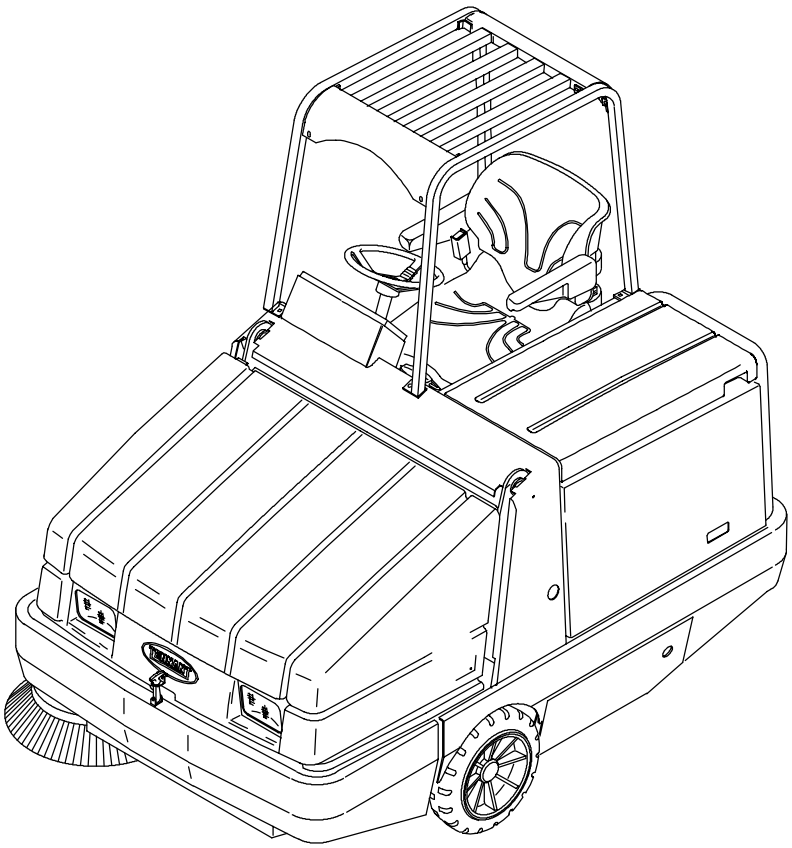
6600/6650

Service Information Manual



(Paper Manual)

330915

Rev. 00

330935 (CD-ROM)

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This manual provides service information for the TENNANT Model 6600/6650.

This machine will provide excellent service. However, the best results will be obtained at minimum costs if:

- The machine is operated with reasonable care.
- The machine is maintained regularly – per the maintenance instructions provided.
- The machine is maintained with TENNANT supplied or approved parts.

Paper Manual Number – 330915

CD-ROM Manual Number – 330935

Revision: 00

Published: 9-03

CALIFORNIA PROPOSITION 65 WARNING:
Engine exhaust from this product contains chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm.

MODEL

6600

ELECTRICAL

Troubleshooting Charts

BEFORE CONDUCTING TESTS:

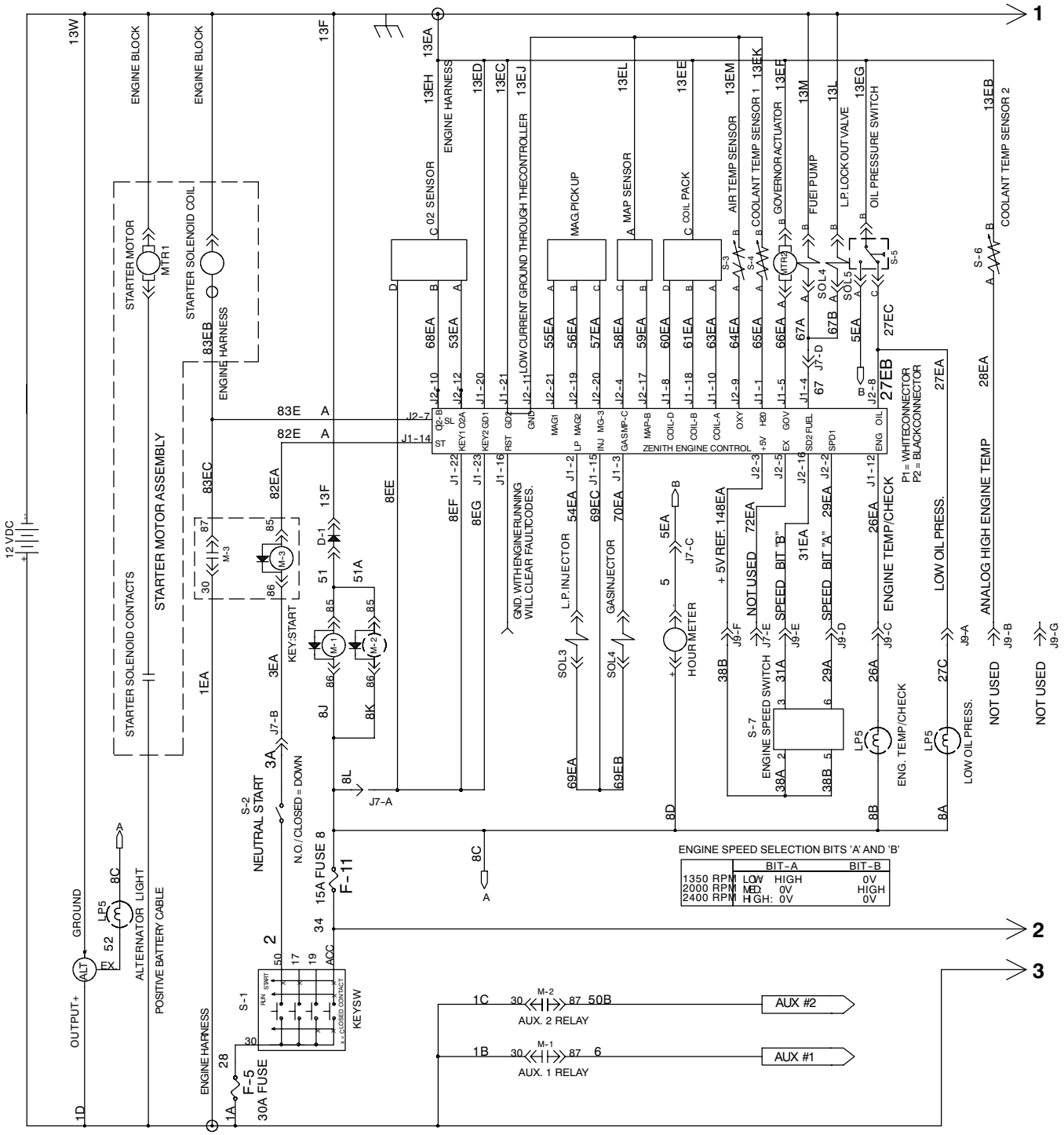
*** Read and Follow ALL Safety Warnings and Precautions in Operator's Manual**

DURING TESTS:

*** Call Technical Services if Diagnostic Time Exceeds One Hour With Unknown Cause or Course of Action**

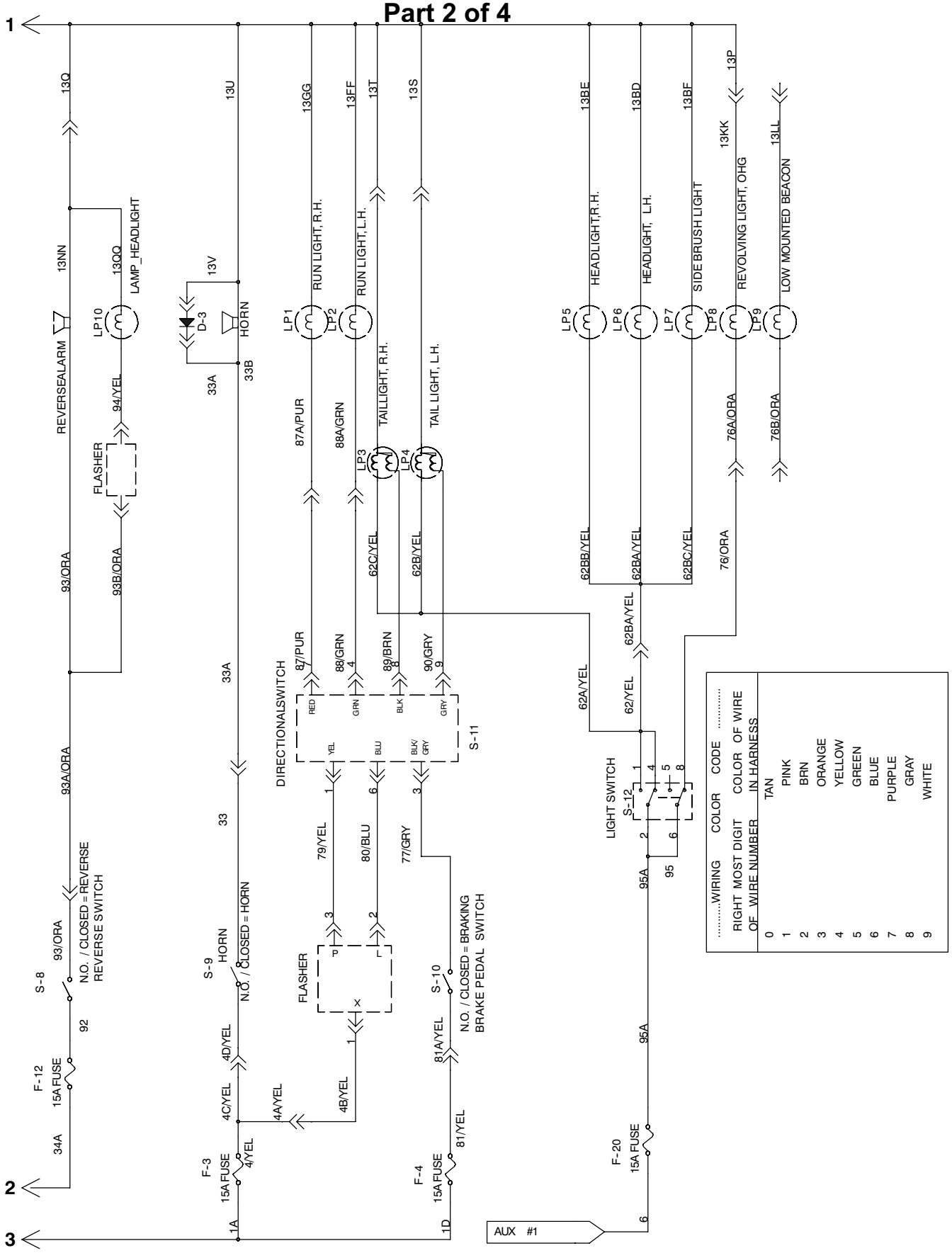
6600 GAS & L.P. OVERALL ELECTRICAL DIAGRAM

Part 1 of 4



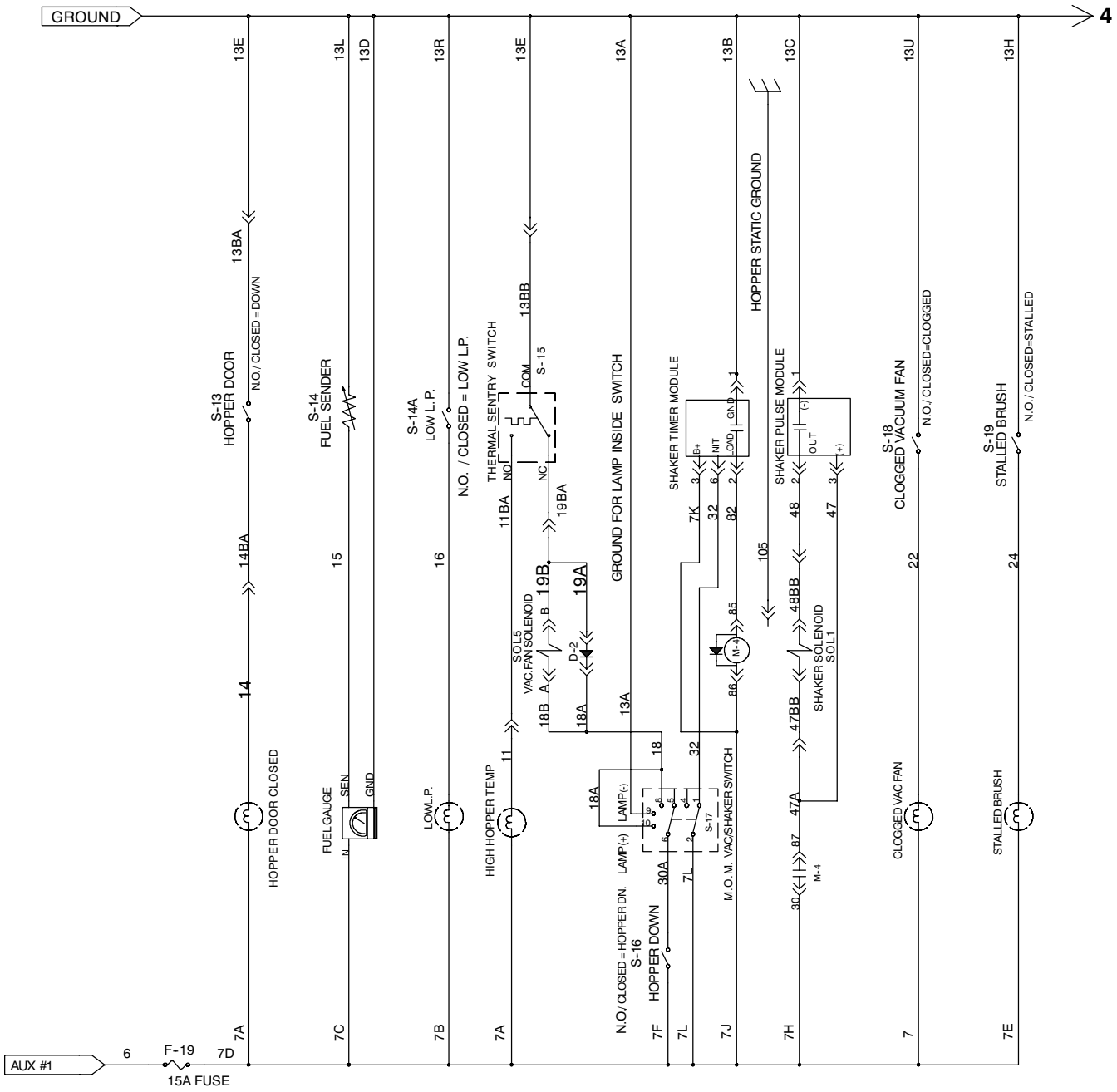
6600 GAS & L.P. OVERALL ELECTRICAL DIAGRAM

Part 2 of 4



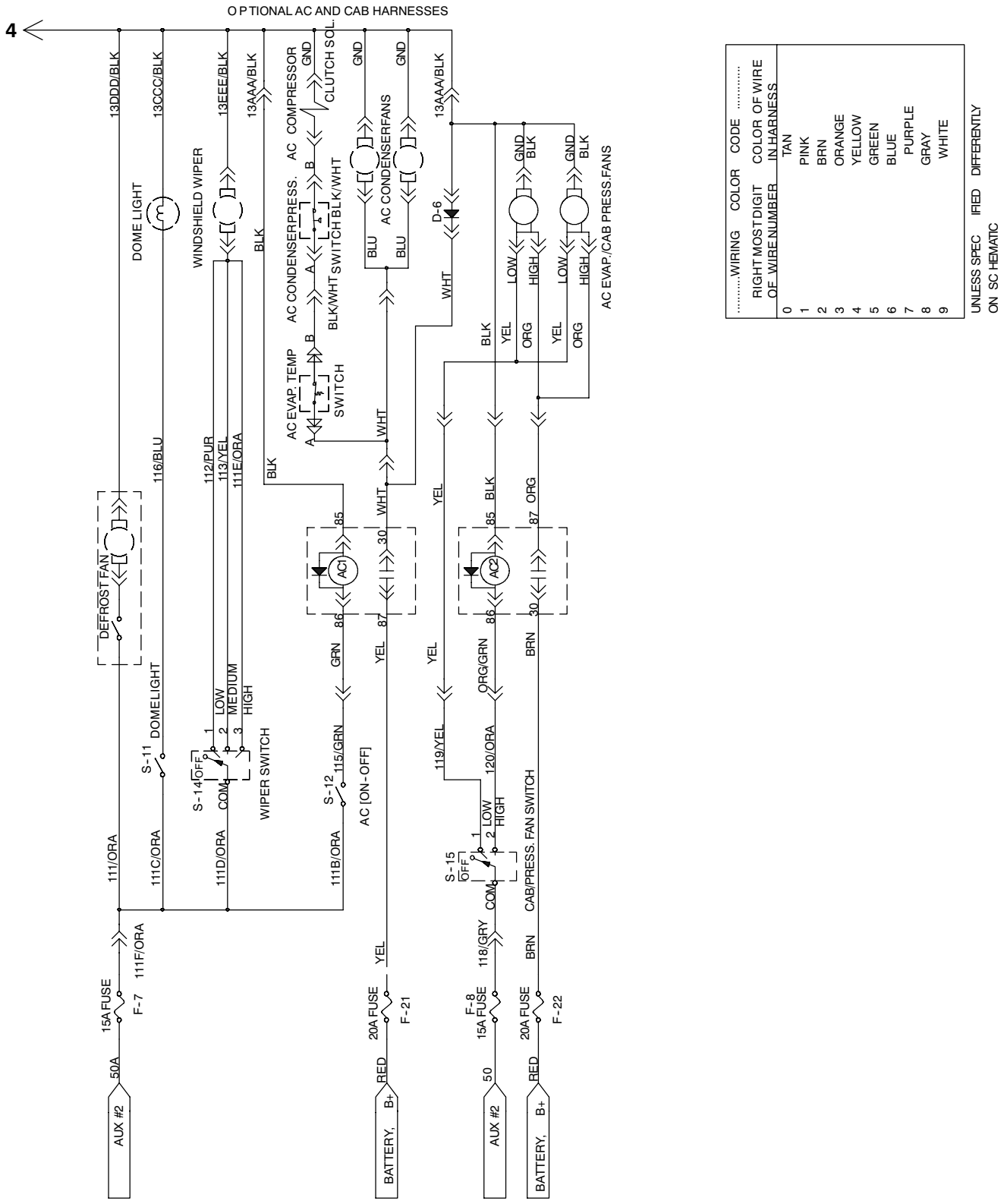
6600 GAS & L.P. OVERALL ELECTRICAL DIAGRAM

Part 3 of 4



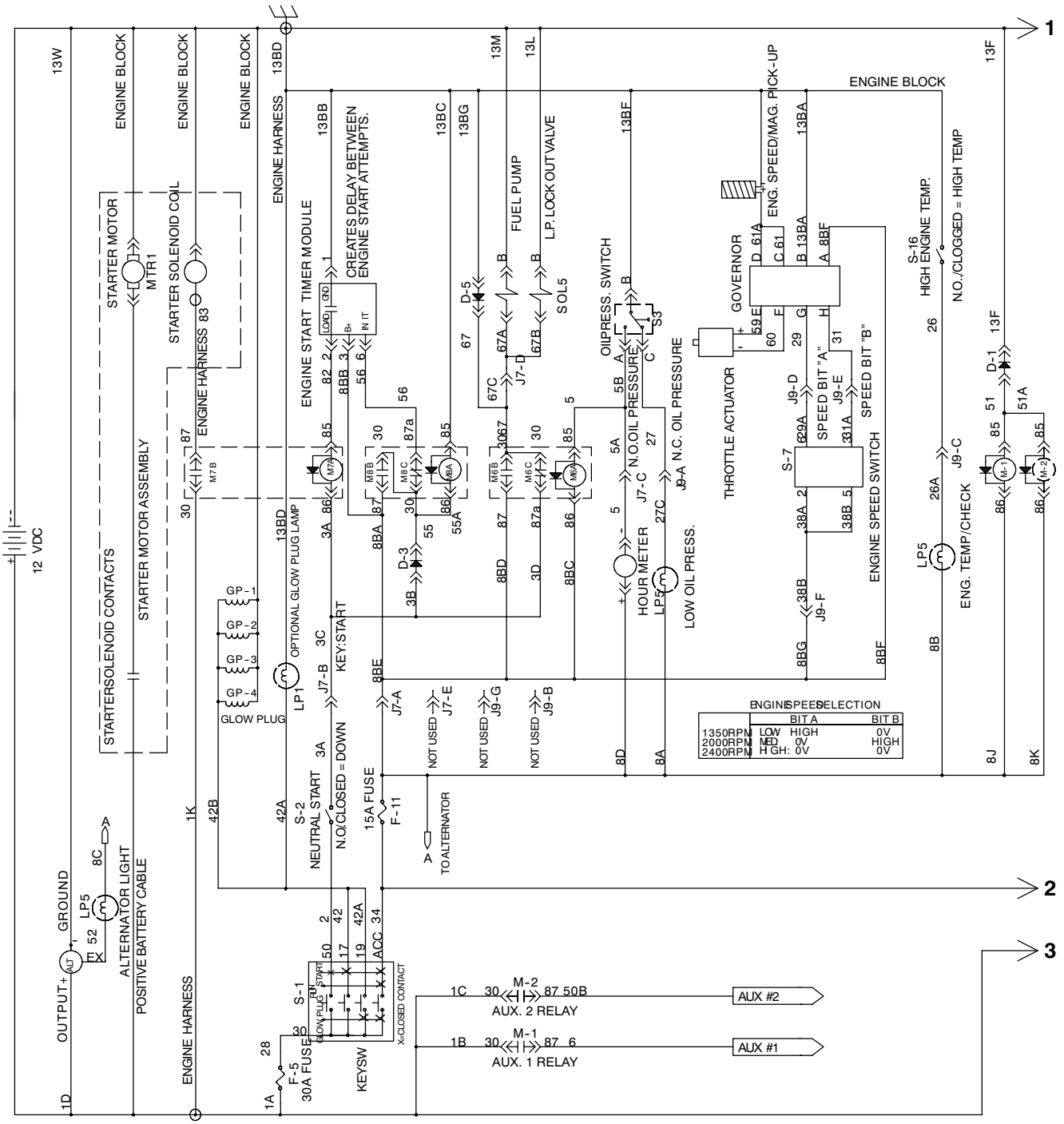
6600 GAS & L.P. OVERALL ELECTRICAL DIAGRAM

Part 4 of 4



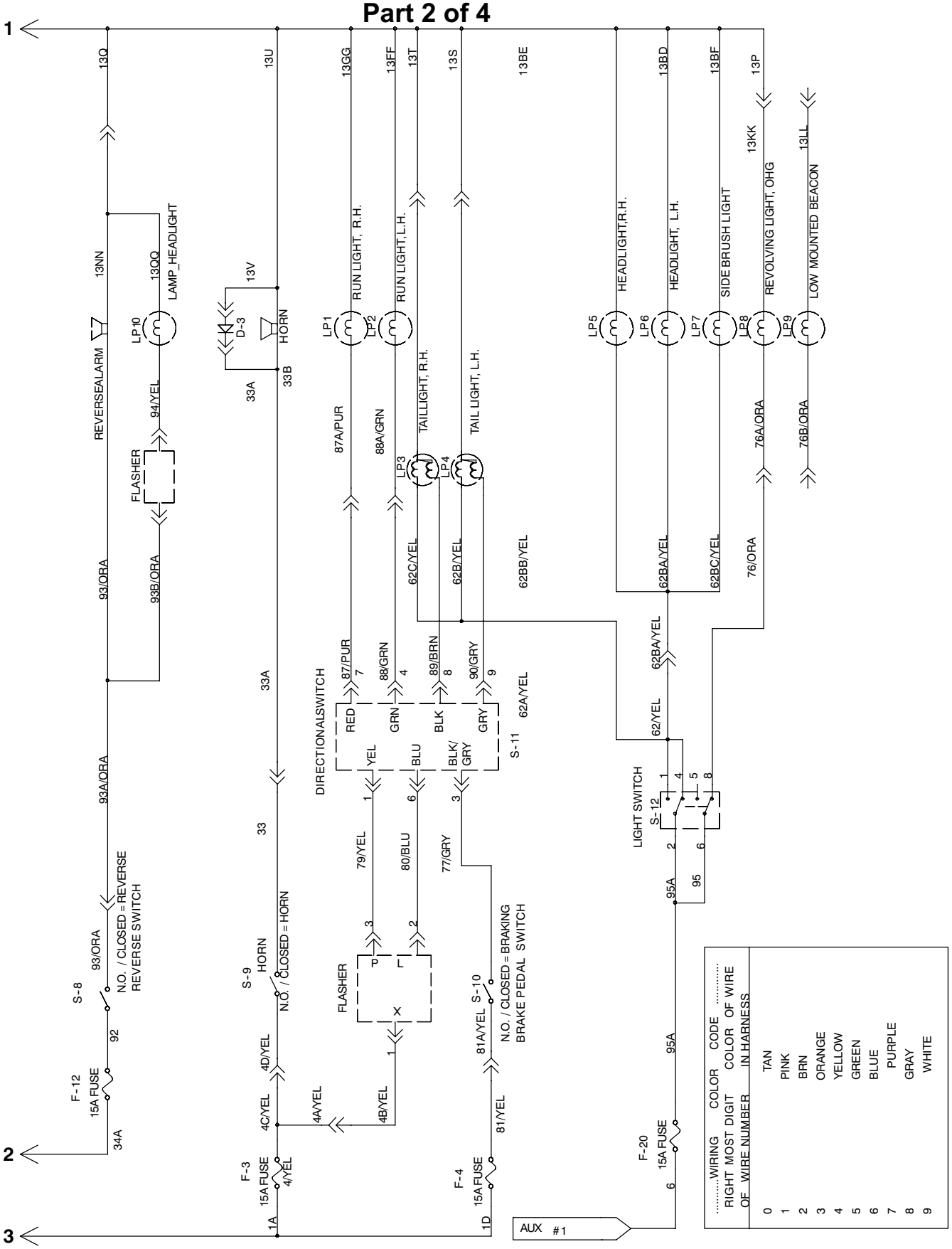
6600 DIESEL OVERALL ELECTRICAL DIAGRAM

Part 1 of 4



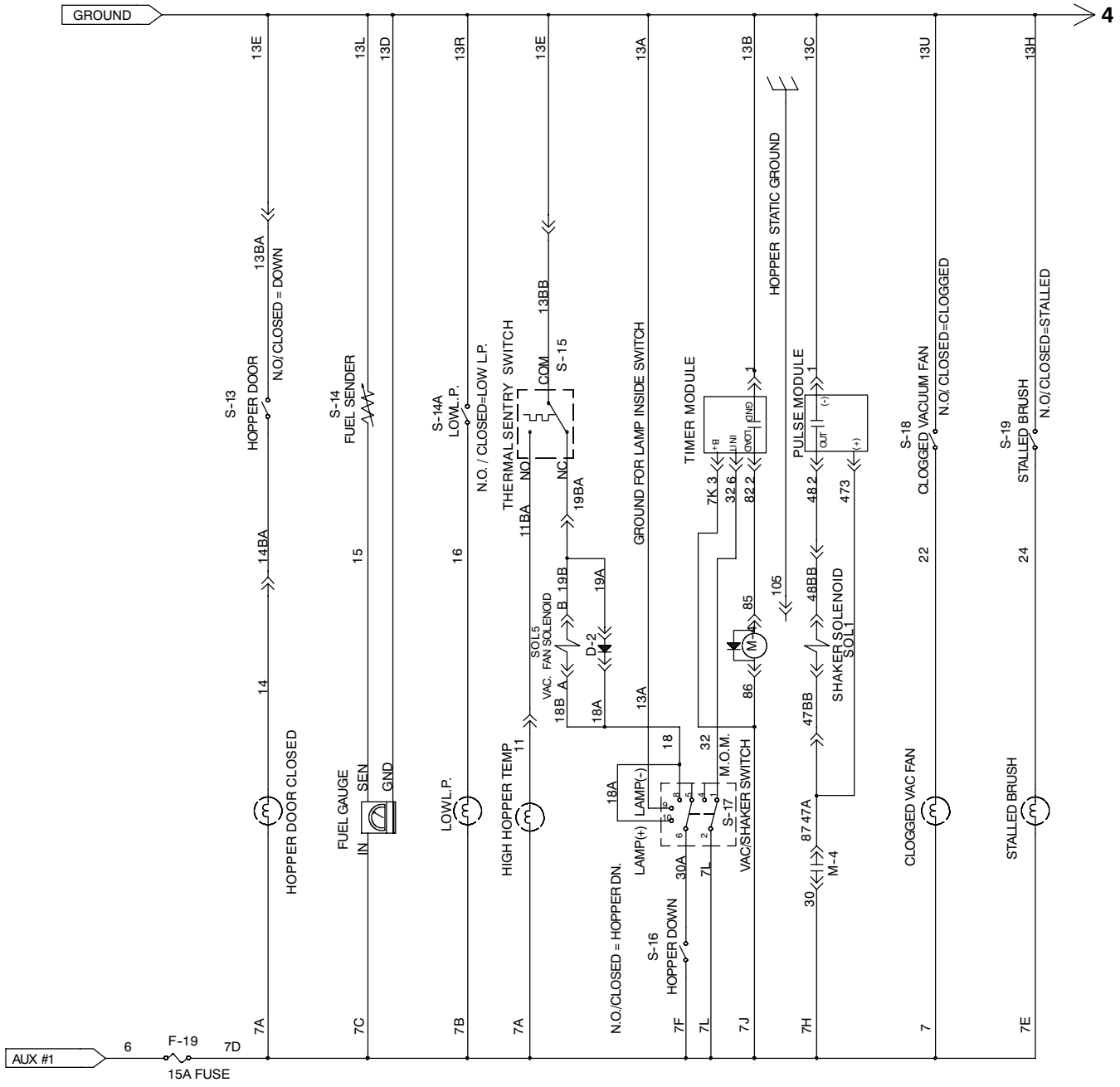
6600 DIESEL OVERALL ELECTRICAL DIAGRAM

Part 2 of 4



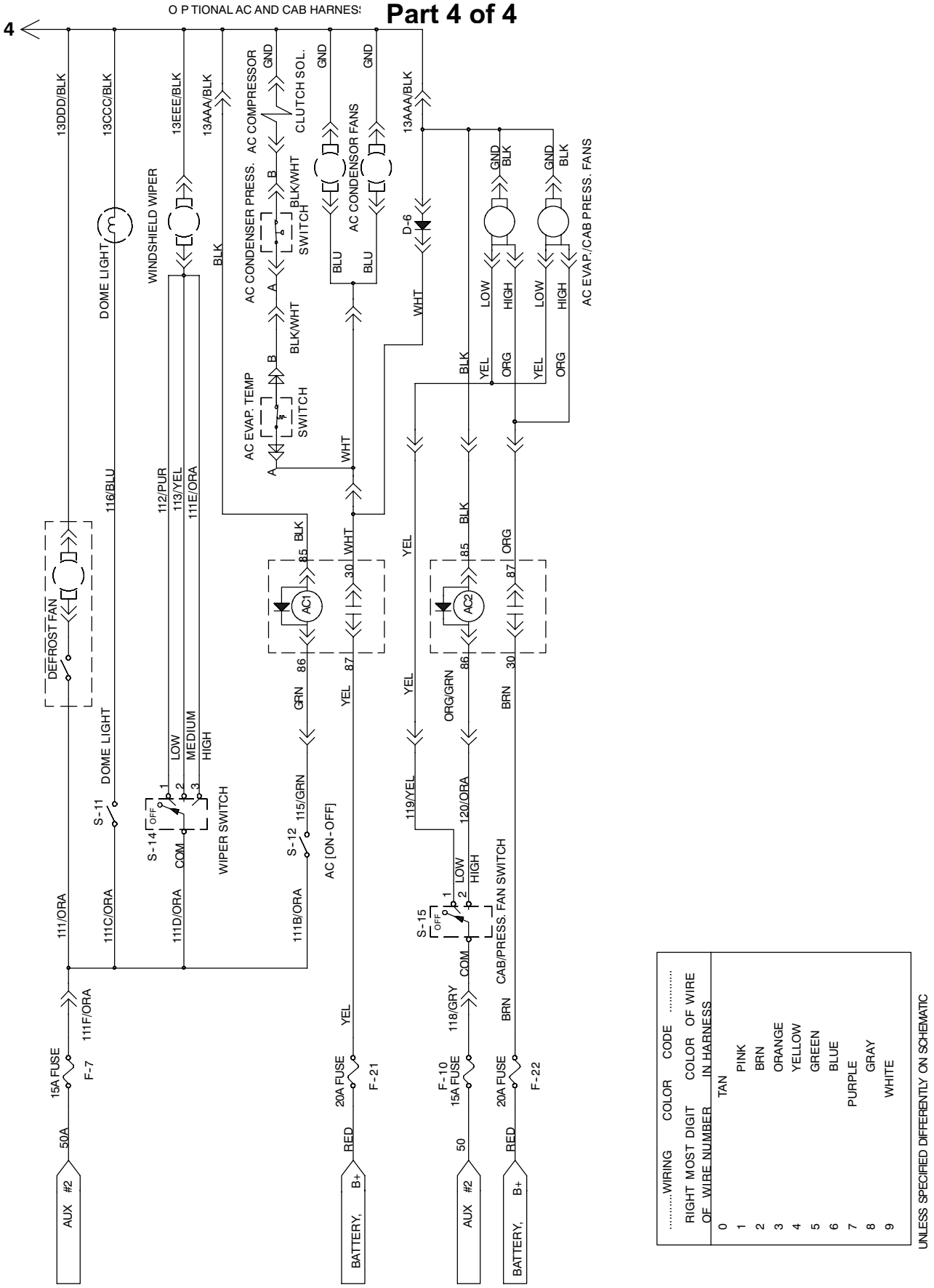
6600 DIESEL OVERALL ELECTRICAL DIAGRAM

Part 3 of 4



6600 DIESEL OVERALL ELECTRICAL DIAGRAM

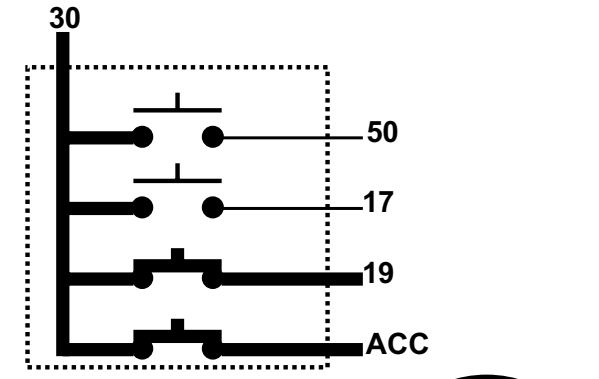
Part 4 of 4

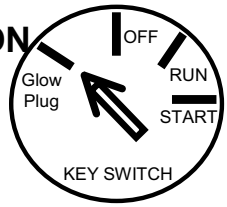


WIRING RIGHT MOST DIGIT OF WIRE NUMBER	COLOR CODE OF WIRE IN HARNESS
0	TAN
1	PINK
2	BRN
3	ORANGE
4	YELLOW
5	GREEN
6	BLUE
7	PURPLE
8	GRAY
9	WHITE

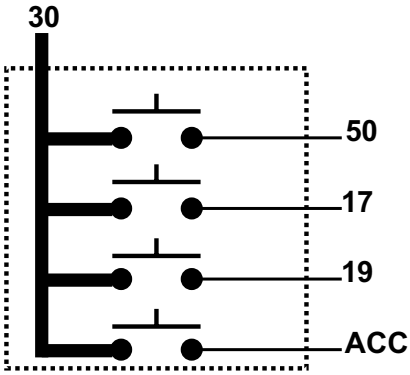
UNLESS SPECIFIED DIFFERENTLY ON SCHEMATIC

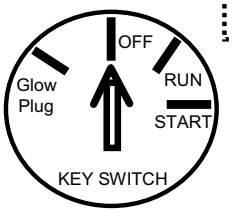
6600 Key Switch



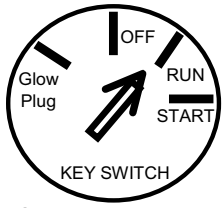


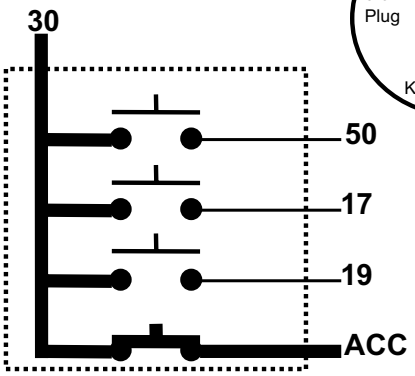
GLOW PLUG POSITION
(Diesel Only)
Spring loaded- Returns to "OFF" unless held



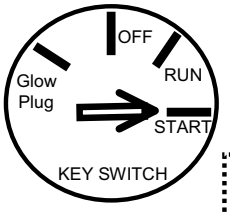


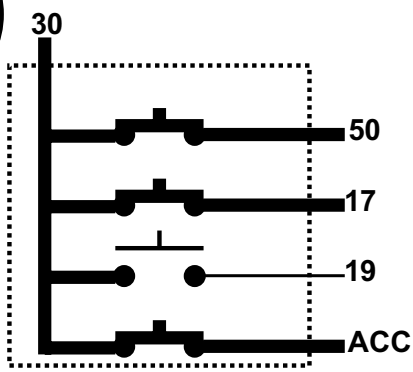
OFF POSITION





RUN POSITION





START POSITION
Spring loaded-Returns to "RUN" unless held

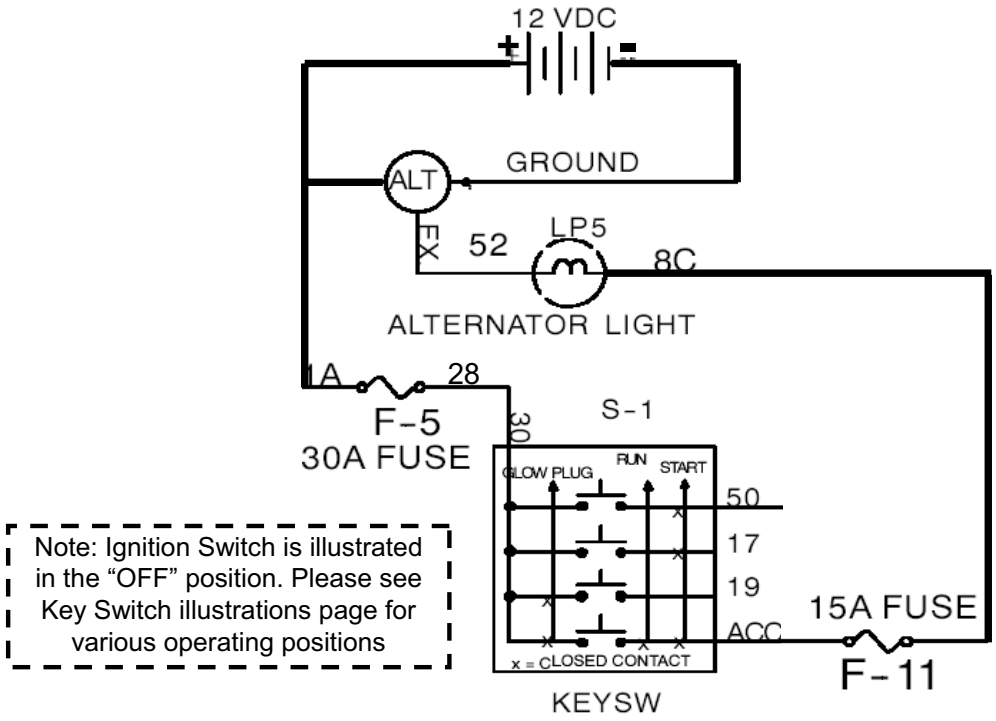
SWITCH TERMINAL MARKING

KEY SWITCH POSITION	30	50	17	19	ACC
GLOW PLUG	●			●	●
OFF	NO CONNECTIONS				
RUN	●				●
START	●	●	●		●

"●—●" Indicates a common connection

NOTE: Common connections in various switch positions should be less than 1Ω

6600 Charging System



Test battery, clean battery terminals, check all connections, wiring, and fuses F-5 & F-11, turn key to "RUN" position (KOEO-Key On, Engine Off)

Is Alternator light lit?

YES

NO

Start engine (KOER-Key On, Engine Running), run engine at high governed RPM

Test ALTERNATOR LIGHT; Re-test battery, re-check battery terminals, connections, wiring, and fuses F-5 & F-11; Restart diagnostic steps

With lights on, check voltage at battery terminals- Is it 13.5 to 16.5 Volts?

YES

NO

Is Alternator light lit?

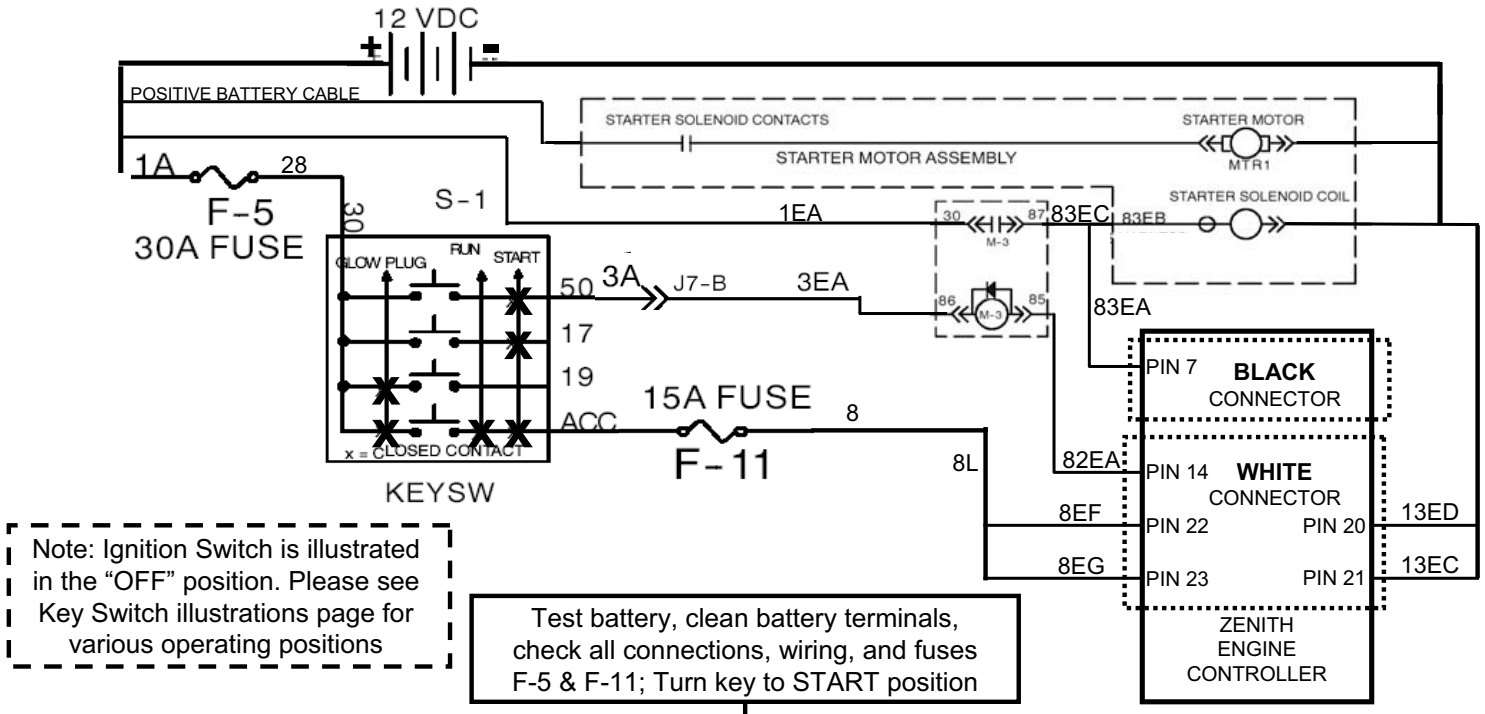
YES

NO

System operating correctly

Re-test battery, re-check battery terminals, connections, wiring, and fuses F-5 & F-11; Suspect faulty alternator

6600 Gas/L.P. Start Circuit



Note: Ignition Switch is illustrated in the "OFF" position. Please see Key Switch illustrations page for various operating positions

Test battery, clean battery terminals, check all connections, wiring, and fuses F-5 & F-11; Turn key to START position

Does STARTER MOTOR "click" or make any other noises?

YES

Re-test battery & battery terminals; Re-check all connections & wiring; Examine engine for excessive internal resistance (due to lack of lubrication, mechanical failure, etc.); Repair or replace STARTER MOTOR

NO

CAUTION!
Disconnect wire harness plug from DIS ignition coil and turn key to OFF position for next test.

With a remote start switch tool or equivalent, connect leads to the two large STARTER SOLENOID studs (the STARTER SOLENOID is an integral part of the STARTER MOTOR)

As the remote start switch is engaged, does the STARTER MOTOR crank the engine?

YES

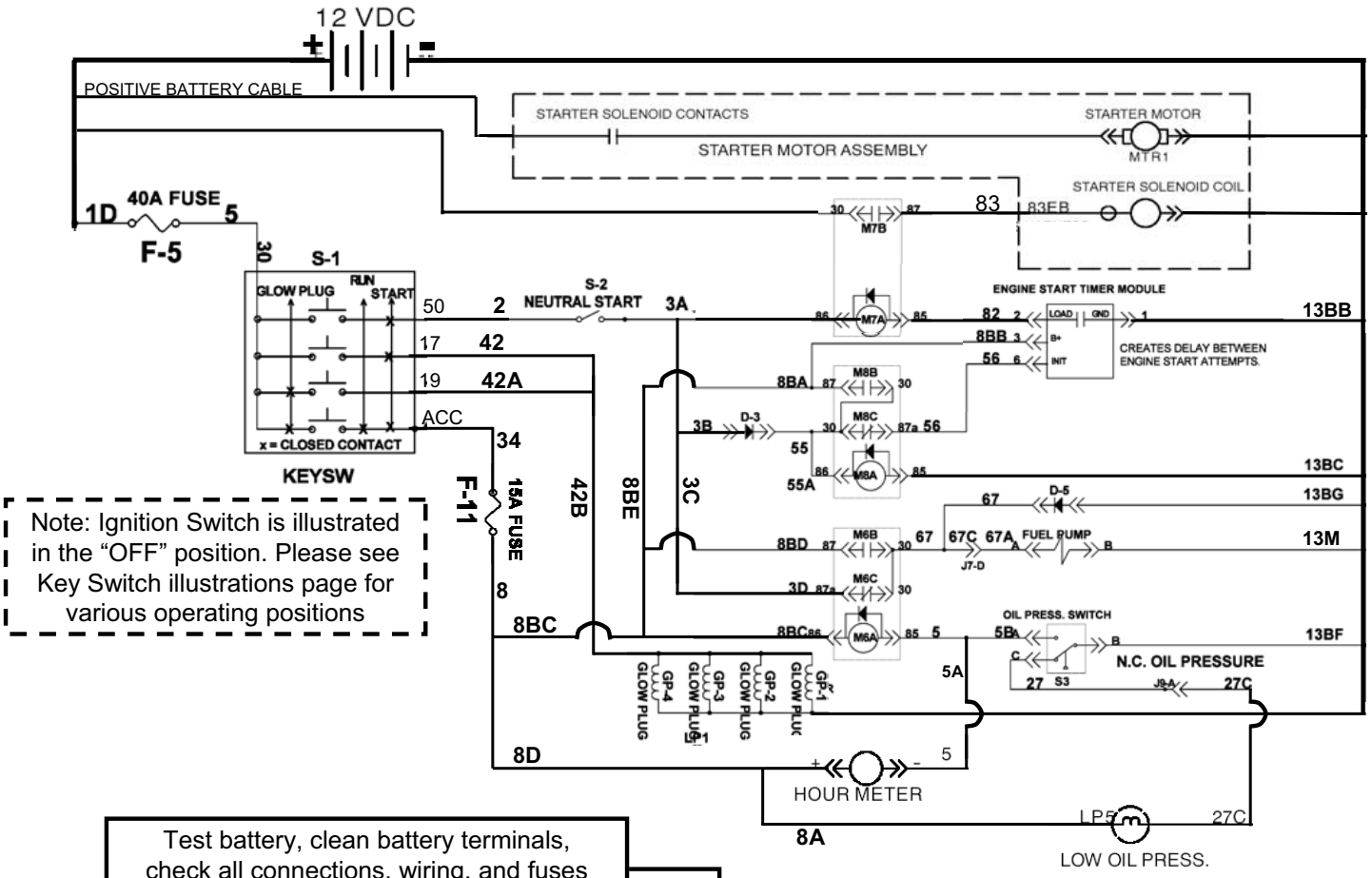
Re-check all connections, wiring and fuses F-5 & F-11; Test relay M-3; Test Key Switch; Test for proper power & ground connections at ZENITH ENGINE CONTROLLER (refer to ZEEMS troubleshooting)

NO

Re-test battery & battery terminals; Re-check all connections & wiring; Examine engine for excessive internal resistance (due to lack of lubrication, mechanical failure, etc.); Repair or replace

PLEAS ed during testing

6600 Diesel Start Circuit



Note: Ignition Switch is illustrated in the "OFF" position. Please see Key Switch illustrations page for various operating positions

Test battery, clean battery terminals, check all connections, wiring, and fuses F-5 & F-11; Turn key to START position

Does STARTER MOTOR "click" or make any other noises?

YES

Re-test battery & battery terminals; Re-check all connections & wiring; Examine engine for excessive internal resistance (due to lack of lubrication, mechanical failure, etc.); Suspect faulty STARTER MOTOR

NO

CAUTION!
Turn key to OFF position for next test.

With a remote start switch tool or equivalent, connect leads to the two large STARTER SOLENOID studs (the STARTER SOLENOID is an integral part of the STARTER MOTOR)

As the remote start switch is engaged, does the STARTER MOTOR crank the engine?

YES

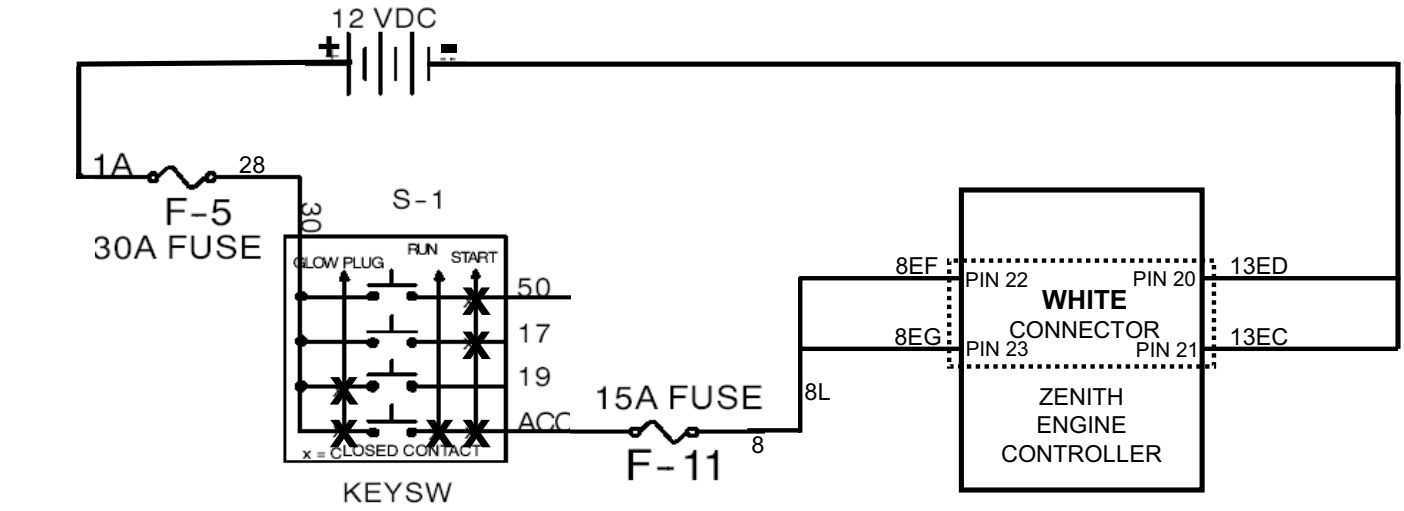
Re-check all connections, wiring and fuses F-5 & F-11; Test relays M-6, M-7, & M8; Test ENGINE START TIMER MODULE; Test Key Switch

NO

Re-test battery & battery terminals; Re-check all connections & wiring; Examine engine for excessive internal resistance (due to lack of lubricatio

PLEASE d during testing

6600 Gas/L.P. Power-Up Circuit



Note: Ignition Switch is illustrated in the "OFF" position. Please see Key Switch illustrations page for various operating positions

Check all connections, wiring, and fuses F-5 & F-11, turn key to "ON" position (KOEO-Key On, Engine Off)

Is battery voltage measured across all power and ground connections at ZENITH ENGINE CONTROLLER?

YES

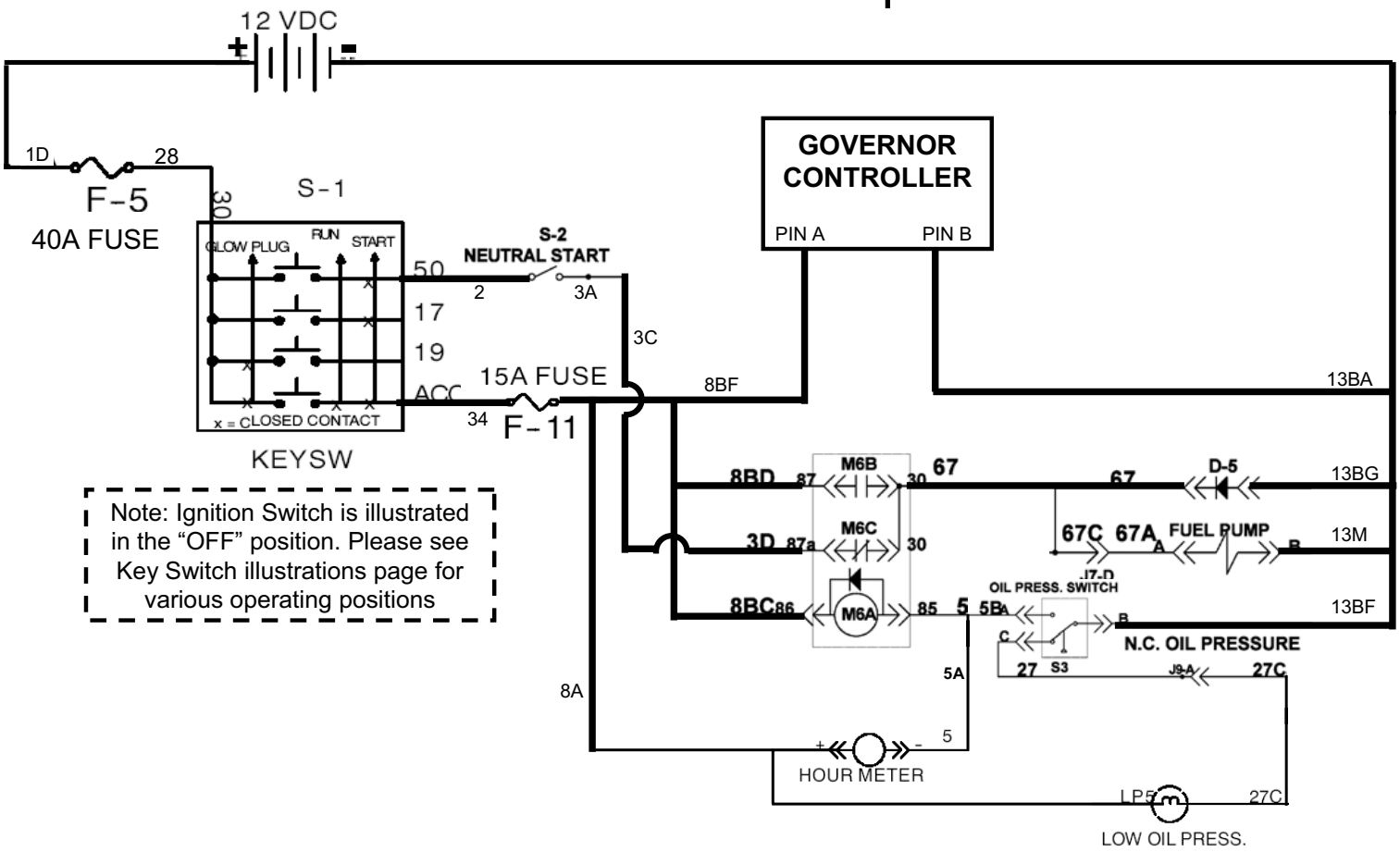
NO

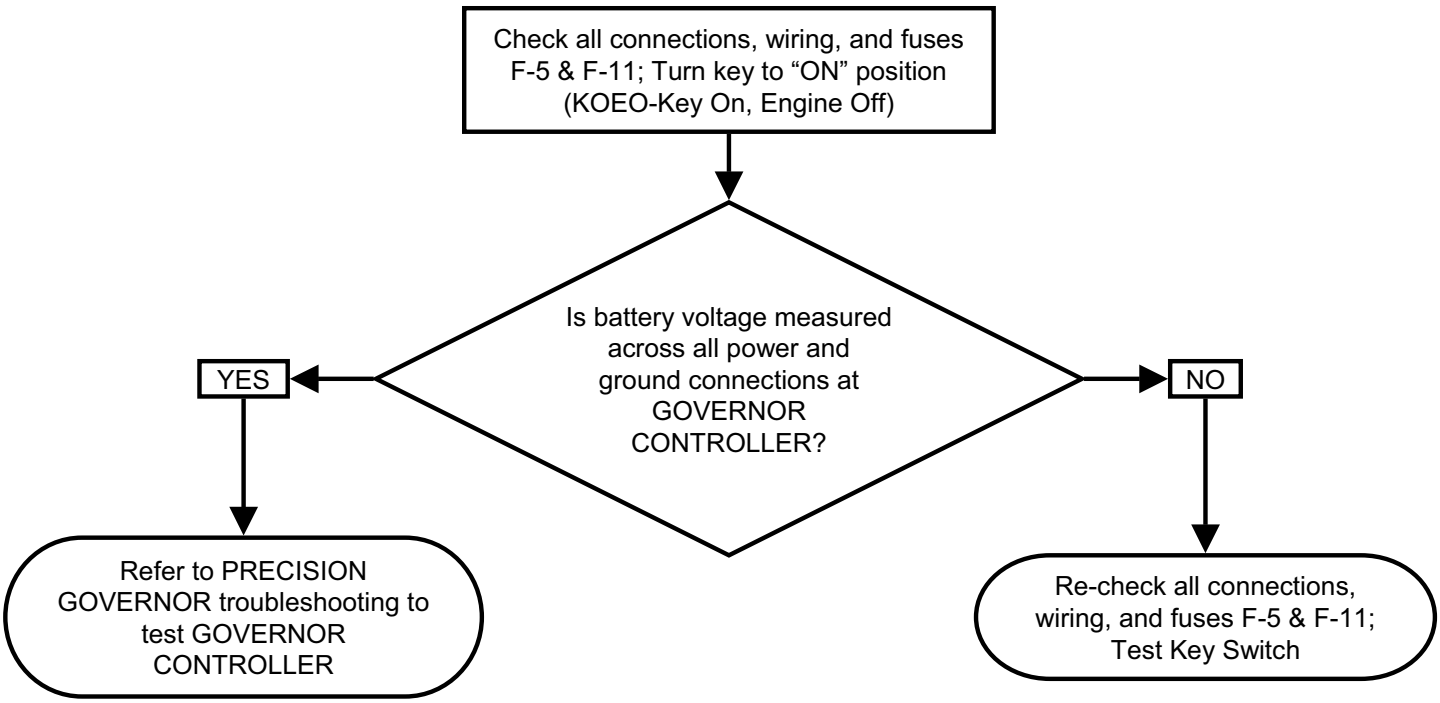
Refer to ZEEMS troubleshooting to test ZENITH ENGINE CONTROLLER

Re-check all connections, wiring, and fuses F-5 & F-11; Test Key Switch

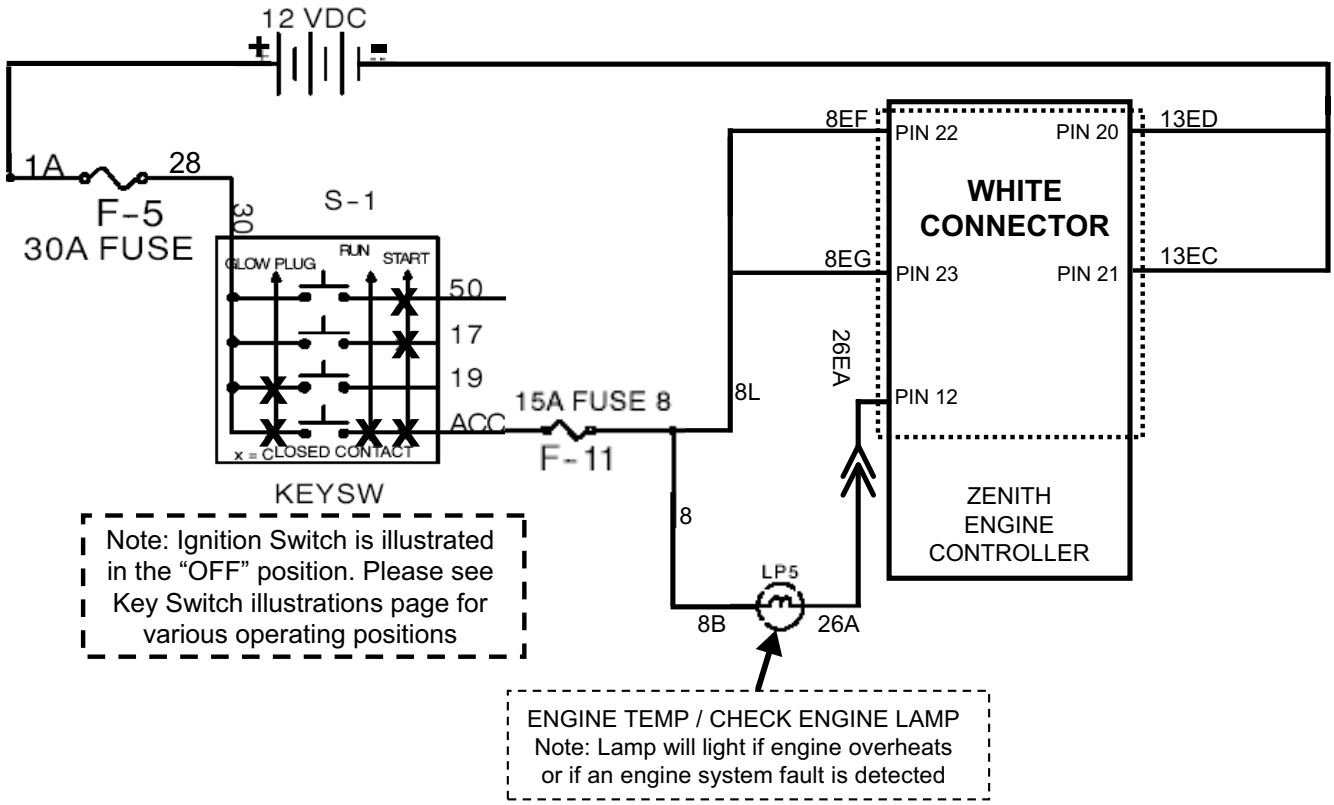
PLEAS d during testing

6600 Diesel Power-Up Circuit





6600 Gas/L.P. Check Engine Lamp Circuit



Check all connections, wiring, and fuses F-5 & F-11, turn key to "ON" position (KOEO-Key On, Engine Off)

Is CHECK ENGINE LAMP flashing?

YES

Refer to "ZENITH ENGINE FAULT CODES" to diagnose engine or sensor faults

NO

Test CHECK ENGINE LAMP; Re-check all connections, wiring, and fuses F-5, & F-11; Test for proper power and ground connections at ZENITH ENGINE CONTROLLER; Test Key Switch; Refer to ZEEMS troubleshooting to test ZENITH ENGINE CONTROLLER

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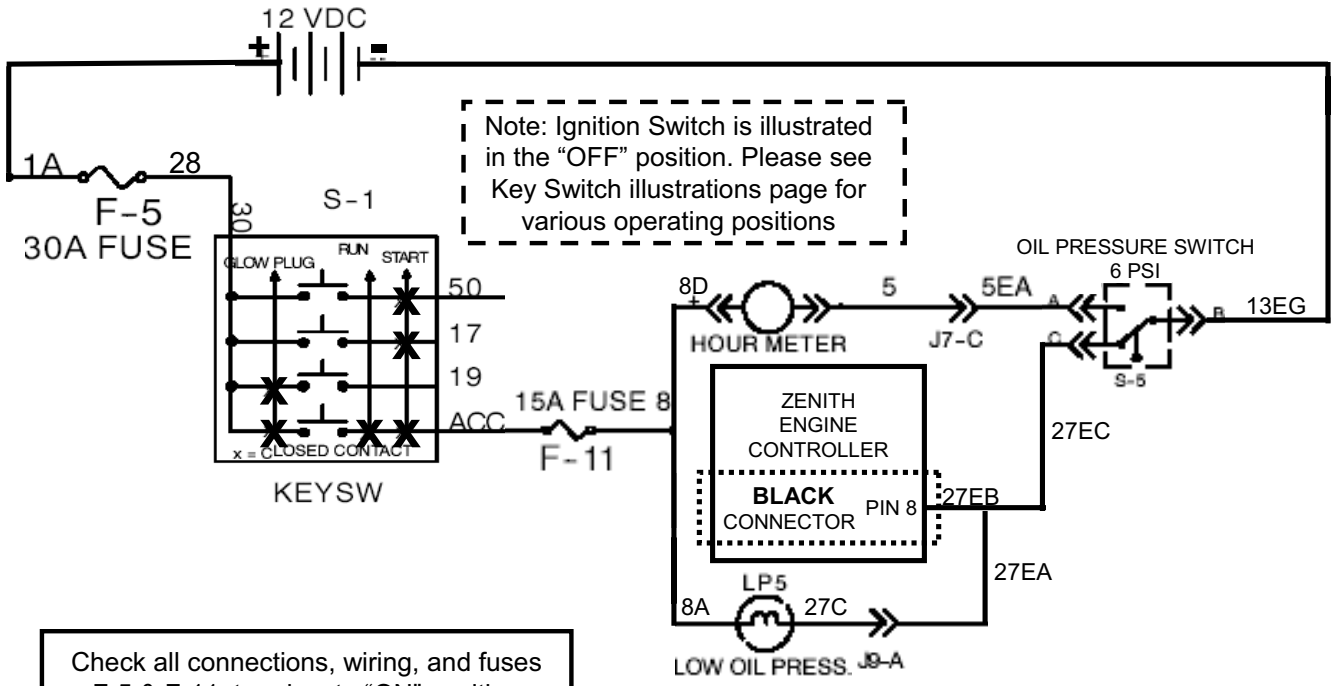
6600 Gas/L.P. Oil Pressure & Hour Meter Circuit



Check all connections, wiring, and fuses F-5 & F-11, turn key to "ON" position (KOEO-Key On, Engine Off)

Is LOW OIL PRESSURE lamp lit?

YES

With engine running, does lamp go out?

YES

With engine running, is battery voltage measured across HOUR METER terminals?

YES

Test or replace HOUR METER

NO

Re-check HOUR METER connections and wiring; Suspect faulty OIL PRESSURE SWITCH

NO

Verify proper oil pressure in engine; Suspect faulty OIL PRESSURE SWITCH

NO

Remove harness plug at OIL PRESSURE SWITCH and place a jumper wire across harness plug wires B & C

Is LOW OIL PRESSURE lamp lit?

YES

Replace OIL PRESSURE SWITCH

NO

Test LOW OIL PRESSURE lamp; Re-check all connections, wiring, and fuses F-5 & F-11; Test Key Switch

PLEAS ed during testing

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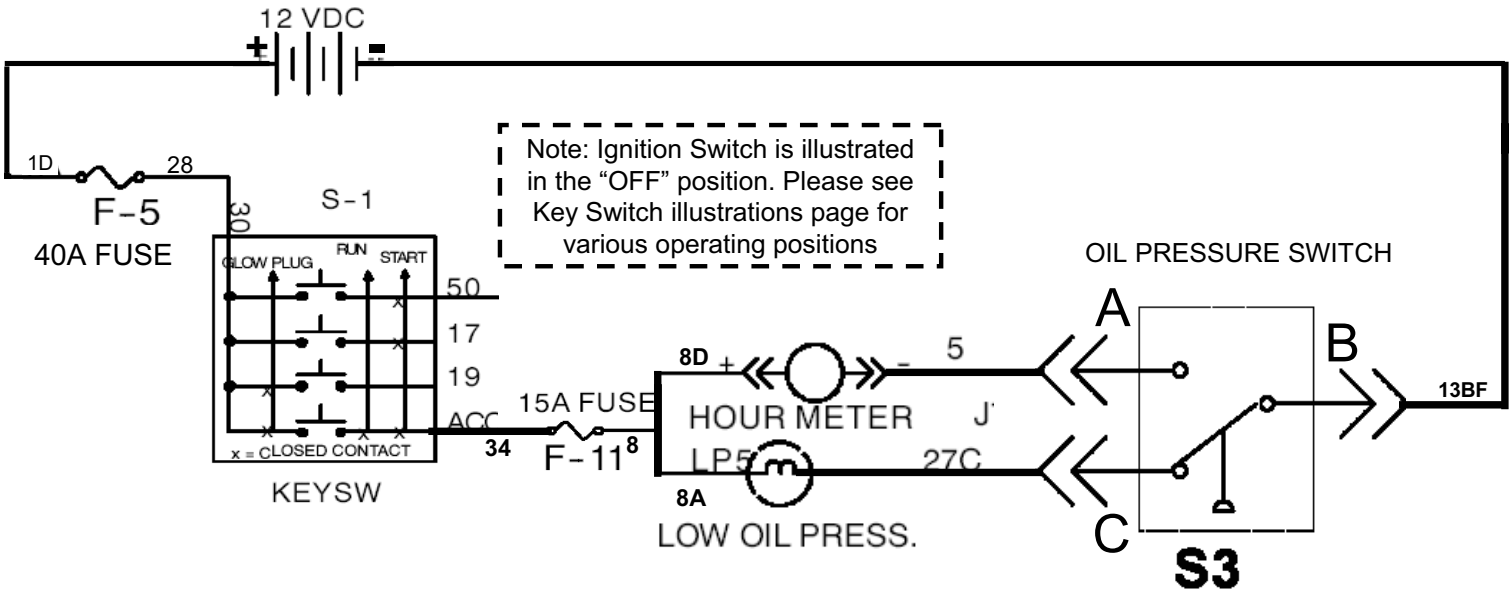
6600 Diesel Oil Pressure & Hour Meter Circuit



Check all connections, wiring, and fuses F-5 & F-11, turn key to "ON" position (KOEO-Key On, Engine Off)

Is LOW OIL PRESSURE LED lit?

YES

NO

With engine running, does lamp go out?

YES

NO

Verify proper oil pressure in engine; Suspect faulty OIL PRESSURE SWITCH

With engine running, does HOUR METER run?

YES

NO

Verify proper oil pressure in engine; Suspect faulty HOUR METER; Suspect faulty OIL PRESSURE SWITCH

Verify proper oil pressure in engine; System operating correctly

Remove harness plug at OIL PRESSURE SWITCH and place a jumper wire across harness plug wires B & C

Is LOW OIL PRESSURE lamp lit?

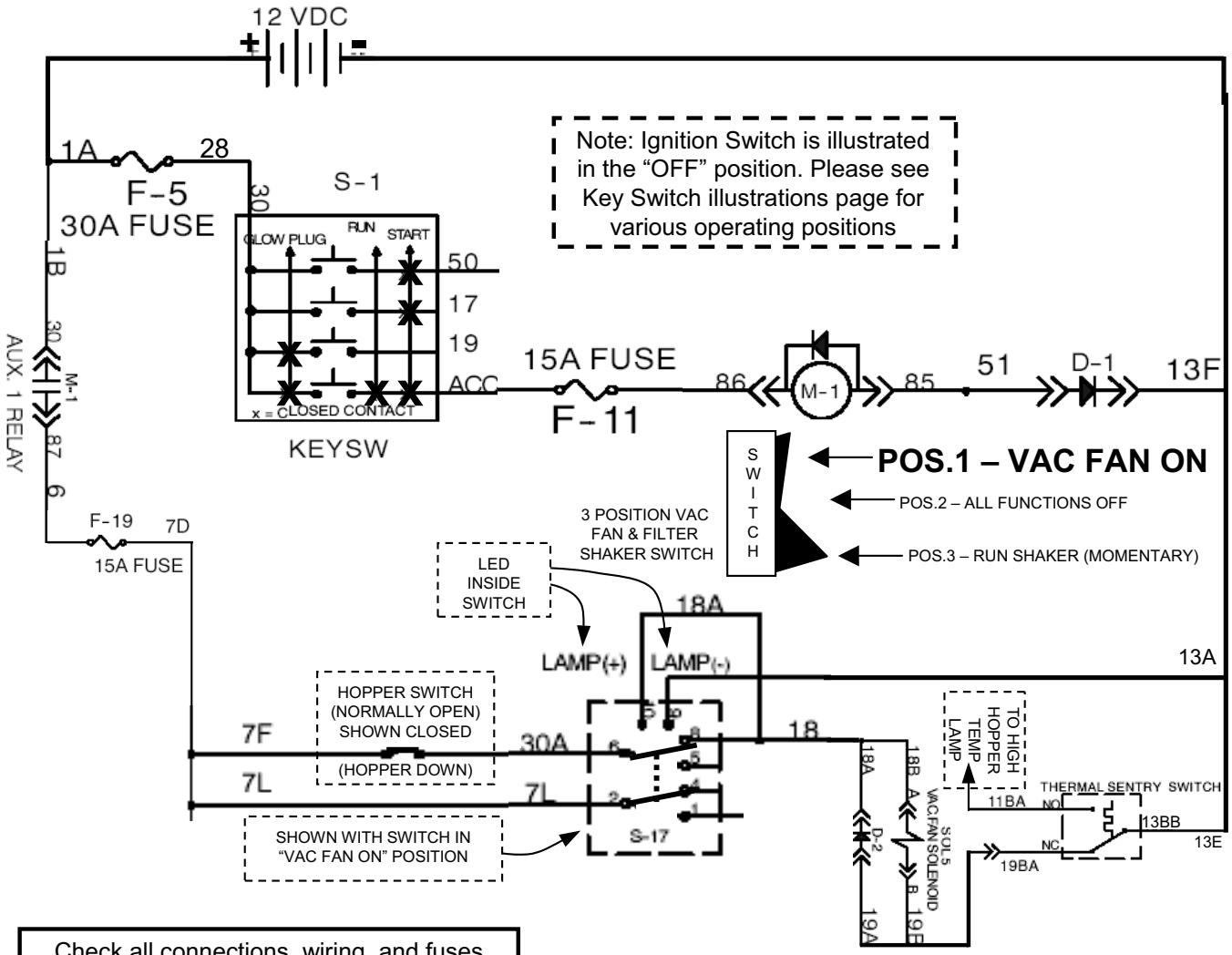
YES

NO

Replace OIL PRESSURE SWITCH

Re-check all connections, wiring, and fuses F-5 & F-11; Test Key Switch

6600 Vacuum Fan Circuit



Check all connections, wiring, and fuses F-5, F-11 & F-19, have hopper in full "DOWN" position, turn key to "ON" position (KOEO-Key On, Engine Off)

With switch in "VAC FAN ON" (position 1), is battery voltage measured across wires at VAC FAN SOLENOID (SOL5) plug?

YES

NO

Repair or replace faulty hydraulic or mechanical components; Suspect faulty VAC FAN SOLENOID coil

Re-check all power & ground connections and fuses F-5, F-11 & F-19; Test HOPPER SWITCH; Test THERMO-SENTRY SWITCH (see circuit chart); Test "3-POSITION" VAC FAN/SHAKER SWITCH; Test relay M-1; Test diodes D-1 & D-2; Test Key Switch

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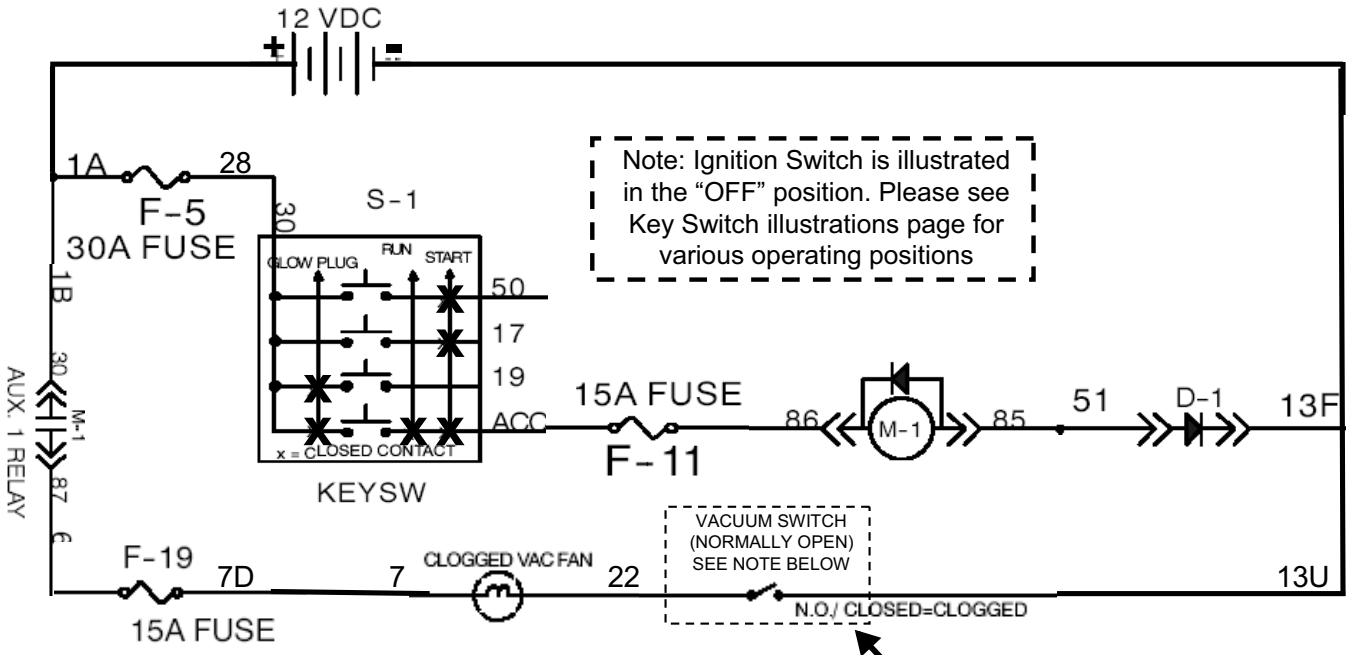
6600 Vacuum Restriction Warning Circuit



VACUUM SWITCH NOTE

Vacuum switch closes if vacuum fan is running with any one of these conditions:
- a blocked (dirty) vacuum panel filter
- a blocked Perma-Filter
- a closed hopper door

Check all connections, wiring, and fuses F-5, F-11 & F-19, turn key to "ON" position (KOEO-Key On, Engine Off)

Remove wire plug from VACUUM SWITCH and place a jumper wire across harness plug wires

Is CLOGGED VAC FAN lamp lit?

YES

Suspect faulty VACUUM SWITCH

NO

Test CLOGGED VAC FAN lamp; Re-check power & ground connections and fuses F-5, F-11 & F-19; Test relay M-1; Test diode D-1; Test Key Switch

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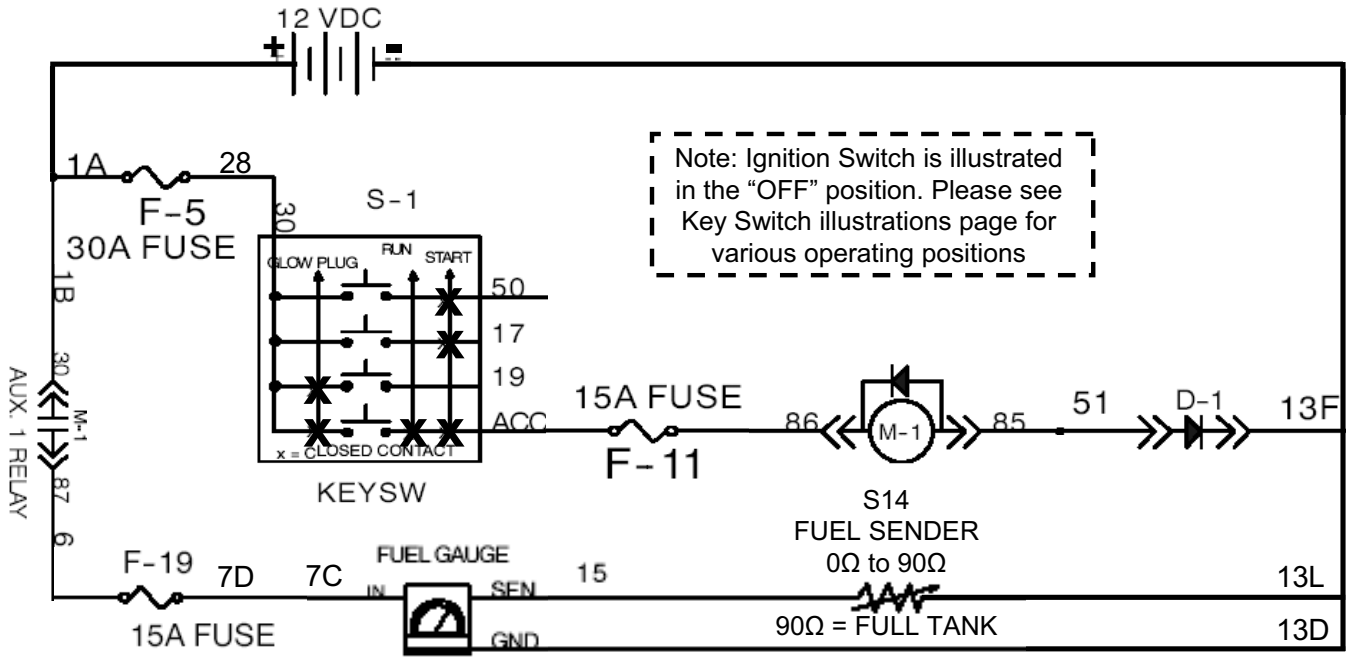
6600 Gas/Diesel Fuel Sender Circuit



Check all connections, wiring, and fuses F-5, F-11 & F-19, turn key to "ON" position (KOEO-Key On, Engine Off)

Remove wires from FUEL SENDER at tank and watch FUEL GAUGE; Place jumper wire across FUEL SENDER wires and watch FUEL GAUGE again

Does FUEL GAUGE needle deflect from FULL to EMPTY?

