

# SECTION 21

## Diesel Diagnostics — 7.3L Engine

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## Preliminary Checkout

This Section covers adjustments, diagnostics, and test procedures for the 7.3L diesel engine Fast Start Glow Plug System and Fuel Injection System.

### Checkout

- Visually inspect the engine compartment to ensure all wiring harnesses and fuel lines are properly routed, free of kinks and not contacting chassis or engine components and securely connected.
- Examine all wiring harnesses and connectors for insulation damage, burned, overheated, loose or broken conditions.
- Be certain the batteries are fully charged.
- All accessories should be off during testing and diagnosis.

## Test Equipment

The following test equipment (Figs. 1 through 5) is required for adjusting idle speed and timing.

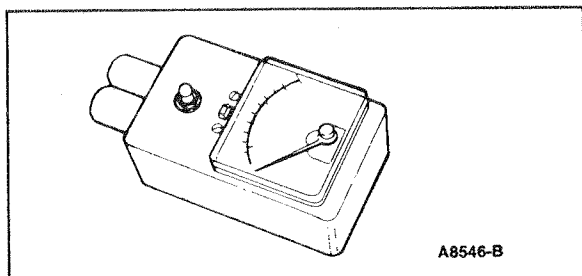


Figure 1 Rotunda 099-00001  
Photoelectric Tachometer  
(For Engine RPM Checking  
Only)

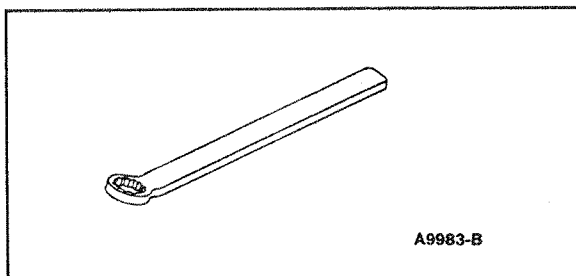


Figure 3 T86T-9000-C Injection Pump  
Mounting Wrench

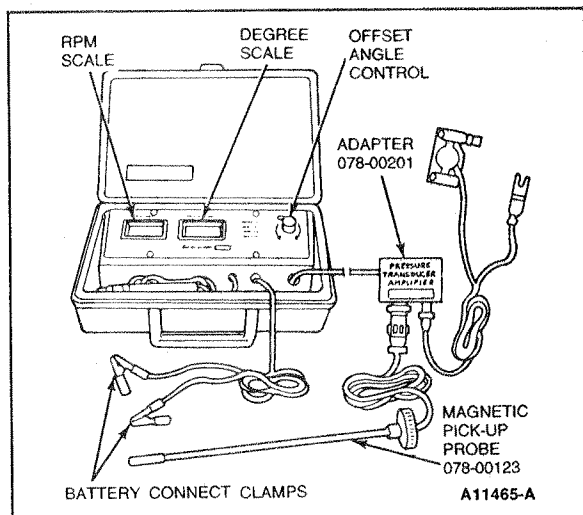


Figure 2 Rotunda 078-00200 Dynamic Timing  
Meter

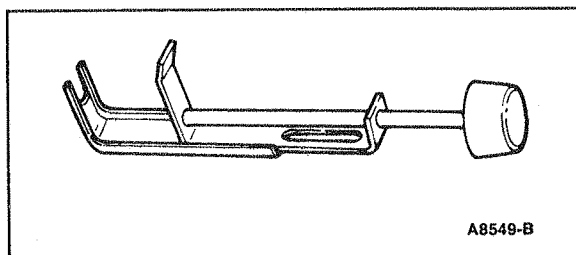


Figure 4 Throttle Control Tool D83T-9000-E

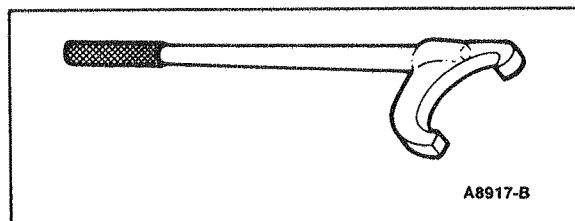


Figure 5 T83T-9000-C Injection Pump  
Rotating Tool

## Test Equipment

The following test equipment (Figs. 6 and 7) is required for performing the Engine Performance Diagnostic Procedure.

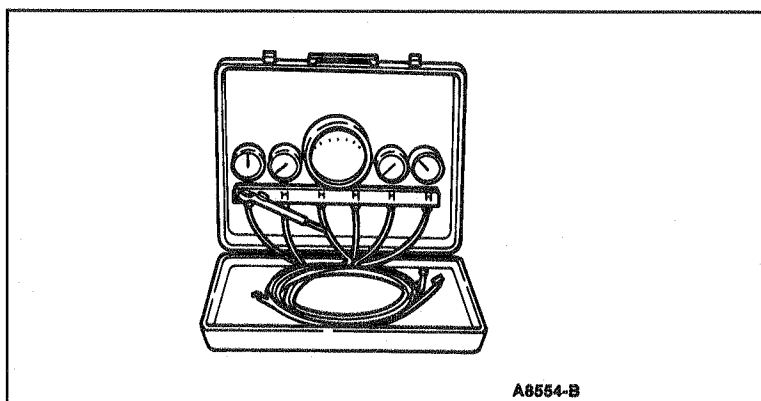


Figure 6 Rotunda 014-00702 Pressure Test Kit

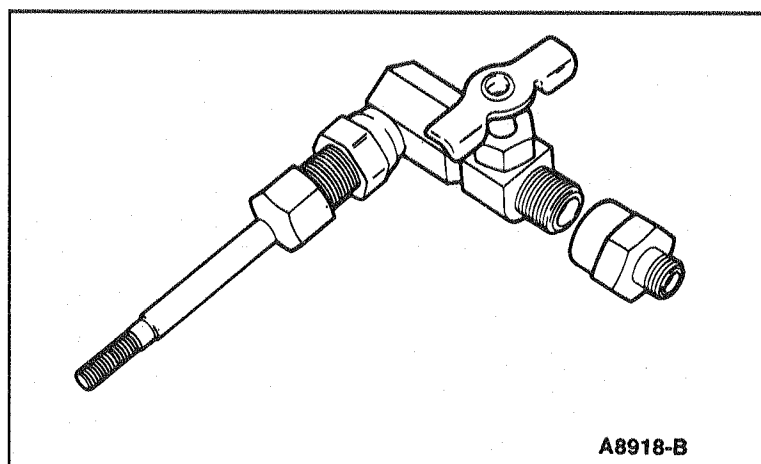


Figure 7 T83T-9000-A Fuel Transfer Pump Pressure Adapter

## Test Equipment

The following test equipment (Figs. 8 and 9) is required for performing the WAIT TO START Lamp Diagnostic Procedure and the Fast Start Glow Plug System Diagnostic Procedure.

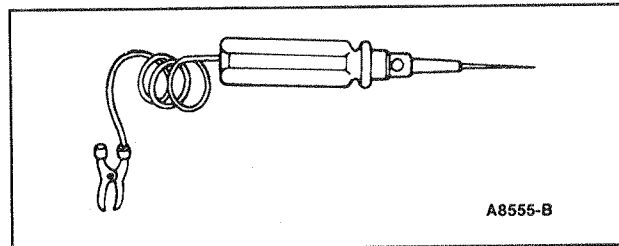


Figure 8 12-Volt Test Lamp

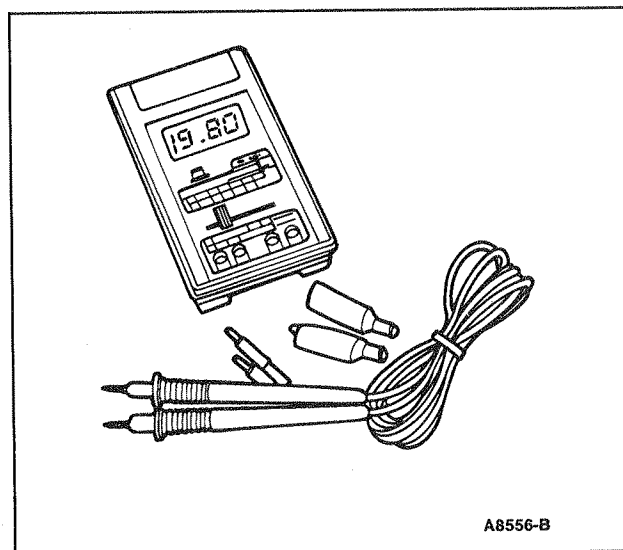


Figure 9 Rotunda 007-00001 Digital Multimeter

## Test Equipment

The following test equipment (Figs. 10 and 11) is required for Injection Nozzle testing and cleaning.

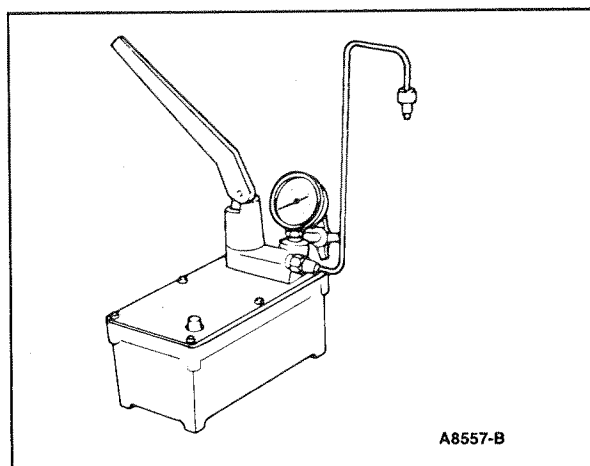


Figure 10 Rotunda 014-00300 Injector Nozzle Tester Special Service Tool  
D83T-9000-F

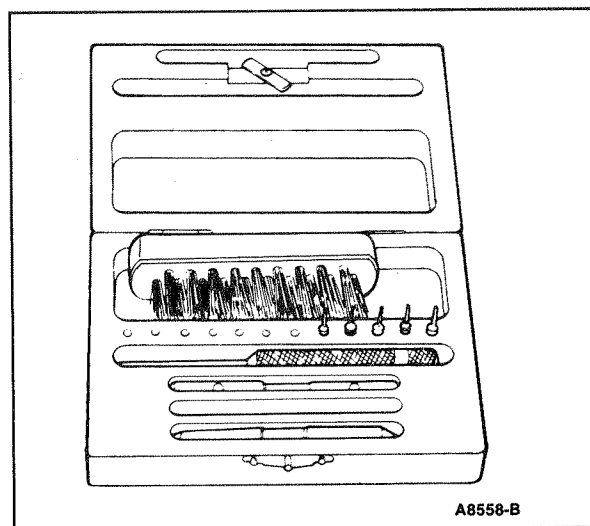


Figure 11 Rotunda 014-00301 Injector Nozzle Cleaning Kit Special Service Tool  
D83T-9000-G

## Idle Speed Setting Procedures

### Curb Idle Speed Adjustment

1. Place transmission in NEUTRAL or PARK.
2. Bring engine up to normal operating temperature.
3. Idle speed is measured with manual transmission in NEUTRAL and automatic transmission in DRIVE.
4. Ensure that curb idle adjusting screw is against the stop. If not, correct vehicle linkage.
5. Check curb idle speed, using Rotunda 099-00001 or equivalent. Curb idle speed is specified on the Vehicle Emissions Control Information (VECI) decal. Adjust to specification using idle speed adjusting screw (Fig. 12).
6. Place transmission in NEUTRAL or PARK. Rev engine momentarily. Place transmission in specified gear and check curb idle rpm. Adjust again if necessary.

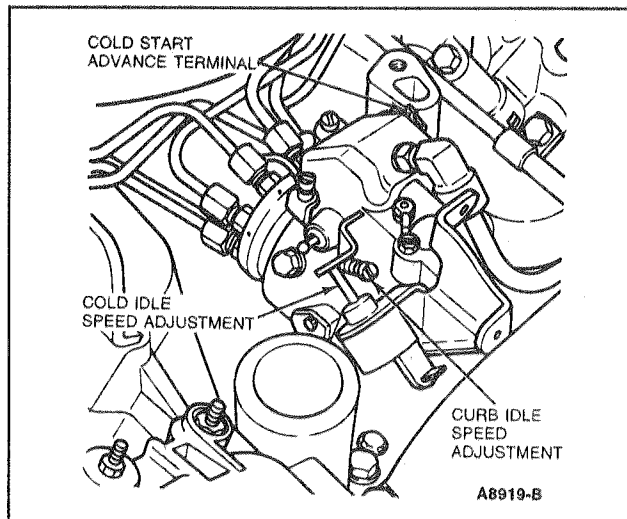


Figure 12 Idle Speed Adjusting Screw

### Fast Idle Adjustment

At Cold Idle Solenoid:

1. Place transmission in NEUTRAL or PARK.
2. Start engine, and bring up to normal operating temperature.
3. Disconnect fast idle solenoid from wiring harness.
4. Apply battery voltage to solenoid to activate it.
5. Rev engine momentarily to set solenoid to activate it.
6. Check fast idle speed setting. Fast idle rpm should be  $875 + 25$ . Adjust to specification by turning solenoid plunger in or out (Fig. 12).
7. Rev engine momentarily and check fast idle rpm. Adjust as necessary.
8. Remove battery voltage from solenoid connector and connect to wiring harness.

## Setting Injection Timing — Static Timing

1. Remove fast idle bracket and solenoid from injection pump.
2. Break torque (keeping nuts snug) on three nuts attaching injection pump to pump mounting adapter using Tool T86T-9000-C or equivalent (Fig. 3).
3. Install rotating Tool T83T-9000-C (Fig. 5), on front of pump and rotate injection pump to align timing mark on injection pump mounting flange with timing mark on pump mounting adapter, to within  $\pm 0.030$  inch.
4. Remove rotating tool and tighten nuts to specification. Visually check timing to verify that timing marks are aligned (Fig. 13).
5. Install fast idle bracket and solenoid and tighten bolts to specification.

