FUEL SYSTEM—2.5L DIESEL ENGINE/2.0L GAS ENGINE

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GENERAL INFORMATION

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GENERAL INFORMATION

INTRODUCTION—2.5L DIESEL

Certain components of the fuel system on the 2.5L diesel engine are controlled by the Bosch Engine controller which is a Powertrain Control Module (PCM). Refer to Powertrain Control Module in the Fuel Injection System—2.5L Diesel Engine section of this group for a list of items controlled by the PCM. The Body Control Module (BCM) is mounted to a bracket located inside the vehicle under the dashpanel to the left of the steering column (Fig. 1). The PCM is mounted at the base of the center console in front of the Air Bag Module. (Fig. 2).

The **Fuel System** consists of: the fuel tank, fuel injection pump (engine mounted), fuel filter/water separator, fuel tank module, electrical fuel gauge sending unit, glow plugs, glow plug relay, PCM, and all the electrical components that control the fuel system. It also consists of fuel tubes/lines/hoses and fittings, vacuum hoses, and fuel injector(s).

A **Fuel Return System.** A separate fuel return system is used. This will route excess fuel: from the fuel injectors; through individual injector drain tubes; through the fuel injection pump overflow valve; and back to the fuel tank through a separate fuel line.

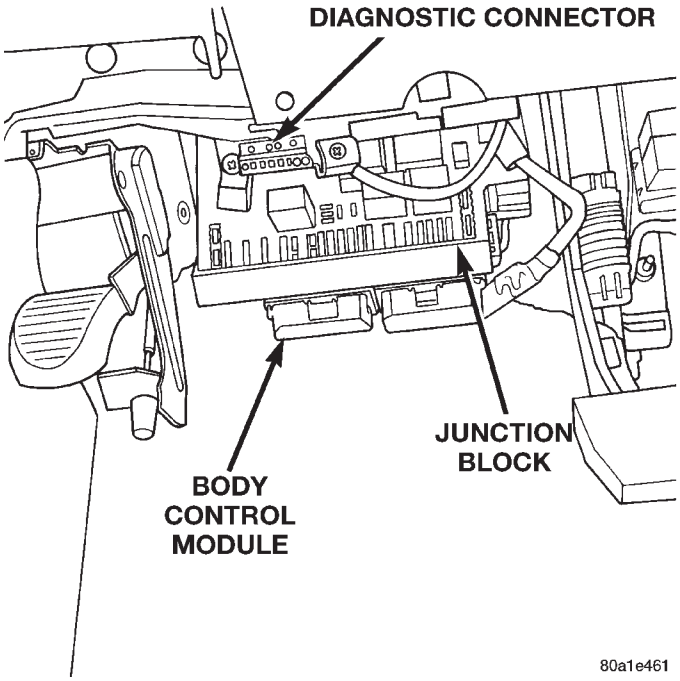

Fig. 1 BCM Location

The **Fuel Tank Assembly** consists of: the fuel tank, two pressure relief/rollover valves, fuel filler tube, fuel tank module containing a fuel gauge sending unit, and a pressure-vacuum filler cap.

GENERAL INFORMATION (Continued)

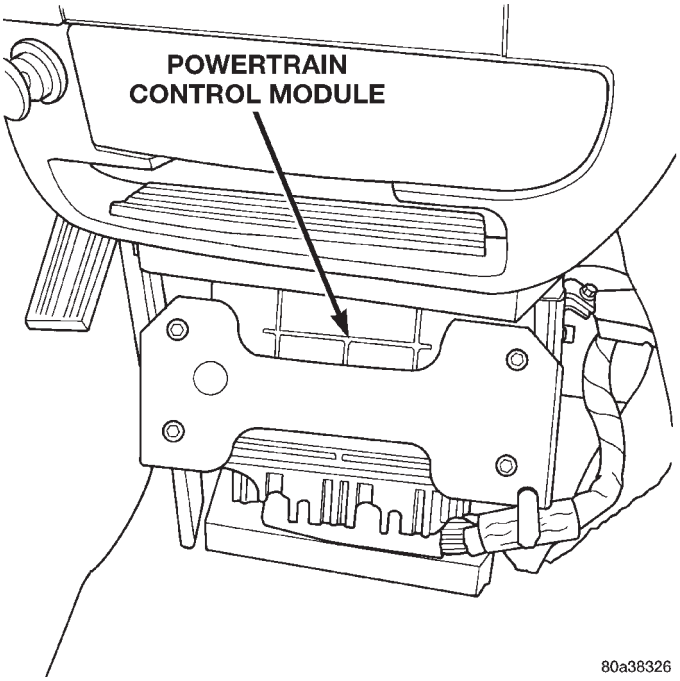

Fig. 2 PCM Location

INTRODUCTION—2.0L ENGINE

Refer to the introduction in group 14 for the 2.4/3.0/3.3/3.8l engines.

FUEL REQUIREMENTS—2.5L DIESEL

Refer to the Lubrication and Maintenance section of this manual for information. Also refer to the Owner Manual.

FUEL REQUIREMENTS—2.0L ENGINE

Your vehicle was designed to meet all emission regulations and provide excellent fuel economy when using high quality unleaded gasoline.

Use high quality unleaded gasoline with a minimum research octane rating of 91.

The vehicle will operate on fuels ranging from unleaded fuel having a minimum research octane of 91 to super unleaded fuel with a minimum research octane of 98.

GASOLINE/OXYGENATE BLENDS

Refer to Gasoline/Oxygenate blends for the 2.4/3.0/3.3/3.8l engines in group 14.

FUEL DELIVERY SYSTEM—2.5L DIESEL ENGINE

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DESCRIPTION AND OPERATION

INTRODUCTION

This Fuel Delivery section will cover components not controlled by the PCM. For components controlled by the PCM, refer to the Fuel Injection System—2.5L Diesel Engine section of this group.

The fuel heater relay, fuel heater and fuel gauge are not operated by the PCM. These components are controlled by the ignition (key) switch. All other fuel system electrical components necessary to operate the engine are controlled or regulated by the PCM.

FUEL SYSTEM PRESSURE WARNING

WARNING: HIGH–PRESSURE FUEL LINES DELIVER DIESEL FUEL UNDER EXTREME PRESSURE FROM THE INJECTION PUMP TO THE FUEL INJECTORS. THIS MAY BE AS HIGH AS 45,000 KPA (6526 PSI). USE EXTREME CAUTION WHEN INSPECTING FOR HIGH–PRESSURE FUEL LEAKS. INSPECT FOR HIGH–PRESSURE FUEL LEAKS WITH A SHEET OF CARDBOARD (Fig. 1). HIGH FUEL INJECTION PRESSURE CAN CAUSE PERSONAL INJURY IF CONTACT IS MADE WITH THE SKIN.