YES → Suspect faulty FUEL SENDER

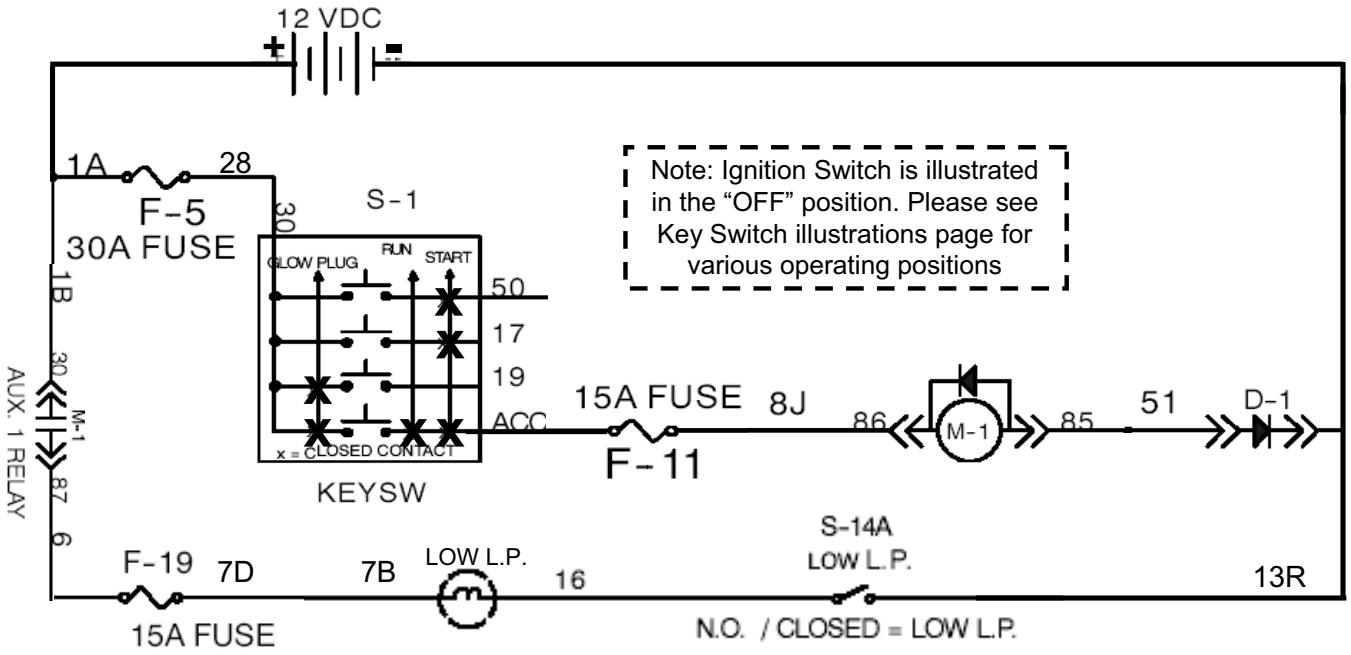
NO → Is battery voltage measured between wires "IN" & "GND" at FUEL GAUGE?

YES → Re-check wiring to FUEL SENDER ; Suspect faulty FUEL GAUGE

NO → Re-check all connections, wiring, and fuses F-5, F-11 & F-19; Test relay M-1; Test diode D-1; Test power and ground circuits; Test Key Switch

PLEAS d during testing

6600 Low L.P. Fuel Sender Circuit



With a full L.P. tank properly connected to machine, with L.P. supply valve fully open, turn key to "ON" position (KOEO-Key On, Engine Off)

Is LOW L.P. lamp lit?

YES → Check all connections and wiring; Suspect faulty LOW L.P. SWITCH

NO → Fully close L.P. supply valve on L.P. tank and run machine until engine runs out of fuel

Is LOW L.P. lamp lit?

YES → System operating properly

NO → Remove plug at LOW L.P. SWITCH and place a jumper wire across harness wires

Is LOW L.P. lamp lit?

YES → Suspect faulty LOW L.P. SWITCH

NO → Test LOW L.P. LAMP; Re-check all connections, wiring, and fuses F-5, F-11 & F-19; Test relay M-1; Test diode D-1; Test power and ground circuits; Test Key Switch

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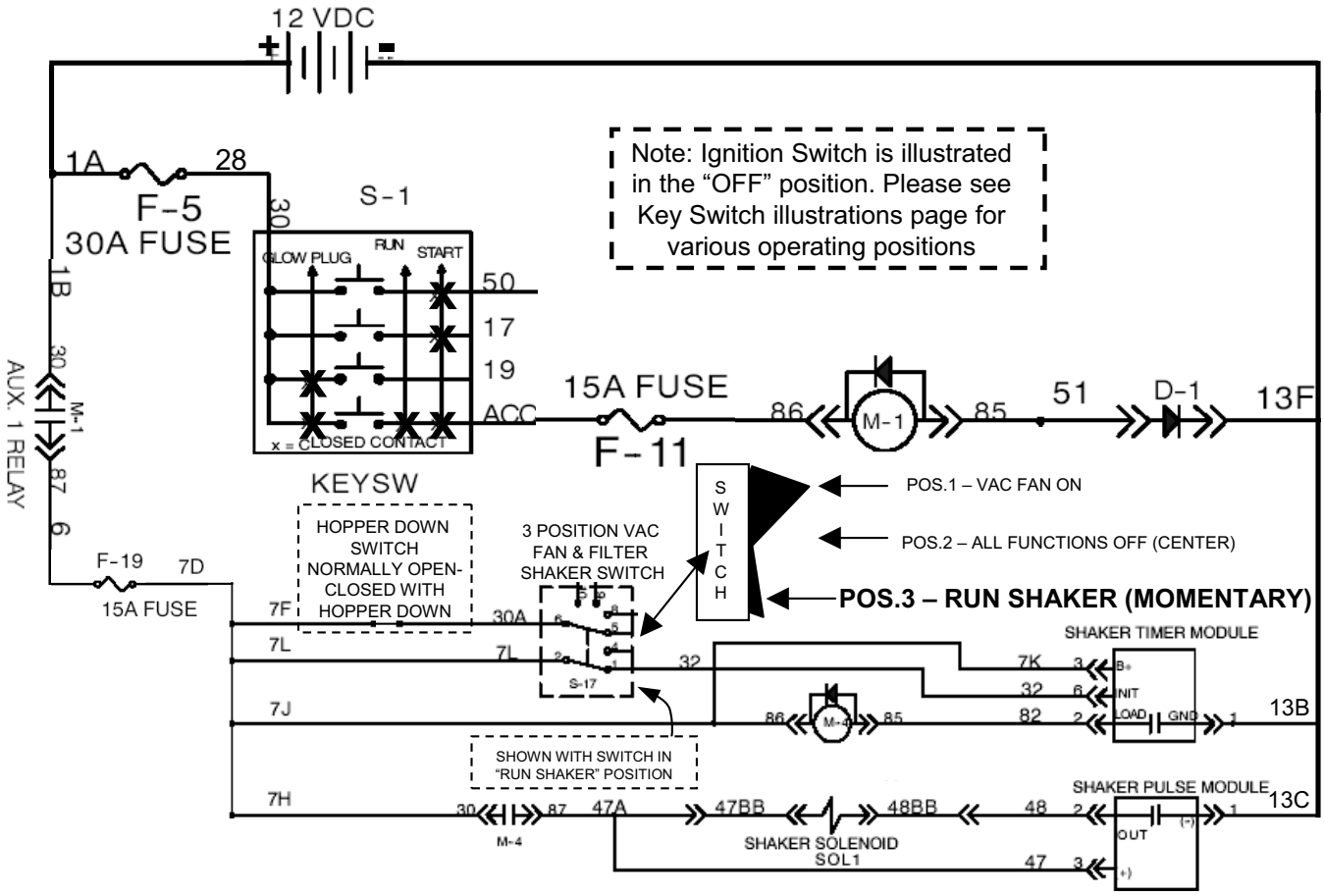
6600 Shaker Motor Circuit



Check all connections, wiring, and fuses F-5, F-11 & F-19, turn key to "ON" position (KOEO-Key On, Engine Off)

Remove wire from #2 post of SHAKER PULSE MODULE; Momentarily push SHAKER SWITCH (position 3)

Does SHAKER SOLENOID pulse as wire is tapped to ground?

YES

NO

Momentarily push SHAKER SWITCH (position 3)- Is battery voltage measured across terminals #3 & #1 at SHAKER PULSE MODULE?

YES

NO

Disconnect SHAKER SOLENOID plug; Connect one SHAKER SOLENOID wire to ground and the other to battery (+)

Suspect faulty SHAKER PULSE MODULE

Repair power or ground circuits leading to SHAKER PULSE MODULE

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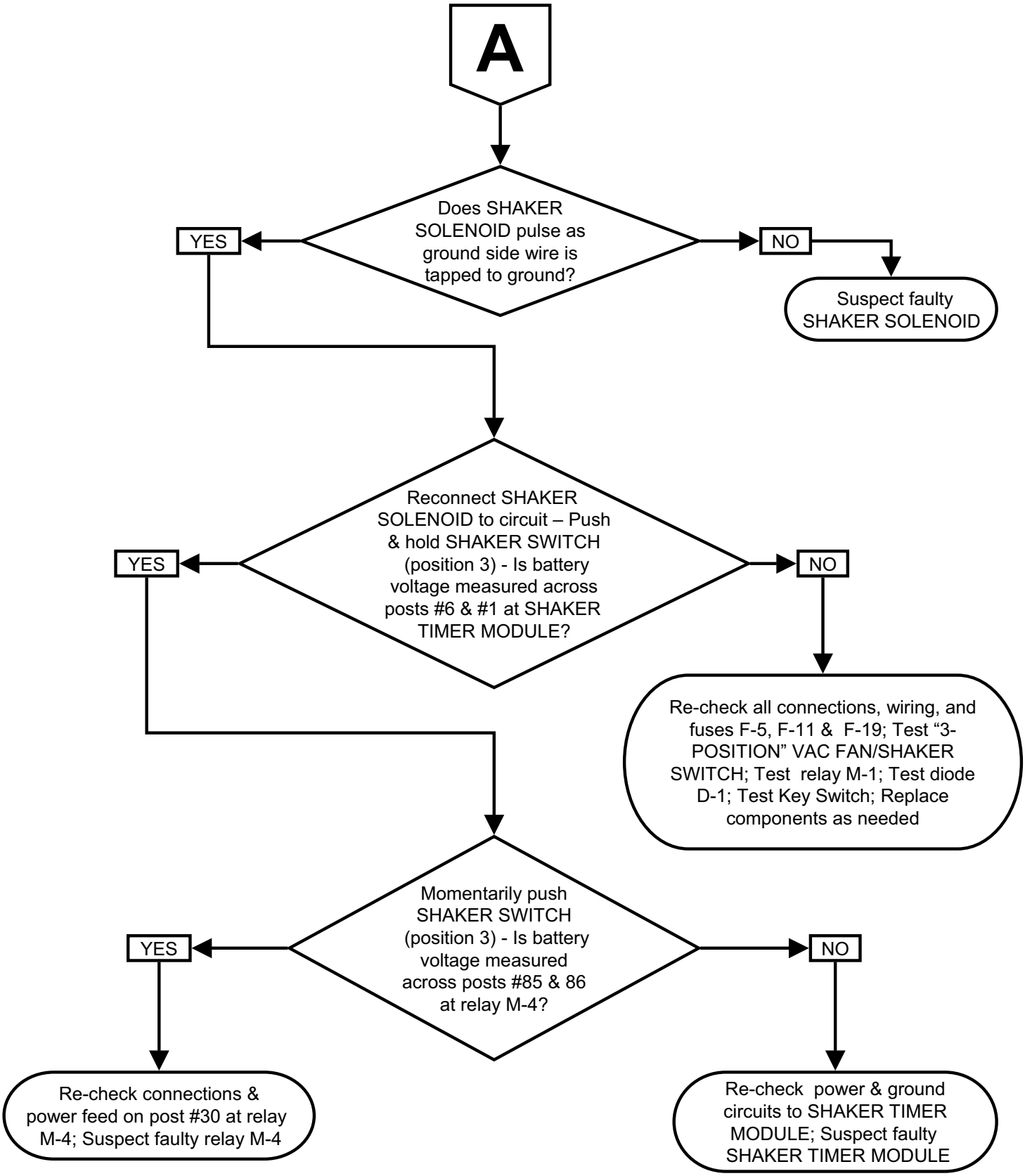
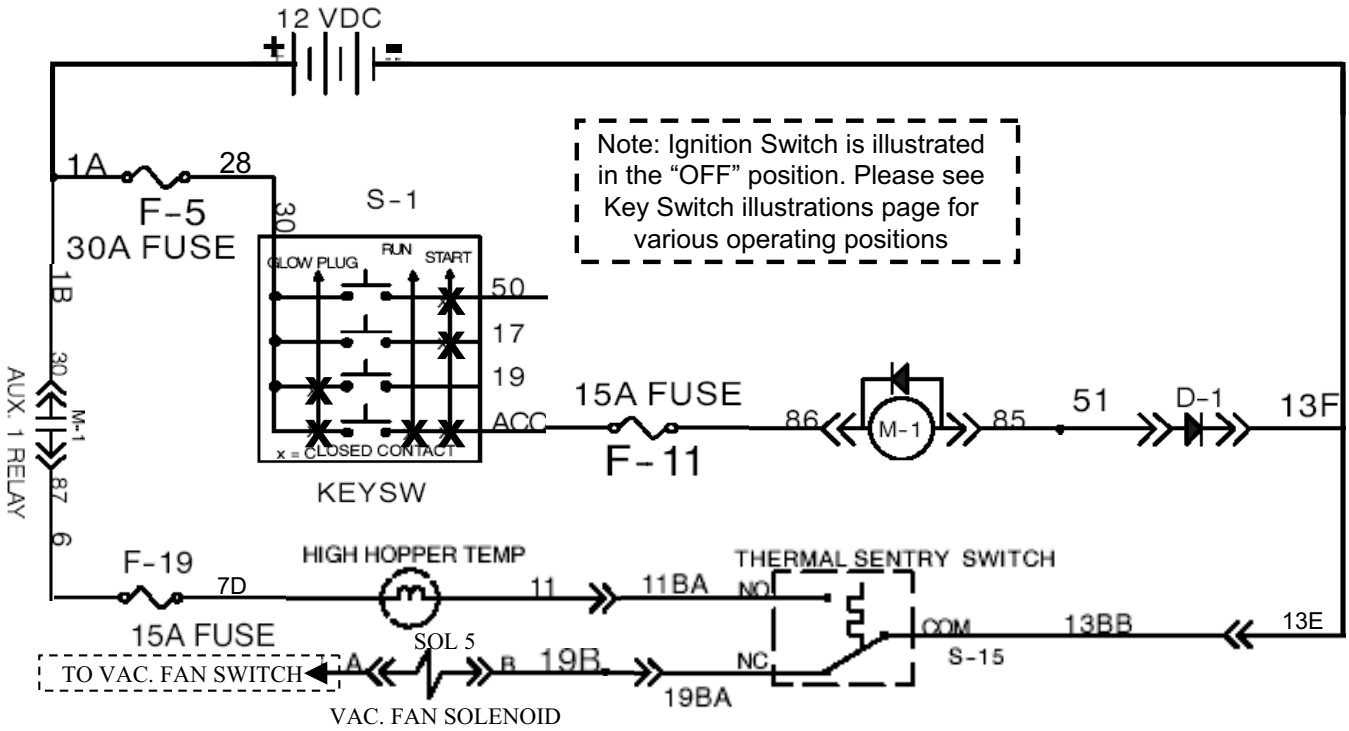
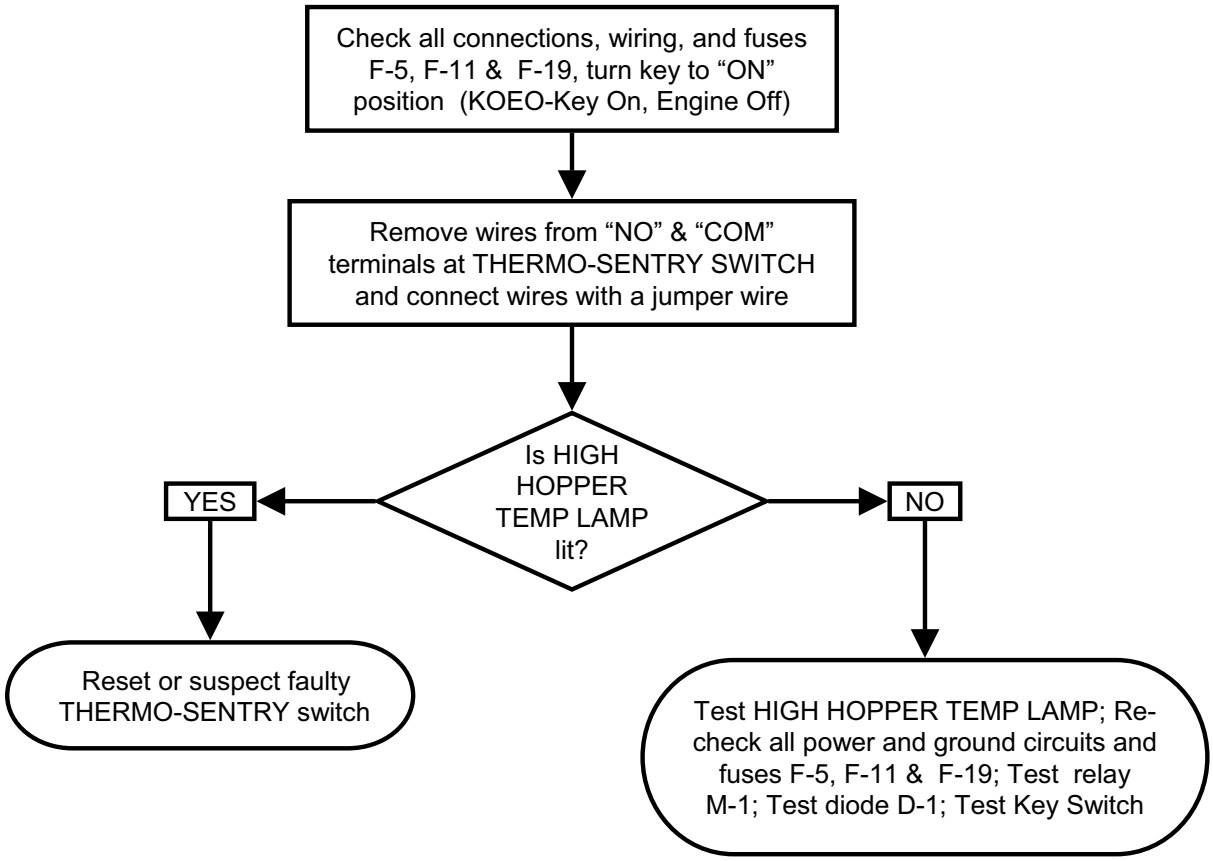
6600 Shaker Motor Circuit (continued)

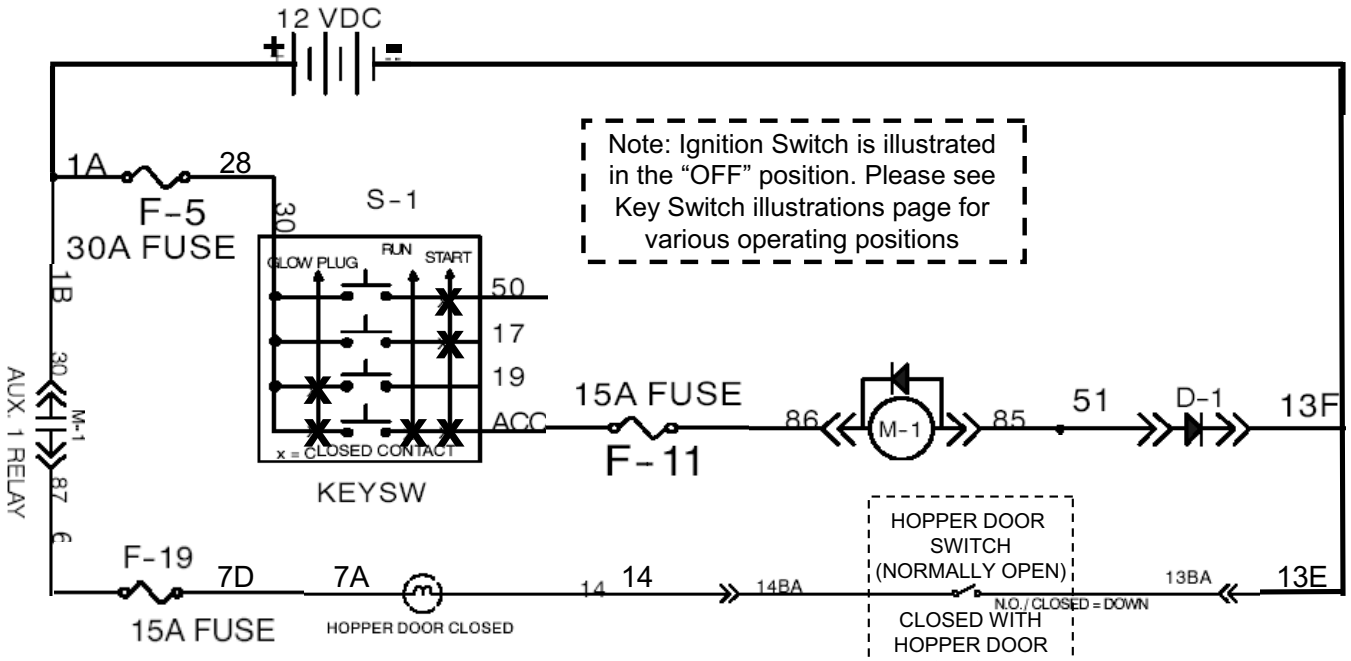


6600 Thermo-Sentry™ Circuit





6600 Hopper Door Switch Circuit



Close Hopper Door; Turn key to "ON" position (KOEO-Key On, Engine Off)

Is HOPPER DOOR CLOSED LAMP lit?

YES

NO

Open Hopper Door; Turn key to "ON" position (KOEO-Key On, Engine Off)

Remove wire harness plug from HOPPER DOOR SWITCH and place a jumper wire across harness wires

Is HOPPER DOOR CLOSED LAMP lit?

YES

NO

Check all connections and wiring; Suspect faulty HOPPER DOOR SWITCH

System operating properly

Is HOPPER DOOR CLOSED LAMP lit?

YES

NO

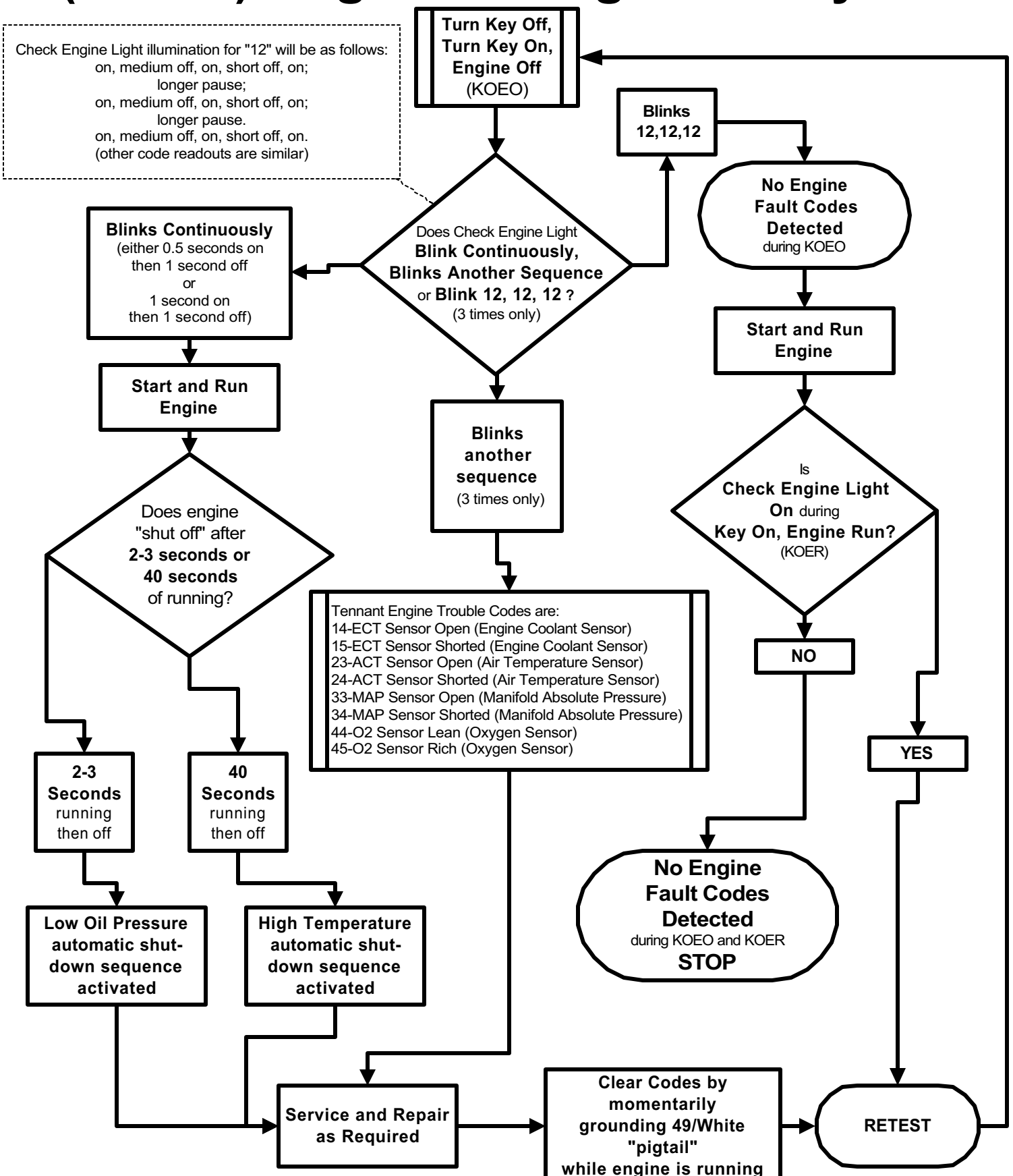
Suspect faulty HOPPER DOOR SWITCH

Test HOPPER DOOR CLOSED LAMP; Re-check all connections, wiring, and fuses F-5, F-11 & F-19; Test relay M-1; Test diode D-1; Test power and ground circuits; Test Key Switch

PLEAS d during testing

Home | Find... | Go To..

6600 with ZEEMS (Zenith) Engine Management System



6600 Gas/L.P. ZEEMS Check Engine Fault Codes

MACHINE STATUS	CHECK ENGINE LAMP
Key On, Engine Off (KOEO) No engine faults detected	Blinks “12,12,12” continuously
Key On, Engine Running (KOER) No engine faults detected	OFF
Key On, Engine Running (KOER) Engine fault(s) detected	ON
Key On, Engine Off (KOEO) Engine fault(s) detected	Blinks engine fault code (see chart below)
Key On, Engine Running (KOER) High engine temperature sensed **AUTOMATIC ENGINE SHUTDOWN OCCURS** NOTE: If key switch is turned off and machine restarted, engine will run 40 seconds until another automatic shutdown	Blinks ON/OFF continuously (0.5 sec. ON, 1 sec. OFF) (Note: There is no separate high engine temp lamp for gas or L.P. engines)
Key On, Engine Running (KOER) Low engine oil pressure sensed **AUTOMATIC ENGINE SHUTDOWN OCCURS** NOTE: If key switch is turned off and machine restarted, engine will run 2 to 3 seconds until another automatic shutdown	Blinks ON/OFF continuously (1 sec. ON, 1 sec. OFF) and LOW OIL PRESSURE lamp turns on

CONDITION with Key On, Engine Off (KOEO)	FAULT CODE DISPLAYED (ON CHECK ENGINE LAMP)
Beginning of fault codes, or OK if no other codes displayed	12, 12, 12
Engine coolant sensor OPEN	14, 14, 14
Engine coolant sensor SHORTED	15, 15, 15
Air temp sensor OPEN	23, 23, 23
Air temp sensor SHORTED	24, 24, 24
MAP sensor OPEN, circuit voltage >4.98V	33, 33, 33
MAP sensor SHORTED	34, 34, 34

TO CLEAR FAULT CODES AND TURN OFF CHECK ENGINE LAMP
Ground PIN # 16 of the WHITE CONNECTOR at the ZENITH ENGINE CONTROLLER while engine is running (Note: Some controllers have a wire pigtail that is connected to PIN # 16

MODEL

6600

HYDRAULIC

Troubleshooting Charts

BEFORE CONDUCTING TESTS:

*** Read and Follow ALL Safety Warnings and Precautions in Operator's Manual**

*** Engine & Hydraulic Oil Must Be At Normal Operating Temperatures after Running Machine and Hydraulics a Minimum of 5 Minutes**

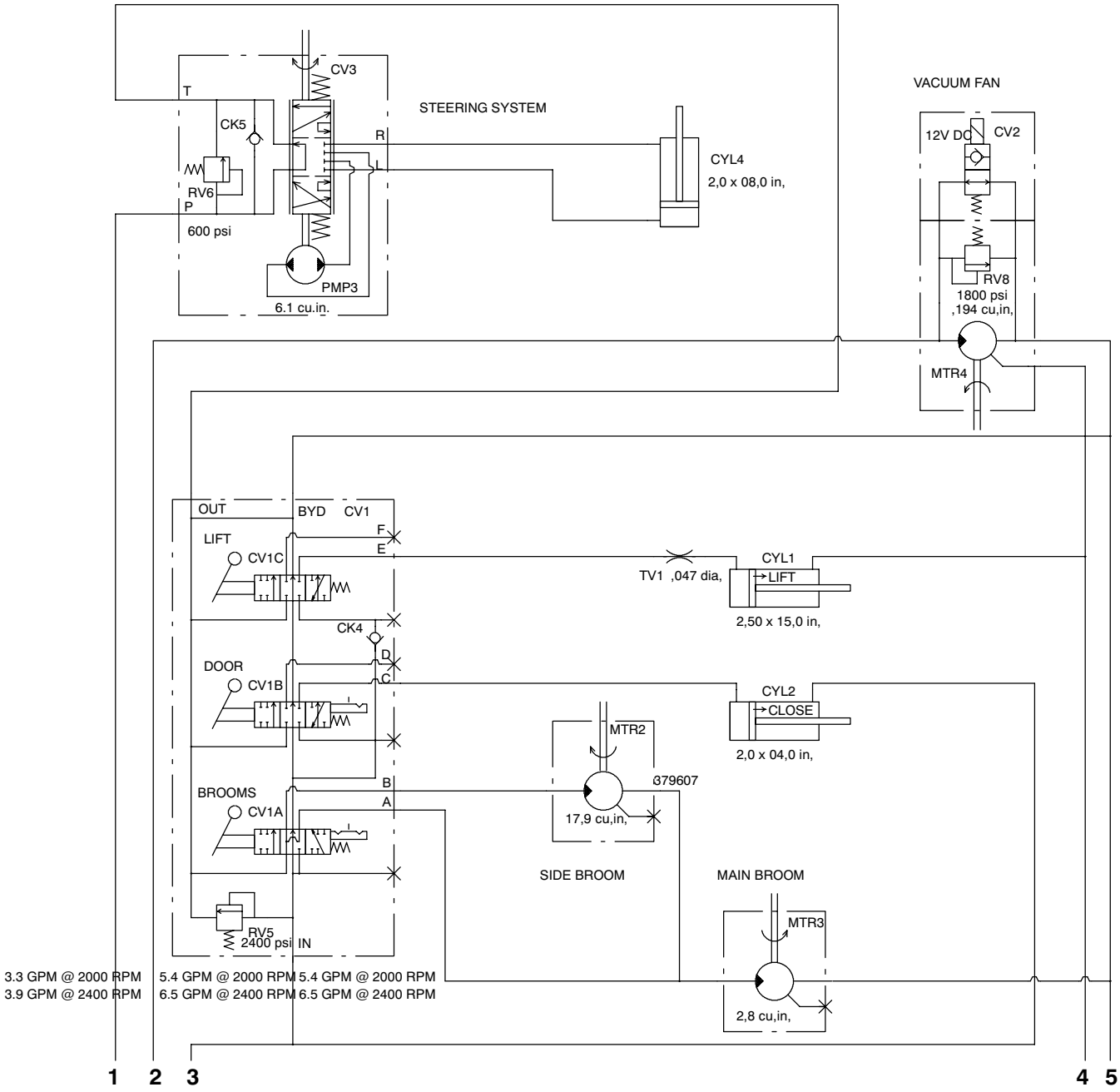
*** Examine Machine For Any Linkage Binding or Mechanical Problems**

DURING TESTS:

*** Maintain Normal Main Brush Pressure as Listed in Operator's Manual**

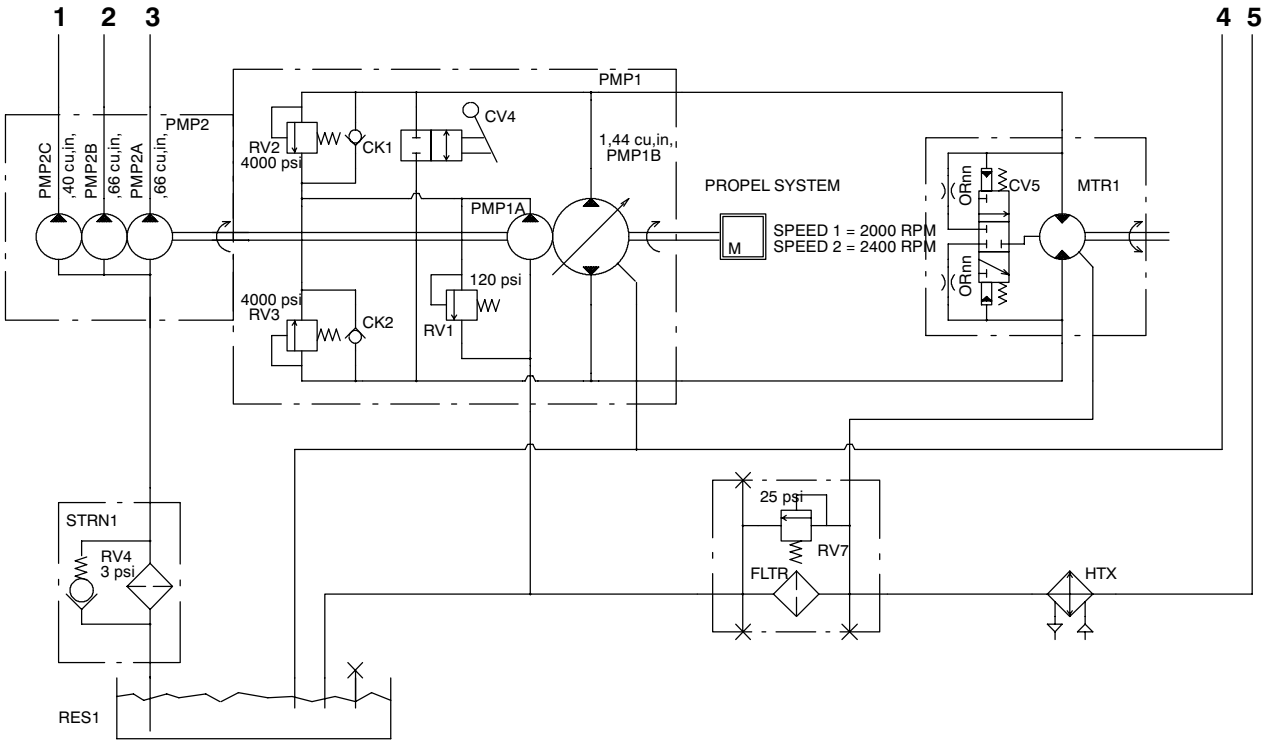
*** Call Technical Services if Diagnostic Time Exceeds One Hour With Unknown Cause or Course of Action**

6600 OVERALL HYDRAULIC DIAGRAM
(Part 1 of 2)



PLEASE NOTE: All specifications listed are for normal operating conditions

6600 OVERALL HYDRAULIC DIAGRAM
(Part 2of 2)



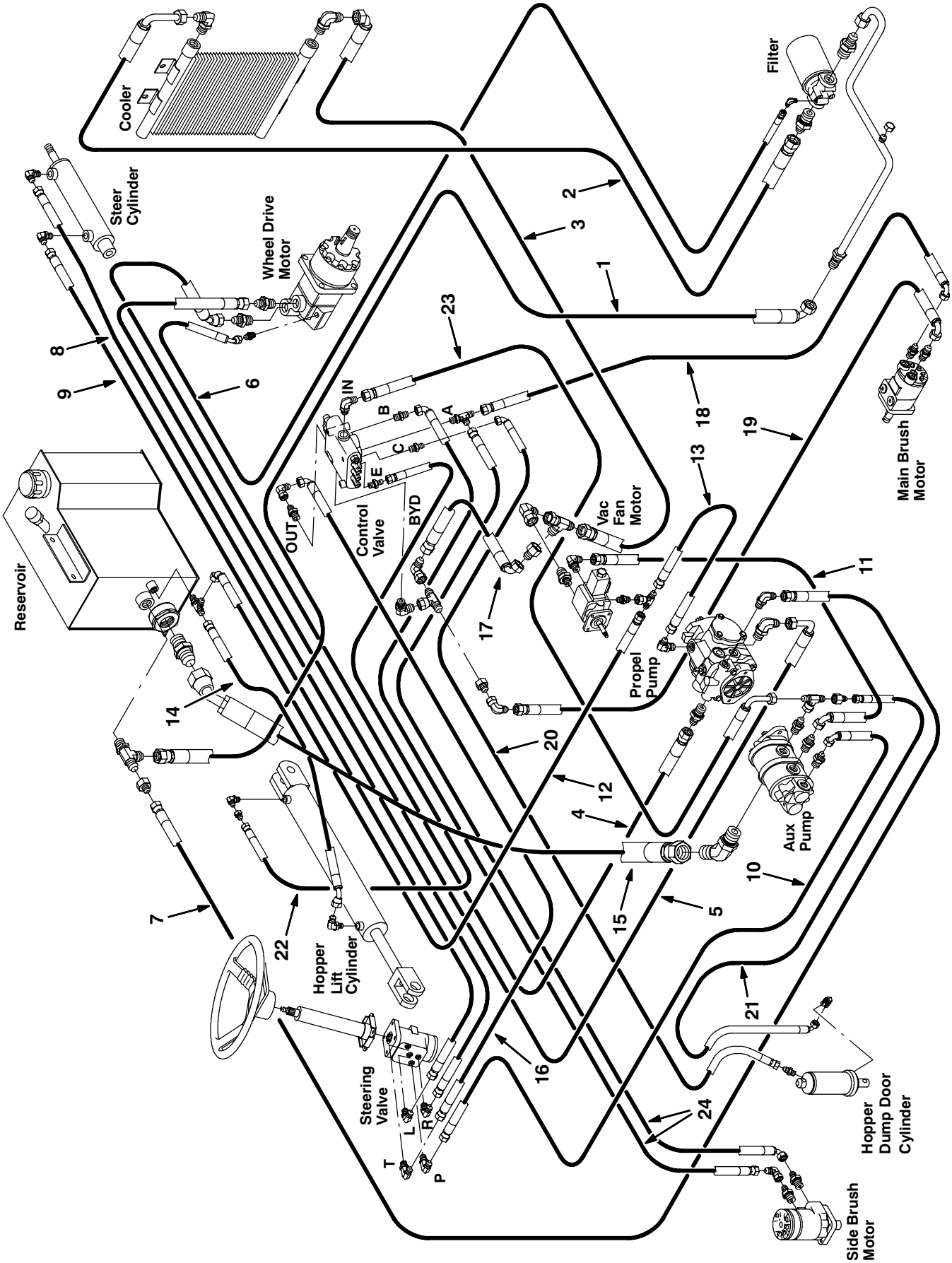
6600

EXPLANATION OF ABBREVIATIONS

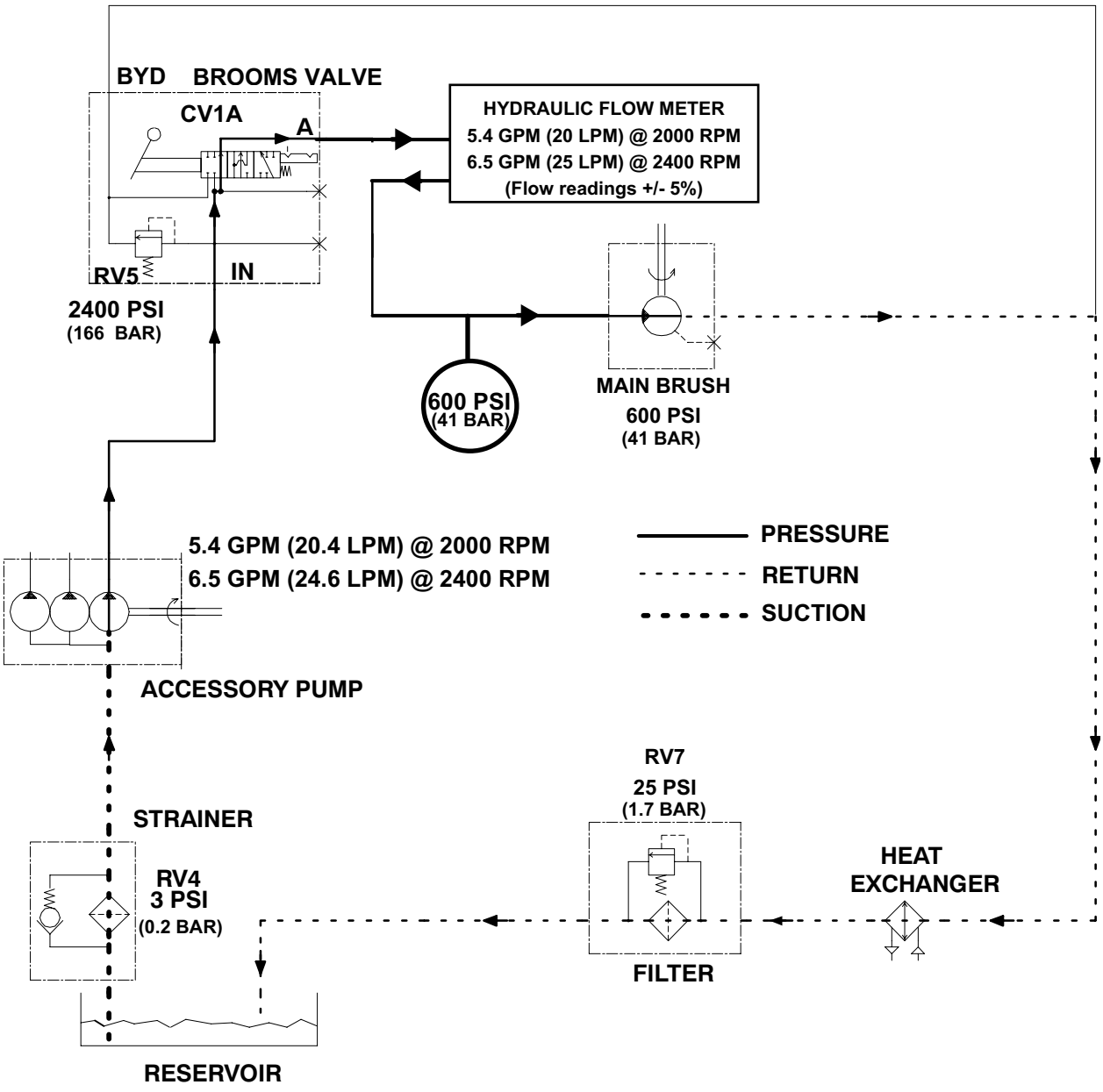
AUX.....Auxiliary
CK.....Check Valve
CM.....Centimeters
CU.....Cubic
CV.....Control Valve
CYL.....Cylinder
DC.....Disconnect Coupler (Hydraulic)
DC.....Direct Current (Electrical)
FLTR.....Filter
GPM.....Gallons per Minute
HTX.....Heat Exchanger
IN.....Inches
LH.....Left Hand
LPM.....Liters per Minute
M.....Motor (Combustion)
MTR.....Motor (Hydraulic)
OR.....Orifice
PC.....Pilot Port Check Valve
PMP.....Pump
PSI.....Pounds per Square Inch
PSWITCH.....Pressure Switch
RES.....Reservoir
RH.....Right Hand
RPM.....Revolutions per Minute
RV.....Relief Valve
STRN.....Strainer
SV.....Solenoid Valve
TV.....Throttle Valve
V.....Volts

PLEASE NOTE: All specifications listed are for normal operating conditions

6600 HYDRAULIC HOSE ROUTING



6600 MAIN BRUSH



MAIN BRUSH RPM

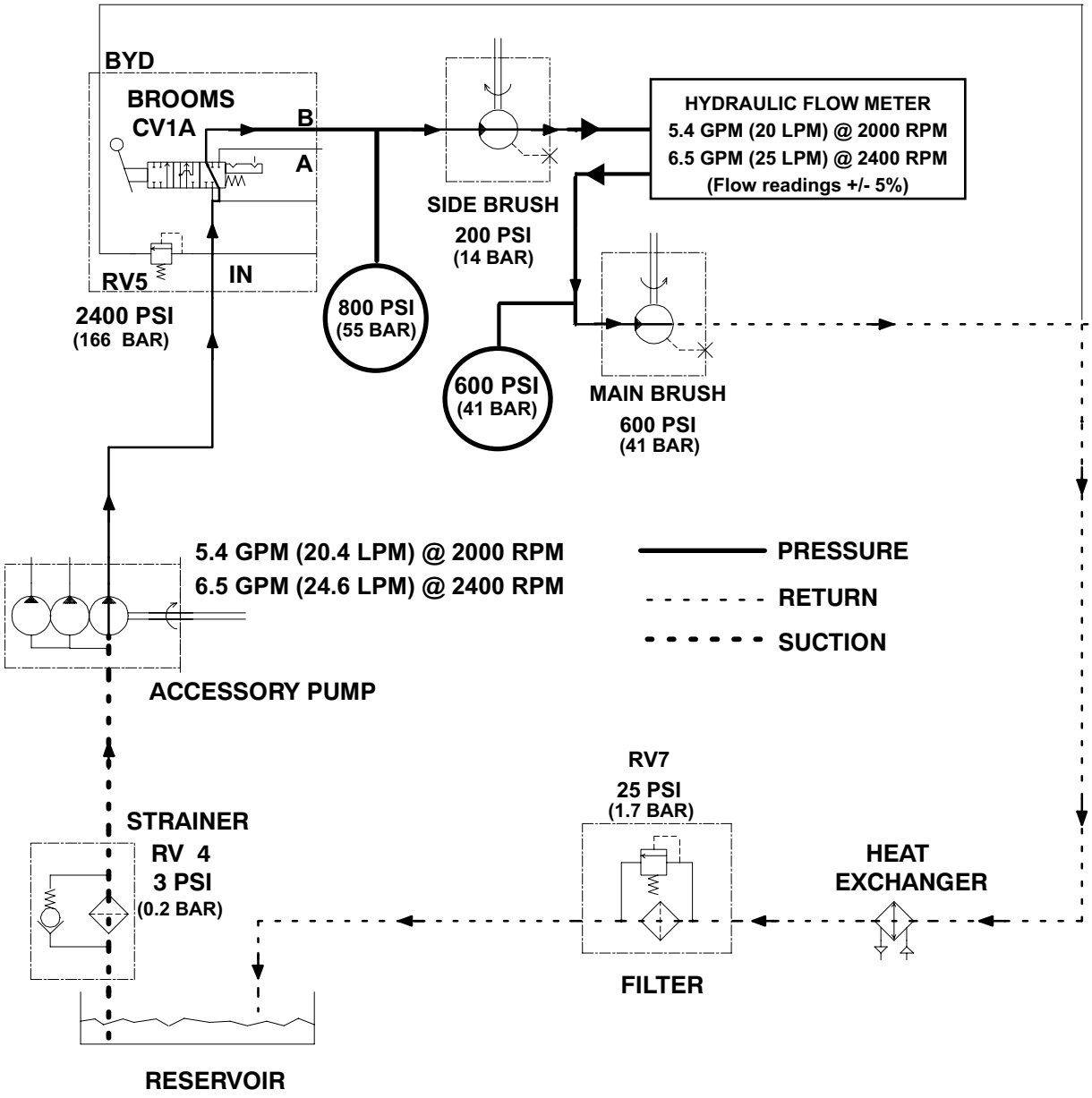
460 RPM +/- 25 RPM @ 2000 RPM

550 RPM +/- 25 RPM @ 2400 RPM

Note: Specs. shown are for main brush down with 2" (5 cm) brush pattern

PLEASE NOTE: All specifications listed are for normal operating conditions

6600 MAIN & SIDE BRUSH



MAIN BRUSH RPM

460 RPM +/- 25 RPM @ 2000 RPM

550 RPM +/- 25 RPM @ 2400 RPM

SIDE BRUSH RPM

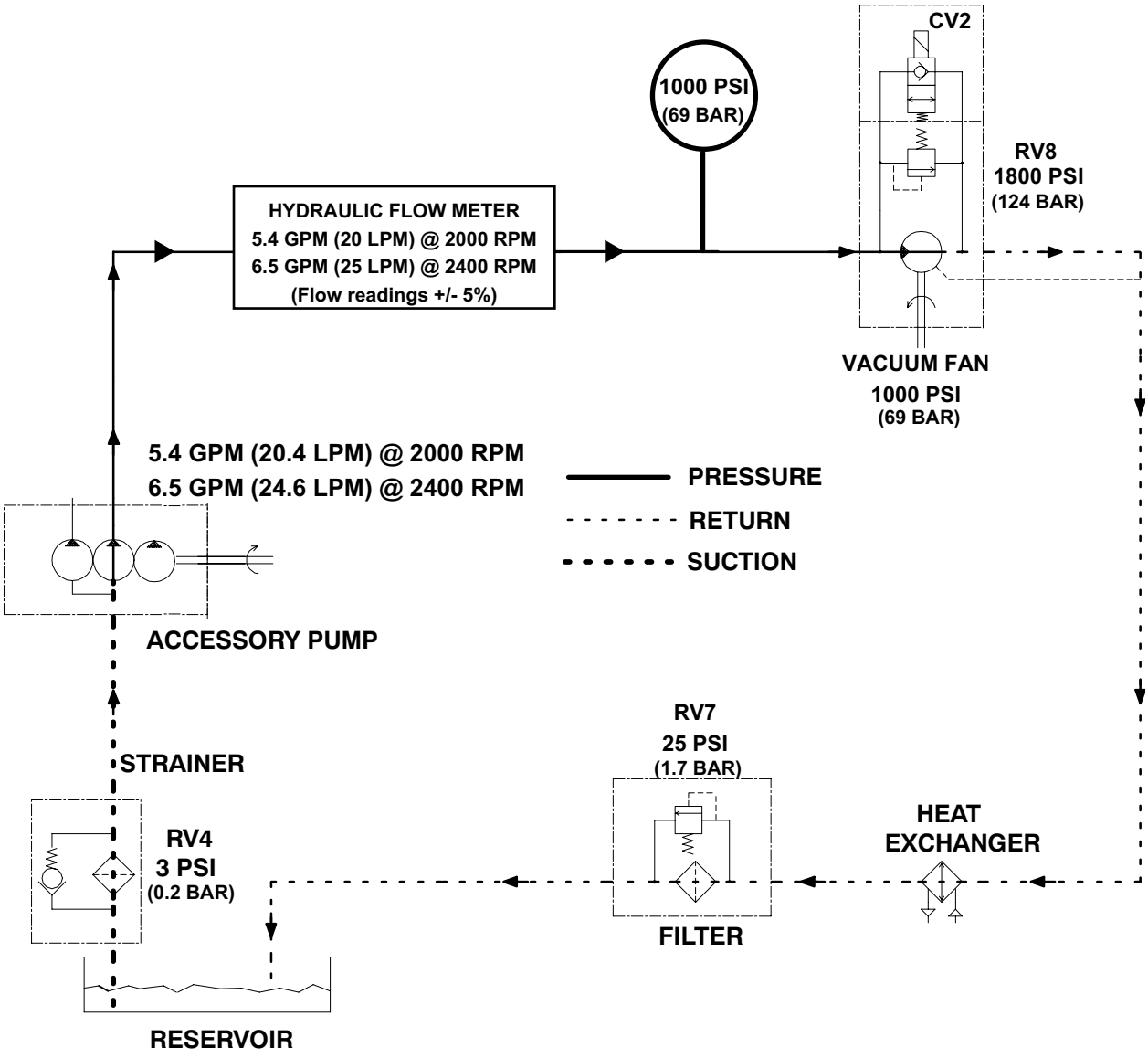
75 RPM +/- 10 RPM @ 2000 RPM

90 RPM +/- 10 RPM @ 2400 RPM

Note: Specs. shown are for main & side brushes down, with 2" (5 cm) main brush pattern

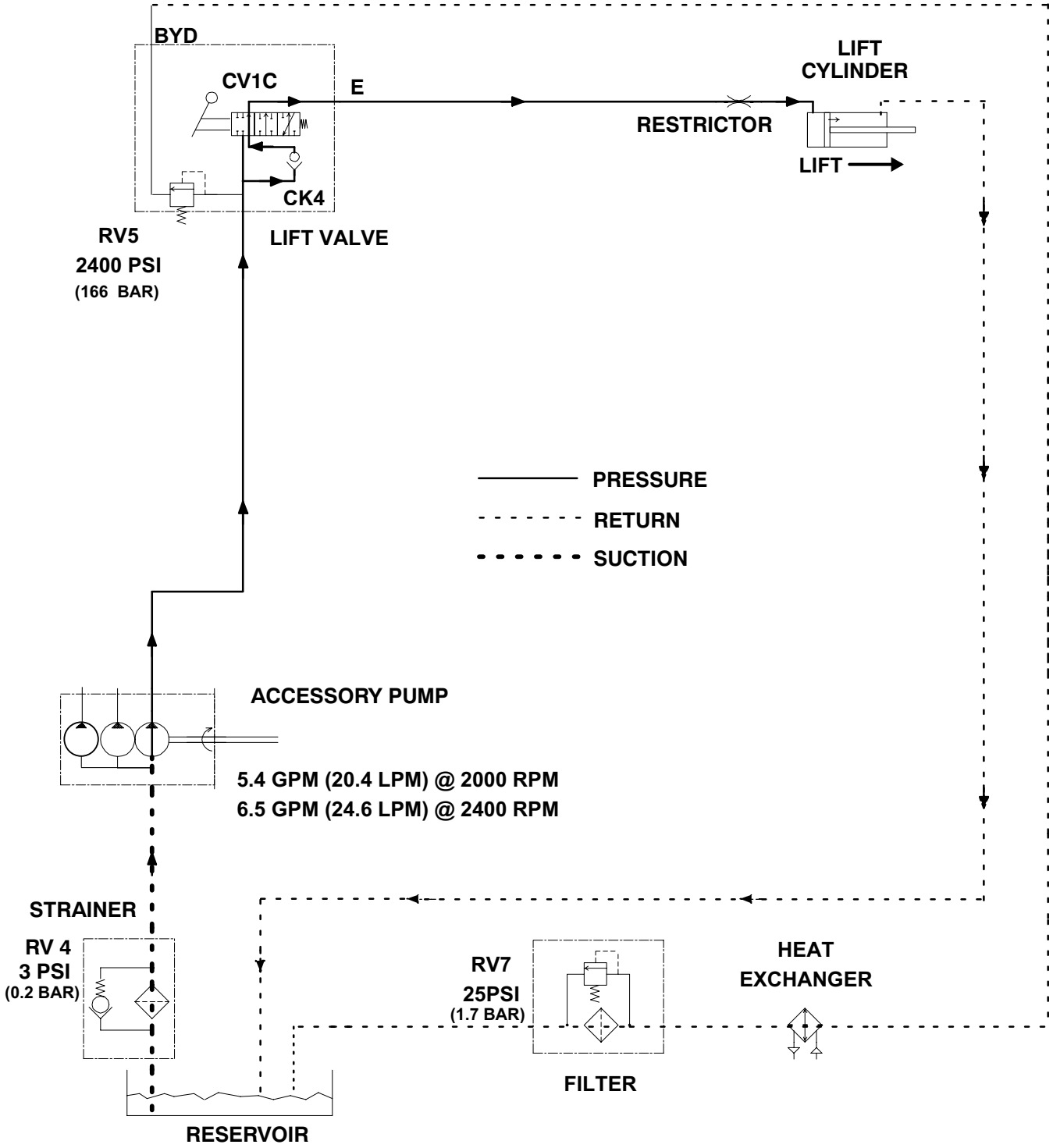
PLEASE NOTE: All specifications listed are for normal operating conditions

6600 VACUUM FAN



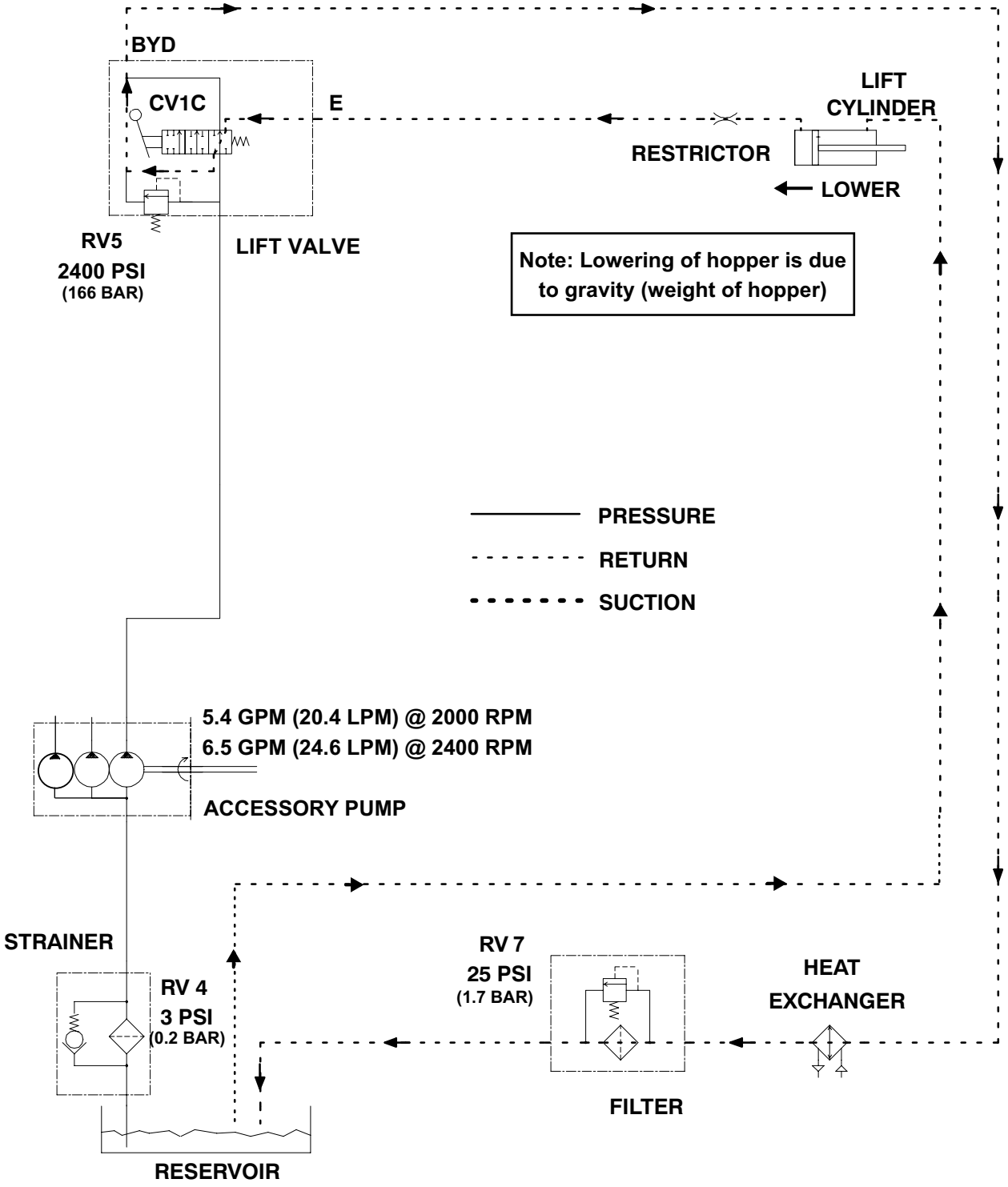
PLEASE NOTE: All specifications listed are for normal operating conditions

6600 RAISE HOPPER



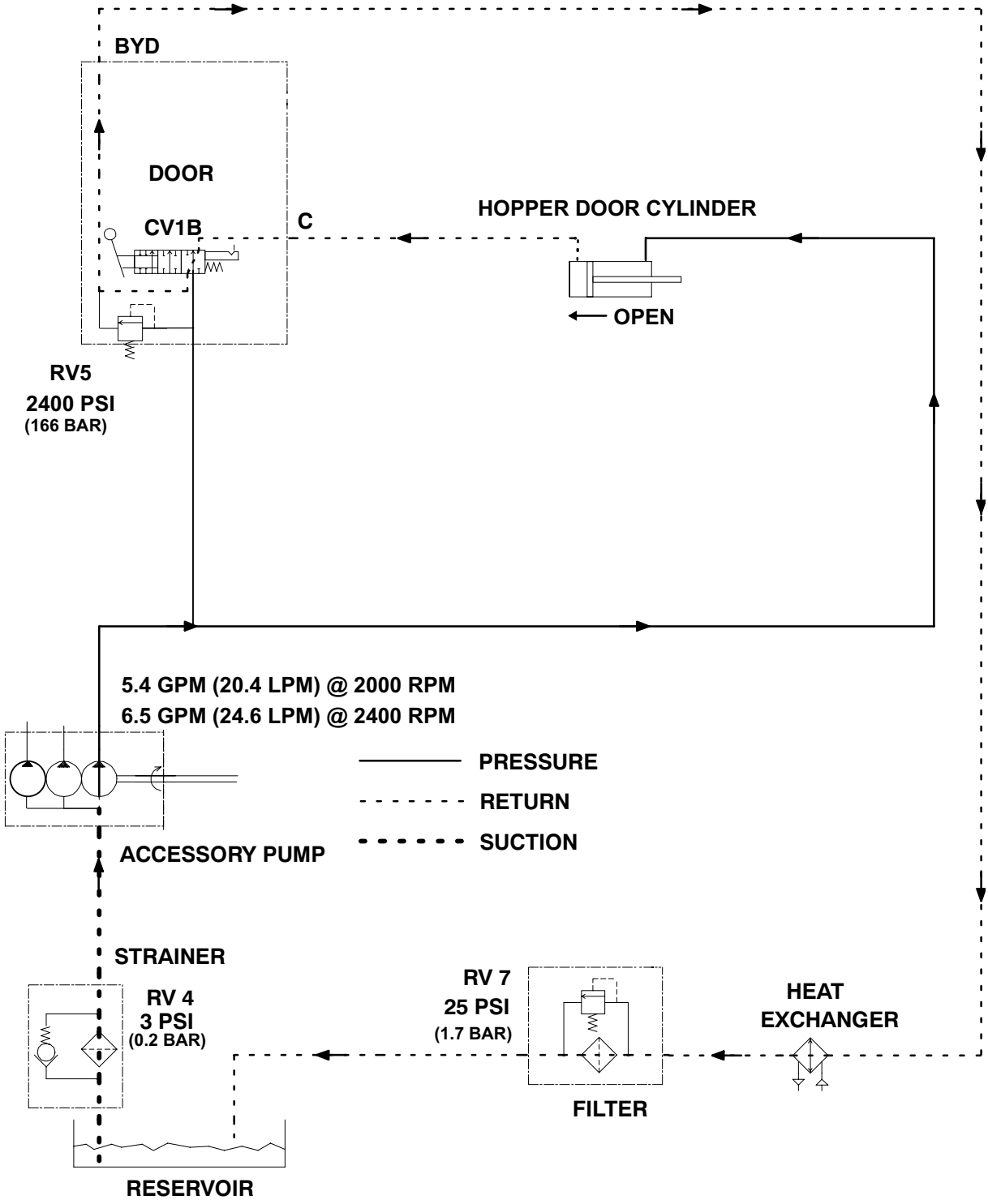
PLEASE NOTE: All specifications listed are for normal operating conditions

6600 LOWER HOPPER



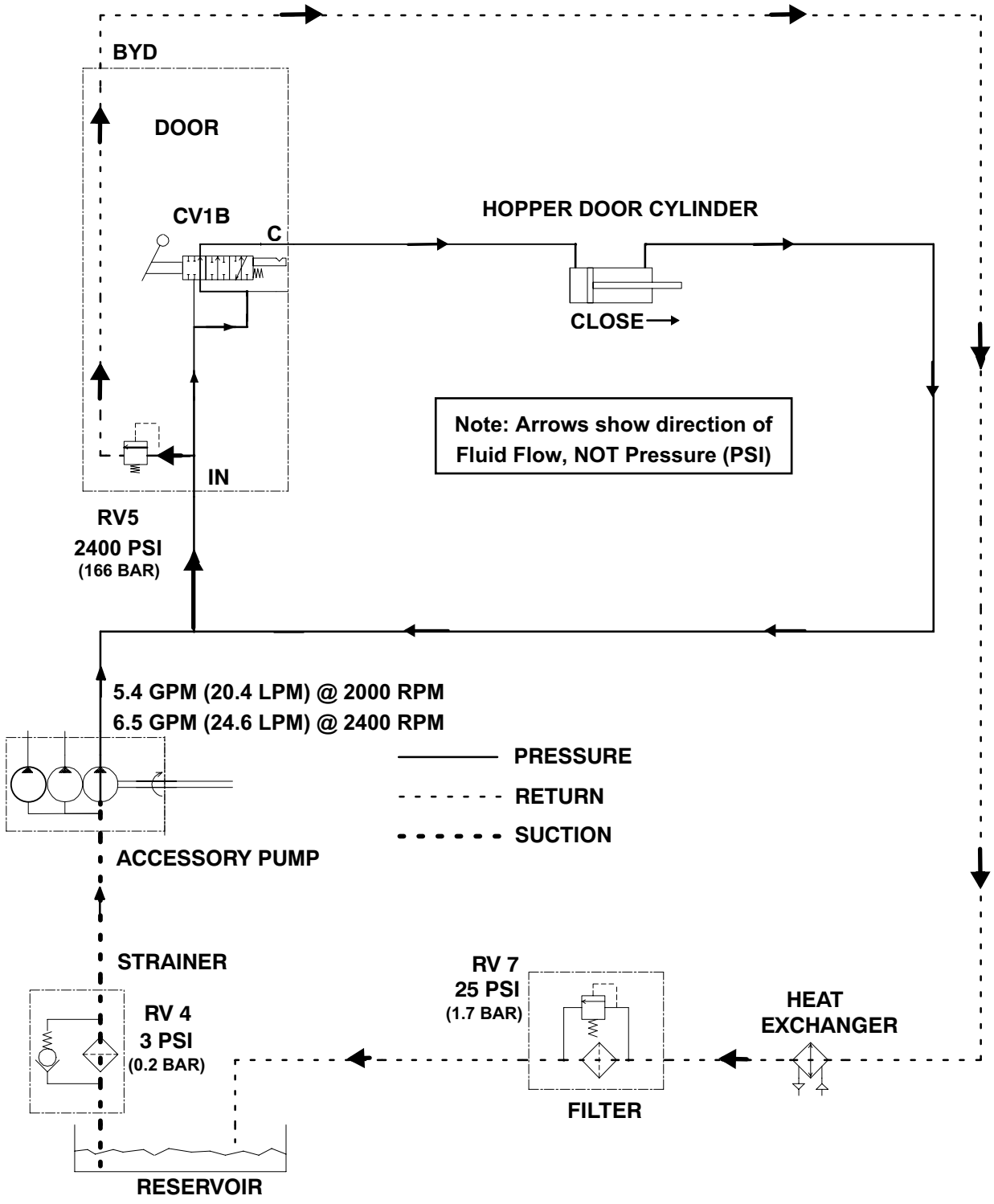
PLEASE NOTE: All specifications listed are for normal operating conditions

6600 OPEN HOPPER DOOR



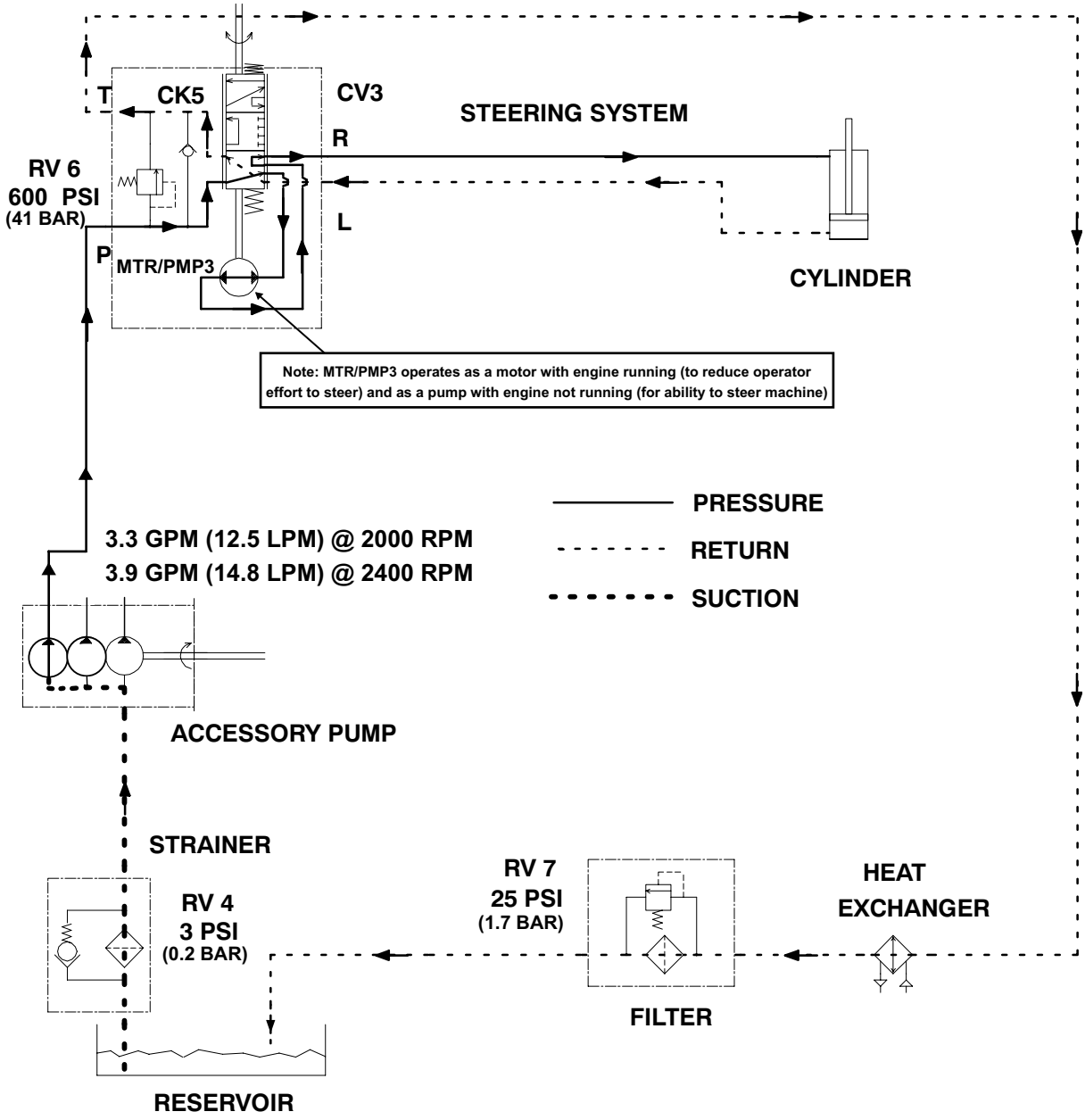
PLEASE NOTE: All specifications listed are for normal operating conditions

6600 CLOSE HOPPER DOOR



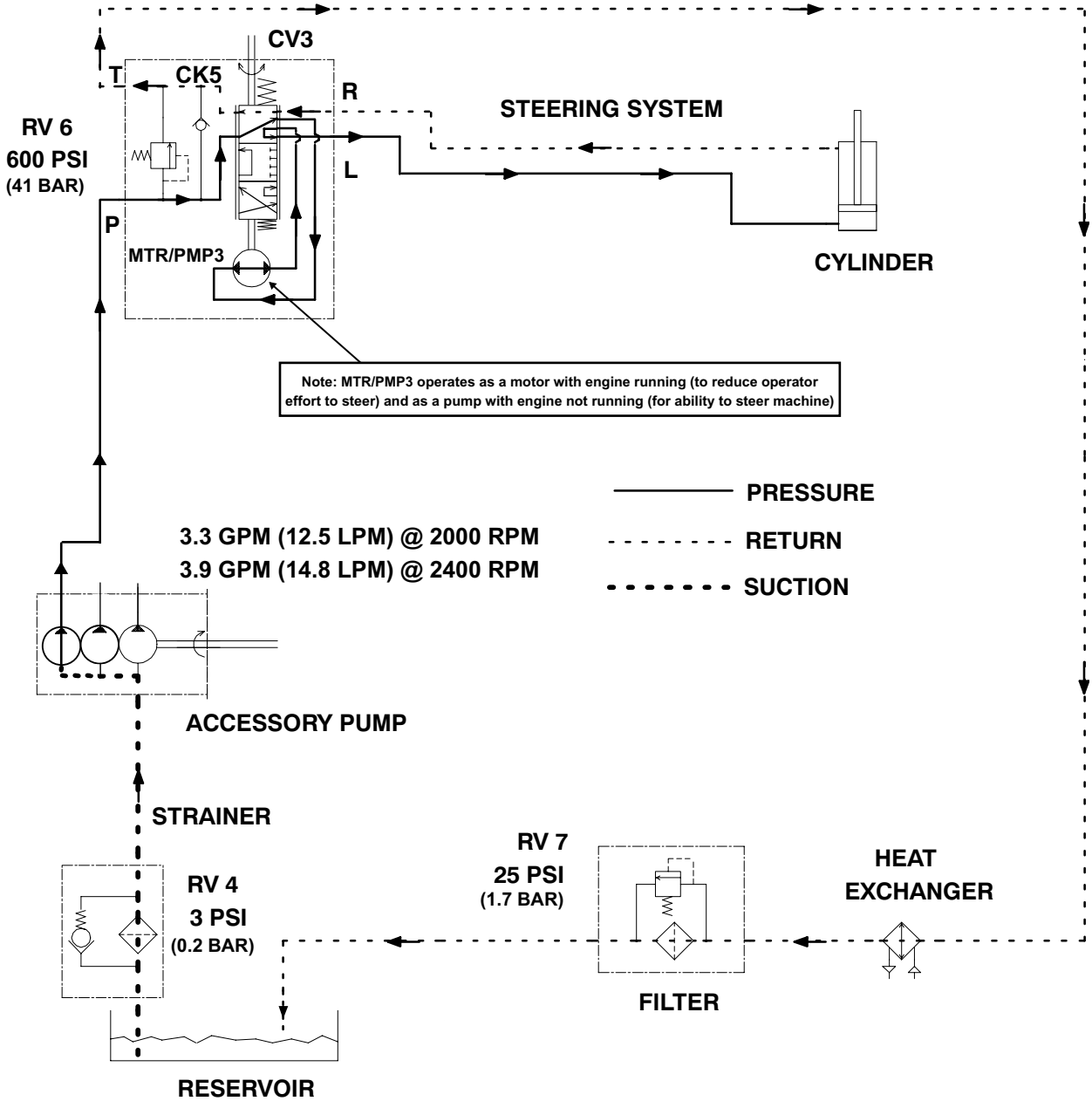
PLEASE NOTE: All specifications listed are for normal operating conditions

6600 RIGHT TURN



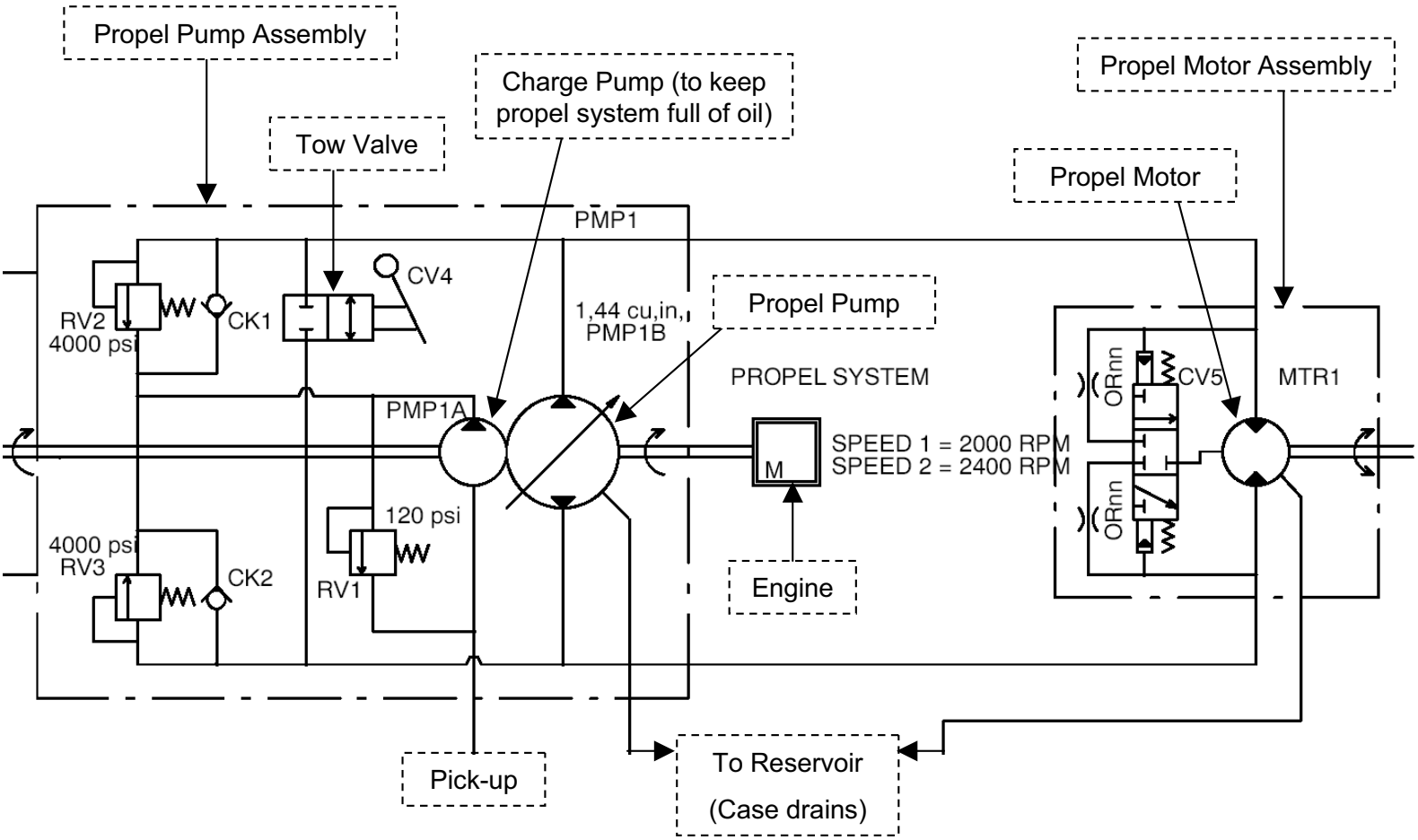
PLEASE NOTE: All specifications listed are for normal operating conditions

6600 LEFT TURN



PLEASE NOTE: All specifications listed are for normal operating conditions

6600 PROPEL SYSTEM



TO ADJUST DIRECTIONAL CONTROL LINKAGE

1. Engage the parking brake.
2. Jack up the rear of the machine. Place jack stands under the frame and lower the machine down.
3. Open engine hood and side door.
4. Locate the centering spring cam arms and cam on the propel pump, near the center frame tube. Loosen the M8 cam bolt.
5. Start the engine.
6. Adjust the cams so the rear wheel does not turn. Turning the cams toward the front of the machine will make the wheel go forward. Turning the cams toward the rear of the machine will make the wheel go backward.
7. Stop the engine.
8. Hold the cams in position and tighten the cam bolts.
9. Start the engine and test to verify adjustment. Repeat if necessary.
10. Lower the machine.
11. Start the engine. Move the directional control pedal forward and backward to make sure machine will not move when the
directional control pedal is in neutral. Readjust as necessary.
12. Raise the hopper and engage hopper support bar.
13. The machine should travel 1.6 kmh (1 mph) maximum forward speed. To adjust, turn the speed control rod (directional control rod with a balljoint and a vibration isolator.) Turning the rod clockwise, as viewed from above, will slow machine. Turning it counterclockwise will speed machine.
14. Lower the hopper and stop the engine.
15. Check the gap between the speed limiter bracket and the contact surface as the drive linkage rod assembly is 1.5--3 mm (0.06 -- 0.12 in).
16. Adjust the balljoint on the end of the speed control rod to get the correct gap. Tighten all jam nuts.

