JLG®

An Oshkosh Corporation Company

Service and Maintenance Manual

Models
450A/AJ
Series II

Prior To
S/N 0300160835

P/N - 3121180

December 3, 2012

ANSI

CE

SECTION A. INTRODUCTION - MAINTENANCE SAFETY PRECAUTIONS

A. GENERAL

This section contains general safety precautions which must be observed during aerial platform maintenance. 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 machine is safe to operate.

⚠ WARNING

MODIFICATION OR ALTERATION OF AN AERIAL WORK PLATFORM SHALL BE MADE ONLY WITH WRITTEN PERMISSION FROM THE MANUFACTURER.

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.

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.

C. MAINTENANCE

⚠ WARNING

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

- WEAR APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT WHEN WORKING ON MACHINE.
- ENSURE REPLACEMENT PARTS OR COMPONENTS ARE IDENTICAL OR EQUIVALENT TO ORIGINAL PARTS OR COMPONENTS.
- 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 AND OPERATOR 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 BOOM UNTIL BOOM 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, NON-FLAMMABLE CLEANING SOLVENTS.

REVISON LOG

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SECTION A - INTRODUCTION - MAINTENANCE SAFETY PRECAUTIONS

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FIGURE NO.	TITLE	PAGE NO.

SECTION 1. SPECIFICATIONS

1.1 CAPACITIES

Table 1-1. Capacities

Fuel Tank	17 gallons (64.3 liters)
Hydraulic Tank (machines to S/N 0300070586)	28 gallons (106 liters)
Hydraulic Tank (S/N 0300070586 & SN 1300000001to Present)	27 gallons (102 liters) 23.6 gal. (89 liters) to the Full line on the sight gauge
Drive Hub	23.75 oz. (0.7 liters)
Drive Brake	2.7 oz. (0.08 liters)

1.2 TIRES

Table 1-2. Tires

Size	Type	Pressure	Weight
12x16.5	Pneumatic	90 psi (6 Bar)	128 lbs. (58 kg)
12x16.5	Foam-Filled	N/A	328 lbs. (149 kg)
33/1550x16.5	Pneumatic	90 psi (6 Bar)	135 lbs. (61 kg)
33/1550x16.5	Foam-Filled	N/A	395 lbs. (179 kg)
14 x 16.1	Pneumatic	40 lbs. (3 bar)	91.5 lbs. (41.5 kg)
14 x 16.1	Foam-Filled	N/A	426 lbs. (193 kg)

1.3 ENGINE

NOTE: *RPM Tolerances are ± 100.*

Table 1-3. Ford LRG-425 (Gas or Dual Fuel)

Type	4 cylinder, 4 stroke, spark ignition
Fuel	Gasoline or Gasoline/LP Gas
Bore	3 in. (96 mm)
Stroke	3.4 in. (86.4 mm)
Displacement	153 cu. in. (2.5 L)
Firing Order	1-3-4-2
BHP at Max. RPM	82
Oil Capacity	4.5 quarts (4.26 L)
Low RPM	1000
Mid RPM Tower Lift, Upper Lift, Tele Swing, Basket Level, Basket Rotate, Jib Lift	1800 1500
High RPM	3000
Spark Plug	AWSF-52-C
Spark Plug Gap	0.044 in. (1.117 mm)

Table 1-4. Deutz F3M1011F

Fuel	Diesel
No. of Cylinders	3s
Bore	3.6 in. (91 mm)
Stroke	4.4 in. (112 mm)
Displacement	133 cu. in. (2184 cm^3)
BHP at Max. RPM	48
Oil Capacity crankcase cooler total capacity	 6.3 quarts (6 L) 4.75 quarts (4.5 L) 11 quarts (10.5 L)
Low RPM	1200
Mid RPM Tower Lift, Upper Lift, Tele Swing, Basket Level, Basket Rotate, Jib Lift	1800 1500
High RPM	2800

Table 1-5. Deutz F3M2011F

Fuel	Diesel
No. of Cylinders	3s
Bore	3.7 in. (94 mm)
Stroke	4.4 in. (112 mm)
Displacement	142 cu. in. (2331 cm^3)
Oil Capacity crankcase cooler total capacity	 6.3 quarts (6 L) 4.75 quarts (4.5 L) 11 quarts (10.5 L)
Low RPM	1200
Mid RPM Tower Lift, Upper Lift, Tele Swing, Basket Level, Basket Rotate, Jib Lift	1800 1500
High RPM	2800

Table 1-6. Caterpillar 3024/C2.2

Fuel	Diesel
No. of Cylinders	4
BHP	46.5 hp (34 kW)
Bore	3.307 in. (84 mm)
Stroke	3.9370 in. (112 mm)
Displacement	134.3 cu. in. (2.2L)
Oil Capacity	10 qt. (9.4 L)
Compression Ratio	19:1
Firing Order	1-3-4-2
Max. RPM	2800

Table 1-7. GM 3.0L

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

Table 1-8. Perkins 404C-22

Fuel	Diesel
No. of Cylinders	4
BHP	50 HP (37.3 kW)
Bore	3.3 in. (84 mm)
Stroke	3.9 in. (100 mm)
Firing Order	1-3-4-2
Displacement	135 cu.in. (2.2 L)
Oil Capacity w/filter	10 qt. (9.4 L)
Compression Ratio	23.3:1
Fuel Consumption	0.63 gal. (2.38 L) /hour

1.4 SPECIFICATIONS AND PERFORMANCE DATA

Reach Specifications

Table 1-9. Reach Specifications - 450

Max. Platform Height	45ft. (13.72 M)
Max. Horizontal Reach	24.5ft. (7.47 M)
Up & Over Height	25 ft. 2 in. (7.7 M)
Main Boom Up Angle	75°
Main Boom Down Angle	-24°

Dimensional Data

Table 1-10. Dimensional Data - 450

Overall Width (12 x 16.5 tire) (33/1550 tire) (14 x 16.1 tire)	 6 ft. 6 in. (1.98 m) 6 ft. 10 in. (2.08 m) 6 ft. 11 in. (2.11 m)
Tailswing	0
Stowed Height	7 ft. 4.4 in. (2.25 m)
Stowed Length	21 ft. 4 in. (6.5 m)
Wheel base	78 in. (1.98 m)
Track Width (12 x 16.5 tire) (33/1550 tire) (14 x 16.1 tire)	 65.3 in. (1.66 m) 66.3 in. (1.69 m) 66.6 in. (1.69 m)
Ground Clearance	14 in. (0.36 m)

Chassis

Table 1-11. Chassis Specifications - 450

Swing	357° non-continuous
Rated Gradeability 2WD 4WD	 30% 45%
Max. Tire Load	7900 lb. (3583 kg)
Axle Oscillation	8 in. (0.2 m)
System Voltage	12 Volts
Max. Hydraulic System Operating Pressure	4500 psi (310 bar)
Gross Machine Weight 450A SII 450AJ SII	 14,500 lbs. (6577 kg) 16,500 lbs. (7484 kg)

1.5 FUNCTION SPEEDS

Table 1-12. Function Speeds (In Seconds)

Function	450A	450AJ
Main Lift Up	24-28	24-28
Main Lift Down	20-24	20-24
Swing Right & Left*	70-90	70-90
Telescope Out	18-22	16-20
Telescope In	12-16	9-14
Platform Rotate Right & Left**	25-32	25-32
Jib Up	N/A	21-31
Jib Down	N/A	19-25
Lower Lift Up	30-38	30-38
Lower Lift Down	22-28	22-28
Drive (2WD High Engine)	38-41 (3.5 MPH)	38-41 (3.5 MPH)
Drive (4WD High Engine)	29-31 (4.5 MPH)	29-31 (4.5 MPH)
Drive above Horizontal (50 ft.)	46-68 (0.75 - 0.50 MPH)	46-68 (0.75 - 0.50 MPH)
*Max 10% Difference Between Left & Right **Max 15% Difference Between Left & Right		

Machine Orientation When Doing Speed Tests

Lift: Boom retracted. Telescope retracted. Lift up, record time, Lift down, record time.

Swing: Boom at full elevation. Telescope retracted. Swing turntable to end stop. Swing opposite direction, record time. Swing opposite direction, record time.

Telescope: Boom at full elevation; Telescope retracted; Telescope out, record time. Telescope In, record time.

Drive: Test to be done on a smooth level surface. Set Drive Select Switch to 2WD High Engine. Start approximately 25 ft (7.62 m) from starting point so unit is at maximum speed when starting test. Record results for a 200 ft. (60.96 m) course. Drive forward, record time. Drive reverse, record time.

Drive (Above Horizontal): Test should be done on a smooth level surface. Set Drive Select Switch to 2WD High Engine. Select Platform Speed Knob out of creep speed. This verifies switches are working when boom is above horizontal. Results should be recorded for a 50 ft course. Drive forward, record time. Drive reverse, record time.

Platform Rotate: Platform level and completely rotated one direction. Rotate opposite direction, record time. Rotate other direction, record time.

Articulating Jib: Platform level and centered with boom. Start with Jib down. Jib up, record time. Jib down, record time.

Lower Lift: Upper Boom horizontal. Telescoped In. Lower Lift up, record time. Lower lift down, record time.

Test Notes

1. Start stop watch with function, not with controller or switch.
2. Drive test results reflect 12x16.5 tires.
3. All speed tests are run from platform. These speeds do not reflect ground control operation.
4. Platform speed knob control must be at full speed (turned clockwise completely).
5. Test with oil temperature above 100° F (38° C). Function speeds vary if hydraulic oil is cold and thick.
6. Some flow control functions may not work with speed knob clicked into creep position.

1.6 TORQUE REQUIREMENTS

Table 1-13. Torque Specification

Description	Torque Value	Interval Hours
Wheel Lugs	170 ft. lb. (230 Nm)	150
Semi-Track Wheel Lugs	90 ft. lb. (122 Nm)	150
Swing Bearing (Loctite)	190 ft. lb. (257 Nm)	50/600*
Starter Solenoid Contacts Coil	95 in. lbs. (9.5 Nm) 40 in. lbs. (4 Nm)	As required
Drive Hub to Axle	240 ft. lb. (325 Nm)	As required
Drive Motor to Axle	120 ft. lb. (163 Nm)	As required
*Check swing bearing bolts for security after first 50 hours of operation and every 600 hours thereafter.		

Table 1-14. Engine Torque Requirements - Ford

Description	Torque Value ft. lb.	Torque Value Nm
Oil Drain Plug	15-25	20-34
Spark Plugs	7-15	9-20
Pump Coupling (dry)	26.5	37
Pump Coupling (Loctite #242)	28.5	40
Flywheel	54-64	73-87
Mechanical Governor Belt Tension (New)	70	311.4
Mechanical Governor Belt Tension (Used)*	50	222.4
* A used belt is one that has been in operation for 10 minutes or more.		

Table 1-15. Engine Torque Requirements - Deutz

Description	Torque Value ft. lb.	Torque Value Nm
Cylinder Head Cover	6	8.5
Cylinder Head Cover	6	8.5
Rocker Arm Adjustment Screw	15	21
Intake Manifold	6	8.5
Air Intake Pipe	15	21
Exhaust Manifold (F3M1011)	28.5	40
Exhaust Manifold (F3M2011)	16	22
Oil Drain Plug	39	55
Oil Pan (sheet metal)	15	21
Oil Pan (cast)	22	31
Pump Coupling (dry)	26.5	37
Pump Coupling (Loctite #242)	28.5	40
Injection Line Attachment (F3M1011)	16	22
Injection Line Attachment (F3M2011)	21	30
Injection Valve Attachment	15	21
Lube Oil Filter Cartridge	19	27

1.7 LUBRICATION

Hydraulic Oil

Table 1-16. Hydraulic Oil

Hydraulic System Operating Temperature Range	S.A.E. Viscosity Grade
+0° to + 180° F (-18° to +83° C)	10W
+0° to + 210° F (-18° to +99° C)	10W-20, 10W30
+50° to + 210° F (+10° to +99° 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.*

NOTE: *When temperatures remain consistently below 20°F (-7°C), JLG Industries recommends using Mobil DTE13.*

Aside from JLG recommendations, 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. If use of hydraulic oil other than Mobilfluid 424 is desired, contact JLG Industries for proper recommendations.

Table 1-17. Mobilfluid 424 Specs

SAE Grade	10W30
Gravity, API	29.0
Density, Lb/Gal. 60°F	7.35
Pour Point, Max	-46°F (-43°C)
Flash Point, Min.	442°F (228°C)
Viscosity	
Brookfield, cP at -18°C	2700
at 40° C	55 cSt
at 100° C	9.3 cSt
Viscosity Index	152

Table 1-18. 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 1-19. UCon Hydrolube HP-5046

Type	Synthetic Biodegradable
Specific Gravity	1.082
Pour Point, Max	-58°F (-50°C)
pH	9.1
Viscosity	
at 0° C (32° F)	340 cSt (1600SUS)
at 40° C (104° F)	46 cSt (215SUS)
at 65° C (150° F)	22 cSt (106SUS)
Viscosity Index	170

Table 1-20. Mobil EAL H 46 Specs

Type	Synthetic Biodegradable
ISO Viscosity Grade	46
Specific Gravity	.910
Pour Point	-44°F (-42°C)
Flash Point	500°F (260°C)
Operating Temp.	0 to 180°F (-17 to 162°C)
Weight	7.64 lb. per gal. (0.9 kg per liter)
Viscosity	
at 40° C	45 cSt
at 100° C	8.0 cSt
Viscosity Index	153

Table 1-21. Exxon Univis HVI 26 Specs

Specific Gravity	32.1
Pour Point	-76°F (-60°C)
Flash Point	217°F (103°C)
Viscosity	
at 40° C	25.8 cSt
at 100° C	9.3 cSt
Viscosity Index	376
NOTE: *Mobil/Exxon recommends that this oil be checked on a yearly basis for viscosity.*	

Table 1-22. Quintolubric 888-46

Density	0.91 @ 15°C (59°F)
Pour Point	<-20°C (<-4°F)
Flash Point	275°C (527°F)
Fire Point	325°C (617°F)
Autoignition Temperature	450°C (842°F)
Viscosity	
at 0° C (32°F)	360 cSt
at 20° C (68°F)	102 cSt
at 40° C (104°F)	46 cSt
at 100° C (212°F)	10 cSt
Viscosity Index	220

1.8 MAJOR COMPONENT WEIGHTS

Table 1-23. Component Weights

Component	Pounds	Kilograms
Frame	2325	1055
Turntable	1500	680
Boom Link	180	82
Boom Timing Link	30	14
Upper Upright	217	98
Lower Upright	115	52
Lower Boom	497	225
Mid Boom	385	175
Upper Boom	1065	484
4 Wheel Drive Axle	200	91
2 Wheel Drive Axle	235	107

1.9 PRESSURE SETTINGS - PSI (BAR)

Table 1-24. Pressure Settings

SETTING	PSI	BAR
Bang-Bang Main Relief	3300	227.5
Steer	2500	172
Platform Level Up	2800	193
Platform Level Down	1800	124
Platform Rotate	1800	124
Articulating Jib	1500	103
Proportional Main Relief	3200	220
Lift Down	1200	83
Swing	1700	117

1.10 SERIAL NUMBER LOCATION

A serial number plate is attached to left rear side of frame. If serial number plate is damaged or missing, machine serial number is also stamped on left side of frame.

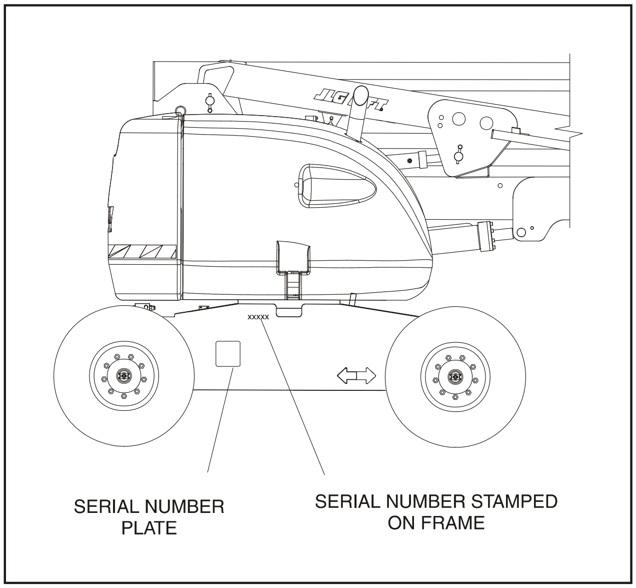


Figure 1-1. Serial Number Locations

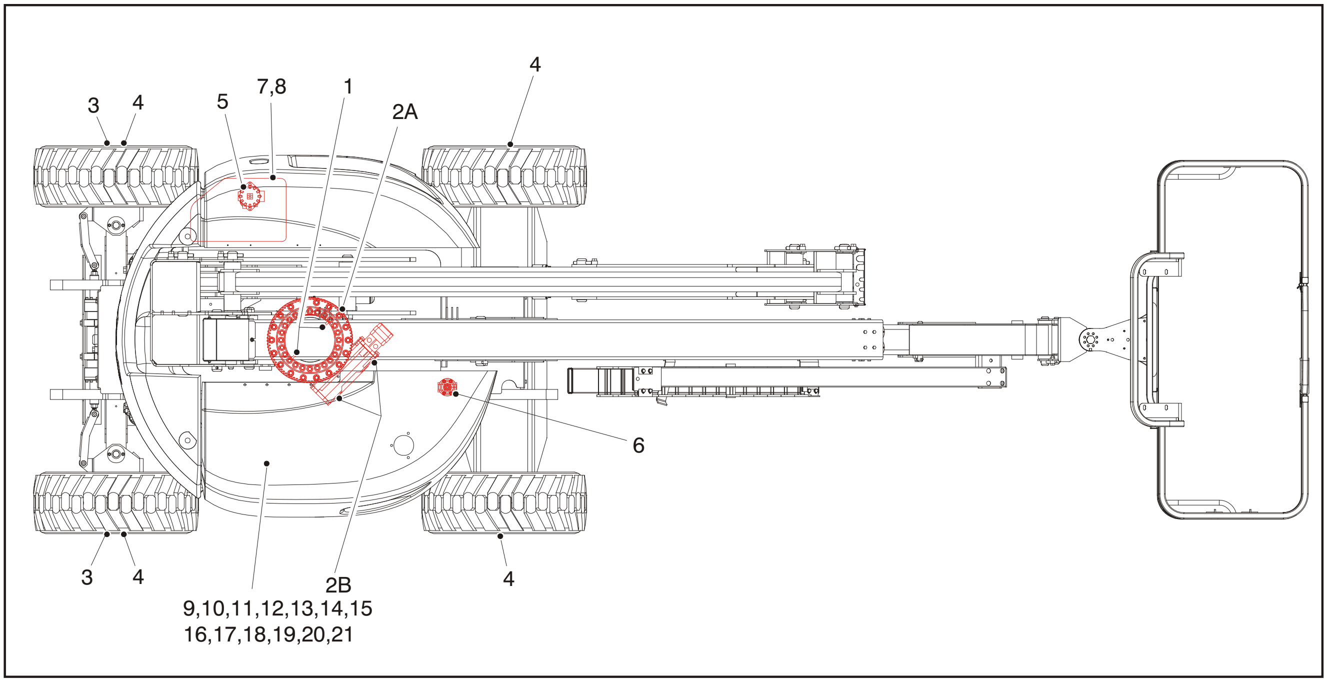


Figure 1-2. Operator Maintenance and Lubrication Diagram

1.11 OPERATOR MAINTENANCE

NOTE: *The following numbers correspond to those in Figure 1-2., Operator Maintenance and Lubrication Diagram.*

Table 1-25. Lubrication Specifications

KEY	SPECIFICATIONS
MPG	Multipurpose Grease having a minimum dripping point of 350° F (177° C). Excellent water resistance and adhesive qualities, and being of extreme pressure type. (Timken OK 40 pounds minimum.)
EPGL	Extreme Pressure Gear Lube (oil) meeting API service classification GL-5 or MIL-Spec MIL-L-2105
HO	Hydraulic Oil. API service classification GL-3, e.g. Mobilfluid 424.
EO	Engine (crankcase) Oil. Gas - API SF, SH, SG class, MIL-L-2104. Diesel - API CC/CD class, MIL-L-2104B/MIL-L-2104C.
OGL	Open Gear Lubricant - Mobiltac 375 or equivalent.

NOTICE

LUBRICATION INTERVALS ARE BASED ON MACHINE OPERATION UNDER NORMAL CONDITIONS. FOR MACHINES USED IN MULTI-SHIFT OPERATIONS AND/OR EXPOSED TO HOSTILE ENVIRONMENTS OR CONDITIONS, LUBRICATION FREQUENCIES MUST BE INCREASED ACCORDINGLY.

NOTE: *It is recommended as a good practice to replace all filters at the same time.*

1. Swing Bearing - Internal Ball Bearing

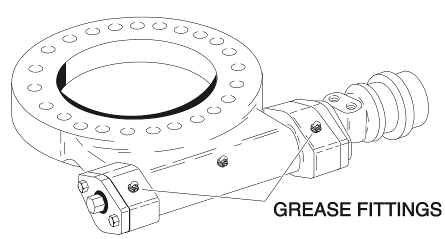
   Lube Point(s) - 2 Grease Fittings
   Capacity - A/R
   Lube - MPG
   Interval - Every 3 months or 150 hrs of operation.

2. A. Swing Bearing - Teeth

   Lube Point(s) - Spray On
   Capacity - A/R
   Lube - OGL
   Interval - Every 3 months or 150 hrs of operation.

   B. End Bearings - Worm Gear*

   Lube Point(s) - 2 Grease Fittings
   Capacity - A/R
   Lube - MPG
   Interval - Every 2 years or 1200 hrs of operation.
   Comments - Remove grease fittings and install plugs after greasing.

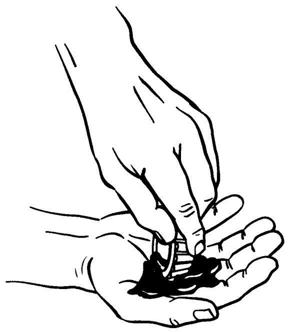


*Install grease fittings into worm gear housing and grease bearings if necessary.

NOTICE

DO NOT OVERGREASE END BEARINGS OR HOUSING OUTER SEAL MAY BLOW AND CAUSE DAMAGE TO EQUIPMENT.

3. Wheel Bearings (2WD Only)



Lube Point(s) - Repack
Capacity - A/R
Lube - MPG
Interval - Every 2 years or 1200 hours of operation.

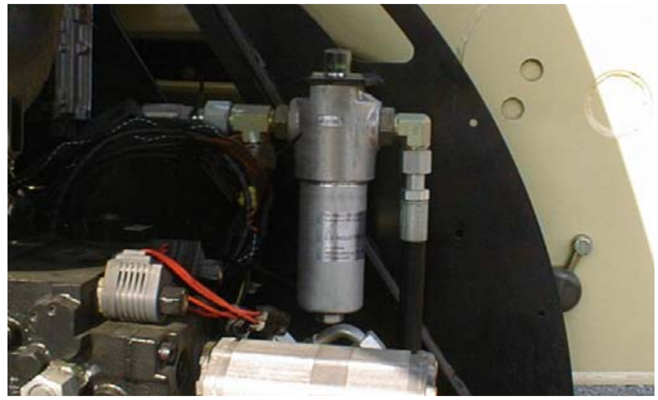
4. Wheel Drive Hub

Lube Point(s) - Level/Fill Plug
Capacity - 17 oz. (0.5 L) - 1/2 Full
Lube - EPGL
Interval - Check level every 3 months or 150 hrs of operation; change every 2 years or 1200 hours of operation.

5. Hydraulic Return Filter

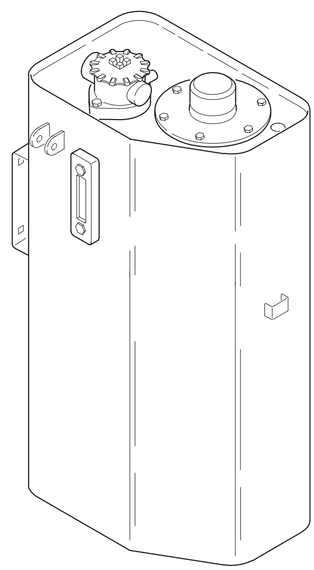
Interval - Change after first 50 hrs., every six months, or 300 hrs. thereafter, or as required by Condition Indicator.

6. Hydraulic Charge Filter



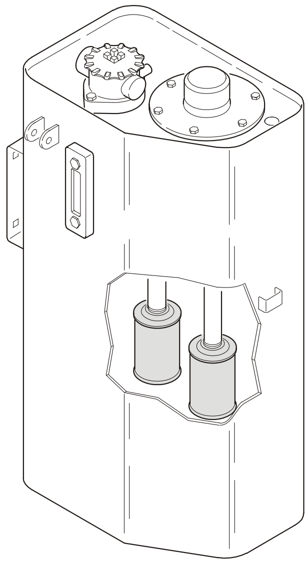
Interval - Change after first 50 hrs. and every 6 months or 300 hrs. thereafter or as indicated by Condition Indicator.

7. Hydraulic Tank



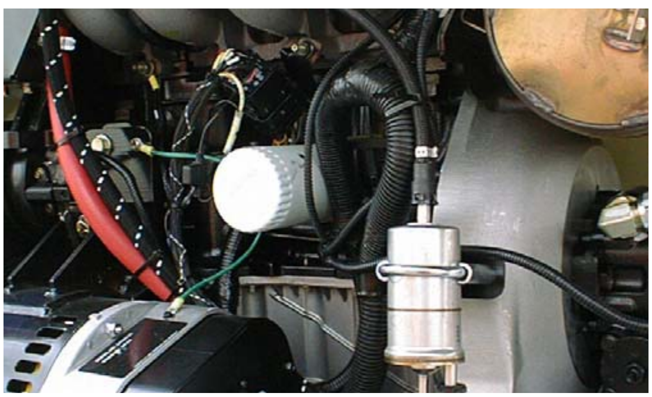
Lube Point(s) - Fill Cap
Capacity - 27 gallons (102 liters); 23.6 gal. (89 liters) to the Full line on the sight gauge.
Lube - HO
Interval - Check Level daily; Change every 2 years or 1200 hours of operation.

8. Suction Strainers



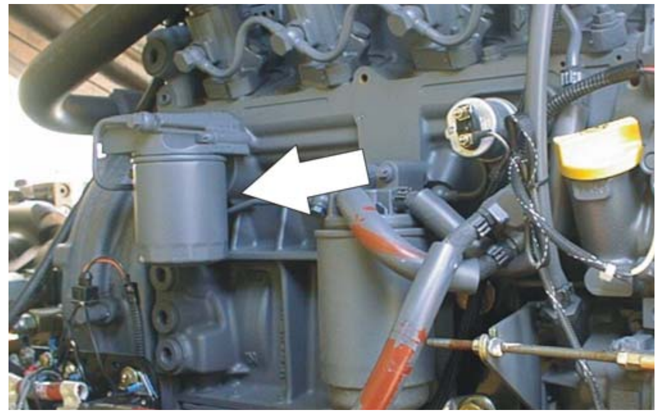
Lube Point(s) - 2
Interval - Every 2 years or 1200 hours of operation, remove and clean at time of hydraulic oil change.

9. Oil Change w/Filter - Ford



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

10. Oil Change w/Filter - Deutz



Lube Point(s) - Fill Cap/Spin-on Element
Capacity - 11 Quarts(10.5 L) Crankcase; 5 Quarts (4.7 L) Cooler
Lube - EO
Interval - Every Year or 1200 hours of operation.
Comments - Check level daily/Change in accordance with engine manual.

11. Oil Change w/Filter - Caterpillar

Lube Point(s) - Fill Cap/Spin-on Element
Capacity - 10 Quarts (9.4 L)
Lube - EO
Interval - Every Year or 600 hours of operation.
Comments - Check level daily/Change in accordance with engine manual.

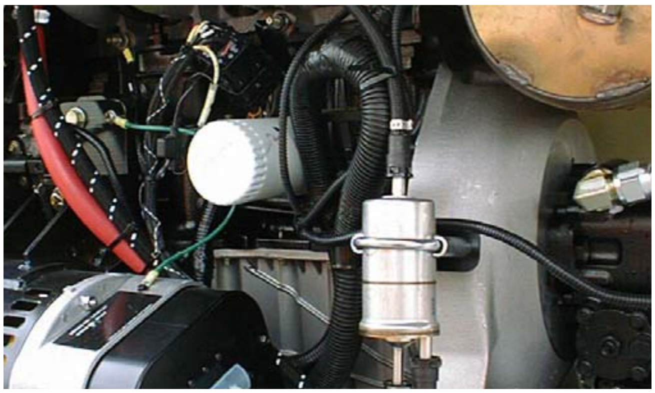
12. Oil Change w/Filter - GM

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.

13. Oil Change w/Filter - Perkins

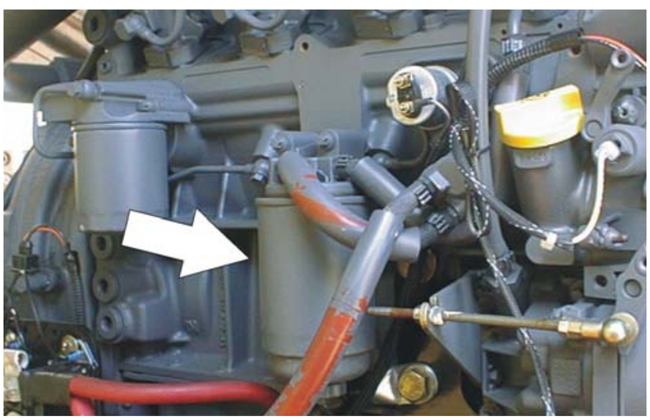
    Lube Point(s) - Fill Cap/Spin-on Element (JLG P/N 7026855)
    Capacity - 10 Quarts (9.4 L)
    Lube - EO
    Interval - Every Year or 600 hours of operation.
    Comments - Check level daily/Change in accordance with engine manual.

14. Fuel Filter - Ford



    Lube Point(s) - Replaceable Element
    Interval - Every Year or 1200 hours of operation

15. Fuel Filter - Deutz

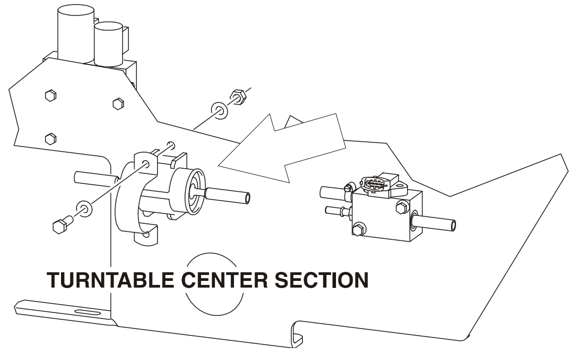


    Lube Point(s) - Replaceable Element
    Interval - Every Year or 600 hours of operation.

16. Fuel Filter - Caterpillar

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

17. Fuel Filter - GM



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

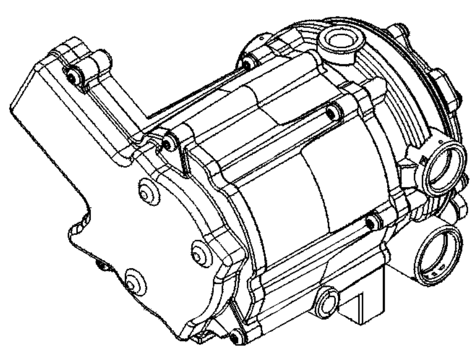
18. Fuel Filter - Perkins

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

19. Air Filter

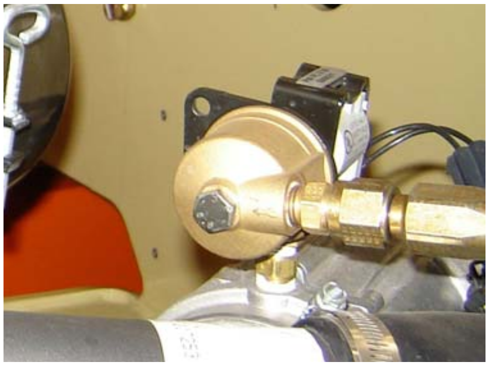
    Lube Point(s) - Replaceable Element
    Interval - Every 6 months or 300 hours of operation or as indicated by the condition indicator.

20. 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.

21. Fuel Filter (Propane) - GM Engine



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

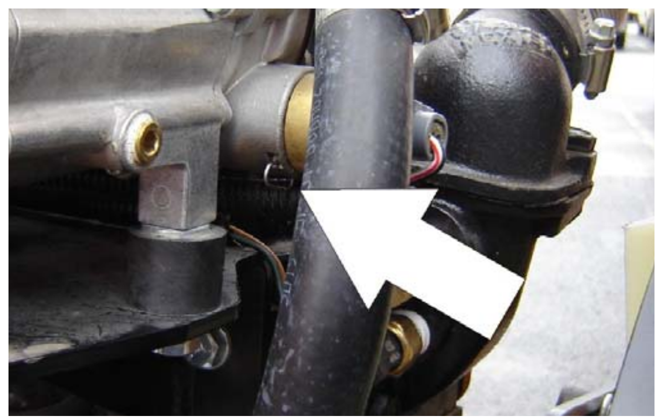
1.12 DRAINING PROPANE REGULATOR OIL BUILD UP (PRIOR TO S/N 0300137808)

Operation oils may build in propane pressure regulator primary and secondary chambers during normal use. These oils are caused by poor fuel quality, fuel supply chain contamination, or regional variation in fuel make up. Significant oil buildup can effect fuel control system operation. Refer to Section 1.11, Operator Maintenance for maintenance intervals. More frequent draining may be required if fuel supply is contaminated.

NOTE: *Warm engine to operating temperature before draining For best results. this will allow oils to flow freely from regulator.*

1. Move equipment to a well ventilated area. Ensure there are no external ignition sources.
2. Start engine and bring to operating temperature.
3. With engine running, close manual tank valve and run engine out of fuel.
4. Push Emergency Stop when engine stops.

5. Disconnect electrical connection to LPG fuel temperature sensor in auxiliary fuel port of the EPR.
6. Remove LPG fuel temperature sensor retainer clip and sensor from regulator body.



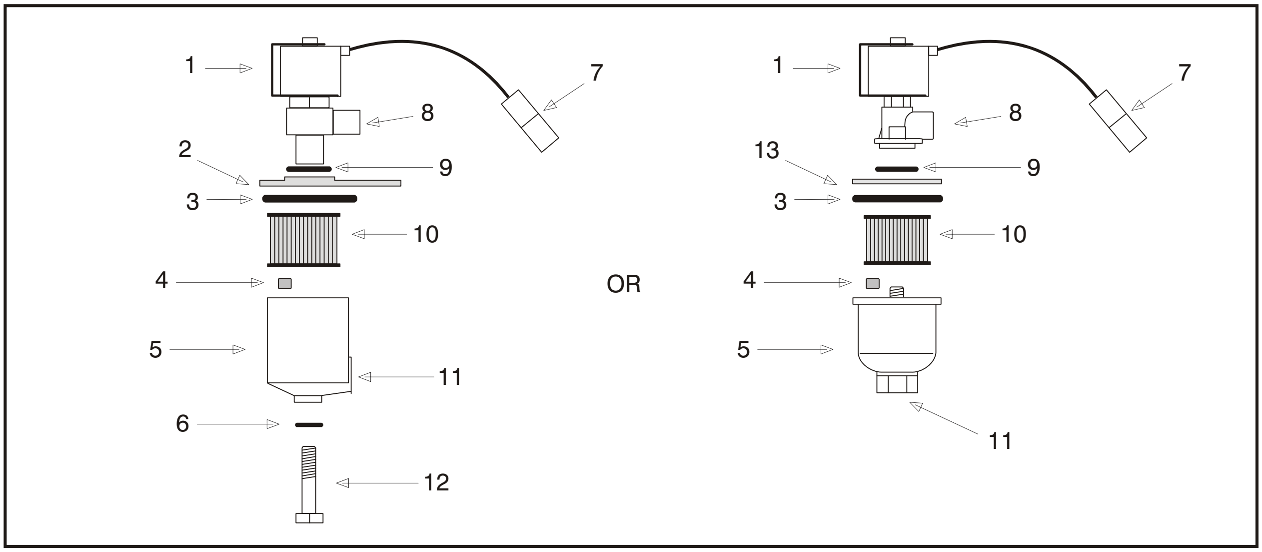
NOTE: *Have a small container ready to collect oil that drains freely from regulator.*

7. Drain all oil. Reinstall LPG fuel temperature sensor and reconnect electrical connector.
8. Open fuel tank manual valve.
9. Pull out Emergency Stop and start engine. Verify all connections are secure.
10. Dispose of any drained oil per local regulations in a safe and proper fashion.

1.13 PROPANE FUEL FILTER REPLACEMENT

Removal

1. Relieve propane fuel system pressure. Refer to 1.14 Propane Fuel System Pressure Relief.
2. Disconnect negative battery cable. Slowly loosen and remove filter housing.
3. Pull filter housing from electric lock off assembly.
4. Remove filter from housing.
5. Locate filter magnet and remove it.
6. Remove and discard housing seal.
7. If equipped, remove and discard retaining bolt seal.
8. Remove and discard mounting plate to lock off O-ring seal.



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
13. Ring

Figure 1-3. Filter Lock Assembly

Installation

NOTE: *NOTE: Reinstall filter magnet in housing before installing new seal.*

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

1.14 PROPANE SYSTEM PRESSURE RELIEF

⚠ CAUTION

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

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

⚠ CAUTION

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

				Values for Zinc Yellow Chromate Fasteners (Ref 4150707)								
				SAE GRADE 5 BOLTS & GRADE 2 NUTS								
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load	Torque (Dry)		Torque Lubricated		Torque (Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140)		Torque (Loctite® 262™ or Vibra-TITE™ 131)	
		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	0.9	6	0.7				
	48	0.1120	0.00661	420	9	1.0	7	0.8				
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	3.4	22	2.5				
	36	0.1640	0.01474	940	31	3.5	23	2.6				
10	24	0.1900	0.01750	1120	43	4.8	32	3.5				
	32	0.1900	0.02000	1285	49	5.5	36	4				
1/4	20	0.2500	0.0318	2020	96	10.8	75	9	105	12		
	28	0.2500	0.0364	2320	120	13.5	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	19	26	16	22
	24	0.3125	0.0580	3700	19	26	14	19	21	29	17	23
3/8	16	0.3750	0.0775	4940	30	41	23	31	35	48	28	38
	24	0.3750	0.0878	5600	35	47	25	34	40	54	32	43
7/16	14	0.4375	0.1063	6800	50	68	35	47	55	75	45	61
	20	0.4375	0.1187	7550	55	75	40	54	60	82	50	68
1/2	13	0.5000	0.1419	9050	75	102	55	75	85	116	68	92
	20	0.5000	0.1599	10700	90	122	65	88	100	136	80	108
9/16	12	0.5625	0.1820	11600	110	149	80	108	120	163	98	133
	18	0.5625	0.2030	12950	120	163	90	122	135	184	109	148
5/8	11	0.6250	0.2260	14400	150	203	110	149	165	224	135	183
	18	0.6250	0.2560	16300	170	230	130	176	190	258	153	207
3/4	10	0.7500	0.3340	21300	260	353	200	271	285	388	240	325
	16	0.7500	0.3730	23800	300	407	220	298	330	449	268	363
7/8	9	0.8750	0.4620	29400	430	583	320	434	475	646	386	523
	14	0.8750	0.5090	32400	470	637	350	475	520	707	425	576
1	8	1.0000	0.6060	38600	640	868	480	651	675	918	579	785
	12	1.0000	0.6630	42200	700	949	530	719	735	1000	633	858
1 1/8	7	1.1250	0.7630	42300	800	1085	600	813	840	1142	714	968
	12	1.1250	0.8560	47500	880	1193	660	895	925	1258	802	1087
1 1/4	7	1.2500	0.9690	53800	1120	1518	840	1139	1175	1598	1009	1368
	12	1.2500	1.0730	59600	1240	1681	920	1247	1300	1768	1118	1516
1 3/8	6	1.3750	1.1550	64100	1460	1979	1100	1491	1525	2074	1322	1792
	12	1.3750	1.3150	73000	1680	2278	1260	1708	1750	2380	1506	2042
1 1/2	6	1.5000	1.4050	78000	1940	2630	1460	1979	2025	2754	1755	2379
	12	1.5000	1.5800	87700	2200	2983	1640	2224	2300	3128	1974	2676

NO. 5000059 REV. J

NOTES:
1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
3. * ASSEMBLY USES HARDENED WASHER

	REFERENCE JLG ANEROBIC THREAD LOCKING COMPOUND			
JLG P/N	Loctite® P/N		ND Industries P/N	Description
0100011	242™		Vibra-TITE™ 121	Medium Strength (Blue)
0100019	271™		Vibra-TITE™ 140	High Strength (Red)
0100071	262™		Vibra-TITE™ 131	Medium - High Strength (Red)

Figure 1-4. Torque Chart (SAE Fasteners - Sheet 1 of 7)

				Values for Zinc Yellow Chromate Fasteners (Ref 4150707)						
				SAE GRADE 8 (HEX HD) BOLTS & GRADE 8 NUTS*						
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load	Torque (Dry or Loctite® 263) K= 0.20		Torque (Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140) K=.18		Torque (Loctite® 262™ or Vibra-TITE™ 131) K=0.15	
		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	1320	43	5				
10	24	0.1900	0.01750	1580	60	7				
	32	0.1900	0.02000	1800	68	8				
1/4	20	0.2500	0.0318	2860	143	16	129	15		
	28	0.2500	0.0364	3280	164	19	148	17		
		In	Sq In	LB	FT-LB	[N.m]	FT-LB	[N.m]	FT-LB	[N.m
5/16	18	0.3125	0.0524	4720	25	35	20	25	20	25
	24	0.3125	0.0580	5220	25	35	25	35	20	25
3/8	16	0.3750	0.0775	7000	45	60	40	55	35	50
	24	0.3750	0.0878	7900	50	70	45	60	35	50
7/16	14	0.4375	0.1063	9550	70	95	65	90	50	70
	20	0.4375	0.1187	10700	80	110	70	95	60	80
1/2	13	0.5000	0.1419	12750	105	145	95	130	80	110
	20	0.5000	0.1599	14400	120	165	110	150	90	120
9/16	12	0.5625	0.1820	16400	155	210	140	190	115	155
	18	0.5625	0.2030	18250	170	230	155	210	130	175
5/8	11	0.6250	0.2260	20350	210	285	190	260	160	220
	18	0.6250	0.2560	23000	240	325	215	290	180	245
3/4	10	0.7500	0.3340	30100	375	510	340	460	280	380
	16	0.7500	0.3730	33600	420	570	380	515	315	430
7/8	9	0.8750	0.4620	41600	605	825	545	740	455	620
	14	0.8750	0.5090	45800	670	910	600	815	500	680
1	8	1.0000	0.6060	51500	860	1170	770	1045	645	875
	12	1.0000	0.6630	59700	995	1355	895	1215	745	1015
1 1/8	7	1.1250	0.7630	68700	1290	1755	1160	1580	965	1310
	12	1.1250	0.8560	77000	1445	1965	1300	1770	1085	1475
1 1/4	7	1.2500	0.9690	87200	1815	2470	1635	2225	1365	1855
	12	1.2500	1.0730	96600	2015	2740	1810	2460	1510	2055
1 3/8	6	1.3750	1.1550	104000	2385	3245	2145	2915	1785	2430
	12	1.3750	1.3150	118100	2705	3680	2435	3310	2030	2760
1 1/2	6	1.5000	1.4050	126500	3165	4305	2845	3870	2370	3225
	12	1.5000	1.5800	142200	3555	4835	3200	4350	2665	3625

NO. 5000059 REV. J

NOTES:
1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
3. * ASSEMBLY USES HARDENED WASHER

Figure 1-5. Torque Chart (SAE Fasteners - Sheet 2 of 7)

				SOCKET HEAD CAP SCREWS						
				Magni Coating (Ref 4150701)*						
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load See Note 4	Torque (Dry) K = .17		Torque (Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140 OR Precoat 85® K=0.16		Torque (Loctite® 262™ or Vibra-TITE™ 131) K=0.15	
		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	122	14	114	13		
	28	0.2500	0.0364	3280	139	16	131	15		
		In	Sq In	LB	FT-LB	[N.m]	FT-LB	[N.m]	FT-LB	[N.m]
5/16	18	0.3125	0.0524	4720	20	25	20	25	20	25
	24	0.3125	0.0580	5220	25	35	20	25	20	25
3/8	16	0.3750	0.0775	7000	35	50	35	50	35	50
	24	0.3750	0.0878	7900	40	55	40	55	35	50
7/16	14	0.4375	0.1063	9550	60	80	55	75	50	70
	20	0.4375	0.1187	10700	65	90	60	80	60	80
1/2	13	0.5000	0.1419	12750	90	120	85	115	80	110
	20	0.5000	0.1599	14400	100	135	95	130	90	120
9/16	12	0.5625	0.1820	16400	130	175	125	170	115	155
	18	0.5625	0.2030	18250	145	195	135	185	130	175
5/8	11	0.6250	0.2260	20350	180	245	170	230	160	220
	18	0.6250	0.2560	23000	205	280	190	260	180	245
3/4	10	0.7500	0.3340	30100	320	435	300	410	280	380
	16	0.7500	0.3730	33600	355	485	335	455	315	430
7/8	9	0.8750	0.4620	41600	515	700	485	660	455	620
	14	0.8750	0.5090	45800	570	775	535	730	500	680
1	8	1.0000	0.6060	51500	730	995	685	930	645	875
	12	1.0000	0.6630	59700	845	1150	795	1080	745	1015
1 1/8	7	1.1250	0.7630	68700	1095	1490	1030	1400	965	1310
	12	1.1250	0.8560	77000	1225	1665	1155	1570	1085	1475
1 1/4	7	1.2500	0.9690	87200	1545	2100	1455	1980	1365	1855
	12	1.2500	1.0730	96600	1710	2325	1610	2190	1510	2055
1 3/8	6	1.3750	1.1550	104000	2025	2755	1905	2590	1785	2430
	12	1.3750	1.3150	118100	2300	3130	2165	2945	2030	2760
1 1/2	6	1.5000	1.4050	126500	2690	3660	2530	3440	2370	3225
	12	1.5000	1.5800	142200	3020	4105	2845	3870	2665	3625

NO. 5000059 REV. J

NOTES: 1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
*3. ASSEMBLY USES HARDENED WASHER OR FASTENER IS PLACED AGAINST PLATED STEEL OR RAW ALUMINUM
4. CLAMP LOAD LISTED FOR SHCS IS SAME AS GRADE 8 OR CLASS 10.9 AND DOES NOT REPRESENT FULL STRENGTH CAPABILITY OF SHCS. IF HIGHER LOAD IS REQUIRED, ADDITIONAL TESTING IS REQUIRED.

Figure 1-6. Torque Chart (SAE Fasteners - Sheet 3 of 7)

				SOCKET HEAD CAP SCREWS						
				Zinc Yellow Chromate Fasteners (Ref 4150707)*						
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load See Note 4	Torque (Dry) K = .20		Torque (Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140 OR Precoat 85® K=0.18		Torque (Loctite® 262™ or Vibra-TITE™ 131) K=0.15	
		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	143	16	129	15		
	28	0.2500	0.0364	3280	164	19	148	17		
		In	Sq In	LB	FT-LB	[N.m]	FT-LB	[N.m]	FT-LB	[N.m]
5/16	18	0.3125	0.0524	4720	25	35	20	25	20	25
	24	0.3125	0.0580	5220	25	35	25	35	20	25
3/8	16	0.3750	0.0775	7000	45	60	40	55	35	50
	24	0.3750	0.0878	7900	50	70	45	60	35	50
7/16	14	0.4375	0.1063	9550	70	95	65	90	50	70
	20	0.4375	0.1187	10700	80	110	70	95	60	80
1/2	13	0.5000	0.1419	12750	105	145	95	130	80	110
	20	0.5000	0.1599	14400	120	165	110	150	90	120
9/16	12	0.5625	0.1820	16400	155	210	140	190	115	155
	18	0.5625	0.2030	18250	170	230	155	210	130	175
5/8	11	0.6250	0.2260	20350	210	285	190	260	160	220
	18	0.6250	0.2560	23000	240	325	215	290	180	245
3/4	10	0.7500	0.3340	30100	375	510	340	460	280	380
	16	0.7500	0.3730	33600	420	570	380	515	315	430
7/8	9	0.8750	0.4620	41600	605	825	545	740	455	620
	14	0.8750	0.5090	45800	670	910	600	815	500	680
1	8	1.0000	0.6060	51500	860	1170	775	1055	645	875
	12	1.0000	0.6630	59700	995	1355	895	1215	745	1015
1 1/8	7	1.1250	0.7630	68700	1290	1755	1160	1580	965	1310
	12	1.1250	0.8560	77000	1445	1965	1300	1770	1085	1475
1 1/4	7	1.2500	0.9690	87200	1815	2470	1635	2225	1365	1855
	12	1.2500	1.0730	96600	2015	2740	1810	2460	1510	2055
1 3/8	6	1.3750	1.1550	104000	2385	3245	2145	2915	1785	2430
	12	1.3750	1.3150	118100	2705	3680	2435	3310	2030	2760
1 1/2	6	1.5000	1.4050	126500	3165	4305	2845	3870	2370	3225
	12	1.5000	1.5800	142200	3555	4835	3200	4350	2665	3625

NO. 5000059 REV. J

NOTES: 1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
*3. ASSEMBLY USES HARDENED WASHER OR FASTENER IS PLACED AGAINST PLATED STEEL OR RAW ALUMINUM
4. CLAMP LOAD LISTED FOR SHCS IS SAME AS GRADE 8 OR CLASS 10.9 AND DOES NOT REPRESENT FULL STRENGTH CAPABILITY OF SHCS. IF HIGHER LOAD IS REQUIRED, ADDITIONAL TESTING IS REQUIRED.

Figure 1-7. Torque Chart (SAE Fasteners - Sheet 4 of 7)

			Values for Zinc Yellow Chromate Fasteners (Ref 4150707				
			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™ OR Vibra-TITE™ 131)	Torque (Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140)
		Sq mm	KN	[N.m]	[N.m]	[N.m]	[N.m]
3	0.5	5.03	2.19	1.3	1.0	1.2	1.4
3.5	0.6	6.78	2.95	2.1	1.6	1.9	2.3
4	0.7	8.78	3.82	3.1	2.3	2.8	3.4
5	0.8	14.20	6.18	6.2	4.6	5.6	6.8
6	1	20.10	8.74	11	7.9	9.4	12
7	1	28.90	12.6	18	13	16	19
8	1.25	36.60	15.9	26	19	23	28
10	1.5	58.00	25.2	50	38	45	55
12	1.75	84.30	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

NO. 5000059 REV. J

NOTES: 1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
*3. ASSEMBLY USES HARDENED WASHER OR FASTENER IS PLACED AGAINST PLATED STEEL OR RAW ALUMINUM
4. CLAMP LOAD LISTED FOR SHCS IS SAME AS GRADE 8 OR CLASS 10.9 AND DOES NOT REPRESENT FULL STRENGTH CAPABILITY OF SHCS. IF HIGHER LOAD IS REQUIRED, ADDITIONAL TESTING IS REQUIRED.

Figure 1-8. Torque Chart (METRIC Fasteners - Sheet 5 of 7)

			Values for Zinc Yellow Chromate Fasteners (Ref 4150707)			
			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™) K = 0.20	Torque (Lub OR Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140) K= 0.18	Torque (Loctite® 262™ OR Vibra-TITE™ 131) K=0.15
		Sq mm	KN	[N.m]	[N.m]	[N.m]
3	0.5	5.03	3.13			
3.5	0.6	6.78	4.22			
4	0.7	8.78	5.47			
5	0.8	14.20	8.85			
6	1	20.10	12.5			
7	1	28.90	18.0	25.2	22.7	18.9
8	1.25	36.60	22.8	36.5	32.8	27.4
10	1.5	58.00	36.1	70	65	55
12	1.75	84.30	52.5	125	115	95
14	2	115	71.6	200	180	150
16	2	157	97.8	315	280	235
18	2.5	192	119.5	430	385	325
20	2.5	245	152.5	610	550	460
22	2.5	303	189.0	830	750	625
24	3	353	222.0	1065	960	800
27	3	459	286.0	1545	1390	1160
30	3.5	561	349.5	2095	1885	1575
33	3.5	694	432.5	2855	2570	2140
36	4	817	509.0	3665	3300	2750
42	4.5	1120	698.0	5865	5275	4395

NO. 5000059 REV. J

NOTES: 1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
*3. ASSEMBLY USES HARDENED WASHER OR FASTENER IS PLACED AGAINST PLATED STEEL OR RAW ALUMINUM
4. CLAMP LOAD LISTED FOR SHCS IS SAME AS GRADE 8 OR CLASS 10.9 AND DOES NOT REPRESENT FULL STRENGTH CAPABILITY OF SHCS. IF HIGHER LOAD IS REQUIRED, ADDITIONAL TESTING IS REQUIRED.

Figure 1-9. Torque Chart (METRIC Fasteners - Sheet 6 of 7)

			Magni Coating (Ref 4150701)* CLASS 12.9 SOCKET HEAD CAP SCREWS M6 AND ABOVE*			
Size	PITCH	Tensile Stress Area	Clamp Load See Note 4	Torque (Dry or Loctite® 263™) K = .17	Torque (Lub OR Loctite® 242™ or 271™ OR Vibra-TITE™ 111 or 140) K = .16	Torque (Loctite® 262™ OR Vibra-TITE™ 131) K = .15
		Sq mm	kN	[N.m]	[N.m]	[N.m]
3	0.5	5.03				
3.5	0.6	6.78				
4	0.7	8.78				
5	0.8	14.20				
6	1	20.10	12.5	13	12	11
7	1	28.90	18.0	21	20	19
8	1.25	36.60	22.8	31	29	27
10	1.5	58.00	36.1	61	58	54
12	1.75	84.30	52.5	105	100	95
14	2	115	71.6	170	160	150
16	2	157	97.8	265	250	235
18	2.5	192	119.5	365	345	325
20	2.5	245	152.5	520	490	460
22	2.5	303	189.0	705	665	625
24	3	353	220.0	900	845	790
27	3	459	286.0	1315	1235	1160
30	3.5	561	349.5	1780	1680	1575
33	3.5	694	432.5	2425	2285	2140
36	4	817	509.0	3115	2930	2750
42	4.5	1120	698.0	4985	4690	4395

NO. 5000059 REV. J

NOTES: 1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
*3. ASSEMBLY USES HARDENED WASHER OR FASTENER IS PLACED AGAINST PLATED STEEL OR RAW ALUMINUM
4. CLAMP LOAD LISTED FOR SHCS IS SAME AS GRADE 8 OR CLASS 10.9 AND DOES NOT REPRESENT FULL STRENGTH CAPABILITY OF SHCS. IF HIGHER LOAD IS REQUIRED, ADDITIONAL TESTING IS REQUIRED.

Figure 1-10. Torque Chart (METRIC Fasteners - Sheet 7 of 7)

NOTES:

SECTION 2. GENERAL

2.1 MACHINE PREPARATION, INSPECTION, AND MAINTENANCE

General

This section provides information needed to place machine in operation readiness and maintain its safe operating condition. Ensure all inspections and maintenance have been completed before placing machine into service for safe operation and maximum service life.

Preparation, Inspection, and Maintenance

It is important to establish a comprehensive inspection and preventive maintenance program. Table 2-1 outlines periodic machine inspections and maintenance recommended by JLG Industries, Inc. Consult your national, regional, or local regulations for further requirements for aerial work platforms. Increase frequency of inspections and maintenance 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. Follow the Operator's and Safety Manual Pre-Start Inspection procedures. The Operator and Safety Manual must be read in its entirety and understood before performing a 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.

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 more than 3 months; or when purchased used. 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 Inspection and Preventative Maintenance Schedule for items requiring inspection.

Reference appropriate areas of this manual for servicing and maintenance procedures.

Annual Machine Inspection

The Annual Machine Inspection must be performed no later than 13 months from date of prior Annual Machine Inspection. It is recommended the annual inspection be done by a JLG Factory-Certified Service Technician.

Reference JLG Annual Machine Inspection Form and Inspection and Preventative Maintenance Schedule for items requiring inspection. Refer to appropriate areas of this manual for service and maintenance procedures.

For 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 any change in machine ownership.

Preventative Maintenance

In conjunction with 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 ability and proficiency to service, repair, and maintain the subject JLG product model.

Reference Preventative Maintenance Schedule and appropriate areas of this manual for servicing and maintenance procedures. 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	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 manual.

Safety and Workmanship

Your safety, and that of others, is the first consideration during 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, clean openings, fittings, and adjacent areas. 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. Ensure all passages and openings are unobstructed. Cover all parts to keep them clean. Be sure all parts are clean before they are installed. Keep new parts in their containers until needed.

Components Removal and Installation

1. Use adjustable lifting devices 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 the capacity of an eyebolt or similar bracket lessens, as the angle between the supporting structure and component becomes less than 90 degrees.
3. If a part resists removal, check to see whether all nuts, bolts, cables, brackets, wiring, etc., have been removed and no adjacent parts are interfering.

Component Disassembly and Reassembly

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

Pressure-Fit Parts

Use anti-seize or a molybdenum disulfide base compound to lubricate the mating surface when assembling pressure-fit parts.

Bearings

1. When a bearing is removed, cover it to keep out dirt and abrasives. Clean bearings in nonflammable cleaning solvent and allow to air dry. Compressed air can be used, but do not spin bearing.

2. Discard bearings if races and balls (or rollers) are pitted, scored, or burned.

3. If bearing is serviceable, apply a light coat of oil and wrap it in clean (waxed) paper. Do not unwrap reusable or new bearings until 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 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 as the original or 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, electrical wiring, and their receptacles when disconnecting or removing them. This ensures they will be correctly reinstalled.

Hydraulic System

1. Keep system clean. If evidence of metal or rubber particles are found in the hydraulic system, drain and flush entire system.

2. Disassemble and reassemble parts on clean work surface. Clean all metal parts with non-flammable cleaning solvent. Lubricate components to aid assembly if required.

Lubrication

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

Battery

Clean battery with 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. Contamination is the primary enemy of a hydraulic system. Contaminants enter the system by using inadequate hydraulic oil, allowing moisture, grease, filings, sealing components, sand, etc., to enter when performing maintenance, or by allowing the pump to cavitate due to insufficient system warm-up, or leaks in the pump supply (suction) lines.

2. Design and manufacturing tolerances of component working parts are very close. Even the smallest amount of dirt or foreign matter entering a system can cause wear or damage to components and ca cause faulty operation. Take every precaution to keep hydraulic oil clean, including reserve oil in storage. Hydraulic system filters should be checked, cleaned, and/or replaced as necessary, at intervals specified 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 ambient temperatures in which the machine is operating, are recommended for use.

NOTE: *Metal particles may appear in oil or filters of new machines due to 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.

NOTICE

STARTUP OF HYDRAULIC SYSTEM WITH OIL TEMPERATURES BELOW -15°F (-26°C) IS NOT RECOMMENDED.

3. If it is necessary to start the system in a sub-zero environment, heat oil with a low density, 100VAC heater to a minimum temperature of -15°F (-26°C).

NOTICE

SYSTEMS USING DTE 13 OIL SHOULD NOT BE OPERATED AT TEMPERATURES ABOVE 200 DEGREES F (94 DEGREES C) UNDER ANY CONDITION.

4. The only exception to the previous is to drain and fill the system with Mobil DTE 13 oil or equivalent. This allows start up at temperatures down to -20° F (-29°C). However, use of this oil will give poor performance at temperatures above 120°F (49° C).

Changing Hydraulic Oil

1. Use of any recommended crankcase or hydraulic oils eliminates the need for changing 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 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 hydraulic oil clean. If oil must be poured from original container into another, clean all possible contaminants from the service container. Always clean filter mesh element and replace cartridge any time system oil is changed.
3. While unit is shut down, make a thorough inspection of all hydraulic components, lines, fittings, etc., as well as a functional check of each system, before placing 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 qualities which meet a variety of single purpose grease requirements. Should any question arise regarding 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

Measure maximum acceptable cylinder drift using the following methods.

Platform Drift

Measure platform to ground drift. Lower booms (if equipped) slightly elevated, upper boom fully extended with rated load in the platform and power off. Maximum allowable drift is 2" (5 cm) in 10 minutes. If 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 cylinder rod with a calibrated dial indicator. Cylinder oil must be at ambient temperature and temperature stabilized.

Cylinder must have normal platform load applied.

If cylinder passes this test, it is acceptable.

NOTE: *This information 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 joint during operation.
2. Filament wound bearings should be replaced if any of the following is observed:
   a. Frayed or separated fibers on 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 bearing area.
   b. Flaking, pealing, scoring, or scratches on pin surface.
   c. Rusting of pin in 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. Clean bearing/pins with a solvent to remove all grease and oil. Filament wound bearing are a dry joint and should not be lubricated.
   c. Inspect pin to ensure it is free of burrs, nicks, and scratches which would damage bearing during installation and operation.

2.6 WELDING ON JLG EQUIPMENT

NOTE: *This instruction applies to repairs, or modifications to the machine and to welding performed from machine on an external structure, or component,*

DO the Following When Welding on JLG Equipment

- Disconnect battery.
- Disconnect moment pin connection (where fitted).
- Ground only to structure being welded.

DO NOT Do the Following When Welding on JLG Equipment

- Ground on frame and weld on any other area than chassis.
- Ground on turntable and weld on any other area than turntable.
- Ground on platform/support and weld on any other area than platform/support.
- Ground on a specific boom section and weld on any other area than that specific boom section.
- Allow pins, wear pads, wire ropes, bearings, gearing, seals, valves, electrical wiring, or hoses to be between grounding position and welded area.

NOTICE

FAILURE TO COMPLY WITH THE ABOVE REQUIREMENTS MAY RESULT IN COMPONENT DAMAGE (I.E. ELECTRONIC MODULES, SWING BEARING, COLLECTOR RING, BOOM WIRE ROPES ETC.)

Table 2-3. Inspection and Preventive Maintenance Schedule

AREA	INTERVAL					
	Pre-Start[1] Inspection	Weekly Preventive Maintenance	Monthly Preventive Maintenance	Pre-Delivery[2] or Frequent[3] Inspection	Annual[4] (Yearly) Inspection	Every 2 Years
Boom Assembly	9					
Boom Weldments				1,2,4	1,2,4	
Hose/Cable Carrier Installations				1,2,9,12	1,2,9,12	
Pivot Pins and Pin Retainers				1,2	1,2	
Sheaves, Sheave Pins				1,2	1,2	
Bearings				1,2	1,2	
Wear Pads				1,2	1,2	
Covers or Shields				1,2	1,2	
Extend/Retract Chain or Cable Systems				1,2,3	1,2,3	
Platform Assembly	9					
Platform	1,2				1,2	
Railing	1,2			1	1,2	
Gate			5	1	1,5	
Floor	1,2			1	1,2	
Rotator		9,5		15		
Lanyard Anchorage Point	2			1,2,10	1,2,10	
Turntable Assembly	9					
Swing Bearing or Worm Gear				1,2,14	1,2,3,13,14	
Oil Coupling		9				
Swing Drive System						
Turntable Lock				1,2,5	1,2,5	
Hood, Hood Props, Hood Latches				5	1,2,5	
Chassis Assembly	9					
Tires	1	16,17		16,17,18	16,17,18	
Wheel Nuts/Bolts	1	15		15	15	
Wheel Bearings						14,24
Oscillating Axle/Lockout Cylinder Systems					5,8	
Outrigger or Extendable Axle Systems				5,8	5,8	
Steer Components						
Drive Motors						
Torque Hubs				11	11	
Functions/Controls	9					
Platform Controls	5	5		6	6	

Table 2-3. Inspection and Preventive Maintenance Schedule

AREA	INTERVAL					
	Pre-Start[1] Inspection	Weekly Preventive Maintenance	Monthly Preventive Maintenance	Pre-Delivery[2] or Frequent[3] Inspection	Annual[4] (Yearly) Inspection	Every 2 Years
Ground Controls	5	5		6	6	
Function Control Locks, Guards, or Detents	1,5	1,5		5	5	
Footswitch	1,5			5	5	
Emergency Stop Switches (Ground & Platform)	5			5	5	
Function Limit or Cutout Switch Systems				5	5	
Capacity Indicator					5	
Drive Brakes				5		
Swing Brakes				5		
Boom Synchronization/Sequencing Systems					5	
Manual Descent or Auxiliary Power				5	5	
Power System	9					
Engine Idle, Throttle, and RPM				3	3	
Engine Fluids (Oil, Coolant, Fuel)	11	9,11		11	11	
Air/Fuel Filter		1,7		7	7	
Exhaust System			1,9	9	9	
Batteries	5	1,9			19	
Battery Fluid		11		11	11	
Battery Charger		5			5	
Fuel Reservoir, Cap, and Breather	11,9		2	1,5	1,5	
Hydraulic/Electric System	9					
Hydraulic Pumps		1,9		1,2,9		
Hydraulic Cylinders		1,9,7	2	1,2,9	1,2,9	
Cylinder Attachment Pins and Pin Retainers		1,9		1,2	1,2	
Hydraulic Hoses, Lines, and Fittings		1,9	12	1,2,9,12	1,2,9,12	
Hydraulic Reservoir, Cap, and Breather	11	1,9	2	1,5	1,5	24
Hydraulic Filter		1,9		7	7	
Hydraulic Fluid	11			7,11	7,11	
Electrical Connections		1		20	20	
Instruments, Gauges, Switches, Lights, Horn		1			5,23	
General						
Operators and Safety Manuals in Storage Box	21			21	21	
ANSI and EMI Manuals/Handbooks Installed					21	
Capacity Decals Installed, Secure, Legible	21			21	21	
All Decals/Placards Installed, Secure, Legible	21			21	21	

Table 2-3. Inspection and Preventive Maintenance Schedule

AREA	INTERVAL					
	Pre-Start[1] Inspection	Weekly Preventive Maintenance	Monthly Preventive Maintenance	Pre-Delivery[2] or Frequent[3] Inspection	Annual[4] (Yearly) Inspection	Every 2 Years
Walk-Around Inspection Performed	21					
Annual Machine Inspection Due				21		
No Unauthorized Modifications or Additions				21	21	
All Relevant Safety Publications Incorporated				21	21	
General Structural Condition and Welds				2,4	2,4	
All Fasteners, Pins, Shields, and Covers				1,2	1,2	
Grease and Lubricate to Specifications				22	22	
Function Test of All Systems	21			21	21, 22	
Paint and Appearance				7	7	
Stamp Inspection Date on Frame					22	
Notify JLG of Machine Ownership					22	

Footnotes:
[1] Prior to use each day; or at each Operator change
[2] Prior to each sale, lease, or delivery
[3] In service for 3 months or 150 Hours; or Out of service for 3 months or more; or Purchased used
[4] Annually, no later than 13 months from the date of the prior inspection

Performance Codes:
1 - Check for proper and secure installation
2 - Visual inspection for damage, cracks, distortion or excessive wear
3 - Check for proper adjustment
4 - Check for cracked or broken welds
5 - Operates Properly
6 - Returns to neutral or "off" position when released
7 - Clean and free of debris
8 - Interlocks function properly
9 - Check for signs of leakage
10 - Decals installed and legible
11 - Check for proper fluid level
12 - Check for chafing and proper routing
13 - Check for proper tolerances
14 - Properly lubricated
15 - Torqued to proper specification
16 - No gouges, excessive wear, or cords showing
17 - Properly inflated and seated around rim
18 - Proper and authorized components
19 - Fully charged
20 - No loose connections, corrosion, or abrasions
21 - Verify
22 - Perform
23 - Sealed Properly
24 - Drain, Clean, Refill

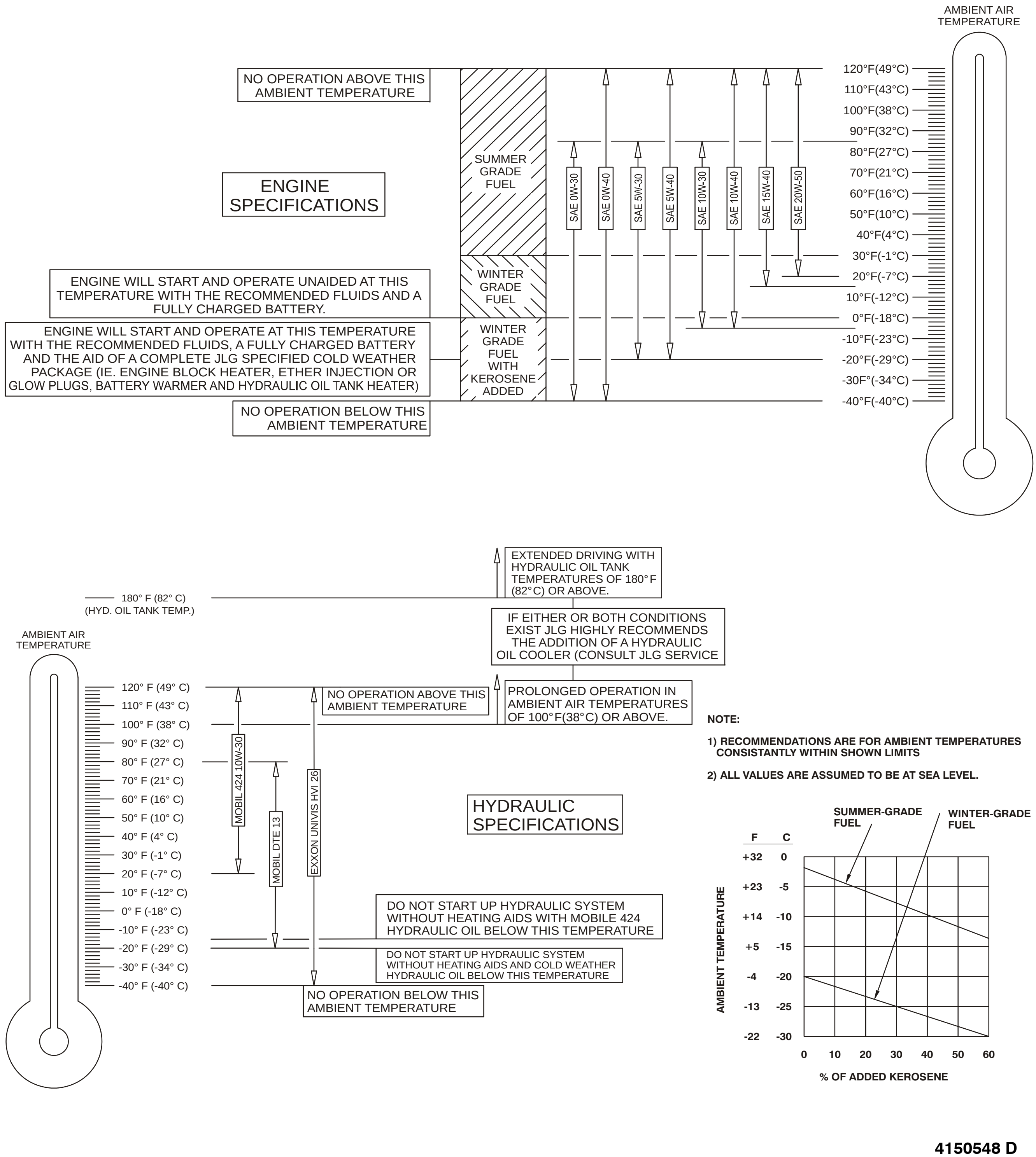


Figure 2-1. Engine Operating Temperature Specifications - Deutz

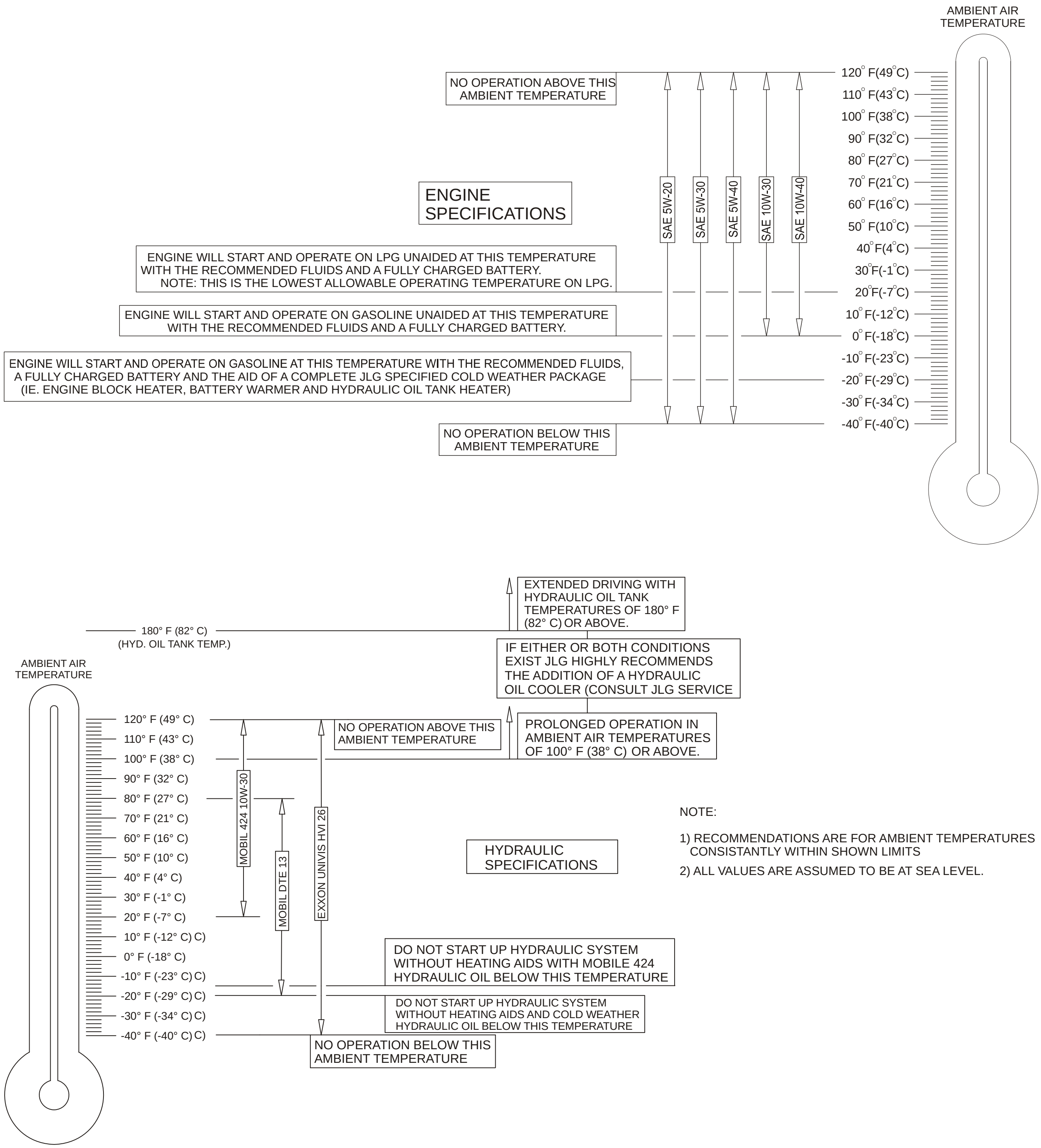


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Figure 2-2. Engine Operating Temperature Specifications - Ford

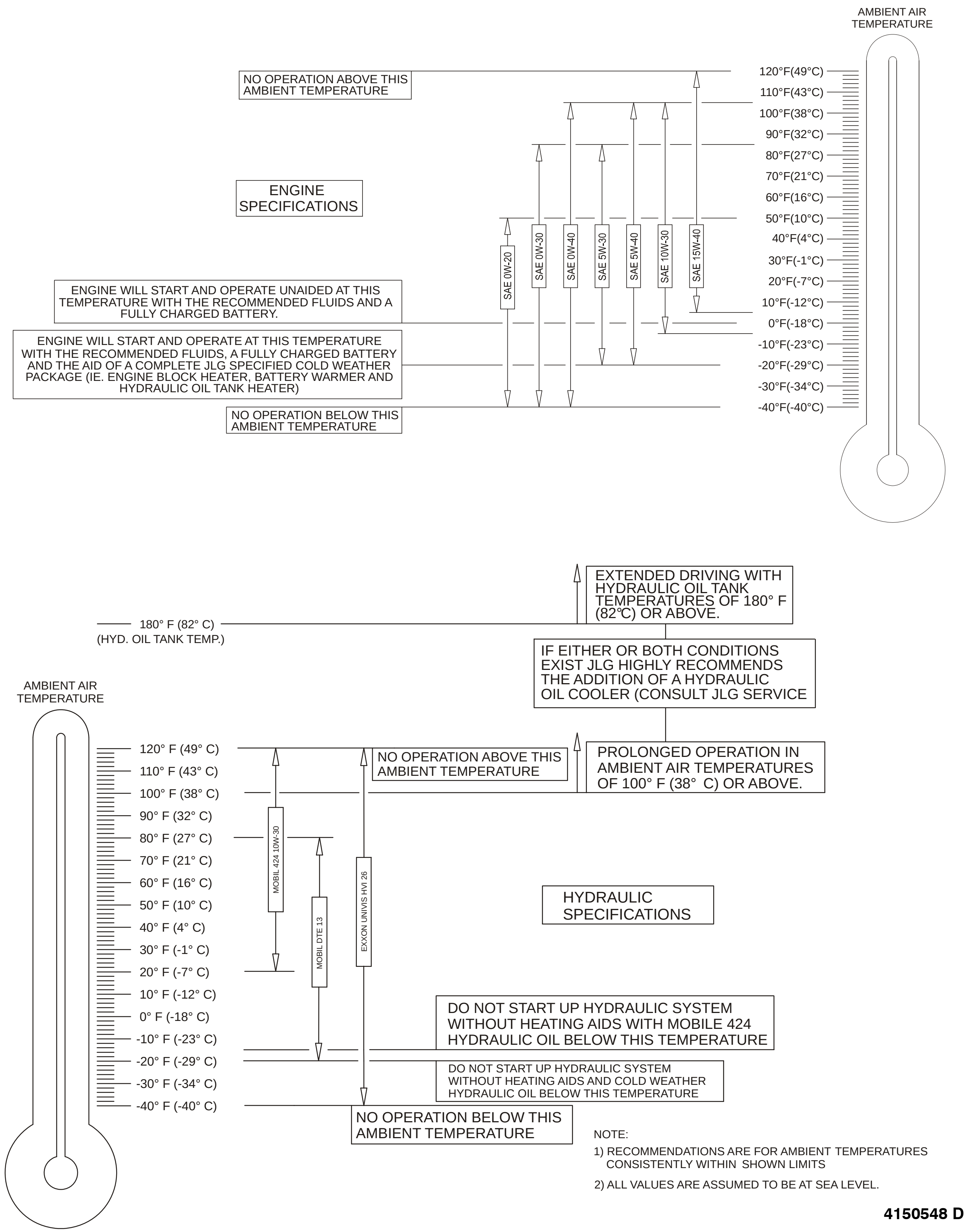


Figure 2-3. Engine Operating Temperature Specifications - Caterpillar

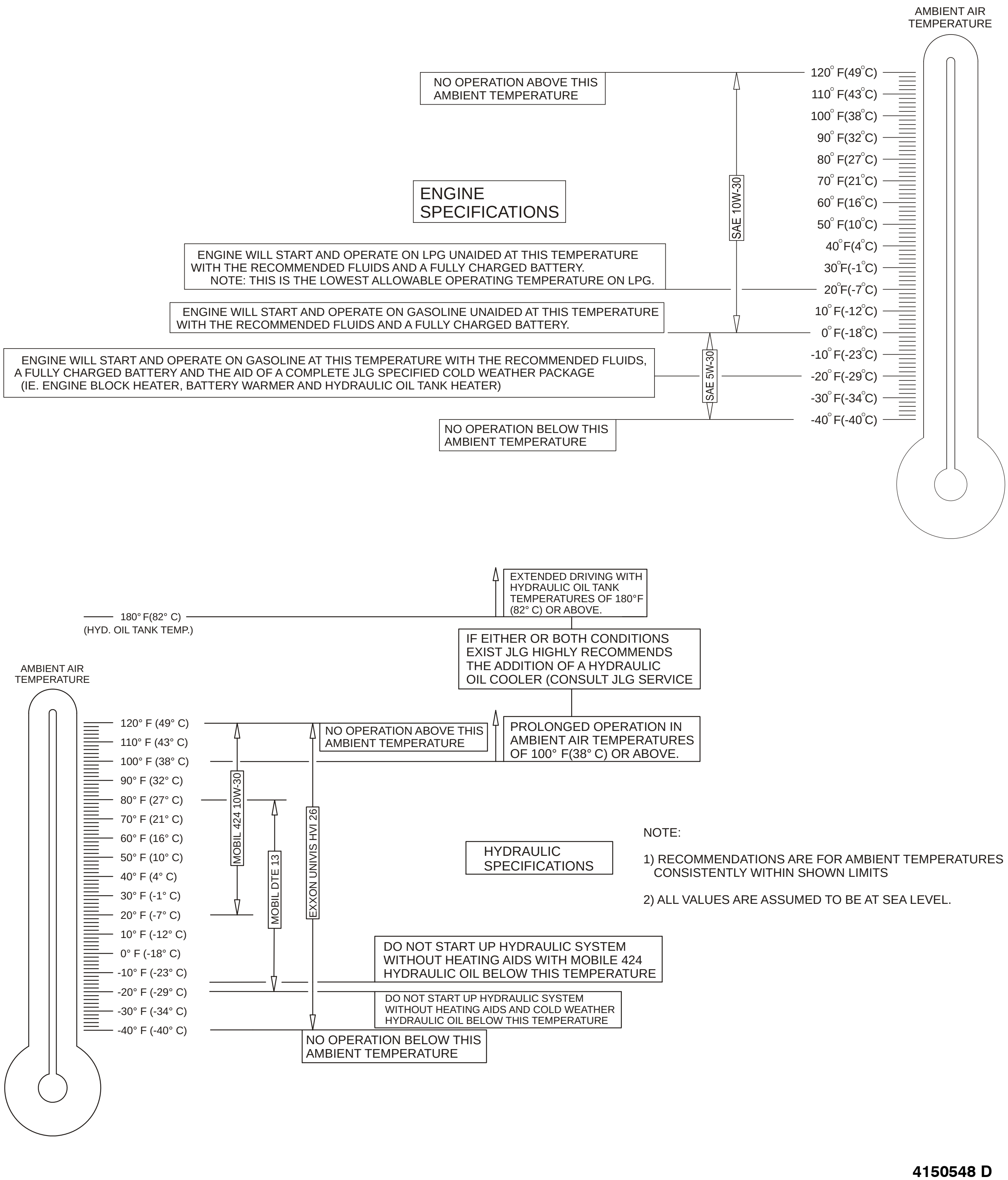


Figure 2-4. Engine Operating Temperature Specifications - GM

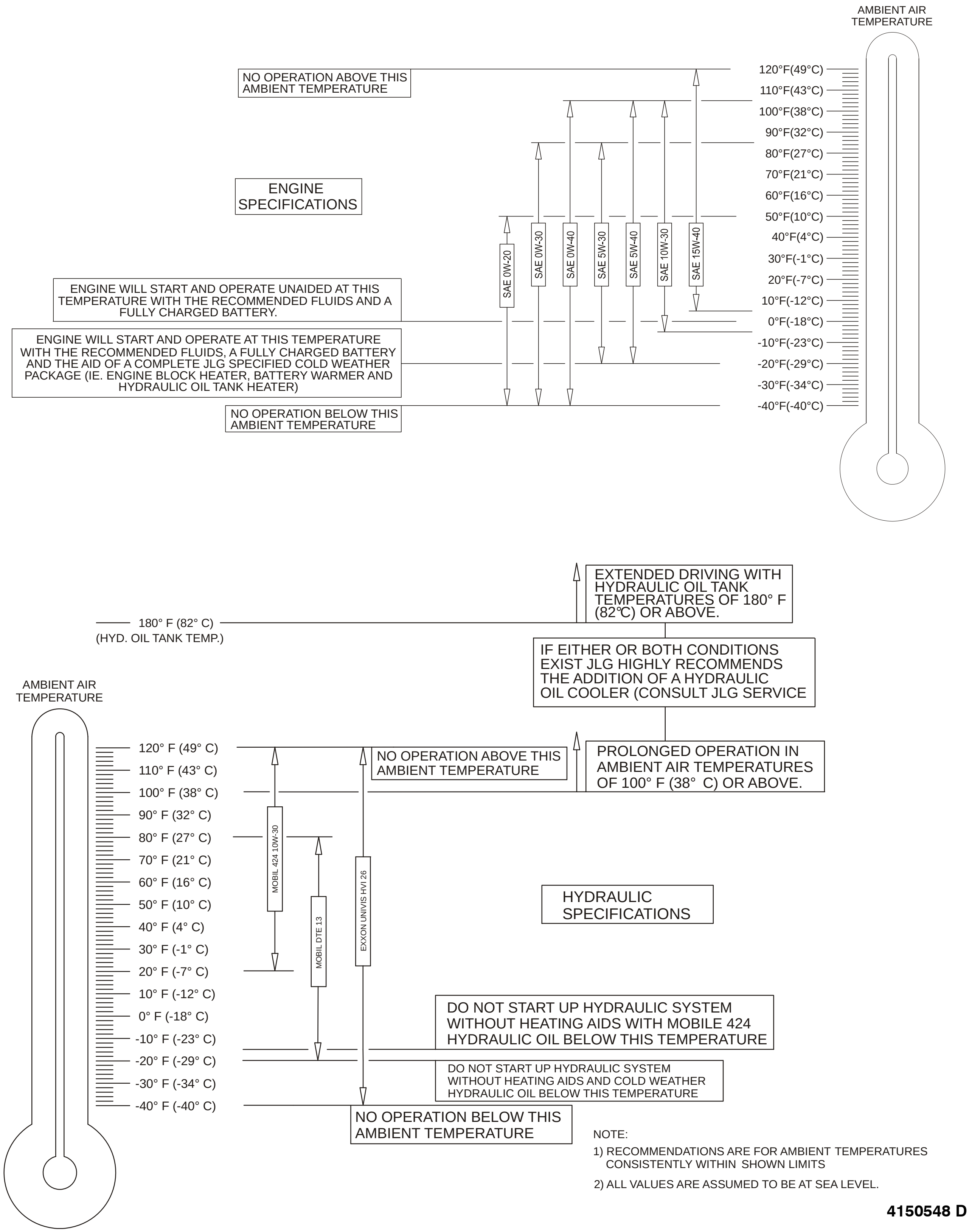


Figure 2-5. Engine Operating Temperature Specifications - Perkins

SECTION 3. CHASSIS & TURNTABLE

3.1 TIRES & WHEELS

Tire Inflation

Pneumatic tire air pressure must be equal to air pressure stenciled on side of JLG product or rim decal for safe and proper machine operation.

Tire Damage

Pneumatic Tires

JLG Industries, Inc. recommends when any cut, rip, or tear is discovered that exposes sidewall or tread area cords in the tire, measures must be taken to remove the JLG product from service immediately. Arrangements must be made for replacement of the tire or tire assembly.

Polyurethane Foam Filled Tires

JLG Industries, Inc. recommends when any of the following are discovered, measures must be taken to remove the JLG product from service immediately and arrangements made for replacement of tire or tire assembly:

- Smooth, even cut through cord plies which exceeds 3" (7.5 cm) in total length.
- Tears or rips (ragged edges) in cord plies which exceeds 1" (2.5 cm) in any direction.
- Punctures which exceed 1" in diameter.
- Damage to bead area cords.

NOTE: *If a tire is damaged but within above criteria, it must be inspected daily to ensure damage does not exceed allowable criteria.*

Solid Flex Tires

JLG Industries, Inc. recommends when severe damage is discovered that can cause any machine instability, measures must be taken to remove the JLG product from service immediately. Arrangements must be made for replacement of tire assembly.

Inspect tires for cracks, tears, wear, imbedded objects, or other defects. Remove imbedded objects.

Tire Replacement

JLG recommends a replacement tire be the same size, ply, and brand as originally installed on the machine. Please refer to the JLG Parts Manual for part number of approved tires for a particular machine model. If not using a JLG approved replacement tire, we recommend that replacement tires have the following characteristics:

- Equal or greater ply/load rating and size of original
- Tire tread contact width equal or greater than original
- Wheel diameter, width, and offset dimensions equal to the original
- Approved for the application by the tire manufacturer (including inflation pressure and maximum tire load)

Unless specifically approved by JLG Industries Inc. do not replace a foam filled or ballast filled tire assembly with a pneumatic tire. When selecting and installing a replacement tire, ensure all tires are inflated to pressure recommended by JLG. Due to size variations between tire brands, both tires on the same axle should be identical.

Wheel Replacement

Rims installed on each product model are designed for stability requirements which consist of track width, tire pressure, and load capacity. Size changes such as rim width, center piece location, larger or smaller diameter, etc., without written factory recommendations, may result in unsafe stability conditions.

Wheel Installation

It is extremely important to apply and maintain proper wheel mounting torque.

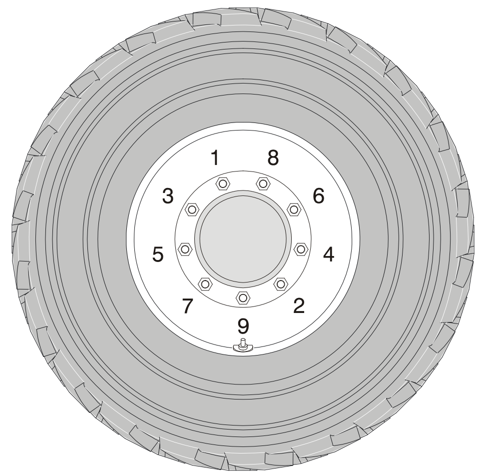
WARNING

WHEEL NUTS MUST BE INSTALLED AND MAINTAINED AT PROPER TORQUE TO PREVENT LOOSE WHEELS, BROKEN STUDS, AND POSSIBLE DANGEROUS SEPARATION OF WHEEL FROM AXLE. USE ONLY NUTS MATCHED TO CONE ANGLE OF WHEEL.

Tighten lug nuts to proper torque to prevent wheels from coming loose. Use a torque wrench to tighten fasteners. If you do not have a torque wrench, tighten fasteners with a lug wrench, then immediately have a service garage or dealer tighten lug nuts to proper torque. Over-tightening will break studs or permanently deform mounting stud holes in wheels. The proper procedure for attaching wheels is as follows:

1. Start all nuts by hand to prevent cross threading. DO NOT use a lubricant on threads or nuts.

2. Tighten nuts in the following sequence:



3. Torque to specifications shown in Table 3-1 below.

Table 3-1. Wheel Torque Chart

TORQUE SEQUENCE		
1st Stage	2nd Stage	3rd Stage
40 ft-lb (55 Nm)	100 ft-lb (130 Nm)	170 ft-lb (255 Nm)

4. Torque wheel nuts after first 50 hours of operation and after each wheel removal. Check torque every 3 months or 150 hours of operation. Torque Hub (Machines built Before S/N 0300071527).

3.2 TORQUE HUB (MACHINES BUILT BEFORE S/N 0300071527)

Roll, Leak, and Brake Testing

Always roll and leak test Torque-Hub units before disassembly and after assembly to make sure gears, bearings, and seals are working properly. The following information briefly outlines what to look for when performing these tests.

NOTE: *Brake must be released before performing roll test. Pressurize brake using Brake Leak Test procedure below or tighten bolts into piston through end plate (See Brake Disassembly Procedure).*

NOTE: *Bolts must be removed while performing brake release test.*

ROLL TEST

The roll test determines if gears are rotating freely and properly. You should be able to rotate gears by applying constant force to the roll checker. If you feel more drag in gears only at certain points, gears are not rolling freely and should be examined for improper installation or defects. Some gear packages roll with more difficulty than others. Do not be concerned if gears in your unit seem to roll hard as long as they roll with consistency.

LEAK TEST (MAIN UNIT)

The leak test makes sure the unit is air tight. You can tell if your unit has a leak if the pressure gauge reading on your leak checking fitting starts to fall after unit is pressurized and allowed to equalize. Leaks most likely occur at pipe plugs, main seal, and wherever O-rings or gaskets are located. 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 on unit exterior, then checking for air bubbles. If a leak is detected in a seal, O-ring, or gasket, the part must be replaced and unit rechecked. Leak test at 10 psi for 20 minutes.

BRAKE TEST

NOTICE

FAILURE TO PERFORM THIS TEST MAY RESULT IN DAMAGED OR INEFFECTIVE BRAKE PARTS.

Input Brake - 1,850 in-lb (208 Nm) Static,
225 psi (15.5 bar) Full Release
3000 psi (207 bar) maximum O-ring check.

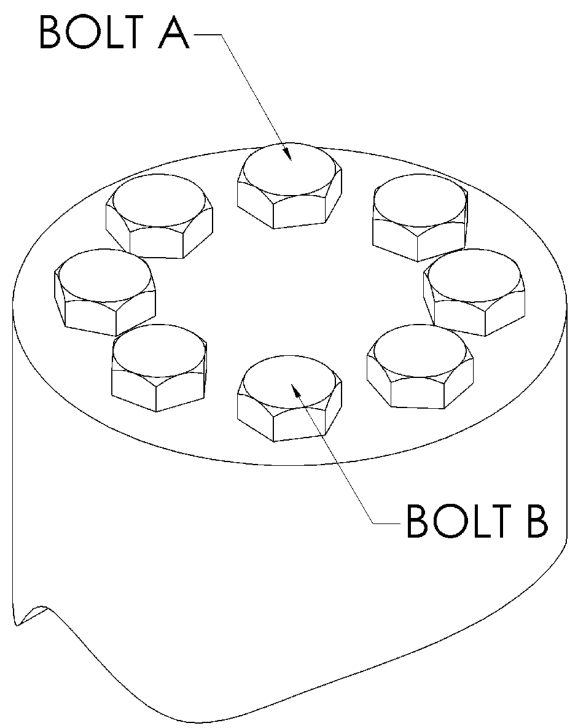
If brake does not release at these pressure values, inspect and repair, or replace brake.

Tightening and Torquing Bolts

If an air impact wrench is used to tighten bolts, extreme care should be taken to ensure bolts are not tightened beyond their specified torque.

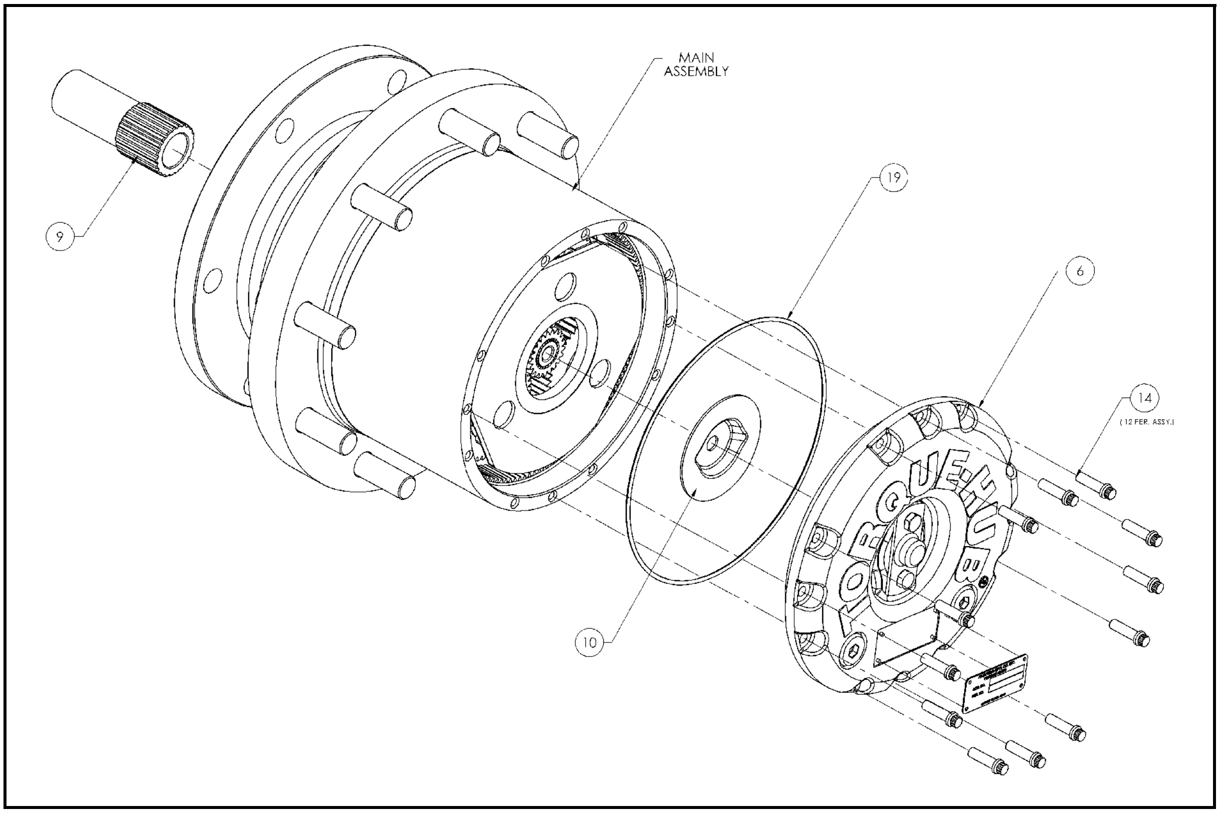
The following steps describe how to tighten and torque bolts or socket head cap screws in a bolt circle:

1. Tighten (but do not torque) bolt “A” until snug.
2. Go to the opposite side of the bolt circle and tighten bolt “B” until equally snug.
3. Crisscross around bolt circle and tighten remaining bolts.
4. Use a torque wrench to apply specified torque to bolt “A”.
5. Using the same sequence, crisscross around bolt circle and apply equal torque to remaining bolts.



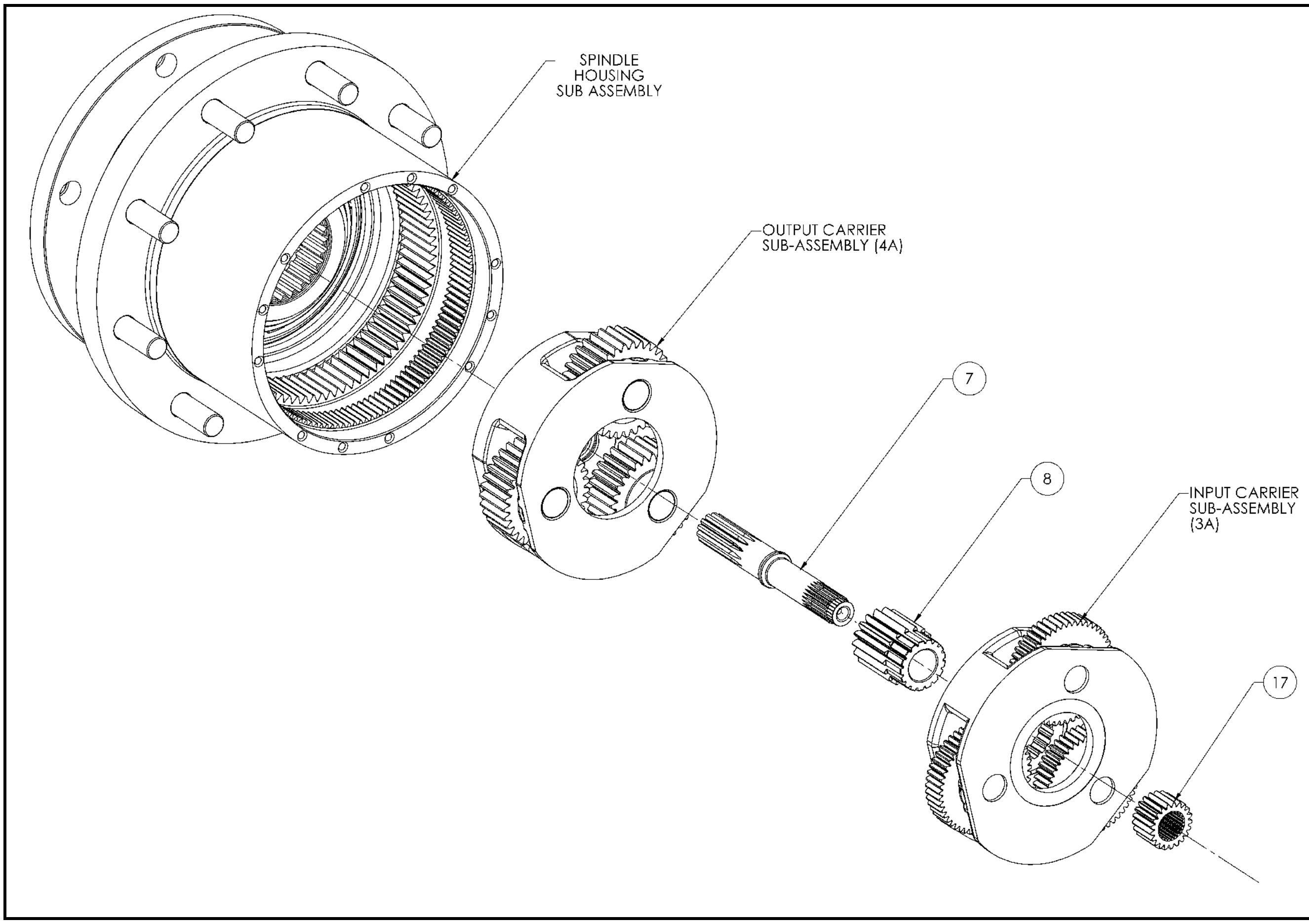
Main Disassembly

1. Perform Roll Check, Leak Check and Brake Check if applicable prior to disassembling unit.
2. Drain oil and note condition and volume.
3. Remove Input Coupling (9) from Spindle (1A) end of unit.
4. Remove Cover Bolts (14) and Cover (6).
5. Remove O-ring (19) and Thrust Spacer (10) from Cover (6).
6. Remove Input Sun Gear (17) from Input Carrier Sub-Assembly (3A).
7. Remove Input Carrier Sub-Assembly (3A) from Housing (1E).
8. Remove Output Sun Gear (8) from Output Carrier Sub-Assembly (4A).
9. Remove Input Shaft (7) from Output Carrier Sub-Assembly (4A).
10. Remove Output Carrier Sub-Assembly (4A) from Housing (1E).



6. Cover
9. Input Coupling
10. Thrust Spacer
14. Cover Bolts
19. O-ring

Figure 3-1. Main Disassembly Drawing 1

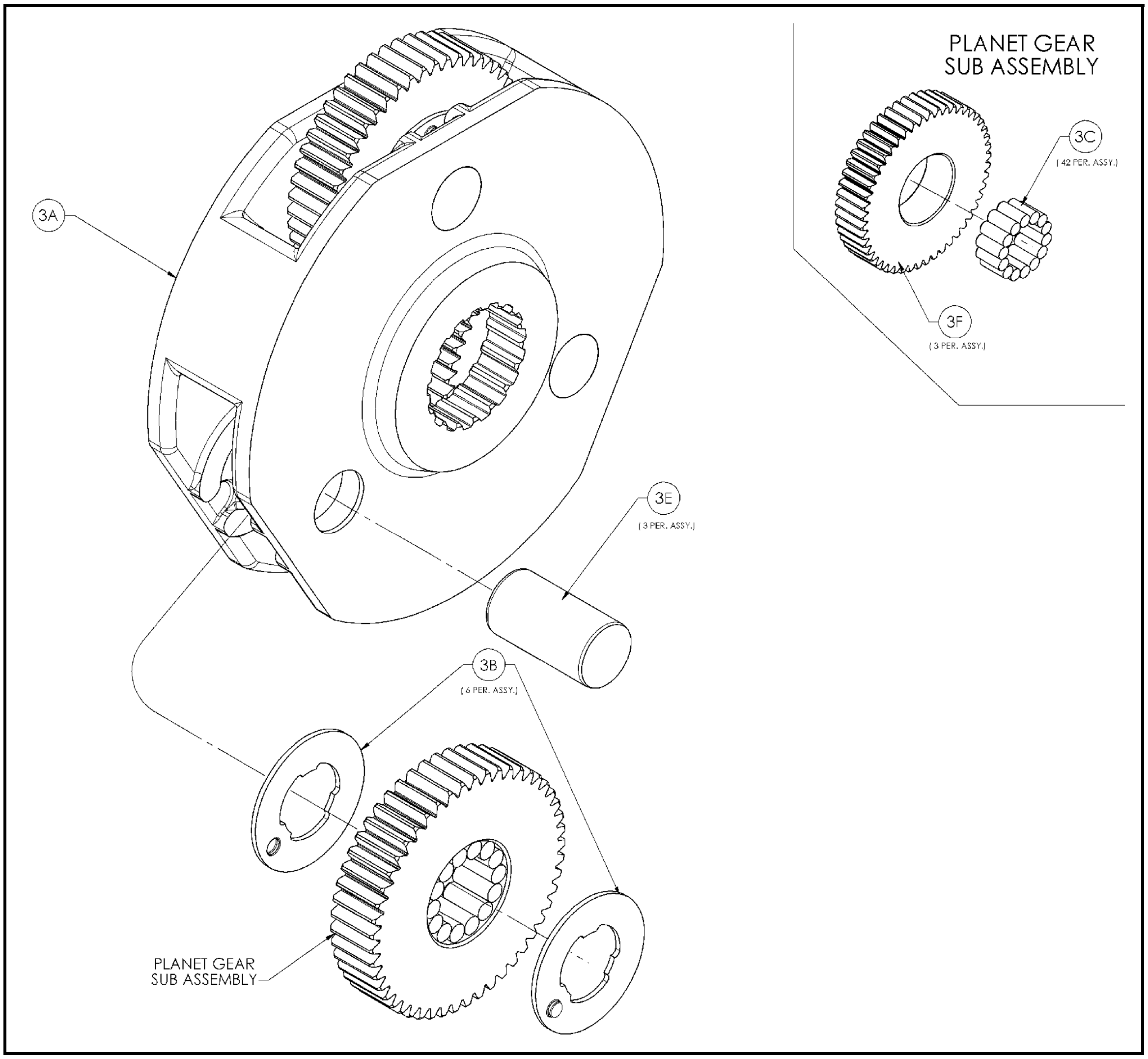


7. Input Shaft
8. Output Sun Gear
17. Input Sun Gear

Figure 3-2. Main Disassembly Drawing 2

Input Carrier Disassembly

1. Place Carrier (3A) on a press with spline end up. Drive Planet Shaft (3E) out of Carrier (3A).
2. Slide Planet Gear (3F) and two Thrust Washers (3B) out of Carrier (3A).
3. Remove 14 needle Bearings (3C) from bore of Planet Gear (3F).
4. Repeat steps 1 through 3 for remaining planet gears.



3A. Carrier
3B. Thrust Washers
3C. Needle Bearings
3E. Planet Shaft
3F. Planet Gear

Figure 3-3. Input Carrier Disassembly

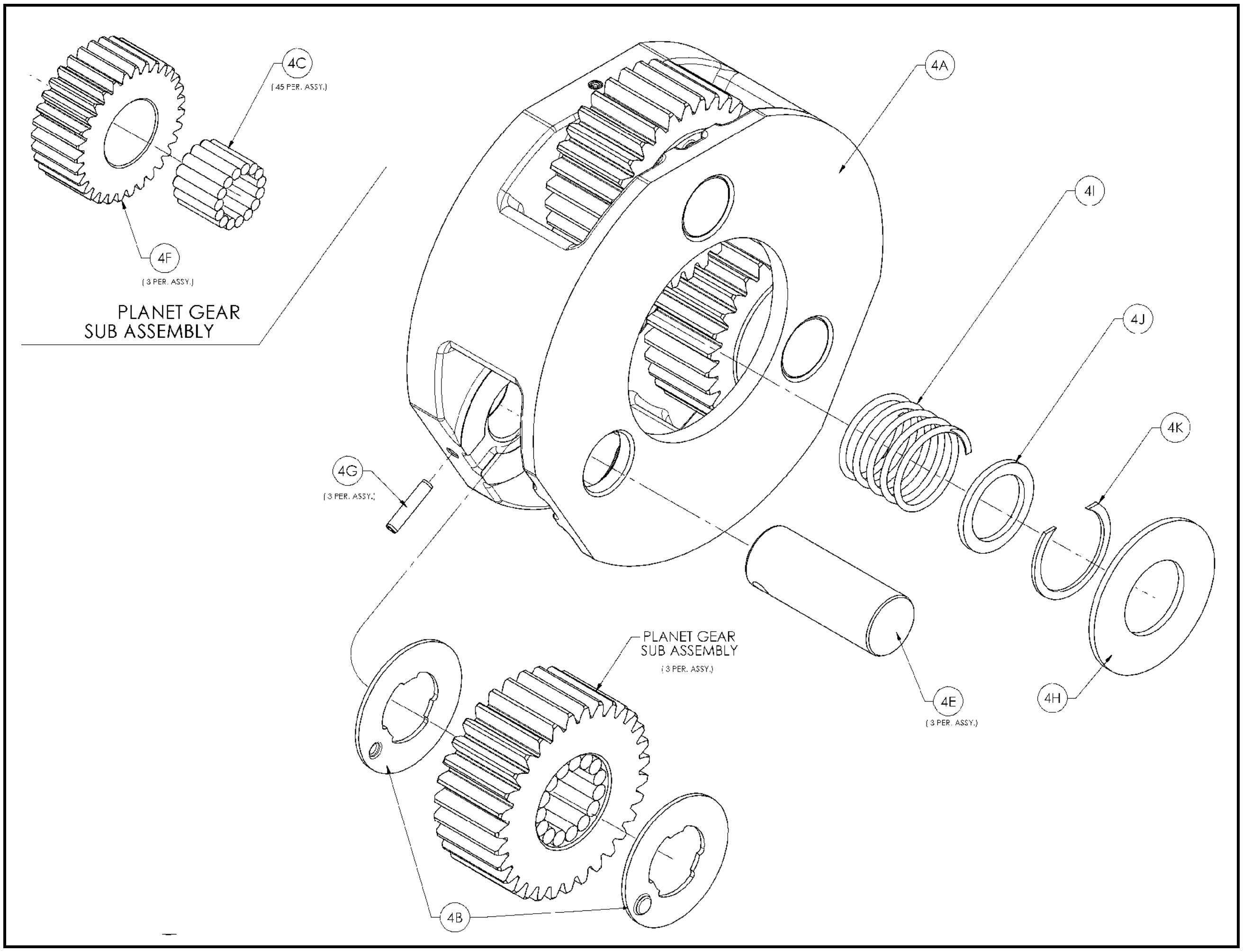
Output Carrier Disassembly

1. Using a small diameter punch, drive Roll Pin (4G) which holds Planet Shaft (4E) in Carrier (4A) into Planet Shaft (4E) until it bottoms.

NOTICE

MAKE SURE ROLL PIN HAS BOTTOMED OR CARRIER CAN BE DAMAGED WHEN PLANET SHAFT IS REMOVED.

2. Remove Planet Shaft (4E) from Carrier (4A). Use a small punch to remove Roll Pin (4G) from Planet Shaft (4E).
3. Slide Planet Gear (4F) and two Thrust Washers (4B) out of Carrier (4A).
4. Remove 15 needle Bearings (4C) from bore of Planet Gear (4F).
5. Repeat steps 1 through 4 for remaining planet gears.
6. Remove Thrust Washer (4H) from Carrier (4A).
7. Remove Retaining Ring (4K) from Carrier (4A) using retaining ring pliers. Pull Thrust Washer (4J) and Spring (4I) out of Carrier (4A).



4A.	Carrier	4G.	Roll Pin
4B.	Thrust Washers	4H.	Thrust Washer
4C.	Needle Bearings	4I.	Spring
4E.	Planet Shaft	4J.	Thrust Washer
4F.	Planet Gear	4K.	Retaining Ring

Figure 3-4. Output Carrier Disassembly

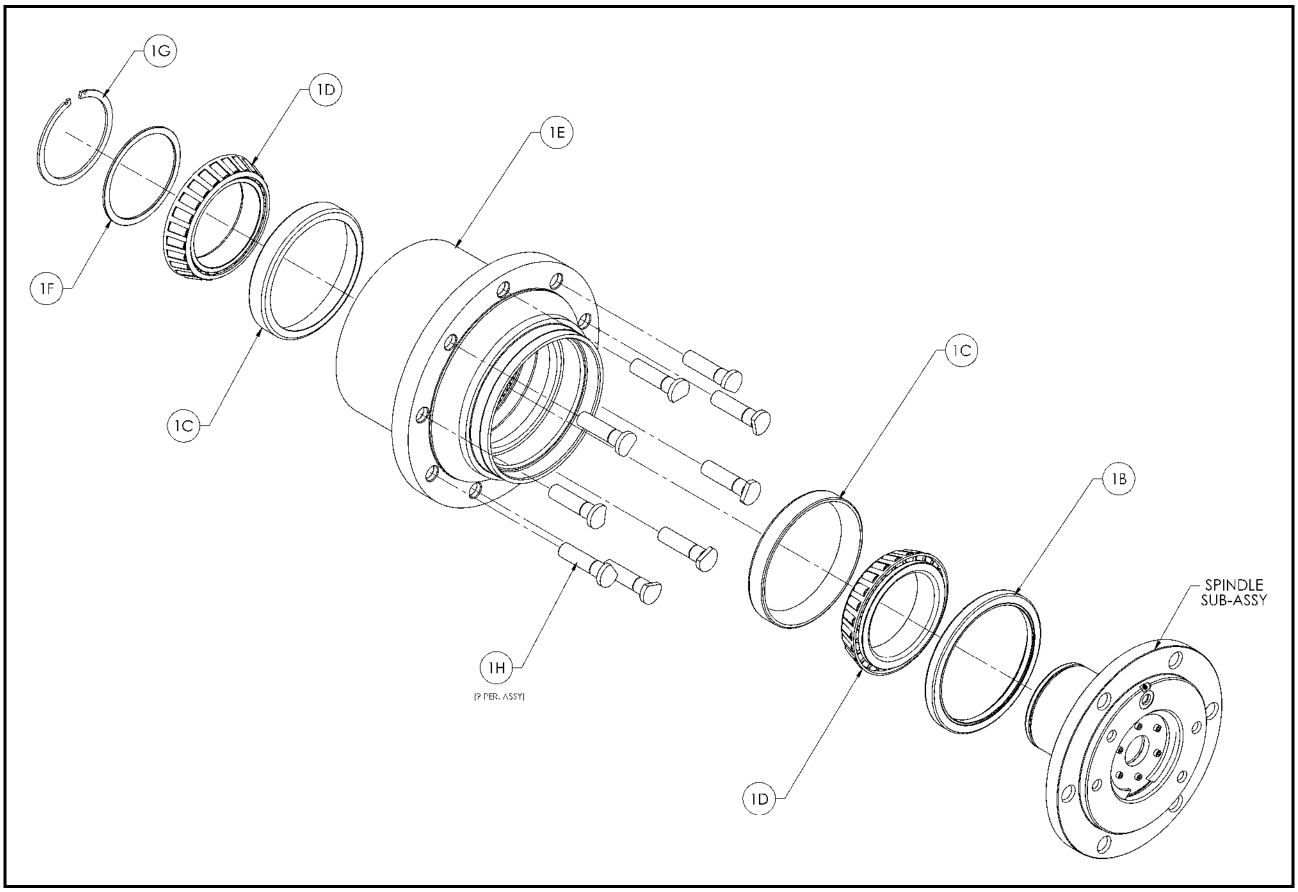
Housing-Spindle Disassembly

1. Place unit on bench with Spindle (1A) end down.

CAUTION

EYE PROTECTION MUST BE WORN WHILE PERFORMING THE NEXT STEP IN THIS PROCEDURE.

2. Using retaining ring pliers, remove Retaining Ring (1G) from groove in Spindle (1A).
3. Remove Bearing Spacer (1F) from top of Bearing Cone (1D).
4. While supporting unit on Housing (1E) flange, press Spindle (1A) out of Housing (1E). Seal (1B) and "B" position Bearing Cone (1D) should come out of Housing (1E) with Spindle (1A).
5. Remove "A" position Bearing Cone (1D) from Bearing Cup (1D) in Housing (1E).
6. Lift Housing (1E) off Spindle (1A).
7. If necessary, press Studs (1N) out of Housing (1E). Locate Housing (1E) on Seal (1B) end.
8. Remove "B" position Bearing Cone (1D) from Spindle (1A).
9. Remove Seal (1B) from Spindle (1A).
10. Using a soft steel rod, knock both Bearing Cups (1C) out of Housing (1E).



1B.	Seal	1F.	Bearing Spacer
1C.	Bearing Cups	1G.	Retaining Ring
1D.	Bearing Cone	1H.	Wheel Stud
1E.	Housing		

Figure 3-5. Housing-Spindle Disassembly

Spindle-Brake Disassembly

NOTE: *This procedure applies only to units with integral input brake (2).*

NOTE: *For this procedure, use Brake Assembly Drawing, which shows proper balloon numbers for individual brake components. In the following instructions, if the number has a "-" between two numbers, it refers to Brake Assembly Drawing only and NOT Torque Hub Assembly Drawing.*

NOTE: *The Koenig Expander Pressure Plug (12) requires a special installation tool. It is not recommended to remove this plug unless it is leaking. The installation tool is available from KVT Solutioneering Group (http://www.kvt-koenig.us) or their distributors as of the date of this publication.*

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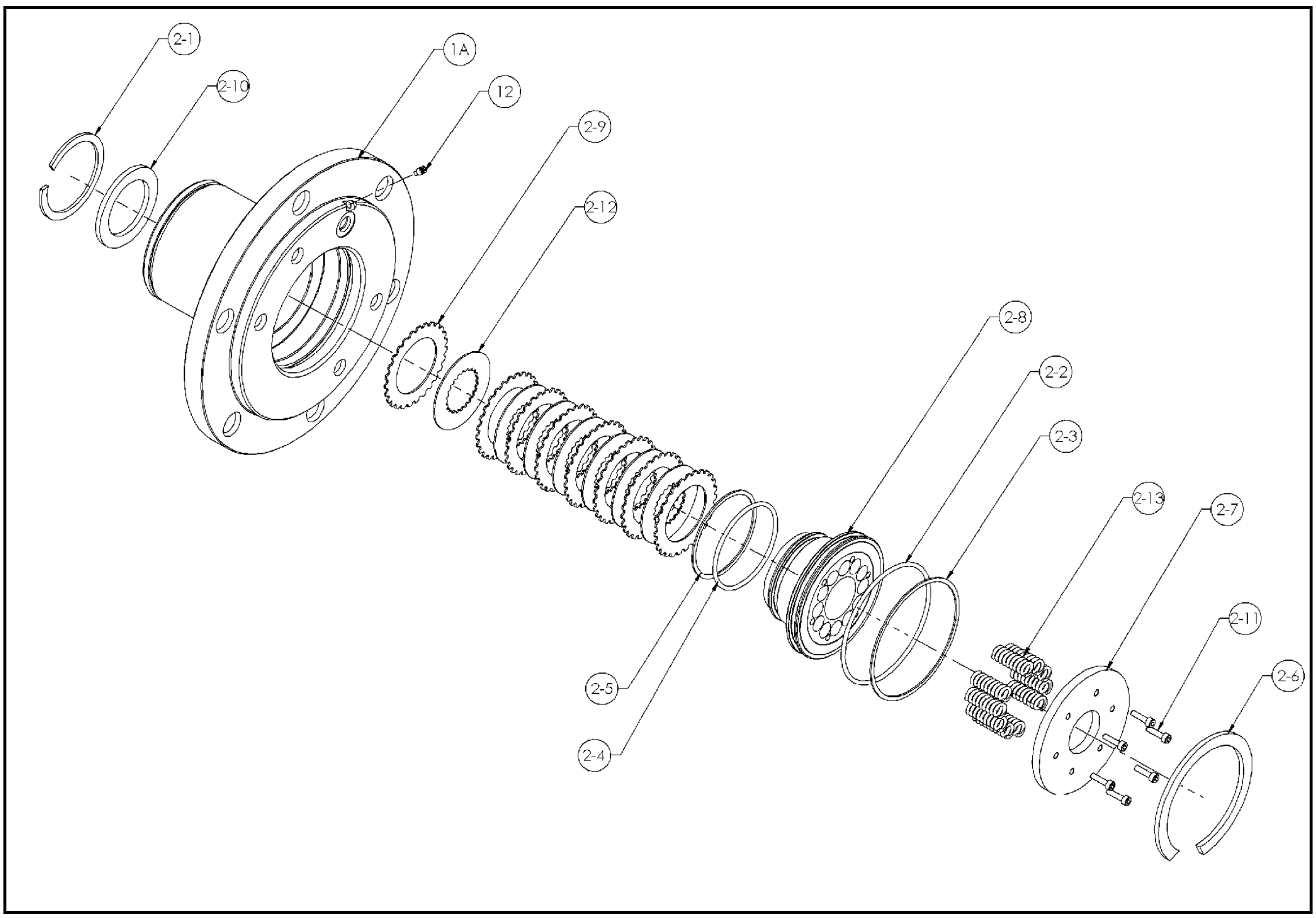


1-A. Spindle
12. Pressure Plug
2-1. Internal Circlip
2-2. O-ring
2-3. Back-up Ring
2-4. O-ring
2-5. Back-up Ring
2-6. Internal Circlip
2-7. End Plate
2-8. Piston
2-9. Stator
2-10. Spacer
2-11. Capscrew
2-12. Rotor
2-13. Compression Spring

Figure 3-6. Spindle Brake Disassembly

⚠ CAUTION

SPRINGS AND COMPRESSED AIR CAN CAUSE EYE DAMAGE OR SERIOUS INJURY. ALWAYS WEAR EYE PROTECTION.

1. Compress Springs (2-13) by installing a minimum of three M4 x 16mm Socket Head Cap Screws (2-11) equally spaced through End Plate (2-7) and into Piston (2-8). Tighten screws incrementally until spring force is removed from Retaining Ring (2-6).
2. Using a small pry bar or screwdriver, pry one end of Retaining Ring (2-6) out of groove in Spindle (1A). Using pliers, pull Retaining Ring (2-6) out of groove.
3. Back Socket Head Cap Screws (2-11) incrementally out of Piston (2-8) until spring force is relieved from End Plate (2-7).
4. Remove Socket Head Cap Screws (2-11) and End Plate (2-7) from brake cavity in Spindle.
5. Remove Compression Springs (2-13) from Piston (2-8).
6. Using an air hose, slowly and carefully pressurize brake port in Spindle (1A) until Piston (2-8) comes out of piston bore of Spindle (1A). Pull Piston (2-8) the rest of the way out of Spindle (1A) by hand.
7. Remove Backup Rings (2-3) & (2-5) and O-rings (2-2) & (2-4) from Piston (2-8).
8. Remove Rotors (2-12) and Stators (2-9) from Spindle (1A).
9. Invert Spindle (1A) and, using retaining ring pliers, remove Retaining Ring (2-1).
10. Remove Spacer (2-10) from Spindle.

Input Carrier Sub-Assembly

⚠ CAUTION

SPRINGS AND COMPRESSED AIR CAN CAUSE EYE DAMAGE OR SERIOUS INJURY. ALWAYS WEAR EYE PROTECTION.

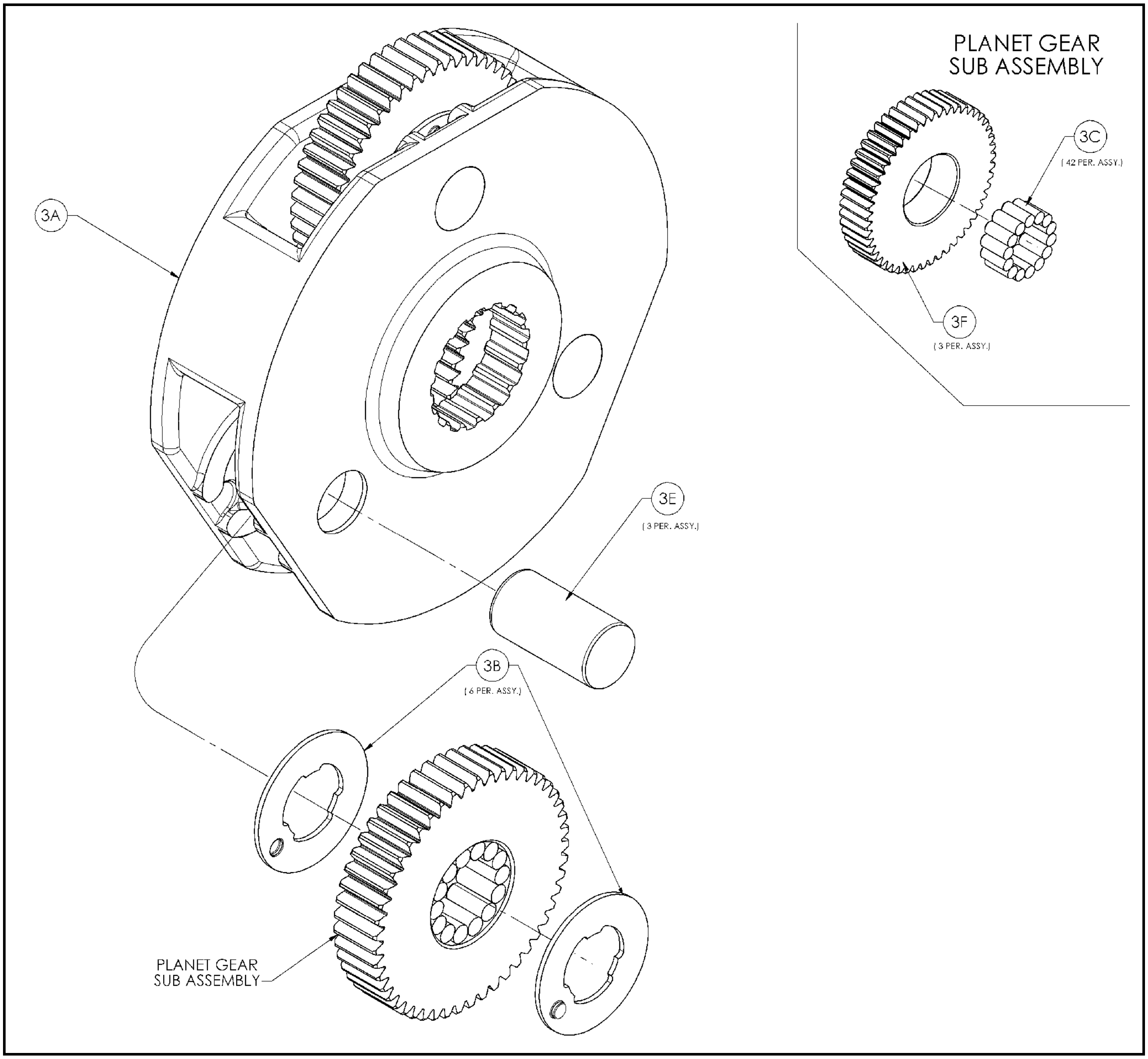
11. Apply a liberal coat of grease to bore of Input Planet Gear (3F).
12. Line inside of Planet Gear (3F) with 14 Needle Rollers (3C).
13. Set Carrier (3A) in an upright position.
14. Insert a Planet Shaft (3E) into planet shaft hole in end of Carrier (3A) opposite splined end.
15. Place one Thrust Washer (3B) on end of Planet Shaft (3E). Make sure flat faces towards inside of Carrier and make sure button fits in pocket inside Carrier (3A).
16. Place one more Thrust Washer (3B) into Carrier (3A) and align as in Step 5.

NOTE: *Grease may need to be applied to Thrust Washers (3B) to hold them in place when installing planet gear. Instead of grease, insert washers from ID of carrier for buttons to fit in pockets of carrier.*

17. Following thrust washers, place Planet Gear (3F) with needle rollers, into Carrier (3A) between Thrust Washers (3B).
18. Push Planet Shaft (3E) through Planet Gear (3F) and other Thrust Washer (3B) until it touches other side of Carrier (3A).
19. Press Planet Shaft (3E) to appropriate depth.

NOTE: *If planet shaft locating tooling is not available, press lightly on Planet Shaft (3E) and make sure not to press Planet Shaft (3E) through small shoulder in Carrier (3A). This shoulder is intended to keep planet pin from working loose in that direction during operation. It is **NOT** intended to keep planet pin from being pressed through carrier.*

20. On side of Carrier (3A) where Planet Shaft (3E) was inserted, stake Carrier (3A) in 3 places using a punch and a hammer around Planet Shaft (3E) to ensure shaft stays in place during operation.
21. Repeat Steps 1 through 10 for remaining Planet Gears (3F).



3A. Carrier
3B. Thrust Washers
3C. Needle Bearings
3E. Planet Shaft
3F. Planet Gear

Figure 3-7. Input Carrier Sub-Assembly

Output Carrier Sub-Assembly

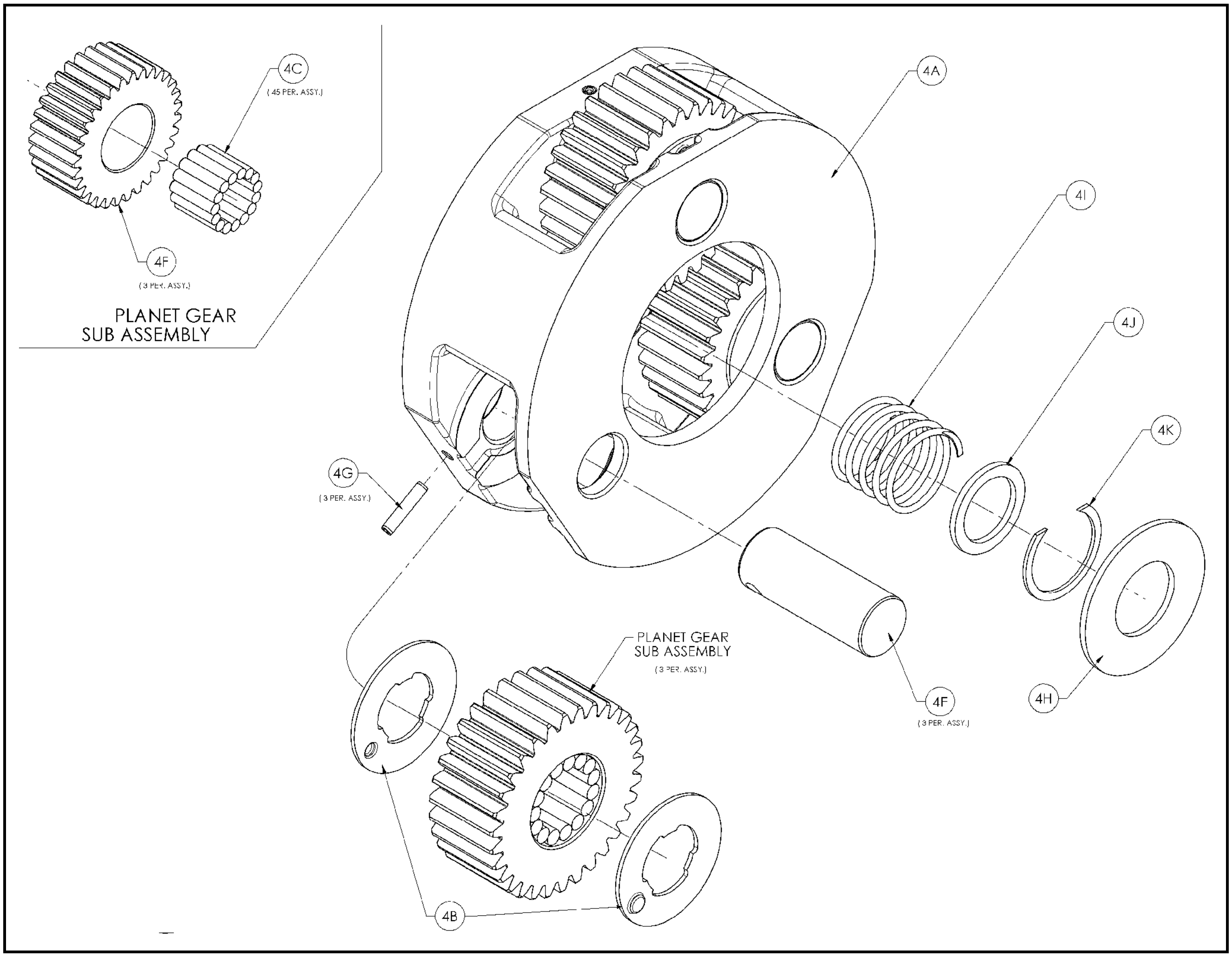
CAUTION

UNCONTROLLED OBJECTS CAN CAUSE EYE DAMAGE OR SERIOUS INJURY. ALWAYS WEAR EYE PROTECTION.

1. Place Spring (4I) in deep counterbore of Output Carrier (4A).
2. Place Washer (4J) on top of Spring (4I).
3. Install Retaining Ring (4K) on snap ring pliers and place on top of Washer (4J). Compress Spring (4I) until Retaining Ring (4K) is seated completely in groove.
4. Apply a liberal coat of grease to bore of one Output Planet Gear (4F).
5. Line inside of Planet Gear (4F) with 15 Needle Rollers (4C).
6. Place Thrust Washer (4H) in shallow counterbore of Output Carrier (4A).
7. Set Carrier (4A) in an upright position.

NOTE: *Insert end of planet shaft that does **NOT** have roll pin hole in carrier **FIRST**.*

8. Insert a Planet Shaft (4E) into one of the planet shaft holes on the Carrier (4A). Place one Thrust Washer (4B) on end of Planet Shaft (4E). Make sure flat faces towards inside of carrier button fits in pocket inside Carrier (4A).
9. Following thrust washer, place Planet Gear (4F) with needle rollers on Planet Shaft (4E).
10. Following planet gear, place one more Thrust Washer (4B) on Planet Shaft (4E). Align Thrust Washer (4B) in same manner described in Step 6.
11. Insert Planet Shaft (4E) through opposite planet shaft hole on Carrier (4A). Use an alignment punch or similar tool to align roll pin holes on Carrier (4A) and Planet Shaft (4E).
12. Drive Roll Pin (4G) down into aligned roll pin holes. Pin should be flush with OD of carrier.
13. Repeat Steps 4,5, & 8-13 for remaining Planet Gears (4F).



4A. Output Carrier
4B. Thrust Washer
4C. Needle Rollers
4E. Planet Shaft
4F. Planet Gear
4G. Roll Pin
4H. Thrust Washer
4I. Spring
4J. Washer
4K. Retaining Ring

Figure 3-8. Input Carrier Sub-Assembly

Spindle-Brake Sub-Assembly

CAUTION

UNCONTROLLED OBJECTS CAN CAUSE EYE DAMAGE OR SERIOUS INJURY. ALWAYS WEAR EYE PROTECTION.

This procedure applies only to units with integral input brake (2).

NOTE: *For this procedure, use Brake Assembly Drawing, which shows proper balloon numbers for individual brake components. In the following instructions, if the number has a "-" between two numbers, it refers to Brake Assembly Drawing only and NOT Torque Hub Assembly Drawing.*

NOTE: *The Koenig Expander Pressure Plug (12) requires a special installation tool. It is not recommended to remove this plug unless it is leaking. The installation tool is available from KVT Solutioneering Group (http://www.kvt-koenig.us) or their distributors as of the date of this manual.*

1. Install Pressure Plug (12) into Spindle (1A) using the following procedure:

- Clean hole in spindle using appropriate Loctite spray
- Dip collar of plug in Loctite 290 or 680 (keep unplugged portion of hole free of Loctite)
- Using appropriate tool, install plug flush with surface of spindle

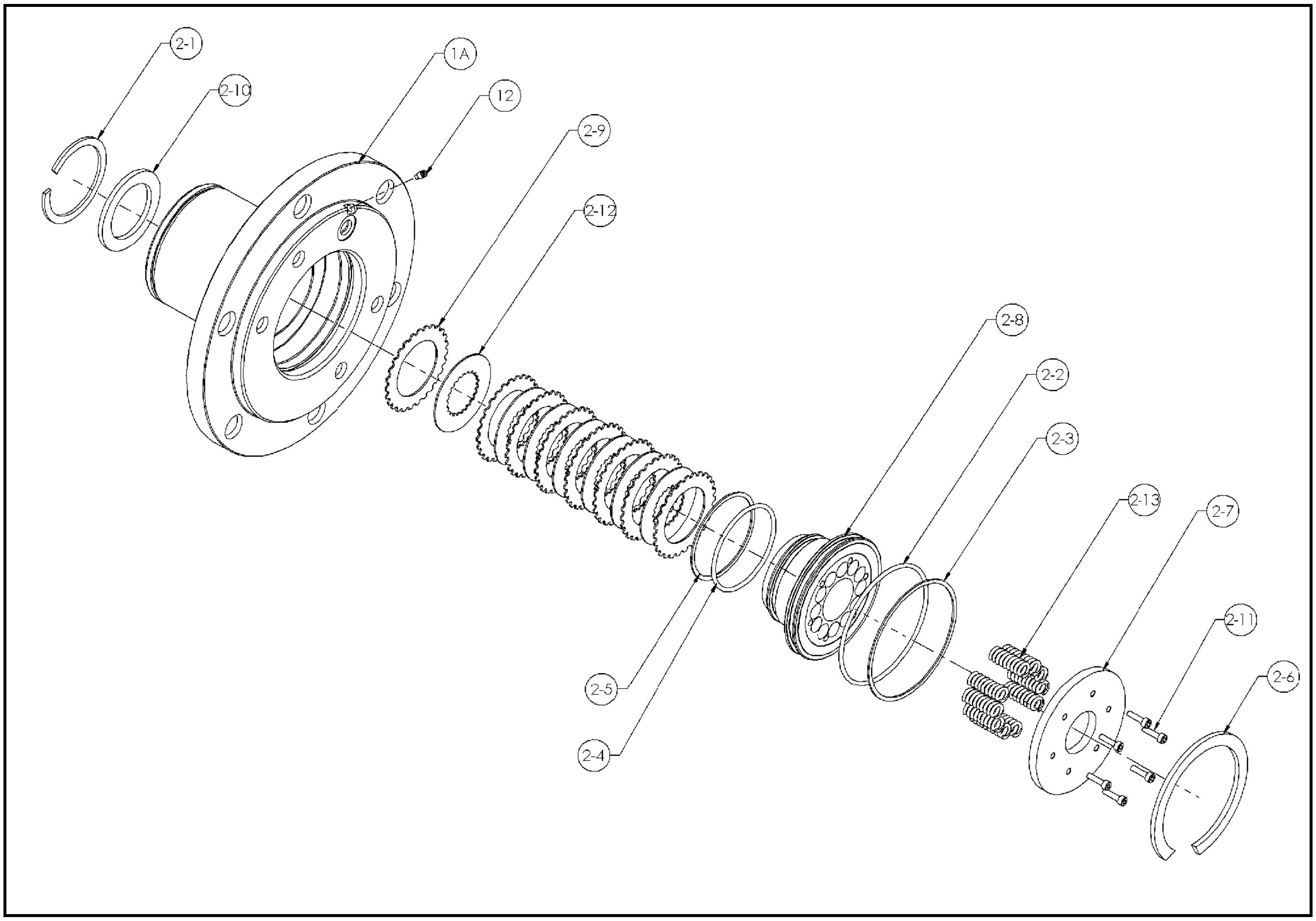
2. Place Spindle (1A) with splined end facing down. Using appropriate tool (See back of manual), install Retaining Ring (2-1) into spindle groove within splines.
3. Place Washer (2-10) on top of Retaining Ring (2-1).
4. Place Stator (2-9) on top of Washer (2-10).
5. Place Rotor (2-12) on top of Stator (2-9).
6. Repeat steps 3 & 4 until there are a total of 8 Stators (2-9) and 7 Rotors (2-12) installed.
7. Place Piston (2-8) with smaller O.D. end facing up.
8. Grease large Backup Ring (2-3) and install in large-diameter groove at bottom of Piston (2-8).
9. Grease large O-Ring (2-2) and install in large diameter groove at bottom of Piston (2-8), on top of large Backup Ring (2-3).
10. Grease small O-Ring (2-5) and install in small diameter groove near top of Piston (2-8). Make sure O-Ring is seated in bottom of groove.
11. Grease small Backup Ring (2-4) and install in small diameter groove near top of Piston (2-8), on top of small O-Ring (2-5).

NOTE: *If piston comes pre-assembled with shipping bolts (2-11), skip to Step 15.*

12. Insert Piston (2-8) into Spindle (1A) until it contacts Stator (2-9).
13. Insert appropriate number of Springs (2-13) into Piston (2-8) counterbore. Use brake spring chart below and a bill of materials for your particular model number to determine number of springs.

BRAKE CODE	BRAKE P/N	NUMBER OF SPRINGS
A	902337	12
B	902341	10
C	902342	8
D	902343	6
E	902345	9

14. Place Pressure Plate (2-7) on top of Springs (2-13).
15. Using snap ring pliers, install Retaining Ring (2-6) into groove in Spindle (1A) and on top of Pressure Plate (2-7). Make sure Retaining Ring (2-6) is seated properly in groove.
16. Remove Shipping Bolts (2-11) in brake pressure plate to release springs in brake. Before removing bolts, use Coupling (9 - Figure 3-11.) to center and align Brake Rotors (2-12) with Spindle (1A).



1-A. Spindle
12. Pressure Plug
2-1. Internal Circlip
2-2. O-ring
2-3. Back-up Ring
2-4. O-ring
2-5. Back-up Ring
2-6. Internal Circlip
2-7. End Plate
2-8. Piston
2-9. Stator
2-10. Spacer
2-11. Capscrew
2-12. Rotor
2-13. Compression Spring

Figure 3-8. Spindle Brake Sub-Assembly

Housing-Spindle Sub-Assembly

NOTE: *Spray a light film of oil on all component parts during assembly.*

CAUTION

UNCONTROLLED OBJECTS CAN CAUSE EYE DAMAGE OR SERIOUS INJURY. ALWAYS WEAR EYE PROTECTION.

1. Press Bearing Cup (1C), position A, into Housing (1E) using appropriate pressing tool (See back of manual).

NOTICE

DO NOT USE EXCESSIVELY HIGH PRESSURE TO PRESS IN STUDS OR HOUSING MAY CRACK. MAKE SURE HEAD OF STUD CONTACTS FACE OF FLANGE ON HOUSING.

2. Turn Housing (1E) over and place into pressing base. Press nine Studs (1H) into Housing (1E).

NOTE: *Spray a generous amount of oil on bearings during installation.*

3. Press Bearing Cup (1C), position “B”, into Housing (1E) using “B” Bearing Cone pressing tool (see back of manual).
4. Place Bearing Cone (1D), into Bearing Cup (1C), position “B”.
5. Grease Seal (1B) lip and press seal into Housing (1E) using seal pressing tool (see back of manual) until seal is flush with end of Housing.
6. Turn Housing (1E) over and lower onto Spindle (1A).
7. Install Bearing Cone (1D) into Bearing Cup (1C), position “A”. and lightly press on Bearing Cup using the “A” Bearing Cone pressing tool (see back of manual) while rotating Housing (1E) in both directions to seat bearings.
8. Place Bearing Spacer (1F) on top of Bearing Cone (1D).
9. Using retaining ring pliers, install Retaining Ring (1G) into Spindle (1A) groove. Make sure ring is completely seated in groove.

NOTE: *Extra bearing pre-load caused by pressing “A” Bearing Cone (1D) must be removed. This should be done by placing a flat piece of steel or a pressing tool on the end of the spindle, and then lightly striking the tool with a piece of barstock. This should be adequate to remove any additional bearing pre-load.*

DW2B INTEGRAL BRAKE CHECK

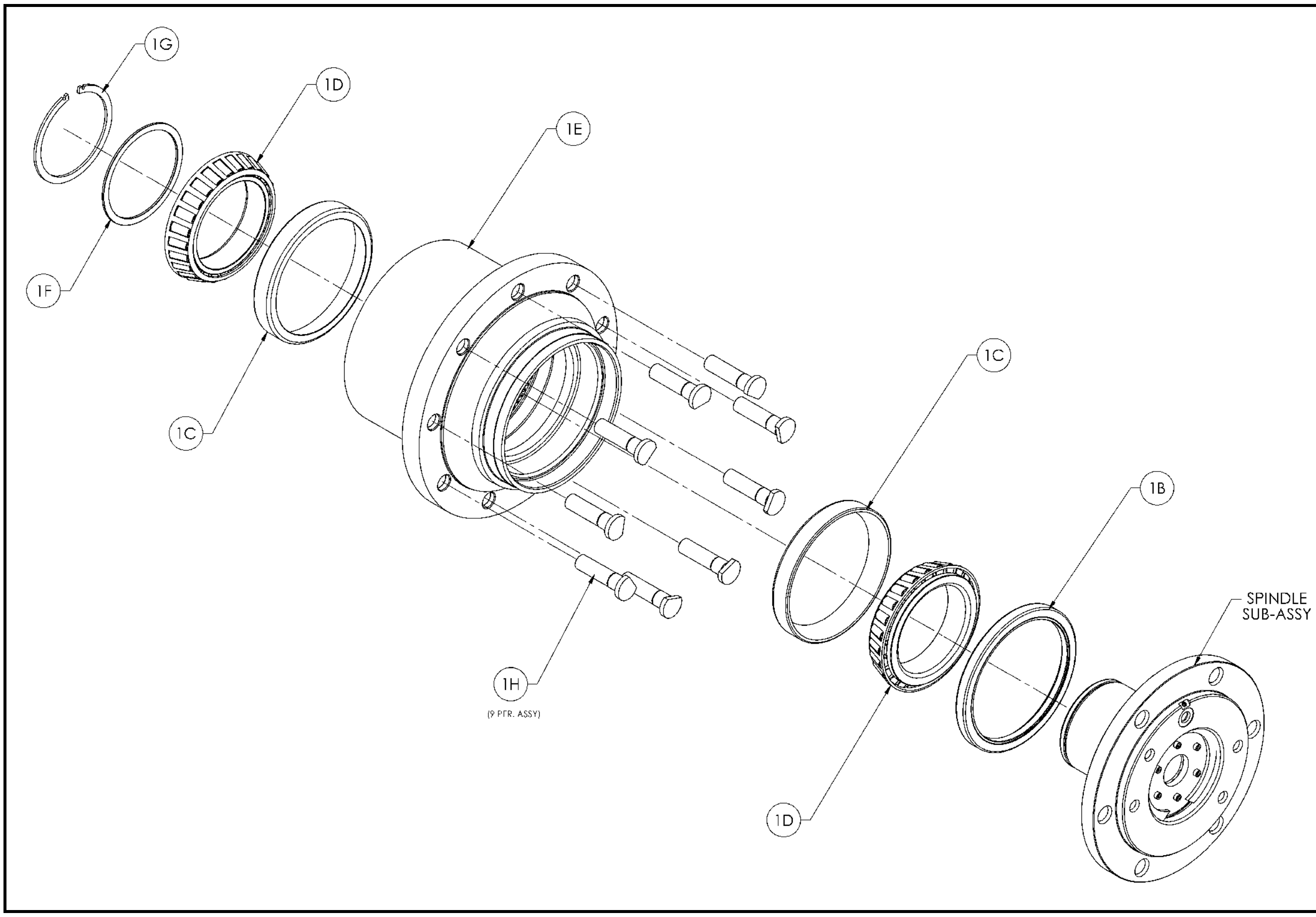
1. Connect hydraulic line from hand pump to brake port.
2. Check brake is set by trying to rotate Input Shaft (7). This can be accomplished by installing an appropriate tool (any tool that can locate on splines of the Input Coupling (9), such as a mating splined shaft) into Input Coupling (9)
3. Bleed brake. Increase hydraulic pressure gradually while trying to rotate input until brake just starts to release. Note this pressure. Make sure pressure falls into appropriate range below:

BRAKE CODE	BRAKE P/N	JUST RELEASE PRESSURE RANGE (psi)
A	902337	185-230
B	902341	155-192
C	902342	125-155
D	902343	93-115
E	902345	132-172

4. Increase pressure to 3,000 psi and hold for 30 seconds to check for leaks. Repair leaks if necessary.

NOTE: *Make sure brake re-engages when pressure is released.*

NOTE: *When done, make sure Input Coupling (9) is centered in Spindle (1A) to make installation of motor possible without release of brake.*



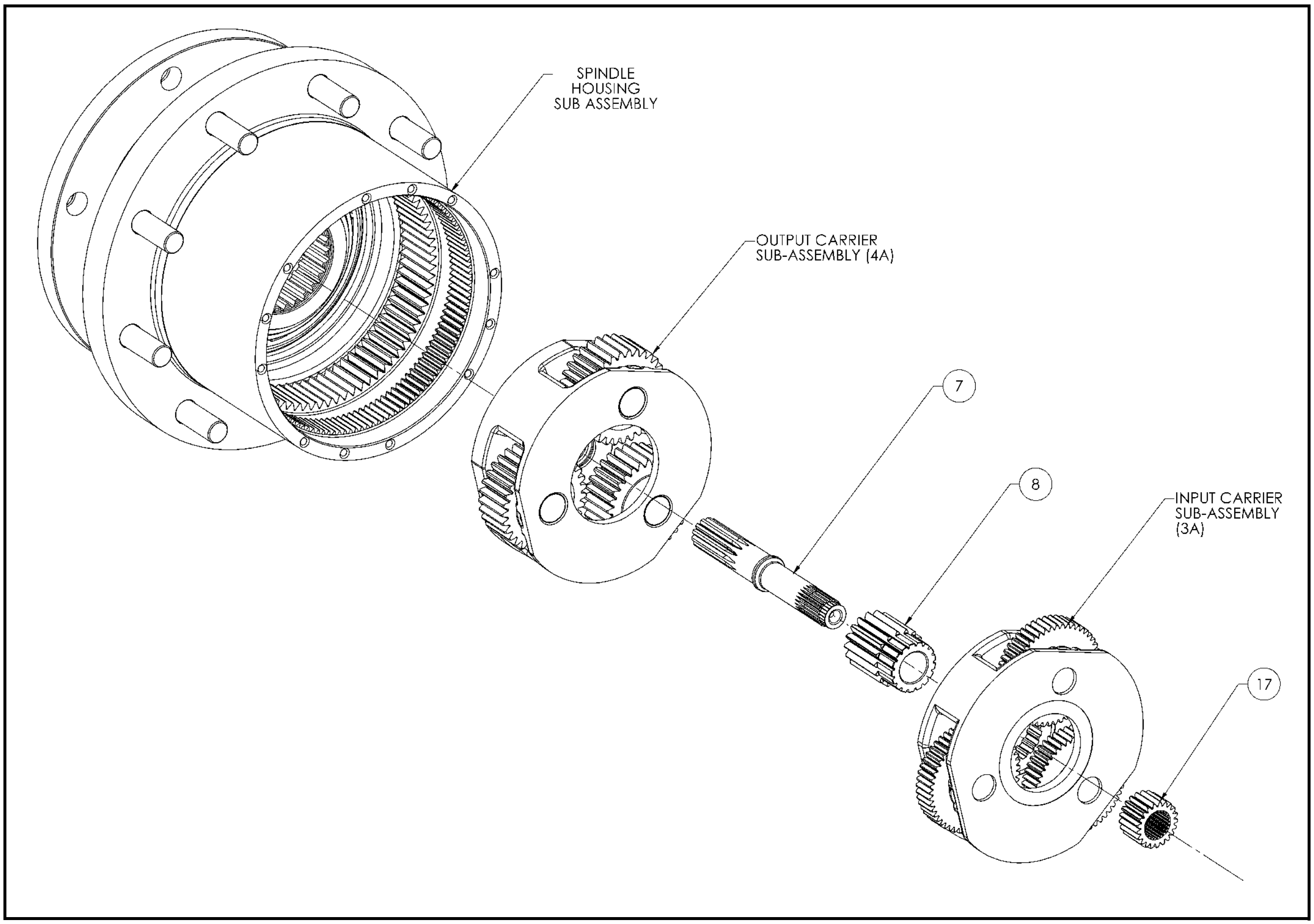
1B. Seal	1F. Bearing Spacer
1C. Bearing Cups	1G. Retaining Ring
1D. Bearing Cone	1H. Wheel Stud
1E. Housing	

Figure 3-9. Housing-Spindle Disassembly

Main Assembly

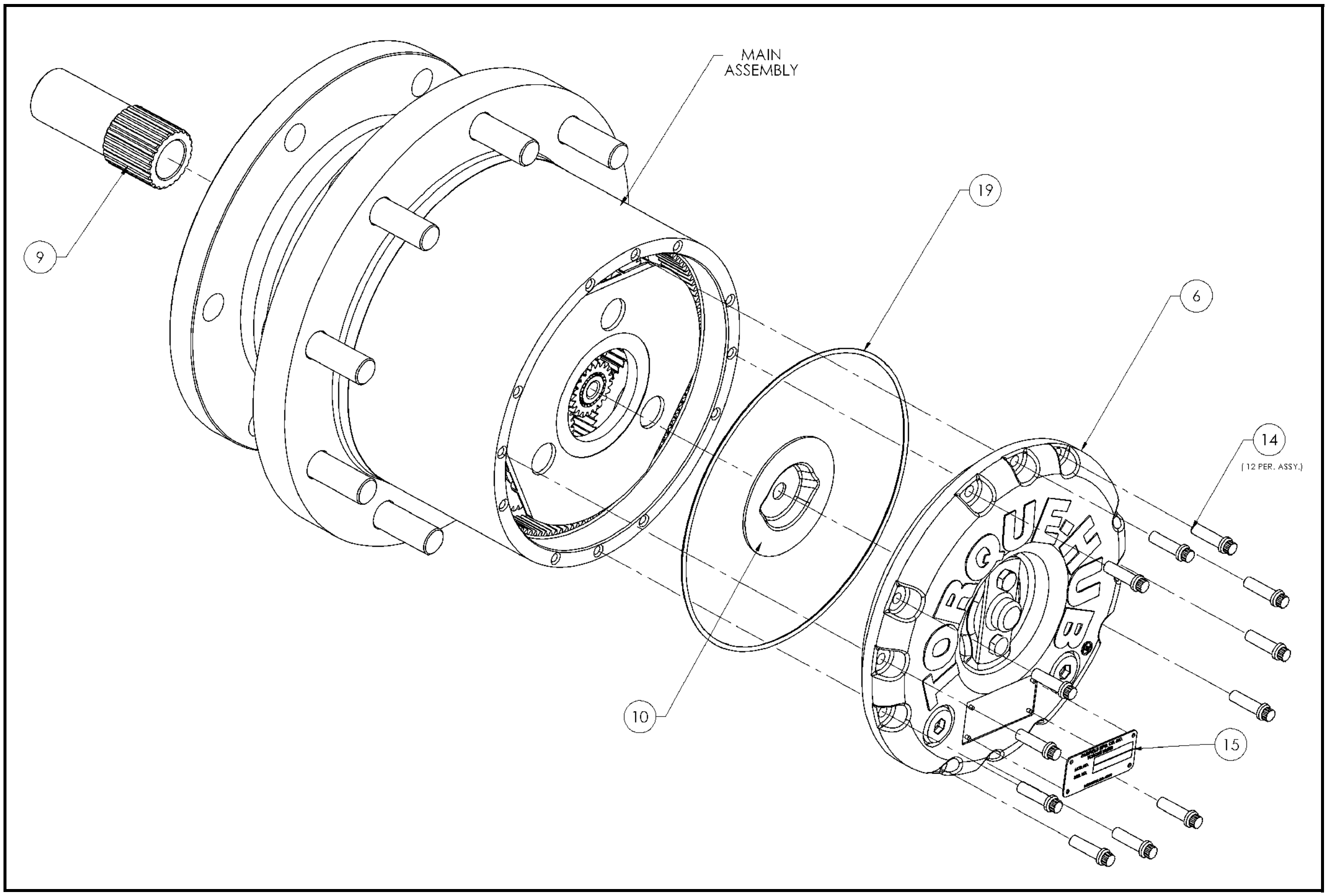
NOTE: *All components should receive a generous amount of lubricant oil as they are being assembled.*

1. Place Housing-Spindle Sub-Assembly on table with Spindle (1A) side down.
2. Place Output Carrier Sub-Assembly into Housing (1E) and onto Spindle (1A).
3. Insert larger diameter splined end of Input Shaft (7) through bore of Output Carrier Sub Assembly (4A) until shoulder of Input Shaft (7) contacts Thrust Washer (4J) (See assembly drawing at back of manual).
4. With modified spline end facing up, place Output Sun Gear (8) into mesh with planet gears from Output Carrier Sub-Assembly (4A).
5. Place Input Carrier Sub-Assembly (3A) onto Output Sun Gear (8) splines.
6. Grease O-Ring (19) and insert into groove in Cover Sub-Assembly (6).
7. Install Cover Sub-Assembly (6) onto Housing (1E) and install twelve Bolts (14) into Cover (6). Torque bolts to 70-80 in-lbs.
8. Attach ID Tag (15) onto unit. If Cover has knobs as part of cover, peen top of each knob to form a head to hold on Tag. If no knobs, use drive screws.
9. Check disconnect, roll and leak check unit, leak check brake, and check brake release pressure.



7. Input Shaft
8. Output Sun Gear
17. Input Sun Gear

Figure 3-10. Main Assembly Drawing1



6. Cover
9. Input Coupling
10. Thrust Spacer
14. Cover Bolts
19. O-ring

Figure 3-11. Figure 3-11. Main Assembly Drawing 2

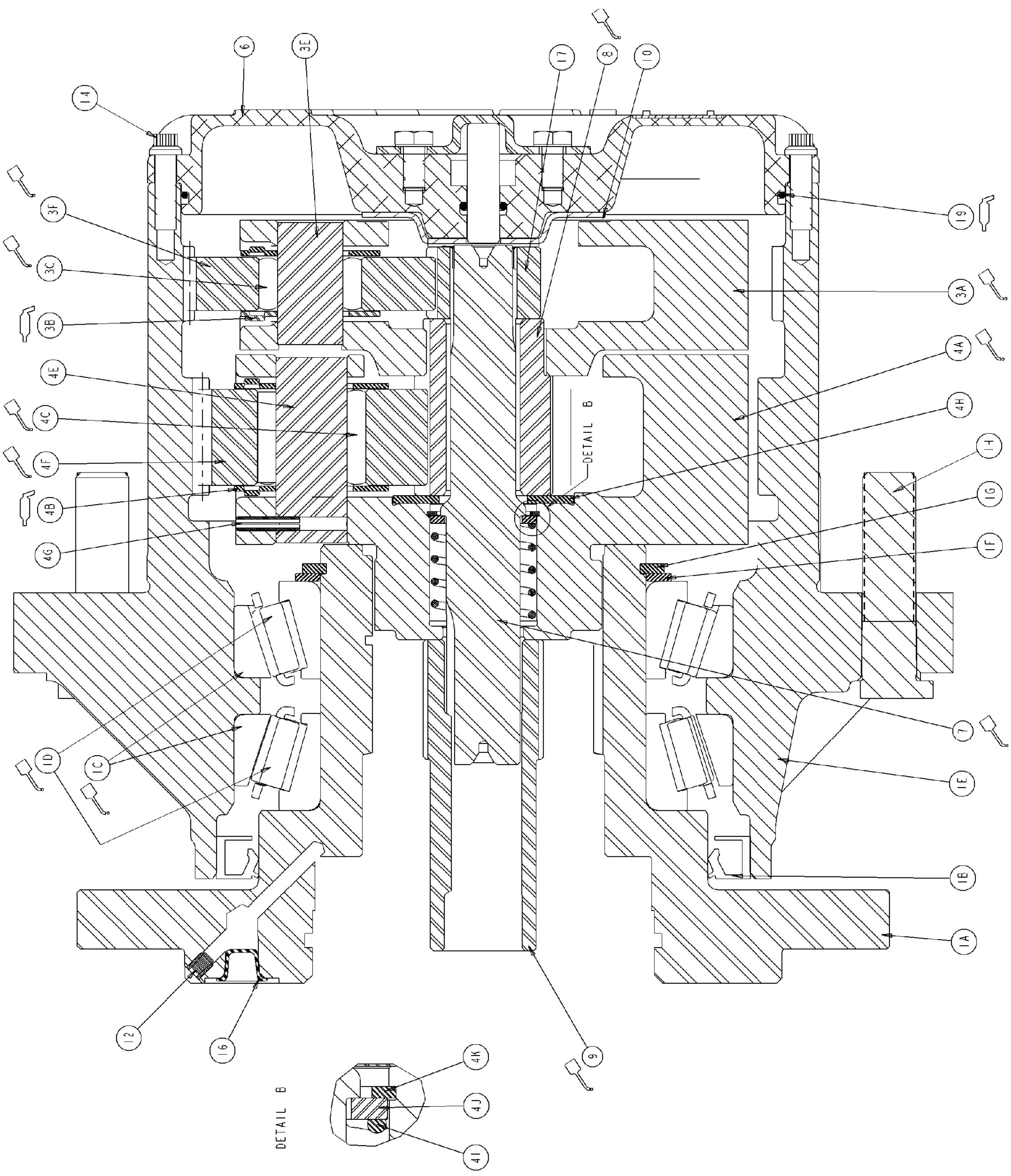


Figure 3-12. Assembly Drawing - Without Integral Input Brake - Sheet 1 of 2

1A	Spindle	4E	Planet Shaft
1G	Retaining Ring - Ext	4C	Needle Bearing
12	Pressure Plug	4I	Spring
16	O-ring Pipe Plug	4K	Retaining Ring - Int
1F	Thrust Washer	4G	Roll Pin
1E	Housing/Ring Gear	4B	Thrust Washer
1N	Stud	4H	Thrust Washer
1C	Tapered Bearing - Cup	4J	Thrust Washer
1D	Tapered Bearing - Cone	17	Sun Gear
1B	Lip Seal	8	Sun Gear
3A	Carrier	7	Input Shaft
3F	Planet Gear	9	Coupling
3E	Planet Shaft	6	Cover Subassembly
3C	Needle Bearing	10	Thrust Spacer
3B	Thrust Washer	15	Id Plate
4A	Carrier	14	12 Pt Flange Bolt
4F	Planet Gear	19	O-ring

Figure 3-13. Assembly Drawing - Without Integral Input Brake - Sheet 2 of 2

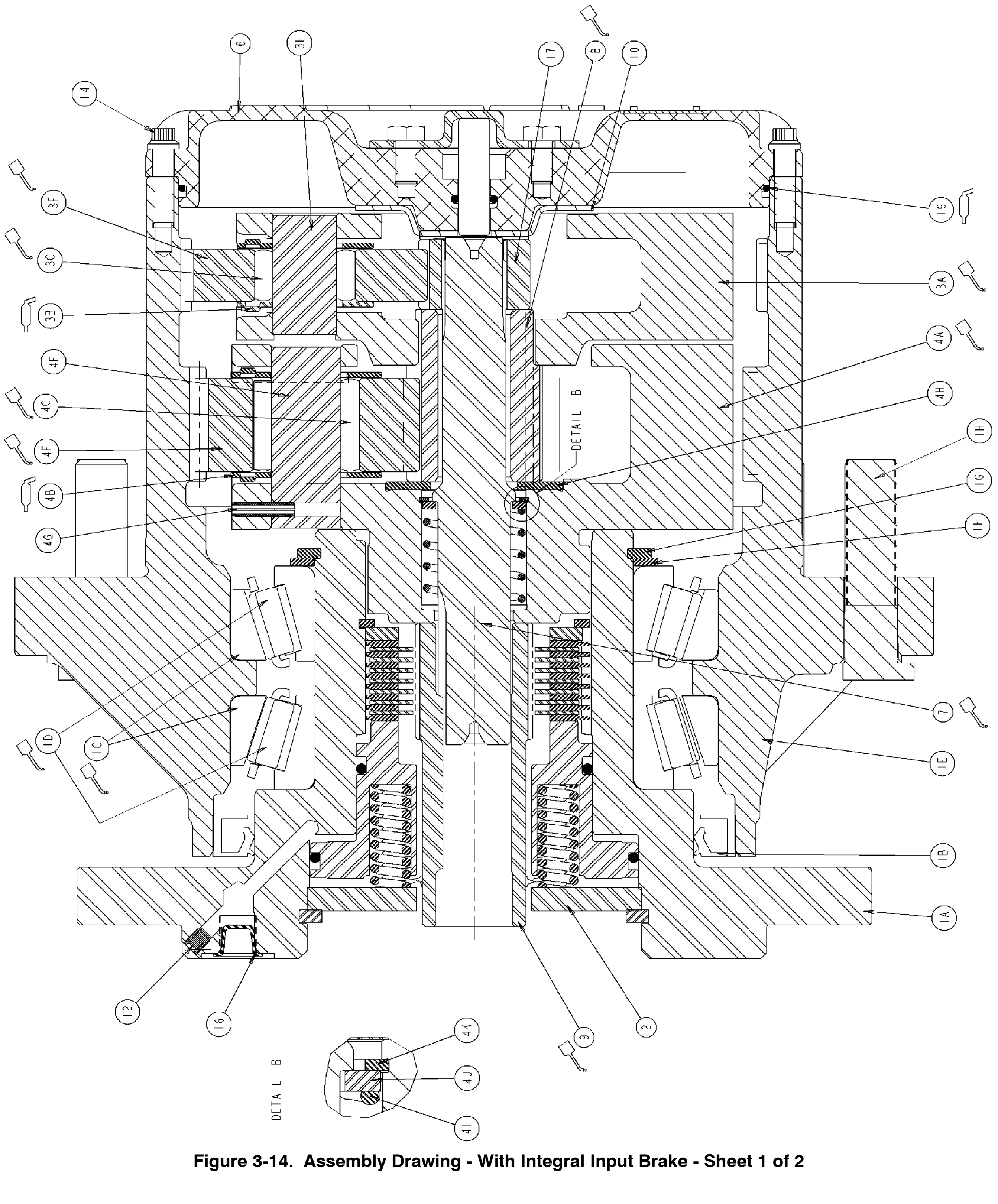


Figure 3-14. Assembly Drawing - With Integral Input Brake - Sheet 1 of 2

1A	Spindle
2	Input Brake
1G	Retaining Ring - Ext
12	Pressure Plug
16	O-ring Pipe Plug
1F	Thrust Washer
1E	Housing/ring Gear
1N	Stud
1C	Tapered Bearing - Cup
1D	Tapered Bearing - Cone
1B	Lip Seal
3A	Carrier
3F	Planet Gear
3E	Planet Shaft
3C	Needle Bearing
3B	Thrust Washer
4A	Carrier
4F	Planet Gear
4E	Planet Shaft
4C	Needle Bearing
4I	Spring
4K	Retaining Ring - Int
4G	Roll Pin
4B	Thrust Washer
4H	Thrust Washer
4J	Thrust Washer
17	Sun Gear
8	Sun Gear
7	Input Shaft
9	Coupling
6	Cover Subassembly
10	Thrust Spacer
15	Id Plate
14	12 Pt Flange Bolt
19	O-ring

Figure 3-15. Assembly Drawing - With Integral Input Brake - Sheet 2 of 2

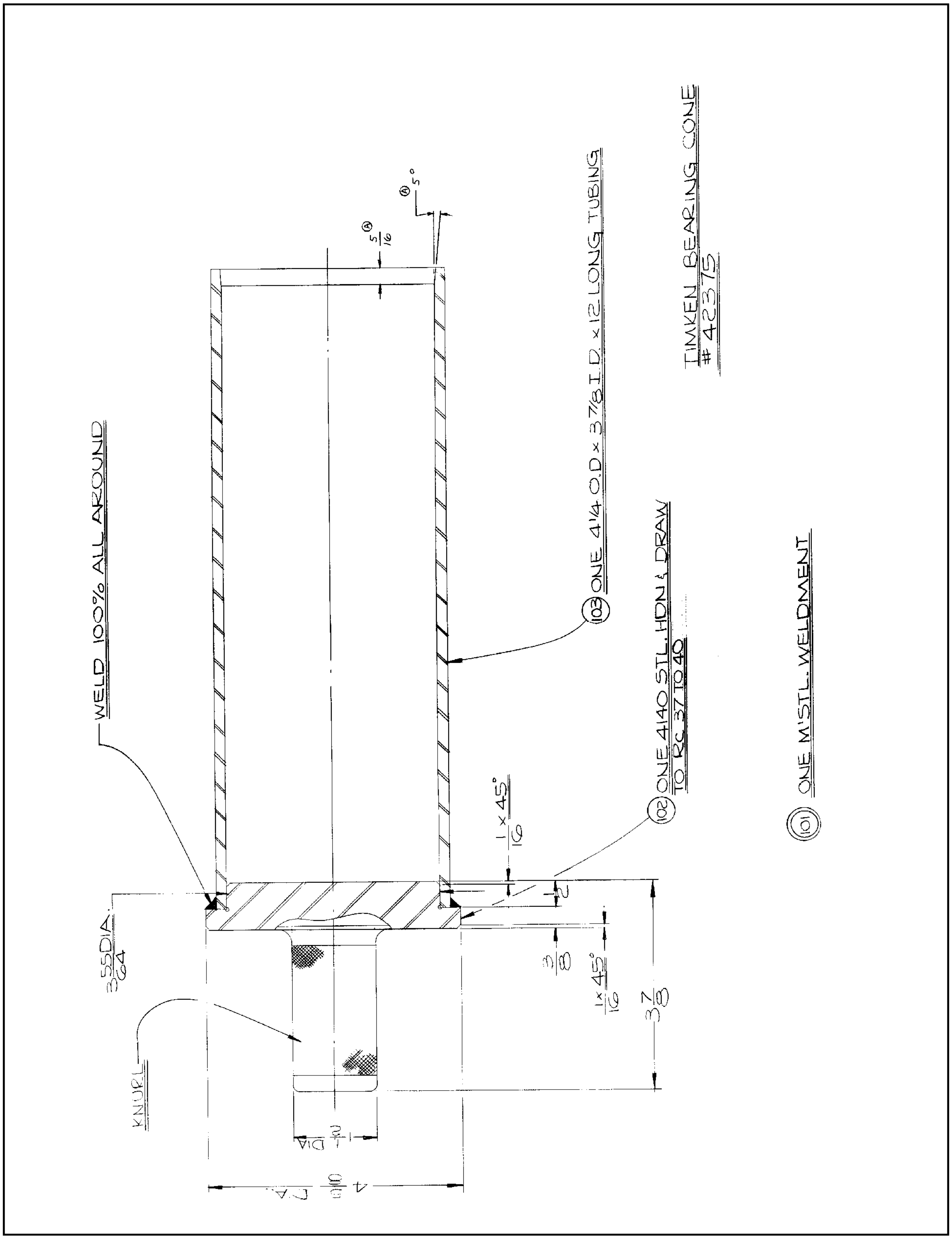


Figure 3-16. Assembly Tools - Bearing Cone Pressing - “B” Bearing

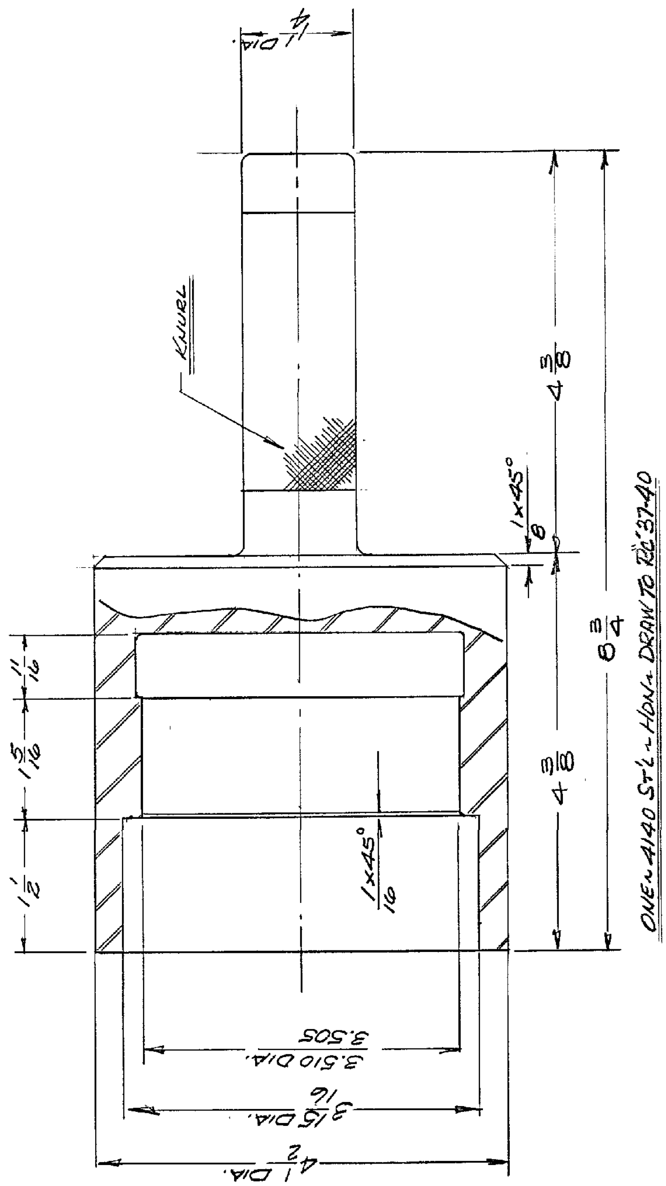


Figure 3-17. Assembly Tools - Bearing Cone Pressing - "A" Bearing

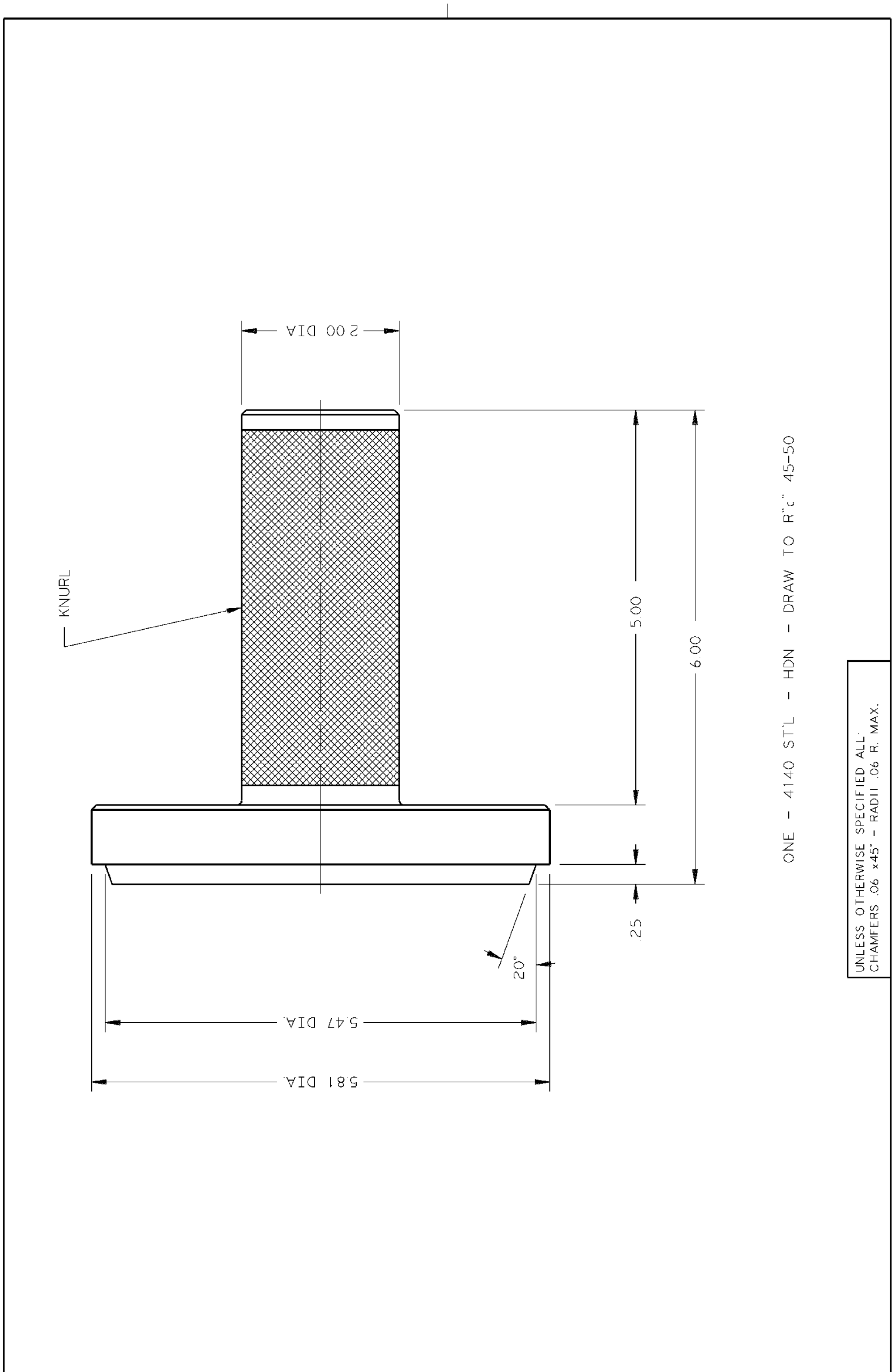


Figure 3-18. Assembly Tools - Bearing Cup Pressing - "A" & "B" Bearings

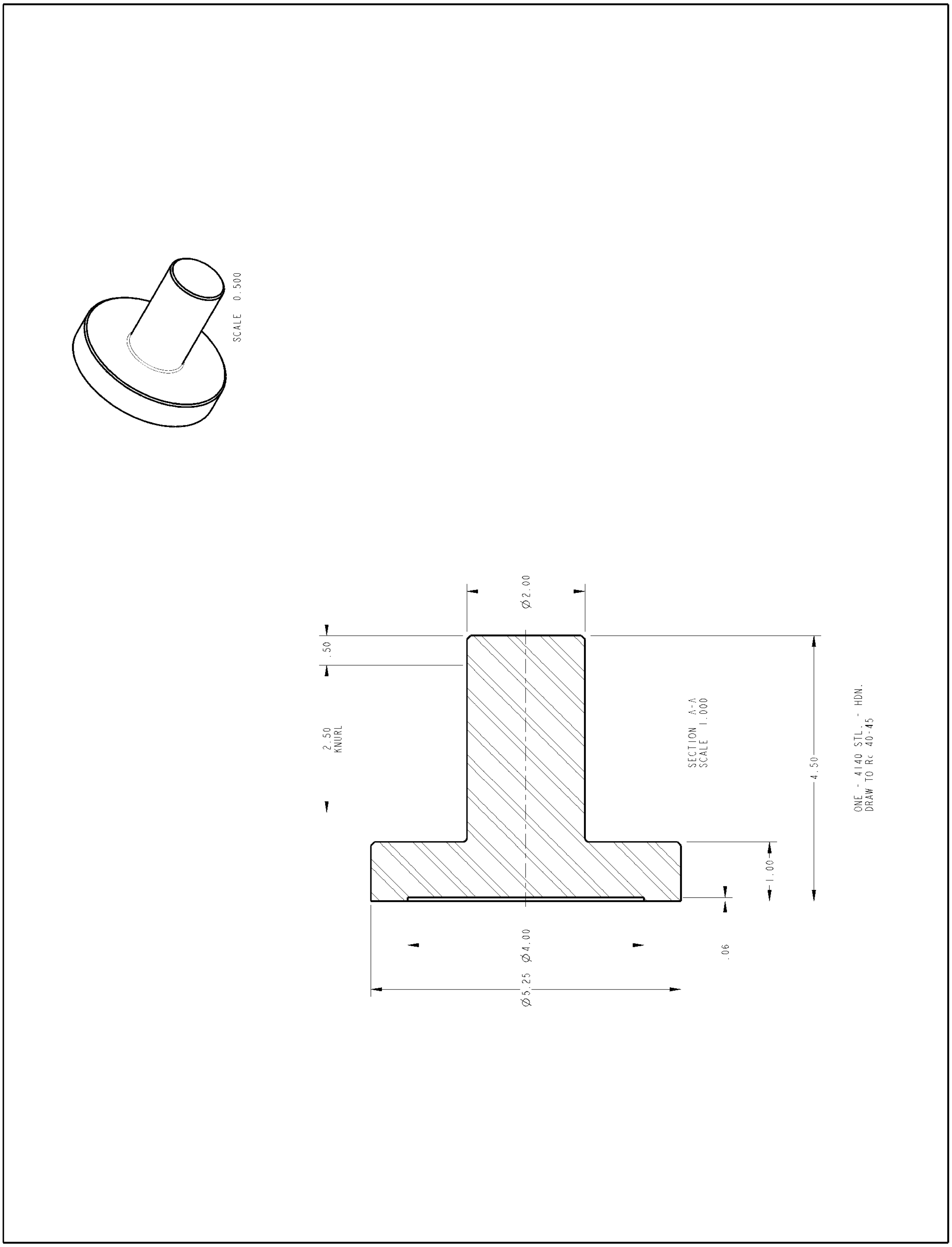


Figure 3-19. Assembly Tools - Seal Pressing

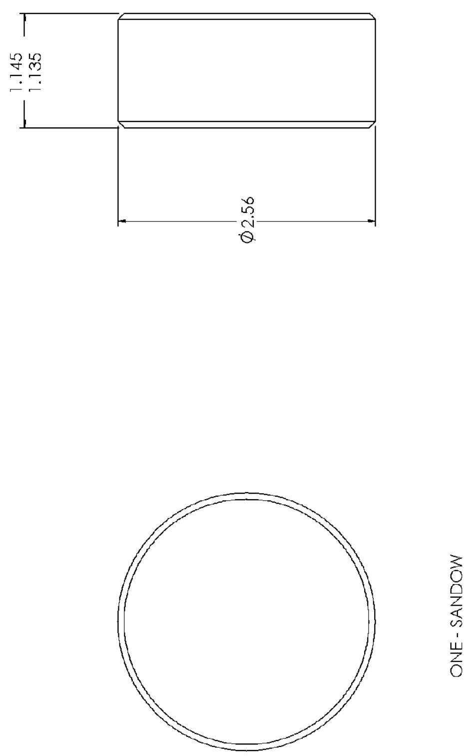


Figure 3-20. Assembly Tools - Spacer - Brake Disc Installation

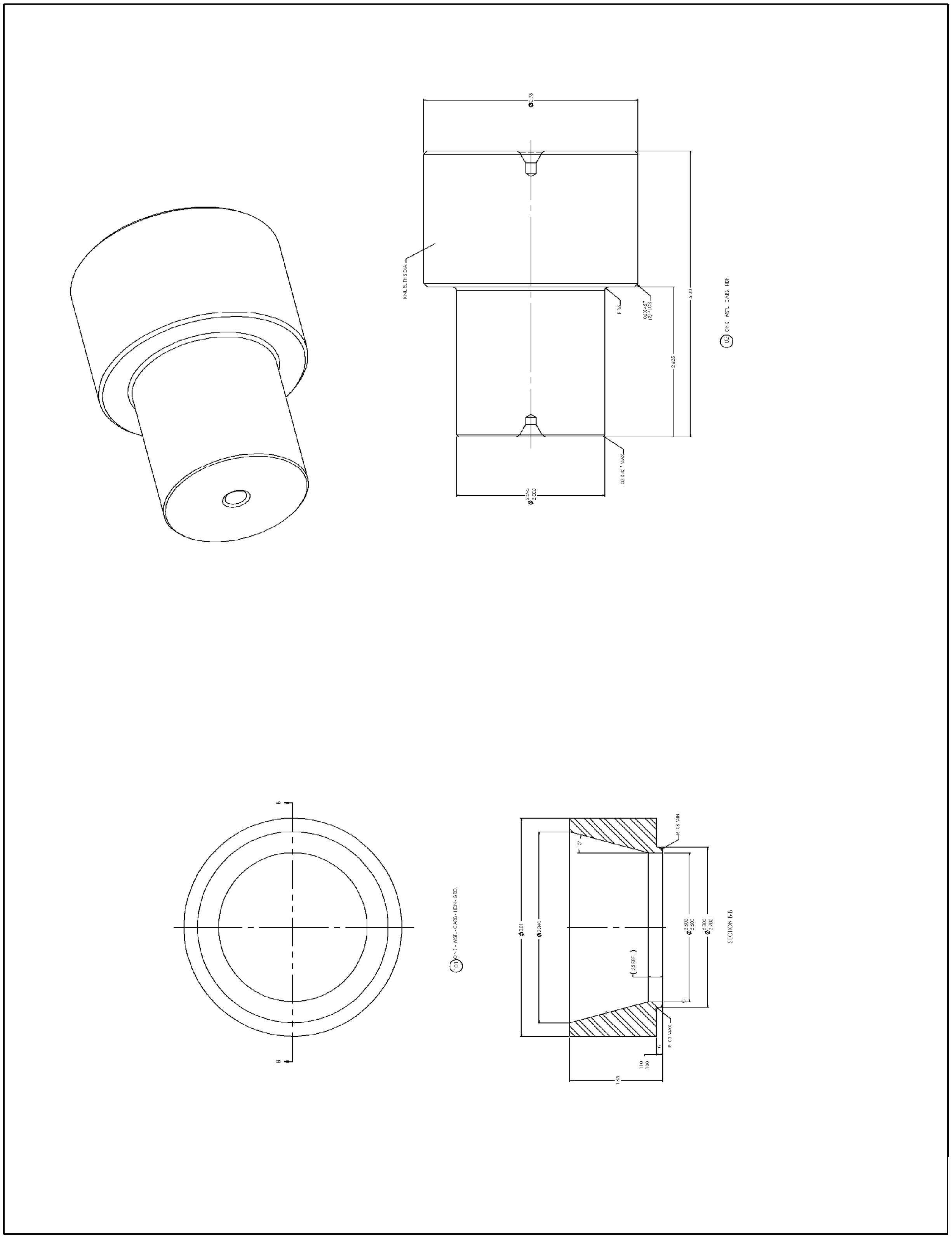


Figure 3-21. Assembly Tools - Brake Retaining Ring Installation

3.3 TORQUE HUB (MACHINES BUILT AFTER S/N 0300071527)

Roll and Leak Testing

Always roll and leak test Torque-Hubs after assembly to make sure that the unit's gears and sealants are working properly. The following information briefly outlines what to look for when performing these tests.