FUEL TANK

The fuel tank and tank mounting used with the diesel powered engine is the same as used with gasoline powered models, although the fuel tank module is different.

The fuel tank contains the fuel tank module and two rollover valves. Two fuel lines are routed to the fuel tank module. One line is used for fuel supply to the fuel filter/water separator. The other is used to return excess fuel back to the fuel tank.

The fuel tank module contains the fuel gauge electrical sending unit. **An electrical fuel pump is not used with the diesel engine.**

DESCRIPTION AND OPERATION (Continued)

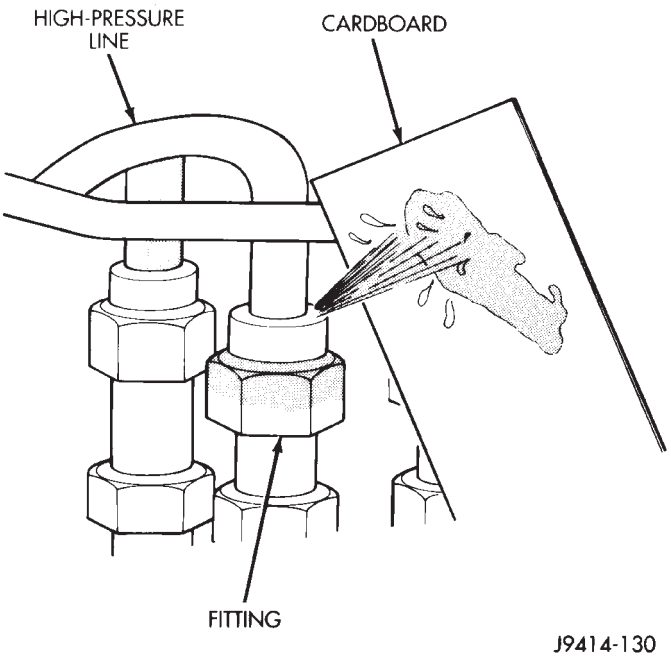


Fig. 1 Typical Fuel Pressure Test at Injector

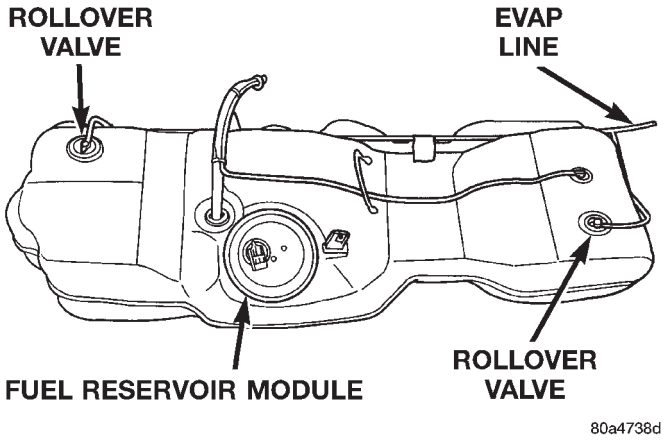


Fig. 2 Fuel Tank

FUEL TANK MODULE

An electric fuel pump is not attached to the fuel tank module for diesel powered engines. Fuel is supplied by the fuel injection pump.

The fuel tank module is installed in the top of the fuel tank (Fig. 2). The fuel tank module contains the following components:

- Fuel reservoir
- A separate in-tank fuel filter
- Electric fuel gauge sending unit
- Fuel supply line connection
- Fuel return line connection

FUEL GAUGE SENDING UNIT

The fuel gauge sending unit is attached to the side of the fuel pump module. The sending unit consists of a float, an arm, and a variable resistor (track). The track is used to send an electrical signal used for fuel gauge operation.

As the fuel level increases, the float and arm move up. This decreases the sending unit resistance, causing the fuel gauge on the instrument panel to read full. As the fuel level decreases, the float and arm move down. This increases the sending unit resistance, causing the fuel gauge on the instrument panel to read empty.

FUEL FILTER/WATER SEPARATOR

The fuel filter/water separator assembly is located in the engine compartment near the strut tower (Fig. 3).

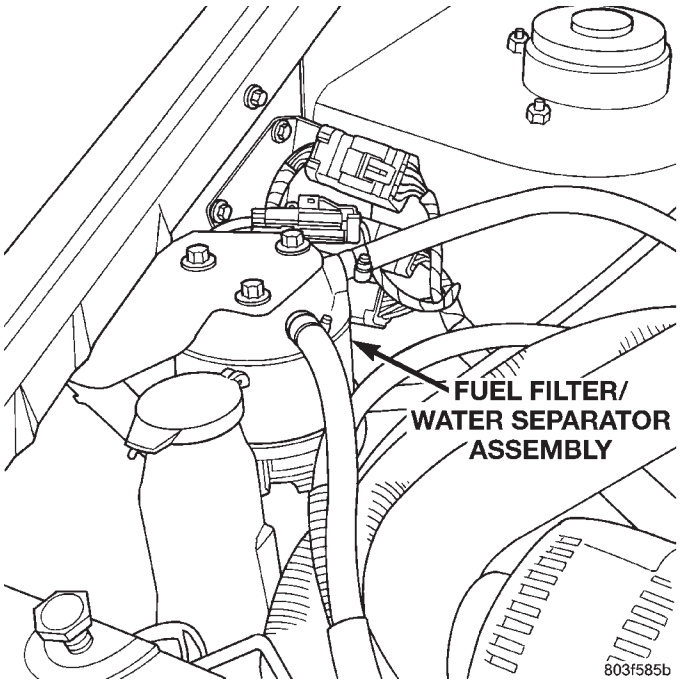


Fig. 3 Fuel Filter/Water Separator Location

The combination fuel filter/water separator protects the fuel injection pump by helping to remove water and contaminants from the fuel. Moisture collects at the bottom of the filter/separator in a plastic bowl.

The fuel filter/water separator assembly contains the fuel filter, fuel heater element, and fuel drain valve.

For information on the fuel heater, refer to Fuel Heater in this group.

Refer to the maintenance schedules in Group 0 in this manual for the recommended fuel filter replacement intervals.

DESCRIPTION AND OPERATION (Continued)

For periodic draining of water from the bowl, refer to Fuel Filter/Water Separator Removal/Installation in this group.

FUEL SHUTDOWN SOLENOID

The fuel shutdown solenoid is controlled and operated by the PCM.

The fuel shutdown (shut-off) solenoid is used to electrically shut off the diesel fuel supply to the high-pressure fuel injection pump. The solenoid is mounted to the rear of the injection pump (Fig. 4).