MODEL

6650

ELECTRICAL

Troubleshooting Charts

BEFORE CONDUCTING TESTS:

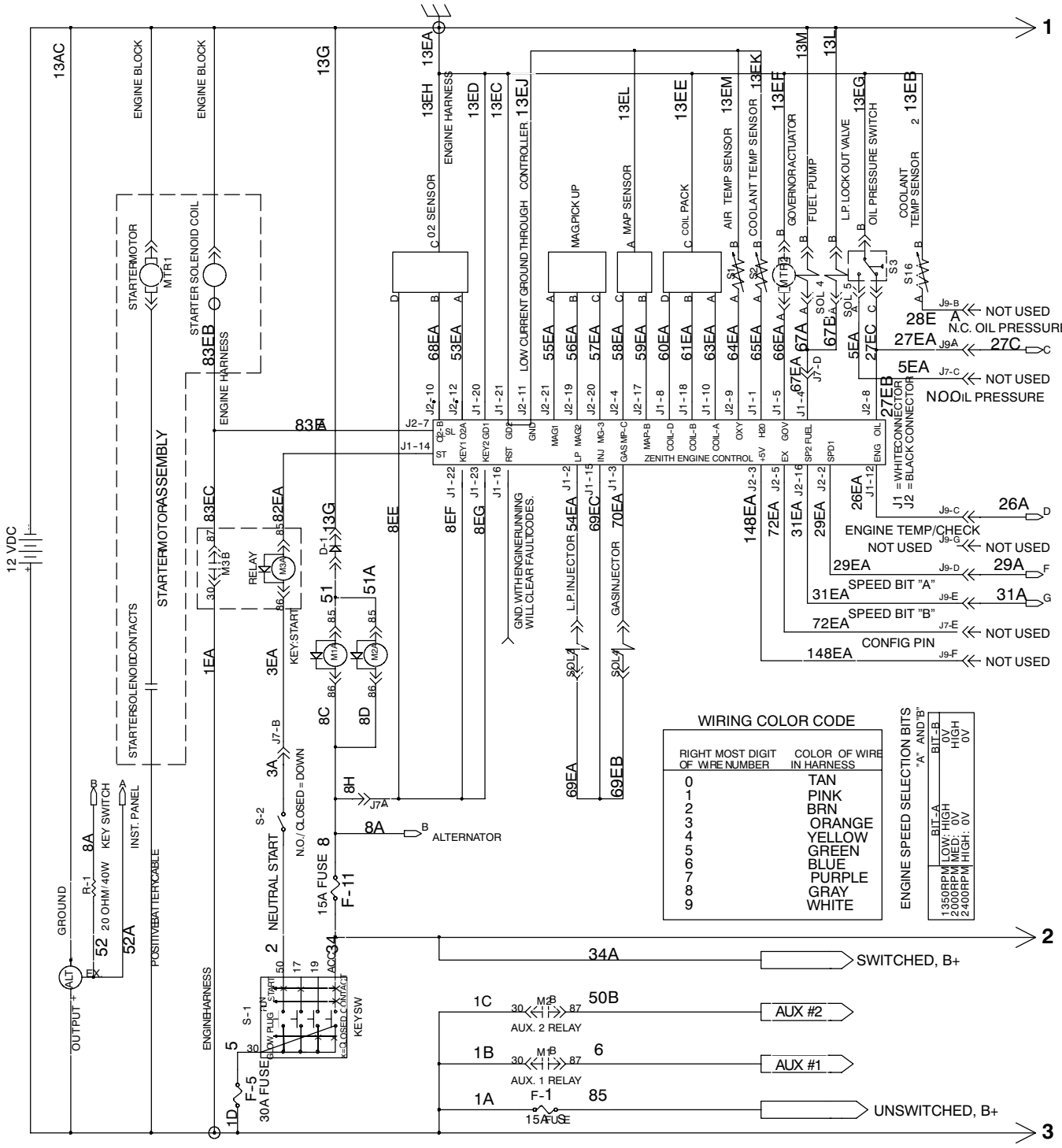
*** Read and Follow ALL Safety Warnings and Precautions in Operator's Manual**

DURING TESTS:

*** Call Technical Services if Diagnostic Time Exceeds One Hour With Unknown Cause or Course of Action**

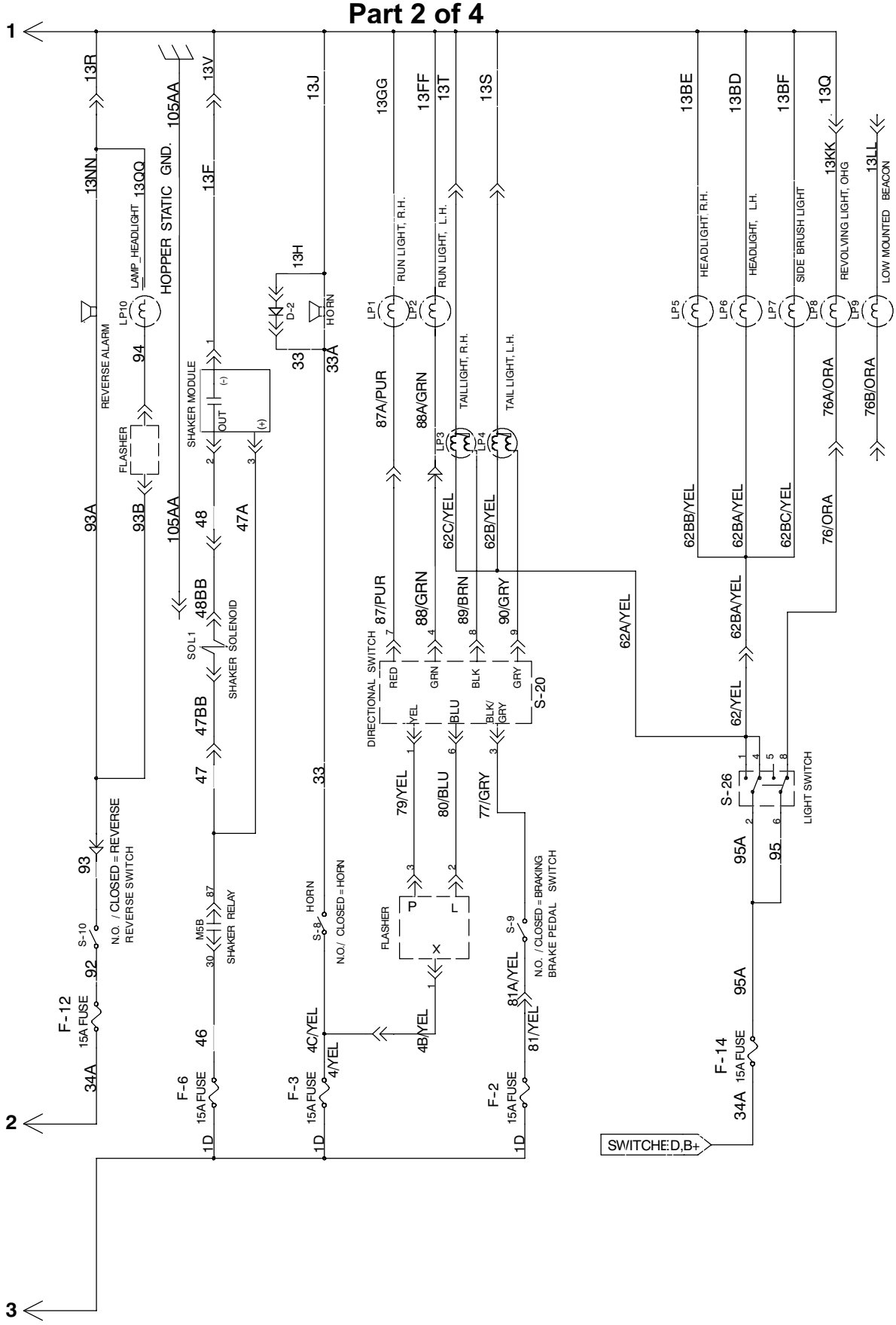
6650 GAS & L.P. OVERALL ELECTRICAL DIAGRAM

Part 1 of 4



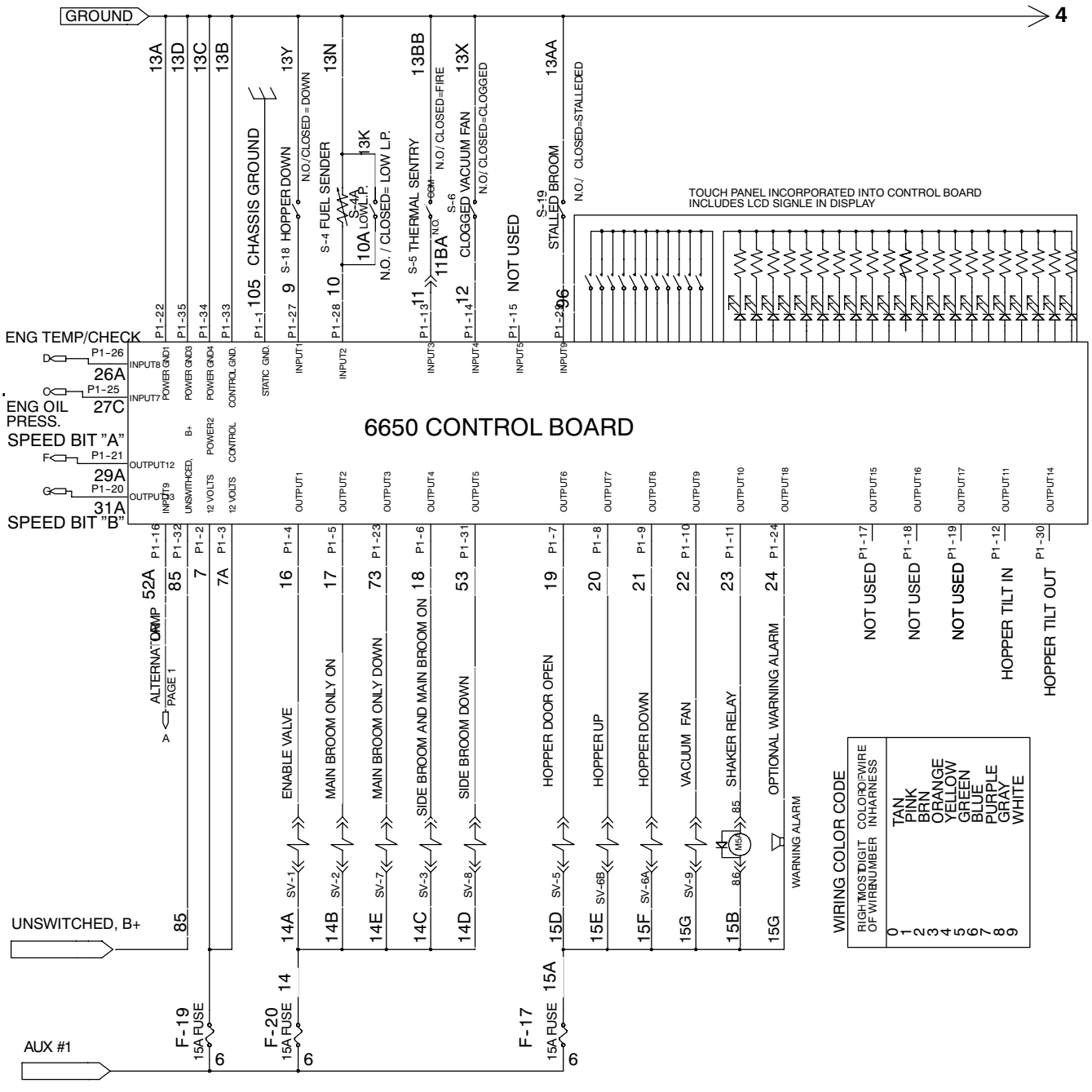
6650 GAS & L.P. OVERALL ELECTRICAL DIAGRAM

Part 2 of 4



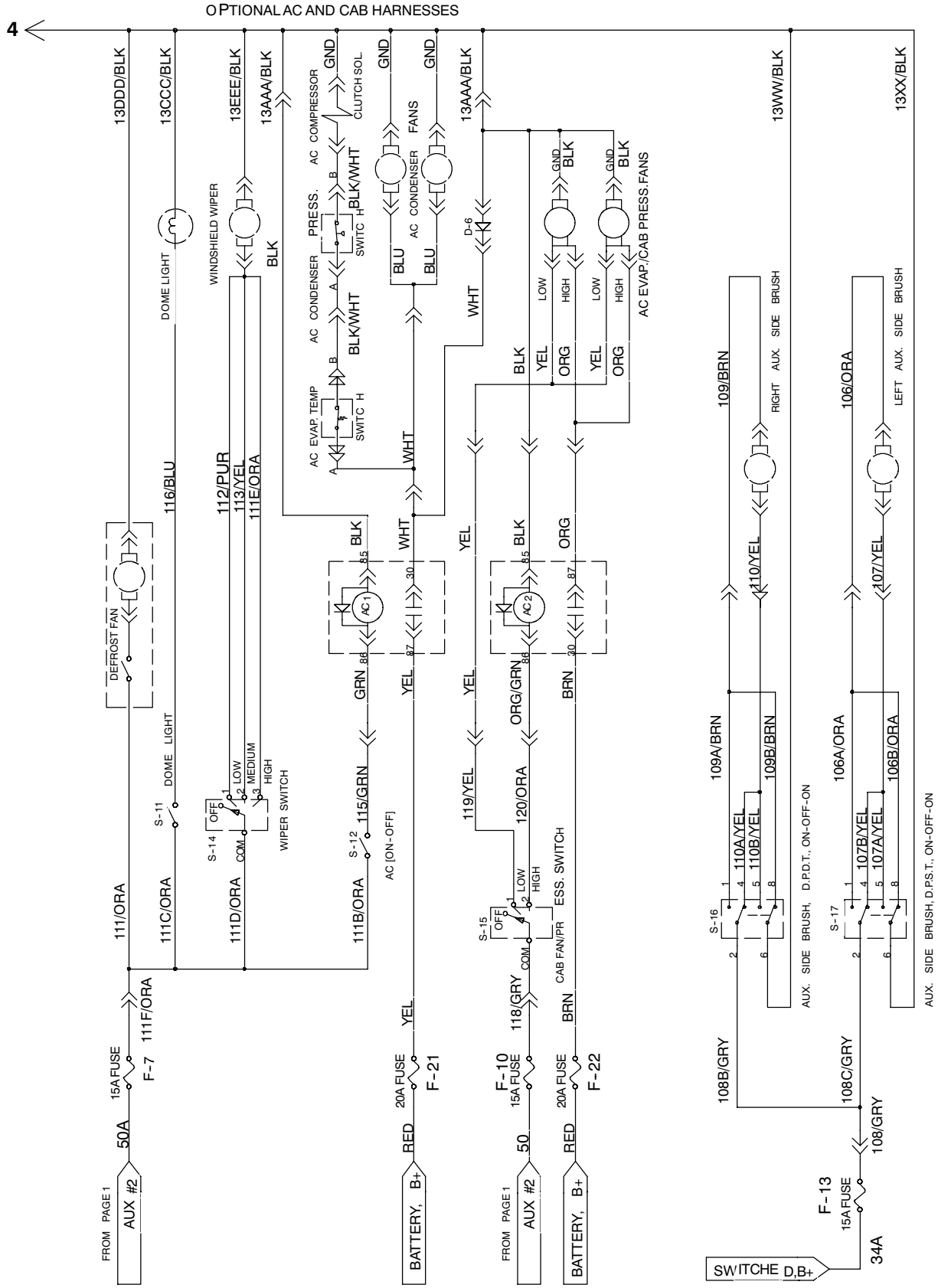
6650 GAS & L.P. OVERALL ELECTRICAL DIAGRAM

Part 3 of 4



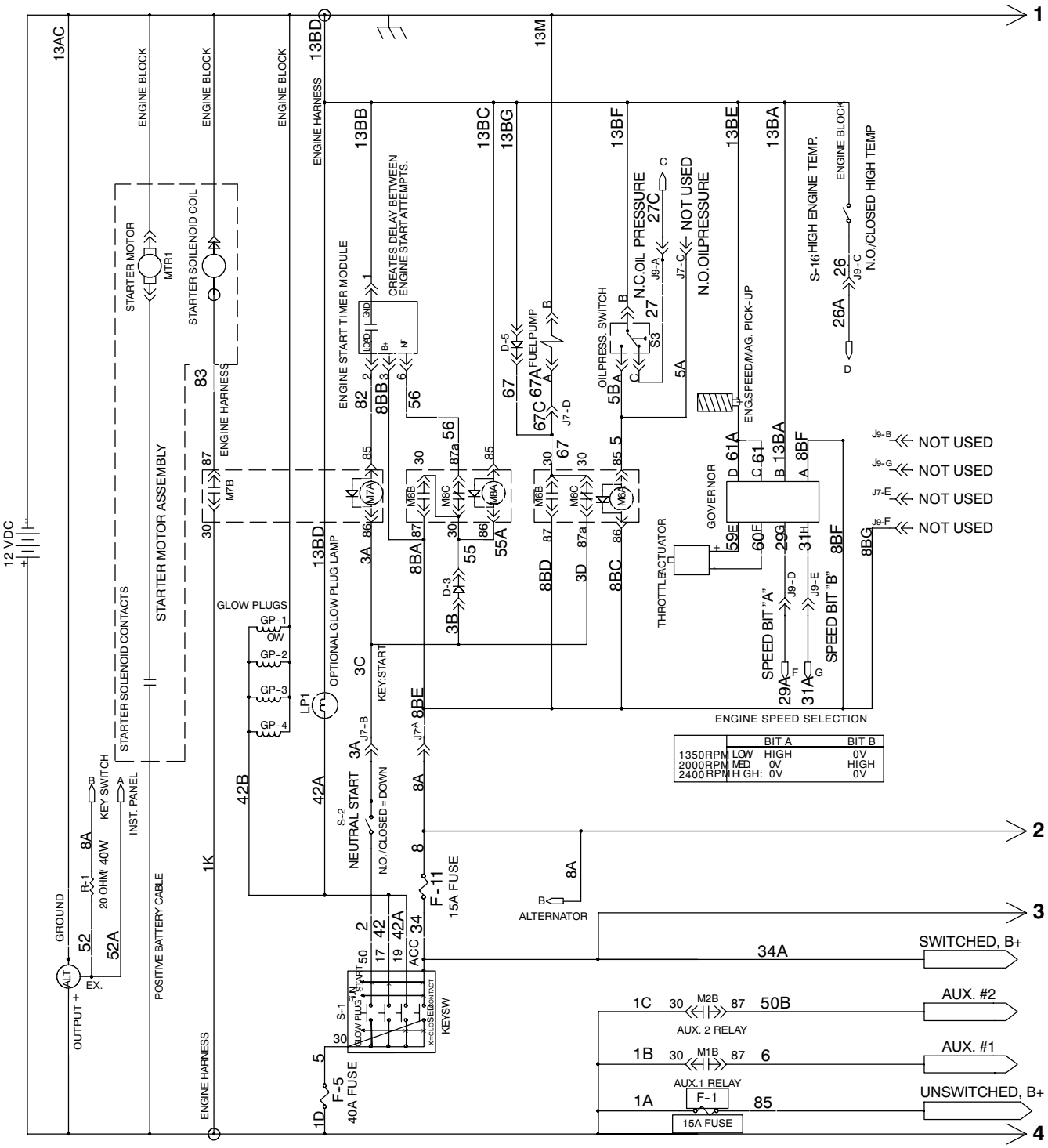
6650 GAS & L.P. OVERALL ELECTRICAL DIAGRAM

Part 4 of 4



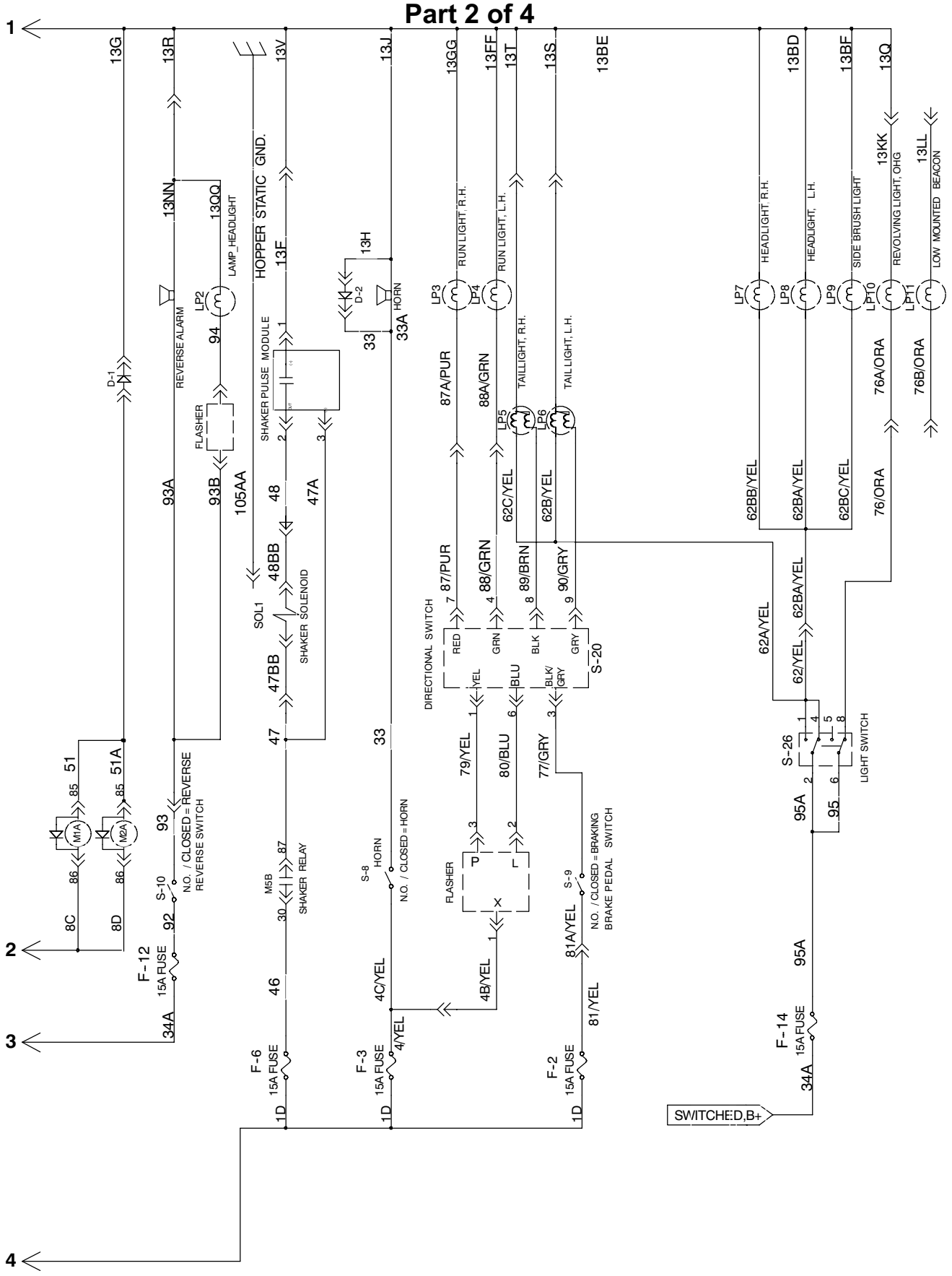
6650 DIESEL OVERALL ELECTRICAL DIAGRAM

Part 1 of 4



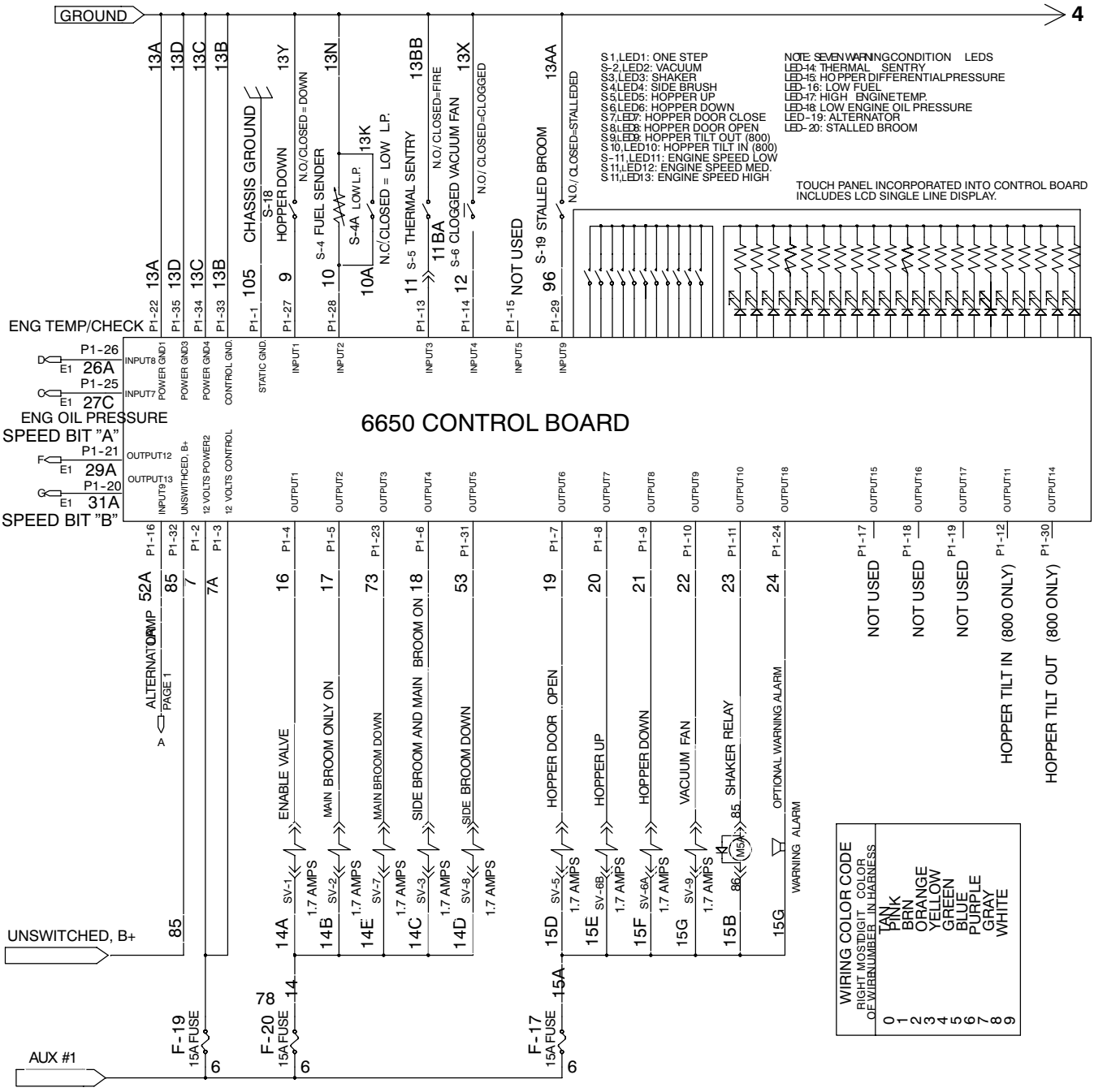
6650 DIESEL OVERALL ELECTRICAL DIAGRAM

Part 2 of 4



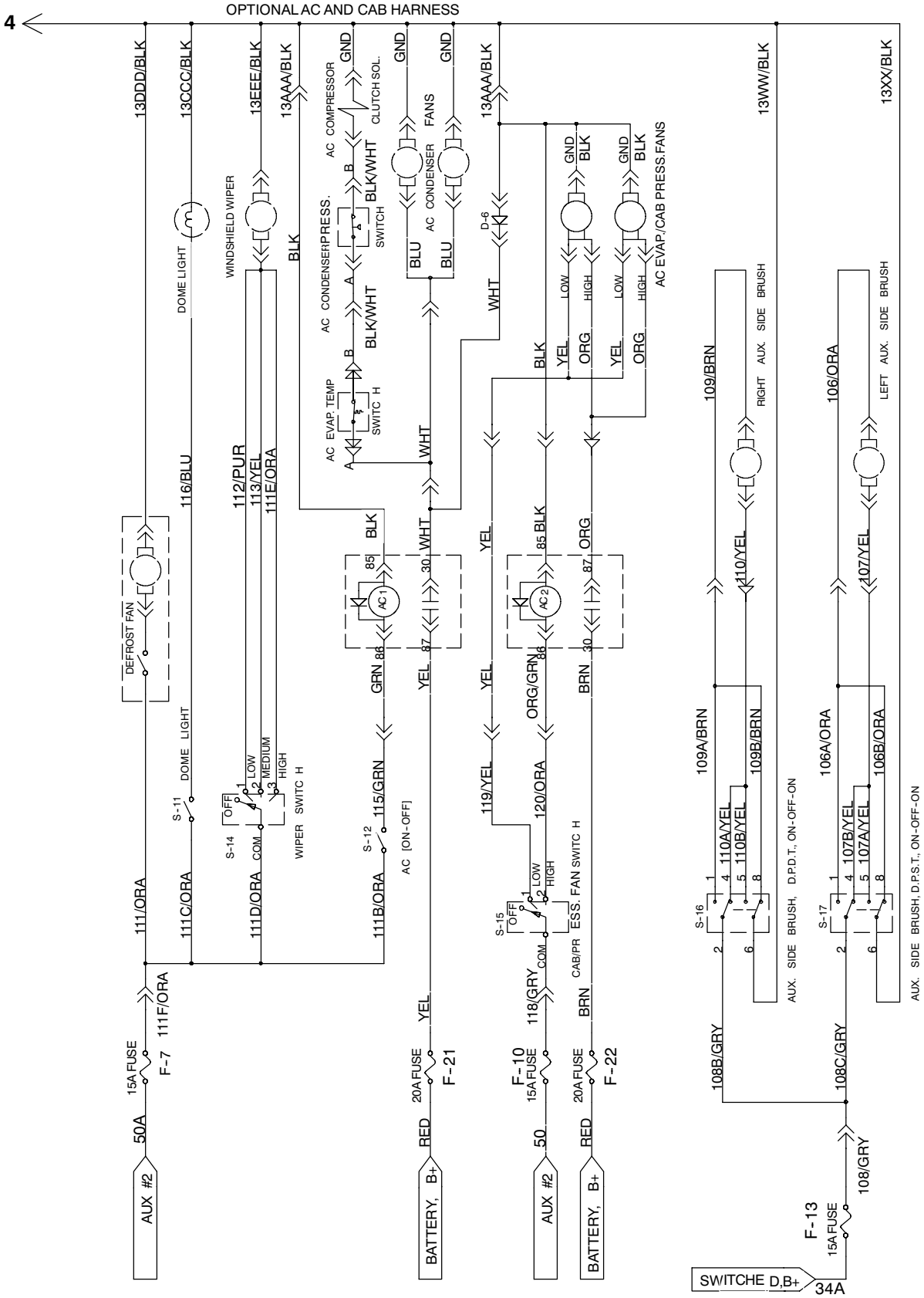
6650 DIESEL OVERALL ELECTRICAL DIAGRAM

Part 3 of 4

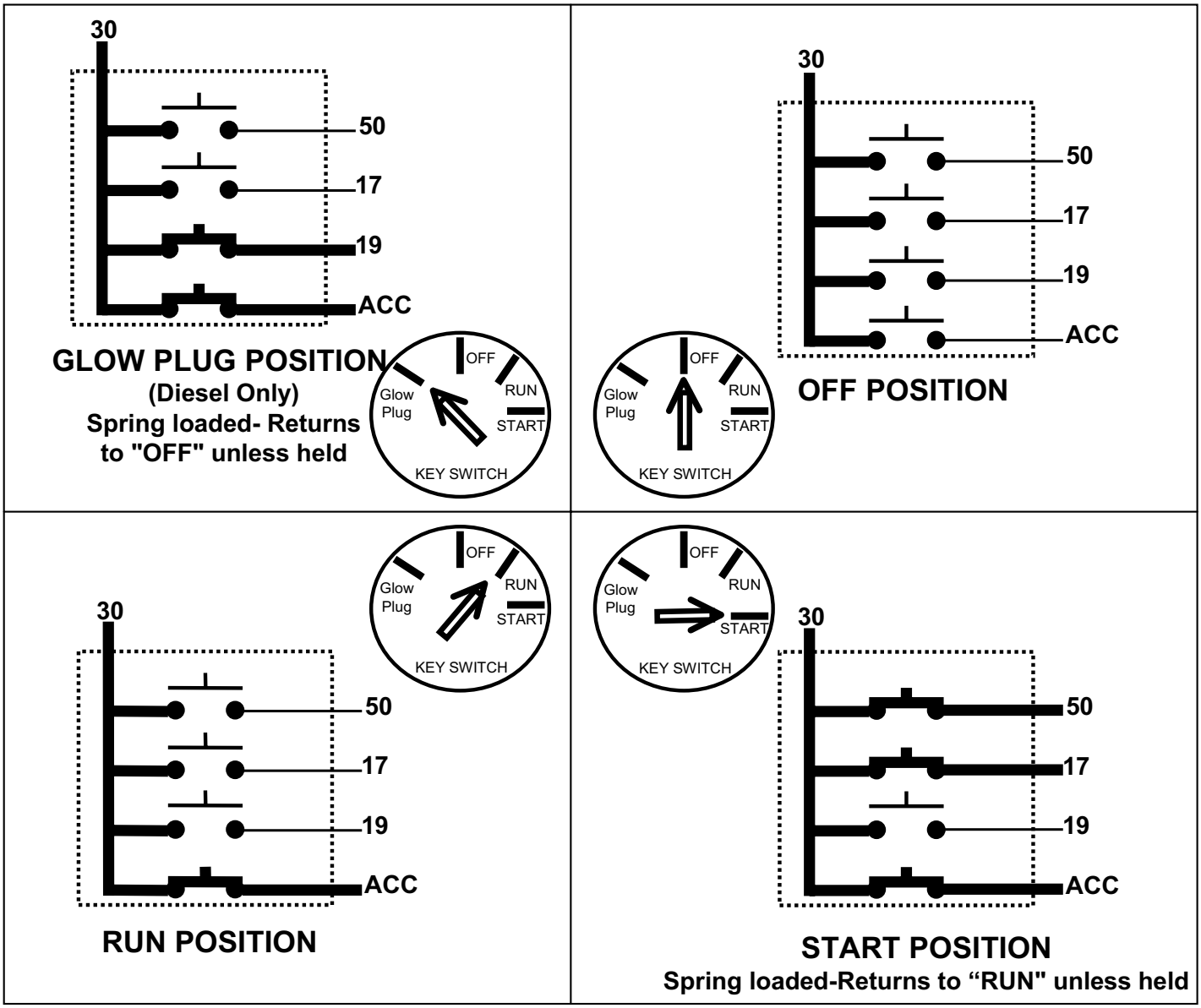


6650 DIESEL OVERALL ELECTRICAL DIAGRAM

Part 4 of 4



6650 Key Switch



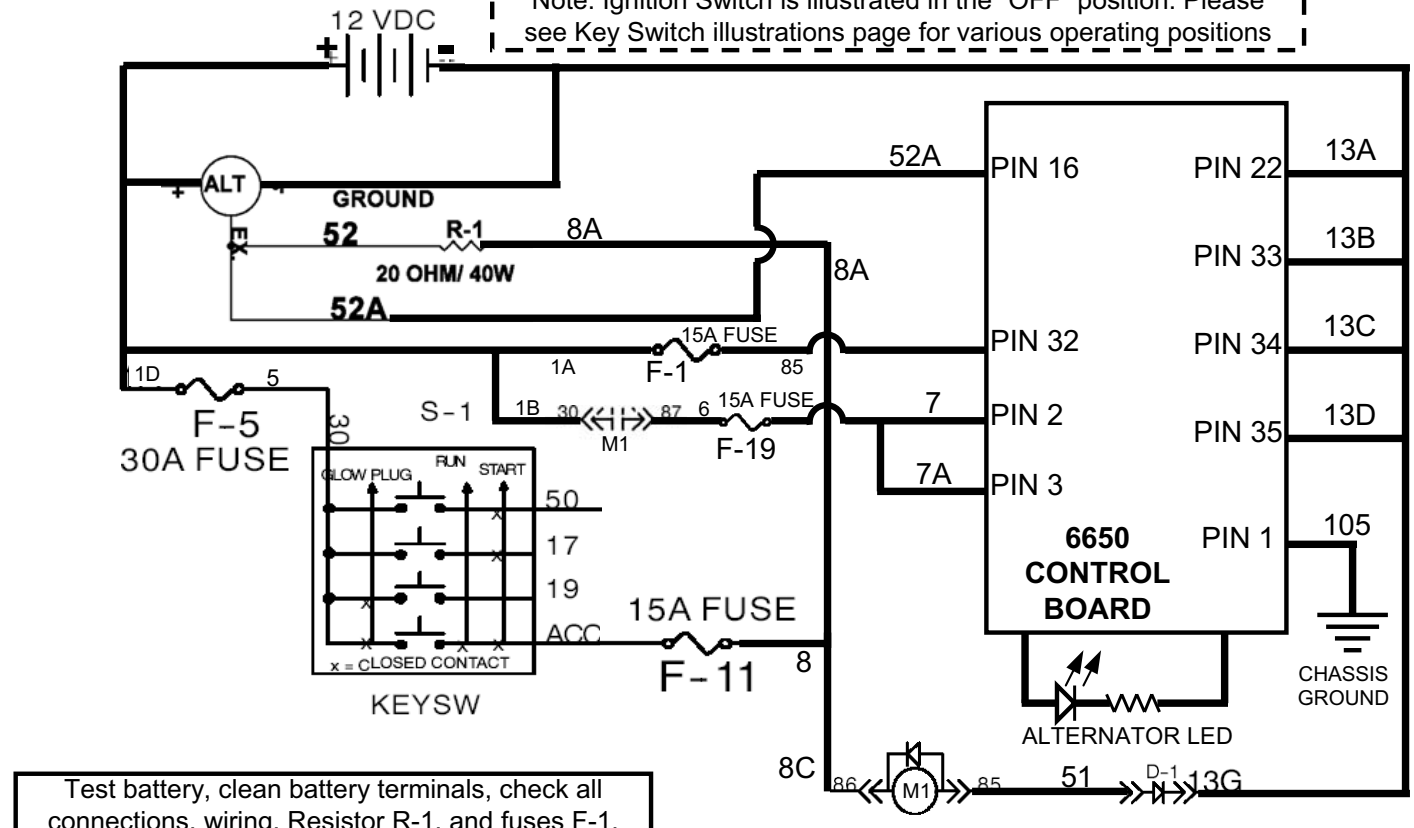
KEY SWITCH POSITION	SWITCH TERMINAL MARKING				
	30	50	17	19	ACC
GLOW PLUG	●			●	●
OFF	NO CONNECTIONS				
RUN	●				●
START	●	●	●		●

"●—●" Indicates a common connection

NOTE: Common connections in various switch positions should be less than 1Ω

6650 Charging System

Note: Ignition Switch is illustrated in the "OFF" position. Please see Key Switch illustrations page for various operating positions



Test battery, clean battery terminals, check all connections, wiring, Resistor R-1, and fuses F-1, F-5, F-11 & F-19, turn key to "ON" position (KOEO-Key On, Engine Off)

Is ALTERNATOR LED lit?

YES

Start engine (KOER-Key On, Engine Running), run engine at high governed RPM

NO

Re-test battery, re-check battery terminals, connections, wiring, Resistor R-1, and fuses F-1, F-5, F-11 & F-19; Suspect faulty 6650 Control Board; Restart diagnostic steps

With lights on, check voltage at battery terminals- Is it 13.5 to 16.5 Volts?

YES

NO

Is ALTERNATOR LED lit?

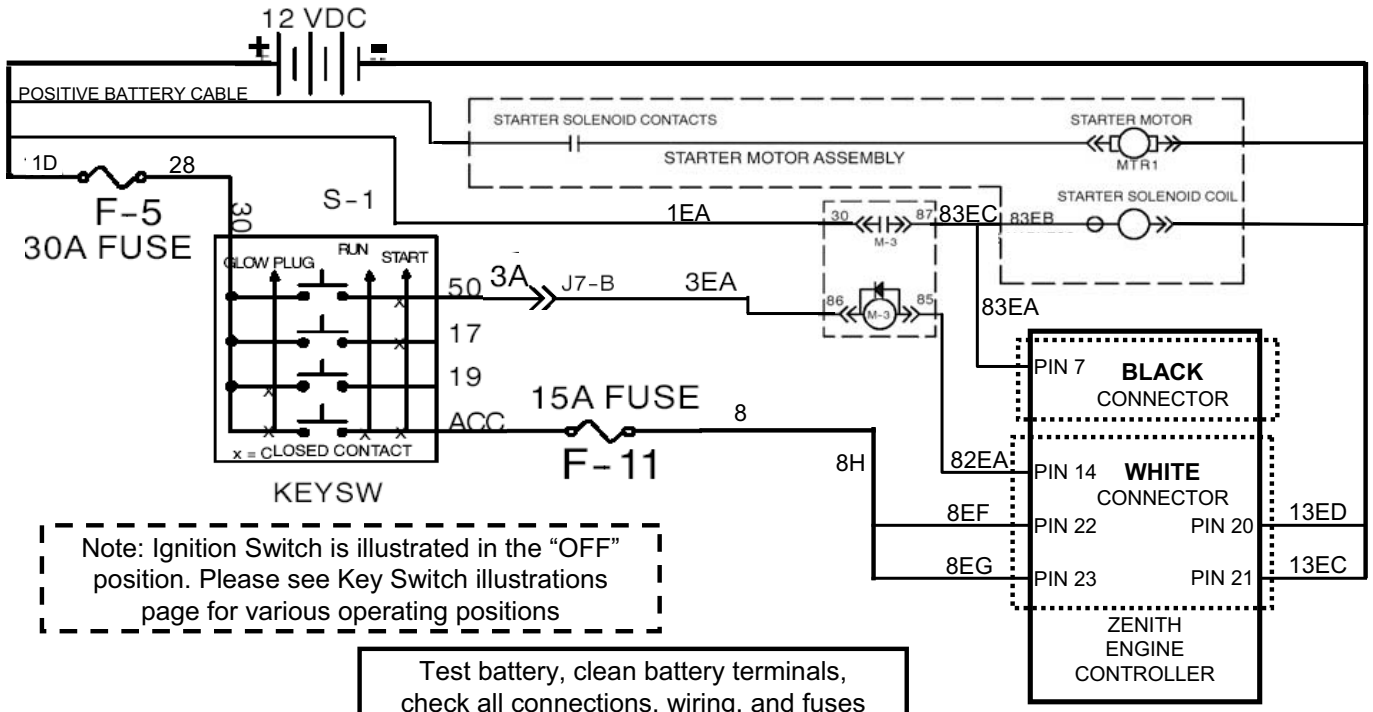
YES

NO

System operating correctly

Re-test battery, re-check battery terminals, connections, wiring, Resistor R-1, and fuses F-1, F-5, F-11 & F-19; Suspect faulty alternator

6650 Gas/L.P. Start Circuit



Note: Ignition Switch is illustrated in the "OFF" position. Please see Key Switch illustrations page for various operating positions

Test battery, clean battery terminals, check all connections, wiring, and fuses F-5 & F-11; Turn key to START position

Does STARTER MOTOR "click" or make any other noises?

YES

Re-test battery & battery terminals; Re-check all connections & wiring; Examine engine for excessive internal resistance (due to lack of lubrication, mechanical failure, etc.); Suspect faulty STARTER MOTOR

NO

CAUTION!
Disconnect wire harness plug from DIS ignition coil and turn key to OFF position for next test.

With a remote start switch tool or equivalent, connect leads to the two large STARTER SOLENOID studs (the STARTER SOLENOID is an integral part of the STARTER MOTOR)

As the remote start switch is engaged, does the STARTER MOTOR crank the engine?

YES

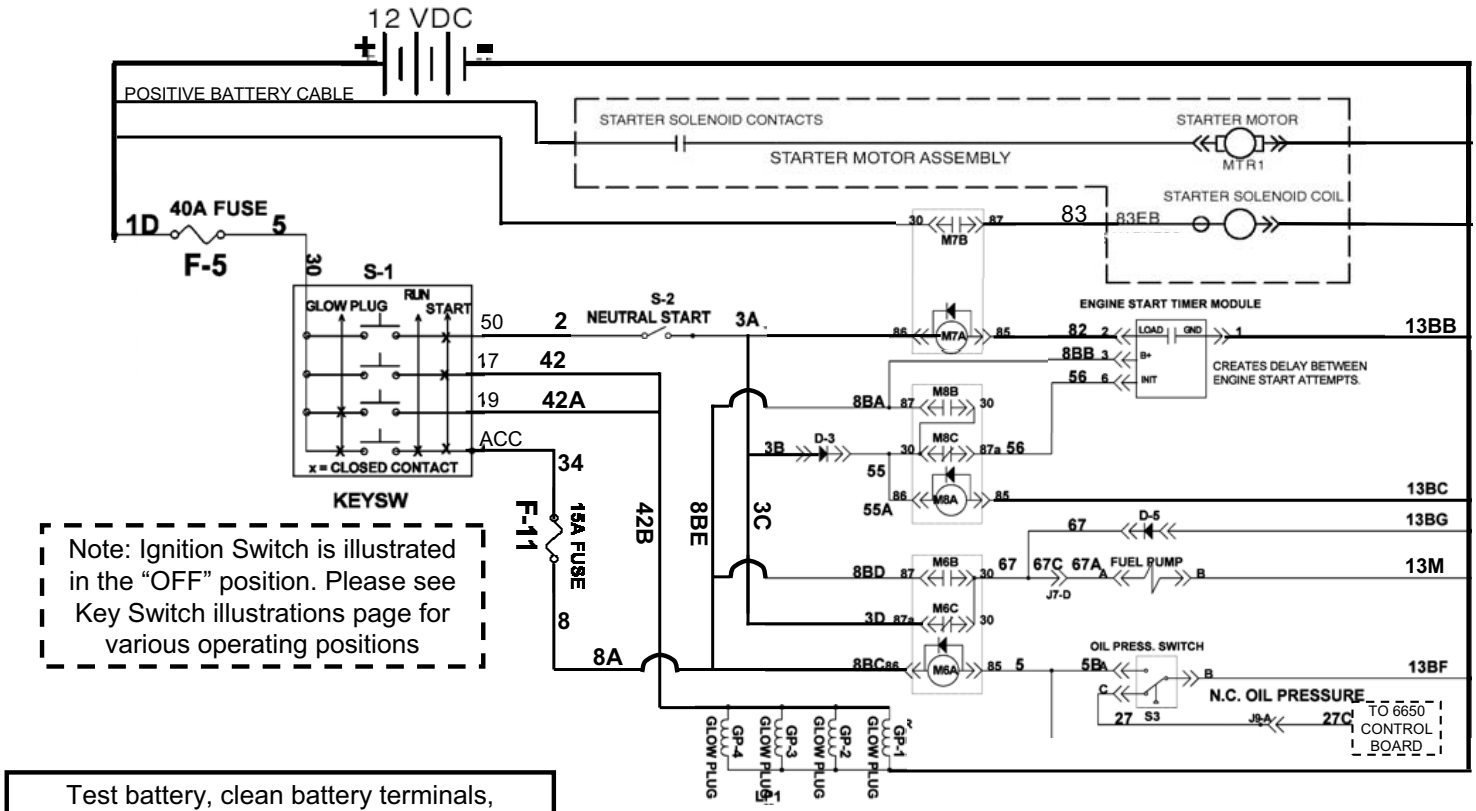
Re-check all connections, wiring and fuses F-5 & F-11; Test relay M-3; Test Key Switch; Test for proper power & ground connections at ZENITH ENGINE CONTROLLER (refer to ZEEMS troubleshooting)

NO

Re-test battery & battery terminals; Re-check all connections & wiring; Examine engine for excessive internal resistance (due to lack of lubrication, mechanical failure, etc.); Suspect faulty ST

Home Find... Go To..

6650 Diesel Start Circuit



Note: Ignition Switch is illustrated in the "OFF" position. Please see Key Switch illustrations page for various operating positions

Test battery, clean battery terminals, check all connections, wiring, and fuses F-5 & F-11; Turn key to START position

Does STARTER MOTOR "click" or make any other noises?

YES

Re-test battery & battery terminals; Re-check all connections & wiring; Examine engine for excessive internal resistance (due to lack of lubrication, mechanical failure, etc.); Suspect faulty STARTER MOTOR

NO

CAUTION!
Turn key to OFF position for next test.

With a remote start switch tool or equivalent, connect leads to the two large STARTER SOLENOID studs (the STARTER SOLENOID is an integral part of the STARTER MOTOR)

As the remote start switch is engaged, does the STARTER MOTOR crank the engine?

YES

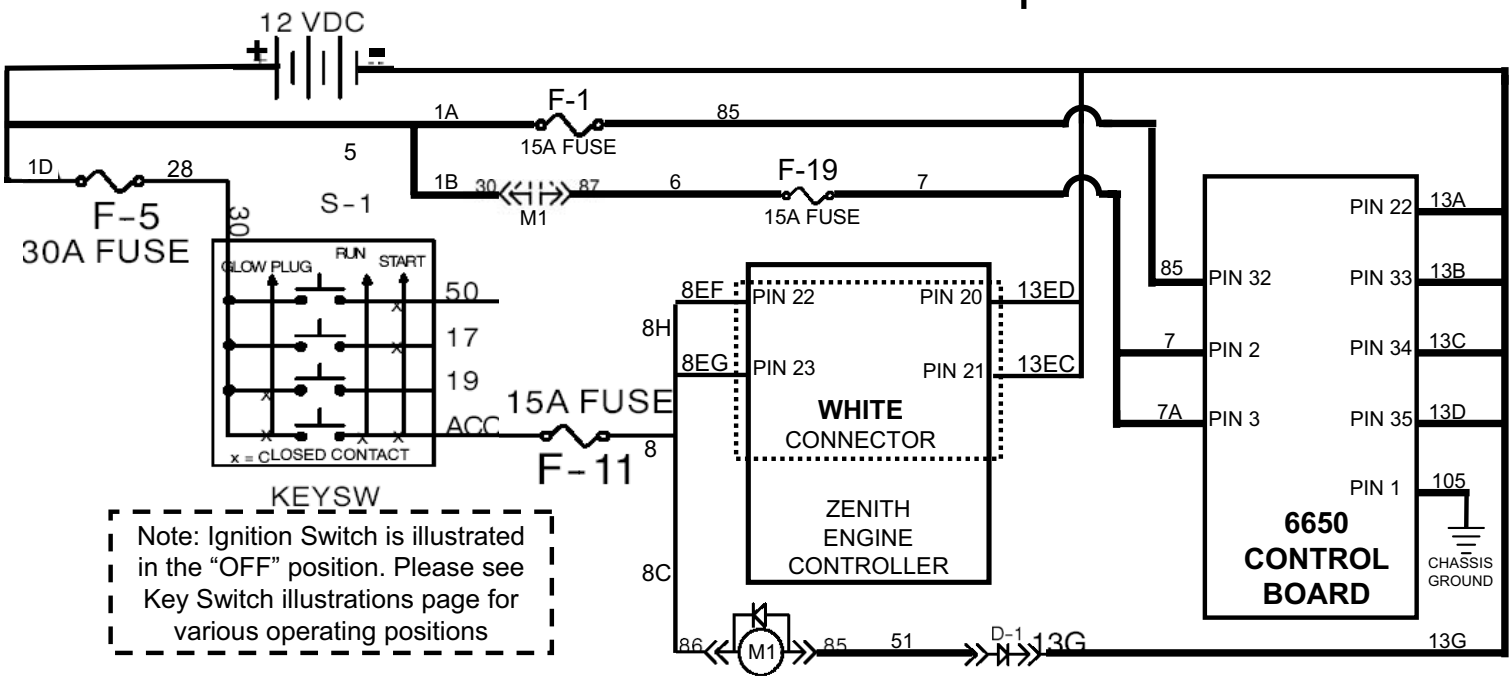
Re-check all connections, wiring and fuses F-5 & F-11; Test relays M-6, M-7, & M8; Test ENGINE START TIMER MODULE; Test Key Switch

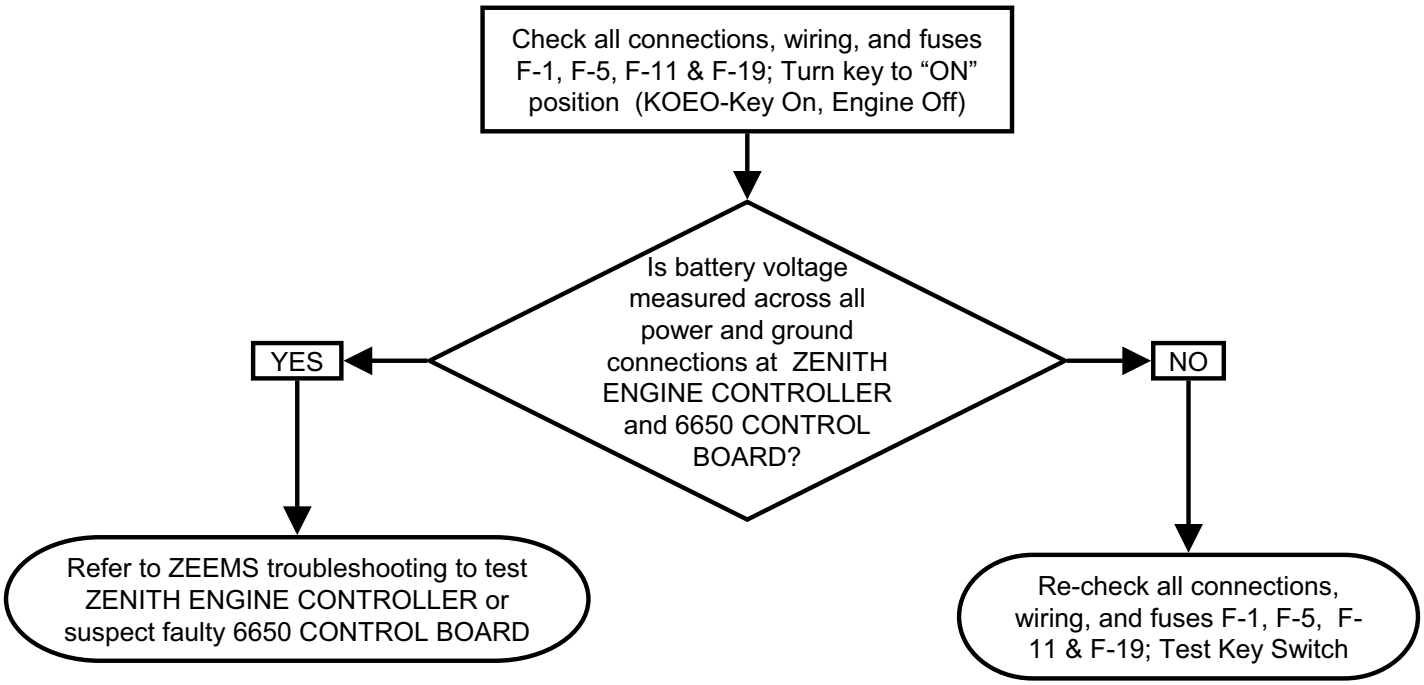
NO

Re-test battery & battery terminals; Re-check all connections & wiring; Examine engine for excessive internal resistance (due to lack of lubrication, mechanical failure, etc.); Suspect faulty START

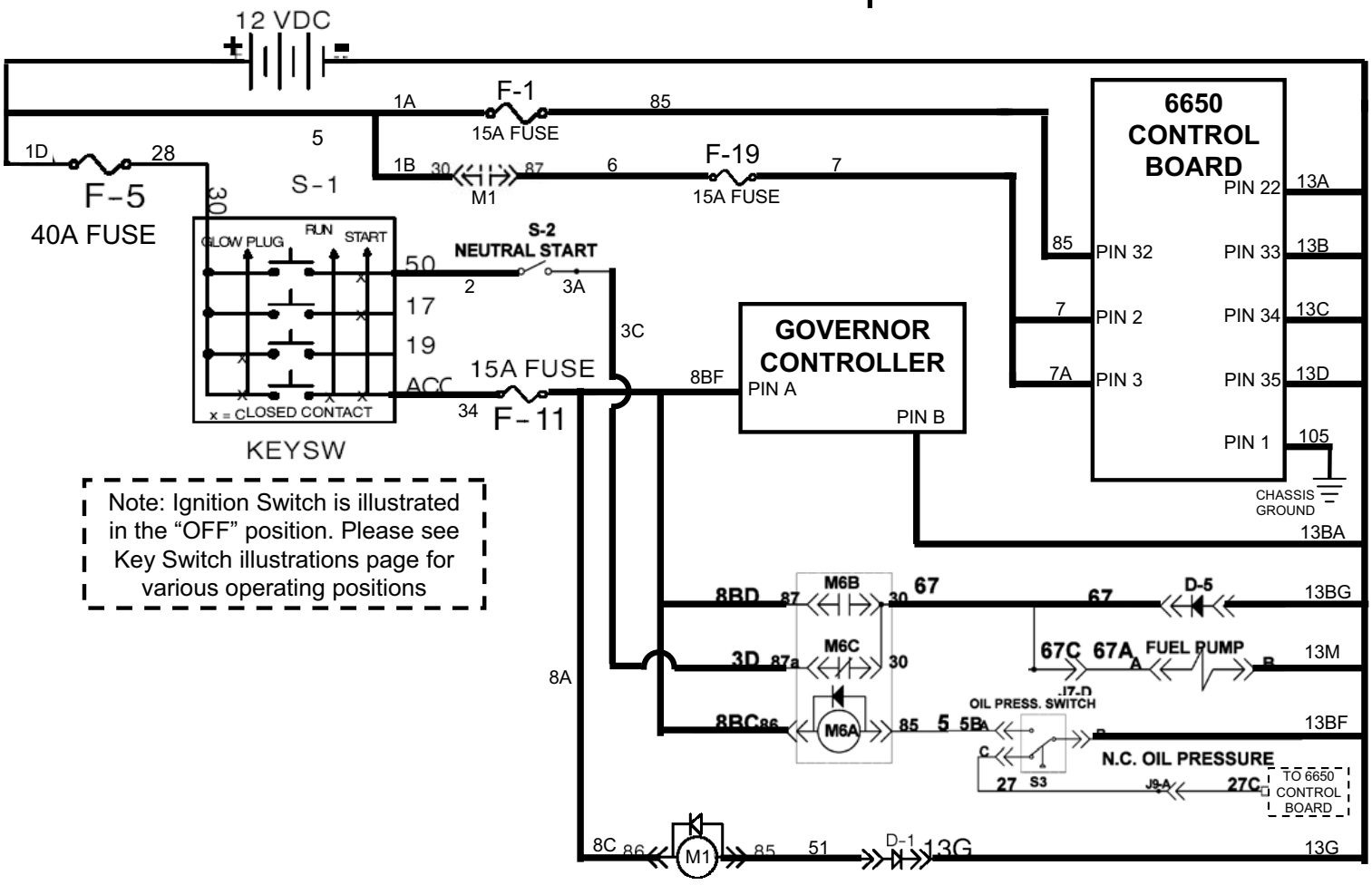
PLEASE NOT ... ng testing

6650 Gas/L.P. Power-Up Circuit





6650 Diesel Power-Up Circuit



Check all connections, wiring, and fuses F-1, F-5, F-11 & F-19; Turn key to "ON" position (KOEO-Key On, Engine Off)

Is battery voltage measured across all power and ground connections at GOVERNOR CONTROLLER and 6650 CONTROL BOARD?

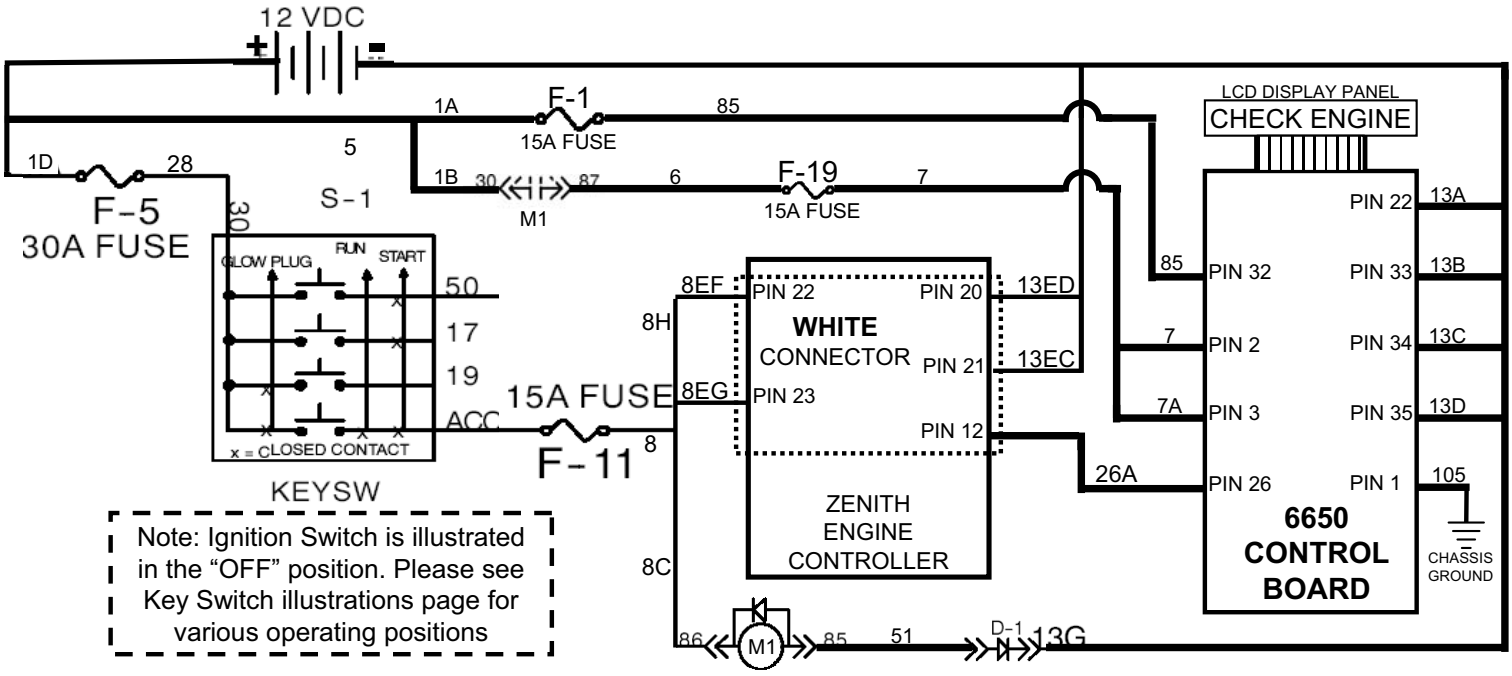
YES

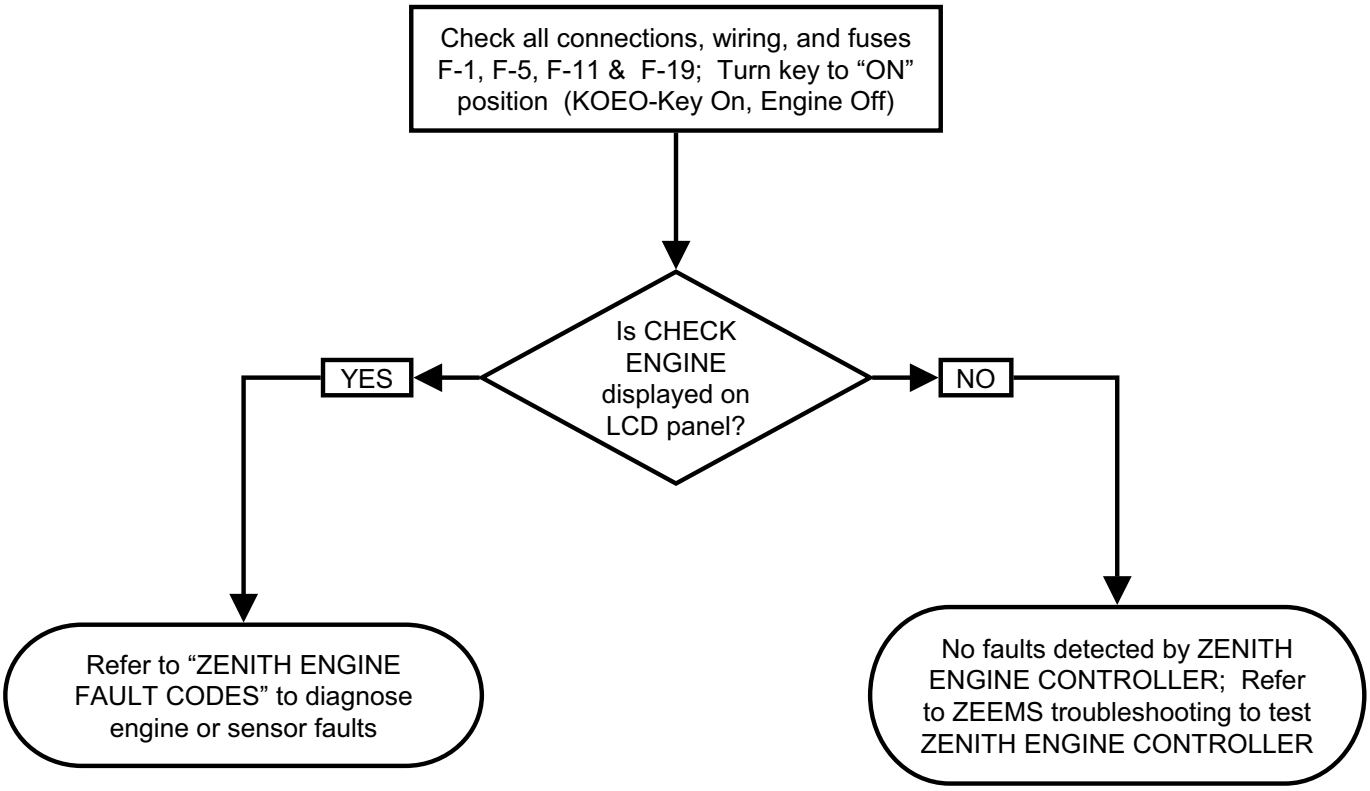
Refer to PRECISION GOVERNOR troubleshooting to test GOVERNOR CONTROLLER or suspect faulty 6650 CONTROL BOARD

NO

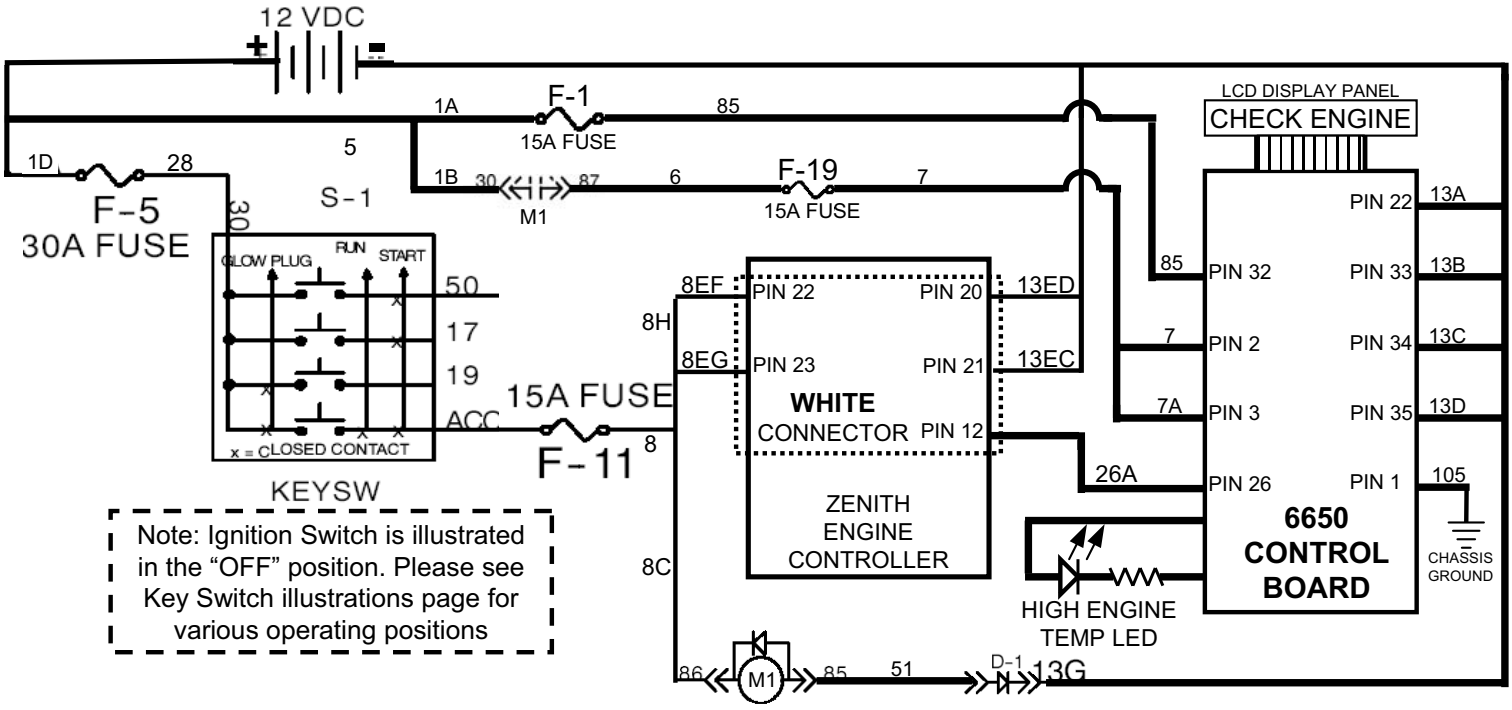
Re-check all connections, wiring, and fuses F-1, F-5, F-11 & F-19; Test Key Switch

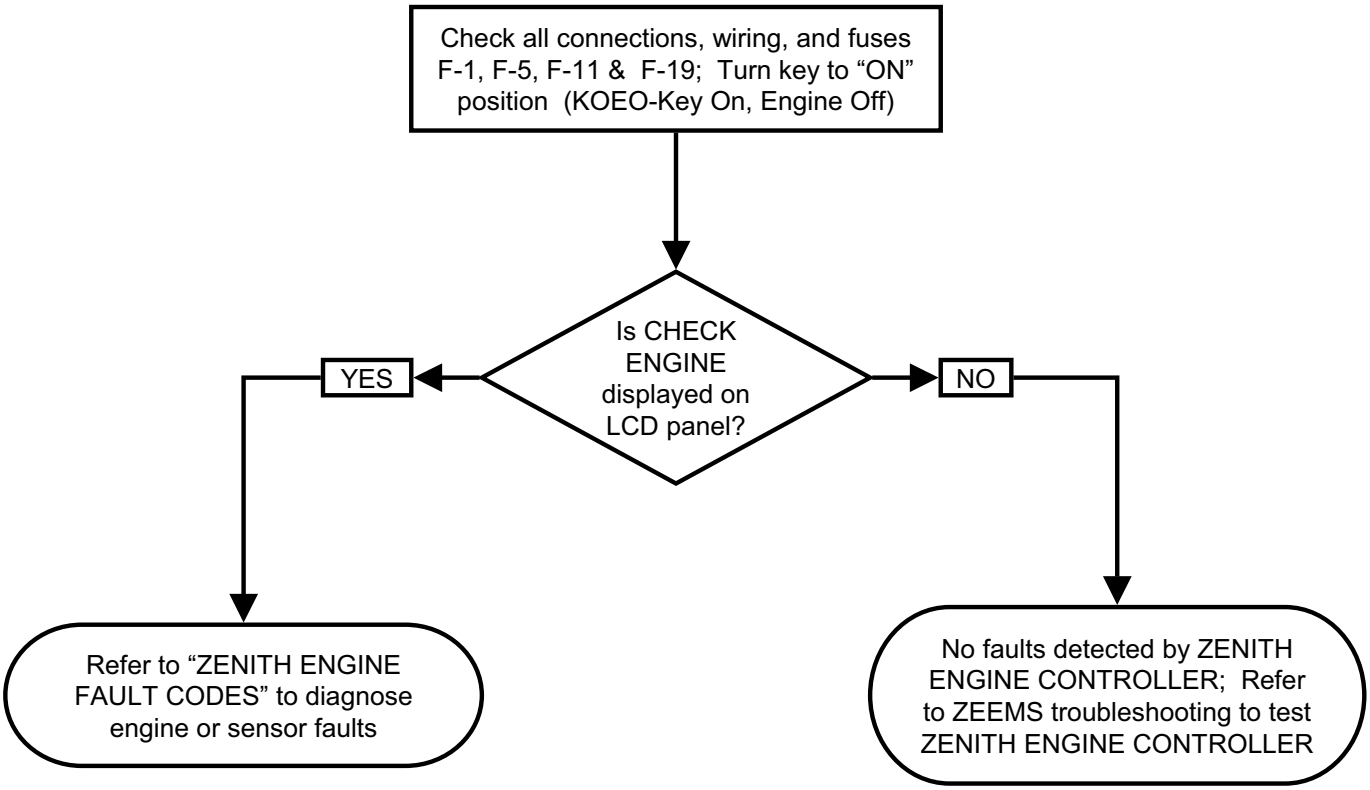
6650 Gas/L.P. Check Engine Circuit



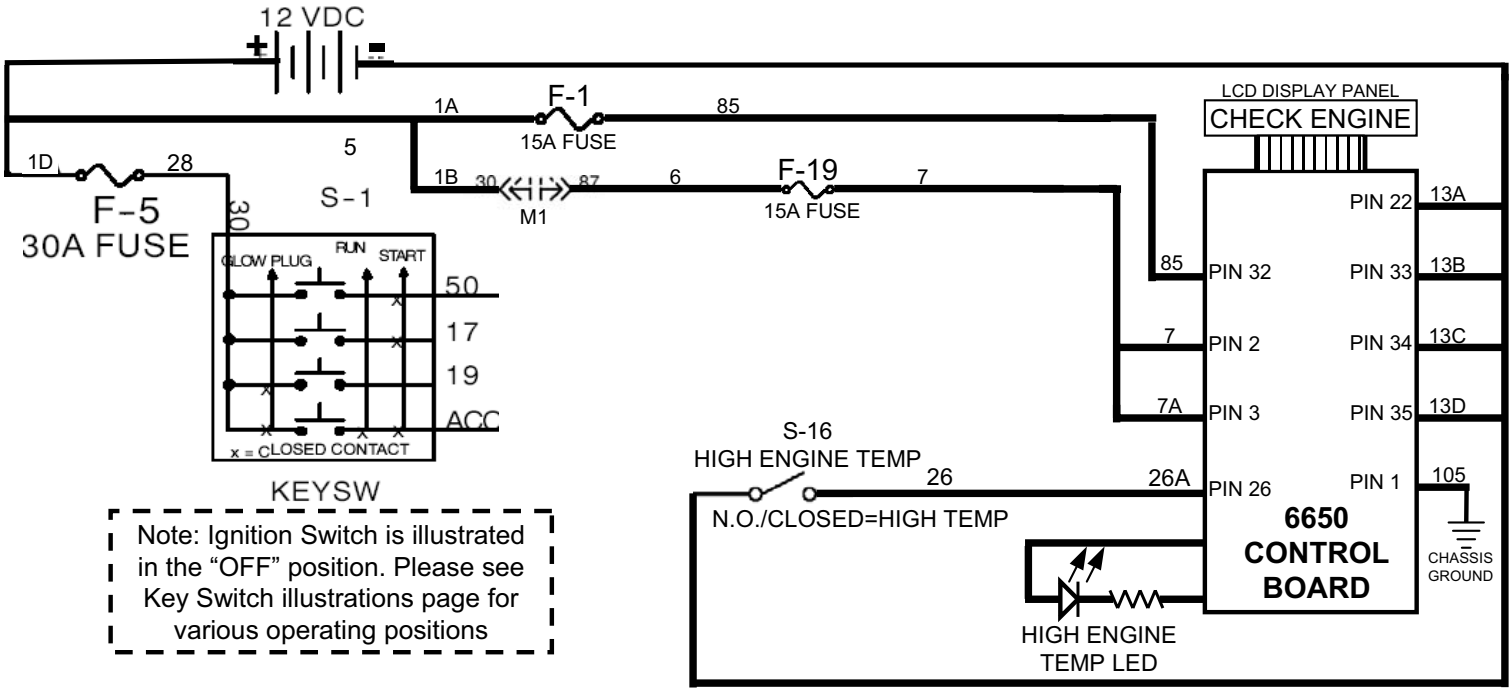


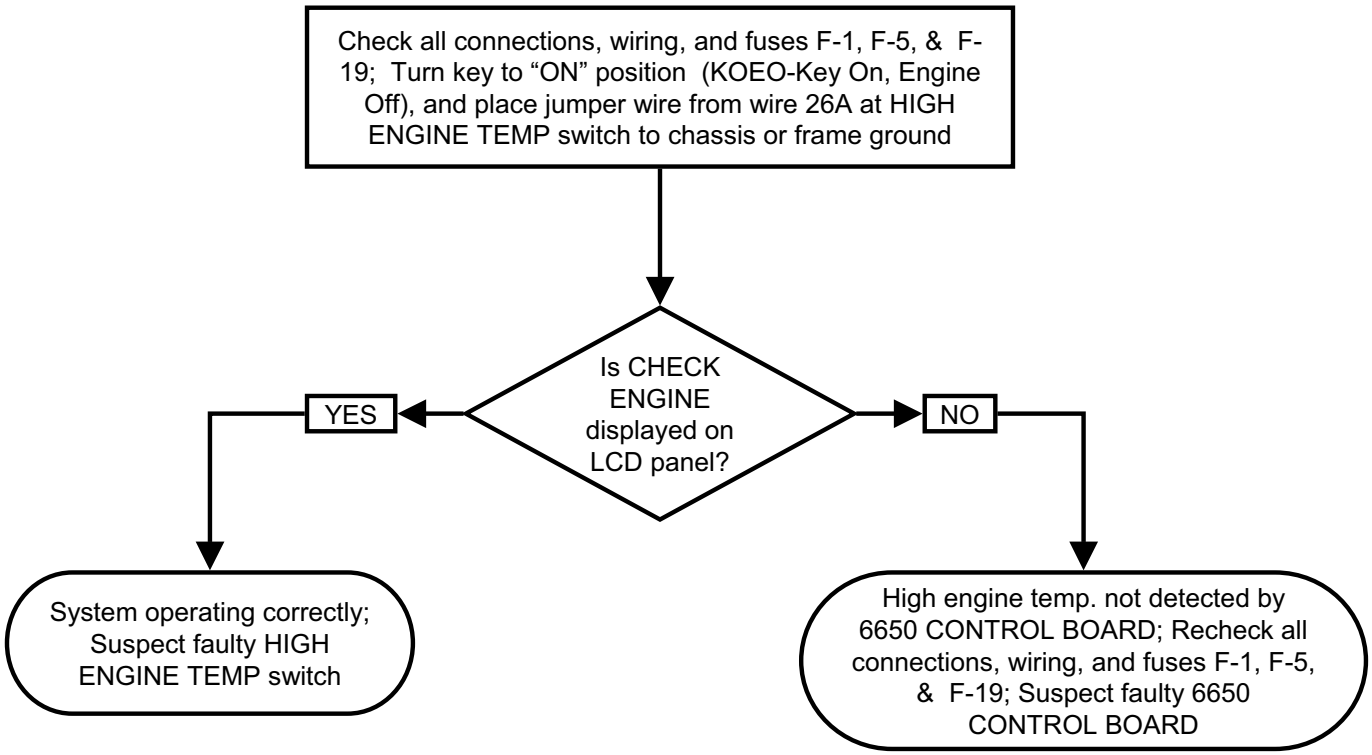
6650 Gas/L.P. High Engine Temperature Circuit



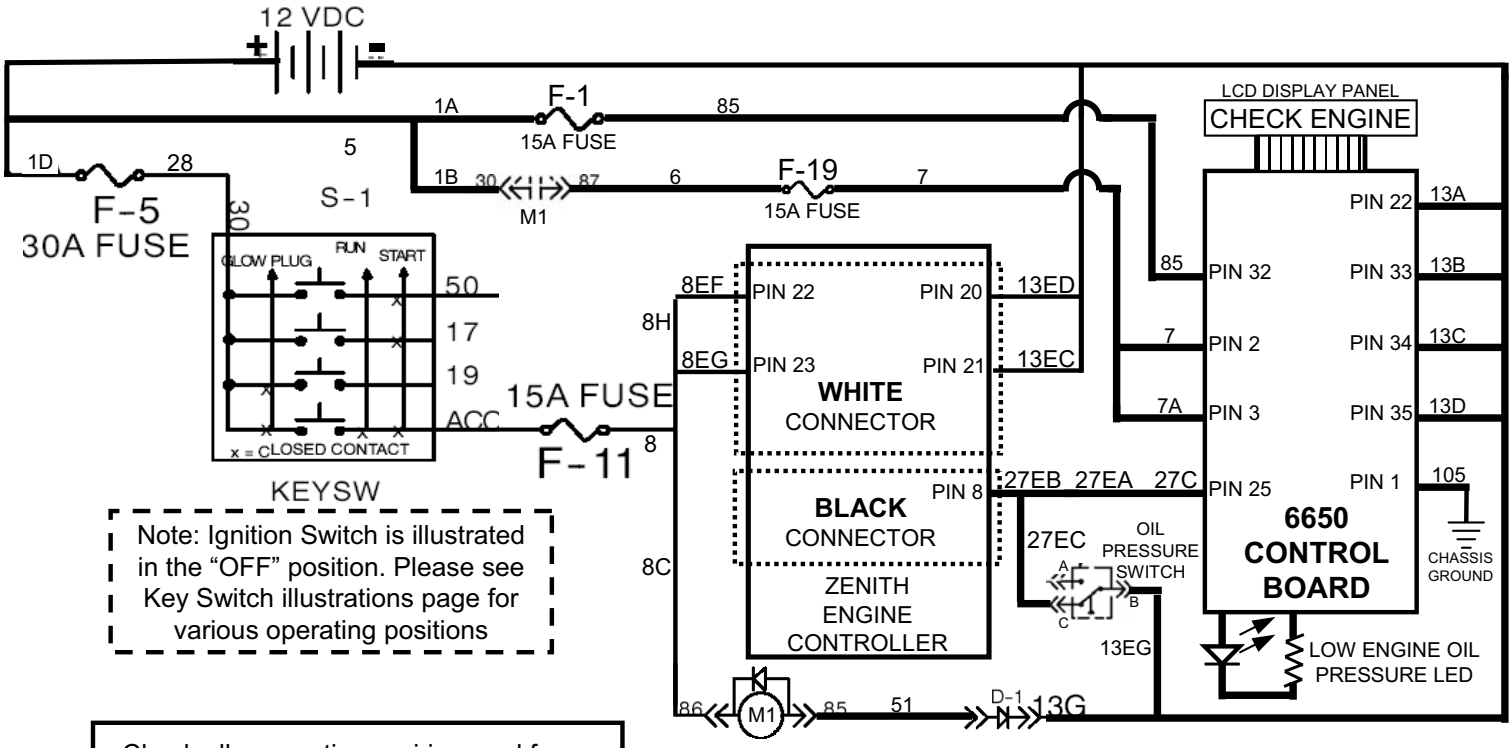


6650 Diesel High Engine Temperature Circuit





6650 Gas/L.P. Oil Pressure Circuit



Note: Ignition Switch is illustrated in the "OFF" position. Please see Key Switch illustrations page for various operating positions

Check all connections, wiring, and fuses F-1, F-5, F-11 & F-19, turn key to "ON" position (KOEO-Key On, Engine Off)

Is LOW OIL PRESSURE LED lit?

YES

With engine running, does lamp go out?

YES

Verify proper oil pressure in engine; System operating correctly

NO

Verify proper oil pressure in engine; Suspect faulty OIL PRESSURE SWITCH

NO

Remove harness plug at OIL PRESSURE SWITCH and place a jumper wire across harness plug wires B & C

Is LOW OIL PRESSURE lamp lit?