ROLL TEST

The purpose of a roll test is to determine if the unit's gears are rotating freely and properly. You should be able to rotate gears by applying a constant force to the roll checker. If you feel more drag in the gears only at certain points, gears are not rolling freely and you should examine them for improper 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 a leak test is to make sure unit is air tight. You can tell if your unit has a leak if pressure gauge test reading starts to fall once you have pressurized the unit. Leaks usually occur at the main seal or wherever O-rings or gaskets are located. Usually, you can detect the exact location of a leak by brushing a soap and water solution around the main seal and where O-rings or gaskets meet unit exterior, then checking for air bubbles. If you detect a leak in a seal, O-ring, or gasket, replace part immediately.

Tightening and Torquing Bolts

NOTICE

USE EXTREME CARE WHEN USING AN AIR IMPACT WRENCH. DO NOT TIGHTEN BOLTS BEYOND THEIR TORQUE SPECIFICATION. NEVER USE AN IMPACT WRENCH TO TIGHTEN SHOULDER BOLTS. ALWAYS TIGHTEN A11 SHOULDER BOLTS BY HAND.

The following steps describe proper procedure for tightening and torquing bolts or socket head **capscrews** in a bolt circle.

1. Tighten (but do not torque) bolt "A" until snug.
2. Go to opposite side of bolt circle and tighten bolt "B" until equally snug.
3. Continue around bolt circle and tighten remaining bolts.
4. Use a torque wrench to apply specified torque to bolt "A".
5. Continue around bolt circle and apply equal torque to remaining bolts.

Oil Information

1. 1. TYPE – EP90
   Use EP90 for normal applications. For applications where lubricant must meet special requirements, the O.E.M can recommend a suitable substitute.
2. OIL TEMPERATURE
   Continuous – 160° F (70° C) Intermittent – 200° F (95° C).
3. OIL CHANGE
   Initial – After 50 hours or 50,000 revolutions of operation. Subsequent – After 1000 hours or (1) year, whichever comes first.

NOTE: *Higher temperatures make it necessary to change oil more frequently.*

4. OIL FILL LEVEL AND VOLUME
   Unit mounted horizontal – half full. (See Diagram A.) Approximate volume - 17 oz. (0.5 1tr).

MAIN DISASSEMBLY for "B" Drives

1. Turn hub (1G) on side, Remove coupling (14) from wide end of spindle (1A).
2. Mark location of shoulder bolt holes on outside of ring gear and hub for easy realignment when rebuilding. Remove four shoulder bolts (13) and 12 bolts (12) from cover (6).
3. Remove 16 flat washers (16) from cover (6).
4. Lift cover sub-assembly (6) off ring gear (4). Set cover on table with interior side facing up.

CAUTION

SHARP EDGES CAN CUT AND CAUSE SERIOUS INJURY. BEWARE OF SHARP EDGES IN COUNTERBORE WHEN REMOVING O-RING.

5. Remove O-ring (5) from counterbore around edge of cover (6A). Discard O-ring.

NOTE: *If O-ring is not in cover counter- bore, it is in ring gear counterbore. Remove it from hub and discard.*

6. Remove thrust washer (11) from counter- bore in top of carrier (3A).
7. Remove input gear (8) from middle of carrier sub-assembly (3).
8. Lift ring gear (4) off hub (1G).
9. Lift carrier sub-assembly (3) out of hub (1G).
10. Remove thrust spacer (9) from input shaft (7) in middle of spindle (1A).
11. Lift input shaft sub-assembly (7) out of middle of spindle (1A). Stand input shaft (7A) on splined end.

⚠ CAUTION

UNCONTROLLED OBJECTS CAN CAUSE EYE DAMAGE OR SERIOUS INJURY. ALWAYS WEAR EYE PROTECTION.

12. Using retaining ring pliers, remove retaining ring (7B) from groove on input shaft (7A).
13. Remove one spacer (7D), one spring (7C), and other spacer (7D) from input shaft (7A).
14. Remove thrust washer (11) from around spindle (1A).
15. Lift internal gear (2) out of hub (1G).
16. Remove O-ring (5) from counterbore in hub (1G). Discard O-ring.
17. Main disassembly for ”B” drives is complete.

Hub-Spindle Disassembly

NOTE: *Start with large end of hub facing up and large end of spindle facing down.*

⚠ CAUTION

UNCONTROLLED OBJECTS CAN CAUSE EYE DAMAGE OR SERIOUS INJURY. ALWAYS WEAR EYE PROTECTION.

1. Remove retaining ring (1I) from around spindle (1A) ia hub (1G).
2. Remove spacer (1H) from around spindle (1A) in hub (1G).
3. Set hub (1G), with small end/spindle facing down, on something that will support the hub’s flange while it lifts hub up so spindle is not resting on anything. Carefully press or hammer spindle (1A) down and out of hub (1G).

NOTE: *If seal (1B) and bearing cone (1D) come out of hub and rest on spindle, remove these parts from spindle and set them aside. Discard seal.*

4. If seal and bearing cone did not come out of small end of hub (1G) when you pressed spindle out of hub, remove seal (1B) and bearing cone (1D) from small end of hub (1G). Discard seal.
5. Bearing cone (1F) should be lying loose in wide end of hub (1G). Remove bearing cone (1F) from inside hub (1G).

NOTE: *Do not strike counterbore with punch if using a punch and hammer when removing bearing cup.*

6. Remove bearing cup (1C) from counterbore in small end of hub (1G).

NOTE: *Do not strike counterbore with punch if using a punch and hammer when removing bearing cup.*

7. Turn hub (1G) over and lift it out of flange-support. Remove bearing cup (1E) from counterbore in wide end of hub (1G).
8. Turn hub (1G) over onto its small end. Remove two pipe plugs (1J) from side of hub (1G).

NOTE: *If your unit does not have studs, skip this step.*

9. Press nine studs (1N) out of stud holes in hub (1G).
10. Hub-spindle disassembly is complete.

Cover Disassembly

1. Remove two bolts (6C) holding disconnect cap (6D) to cover (6A).
2. Remove disconnect cap (6D) from on top of cover cap (6B) and cover (6A).
3. Remove two bolts (6C) holding cover cap (6B) to cover (6A).
4. Remove cover cap (6B) from cover (6A).
5. Remove disconnect rod (6K) from cover cap (6B).
6. Pry O-ring (6F) out of groove inside cover cap (6B). Discard O-ring.
7. Remove O-ring (6G) from flange of cover cap (6B). Discard O-ring.
8. Remove pipe plug (6H) from cover (6A).
9. Cover disassembly is complete.

Carrier Disassembly

NOTE: *Discard old needle rollers and use new ones during reassembly.*

1. Using a punch and hammer, drive roll pin (3G) into planet shaft (3E).

NOTICE

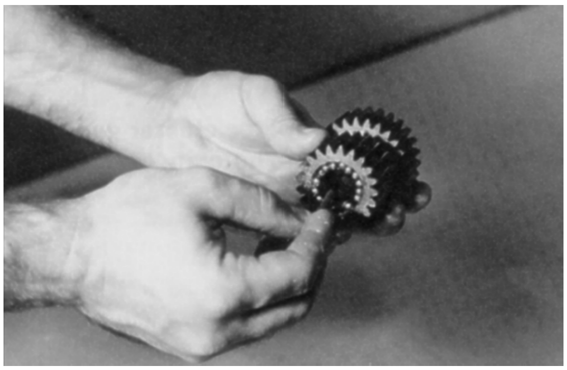
DRIVE ROLL PIN ALL THE WAY INTO PLANET SHAFT OR CARRIER WILL BE DAMAGED WHEN PLANET SHAFT IS REMOVED.

2. Using a punch and hammer, drive planet shaft (3E) out of planet shaft hole in carrier housing (3A).
3. When you remove planet shaft (3E) from carrier housing, one thrust washer (38), one cluster gear (3F), and one more thrust washer (3B) will come off planet shaft and come to rest inside carrier. Remove these parts from inside carrier.
4. Remove 16 needle rollers (3C) from inside one end of cluster gear (3F). Discard needle rollers.
5. Remove one spacer (3D) from inside cluster gear (3F).
6. Remove remaining 16 needle rollers (3C) from other side of cluster gear (3F). Discard needle rollers.

7. Repeat steps 1-6 to remove and disassemble two remaining cluster gears.
8. At this point carrier disassembly is complete.

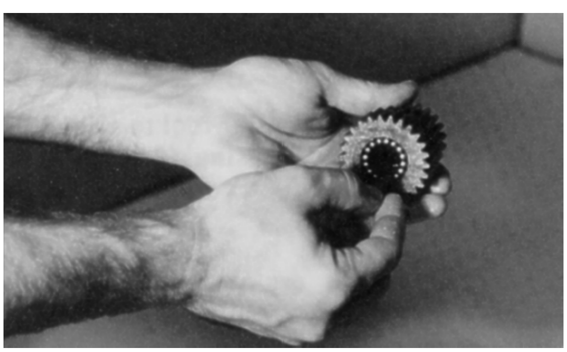
Assemble Carrier

1. Apply grease to inside of one cluster gear (3F) and line one half of cluster gear with 16 needle rollers (3C).

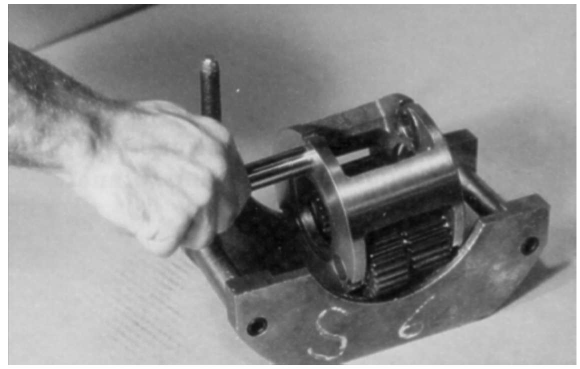


2. Place spacer (3D) inside cluster gear (3F) so it rests on top of needle rollers.

3. Line remaining half of cluster gear (3F) with 16 needle rollers.



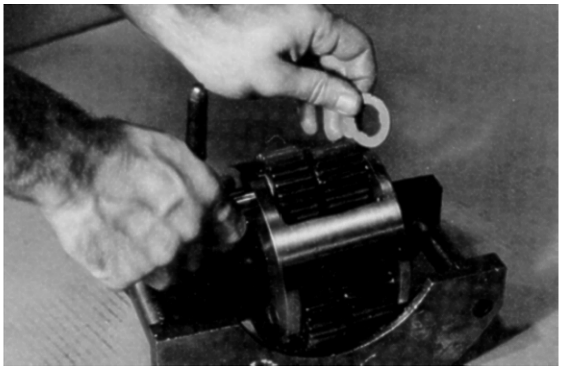
4. Set carrier housing (3A) on table, sideways. Insert a planet shaft (3E), roll pin hole last, into one of the planet shaft holes from roll-pin-holed side of carrier housing (3A).



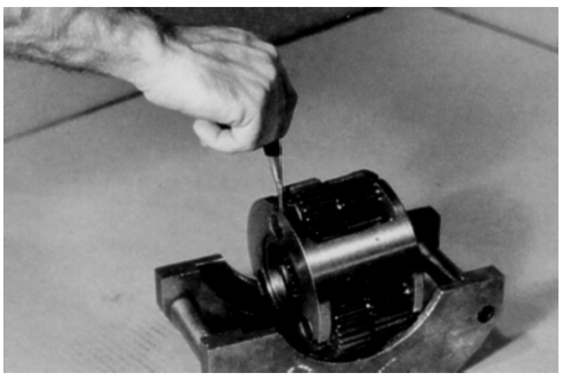
5. Place thrust washer (3B) on end of planet shaft (3E) inside carrier. Fit tang of thrust washer into slot on inside edge of planet shaft hole.

6. Following thrust washer, place cluster gear (3F), large end toward roll pin hole in carrier housing, on planet shaft (3E).

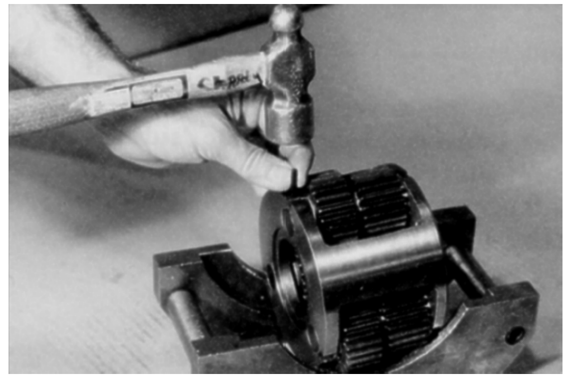
7. Following cluster gear, place one more thrust washer (3B) onto planet shaft (3E) through opposite planet shaft hole in carrier housing (3A).



8. Use an alignment punch or similar tool to align roll pin holes in carrier housing (3A) and planet shaft (3E).



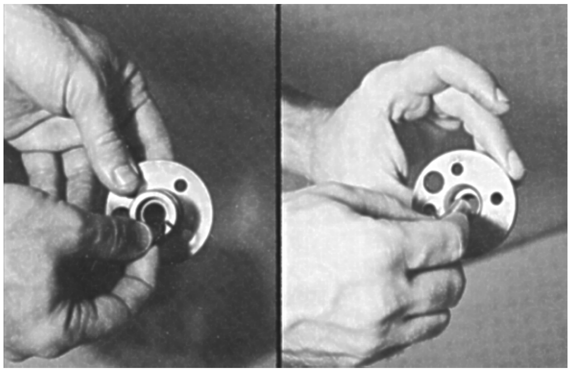
9. Drive roll pin (3G) into aligned roll pin holes in carrier housing (3A) and planet shaft (3E).



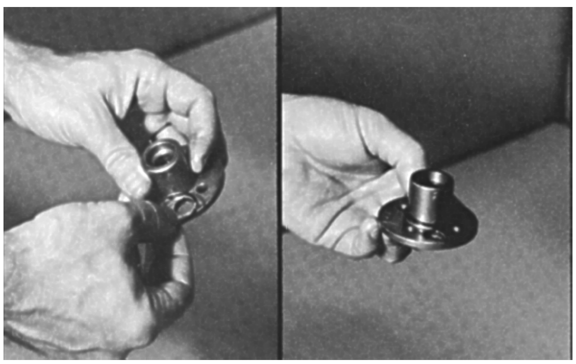
10. Repeat steps 1 thru 9 to assemble and install two remaining cluster gears.
11. At this point carrier sub-assembly is complete.

Cover Sub-Assembly

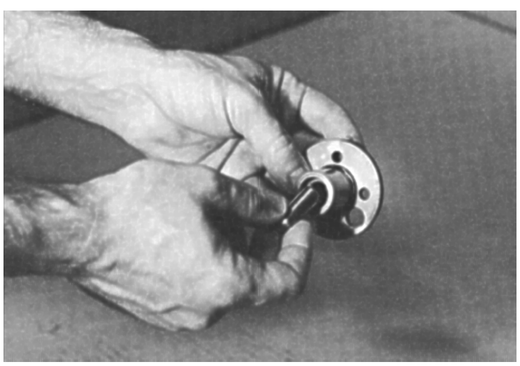
1. Using disconnect rod, push O-ring (6F) into groove inside cover cap (6B).



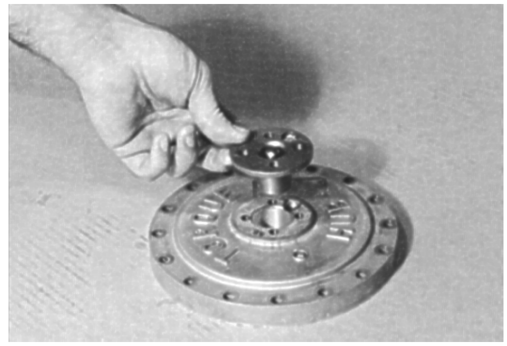
2. Place O-ring (6G) onto cover cap (6B) so it rests against flange of cover cap.



3. Insert disconnect rod (6E) into cover cap (6B).

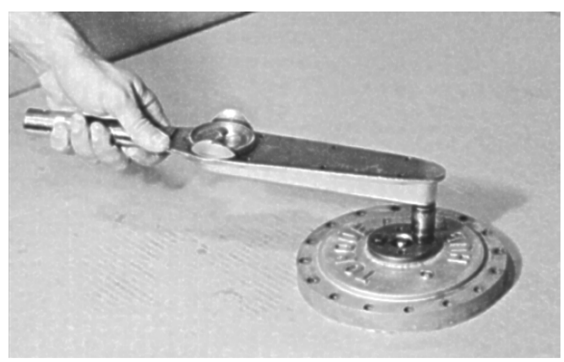


4. Set cover (6A) on table, exterior side up. Place cover cap (6B) on cover (6A), aligning pipe plug hole in cover cap over pipe plug hole in cover.

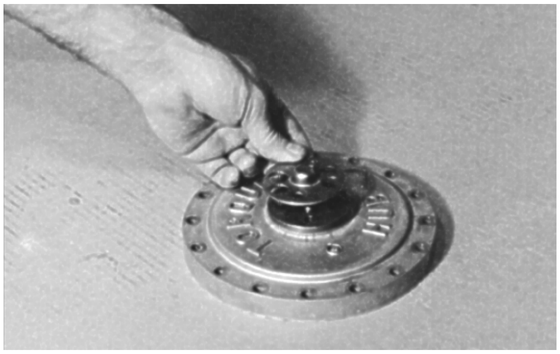


5. Place two cover cap bolts (6C) in any two bolt holes 180° apart on cover cap (6B) and tighten bolts.

6. Using a torque wrench, apply 36 to 49 in-lb (4 to 5 Nm) of torque to both bolts (6C).

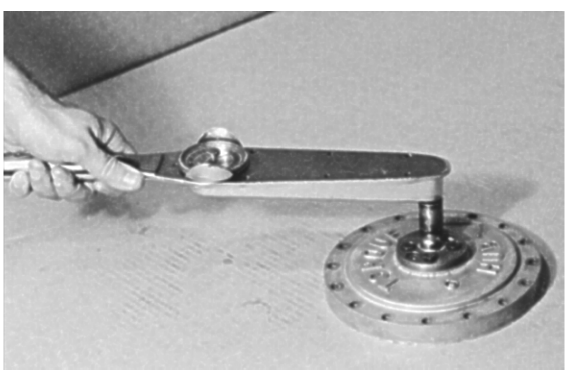


7. With large end down, place disconnect cap (6D) on cover cap (6B), aligning pipe plug hole in disconnect cap over pipe plug hole in cover cap.

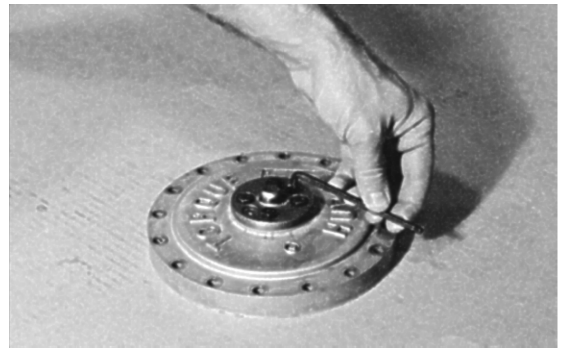


8. Place two remaining bolts (6C) in bolt holes in disconnect cap (6D) and tighten bolts.

9. Using a torque wrench, apply 36 to 49 in-lb (4 to 5 Nm) of torque to both bolts (6C).



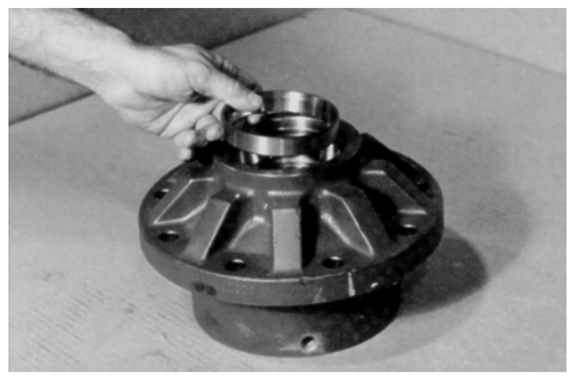
10. Apply a light coat of "Never-Seize" to pipe plug (6H) and tighten it in pipe plug hole in cover (6A).



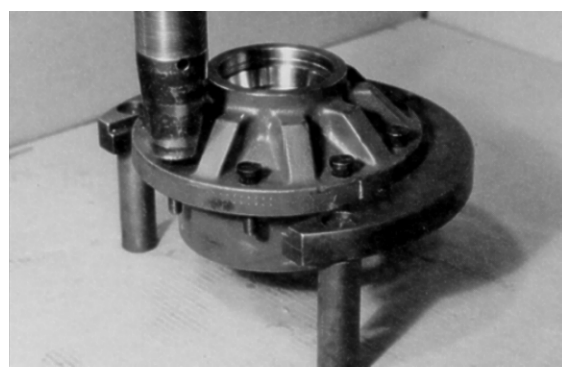
Hub-Spindle Sub-Assembly

NOTE: *Make sure cup sits square with counterbore before pressing.*

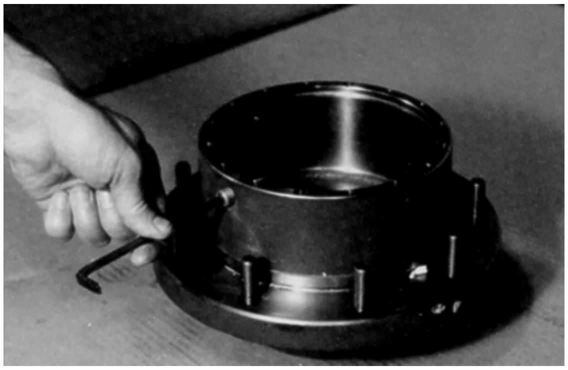
1. Set hub (1G) on large end. Press bearing cup (1C) into counterbore in small end of hub (1G).



2. Press nine studs (1N) in stud holes in hub (1G).

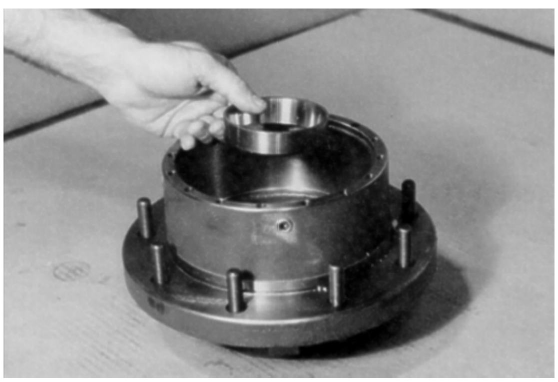


3. Apply a light coat of “Never-Seize” to two pipe plugs (1J) and tighten them in two pipe plug holes in side of hub (1G).

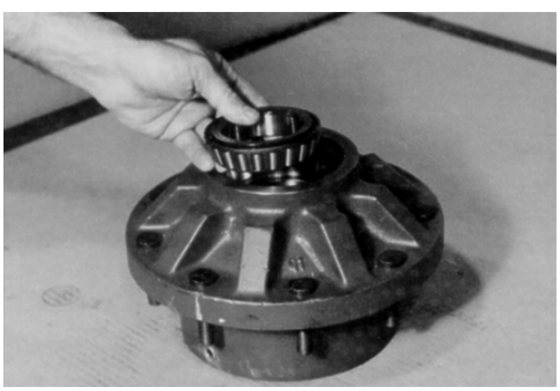


NOTE: *Make sure cup sits square with counterbore before pressing.*

4. Turn hub (1G) over to small end. Press bearing cup (1E) into counterbore in deep end of hub (1G).



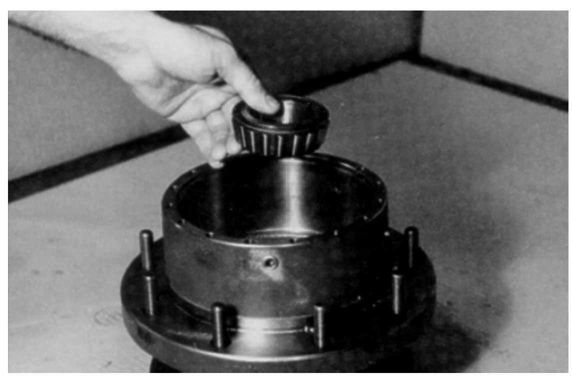
5. Set hub (1G) on large end. Place bearing cone (1D) into bearing cup (1C).



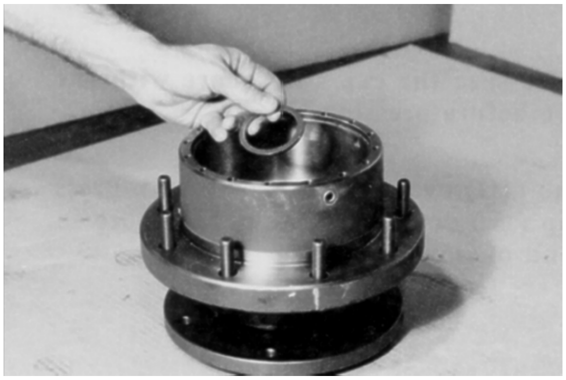
6. Press seal (1B) in small end of hub (1G).

7. Oil spindle, then lower hub (1G) small end down, onto spindle (1A).

8. Press bearing cone (1F) on spindle (1A) in hub (1G).



9. Place spacer (1H) on spindle (1A) in hub (1G).



NOTE: *Make sure retaining ring is securely seated in groove.*

10. Place retaining ring (1I) over spacer onto spindle (1A) in hub (1G).

11. At this point hub-spindle sub-assembly is complete.

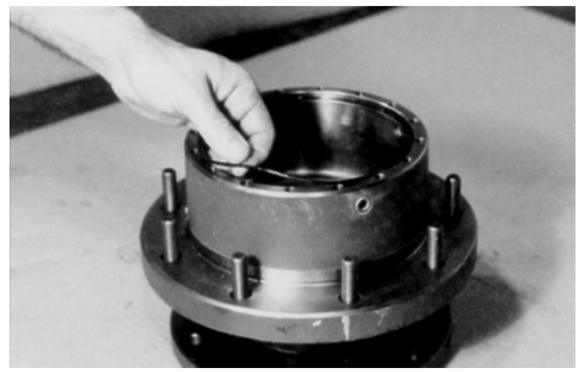
Main Assembly

CAUTION

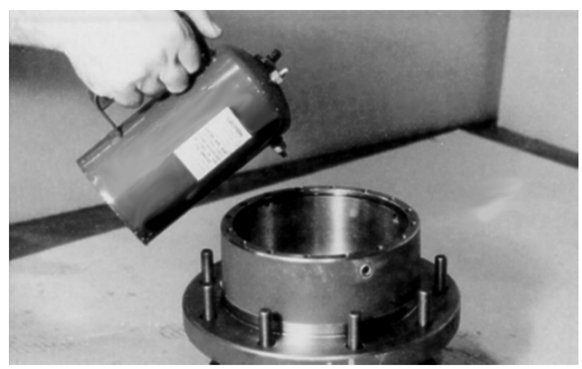
SHARP EDGES CAN CUT AND CAUSE SERIOUS INJURY. BEWARE OF SHARP EDGES IN COUNTERBORE WHEN REMOVING O-RING.

1. Grease O-ring (5) and place it into counterbore in hub (1G).

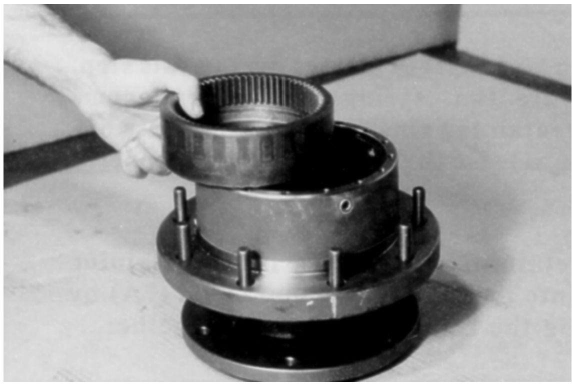
NOTE: *O-ring may be stretched or pinched together to make it fit into counterbore.*



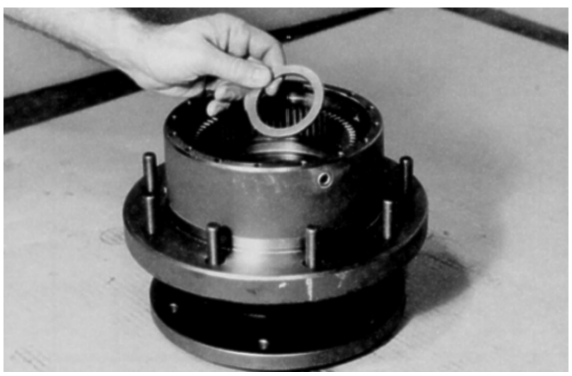
2. Oil exposed surfaces inside hub (1G).



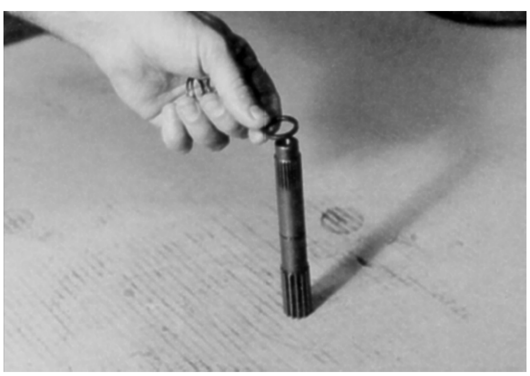
3. Place internal gear (2) in hub (1G) so its internal splines mesh with external splines of spindle (1A). Oil internal gear (2).



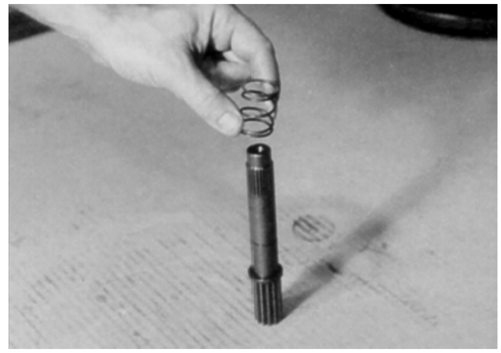
4. Place thrust washer (11) around spindle (1A) so it rests on bottom of internal gear (2).



5. Stand input shaft (7A) on splined end. Place one spacer (7D) on smooth end of input shaft (7A).



6. Place spring (7C) on smooth end of input shaft (7A).

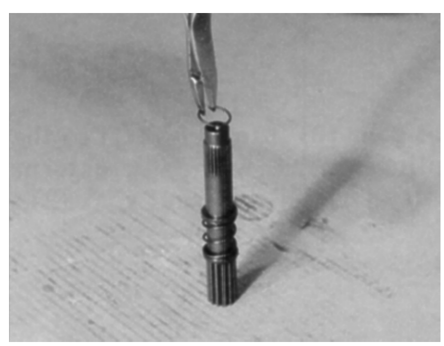


7. Place other spacer (7D) on smooth end of input shaft (7A).

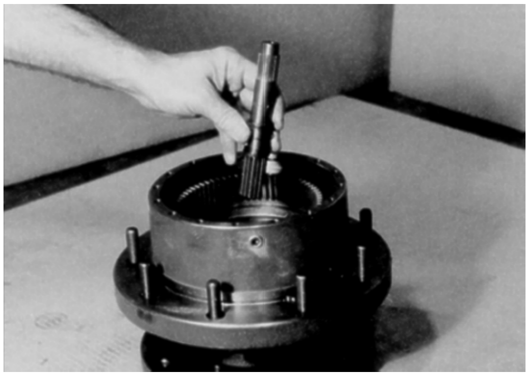
⚠ CAUTION

UNCONTROLLED OBJECTS CAN CAUSE EYE DAMAGE OR SERIOUS INJURY. ALWAYS WEAR EYE PROTECTION.

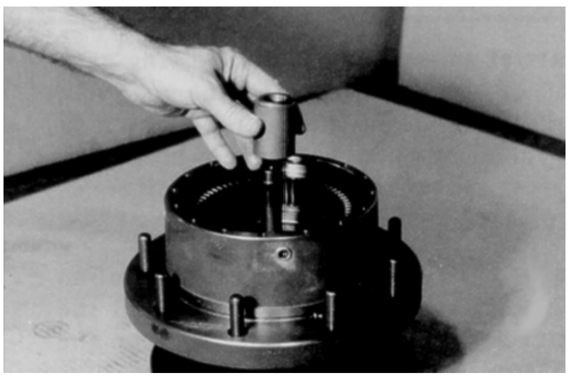
8. Using retaining ring pliers, insert retaining ring (7B) in groove on input shaft (7A) by compressing spring and spacers together.



9. With large splined end down, place input shaft sub-assembly (7) into spindle (1A).



10. Place thrust spacer (9) onto input shaft (7).



11. Set carrier sub-assembly (3) on a flat work surface so large ends of cluster gears (3F) face up. Locate punch marks on face of each cluster gear (3F) and position them at 12 o'clock.

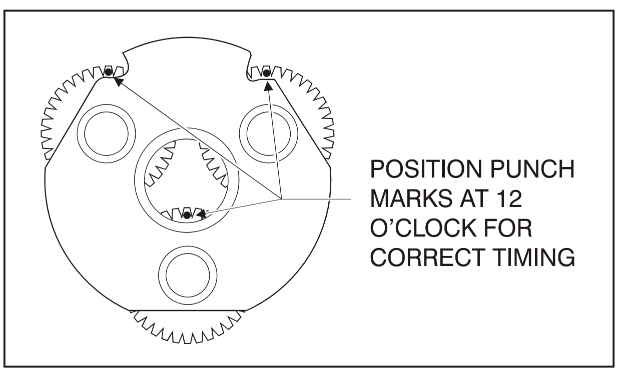
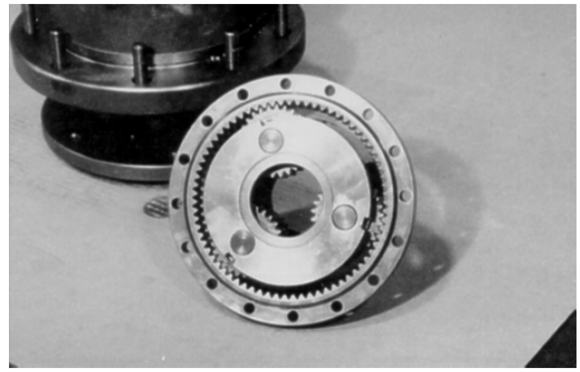


Figure 3-22. Cluster Gear Punch Marks

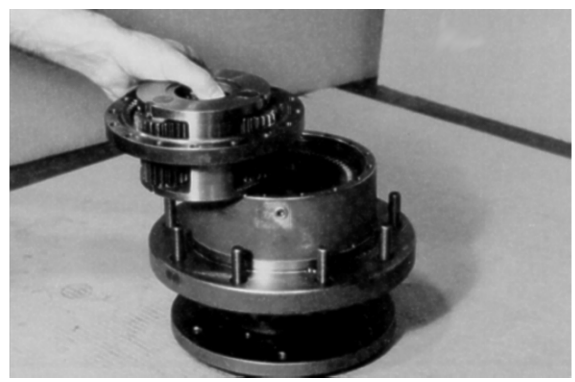
12. With "X" marked side facing up, place ring gear (4) around cluster gears (3F).

NOTE: *This will hold punch marks in position while installing carrier into hub.*

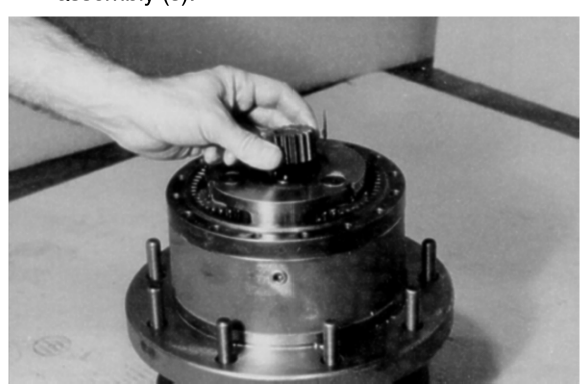


13. Place carrier sub assembly (3) and ring gear (4) together into mesh with internal gear (2), aligning "X" marked shoulder bolt hole in ring gear (4) over one of the shoulder bolt holes in hub. Mark location of shoulder bolt holes on outside of ring gear and hub.

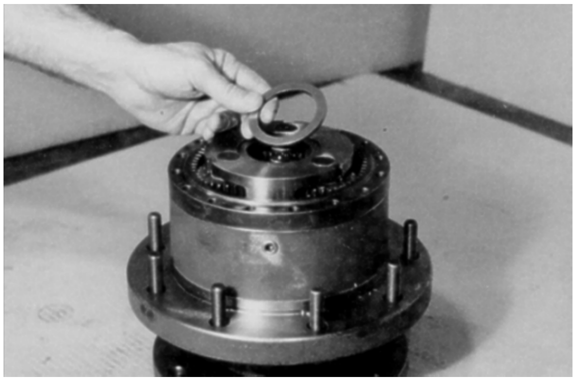
NOTE: *You may lift ring gear off hub to align shoulder bolt holes. Ring gear and carrier are installed together only to keep punch marks on carrier in place.*



14. With internal splines facing up (counterbore end facing down), place input gear (8) into mesh with carrier sub-assembly (3).



15. Oil all exposed surfaces inside hub (1G). Place thrust washer (11) into counterbore in top of carrier.

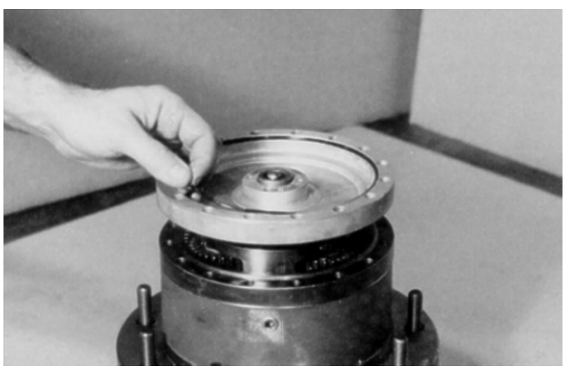


⚠ CAUTION

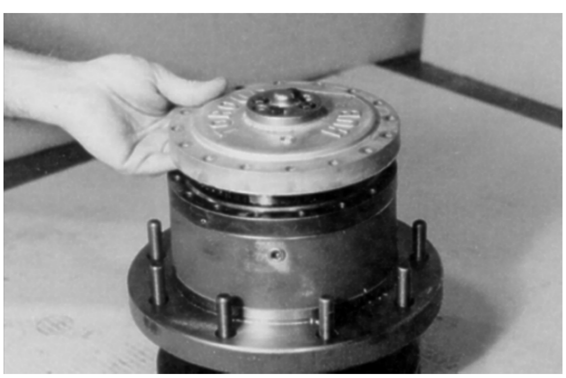
SHARP EDGES IN COUNTERBORE CAN CUT AND CAUSE INJURY WHEN INSTALLING O-RING.

16. Set cover (6A) on table, interior side up. Grease O-ring (5) and place in counterbore around edge of cover (6A).

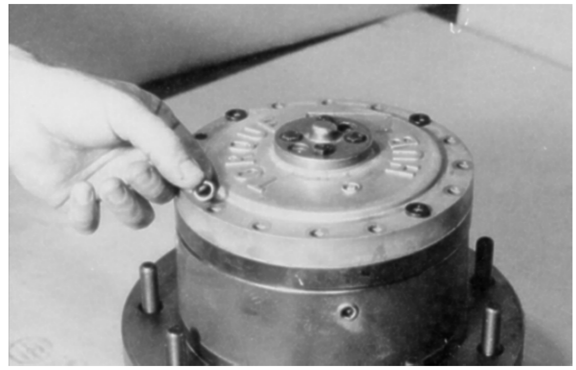
NOTE: *O-ring may be stretched or pinched together to make it fit counterbore.*



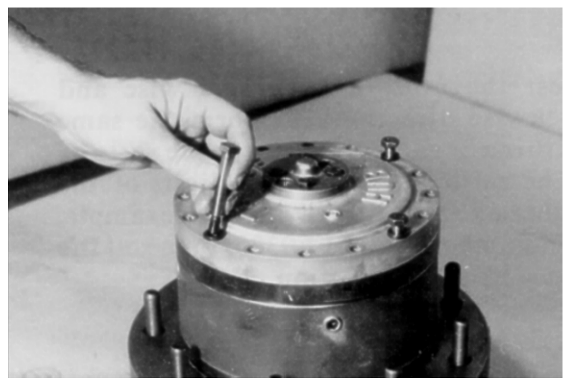
17. Place cover sub-assembly (6) on ring gear (4). Align pipe plug holes before disassembly.



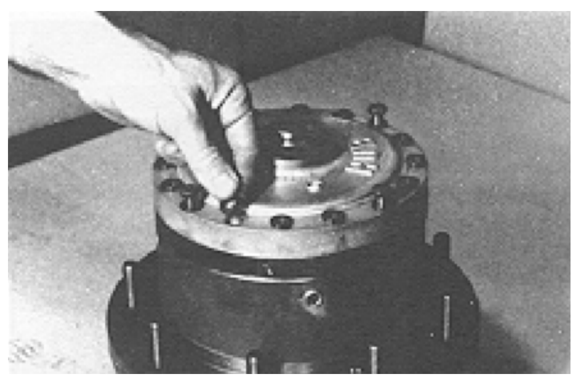
18. Place four flat washers (16) on top of bolt holes in cover sub-assembly.



19. Place shoulder bolts (13) in four shoulder bolt holes in cover (6) and hand-tighten.

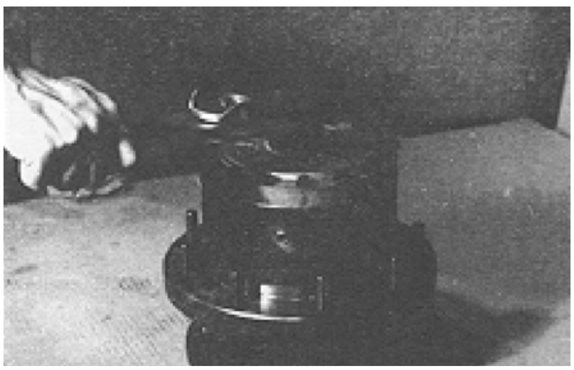


20. Place remaining 12 flat washers (16) on remaining bolt holes in cover (6).

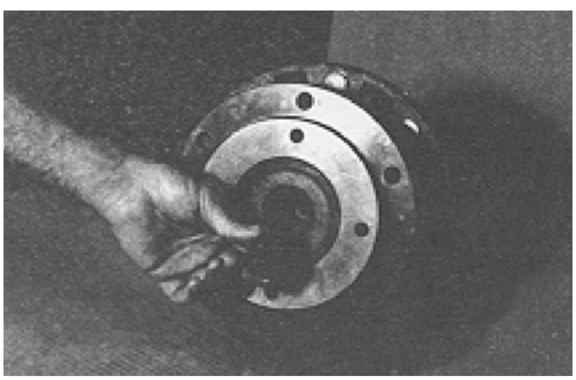


21. Place 12 bolts in remaining bolt holes in cover (6) and tighten.

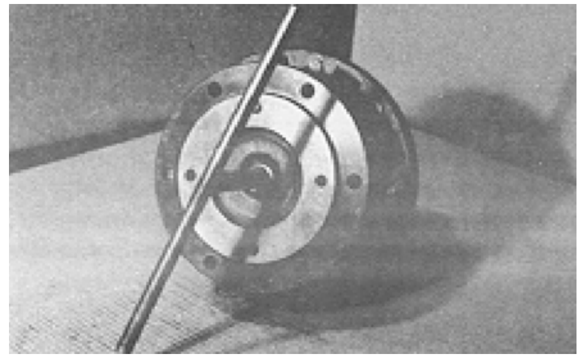
22. Torque shoulder bolts (13) 18 to 25 ft-lb (25 to 34 Nm). Torque bolts (12) 18 to 25 ft-lb (25 to 34 Nm).



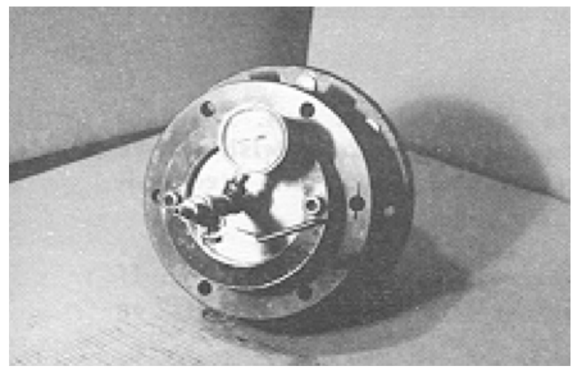
23. Turn hub (1G) on its side. Insert coupling (14) into end of spindle (1A).



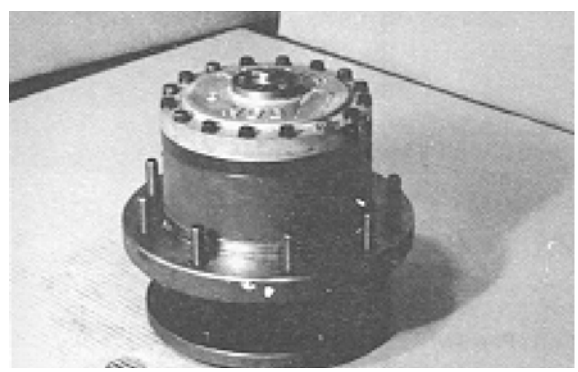
24. Roll test unit in clockwise and counterclockwise directions. Perform same number of turns in each direction as the ratio of the unit. The ratio is the last two digits of the model number on the unit's ID tag.



25. Leak test unit at a pressure of 5 psi (34.47 kPa) for 2 to 3 minutes.



26. At this point main assembly is complete.

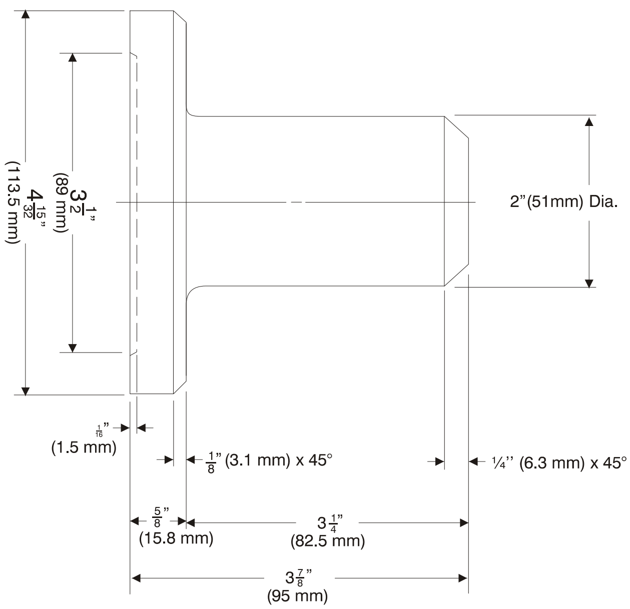


Tool List

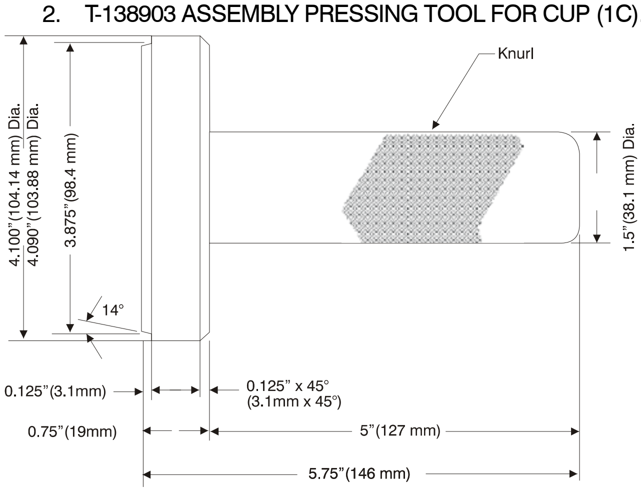
The following specialized tools are used to assemble this unit. Tool diagrams in this manual are intended for the customer who may wish to have a tool made. All tools are one piece and must be made from mild steel. All dimensions are in inches.

NOTE: *Tools may be carburized and hardened to improve tool life. If this is done, tools must be ground on all surfaces labeled with a "G" on the tool diagram.*

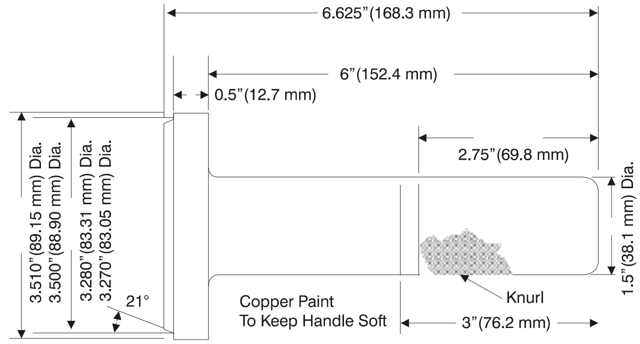
1. T-118126 SEAL PRESSING TOOL FOR SEAL (1B).



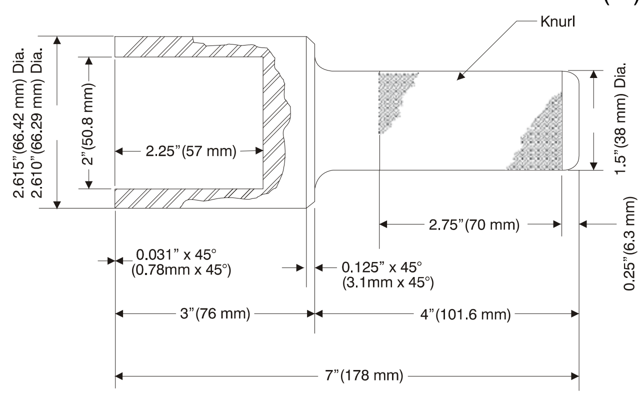
2. T-138903 ASSEMBLY PRESSING TOOL FOR CUP (1C).



3. T-140433 ASSEMBLY PRESSING TOOL FOR CUP (1E).



4. T-109691 ASSEMBLY PRESSING TOOL FOR CONE (1F).



* These tools are for specific seals, cups or cones. There is a specific tool for each cup and cone.

3.4 RE-ALIGNING TORQUE HUB INPUT COUPLING

The following procedure applies to torque hubs with integral brakes:

Equipment Required

1. Hydraulic power supply (hand pump) capable of producing 200 psi (13.8 bar).
2. Hydraulic fittings to adapt hydraulic supply to brake release port on hub.

Procedure

1. Using appropriate fittings, connect a line from hydraulic power supply to brake port.
2. Pressurize brake release port to 155 - 200 psi (10.6 - 13.8 bar) to release brake.
3. Verify brake is released by rotating input coupling or hub spindle. Once brake is released, input coupling is free to re-align with drive motor.
4. Install drive motor on hub. Release hydraulic pressure at brake release port. Coupling remains in position.
5. Disconnect hydraulic power supply and reconnect line to brake release port.

3.5 DRIVE MOTOR

NOTE: *This procedure covers 2WD motors used on Caterpillar, Deutz, and Ford powered machines built prior to S/N 0300100514).*

Disassembly

1. Clean outside of unit thoroughly.
2. Clamp shaft in a protected jaw vise with back plate end up.
3. Remove six cap screws (23 or 28 & 29) from back plate (22 or 27).
4. Use a plastic mallet and tap back plate (22 or 27) to loosen it.
5. Remove O-ring (21) from back plate.
6. Remove complete piston block assembly from housing assembly.
7. Remove piston assemblies (11), spider (12), and pivot (130 from piston block assembly.
8. Piston block assembly need not be disassembled unless pins (16) or spring (18) is damaged.

CAUTION

UNCONTROLLED OBJECTS CAN CAUSE EYE DAMAGE AND SERIOUS INJURY. SPRING (18) IS HIGHLY COMPRESSED. DO NOT REMOVE SNAP RING (19) WITHOUT COMPRESSING SPRING. ALWAYS WEAR EYE PROTECTION.

The following parts are needed to disassemble piston block:

2 each 3/8" I.D. x 1 1/8" O.D. flat washers.

1 each 3/8" x 3 1/4" N.C. cap screw.

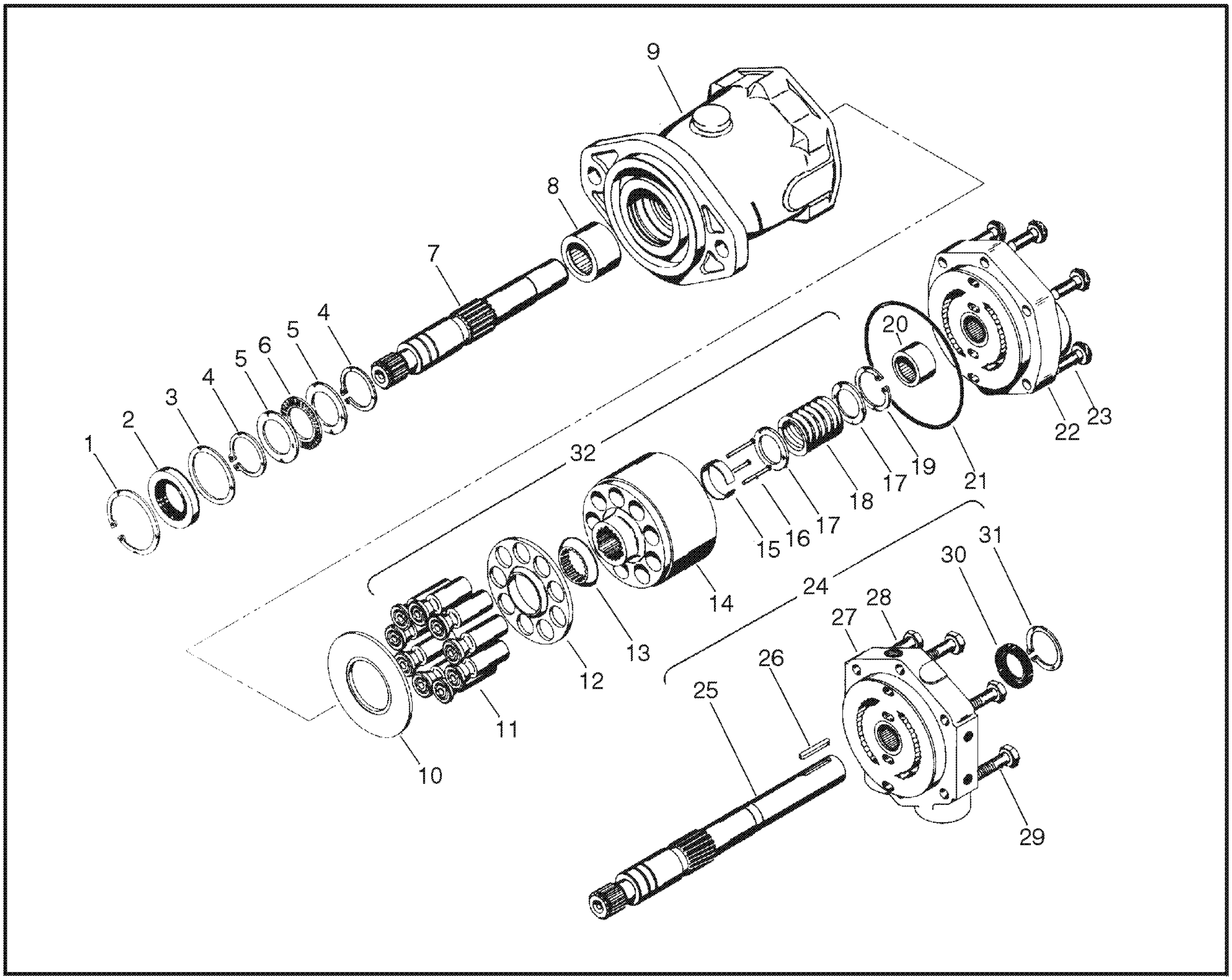
1 each 3/8" N.C. nut.

Place one flat washer over 3/8" x 3 1/4" cap screw, and place this through center of piston block. Place other washer over cap screw and let it rest on three pins (16). Screw on nut and compress spring inside piston block. Use snap ring pliers to remove internal snap ring (19). Remove bolt and two washers. Remove two washers (17), spring (18), three pins (16), and pin keeper (15).

1. Remove thrust race (10) from housing.
2. Remove snap ring (1) from housing.
3. Remove shaft seal (2) from housing.
4. Remove washer (3) from housing.
5. Remove drive shaft (7 or 25) from housing.
6. Remove two snap rings (4), thrust washer (5), and thrust bearing (6), from drive shaft.
7. On through shaft type assembly, remove snap ring (31) and shaft seal (30) from back plate (27).

Inspection

1. Wash all parts thoroughly in a suitable solvent.
2. Examine needle bearings (8) and (20) in housing (9) and back plate (22 or 27). If needles are free of excessive play and remain in bearing cage, there is no need to replace the bearing.
3. Inspect thrust washer (5) and thrust bearing (6). Surfaces should be free of any signs of wear or fretting.
4. Inspect spider (12) and pivot (13). Conical surfaces should be free of wear and score marks.
5. Inspect piston (11). O.D. surface should be smooth and free of scoring. Shoes should fit snug to piston. Face of shoes should be flat and free of scoring and flaking. **Do not lap piston shoes.**
6. Inspect piston block (14). Bore should be free of scoring. Surfaces that contact back plate should be smooth and free of grooves or metal build up. **Do not lap piston block.**
7. Inspect thrust race (10). Surface should show no signs of scoring or grooves.
8. Inspect flat surface on back plate (22 or 27). It should be free of excessive scoring or metal build up. **Do not lap back plate.**
9. Inspect drive shaft (7 or 25) for fretting in bearing areas. Check spline area for twisted or broken teeth. If keyed shaft, check for cracked or chipped keyway.



1. Snap Ring
2. Shaft Seal
3. Washer
4. Snap Ring
5. Thrust Washer
6. Thrust Bearing
7. Drive Shaft
8. Needle Bearing
9. Housing Assembly
10. Thrust Race
11. Piston Assembly
12. Spider
13. Pivot
14. Piston Block
15. Pin Keeper
16. Pin
17. Washer
18. Spring
19. Snap Ring
20. Needle Bearing
21. O-ring
22. Backplate Assembly
23. Capscrew
24. Through Shaft
25. Drive Shaft
26. Key
27. Backplate
28. Capscrew
29. Capscrew
30. Shaft Seal
31. Snap Ring
32. Rotating Kit Assembly

Figure 3-23. Drive Motor

Assembly

1. Use filtered system oil to lubricate all critical moving parts before assembly.
2. Install one snap ring (4) in rear groove of drive shaft (7 or 25). Install one thrust washer (5), thrust bearing (6), and second thrust washer (5) on drive shaft (7 or 25). Install second snap ring (4) in front groove on drive shaft.
3. Replace needle bearing (8) in housing (9) if necessary. Install shaft in housing assembly (9) and install washer (3). Oil I.D. of new shaft seal (2) and press into position. Retain with snap ring (1).
4. Compress pin keeper (15) and install in spline area of piston block (14).
5. Install three pins (16) in special grooves of spline with head end of pin toward inside of block.
6. Install washer (17), spring (18), and second washer (17). Use two 3/8" I.D. washers and 3/8" x 3-1/4" cap screw to compress spring. Retain with snap ring (19). Remove 3/8" x 3-1/4" cap screw and two washers.
7. Install pivot (13), spider (12), and piston assemblies (11) in piston block assembly.
8. Lubricate thrust race (10) and install in housing assembly.
9. Install piston block assembly in housing assembly. The piston shoes must contact the thrust race (10). Be sure all parts are in their proper position.
10. Install new needle bearing (20) in back plate (22 or 27) if necessary.
11. Install new O-ring (21) on back plate (22 or 27).
12. Install back plate (22 or 27) on housing.
13. Install six cap screws (23 or 28 & 29) and torque to 15 to 18 ft-lb (21 to 25 Nm).
14. On through shaft type assembly, install shaft seal (30) and snap ring (31) in back plate (27). Install key (26) in drive shaft (25).

Drive Motor Troubleshooting

Pump must be isolated from motor to determine which unit is actually malfunctioning. A worn pump or worn motor give the same indication. It is advisable to first run a pressure and flow check on the pump to make sure it is performing within operating specifications. The following trouble shooting suggestions are based on assumptions pump has been flow and pressure checked and is within operating specifications.

Table 3-2. Motor Trouble Shooting

Possible Trouble	Cause	Remedies
Motor turns while unloaded but slows down or stops when load is applied	A. Soored back plate.	A. Remove back plate and examine surface condition of flat area; if scored, replace back plate. **Do not lap**
	B. Scored or worn piston shoes.	B. Disassemble motor, examine condition of shoes on pistons as a complete set if necessary. **Do not lap.**
	C. Low relief valve pressure.	C. Check relief valve for proper pressure setting; adjust or replace relief valve.
Motor will not turn.	A. Severely scored back plate.	A. Disassemble motor completely. Inspect all parts, replace all worn parts, Clean all parts, replace all worn parts and flush hydraulic system.
Motor free wheels.	A. Oil flow and pressure shut off going to motor.	When the hydraulic system is shut off, either by shutting off the engine on a closed loop system or returning the control valve spool to neutral on a open center system, the motor will free wheel after it has leaked off. This is inherent in the design. On a closed loop or propulsion system, the motor will not free wheel as long as charge pressure is maintained to and from the motor.
Excessive case drain flow.	A. Excessive internal wear in motor.	Disassemble motor, inspect parts and replace as necessary. Case drain flow should not exceed 1.5 GPM at full pressure.

3.6 DRIVE MOTOR

NOTE: *This procedure covers:*

2WD motors used on GM powered machines.

2WD motors used on Caterpillar, Deutz, and Ford powered machines S/N 0300100514 to Present.

All 4WD motors.

Description

Drive motors are low to medium power, two-position axial piston motors incorporating an integral servo piston. They are designed for operation in open and closed circuit applications. The standard control is a direct acting single line hydraulic control. The integral servo piston controls motor displacement.

Motors are spring biased to maximum displacement and hydraulically shifted to minimum displacement. Minimum and maximum displacement can be set with fixed internal stops. The large diameter servo piston allows smooth acceleration and deceleration with relatively large circuit orificing.

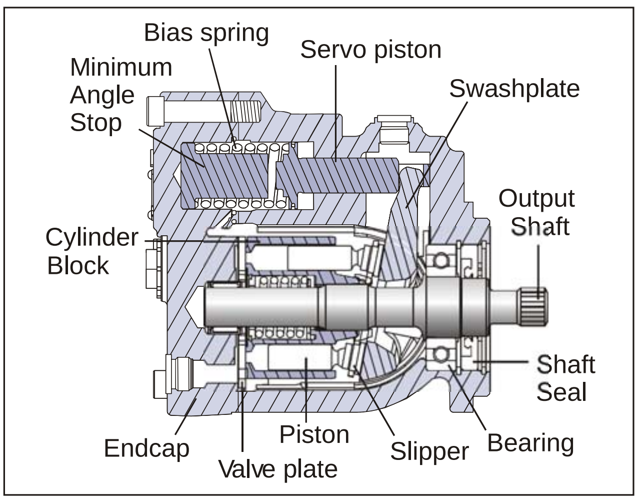
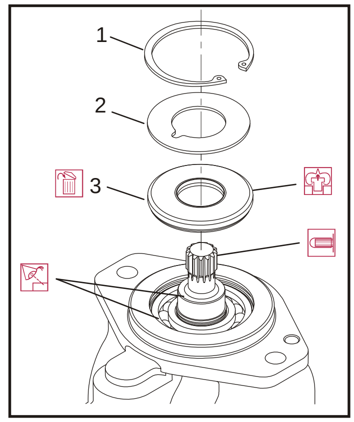


Figure 3-24. Drive Motor Cross Section

Shaft Seal Replacement

REMOVAL

1. Remove snap ring (1) and support washer (2).



1. Snap Ring
2. Support Washer
3. Shaft Seal

Figure 3-25. Removing Shaft Seal

NOTE: *To avoid damaging shaft during removal, install a large sheet metal screw into chuck of a slide hammer. Drive screw into seal surface and use slide hammer to pull seal.*

2. Carefully pry out and discard shaft seal (3).

INSPECT COMPONENTS

Inspect new seal, motor housing seal bore, and sealing area on shaft for rust, wear, and contamination. Polish shaft and clean housing if necessary.

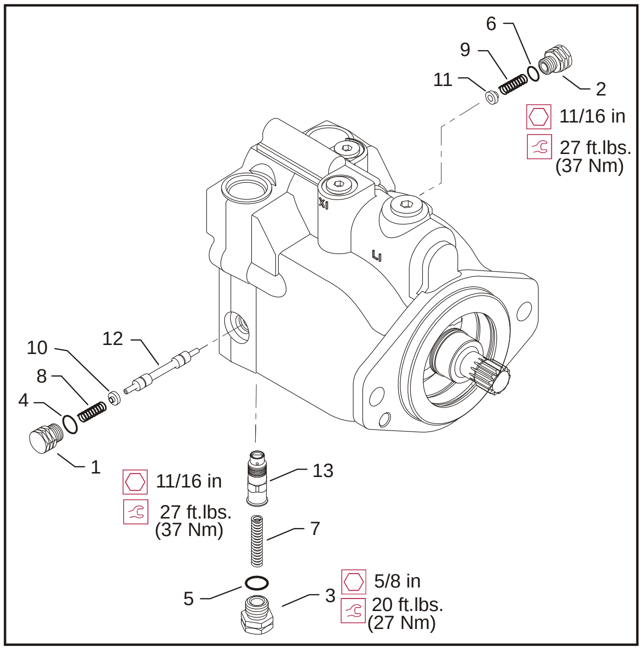
INSTALLATION

1. Cover shaft splines with an installation sleeve to protect shaft seal during installation.
2. Install a new shaft seal (3) with cupped side facing motor. Press seal into housing until it bottoms out. Press evenly to avoid binding and damaging seal.
3. Install seal support washer (2).
4. Install snap ring (1).
5. Remove installation sleeve.

Loop Flushing Valve

REMOVAL

1. Use an 11/16" internal hex wrench to remove plug (1) and (2).



1. Plug
2. Plug
3. Plug
4. O-ring
5. O-ring
6. O-ring
7. Spring
8. Spring
9. Spring
10. Washer
11. Washer
12. Shift Spool
13. Orifice Poppet

Figure 3-26. Loop Flushing Spool

2. Use a 1/4" in hex wrench to remove plug (3).
3. Remove O-rings (4, 5, and 6).
4. Use pliers to remove centering springs (7, 8, and 9).
5. Remove spring retaining washers (10 and 11).
6. Remove shift spool (12).
7. Remove orifice poppet (13).

INSPECT COMPONENTS

Inspect new O-rings and sealing area for rust, wear, or contamination. Check springs and poppet for wear.

INSTALLATION

1. Install orifice poppet (13).
2. Install shift spool (12).
3. Install spring retaining washers on springs (10 and 11).
4. Carefully install centering springs (7, 8, and 9).
5. Install new O-rings (6, 4, and 5).
6. Use a 1/4" hex wrench to torque plug (3) to 20 ft-lb (27 Nm).
7. Use an 11/16" internal hex and torque plugs (2 and 1) to 27 ft-lb (37 Nm).

Troubleshooting

Table 3-3. Excessive Noise and/or Vibration

Item	Description	Action
Check oil level in reservoir and oil supply to motor.	Insufficient hydraulic fluid could lead to cavitation that would cause system noise.	Fill reservoir to proper level and ensure oil supply to motor is adequate and lines are unobstructed.
Check for air in system.	Air trapped in system lines or motor could result in cavitation that would cause system noise.	Ensure system lines and components are purged of air.
Inspect output shaft couplings.	A loose or incorrect shaft coupling will produce vibrations that could result in system noise.	Ensure correct coupling is used and fits properly on shaft.
Inspect output shaft alignment.	Misaligned shafts create excessive frictional vibration that could result in system noise.	Ensure that the shafts are properly aligned.
Hydraulic oil viscosity above limits.	Viscosity above acceptable limits will result in cavitation that would lead to system noise.	Replace hydraulic oil with appropriate fluid for operating conditions.

Table 3-4. System Operating Hot

Item	Description	Action
Check oil level in reservoir and oil supply to pump.	Insufficient amount of hydraulic fluid will not meet system cooling demands.	Fill reservoir to proper level.
Inspect heat exchanger (if equipped).	If heat exchanger fails or becomes obstructed, it may not meet system cooling demands.	Ensure heat exchanger is receiving adequate air flow and is in good operating condition. Repair or replace as necessary.
Check system relief valves.	If a system relief valve becomes unseated for an extended period of time or fails for any other reason, the system could become overheated.	Repair or replace any malfunctioning relief valves and verify loads on machine are not excessive.

Table 3-5. Won’t Shift or Slow to Start

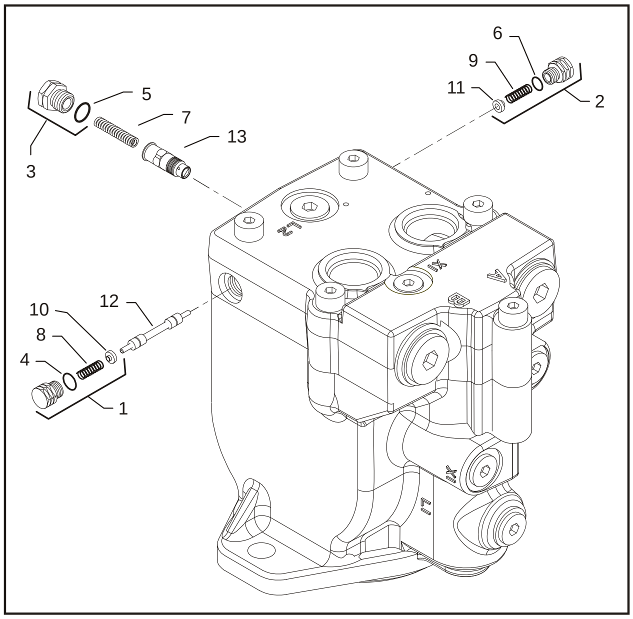
Item	Description	Action
Check signal line to servo control port.	Obstructed or restricted flow through the servo control signal lines could result in slow shift or no shift conditions within the motor.	Ensure signal lines are not obstructed or restricted and that signal pressure is adequate to shift the motor.
Check correct supply and drain orifices are properly installed and not obstructed.	Supply and drain orifices determine motor shift rate. The smaller the orifice, the longer time it takes to shift the motor. Obstruction also increases shift times.	Ensure proper control orifices are installed in motor and check they are not obstructed. Clean or replace as needed.

Disassembly

NOTE: *Removal of endcap voids warranty.*

During assembly, coat all moving parts with a film of clean hydraulic oil. This ensures parts are lubricated during start-up.

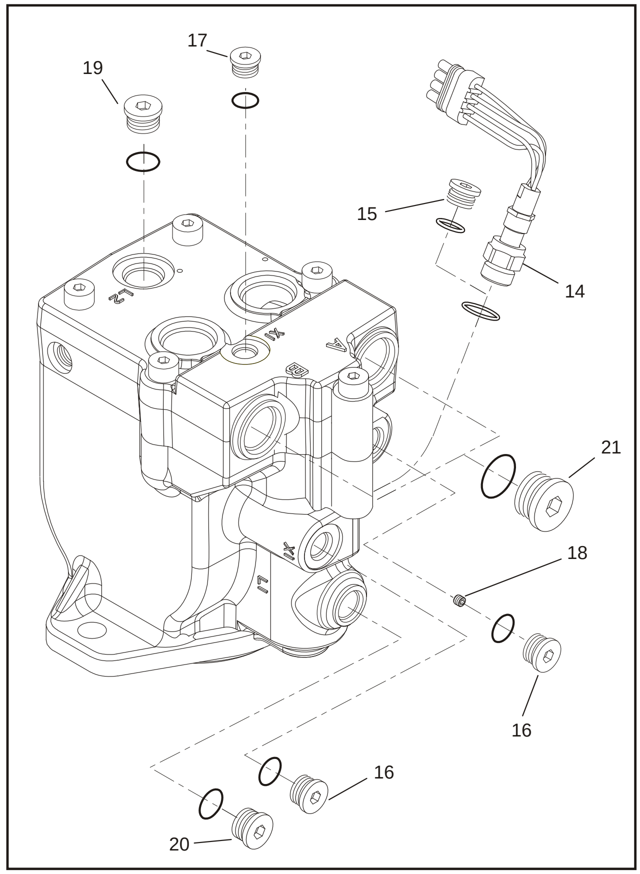
Replace all O-Rings and gaskets. Lightly lubricate O-rings with clean petroleum jelly prior to assembly.



1. Plug	5. O-ring	9. Spring	12. Shift Spool
2. Plug	6. O-ring	10. Washer	13. Orifice Poppet
3. Plug	7. Spring	11. Washer	
4. O-ring	8. Spring		

Figure 3-27. Loop Flushing Spool

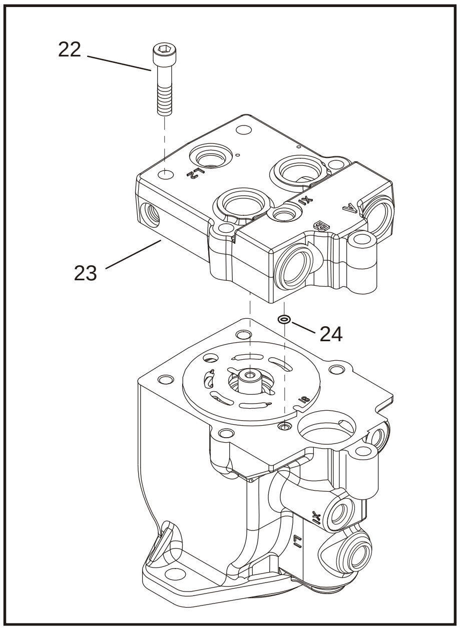
1. Using a 11/16" wrench, remove plug (1) and (2).
2. Using a 5/8" hex wrench, remove plug (3).
3. Remove O-rings (4, 5, and 6).
4. Using pliers, remove centering springs (7, 8, and 9).
5. Remove spring retaining washers (10 and 11).
6. Remove shift spool (12).
7. Remove orifice poppet (13).



14. Lock Nut	18. Cavity Plug
15. O-ring Plug	19. Drain Plug
16. Control Line Plug	20. Drain Plug
17. Control Line Plug	21. Work Port Plug

Figure 3-28. Plugs, Fittings, and Speed Sensor

8. Remove all fittings from unit. Discard O-rings.
9. Using an 11/16" hex wrench, loosen speed sensor lock nut (14) if equipped and remove speed sensor. Units without speed sensor have an O-ring plug (15) installed in that location; remove it with a 1/4" inch internal hex wrench.
10. Using a 1/4" internal hex wrench, remove control line plugs (16, 17). Discard O-rings. Using a 3 mm hex wrench, remove cavity plug (18) (if equipped with two-line control), from X2 cavity.
11. Using a 5/16" internal hex wrench, remove drain plugs (19, 20). Discard O-rings.
12. If equipped with axial ports, use a 9/16" an internal hex wrench and remove work port plugs (21). Discard O-rings.

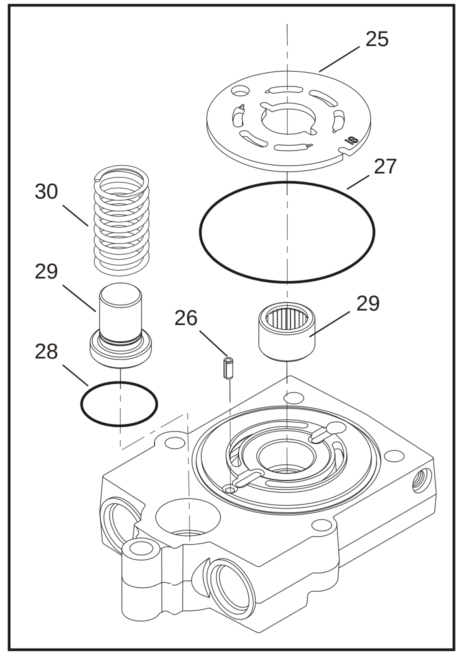


22. Screw
23. End Cap
24. O-ring

Figure 3-29. End Cap

13. Using an 8 mm internal hex wrench, remove endcap screws (22).
14. Remove endcap (23). Remove O-ring (24) from housing or endcap.

NOTE: *When endcap screws are removed, pressure from servo spring will cause endcap to bind on shaft. Press down on portion of endcap covering servo piston and hold endcap level while removing.*



25. Valve Plate
26. End Cap
27. O-ring
28. O-ring
29. Angle Stop
30. Servo Spring

Figure 3-30. Valve Plate & Rear Shaft Bearing

NOTICE

DO NOT SCRATCH VALVE PLATE SURFACE.

15. Remove valve plate (25) and timing pin (26) from endcap.

NOTE: *Each displacement has a unique valve plate. For identification, the last two digits of the valve plate part number are stamped on its surface.*

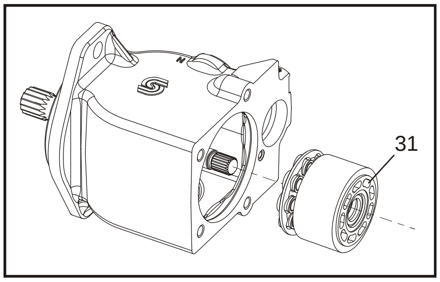
16. Remove and discard O-rings (27, 28).
17. Remove rear shaft bearing (29) from endcap with a bearing puller.

NOTICE

DO NOT DRIVE BEARING PAST REAR SHAFT JOURNAL. BEARING MAY BECOME TRAPPED ON SHAFT AND DAMAGED.

NOTE: *Bearing may be difficult to remove with a puller. Try this as an alternative: Pack bearing cavity with heavy grease. After shaft is removed, insert it into bearing cavity and tap lightly with a soft mallet on the splined end. Grease will force out bearing.*

18. Remove minimum angle stop (29) and servo spring (30) from housing.



31. Cylinder Kit Assembly

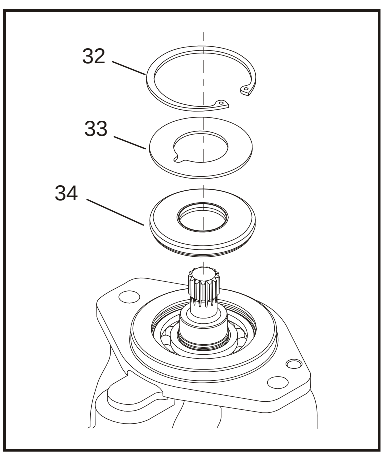
Figure 3-31. Cylinder Kit

19. Turn housing on its side and remove cylinder kit assembly (31). Set assembly aside, being careful not to scratch the running surface.

NOTE: *Grooves on surface of cylinder kit identify its displacement:*

Table 3-6. Displacement Identifiers

# of Grooves	Frame L	Frame K
1	25	38
2	30	45
3	35	- -

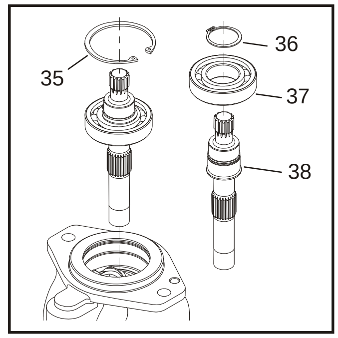


32. Snap Ring
33. Support Washer
34. Shaft Seal

Figure 3-32. Shaft Seal

20. Turn housing over and remove snap ring (32) retaining shaft seal, and support washer. Remove support washer (33) and carefully pry out shaft seal (34). Discard seal.

NOTE: *To avoid damaging shaft during seal removal. Install a large sheet metal screw into the chuck of a slide hammer. Drive screw into seal surface and use slide hammer to pull seal.*

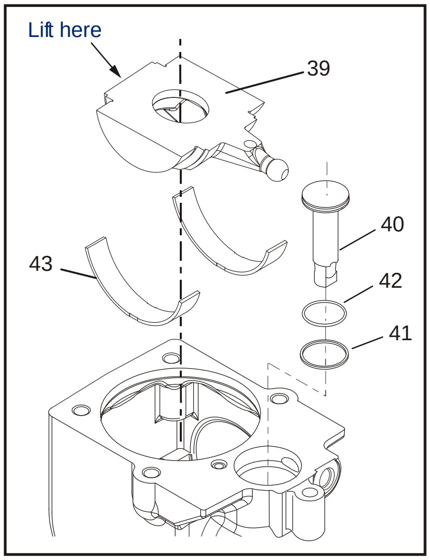


35. Inner Snap Ring
36. Snap Ring
37. Bearing
38. Shaft

Figure 3-33. Shaft & Front Bearing

21. Remove inner snap ring (35) and shaft/bearing assembly.

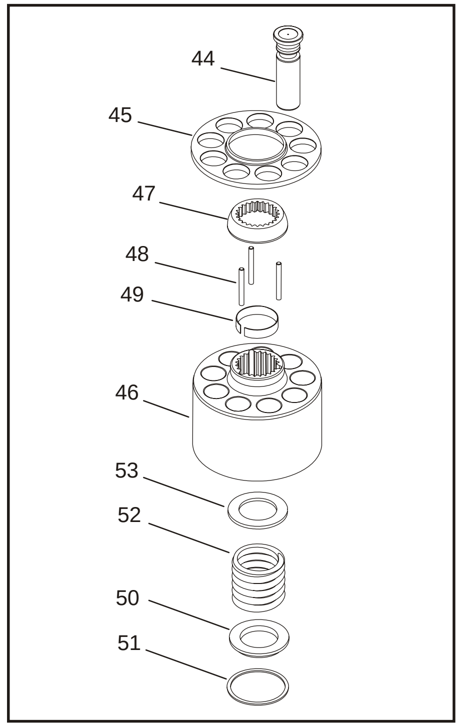
22. Remove snap ring (36) retaining shaft front bearing. Pull bearing (37) off shaft (38).



39. Swashplate
40. Servo Piston
41. Piston Seal
42. O-ring
43. Journal Bearings

Figure 3-34. Swash Plate & Servo Piston

23. Turn housing over and remove swashplate (39) by lifting on end opposite servo lever.
24. Remove servo piston (40). Remove piston seal (41) and O-ring (42) from servo piston. Discard seal and O-ring.
25. Remove journal bearings (43) from housing. If bearings will be reused, note location and orientation of each bearing for reassembly.



44. Piston
45. Slipper Retainer
46. Cylinder Block
47. Ball Guide
48. Holddown Pins
49. Retaining Ring
50. Block Spring Washer
51. Spiral Retaining Ring
52. Block Spring
53. Inner Block Spring Washer

Figure 3-35. Cylinder Kit Disassembly

26. Remove pistons (44) and slipper retainer (45) from cylinder block (46).

NOTE: *Pistons are not selectively fitted. Units with high hourly usage may develop wear patterns. Number pistons and bores for reassembly if they will be reused.*

27. Remove ball guide (47), hold-down pins (48), and retaining ring (49) from cylinder block.

NOTE: *Most repairs do not require block spring removal. Perform this procedure only if you suspect problems with the block spring.*

WARNING

RISK OF PERSONAL INJURY: COMPRESSING BLOCK SPRING REQUIRES FORCE OF ABOUT 80 TO 90 LBF (350 TO 400 N). USE A PRESS SUFFICIENT TO MAINTAIN THIS FORCE WITH REASONABLE EFFORT. ENSURE SPRING IS SECURE BEFORE ATTEMPTING TO REMOVE SPIRAL RETAINING RING. RELEASE PRESSURE SLOWLY AFTER RETAINING RING IS REMOVED.

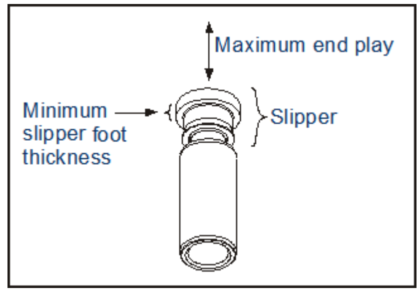
28. Turn block over. Using a press, apply pressure on block spring washer (50) to compress block spring enough to safely remove spiral retaining ring (51). Maintain pressure and unwind spiral retaining ring (51). Carefully release pressure and remove outer block spring washer (50), block spring (52), and inner block spring washer (53) from cylinder block.

Inspection

After disassembly, wash all parts (including end-cap and housing) thoroughly with clean solvent and allow to air dry. Blow out oil passages in housing and endcap with compressed air. Conduct inspection in a clean area and keep all parts free from contamination. Clean and dry parts again after any rework or resurfacing.

PISTON

Inspect pistons for damage and discoloration. Discolored pistons may indicate excessive heat. Do not reuse.



SLIPPERS

Inspect running surface of slippers. Replace piston assemblies with scored or excessively rounded slipper edges. Measure slipper foot thickness. Replace piston assemblies with excessively worn slippers. Check slipper axial end-play. Replace piston assemblies with excessive end-play.

Minimum slipper foot thickness and maximum axial end-play are shown in table 3.7.

Table 3-7. Slipper Foot Thickness & End Play

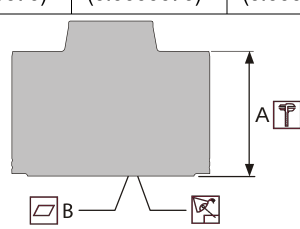
Measurement		L Frame	K Frame
Slipper Foot Thickness	mm (in.)	2.71 (0.11)	4.07 (0.16)
Piston/Slipper End Play		0.15 (0.006)	

CYLINDER BLOCK

Measure cylinder block height. Replace blocks worn beyond minimum height specification. Inspect running surface of cylinder block. Replace or resurface worn or scratched blocks. Blocks may be resurfaced if resurfacing will not reduce block height below minimum specification shown in Table 3-8, Cylinder Block Measurements.

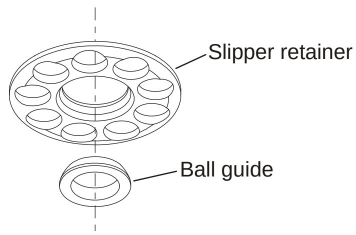
Table 3-8. Cylinder Block Measurements

Measurement	L25	L30	L35	K38	K45
Minimum Cylinder Block Height (A)	50.8 (2.00)	50.8 (2.00)	50.8 (2.00)	54.4 (2.14)	54.4 (2.14)
Cylinder Block Surface Flatness	0.002 (0.0000079)	0.002 (0.0000079)	0.002 (0.0000079)	0.002 (0.0000079)	0.002 (0.0000079)



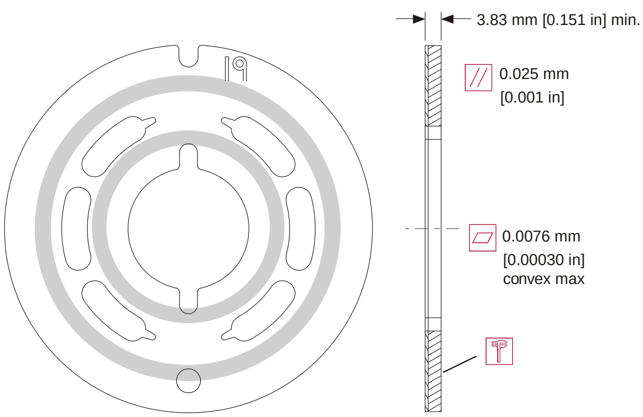
BALL GUIDE AND SLIPPER RETAINER

Inspect ball guide and slipper retainer for damage, discoloration, or excessive wear. A discolored ball guide or slipper retainer indicates excessive heat. Do not reuse.



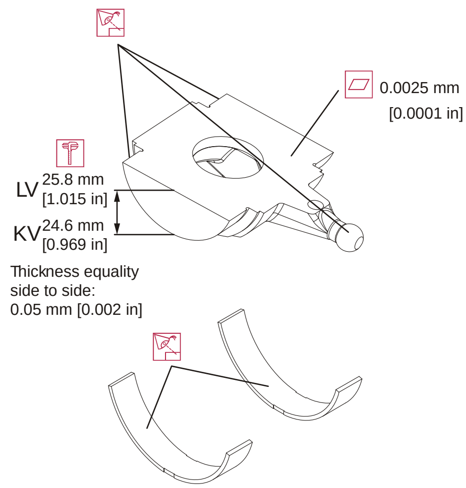
VALVE PLATE

Valve plate condition is critical to motor efficiency. Inspect valve plate surfaces for excessive wear, grooves, or scratches. Replace or resurface grooved or scratched valve plates. Measure valve plate thickness and replace if worn beyond minimum specification. Valve plate can be resurfaced if finished thickness is not below minimum specification shown in drawing.



SWASHPLATE AND JOURNAL BEARINGS

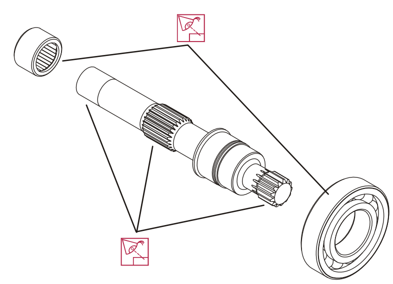
Inspect running face, servo ball-joint, and swashplate journal surfaces for damage or excessive wear. Some material transfer may appear on these surfaces and is acceptable providing surface condition meets specifications shown. Measure swashplate thickness from journals to running face. Replace swashplate if damaged or worn beyond minimum specification.



Inspect journal bearings for damage or excessive wear. Replace journal bearings if scratched, warped, or excessively worn. Polymer wear layer must be smooth and intact.

SHAFT BEARINGS

Inspect bearings for excessive wear or contamination. Rotate bearings while feeling for uneven movement. Bearings should spin smoothly and freely. Replace bearings that appear worn or do not rotate smoothly.

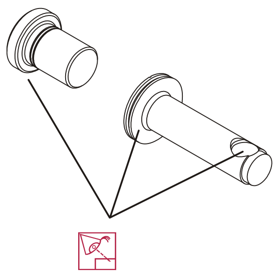


SHAFT

Inspect motor shaft. Look for damage or excessive wear on output and block splines. Inspect bearing surfaces and sealing surface. Replace shafts with damaged or excessively worn splines, bearing surfaces, or sealing surfaces.

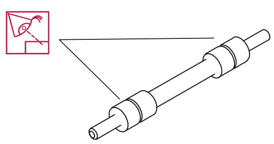
SERVO PISTON AND MINIMUM ANGLE STOP

Inspect minimum angle stop, servo piston head, and servo piston ball-socket for damage or excessive wear. Replace if necessary.



LOOP FLUSHING SPOOL

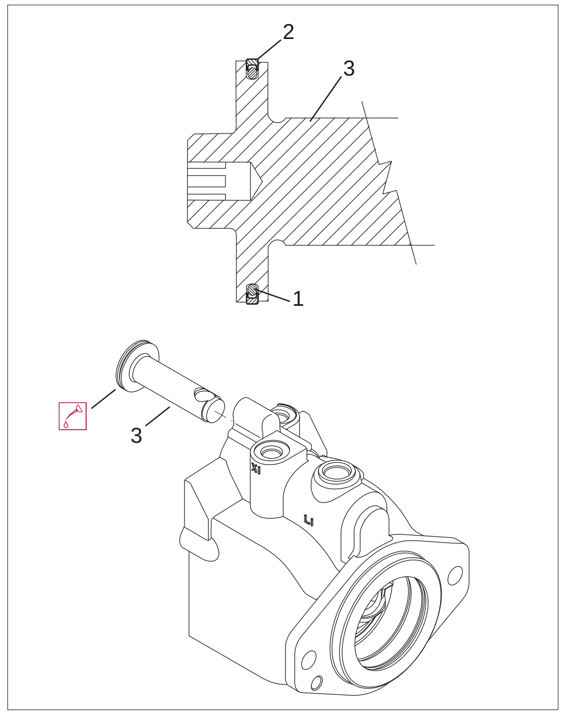
Inspect loop flushing spool. Check for cracks or damage. Replace if necessary.



Assembly

1. Install new O-ring (1) and piston seal (2) to servo piston (3). Install piston seal over O-ring.

NOTE: *Installing piston seal stretches it, making it difficult to install servo piston in its bore. Allow 30 minutes for seal to relax after installation. To speed up seal relaxation, compress seal by installing piston head in servo cavity in end-cap and let it stand for at least five minutes.*



1. O-ring
2. Piston Seal
3. Servo Piston

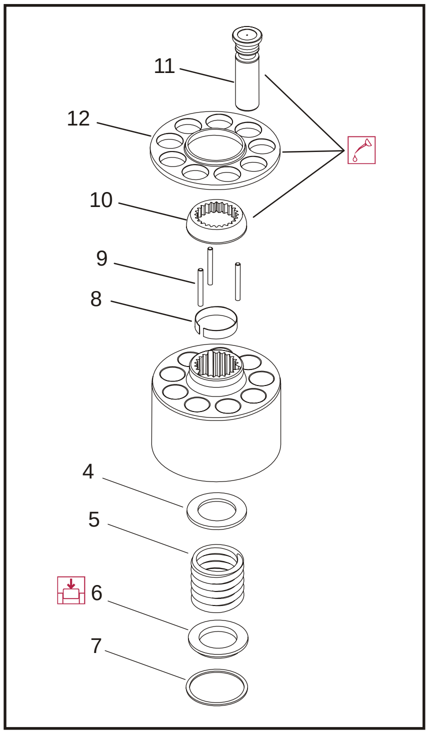
Figure 3-36. Servo Piston

2. After piston seal has relaxed, lubricate and install servo piston into housing bore. Align piston with ball socket facing inside of housing.

⚠ WARNING

COMPRESSED SPRING MAY FLY OUT AND CAUSE SERIOUS INJURY. COMPRESSING BLOCK SPRING REQUIRES ABOUT 80 TO 90 LBF (350 TO 400 N) OF FORCE. USE A PRESS SUFFICIENT TO MAINTAIN THIS FORCE WITH REASONABLE EFFORT. ENSURE SPRING IS SECURE BEFORE ATTEMPTING TO INSTALL SPIRAL RETAINING RING. RELEASE PRESSURE SLOWLY AFTER RETAINING RING IS INSTALLED.

3. Install inner block spring washer (4), block spring (5), and outer washer (6) in cylinder block. Using a press, compress block spring enough to expose retaining ring groove. Wind spiral retaining ring (7) into cylinder block.



4. Block Spring Washer
5. Block Spring
6. Outer Washer
7. Spiral Retaining Ring
8. Retaining Ring
9. Holddown Pins
10. Ball Guide
11. Piston
12. Slipper Retainer

Figure 3-37. Cylinder Kit Assembly

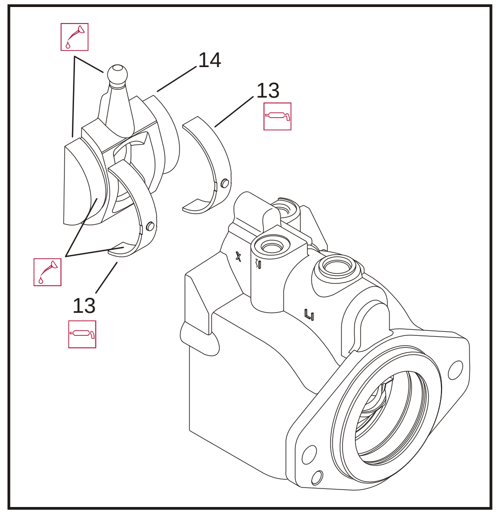
4. Turn block over and install retaining ring (8), holddown pins (9), and ball guide (10) to cylinder block.

NOTICE

IF REUSING PISTONS, INSTALL THEM IN ORIGINAL BLOCK BORES.

5. Install pistons (11) to slipper retainer (12). Install piston/retainer assembly in cylinder block. Ensure concave surface of retainer seats on the ball guide. Lubricate pistons, slippers, retainer, and ball guide before assembly. Set cylinder kit aside on a clean surface until needed.

6. Install journal bearings (13) into housing seats. Use assembly grease to keep bearings seated during assembly. Ensure locating nubs drop into cavities in seats. If reusing bearings, install them in original location and orientation. Lubricate journal bearings.

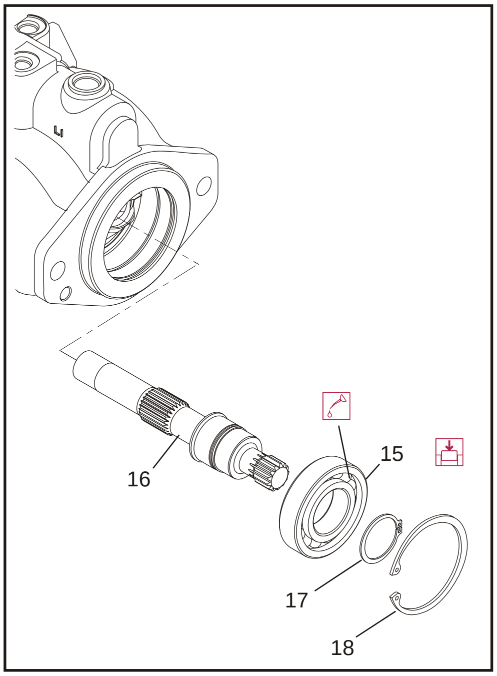


13. Journal Bearings
14. Swash Plate

Figure 3-38. Swash Plate and Journal Bearing

7. Install swashplate (14) in housing. Tilt swashplate and guide servo lever ball into its socket in servo piston rod. Ensure swashplate seats into journal bearings and moves freely. Lubricate swashplate running surface.

8. Press front shaft bearing (15) onto shaft (16). Press bearing onto shaft with lettering facing out. Lubricate bearing rollers. Install snap-ring (17) on shaft.

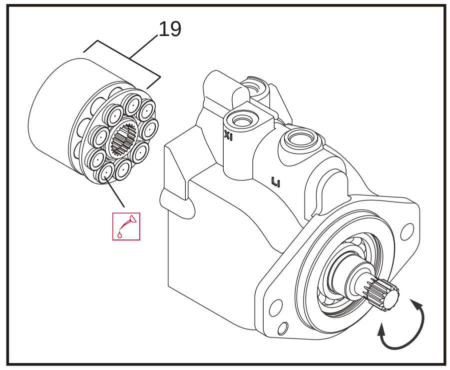


15. Front Shaft Bearing
16. Shaft
17. Snap Ring
18. Snap Ring

Figure 3-39. Shaft and Front Bearing

9. While holding swashplate in place, turn housing on its side. Install shaft/bearing assembly into housing from flange end. Install snap ring (18).

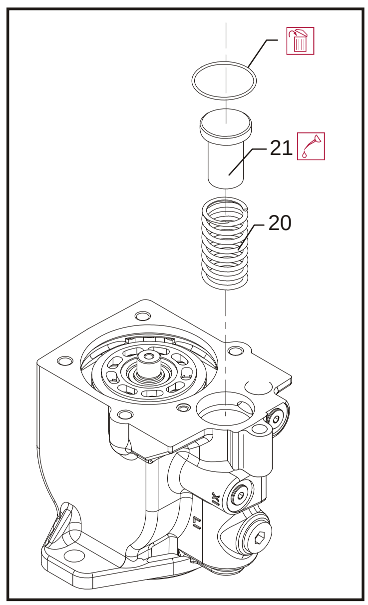
10. Verify swashplate and bearings are properly seated. Install cylinder kit (19) onto shaft. Install with slippers facing swashplate. Rock shaft to align block splines and slide cylinder kit into place. Orient motor with shaft pointing downward and verify cylinder kit, swashplate, journal bearings, and servo piston are all secure and properly installed.



19. Cylinder Kit

Figure 3-40. Cylinder Kit Installation

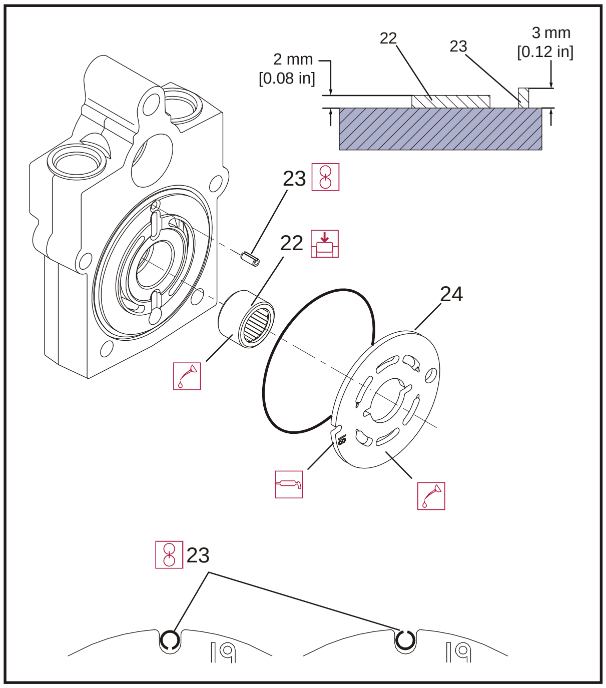
11. Lubricate and install servo spring (20), and minimum angle stop (21) into housing bore.



20. Servo Spring
21. Minimum Angle Stop

Figure 3-41. Servo Spring and Minimum Angle Stop

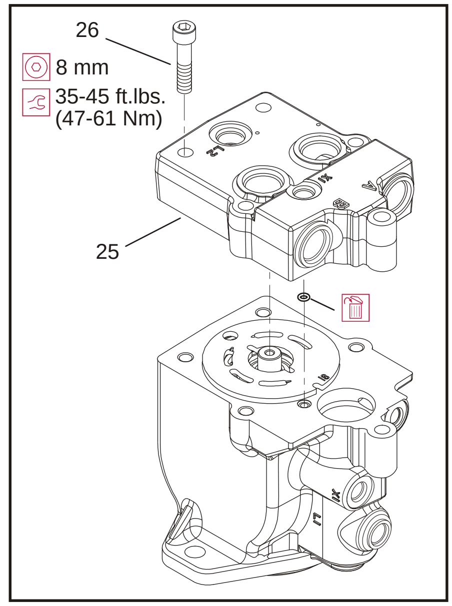
12. Press rear shaft bearing (22) into endcap. Install bearing with letters facing out. Press until bearing surface is 0.08 ±0.01 in (2 ±0.25 mm) above endcap surface.



22. Rear Shaft Bearing
23. Timing Pin
24. Valve Plate

Figure 3-42. Valve Plate and Rear Bearing

13. Install timing pin (23) into bore in endcap. Install pin with groove facing toward or away from shaft. Press pin until end protrudes 0.12 ±0.01 in (3 ±0.25 mm) above endcap surface.
14. Install valve plate (24) on endcap. Install valve plate with yellow surface toward cylinder block. Align slot in valve plate with timing pin. Apply a liberal coat of assembly grease to endcap side of valve plate to keep it in place during installation.
15. Install endcap (25) on housing with endcap screws (26). Check endcap properly seats on housing without interference. Improper assembly of internal components may prevent endcap from seating properly. Ensure O-rings seat properly when installing endcap.

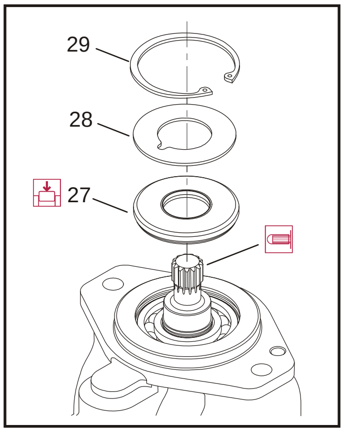


25. End Cap
26. Screw

Figure 3-43. End Cap

16. Using an 8 mm internal hex wrench, tighten endcap screws. Tighten screws in opposite corners slowly and evenly to compress servo spring and properly seat endcap. Torque endcap screws 35 to 45 ft-lb (47-61 Nm).
17. Before installing shaft seal, ensure shaft turns smoothly with less than 120 in-lb (13.5 Nm) of force. If shaft does not turn smoothly within specified force, disassemble and check unit.

18. Cover shaft splines with an installation sleeve. Install a new shaft seal (27) with cup side facing motor. Press seal into housing until it bottoms out. Press evenly to avoid binding and damaging seal. Install seal support washer (28) and snap ring (29).



27. Shaft Seal
28. Seal Support Washer
29. Snap Ring

Figure 3-44. Shaft Seal

19. Install remaining plugs and fittings to housing. Refer to drawing below for wrench sizes and installation torques.

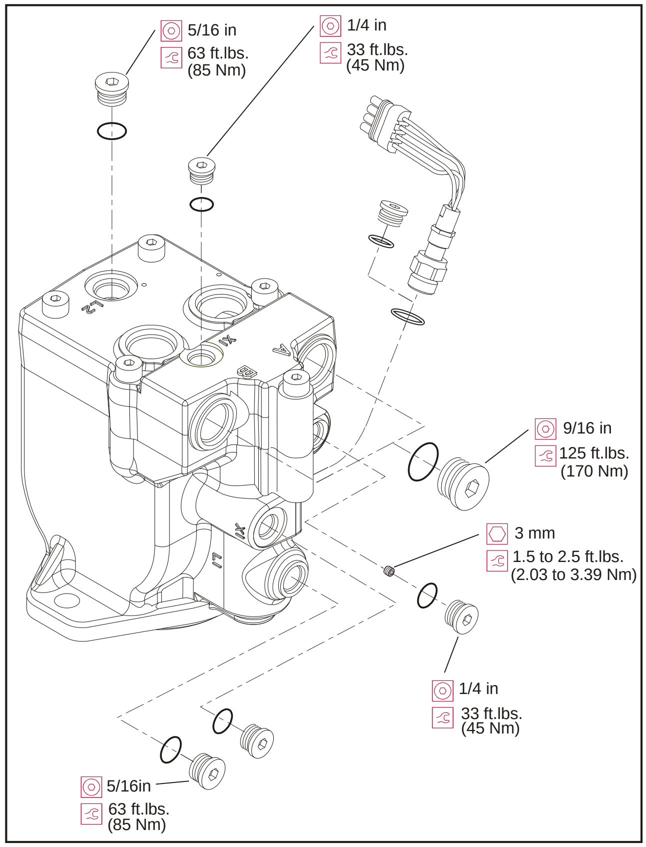
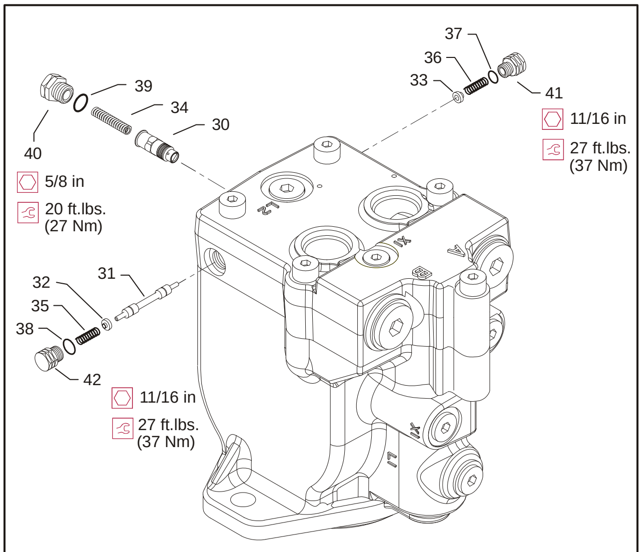


Figure 3-45. Plugs and Fittings Installation

20. Install orifice poppet (30).
21. Install shift spool (31).
22. Install spring retaining washers on springs (32 and 33).
23. Carefully install centering springs (34, 35, and 36).
24. Install new O-rings (37, 38, and 39).
25. Using a 5/8" wrench, torque plug (40) to 20 ft-lb (27 Nm).
26. Using a 11/16" wrench, torque plugs (41 and 42) to 27 ft-lb (37 Nm).



30. Orifice Poppet	34. Spring	37. O-ring	40. Plug
31. Shift Spool	35. Spring	38. O-ring	41. Plug
32. Spring	36. Spring	39. O-ring	42. Plug
33. Spring			

Figure 3-46. Loop Flushing Spool

Initial Start-up Procedures

Follow this procedure when starting up a new motor or after reinstalling a motor.

Prior to installing motor, inspect for damage incurred during shipping or storage. Make certain all system components (reservoir, hoses, valves, fittings, heat exchanger, etc.) are clean before filling with fluid.

1. Fill reservoir with recommended hydraulic fluid. Always filter fluid through a 10 micron filter when pouring into reservoir. Never reuse hydraulic fluid.
2. Fill inlet line leading from pump to reservoir. Check inlet line for properly tightened fittings and be certain it is free of restrictions and air leaks.
3. Fill pump and motor housing with clean hydraulic fluid. Pour filtered oil directly into upper most case drain port.
4. Install case drain lines into upper most case drain ports to ensure pump and motor stay filled with oil.
5. Install a 0 to 500 psi (0 to 35 bar) gauge in charge pressure gauge port of pump to monitor system pressure during start up.
6. Watch pressure gauge and run engine at lowest possible speed until system pressure builds to normal levels (minimum 160 psi [11 bar]). Once system pressure is established, increase to full operating speed. If system pressure is not maintained; shut down engine, determine cause, and take corrective action.
7. Operate hydraulic system at least fifteen minutes under light load conditions.
8. Check and adjust control settings as necessary after installation.
9. Shut down engine and remove pressure gauge. Replace plug at charge pressure gauge port.
10. Check fluid level in reservoir; add clean filtered fluid if necessary. Motor is now ready for operation.

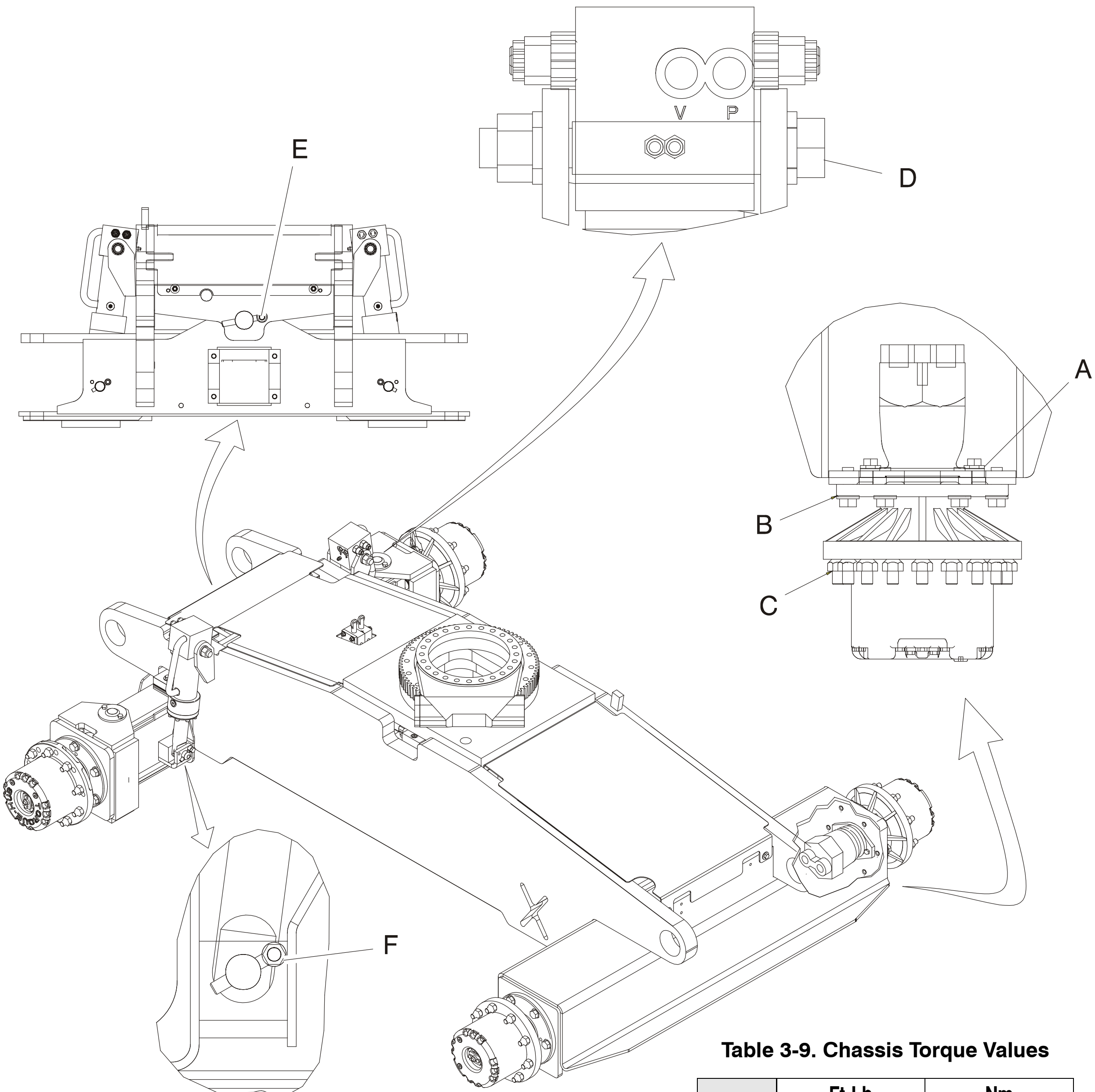


Table 3-9. Chassis Torque Values

	Ft-Lb	Nm
A	120	163
B	240	325
C	170	230
D	140	190
E	165	224
F	35	47

This figure applies to USA built machines prior to S/N 0300107512 and Belgium built machines prior to S/N 1300003222

Figure 3-47. Chassis Torque Values - Sheet 1 of 2

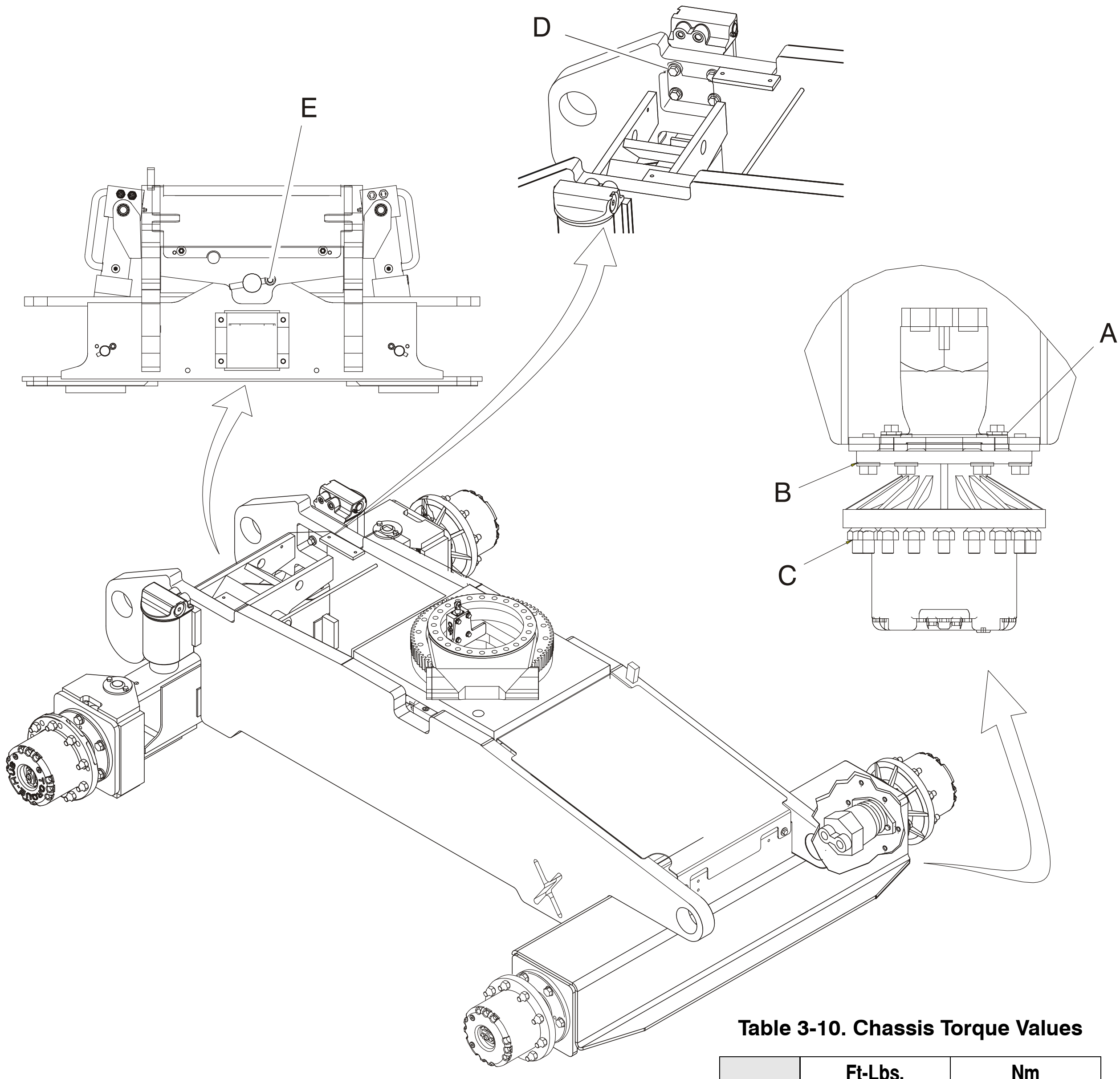


Table 3-10. Chassis Torque Values

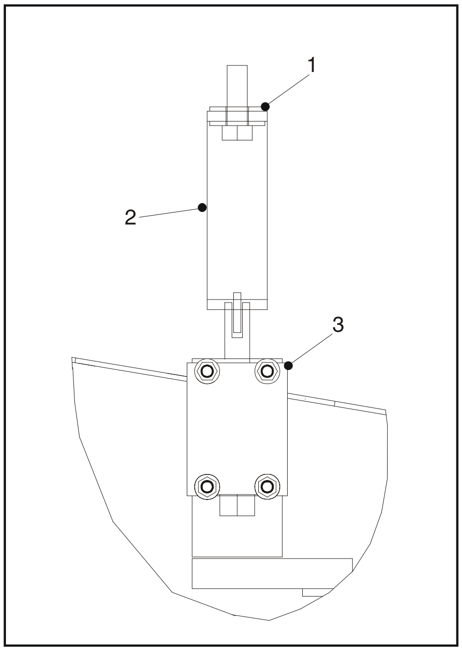
	Ft-Lbs.	Nm
A	120	163
B	240	325
C	170	230
D	85	115
E	165	224

This figure applies to USA built machines S/N 0300107512 to Present and Belgium built machines S/N 1300003222 to Present

Figure 3-47. Chassis Torque Values - Sheet 2 of 2

3.7 ADJUSTMENT PROCEDURE FOR LOCKOUT VALVE

11. With turntable centered, adjust bracket with washers to push plunger in 5/16" ± 1/16" (7.9 ± 1.6 mm).



1. Washer
2. Bracket
3. Lockout Valve

Figure 3-47. Valve Adjustment

1. The ideal adjustment is 3/8" (9.5 mm). Do not push plunger in more than 3/8" (9.5 mm). The extra adjustment is needed for turntable bearing play.

3.8 OSCILLATING AXLE BLEEDING PROCEDURE AND LOCKOUT TEST

Lockout Cylinder Bleeding (Early Cylinders)

NOTE: *The following procedure is for machines built in the USA prior to S/N 0300107512 and machines built in Belgium prior to S/N 1300003222.*

NOTICE

FULLY LOWER PLATFORM AND CENTER BOOM OVER REAR AXLE BEFORE STARTING BLEEDING PROCEDURE.

ENSURE MACHINE IS ON A LEVEL SURFACE AND REAR WHEELS ARE BLOCKED, AND BRAKE WIRE IS DISCONNECTED.

1. Make sure machine is on a level surface.
2. Center boom over rear axle to make sure cam valve in the rotary coupling is depressed.
3. Place chocks under tires to ensure machine does not move. Disable machine brakes by disconnecting brake solenoid(s) on brake valve.
4. Use suitable containers to catch excess hydraulic fluid. Place containers under each lockout cylinder.
5. Open one bleeder screw at a time.
6. Start engine, position drive control lever forward or reverse.
7. Close bleeder screws when all air is dissipated (bled).
8. Reconnect brake solenoid(s) and remove wheel chocks.
9. Perform oscillating axle lockout test.
10. If necessary, repeat steps 1 thru 7.

Lockout Cylinder Bleeding (Ram Cylinders)

NOTE: *The following procedure is for machines built in the USA S/N 0300107512 to present and machines built in Belgium S/N 1300003222 to present.*

1. Position turntable to normal stowed position so axle is free to oscillate. Drive charge pressure will pass through lockout valve built into swivel and down to pilot section of holding valves on cylinders. This will automatically purge air from pilot section of circuit.
2. Attach end of clear tubing to bleeder valve nipple and place other end in container to catch oil. Using a 3/8" wrench, slowly turn bleeder valve counterclockwise to bleed air from cylinder. Have operator in platform just crack drive controller in reverse. This will activate brake valve sending charge pressure to lockout cylinder. Close valve when an unbroken, steady stream of oil is seen.
3. Repeat procedure for other lockout cylinder.

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 boom is fully retracted, lowered, and centered between drive wheels before starting lockout cylinder test.*

1. Place a 6" (15 cm) high block with ascension ramp in front of left front wheel.
2. From platform control station, activate machine hydraulic system.
3. Place FUNCTION SPEED CONTROL and DRIVE SPEED/TORQUE SELECT control switches to LOW positions.
4. Place DRIVE control lever to FORWARD position and carefully drive machine up ascension ramp until left front wheel is on top of block.
5. Carefully activate SWING control lever and position boom over right side of machine.
6. With boom over right side of machine, place DRIVE control lever to REVERSE and drive machine off of block and ramp.
7. Have an assistant check to see left front wheel remains locked in position off of ground.
8. Carefully activate SWING control lever and return boom to stowed position (centered between drive wheels). When boom reaches center, stowed position, lockout cylinders should release and allow wheel to rest on ground, it may be necessary activate DRIVE to release cylinders.
9. Place 6" (15 cm) high block with ascension ramp in front of right front wheel.
10. Place DRIVE control lever to FORWARD and carefully drive machine up ascension ramp until right front wheel is on top of block.
11. Carefully activate SWING control lever and position boom over left side of machine.
12. With boom over left side of machine, place DRIVE control lever to REVERSE and drive machine off of block and ramp.
13. Have an assistant check to see that right front wheel remains locked in position off ground.
14. Carefully activate SWING control lever and return boom to stowed position (centered between drive wheels). When boom reaches center, stowed position, lockout cylinders should release and allow wheel to rest on ground, it may be necessary activate DRIVE to release cylinders.
15. If lockout cylinders do not function properly, have qualified personnel correct the malfunction before any further operation.

3.9 SWING BEARING

Description

The swing bearing has five major components: housing, worm, worm gear, output pinion, and gear/pinion cap.

Servicing of these units requires a press, a 3/8" 12 point socket, a 1/2" socket, a 3/4" socket, torque wrench (80 ft-lb), steel hammer, soft face hammer, bearing puller (external and internal), and a large flat blade screw driver. Also needed are a shim and seal kit (refer to JLG Parts Manual), 3/4" steel rod at least 10" long, silicone sealant, Mobil SHC 007 grease, Mobil SHC 460 grease, Loctite #242 for bolts, and other parts that may be worn out.

Removal

Refer to Figure 3-48., Swing Bearing Installation.

1. Attach an adequate support sling to boom and draw all slack from sling. Prop or block boom if possible.
2. Tag and disconnect hydraulic lines (1) running through center of turntable (2) and frame (3). Use a suitable container catch residual hydraulic fluid. Cap lines and ports.

1. Clean area around swing motor (4) to prevent any dirt from entering system.
2. Tag and disconnect hydraulic lines running to swing motor. Cap or plug all openings.
3. Attach suitable overhead lifting equipment to base of turntable weldment (2).
4. Scribe a line on inner race of swing bearing (5) and underside of turntable to help align bearing during installation. Remove bolts (6) and washers (7) from turntable and bearing inner race. Discard bolts.
5. Use lifting equipment to lift complete turntable assembly from bearing. Ensure no damage occurs to turntable, bearing, or frame components. Carefully place turntable on a suitably supported trestle.
6. Scribe a line on outer race of swing bearing and frame to help align bearing during installation.
7. Remove bolts (8) and washers (9) from outer race of bearing to frame. Discard bolts.
8. Use suitable lifting equipment to remove bearing and rotation box assembly from frame. Move to a clean, suitably supported work area.

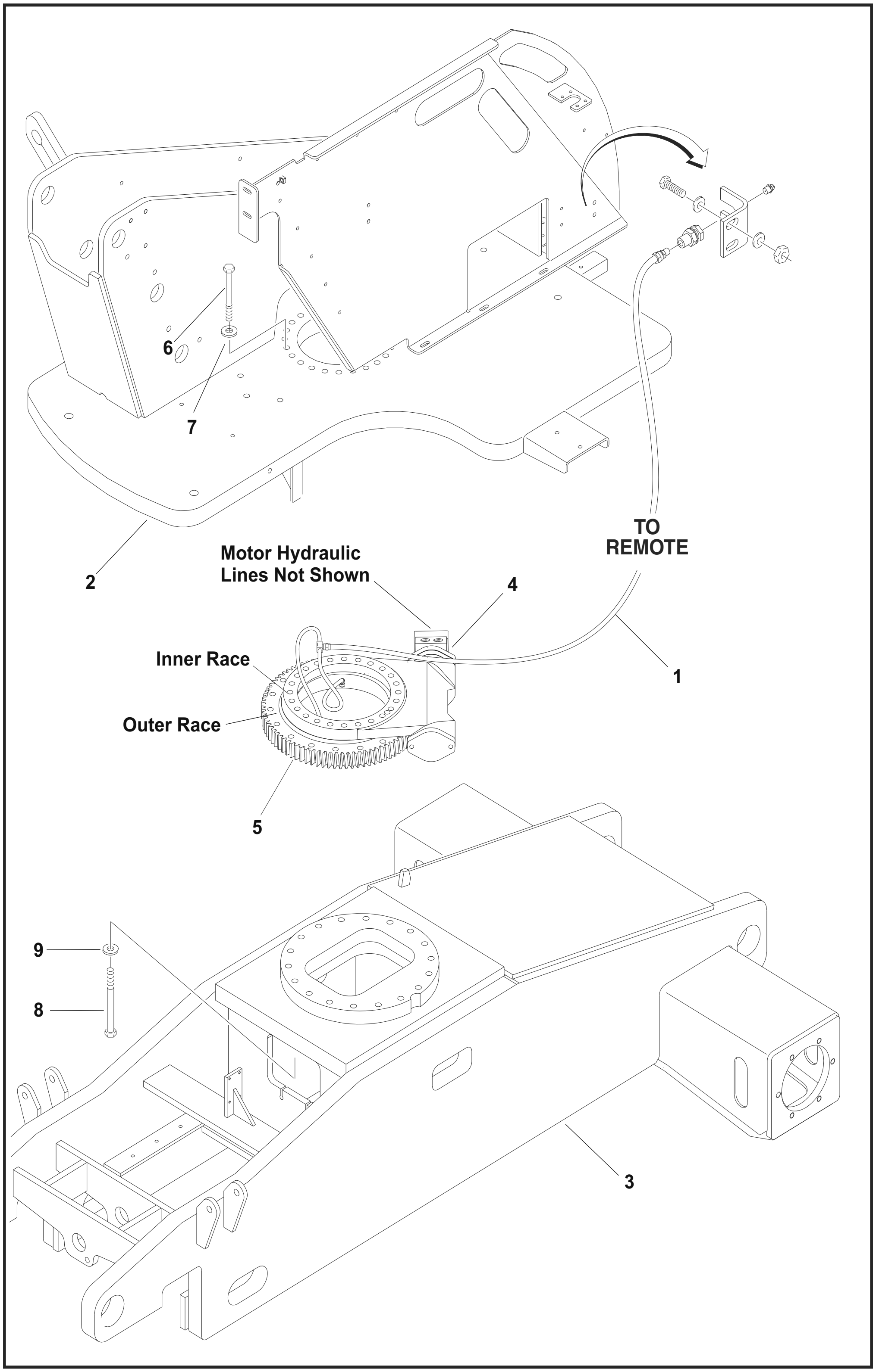


Figure 3-48. Swing Bearing Installation

Disassembly

Refer to Figure 3-49., Swing Bearing Drive.

1. Clean area around swing motor (1) to prevent any dirt from entering system.
2. Tag and disconnect hydraulic lines running to swing motor. Cap or plug all openings.

NOTICE

SECURE WORM GEAR SHAFT SO IT DOES NOT PULL OUT ANY WHEN REMOVING THE SWING MOTOR. FAILURE TO DO SO COULD DAMAGE WORM GEAR SEALS.

3. Remove bolts (2) and washers (3) securing swing motor to swing drive housing (4).
4. Carefully pull swing motor from housing.

Refer to Figure 3-55., Swing Motor Removal and Installation.

1. Remove two 5/16" bolts (5) and washers (6) that hold turntable bearing (7) to housing (4).
2. Remove two #6 machine screws (8) on cover plate (9) immediately in front of pinion (10).
3. Remove eight 3/8" 12 point cap screws (11) from gear pinion cap (12). Pry cap from housing. Cover plate (9) will come off with cap. Note where sealant is on cover and plate so it can be applied in same location during assembly. Note number and color of shims (14) between cap and housing.
4. Remove six small screws (15) from cover plate. Pry cover plate (9) from cap (12). Discard cover plate. Note number and color of shims (13) between cover plate and cap.

NOTE: *If there are five screws or drive screws holding cover plate to cap, a new cap (12) should be ordered. This is an older version; new cover plate has six holes.*

5. Lift directly up and remove pinon and gear assembly (10, 16, 17, 34, 18 - 22) from housing (4).
6. Disassemble pinion and gear assembly using a press. Support worm gear (20) on press wIth pinion (10) facing down, allowing room for pinion to be pressed out of gear. Press pinon out of bearing (22), spacer (21), and worm gear (20).
7. Remove face seal (18) and O-ring (19) from face of worm gear (20). Note how seal is assembled.
8. Remove bearing (17) and Nilos Ring (16) from pinion (18) with an external bearing puller or press.
9. Remove motor adapter (33) and shim (34).
10. Remove two 1/2" bolts (25) from worm cap (26) with a 3/4" socket. Remove shIms (27) and seal (28) and discard.
11. Remove worm (29) from housing (4) by pushing worm from motor end using a steel rod and hammer. Use a soft hammer to tap worm on hex end to remove bearing (36) from opposite end of housing.
12. Remove bearing (30) from worm (29) using an external bearing puller or press.
13. Remove press fit bearing cup (35) from adapter (33) using a small pry bar or by welding a small bead of weld on internal diameter of the cup.

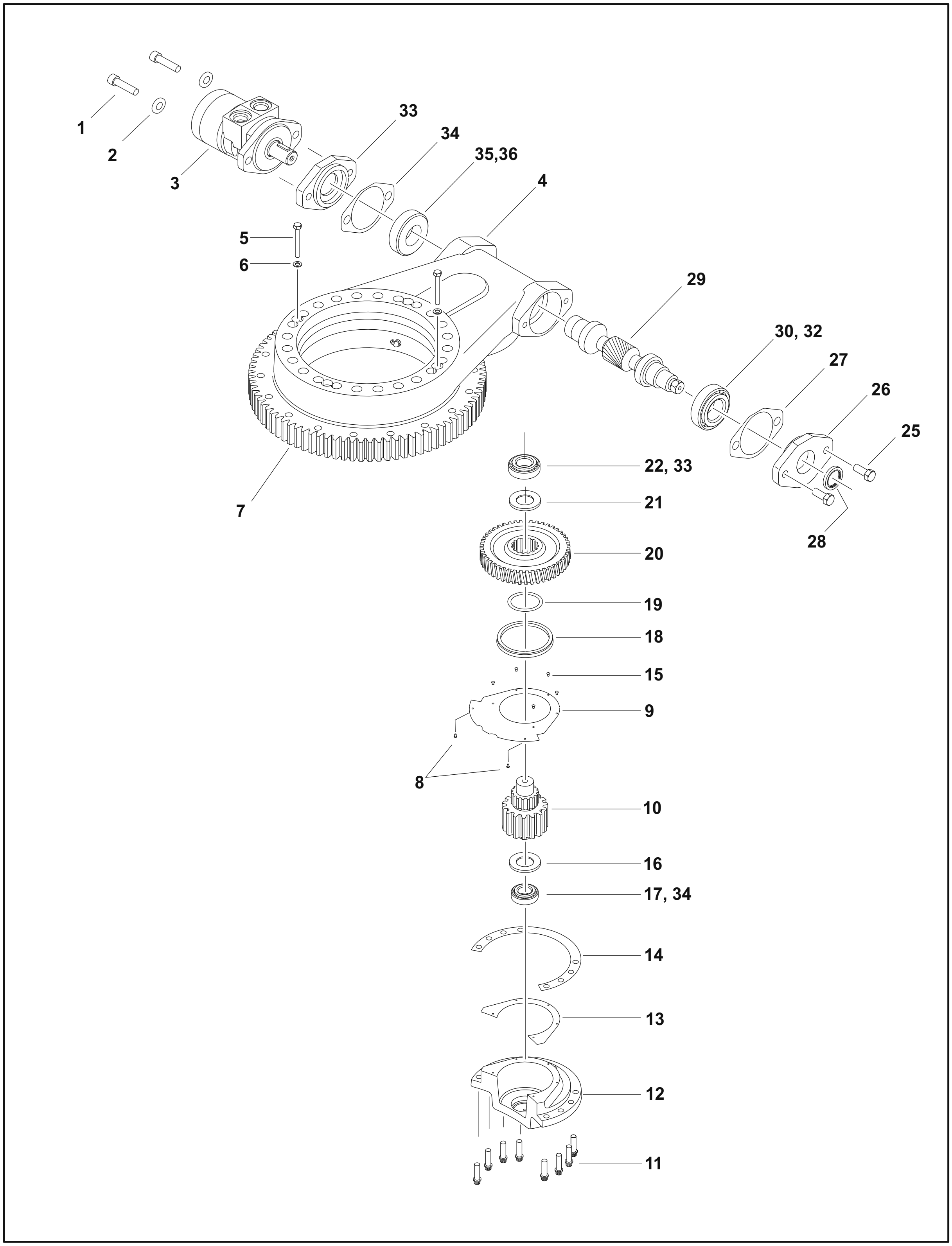


Figure 3-49. Swing Bearing Drive

Assembly

Refer to Figure 3-49., Swing Bearing Drive.

1. Press bearing cup (17) in cap (12).
2. Place bearing cup (33) in housing (4).
3. Put face seal (18) and O-ring (19) on hub of worm gear (20).
4. Place worm gear (20) on press with face seal up and press pinion (10) into worm gear. Place Nilos Ring (16) on pinion so cup shape is up and press bearing (34) on pinion tight to Nilos Ring.
5. Turn assembly over and place spacer (21) on pinion against gear hub so hub of spacer faces up. Press bearing (22) on pinion and tight to spacer and gear.
6. Place pinion gear assembly in housing. Place gear cap (12) and shims (14) over gear/pinion assembly to achieve a slight preload on pinion bearings. Remove cap and shims and set shims aside. Install a new cover plate (9) on cap with six screws (15) and shims (13) equal or close to total thickness of shims removed. Apply sealant (Permatex #2) to both sides of each shim and tighten screws, taking care not to twist screws off. Set assembly aside.

NOTICE

ROLLER BEARINGS (30,36) AND CUPS (32,35) MUST BE INSTALLED WITH SMALL ENDS FACING OUT ON EACH SIDE OF MACHINE OR EXCESSIVE PLAY WILL CAUSE BINDING AND DAMAGE TO EQUIPMENT.

7. Install bearing (36) with small end facing to outside of machine on bore end of worm (34).
8. Install worm (29), hex end first, into housing (4).

NOTICE

IF COMPRESSED AIR OR ELECTRICALLY OPERATED IMPACT WRENCH IS USED FOR TIGHTENING THE BEARING ATTACHMENT BOLTS, THE TORQUE SETTING ACCURACY OF THE TOOL SHOULD BE CHECKED PRIOR TO USE.

9. Install bearing cup (35) into worm bore of housing.
10. Install motor adapter (33) and 1 shim (34) to bore end of housing using Install bearing (30) with small end facing to outside of machine on hex end of worm (29). Place bearing cup (32) over bearing and lightly tap cup into bore using a soft hammer.
11. Install worm cap (26) using shims (27) to achieve 0.000 to 0.001" end play. Use 3/4" bolts (25) and sealant. Torque to 80 ft-lb (108.5 Nm).
12. Install pinion/gear assembly in housing so gear teeth mesh with worm gear teeth.
13. Apply silicone sealant to housing surface where cap assembly touch. This includes vertical surface.
14. Place gear cap assembly over pinion assembly and install shims set aside in step 6.
15. Install eight 3/8" 12 point screws (11) and torque to 60 ft-lb (81 Nm).
16. Install 2 small screws (8).
17. Install seal (28) in worm cap (26) at hex end of worm.
18. Install motor (3) to adapter (33) with two 1/2" bolts (1), washers (2), and sealant. Torque to 80 ft-lb (108.5 Nm).
19. Install turntable bearing (7) to housing (4) with two 5/16" bolts (5) and washers (6).
20. Fill unit with SHC 007 grease. Grease top bearing with Mobil SHC 460 grease.

Installation

Refer to Figure 3-48., Swing Bearing Installation.

1. Install bearing to rotation box with two capscrews, with fill plug of bearing close to gear as bolt pattern allows. Do not tighten capscrews.
2. Line up high spot (blue) of bearing with center tooth of worm gear. Set backlash to 0.008 - 0.010 inch (0.20 - 0.25 mm). Tighten capscrews as shown in Figure 3-50., Swing Bearing Torque Sequence.
3. Apply Mobiltac 375 Open Gear Compound or equivalent to bearing and worm gear teeth.
4. Grease bearing. Grease fitting is on inside wall of inner race of bearing or on newer bearings remove plugs on both sides of bearing. Reinstall plugs after greasing.

NOTE: *If Mobiltac 375 Open Gear Compound is not available, Multi-Purpose Grease (MPG) can be substituted, however service interval will be shorter.*

5. Using suitable lift equipment and install bearing/rotation box assembly to frame with soft spot (red) 90 degree relative to load axis. If reusing old bearing, ensure scribed line of outer bearing race aligns with scribed mark on frame.

⚠ WARNING

SWING BEARING IS THE ONLY STRUCTURAL LINK BETWEEN FRAME AND TURNTABLE. JLG INDUSTRIES RECOMMENDS ALL REMOVED GRADE 8 BEARING NUTS AND BOLTS BE DISCARDED AND REPLACED WITH NEW NUTS AND BOLTS. IT IS IMPERATIVE THAT REPLACEMENT HARDWARE MEETS JLG SPECIFICATIONS. USE OF GENUINE JLG HARDWARE IS HIGHLY RECOMMENDED.

6. Apply a light coating of Loctite 271 to new bearing bolts and loosely install bolts and washers through frame and outer bearing race.

NOTICE

IF COMPRESSED AIR OR ELECTRICALLY OPERATED IMPACT WRENCH IS USED TO TIGHTEN BEARING ATTACHMENT BOLTS, CHECK TORQUE SETTING ACCURACY OF TOOL BEFORE USE.

7. Tighten bolts to an initial torque of 130 ft-lb (176 Nm) following torque sequence shown in Figure 3-50., Swing Bearing Torque Sequence. Tighten to a final torque of 190 ft-lb (257 Nm) following same sequence.

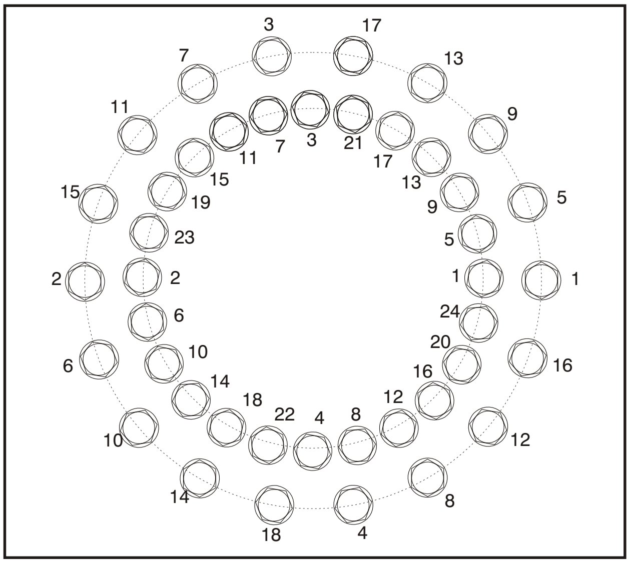


Figure 3-50. Swing Bearing Torque Sequence

8. Remove lifting equipment from bearing.
9. Use suitable lift equipment to carefully position turntable assembly above machine frame.
10. Carefully lower turntable onto swing bearing. Ensure scribed line of inner race of bearing aligns with scribed mark on turntable. If a new swing bearing is used, ensure filler plug fitting is at 90 degrees from fore and aft centerline of turntable.
11. Apply a light coating of Loctite 271 to new bearing bolts and install through turntable and inner race of bearing.
12. Tighten bolts to an initial torque of 130 ft-lb (176 Nm) following torque sequence shown in Figure 3-52. Tighten to a final torque of 190 ft-lb (257 Nm) following same sequence.
13. Remove lift equipment.
14. Route hydraulic lines through center of turntable and frame. Connect as tagged prior to removal.
15. Following all applicable safety precautions, activate hydraulic system and functionally check swing system for proper and safe operation.

Turntable Bearing Mounting Bolt Condition Check

NOTE: *This check is designed to replace existing bearing bolt torque checks on JLG Lifts in service. This check must be performed after first 50 hours of machine operation and every 600 hours of machine operation thereafter. Replace missing or loose bolts with new bolts and torque to value specified in torque chart after lubricating bolt threads with Loctite #271. After replacing and re-torquing bolt or bolts, recheck all existing bolts for looseness.*

Check Frame To Bearing Bolts

1. Fully retracted boom and elevate to 70 degrees (full elevation).
2. Try and insert a 0.0015" feeler gauge between bolt head and hardened washer at positions shown in Figure 3-51., Swing Bearing Feeler Gauge Check.

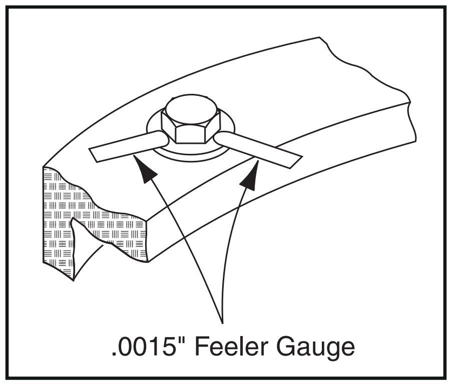


Figure 3-51. Swing Bearing Feeler Gauge Check

3. Ensure 0.0015" feeler gauge will not fit under bolt head to bolt shank.
4. Swing turntable 90 degrees, and check some selected bolts at the new position.
5. Continue rotating turntable at 90 degrees intervals until a sampling of bolts have been checked in all quadrants.

Check Turntable To Bearing Bolts

1. Fully retract boom and elevate to 70 degrees (full elevation).Try and insert a 0.0015" feeler gauge between bolt head and hardened washer at positions shown in Figure 3-52., Swing Bearing Feeler Gauge Check.

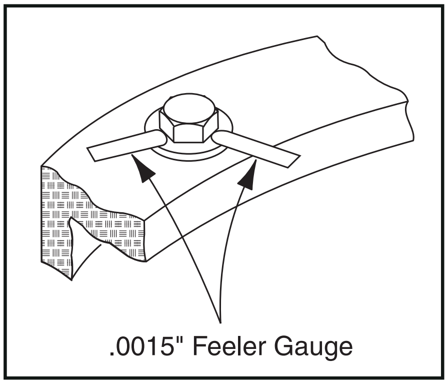


Figure 3-52. Swing Bearing Feeler Gauge Check

2. Lower boom to horizontal and fully extend boom.
3. Try and insert a 0.0015" feeler gauge between bolt head and hardened washer at position indicated by arrow in Figure 3-52., Swing Bearing Feeler Gauge Check.

Wear Tolerance

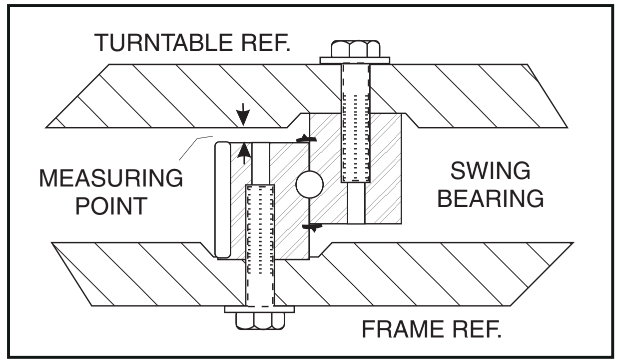


Figure 3-53. Swing Bearing Tolerance Measuring Point

1. Position boom over side of machine with upper boom horizontal, telescope fully extended, and mid/ lower boom stowed. Measure and record distance between swing bearing and turntable using a magnetic base dial indicator.
2. At same point, position boom over side of machine with Upper Boom and Mid/Lower Boom fully elevated. Measure and record distance between swing bearing and turntable using a magnetic base dial indicator.
3. If there is a difference greater than 0.057" (1.40 mm), replace swing bearing.
4. If there is a difference less than 0.057" (1.40 mm) and any of the following conditions exist, remove and inspect bearing.
   a. Metal particles in grease.
   b. Increased drive power.
   c. Noise.
   d. Rough rotation.
5. If bearing inspection shows no defects, reassemble bearing and return to service.

3.10 SWING MOTOR

NOTICE

IF HYDRAULIC SYSTEM FLUID BECOMES OVERHEATED [IN EXCESS OF 200°F (93.3°C)], SEALS CAN SHRINK, HARDEN, OR CRACK AND LOSE THEIR SEALING ABILITY.

Preparation Before Disassembly

WARNING

PETROLEUM-BASE SOLVENTS ARE FLAMMABLE. BE EXTREMELY CAREFUL WHEN USING ANY SOLVENT. EVEN A SMALL EXPLOSION OR FIRE COULD CAUSE INJURY OR DEATH.

CAUTION

WEAR EYE PROTECTION AND BE SURE TO COMPLY WITH OSHA OR OTHER MAXIMUM AIR PRESSURE REQUIREMENTS.

NEVER STEAM OR HIGH PRESSURE WASH HYDRAULIC COMPONENTS. DO NOT FORCE OR ABUSE CLOSELY FITTED PARTS.

- Before you disassemble motor or any of its components read this entire section. It provides important information on parts and procedures to service motor.
- Before disconnecting and removing motor, thoroughly clean off all outside dirt, especially from around fittings and hose connections. Remove rust or corrosion from coupling shaft.
- Remove coupling shaft connections and hose fittings and immediately plug port holes and fluid lines.
- Remove motor from system, drain fluid, and move it to a clean work surface.
- Clean and dry motor before disassembly.
- Keep parts separate to avoid nicks and burrs.
- Discard all seals and seal rings as they are removed from motor. Replace all seals, seal rings and any damaged or worn parts with OEM approved service parts.
- As you disassemble motor, clean all parts except seals in clean petroleum-based solvent, and blow them dry.

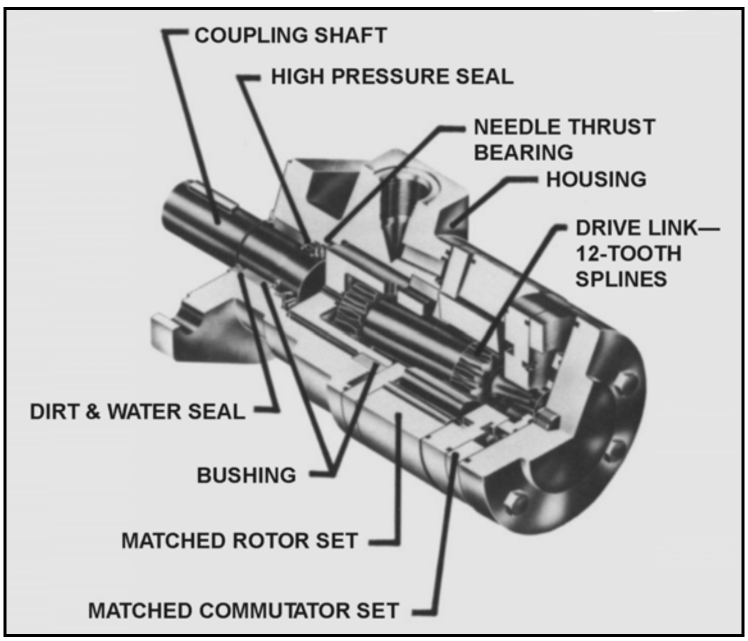


Figure 3-54. Swing Motor - Cutaway

Table 3-11. Swing Motor Troubleshooting

Trouble	Cause	Remedy
Oil Leakage	1. Hose fittings loose, worn or damaged.	Check & replace damaged fittings or “O” Rings. Torque to manufacturers specifications.
	2. Oil seal rings (4) deteriorated by excess heat.	Replace oil seal rings by disassembling unit.
	3. Special bolt (1, 1 A, 1B or 1C) loose or its sealing area deteriorated by corrosion.	(a) Loosen then tighten single bolt to torque specification. (b) Replace bolt.
	4. Internal shaft seal (16) worn or damaged.	Replace seal. Disassembly of motor unit necessary.
	5. Worn coupling shaft (12) and internal seal (16).	Replace coupling shaft and seal by disassembling unit.
Significant loss of speed under load	1. Lack of sufficient oil supply	(a) Check for faulty relief valve and adjust or replace as required. (b) Check for and repair worn pump. (c) Check for and use correct oil for temperature of operation.
	2. High internal motor leakage	Replace worn rotor set by disassembling unit.
	3. Severely worn or damaged internal splines.	Replace rotor set, drive link and coupling shaft by disassembling unit.
	4. Excessive heat.	Locate excessive heat source (usually a restriction) in the system and correct the condition.
Low mechanical efficiency or undue high pressure required to operate unit	1. Line blockage	Locate blockage source and repair or replace.
	2. Internal interference	Disassemble unit, identify and remedy cause and repair, replacing parts as necessary.
	3. Lack of pumping pressure	Check for and repair worn pump.
	4. Excessive binding or loading in system external to motor unit.	Locate source and eliminate cause.

Removal

Refer to Figure 3-55., Swing Motor Removal and Installation.

1. Thoroughly clean area around swing motor to prevent dirt from entering system.
2. Tag and disconnect hydraulic lines to swing motor. Cap or plug all openings.
3. Secure worm gear shaft so it does not pull out any when removing swing motor. Failure to do so could damage worm gear seals.
4. Remove bolts securing swing motor to swing drive assembly.
5. Carefully pull the swing motor from the swing drive.

Preparation Before Disassembly

- Read this entire section before you disassemble motor or any of its components for important information on parts and procedures.
- Thoroughly clean off outside dirt, especially around fittings and hose connections, before disconnecting and removing motor. Remove rust or corrosion from coupling shaft.
- Remove coupling shaft connections and hose fittings and immediately plug port holes and fluid lines.
- Remove motor, drain fluids, and take it to a clean work surface.
- Clean and dry motor before disassembly.
- As you disassemble motor, clean all parts except seals in clean petroleum-based solvent and blow them dry.

⚠ WARNING

PETROLEUM-BASE SOLVENTS ARE FLAMMABLE. BE EXTREMELY CAREFUL WHEN USING ANY SOLVENT. EVEN A SMALL EXPLOSION OR FIRE COULD CAUSE INJURY OR DEATH.

⚠ CAUTION

WEAR EYE PROTECTION AND BE SURE TO COMPLY WITH OSHA OR OTHER MAXIMUM AIR PRESSURE REQUIREMENTS.

NOTICE

NEVER STEAM OR HIGH PRESSURE WASH HYDRAULIC COMPONENTS. DO NOT FORCE OR ABUSE CLOSELY FITTED PARTS.

- Keep parts separate to avoid nicks and burrs.
- Discard seals and seal rings as they are removed from motor. Replace all seals, seal rings and any damaged or worn parts with OEM approved service parts.

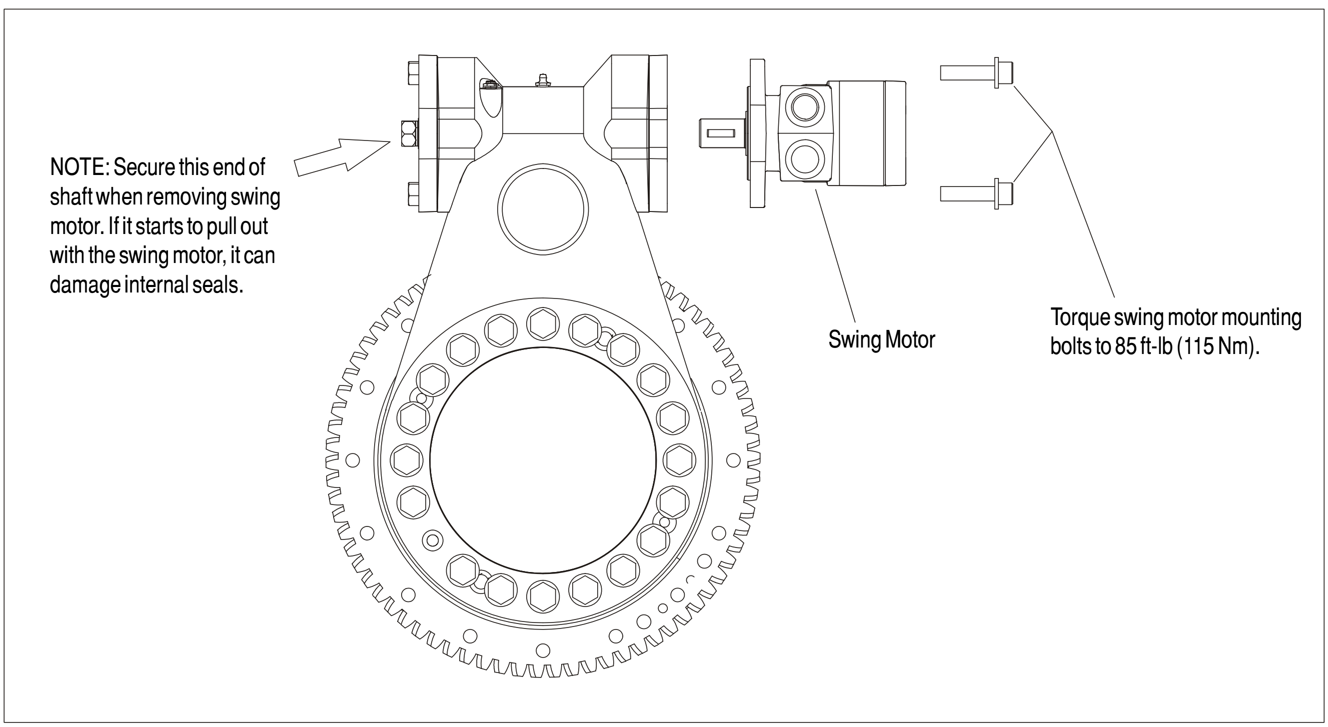
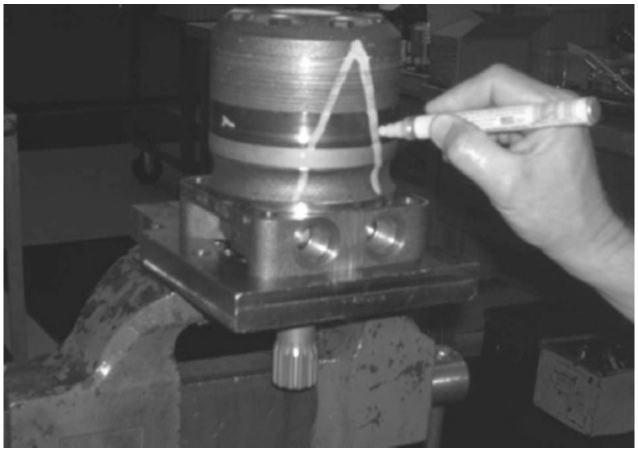


Figure 3-55. Swing Motor Removal and Installation

Disassembly and Inspection

Refer to Figure 3-56., Swing Motor - Exploded View.

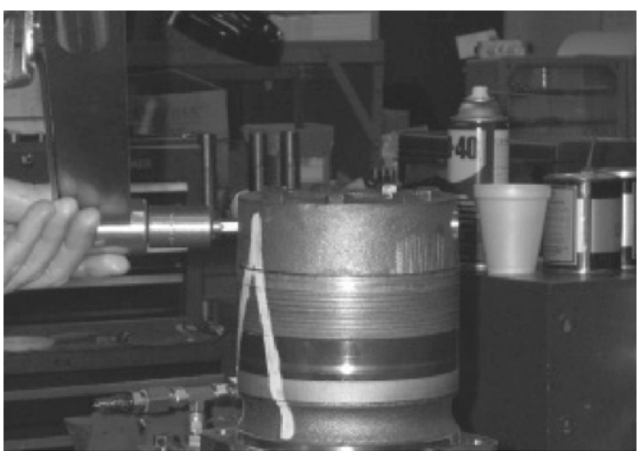
1. Place motor in a soft jawed vice, with coupling shaft (12) pointed down and vise jaws clamping firmly on sides of housing (18) mounting flange, or port bosses. Remove manifold port O-rings if applicable.

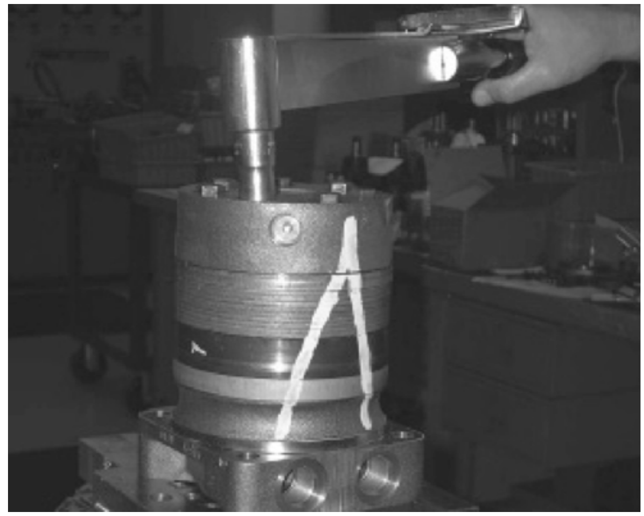


⚠ CAUTION

IF MOTOR IS NOT HELD FIRMLY IN VISE, IT COULD DISLODGE DURING SERVICE PROCEDURES AND CAUSE INJURY.