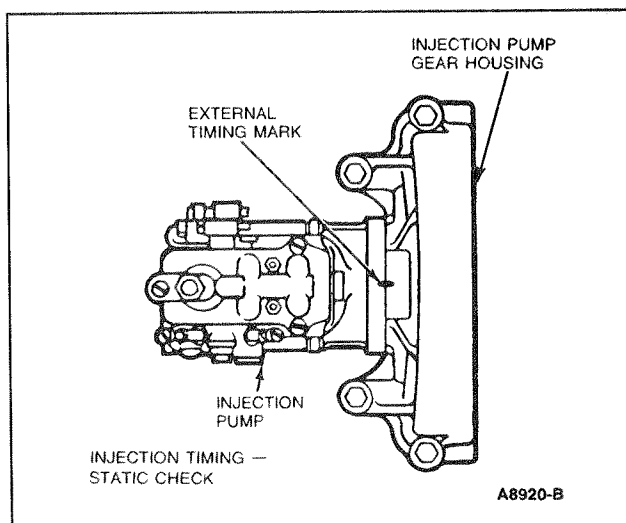


Figure 13 Injection Pump Timing Marks



## Setting Injection Timing — Dynamic Timing

1. Bring engine up to normal operating temperature.

NOTE: When checking or setting dynamic injection timing on the 7.3L engine it is mandatory that the engine be stabilized at normal operating temperature of 89°C-100°C (192°F-212°F). This temperature is needed to ensure proper fuel ignition in the precombustion chambers.

2. Stop engine and install Dynamic Timing Meter, Rotunda 078-00200 or equivalent, by placing magnetic pickup in timing pointer probe hole (Fig. 14). Insert pickup until it almost touches vibration damper.

NOTE: To prevent incorrect readings, ensure that vibration damper is clean and free of foreign debris and rust scale. If required, sand the area to remove rust and apply a light coat of paint to the area.

3. Attach clamp from Timing Meter Adapter Rotunda 078-00201 or equivalent, to the line pressure sensor on No. 1 injector nozzle (F-Series) or No. 4 injector nozzle (E-Series) and connect to timing meter (Fig. 15).

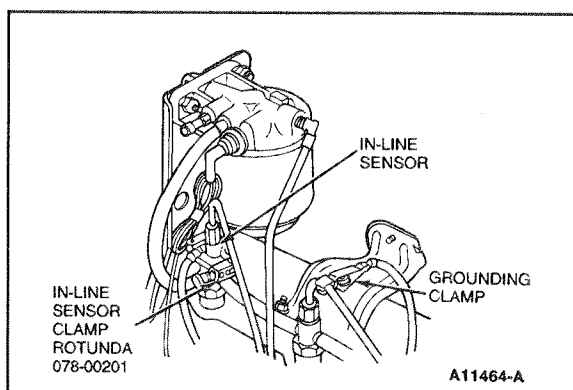
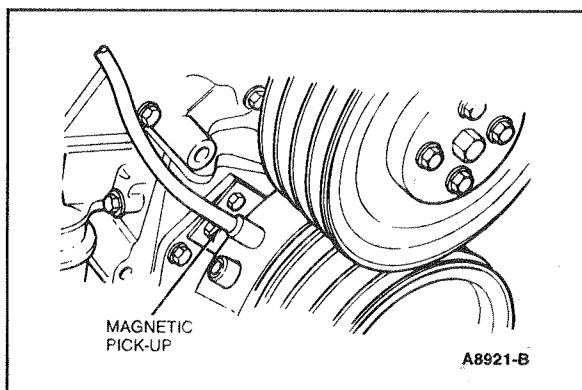


Figure 14 Magnetic Pickup — Dynamic Timing

Figure 15 Luminosity Probe — Dynamic Timing

4. Connect dynamic timing meter to battery and dial in minus 20 degrees offset on meter. Disconnect cold start advance solenoid connector from solenoid terminal (Fig. 12).

NOTE: Ensure that all wire leads are located away from the front accessory drive belts.

5. With transmission in NEUTRAL and rear wheels raised off the ground, start engine. Using Throttle Control Tool D87T-9000-E or equivalent, set engine speed to 2000 rpm with no accessory load. Observe injection timing on dynamic timing meter. Injection timing should be 6.5 degrees BTDC at 2000 rpm.

6. Apply battery voltage to cold start advance solenoid terminal to activate it.

NOTE: Activating cold start advance solenoid can result in engine speed increase. Adjust throttle control to attain 2000 rpm, if required.

7. Check timing at 2000 rpm. The timing should be advanced at least 1 degree before the timing obtained in Step 5. If the advance is less than 1 degree, replace fuel injection pump top cover assembly.
8. If dynamic timing is not within  $\pm 2$  degrees of specification, adjustment of pump timing is necessary.

## Setting Injection Timing — Dynamic Timing

9. Turn engine off. Note timing mark alignment. Remove fast idle bracket and solenoid from injection pump. Break torque (keeping nuts snug) on nuts attaching injection pump to pump mounting adapter with Tool T86T-9000-C or equivalent.
10. Install rotating tool, T83T-9000-C or equivalent, on front of pump. Rotate clockwise (when viewed from front of engine) to retard, and counterclockwise to advance timing, by lightly tapping tool with a rubber mallet. Two degrees of dynamic timing is approximately 0.75mm (.030 inch) of timing mark movement.
11. Remove rotating tool and tighten nuts to specification. Start engine and recheck timing. Repeat Steps 9, 10 and 11 as necessary, to set timing to  $\pm 1$  degree of specification.
12. Turn engine off. Remove dynamic timing components. Install fast idle bracket and solenoid and tighten bolts to specification.

## System Description and Diagnosis

This portion of this Section contains a brief description of the 7.3L diesel engine "WAIT TO START" Lamp System, Solid-State Glow Plug System and Fuel Injection System. It also contains detailed diagnostic procedures for these systems.

The diagnostic procedures are broken into two parts. The first part is Symptom Analysis. This Section should be consulted first, as it will provide direction to perform a specific service or to a specific diagnostic procedure.

The second part contains the "WAIT TO START" Lamp, Solid-State Glow Plug System and Engine Performance diagnostic procedures. At the beginning of each of these procedures, there is an explanation of how to use that procedure. Read this explanation before performing the tests.

## Warning Lamps

### Wait To Start Lamp

The "WAIT TO START" lamp comes on when the ignition switch is turned to the RUN position, and the engine is below normal operating temperature. It will remain lit for 4 to 10 seconds, depending on engine temperature. If engine is at or above normal operating temperature the lamp will not turn on.

NOTE: If the ignition switch is left in the ON position for an extended period of time or the engine is not started within the two minute cycling time, the glow plug system must be reset by turning the ignition switch to OFF position.

### Fuel Filter Restriction Warning Lamp

The 7.3L diesel is equipped with a fuel filter restriction sensor. A restriction indicator lamp is located in the instrument cluster to alert the operator.

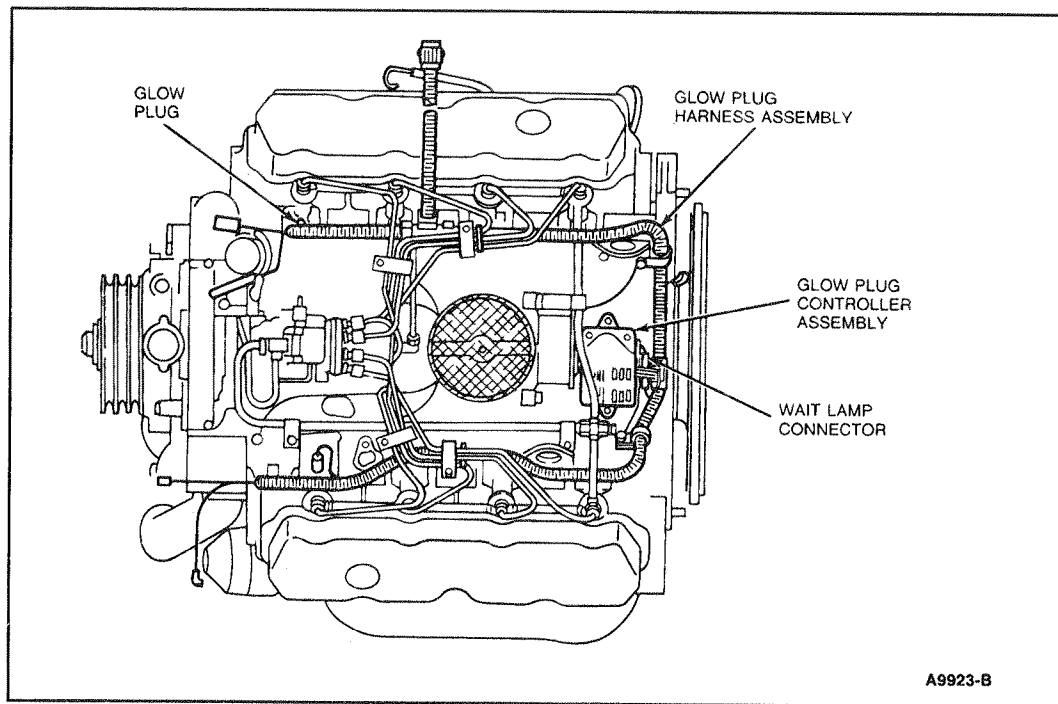
The lamp should turn on when the ignition switch is in the START position to indicate proper lamp and sensor function. If the lamp comes on during normal engine operation, replace the filter as soon as possible.

### Water In Fuel Warning Lamp

The "WATER IN FUEL" warning lamp should turn on when the ignition switch is in the START position to indicate proper lamp and sensor function. The lamp will come on if the fuel filter/water separator has a significant amount of water in it. If the lamp comes on during normal engine operation, drain the fuel bowl in the filter as soon as possible. Water in the fuel could cause extensive damage to the fuel injection system.

## Solid-State Glow Plug System

The solid-state glow plug system consists of the glow plug controller, the glow plug harness assembly and glow plugs (Fig. 16).



*Figure 16 Solid State Glow Plug Control System*

The system determines the glow plug temperature by electronically measuring the resistance of the glow plugs. It then maintains this temperature regardless of ambient temperatures.

The system is actuated when the ignition switch is turned to the RUN position. The "WAIT TO START" lamp lights until the glow plugs reach the proper temperature. The lamp goes out and the engine can be started.

The afterglow operation of the glow plugs continues after the "WAIT TO START" lamp turns off. The glow plugs cycle on and off for a period of time. This helps to reduce white smoke after engine start-up.

The glow plug system can be recycled by turning the ignition off and on. This immediately restarts the glow plug cycle. The engine can be started as soon as the "WAIT TO START" lamp goes off.

## Solid-State Glow Plug System

### Glow Plug Controller

The power relay is mounted on top of the solid-state controller circuit board. The complete assembly is mounted on the rear of the intake manifold (Fig. 17).

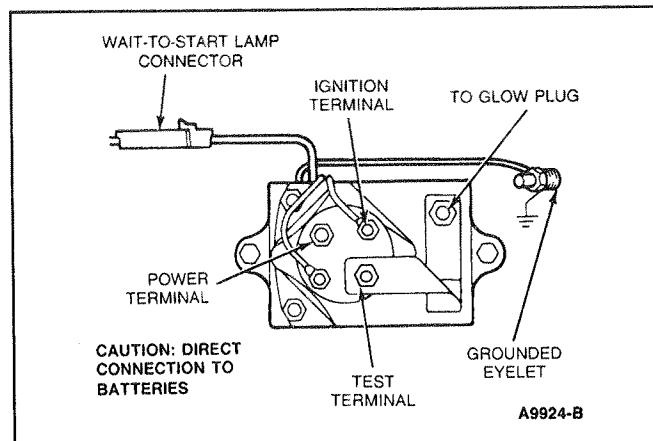


Figure 17 Solid-State Glow Plug Controller

### Glow Plugs

The system uses positive temperature coefficient (PTC) glow plugs. The resistance of the glow plugs changes as the temperature rises. The glow plugs use bullet-type terminals (Fig. 18).

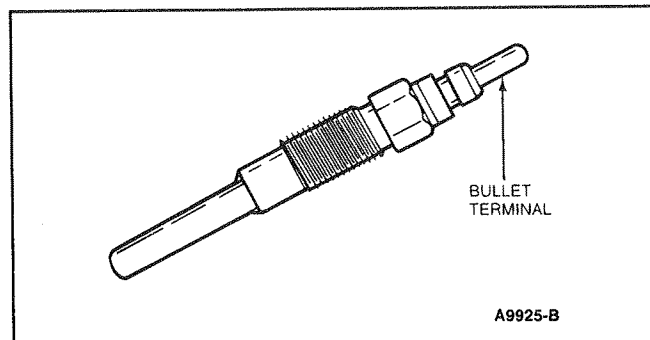


Figure 18 Glow Plugs

## Solid-State Glow Plug System

### Wiring Schematic

Use the electrical schematic (Fig. 19) when diagnosing the glow plug system.

