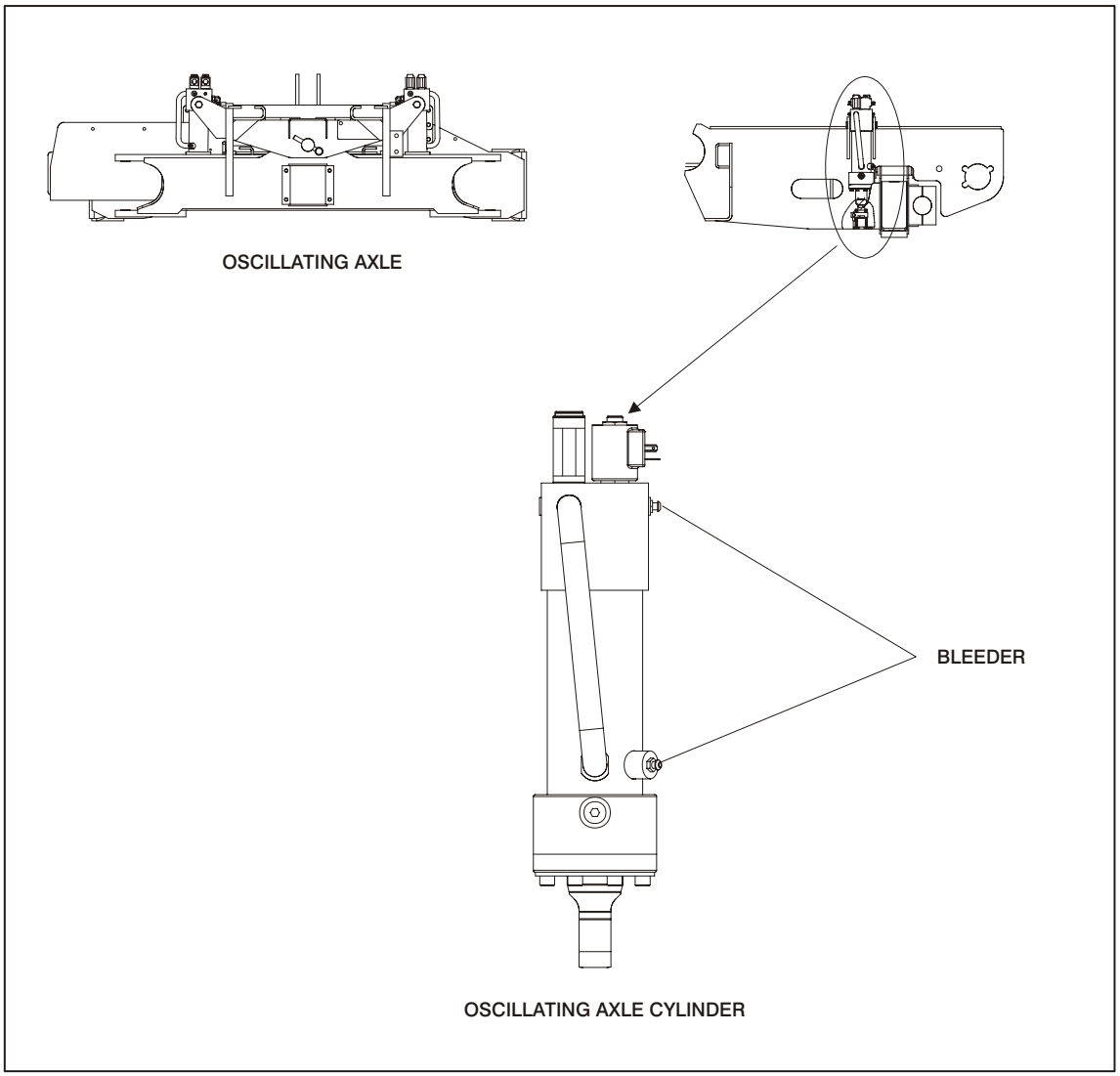


Figure 4-34. Oscillating Axle Bleeding

1. Attach 1/4" hose to bleeder valve to capture oil.
2. Oscillate axle fully in one direction.
3. Open the bleeder valve at the top of the retracted cylinder approx. 1/2 turn and open bleeder valve at the bottom of extended cylinder approx. 1/2 turn.
4. Run pump for 10 seconds, close bleeder valves.
5. Oscillate axle fully in the opposite direction and repeat steps 3 and 4.

SECTION 5. JLG CONTROL SYSTEM

5.1 HAND HELD ANALYZER

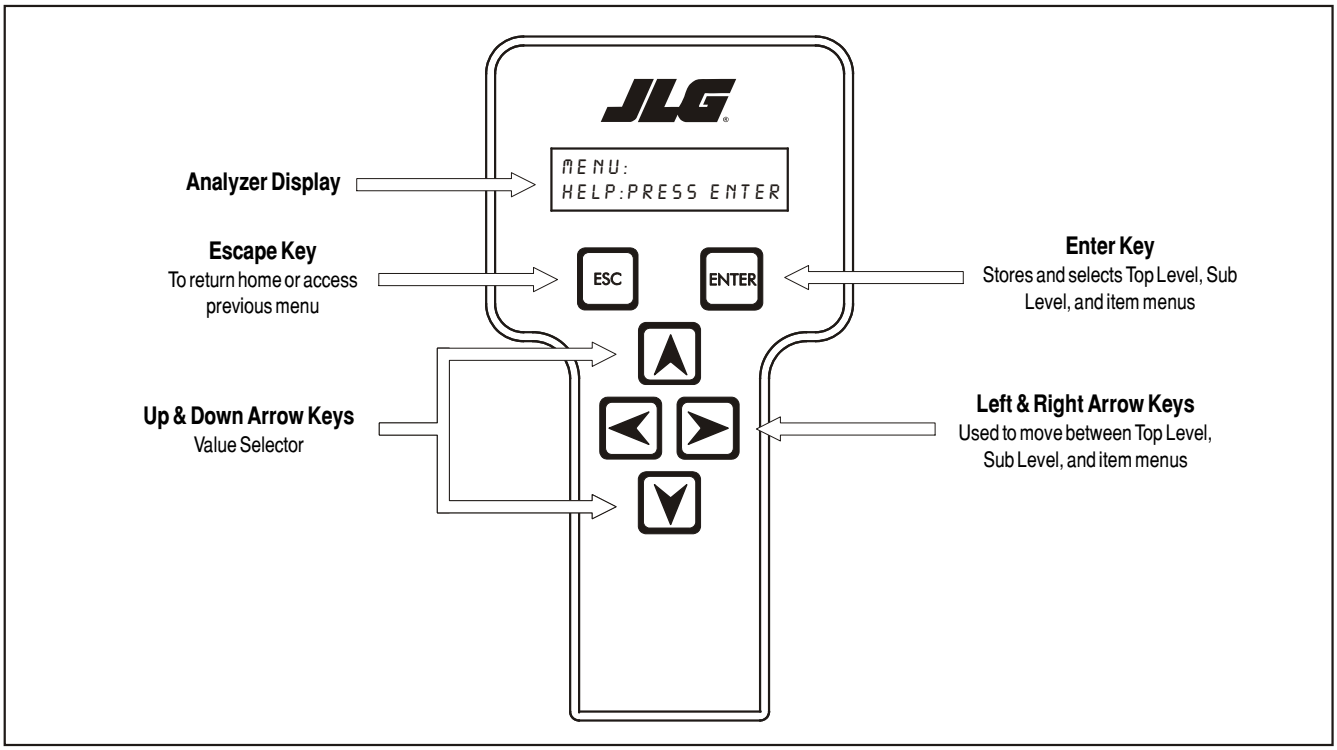


Figure 5-1. Hand Held Analyzer

To Connect the Hand Held Analyzer:

1. Connect the four pin end of the cable supplied with the analyzer, to the four position connector on the PCB in the ground control station or at the platform control station as shown in. Connect the remaining end of the cable to the analyzer.

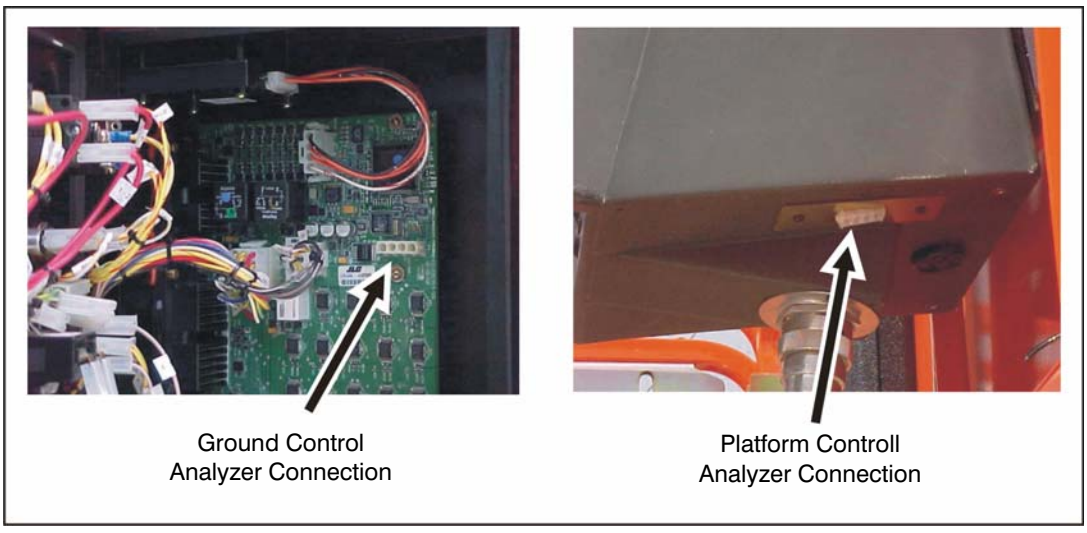


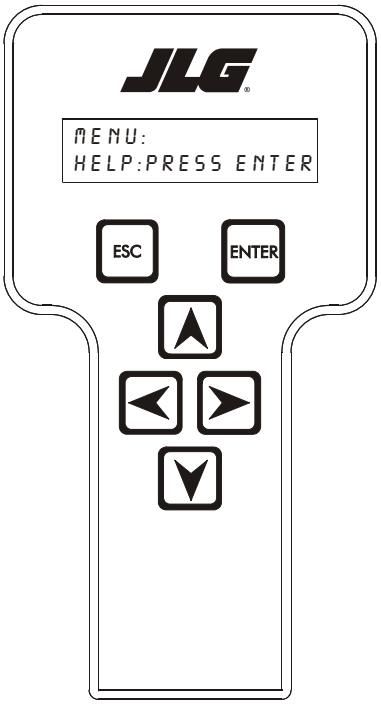
Figure 5-2. Analyzer Connection

NOTE: *The cable has a four pin connector at each end of the cable; the cable cannot be connected backwards.*

2. Power up the Control System by turning the lower key to the platform position and pulling both emergency stop buttons on.

Using the Analyzer:

With the machine power on and the analyzer connected properly, the analyzer will display the following:



HELP:

PRESS ENTER

At this point, using the **RIGHT** and **LEFT** arrow keys, you can move between the top level menu items. To select a displayed menu item, press **ENTER.** To cancel a selected menu item, press **ESC**; then you will be able to scroll using the right and left arrow keys to select a different menu item.

The top level menus are as follows:

HELP

DIAGNOSTICS

ACCESS LEVEL

PERSONALITIES

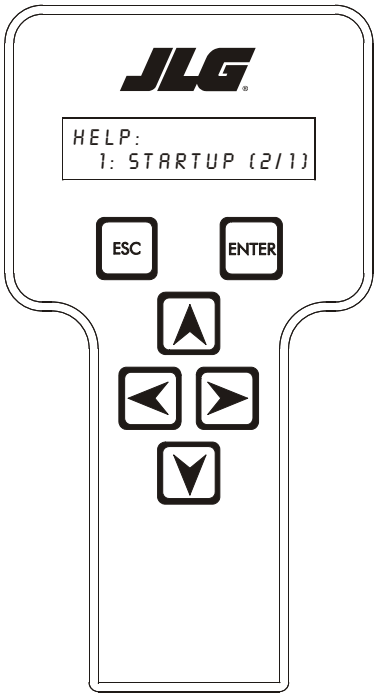
MACHINE SETUP

ACTIVATE TESTS

CALIBRATION

If you press **ENTER**, at the HELP:PRESS ENTER display, and a fault is present during power up, the analyzer display will scroll the fault across the screen. If there was no fault detected during power up, the display will read:
In platform mode**, HELP: EVERYTHING OK,**
In ground mode**, GROUND MODE OK**

If **ENTER** is pressed again, the display moves to the following display:



LOGGED HELP

1: STARTUP (2/1): (Or last recorded fault**)**

At this point, the analyzer will display the current fault, if any are present. You may scroll through the fault logs to view what the last fifteen faults were. Use the right and left arrow keys to scroll through the fault logs. To return to the beginning, press **ESC** two times.

When a top level menu is selected, a new set of menu items may be offered; If for example you choose Personalities:

DRIVE

LIFT

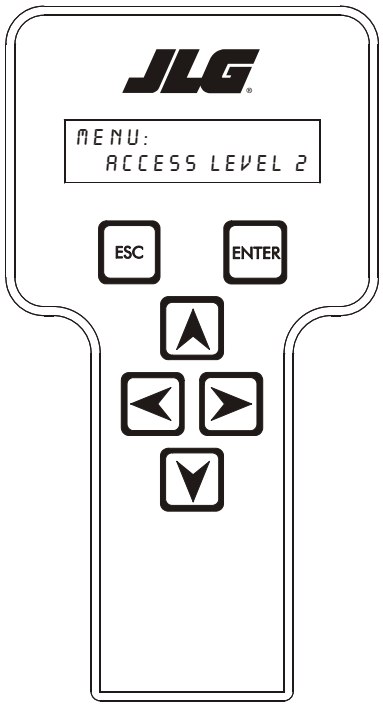
STEER

GROUND

Pressing **ENTER** with any of the above displayed menus, will display additional sub-menus within the selected menu. In some cases the next level is the parameter or information to be changed. Refer to the flow chart for what menus are available within the top level menus. You may only view the personality settings for selected menus while in access level 2. Remember, you may always cancel a selected menu item by pressing the **ESC** key.

Changing the Access Level of the Hand Held Analyzer:

When the analyzer is first connected, you will be in access level 2 which enables you to only view most configuration settings which cannot be changed until you enter a password to advance to a lower level. This ensures that a setting cannot be accidentally altered. To change the access level, the correct password must be entered. To enter the password, scroll to the **ACCESS LEVEL** menu. For example:



MENU:

ACCESS LEVEL 2

Press **ENTER** to select the **ACCESS LEVEL** menu.

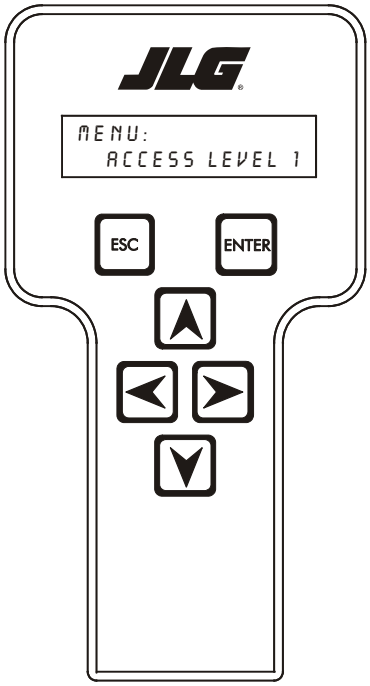
Using the **UP** or **DOWN** arrow keys, enter the first digit of the password, 3.

Then using the **RIGHT** arrow key, position the cursor to the right one space to enter the second digit of the password.

Use the **UP** or **DOWN** arrow key to enter the second digit of the password which is 3.

Repeat this process until you have entered all five digits of the password which is **33271**.

Once the correct password is displayed, press **ENTER**. The access level should display the following, if the password was entered correctly:



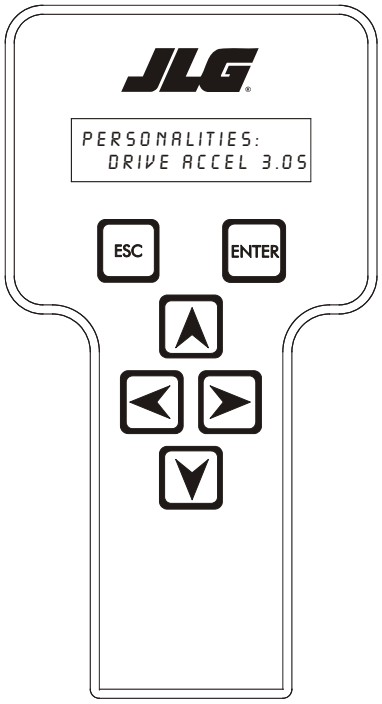
MENU:

ACCESS LEVEL 1

Repeat the above steps if the correct access level is not displayed or you can not adjust the personality settings:

Adjusting Parameters Using the Hand Held Analyzer

Once you have gained access to level 1, and a personality item is selected, press the UP or DOWN arrow keys to adjust its value, for example:



PERSONALITIES:

DRIVE ACCEL 3.0s

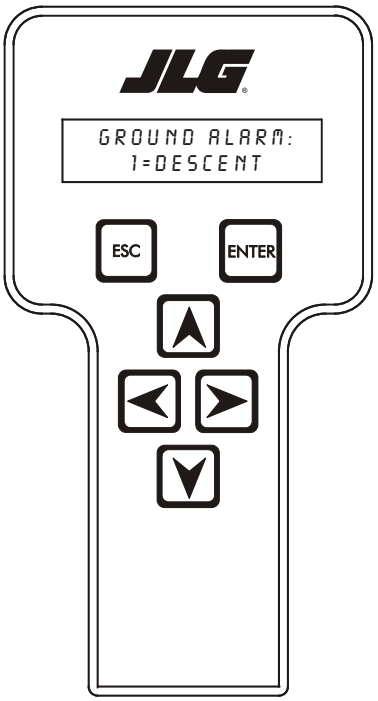
There will be a minimum and maximum for the value to ensure efficient operation. The Value will not increase if the **UP** arrow is pressed when at the maximum value nor will the value decrease if the **DOWN** arrow is pressed and the value is at the minimum value for any particular personality. If the value does not change when pressing the up and down arrows, check the access level to ensure you are at access level 1.

Machine Setup

When a machine digit item is selected, press the **UP** or **DOWN** arrow keys to adjust its value, for example:

⚠ WARNING

FAILURE TO MAKE THE PROPER SETTINGS FOR THE PARTICULAR MACHINE CAN RESULT IN IMPROPER OPERATION.



GROUND ALARM:

1=DESCENT

The effect of the machine digit value is displayed along with its value. The above display would be selected if the machine was equipped with a ground alarm and you wanted it to sound when driving. There are certain settings allowed to install optional features or select the machine model.

When selecting the machine model to match the size of the machine, the personality settings will return to default settings.

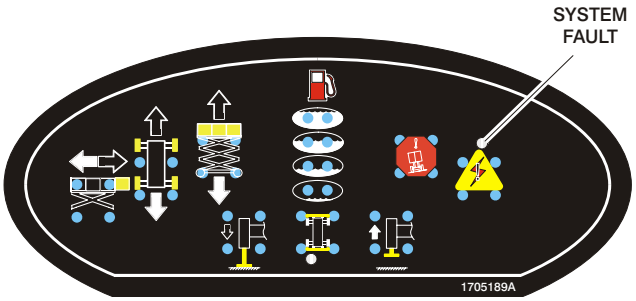
NOTE: *Refer to the appropriate Machine Personality Settings Table, and the Machine Setup Table in the JLG Service Manual for the default settings.*

Password 33271 will give you access to level 1, which will permit you to change all machine personality and/or machine setup settings.

⚠ WARNING

CHANGING THESE SETTINGS MAY ADVERSELY AFFECT THE PERFORMANCE OF YOUR MACHINE.

The flash code is indicated on the face of the platform control box as shown:



NOTE: *Flash codes are also displayed on the handheld analyzer. For descriptions see Table 5-1, Fault Code Listing.*

NOTICE

IT IS A GOOD PRACTICE TO AVOID PRESSURE-WASHING ELECTRICAL/ELECTRONIC COMPONENTS. SHOULD PRESSURE-WASHING BE UTILIZED TO WASH AREAS CONTAINING ELECTRICAL/ELECTRONIC COMPONENTS, JLG INDUSTRIES, INC. RECOMMENDS A MAXIMUM PRESSURE OF 750 PSI (52 BAR) AT A MINIMUM DISTANCE OF 12 INCHES (30.5 CM) AWAY FROM THESE COMPONENTS. IF ELECTRICAL/ELECTRONIC COMPONENTS ARE SPRAYED, SPRAYING MUST NOT BE DIRECT AND BE FOR BRIEF TIME PERIODS TO AVOID HEAVY SATURATION.

5.2 FLASH CODES AND DESCRIPTIONS

Table 5-1. Fault Code Listing - Software P1.X

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
None		**No flash code is indicated for the following help messages. They are intended to hint at a possible problem if the vehicle is not behaving as expected.**	**1**
	FUNCTION SELECTED BUT TRIGGER SWITCH OPEN	Reported when the trigger is not closed with function selected and joystick out of center.	
	RUNNING AT CUTBACK – ABOVE ELEVATION	Reported any time the machine is considered to be above elevation.	
	ACCESSORY FAULT	Reports when CAN faults are reported by an accessory module.	
	FRONT LEFT LEVELING JACK AT END OF STROKE	Reported when the front left leveling jack is reported to be at the end of stroke pressure.	
	FRONT RIGHT LEVELING JACK AT END OF STROKE	Reported when the front right leveling jack is reported to be at the end of stroke pressure.	
	REAR LEFT LEVELING JACK AT END OF STROKE	Reported when the rear left leveling jack is reported to be at the end of stroke pressure.	
	REAR RIGHT LEVELING JACK AT END OF STROKE	Reported when the rear right leveling jack is reported to be at the end of stroke pressure.	
	LEVELING JACK SET PREVENTED - ECM LOST	Reported when autoleveling is not available when communication with the ECM times-out.	
	GENERATOR PREVENTED - ECM LOST	Reported when generator is not available when communication with the ECM times-out.	
	DRIVE PREVENTED - ECM LOST	Reported when elevated drive is not available when communication with the ECM times-out.	
	ELEVATION SENSOR DISAGREEMENT	Reported when elevation prox switch is closed when the 26 ft (3394RT) or 30 ft (4394RT) voltage is reached on the elevation angle sensor. (prevents further lift up from platform controls)	
2/1		**Flash code 2/1 indicates issues at power up.**	**2**
	KEYSWITCH FAULTY – PLATFORM & GROUND ACTIVE TOGETHER	Reported when the ground module is reading both ground and platform modes are selected by the keyswitch. The control system defaults control to ground mode.	

Table 5-1. Fault Code Listing - Software P1.X

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
2/2		Flash code 2/2 indicates difficultly with the platform controls.	**3**
	TRIGGER SWITCH WIRING SHORTED HIGH IN PLATFORM CABLE	Reports when the CAN message coming from the platform board and the DI on ground board conflict.	
	TRIGGER SWITCH WIRING SHORTED LOW IN PLATFORM CABLE	Reports when the CAN message coming from the platform board and the DI on ground board conflict.	
	FUNCTION LOCKED OUT – DRIVE SELECT PERMANENTLY CLOSED	Reported when drive select is closed during power up.	
	FUNCTION LOCKED OUT – LIFT SELECT PERMANENTLY CLOSED	Reported when lift select is closed during power up.	
	FUNCTION LOCKED OUT – FRONT DECK SELECT PERMANENTLY CLOSED	Reported when front deck select is closed during power up.	
	FUNCTION LOCKED OUT – REAR DECK SELECT PERMANENTLY CLOSED	Reported when rear deck select is closed during power up.	
	FUNCTION LOCKED OUT – START PERMANENTLY CLOSED	Reported when the start switch is closed during power up.	
	FUNCTION LOCKED OUT – STEER LEFT PERMANENTLY CLOSED	Reported when the left steer switch is closed during power up.	
	FUNCTION LOCKED OUT – STEER RIGHT PERMANENTLY CLOSED	Reported when the right steer switch is closed during power up.	
	FUNCTION LOCKED OUT – AUX POWER SWITCH PERMANENTLY CLOSED	Reported when the auxiliary switch is closed during power up.	
	FUNCTION LOCKED OUT – GENERATOR SWITCH PERMANENTLY CLOSED	Reported when the generator switch is closed during power up.	
	FUNCTION LOCKED OUT – AUTOLEVEL SWITCH PERMANENTLY CLOSED	Reported when the leveling jack select switch is closed during power up.	
	TRIGGER CLOSED TOO LONG WHILE IN NEUTRAL	Reported when trigger is closed for ten seconds and no function selected.	
	FUNCTION LOCKED OUT – JOYSTICK NOT CENTERED	Reported when joystick is not centered while selecting a function.	
	FUNCTION LOCKED OUT – TRIGGER SWITCH PERMANENTLY CLOSED	Reported when the trigger switch is closed during power up.	
	JOYSTICK FAULTY – STEER SWITCHES ACTIVE TOGETHER	Reported when both the left and right steer switches are closed at the same time.	
	FUNCTION LOCKED OUT – HORN SWITCH PERMANENTLY CLOSED	Reported when the horn switch is closed during power up.	
	JOYSTICK CALIBRATION FAULTY	Reported when joystick calibration is improper. (Platform P1.6 or later only)	

Table 5-1. Fault Code Listing - Software P1.X

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
2/3		**Flash code 2/3 indicates difficultly with ground controls.**	
	FUNCTION LOCKED OUT – GROUND LIFT UP PERMANENTLY CLOSED	Reported when the ground lift up switch is closed during power up.	
	FUNCTION LOCKED OUT – GROUND LIFT DOWN PERMANENTLY CLOSED	Reported when the ground lift down switch is closed during power up.	
	FUNCTION LOCKED OUT – GROUND FRONT DECK EXT PERMANENTLY CLOSED	Reported when the ground front deck extend switch is closed during power up.	
	FUNCTION LOCKED OUT – GROUND FRONT DECK RET PREMANENTLY CLOSED	Reported when the ground front deck retract switch is closed during power up.	
	FUNCTION LOCKED OUT – GROUND REAR DECK EXT PERMANENTLY CLOSED	Reported when the ground rear deck extend switch is closed during power up.	
	FUNCTION LOCKED OUT – GROUND REAR DECK RET PERMANENTLY CLOSED	Reported when the ground rear deck retract switch is closed during power up.	
	GROUND LIFT UP/DOWN ACTIVE TOGETHER	Reported when the ground lift up and lift down switches are closed at the same time.	**4**
	GROUND FRONT DECK EXTEND/RETRACT ACTIVE TOGETHER	Reported when the ground front deck extend and retract switches are closed at the same time.	
	GROUND REAR DECK EXTEND/RETRACT ACTIVE TOGETHER	Reported when the ground rear deck extend and retract switches are closed at the same time.	
	NO SIGNAL FROM TILT SENSOR X AXIS – CHECK WIRING	Reported when sensor X-axis value is not valid.	
	NO SIGNAL FROM TILT SENSOR Y AXIS – CHECK WIRING	Reported when sensor Y-axis value is not valid.	
	LEVEL SENSOR FAILURE	Reported when the tilt sensor frequency is outside the range of acceptable value.	
	FUNCTION LOCKED OUT – GROUND AUX SWITCH PERMANENTLY CLOSED	Reported when the ground auxiliary power switch is closed during power up.	
	FUNCTION LOCKED OUT – GROUND START SWITCH PERMANENTLY CLOSED	Reported when the ground start switch is closed during power up.	