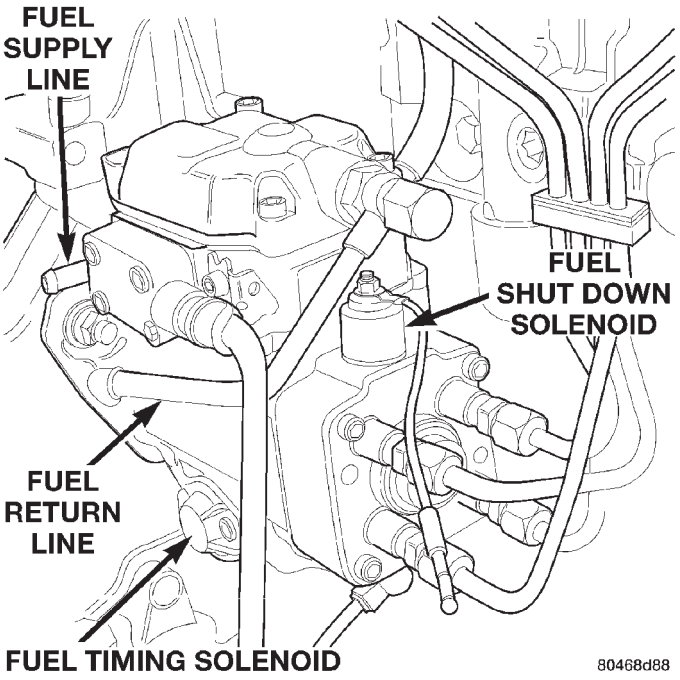


Fig. 4 Fuel Shutdown Solenoid and Overflow Valve Location

The solenoid controls starting and stopping of the engine regardless of the position of the accelerator pedal. When the ignition (key) switch is OFF, the solenoid is shut off and fuel flow is not allowed to the fuel injection pump. When the key is placed in the ON or START positions, fuel supply is allowed at the injection pump.

FUEL INJECTION PUMP

The fuel injection pump is a mechanical distributor–type, Bosch VP36 series (Fig. 5). A gear on the end of the injection pump shaft meshes with the drive gear at the front of engine. The pump is mechanically timed, relative to the position of the cam and crankshaft. The PCM can make adjustments to the timing of the injection pump.

The injection pump contains the fuel shutdown solenoid, fuel temperature sensor, control sleeve sensor, fuel quantity actuator and the fuel timing solenoid (Fig. 5).

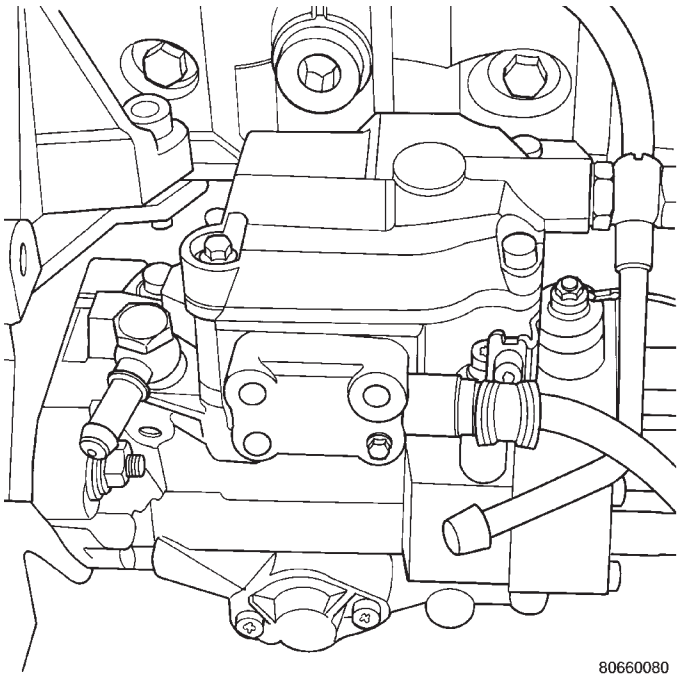


Fig. 5 Fuel Injection Pump

In the electronically controlled injection pump, the pump plunger works the same as the pump plunger in a mechanically controlled injection pump, but the amount of fuel and the time the fuel is injected is controlled by the vehicle's PCM, instead of by a mechanical governor assembly. A solenoid controlled by the PCM is used in place of the mechanical governor assembly, and it moves a control sleeve inside the pump that regulates the amount of fuel being injected. There is no mechanical connection between the accelerator pedal and the electronically controlled injection pump. Instead, a sensor connected to the accelerator pedal sends a signal to the PCM that represents the actual position of the accelerator pedal. The PCM uses this input, along with input from other sensors to move the control sleeve to deliver the appropriate amount of fuel. This system is known as "Drive-By-Wire"

The actual time that the fuel is delivered is very important to the diesel combustion process. The PCM monitors outputs from the engine speed sensor (flywheel position in degrees), and the fuel injector sensor (mechanical movement within the #1 cylinder fuel injector). Outputs from the Accelerator Pedal Position sensor, engine speed sensor (engine rpm) and engine coolant temperature sensor are also used. The PCM will then compare its set values to these outputs to electrically adjust the amount of fuel timing (amount of advance) within the injection pump. This is referred to as "Closed Loop" operation. The PCM monitors fuel timing by comparing its set value to when the injector #1 opens. If the value is greater than a preset value a fault will be set.

DESCRIPTION AND OPERATION (Continued)

Actual electric fuel timing (amount of advance) is accomplished by the fuel timing solenoid mounted to the bottom of the injection pump (Fig. 5). Fuel timing will be adjusted by the PCM, which controls the fuel timing solenoid.

An overflow valve is attached into the fuel return line at the rear of the fuel injection pump (Fig. 4). This valve serves two purposes. One is to ensure that a certain amount of residual pressure is maintained within the pump when the engine is switched off. This will prevent the fuel timing mechanism within the injection pump from returning to its zero position. The other purpose is to allow excess fuel to be returned to the fuel tank through the fuel return line. The pressure values within this valve are preset and can not be adjusted.

The fuel injection pump supplies high–pressure fuel of approximately 45,000 kPa (6526 psi) to each injector in precise metered amounts at the correct time.

For mechanical injection pump timing, refer to Fuel Injection Pump Timing in the Service Procedures section of this group.

FUEL INJECTORS

Fuel drain tubes (Fig. 6) are used to route excess fuel back to the overflow valve (Fig. 4) at the rear of the injection pump. This excess fuel is then returned to the fuel tank through the fuel return line.