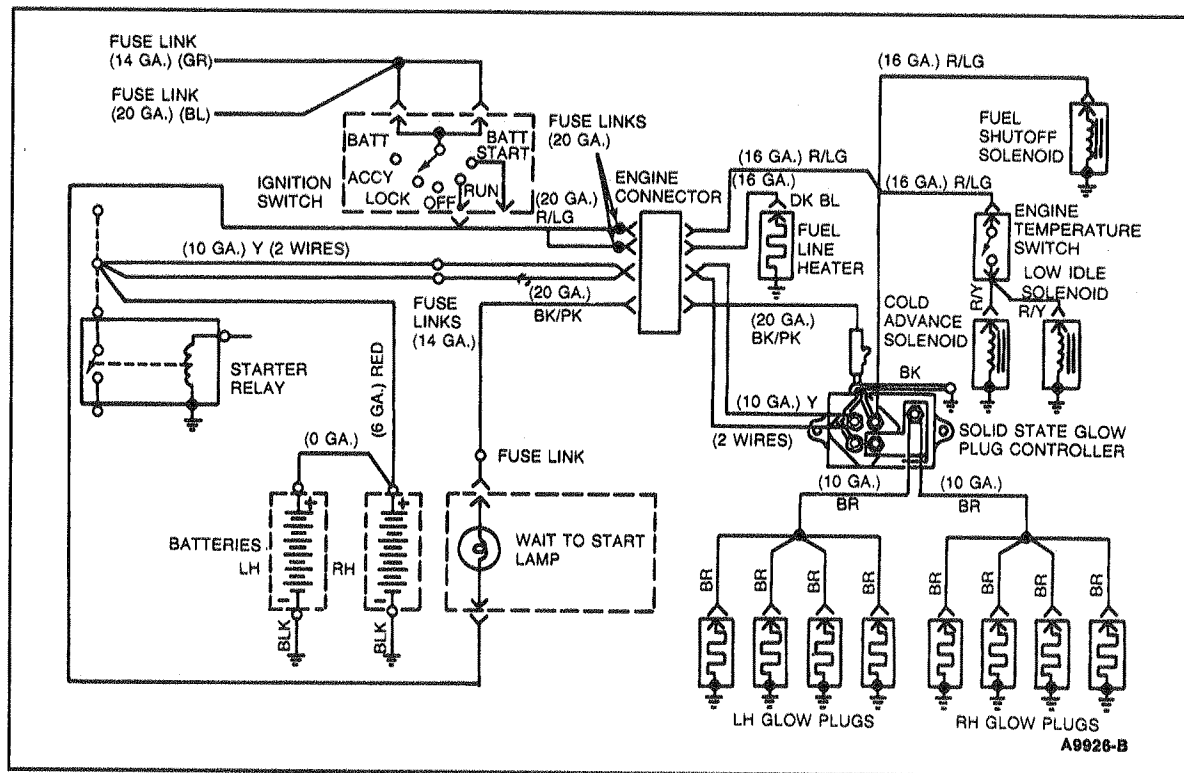


Figure 19 Wiring Schematic

## Fuel System Description

Figure 20 shows a schematic of the fuel supply and return lines. The lift pump draws the fuel through the water/fuel separator from the supply tank. The fuel is then pumped through the fuel heater, and the fuel filter to the injection pump inlet. The injection pump then distributes the fuel to the injection nozzles.

Fuel is returned to the fuel tank by way of fuel return lines. A line runs off the fuel filter, then connects to the right bank of injection nozzles. This line connects at the rear left of the engine to the fuel return lines from the injection pump and left bank of injection nozzles. Fuel is then returned to the fuel supply tank.

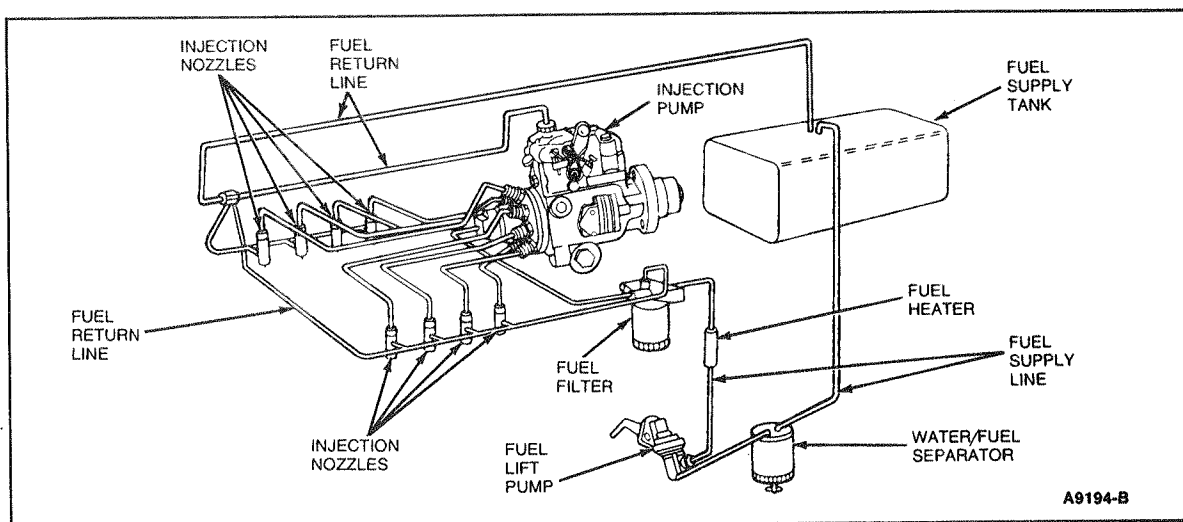


Figure 20 Fuel System Schematic



## Symptom Analysis

Consult the Symptom Analysis Diagnostic Procedures first. These will indicate a service to be performed or provide direction to either the Fast Start Glow Plug System Diagnostic Procedure or the Engine Performance Diagnostic Procedure.

If the GLOW PLUG lamp is suspected of being faulty, go directly to the GLOW PLUG diagnostic procedure before performing the Glow Plug System Diagnostic Procedure.

If the problem is Loss of Power and/or Increased Fuel Consumption, go directly to the Engine Performance Diagnostic Procedure.

### Evaluating "Normal" Diesel Engine Exhaust Smoke

The following is a description of what is "normal" and expected exhaust smoke for a vehicle with a diesel engine. Diesel exhaust smoke can be classified into two categories according to the color of the smoke.

The first category is blue-white smoke.

- Blue-white smoke may be observed at engine start-up whether the engine is up to operating temperatures or not. This start-up smoke will be observed at all ambient temperatures and should last no longer than a minute after the vehicle is driven.
- When ambient temperature is below 10°C (50°F), blue-white smoke can return after the engine warm-up due to extended idling. This is due to the combustion chambers cooling down during periods of extended idling time.

Heavy blue-white smoke will also occur when the engine is operated at wide-open throttle (accelerator pedal to the floor) with the transmission in NEUTRAL or with a lightly loaded vehicle in any transmission gear setting. The smoke is a normal characteristic for a diesel engine with a light min.-max. governor spring in the fuel injection pump. This results in the following characteristics due to the engine operating above its rated speed (3300 rpm) in a no-load or lightly loaded condition:

- Heavy blue-white smoke.
- Fuel injection pump governor hunting resulting in high speed engine rpm surging.
- Engine sputtering or misfiring.

The conditions can be eliminated by not operating the engine above its maximum full load rated speed of 3300 rpm.

NOTE: Chassis fuel system air leaks may also cause continuous heavy blue-white smoke.

The second category of diesel exhaust smoke is black smoke. Black smoke occurs whenever the engine is working hard. The engine works hard when it is going up a steep grade, pulling a trailer, carrying a heavy load, or during acceleration. More black smoke will be observed when operating the vehicle at higher altitudes. If black smoke is observed while the engine is idling (at low altitude) or under normal driving conditions, the problem should be diagnosed as soon as possible.

## Engine Cranks But Will Not Start (Cold)

TEST STEP		RESULT	ACTION TO TAKE
<b>A0</b>	STARTING PROCEDURE		
<p><b>NOTE:</b> If the ignition key is left in the ON position for an extended period of time or the engine is not started within the two minute cycling time, the glow plug system must be reset by turning the ignition key to OFF position.</p> <ul style="list-style-type: none"> <li>• Check and follow correct starting procedure on vehicle visor.</li> </ul>		<p>OK ► RETURN vehicle to customer.</p> <p>OK/NO ► GO to <b>A1</b>.</p>	
<b>A1</b>	GLOW PLUG MODULE RELAY		
<ul style="list-style-type: none"> <li>• Open hood.</li> <li>• Listen for glow plug module relay click when ignition switch is turned to ON position.</li> </ul>		<p>OK ► GO to <b>A2</b>.</p> <p>OK/NO ► GO to Glow Plug System Diagnostic Procedure.</p>	
<b>A2</b>	FUEL FLOW CHECK		
<ul style="list-style-type: none"> <li>• Loosen one injection nozzle line nut (1/2 to one turn) while cranking engine.</li> </ul>		<p>Fuel discharges ► GO to Glow Plug System Diagnostic Procedure.</p> <p>Fuel does not discharge ► GO to <b>A3</b>.</p>	
<b>A3</b>	ENERGIZE TO RUN SOLENOID (ETR)		
<ul style="list-style-type: none"> <li>• Check voltage at ETR solenoid (terminal located at front of injection pump) while cranking engine. Voltage must be at least 9 volts.</li> <li>• Check solenoid terminal for dirt/corrosion and loose/broken electrical connection.</li> </ul>		<p>OK ► GO to <b>A4</b>.</p> <p>OK/NO ► REFER to Shop Manual, Section 31-01. REPEAT Test Step <b>A3</b>.</p>	
<b>A4</b>	CHECK COLD IDLE SPEED/ADVANCE		
<ul style="list-style-type: none"> <li>• Check voltage at cold advance solenoid (terminal located at left rear of injection pump) while cranking engine. Voltage must be at least 9 volts.</li> <li>• If no voltage is present, verify switching function of temperature sensing switch located behind thermostat housing.</li> </ul>		<p>OK ► GO to Engine Performance Diagnostic Procedure.</p> <p>OK/NO ► REFER to Shop Manual, Section 31-01. REPEAT Test Step <b>A4</b>.</p>	

## Engine Cranks But Will Not Start (Normal Operating Temperature)

TEST STEP		RESULT	ACTION TO TAKE
<b>B0</b>	STARTING PROCEDURE		
<ul style="list-style-type: none"> <li>Check and follow correct starting procedure on vehicle visor.</li> </ul>		(OK) ► (OK) ►	RETURN vehicle to customer. GO to <b>B1</b> .
<b>B1</b>	FUEL FLOW CHECK		
<ul style="list-style-type: none"> <li>Loosen one injection nozzle line nut (1/2 to one turn) while cranking engine.</li> </ul>		Fuel discharges ► Fuel does not discharge ►	GO to Engine Performance Diagnostic Procedure. GO to <b>B2</b> .
<b>B2</b>	ENERGIZE-TO-RUN SOLENOID (ETR)		
<ul style="list-style-type: none"> <li>With ignition switch in the ON position, check voltage at ETR solenoid (terminal at front of injection pump). Voltage must be at least 9 volts.</li> <li>Check solenoid terminal for dirt/corrosion and loose/broken electrical connection.</li> </ul>		(OK) ► (OK) ►	GO to Engine Performance Diagnostic Procedure. REFER to Shop Manual, Section 31-01. REPEAT Test Step <b>B2</b> .

## Engine Quits, Stalls or Stumbles

TEST STEP		RESULT	ACTION TO TAKE
<b>C0</b>	<b>IDLE SPEED</b>		
<ul style="list-style-type: none"> <li>Perform Test Step <b>EPC.10</b> in the Engine Performance Diagnostic Procedure.</li> </ul>		(OK) ► (X) ►	GO to <b>C1</b> .  ADJUST idle speed as described in this Section, under Adjustments.
<b>C1</b>	<b>ENERGIZE-TO-RUN SOLENOID (ETR)</b>		
<ul style="list-style-type: none"> <li>Check ETR solenoid (terminal located at left front of injection pump) for dirt/corrosion and loose/broken electrical connection. While cranking, voltage must be at least 9 volts.</li> </ul>		(OK) ► (X) ►	GO to <b>C2</b> or <b>C3</b> as required.  CLEAN, SERVICE or REPLACE terminal connection. REFER to Shop Manual, Section 31-01. REPEAT Test Step <b>C1</b> .
<b>C2</b>	<b>COLD ADVANCE SYSTEM (COLD ENGINE)</b>		
<ul style="list-style-type: none"> <li>Check voltage at cold advance solenoid (terminal located at left rear of injection pump) while cranking engine. Voltage must be at least 9 volts.</li> <li>If no voltage is present, verify switching function of temperature sensing switch located behind thermostat housing.</li> </ul>		(OK) ► (X) ►	GO to Engine Performance Diagnostic Procedure.  REFER to Shop Manual, Section 31-01. REPEAT Test Step <b>C2</b> .
<b>C3</b>	<b>COLD ADVANCE SYSTEM (HOT ENGINE)</b>		
<ul style="list-style-type: none"> <li>Check for voltage at cold advance solenoid (terminal located at left rear of injection pump) while cranking engine. No voltage should be present.</li> </ul>		(OK) ► (X) ►	GO to Engine Performance Diagnostic Procedure.  REPLACE temperature sensing switch. REPEAT Test Step <b>C3</b> .

## Engine Misses

TEST STEP		RESULT	ACTION TO TAKE
<b>D0</b>	<b>DETERMINE WHEN MISS OCCURS</b>		
<ul style="list-style-type: none"> <li>Engine will miss when cold if one or more glow plugs are not heating.</li> </ul>		Engine misses only when cold	REFER to Glow Plug System Diagnostic Procedure.
		Engine misses at normal operating temperature	GO to <b>D1</b> .
<b>D1</b>	<b>ISOLATE MISS</b>		
<ul style="list-style-type: none"> <li>Loosen each injection nozzle line nut (one at a time) while running engine. Refer to Injection Nozzle Testing in this Section.</li> </ul>		Miss not isolated to specific cylinder	GO to Engine Performance Diagnostic Procedure.
		Miss isolated to specific cylinder(s)	GO to <b>D2</b> .
<b>D2</b>	<b>CHECK NOZZLE FUEL DELIVERY</b>		
<ul style="list-style-type: none"> <li>Check injection nozzle fuel line(s) for kinks or restrictions as described in Shop Manual, Section 22-08.</li> <li>Perform injection nozzle test as described under Injection Nozzle Testing in this Section.</li> </ul>		Nozzle(s) and lines OK	GO to <b>D3</b> .
		Nozzle(s) and/or lines Not OK	REPLACE defective line(s) as described in Shop Manual, Section 22-08. REPLACE nozzle(s) as described under Injection Nozzle Testing in this Section.
<b>D3</b>	<b>CYLINDER COMPRESSION CHECK</b>		
<ul style="list-style-type: none"> <li>Perform cylinder compression test as described in Shop Manual, Section 22-08.</li> </ul>		OK	GO to Engine Performance Diagnostic Procedure.
		<del>OK</del>	GO to <b>D4</b> .
<b>D4</b>	<b>CHECK CRANKCASE PRESSURE</b>		
<ul style="list-style-type: none"> <li>Perform Engine Performance Diagnostic Procedure Test Step <b>EPC.12</b>.</li> </ul>		OK	SERVICE or REPLACE valve train as described in Shop Manual, Section 22-08.
		<del>OK</del>	OVERHAUL power cylinder as described in Shop Manual, Section 22-08.