Table 5-1. Fault Code Listing - Software P1.X

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
2/5		**Flash code 2/5 indicates issues that may cutout functions.**	
	ELEV ANGLE SENSOR FAULTY – NOT MOUNTED OR VOLTAGE OUT OF RANGE	Reported when the elevation rotary sensor voltage is outside the range of acceptable values.	
	ELEV ANGLE SENSOR HAS NOT BEEN CALIBRATED	Reported when the rotary calibration value does not exist.	
	ELEVATION PROX SWITCH PERMANENTLY CLOSED	Reported when the elevation rotary sensor is reporting above elevation and the elevation proximity switch is still closed.	
	ELEVATION PROX SWITCH PERMANENTLY OPEN	Reported when the elevation rotary sensor is reporting stowed and the elevation proximity switch is open.	
	FRONT LEFT LEVELING JACK PRESSURE TRANSDUCER FAILURE	Reported when the front left leveling jack pressure reading is well below 0PSI.	
	FRONT RIGHT LEVELING JACK PRESSURE TRANSDUCER FAILURE	Reported when the front right leveling jack pressure reading is well below 0PSI.	
	REAR LEFT LEVELING JACK PRESSURE TRANSDUCER FAILURE	Reported when the rear left leveling jack pressure reading is well below 0PSI.	
	REAR RIGHT LEVELING JACK PRESSURE TRANSDUCER FAILURE	Reported when the rear right leveling jack pressure reading is well below 0PSI.	
	PLATFORM OVERLOAD	Reported when the overload is setup and the LSS is reading the platform is overloaded.	
	FRONT LEFT LEVELING JACK STOW SWITCH PERMANENTLY CLOSED	Reported when the FRONT LEFT Leveling Jack Stow Switch is closed and the FRONT LEFT pressure transducer reads "Set" pressure.	**5**
	FRONT RIGHT LEVELING JACK STOW SWITCH PERMANENTLY CLOSED	Reported when the FRONT RIGHT Leveling Jack Stow Switch is closed and FRONT RIGHT pressure transducer reads "Set" pressure.	
	REAR LEFT LEVELING JACK STOW SWITCH PERMANENTLY CLOSED	Reported when the REAR LEFT Leveling Jack Stow Switch is closed and the REAR LEFT pressure transducer reads "Set" pressure.	
	REAR RIGHT LEVELING JACK STOW SWITCH PERMANENTLY CLOSED	Reported when the REAR RIGHT Leveling Jack Stow Switch is closed and the REAR RIGHT pressure transducer reads "Set" pressure.	
	ELEV ANGLE SENSOR HAS NOT BEEN CALIBRATED	Reported when elevation height calibration has not been performed or is not logical (increasing voltages from stowed). Vehicle assumed to be at full height.	
	ELEV ANGLE SENSOR FAULTY - NOT MOUNTED OR VOLTAGE OUT OF RANGE	Reported when elevation angle sensor is outside the 0.30V to 4.85V range. Vehicle assumed to be at full height.	
	ELEV ANGLE SENSOR NOT DETECTING CHANGE	Reported when elevation angle sensor voltage does not change for 5 sec during lift up > 20%. Vehicle assumed to be at full height. Fault cleared only in valid stowed position.	

Table 5-1. Fault Code Listing - Software P1.X

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
2/6		**Flash code 2/6 indicates leveling jack or power deck issues.**	**6**
	FRONT LEFT LEVELING JACK OPEN CIRCUIT	Reported by the I/O module and during system test when the front left leveling jack is open circuit.	
	FRONT LEFT LEVELING JACK SHORT TO GROUND	Reported by the I/O module and during system test when the front left leveling jack is short to ground.	
	FRONT LEFT LEVELING JACK SHORT TO BATTERY	Reported by the I/O module and during system test when the front left leveling jack is short to battery.	
	FRONT RIGHT LEVELING JACK OPEN CIRCUIT	Reported by the I/O module and during system test when the front right leveling jack is open circuit.	
	FRONT RIGHT LEVELING JACK SHORT TO GROUND	Reported by the I/O module and during system test when the front right leveling jack is short to ground.	
	FRONT RIGHT LEVELING JACK SHORT TO BATTERY	Reported by the I/O module and during system test when the front right leveling jack is short to battery.	
	REAR LEFT LEVELING JACK OPEN CIRCUIT	Reported by the I/O module and during system test when the rear left leveling jack is open circuit.	
	REAR LEFT LEVELING JACK SHORT TO GROUND	Reported by the I/O module and during system test when the rear left leveling jack is short to ground.	
	REAR LEFT LEVELING JACK SHORT TO BATTERY	Reported by the I/O module and during system test when the rear left leveling jack is short to battery.	
	REAR RIGHT LEVELING JACK OPEN CIRCUIT	Reported by the I/O module and during system test when the rear right leveling jack is open circuit.	
	REAR RIGHT LEVELING JACK SHORT TO GROUND	Reported by the I/O module and during system test when the rear right leveling jack is short to ground.	
	REAR RIGHT LEVELING JACK SHORT TO BATTERY	Reported by the I/O module and during system test when the rear right leveling jack is short to battery.	
	LEVELING JACK EXTEND VALVE OPEN CIRCUIT	Reported by the I/O module and during system test when the leveling jack extend valve is open circuit.	

Table 5-1. Fault Code Listing - Software P1.X

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
2/6	LEVELING JACK EXTEND VALVE SHORT TO GROUND	Reported by the I/O module and during system test when the leveling jack extend valve is short to ground.	**6**
	LEVELING JACK EXTEND VALVE SHORT TO BATTERY	Reported by the I/O module and during system test when the leveling jack extend valve is short to battery.	
	LEVELING JACK RETRACT VALVE OPEN CIRCUIT	Reported by the I/O module and during system test when the leveling jack retract valve is open circuit.	
	LEVELING JACK RETRACT VALVE SHORT TO GROUND	Reported by the I/O module and during system test when the leveling jack retract valve is short to ground.	
	LEVELING JACK RETRACT VALVE SHORT TO BATTERY	Reported by the I/O module and during system test when the leveling jack retract valve is short to battery.	
	FRONT DECK EXTEND VALVE OPEN CIRCUIT	Reported by the I/O module and during system test when the front deck extend valve is open circuit.	
	FRONT DECK EXTEND VALVE SHORT TO GROUND	Reported by the I/O module and during system test when the front deck extend valve is short to ground.	
	FRONT DECK EXTEND VALVE SHORT TO BATTERY	Reported by the I/O module and during system test when the front deck extend valve is short to battery.	
	FRONT DECK RETRACT VALVE OPEN CIRCUIT	Reported by the I/O module and during system test when the front deck retract valve is open circuit.	
	FRONT DECK RETRACT VALVE SHORT TO GROUND	Reported by the I/O module and during system test when the front deck retract valve is short to ground.	
	FRONT DECK RETRACT VALVE SHORT TO BATTERY	Reported by the I/O module and during system test when the front deck retract valve is short to battery.	
	REAR DECK EXTEND VALVE OPEN CIRCUIT	Reported by the I/O module and during system test when the rear deck extend valve is open circuit.	
	REAR DECK EXTEND VALVE SHORT TO GROUND	Reported by the I/O module and during system test when the rear deck extend valve is short to ground.	
	REAR DECK EXTEND VALVE SHORT TO BATTERY	Reported by the I/O module and during system test when the rear deck extend valve is short to battery.	
	REAR DECK RETRACT VALVE OPEN CIRCUIT	Reported by the I/O module and during system test when the rear deck retract valve is open circuit.	
	REAR DECK RETRACT VALVE SHORT TO GROUND	Reported by the I/O module and during system test when the rear deck retract valve is short to ground.	
	REAR DECK RETRACT VALVE SHORT TO BATTERY	Reported by the I/O module and during system test when the rear deck retract valve is short to battery.	

Table 5-1. Fault Code Listing - Software P1.X

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
4/3		**Flash code 4/3 indicates engine issues.**	
	FUEL SENSOR SHORT TO BATTERY	Reported when the fuel sensor is reading a value that is much too high.	
	FUEL SENSOR SHORT TO GROUND	Reported when the fuel sensor is reading ground.	
	FUEL SENSOR DISCONNECTED	Reported when the fuel sensor is reading a value that is too high.	
	OIL PRESSURE SHORT TO BATTERY	Reported when the oil pressure sensor is reading a value that is too high.	
	OIL PRESSURE SHORT TO GROUND	Reported when the oil pressure sensor is reading a value that is too low.	
	COOLANT TEMPERATURE SHORT TO GROUND	Reported when the coolant temperature sensor is reading a value that is too low.	
	FORD FAULT CODE	Reported by the Ford engine.	**7**
	ENGINE TEMPERATURE HIGH	This fault is not reported at this time.	
	AIR FILTER BYPASSED	This fault is not reported at this time.	
	NO ALTERNATOR OUTPUT	Reported when the engine is running for at least a few seconds and the alternator input is on the ground board is high.	
	OIL PRESSURE LOW	Reported when the oil pressure is below eight PSI and the engine is running for at least a few seconds.	
	485 COMMUNICATIONS LOST	Reported when a Ford engine is selected and communications with the Ford engine controller are lost.	
	ENGINE SHUTDOWN COMMANDED – CHECK ENGINE SENSORS	Reported when the engine is commanded to shutdown by the control system.	
	WRONG ENGINE SELECTED	Reported when CAN ECM is detected and not configured.	
	DEUTZ ECM FAULT CODE	Reported when the Deutz Engine Controller is giving a fault.	
4/4		**Flash code 4/4 indicates a battery supply issue.**	
	BATTERY LOW	Reported when the voltage on the system is below 11 volts.	
	BATTERY TOO HIGH – SYSTEM SHUTDOWN	Reported when the voltage on the system is above 16 volts.	**8**
	BATTERY TOO LOW – SYSTEM SHUTDOWN	Reported when the voltage on the system is below 9 volts.	
	LSS BATTERY VOLTAGE HIGH	Reported when the voltage on the LSS is above 34 volts.	
	LSS BATTERY VOLTAGE LOW	Reported when the voltage on the LSS is below 9 volts.	
5/5		**Flash code 5/5 indicates a speed sensor issue.**	
	SPEED SENSOR READING INVALID SPEED	Reported when the speed sensor is reading a value over 4000 RPM.	**9**
	SPEED INPUT LOST	Reported when the speed sensor is reading zero RPM and the oil pressure is over eight PSI.	
6/6		Flash code 6/6 indicates CANbus issues.	**10**
	CAN BUS FAILURE	Reported when there is a problem with the CANbus.	
	LSS NOT SENDING CAN MESSAGES	Reported when the LSS is configured and not seen on the CAN-bus.	
	ENGINE CONTROLLER CAN COMMUNICATION LOST	Reported when the engine is configured to be CAN controlled and the system is not communicating with it.	
	TWO PLATFORM MODULES DETECTED	Reported when there are two platform modules connected to the control system.	

Table 5-1. Fault Code Listing - Software P1.X

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
8/*		**Flash codes 8/* indicate load cells issues.**	
8/1	LSS CELL #1 ERROR	Reported when there is a problem with cell #1 on the LSS.	
8/2	LSS CELL #2 ERROR	Reported when there is a problem with cell #2 on the LSS.	**11**
8/3	LSS CELL #3 ERROR	Reported when there is a problem with cell #3 on the LSS.	
8/4	LSS CELL #4 ERROR	Reported when there is a problem with cell #4 on the LSS.	
9/*		**Flash codes 9/* indicate LSS or memory issues.**	
9/1	LSS WATCHDOG RESET	Reported when the LSS's microprocessor watchdog has been triggered.	
9/2	LSS EEPROM ERROR	Reported when there is a problem with the stored memory in the LSS.	
9/3	LSS HAS NOT BEEN CALIBRATED	Reported when the LSS is configured but not calibrated.	
9/9	LSS NEEDS TO BE RE-CALIBRATED	Reported when the LSS is configured and reporting a value that is less than half of the offset value; this will be reported as a negative value.	**12**
	LSS INTERNAL ERROR – PIN EXCITATION	Reported when a pin in the LSS is reporting a voltage below 4.25 volts.	
	LSS INTERNAL ERROR – DRIVER FAULT	Reported when the LSS detects this internal error.	
	LSS INTERNAL ERROR – DRDY MISSING FROM A/D	Reported when the LSS detects this internal error.	
	EEPROM FAILURE – CHECK ALL SETTINGS	Reported when the memory in the ground or platform module has become corrupt.	

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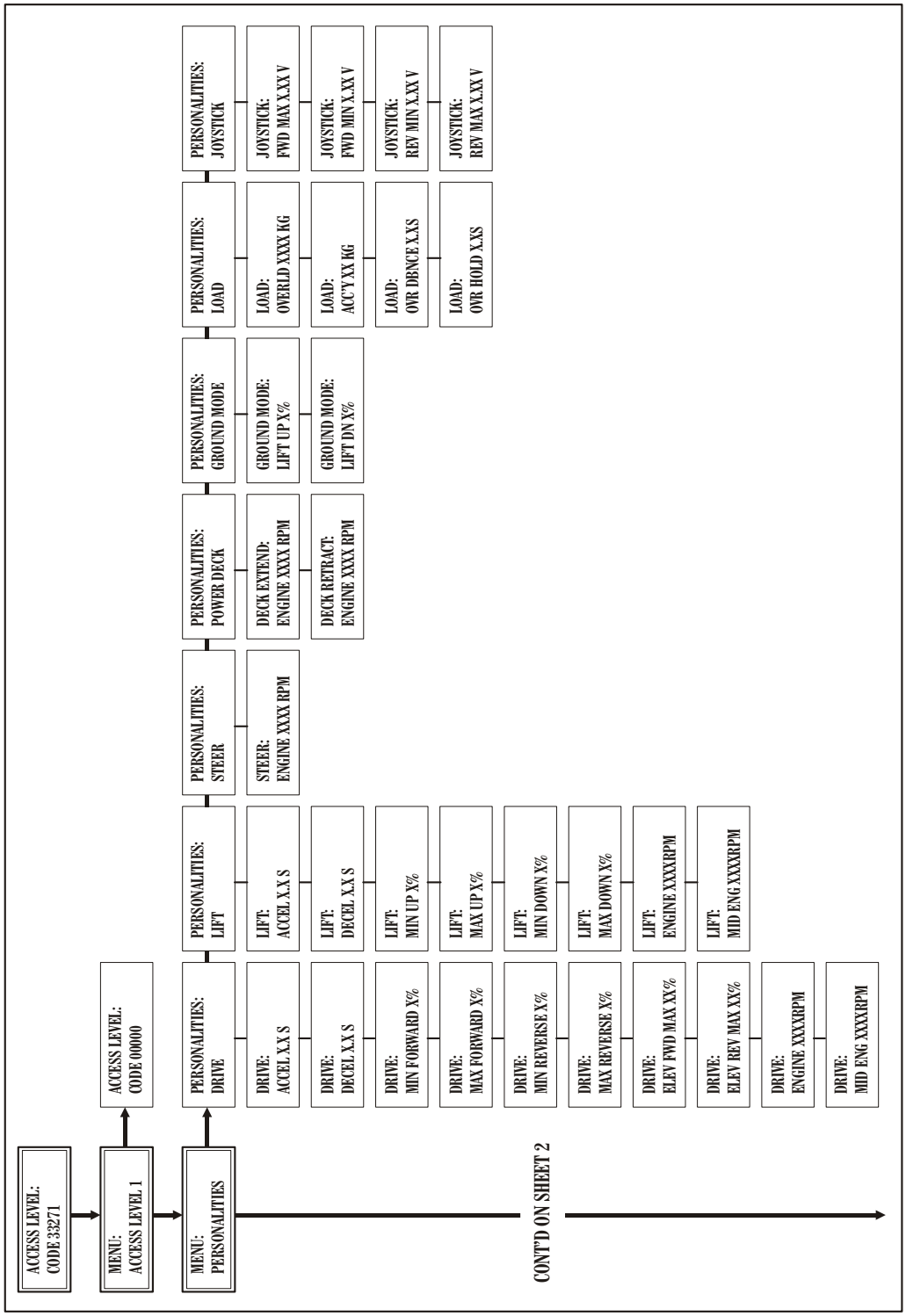

Figure 5-3. Analyzer Flow Chart - SW P1.X - Sheet 1 of 3

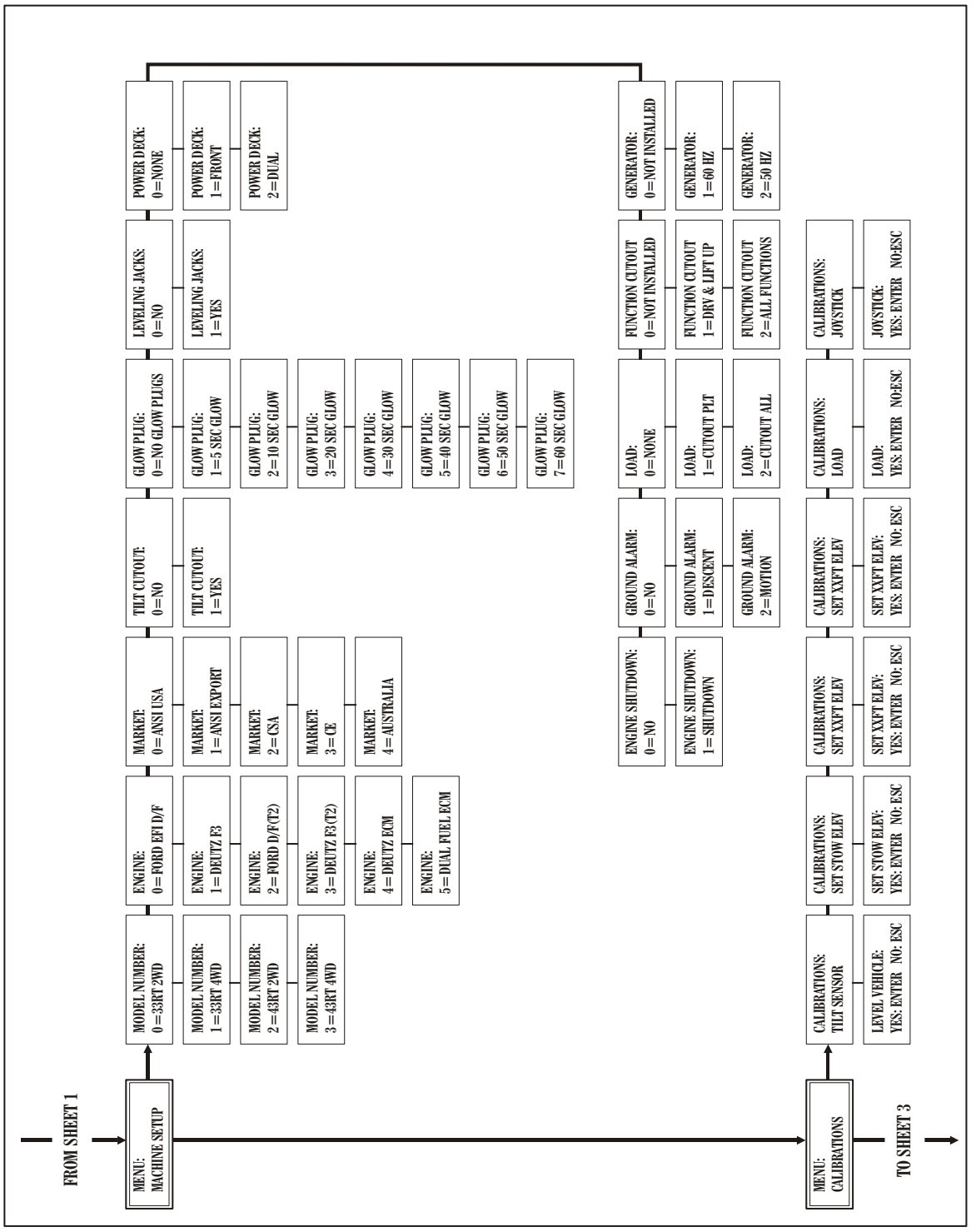

Figure 5-4. Analyzer Flow Chart - SW P1.X - Sheet 2 of 3

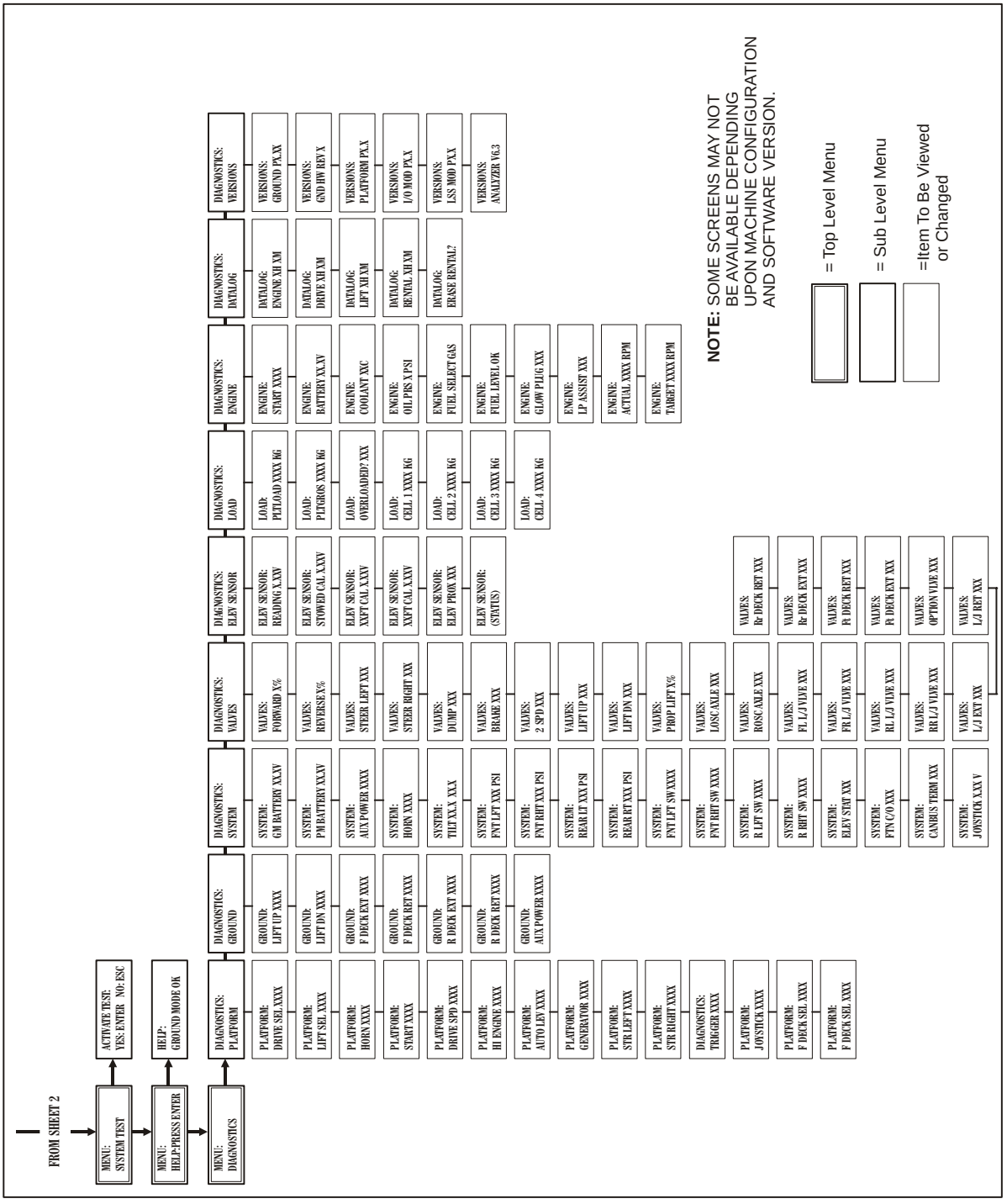

Figure 5-5. Analyzer Flow Chart - SW P1.X - Sheet 3 of 3

Table 5-2. Machine Model Adjustment

Adjustment	Adjustment Range	Model Default Values			
		3394RT 2WD	3394RT 4WD	4394RT 2WD	4394RT 4WD
DRIVE					
Accel	0.1 - 5.0 (sec)	3	3	3	3
Decel	0.1 - 3.0 (sec)	1.2	1.2	1.2	1.2
Min Forward	0 - 35%	24	24	24	24
Max Forward	0 -100%	56	56	56	56
Min Reverse	0 - 35%	24	24	24	24
Max Reverse	0 -100%	55	55	55	55
Elev Fwd Max	20 - 50%	41	41	41	41
Elev Rev Max	21 - 50%	41	41	41	41
Engine	800 - 2900RPM	2800	2800	2800	2800
Mid Engine	800 - 2700RPM	2000	2000	2000	2000
LIFT					
Accel	0.1 - 5.0 (sec)	2	2	2	2
Decel	0.8 - 1.5 (sec)	1	1	1	1
Min Up	0 - 35%	12	12	12	12
Max Up	0 - 65%	55	55	45	45
Min Down	0 - 35%	12	12	12	12
Max Down	0 - 65%	55	55	40	40
Engine	800 - 2900RPM	2800	2800	2800	2800
Mid Engine	800 - 2700RPM	2000	2000	2000	2000
STEER					
Engine	800 - 2900RPM	2800	2800	2800	2800
POWER DECK					
Deck Extend	800 - 2900RPM	1200	1200	1200	1200
Deck Retract	800 - 2900RPM	1200	1200	1200	1200
GROUND					
Lift Up	0 - 65%	55	55	45	45
Lift Down	0 - 65%	55	55	40	40
LOAD					
Overload	1000 - 2700 lbs (454 - 1225 kg)	2475 (1123 kg)	2475 (1123 kg)	1650 (748 kg)	1650 (748 kg)
Acc'y	0 - 500 lbs (0 - 227 kg)	0	0	0	0
Overload Dbnce	0 - 10 (sec)	3	3	3	3
Overload Hold	1 - 10 (sec)	5	5	5	5
JOYSTICK					
Forward Max	0.00 - 5.00V	0.75	0.75	0.75	0.75
Forward Min	0.00 - 5.00V	2.24	2.24	2.24	2.24
Reverse Min	0.00 - 5.00V	2.82	2.82	2.82	2.82
Reverse Max	0.00 - 5.00V	4.32	4.32	4.32	4.32

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NOTE: *These settings may be changed in order to achieve optimal performance.*

NOTE: *When configuring an RT, the Machine Configuration must be completed before any Personality settings can be changed. Changing the Personality settings first and then changing the Model of the Machine Configuration will cause the Personality settings to return to default values.*