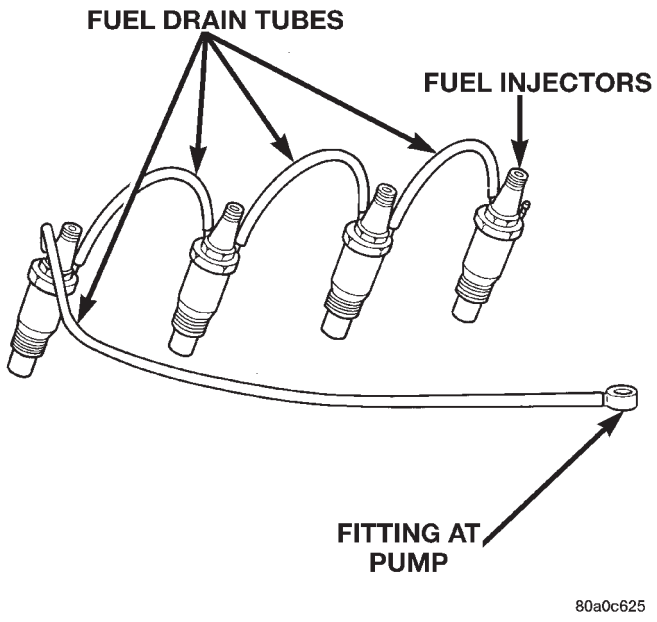


Fig. 6 Fuel Injectors and Drain Tubes

The injectors are connected to the fuel injection pump by the high– pressure fuel lines. A separate injector is used for each of the four cylinders. An injector containing a sensor (Fig. 7) is used on the cylinder number one injector. This injector is called instrumented injector #1 or needle movement sensor. It is used to tell the PCM when the #1 injector's internal spring-loaded valve seat has been forced open by pressurized fuel being delivered to the cylinder, which is at the end of its compression stroke. When the instrumented injector's valve seat is force open, it sends a small voltage spike pulse to the PCM. This tells the PCM that the engine is at TDC on the number one cylinder. It is not used with the other three injectors.

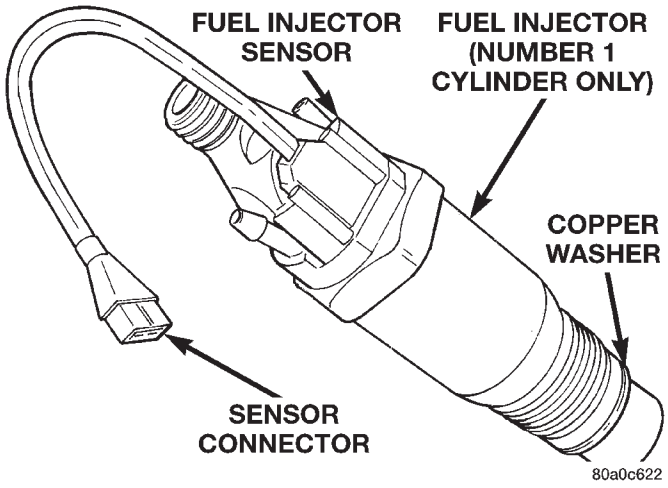


Fig. 7 Fuel Injector Sensor

Fuel enters the injector at the fuel inlet (top of injector) and is routed to the needle valve bore. When fuel pressure rises to approximately 15,000–15,800 kPa (2175–2291 psi), the needle valve spring tension is overcome. The needle valve rises and fuel flows through the spray holes in the nozzle tip into the combustion chamber. The pressure required to lift the needle valve is the injector opening pressure setting. This is referred to as the "pop-off" pressure setting.

Fuel pressure in the injector circuit decreases after injection. The injector needle valve is immediately closed by the needle valve spring and fuel flow into the combustion chamber is stopped. Exhaust gases are prevented from entering the injector nozzle by the needle valve.

A copper washer (gasket) is used at the base of each injector (Fig. 7) to prevent combustion gases from escaping.

Fuel injector firing sequence is 1–3–4–2.

FUEL TUBES/LINES/HOSES AND CLAMPS—LOW-PRESSURE TYPE

Also refer to the proceeding section on Quick–Connect Fittings.

Inspect all hose connections such as clamps, couplings and fittings to make sure they are secure and

DESCRIPTION AND OPERATION (Continued)

leaks are not present. The component should be replaced immediately if there is any evidence of degradation that could result in failure.

Never attempt to repair a plastic fuel line/tube or a quick–connect fitting. Replace complete line/tube as necessary.

Avoid contact of any fuel tubes/hoses with other vehicle components that could cause abrasions or scuffing. Be sure that the fuel lines/tubes are properly routed to prevent pinching and to avoid heat sources.

The lines/tubes/hoses are of a special construction. If it is necessary to replace these lines/tubes/hoses, use only original equipment type.

The hose clamps used to secure the rubber hoses are of a special rolled edge construction. This construction is used to prevent the edge of the clamp from cutting into the hose. Only these rolled edge type clamps may be used in this system. All other types of clamps may cut into the hoses and cause fuel leaks.

Where a rubber hose is joined to a metal tube (staked), do not attempt to repair. Replace entire line/tube assembly.

Use new original equipment type hose clamps. Tighten hose clamps to 2 N·m (20 in. lbs.) torque.

QUICK-CONNECT FITTINGS—LOW PRESSURE TYPE

Different types of quick-connect fittings are used to attach various fuel system components. These are: a single-tab type, a two-tab type or a plastic retainer ring type (Fig. 8). Refer to Quick-Connect Fittings in the Removal/Installation section for more information.

CAUTION: The interior components (o-rings, spacers) of quick-connect fitting are not serviced separately, but new pull tabs are available for some types. Do not attempt to repair damaged fittings or fuel lines/tubes. If repair is necessary, replace the complete fuel tube assembly.

HIGH-PRESSURE FUEL LINES

CAUTION: The high–pressure fuel lines must be held securely in place in their holders. The lines cannot contact each other or other components. Do not attempt to weld high–pressure fuel lines or to repair lines that are damaged. Only use the recommended lines when replacement of high–pressure fuel line is necessary.

High–pressure fuel lines deliver fuel under pressure of up to approximately 45,000 kPa (6526 PSI) from the injection pump to the fuel injectors. The lines expand and contract from the high–pressure fuel pulses generated during the injection process. All high–pressure fuel lines are of the same length and inside diameter. Correct high–pressure fuel line usage and installation is critical to smooth engine operation.