## Engine Knocks

TEST STEP		RESULT	ACTION TO TAKE
<b>E0</b>	<b>BELT DRIVEN ACCESSORIES</b>		
<ul style="list-style-type: none"> <li>Check engine front drive components for proper operation.</li> </ul>		(OK) ► (OK) ►	GO to <b>E1</b> .  SERVICE or REPLACE as necessary. REFER to specific accessory Shop Manual Section.
<b>E1</b>	<b>ENGINE COOLANT TEMPERATURE</b>		
<ul style="list-style-type: none"> <li>Verify engine is not overheating.</li> </ul>		(OK) ► (OK) ►	GO to <b>E2</b> .  REFER to Shop Manual, Section 27-02.
<b>E2</b>	<b>ISOLATE ENGINE KNOCK</b>		
<ul style="list-style-type: none"> <li>Loosen each injection nozzle line nut (one at a time) while running engine. Refer to Injection Nozzle Testing.</li> </ul>		Engine knock not isolated to specific cylinder ►  Engine knock isolated to specific cylinder(s) ►	GO to Engine Performance Diagnostic Procedure.  GO to <b>E3</b> .
<b>E3</b>	<b>CHECK NOZZLE FUEL DELIVERY</b>		
<ul style="list-style-type: none"> <li>Check injection nozzle fuel line(s) for kinks or restrictions as described in Shop Manual Section 22-08.</li> <li>Perform injection nozzle test as described under Injection Nozzle Testing.</li> </ul>		Nozzle(s) and lines OK ►  Nozzle(s) and/or lines not OK ►	GO to Engine Performance Diagnostic Procedure.  REPLACE defective line(s) as described in Shop Manual, Section 22-08. REPLACE nozzle(s) as described under Injection Nozzle Testing.

## Low Oil Pressure With Proper Oil Level









TEST STEP		RESULT	ACTION TO TAKE
<b>F0</b>	OIL PRESSURE TRANSDUCER		
<ul style="list-style-type: none"> <li>• Verify accuracy of oil pressure transducer. Use Adapter 5633 with Pressure Test Kit 014-00702 or equivalent. Refer to Pressure Test Kit hookup illustration in this Section.</li> </ul>		(OK) ► (X) ►	GO to <b>F1</b> .  REPLACE transducer. REPEAT Test Step <b>F0</b> .
<b>F1</b>	CHANGE ENGINE OIL AND FILTER		
<ul style="list-style-type: none"> <li>• Change engine oil and filter and run engine until normal operating temperature is reached. Check oil pressure reading.</li> </ul>		(OK) ► (X) ►	RETURN vehicle to customer.  SERVICE or REPLACE lubrication system components as necessary. (REFER to Shop Manual, Section 22-08.)

## Blue/White Smoke (Engine At Normal Operating Temperature)

TEST STEP		RESULT	ACTION TO TAKE
<b>G0</b>	ENGINE TEMPERATURE		
<b>NOTE: Refer to Symptom Analysis.</b> <ul style="list-style-type: none"> <li>Verify that engine stabilizes in normal operating range.</li> </ul>		(OK) ► GO to <b>G2</b> . (X) ► GO to <b>G1</b> .	
<b>G1</b>	THERMOSTAT OPERATION		
<ul style="list-style-type: none"> <li>Remove thermostat. (Refer to Shop Manual, Section 22-08.)</li> <li>Test thermostat for proper operation. (Refer to Shop Manual, Section 22-08.)</li> </ul>		(OK) ► REPLACE thermostat housing with integral air bleed check valve. REPEAT Test Step <b>G0</b> . (X) ► REPLACE thermostat. (REFER to Shop Manual, Section 22-08). REPEAT Test Step <b>G0</b> .	
<b>G2</b>	EXCESSIVE OIL LEVEL		
<ul style="list-style-type: none"> <li>Check engine oil level indicator for excessive oil fill.</li> </ul>		(OK) ► GO to <b>G3</b> . (X) ► DRAIN excess oil from oil pan. If problem still exists, GO to <b>G3</b> .	
<b>G3</b>	FUEL RETURN		
<ul style="list-style-type: none"> <li>Perform fuel return pressure test as described in Test Step <b>EPC.5</b> of the Engine Performance Diagnostic Procedure.</li> </ul>		(OK) ► PERFORM entire Engine Performance Diagnostic Procedure. (X) ► SERVICE or REPLACE fuel return line(s) as necessary. (Refer to Shop Manual, Section 24-50.) REPEAT Step <b>G3</b> .	



# Excessive Black Smoke

TEST STEP		RESULT	ACTION TO TAKE
<b>H0</b>	VERIFY SMOKE LEVEL		
<p><b>NOTE: Refer to Symptom Analysis</b></p> <ul style="list-style-type: none"> <li>Verify under what conditions black smoke occurs.</li> </ul>		<p>Light load and/or low altitude</p> <p>Under heavy load</p>	<p>GO to <b>H1</b> .</p> <p><b>NOTE: For warranty claim approval, Engine Performance Chart must be filled out for the following steps: EPC.2; EPC.6; EPC.11; EPC.13</b></p> <p>Normal when going up steep grades, pulling a trailer, maximum load, maximum acceleration or at high altitudes.</p>
<b>H1</b>	EXHAUST SYSTEM CONDITION		
<ul style="list-style-type: none"> <li>Complete Test Step <b>EPC.2</b> of Engine Performance Diagnostic Procedure, and record problem description and results on Engine Performance Chart.</li> </ul>		<p> </p> <p> </p>	<p>GO to <b>H2</b> .</p> <p>SERVICE or REPLACE exhaust system as necessary. (REFER to Shop Manual, Section 26-01.) If problem still exists, GO to <b>H2</b> .</p>
<b>H2</b>	CHECK AIR CLEANER RESTRICTION		
<ul style="list-style-type: none"> <li>Complete Test Step <b>EPC.6</b> of Engine Performance Diagnostic Procedure and record results on Engine Performance Chart.</li> </ul>		<p> </p> <p> </p>	<p>GO to <b>H3</b> .</p> <p>REPLACE air filter element and/or SERVICE system. REPEAT Test Step <b>H2</b> .</p>

## Excessive Black Smoke

TEST STEP		RESULT	ACTION TO TAKE
<b>H3</b>	<b>INJECTION PUMP TIMING</b>		
<ul style="list-style-type: none"> <li>Complete Test Step <b>EPC.10</b> of Engine Performance Diagnostic Procedure and record results on Engine Performance Chart.</li> </ul>		(OK) ► (OK) ►	GO to <b>H4</b> .  ADJUST timing. (REFER to Adjustments in this Section.) If problem still exists, GO to <b>H4</b> .
<b>H4</b>	<b>INJECTION NOZZLES</b>		
<ul style="list-style-type: none"> <li>Complete Test Step <b>EPC.11</b> of Engine Performance Diagnostic Procedure and record results on Engine Performance Chart.</li> </ul>		(OK) ► (OK) ►	REPLACE injection pump as described in Shop Manual, Section 22-08.  REPLACE damaged injection nozzle fuel inlet lines (REFER to Shop Manual, Section 22-08). REPLACE nozzles as described in this Section, and Shop Manual, Section 22-08. If problem still exists, REPLACE injection pump as described in Shop Manual, Section 22-08.

## Solid-State Glow Plug System Diagnostic Procedure

Perform the Glow Plug System Basic Diagnostic Test (hereafter referred to as Basic Test) first. If the vehicle passes the Basic Test without running any Pinpoint Tests, the Glow Plug system is OK and the vehicle's problem exists somewhere else other than the Glow Plug System. However, if a step of the Basic Test fails, run only the Pinpoint Test specified by the failed step.

Refer to Figure 21 for test lamp connections and Glow Plug System wiring harness test points referred to in the Basic Test and the Pinpoint Tests. Perform only those services specified by the Pinpoint Tests.

Operation of the Glow Plug System is completely automatic. If, after completing a specific Pinpoint Test it is determined that a component must be replaced, the glow plugs should be disconnected until system has been re-checked by repeating the Basic Test to make sure the Glow Plug System works properly.

A Fast Start Glow Plug System Troubleshooting Chart is available for use by technicians. The technician can use it as a check list while performing tests and diagnostic procedures.

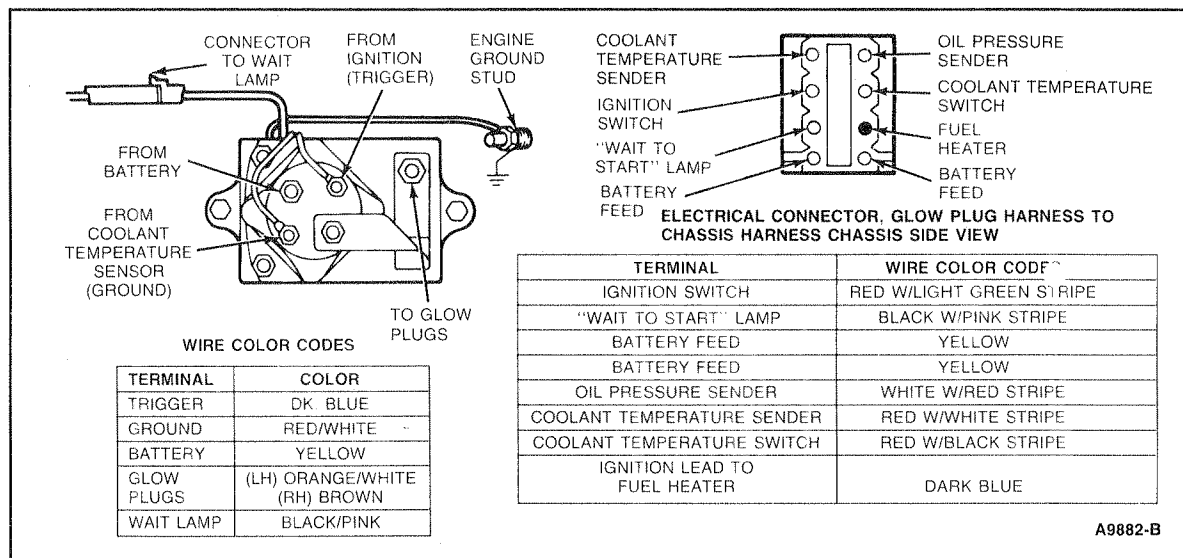


Figure 21 Glow Plug System Diagnostic Test Points

## Glow Plug Pinpoint Testing

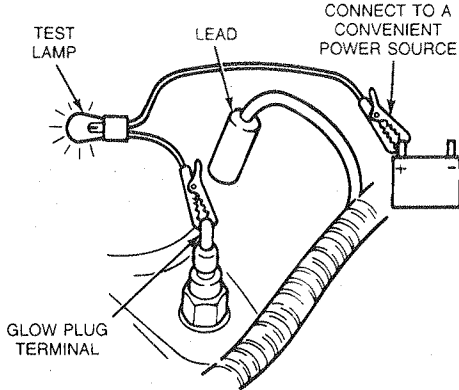
The following is a series of Pinpoint Tests that can be used to diagnose the glow plug system.

**CAUTION:** Never bypass the timed pulse function of the glow plug system. A constant 12 volt current to the glow plugs will cause them to overheat and fail within seconds, possibly resulting in severe engine damage.

## Glow Plug Testing

### Pinpoint Test

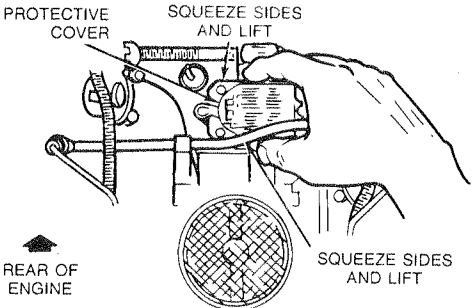
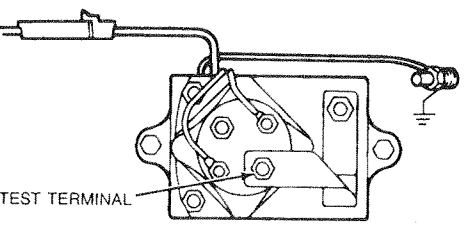
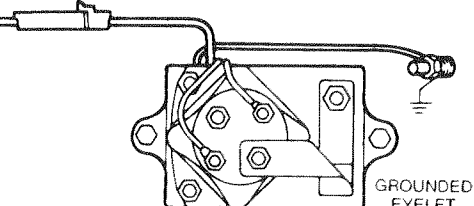
**A**

TEST STEP		RESULT	ACTION TO TAKE
A1	CHECK GLOW PLUGS		
<ul style="list-style-type: none"><li>Ignition switch in OFF position and leads removed from glow plugs.</li><li>Check continuity between glow plug terminal and a power source with glow plugs installed in engine.</li></ul> <div><p>A9970-B</p></div>		<div><div>OK</div><div>➤</div>GO to <b>A2</b> .</div> <div><div><del>OK</del></div><div>➤</div>REPLACE plug(s). GO to <b>A2</b> .</div>	

# Glow Plug Testing

## Pinpoint Test

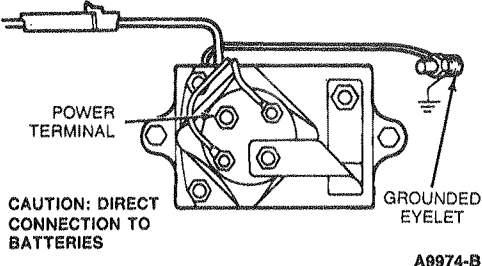
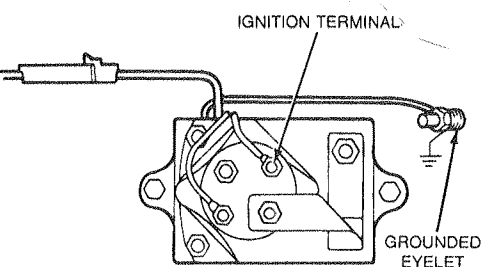
A