Table 5-3. Machine Configuration Programming Information

Configuration Digit	Setting	Description	Default Number
1 (MODEL)	0 1 2 3	33RT 2WD 33RT 4WD 43RT 2WD 43RT 4WD	1
2 (ENGINE)	0 1 2 3 4 5	FORD EFI D/F DEUTZ F3 FORD D/F (T2) DEUTZ F3 (T2) DEUTZ ECM DUAL FUEL ECM - GM/PSI Engine	4
3 (MARKET)	0 1 2 3 4	ANSI USA ANSI EXPORT CSA CE AUSTRALIA	0
4 (TILT CUTOUT)	0 1	NO - Tilt Cutout is not active Yes - Tilt Cutout is active (Screen only visible to CE Market)	1
5 (GLOW PLUGS)	0 1 2 3 4 5 6 7	NO GLOW PLUGS 5 SEC GLOW 10 SEC GLOW 20 SEC GLOW 30 SEC GLOW 40 SEC GLOW 50 SEC GLOW 60 SEC GLOW	5
6 (LEVELING JACKS)	0 1	No - Leveling Jacks not installed on vehicle. YES – Leveling Jacks are installed on vehicle.	0
7 (POWER DECK)	0 1 2	NONE – Power Deck Extensions not installed on vehicle. FRONT – Power Deck Extension is installed on the Front of the vehicle. DUAL – Power Deck Extensions are installed on the Front and Rear of the vehicle.	0
8 (GENERATOR)	0 1 2	NOT INSTALLED – Generator is not installed on the vehicle. 60HZ – Generator is installed and engine speed set for 2000RPM when enabled. 50HZ – Generator is installed and engine speed set for 1700RPM when enabled.	0
9 (FUNCTION CUTOUT)	0 1 2	NOT INSTALLED – Vehicle is not equipped with a Function Cutout device. DRV & LIFT UP – Vehicle is equipped with a Function Cutout device. Drive and Lift Up will be prevented when active. ALL FUNCTIONS – Vehicle is equipped with a Function Cutout device. All Functions will be prevented when active.	0

Table 5-3. Machine Configuration Programming Information

Configuration Digit	Setting	Description	Default Number
10 (LOAD)	0 1 2	NOT INSTALLED – Load Sensing System (LSS) is not fitted to the vehicle. CUTOUT PLT – Load Sensing System (LSS) is fitted, and Platform Controls are prevented in the event of an Overload. Ground Controls remain functional. This is the default setting for CE machines. CUTOUT ALL – Load Sensing System (LSS) is fitted. Platform and Ground Controls are prevented in the event of an Overload. ***NOTE:*** *Certain market selections will alter default setting.*	0
11 (GROUND ALARM)	0 1 2	NOT INSTALLED – Vehicle alarm will function for Overload (if LOAD enabled). DESCENT – Vehicle alarm will function for Overload (if LOAD enabled) and during Lift Down motion. MOTION – Vehicle alarm will function for Overload (if LOAD enabled), during Drive motion, and during Lift motion. ***NOTE:*** *Certain market selections will alter default setting.*	2
12 (ENGINE SHUTDOWN)	0 1	NO - The engine will not be automatically shutdown. SHUTDOWN - The engine will automatically shutdown in the event of high engine coolant temperature, low oil pressure, or a temperature sensor or oil pressure sensor fault.	1

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Table 5-4. Machine Tilt Configuration

Model	Market	LImits
33RT 2WD, 33RT 4WD	ANSI USA	Lift Up and Drive prevented when Elevated and Tilted beyond the following limits: Front to Back: ±5° to Full Height Side to Side: ±5° to 26 Feet; ±4° to 30 Feet; ±3° to Full Height
	ANSI EXPORT	Same as ANSI USA
	CSA	Lift Up and Drive prevented when Elevated and Tilted beyond the following limits: Front to Back: ±3° to Full Height Side to Side: ±3° to Full Height
	CE	Tilt Lamp energized when Tilted beyond the following limits: Front to Back: ±5° to Full Height Side to Side: ±3° to Full Height
	AUSTRALIA	Same as ANSI USA
33RT 2WD 33RT 4WD	ANSI USA	Lift Up and Drive prevented when Elevated and Tilted beyond the following limits: Front to Back: ±5° to Full Height Side to Side: ±5° to 30 Feet; ±4° to 36 Feet; ±3° to Full Height
	ANSI EXPORT	Same as ANSI USA
	CSA	Lift Up and Drive prevented when Elevated and Tilted beyond the following limits: Front to Back: ±3° to Full Height Side to Side: ±3° to Full Height
	CE	Tilt Lamp energized when Tilted beyond the following limits: Front to Back: ±5° to Full Height Side to Side: ±3° to Full Height
	AUSTRALIA	Same as ANSI USA

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NOTE: *Vehicle Tilt Configuration based on Model and Market Settings*

NOTE: *Bold Italic Numbers indicate the default setting. Plain text indicates another available selection. Bold, Italic underlined numbers indicate the default when the option is factory installed.*

3394RT 2WD																			
	MODEL NUMBER	ENGINE	MARKET	TILT CUTOUT		GLOW PLUG								LEVELING JACKS		POWER DECK			
ANSI USA	***0***	***4***	***0***	X	***1***	0	1	2	3	4	***5***	6	7	***0***	1	***0***	1	2	
ANSI EXPORT	***0***	***4***	***1***	X	***1***	0	1	2	3	4	***5***	6	7	***0***	1	***0***	1	2	
CSA	***0***	***4***	***2***	X	***1***	0	1	2	3	4	***5***	6	7	***0***	1	***0***	1	2	
CE	***0***	***4***	***3***	***0***	1	0	1	2	3	4	***5***	6	7	***0***	1	***0***	1	2	
AUSTRALIA	***0***	***4***	***4***	X	***1***	0	1	2	3	4	***5***	6	7	***0***	1	***0***	1	2	

3394RT 2WD															
	GENERATOR			FUNCTION CUTOUT			LOAD			GROUND ALARM			ENGINE SHUTDOWN		
ANSI USA	***0***	1	2	***0***	1	2	***0***	X	X	0	1	***2***	0	***1***	
ANSI EXPORT	***0***	1	2	***0***	1	2	0	***1***	2	0	1	***2***	0	***1***	
CSA	***0***	1	2	***0***	1	2	***0***	X	X	0	1	***2***	0	***1***	
CE	***0***	1	2	***0***	1	2	0	***1***	2	***0***	1	2	0	***1***	
AUSTRALIA	***0***	1	2	***0***	1	2	***0***	X	2	X	X	***2***	0	***1***	

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NOTE: *.Bold Italic Numbers indicate the default setting. Plain text indicates another available selection. Bold, Italic underlined numbers indicate the default when the option is factory installed.*

3394RT 4WD																			
	MODEL NUMBER	ENGINE	MARKET	TILT CUTOUT		GLOW PLUG								LEVELING JACKS		POWER DECK			
ANSI USA	***1***	***4***	***0***	X	***1***	0	1	2	3	4	***5***	6	7	***0***	1	***0***	1	2	
ANSI EXPORT	***1***	***4***	***1***	X	***1***	0	1	2	3	4	***5***	6	7	***0***	1	***0***	1	2	
CSA	***1***	***4***	***2***	X	***1***	0	1	2	3	4	***5***	6	7	***0***	1	***0***	1	2	
CE	***1***	***4***	***3***	***0***	1	0	1	2	3	4	***5***	6	7	***0***	1	***0***	1	2	
AUSTRALIA	***1***	***4***	***4***	X	***1***	0	1	2	3	4	***5***	6	7	***0***	1	***0***	1	2	

3394RT 4WD															
	GENERATOR			FUNCTION CUTOUT			LOAD			GROUND ALARM			ENGINE SHUTDOWN		
ANSI USA	***0***	1	2	***0***	1	2	***0***	X	X	0	1	***2***	0	***1***	
ANSI EXPORT	***0***	1	2	***0***	1	2	0	***1***	2	0	1	***2***	0	***1***	
CSA	***0***	1	2	***0***	1	2	***0***	X	X	0	1	***2***	0	***1***	
CE	***0***	1	2	***0***	1	2	0	***1***	2	***0***	1	2	0	***1***	
AUSTRALIA	***0***	1	2	***0***	1	2	***0***	X	2	X	X	***2***	0	***1***	

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NOTE: *Bold Italic Numbers indicate the default setting. Plain text indicates another available selection. Bold, Italic underlined numbers indicate the default when the option is factory installed.*

4394RT 2WD																			
	MODEL NUMBER	ENGINE	MARKET	TILT CUTOUT		GLOW PLUG								LEVELING JACKS		POWER DECK			
ANSI USA	***2***	***4***	***0***	X	***1***	0	1	2	3	4	***5***	6	7	***0***	1	***0***	1	2	
ANSI EXPORT	***2***	***4***	***1***	X	***1***	0	1	2	3	4	***5***	6	7	***0***	1	***0***	1	2	
CSA	***2***	***4***	***2***	X	***1***	0	1	2	3	4	***5***	6	7	***0***	1	***0***	1	2	
CE	***2***	***4***	***3***	***0***	1	0	1	2	3	4	***5***	6	7	***0***	1	***0***	1	2	
AUSTRALIA	***2***	***4***	***4***	X	***1***	0	1	2	3	4	***5***	6	7	***0***	1	***0***	1	2	

4394RT 2WD															
	GENERATOR			FUNCTION CUTOUT			LOAD			GROUND ALARM			ENGINE SHUTDOWN		
ANSI USA	***0***	1	2	***0***	1	2	***0***	X	X	0	1	***2***	0	***1***	
ANSI EXPORT	***0***	1	2	***0***	1	2	0	***1***	2	0	1	***2***	0	***1***	
CSA	***0***	1	2	***0***	1	2	***0***	X	X	0	1	***2***	0	***1***	
CE	***0***	1	2	***0***	1	2	0	***1***	2	***0***	1	2	0	***1***	
AUSTRALIA	***0***	1	2	***0***	1	2	***0***	X	2	X	X	***2***	0	***1***	

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NOTE: *Bold Italic Numbers indicate the default setting. Plain text indicates another available selection. Bold, Italic underlined numbers indicate the default when the option is factory installed.*

4394RT 4WD																			
	MODEL NUMBER	ENGINE	MARKET	TILT CUTOUT		GLOW PLUG								LEVELING JACKS		POWER DECK			
ANSI USA	***3***	***4***	***0***	X	***1***	0	1	2	3	4	***5***	6	7	***0***	1	***0***	1	2	
ANSI EXPORT	***3***	***4***	***1***	X	***1***	0	1	2	3	4	***5***	6	7	***0***	1	***0***	1	2	
CSA	***3***	***4***	***2***	X	***1***	0	1	2	3	4	***5***	6	7	***0***	1	***0***	1	2	
CE	***3***	***4***	***3***	***0***	1	0	1	2	3	4	***5***	6	7	***0***	1	***0***	1	2	
AUSTRALIA	***3***	***4***	***4***	X	***1***	0	1	2	3	4	***5***	6	7	***0***	1	***0***	1	2	

4394RT 4WD															
	GENERATOR			FUNCTION CUTOUT			LOAD			GROUND ALARM			ENGINE SHUTDOWN		
ANSI USA	***0***	1	2	***0***	1	2	***0***	X	X	0	1	***2***	0	***1***	
ANSI EXPORT	***0***	1	2	***0***	1	2	0	***1***	2	0	1	***2***	0	***1***	
CSA	***0***	1	2	***0***	1	2	***0***	X	X	0	1	***2***	0	***1***	
CE	***0***	1	2	***0***	1	2	0	***1***	2	***0***	1	2	0	***1***	
AUSTRALIA	***0***	1	2	***0***	1	2	***0***	X	2	X	X	***2***	0	***1***	

4150390 J

NOTES:

SECTION 6. GENERAL ELECTRICAL INFORMATION & SCHEMATICS

6.1 GENERAL

This section contains schematics to be used for locating and correcting most of the operating problems which may develop. If a problem should develop which is not presented in this section or which is not corrected by listed corrective actions, technically qualified guidance should be obtained before proceeding with any maintenance.

6.2 MULTIMETER BASICS

A wide variety of multimeters or Volt Ohm Meters (VOM) can be used for troubleshooting your equipment. A digital meter with reasonable accuracy (within 7%) is recommended for the measurements in these procedures. This section shows diagrams of a common, digital VOM configured for several different circuit measurements. Instructions for your VOM may vary. Please consult the meter operator's manual for more information.

Grounding

"Grounding the meter" means to take the black lead (which is connected to the COM (common) or negative port) and touch it to a good path to the negative side of the voltage source.

Backprobing

To "backprobe" means to take the measurement by accessing a connector's contact on the same side as the wires, the back of the connector. Readings can be done while maintaining circuit continuity this way. If the connector is the sealed type, great care must be taken to avoid damaging the seal around the wire. It is best to use probes or probe tips specifically designed for this technique, especially on sealed connectors. Whenever possible insert probes into the side of the connector such that the test also checks both terminals of the connection. It is possible to inspect a connection within a closed connector by backprobing both sides of a connector terminal and measuring resistance. Do this after giving each wire a gentle pull to ensure the wires are still attached to the contact and contacts are seated in the connector.

Min/Max

Use of the "Min/Max" recording feature of some meters can help when taking measurements of intermittent conditions while alone. For example, you can read the voltage applied to a solenoid when it is only operational while a switch, far from the solenoid and meter, is held down.

Polarity

Finding a negative voltage or current reading when expecting a positive reading frequently means the leads are reversed. Check what reading is expected, the location of the signal and that the leads are connected to the device under test correctly. Also check that the lead on the "COM" port goes to the ground or negative side of the signal and the lead on the other port goes to the positive side of the signal.

Scale

M = Mega = 1,000,000 * (Displayed Number)

k = kilo = 1,000 * (Displayed Number)

m = milli = (Displayed Number) / 1,000

μ = micro = (Displayed Number) / 1,000,000

Example: 1.2 kΩ = 1200 Ω

Example: 50 mA = 0.05 A

Voltage Measurement

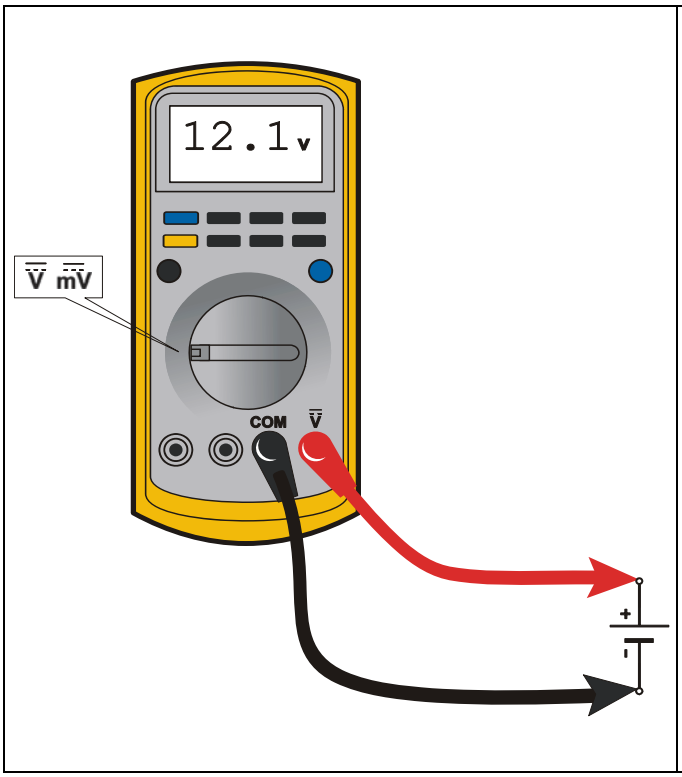

Figure 6-1. Voltage Measurement (DC)

- If meter is not auto ranging, set it to the correct range (See multimeter's operation manual)
- Use firm contact with meter leads

Resistance Measurement

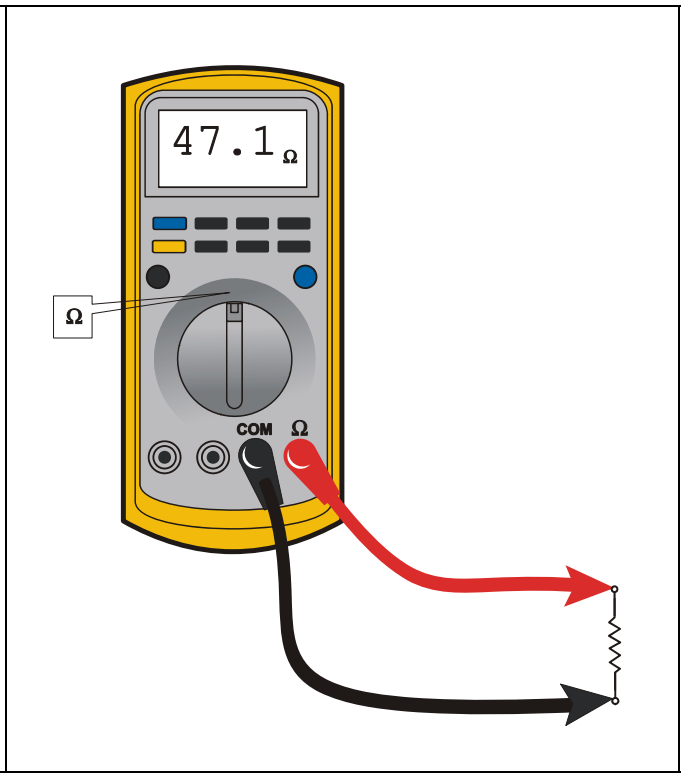

Figure 6-2. Resistance Measurement

- First test meter and leads by touching leads together. Resistance should read a short circuit (very low resistance)
- Circuit power must be turned OFF before testing resistance
- Disconnect component from circuit before testing
- If meter is not auto ranging, set it to the correct range (See multimeter's operation manual)
- Use firm contact with meter leads

Continuity Measurement

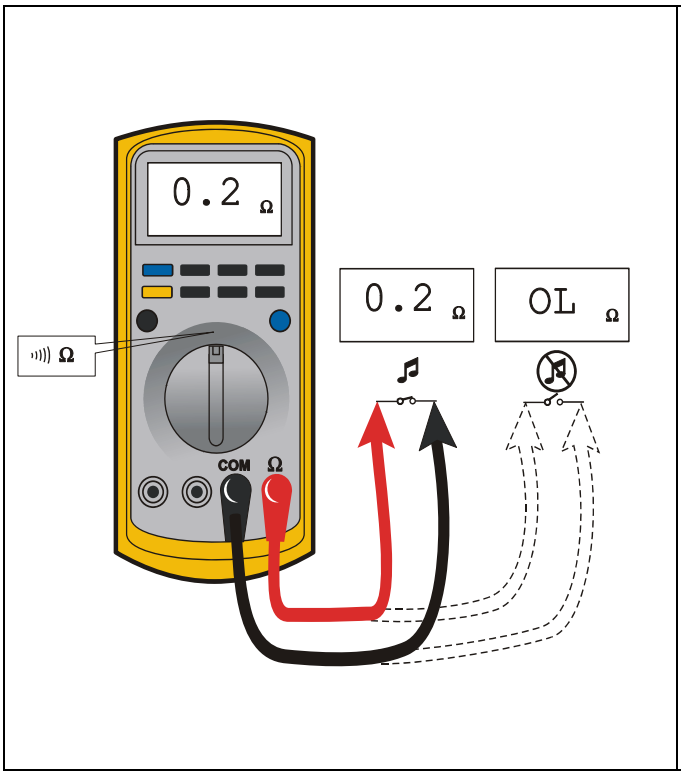

Figure 6-3. Continuity Measurement

- Some meters require a separate button press to enable audible continuity testing
- Circuit power must be turned OFF before testing continuity
- Disconnect component from circuit before testing
- Use firm contact with meter leads
- First test meter and leads by touching leads together. Meter should produce an audible alarm, indicating continuity

Current Measurement

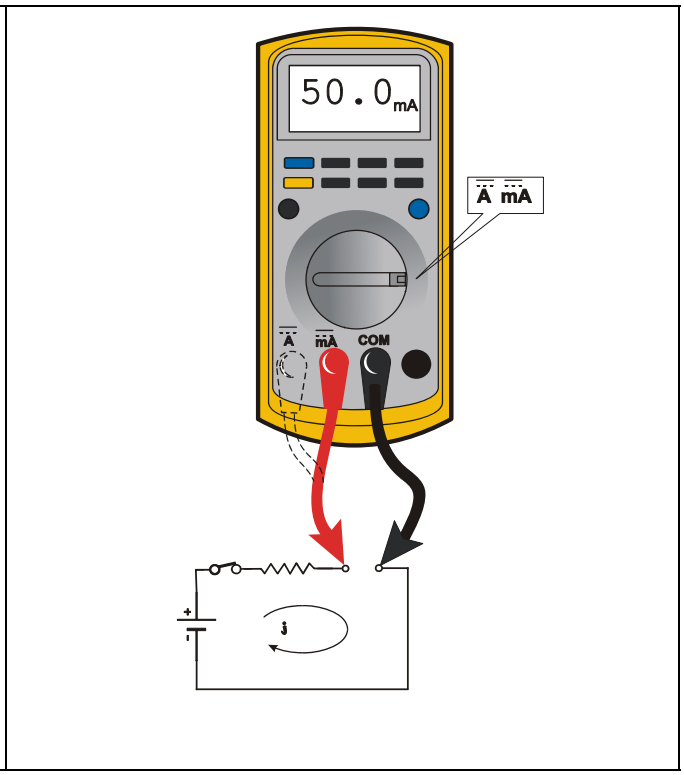

Figure 6-4. Current Measurement (DC)

- Set up the meter for the expected current range
- Be sure to connect the meter leads to the correct jacks for the current range you have selected
- If meter is not auto ranging, set it to the correct range (See multi meter's operation manual)
- Use firm contact with meter leads

Continuity Measurement Over Long Distances

When trying to determine continuity of a harness or wire, longer than the reach of standard instrument leads, is possible to perform the check without excessively long leads. Using the other wires in the harness one can determine the condition of a particular wire in the harness.

Requirements:

- Harness with at least three separate wires including the wire under test.
- These wires must be able to be isolated from other wires, etc.
- Jumper or method to connect contacts on one side of harness.
- Meter that can measure resistance or continuity.

Procedure

Test multimeter leads resistance. Subtract this value from the measured resistance of the wires to get a more accurate measurement.

Consult the circuit schematic to determine which wires to use in addition to wire under test, here called wire #1 and wire #2, and how to isolate these wires. These wires should appear in the same connectors as the wire under test or are within reach of the jumper.

1. Disconnect all connections associated with the wire under test and the two additional wires. If harness is not completely isolated disconnect battery terminals also, as a precaution.
2. Measure continuity between all three wires, the wire under test, wire #1 and wire #2. These should be open. If not, repair the shorted wires or replace the harness.
3. On one side, jumper from contact of wire #1 and wire #2.
4. Measure continuity between wire #1 and wire #2. If there is continuity, both wires are good and can be used for this test. If there is not continuity, either wire could be bad. Check connections and measurement setup. Redo measurement. If still no continuity, repair wires or consult schematic for other wires to use for test.
5. Jumper from wire under test to wire #1.
6. Measure continuity. If there is continuity, the wire under test is good. Resistance of a wire increases as the length increases and as the diameter decreases.

One can find the continuity of two wires, here #1 and #2, at once by following steps 1 through 4. If there is a problem the third wire is used to troubleshoot the other wires. To find the problem, start at step 1 and use the entire procedure.

6.3 APPLYING SILICONE DIELECTRIC COMPOUND TO AMP CONNECTORS

Silicone Dielectric Compound must be used on the AMP connections for the following reasons:

- To prevent oxidation at the mechanical joint between male and female pins.
- To prevent electrical malfunction caused by low level conductivity between pins when wet.

Use the following procedure to apply Silicone Dielectric Compound to the electrical connectors.

1. To prevent oxidation and low level conductivity, silicone dielectric grease must be packed completely around male and female pins on the inside of the connector after the mating of the housing to the header. This is easily achieved by using a syringe to fill the header with silicone dielectric compound, to a point just above the top of the male pins inside the header. When assembling the housing to the header, it is possible that the housing will become air locked, thus preventing the housing latch from engaging.
2. Pierce one of the unused wire seals to allow the trapped air inside the housing to escape.
3. Install a hole plug into this and/or any unused wire seal that has silicone dielectric compound escaping from it.

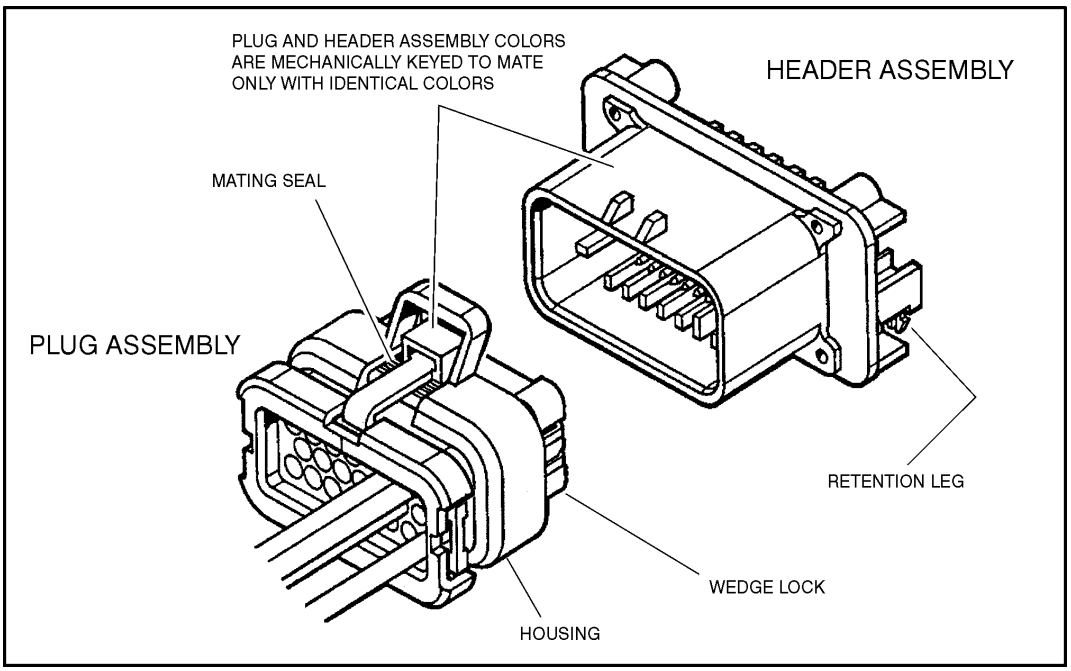

Figure 6-5. AMP Connector

Assembly

Check to be sure the wedge lock is in the open, or as-shipped, position (See Figure 6-6. Connector Assembly (1 of 4)). Proceed as follows:

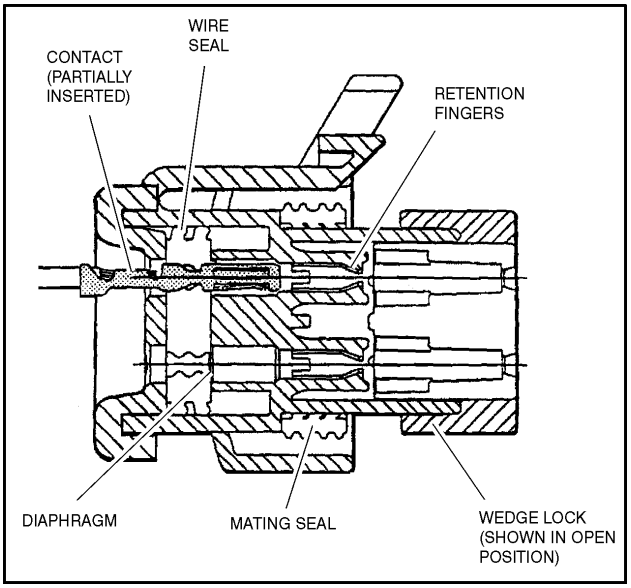

Figure 6-6. Connector Assembly (1 of 4)

1. To insert a contact, push it straight into the appropriate circuit cavity as far as it will go (See Figure 6-7. Connector Assembly (2 of 4)).
2. Pull back on the contact wire with a force of 1 or 2 lbs. to be sure the retention fingers are holding the contact (See Figure 6-7. Connector Assembly (2 of 4)).
3. After all required contacts have been inserted, the wedge lock must be closed to its locked position. Release the locking latches by squeezing them inward (See Figure 6-8. Connector Assembly (3 of 4)).
4. Slide the wedge lock into the housing until it is flush with the housing (See Figure 6-9. Connector Assembly (4 of 4)).