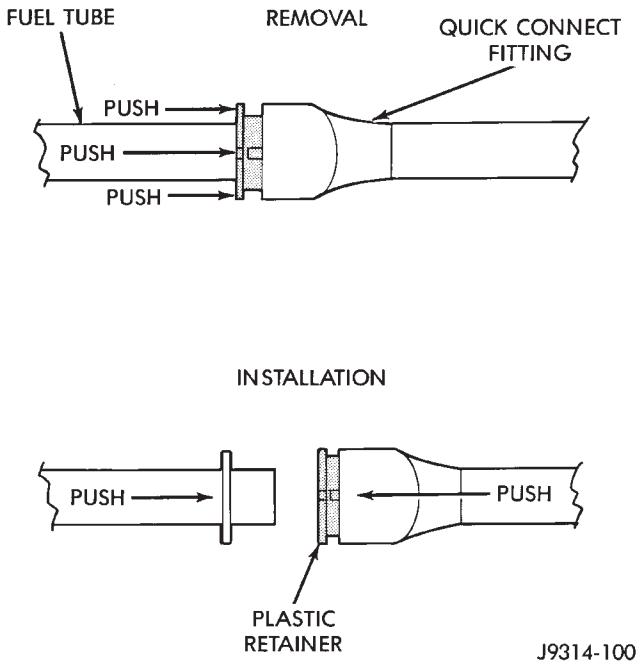


Fig. 8 Plastic Retainer Ring-Type Fitting

WARNING: USE EXTREME CAUTION WHEN INSPECTING FOR HIGH–PRESSURE FUEL LEAKS. INSPECT FOR HIGH–PRESSURE FUEL LEAKS WITH A SHEET OF CARDBOARD. HIGH FUEL INJECTION PRESSURE CAN CAUSE PERSONAL INJURY IF CONTACT IS MADE WITH THE SKIN.

FUEL DRAIN TUBES

These rubber tubes are low–pressure type.

Some excess fuel is continually vented from the fuel injection pump. During injection, a small amount of fuel flows past the injector nozzle and is not injected into the combustion chamber. This fuel drains into the fuel drain tubes (Fig. 9) and back to the tee banjo fitting, which is connected to the same line as the overflow valve, which allows a variable quantity to return to the fuel tank. The overflow valve is calibrated to open at a preset pressure. Excess fuel not required by the pump to maintain the minimum pump cavity pressure is then returned through the overflow valve and on to the fuel tank through the fuel return line.

DESCRIPTION AND OPERATION (Continued)

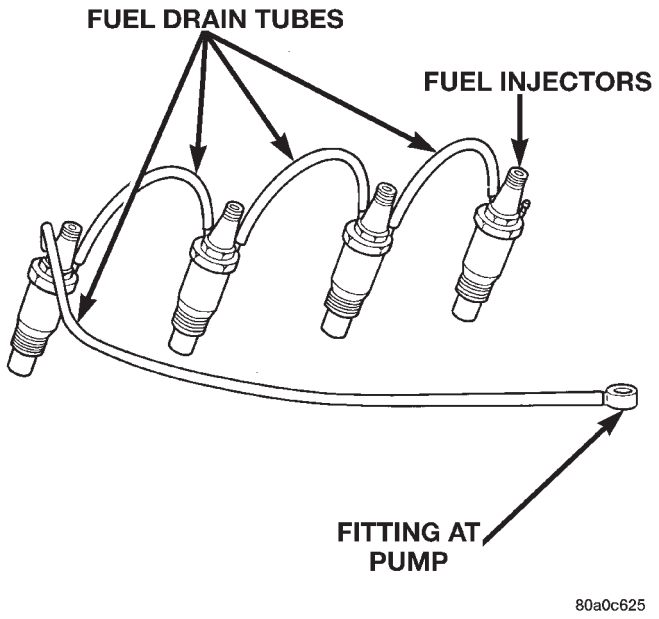


Fig. 9 Fuel Drain Tubes

FUEL HEATER

The fuel heater is used to prevent diesel fuel from waxing during cold weather operation. The fuel heater is located in the bottom plastic bowl of the fuel filter/water separator (Fig. 10).

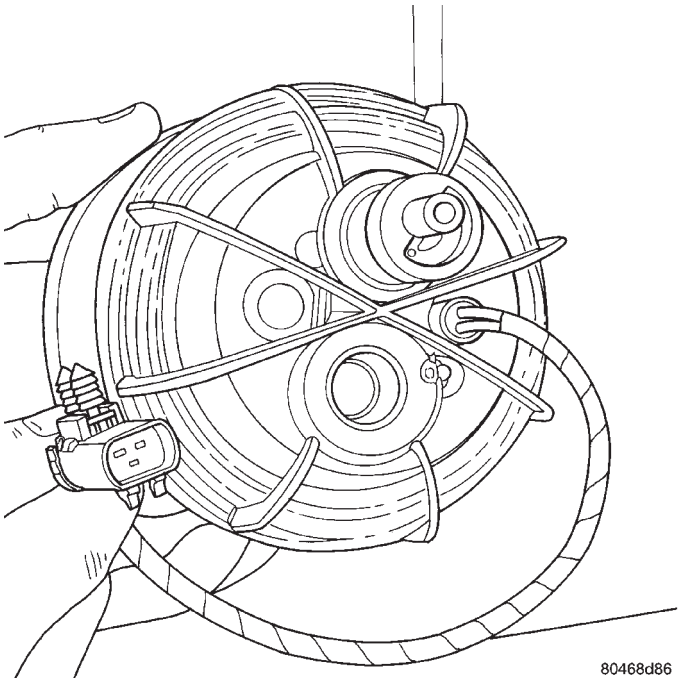


Fig. 10 Fuel Heater Temperature Sensor and Element Location

The element inside the heater assembly is made of a Positive Temperature Coefficient (PTC) material, and has power applied to it by the fuel heater relay anytime the ignition key is in the "on" position. PTC material has a high resistance to current flow when its temperature is high, which means that it will not generate heat when the temperature is above a certain value. When the temperature is below 7°C (45° F), the resistance of the PTC element is lowered, and allows current to flow through the fuel heater element warming the fuel. When the temperature is above 29°C (85° F), the PTC element's resistance rises, and current flow through the heater element stops.

Voltage to operate the fuel heater is supplied from the ignition (key) switch and through the fuel heater relay. Refer to the following Fuel Heater Relay for additional information. **The fuel heater and fuel heater relay are not controlled by the Powertrain Control Module (PCM).**

Current draw for the heater element is 150 watts at 14 volts (DC).

FUEL HEATER RELAY

Voltage to operate the fuel heater is supplied from the ignition (key) switch through the fuel heater relay. **The PCM is not used to control this relay.**

The fuel heater relay is located in the PDC. The PDC is located next to the battery in the engine compartment (Fig. 11). For the location of the relay within the PDC, refer to label on PDC cover.