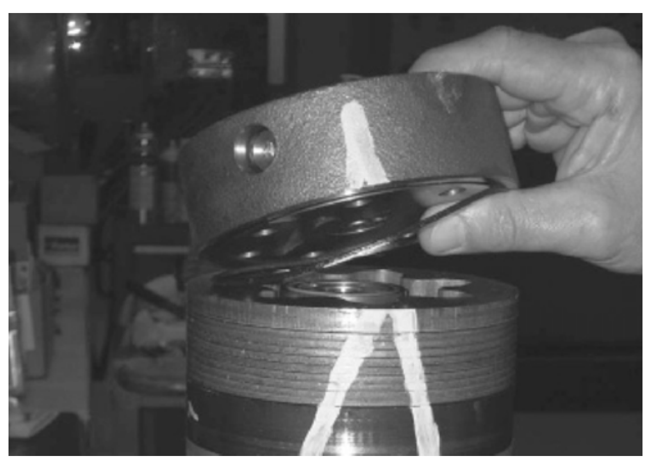
2. Scribe an alignment mark down and across motor components from end cover (2) to housing (18) to facilitate reassembly orientation where required.





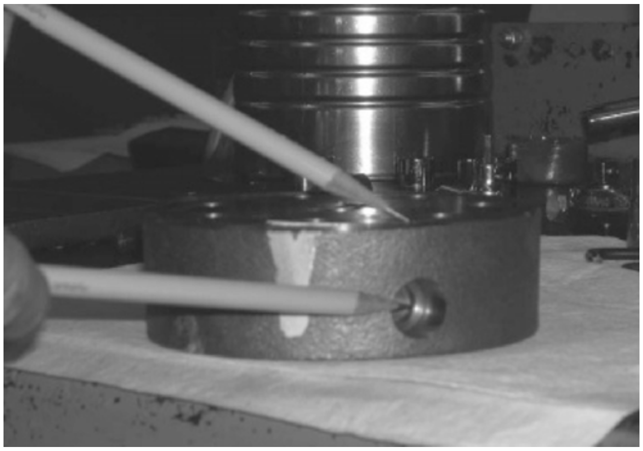
3. Remove special ring head bolts (1) with 1/2" or 9/16" socket. Inspect bolts for damaged threads or sealing rings. Replace damaged bolts.

4. Remove end cover assembly (2) and seal ring (4). Discard seal ring.



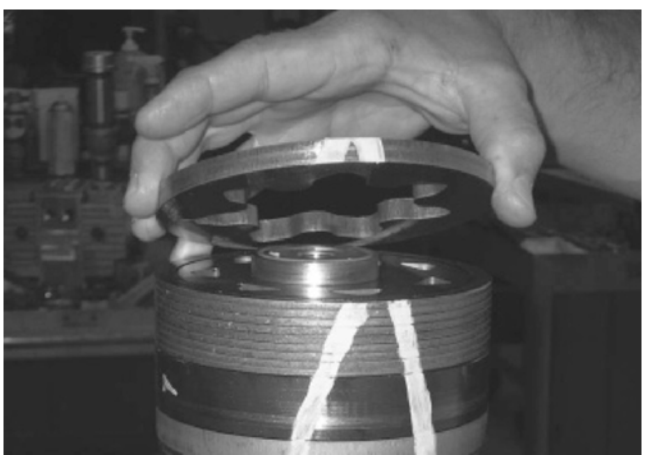
5. Thoroughly wash end cover (2) in proper solvent and blow dry. Be sure end cover valve apertures are

free of contamination. Inspect end cover for cracks and bolt head recesses for good bolt head sealing surfaces. Replace end cover as necessary.



NOTE: *A polished pattern (not scratches) on the cover from rotation of commutator (5) is normal. Discoloration would indicate excess fluid temperature, thermal shock, or excess speed and require system investigation for cause and close inspection of end cover, commutator, manifold, and rotor set.*

6. Remove commutator ring (6) and inspect for cracks or burrs.



7. Remove commutator (5) and seal ring (3). Remove seal ring from commutator. Use an air hose to blow air into ring groove until seal ring lifts out. Discard seal ring. Inspect commutator for cracks or burrs, wear, scoring, spalling, or brinelling. Replace commutator and commutator ring as a matched set If any of these conditions exist.

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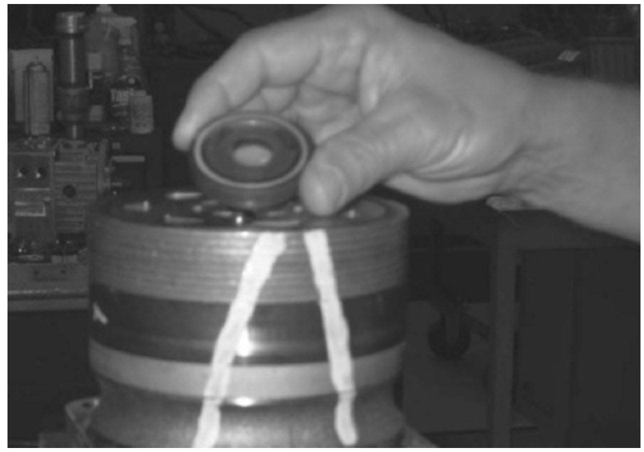
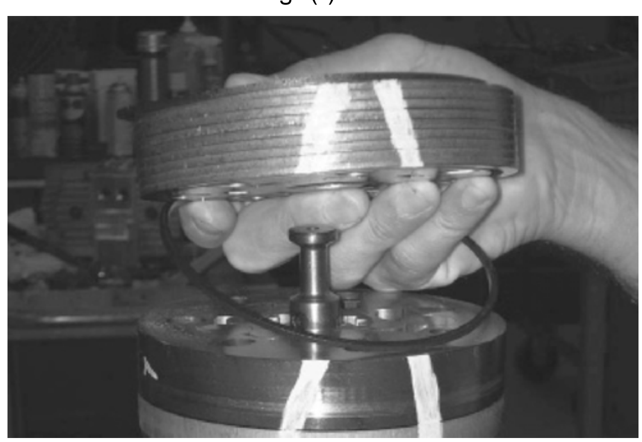
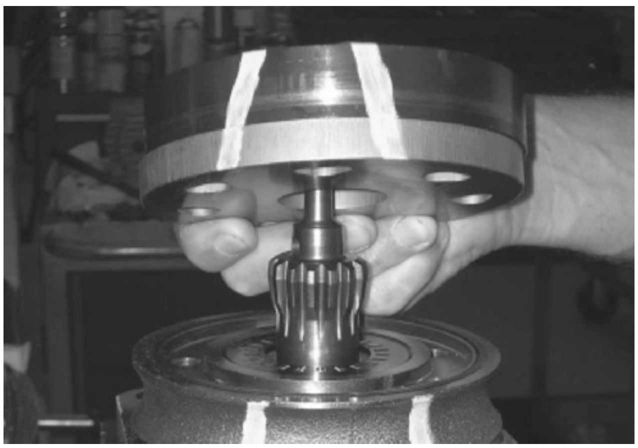


1. Remove manifold (7). Inspect for cracks, surface scoring, brinelling, or spalling and replace if any of these conditions exist. A polished pattern on the ground surface from commutator or rotor rotation is normal. Remove and discard seal rings (4) on both sides of manifold.



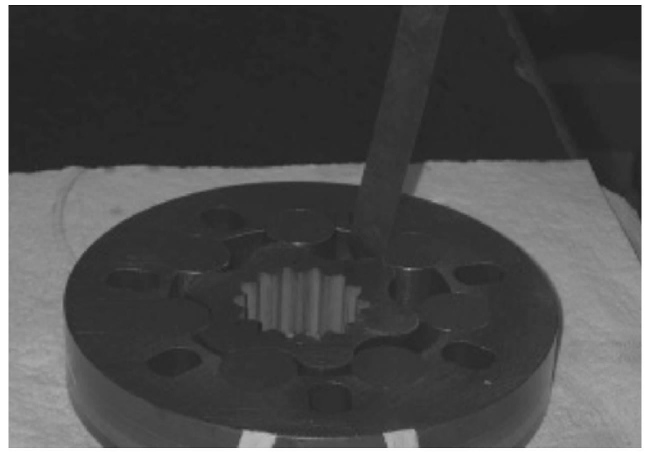
NOTE: *Manifold consists of plates bonded together and cannot be disassembled. Compare both sides of manifold to ensure same surface is reassembled against rotor set.*

2. Remove rotor set (8) and wearplate (9), together to retain rotor set in its assembled form, maintaining same rotor vane to stator contact surfaces. Drive link (10) may come away from coupling shaft (12) with rotor set, and wearplate. You may have to shift the rotor set on the wearplate to work drive link out of rotor and wearplate. Inspect rotor set in its assembled form for nicks, scoring, or spalling on any surface and for broken or worn splines. If rotor set component requires replacement, complete rotor set must be replaced as it is a matched set. Inspect wearplate for cracks, brinelling, or scoring.
3. Discard seal ring (4) between rotor set and wearplate.



NOTE: *Rotor set (8) components may become disassembled during service. Mark surface of rotor and stator facing UP, with etching ink or grease pencil before removal to ensure correct reassembly of rotor into stator and rotor set into motor. Mark all rotor components and mating spline components for exact repositioning at assembly for maximum wear life and performance of rotor set and motor.*

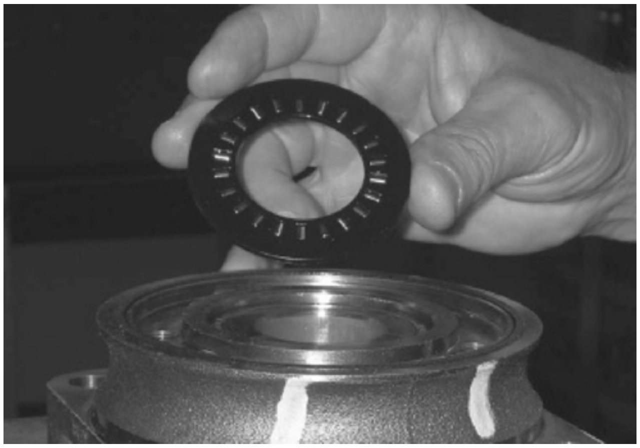
NOTE: *A polished pattern on wear plate from rotor rotation is normal.Place rotor set (8) and wear plate (9) on a flat surface and center rotor in stator so two rotor lobes (180 degrees apart) and a roller vane centerline are on the same stator centerline. Check rotor lobe to roller vane clearance with a feeler gage at this common centerline. If there is more than 0.005" (0.13 mm) of clearance, replace rotor set.*



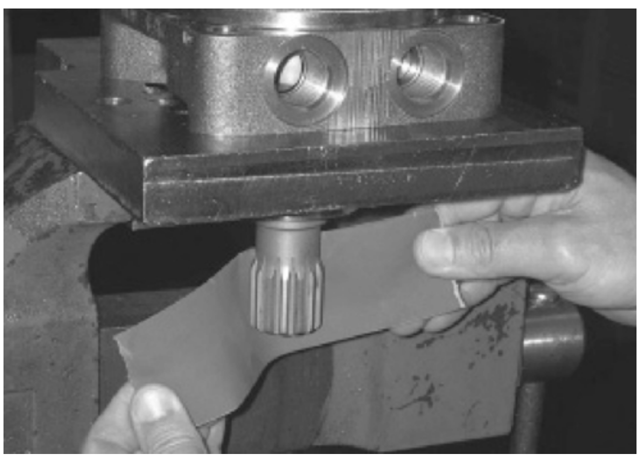
NOTE: *If rotor set (8) has two stator halves and two sets of seven vanes as shown, check rotor lobe to roller vane clearance at both ends of rotor.*

4. Remove drive link (10) from coupling shaft (12) if it was not removed with rotor set and wear plate. Inspect drive link for cracks and worn or damaged splines. No perceptible lash (play) should be noted between mating spline parts. Remove seal ring (4) from housing (18) and discard.

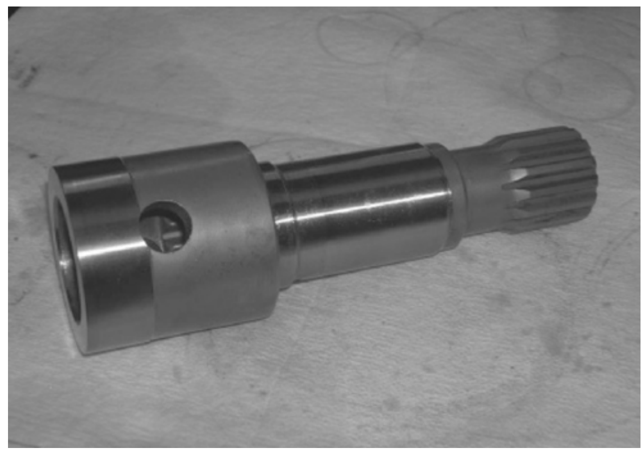
5. Remove thrust bearing (11) from top of coupling shaft (12). Inspect for wear, brinelling, corrosion, and missing rollers.



6. Check exposed portion of coupling shaft (12) for signs of rust and corrosion which might prevent its withdrawal through seal and bearing. Use crocus cloth or fine emery paper as needed.



7. Remove coupling shaft (12), by pushing on output end of shaft. Inspect coupling shaft bearing and seal surfaces for spalling, nicks, grooves, severe wear or corrosion and discoloration. Inspect for damaged or worn internal and external splines or keyway. Replace shaft if any of these conditions exist.



NOTE: *Minor shaft wear in seal area is permissible. If wear exceeds 0.020" (0.51 mm) diametrically, replace coupling shaft. A slight "polish" is permissible in shaft bearing areas. Anything more requires coupling shaft replacement.*

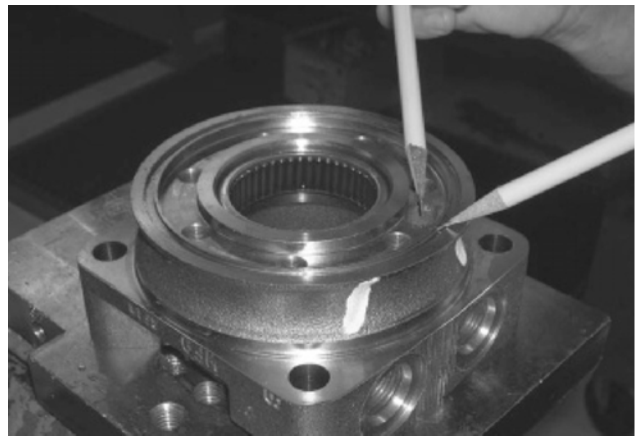
1. Remove and discard seal ring (4) from housing (18).

2. Remove thrust bearing (15) and thrust washer (14). Inspect for wear, brinelling, corrosion and a full complement of retained rollers.

3. Remove seal (16) and back up ring (17) from housing (18) and backup washer (25). Discard both.

4. Remove housing (18) from vise. Invert housing and remove seal (20) with a blind hole bearing or seal puller. Discard seal.

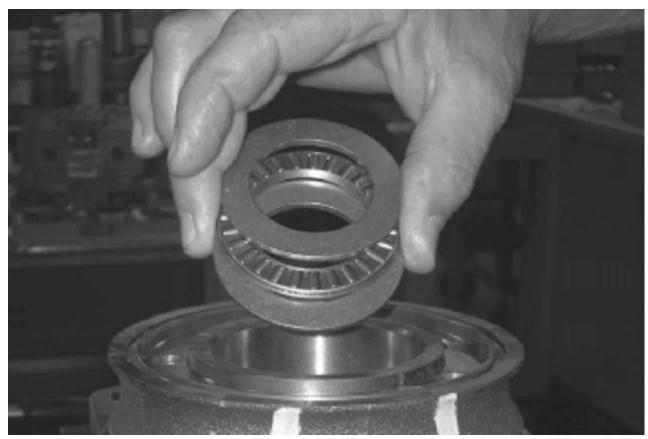
5. Inspect housing (18) assembly for cracks, machined surfaces for nicks, burrs, brinelling, or corrosion. Remove burrs that can be removed without changing dimensional characteristics. Inspect tapped holes for thread damage. If housing is defective in these areas, discard housing assembly.

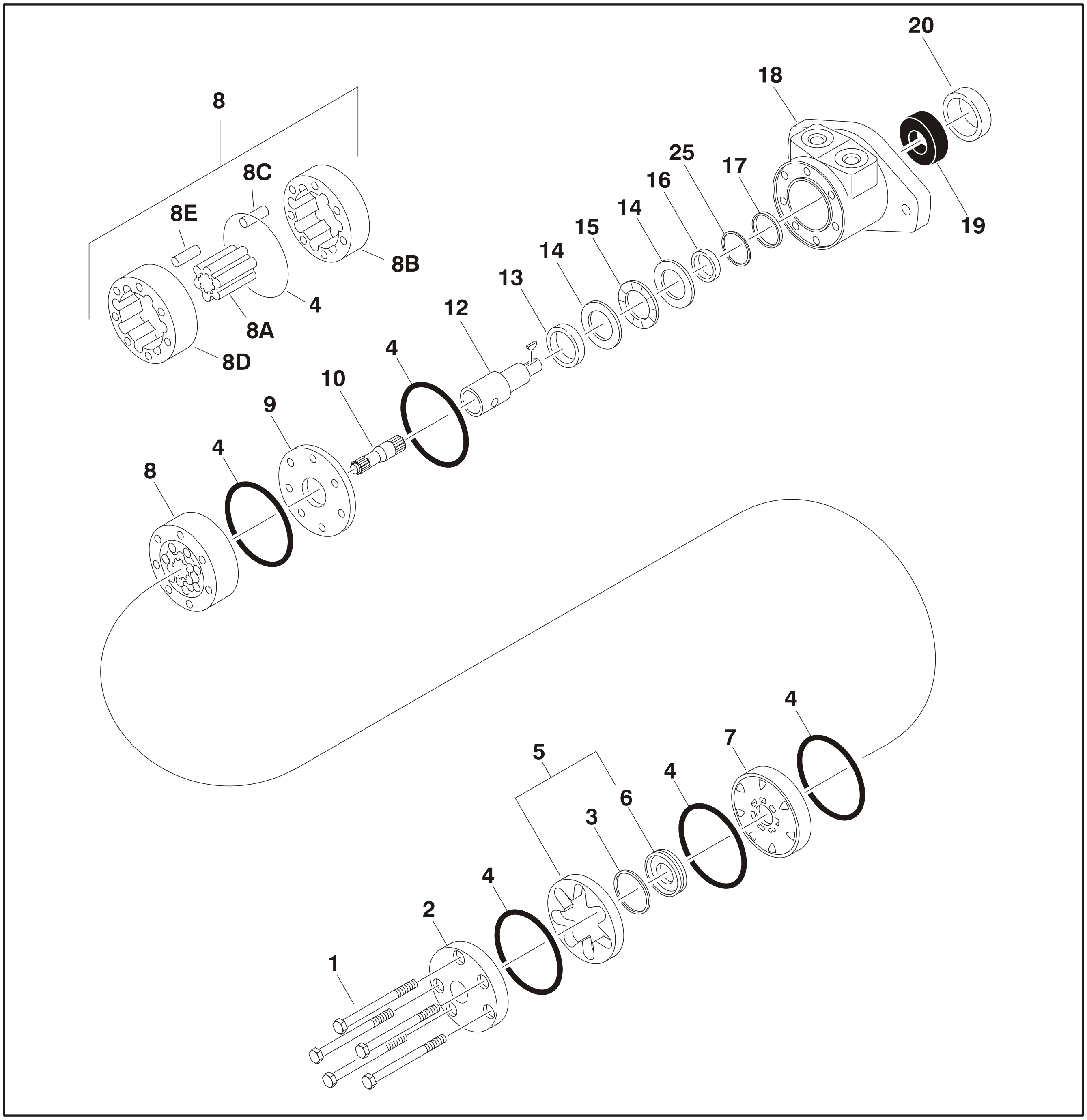


6. If housing (18) assembly has passed inspection to this point, inspect housing bearings/bushings (19) and (13) if they are captured in housing cavity. Two thrust washers (14) and thrust bearing (15) bearing rollers must be firmly retained in bearing cages, but must rotate and orbit freely. All rollers and thrust washers must be free of brinelling and corrosion. Bushing (19) or (13) to coupling shaft diameter clearance must not exceed 0.010 inch (0.025 mm). A bearing, bushing, or thrust washer that does not pass inspection must be replaced. If housing has passed this inspection, disassembly of motor is complete.

7. Measure and note depth or location of bearing/bushing (13) in relation to housing wear plate surface, and depth or location of bearing/bushing (19) in relation to beginning of bearing/bushing counter bore before removing bearings/bushings. This ensures correct reassembly of new bearings/bushings.

8. Use a suitable size bearing puller to remove bearing/bushings (19) and (13) from housing (18) If Bearings, bushing or thrust washers must be replaced without damaging housing. Remove thrust washers (14) and thrust bearing (15) if previously retained in housing by bearing (13).





1. Bolt	6. Commutator Ring	8C. Stator Vane	12. Coupling Shaft	17. Backup Ring	22. Not Used
2. End Cover	7. Manifold	8D. Stator Half	13. Inner Bushing	18. Housing	23. Not Used
3. Seal Ring	8. Rotor Set	9. Wear Plate	14. Thrust Washer	19. Outer Bushing	24. Not Used
4. Seal Ring	8A. Rotor	10. Drive Link	15. Thrust Bearing	20. Dirt & Water Seal	25. Backup Washer
5. Commutator	8B. Stator Half	11. Thrust Bearing	16. Seal	21. Not Used	

Figure 3-56. Swing Motor - Exploded View

Assembly

Refer to Figure 3-56., Swing Motor - Exploded View.

Replace seals and seal rings with new ones each time motor unit is reassembled. Lubricate seals and seal rings with SAE 10W40 oil or clean grease before assembly.

NOTE: *Do not oil or grease parts before assembly unless otherwise indicated.*

WARNING

SOLVENTS ARE FLAMMABLE. EVEN A SMALL EXPLOSION OR FIRE CAN CAUSE INJURY OR DEATH. BE EXTREMELY CAREFUL WHEN USING ANY SOLVENT.

Wash all parts in clean petroleum-based solvents before assembly. Blow dry with compressed air. Remove any paint chips from end cover mating surfaces, commutator set, manifold rotor set, wear plate and housing, and from port and sealing areas.

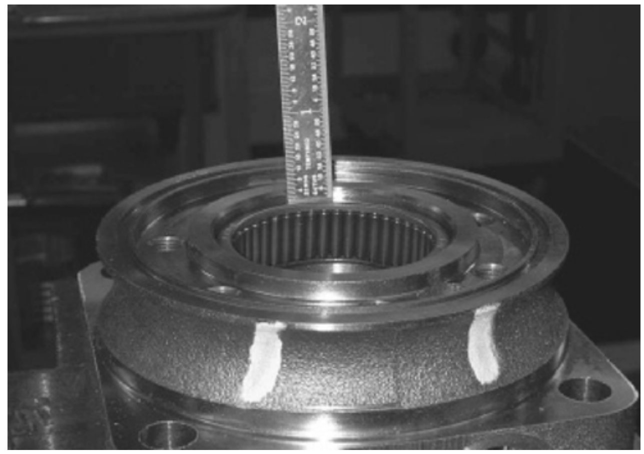
WARNING

WEAR EYE PROTECTION AND BE SURE TO COMPLY WITH OSHA OR OTHER MAXIMUM AIR PRESSURE REQUIREMENTS.

1. If housing (18) bearing components were removed for replacement, thoroughly coat and pack a new outer bearing/bushing (19) with clean corrosion resistant grease recommended in material section. Press new bearing/bushing into counterbore at mounting flange end of housing, using appropriately sized bearing mandrel as described to control bearing/ bushing depth. Housing requires use of bearing mandrel to press bearing/ bushing (19) into housing to a required depth of 0.151/0.161" (3.84/4.09 mm) from end of bearing counterbore.

NOTE: *Bearing mandrel must be pressed against lettered end of bearing shell. Housing bore must be square with press base and bearing/bushing not cocked when pressing a bearing/bushing into housing.*

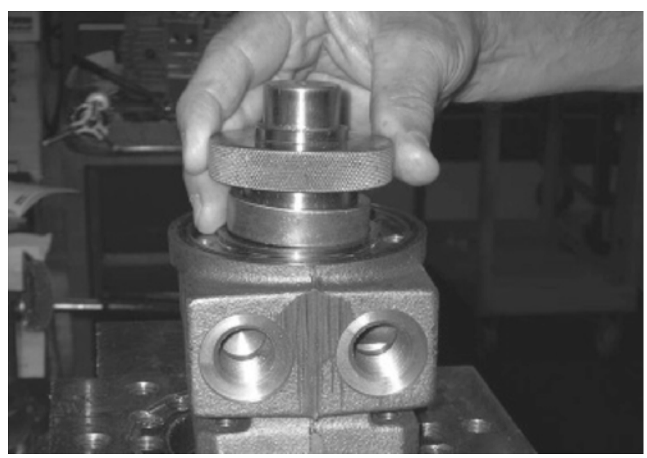
NOTE: *If A bearing mandrel is not available and alternate methods are used to press in bearing/bushing (13) and (19). bearing/bushing depths specified must be achieved to Ensure adequate bearing support and correct relationship to adjacent components when assembled.*



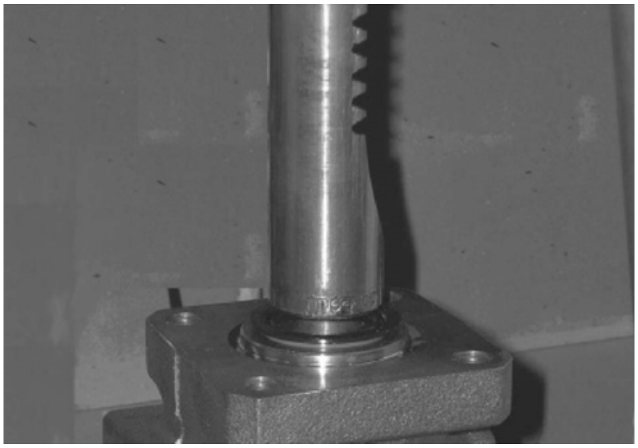
NOTICE

BEARING/BUSHINGS (13) AND (19) HAVE A PRESS FIT INTO HOUSING AND MUST BE DISCARDED WHEN REMOVED.

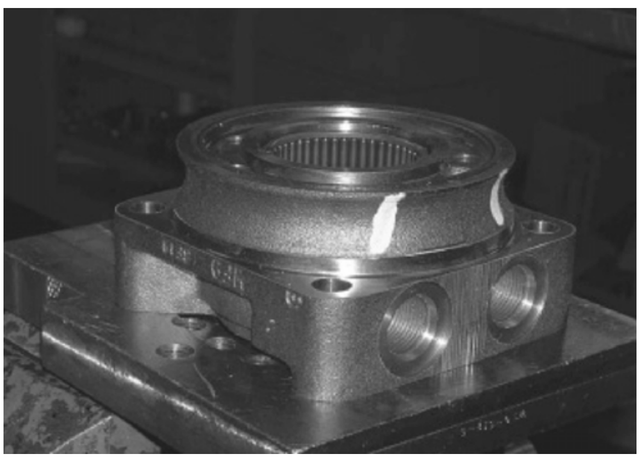
2. Inner housing bearing/bushing (13) can now be pressed into its counter-bore in housing (18) flush to 0.03 inch (0.76 mm) below housing wear plate contact face. Use opposite end of bearing mandrel used to press in outer bearing/bushing (19).



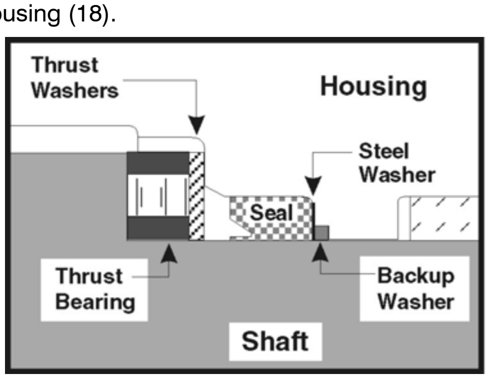
3. Press new dirt and water seal (20) into housing (18) outer bearing counterbore. Press in dirt and water seal (20) until flange is flush against housing.



4. Place housing (18) assembly into a soft jawed vise with coupling shaft bore down, clamping against mounting flange.



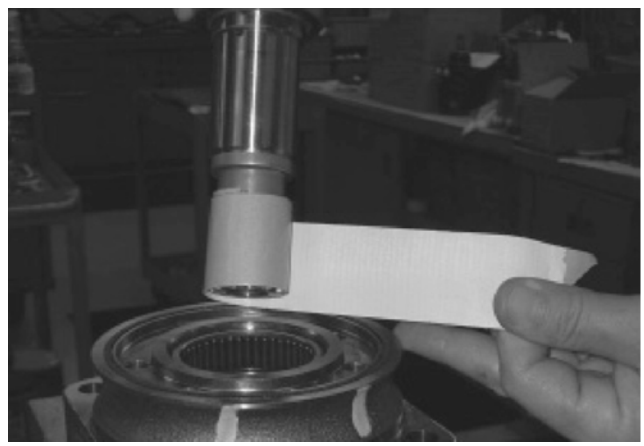
5. Assemble a new backup ring (17), new backup washer (25), and new seal (16) with seal lip facing toward inside of motor, into their counterbores in housing (18).



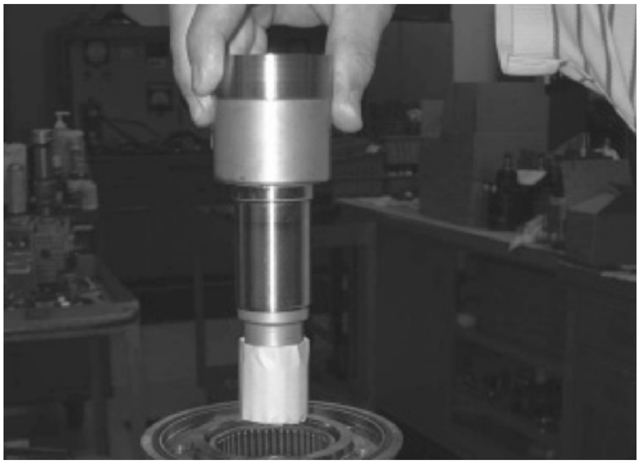
6. Install thrust washer (14) and thrust bearing (15).

NOTE: *Motor requires one thrust washer (14) with thrust bearing (15). Coupling shaft is seated directly against thrust bearing.*

7. Apply masking tape around splines or keyway on shaft (12) to prevent damage to seal.



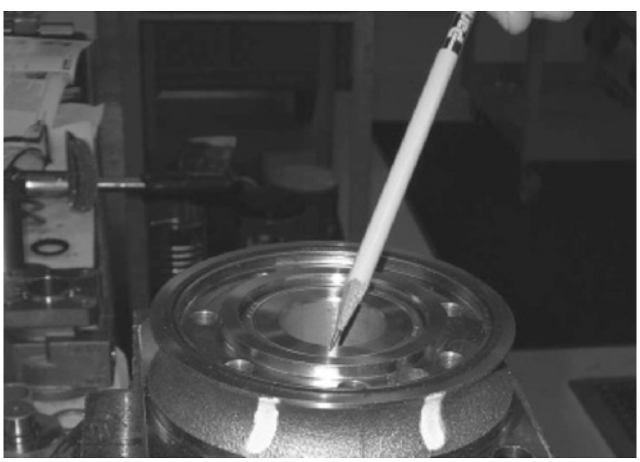
8. Apply a generous amount of clean, corrosion resistant grease to lower (outer) housing bearing/bushing (19). Install coupling shaft (12) into housing (18), seating it against thrust bearing (15).



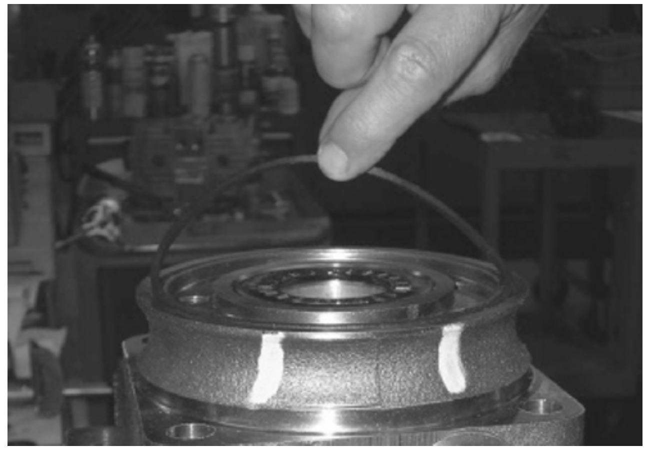
NOTICE

OUTER BEARING (19) IS NOT LUBRICATED BY SYSTEM HYDRAULIC FLUID. BE SURE IT IS THOROUGHLY PACKED WITH RECOMMENDED GREASE.

NOTE: *Coupling shaft (12) will be flush or just below housing wear surface when properly seated with coupling shaft (12). Coupling shaft must rotate smoothly on thrust bearing package.*

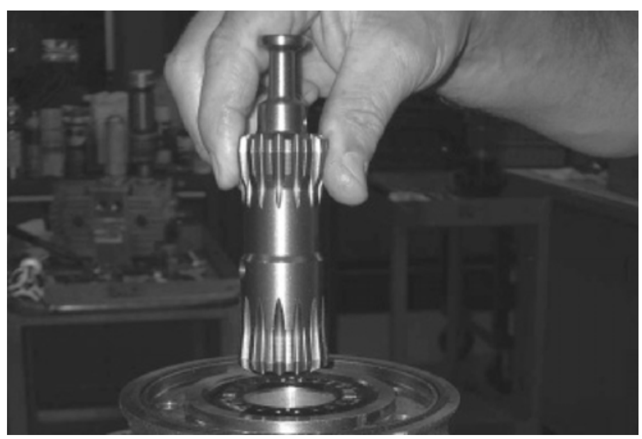


9. Apply a small amount of clean grease to a new seal ring (4) and insert it in housing (18) seal ring groove.



NOTE: *One or two alignment studs screwed finger tight into housing (18) bolt holes, approximately 180 degrees apart, will facilitate assembly and alignment of components required in the following procedures. Studs can be made by cutting off heads of 3/8-24 UNF 2A or 5/16-24 UNF 2A bolts as required that are over 0.5 inch (12.7 mm) longer than bolts (1) used in motor.*

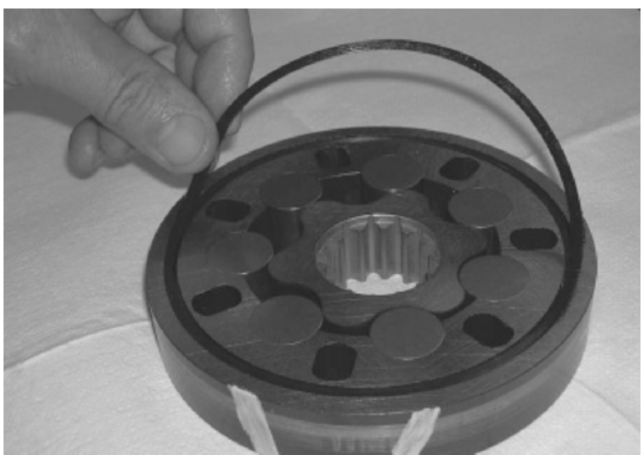
10. Install drive link (10), long splined end down, in coupling shaft (12) and engage drive link splines in mesh with coupling shaft splines.



NOTE: *Use alignment marks on coupling shaft and drive link before disassembly to assemble drive link splines in their original position in mating coupling shaft splines.*

11. Assemble wear plate (9) over drive link (10) and alignment studs onto housing (18).

12. Apply a small amount of clean grease to a new seal ring (4) and assemble it into seal ring groove on wear plate side of rotor set stator.



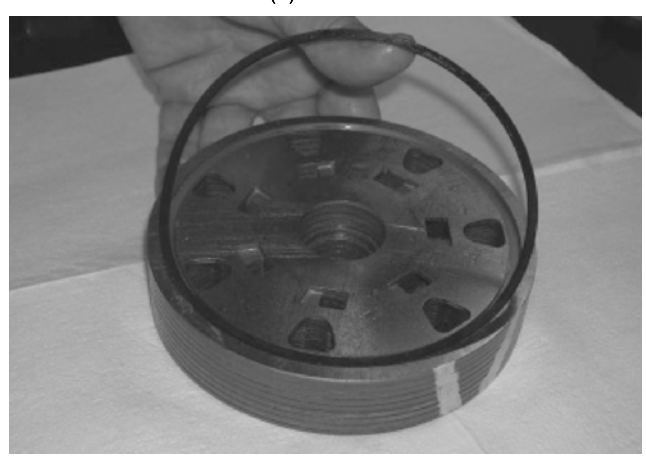
NOTE: *If rotor set is disassembled and cannot be easily reassembled, go to One Piece Stator Assembly, page 3-88 or Two Piece Stator Assembly, page 3-89.*

13. Place assembled rotor set (8) on wear plate (9) with rotor counterbore and seal ring side down and splines into mesh with drive link splines.

NOTE: *It may be necessary to turn one alignment stud out of housing (18) temporarily to assemble rotor set (8) or manifold (7) over drive link.*

NOTE: *Rotor set rotor counterbore side must be down against wear plate for drive link clearance and to maintain original rotor-drive link spline contact. A rotor set without a counterbore that was not etched before disassembly can be reinstalled using drive link spline pattern on rotor splines if apparent, to determine which side was down. Rotor set seal ring groove faces toward wear plate (9).*

14. Apply clean grease to a new seal ring (4) and assemble it in seal ring groove in rotor set contact side of manifold (7).



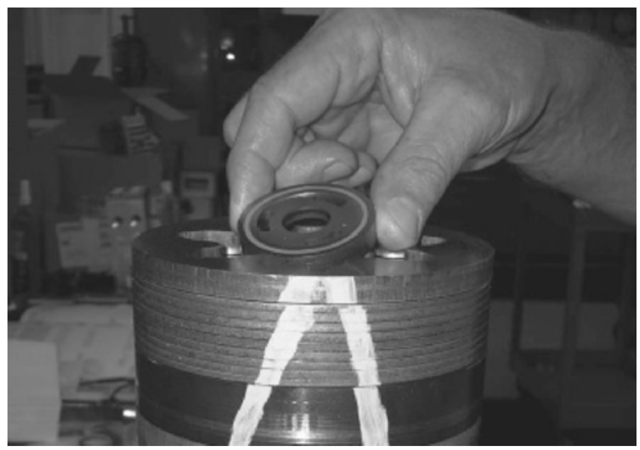
NOTE: *Manifold (7) is made of several permanently bonded plates. Manifold surface that contacts rotor set has a series of irregular shaped cavities on largest circumference or circle around inside diameter. Polished impression left on manifold by rotor set is another indication of which surface must contact rotor set.*

15. Place manifold (7) over alignment studs and drive link (10) and onto rotor set. Be sure correct manifold surface is against rotor set.

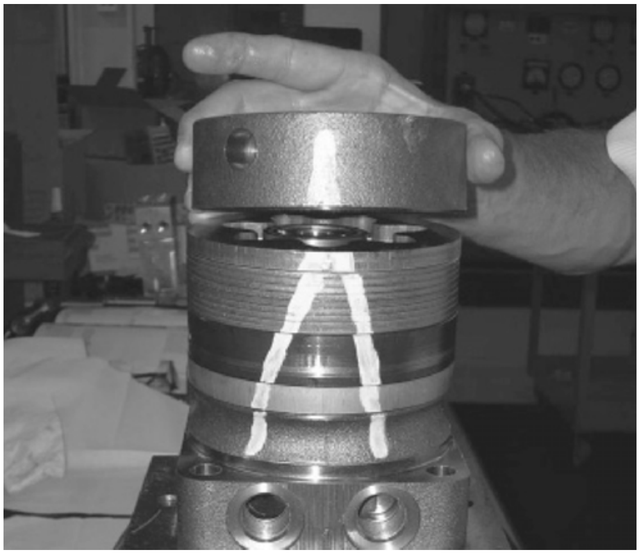
16. Apply grease to new seal ring (4) and insert it in manifold seal ring groove.

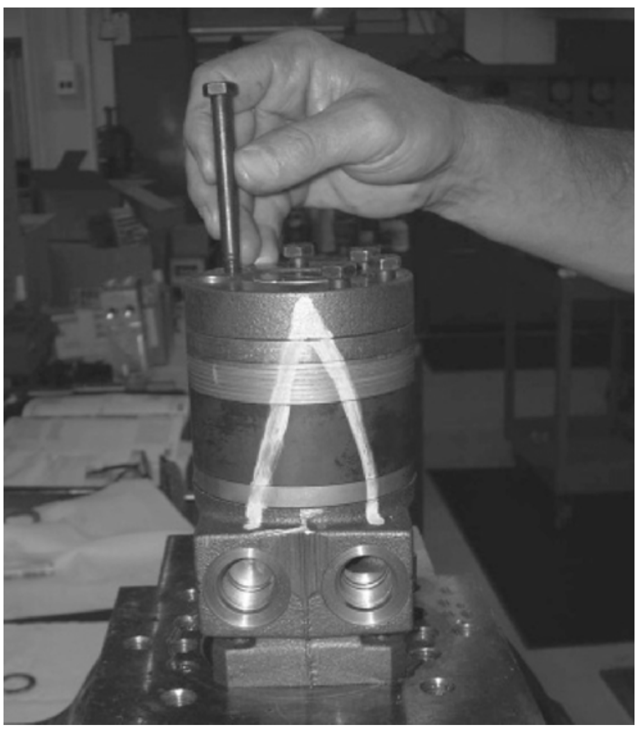
17. Install commutator ring (6) over alignment studs on manifold.

18. Install new seal ring (3) flat side up, into commutator (5). Assemble commutator over end of drive link (10) on manifold (7) with seal ring side up.



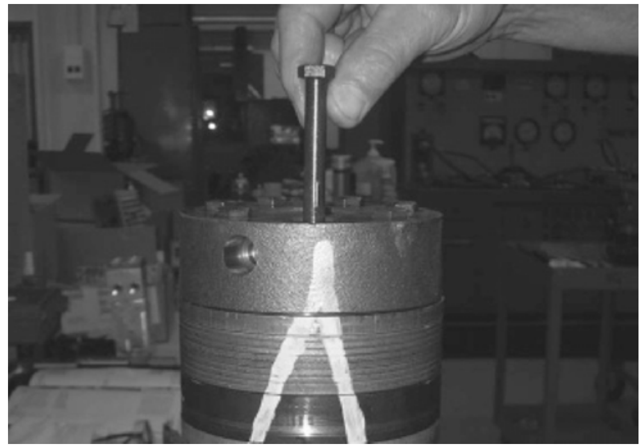
19. Install new seal ring (4) in end cover (2) and install end cover over alignment studs and on commutator set. If end cover has only 5 bolt holes be sure cover holes are aligned with 5 threaded holes in housing (18). Correct 5 bolt end cover bolt hole relationship to housing port bosses is shown:

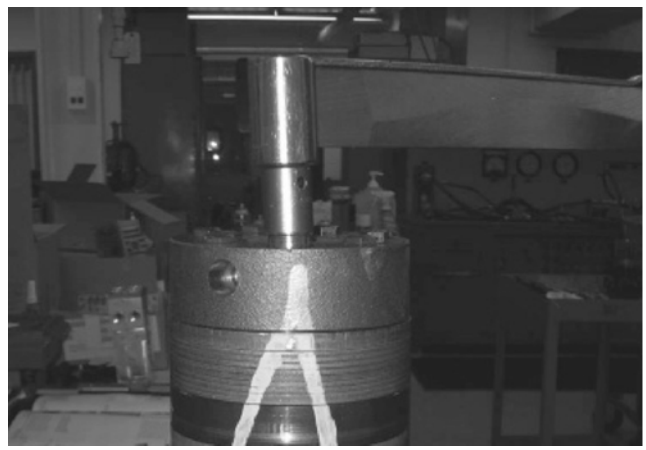


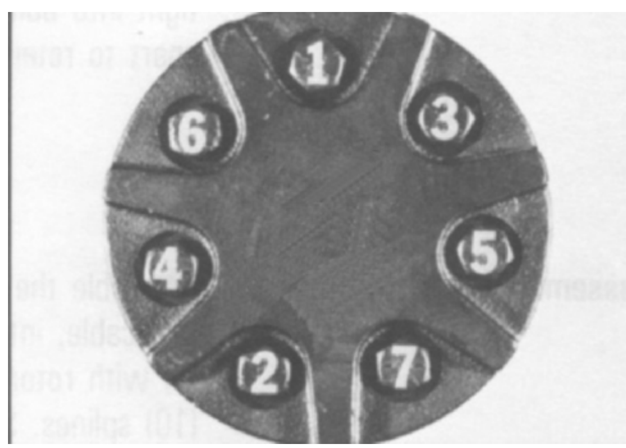


NOTE: *If end cover has a valve (24) or five bolt holes, use line scribed on cover to radially align end cover to its original position.*

20. Assemble bolts (1) and screw in finger tight. Remove and replace two alignment studs with bolts after other bolts are in place. Alternately and progressively tighten bolts to pull end cover and other components into place with a final torque of 25-30 ft-lb (34-41 Nm).







One Piece Stator Assembly

A disassembled rotor stator and vanes that cannot be readily assembled by hand can be assembled using the following procedures:

1. Place stator on wear plate (9) with seal ring (4) side down, after following assembly procedures 1 through 13. Be sure seal ring is in place.

2. If assembly alignment studs are not used, align stator bolt holes with wear plate and housing bolt holes. Turn two bolts (1) finger tight in bolt holes approximately 180 degrees apart to retain stator and wear plate stationary.
3. Assemble rotor, counterbore down if applicable, into stator, and onto wear plate (9) with rotor splines into mesh with drive link (10) splines.

4. Assemble six vanes, or as many vanes that readily assemble in stator vane pockets.

NOTICE

EXCESSIVE FORCE USED TO PUSH ROTOR VANES IN PLACE COULD SHEAR OFF COATING APPLIED TO STATOR VANE POCKETS.

5. Grasp output end of coupling shaft (12) with locking pliers or other appropriate turning device and rotate coupling shaft, drive link and rotor to seat rotor and assembled vanes into stator, creating the necessary clearance to assemble the seventh or full complement of seven vanes. Assemble the seven vanes using minimum force.

Remove two bolts (1) if used to retain stator and wear plate.

Go to Step 14 on page 3-85 to continue assembly.

Two Piece Stator Assembly

A disassembled rotor set (8) that cannot be easily by hand and has a two piece stator, can be assembled using the following procedures:

1. Place stator half on wear plate (9) with seal ring (4) side down, after following motor assembly procedures 1 through 13. Be sure seal ring is in place.
2. Align stator bolt holes with wear plate and housing bolts. Turn two alignment studs finger tight into bolt holes approximately 180 degrees apart to keep stator half and wear plate stationary.
3. Assemble rotor, counterbore down if applicable, into stator half, and onto wear plate (9) with rotor splines into mesh with drive link (10) splines.

NOTE: *Use marking applied to rotor set components to reassemble components in their original relationship to ensure ultimate wear life and performance.*

4. Assemble six vanes, or as many vanes that readily assemble into stator vane pockets.

NOTICE

EXCESSIVE FORCE USED TO PUSH ROTOR VANES IN PLACE COULD SHEAR OFF COATING APPLIED TO STATOR VANE POCKETS.

5. Grasp output end of coupling shaft (12) with locking pliers or other appropriate turning device and rotate coupling shaft, drive link and rotor to seat rotor and assembled vanes (8C) into stator half, creating necessary clearance to assemble seventh or full complement of seven vanes. Assemble the seven vanes using minimum force.
6. Place second stator half on a flat surface with seal ring groove up. Apply a small amount of grease to a new seal ring (4) and install it in stator half ring groove.
7. Assemble second stator half over two alignment studs and rotor with seal ring side down onto the first stator half aligning any timing marks applied for this purpose.

NOTICE

IF STATOR HALF (8B) IS A DIFFERENT HEIGHT (THICKNESS) THAN STATOR HALF (8D) STATOR VANES (8C) OR (8E)OF THE SAME LENGTH (HEIGHT) AS STATOR HALF MUST BE REASSEMBLED IN THEIR RESPECTIVE STATOR HALF FOR ROTOR SET TO FUNCTION PROPERLY.

8. Assemble six vanes, or as many vanes that readily assemble into stator vane pockets.
9. Grasp output end of coupling shaft (12) with locking pliers or other appropriate turning device and rotate coupling shaft, drive link, and rotor to seat rotor and assembled vanes into stator, creating necessary clearance to assemble seventh or full complement of seven vanes. Assemble seven vanes using minimum force.

Go to Step 14 on page 3-85 to continue assembly.

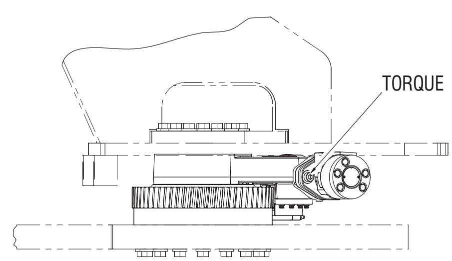
Final Checks

1. Pressurize motor with 100 psi dry air or nitrogen and submerge in solvent to check for external leaks.
2. Check motor for rotation. Torque required to rotate coupling shaft should not be more than 50 ft-lb (68 Nm).
3. Pressure port with “A” cast under it on housing (18) is for clockwise coupling shaft rotation as viewed from the output end of coupling shaft. Pressure port with “B” cast under it is for counter clockwise coupling shaft rotation.
4. Use test stand and check motor operation.

Installation

Refer to Figure 3-55., Swing Motor Removal and Installation.

1. Carefully insert swing motor into swing drive, making sure swing motor shaft key is aligned correctly.
2. Secure swing motor to swing drive assembly with two bolts and flat washers. Apply threadlocker JLG P/N 0100019 to threads of retaining bolts and torque to 85 ft-lb (115 Nm).



3. Connect hydraulic lines running to swing motor as tagged during removal.

3.11 SEMI-TRACK

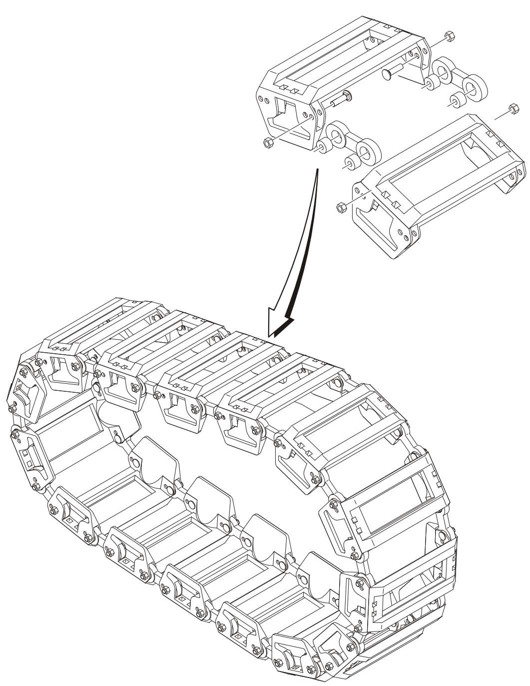
The semi-track option is available in soft or hard tracks and provides increased traction in rough terrain.

Testing

With both sides installed, drive machine slowly in both directions to check track does not catch or hit any part of machine. Test machine until it can be driven at top speed and on side slopes without tracks hitting. Check track frequently first few days after use that all bolts are tight and no damage is being caused to tires or machine.

Removing

If tracks are muddy, wash or drive machine through water before removing. If tracks will be stored in the laid out position just as they come off machine, move machine to storage area to remove tracks. If tracks are going to be rolled up and put on a pallet, it is best to remove them on a hard surface. Remove bolts that hold track together. These bolts are accessible over the front tires. After nuts are removed, pound them flush with pad. Drive machine ahead until bolts are at the bottom between tires. Remove inside bolts by turning them out with a wrench and punch out the outside bolts. Drive machine ahead and take off tracks. If track is to be rolled up, set track on edge and roll it. Secure end of track and put loose hardware in end of track.



Normal Wear

It is normal for the bushing to wear down to the bolt and for the link hole to wear oblong until it is ready to break out the end.

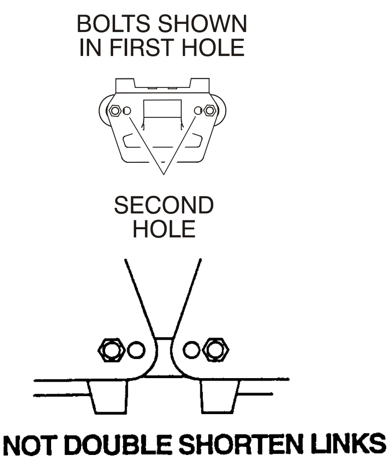
Adjustment

NOTICE

IMPROPER SLACK ADJUSTMENT CAN CAUSE TRACK PARTS TO BREAK.

Place a straight edge long enough to reach from idler to drive wheel on the tracks. Measure maximum amount of track sag from high point of track segment to bottom of straight edge. Properly adjusted track will have 1 to 2 inches (25 to 50 mm) slack. (See Figure 3-57.)

To adjust the slack measurement, move bolts from first hole to the second to create less slack, or from to second to the first to create more slack.



TRACK LINK ADJUSTMENT

Table 3-12.Adjustment Chart

Move	1 Hole	2 Holes	3 Holes	4 Holes	5 Holes	6 Holes	7 Holes	8 Holes	9 Holes	10 Holes	11 Holes	12 Holes
Equals	0.81 in (20.5 mm)	1.62 in (41 mm)	2.43 in (62 mm)	3.25 in (82.5 mm)	4.06 in (103 mm)	4.87 in (124 mm)	5.68 in (144 mm)	6.50 in (165 mm)	7.31 in (186 mm)	8.12 in (206 mm)	8.93 in (227 mm)	9.75 in (248 mm)

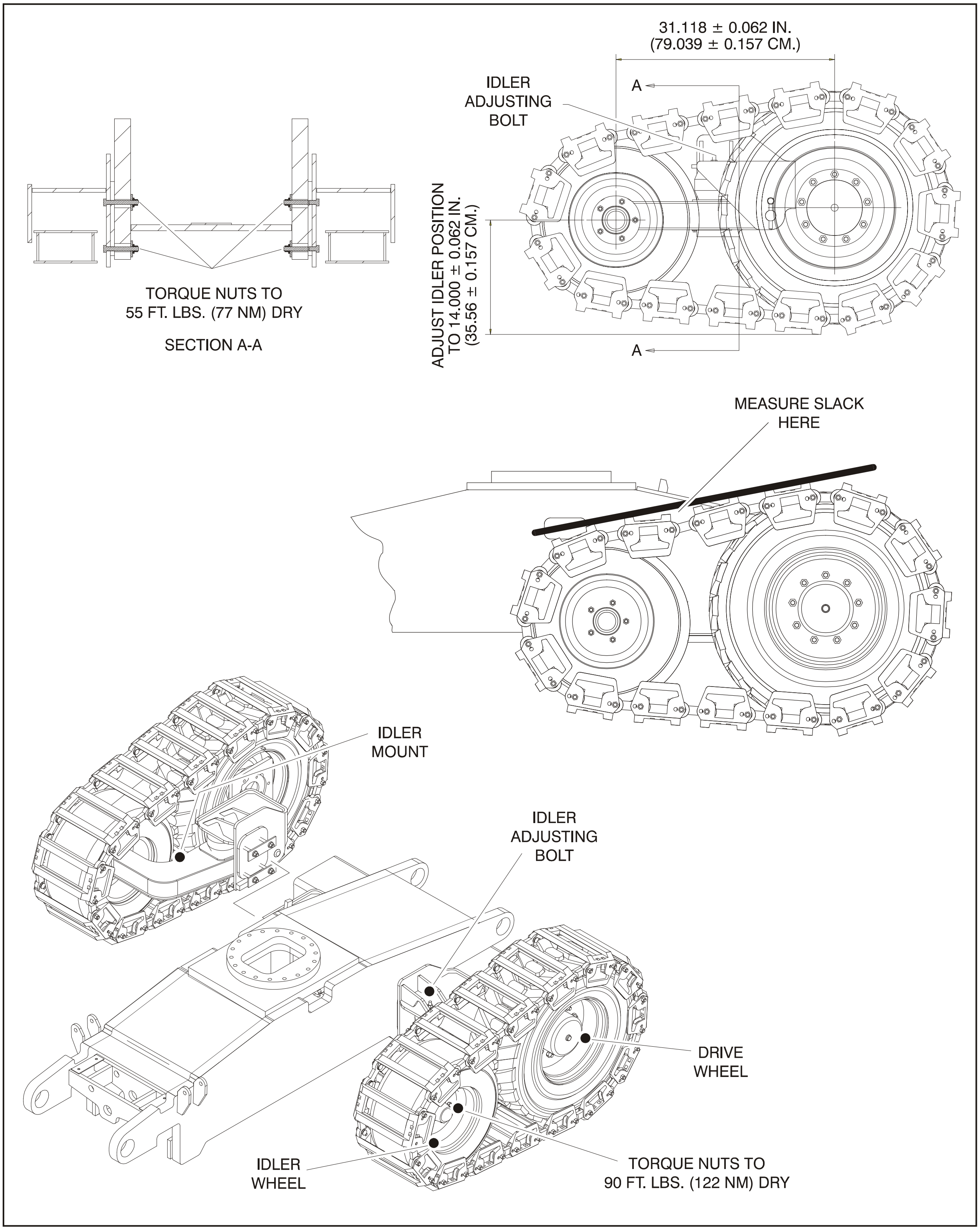


Figure 3-57. Track Adjustment and Installation

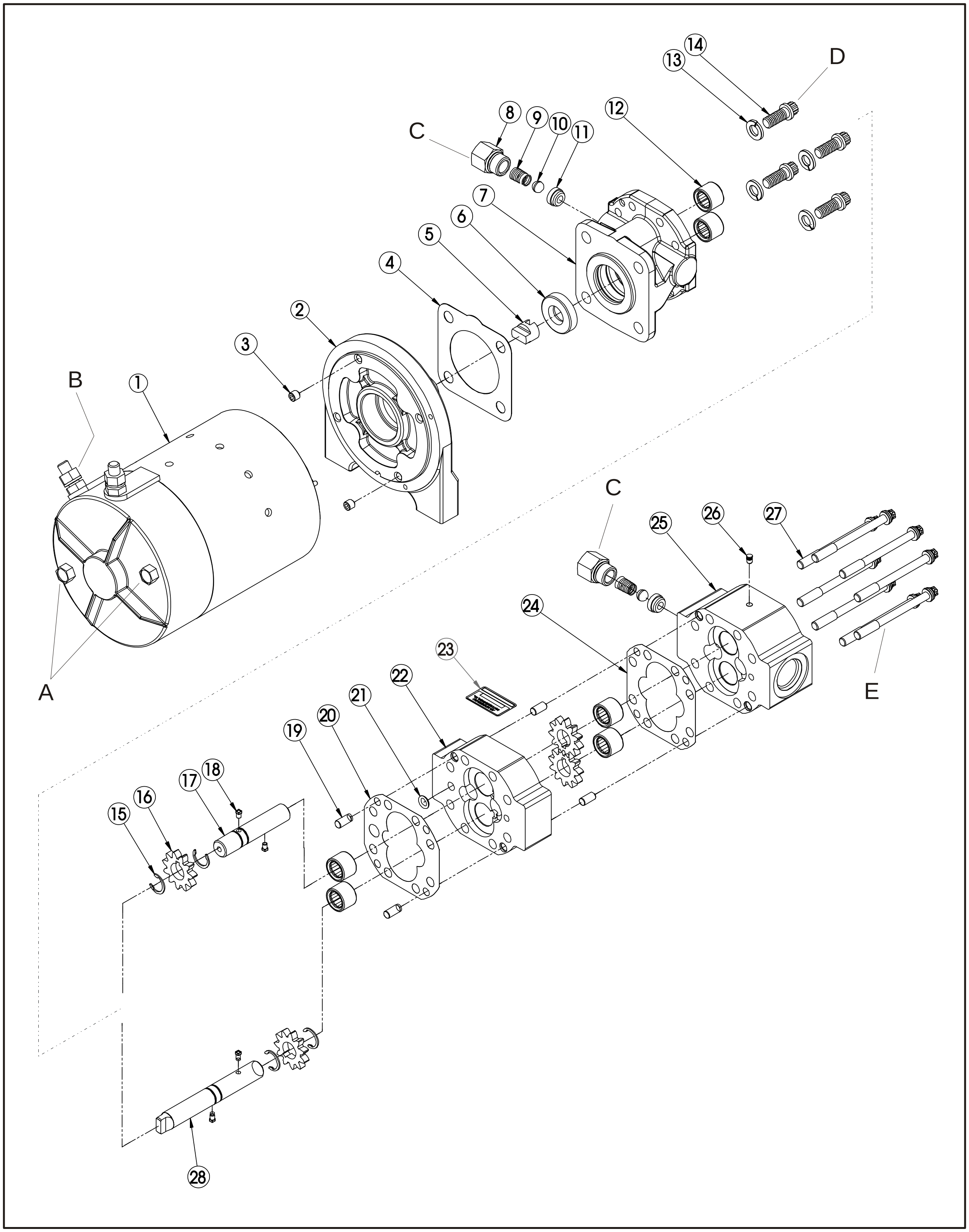


Figure 3-58. Auxiliary Pump - Sheet 1 of 2

1. Motor	11. Seat	21. O-ring
2. Adapter	12. Needle Bearing	22. Gear Housing
3. Setscrew	13. Washer	23. I.D. Label
4. Mounting Gasket	14. Screw	24. Gasket
5. Coupling	15. Retaining Ring	25. Gear Housing
6. Shaft Seal	16. Gear	26. Beta Plug
7. Stator	17. Idler Shaft	27. Screw
8. Cap Assembly	18. Drive Pin	28. Drive Shaft
9. Spring	19. Dowel Pin	29. Plastic Plug
10. Ball	20. Gasket	30. Plastic Plug

A. Torque 96 to 120 inch-pounds (11 to 13.5 Nm)

B. Torque to 84 inch-pounds (9.5 Nm)

C. Torque 144 to 180 inch-pounds (16 to 20 Nm)

D. Torque 180 to 216 inch-pounds (16 to 24 Nm)

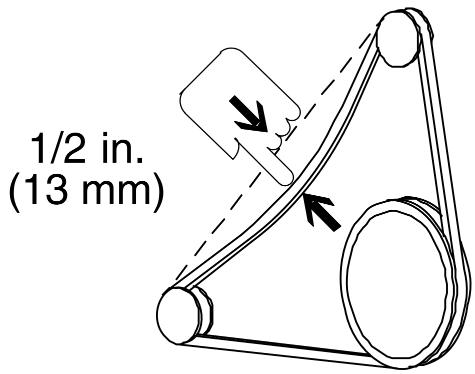
E. Torque 114 to 150 inch-pounds (12 to 17 Nm)

Figure 3-59. Auxiliary Pump - Sheet 2 of 2

3.12 GENERATOR

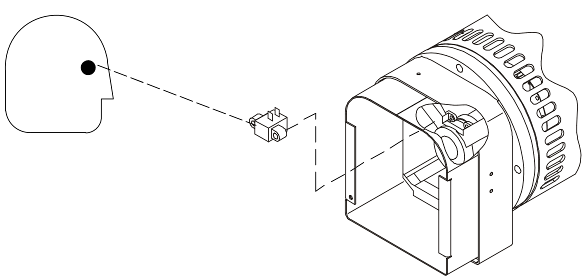
Every 250 hours

Check drive belt for proper tension every 250 hours of operation.

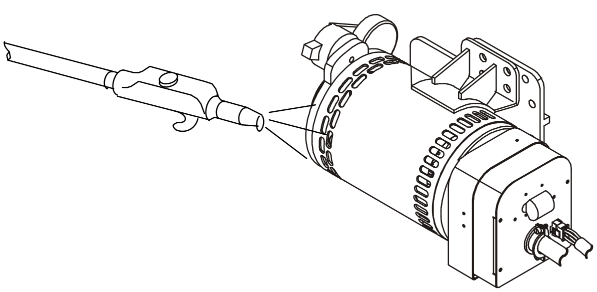


Every 500 hours

Service generator brushes and slip rings every 500 hours of operation. Hostile environments may require more frequent service.



Blow out inside of generator with compressed air every 500 hours of service. Clean monthly If operating in a hostile environment.

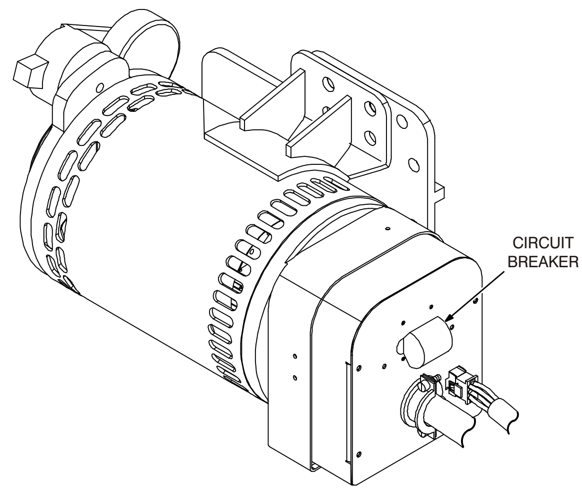


Overload Protection

CAUTION

STOP ENGINE WHENEVER CHECKING OR INSPECTING CIRCUIT BREAKER.

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



Brushes and Slip Rings

Refer to Figure 3-60., Inspecting Generator Brushes, Replacing Brushes, and Cleaning Slip Rings.

INSPECTING BRUSH POSITION

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

INSPECTING BRUSHES

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

Replace brushes if damaged, or at or near minimum length.

CLEANING SLIP RINGS

Visually inspect slip rings. Rings turn dark brown under normal use. If slip rings are corroded or their surface is uneven, remove belt to turn shaft by hand for cleaning.

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

Reinstall belt, brush holder assembly, and end panel.

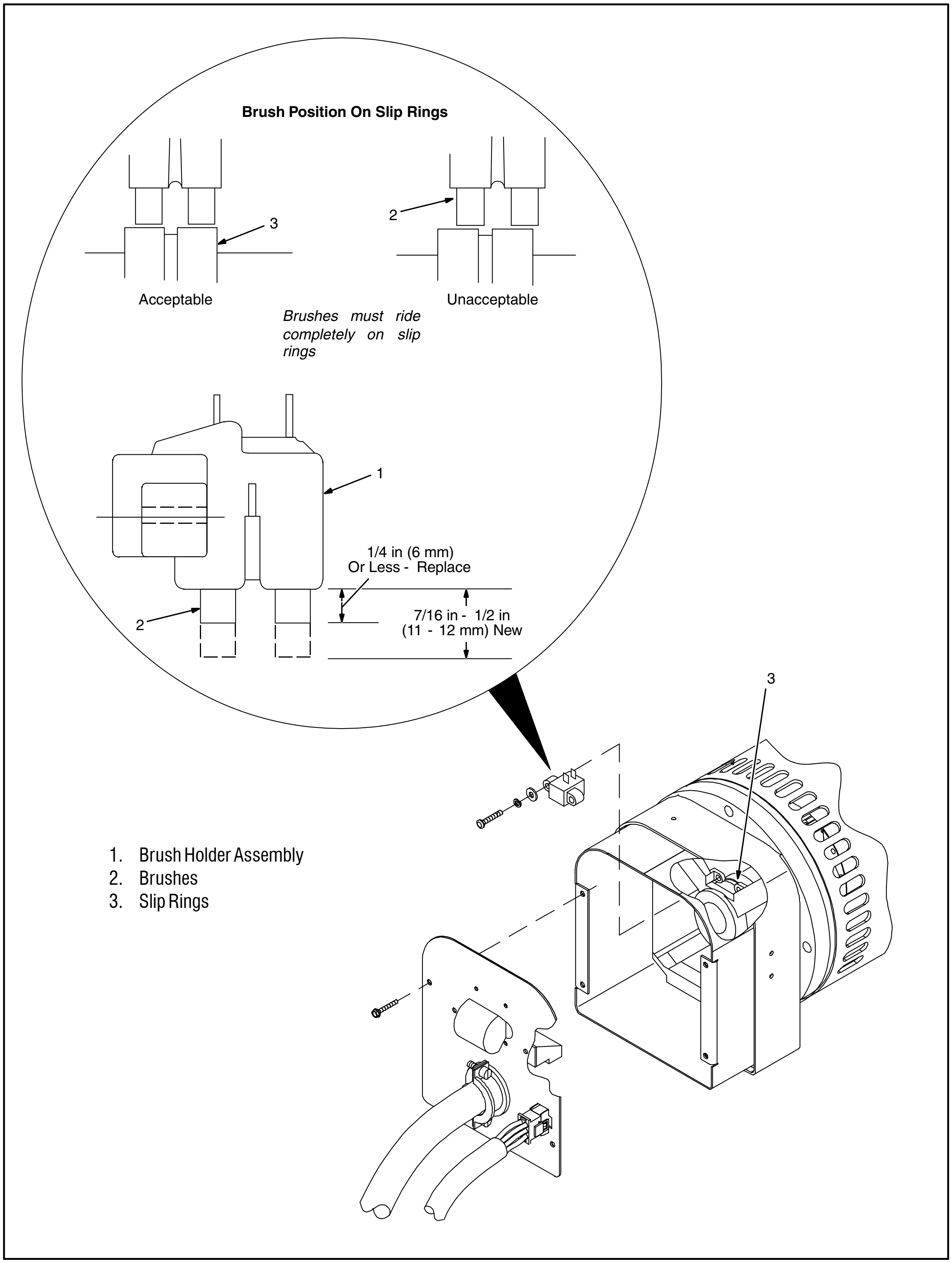


Figure 3-60. Inspecting Generator Brushes, Replacing Brushes, and Cleaning Slip Rings

3.13 FORD EFI ENGINE

Performing Diagnostics

1. Verify complaint and determine if it is a deviation from normal operation.
2. Once complaint is 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 to verify proper system operation. 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 symptom from symptom tables and follow diagnostic path or suggestions to complete repair.
6. After repair has been made and validated for proper operation, temporarily reinstall the old part to verify it was the problem source.

If no matching symptom is available, analyze the complaint and develop a plan for diagnostics using 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 electrical and mechanical loads or accessory equipment is “OFF” or disconnected before performing diagnosis.
- Inspect engine fluids for correct levels and 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 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

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 is displayed on the JLG Control System Analyzer. Refer to Section 6 - JLG Control System

CLEARING TROUBLE CODES

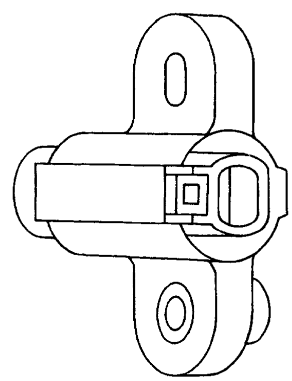
To clear ECM trouble codes, disconnect negative terminal from battery for approximately 15 minutes.

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 and 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 injectors in the proper sequence. The ECM uses the CMP signal to indicate 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 when engine is running, DTC 53 will set. If CMP signal is lost when engine is running, the fuel injection system shifts to a calculated sequential fuel injection mode based on the last fuel injection pulse, and the engine continues to nun. As long as the fault is present, the engine can be restarted. It will run in the previously established injection sequence.

Table 3-13. ECM Diagnostic Trouble Codes

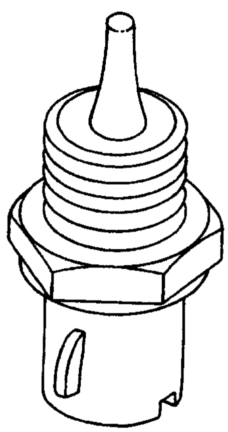
Diagnostic Trouble Code	Description
0,11	All Systems OK
12	Throttle Position (TP) Sensor Low Voltage
13	Hand Throttle Low Voltage
14	Manifold Absolute Pressure (MAP) Low Voltage
15	Manifold Surface Temperature (MST) Low Voltage
21	Overspeed
22	Throttle Position (TP) Sensor High Voltage
23	Hand Throttle High Voltage
24	Manifold Absolute Pressure (MAP) High Voltage
25	Manifold Surface Temperature (MST) High Voltage
26	Initial Throttle Position Sensor (TPS) High Voltage
31	Fuel Pump Low Voltage
32	Heated Oxygen Sensor (HEGO1) Low Voltage
33	Engine Coolant Temperature (ECT) Sensor High Voltage
34	Heated Oxygen Sensor (HEGO2) Low Voltage
35	Intake Air Temperature (IAT) Sensor High Voltage
36	Heated Oxygen Sensor (HEGO1) Inactive
41	Fuel Pump High Voltage
42	Heated Oxygen Sensor (HEGO1) High Voltage
43	Engine Coolant Temperature (ECT/CHT) Sensor Low Voltage
44	Heated Oxygen Sensor (HEGO2) High Voltage
45	Intake Air Temperature (IAT) Sensor Low Voltage
46	Heated Oxygen Sensor (HEGO2) inactive
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
57	Engine Control Module (ECM) communications error
61	System Voltage Low
62	System Voltage High
63	Rev Limit Exceeded
64	Adaptive fuel coefficient saturated

NOTE: *Critical Codes are numbered in* **bold** *and* **underlined.**

ENGINE COOLANT TEMPERATURE (ECT) SENSOR

The Engine Coolant Temperature (ECT) sensor is a 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, temperature should rise steadily to about 85°C (185°F), then stabilize when the thermostat opens. If engine has not been run for several hours (overnight), engine coolant temperature and intake air temperature displays should be close to each other. A fault in the engine coolant sensor circuit sets 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 located within the ECM. The EEPROM contains program and calibration information needed to control engine operations. If replaced, the new ECM must be programmed. An IBM-compatible computer and software containing the correct program and calibration for the application are required to program the ECM.

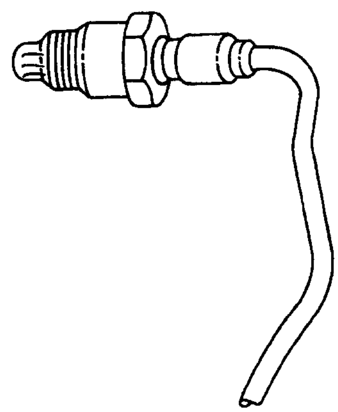
HEATED OXYGEN SENSOR

The heated oxygen sensor is mounted in the exhaust stream to monitor exhaust gas oxygen content. Oxygen 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. Heated oxygen sensor voltage can be monitored on an IBM PC-compatible computer with diagnostic software. By monitoring oxygen sensor voltage output, the ECM calculates the pulse width command for injectors to produce proper combustion chamber mixture.

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

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

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



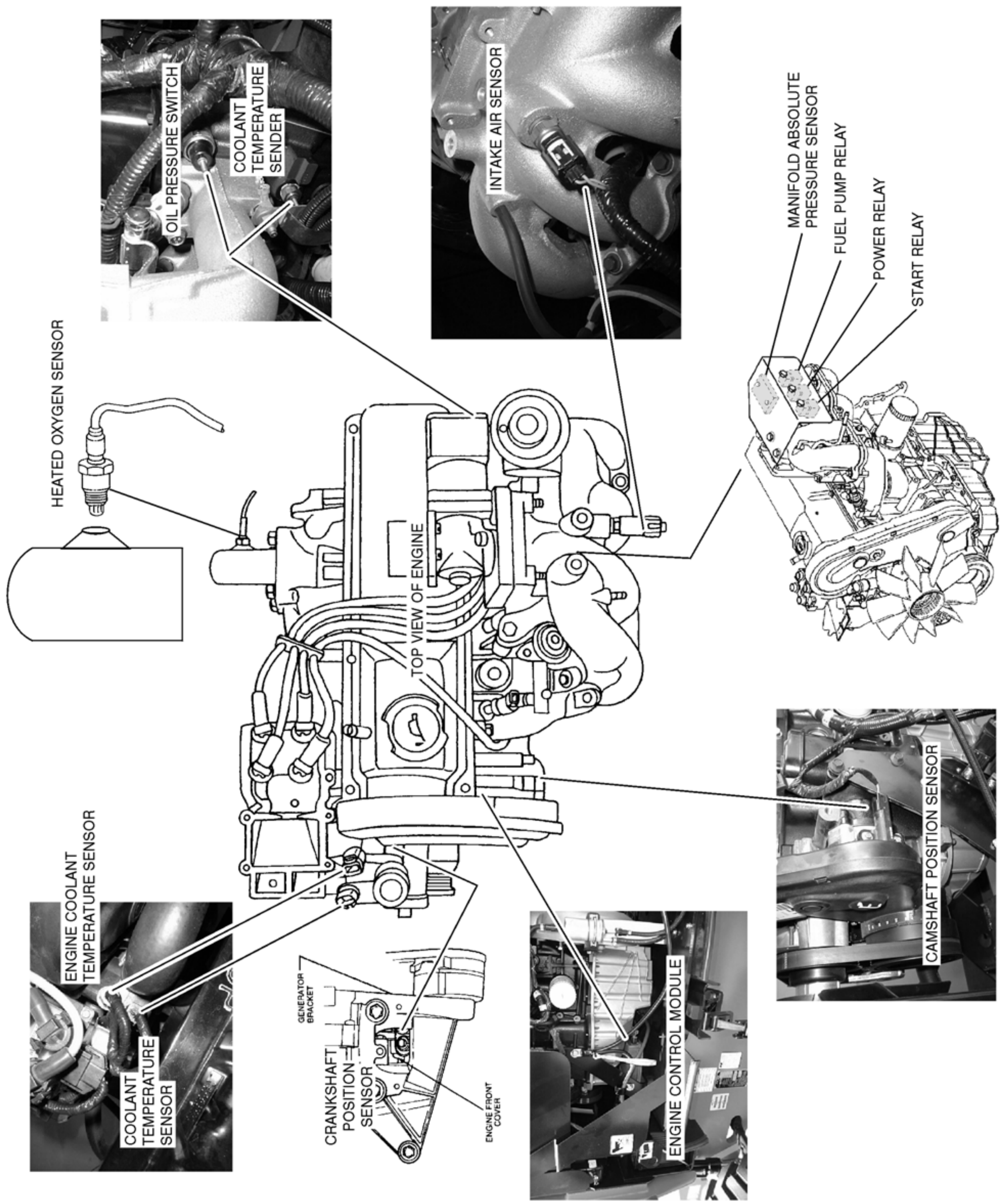
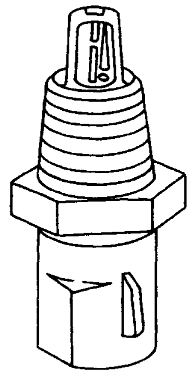


Figure 3-61. EFI Component Location

Intake Air Temperature (IAT) Sensor



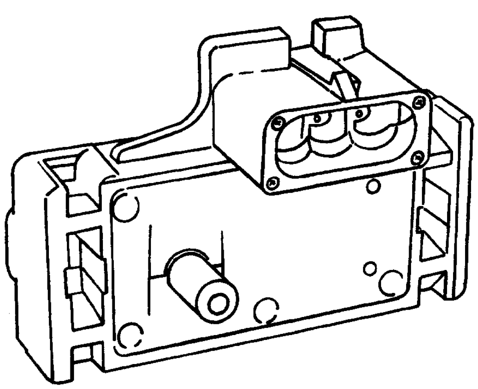
The intake air temperature (IAT) sensor is a thermistor which changes resistance based on temperature of air entering the engine. Low temperature produces a high resistance of 100,000 ohms at -40°C (-40°F). High temperature causes a low resistance of 70 ohms at 130°C (266°F). The ECM supplies a 5-volt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

Manifold Absolute Pressure (MAP) Sensor

The Manifold Absolute Pressure (MAP) sensor responds to changes in intake manifold pressure (vacuum). MAP sensor signal voltage to ECM varies from below 2 volts at idle (high vacuum) to above 4 volts with ignition ON, engine not running, or at wide-open throttle (low vacuum). The MAP sensor determines:

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

If the ECM detects a voltage 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)

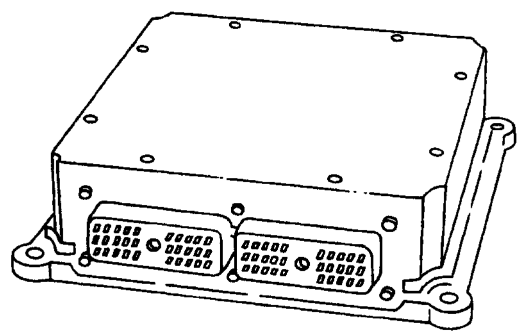
The ECM controls the following:

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

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

The ECM supplies 5 or 12 volts to power various sensors or switches. Power is supplied through resistances in the ECM which are so high in value 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 fuel injectors, electronic governor, etc., by controlling ground or power feed circuits 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 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

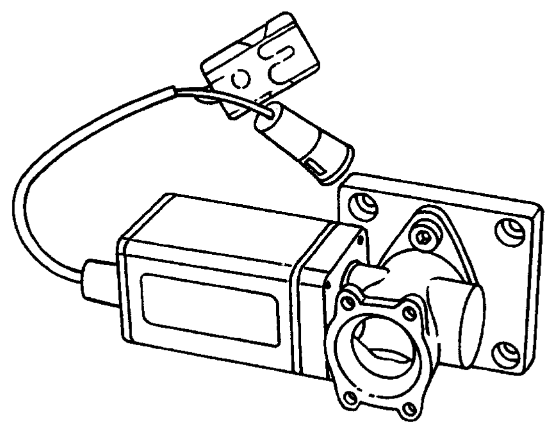
The ECM is designed to withstand normal current draws associated with engine operation. When servicing the ECM, observe the following guidelines:

- Do not overload any circuit.
- Do not probe wires for testing. This can cause a voltage drop that affects ECM operation.
- 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 can damage electronic components.
- Do not use non-standard practices such as charging the battery with an arc welder.
- Take 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 signal line voltage and calculates throttle position. The TP sensor signal changes as the throttle valve angle is changed, At a closed throttle position, TP sensor output is low. As the throttle valve opens, output increases so that at wide open throttle (WOT), 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 DTC 12 or DTC 22 are set, the throttle is forced to a 6% (idle) position.



3.14 CIRCUIT TESTING TOOLS

NOTICE

DO NOT USE A TEST LIGHT TO DIAGNOSE ENGINE ELECTRICAL SYSTEMS UNLESS SPECIFICALLY INSTRUCTED. A TEST LIGHT CAN PUT AN EXCESSIVE LOAD ON AN ECM CIRCUIT AND CAUSE COMPONENT DAMAGE. ONLY USE A DIGITAL VOLTMETER WITH AN INPUT IMPEDANCE OF AT LEAST 10 MEGOHMS FOR VOLTAGE MEASUREMENTS.

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 are 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.

Follow these guidelines to prevent possible electrostatic discharge damage:

- Do not touch 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 package to a known good ground on equipment.
- If 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 part.

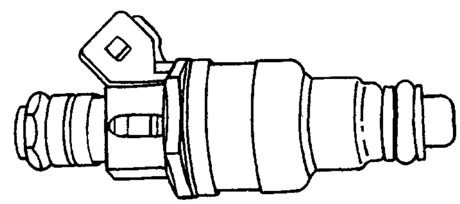
Fuel System

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.

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

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



FUEL METERING SYSTEM COMPONENTS

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

- Fuel injectors
- Fuel rail
- Fuel pressure regulator/filter assembly
- Electronic governor
- ECM
- Crankshaft position (CKP) sensor
- Camshaft position (CMP) sensor
- Fuel pump
- Fuel pump relay

BASIC SYSTEM OPERATION

The fuel metering system starts with fuel in the fuel tank. Fuel is drawn to the fuel pump through a pre-filter. The electric fuel pump then delivers fuel to the fuel rail through an inline fuel filter. The pump is designed to provide fuel at a pressure above 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.

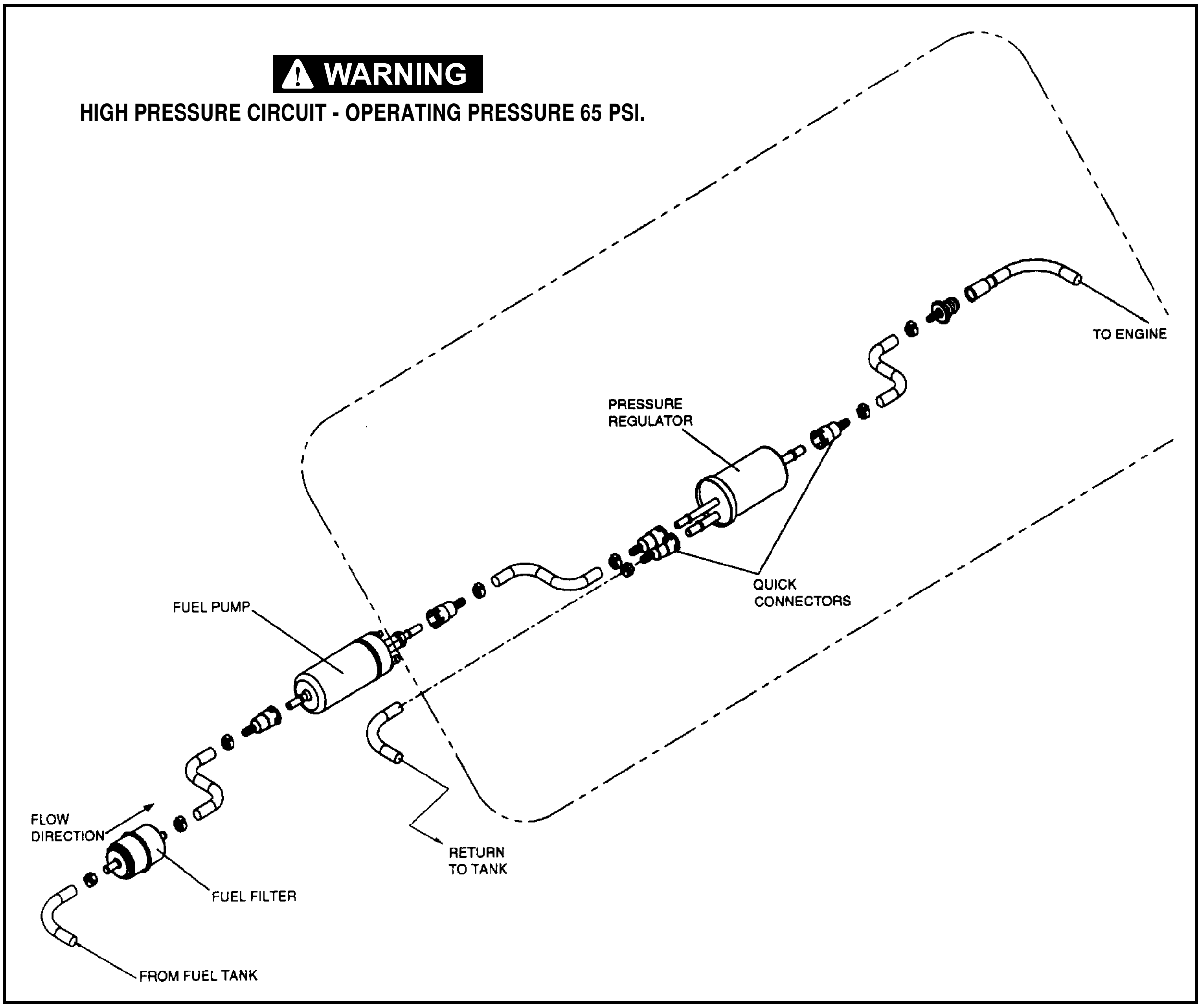


Figure 3-62. Typical Fuel System

FUEL METERING SYSTEM PURPOSE

The basic function of the air/fuel metering system is to control 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 air/fuel ratio to the engine by controlling the amount of time 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 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.

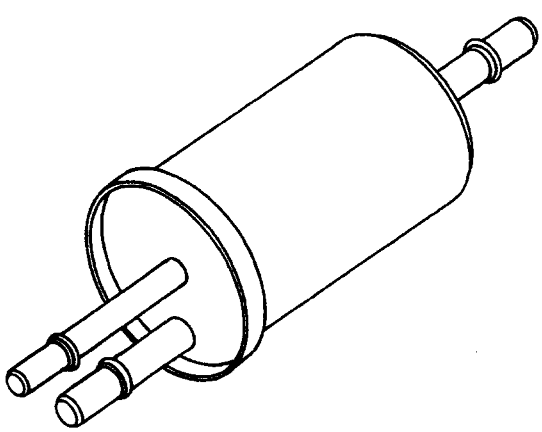
FUEL PRESSURE REGULATOR

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

NOTICE

USE AN IDENTICAL FILTER/REGULATOR ASSEMBLY WHEN REPLACING THE FUEL FILTER. A STANDARD FUEL FILTER DOES NOT REGULATE PRESSURE AND COULD CAUSE ENGINE PROBLEMS OR COMPONENT DAMAGE.



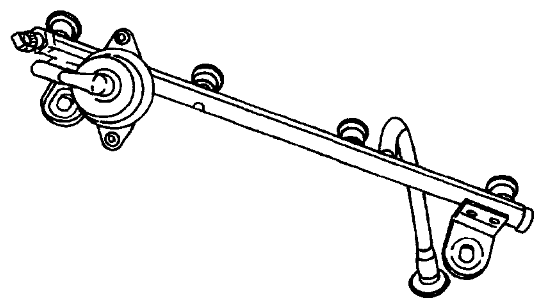
FUEL PUMP ELECTRICAL CIRCUIT

When key is first turned “ON,” the ECM energizes the fuel pump relay for two seconds to build up fuel pressure quickly. If engine is not started within two seconds, the ECM shuts the fuel pump off and waits until engine is cranked. When 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 causes poor performance.

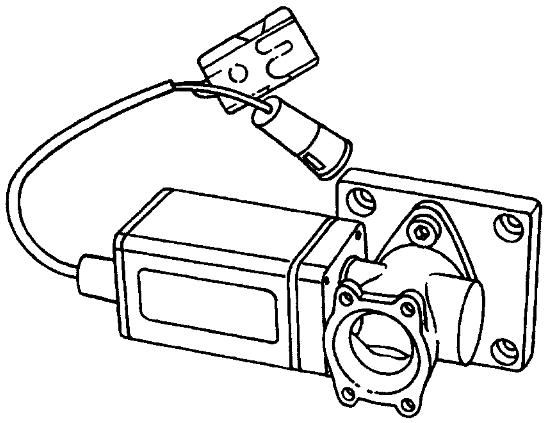
FUEL RAIL

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



ELECTRONIC GOVERNOR AND THROTTLE BODY

In the 2.5L EFI industrial engine, throttle control is achieved by using an electronic governor 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 throttle signal from ECM to governor. Engine speeds are stored in the configuration program for each specific application, and can be changed with ECM calibration software. When 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 that 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 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 operates 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 heated oxygen sensor (HO2S) signal. it uses a pre-programmed routine to calculate air/fuel ratio based on inputs from the TP, ECT, and MAP sensors.

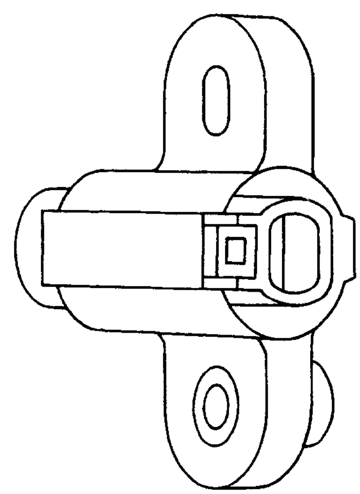
The system remains in open loop until the following conditions are met:

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

After these conditions are met, the engine is operating in “closed loop.” In closed loop, The ECM continuously adjusts 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 enriches the mixture by increasing fuel injector “on” time. When the HO2S reports a rich condition (high sensor signal voltage) the ECM leans out the mixture by reducing fuel injector “on” time.

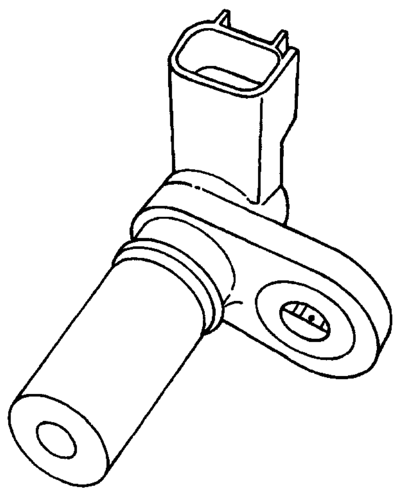
CAMSHAFT POSITION (CMP) SENSOR

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 reference pulses which the ECM uses to calculate RPM and crank-shaft position.



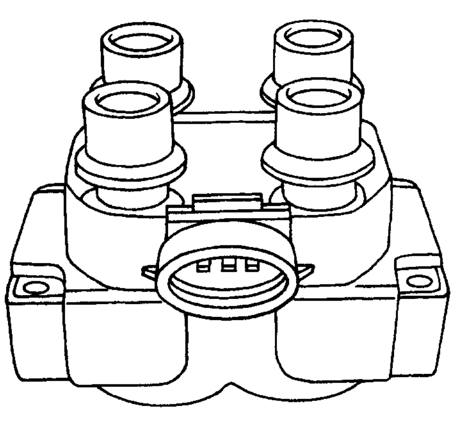
ELECTRONIC IGNITION

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

IGNITION COIL

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

Primary coils in the coil pack are triggered by "Ignition Coil Feed #1" and "Ignition Coil Feed #2" ECM signals.



3.15 DEUTZ ENGINE

NOTE: *Refer to engine manufacturer's manual for detailed operating and maintenance instructions.*

Checking Oil Level

1. Make sure machine and engine are level and switch engine OFF before checking oil level.
2. Remove oil dipstick and wipe with clean cloth.
3. Insert dipstick to the stop and remove again.
4. Check oil level. Top oil level to MAX mark with an approved grade and type of oil outlined in engine manufacturer's operator's manual.
5. Replace dipstick until fully seated.

Changing Engine Oil

1. Allow engine to warm up. Engine oil should reach approximately 176° F (80° C).
2. Make sure machine and engine are level and switch off engine.
3. Place oil tray under engine.

⚠ CAUTION

HOT ENGINE OIL CAN CAUSE BURNS. AVOID CONTACT WITH HOT OIL WHEN DRAINING.

NOTICE

COLLECT USED OIL IN A CONTAINER SUITABLE FOR DISPOSAL OR RECYCLING. DISPOSE OF USED ENGINE OIL IN ACCORDANCE WITH ENVIRONMENTAL REGULATIONS.

4. Open oil drain valve and drain oil.
5. Close oil drain valve.
6. Pour in new engine oil. Refer to Section 1 for capacity and refer to Figure 3-63., Engine Oil Viscosity.

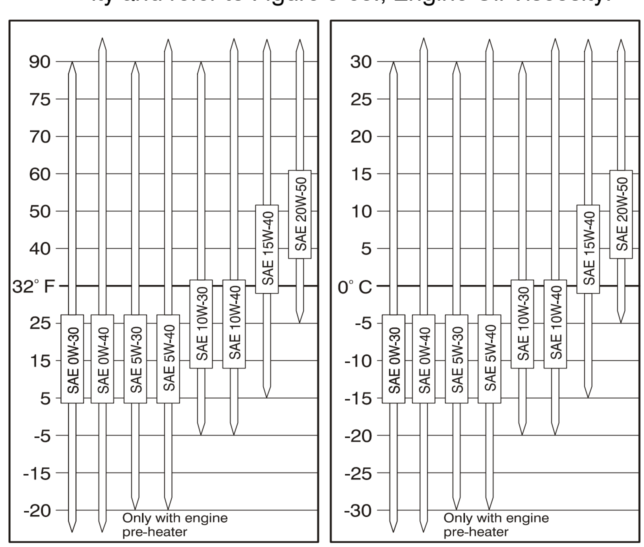
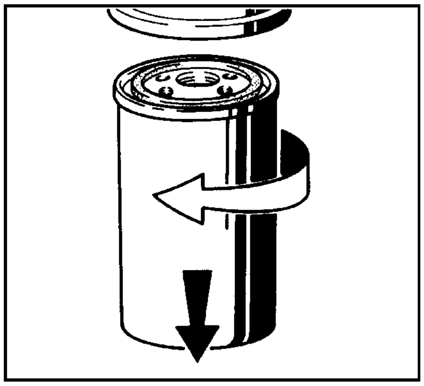


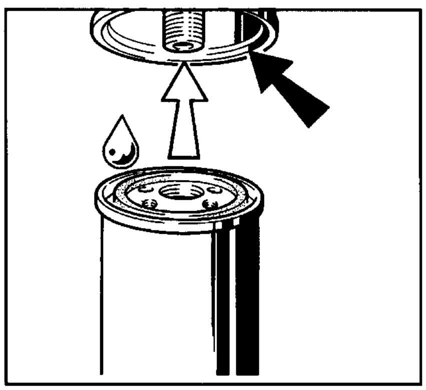
Figure 3-63. Engine Oil Viscosity

Changing Oil Filter

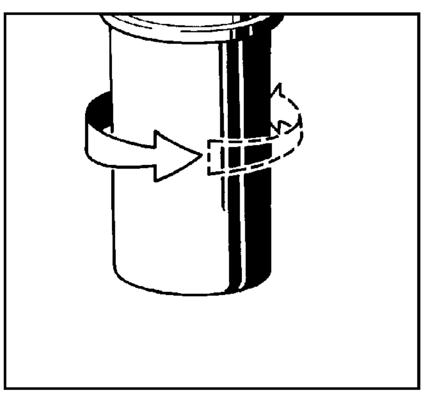
1. Wipe area around filter to clean any dirt from area.
2. Using a suitable oil filter removal tool, loosen lube oil filter cartridge and spin off.



3. Catch any escaping oil.
4. Clean any dirt from filter carrier sealing surface.
5. Lightly coat new oil filter rubber gasket with clean oil.



6. Screw in new filter by hand until gasket is flush.



7. Hand-tighten filter another half-turn.
8. Check oil level.
9. Check oil pressure.
10. Check oil filter cartridge for leaks.

Replacing Fuel Filter

WARNING

MAKE SURE THERE ARE NO OPEN FLAMES OR SPARKS IN THE AREA WHEN WORKING ON FUEL SYSTEM. DO NOT SMOKE WHEN WORKING ON FUEL SYSTEM.

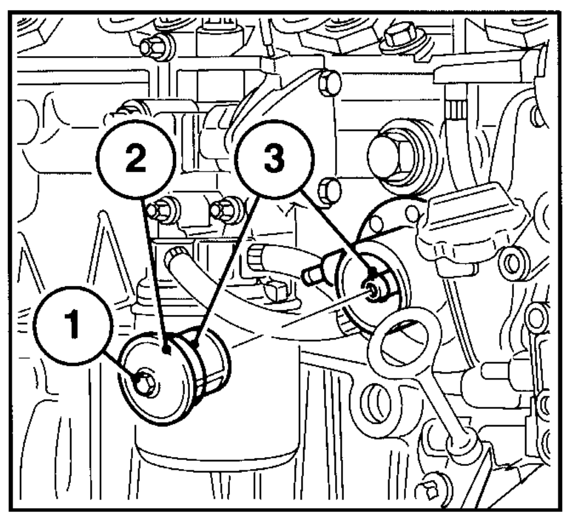
1. Wipe area around filter to clean any dirt from area.
2. Undo fuel filter cartridge and spin off.
3. Catch any escaping fuel.
4. Clean any dirt from filter carrier sealing surface.
5. Apply a light film of oil or diesel fuel to rubber gasket of new filter cartridge.
6. Screw in new filter by hand until the gasket is flush.
7. Hand-tighten filter another half-turn.
8. Open fuel shut-off valve.
9. Check for leaks.

Cleaning Fuel Strainer

WARNING

FUEL IS FLAMMABLE. MAKE SURE THERE ARE NO OPEN FLAMES OR SPARKS IN THE AREA WHEN WORKING ON FUEL SYSTEM. DO NOT SMOKE WHEN WORKING ON FUEL SYSTEM.

1. Unscrew hexagonal nut (1).



2. Remove fuel strainer cover (2).
3. Clean fuel strainer with diesel fuel and replace if necessary.
4. Place seal (3) in position.
5. Install fuel strainer cover (2) in position and tighten hexagonal screw (1).
6. Check for leaks.

3.16 DEUTZ EMR 2 (S/N 85332 TO PRESENT)

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

Engine sensors provide control unit electronics with information of the current condition of engine and preconditions (throttle position etc.). The EMR2 controls an actuator that operates the injection pump control rod and adjusts fuel quantity to meet performance requirements.

Regulating rod position is reported back and corrected by the control rod travel sensor, situated together with rotation magnets in the actuator housing.

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

To switch 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 to 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 programming over the ISO9141 interface, the EMR2 possesses a motor-specific data set matched by serial number to the engine. Modules cannot be swapped between engines.

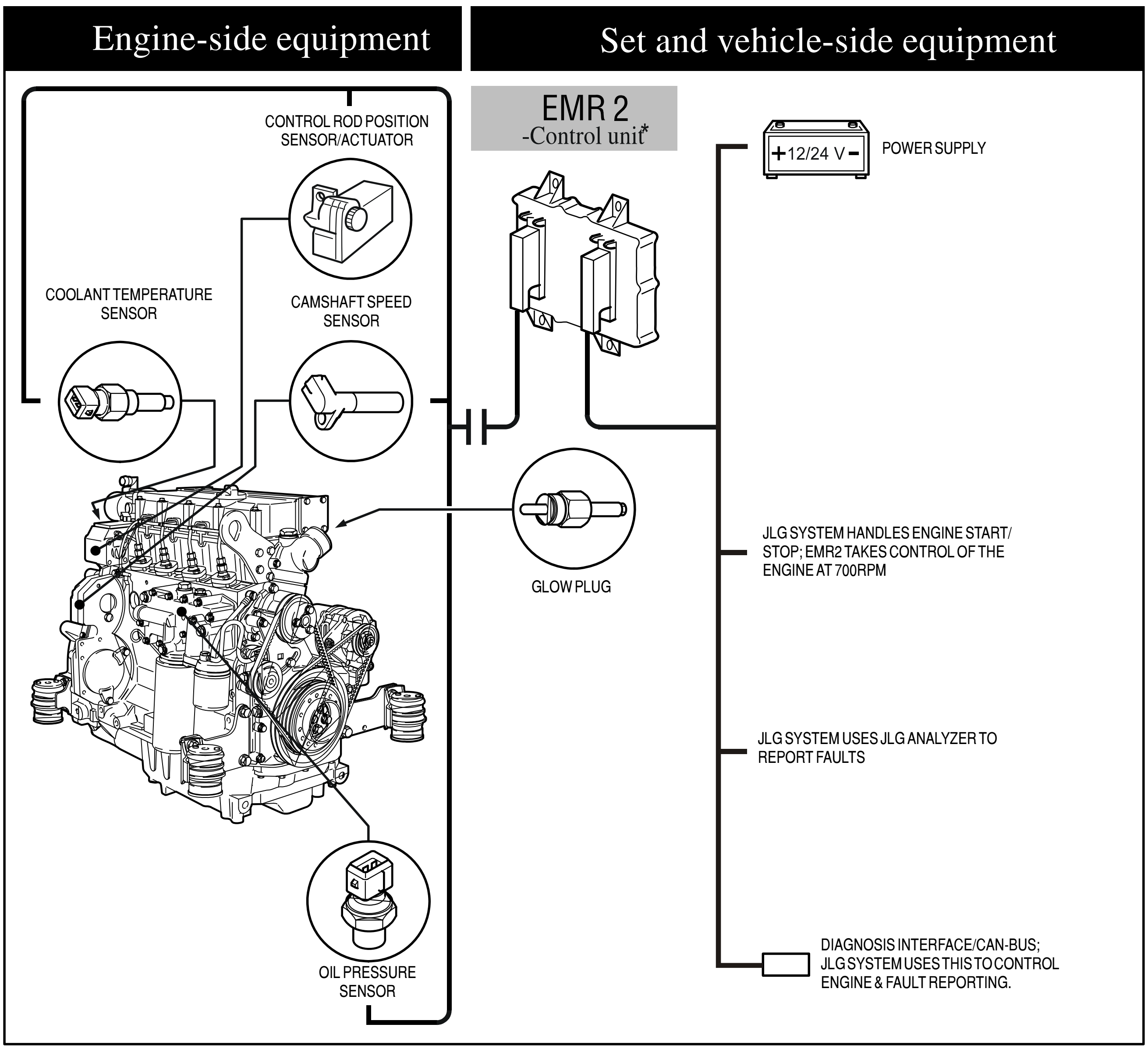


Figure 3-64. EMR 2 Engine Side Equipment

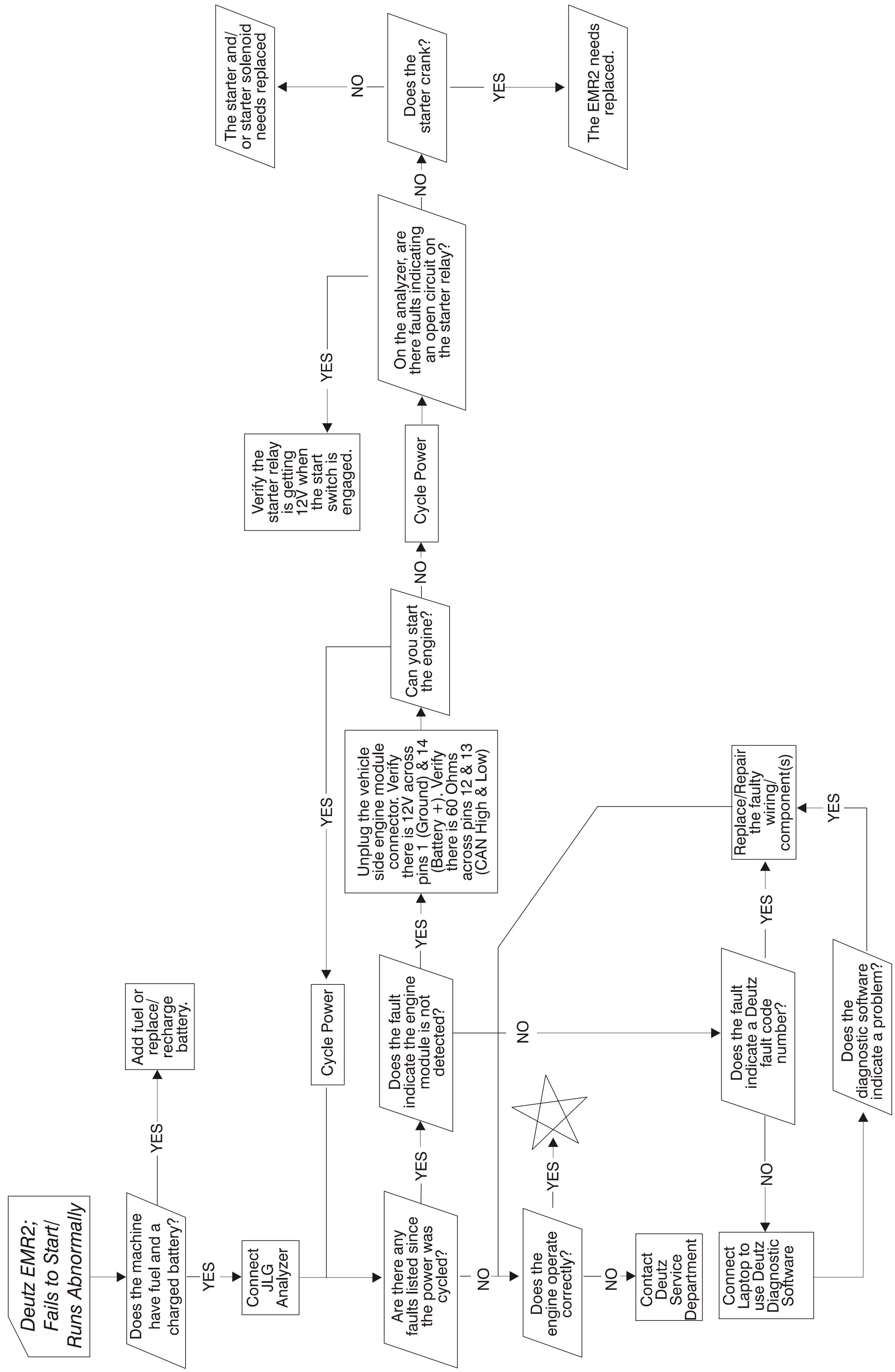


Figure 3-65. Deutz EMR 2 Troubleshooting Flow Chart

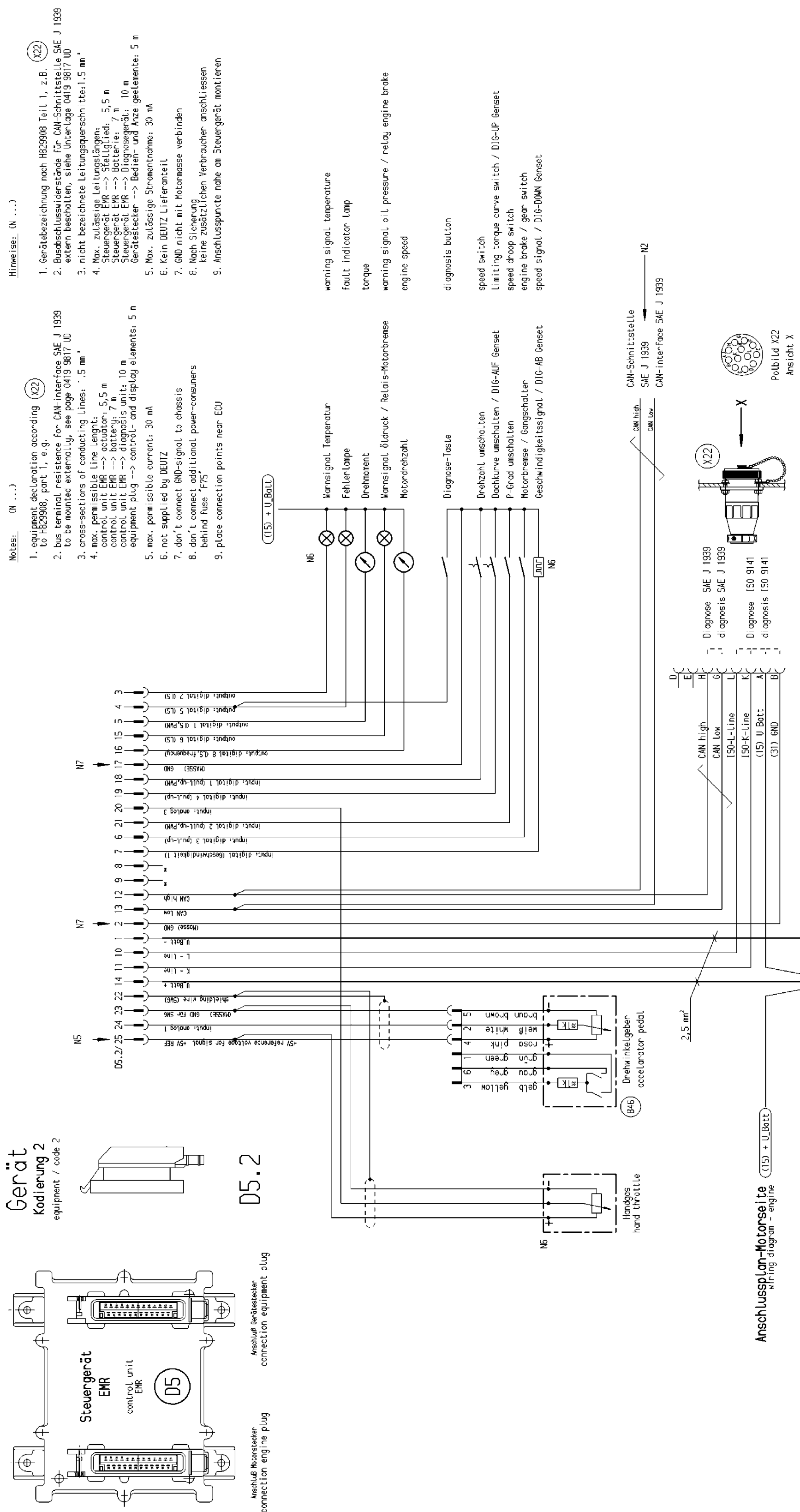


Figure 3-66. Deutz EMR 2 Vehicle Side Connection Diagram

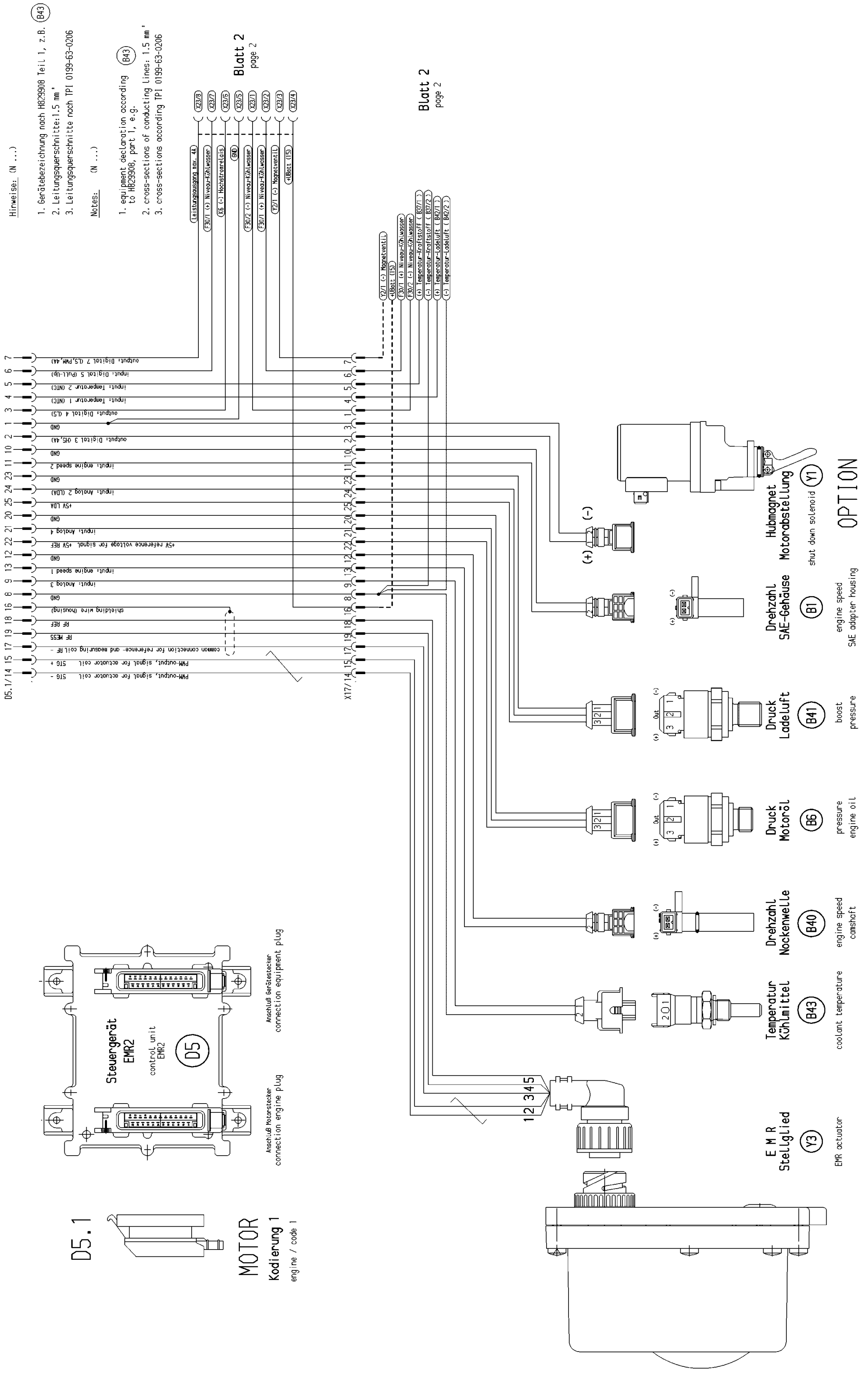


Figure 3-67. Deutz EMR 2 Engine Side Connection Diagram - Sheet 1 of 2

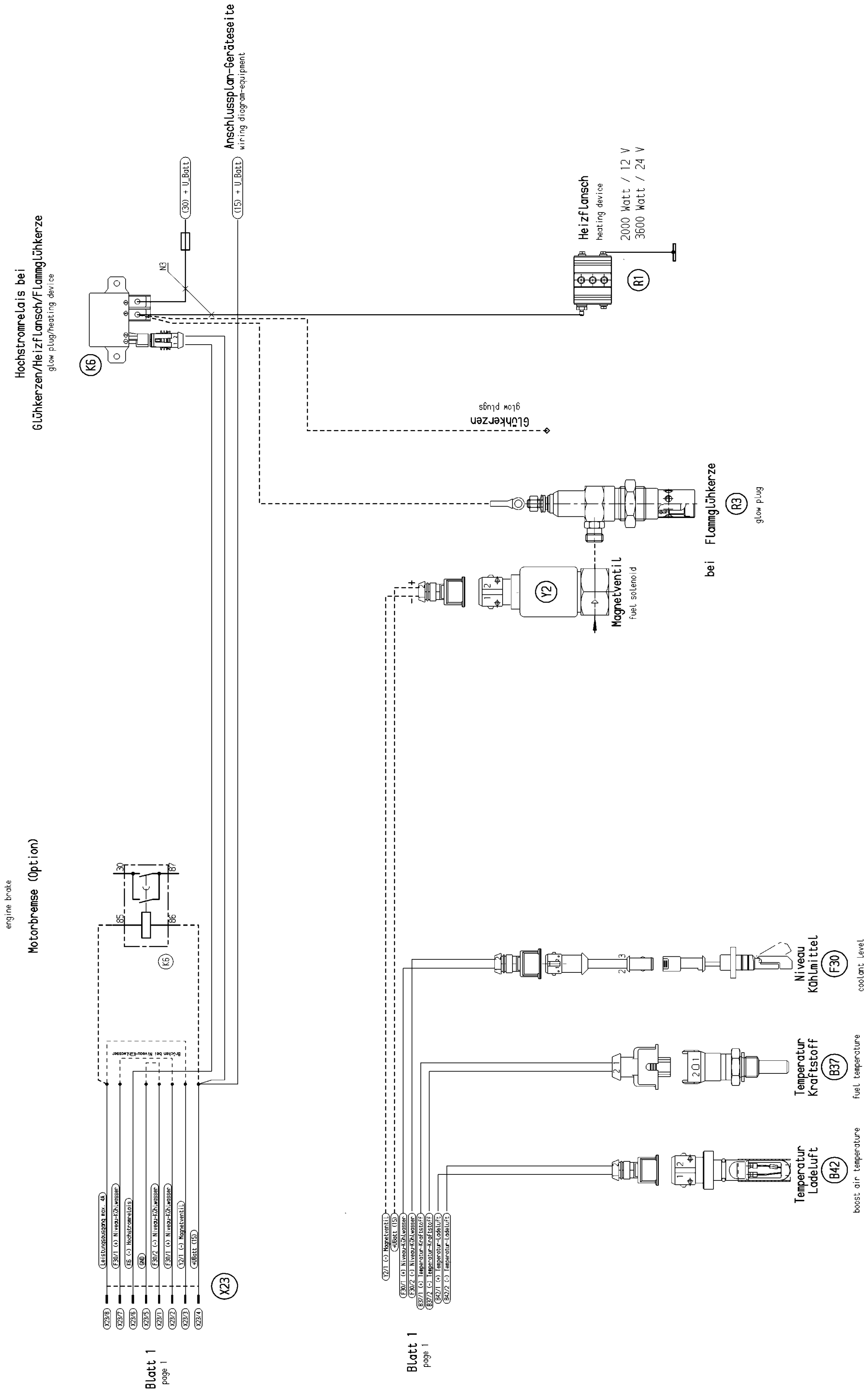
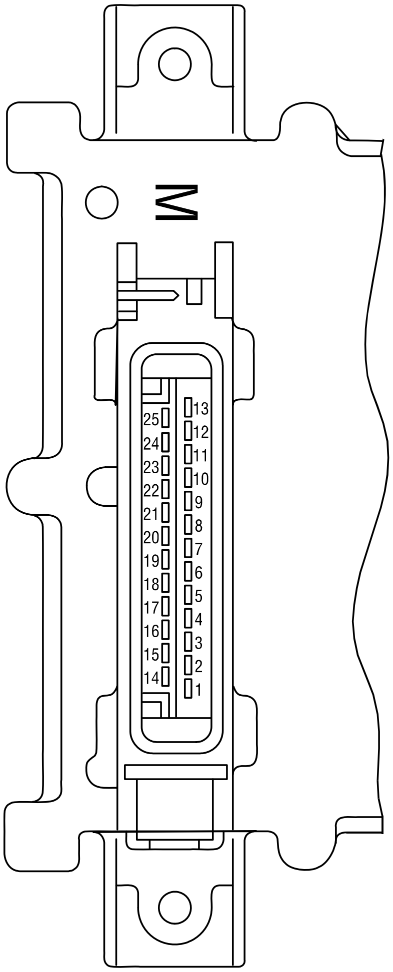


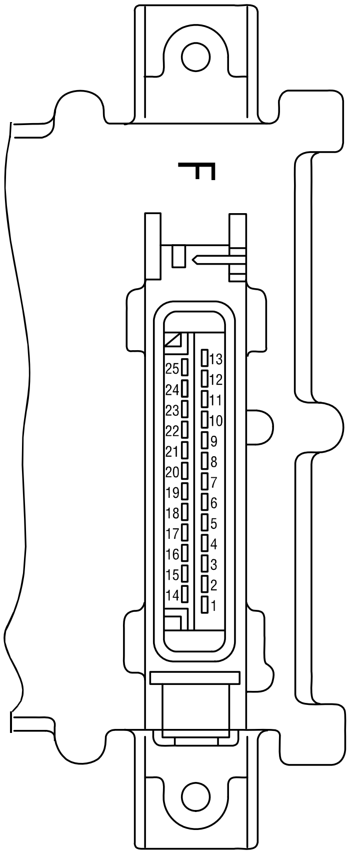
Figure 3-68. Deutz EMR 2 Engine Side Connection Diagram - Sheet 2 of 2



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 3-69. 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 3-70. 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. 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.	Engine stop.	Check parameter (21). Check speed settings.
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 3-71. 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 3-72. 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 3-73. 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 3-74. 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 3-75. EMR2 Fault Codes - Sheet 5 of 5

3.17 GM ENGINE GENERAL MAINTENANCE

Drive Belt Maintenance

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

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

Engine Electrical System Maintenance

The engine electrical system uses computers and microprocessors to control engine ignition, fuel control, and emissions. Periodic inspection of electrical wiring is required due to sensitivity of computers to good electrical connections. When inspecting electrical system:

- Check and clean battery terminal connections and ensure connections are tight.
- Check battery for any cracks or damage to the case.
- Check positive and negative battery cables for corrosion, rubbing, or chafing. Check connection to chassis is tight.
- Check entire engine wire harness for rubbing chafing, cuts, or damaged connections. Repair as needed.
- Check all wire harness connectors 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.
- Make sure all electrical components are fitted securely.
- Check ground and platform control stations to ensure all warning indicator lights are functioning.

Checking/Filling Engine Oil Level

NOTICE

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

NOTICE

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

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

1. Stop engine if running.
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.

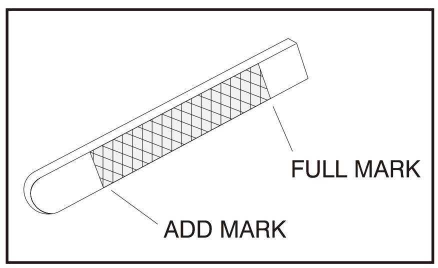


Figure 3-76. Engine Oil Dip Stick

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

Changing Engine Oil

NOTICE

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

To change oil:

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

Coolant Fill Procedure - Dual Fuel Engine

NOTICE

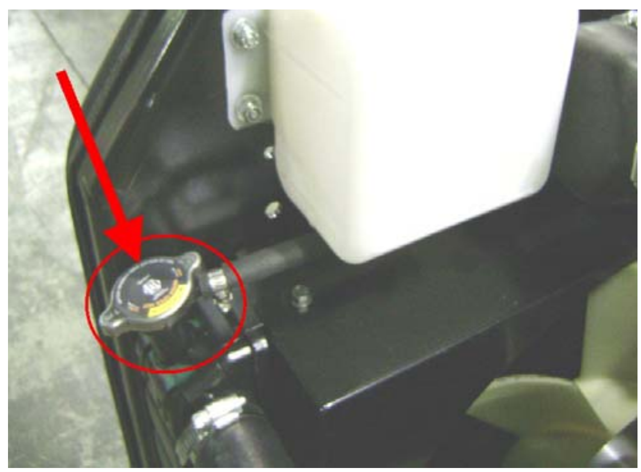
DAMAGE TO ENGINE COULD OCCUR IF NOT PROPERLY FILLED WITH COOLANT. LPG FUELED ENGINES ARE MOST PRONE TO CREATING AN AIR LOCK DURING A COOLANT FILL OPERATION DUE TO THE ELECTRONIC PRESSURE REGULATOR (EPR) BEING THE HIGHEST POINT IN THE COOLING SYSTEM. AN EPR THAT APPEARS TO HAVE FROST FORMING ON IT IS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

CAUTION

MAKE SURE ENGINE IS COOL BEFORE PERFORMING ANY MAINTENANCE WORK.

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

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



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

NOTICE

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

4. Run engine for 5 minutes after it reaches operating temperature. Shut engine off and continue to step 5.

⚠ CAUTION

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

5. Verify two coolant hoses on the EPR are warm. If they are not warm repeat step 3 and 4, otherwise continue to step 6.

NOTICE

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

6. Fill radiator with coolant as needed and install radiator cap. Remove cap off coolant recovery bottle and fill just below HOT FULL line. Reinstall caps.

3.18 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 gasoline mode, the gasoline fuel pump is energized. While in 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.

Gasoline dual fuel system primary components are the gasoline tank, electric fuel pump and filter, fuel supply line, injector rail and injectors, and fuel pressure regulator.

The LPG dual fuel system primary components are the LPG fuel tank, in-fuel filter, LPG Low Pressure lock-off, Electronic Pressure Regulator (EPR), and 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 shared by both systems include the Electronic Throttle Control and 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 other fuels, is subject to contamination from outside sources. Refueling 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 is 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 fuel system operation and should be replaced as Section 1. In severe operating conditions 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 Propane fuel to flow through the device. The valve opens during cranking and run cycles of the engine. Lock off supply voltage is controlled by the ECM.

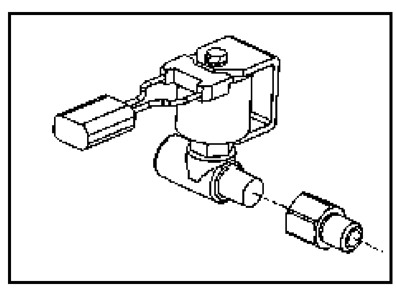
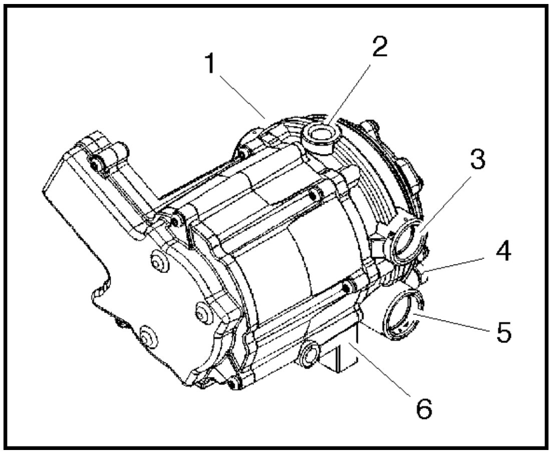


Figure 3-77. Electric Fuel Lock Off

EPR Assembly

The EPR assembly is a combination Low Pressure Regulator and a Voice Coil Assembly. The Voice coil is an electronic actuator 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 FPS and FTP data to calculate 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 3-78. 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 propane passes through the heat exchanger, the fuel expands and creates pressure inside the chamber. Pressure rises as fuel expands when 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 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.

NOTICE

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

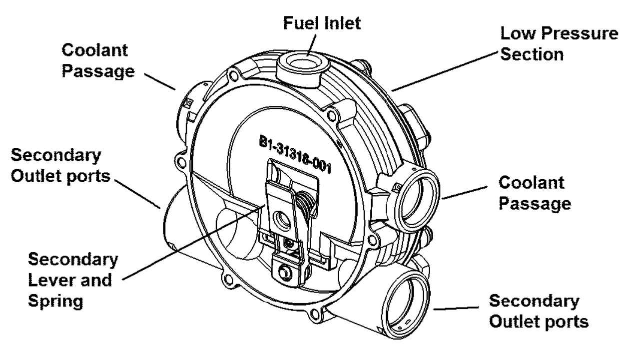


Figure 3-79. Low Pressure Regulators

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 engine speed increase the AVV increases and the air valve is lifted higher 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.

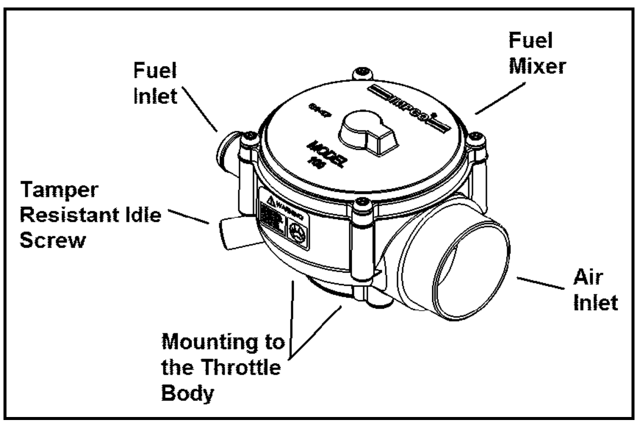


Figure 3-80. Air Fuel Mixer

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

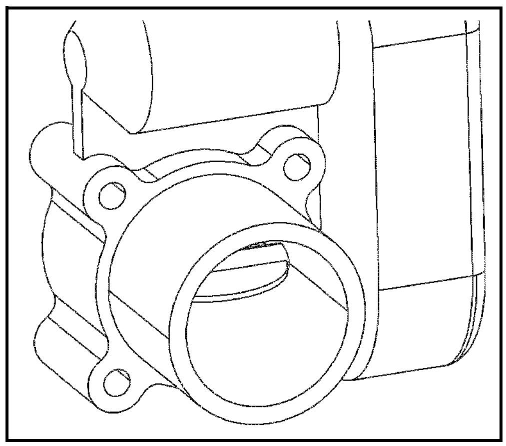


Figure 3-81. ETC throttle control device

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 Hot Exhaust Gas Oxygen sensor (HEGO) mounted in the exhaust system sends a voltage signal to the controller. The controller calculates corrections needed for the air fuel ratio. The controller then outputs signals to the EPR to correct amount of fuel 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 Platform Control Station. Malfunctions in the system are identified by a Diagnostic Code number. In addition to notifying the operator of a system malfunction the controller also stores malfunction information in its memory.

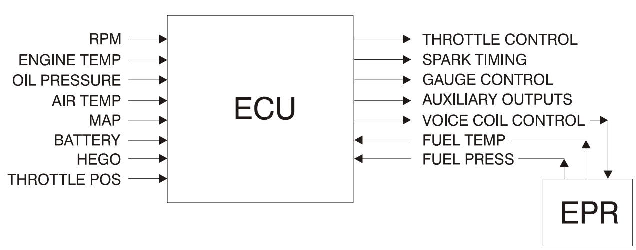


Figure 3-82. LPG Engine Control Unit (ECM)

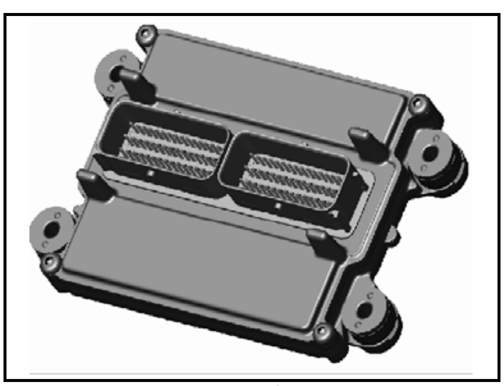


Figure 3-83. ECM Assembly

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 measures the amount of oxygen present in the exhaust stream and communicate that to the ECM via an electrical signal. The amount of oxygen present in the exhaust stream indicates whether the fuel/air ratio is too rich or too lean. If the HEGO sensor signal indicates that the exhaust stream is too rich the ECM will decrease or lean the fuel mixture during engine operation, if the mixture is too lean the ECM will richen the mixture. The ECM continuously monitors the HEGO sensor output. If a rich or lean condition is present for an extended period of time, and the ECM cannot correct the condition, the ECM will set a diagnostic code and turn on the MIL light in control box.

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

NOTICE

HEATED EXHAUST GAS OXYGEN SENSOR IS AN EMISSION CONTROL DEVICE. IF THE HEGO FAILS TO OPERATE, REPLACE IT WITH AN OEM REPLACEMENT PART. 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.

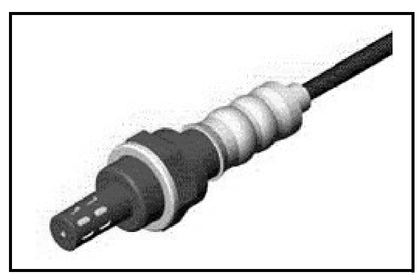


Figure 3-84. Heated Exhaust Gas Oxygen Sensor (HEGO)

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 receives a signal from the ECM to prime the fuel system for approximately 2 seconds prior to start. Priming 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 is regulated by the engine's ECM. The ECM receives 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 bleeds off any vapor that develops in the line and returns a small amount of fuel to the tank. 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 bleed circuits through manifold bypass valve returns to the fuel tank.

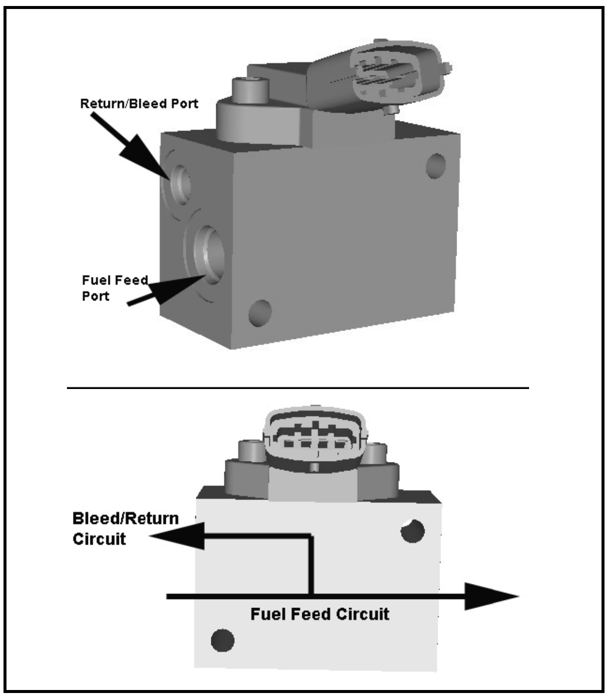


Figure 3-85. Gasoline Fuel Pressure and Temperature Manifold Assembly

Fuel Filter

After fuel is drawn into the fuel pump, the fuel flows through the gasoline fuel filter. The fuel filter traps 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 RPM's. The engine has been calibrated to deliver the precise amount of fuel for optimum performance and emission control.

3.19 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 RISK OF FIRE AND PERSONAL INJURY, RELIEVE PROPANE FUEL SYSTEM PRESSURE (WHERE APPLICABLE) BEFORE SERVICING 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 IS PRESENT IN THE FUEL SYSTEM. ENSURE WORK AREA IS WELL VENTILATED BEFORE DISCONNECTING ANY FUEL LINE.

Propane Fuel System Leak Test

CAUTION

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

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

Propane Fuel Filter Replacement

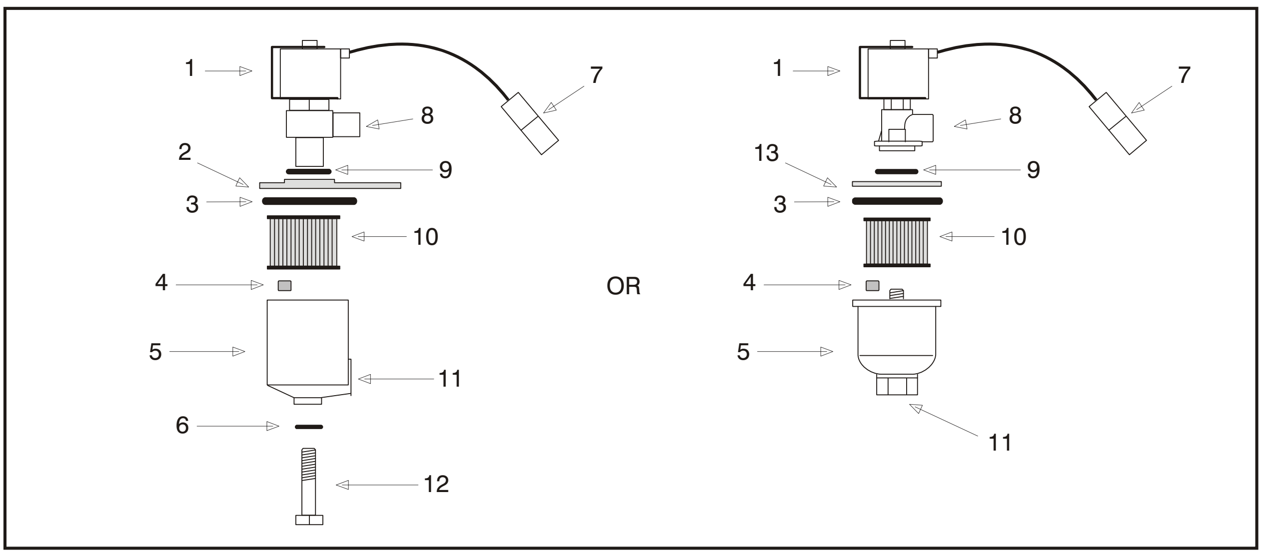
Removal

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

Installation

NOTE: *Reinstall filter magnet in housing before installing new seal*

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

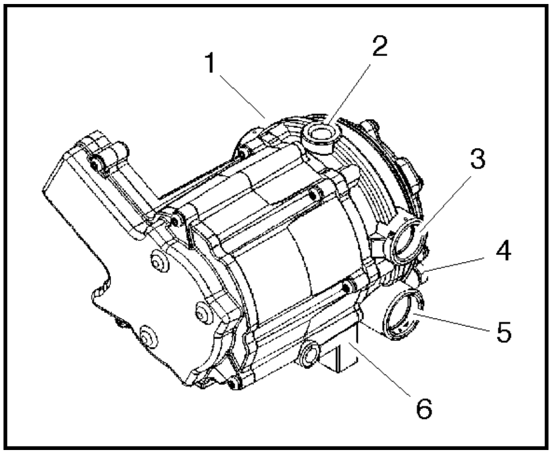


1. Electric Lock Off Solenoid	6. Seal	10. Filter
2. Mounting Plate	7. Electrical Connector	11. Fuel Inlet
3. Housing Seal	8. Fuel Outlet	12. Retaining Bolt
4. Filter Magnet	9. O-ring	13. Ring
5. Filter Housing		

Figure 3-86. Filter Lock Assembly

Electronic Pressure Regulator (EPR) Assembly Replacement

The EPR assembly consists 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 is detailed in this section.



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

Figure 3-87. EPR Assembly

REMOVAL

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

NOTE: *Fuel system will have residual vapor pressure.*

4. Disconnect electrical connector from Electric Lock Off.
5. Remove Electric Lock Off from regulator.
6. Remove lock pin from vapor fitting on regulator housing. Remove fitting and hose. Retain pin.
7. Remove lock pin from pressure sensor on regulator housing and remove sensor. Retain pin.
8. Pinch off hoses on coolant lines to regulator using clamp pliers.
9. Remove lock pin water fittings on regulator housing. Remove fittings and hoses. Retain pin.
10. Disconnect EPR electrical connector
11. Remove three nuts from EPR isolators and EPR mounting bracket
12. Remove EPR from bracket
13. Remove 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 O-RINGS ON VAPOR AND WATER FITTINGS FOR ANY DAMAGE. REPLACE IF NECESSARY.

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

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

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

3. Install fuel temperature sensor into regulator opening and lock in place with locking pin. Connect electrical connector.
4. Insert fuel vapor line and fitting into regulator port. Lock in place with locking pin.
5. Install water hoses and fittings into regulator. Lock in place with locking pin. Remove clamp pliers from hoses.
6. Install electric lock off into regulator inlet and tighten into proper location. Connect electrical connector.
7. Connect fuel supply line and tighten until fully seated.
8. Connect EPR electrical connector.
9. Open manual valve.
10. Start vehicle and leak check propane fuel system at each serviced fitting. Refer to Propane Fuel System Leak Test.

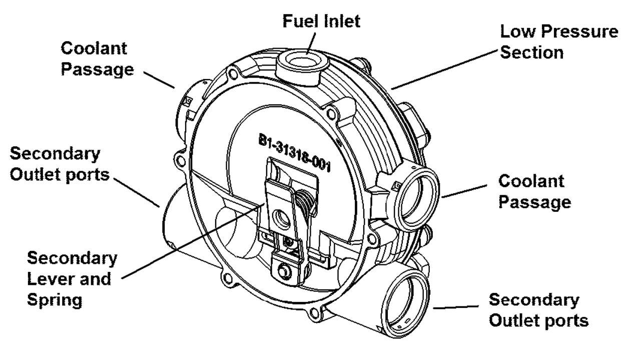


Figure 3-88. Pressure Regulator Section

PRESSURE REGULATOR SECTION REMOVAL

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

NOTICE

DO NOT REMOVE SECONDARY DIAPHRAGM RETAINING PLATE AND DIAPHRAGM OR ACTUATOR SECTION WARRANTY WILL BE VOID.

PRESSURE REGULATOR SECTION INSTALLATION

1. Install regulator to actuator section with six (6) retaining screws. Tighten to 70 in-lb (8 Nm).
2. Install EPR. Refer to EPR Installation.

Temperature Manifold Absolute Pressure (TMAP) Sensor

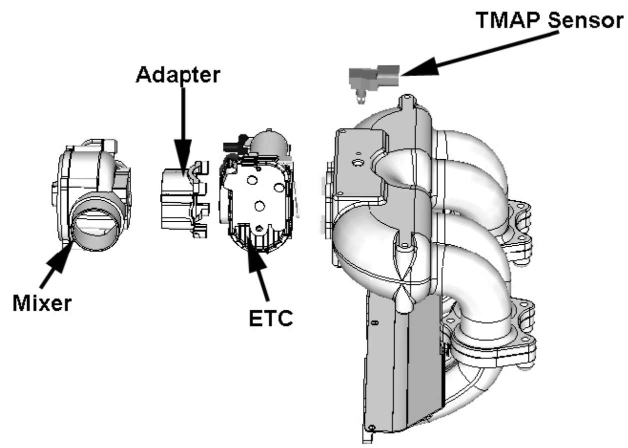


Figure 3-89. (TMAP) Sensor & Electronic Throttle Control (ETC)

REMOVAL

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

INSTALLATION

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

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

Electronic Throttle Control Replacement

See Figure 3-89.

REMOVAL

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

INSTALLATION

NOTICE

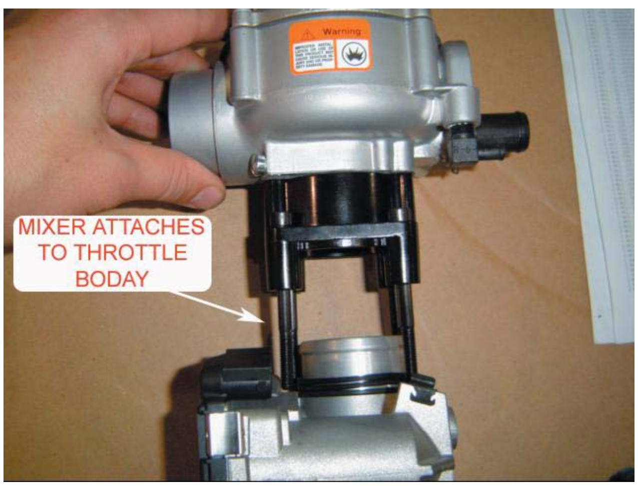
LIGHTLY LUBRICATE THROTTLE CONTROL DEVICE TO ADAPTER O-RINGS.

1. Install O-ring on throttle body. Slide down to bottom of surface.

Continued on next page.

2. Install two quad seals one seal at a time so seal does not roll. Seal must sit flat on 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 intake. Note orientation of air inlet and throttle body cover.



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

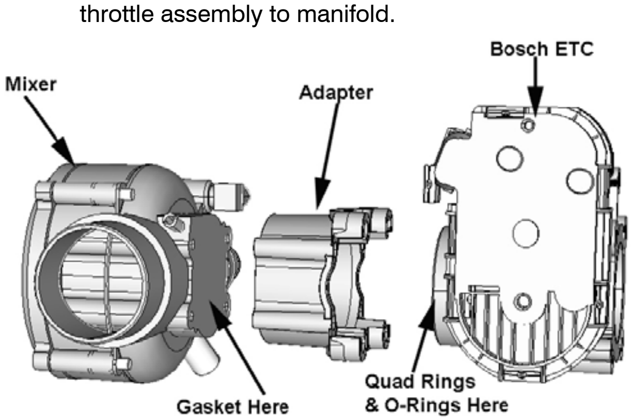


Figure 3-90. Mixer Assembly

MIXER REPLACEMENT

See Figure 3-90.

REMOVAL

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

Coolant Hose Replacement

REMOVAL

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

INSTALLATION

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

1. Install hose clamps to each hose. Set clamp back on each hose to make installation easier.
2. Install hoses on fittings.
3. Secure by positioning each clamp.

Vapor Hose Replacement

REMOVAL

1. Disconnect hose clamps using hose clamp pliers.
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 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 and remove controller.

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 ft-lb (41 Nm).
2. Start engine.
3. Check and clear DTC codes.
4. Verify engine is in closed loop and no warning lights are illuminated.

3.20 GM ENGINE LPG FUEL SYSTEM DIAGNOSIS

Fuel System Description

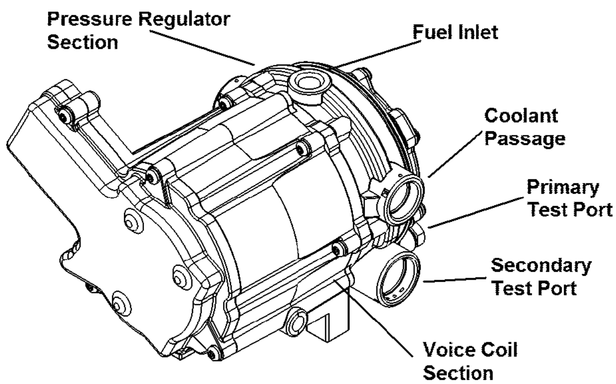


Figure 3-91. EPR Assembly

The LPG fuel system Engine Control Unit (ECM) relies on engine sensors and output data from the Electronic Pressure Regulator (EPR) to maintain fuel and emission control. The ECM determines target fuel calibration and commands 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 continue to communicate during normal operation.

If 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 and allow more fuel to enter the mixer.

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

Fuel is then drawn from the secondary chamber of the LPR by vacuum generated from 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, fuel mixes with air entering the engine. This air/ fuel mixture is then drawn into the engine for combustion.

Diagnostic Aids

This procedure is for diagnosing 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 vehicle has sufficient quantity of fuel and liquid fuel is being delivered to the LPR. Ensure LPG tank manual shut off valve is fully opened and 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

Numbers below refer to step numbers on the diagnostic table.

5. This step determines if LPR requires replacement
6. This step determines if problems are in mechanical side of Pressure Regulator or Electronic Voice Coil
10. This step determines if Mixer requires replacement
14. This step determines if Lock Off requires replacement
17. This step determines if Fuel Filter requires replacement.

Table 3-14. LPF Fuel System Diagnosis

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

Table 3-14. LPF Fuel System Diagnosis

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

Table 3-15. Symptom Diagnosis

Checks	Action
Important Preliminary Checks	
Before Using This Section	Before using this section, you should have performed On Board Diagnostic Check and determined that: 1. The Control Module and MIL (Malfunction Indicator Lamp) are operating correctly. 2. There are no Diagnostic Trouble Codes (DTCs) stored, or a DTC exists but without a MIL. Several of the following symptom procedures call for a careful visual and physical check. Visual and physical checks are very important. These checks can lead to correcting a problem without further checks that may save valuable time.
LPG Fuel System Check	1. Verify customer complaint. 2. Locate correct symptom table. 3. Check items indicated under that symptom. 4. Operate vehicle under 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	1. Check all ECM system fuses and circuit breakers. 2. Check the ECM ground for being clean, tight and in its proper location. 3. Check the vacuum hoses for splits, kinks and proper connections. 4. Check thoroughly for any type of leak or restriction. 5. Check for air leaks at all mounting areas of intake manifold sealing surfaces. 6. Check for proper installation of the mixer module assembly. 7. Check for air leaks at mixer assembly. 8. Check ignition wires for the following conditions: - Cracking - Hardness - Proper routing - Carbon tracking 9. Check 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 scan tool readings do not indicate problems, 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 DTC tables. If a fault is intermittent, use of DTC tables may result in replacement of good parts.
Faulty Electrical Connections or Wiring	Faulty electrical connections or wiring can cause most intermittent problems. 1. Check suspected circuit for the following conditions: - Faulty fuse or circuit breaker - Connectors poorly mated - Terminals not fully seated in the connector (backed out) - Terminals not properly formed or damaged - Terminal to wires poorly connected - Terminal tension insufficient. 2. Carefully remove all connector terminals in the problem circuit to ensure proper contact tension. If necessary, replace all connector terminals in the problem circuit to ensure proper contact tension. Checking for poor terminal to wire connections requires removing terminal from connector body.
Operational Test	If a visual and physical check does not locate cause of the problem, drive vehicle with a scan tool. When problem occurs, an abnormal voltage or scan reading indicates the problem may be in that circuit.

Table 3-15. Symptom Diagnosis

Checks	Action
Intermittent Malfunction Indicator Lamp (MIL)	The following components can cause intermittent MIL and no DTC(s): 1. A defective relay, Control Module driven solenoid, or a switch that can cause electrical system interference. Normally, the problem will occur when the faulty component is operating. 2. Improper installation of electrical devices, such as lights, 2-way radios, electric motors, etc. 3. Ignition secondary voltage shorted to a ground. 4. Malfunction Indicator Lamp (MIL) circuit or the Diagnostic Test Terminal intermittently shorted to ground. 5. Control Module grounds.
Loss of DTC Memory	To check for the loss of DTC Memory: 1. Disconnect TMAP sensor. 2. Idle engine until Malfunction Indicator Lamp illuminates. The ECM should store a TMAP DTC. The TMAP DTC should remain in memory when ignition is turned OFF. If the TMAP DTC does not store and remain, the ECM is faulty
Additional Checks	
No Start	
DEFINITION: Engine cranks OK, but does not start.	
Preliminary Checks	Refer to Important Preliminary Checks.
Control Module Checks	If a scan tool is available: 1. Check for proper communication with both the ECM 2. Check the fuse in the ECM battery power circuit. Refer to Engine Controls Schematics. 3. 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	1. Check TMAP sensor. 2. Check magnetic pickup sensor (RPM).
Fuel System Checks	**Important:** A closed LPG manual fuel shut off valve will create a no start condition. 1. Check for air intake system leakage between mixer and throttle body. 2. Verify proper operation of low pressure lock-off solenoids. 3. Check fuel system pressures. Refer to LPG Fuel System Diagnosis. 4. 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. 1. Check proper ignition voltage output with J 26792 or equivalent. 2. Verify spark plugs are correct for use with LPG (R42LTS) 3. Check spark plugs for the following conditions: - Wet plugs - Cracks - Wear - Improper gap - Burned electrodes - Heavy deposits 4. Check for bare or shorted ignition wires. 5. 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 a 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 3-15. Symptom Diagnosis

Checks	Action
Exhaust System Checks	1. Check exhaust system for a possible restriction: - Inspect exhaust system for damaged or collapsed pipes - Inspect muffler for signs of heat distress or internal failure. 2. Check for plugged catalytic converter. Refer to Restricted Exhaust System Diagnosis
Hard Start	
DEFINITION: Engine cranks OK, but does not start for a long time. Engine does eventually run or may start, but immediately dies.	
Preliminary Checks	1. Refer to Important Preliminary Checks. 2. Make sure operator is using correct starting procedure.
Sensor Checks	1. Check Engine Coolant Temperature (ECT) sensor with scan tool. Compare engine coolant temperature with ambient air temperature on a cold engine. IF coolant temperature reading is more than 5 degrees greater or less than ambient air temperature on a cold engine, check for high resistance in coolant sensor circuit. Refer to DTC 111 2. Check Crankshaft Position (CKP) sensor. 3. Check the Throttle Position Sensor (TPS).
Fuel System Checks	Important: A closed LPG manual fuel shut off valve will create an extended crank OR no start condition. 1. Verify excess flow valve in LPG manual shut-off valve is not tripped. 2. Check mixer module assembly for proper installation and leakage. 3. Verify proper operation of low pressure lock-off solenoids. 4. Verify proper EPR operation. 5. Check for air intake system leakage between mixer and throttle body. 6. Check the fuel system pressures. Refer to Fuel System Diagnosis.
Ignition System Checks	Note: LPG being a gaseous fuel requires higher secondary ignition system voltages for equivalent gasoline operating conditions. 1. Check proper ignition voltage output with J 26792 or the equivalent. 2. Verify spark plugs are correct for use with LPG (R42LTS) 3. Check spark plugs for the following conditions: - Wet plugs - Cracks - Wear - Improper gap - Burned electrodes - Heavy deposits 4. Check for bare or shorted ignition wires. 5. Check for moisture in distributor cap if applicable. 6. Check for loose ignition coil connections. **NOTICE:** 1. If engine starts but then immediately stalls, Check 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 a gasoline fuel supply system. 1. Check for the following: - Vacuum leaks - Improper valve timing - Low compression - Bent pushrods - Worn rocker arms - Broken or weak valve springs - Worn camshaft lobes 2. Check intake and exhaust manifolds for casting flash.

Table 3-15. Symptom Diagnosis

Checks	Action
Exhaust System Checks	1. Check exhaust system for a restriction: - Inspect exhaust system for damaged or collapsed pipes. - Inspect muffler for signs of heat distress or internal failure. 2. Check for plugged catalytic converter. Refer to Restricted Exhaust System Diagnosis or Exhaust System in GM Base Engine Service Manual.
Additional Checks	
Cuts Out, Misses	
DEFINITION: A surging or jerking that follows engine speed, usually more pronounced as engine load increases which is not normally felt above 1500 RPM. Exhaust has a steady spitting sound at idle, low speed, or hard acceleration for fuel starvation that can cause the engine to cut-out.	
Preliminary Checks	Refer to Important Preliminary Checks.
Ignition System Checks	1.Start engine. 2. Wet down secondary ignition system with water from a spray bottle and look/listen for arcing or misfiring as you apply water. 3. Check for proper ignition output voltage with spark tester J 26792. 4. Check for a cylinder misfire. 5. Verify spark plugs are correct for use with LPG (R42LTS) 6. Remove spark plugs in these cylinders and check for the following conditions: - Insulation cracks. - Wear. - Improper gap. - Burned electrodes. - Heavy deposits. 7. Visually/Physically inspect secondary ignition for the following: - Ignition wires for arcing, cross-firing and proper routing. - Ignition coils for cracks or carbon tracking.
Engine Mechanical Checks	1. Perform a cylinder compression check. 2. Check engine for the following: - Improper valve timing - Bent pushrods. - Worn rocker arms. - Worn camshaft lobes. - Broken or weak valve springs. 3. Check intake and exhaust manifold passages for casting flash.
Fuel System Checks	1. Check the fuel system - plugged fuel filter, low fuel pressure, etc. Refer to LPG Fuel System Diagnosis. 2. Check the condition of the wiring to the low pressure lock-off solenoid.
Additional Check	Check for Electromagnetic Interference (EMI). - EMI on reference circuit can cause a missing condition. - Monitoring engine RPM with a scan tool can detect an EMI. - A sudden increase in RPM with little change in actual engine RPM indicates EMI is present. - If problem exists, check routing of secondary wires and ground circuit.

Table 3-15. Symptom Diagnosis

Checks	Action
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	1. Check fuel pressure. Refer to LPG Fuel System Diagnosis. 2. Check for low fuel pressure during a moderate or full throttle acceleration. If fuel pressure drops below specification, there is possibly a faulty low pressure regulator or a restriction in the fuel system. 3. Check Manifold Absolute Pressure (MAP) sensor response and accuracy. 4. Check LPL electrical connection 5. Check mixer air valve for sticking or binding. 6. Check mixer module assembly for proper installation and leakage. 7. Check EPR electrical connections.
Ignition System Checks	Note: LPG being a gaseous fuel requires higher secondary ignition system voltages than equivalent gasoline operating conditions. If a problem is reported on LPG and not gasoline, do not discount the possibility of an LPG only ignition system failure and test system accordingly. 1. Check for proper ignition voltage output with J 26792 or the equivalent. 2. Verify spark plugs are correct for use with LPG (R42LTS) 3. Check for faulty spark plug wires 4. Check for fouled spark plugs.
Additional Check	1. Check for manifold vacuum or air induction system leaks 2. Check generator output voltage.
Backfire	
DEFINITION: Fuel ignites in the intake manifold or exhaust system, making a loud popping noise.	
Preliminary Check	Refer to Important Preliminary Checks.
Ignition System Checks	NOTE: LPG, being a gaseous fuel, requires higher secondary ignition system voltages for than equivalent gasoline operating conditions. The ignition system must be maintained in peak condition to prevent backfire. 1. Check for proper ignition coil output voltage using spark tester J26792 or equivalent. 2. Check spark plug wires by connecting an ohmmeter to ends of each wire in question. If meter reads over 30,000 ohms, replace wires. 3. Check connection at each ignition coil. 4. Check for deteriorated spark plug wire insulation. 5. Check spark plugs. Correct spark plugs for LPG are (R42LTS) 6. Remove and inspect plugs for the following conditions: - Wet plugs. - Cracks. - Wear. - Improper gap. - Burned electrodes. - Heavy deposits.
Engine Mechanical Check	NOTE: 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. 1. Check engine for the following: - Improper valve timing. - Engine compression. - Manifold vacuum leaks. - Intake manifold gaskets. - Sticking or leaking valves. - Exhaust system leakage. 2. Check intake and exhaust system for casting flash or other restrictions.
Fuel System Checks	Perform a fuel system diagnosis. Refer to LPG Fuel System Diagnosis.

Table 3-15. Symptom Diagnosis

Checks	Action
Lack of Power, Sluggishness, or Sponginess	
DEFINITION: Engine delivers less than expected power. There is little or no increase in speed when partially applying accelerator pedal.	
Preliminary Checks	1. Refer to Important Preliminary Checks. 2. Refer to LPG Fuel system OBD System Check 3. Compare customer' s vehicle with a similar unit. Make sure customer has an actual problem. Do not compare power output of vehicle operating on LPG to a vehicle operating on gasoline as fuels have different drive feel characteristics. 4. Remove air filter and check for dirt or restriction. 5. Check vehicle transmission Refer to OEM transmission diagnostics.
Fuel System Checks	1. Check for a restricted fuel filter, contaminated fuel, or improper fuel pressure. Refer to LPG Fuel System Diagnosis. 2. Check for the proper ignition output voltage with the spark tester J 26792 or the equivalent. 3. Check for proper installation of the mixer module assembly. 4. Check all air inlet ducts for condition and proper installation. 5. Check for fuel leaks between the LPR and the mixer. 6. Verify that the LPG tank manual shut-off valve is fully open. 7. Verify that liquid fuel (not vapor) is being delivered to the LPR.
Sensor Checks	1. Check Heated Exhaust Gas Oxygen Sensor (HEGO) for contamination and performance. 2. Check proper operation of MAP sensor. 3. Check proper operation of TPS sensor.
Exhaust System Checks	Check exhaust system for a possible restriction: - Inspect exhaust system for damaged or collapsed pipes. - Inspect 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	1. Check ECM grounds for being clean, tight, and in their proper locations. 2. Check generator output voltage. 3. 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 suspected circuit and/or systems. - Check scan tool data.
Poor Fuel Economy	
DEFINITION: Economy is noticeably lower as shown by refueling records.	
Preliminary Checks	1. Refer to Important Preliminary Checks. 2. Check air cleaner element (filter) for dirt or restriction. 3. Visually (Physically) check vacuum hoses for splits, kinks, and proper connections. 4. Check operator driving habits for the following items: - Is there excessive idling or stop and go driving? - Are tires at correct air pressure? - Are excessively heavy loads being carried? - Is there often rapid acceleration? 5. Suggest to owner to fill fuel tank and recheck fuel economy. 6. Suggest a different operator use equipment and record results.
Fuel System Checks	1. Check LPR fuel pressure. Refer to LPG Fuel System Diagnosis. 2. Check fuel system for leakage.
Sensor Checks	Check Temperature Manifold Absolute Pressure (TMAP) sensor.

Table 3-15. Symptom Diagnosis

<table>
<tr><th>Checks</th><th>Action</th></tr>
<tr><td>Ignition System Checks</td><td>1. Verify that the spark plugs are correct for use with LPG (R42LTS)
2. Check spark plugs. Remove and inspect plugs for the following conditions:
- Wet plugs
- Cracks
- Wear
- Improper gap
- Burned electrodes
- Heavy deposits
3. Check ignition wires for the following items:
- Cracking
- Hardness
- Proper connections</td></tr>
<tr><td>Cooling System Checks</td><td>Check engine thermostat for always being open or for the wrong heat range</td></tr>
<tr><td>Additional Check</td><td>1. Check transmission shift pattern. Refer to OEM Transmission Controls section Service Manual.
2. Check for dragging brakes.</td></tr>
<tr><td colspan="2">Rough, Unstable, or Incorrect Idle, Stalling</td></tr>
<tr><td colspan="2">DEFINITION: Engine runs unevenly at idle. If severe enough, engine or vehicle may shake. Engine idle speed may vary in RPM. Either condition may be severe enough to stall the engine.</td></tr>
<tr><td>Preliminary Check</td><td>Refer to Important Preliminary Checks.</td></tr>
<tr><td>Sensor Checks</td><td>1. 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). ECM will reduce the amount of fuel delivered to the engine causing a severe driveability problem.
2. Check the Heated Exhaust Gas Oxygen Sensor (HEGO) performance:
3. Check the Temperature Manifold Absolute Pressure (TMAP) sensor response and accuracy.</td></tr>
<tr><td>Fuel System Checks</td><td>1. Check for rich or lean symptom that causes the condition. Drive the vehicle at the speed of the complaint. Monitoring the oxygen sensors will help identify the problem.
2. Check for a sticking mixer air valve.
3. Verify proper operation of the EPR.
4. Perform a cylinder compression test. Refer to Engine Mechanical in the Service Manual.
5. Check the LPR fuel pressure. Refer to the LPG Fuel System Diagnosis.
6. Check mixer module assembly for proper installation and connection.</td></tr>
<tr><td>Ignition System Checks</td><td>1. Check for proper ignition output voltage using spark tester J26792 or equivalent.
2. Verify spark plugs are correct for use with LPG (R42LTS)
3. Check spark plugs. Remove and inspect plugs for the following conditions:
- Wet plugs
- Cracks
- Wear
- Improper gap
- Burned electrodes
- Blistered insulators
- Heavy deposits
4. Check spark plug wires by connecting an ohmmeter to ends of each wire in question. If meter reads over 30,000 ohms, replace wires.</td></tr>
<tr><td>Additional Checks</td><td>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.
1. Check for vacuum leaks. Vacuum leaks can cause a higher than normal idle and low throttle angle control command.
2.Check ECM grounds for being clean, tight, and in their proper locations.
3. Check battery cables and ground straps. They should be clean and secure. Erratic voltage may cause faulty sensor readings resulting in poor idle quality.</td></tr>
</table>

Table 3-15. Symptom Diagnosis

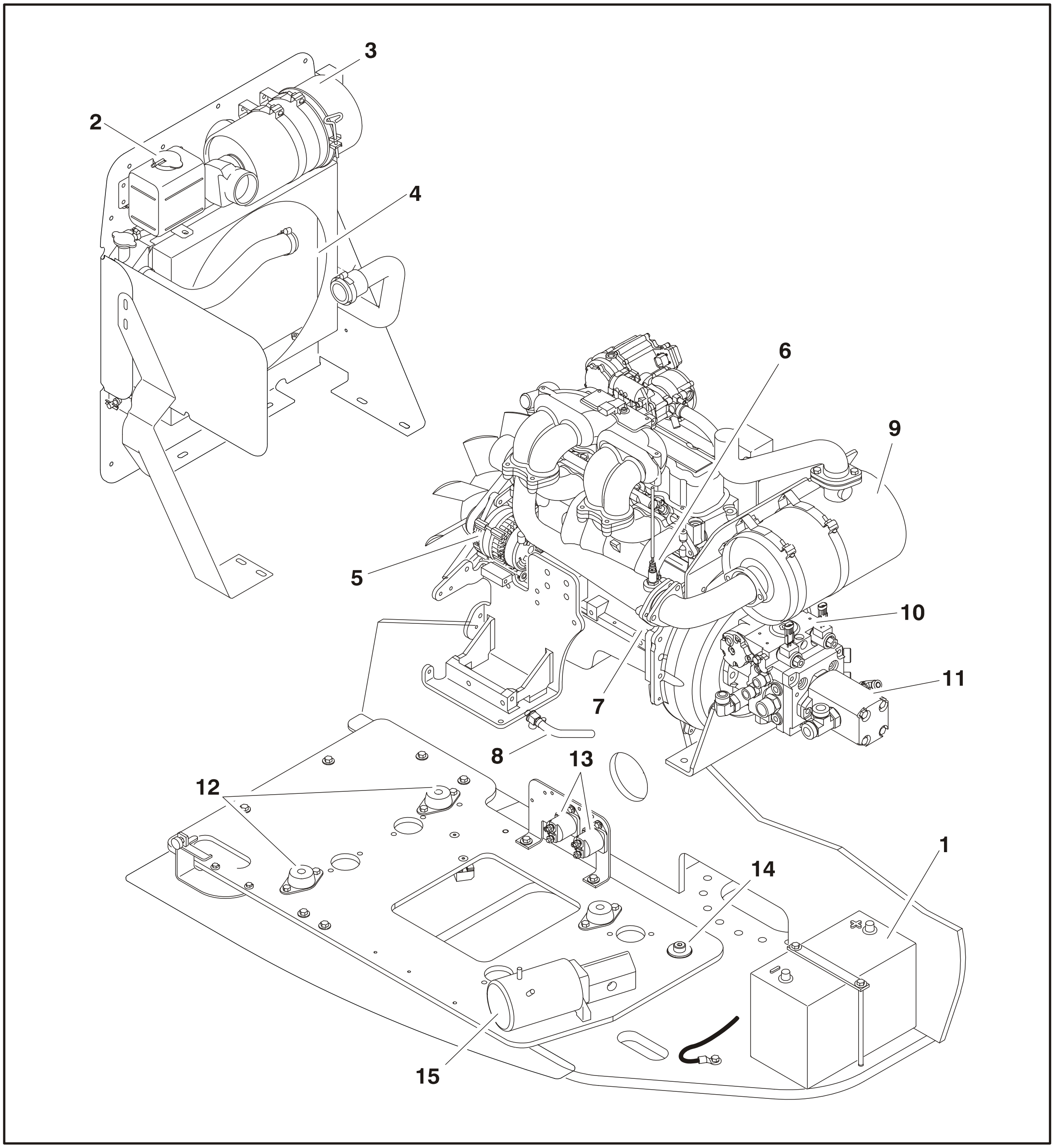
Checks	Action
Engine Mechanical Check	Check engine for the following: - Broken motor mounts. - Improper valve timing. - Low compression. - Bent pushrods. - Worn rocker arms. - Broken or weak valve springs. - Worn camshaft lobes.
Surges/Chuggles	
DEFINITION: Engine has a power variation under a steady throttle or cruise. Vehicle feels as if it speeds up and slows down with no change in accelerator pedal.	
Preliminary Checks	Refer to Important Preliminary Checks.
Sensor Checks	Check Heated Exhaust Gas Oxygen Sensor (HEGO) performance.
Fuel System Checks	1. Check Rich or Lean symptom that causes condition. Drive vehicle at speed of complaint. Monitoring oxygen sensors will help identify problem. 2. Check fuel pressure while condition exists. Refer to LPG Fuel System Diagnosis. 3. Verify proper fuel control solenoid operation. 4. Verify LPG manual shut-off valve is fully open. 5. Check in-line fuel filter for restrictions.
Ignition System Checks	1. Check proper ignition output voltage using spark tester J26792 or equivalent. 2. Verify spark plugs are correct for use with LPG (R42LTS). 3. Check spark plugs. Remove and inspect plugs for the following conditions: - Wet plugs. - Cracks. - Wear. - Improper gap. - Burned electrodes. - Heavy deposits. 4. Check Crankshaft Position (CKP) sensor.
Additional Check	1. Check ECM grounds clean, tight, and in proper locations. 2. Check generator output voltage. 3. Check vacuum hoses for kinks or leaks. 4. Check transmission.