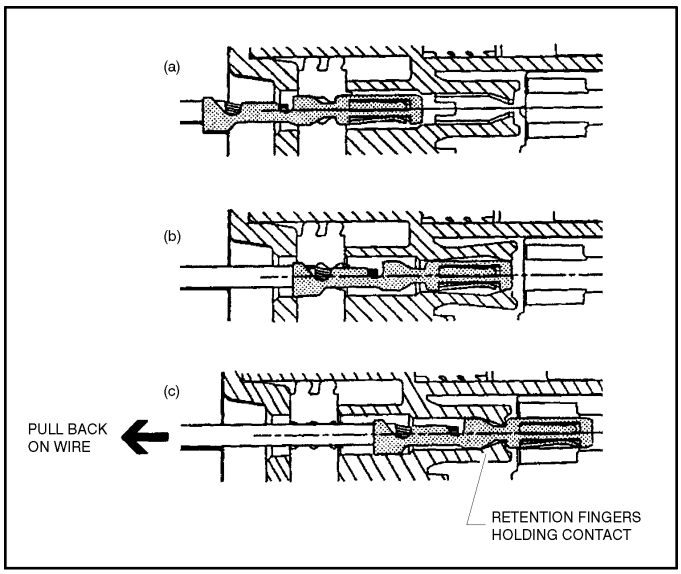

Figure 6-7. Connector Assembly (2 of 4)

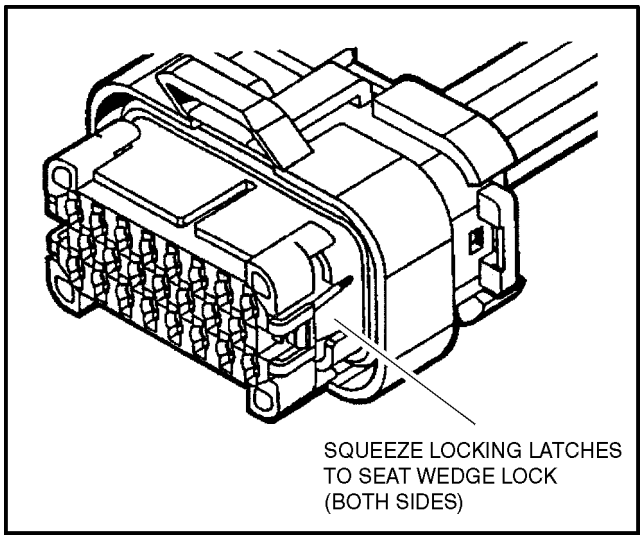

Figure 6-8. Connector Assembly (3 of 4)

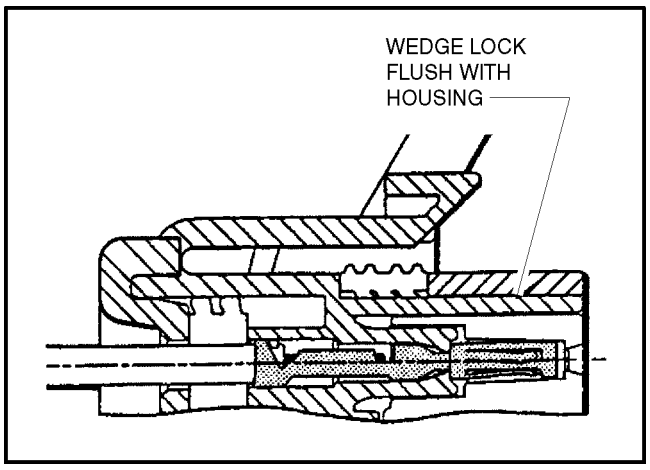

Figure 6-9. Connector Assembly (4 of 4)

Disassembly

5. Insert a 4.8 mm (3/16”) wide screwdriver blade between the mating seal and one of the red wedge lock tabs.
6. Pry open the wedge lock to the open position.
7. While rotating the wire back and forth over a half turn (1/4 turn in each direction), gently pull the wire until the contact is removed.

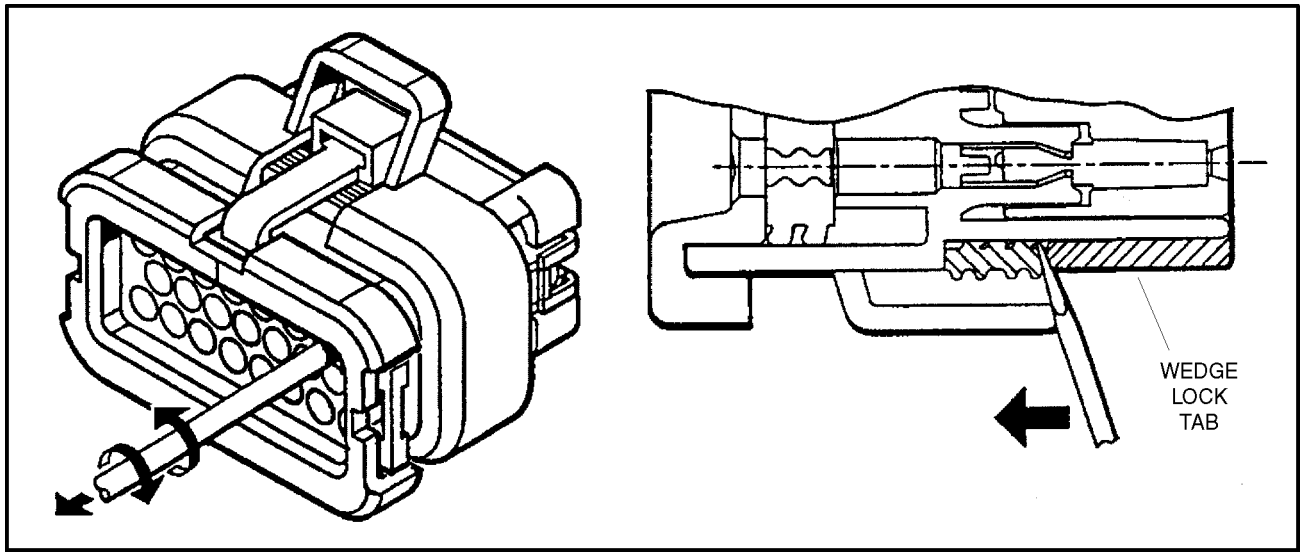

Figure 6-10. Connector Disassembly

NOTE: *The wedge lock should never be removed from the housing for insertion or removal of the contacts.*

Wedge Lock

The wedge lock has slotted openings in the forward, or mating end. These slots accommodate circuit testing in the field, by using a flat probe such as a pocket knife. DO NOT use a sharp point such as an ice pick.

Service - Voltage Reading

⚠ CAUTION

DO NOT PIERCE WIRE INSULATION TO TAKE VOLTAGE READINGS.

It has been common practice in electrical troubleshooting to probe wires by piercing the insulation with a sharp point. This practice should be discouraged when dealing with the AMPSEAL plug assembly, or any other sealed connector system. The resulting pinholes in the insulation will allow moisture to invade the system by traveling along the wire strands. This nullifies the effectiveness of the connector seals and could result in system failure.

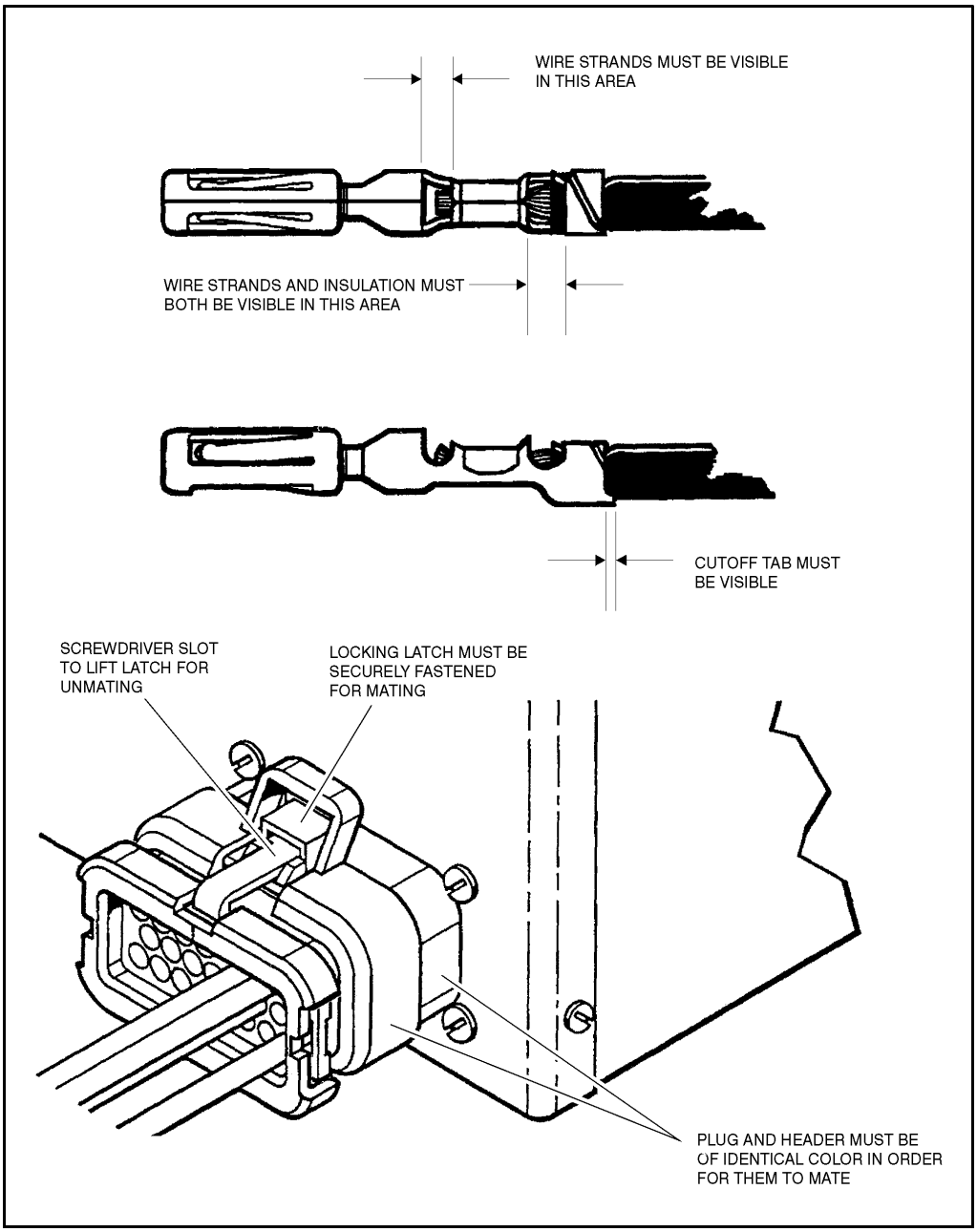

Figure 6-11. Connector Installation

6.4 WORKING WITH DEUTSCH CONNECTORS

DT/DTP Series Assembly

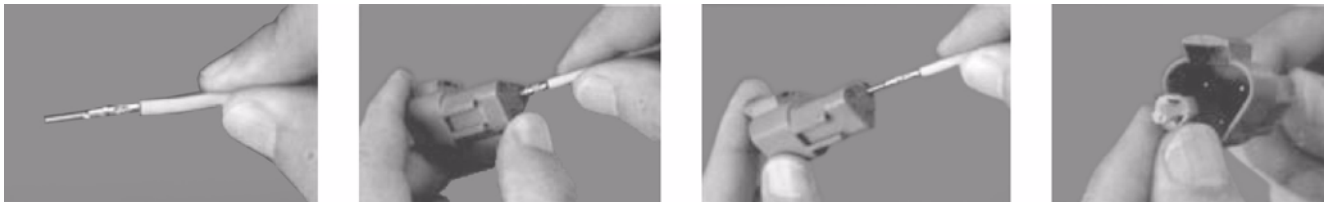

Figure 6-12. DT/DTP Contact Installation

1. Grasp crimped contact about 25mm behind the contact barrel.
2. Hold connector with rear grommet facing you.
3. Push contact straight into connector grommet until a click is felt. A slight tug will confirm that it is properly locked in place.
4. Once all contacts are in place, insert wedgelock with arrow pointing toward exterior locking mechanism. The wedge-lock will snap into place. Rectangular wedges are not oriented. Thy may go in either way.

NOTE: *The receptacle is shown - use the same procedure for plug.*

DT/DTP Series Disassembly

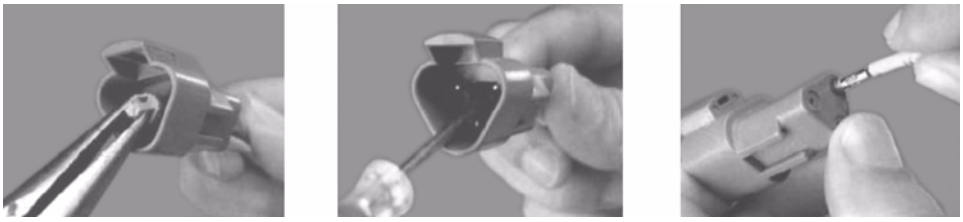

Figure 6-13. DT/DTP Contact Removal

5. Remove wedgelock using needlenose pliers or a hook shaped wire to pull wedge straight out.
6. To remove the contacts, gently pull wire backwards, while at the same time releasing the locking finger by moving it away from the contact with a screwdriver.
7. Hold the rear seal in place, as removing the contact may displace the seal.

HD30/HDP20 Series Assembly

Figure 6-14. HD/HDP Contact Installation

8. Grasp contact about 25mm behind the contact crimp barrel.
9. Hold connector with rear grommet facing you.

10. Push contact straight into connector grommet until a positive stop is felt. A slight tug will confirm that it is properly locked in place.

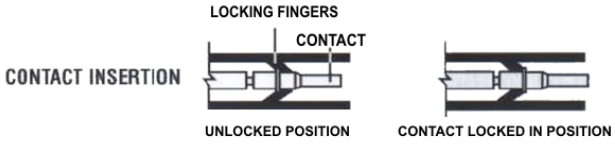

Figure 6-15. HD/HDP Locking Contacts Into Position

NOTE: *For unused wire cavities, insert sealing plugs for full environmental sealing*

HD30/HDP20 Series Disassembly

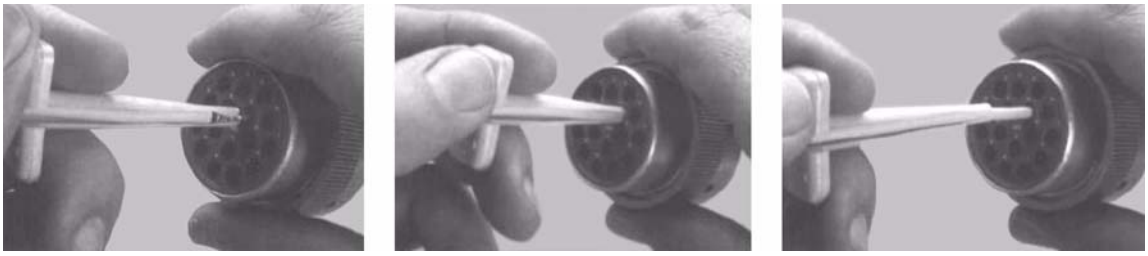

Figure 6-16. HD/HDP Contact Removal

11. With rear insert toward you, snap appropriate size extractor tool over the wire of contact to be removed.
12. Slide tool along into the insert cavity until it engages contact and resistance is felt.
13. Pull contact-wire assembly out of connector.

Figure 6-17. HD/HDP Unlocking Contacts

NOTE: *Do Not twist or insert tool at an angle.*

6.5 SWITCHES

Basic check

The following check determines if the switch is functioning properly, not the circuit in which the switch is placed. A switch is functioning properly when there is continuity between the correct terminals or contacts only when selected.

1. De-energize the circuit.
2. Isolate the switch from the rest of the circuit if possible. If not possible, keep in mind it may affect readings.
3. Access the terminals to the switch.
4. If the switch has two terminals:
   a. Measure resistance across the terminals.
   b. Change the switch position.
   c. Measure resistance again with the leads in the same positions. If the meter was reading short, it should read an open. If the meter was reading open it should read short.
5. If the switch has more than two terminals, consult the schematic or switch diagram to determine what terminals will be connected. The test is similar to testing a switch with two terminals.
   a. Place one meter lead on the common contact and the other on a different contact in the same circuit.
   b. Cycle through all positions of the switch. The meter should read short only when the switch connects the two terminals and open otherwise.
   c. If the switch has more than one common contact repeat the process for that circuit.

Limit Switches

Limit switches are used to control movement or indicate position. Mechanical limit switches are just like manually operated switches except that the moving object operates the switch. These switches can be tested the same way as a standard switch by manually operating the sensing arm.

Another type of limit switch used by JLG is the inductive proximity switch, also referred to as a "prox switch". Inductive proximity switches are actuated only by ferrous metal (metal that contains Iron, such as steel) near the switch. They do not require contact, and must be energized to actuate. These types of switches can be used to detect boom or platform position, for example. These switches have a sensing face where the switch can detect ferrous metal close to it. To find the sensing face, take note how the switch is mounted and how the mechanisms meet the switch. Test this type of switch as follows:

1. Remove prox switch from its mount.
2. Reconnect harness if it was disconnected for step a, and turn on machine.
3. Hold switch away from metal and observe switch state in the control system diagnostics using the Analyzer. See vehicle or control system documentation on how to do this.
4. Place sensing face of switch on the object to be sensed by the switch. If that is not available, use a piece of ferrous metal physically similar to it. The switch state in the control system diagnostics should change.
5. When reinstalling or replacing switch be sure to follow mounting instructions and properly set the gap between the switch and object sensed.

Automatic Switches

If the switch is actuated automatically, by temperature or pressure for example, find a way to manually actuate the switch to test it. Do this either by applying heat or pressure, for example, to the switch. These switches may need to be energized to actuate.

1. Connect instrumentation to monitor and/or control the parameter the switch is measuring.
2. Observe switch state in control system with the Analyzer. See vehicle or control system documentation on how to do this.
3. Operate system such that the switch actuates. This could be going over a certain pressure or temperature, for example. The state indicated in the control system should change.

Switch Wiring - Low Side, High Side

When controlling a load, a switch can be wired between the positive side of the power source and the load. This switch is called a "high side" switch. The switch supplies the power to the load. When a switch is wired between the negative side of the power source and the load, it is a "low side" switch. The switch provides the ground to the load.

A low side switch will allow voltage to be present on the load. No power is applied because the switch is stopping current flow. This voltage can be seen if the measurement is taken with one test lead on the load and the other on the battery negative side or grounded to the vehicle. What is actually being measured is the voltage drop across the switch. This could mislead a technician into thinking the load is receiving power but not operating. To produce an accurate picture of power or voltage applied to the load, measure voltage across the load's power terminals. Also, the technician can measure the voltage at both power terminals with respect to battery ground. The difference between those two measurements is the voltage applied to the load.