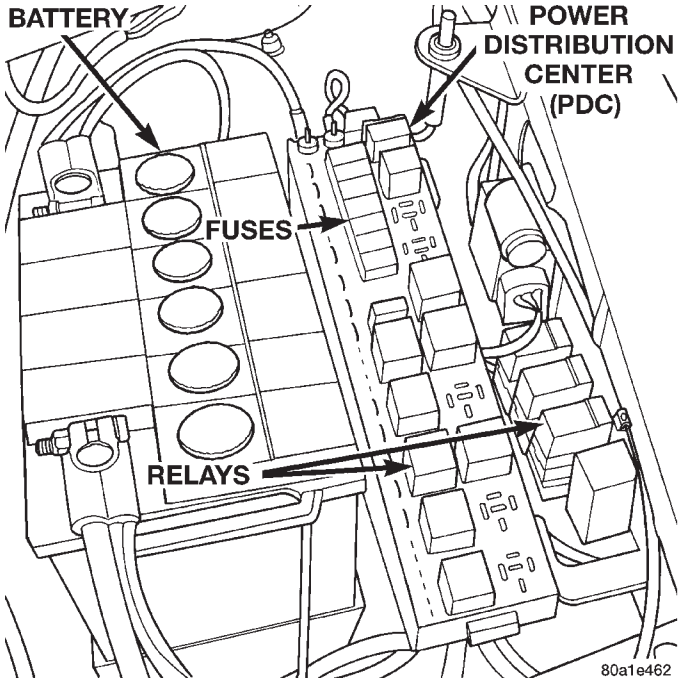


Fig. 11 Relay Location

WASTEGATE (TURBOCHARGER)

Refer to Group 11, Exhaust System and Intake Manifold for information.

DIAGNOSIS AND TESTING

GENERAL INFORMATION

This section of the group will cover a general diagnosis of diesel engine fuel system components.

Diagnostic Trouble Codes: Refer to On-Board Diagnostics in Group 25, Emission Control System for a list of Diagnostic Trouble Codes (DTC's) for certain fuel system components.

The PCM must be tested with the DRBIII scan tool. The DRBIII should be the first step in any diagnosis of engine performance complaints. Refer to the 1997 GS 2.5L Diesel Powertrain Diagnostic Procedures manual for diagnosis and testing of the diesel engine control system.

VISUAL INSPECTION

A visual inspection for loose, disconnected, or incorrectly routed wires and hoses should be made before attempting to diagnose or service the diesel fuel injection system. A visual check will help find these conditions. It also saves unnecessary test and diagnostic time. A thorough visual inspection of the fuel injection system includes the following checks:

(1) Be sure that the battery connections are tight and not corroded.

(2) Be sure that the 68 way connector is fully engaged with the PCM (Fig. 12).

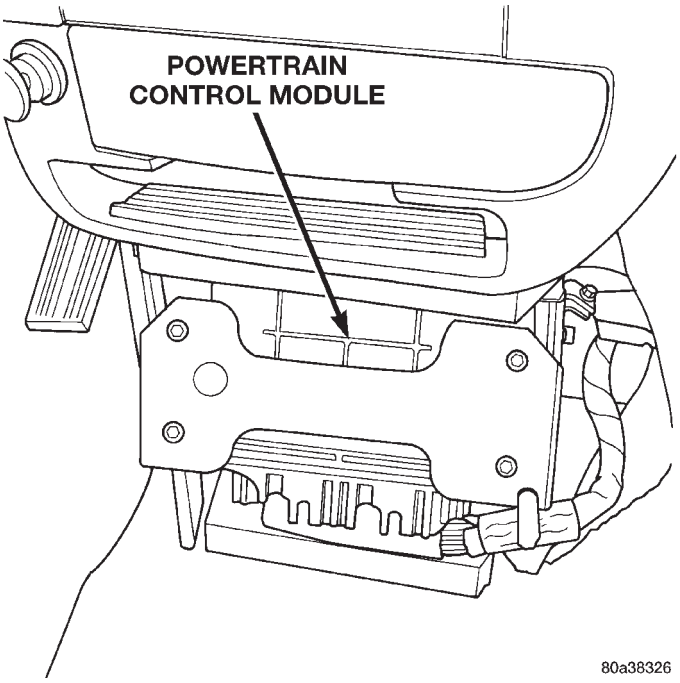


Fig. 12 PCM Location—Typical

(3) Verify that the electrical connections for the Diesel PCM relay are clean and free of corrosion. This relay is located in the PDC. For the location of the relay within the PDC, refer to label on PDC cover.

(4) Verify that the electrical connections for the fuel heater relay are clean and free of corrosion. This relay is located in the PDC. For the location of the relay within the PDC, refer to label on PDC cover.

(5) Be sure the electrical connectors at the ends of the glow plugs (Fig. 13) are tight and free of corrosion.

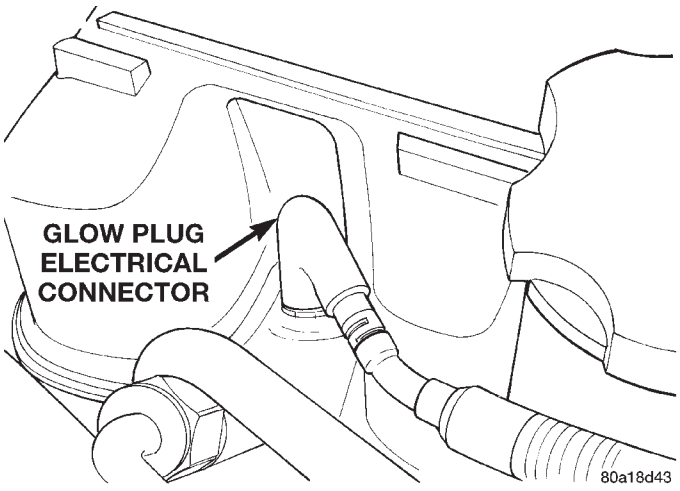


Fig. 13 Glow Plug Connector

(6) Be sure that the electrical connections at the glow plug relay are tight and not corroded. The glow plug relay is located in the engine compartment on the left–inner fender (Fig. 14).

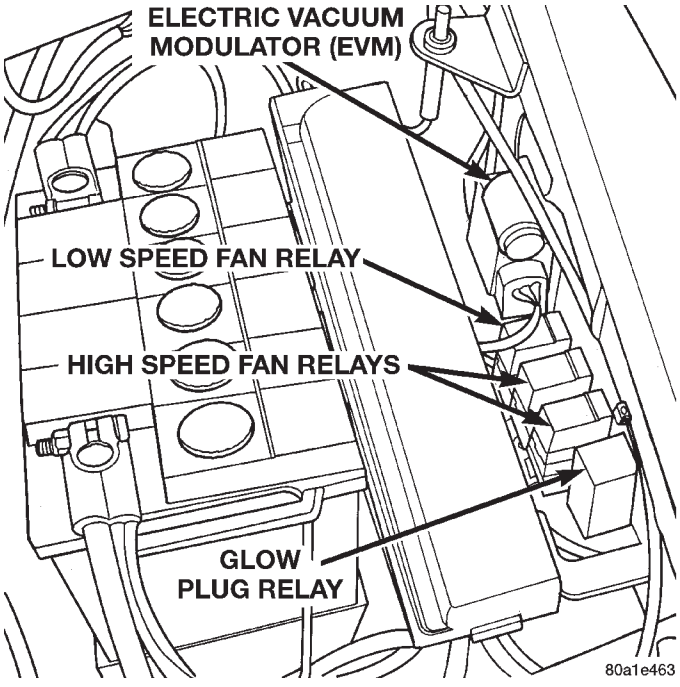


Fig. 14 Glow Plug Relay Location

DIAGNOSIS AND TESTING (Continued)

(7) Inspect the starter motor and starter solenoid connections for tightness and corrosion.