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

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

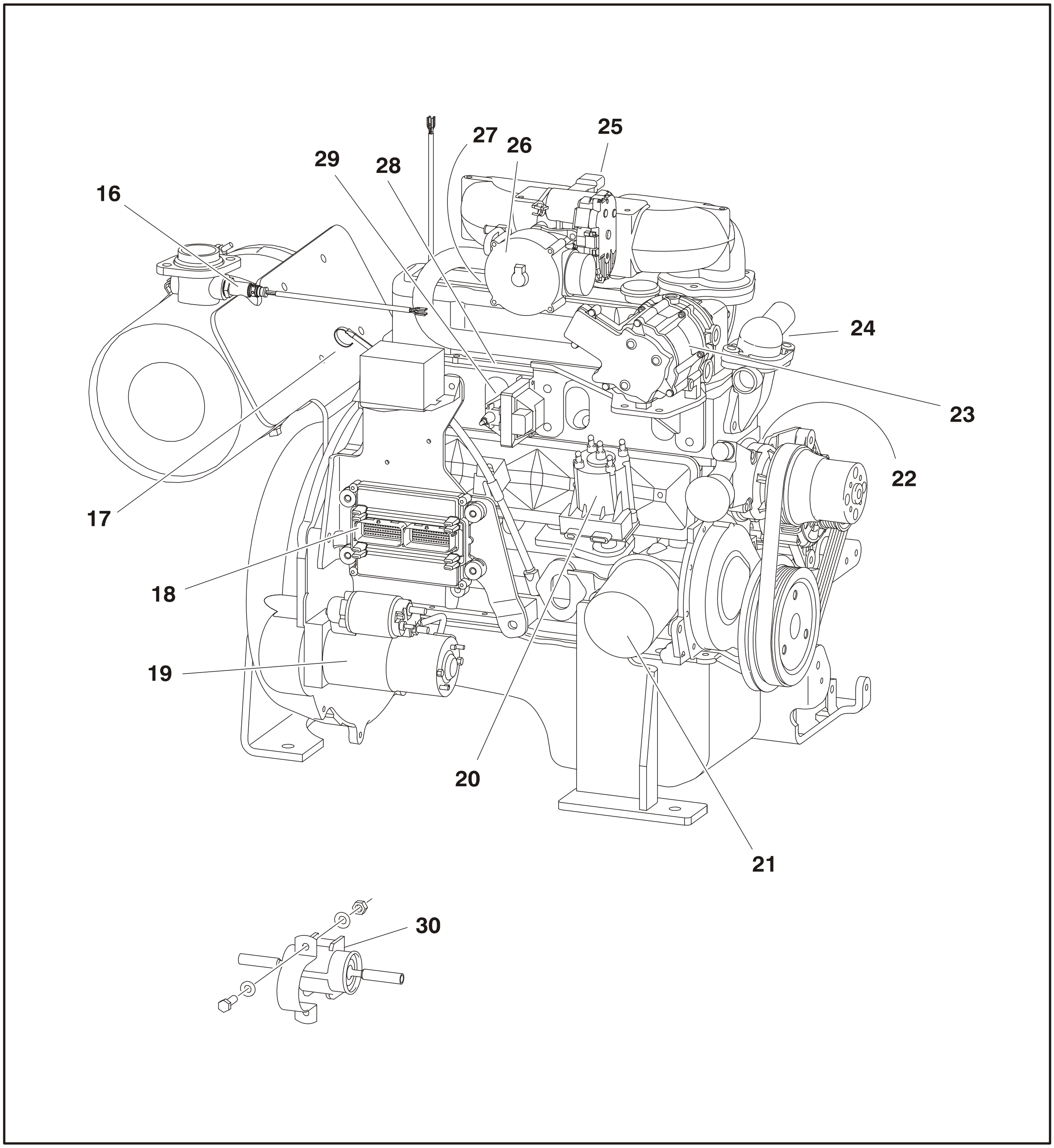
Table 3-16. DTC to SPN/FMI Cross Reference Chart

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



1. Battery	6. O2 Sensor	11. Gear Pump
2. Coolant Overflow	7. Crankshaft Position Sensor	12. Motor Mount
3. Air Cleaner	8. Oil Drain Valve	13. Start/Aux Power Relays
4. Radiator	9. Muffler	14. Engine Tray Pivot
5. Alternator	10. Piston Pump	15. Auxiliary Pump

Figure 3-92. GM 3.0L Engine - Sheet 1 of 2



16. O2 Sensor	21. Oil Filter	26. Mixer
17. Dipstick	22. Water Pump	27. PCV Valve
18. Control Module	23. Coolant Sensor	28. Oil Pressure Switch
19. Starter	24. Pressure Regulator	29. Coil
20. Distributor	25. MAP Sensor	30. Fuel Filter

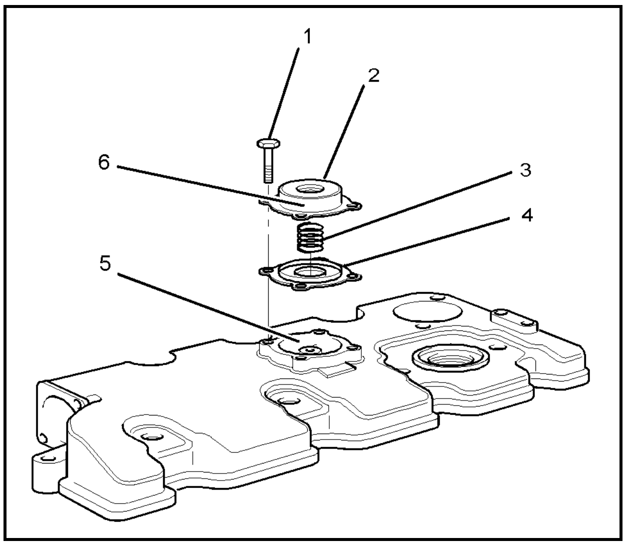
Figure 3-93. GM 3.0L Engine - Sheet 2 of 2

3.21 PERKINS ENGINE GENERAL MAINTENANCE

Replacing the Engine Crankcase Breather

NOTICE

KEEP PARTS CLEAN FROM CONTAMINANTS. CONTAMINANTS MAY CAUSE RAPID WEAR AND SHORTENED COMPONENT LIFE.



1. Screws for the breather cover
2. Breather cover
3. Spring
4. Diaphragm and plate
5. Cavity
6. Vent hole

Figure 3-94. Crankcase Breather - Perkins

1. Loosen screws (1) and remove breather cover (2) from valve mechanism cover.
2. Remove spring (3). Remove diaphragm and plate (4).
3. Clean vent hole (6) and cavity (5) in valve mechanism cover.

NOTICE

MAKE SURE THAT THE COMPONENTS OF THE BREATHER ASSEMBLY ARE INSTALLED CORRECTLY. ENGINE DAMAGE MAY OCCUR IF THE BREATHER ASSEMBLY IS NOT WORKING CORRECTLY.

4. Install new diaphragm and plate (4) for breather assembly into cavity (5) of valve mechanism cover.
5. Install new spring (3).
6. Install breather cover (2) and four screws (1). Tighten screws.

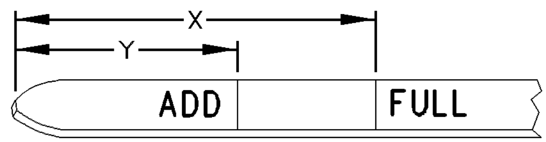
Engine Oil Level - Check

WARNING

HOT OIL AND COMPONENTS CAN CAUSE SEVERE BURNS. DO NOT ALLOW HOT OIL OR COMPONENTS TO CONTACT SKIN.

NOTE: *Perform this maintenance with engine stopped.*

1. Maintain oil level between “ADD” mark (Y) and “FULL” mark (X) on oil level gauge (1). Do not fill crankcase above “FULL” mark (X).



NOTE: *Operating your engine when oil level is above “FULL” mark could cause your crankshaft to dip into the oil. Air bubbles created from crankshaft dipping into the oil reduces the oil's lubricating characteristics and could result in loss of power.*

2. Remove oil filler cap and add oil, if necessary. Clean oil filler cap and reinstall.

Engine Oil and Filter - Change

WARNING

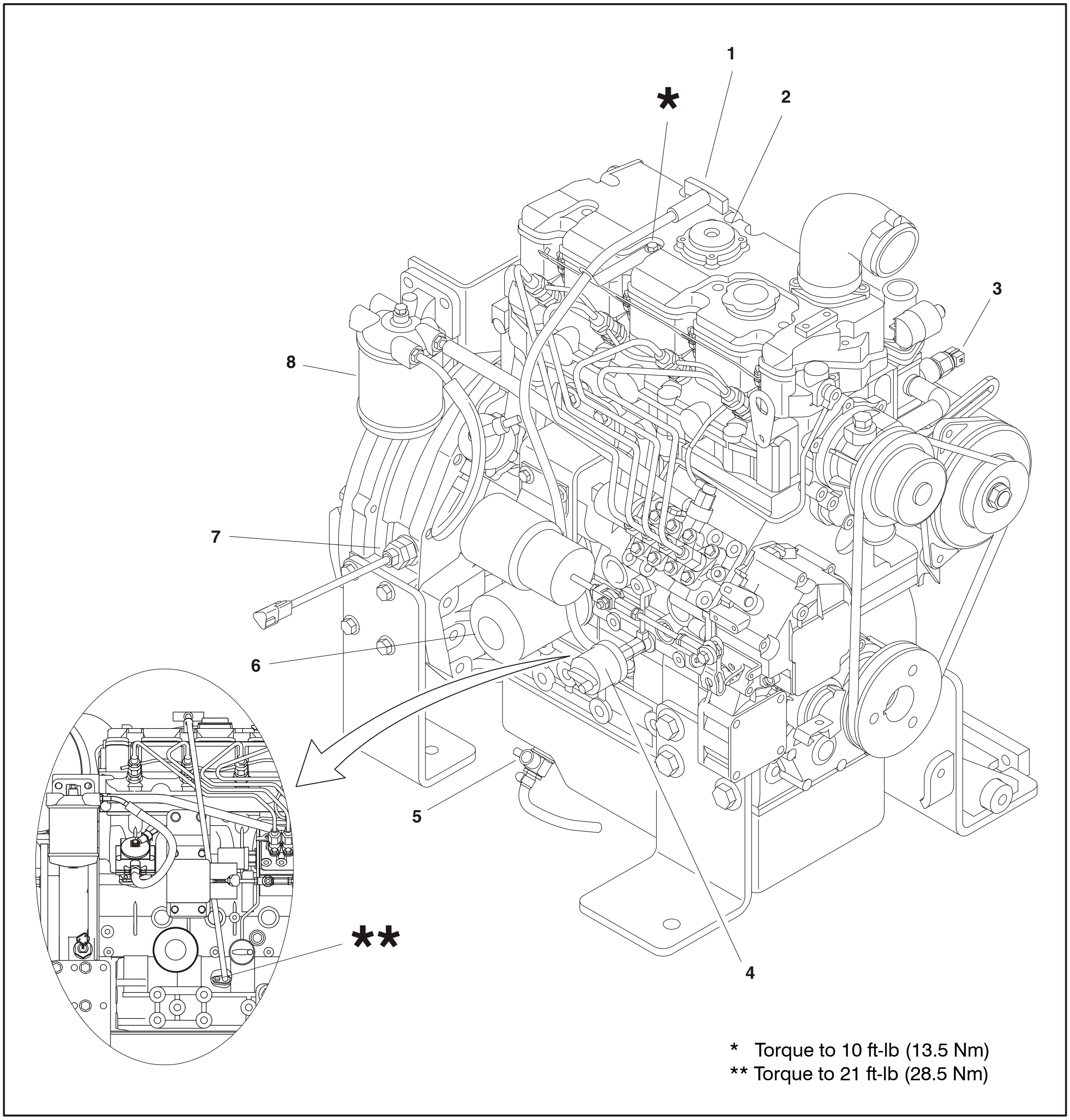
HOT OIL AND COMPONENTS CAN CAUSE SEVERE BURNS. DO NOT ALLOW HOT OIL OR COMPONENTS TO CONTACT SKIN.

NOTICE

CARE MUST BE TAKEN TO ENSURE FLUIDS ARE CONTAINED DURING PERFORMANCE OF INSPECTION, MAINTENANCE, TESTING, ADJUSTING, AND REPAIR OF THE PRODUCT. BE PREPARED TO COLLECT THE FLUID WITH SUITABLE CONTAINERS BEFORE OPENING ANY COMPARTMENT OR DISASSEMBLING ANY COMPONENT CONTAINING FLUIDS. DISPOSE ALL FLUIDS ACCORDING TO LOCAL REGULATIONS AND MANDATES.

NOTICE

KEEP ALL PARTS CLEAN OF CONTAMINANTS. CONTAMINANTS MAY CAUSE RAPID WEAR AND SHORTENED COMPONENT LIFE.



1. Dipstick
2. Crankcase Breather
3. Coolant Sensor
4. Oil Pressure Sensor
5. Oil Drain Valve
6. Oil Filter
7. Speed Sensor
8. Fuel Filter

Figure 3-95. Perkins Engine

NOTE: *Do not drain oil when engine is cold. As oil cools, suspended waste particles settle on bottom of oil pan and not removed with oil. Drain crankcase with engine stopped. Drain crankcase with oil warm. This draining method allows waste particles suspended in oil to be drained correctly. Failure to follow this procedure will allow waste particles to recirculate through engine lubrication system with new oil.*

DRAINING ENGINE OIL

Run engine until normal operating temperature is reached, then stop engine. Turn drain valve knob counter-clockwise to drain oil. Turn drain valve knob clockwise to close drain valve after oil has drained.

FILLING ENGINE CRANKCASE

1. Remove oil filler cap. Refer to Operation and Maintenance Manual for more information on lubricant specifications. Fill crankcase with correct amount of oil. Refer to Operation and Maintenance Manual for more information on refill capacities.

NOTICE

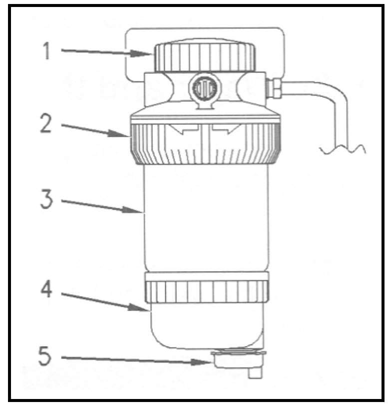
UNDERFILLING OR OVERFILLING CRANKCASE WITH OIL CAN DAMAGE ENGINE.

NOTICE

TO PREVENT CRANKSHAFT BEARING DAMAGE, CRANK ENGINE WITH THE FUEL OFF. THIS WILL FILL OIL FILTERS BEFORE STARTING ENGINE. DO NOT CRANK ENGINE FOR MORE THAN 30 SECONDS.

2. Start engine and run at “LOW IDLE” for two minutes. Perform this procedure to ensure lubrication system has oil and oil filters are filled. Inspect oil filter for leaks.
3. Stop engine and allow oil to drain to sump for a minimum of ten minutes.
4. Remove oil level gauge and check oil level. Maintain oil level between “MIN”” and “MAX” marks on oil level gauge.

Fuel Filter/Water Separator



1. Cap
2. Locking Ring
3. Element
4. Water Separator Bowl
5. Drain

Figure 3-96. Fuel Filter/Water Separator

WARNING

FUEL LEAKED OR SPILLED ONTO HOT SURFACES OR ELECTRICAL COMPONENTS CAN CAUSE A FIRE. TO HELP PREVENT POSSIBLE INJURY, TURN START SWITCH OFF WHEN CHANGING FUEL FILTERS OR WATER SEPARATOR ELEMENTS. CLEAN UP FUEL SPILLS IMMEDIATELY.

NOTICE

FUEL/WATER SEPARATOR REMOVES WATER FROM FUEL AND IS NOT A FILTER. NEVER RUN ENGINE WITH SEPARATOR MORE THAN HALF FULL OF WATER. ENGINE DAMAGE MAY RESULT.

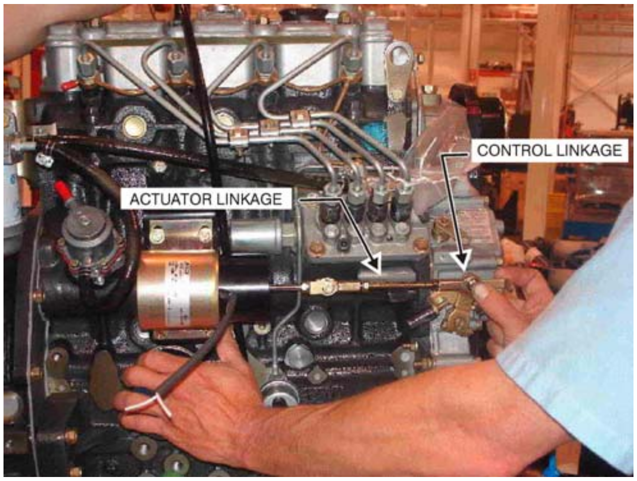
1. Open drain at bottom of separator. Catch water in a suitable container and dispose of properly.
2. Close drain.

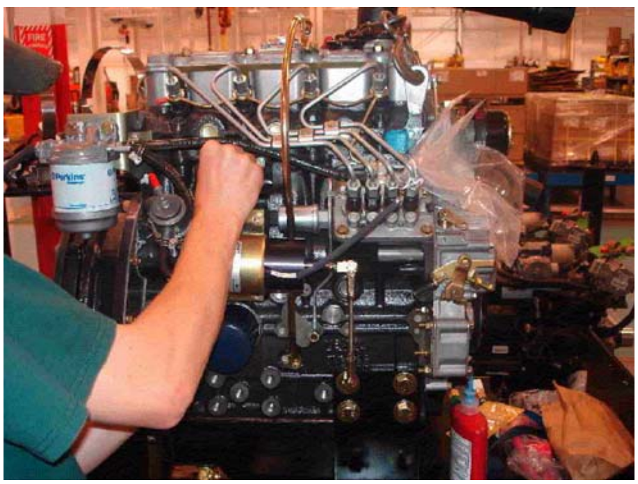
NOTICE

FUEL/WATER SEPARATOR IS UNDER SUCTION DURING ENGINE OPERATION. DRAIN VALVE MUST BE SECURELY TIGHTENED TO PREVENT AIR FROM ENTERING FUEL SYSTEM.

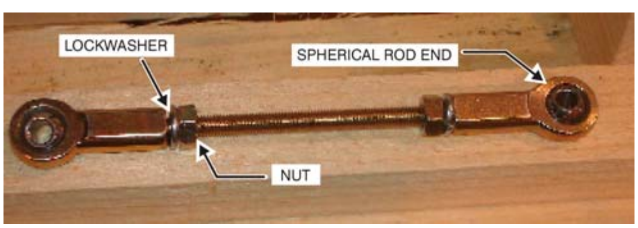
Setting Actuator

1. Remove bolt from control linkage

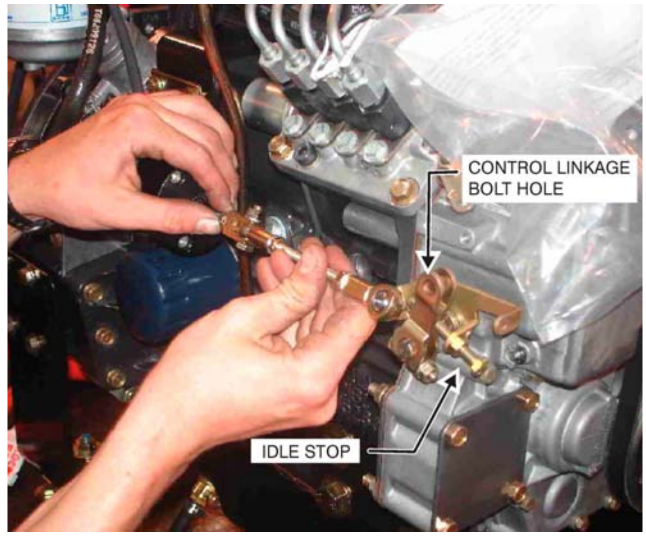




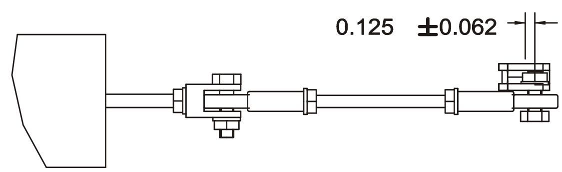
2. With control linkage pushed against idle stop, begin to make adjustments to actuator linkage in to align bearing of spherical rod end with control linkage bolt hole. When making linkage adjustments, thread spherical rod end and threaded rod evenly (Turn threaded rod for every turn of spherical rod end.)



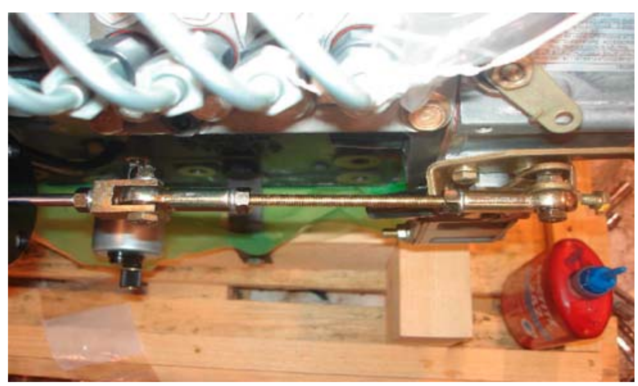
NOTE: *During this procedure it's very important to keep control linkage pushed against stop.*



3. Once adjustments are made to align spherical rod end bearing with control linkage bolt hole, lengthen actuator linkage by continuing to turn spherical rod end and threaded rod 2-2½ turns (1-1¼ turns of spherical rod end and 1-1¼ turns of threaded rod.) This will provide 1/8" (3 mm) preload.



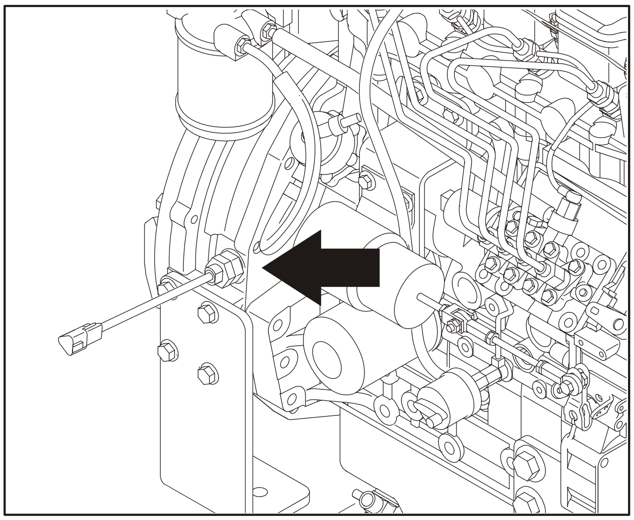
4. Use a measuring device to ensure preload is approximately 1/8" (3 mm), then secure actuator linkage to control linkage with original bolt and nut. Make sure spherical ball is seated in control linkage bolt hole.
5. Tighten two nuts on threaded rod of actuator linkage heads using two wrenches to prevent binding of clevis.



Speed Sensor Installation

NOTE: *A new speed sensor comes with two hex nuts.*

1. Remove one hex nut from speed sensor and discard it.
2. Install speed sensor in housing until it contacts flywheel.



3. Back off sensor 1/4 to 3/4 turn. Ensure sensor flats are vertical and tighten nut.

3.22 ENGINE RADIATOR FILL PROCEDURE - PERKINS & CATERPILLAR

NOTICE

SOME ENGINES REQUIRE A SPECIAL RADIATOR FILL PROCEDURE DUE TO COOLING SYSTEM CONFIGURATION. FAILURE TO FOLLOW THIS PROCEDURE CAN DAMAGE ENGINE.

WARNING

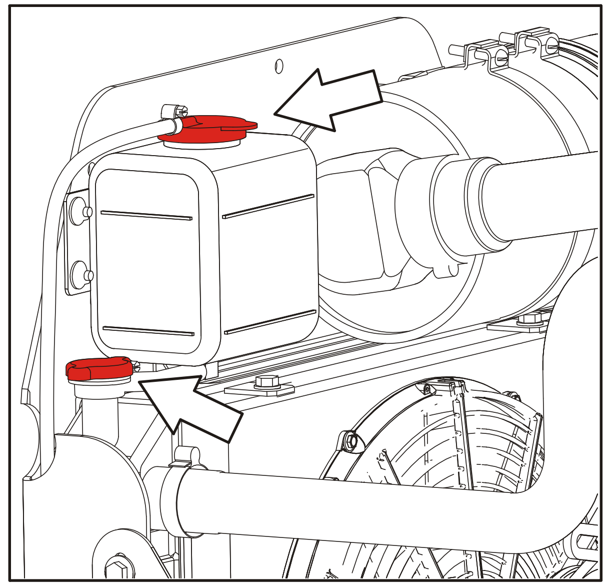
THE FOLLOWING FILL PROCEDURE SHOULD ONLY BE PERFORMED WHEN ENGINE IS COLD.

WARNING

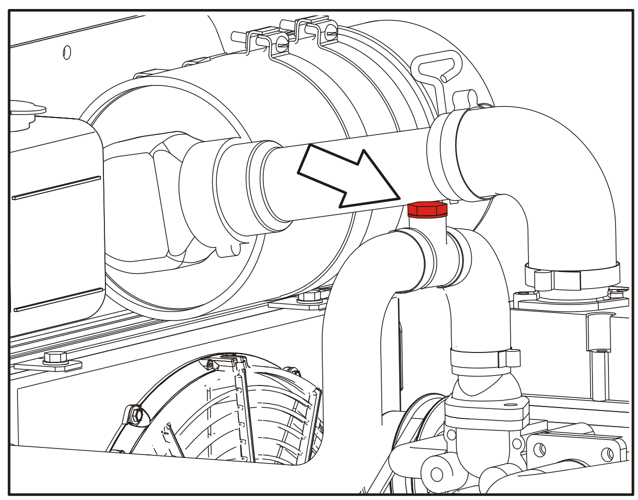
ENGINE COOLANT IS UNDER PRESSURE. DO NOT REMOVE RADIATOR CAP WHEN ENGINE IS WARM.

NOTE: *If radiator cap is removed at any time after the following steps are performed, coolant will flow out whether engine is cold or hot.*

1. Remove radiator and reservoir caps.

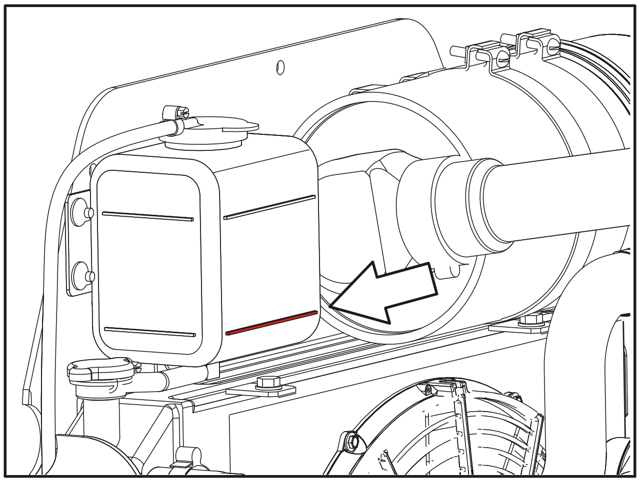


2. Fill radiator to top. Allow coolant to settle and add coolant as necessary to top off radiator.
3. Reinstall radiator cap.
4. Remove plug from adapter and add coolant at this location until radiator hose is full of coolant.



5. Using sealant JLG P/N 0100020 (Loctite #567), install plug back into adapter.

6. Remove fill cap and fill coolant recovery reservoir to cold level line. Put fill cap back on reservoir when done.

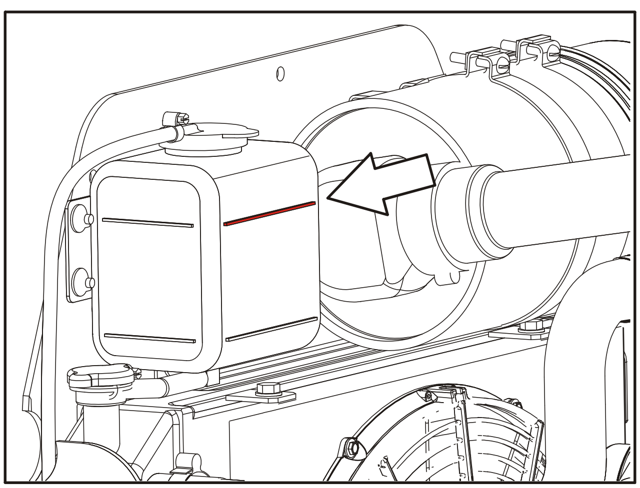


7. Start engine and run it long enough to bring coolant to operating temperature. Turn off engine.

⚠ WARNING

REMOVING RADIATOR CAP WITH COOLANT HOT AND UNDER PRESSURE CAN CAUSE SEVERE INJURIES. ALLOW ENGINE AND COOLING SYSTEM TO COOL BEFORE REMOVING RADIATOR CAP.

8. Make sure coolant reaches hot level line on coolant recovery reservoir. Add coolant as needed.



NOTICE

IF RADIATOR CAP IS REMOVED AND COOLANT IS LOST, REPEAT THIS PROCEDURE TO ENSURE COOLING SYSTEM IS FILLED TO PROPER LEVEL.

3.23 DGC DIAGNOSTIC SUPPORT AND TROUBLE CODE DEFINITIONS

This section defines diagnostics and recommended troubleshooting procedures associated with EControls, Diesel Governor Control (DGC), and Engine Control Module (ECM) used on industrial engines.

Section Layout

This section is organized in the following manner:

DTC XXXX- Diagnostic Condition

Block Diagram of Circuit

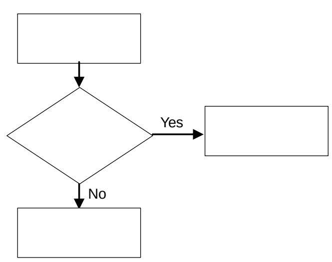
- *External Hardware Input/Output*- This identifies the hardware that either sends an input to the ECM or is driven by and ECM output.
- *Check Condition*- This defines what condition to troubleshoot the fault condition.
- *Fault Condition(s)*- This identifies the condition(s) that set the fault.
- *Corrective Action(s)*- This identifies the *RECOMMENED* corrective action(s) that the ECM is generally programmed to perform. In some instances, the calibration engineer(s) may choose to perform a different action.
- Emissions or Non-emissions related fault

Text to identify the circuit of interest and its use for control.

Text to describe the conditions that cause the fault to set.

DTC XXXX- Diagnostic Condition

Note: Helpful tips used to aid troubleshooting



Troubleshooting flow chart

Diagnostic Aids
- Tip #1
- Tip #2 …

List of Abbreviations in this Section

AL	Adaptive Learn
BP	Barometric Pressure
CAN	Controller Area Network
CCP	CAN Calibration Protocol
CHT	Cylinder Head Temperature
CL	Closed Loop
CNG	Compressed Natural Gas
DBW	Drive-By-Wire
DGC	Diesel Governor Control
DM	Diagnostic Message
DMM	Digital Multi-Meter (high impedance)
DST	Diagnostic Scan Tool
DTC	Diagnostic Trouble Code
DVOM	Digital Voltage and Ohm Meter (high impedance)
ECI	EControls Inc.
ECIPP	EControls Inc. Proprietary Protocol
ECM	Engine Control Module
ECT	Engine Coolant Temperature
ECU	Engine Control Unit
EDIS	EControls Display and Interface Software
EGO	Exhaust Gas Oxygen Sensor, typically heated
EMWT	Exhaust Manifold Water Temperature
EPR	Electronic Pressure Regulator
ERWT	Exhaust Manifold Riser Temperature
ETB	Electronic Throttle Body
ETC	Electronic Throttle Control
FDR	Flight Data Recorder
FMI	Failure Mode Indicator
FO	Firing Order
FP	Fuel Pressure
FPP	Foot Pedal Position
FRP	Fuel Rail Pressure
FRT	Fuel Rail Temperature
FSS	Fault Snapshot
FT	Fuel Temperature
GCP	Global Control Platform
HDGCP	Heavy-Duty Global Control Platform (On-Road Heavy-Duty)
HEGO	Heated Exhaust Gas Oxygen Sensor (same as HO2S)
HO2S	Heated Oxygen Sensor (same as HEGO)
IAC	Idle Air Control
IAT	Intake Air Temperature
ICAV	Instant Crank Angle Velocity
IVS	Idle Validation Switch
LDGCP	Light-Duty Global Control Platform (Industrial, Smart/Logic Coil)
LED	Light Emitting Diode
LPG	Liquefied Propane Gas
MAP	Manifold Absolute Pressure
MGCP	Marine Global Control Platform
μP	Microprocessor
Mfg	Manufacture
MIL	Malfunction Indicator Lamp
NG	Natural Gas
OBD	On-Board Diagnostics
OEM	Original Equipment Manufacture
PC	Personal Computer
PCU	Powertrain Control Unit
PFI	Port Fuel Injection
PGN	Parameter Group Number
PWM	Pulse Width Modulated
RAM	Random Access Memory
RPM	Revolutions Per Minute
Rx	Receive
SAE	Society of Automotive Engineering
SA	Source Address
SPFI	Sequential Port Fuel Injection
SPN	Suspect Parameter Number
Tach	Tachometer
TBI	Throttle Body Injection
TDC	Top Dead Center
TIP	Throttle Inlet Pressure
TPS	Throttle Position Sensor
TSC	Torque/Speed Control
Tx	Transmit
UEGO	Universal Exhaust Gas Oxygen Sensor (Wide-Range EGO)
VDC	Voltage, Direct Current
VR	Variable Reluctance
Vsw	Switched, Ignition Voltage
WGP	Waste-Gate Pressure

Fault Code Broadcast

All diagnostic trouble codes are broadcast through EDIS for display on a PC. EDIS can acquire the data from the ECU via CAN using the EControls Inc. Proprietary Protocol (ECIPP). Faults may also be acquired over the CAN network through CAN J1939-based scan tools or multi-function display units.

Diagnostic Trouble Codes

Numeric diagnostic trouble codes assigned to faults in this manual are cross-referenced to SAE.s “Recommended Practice for Diagnostic Trouble Code Definitions” (SAE J2012). While these codes are recommended, customers may define their own codes by assigning a new number to the flash code in the diagnostic calibration. This assigns the DTC as displayed in EDIS and flash code output on the MIL output pin. EDIS may be used to connect to the DGC ECM via CAN.

CAN

The DGC supports SAE J1939 CAN based diagnostic support. This includes:

- DM1: Active Diagnostic Trouble Codes
- DM2: Previously Active Diagnostic Trouble Codes
- DM3: Diagnostic Data Clear/Reset of Previously Active DTCs
- DM4: Freeze Frame Parameters
- DM5: Diagnostic Readiness (bytes 1, 2, and 3 are supported)
- DM11: Diagnostic Data Clear/Reset For Active DTCs
- DM12: Emissions-Related Active Diagnostic Trouble Codes
- DM19: Calibration Information

All diagnostic trouble codes broadcast over CAN are SAE J1939 DM1 and DM2 formatted messages. DGC ECMs are compliant with J1939 OBD-M, supporting the Diagnostic Messages above as well as user indicators and CAN data defined in the OBD-M protocol. Faults available for broadcast and their respective SPN/FMI numbers are dependent on the application and engine calibration. There are 4 CAN SPN/FMI lists available in the DGC software set, contact EControls Inc. for a list of CAN SPN/FMIs.

Data capture at occurrence of a fault, known in the ECM as fault snapshot (FSS), is available upon DM4 request. The following bytes are supported for DM4 if configured in ECM software:

- Byte 1: Freeze Frame Length
- Byte 2-6: SPN, FMI, SPN Conversion Method, and Occurrence
- Byte 7: Manifold Absolute Pressure
- Byte 8-9: Engine Speed
- Byte 10: Engine Load (MAP based estimate)
- Byte 11: Engine Coolant Temperature
- Byte 14: # of starts since fault was last active
- Byte 15: Index into FSS_storage table for Fault Snap Shot retrieval

Resetting active and previously active DTCs is handled through DM11 and DM3, respectively DM1 and DM2 lamp indicators are assigned to each fault based on the faults diagnostic action as defined in the calibration. Lamps are assigned based on configuration outlined in Table 3-17.

Table 3-17. J1939 Diagnostic Lamp Configuration

ECI DIAGNOSTIC ACTION	J1939 LAMP
MIL	MIL
Soft Warning	Amber
Hard Warning, Low Rev Limit, Shutdown	Red Stop
Power Derate 1 & 2	Protect
Forced Idle	None (use in combination with other action)

MIL Output

Malfunction Indicator Lamp (MIL) output displays fault information to the equipment operator. The MIL is always on (grounded) when the system is in a key-on (Vsw), engine-off state. This shows the output is functional. If a DTC is logged as previously-active (historic), the MIL sends a single flash for the “Blink on-time” every “Blink off-time.”

Diagnostic Calibration Configuration and Corrective Actions

Each fault within the DGC is capable of being uniquely configured in the engines diagnostic calibration to cause one or more corrective actions while a given fault is active.

Table 2 identifies configuration options and corrective actions available for configuration of each fault.

The desired action is set by OEM calibration engineers.

Table 3-18. Diagnostic Corrective Actions

CORRECTIVE ACTION	DESCRIPTION
Enable	Enables the fault for fault detection
Shutdown	Cause an engine shutdown when fault becomes active
Never Forget	Retain fault as historic/previously active until cleared by a technician and does not allow historic fault to be “auto-cleared”
Turn on MIL	Turn on MIL output when fault becomes active
CL Disable	Disable closed-loop while the fault is active
CL Disable Key- Cyc	Disable closed-loop while the fault is active and for the remainder of the key cycle
AL Disable	Disable adaptive learn while the fault is active
AL Disable Key-Cyc	Disable adaptive learn while the fault is active and for the remainder of the key cycle
Power Derate 1	Limit TPS to the Power Derate 1 percent set in the diagnostic calibration while the fault is active. The Power Derate 1 TPS percent should be set higher than Power Derate 2 as Power Derate 2 adds a higher level of protection.
Power Derate 2	Limit TPS to the Power Derate 2 percent set in the diagnostic calibration while the fault is active. If the calibration is set to “Latched for Key-Cycle” Power Derate 2 remains active until engine speed and FPP conditions are satisfied. The Power Derate 2 TPS percent should be set lower than Power Derate 1 as Power Derate 2 adds a higher level of protection.
Low Rev Limit	Limit RPM to the Low Rev Limit speed set in the diagnostic calibration while the fault is active. If the calibration is set to “Latched for Key-Cycle” Low Rev Limit remains active until engine speed and FPP conditions are satisfied.
Forced Idle	Limit RPM to the Forced Idle speed set in the diagnostic calibration while the fault is active and for the remainder of the key cycle
Soft Warning	Turn on the soft warning output when the fault becomes active
Hard Warning	Turn on the hard warning output when the fault becomes active
Stopped Check	Run fault detection/checking while the engine is in a key-on, engine-off condition. NOTE: It is recommended that this feature only be used for general sensor faults (high/low voltage) and some output drivers

Fault/Diagnostic Trouble Code Interaction

All fault and diagnostic information is managed through the Faults page. Interaction includes viewing fault messages, downloading fault data (fault snapshot and flight data recorder), erasing faults from memory, and defining variables for fault data logging.

Faults are separated into two categories, Active and Historic. Active faults are active in real-time and historic faults have been generated at some instance in time that may or may not be active in real-time. Once a fault has become active, it is immediately logged as historic and a snapshot and flight data log is saved. Figure 3-97. shows an example of the fault page when an active fault has been generated. Notice fault is present in active and historic lists and the Malfunction Indicator Lamp (MIL) has been illuminated. Figure 3-98. shows an example of the fault page with a historic fault stored in memory.

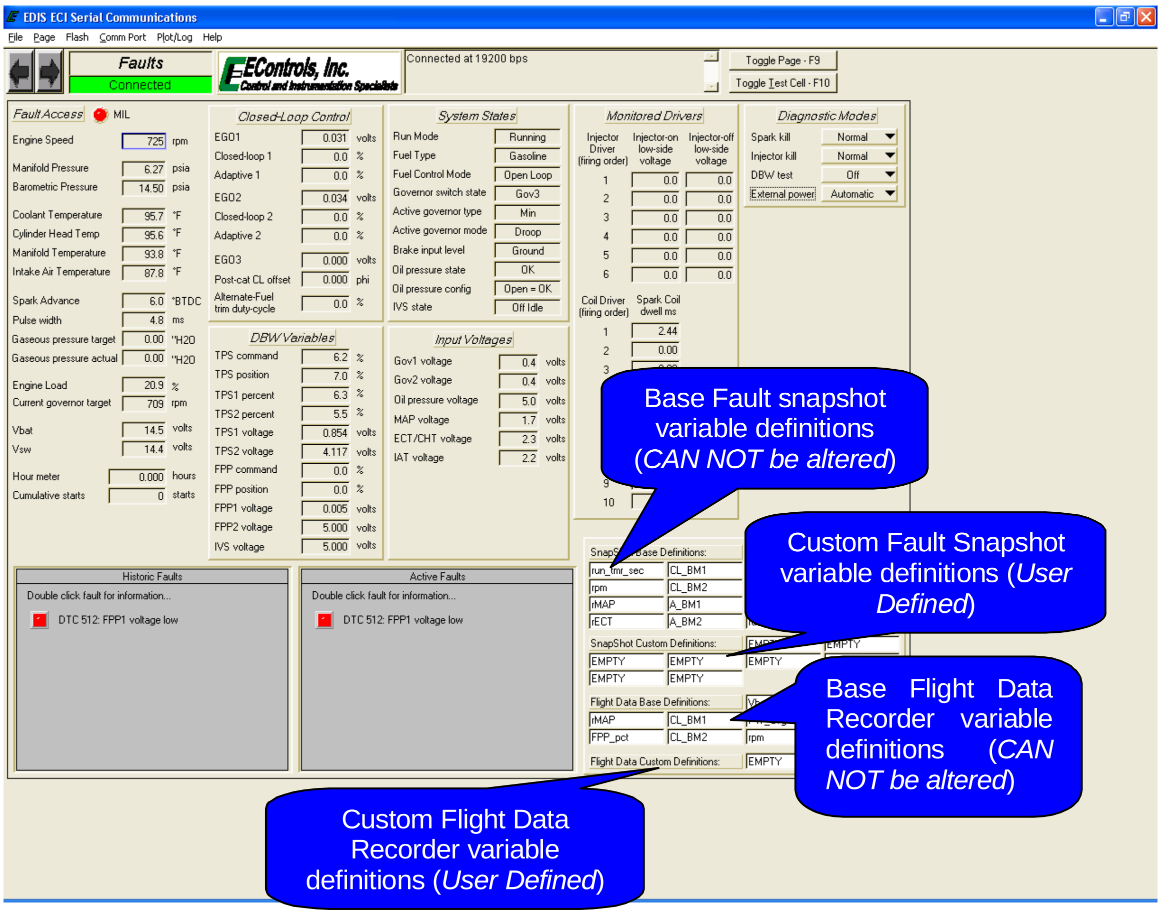


Figure 3-97. Faults Page with Active Fault Message

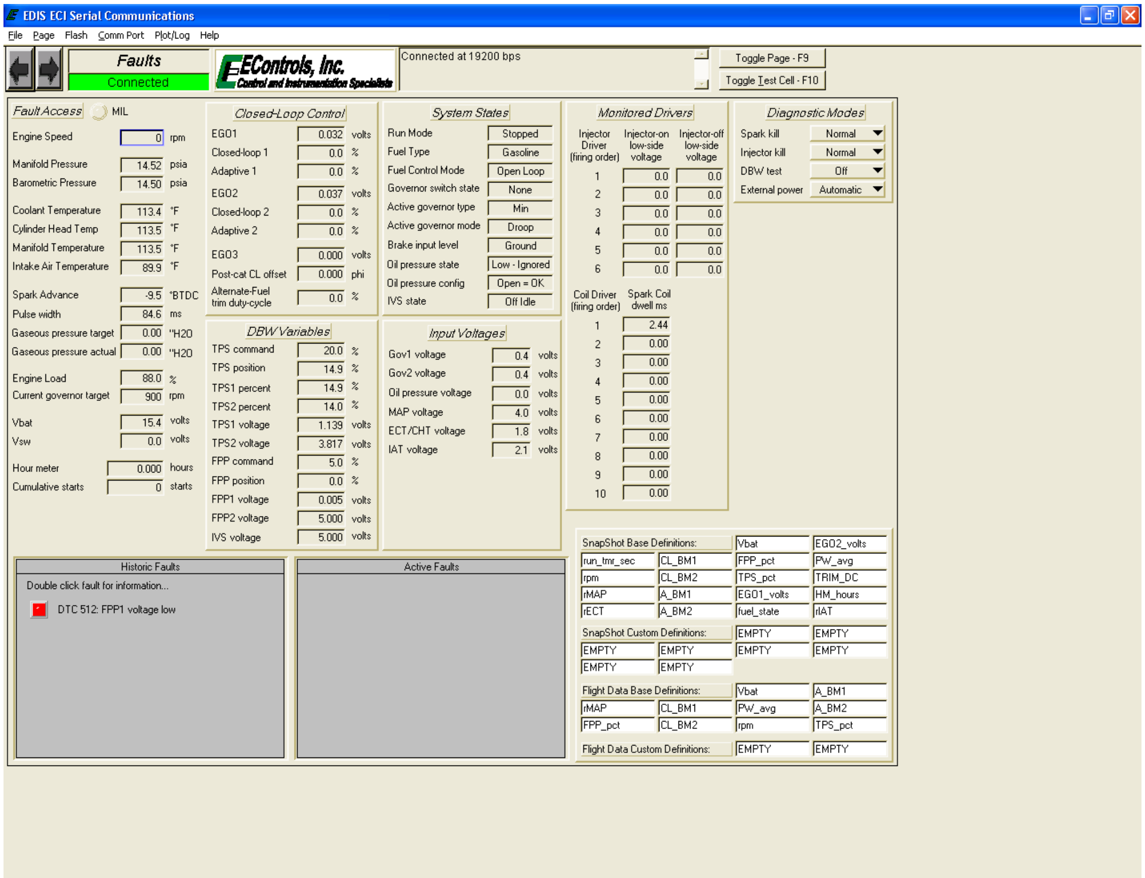


Figure 3-98. Faults Page with Historic Fault Message

Once an active fault has occurred, two sets of data are recorded; fault snapshot and flight data recorder. The fault snapshot (FSS) is a sample of data taken when the fault triggered. Variables included in the FSS are defined in the Snapshot Base and Snapshot Custom Definition fields found on the Faults Page. An FSS is saved with each of the first eight (8) faults the first time the fault becomes active.

Conversely, the flight data recorder (FDR) is a ten-second stream of data that includes eight-seconds prior and two-seconds after triggering the fault. An FDR is saved for each of the first two (2) faults for the first time the fault becomes active. Variables included in the FDR are defined in the Flight Data Base and Flight Data Custom Definition fields found on the Faults Page.

FDR information is stored in RAM, therefore this data is only available if the ECM has not lost battery power. In addition, if there is a “Dirty Flash Page” in the ECM, FDR data will not be available. FSS data is stored in EEPROM and is retained when the ECM loses battery power.

Both sets of data are accessed from the Historic Fault Information interface and can be saved to a PC upon retrieval. Base variables for FSS and FDR are generally defined by the OEM to include variables most often referenced during fault diagnosis. Base definitions are not fault dependent. Additional variables may be selected for capture during a fault occurrence through a single, left-click of the custom table and selecting desired variables from a list. An example of custom fault variable definitions is shown in Figure 3-99.

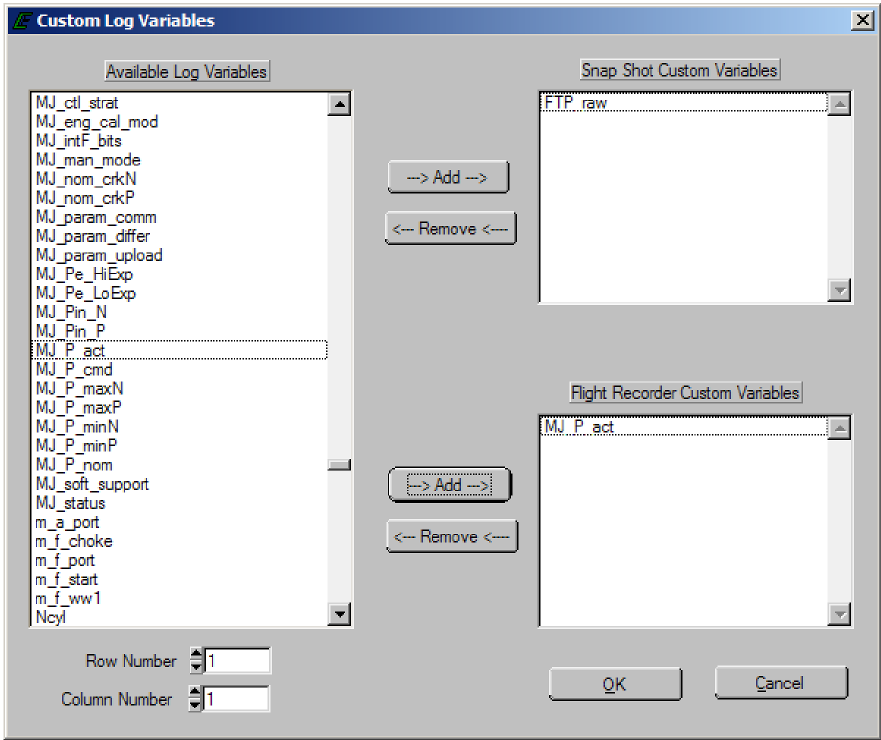


Figure 3-99. Custom Fault Variable Interface

Accessing fault information is accomplished through a double left-click of the fault LED in the historic fault list. This produces the Historic Fault Information interface shown in Figure 3-100. From this interface a user can interpret a diagnostic trouble code (DTC) message, identify whether or not the fault occurred during the current key cycle, identify if the fault caused engine shutdown, determine how many key cycles have occurred since fault was last active, clear selected or all historic faults, and view snapshot and flight data. Table 3-19 outlines options displayed in the Historic Fault Information screen. Historic faults are not overwritten if the same fault becomes active, storing data from the original active fault.

Figure 3-101. is an example of a fault snapshot after View Fault Snapshot is selected. Data is presented in two columns; base and custom variables. FSS data may be saved to a PC in text format with an .fss extension when retrieved. An FSS saved to a PC may be reviewed in any ASCII based software program.

Figure 3-102. shows the Flight Data Recorder interface after View Flight Data Recorder is selected. The FDR captures a ten second (eight seconds prior and two seconds after generating the fault) strip of data for base and custom variables. FDR data is presented in an interface similar to the Plot interface for a quick graphical presentation.

From this interface, FDR data may be saved to the PC in text, tab-delimited format with an .fdr file extension. Once saved to PC, FDR data may be reviewed with any graphical post-processing software capable of handling tab-delimited formatting.

Fault information may be manually erased using the “Clear” button functions. Once a “Clear” function has been selected, the dialog prompt shown in Figure 3-103. will be displayed. Choosing YES deletes all fault information from the ECM.

DBW Diagnostic Test

The DGC engine control module uses a diagnostic test to verify proper drive-by-wire throttle actuator operation. This diagnostic test is software selectable through the EDIS using the ECIPP protocol. The test permits full-authority operation of an electronic throttle via the throttle command input while engine is in “Stopped” state only. The ECM reverts to normal operation if “Off” state is selected, ignition voltage is lost, or engine speed is sensed.

To enable test, go to DBW page of the EDIS. Set “DBW test mode” to “Enabled”. Double-click “TPS Command” setting and enter desired DBW throttle actuator position. The throttle actuator should move to position entered. To disable test, set “DBW test mode” to “Off.”

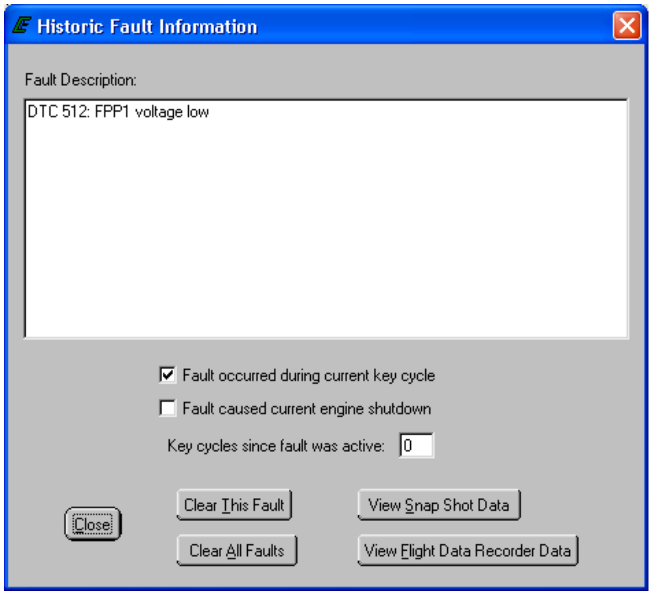


Figure 3-100. Historic Fault Information Interface

Table 3-19. Historic Fault Information Interface Functions

Fault Description Message Box	Customized text that references the DTC flash code and describes the fault.
Fault During Key Cycle Checkbox	Informs that the fault occurred during the current key-on event.
Fault Caused Engine Shutdown Checkbox	Informs that the fault caused the engine to shutdown.
Key Cycles Since Fault Active Indicator	Displays the amount of key-on events since the fault was last active.
Clear This Fault Button*	Erases the selected historic fault from the ECM.
Clear All Faults Button*	Erases all historic faults from the ECM.
View Snap Shot Data Button	Retrieves a data “snap shot” from the ECM for variables defined in the base and custom snapshot variable definition lists. An example of a fault snap shot is shown in Figure 5.
View Flight Data Recorder Data Button	Retrieves a 10-second data strip chart (8 seconds prior, 2seconds after fault trigger) from the ECM for variables defined in the base and custom flight data recorder definition lists. An example of a fault snap shot is shown in Figure 6.
Close Button	Exits the Historic Fault Information interface. DOES NOT cancel or clear any faults.
* Snapshot and flight data recorder data for historic faults is erased after the prompt shown in Figure 3-103. is satisfied	

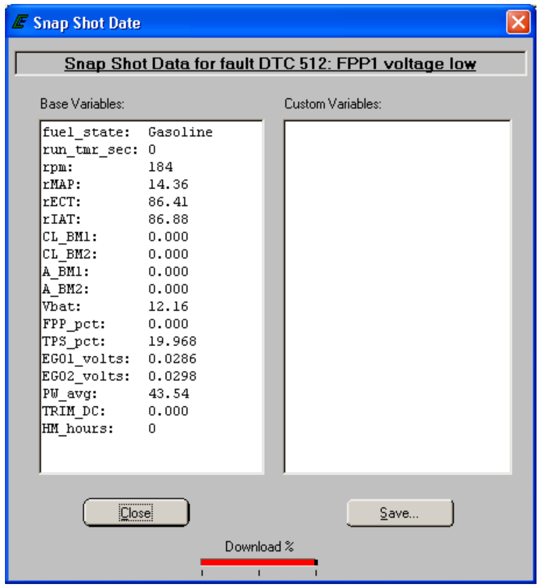


Figure 3-101. Snapshot Data Interface

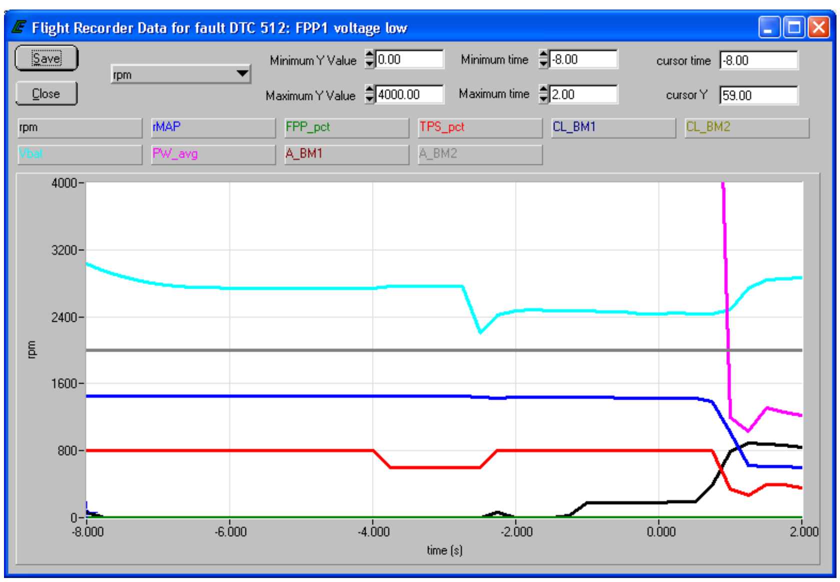


Figure 3-102. Flight Data Recorder Interface

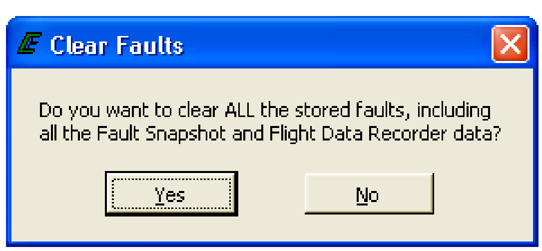
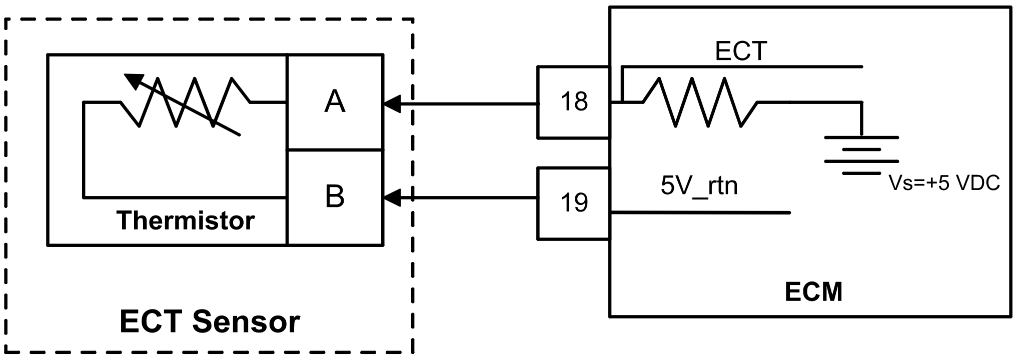


Figure 3-103. Clear Faults Prompt

3.24 DIAGNOSTIC TROUBLE CODE FAULT DESCRIPTIONS

DTC 116- ECT Higher Than Expected Stage 1



- Engine Coolant Temperature Sensor.
- Check Condition-Engine Running.
- Fault Condition-Engine Coolant Temperature reading or estimate greater than stage 1 limit when operating at a speed greater than defined in diagnostic calibration.
- Corrective Action(s): Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault. Recommend a power derate 1/2 and/or a low rev limit to protect engine from possible damage.
- Non-emissions related fault.

The Engine Coolant Temperature sensor is a thermistor (temperature sensitive resistor) located in engine coolant. Some engines use a CHT sensor located in cylinder head coolant. Some engines use an ECT (Engine Coolant Temperature) sensor located in coolant near the thermostat. If engine is equipped with a CHT sensor, the ECT value is estimated. If equipped with an ECT sensor, the CHT value is estimated. They are used for engine airflow calculation, ignition timing control, to enable certain features, and for engine protection. The ECM provides a voltage divider circuit. The sensor reads higher voltage when cold and lower when warm.

This fault helps protect engine in the event of over temperature. When coolant exceeds x deg. F and engine RPM exceeds y RPM for the latch time this fault will set.

Diagnostic Aids

If “ECT High Voltage” fault is also present, follow troubleshooting procedures for that fault as it may have caused “ECT Higher Than Expected 1.”

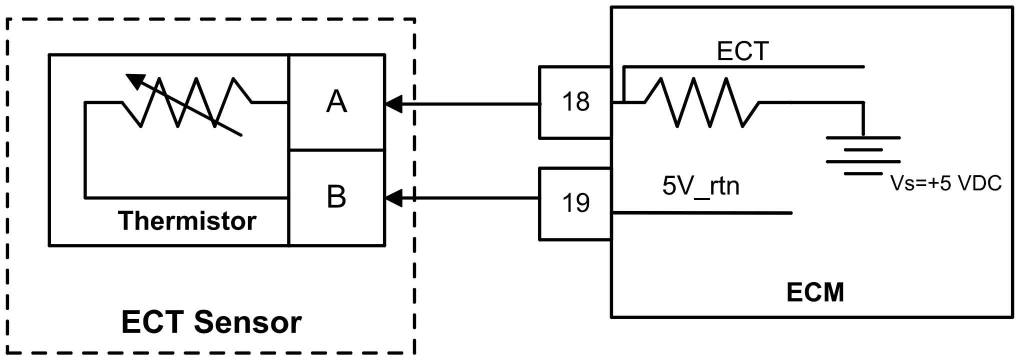
Cooling system with air-to-water heat exchanger (radiator) and fan:

- Check radiator has a proper amount of ethylene glycol/ water and is not leaking.
- Ensure there is no trapped air in cooling path.
- Inspect cooling system (radiator and hoses) for cracks and connections are leak free.
- Check fan is operating properly.
- Check thermostat is not stuck closed.

Cooling system with water-to-water heat exchanger:

- Check heat exchanger has proper amount of ethylene glycol/water and that the heat exchanger is not leaking.
- Ensure there is no trapped air in the cooling path.
- Inspect cooling system (radiator and hoses) for cracks and connections are leak free.
- Check raw water pickup is not blocked/restricted by debris and hose is tightly connected.
- Check thermostat is not stuck closed.
- Check raw water pump/impeller is intact and not restricted.

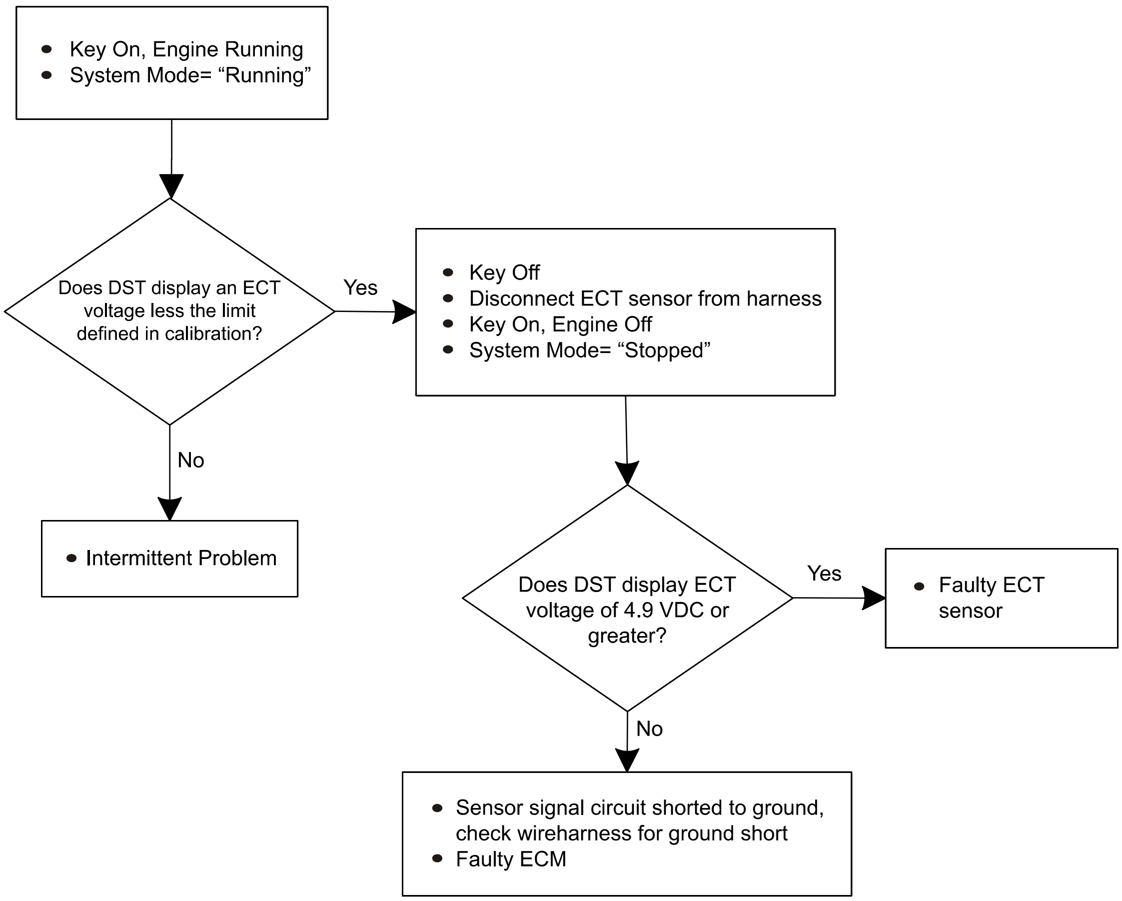
DTC 117- ECT/CHT Low Voltage



- Engine Coolant Temperature Sensor
- Check Condition-Engine Running
- Fault Condition-CHT/ECT sensor voltage less than the limit defined in the diagnostic calibration
- Corrective Action(s)- Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault, or any combination thereof as defined in calibration. Recommend a power derate 1/2 to reduce the possibility of engine damage due to the inability to sense temperature.
- Non-emissions related fault

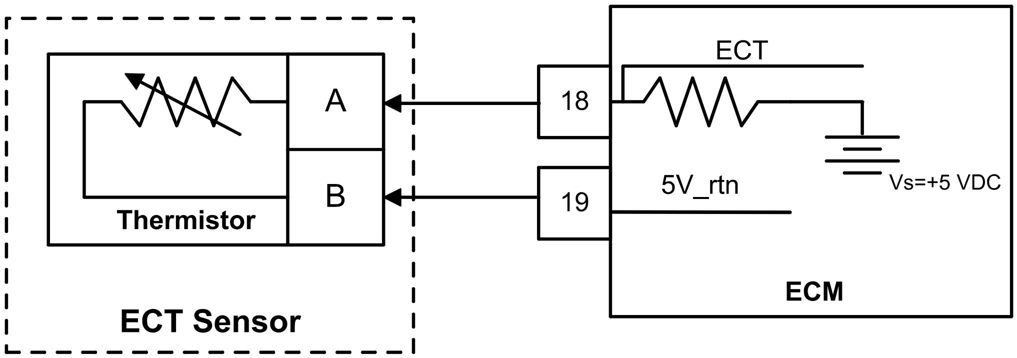
The Engine Coolant Temperature sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. Some engines use an ECT sensor that is located in the coolant near the thermostat. Some engines use a CHT (Cylinder Head Temperature) sensor that is located in the coolant in the cylinder head. If the engine is equipped with an ECT sensor then the CHT value is estimated. If equipped with a CHT sensor then the ECT value is estimated. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm.

This fault will set if the signal voltage is less than the limit defined in the diagnostic calibration anytime the engine is running. The limit is generally set to 0.10 VDC. The ECM will use a default value for the CHT/ECT sensor in the event of this fault.



Key On, Engine Running
System Mode= "Running"
Does DST display an ECT voltage less the limit defined in calibration?
Yes
No
Key Off
Disconnect ECT sensor from harness
Key On, Engine Off
System Mode= "Stopped"
Intermittent Problem
Does DST display ECT voltage of 4.9 VDC or greater?
Yes
No
Faulty ECT sensor
Sensor signal circuit shorted to ground, check wireharness for ground short
Faulty ECM

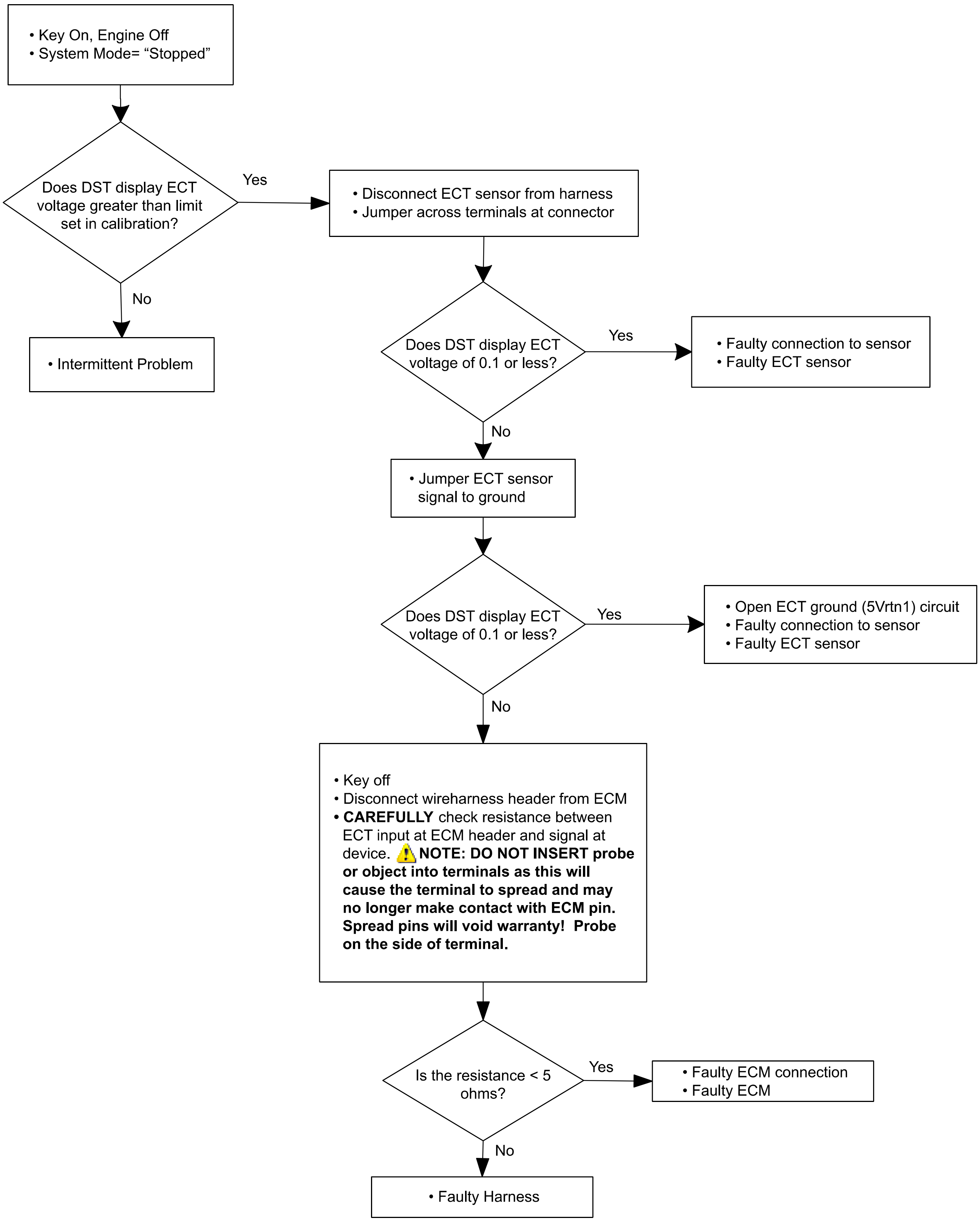
DTC 118- ECT/CHT High Voltage



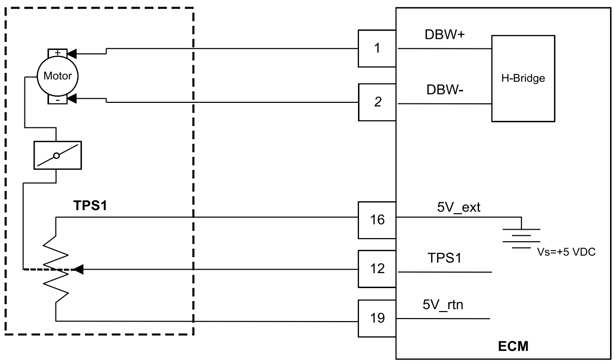
- Engine Coolant Temperature Sensor
- Check Condition-Engine Running
- Fault Condition-CHT/ECT sensor voltage higher than the limit defined in the diagnostic calibration
- Corrective Action(s)- Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault, or any combination thereof as defined in calibration. Recommend a power derate 1/2 to reduce the possibility of engine damage due to the inability to sense temperature.
- Non-emissions related fault

The Engine Coolant Temperature sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. Some engines use an ECT sensor that is located in the coolant near the thermostat. Some engines use a CHT (Cylinder Head Temperature) sensor that is located in the coolant in the cylinder head. If the engine is equipped with an ECT sensor then the CHT value is estimated. If equipped with a CHT sensor then the ECT value is estimated. The ECM provides a voltage divider circuit so that when the coolant is cool, the signal reads higher voltage, and lower when warm.

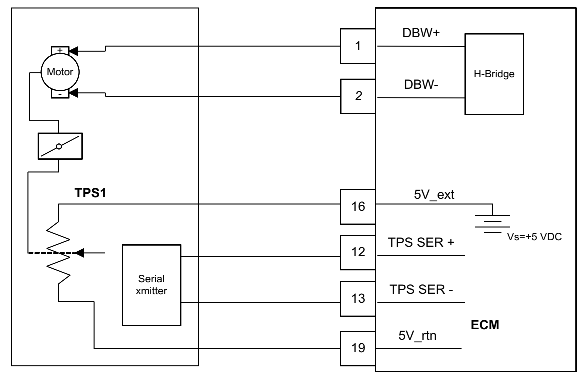
This fault will set if the signal voltage is higher than high voltage limit as defined in diagnostic calibration anytime engine is running. The limit is generally set to 4.90 VDC. In many cases, this condition is caused by the CHT/ECT sensor being disconnected from the engine harness, an open-circuit or short-to-power of the CHT/ECT circuit in the wire harness, or a failure of the sensor. The ECM will use a default value for the CHT/ECT sensor in the event of this fault.


• Key On, Engine Off
• System Mode= “Stopped”
Does DST display ECT voltage greater than limit set in calibration?
Yes
No
• Intermittent Problem
• Disconnect ECT sensor from harness
• Jumper across terminals at connector
Does DST display ECT voltage of 0.1 or less?
Yes
• Faulty connection to sensor
• Faulty ECT sensor
No
• Jumper ECT sensor signal to ground
Does DST display ECT voltage of 0.1 or less?
Yes
• Open ECT ground (5Vrtn1) circuit
• Faulty connection to sensor
• Faulty ECT sensor
No
• Key off
• Disconnect wireharness header from ECM
• CAREFULLY check resistance between ECT input at ECM header and signal at device. NOTE: DO NOT INSERT probe or object into terminals as this will cause the terminal to spread and may no longer make contact with ECM pin. Spread pins will void warranty! Probe on the side of terminal.
Is the resistance < 5 ohms?
Yes
• Faulty ECM connection
• Faulty ECM
No
• Faulty Harness

DTC 122- TPS1 Signal Voltage Low



Electronic Throttle Actuator w/Analog Position Feedback



Electronic Throttle Actuator w/Serial Position Feedback

- Throttle Position Sensor 1.
- Check Condition-Key On, Engine Off.
- Fault Condition-TPS1 sensor voltage lower than the limit defined in the diagnostic calibration.
- Corrective Action(s): Sound audible warning or illuminate secondary warning lamp, shutdown engine.
- Non-emissions related fault.

In the case of a diesel engine, an actuator controls a fuel injection pump, directly affecting the fueling level into the cylinders. This may be by direct manipulation of the fuel injection pump rack or by manipulation of the mechanical governor control level or “throttle arm.”

In the DGC ECM and EDIS, references to the throttle and throttle position sensor refer to these fuel injection pump control actuators and their position feedback sensors. When the fuel injection pump is electronically controlled it can be used to control the idle stability and limit engine speed based on operating conditions.

The Throttle Position Sensor uses either;

1) a variable resistor and voltage divider circuit

or

2) a non-contact hall-effect sensor to determine throttle actuator position, and is located within the throttle actuator.

There are two types of throttle actuators;

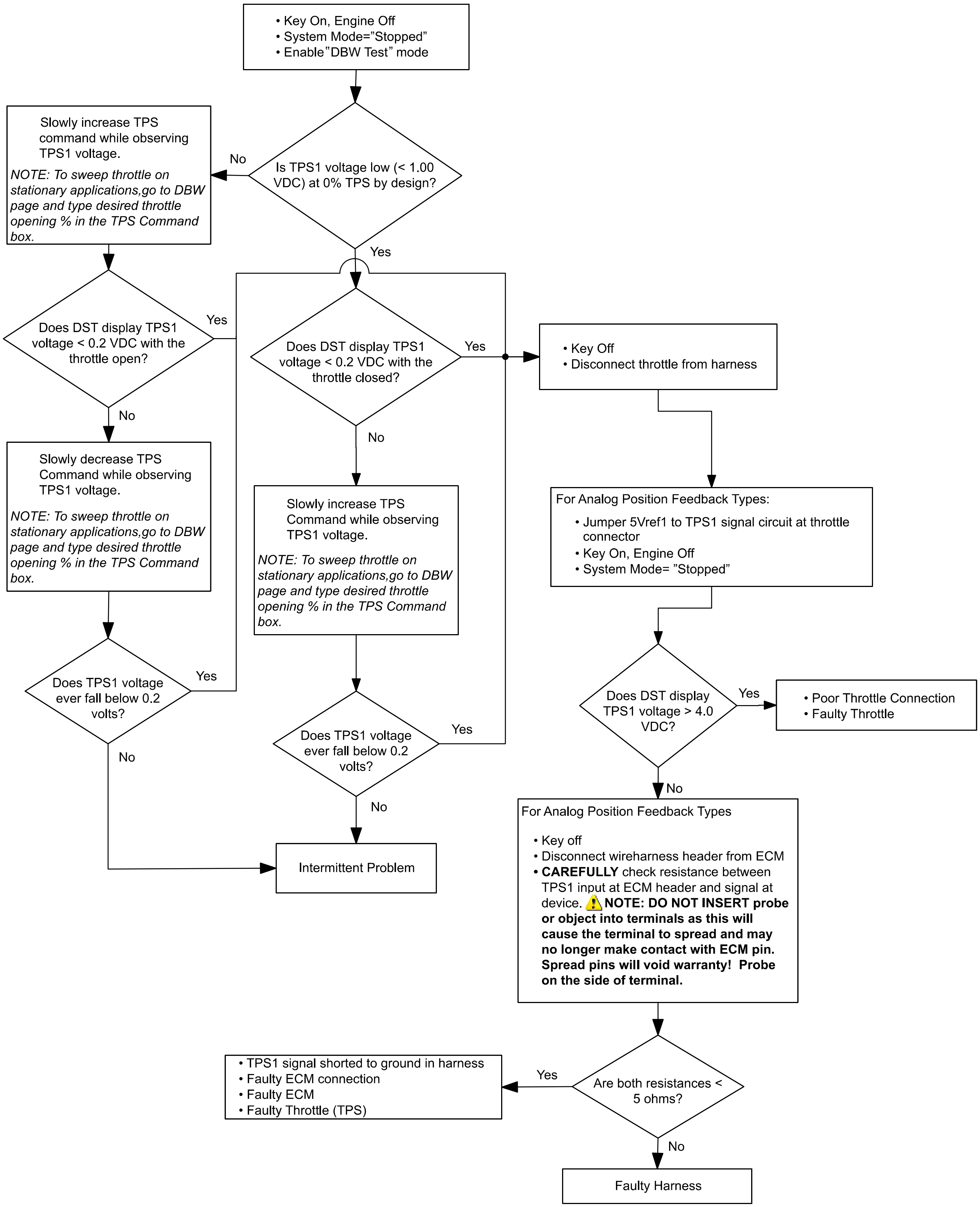
1) actuator with analog position feedback

and

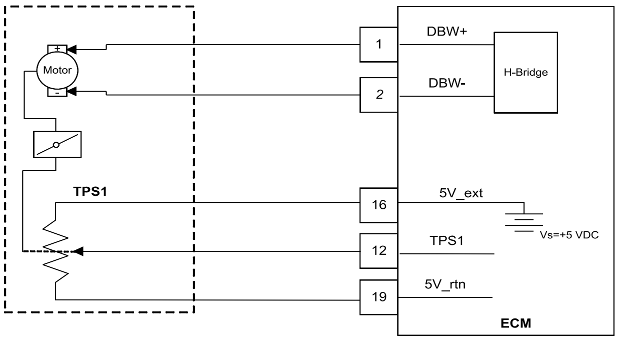
2) actuator with digital position feedback.

The first type, with analog position feedback, provides an analog return signal between 0 and 5 volts that is proportional to the throttle actuator position. The second type, with digital position feedback, provides a serial data signal to the ECM with the throttle actuator position voltage level encoded in the data stream.

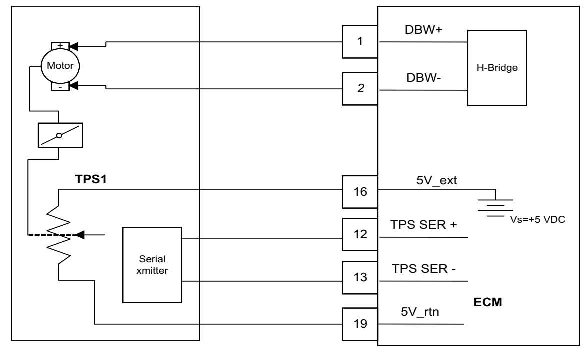
This fault sets if TPS1 voltage is lower than the low voltage limit as defined in the diagnostic calibration at any operating condition while the engine is cranking or running. The limit is generally set to 4.90 VDC. In many cases, this condition is caused by the TPS sensor being disconnected from the engine harness, an open-circuit or short-to-ground of the TPS circuit in the wire harness, or a failure of the sensor. This fault should be configured to trigger an engine shutdown and the engine will not start with this fault active.


• Key On, Engine Off
• System Mode="Stopped"
• Enable"DBW Test" mode
Is TPS1 voltage low (< 1.00 VDC) at 0% TPS by design?
No
Slowly increase TPS command while observing TPS1 voltage.
NOTE: To sweep throttle on stationary applications,go to DBW page and type desired throttle opening % in the TPS Command box.
Yes
Does DST display TPS1 voltage < 0.2 VDC with the throttle open?
Yes
No
Slowly decrease TPS Command while observing TPS1 voltage.
NOTE: To sweep throttle on stationary applications,go to DBW page and type desired throttle opening % in the TPS Command box.
Does TPS1 voltage ever fall below 0.2 volts?
Yes
No
Does DST display TPS1 voltage < 0.2 VDC with the throttle closed?
Yes
No
Slowly increase TPS Command while observing TPS1 voltage.
NOTE: To sweep throttle on stationary applications,go to DBW page and type desired throttle opening % in the TPS Command box.
Does TPS1 voltage ever fall below 0.2 volts?
Yes
No
Intermittent Problem
• Key Off
• Disconnect throttle from harness
For Analog Position Feedback Types:
• Jumper 5Vref1 to TPS1 signal circuit at throttle connector
• Key On, Engine Off
• System Mode= "Stopped"
Does DST display TPS1 voltage > 4.0 VDC?
Yes
• Poor Throttle Connection
• Faulty Throttle
No
For Analog Position Feedback Types
• Key off
• Disconnect wireharness header from ECM
• CAREFULLY check resistance between TPS1 input at ECM header and signal at device. NOTE: DO NOT INSERT probe or object into terminals as this will cause the terminal to spread and may no longer make contact with ECM pin. Spread pins will void warranty! Probe on the side of terminal.
Are both resistances < 5 ohms?
Yes
• TPS1 signal shorted to ground in harness
• Faulty ECM connection
• Faulty ECM
• Faulty Throttle (TPS)
No
Faulty Harness

DTC 123- TPS1 Signal Voltage High



Electronic Throttle Actuator w/Analog Position Feedback



Electronic Throttle Actuator w/Serial Position Feedback

- Throttle Position Sensor 1.
- Check Condition-Key On, Engine Off.
- Fault Condition-TPS1 sensor voltage higher than the limit defined in the diagnostic calibration.
- Corrective Action(s): Sound audible warning or illuminate secondary warning lamp, shutdown engine.
- Non-emissions related fault.

In the case of a diesel engine, an actuator controls a fuel injection pump, directly affecting fueling level into the cylinders. This may be by direct manipulation of the fuel injection pump rack or by manipulation of the mechanical governor control level or “throttle arm.” In the DGC ECM and EDIS, references to throttle and throttle position sensor refer to these fuel injection pump control actuators and their position feedback sensors. When the fuel injection pump is electronically controlled it can be used to control the idle stability and limit engine speed based on operating conditions.

The Throttle Position Sensor uses either;

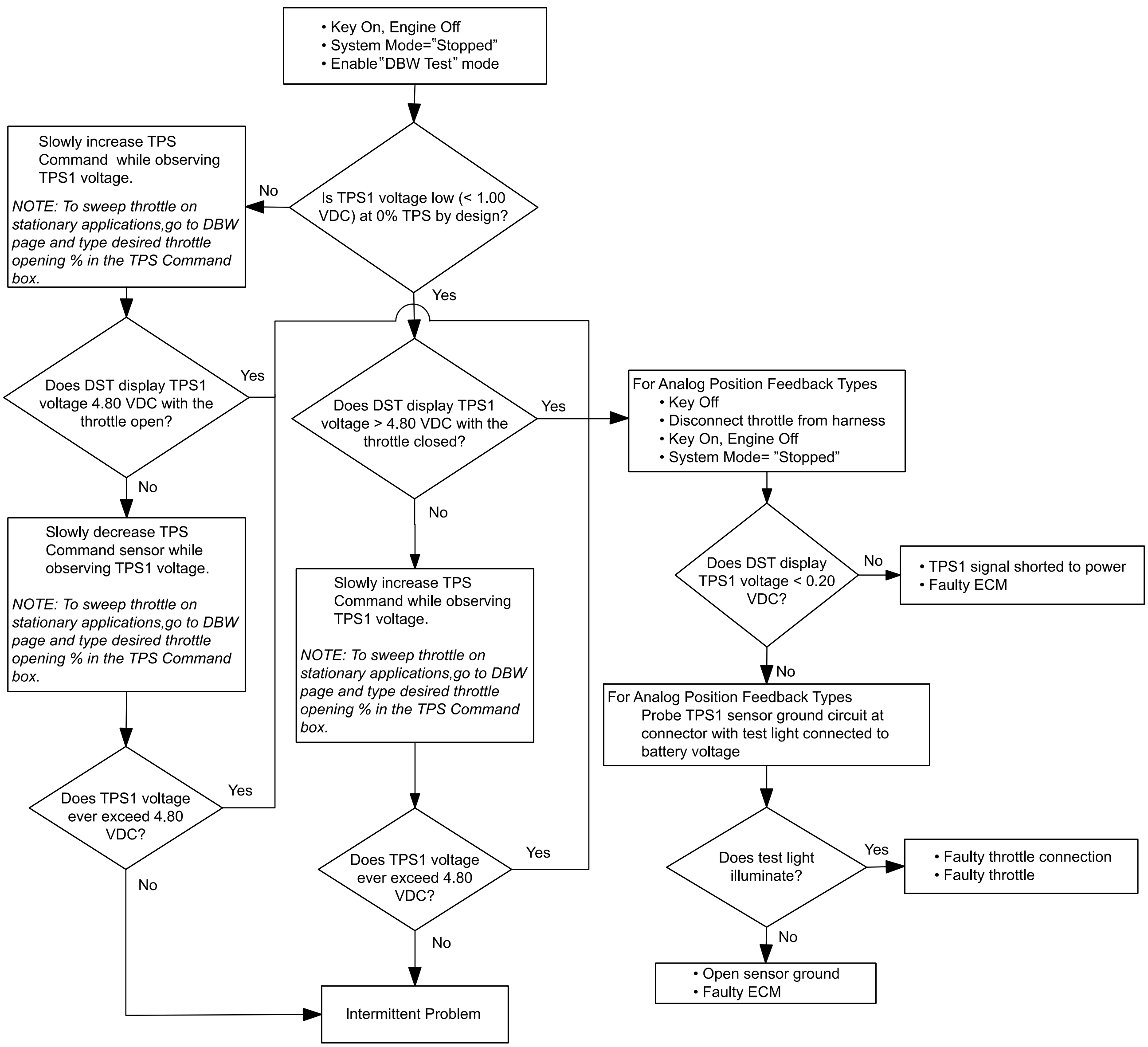
1) a variable resistor and voltage divider circuit

or

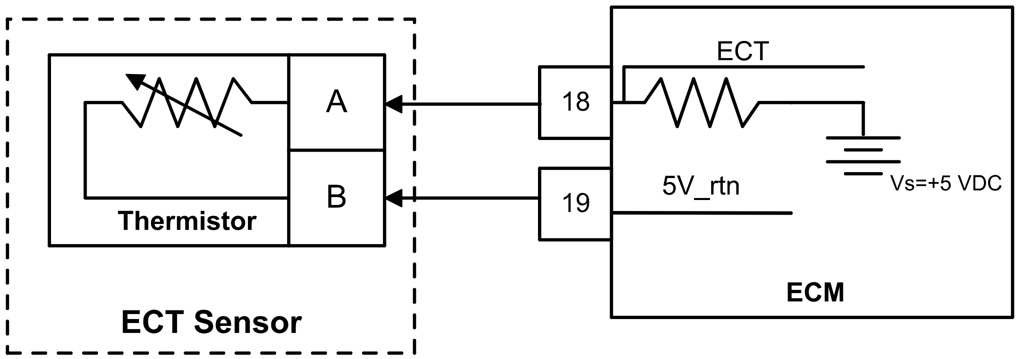
2) a non-contact hall-effect sensor to determine throttle actuator position, and is located within the throttle actuator.

There are two types of throttle actuators, 1) actuator with analog position feedback and 2) actuator with digital position feedback. The first type, with analog position feedback, provides an analog return signal between 0 and 5 volts that is proportional to the throttle actuator position. The second type, with digital position feedback, provides a serial data signal to the ECM with the throttle actuator position voltage level encoded in the data stream.

This fault will set if TPS1 voltage is higher than the limit set in the diagnostic calibration at any operating condition while the engine is cranking or running. The limit is generally set to 4.90 VDC. In many cases, this condition is caused by a short-to-power of the TPS circuit in the wire harness or a failure of the sensor. This fault should be configured to trigger an engine shutdown and the engine will not start with this fault active.


• Key On, Engine Off
• System Mode="Stopped"
• Enable"DBW Test" mode
Is TPS1 voltage low (< 1.00 VDC) at 0% TPS by design?
No
Slowly increase TPS Command while observing TPS1 voltage.
NOTE: To sweep throttle on stationary applications,go to DBW page and type desired throttle opening % in the TPS Command box.
Yes
Does DST display TPS1 voltage 4.80 VDC with the throttle open?
Yes
No
Slowly decrease TPS Command sensor while observing TPS1 voltage.
NOTE: To sweep throttle on stationary applications,go to DBW page and type desired throttle opening % in the TPS Command box.
Does TPS1 voltage ever exceed 4.80 VDC?
Yes
No
Does DST display TPS1 voltage > 4.80 VDC with the throttle closed?
Yes
No
Slowly increase TPS Command while observing TPS1 voltage.
NOTE: To sweep throttle on stationary applications,go to DBW page and type desired throttle opening % in the TPS Command box.
Does TPS1 voltage ever exceed 4.80 VDC?
Yes
No
Intermittent Problem
For Analog Position Feedback Types
• Key Off
• Disconnect throttle from harness
• Key On, Engine Off
• System Mode= "Stopped"
Does DST display TPS1 voltage < 0.20 VDC?
No
• TPS1 signal shorted to power
• Faulty ECM
No
For Analog Position Feedback Types
Probe TPS1 sensor ground circuit at connector with test light connected to battery voltage
Does test light illuminate?
Yes
• Faulty throttle connection
• Faulty throttle
No
• Open sensor ground
• Faulty ECM

DTC 217- ECT Higher Than Expected 2



- Engine Coolant Temperature Sensor.
- Check Condition-Engine Running.
- Fault Condition-Engine Coolant Temperature reading or estimate greater than the stage 2 limit when operating at a speed greater than defined in the diagnostic calibration.
- Corrective Action(s)- Sound audible warning or illuminate secondary warning lamp, disable adaptive learn fueling correction during active fault. Recommend a power derate 2 and/or a forced idle or engine shutdown to protect engine from possible damage.
- Non-emissions related fault

The Engine Coolant Temperature sensor is a thermistor (temperature sensitive resistor) located in the engine coolant. Some engines use a CHT sensor that is located in the coolant in the cylinder head. Some engines use an ECT (Engine Coolant Temperature) sensor that is located in the coolant near the thermostat. If the engine is equipped with a CHT sensor then the ECT value is estimated. If equipped with an ECT sensor then the CHT value is estimated. The ECM provides a voltage divider circuit so when the sensor reading is cool the sensor reads higher voltage, and lower when warm.

This fault helps protect the engine in the event of over temperature. When coolant exceeds x deg. F and engine RPM exceeds y RPM for the latch time this fault will set.

Diagnostic Aids

If “ECT High Voltage” fault is present, follow troubleshooting procedures for that fault as it may have caused “ECT Higher Than Expected 2.”

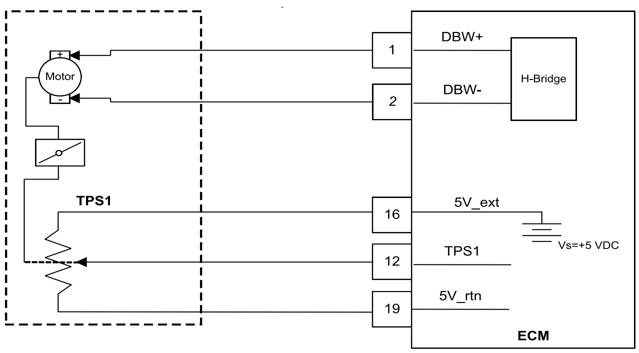
If cooling system uses an air-to-water heat exchanger (radiator) and fan:

- Check radiator has a proper amount of ethylene glycol/water and is not leaking.
- Make sure there is no trapped air in the cooling path.
- Inspect cooling system (radiator and hoses) for cracks and ensure connections are leak free.
- Check fan is operating properly.
- Check thermostat is not stuck closed.

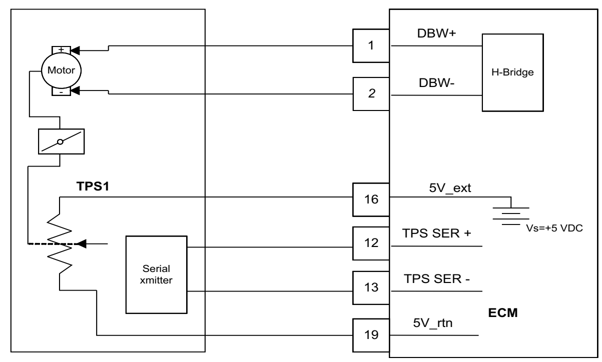
If cooling system uses a water-to-water heat exchanger:

- Check heat exchanger has proper amount of ethylene glycol/water and heat exchanger is not leaking.
- Make sure there is no trapped air in the cooling path.
- Inspect cooling system (radiator and hoses) for cracks and connections are leak free.
- Check raw water pickup is not blocked/restricted by debris and hose is tightly connected.
- Check thermostat is not stuck closed.
- Check raw water pump/impeller is intact and not restricted.

DTC 219- RPM Higher Than Max Allowed Governed Speed



Electronic Throttle Actuator w/Analog Position Feedback



Electronic Throttle Actuator w/Serial Position Feedback

- Max Govern Speed Override- Crankshaft Position Sensor
- Check Condition-Engine Running.
- Fault Condition-Engine speed greater than the max governor override speed as defined in the diagnostic calibration.
- Corrective Action(s): Sound audible warning or illuminate secondary warning lamp, reduce throttle to limit speed. Recommend closed loop and adaptive learn fueling correction remains active during fault.
- Non-emissions related fault

This fault sets anytime engine RPM exceeds limit set in diagnostic calibration for latch time or more. This speed overrides any higher max governor speeds programmed by the user. This fault is designed to help prevent engine or equipment damage.

Throttle lowers to govern engine to speed set in diagnostic calibration.

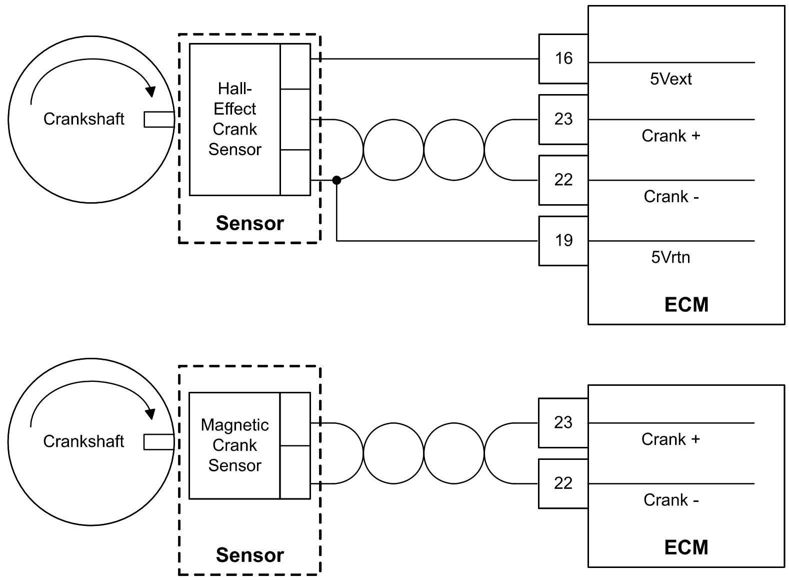
DTC 219- RPM Higher Than Max Allowed Governed Speed (continued).

Diagnostic Aids

NOTE: If any other DTCs are present, diagnose those first.

- Ensure no programmed governor speeds exceed limit set in diagnostic calibration for Max Gov Override Speed
- Check mechanical operation of the throttle actuator

DTC 336- Crank Signal Input Noise



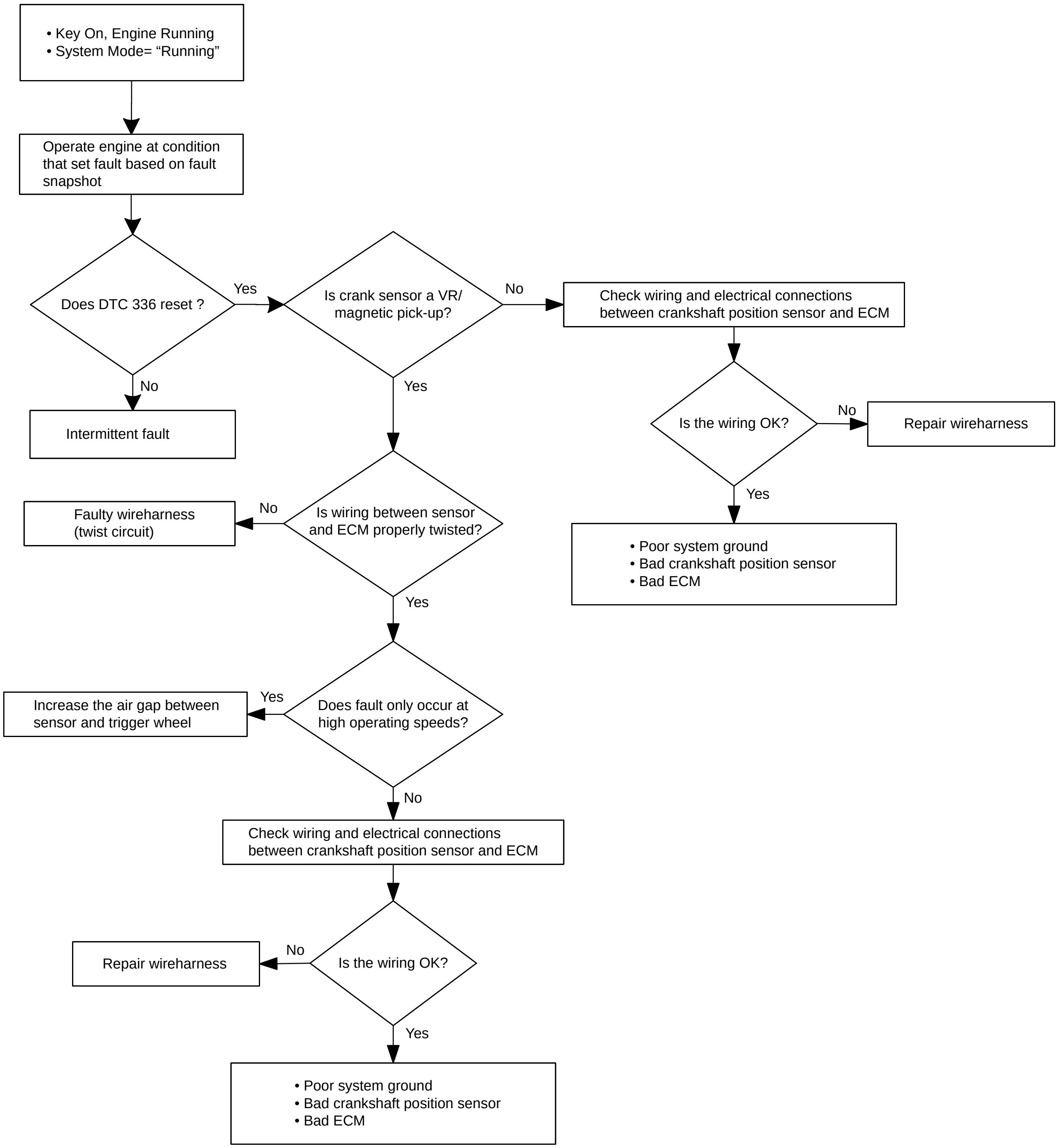
- Crankshaft Position sensor.
- Check Condition- Key On, Engine On.
- Fault Condition- Electrical noise or irregular crank pattern detected causing x number of crank resynchronization events as defined in diagnostic calibration.
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp and disable adaptive fueling correction for remainder of key-cycle.
- Emissions related fault

The crankshaft position sensor is a magnetic sensor (variable reluctant/magnetic pick-up or Hall effect) installed in the engine block adjacent to a “coded” trigger wheel located on the crankshaft. The sensor-trigger wheel combination determines crankshaft position (with respect to TDC cylinder #1 compression) and the rotational engine speed.

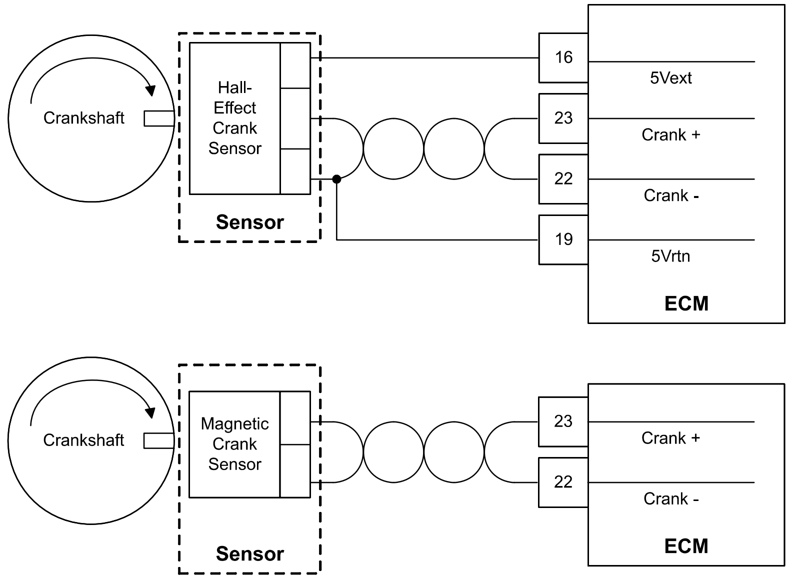
Determination of crankshaft position and speed is necessary to properly activate the ignition, fuel injection, and throttle governing systems for precise engine control.

The ECM must see a valid crankshaft position signal while running. If no signal is present, the signal amplitude is too high (due to improper air gap with respect to trigger wheel), or an irregular crank pattern is detected causing the ECM to resynchronize x times for y ms or longer as defined in the diagnostic calibration, this fault will set. Irregular crank patterns can be detected by the ECM due to electrical noise, poor machining of trigger wheel, or trigger wheel runout and/or gear lash.

Ensure crank circuit used with VR/magnetic pick-up sensors are properly twisted.


• Key On, Engine Running
• System Mode= “Running”
Operate engine at condition that set fault based on fault snapshot
Does DTC 336 reset ?
Yes
No
Intermittent fault
Is crank sensor a VR/ magnetic pick-up?
No
Yes
Check wiring and electrical connections between crankshaft position sensor and ECM
Is the wiring OK?
No
Repair wireharness
Yes
• Poor system ground
• Bad crankshaft position sensor
• Bad ECM
Is wiring between sensor and ECM properly twisted?
No
Faulty wireharness (twist circuit)
Yes
Does fault only occur at high operating speeds?
Yes
Increase the air gap between sensor and trigger wheel
No
Check wiring and electrical connections between crankshaft position sensor and ECM
Is the wiring OK?
No
Repair wireharness
Yes
• Poor system ground
• Bad crankshaft position sensor
• Bad ECM

DTC 337- Loss of Crank Input Signal



- Crankshaft Position sensor.
- Check Condition- Key On, Engine On.
- Fault Condition- Loss of crankshaft position signal while valid camshaft position signals continue for x number of cam pulses as defined in the diagnostic calibration.
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp.
- Emissions related fault.

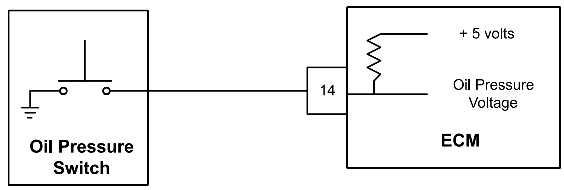
The crankshaft position sensor is a magnetic sensor (variable reluctant/magnetic pick-up or Hall effect) installed in the engine block adjacent to a ì§codedì¨ trigger wheel located on the crankshaft. The sensor-trigger wheel combination is used to determine crankshaft position (with respect to TDC cylinder #1 compression) and rotational engine speed. Determination of the crankshaft position and speed is necessary to properly activate the ignition, fuel injection, and throttle governing systems for precise engine control.

The ECM must see a valid crankshaft position signal while running. If no signal is present while x cam pulses continue, the fault will set. The engine typically stalls or dies as a result of this fault condition due to lack of crankshaft speed input, resulting in loss of ignition timing control.

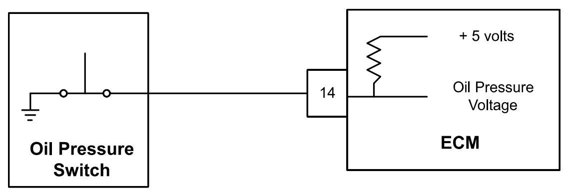
Diagnostic Aids

- Check crankshaft position sensor is securely connected to harness.
- Check crankshaft position sensor is securely installed in engine block.
- Check crankshaft position sensor circuit wiring for open circuit.

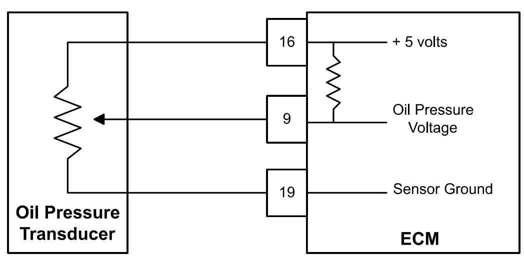
DTC 521- Oil Pressure Sender/Switch High Pressure



Normally-Open Switch-Type



Normally-Closed Switch-Type



Sensor-Type

- Engine Oil Pressure
- Check Condition- Key on, Engine on (or Engine off)
- Fault Condition- For sender types, oil pressure higher than x psia while engine speed is greater that y RPM. For switch types, oil pressure is indicating high when the engine has been stopped for more than n seconds.
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, possibly configure for power derate 1 or low rev limit
- Non-emissions related fault

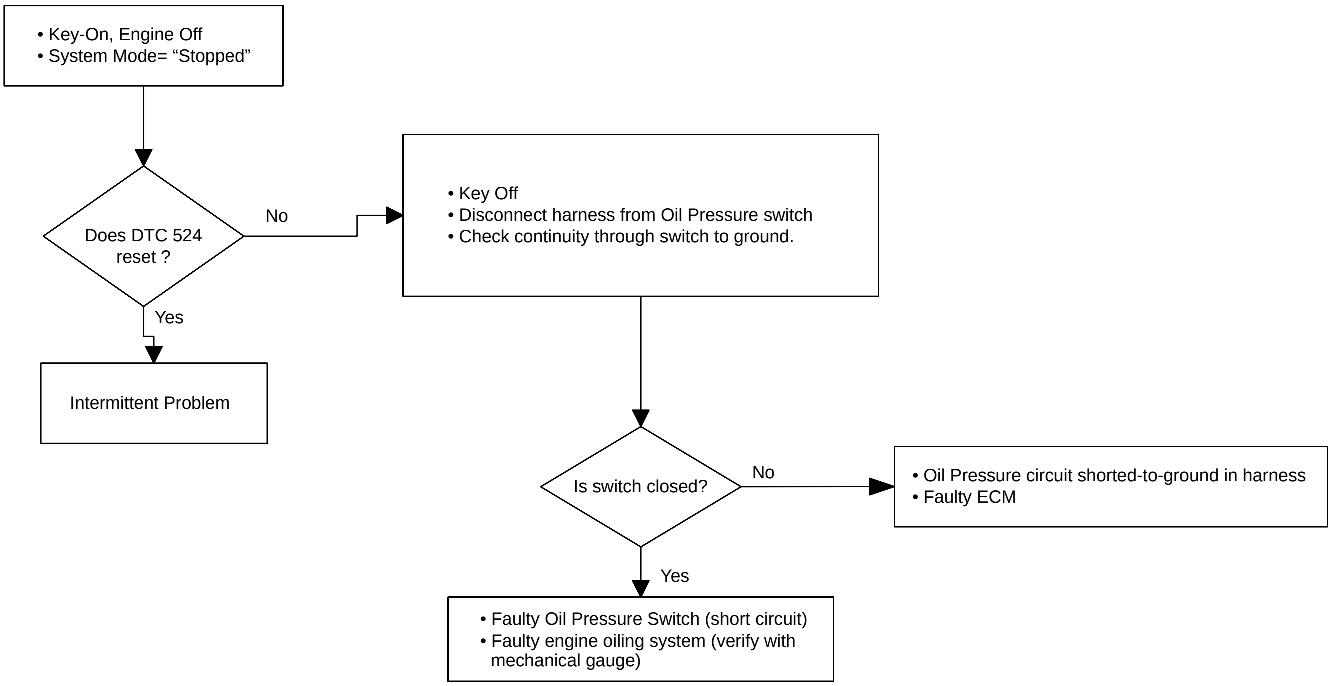
The ECM can be configured to monitor oil pressure through a proportional transducer or through a switch. Oil pressure monitoring is important to prevent engine damage due to low oil pressure resulting in higher friction and lack of lubrication. In addition, high oil pressure can be undesirable because it can cause oil to leak past seals and rings, can be a result of a restriction in the oil flow path, or can be a sign of a malfunctioning oiling system.

Additionally for normally-open type oil pressure switches, a high pressure indication while the engine is off is a symptom of a failed oil pressure switch. The ECM can monitor oil pressure indication when the engine is stopped for this failure mode.

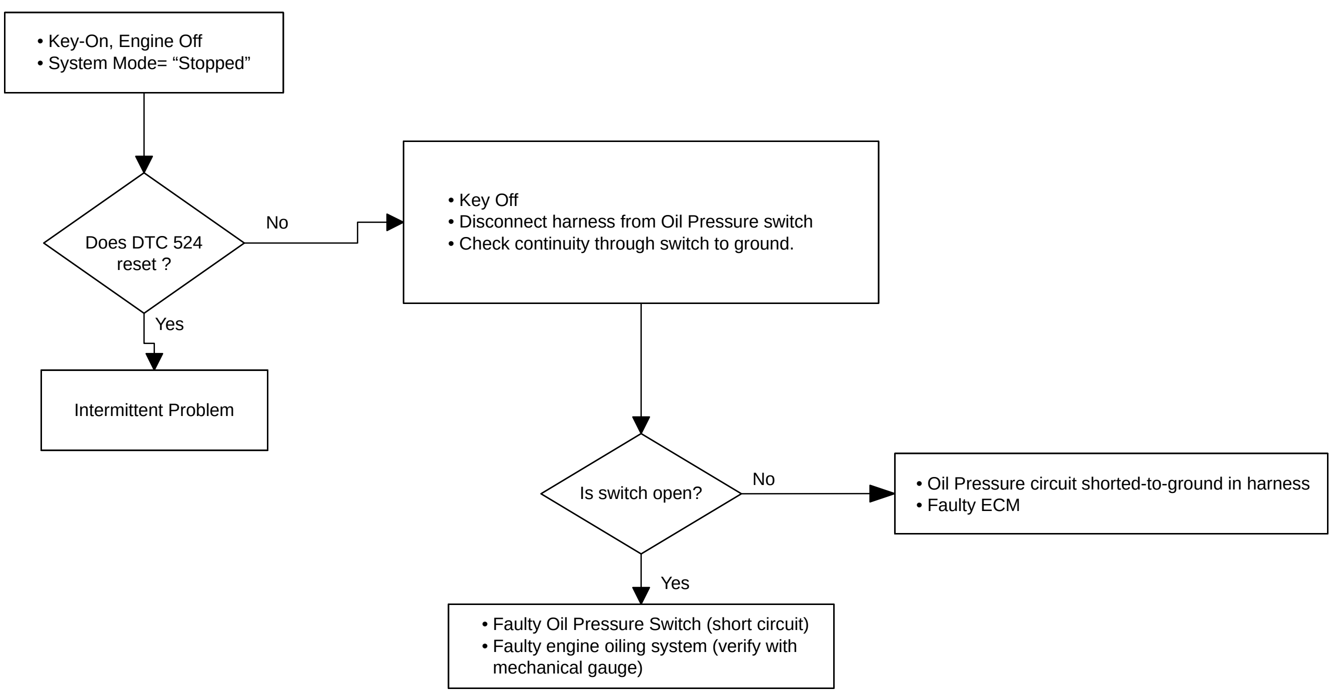
For sender types, this fault sets if engine oil pressure is higher than x psia and engine speed greater than y RPM as defined in diagnostic calibration.

For switch types, this fault sets if the engine oil pressure is indicating high when the engine is stopped for more than n seconds. Recommend a power derate and/or low rev limit to help prevent possible engine damage and reduce oil pressure.

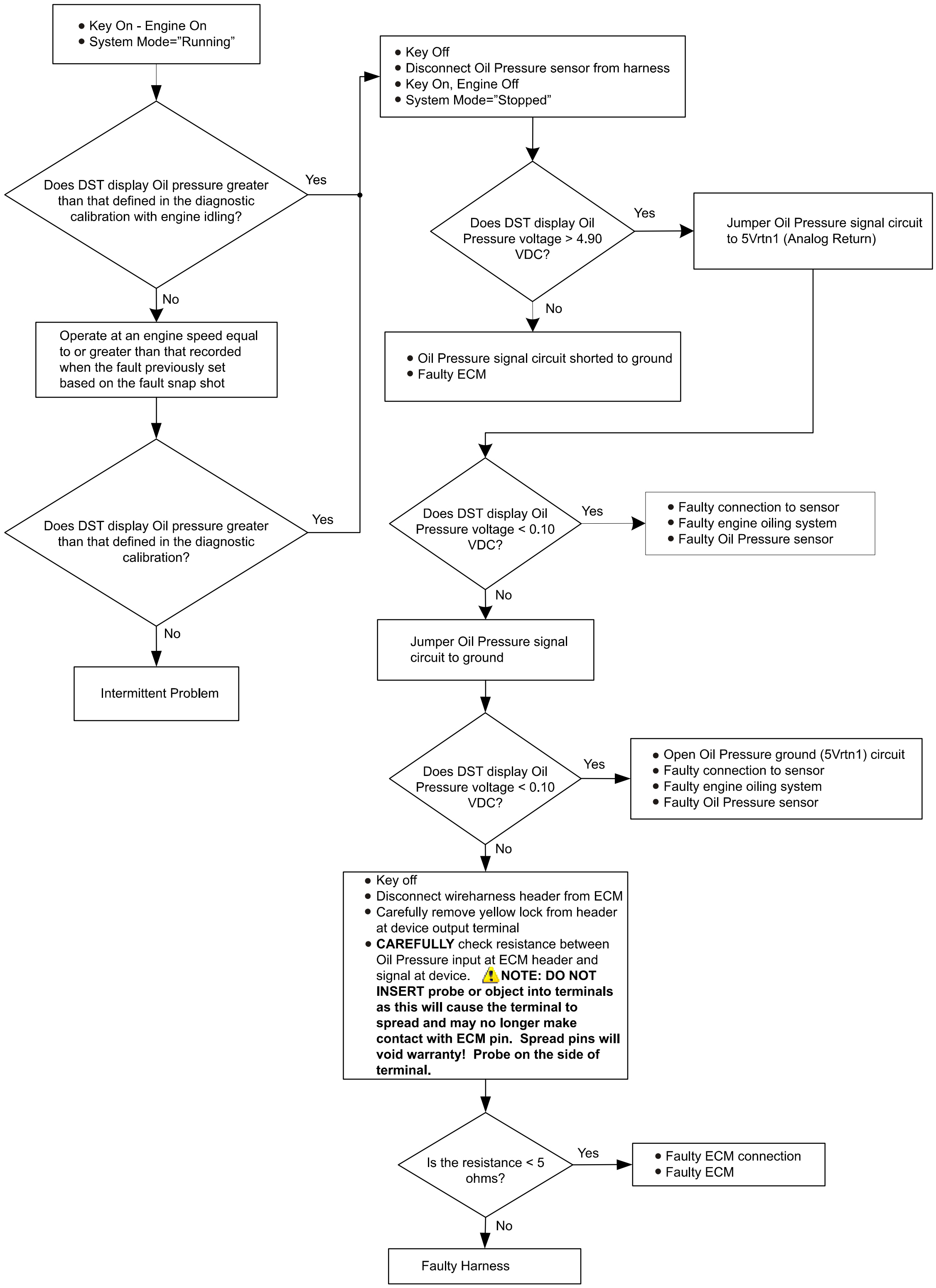
Normally Open Switch



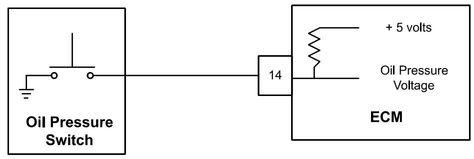
Normally Closed Switch



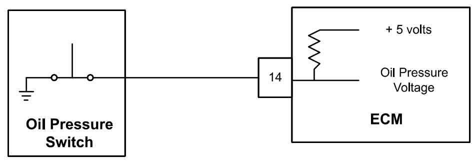
Sensor/Transducer Type



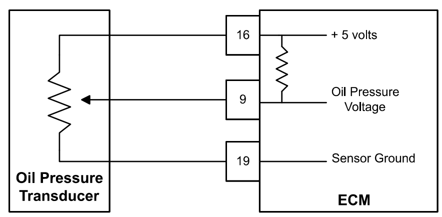
DTC 524- Oil Pressure Low



Normally-Open Switch-Type



Normally-Closed Switch-Type



Sensor-Type

- Engine Oil Pressure.
- Check Condition- Key on, Engine on.
- Fault Condition- Engine oil pressure lower than expected while engine has been running for a minimum amount of time while engine speed is above some limit as defined in the diagnostic calibration.
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, generally configured to derate the engine and trigger an engine shutdown.
- Non-emissions related fault.

The ECM can be configured to monitor oil pressure through a proportional transducer or through a switch. Oil pressure monitoring is important to prevent engine damage due to low oil pressure resulting in higher friction and lack of lubrication. In addition, high oil pressure can be undesirable because it can cause oil to leak past seals and rings, can be a result of a restriction in the oil flow path, or can be a sign of a malfunctioning oiling system.

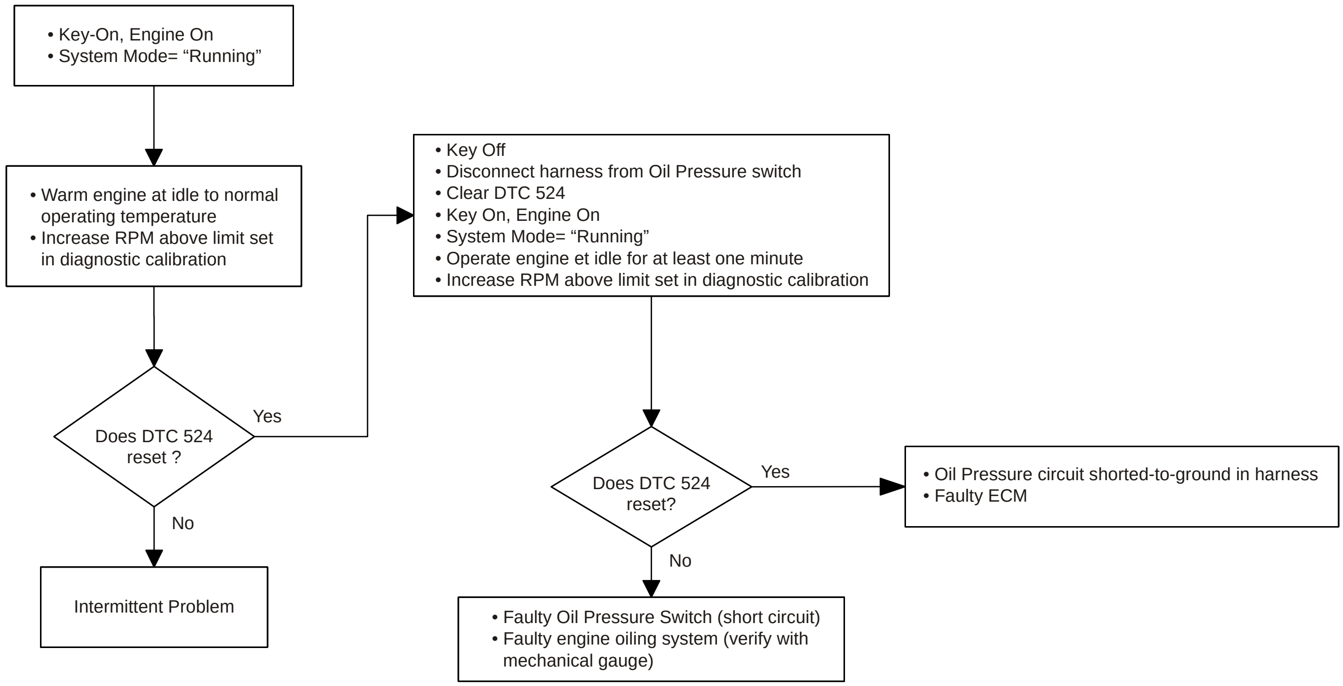
For systems that use a transducer, this fault sets if engine oil pressure is less than x psia and engine speed is greater than y RPM after engine has been running for z seconds as defined in diagnostic calibration. For systems that use a switch, this fault can be configured two different ways. It may use a normally closed switch or a normally open switch.

If switch is normally open, the fault sets if the circuit becomes grounded.

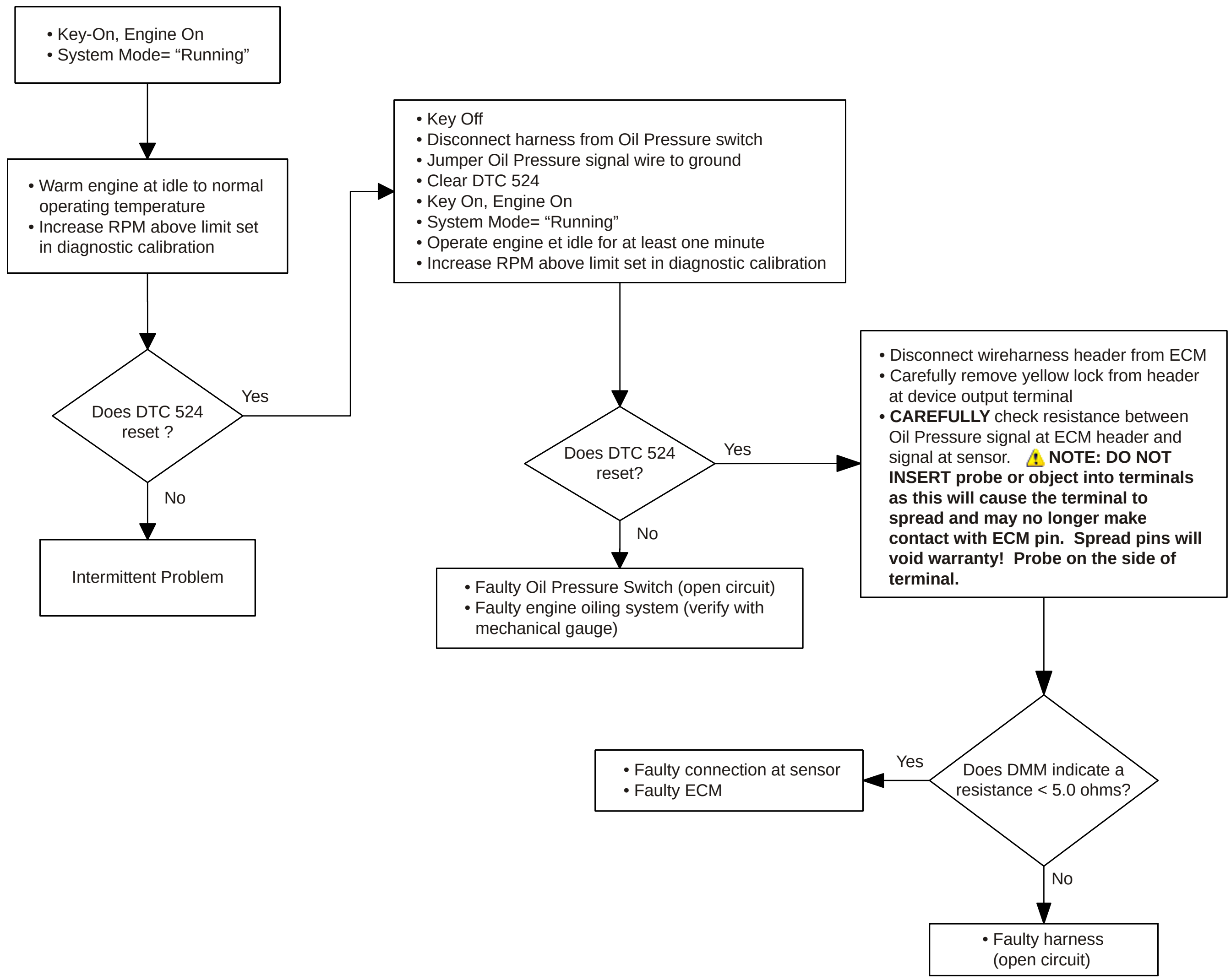
If switch is normally closed, fault sets if circuit becomes open.

Go to Faults page in EDIS to determine how the input is configured. (“Open=OK” is normally open and “Ground=OK” is normally closed). The engine should be configured to derate or force idle and/or shut down in the event of this fault to prevent possible damage.

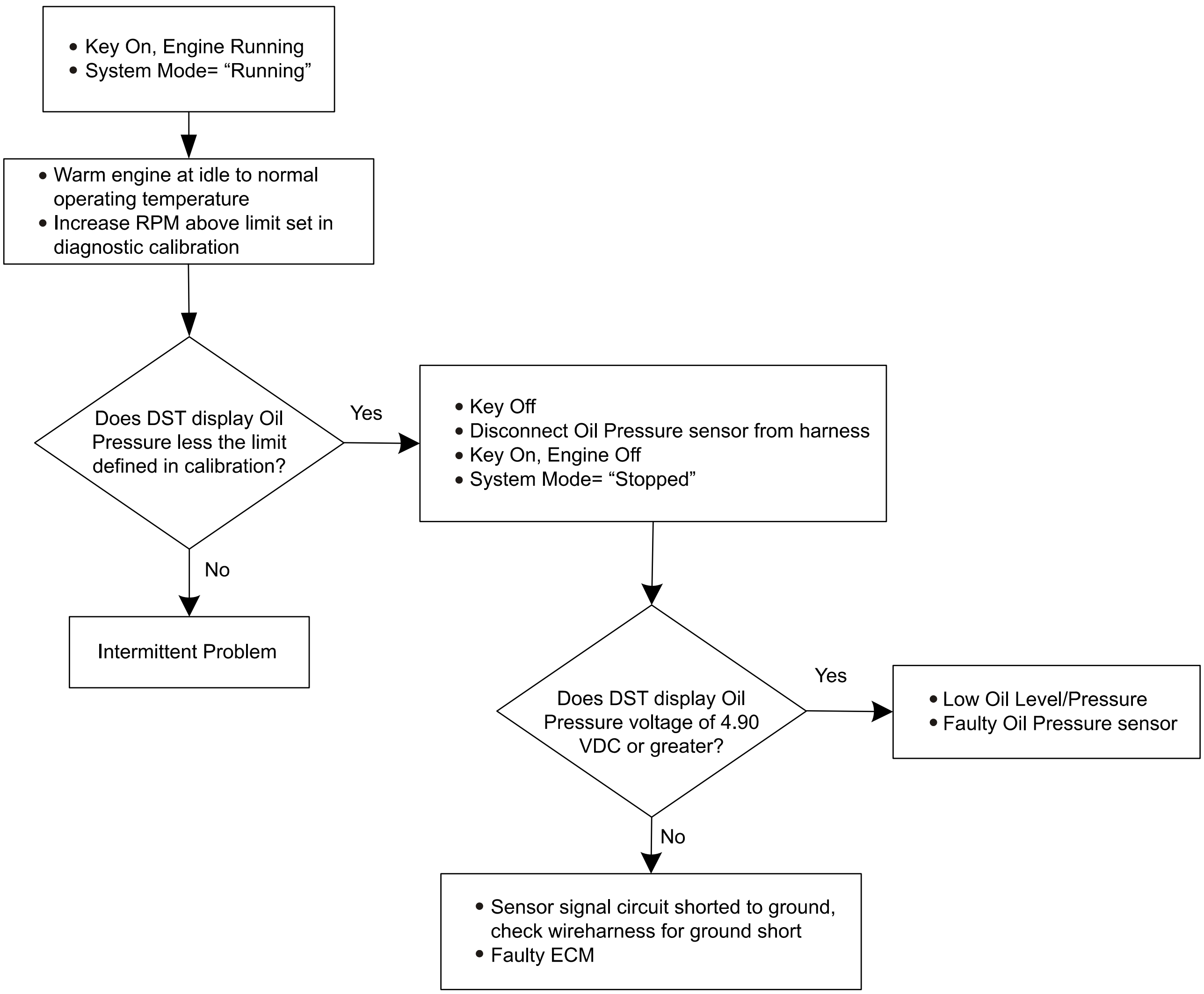
Normally Open Switch



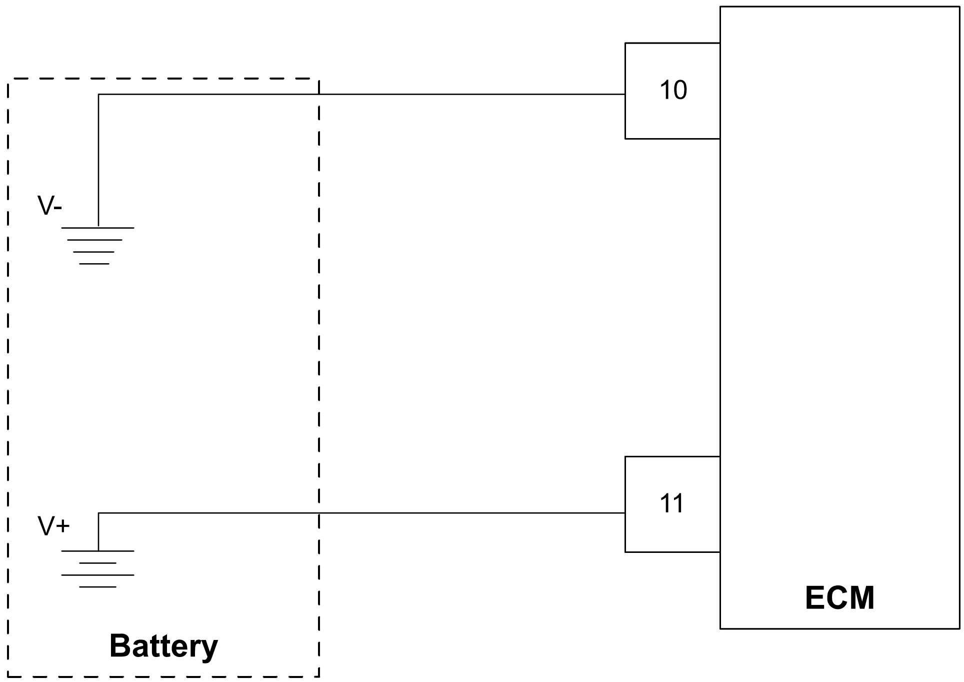
Normally Closed Switch



Sensor/Transducer Type



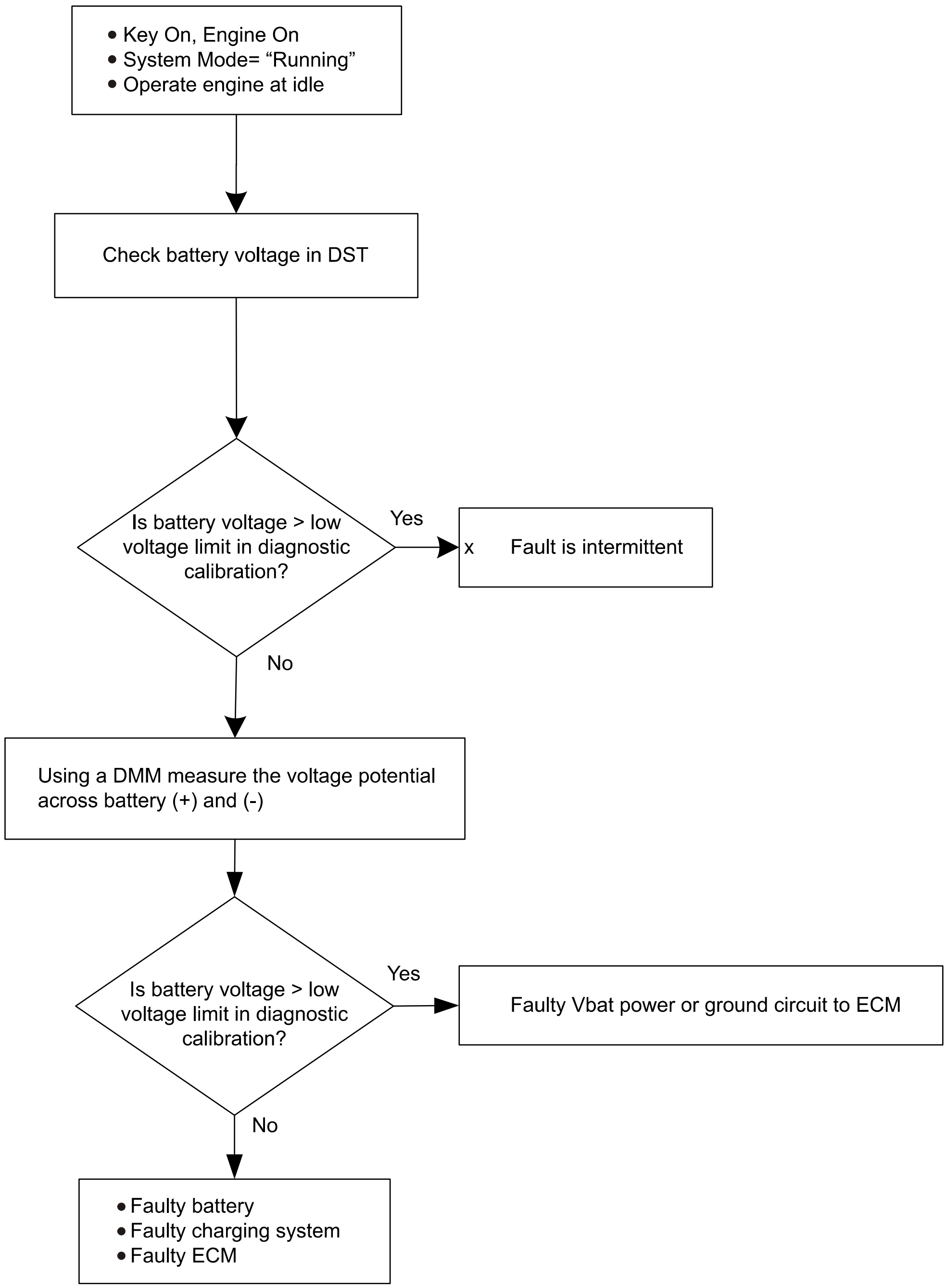
DTC 562- Battery Voltage (VBat) Low



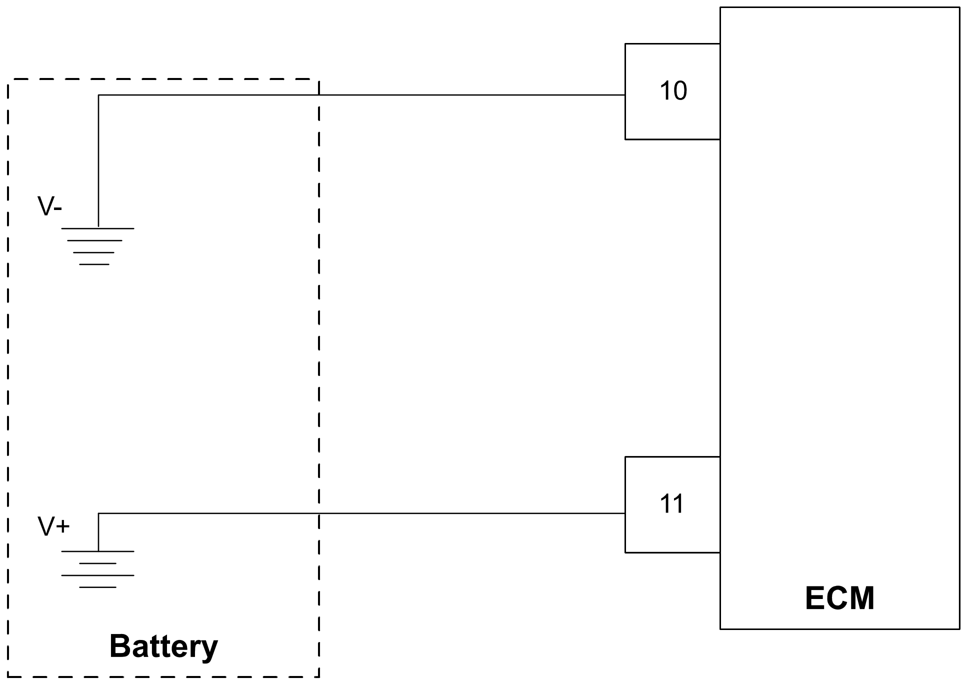
- System voltage to ECM.
- Check Condition- Key on, Engine on.
- Fault Condition- Battery voltage to ECM less than x volts while the engine is operating at y RPM or greater as defined in the diagnostic calibration.
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive fueling correction for remainder of key cycle.
- Non-emissions related fault.

Battery voltage powers the ECM and must be within limits to correctly operate throttle actuator, power supplies, and other powered devices the ECM controls.

This fault sets if the ECM detects system voltage less than x volts while the engine is operating at y RPM as defined in diagnostic calibration as the alternator should be charging the system.


• Key On, Engine On
• System Mode= “Running”
• Operate engine at idle
Check battery voltage in DST
Is battery voltage > low voltage limit in diagnostic calibration?
Yes
x
Fault is intermittent
No
Using a DMM measure the voltage potential across battery (+) and (-)
Is battery voltage > low voltage limit in diagnostic calibration?
Yes
Faulty Vbat power or ground circuit to ECM
No
• Faulty battery
• Faulty charging system
• Faulty ECM

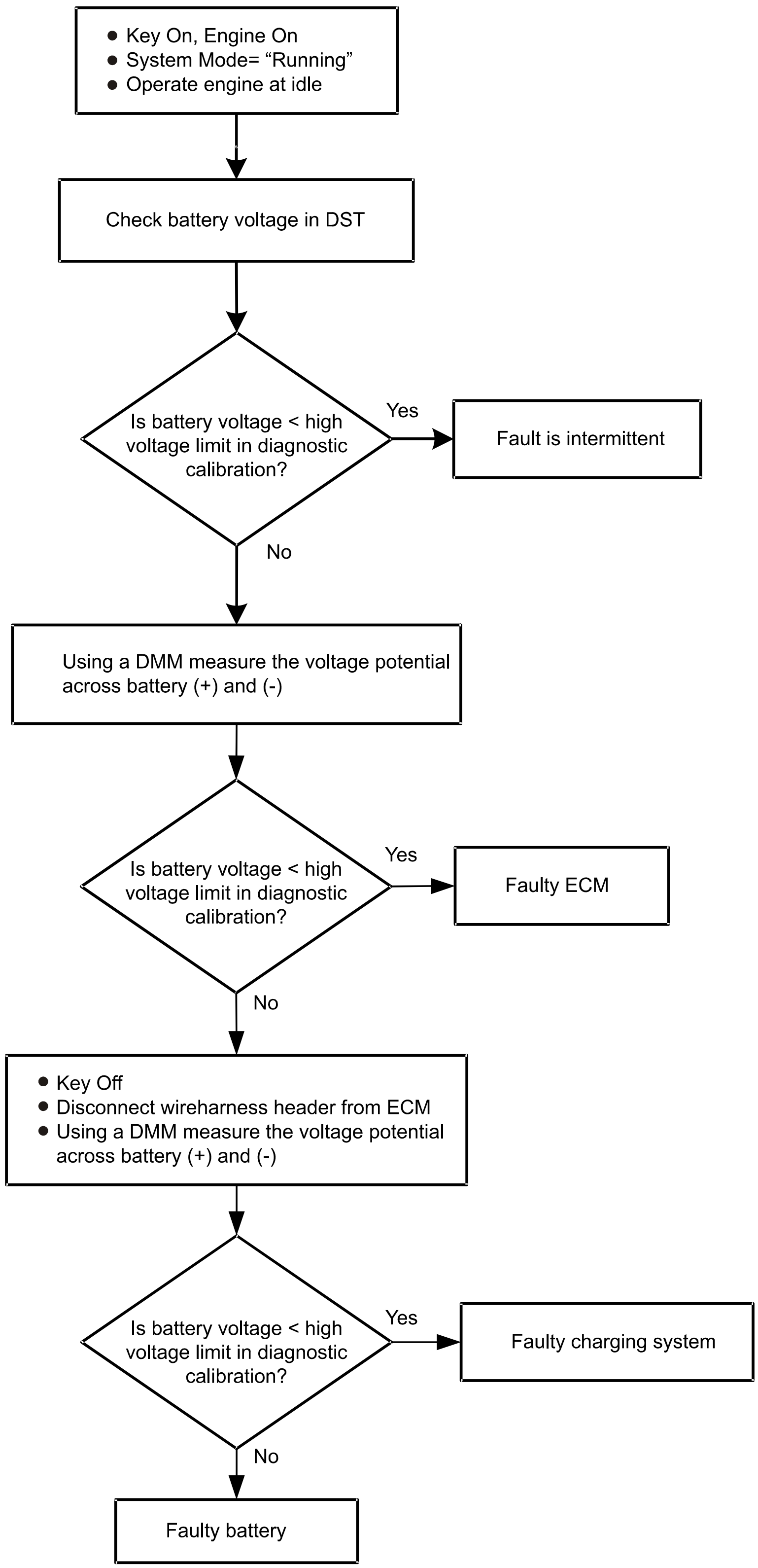
DTC 563- Battery Voltage (VBat) High



- System voltage to ECM.
- Check Condition-Key on, Engine Cranking or Running.
- Fault Condition- Battery voltage to ECM greater than x volts while the engine is running as defined in the diagnostic calibration.
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive fueling correction for remainder of key cycle.
- Non-emissions related fault.

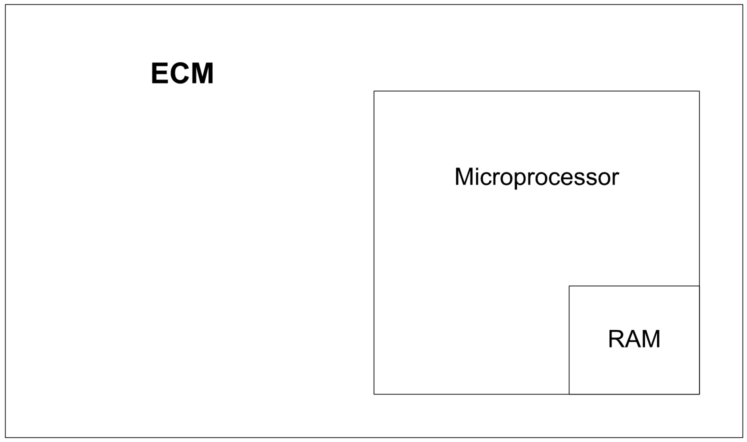
Battery voltage powers the ECM and must be within limits to correctly operate throttle actuator, power supplies, and other powered devices the ECM controls.

This fault sets if the ECM detects system voltage greater than x volts while engine is running or cranking as defined in diagnostic calibration.



Key On, Engine On
System Mode= “Running”
Operate engine at idle
Check battery voltage in DST
Is battery voltage < high voltage limit in diagnostic calibration?
Yes
Fault is intermittent
No
Using a DMM measure the voltage potential across battery (+) and (-)
Is battery voltage < high voltage limit in diagnostic calibration?
Yes
Faulty ECM
No
Key Off
Disconnect wireharness header from ECM
Using a DMM measure the voltage potential across battery (+) and (-)
Is battery voltage < high voltage limit in diagnostic calibration?
Yes
Faulty charging system
No
Faulty battery

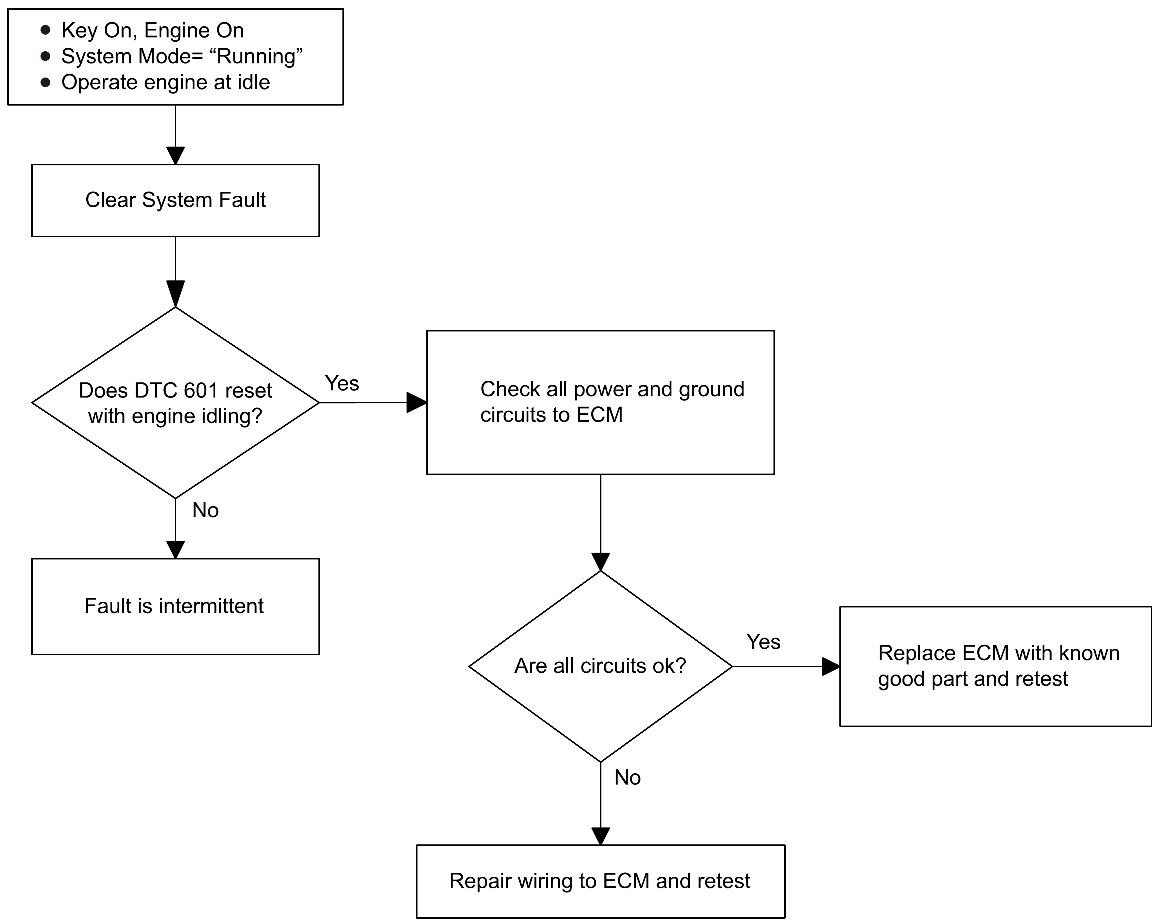
DTC 601- Microprocessor Failure - FLASH



- Engine Control Module- Flash Memory.
- Check Condition- Key on.
- Fault Condition- Internal microprocessor error.
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive fueling correction for remainder of key cycle, recommend power derate 2 and low rev limit to reduce possible engine damage and/or overspeed condition.
- Non-emissions related fault.

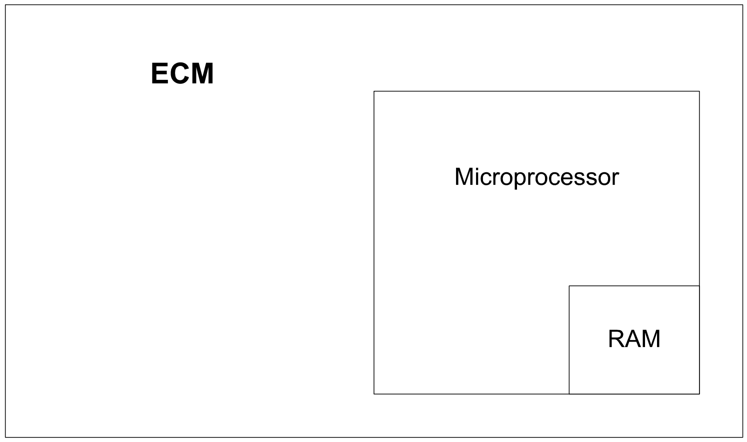
The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault.

If this fault sets, the ECM will reset itself and log the code. The fault should be configured to never forget and will not self-erase and will not clear until a technician performs diagnostics and manually clears the code. This fault should be configured to set a power derate 2 and low rev limit to reduce possible engine damage and reduce possibility of an overspeed condition. A fault of flash memory can occur for any calibration variable set and thus could cause undesirable operation.



Key On, Engine On
System Mode= “Running”
Operate engine at idle
Clear System Fault
Does DTC 601 reset with engine idling?
Yes
Check all power and ground circuits to ECM
No
Fault is intermittent
Are all circuits ok?
Yes
Replace ECM with known good part and retest
No
Repair wiring to ECM and retest

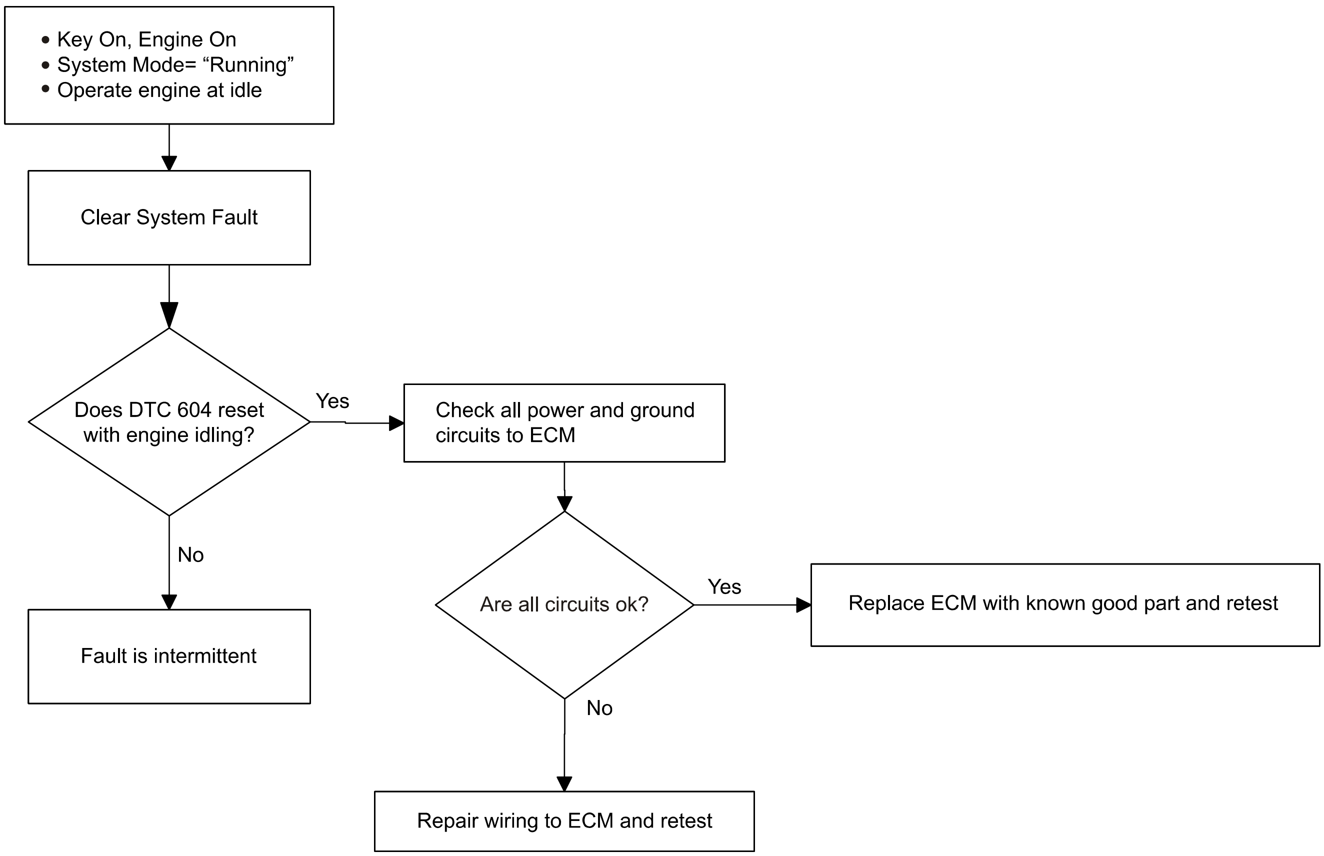
DTC 604- Microprocessor Failure - RAM



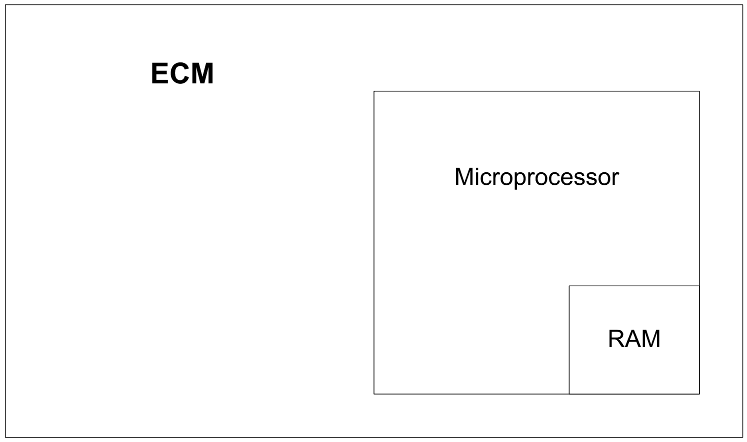
- Engine Control Module- Random Access Memory.
- Check Condition- Key on.
- Fault Condition- Internal ECM microprocessor memory access failure.
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive fueling correction for remainder of key cycle, recommend power derate 2 and low rev limit to reduce possible engine damage and/or overspeed condition.
- Non-emissions related fault

Random Access Memory is located in the microprocessor and can be read or written at any time. Data stored in RAM include DTCs (when fault configuration is set to “Battery Power Retained"), adaptive fuel learn tables, octane adaptation table, misfire adaptation tables, and closed loop fuel multipliers. The ECM has checks that must be satisfied each time an instruction is executed.

This fault sets if the ECM detects a problem accessing or writing information to RAM and should be configured to set a power derate 2 and low rev limit to reduce possible engine damage and reduce possibility of an overspeed condition. If this fault sets, the ECM will reset itself and log the code. This fault should be erased by a technician after diagnostics are performed. The fault should be configured to never forget and will not self-erase.


• Key On, Engine On
• System Mode= “Running”
• Operate engine at idle
Clear System Fault
Does DTC 604 reset with engine idling?
Yes
No
Check all power and ground circuits to ECM
Fault is intermittent
Are all circuits ok?
Yes
No
Replace ECM with known good part and retest
Repair wiring to ECM and retest

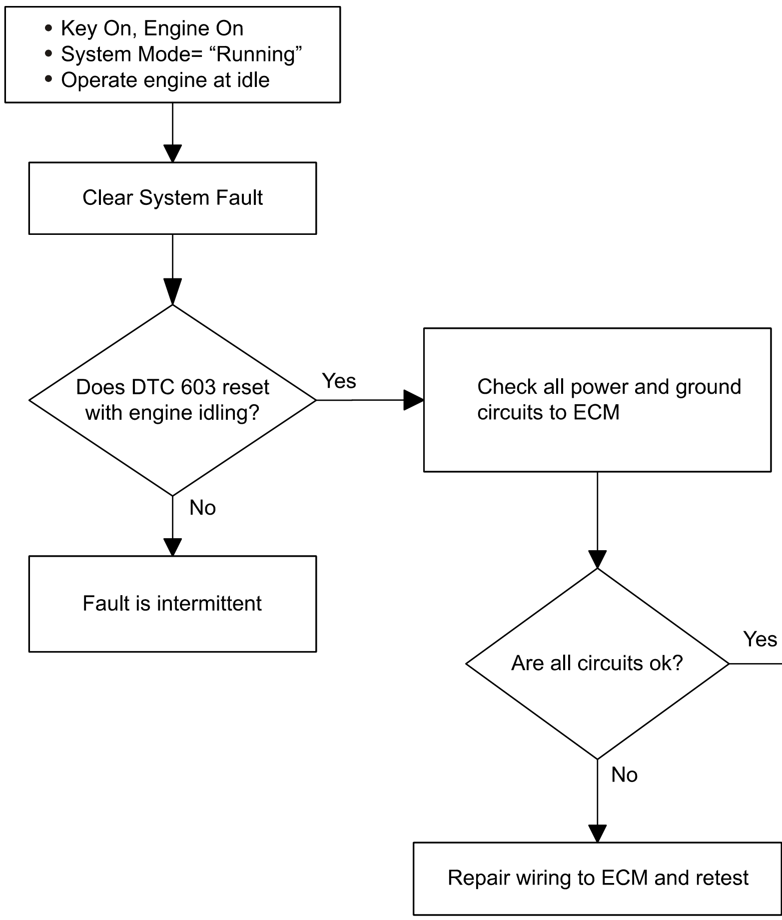
DTC 606- Microprocessor Failure - COP



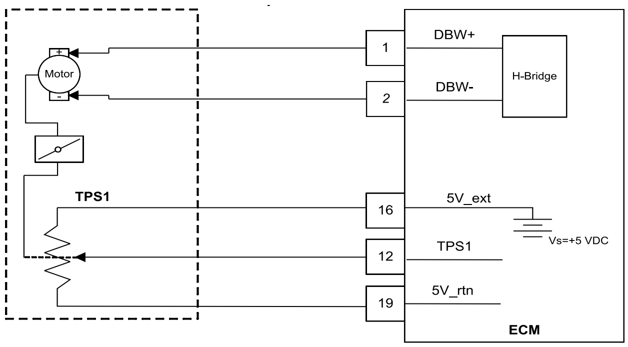
- Engine Control Module.
- Check Condition- Key on.
- Fault Condition- Internal microprocessor error.
- Corrective Action(s) - Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp, disable adaptive fueling correction for remainder of key cycle, recommend power derate 2 and low rev limit to reduce possible engine damage and/or overspeed condition.
- Non-emissions related fault.

The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault.

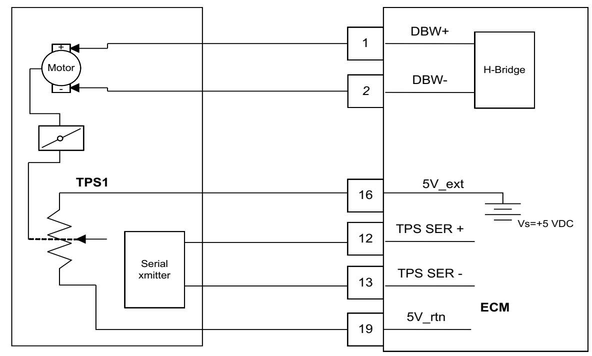
If this fault sets, the ECM will reset itself and log the code. The fault should be configured to never forget and will not self-erase and will not clear until a technician performs diagnostics and manually clears the code. This fault should be configured to set a power derate 2 and low rev limit to reduce possible engine damage and reduce possibility of an overspeed condition.


• Key On, Engine On
• System Mode= “Running”
• Operate engine at idle
Clear System Fault
Does DTC 603 reset with engine idling?
Yes
No
Check all power and ground circuits to ECM
Fault is intermittent
Are all circuits ok?
Yes
No
Replace ECM with known good part and retest
Repair wiring to ECM and retest

DTC 642- 5 Volt External Low Voltage



Electronic Throttle Actuator w/Analog Position Feedback



Electronic Throttle Actuator w/Serial Position Feedback

- Engine Control Module.
- Check Condition- Key on.
- Fault Condition- ECM 5-volt output is below the acceptable limit.
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp.
- Non-emissions related fault.

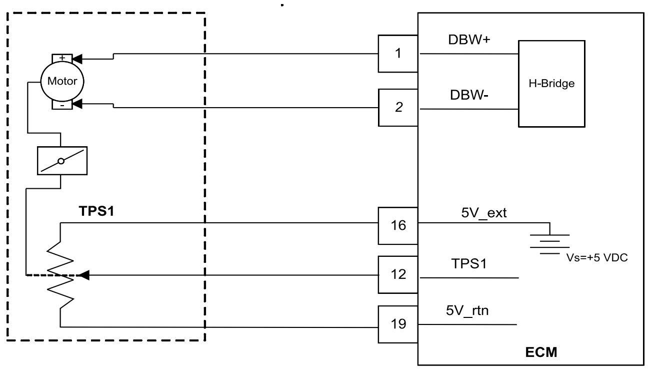
The ECM supplies 5-volt power to sensors, switches, and actuators external to the ECM. By supplying the power to these devices, the ECM can accurately measure their output relative to its own ground reference. The ECM can also control when the devices are active and put the devices in a low or no power state based on the current operating condition of the engine or vehicle.

If this fault sets, something other than the ECM is drawing ECM 5-volt power output below an acceptable threshold. This may be due to a short in wire harness, malfunctioning device, or ECM power output circuitry failure.

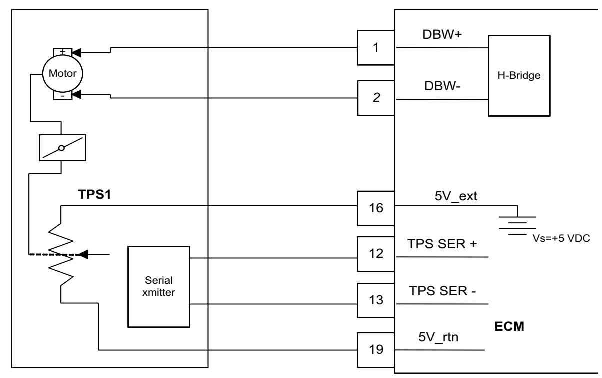
Diagnostic Aids

- Measure ECM 5-volt output while cycling key on with engine stopped. Verify output is lower than fault thresholds configured in diagnostic calibration.
- Inspect 5-Volt output circuit in wire harness and look for shorts to ground or other harness circuits.
- Disconnect each device powered by the ECM 5-volt output one-at-a-time. Powered devices may include throttle actuator, smart sensors, smart actuators, etc. After disconnecting device, observe system fault and determine if fault has cleared. If fault clears, troubleshoot disconnected device for failures.
- With all 5-volt powered devices disconnected, look for a change in fault state and measure ECM 5-volt output, and verify it is within acceptable limits.

DTC 643- 5 Volt External High Voltage



Electronic Throttle Actuator w/Analog Position Feedback



Electronic Throttle Actuator w/Serial Position Feedback

- Engine Control Module.
- Check Condition- Key on.
- Fault Condition- ECM 5-volt output is above the acceptable limit.
- Corrective Action(s)- Illuminate MIL and/or sound audible warning or illuminate secondary warning lamp.
- Non-emissions related fault.

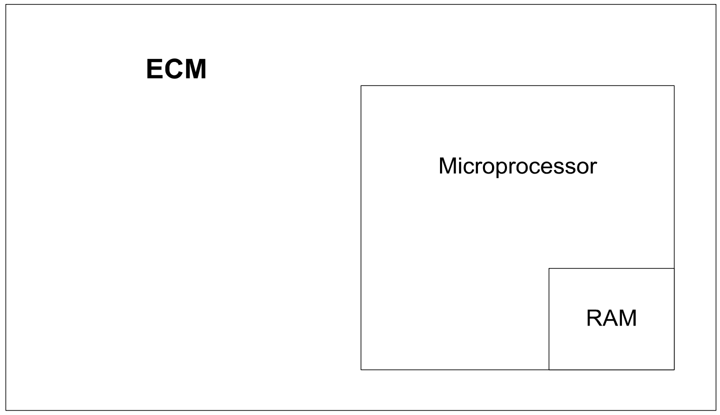
The ECM supplies 5-volt power to sensors, switches, and actuators external to the ECM. By supplying the power to these devices, the ECM can accurately measure their output relative to its own ground reference. The ECM can also control when devices are active and put devices in a low or no power state based on current operating condition of engine or vehicle.

If this fault sets, something other than the ECM is drawing the 5-volt power output of the ECM above an acceptable threshold. This may be due to a short in the wire harness, malfunctioning device, or failure of the ECM power output circuitry.

Diagnostic Aids

- Measure 5-volt ECM output while cycling key on and engine stopped. Verify output is lower than fault thresholds configured in diagnostic calibration.
- Inspect 5-Volt output circuit in wire harness and look for shorts to ground or other harness circuits.
- Disconnect each device powered by the ECM 5-volt output one-at-a-time. Powered devices may include the throttle actuator, smart sensors, smart actuators, etc. After disconnecting device, observe system fault and determine if fault has cleared. If fault clears, troubleshoot disconnected device for failures.
- With all 5-volt powered devices disconnected, look for a change in fault state, measure the ECM 5-volt output and verify it is within acceptable limits.

DTC 1612- Microprocessor Failure - RTI 1

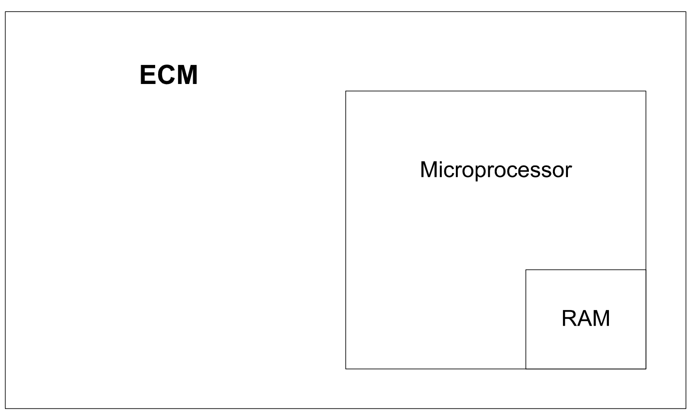


- Engine Control Module.
- Check Condition- Key on.
- Fault Condition- Internal microprocessor error.
- MIL- On until code is cleared by technician.
- Adaptive- Disabled for the remainder of the key-on cycle.
- Closed Loop- Enabled.
- Power Derate (level 2 until fault is cleared manually).

The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) is enforced and maximum throttle position is 20%. This is enforced until fault is manually cleared.