6.6 SCHEMATICS

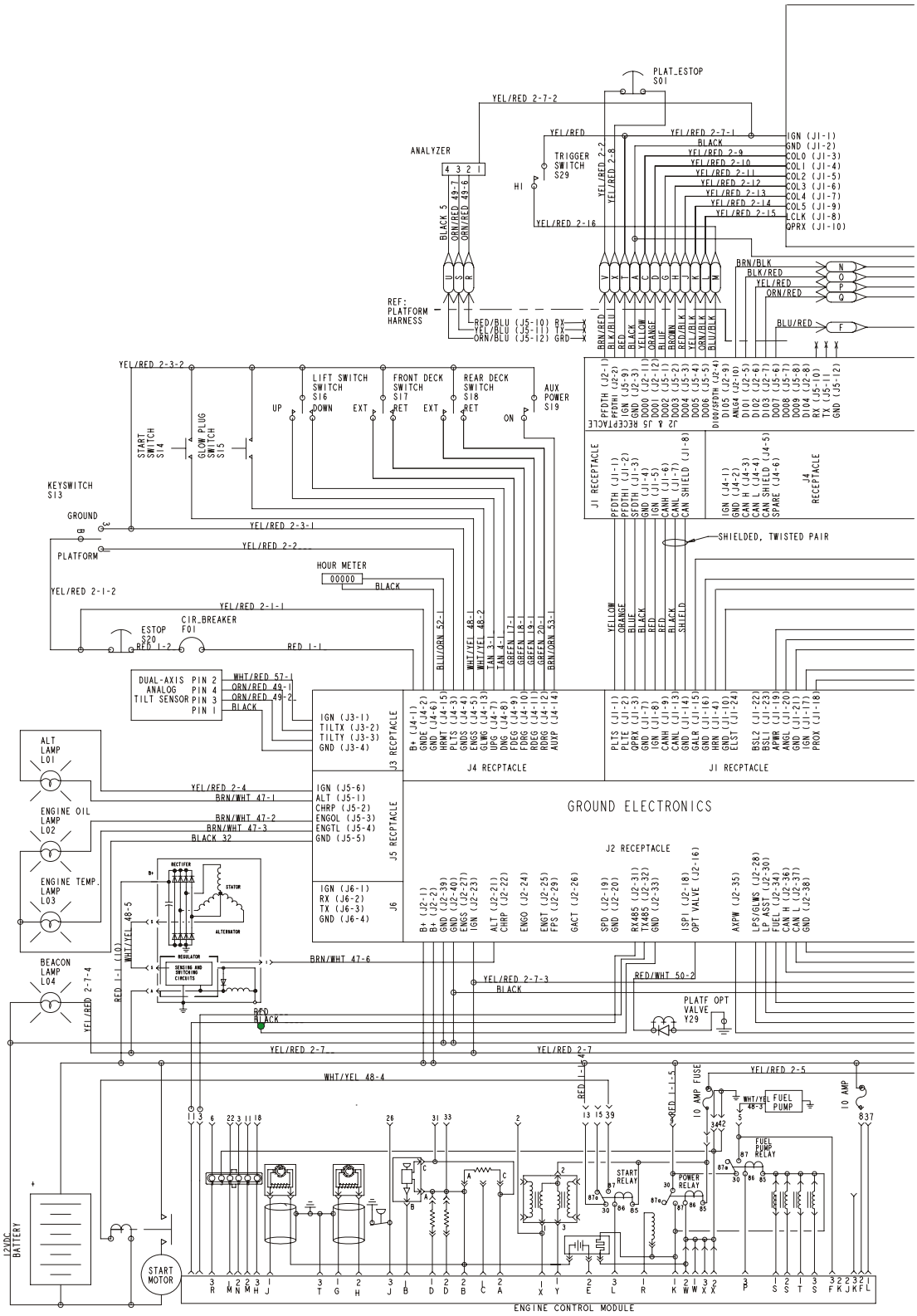

Figure 6-18. Electrical Schematic - Dual Fuel - Sheet 1 of 3

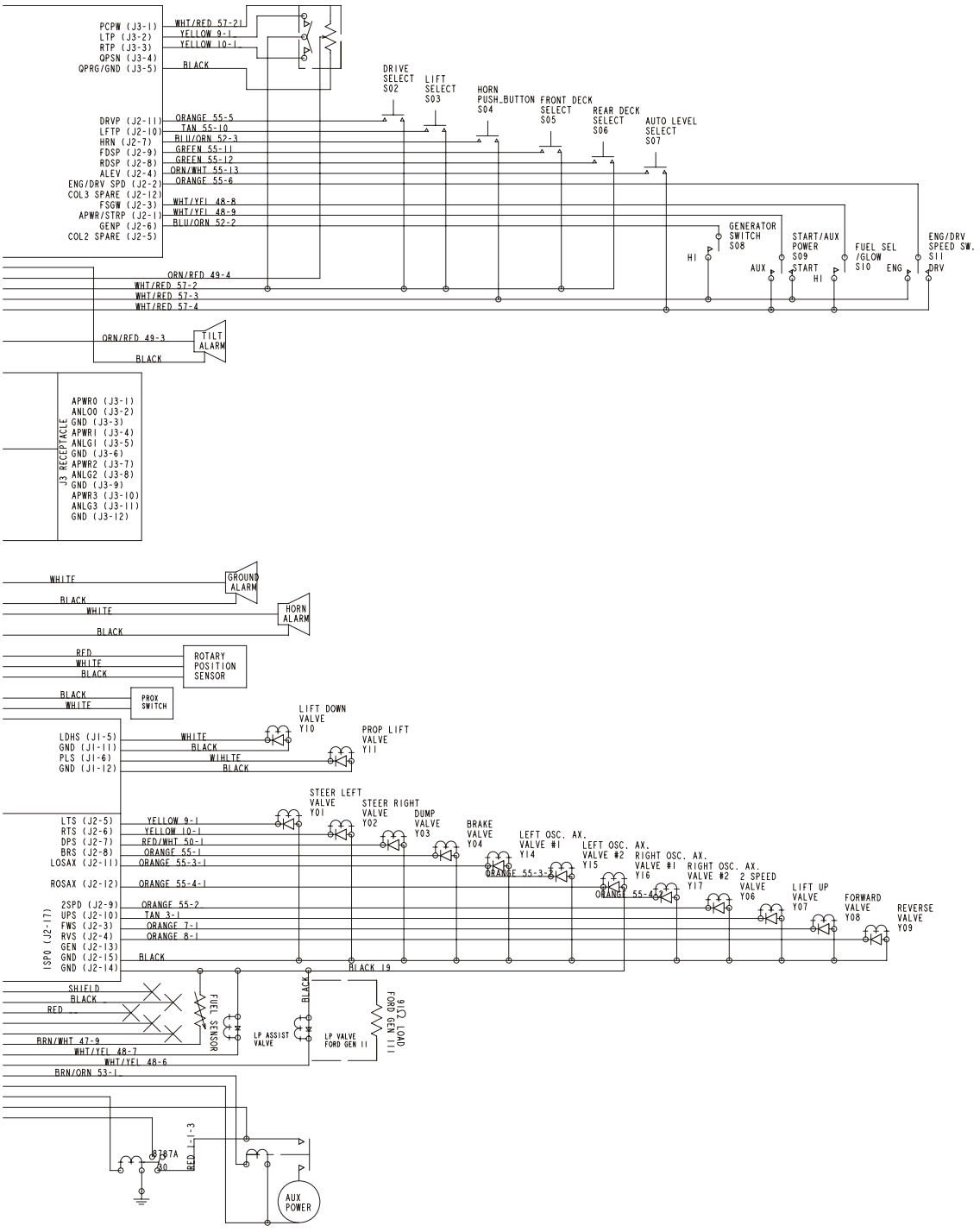

Figure 6-19. Electrical Schematic - Dual Fuel - Sheet 2 of 3

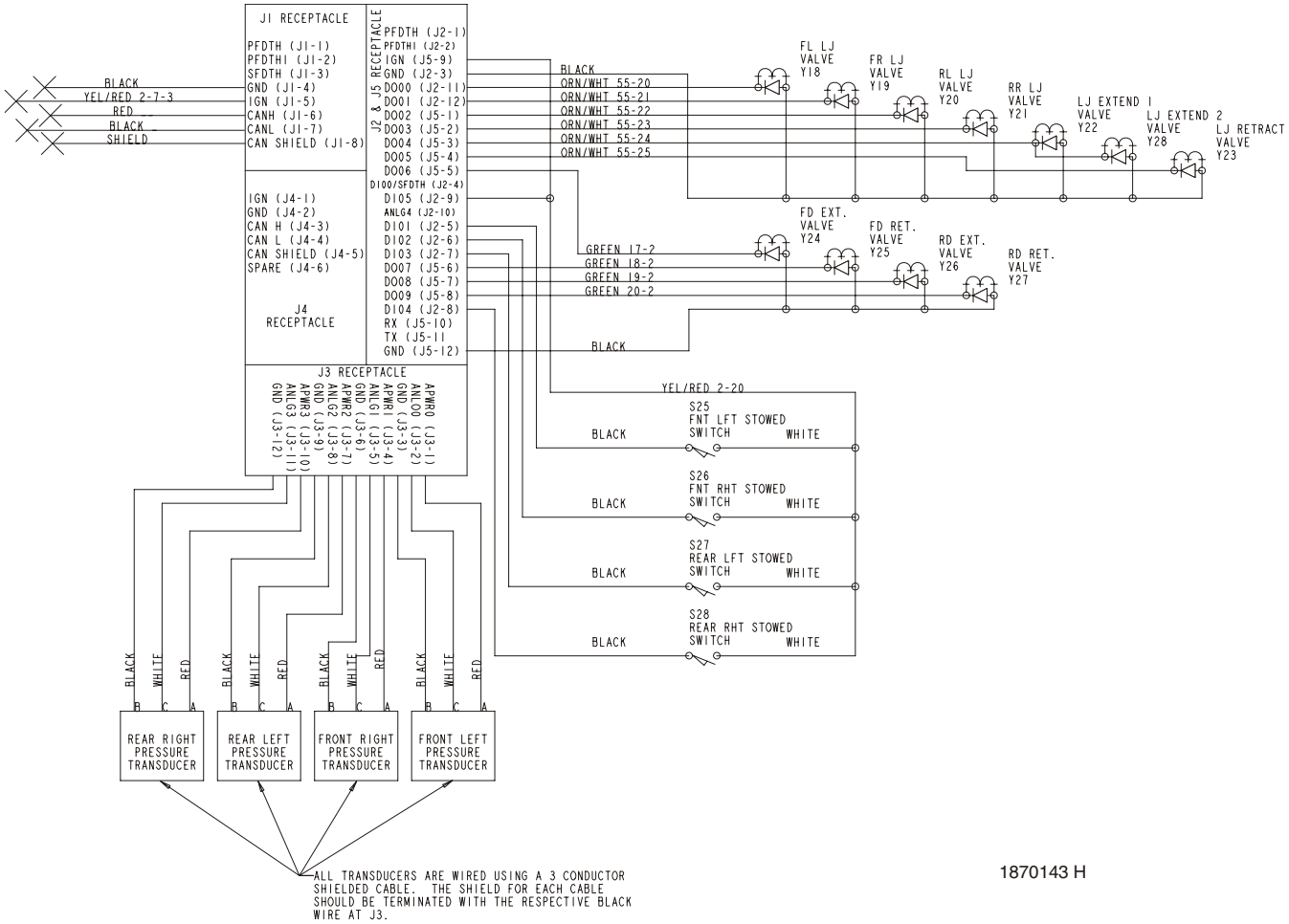

Figure 6-20. Electrical Schematic - Dual Fuel - Sheet 3 of 3

NOTES:

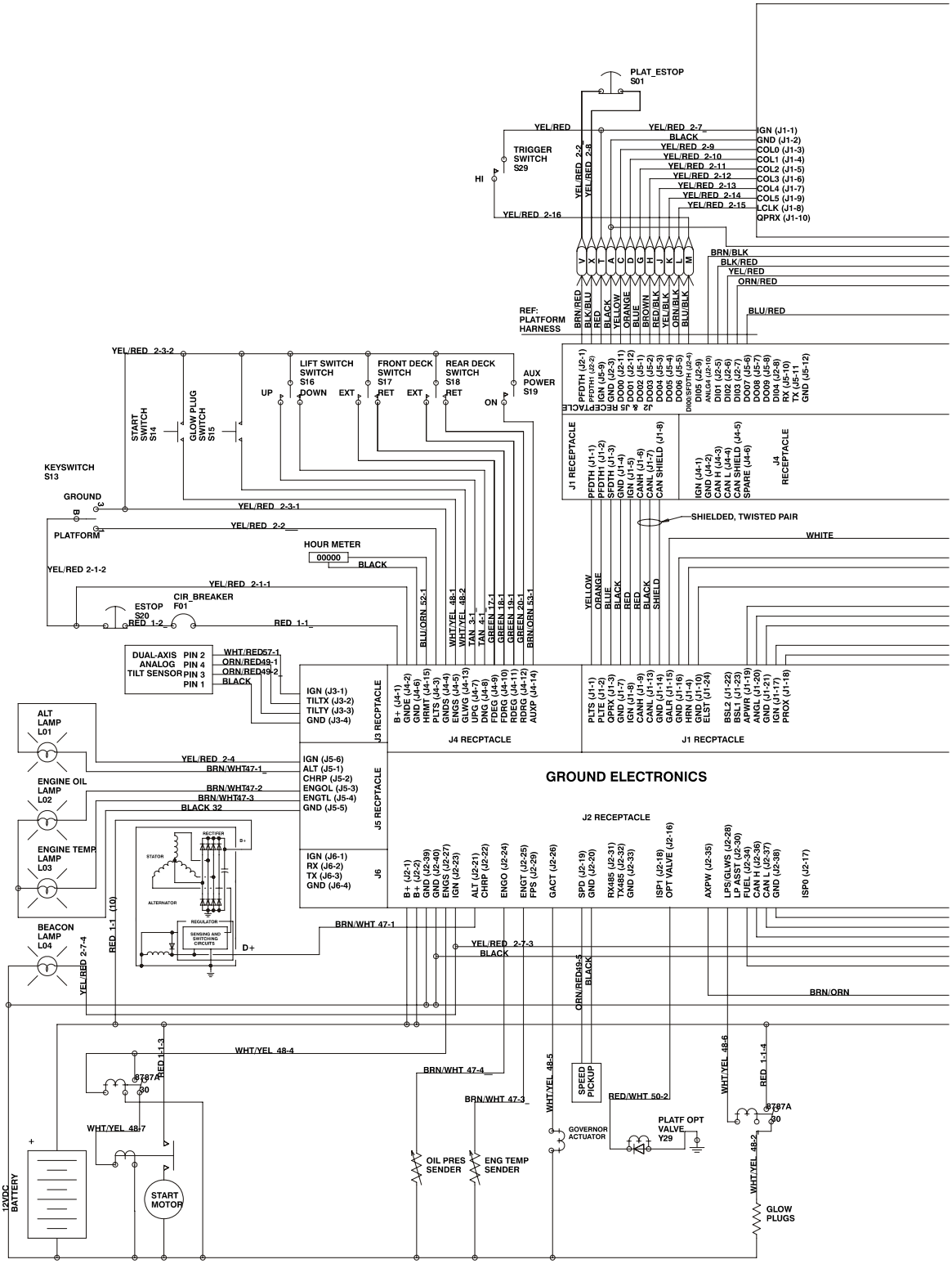

Figure 6-21. Electrical Schematic Diesel (Prior to S/N 138634) - Sheet 1 of 3

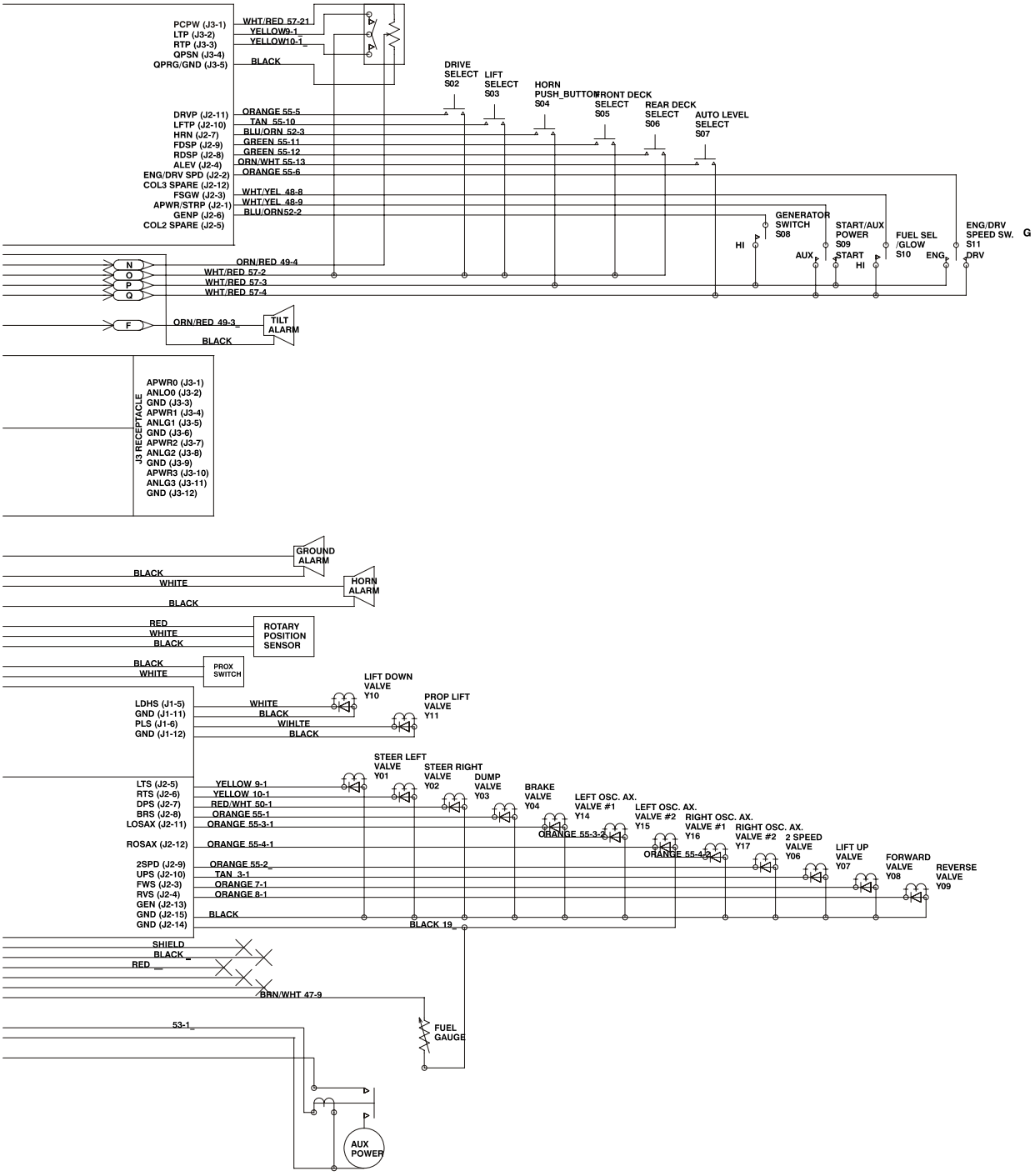

Figure 6-22. Electrical Schematic Diesel (Prior to S/N 138634) - Sheet 2 of 3

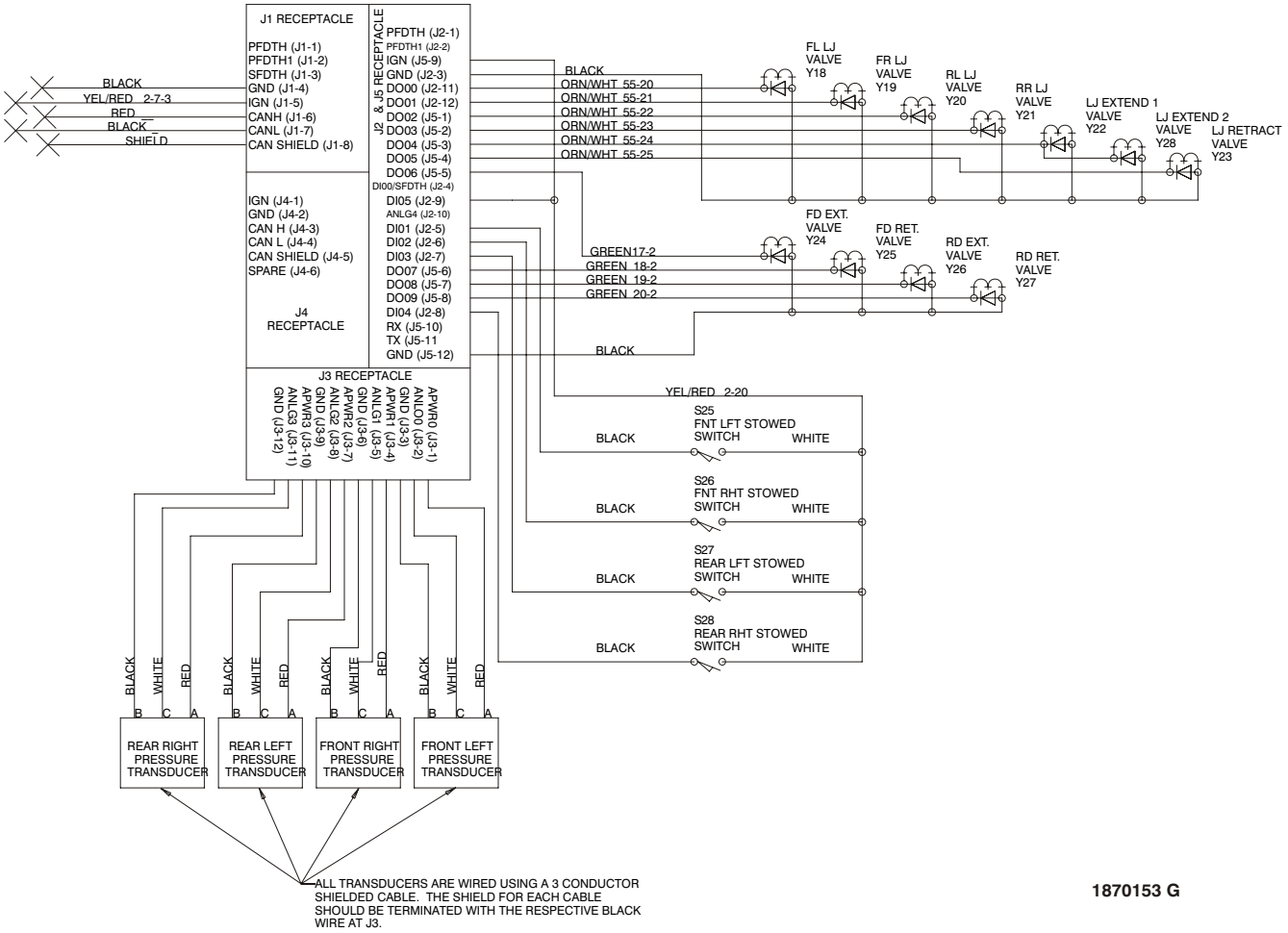

Figure 6-23. Electrical Schematic Diesel (Prior to S/N 138634) - Sheet 3 of 3

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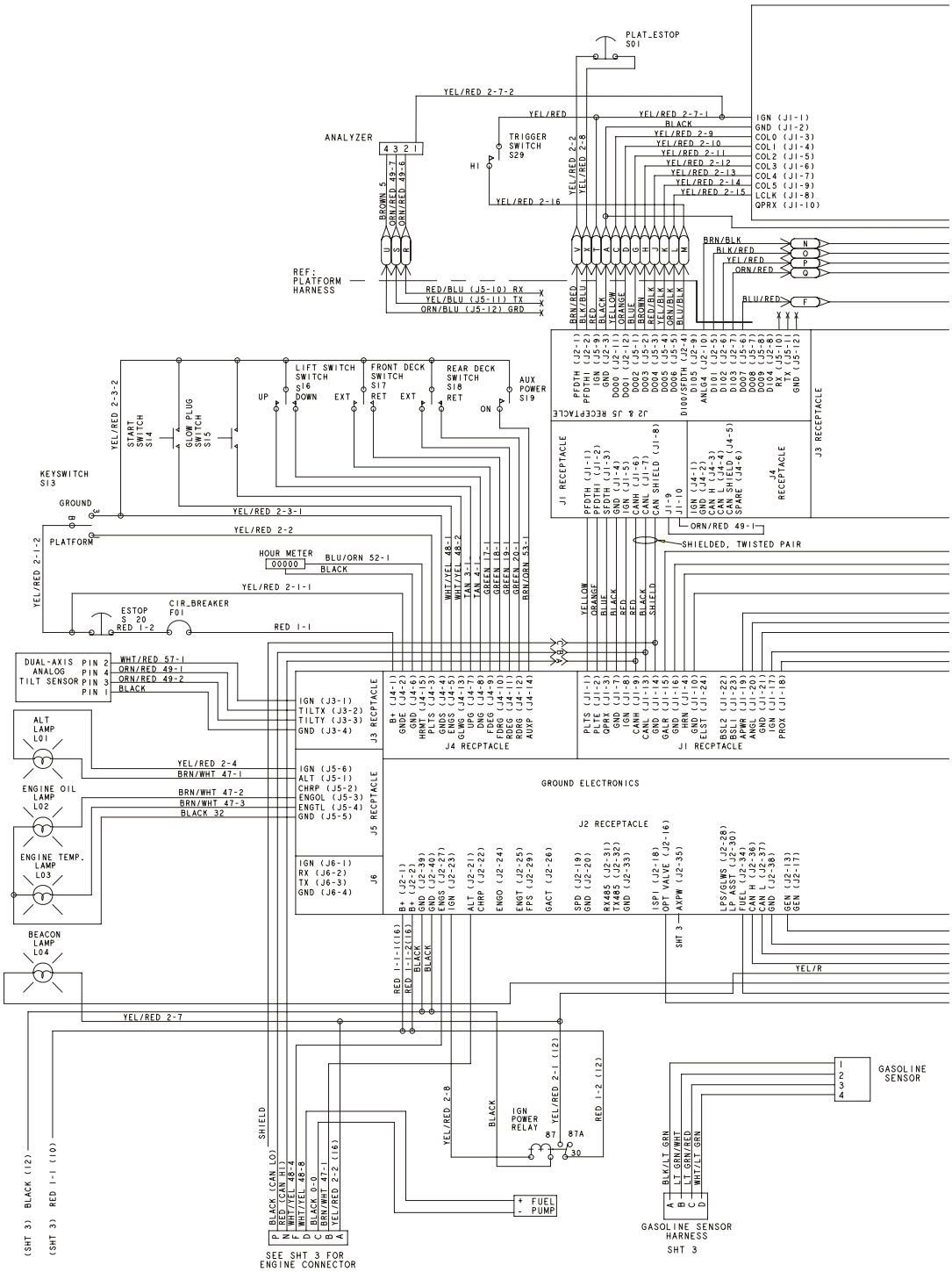