(8) Verify that the electrical connector is firmly connected to the fuel shutdown solenoid. Inspect the connector for corrosion or damaged wires. The solenoid is mounted to the rear of the injection pump (Fig. 15).

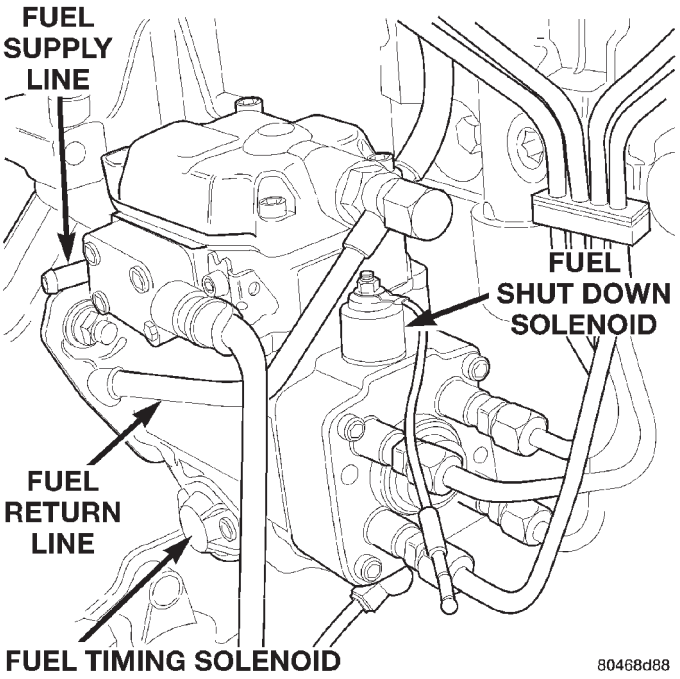


Fig. 15 Fuel Shutdown Solenoid Location

(9) Verify that the fuel heater electrical connector is firmly attached to the filter bowl at the bottom of the fuel filter/water separator. Inspect the connector for corrosion or damaged wires.

(10) Verify that the electrical pigtail connector (sensor connector) (Fig. 16) for the fuel injector sensor is firmly connected to the engine wiring harness. Inspect the connector for corrosion or damaged wires. This sensor is used on the #1 cylinder injector only.

(11) Verify that the electrical pigtail connector (sensor connector) (Fig. 17) for the fuel timing solenoid is firmly connected to the engine wiring harness. Inspect the connector for corrosion or damaged wires. The fuel timing solenoid is located on the bottom of the fuel injection pump (Fig. 17).

(12) Inspect for exhaust system restrictions such as pinched exhaust pipes or a collapsed or plugged muffler.

(13) Verify that the harness connector is firmly connected to the vehicle speed sensor (Fig. 18).

(14) Verify turbocharger wastegate operation. Refer to Group 11, Exhaust System and Intake Manifold Group for information.

(15) Verify that the harness connector is firmly connected to the engine coolant temperature sensor.

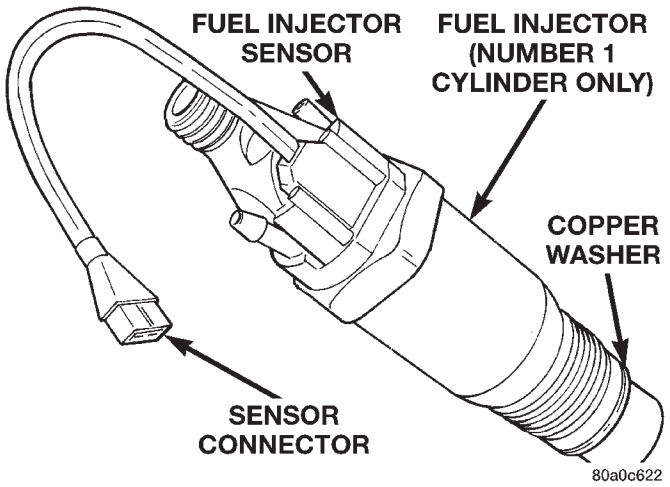


Fig. 16 Fuel Injector Sensor

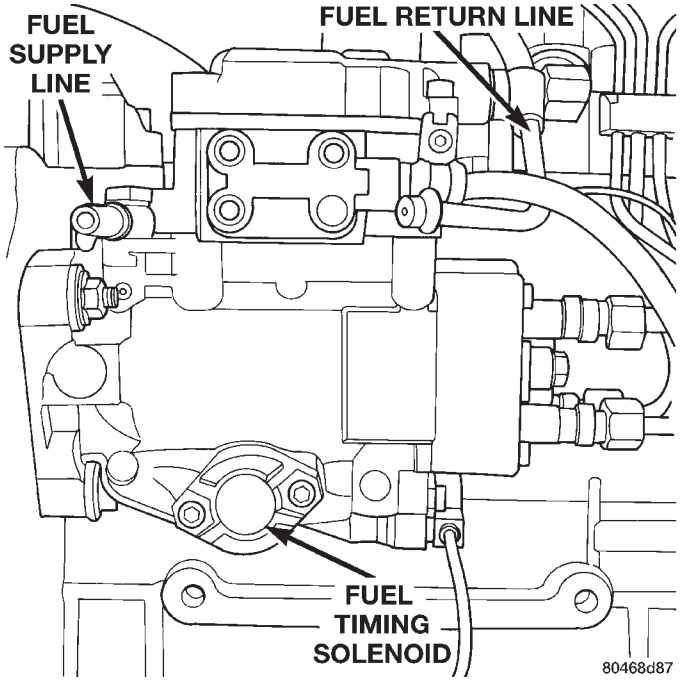


Fig. 17 Fuel Timing Solenoid

The sensor is located on the side of cylinder head near the rear of fuel injection pump (Fig. 19).

(16) Check for air in the fuel system. Refer to the Air Bleed Procedure.

(17) Inspect all fuel supply and return lines for signs of leakage.

(18) Be sure that the ground connections are tight and free of corrosion. Refer to Group 8, Wiring for locations of ground connections.

(19) Inspect the air cleaner element (filter) for restrictions.