TEST STEP	RESULT	ACTION TO TAKE
<p><b>A2</b>   CHECK HARNESS</p> <ul style="list-style-type: none"> <li>Ignition switch in OFF position and leads removed from glow plugs.</li> <li>Squeeze sides of protective cover and remove.</li> <li>Check continuity between each glow plug lead and test terminal of control unit.</li> </ul>  <p>A9971-B</p>  <p>A9972-B</p>	<p>OK at all leads</p> <p>Not OK at any or all leads</p>	<p>GO to <b>A3</b>.</p> <p>SERVICE or REPLACE harness. GO to <b>A3</b>.</p>
<p><b>A3</b>   CHECK CONTROL UNIT</p> <ul style="list-style-type: none"> <li>Ignition switch in OFF position.</li> <li>Contact ohmmeter to ground wire terminal eyelet and to ground post on each battery.</li> </ul>  <p>A9973-B</p>	<p>Less than 1 ohm</p> <p>More than 1 ohm</p>	<p>GO to <b>A4</b>.</p> <p>CLEAN or SERVICE ground connection. REPEAT check. GO to <b>A4</b>.</p>

# Glow Plug Testing

## Pinpoint Test

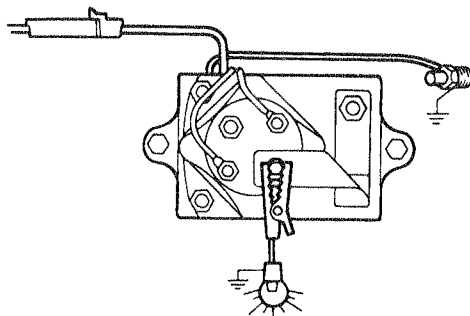
### A

TEST STEP	RESULT	ACTION TO TAKE
<p><b>A4</b> CHECK SUPPLY VOLTAGE</p> <ul style="list-style-type: none"> <li>Ignition switch in OFF position.</li> <li>Connect voltmeter to control unit power terminal and ground.</li> </ul>  <p>CAUTION: DIRECT CONNECTION TO BATTERIES</p> <p>A9974-B</p>	<p>More than 10 volts</p> <p>Less than 10 volts</p>	<p>GO to <b>A5</b>.</p> <p>SERVICE wiring or RECHARGE battery. GO to <b>A5</b>.</p>
<p><b>A5</b> CHECK VOLTAGE FROM IGNITION SWITCH</p> <ul style="list-style-type: none"> <li>Check voltmeter to Ignition Terminal on control unit and ground.</li> <li>Turn ignition switch to ON position and all accessories off.</li> </ul>  <p>A9975-B</p>	<p>More than 8 volts</p> <p>Less than 8 volts</p>	<p>GO to <b>A6</b>.</p> <p>CHECK fusible link, SERVICE wiring or RECHARGE battery. GO to <b>A6</b>.</p>

# Glow Plug Testing

## Pinpoint Test

### A

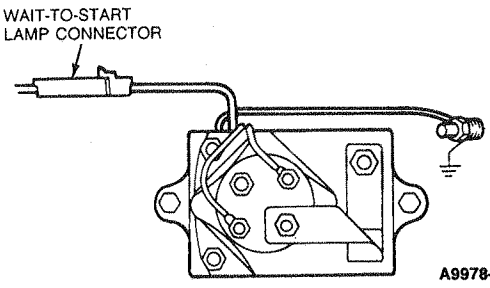
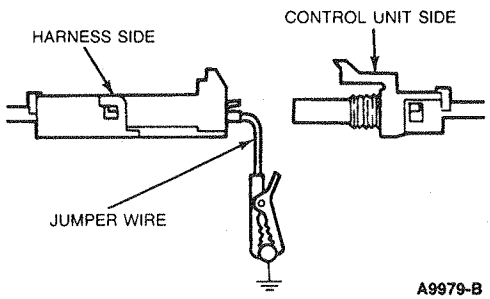
TEST STEP		RESULT	ACTION TO TAKE																					
A6	FUNCTIONAL TEST																							
<ul style="list-style-type: none"><li>• With ignition switch in OFF position connect 12 volt test light to test terminal on control unit.</li><li>• Position test light so it can be viewed from driver's position.</li><li>• Turn ignition switch to ON position and monitor system operation.</li><li>• Compare test light times to Test Light Chart.</li></ul> <div><p>A9976-B</p></div> <p><b>TEST LIGHT CHART</b></p> <p><b>NOTE:</b> Total Test Light "ON" Time includes time from the beginning of the initial "ON" cycle" to the end of the last "ON-OFF cycle" measured in seconds.</p> <table><tr><th>Control* Unit Temp. °F</th><th>"Wait-to-Start" Lamp "ON" Time (Sec.)</th><th>Test Light Total Time (Sec.)</th></tr><tr><td>- 20°C</td><td>7-15</td><td>35-70</td></tr><tr><td>0°F</td><td>7-12</td><td>25-60</td></tr><tr><td>35°F</td><td>5-12</td><td>15-35</td></tr><tr><td>70°F</td><td>3-5</td><td>7-15</td></tr><tr><td>105°F</td><td>1-3</td><td>3-5</td></tr><tr><td>140°F</td><td>1 or Less</td><td>1-3</td></tr></table> <p>*Temperature of Control Unit, NOT ambient temperature</p> <p><b>NOTE:</b> The "Wait-to-Start" Lamp and/or Test Light may not illuminate if engine temperature is at or near normal operating temperature.</p>		Control* Unit Temp. °F	"Wait-to-Start" Lamp "ON" Time (Sec.)	Test Light Total Time (Sec.)	- 20°C	7-15	35-70	0°F	7-12	25-60	35°F	5-12	15-35	70°F	3-5	7-15	105°F	1-3	3-5	140°F	1 or Less	1-3	<p>Test light times within specifications</p> <p>Test light times out of specifications</p>	<p>System function is correct.</p> <p>DISCONNECT power at both batteries. REPLACE control unit. REPEAT test.</p>
Control* Unit Temp. °F	"Wait-to-Start" Lamp "ON" Time (Sec.)	Test Light Total Time (Sec.)																						
- 20°C	7-15	35-70																						
0°F	7-12	25-60																						
35°F	5-12	15-35																						
70°F	3-5	7-15																						
105°F	1-3	3-5																						
140°F	1 or Less	1-3																						



# **“Wait-To-Start” Lamp Testing**

## **Pinpoint Test**

**B**

TEST STEP		RESULT	ACTION TO TAKE
<b>B1</b>	"WAIT-TO-START" LAMP STAYS ON		
<ul style="list-style-type: none"> <li>Disconnect the "wait-to-start" lamp connector at control unit.</li> <li>Turn ignition switch to ON position.</li> </ul>  <p>A9978-B</p>		<p>Lamp On</p> <p>Lamp Off</p>	<p>SERVICE wiring to lamp.</p> <p>DISCONNECT power at both batteries. REPLACE control unit.</p>
<b>B2</b>	"WAIT-TO-START" LAMP DOES NOT GO ON		
<ul style="list-style-type: none"> <li>Disconnect the "wait-to-start" lamp connector at control unit.</li> <li>Connect jumper wire from harness side to ground.</li> <li>Turn ignition switch to ON position.</li> </ul>  <p>A9979-B</p>		<p>Lamp On</p> <p>Lamp Off</p>	<p>GO to Hard Starting Checks.</p> <p>REPLACE bulb or SERVICE wiring.</p>

## Glow Plug Failure Analysis

The following are examples of glow plug failure. Each example gives a different clue to glow plug failure analysis.

- There is no visible damage, but glow plug is electrically open (Fig. 22). This indicates an internal heating element failure.
- Glow plug tip that is missing can be caused by incorrect timing or poor fuel quality (Fig. 23).
- Multiple, distorted glow plugs are usually caused by electrical overheating (Fig. 24). A complete evaluation of the glow plug control system should be made.

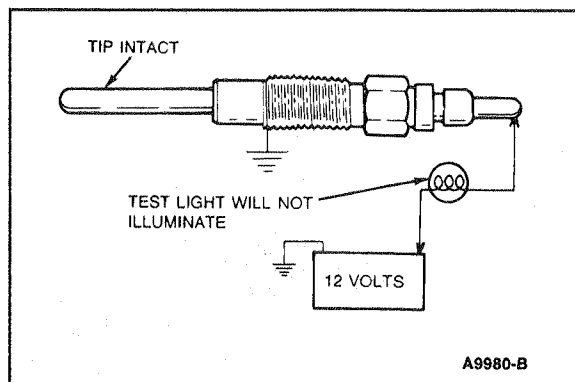


Figure 22 Electrically Open

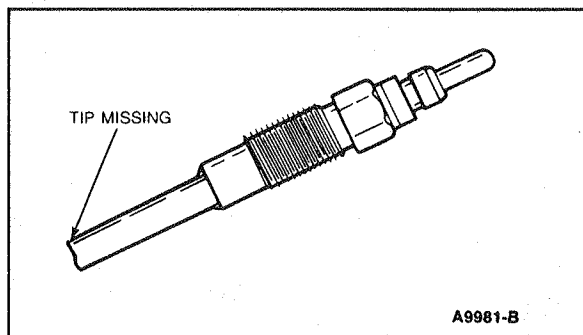


Figure 23 Missing Tips

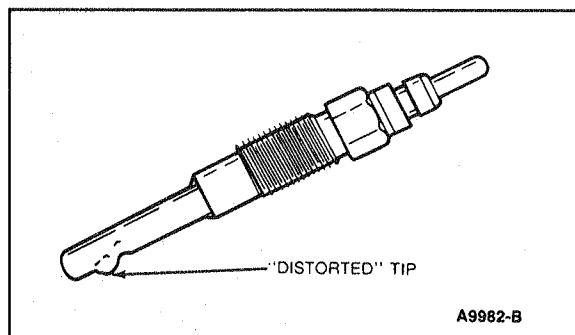


Figure 24 Distorted Tips

## Engine Performance Diagnostic Procedure

The Engine Performance Diagnostic Procedure begins with those items which are the high frequency, easy-to-diagnose problems, and progresses to the low frequency, hard to diagnose problems. Use of this procedure will promote rapid as well as accurate diagnosis.

The Engine Performance Diagnostic Procedure follows, step by step, the Engine Performance Chart. Each test step is labeled to coincide with the Engine Performance Chart steps.

NOTE: Under no circumstances should the fuel injection pump be replaced until the Engine Performance Chart has been completely filled out. The only exceptions to this is in the case of Excessive Black Smoke (Symptom Analysis Diagnostic Procedure H) and external leaks. In these cases, only those steps specified need to be filled out. Warranty claims for the fuel injection pump or injectors will not be accepted unless the Engine Performance Chart is filled out as specified and all tamperproof seals are intact.

NOTE: Service each problem detected before going on to the next step. If service corrects the original complaint, it will not be necessary to proceed to the next test step. However, if the complaint is not corrected, continue with the test until the complaint is corrected.

The following explanations refer to the basic test steps of the Engine Performance Diagnostic Procedure and Chart. They give a brief description of how these problems can affect performance, and an understanding of the importance of each test step.

1. **External Leakage:** Fuel leakage can be a reason for diesel fuel smell or low economy. Oil leakage can be a reason for high oil consumption. An air intake system leak can shorten engine life, especially under dusty conditions. Coolant leakage can result in engine overheating.
2. **Exhaust System Condition:** Kinks or dents in the exhaust system can cause high exhaust back pressure. This can result in loss of power and high smoke levels.
3. **Fuel Quality:** Diesel engines need clean fuel, free of air, dirt and water. Any contamination may result in poor engine performance.
4. **Fuel System Condition:** Kinks in the fuel lines or hoses can block or restrict fuel flow and loose connections can leak air into the fuel. This can result in loss of power and high smoke levels.

NOTE: The fuel supply system must deliver the proper quantity of fuel with no pressure loss or air leaks in chassis fuel system.

5. **Fuel System Return Line Restriction:** A restriction in the fuel return line will raise the pressure in the injection pump causing an adverse effect on injection pump timing, resulting in excessive smoke levels or loss of power.
6. **Air Cleaner Restriction:** A dirty air cleaner may result in low power, excessive smoke and poor fuel economy.
7. **Transfer Pump Pressure:** This is the pressure which is available to charge the injection plunger. Low pressure will result in low power, and excessive smoke levels.
8. **Accelerator Linkage:** If the accelerator linkage is improperly adjusted, the engine cannot reach full rated rpm and top speed and pulling power will be reduced, or curb idle speed will be excessive.