DTC 1613- Microprocessor Failure - RTI 2

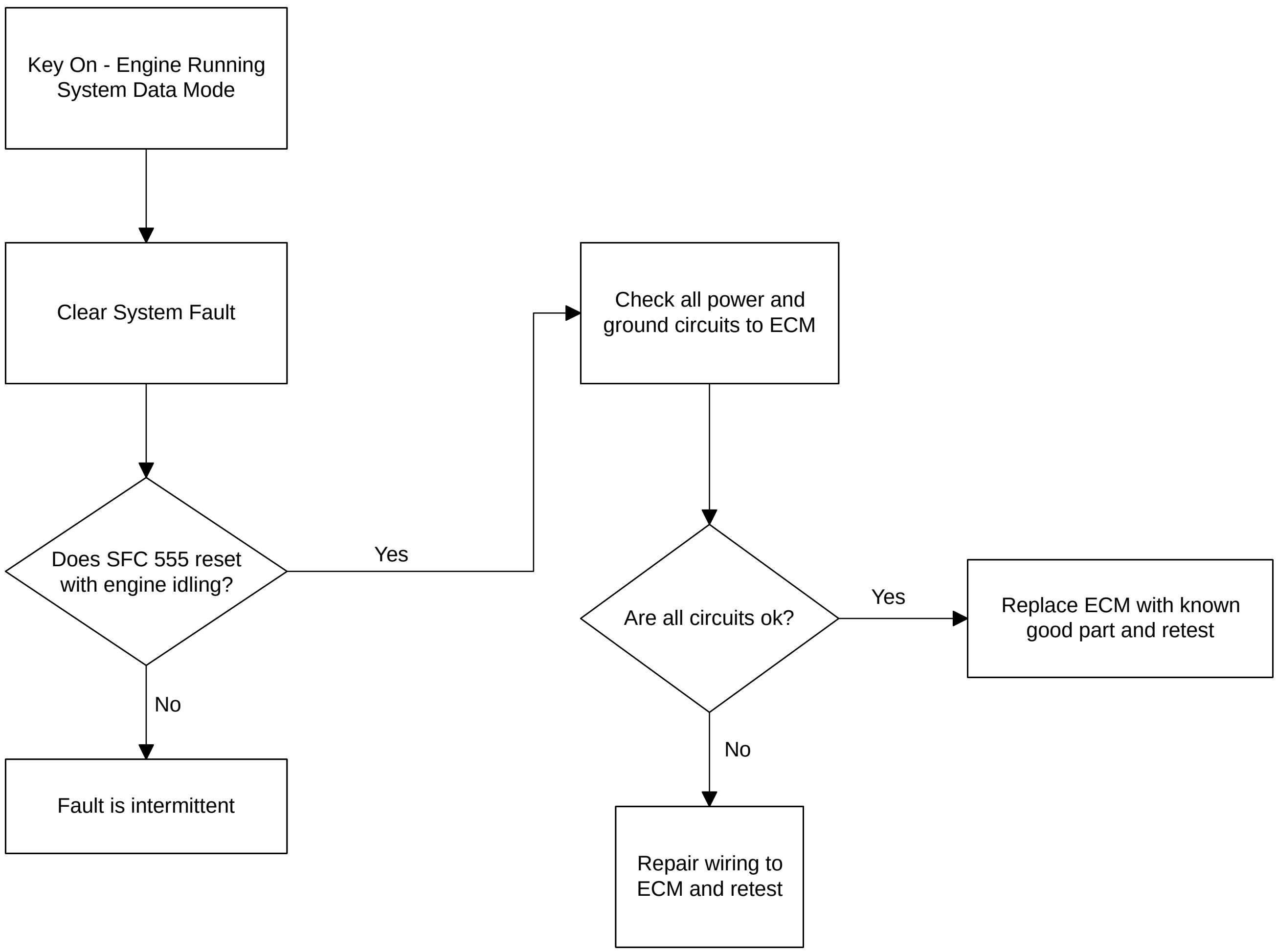


- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

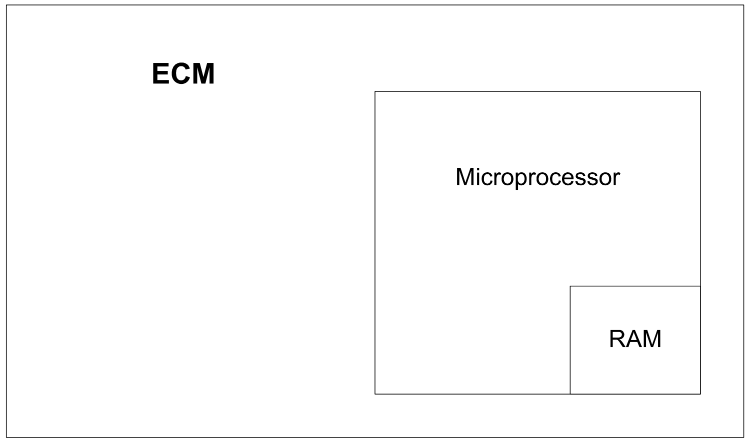
The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

SFC 555- RTI 2 Loss



DTC 1614- Microprocessor Failure - RTI 3

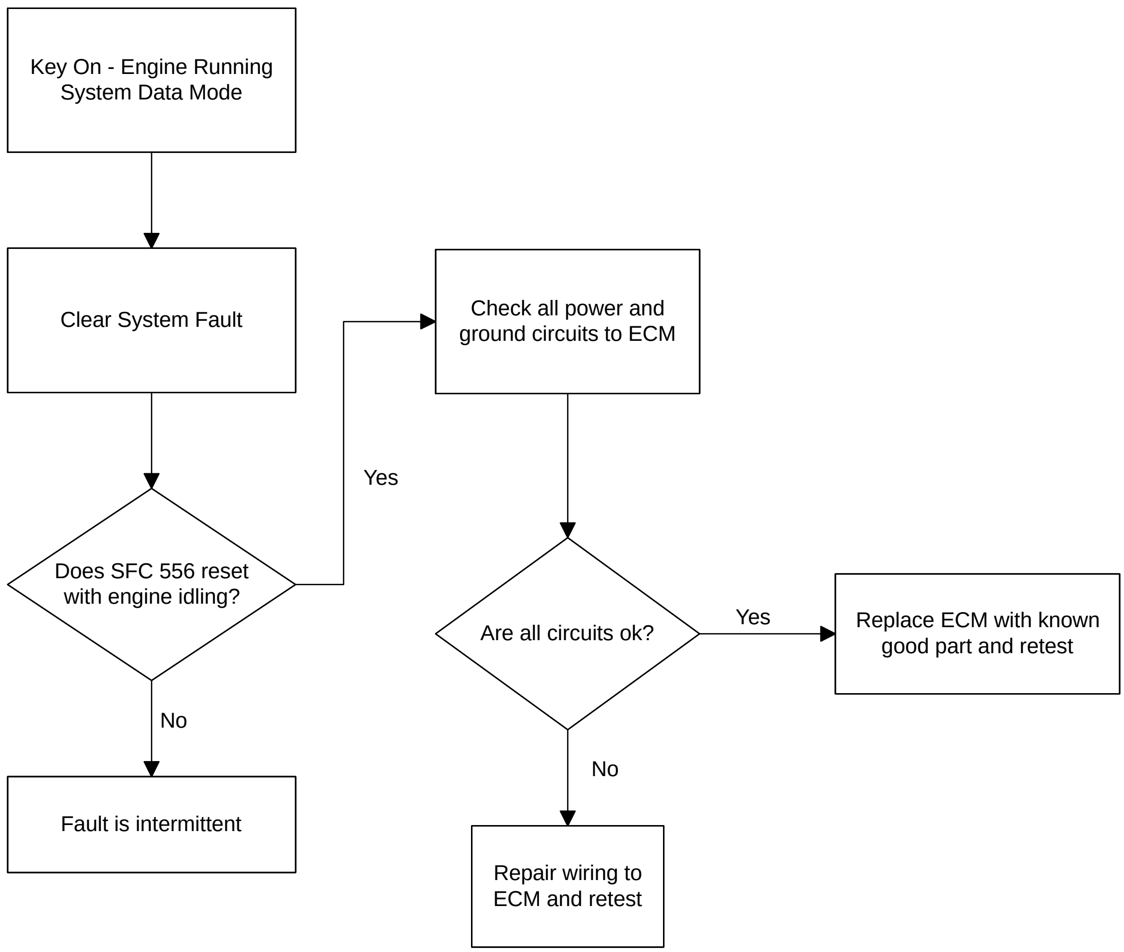


- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

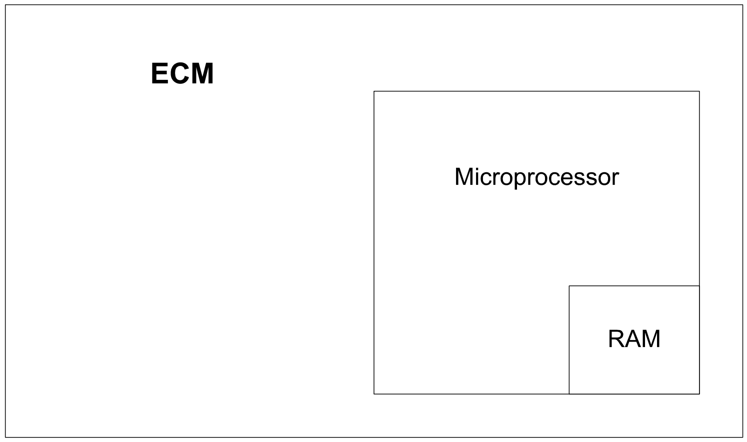
The ECM has checks that must be satisfied each time an instruction is executed. Several different things happen within the microprocessor that causes this fault. The ECM will reset itself in the event this fault is set, and MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

SFC 556- RTI 3 Loss



DTC 1615- Microprocessor Failure - A/D

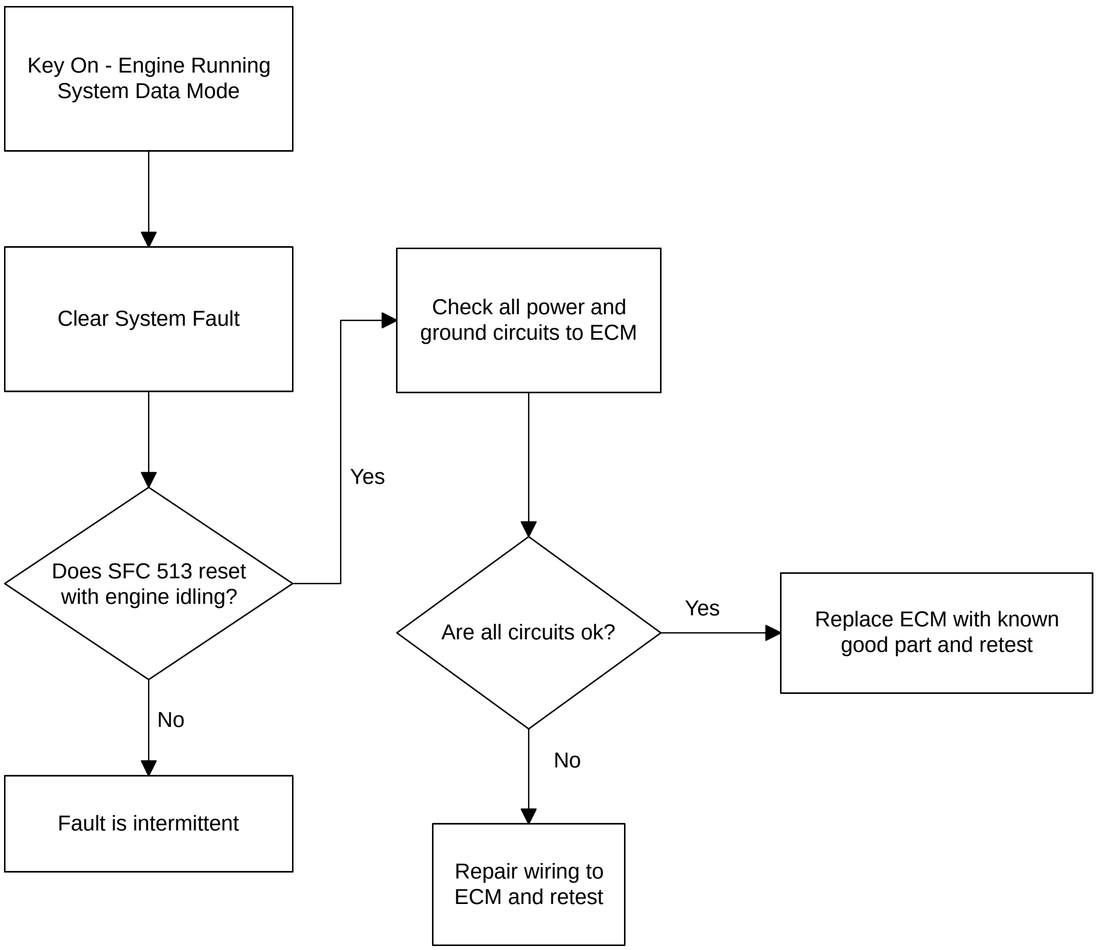


- Engine Control Module.
- Check Condition- Key on.
- Fault Condition- Internal microprocessor error.
- MIL- On until code is cleared by technician.
- Adaptive- Disabled for the remainder of the key-on cycle.
- Closed Loop- Enabled.
- Power Derate (level 2 until fault is cleared manually).

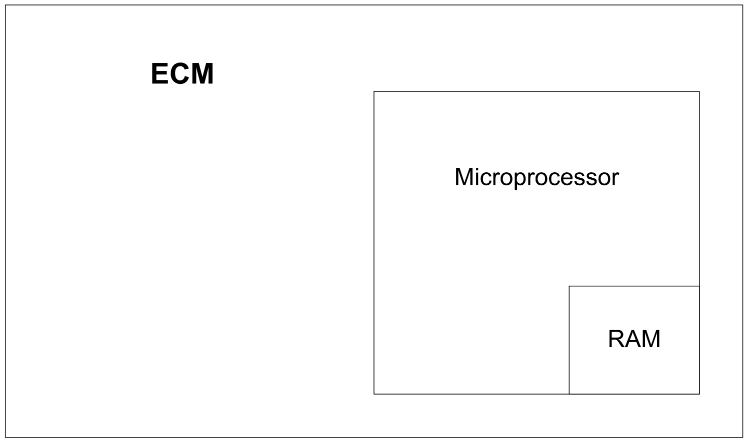
The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until the fault is manually cleared.

SFC 513- A/D Loss



DTC 1616- Microprocessor Failure - interrupt

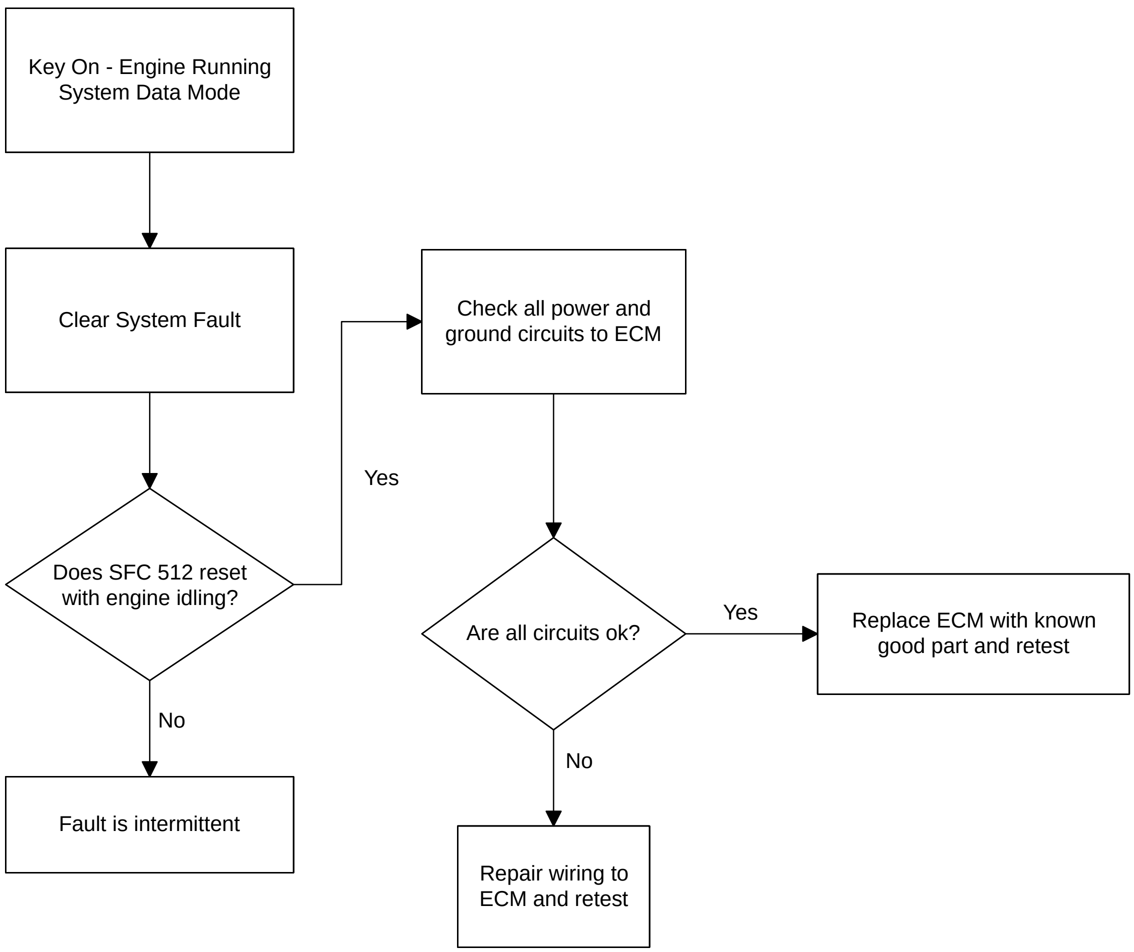


- Engine Control Module
- Check Condition- Key on
- Fault Condition- Internal microprocessor error
- MIL- On until code is cleared by technician
- Adaptive- Disabled for the remainder of the key-on cycle
- Closed Loop- Enabled
- Power Derate (level 2 until fault is cleared manually)

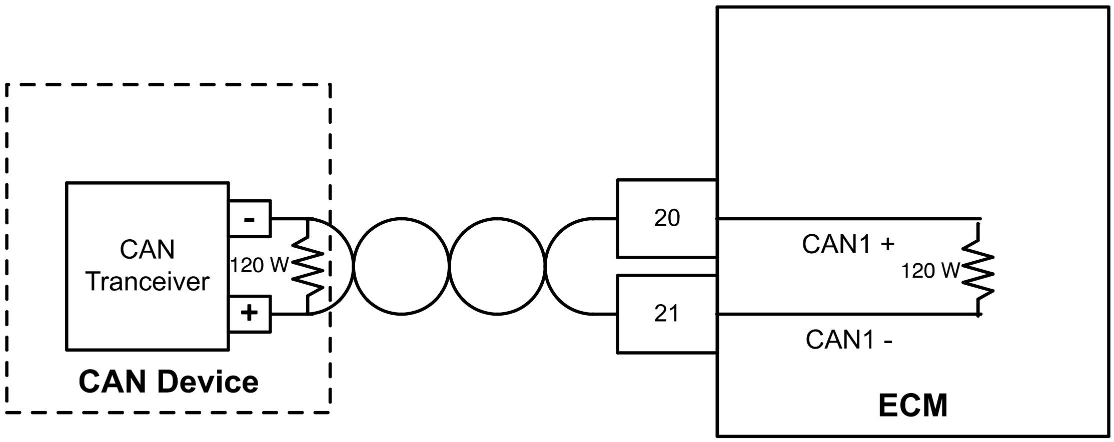
The ECM has checks that must be satisfied each time an instruction is executed. Several different things can happen within the microprocessor that will cause this fault. The ECM will reset itself in the event this fault is set, and the MIL will be on until the code is cleared. This fault should be erased after diagnosis by removing battery power. It will not self-erase.

During this active fault, Power Derate (level 2) will be enforced. When this is enforced, maximum throttle position will be 20%. This is enforced until fault is manually cleared.

SFC 512- Invalid Interrupt



DTC 1625- CAN J1939 Shutdown Request



- Controller Area Network
- Check Condition- Key On, Engine Off and/or Running
- Fault Condition- ECM has received shutdown message from another CAN device and is shutdown on request.
- Corrective Action(s)- Illuminate MIL, sound audible warning or illuminate secondary warning lamp
- Non-emissions related fault

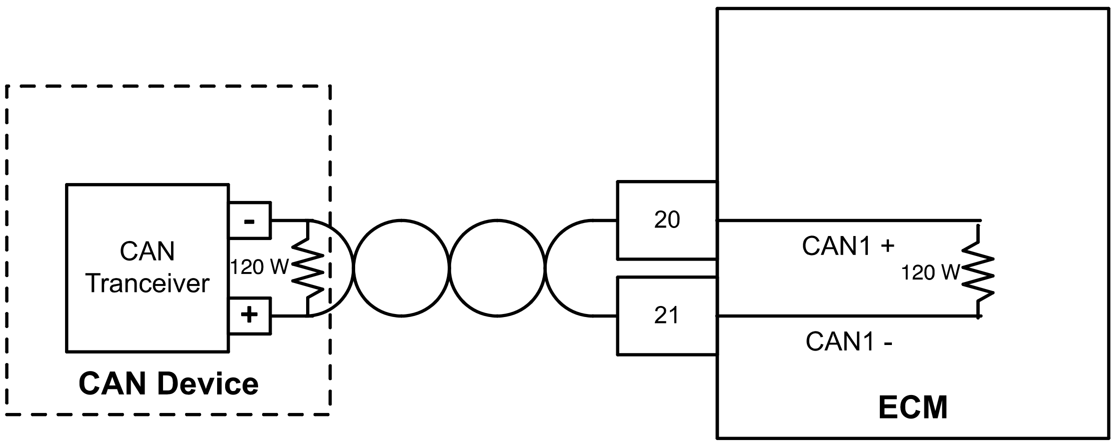
In some situations, external controllers may send a request to the ECM to shutdown engine operation and stop the engine. This request may be sent in response to a safety related condition in the vehicle.

This fault sets if the ECM receives a J1939 shutdown request via the CAN interface. This is the expected behavior.

Diagnostic Aids

- ECM has shutdown engine upon command by an external controller. This is requested and expected behavior.

DTC 1626- CAN J1939 Transmit (Tx) Fault



- Controller Area Network.
- Check Condition- Key On, Engine Off and/or Running.
- Fault Condition- ECM CAN transceiver transmit error counts greater than the limit defined in the diagnostic calibration (must be < 125 failures).
- Corrective Action(s)- Illuminate MIL, sound audible warning or illuminate secondary warning lamp.
- Non-emissions related fault.

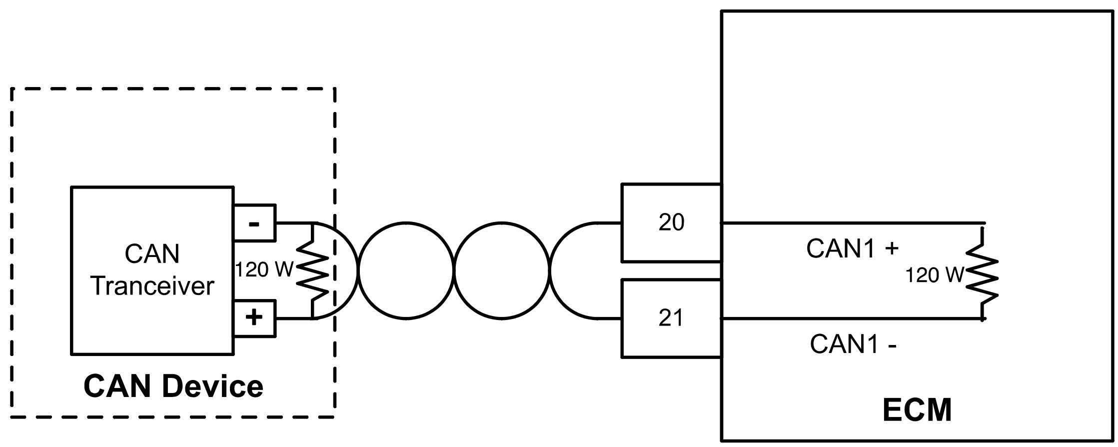
The Controller Area Network (CAN) is a serial communication network used to transmit and receive data between intelligent devices. Systems that utilize CAN communication include smart actuators, smart sensors, dash panels and gauges, and other microcomputers. Each smart sensor, actuator, or controller incorporates a CAN transceiver that interprets logic level signals on the network and translates the information into digital data.

This fault will set if CAN communication is enabled and the ECM transceiver broadcasts a number of packets (as defined in the diagnostic calibration, must be set to less than 125 failures) to the network that are not received.

Diagnostic Aids

- Verify all CAN devices are powered and are properly grounded
- Verify the CAN network is properly terminated
- Check CAN wire routing with respect to noise sources (ignition coils, spark plug coil wires, etc.) and shield if necessary
- Check CAN (+) and (-) wires for short circuits

DTC 1627- CAN J1939 Receive (Rx) Fault



- Controller Area Network.
- Check Condition- Key On, Engine Off and/or Running.
- Fault Condition- ECM CAN transceiver receive error counts greater than the limit defined in the diagnostic calibration (must be < 125 failures).
- Corrective Action(s)- Illuminate MIL, sound audible warning or illuminate secondary warning lamp.
- Non-emissions related fault.

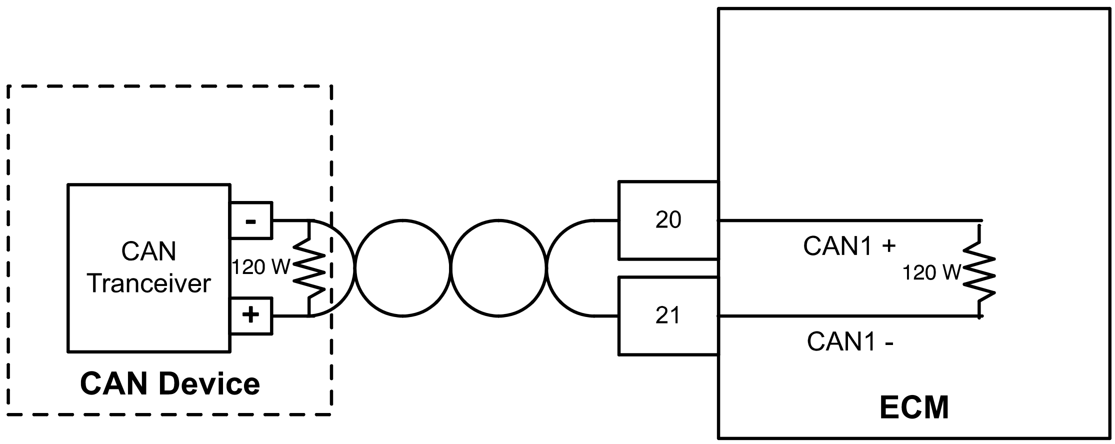
The Controller Area Network (CAN) is a serial communication network used to transmit and receive data between intelligent devices. Systems that utilize CAN communication include smart actuators, smart sensors, dash panels and gauges, and other microcomputers. Each smart sensor, actuator, or controller incorporates a CAN transceiver that interprets logic level signals on the network and translates the information into digital data.

This fault will set if CAN communication is enabled and the ECM transceiver is expecting to see network traffic and either does not see traffic (as defined in the diagnostic calibration, must be set to less than 125 failures).

Diagnostic Aids

- Verify all CAN devices are powered and are properly grounded
- Verify CAN network is properly terminated
- Check CAN wire routing with respect to noise sources (ignition coils, spark plug coil wires, etc.) and shield if necessary
- Check CAN (+) and (-) wires for short circuits

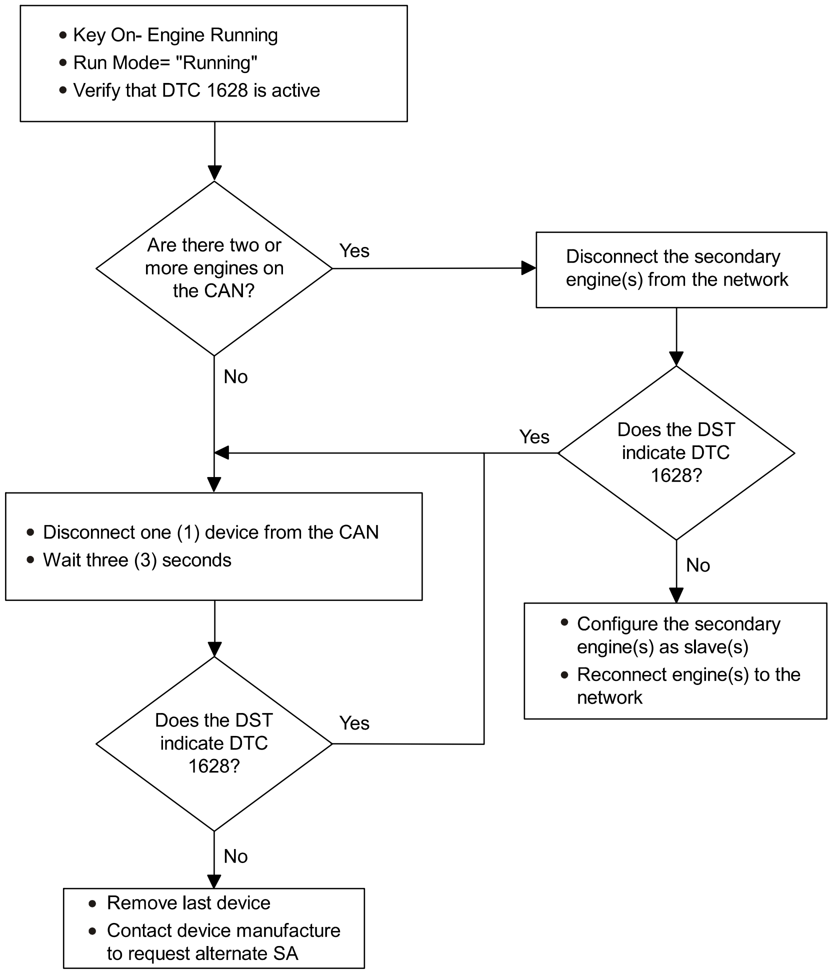
DTC 1628- CAN Address Conflict Failure



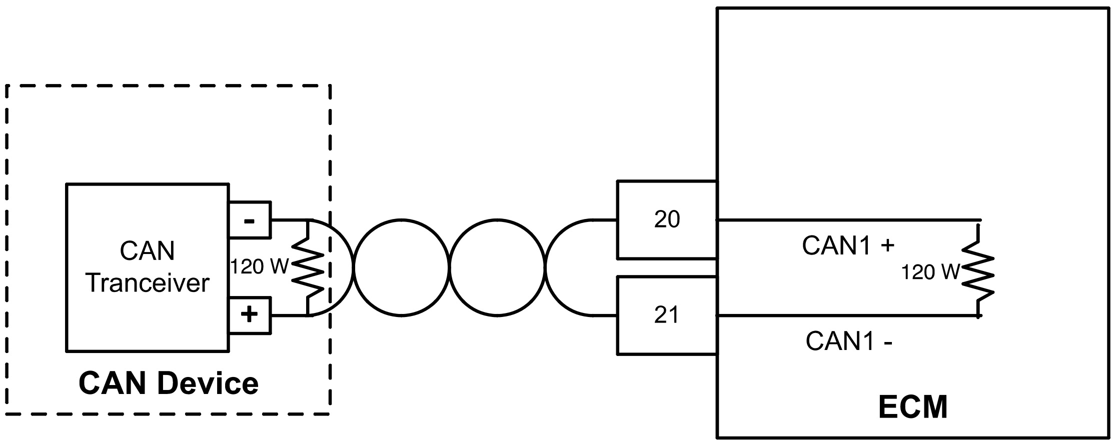
- CAN device(s).
- Check Condition- Key On, Engine on.
- Fault Condition- two or more devices on the network that contain the same SA.
- Corrective Action(s)- Sound audible warning or illuminate secondary warning lamp.
- Non-emissions related fault.

The Controller Area Network serves as a communication portal between intelligent devices. These devices may be but are not limited to other engine ECMs (slave), diagnostic tools, “smart” gauges, “smart” sensors, powertrain control units, vehicle controllers, actuators, etc. The network permits several devices to communicate with each other receiving and broadcasting commands as programmed. This type of network allows devices to be added to an entire system through only two conductors and permits all other devices to broadcast and receive commands to and from the device when properly commanded.

This fault indicates there are two (2) or more devices on the network that use the same source address.


• Key On- Engine Running
• Run Mode= "Running"
• Verify that DTC 1628 is active
Are there two or more engines on the CAN?
Yes
Disconnect the secondary engine(s) from the network
No
Yes
Does the DST indicate DTC 1628?
• Disconnect one (1) device from the CAN
• Wait three (3) seconds
No
• Configure the secondary engine(s) as slave(s)
• Reconnect engine(s) to the network
Does the DST indicate DTC 1628?
Yes
No
• Remove last device
• Contact device manufacture to request alternate SA

DTC 1629- J1939 TSC1 Message Receipt Loss



- Controller Area Network.
- Check Condition- Key On, Engine Running.
- Fault Condition- ECM is expecting to receive J1939 TSC1 messages and has not received a message for more than n seconds (as defined in the diagnostic calibration).
- Corrective Action(s)- Illuminate MIL, sound audible warning or illuminate secondary warning lamp. Govern engine speed at a forced idle.
- Non-emissions related fault.

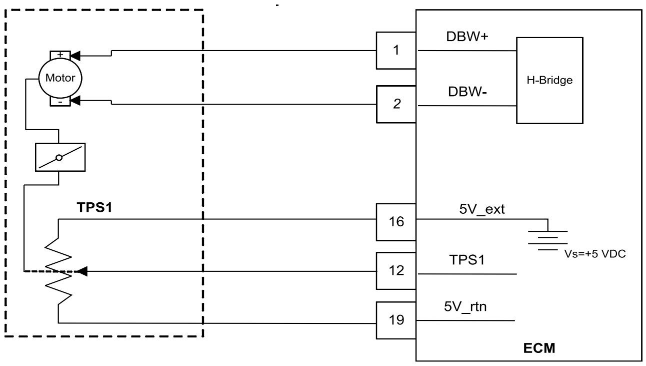
J1939 TSC1 may be used to send a commanded (or desired) engine speed to the ECM. If configured, the ECM governs engine speed to commanded speed if possible. When operating in this mode, the ECM expects to receive TSC1 messages on a regular interval. When this message is not received, the ECM must operate the engine at a default idle speed until commanded to do otherwise.

This fault sets if CAN communication is enabled, the engine is running, and no TSC1 messages are received over the CAN bus for more than n seconds (as determined by diagnostic calibration).

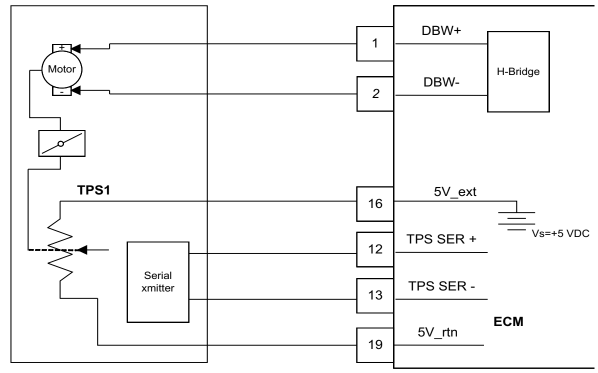
DIAGNOSTIC AIDS

- Verify CAN device generating the TSC1 message is powered and properly grounded.
- Verify CAN network is properly terminated.
- Check CAN wire routing with respect to noise sources (ignition coils, spark plug coil wires, etc.) and shield if necessary.
- Check CAN (+) and (-) wires for short circuits.

DTC 1652- TPS1 Loss of Communications



Electronic Throttle Actuator w/Analog Position Feedback



Electronic Throttle Actuator w/Serial Position Feedback

- Throttle Actuator (with serial/digital position feedback).
- Check Condition- Key On, Engine Running and/or Stopped.
- Fault Condition- ECM is expecting to receive throttle position information from the throttle actuator and is not.
- Corrective Action(s)- Illuminate MIL, sound audible warning or illuminate secondary warning lamp. Shutdown engine.
- Non-emissions related fault.

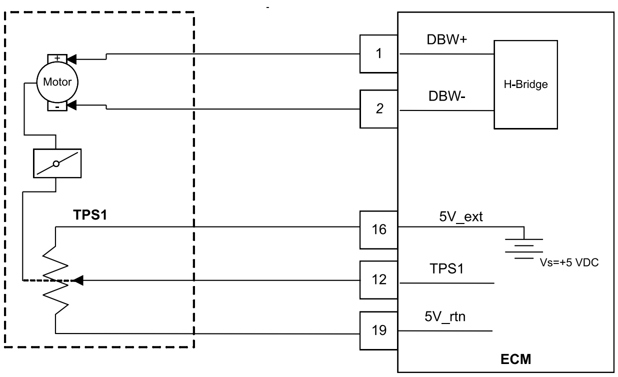
For a throttle actuator with serial/digital position feedback, the ECM receives a constant data stream from the throttle actuator. If communication is absent or interrupted, the ECM can no longer control the throttle position.

This fault will set if the key is on, the throttle actuator is receiving power, and the ECM is not receiving digital information from the actuator.

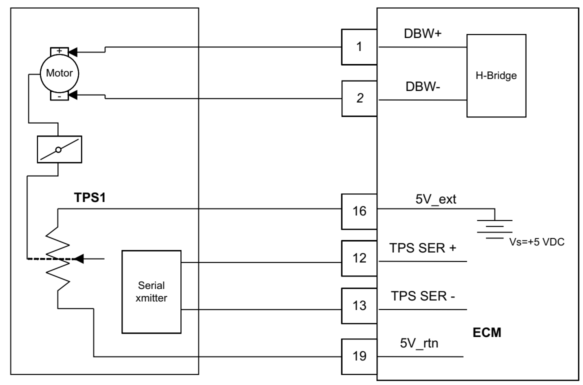
Diagnostic Aids

- Verify throttle actuator 5V supply voltage is present at the actuator.
- Check for a all four TPS feedback wires for short circuits.
- Check TPS SER+ and TPS SER- wire routing with respect to noise sources (ignition coils, spark plug coil wires, etc.) and shield if necessary.

DTC 2111- Unable to Reach Lower TPS



Electronic Throttle Actuator w/Analog Position Feedback



Electronic Throttle Actuator w/Serial Position Feedback

- Throttle Position Sensor
- Check Condition-Cranking or Running
- Fault Condition-Throttle command is 20% less than throttle position for 200ms or longer
- MIL-On during active fault
- Engine Shut Down

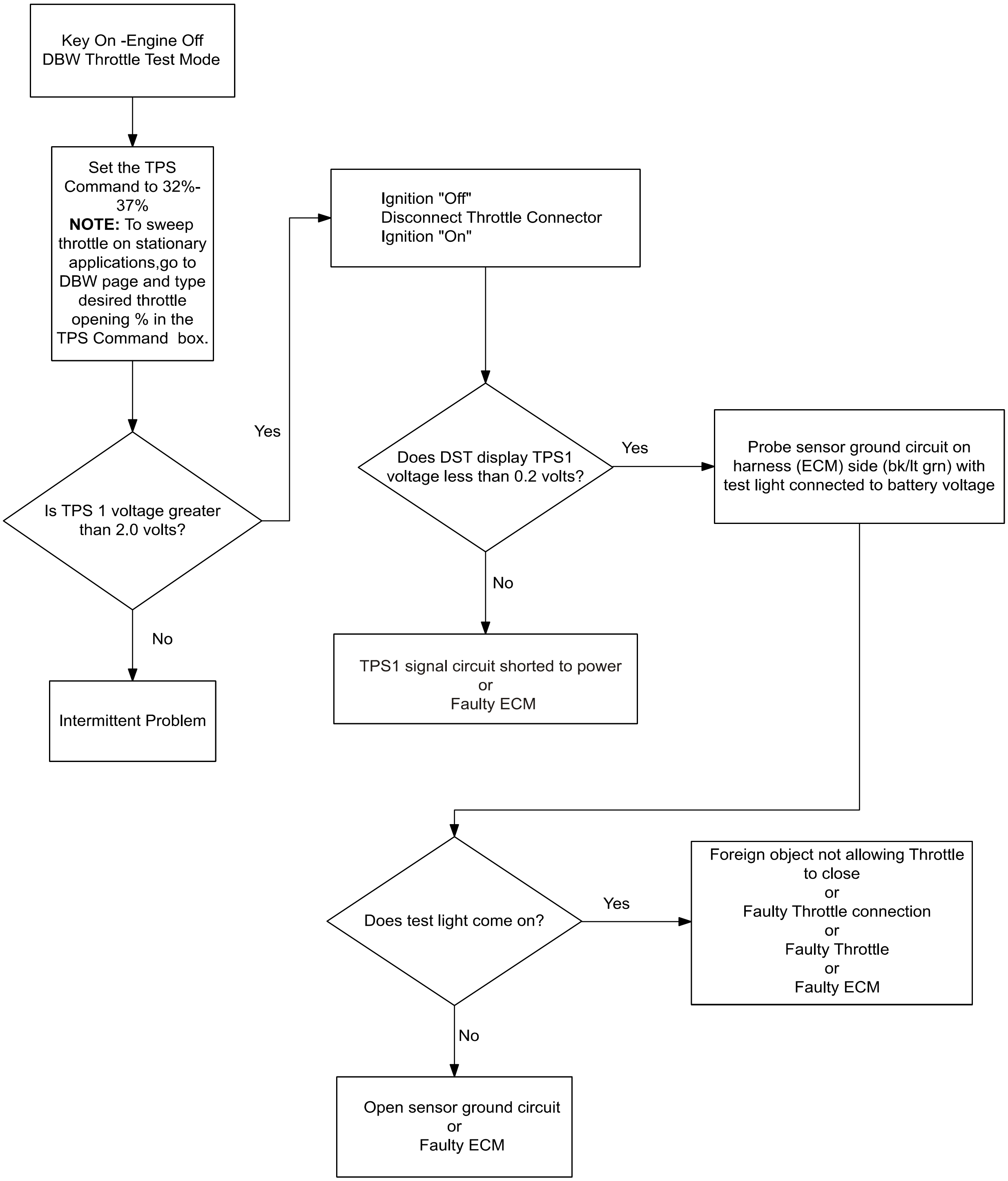
On a diesel engine, an actuator controls a fuel injection pump, directly affecting the fueling level into the cylinders. This may be by direct manipulation of the fuel injection pump rack or by manipulation of the mechanical governor control level or “throttle arm.” In the DGC ECM and EDIS, references to the throttle and throttle position sensor refer to these fuel injection pump control actuators and their position feedback sensors. When the fuel injection pump is electronically controlled it can control idle stability and limit engine speed based on operating conditions.

The Throttle Position Sensor uses either 1) a variable resistor and voltage divider circuit or 2) a non-contact hall-effect sensor to determine throttle actuator position, and is located within the throttle actuator.

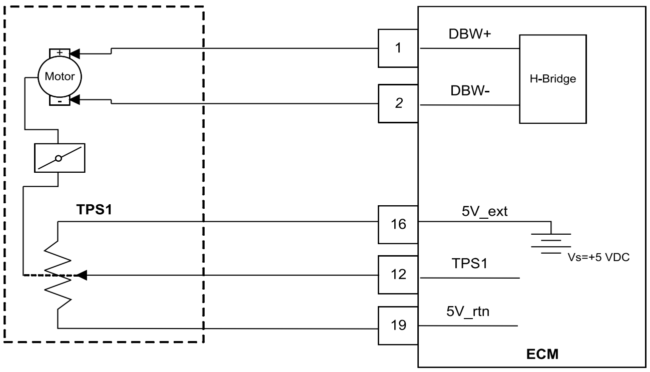
There are two types of throttle actuators, 1) actuator with analog position feedback and 2) actuator with digital position feedback. The first type, with analog position feedback, provides an analog return signal between 0 and 5 volts that is proportional to the throttle actuator position. The second type, with digital position feedback, provides a serial data signal to the ECM with the throttle actuator position voltage level encoded in the data stream.

Fault sets if throttle command is 20% less than actual throttle position. During active fault, MIL light is on and engine shuts down.

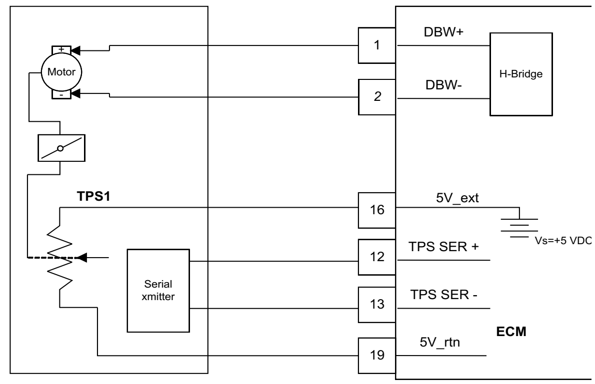
SFC 638-Throttle Unable To Close



DTC 2112- Unable to Reach Higher TPS



Electronic Throttle Actuator w/Analog Position Feedback



Electronic Throttle Actuator w/Serial Position Feedback

- Throttle Position Sensor.
- Check Condition-Cranking or Running.
- Fault Condition-Throttle command is 20% more than actual throttle position.
- MIL-On during active fault.
- Engine Shut Down.

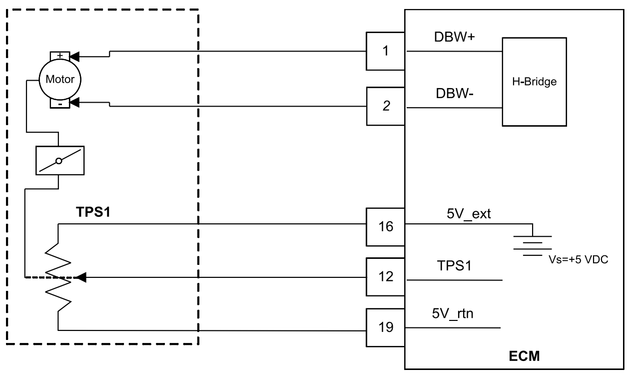
On a diesel engine, an actuator controls a fuel injection pump, directly affecting the fueling level into the cylinders. This may be by direct manipulation of the fuel injection pump rack or by manipulation of the mechanical governor control level or “throttle arm.” In the DGC ECM and EDIS, references to throttle and throttle position sensor refer to these fuel injection pump control actuators and their position feedback sensors. When the fuel injection pump is electronically controlled it can control idle stability and limit engine speed based on operating conditions.

The Throttle Position Sensor uses either 1) a variable resistor and voltage divider circuit or 2) a non-contact hall-effect sensor to determine throttle actuator position, and is located within the throttle actuator.

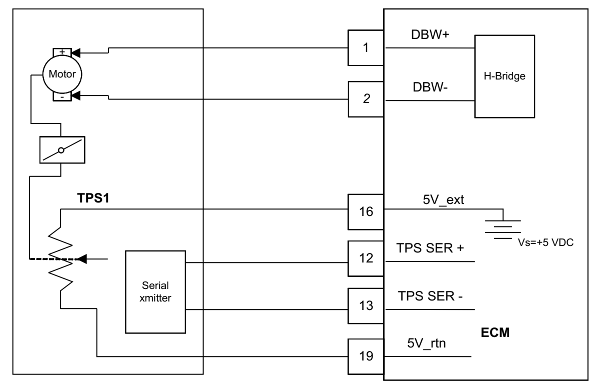
There are two types of throttle actuators, 1) actuator with analog position feedback and 2) actuator with digital position feedback. The first type, with analog position feedback, provides an analog return signal between 0 and 5 volts that is proportional to the throttle actuator position. The second type, with digital position feedback, provides a serial data signal to the ECM with the throttle actuator position voltage level encoded in the data stream.

This fault sets if throttle command is 20% or more than actual throttle position. During this active fault the MIL light is on and engine will shut down.

DTC 9999- Throttle Actuator Failsafe Spring Failure



Electronic Throttle Actuator w/Analog Position Feedback



Electronic Throttle Actuator w/Serial Position Feedback

- Throttle Actuator
- Check Condition- Key Off, Engine Stopped
- Fault Condition- When key is off (or actuator is unpowered), the ECM is expecting failsafe spring in actuator to return throttle position to near 0%. If throttle does not reach this position when actuator is powered, a fault is generated.
- Corrective Action(s)- Illuminate MIL, sound audible warning or illuminate secondary warning lamp. Govern engine speed to a forced idle speed.
- Non-emissions related fault

Throttle actuator has a return spring that causes throttle to move to a near 0% position when powered off. This causes engine shutdown following a key off. If ECM detects throttle position to be above x volts when key is off (as determined by diagnostic calibration), it will power up the actuator and attempt to drive it to a zero position. This should ensure engine is stopped.

Fault sets if throttle does not return to a near 0% position with key OFF.

Diagnostic Aids

- Disconnect throttle actuator from wire harness. Remove throttle actuator from engine and manually move it. Verify internal spring forces throttle back to near 0% position.
- Inspect throttle arm or fuel rack on fuel pump. Verify it is not stuck.

DTC to SPN/FMI Table

FAULT INDEX	DESCRIPTION	DTC SET	
		SPN	FMI
2	DTC 118: ECT voltage high	110	3
3	DTC 117: ECT voltage low	110	4
4	DTC 116: ECT higher than expected stage 1	110	15
9	DTC 563: Vbat voltage high	168	15
10	DTC 562: Vbat voltage low	168	17
11	DTC 643: Sensor supply voltage 1 high	1079	3
12	DTC 642: Sensor supply voltage 1 low	1079	4
13	DTC 123: TPS1 voltage high	51	3
14	DTC 122: TPS1 voltage low	51	4
29	DTC 524: Oil pressure low	100	1
86	DTC 217: ECT higher than expected stage 2	110	0
89	DTC 2112: Unable to reach higher TPS	51	7
90	DTC 2111: Unable to reach lower TPS	51	7
96	DTC 336: CRANK input signal noise	636	2
98	DTC 606: Microprocessor failure - COP	629	31
99	DTC 1612: Microprocessor failure - RTI 1	629	31
100	DTC 1613: Microprocessor failure - RTI 2	629	31
101	DTC 1614: Microprocessor failure - RTI 3	629	31
102	DTC 1615: Microprocessor failure - A/D	629	31
103	DTC 1616: Microprocessor failure - Interrupt	629	31
104	DTC 601: Microprocessor failure - FLASH	628	13
105	DTC 604: Microprocessor failure - RAM	630	12
106	DTC 219: RPM higher than max allowed govern speed	515	15
144	DTC 337: Crank signal loss	636	4
145	DTC 1625: J1939 shutdown request	1384	31
146	DTC 1626: CAN-J1939 Tx fault	639	12
147	DTC 1627: CAN-J1939 Rx fault	639	12
175	DTC 1628: J1939 CAN address / engine-number conflict	639	13
188	DTC 521: Oil pressure high	100	0
189	DTC 1652: TPS1 loss of communications	51	9
190	DTC 1629: CAN-J1939 TSC1 Parameter Rx Fault	695	9
191	DTC 1113: Unable to achieve lower RPM	515	31
192	DTC 9999: TPS1 failsafe spring failure	51	7

NOTICE

OUTLET PIPE MUST BE CENTERED WITHIN 1/4" (6.35 MM) MINIMUM CLEARANCE TO EXHAUST VENTURI AROUND VENTURI'S PERIMETER. IF EXHAUST PIPE TOUCHES VENTURI, IT WILL MELT THE HOOD. IF EXHAUST PIPE IS NOT CENTERED, ADJUST MUFFLER OR OUTLET AS NEEDED FOR NECESSARY CLEARANCE.

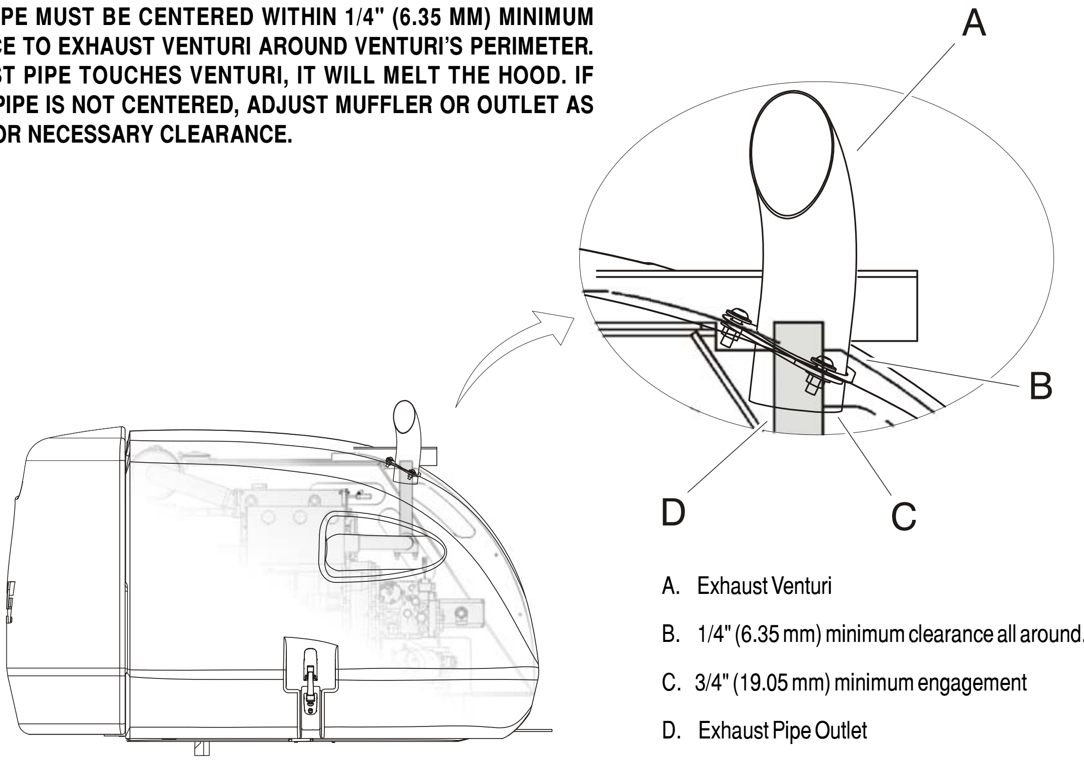
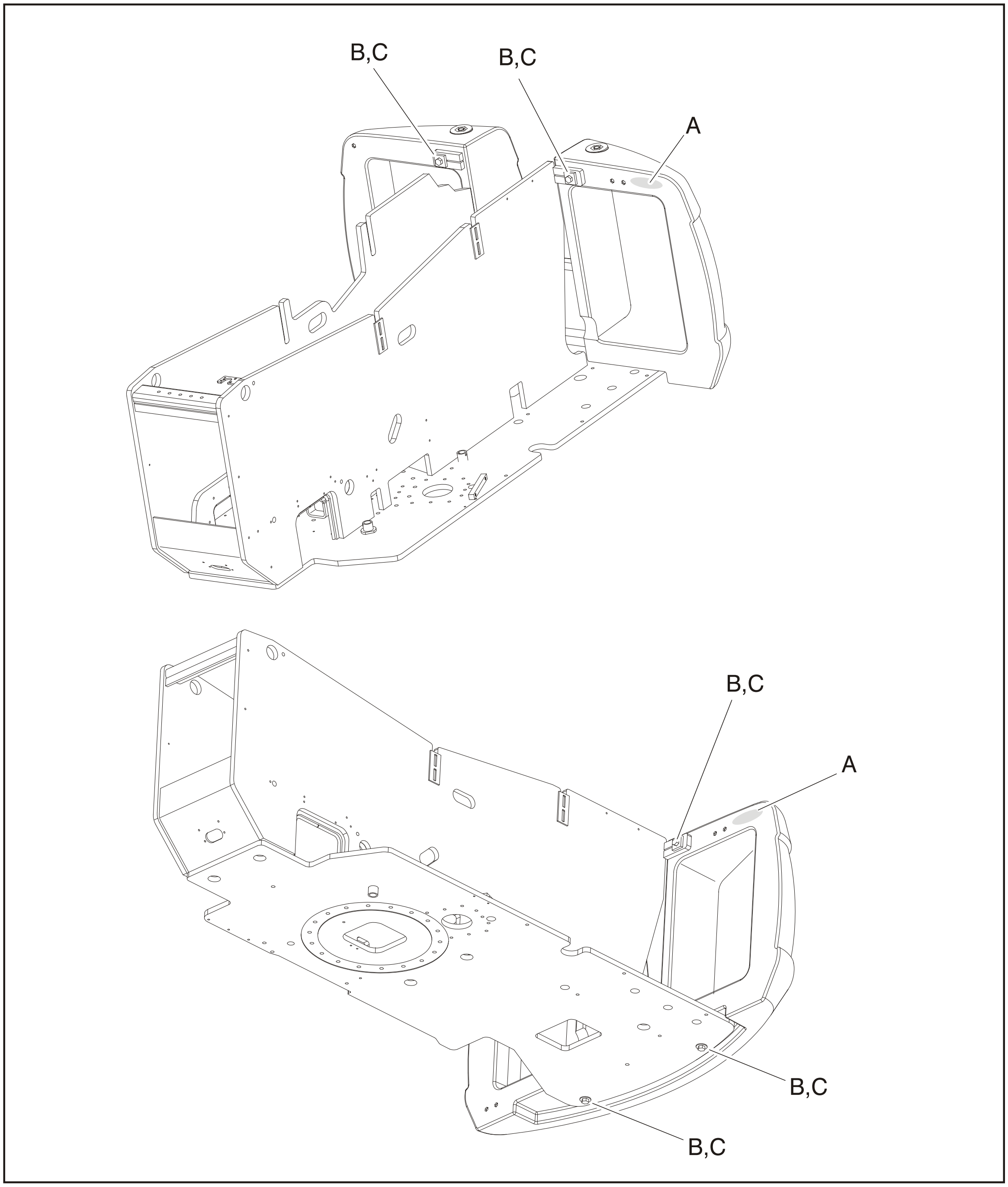


Figure 3-104. Exhaust Venturi Adjustment



A. Part Number\Actual Weight Stamping

B. Apply Loctite #271 to Bolt Threads and to Threads in Counterweight.

C. Torque to 400 ft-lb (542 Nm). Typical Four Places.

Figure 3-105. Counterweight

SECTION 4. BOOM & PLATFORM

4.1 BOOM MAINTENANCE

NOTICE

DO NOT USE A LIFTING DEVICE TO LIFT BOOMS UNLESS HOLDING VALVES HAVE BEEN REMOVED FIRST. FAILURE TO DO SO WILL RESULT IN SEVERE DAMAGE TO BOOM.

Removal of Boom Assembly

1. Remove platform and platform support as follows:
   a. Disconnect control console electrical cable.
   b. Tag and disconnect hydraulic lines to rotate cylinders. Cap hydraulic lines and ports.
   c. Use an appropriately rated overhead crane or suitable lifting device and nylon support straps to support the platform/support.

NOTE: *Properly support cylinder when removing retaining pin from rod end of level cylinder.*

   d. Remove bolts and keeper pins from retaining pins. Remove retaining pins from platform support using suitable brass drift and hammer.
2. Remove boom from turntable as follows:
   a. Disconnect wiring harness from ground control harness connector.

NOTICE

CAP HYDRAULIC LINES AND PORTS IMMEDIATELY AFTER DISCONNECTING LINES TO PREVENT ENTRY OF CONTAMINANTS INTO SYSTEM.

   b. Tag and disconnect hydraulic lines from boom to control valve. Use a suitable container to retain any residual hydraulic fluid. Cap all hydraulic lines and ports.
   c. Using appropriately rated lifting equipment, support boom weight along entire length.
   d. Remove bolts and keeper pins from lift cylinder pivot pin. Using a suitable brass drift and hammer, remove pivot pin from lower boom.

NOTE: *To gain access for removal of pivot pins, it may be necessary to remove ground control box, hydraulic and fuel tanks, and counterweight.*

   e. Remove retaining hardware from level link pivot pin. Using a suitable brass drift and hammer, remove pin from level link and turntable.
   f. Remove hardware securing lower boom pivot pin. Using a suitable brass drift and hammer, remove pin from the turntable.
   g. Using all applicable safety precautions, carefully lift boom assembly clear of turntable and lower to ground or suitable supported work surface.

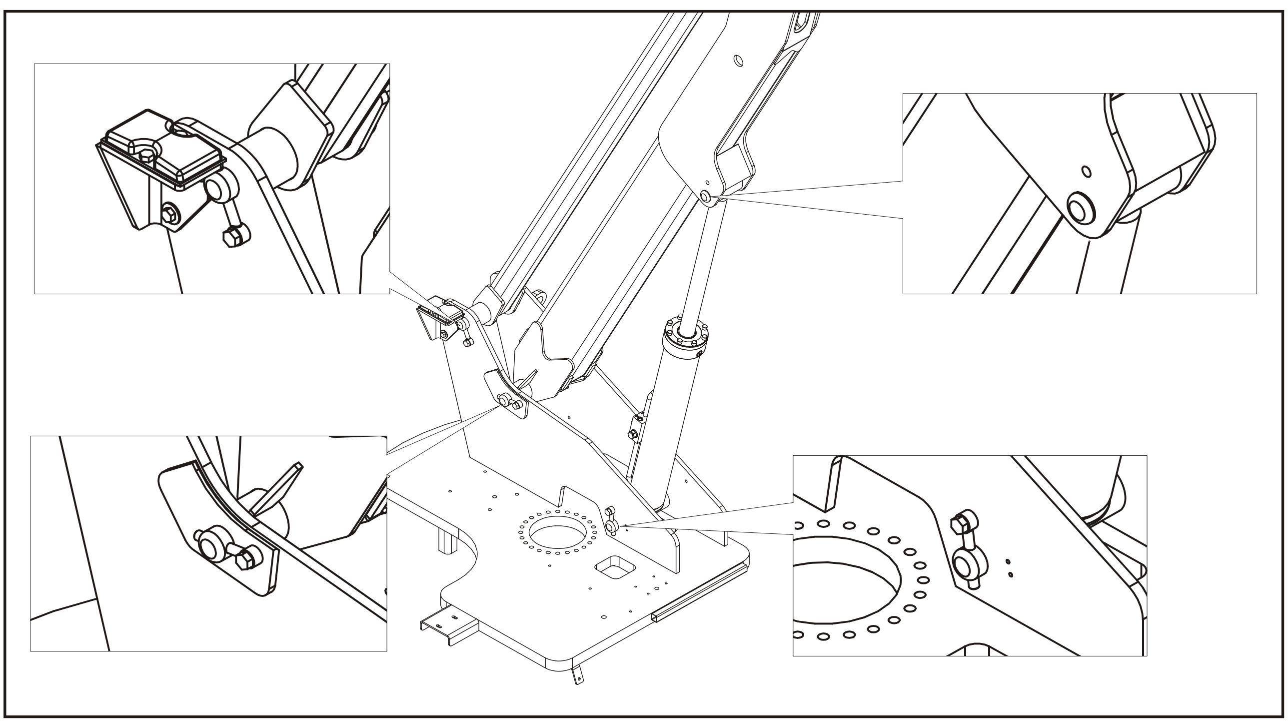


Figure 4-1. Location of Components - Boom Removal

Disassembly of Main Boom

1. Loosen jam nuts on aft end of fly boom wear pad adjustment and loosen adjustments.
2. Using a portable power source, attach hose to telescope cylinder port block. Using all applicable safety precautions, activate hydraulic system and extend cylinder to gain access to cylinder rod retaining pin. Shut down hydraulic system.
3. Carefully disconnect hydraulic hose from retract port of cylinder. There will be initial weeping of hydraulic fluid which can be caught in a suitable container. After initial discharge, there should be no further leakage from the retract port.
4. Remove hardware securing telescope cylinder to the fly boom section, then remove pin from fly.
5. Remove hardware securing telescope cylinder to the base boom section.

NOTICE

WHEN REMOVING TELESCOPE CYLINDER FROM BOOM SECTIONS. CARE SHOULD BE TAKEN NOT TO LEAVE CYLINDER REST ON POWERTRACK WHICH COULD CAUSE DAMAGE TO POWERTRACK.

6. Using a suitable lifting device, remove telescope cylinder from boom sections.
7. Using a piece of tape, mark length of hoses and wires from front of fly boom and bottom of base boom for reassembly.
8. Remove hardware securing front wear pads on base boom section. Remove wear pads.
9. Remove hardware securing powertrack to aft end of fly boom section.
10. Using a suitable lifting device, remove fly boom from boom section.
11. Remove hydraulic lines and electrical cables from powertrack.
12. Remove hardware securing powertrack to base boom section. Remove powertrack.

Inspection

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

Assembly of Main Boom

1. Install power track to the attach point on the base boom section. Secure power track with the attaching hardware.
2. Install hydraulic lines and electrical cables into power track.
3. Install wear pads to the aft end of the fly section.
4. Using suitable lifting equipment, slide fly section into the base section until power track attach point aligns with holes in side of base section.
5. Attach power track to aft end of fly boom section. Secure power track with attaching hardware.
6. Using suitable lifting equipment, slide fly boom section out to gain access to telescope cylinder attach pin hole.
7. Measure distance between telescope cylinder port block attach point on base boom section and attach point on fly boom section.
8. Connect a suitable auxiliary hydraulic power source to telescope cylinder port block.
9. Extend telescope cylinder the distance of the two attach points.
10. Secure sling and lifting device at telescope cylinder's approximate center of gravity. Lift cylinder to aft end of boom assembly.

NOTICE

WHEN INSERTING TELESCOPE CYLINDER INTO BOOM, CARE MUST BE TAKEN NOT TO DAMAGE POWER TRACK ASSEMBLY.

11. Slowly slide telescope cylinder into boom assembly Align rod end with attach point in fly section. Insert pin and secure with retaining ring.
12. Align bolt holes at aft end of base boom section with telescope cylinder port block. Secure telescope cylinder with hardware.
13. Install wear pads at end of base boom section. Using shims, adjust adjustable wear pads to zero clearance. Adjust pads alternately side to side, so fly boom section is centered in base boom section.
14. Retract boom section fully. Using shims, adjust wear pads at aft end of boom section to zero clearance. Adjust pads alternately side to side, so fly boom section is centered in base boom section.
15. Disconnect auxiliary power source from telescope cylinder.

Installation of Boom Assembly

1. Using suitable lifting equipment, position boom assembly on turntable so boom pivot holes in boom and turntable are aligned.
2. Install boom pivot pin, ensuring location of hole in pivot pin aligns with attach point on upright.
3. Using all applicable safety precautions, operate lifting equipment to position boom lift cylinder and level link so holes in cylinder rod end and level link are aligned with one in turntable. Insert cylinder pins.
4. If necessary, gently tap pins into position with a soft headed mallet, ensuring attach holes in pins are aligned with attach holes in boom structure. Secure with hardware.
5. Connect all hosing and wiring.
6. Install platform to boom assembly.
7. Connect all hosing and wiring at platform control station.
8. Using all safety precautions, operate machine systems and extend and retract boom for four or five cycles.
9. Shut down machine systems and check for leaks.

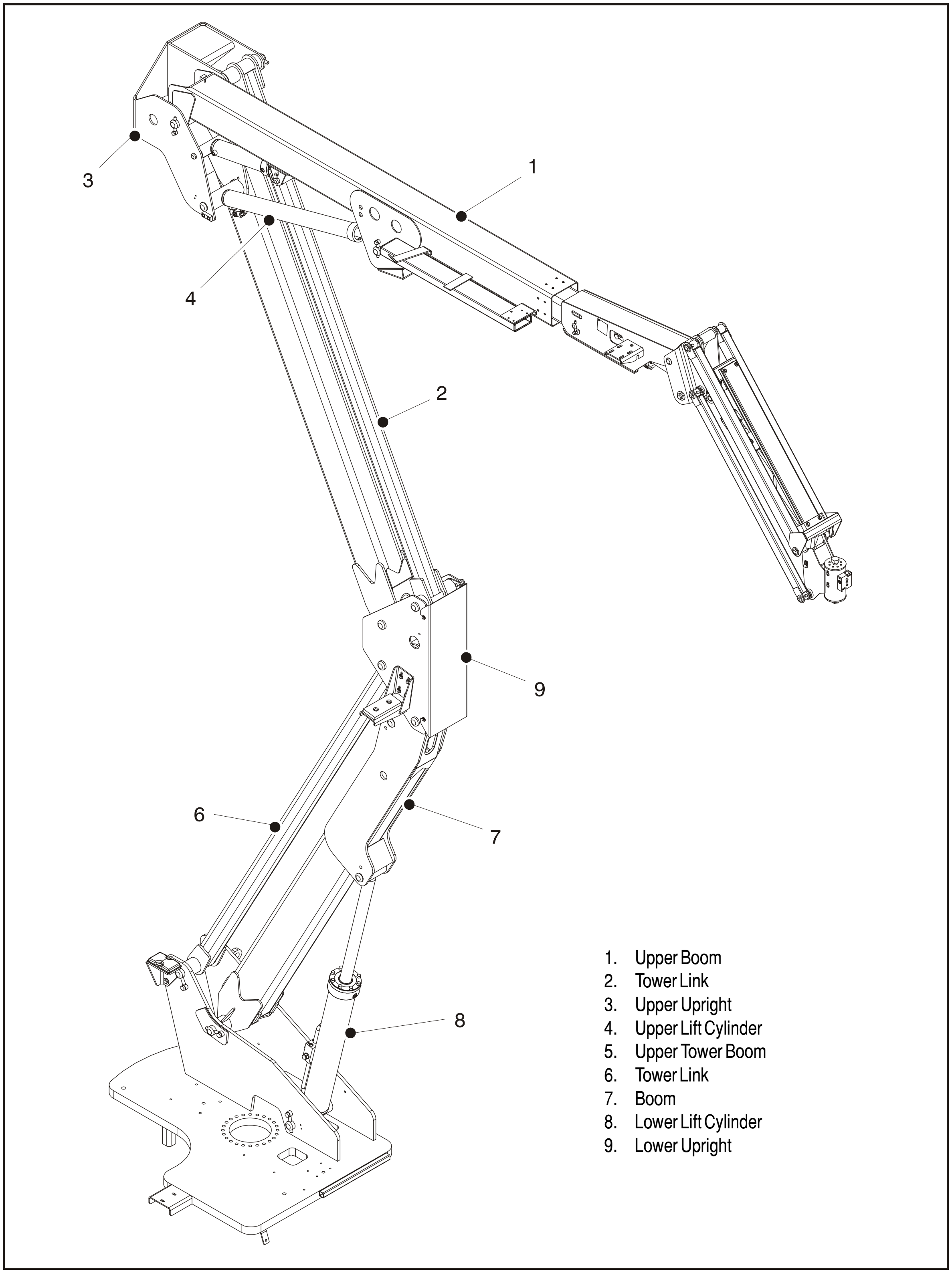


Figure 4-2. Boom Assembly

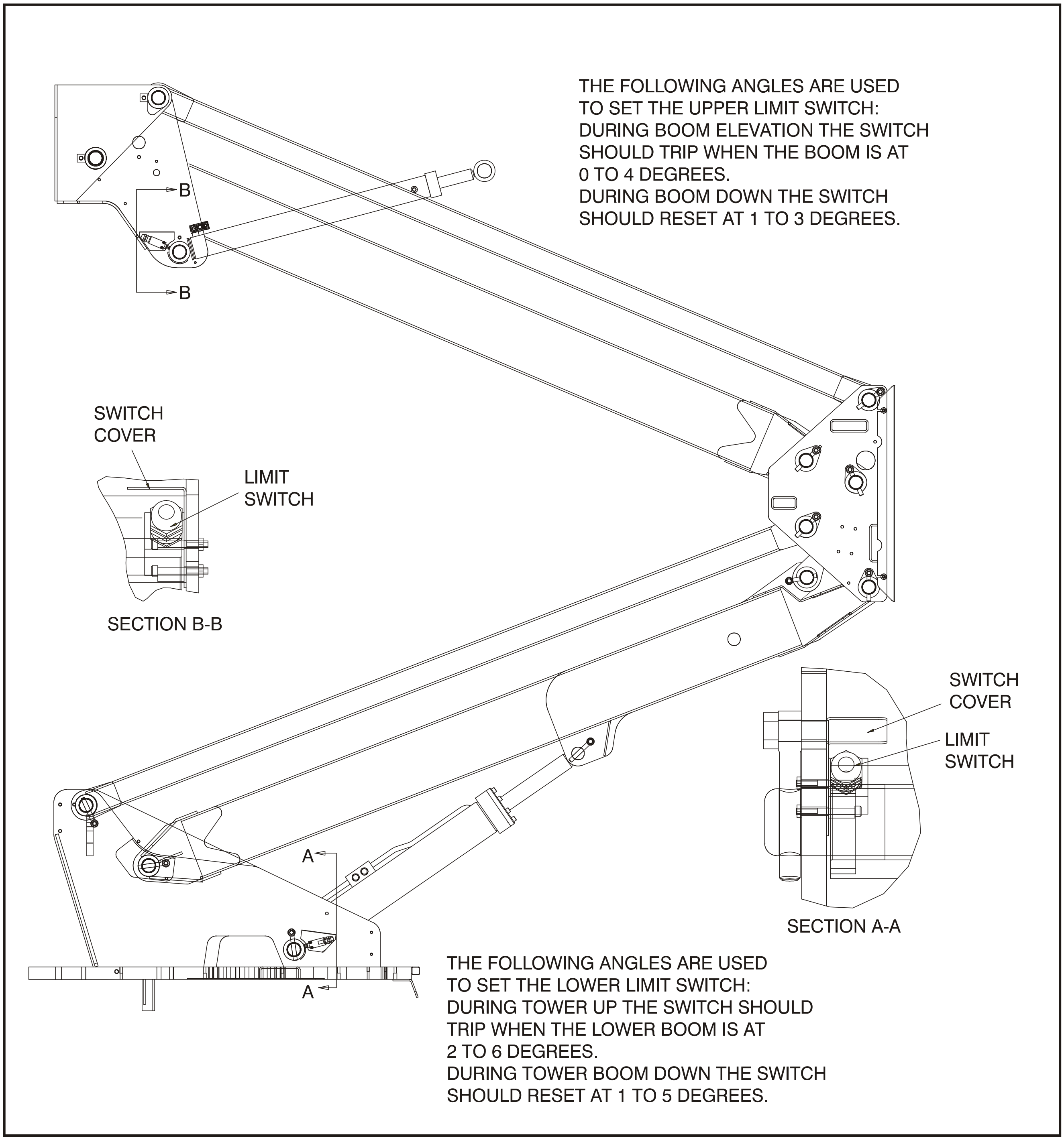


Figure 4-2. Boom Limit Switches - US Manufactured

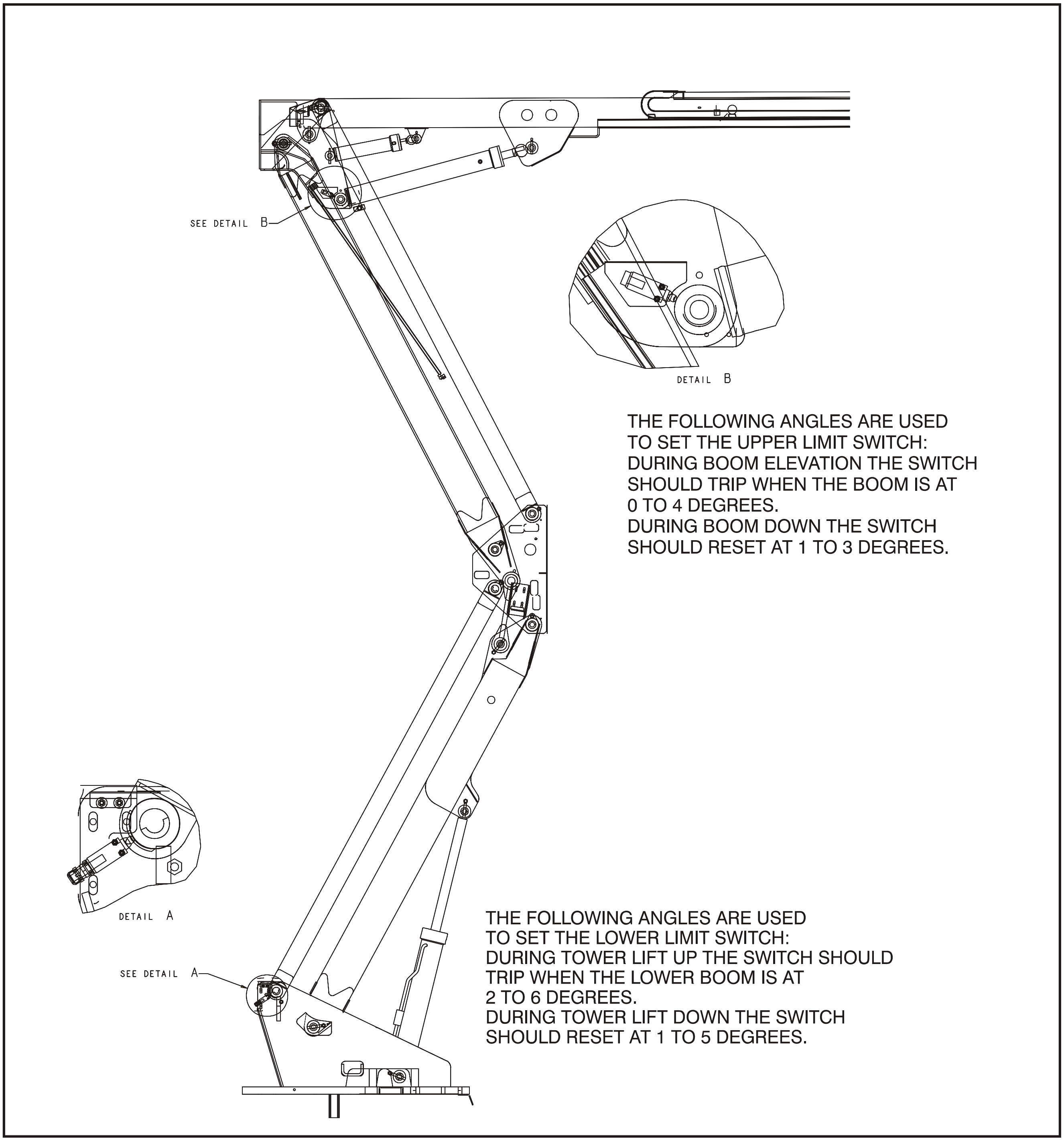


Figure 4-3. Boom Limit Switches - Euro Manufactured

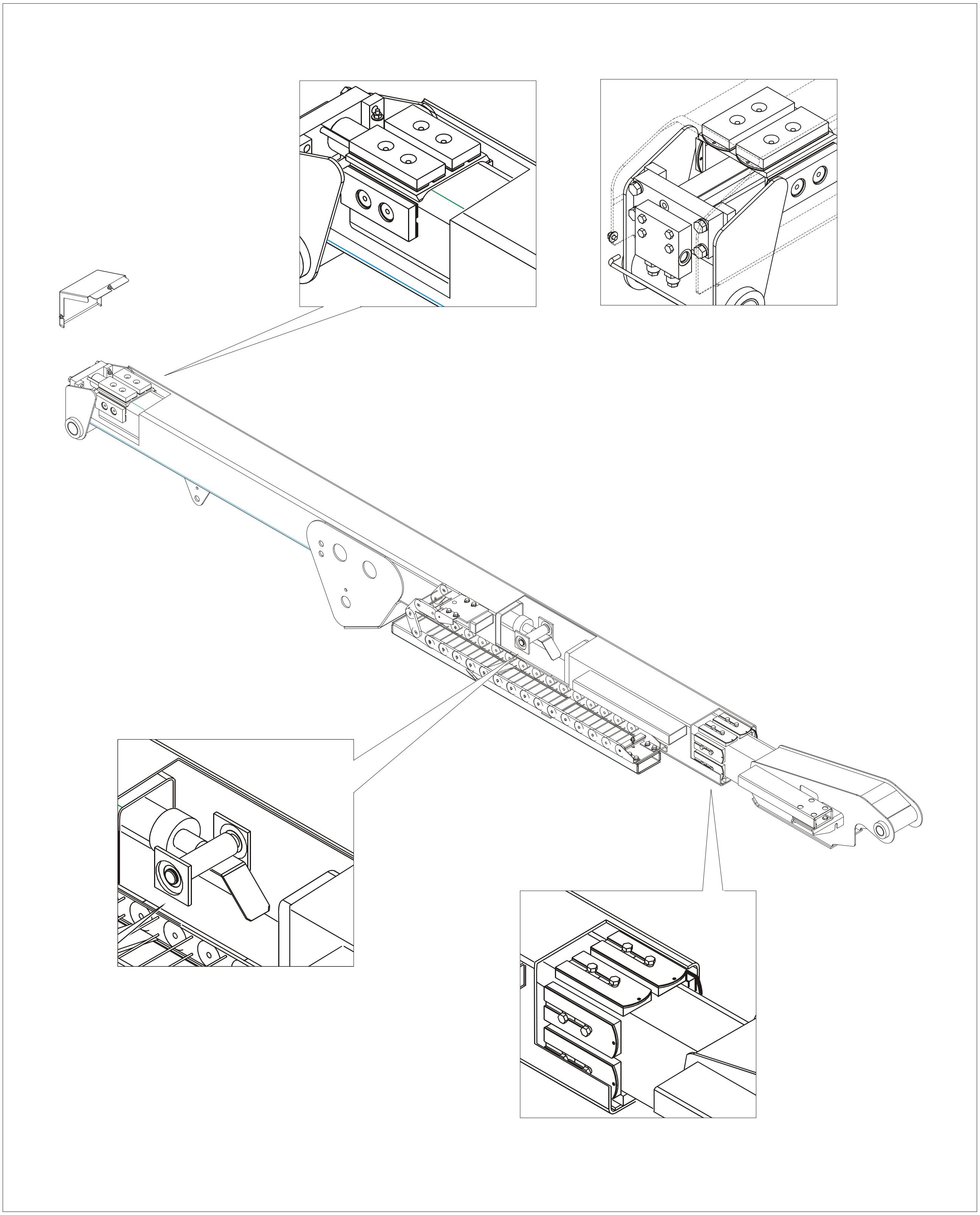


Figure 4-4. Main Boom

4.2 ROTATOR

Theory of Operation

See Figure 4-6., Rotator Assembly - Cutaway

Fluid entering Port P2 under pressure will bear on the piston (4) and force piston sleeve (3) upwards. The left-handed spline of piston sleeve (3) will combine with right-handed spline of shaft (2A) and cause rapid counter-clockwise rotation of shaft and flange (2B) (looking down). Fluid entering Port P1 will reverse rotation.

Displacement and torque are identical for clockwise and counterclockwise rotation.

Shaft (2A) is integral with shaft flange (2B) and bearing tube (2C). The shaft is supported radially by the large upper radial bearing (19) and lower radial bearing (18). Axially, shaft is separated from housing by upper and lower thrust rings (20). End cap (5) is adjusted for axial clearance and locked in position by cap screws (7).

Disassembly and Inspection

Place on a clean workbench with room to place internal parts as they are removed. Remove all hydraulic fittings Loosen cap screws(7) and unscrew locknut (6) and end cap (5). Shaft is now free to move up and out of engagement with piston sleeve (3). Note orientation between spline teeth (see Figure II), as this will greatly simplify actuator timing upon reassembly.

After removing shaft, piston sleeve, and piston assembly can now be moved down and out of housing. Remove all seals and bearings from their grooves, except static piston seals (9) and (11). These seals generally do not require replacement. Clean all parts thoroughly and inspect for wear. A small amount of wear in spline teeth has little effect on actuator strength. New spline sets are manufactured with a backlash of about 0.005" (0.127 mm) per mating set. After long service, a backlash of about 0.015" (0.381 mm) per set may still be acceptable in most cases, depending on required accuracy of application.

Item (1) is the integral housing and ring gear. Check ring gear for wear and weld damage to the pins. Inspect cylinder bore for wear and scratches. Surface finish should be 32 RMS or better; re-hone if necessary. Radial bearings (18) and (1 9) and piston bearings (17) have a maximum radial clearance of 0.006" (0.152 mm). Clearance in excess of 0.008" (0.203 mm) requires bearing replacement. Rough and grooved shaft journals require shaft replacement.

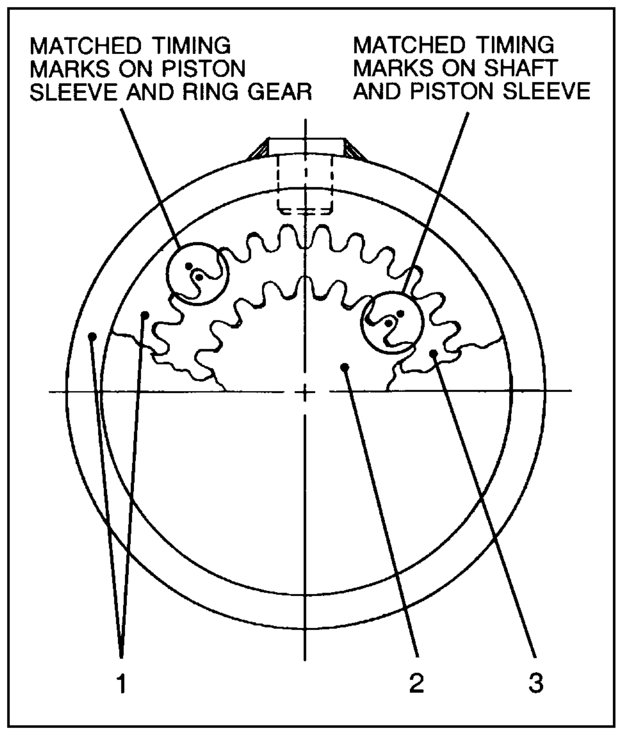
Assembly and Testing

Wash all parts thoroughly in cleaning solvent and blow dry. Coat all sealing and working surfaces with a good grade hydraulic oil. Install seals and bearings in piston sleeve, piston, shaft, and end cap. Exclusion seal lips (16) face outward, and high pressure seal lips face inward.

Place actuator in a vertical position, install piston sleeve (3) in timed relation to housing, applying firm pressure as new seals and bearings enter housing and become compressed by housing chamber.

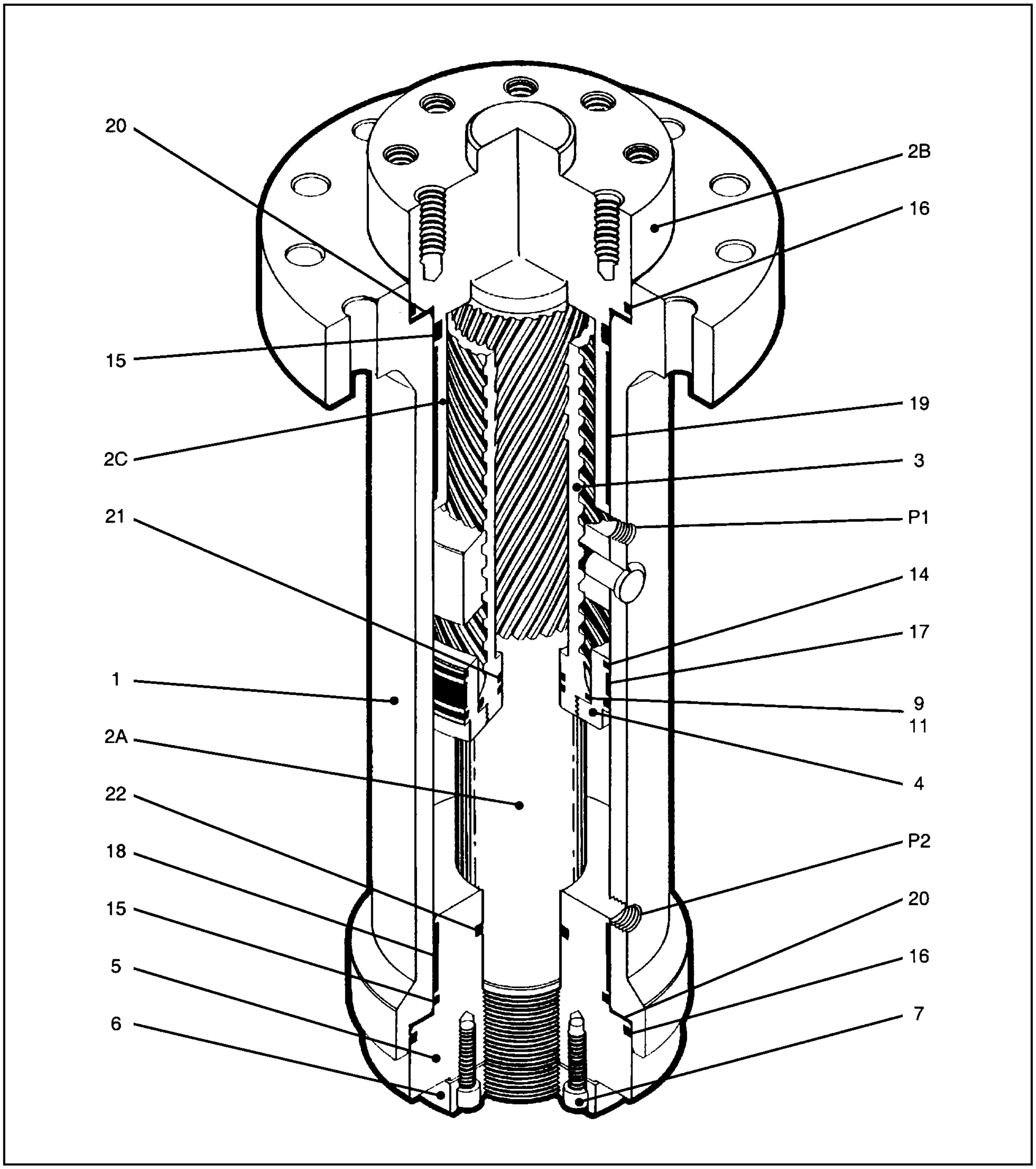
NOTICE

DO NOT MISALIGN SLEEVE TOO MUCH ANY ONE WAY, AS IT WILL MAR CYLINDER BORE. TIMING MARKS (SMALL PUNCH MARKS ON FACE OF EACH GEAR), MUST BE ALIGNED FOR PROPER SHAFT ORIENTATION. REFER TO FIGURE 4-5., TIMING MARKS.



1. Integral Housing & Ring Gear
2. Shaft
3. Piston Sleeve

Figure 4-5. Timing Marks



1. Housing & Ring Gear	5. End Cap	15. O-ring	21. O-ring
2A. Shaft	6. Locknut	16. Exclusion Seals	22. O-ring
2B. Flange	7. Capscrew	17. Piston Bearing	P1 Pressure Port
2C. Bearing Tube	9. Piston Seal	18. Radial Bearing	P2 Pressure Port
3. Piston Sleeve	11. Piston Seal	19. Radial Bearing	
4. Piston	14. O-ring	20. Thrust Bearing	

Figure 4-6. Rotator Assembly - Cutaway

If actuator is not equipped with grease fittings, coat thrust bearings (20) with grease before sliding on shaft and end cap.

Shaft is installed by again aligning punched timing marks. Temporarily taping threaded portion of shaft will help installation past shaft seals (masking tape works well).

Apply anti-seize to threaded and surrounding areas of end caps.

NOTE: *End caps on 60K and larger actuators may need to be installed with actuator in a vertical position.*

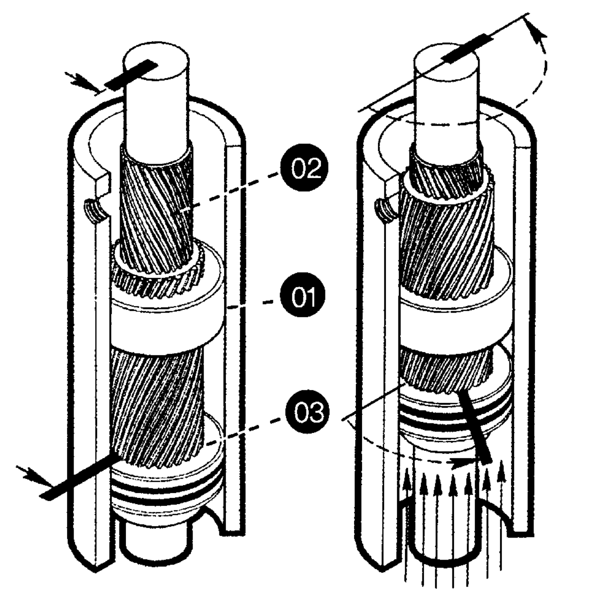
End cap (5) is torqued to 60-400 ft-lb (84-560 Nm) depending on the actuator size, so actuator begins rotation at approximately 100 psi (6.9 bar) pressure. Shaft flange cannot be rotated by hand; combined backdrive efficiency and friction prevent manual rotation. If end cap is torqued too high, actuator may require as much as 300 psi (20.7 bar) to rotate. If end cap is not torqued high enough, shaft axial motion and radial backlash will result. End cap must be secured against shaft by tightening cap screws (7), or installing axial setscrews, depending on model. Apply hydraulic pressure and check for breakaway pressure and shaft axial motion.

To test for leakage, pressurize Port P2 to 3000 psi (206.8 bar). No oil should seep from Port P1 or from around end cap (5). Repeat test by pressurizing Port P1 and check for leakage out of Port P2, around shaft flange (2B), and from ring gear pin welds.

4.3 ROTARY ACTUATOR (S/N 0300130812 AND 1300006433 TO PRESENT)

Theory of Operation

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



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

As fluid pressure is applied, piston is displaced axially while helical gearing causes piston and shaft to rotate simultaneously.

The double helix design compounds rotation: shaft rotation is about twice that of the piston.

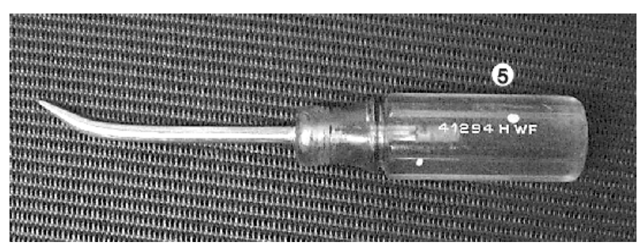
Shaft is supported radially by large upper radial bearing and lower radial bearing. Axially, shaft is separated from housing by upper and lower thrust washers. The end cap is adjusted for axial clearance and locked in position by set screws or pins.

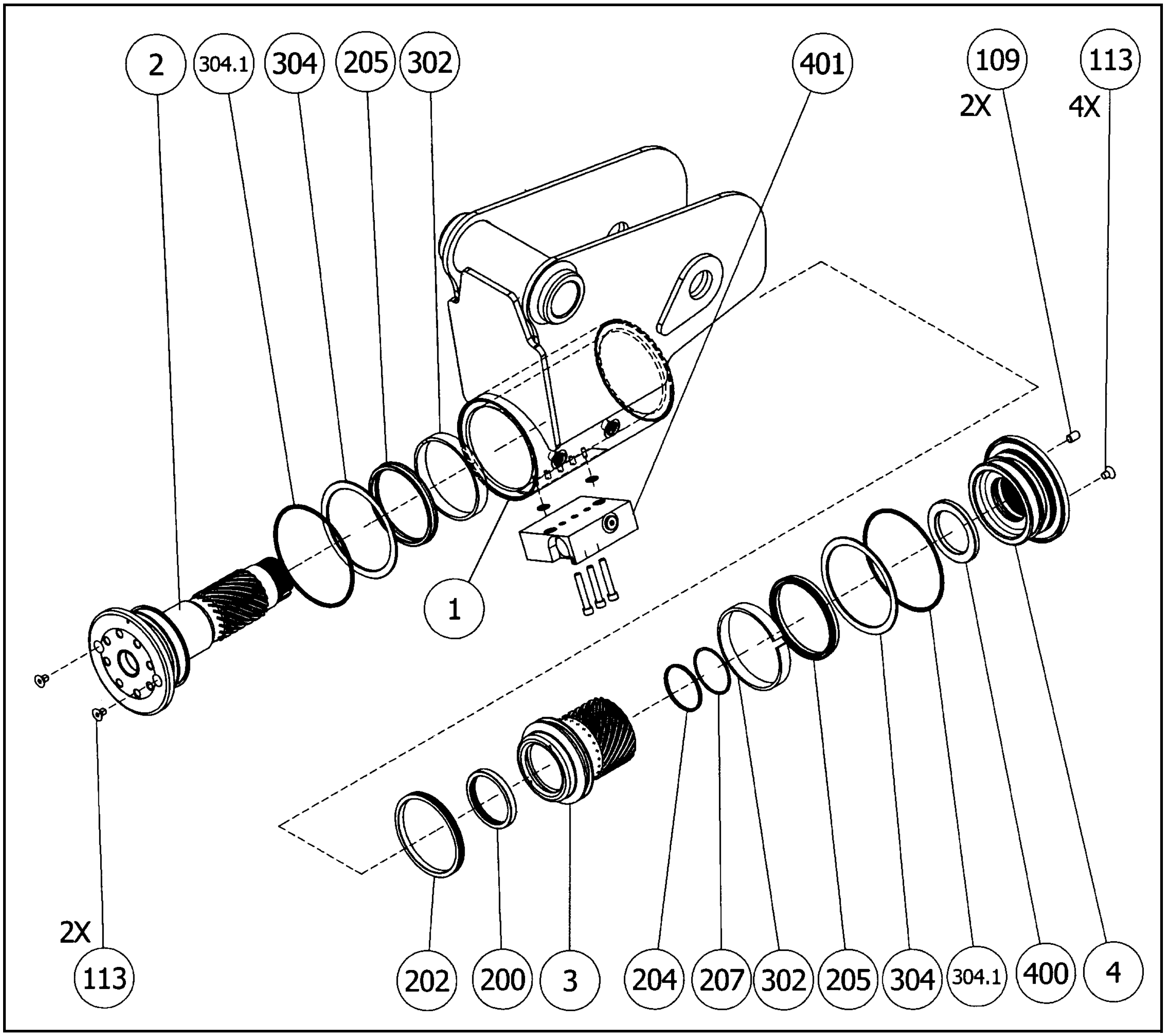
Required Tools

Basic tools required for assembly and disassembly of the actuator and their intended functions are as follows:

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

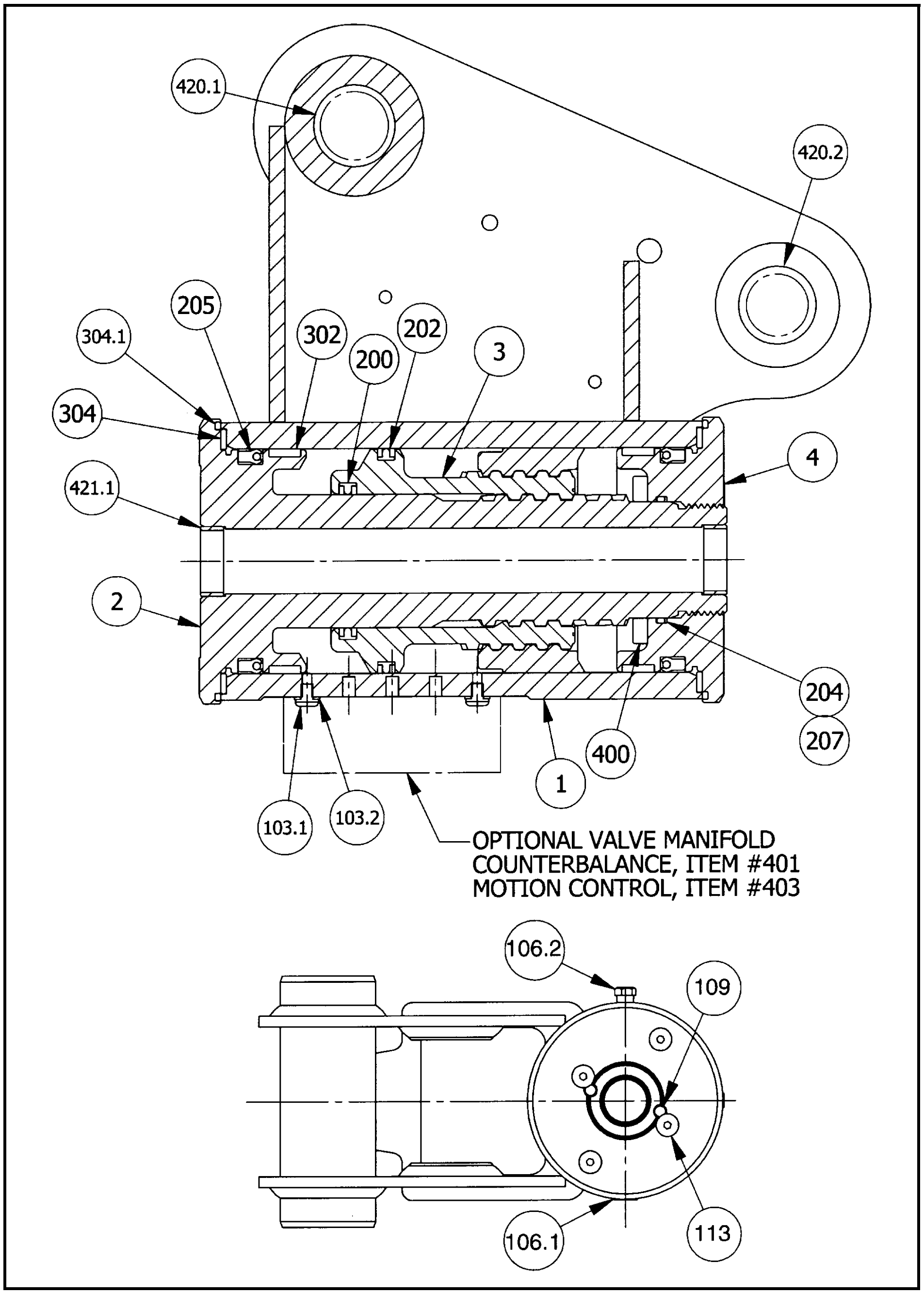
The seal tool is a customized flat-head screwdriver. To make this tool, heat flat end with a torch and bend to a slight radius in a vice. Round off sharp edges with a grinder.





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

Figure 4-7. Rotary Actuator - Exploded View

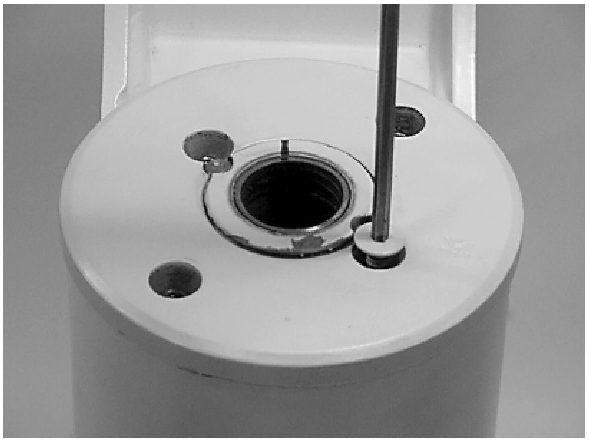


PARTS	HARDWARE	SEALS	BEARINGS	ACCESSORIES
1. Housing	103.1. Screw	200. T-Seal	302. Wear Guide	400. Stop Tube
2. Shaft	103.2 . Washer	202. T-Seal	304. Thrust Washer	420.1 Bushing
3. Piston Sleeve	106.1. Port Plug	204. O-Ring		420.2 Bushing
4. End Cap	106.2. Port Plug	205. Cup Seal		421.1 Bushing
	109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

Figure 4-8. Rotary Actuator - Assembly Drawing

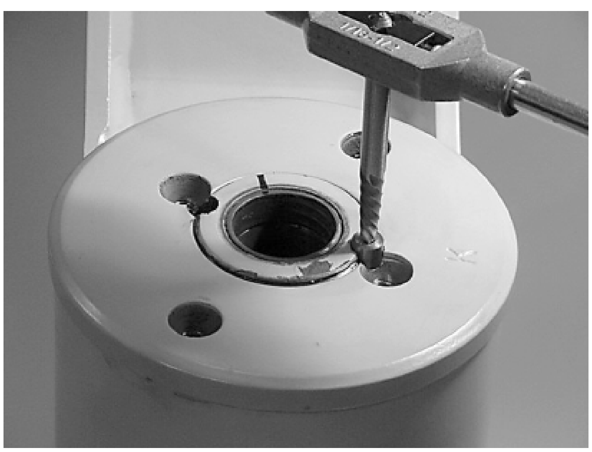
Disassembly

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



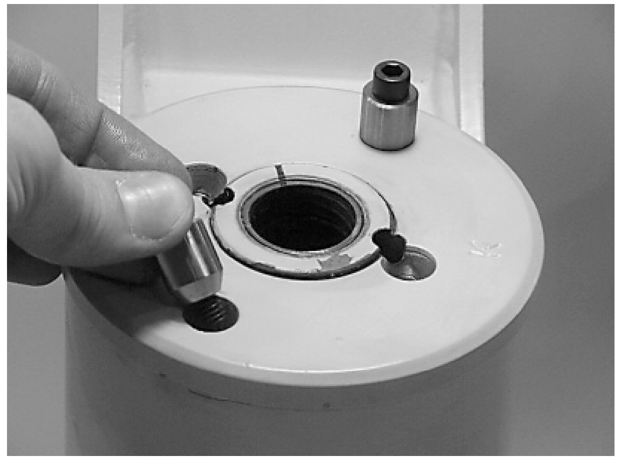
2. Using a 1/8" (3.18mm) drill bit, drill hole in center of each lock pin to a depth of approximately 3/16" (4.76mm).

3. Remove lock pins using an ”Easy Out” (#2 shown).

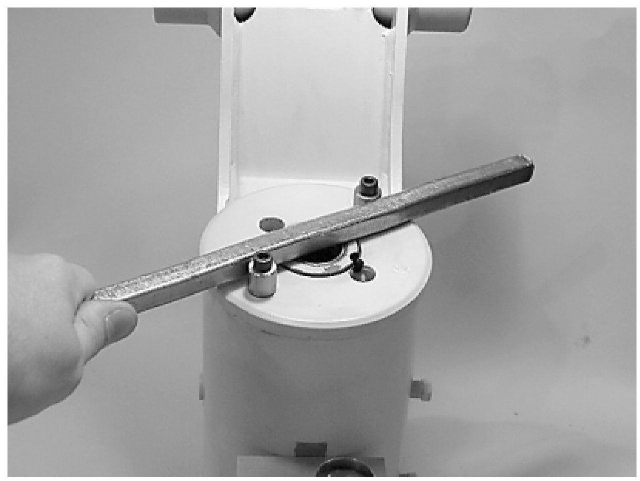


If pin will not come out with ”Easy Out”, use 5/16" drill bit to a depth of 1/2" (12.7mm) and drill out entire pin.

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



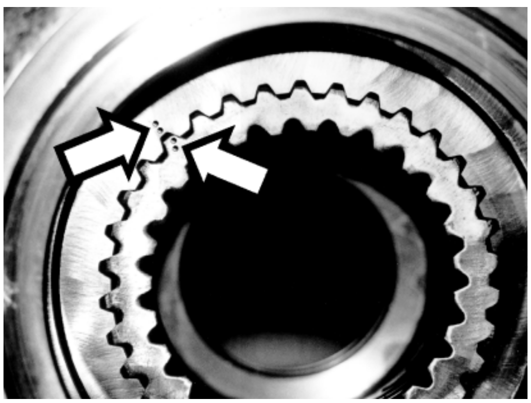
5. Using a metal bar or similar, unscrew end cap (4) by turning it counter clockwise.

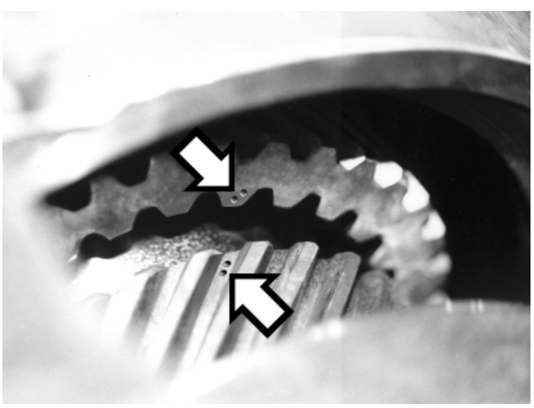


6. Remove end cap (4) and set aside.

7. Remove stop tube if included. Stop tube is an available option to limit actuator rotation.

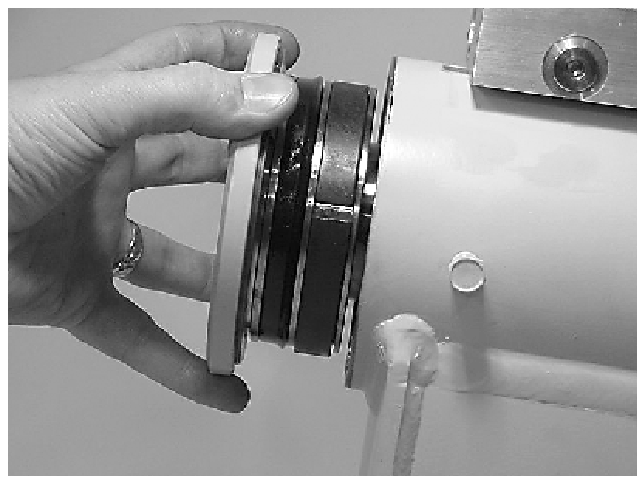
8. Actuator has timing marks for proper engagement.





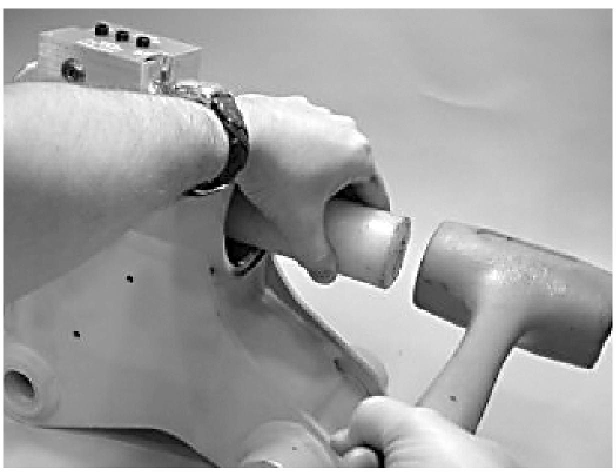
9. Use a felt marker to clearly indicate timing marks between shaft and piston before removing shaft, (2). This will greatly simplify timing during assembly.

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

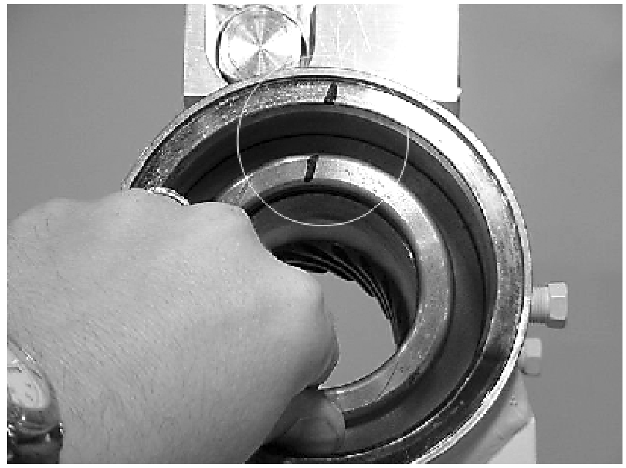


11. Mark housing (1) ring gear in relation to piston O.D. gear before removing piston (3). There should now be timing marks on housing (1) ring gear, piston (3) and shaft (2).

12. Use a rubber mallet and plastic mandrel to prevent damage when removing piston (3).

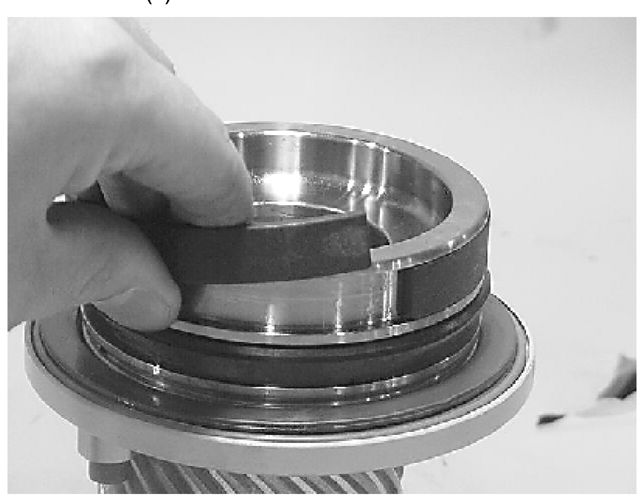


13. Mark piston and housing with a marker where piston gear teeth come out of engagement with housing gear teeth as shown.

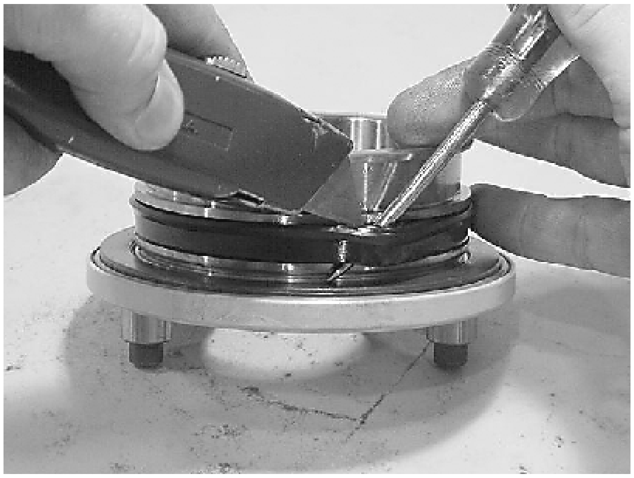


14. Remove O-ring (204) and backup ring (207) from end cap (4) and set aside.

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



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



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

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

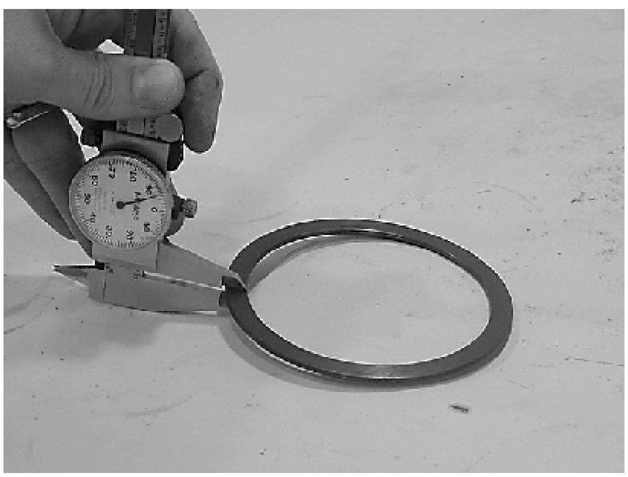
19. Remove piston O.D. seal (202).

20. Remove piston I.D. seal (200).

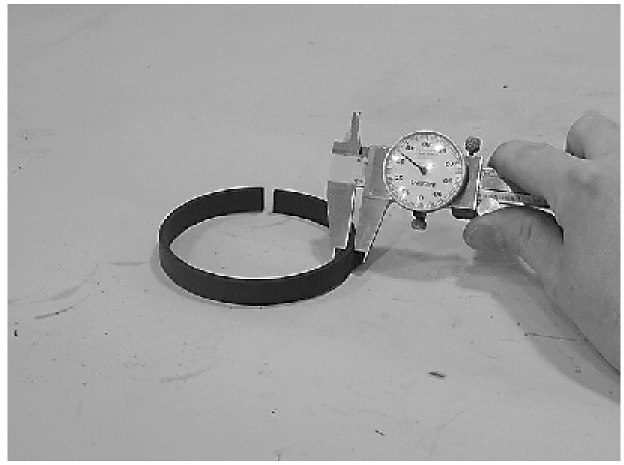
Inspection

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

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

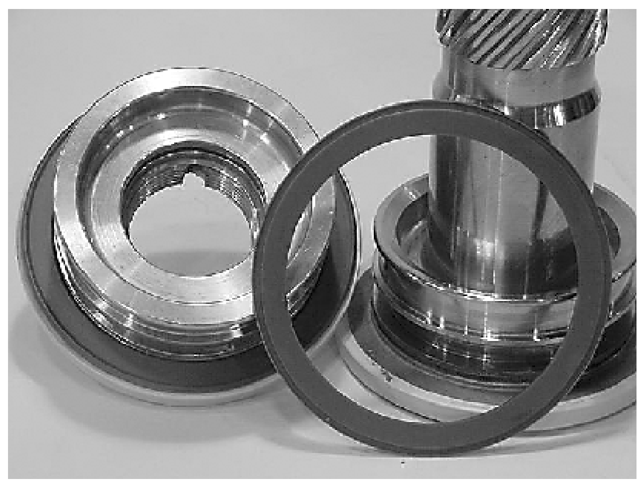


3. Inspect wear guide condition and measure thickness (not less than 0.123" or 3.12 mm).

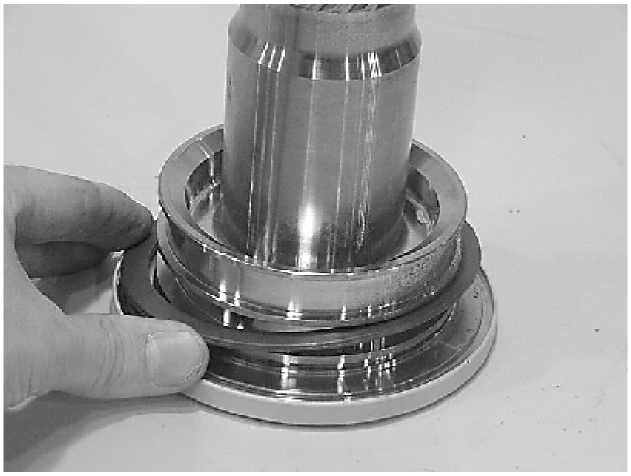


Assembly

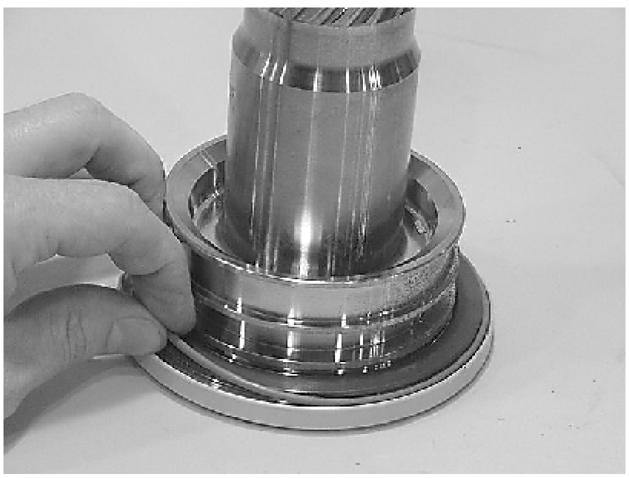
1. Gather all components and tools to one location before reassembly. Use cut-away drawing to reference seal orientations.



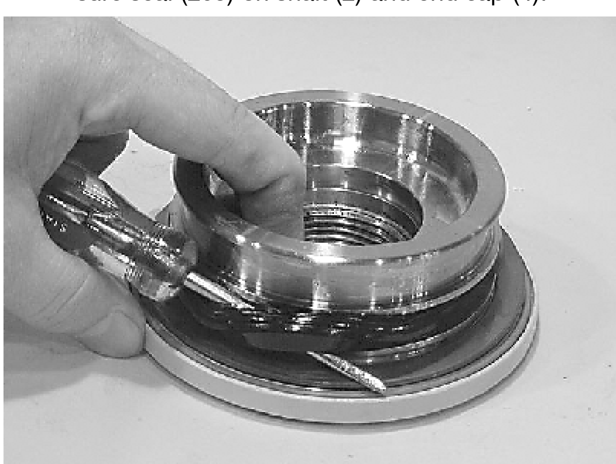
2. Install thrust washer (304) on shaft (2) and end cap (4).



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



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



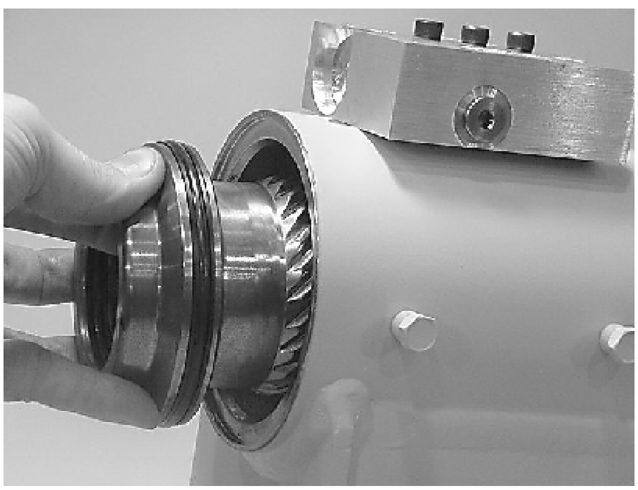
5. Install wear guide (302) on end cap (4) and shaft (2).

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

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

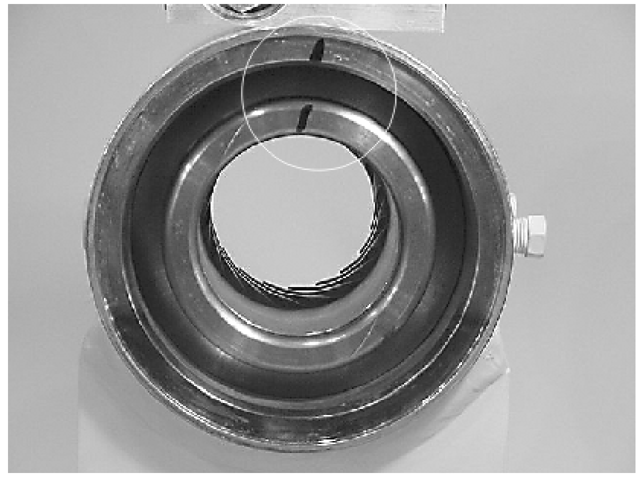
9. Repeat for outer seal (202).

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



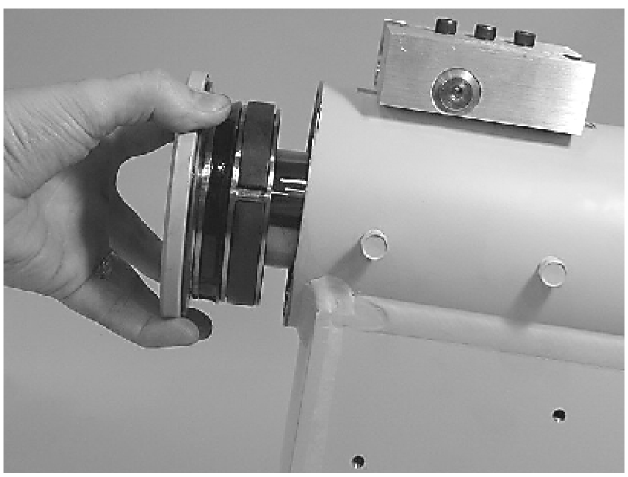
11. Looking from angle shown, rotate piston (3) until marks on piston and housing (1) line up as shown.

12. Using a rubber mallet, tap piston into housing to point where gear teeth meet.

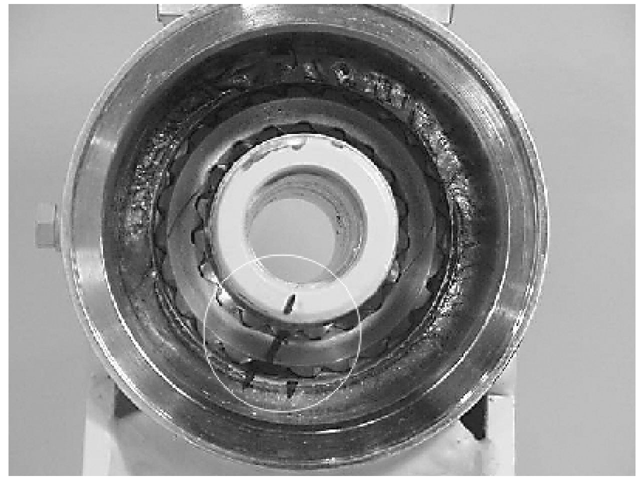


13. Look from opposite end of housing (1) to see if timing marks are lining up. When they do, tap piston (3) in until gear teeth mesh together. Tap piston into housing until it bottoms out.

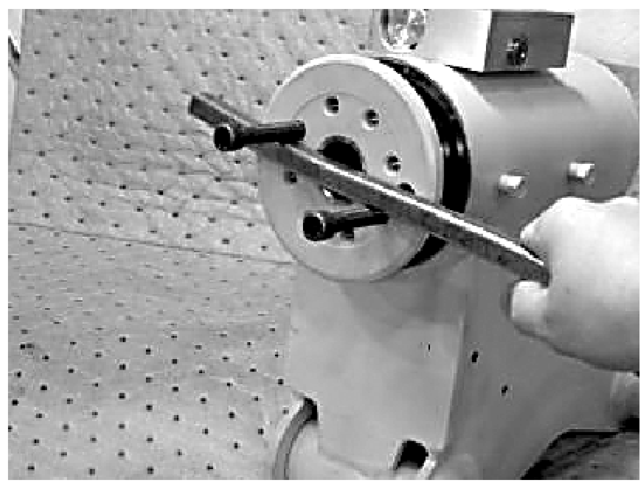
14. Install shaft (2) into piston (3). Be careful not to damage seals. Do not engage piston gear teeth yet.



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

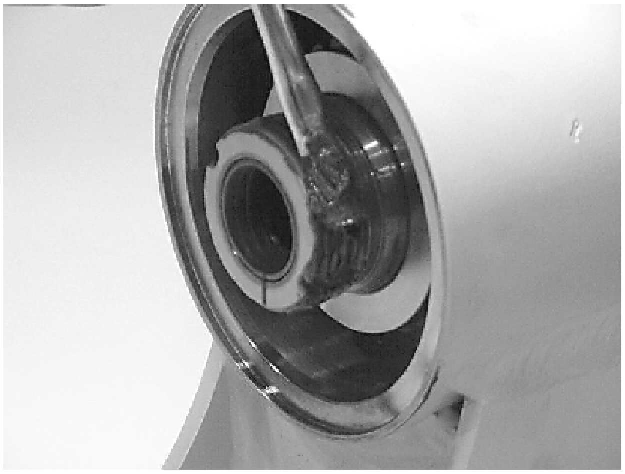


16. Install 2 bolts in threaded holes in flange. Using a bar, rotate shaft in a clockwise direction until wear guides are seated inside housing bore.



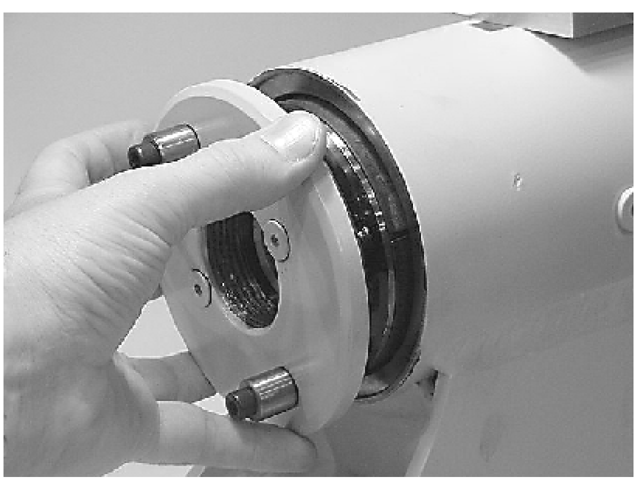
17. Install stop tube onto shaft end. Stop tube is an available option to limit actuator rotation.

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

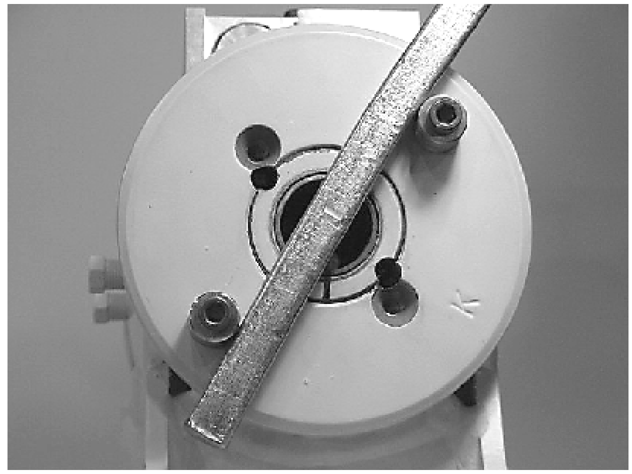


19. Install 0-ring (204) and back-up ring (207) in inner seal groove on end cap (4).

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

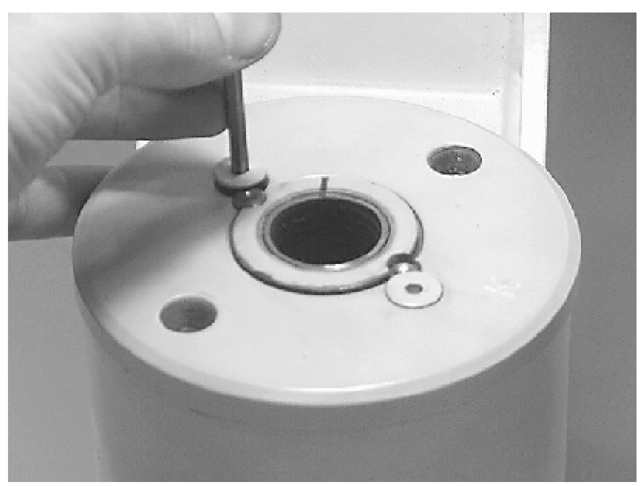


21. Tighten end cap (4). In most cases original holes for lock pins will line up.



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

23. Insert set screws (113) over lock pins. Tighten to 25 in-lb (2.825 Nm).



Installing Counterbalance Valve

Refer to Figure 4-9., Rotator Counterbalance Valve.

1. Clean actuator surface of any contamination and foreign debris including old Loctite.
2. Make sure new valve has O-rings in counterbores of valve to seal it to actuator housing.
3. Bolts that come with valve are grade 8 bolts. Install new bolts with a new valve. Apply Loctite #242 to the shank of three bolts during installation.
4. Torque 1/4" bolts 110 to 120 in-lb (12.4 to 13.5 Nm). Do not torque over 125 in-lb (14.1 Nm). Torque 5/16" bolts 140 in-lb (15.8 Nm). Do not torque over 145 in-lb (16.3 Nm).

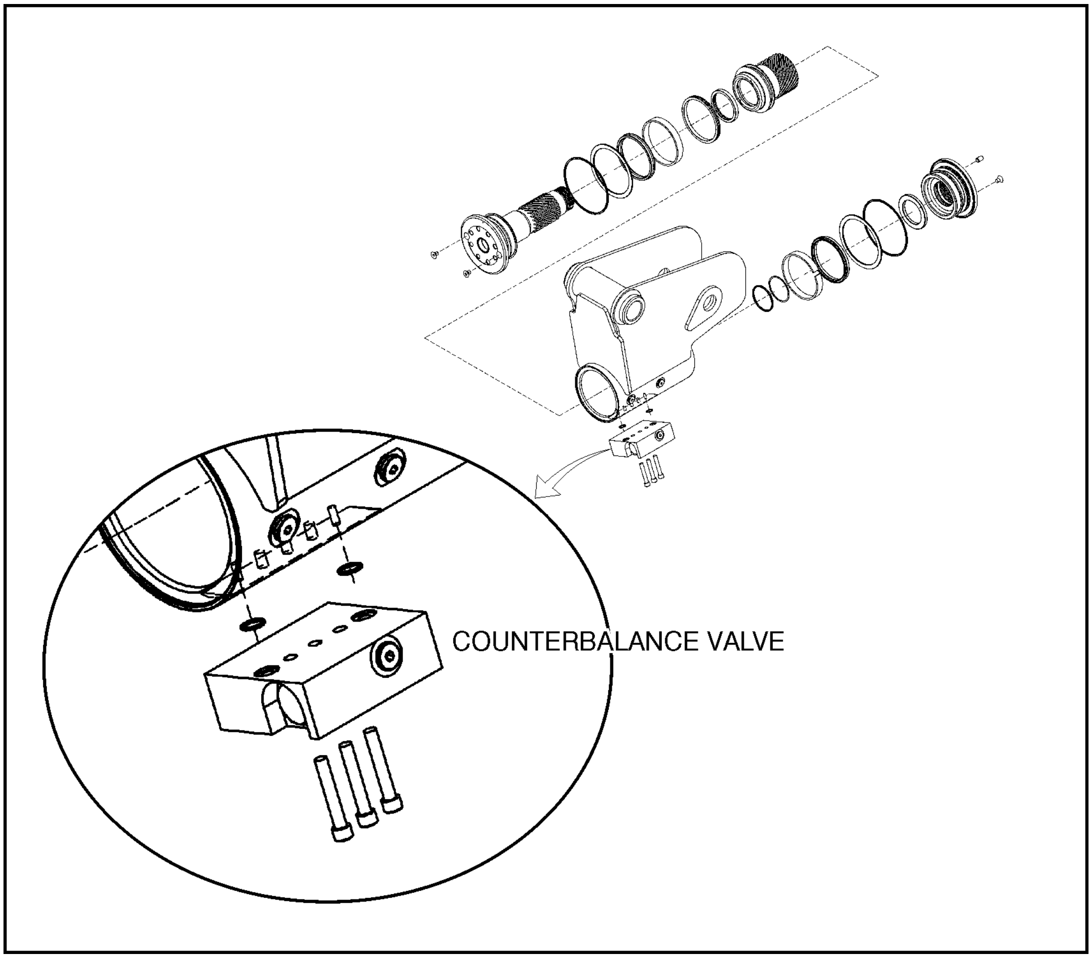
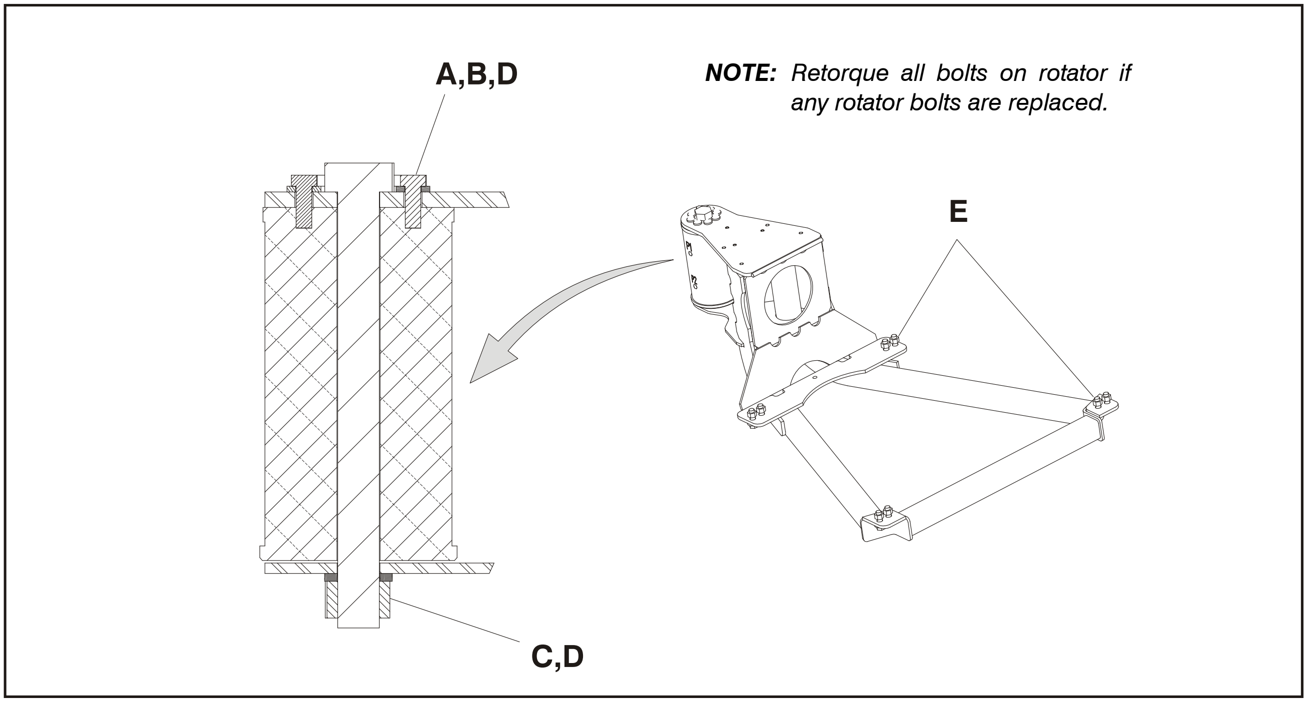


Figure 4-9. Rotator Counterbalance Valve



A Torque to 50 ft-lb (68 Nm)
B Loctite #242
C Torque to 480 ft-lb (650 Nm)
D Check torque every 150 hours of operation
E Torque to 85 ft-lb (115 Nm)

Figure 4-10. Platform Support Torque Values

SECTION 5. HYDRAULICS

5.1 CYLINDER REPAIR -USA MANUFACTURED ONLY

NOTE: Following are general procedures that apply to all cylinders on this machine. Procedures that apply to a specific cylinder will be so noted.

Disassembly

NOTICE

DISASSEMBLE CYLINDER ON A CLEAN WORK SURFACE IN A DIRT FREE WORK AREA OR CONTAMINATION MAY DAMAGE EQUIPMENT.

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

WARNING

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

2. Operate hydraulic power source and extend cylinder. Shut down and disconnect power source. Adequately support cylinder rod, if applicable.
3. If applicable, remove cartridge-type holding valve and fittings from cylinder port block. Discard O-rings.
4. Place cylinder barrel in a suitable holding fixture. Tap around outside of cylinder head retainer with a suitable hammer to break thread-locking compound.

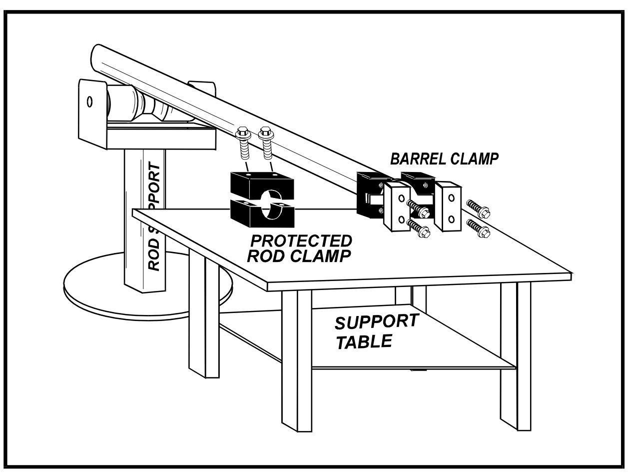


Figure 5-1. Cylinder Barrel Support

5. Mark cylinder head and barrel with a center punch for easy realignment. Using an allen wrench, loosen eight cylinder head retainer cap screws and remove cap screws from cylinder barrel.

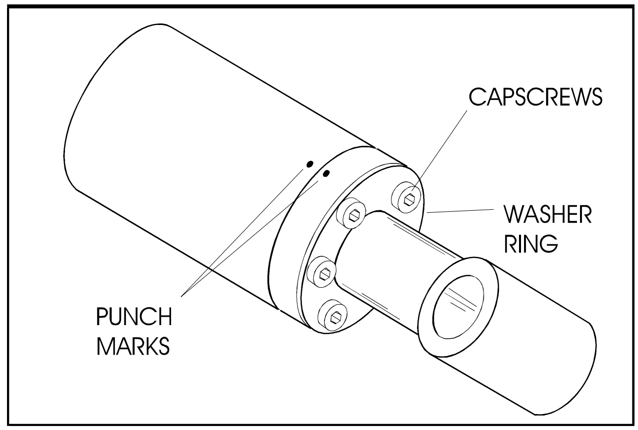
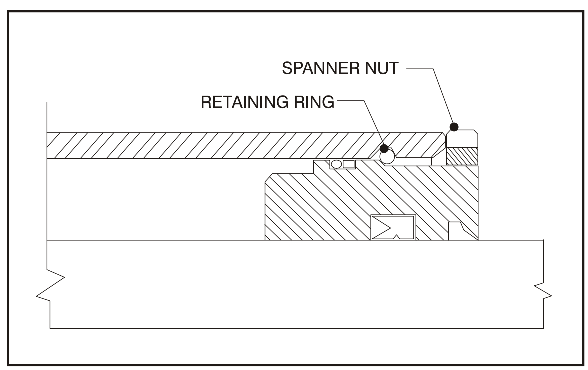


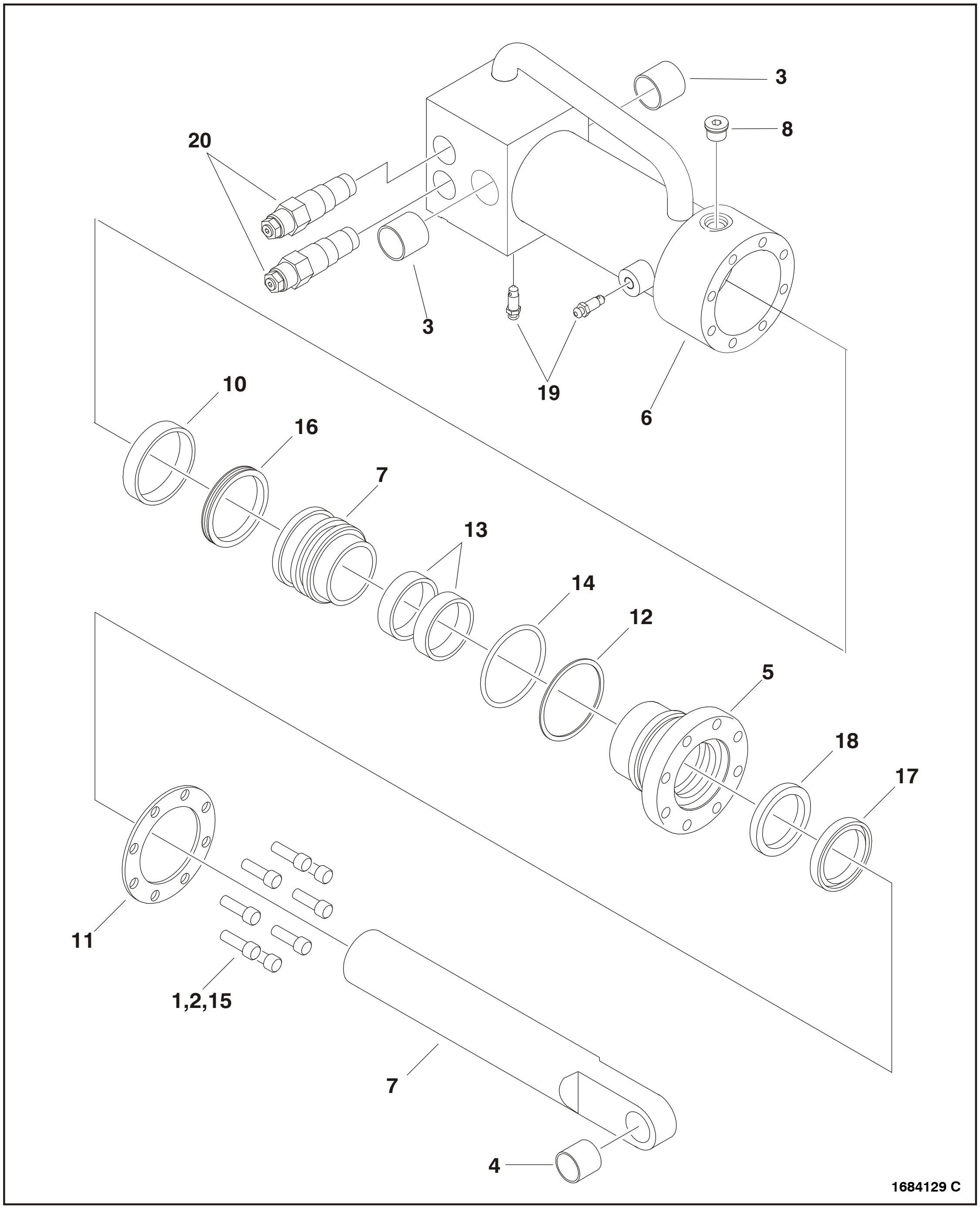
Figure 5-2. Cap Screw Removal

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

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

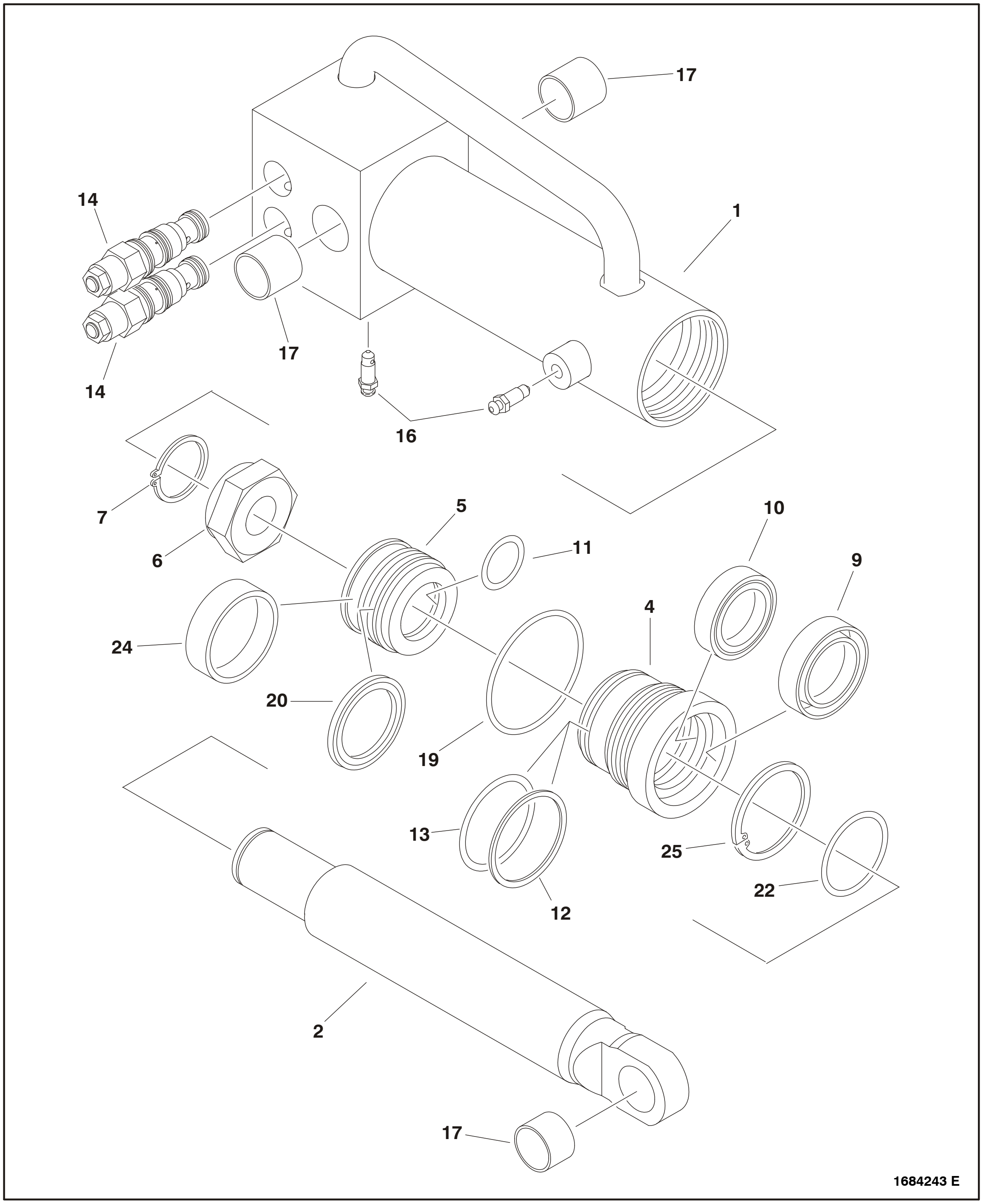


8. Attach a suitable pulling device to cylinder rod port block end or cylinder rod end.



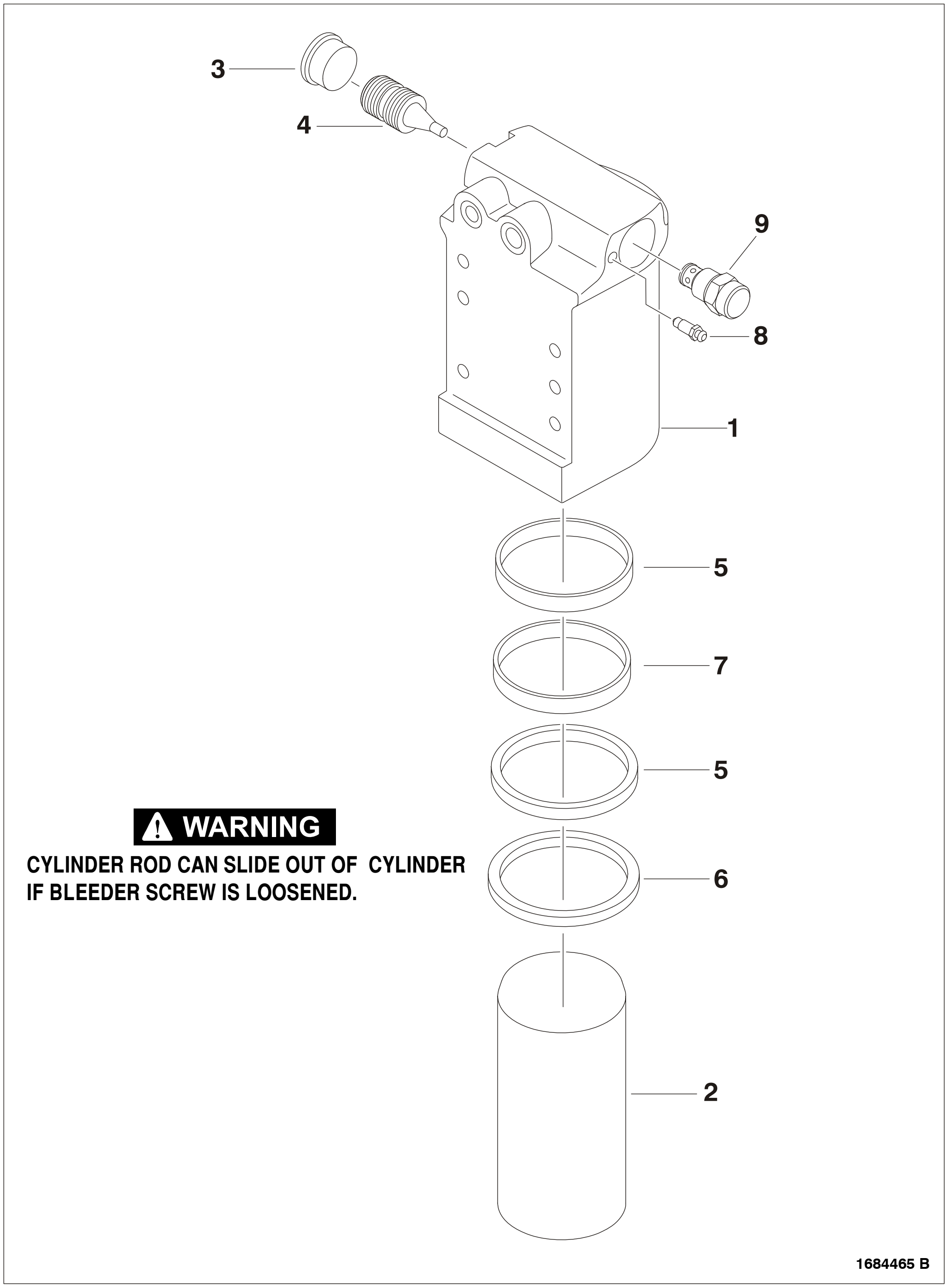
1. Loctite #242	6. Barrel	11. Washer Ring	16. T-Seal
2. Locking Primer	7. Rod/Piston	12. Backup Ring	17. Wiper Seal
3. Bushing	8. O-Ring Plug	13. Wear Ring	18. Rod Seal
4. Bushing	9. Not Used	14. O-Ring	19. Bleeder Valve
5. Head	10. Wear Ring	15. Bolt	20. Counterbalance Valve

Figure 5-3. Axle Lockout Cylinder - USA Built Machines Prior to S/N 03000107512



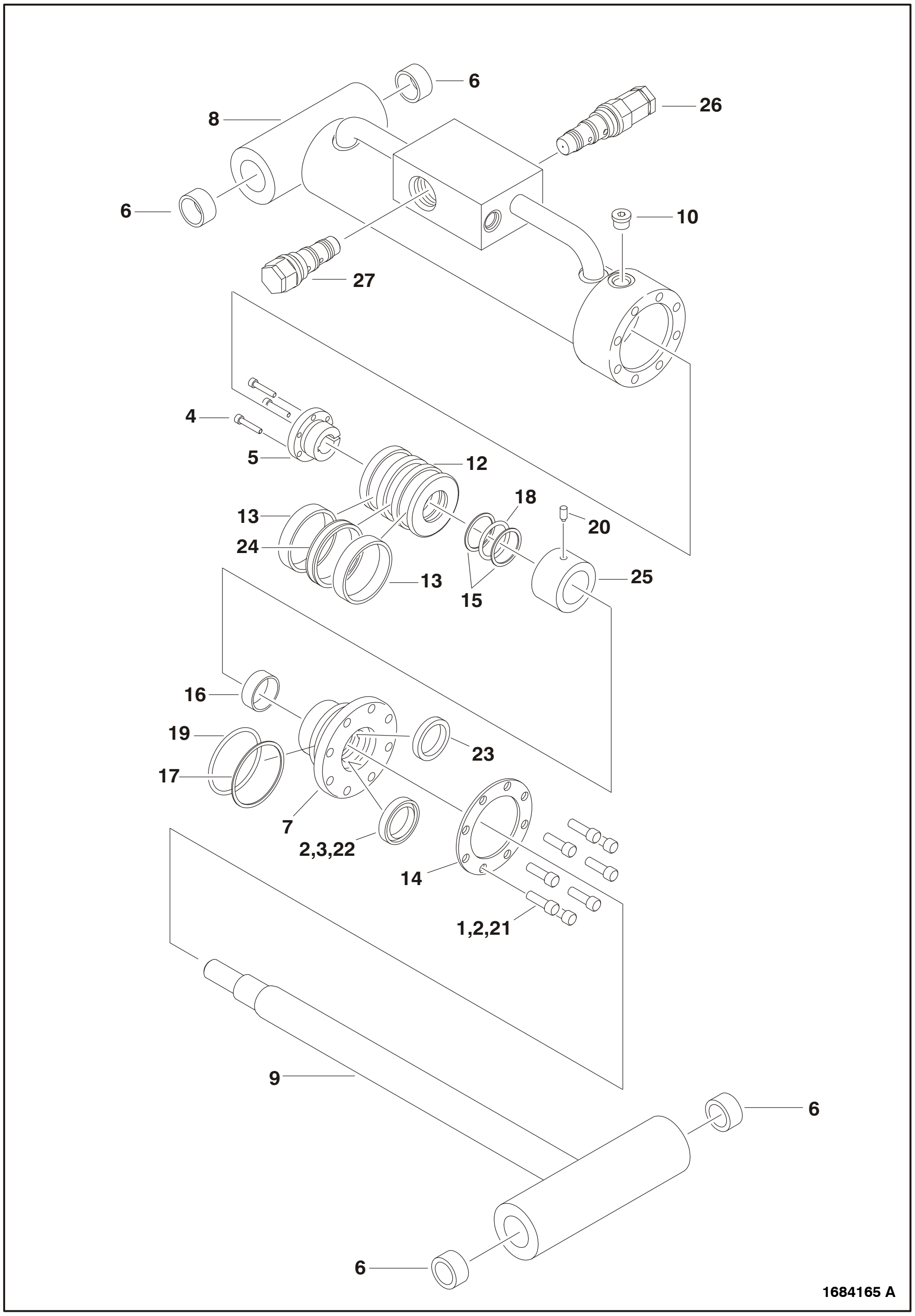
1. Barrel	6. Locknut	11. O-Ring	16. Bleeder	21. O-Ring
2. Rod	7. Retaining Ring	12. Backup Ring	17. Bearing	22. O-Ring
3. Not Used	8. Not Used	13. O-Ring	18. Not Used	23. Not Used
4. Head	9. Wiper	14. Valve Cartridge	19. O-Ring	24. Wear Ring
5. Piston	10. Seal	15. Not Used	20. Seal	25. Retaining Ring

Figure 5-4. Axle Lockout Cylinder - Belgium Built Machines Prior to S/N 1300003222



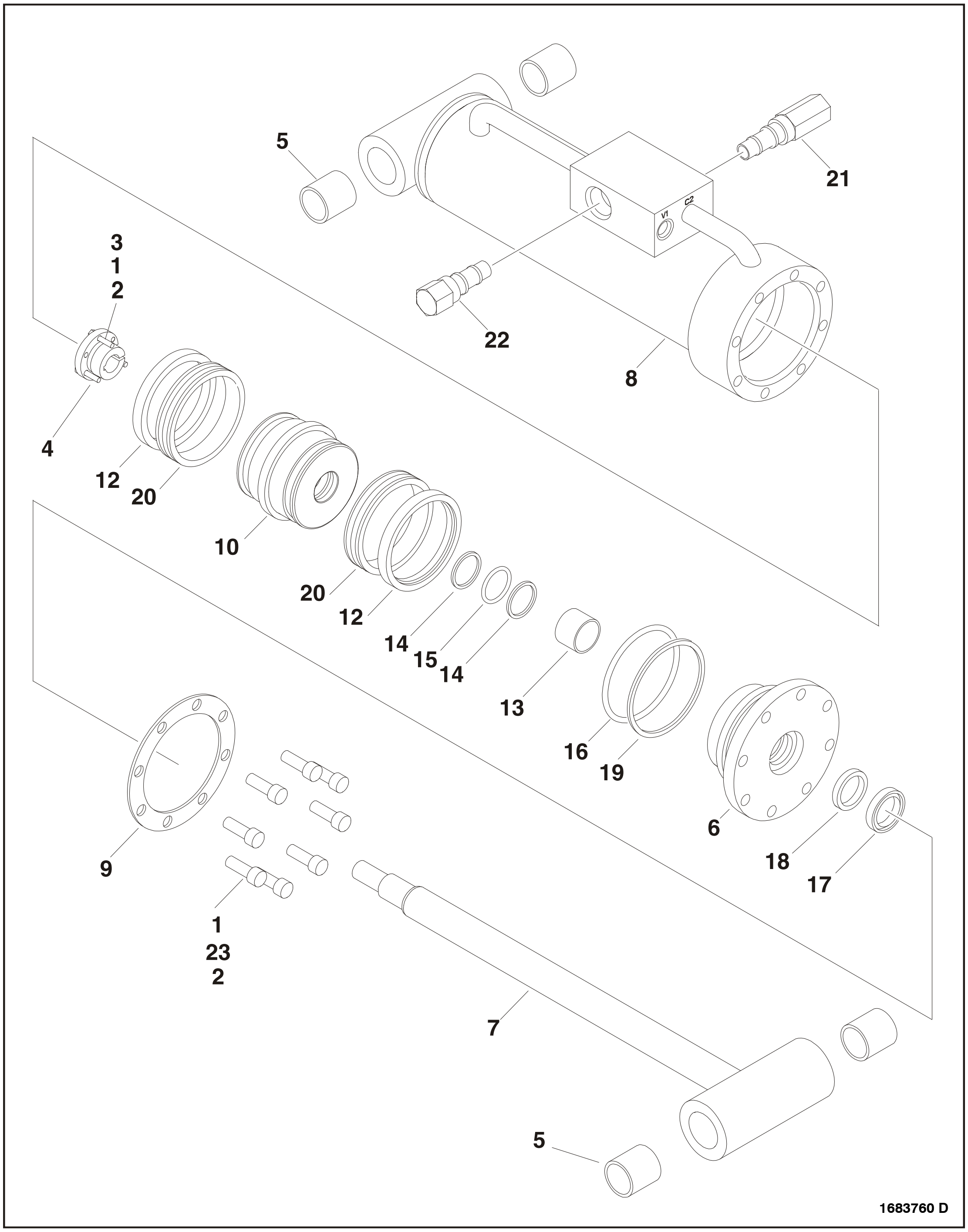
1. Barrel
2. Rod
3. Plug
4. Pilot Piston
5. Wear Ring
6. Wiper
7. Rod Seal
8. Bleeder
9. Valve Cartridge

Figure 5-5. Axle Lockout Cylinder - USA Built Machines 0300107512 to Present & Belgium Built Machines 1300003222 to Present



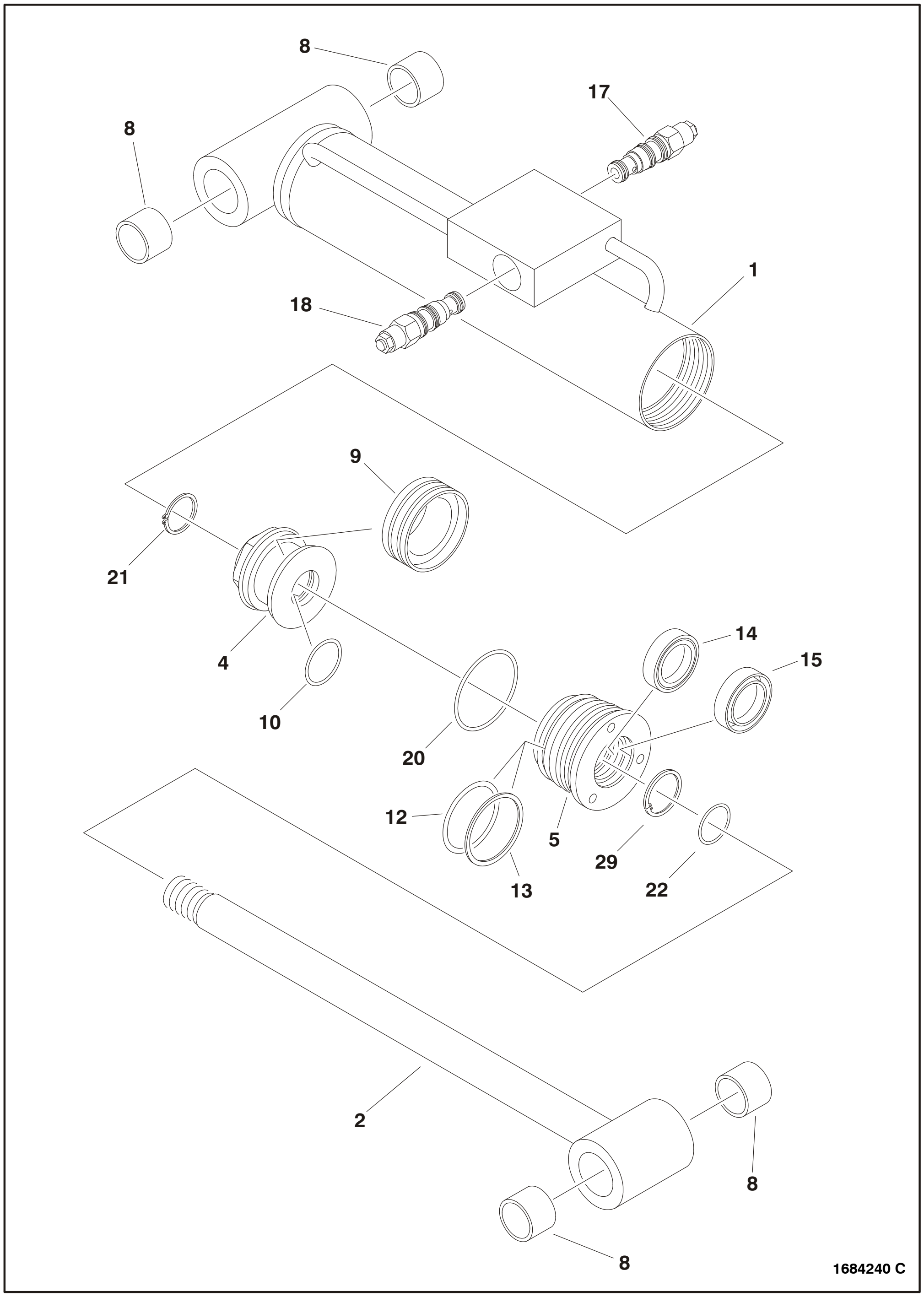
1. Loctite #242
2. Locking Primer
3. Loctite RC609
4. Bolt
5. Tapered Bushing
6. Composite Bushing
7. Head
8. Barrel
9. Rod
10. O-Ring Plug
11. Not Used
12. Piston
13. Wear Ring
14. Washer Ring
15. Backup Ring
16. Wear Ring
17. Backup Ring
18. O-Ring
19. O-Ring
20. Setscrew
21. Bolt
22. Wiper
23. Seal
24. T-Seal
25. Spacer Tube
26. Valve Cartridge
27. Valve Cartridge

Figure 5-6. Platform Level Assembly (450A)



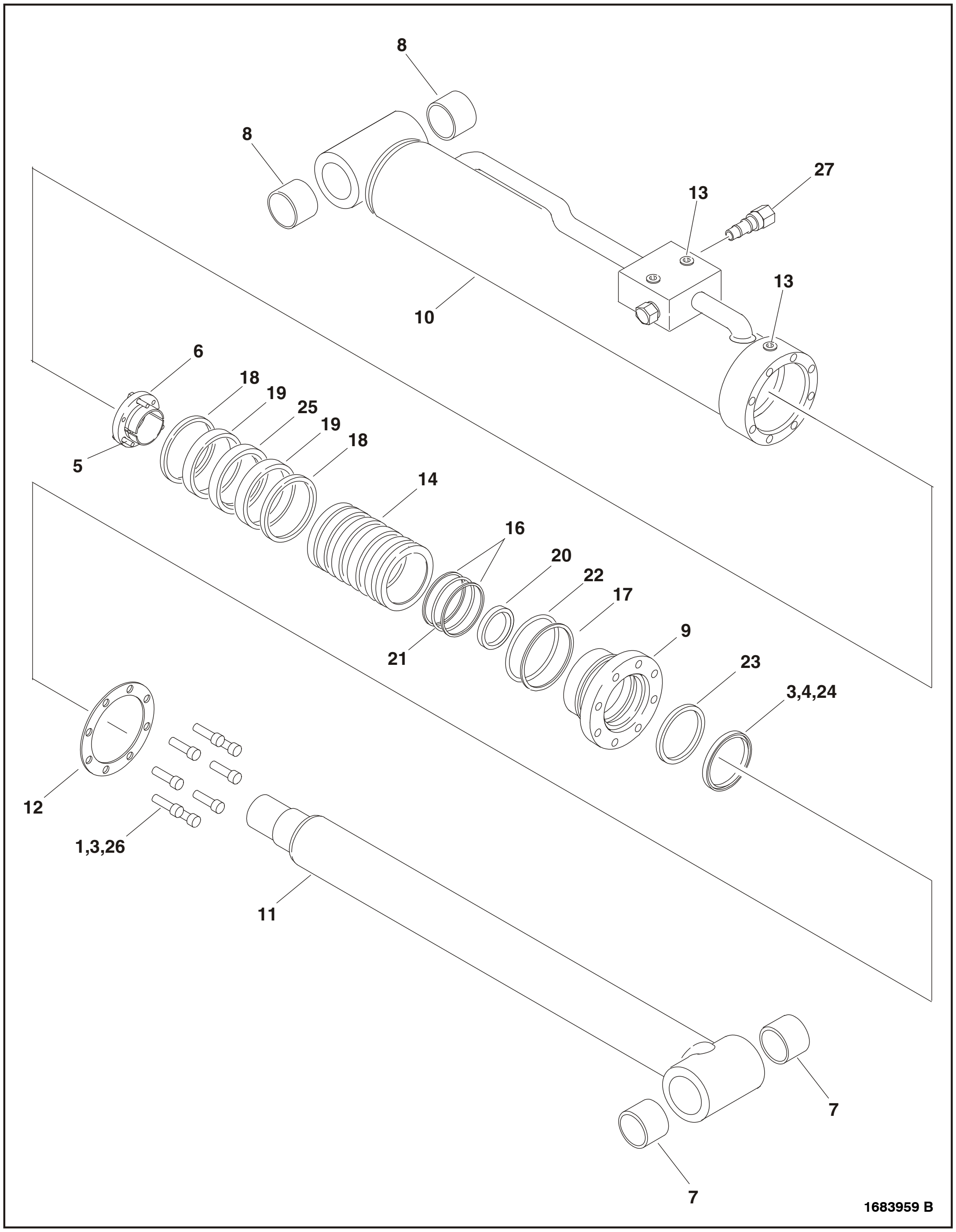
1. Loctite #242
2. Locking Primer #7471
3. Bolt
4. Tapered Bushing
5. Composite Bushing
6. Head
7. Rod
8. Barrel
9. Ring Washer
10. Piston
11. Not Used
12. Lock Ring
13. Wear Ring
14. Backup Ring
15. O-Ring
16. O-Ring
17. Wiper
18. Seal
19. Backup Ring
20. Seal
21. Valve Cartridge
22. Valve Cartridge
23. Bolt

Figure 5-7. Platform Level Cylinder (450AJ) - USA Built Machines



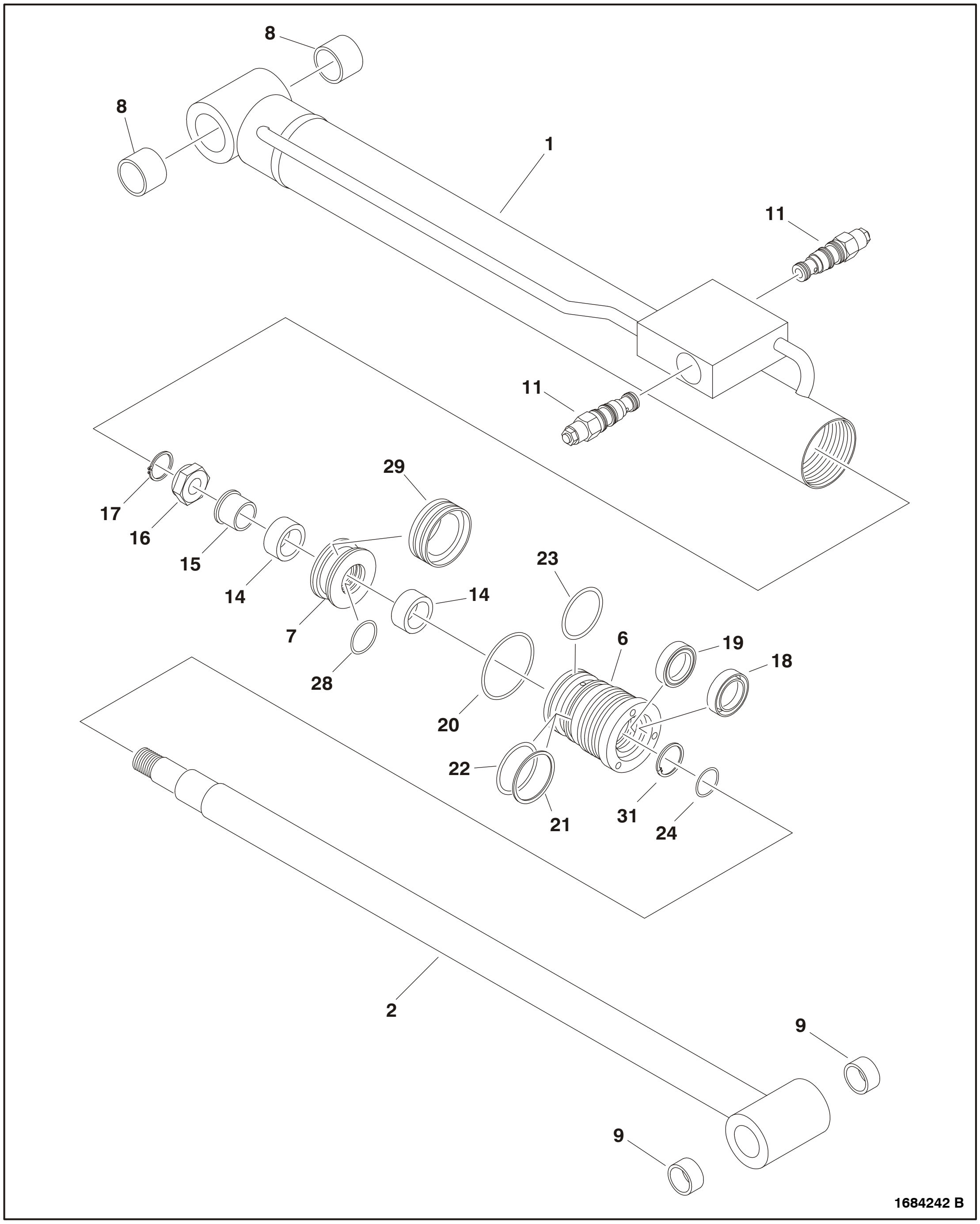
1. Barrel
2. Rod
3. Not Used
4. Piston
5. Head
6. Not Used
7. Not Used
8. Bearing
9. Seal
10. O-Ring
11. Not Used
12. O-Ring
13. Backup Ring
14. Seal
15. Wiper
16. Not Used
17. Valve Cartridge
18. Valve Cartridge
19. Not Used
20. O-Ring
21. Retaining Ring
22. O-Ring
23. Not Used
24. Not Used
25. Not Used
26. Not Used
27. Not Used
28. Not Used
29. Retaining Ring

Figure 5-8. Platform Level Cylinder (450AJ) - Belgium Built Machines



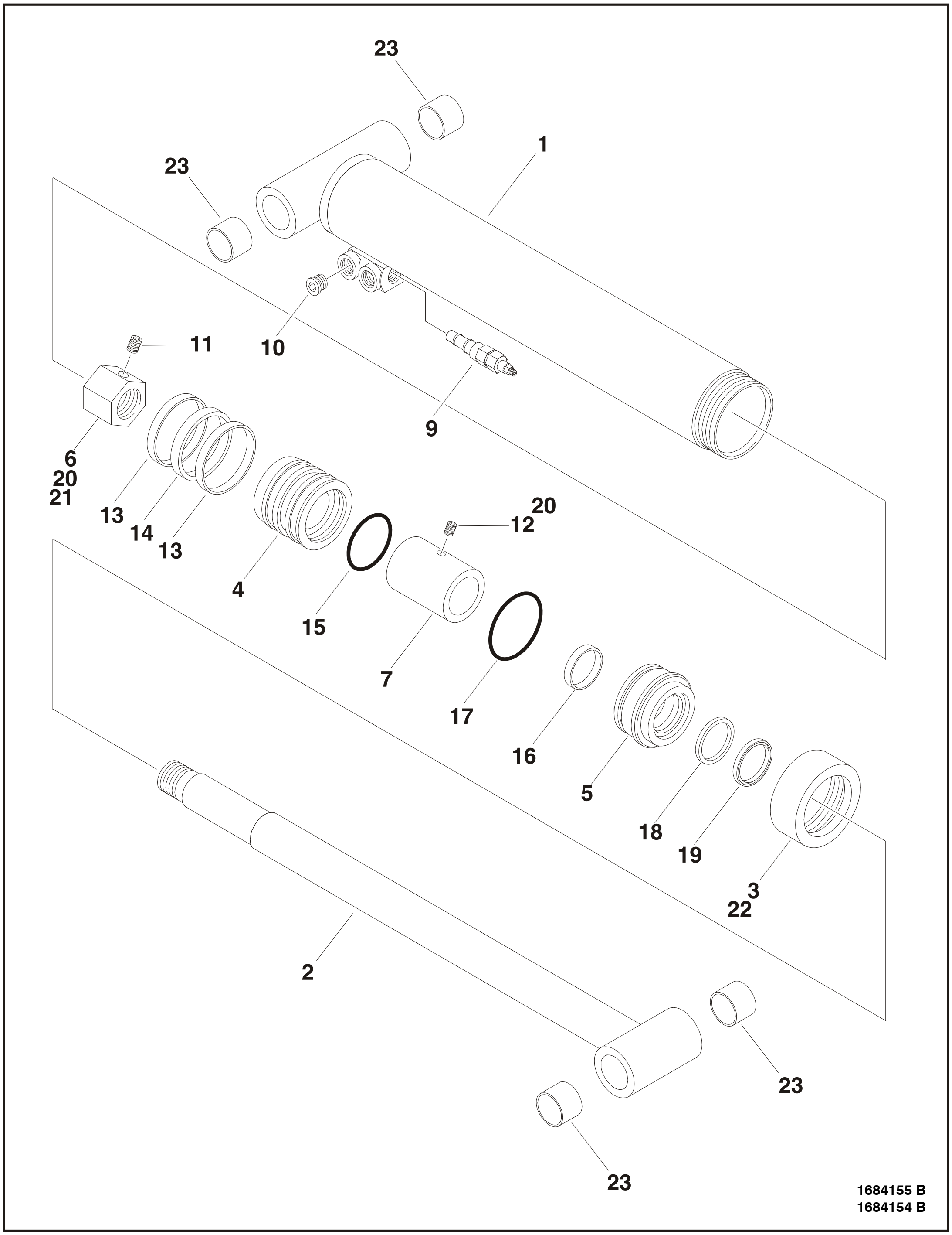
1. Loctite #242
2. Not Used
3. Locking Primer
4. Loctite RC609
5. Bolt
6. Tapered Bushing
7. Bushing
8. Bushing
9. Bushing
10. Barrel
11. Rod
12. Ring Washer
13. O-Ring Plug
14. Piston
15. Not Used
16. Backup Ring
17. Backup Ring
18. Seal
19. Wear Ring
20. Wear Ring
21. O-Ring
22. O-Ring
23. Seal
24. Wiper
25. T-Seal
26. Bolt
27. Valve Cartridge