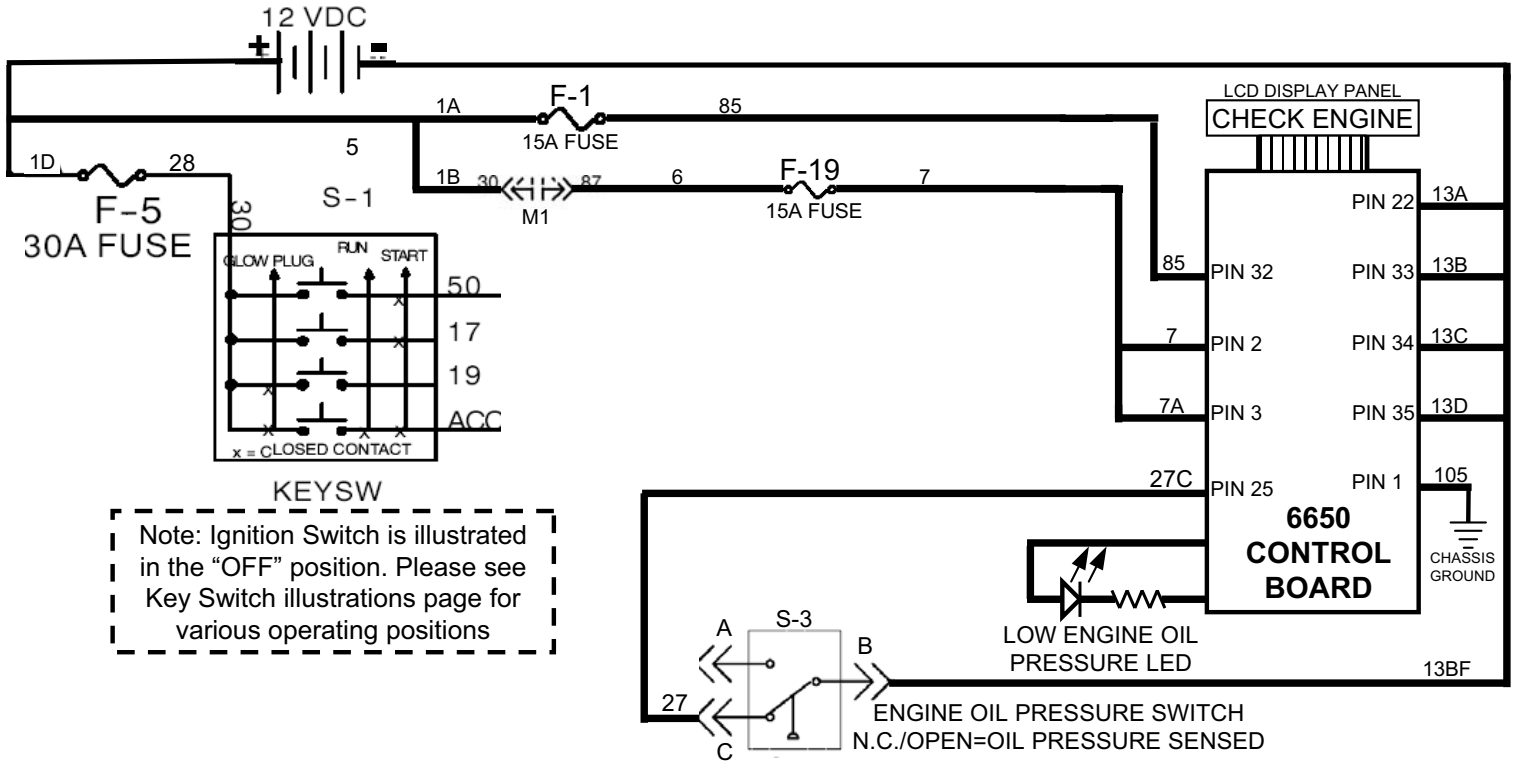
YES

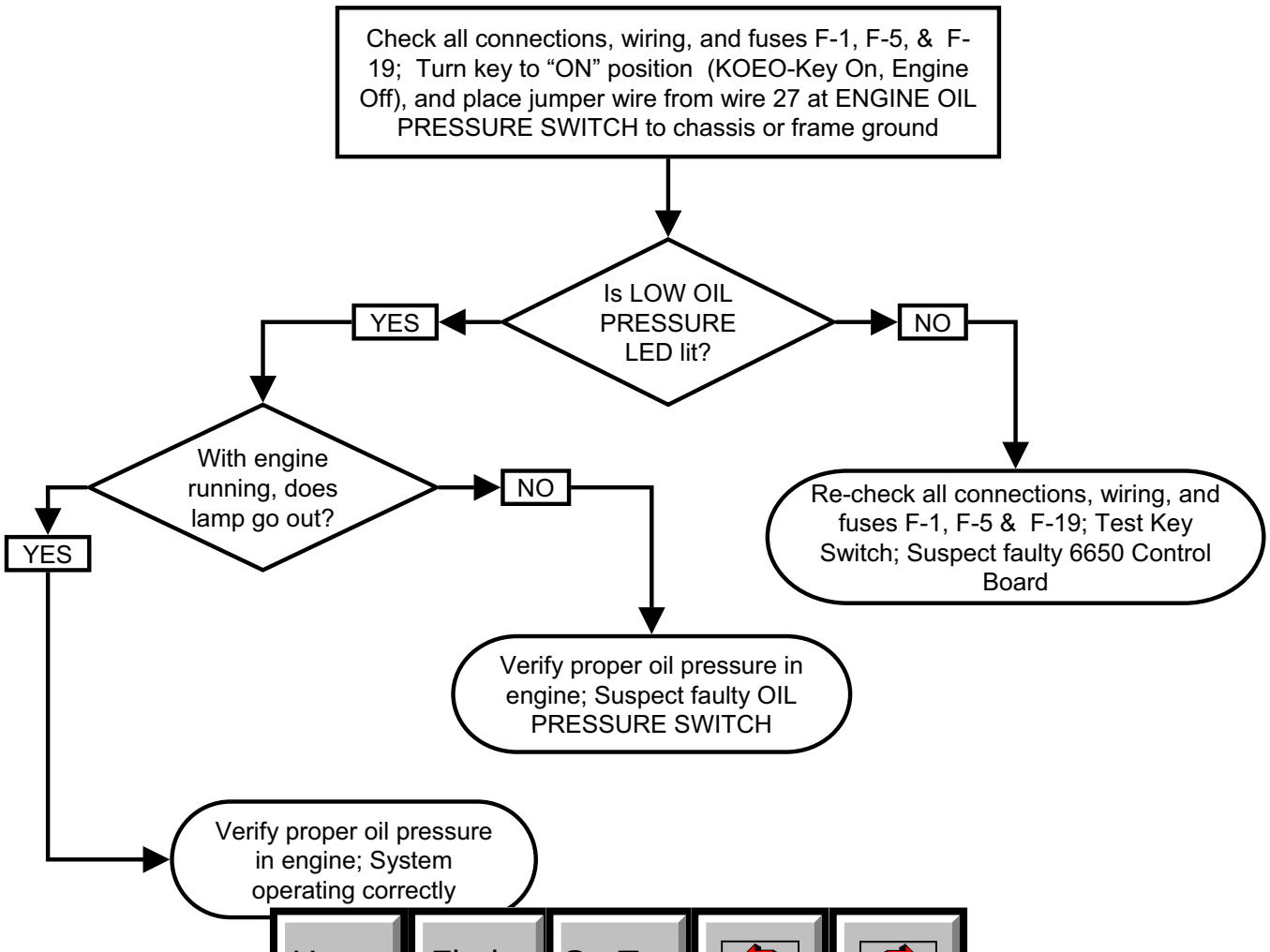
Replace OIL PRESSURE SWITCH

NO

Re-check all connections, wiring, and fuses F-5 & F-11; Test Key Switch; Suspect faulty 6650 Control Board

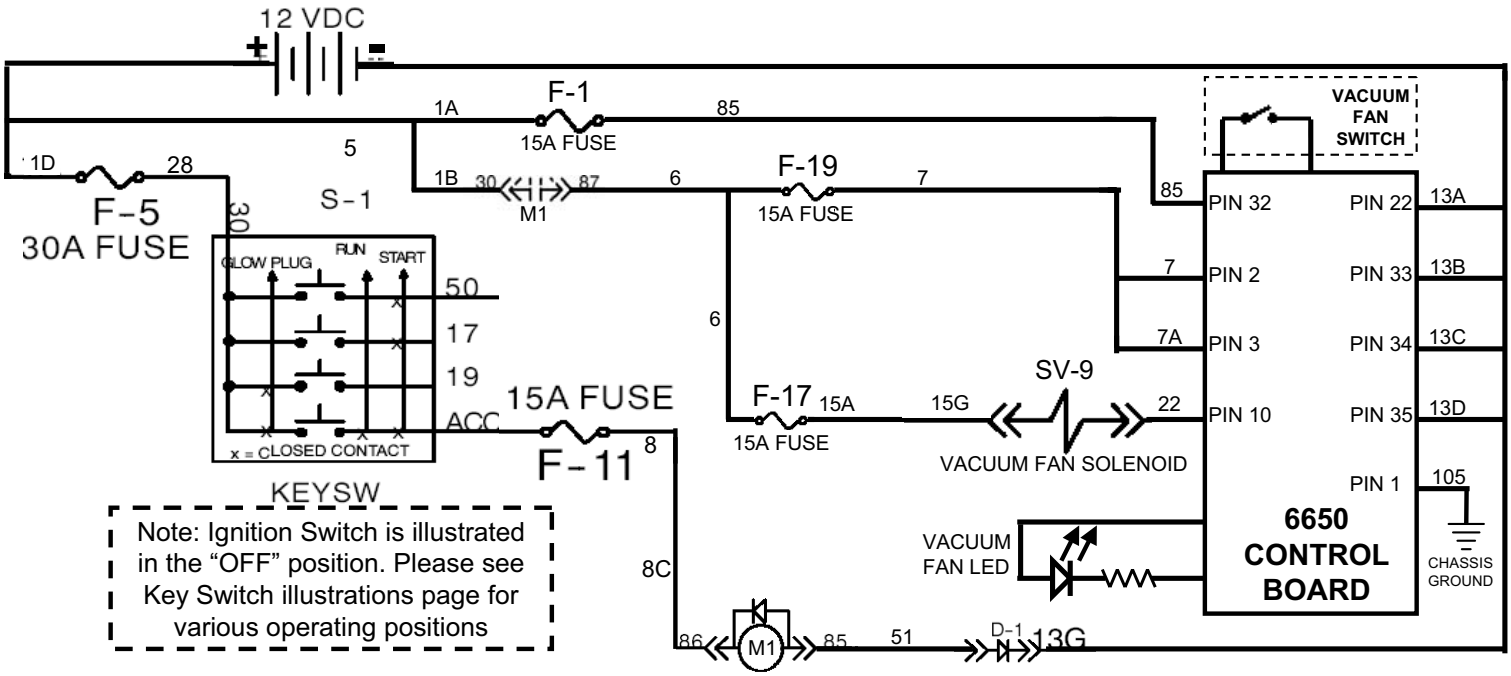
6650 Diesel Oil Pressure Circuit





Home Find... Go To..

6650 Vacuum Fan Circuit



Check all connections, wiring, and fuses F-1, F-5, F-11 & F-19, have hopper in full "DOWN" position, turn key to "ON" position (KOEO-Key On, Engine Off)

NOTE: **DO NOT UNPLUG** connector at VACUUM FAN SOLENOID (SV-9) when doing voltage tests. Unplugging connector will give false readings.

Note: Typical Solenoid Valve Coil Resistance is 6 to 8 Ohms

Turn VACUUM FAN ON (VAC FAN LED should be lit); Is battery voltage measured across wires at VAC FAN SOLENOID (SV-9) plug?

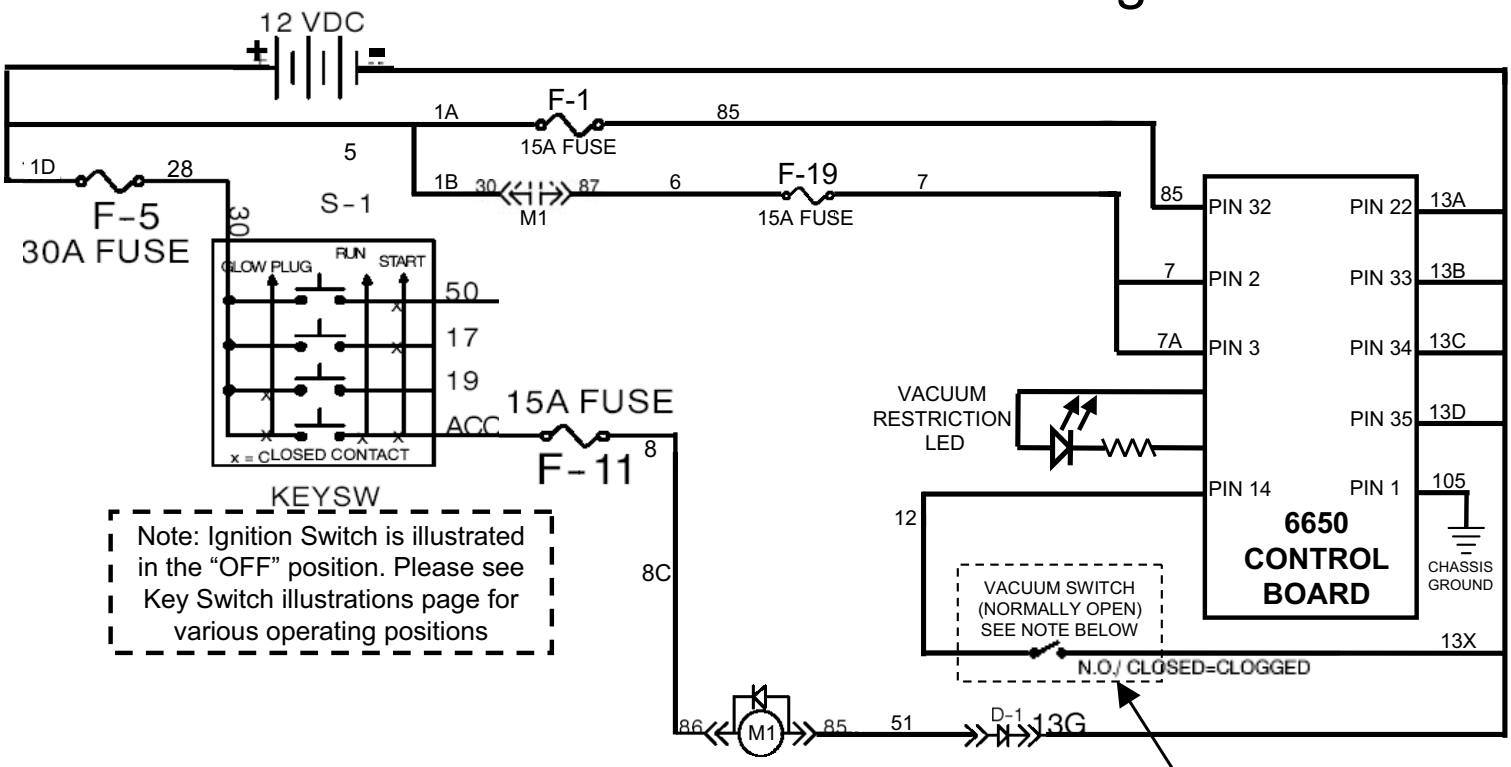
YES

Repair or replace faulty hydraulic or mechanical components (refer to 6650 HYDRAULIC TROUBLESHOOTING); Suspect faulty VAC FAN SOLENOID coil

NO

Re-check all power & ground connections and fuses F-1, F-5, F-11 & F-19; Test HOPPER SWITCH; Test THERMO-SENTRY SWITCH (see circuit chart); Test relay M-1; Test diode D-1; Test Key Switch; Suspect faulty 6650 Control Board

6650 Vacuum Restriction Warning Circuit



Note: Ignition Switch is illustrated in the "OFF" position. Please see Key Switch illustrations page for various operating positions

VACUUM SWITCH NOTE
Vacuum switch closes if vacuum fan is running with any one of these conditions:
- a blocked (dirty) vacuum panel filter
- a blocked Perma-Filter
- a closed hopper door

Check all connections, wiring, and fuses F-1, F-5, & F-11, turn key to "ON" position (KOEO-Key On, Engine Off)

Remove wire plug from VACUUM SWITCH and place a jumper wire across harness plug wires

Is CLOGGED DUST FILTER LED lit?

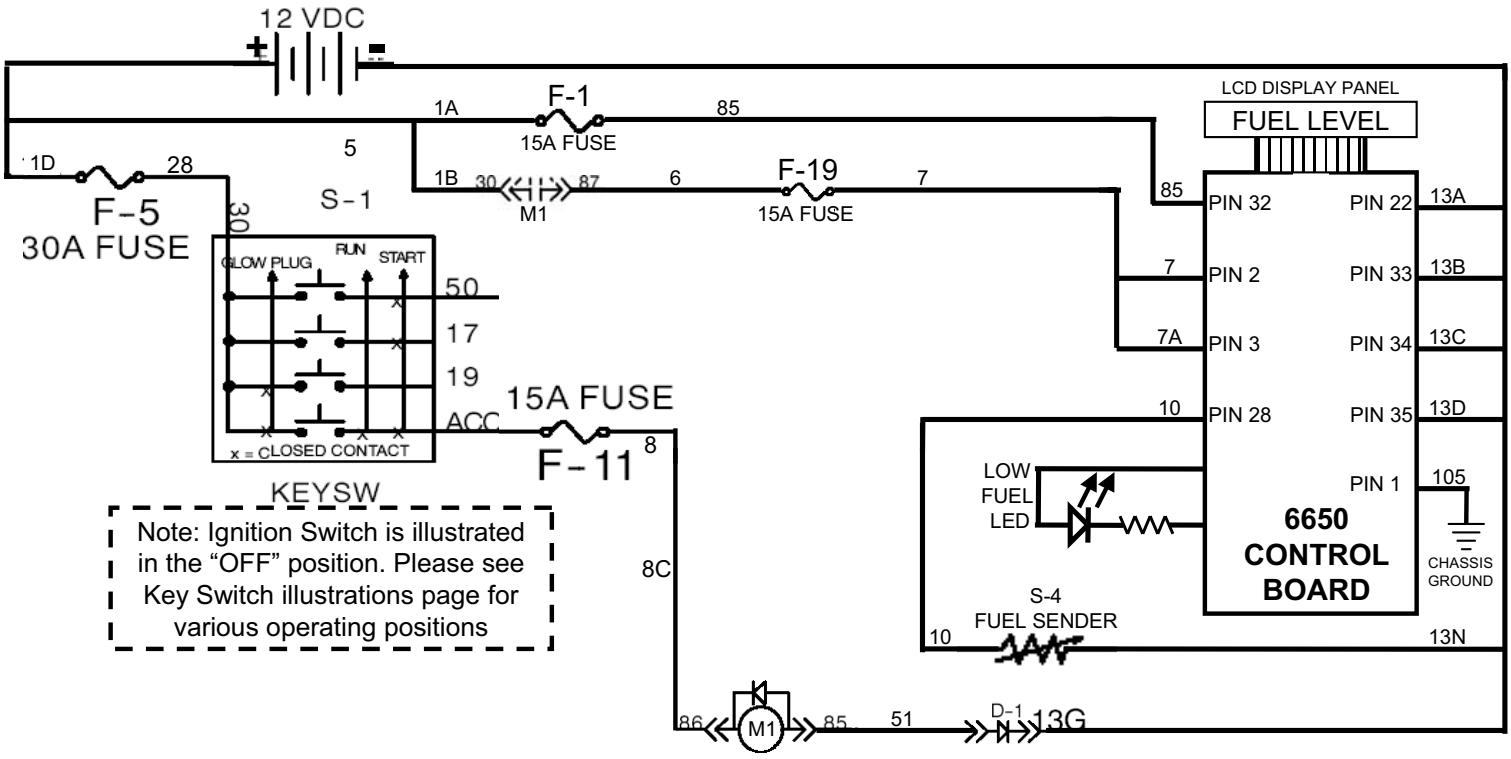
YES

Suspect faulty VACUUM SWITCH

NO

Re-check power & ground connections and fuses F-1, F-5, & F-11; Test relay M-1; Test diode D-1; Test Key Switch; Suspect faulty 6650 Control Board

6650 Gas/Diesel Fuel Sender Circuit



Check all connections, wiring, and fuses F-1, F-5, F-11 & F-19, turn key to "ON" position (KOEO-Key On, Engine Off)

Remove wires from FUEL SENDER at tank and watch FUEL GAUGE; Place jumper wire across FUEL SENDER wires and watch FUEL GAUGE again

Does LOW FUEL LED light and FUEL GAUGE on LCD panel deflect from FULL to EMPTY?

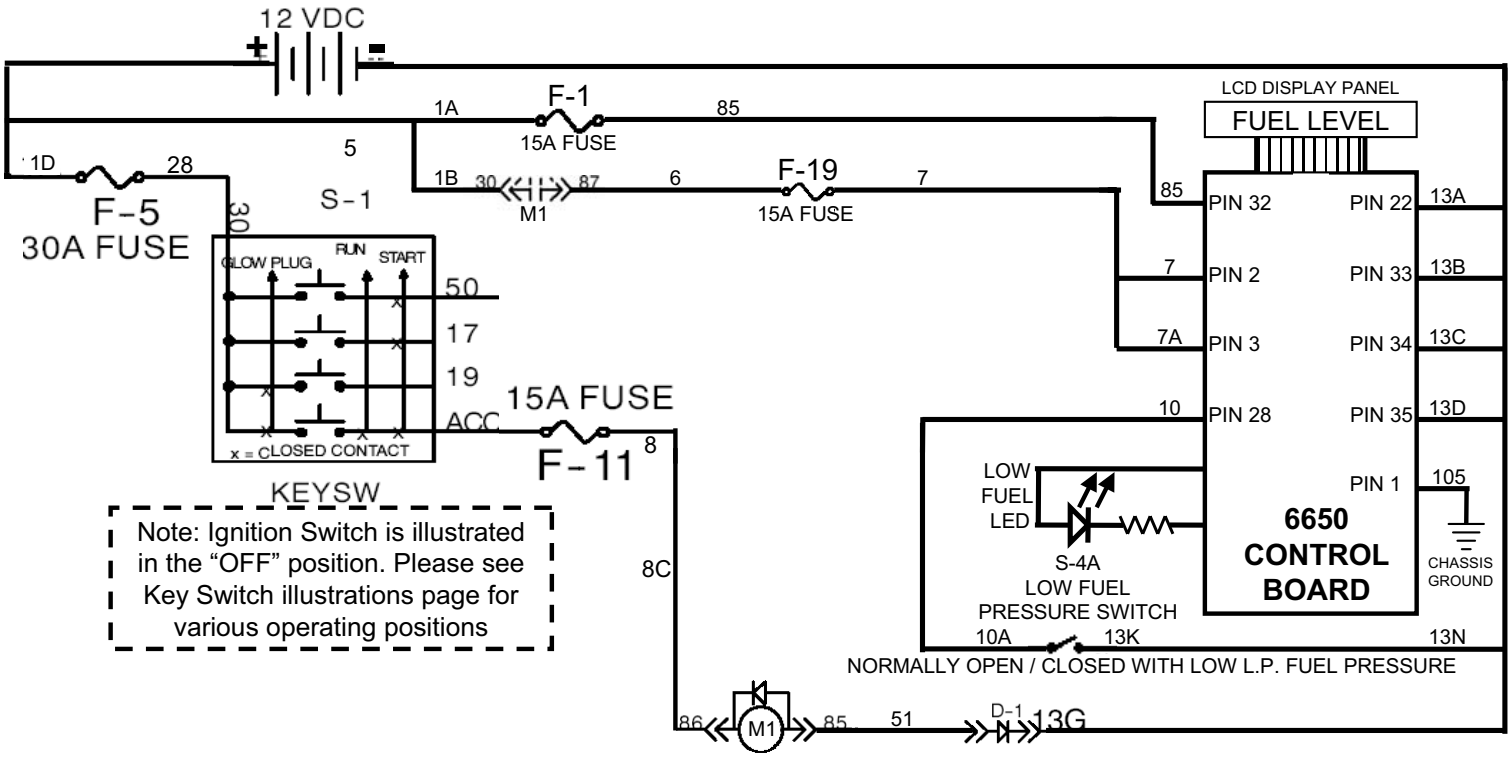
YES

Suspect faulty FUEL SENDER

NO

Re-check all connections, wiring, and fuses F-1, F-5, F-11 & F-19; Suspect faulty 6650 Control Board

6650 Low L.P. Fuel Sender Circuit



Check all connections, wiring, and fuses F-1, F-5, F-11 & F-19; With a full L.P. tank properly connected to machine, with L.P. supply valve fully open, turn key to "ON" position (KOEO-Key On, Engine Off)

Is LOW FUEL LED lit?

YES → Check all connections and wiring; Suspect faulty LOW L.P. SWITCH

NO → Fully close L.P. supply valve on L.P. tank and run machine until engine runs out of fuel

Is LOW FUEL LED lit?

YES → System operating properly

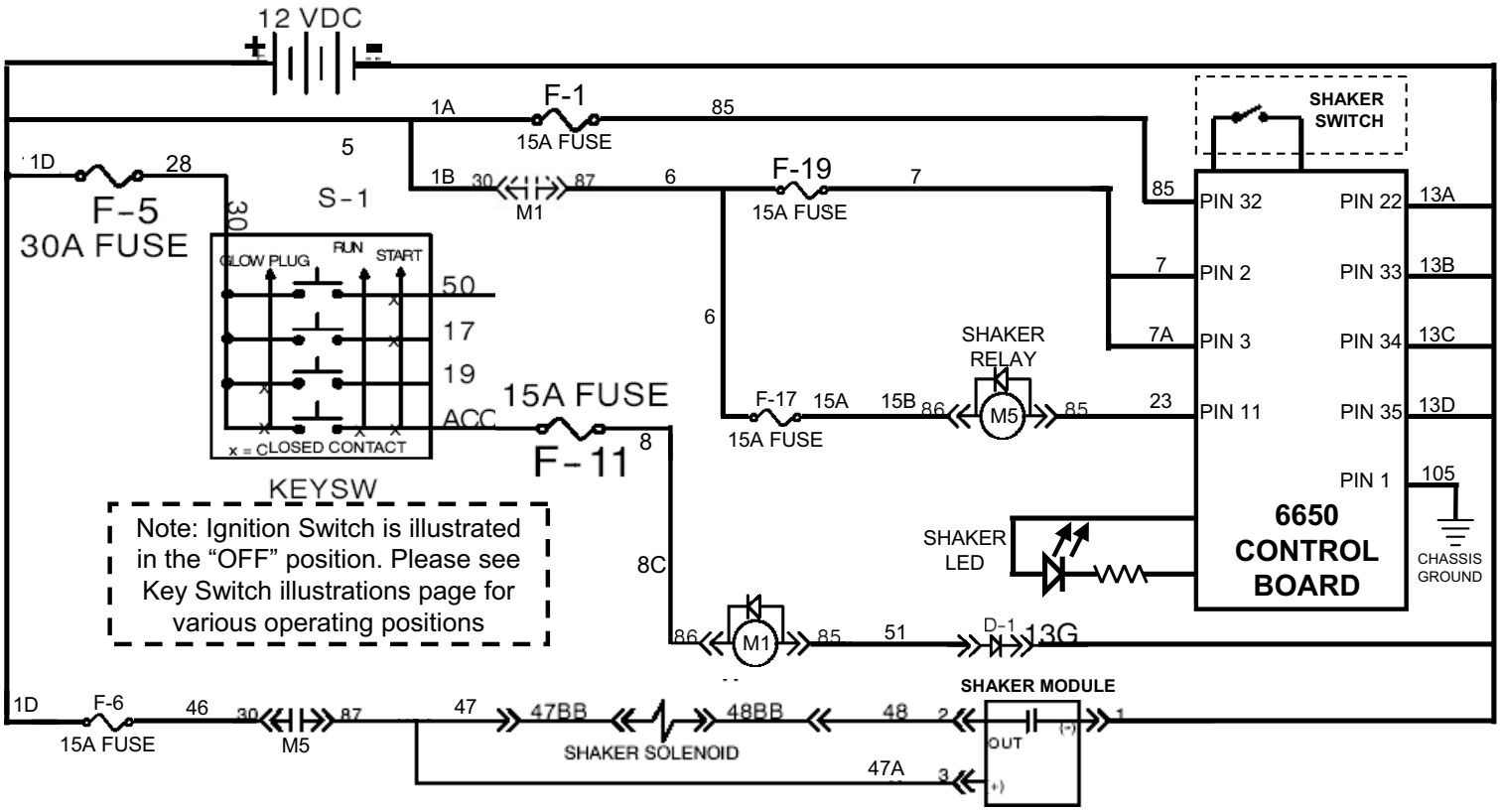
NO → Remove plug at LOW L.P. PRESSURE SWITCH and place a jumper wire across harness wires

Is LOW FUEL LED lit?

YES → Suspect faulty LOW L.P. SWITCH

NO → Re-check all connections, wiring, and fuses F-1, F-5, F-11 & F-19; Test relay M-1; Test diode D-1; Test power and ground circuits; Test Key Switch; Suspect faulty 6650 Control Board

6650 Shaker Motor Circuit



Check all connections, wiring, and fuses F-1, F-5, F-6, F-11, F-17 & F-19, turn key to "ON" position (KOEO-Key On, Engine Off)

Remove wire from #2 post of SHAKER PULSE MODULE; Momentarily push SHAKER button

Does SHAKER SOLENOID pulse as wire is tapped to ground?

YES

NO

Momentarily push SHAKER SWITCH - Is battery voltage measured across terminals #3 & #1 at SHAKER PULSE MODULE?

YES

NO

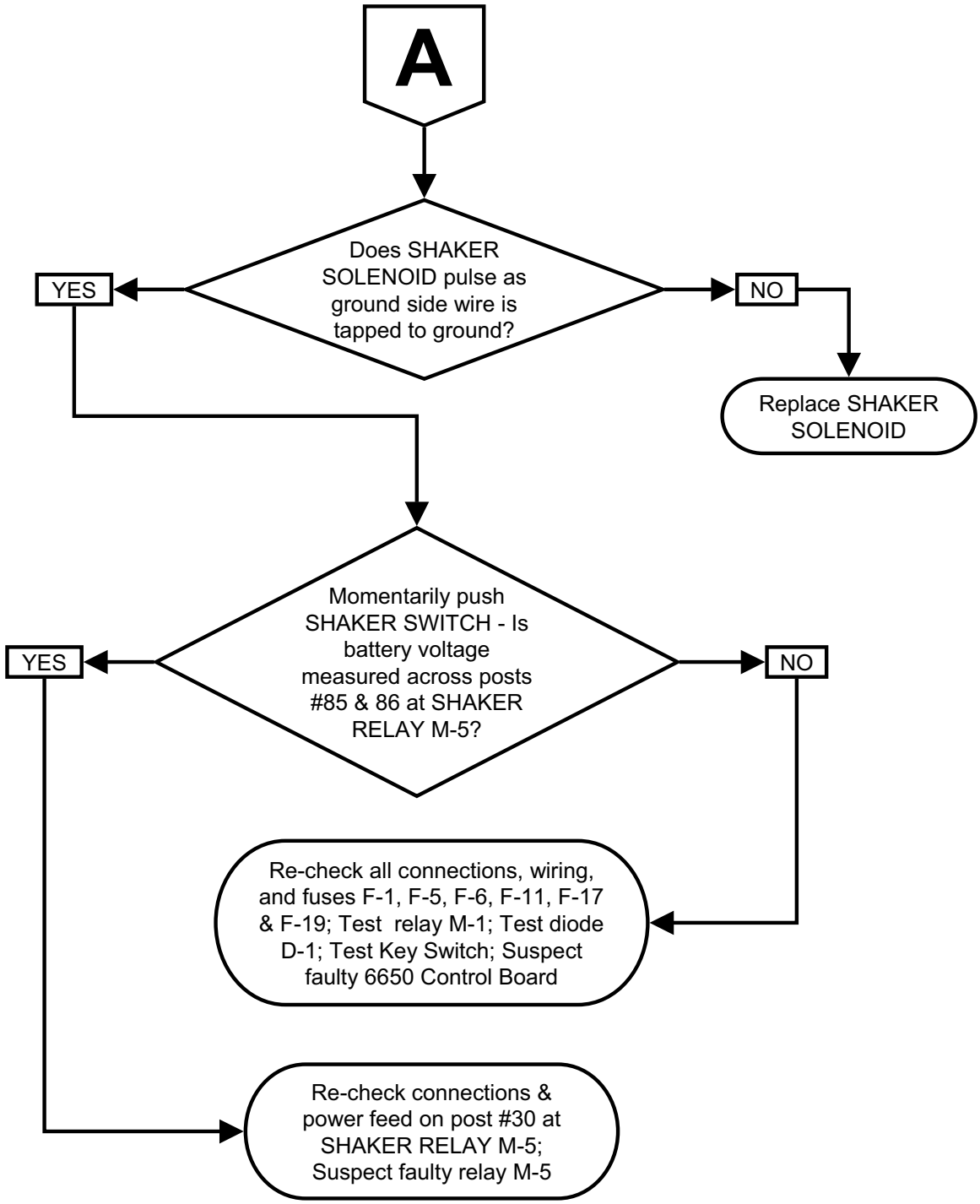
Disconnect SHAKER SOLENOID plug; Connect one SHAKER SOLENOID wire to ground and the other to battery (+)

Repair power or ground circuits leading to SHAKER MODULE

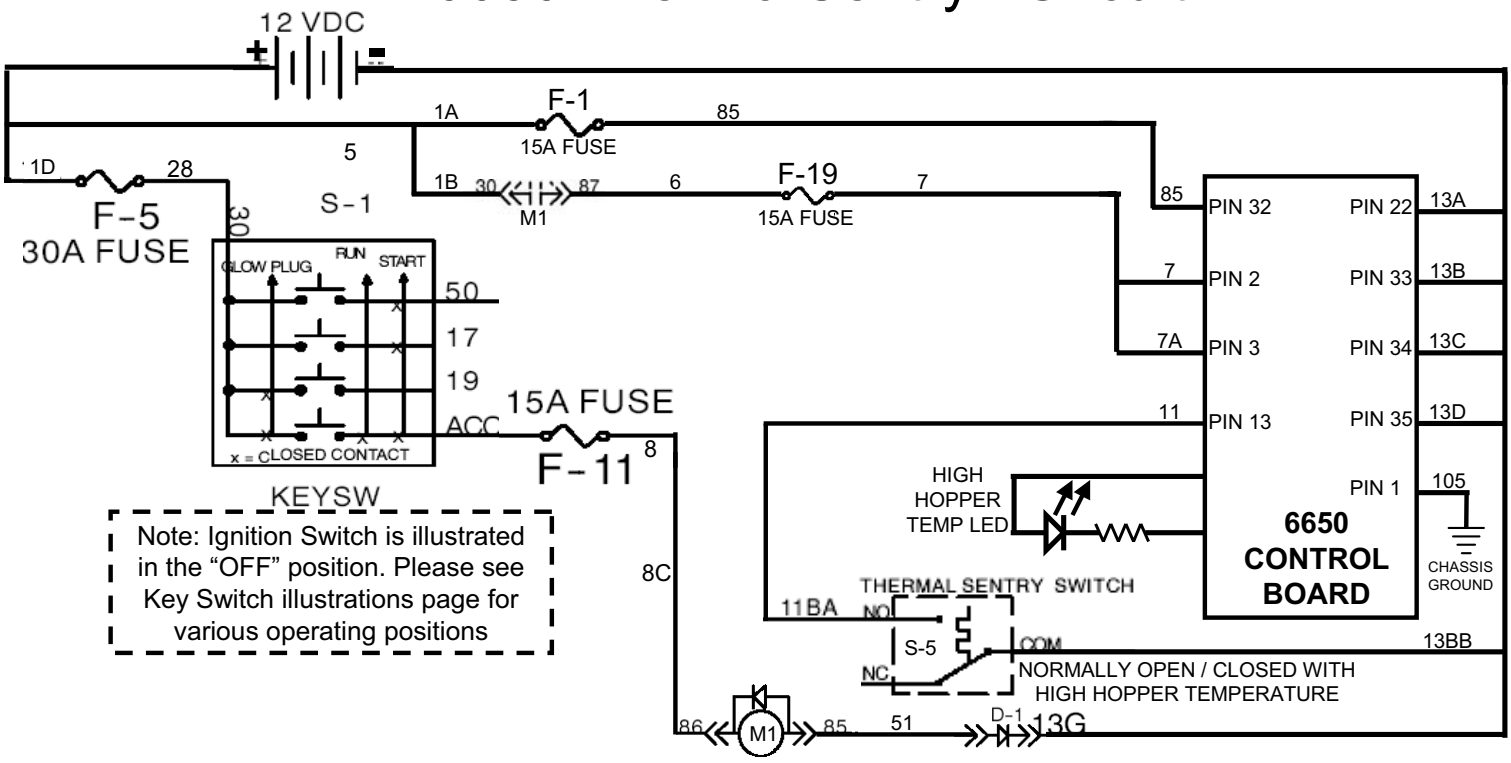
Go to **A** Next Page

Replace SHAKER MODULE

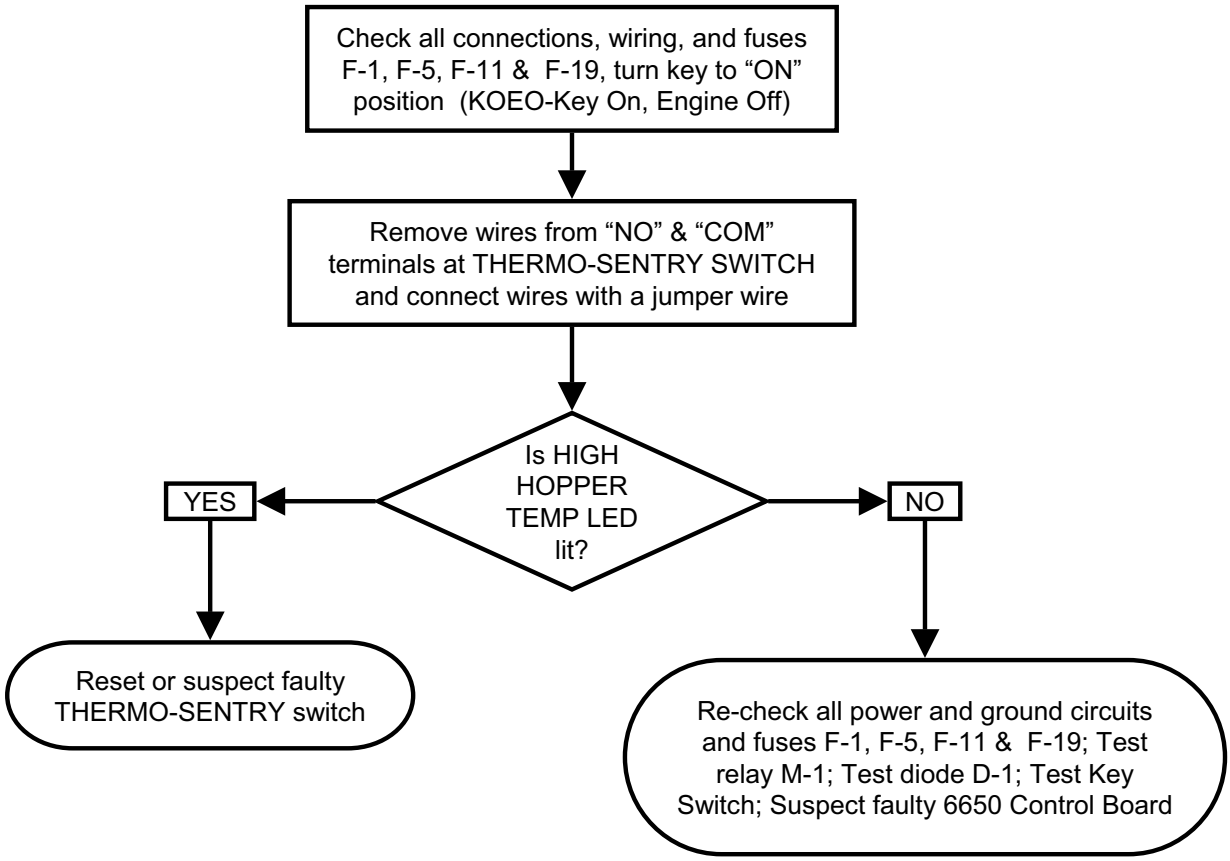
6650 Shaker Motor Circuit (continued)



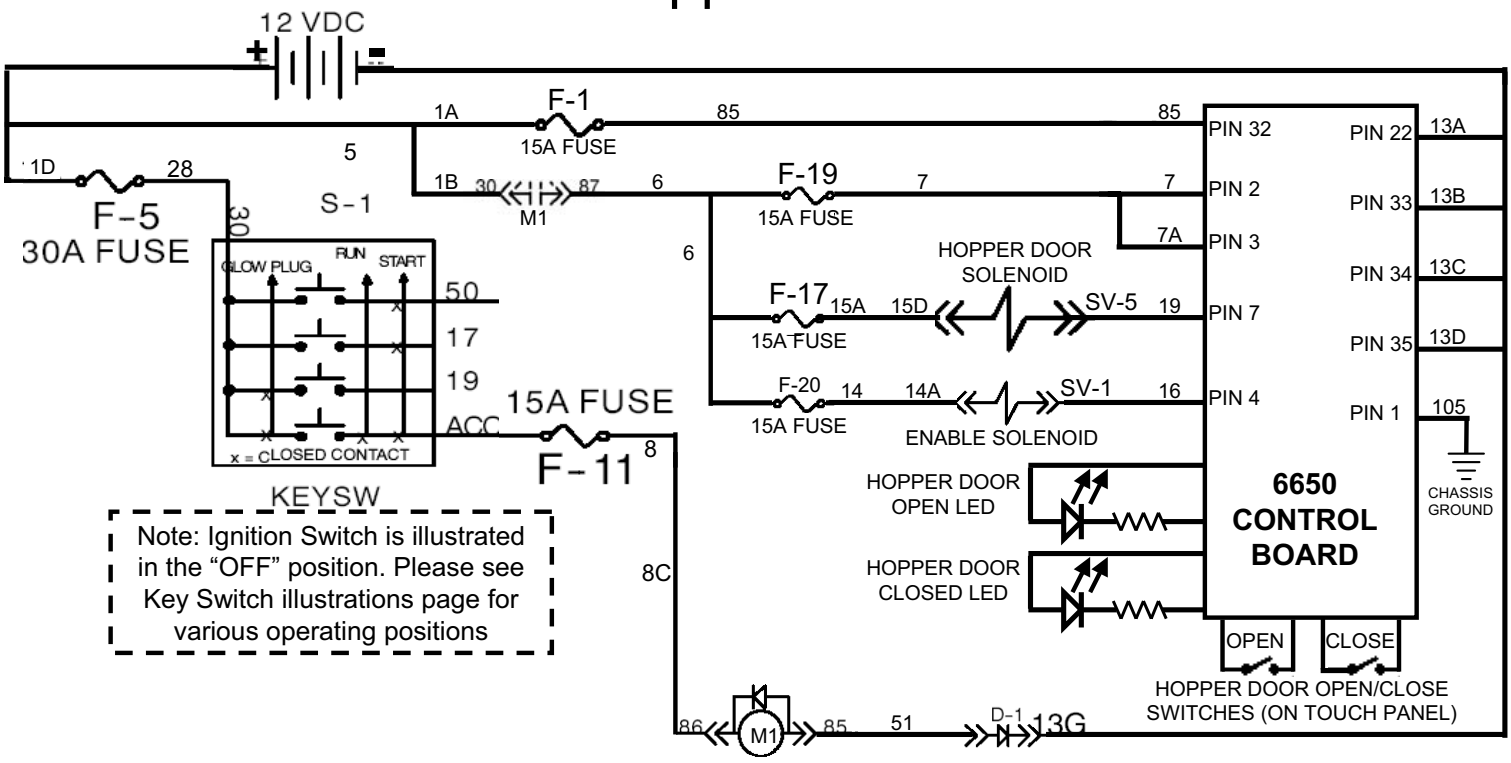
6650 Thermo-Sentry™ Circuit



Note: Ignition Switch is illustrated in the "OFF" position. Please see Key Switch illustrations page for various operating positions



6650 Hopper Door Circuit



Note: Ignition Switch is illustrated in the "OFF" position. Please see Key Switch illustrations page for various operating positions

NOTE: **DO NOT UNPLUG** connector at ENABLE SOLENOID (SV-1) or HOPPER DOOR SOLENOID (SV-5) when doing voltage tests. Unplugging connector will give false readings.

Check all connections, wiring, and fuses F-1, F-5, F-11, F-17 & F-19; Start engine and push HOPPER DOOR CLOSED button until HOPPER DOOR CLOSED LED is lit; Shut off engine; Turn key to "ON" position (KOEO-Key On, Engine Off)

Note: Typical Solenoid Valve Coil Resistance is 6 to 8 Ohms

Push HOPPER DOOR OPEN button - Is battery voltage measured across wires at ENABLE SOLENOID (SV-1) plug and HOPPER DOOR OPEN SOLENOID (SV-5) plug?

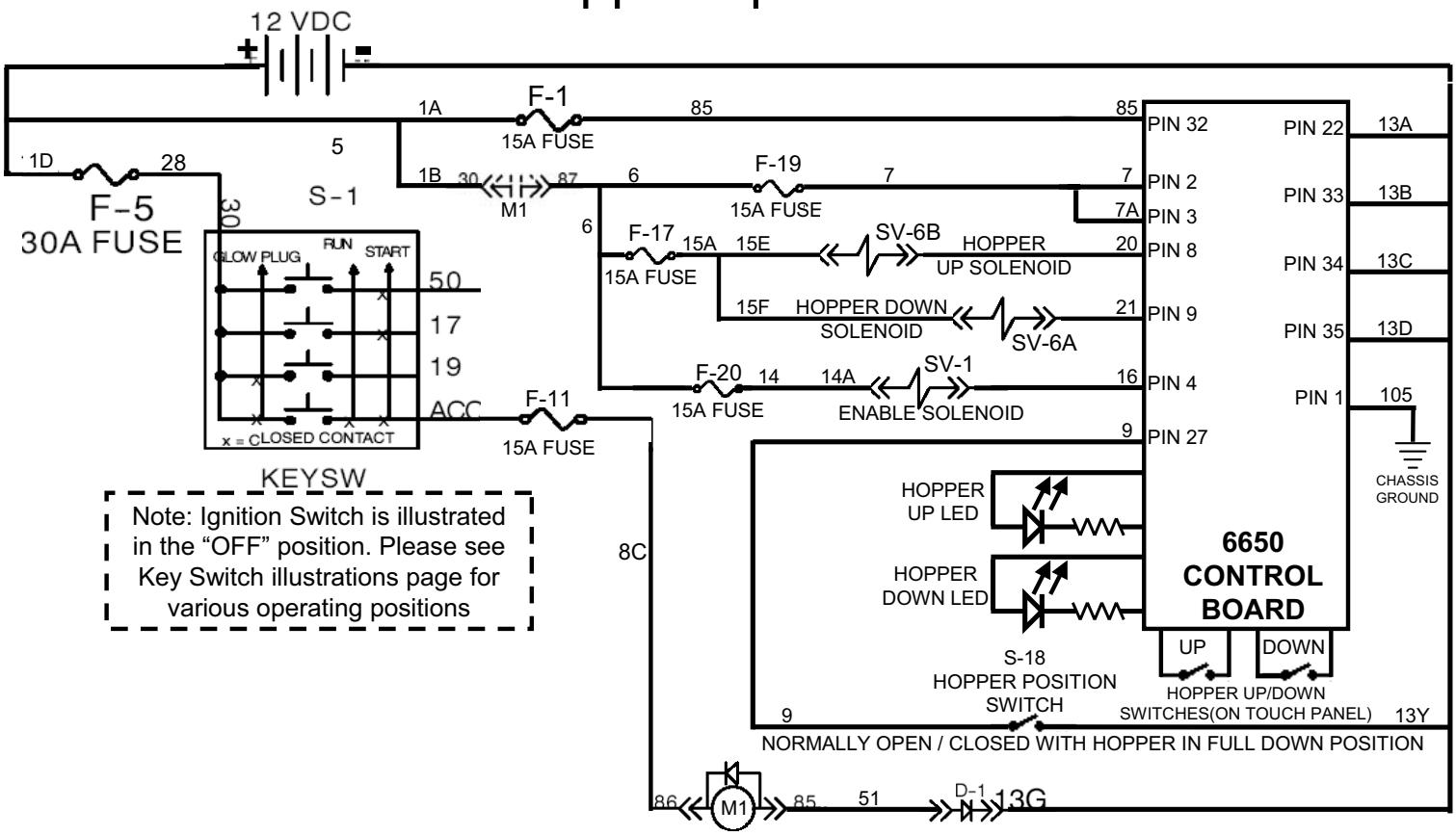
YES

NO

Repair or replace faulty hydraulic or mechanical components (refer to 6650 HYDRAULIC TROUBLESHOOTING); Suspect faulty HOPPER DOOR OPEN SOLENOID coil

Re-check all power & ground connections and fuses F-1, F-5, F-11, F-17 & F-19; Test relay M-1; Test diode D-1; Test Key Switch; Suspect faulty 6650 Control Board

6650 Hopper Up/Down Circuit



Note: Ignition Switch is illustrated in the "OFF" position. Please see Key Switch illustrations page for various operating positions

Check all connections, wiring, and fuses F-1, F-5, F-11, F-17 & F-19; Turn key to "ON" position (KOEO-Key On, Engine Off); Push and hold HOPPER UP button and measure voltage across wires at ENABLE SOLENOID (SV-1) plug, then HOPPER UP SOLENOID (SV-6B) plug. Push and hold HOPPER DOWN button and measure voltage across wires at ENABLE SOLENOID (SV-1) plug, then HOPPER DOWN SOLENOID (SV-6A).

NOTE: **DO NOT UNPLUG** connectors at ENABLE SOLENOID (SV-1) or HOPPER UP and DOWN SOLENOIDS (SV-6B & SV-6A) when doing voltage tests. Unplugging connector will give false readings.

Note: Typical Solenoid Valve Coil Resistance is 6 to 8 Ohms

Is battery voltage measured across wires at HOPPER UP and DOWN SOLENOIDS (SV-6B & SV-6A)?

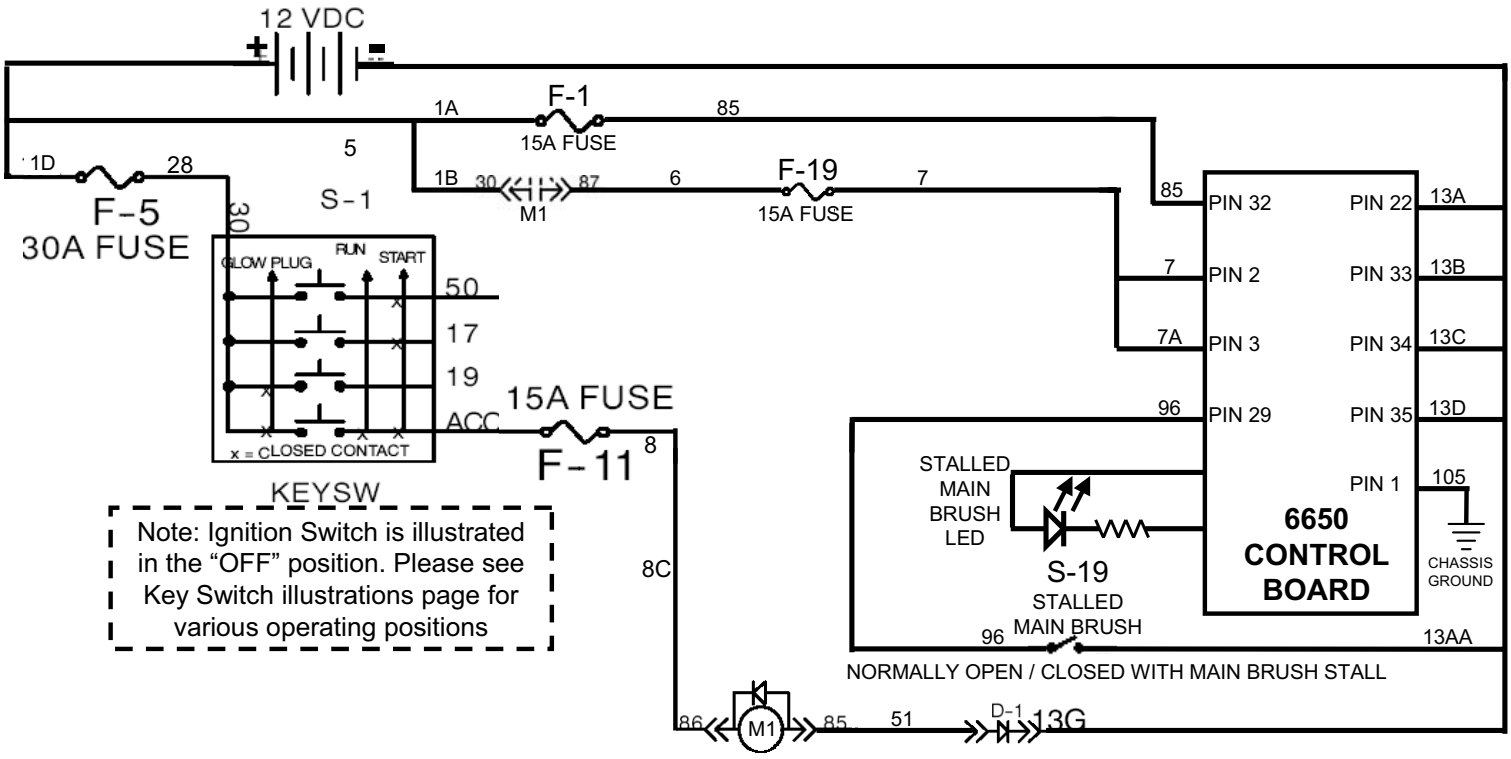
YES

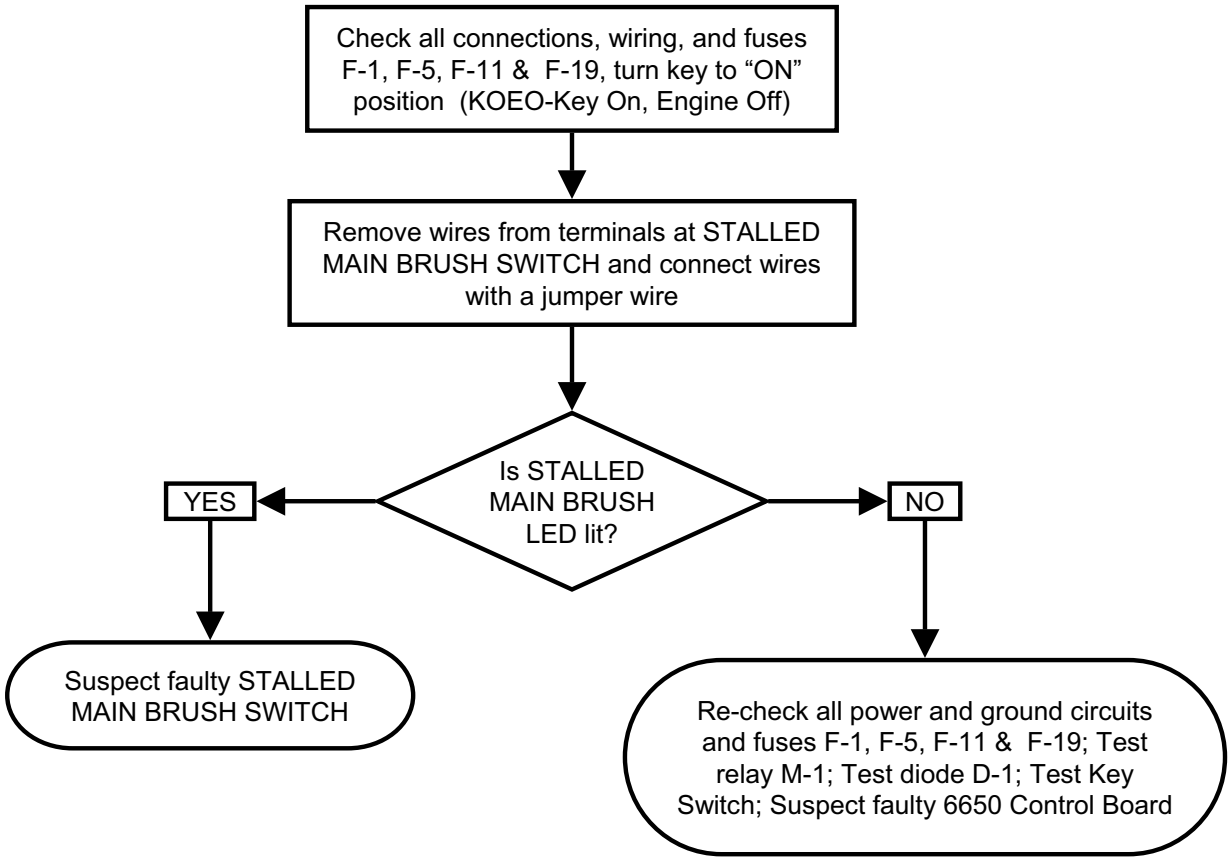
NO

Repair or replace faulty hydraulic or mechanical components (refer to 6650 HYDRAULIC TROUBLESHOOTING); Suspect faulty HOPPER UP or DOWN SOLENOID coil

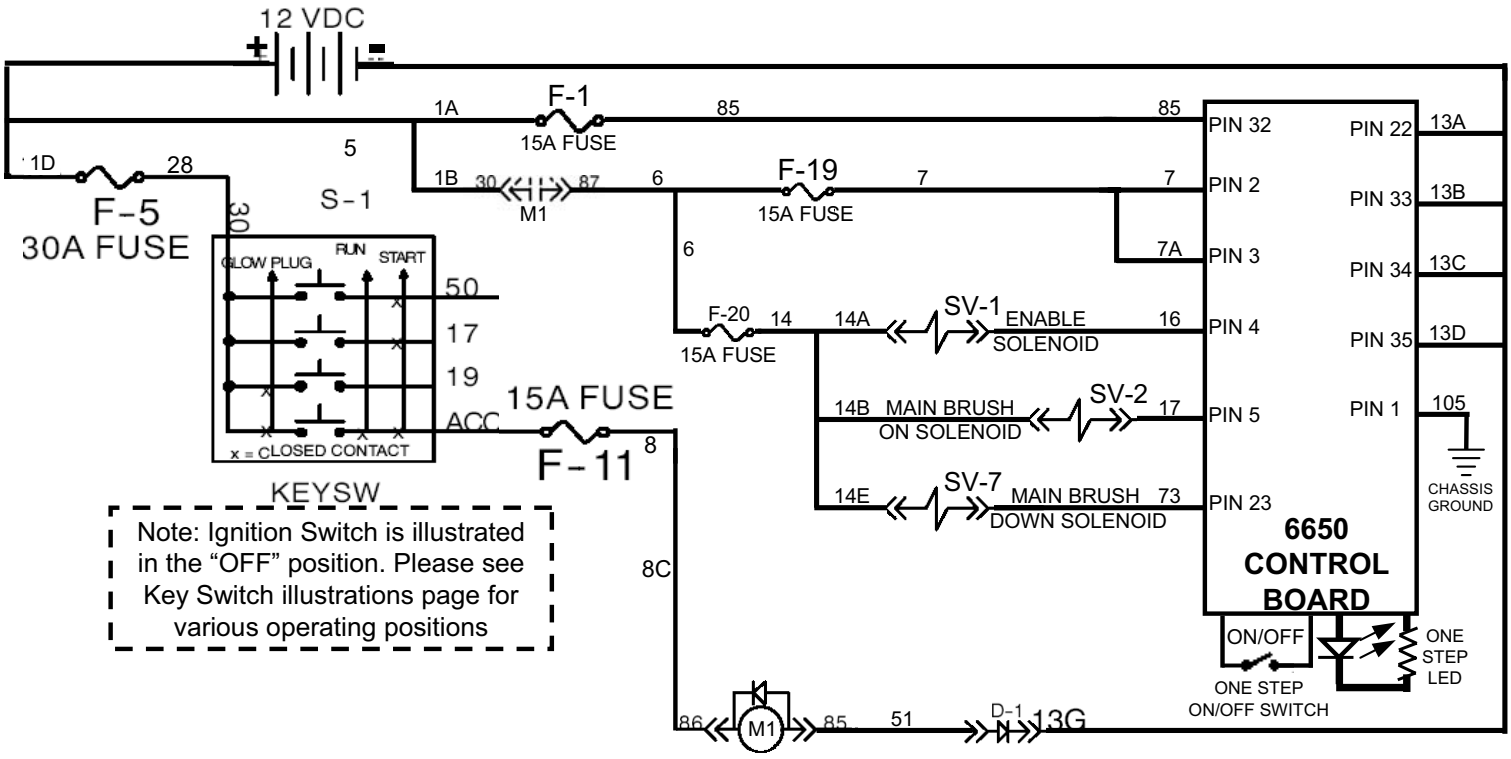
Re-check all power & ground connections and fuses F-1, F-5, F-11, F-17 & F-19; Test relay M-1; Test diode D-1; Test Key Switch; Suspect faulty 6650 Control Board

6650 Main Brush Stall Circuit





6650 Main Brush On & Down Circuit



NOTE: **DO NOT UNPLUG** connectors at ENABLE SOLENOID (SV-1), MAIN BRUSH ON SOLENOID (SV-2), or MAIN BRUSH DOWN SOLENOID (SV-7) when doing voltage tests. Unplugging connector will give false readings.

Check all connections, wiring, and fuses F-1, F-5, F-11, F-19 & F-20; Turn key to "ON" position (KOEO-Key On, Engine Off); Push ONE-STEP button and measure voltage across wires at ENABLE SOLENOID (SV-1), MAIN BRUSH ON SOLENOID (SV-2), and MAIN BRUSH DOWN SOLENOID (SV-7)

Note: Typical Solenoid Valve Coil Resistance is 6 to 8 Ohms

Is battery voltage measured across wires at ENABLE SOLENOID (SV-1), MAIN BRUSH ON SOLENOID (SV-2), and MAIN BRUSH DOWN SOLENOID (SV-7)?

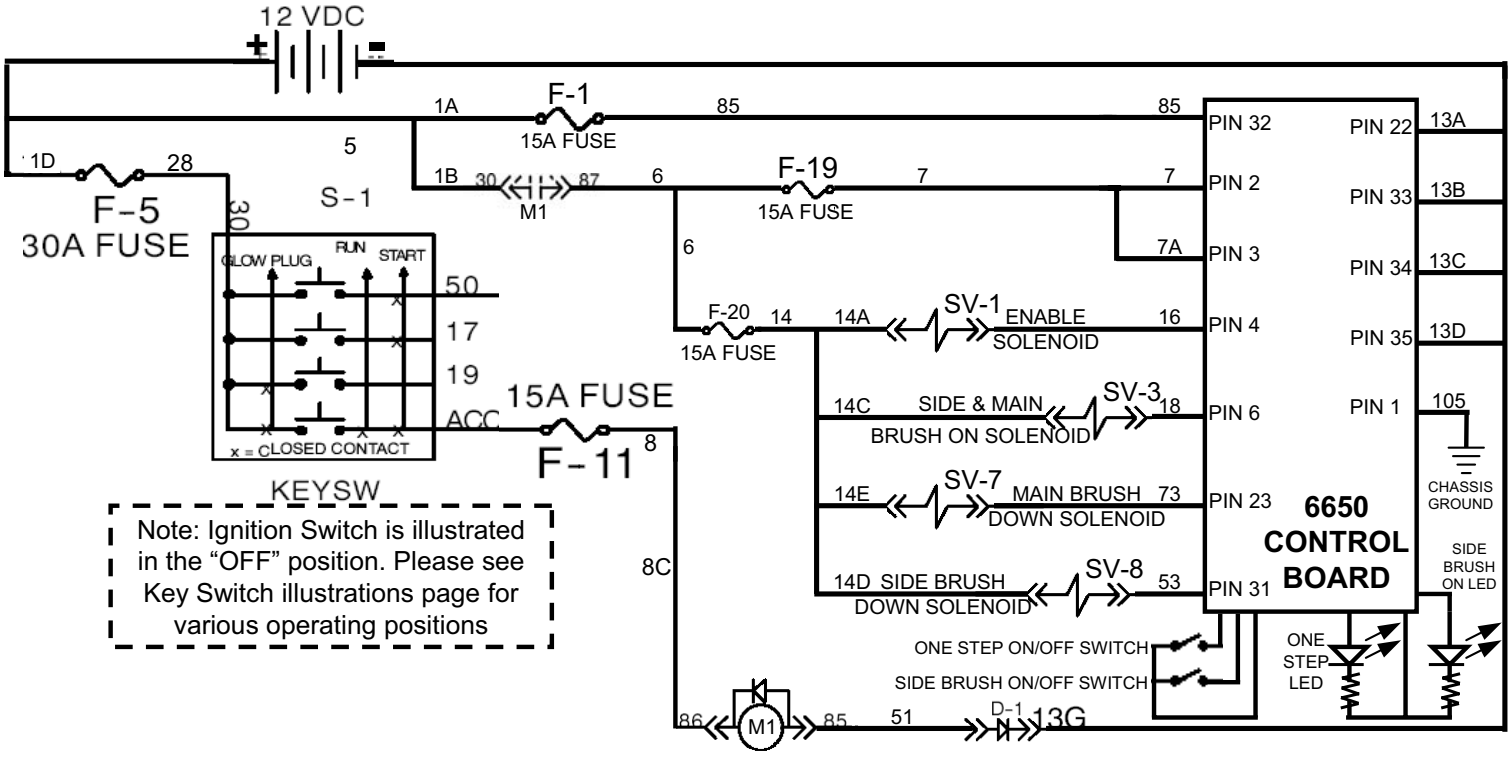
YES

NO

Repair or replace faulty hydraulic or mechanical components (refer to 6650 HYDRAULIC TROUBLESHOOTING); Suspect faulty SOLENOID coil

Re-check all power & ground connections and fuses F-1, F-5, F-11, F-19 & F-20; Test relay M-1; Test diode D-1; Test Key Switch; Suspect faulty 6650 Control Board

6650 Main & Side Brush On & Down Circuit



Note: Ignition Switch is illustrated in the "OFF" position. Please see Key Switch illustrations page for various operating positions

NOTE: **DO NOT UNPLUG** connectors at ENABLE SOLENOID (SV-1), SIDE & MAIN BRUSH ON SOLENOID (SV-3), MAIN BRUSH DOWN SOLENOID (SV-7), or SIDE BRUSH DOWN SOLENOID (SV-8) when doing voltage tests. Unplugging connectors will give false readings.

Check all connections, wiring, and fuses F-1, F-5, F-11, F-19 & F-20; Turn key to "ON" position (KOEO-Key On, Engine Off); Push ONE-STEP button (be sure that the SIDE BRUSH is also turned on) and measure voltage across wires at ENABLE SOLENOID (SV-1), SIDE & MAIN BRUSH ON SOLENOID (SV-3), MAIN BRUSH DOWN SOLENOID (SV-7), and SIDE BRUSH DOWN SOLENOID (SV-8)

Note: Typical Solenoid Valve Coil Resistance is 6 to 8 Ohms

Is battery voltage measured across wires at ENABLE SOLENOID (SV-1), SIDE & MAIN BRUSH ON SOLENOID (SV-3), MAIN BRUSH DOWN SOLENOID (SV-7), and SIDE BRUSH DOWN SOLENOID (SV-8)?

YES

NO

Repair or replace faulty hydraulic or mechanical components (refer to 6650 HYDRAULIC TROUBLESHOOTING); Suspect faulty SOLENOID coil

Re-check all power & ground connections and fuses F-1, F-5, F-11, F-19 & F-20; Test relay M-1; Test diode D-1; Test Key Switch; Suspect faulty 6650 Control Board

6650 Interlocks

Condition		Indication
To START Main & side brushes (ON & DOWN)		
Turn on ONE-STEP button (causes the following:) • Main & side brush on & down (Note: Main brush must be on for the side brush to operate) • Vacuum fan on • Shaker system off • Hopper door open	Solenoid Valves Energized: SV-1, SV-3, SV-5, SV-7, SV-8, SV-9	ONE-STEP LED ON SIDE BRUSH LED ON VACUUM FAN LED ON ENG.SPEED #2 or #3 LED ON HOPPER OPEN LED ON
To STOP Main & side brushes (OFF & UP) Note: Any one of the following will cause this to happen		
Turn off ONE-STEP button (causes the following:) • Main & side brush off & up • Vacuum fan off • Shaker system on • Hopper door closed	Solenoid Valves Energized: SV-1(6 to 8 seconds), then NONE	HOPPER CLOSED LED ON SHAKE FILTER LED ON (10 seconds)
Select LOW ENGINE SPEED		ENG.SPEED #1 LED ON
Close the hopper door		HOPPER CLOSED LED ON
Excessive hopper temperature		THERMO SENTRY LED ON HOPPER CLOSED LED ON
Lift the hopper	Solenoid Valves Energized: SV-1, SV-6A or SV-6B	HOPPER UP LED ON

Condition		Indication
To START Vacuum Fan (ON) Note: Any one of the following will cause this to happen		
Turn on ONE-STEP button	Solenoid Valves Energized: SV-1, SV-3, SV-5, SV-7, SV-8, SV-9	ONE-STEP LED ON SIDE BRUSH LED ON VACUUM FAN LED ON ENG.SPEED #2 or #3 LED ON HOPPER OPEN LED ON
Turn on VACUUM FAN button with ONE-STEP system OFF Note: This is the Vacuum Wand Mode – High engine speed is automatically selected	Solenoid Valves Energized: SV-9	VACUUM FAN LED ON
To STOP Vacuum Fan (OFF) Note: Any one of the following will cause this to happen		
Turn off ONE-STEP button	Solenoid Valves Energized: SV-1(6 to 8 seconds), then NONE	HOPPER CLOSED LED ON SHAKE FILTER LED ON (10 seconds)
Turn off VACUUM FAN button	Solenoid Valves Energized: NONE (W/ ONE-STEP SYSTEM OFF)	VACUUM FAN LED OFF
Turn on SHAKER button		VACUUM FAN LED OFF SHAKER LED ON

6650 Interlocks (continued)

Condition		Indication
To START Shaker System (ON) Note: Any one of the following will cause this to happen		
Turn on SHAKER button	Solenoid Valves Energized: NONE (W/ ONE-STEP SYSTEM OFF)	SHAKE FILTER LED ON (10 seconds)
Turn off VACUUM FAN button (Note: Triggers an automatic 10 second shake cycle)		SHAKE FILTER LED ON (10 seconds)
Turn off ONE-STEP button (Note: Triggers an automatic 10 second shake cycle)	Solenoid Valves Energized: SV-1(6 to 8 seconds), then NONE	HOPPER CLOSED LED ON SHAKE FILTER LED ON (10 seconds)
To STOP Shaker System (OFF) Note: Any one of the following will cause this to happen		
Turn on ONE-STEP button	Solenoid Valves Energized: SV-1, SV-3, SV-5, SV-7, SV-8, SV-9	ONE-STEP LED ON (See prev. page) SHAKE FILTER LED OFF
Turn on VACUUM FAN button	Solenoid Valves Energized: SV-9 (W/ ONE-STEP SYSTEM OFF)	VACUUM FAN LED ON SHAKE FILTER LED OFF
Turn off SHAKER button	Solenoid Valves Energized: NONE (W/ ONE-STEP SYSTEM OFF)	SHAKE FILTER LED OFF
SHAKER system times out		SHAKE FILTER LED OFF

Condition		Indication
To START Hopper Lift or Lower		
PUSH and HOLD HOPPER UP or DOWN button	Solenoid Valves Energized: SV-1, SV-6A or SV-6B	HOPPER UP or DOWN LED ON
To STOP Hopper Lift or Lower		
Release HOPPER UP or DOWN button	Solenoid Valves Energized: NONE	HOPPER UP or DOWN LED OFF
Note: The hopper will lift or lower only while the button is held or until the end of travel. Either operation will automatically cancel the One-Step operation. If engine is at low speed, it will automatically increase to medium. The hopper door is automatically closed when hopper is fully lowered and hopper down switch is closed.		

Condition		Indication
To OPEN Hopper Door Note: Any one of the following will cause this to happen		
Turn on HOPPER OPEN button	Solenoid Valves Energized: SV-1(6 to 8 seconds), then NONE	HOPPER OPEN LED ON
Turn on ONE-STEP button	Solenoid Valves Energized: SV-1, SV-3, SV-5, SV-7, SV-8, SV-9	ONE-STEP LED ON (See prev. page) HOPPER OPEN LED ON
To CLOSE Hopper Door Note: Any one of the following will cause this to happen		
Turn on HOPPER CLOSE button	Solenoid Valves Energized: SV-1(6 to 8 seconds), then NONE	HOPPER UP or DOWN LED ON
Turn off ONE-STEP button		HOPPER UP or DOWN LED ON
Fully lower hopper		HOPPER UP or DOWN LED ON
Excessive hopper temperature		MO-SENTRY LED ON

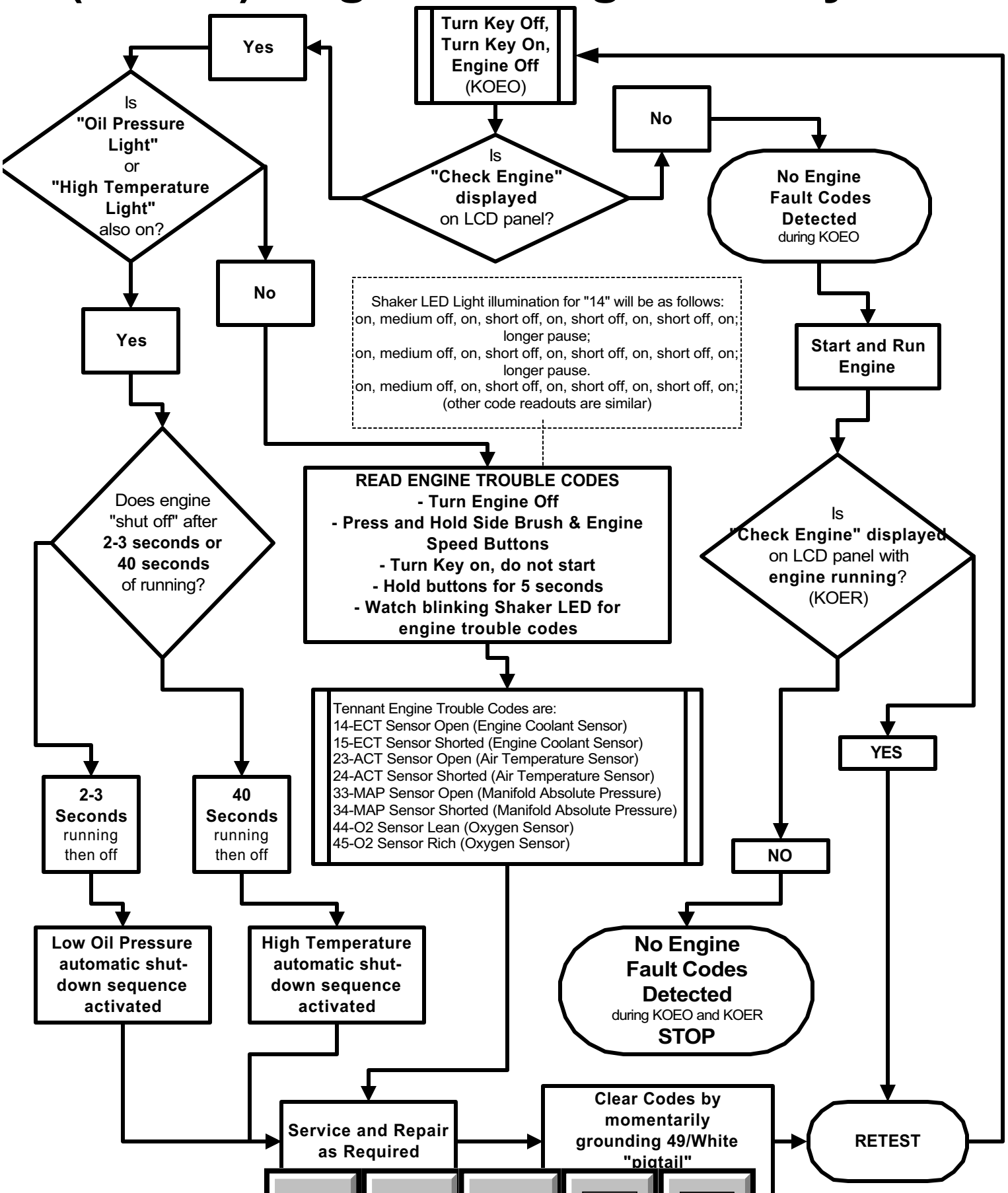
6650 Operational/Diagnostic/Maintenance Modes

Six Operational Modes

MODE & DESCRIPTION	TO INITIATE
1) NORMAL MODE Use this mode to perform normal sweeping functions with machine	• Turn OFF machine • START and RUN Machine
2) MANUAL MODE Use this mode to turn on any system without regard to the state of inputs, sensors or interlocks	• Turn OFF machine • Press and hold SHAKER and ENGINE SPEED buttons • START and RUN Machine • Hold buttons for 5 seconds and release • The word “MANUAL” should be displayed on the LCD panel display
3) INPUT DISPLAY MODE Use this mode to observe if the inputs to the machine control board are operating correctly - the LED’s on instrument panel will show the state of each input	• Turn OFF machine • Press and hold HOPPER OPEN and HOPPER CLOSED buttons • START and RUN Machine • Hold buttons for 5 seconds and release • The word “INPUT” should be displayed on the LCD panel display
4) SELF TEST / DISPLAY ERROR / DISPLAY SOFTWARE REVISION MODE Use this mode to run a self-test on all of the machine control board outputs – when test is complete, the software revision is displayed – if panel passes test, “OK” will also be displayed - if panel fails test, the pin number of the failed output(s) is also displayed	• Turn OFF machine • Press and hold VACUUM FAN and ENGINE SPEED buttons • START and RUN Machine • Hold buttons for 5 seconds and release • The software revision and any self-test faults should be displayed on the LCD panel display NOTE: If “OPEN LOAD” or “SHORT LOAD” is displayed after pin number, then the self-test found a load that is electrically open or shorted to BATTERY + (check output wires or replace load as needed)
5) DISPLAY “CHECK ENGINE FAULTS” MODE Use this mode to decode any ZENITH ENGINE CONTROLLER (ZEEMS) faults when the words “CHECK ENGINE” are displayed on the LCD panel	• Turn OFF machine • Press and hold SIDE BRUSH and ENGINE SPEED buttons • Turn key switch to “ON”, but **DO NOT START** the engine • Hold buttons for 5 seconds and release • The ZEEMS engine control faults will now be displayed by blinking the SHAKER LED (see “6650 ZEEMS ENGINE FAULT CODES”)
6) CONTRAST ADJUST MODE Use this mode to adjust the contrast of the LCD panel display	• Turn OFF machine • Press and hold HOPPER UP and HOPPER DOWN buttons • Turn key switch to “ON”, but **DO NOT START** the engine • Hold buttons for 5 seconds and release • The word “CONTRAST” should be displayed on the LCD panel NOTE: Hold the HOPPER DOWN button to darken the LCD display Hold the HOPPER UP button to lighten the LCD display

TO EXIT FROM ANY MODE, THE KEY SWITCH MUST BE CYCLED “OFF”

6650 with ZEEMS (Zenith) Engine Management System



6650 ZEEMS Check Engine Fault Codes

MACHINE STATUS	LCD PANEL
Key On, Engine Off (KOEO) No engine faults detected	Fuel level & hour meter reading displayed
Key On, Engine Running (KOER) No engine faults detected	Fuel level & hour meter reading displayed
Key On, Engine Running (KOER) Engine fault(s) detected	"CHECK ENGINE" displayed (see MODE 5 on previous page)
Key On, Engine Off (KOEO) Engine fault(s) detected	"CHECK ENGINE" displayed (see MODE 5 on previous page)
Key On, Engine Running (KOER) High engine temperature sensed **AUTOMATIC ENGINE SHUTDOWN OCCURS** NOTE: If key switch is turned off and machine restarted, engine will run 40 seconds until another automatic shutdown	"CHECK ENGINE" displayed (see MODE 5 on previous page)
Key On, Engine Running (KOER) Low engine oil pressure sensed **AUTOMATIC ENGINE SHUTDOWN OCCURS** NOTE: If key switch is turned off and machine restarted, engine will run 2 to 3 seconds until another automatic shutdown	"CHECK ENGINE" displayed (see MODE 5 on previous page)

CONDITION NOTE: See MODE 5 on previous page	FAULT CODE DISPLAYED (ON SHAKER LED)
Beginning of fault codes, or OK if no other codes displayed	12, 12, 12
Engine coolant sensor OPEN	14, 14, 14
Engine coolant sensor SHORTED	15, 15, 15
Air temp sensor OPEN	23, 23, 23
Air temp sensor SHORTED	24, 24, 24
MAP sensor OPEN, circuit voltage >4.98V	33, 33, 33
MAP sensor SHORTED	34, 34, 34

TO CLEAR FAULT CODES AND TURN OFF "CHECK ENGINE" WARNING
Ground PIN # 16 of the WHITE CONNECTOR at the ZENITH ENGINE CONTROLLER while engine is running (Note: Some controllers have a wire pigtail that is connected to PIN # 16)

6650 Machine Control Board Pin Functions

PIN #	INPUT or OUTPUT	FUNCTION	ACTIVE VOLTAGE	INACTIVE VOLTAGE
1	INPUT	Chassis ground	Battery ground (B-)	Battery ground (B-)
2,3	INPUT	Battery positive (B+)	Battery positive (B+)	0 VDC
4,5,6,7,8,9, 10,11	OUTPUT	Low side drivers	0 VDC	Battery positive (B+)
12	NOT PRESENTLY USED			
13,14,15,16	INPUT	DIGITAL - Activates when grounded	0 VDC	5 VDC
17,18,19	NOT PRESENTLY USED			
20,21	OUTPUT	Governor speed control	OPEN	Battery positive (B+)
22	INPUT	Battery ground (B-)	Battery ground (B-)	Battery ground (B-)
23,24	OUTPUT	Low side drivers	0 VDC	Battery positive (B+)
25,26,27	INPUT	DIGITAL - Activates when grounded	0 VDC	5 VDC
28	INPUT	Fuel gauge input	>100 ohms = full tank <5 ohms = empty tank	
29	INPUT	DIGITAL - Activates when grounded	0 VDC	5 VDC
30	NOT PRESENTLY USED			
31	OUTPUT	Low side driver	0 VDC	Battery positive (B+)
32	INPUT	Memory storage	Battery positive (B+)	Battery positive (B+)
33,34,35	INPUT	Battery ground (B-)	Battery ground (B-)	Battery ground (B-)

MODEL
6650
HYDRAULIC
Troubleshooting Charts

BEFORE CONDUCTING TESTS:

*** Read and Follow ALL Safety Warnings and Precautions in Operator's Manual**

*** Engine & Hydraulic Oil Must Be At Normal Operating Temperatures after Running Machine and Hydraulics a Minimum of 5 Minutes**

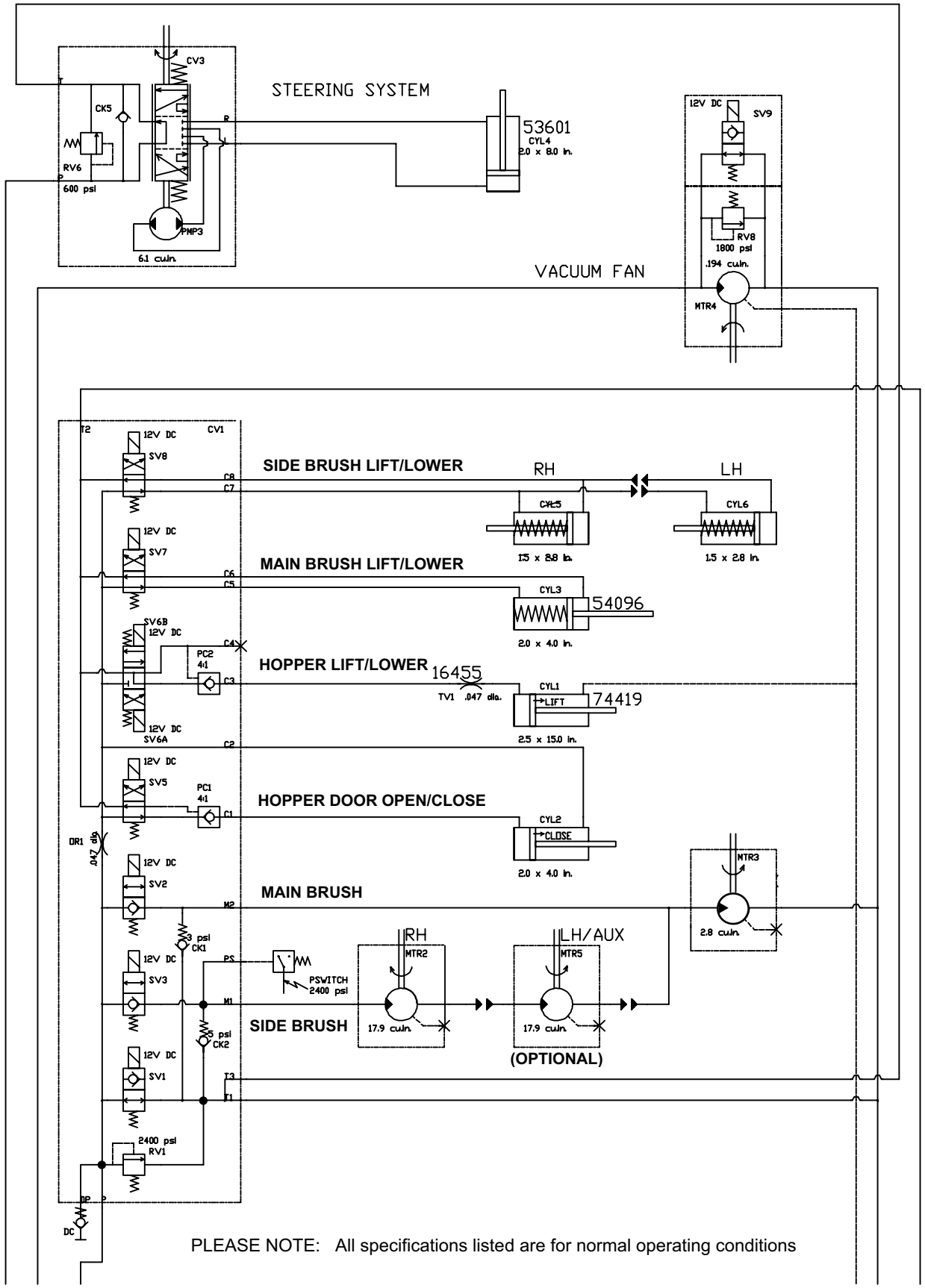
*** Examine Machine For Any Linkage Binding or Mechanical Problems**

DURING TESTS:

*** Maintain Normal Main Brush Pressure as Listed in Operator's Manual**

*** Call Technical Services if Diagnostic Time Exceeds One Hour With Unknown Cause or Course of Action**

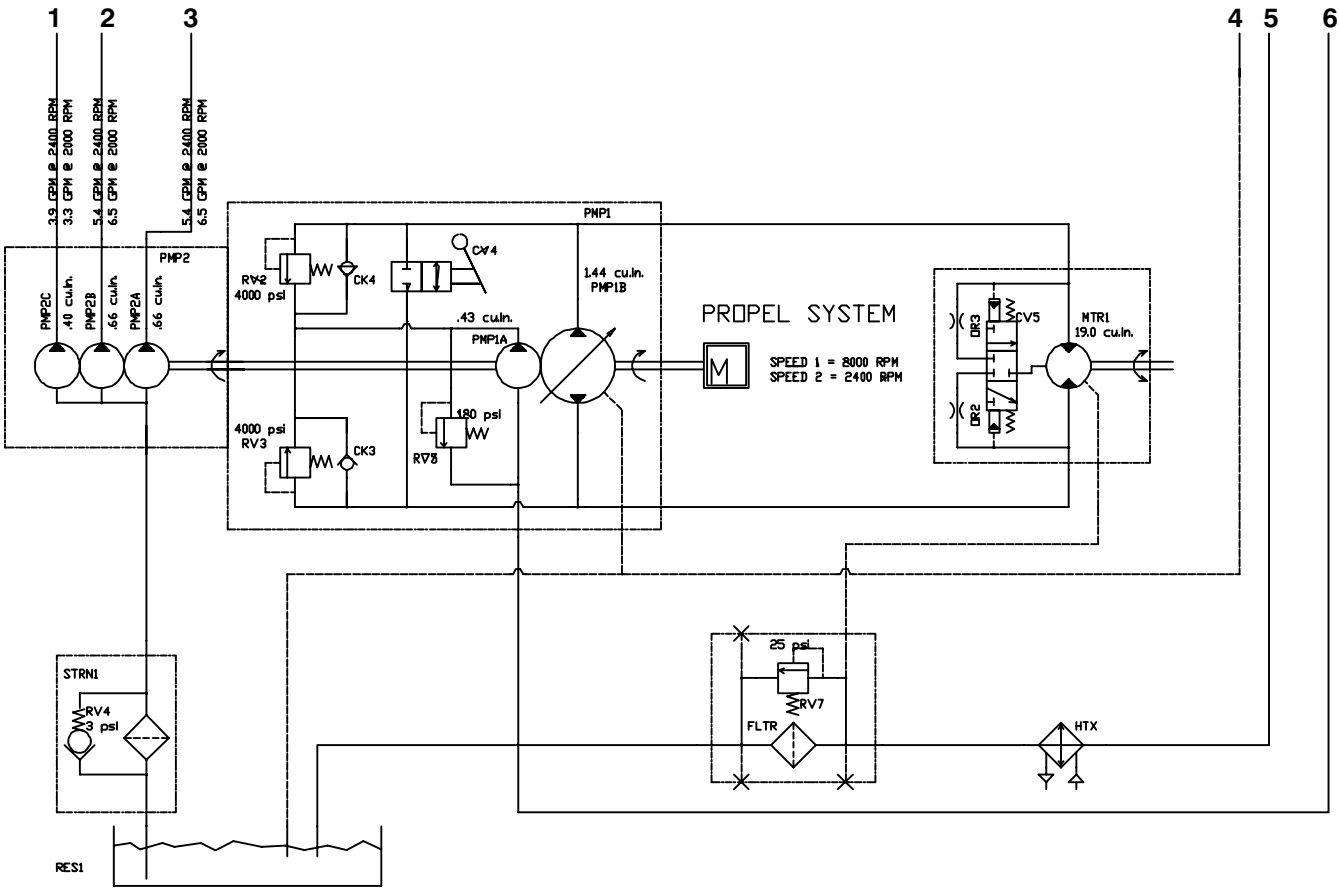
6650 OVERALL HYDRAULIC DIAGRAM
(Part 1 of 2)



PLEASE NOTE: All specifications listed are for normal operating conditions

1 2 3 4 5 6

6650 OVERALL HYDRAULIC DIAGRAM
(Part 2 of 2)

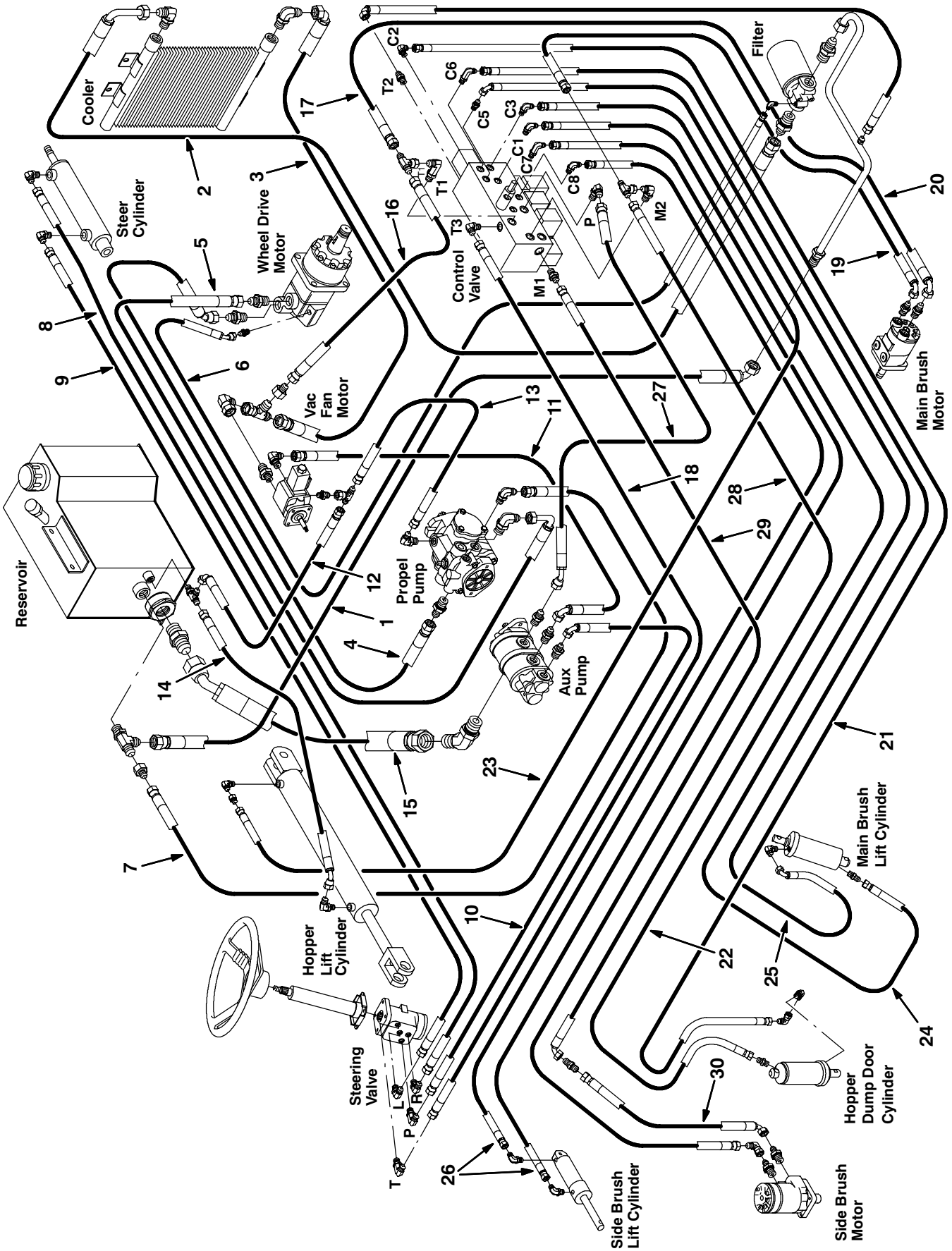


EXPLANATION OF ABBREVIATIONS

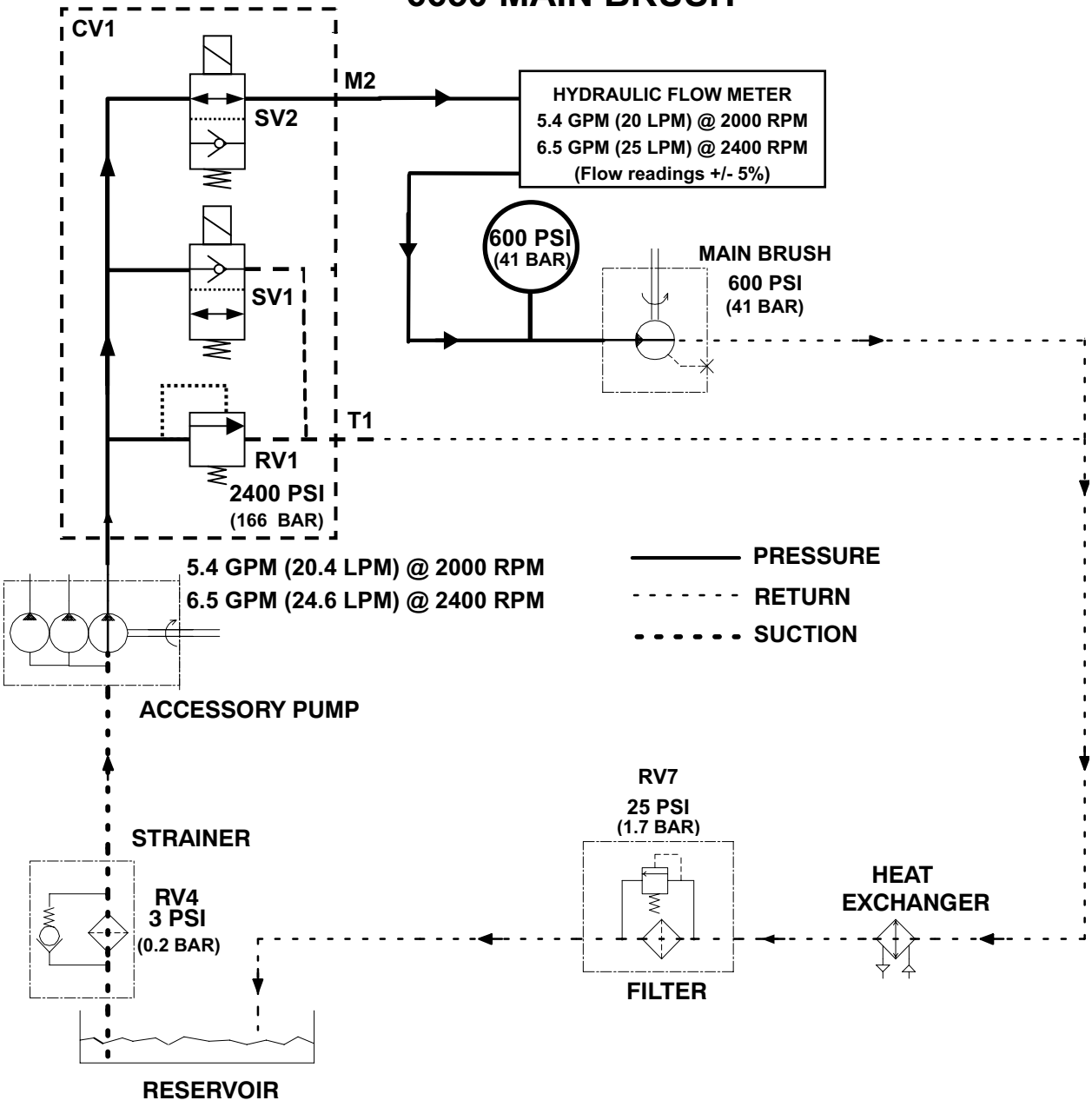
AUX.....Auxiliary
CK.....Check Valve
CM.....Centimeters
CU.....Cubic
CV.....Control Valve
CYL.....Cylinder
DC.....Disconnect Coupler (Hydraulic)
DC.....Direct Current (Electrical)
FLTR.....Filter
GPM.....Gallons per Minute
HTX.....Heat Exchanger
IN.....Inches
LH.....Left Hand
LPM.....Liters per Minute
M.....Motor (Combustion)
MTR.....Motor (Hydraulic)
OR.....Orifice
PC.....Pilot Port Check Valve
PMP.....Pump
PSI.....Pounds per Square Inch
PSWITCH.....Pressure Switch
RES.....Reservoir
RH.....Right Hand
RPM.....Revolutions per Minute
RV.....Relief Valve
STRN.....Strainer
SV.....Solenoid Valve
TV.....Throttle Valve
V.....Volts

PLEASE NOTE: All specifications listed are for normal operating conditions

6650 HYDRAULIC HOSE ROUTING



6650 MAIN BRUSH



MAIN BRUSH RPM

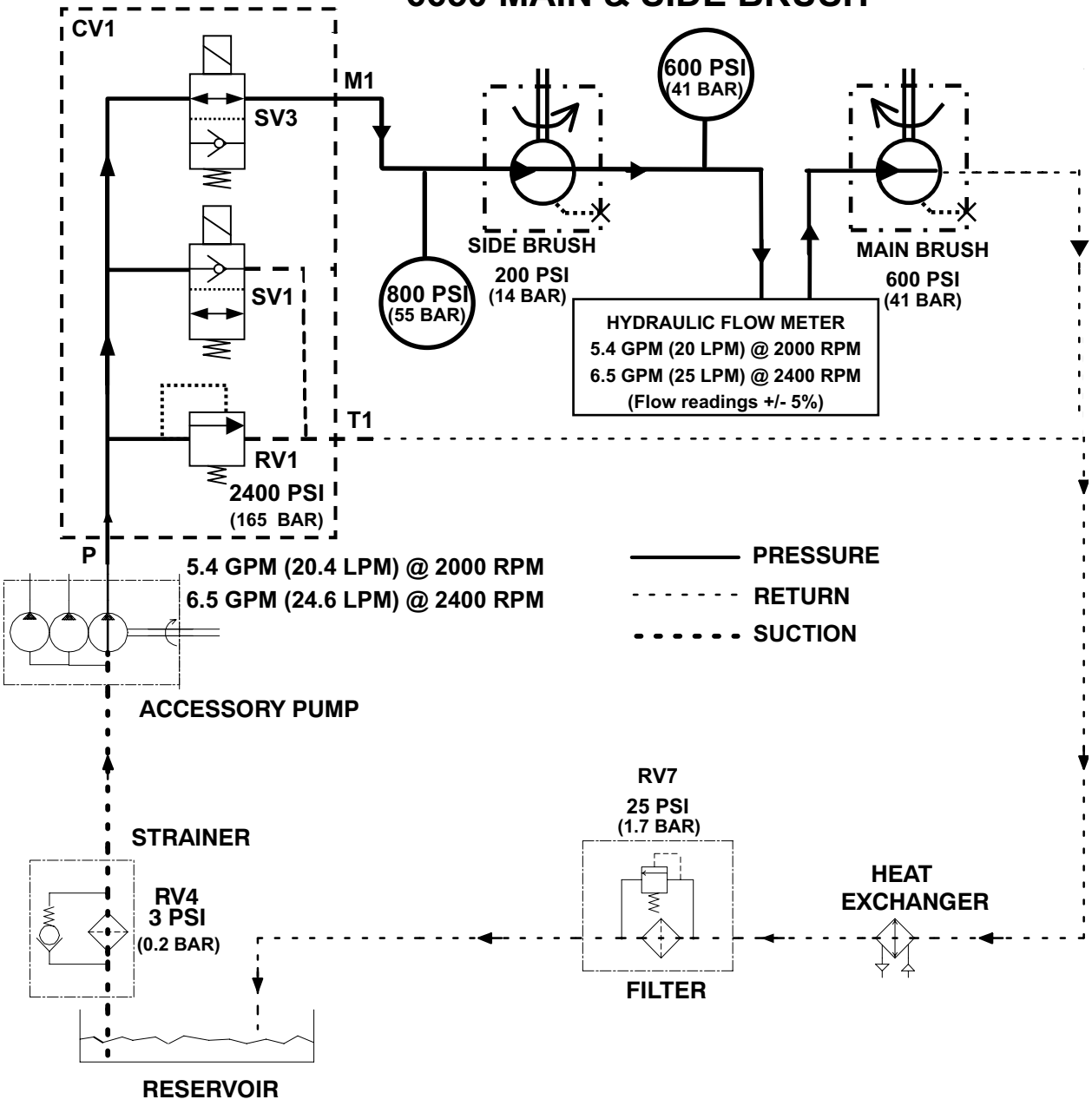
460 RPM +/- 25 RPM @ 2000 RPM

550 RPM +/- 25 RPM @ 2400 RPM

Note: Specs. shown are for main brush down with 2 inch (5 cm) brush pattern

PLEASE NOTE: All specifications listed are for normal operating conditions

6650 MAIN & SIDE BRUSH



MAIN BRUSH RPM

460 RPM +/- 25 RPM @ 2000 RPM

550 RPM +/- 25 RPM @ 2400 RPM

SIDE BRUSH RPM

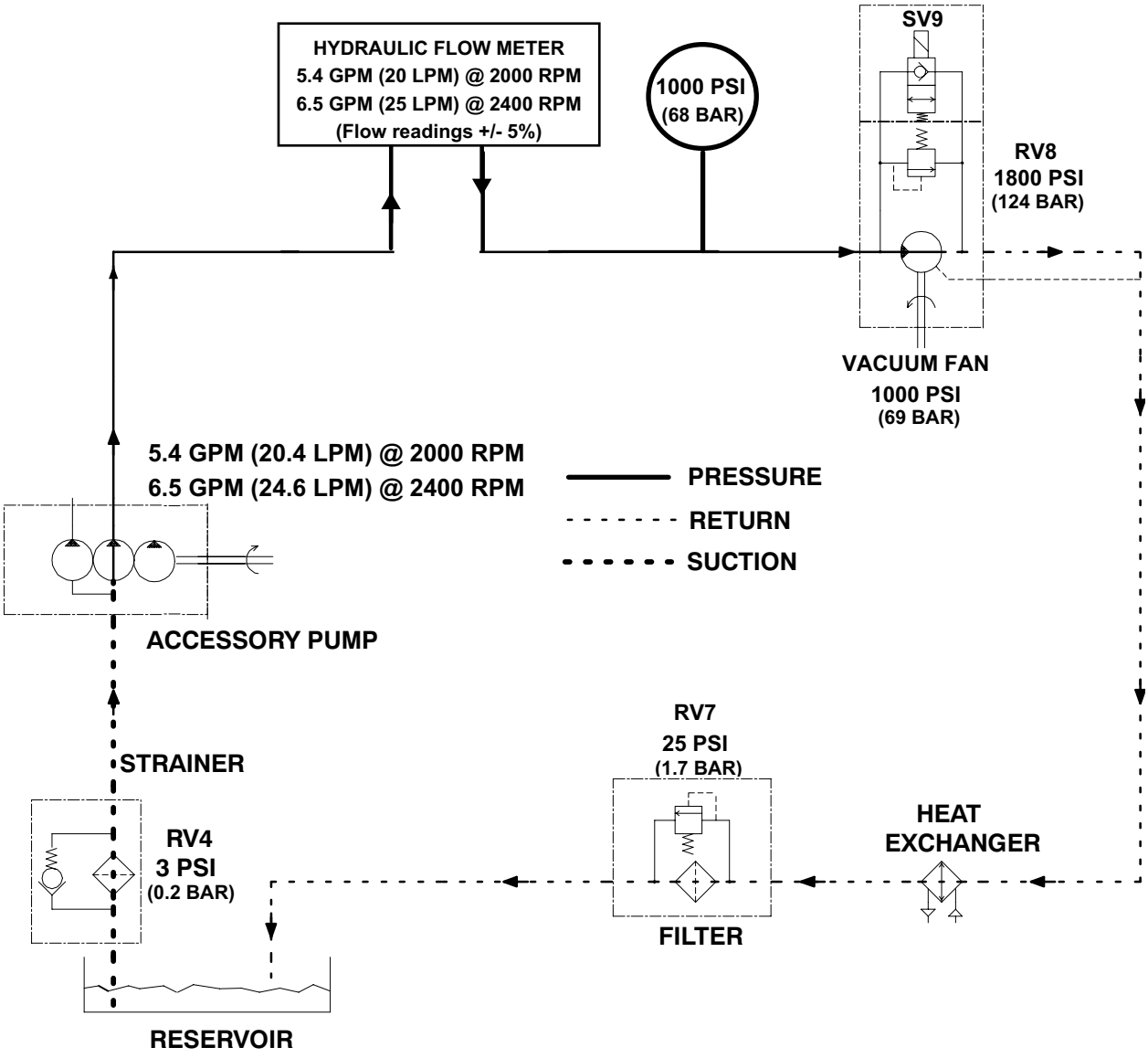
75 RPM +/- 10 RPM @ 2000 RPM

90 RPM +/- 10 RPM @ 2400 RPM

Note: Specs. shown are for main & side brushes down, with 2 inch (5 cm) main brush pattern

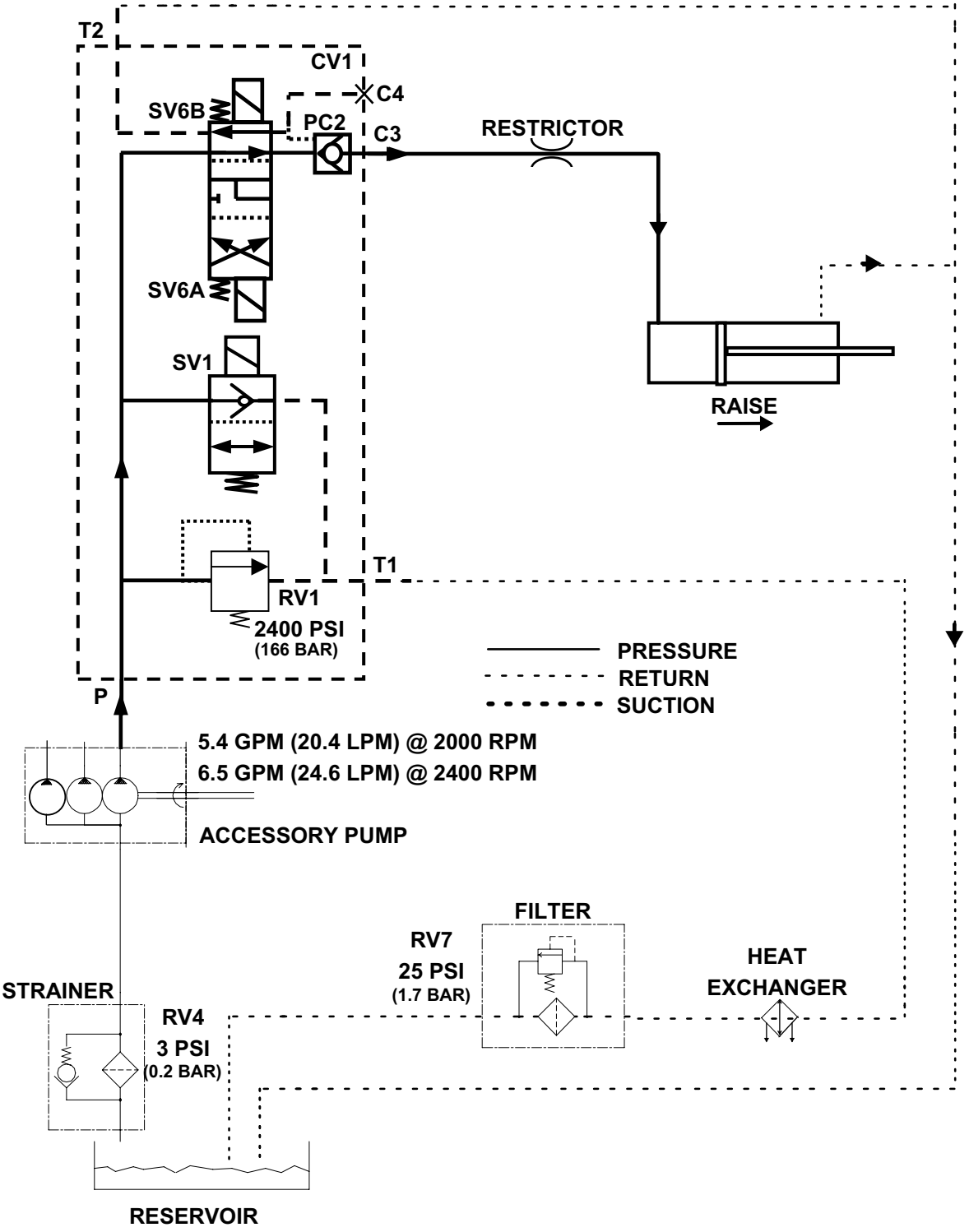
PLEASE NOTE: All specifications listed are for normal operating conditions

6650 VACUUM FAN



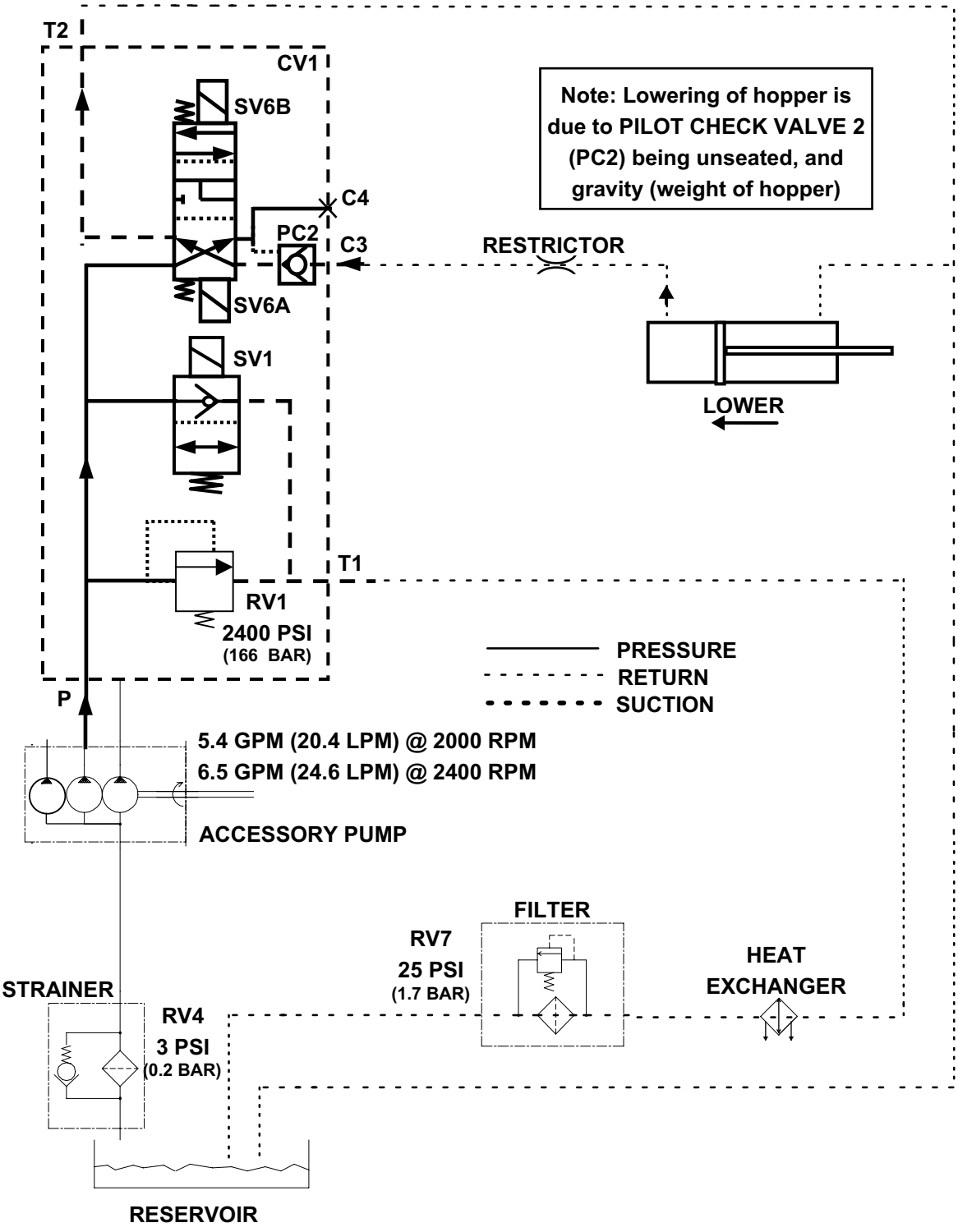
PLEASE NOTE: All specifications listed are for normal operating conditions

6650 RAISE HOPPER



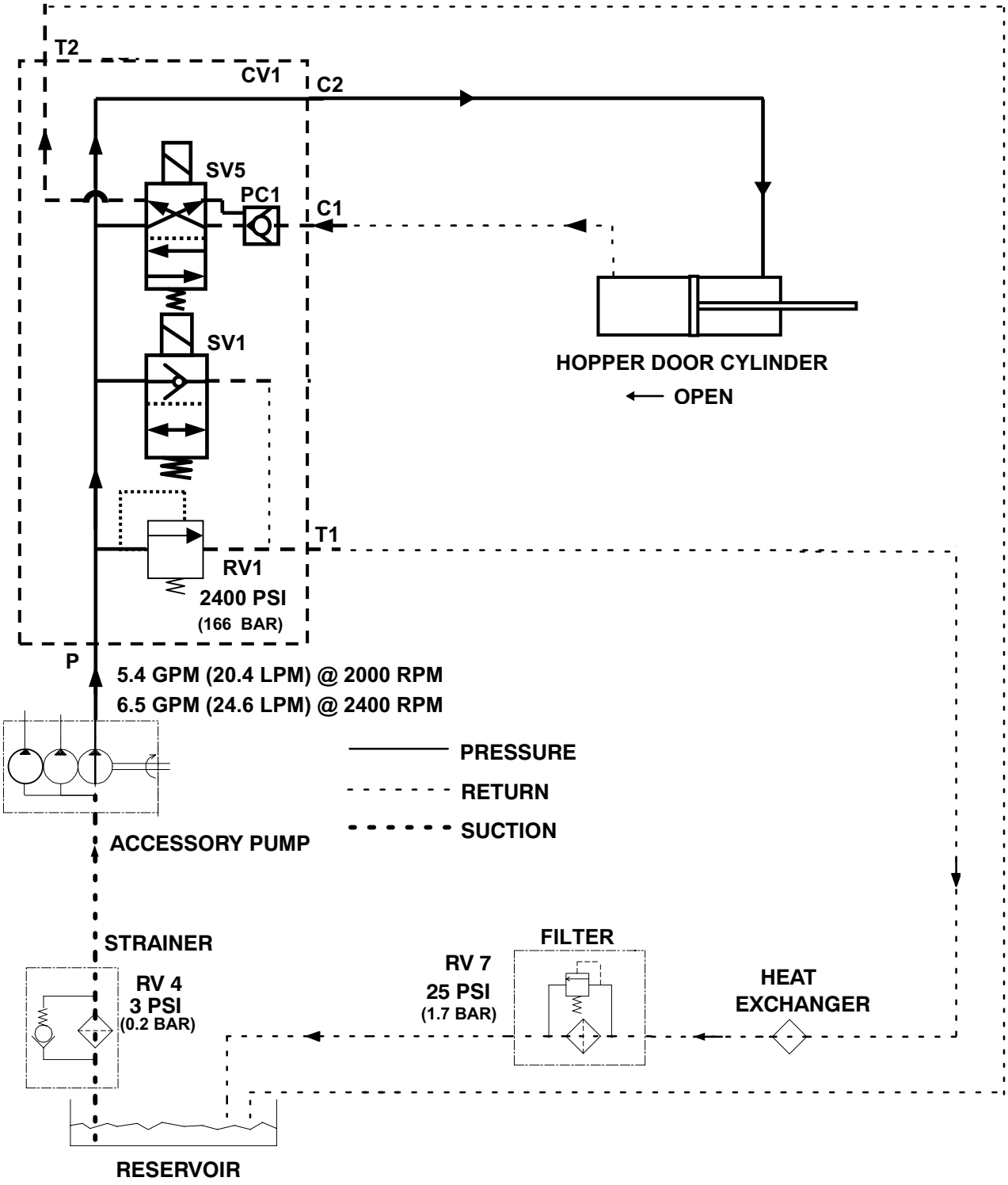
PLEASE NOTE: All specifications listed are for normal operating conditions

6650 LOWER HOPPER



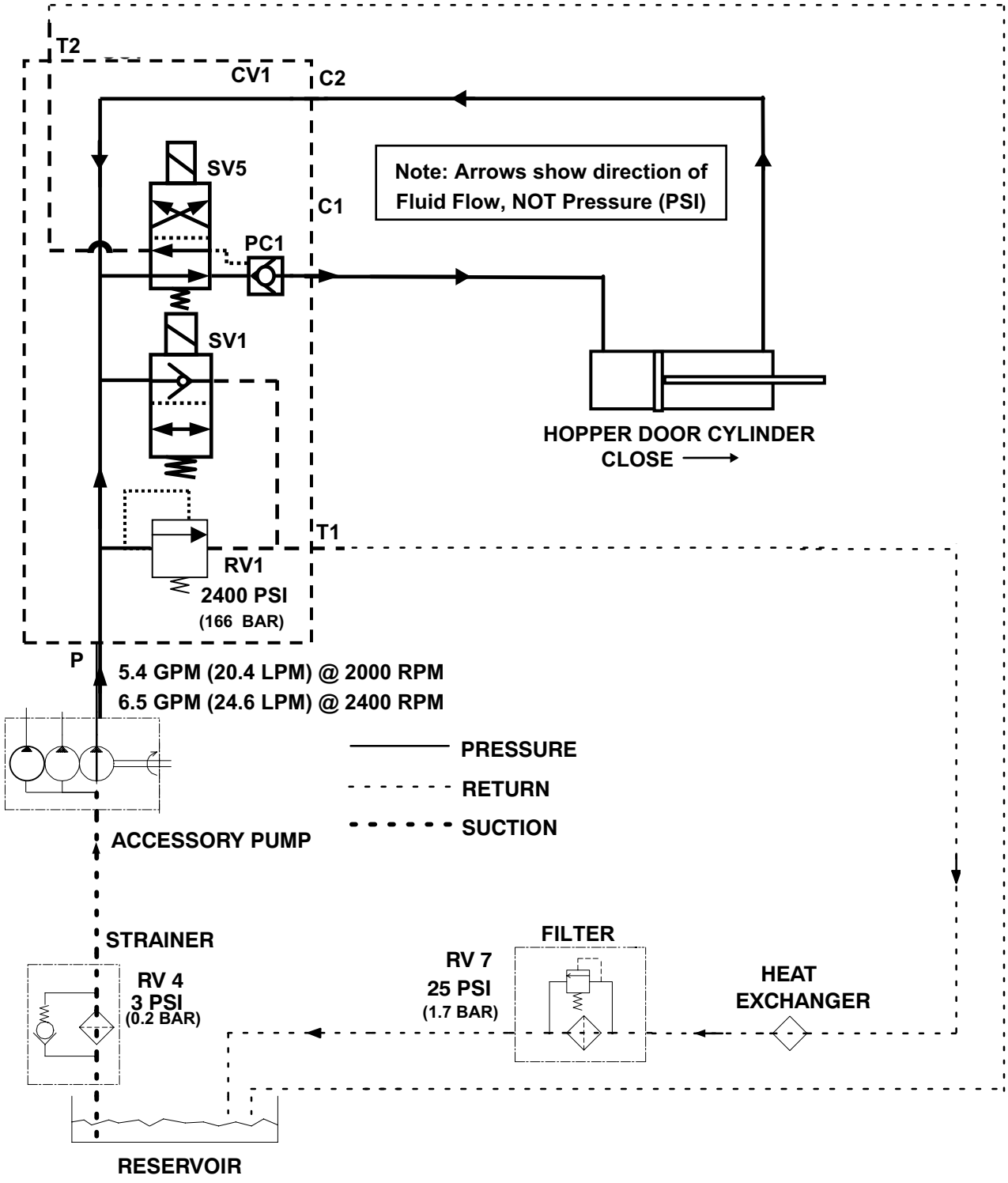
PLEASE NOTE: All specifications listed are for normal operating conditions

6650 OPEN HOPPER DOOR



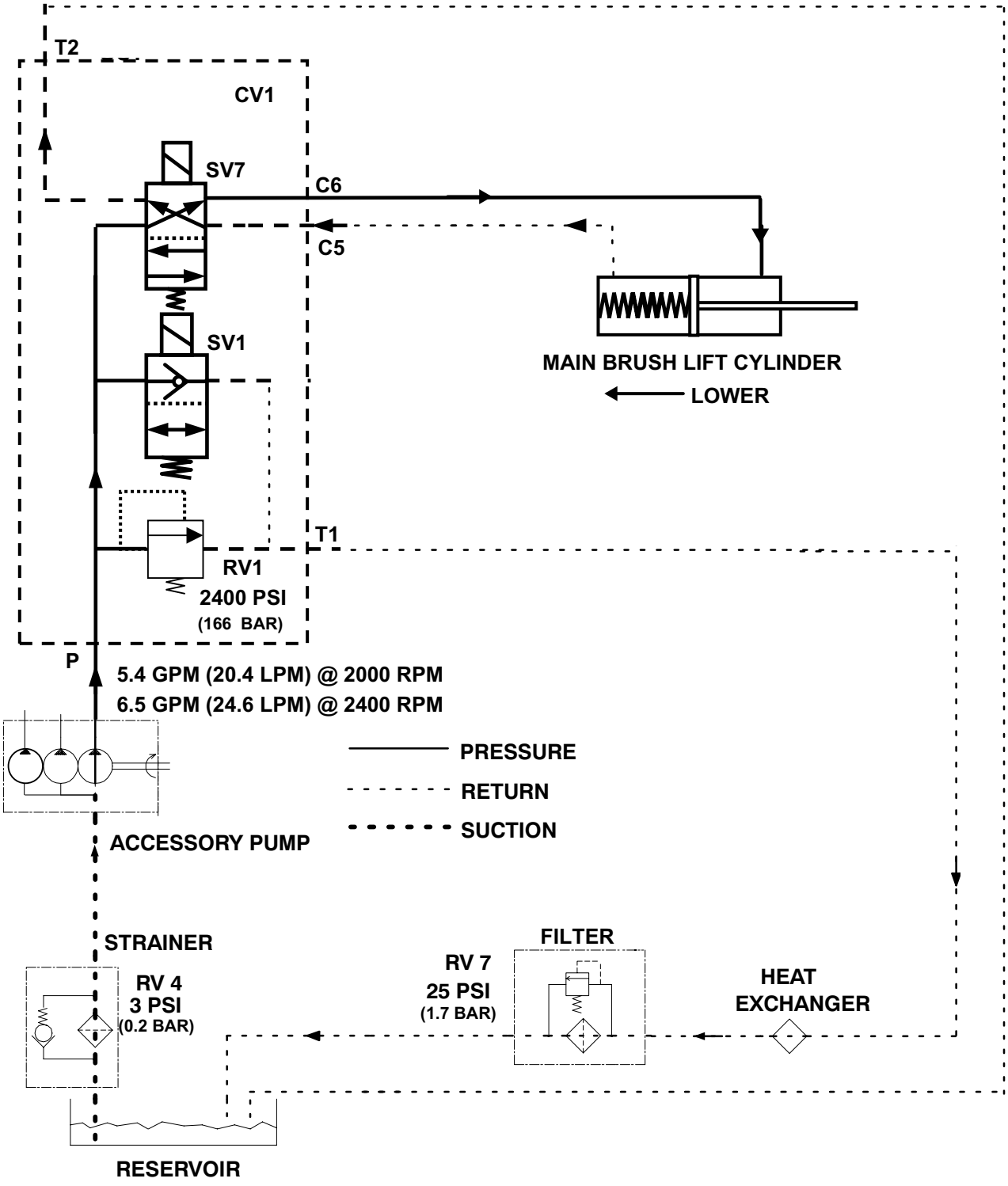
PLEASE NOTE: All specifications listed are for normal operating conditions

6650 CLOSE HOPPER DOOR



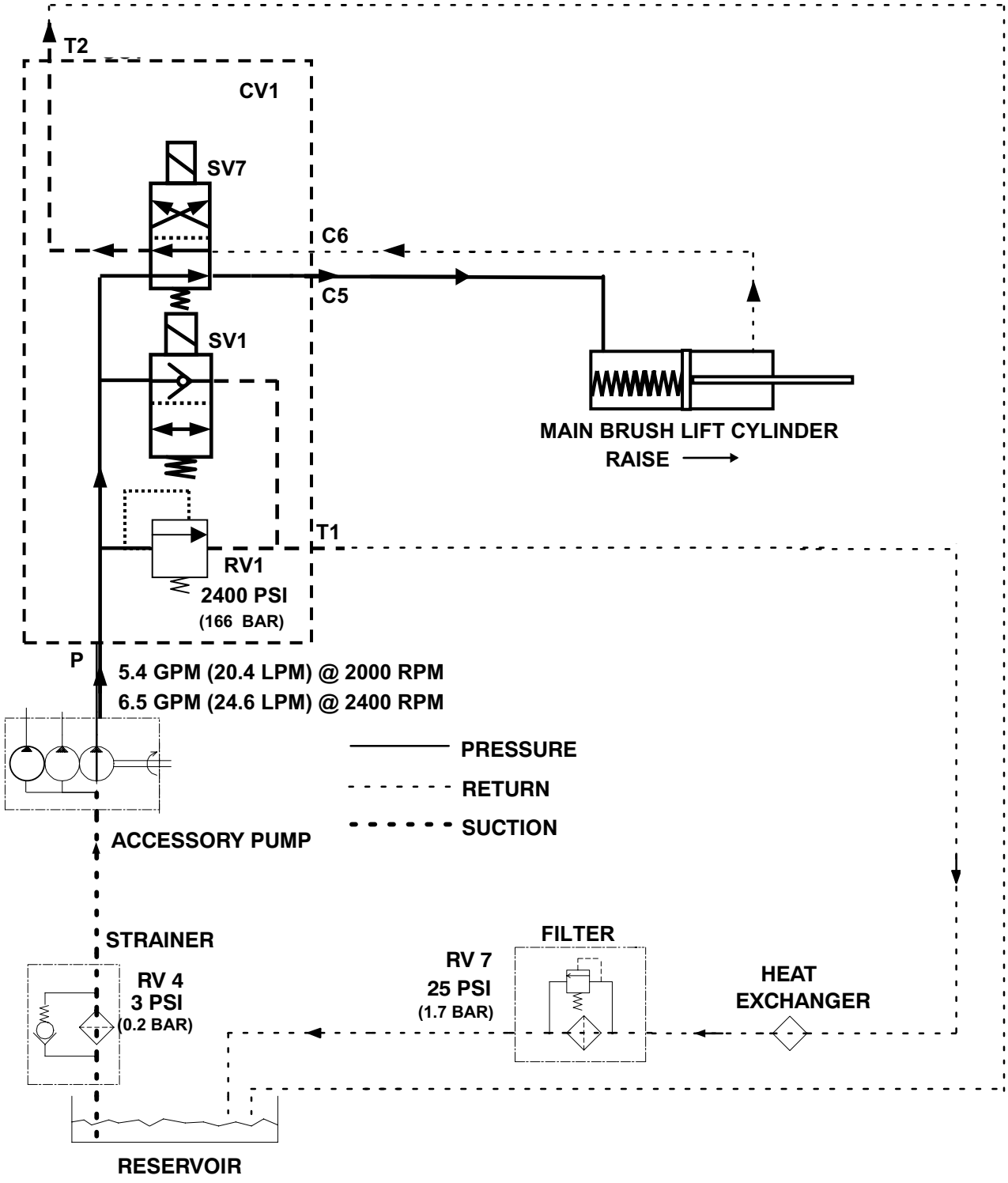
PLEASE NOTE: All specifications listed are for normal operating conditions

6650 LOWER MAIN BRUSH



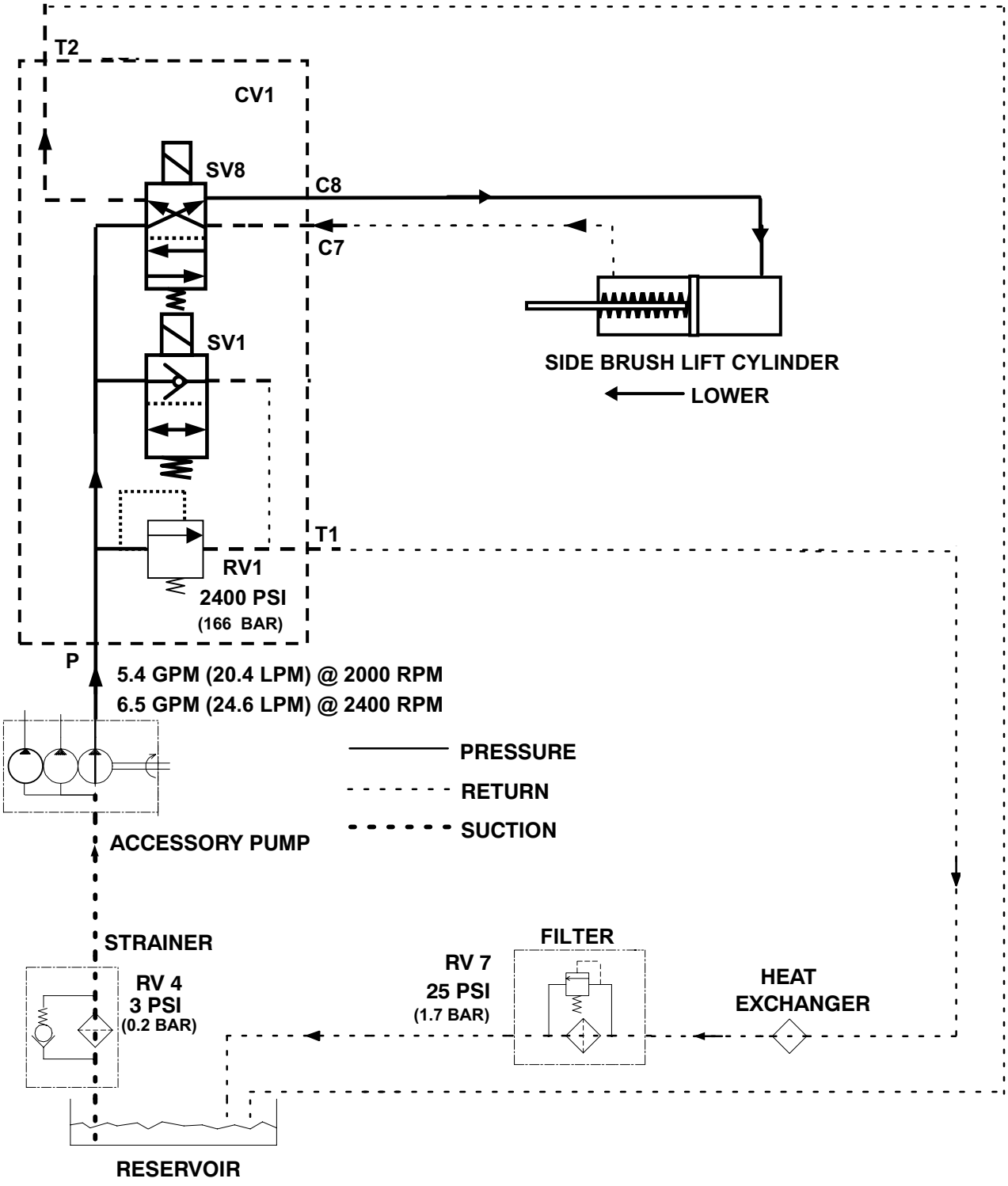
PLEASE NOTE: All specifications listed are for normal operating conditions

6650 RAISE MAIN BRUSH



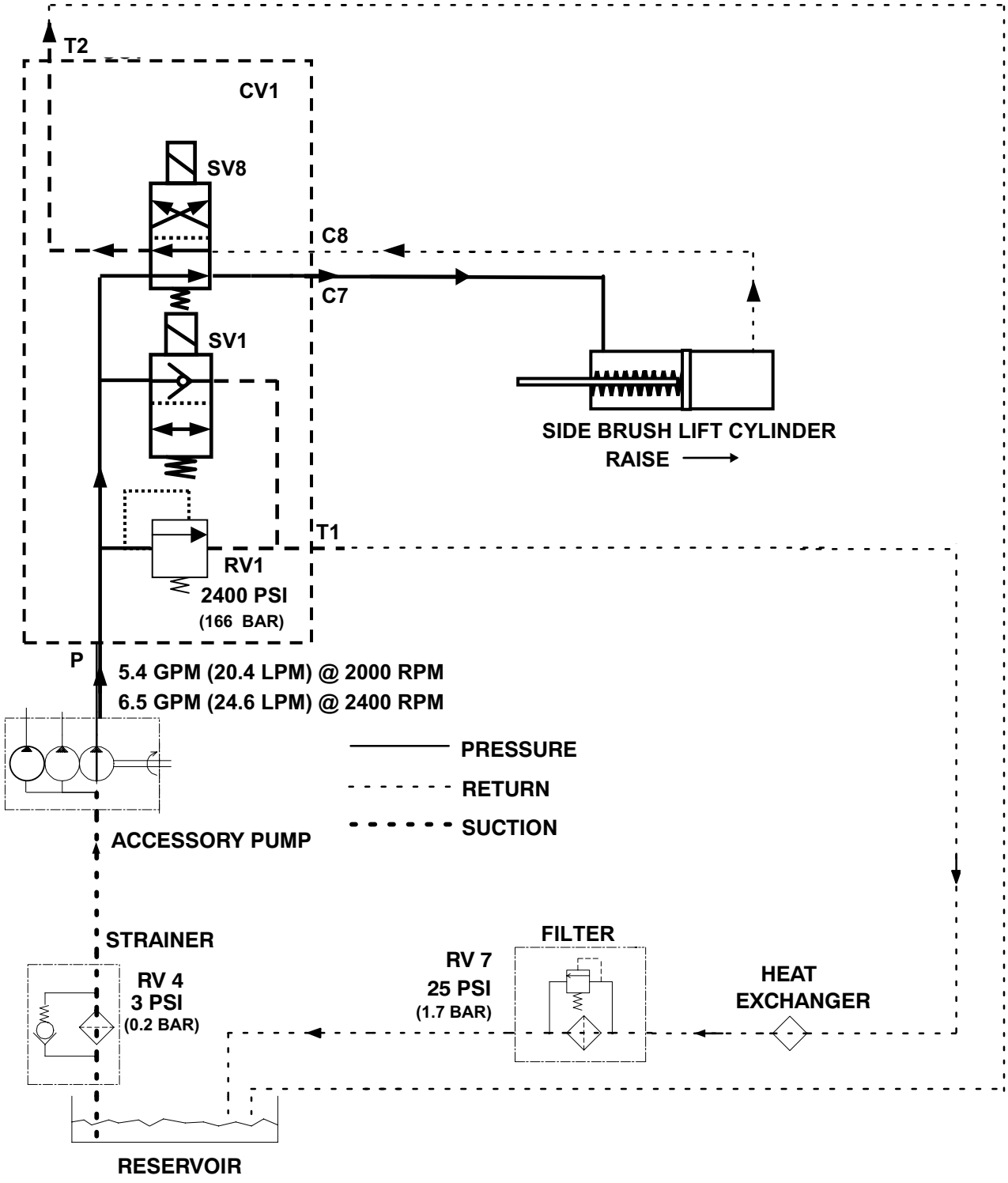
PLEASE NOTE: All specifications listed are for normal operating conditions

6650 LOWER SIDE BRUSH



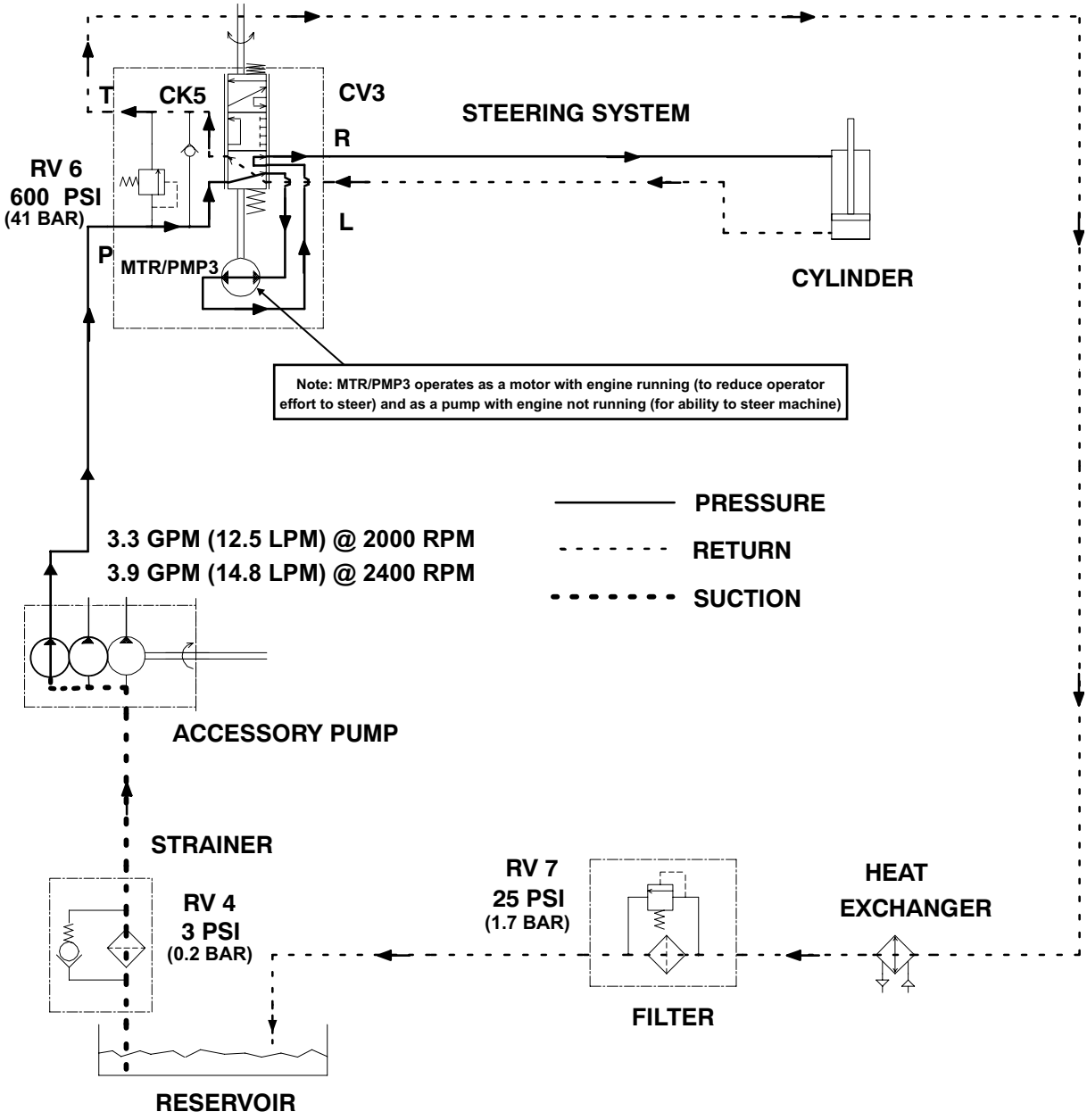
PLEASE NOTE: All specifications listed are for normal operating conditions

6650 RAISE SIDE BRUSH



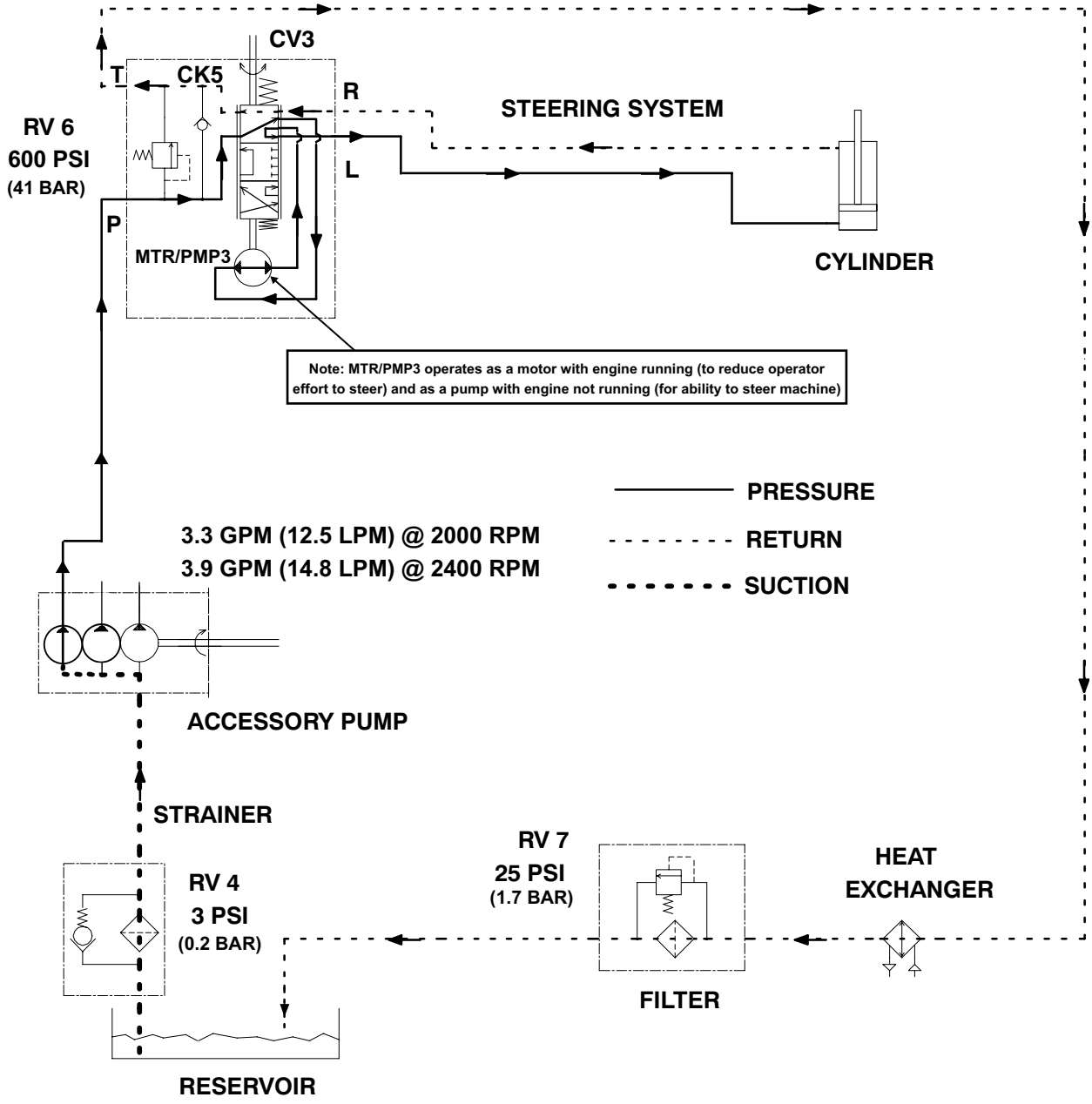
PLEASE NOTE: All specifications listed are for normal operating conditions

6650 RIGHT TURN



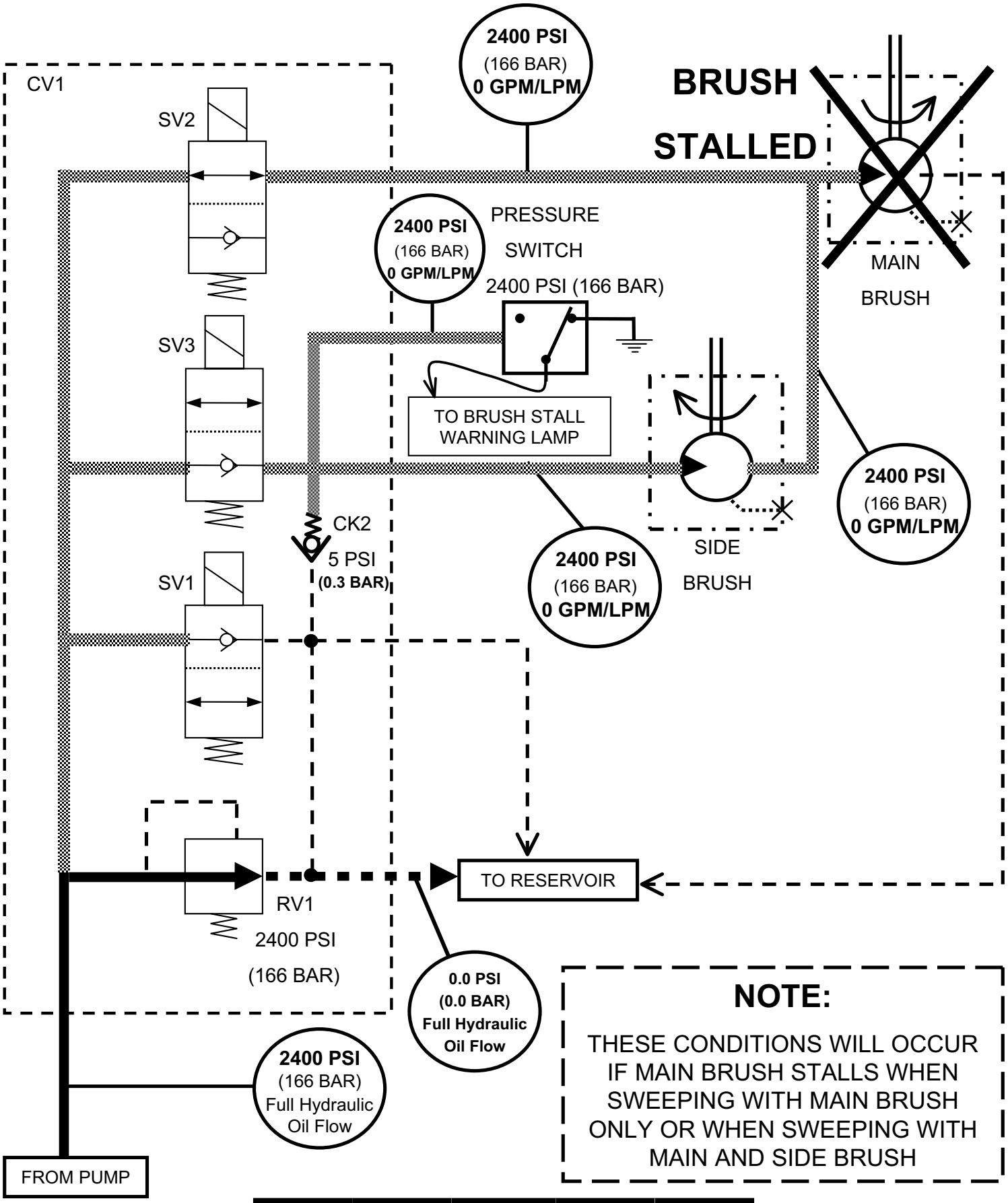
PLEASE NOTE: All specifications listed are for normal operating conditions

6650 LEFT TURN



PLEASE NOTE: All specifications listed are for normal operating conditions

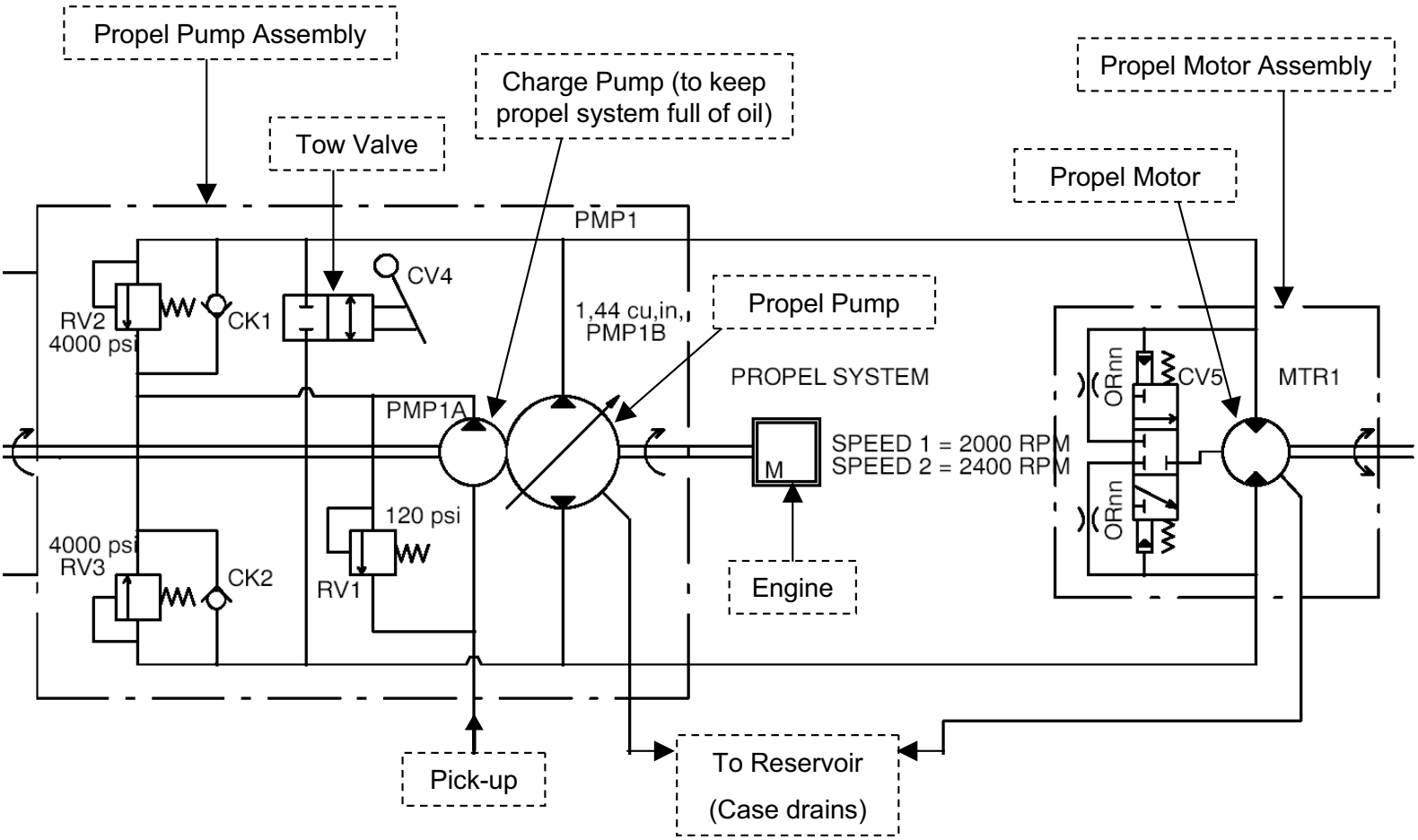
6650 MAIN BRUSH STALL TRIGGERING PRESSURE SWITCH



NOTE:

THESE CONDITIONS WILL OCCUR IF MAIN BRUSH STALLS WHEN SWEEPING WITH MAIN BRUSH ONLY OR WHEN SWEEPING WITH MAIN AND SIDE BRUSH

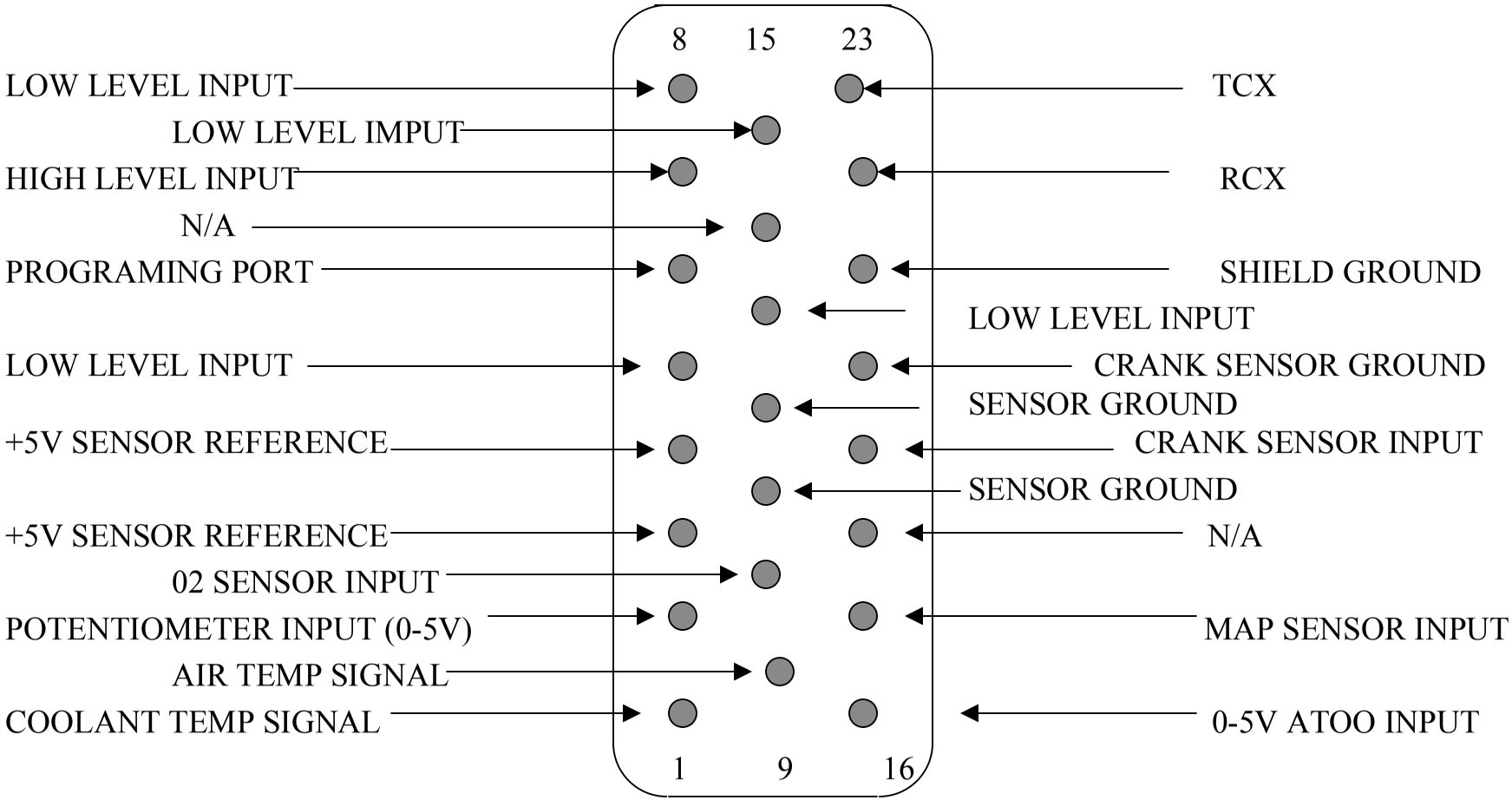
6650 PROPEL SYSTEM



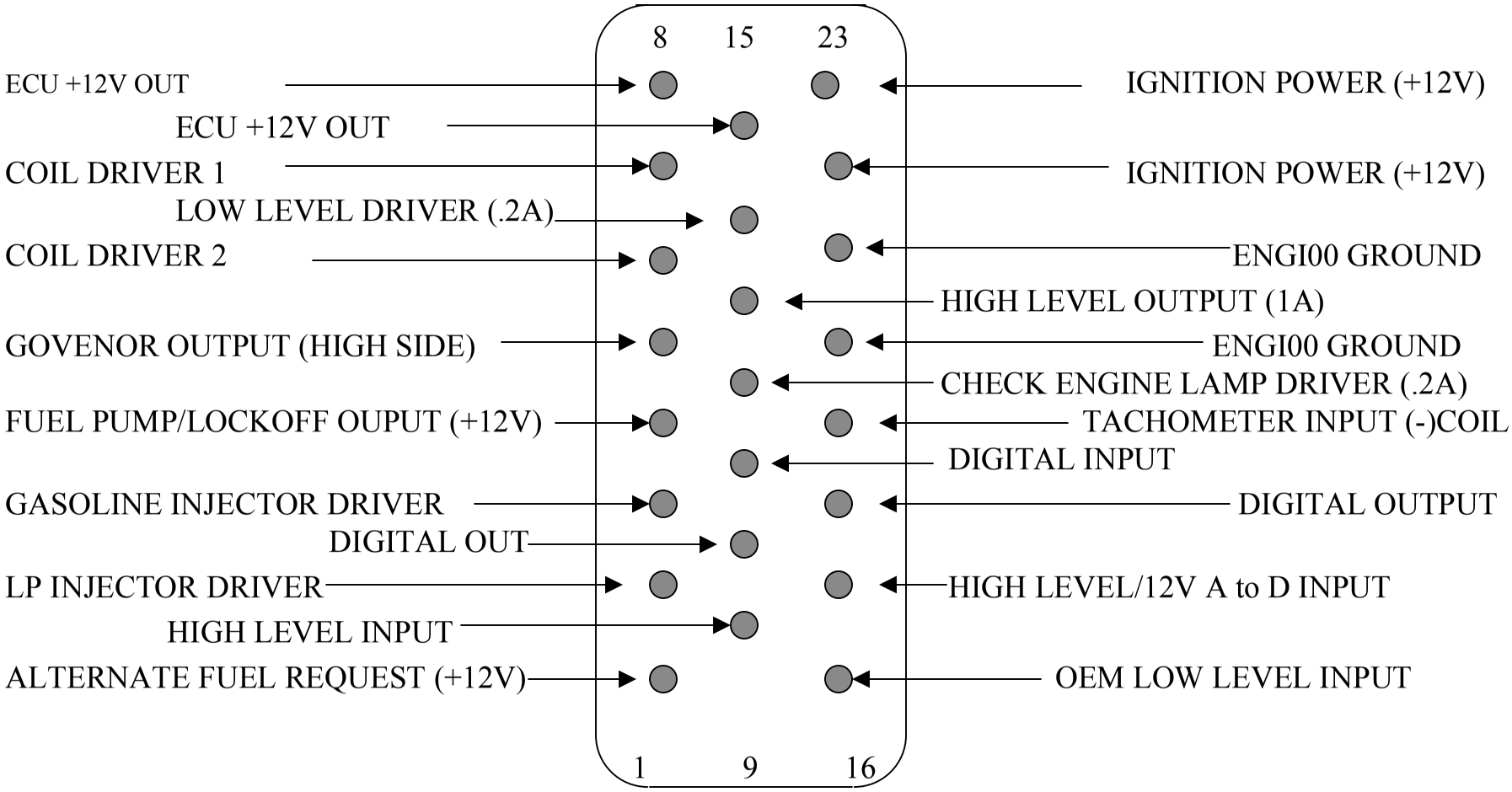
TO ADJUST DIRECTIONAL CONTROL LINKAGE

1. Engage the parking brake.
2. Jack up the rear of the machine. Place jack stands under the frame and lower the machine down.
3. Open engine hood and side door.
4. Locate the centering spring cam arms and cam on the propel pump, near the center frame tube. Loosen the M8 cam bolt.
5. Start the engine.
6. Adjust the cams so the rear wheel does not turn. Turning the cams toward the front of the machine will make the wheel go forward. Turning the cams toward the rear of the machine will make the wheel go backward.
7. Stop the engine.
8. Hold the cams in position and tighten the cam bolts.
9. Start the engine and test to verify adjustment. Repeat if necessary.
10. Lower the machine.
11. Start the engine. Move the directional control pedal forward and backward to make sure machine will not move when the
directional control pedal is in neutral. Readjust as necessary.
12. Raise the hopper and engage hopper support bar.
13. The machine should travel 1.6 kmh (1 mph) maximum forward speed. To adjust, turn the speed control rod (directional control rod with a balljoint and a vibration isolator.) Turning the rod clockwise, as viewed from above, will slow machine. Turning it counterclockwise will speed machine.
14. Lower the hopper and stop the engine.
15. Check the gap between the speed limiter bracket and the contact surface as the drive linkage rod assembly is 1.5--3 mm (0.06 -- 0.12 in).
16. Adjust the balljoint on the end of the speed control rod to get the correct gap. Tighten all jam nuts.

ECU - Black Connector



ECU - White Connector



White Connector

Pin Number	Description	Acronym Used	Voltage Range, Nominal Voltage	Key Off, engine Off, Voltage	Key On, Engine Off Voltage	Active Circuit Voltage	Notes
1	Alternative Fuel Request		0-12 vDC	0 vDC	0 vDC	12 vDC	Use only with dual fuel applications
2	High Level Input		0-12 vDC	0 vDC	0 vDC	12 vDC	
3	LP Injector Driver		0-12 vDC	0 vDC	12 vDC	0 vDC	Grounds circuit to "turn on"
4	Fuel pump/lock off control		0-12 vDC	0 vDC	0 vDC	12 vDC	Sends 12 vDC to fuel pump or lock off
5	Governor Output		0-12 vDC	0 vDC	0 vDC, pulsed voltage	12 vDC	Sends 12 vDC to governor, @210 hz, duty cycles varies
6	Coil Driver # 2		0-12 vDC	0 vDC	0 vDC	12 vDC	Sends 12 vDC to coil
7	Coil Driver # 1		0-12 vDC	0 vDC	0 vDC	12 vDC	Sends 12 vDC to coil
8	ECU 12 vDC out		0-12 vDC	0 vDC	12 vDC	12 vDC	Sends 12 vDC to ????
9	High level input		0-12 vDC	0 vDC	0 vDC	12 vDC	
10	Digital Out Signal		0-12 vDC	0 vDC	0 vDC	Pulsed	On or off signal
11	Digital Input		0-12 vDC	0 vDC	0 vDC	12 vDC	Square wave
12	Check Engine Lamp Driver (0.2a)		0-12 vDC	0 vDC	0 vDC	12 vDC	On or off signal
13	High level output		0-12 vDC	0 vDC	0 vDC	12 vDC	On or off signal
14	Low Level Driver (0.2a)		0-12 vDC	0 vDC	0 vDC	12 vDC	On or off signal
15	ECU 12 vDC out to fuel injector		0-12 vDC	0 vDC	0 vDC	12 vDC	Sends 12 vDC to fuel injector
16	OEM Low Level Input		0-5 vDC	0 vDC	0 vDC	5 vDC	
17	High level / 12 A to D Input		0-12 vDC	0 vDC	0 vDC	12 vDC	
18	Digital Output		0-12 vDC	0 vDC	0 vDC	Pulsed	On or off signal
19	Tachometer Input from Ignition Coil		0-250 vDC	0 vDC	12 vDC	0-250 vDC	
20	Engine Ground for governor, lockoff, fuel pump, distrubutor ground		0 vDC	0 vDC	0 vDC	0 vDC	Ground
21	Engine Ground for governor, lockoff, fuel pump, distrubutor ground		0 vDC	0 vDC	0 vDC	0 vDC	Ground
22	Ignition Power		0-12 vDC	0 vDC	12 vDC	12 vDC	Power into ECU
23	Ignition Power		0-12 vDC	0 vDC	12 vDC	12 vDC	Power into ECU

ector	Description	Acronym Used	Voltage Range, Nominal Voltage	Key Off, engine Off, Voltage	Key On, Engine Off Voltage	Active Circuit Voltage	Notes
1	Coolant Temperature Sensor Signal	CTS	0-5 vDC	0 vDC	0-5 vDC	0-5 vDC	
2	Potentiometer Input		0-5 vDC	0 vDC	0-5 vDC	0-5 vDC	
3	Sensor Reference		5 vDC	0 vDC	5 vDC	5 vDC	Signal from ECU to input sensors
4	Sensor Reference to MAP sensor		5 vDC	0 vDC	5 vDC	5 vDC	Signal from ECU to input sensors
5	Low Level Input		5 vDC	0 vDC	0 vDC	0-5 vDC	
6	Programming Port		0-5 vDC	0 vDC	0 vDC	0-5 vDC	Signal into ECU, to reprogram memory
7	High Level Input		0-12 vDC	0 vDC	0 vDC	0-5 vDC	
8	Low Level Input		5 vDC	0 vDC	0 vDC	0-5 vDC	
9	Intake Air Temperature Sensor Signal	IAT	0-5 vDC	0 vDC	0-5 vDC	0-5 vDC	
10	O2 Sensor Input		0-1 vDC	0 vDC	0.45 vDC	0-1 vDC	
11	Sensor Ground, MAP, CTS and IAT		0 vDC	0 vDC	0 vDC	0 vDC	
12	Sensor Ground		0 vDC	0 vDC	0 vDC	0 vDC	
13	Low Level Input		0-5 vDC	0 vDC	0 vDC	5 vDC	
14	N/A		N/A	N/A	N/A	N/A	
15	Low Level Input		0-5 vDC	0 vDC	0 vDC	5 vDC	
16	Input, from dash panel low, med, high RPM		0-12 vDC	0 vDC	0 vDC	5 vDC	
17	MAP Sensor Signal Input	MAP	0-5 vDC	0 vDC	4.70 vDC	0-5 vDC	Measure BARO with Key on engine off
18	N/A		N/A	N/A	N/A	N/A	N/A
19	Crank Sensor Input		0-5 vDC	0 vDC	0 vDC	0-5 vDC	Square wave
20	Crank Sensor Ground		0 vDC	0 vDC	0 vDC	0 vDC	
21	Shield Ground		0 vDC	0 vDC	0 vDC	0 vDC	Protected ground circuit
22	Receive Signal from data recording device		0-5 vDC	0 vDC	0 vDC	0-5 vDC	Square wave
23	Transmit Signal to data recording device		0-5 vDC	0 vDC	0 vDC	0-5 vDC	Square wave

Maintenance Schedule
Power Solutions, Inc
GM Powertrain

2.0L, 2.2L, 3.0L, 4.3L, 5.71L, 7.4L, and 8.1L Engines

Initial Start-Up Sequence Checks	Operation	Daily	Weekly	Every 50 Hrs	Every 100 Hrs	Every 200 Hrs	Every 400 Hrs	Every 800 Hrs	As Req'd
1	Check Engine Oil Level	x							
2	Check Coolant Level (4)	x							
	Check Fluid Leaks	x							
	Governor, Mechanical (Check oil level)(2)		x						
	Change Engine Oil & Filter (1)					x			
	Battery, Check Charge & Fluid Level (3)		x						
	Inspect & Clean Radiator Exterior (3)		x						
	Clean Battery Cables (3)								x
	Check Belts and Belt Tension				x				
	Lubricate Throttle, Governor & Choke Linkage (Carbureted Engines Only)				x				
	Check & Adjust Idle Speed (Carbureted Engines Only)								x
	Inspect and Clean Air Cleaner Element		x						
	Replace Primary Air Cleaner Element (1)						x		
	Replace Safety Air cleaner Element								x
	Replace Engine Coolant (3)(4)							x	
	Replace Fuel Filter (5)					x			
	Spark Plugs, Clean, Adjust & Test or Replace (3)						x		
	Replace PCV Valve (If equipped)(3)							x	
	Check PCV Hoses, Tubes, Fittings (3)							x	
	Replace Spark Plugs (3)								x
	Adjust Throttle & Governor (3)								x
7	Check All Bolts & Nuts for Tightness (3)								x

(1) More frequent intervals may be required in dusty or dirty operating conditions.
(2) Mechanical governor (belt driven).
(3) Seasonal or as required.
(4) Check engine coolant condition & protection, hoses & clamps annually (prior to cold weather).
(5) More frequent intervals may be required with dirt in fuel system.

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Engine	2.0L	2.2L	3.0L	4.3L	5.7L	7.4L	8.1L
Oil Capacity Without Filter			5 qt.	4.5 qt.	5 qt.	8 qt.	8 qt.
Coolant Capacity Without Radiator			4 qt.	7 qt.	7.8 qt.	14.5 qt.	14.5 qt
Coolant Capacity With Radiator			12 qt.	17 qt.	17.5 qt	28 qt 31 qt (Turbo	

General Specifications

Power Solutions, Inc

GM Powertrain Industrial Engines

Engine	**3.0L**
Type	3.0L L4
Displacement cc (c.i.d)	2966 (181)
Compression Ratio	9.2:1
Valve Configuration	Push Rod Actuated Overhead Valve
Valve Lifters	Flat Follower
Bore x Stroke mm(inches)	101.60x91.44(4.00x3.60)
Main Bearing Caps	2 Bolt
Balance method	External
Intake Manifold	TBI, Carburetor, Mixer
Firing Order	1-3-4-2
Oil Capacity With Oil Filter	5 qts. (4.7L) 5.5 qts. (5.2L)
Oil Filter	PF-25 or Equivalent
Coolant Capacity (Engine)	4 qts. (3.78L)
Fuel Type	Gasoline, LPG, NG
Engine Rotation (Flywheel End)	CCW
Ignition System	Solid State Distributor
Ignition Timing (Degrees BTDC) Gasoline (Carb) Gasoline (TBI) LPG NG Dual Fuel	 0 0 10 (4 Europe) 10 0
Spark Plugs	AC Delco R46TS
Spark Plug Gap Gasoline (Carb) TBI LPG NG Dual Fuel	 0.04
Valve Clearance (Lash) Intake Exhaust	 1/2 to 1 Turn Down From 0 Lash
Manufactured	Toluca, Mexico

ZEEMS

Zenith Electronic Engine Management System

Propane and Gasoline Electronic Fuel Injection

ZEEMS

Home Page

The ZEEMS Advantages

Precise fuel control
throughout all operating temperatures and conditions

Precise ignition timing control
throughout all operating temperatures and conditions

Virtually **eliminates "flat spots" and engine run-on** (dieseling)

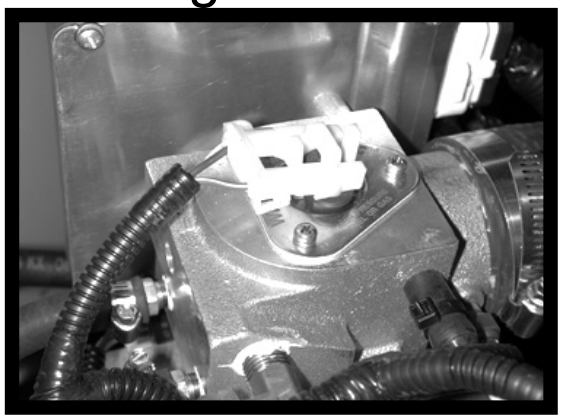
Achieves **maximum power with lowest emissions**

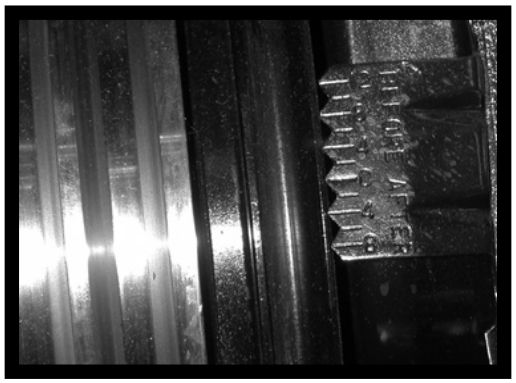
The ZEEMS Control system electrically controls the following:

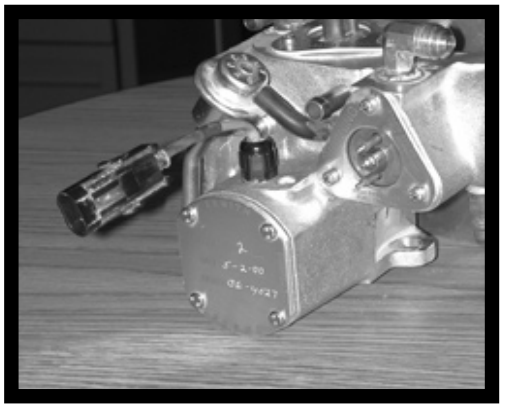
Fuel Delivery via fuel injector (gas, propane or both)

Ignition timing via ECU and High Energy Ignition (HEI) system

Engine RPM via throttle shaft actuator control







Speed-Density Discussion

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The ZEEMS System

The ZEEMS system is a
"Speed-Density" design.