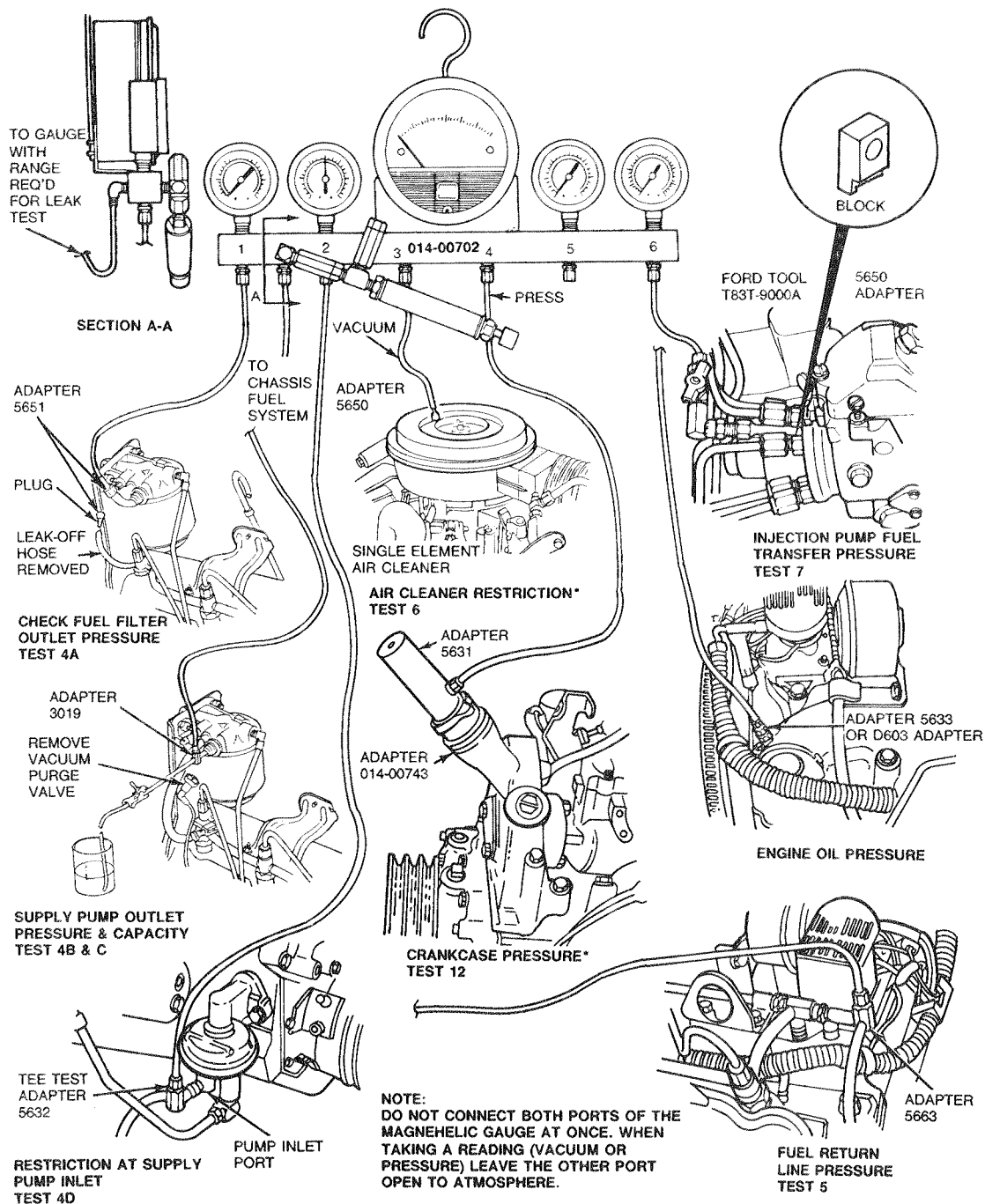
## Engine Performance Diagnostic Procedure

9. Engine Idle Speed: Low engine idle speed may cause stalling or rough running.
10. Injection Timing: Incorrect timing can be responsible for poor fuel economy, rough idling or hard starting and excessive smoke.
11. Injection Nozzle Test: The injection nozzles must be removed from the engine for this test. This is a functional test of injection nozzle performance. Incorrect nozzle performance will cause misses, poor fuel economy, loss of power and excessive smoke.
12. Crankcase Pressure: This test measures the amount of crankcase blow-by. More blow-by will create high pressures. Crankcase pressure readings, plus rate of oil consumption, should be used to evaluate engine mechanical condition.

To perform the Engine Performance Diagnostic Procedure it will be necessary to connect the Pressure Test Kit, Rotunda 014-00702 or equivalent, to the various components as shown in Figure 25.

**NOTE:** If the problem is hard starting, follow the procedures for troubleshooting the glow plug system prior to troubleshooting the fuel system.

# Engine Performance Diagnostic Procedure














A11466-A

Figure 25 Pressure Test Kit Hookup — Rotunda Model 014-00702

## Engine Performance

TEST STEP	RESULT	ACTION TO TAKE
<b>EPC.1</b> CHECK FOR EXTERNAL LEAKAGE  • With engine running, visually check for leakage of: 1. Fuel 2. Engine oil 3. Proper installation and dirt past air cleaner 4. Coolant	No leakage  Leakage detected	GO to <b>EPC.2</b> .  SERVICE or REPLACE faulty component(s). If problem still exists, GO to <b>EPC.2</b> .
<b>EPC.2</b> CHECK EXHAUST SYSTEM  • Visually check exhaust system for dents or kinks which could cause restriction.	OK  OK	GO to <b>EPC.3A</b> .  SERVICE or REPLACE exhaust system as required. (Refer to Shop Manual, Section 26-01) GO to <b>EPC.3A</b> .
<b>EPC.3A</b> CHECK FOR AIR IN FUEL  • Install a length of clear PVC hose in place of rubber hose between fuel filter outlet and injection nozzle return system. • Run engine for two minutes. Then, run engine at 3,000 rpm and check for bubbles in clear hose. <b>NOTE: Correct direction of fuel flow is from fuel filter toward fuel return system. Fuel flow in opposite direction is indication of restriction in fuel supply system.</b> <b>NOTE: On vehicles with dual fuel tanks, check with tank selector switch in each position for a minimum of two minutes.</b>	Fuel flow direction OK, bubbles less than 1.58mm (1/16 inch) diameter.  Fuel flow direction OK, bubbles 1.58mm (1/16 inch) diameter or larger  Fuel flow direction not OK	GO to <b>EPC.3B</b> .  GO to Fuel System Air Leak Diagnosis in this Section. REPEAT Test Step <b>EPC.3A</b> when air leaks are eliminated.  GO to <b>EPC.5A</b> . REPEAT <b>EPC.3A</b> , when fuel flow direction is corrected.
<b>EPC.3B</b> CHECK FUEL FOR CONTAMINATION  • Obtain a fuel sample and visually examine fuel in a clear container (including bottom of container), for particles, clouding, or liquid contamination, such as water.	OK  OK	Go to <b>EPC.3C</b> .  REPLACE fuel filter. CLEAN and/or SERVICE fuel system as required. Refer to Shop Manual, Section 24-50. GO to <b>EPC.3C</b> .

## Engine Performance

TEST STEP	RESULT 	ACTION TO TAKE
<b>EPC.3C</b> CHECK FUEL FOR CETANE VALUE <ul style="list-style-type: none"> <li>• Check cetane value of fuel sample taken in Test Step <b>EPC.3B</b> using cetane tester included with Dynamic Timing Meter, 078-00200 or equivalent.</li> <li>• Cetane value should be minimum of 40.</li> </ul>	More than 40   Less than 40 	GO to <b>EPC.4A</b> .  Complete Tests EPC.4, 5, 6 and 8. INFORM owner* to change fuel source. GO to <b>EPC.4A</b> .  <b>*NOTE: Do not replace fuel injection pump because of low cetane problem.</b>
<b>EPC.4A</b> FUEL FILTER OUTLET PRESSURE <ul style="list-style-type: none"> <li>• Remove air bleed orifice hose from fuel filter fitting.</li> <li>• Install adapter 5651 with Pressure Test Kit 014-00702, or equivalent. (Refer to Pressure Test Kit Hook-Up Illustration.)</li> <li>• Run engine at 3,300 rpm, with no load.</li> <li>• Record pressure reading. On dual tank vehicles, check both tanks.</li> <li>• Pressure should be minimum of 1 psi at 3,300 rpm.</li> </ul>	    	GO to <b>EPC.4C</b> .  GO to <b>EPC.4B</b> .
<b>EPC.4B</b> FUEL SUPPLY PUMP OUTLET PRESSURE <ul style="list-style-type: none"> <li>• Remove vacuum purge valve from fuel filter adapter.</li> <li>• Install adapter 3019 and Pressure Test Kit 014-00702, or equivalent. (Refer to Pressure Test Kit Hook-Up Illustration.)</li> </ul> <b>NOTE: Make sure clamp is closed on sampling hose.</b> <ul style="list-style-type: none"> <li>• Leave adapter from Test Step <b>EPC.4A</b> installed and cap end.</li> <li>• Run engine at idle, no load.</li> <li>• Record pressure reading. On dual tank vehicles, check both tanks.</li> <li>• Pressure should be minimum of 2 psi at idle.</li> </ul>	    	REPLACE fuel filter and REPEAT Test Step <b>EPC.4A</b> .  GO to <b>EPC.4C</b> .

## Engine Performance

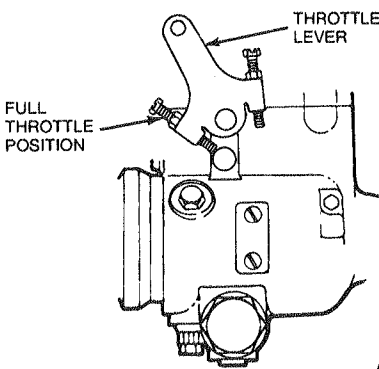
TEST STEP		RESULT	ACTION TO TAKE
<b>EPC.4C</b>	<b>FUEL PUMP CAPACITY</b>		
<ul style="list-style-type: none"> <li>Position end of sample hose on adapter 3019 in a clear, one quart, graduated fuel container.</li> <li>Follow procedures for Test Step <b>EPC.4B</b> and open clamp on sample hose, allowing fuel to flow into fuel container, for 30 seconds.</li> <li>Record volume. On dual tank vehicles, check both tanks.</li> <li>Volume should be a minimum of one pint in 30 seconds at idle, no load.</li> </ul>		Pressure and volume OK ►  Pressure OK Volume Not OK ►  Volume OK Pressure Not OK ►  Pressure and Volume Not OK ►	GO to <b>EPC.5</b> .  GO to <b>EPC.4D</b> .  REPLACE fuel supply pump and REPEAT Test Step <b>EPC.4A</b> .  GO to <b>EPC.4D</b> .
<b>EPC.4D</b>	<b>CHECK RESTRICTION AT FUEL SUPPLY PUMP</b>		
<ul style="list-style-type: none"> <li>Connect fuel return line removed in Test Step <b>EPC.4A</b> .</li> <li>Install adapter 5632 and Pressure Test Kit to fuel supply pump inlet.</li> <li>With rear wheels off the ground and transmission in NEUTRAL or PARK, run engine at 3,300 rpm.</li> <li>Record vacuum reading. On dual tank vehicles, check both tanks.</li> <li>Vacuum should be less than 6 in-Hg.</li> </ul>		(OK) ►  (OK) ►	GO to <b>EPC.4A</b> .  SERVICE or REPLACE restricted chassis fuel line(s). Refer to Shop Manual, Section 24-50. REPEAT Test Step <b>EPC.4A</b> .
<b>EPC.5</b>	<b>CHECK FUEL RETURN PRESSURE</b>		
<ul style="list-style-type: none"> <li>Remove fuel return line at junction fitting at left rear of engine.</li> <li>Install adapter 5663 and Pressure Test Kit 014-00702, or equivalent.</li> <li>Run engine at 3,300 rpm, no load, transmission in NEUTRAL or PARK.</li> <li>Record pressure reading. On dual tank vehicles, check both tanks.</li> <li>Maximum pressure should not exceed 2 psi at 3,300 rpm.</li> </ul> <p><b>NOTE:</b> Fuel return hose removed in <b>EPC.4A</b> must be connected for this test.</p>		(OK) ►  (OK) ►	GO to <b>EPC.6</b> .  SERVICE or REPLACE fuel return line(s) as necessary. REFER to Shop Manual, Section 24-50. REPEAT Test Step <b>EPC.5</b> .



## Engine Performance

TEST STEP		RESULT	ACTION TO TAKE
<b>EPC.6</b>	<b>CHECK AIR INTAKE RESTRICTION</b>		
<ul style="list-style-type: none"> <li>Remove cap on air cleaner test port and install adapter 5650 and Pressure Test Kit 014-00702, or equivalent.</li> <li>Run engine at 3,300 rpm, no load.</li> <li>Record restriction reading.</li> <li>Restriction should not exceed 25 inches of H<sub>2</sub>O.</li> </ul>		More than 2 inches H <sub>2</sub> O but less than 25 inches H <sub>2</sub> O	REMOVE adapter. INSTALL cap on air cleaner port. GO to <b>EPC.7</b> .
		25 inches H <sub>2</sub> O or more	REPLACE filter element and CHECK intake system for blockage. REPEAT Test Step <b>EPC.6</b> .
		Less than 2 inches H <sub>2</sub> O	CORRECT restriction in fitting on air cleaner test port. REPEAT Test Step <b>EPC.6</b> .
<b>EPC.7</b>	<b>CHECK INJECTION PUMP TRANSFER PRESSURE</b>		
<ul style="list-style-type: none"> <li>Remove screw from transfer pump pressure port cover.</li> <li>Install Tool T83T-9000-A or equivalent through cover and O-ring and into port. Install adapter 5650 and Pressure Test Kit 014-00702 or equivalent.</li> <li>Fittings must be tight and not leaking.</li> <li>Run engine at 3,300 rpm, no load, with transmission in NEUTRAL.</li> <li>Record pressure reading.</li> <li>Pressure should be 90 to 110 PSI.</li> </ul>		<div>OK</div>	GO to <b>EPC.8</b> .
		<div>OK</div>	REPLACE injection pump. (REFER to Shop Manual, Section 22-08.) If performance problem still exists after installing new pump, CHECK and ADJUST injection pump dynamic timing. (REFER to adjustments in this Section.) If performance problem still exists after adjusting timing, GO to <b>EPC.8</b> .