Figure 5-9. Jib Cylinder - USA Built Machines



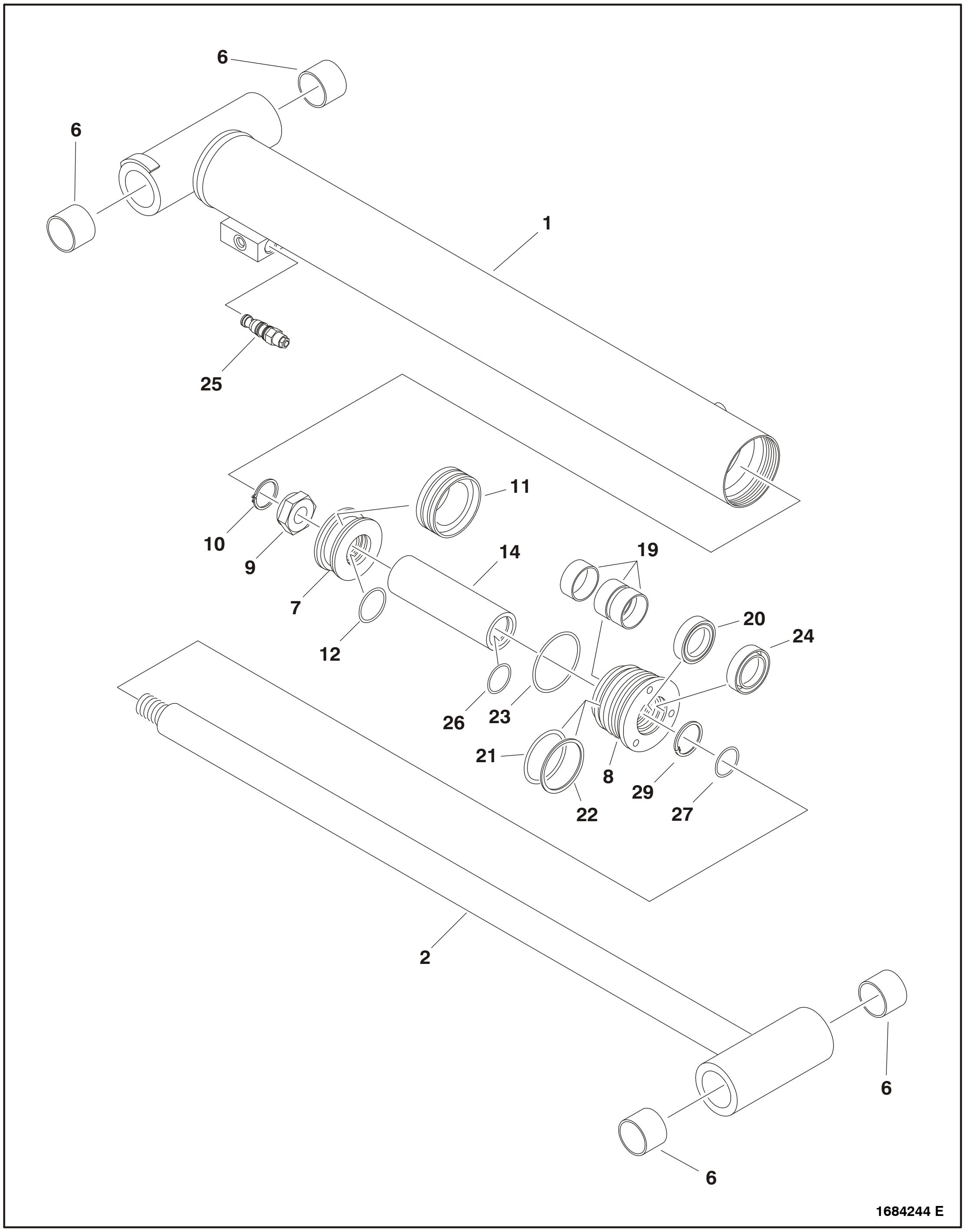
1. Barrel	7. Piston	12. Not Used	17. Retaining Ring	22. O-Ring	27. Not Used
2. Rod	8. Bearing	13. Not Used	18. Wiper	23. O-Ring	28. O-Ring
3. Not Used	9. Bearing	14. Bushing	19. Seal	24. O-Ring	29. Seal
4. Not Used	10. Not Used	15. Sleeve	20. O-Ring	25. Not Used	30. Not Used
5. Not Used	11. Valve Cartridge	16. Nut	21. Backup Ring	26. Not Used	31. Retaining Ring
6. Head					

Figure 5-10. Jib Cylinder - Belgium Built Machines



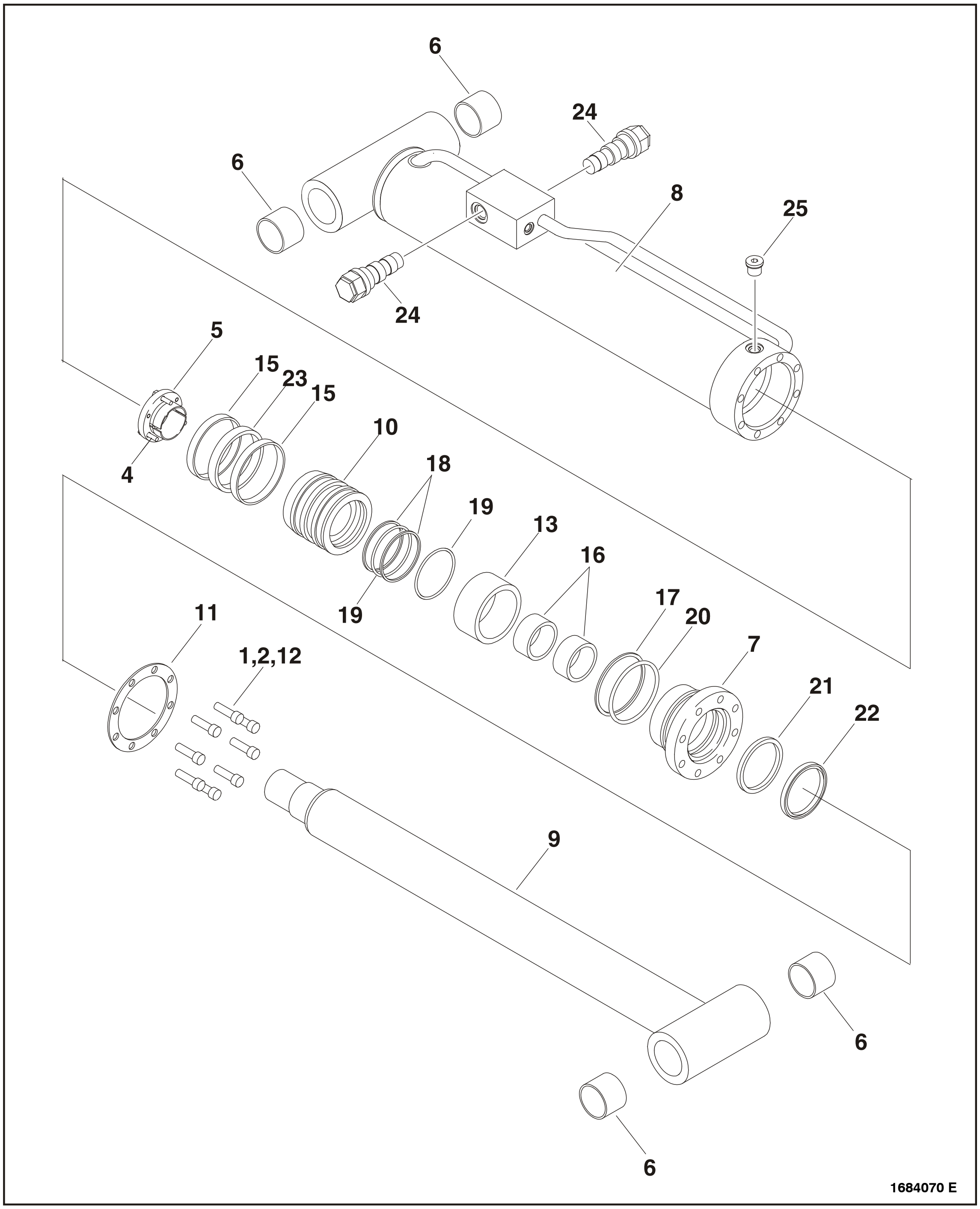
1. Barrel	6. Hex Nut	11. Setscrew	16. Wear Ring	21. Locking Primer
2. Rod	7. Tube Spacer	12. Setscrew	17. O-Ring	22. Loctite
3. End Cap	8. Not Used	13. Wear Ring	18. Seal	23. Bushing
4. Piston	9. Valve Cartridge	14. Seal	19. Wiper	
5. Head	10. O-Ring Plug	15. O-Ring	20. Loctite #242	

Figure 5-11. Main Lift Cylinder - USA Built Machines



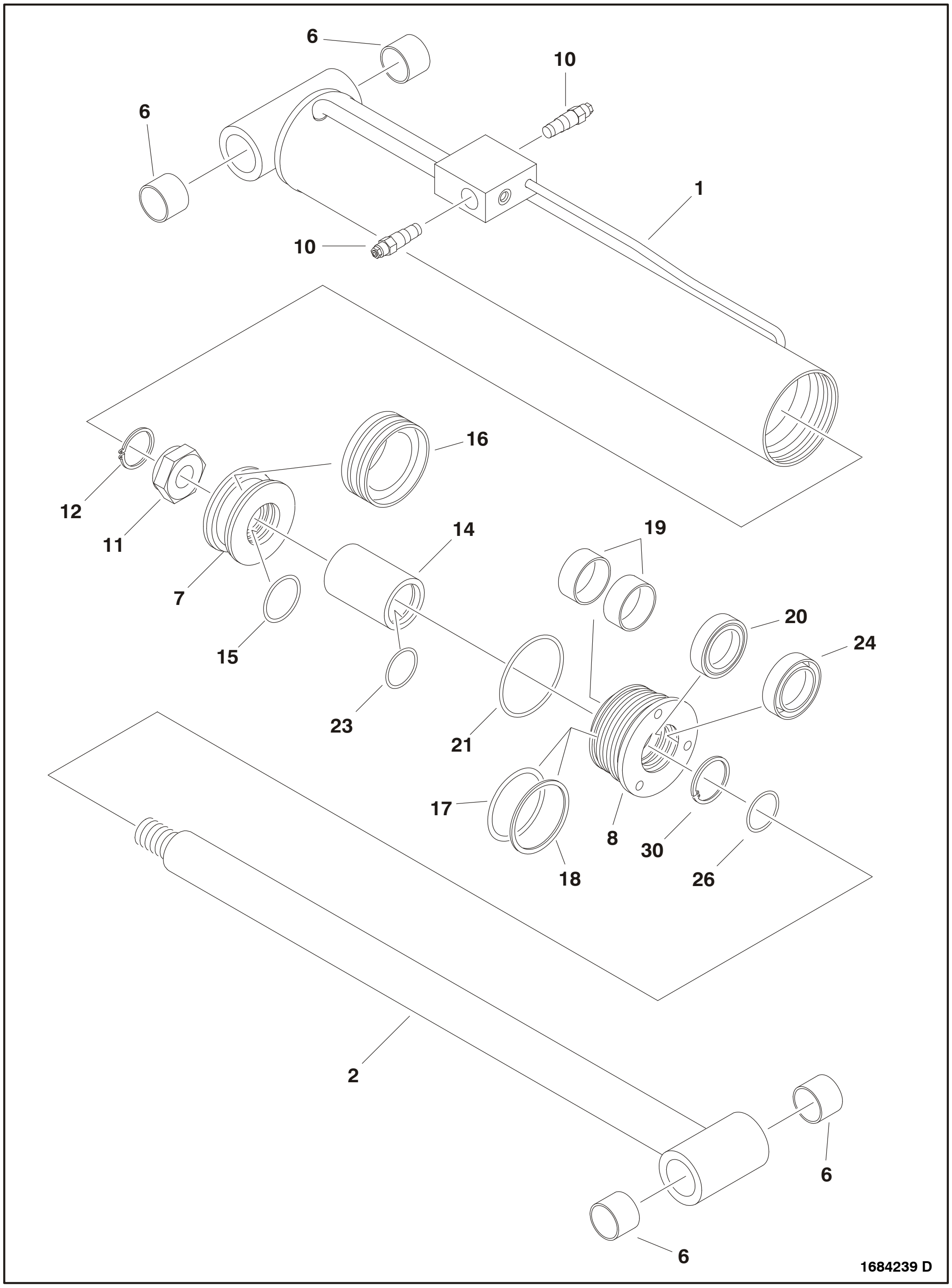
1. Barrel	6. Bearing	11. Seal	16. Not Used	21. O-Ring	26. O-Ring
2. Rod	7. Piston	12. O-Ring	17. Not Used	22. Backup Ring	27. O-Ring
3. Not Used	8. Head	13. Not Used	18. Not Used	23. O-Ring	28. Not Used
4. Not Used	9. Nut	14. Spacer	19. Wear Ring	24. Wiper	29. Retaining Ring
5. Not Used	10. Retaining Ring	15. Not Used	20. Seal	25. Valve Cartridge	

Figure 5-12. Main Lift Cylinder - Belgium Built Machines



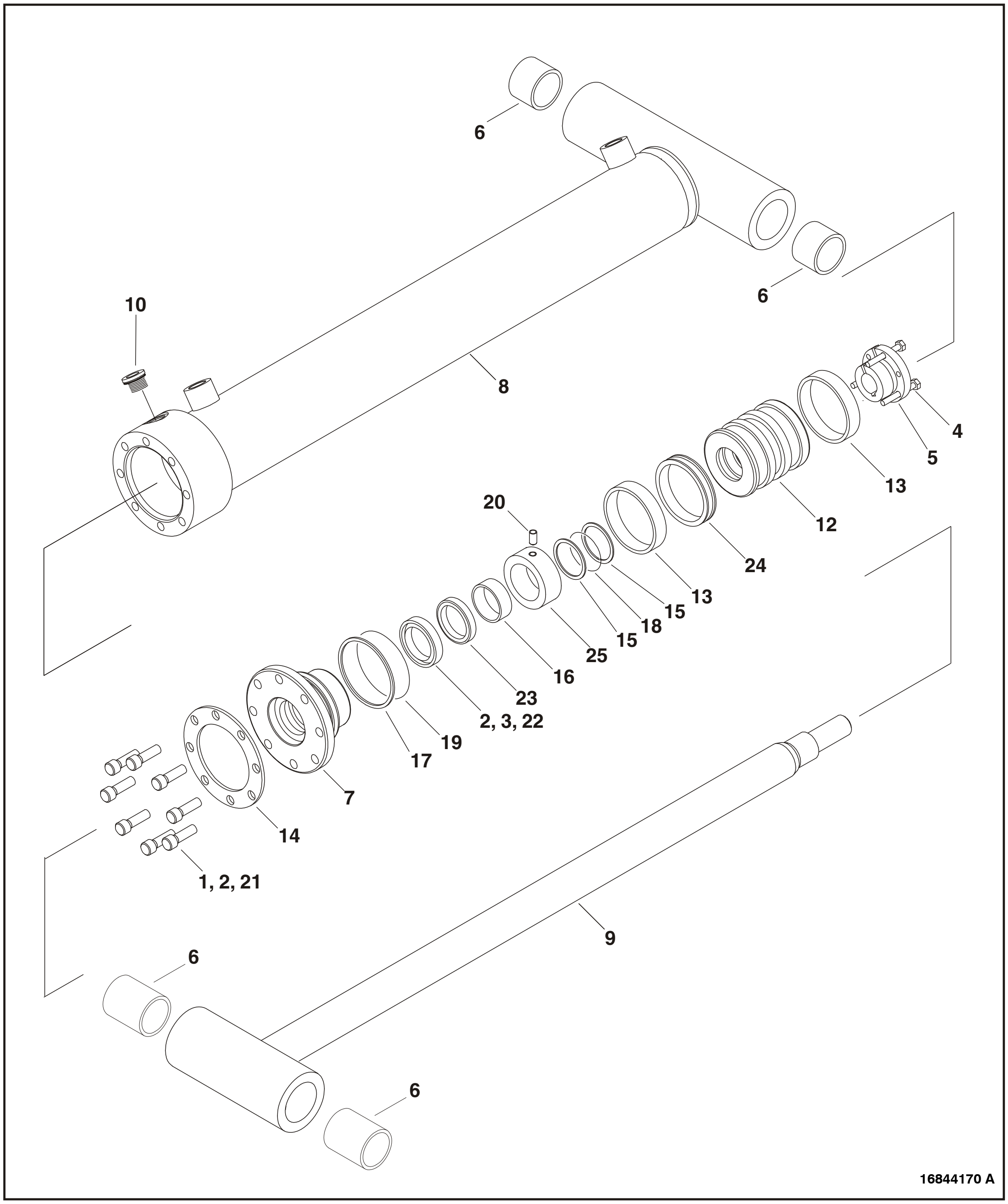
1. Loctite #242	6. Bushing	11. Ring Washer	16. Wear Ring	21. Seal
2. Locking Primer	7. Head	12. Bolt	17. Backup Ring	22. Wiper
3. Loctite RC609	8. Barrel	13. Tube Spacer	18. Backup Ring	23. T-Seal
4. Bolt	9. Rod	14. Not Used	19. O-Ring	24. Valve Cartridge
5. Tapered Bushing	10. Piston	15. Wear Ring	20. O-Ring	25. O-Ring Plug

Figure 5-13. Tower Lift Cylinder - USA Built Machines



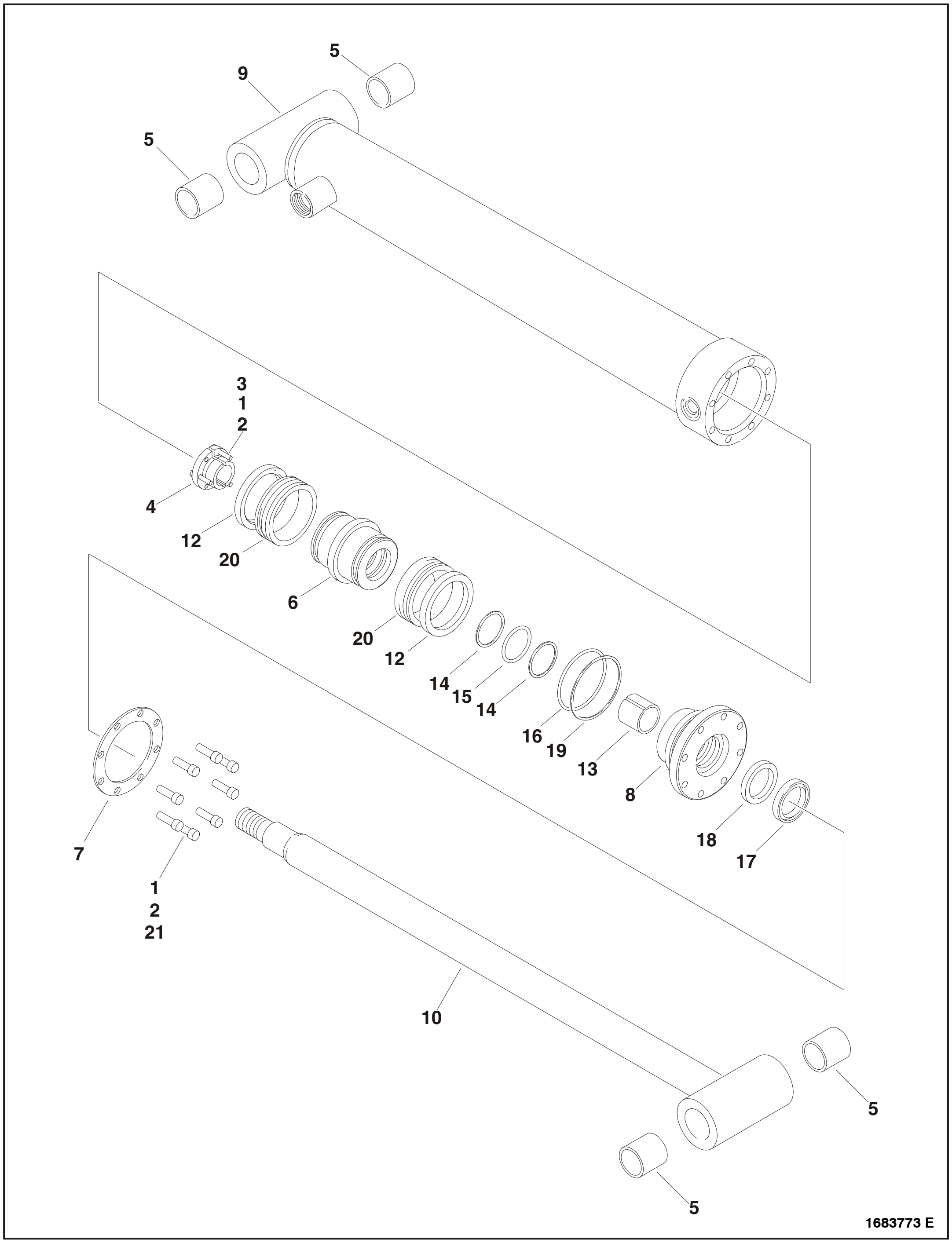
1. Barrel	6. Bearing	11. Nut	16. Seal	21. O-Ring	26. O-Ring
2. Rod	7. Piston	12. Retaining Ring	17. O-Ring	22. Not Used	27. Not Used
3. Not Used	8. Head	13. Not Used	18. Backup Ring	23. O-Ring	28. Not Used
4. Not Used	9. Not Used	14. Spacer	19. Wear Ring	24. Wiper	29. Not Used
5. Not Used	10. Valve Cartridge	15. O-Ring	20. Seal	25. Not Used	30. Retaining Ring

Figure 5-14. Tower Lift Cylinder - Belgium Built Machines



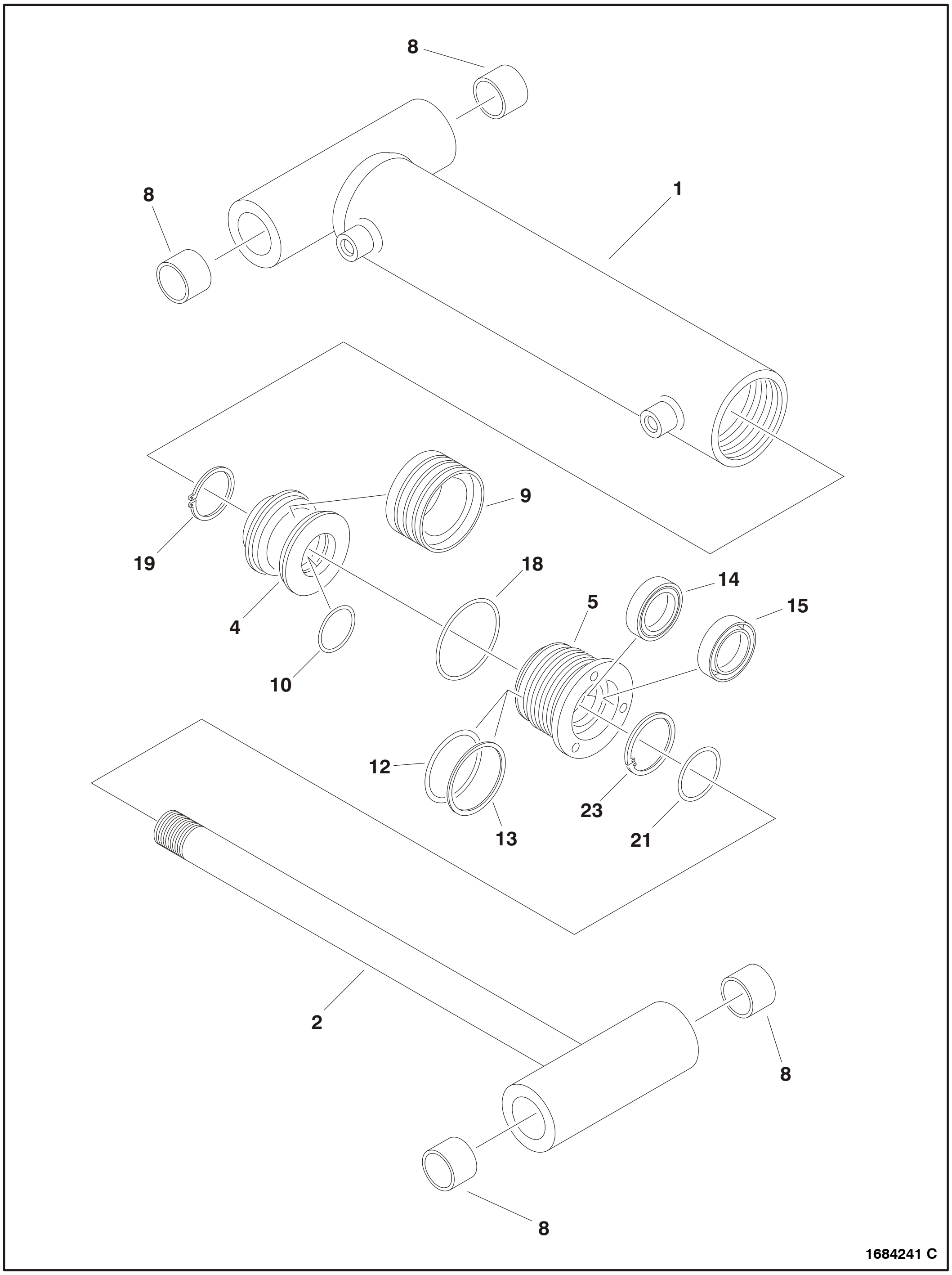
1. Loctite #242	6. Composite Bushing	11. Not Used	16. Wear Ring	21. Bolt
2. Locking Primer	7. Head	12. Piston	17. Backup Ring	22. Wiper
3. Loctite RC609	8. Barrel	13. Wear Ring	18. O-Ring	23. Seal
4. Capscrew	9. Rod	14. Washer Ring	19. O-Ring	24. T-Seal
5. Tapered Bushing	10. O-Ring Plug	15. Backup Ring	20. Setscrew	25. Spacer Tube

Figure 5-15. Master Cylinder (450A)



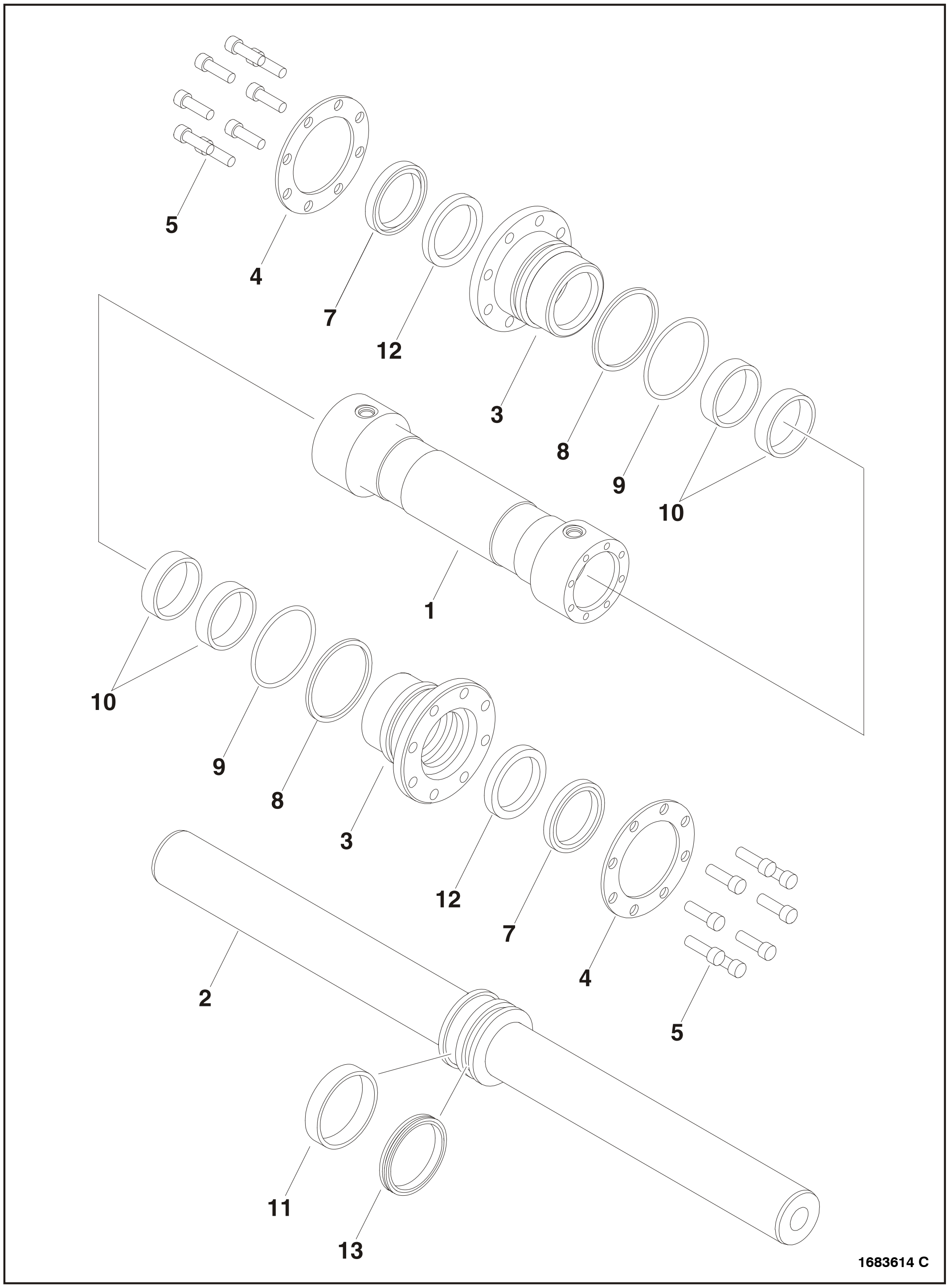
1. Loctite #242
2. Locking Primer
3. Bolt
4. Tapered Bushing
5. Composite Bushing
6. Piston
7. Ring Washer
8. Head
9. Barrel
10. Rod
11. Not Used
12. Lock Ring
13. Wear Ring
14. Backup Ring
15. O-Ring
16. O-Ring
17. Wiper
18. Seal
19. Backup Ring
20. Seal
21. Bolt

Figure 5-16. Master Cylinder (450AJ) - USA Built Machines



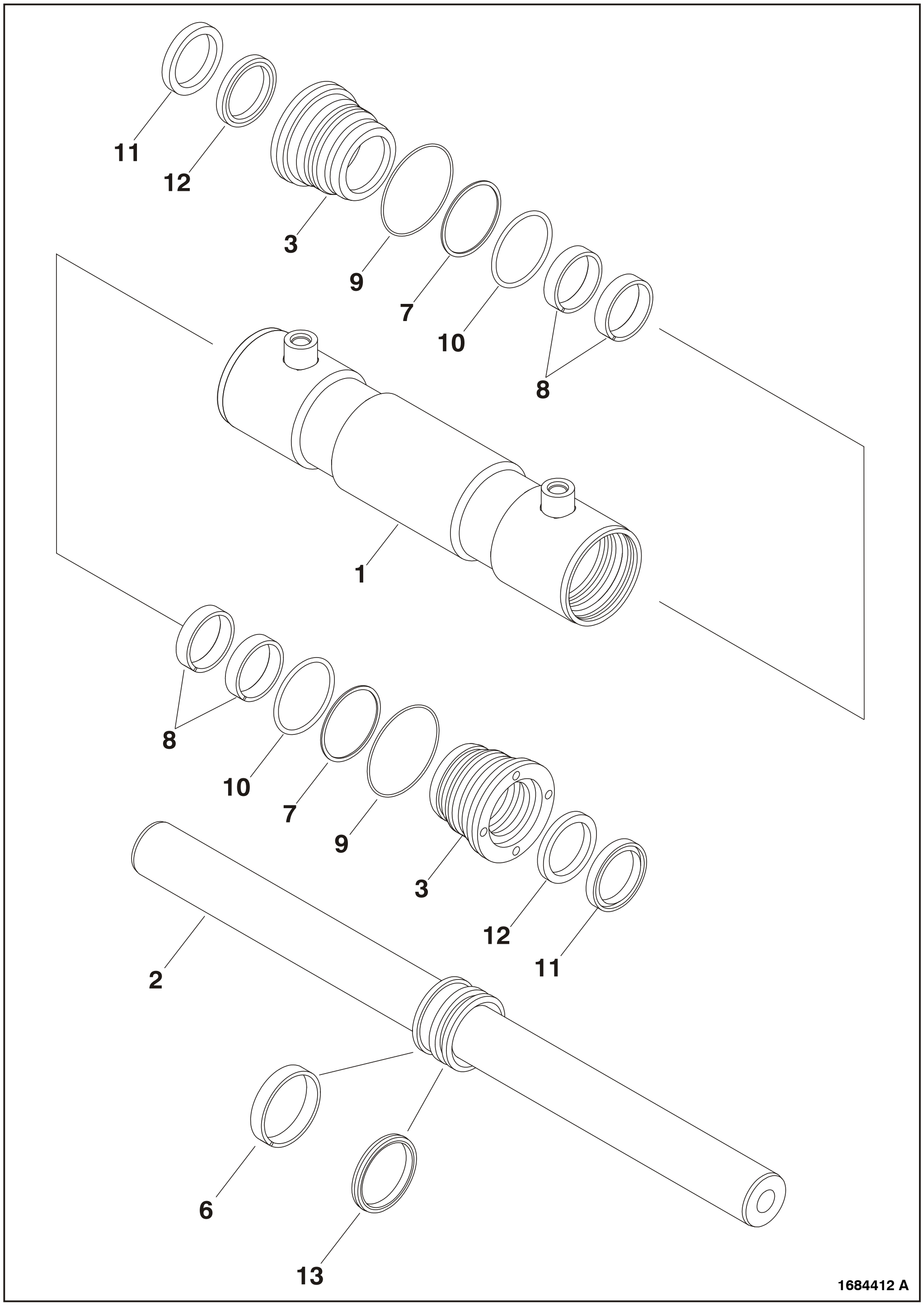
1. Barrel	6. Not Used	11. Not Used	16. Not Used	21. O-Ring
2. Rod	7. Not Used	12. O-Ring	17. Not Used	22. Not Used
3. Not Used	8. Bearing	13. Backup Ring	18. O-Ring	23. Retaining Ring
4. Piston	9. Seal	14. Seal	19. Retaining Ring	
5. Head	10. O-Ring	15. Wiper	20. Not Used	

Figure 5-17. Master Cylinder(450AJ) - Belgium Built Machines



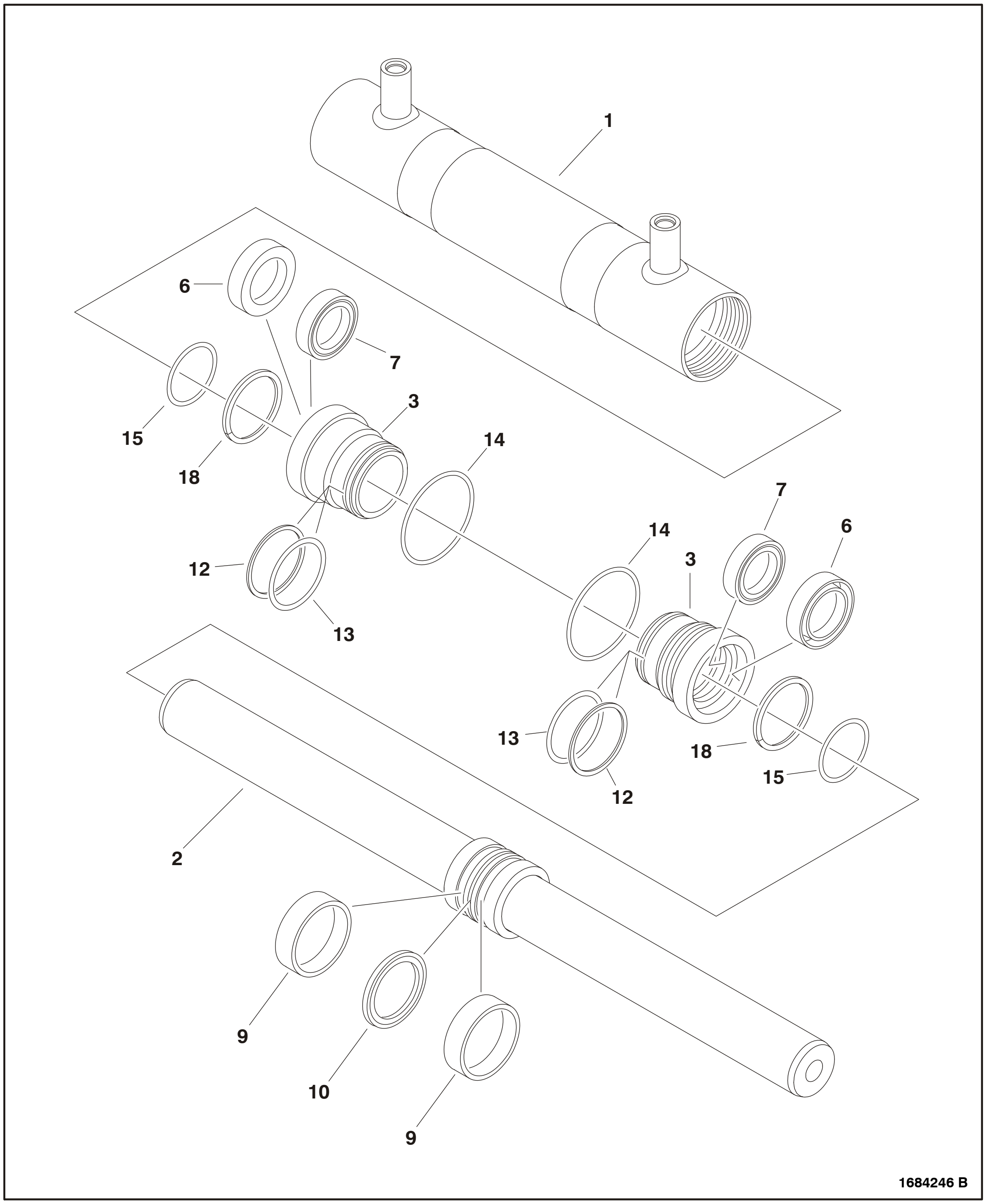
1. Barrel	5. Bolt	9. O-Ring	13. T-Seal
2. Rod	6. Not Used	10. Wear Ring	14. Loctite #242 (Not Shown)
3. Cap	7. Wiper	11. Wear Ring	15. Locking Primer (Not Shown)
4. Ring Washer	8. Backup Ring	12. Seal	

Figure 5-18. Steer Cylinder - USA Machines Prior to S/N 87393



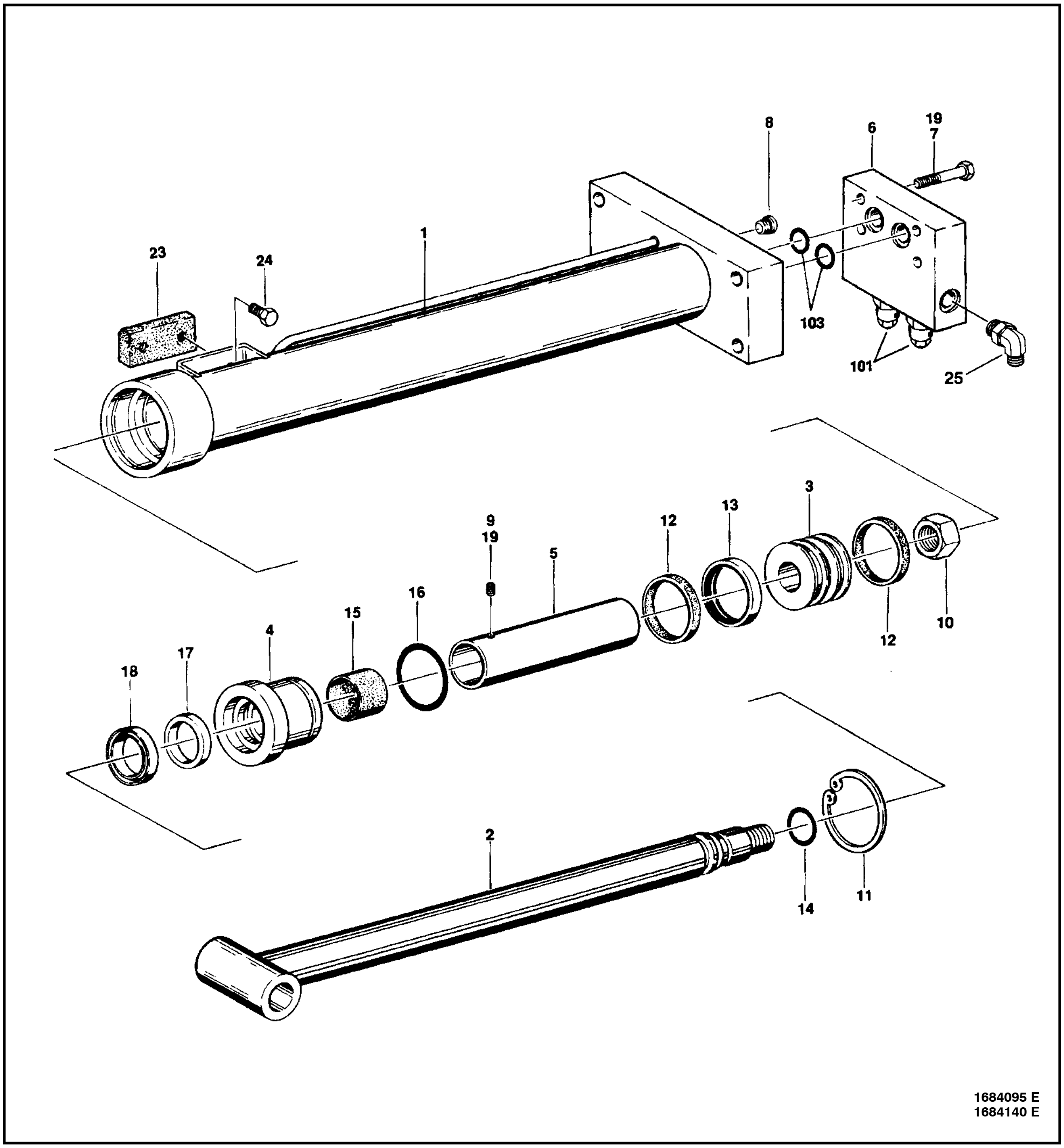
1. Barrel	5. Not Used	9. O-Ring	13. T-Seal
2. Rod	6. Wear Ring	10. O-Ring	
3. Cylinder Head	7. Backup Ring	11. Wiper	
4. Anti-Seize	8. Wear Ring	12. Seal	

Figure 5-19. Steer Cylinder Assembly - USA Machines S/N 87393 to Present



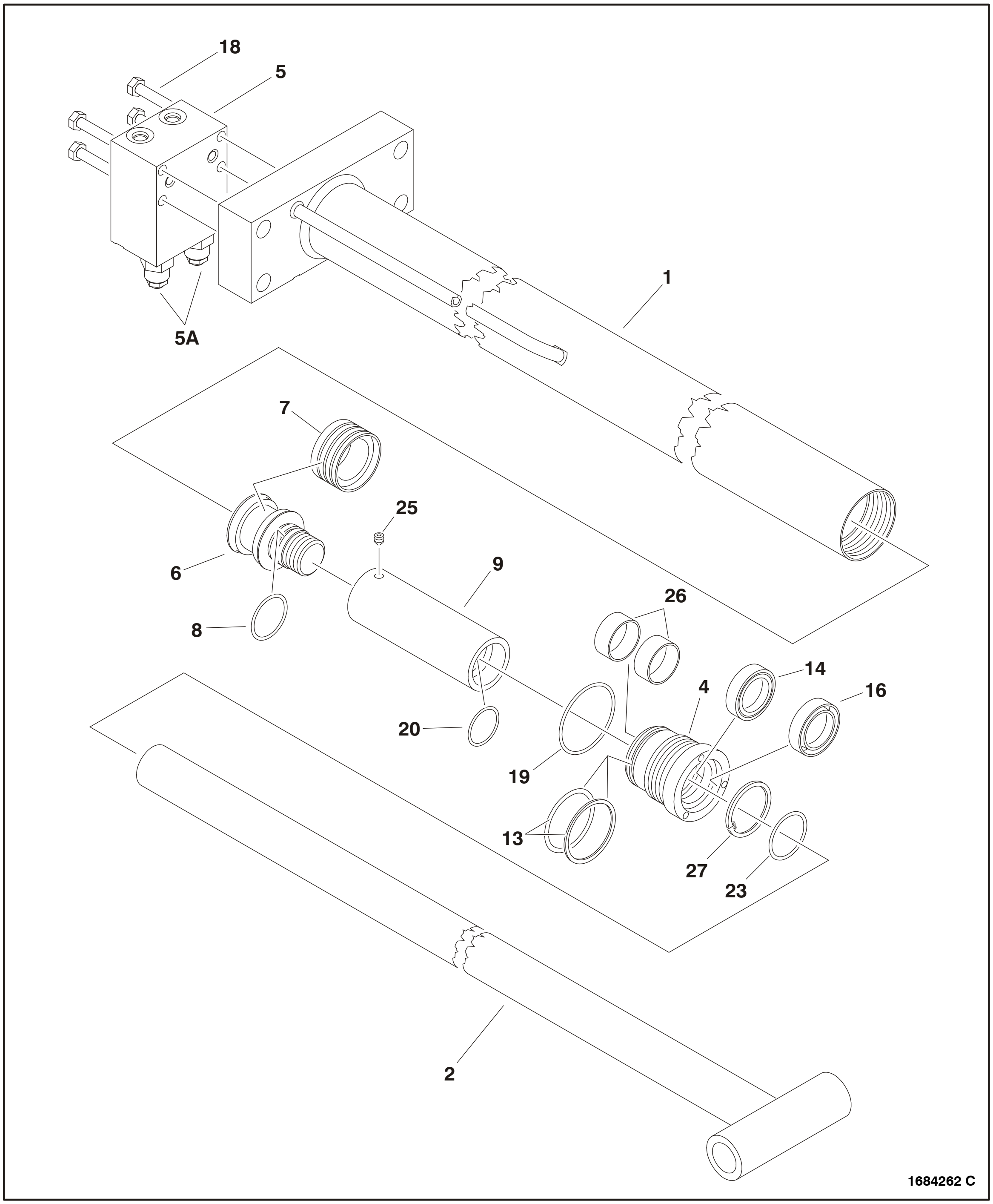
1. Barrel	7. Seal	13. O-Ring
2. Rod	8. Not Used	14. O-Ring
3. Head	9. Wear Ring	15. O-Ring
4. Not Used	10. Seal	16. Not used
5. Not Used	11. Not Used	17. Not Used
6. Wiper	12. Backup Ring	18. Retaining Ring

Figure 5-20. Steer Cylinder - Belgium Built Machines



1. Barrel	6. Valve	11. Retaining Ring	16. O-Ring	21. Not Used
2. Rod	7. Bolt	12. Wear Ring	17. Rod Seal	22. Not Used
3. Piston	8. O-Ring Plug	13. Cap Seal	18. Wiper	23. Wear Pad
4. Head	9. Setscrew	14. O-Ring	19. Loctite #242	24. Bolt
5. Tube Spacer	10. Locknut	15. Wear Ring	20. Not Used	25. Adapter

Figure 5-21. Telescope Cylinder - USA Built Machines



1. Barrel	6. Piston	11. Not Used	16. Wiper	21. Not Used	26. Wear Ring
2. Rod	7. Seal	12. Not Used	17. Not Used	22. Not Used	27. Retaining Ring
3. Not Used	8. O-Ring	13. O-Ring	18. Bolt	23. O-Ring	
4. Head	9. Spacer	14. Seal	19. O-Ring	24. Not Used	
5. Valve Block	10. Not Used	15. Not Used	20. O-Ring	25. Setscrew	

Figure 5-22. Telescope Cylinder - Belgium Built Machines

NOTICE

USE EXTREME CARE WHEN REMOVING CYLINDER ROD, HEAD, AND PISTON. PULLING ROD OFF-CENTER CAN DAMAGE PISTON AND CYLINDER BARREL SURFACES.

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

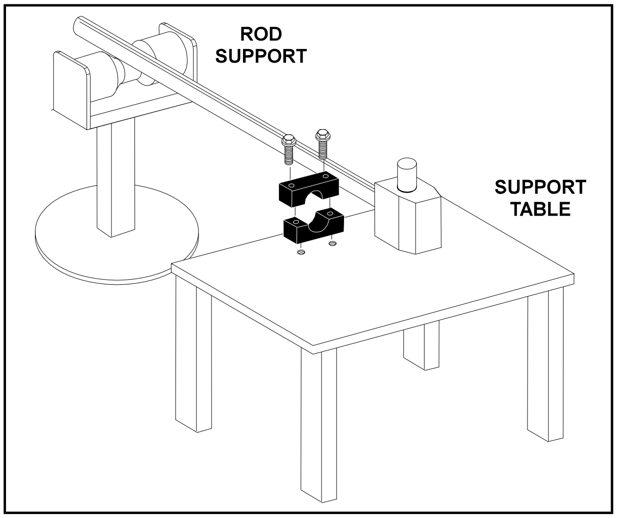


Figure 5-23. Cylinder Rod Support

10. 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.

11. Loosen and remove nut which attaches piston to rod, and remove piston.
12. Loosen and remove cap screw(s), if applicable, which attach tapered bushing to piston.
13. Insert cap screw(s) in threaded holes in outer piece of tapered bushing. Progressively tighten cap screw(s) until bushing is loose on piston.
14. Remove bushing from piston.

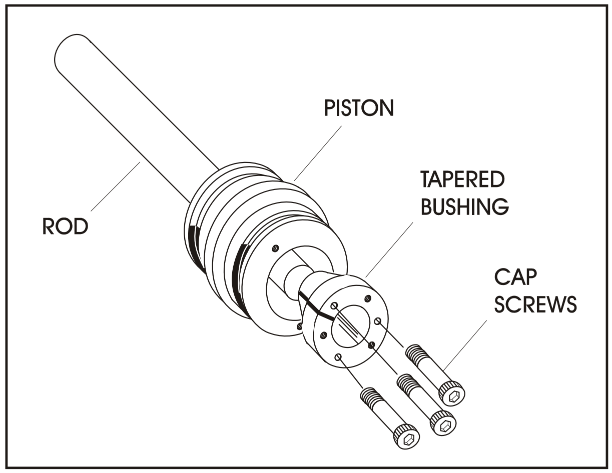


Figure 5-24. Tapered Bushing Removal

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

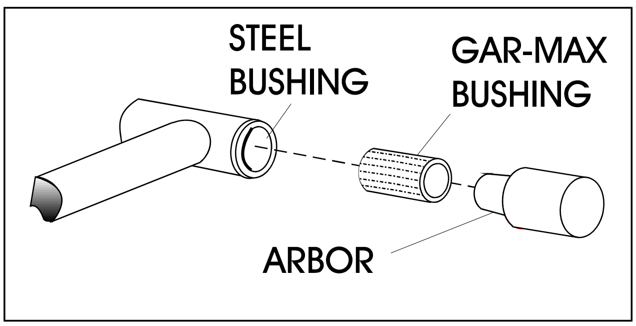


Figure 5-25. Gar-Max Bearing Installation

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: Use proper cylinder seal kit for cylinder assembly. See your JLG Parts Manual.

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

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

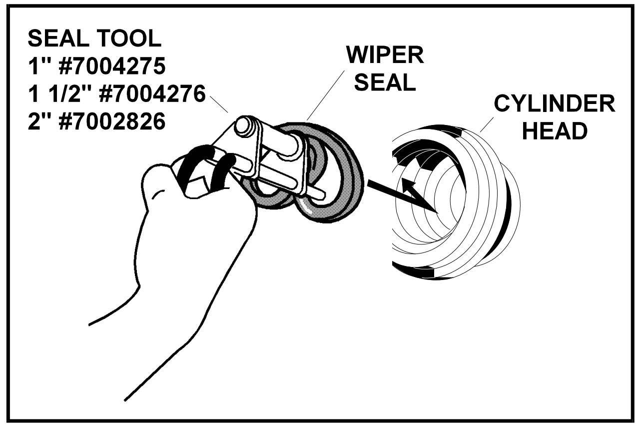


Figure 5-26. Rod Seal Installation

NOTICE

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

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

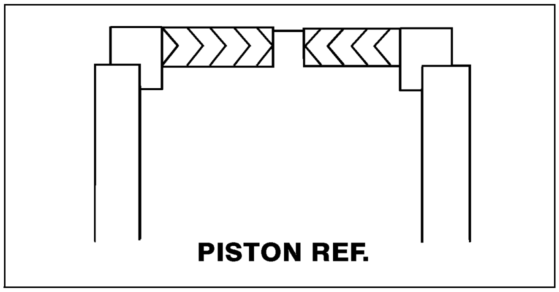


Figure 5-27. Poly-Pak Piston Seal Installation

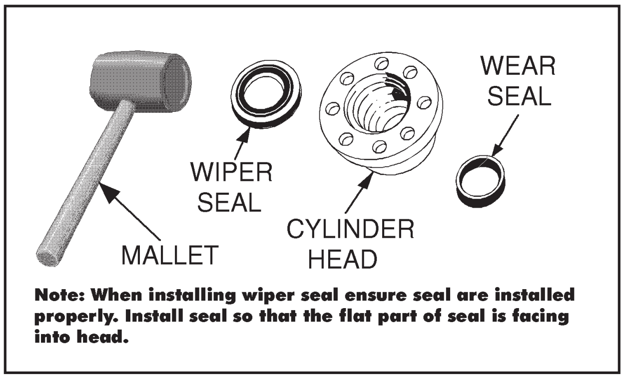


Figure 5-28. Wiper Seal Installation

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

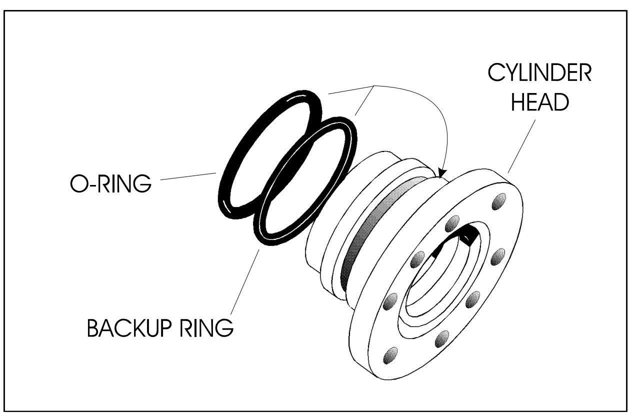


Figure 5-29. Installation of Head Seal Kit

4. Install washer ring onto rod, carefully install head gland on rod, ensuring wiper and rod seals are not damaged or dislodged. Push head along rod to rod end, as applicable.
5. Carefully slide piston spacer on rod.

NOTE: Upper telescope cylinder piston has an O-ring installed inside spacer.

6. If applicable, correctly place a new O-ring and backup rings in the inner piston diameter groove.

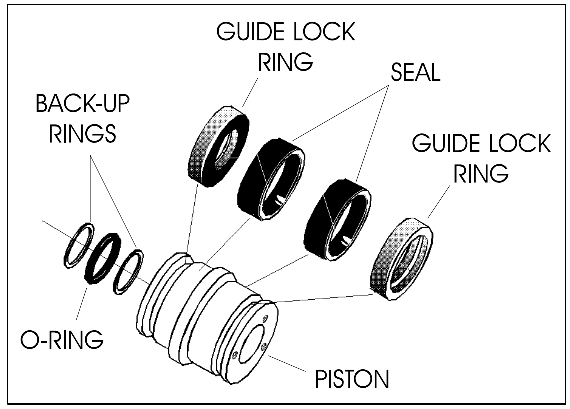


Figure 5-30. Piston Seal Kit Installation

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

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

⚠ WARNING

WHEN REBUILDING THE MASTER, SLAVE, LIFT, OR TELESCOPE CYLINDERS, APPLY LOCTITE #242 TO TAPERED BUSHING BOLTS, THEN TIGHTEN SECURELY. (SEE TABLE 2-1 AND 2-3. TORQUE SPECIFICATIONS).

10. Install bolts in tapered bushing using loctite #242. (See Table 2-1 and 2-3. Torque Specifications.)

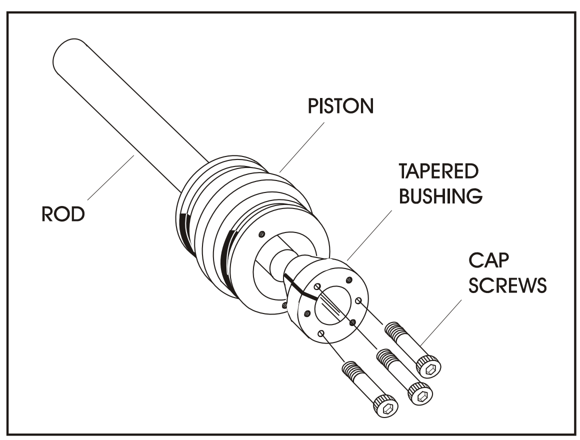


Figure 5-31. Tapered Bushing Installation

11. Remove cylinder rod from holding fixture.
12. Place new guide locks and seals in applicable outside diameter grooves of cylinder piston. (See Figure 2-28. Piston Seal Kit Installation.)
13. Position cylinder barrel in a suitable holding fixture.

NOTICE

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

14. With barrel clamped securely, and while adequately supporting rod, insert piston end into barrel cylinder. Ensure piston loading O-ring and seal ring are not damaged or dislodged.
15. Continue pushing rod into barrel until cylinder head gland can be inserted into barrel cylinder.
16. Secure cylinder head gland using washer ring and socket head bolts. (See Table 2-1 and 2-3. Torque Specifications.)

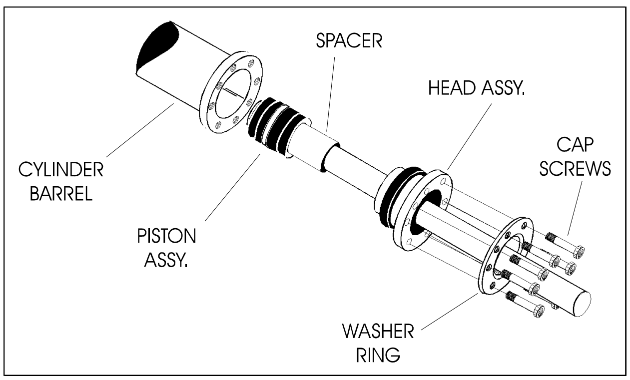


Figure 5-32. Rod Assembly Installation

17. After cylinder has been reassembled, rod should be pushed all the way in (fully retracted) before reinstallation of any holding valve or valves.
18. If applicable, install cartridge-type holding valve and fittings in rod port block. Use new O-rings as applicable. (See Table 2-2. Holding Valve Torque Specifications).

Table 5-1. Cylinder Head and Tapered Bushing Torque Specifications

Description	Head Torque Value (Wet)	Tapered Bushing Torque Value (Wet)
Lift Cylinder	120 ft. lbs. (163 Nm)	9 ft. lbs. (12 Nm)

Table 5-1. Cylinder Head and Tapered Bushing Torque Specifications

Description	Head Torque Value (Wet)	Tapered Bushing Torque Value (Wet)
Slave Cylinder	30 ft. lbs. (41 Nm)	5 ft. lbs. (9 Nm)
Master Cylinder	30 ft. lbs. (41 Nm)	5 ft. lbs. (9 Nm)
Jib Cylinder	30 ft. lbs. (41 Nm)	5 ft. lbs. (9 Nm)
Lockout Cylinder	80 ft. lbs. (109 Nm)	N/A
Steer Cylinder Piston Nut Torque Specifications		
Steer Cylinder	LBS.	NM
	150 ft. lbs	204 Nm

Table 5-2. Holding Valve Torque Specifications

Description	Torque Value
SUN - 7/8 HEX M20 X 1.5 THDS.	30-35 ft. lbs. (41-48 Nm)
SUN - 1 1/8 HEX 1 -14 UNS THDS.	45-50 ft. lbs. (61-68 Nm)
SUN - 1 1/4 HEX M36 X 2 THDS.	150-160 ft. lbs. (204-217 Nm)
RACINE - 1 1/8 HEX 1 1/16 - 12 THDS.	50-55 ft. lbs. (68-75 Nm)
RACINE - 1 3/8 HEX 1 3/16 - 12 THDS.	75-80 ft. lbs. (102-109 Nm)
RACINE - 1 7/8 HEX 1 5/8 - 12 THDS.	100-110 ft. lbs. (136-149 Nm)

NOTICE

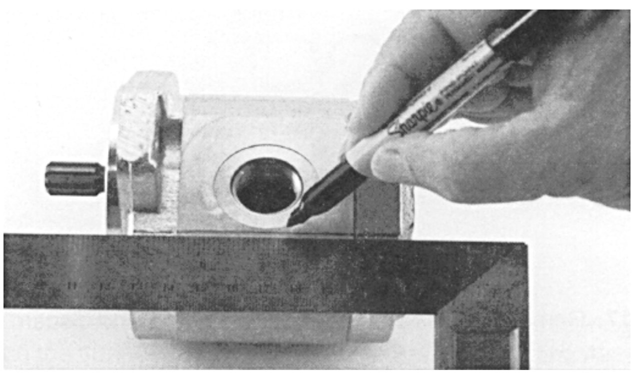
IF CYLINDER IS TEST PRIOR TO INSTALLATION ON MACHINE, USE EXTREME CARE TO INSURE OUTER END OF ROD IS SUPPORTED. USE A TRAVELING OVERHEAD HOIST, FORK-LIFT, OR OTHER MEANS TO SUPPORT OVERHANGING WEIGHT OF EXTENDING ROD.

5.2 HYDRAULIC PUMP (GEAR)

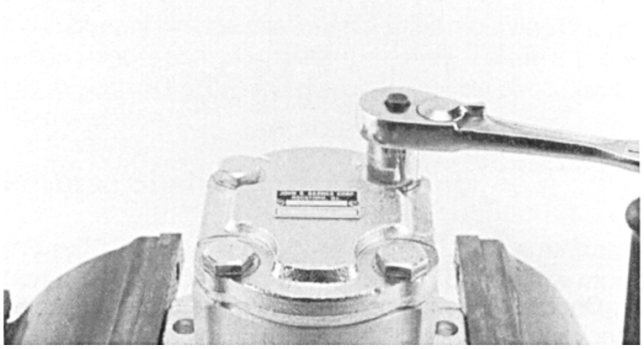
Disassembly

NOTE: The following general instructions also apply to multiple section gear pumps. The only extra parts are the coupling between drive shafts and center distance plate which divides the two pump sections. This repair procedure also applies to "W" series Gear Motors.

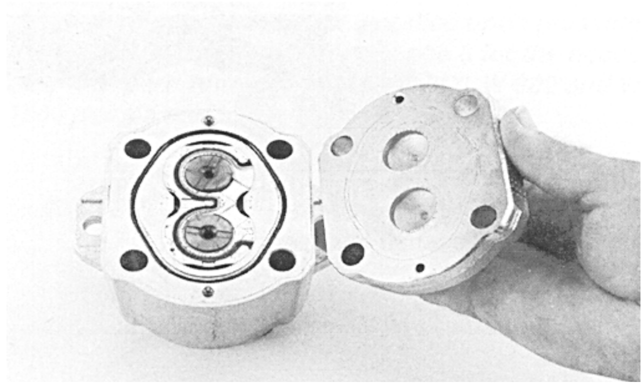
1. It is very important to work in a clean work area when repairing hydraulic products. Plug ports and wash exterior of pump with a proper cleaning solvent before continuing.
2. Remove port plugs and drain oil from pump.



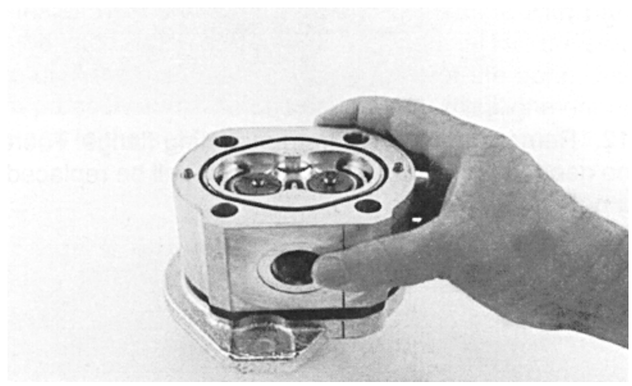
3. Use a permanent marker pen to mark a line across mounting flange, gear housing and end cover. This will assure proper reassembly and rotation of pump.
4. Remove key from drive shaft if applicable.



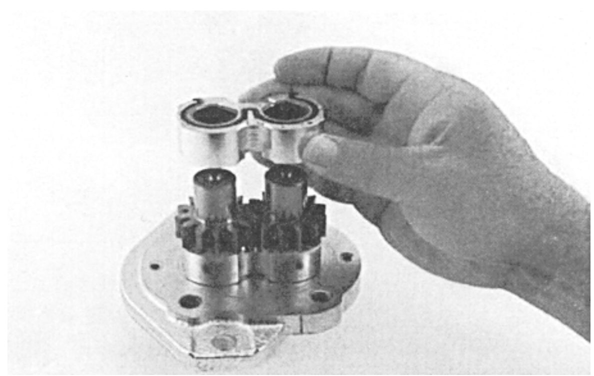
5. Clamp mounting flange in a protected jaw vise with pump shaft facing down.
6. Loosen four metric hex head bolts.
7. Remove pump from vise and place on clean work bench, remove the four hex head bolts and spacers if applicable.



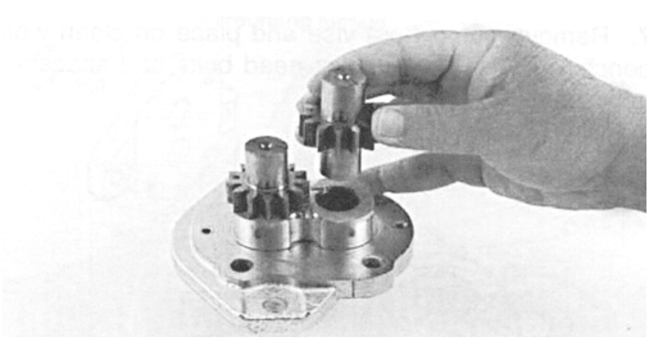
8. Lift and remove end cover.



9. Carefully remove gear housing and place on work bench. Make sure rear bearing block remains on drive and idler shafts.

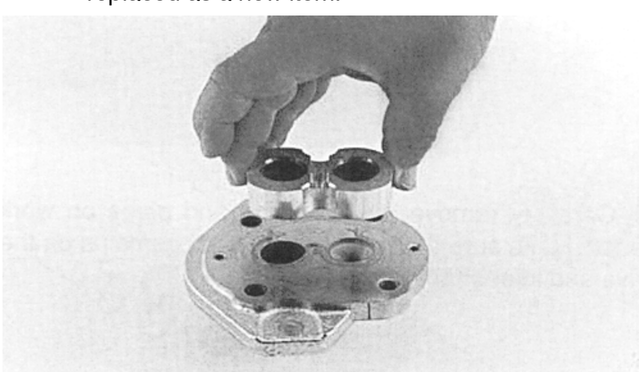


10. Remove rear bearing block from drive and idler shafts.

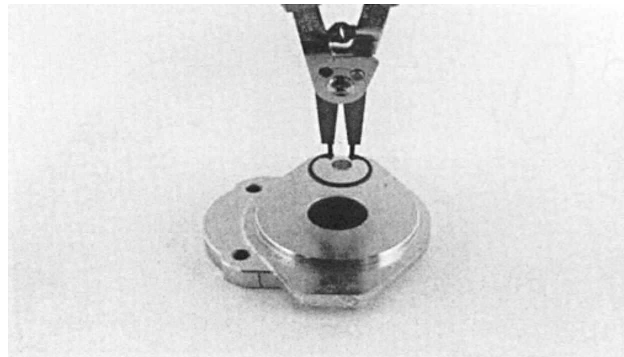


11. Remove idler shaft from bearing block.

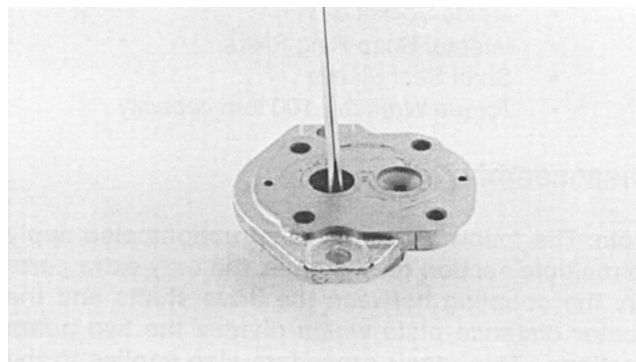
12. Remove drive shaft from mounting flange. There is no need to protect the shaft seal as it will be replaced as a new item.



13. Remove front bearing block.

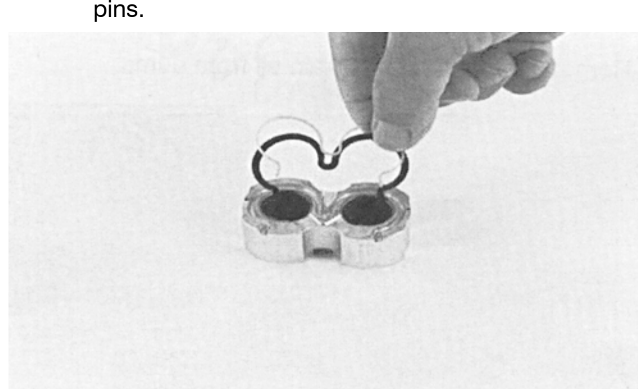


14. Turn mounting flange over, with shaft seal up, and remove retaining ring with proper snap ring pliers.



15. Remove oil seal from mounting flange, be careful not to mar or scratch seal bore.

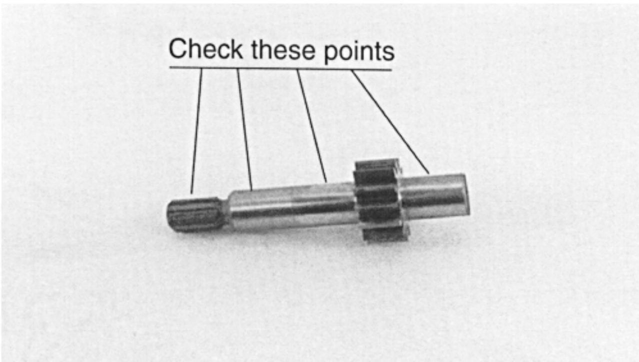
16. Remove dowel pins from gear housing. Do not lose pins.



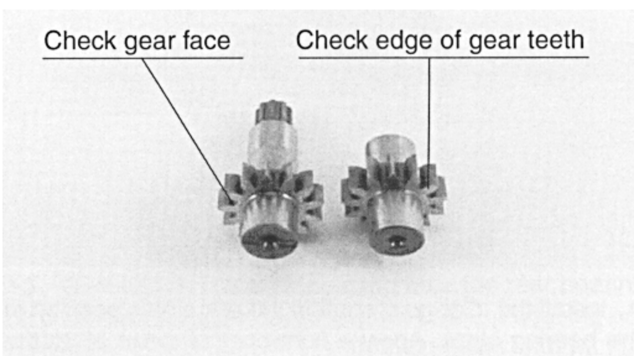
17. Remove seals from both bearing blocks and discard.

Inspect Parts For Wear

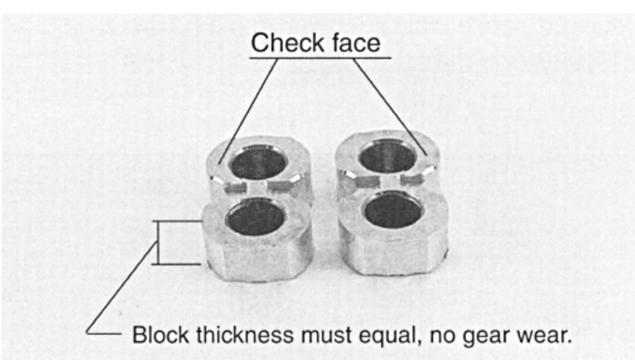
1. Clean and dry all parts thoroughly before inspection. It is not necessary to inspect seals. They will be placed as new items.



2. Check drive shaft spine for twisted or broken teeth, check keyed drive shaft for broken or chipped keyway. No marks or grooves on shaft in seal area, some discoloration of shaft is allowable.
3. Inspect drive gear shaft and idler gear shafts at bearing points and seal area for rough surfaces and excessive wear.



4. Inspect gear face for scoring or excessive wear. If face edge of gear teeth are sharp, they will mill into the bearing blocks. If wear has occurred, parts are unusable.



5. Inspect bearing blocks for excessive wear or scoring on surfaces in contact with gears. Inspect bearings for excessive wear or scoring.
6. Inspect area inside gear housing. A clean ”wipe” on the inside surface of the intake side is normal. There should not be excessive wear, deep scratches, or gouges.

General Information

NOTICE

FAILURE TO PROPERLY ASSEMBLE THIS PUMP WILL RESULT WITH LITTLE OR NO FLOW AT RATED PRESSURE. RELATIONSHIP OF MOUNTING FLANGE, BEARING BLOCKS, AND GEAR HOUSING MUST BE CORRECT.

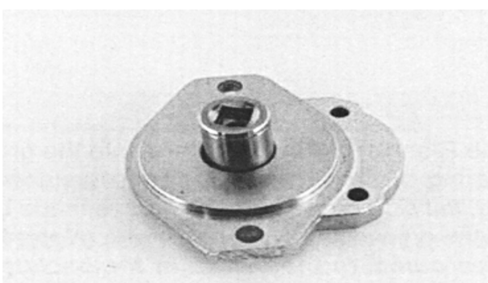
Reverse Shaft Rotation of Pump

NOTE: *Pump is not bi-rotational. Use the following procedure if shaft rotation direction is changed.*

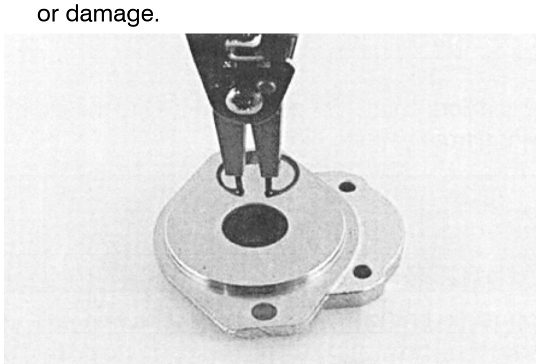
Reverse shaft rotation of the ”W” series gear pump by rotating, as a group, two bearing blocks and gear housing 180° in relationship to remaining parts of pump. This places pressure port on opposite side of pump from its original position.

Assembly

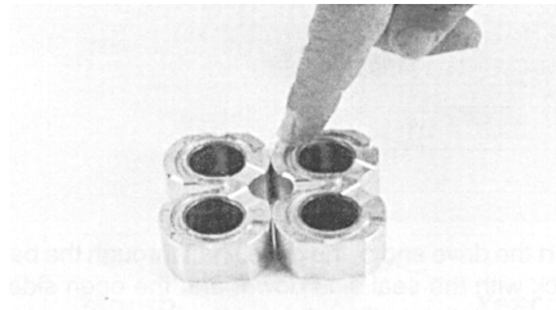
NOTE: *Install new seals when reassembling pump or motor. Go to page 8 for kit part numbers for W-600, W-900, and W-1500 pumps and motors.*



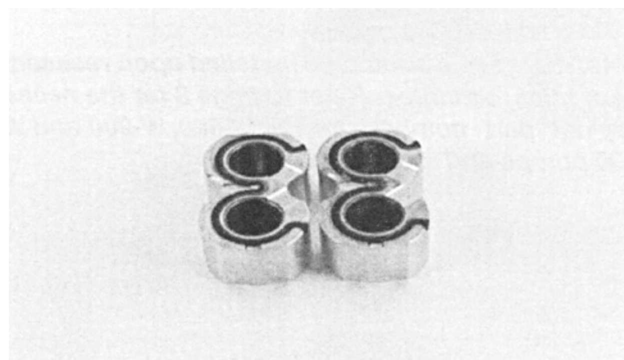
1. Install new shaft seal in mounting flange with part lumber side facing outboard. Press seal into seal bore until seal reaches the bottom of bore. Uniform pressure must be used to prevent seal misalignment or damage.



2. Install retaining ring in groove in seal bore of mounting flange.

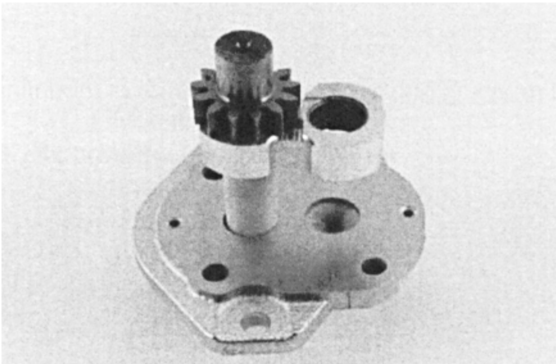


3. Place front and back bearing blocks on a clean surface with E-seal grooves facing up. Apply a light coating of petroleum jelly in the grooves. Coat E-seal and backup with petroleum jelly. This helps keep seals in place during reassembly.

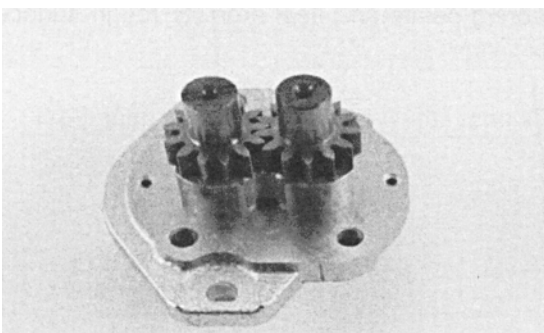


4. Place E-seals, *flat side outward,* into grooves in both bearing blocks. C*arefully* place backup ring, *flat side outward,* in groove made by E-seal and groove in bearing block. *(Note: W900 series pump - In center of backup ring and E-seal there is a notch. Make sure notches line up so backup ring will set flush with E-seal).* Backup ring in W1500 pump is symmetrical.
5. Place mounting flange, with shaft seal side down, on a clean flat surface.

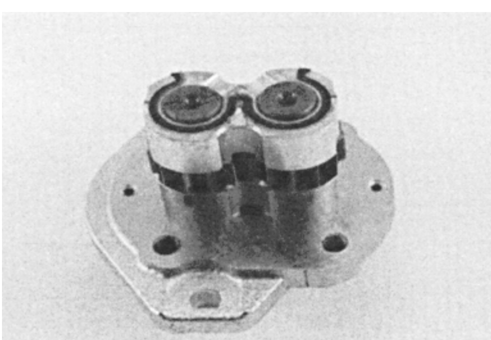
6. Apply a light coating of petroleum jelly to exposed face of front bearing block.



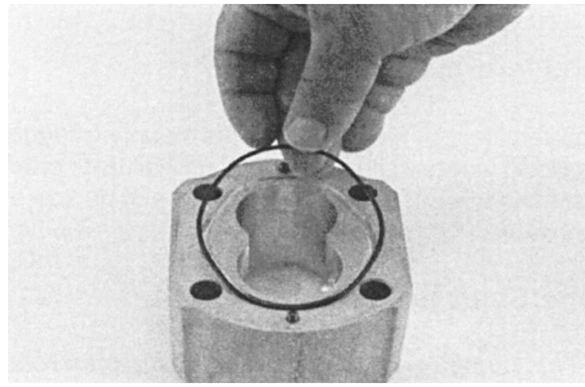
7. Insert drive end of drive shaft through bearing block with seal side down and open side of E-seal pointing to intake side of pump.
8. Install seal sleeve over drive shaft. Carefully slide drive shaft through shaft seal. Remove seal sleeve from shaft.



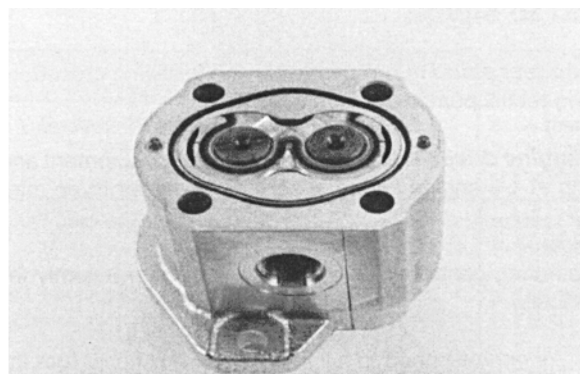
9. Install idler gear shaft in remaining position in bearing block. Apply a light coat of clean oil to face of drive and idler gears.



10. Place rear bearing block over drive and idler gear shafts with seal side up and open end of E-seal facing intake side of pump.
11. Install two dowel pins in mounting flange holes or two long dowel pins through gear housing if pump is a multiple section pump.

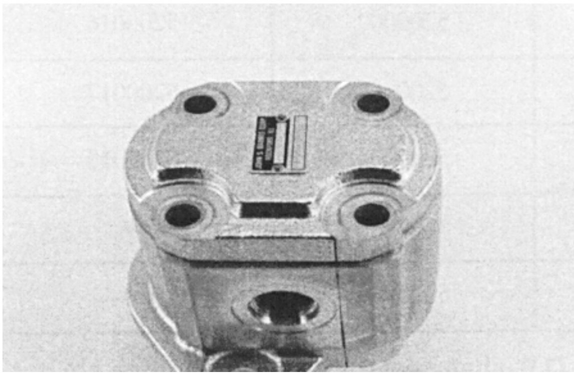


12. Apply a light coating of petroleum jelly in grooves on both sides of gear housing. Coat new O-rings and install in grooves.

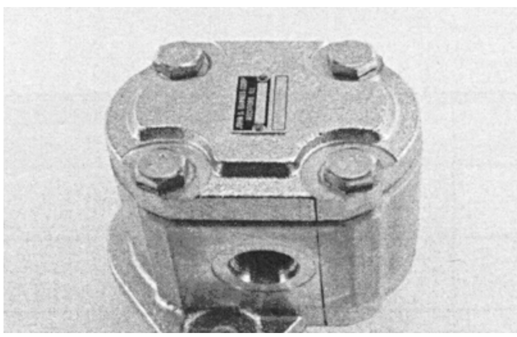


13. Gently slide gear housing over rear bearing block assembly. Slide housing down until it engages the dowel pins. Press firmly in place with hands, do not force or use any tool. Check intake port in housing is on same side as open end of E-seal and marked lines on mounting flange and gear housing are in alignment.

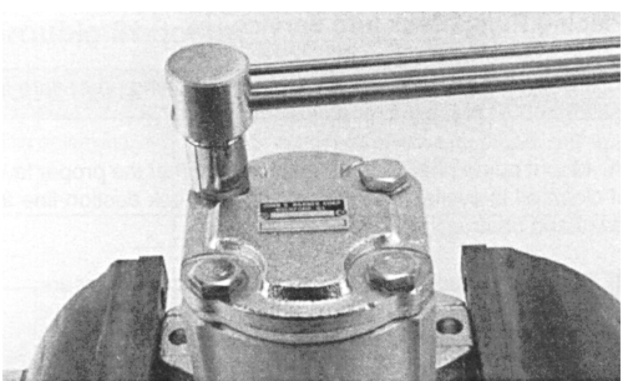
NOTE: Rear bearing block surface should be slightly below gear housing face. If bearing block is higher than rear face of gear housing, E-seal or O-ring have shifted out of groove. Remove gear housing and check for proper seal installation.



14. Install two remaining dowel pins in rear of gear housing, if applicable, and place end cover over back of pump.



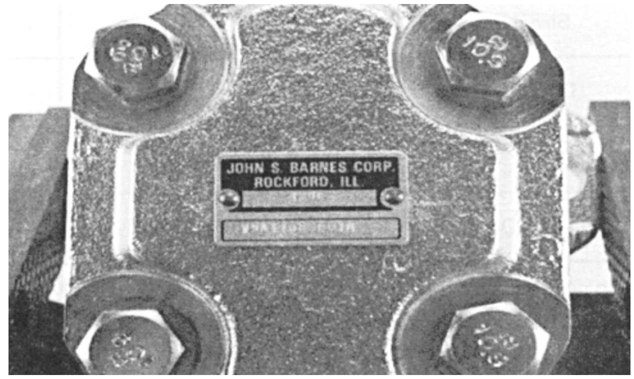
15. Install four spacers (if applicable) and hex head bolts through bolt holes in end cover. Hand tighten.



16. Place mounting flange of pump back in protected jawed vise and alternately torque bolts to torque specifications in the torque chart. All torque figures are for ”dry torque” bolts.

17. Remove pump from vise.

18. Place a small amount of clean oil in pump inlet and rotate drive shaft away from inlet one revolution. If drive shaft binds, disassemble pump and check for assembly problems, then reassemble pump.



19. Name plate located on end cover contains build date code and model number. Please refer to this information when corresponding with the J.S. Barnes Service Department.

Table 5-3.Hydraulic Pump Bolt Torque Chart

Pump Series	Thread Size	Torque Values, Black Oxide End Cover	Torque Values, Zinc Plated End Cover
W-600	M 8 x 1.25	18-21 ft.lb. 24-30 Nm	16-18 ft.lb. 21.7-24.4 Nm
W-900	M 10 x 1.5	50-55 ft.lb. 68-75 Nm	38-43 ft.lb. 51.5-58.3 Nm
W-1500	M 12 x 1.75	80-85 ft.lb. 108-115 Nm	68-73 ft.lb. 92.2-99 Nm

Placing Pump Back Into Service

1. *If shop test stand is available,* the following procedure for testing rebuilt pumps is recommended:
   a. Mount pump on test stand. Make sure proper level of clean oil is available in reservoir. Check suction line for leaks and obstructions.
   b. Start pump and run for three minutes at zero pressure.
   c. Intermittently load pump to 500 P.S.I. for three minutes.
   d. Intermittently load pump to 1000 P.S.I. for three minutes.
   e. Intermittently load pump to 2000 P.S.I. for three minutes.
   f. Remove pump from test stand and check for freeness of drive shaft. Check pump for signs of external leakage.
2. *If shop test stand is not available,* the following procedure for testing rebuilt pumps is recommended:
   a. *For engine driven pumps,* mount pump on equipment and run pump at 1/2 engine speed at zero pressure for three minutes.
   b. Operate control valve and build pressure intermittently for three minutes.
   c. Increase engine speed to full throttle and build pressure intermittently for three minutes.
   d. Stop engine and check pump for external leaks.

5.3 VARIABLE PUMP

Ports and Pressure Gauges

Proper servicing of pumps and motors requires pressure be measured and monitored at various points in the hydraulic circuit. The Series 42 pump has several locations at which to take these measurements. The following outlines show locations of various gauge ports. The following table shows recommended gauge size and fitting size for each port.

Table 5-4. Recommended Gauge Size

Gauge Port Name	Pressure Measured	Recommended Gauge Size		Fitting
		PSI	Bar	
M1 & M2	System Pressure Ports A & B	10000	600	9/16-18 ORF
M3	Charge	1000	60	3/4-16 ORF
M4 & M5	Servo	1000	60	9/16-18 ORF
L1 & L2	Case	500	35	1-1/16-12 ORF
S	Charge Pump Inlet Vacuum	30 in. Hg Vac.	1	1-1/16-12 ORF

NFPE Control

The 3-position FNR control, and electric and hydraulic non-feedback proportional (NFPE and NFPH) controls are non-feedback type controls. FNR and NFPE controls consist of pump housing mounted modules. Hydraulic input for NFPH is received through ports on top of pump [9/16–18 SAE O-ring fitting].

The non-feedback controls are factory set. Control modules can be removed to clean ports and change O-rings.

Orifice plugs for the FNR and NFPE are located inside the servo piston covers. Orifice plugs for the NFPH are located in the NFPH ports. Orifice plugs may be cleaned or replaced.

Removal and Installation of FNR and NFPE Modules

1. Clean pump and module housings.
2. Remove four screws retaining module to pump housing (4 mm Int. Hex). Remove module from housing.
3. Remove O-rings from the control ports. Examine ports for cleanliness.
4. Clean sealing surfaces.
5. Replace locator pin.
6. Install new O-rings.
7. Replace screws. Torque to 3.5 - 4.5 ft-lb (4.7-6.1 Nm).

Removal and Installation of FNR and NFPE Control Orifices

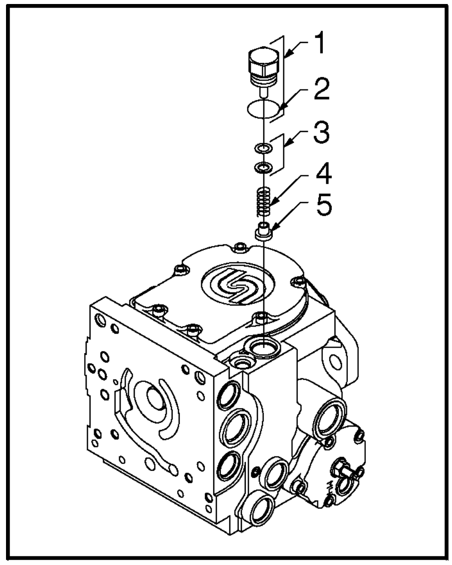
NOTE: Future models may contain an orifice plate between module and pump housing. This will take the place of the orifice plugs beneath the servo piston cover.

1. Remove servo piston cover.
2. Remove orifice plug (1/8" Int. Hex).
3. Examine orifice and port for cleanliness.
4. Install orifice plug. Torque to 1.5 - 2.5 ft-lb (2.0-3.4 Nm).

Charge Relief Valve

Charge relief valve may be removed for cleaning and installation of new O-rings. The pressure setting may be changed. Setting will vary for different charge flows depending on charge pump size and pump speed. Factory setting is set relative to case pressure at 1800 rpm. Actual charge pressure will vary at different speeds.

SHIM ADJUSTABLE STYLE

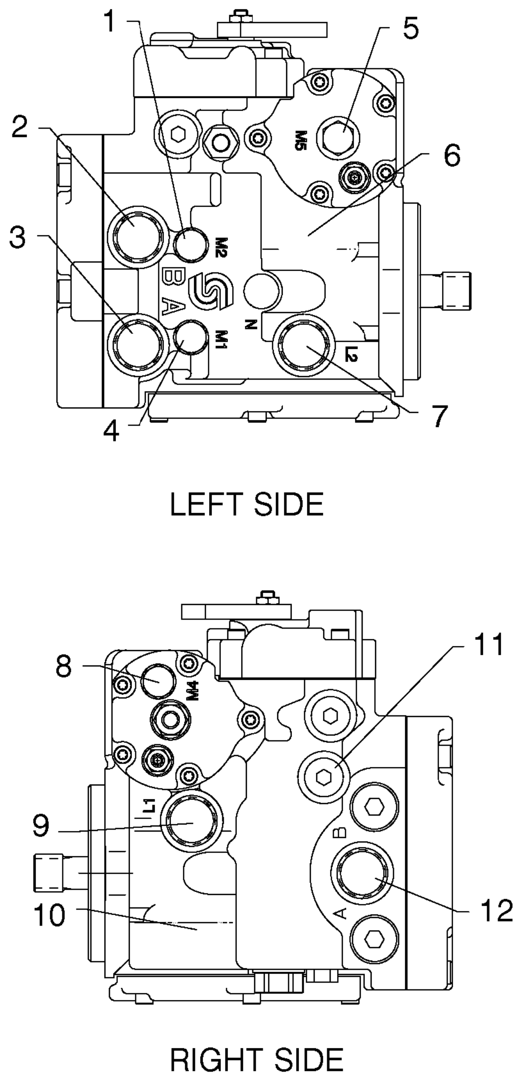


1. Plug
2. O-Ring
3. Shims
4. Spring T-Seal
5. Poppet

Figure 5-33. Shim Adjustable Charge Relief Valve Components

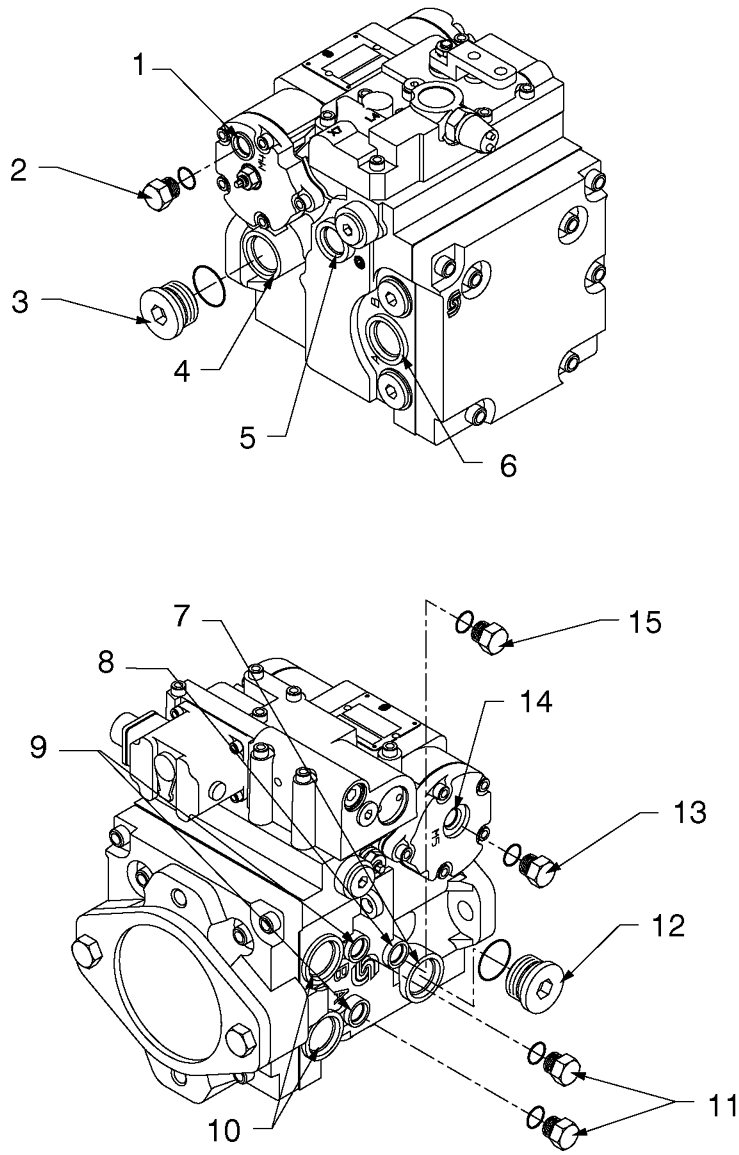
1. Remove shim adjustable charge relief valve plug (1" Hex) from pump housing. Remove O-ring from plug.
2. Remove spring and poppet from housing.
3. Do not alter shims which may be installed between spring and valve plug, or interchange parts with another valve. Inspect poppet and mating seat in housing for damage or foreign material.
4. If desired, charge relief valve setting can be changed. An approximate rule of thumb is 4 bar / 1.25 mm (58 psi / 0.050 in). Effective setting will vary.

   To confirm charge relief valve setting, measure charge pressure (port M3) with pump in stroke. Charge pressure should level off when relief setting is reached.



1. System Pressure Gauge Port M2
2. System Pressure Port B
3. System Pressure Port A
4. System Pressure Gauge Port M1
5. Servo Pressure Gauge Port M5
6. Case Drain Port L2 (non-feedback)
7. Case Drain Port L2
8. Servo Pressure Gauge Port L4
9. Case Drain Port L1
10. Case Drain Port L1 (non-feedback)
11. Charge Pressure Gauge
12. Charge Pump Inlet Port S

Figure 5-34. Gauge Port Locations

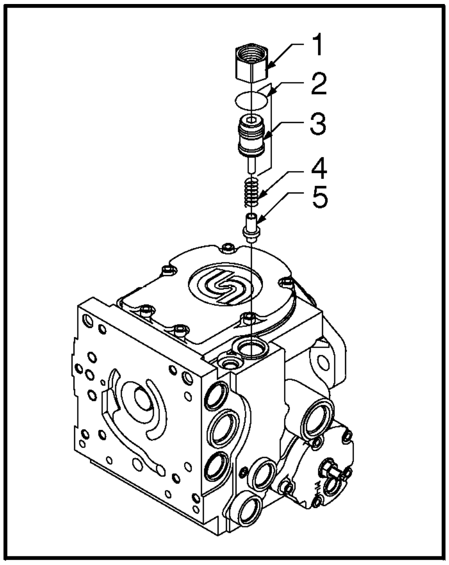


#	Plug/ Fitting	Torque	
		lb. ft.	Nm
1	Servo Gauge Port M4	N/A	N/A
2	11/16	20-35	27-47
3	9/16	70-100	95-135
4	Case Drain Port L1	N/A	N/A
5	Charge Pressure Gauge M3	N/A	N/A
6	Charge Pump Inlet Port S	85	115
7	Case Drain Port L2	N/A	N/A
8	Port N	N/A	N/A
9	System Gauge M1 & M2	N/A	N/A
10	System Ports A&B	85	115
11	11/16	20-35	27-47
12	9/16	70-100	95-135
13	11/16	20-35	27-47
14	Servo Gauge M5	N/A	N/A
15	11/16	20-35	27-47

Figure 5-35. Plugs/Fittings Size & Torque

5. Install new O-ring on valve plug. Reinstall poppet, spring, and plug (with shims and O-ring) into pump housing. Torque to 40-100 ft-lb (55-135 Nm).

SCREW ADJUSTABLE STYLE

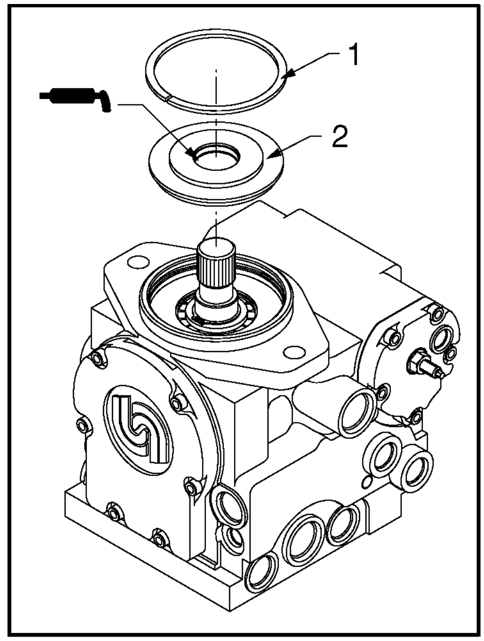


1. Lock Nut
2. O-Ring
3. Plug
4. Spring T-Seal
5. Poppet

Figure 5-36. Screw Adjustable Charge Relief Valve Components

1. Mark plug, lock nut, and housing to maintain original adjustment before removing screw adjustable relief valve plug. Loosen lock nut (1-1/16" Hex) and remove plug (8 mm Int. Hex). Remove O-ring from plug.
2. Remove spring and poppet from housing.
3. Inspect poppet and mating seat in housing for damage or foreign material.
4. Install new O-ring on valve plug. Reinstall poppet and spring. Reinstall plug and lock nut. Torque to 34 - 42 ft-lb (47-57 Nm), aligning marks made at disassembly.
5. Check and adjust, if necessary, charge pressure. For screw adjustable “anti-stall” charge relief valves, an approximate rule of thumb is 2.8 bar/quarter turn (40 psi/quarter turn).
6. Measure charge pressure (port M3) with pump in stroke. Charge pressure should level off when relief setting is reached.

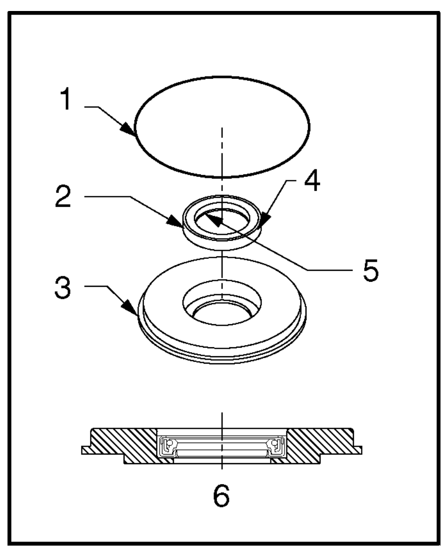
Shaft Seal and Shaft Replacement



1. Retaining Ring
2. Seal Carrier Assembly

Figure 5-37. Shaft Seal Components

A lip type shaft seal is used in Series 42 pumps. Seal and shaft can be replaced without major unit disassembly. Replacement generally requires removing pump from machine.



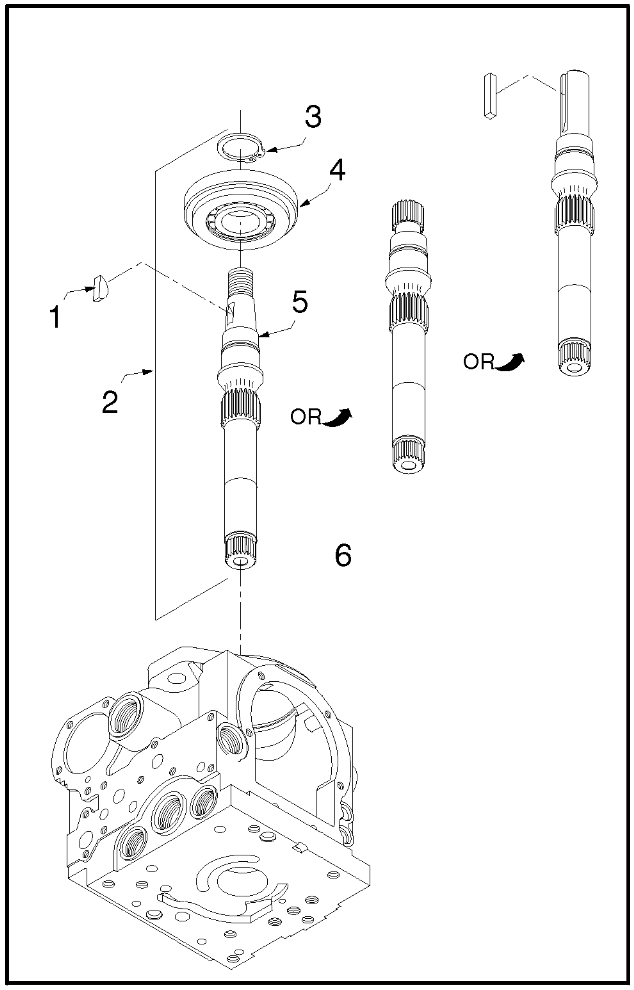
1. O-Ring
2. Seal
3. Seal Carrier
4. Sealant may be used on outside diameter
5. Inside Lip (face down)
6. Press Seal to Bottom of Seal Carrier

Figure 5-38. Installation of Shaft Seal

1. Position pump with shaft facing up.

NOTE: If the unit is positioned horizontally when the shaft is removed, the cylinder block could move out of place, making shaft installation difficult.

2. Remove retaining ring from housing.
3. Pull out seal carrier assembly.
4. Remove O-ring from seal carrier. To install a new shaft only, go to step 8.
5. Place seal carrier in an arbor press with shaft bearing side down and press out old seal. An appropriately sized pipe spacer or socket wrench can be used as a press tool. Seal is not reusable.
6. Inspect seal carrier and new seal for damage. Inspect sealing area on shaft for rust, wear, or contamination. Polish sealing area on shaft if necessary.
7. Press new seal into shaft bearing side of seal carrier. Seal lip must face outside of pump. Be careful not to damage seal. Outside diameter of seal may be coated with a sealant (e.g. Loctite High Performance Sealant #59231) before installation. This aids in preventing leaks caused by damage to seal bore in seal carrier. If shaft is not being replaced go to step 11.
8. Remove shaft and roller bearing assembly from pump or motor. Bearing assembly can be transferred to the new shaft (steps 9 and 10).
9. Remove retaining ring that secures roller bearing assembly with a snap ring pliers. Remove roller bearing assembly.



1. Key
2. Shaft Assembly
3. Retaining Ring
4. Roller Bearing
5. Shaft

Figure 5-39. Shaft Components

1. Place roller bearing assembly on new shaft and secure with retaining ring.
2. Wrap spline or key end of shaft with thin plastic to prevent damage to seal lip during installation. Lubricate inside diameter of shaft seal with petroleum jelly.
3. Place O-ring onto shaft bearing and lubricate with petroleum jelly.
4. Slide seal carrier assembly over shaft and into housing bore. Press against O-ring. Hold inward pressure against shaft to compress cylinder block spring while pressing seal carrier into place.
5. Install retaining ring.

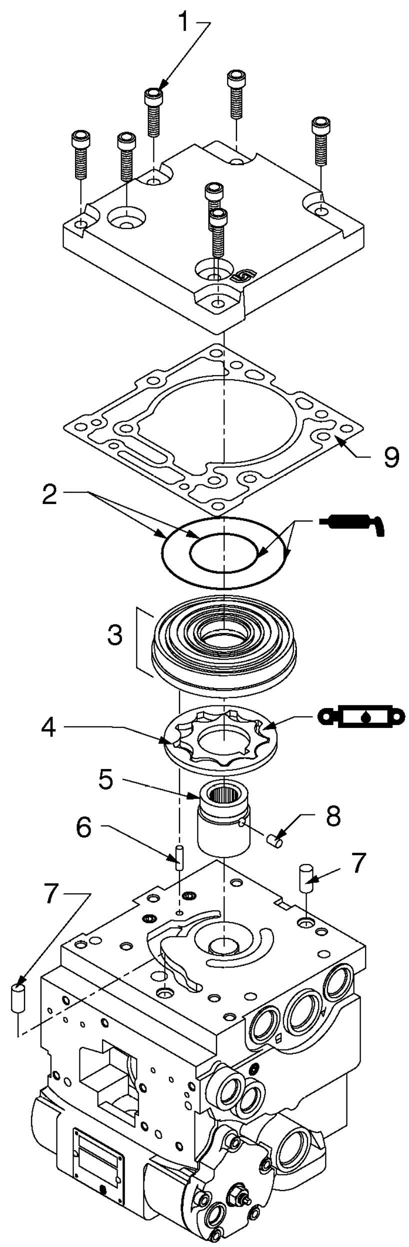
Charge Pump

Disassemble charge pump to inspect and clean, or change auxiliary shaft drive coupling.

1. Remove auxiliary pump, if necessary.
2. Remove screws retaining charge pump cover to pump housing (Torx T). Seven screws are used with “no pad” or SAE “A” auxiliary mounting pad charge pump cover, and six screws are used with SAE “B” auxiliary mounting pad charge pump cover. Remove charge pump cover, gasket, and cover locating pins.
3. Remove gerotor cover assembly from charge pump cover or back of pump housing. Remove gerotor cover O-rings. Two O-rings are used on gerotor cover of all pumps. (An additional O-ring was used on gerotor cover of very early production pumps with SAE “A” pad option.)
4. Remove gerotor assembly from gerotor cover or pump housing.
5. Remove gerotor drive pin and drive coupling. Remove gerotor cover locating pin from pump housing.
6. Inspect each part separately if they are to be reused. If either gerotor assembly parts needs to be replaced, they must both be replaced. Always replace O-rings and charge pump cover gasket. Inspect journal bearing in gerotor cover for excessive wear.
7. Lubricate gerotor assembly with clean hydraulic oil before assembly.
8. Install gerotor drive pin into hole in drive coupling. Apply grease or petroleum jelly to keep in place.
9. Install drive coupling onto pump shaft with smaller outside diameter facing away from pump shaft. Different couplings are used with different auxiliary pad options.
10. Install gerotor assembly onto coupling.
11. Install gerotor cover locating pin into pump housing. Install gerotor cover assembly over gerotor. Locating pin must engage slot in gerotor cover.

NOTE: Charge pump rotation is determined by location of gerotor recess and pressure balance hole in gerotor cover. Different gerotor covers are used for clockwise and counterclockwise rotation pumps.

12. Install new pressure balance O-rings onto gerotor cover and retain with petroleum jelly or grease. (An additional O-ring was used on gerotor cover of very early production pumps with SAE ”A” pad option.)
13. Install charge pump cover locating pins and new charge pump cover gasket.
14. Install charge pump cover. Cover must engage gerotor cover and locating pins. Install charge pump cover screws. Torque evenly to 26 - 32 ft-lb (36-43 Nm).
15. Reinstall auxiliary pump if necessary.



1. Cover Retaining Screw
2. O-Ring
3. Geroter Cover
4. Geroter Assembly
5. Drive Coupling
6. Geroter Cover Locating Pin
7. Charge Pump Cover Locating Pin
8. Geroter Drive Pin
9. Gasket

Figure 5-40. Charge Pump Components

5.4 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. Use the following start-up procedure whenever a new pump or motor is installed in a machine, or a system is restarted after a pump or motor has been removed and reinstalled.

⚠ WARNING

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

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

Fill reservoir with recommended hydraulic fluid. This fluid should be passed through a 10 micron (nominal, no bypass) filter before entering reservoir. Using contaminated fluid can damage components, which may result in unexpected vehicle/machine movement.

NOTICE

IF A PUMP OR MOTOR IS REPLACED DUE TO INTERNAL DAMAGE, REMAINING UNITS (PUMP OR MOTORS) NEED TO BE INSPECTED FOR DAMAGE AND CONTAMINATION, AND THE ENTIRE HYDRAULIC SYSTEM FLUSHED AND FLUID REPLACED. FAILURE TO DO SO MAY CAUSE CONSIDERABLE DAMAGE TO THE ENTIRE SYSTEM.

Inlet line from reservoir to pump must be filled prior to start-up. Check inlet line for properly tightened fittings, restrictions, and air leaks.

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

Fill pump and motor housing with clean hydraulic fluid prior to start up. Fill housing by pouring filtered oil in upper case drain port.

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

NOTE: In initial start-up conditions, it may be convenient to fill the housing before installing the case drain line. Component (especially motor) location may prevent case drain port access after installation.

NOTE: Make certain oil used to fill the component housing is as clean as possible and store the fill container properly to prevent it from becoming contaminated.

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

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

WARNING

DO NOT START 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 engine until charge pressure starts to rise. Start engine and run at lowest possible RPM until charge pressure is established. Excess air should be bled from system lines as close to motors as possible.

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

Once charge pressure is 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 cause of improper pressure.

WARNING

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

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

Machine is now ready for operation.

5.5 PRESSURE SETTING PROCEDURE

Cold temperatures have a significant impact on pressure readings. JLG Industries Inc. recommends operating machine until 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.

Bang-Bang Main Relief

1. Install a high pressure gauge at port marked “M1” located on front face of valve block.
2. Activate telescope in.
3. Adjust relief valve to 3300 psi (227.5 Bar), located on front face of block, it’s the 5th relief valve counting left to right. Turn clockwise to increase and counterclockwise to decrease.

Steer

1. Install a high pressure gauge at port marked “M3”.
2. Activate steer and adjust relief valve to 2500 psi (172 Bar). The relief valve is located on front face of block, 3rd relief valve counting left to right. Turn clockwise to increase and counterclockwise to decrease.

Platform Level Up

1. Install a high pressure gauge at the port marked “M2”, located on the platform valve block.
2. Activate level up to end of stroke. You should read 2800 psi (193 Bar).
3. The level up relief valve is located next to the check port. Turn clockwise to increase and counterclockwise to decrease.

Platform Level Down

1. Install a high pressure gauge at port marked “M1”, located on platform valve block.
2. Activate level down to end of stroke, reading 1800 psi (125 Bar).
3. The level down relief valve is located next to the check port. Turn clockwise to increase and counterclockwise to decrease.

Articulating Jib

1. Install a high pressure gauge on port marked “M3” on Jib block, located on platform valve block.
2. Activate Jib up or down. You should read 1500 psi (103 Bar).
3. The relief valve is located on the Jib block. Turn clockwise to increase, counterclockwise to decrease.

Proportional Main Relief

1. Install a high pressure gauge at port marked “M2”, located on front face of block.
2. Raise boom up to end of stroke, or remove hose from port #10 and plug and cap, then activate lift up.
3. This valve should be adjusted to 3200 psi (220 Bar). This relief valve is located on front face of block and is the 4th relief valve counting left to right. Turn clockwise to increase, counterclockwise to decrease.

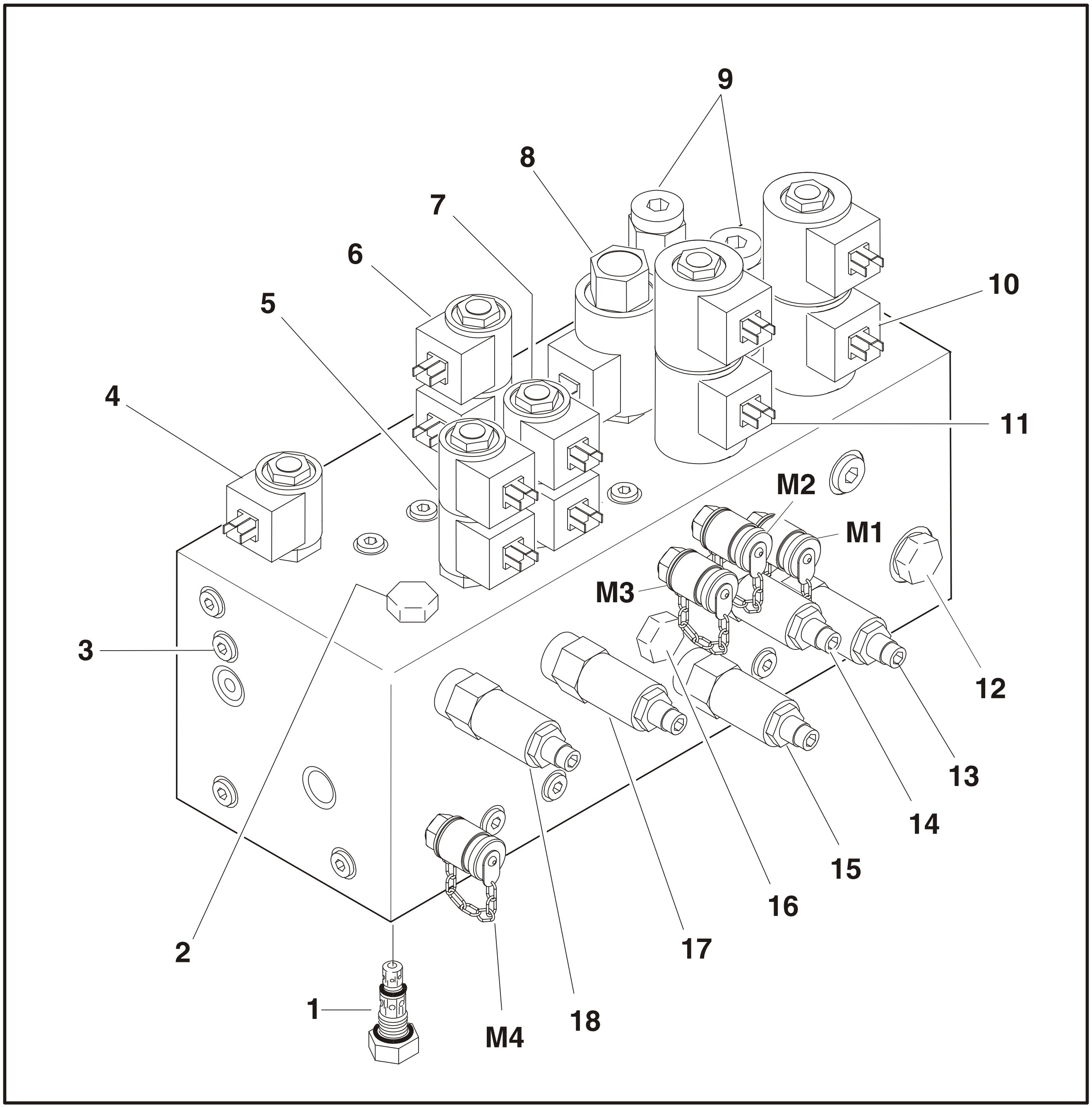
Lift Down

1. Install a high pressure gauge at port marked “M2”.
2. Activate lift down.
3. This relief valve should be adjusted to 1200 psi. The relief valve is located on front face of block, and is the 2nd relief valve counting left to right. Turn clockwise to increase, counterclockwise to decrease.

Swing

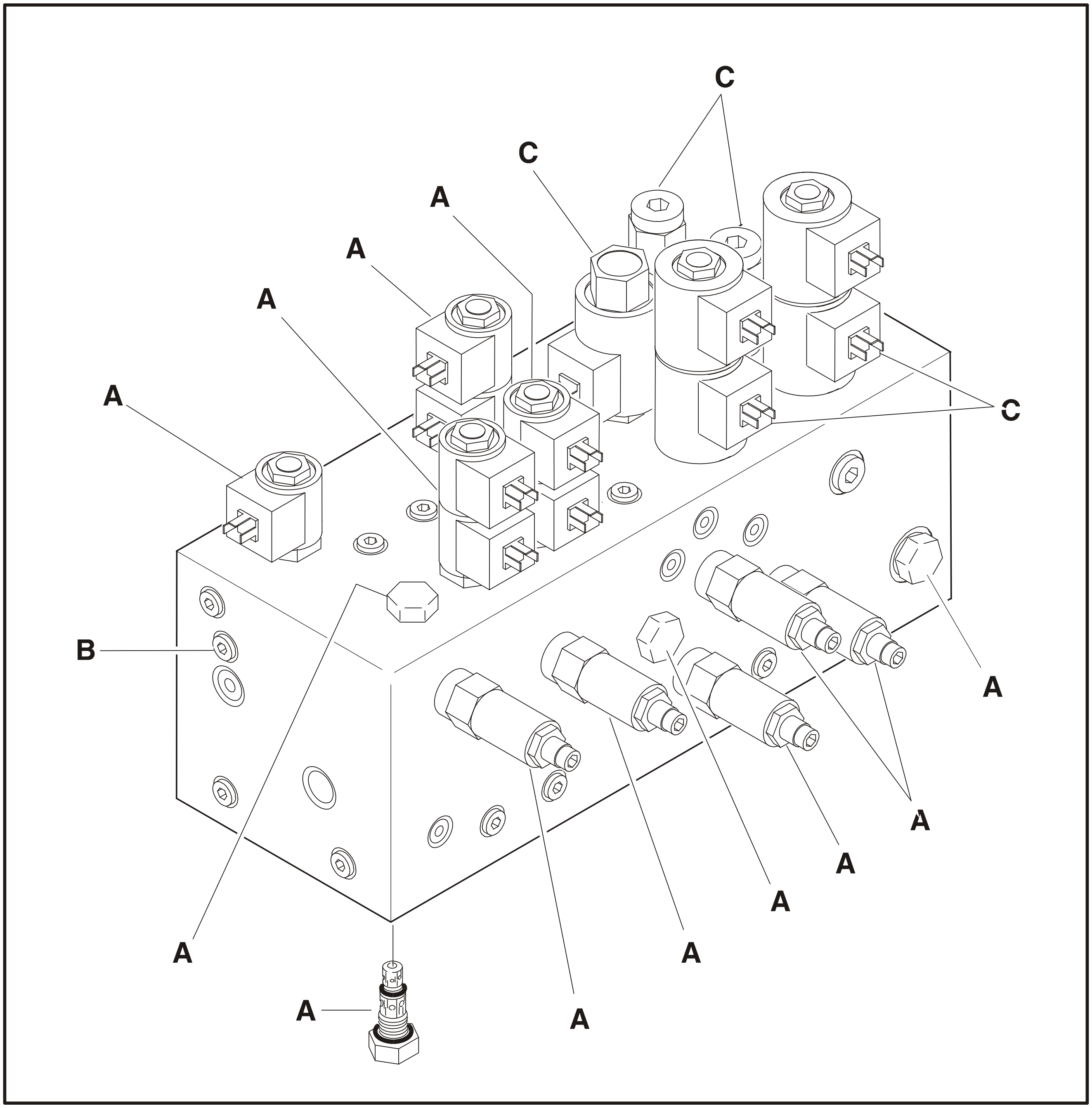
1. Left and right are done with (1) adjustment.
2. Install a high pressure gauge at the port marked “M4”, located on the front face of the main valve.
3. Either remove (1) of the swing hoses, plug and cap or swing turntable around until it hits the stop.
4. Activate swing. Pressure should be 1700 psi. The relief valve is located on front face of block, the first relief valve counting left to right. Turn clockwise to increase, counterclockwise to decrease

.



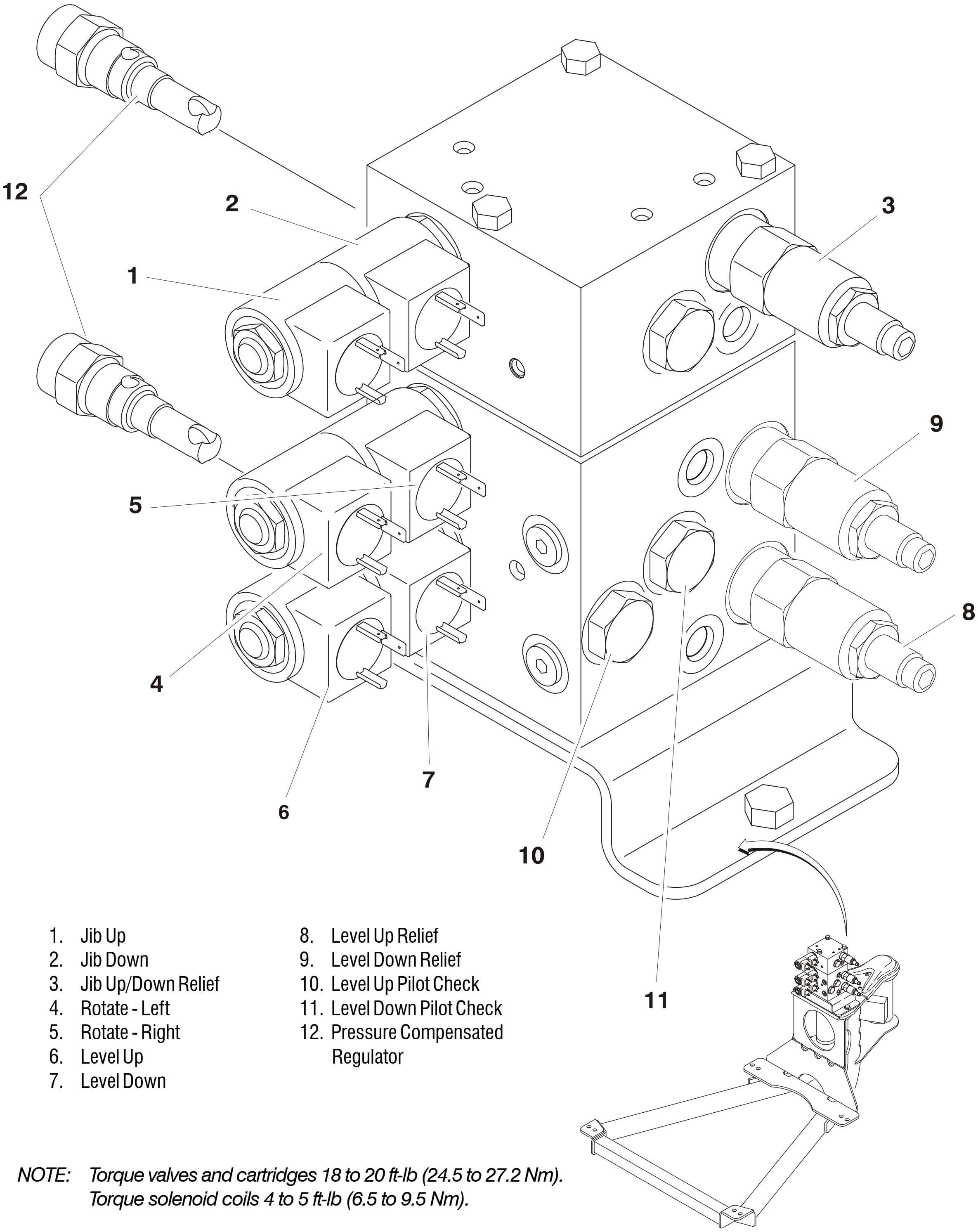
1. Check Valve
2. Load Shuttle
3. Load Shuttle
4. Main Dump
5. Swing
6. Steer
7. Upper Lift
8. Proportional Dump
9. Directional Pilot
10. Telescope
11. Lower Lift
12. Flow Regulator
13. Bang Bang Relief
14. Proportional Main Relief
15. Steer Relief
16. Load Shuttle (Steer)
17. Lift Down Relief
18. Swing Relief

Figure 5-41. Main Control Valve



A	18-20 ft. lbs. (24.5 - 27.2 Nm)
B	4-5 ft. lbs. (5.4 - 6.8 Nm)
C	25-27 ft. lbs. (34 - 36.7 Nm)

Figure 5-42. Main Control Valve Torque Values



1. Jib Up
2. Jib Down
3. Jib Up/Down Relief
4. Rotate - Left
5. Rotate - Right
6. Level Up
7. Level Down
8. Level Up Relief
9. Level Down Relief
10. Level Up Pilot Check
11. Level Down Pilot Check
12. Pressure Compensated Regulator

NOTE: Torque valves and cartridges 18 to 20 ft-lb (24.5 to 27.2 Nm).
Torque solenoid coils 4 to 5 ft-lb (6.5 to 9.5 Nm).

Figure 5-43. Platform Control Valve

NOTES:

SECTION 6. JLG CONTROL SYSTEM

6.1 INTRODUCTION

NOTICE

WHEN INSTALLING ANY NEW MODULE CONTROLLER ON THE MACHINE, THE CONTROLLER MUST BE PROGRAMMED FOR PROPER MACHINE CONFIGURATION, INCLUDING OPTIONS AND PROPERLY CALIBRATING THE TILT SENSOR.

NOTICE

AVOID PRESSURE-WASHING ELECTRICAL AND ELECTRONIC COMPONENTS. IF PRESSURE-WASHING AREAS CONTAINING ELECTRICAL OR 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 OR ELECTRONIC COMPONENTS ARE SPRAYED, SPRAYING MUST NOT BE DIRECT FOR BRIEF TIME PERIODS TO AVOID HEAVY SATURATION.

The JLG designed Control System is a 12 volt based motor control unit installed on the boom lift.

The JLG Control System has reduced the need for exposed terminal strips, diodes, and trimpots. It provides simplicity in viewing and adjusting various personality settings for smooth control of acceleration, deceleration, creep, and min and max.-speed for all boom, drive, and steering functions.

Upper lift, swing, and drive are controlled by individual joysticks. Steering is controlled by a rocker switch built into the top of the drive joystick. To activate Drive, Lift, and Swing pull up the slide lock on the joystick and move the handle in desired direction.

The control system will control voltage output to valves and pump, as programmed for smooth operation and maximum cycle time. Ground control speeds for all boom functions can be programmed into the control system.

The JLG Control System controller has a built in LED to indicate any faults. The system stores recent faults which may be accessed for troubleshooting. Optional equipment includes a soft touch system, head and tail lights, and ground alarm. These options must be programmed into the control system when installed.

The Control System may be accessed utilizing a custom designed, hand held analyzer (Analyzer Kit, JLG part no. 2901443). It displays two lines of information at a time by scrolling through the program.

NOTE: *Each module has a label with the JLG part number and a serial number which contains a date code.*

The following instructions are for the hand held analyzer.

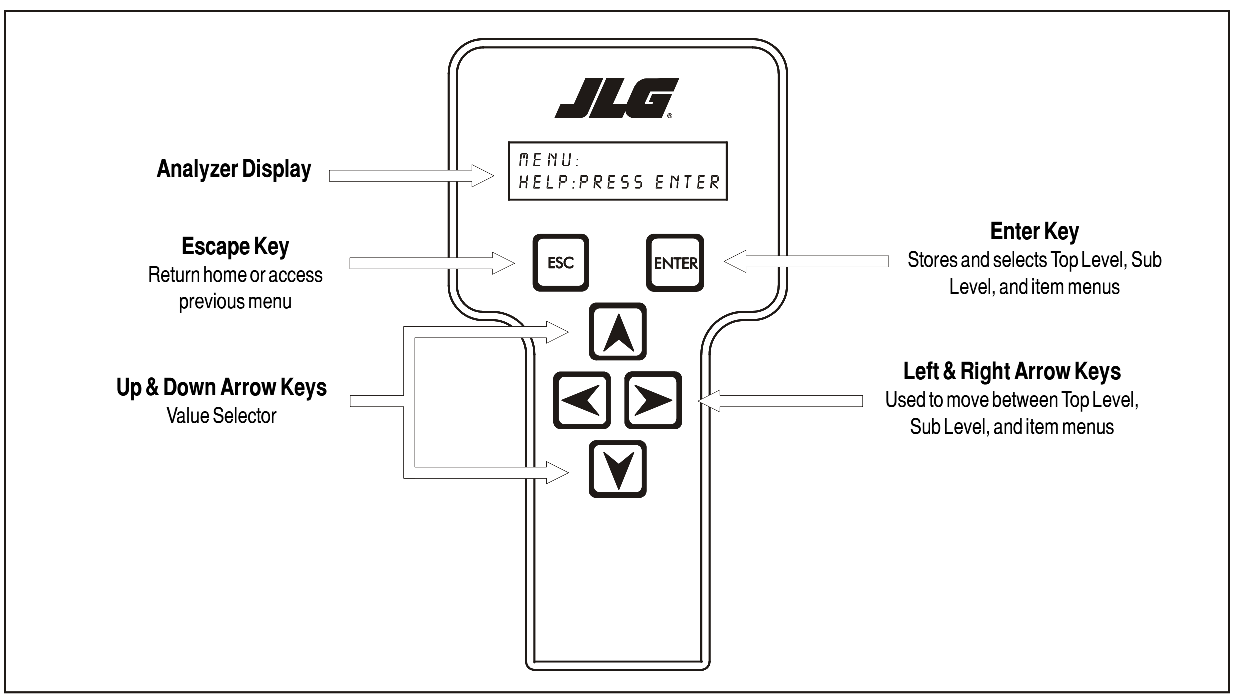


Figure 6-1. Hand Held Analyzer

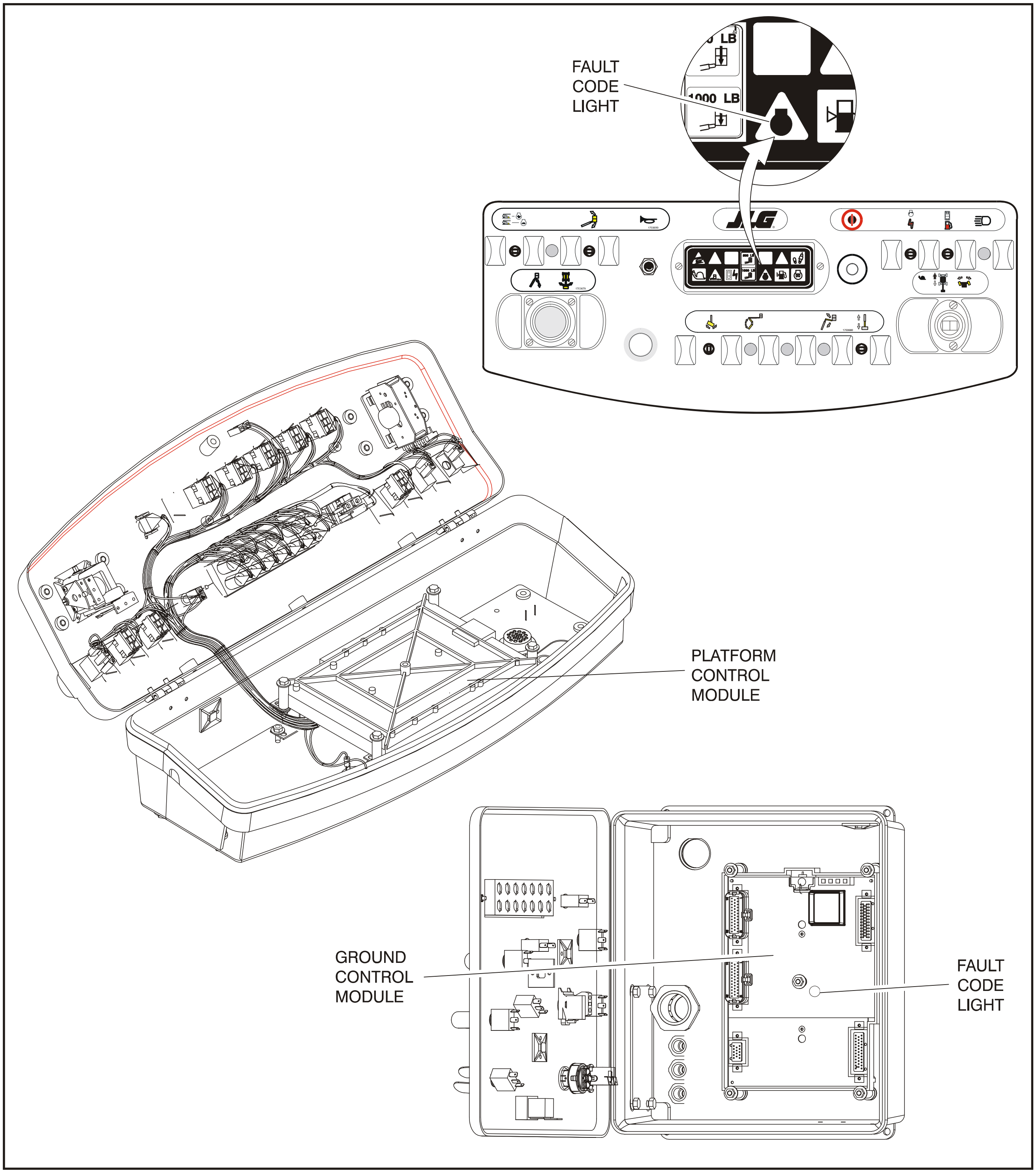


Figure 6-2. Control Module Location

6.2 CONNECT JLG CONTROL SYSTEM ANALYZER

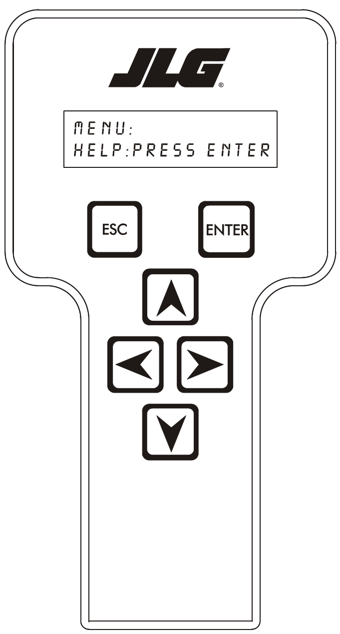
1. Connect four pin end of cable supplied with analyzer to controller module located on platform box or at controller module inside ground control box. Connect remaining end of cable to analyzer.

NOTE: *Cable has a keyed four pin connector at each end. It cannot be connected backwards.*

2. Power up Control System by turning lower key to platform or ground position and pulling both emergency stop buttons out.

6.3 USING ANALYZER

Analyzer displays the following with machine power on and analyzer connected properly:



HELP:
PRESS ENTER

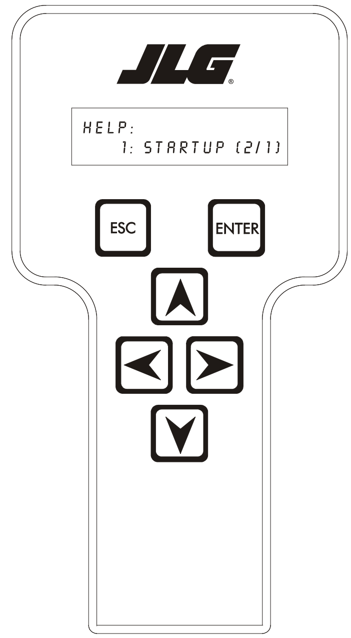
Move between top level menu items using **RIGHT** and **LEFT** arrow keys. To select a displayed menu item, press **ENTER**. To cancel a selected menu item press **ESC**. Scroll using right and left arrow keys to select a different menu item.

Top level menus:

HELP
DIAGNOSTICS
SYSTEM TEST
ACCESS LEVEL
PERSONALITIES
MACHINE SETUP
CALIBRATIONS (view only)

If you press **ENTER**, at the **HELP: PRESS ENTER** display, and a fault is present, the analyzer display will scroll the fault across the screen. If no fault is detected, the display shows: **HELP: EVERYTHING OK.** If powered up at the ground station, the display shows: **GROUND OK.**

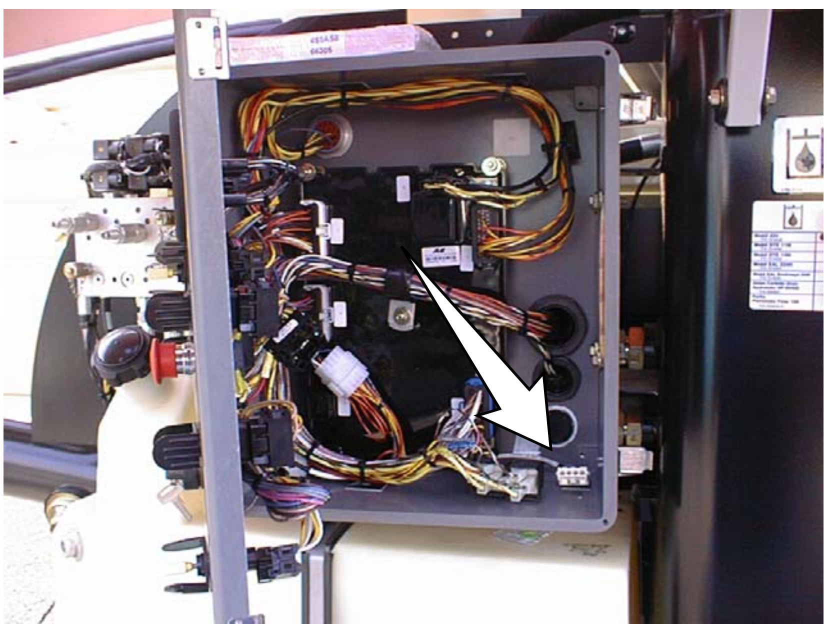
If **ENTER** is pressed again, display shows the following:



LOGGED HELP
1: POWER CYCLE (0/0)

Analyzer displays last system fault if any are present. Use right and left arrow keys to scroll through fault logs and view last 25 faults. Press **ESC** two times to return to MENU screen. **POWER CYCLE (0/0)** indicates a power up.

PLATFORM CONNECTION



GROUND CONTROL CONNECTION

Figure 6-3. Analyzer Connecting Points

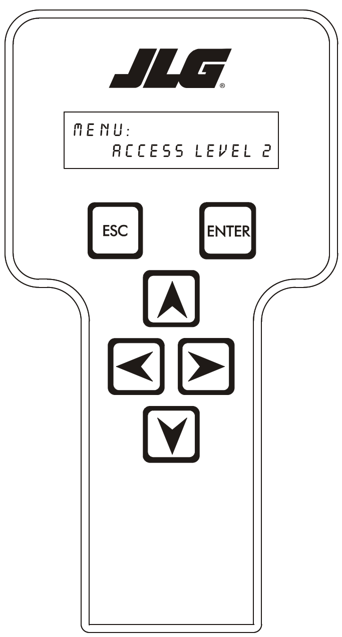
When a top level menu is selected, a new set of menu items may be offered: for example:

DRIVE
BOOM
SYSTEM
DATALOG
VERSIONS

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

6.4 CHANGING HAND HELD ANALYZER ACCESS LEVEL

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



MENU:
ACCESS LEVEL 2

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

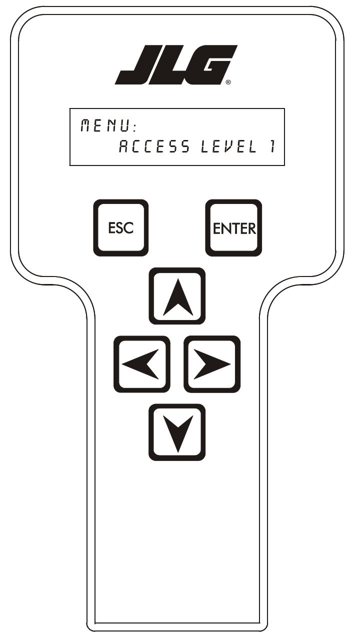
Using **UP** or **DOWN** arrow keys, enter first digit of password, 3.

Use **RIGHT** arrow key to position cursor right one space to enter second digit of password.

Use **UP** or **DOWN** arrow key to enter second digit of password which is 33271.

Continue using arrow keys until all remaining digits of password is shown.

Once correct password is displayed, press **ENTER**. Access level displays the following if password was entered correctly:



MENU:
ACCESS LEVEL 1

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

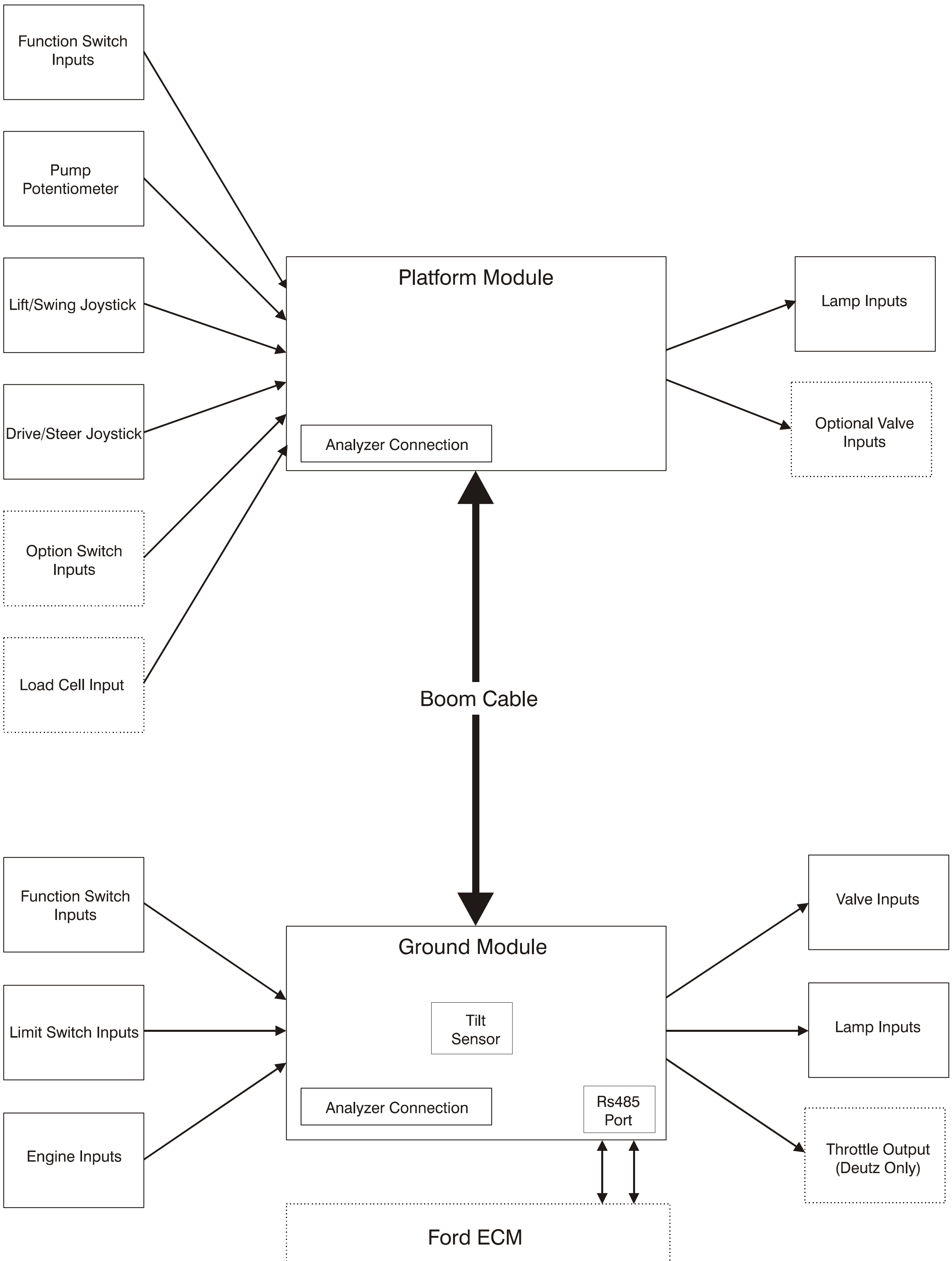
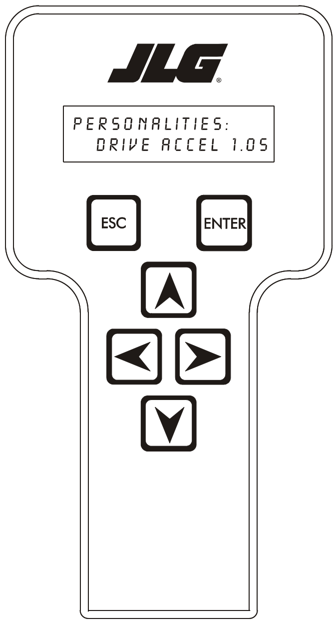


Figure 6-4. ADE Control System Block Diagram

6.5 ADJUSTING PARAMETERS USING THE HAND HELD ANALYZER

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

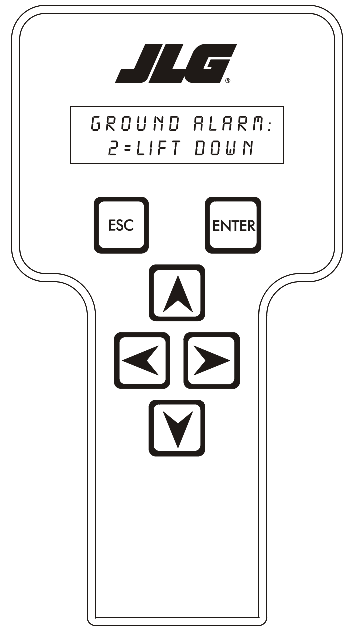


PERSONALITIES:
DRIVE ACCEL 1.0s

There is a minimum and maximum value for efficient operation. Value will not increase if **UP** arrow is pressed at maximum value and will not decrease if **DOWN** arrow is pressed at minimum value for any particular personality. If value does not change when pressing up and down arrows, make sure you are at access level 1.

6.6 MACHINE SETUP

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



GROUND ALARM:
2 = LIFT DOWN

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

When selecting machine model to match machine size, personality settings default to factory recommended setting.

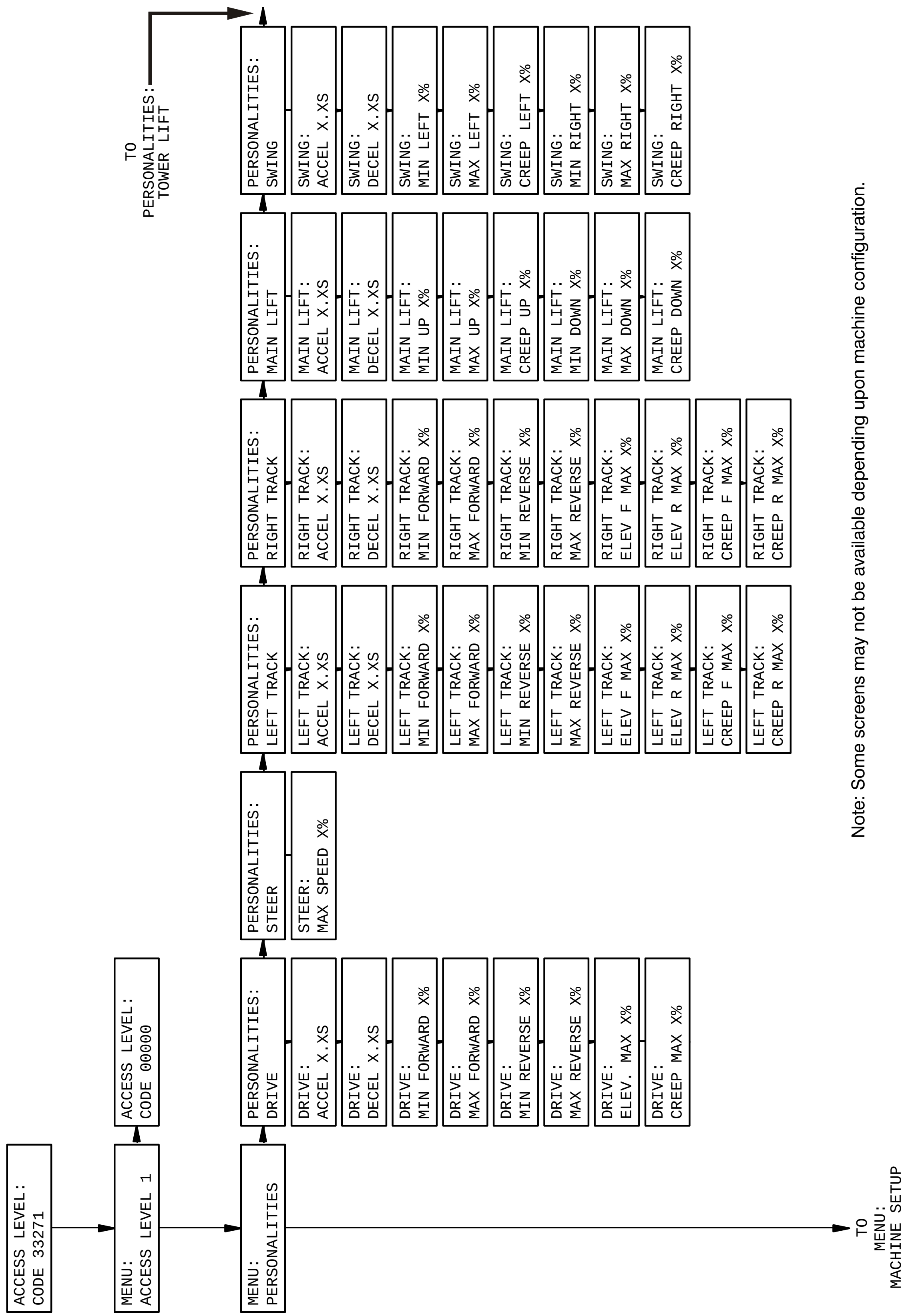
NOTE: *Refer to Table 6-1, Personality Ranges/Defaults, and in this Service Manual for the recommended factory settings.*

NOTE: *Password 33271 gives you access to level 1, which permits you to change all machine personality settings.*

JLG strongly recommends you do not change the **ELEVATION CUTBACK** setting.

⚠ WARNING

CHANGING ELEVATION CUTBACK SETTING MAY ADVERSELY AFFECT MACHINE PERFORMANCE.



Note: Some screens may not be available depending upon machine configuration.