Figure 6-24. Electrical Schematic - Dual Fuel GM - Sheet 1 of 5

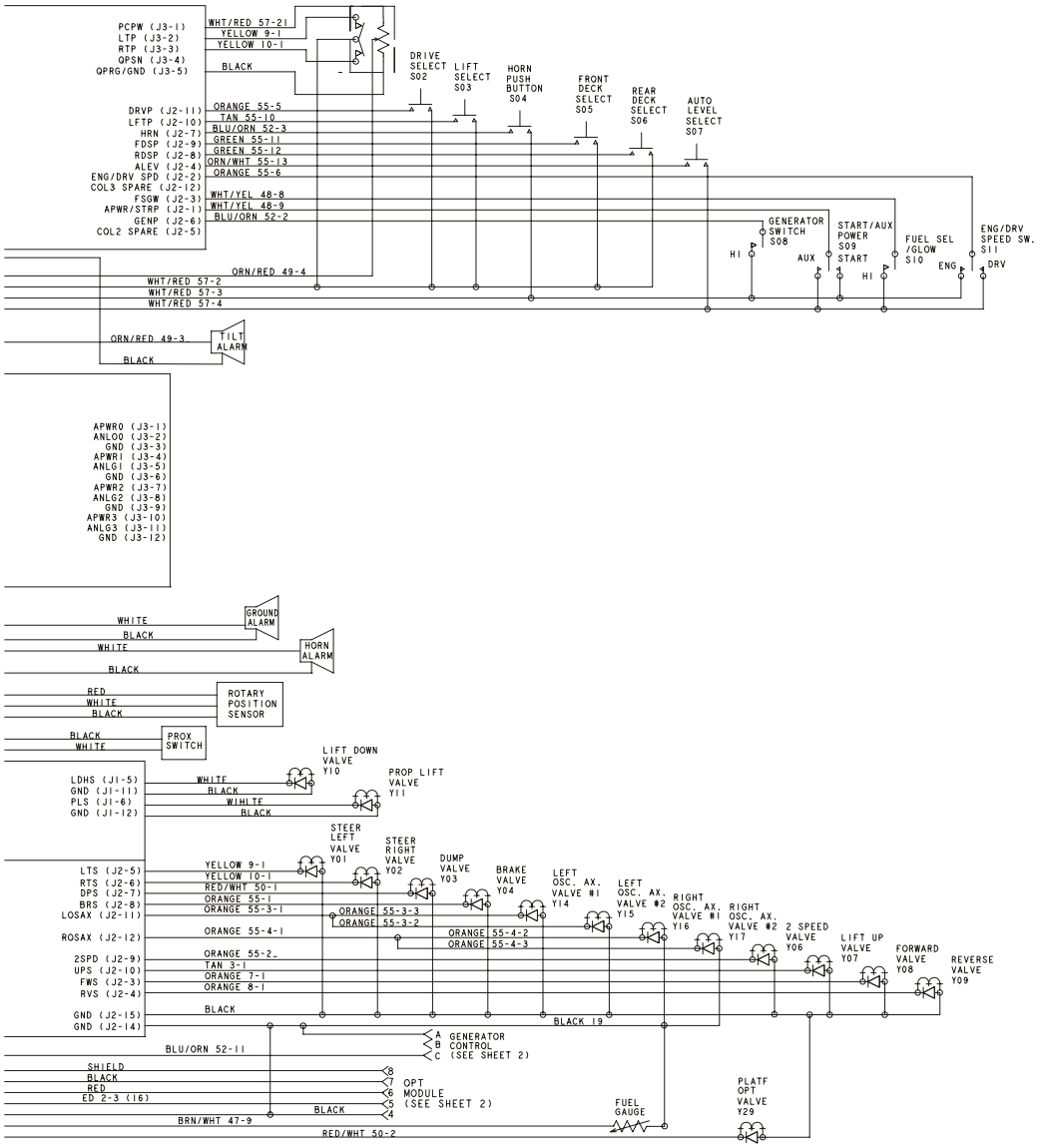

Figure 6-25. Electrical Schematic - Dual Fuel GM - Sheet 2 of 5

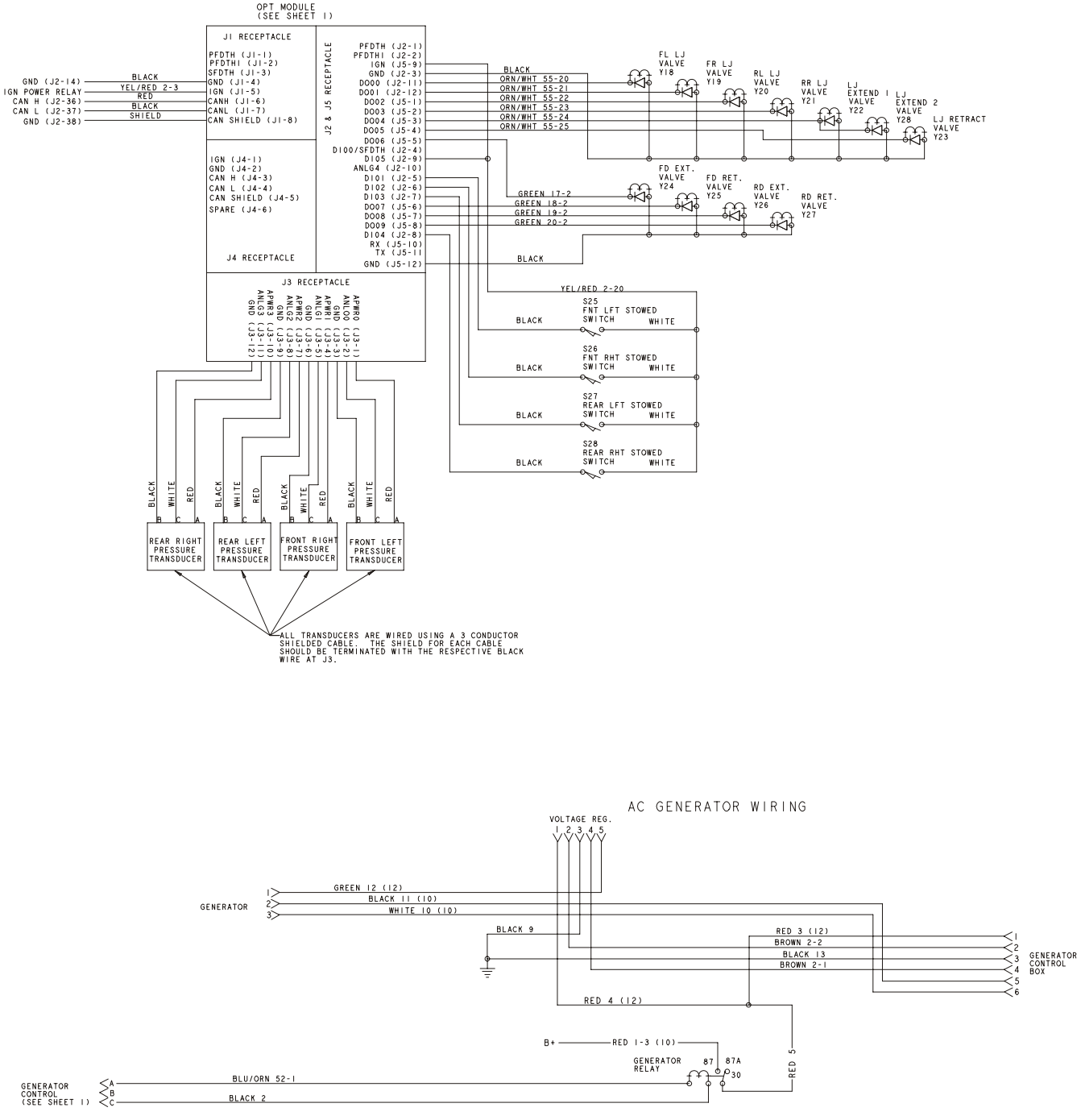

Figure 6-26. Electrical Schematic Dual Fuel - GM - Sheet 3 of 5

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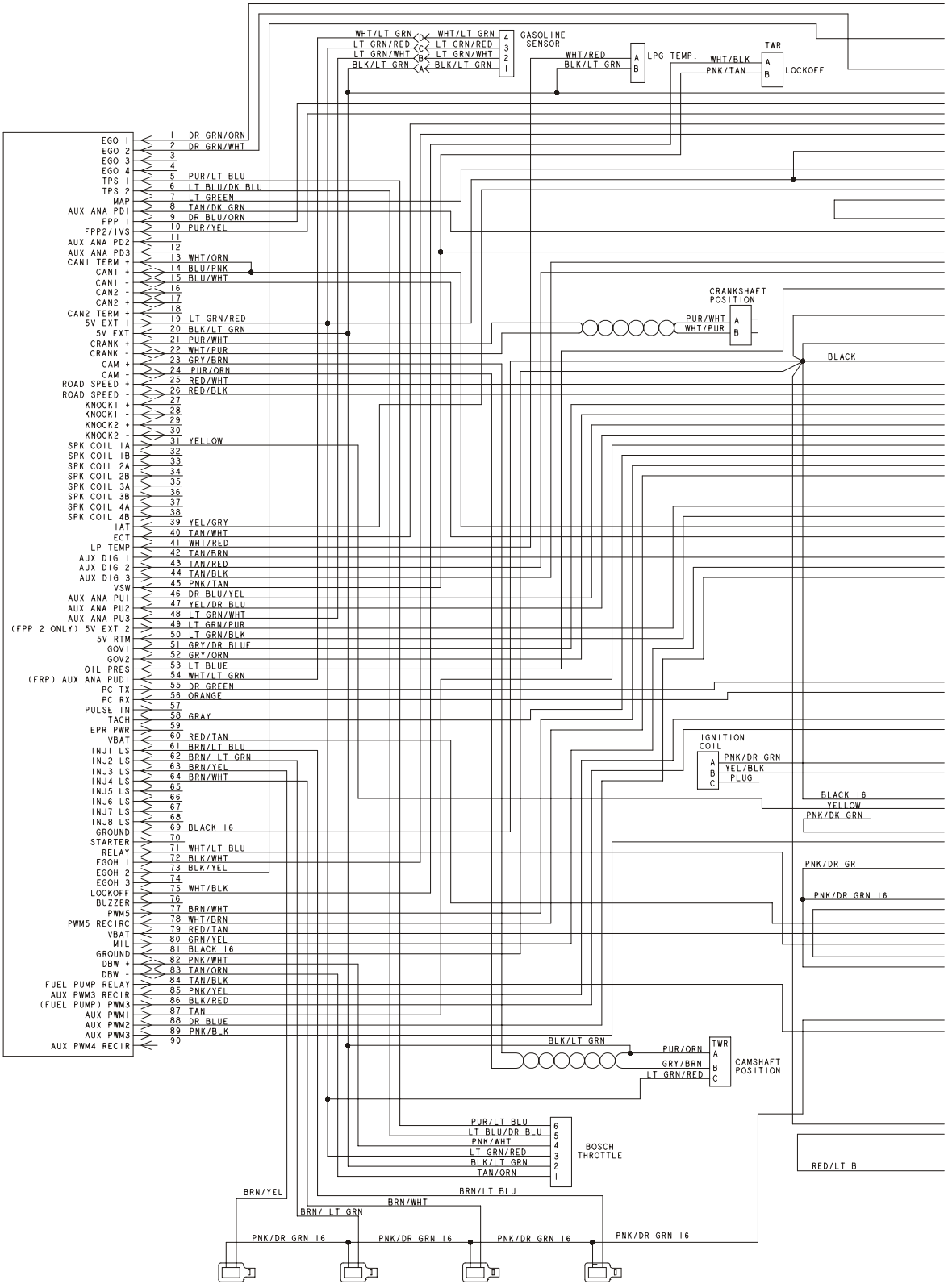

Figure 6-27. Electrical Schematic Dual Fuel - GM - Sheet 4 of 5

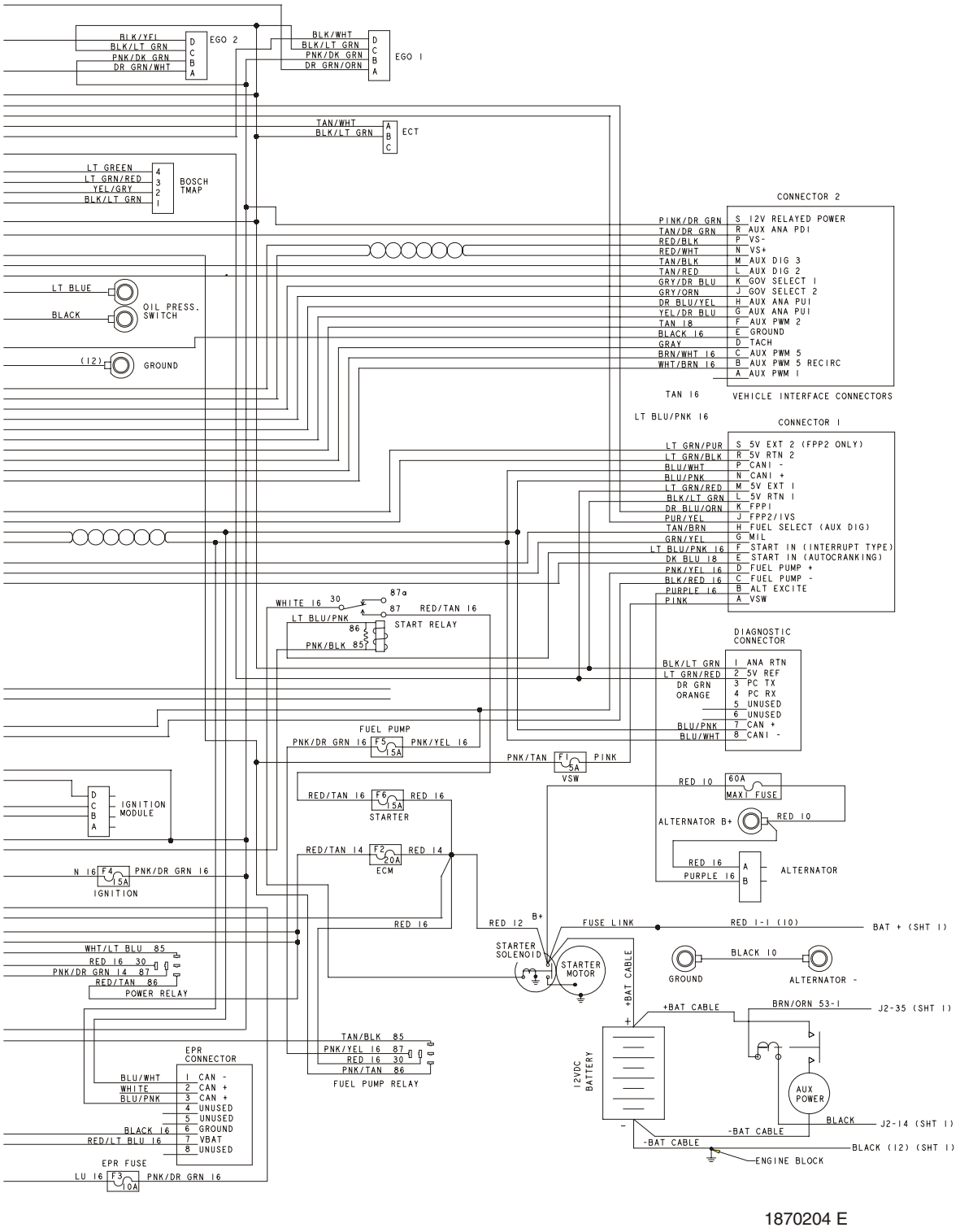

Figure 6-28. Electrical Schematic Dual Fuel - GM - Sheet 5 of 5

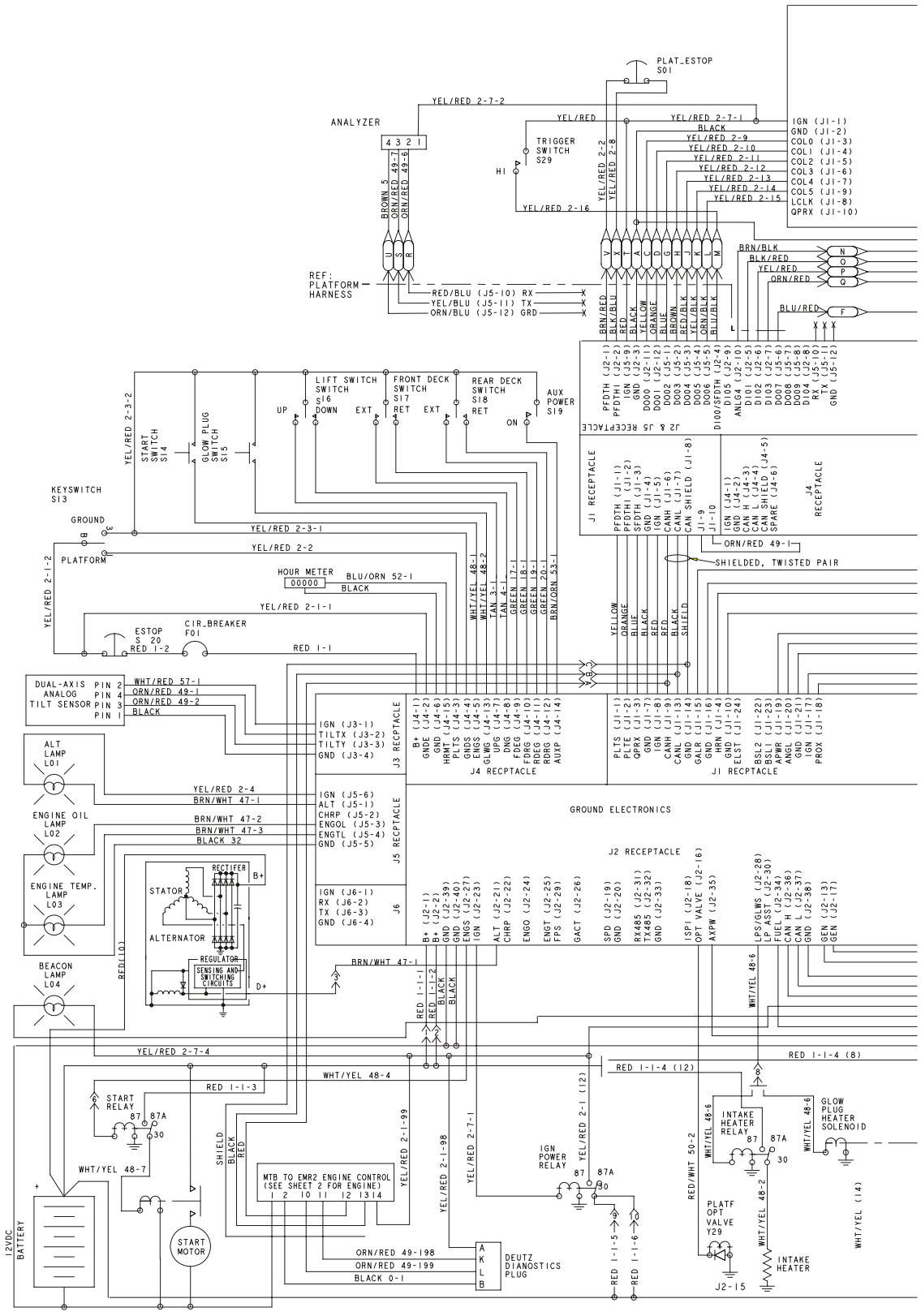

Figure 6-29. Electrical Schematic Diesel (S/N 138634 to Present) - Sheet 1 of 3

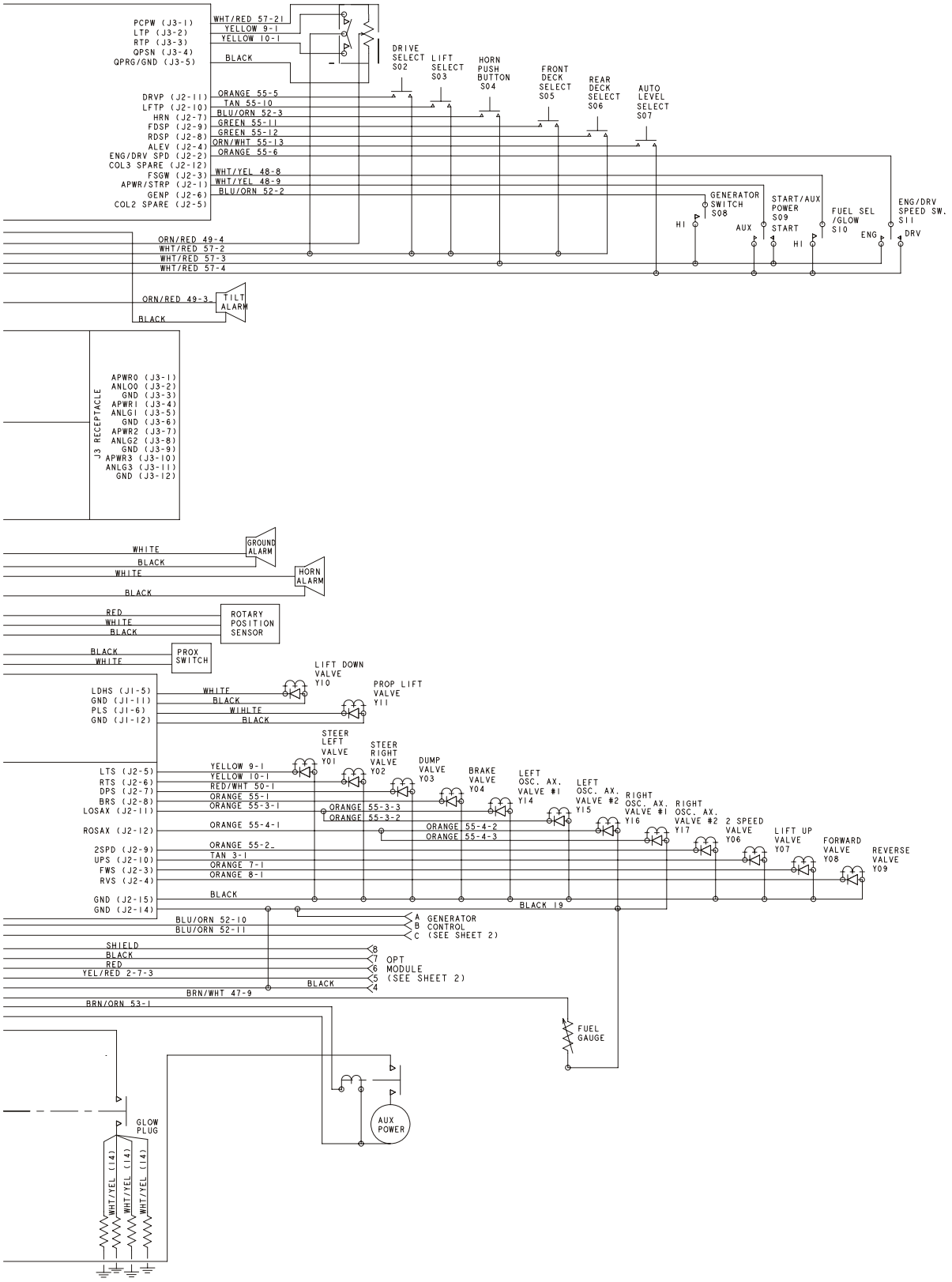

Figure 6-30. Electrical Schematic Diesel (S/N 138634 to Present) - Sheet 2 of 3

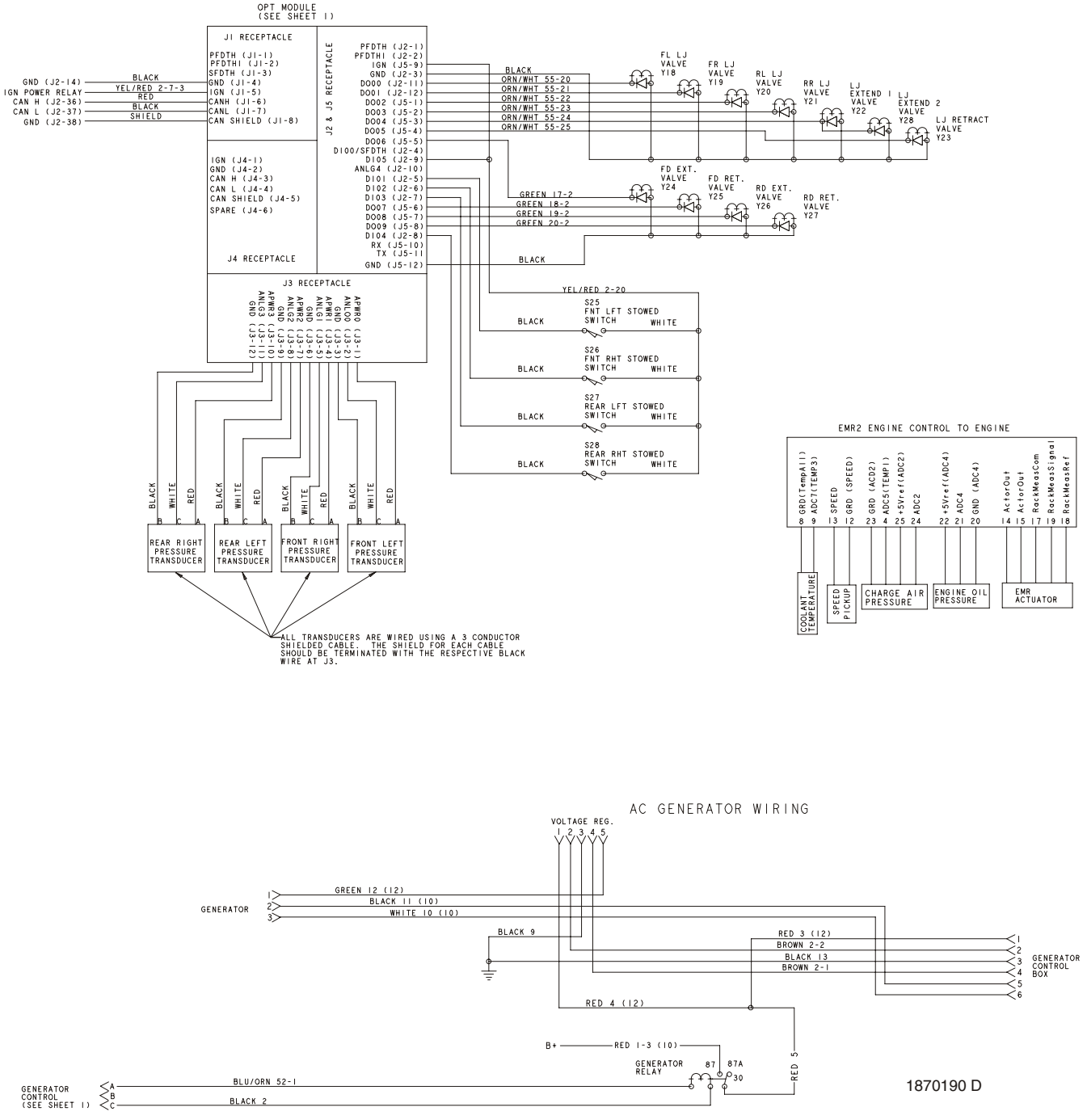

Figure 6-31. Electrical Schematic Diesel (S/N 138634 to Present) - Sheet 3 of 3

NOTES:

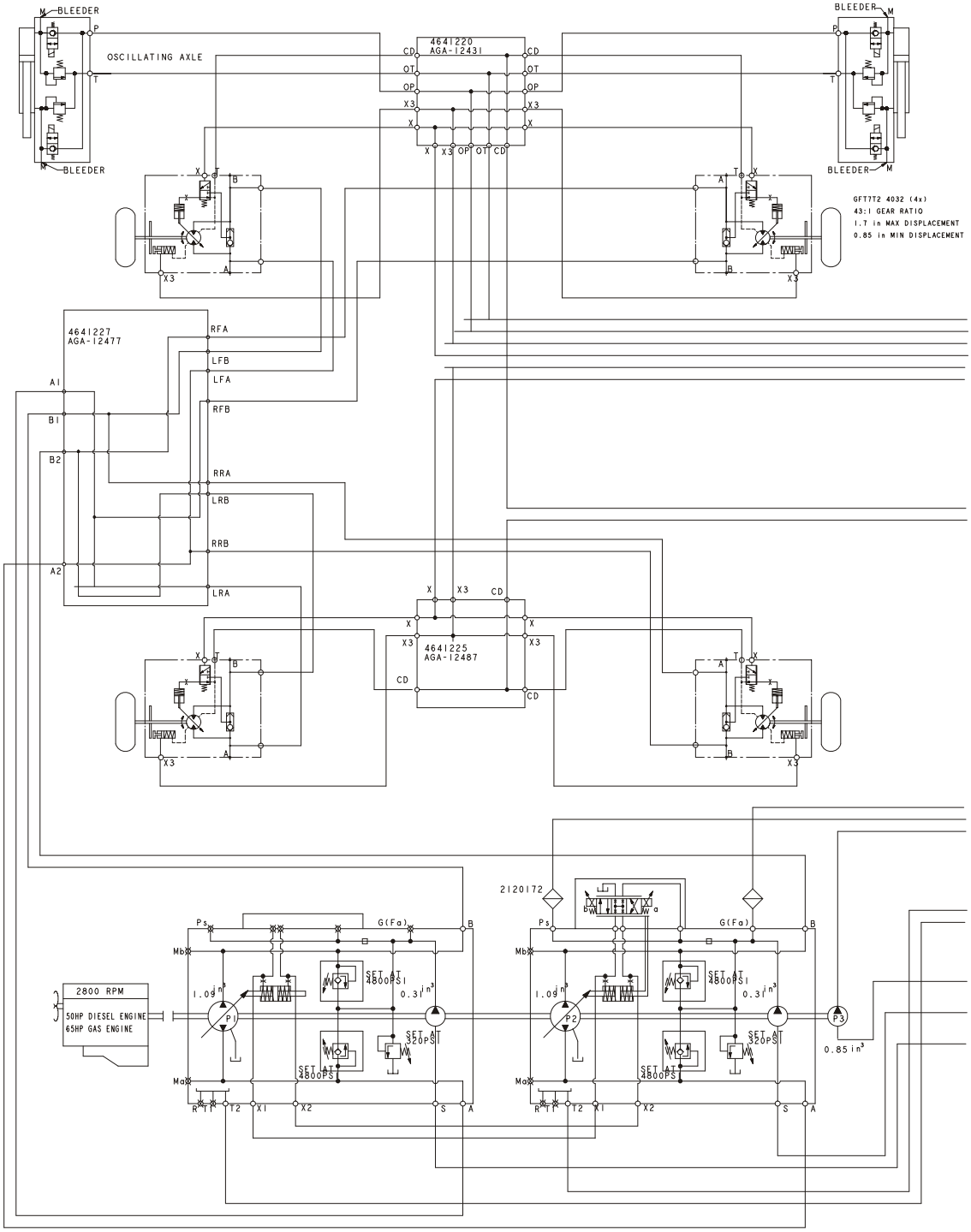

Figure 6-32. Hydraulic Schematic 4WD - Sheet 1 of 4

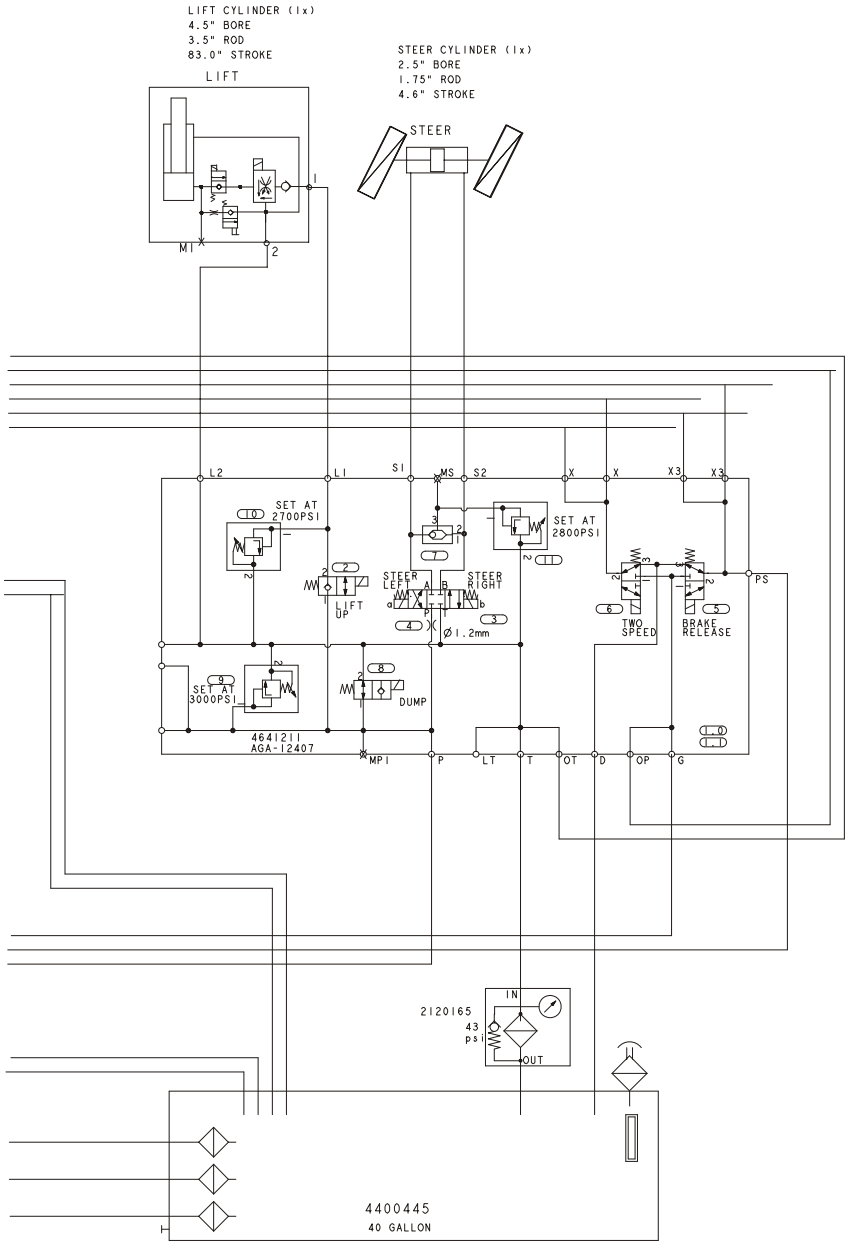

Figure 6-33. Hydraulic Schematic 4WD - Sheet 2 of 4

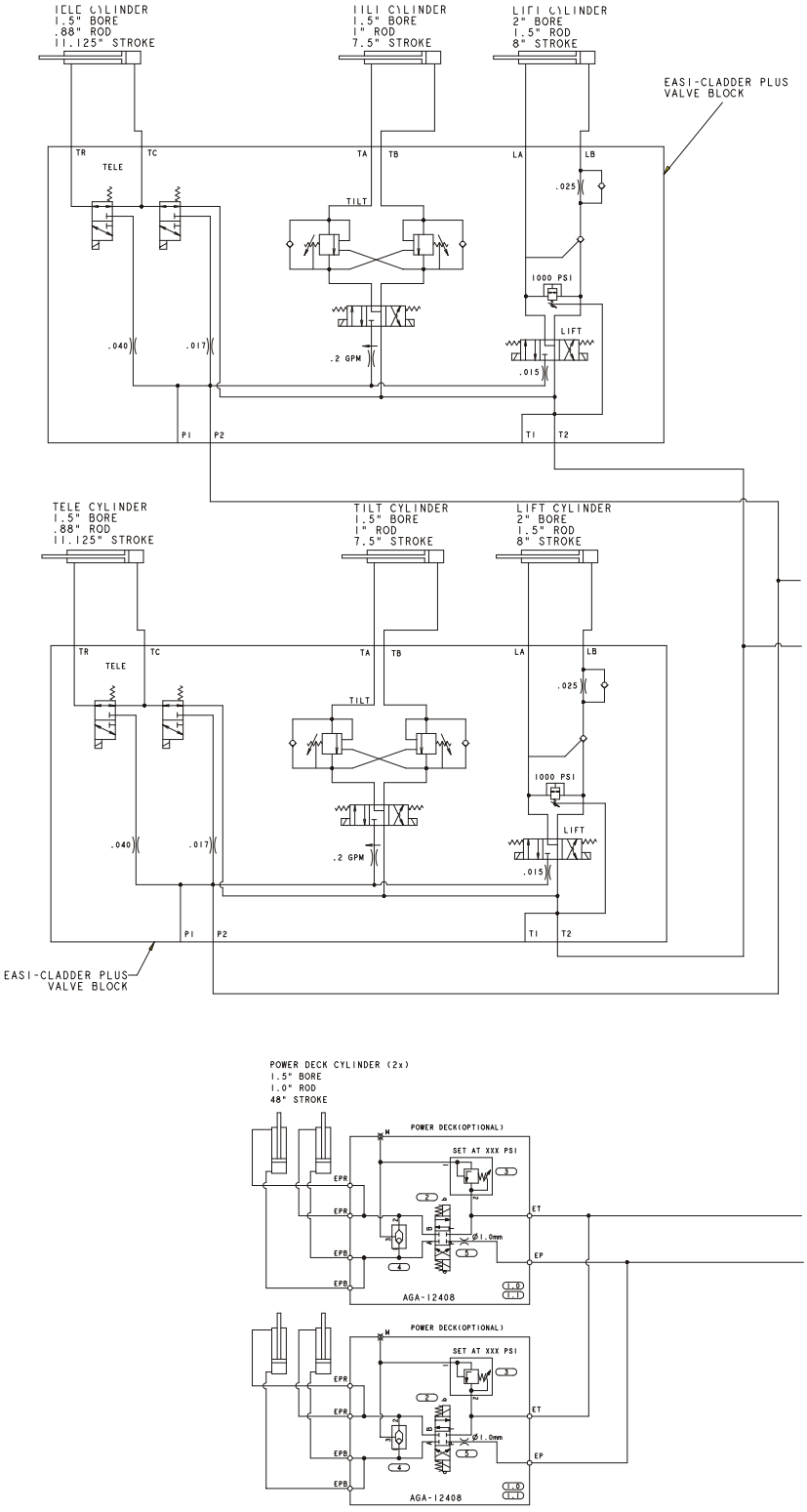

Figure 6-34. Hydraulic Schematic 4WD - Sheet 3 of 4

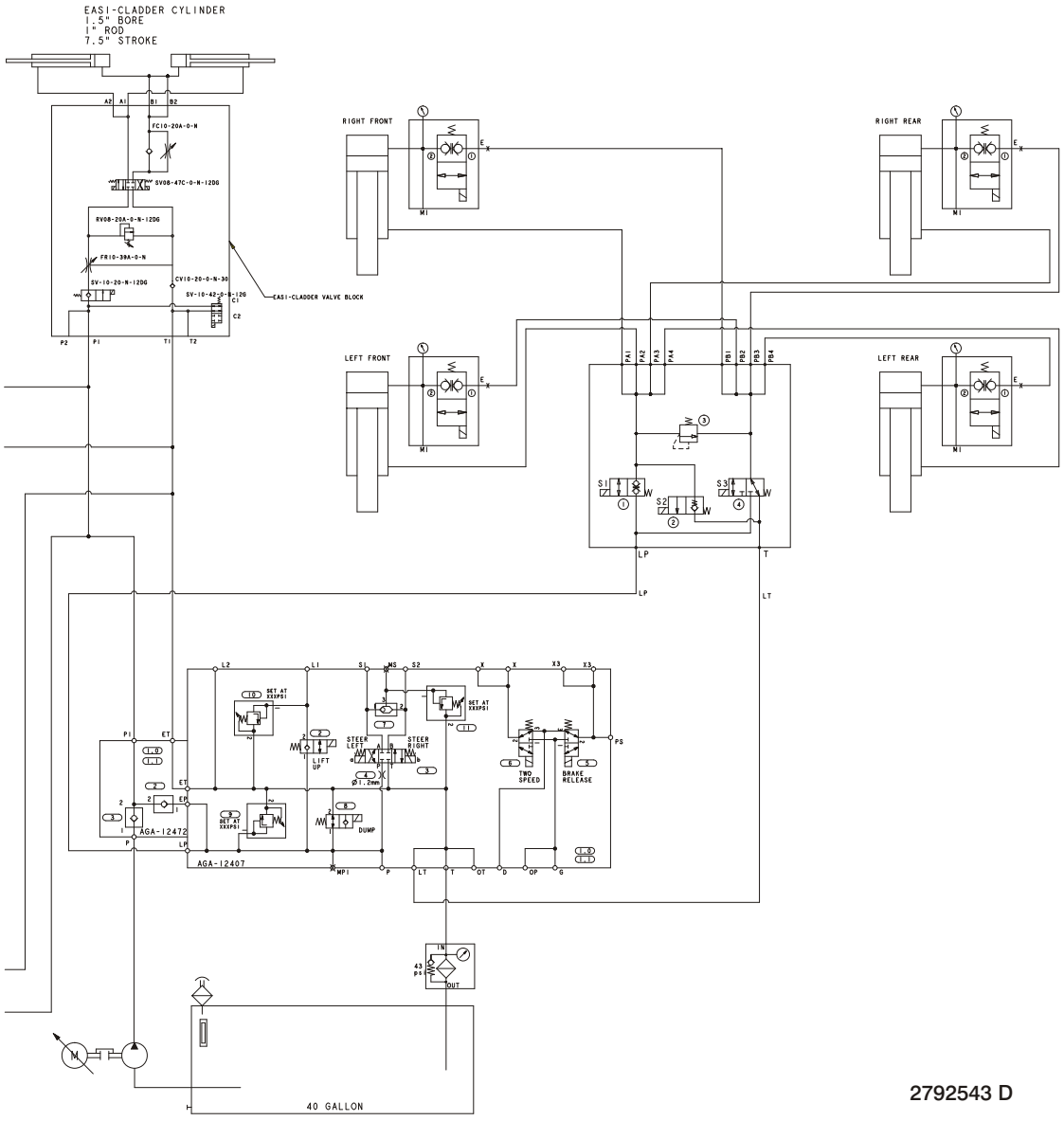

Figure 6-35. Hydraulic Schematic 4WD - Sheet 4 of 4

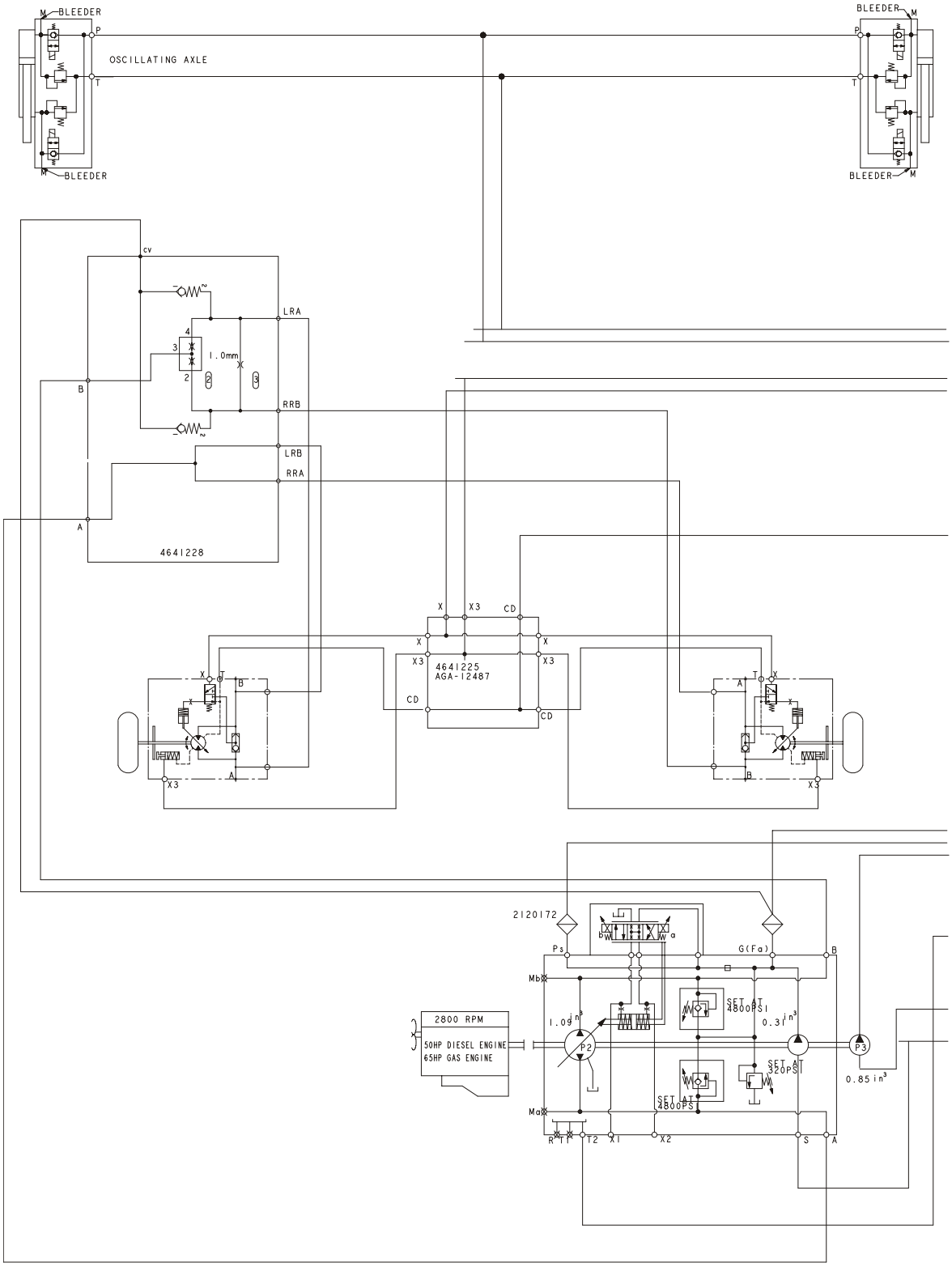

Figure 6-36. Hydraulic Schematic 2WD - Sheet 1 of 4

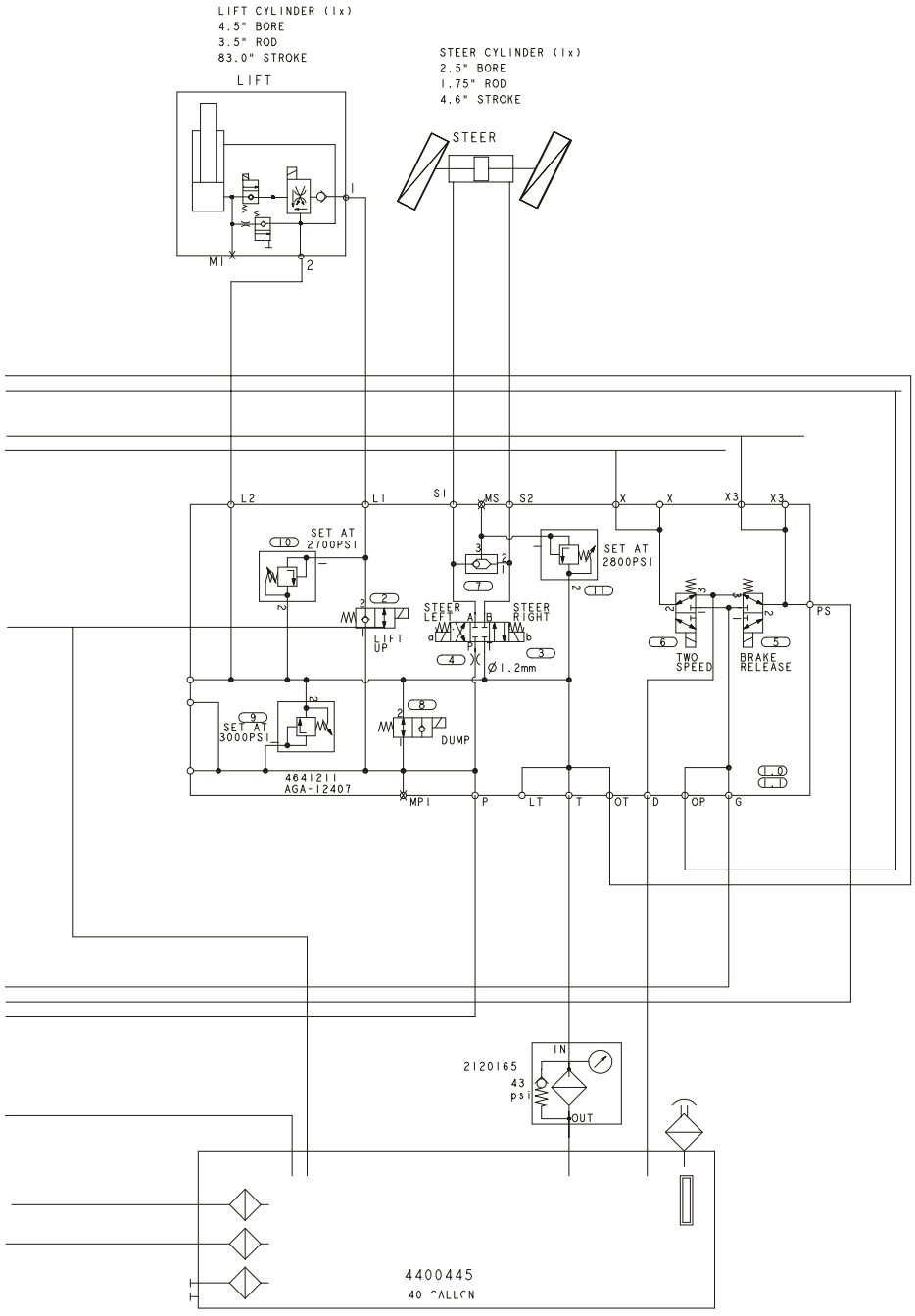

Figure 6-37. Hydraulic Schematic 2WD - Sheet 2 of 4

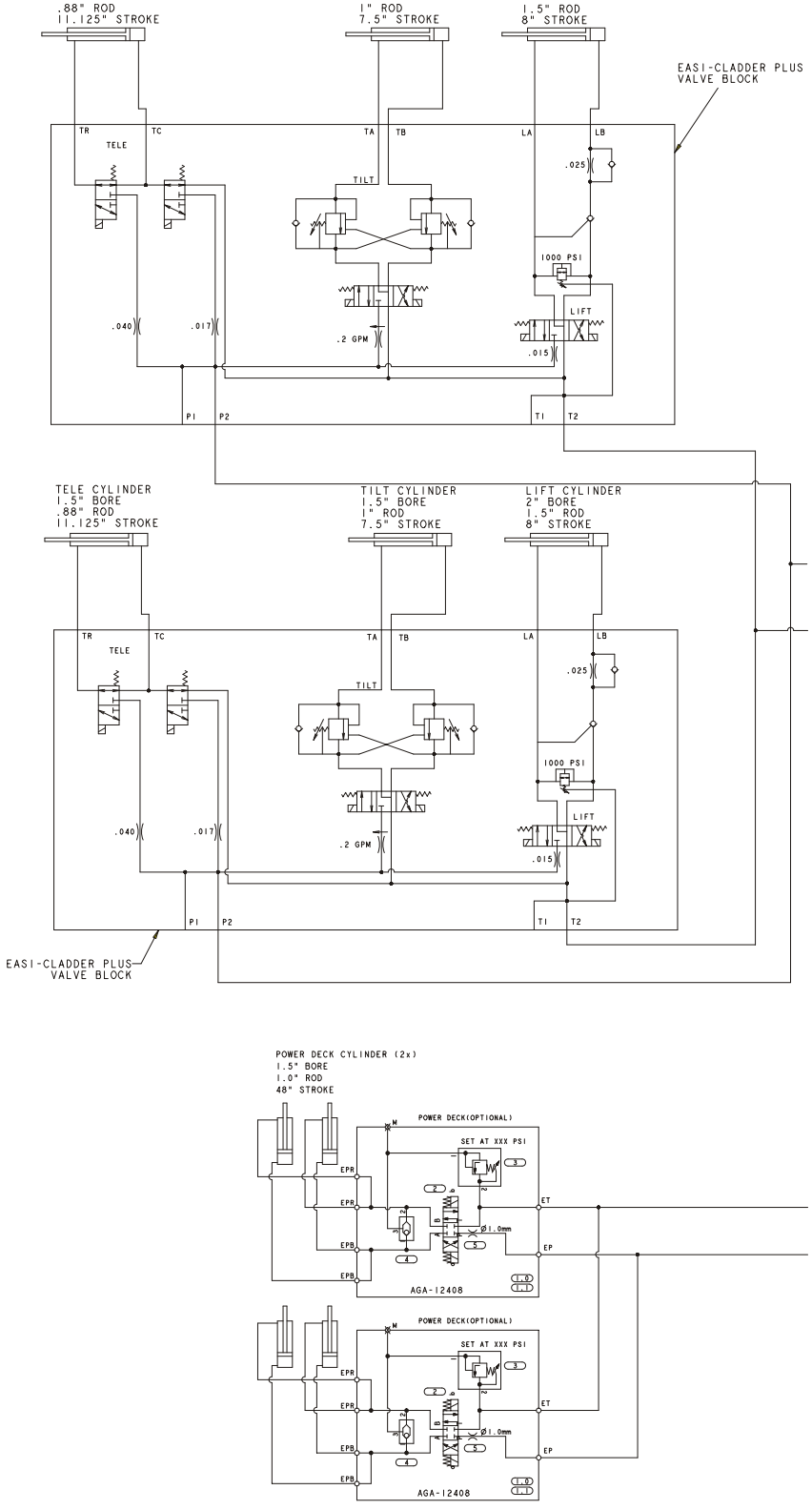

Figure 6-38. Hydraulic Schematic 2WD - Sheet 3 of 4

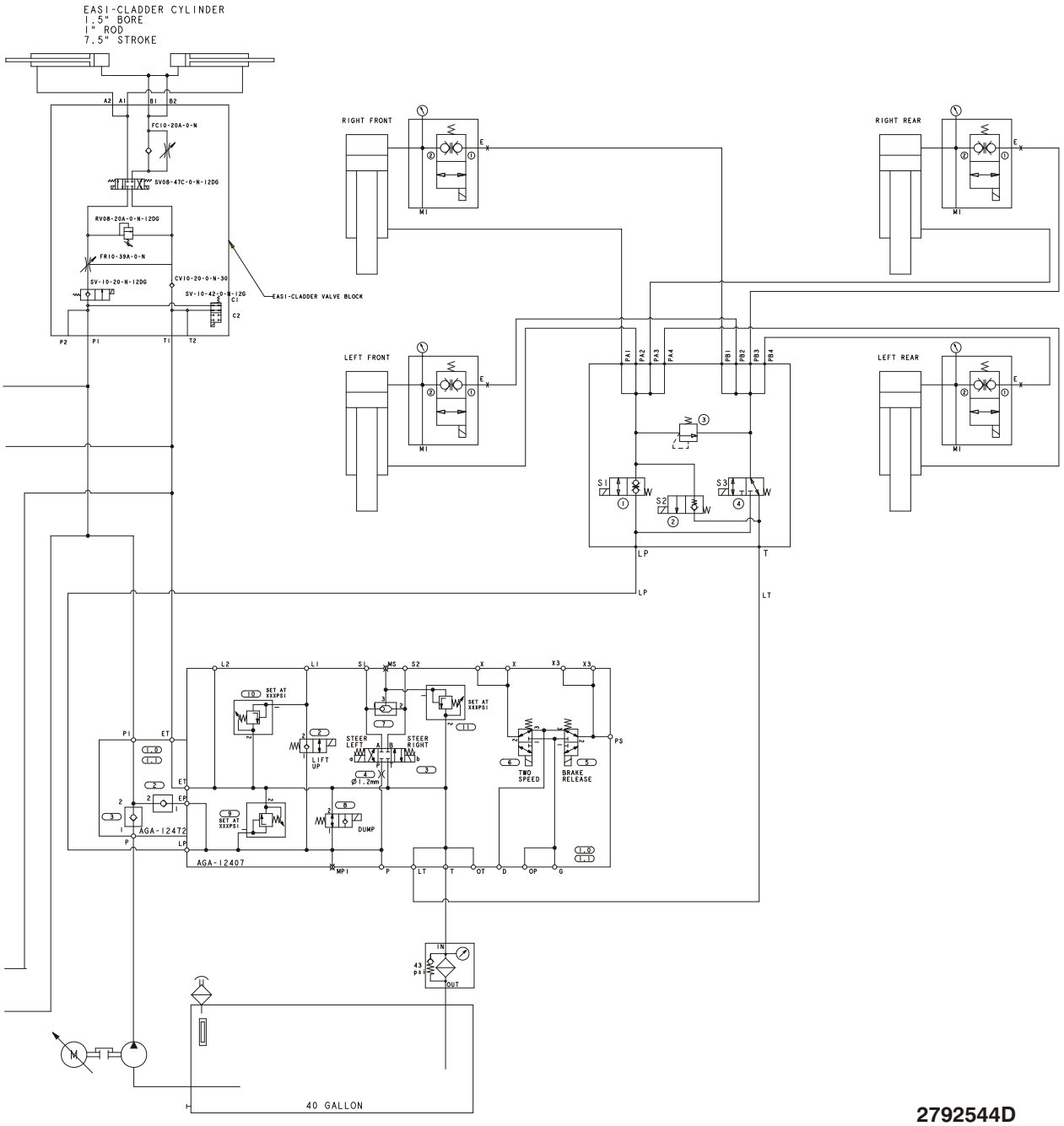

Figure 6-39. Hydraulic Schematic 2WD - Sheet 4 of 4

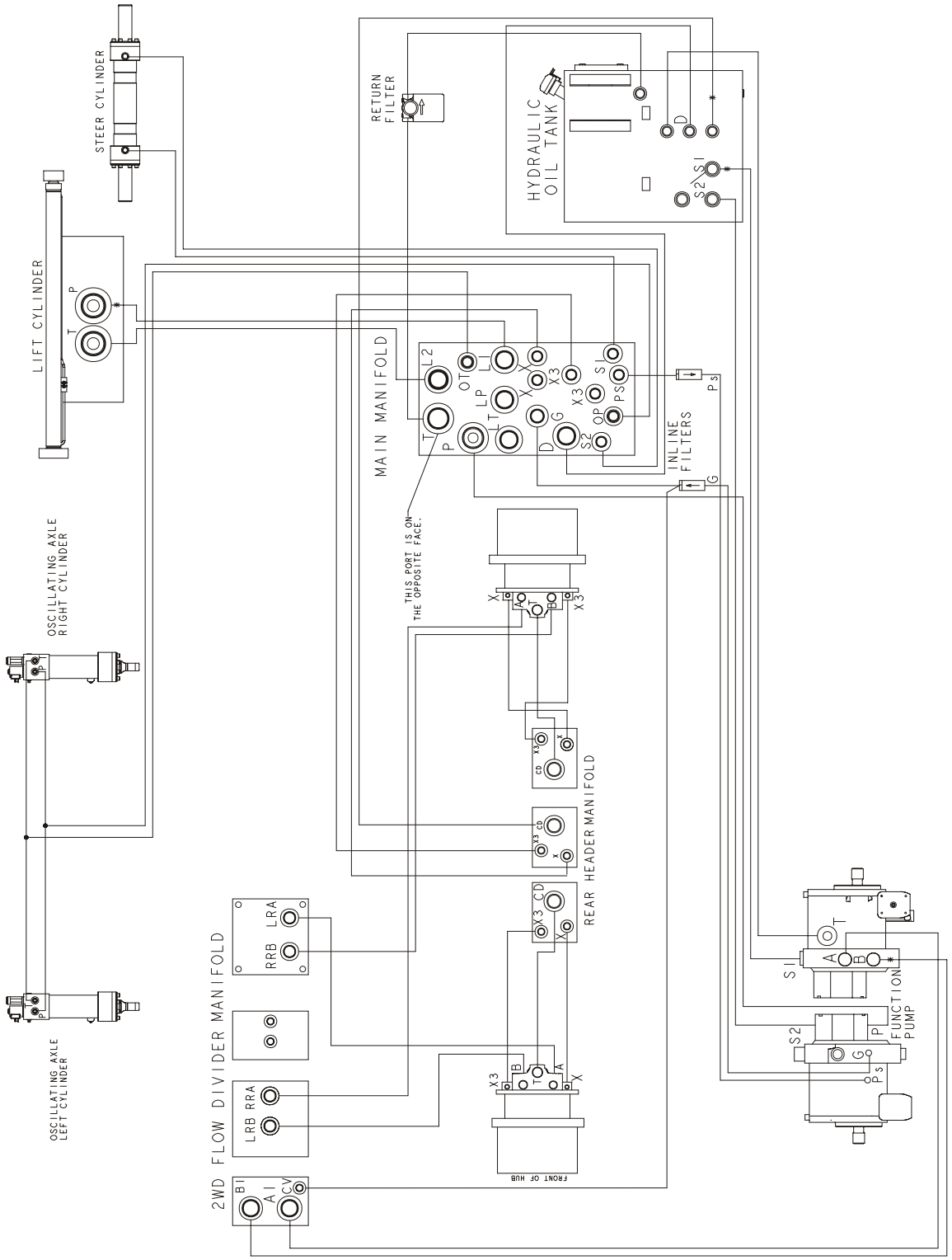

Figure 6-40. Hydraulic Diagram - (2WD)