## Engine Performance

TEST STEP	RESULT	ACTION TO TAKE
<p><b>EPC.8</b> ACCELERATOR LINKAGE ADJUSTMENT</p> <ul style="list-style-type: none"> <li>• With engine off, check that throttle lever contacts injection pump stop at full accelerator pedal depression. Full throttle screw is not adjustable. Tampering may cause injection pump damage.</li> </ul>  <p style="text-align: right;">A11545-A</p>	<p>Ⓞ ▶</p> <p>Ⓞ/ ▶</p>	<p>GO to <b>EPC.9</b> .</p> <p>ADJUST or SERVICE vehicle throttle linkage as necessary. (Refer to Shop Manual, Section 24-60.) GO to <b>EPC.9</b> .</p>
<p><b>EPC.9</b> CHECK ENGINE IDLE SPEED</p> <ul style="list-style-type: none"> <li>• Check engine idle speed as described under Adjustments in this Section.</li> <li>• Bring engine up to normal operating temperature.</li> <li>• Idle speed is measured with manual transmission in NEUTRAL and automatic transmission in DRIVE.</li> <li>• Idle speed is shown on Vehicle Emission Control Information (VECI) decal.</li> </ul>	<p>Ⓞ ▶</p> <p>Ⓞ/ ▶</p>	<p>GO to <b>EPC.10</b> .</p> <p>ADJUST as necessary. GO to <b>EPC.10</b> .</p>

## Engine Performance

TEST STEP		RESULT	ACTION TO TAKE
<b>EPC.10</b>	<b>DYNAMIC INJECTION PUMP TIMING**</b>		
<ul style="list-style-type: none"> <li>• Install Dynamic Timing Meter and check injection pump timing. (Refer to Dynamic Injection Pump Timing.) Compare value to specification and correct for fuel cetane value and altitude. Measure at 1,400 rpm, no load.</li> </ul> <p><b>**Engine must be at normal operating temperature.</b></p> <ul style="list-style-type: none"> <li>• Record dynamic timing in Box A, Step 10 of the 7.3L Engine Performance Chart.</li> <li>• Apply +12 volt battery power to the injection pump timing advance solenoid and record dynamic timing in Box B, Step 10 of the 6.9L Engine Performance Chart.</li> </ul>		<p>B is more than 1° advanced from A, and A is within <math>\pm 2^\circ</math>. ▶</p> <p>B is more than 1° advanced from A, and A is not within <math>\pm 2^\circ</math>. ▶</p> <p>B is less than 1° advanced from A. ▶</p>	<p>GO to <b>EPC.11</b> .</p> <p>ADJUST timing. (REFER to Shop Manual, Section 22-08 and adjustments.) If performance problem still exists after adjusting timing, GO to <b>EPC.11</b> .</p> <p>REPLACE fuel injection pump and REPEAT <b>EPC.10</b> .</p>
<b>EPC.11</b>	<b>CHECK INJECTION NOZZLES AND INLET LINES</b>		
<p><b>NOTE: Perform this check only if engine has an obvious combustion knock or miss.</b></p> <ul style="list-style-type: none"> <li>• Check injection nozzle inlet lines for kinks or restriction. (Refer to Shop Manual, Section 22-08.)</li> <li>• Test injection nozzles as described in this Section.</li> </ul> <p><b>NOTE: Warranty claims for injection nozzles will not be accepted unless the completed Engine Performance chart is submitted with the returned parts.</b></p>		<p>Lines and nozzles OK ▶</p> <p>Lines and/or nozzles not OK ▶</p>	<p>GO To <b>EPC.12</b> .</p> <p>REPLACE damaged injection nozzle fuel inlet lines. (REFER to Shop Manual, Section 22-08.)</p> <p>REPLACE injection nozzles as described in this Section and Shop Manual, Section 22-08.</p> <p>If performance problem still exists, GO to <b>EPC.12</b> .</p>

## Engine Performance

TEST STEP		RESULT	ACTION TO TAKE
EPC.12	CRANKCASE PRESSURE TEST		
<ul style="list-style-type: none"> <li>Remove crankcase depression regulator valve and securely plug opening to prevent blow-by. (Refer to Shop Manual, Section 22-08.)</li> <li>Remove oil filler cap and install adapter 5631, and Pressure Test Kit 014-00702, or equivalent. (Refer to Pressure Test Kit Hook-Up illustration.)</li> <li>Ensure dipstick is seated in dipstick tube.</li> <li>Run engine at 3,300 rpm no load, with transmission in NEUTRAL.</li> <li>Record pressure reading.</li> <li>Pressure should not exceed 6 inches H<sub>2</sub>O at 3,300 rpm.</li> </ul> <p><b>NOTE:</b> Warranty claims for injection pumps will not be accepted unless all tamper-resistant seals are intact and the completed Engine Performance Chart is submitted with the returned parts.</p>		OK ►	REPLACE injection pump, and CHECK and ADJUST timing. (REFER to Shop Manual, Section 22-08 and Adjustments in this Section.)
		<del>OK</del> ►	Problem is internal to the engine. (REFER to Shop Manual, Section 22-08.)

## Fuel System Air Leak Diagnosis

Hard starting, white smoke in the normal engine operating range, poor idle quality, or lack of power under load can be caused by several conditions. One of these conditions is air leaks in the fuel supply system. This procedure is provided to assist in the diagnosis of 7.3L diesel engine fuel system air leaks.

To perform the Fuel System Air Leak Diagnosis, the following adapters (Fig. 26 and 27) need to be assembled as shown from locally available materials.

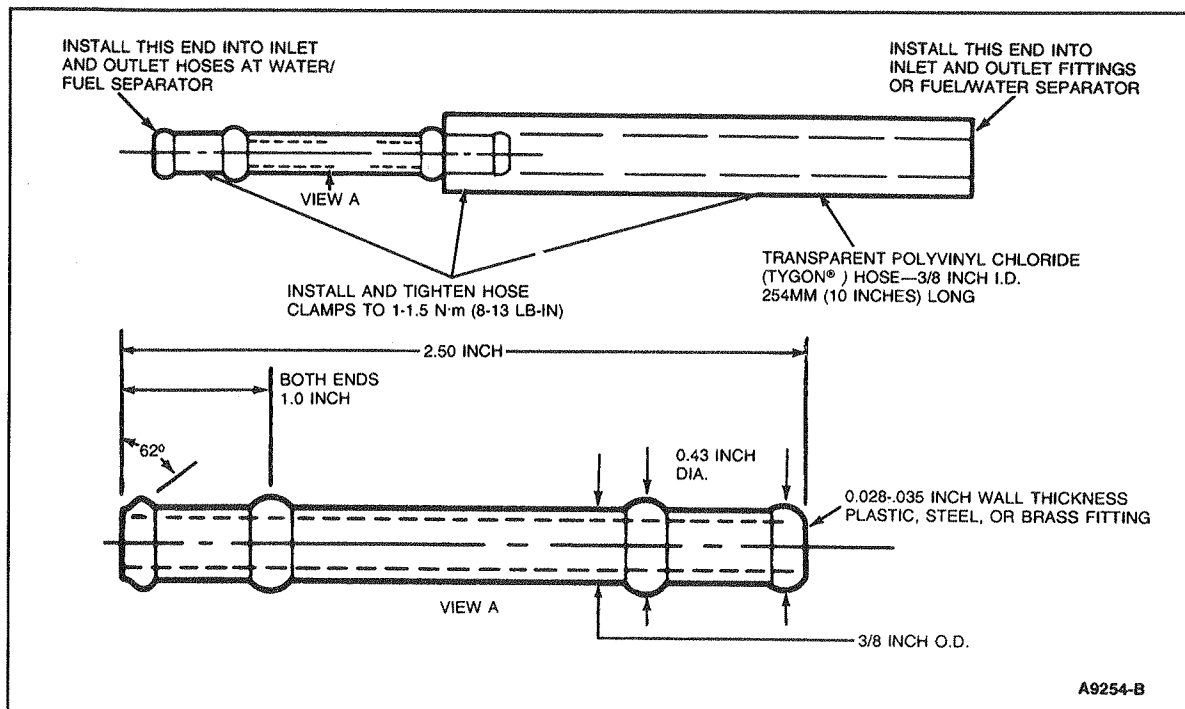


Figure 26 Water/Fuel Separator Adapter, Two Required

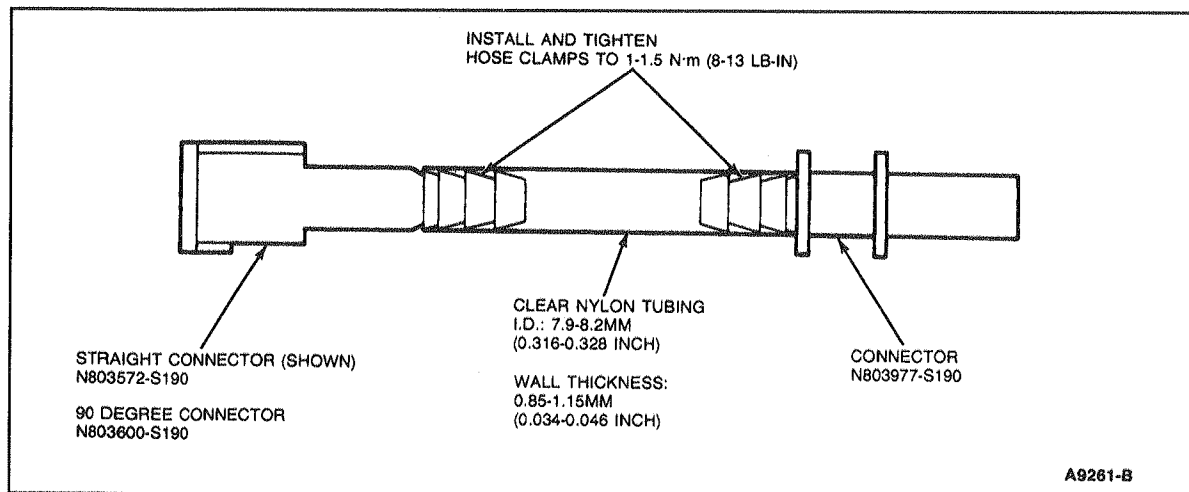
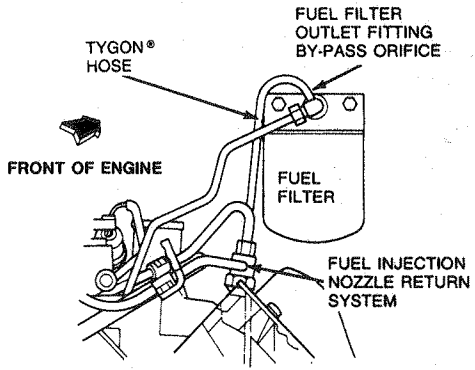


Figure 27 Selector Valve/Fuel Tank Push Connect Adapter — F-Series (Two Required)










## Fuel System Air Leak Diagnosis

TEST STEP	RESULT	ACTION TO TAKE
<p><b>J1</b>   CHECK HOSE CONNECTIONS</p> <p><b>NOTE:</b> Prior to starting the diagnostic procedure, verify that the fuel tank(s) contain at least a half tank of fuel — the fuel level compensates for the range of vehicle attitudes that may uncover the fuel sender pickup hose or sender by-pass in the fuel tank when the fuel level is low. Visually inspect the fuel system for obvious problems such as kinked hoses, damaged lines or push-connect fittings.</p> <ul style="list-style-type: none"> <li>• Verify that the push-connect fitting clip is in place.</li> <li>• Verify that the push-connect fittings are properly installed on the tube end by pulling the fitting away from the tube (axially along the tube). The fitting should not pull off from the tube end. If the fitting does pull away, push the fitting axially back on to the tube until a definite click is heard.</li> <li>• Pull and push the fitting one more time to verify proper installation.</li> </ul> <div data-bbox="247 1316 630 1635"> <p style="text-align: center;">A11546-A</p> </div>	<div style="display: flex; flex-direction: column; align-items: center;"> <div style="margin-bottom: 20px;"> <span style="border: 1px solid black; border-radius: 50%; padding: 2px 5px;">OK</span> <span style="font-size: 2em; margin: 0 5px;">▶</span> </div> <div> <span style="border: 1px solid black; border-radius: 50%; padding: 2px 5px;"><del>OK</del></span> <span style="font-size: 2em; margin: 0 5px;">▶</span> </div> </div>	<p>GO to <b>J2</b> .</p> <p><b>SERVICE</b> or <b>REPLACE</b> fuel lines, clamps or push-connect fittings. REFER to Light Truck Shop Manual, Volume B, Section 25-50, for push-connect fitting service.</p>

## Fuel System Air Leak Diagnosis

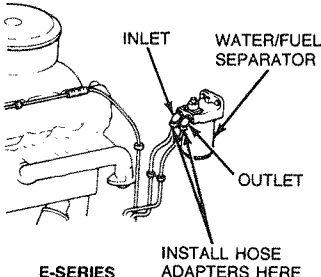
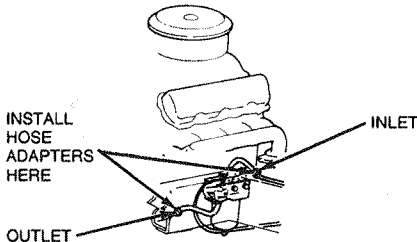
TEST STEP		RESULT	ACTION TO TAKE
<b>J2</b>	CHECK SYSTEM FOR BUBBLES OR FOAM		
<ul style="list-style-type: none"> <li>Remove the rubber fuel return bypass hose which connects the fuel filter outlet fitting bypass orifice to the return lines at the fuel injection nozzles.</li> </ul> <p><b>CAUTION:</b> Care should be taken when removing or installing hose to the plastic fitting at the fuel injection nozzle return lines. Lubricate hose with diesel fuel to ease installation.</p> <ul style="list-style-type: none"> <li>Install a 305mm (12-inch) length of 3/16" I.D. clear polyvinyl chloride, TYGON® hose (to view fuel flow) in place of the above rubber fuel hose, then tighten hose clamps to 1-1.5 N•m (8-13 lb-in).</li> <li>Run engine at approximately 3,000 rpm for two to three minutes to clear air from the system, which was induced by the previous operation.</li> <li>Observe fuel hose for air bubbles at 3,000 engine rpm.</li> <li>Any continuous stream of bubbles larger than 1.58mm (1/16 inch) indicates air ingestion. A moving concentration of bubbles of any size, or foam, is unacceptable.</li> </ul> <p><b>NOTE:</b> TYGON® is a registered trademark of Norton Industries Plastics.</p> <div style="text-align: center;">  <p>The diagram illustrates the fuel system components and their connections. It shows the 'FRONT OF ENGINE' on the left, the 'FUEL FILTER' in the center, and the 'FUEL INJECTION NOZZLE RETURN SYSTEM' on the right. A 'TYGON® HOSE' is shown connecting the 'FUEL FILTER OUTLET FITTING BY-PASS ORIFICE' to the return system. Labels include: TYGON® HOSE, FUEL FILTER OUTLET FITTING BY-PASS ORIFICE, FUEL FILTER, FRONT OF ENGINE, and FUEL INJECTION NOZZLE RETURN SYSTEM.</p> </div> <p>F-SERIES SHOWN, E-SERIES FILTER MOUNTED ON LH SIDE OF ENGINE</p>		<p>⊙ ➤ Problem elsewhere in system. REMOVE TYGON® hose and INSTALL original hose. REFER to Symptom Analysis in this Section.</p> <p>⊗ ➤ GO to <b>J3</b>.</p>	