Figure 6-1. Analyzer Flow Chart, Prior to Version 5.X Software - Sheet 1 of 4

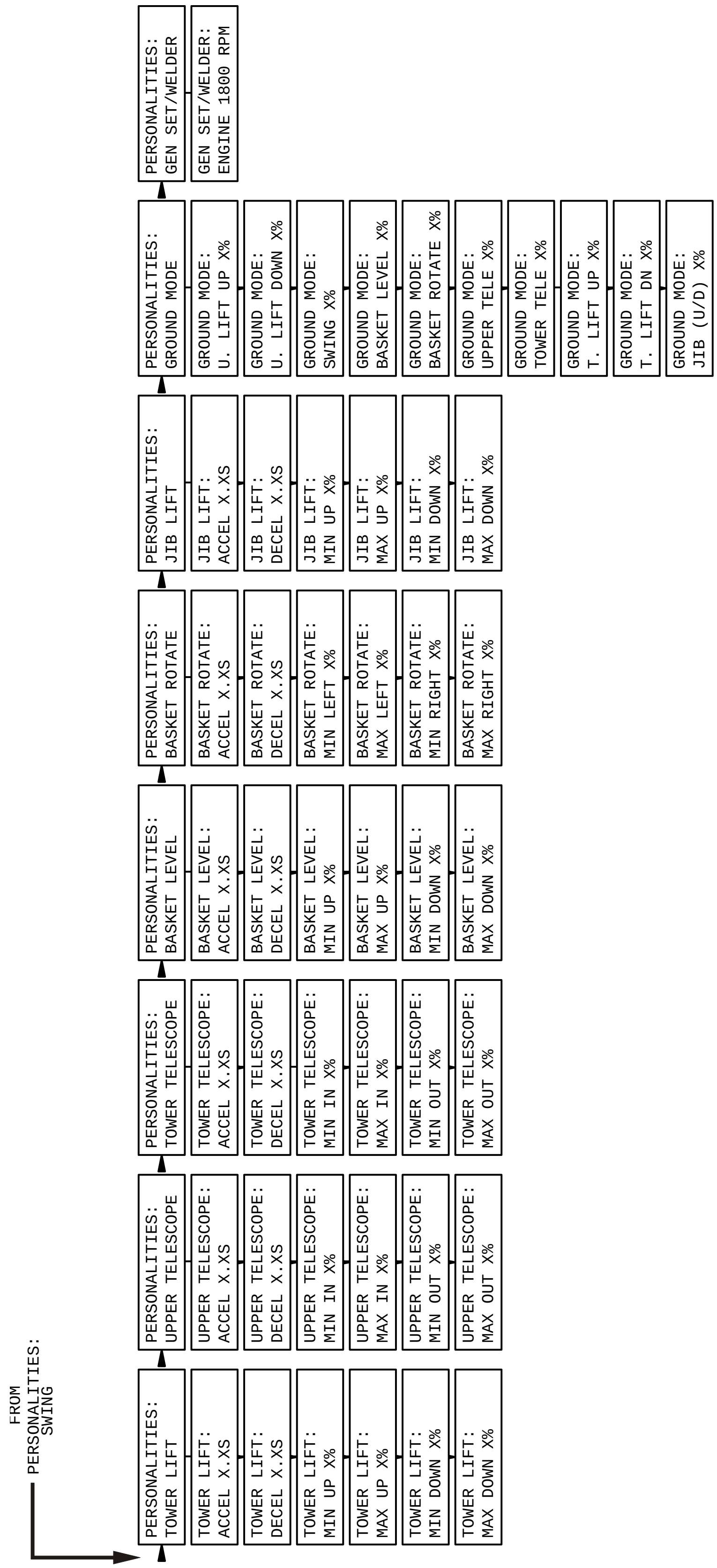


Figure 6-1. Analyzer Flow Chart, Prior to Version 5.X Software - Sheet 2 of 4

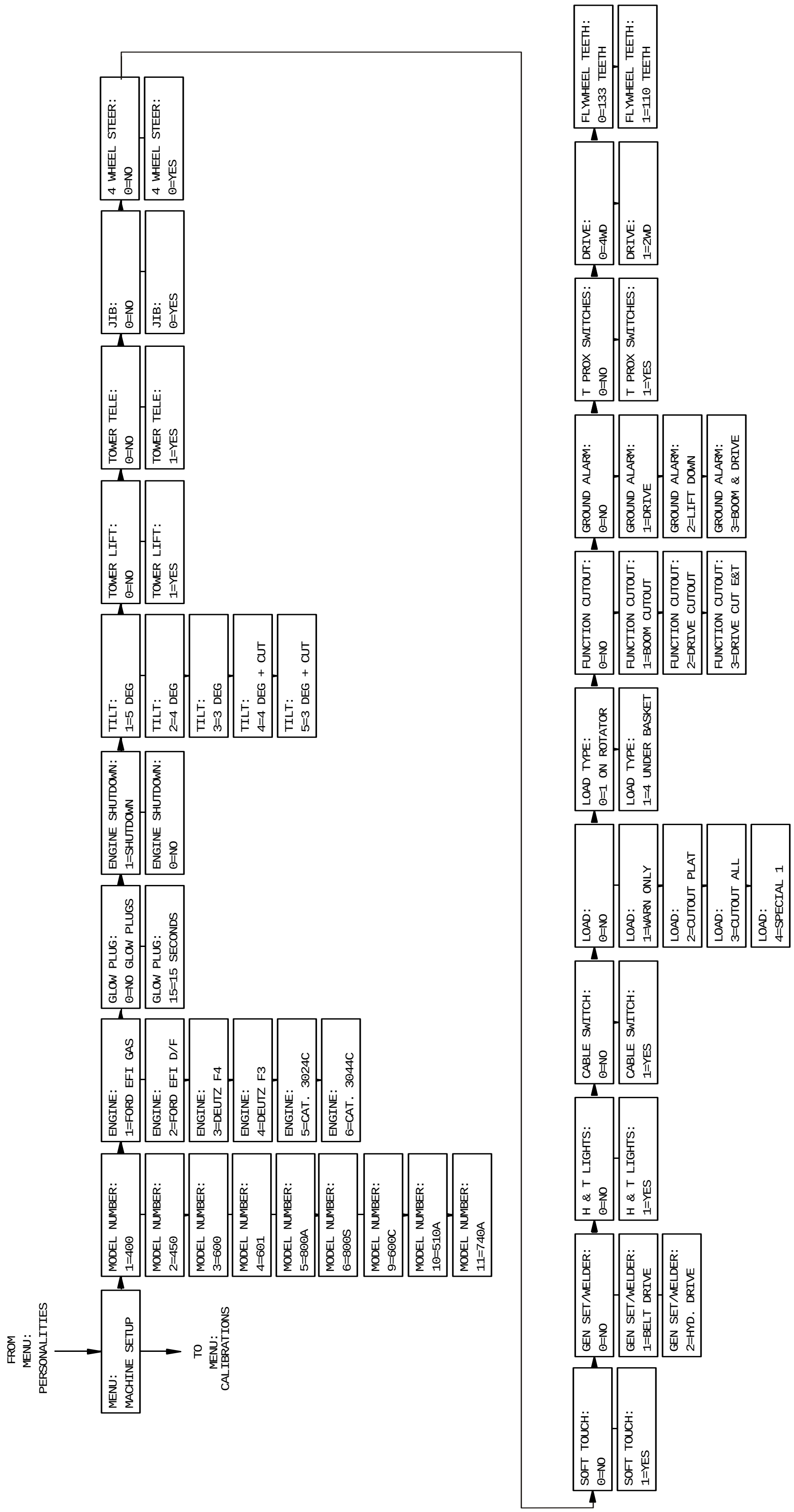


Figure 6-5. Analyzer Flow Chart, Prior to Version 5.X Software - Sheet 3 of 4

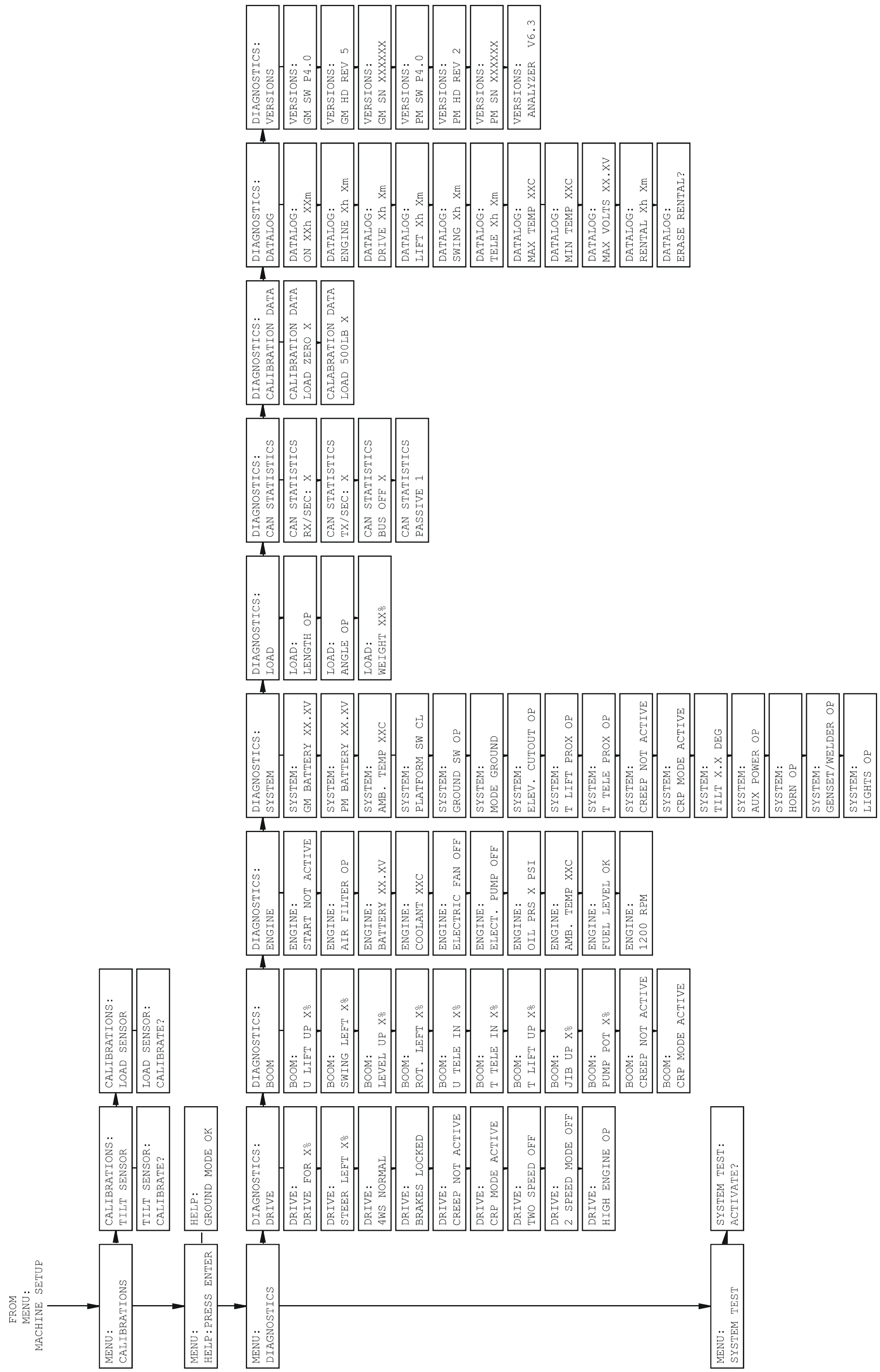
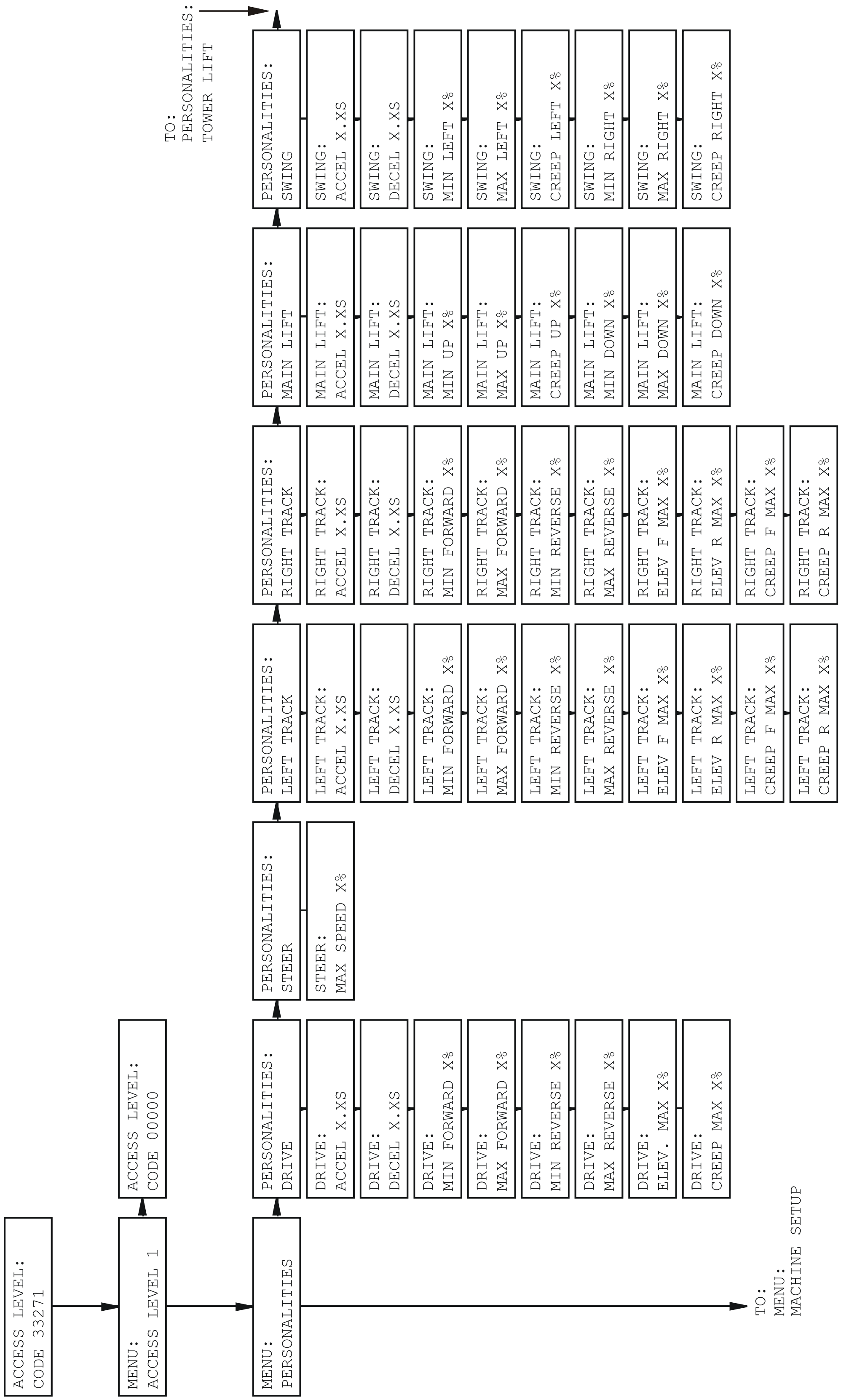


Figure 6-6. Analyzer Flow Chart, Prior to Version 5.X Software - Sheet 4 of 4



NOTE: *Some screens may not be available depending upon machine configuration.*

Figure 6-7. Analyzer Flow Chart, Version 5.X Software - Sheet 1 of 4

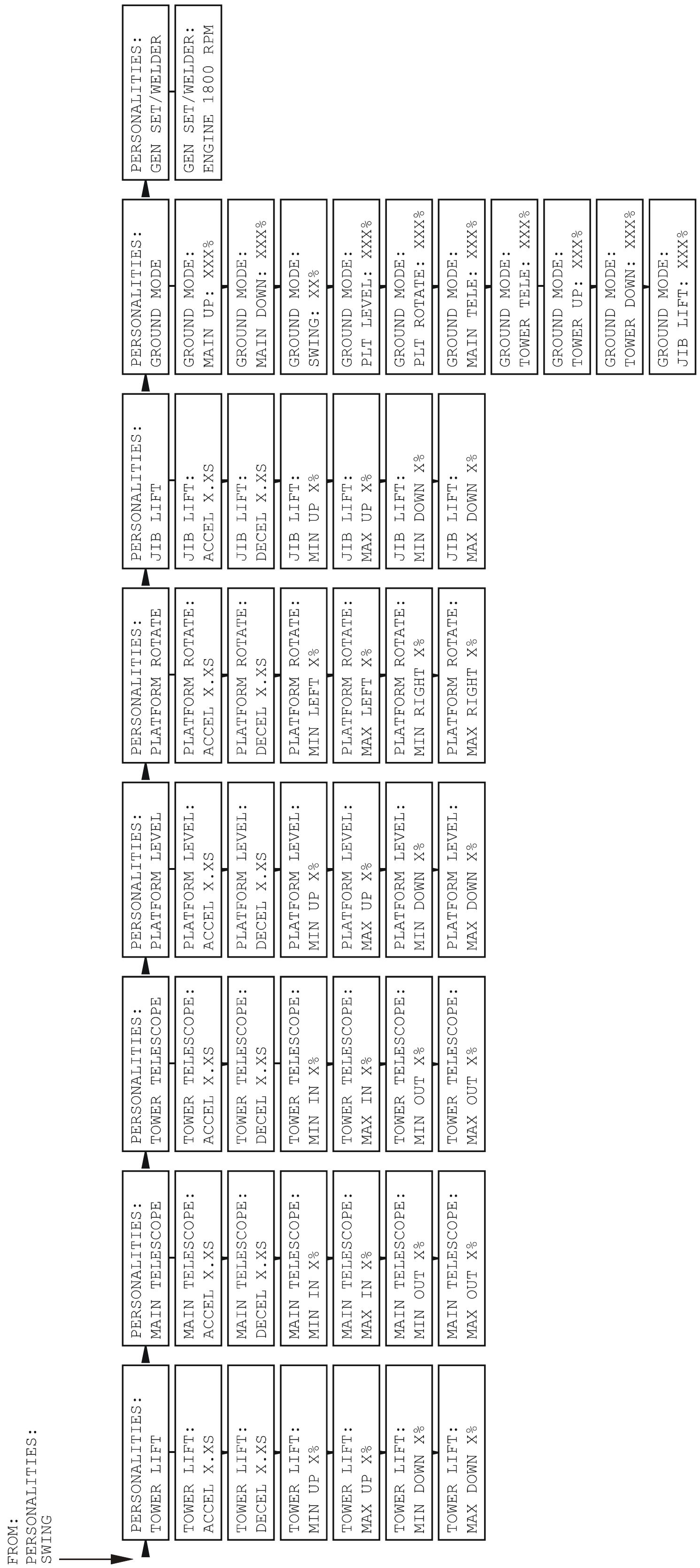


Figure 6-8. Analyzer Flow Chart, Version 5.X Software - Sheet 2 of 4

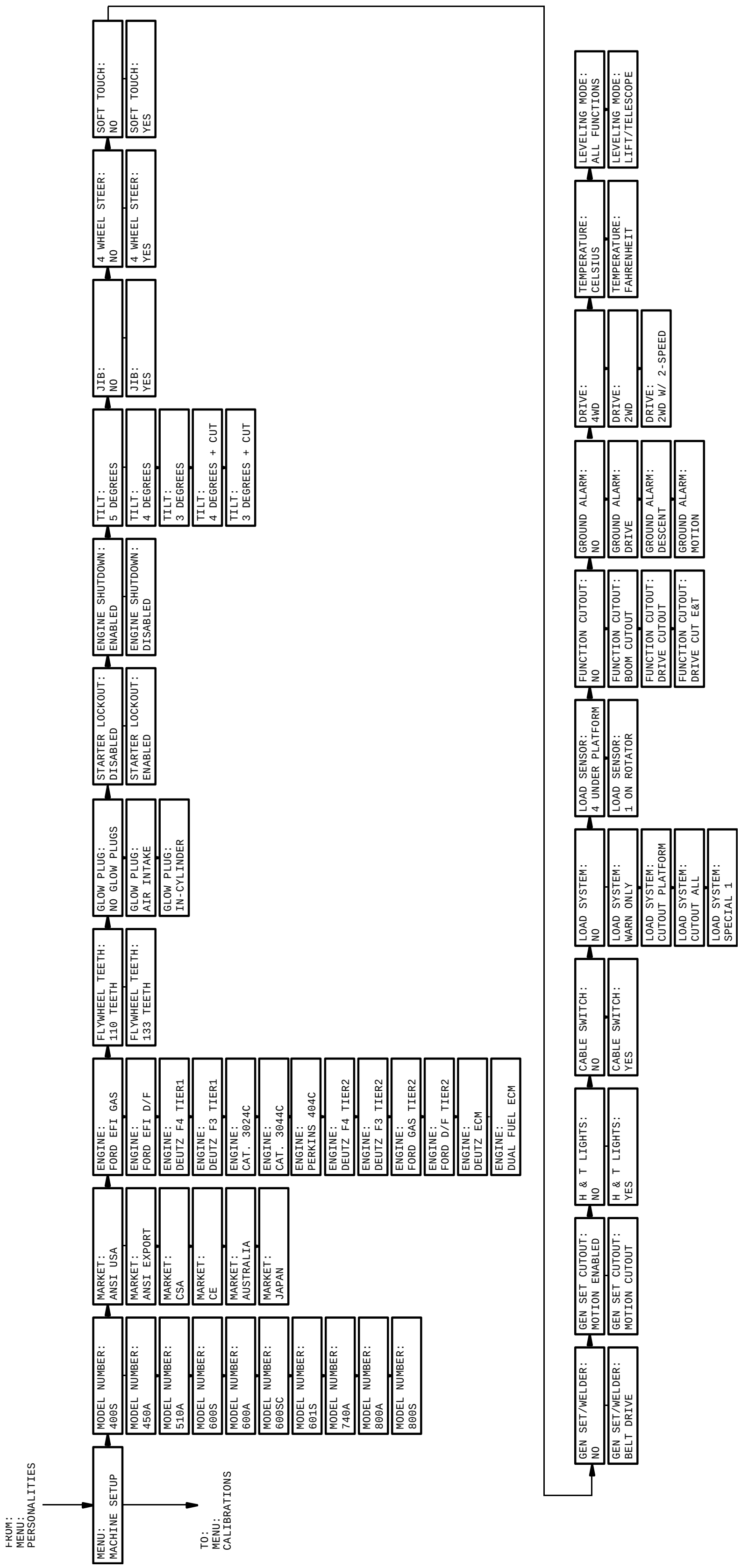


Figure 6-9. Analyzer Flow Chart, Version 5.X Software - Sheet 3 of 4

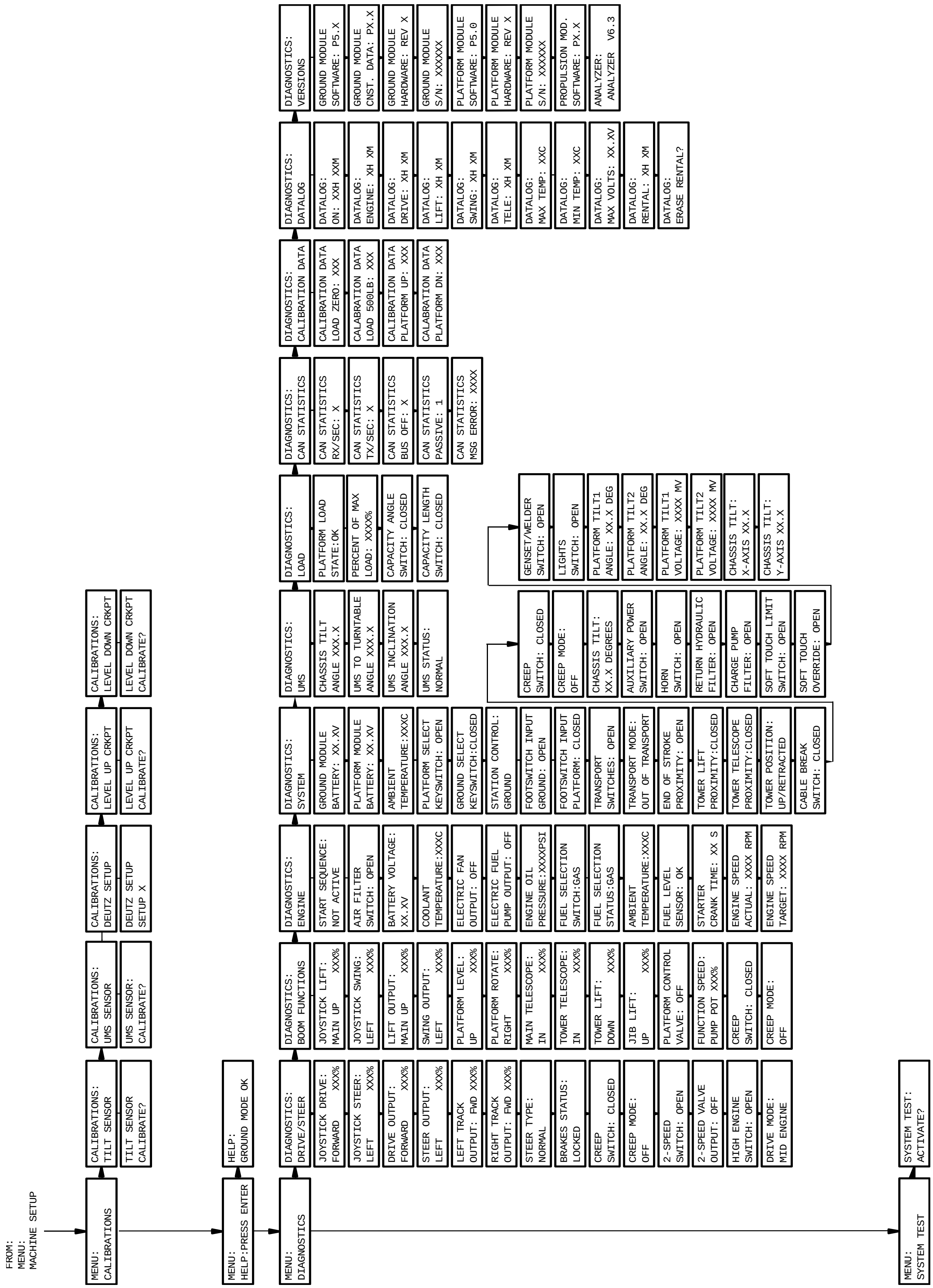


Figure 6-10. Analyzer Flow Chart, Version 5.X Software - Sheet 4 of 4

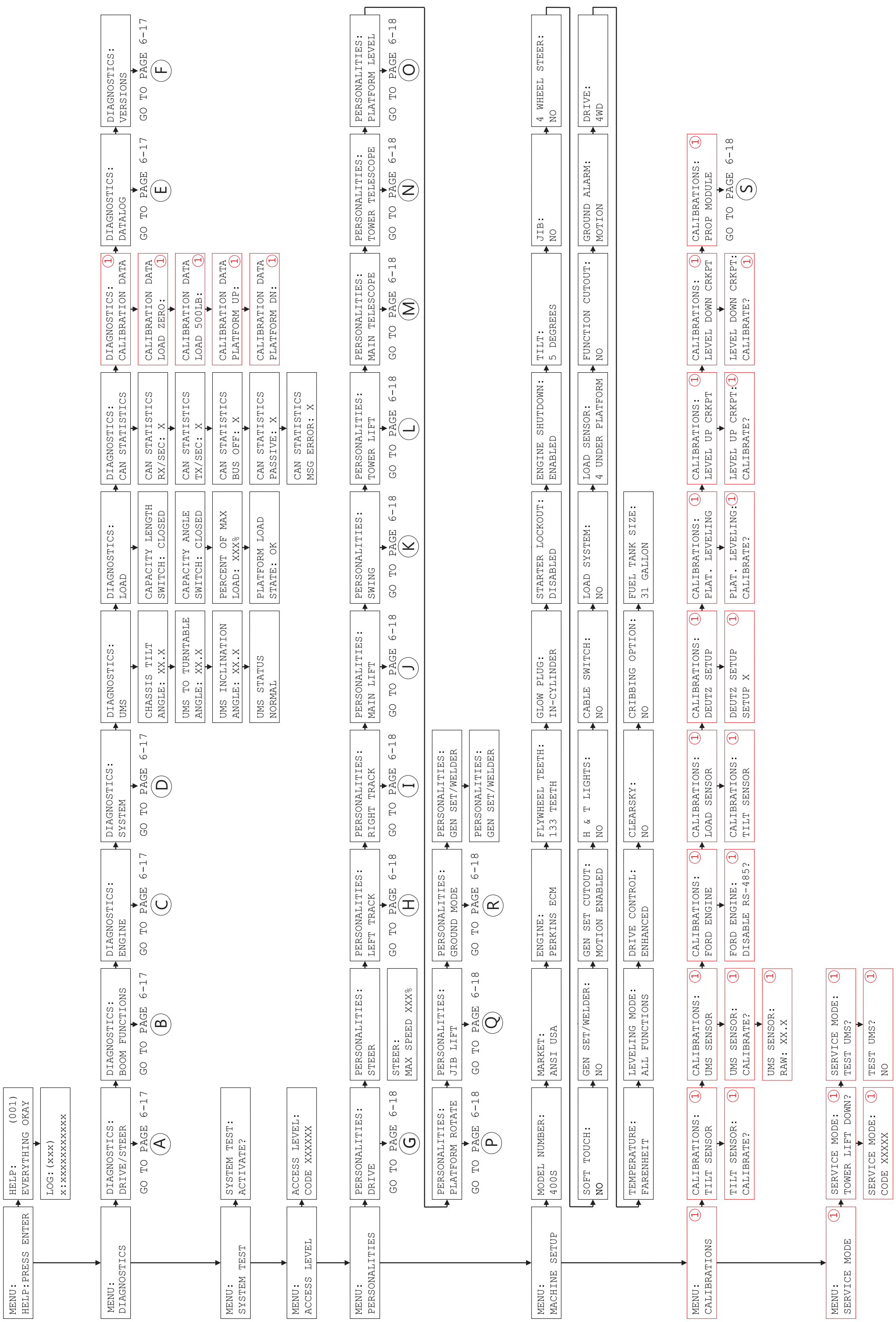


Figure 6-11. Analyzer Flow Chart, Version 6.X Software - Sheet 1 of 3

A DIAGNOSTICS: DRIVE/STEER
- JOYSTICK DRIVE: FORWARD XXX%
- JOYSTICK STEER: LEFT XXX%
- DRIVE OUTPUT: FORWARD XXX%
- DRIVE FORWARD COMMANDED:XXXXMA
- DRIVE REVERSE COMMANDED:XXXXMA
- DRIVE OUTPUT: ACTUAL: XXXXMA
- STEER OUTPUT: LEFT XXX%
- LEFT TRACK OUTPUT: FWD XXX%
- LEFT TRACK FWD COMMANDED:XXXXMA
- LEFT TRACK REV COMMANDED:XXXXMA
- LEFT TRACK ACTUAL: XXXXMA
- RIGHT TRACK OUTPUT: FWD XXX%
- RIGHT TRACK FWD COMMANDED:XXXXMA
- RIGHT TRACK REV COMMANDED:XXXXMA
- RIGHT TRACK ACTUAL:XXXXMA
- STEER TYPE: NORMAL
- BRAKES STATUS: LOCKED
- CREEP: SWITCH: CLOSED
- CREEP MODE: OFF
- 2-SPEED: SWITCH: OPEN
- 2-SPEED VALVE OUTPUT: OFF
- HIGH ENGINE SWITCH: OPEN
- DRIVE MODE: MID ENGINE
- DRV. ORIENTATION FEATURE:DISABLED
- DRV. ORIENTATION SWITCH: OPEN
- DRV. ORIENTATION OVERRIDE: OPEN
- DRV. ORIENTATION STATUS:CONFIRMED
- DRIVE CONTROL: NORMAL
- CRIBBING MODE: DISABLED

B DIAGNOSTICS: BOOM FUNCTIONS
- JOYSTICK LIFT: MAIN UP XXX%
- JOYSTICK SWING: LEFT XXX%
- LIFT OUTPUT: MAIN UP XXX%
- SWING OUTPUT: LEFT XXX%
- PLATFORM LEVEL: UP XXX%
- PLATFORM ROTATE: LEFT XXX%
- MAIN TELESCOPE: IN XXX%
- TOWER TELESCOPE: IN XXX%
- TOWER LIFT: UP XXX%
- JIB LIFT: UP XXX%
- PLATFORM CONTROL VALVE: OFF
- FUNCTION SPEED: PUMP POT XXX%
- CREEP SWITCH: CLOSED
- CREEP MODE: OFF

C DIAGNOSTICS: ENGINE
- START SEQUENCE: NOT ACTIVE
- BATTERY VOLTAGE: XX.XV
- COOLANT TEMPERATURE:XXXF
- ELECTRIC FAN OUTPUT: OFF
- ELECTRIC FUEL PUMP OUTPUT: OFF
- ENGINE OIL PRESSURE:XXX PSI
- FUEL SELECTION SWITCH: GAS
- AMBIENT TEMPERATURE:XXXF
- TOWER LIFT: UP XXX%
- FUEL LEVEL SENSOR: OK
- STARTER CRANK TIME: XX S
- ENGINE SPEED ACTUAL: XXXX RPM
- ENGINE SPEED TARGET: XXXX RPM

D DIAGNOSTICS: SYSTEM
- GROUND MODULE: BATTERY: XX:XV
- PLATFORM MODULE: BATTERY: XX:XV
- AMBIENT TEMPERATURE:XXXF
- PLATFORM SELECT KEYSWITCH: OPEN
- GROUND SELECT KEYSWITCH: OPEN
- STATION CONTROL: GROUND
- FOOTSWITCH INPUT GROUND: OPEN
- FOOTSWITCH INPUT PLATFORM: OPEN
- TRANSPORT SWITCHES: OPEN
- TRANSPORT MODE: OUT OF TRANSPORT
- END OF STROKE PROXIMITY:CLOSED
- TOWER LIFT PROXIMITY:CLOSED
- TOWER TELESCOPE PROXIMITY:CLOSED
- TOWER POSITION: RETRACTED
- CABLE BREAK SWITCH: CLOSED
- CREEP SWITCH: CLOSED
- CREEP MODE: OFF
- CHASSIS TILT: XX.X DEGREES
- CHASSIS TILT X-AXIS: XX.X
- CHASSIS TILT Y-AXIS: XX.X
- AUXILIARY POWER SWITCH: OPEN
- HORN SWITCH: OPEN
- RETURN HYDRAULIC FILTER: OPEN
- CHARGE PUMP FILTER: OPEN
- SOFT TOUCH LIMIT SWITCH: OPEN
- SOFT TOUCH OVERRIDE: OPEN
- GENSET.WELDER SWITCH: OPEN
- LIGHTS SWITCH: OPEN
- PLATFORM TILT1 ANGLE: XX.X
- PLATFORM TILT2 ANGLE: XX.X
- PLATFORM TILT1 VOLTAGE: XX MV
- PLATFORM TILT2 VOLTAGE: XX MV

E DIAGNOSTICS: DATALOG
- DATALOG: ON: XXXh XXm
- DATALOG: ENGINE: XXXh XXm
- DATALOG: DRIVE: XXXh XXm
- DATALOG: LIFT: XXXh XXm
- DATALOG: SWING: XXXh XXm
- DATALOG: TELE: XXXh XXm
- DATALOG: MAX TEMP: XXXF
- DATALOG: MIN TEMP: XXXF
- DATALOG: MAX VOLTS: XX.XV
- DATALOG: RENTAL: XXXh XXm
- DATALOG: ERASE RENTAL? 1 → CLEAR RENTAL: YES:ENTER,NO:ESC 1

F DIAGNOSTICS: VERSIONS
- GROUND MODULE SOFTWARE: XX.XX
- GROUND MODULE COST. DATA:XX.XX
- GROUND MODULE HARDWARE: REV XX
- GROUND MODULE S/N: XXXXXX
- PLATFORM MODULE SOFTWARE: XX.XX
- PLATFORM MODULE HARDWARE: REV XX
- PLATFORM MODULE S/N: XXXXXX
- PROPULSION MOD SOFTWARE: XX.XX
- TCU MODULE SOFTWARE: XX.XX
- TCU MODULE HARDWARE: XX.XX
- TCU MODULE S/N: XXXXXX
- GATEWAY MODULE SOFTWARE: XX.XX
- GATEWAY MODULE HARDWARE: REV XX
- ANALYZER ANALYZER: XX.XX

Figure 6-12. Analyzer Flow Chart, Version 6.X Software - Sheet 2 of 3

Figure 6-13. Analyzer Flow Chart, Version 6.X Software - Sheet 3 of 3

6.7 MACHINE PERSONALITY SETTINGS

NOTE: *Adjust personality settings within range for optimum machine performance.*

Table 6-1. Personality Ranges/Defaults

FUNCTION	PERSONALITY	RANGE	DEFAULTS
DRIVE	ACCELeration	0.1s to 5.0s	1.5
	DECELeration	0.1s to 3.0s	1.5
	MINimum speed	0 to 35%	30
	MAXimum speed	0 to 100%	50
	REVerse MINimum speed	0 to 35%	30
	REVerse MAXimum speed	0 to 100%	50
	ELEVATED MAXimum speed	0 to 50%	38
	CREEP MAXimum speed	0 to 50%	40
	Engine RPM	800 to 2900	1800
TOWER LIFT	ACCELeration	0.1 to 5.0	1.0
	DECELeration	0.1 to 3.0	1.0
	MINimum UP speed	0 to 60%	28
	MAXimum UP speed	0 to 100%	45
	MINimum DOWN speed	0 to 60%	27
	MAXimum DOWN speed	0 to 100%	42
	Engine RPM	800 to 2900	1800
UPPER LIFT	ACCELeration	0.1 to 5.0	2.0
	DECELeration	0.1 to 3.0	1.0
	MINimum UP speed	0 to 60%	36
	MAXimum UP speed	0 to 100%	50
	CREEP Maximum UP speed	0 to 65%	40
	MINimum DOWN speed	0 to 60%	29
	MAXimum DOWN speed	0 to 100%	48
	CREEP maximum DOWN speed	0 to 75%	37
	Engine RPM	800 to 2900	1800

Table 6-1. Personality Ranges/Defaults

FUNCTION	PERSONALITY	RANGE	DEFAULTS
SWING	ACCELeration	0.1 to 5.0s	2.0
	DECELeration	0.1 to 3.0s	1.5
	MINimum LEFT speed	0 to 50%	32
	MAXimum LEFT speed	0 to 100%	58
	CREEP maximum LEFT speed	0 to 65%	40
	MINimum RIGHT speed	0 to 50%	38
	MAXimum RIGHT speed	0 to 100%	58
	CREEP maximum RIGHT speed	0 to 65%	40
	Engine RPM	800 to 2900	1400
TELESCOPE UPPER	ACCELeration	0.1 to 5.0	2.0
	DECELeration	0.1 to 3.0	1.0
	MINimum IN speed	0 to 65%	27
	MAXimum IN speed	0 to 100%	40
	MINimum OUT speed	0 to 65%	27
	MAXimum OUT speed	0 to 100%	37
	Engine RPM	800 to 2900	1800
BASKET LEVEL	ACCELeration	0.1 to 5.0	2.5
	DECELeration	0.1 to 3.0	0.5
	MINimum UP speed	0 to 65%	15
	MAXimum UP speed	0 to 100%	25
	MINimum DOWN speed	0 to 65%	17
	MAXimum DOWN speed	0 to 100%	25
	Engine RPM	800 to 2900	1500
BASKET ROTATE	ACCELeration	0.1 to 5.0	2.0
	DECELeration	0.1 to 3.0	0.5
	MINimum LEFT speed	0 to 65%	15
	MAXimum LEFT speed	0 to 100%	25
	MINimum RIGHT speed	0 to 65%	15
	MAXimum RIGHT speed	0 to 100%	25
	Engine RPM	800 to 2900	1500

Table 6-1. Personality Ranges/Defaults

FUNCTION	PERSONALITY	RANGE	DEFAULTS
JIB LIFT	ACCELeration	0.1 to 5.0	3.0
	DECELeration	0.1 to 3.0	0.5
	MINimum UP speed	0 to 65%	16
	MAXimum UP speed	0 to 100%	40
	MINimum DOWN speed	0 to 65%	16
	MAXimum DOWN speed	0 to 100%	27
	Engine RPM	800 to 2900	1800
STEER	MAXimum speed	0 to 100%	100
	Engine RPM	800 to 2900	1800
GROUND MODE	Tower LIFT UP speed	0 to 100%	42
	Tower LIFT DOWN speed	0 to 100%	37
	Upper LIFT UP	0 to 100%	50
	Upper LIFT DOWN	0 to 100%	60
	SWING speed	0 to 100%	60
	Upper TELEscope speed	0 to 100%	43
	BASKET ROTATE speed	0 to 100%	50
	BASKET LEVEL speed	0 to 100%	50
	JIB LIFT speed	0 to 100%	25

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Table 6-2. Machine Configuration Programming Information Prior to Software Version P5.3

Configuration Digit	Number	Description	Default Number
MODEL NUMBER: 1	1 2 3 4 5 6 7 8 9 10	400S 450A 510A 600S 600A 600SC 601S 740A 800A 800S	1
MARKET: 2	0 1 2 3 4 5	ANSI USA ANSI EXPORT CSA CE AUSTRALIA JAPAN	0
ENGINE: 3* * Engine selections vary depending on model selection.	1 2 3 4 5 6 7 8 9 10 11	FORD EFI GAS: Ford LRG425 EFI Gas (Tier 1) FORD EFI D/F: Ford LRG425 EFI dual fuel (Tier 1) DEUTZ F4 TIER1: Deutz F4M1011F Diesel (Tier 1) DEUTZ F3 TIER1: Deutz F3M1011F Diesel (Tier 1) CAT. 3024C: CAT 3024C Diesel (Tier 2) CAT. 3044C: CAT 3044C Diesel (Tier 2) DEUTZ F4 TIER2: Deutz F4M2011 Diesel (Tier 2) DEUTZ F3 TIER2: Deutz F3M2011 Diesel (Tier 2) FORD GAS TIER2: Ford LRG425 EFI Gas (Tier 2) FORD D/F TIER2: Ford LRG425 EFI Dual Fuel (Tier 2) DEUTZ ECM: Engine Control Module - ECM	11
FLYWHEEL TEETH: 4* * This menu item is only visible if Deutz engine selections 3 or 4 are selected.	0 1	133 TEETH: 133 flywheel teeth. 110 TEETH: 110 flywheel teeth.	1

Table 6-2. Machine Configuration Programming Information Prior to Software Version P5.3

Configuration Digit	Number	Description	Default Number
GLOW PLUG: 5	0	NO GLOW PLUGS: No glow plugs installed.	1
	1	W/O STARTER LOCK: Automatic pre-glow time determined by ambient air temperature; engine start can be attempted at any time during pre-glow.	
	2	W/ STARTER LOCK: Automatic pre-glow time determined by ambient air temperature; engine start is NOT permitted until pre-glow is finished.	
ENGINE SHUTDOWN: 6	0	DISABLED: No engine shutdown.	1
	1	ENABLED: Shutdown engine when coolant temperature is greater than 110 deg. C or oil pressure is less than 8 psi.	
TILT: 7* * Certain market selections will limit tilt options.	1	5 DEGREES: Reduces the maximum speed of all boom functions to creep when tilted more than 5 degrees and above elevation; also reduces drive speed to creep.	1
	2	4 DEGREES: Reduces maximum speed of all boom functions to creep when tilted more than 4 degrees and above elevation; also reduces drive speed to creep.	
	3	3 DEGREES: Reduces maximum speed of all boom functions to creep when tilted more than 3 degrees and above elevation; also reduces drive speed to creep.	
	4	4 DEGREES + CUT: Reduces maximum speed of all boom functions to creep when tilted more than 4 degrees and above elevation; also disallows tower lift up, tower telescope out, drive, main telescope out, and main lift up.	
	5	3 DEGREES + CUT: Reduces maximum speed of all boom functions to creep when tilted more than 3 degrees and above elevation; also disallows tower lift up, tower telescope out, drive, main telescope out, and main lift up. *Note: Any selections above will light the tilt lamp when a tilted condition occurs and sound the platform alarm when machine is above elevation.*	
JIB: 8* * Only visible under certain model selections	0	NO: No jib installed.	0
	1	YES: Jib installed which has up and down movements only.	
4 WHEEL STEER: 9* * Only visible under certain model selections.	0	NO: No four-wheel steer installed.	0
	1	YES: Four-wheel steer installed.	
SOFT TOUCH: 10* * Only visible under certain model selections.	0	NO: No soft touch system installed.	0
	1	YES: Soft touch system installed.	
GEN SET/WELDER: 11	0	NO: No generator installed.	0
	1	BELT DRIVE: Belt driven setup.	

Table 6-2. Machine Configuration Programming Information Prior to Software Version P5.3

Configuration Digit	Number	Description	Default Number
GEN SET CUTOUT: 12* * Only visible if Gen Set / Welder Menu selection is not 0.	0 1	MOTION ENABLED: Motion enabled when generator is ON. MOTION CUTOUT: Motion cutout in platform mode only.	0
H & T LIGHTS: 13	0 1	NO: No head and tail lights installed. YES: Head and tail lights installed.	0
CABLE SWITCH: 14* * Only visible under certain model selections. * Certain market and model selections will alter the default setting.	0 1	NO: No broken cable switch installed. YES: Broken cable switch installed.	0
LOAD SYSTEM: 15* * Only visible under certain model selections. * Certain market selections will limit load system options or alter default setting.	0 1 2 3 4	NO: No load sensor installed. WARN ONLY: Functions in creep, overload lamp lit, platform alarm beeps (5 sec ON, 2 sec OFF). CUTOUT PLATFORM: All functions cutout, overload lamp lit, platform alarm beeps (5 sec ON, 2 sec OFF). CUTOUT ALL: All functions cutout, flash overload light (500mS on, 500mS off), platform alarm beeps (5 sec ON, 2 sec OFF). SPECIAL 1: Functions in creep, overload lamp lit, disables main telescope out & main lift up, platform alarm beeps (5 sec ON, 2 sec OFF).	0
LOAD SENSOR: 16* * Only visible if Load Sensor Menu selection is not 0. * Market selections will limit certain load sensor options.	0 1	1 ON ROTATOR: Use the on-board load sensor for all models except those which use the Leveling Platform Module. 4 UNDER PLATFORM: Use the EIM for load sensing.	1
FUNCTION CUTOUT: 17* * Only visible under certain market selections. * Certain market selections will limit function cutout options or alter default setting.	0 1 2 3	NO: No drive cutout. BOOM CUTOUT: Boom function cutout while driving above elevation. DRIVE CUTOUT: Drive cutout above elevation. DRIVE CUT E&T: Drive cutout above elevation and tilted.	0

Table 6-2. Machine Configuration Programming Information Prior to Software Version P5.3

Configuration Digit	Number	Description	Default Number
GROUND ALARM: 18* * Certain market selections will alter default setting.	0 1 2 3	NO: No ground alarm installed. DRIVE: Travel alarm sounds when the drive function is active (Option). DESCENT: Descent alarm sounds when lift down is active (Option). MOTION: Motion alarm sounds when any function is active (Option).	0
DRIVE: 19* * Only visible under certain model selections.	0 1 2	4WD: Four wheel drive. 2WD: Two wheel drive. 2WD W/ 2-SPEED: Two wheel drive with 2-speed valve.	0
TEMPERATURE: 20	0 1	CELSIUS: Celsius unit selection. FAHRENHEIT: Fahrenheit unit selection.	1
LEVELING MODE: 21* * Only visible on 800S models.	0 1	ALL FUNCTIONS: Platform level with all functions. LEVEL LIFT/TELESCOPE: Platform level on lift and telescope only.	0

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Table 6-3. Machine Configuration Programming Information Software Version P5.3 to P6.1

Configuration Label/ Digit	Number	Description	Default Number
MODEL NUMBER: 1	1	400S	1
	2	450A	
	3	510A	
	4	600S	
	5	600A	
	6	600SC	
	7	601S	
	8	740A	
	9	800A	
	10	800S	
MARKET: 2	0	ANSI USA	0
	1	ANSI EXPORT	
	2	CSA	
	3	CE	
	4	AUSTRALIA	
	5	JAPAN	

Table 6-3. Machine Configuration Programming Information Software Version P5.3 to P6.1

Configuration Label/ Digit	Number	Description	Default Number
ENGINE: 3* * Engine selections vary depending on model selection.	1	FORD EFI GAS: Ford LRG425 EFI Gas (Tier 1)	7
	2	FORD EFI D/F: Ford LRG425 EFI dual fuel (Tier 1)	
	3	DEUTZ F4 TIER1: Deutz F4M1011F Diesel (Tier 1)	
	4	DEUTZ F3 TIER1: Deutz F3M1011F Diesel (Tier 1)	
	5	CAT. 3024C: CAT 3024C Diesel (Tier 2)	
	6	CAT. 3044C: CAT 3044C Diesel (Tier 2)	
	7	PERKINS 404C (Tier 2)	
	8	DEUTZ F4 TIER2: Deutz F4M2011 Diesel (Tier 2)	
	9	DEUTZ F3 TIER2: Deutz F3M2011 Diesel (Tier 2)	
	10	FORD GAS TIER2: Ford LRG425 EFI Gas (Tier 2)	
	11	FORD D/F TIER2: Ford LRG425 EFI Dual Fuel (Tier 2)	
	12	DEUTZ ECM: Engine Control Module - ECM	
	13	DUAL FUEL ECM: GM/PSI 3.0L Dual Fuel (Tier 2)	
FLYWHEEL TEETH: 4* * This menu item is only visible if Deutz engine selections 3 or 4 are selected.	0	133 TEETH: 133 flywheel teeth.	1
	1	110 TEETH: 110 flywheel teeth.	
GLOW PLUG: 5	0	NO GLOW PLUGS: No glow plugs installed.	2
	1	AIR INTAKE: Glow plugs installed in the air intake on the manifold.	
	2	IN-CYLINDER: Glow plugs installed in each cylinder.	
STARTER LOCKOUT: 6	0	DISABLED: Automatic pre-glow time determined by ambient air temperature; engine start can be attempted at any time during pre-glow.	0
	1	ENABLED: Automatic pre-glow time determined by ambient air temperature; engine start is NOT permitted until pre-glow is finished.	

Table 6-3. Machine Configuration Programming Information Software Version P5.3 to P6.1

Configuration Label/ Digit	Number	Description	Default Number
ENGINE SHUTDOWN: 7	0 1	DISABLED: No engine shutdown. ENABLED: Shutdown engine when coolant temperature is greater than 110 deg. C or the oil pressure is less than 8 PSI.	1
TILT: 8* * Certain market selections will limit tilt options and alter default setting. *Note: Any of the selections above will light the tilt lamp when a tilted condition occurs and will sound the platform alarm when the machine is also above elevation.*	1 2 3 4 5	5 DEGREES: Reduces the maximum speed of all boom functions to creep when tilted more than 5 degrees and above elevation; also reduces drive speed to creep. 4 DEGREES: Reduces the maximum speed of all boom functions to creep when tilted more than 4 degrees and above elevation; also reduces drive speed to creep. 3 DEGREES: Reduces the maximum speed of all boom functions to creep when tilted more than 3 degrees and above elevation; also reduces drive speed to creep. 4 DEGREES + CUT: Reduces the maximum speed of all boom functions to creep when tilted more than 4 degrees and above elevation; also disallows tower lift up, tower telescope out, drive, main telescope out and main lift up. 3 DEGREES + CUT: Reduces the maximum speed of all boom functions to creep when tilted more than 3 degrees and above elevation; also disallows tower lift up, tower telescope out, drive, main telescope out and main lift up.	1
JIB: 9* * Only visible under certain model selections.	0 1	NO: No jib installed. YES: Jib installed which has up and down movements only.	0
4 WHEEL STEER: 10* * Only visible under certain model selections.	0 1	NO: No four-wheel steer installed. YES: Four-wheel steer installed.	0
SOFT TOUCH: 11* * Only visible under certain model selections.	0 1	NO: No soft touch system installed. YES: Soft touch system installed.	0
GEN SET/WELDER: 12	0 1	NO: No generator installed. BELT DRIVE: Belt driven setup.	0

Table 6-3. Machine Configuration Programming Information Software Version P5.3 to P6.1

Configuration Label/ Digit	Number	Description	Default Number
GEN SET CUTOUT: 13* * Only visible if Gen Set / Welder Menu selection is not 0.	0 1	MOTION ENABLED: Motion enabled when generator is ON. MOTION CUTOUT: Motion cutout in platform mode only.	0
H & T LIGHTS: 14	0 1	NO: No head and tail lights installed. YES: Head and tail lights installed.	0
CABLE SWITCH: 15* * Only visible under certain model selections. * Certain market and model selections will alter the default setting.	0 1	NO: No broken cable switch installed. YES: Broken cable switch installed.	0
LOAD SYSTEM: 16* * Only visible under certain market selections. * Certain market selections will limit load system options or alter default setting.	0 1 2 3 4	NO: No load sensor installed. WARN ONLY: Functions in creep, overload lamp lit, platform alarm beeps (5 sec ON, 2 sec OFF). CUTOUT PLATFORM: All functions cutout, overload lamp lit, platform alarm beeps (5 sec ON, 2 sec OFF). CUTOUT ALL: All functions cutout, flash overload light (500mS on, 500mS off), platform alarm beeps (5 sec ON, 2 sec OFF). SPECIAL 1: Functions in creep, overload lamp lit, disables main telescope out & main lift up, platform alarm beeps (5 sec ON, 2 sec OFF).	0
LOAD SENSOR: 17* * Only visible if Load Sensor Menu selection is not 0 and under certain market selections. * Certain market selections will limit load sensor options.	0 1	1 ON ROTATOR: Use the on-board load sensor for all models except those which use the Leveling Platform Module. 4 UNDER PLATFORM: Use the EIM for load sensing.	1

Table 6-3. Machine Configuration Programming Information Software Version P5.3 to P6.1

Configuration Label/ Digit	Number	Description	Default Number
FUNCTION CUTOUT: 18* * Only visible under certain market selections. * Certain market selections will limit function cutout options or alter default setting.	0 1 2 3	NO: No drive cutout. BOOM CUTOUT: Boom function cutout while driving above elevation. DRIVE CUTOUT: Drive & steer cutout above elevation. DRIVE CUT E&T: Drive & steer cutout above elevation and tilted.	0
GROUND ALARM: 19* * Certain market selections will alter default setting.	0 1 2 3	NO: No ground alarm installed. DRIVE: Travel alarm sounds when the drive function is active (Option). DESCENT: Descent alarm sounds when lift down is active (Option). MOTION: Motion alarm sounds when any function is active (Option).	3
DRIVE: 20* * Only visible under certain model selections.	0 1 2	4WD: Four wheel drive. 2WD: Two wheel drive. 2WD W/ 2-SPEED: Two wheel drive with 2-speed valve.	0
TEMPERATURE: 21* * Certain market selections will alter default setting.	0 1	CELSIUS: Celsius unit selection. FAHRENHEIT: Fahrenheit unit selection.	1
LEVELING MODE: 22* * Only visible on 800S models.	0 1	ALL FUNCTIONS: Platform level with all functions. LEVEL LIFT/TELESCOPE: Platform level on lift and telescope only.	0

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Table 6-4. Machine Configuration Programming Information Software Version P6.1 to Present

Configuration Label/ Digit	Number	Description	Default Number
MODEL NUMBER: 1	1	400S	1
	2	450A	
	3	510A	
	4	600S	
	5	600A	
	6	600SC	
	7	601S	
	8	740A	
	9	800A	
	10	800S	
MARKET: 2	0	ANSI USA	0
	1	ANSI EXPORT	
	2	CSA	
	3	CE	
	4	AUSTRALIA	
	5	JAPAN	

Table 6-4. Machine Configuration Programming Information Software Version P6.1 to Present

Configuration Label/ Digit	Number	Description	Default Number
ENGINE: 3* * Engine selections vary depending on model selection.	1	FORD EFI GAS: Ford LRG425 EFI Gas (Tier 1)	14
	2	FORD EFI D/F: Ford LRG425 EFI dual fuel (Tier 1)	
	3	DEUTZ F4 TIER1: Deutz F4M1011F Diesel (Tier 1)	
	4	DEUTZ F3 TIER1: Deutz F3M1011F Diesel (Tier 1)	
	5	CAT. 3024C: CAT 3024C Diesel (Tier 2)	
	6	CAT. 3044C: CAT 3044C Diesel (Tier 2)	
	7	PERKINS 404C (Tier 2)	
	8	DEUTZ F4 TIER2: Deutz F4M2011 Diesel (Tier 2)	
	9	DEUTZ F3 TIER2: Deutz F3M2011 Diesel (Tier 2)	
	10	FORD GAS TIER2: Ford LRG425 EFI Gas (Tier 2)	
	11	FORD D/F TIER2: Ford LRG425 EFI Dual Fuel (Tier 2)	
	12	DEUTZ ECM: Engine Control Module - ECM (Tier 2 and Tier 3)	
	13	DUAL FUEL ECM: GM/PSI 3.0L Dual Fuel (Tier 2)	
	14	PERKINS ECM	
	15	CAT ECM	
FLYWHEEL TEETH: 4* * This menu item is only visible if Deutz engine selections 3 or 4 are selected.	0	133 TEETH: 133 flywheel teeth.	1
	1	110 TEETH: 110 flywheel teeth.	
GLOW PLUG: 5	0	NO GLOW PLUGS: No glow plugs installed.	2
	1	AIR INTAKE: Glow plugs installed in the air intake on the manifold.	
	2	IN-CYLINDER: Glow plugs installed in each cylinder.	

Table 6-4. Machine Configuration Programming Information Software Version P6.1 to Present

Configuration Label/ Digit	Number	Description	Default Number
STARTER LOCKOUT: 6	0 1	DISABLED: Automatic pre-glow time determined by ambient air temperature; engine start can be attempted at any time during pre-glow. ENABLED: Automatic pre-glow time determined by ambient air temperature; engine start is NOT permitted until pre-glow is finished.	0
ENGINE SHUTDOWN: 7	0 1	DISABLED: No engine shutdown. ENABLED: Shutdown engine when coolant temperature is greater than 110 deg. C or the oil pressure is less than 8 PSI.	1
TILT: 8* * Certain market selections will limit tilt options and alter default setting. *Note: Any of the selections above will light the tilt lamp when a tilted condition occurs and will sound the platform alarm when the machine is also above elevation.*	1 2 3 4 5	5 DEGREES: Reduces the maximum speed of all boom functions to creep when tilted more than 5 degrees and above elevation; also reduces drive speed to creep. 4 DEGREES: Reduces the maximum speed of all boom functions to creep when tilted more than 4 degrees and above elevation; also reduces drive speed to creep. 3 DEGREES: Reduces the maximum speed of all boom functions to creep when tilted more than 3 degrees and above elevation; also reduces drive speed to creep. 4 DEGREES + CUT: Reduces the maximum speed of all boom functions to creep when tilted more than 4 degrees and above elevation; also disallows tower lift up, tower telescope out, drive, main telescope out and main lift up. 3 DEGREES + CUT: Reduces the maximum speed of all boom functions to creep when tilted more than 3 degrees and above elevation; also disallows tower lift up, tower telescope out, drive, main telescope out and main lift up.	1
JIB: 9* * Only visible under certain model selections.	0 1	NO: No jib installed. YES: Jib installed which has up and down movements only.	0
4 WHEEL STEER: 10* * Only visible under certain model selections.	0 1	NO: No four-wheel steer installed. YES: Four-wheel steer installed.	0
SOFT TOUCH: 11* * Only visible under certain model selections.	0 1	NO: No soft touch system installed. YES: Soft touch system installed.	0

Table 6-4. Machine Configuration Programming Information Software Version P6.1 to Present

Configuration Label/ Digit	Number	Description	Default Number
GEN SET/WELDER: 12	0 1	NO: No generator installed. BELT DRIVE: Belt driven setup.	0
GEN SET CUTOUT: 13* * Only visible if Gen Set / Welder Menu selection is not 0.	0 1	MOTION ENABLED: Motion enabled when generator is ON. MOTION CUTOUT: Motion cutout in platform mode only.	0
H & T LIGHTS: 14	0 1	NO: No head and tail lights installed. YES: Head and tail lights installed.	0
CABLE SWITCH: 15* * Only visible under certain model selections. * Certain market and model selections will alter the default setting.	0 1	NO: No broken cable switch installed. YES: Broken cable switch installed.	0
LOAD SYSTEM: 16* * Only visible under certain market selections. * Certain market selections will limit load system options or alter default setting.	0 1 2 3 4	NO: No load sensor installed. WARN ONLY: Functions in creep, overload lamp lit, platform alarm beeps (5 sec ON, 2 sec OFF). CUTOUT PLATFORM: All functions cutout, overload lamp lit, platform alarm beeps (5 sec ON, 2 sec OFF). CUTOUT ALL: All functions cutout, flash overload light (500mS on, 500mS off), platform alarm beeps (5 sec ON, 2 sec OFF). SPECIAL 1: Functions in creep, overload lamp lit, disables main telescope out & main lift up, platform alarm beeps (5 sec ON, 2 sec OFF).	0

Table 6-4. Machine Configuration Programming Information Software Version P6.1 to Present

Configuration Label/ Digit	Number	Description	Default Number
LOAD SENSOR: 17* * Only visible if Load Sensor Menu selection is not 0 and under certain market selections. * Certain market selections will limit load sensor options.	0 1	1 ON ROTATOR: Use the on-board load sensor for all models except those which use the Leveling Platform Module. 4 UNDER PLATFORM: Use the EIM for load sensing.	1
FUNCTION CUTOUT: 18* * Only visible under certain market selections. * Certain market selections will limit function cutout options or alter default setting.	0 1 2 3	NO: No drive cutout. BOOM CUTOUT: Boom function cutout while driving above elevation. DRIVE CUTOUT: Drive & steer cutout above elevation. DRIVE CUT E&T: Drive & steer cutout above elevation and tilted.	0
GROUND ALARM: 19* * Certain market selections will alter default setting.	0 1 2 3	NO: No ground alarm installed. DRIVE: Travel alarm sounds when the drive function is active (Option). DESCENT: Descent alarm sounds when lift down is active (Option). MOTION: Motion alarm sounds when any function is active (Option).	3
DRIVE: 20* * Only visible under certain model selections.	0 1 2	4WD: Four wheel drive. 2WD: Two wheel drive. 2WD W/ 2-SPEED: Two wheel drive with 2-speed valve.	0
TEMPERATURE: 21* * Certain market selections will alter default setting.	0 1	CELSIUS: Celsius unit selection. FAHRENHEIT: Fahrenheit unit selection.	1

Table 6-4. Machine Configuration Programming Information Software Version P6.1 to Present

Configuration Label/ Digit	Number	Description	Default Number
LEVELING MODE: 22* * Only visible on 800S models.	0 1	ALL FUNCTIONS: Platform level with all functions. LEVEL LIFT/TELESCOPE: Platform level on lift and telescope only.	0
DRIVE CONTROL: 23	0 1 2	NORMAL: Drive coils are energized from the Ground Module. PROPULSION: Drive coils are energized from the Propulsion Module. ENHANCED: Drive coils are energized from the Ground Module and the ground side of the drive coils are brought back to current feedback returns.	2
CLEARSKY: 24	0 1	NO: Clearsky (telematics) option is disabled. YES: Clearsky (telematics) option is enabled.	0
CRIBBING OPTION: 25	0 1	NO: Cribbing Option is disabled. YES: Cribbing Option is enabled.	0

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NOTE: *Bold Italic Numbers indicate default setting. Plain text indicates available selection. Bold, Italic underlined numbers indicate default when option is factory installed. Shaded cells indicate hidden menu or selection.*

450A Series II

	MODEL NUMBER	MARKET	ENGINE	FLYWHEEL TEETH		GLOW PLUGS			STARTER LOCKOUT		ENGINE SHUTDOWN		TILT					JIB	4 WHEEL STEER	SOFT TOUCH		GEN SET / WELDER		GEN SET CUTOUT	
ANSI USA	***2***	***0***	***7***	0	***1***	0	1	***2***	***0***	1	0	***1***	***1***	2	3	4	5	***0***	***0***	***0***	1	***0***	1	***0***	1
ANSI EXPORT	***2***	***1***	***7***	0	***1***	0	1	***2***	***0***	1	0	***1***	***1***	2	3	4	5	***0***	***0***	***0***	1	***0***	1	***0***	1
CSA	***2***	***2***	***7***	0	***1***	0	1	***2***	***0***	1	0	***1***	***1***	2	3	4	5	***0***	***0***	***0***	1	***0***	1	***0***	1
CE	***2***	***3***	***7***	0	***1***	0	1	***2***	***0***	1	0	***1***	X	***2***	3	4	5	***0***	***0***	***0***	1	***0***	1	***0***	1
AUSTRALIA	***2***	***4***	***7***	0	***1***	0	1	***2***	***0***	1	0	***1***	X	***2***	3	4	5	***0***	***0***	***0***	1	***0***	1	***0***	1
JAPAN	***2***	***5***	***7***	0	***1***	0	1	***2***	***0***	1	0	***1***	***1***	2	3	4	5	***0***	***0***	***0***	1	***0***	1	***0***	1

450A Series II

	HEAD & TAIL LIGHTS		CABLE BREAK SWITCH		LOAD SYSTEM					LOAD SENSOR		FUNCTION CUTOUT				GROUND ALARM				DRIVE TYPE			TEMPERATURE		LEVELING MODE	
ANSI USA	***0***	1	0	***1***	***0***	X	X	X	X	0	***1***	***0***	X	X	X	***0***	1	2	3	***0***	1	2	0	***1***	***0***	1
ANSI EXPORT	***0***	1	0	***1***	***0***	***1***	2	3	4	0	***1***	***0***	1	2	3	***0***	1	2	3	***0***	1	2	0	***1***	***0***	1
CSA	***0***	1	0	***1***	***0***	X	X	X	X	0	***1***	***0***	1	2	3	0	1	2	***3***	***0***	1	2	***0***	1	***0***	1
CE	***0***	1	0	***1***	0	X	2	***3***	X	0	***1***	0	***1***	X	X	0	1	2	***3***	***0***	1	2	***0***	1	***0***	1
AUSTRALIA	***0***	1	0	***1***	***0***	***1***	2	3	4	0	***1***	***0***	1	2	3	***0***	1	2	3	***0***	1	2	***0***	1	***0***	1
JAPAN	***0***	1	0	***1***	0	***1***	2	3	4	0	***1***	***0***	1	2	3	0	1	2	***3***	***0***	1	2	***0***	1	***0***	1

NOTE: *Bold Italic Numbers indicate default setting. Plain text indicates available selection. Bold, Italic underlined numbers indicate default when option is factory installed. Shaded cells indicate hidden menu or selection.*

450AJ Series II	MODEL NUMBER	MARKET	ENGINE	FLYWHEEL TEETH		GLOW PLUGS			STARTER LOCKOUT		ENGINE SHUTDOWN		TILT					JIB	4 WHEEL STEER	SOFT TOUCH		GEN SET / WELDER		GEN SET CUTOUT	
ANSI USA	***2***	***0***	***11***	0	***1***	0	***1***	2	***0***	1	0	***1***	***1***	2	3	4	5	***1***	***0***	***0***	1	***0***	1	***0***	1
ANSI EXPORT	***2***	***1***	***11***	0	***1***	0	***1***	2	***0***	1	0	***1***	***1***	2	3	4	5	***1***	***0***	***0***	1	***0***	1	***0***	1
CSA	***2***	***2***	***11***	0	***1***	0	***1***	2	***0***	1	0	***1***	***1***	2	3	4	5	***1***	***0***	***0***	1	***0***	1	***0***	1
CE	***2***	***3***	***11***	0	***1***	0	***1***	2	***0***	1	0	***1***	X	***2***	3	4	5	***1***	***0***	***0***	1	***0***	1	***0***	1
AUSTRALIA	***2***	***4***	***11***	0	***1***	0	***1***	2	***0***	1	0	***1***	X	***2***	3	4	5	***1***	***0***	***0***	1	***0***	1	***0***	1
JAPAN	***2***	***5***	***11***	0	***1***	0	***1***	2	***0***	1	0	***1***	***1***	2	3	4	5	***1***	***0***	***0***	1	***0***	1	***0***	1

450AJ Series II	HEAD & TAIL LIGHTS		CABLE BREAK SWITCH		LOAD SYSTEM					LOAD SENSOR		FUNCTION CUTOUT				GROUND ALARM				DRIVE TYPE			TEMPERATURE		LEVELING MODE	
ANSI USA	***0***	1	0	***1***	***0***	X	X	X	X	0	***1***	***0***	X	X	X	***0***	1	2	3	***0***	1	2	0	***1***	***0***	1
ANSI EXPORT	***0***	1	0	***1***	***0***	***1***	2	3	4	0	***1***	***0***	1	2	3	***0***	1	2	3	***0***	1	2	0	***1***	***0***	1
CSA	***0***	1	0	***1***	***0***	X	X	X	X	0	***1***	***0***	1	2	3	0	1	2	***3***	***0***	1	2	***0***	1	***0***	1
CE	***0***	1	0	***1***	0	X	2	***3***	X	0	***1***	0	***1***	X	X	0	1	2	***3***	***0***	1	2	***0***	1	***0***	1
AUSTRALIA	***0***	1	0	***1***	***0***	***1***	2	3	4	0	***1***	***0***	1	2	3	***0***	1	2	3	***0***	1	2	***0***	1	***0***	1
JAPAN	***0***	1	0	***1***	0	***1***	2	3	4	0	***1***	***0***	1	2	3	0	1	2	***3***	***0***	1	2	***0***	1	***0***	1

6.8 SYSTEM TEST

The Control System Incorporates a built-in system test to check system components and functions.

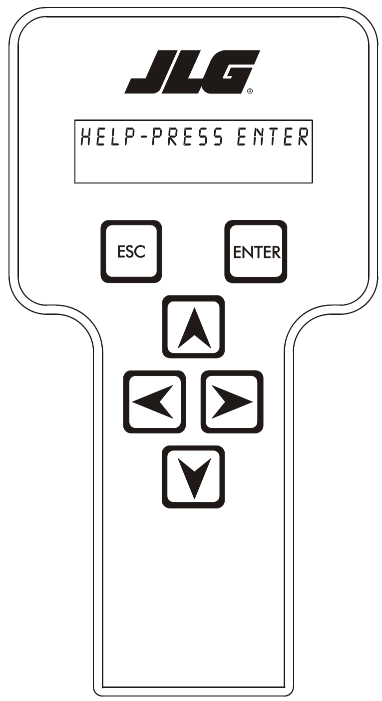
Test from Platform

1. Position Platform/Ground select switch to Platform.

2. Plug analyzer into connector at base of platform control box.

3. Pull out Emergency Stop switch and start engine.

4. The analyzer screen should read:



5. Use arrow button to reach SYSTEM TEST and press Enter. Analyzer prompts you asking if you want to activate the system test; press Enter again to activate.

6. Follow flow path in Figure 6-14., System Test Flow Chart - Platform Tests and go through component tests. Press ESC key during any part of test to return to main menu without completing all tests or wait until all tests are complete. During TEST ALL INPUTS sequence, the analyzer allows control switches to be operated and shows if they are closed (CL) or open (OP).

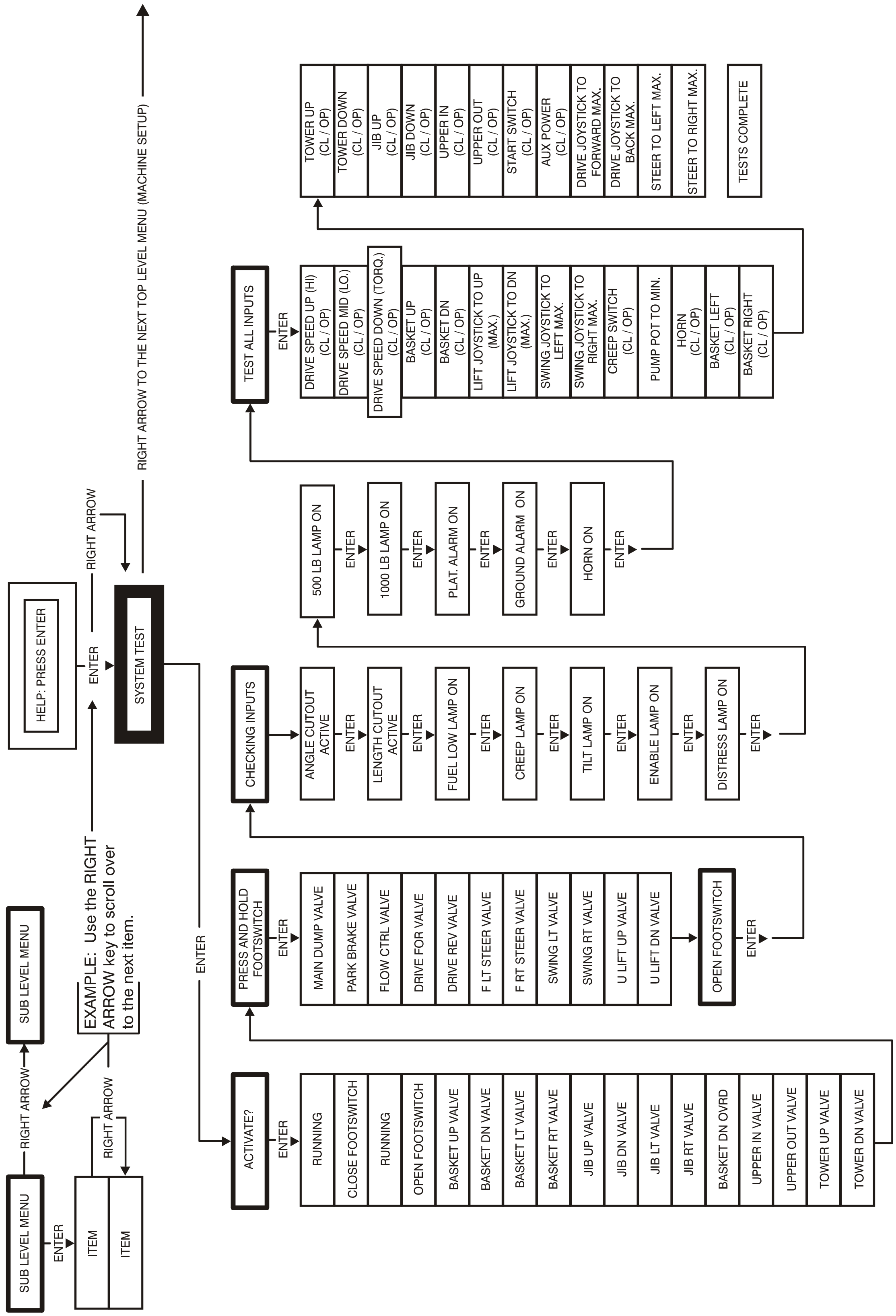
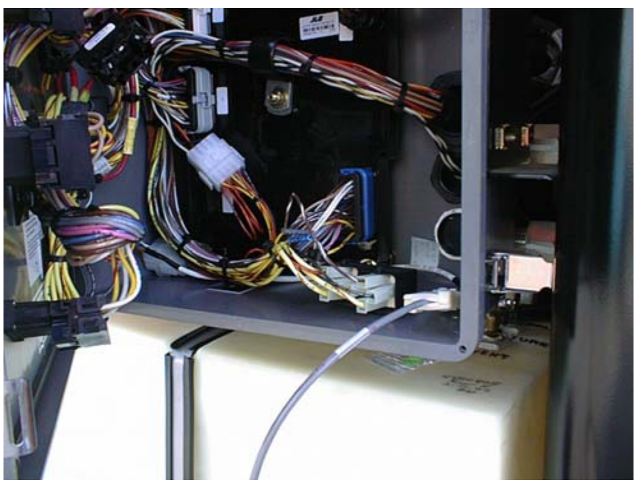


Figure 6-14. System Test Flow Chart - Platform Tests

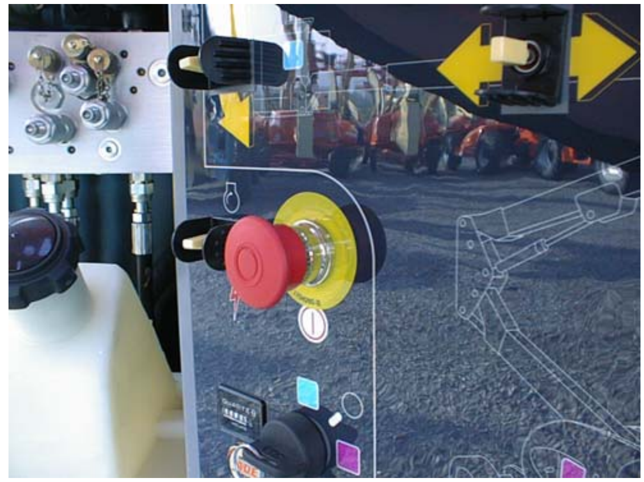
Test from the Ground Station

1. Set Platform/Ground select switch to Ground.

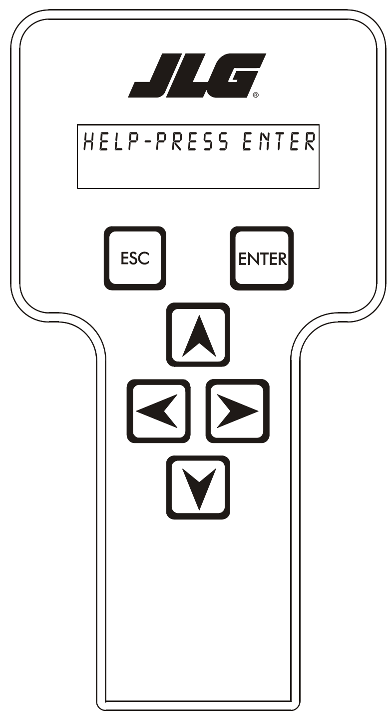
2. Plug analyzer into connector inside Ground control box.



3. Pull out the Emergency Stop switch. and Start the engine.



4. The analyzer screen should read:



5. Use arrow button to reach SYSTEM TEST. Press Enter. Analyzer will prompt you asking if you want to activate system test. Press Enter again to activate.

6. Follow flow path in Figure 6-15., System Test Flow Chart - Ground Station Tests and go through component tests. Press ESC key during any part of test to return to main menu without completing all tests or wait until all tests are complete. During TEST ALL INPUTS sequence, the analyzer allows control switches to be operated and shows if they are closed (CL) or open (OP).

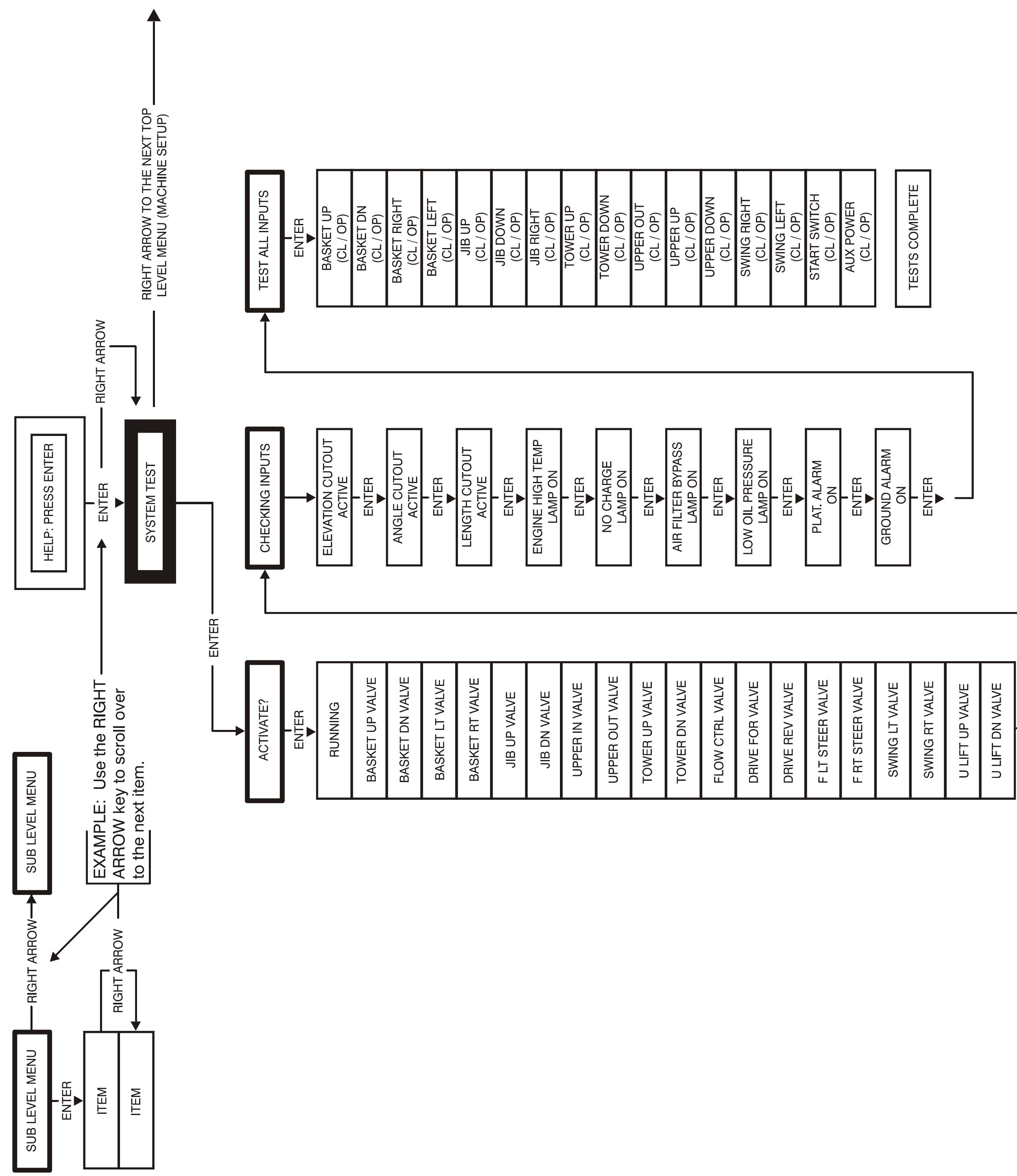


Figure 6-15. System Test Flow Chart - Ground Station Tests

Table 6-5. System Test Messages

Message Displayed on Analyzer	Message Displayed on Analyzer	Description
RUNNING		Initial display when system test is run; certain “critical” checks are made. Problems that can be reported include below messages.
	ONLY 1 ANALYZER!	Do not connect two Analyzers while running the system test.
	BATTERY TOO LOW	The system test cannot run with battery voltage below minimum (9 V).
	BATTERY TOO HIGH	The system test cannot run with battery voltage above maximum. (16 V).
	CHECK CAN WIRING	The system test cannot run in platform mode unless data is being received from the platform and ground modules. The system test cannot run in ground mode unless data is being received from the platform module.
	CHECK SPEED	There is an open- or short- circuit in the speed encoder wiring. Check speed encoder.
	BAD GROUND MODULE	An internal problem was detected in the ground module.
	HIGH TILT ANGLE	The vehicle is very tilted (19.3?), or the tilt sensor has been damaged. Check tilt sensor.
	HOT ENGINE	The engine temperature exceeds 100°C. This is only a warning.
	BAD I/O PORTS	The controller detected a problem with its internal circuits at switch on. If other problems are also detected, the controller may need replacing.
	SUSPECT EEPROM	The controller detected a problem with its EEPROM stored personality settings at switch on. Check and, if necessary correct, all personality settings.
	OPEN FSW	In platform mode, the footswitch must be open at the start of the test.
	CLOSE FSW	In platform mode, the footswitch must be closed when this message is displayed; the footswitch MUST BE KEPT CLOSED during the valve & contactor tests.
	BAD FSW	The two footswitch signals are not changing together, probably because one is open-circuit. One footswitch signal (“FSW1”) is routed to the power module, the other (“FSW2”) is routed to the platform module. Check footswitch and wiring.

Table 6-5. System Test Messages

Message Displayed on Analyzer	Message Displayed on Analyzer	Description
TESTING VALVES		Indicates valve test is beginning. Each valve is alternately energized and de-energized; checks are made for open- and short- circuit valve coils. NOTE: In platform mode, the footswitch must be closed. NOTE: Tower lift valves are not tested if TOWER LIFT=NO. Tower telescope valves are not tested if TOWER TELE=NO. Jib valves are not tested if JIB = NO. Extendable axle valves are not tested if EXT AXLES=NO. Four wheel steer valves are not tested if 4WS=NO. NOTE: Left/right jib valves are not tested unless JIB = SIDESWING. Problems that can be reported include below messages.
	CANT TEST VALVES	There is a wiring problem, which prevents the valve test from functioning correctly. Check valve wiring. Check ground alarm & hour meter wiring.
	XXXXXXX S/C	Named valve is drawing too much current so is presumed to be short-circuited. Check valve wiring.
	XXXXXXX O/C	Named valve is drawing too little current so is presumed to be open-circuit. Check valve wiring.
CHECKING INPUTS		Indicates inputs test is beginning. Every input is checked to ensure that it is in its “normal” position; function switches should be open, cutout switches should be closed, joysticks should be in neutral. In platform mode any non-neutral platform switch or joystick is reported; any active cutouts are reported. In ground mode any non-neutral ground switches is reported; any active cutouts are reported. NOTE: Switches not in use (due to the settings of machine digits), are not checked. NOTE: Pump pot is checked only for a wire-off condition; it can be at any demand from creep to maximum. Problems that can be reported include below messages.
	CHECK XXXXXXX	The named switch is not in its “normal” position. Check switch & wiring.
	CHECK XXXXXXX JOY	The named joystick appears to be faulty. Check joystick.
TESTING LAMPS		Indicates lamps test is beginning. Each lamp is energized in turn; a prompt asks for confirmation the lamp is lit. ENTER must be pressed or clicked to continue the test. NOTE: Lamps, which are not in use (due to the settings of machine digits), are not checked. NOTE: Platform Lamps are only tested in platform mode. NOTE: The GM overload lamp and 500# capacity lamp are not tested. NOTE: Head and tail lamps are tested in both platform and ground mode if enabled by a machine digit.
TESTING ALARMS		Indicates alarms test is beginning. Each alarm is energized in turn; a prompt asks for confirmation the alarm is sounding. ENTER must be pressed or clicked to continue test. NOTE: Platform alarm and horn are only tested in platform mode. NOTE: Ground alarm is not tested if GROUND ALARM = NO.

Table 6-5. System Test Messages

Message Displayed on Analyzer	Message Displayed on Analyzer	Description
TEST ALL INPUTS?		Prompts whether to check every operator input. If ESC is pressed or clicked, system test ends. If ENTER is pressed or clicked, each operator input is prompted for in turn. In platform mode every platform switch and joystick is tested. In ground mode every ground switch is tested. NOTE: Tower lift switches are not tested if TOWER LIFT=NO. Tower telescope switches are not tested if TOWER TELE=NO. Jib switches are not tested if JIB = NO. Extendable axle switches are not tested if EXT AXLES=NO. Four wheel steer switches are not tested if 4WS=NO. NOTE: Left/right jib switches are not tested unless JIB = SIDESWING. Prompts displayed during the operator input test below messages.
	CLOSE XXXXXXX	Named switch should be closed.
	OPEN XXXXXXX	Named switch should be opened.
	XXXXXXX XXXXXXX TO MAX	Named joystick should be pushed to its full extent in the named direction.
	XXXXXXX XXXXXXX TO MIN	Named joystick should be returned to neutral from the named direction.
	PUMP POT TO MAX	Pump pot should be turned to maximum.
	PUMP POT TO MIN	Pump pot should be turned to minimum.
	MULTIPLE CLOSURE	More than one operator input is closed; if only one has been operated, there could be a short between two inputs.
TESTS COMPLETE		Indicates system test is complete. Problems reported should have been noted and now be rectified. Press ESC/CANCEL to return to RUN SYSTEM TEST Analyzer menu.

Table 6-6. Machine Diagnostics Parameters

Diagnostics Submenu (Displayed on Analyzer 1st Line)	Parameter (Displayed on Analyzer 2nd Line)	Parameter Value (Displayed on Analyzer 2nd Line)	Description
DRIVE:			
	DRIVE	FOR/REV XXX%	Displays drive joystick direction & demand
	STEER	RIGHT/LEFT XXX%	Displays steer switch direction & demand
	4WS	NORMAL/COOR/CRAB	Displays status of four wheel steer input (Displayed if 4WS = 1)
	BRAKES	LOCKED/RELEASED	Displays brake control system status
	CREEP	ACTIVE/NOT ACTIVE	Displays pump pot creep switch status
	CRP MODE	ACTIVE/NOT ACT	Displays creep mode status
	QPRX1	ACTIVE/NOT ACTIVE	Displays status of Q-Prox sensor in drive joystick (Displayed if JOYSTICK TYPE = 1)
	QPRX2	ACTIVE/NOT ACTIVE	Displays status of Q-Prox sensor in drive joystick (Displayed if JOYSTICK TYPE = 1)
	TWO SPEED	OP/CL	Displays status of two speed switch input if selected model has two speed.
	2 speed mode	ON/OFF	Displays status of two speed valve if selected model has two speed
	high engine	OP/CL	Displays status of high engine switch
	LT F ANG	XX.X	Displays status of left front steer angle (Displayed if MODEL NUMBER = 7 or 8)
	RT F ANG	XX.X	Displays status of right front steer angle (Displayed if MODEL NUMBER = 7 or 8)
	LT R ANG	XX.X	Displays status of left rear steer angle (Displayed if MODEL NUMBER = 7 or 8)
	RT R ANG	XX.X	Displays status of right rear steer angle (Displayed if MODEL NUMBER = 7 or 8)
	DOS LIM sw	OP/CL	Displays status of Drive Orientation System limit switch. (Displayed if MODEL NUMBER = 7 or 8)
	DOS O/R sw	OP/CL	Displays status of Drive Orientation Limit System override switch. (Displayed if MODEL NUMBER = 7 or 8)

Table 6-6. Machine Diagnostics Parameters

Diagnostics Submenu (Displayed on Analyzer 1st Line)	Parameter (Displayed on Analyzer 2nd Line)	Parameter Value (Displayed on Analyzer 2nd Line)	Description
BOOM:			
	U LIFT	UP/DOWN XXX%	Displays upper lift joystick direction & demand
	SWING	RIGHT/LEFT XXX%	Displays swing joystick direction & demand
	QPRX1	ACTIVE/NOT ACTIVE	Displays status of Q-Prox sensor in lift/swing joystick (Displayed if JOYSTICK TYPE = 1)
	QPRX2	ACTIVE/NOT ACTIVE	Displays status of Q-Prox sensor in lift/swing joystick (Displayed if JOYSTICK TYPE = 1)
	LEVEL	UP/DOWN XXX%	Displays basket level switch direction & demand. NOTE: demand is controlled by the pump pot
	ROT.	RIGHT/LEFT XXX%	Displays basket rotate switch direction & demand. NOTE: demand is controlled by the pump pot
	U TELE	IN/OUT XXX%	Displays upper telescope switch direction & demand. NOTE: demand is controlled by the pump pot
	T TELE	IN/OUT XXX%	Displays tower telescope switch direction & demand. NOTE: demand is controlled by the pump pot Not displayed if TOWER TELE=NO (machine digit = 0)
	T LIFT	UP/DOWN XXX%	Displays tower lift switch direction & demand. NOTE: demand is controlled by the pump pot Not displayed if TOWER LIFT=NO (machine digit = 0)
	JIB	UP/DOWN XXX%	Displays jib lift switch direction & demand. NOTE: demand is controlled by the pump pot Not displayed if JIB = NO (machine digit = 0)
	JIB	RIGHT/LEFT XXX%	Displays jib swing switch direction & demand. NOTE: demand is controlled by the pump pot Displayed if JIB = SIDESWING (machine digit = 2)
	JIB INLINE	OP/CL	Displays status of jib inline limit switch. Displayed on models equipped with the Jib Stow System
	JIB LIMIT	OP/CL	Displays status of jib right limit switch. Displayed on models equipped with the Jib Stow System
	JIB LIM OVRD	OP/CL	Displays status of jib limit override switch. Displayed on models equipped with the Jib Stow System
	PCV	ON/OFF	Displays status of Platform Control Valve. Displayed on models equipped with Electronic Platform Leveling.
	PUMP POT	XXX%	Displays pump pot demand. Not displayed if MODEL = 601 (machine digit = 4)
	CREEP	ACTIVE/NOT ACTIVE	Displays pump pot creep switch status
	CRP MODE	ACTIVE/NOT ACT	Displays creep mode status

Table 6-6. Machine Diagnostics Parameters

Diagnostics Submenu (Displayed on Analyzer 1st Line)	Parameter (Displayed on Analyzer 2nd Line)	Parameter Value (Displayed on Analyzer 2nd Line)	Description
ENGINE:			
	START	ACTIVE/NOT ACTIVE	Displays status of the engine start circuit
	AIR FILTER	OP/CL	Displays measured status of air filter by-pass switch. (Not displayed if MODEL NUMBER = 7 or 8)
	BATTERY	XX.XV	Displays measured battery voltage
	COOLANT	XXXC	Displays measured coolant temperature
	OIL PRS	LOW / OK or XXPSI	Displays measured oil pressure
	FUEL SELECT	GAS/LP	Displays status of fuel select switch. (Displayed if MODEL NUMBER = 2)
	AMB. TEMP	XXXC	Displays measured ambient air temperature
	FUEL LEVEL	? / ? / ? / FULL or LOW / OK	Displays measured fuel level
	XXXX rpm		Engine RPM

Table 6-6. Machine Diagnostics Parameters

Diagnostics Submenu (Displayed on Analyzer 1st Line)	Parameter (Displayed on Analyzer 2nd Line)	Parameter Value (Displayed on Analyzer 2nd Line)	Description
SYSTEM:			
	GM BATTERY	XX.XV	Ground module battery voltage
	PM BATTERY	XX.XV	Platform module battery voltage
	AMB. TEMP	XXXC	Ambient temperature
	FSW1	OP/CL	Displays footswitch status. NOTE: FSW1 is wired to the ground module.
	FSW2	OP/CL	Displays footswitch status. NOTE: FSW2 is wired to the platform module.
	ABOVE ELEV.	OP/CL/YES/NO	Displays above elevation cutout switch status or above angle status
	LEN SW 1	OP/CL	Displays status of boom length retracted limit switch (Displayed if MODEL NUMBER = 7 or 8)
	LEN SW 2	OP/CL	Displays status of boom length retracted limit switch (Displayed if MODEL NUMBER = 7 or 8)
	RETRACTED	YES/NO	Displays status of boom length retracted (Displayed if MODEL NUMBER = 7 or 8)
	TRANSPORT	YES/NO	Displays status of transport position
	U LIFT CUTOUT	OP/CL	Displays status of boom length retracted limit switch (Displayed if MODEL NUMBER = 6)
	T LIFT PROX	OP/CL	Displays status of tower lift proximity switch (Displayed if TOWER PROX SWITCHES = 1)
	T TELE PROX	OP/CL	Displays status of tower telescope proximity switch (Displayed if TOWER PROX SWITCHES = 1)
	BR CABLE CUT.	OP/CL	Displays status of broken cable switch (Displayed if BROKEN CABLE SWITCH = 1)
	CREEP	ACTIVE/NOT ACTIVE	Displays pump pot creep switch status. Not displayed if MODEL = 601 (machine digit = 4)
	CRP MODE	ACTIVE/NOT ACT	Displays creep mode status
	SUPER CREEP	ON/OFF	Displays super creep mode status (Displayed if MODEL NUMBER = 7 or 8)
	TILT	XX.X DEG	Displays measured vehicle tilt. (Displayed if internal tilt sensor is configured)
	LO TILTED -	NO/YES	Displays status of lo tilt input. (Displayed if external tilt sensor is configured)

Table 6-6. Machine Diagnostics Parameters

Diagnostics Submenu (Displayed on Analyzer 1st Line)	Parameter (Displayed on Analyzer 2nd Line)	Parameter Value (Displayed on Analyzer 2nd Line)	Description
	HI TILTED -	NO/YES	Displays status of hi tilt input. (Displayed if external tilt sensor is configured)
	AUX POWER	OP/CL	Displays the status of the auxiliary power switch input
	HORN	OP/CL	Displays the status of the horn input
	R FILTER	OP/CL	Displays the status of the return hydraulic filter by-pass switch. Displayed ONLY if MODEL = 600 (Configuration digit = 3)
	C FILTER	OP/CL	Displays measured status of charge pump filter bypass switch. Displayed ONLY if MODEL = 600 (Configuration digit = 3)
	JIB BLOCK	OP/CL	Jib block limit switch status. Not displayed if associated configuration digit = 0
	BASKET STOWD	YES/NO	Status of basket stowed mode. (Displayed if MODEL NUMBER = 7 or 8)
	SOFT LIMIT	OP/CL	Status of soft touch limit switch. Not displayed if associated configuration digit = 0
	SOFT O/R	OP/CL	Status of soft touch override switch. Not displayed if associated configuration digit = 0
	GEN SET/WELDER	OP/CL	Generator/welder switch input status. Not displayed if associated configuration digit = 0
	LIGHTS	OP/CL	Head and tail light switch input status. Not displayed if associated configuration digit = 0
	BSK TILT1	XX.X	Indicated platform tilt angle. Displayed on models equipped with Electronic Platform Leveling.
	BSK TILT2	XX.X	Indicated platform tilt angle. Displayed on models equipped with Electronic Platform Leveling.
	AXLE RET SW	OP/CL	Status of axle extension user switches. (Displayed if MODEL NUMBER = 7 or 8)
	AXLE EXT SW	OP/CL	Status of axle retraction user switches. (Displayed if MODEL NUMBER = 7 or 8)
	AXLE LIM SW	RET/EXT	Status of axle extension limit switches. (Displayed if MODEL NUMBER = 7 or 8)
	DOS LIM SW	OP/CL	Drive Orientation System Limit Switch status. (Displayed if MODEL NUMBER = 7 or 8)
	DOS O/R SW	OP/CL	Drive Orientation System Override switch status. (Displayed if MODEL NUMBER = 7 or 8)
	CAPACITY SW	500/1000	Capacity selection switch status. (Displayed if MODEL NUMBER = 7 or 8)

Table 6-6. Machine Diagnostics Parameters

Diagnostics Submenu (Displayed on Analyzer 1st Line)	Parameter (Displayed on Analyzer 2nd Line)	Parameter Value (Displayed on Analyzer 2nd Line)	Description
	osc axle p sw	OP/CL	Oscillating axle pressure switch status. (Displayed if OSCILLATING AXLE = 1)
	sky welder	YES/NO	Status of Sky Welder selected during boom sensor calibration. (Displayed if MODEL NUMBER = 7 or 8)
	sky cutter	YES/NO	Status of Sky Cutter status selected during boom sensor calibration. (Displayed if MODEL NUMBER = 7 or 8)
	sky glazier	YES/NO	Status of Sky Glazier selected during boom sensor calibration. (Displayed if MODEL NUMBER = 7 or 8)
	sky Bright	YES/NO	Status of Sky Bright selected during boom sensor calibration. (Displayed if MODEL NUMBER = 7 or 8)
	Pipe Racks	YES/NO	Status of Pipe Racks selected during boom sensor calibration. (Displayed if MODEL NUMBER = 7 or 8)
	Camera mount	YES/NO	Status of Camera Mount selected during boom sensor calibration. (Displayed if MODEL NUMBER = 7 or 8)
LOAD:			Not displayed if LOAD=NO, LENGTH=NO, and ANGLE=NO (machine digits = 0)
	LENGTH	OP /CL	Measured length, Not displayed if MODEL NUMBER = 7 or 8
	ANGLE	OP / CL	Measured angle, Not displayed if MODEL NUMBER = 7 or 8
	WEIGHT	XXXX%	Percentage of maximum calibrated weight on the platform. An uncalibrated load cell reads 1000% Displayed if LOAD is not 0 and LOAD TYPE is 0.
		OK/OVERLOADED	LSS system status. Displayed if LOAD is not 0 and LOAD TYPE is 1.

Table 6-6. Machine Diagnostics Parameters

Diagnostics Submenu (Displayed on Analyzer 1st Line)	Parameter (Displayed on Analyzer 2nd Line)	Parameter Value (Displayed on Analyzer 2nd Line)	Description
MOMENT:			Displayed if MODEL NUMBER = 7 or 8
	(LB-IN) ACTUAL	XXXXXXXX	Current moment value
	(LB-IN) OVER	XXXXXXXX	Current over moment setpoint.
	(LB-IN) UNDER	XXXXXXXX	Current under moment setpoint.
	CAL PT UNDER	XXXXXXXX	Under moment value recorded during boom sensor calibration.
	CAL PT WIT YEL	XXXXXXXX	Yellow witness mark moment value recorded during boom sensor calibration.
	CAL PT WIT GRN	XXXXXXXX	Green witness mark moment value recorded during boom sensor calibration.
	CYL PIN RATIO	X.XXX	Current cylinder moment pin ratio of X and Y forces.
	PIN E FLAGS	0xXXXX	Current error flag status of cylinder moment pin.
	sky welder	YES/NO	Status of Sky Welder selected during boom sensor calibration. (Displayed if MODEL NUMBER = 7 or 8)
	sky cutter	YES/NO	Status of Sky Cutter selected during boom sensor calibration. (Displayed if MODEL NUMBER = 7 or 8)
	sky glazier	YES/NO	Status of Sky Glazier selected during boom sensor calibration. (Displayed if MODEL NUMBER = 7 or 8)
	sky Bright	YES/NO	Status of Sky Bright selected during boom sensor calibration. (Displayed if MODEL NUMBER = 7 or 8)
	Pipe Racks	YES/NO	Status of Pipe Racks selected during boom sensor calibration. (Displayed if MODEL NUMBER = 7 or 8)
	Camera mount	YES/NO	Status of Camera Mount selected during boom sensor calibration. (Displayed if MODEL NUMBER = 7 or 8)

Table 6-6. Machine Diagnostics Parameters

Diagnostics Submenu (Displayed on Analyzer 1st Line)	Parameter (Displayed on Analyzer 2nd Line)	Parameter Value (Displayed on Analyzer 2nd Line)	Description
ENVELOPE:			Displayed if MODEL NUMBER = 7 or 8
	LENGTH	XXXX.X	Current indicated boom length in inches.
	ANGLE 1	XX.X	Current indicated boom angle 1 in degrees.
	ANGLE 2	XX.X	Current indicated boom angle 2 in degrees.
	A/D LNGTH	XXXXX	Current indicated boom length in A/D counts.
	A/D ANG1	XXXXX	Current indicated boom angle 1 in A/D counts or raw angle if calibrated.
	A/D ANG2	XXXXX	Current indicated boom angle 2 in A/D counts or raw angel if calibrated.
CAN STATISTICS:			CAN Statistics as detected by Ground Module
	RX/SEC	XXX	Number of received messages per second
	TX/SEC	XXX	Number of transmitted messages per second
	BUS OFF	XX	Number of bus off occurrences
	PASSIVE	XX	Number of bus passive occurrences

Table 6-6. Machine Diagnostics Parameters

Diagnostics Submenu (Displayed on Analyzer 1st Line)	Parameter (Displayed on Analyzer 2nd Line)	Parameter Value (Displayed on Analyzer 2nd Line)	Description
CALIBRATION DATA			
	BASKET UP	XXX	Basket up calibration point
	Basket DOWN	XXX	Basket down calibration point
	L FWD DRIVE	XXX	Left forward drive calibration point
	R FWD DRIVE	XXX	Right forward drive calibration point
	L REV DRIVE	XXX	Left reverse drive calibration point
	R REV DRIVE	XXX	Right reverse drive calibration point
	F LT STEER	XXX	Forward left steer calibration point
	F RT STEER	XXX	Forward right steer calibration point
	R LT STEER	XXX	Reverse left steer calibration point
	R RT STEER	XXX	Reverse right steer calibration point
	U LIFT UP	XXX	Upper lift up calibration point
	U LIFT DOWN	XXX	Upper lift down calibration point
	U TELE IN	XXX	Upper telescope in calibration point
	U TELE OUT	XXX	Upper telescope out calibration point
	BM ANG 1 LO	XXX	Boom angle 1 low calibration point
	BM ANG 1 HI	XXX	Boom angle 1 high calibration point
	BM ANG 2 LO	XXX	Boom angle 2 low calibration point
	BM ANG 2 HI	XXX	Boom angle 2 high calibration point
	LEN RETRACT	XXX	Length sensor retracted calibration point
	LEN EXTEND	XXXXX	Length sensor extended calibration point
	LEN WIT	XXXXX	Witness mark calibration point
	LEN SWITCH	XXXX	Length switch calibration point

Table 6-6. Machine Diagnostics Parameters

Diagnostics Submenu (Displayed on Analyzer 1st Line)	Parameter (Displayed on Analyzer 2nd Line)	Parameter Value (Displayed on Analyzer 2nd Line)	Description
DATALOG:			
	ON	XXXXhXXm	Total controller on (EMS) time
	ENGINE	XXXXhXXm	Engine run time
	DRIVE	XXXXhXXm	Total controller drive operation time
	LIFT	XXXXhXXm	Total controller lift operation time
	SWING	XXXXhXXm	Total controller swing operation time
	TELE	XXXXhXXm	Total controller telescope operation time
	MAX TEMP	XXC	Maximum measured ambient temp.
	MIN TEMP	XXC	Minimum measured ambient temp.
	MAX volts	XX.XV	Maximum measured battery voltage
	RENTAL	XXXXhXXm	Total controller operation time. NOTE: can be reset
	ERASE RENTAL?		Not available at Access Level 2. ENTER resets rental data log time to zero.
VERSIONS:			
	GM SW	PX.X	Ground module software version
	GM HW REV	XXXX	Ground module hardware revision
	GM SN	XXXXXX	Ground module serial number
	PM SW	PX.X	Platform module software version
	PM HW REV	XXXX	Platform module hardware revision
	PM SN	XXXXXX	Platform module serial number
	cm sw	PX.X	Chassis module software version
	bm sw	PX.X	BLAM module software version
	c pin SW		Cylinder moment load pin transmits software version.
	C PIN SN		Cylinder moment load pin transmits serial number.
	ANALYZER	VX.XXXX	Analyzer software version

Table 6-7. Help Fault Codes, Displayed Faults, and Descriptions - Prior to S/N 0300066949

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
	EVERYTHING OK	The "normal" help message in platform mode	
	GROUND MODE OK	The "normal" help message in ground mode	
	DRIVING AT CREEP - TILTED	Drive speed is limited to creep because the vehicle is tilted.	
	FSW OPEN	A drive or boom function has been selected but footswitch is open.	
	RUNNING AT CREEP - CREEP SWITCH OPEN	All function speeds are limited to creep because the creep switch is open.	
	RUNNING AT CREEP - TILTED AND ABOVE ELEVATION	All function speeds are limited to creep because the vehicle is tilted and above elevation.	
	RUNNING AT CUTBACK - ABOVE ELEVATION	Drive speed is limited to "ELEVATED MAX" because the vehicle is above elevation.	
	TESTS ACTIVE – RECYCLE EMS TO END	The system tests have been activated; normal vehicle operation is not allowed.	
1/1	Flash code 1/1 indicates a "sleep" mode. NOT REQUIRED		
2/1	Flash code 2/1 indicates problems with footswitch.		2
	FSW FAULTY	The two foot switch signals do not agree. EMS recycle required.	
	KEYSWITCH FAULTY	Both platform and ground modes are selected simultaneously	
2/2	Flash code 2/2 indicates problems with drive & steer selection.		3
	DRIVE JOYSTICK FAULTY	Drive joystick center tap is out of valid range or wiper is wire-off.	
	DRIVE LOCKED – JOYSTICK MOVED BEFORE EMS/FSW	Drive was selected before and during footswitch closure.	
	FSW INTERLOCK TRIPPED	Footswitch was closed for seven seconds with no function selected.	
	STEER LOCKED – SELECTED BEFORE EMS/FSW	Steer was selected before and during footswitch closure.	
	STEER SWITCHES FAULTY	Both steer switches are active together.	
	WAITING FOR FSW TO BE OPEN	Footswitch was closed when platform mode was selected.	
	JOYSTICK FAULTS – CHECK PLATFORM BOX WIRING	More than one of the drive, lift, and swing joystick center tap or wiper voltages is out of range. This is probably due to a short-circuit across a joystick pot.	

Table 6-7. Help Fault Codes, Displayed Faults, and Descriptions - Prior to S/N 0300066949

2/3	Flash code 2/3 indicates problems with boom function selection.		3
	LIFT/SWING JOYSTICK FAULTY	Lift or swing joystick center tap is out of valid range or wiper is wire-off.	
	LIFT/SWING LOCKED - JOYSTICK MOVED BEFORE EMS/FSW	Platform upper lift or swing was selected before and during foot-switch closure.	
	PUMP POT FAULTY	Pump pot is open-circuit; all platform boom functions except upper lift & swing will run at creep.	
	PUMP SWITCHES FAULTY - CHECK DIAGNOSTICS/BOOM	A boom function (lower lift, telescope, basket level, basket rotate, jib) has both directions selected together.	
	PUMP SWITCHES LOCKED - SELECTED BEFORE EMS/FSW	A platform boom function (lower lift, telescope, basket level, basket rotate, jib) was selected before key switch or footswitch closure.	
	PUMP SWITCHED LOCKED - SELECTED BEFORE EMS	A ground boom function (lower lift, telescope, basket level, basket rotate, jib) was selected before key switch.	
	SWING/LIFT JOYSTICK FAULTY	Swing joystick center tap is out of valid range or wiper is wire-off.	
2/4	Flash code 2/4 indicates that steering digital inputs are faulty. NOT REQUIRED		
2/5	Flash code 2/5 indicates that a function is prevented due to a cutout.		4
	BOOM PREVENTED - DRIVE SELECTED	A boom function is selected while a drive function is selected and drive cutout is configured to prevent simultaneous drive & boom operation.	
	DRIVE PREVENTED - ABOVE ELEVATION	Drive is selected while above elevation and drive cutout is configured to prevent drive.	
	DRIVE PREVENTED - BOOM MOVEMENT SELECTED	Drive is selected while a boom function is selected and drive cutout is configured to prevent simultaneous drive & boom operation.	
	DRIVE PREVENTED - TILTED & ABOVE ELEVATION	Drive is selected while tilted and above elevation and tilt is configured to cutout drive.	
	BOOM PREVENTED – FUNCTION CUTOUT ACTIVE	A boom function is selected while function cutout is active and configured to cutout boom functions.	
	BOOM & DRIVE PREVENTED-FUNCTION CUTOUT ACTIVE	Drive or a boom function is selected while function cutout is active and configured to cutout all functions.	
2/7	Flash code 2/7 indicates that the accelerator input is faulty. NOT REQUIRED		
2/8	Flash code 2/8 indicates that the hydraulic filter is being bypassed.		5
	RETURN FILTER BYPASSED	Hydraulic return filter clogged	
	CHARGE PUMP FILTER BYPASSED	Charge pump filter clogged	
3/1	Flash code 3/1 indicates that a contactor did not close when energized. NOT REQUIRED		

Table 6-7. Help Fault Codes, Displayed Faults, and Descriptions - Prior to S/N 0300066949

3/2	Flash code 3/2 indicates that a contactor did not open when energized. NOT REQUIRED		
3/3	Flash code 3/3 indicates that a driver is short-circuit.		6
	ADD DRIVER FAULTS		
3/5	Flash code 3/5 indicates a brake pressure problem. NOT REQUIRED		7
4/2	Flash code 4/2 indicates that the engine is over temperature. NOT REQUIRED		8
4/3	Flash code 4/3 indicates problems with the engine		9
	ENGINE TEMP GREATER THAN 130°C (266° F)		
	AIR FILTER BYPASSED	Air filter clogged	
	NO aLTERNATOR OUTPUT	The measured battery voltage is less than 12.5 VDC	
	OIL PRESSURE LESS THAN 0.5 BAR (8PSI)		
4/4	Flash code 4/4 indicates problems with the battery supply.		7
	BATTERY LOW	Battery voltage is below 11V. This is a warning - the controller does not shut down.	
	BATTERY TOO HIGH - SYSTEM SHUT DOWN	Battery voltage is above 18V. EMS recycle required.	
	BATTERY TOO LOW - SYSTEM SHUT DOWN	Battery voltage is below 6V. EMS recycle required.	
5/5	Flash code 5/5 indicates problems with vehicle engine RPM or the encoder.		8
	SPEED SENSOR READING INVALID SPEED	Speed sensor is indicating an impossible number of pulses. This is probably due to a faulty speed sensor.	
	SPEED INPUT LOST	Diesel engine speed input to system has been lost. This is probably due to wiring problems at ground module or a faulty speed sensor.	
	ENGINE SPEED DOES NOT MATCH COMMAND	Diesel engine governor has stuck. This is probably due to electrical or mechanical problems with the governor.	
6/6	Flash code 6/6 indicates problems with the CAN bus.		10
	CAN BUS FAILURE:	Ground module or platform module not receiving. This is probably due to wiring problems between platform and ground modules.	
7/7	Flash code 7/7 indicates problems with a motor. NOT REQUIRED		
9/9	Flash code 9/9 indicates problems with the controller.		11
	PLATFORM MODULE FAILURE: hwfs CODE 1	Platform module V(Low) FET has failed	
	GROUND MODULE FAILURE: hwfs CODE 1	Ground module V(Low) FET has failed	

Table 6-8. Help Fault Codes, Displayed Faults, and Descriptions - S/N 0300066949 & S/N 1300000001 to Present

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 vehicle is not behaving as expected.	**1**
	EVERYTHING OK	The "normal" help message in platform mode	
	GROUND MODE OK	The "normal" help message in ground mode	
	FSW OPEN	A drive or boom function has been selected but footswitch is open.	
	RUNNING AT CREEP – CREEP SWITCH OPEN	All function speeds are limited to creep because the creep switch is open.	
	RUNNING AT CREEP – TILTED AND ABOVE ELEVATION	All boom function speeds are limited to creep because vehicle is tilted and above elevation.	
	RUNNING AT CUTBACK – OUT OF TRANSPORT POSITION	Drive speed is limited to "ELEVATED MAX" because vehicle is out of transport position.	
	CHASSIS TILT SENSOR OUT OF RANGE	The chassis tilt sensor has indicated a tilt angle greater than 19 degrees for more than 4 seconds. Not reported during 2 second power-up.	
	LOAD SENSOR READING UNDER WEIGHT	Load sensor is reading 20% or more under calibrated zero point. This fault may occur if basket is resting on ground. Not reported during 2 second power-up.	
	ENVELOPE ENCROACHED – HYDRAULICS SUSPENDED	Machines with envelope control ONLY. System has detected an envelope violation	
	OVER MOMENT – HYDRAULICS SUSPENDED	Only occurs on machines with moment control. The system has detected an over moment violation.	
	UNDER MOMENT – HYDRAULICS SUSPENDED	Machines with moment control ONLY. System has detected an under moment violation.	
1/1		**Flash code 1/1 indicates a "sleep" mode.** **NOT REQUIRED**	
2/1		**Flash code 2/1 indicates problems with footswitch.**	**2**
	FSW FAULTY	The two footswitch inputs have read the same state for more than one second. An EMS cycle is required.	
	KEYSWITCH FAULTY	Platform and ground modes selected simultaneously	

Table 6-8. Help Fault Codes, Displayed Faults, and Descriptions - S/N 0300066949 & S/N 1300000001 to Present

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
2/2		**Flash code 2/2 indicates problems with drive & steer selection. Except where noted, these faults are not reported during 2 second power-up sequence.**	3
	DRIVE LOCKED – JOYSTICK MOVED BEFORE FOOTSWITCH	Drive selected before and during footswitch closure. Can be reported during power-up sequence.	
	FSW INTERLOCK TRIPPED	Footswitch closed for seven seconds with no function selected. Can be reported during power-up sequence.	
	STEER LOCKED – SELECTED BEFORE FOOTSWITCH	Steer was selected before and during footswitch closure.	
	STEER SWITCHES FAULTY	Both steer switches are active at same time.	
	D/S JOY. OUT OF RANGE LOW	Resistive joysticks: These faults do not occur.	
	D/S JOY. OUT OF RANGE LOW	Resistive joysticks: These faults do not occur.	
	D/S JOY. OUT OF RANGE HIGH	Resistive joysticks: These faults do not occur if Vref voltage is below 8.1 volts. If Vref is above 7.7 volts, Vref is operating out of tolerance or a short to battery has occurred.	
	D/S JOY. CENTER TAP BAD	Resistive joysticks: These faults occur when center tap voltage is not between 3.08 volts and 3.83 volts. Due to resistor tolerances there is a +/-.1 volt range around these values where fault may be indicated.	
	WAITING FOR FSW TO BE OPEN	Footswitch closed when platform mode was selected. Can be reported during power-up sequence.	
	FOOTSWITCH SELECTED BEFORE START	User attempted to start machine with footswitch engaged.	
2/3		**Flash code 2/3 indicates problems with boom function selection.**	3
	LIFT/SWING LOCKED – JOYSTICK MOVED BEFORE FOOTSWITCH	Platform upper lift or swing was selected before and during footswitch closure.	
	PUMP SWITCHES FAULTY – CHECK DIAGNOSTICS/BOOM	A boom function (lower lift, telescope, basket level, basket rotate, jib) has both directions selected together.	
	PUMP SWITCHES LOCKED – SELECTED BEFORE FOOTSWITCH	A platform boom function (lower lift, telescope, basket level, basket rotate, jib) was selected before key switch or footswitch closure.	
	PUMP SWITCHES LOCKED – SELECTED BEFORE AUX POWER	A ground boom function (lower lift, telescope, basket level, basket rotate, jib) was selected before aux power.	
	l/s joy. out of range low	Resistive joysticks: These faults do not occur.	
	l/s joy. out of range high	Resistive joysticks: These faults do not occur if Vref voltage is below 8.1 volts. If Vref is above 7.7 volts, Vref is operating out of tolerance or a short to battery has occurred.	
	l/s joy. center tap bad	Resistive joysticks: These faults occur when center tap voltage is not between 3.08 volts and 3.83 volts. Due to resistor tolerances there is a +/-.1 volt range around these values where fault may be indicated.	
	PUMP SWITCHES LOCKED – SELECTED BEFORE START SWITCH	Hydraulic function switch closed before start switch closed.	
	FOOTSWITCH SELECTED BEFORE START	User attempted to start machine with footswitch engaged.	
2/4		**Flash code 2/4 indicates steering digital inputs are faulty.** **NOT REQUIRED**	

Table 6-8. Help Fault Codes, Displayed Faults, and Descriptions - S/N 0300066949 & S/N 1300000001 to Present

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
2/5		**Flash code 2/5 indicates a function is prevented due to a cutout.**	4
	BOOM PREVENTED – DRIVE SELECTED	A boom function is selected while a drive function is selected and drive cutout is configured to prevent simultaneous drive & boom operation.	
	DRIVE PREVENTED – ABOVE ELEVATION	Drive is selected while above elevation and drive cutout is configured to prevent drive.	
	DRIVE PREVENTED – BOOM SELECTED	Drive is selected while a boom function is selected and drive cutout is configured to prevent simultaneous drive & boom operation.	
	DRIVE PREVENTED – TILTED & ABOVE ELEVATION	Drive is selected while tilted and above elevation and tilt is configured to cutout drive.	
	JIB SWING PREVENTED – IN 1000# MODE	User is trying to jib swing in 1000# mode, which is not allowed.	
	CAN DONGLE ATTACHED – HYDRAULICS NOT RESTRICTED	System allows user to operate all hydraulics with very limited restrictions.	
	MODEL CHANGED – HYDRAULICS SUSPENDED – CYCLE EMS	User changed model number using analyzer. User must cycle power before hydraulics system will be active again.	11
	BACKUP BLAM COMMUNICATIONS ACTIVE	Serial backup communications link to BLAM module is active	
	DISCONNECT ANALYZER AND CYCLE EMS TO PERFORM BOOM RETRIEVAL	Ground module needs to use RS232 backup communications link to BLAM module but an analyzer is connected. Remove analyzer and cycle power	
	FUNCTIONS LOCKED OUT - PLATFORM MODULE SOFTWARE VERSION IMPROPER	Major version of platform module does not match major version of ground module	
	FUNCTIONS LOCKED OUT - CHASSIS MODULE SOFTWARE VERSION IMPROPER	Major version of chassis module does not match major version of ground module	
	FUNCTIONS LOCKED OUT - BLAM MODULE SOFTWARE VERSION IMPROPER	Major version of BLAM module does not match major version of ground module	
2/7		**Flash code 2/7 indicates that accelerator input is faulty.** **NOT REQUIRED**	
2/8		**Flash code 2/8 indicates a problem with a hydraulic filter. Not reported during 2 second power-up.**	5
	RETURN FILTER BYPASSED	Hydraulic return filter clogged	
	charge pump filter bypassed	Charge pump filter clogged	
3/1		**Flash code 3/1 indicates a contactor did not close when energized.** **NOT REQUIRED**	
3/2		**Flash code 3/2 indicates a contactor did not open when energized.** **NOT REQUIRED**	

Table 6-8. Help Fault Codes, Displayed Faults, and Descriptions - S/N 0300066949 & S/N 1300000001 to Present

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
3/3		**Flash code 3/3 indicates a driver problem. All driver faults are detected in a similar manner. Open circuit faults are detected when analog feedback reads too high and output is commanded off. Short to ground is detected when analog feedback reads low and output is commanded on. Short to battery is detected when analog feedback reads Vbat and output is commanded off. Not reported during 2 second power-up. An EMS cycle is required.**	6
	RIGHT FORWARD DRIVE PUMP SHORT TO GROUND	Machines with a chassis module ONLY.	
	RIGHT FORWARD DRIVE PUMP SHORT TO BATTERY	Machines with a chassis module ONLY.	
	RIGHT FORWARD DRIVE PUMP OPEN CIRCUIT	Machines with a chassis module ONLY.	
	RIGHT REVERSE DRIVE PUMP SHORT TO GROUND	Machines with a chassis module ONLY.	
	RIGHT REVERSE DRIVE PUMP SHORT TO BATTERY	Machines with a chassis module ONLY.	
	RIGHT REVERSE DRIVE PUMP OPEN CIRCUIT	Machines with a chassis module ONLY.	
	LEFT FORWARD DRIVE PUMP SHORT TO GROUND	Machines with a chassis module ONLY.	
	LEFT FORWARD DRIVE PUMP SHORT TO BATTERY	Machines with a chassis module ONLY.	
	LEFT FORWARD DRIVE PUMP OPEN CIRCUIT	Machines with a chassis module ONLY.	
	LEFT REVERSE DRIVE PUMP SHORT TO GROUND	Machines with a chassis module ONLY.	
	LEFT REVERSE DRIVE PUMP SHORT TO BATTERY	Machines with a chassis module ONLY.	
	LEFT REVERSE DRIVE PUMP OPEN CIRCUIT	Machines with a chassis module ONLY.	
	ALTERNATOR/ECM POWER SHORT TO GROUND		
	HOUR METER SHORT TO GROUND		
	HOUR METER SHORT TO BATTERY		
	HORN SHORT TO GROUND		
	HORN OPEN CIRCUIT		
	HORN SHORT TO BATTERY		
	AUX POWER SHORT TO GROUND		
	AUX POWER OPEN CIRCUIT		
	AUX POWER SHORT TO BATTERY		
	GLOW PLUG SHORT TO GROUND	Machines with glowplugs configured ONLY.	
	GLOW PLUG OPEN CIRCUIT	Machines with glowplugs configured ONLY	
	GLOW PLUG SHORT TO BATTERY	Machines with glowplugs configured ONLY	
	LP LOCK SHORT TO GROUND	Machines with dual-fuel engines ONLY.	
	LP LOCK OPEN CIRCUIT	Machines with dual-fuel engines ONLY.	

Table 6-8. Help Fault Codes, Displayed Faults, and Descriptions - S/N 0300066949 & S/N 1300000001 to Present

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
	LP LOCK SHORT TO BATTERY	Machines with dual-fuel engines ONLY.	
	LP START ASSIST SHORT TO GROUND	Machines with dual-fuel engines ONLY.	
	LP START ASSIST OPEN CIRCUIT	Machines with dual-fuel engines ONLY.	
	LP START ASSIST SHORT TO BATTERY	Machines with dual-fuel engines ONLY.	
	MAIN DUMP SHORT TO GROUND		
	MAIN DUMP OPEN CIRCUIT		
	MAIN DUMP SHORT TO BATTERY		
	PARKING BRAKE SHORT TO GROUND		
	PARKING BRAKE OPEN CIRCUIT		
	PARKING BRAKE SHORT TO BATTERY		
	START SOLENOID SHORT TO GROUND	Machines with diesel engines ONLY.	
	START SOLENOID OPEN CIRCUIT	Machines with diesel engines ONLY.	
	START SOLENOID SHORT TO BATTERY	Machines with diesel engines ONLY.	
	MAIN LIFT APU SHORT TO GROUND	1250AJP ONLY.	
	MAIN LIFT APU OPEN CIRCUIT	1250AJP ONLY.	
	MAIN LIFT APU SHORT TO BATTERY	1250AJP ONLY.	
	MAIN LIFT PILOT PRESSURE FAILURE	1250AJP ONLY.	
	NO MAIN LIFT PILOT PRESSURE	1250AJP ONLY.	
	MAIN LIFT PILOT PRESSURE SWITCH FAILURE	1250AJP ONLY.	
	STEER DUMP SHORT TO GROUND		
	STEER DUMP OPEN CIRCUIT		
	STEER DUMP SHORT TO BATTERY		
	TWO SPEED SHORT TO GROUND		
	TWO SPEED OPEN CIRCUIT		
	TWO SPEED SHORT TO BATTERY		
	GROUND ALARM SHORT TO GROUND	Machines with ground alarm configured ONLY.	
	GROUND ALARM OPEN CIRCUIT	Machines with ground alarm configured ONLY	
	GROUND ALARM SHORT TO BATTERY	Machines with ground alarm configured ONLY	
	GEN SET/WELDER SHORT TO GROUND	Machines with a generator configured ONLY.	
	GEN SET/WELDER OPEN CIRCUIT	Machines with a generator configured ONLY.	
	GEN SET/WELDER SHORT TO BATTERY	Machines with a generator configured ONLY	
	HEAD TAIL LIGHT SHORT TO GROUND	Machines with headlights option configured ONLY.	

Table 6-8. Help Fault Codes, Displayed Faults, and Descriptions - S/N 0300066949 & S/N 1300000001 to Present

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
	HEAD TAIL LIGHT OPEN CIRCUIT	Machines with headlights option configured ONLY	
	HEAD TAIL LIGHT SHORT TO BATTERY	Machines with headlights option configured ONLY	
	BASKET UP OVERRIDE SHORT TO GROUND	Machines with electronic leveling systems ONLY.	
	BASKET UP OVERRIDE OPEN CIRCUIT	Machines with electronic leveling systems ONLY.	
	BASKET UP OVERRIDE SHORT TO BATTERY	Machines with electronic leveling systems ONLY.	
	BASKET UP SHORT TO GROUND		
	BASKET UP OPEN CIRCUIT		
	BASKET UP SHORT TO BATTERY		
	BASKET DOWN SHORT TO GROUND		
	BASKET DOWN OPEN CIRCUIT		
	BASKET DOWN SHORT TO BATTERY		
	BASKET DOWN OVERRIDE SHORT TO GROUND	Machines with electronic leveling systems ONLY.	
	BASKET DOWN OVERRIDE OPEN CIRCUIT	Machines with electronic leveling systems ONLY.	
	BASKET DOWN OVERRIDE SHORT TO BATTERY	Machines with electronic leveling systems ONLY.	
	TOWER LIFT APU VALVE STUCK OPEN	1250AJP ONLY.	
	TOWER LIFT ENABLE STUCK OPEN	250AJP ONLY.	
	TOWER LIFT ENABLE SHORT TO GROUND	250AJP ONLY.	
	TOWER LIFT ENABLE OPEN CIRCUIT	250AJP ONLY.	
	TOWER LIFT ENABLE SHORT TO BATTERY	250AJP ONLY.	
	TOWER TELESCOPE APU SHORT TO GROUND	250AJP ONLY.	
	TOWER TELESCOPE APU OPEN CIRCUIT	250AJP ONLY.	
	TOWER TELESCOPE APU SHORT TO BATTERY	250AJP ONLY.	
	BASKET LEFT OPEN CIRCUIT		
	BASKET LEFT SHORT TO BATTERY		
	BASKET LEFT SHORT TO GROUND		
	BASKET RIGHT SHORT TO GROUND		
	BASKET RIGHT OPEN CIRCUIT		
	BASKET RIGHT SHORT TO BATTERY		
	JIB UP SHORT TO GROUND		
	JIB UP OPEN CIRCUIT		
	JIB UP SHORT TO BATTERY		
	JIB DOWN SHORT TO GROUND		

Table 6-8. Help Fault Codes, Displayed Faults, and Descriptions - S/N 0300066949 & S/N 1300000001 to Present

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
	JIB DOWN OPEN CIRCUIT		
	JIB DOWN SHORT TO BATTERY		
	JIB LEFT SHORT TO GROUND		
	JIB LEFT OPEN CIRCUIT		
	JIB LEFT SHORT TO BATTERY		
	JIB RIGHT SHORT TO GROUND		
	JIB RIGHT OPEN CIRCUIT		
	JIB RIGHT SHORT TO BATTERY		
	TOWER UP SHORT TO GROUND		
	TOWER UP OPEN CIRCUIT		
	TOWER UP SHORT TO BATTERY		
	TOWER DOWN SHORT TO GROUND		
	TOWER DOWN OPEN CIRCUIT		
	TOWER DOWN SHORT TO BATTERY		
	TOWER IN SHORT TO GROUND		
	TOWER IN OPEN CIRCUIT		
	TOWER IN SHORT TO BATTERY		
	TOWER OUT SHORT TO GROUND		
	TOWER OUT OPEN CIRCUIT		
	TOWER OUT SHORT TO BATTERY		
	MAIN IN SHORT TO GROUND		
	MAIN IN OPEN CIRCUIT		
	MAIN IN SHORT TO BATTERY		
	MAIN OUT SHORT TO GROUND		
	MAIN OUT OPEN CIRCUIT		
	MAIN OUT SHORT TO BATTERY		
	LIFT UP DUMP SHORT TO GROUND		
	LIFT UP DUMP OPEN CIRCUIT		
	LIFT UP DUMP SHORT TO BATTERY		
	LIFT DOWN HOLDING SHORT TO GROUND		
	LIFT DOWN HOLDING OPEN CIRCUIT		
	LIFT DOWN HOLDING SHORT TO BATTERY		
	LIFT PILOT VALVE SHORT TO GROUND	Machines with gravity lift down ONLY.	
	LIFT PILOT VALVE SHORT TO BAT-TERY	Machines with gravity lift down ONLY.	
	LIFT PILOT VALVE OPEN CIRCUIT	Machines with gravity lift down ONLY.	
	LIFT DOWN AUX VALVE SHORT TO GROUND	Machines with gravity lift down ONLY.	
	LIFT DOWN AUX VALVE SHORT TO BATTERY	Machines with gravity lift down ONLY.	

Table 6-8. Help Fault Codes, Displayed Faults, and Descriptions - S/N 0300066949 & S/N 1300000001 to Present

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
	LIFT DOWN AUX VALVE OPEN CIRCUIT	Machines with gravity lift down ONLY.	
	TOWER LIFT APU SHORT TO GROUND	1250AJP ONLY.	
	TOWER LIFT APU OPEN CIRCUIT	1250AJP ONLY.	
	TOWER LIFT APU SHORT TO BATTERY	1250AJP ONLY.	
	MAIN LIFT ENABLE SHORT TO GROUND	1250AJP ONLY.	
	MAIN LIFT ENABLE OPEN CIRCUIT	1250AJP ONLY.	
	MAIN LIFT ENABLE SHORT TO BATTERY	1250AJP ONLY.	
	TOWER TELE APU VALVE STUCK OPEN	1250AJP ONLY.	
	TOWER TELE ENABLE STUCK OPEN	1250AJP ONLY.	
	TOWER TELE APU SHORT TO GROUND	1250AJP ONLY.	
	TOWER TELE APU OPEN CIRCUIT	1250AJP ONLY.	
	TOWER TELE APU SHORT TO BATTERY	1250AJP ONLY.	
	PVG VALVE SHORT TO GROUND	1250AJP ONLY.	
	PVG VALVE OPEN CIRCUIT	1250AJP ONLY.	
	PVG VALVE SHORT TO BATTERY	1250AJP ONLY.	
	FOX SPARE OUTPUT SHORT TO GROUND	Fox machines ONLY.	
	FOX SPARE OUTPUT SHORT TO BATTERY	Fox machines ONLY.	
	FOX SPARE OUTPUT OPEN CIRCUIT	Fox machines ONLY.	
	HOUR METER OPEN CIRCUIT	This fault cannot be detected during normal operation. It may be reported during self test.	
	RESTRICTED TO TRANSPORT – AXLE LOCKOUT VALVE STB OR OC	Machines with electrically released oscillating axles configured ONLY. A short to battery or open circuit has been detected on axle lockout valve and machine is restricted to transport position.	
	RESTRICTED TO TRANSPORT – PARKING BRAKE STB	Machines with electrically released oscillating axles configured ONLY. A short to battery has been detected on parking brake valve and machine is restricted to transport position.	

Table 6-8. Help Fault Codes, Displayed Faults, and Descriptions - S/N 0300066949 & S/N 1300000001 to Present

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
3/4		**Flash code 3/4 indicates a driver problem on a platform valve block valve driver. All driver faults are detected in a similar manner. Open circuit faults are detected when analog feedback reads too high and output is commanded off. Short to ground is detected when analog feedback reads low and output is commanded on. Short to battery is detected when analog feedback reads Vbat and output is commanded off. Not reported during 2 second power-up. An EMS cycle is required.**	6
	BASKET UP SHORT TO BATTERY		
	BASKET UP SHORT TO GROUND		
	BASKET UP OPEN CIRCUIT		
	BASKET UP SHORT TO BATTERY OR OPEN CIRCUIT	Machines with electronic basket leveling ONLY.	
	BASKET DOWN SHORT TO BATTERY		
	BASKET DOWN SHORT TO GROUND		
	bASKET DOWN OPEN CIRCUIT		
	BASKET DOWN SHORT TO BATTERY OR OPEN CIRCUIT	Machines with electronic basket leveling ONLY.	
	BASKET LEFT SHORT TO BATTERY		
	BASKER LEFT SHORT TO GROUND		
	BASKET LEFT OPEN CIRCUIT		
	BASKET RIGHT SHORT TO BATTERY		
	BASKET RIGHT SHORT TO GROUND		
	BASKET RIGHT OPEN CIRCUIT		
	JIB UP SHORT TO BATTERY		
	JIB UP SHORT TO GROUND		
	JIB UP OPEN CIRCUIT		
	JIB DOWN SHORT TO BATTERY		
	JIB DOWN SHORT TO GROUND		
	JIB DOWN OPEN CIRCUIT		
	JIB LEFT SHORT TO BATTERY		
	JIB LEFT SHORT TO GROUND		
	JIB LEFT OPEN CIRCUIT		
	JIB RIGHT SHORT TO BATTERY		
	JIB RIGHT SHORT TO GROUND		
	JIB RIGHT OPEN CIRCUIT		
	PLATFORM CONTROL VALVE SHORT TO BATTERY	Machines with electronic basket leveling ONLY.	
	PLATFORM CONTROL VALVE SHORT TO GROUND	Machines with electronic basket leveling ONLY.	
	PLATFORM CONTROL VALVE OPEN CIRCUIT	Machines with electronic basket leveling ONLY.	
3/5		**Flash code 3/5 indicates a brake pressure problem. NOT REQUIRED**	
4/2		**Flash code 4/2 indicates that the engine is over temperature. NOT REQUIRED**	

Table 6-8. Help Fault Codes, Displayed Faults, and Descriptions - S/N 0300066949 & S/N 1300000001 to Present

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
4/3		**Flash code 4/3 indicates engine problems. These faults are not reported during 2 second power-up sequence except where noted.**	9
	HIGH ENGINE TEMP	Occurs when engine temperature is above 117 degrees Celsius for Ford and 130 degrees Celsius for Deutz engines.	
	AIR FILTER BYPASSED	Air filter clogged	
	NO ALTERNATOR OUTPUT	Engine running for 15 seconds or more and battery voltage still below 11.5 volts.	
	LOW OIL PRESSURE	If a Deutz engine is configured, oil pressure is below 8 PSI and engine has been running for at least 10 seconds. If a Ford engine is configured, Ford ECM has reported a low oil pressure fault.	
	OIL PRESSURE SHORT TO BATTERY	If a Deutz engine is configured, this indicates oil pressure sensor is reading above 6.6 volts.	
	OIL PRESSURE SHORT TO GROUND	If a Deutz engine is configured, this indicates oil pressure sensor is reading below 0.1 volts for more than 5 seconds. This fault is not detected during crank.	
	COOLANT TEMPERATURE SHORT TO GROUND	If a Deutz engine is configured, this indicates coolant temperature is reading below 0.1 volts.	
	FORD FAULT CODE ##	All Ford fault codes except 63 are simply passed through from the FORD ECM. They only occur if a Ford engine is selected in machine configuration digits. Can be reported during power-up sequence.	
	ENGINE FAULT CODE : ###(SPN) :###(FMI)	All J1939 CANBUS ECMs report fault messaging in this format. SPN number represents what is broken and FMI number represents how component is broken.	
	FORD FAULT CODE UNKNOWN	An unrecognized Ford ECM fault code has been received. Can be reported during power-up sequence.	
	485 COMMUNICATIONS LOST	Ford engine ONLY. No responses received from ECM for 2.5 seconds. Can be reported during power-up sequence.	
	FUEL SENSOR SHORT TO BATTERY	Fuel sensor reading above 4.3 volts.	
	FUEL SENSOR SHORT TO GROUND	Fuel sensor is reading below 0.2 volts.	
	WRONG ENGINE SELECTED – ECM PRESENT	Engine Control Module (ECM) detected on the CANBUS. Only applies when non-CANBUS engine setups are configured.	
	ECM CAN COMMUNICATION LOST	Engine is configured to have a CANBUS controlled engine and JLG system does not detect an ECM. This fault can be the result of power lost to ECM or a break in CANBUS communications connection from ECM to JLG system.	
4/4		**Flash code 4/4 indicates problems with battery supply. Not reported during 2 second power-up.**	7
	BATTERY LOW	Battery voltage is below 11V for more than 5 seconds. Fault is not detected during crank. This is a warning – controller does not shut down.	
	BATTERY TOO HIGH – SYSTEM SHUT DOWN	Battery voltage is above 16V. EMS recycle required.	
	BATTERY TOO LOW – SYSTEM SHUT DOWN	Battery voltage is below 9V.	

Table 6-8. Help Fault Codes, Displayed Faults, and Descriptions - S/N 0300066949 & S/N 1300000001 to Present

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
4/5		**Flash code 4/5 indicates problems with the S-D CAN based PVG valves currently used on the 1250AJP only.**	7
	MAIN LIFT PVG COMMUNICATIONS	CAN communications lost with Main Lift PVG valve.	
	tower lift pvg communications	CAN communications lost with Tower Lift PVG valve.	
	tOWER TELESCOPE PVG COMUNI-CATIONS	CAN communications lost with Tower Telescope PVG valve.	
	MAIN LIFT PVG internal fault	Main boom lift pvg valve internal fault.	
	tower lift pvg internal fault	Tower boom lift pvg valve has an internal fault.	
	tOWER TELESCOPE PVG internal fault	Tower boom telescope pvg valve internal fault.	
	MAIN LIFT PVG VALVE HIGH VOLT-AGE	Main boom lift pvg valve high excitation voltage.	
	TOWER LIFT PVG VALVE HIGH VOLT-AGE	Tower boom lift pvg valve high excitation voltage.	
	TOWER TELESCOPE PVG VALVE HIGH VOLTAGE	Tower boom telescope pvg valve high excitation voltage.	
	MAIN LIFT PVG VALVE LOW VOLTAGE	Main boom lift pvg valve low excitation voltage.	
	TOWER LIFT PVG VALVE LOW VOLT-AGE	Tower boom lift pvg valve low excitation voltage.	
	TOWER TELESCOPE PVG VALVE LOW VOLTAGE	Tower boom telescope pvg valve low excitation voltage.	
	MAIN LIFT PVG VALVE STUCK NEU-TRAL	Main boom lift pvg valve spool stuck in neutral position.	
	TOWER LIFT PVG VALVE STUCK NEUTRAL	Tower boom lift pvg valve spool stuck in neutral position.	
	TOWER TELESCOPE PVG VALVE STUCK NEUTRAL	Tower boom telescope pvg valve spool stuck in neutral position.	
	MAIN LIFT PVG VALVE STUCK EXTENDED	Main boom lift pvg valve spool stuck in extended position.	
	TOWER LIFT PVG VALVE STUCK EXTENDED	Tower boom lift pvg valve spool stuck in extended position.	
	TOWER TELESCOPE PVG VALVE STUCK EXTENDED	Tower boom telescope pvg valve spool stuck in extended position.	
	MAIN LIFT PVG VALVE STUCK RETRACTED	Main boom lift pvg valve spool stuck in retracted position.	
	TOWER LIFT PVG VALVE STUCK RETRACTED	Tower boom lift pvg valve spool stuck in retracted position.	
	TOWER TELESCOPE PVG VALVE STUCK RETRACTED	Tower boom telescope pvg valve spool stuck in retracted position.	
	MAIN LIFT PVG VALVE OBSTRUCTED	Main boom lift pvg valve spool could not achieve command.	
	TOWER LIFT PVG VALVE OBSTRUCTED	Tower boom lift pvg valve spool could not achieve command.	
	TOWER TELESCOPE PVG VALVE OBSTRUCTED	Tower boom telescope pvg valve spool could not achieve command.	

Table 6-8. Help Fault Codes, Displayed Faults, and Descriptions - S/N 0300066949 & S/N 1300000001 to Present

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
	MAIN LIFT PVG VALVE COMMAND IMPROPER	Main boom lift pvg valve received invalid control system command.	
	TOWER LIFT PVG VALVE COMMAND IMPROPER	Tower boom lift pvg valve received invalid control system command.	
	TOWER TELESCOPE PVG VALVE COMMAND IMPROPER	Tower boom telescope pvg valve received invalid control system command.	
	MAIN LIFT PVG VALVE TIMEOUT	Main boom lift pvg valve has not received a position command in 250mS.	
	TOWER TELESCOPE PVG VALVE TIMEOUT	Tower boom lift pvg valve has not received a position command in 250mS.	
	TOWER TELESCOPE PVG VALVE TIMEOUT	Tower boom telescope pvg has not received a position command in 250mS.	
	MAIN LIFT PVG VALVE SETUP FAULT	Main boom lift pvg valve setup data is incorrect. Requires valve calibration.	
	TOWER LIFT PVG VALVE SETUP FAULT	Incorrect tower boom lift pvg valve setup data. Requires valve calibration.	
	TOWER TELESCOPE PVG VALVE SETUP FAULT	Incorrect tower boom telescope pvg valve setup data. Requires valve calibration.	
	MAIN LIFT PVG VALVE SENT UNRECOGNIZED FAULT	Main boom lift pvg valve sent unrecognized fault.	
	TOWER LIFT PVG VALVE SENT UNRECOGNIZED FAULT	Tower boom lift pvg valve sent an unrecognized fault.	
	TOWER TELESCOPE PVG VALVE SENT UNRECOGNIZED FAULT	Tower boom telescope pvg valve sent an unrecognized fault.	
	MAIN LIFT PVG VALVE PARAMETERS INCORRECT	Main lift pvg valves spool data is incorrect. Requires valve calibration.	
	TOWER LIFT PVG VALVE PARAMETERS INCORRECT	The tower lift pvg valves spool data is incorrect. Requires valve calibration.	
	TOWER TELESCOPE PVG VALVE PARAMETERS INCORRECT	The tower telescope pvg valves spool data is incorrect. Requires valve calibration.	
	MAIN LIFT PVG VALVE LOCATION IMPROPER	Main lift pvg valve was hosed wrong or wiring incorrect during calibration.	
	TOWER LIFT PVG VALVE LOCATION IMPROPER	Tower lift pvg valve was hosed wrong or wiring incorrect during calibration.	
	TOWER TELESCOPE PVG VALVE LOCATION IMPROPER	Tower telescope pvg valve was hosed wrong or wiring incorrect during calibration.	
	MAIN LIFT PVG VALVE WIRING INCORRECT	Power wire for main lift pvg valve not wired to that valve.	
	TOWER LIFT PVG VALVE WIRING INCORRECT	Power wire for tower lift pvg valve not wired to that valve.	
	TOWER TELESCOPE PVG VALVE WIRING INCORRECT	Power wire for tower telescope pvg valve not wired to that valve.	
5/5		**Flash code 5/5 indicates problems with vehicle engine RPM or the encoder. Not reported during 2 second power-up.**	8
	SPEED SENSOR READING INVALID SPEED	Diesel engines only. RPM pickup indicating a speed greater than 4000 RPM or approximately 8875 Hz.	
	SPEED INPUT LOST	Diesel engines only. No RPM detected and oil pressure input reading above 8 PSI for more than three seconds. This is probably due to wiring problems at ground module or a faulty speed sensor.	

Table 6-8. Help Fault Codes, Displayed Faults, and Descriptions - S/N 0300066949 & S/N 1300000001 to Present

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
6/6		**Flash code 6/6 indicates problems with the CAN bus.**	10
	PLATFORM CAN COMMUNICATIONS LOST	Ground module or platform module not receiving CAN messages. This is probably due to wiring problems between platform and ground modules.	
	BLAM CAN COMMUNICATIONS LOST	Machines with a BLAM ONLY. Ground module or BLAM module not receiving CAN messages. This is probably due to wiring problems between BLAM and ground modules.	
	CHASSIS CAN COMMUNICATIONS LOST	Machines with a chassis module ONLY. Ground module or chassis module is not receiving CAN messages. This is probably due to wiring problems between chassis and ground modules.	
	CYLINDER LOAD PIN CAN COMMUNICATIONS LOST	Machines with a cylinder load pin ONLY. Ground module or cylinder load pin not receiving CAN messages. This is probably due to wiring problems between cylinder load pin and ground module.	
	EXCESSIVE CAN BUS COMMUNICATION ERRORS	More than 500 Bus Off or more than 500 Bus Passive conditions detected by Ground Module in current power cycle.	
	MAIN ANGL1 CAN COMMUNICATIONS LOST	Control system lost CAN communications with main boom angle sensor #1 (1250AJP only)	
	MAIN ANGL2 CAN COMMUNICATIONS LOST	Control system lost CAN communications with main boom angle sensor #2 (1250AJP only)	
7/7		**Flash code 7/7 indicates problems with a motor.** **NOT REQUIRED**	
8/1		**Flash code 8/1 indicates problems with the Chassis tilt detection system.**	10
	CHASSIS TILT SENSOR NOT CALIBRATED	Leveling (zeroing) calibration not performed for chassis tilt sensor.	
8/2		**Flash code 8/2 indicates problems with the platform load sensing system.**	10
	LOAD SENSOR NOT CALIBRATED	Calibration procedure not been performed for load sensor.	

Table 6-8. Help Fault Codes, Displayed Faults, and Descriptions - S/N 0300066949 & S/N 1300000001 to Present

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
8/3		**Flash code 8/3 indicates problems with the Basket Leveling system.**	10
	BASKET LEVELING CRACKPOINT UP NOT CALIBRATED	Only occurs on machines with electronic leveling systems. Indicates that the basket up valve crackpoint has not been calibrated	
	BASKET LEVELING CRACKPOINT DOWN NOT CALIBRATED	Only occurs on machines with electronic leveling systems. Indicates that the basket down valve crackpoint has not been calibrated	
	BASKET LEVELING SENSOR 1 NOT ZERO CALIBRATED	Only occurs on machines with electronic leveling systems. Indicates that the primary basket leveling tilt sensor has not been calibrated.	
	BASKET LEVELING SENSOR 1 ZERO OUT OF RANGE	Only occurs on machines with electronic leveling systems. Indicates that the primary basket leveling tilt sensor zero is outside of the allowable range	
	BASKET LEVELING SENSOR 1 SHORT TO BATTERY	Only occurs on machines with electronic leveling systems. Indicates that the primary basket leveling tilt sensor is shorted to battery. An EMS cycle is required.	
	BASKET LEVELING SENSOR 1 SHORT TO GROUND OR OPEN CIRCUIT	Only occurs on machines with electronic leveling systems. Indicates that the primary basket leveling tilt sensor is either shorted to ground or is not connected. An EMS cycle is required.	
	BASKET LEVELING SENSOR 2 NOT ZERO CALIBRATED	Only occurs on machines with electronic leveling systems. Indicates that the secondary basket leveling tilt sensor is not zero calibrated.	
	BASKET LEVELING SENSOR 2 ZERO OUT OF RANGE	Only occurs on machines with electronic leveling systems. Indicates that the secondary basket leveling system tilt sensor zero is outside the allowable range.	
	BASKET LEVELING SENSOR 2 SHORT TO BATTERY	Only occurs on machines with electronic leveling systems. Indicates that the secondary basket leveling tilt sensor is shorted to battery. An EMS cycle is required.	
	BASKET LEVELING SENSOR 2 SHORT TO GROUND OR OPEN CIRCUIT	Only occurs on machines with electronic leveling systems. Indicates that the secondary basket leveling tilt sensor is either shorted to ground or not connected. An EMS cycle is required.	
	BASKET LEVELING TILT REFERENCE 1 OUT OF RANGE	Only occurs on machines with electronic leveling systems. Indicates that the reference voltage for the primary basket leveling tilt sensor is outside the expected range (4.9 to 5.1 volts). An EMS cycle is required.	
	BASKET LEVELING TILT REFERENCE 2 OUT OF RANGE	Only occurs on machines with electronic leveling systems. Indicates that the reference voltage for the secondary basket leveling tilt sensor is outside the expected range. (4.9 to 5.1 volts). An EMS cycle is required.	
	BASKET LEVELING TILT SENSOR DIFFERENCE TOO GREAT	Only occurs on machines with electronic leveling systems. Indicates that the basket leveling tilt readings both appear to be good but their measurements do not agree within a specified adjustable tolerance. An EMS cycle is required.	
	BASKET LEVELING SYSTEM TIME-OUT	Only occurs on machines with electronic leveling systems. Indicates that the basket was not able to maintain the desired level within an adjustable range for and adjustable time	
	BASKET LEVELING OVERRIDE ON	User has forced basket leveling on through Access Level 0.	
	BASKET LEVELING OVERRIDE OFF	User has forced basket leveling off through Access Level 0.	
	BASKET LEVELING TILT SENSOR 1 COMMUNICATIONS LOST	Communications have been lost with a serial leveling sensor. Only on 1200S and 1350S models. An EMS cycle is required.	
	BASKET LEVELING TILT SENSOR 2 COMMUNICATIONS LOST	Communications have been lost with a serial leveling sensor. Only on 1200S and 1350S models. An EMS cycle is required.	

Table 6-8. Help Fault Codes, Displayed Faults, and Descriptions - S/N 0300066949 & S/N 1300000001 to Present

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
8/4		**Flash code 8/4 indicates problems with the envelope system. Only occur on machines with envelope control.**	10
	BOOM ANGLE SENSOR DISAGREEMENT	The boom angle sensors are reporting angles that differ too greatly. An EMS cycle is required.	
	BOOM LENGTH SWITCH FAILED	The boom length switch inputs are reporting the same state. An EMS cycle is required.	
	BOOM LENGTH SWITCH/SENSOR DISAGREEMENT	The boom length switch and sensor differ in their reports of extended or retracted. An EMS cycle is required.	
	BOOM LENGTH SENSOR NOT DETECTING LENGTH CHANGE	The boom length sensor has not detected a change in length while the user is commanding telescope. An EMS cycle is required.	
	BOOM LENGTH SENSOR OUT OF RANGE HIGH	Indicates that the voltage for the boom length sensor is above the expected range.	
	BOOM LENGTH SENSOR OUT OF RANGE LOW	Indicates that the voltage for the boom length sensor is below the expected range.	
	BOOM LENGTH SENSOR VALUE OUT OF RANGE HIGH	Indicates the length reported for the boom length sensor is above the expected range. An EMS cycle is required.	
	BOOM LENGTH SENSOR VALUE OUT OF RANGE LOW	Indicates the length reported for the boom length sensor is below the expected range. An EMS cycle is required.	
	BOOM ANGLE SENSOR #1 COMMUNICATIONS FAULT	Boom angle sensor #1 lost communications with the BLAM. An EMS cycle is required.	
	BOOM ANGLE SENSOR #2 COMMUNICATIONS FAULT	Boom angle sensor #2 lost communications with the BLAM. An EMS cycle is required.	
	ANGLE SENSOR #1 INVALID ANGLE	An EMS cycle is required.	
	ANGLE SENSOR #2 INVALID ANGLE	An EMS cycle is required.	
	WRONG TELE RESPONSE	The boom telescope is contrary to the user command	
	WRONG LIFT RESPONSE	The boom lift is contrary to the user command	
	TOWER ANGLE SENSOR DISAGREEMENT	The tower angle sensors are reporting angles that differ too greatly. An EMS cycle is required.	
	TOWER LENGTH SENSOR DISAGREEMENT	The tower length sensors are reporting angles that differ too greatly. An EMS cycle is required.	
	MAIN ANGLE SENSOR DISAGREEMENT	The main boom angle sensors are reporting angles that differ too greatly. An EMS cycle is required.	
	BOOM LENGTH SENSOR #1 OUT OF RANGE HIGH	Reported from the BLAM, indicates tower length sensor one value is out of range high.	
	BOOM LENGTH SENSOR #1 OUT OF RANGE LOW	Reported from the BLAM, indicates tower length sensor one value is out of range low.	
	BOOM LENGTH SENSOR #2 OUT OF RANGE HIGH	Reported from the BLAM, indicates tower length sensor two value is out of range high.	
	BOOM LENGTH SENSOR #2 OUT OF RANGE LOW	Reported from the BLAM, indicates tower length sensor two value is out of range low.	
	TWR LENGTH SENSOR NOT DETECTING LENGTH CHANGE	Tower tele is being commanded and the length sensors are not changing value.	
	TWR LENGTH MOVEMENT WITHOUT CMD	Tower length is changing without a tower tele command	
	TWR LENGTH SENSOR ONE VALUE OUT OF RANGE HIGH	This fault is reported by the Ground module when the length sensor value is outside the constant data limit	

Table 6-8. Help Fault Codes, Displayed Faults, and Descriptions - S/N 0300066949 & S/N 1300000001 to Present

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
	TWR LENGTH SENSOR ONE VALUE OUT OF RANGE LOW	This fault is reported by the Ground module when the length sensor value is outside the constant data limit	
	TWR LENGTH SENSOR TWO VALUE OUT OF RANGE HIGH	This fault is reported by the Ground module when the length sensor value is outside the constant data limit	
	TWR LENGTH SENSOR TWO VALUE OUT OF RANGE LOW	This fault is reported by the Ground module when the length sensor value is outside the constant data limit	
	TWR ANGL1 INVALID ANGLE	Tower boom angle sensor #1 out of range	
	TWR ANGL2 INVALID ANGLE	Tower boom angle sensor #2 out of range	
	INVALID ANGLE SENSOR #1 MODEL	Wrong tower angle sensor Mfgr. Installed on a 1250AJP (Must be a Rieker, not Spectron)	
	INVALID ANGLE SENSOR #2 MODEL	Wrong tower angle sensor Mfgr. Installed on a 1250AJP (Must be a Rieker, not Spectron)	
	MAIN ANGL1 INVALID ANGLE	Main boom angle sensor #1 out of range	
	MAIN ANGL2 INVALID ANGLE	Main boom angle sensor #2 out of range	
	MAIN ANGLE SENSOR NOT DETECTING ANGLE CHANGE	The main boom is being commanded to move and the main angle sensors are not detecting any movement	
	MAIN ANGLE MOVEMENT WITHOUT CMD	The main boom angle is changing without a main lift command	
	WRONG TWR TELE RESPONSE	The tower telescope is moving in the opposite direction the user is commanding.	
	WRONG TWR LIFT RESPONSE	The tower lift is moving in the opposite direction the user is commanding	
	TWR CYL ANGLE SENSOR OUT OF RANGE LOW	The tower cylinder angle sensor is below 4721 A/D counts	
	TWR CYL ANGLE SENSOR OUT OF RANGE HIGH	The tower cylinder angle sensor is above 29535 A/D counts.	
	TWR CYL ANGLE NOT DETECTING ANGLE CHANGE	The cylinder angle is not changing during a tower lift up/down user command.	
	TWR CYL ANGLE MOVEMENT WITHOUT CMD	The cylinder angle is changing without a tower lift command	
	MAIN TRN ANGLE SW FAILED	The system detected a disagreement of the N.O. vs N.C. contacts on the main boom angle switch.	
	TWR TRN SW DISAGREEMENT	The system detected a disagreement between the tower boom length switch and the tower length sensors.	
	TRN DUAL CAP SWITCHES BAD	The system detected both the Dual capacity and the transport switches are bad.	
	TRN DUAL CAP BAD TRANSITION	The system detected that the Dual capacity or the transport switches changed state out of order.	
	MAIN TRN LEN SW DISAGREEMENT	The system detected a disagreement between the main boom transport length switches.	
	DCAP LEN SW DISAGREEMENT	The system detected a disagreement between the main boom dual capacity length switches.	
	MAIN BOOM TRN ANGLE SW/SENSOR DISAGREEMENT	The system detected a disagreement between the main boom transport angle switch and the main boom angle sensors.	
	CYL ANGLE SENSOR/SW DISAGREEMENT	The system detected a disagreement of the tower angle input from the BLAM and the tower cylinder angle sensor.	

Table 6-8. Help Fault Codes, Displayed Faults, and Descriptions - S/N 0300066949 & S/N 1300000001 to Present

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
8/5		**Flash code 8/5 indicates problems with the moment or load pin system. Only occur on machines with moment or load pin control. An EMS cycle is required.**	10
	MOMENT PIN HORIZONTAL FORCE OUT OF RANGE	The horizontal force is out of the allowed range.	
	MOMENT PIN VERTICAL FORCE OUT OF RANGE	The vertical force is out of the allowed range.	
	LOAD PIN HORIZONTAL FORCE OUT OF RANGE	The horizontal force is out of the allowed range.	
	LOAD PIN VERTICAL FORCE OUT OF RANGE	The vertical force is out of the allowed range.	
	MOMENT PIN SENSOR FAULT	The moment pin has reported a fault flag.	
	LOAD PIN SENSOR FAULT	The load pin has reported a fault flag.	
	NEW MOMENT PIN DETECTED FAULT	A moment pin was detected on the system different from the one used to calibrate the machine.	
	NEW LOAD PIN DETECTED FAULT	A load pin was detected on the system different from the one used to calibrate the machine.	

Table 6-8. Help Fault Codes, Displayed Faults, and Descriptions - S/N 0300066949 & S/N 1300000001 to Present

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
8/6		**Flash code 8/6 indicates steering system problem. An EMS cycle is required except as noted.**	10
	RESTRICTED TO TRANSPORT – OSC AXLE PRESS SW DISAGREEMENT	Only occurs on machines with electrically released oscillating axles configured. The oscillating axle pressure switch indicates pressure while the machine is not driving or does not indicate pressure while the machine is driving and the machine is restricted to transport position.	
	AXLE EXT STB OR OC	A short to battery or open circuit was detected on the axles extension valve.	
	AXLE EXT STG	A short to ground was detected on the axles extension valve.	
	AXLE RET STB OR OC	A short to battery or open circuit was detected on the axles retract valve.	
	AXLE RET STG	A short to ground was detected on the axles retract valve.	
	RT FNT STEER RT STB OR OC	A short to battery or open circuit has been detected on the right front steer right valve.	
	RT FNT STEER RT STG	A short to ground has been detected on the right front steer right valve.	
	RT FNT STEER LT STB OR OC	A short to battery or open circuit has been detected on the right front steer left valve.	
	RT FNT STEER LT STG	A short to ground has been detected on the right front steer left valve.	
	LT FNT STEER RT STB OR OC	A short to battery or open circuit has been detected on the left front steer right valve.	
	LT FNT STEER RT STG	A short to ground has been detected on the left front steer right valve.	
	LT FNT STEER LT STB OR OC	A short to battery or open circuit has been detected on the left front steer left valve.	
	LT FNT STEER LT STG	A short to ground has been detected on the left front steer left valve.	
	RT REAR STEER RT STB OR OC	A short to battery or open circuit has been detected on the right rear steer right valve.	
	RT REAR STEER RT STG	A short to ground has been detected on the right rear steer right valve.	
	RT REAR STEER LT STB OR OC	A short to battery or open circuit has been detected on the right rear steer left valve.	
	RT REAR STEER LT STG	A short to ground has been detected on the right rear steer left valve.	
	LT REAR STEER RT STB OR OC	Left rear steer right valve short to battery or open circuit.	
	LT REAR STEER RT STG	Left rear steer left valve short to ground.	
	LT REAR STEER LT STB OR OC	Left rear steer left valve short to battery or open circuit.	
	LT REAR STEER LT STG	Left rear steer left valve short to ground.	
	FRONT LEFT WHEEL FAULT – CHECK MOUNTING	Steering angle sensor decoupled.	
	FRONT RIGHT WHEEL FAULT – CHECK MOUNTING	Steering angle sensor decoupled.	
	REAR LEFT WHEEL FAULT – CHECK MOUNTING	Steering angle sensor decoupled.	
	REAR RIGHT WHEEL FAULT – CHECK MOUNTING	Steering angle sensor decoupled.	
	FRONT LEFT WHEEL BLOCKED	Wheel not responding to steer commands. Fault clears when condition clears.	
	FRONT RIGHT WHEEL BLOCKED	Wheel not responding to steer commands. Fault clears when condition clears.	

Table 6-8. Help Fault Codes, Displayed Faults, and Descriptions - S/N 0300066949 & S/N 1300000001 to Present

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
	REAR LEFT WHEEL BLOCKED	Wheel not responding to steer commands. Fault clears when condition clears.	
	REAR RIGHT WHEEL BLOCKED	Wheel not responding to steer commands. Fault clears when condition clears.	
	FRONT LEFT WHEEL SENSOR OUT OF RANGE LOW	Steering angle sensor short to ground or open circuit detected.	
	FRONT LEFT WHEEL SENSOR OUT OF RANGE HIGH	Steering angle sensor short to battery detected.	
	FRONT RIGHT WHEEL SENSOR OUT OF RANGE LOW	Steering angle sensor short to ground or open circuit detected.	
	FRONT RIGHT WHEEL SENSOR OUT OF RANGE HIGH	Steering angle sensor short to battery detected.	
	REAR LEFT WHEEL SENSOR OUT OF RANGE LOW	Steering angle sensor short to ground or open circuit detected.	
	REAR LEFT WHEEL SENSOR OUT OF RANGE HIGH	Steering angle sensor short to battery detected.	
	REAR RIGHT WHEEL SENSOR OUT OF RANGE LOW	Steering angle sensor short to ground or open circuit detected.	
	REAR RIGHT WHEEL SENSOR OUT OF RANGE HIGH	Steering angle sensor short to battery detected.	
8/7		**Flash code 8/7 indicates new main angle sensors**	10
	NEW MAIN ANGL1 SENSOR DETECTED	System detected a different main angle #1 sensor than it was calibrated with. (1250AJP only.)	
	NEW MAIN ANGL2 SENSOR DETECTED	System detected a different main angle #2 sensor than it was calibrated with. (1250AJP only.)	

Table 6-8. Help Fault Codes, Displayed Faults, and Descriptions - S/N 0300066949 & S/N 1300000001 to Present

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
9/9		**Flash code 9/9 indicates problems with the controller or the user disabling safety systems from Access Level 0.**	11
	PLATFORM MODULE SOFTWARE UPDATE REQUIRED	Platform module code is too old to support the EIM or BPE load sensor and machine is configured to use one of these two sensors. PM code must be updated to a newer version.	
	GROUND MODULE CONSTANT DATA UPDATE REQUIRED	Ground module has old constant data that is not compatible with current ground module software. GM constant data must be updated to a newer version. An EMS cycle is required.	
	HIGH RESOLUTION A2D FAILURE – INTERRUPT LOST	ADS1213 chip in the platform module has stopped asserting its interrupt (DRDY) line for some reason. An EMS cycle is required.	
	HIGH RESOLUTION A2D FAILURE-REINIT LIMIT	ADS1213 has needed to be reset 3 or more times. An EMS cycle is required.	
	PLATFORM MODULE FAILURE: hwfs CODE 1	Platform module V(Low) FET has failed. An EMS cycle is required.	
	GROUND MODULE FAILURE: hwfs CODE 1	Ground module V(Low) FET has failed. An EMS cycle is required.	
	GROUND SENSOR REF VOLTAGE OUT OF RANGE	Seven volt reference voltage for joysticks, sensors, etc. is out of range. Not reported during 2 second power-up. An EMS cycle is required.	
	GROUND MODULE FAILURE: hIGH SIDE DRIVER CUTOUT FAULTY	Hardware based high side driver cutout circuit fault. An EMS cycle is required.	
	PLATFORM SENSOR REF VOLTAGE OUT OF RANGE	These faults occur when the seven volt reference voltage used for the joysticks, sensors, etc goes out of range. Not reported during 2 second power-up. An EMS cycle is required.	
	EEPROM FAILURE – CHECK ALL SETTINGS	EEPROM critical failure. Personalities, machine configuration digits, etc may be reset to default values and should be checked. An EMS cycle is required.	
	CHASSIS TILT SENSOR NOT GAIN CALIBRATED	Chassis tilt sensor calibration information has been lost. Machine indicates it is tilted at all times. This calibration data is programmed into unit at the factory.	
	CHASSIS TILT SENSOR GAIN OUT OF RANGE	Chassis tilt sensor calibration has become corrupted. This calibration data is programmed into unit at the factory.	
	ENVELOPE CONTROL DISABLED	Machines with envelope control ONLY. User has forced envelope control off with analyzer from Access Level 0.	
	MOMENT CONTROL DISABLED	Only occurs on machines with envelope control ONLY. The user has forced moment control off with the analyzer from Access Level 0.	
	STEER SENSORS NOT CALIBRATED	Machines with a chassis module ONLY. Steer sensors require calibration.	
	BOOM SENSORS NOT CALIBRATED	Machines with a BLAM module ONLY. Boom sensors require calibration.	
	LIFT CRACKPOINTS NOT CALIBRATED	1200S and 1350S machines ONLY. Lift valves require a calibration.	
	TELESCOPE CRACKPOINTS NOT CALIBRATED	1200S and 1350S machines ONLY. Telescope valves require a calibration.	
	DRIVE CRACKPOINTS NOT CALIBRATED	1200S and 1350S machines ONLY. Drive valves require a calibration.	

Table 6-8. Help Fault Codes, Displayed Faults, and Descriptions - S/N 0300066949 & S/N 1300000001 to Present

Fault Flash Code	Communicated (Displayed on Analyzer) Fault	Description	Priority
	BLAM SENSOR SUPPLY OUT OF RANGE HIGH	Supply voltage for boom angle sensors is above expected range. An EMS cycle is required.	
	BLAM SENSOR SUPPLY OUT OF RANGE LOW	Supply voltage for boom angle sensors is below expected range. An EMS cycle is required.	
	LENGTH SENSOR REF VOLTAGE HIGH	Supply voltage for boom length sensors is above expected range. An EMS cycle is required.	
	LENGTH SENSOR REF VOLTAGE LOW	Supply voltage for boom length sensors is below expected range. An EMS cycle is required.	
	BLAM HIGH RES A/D FAILURE	High resolution analog to digital converter in the BLAM module has failed. An EMS cycle is required.	
	CHASSIS SENSOR SUPPLY OUT OF RANGE LOW	Supply voltage for chassis sensors is below expected range. An EMS cycle is required.	
	CHASSIS SENSOR SUPPLY OUT OF RANGE HIGH	Supply voltage for chassis sensors is above expected range. An EMS cycle is required.	
	BLAM BACKUP COMMUNICATIONS LINK FAULTY	Backup communications link to the BLAM failed test at startup.	
	BLAM BACKUP COMMUNICATIONS LOST - HYDRAULICS SUSPENDED	Backup communications link to the BLAM module was activated but could not establish/maintain communications with the BLAM.	

4150461-E

NOTES:

SECTION 7. BASIC ELECTRICAL INFORMATION & SCHEMATICS

7.1 GENERAL

This section contains basic electrical information and schematics for locating and correcting most operating problems. If a problem develops which is not presented in this section or not corrected by listed corrective actions, obtain technically qualified guidance before proceeding with any maintenance.

7.1 MULTIMETER BASICS

A wide variety of multimeters or Volt Ohm Meters (VOM) can be used for troubleshooting your equipment. This section shows diagrams of a common, digital VOM configured for several different circuit measurements. Instructions for your VOM may vary. Please consult meter operator's manual for more information.

Grounding

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

Backprobing

"Backprobe" means to take the measurement by accessing a connector's contact on the same side as the wires, on back of the connector. Readings can be done while maintaining circuit continuity. If connector is the sealed type, great care must be taken to avoid damaging 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 so the test 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 wires are still attached to the contact and contacts are seated in the connector.

Min/Max

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

Polarity

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

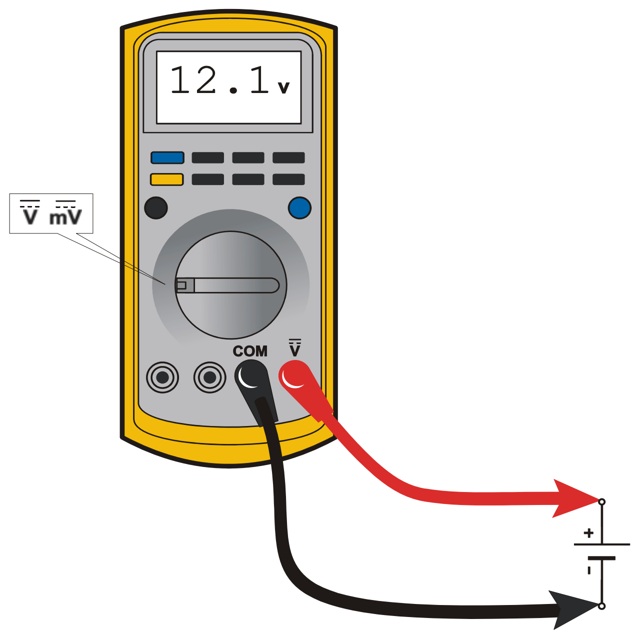


Figure 7-1. Voltage Measurement (DC)

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

Resistance Measurement

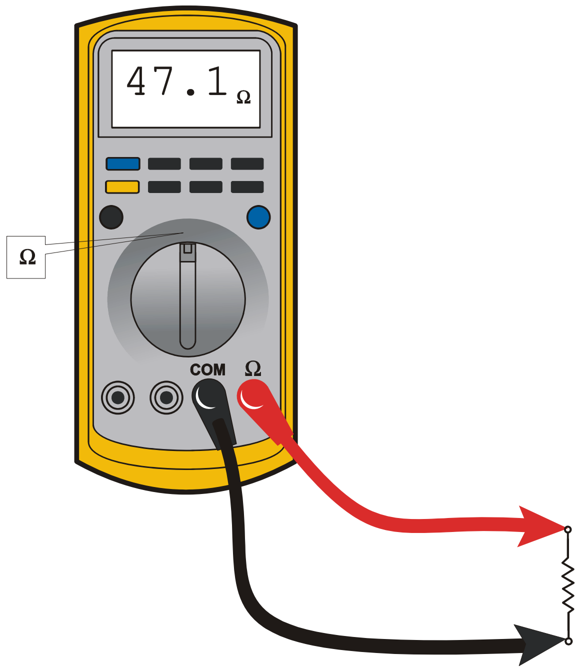


Figure 7-2. Resistance Measurement

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

Continuity Measurement

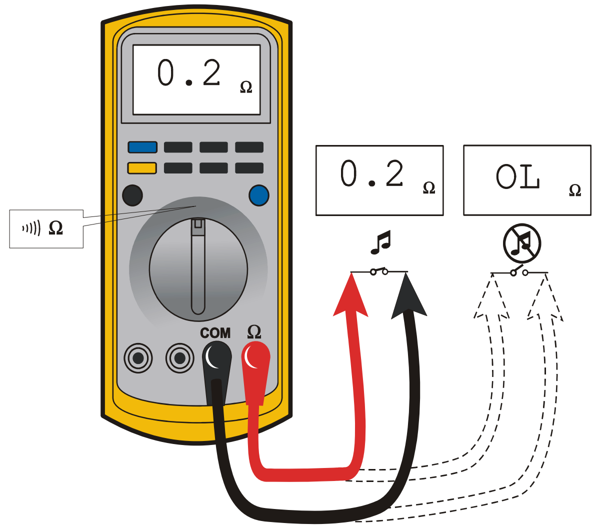


Figure 7-3. Continuity Measurement

- Some meters require a separate button press to enable audible continuity testing.
- Circuit power must be 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

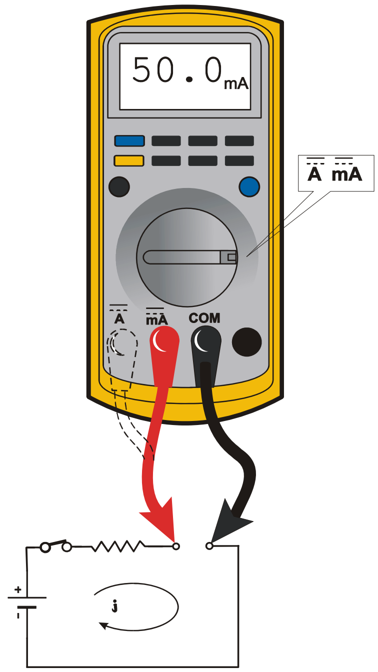


Figure 7-4. Current Measurement (DC)

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

7.2 APPLYING SILICONE DIELECTRIC COMPOUND TO ELECTRICAL CONNECTIONS

NOTE: *Do NOT apply dielectric grease to the following connections:*

- Main Boom Rotary sensor connections (on Celesco Sensor).
- LSS Modules connections,
- Deutz EMR 2 ECM connection.

Silicone Dielectric Compound must be used on all electrical connections except those listed above for the following reasons:

- To prevent oxidation at 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. This procedure applies to all plug connections not enclosed in a box. Silicone grease should not be applied to connectors with external seals.

1. To prevent oxidation, silicone grease must be packed completely around male and female pins on inside of connector before assembly. This is most easily achieved using a syringe.

NOTE: *Over a period of time, oxidation increases electrical resistance at the connection, causing circuit failure.*

2. To prevent shorting, silicone grease must be packed around each wire where they enter the connector housing. Also, silicone grease must be applied at the joint where male and female connectors come together. Any other joints (around strain reliefs, etc.) where water could enter, connector should also be sealed.

NOTE: *This condition is especially common when machines are pressure washed since washing solution is much more conductive than water.*

3. Anderson connectors for battery boxes and battery chargers should have silicone grease applied to contacts only.

NOTE: *Curing-type sealants can also be used to prevent shorting and are less messy, but make future pin removal more difficult.*

7.3 AMP CONNECTOR

Applying Silicone Dielectric Compound to AMP Connectors

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

- To prevent oxidation at 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 electrical connectors.

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

Assembly

Check wedge lock is in the open, or as-shipped position (See Figure 7-5.). Proceed as follows:

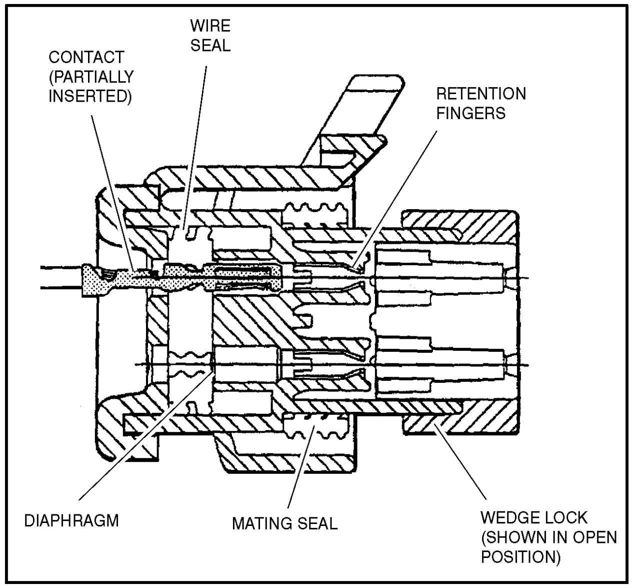


Figure 7-5. Connector Assembly Figure 1

1. Push contact straight into appropriate circuit cavity as far as it will go (See Figure 7-7.).
2. Pull contact wire with a force of 1 or 2 lbs. to be sure retention fingers hold contact (See Figure 7-7.).

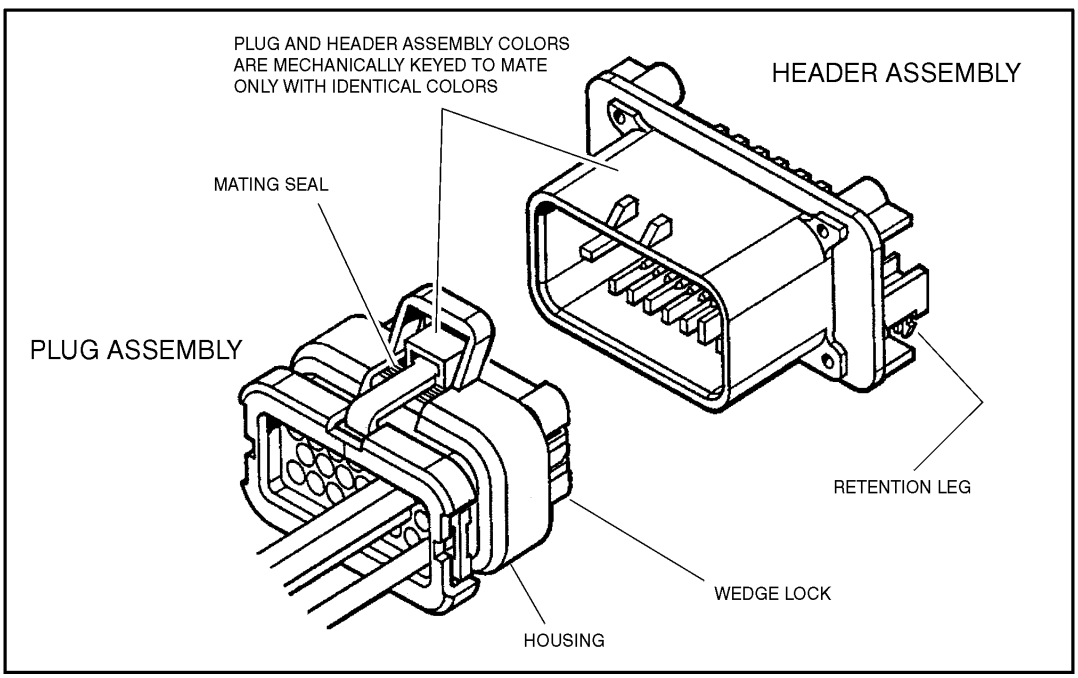


Figure 7-6. AMP Connector

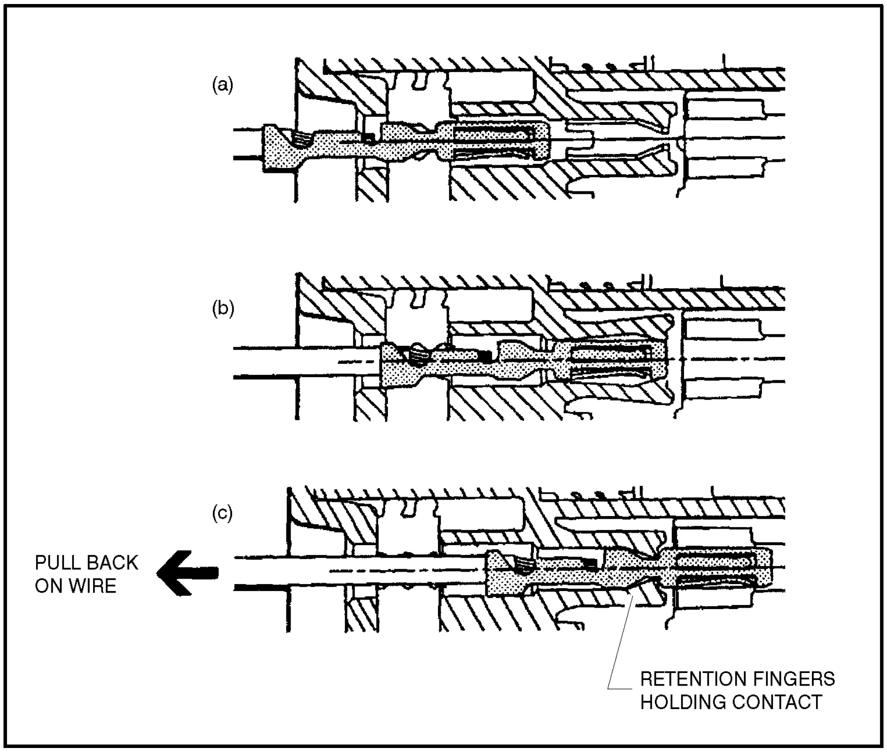


Figure 7-7. Connector Assembly Figure 2

3. After all required contacts are inserted, close wedge lock to its locked position. Release locking latches by squeezing them inward (See Figure 7-8.).

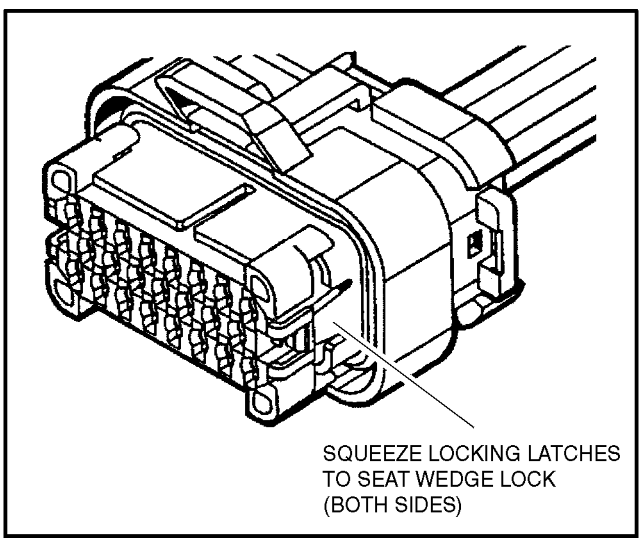


Figure 7-8. Connector Assembly Figure 3

4. Slide wedge lock into housing until flush with housing (See Figure 7-9.).

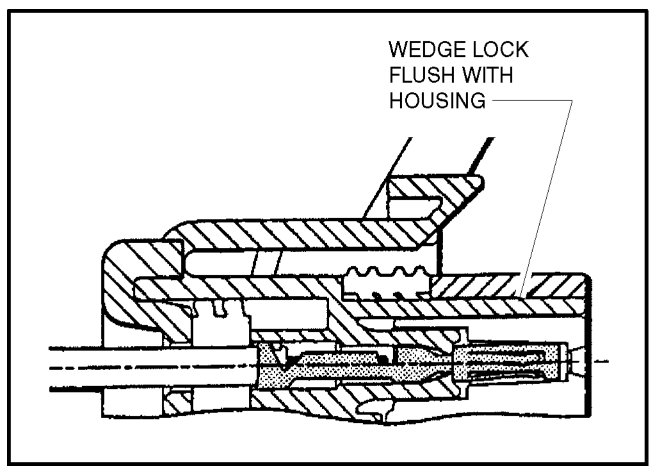


Figure 7-9. Connector Assembly Figure 4

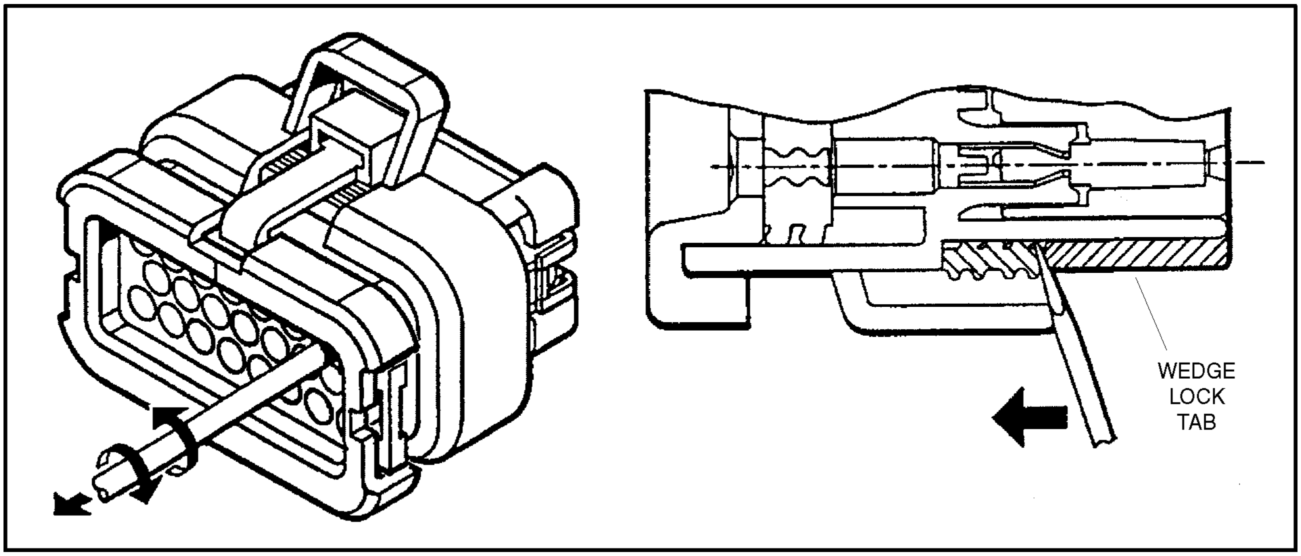


Figure 7-10. Connector Disassembly

Disassembly

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

NOTE: Wedge lock should never be removed from housing for contact insertion or removal.

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

NOTICE

DO NOT PIERCE WIRE INSULATION TO TAKE VOLTAGE READINGS.

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

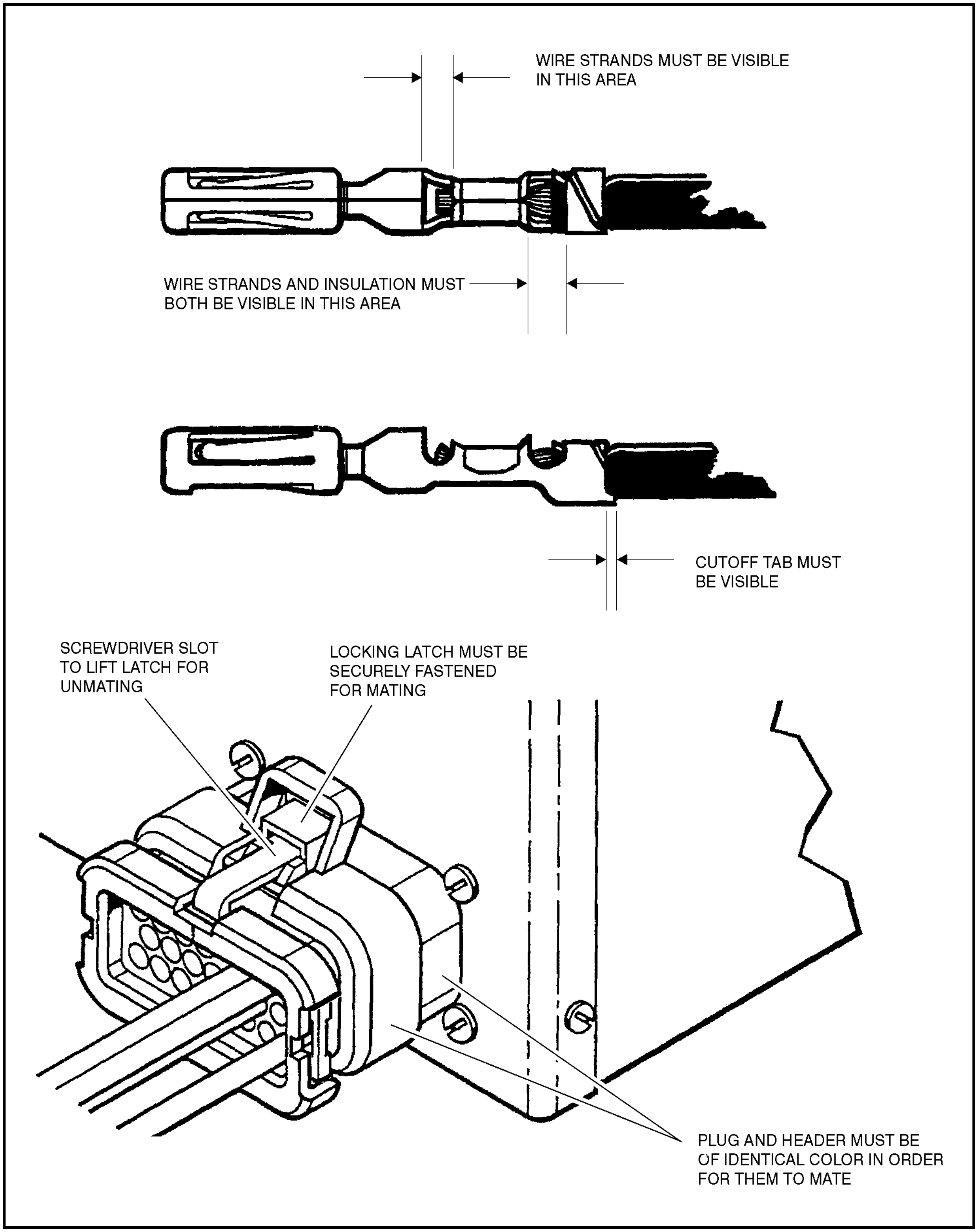


Figure 7-11. Connector Installation

7.4 DEUTSCH CONNECTORS

DT/DTP Series Assembly

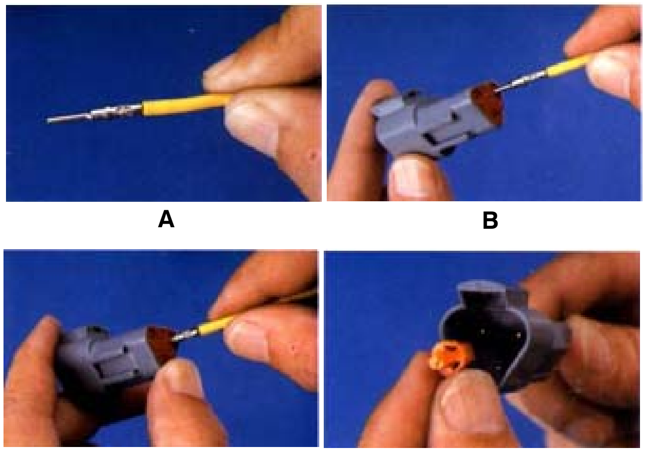


Figure 7-12. DT/DTP Contact Installation

1. Grasp crimped contact about 25mm behind 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 wedgelock will snap into place. Rectangular wedges are not oriented. They may go in either way.

NOTE: Receptacle shown - use same procedure for plug.

DT/DTP Series Disassembly

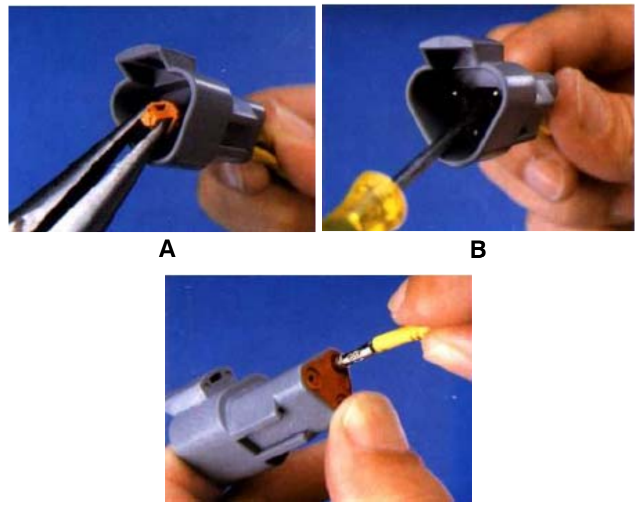


Figure 7-13. DT/DTP Contact Removal

1. Remove wedgelock (A) using needlenose pliers or a hook shaped wire to pull wedge straight out.

NOTE: Hold rear seal in place. Removing contact may displace seal.

2. Gently pull wire and contact out of connector (C), while at the same time releasing locking finger by moving it away from contact with a screwdriver (B).

HD30/HDP20 Series Assembly

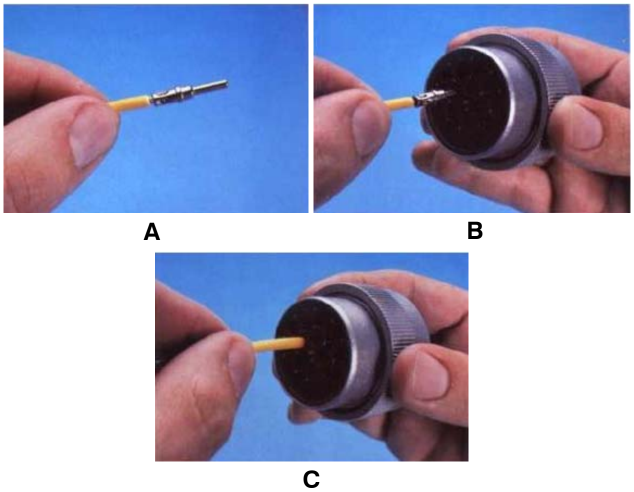


Figure 7-14. HD/HDP Contact Installation

1. Grasp contact about 25mm behind contact crimp barrel.
2. Hold connector with rear grommet facing you.
3. Push contact straight into connector grommet until a positive stop is felt. A slight tug will confirm it is locked in place.