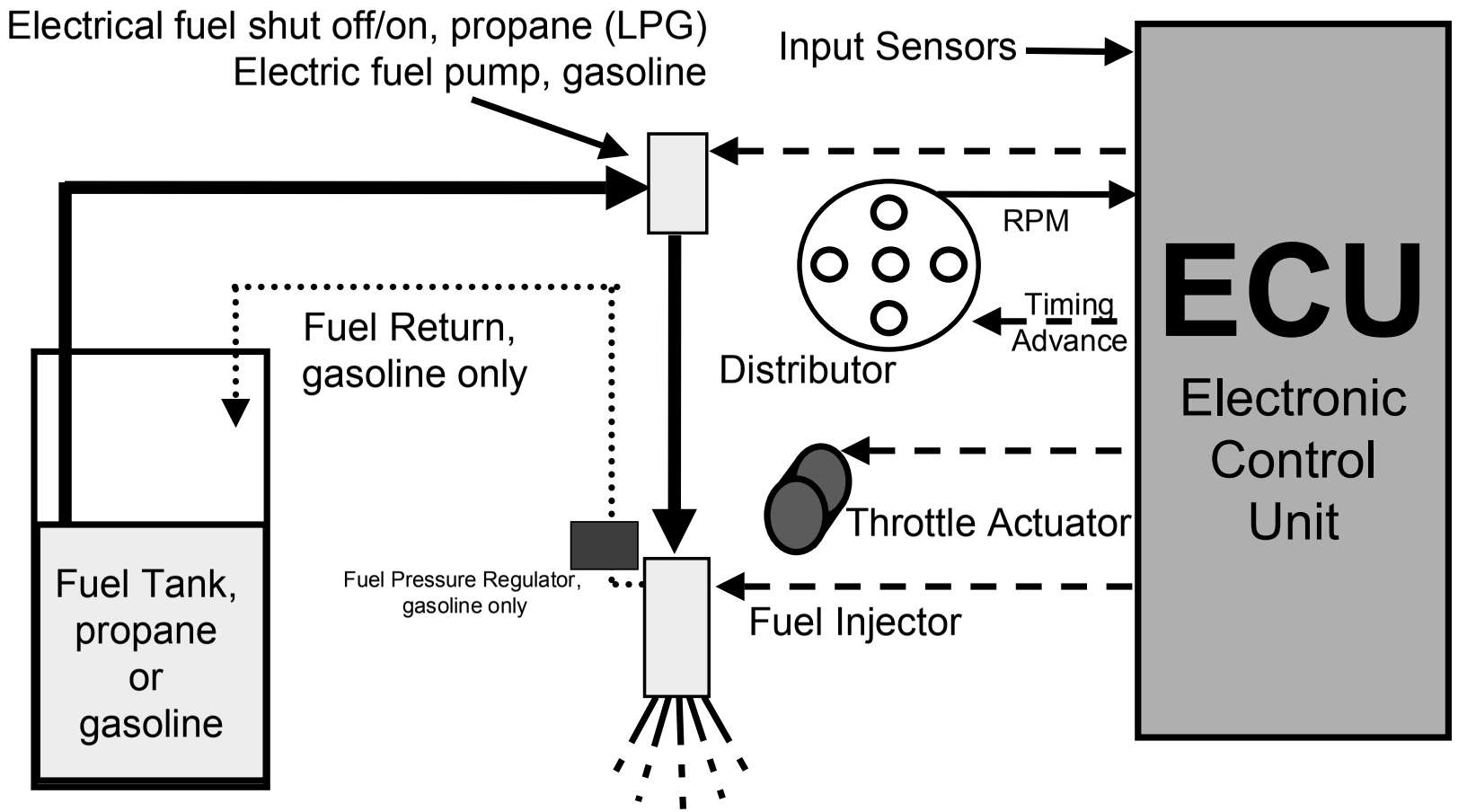
This system measures the engine RPM
(speed of the engine)

and calculates the
Density of the Air
(from atmospheric pressure and temperature of the air)

to determine the optimum fuel and timing settings
for the altitude and climatic conditions.

Block Diagram

ZEEMS Block Diagram



ECU page 1

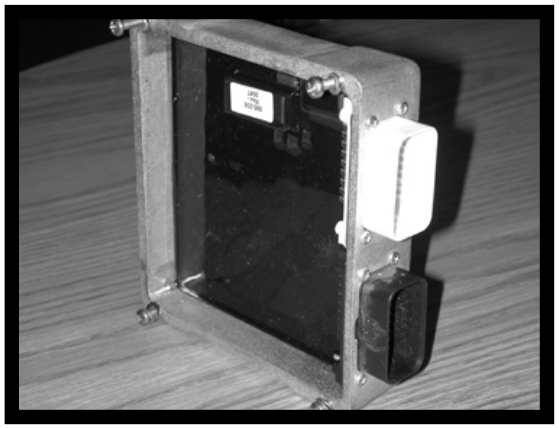
The ECU is the 'control center' of the ZEEMS, sometimes called the processor or "brain box" (logic device)

The ECU monitors the input sensors, → compares to programmed "look up tables" → and then controls the output devices.

ECU

Electronic Control Unit

ECU page 2



The **Black Connector** is used for low level current devices, such as input signals, transmit and receive signals, and other low voltage signals.

ECU

Electronic Control Unit

The **White Connector** is used for high current loads, such as battery power and ground and controlling the out put devices.

Battery Ground Feed
Pins 20 & 21 on
White Connector

Battery Power Feed
Pins 22 & 23 on
White Connector

The ECU monitors most input sensors once every distributor pulse or engine "event", depending on engine RPM and operating conditions.

One engine "event" is an ignition pulse (spark plug firing).

ECU

Electronic Control Unit

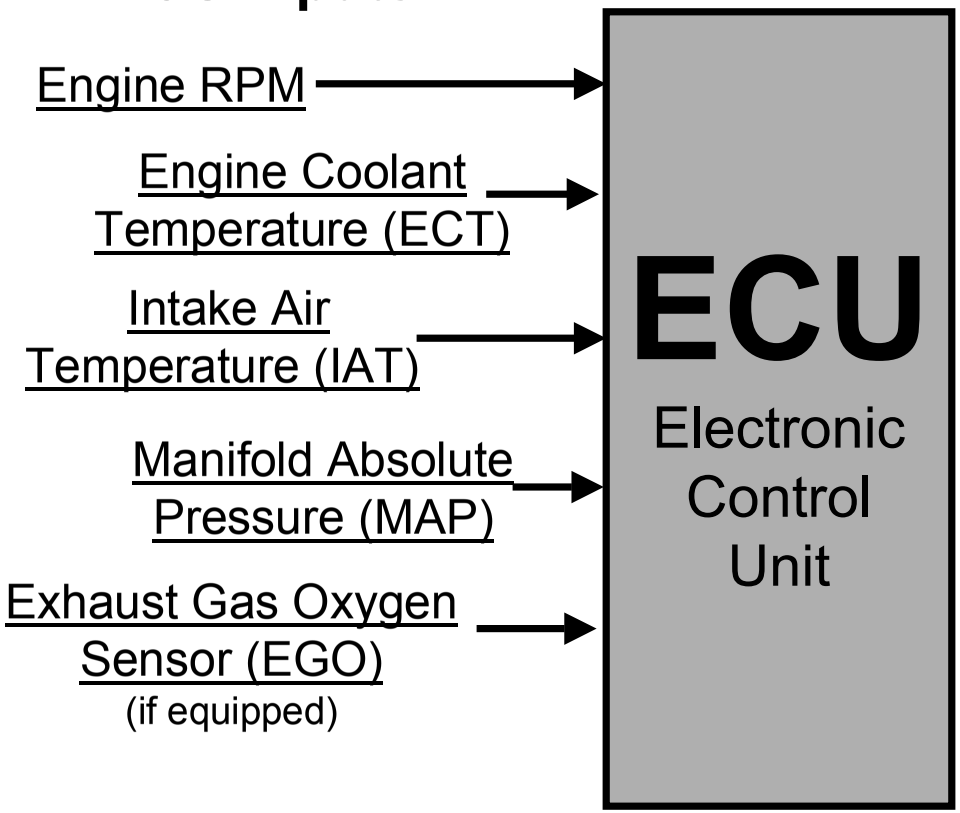
There are two distributor pulses (events) per engine revolution on a 4 cylinder, 4 cycle engine

Therefore:
500 RPM = 1000 events
1000 RPM = 2000 events
2000 RPM = 4000 events

Inputs Introduction

The ZEEMS systems uses several input devices to monitor the engine and atmospheric conditions.

ECU Inputs



Lets examine each input sensor in depth

RPM

ECU Inputs

Engine RPM →

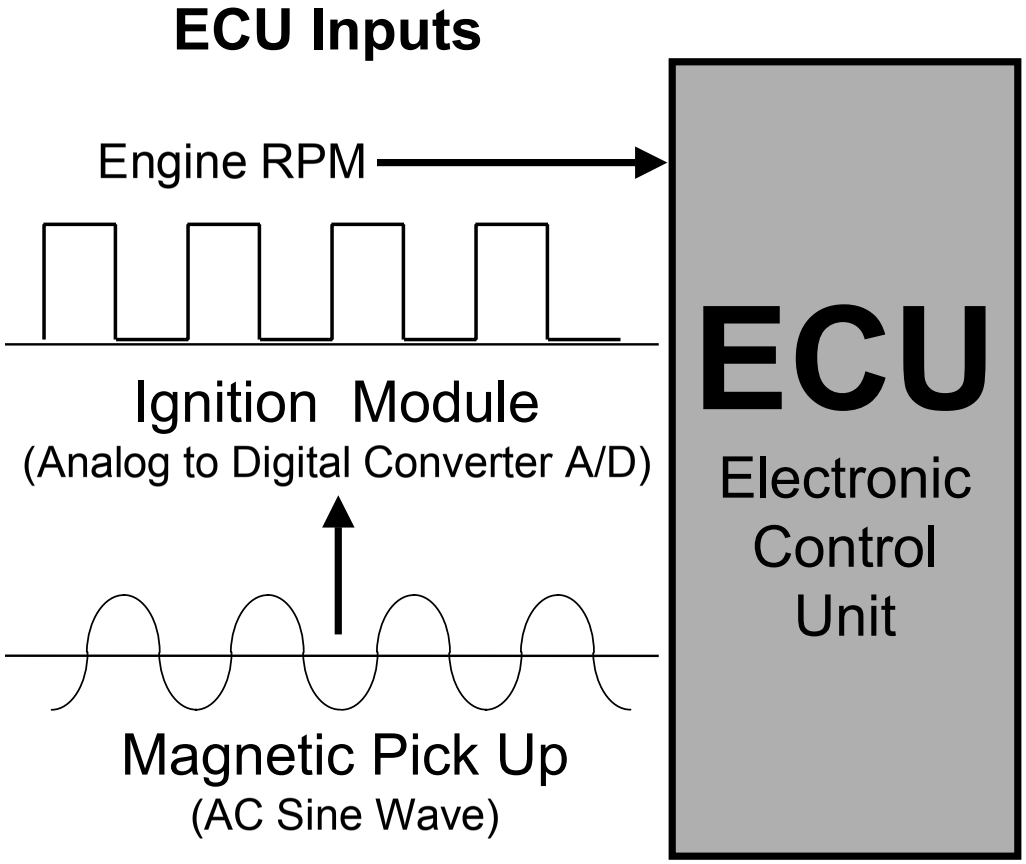
ECU

Electronic Control Unit

Engine RPM

Engine RPM is determined from the distributor pulses generated by the magnetic pick up and converted to a digital pattern by the HEI (High Energy Ignition) module.

RPM



Engine RPM

For every ignition pulse, a signal is received at the ECU.

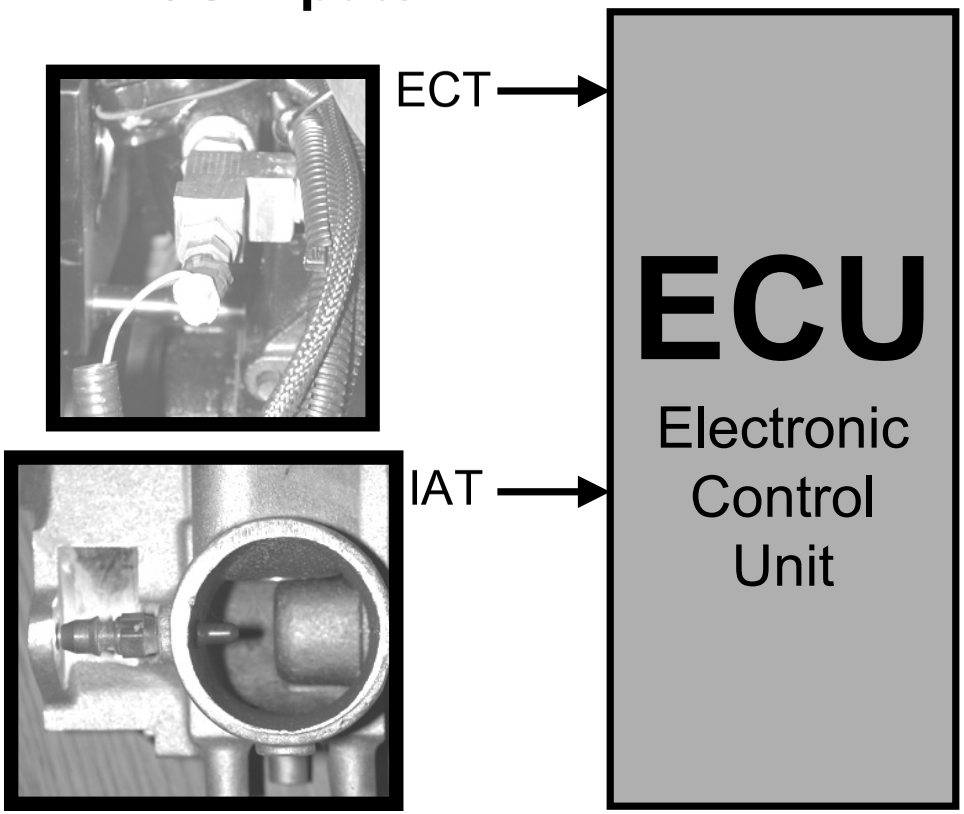
The ECU then signals fuel injector to “turn on” and spray fuel.

One fuel injector pulse per “event”.

ECT & IAT

Engine Coolant Temp Sensor (ECT) , Intake Air Temp Sensor (IAT)

ECU Inputs



The ECT is located in or near the water outlet from the engine block to the radiator.

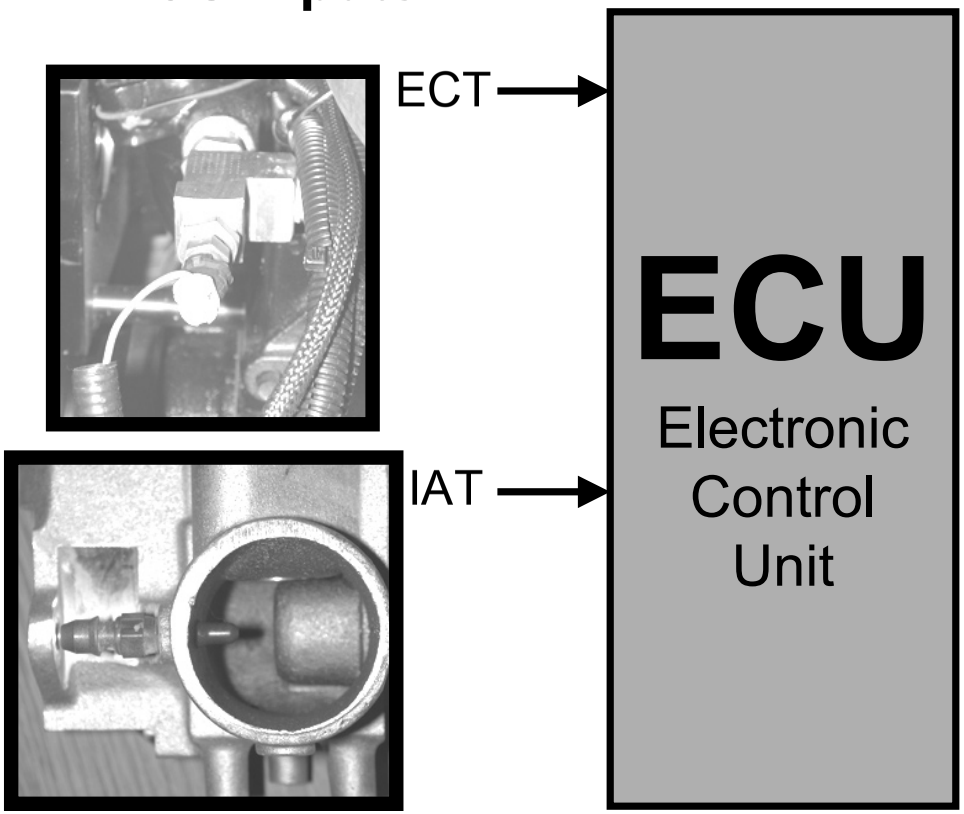
The IAT is located in the throttle body assembly.

Both sensors are two (2) wire sensors.

ECT & IAT

Engine Coolant Temp Sensor (ECT) , Intake Air Temp Sensor (IAT)

ECU Inputs



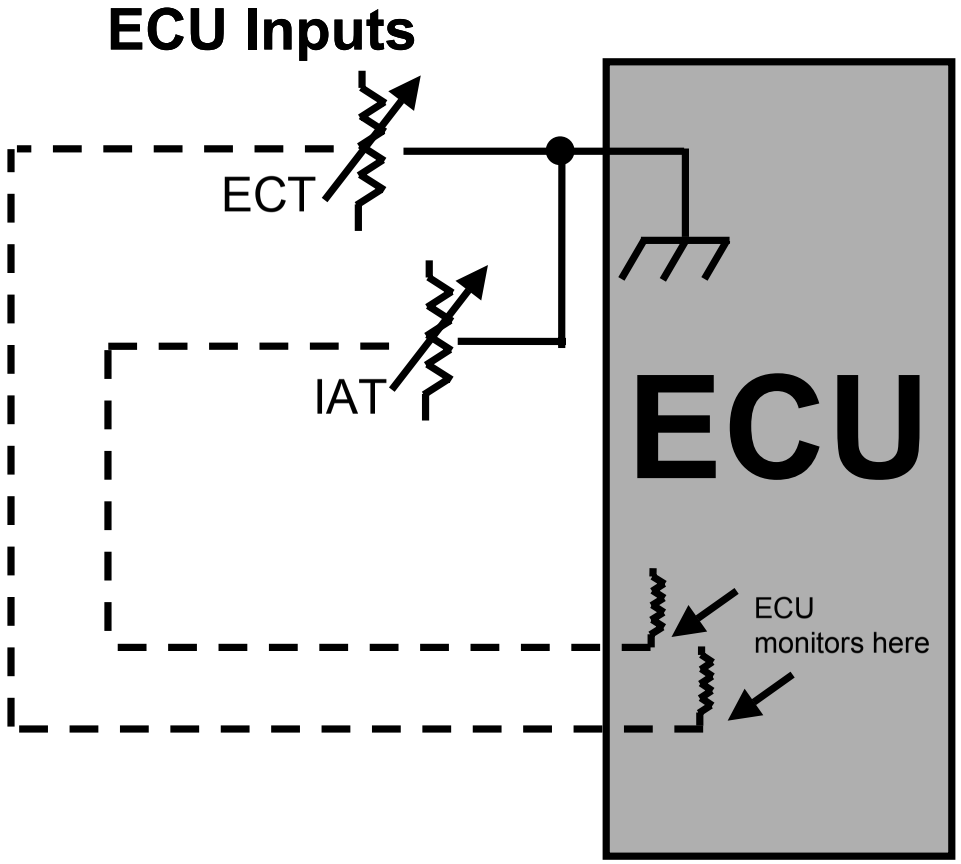
The ZEEMS system uses a Negative Temperature Coefficient (NTC) thermistors for the ECT and IAT sensors.

A thermistor changes its internal resistance as the temperature changes.

A “NTC” thermistor resistance increases as the temperature decreases, and the resistance decreases as the temperature increases.

ECT & IAT

Engine Coolant Temp Sensor (ECT) , Intake Air Temp Sensor (IAT)



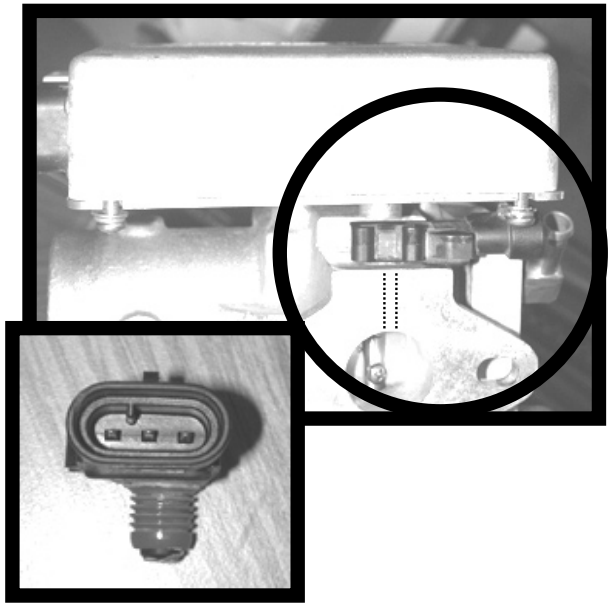
The ECU “monitors” the ECT and IAT wires to determine the temperature changes.

MAP

Manifold Absolute Pressure Sensor

ECU Inputs

Manifold Absolute Pressure Sensor →



ECU

Electronic Control Unit

The MAP is located between the throttle body assembly and the ECU .

This MAP sensor is a three (3) wire sensor similar in operation to a potentiometer.

Routing to the intake manifold source is accomplished by a passage way drilled from the throttle bore directly into the MAP.

MAP

ECU Inputs

Manifold Absolute Pressure Sensor →

ECU

Electronic Control Unit

The MAP changes its internal resistance as the atmospheric or intake manifold pressure changes.

The MAP sensor with the ECU calculates the barometric pressure when the key is turned on. (KOEO=Key On Engine Off).

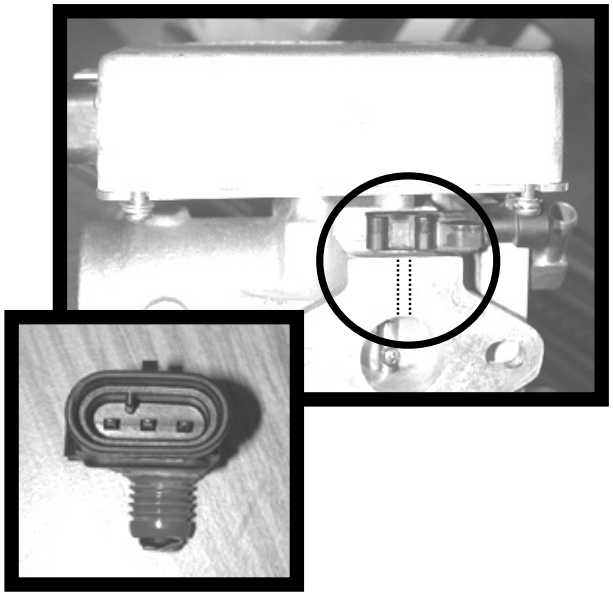
As the engine starts/runs, the MAP's internal resistance changes causing the signal wire voltage to change. (KOER = Key On Engine Run).

Home
Find...
Go To..

MAP

ECU Inputs

Manifold Absolute Pressure Sensor →



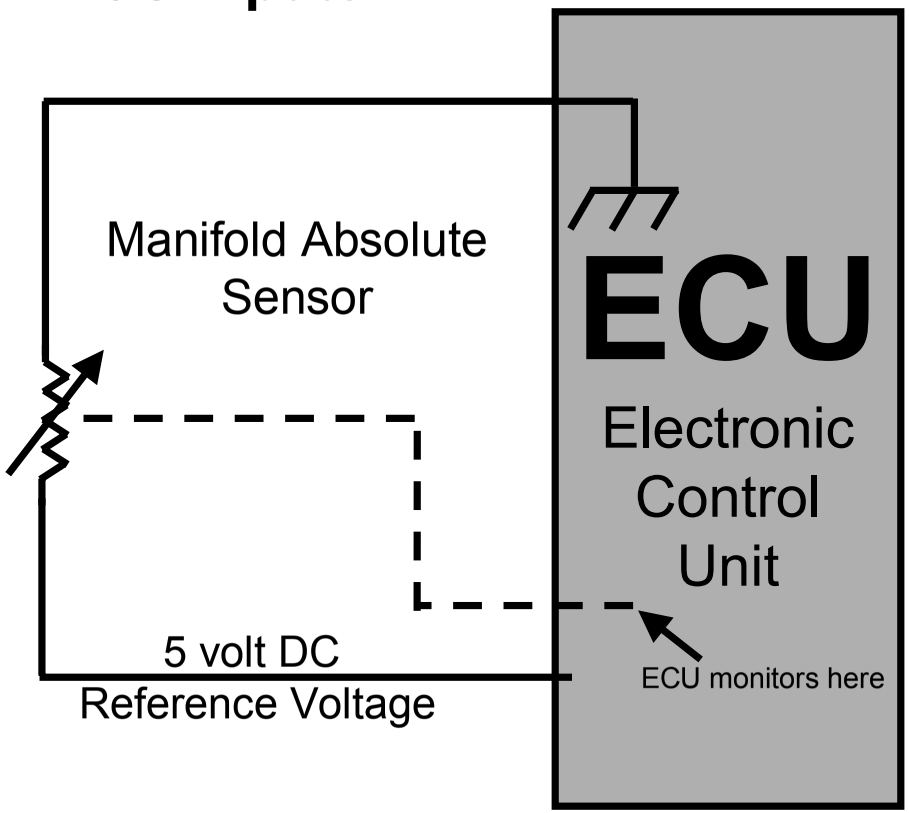
ECU

Electronic Control Unit

This sensor has two chambers internally. These chambers are isolated by a silicone diaphragm.

MAP

ECU Inputs

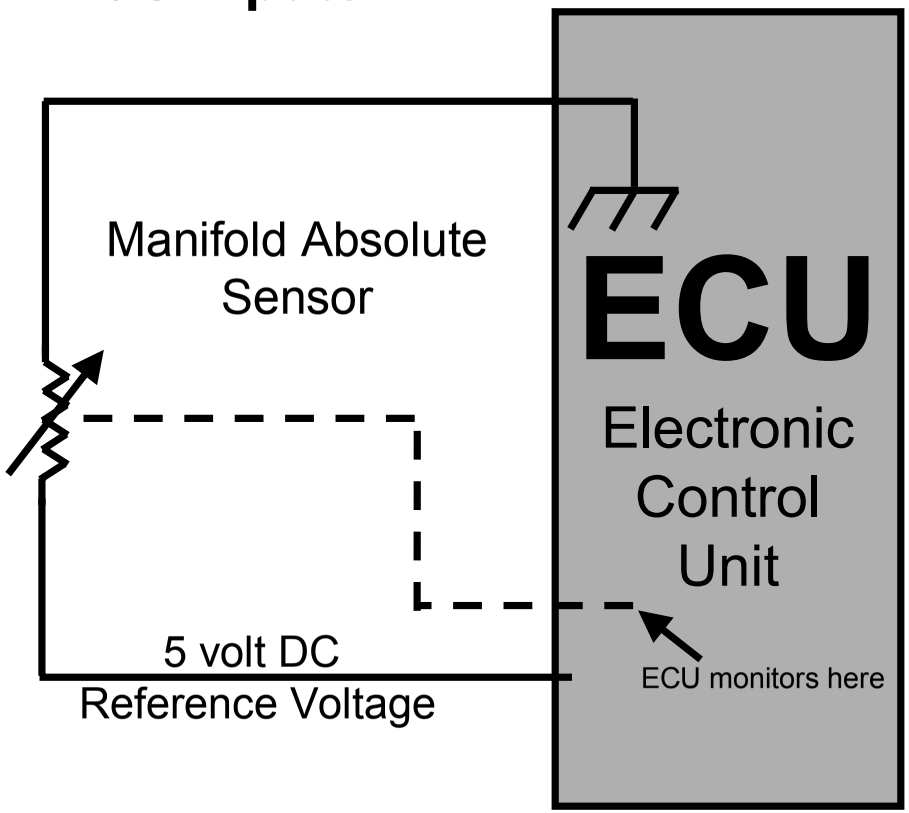


The ECU sends a fixed 5 vDC +/- 10% voltage to the MAP.

The ECU "monitors" the signal wire to determine the barometric pressure and/or engine load changes. (intake manifold pressure).

MAP

ECU Inputs



MAP
Manifold Absolute Pressure Sensor

The ECU sends a fixed 5 vDC +/- 10% voltage to the MAP.
This is a ***must!***
If voltage is not 5vDC +/-10%, suspect the ECU is faulty

Question
What voltage will be "seen" with the key on, KOEO?

Answer
This is the "baro" voltage at this location.
This number is constant depending on actual barometric pressure.

Inputs, EGO page 1

EGO
Exhaust Gas
Oxygen Sensor

EGO

(if equipped)

ECU Inputs

Exhaust Gas Oxygen Sensor →

Click here for a detailed explanation on Oxygen sensors

ECU
Electronic Control Unit

The EGO is located on the exhaust pipe within six (6) inches of the exhaust manifold. (15 cm)

This sensor is a four (4) wire sensor.

The ZEEMS system uses a heated EGO sensor.

Home
Find...
Go To..

EGO

(if equipped)

ECU Inputs

Exhaust Gas Oxygen Sensor →

Click here for a detailed explanation on Oxygen sensors

ECU

Electronic Control Unit

EGO

Exhaust Gas Oxygen Sensor

The EGO sensor generates a DC voltage (0-1vDC) that is proportional to the Oxygen content of the exhaust stream and ambient oxygen.

When the Oxygen (O2) content in the exhaust stream goes up the voltage goes down.

Question

If the engine is running with too much fuel and no misfires, will the EGO voltage be high or low?

Inputs, EGO page 2

EGO

(if equipped)

ECU Inputs

Exhaust Gas Oxygen Sensor

Click here for a detailed explanation on Oxygen sensors

ECU

Electronic Control Unit

EGO

Exhaust Gas Oxygen Sensor

When the EGO sensor approaches 600 degrees “F”/ 300 degrees “C” it starts to operate properly.

An internal heater brings the EGO to its operating temp and maintains this temp if the exhaust gases temp decreases.

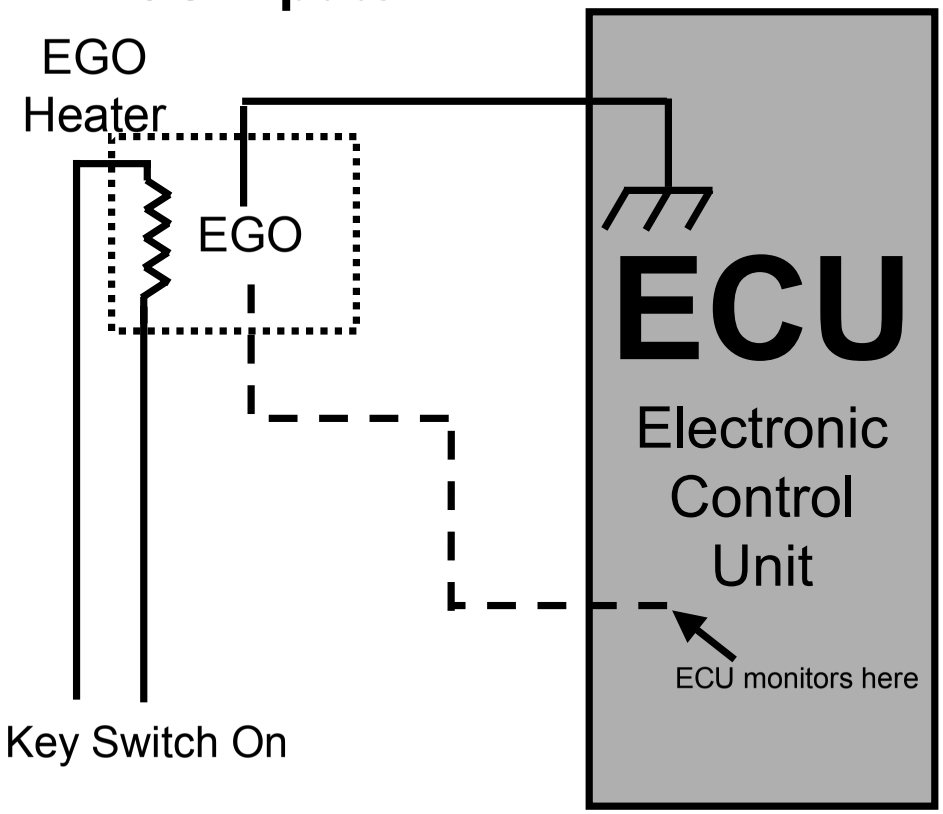
The EGO heater is a 12v heater controlled by the ignition switch. This is not controlled by the ECU. These are the white wires going to sensor harness.

EGO

(if equipped)

EGO
Exhaust Gas
Oxygen Sensor

ECU Inputs



The EGO generates voltages between 0-1vDC.

The ECU “monitors” the signal wire to determine the O2 content of the exhaust stream.

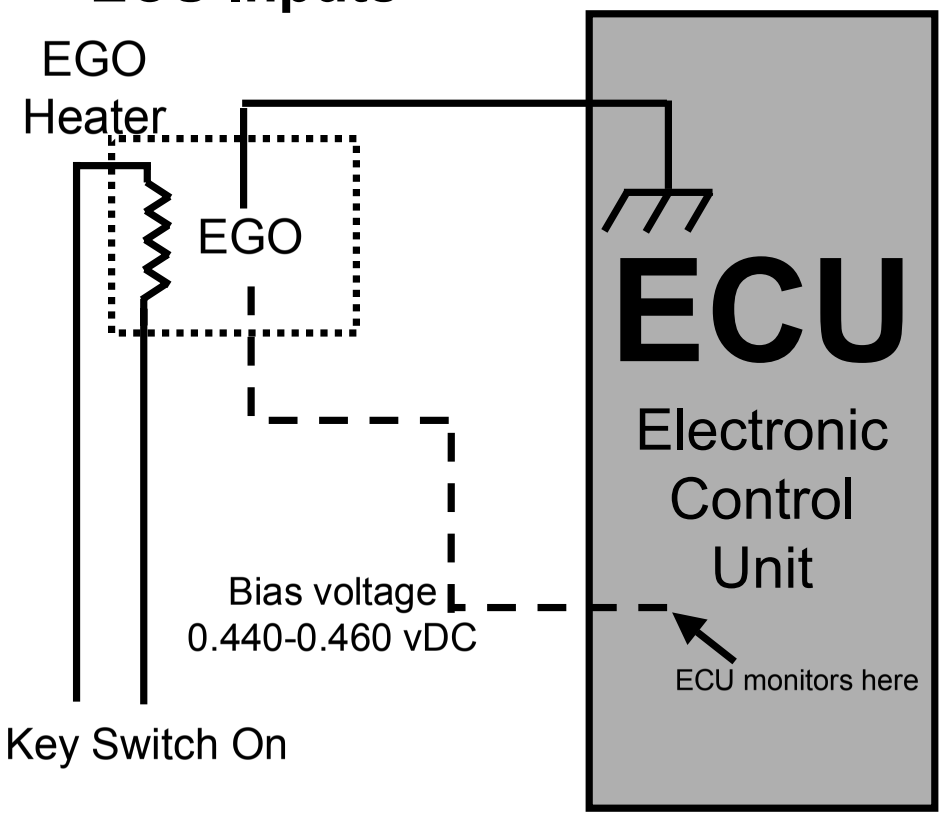
Inputs, EGO page 3a

EGO
Exhaust Gas
Oxygen Sensor

EGO

(if equipped)

ECU Inputs



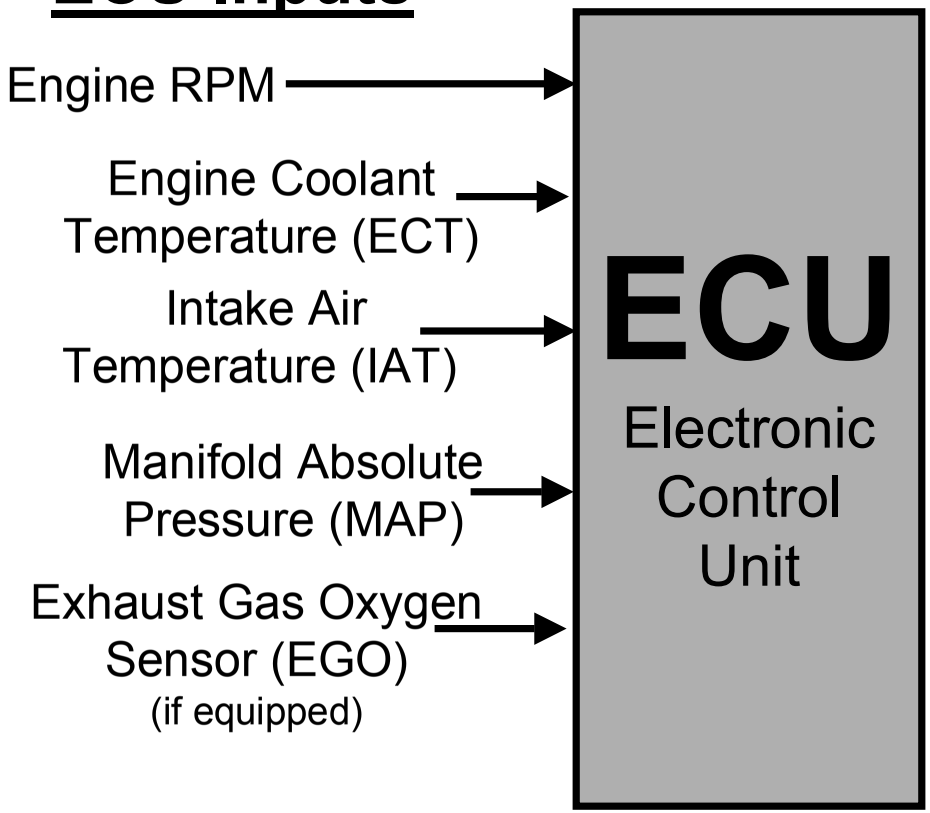
The ECU internally sends a 'bias' voltage to the EGO signal wire. This 'bias' voltage is in the 0.4 - 0.5 vDC range.

If the EGO generates a voltage higher than the bias voltage the ECU determines less fuel is required, if under the bias voltage, more fuel is required.

Inputs Review

The ZEEMS systems uses several input devices to monitor the engine and atmospheric conditions.

ECU Inputs



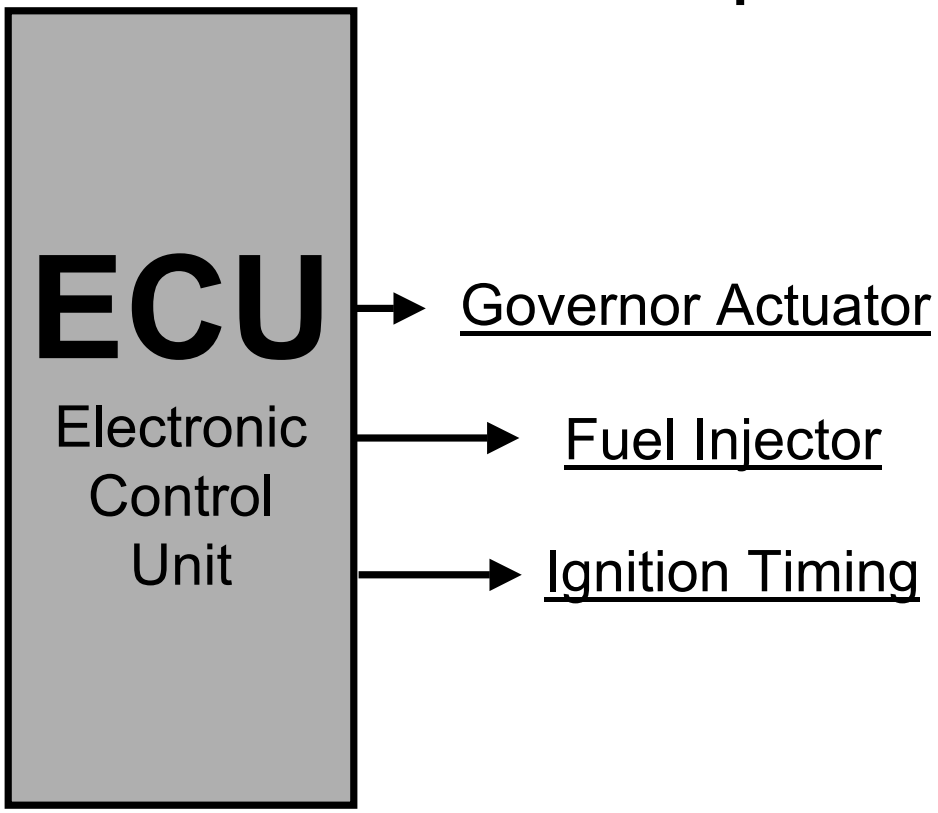
Input Sensor Review

Output Control Introduction

The ZEEMS systems uses three output devices.
Commands to the outputs are determined from input conditions.

Output Controls

Lets examine each output device in depth



Governor

The Governor is an electric actuator which controls (turns) the throttle plate.

The governor actuator motor is the only connection to the throttle plate.

The governor uses two wires to control the actuator.

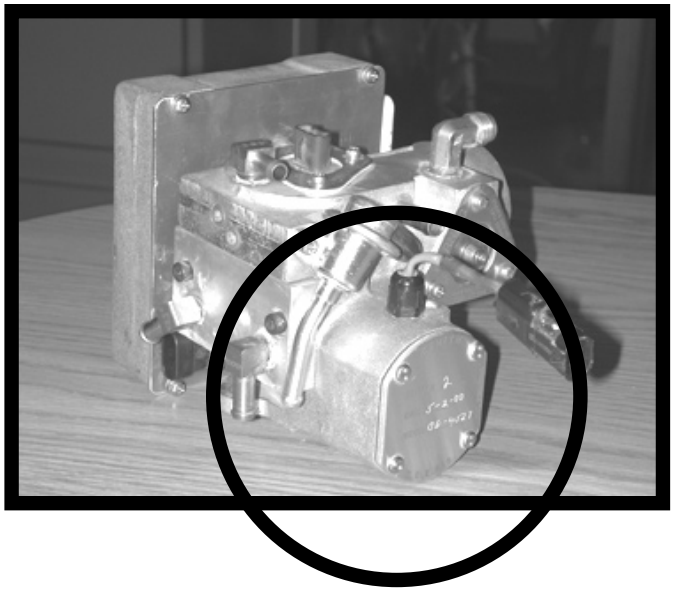
A ground wire and the control circuit from the ECU.

ECU

Electronic Control Unit

ECU Outputs

→ Governor Actuator



Governor

The governor is located on the throttle body assembly and is the only part that is not field replaceable.

The throttle plate has a mechanical stop and must be tested/reset at 1000-1200 hour intervals.

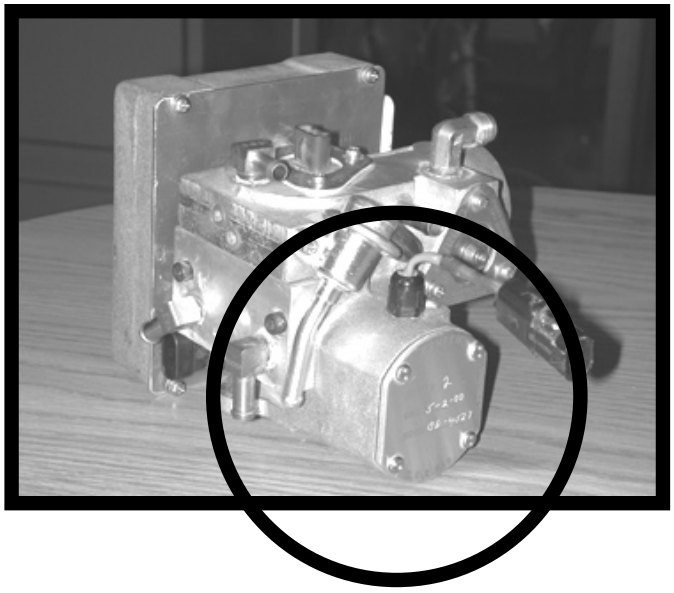
The proper RPM for the mechanical stop is 750 RPM.

ECU

Electronic Control Unit

ECU Outputs

→ Governor Actuator



Governor

To control the governor, the ECU uses two inputs:

- **dash switch** (2 or 3 speed)
- **engine RPM**

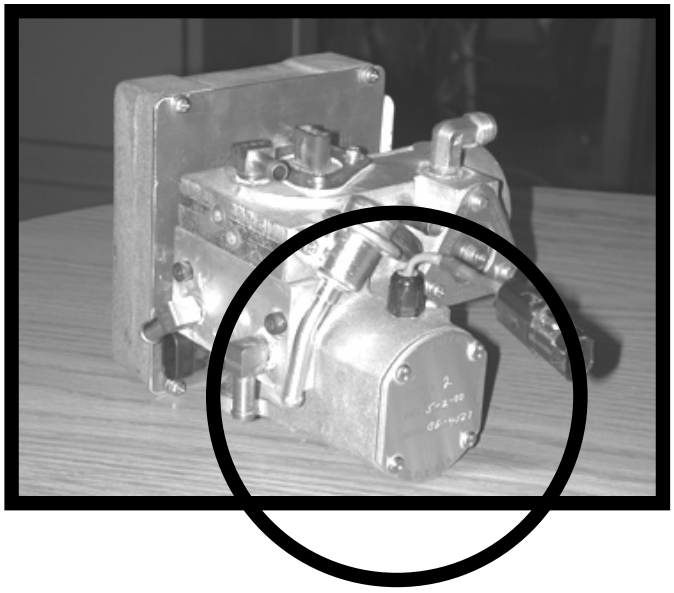
From the RPM input (condition), the ECU commands the governor to increase or decrease the RPM depending on the engine load and other operating conditions to match the dash switch desired RPM.

ECU

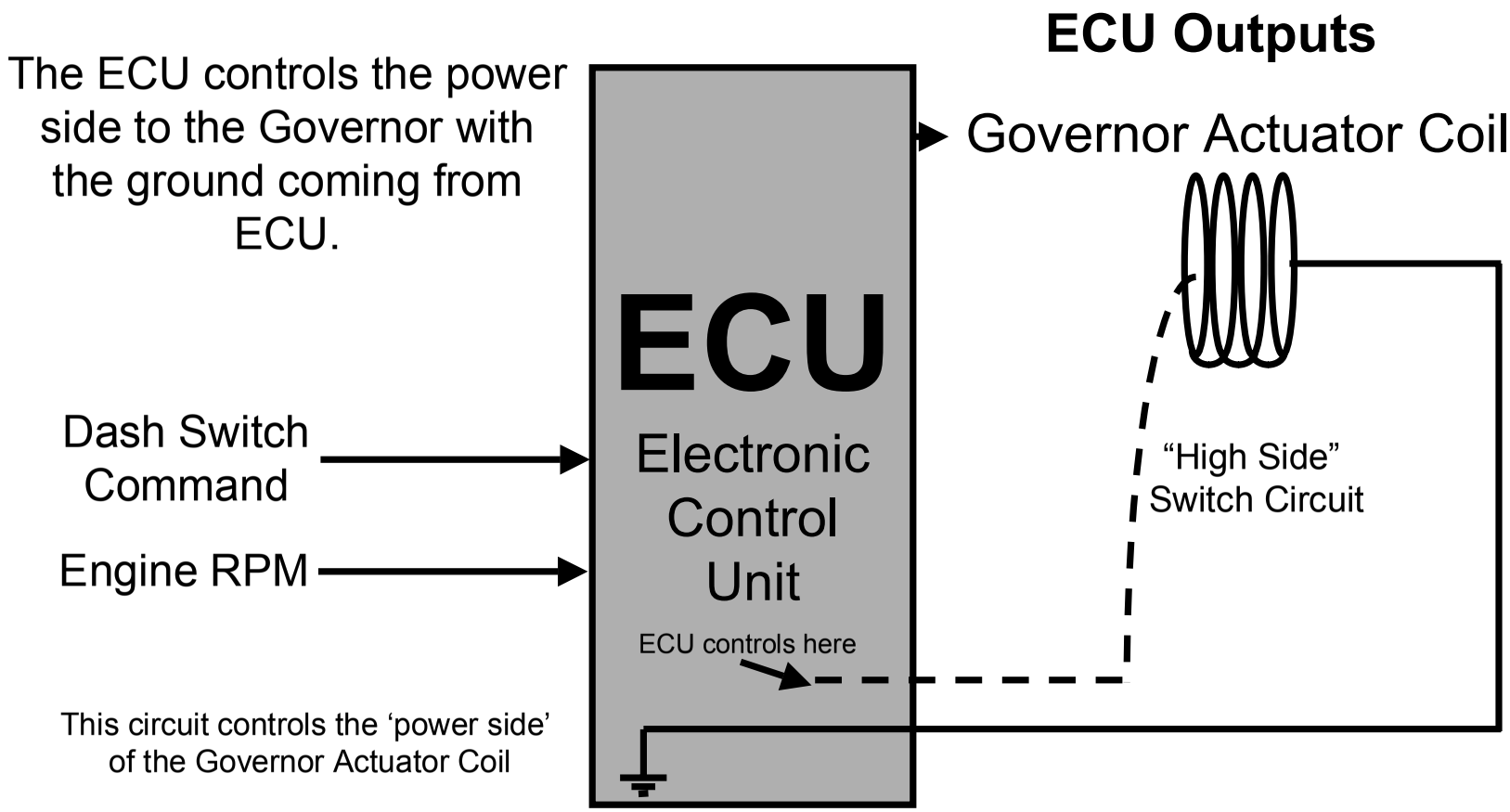
Electronic Control Unit

ECU Outputs

→ Governor Actuator

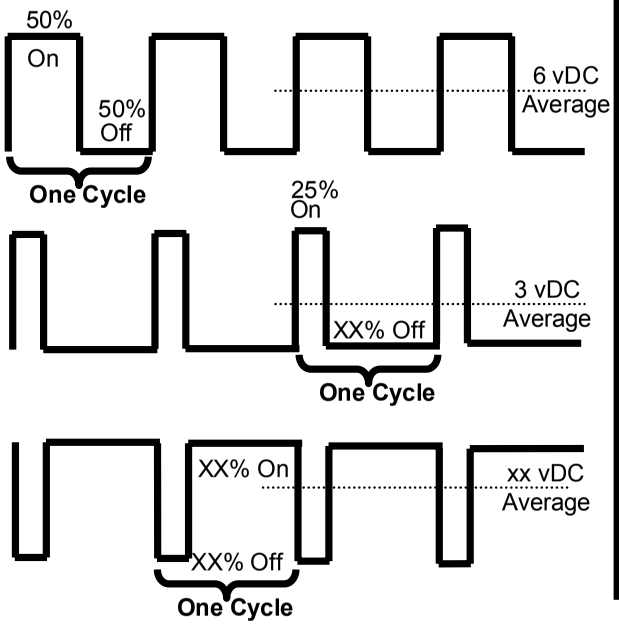


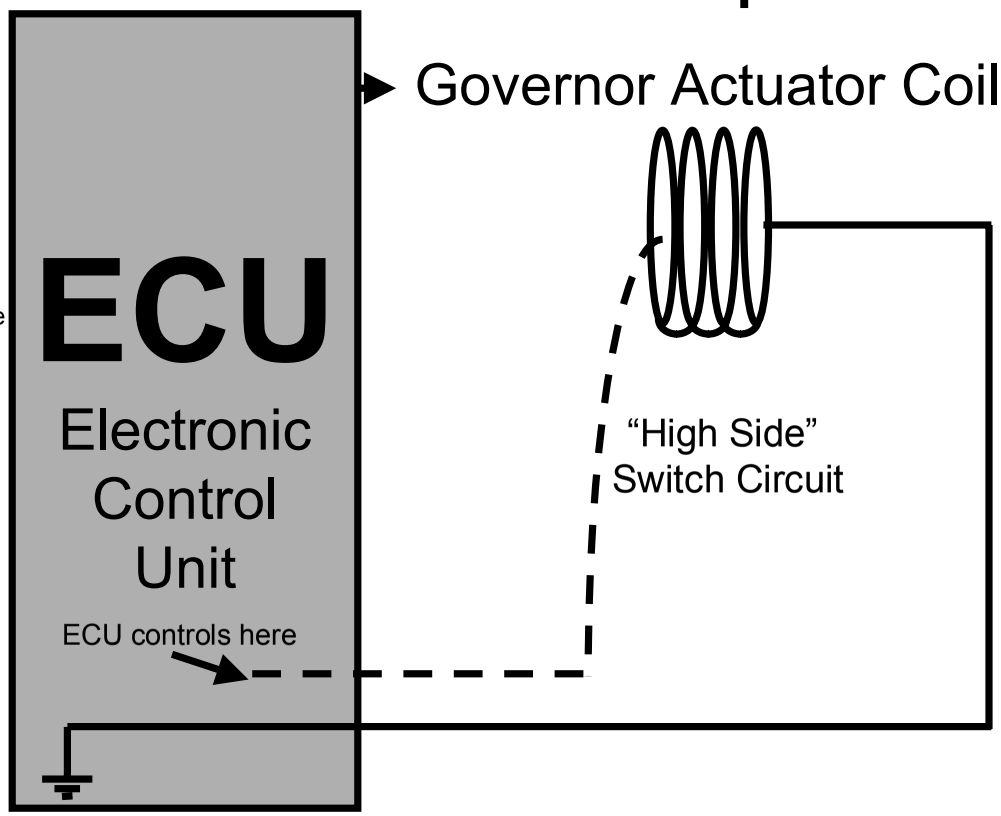
Governor


ECU Outputs
The ECU controls the power side to the Governor with the ground coming from ECU.
Governor Actuator Coil
ECU
Electronic Control Unit
ECU controls here
Dash Switch Command
Engine RPM
"High Side" Switch Circuit
This circuit controls the 'power side' of the Governor Actuator Coil

Governor

The ECU controls the governor by changing the 'on-time' or pulse width modulation (PWM) (duty cycle change) during fixed frequency pulses.



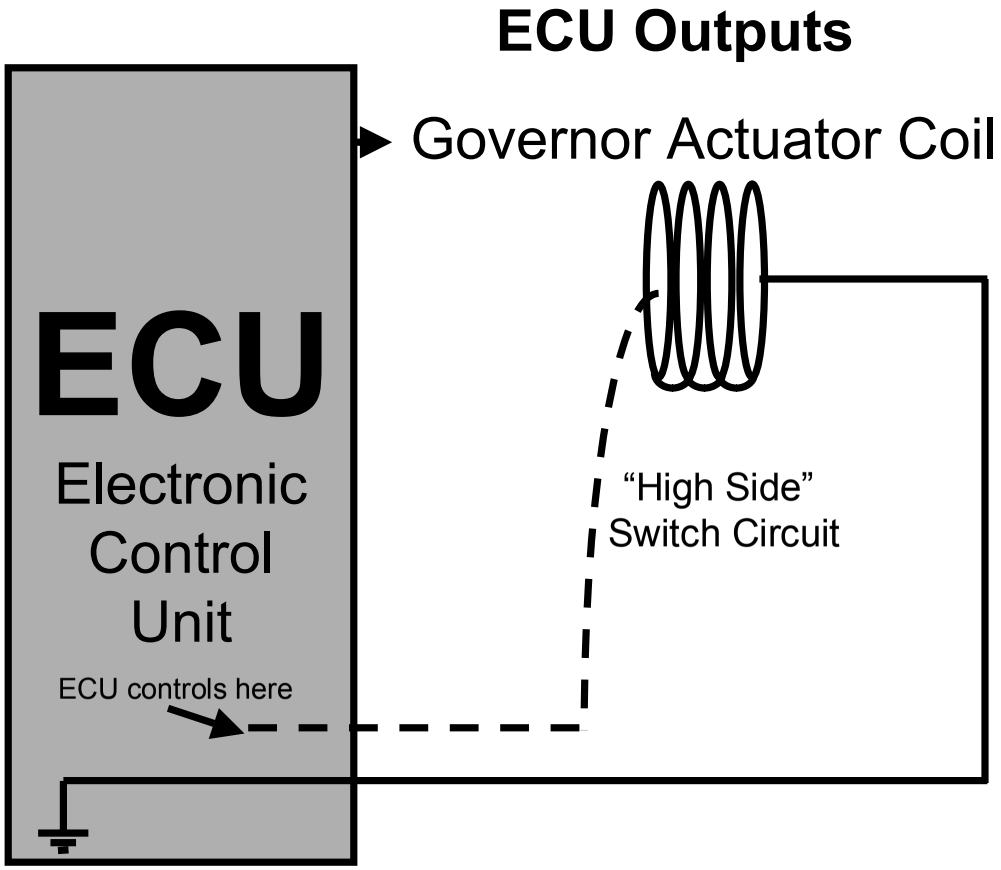


Governor

The frequency of the governor control circuit is 240 hertz +/-2%.

The duty cycle will vary according to the engine load, based on the throttle plate setting, ignition timing, quality of fuel and many other factors.

The duty cycle must change as the demand for engine RPM is commanded.



Governor

If the ECU or throttle body/governor assembly is replaced or the base idle setting is altered, the ECU must relearn the base throttle setting. This procedure takes 2-4 minutes during normal operation.

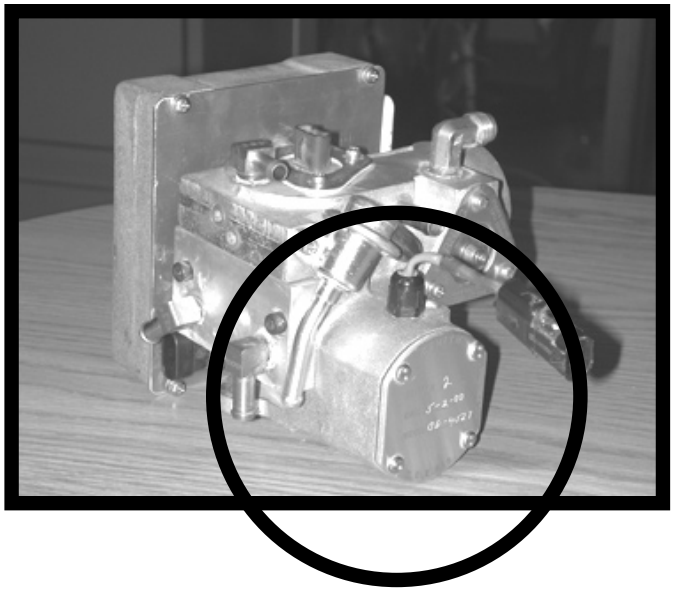
This ‘idle setting relearn’ procedure is a ‘self-programming’ operation of the ECU

ECU

Electronic Control Unit

ECU Outputs

Governor



Governor

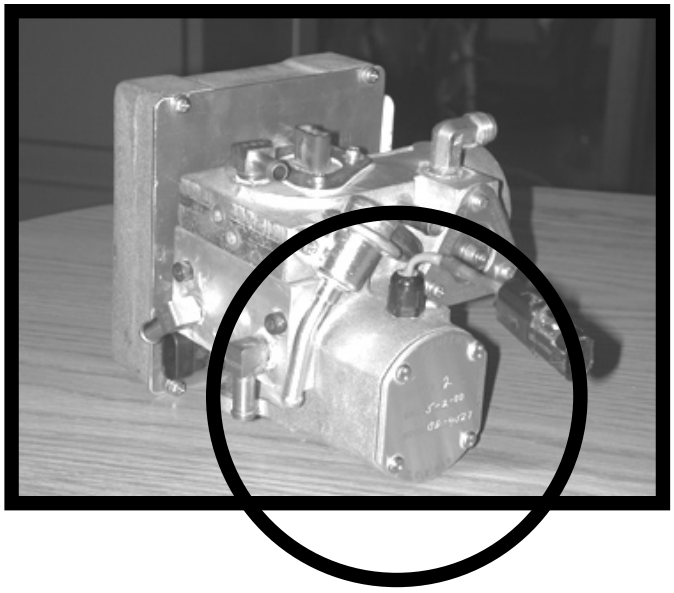
The proper RPM for the mechanical stop is 750 RPM.

To adjust:
(engine must be over 171 degrees F)
- unplug the actuator (governor)
- remove sealant over stop screw
- start engine and monitor RPM
- turn stop screw to desired RPM
- turn engine off
- connect actuator (gov)
- restart engine, run for 2 minutes
- re-run base RPM test (readjust)
- reseal stop screw

ECU
Electronic Control Unit

ECU Outputs

Governor



Fuel Injector

The Fuel Injector is an electric actuator which controls the fuel flow to the engine.

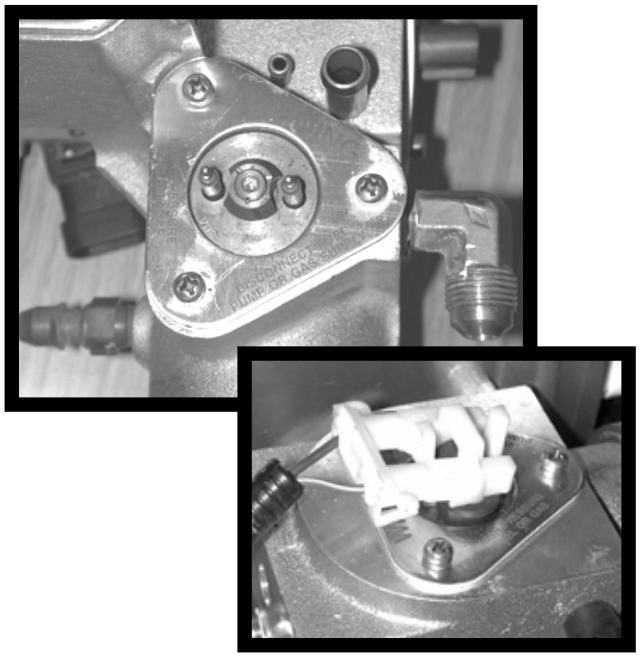
The gasoline fuel injector is calibrated at
10 psi w/o EGO (0.69 bar)
15 psi with EGO (1.0 bar)
and the
propane fuel injector is calibrated at
24 psi. w/o EGO (1.65 bar)
calibrated at
14 psi. with EGO (0.96 bar)
No normal servicing is required.

ECU

Electronic Control Unit

ECU Output

Fuel Injector



Fuel Injector

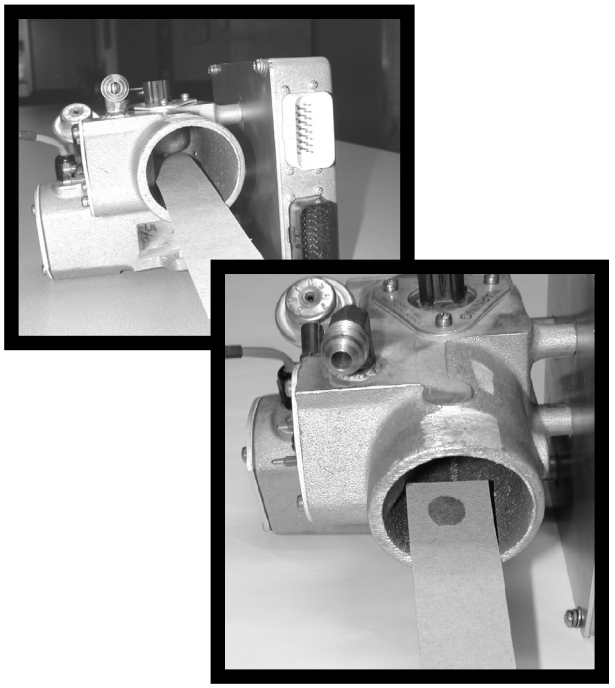
With the engine not running and the key in the off position.

Insert a narrow piece of thin cardboard under the fuel injector nozzle.
Wait for 5-10 minutes, the cardboard should remain "stain free",
if the cardboard is stained, the injector is leaking.

ECU

Electronic Control Unit

Gasoline
Fuel Injector Leak Test



Fuel Injector

To control the fuel injector, the ECU provides the power and controls the “ground side” of the circuit.

The injector fires once per engine event and varies the pulse width (on-time) according to the engine conditions.

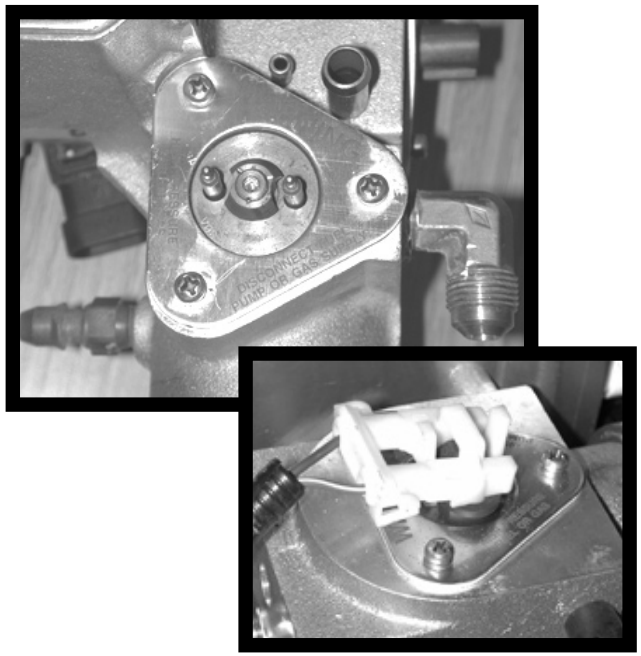
The engine conditions are monitored by the input sensors and the the ECU commands the fuel injector with a longer or shorter pulse width (on time).

ECU

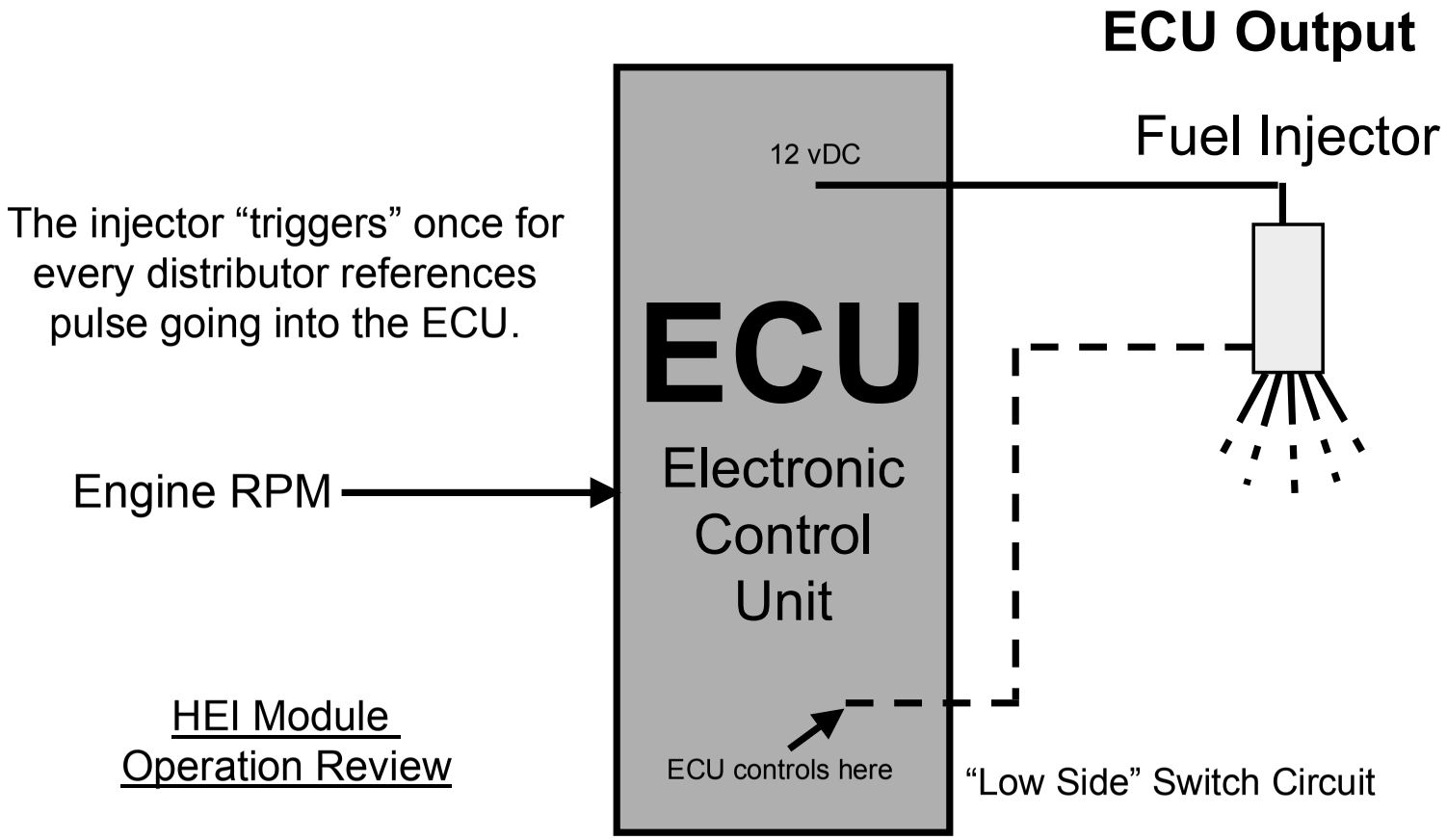
Electronic Control Unit

ECU Output

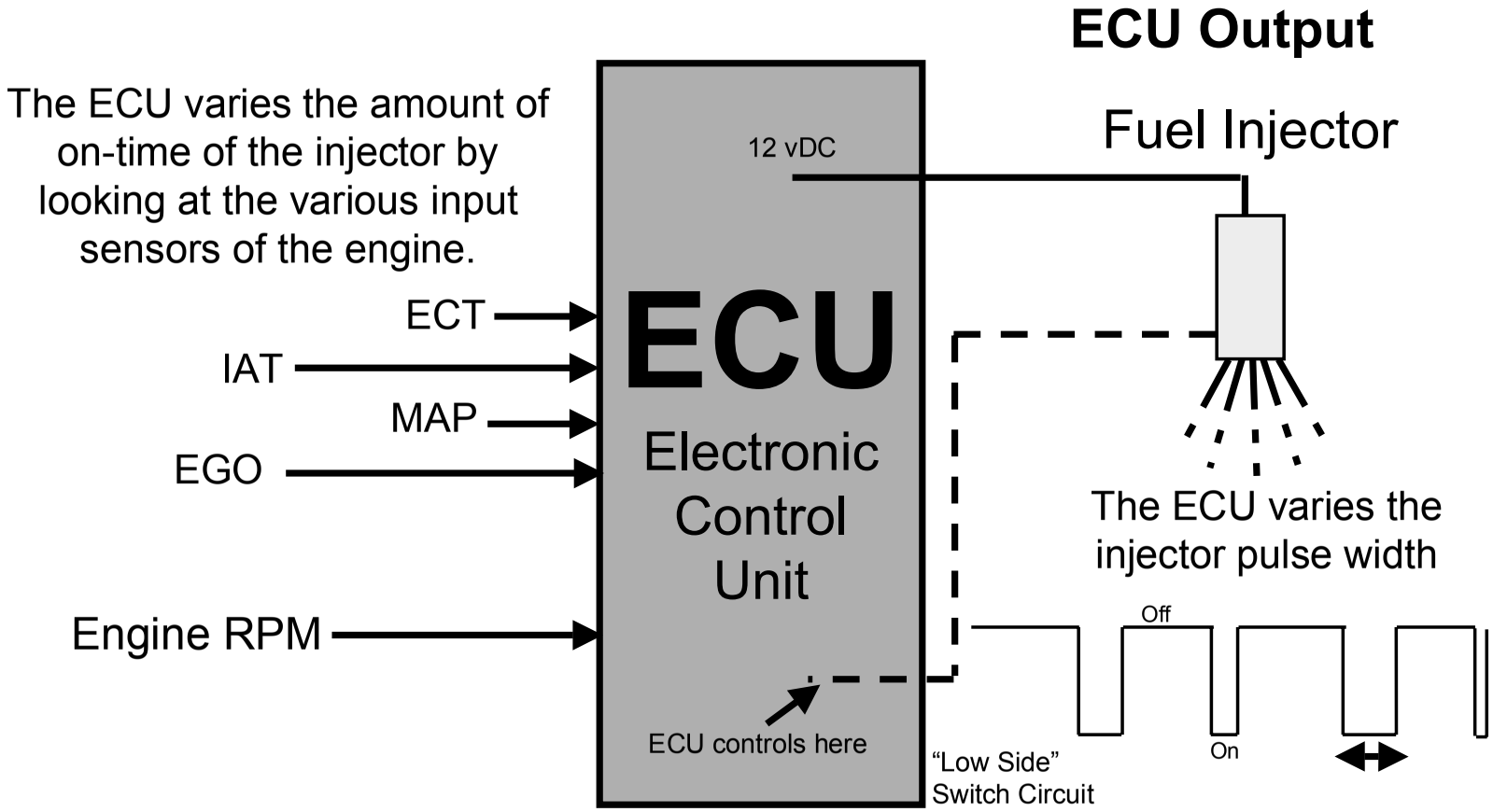
Fuel Injector



Fuel Injector



Fuel Injector

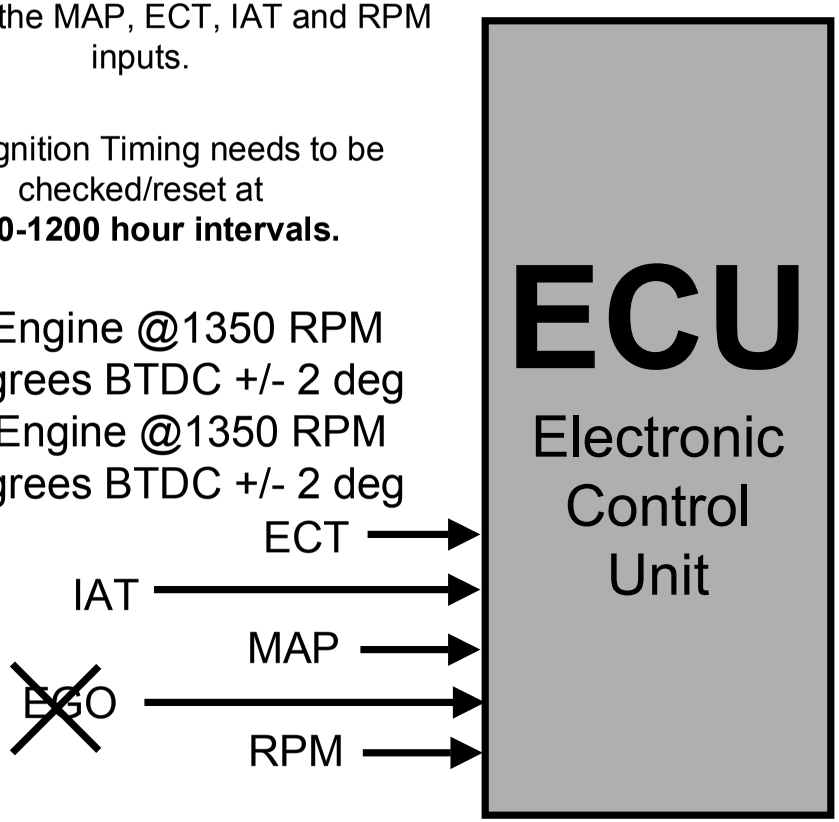


Ignition Timing

The ECU controls the ignition timing based on the MAP, ECT, IAT and RPM inputs.

Base Ignition Timing needs to be checked/reset at **1000-1200 hour intervals.**

Gas Engine @1350 RPM
17 degrees BTDC +/- 2 deg
LPG Engine @1350 RPM
25 degrees BTDC +/- 2 deg

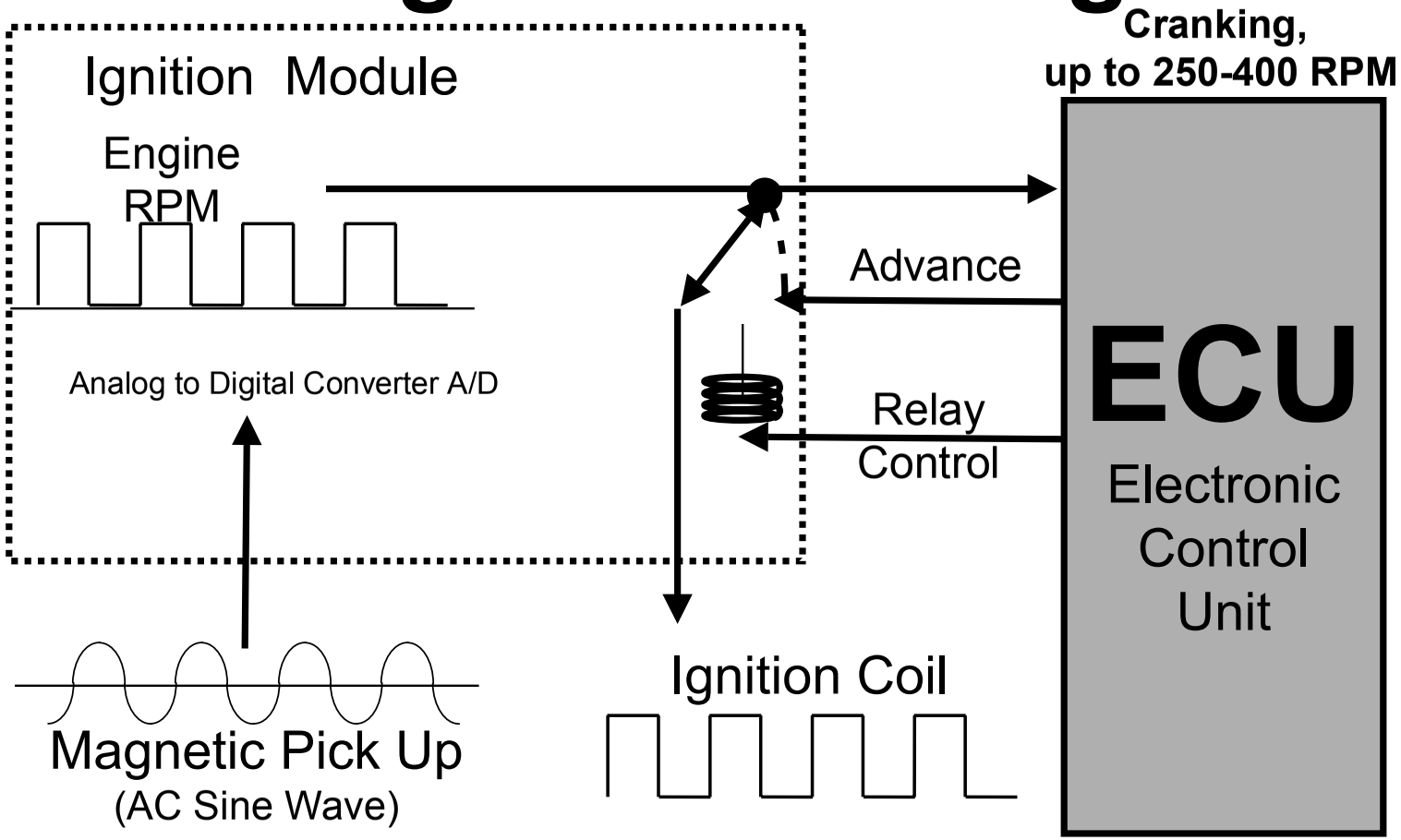


ECU Output

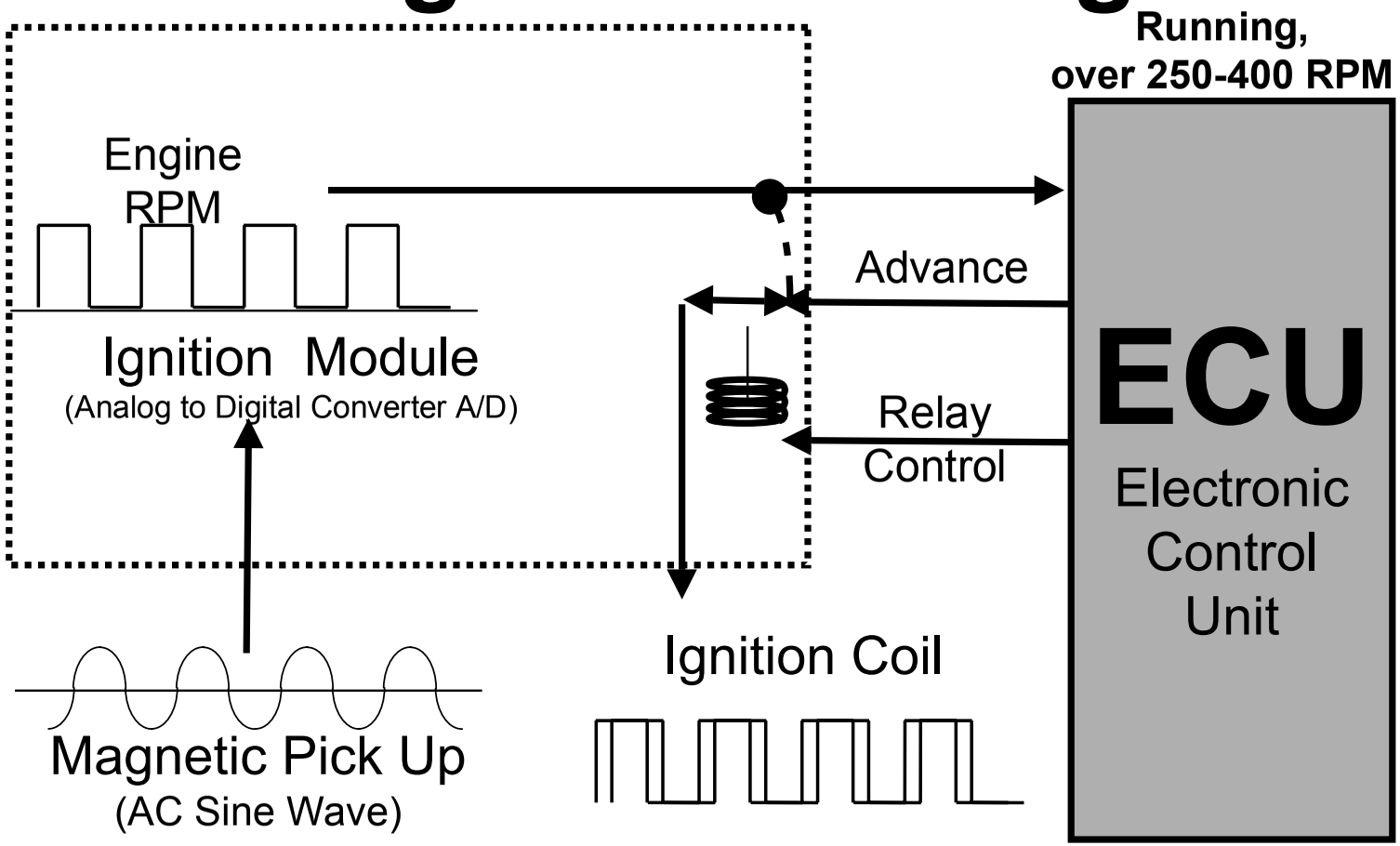
Ignition Timing

Timing Advance Discussion

Ignition Timing



Ignition Timing



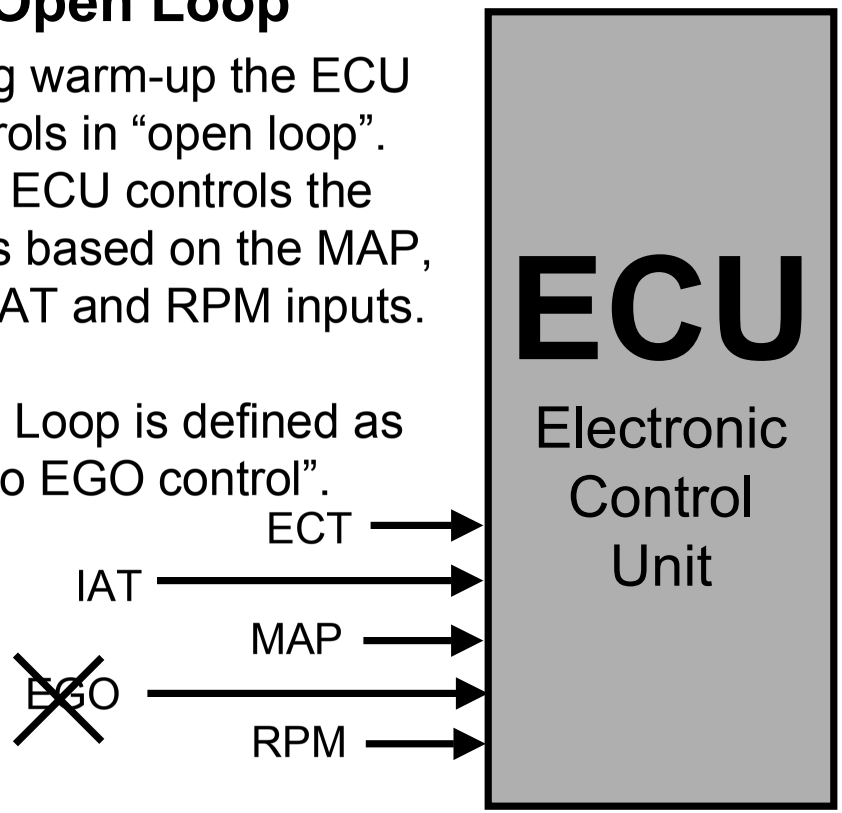
Open & Closed Loop

Open Loop

During warm-up the ECU controls in “open loop”. The ECU controls the outputs based on the MAP, ECT, IAT and RPM inputs.