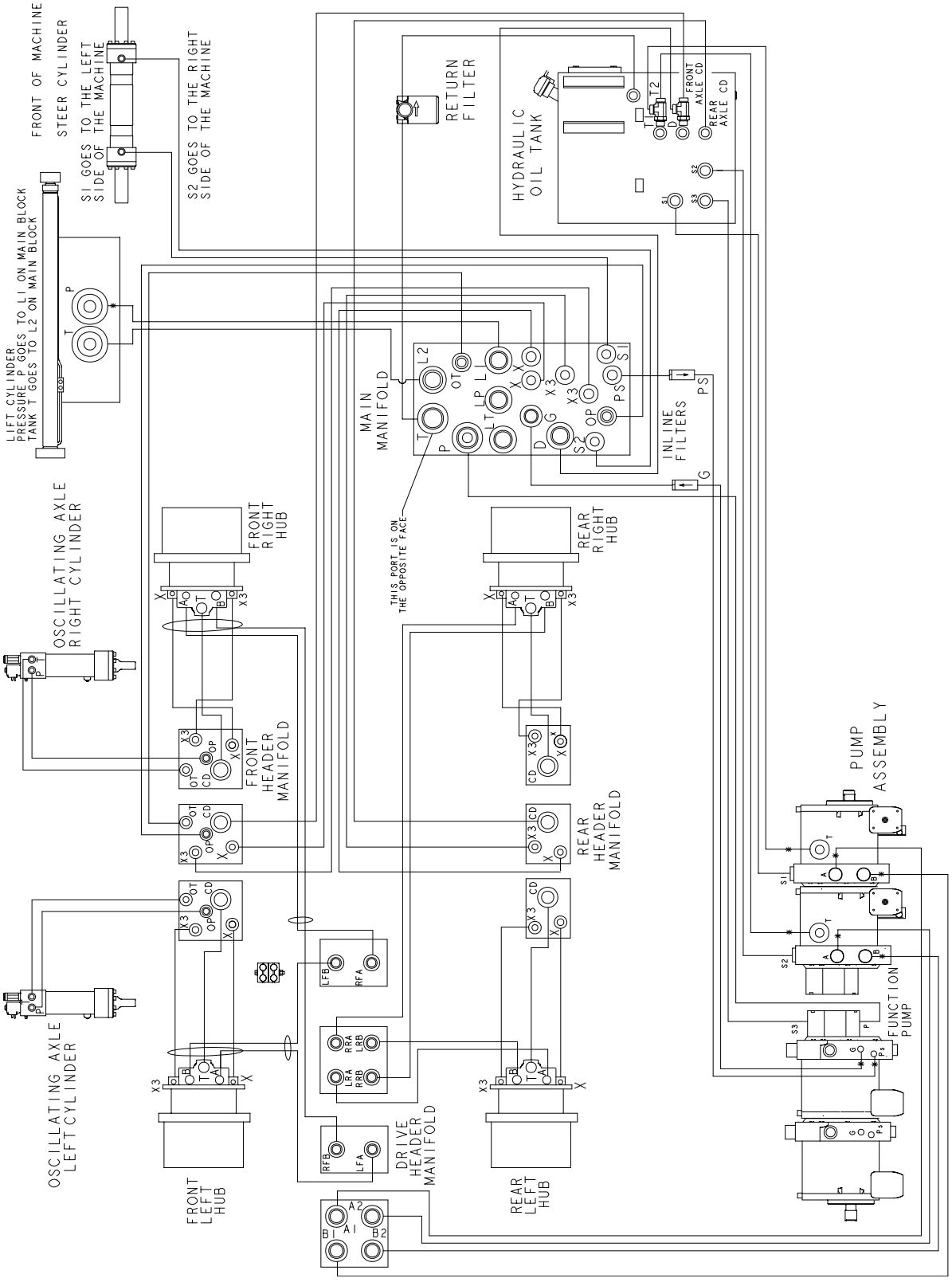

Figure 6-41. Hydraulic Diagram - (4WD)

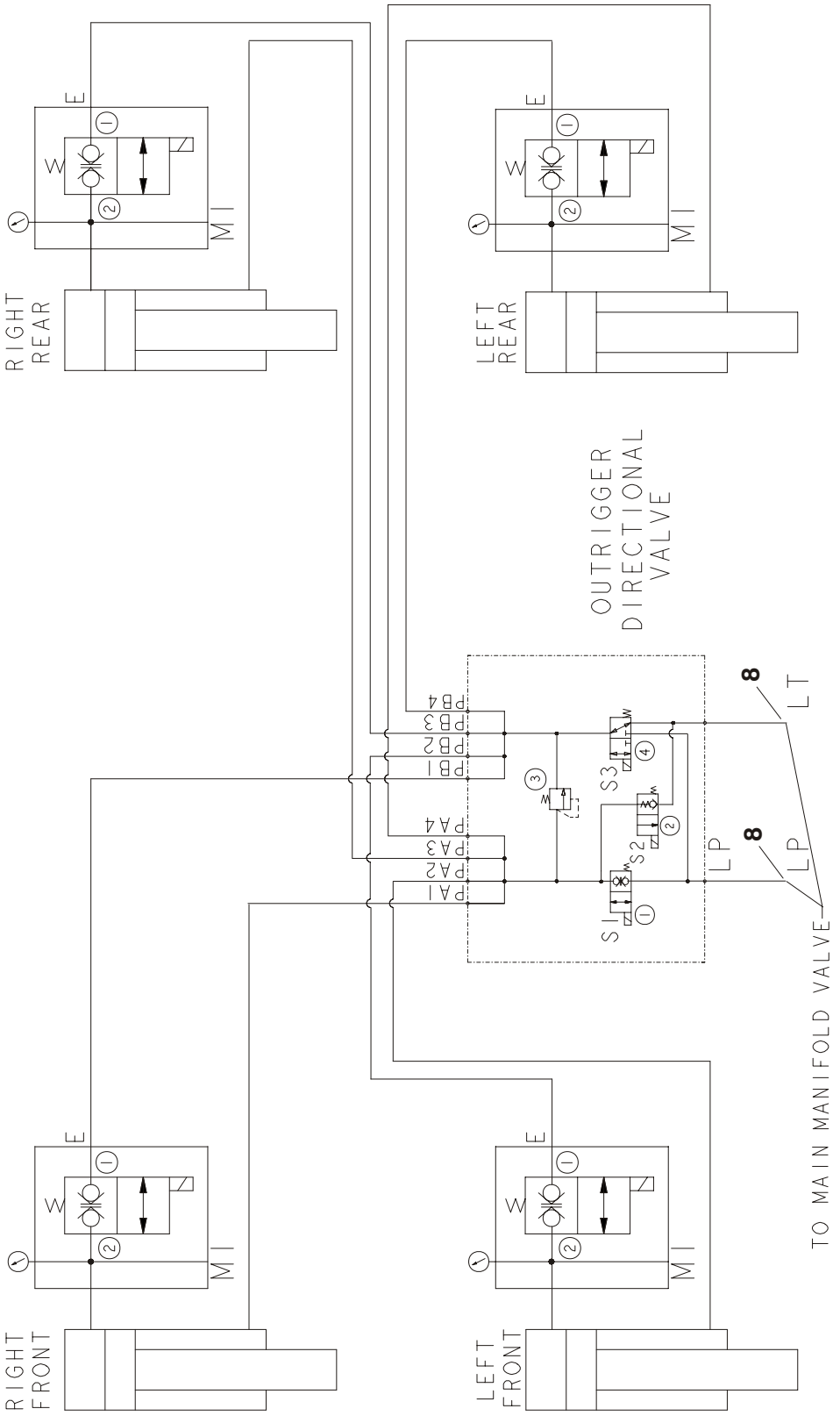

Figure 6-42. Hydraulic Diagram - (Leveling Jacks)

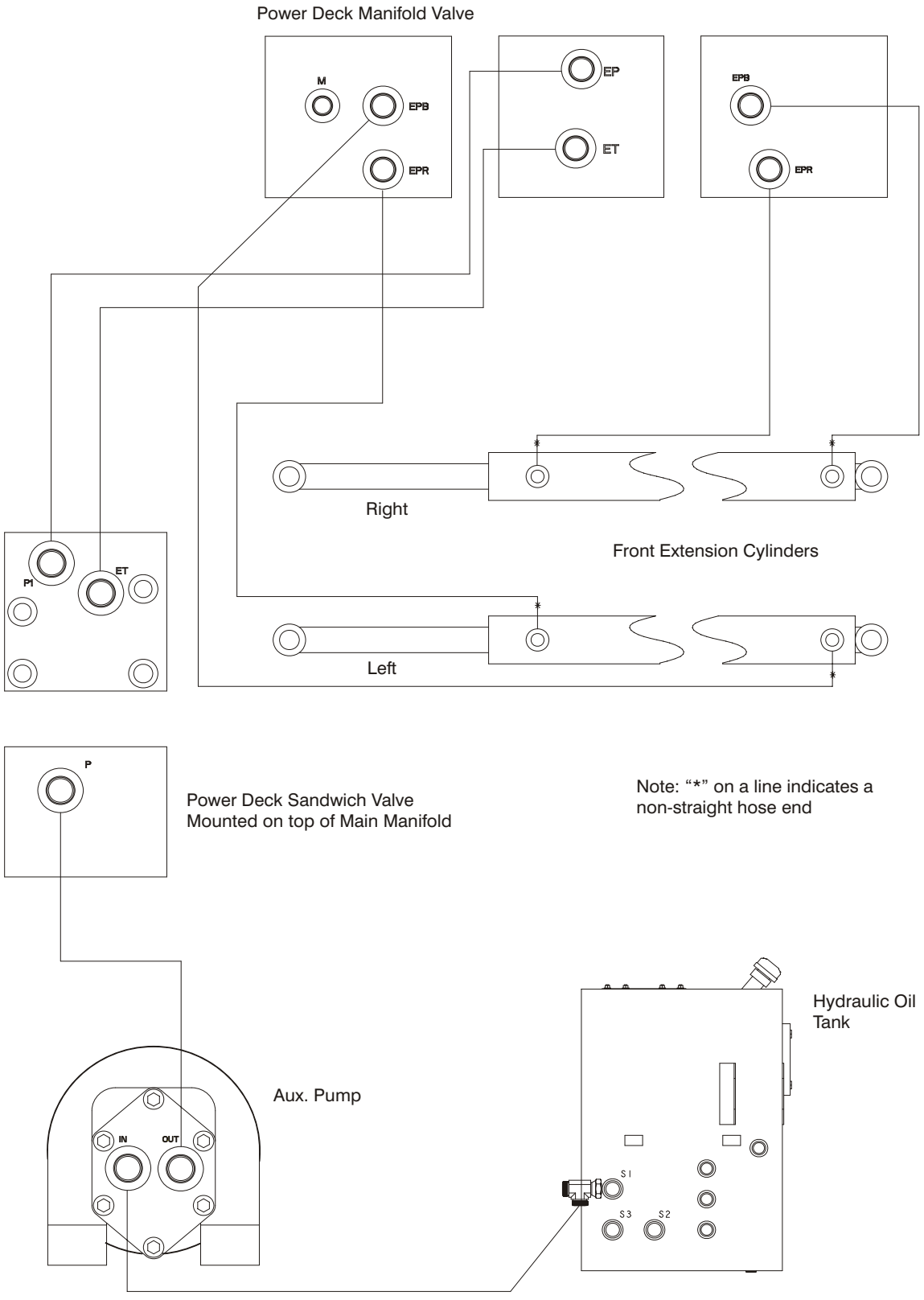

Figure 6-43. Hydraulic Diagram - Deck Extension (Single)

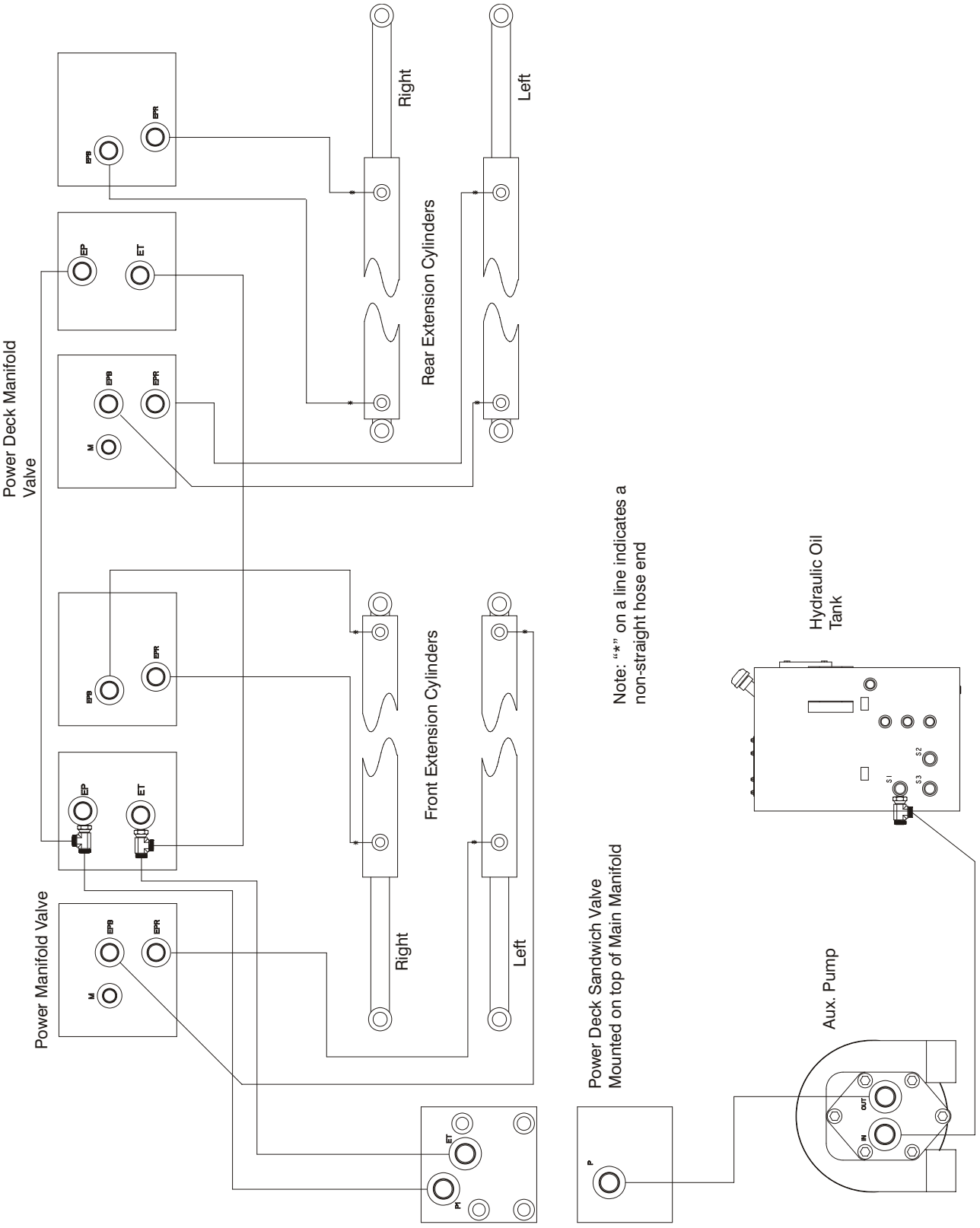

Figure 6-44. Hydraulic Diagram - Deck Extension (Dual)

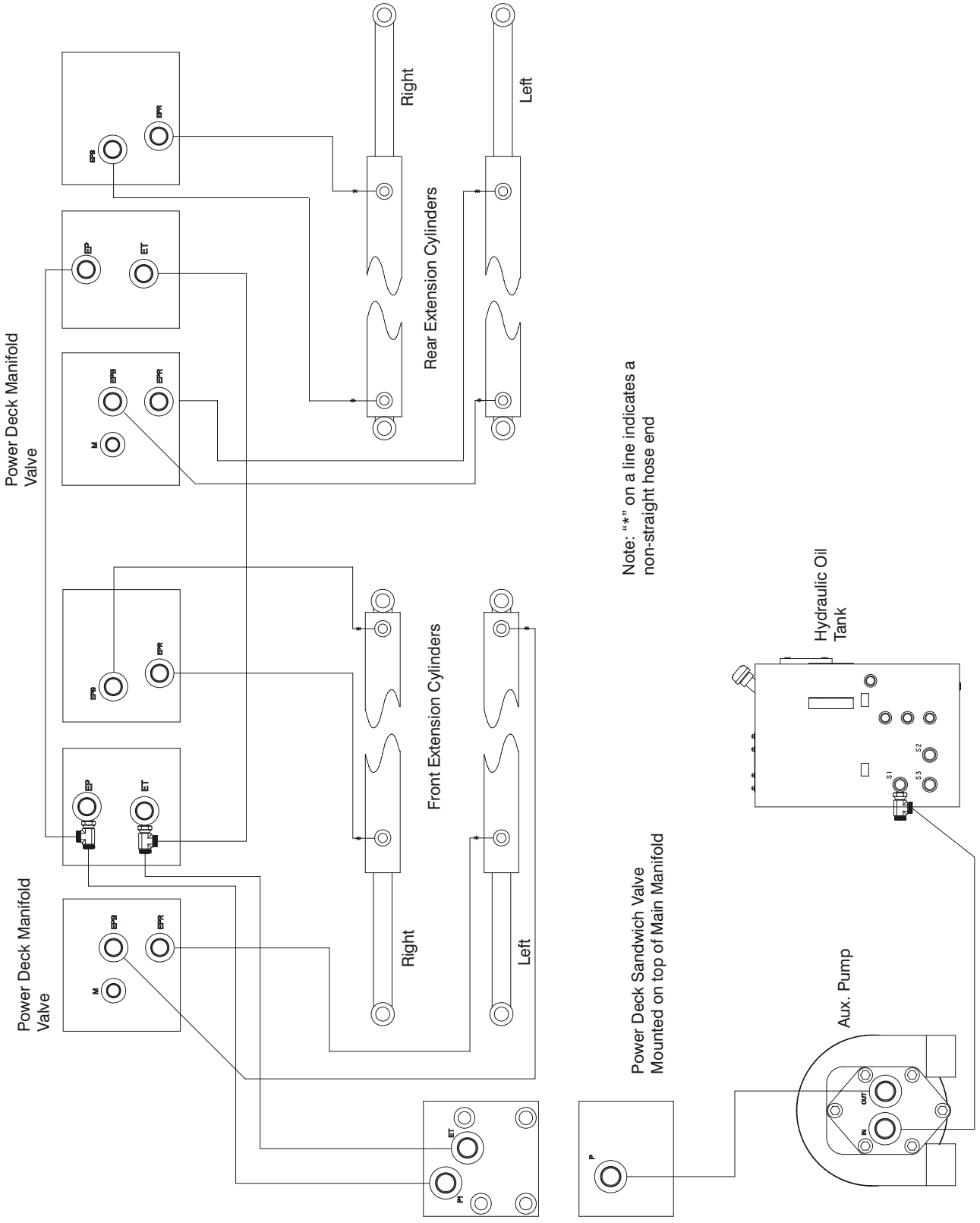

Figure 6-45. Hydraulic Diagram - Deck Extension (Dual Megadeck)

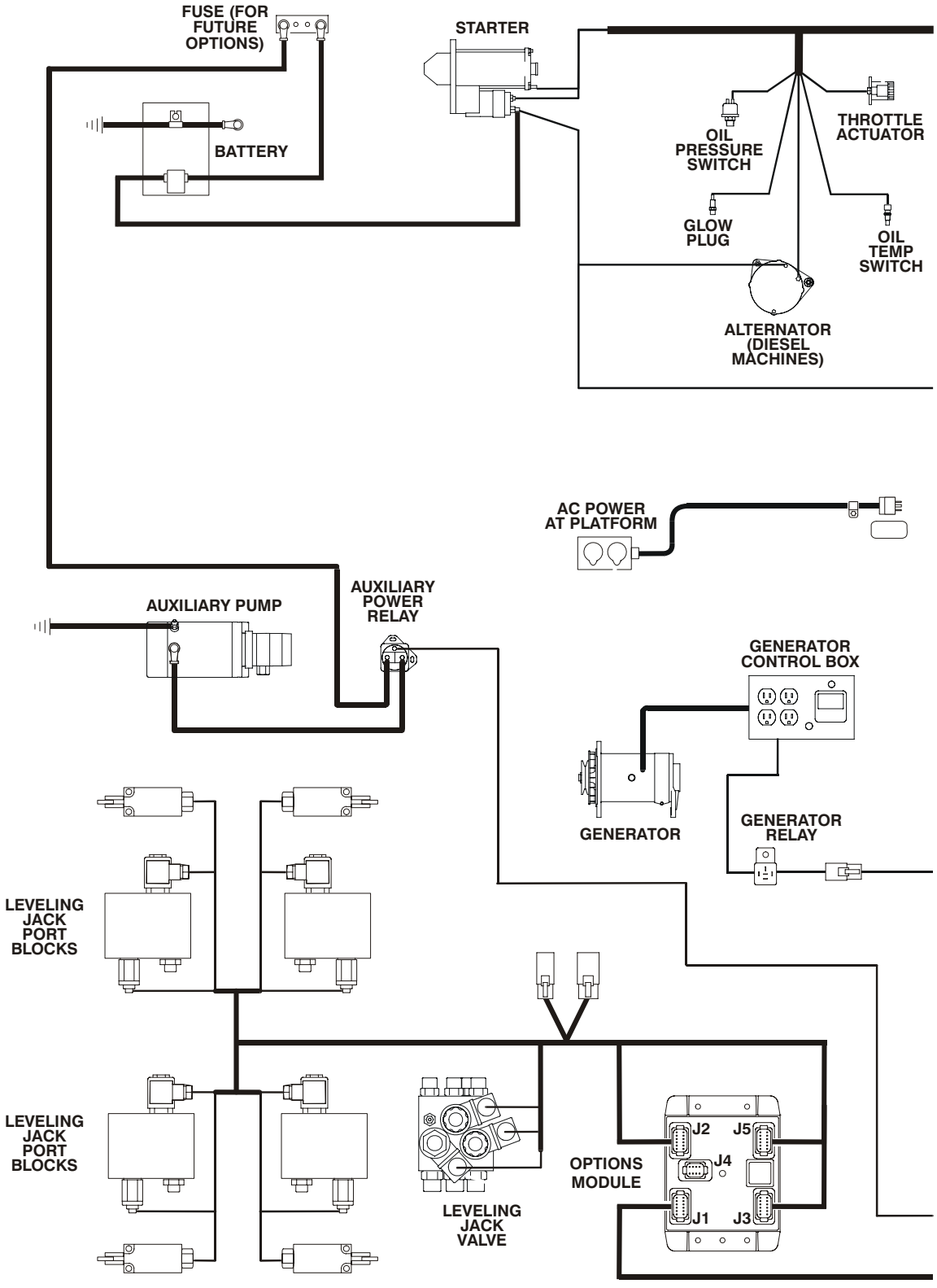

Figure 6-46. Electrical Components Installation - Sheet 1

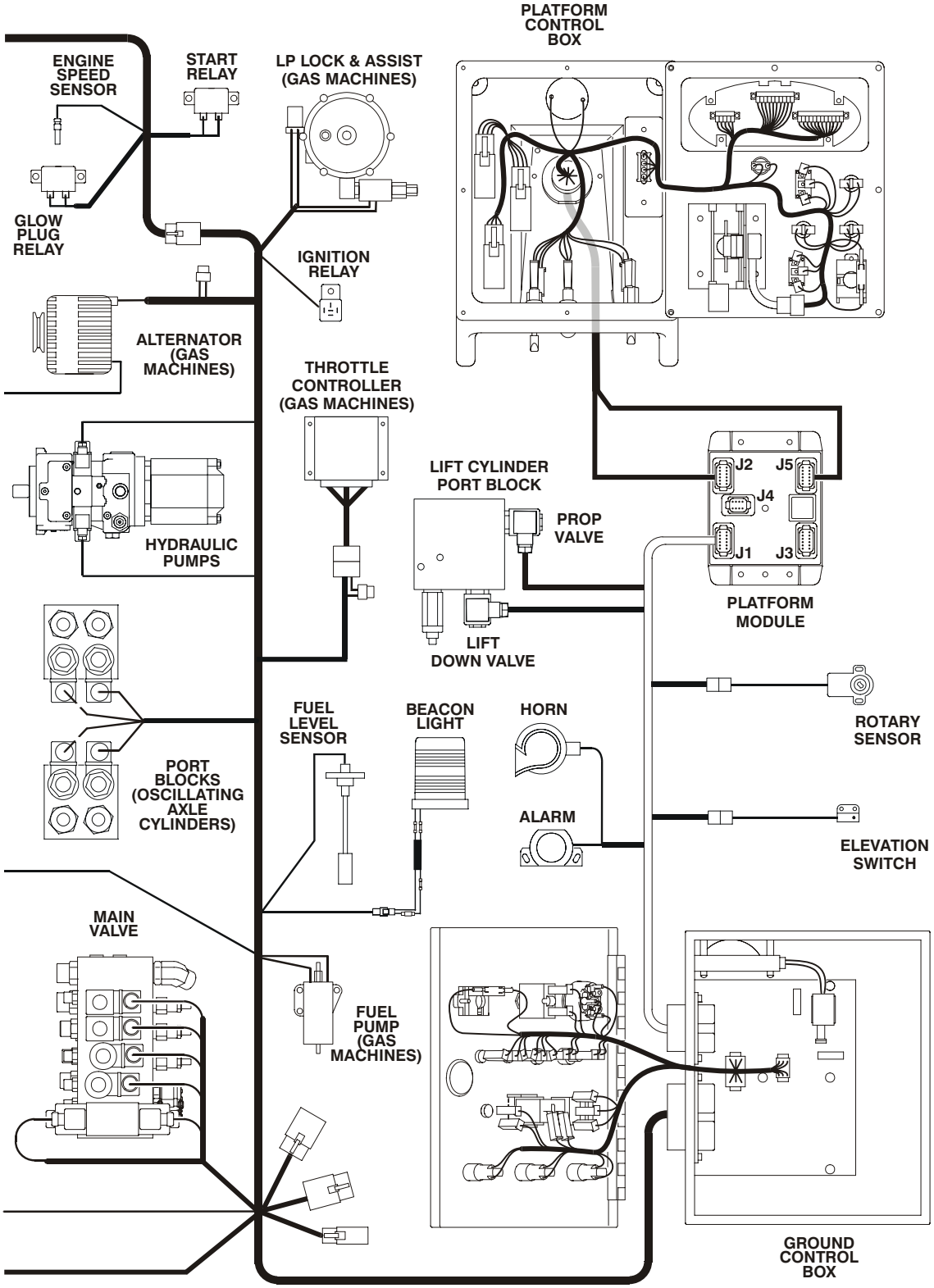

Figure 6-47. Electrical Components Installation - Sheet 2

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