## Fuel System Air Leak Diagnosis

TEST STEP	RESULT 	ACTION TO TAKE
<b>J3</b>   CHECK DIRECTION OF FLOW  <ul style="list-style-type: none"> <li>Observe direction of flow of bubbles. Bubbles should flow from fuel filter outlet fitting to the fuel injection nozzle return system.</li> </ul>	<div>   </div> <div>   </div>	<p>GO to <b>J4</b> for single tank system. GO to <b>J5</b> for dual tank system.</p> <p>Fuel System is restricted. GO to Engine Performance Diagnosis in this Section. PERFORM Steps <b>EPC.4A</b> through <b>EPC.4D</b>.</p>
<b>J4</b>   CHECK HOSE CONNECTIONS  <ul style="list-style-type: none"> <li>Check for damage to hose connections at rubber fuel hose from chassis fuel line to mechanical lift pump and at inlet and outlet hoses at water separator.</li> <li>Tighten hose clamps to 1-1.5 N·m (8-13 lb-in).</li> <li>After tightening hose clamps, run engine for five minutes at 3,000 rpm and check for air bubbles in TYGON® hose.</li> </ul>	<div>   </div> <div>   </div>	<p>REPLACE TYGON® hose with original hose. Problem resolved.</p> <p>GO to <b>J5</b>.</p>

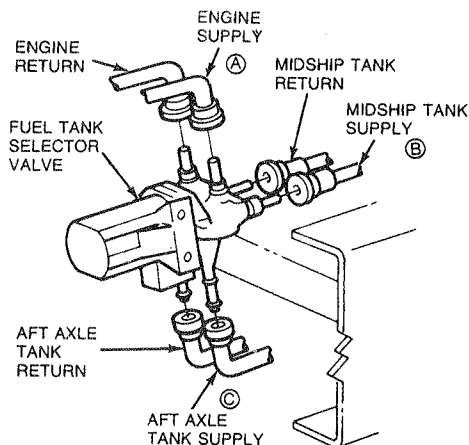


## Fuel System Air Leak Diagnosis

TEST STEP		RESULT	ACTION TO TAKE
<b>J5</b>	<b>CHECK WATER/FUEL SEPARATOR FOR BUBBLES</b>		
<ul style="list-style-type: none"> <li>Disconnect water/fuel separator inlet hose. Install hose adapter and tighten clamps to 1-1.5 N•m (8-13 lb-in).</li> </ul> <p><b>NOTE: Refer to Air Leak Diagnosis — Hose Adapter procedures in this Section.</b></p> <ul style="list-style-type: none"> <li>Disconnect water/fuel separator outlet hose. Install hose adapter and tighten clamps to 1-1.5 N•m (8-13 lb-in).</li> </ul> <p><b>CAUTION: Disconnect hoses and install adapters one at a time to prevent hose mix-up.</b></p> <div style="text-align: center;"> <p><b>F-SERIES</b></p>  <p><b>E-SERIES</b></p>  <p><b>A11548-A</b></p> </div> <ul style="list-style-type: none"> <li>Operate engine at 1,500 rpm for five minutes to develop steady fuel flow. Then, operate engine at 3,000 rpm for an additional two minutes and check for bubbles in hose adapters.</li> </ul>		<p>Air bubbles present in inlet hose, single tank system. ➤</p> <p>Air bubbles present in inlet hose, dual tank system. ➤</p> <p>Air bubbles present in outlet hose only. ➤</p>	<p>SERVICE hoses and connections between water/fuel separator as necessary. REPEAT Test Step <b>J5</b>.</p> <p>GO to <b>J6</b>.</p> <p>CHECK hose adapter at water/fuel separator inlet for air leaks. Operate water/fuel separator drain <b>with engine off</b>. REPEAT Test Step <b>J5</b>. If bubbles persist, REPLACE water/fuel separator. REPEAT Test Step <b>J2</b>.</p>
<b>J6</b>	<b>OPERATE SELECTOR VALVE — DUAL TANKS</b>		
<ul style="list-style-type: none"> <li>Start and run engine.</li> <li>Observe TYGON® hose while switching selector valve between tanks.</li> </ul>		<p>Bubbles present in both tank positions. ➤</p> <p>Bubbles present in only one tank position. ➤</p>	<p>GO to <b>J4</b>.</p> <p>GO to <b>J7</b>.</p>

## Fuel System Air Leak Diagnosis

TEST STEP		RESULT	ACTION TO TAKE
<b>J7</b>	<b>CHECK SELECTOR VALVE CONNECTIONS</b>		
	<ul style="list-style-type: none"> <li>• Check push-connect fittings for tightness as outlined in Test Step <b>J1</b>.</li> <li>• Fittings should be tight.</li> </ul>	<p>OK ► GO to <b>J8</b>.</p> <p>OK/✗ ► SERVICE push-connect fittings, as necessary. REFER to Shop Manual, Section 25-50 for push-connect fitting service.</p>	
<b>J8</b>	<b>BY-PASS SELECTOR VALVE</b>		
	<ul style="list-style-type: none"> <li>• Disconnect push-connect fittings from fuel tank selector valve for affected tank.</li> <li>• Install push-connect fitting adapters between fuel lines and selector valve.</li> <li>• Run engine at 3,000 rpm for two to three minutes to clear any air injected during adapter installation. Run engine an additional one to two minutes and observe transparent fuel lines in adapters.</li> </ul>	<p>Bubbles not present in either adapter ►</p> <p>Bubbles present in both adapters ►</p> <p>Bubbles present in selector valve outlet adapter ►</p>	<p>Air leak is between fuel tank selector valve and water/fuel separator. SERVICE fuel lines and connections as necessary. REPEAT Test Step <b>J2</b>.</p> <p>Air leak is between fuel tank and selector valve. SERVICE fuel lines and connections as necessary. REPEAT Test Step <b>J2</b>.</p> <p>REPLACE fuel tank selector valve. REPEAT Test Step <b>J2</b>.</p>



1. INSTALL ONE ADAPTER AT POINT A
2. INSTALL OTHER ADAPTER AT:  
POINT B FOR MIDSHIP TANK  
POINT C FOR AFT AXLE TANK

A11549-A

## Injection Nozzle Testing

Where ideal conditions of good combustion, specified engine temperature control, and absolutely clean fuel prevail, nozzles require little attention. Nozzle trouble is usually indicated by one or more of the following symptoms:

- Smoky exhaust (black)
- Loss of power
- Misfiring
- Increased fuel consumption
- Combustion Knock
- Engine Overheating

When faulty nozzle operation is suspected on an engine that is misfiring or puffing black smoke, a simple test can be made to determine which cylinder(s) is causing the problem.

- Run the engine at the rpm which makes the problem most pronounced.
- Momentarily loosen the high-pressure fuel inlet line connection on one nozzle assembly one-half to one turn. Then, tighten connection to specification.
- Check each cylinder in the same manner.
- If one nozzle is found where loosening makes no difference in the misfiring, or the puffing black smoke stops, that nozzle should be tested. Test only the suspect nozzle(s).

Remove suspect nozzles as outlined in Shop Manual, Section 22-08. After removing nozzle(s) from the engine, the Injection Nozzle Test should be performed. This test will provide valuable information regarding the condition of the nozzle(s). A clean workbench, clean washing fluid containers, clean tools, and clean hands are all essential to produce satisfactory results.

NOTE: It is advisable to test the nozzles before cleaning them.

Figure 28 shows the Rotunda Injection Nozzle Tester, Model No. 014-00300, used for this test.

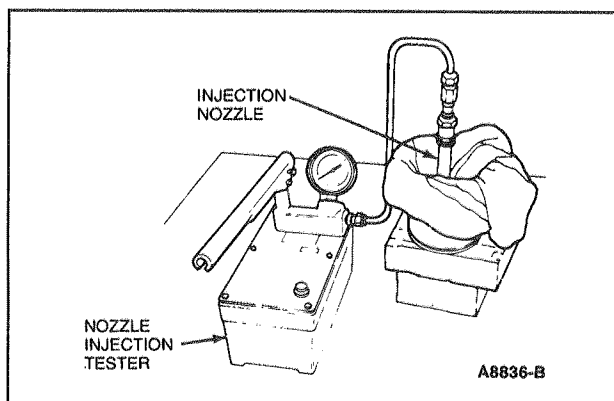


Figure 28 Injection Nozzle Tester

## Injection Nozzle Testing

NOTE: Perform this check only if engine has an obvious combustion knock or miss.

1. Prepare stand for making tests. Fill stand reservoir with clean Calibration Fluid. Open tester valve slightly and operate tester handle to expel air from tester and outlet pipe. Operate tester until solid fluid (without air bubbles) flows from end of outlet pipe. Close tester valve.
2. Connect injection nozzle to test stand. Care should be taken to avoid cross-threading. Tighten connector nut securely with end wrench. Nozzle Adapter which is supplied with tester 014-00300 has RH thread to nozzle assembly and LH thread to tester piping.
3. Bleed air from nozzle. Open stand valve and operate tester handle for 8 to 10 quick strokes to expel (bleed) air from injection nozzle. Fluid should discharge from the spray hole in nozzle tip.

**WARNING: ALWAYS WEAR APPROVED SAFETY GLASSES WHEN OPERATING THE TESTER. VOLATILE LIQUIDS CAN BE EXTREMELY FLAMMABLE WHEN VAPORIZED. AVOID ANY CONDITIONS (SPARKS, OPEN FLAMES, LIT CIGARETTES, ETC.) WHICH MIGHT IGNITE THE FLUID USED DURING THE TEST PROCEDURE. THE ONLY LIQUID APPROVED FOR USE IN THIS TESTER IS SAE CALIBRATION NO. 208629, OR EQUIVALENT CALIBRATION FLUID (SAE J968D OR ISO 4113).**

**WHEN A NOZZLE IS BEING TESTED OR IS IN OPERATION, KEEP HANDS AND OTHER PARTS OF THE BODY AWAY FROM THE NOZZLE. THE LIQUID DISCHARGE LEAVES THE NOZZLE TIP WITH SUFFICIENT FORCE TO PENETRATE THE SKIN AND CAUSE SERIOUS INJURY. THE NOZZLE TIP SHOULD BE ENCLOSED IN A TRANSPARENT RECEPTACLE IF AVAILABLE.**

4. Check nozzle opening pressure. Close pump valve, and operate pump handle in slow even strokes to bring system up to pressure. Record highest pressure reached before nozzle opens. Repeat operation, increasing handle speed if necessary to establish consistent readings. Refer to Fig. 29 for nozzle opening pressures.

NOTE: Disregard tip leakage during this test.

NOTE: Spray pattern testing is not required.

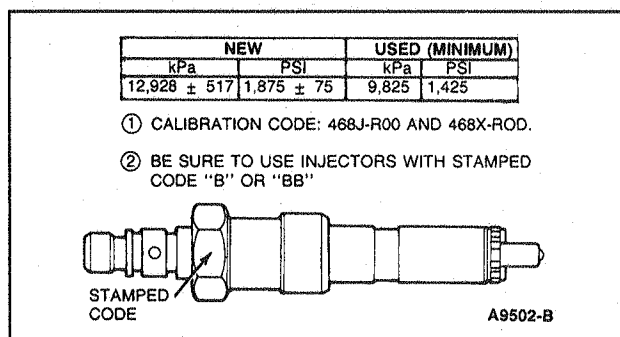


Figure 29 Nozzle Opening Pressure

## Injection Nozzle Testing

5. Check for tip leakage. Blow nozzle tip dry using filtered compressed air. Operate test pump to maintain pressure at about 1378 kPa (200 psi) below the opening pressure obtained in Test 1. Wetting of the nozzle tip is acceptable as long as a drop does not fall, within five seconds (Fig. 30).

NOTE: Make sure that any accumulation at the nozzle tip is **not** due to test fluid leaking down the outside of the nozzle body from the return openings. If questionable, wrap a shop cloth around the nozzle body to prevent fluid leaking down the outside of the nozzle body from reaching the tip.

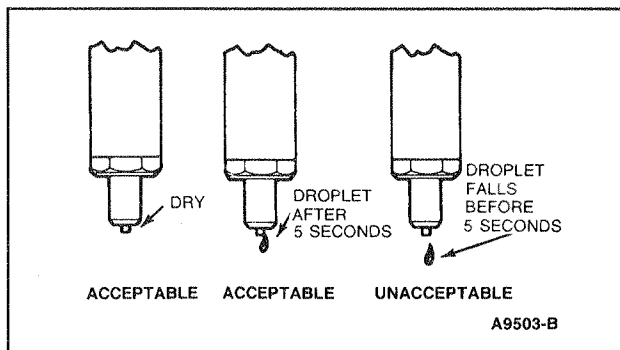


Figure 30 Nozzle Leakage Patterns

6. After testing is completed, make sure to open the pump valve to release the built up pressure prior to removing the nozzle from the tester. When nozzle is removed, cap the nozzle tip and inlet until installed back in engine.

NOTE: If nozzle passes the nozzle opening pressure and tip leakage tests, it is suitable for further service in the engine.

NOTE: Nozzles showing leakage at nozzle tip spray hole or opening pressure below the minimum permissible limit, are damaged or worn and must be replaced, if within warranty coverage. Servicing the nozzle(s) (disassemble, clean and rebuild) instead of replacement to correct nozzle tip leakage or low opening pressure is only permissible beyond the warranty period if so desired.

NOTE: Warranty claims for replacement of the nozzle(s) will not be accepted unless the **completed** Engine Performance (Diagnostic) Chart is submitted with the returned part(s).