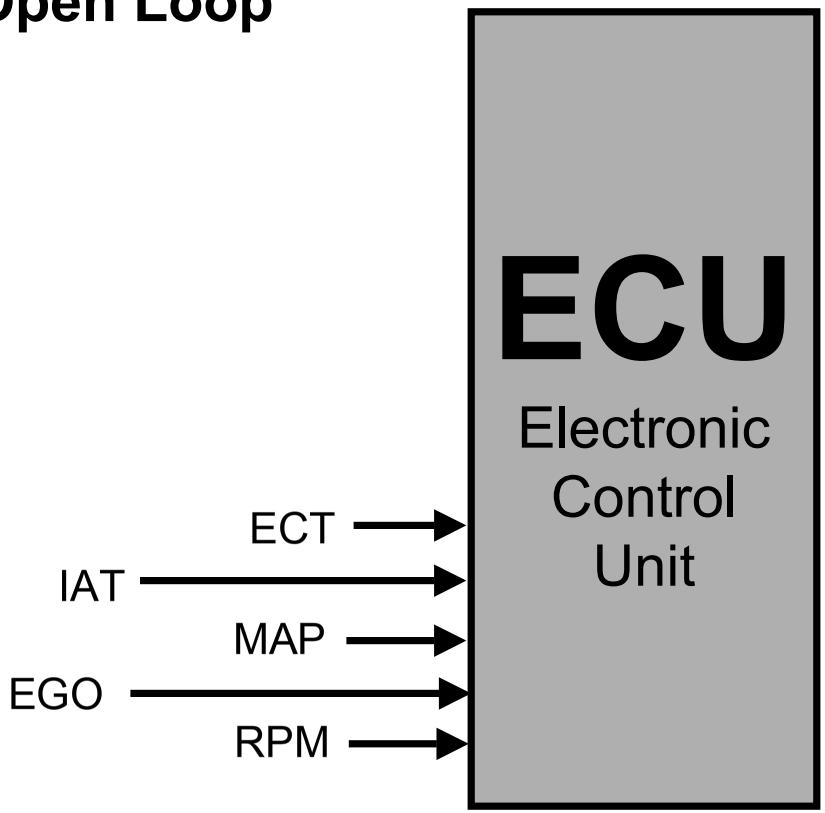
Open Loop is defined as “no EGO control”.

Closed Loop



Open & Closed Loop

Open Loop



Closed Loop

To achieve 'closed loop' these conditions must be meet:
- engine fully warm
- EGO hot and operating
- engine running for 15-120 seconds

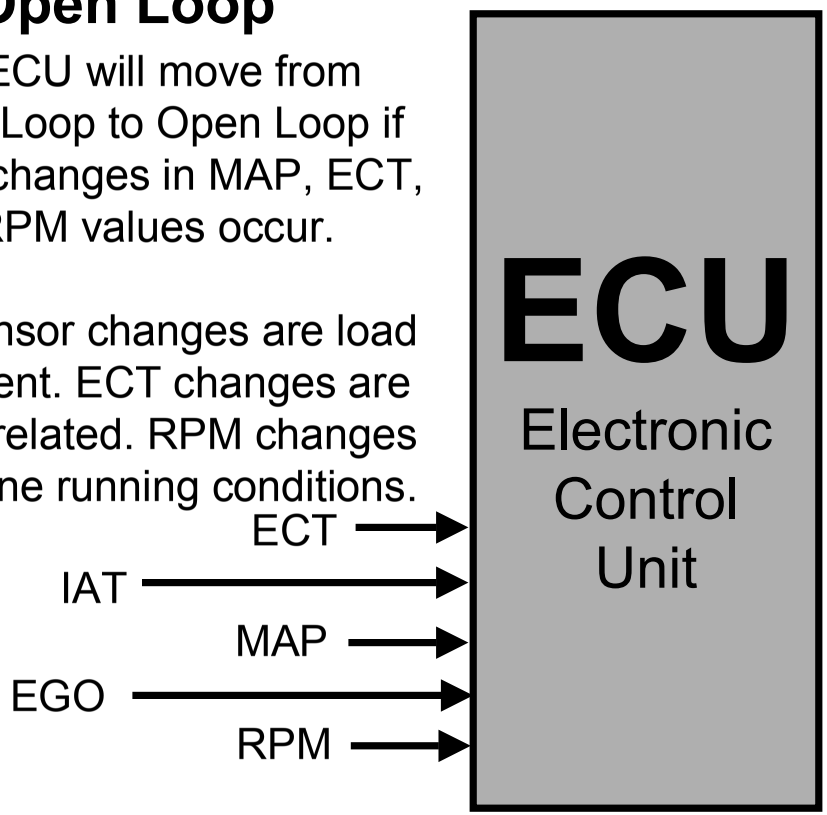
Closed Loop is defined as the EGO is monitoring the the O2 content of the exhaust stream and the ECU is adjusting the fuel injector pulse width based on the EGO values.

Closed Loop to Open Loop

Open Loop

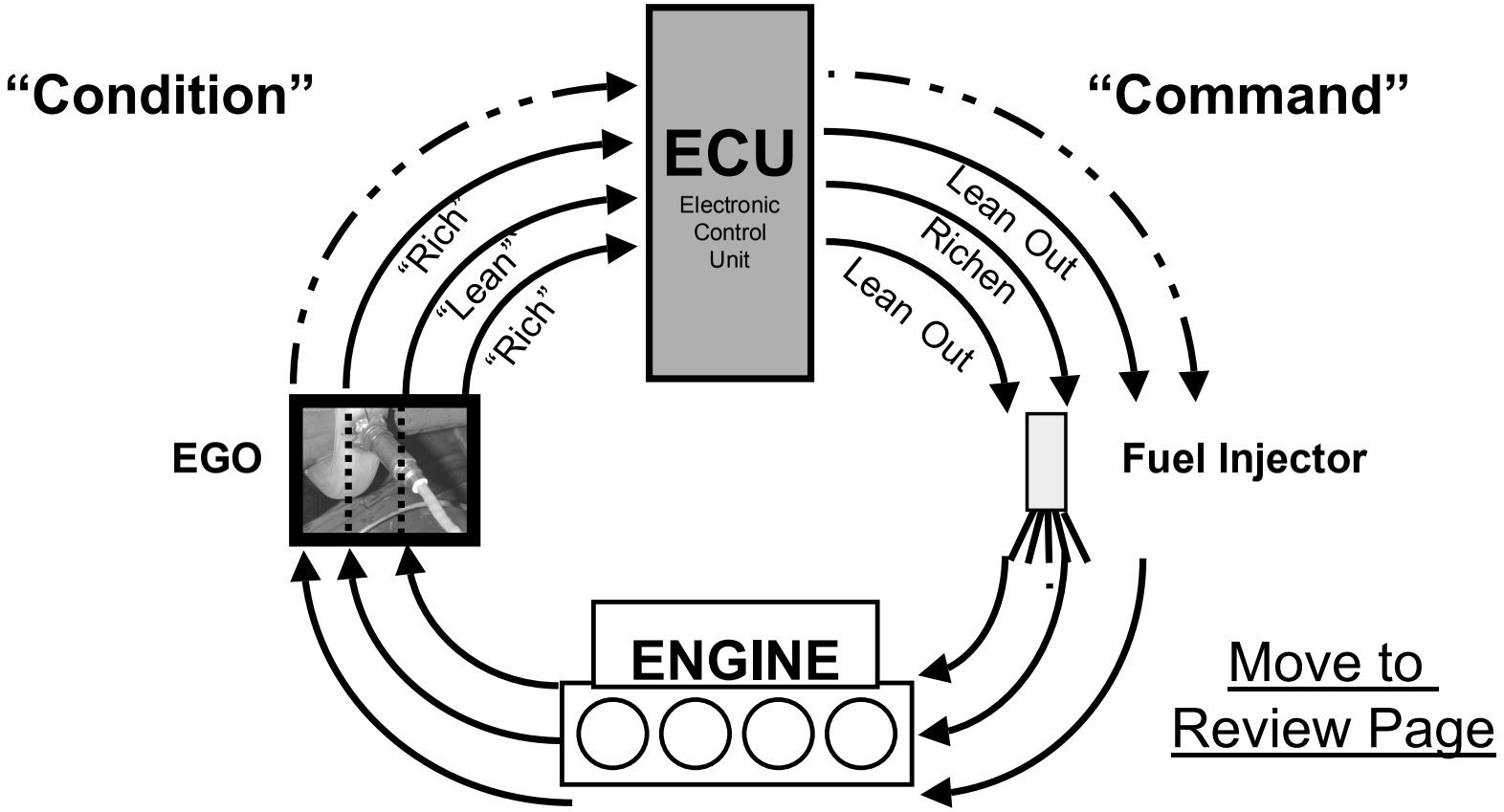
The ECU will move from Closed Loop to Open Loop if sudden changes in MAP, ECT, or RPM values occur.

MAP sensor changes are load dependent. ECT changes are coolant related. RPM changes are engine running conditions.



Home
Find...
Go To..

Closed Loop Operation



Move to Review Page

Review Questions and Answers

Open/Closed Loop Discussion

Review Questions and Answers

Name the five (5) input sensors
(input sensor review)

Name the three (3) output actuators
(actuator review)

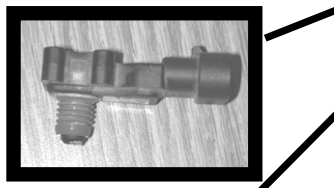
If the engine coolant temperature is high,
will the ECT resistance be high or low? (ECT review)

How does the EGO sensor produce voltage? (EGO review)

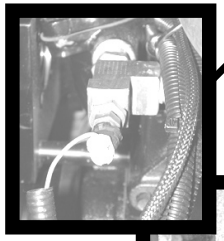
If the MAP sensor signal voltage 2.8vDC, (KOEO)
at what altitude is the machine located at? (MAP review)

Key On

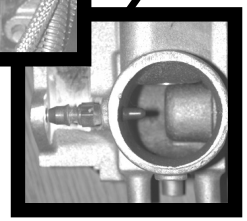
Calculates or measures:
- Altitude, barometric pressure
- Coolant temperature
- Ambient temperature



MAP



ECT



IAT

ECU
Electronic Control Unit

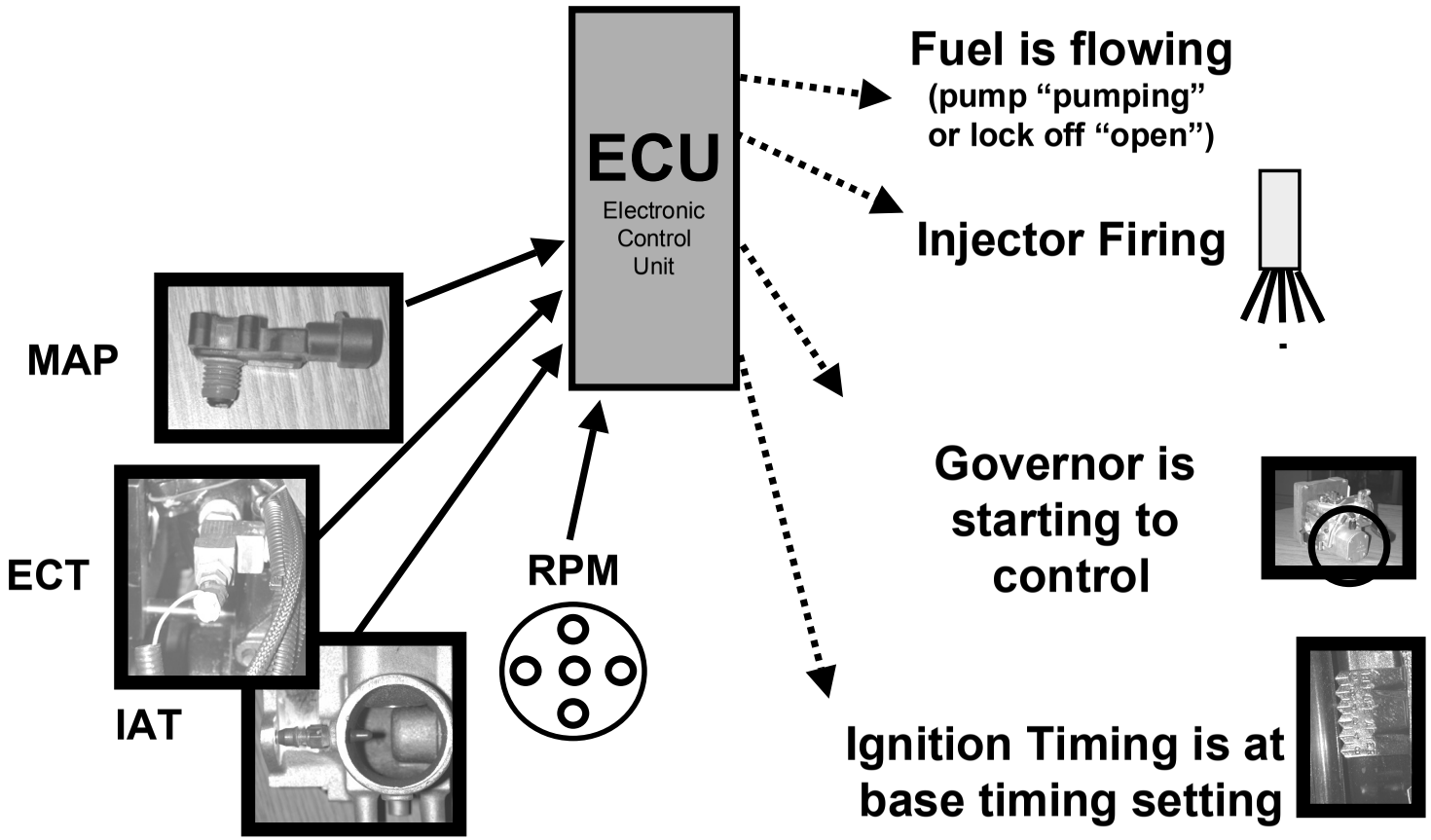
ECU Turns on Fuel Pump (gasoline)

or

Opens Fuel Lock Off (propane)

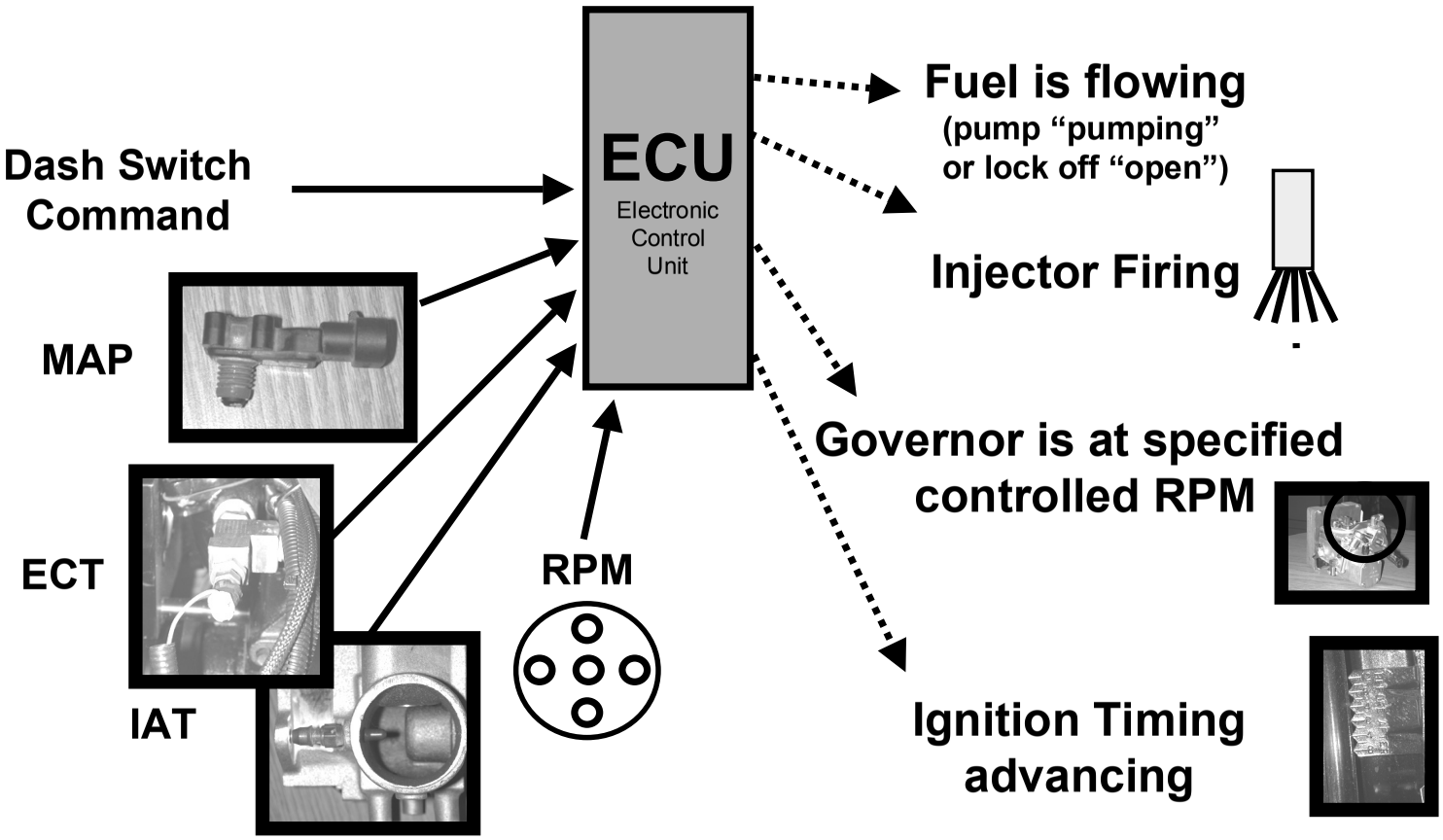
This will be "on" for 2 seconds if a RPM signal is not received. Listen and "feel" the pump run or the lock off to "turn on".

Cranking


ECU
Electronic
Control
Unit
Fuel is flowing
(pump "pumping"
or lock off "open")
Injector Firing
MAP
ECT
IAT
RPM
Governor is
starting to
control
Ignition Timing is at
base timing setting

Running

without EGO Sensor

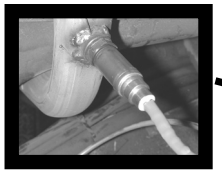


Operation page 4 with EGO

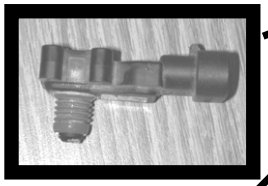
System Operation

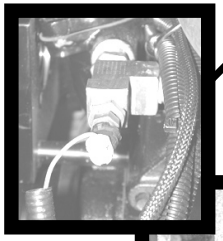
Running

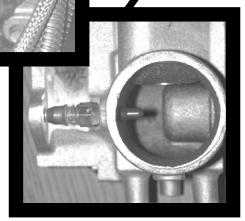
with EGO Sensor



Dash Switch Command

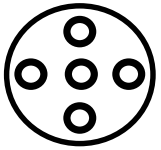


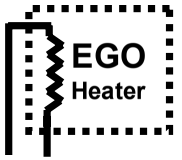




ECU
Electronic Control Unit

RPM

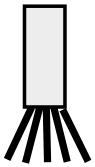




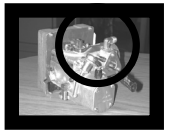
Key On
Not ECU
Controlled

Fuel is flowing
(pump "pumping"
or lock off "open")

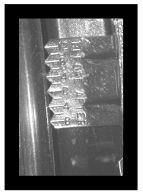
Injector Firing



Governor is at specified controlled RPM



Ignition Timing advancing

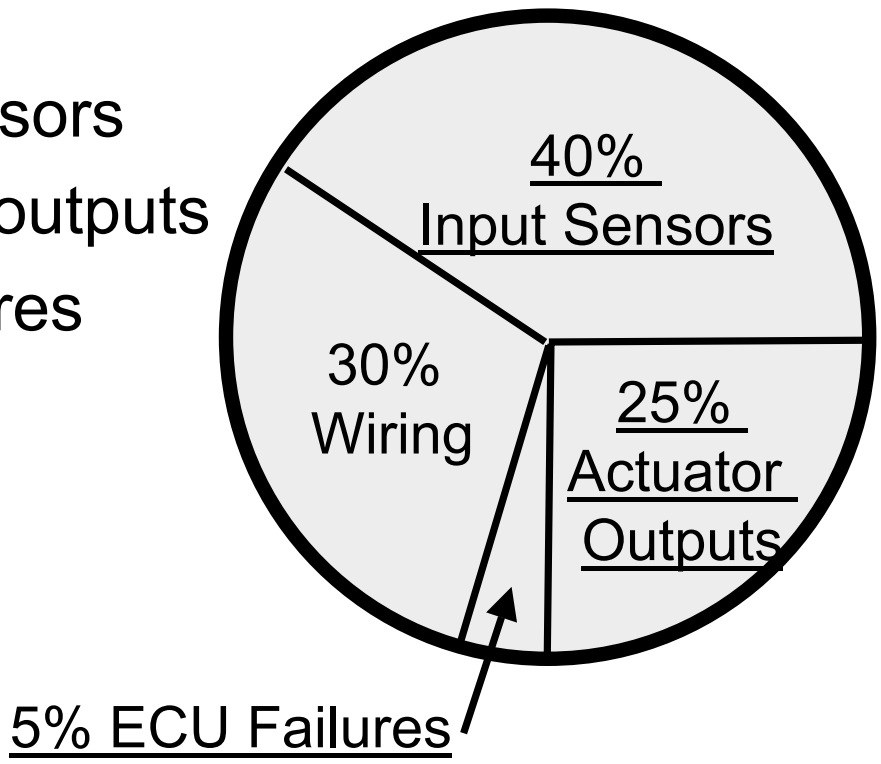


Review
Questions and Answers

Diagnostics

Diagnostics

- Failures
  - 30% Wiring
  - 40% Input sensors
  - 25% Actuator outputs
  - 5% ECU Failures



Diagnostics

- ECU Quick Tests

(These quick tests can determine whether the ECU can control correctly. These test/s have a high accuracy rating to determine a defective ECU.)

- MAP Reference Voltage Test
  - (KOEO, Black Connector Pin 4)
  - Measure Reference voltage to MAP Sensor
    - Turn Key Off
    - Remove wire harness to MAP
    - Turn key on (KOEO)
    - Voltmeter red lead to Terminal “C” on the MAP Sensor, black lead to Terminal “A”
    - Results should be 5.0 vDC +/- 10% (4.5 - 5.5 vDC)
    - MAP Sensor Review

Diagnostics

- Output Control Frequency Test
  - (KOER, White Connector Pin 5)
  - Measure Frequency to Governor Actuator
    - Turn Key Off
    - Connect frequency meter red lead to Terminal “A” on Governor Actuator, black lead to Terminal “B”
      - Leave governor actuator connected in circuit
    - Start Engine (KOER)
    - Results should be 240 Hertz +/- 2% at stable RPM
    - Governor Actuator Review

Diagnostics

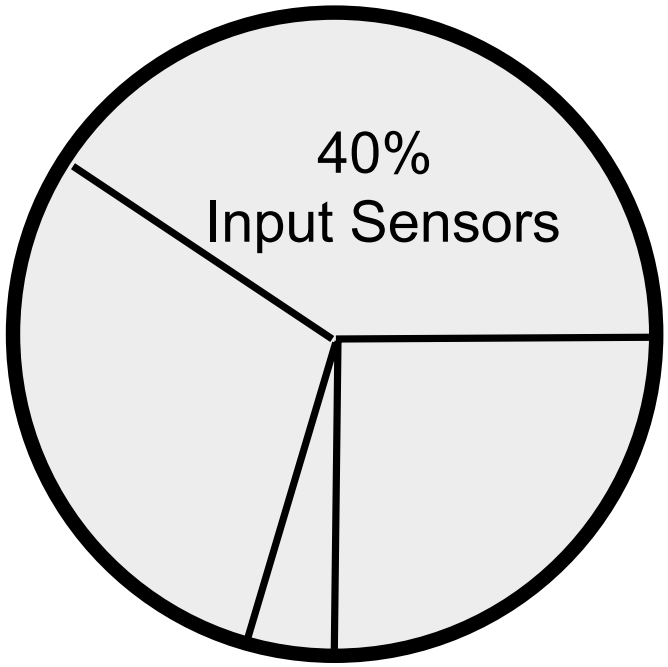
- Processor Quick Tests
  - EGO Bias Voltage Test (KOEO, Black Connector Pin 10)
    - (if equipped)
    - Measure “Bias” voltage to EGO Sensor
      - Turn Key Off
      - Remove wire harness to EGO
      - Turn key on
      - Voltmeter red lead to Terminal “??” on EGO Sensor, black lead to Terminal “??”
      - Results should be 0.4 - 0.5 vDC
      - EGO Sensor Review

Diagnostics

- Processor Quick Tests

- Conclusion
  - If all of these tests fail, suspect a faulty power or ground circuit/s to the ECU.
  - If one or two of these tests fail, suspect a faulty ECU.

- Input Sensor Quick Tests
  - IAT Testing
  - ECT Testing
  - MAP Testing
  - EGO Testing
  - Distributor Reference



- IAT and ECT Testing
  - Remove wiring harness from sensor/s
  - Install “test harness” to IAT or ECT sensor
  - Measure the resistance values in Ohms and compare to chart below

Temp F	Temp C	Nominal Resistance		Minimum Resistance	Maximum Resistance
266	**130**	**84**		80	88
230	**110**	**144**		139	151
212	**100**	**189**		182	199
176	**80**	**349**		334	369
140	**60**	**693**		657	734
104	**40**	**1484**		1398	1579
68	**20**	**3481**		3254	3719
32	**0**	**9099**		8442	9767
-4	**-20**	**27050**		24910	2910
-40	**-40**	**93630**		85570	101400

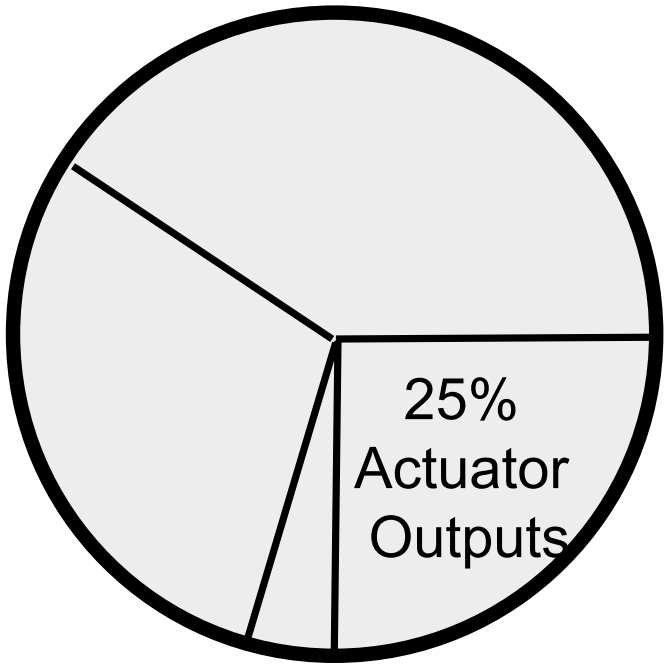
- IAT and ECT Testing
  - Remove wiring harness from sensor/s
  - Turn Key On (KOEO)
  - Measure voltage between terminals “A” & “B” of the wiring harness going to the IAT or ECT
    - Black Voltmeter lead to “B”, red lead to “A”
    - Voltage should be 5 vDC +/- 10% (KOEO)

- MAP Testing
  - Complete ECU reference voltage test at MAP
  - With the MAP connected “in-circuit”
  - Connect a voltmeter as follows, key on (KOEO)
    - Red lead to terminal “B”, black lead to ground
    - Measure the Voltage values and compare to chart
    - These voltages will vary according the current weather conditions at your location

Altitude above Sea Level		Nominal Voltage DC
0-1000		5.00-4.60
1000-2000		4.60-4.10
2000-3000		4.10-3.60
3000-4000		3.60-3.20

- EGO Testing (if equipped)
  - Complete EGO Bias voltage test
  - With the EGO connected “in-circuit”
  - Connect a voltmeter as follows, key on (KOEO)
    - Red lead to terminal “XX”, black lead to ground
  - Complete EGO test in machine per EGO testing sequence
    - ‘Richen Mixture’ EGO voltage 0.8 vDC or higher
    - ‘Lean Mixture’ EGO voltage 0.3 vDC or lower
    - (EGO Sensor Review)

- Failures
  - 30% Wiring
  - 40% Input sensors
  - 25% Actuator outputs
  - 5% ECU Failures



- Fuel Injector Testing
  - Disconnect wire/s to fuel injector
  - Measure the resistance of the fuel injector
    - 1.2 - 1.4 Ohms is specification
  - Turn Key on and measure voltage on the harness
    - Volt meter red lead to terminal “A”, black lead to terminal “B”, turn key on (KOEO)
    - Voltage should be 9-14 vDC
  - Complete fuel injector “tap test”

- Governor Actuator Testing
  - Disconnect wire/s to Governor Actuator
  - Measure the resistance of the actuator
    - 3.0-4.5 Ohms is specification
  - Turn Key on and measure voltage on the harness
    - Volt meter red lead to terminal “A”, black lead to terminal “B”, turn key on (KOEO)
    - Voltage should be battery voltage (+/-0.4vDC)

- Governor Actuator Testing
  - Connect ammeter to one wire going to governor actuator
  - Turn key on (KOEO)
    - Measure governor actuator amperage draw
    - Specification is 0.5 - 2.5 amp when Governor actuator is “activated” (3 amps maximum draw)
    - If higher than three amp draw, suspect sticking throttle plates or other mechanical binding

- Ignition Timing Testing
  - Set to lowest governed RPM (1350)
  - Start engine and monitor ignition timing

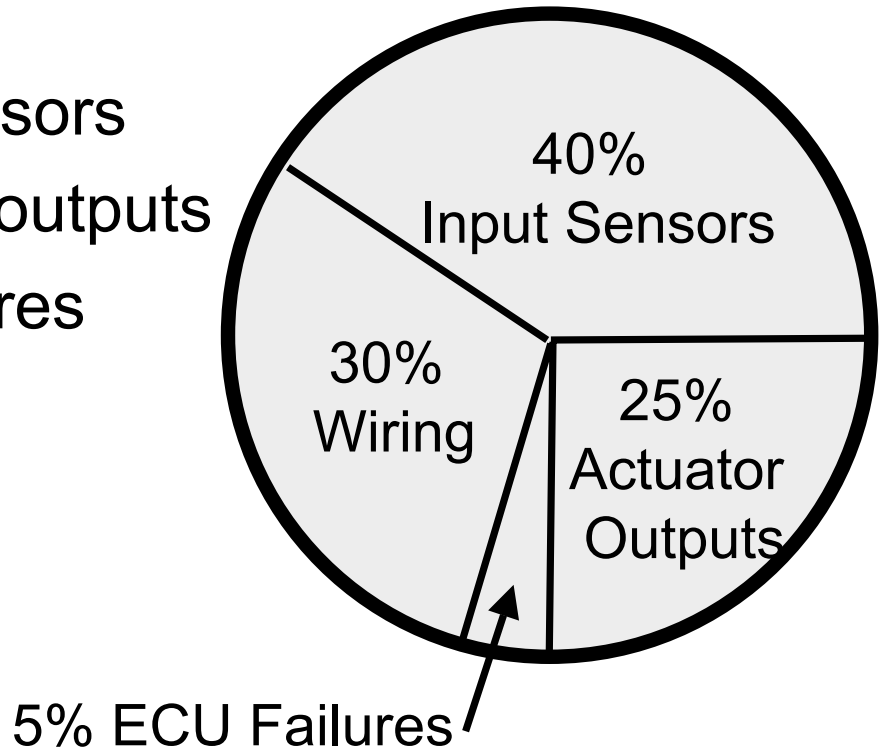
    - Gas Engine @1350 RPM

    17 degrees BTDC +/- 2 deg

    - LPG Engine @1350 RPM

    25 degrees BTDC +/- 2 deg

- Diagnostic Review
  - 30% Wiring
  - 40% Input sensors
  - 25% Actuator outputs
  - 5% ECU Failures



Specifications

IAT and ECT

Temp F	Temp C	Nominal Resistance		Minimum Resistance	Maximum Resistance
266	130	84		80	88
230	110	144		139	151
212	100	189		182	199
176	80	349		334	369
140	60	693		657	734
104	40	1484		1398	1579
68	20	3481		3254	3719
32	0	9099		8442	9767
-4	-20	27050		24910	2910
-40	-40	93630		85570	101400

MAP

Altitude above Sea Level		Nominal Voltage DC
0-1000		5.0 - 4.7
1000-2000		4.7 - 4.3
2000-3000		4.3 - 4.1
3000-4000		4.1 - 3.9
4000-5000		3.9 - 3.8

Fuel Pressure

Gasoline

10 psi (0.69 bar) w/o EGO

~~15 psi (1.0 bar) w/EGO~~

Propane

~~14 psi. (0.96 bar) w/EGO~~

~~24 psi. (1.65 bar)~~ w/o EGO

14 psi (0.96 bar)

Fuel Injector

1.2 - 1.4 Ohms

Timing @1350 RPM

Gas 17 deg BTDC +/- 2 deg

LPG 25 deg BTDC +/- 2 deg

Governor Actuator

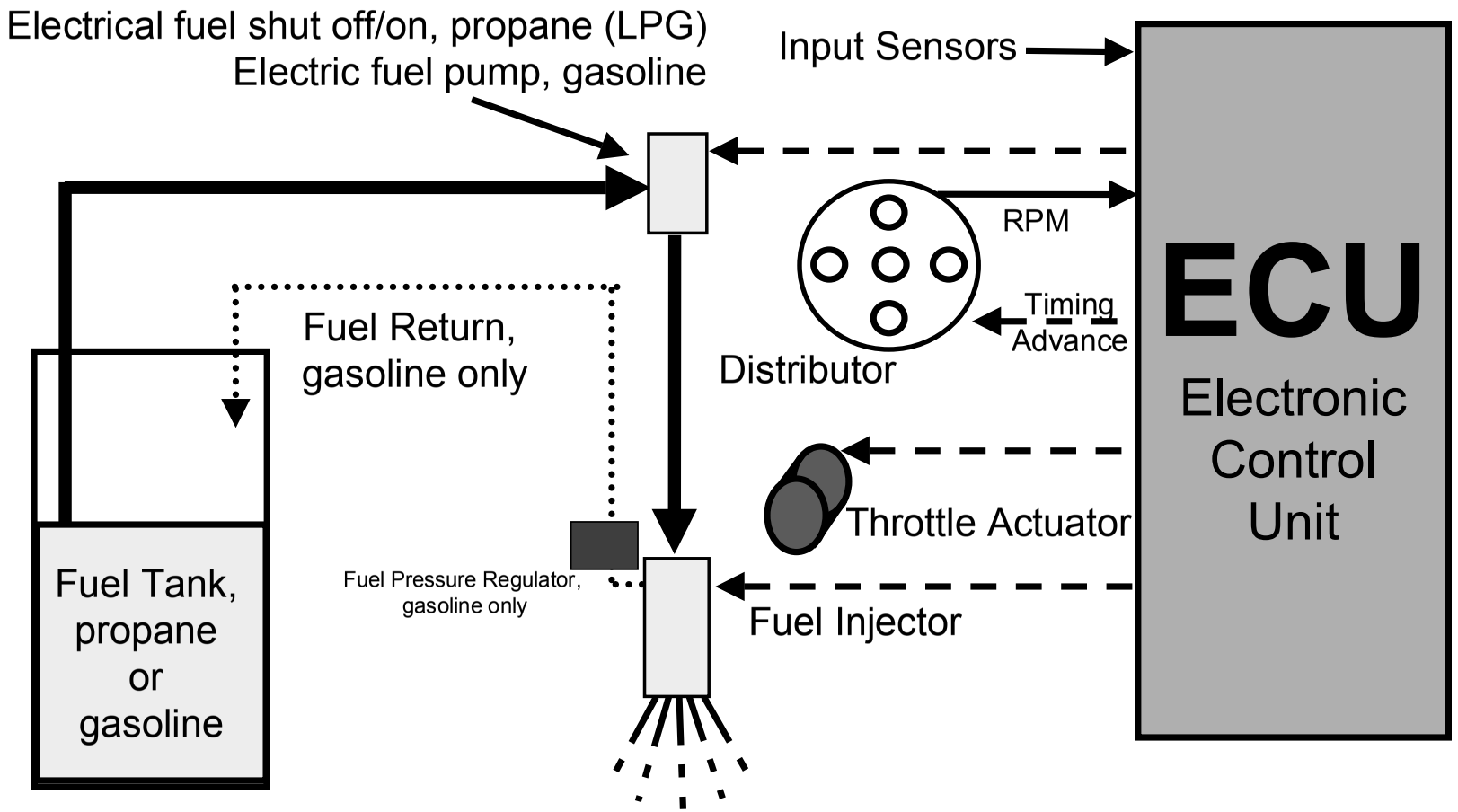
3.0-4.5 Ohms

3 amp max current draw

Review
Questions and Answers

Block Diagram Review

ZEEMS Block Diagram

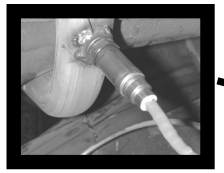


Operation Review

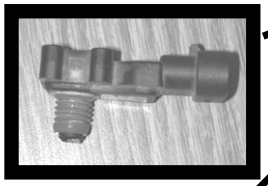
System Operation

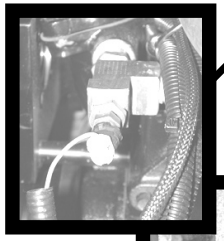
Running

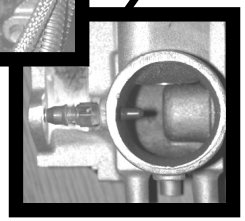
with EGO Sensor



Dash Switch Command

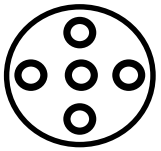


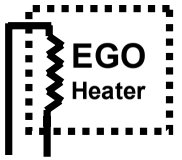




ECU
Electronic Control Unit

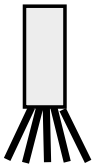
RPM



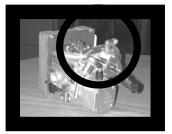


Fuel is flowing
(pump "pumping" or lock off "open")

Injector Firing



Governor is at specified controlled RPM



Ignition Timing advancing

Home
Find...
Go To..

ZEEMS

550/1550 Engine Replacement Kit Numbers
392556 Perkins Diesel
392557 GM 3.0 L LPG
392558 GM 3.0 L Gas

ZEEMS

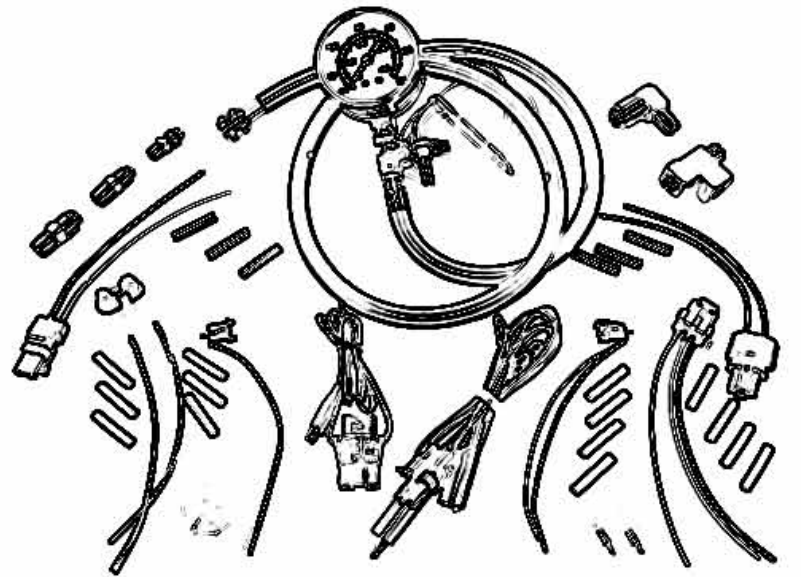
Zenith Electronic Engine Management System

Propane and Gasoline Electronic Fuel Injection

END

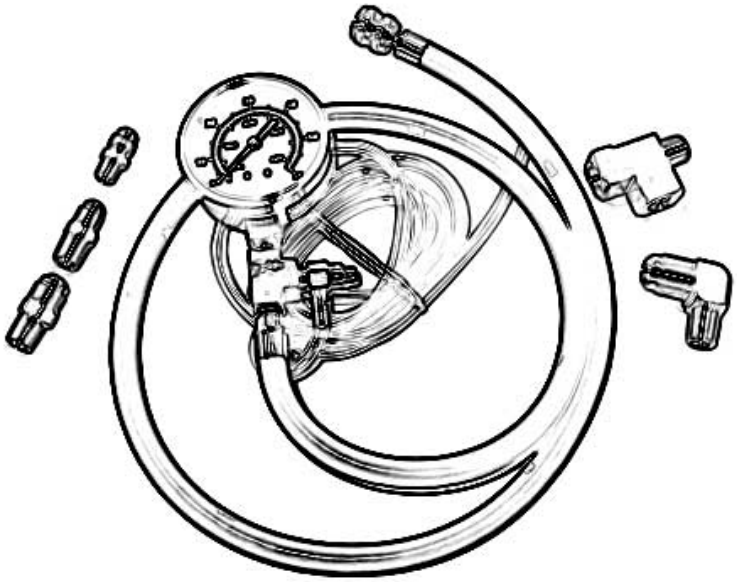
ZEEMS Troubleshooting Test Kit

Complete Test Kit – Tennant Part # 371772 – Zenith Part # C282-311

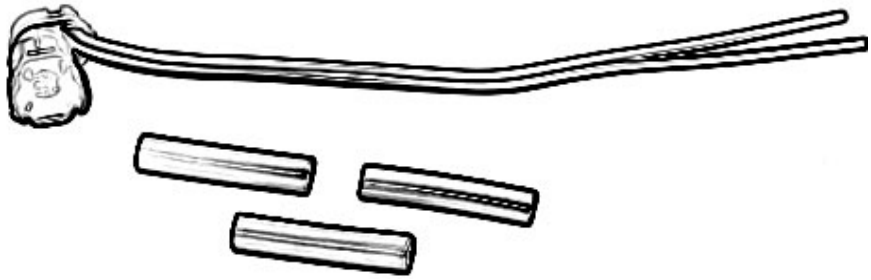


Pressure Gauge – Tennant Part # 371784 – Zenith Part # C190-181

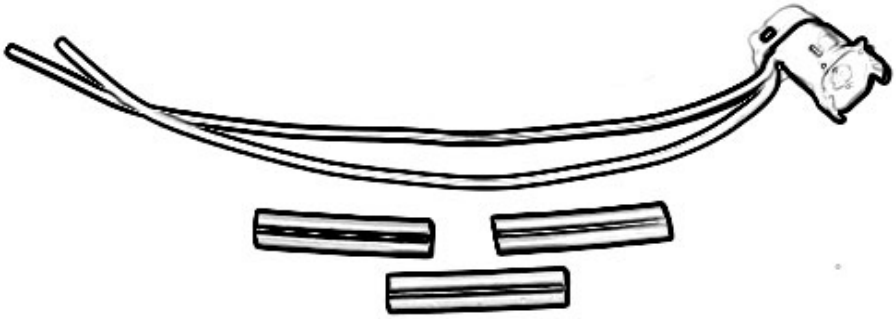
Male Connector 45 Flare – Tennant Part # 371783 – Zenith Part # T220-17
Assly Street TEE w/fittings – Tennant Part # 371785 – Zenith Part # C210-7
Male Connector SAE 45 Flare – Tennant Part # 371786 – Zenith Part # T220-16
Connector Fitting – Tennant Part # 371787 – Zenith Part # T220-5
Male Pipe X Female Pipe Tee – Tennant Part # 371788 – Zenith Part # T270-7



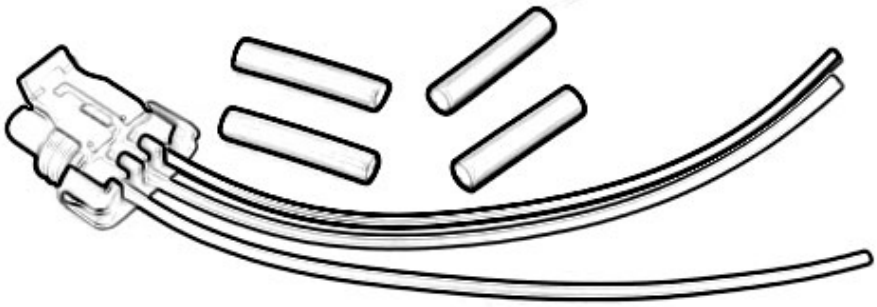
Service Connector – Air Temp Sensor – Tennant Part # 371773 – Zenith Part # C282-305



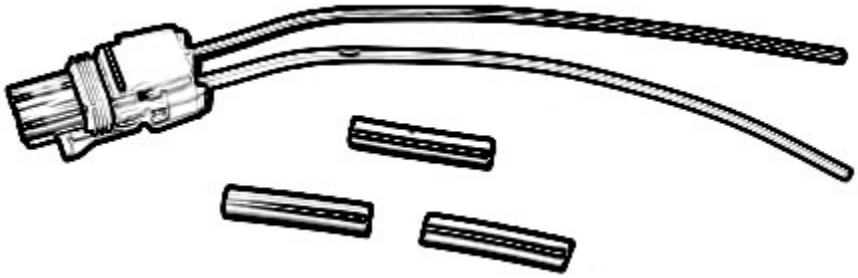
Service Connector – Coolant Temp Sensor – Tennant Part # 371774 – Zenith Part # C282-306



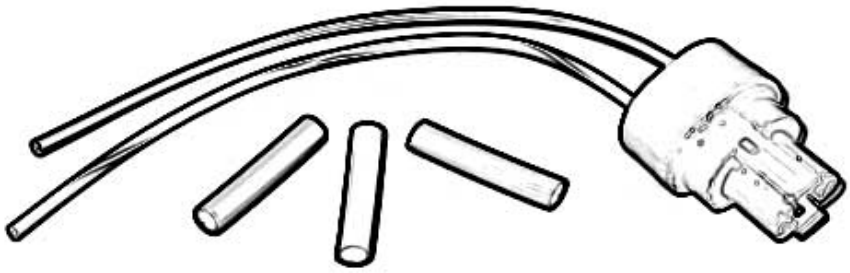
Service Connector – MAP Sensor – Tennant Part # 371775 – Zenith Part # C282-307



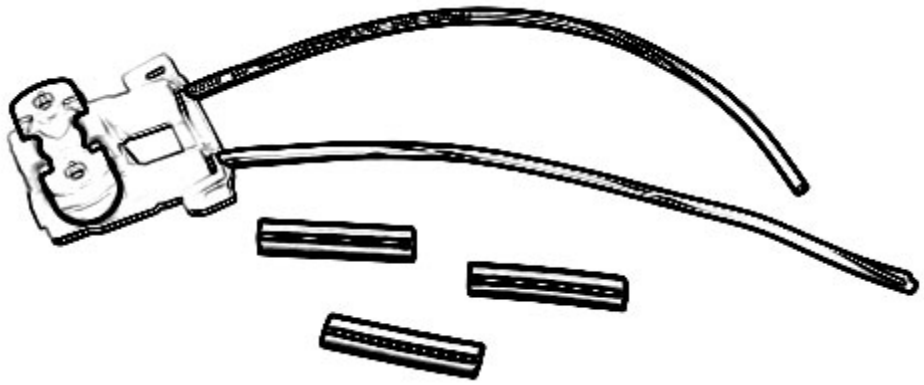
Service Connector – Governor – Tennant Part # 371776 – Zenith Part # C282-308



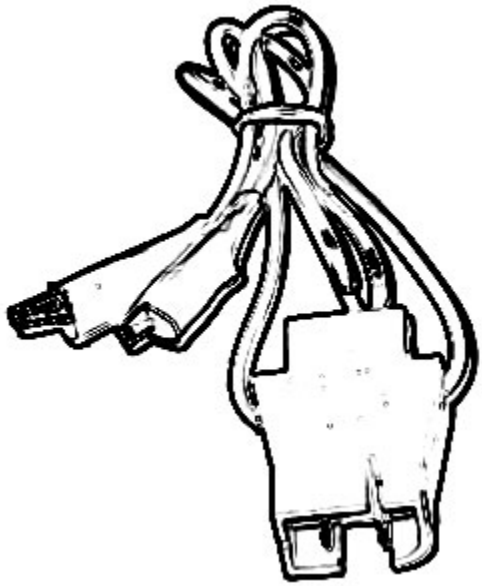
Service Connector – Gasoline Injector – Tennant Part # 371777 – Zenith Part # C282-309



Service Connector – LPG Injector – Tennant Part # 371778 – Zenith Part # C282-310



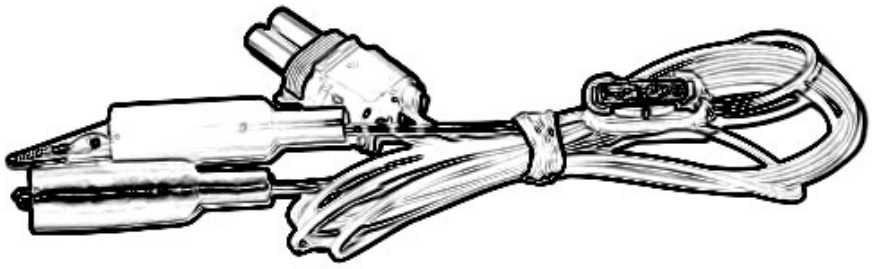
GM Micropak Coil Adapter – Tennant Part # 371779 – Zenith Part # C201-33



Gas Injector - Noid Light – Tennant Part # 371780 – Zenith Part # C282-110

LPG Injector - Noid Light – Tennant Part # 371781 – Zenith Part # C282-109

Actuator Power Tool – Tennant Part # 371782 – Zenith Part # C282-113



AIR AND COOLANT SENSOR RESISTANCE

Temp deg F	Temp deg F	Nominal Resistance ohms	Minimum Resistance ohms	Maximum Resistance ohms
-40	-40	93630	85570	101400
-30	-22	49320	45250	53310
-20	-4	27050	24910	29160
-10	14	15420	14250	16580
0	32	9099	8442	9767
10	50	5546	5165	5939
20	68	3481	3254	3719
25	77	2787	2609	2974
30	86	2245	2106	2393
40	104	1484	1398	1579
50	122	1004	949	1065
60	140	693	657	734
70	158	488	465	516
80	176	349	334	369
90	194	255	244	268
100	212	189	182	199
110	230	144	139	151
120	248	109	105	114
130	266	84	80	88

Table 7:1

WIRING DIAGRAMS

Refer to Section 3, Engine Electrical, for wiring diagrams.

Note: The wiring diagrams are specific to the engine and machine application. If the following wiring diagrams do not match the machine being repaired contact Power Solutions, Inc., or the machine manufacturer for a copy of the diagram.

DIAGNOSTIC PROCEDURES

Diagnostic procedures are listed separately for each fuel but, unlike mechanical fuel systems that require different thinking processes for gasoline and LPG, the diagnostic procedures for both the gasoline and LPG ZEEMS system follow the same thinking pattern.

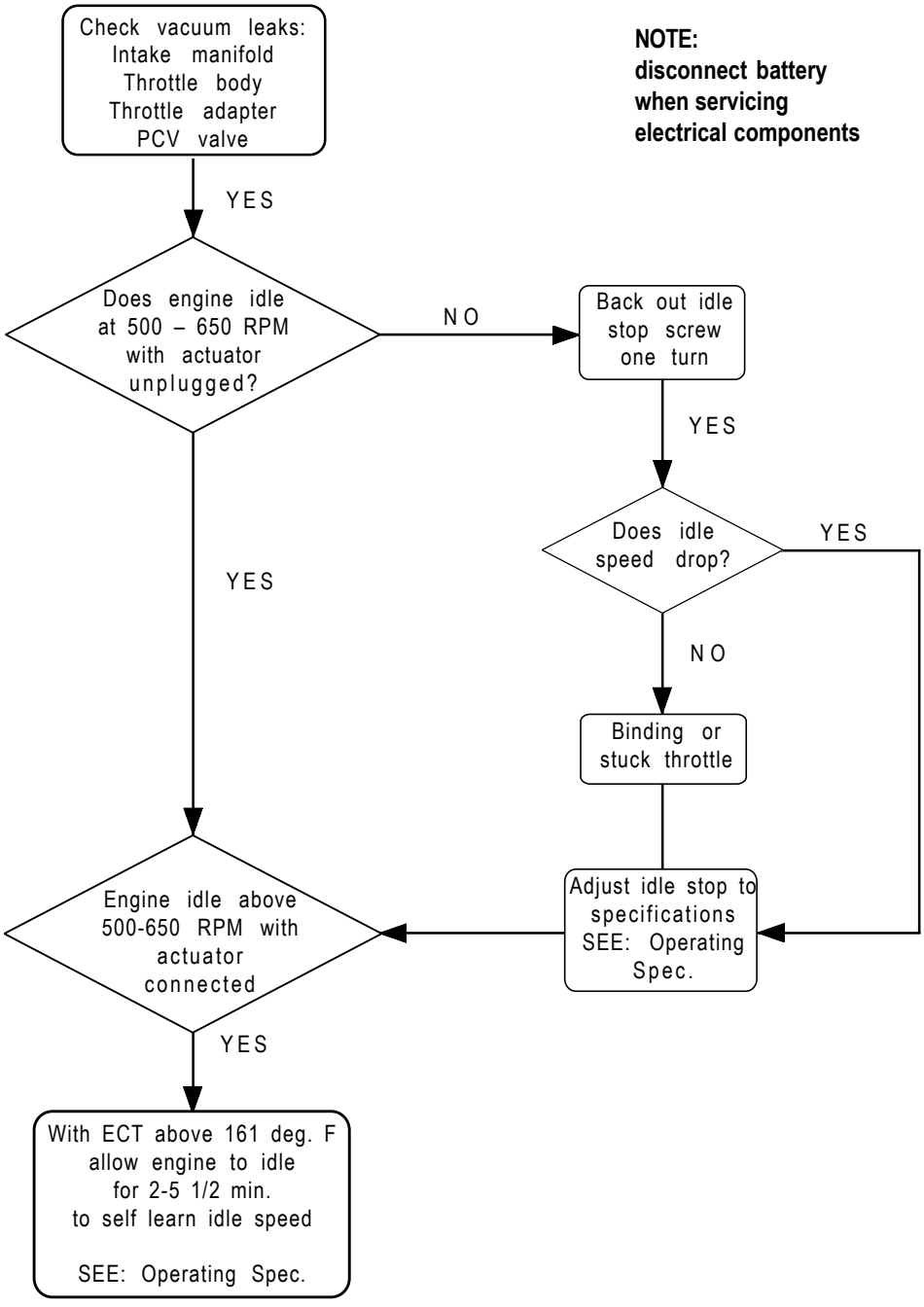
Below is a brief list of items to check BEFORE entering the ZEEMS diagnostic charts that follow. Too often the tendency is to blame the most unfamiliar part of a new system and we forget to ‘get back to the basics’.

The following is a quick check list of items to check.

- ☑ Ignition System Operation
- ☑ Ignition Timing
- ☑ Fuel pressures
- ☑ Fuel level
- ☑ Electrical Connections
- ☑ Alternator charging voltages
- ☑ Battery condition

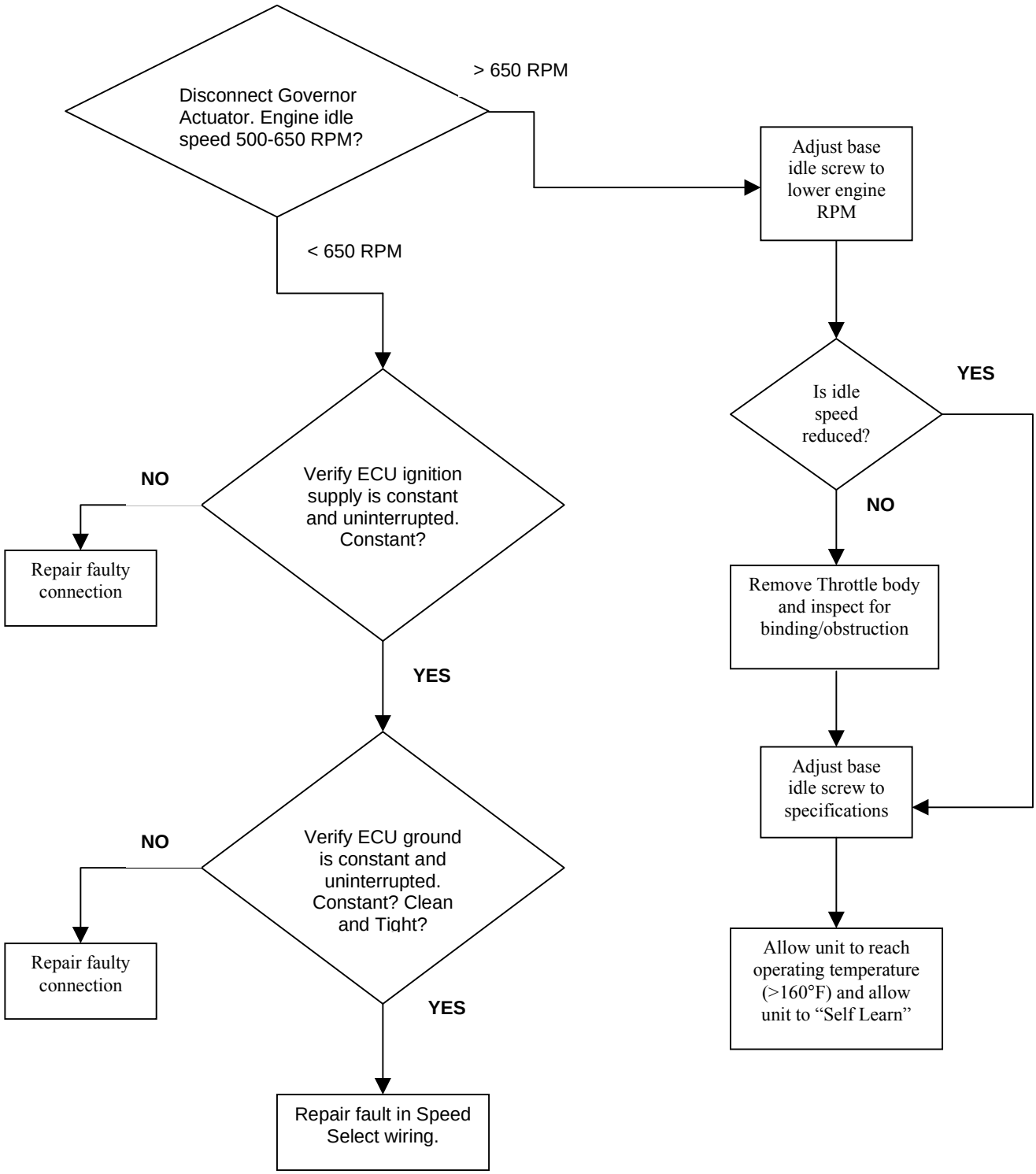
Diagnostic Procedures - Continued

Engine Idle Speed High



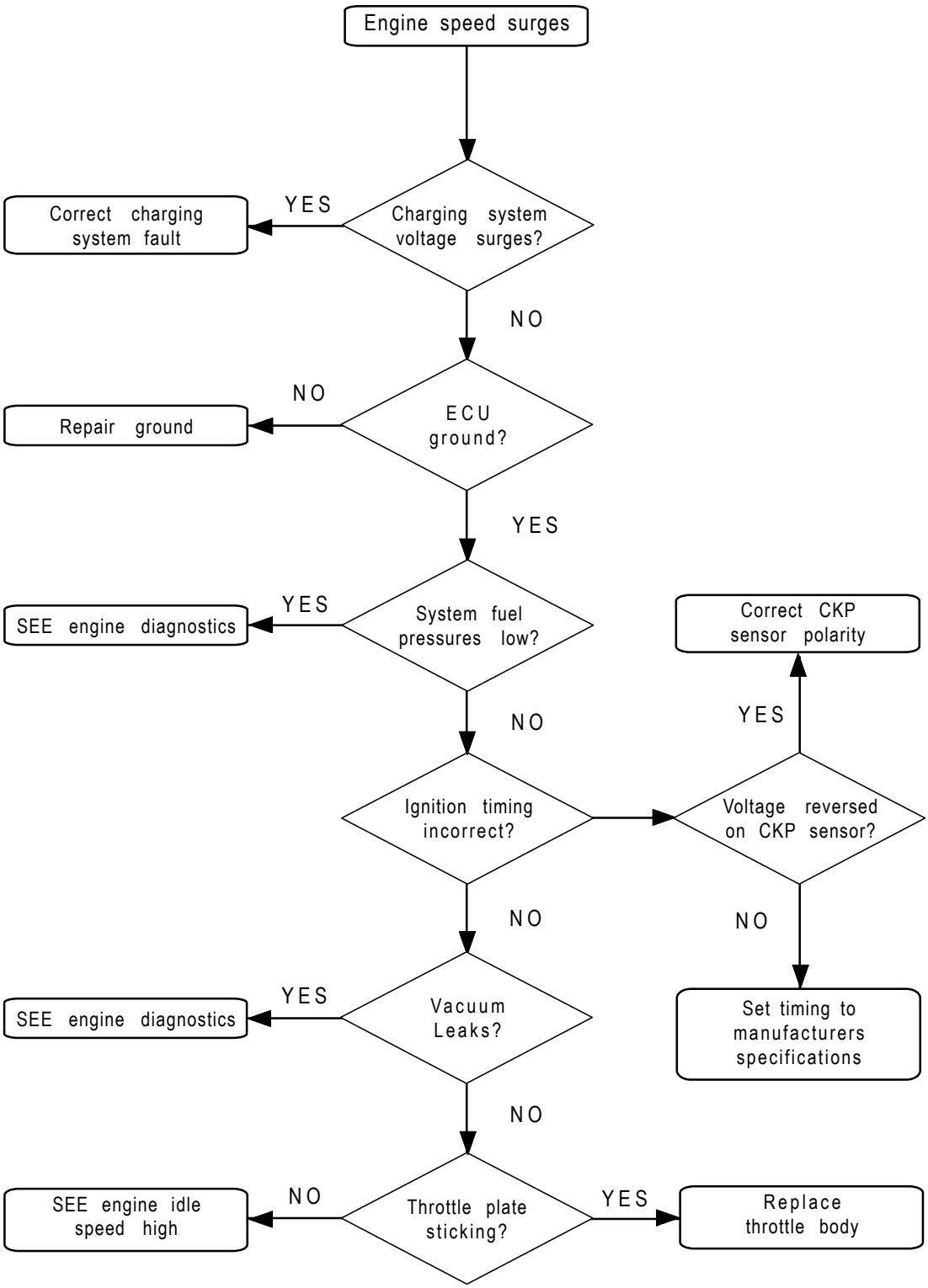
Diagnostic Procedures - Continued

Engine Speed “Spikes” Intermittently



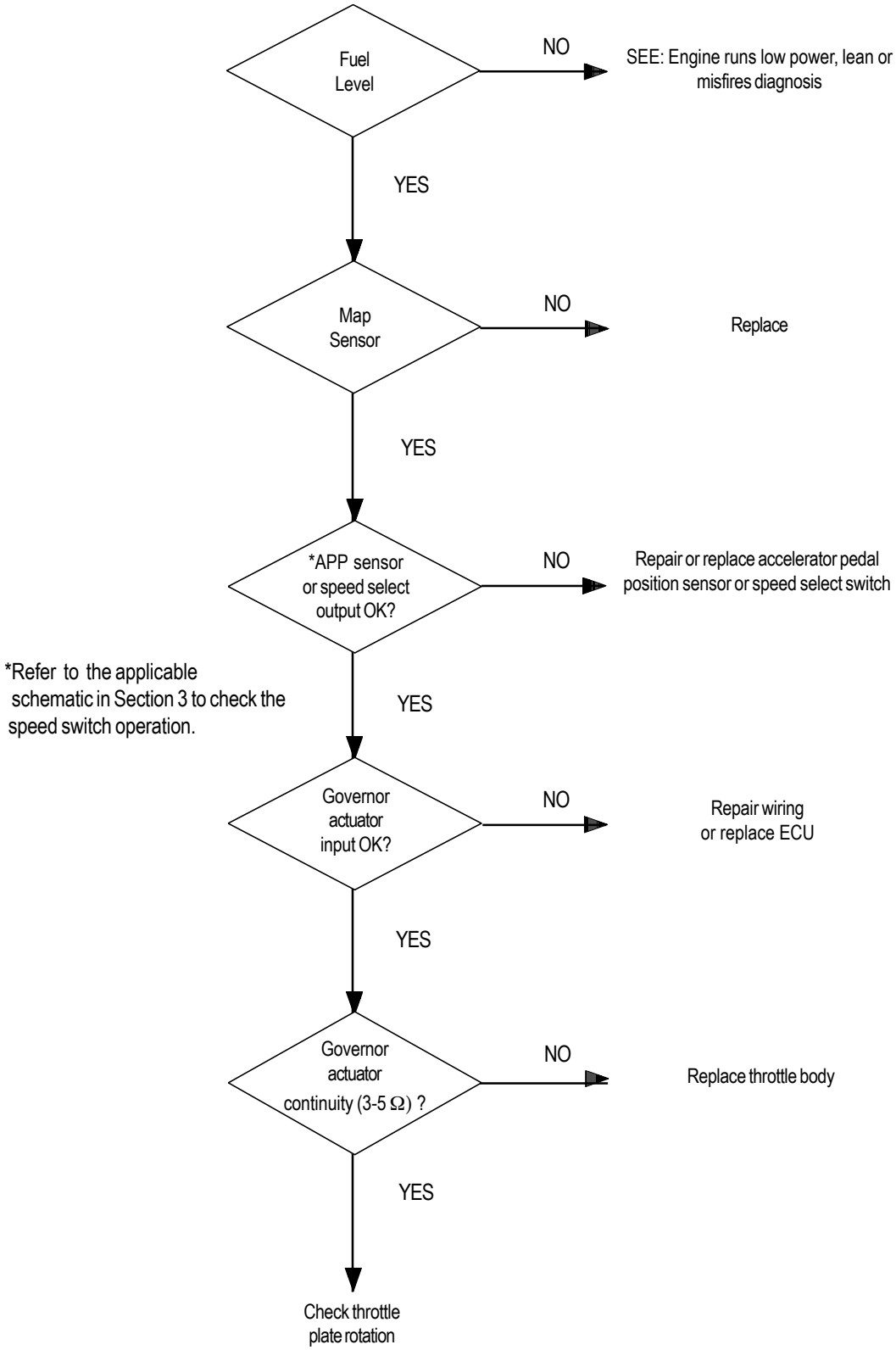
Diagnostic Procedures - Continued

Engine Runs Erratically, Poor Governor Performance



Diagnostic Procedures - Continued

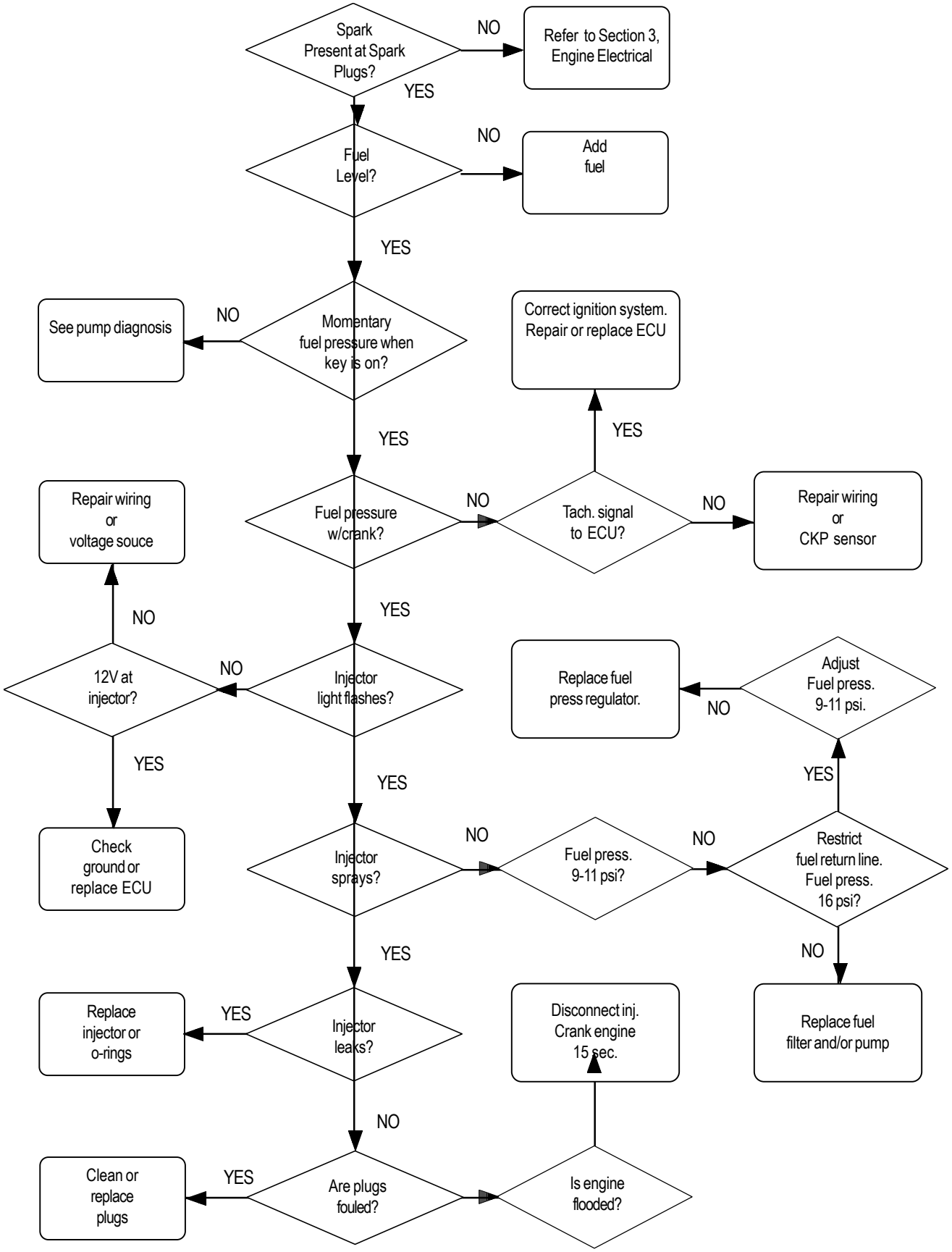
Engine Runs, But Will Not Accelerate



*Refer to the applicable schematic in Section 3 to check the speed switch operation.