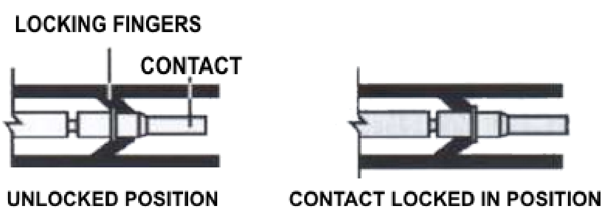


Figure 7-15. HD/HDP Locking Contacts Into Position

NOTE: Insert sealing plugs in unused wire cavities for full environmental sealing

HD30/HDP20 Series Disassembly

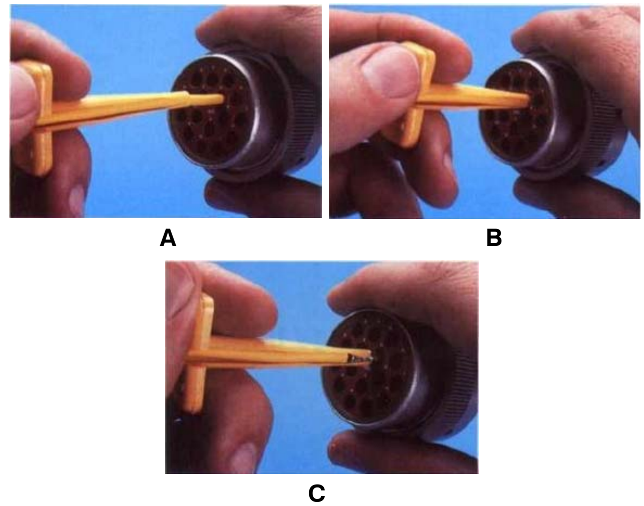


Figure 7-16. HD/HDP Contact Removal

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

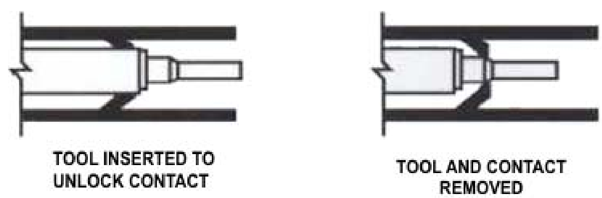


Figure 7-17. HD/HDP Unlocking Contacts

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

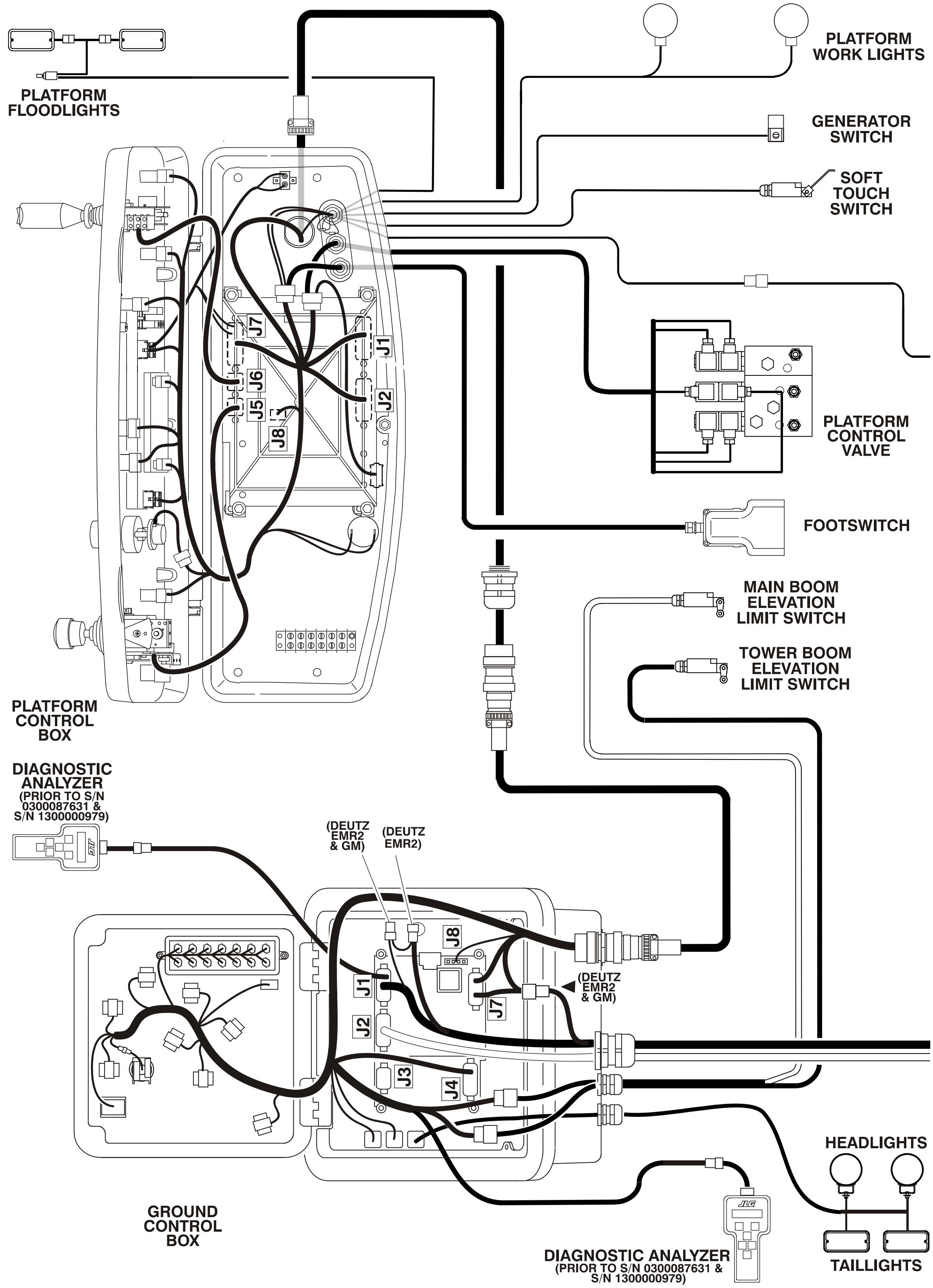


Figure 7-18. Electrical Components Installation - Sheet 1

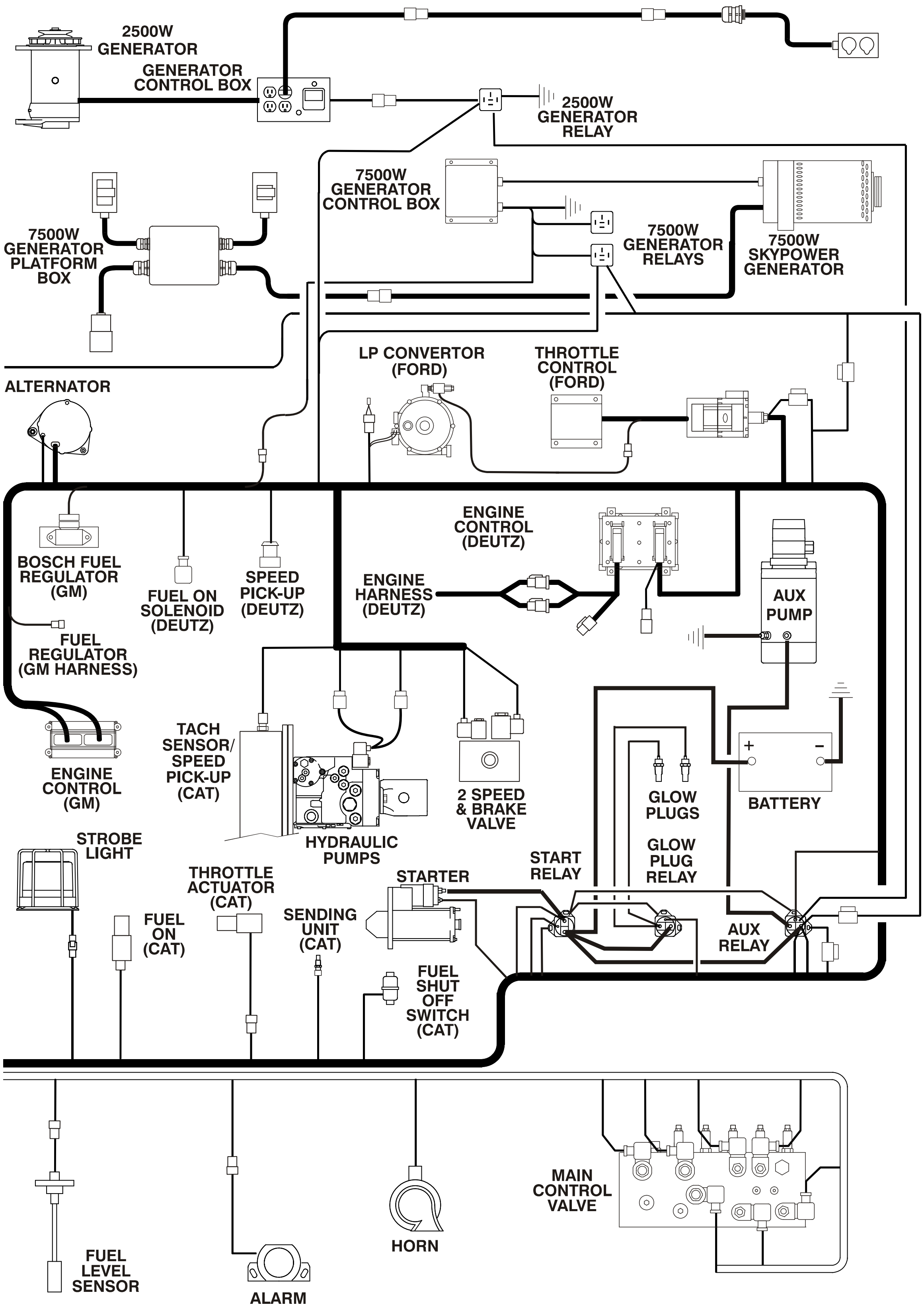
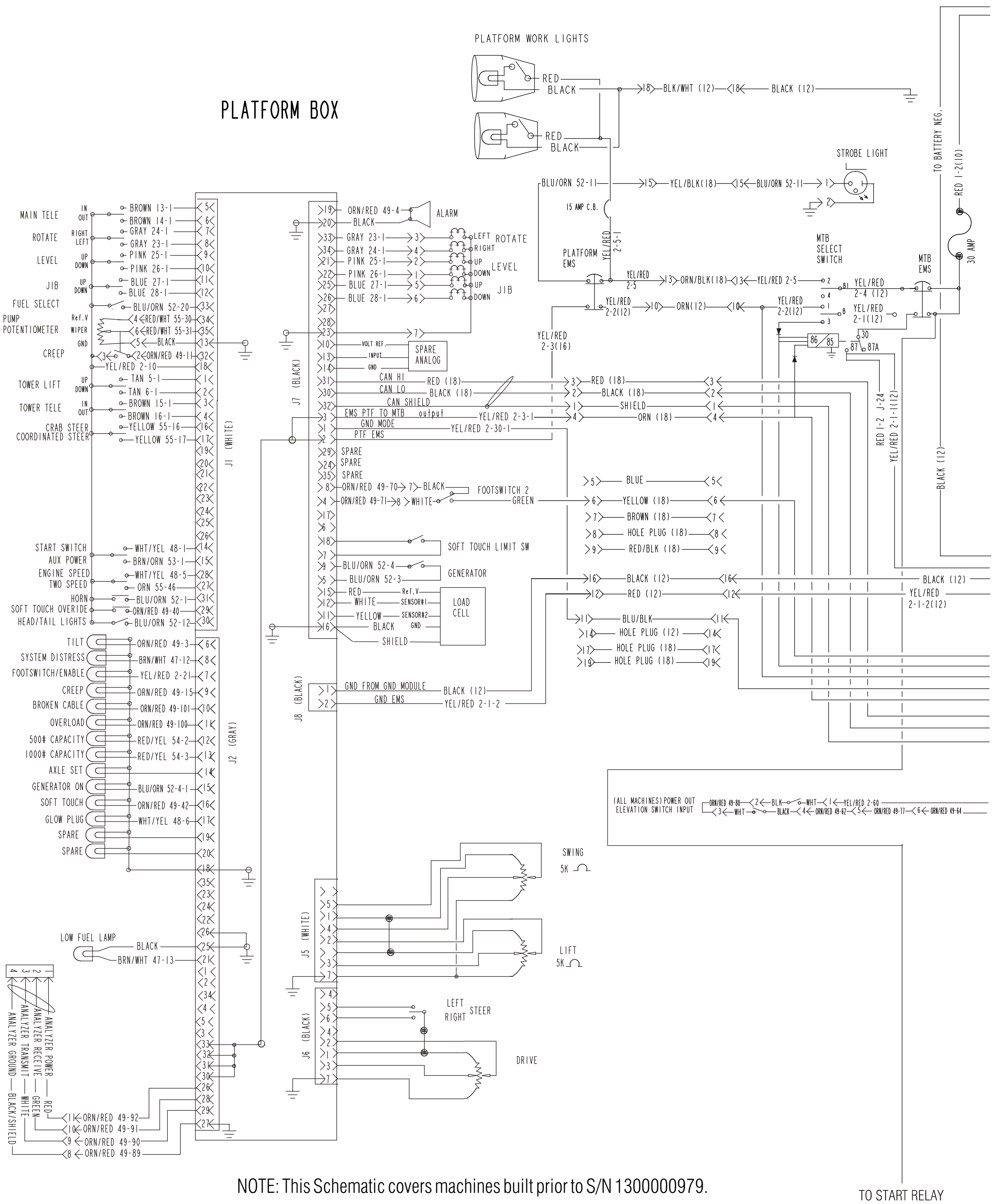


Figure 7-19. Electrical Components Installation - Sheet 2



NOTE: This Schematic covers machines built prior to S/N 1300000979.

Figure 7-20. Electrical Schematic - Sheet 1 of 4

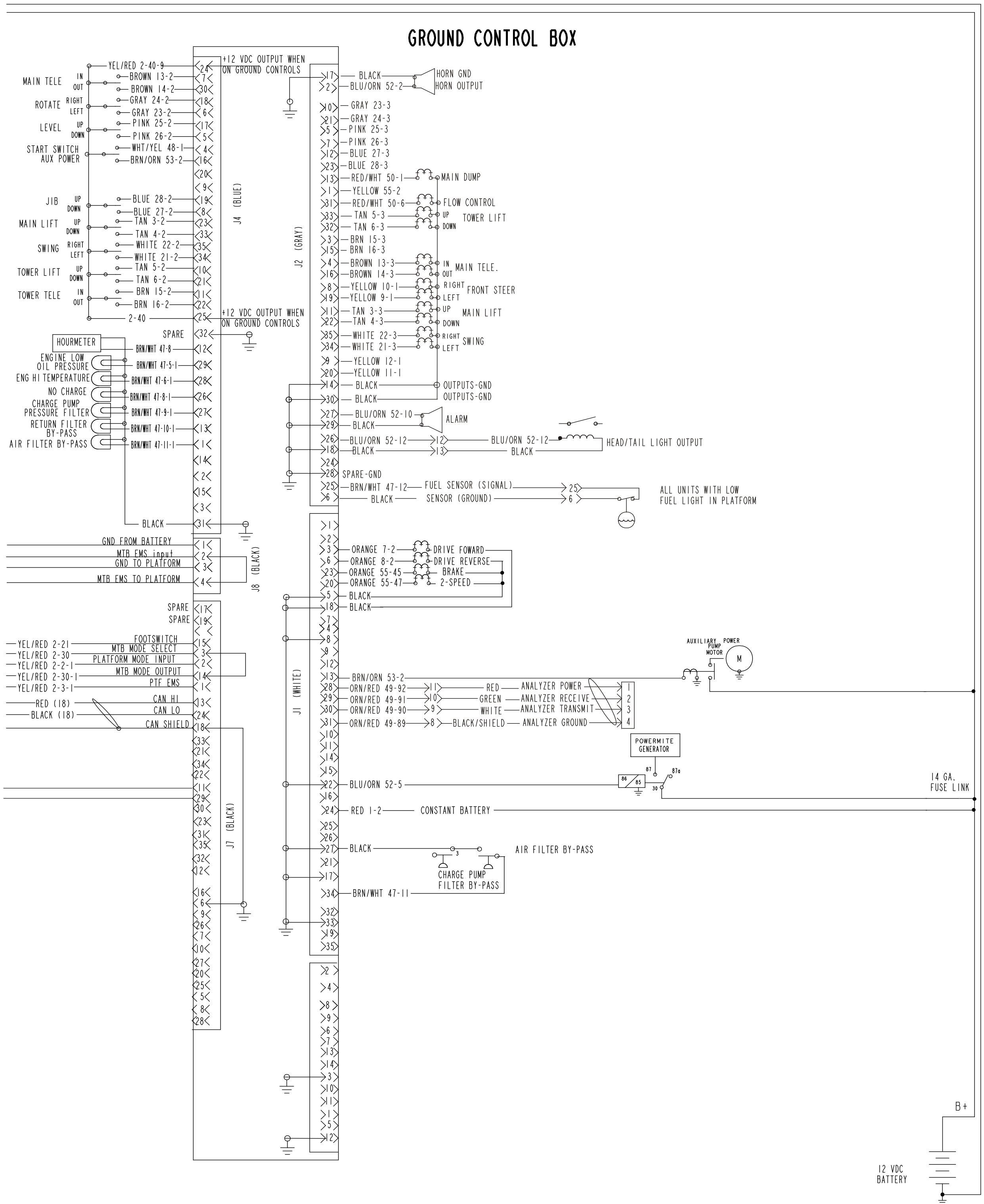
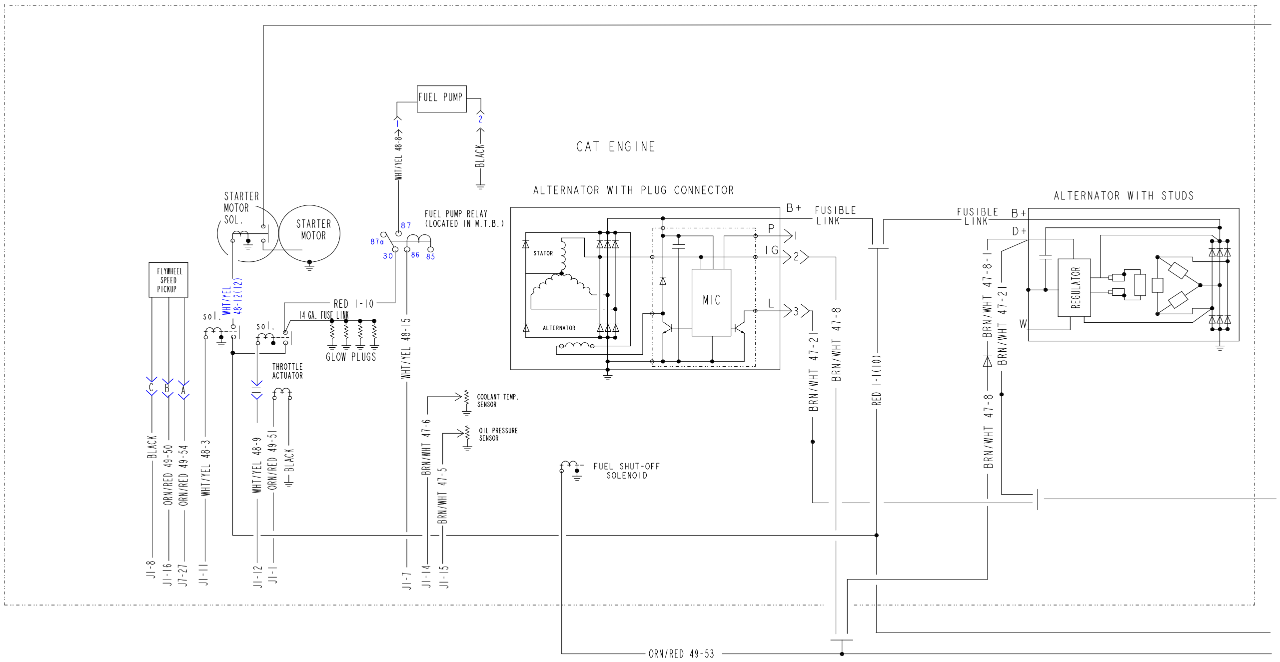


Figure 7-21. Electrical Schematic - Sheet 2 of 4



NOTE: This Schematic covers machines built prior to S/N 1300000979.

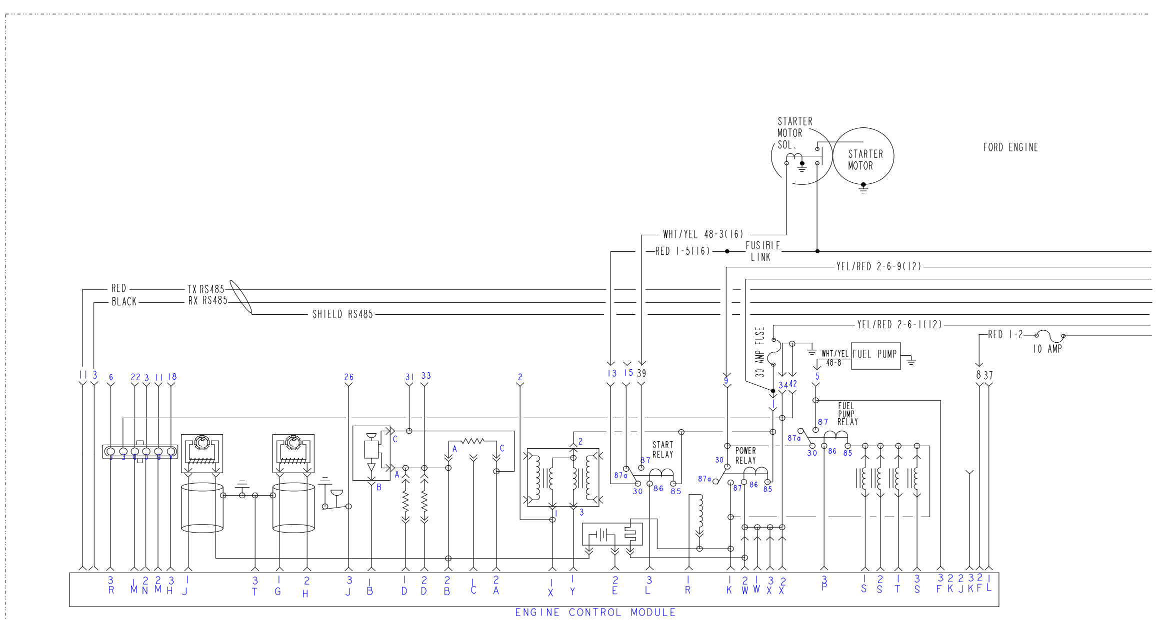


Figure 7-22. Electrical Schematic - Sheet 3 of 4

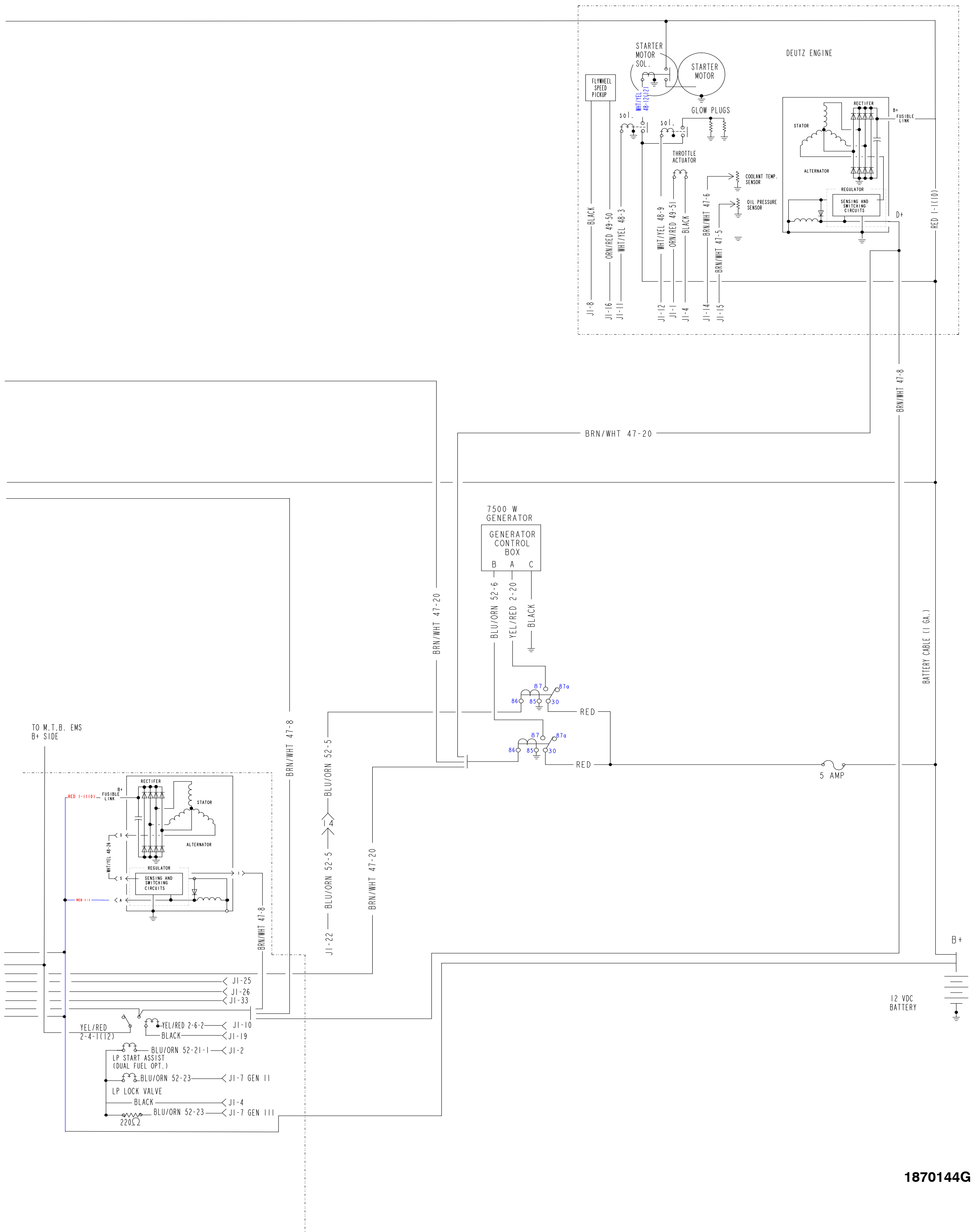


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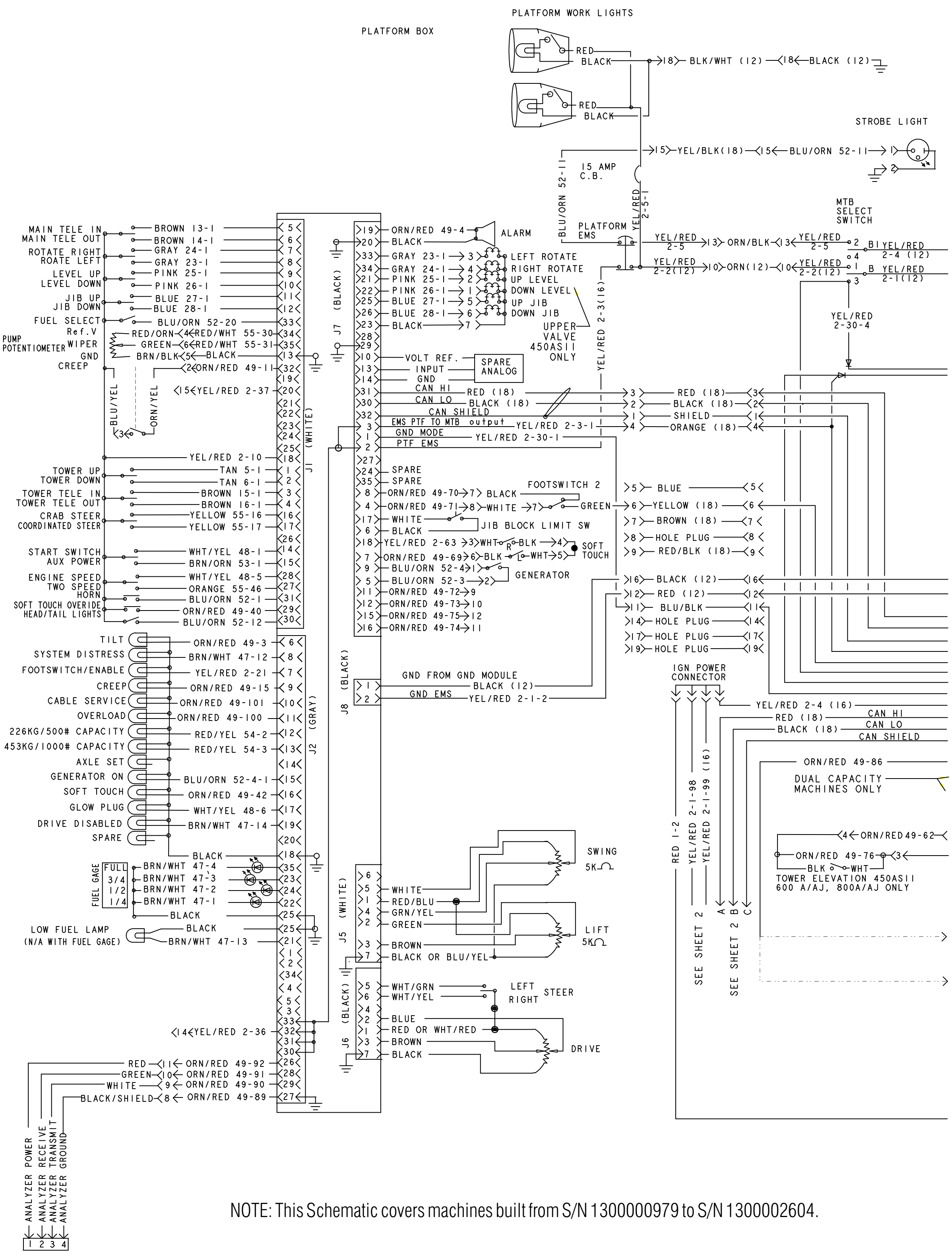
Figure 7-23. Electrical Schematic - Sheet 4 of 4



NOTE: This Schematic covers machines built from S/N 1300000979 to S/N 1300002604.

Figure 7-24. Electrical Schematic - Deutz EMR2 & GM Engine - Sheet 1 of 6

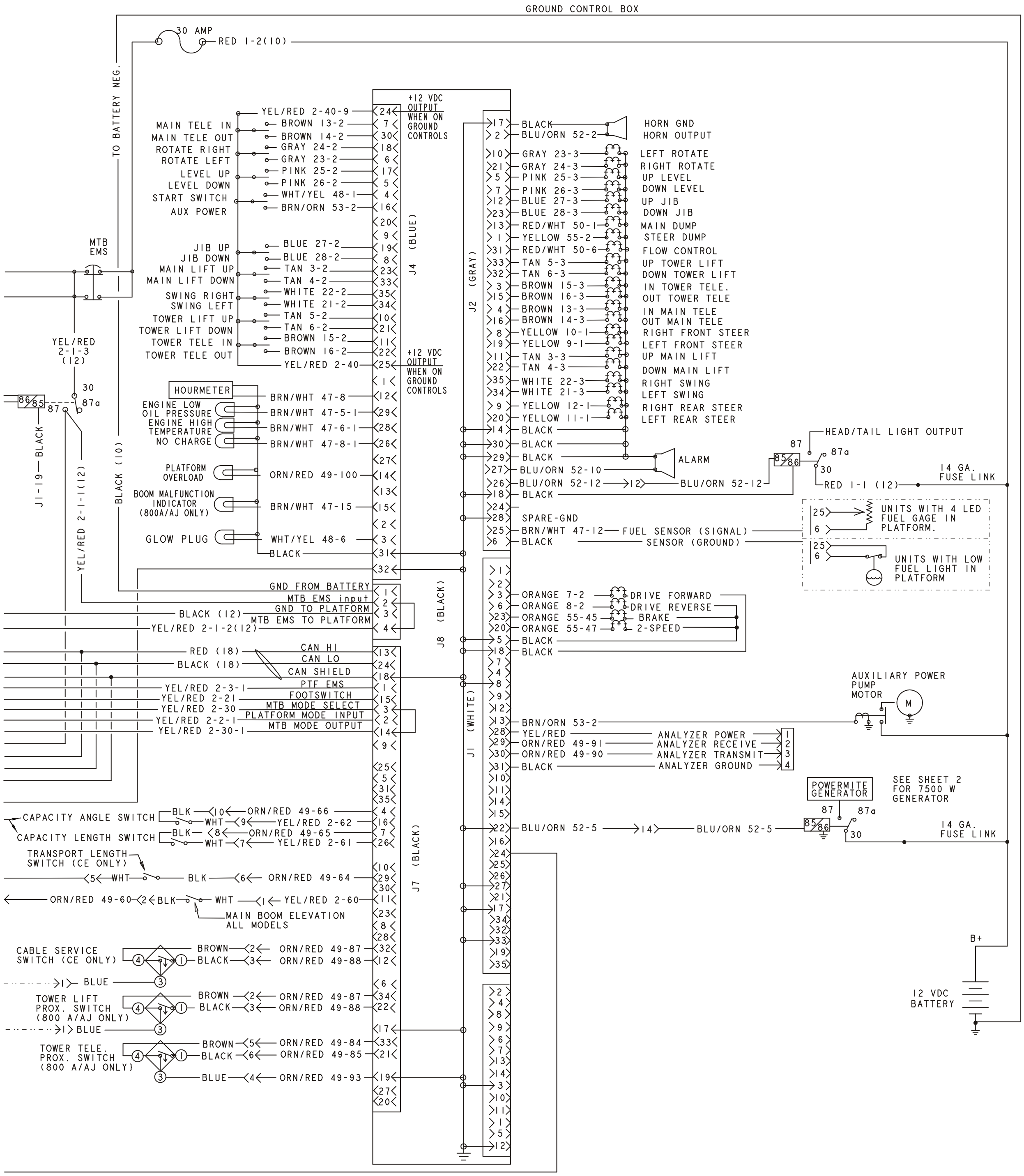


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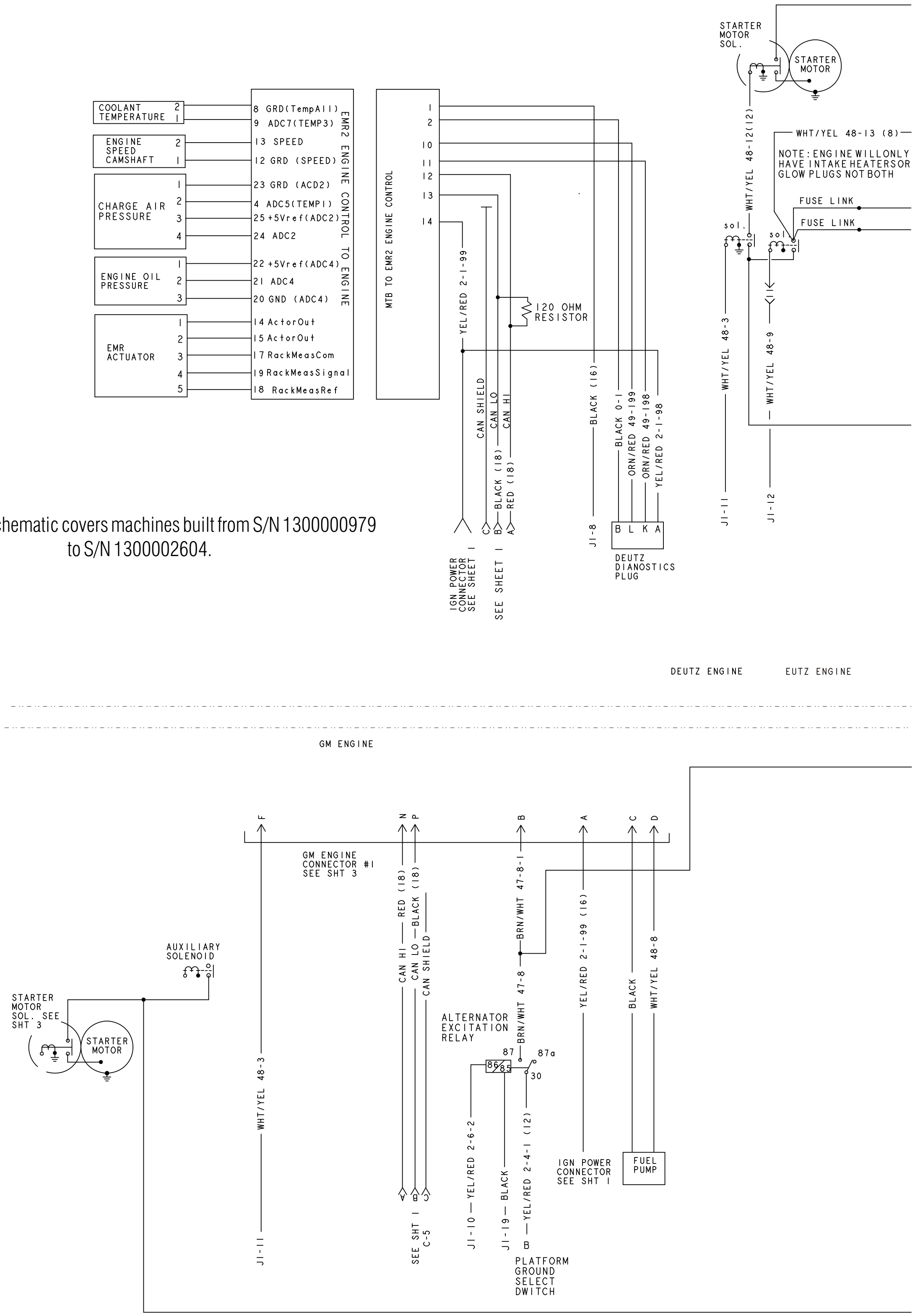
Figure 7-25. Electrical Schematic - Deutz EMR2 & GM Engine - Sheet 2 of 6



NOTE: This Schematic covers machines built from S/N 1300000979 to S/N 1300002604.

Figure 7-26. Electrical Schematic - Deutz EMR2 & GM Engine - Sheet 3 of 6

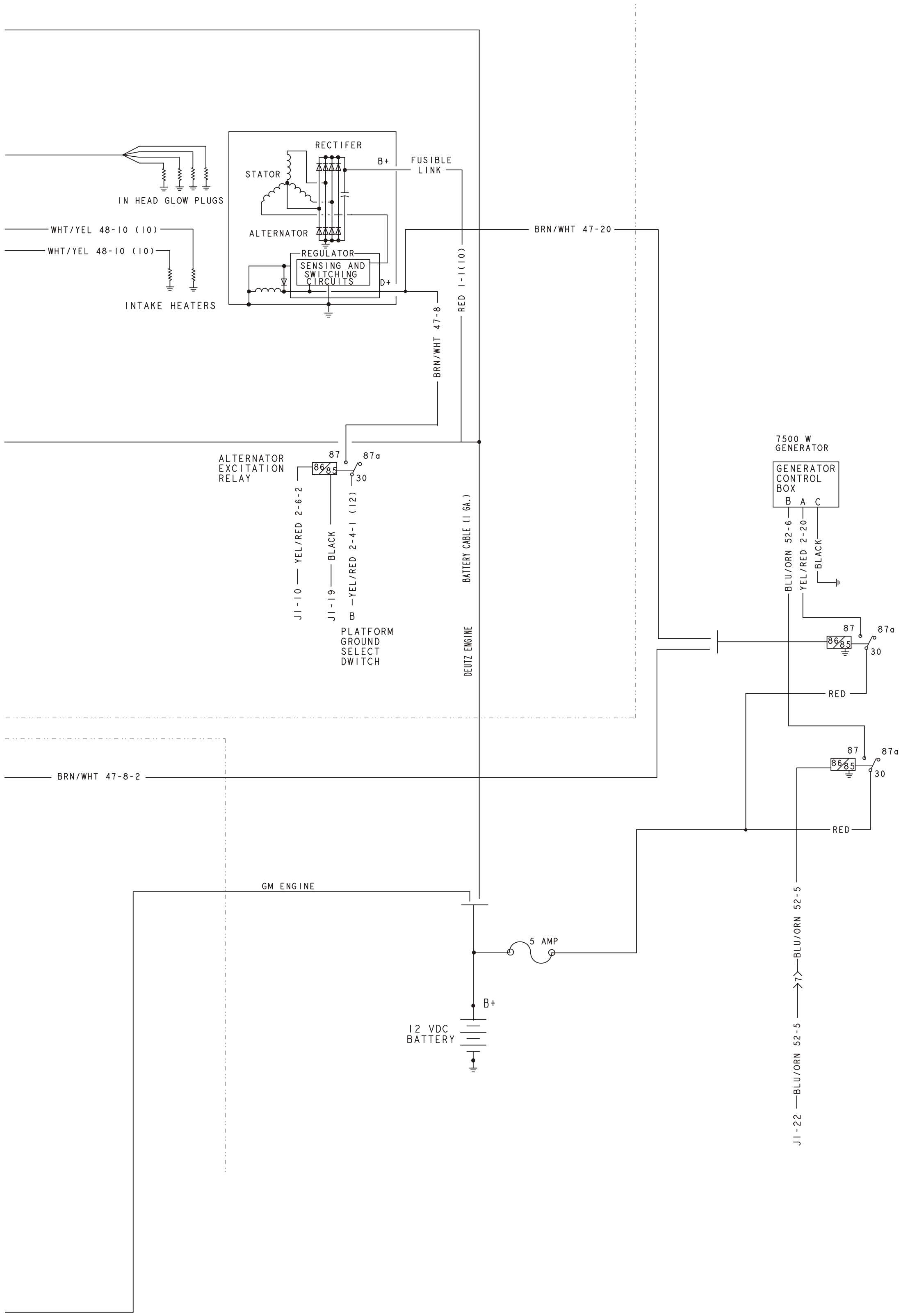
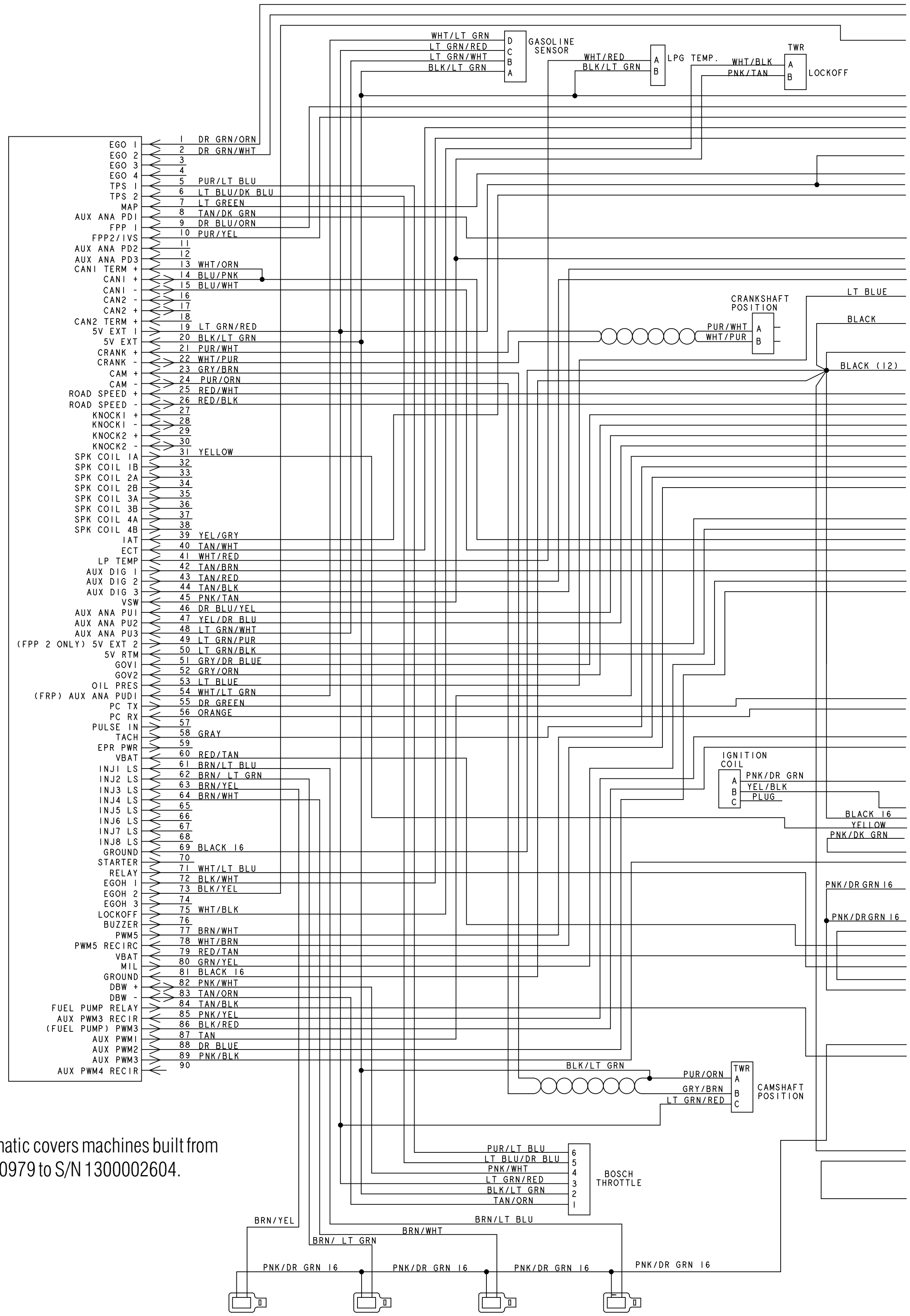


Figure 7-27. Electrical Schematic - Deutz EMR2 & GM Engine - Sheet 4 of 6



NOTE: This Schematic covers machines built from S/N 1300000979 to S/N 1300002604.

Figure 7-28. Electrical Schematic - Deutz EMR2 & GM Engine - Sheet 5 of 6

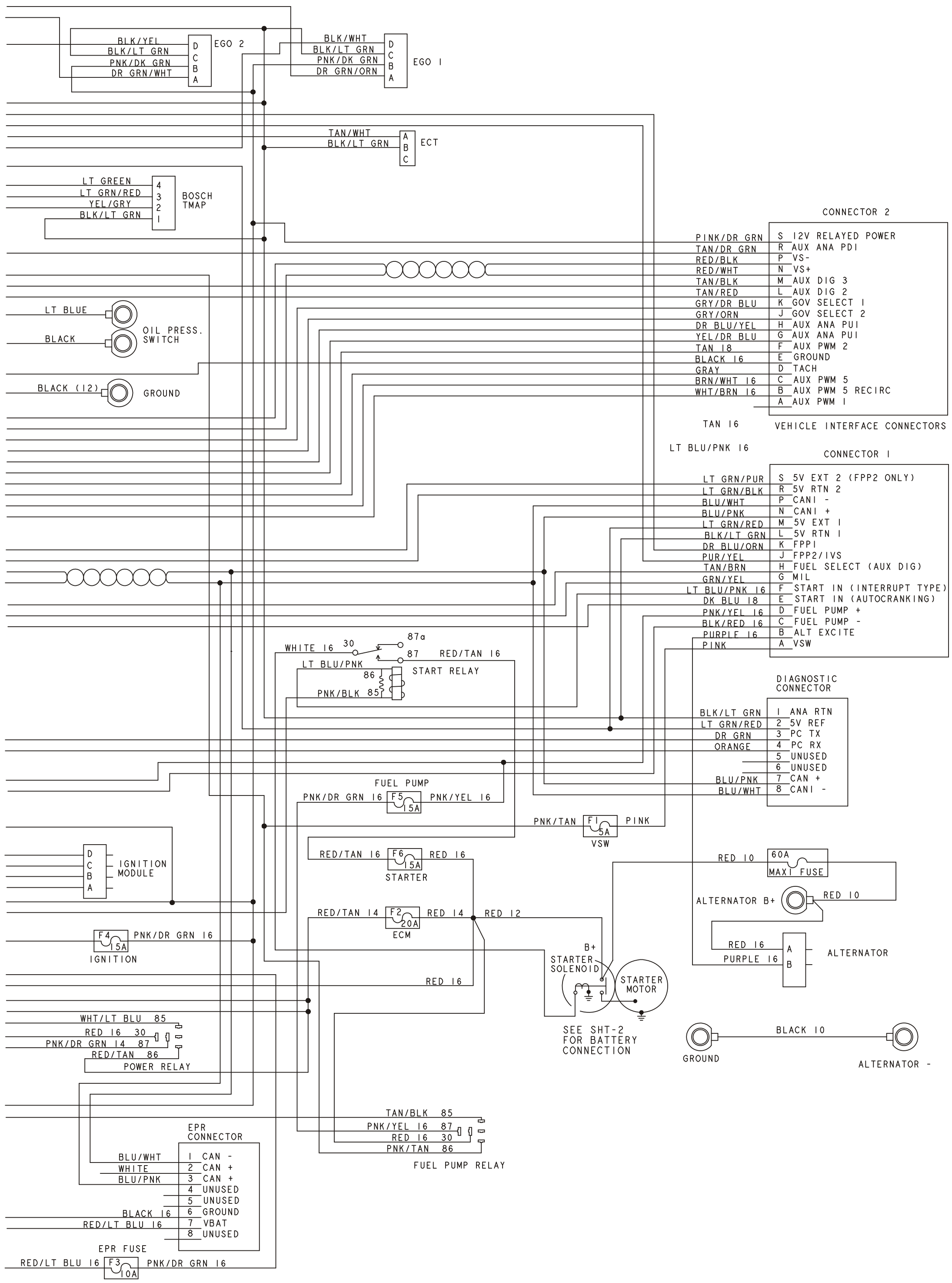


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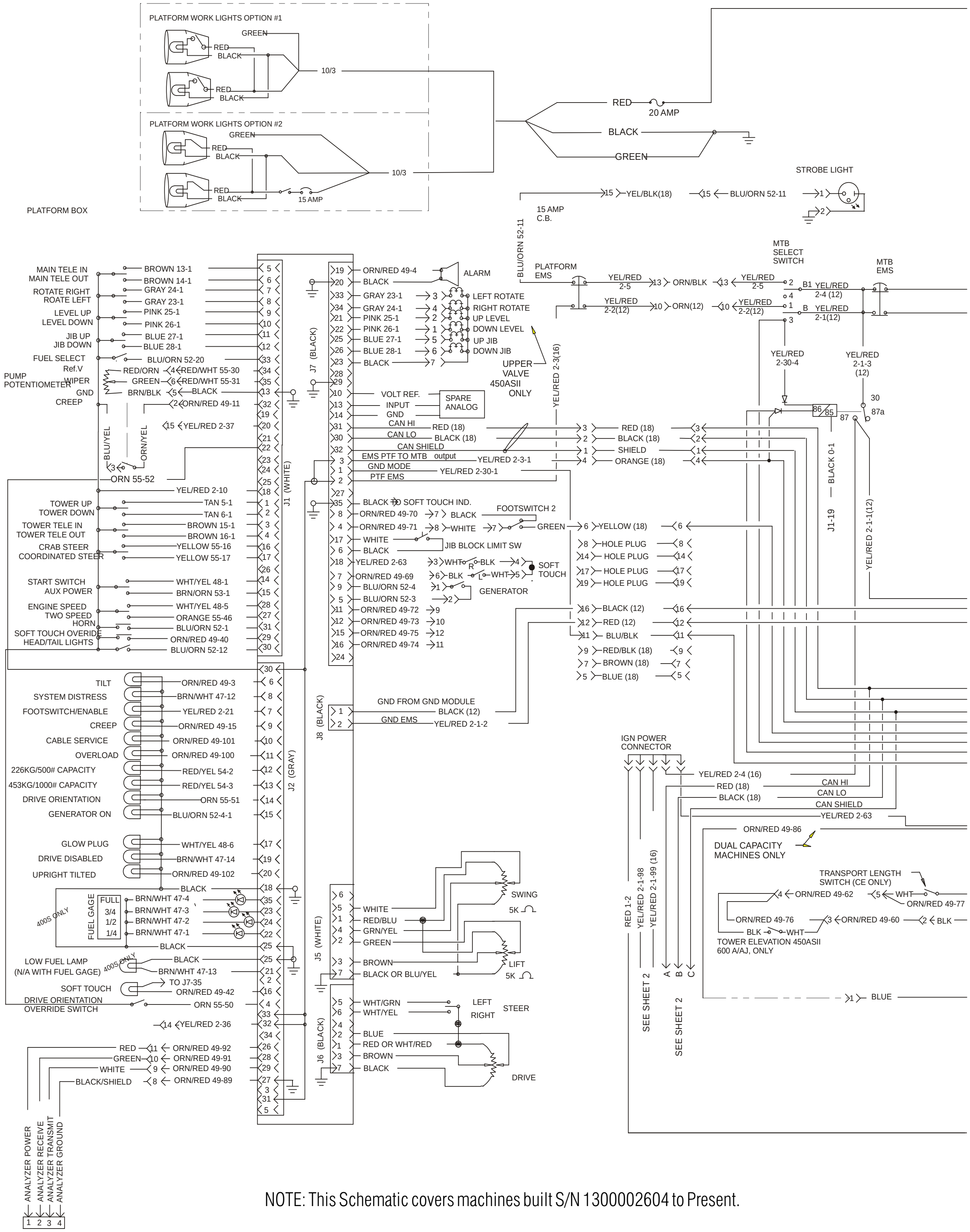
Figure 7-29. Electrical Schematic - Deutz EMR2 & GM Engine - Sheet 6 of 6



NOTE: This Schematic covers machines built S/N 1300002604 to Present.

Figure 7-30. Electrical Schematic - Deutz, GM, & CAT Engine - Sheet 1 of 6

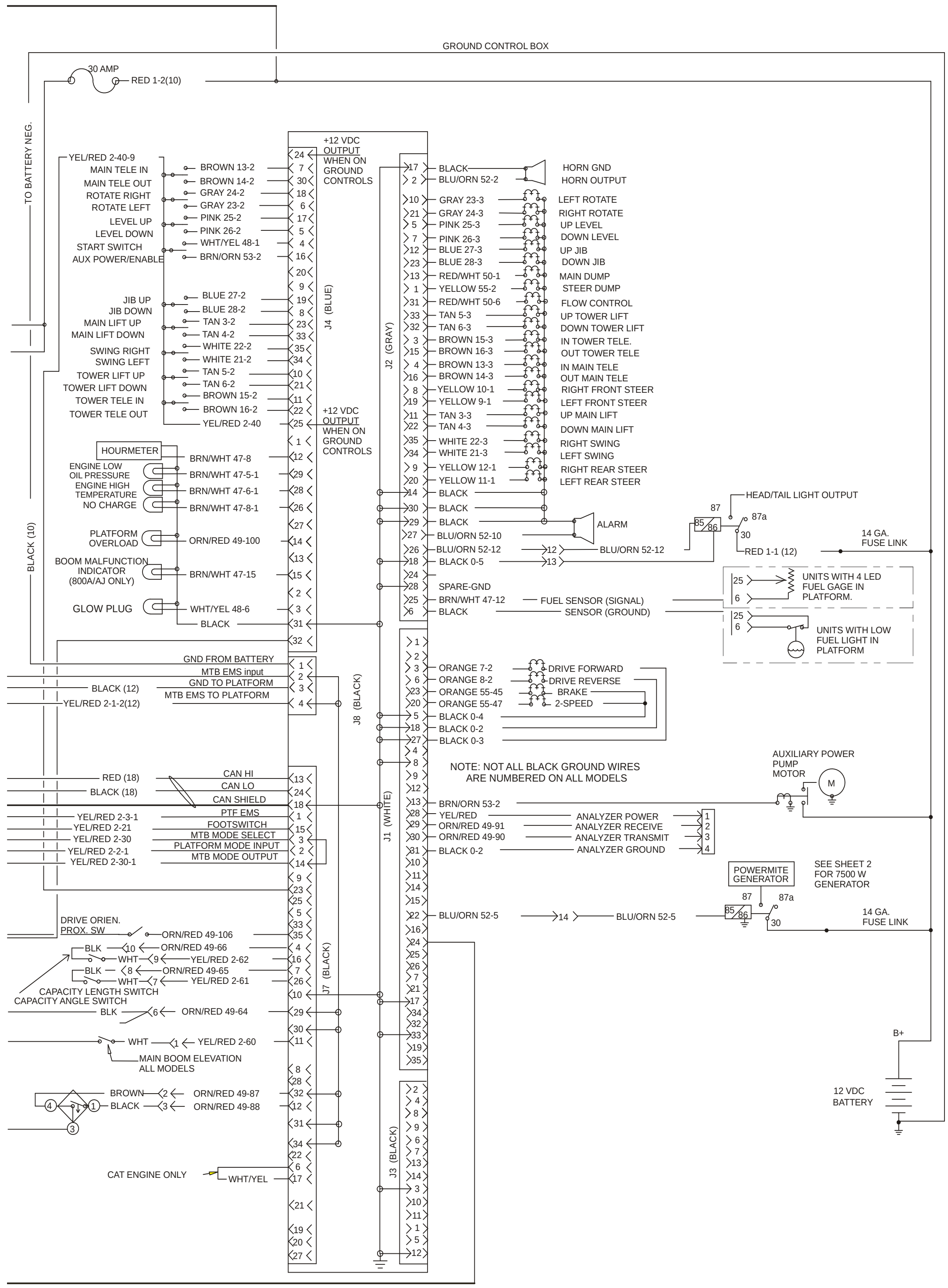
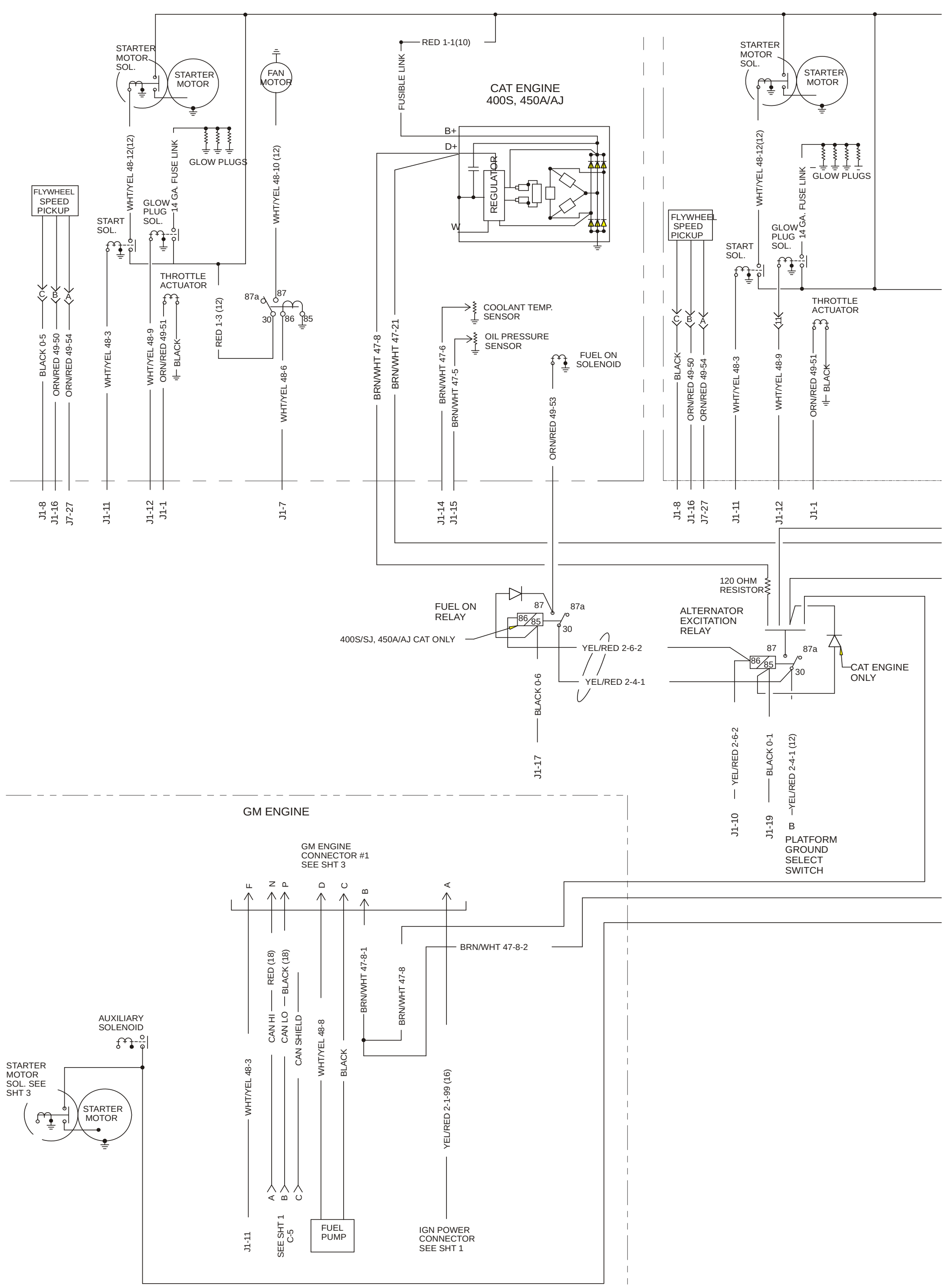
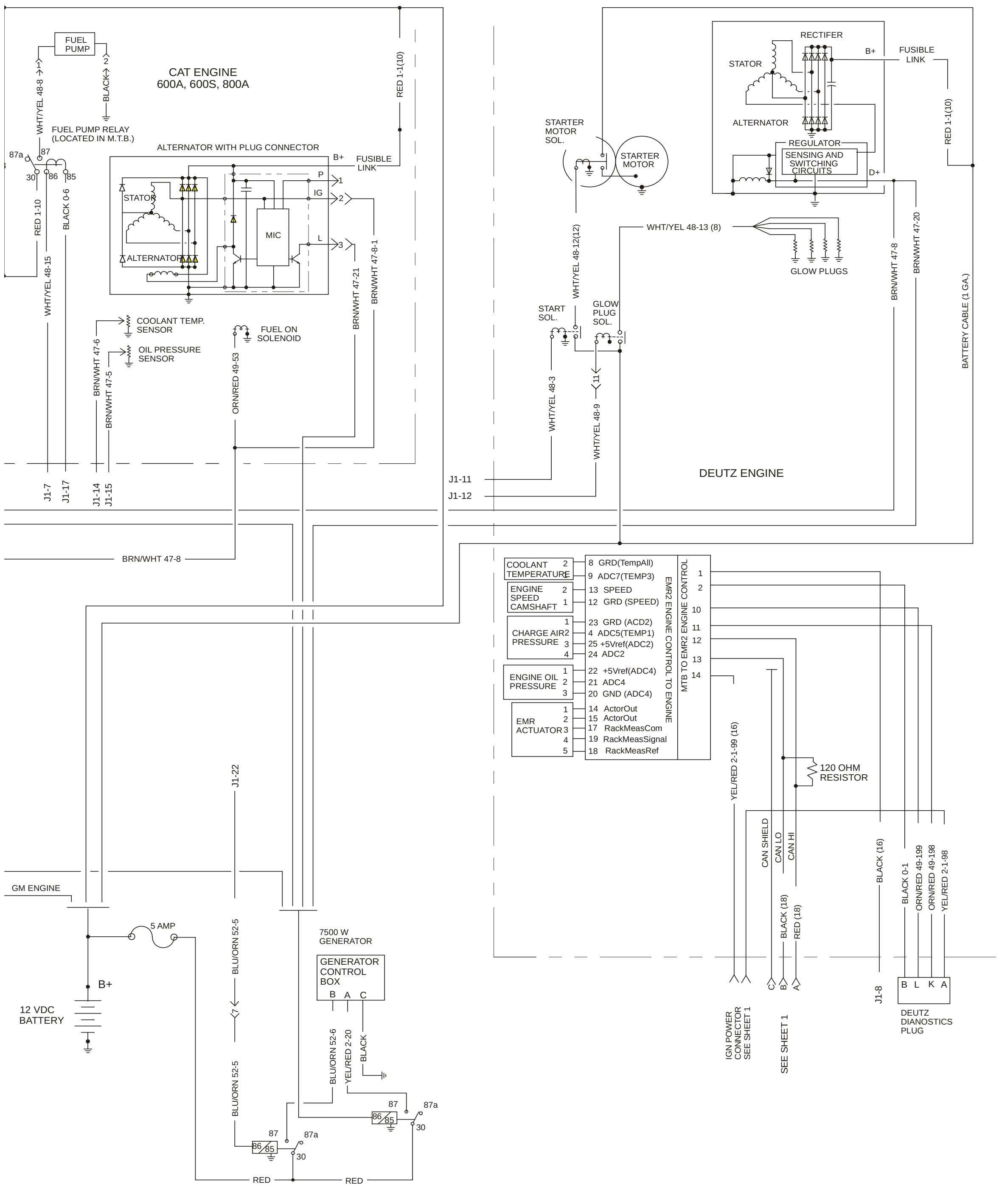


Figure 7-31. Electrical Schematic - Deutz, GM, & CAT Engine - Sheet 2 of 6



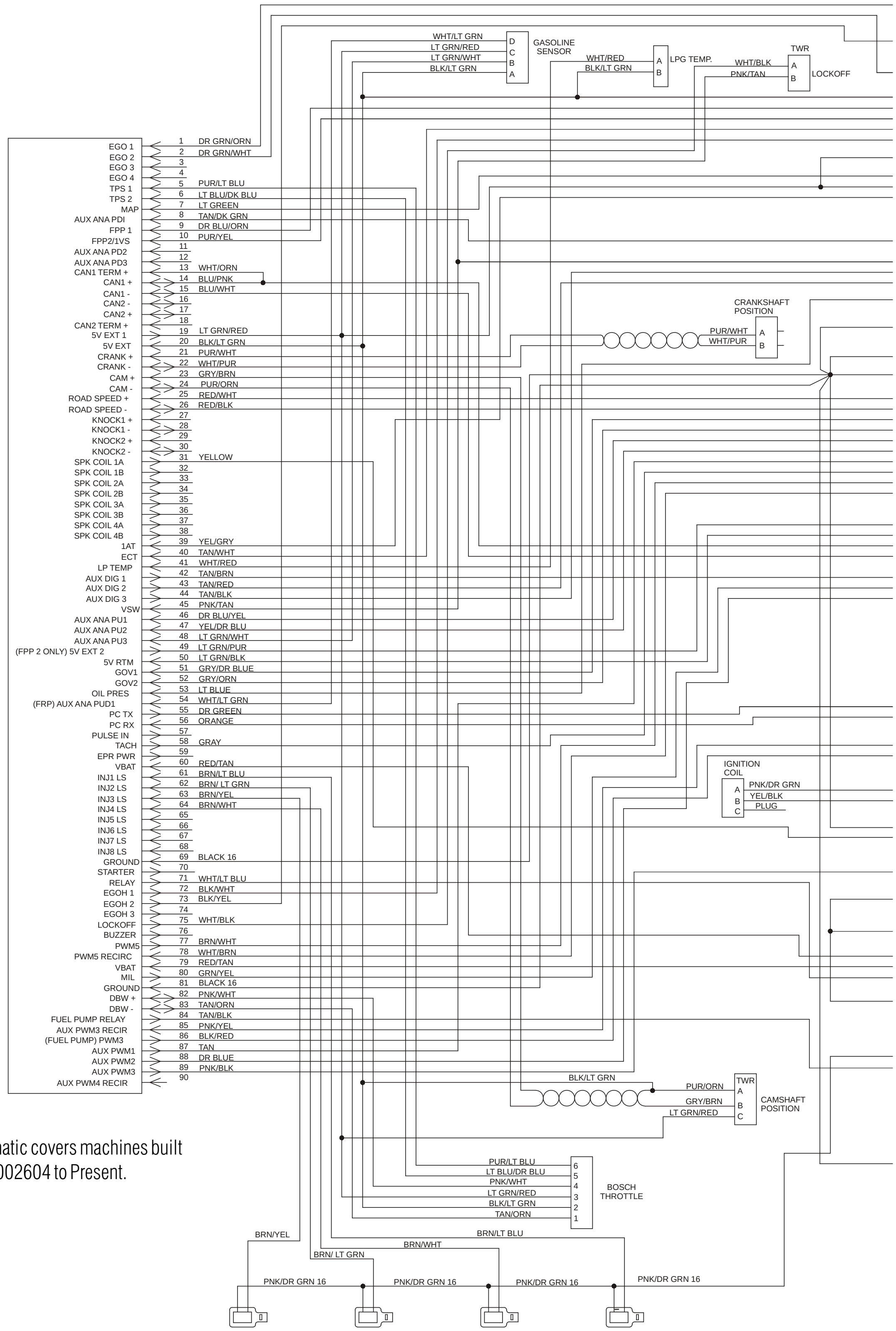
NOTE: This Schematic covers machines built S/N 1300002604 to Present.

Figure 7-32. Electrical Schematic - Deutz, GM, & CAT Engine - Sheet 3 of 6



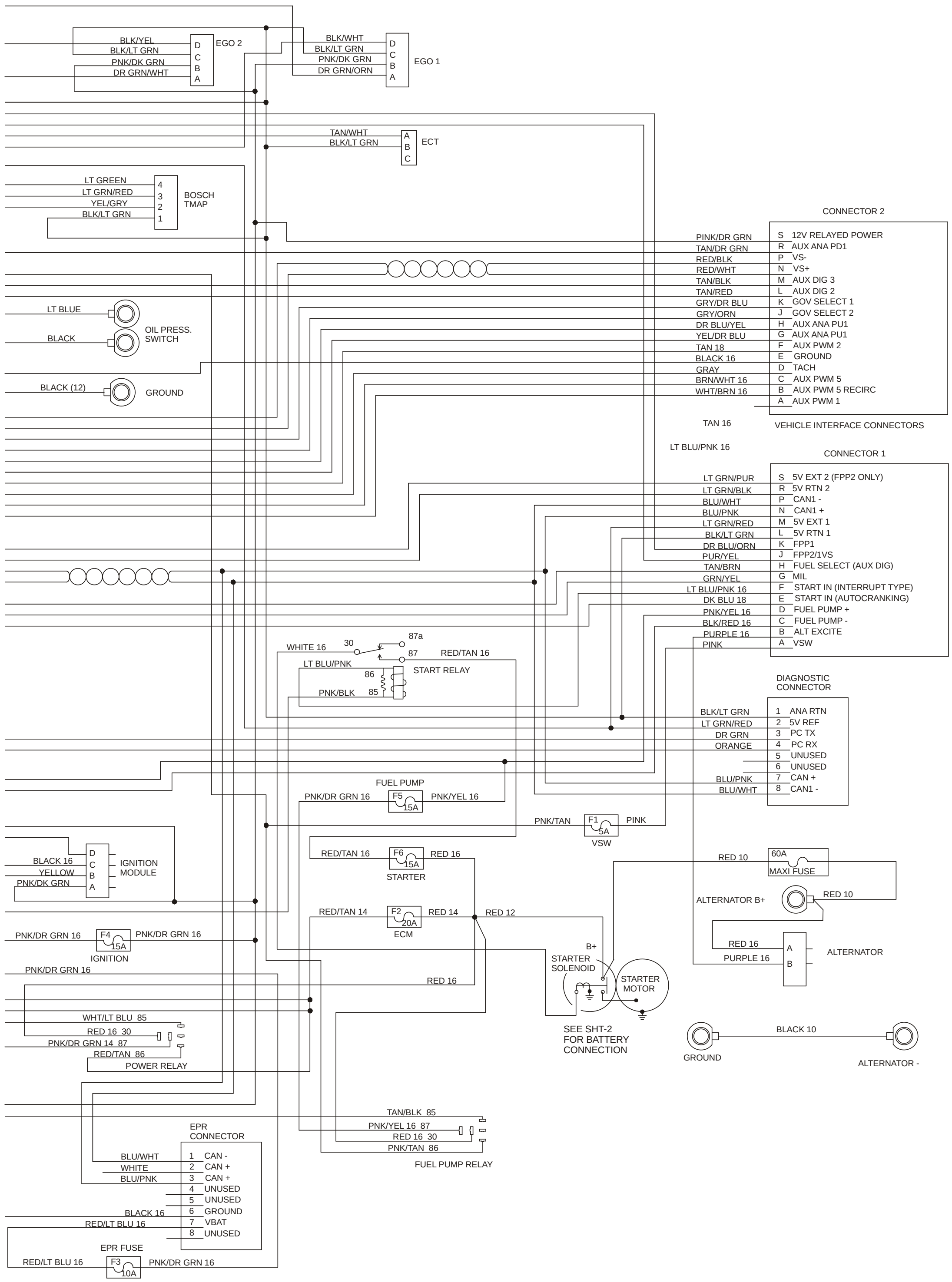
1870215 D

Figure 7-33. Electrical Schematic - Deutz, GM, & CAT Engine - Sheet 4 of 6



NOTE: This Schematic covers machines built S/N 1300002604 to Present.

Figure 7-34. Electrical Schematic - Deutz, GM, & CAT Engine - Sheet 5 of 6



1870215 D

Figure 7-35. Electrical Schematic - Deutz, GM, & CAT Engine - Sheet 6 of 6

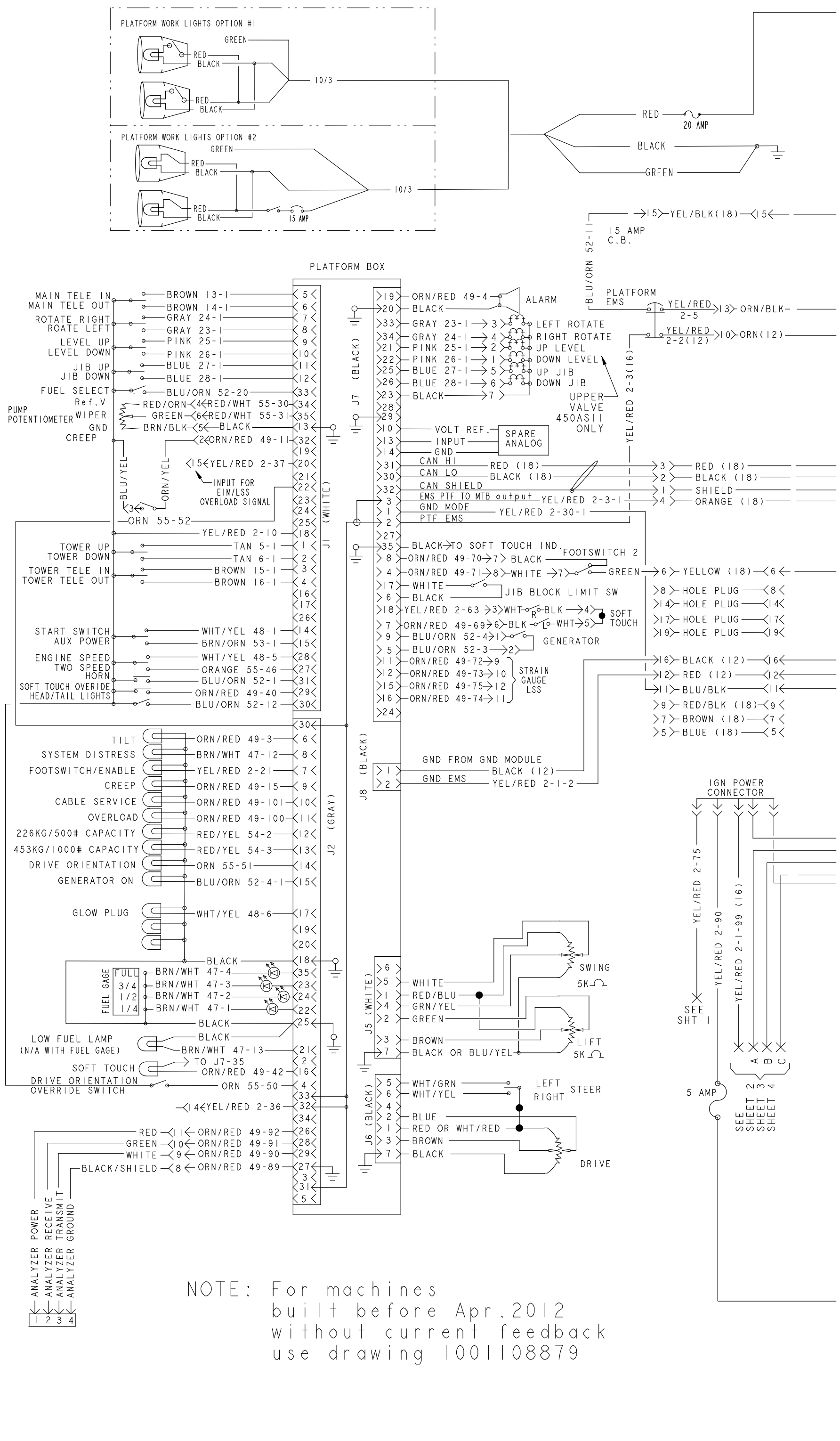


Figure 7-36. Electrical Schematic 1001141989 - Sheet 1of 4 (LH)

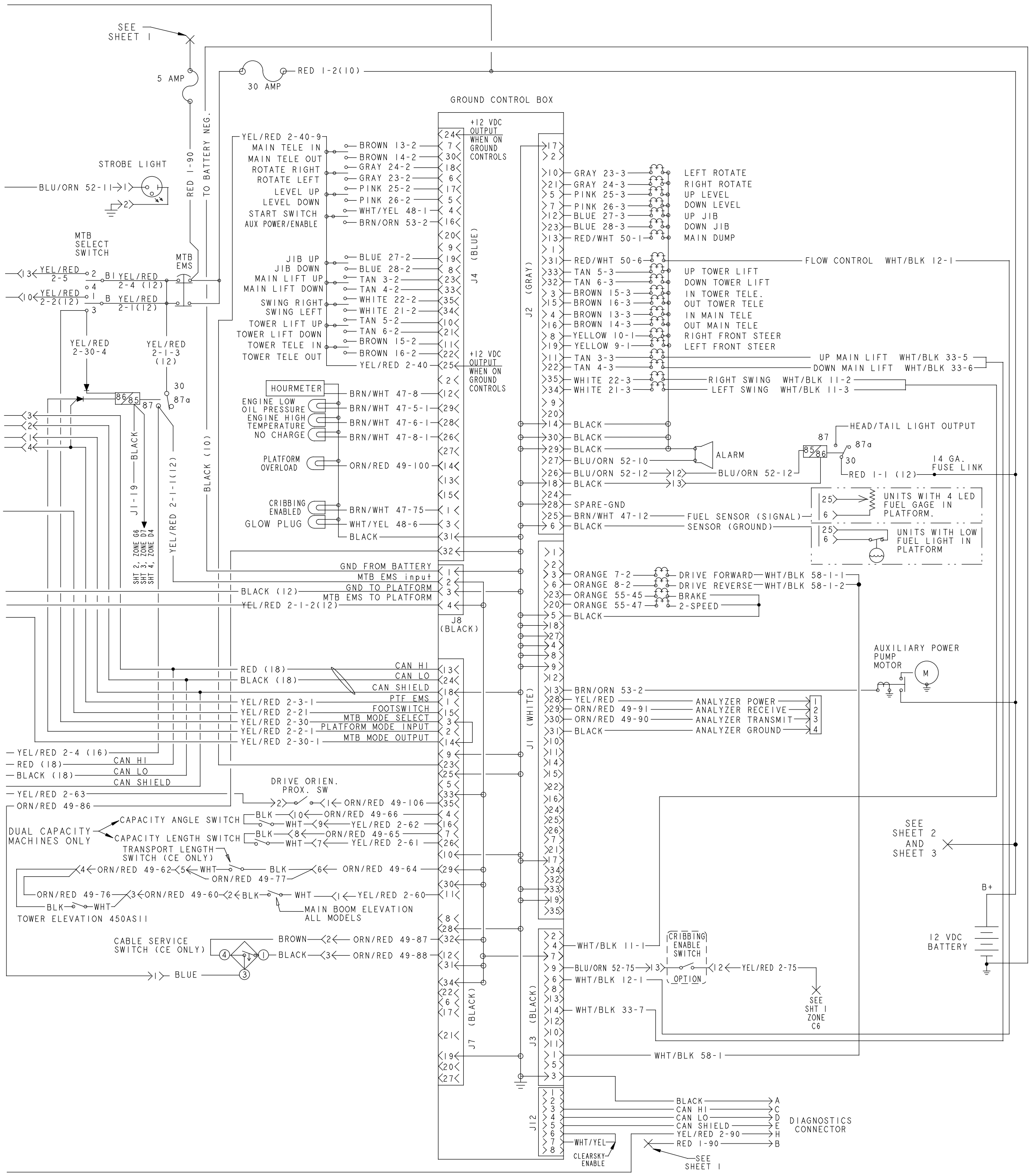
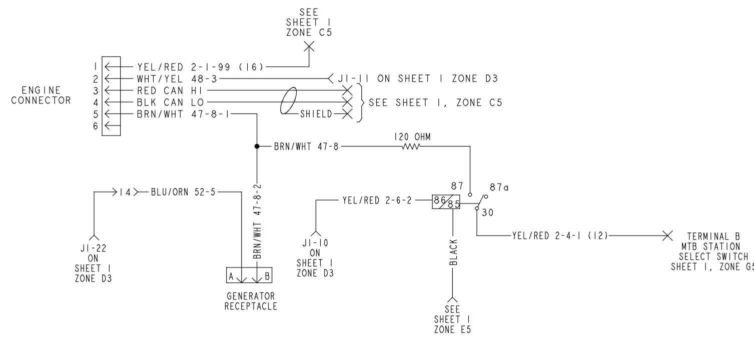


Figure 7-37. Electrical Schematic 1001141989 - Sheet 1of 4 (RH)



JLG SCHEMATIC FOR
CAT/PERKINS ENGINE

VENDOR SCHEMATIC
FOR CAT/PERKINS ENGINE

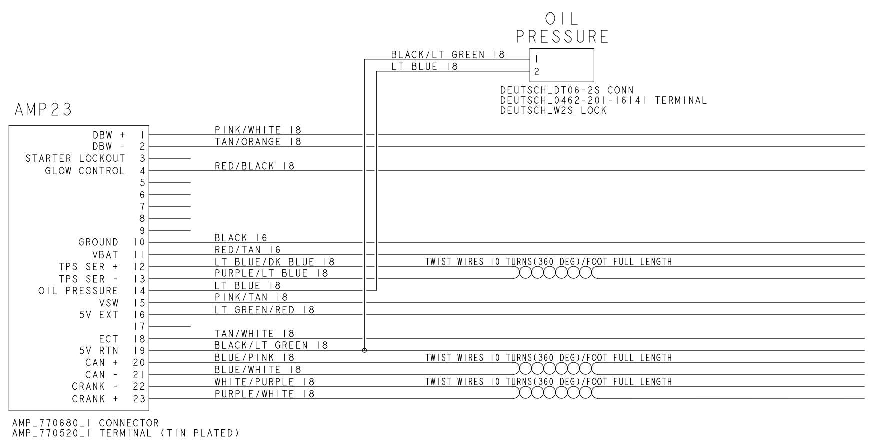


Figure 7-38. CAT/Perkins Engine Electrical Schematic 1001141989 - Sheet 2 of 4 (LH)

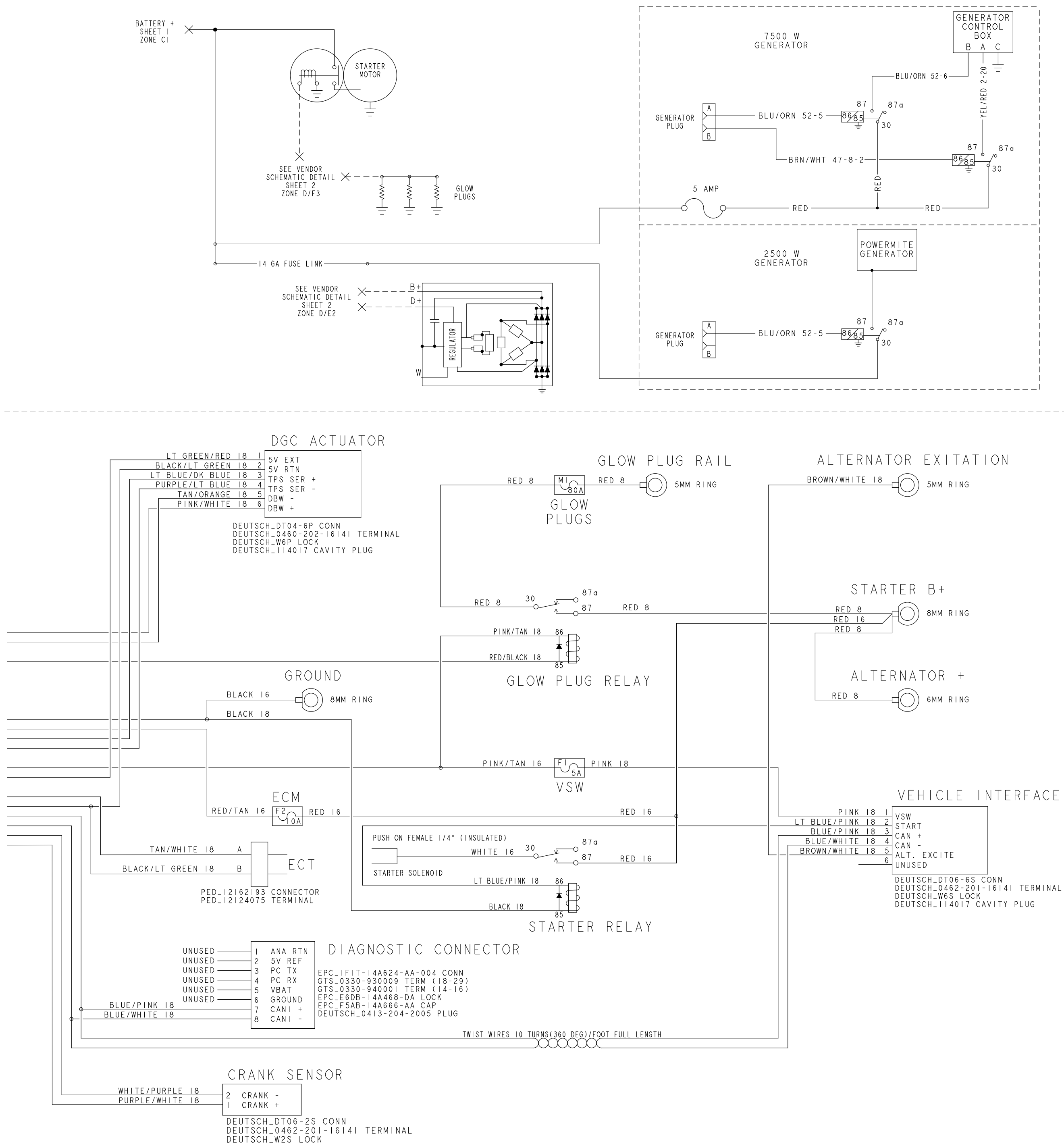


Figure 7-39. CAT/Perkins Engine Electrical Schematic 1001141989 - Sheet 2 of 4 (RH)

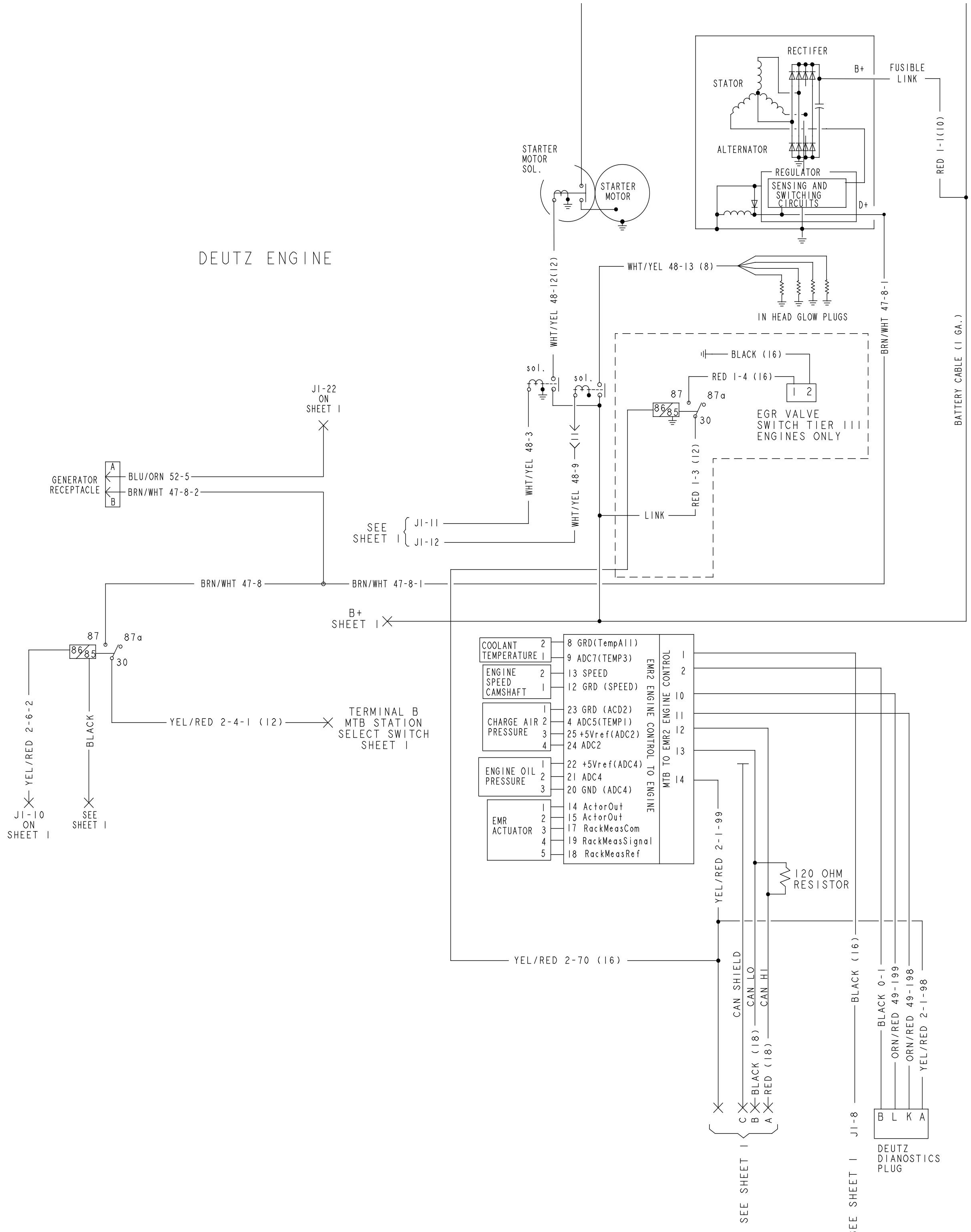


Figure 7-40. Deutz Engine Electrical Schematic 1001141989 - Sheet 3 of 4

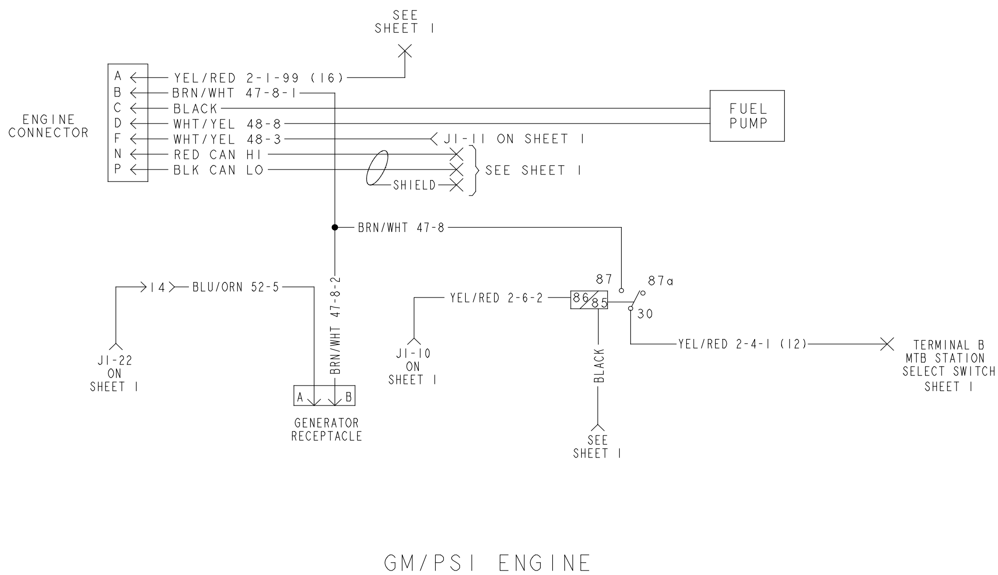


Figure 7-41. GM/PSI Engine Electrical Schematic 1001141989 - Sheet 4 of 4

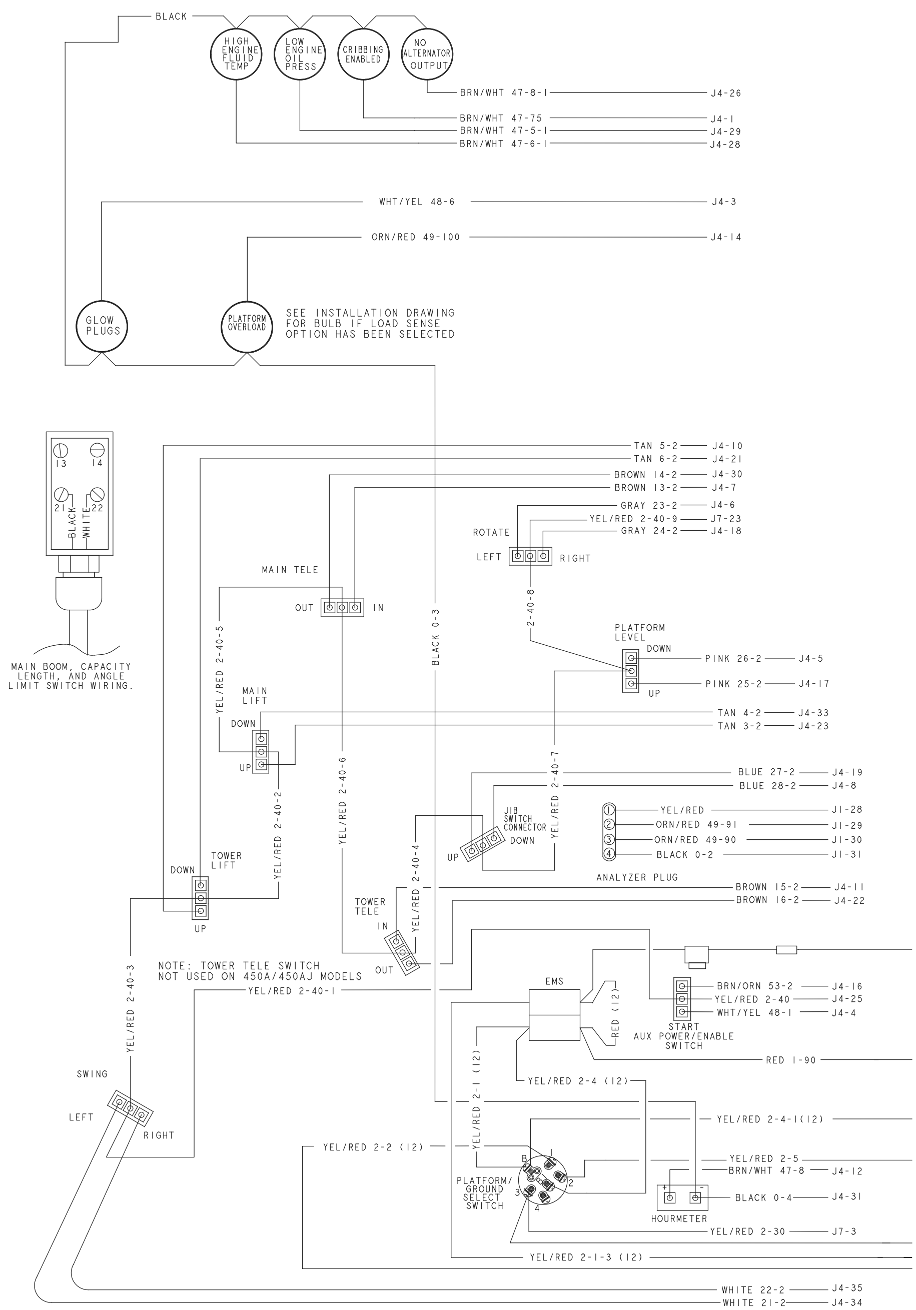


Figure 7-42. Electrical Schematic 1001102901(LH)

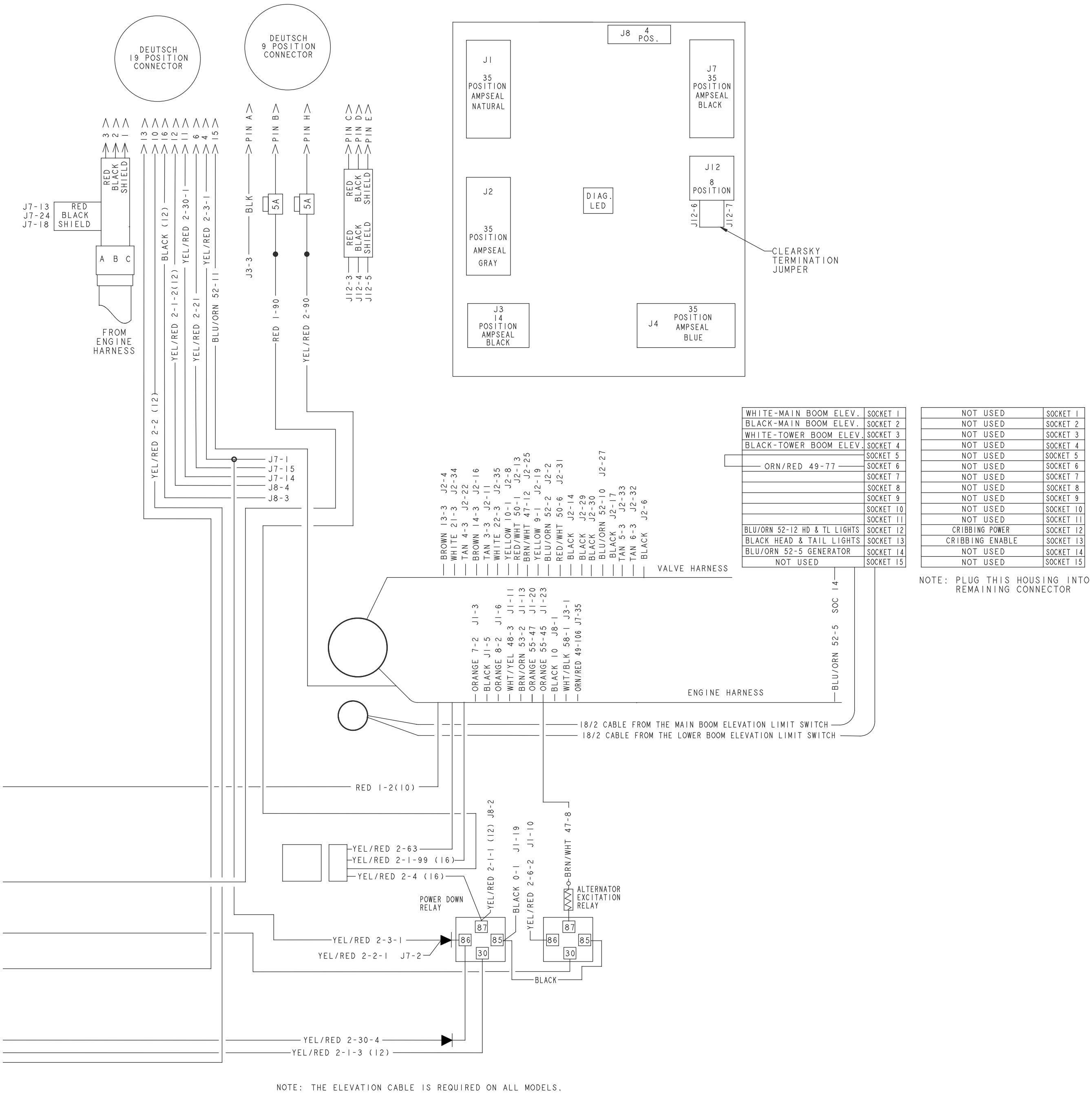
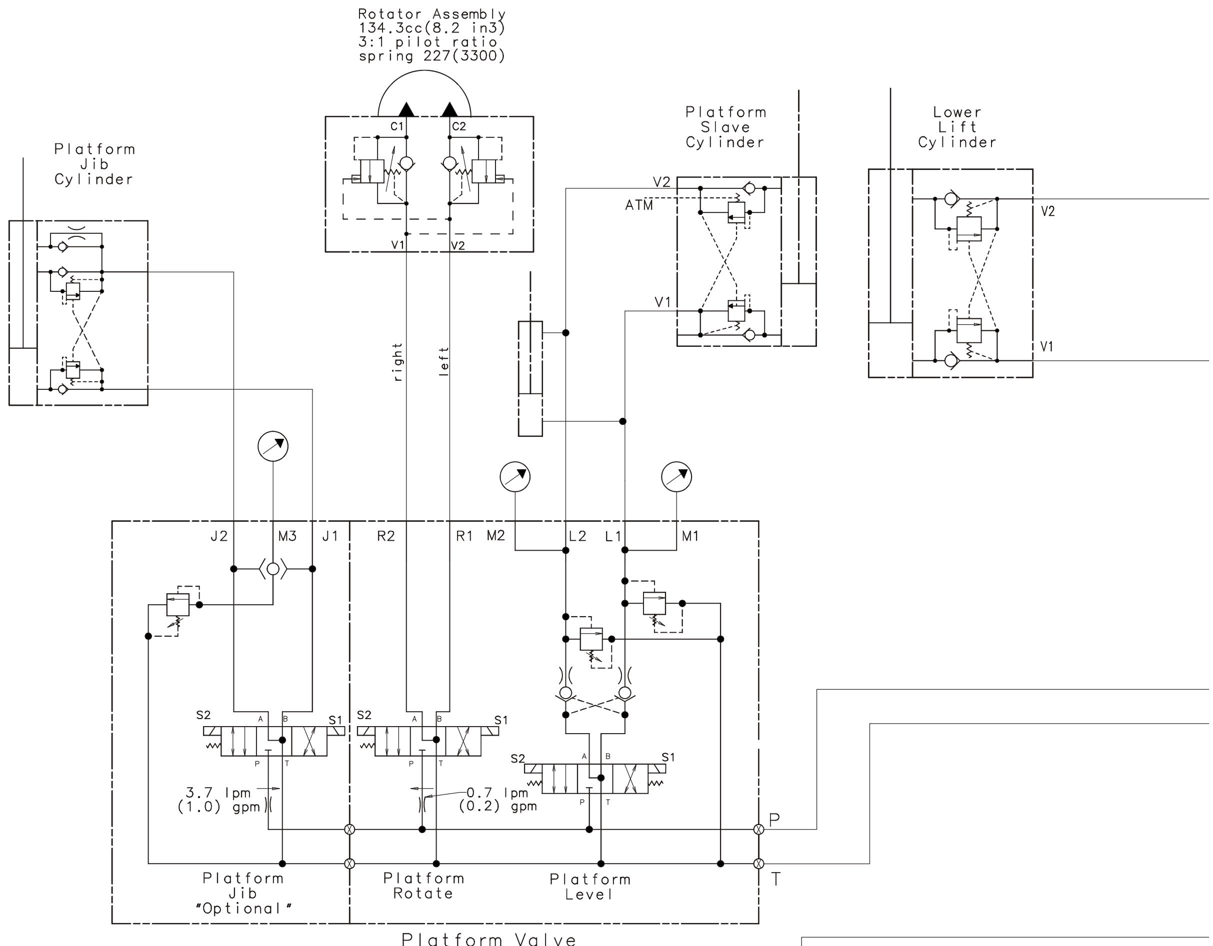


Figure 7-43. GM/PSI Engine Electrical Schematic 1001102901 (RH)



Upper Lift Cylinder
450: bore 76 mm (3")
rod 44.45 mm (1.75")
stroke 701.6 mm (27.6")
510: bore 100 mm (3.93")
rod 50 mm (1.96")
stroke 629 mm (24.5")

Lower Lift Cylinder
450, 510:
bore 130 mm (5")
rod 63.5 mm (2.5")
stroke 660 mm (26")

Telescope Cylinder
450: bore 50.8 mm (2")
rod 31.75 mm (1.25")
stroke "A" 2337 mm (92")
"AJ" 1549 mm (61")
510: bore 50 mm (1.96")
rod 35 mm (1.38")
stroke 2540 mm (100")

Jib Cylinder
450, 510:
bore 63 mm (2.5")
rod 36 mm (1.5")
stroke 580 mm (23")

Slave Cylinder
450, 510:
bore 75 mm (3")
rod 32 mm (1.25")
stroke 294 mm (11.5")

Master Cylinder
450, 510:
bore 75 mm (3")
rod 32 mm (1.25")
stroke 292 mm (11.5")

Steer Cylinders
450, 510:
bore 60 mm (2.5")
rod 45 mm (1.75")
stroke 117 mm (4.5")

Relief Valvbe Settings:

P1 Main relief 3300 psi, 230 bar
P2 Main relief 3200 psi, 220 bar
Steer port relief 2500 psi, 170 bar
Lift down relief 1200 psi, 80 bar
Swing relief 1700 psi, 120 bar
Platform level retract 1800 psi, 125 bar
Platform level extend 2800 psi, 190 bar
Platform Jib 1500 psi, 105 bar

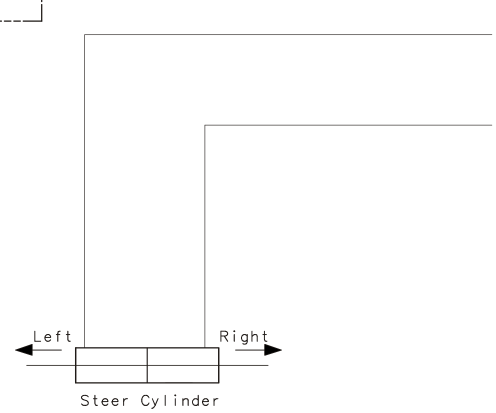


Figure 7-44. Hydraulic Schematic 2792780 D - Sheet 1 of 3 (LH)

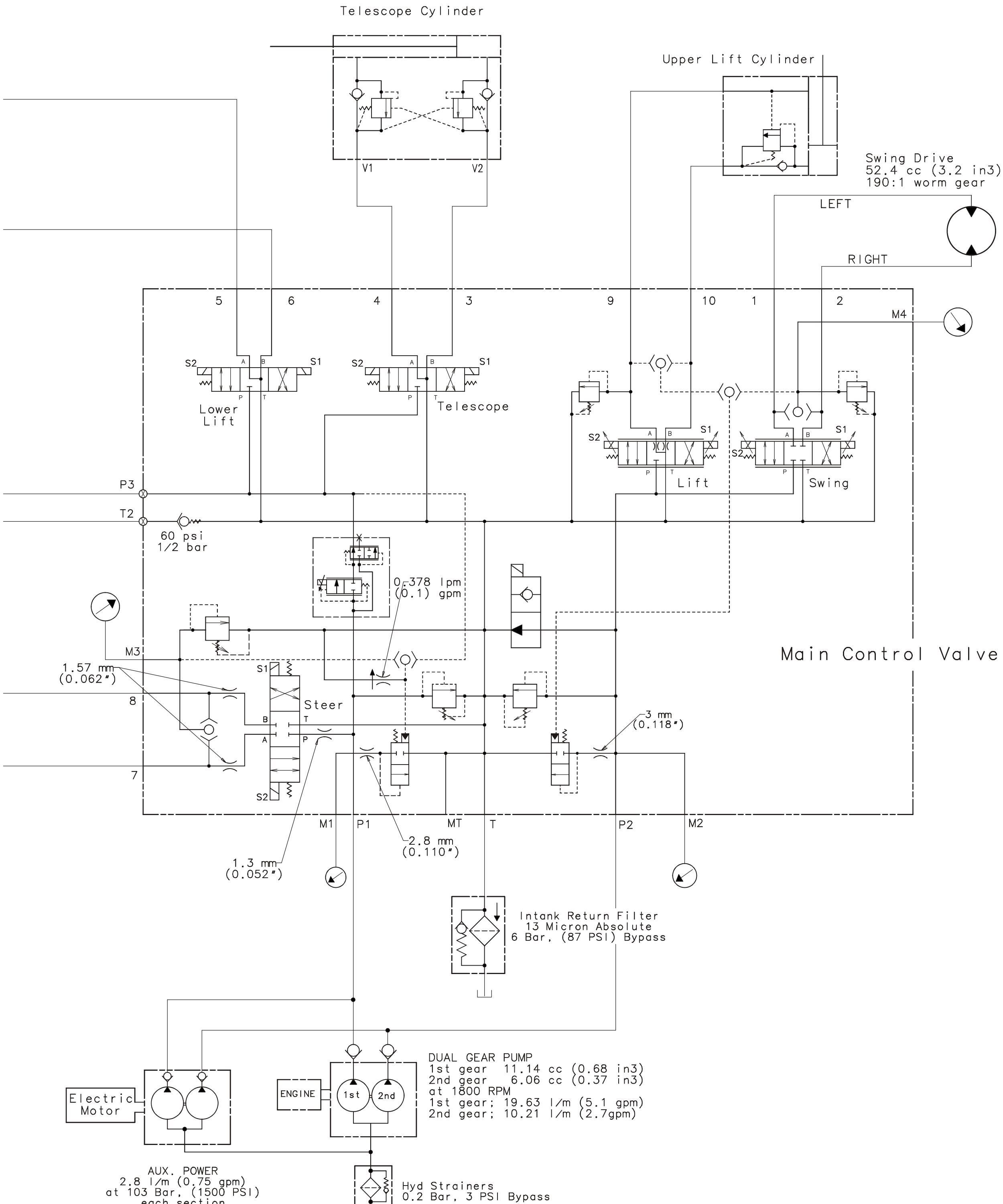


Figure 7-45. Hydraulic Schematic 2792780 D - Sheet 1 of 3 (RH)

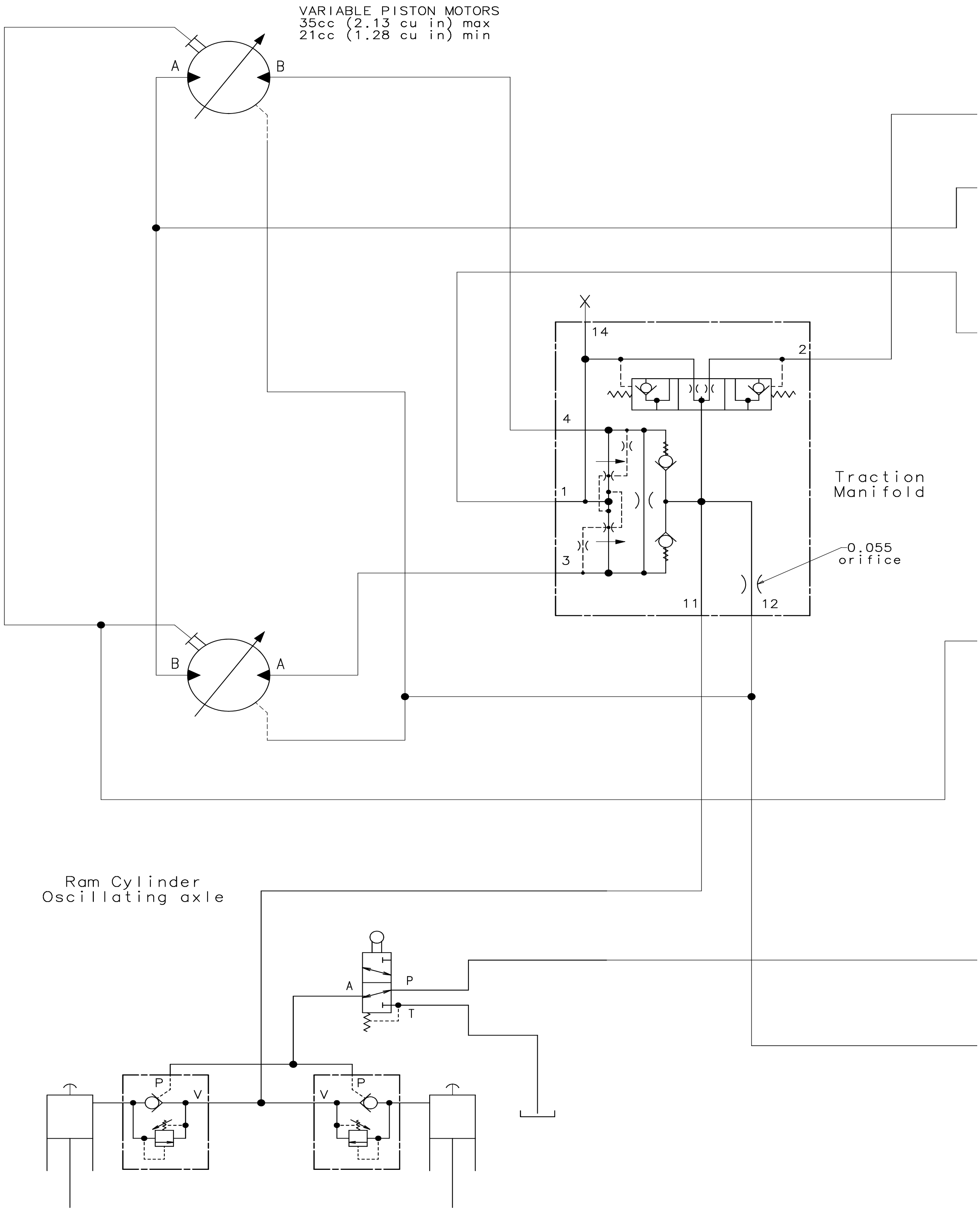


Figure 7-46. Hydraulic Schematic 2792780 D - Sheet 2 of 3 (LH)

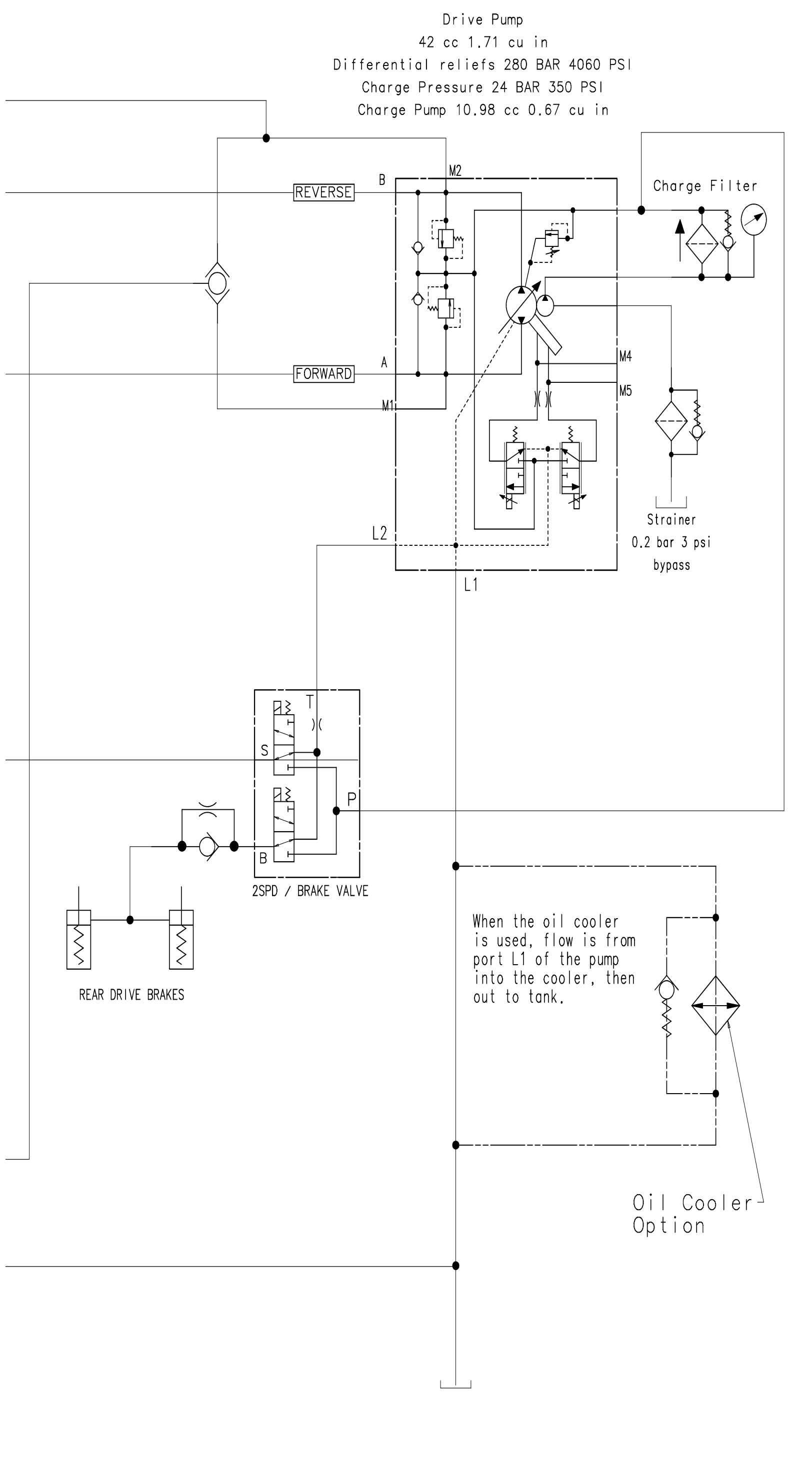


Figure 7-47. Hydraulic Schematic 2792780 D - Sheet 2 of 3 (RH)

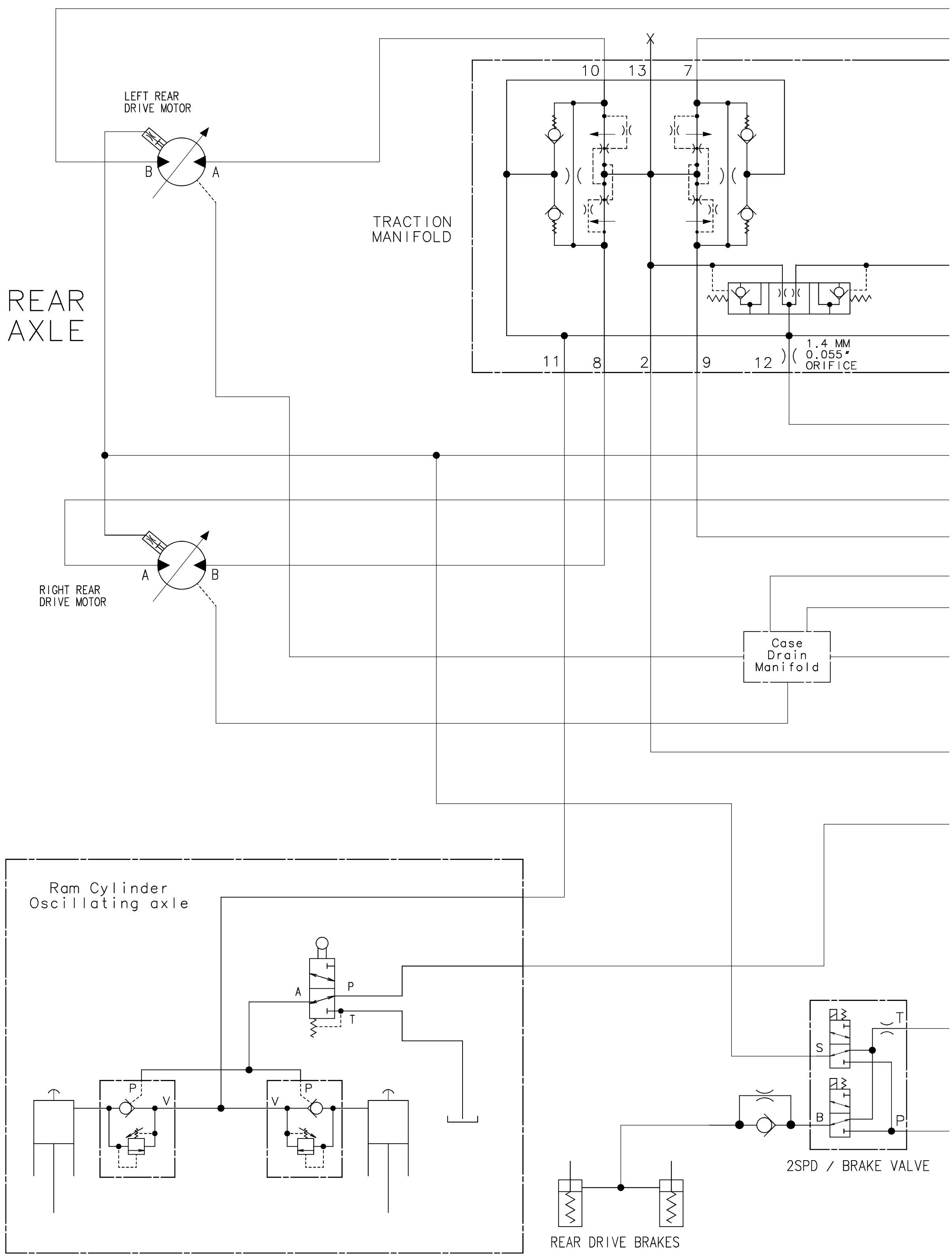


Figure 7-48. Hydraulic Schematic 2792780 D - Sheet 3 of 3 (LH)

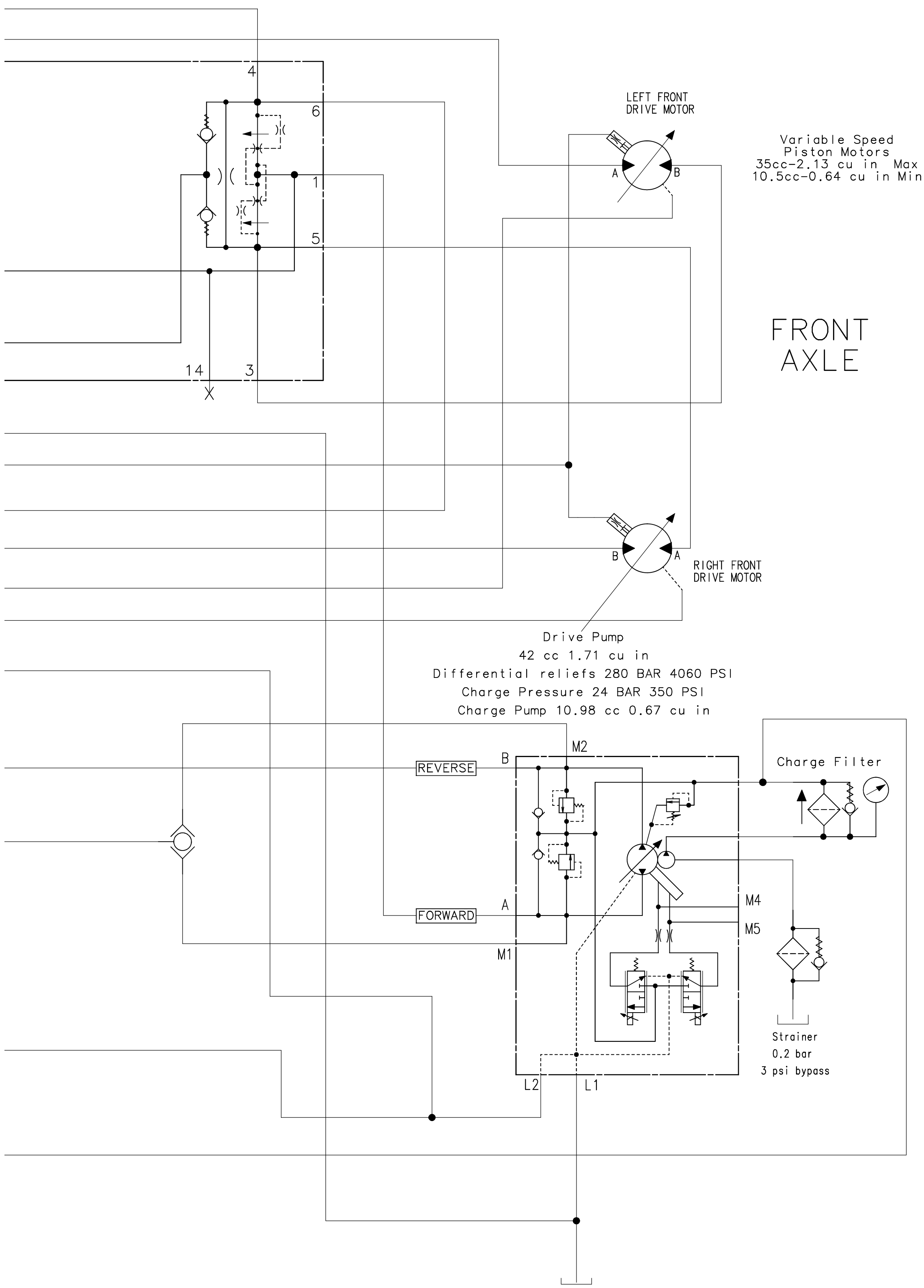
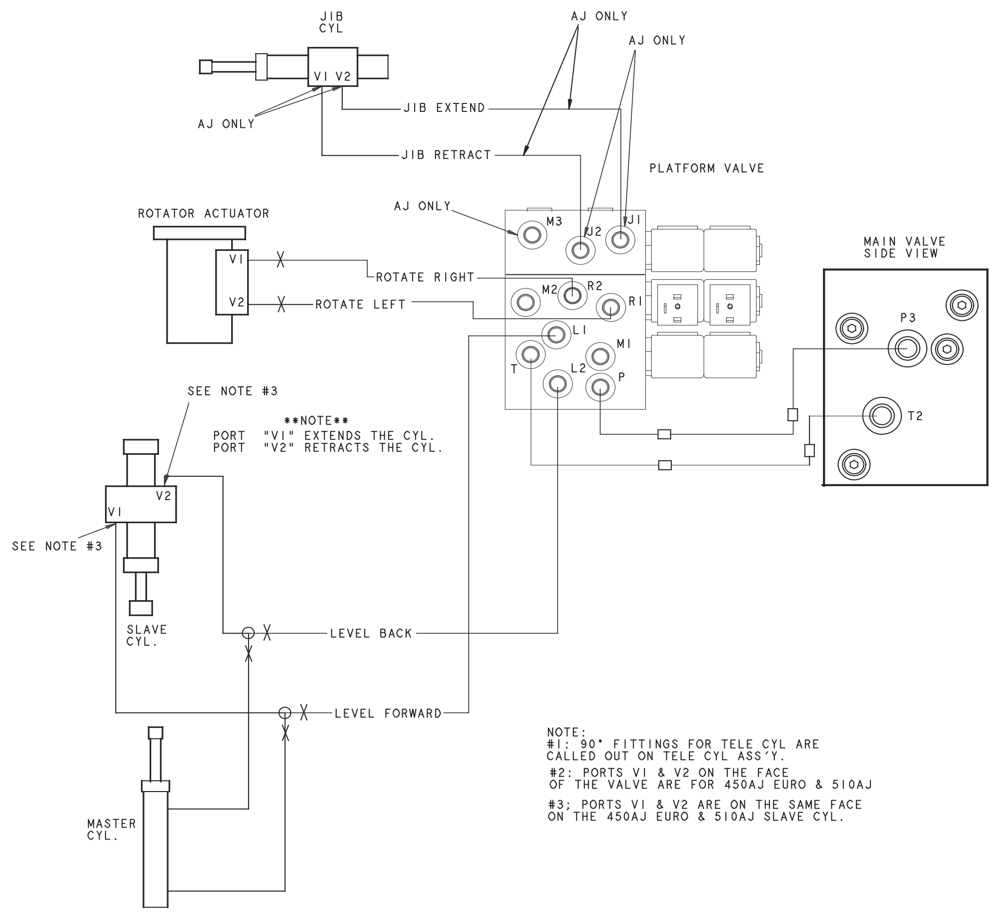


Figure 7-49. Hydraulic Schematic 2792780 D - Sheet 3 of 3 (RH)



PAGE NO.	Hydraulic Drawing 1283460 Description
1	HYDRAULIC DIAGRAM 450A (USA BUILT) HYDRAULIC DIAGRAM 450AJ (USA BUILT) HYDRAULIC DIAGRAM 510AJ/450AJ T/T (EURO BUILT) HYDRAULIC DIAGRAM 510AJ/450AJ TOWER BOOM (EURO BUILT) HYDRAULIC DIAGRAM 510AJ UPPER BOOM (EURO BUILT) HYDRAULIC DIAGRAM 450AJ UPPER BOOM (EURO BUILT)
2	HYDRAULIC 4-WHEEL DRIVE CIR 450A /450AJ DEUTZ HYDRAULIC 4-WHEEL DRIVE CIR 450A/450AJ GM ENGINE HYDRAULIC 4-WHEEL DRIVE CIR 510AJ DEUTZ HYDRAULIC ARTIC 4-WHEEL DRIVE CIR 450A /450AJ (USA BUILT)
3	HYDRAULIC 2-WHEEL DRIVE CIR. GM/DEUTZ/CAT
4	450A / 450AJ / 510AJ HYDRAULIC OSC. AXLE CIR. 2WD HYDRAULIC OSC. AXLE CIR. 4WD
5	450A / 450AJ / 510AJ HYDRAULIC FIXED AXLE CIR. 2WD HYDRAULIC FIXED AXLE CIR. 4WD
6	HYDRAULIC TOW CIR.
7	HYDRAULIC DIAGRAM 450A GM ENGINE (USA BUILT) HYDRAULIC DIAGRAM 450AJ GM ENGINE (USA BUILT)

Figure 7-50. Hydraulic Schematic 1283460 - Sheet 1 of 7 (RH)

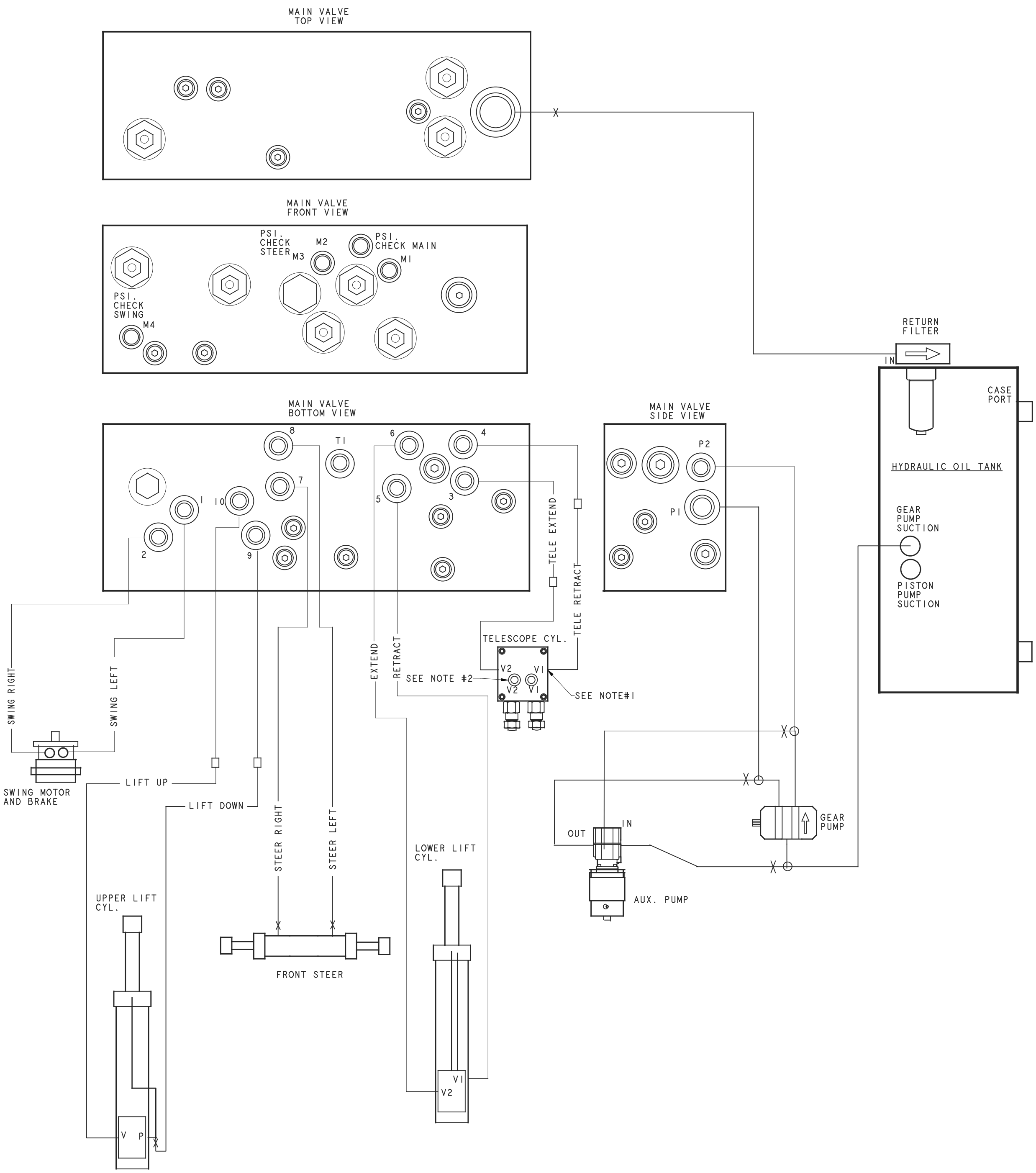


Figure 7-51. Hydraulic Schematic 1283460 - Sheet 1 of 7 (RH)

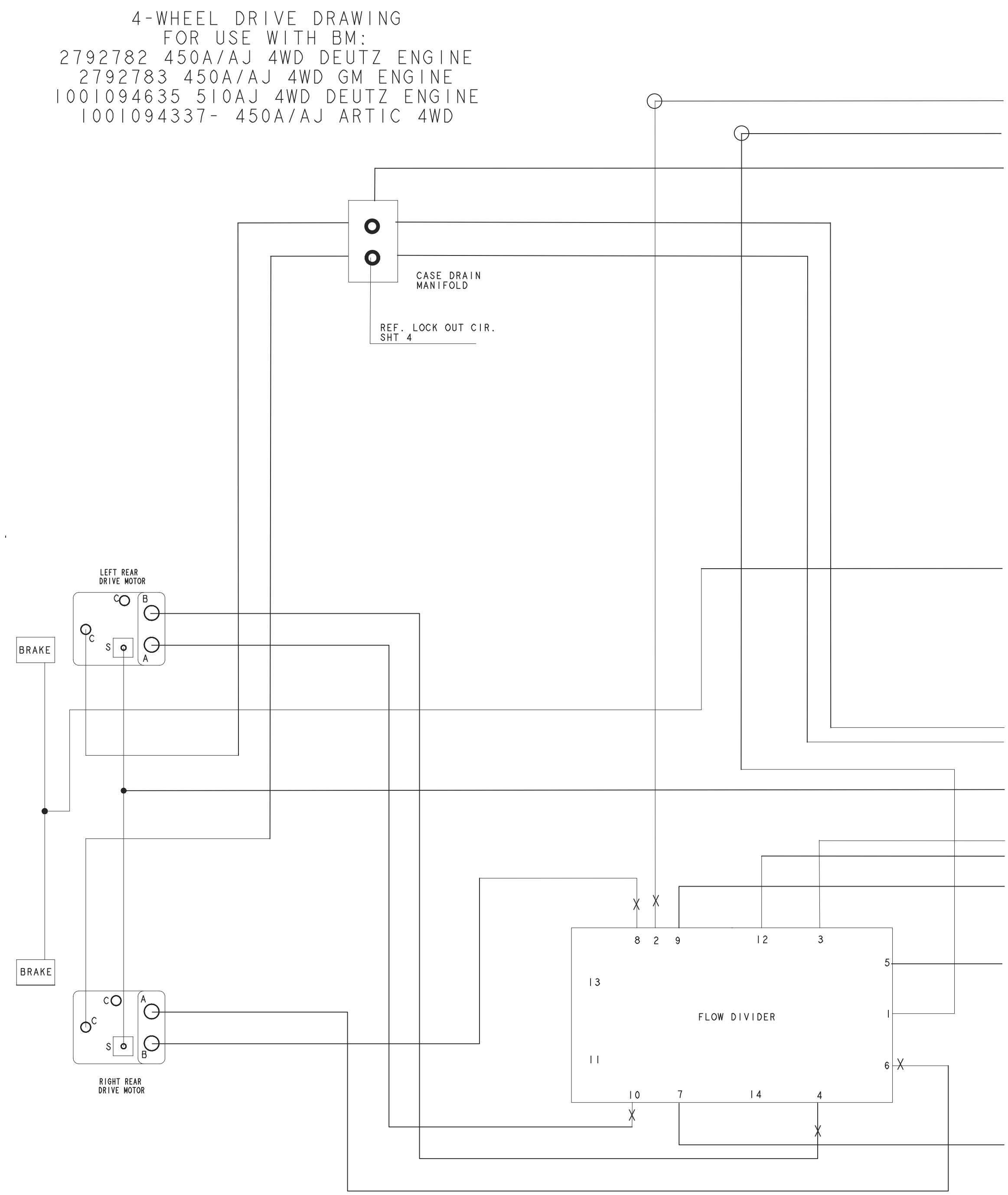


Figure 7-52. Hydraulic Schematic 1283460 - Sheet 2 of 7 (LH)

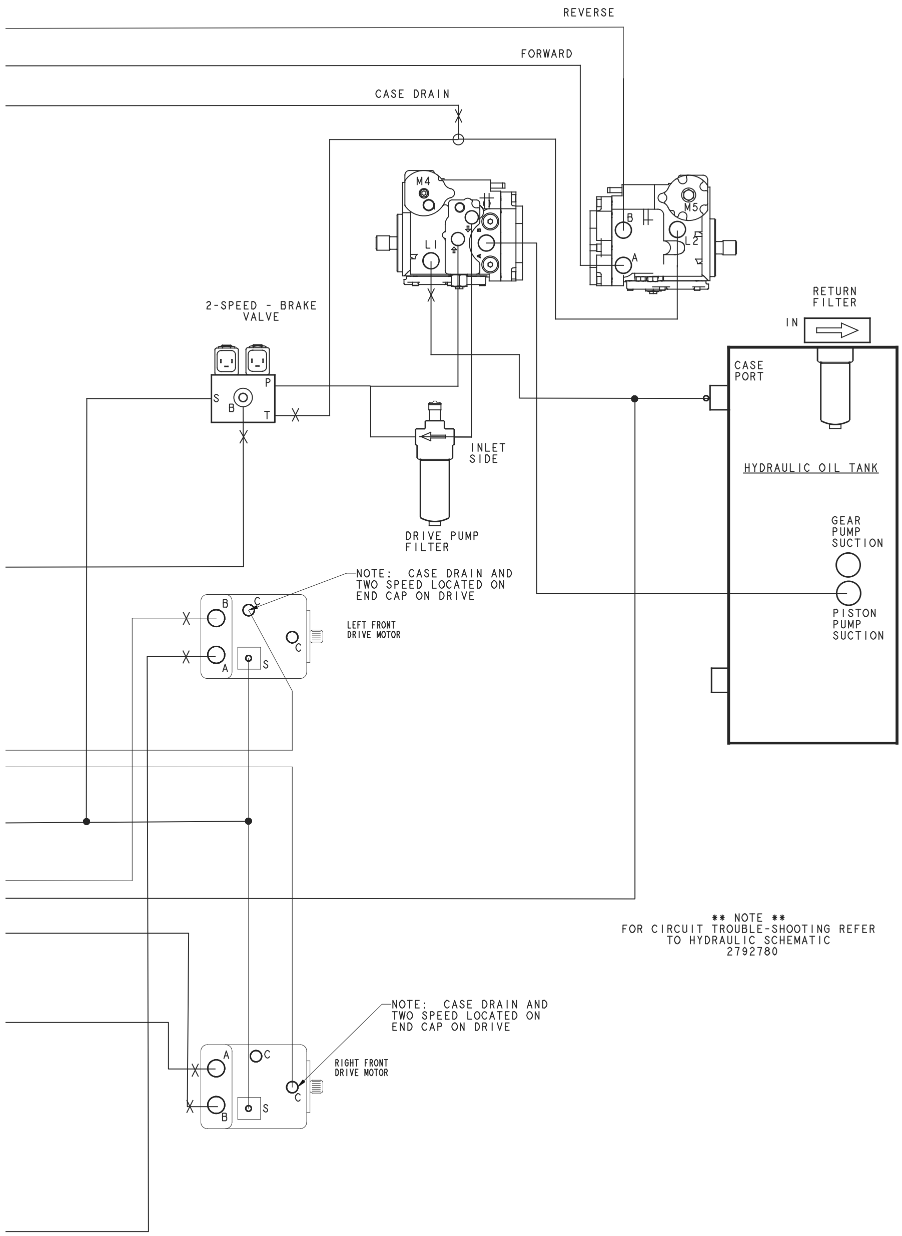


Figure 7-53. Hydraulic Schematic 1283460 - Sheet 2 of 7 (RH)

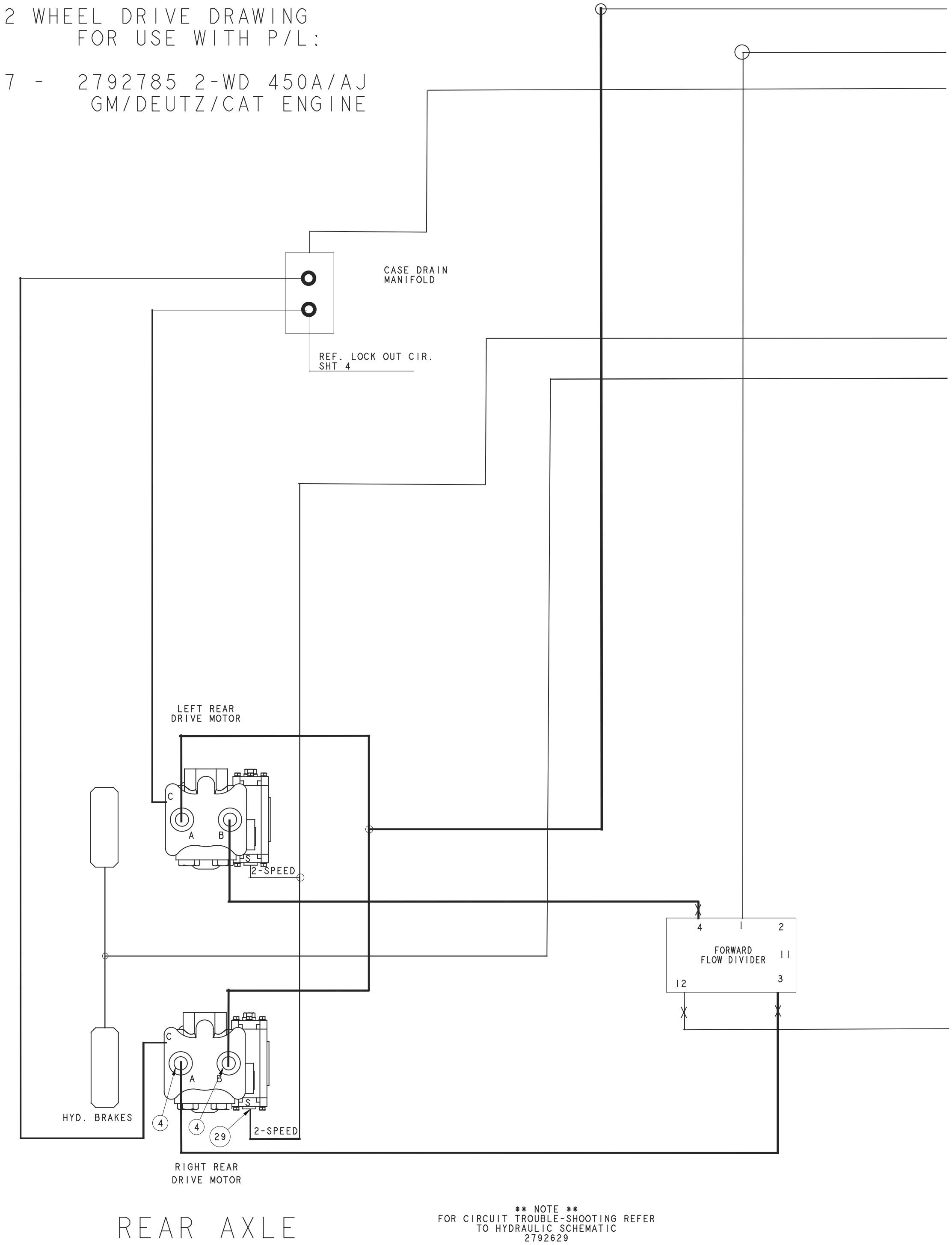


Figure 7-54. Hydraulic Schematic 1283460 - Sheet 3 of 7 (LH)

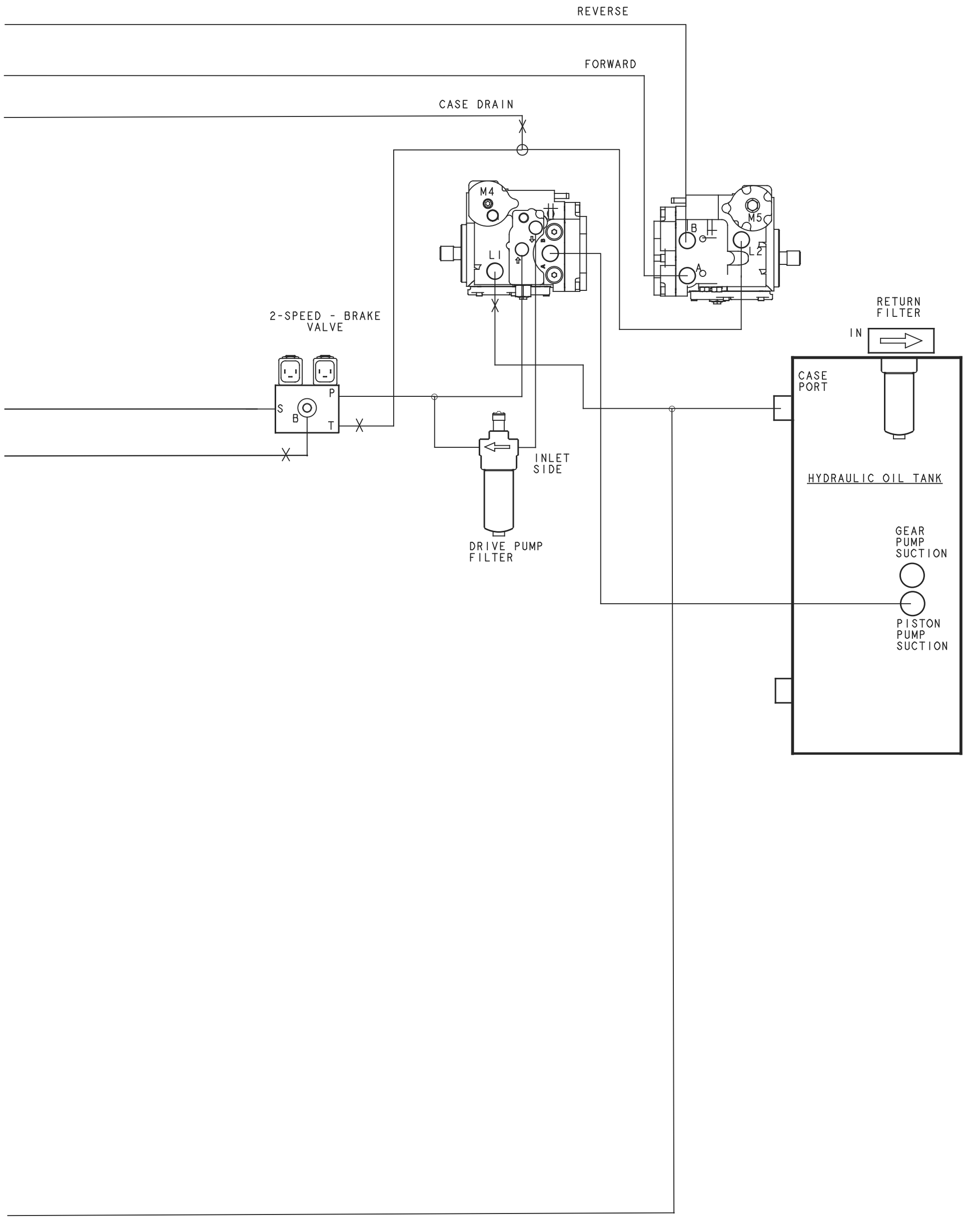


Figure 7-55. Hydraulic Schematic 1283460 - Sheet 3 of 7 (RH)

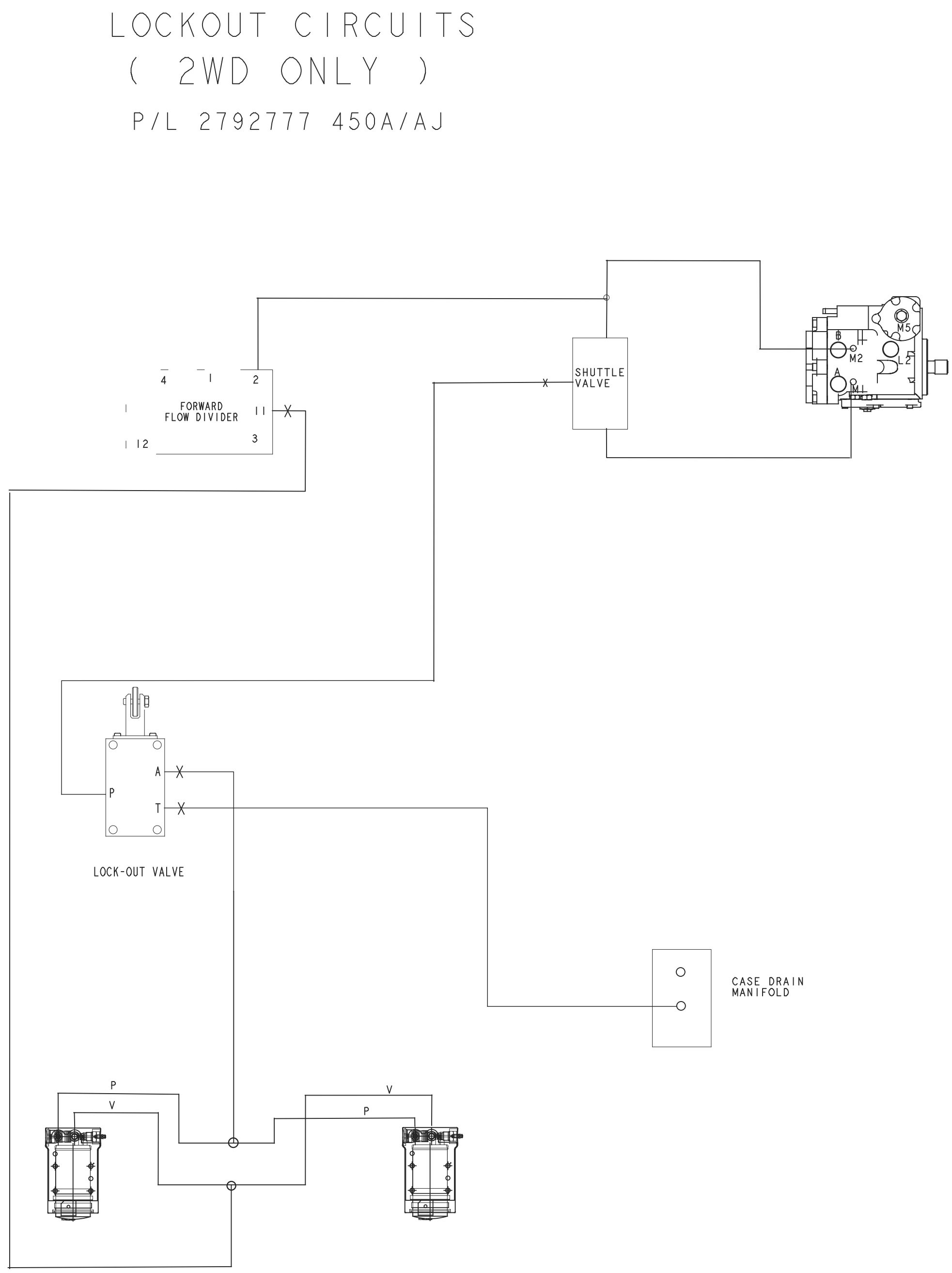


Figure 7-56. Hydraulic Schematic 1283460 - Sheet 4 of 7 (LH)

LOCKOUT CIRCUITS

(4WD ONLY)

P/L 2792778 450A/AJ 510AJ

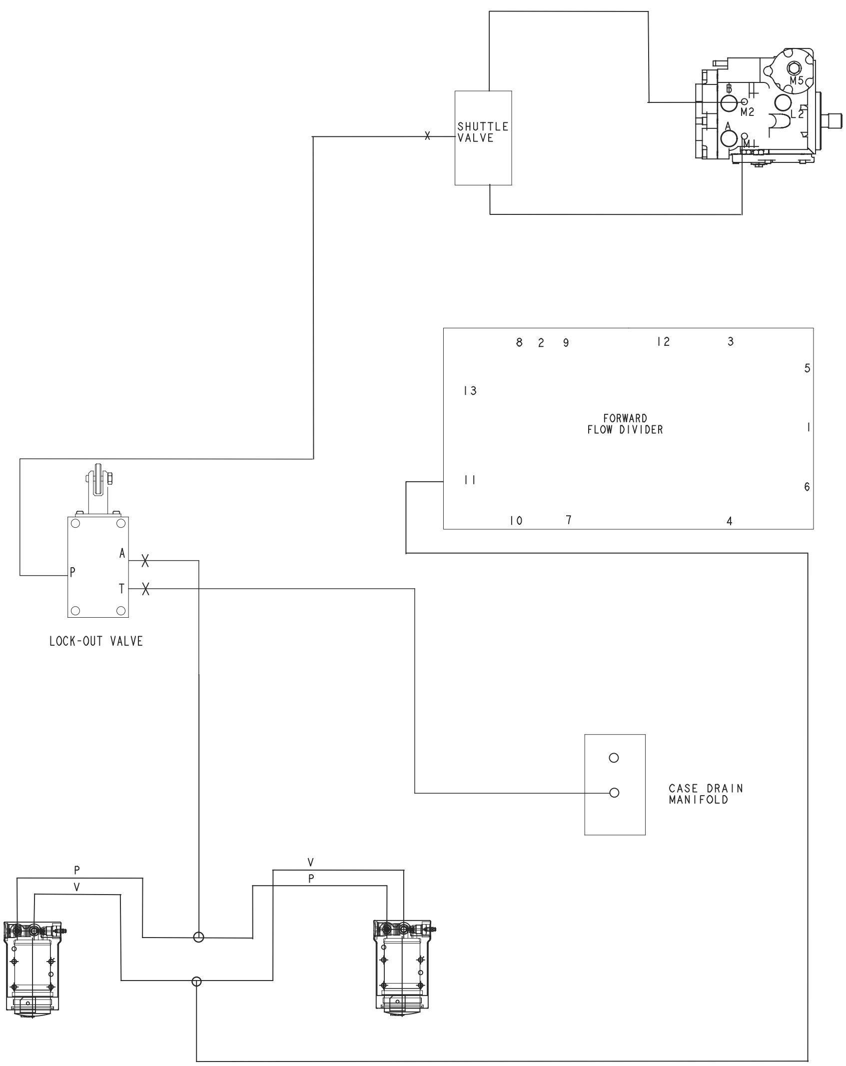


Figure 7-57. Hydraulic Schematic 1283460 - Sheet 4 of 7 (RH)

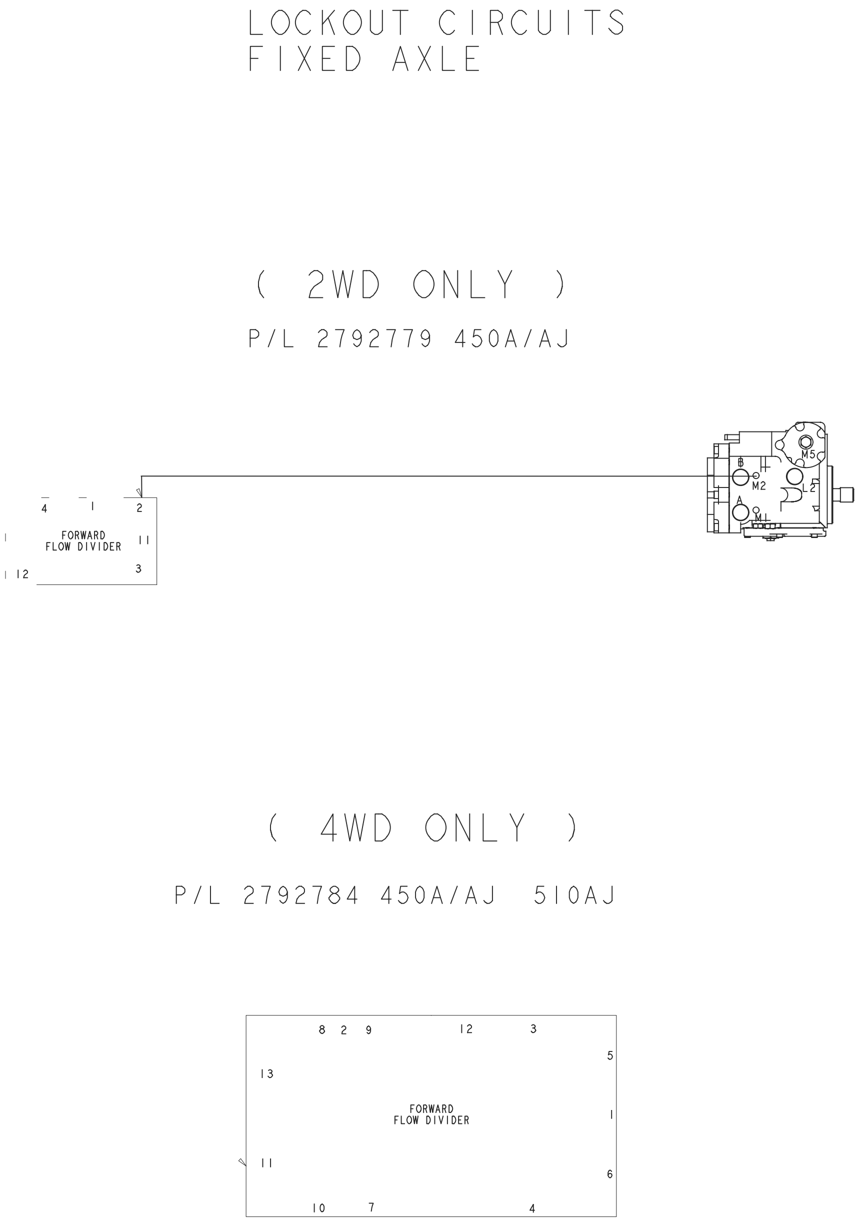


Figure 7-58. Hydraulic Schematic 1283460 - Sheet 5 of 7

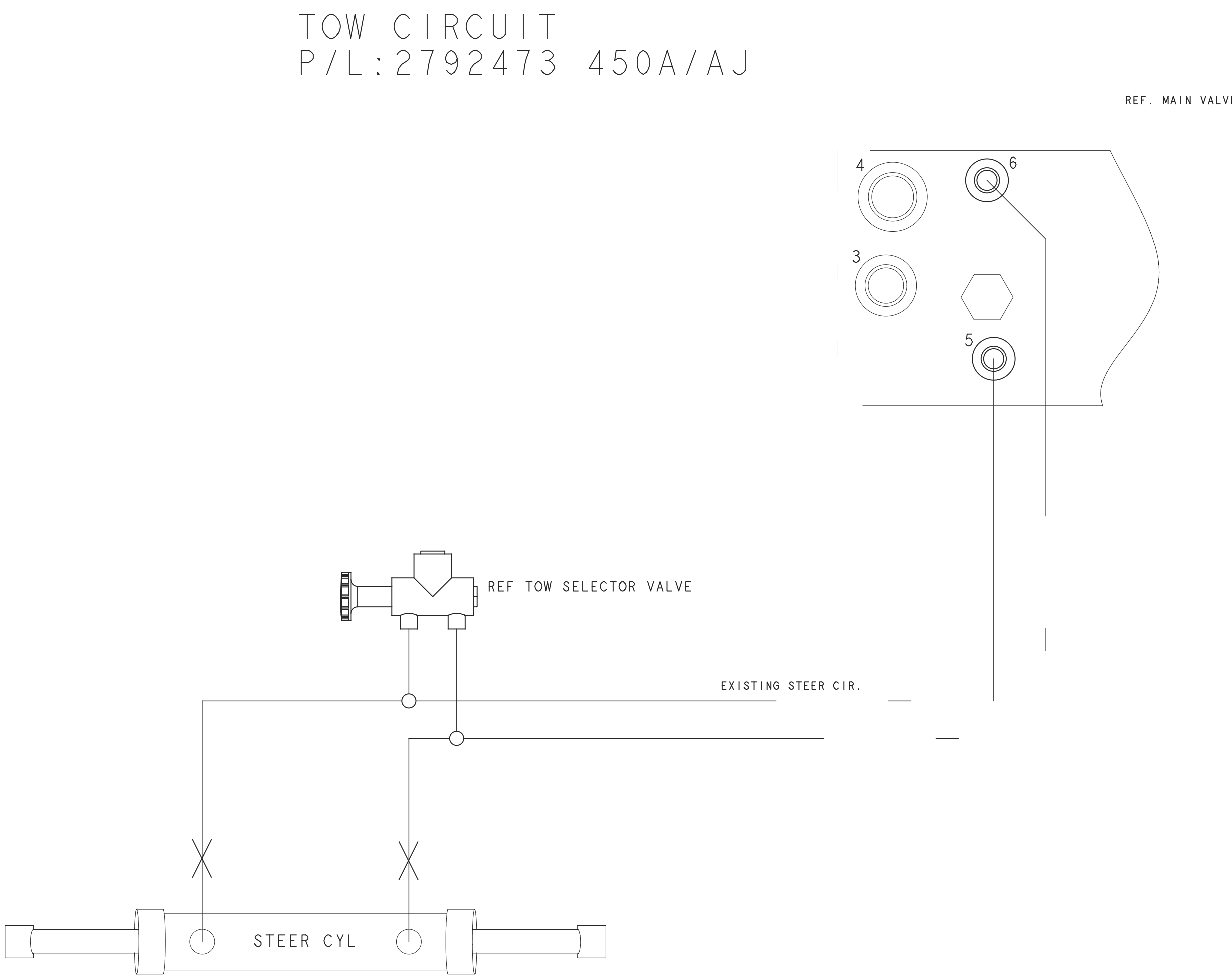


Figure 7-59. Hydraulic Schematic 1283460 - Sheet 6 of 7

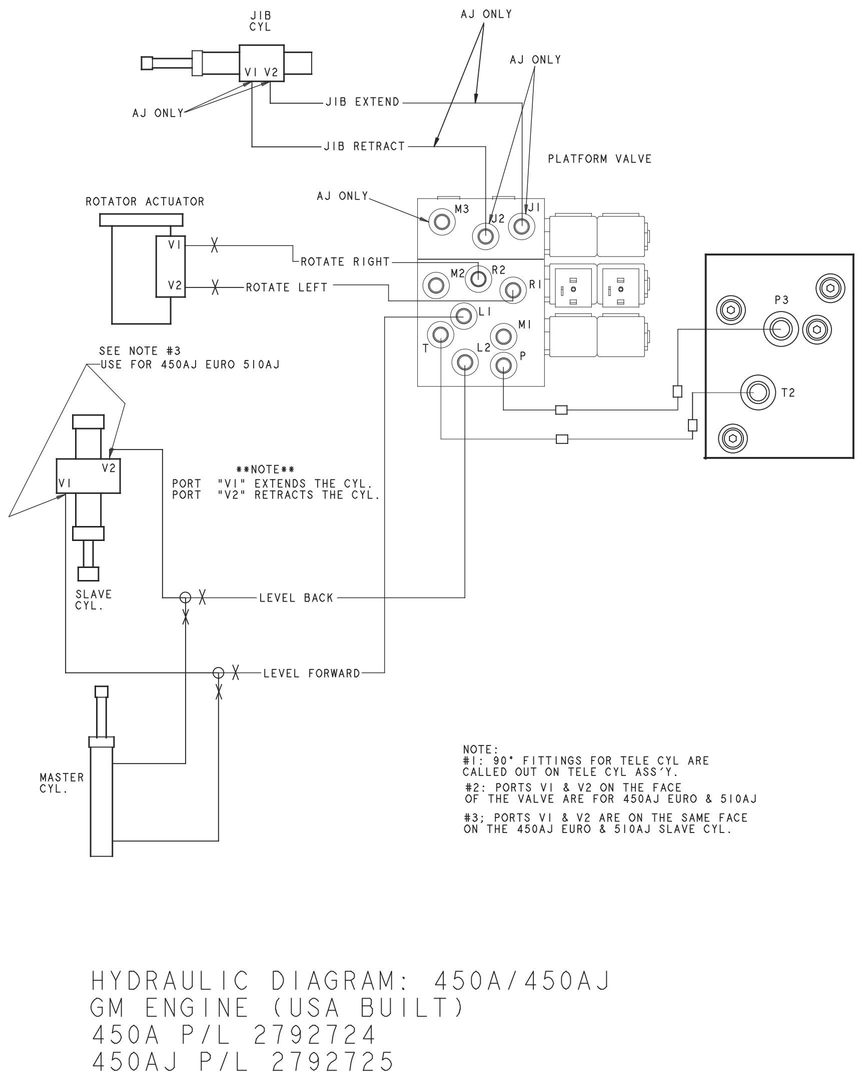


Figure 7-60. Hydraulic Schematic 1283460 - Sheet 7 of 7 (LH)

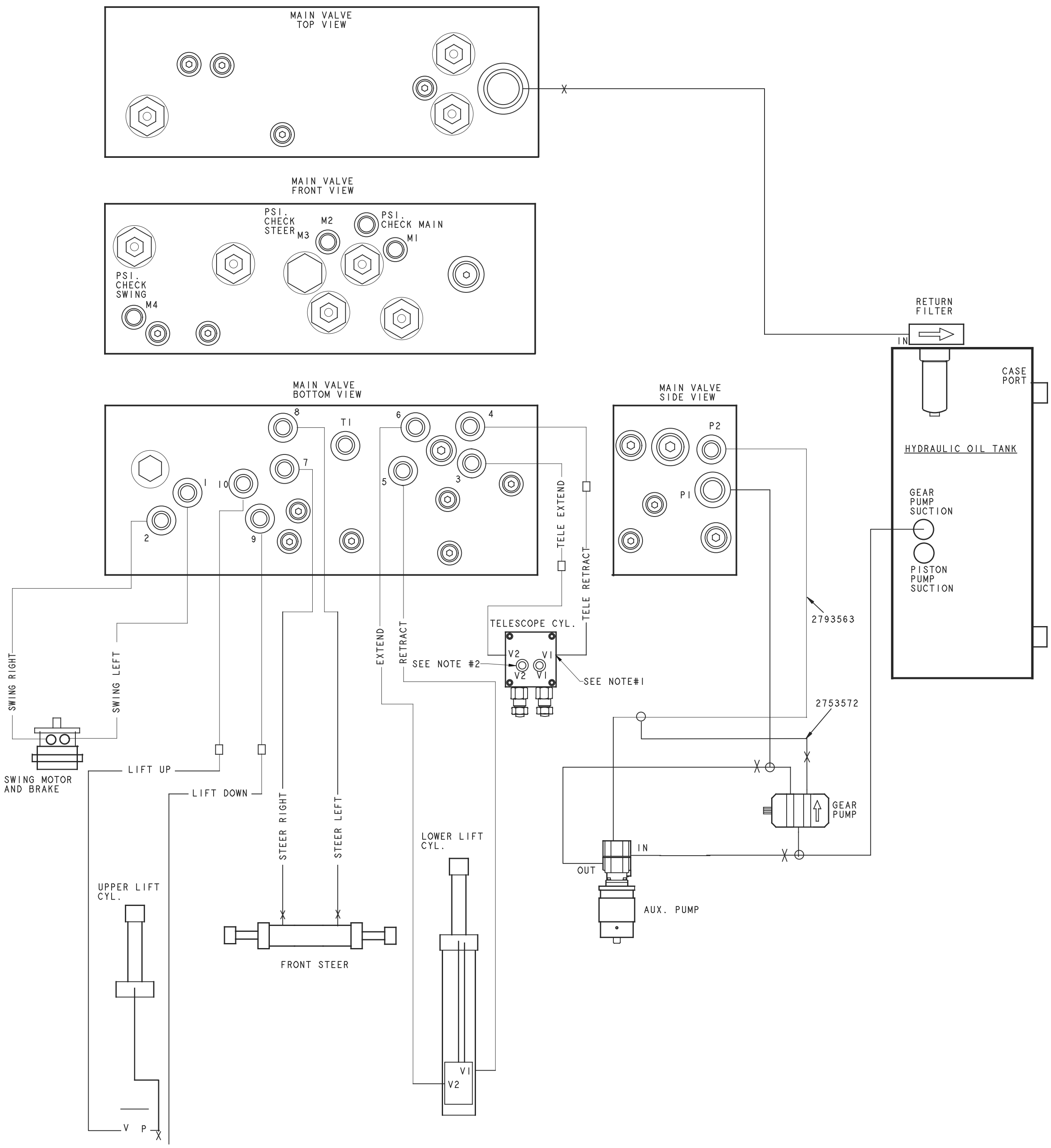


Figure 7-61. Hydraulic Schematic 1283460 - Sheet 7 of 7 (RH)

NOTES:

PROPOSITION 65 WARNING

- Battery posts, terminals and related accessories contain lead and lead compounds, chemicals known to the State of California to cause cancer and reproductive harm.
- Batteries also contain other chemicals known to the State of California to cause cancer.
- Wash hands after handling.

⚠ WARNING: ⚠

The engine exhaust from this product contains chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm.

1702961

3121180

An Oshkosh Corporation Company

Corporate Office
JLG Industries, Inc.
1 JLG Drive
McConnellsburg PA. 17233-9533
USA
☎ (717) 485-5161
(717) 485-6417

JLG Worldwide Locations

JLG Industries (Australia)
P.O. Box 5119
11 Bolwarra Road
Port Macquarie
N.S.W. 2444
Australia
☎ +61 2 65 811111
+61 2 65 813058

JLG Latino Americana Ltda.
Rua Eng. Carlos Stevenson,
80-Suite 71
13092-310 Campinas-SP
Brazil
☎ +55 19 3295 0407
+55 19 3295 1025

JLG Industries (UK) Ltd
Bentley House
Bentley Avenue
Middleton
Greater Manchester
M24 2GP - England
☎ +44 (0)161 654 1000
+44 (0)161 654 1001

JLG France SAS
Z.I. de Baulieu
47400 Fauillet
France
☎ +33 (0)5 53 88 31 70
+33 (0)5 53 88 31 79

JLG Deutschland GmbH
Max-Planck-Str. 21
D - 27721 Ritterhude - Ihlpohl
Germany
☎ +49 (0)421 69 350 20
+49 (0)421 69 350 45

JLG Equipment Services Ltd.
Rm 1107 Landmark North
39 Lung Sum Avenue
Sheung Shui N. T.
Hong Kong
☎ (852) 2639 5783
(852) 2639 5797

JLG Industries (Italia) s.r.l.
Via Po. 22
20010 Pregnana Milanese - MI
Italy
☎ +39 029 359 5210
+39 029 359 5845

Oshkosh-JLG Singapore
Technology Equipment Pte Ltd
29 Tuas Ave 4,
Jurong Industrial Estate
Singapore, 639379
☎ +65-6591 9030
+65-6591 9031

Plataformas Elevadoras
JLG Iberica, S.L.
Trapadella, 2
P.I. Castellbisbal Sur
08755 Castellbisbal, Barcelona
Spain
☎ +34 93 772 4700
+34 93 771 1762

JLG Sverige AB
Enkopingsvagen 150
Box 704
SE - 176 27 Jarfalla
Sweden
☎ +46 (0)850 659 500
+46 (0)850 659 534

www.jlg.com