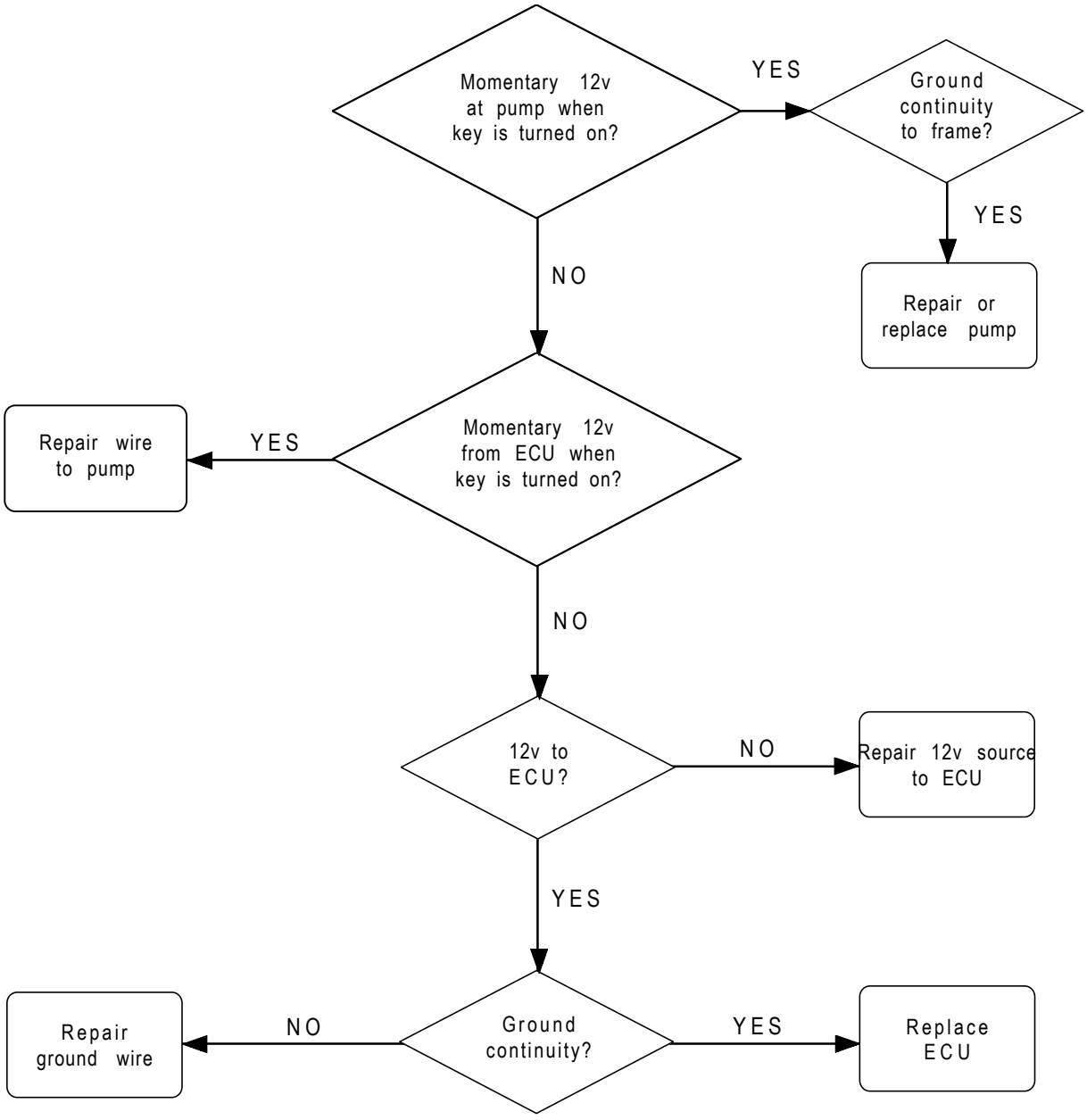
Diagnostic Procedures - Continued

Engine Won't Start - Gasoline



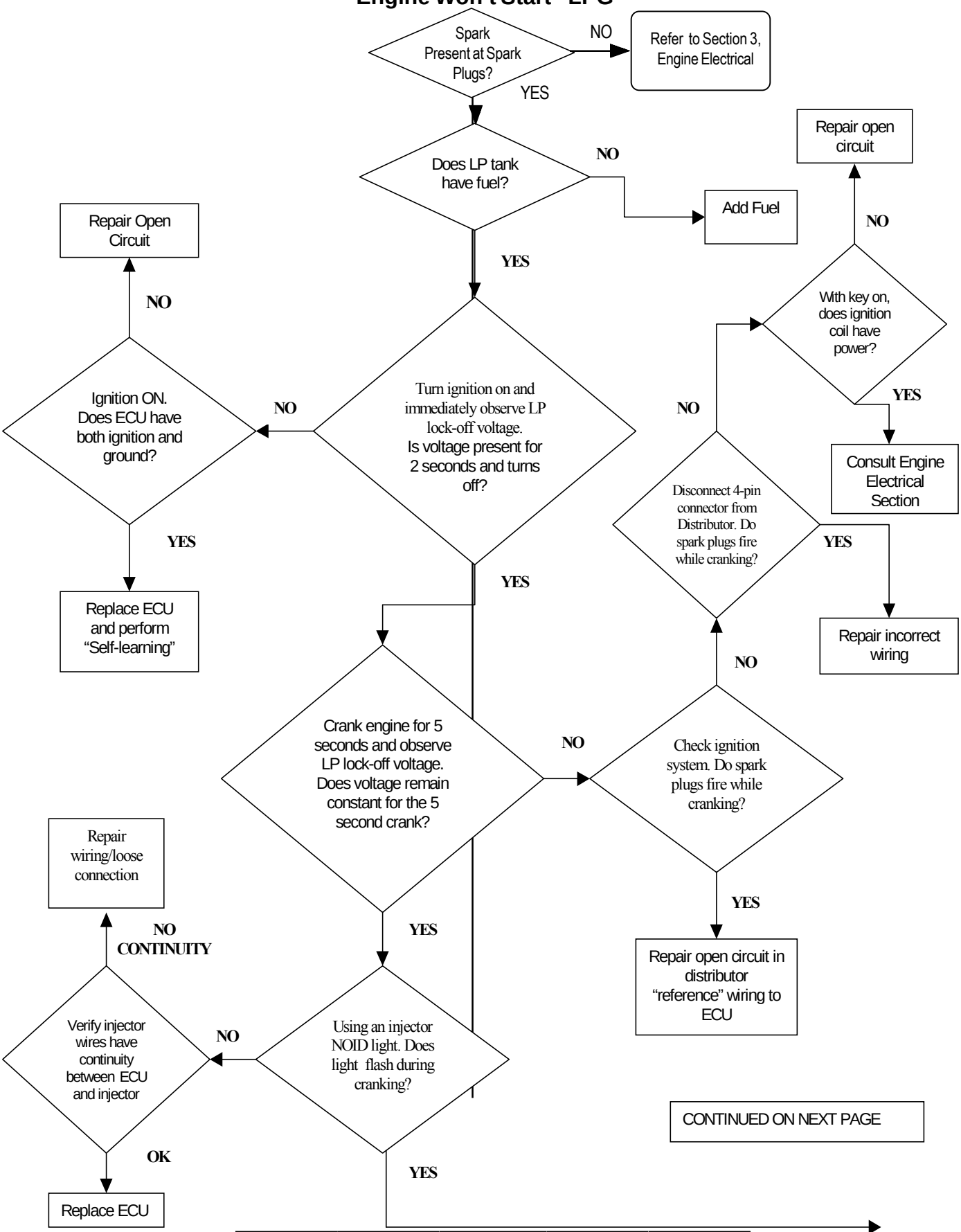
Diagnostic Procedures - Continued

Gasoline Fuel Pump Diagnosis



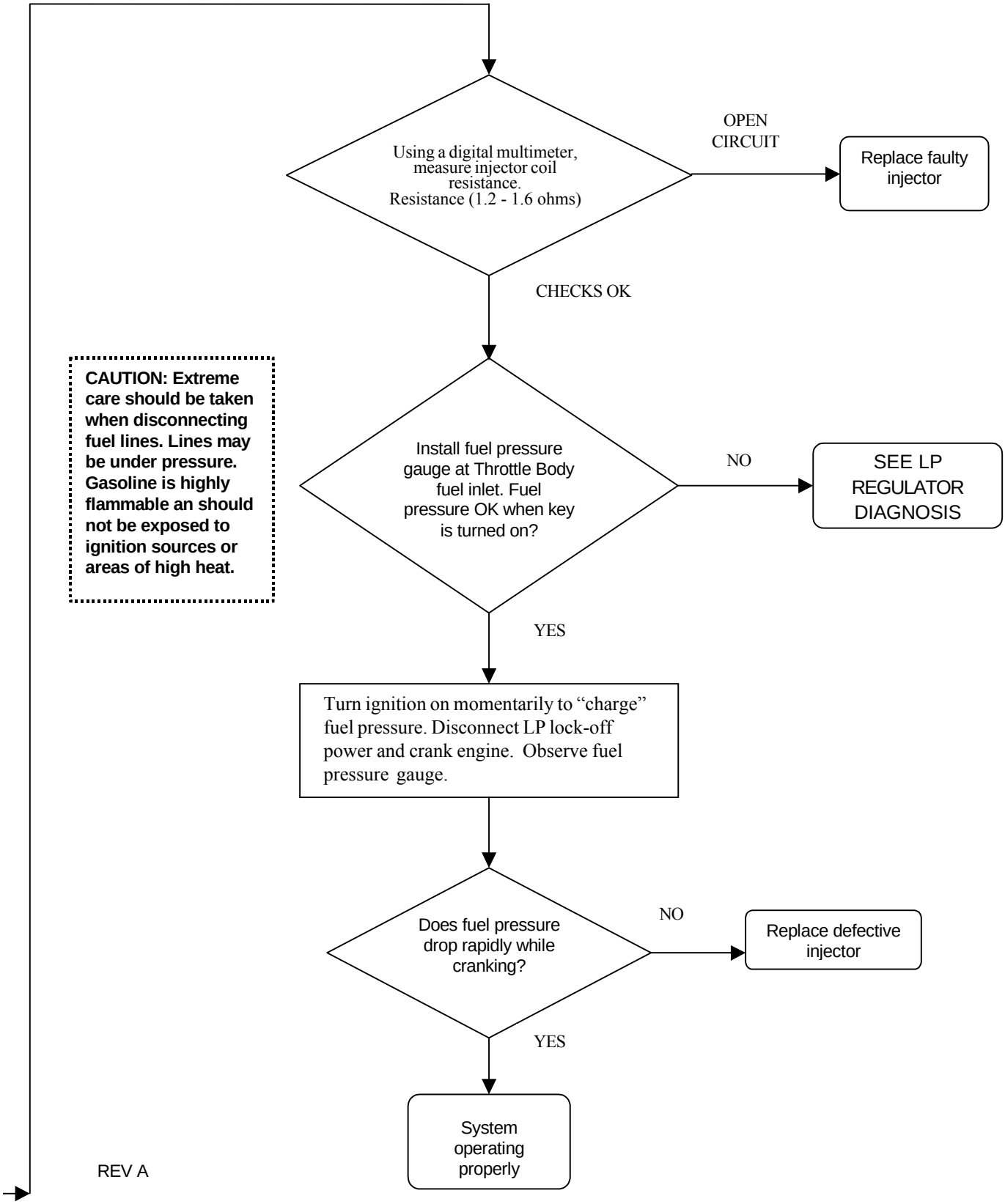
Diagnostic Procedures - Continued

Engine Won't Start - LPG



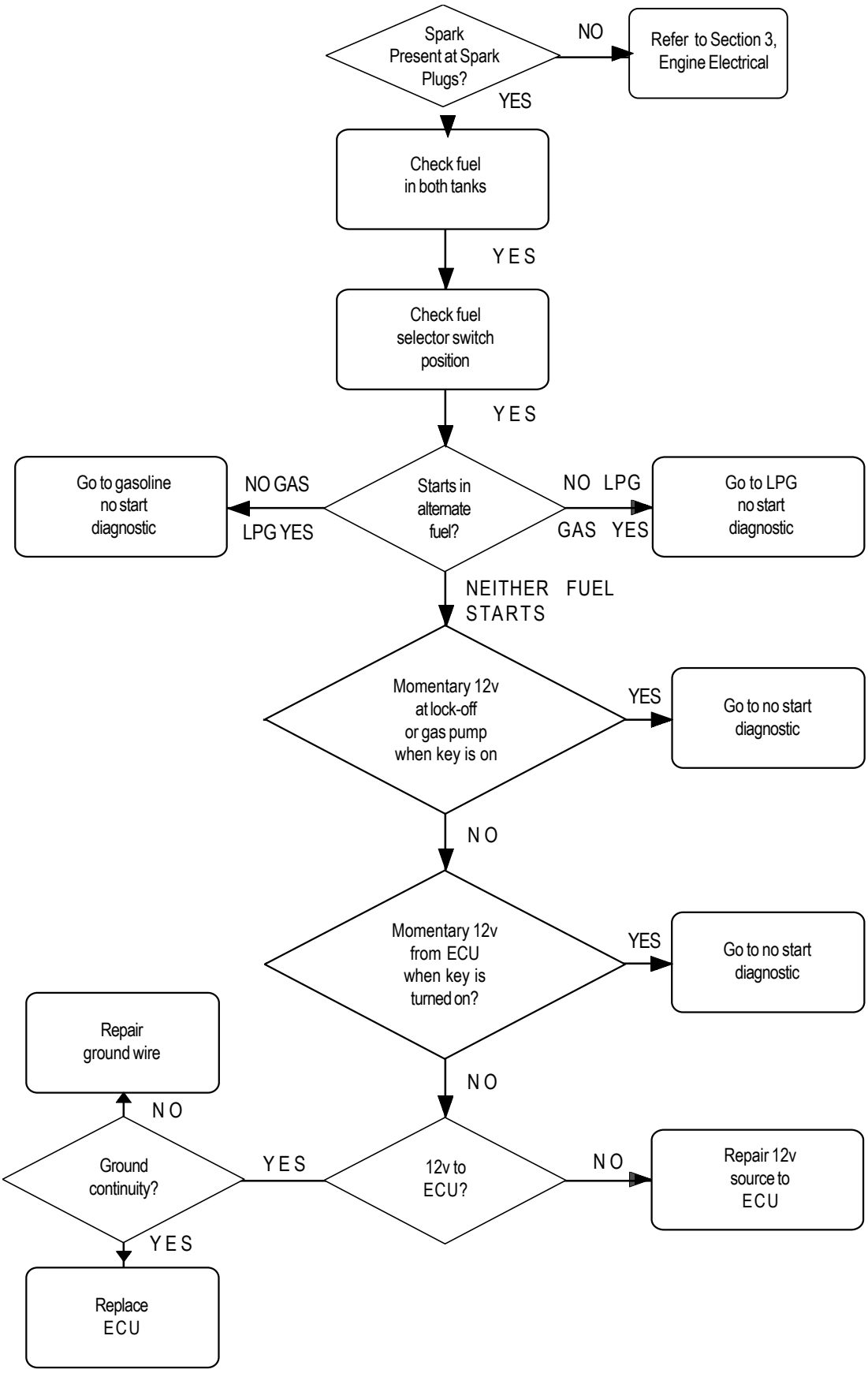
Diagnostic Procedures - Continued

Engine Won't Start - LPG (Continued)



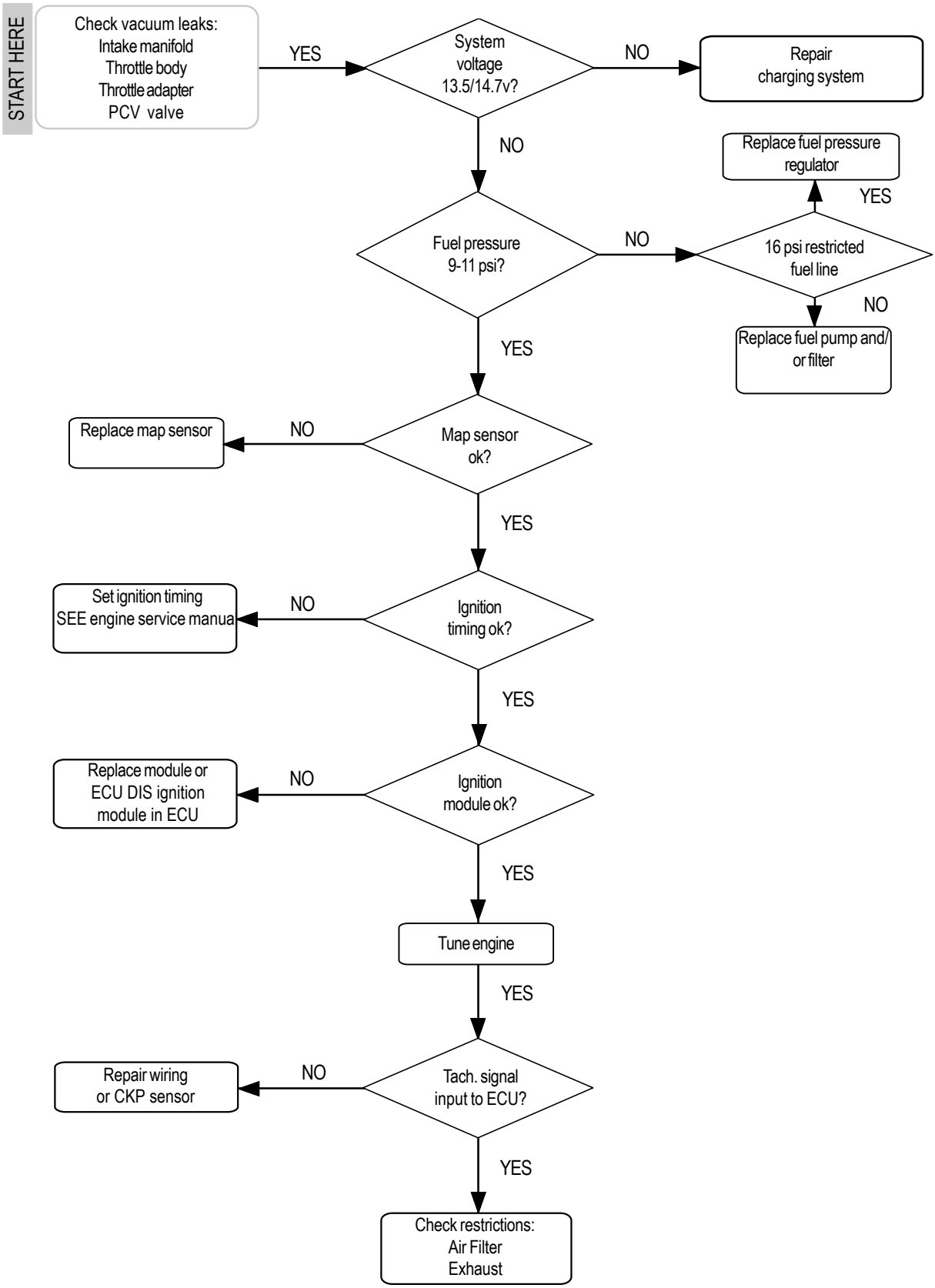
Diagnostic Procedures - Continued

Engine Won't Start — Dual Fuel



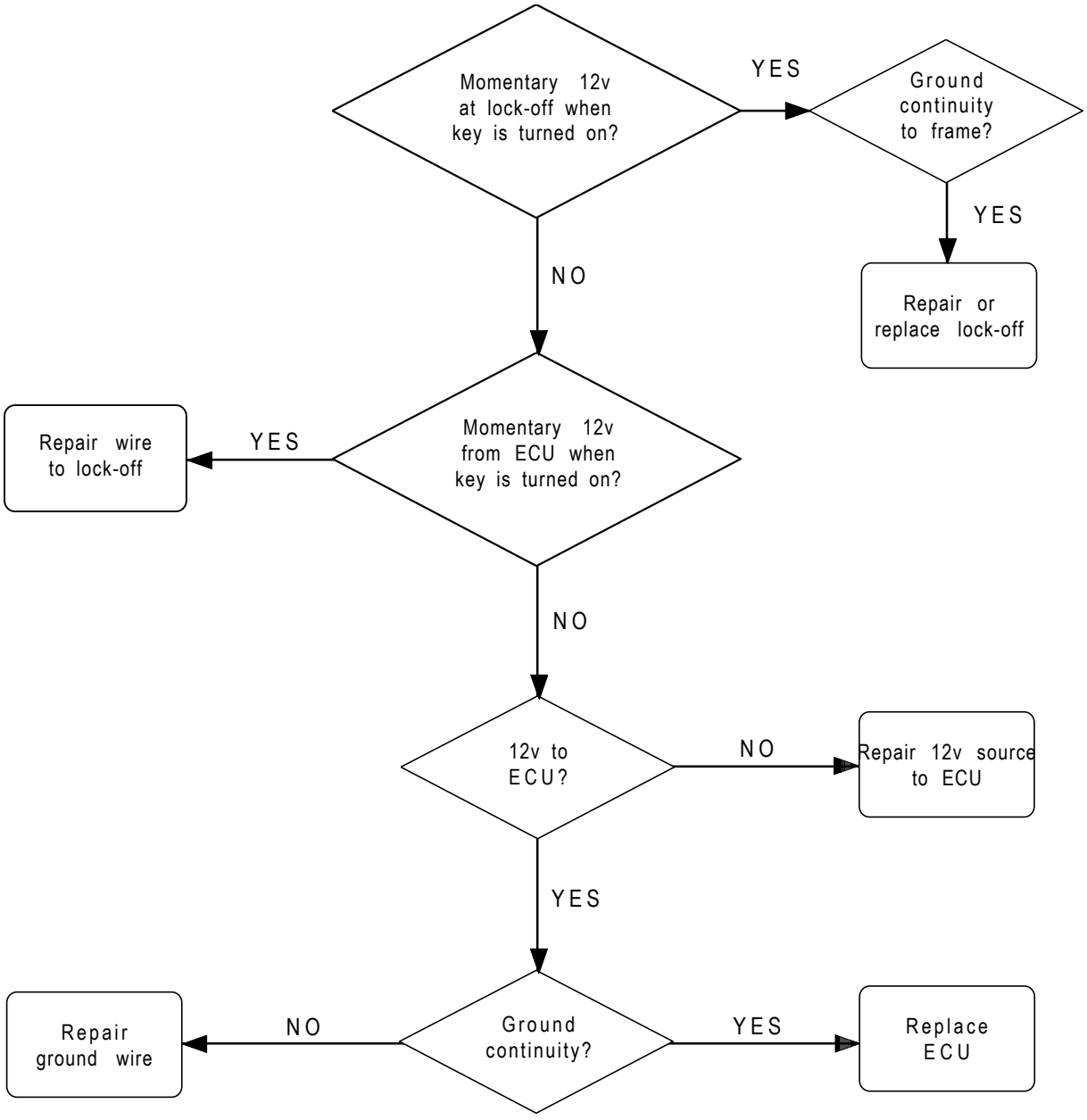
Diagnostic Procedures - Continued

Engine Runs, Low Power, Lean or Misfires — Gasoline



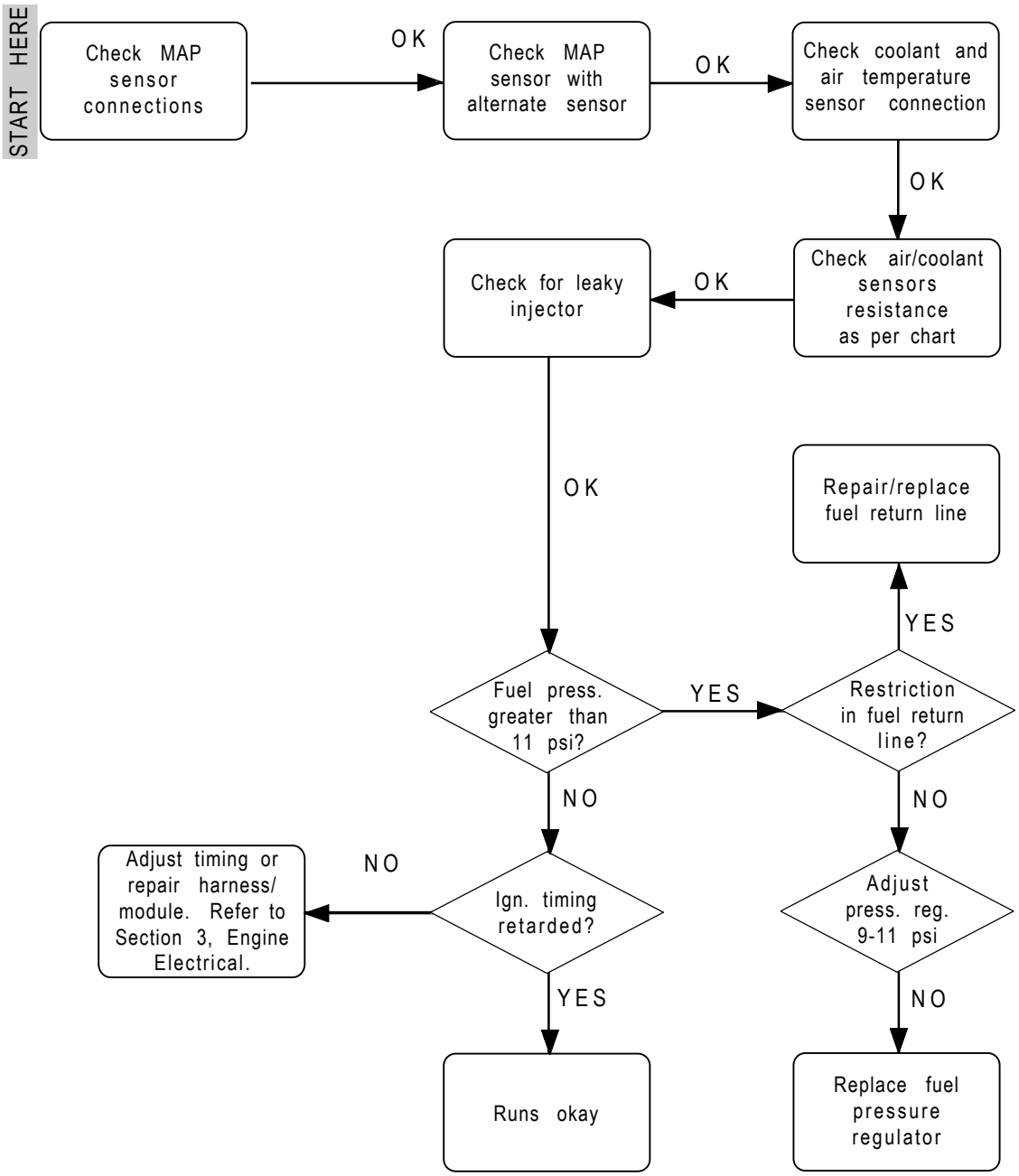
Diagnostic Procedures - Continued

LPG Lock-Off Diagnosis



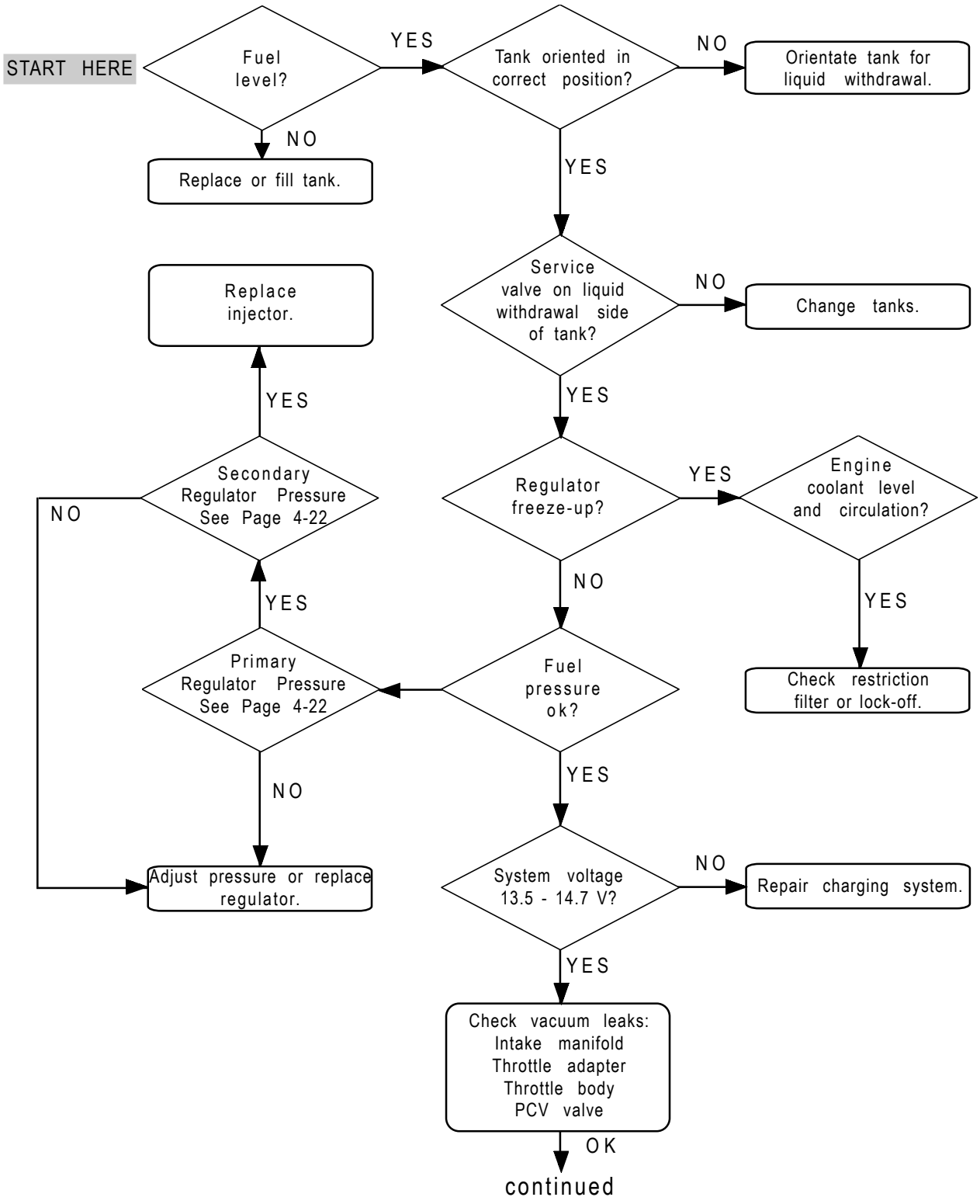
Diagnostic Procedures - Continued

Engine Runs Rich — Gasoline



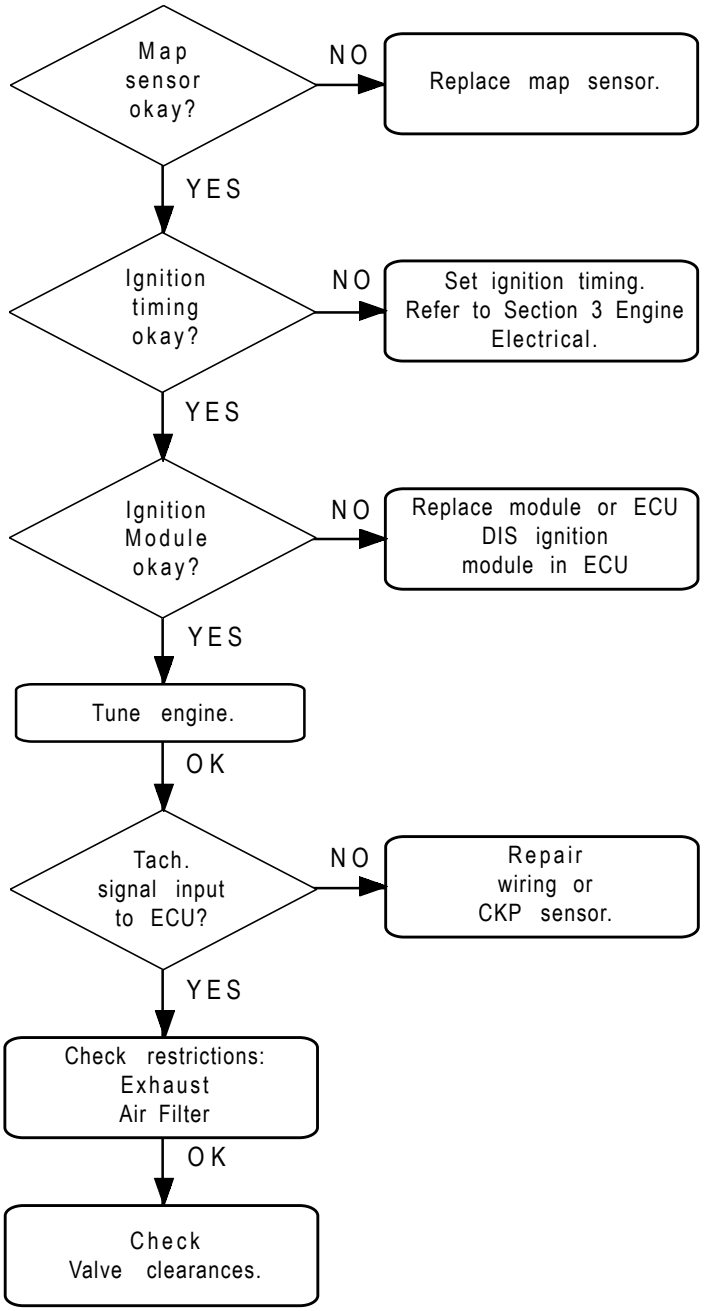
Diagnostic Procedures - Continued

Engine Runs, Low Power, Lean or Misfires — LPG



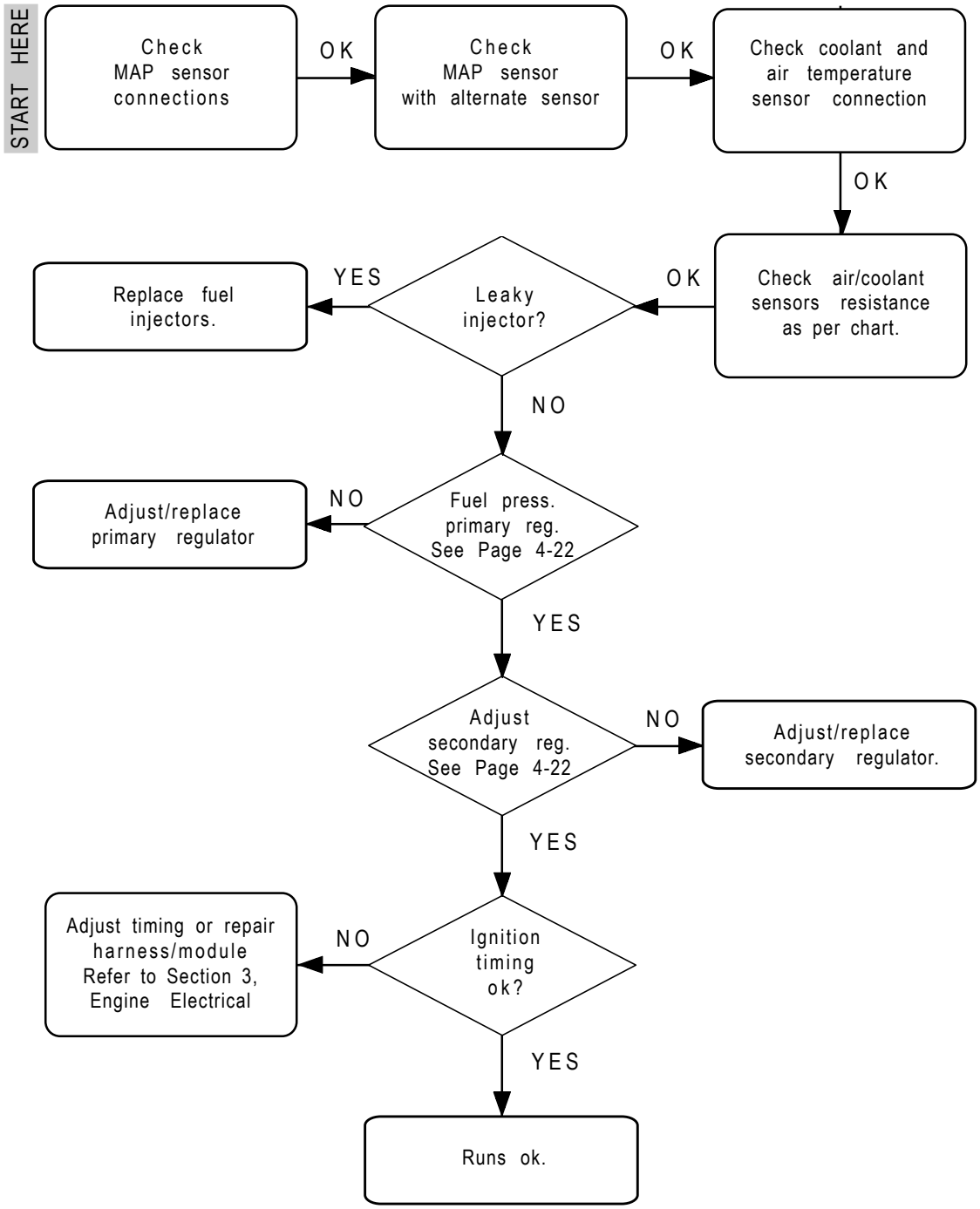
Diagnostic Procedures - Continued

Engine Runs, Low power, Lean or Misfires — LPG (Continued)



Diagnostic Procedures - Continued

Engine Runs Rich — LPG



Operation and Maintenance

Manual

PSI's 4.3L OPU

Industrial Gasoline
and
Alternate Fueled Engines

1.6L, 3.0L, 4.3L, 5.7L, 7.4L and 8.1L Engines

A GM *Powertrain* Product
by Power Solutions, Inc.
Wood Dale, IL 60191

36100007/REV030101

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Introduction

Power Solutions, Inc. is pleased that you have selected a **GM** ***Powertrain*** engine for your requirements. Power Solutions, Inc. takes great pride in our tradition of quality products produced from the **GM** ***Powertrain*** line of industrial gasoline and alternative fuel engines.

Power Solutions engines are inspected and tested before leaving the factory. However, certain checks should be made before placing the engine into regular service. **Please read the Initial Start-Up inspection requirements in the Maintenance Section of this manual.**

How to Use this Manual

This manual contains instructions on the safe operation and preventive maintenance of your **GM** ***Powertrain*** industrial engine. We urge you to read this manual prior to start up or operation of the engine.

The Table of Contents permits you to quickly open the manual to any section.

Power Solutions, Inc., engines are built with a variety of standard and/or optional components to suit a broad range of customer requirements. This manual **does not** identify equipment as standard or optional. All the equipment described in this manual may not be found on your engine or power unit.

Please pay special attention to the **NOTES, CAUTIONS,** and **WARNINGS. WARNINGS** remind you to be careful in areas where carelessness can cause personal injury. **CAUTIONS** are given to prevent you from error that could cause damage to the equipment. **NOTES** give you added information designed to help you.

The descriptions and specifications contained in this manual were in effect at the time of publication. Power Solutions, Inc. reserves the right to discontinue models at any time, or to change specifications or design without notice and without incurring obligation.

Power Solutions, Inc.
655 Wheat Lane
Wood Dale, IL 60191

Engine Identification

An identification label is affixed to the right side of the engine on the rocker cover when looking at the engine from the flywheel end.. (The engine serial number is also stamped into the left side of the cylinder block near the engine flywheel.) The label contains the engine model number (i.e. 4.3L, 5.7L, etc.) and a serial number which identifies the engine from other **GM** ***Powertrain*** engines provided by Power Solutions, Inc. The engine model and serial number are required when seeking information concerning the engine and/or ordering replacement service parts.

Parts and Service

Replacement parts can be obtained from Power Solutions, Inc. by calling the Service Parts Department at **800-551-2938.** The engine model and serial number will be required when seeking information and/or ordering parts.

Service and technical support for **GM** ***Powertrain*** engines supplied by Power Solutions, Inc. can be obtained by contacting the Service Department at **800-551-2938.**

Service Literature

Additional operator manuals and service manuals for specific **GM** ***Powertrain*** engines provided by Power Solutions, Inc. can be obtained by contacting the Parts or Service Department at **800-551-2938**

Operating Instructions

Controls

Ignition Switch

The ignition switch is located on the control panel. The switch is a 3 position switch, OFF, RUN and START. The OFF position disconnects the electrical system from the battery. The key can be removed from the switch when it is in this position.

In the RUN position, the electrical system is activated.

Engage the starter by turning the key to the START position. Release the key when the engine starts and it will return to the ON position.

Safety Gauges

Power Solutions, Inc., industrial power units are equipped with instrument panels which contain shut down gauges for High Engine Water Temperature and Low Engine Oil Pressure. A push button 'Tattletale' relay is utilized with this system. When starting the engine it is necessary to 'depress' the safety switch override button, until the engine starts and engine oil pressure is obtained (usually 2 to 5 seconds). The engine will continue to run when the button is released.

CAUTION: If the engine does not continue to run when the button is released, it will be necessary to check the instrument panel fuse and/or the engine lubrication system (i.e. oil level, etc.) before restarting the engine.

NOTE: Power Solutions, Inc. provides engines to many different original equipment manufacturers. Not all manufacturers use the PSI instrument panel. Please refer to the equipment Operators Manual for instructions on engine starting.

Fuel Systems

Several different fuel systems have been used on Power Solutions, Inc. **GM** ***Powertrain*** engines. A chart identifiying the different types of fuel systems used by engine model can be found in the back of this manual.

NOTE: Some fuel systems are installed by the original equipment manufacturer. Therefore it may be necessary to contact the equipment manufacturer for information pertaining to your specific fuel system if it cannot be found in the chart.

Governors

As with fuel systems, several different governor controls have also been used with the Power Solutions, Inc. **GM** ***Powertrain*** engines. A chart identifying the different types of governor systems used is included at the back of this manual.

NOTE: Some governors are installed by the original equipment manufacturer. If your governor is not included in the chart, it will be necessary to contact the equipment manufacturer.

Instruments

Oil Pressure Gauge

The oil pressure gauge show the engine lubrication system pressure in pounds per square inch (psi) and should be checked frequently to ensure that the system is functioning correctly. Should the pressure fluctuate or drop, stop the engine and find the cause. Do not operate the engine at lower than normal oil pressure (see maintenance schedule for minimum engine oil pressure).

CAUTION: Do not continue to operate your engine below the normal operating range. Severe engine damage could occur.

Temperature Gauge

The temperature gauge registers the coolant temperature and will indicate overheating which may arise from low coolant level, plugged radiator, loose fan belt or faulty thermostat. Coolant level should be checked daily.

CAUTION: If the engine continues to overheat, have the cooling system checked and serviced.

Instruments (cont.)

Voltmeter

The voltmeter indicates the battery charging voltage. If the meter consistently indicates less than 13 volts or more than 15.7 volts under normal operating conditions, you should have the engine electrical system checked by a qualified service technician.

Tachometer/Hourmeter

The tachometer indicates the engine speed in hundreds of revolutions per minute (rpm). It serves, as a guide to insure that engine speed is set correctly.

The hourmeter records the hours of operation and is used to determine when periodic maintenance is required.

Starting the Engine

Warning:

All internal combustion engines give off various fumes and gases while running. Do no start or run the engine in a closed or poorly ventilated building where exhaust gases can accumulate. Avoid breathing these gases as they may contain poisonous carbon monoxide, which can endanger your health or life if inhaled steadily for even a few minutes.

If the engine is equipped with a manual clutch it must be disengaged prior to starting the engine. Starting the engine with the clutch engaged imposes unnecessary strain on the battery, starter, and driven components.

CAUTION: If the engine stalls or falters during starting, wait 3 to 4 seconds before re-engaging the starter. This will prevent possible damage to the starter or the engine. DO NOT operate the starter for periods longer than 30 seconds at a time. An interval of at least 1-minute should be observed between cranking periods to protect the starter from overheating.

Carbureted, Mechanical Governor, Manual Choke

Pull the throttle cable out approximately ½ inch, and the choke out full. Turn the ignition key to the START position. After the engine starts, release the key, decrease the throttle setting and adjust the choke cable for fast idle warm-up. When the engine is at operating temperature, push the choke in all the way.

When the engine is warm, it may not be necessary to use the choke for starting.

Carbureted, Electric Choke, Electronic Governor

Turn the On/Off switch on the instrument panel to the ON position. Turn the ignition key to the ON position. This allows the electric choke to pre-set prior to starting. Turn the ignition key to the START position. After the engine starts release the key to the ON position. Allow a few minutes for the engine to warm up. Move the governor control switch to the **LOW** position. Engage the clutch, then move the governor control switch to the **HI** position.

LPG or NG Fuel Systems, Velocity Governors

Turn on the gas supply to the engine. Turn the ignition key to the START position. After the engine starts release the key to the ON position.

PSI Fuel Injection (Gasoline)

Turn the ignition key to the ON position, this energizes the electric fuel pump to charge the fuel system with fuel. Turn the ignition key to the START position. After the engine starts release the key to the ON position.

PSI Fuel Injection (Gasoline/LPG)(Dual Fuel)

Select the desired fuel switch position for starting the engine (Gasoline/LPG). Turn the ignition key switch ON, then move ignition key to the START position. After the engine starts release the key to the ON position.

Zenith Z.E.E.M.S. Throttle Body Fuel Injection, Integral Governor

Turn the ignition key to the ON position to energize the fuel pump. Ensure that the Hi/Lo switch on the instrument is in the Lo position. Turn the ignition key to the START position. After the engine starts release the key to the ON position. Allowing a few minutes for engine warm-up, move the Hi/Lo switch to the Hi position.

Stopping the Engine

Normal Conditions: Following normal operating conditions, **lower the engine speed to idle,** pushing the throttle cable in on mechanical systems or with electronic systems placing the Hi/Lo switch in the Lo position.

If the machine is equipped with a clutch, move the clutch lever to the disengaged position.

Run engine for a few minutes at idle to allow the coolant system to cool down before turning the ignition switch to the OFF position.

Abnormal Conditions (Carbureted): Under abnormally overheated conditions, the engine may continue to run after the switch is turned OFF. If this is encountered, turn the ignition switch to the ON position immediately and allow the engine to run at idle until it has cooled down enough to stop.

(Fuel Injected) Fuel injected engines generally will not after run, even if hot. These systems require that the fuel delivery be shut off completely when turning the ignition switch to the OFF position.

WARNING:

Avoid injury when checking a Hot Engine. Allow the engine to cool down before removing the radiator cap.

CAUTION: Before restarting the engine ensure that both the coolant system and the engine oil level have been checked and re-filled if necessary.

Fuel Recommendations

Fuel Quality

Using a high quality unleaded gasoline will help maintain the power, fuel economy and emissions performance of your engine. A properly formulated gasoline will be comprised of well refined hydrocarbons and chemical additives and will perform the following functions:

Minimize varnish, lacquer, and other induction system deposits.

Prevent gum formation or other deterioration during storage.

Protect fuel tank and other fuel system components from corrosion or degradation.

Fuel Recommendations (cont.)

Provide the correct seasonally and geographically adjusted volatility which should provide easy starting in the winter and summer.

Avoid fuel system icing.

In addition, the fuel must be free of water, debris, and other impurities.

It is recommended that the fuel supply be kept fresh when the engine is in storage (especially in hot weather). The fuel tank should be kept at least ¾ full.

Fuel stored for more than two months should be drained, properly discarded, and the fuel tank re-filled.

Anti-Knock Index (Octane Rating)

This engine is designed to operate on unleaded 87 or 89 octane gasoline with an (R + M)/2"minimum anti-knock index. Federal regulations require that each retail gasoline dispensing pump must display a label bearing the minimum index rating.

Use of unleaded gasoline with anti-knock index rating lower than 87 can cause persistent, heavy spark knock, which can lead to engine damage. If your engine knocks heavily when you use gasoline with an anti-knock index rating of 87 or higher, or if you hear continuous spark knock while maintaining constant operating speeds, consult a dealer or qualified technician.

Gasohol and Alcohol/Gasoline Fuels

Gasohol, a mixture of gasoline and ethanol (grain alcohol), is available in some areas. PSI, GM *Powertrain* engines should operate satisfactorily on gasohol blends containing no more than 10% ethanol by volume and having and anti-knock index of 87 or 89.
CAUTION: In some cases, methanol (wood alcohol) or other alcohol's may be added to gasoline. PSI GM *Powertrain* engines should operate satisfactorily on blends containing up to 5% methanol by volume when cosolvents and other necessary additives are used. DO NOT USE blends containing more than 5% methanol by volume or blends that do not contain cosolvents and corrosion inhibitors.

CAUTION: Discontinue use of any gasohol or alcohol/gasoline blend if fuel system problems occur. Do not use such fuels unless they are UNLEADED.

Spark plugs

Always use the recommended spark plugs for your engine. Hotter or colder plugs, or similar plugs that are not exact equivalents to the recommended plugs, can cause permanent engine damage, reduce the engines useful life, and cause many other problems such as hard starting, spark knock and run-on. Installing new spark plugs regularly is one of the best ways to keep your engine at peak performance.

Power Loss at Higher Elevations

All engines will experience power loss when operated at elevations above sea level, unless they are turbocharged or supercharged. Turbochargers and superchargers are mechanical pumps that put extra air into the engine to make up for the lower air density at higher elevations.

Carbureted Engines

Carbureted engines will loose power for two reasons. First, power is reduced 3.5% for each 1000 feet it is operated above sea level due to the decreased air density. With less dense air, the engine receives less oxygen to burn the fuel. The engine power is decreased in direct proportion to the reduction of available oxygen. Second, the reduced oxygen causes the fuel mixture to have too much fuel for the available oxygen. This is a rich mixture (rich with fuel) and not only causes the engine to produce sooty black exhaust, but causes additional loss of power and premature spark plug fouling. Engines that are operated over 3000 feet of elevation, that exhibit black smoke or produce less than optimum power should have the fuel system re-calibrated. For additional information on optimizing your engine for higher elevations contact your dealer or Power Solutions, Inc. at 800-551-2938.

Caution: Engines re-calibrated for high elevations will run ***lean*** at lower elevations. Lean running can burn valves, will reduce valve and valve seat life and can cause engine overheating. Failures caused by these problems are not covered by warranty.

Fuel Injected Engines

Fuel injected engines will loose 3.5% power for every 1000 feet the engine is operated above sea level. All fuel injection systems installed by Power Solutions, Inc. are equipped with a “manifold absolute pressure sensor” (MAP Sensor). The MAP sensor senses barometric pressure and automatically corrects the fuel system calibration for changes in altitude. This means the air/fuel mixture will always be optimized, regardless of elevation (or barometric pressure), however, the engine will still loose 3.5% power for every 1000 feet increase in elevation.

MAINTENANCE INSTRUCTIONS

Initial Start Up Maintenance

The initial start-up checks must be made before putting the engine into service. Please refer to the Maintenance Schedule on page II and perform the initial start-up operations in the sequence shown in column 1.

Routine Maintenance

Routine maintenance provides the best solution for making sure that the engine is ready when you are. The following are some routine service points:

Keep the fuel tank filled. A full tank of fuel reduces the possibility of condensation forming in the fuel tank and moisture entering the fuel system
Make frequent checks of the engine oil and coolant levels
Repair any oil or coolant leaks immediately
Check battery condition and cables frequently
Keep the engine air filter clean
Monitor engine coolant temperature
Monitor engine oil pressure
Check voltmeter and charging system

Scheduled Preventive Maintenance

Refer to the Maintenance Schedule on page II to ensure that all of the maintenance items listed are checked and replaced as recommended at the hours shown.

Engine Oil Level Check

The engine oil level should be checked daily. It is recommended that the oil be checked just before the engine is started for the first time for that day. The oil level should be between the 'Add' and the 'Full' marks on the dipstick.

CAUTION: Do not operate the engine with the oil level below the bottom or 'Add' mark on the dipstick, or above the top or 'Full' mark on the dipstick.

Adding Engine Oil

It is normal to add some oil in the period of time between oil changes. The amount will vary with the severity of operation. When adding or replacing engine oil, be sure the oil meets or exceeds the recommended specification.

Changing Engine Oil and Filter

The engine oil and filter must be changed every 200 hours or every 3 months whichever occurs first. Under normal operating conditions, you do not need to change them more often if you use oil and filters of the recommended quality.

The oil and filter should be changed more often if the engine is operating in dusty or extremely dirty areas, or during cold weather. No oil additives or break-in oil change is required.

Engine Oil Quality

To achieve proper engine performance and durability, it is important that you use only engine lubricating oils of the correct quality in your engine. Proper quality oils also provide maximum efficiency for crankcase ventilation systems, which reduces pollution.

Important: use only engine oils displaying the American Petroleum Institute (API) **"Starburst"** Certification Mark **'FOR GASOLINE ENGINES'** on the container.

Gasoline engines that are converted for LPG or NG fuels **MUST** use oils labeled **'FOR GASOLINE ENGINES'.** Do not use oils that are specifically formulated for Diesel Engines only. CC or CD classification oils, even when labeled Heavy Duty or for Natural Gas Engines, **ARE NOT ACCEPTABLE**.

Engine Oil Recommendation

Multi-viscosity oils are recommended. SAE 10W-30 is recommended for your engine from 0 degrees F (-18 degrees C) or above. If ambient temperatures are consistently below 0 degrees F, SAE 5W-30 oil can be used. Synthetic oils are not recommended for industrial or stationary engines.

Oil Filter

The PSI GM *Powertrain* engines use an AC Delco oil filter as original equipment. An equivalent oil filter must be used when servicing the engine (see Engine Specifications for the recommended oil filter for your engine).

The filter protects your engine from harmful, abrasive, or sludgy particles without blocking the flow of oil to vital engine parts.

To replace the filter, use a proper filter wrench to remove the filter.

Clean the filter mounting base and lightly coat the gasket surface of the new filter with engine oil. Hand tighten the filter until the gasket contacts the base, then tighten another ½ turn. Fill the engine with the correct amount of oil, run the engine and check for oil leaks at the drain plug and oil filter gasket. Tighten as necessary to stop any oil leakage noted.

Engine Air Cleaner

The engine air cleaner filters air entering the engine intake system and acts as a silencer and flame arrester when assembled to the intake system.

Air that contains dirt and grit produces an abrasive fuel mixture and can cause severe damage to the cylinder walls and piston rings. Damage to the cylinder walls and piston rings will cause high oil consumption and shorten engine life.

A restricted or dirty air cleaner will also cause a rich fuel mixture. Thus, it is extremely important that the air cleaner be serviced properly at the recommended intervals.

CAUTION: Service the air cleaner more frequently under severe dusty or dirty conditions.

Remove the primary air cleaner element from the air cleaner assembly and inspect the element for foreign material restrictions or signs of excessive wear or damage. Replace the element if necessary.

Remove all dust and foreign matter from the air cleaner housing.

Reinstall the air cleaner element. Reinstall the air cleaner cup, and securely fasten the retaining clips.

Safety Element

If your engine is equipped with an air cleaner which utilizes a safety element, ensure that the element is properly in place before installing the primary element.

Change the safety element annually.

Cooling System

Coolant Level

Check the coolant level of the radiator daily and only when the engine is cool. Generally a good time to do this is just prior to starting the engine for the first time each day.

Maintain the coolant level at ¾ to 1½ inches below the filler neck seat of the radiator when the coolant is cold. When ever coolant level checks are made inspect the condition of the radiator cap rubber seal. Make sure it is clean and free of any dirt particles which would keep it from seating on the filler neck seat. Rinse off with clean water if necessary. Also make sure that the filler neck seat is free of any dirt particles.

WARNING

Never remove the radiator cap under any conditions while the engine is operating. Failure to follow these instruction could result in damage to the cooling system, engine, or cause personal injury. To avoid having scalding hot coolant or steam blow out of the radiator, use extreme caution when removing the radiator cap from a hot radiator. If possible, wait until the engine has cooled, then wrap a thick cloth around the radiator cap and turn slowly to the first stop. Step back while the pressure is released from the cooling system. When all the pressure has been released, press down on the cap and remove it slowly.

DO NOT add coolant to any engine that has become overheated until the engine cools. Adding coolant to an extremely hot engine can result in a cracked block or cylinder head.

Use only a permanent-type coolant when refilling or flushing the coolant system. Recommended ethylene glycol mix 52/48 is normal up to a maximum of 60% glycol, 40% water.

Refer to the mixture chart on the container for additional antifreeze protection information. DO NOT use alcohol or methanol antifreeze, or mix them with the specified coolant.

Plain water may be used in an emergency (except in freezing temperatures), but replace it with the specified coolant as quickly as possible to avoid damage to the system.

Radiator

Inspect the exterior of the radiator for obstructions. Remove all bugs, dirt or foreign material with a soft brush or cloth. Use care to avoid damaging the core fins. If available, use low pressure compressed air or a stream of water in the opposite direction of the normal air flow.

Check all hoses and connections for leaks. If any of the hoses are cracked, frayed, or feel spongy, they must be replaced.

Fan Belts

The water pump is usually belt driven. The same belt may also drive the fan and/or the alternator. The drive belts should be properly adjusted at all times. A loose belt can cause improper alternator, fan and water pump operation, in addition to overheating.

Serpentine Belt

Some GM *Powertrain* engines utilize serpentine belts on the front of the engine. This type of belt system incorporates a belt tensioning device which keeps the belt at the proper tension.

This belt should be checked routinely for cracks or 'checking' on the groove side of the belt. If cracks or 'checking' are apparent the belt must be changed.

V-Type Belt

V-Type belts are generally tensioned by adjusting the alternator, or through a mechanical belt tensioner. The belt is generally correctly tensioned when there is an ½ inch of depression on the belt between the water pump and the crankshaft pulley.

Fuel Filter

Carbureted Engines

On carbureted engines, an in-line fuel filter is incorporated into the fuel supply line. It is recommended that this filter be changed every 250 hours or every 6 months which ever occurs first.

TBI Engines

On PSI Fuel Injection or Fuel Injection/Dual Fuel two fuel filters are used in the gasoline fuel supply line to the engine TBI unit.

A coarse fuel filter is located in the supply line between the fuel tank and the electric fuel pump. This filter protects the fuel pump from debris in the fuel tank.
This filter must be changed every 200 hours or every 6 months which ever occurs first.

A primary fuel filter is located between the fuel pump and the TBI unit on the engine. This filter protects the injectors from microscopic particles in the fuel which can cause plugging of the injectors. This filter **MUST** be changed every 500 hours or annually which ever occurs first.

Zenith Z.E.E.M.S. TBI Fuel Injection requires an in-line fuel filter in the fuel supply line from the fuel tank to the TBI unit, ahead of the electric fuel supply pump. This filter must be changed every 200 hours or every 6 months which ever occurs first.

CAUTION: Failure to change the fuel system filters as recommended can result in premature failure of the TBI fuel system components.

NOTE: Some original equipment manufacturers install their own fuel systems. Please refer to the manufacturers manual if the gasoline fuel system is different than described here.

WARNING

Use extreme care when changing the fuel filters on gasoline engines. Gasoline is highly flammable and should not be exposed to open flame, sparks, or hot engine components. Allow the engine to cool to ambient temperatures prior to changing fuel filters.

Ignition Systems

Types of Ignition Systems

Three types of ignition systems are used on PSI GM *Powertrain* engines. Solid state electronic distributor, solid state electronic distributor with ECU (Electronic Control Unit) and distributor-less electronic ignition with ECU.

Please refer to the General Specification chart to determine the ignition system used on your particular engine.

Ignition Timing

Proper adjustment of the ignition timing must be obtained to provide the optimum engine power output and economy.

To properly adjust timing refer to the timing procedure section of this manual.

Spark Plugs

Spark plugs should be replaced at the recommended intervals described in the Maintenance Schedule. Use only the recommended spark plug or an equivalent as described in the General Specifications.

Spark plug gap, should be adjusted as recommended in the General Specifications.

When removing spark plugs, always note which cylinder each plug came out of. Look at the porcelain around the center electrode of each plug. You can detect many engine problems from the color and type of deposits that have built up on the white porcelain. For example, if the deposits are a glossy brown, that cylinder is burning excess oil. If the deposits are a very dark gray or sooty black color, your engine is running rich, and you are burning excess fuel. The optimum color of the deposits on the porcelain is light tan or light brown. This shows optimum fuel mixture and proper engine running conditions. If the deposits are almost white, the engine may be running excessively lean. Lean running is very detrimental to your engine life, and should be corrected immediately.
If one or more cylinders are burning oil, the smoke from the engine will be a blue-gray color. Most common causes are piston rings (worn out or not broken in) and valve stem seals (cut, nicked, or worn out). If the engine is running rich the exhaust smoke will be a sooty black color and it will smell like gasoline (on gasoline engines).

Storage

One to Six Months

If the engine or machine is to be placed in storage for a period of one to six months it is recommended that the following steps be followed:

Add **'Stabil'** or equivalent fuel conditioner to the fuel tank as recommended on the bottle. Run the engine for approximately 10 to 15 minutes to insure that the treated fuel is completely through the fuel system.

Fill the fuel tank with fuel

Protect the air cleaner inlet from water entry

Protect the exhaust outlet or muffler outlet from water entry

Check the coolant protection and top off radiator

Store indoors if possible

For Extended Periods

Follow the above recommended procedures, plus do the following:

Drain the engine crankcase and refill with recommended oil

Change the oil filter

Disconnect and remove the battery

Clean exterior surface of the engine

If the engine is equipped with an automotive type clutch or PTO clutch, make sure that the clutch is disengaged

Removing the Engine From Extended Storage

When removing the engine from extended storage:

Install a fully charged battery

Remove all protective coverings from the air inlet, air cleaner, exhaust, and muffler openings

Check the coolant level in the radiator and verify the protection level of the coolant

Removing the Engine From Extended Storage (cont.)

Start the engine and allow it to run at slow idle. Verify engine oil pressure

Run the engine at idle until the coolant temperature approaches 120 degrees F (49 degrees C)

Run the engine a various speeds for approximately 15 minutes

Shut the engine down, drain the oil, change the oil filter, and re-fill with the recommended grade of oil

GM Engine Timing Procedures

Carbureted, LPG an NG 3.0L, 4.3L, 5.7L, 7.4L PSI/GM Engines

PSI Timing Connector Part Number 33000036 **MUST** be used when checking and adjusting the engine timing.

1. With the engine shut-off, plug the 33000036 Timing Connector into the distributor. **DO NOT** connect the alligator clip to any positive or negative terminal. (Connecting this wire to any battery terminal prior to starting the engine will cause the distributor module to fail when starting the engine.)
2. Start the engine and run at slow idle. 800 to 1000 rpm.
3. Connect the alligator clip to a B+ terminal. (This connection cancels the programmed timing advance from the distributor module. You will notice a change in engine sound and rpm when making this connection.)
4. Connect an electronic timing light to the No.1 spark plug wire. (The front cylinder on the 3.0L engine and the front cylinder on the left bank of the 4.3L, 5.7L and 7.4L engines.)
5. Check and adjust the distributor as necessary viewing the timing mark on the crankshaft pulley in relation to the pointer on the engine timing case. (On some engines there may be a timing port in the flywheel housing also.)
6. Refer to the General Specifications chart in this manual, for the initial timing specification for your engine and type of fuel being used.

PSI Fuel Injected and Dual Fuel engines

For engines equipped with this type of fuel system, the engine timing is controlled by the ECM (Engine Control Module).

Checking the initial timing on engines equipped with PSI fuel injected and dual fuel engines incorporating and ECM can only be accomplished when using a laptop computer or a hand held diagnostic meter. It will be necessary to contact the OEM or PSI for the necessary equipment and instructions for checking and adjusting the engine timing. (CAUTION: **Failure to follow the correct specified procedures when checking and adjusting the engine timing, can cause severe damage to the engine.)**

Zenith Z.E.E.M.S. Throttle Body Fuel Injected Engines

Engine timing for Zenith TBI fuel injected engines is checked and adjusted following the procedures noted under Carbureted engines. Check the General Specifications chart for the correct engine timing.

Generator Timing

PSI/GM engines operating on generators are timed at 1800 RPM. Timing procedures are the same as for Carbureted engines. Check the General Specifications chart for the correct engine timing for the type of fuel being used.

Maintenance Schedule

Power Solutions, Inc.

GM *Powertrain*

1.6L, 3.0L, 4.3L, 5.7L, 7.4L, and 8.1L Engines

Initial Start-Up Sequence Checks	Operation	Daily	Weekly	Every 50 hrs	Every 100 hrs	Every 200 hrs	Every 400 hrs	Every 800 hrs	As Req.
1	Check Engine Oil Level	x							
2	Check Coolant Level	x							
3	Check for Fluid Leaks	x							
4	Governor, Mechanical (Check oil level)(2)		x						
	Change Engine Oil & Filter (1)					x			
5	Battery, Check Charge & Fluid Level		x						
	Inspect & Clean Radiator Exterior		x						
	Clean Battery Cables								x
6	Check Belts and Belt Tension				x				
	Lubricate Throttle, Governor & Choke Linkage (Carbureted Engines Only)				x				
	Check & Adjust Idle Speed (Carbureted Engines Only)								x
	Inspect and Clean Air Cleaner Element		x						
	Replace Primary Air Cleaner Element (1)						x		
	Replace Safety Air Cleaner Element								x
	Check Coolant Protection & Tighten Hose Clamps						x		
	Replace Engine Coolant (3)							x	
	Replace Gasoline Fuel Filter (4)						x		
	Replace LPG Filter – Zenith EFI (4)							x	
	Replace PCV Valve (If Equipped)							x	
	Check PCV Hoses, Tubes, and Fittings							x	
	Replace Spark Plugs (3)							x	
	Distributor Cap & Rotor (5)							x	
	Secondary Ignition Wires								x
	Adjust Throttle & Governor (3)								x
7	Check All Engine Bolts & Nuts for Tightness								x

(1) More frequent intervals may be required in dusty or dirty operating conditions.
(2) Mechanical governor (belt driven).
(3) To be performed at specified interval or annually, whichever occurs first.
(4) More frequent intervals may be required with dirt in the fuel system.
(5) Does not apply to engines with DIS ignition.

Capacities

Engine	1.6L	3.0L	4.3L	5.7L	7.4L	8.1L
Oil Capacity Without Filter	**3.4 qts.**	**4 qts.**	**4.5 qts.**	**5 qts.**	**8 qts.**	**8 qts.**
Oil Capacity With Filter	**3.7 qts.**	**4.5 qts.**	**5 qts.**	**5.5 qts.**	**9 qts.**	**9 qts.**
Coolant Capacity Without Radiator	**3.5 qts.**	**4 qts.**	**7.75 qts.**	**8.1 qts.**	**14.5 qts.**	**14.5 qts.**
Coolant Capacity With Radiator	**10 qts.**	**12 qts.**	**17 qts.**	**17.5 qts.**	**28 qts.** **31 qt (Turbo)**	**28.5 qts.**

Revised 12/27/01

Power Solutions, Inc.
GM *Powertrain* Industrial Engines

Filter Chart

Engine	1.6L	3.0L	4.3L	5.7L	7.4L/7.4LT	8.1L
Oil Filter	94632619	P-25 or Equivalent	PF-47/PF-52 or Equivalent	PF-1218 Equivalent	PF-1218 or Equivalent	PF-454 or Equivalent
Fuel Filter (Carbureted)		32500020 (101021)	32500020 (101021)			
Fuel Filter (PSI TBI Coarse)		32500111	32500111			
Fuel Filter (PSI TBI Fine)		32500058	32500058			
Fuel Filter Zenith Z.E.E.M.S	Gasoline C282-224 LPG C282-5	32500292	32500292			
Air Filter Primary (PSI Power Unit)		P822768	P8228889			
Air Filter Safety (PSI Power Unit)		P822769	P829333			

Revised 05/31/00

Power Solutions, Inc.
GM *Powertrain* Industrial Engines

Fuel System Chart

Engine	1.6 L	3.0L	4.3L	5.7L	7.4L/T	8.1L
Zenith Carburetor (013448) Manual Choke		x				
Zenith Carburetor (015017) Electric Choke		x				
Zenith Carburetor (015052) used w/Dual Fuel System		x	**x**			
Holley Carburetor (0-7448) Electric Choke			**x**			
Holley Carburetor(0-82010) Electric Choke			**x**			
Impco LPG Fuel System		x	**x**	**x**	**x**	
Nolff LPG Fuel System	x	x	**x**	**x**	**x**	**x**
PSI Fuel Injection (Gasoline)	x	x	**x**			
PSI Fuel Injection/LPG Mixer (Dual Fuel)	x	x	**x**			
Impco Natural Gas Mixer		x	**x**	**x**	**x**	
Nolff Natural Gas Mixer	x	x	**x**	**x**	**x**	**x**
Zenith Z.E.E.M.S Fuel Injection	x	x	**x**			

Governor Chart

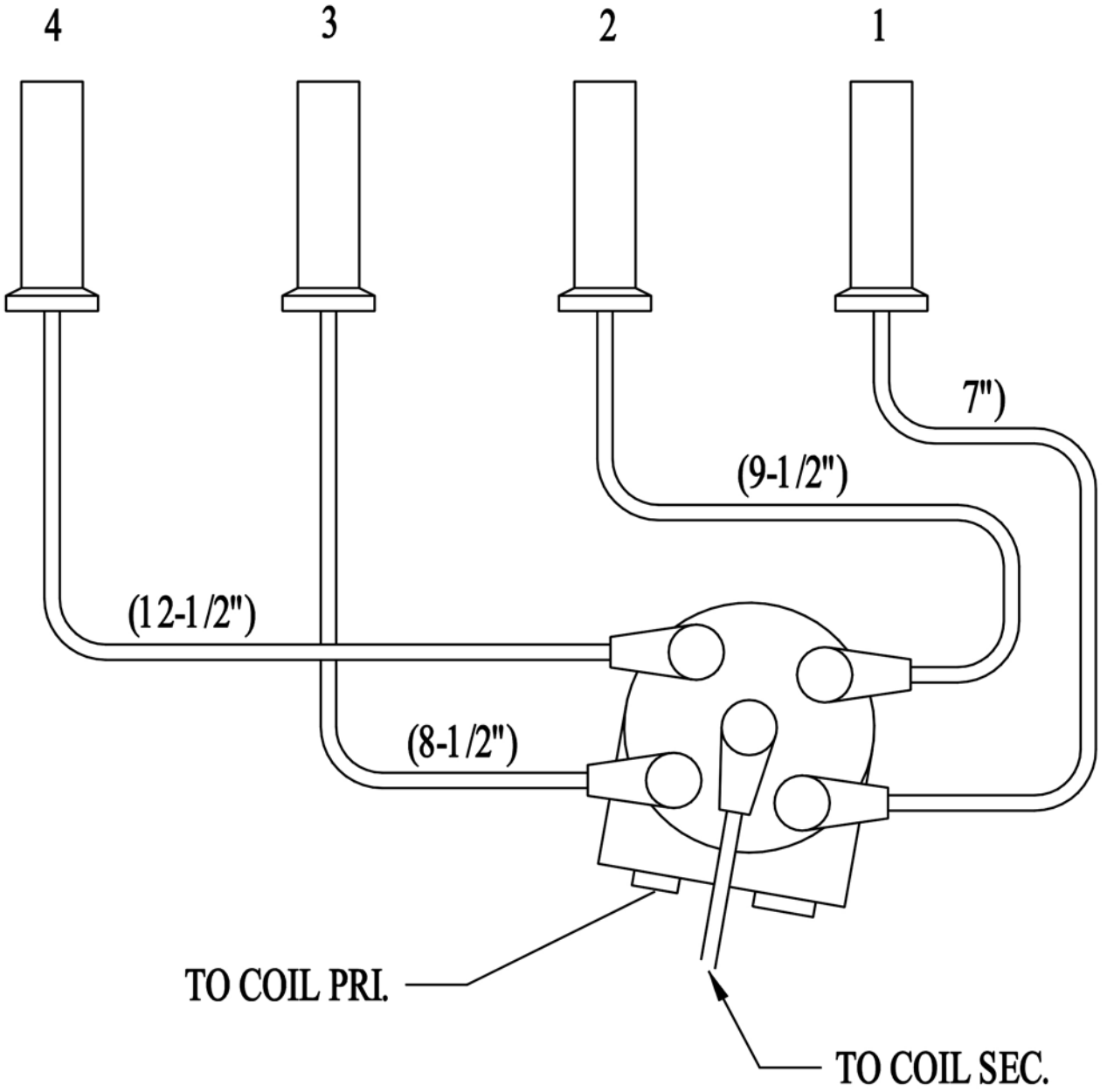
Engine	1.6L	3.0L	4.3L	5.7L	7.4L/T	8.1L
Hoof Mechanical (Belt Driven)(No Longer Available)		x				
Hoof Velocity Governor		x(NLA)	x(NLA)	x	x	
Aisan Velocity Governor		x	x			
Barber Colman Electronic		x	x			
Governors America		x	x	x	x	
Barber Colman Power Flow, PSI ECU		x	x	x		x
Zenith Z.E.E.M.S. Fuel Injection	Integral	Integral	Integral			
Woodward						x

Revised 06/05/01

GENERAL SPECIFICATIONS
Power Solutions, Inc.
GM *Powertrain* Industrial Engines

Engine	1.6L	3.0L	4.3L	5.7L	7.4L/7.4L Turbo	8.1L/8.1L Turbo
Type	1.6-2V	3.0L L4	4.3L V-6	5.7L V-8 GEN-1E	7.4L V-8	8.1L V-8
Displacement cc (c.i.d.)	1600 (98)	2966 (181)	4294 (262)	5735 (350)	7441 (454)	8127 (496)
Compression Ratio	9.4:1	9.2:1	9.4:1	9.4:1	8.9:1	9.1:1
Valve Configuration	Overhead Cam	Push Rod Actuated Overhead Valve	Push Rod Actuated Overhead Valve	Push Rod Actuated Overhead Valve	Push Rod Actuated Overhead Canted Valve	Push Rod Actuated Overhead Valve
Valve Lifters	Hydraulic	Flat Follower	Hydraulic Roller	Hydraulic Roller	Hydraulic Roller	Hydraulic Roller
Bore x Stroke mm (inches)	79.0x81.5 (3.11x3.21)	101.60x91.44 (4.00x3.60)	101.60x88.39 (4.00x3.48)	101.60x88.39 (4.00x3.48)	107.95x101.60 (4.25x4.00)	107.95x111 (4.25x4.37)
Main Bearing Caps	2 Bolt	2 Bolt	2 Bolt	2 Bolt	4 Bolt	4 Bolt
Balance Method	External	External	Internal Balance Shaft	External	External	External
Intake Manifold	TBI	TBI, Carburetor, Mixer	TBI, Carburetor, Mixer	Mixer	Mixer	Mixer
Firing Order	1-3-4-2	1-3-4-2	1-6-5-4-3-2	1-8-4-3-6-5-7-2	1-8-4-3-6-5-7-2	1-8-7-2-6-5-4-3
Oil Capacity With Oil Filter	3.4 qts. (3.2L) 3.7 qts. (3.5L)	4 qts. (3.8L) 5 qts. (4.7L)	4.5 qts. (4.3L) 5 qts. (4.7L)	4.5 qts. (4.3L) 5 qts. (4.7L)	8 qts. (7.6L) 9 qts. (8.5L)	8 qts. (7.6L) 9 qts (8.5L)
Oil Filter		PF-25 or Equivalent	PF-47/PF-52 or Equivalent	PF-1218 or Equivalent	PF-1218 or Equivalent	PF-454 or Equivalent
Minimum Oil Pressure (Hot)	21 psi @ idle	6 psi @ 1000 rpm 18 psi @ 2000 rpm	6 psi @1000 rpm 18 psi @ 2000 rpm	6 psi @ 1000 rpm 18 psi @ 2000 rpm	6 psi @ 1000 rpm 18 psi @ 2000 rpm	5 psi @ 1000 rpm 15 psi @ 2000 rpm
Coolant Capacity (Engine)	3.5 qts.	4 qts. (3.78L)	7.75 qts. (7.3L)	8.1 qts (7.8L)	14.5 qts (13.7L)	14.5 qts (13.7L)
oolant Capacity (W/PSI Rad)	10 qts	12 qts. (11.4L)	17 qts. (16L)	17.5 qts. (16.6L)	28 (26.5L)	28 qts (26.5L)
Fuel Type	Gasoline, LPG	Gasoline, LPG, NG	Gasoline, LPG, NG	LPG, NG	LPG, NG	LPG, NG
gine Rotation (Flywheel End)	CCW	CCW	CCW	CCW	CCW	CCW
Ignition System	Distributor-less Electronic (ECU)	Solid State Distributor	Solid State Distributor	Solid State Distributor	Solid State Distributor	Distributor-less Electronic ECU
nition Timing (Degrees BTDC)						
Gasoline (Carb)		0	0	0	0	
Gasoline (TBI)	DIS	0	0	0	0	DIS
LPG	No Adjustment	10 (4 Europe)	10 (4 Europe)	10 (4 Europe)	10	No Adjustment
NG		10	10	10	10	
Dual Fuel		0	0	0	0	
nition Timing (Degrees BTDC)						
Generators 1800 RPM	DIS					
LPG	No Adjustment	26	26	26	26	26
NG		36	36	36	36	30
Spark Plugs	AC Delco 93206675	AC Delco R45TS	AC Delco R42LTS	AC Delco R42LTS	AC Delco R42LTS	AC Delco R42LTS
Spark Plug Gap						
TBI			.035	.035		
LPG	.8mm-.9mm	.045	.035	.035	.035	.030/.025T
NG	all	all	.035	.035	.035	.030/.025T
Dual Fuel			.035	.035	.035	.030/.025T
Valve Clearance (Lash)						
Intake	No Adjustment	½ to 1 Turn Down From	Net Lash	1 Turn Down From	Net Lash	Net Lash
Exhaust	OHC Engine	0 Lash	No Adjustment	0 Lash	No Adjustment	No Adjustment
Manufactured	Brazil	Toluca, Mexico	Tonawanda, NY	Toluca, Mexico	Tonawanda, NY	Tonawanda, NY

Revised 02/09/02



3.0L Engine Spark Plug Wire Routing

Torque Standard

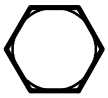
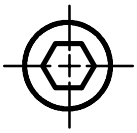
Inch Fasteners

Thread Size	SAE Grade 1	SAE Grade 2 Carriage Bolts	Thread Cutting Thread Rolling	SAE Grade 5 Socket and Stainless Steel	SAE Grade 8	Headless Socket Set Screws	Square Head Set Screws	
4 (.112)	(5)–(6.5)					(4)–(6)		INCH POUNDS
5 (.125)	(6)–(8)					(9)–(11)		
6 (.138)	(7)–(9)		(20)–(24)			(9)–(11)		
8 (.164)	(12)–(16)		(40)–(47)			(17)–(23)		
10 (.190)	(20)–(26)		(50)–(60)			(31)–(41)		
1/4 (.250)	4–5	5–6	7–10	7–10	10–13	6–8	17–19	FOOT POUNDS
5/16 (.312)	7–9	9–12	15–20	15–20	20–26	13–15	32–38	
3/8 (.375)	13–17	16–21		27–35	36–47	22–26	65–75	
7/16 (.438)	20–26	26–34		43–56	53–76	33–39	106–124	
1/2 (.500)	27–35	39–51		65–85	89–116	48–56	162–188	
5/8 (.625)		80–104		130–170	171–265		228–383	
3/4 (.750)		129–168		215–280	313–407		592–688	
1 (1.000)		258–335		500–650	757–984		1281–1489	

Torque Foot Pounds (Inch Pounds) Zinc Plated

Torque Standard

Inch Fasteners

Fastener Identification	Type	Material	Nominal Size	Mechanical Properties		
				Proof Load (PSI)	Yield Strength Min (PSI)	Tensile Strength Min (PSI)
	SAE Grade 1 Machine Screws	Low or Medium Carbon Steel	#2 Thru #10			55,000
			1/4 Thru 1 1/2	33,000	36,000	60,000
	SAE Grade 2 Carriage Bolts	Low or Medium Carbon Steel	1/4 Thru 3/4	55,000	57,000	74,000
			Over 3/4 Thru 1 1/2	33,000	36,000	60,000
	Stainless Steel	18–8 Austenitic Stainless Steel			50,000	90,000
	SAE Grade 5	Medium Carbon Steel Quenched Tempered	1/4 Thru 1	85,000	92,000	120,000
			Over 1 to 1 1/2	74,000	81,000	105,000
	Socket Screws	High Carbon Alloy Steel Quenched Tempered		136,000		160,000
	SAE Grade 8	Medium Carbon Al-loy Quenched Tempered	1/4 Thru 1 1/2	120,000	130,000	150,000

Torque Standard

METRIC Fasteners

Thread Size	4.8/5.6	8.8 Stainless Steel	10.9	12.9	Set Screws	
M3	43–56 Ncm	99–128 Ncm	139–180 Ncm	166–215 Ncm	61–79 Ncm	NEWTON CENTIMETERS
M4	99–128 Ncm	223–290 Ncm	316–410 Ncm	381–495 Ncm	219–285 Ncm	
M5	193–250 Ncm	443–575 Ncm	624–810 Ncm	747–970 Ncm	427–554 Ncm	
M6	3.3–4.3 Nm	7.6–9.9 Nm	10.8–14 Nm	12.7–16.5 Nm	7.5–9.8 Nm	
M8	8.1–10.5 Nm	18.5–24 Nm	26.2–34 Nm	31–40 Nm	18.3–23.7 Nm	NEWTONMETERS
M10	16–21 Nm	37–48 Nm	52–67 Nm	63–81 Nm		
M12	28–36 Nm	64–83 Nm	90–117 Nm	108–140 Nm		
M14	45–58 Nm	102–132 Nm	142–185 Nm	169–220 Nm		
M16	68–88 Nm	154–200 Nm	219–285 Nm	262–340 Nm		
M20	132–171 Nm	300–390 Nm	424–550 Nm	508–660 Nm		
M22	177–230 Nm	409–530 Nm	574–745 Nm	686–890 Nm		
M24	227–295 Nm	520–675 Nm	732–950 Nm	879–1140 Nm		

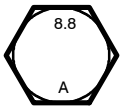
Zinc Plated

Conversion Tables

Ncm to Inch Pound x 0.08851
Nm to Foot Pound x 0.7376
Inch Pound to Ncm x 11.2982
Foot Pound to Nm x 1.3558

Torque Standard

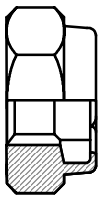
METRIC Fasteners

Fastener Identification	Type Class	Material	Nominal Size	Mechanical Properties		
				Yield Stress (Min) MPa	Yield Point .2% Elongati (Min) MPa	Tensile Strength (Min) MPa
	3.6/4.6 Carriage Bolts	Low or Medium Carbon Steel		190 (27,550 PSI) 240 (34,800 PSI)		330 (47,850 PSI) 400 (58,000 PSI)
	4.8 Pan Head Machine Screws	Low or Medium Carbon Steel		340 (49,300 PSI)		420 (60,900 PSI)
	A2–70 Stainless Steel	Austenitic Stainless Steel		450 (65,300 PSI)		700 (101,000 PSI)
	8.8 Hex Head (Grade 5)	Medium Carbon Steel Quenched Tempered	≤ M16		640 (92,800 PSI)	800 (116,000 PSI)
			> M16		660 (95,700 PSI)	830 (120,350 PSI)
	10.9 Hex Head Flat Head (Grade 8)	Medium Carbon Steel Quenched Tempered			940 (136,300 PSI)	1040 (150,800 PSI)
	12.9 Socket Head	Alloy Steel			1100 (159,500 PSI)	1220 (176,900 PSI)

Conversion Table

Mega Pascals to Pounds per Square Inch x 145.138

Torque Standard

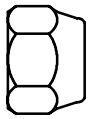


Nylon Insert Lock Nuts
Nut-Hex Light THIN
(Cad or Zinc Plated)

Size	Grade 2 Bolt	Grade 5 Bolt
1/4–20	5–8	7–8
1/4–28	4–6	5–6
5/16–18	8–14	13–14
5/16–24	9–14	13–14
3/8–16	12–18	15–18
3/8–24	12–18	16–18
1/2–13	26–40	37–40
1/2–20	27–42	41–42
5/8–11	58–89	73–89
5/8–18	60–92	82–92

Torque in Foot Pounds

Torque Standard



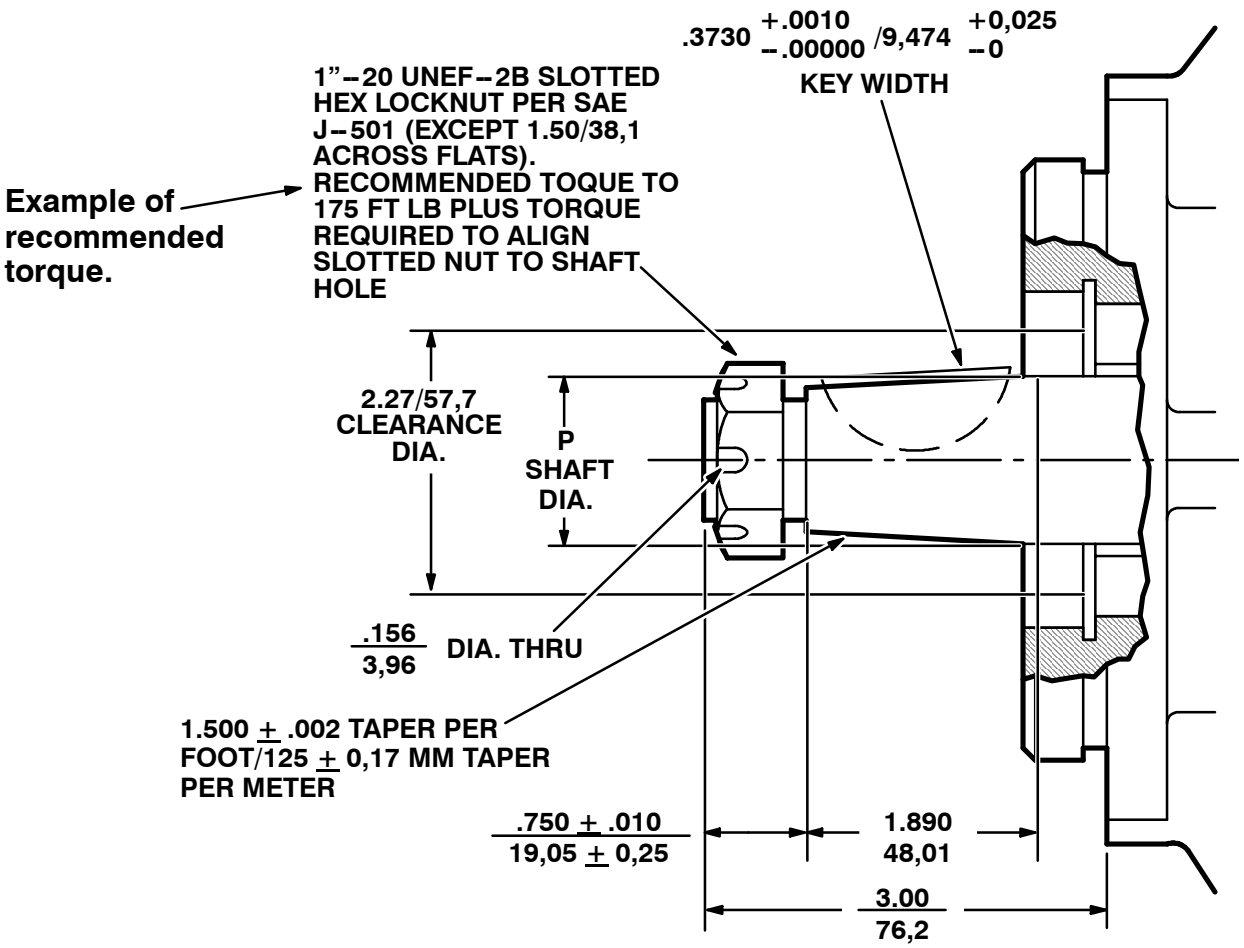
Wheel Bolt and Nuts

Stud or Bolt Size and Thread	Recommended Torque in Foot Pounds
7/16–20	75–85
1/2–20	75–85
9/16–18	80–90
5/8–18	140–170

Wheel Bearing Adjustment

1. Tighten the spindle nut to 12 ft lbs while turning the wheel assembly forward by hand to fully seat the bearings.
2. Back off the nut to the “just loose” position.
3. Hand tighten the spindle nut. Loosen the spindle nut until either hole in the spindle lines up with a slot in the nut. (Not more than 1/2 flat.)
4. Install the cotter pin. Bend the ends of the cotter pin against the nut, cut off extra length to ensure ends will not interfere with the dust cap.

Tightening Nuts on Tapered Shafts

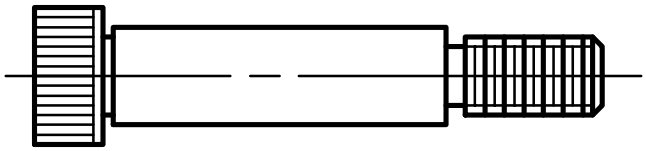


Check with the manufacturer to see what the recommended maximum torque is. Tighten the slotted nut to a lower torque, and then tighten the nut to align the cotter pin hole with the slot on the nut. Do not exceed the recommended torque. Do not back off the nut to align the holes.

Motor	Tapered Shaft	Nut Info.	Torque Specification Recommendations
A&H Series	1.00 dia.	.75−16 UNF 1.107 Hex	150 ft lb dry 125 ft lb lubricated Plus torque to align for pin
2000 Series	1.25 dia.	1−20 UNEF 1.44 Hex	225 ft lb dry 225 ft lb lubricated PLUS torque to align for pin
4000 Series	1.625 dia.	1.25−18 UNEF 2.187 Hex	475 ft lb dry 375 ft lb lubricated PLUS torque to align for pin
6000 Series	1.75 dia.	1.25−18 UNEF 2.187 Hex	475 ft lb dry 375 ft lb lubricated PLUS torque to align for pin

Torque Standard

Shoulder Bolts



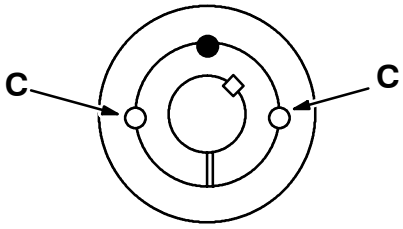
Nominal Diameter	Thread Size	Recommended Seating Torque
.250	10–24	45 In Lbs
.312	1/4–20	9 Ft Lbs
.375	5/16–18	19 Ft lbs
.500	3/8–16	32 Ft Lbs
.625	1/2–13	82 Ft Lbs
.750	5/8–11	164 Ft Lbs

Metric

Nominal Diameter	Thread Size	Recommended Seating Torque
6	M5x0.8	7 Nm
8	M6x1.0	12 Nm
10	M8x1.25	29 Nm
12	M10x1.5	57 Nm
16	M12x1.75	100 Nm

Taper Lock® Bushings

IMPORTANT: Follow all these instructions carefully. This is necessary to insure satisfactory performance.



1008 to 3030

To Install

1. Clean shaft, bore and outside of bushing, and hub bore of all oil, lacquer, and dirt.
2. Insert bushing in hub. Match the hole pattern, not threaded holes (each hole will be threaded on one side only).
3. Oil setscrews and thread into those half threaded holes indicated by C on above diagram.
4. Alternately torque setscrews to recommended torque setting in chart below.
5. Using a block, sleeve, or drift, hammer large end of bushing (do not hammer bushing directly).
6. Repeat steps 4 and 5 until torque wrench reading after hammering is the same as before hammering.
7. Fill all unoccupied holes with grease.

To Remove

1. Remove all setscrews.
2. Insert setscrews in holes indicated by ● on the diagram. Loosen bushing by alternately tightening setscrews.
3. To reinstall, complete all seven (7) steps installation steps.

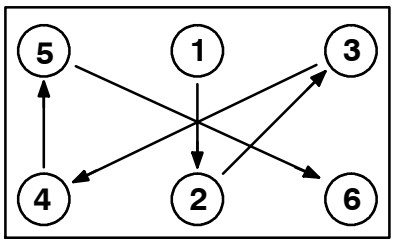
Recommended Wrench Torque

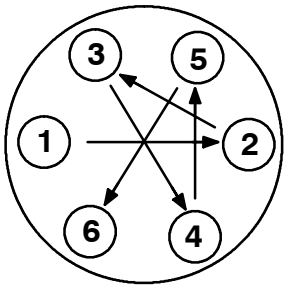
Bushing No.	Screws	Wrench Torque (Pound-Inch)	Hammer Size
1008, 1108 1210, 1215, 1310 1610, 1615	1/4” Setscrews 3/8” Setscrews 3/8” Setscrews	55 175 175	6 lb 6 lb 6 lb
2012 2517, 2525 3020, 3030	7/16” Setscrews 1/2” Setscrews 5/8” Setscrews	280 430 800	6 lb 6 lb 6 lb

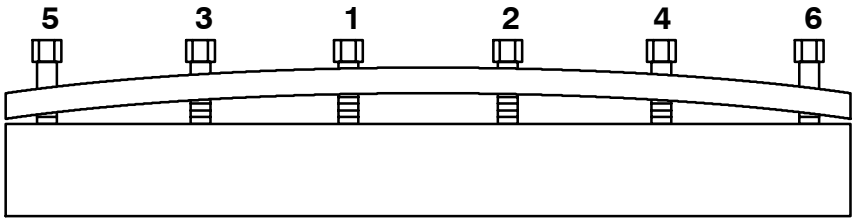
If two bushings are used on same component and shaft, fully tighten one bushing before working on the other.

Sequence Tightening

On some assemblies, it is advisable to use a crisscross pattern. Always avoid starting in one spot and tightening one after another in a row. Remember that the object is to tighten the parts in such a manner that even stress is set up throughout, at the same time allowing the parts to be drawn together so that their mating surfaces will contact.







Torque in Steps

1. Run each fastener, in proper sequence, up to the recommended torque.
2. Repeat the process of running up each fastener, in proper sequence, up to the recommended torque.
3. If necessary, repeat step two until all the fasteners are tightened to the recommended torque.