(20) Be sure that the turbocharger output hose is properly connected to the charge air cooler (intercooler) inlet tube. Verify that the charge air cooler output hose is properly connected to the cooler and

DIAGNOSIS AND TESTING (Continued)

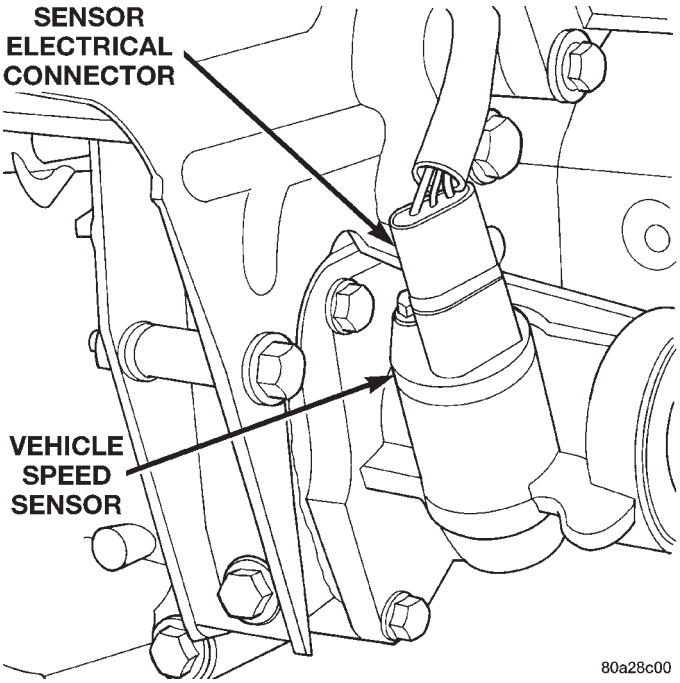


Fig. 18 Vehicle Speed Sensor—Typical

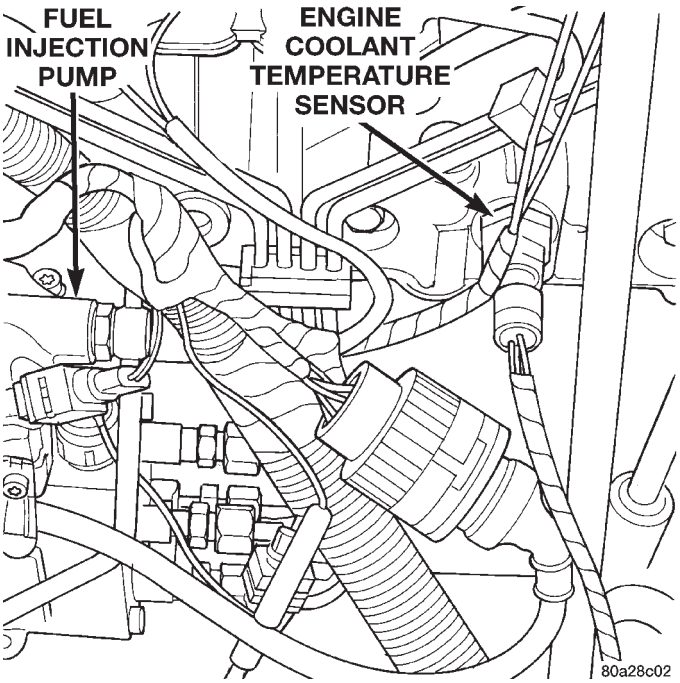


Fig. 19 Engine Coolant Temperature Sensor Location

the intake manifold. Refer to Group 11, Exhaust System and Intake Manifold for information.

(21) Be sure that the vacuum hoses to the vacuum pump are connected and not leaking. The pump is located on the front of engine (internal) and is driven from the crankshaft gear and chain (Fig. 20). Disconnect the hose and check for minimum vacuum from the pump. Refer to Group 5, Brake System for specifications and procedures.

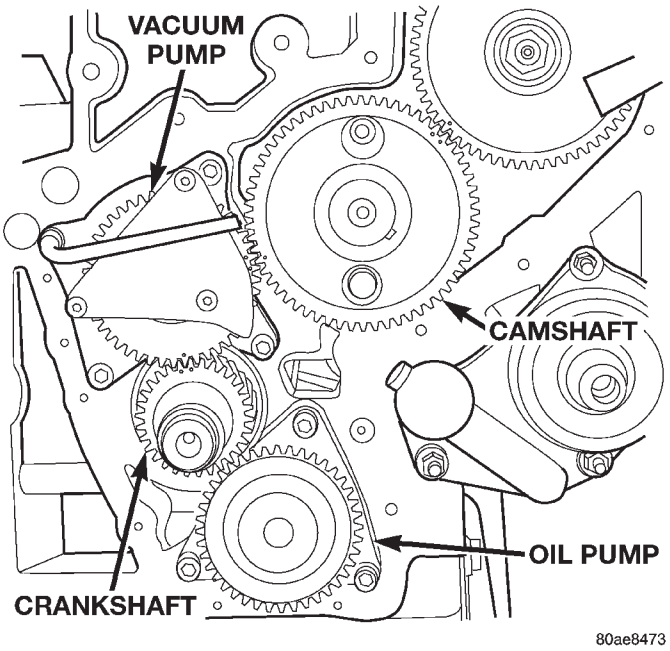


Fig. 20 Vacuum Pump at Front of Engine

(22) Be sure that the accessory drive belt is not damaged or slipping.

(23) Verify there is a good connection at the engine speed sensor. Refer to the Fuel Injection System in this section for location of the engine speed sensor location.

(24) Verify there is a good connection at the Mass Air Flow Sensor, which is a part of the air intake assembly.

AIR IN FUEL SYSTEM

Air will enter the fuel system whenever the fuel supply lines, fuel filter/water separator, fuel filter bowl, injection pump, high–pressure lines or injectors are removed or disconnected. Air will also enter the fuel system whenever the fuel tank has been run empty.

Air trapped in the fuel system can result in hard starting, a rough running engine, engine misfire, low power, excessive smoke and fuel knock. After service is performed, air must be bled from the system before starting the engine.

Inspect the fuel system from the fuel tank to the injectors for loose connections. Leaking fuel is an indicator of loose connections or defective seals. Air can also enter the fuel system between the fuel tank and the injection pump. Inspect the fuel tank and fuel lines for damage that might allow air into the system.

For air bleeding, refer to Air Bleed Procedure in the Service Procedures section of this group.

DIAGNOSIS AND TESTING (Continued)

FUEL HEATER RELAY TEST

The fuel heater relay is located in the Power Distribution Center (PDC). Refer to Relays—Operation/Testing in Fuel Ingection System section of this group for test procedures.

FUEL INJECTOR TEST

The fuel injection nozzels, located on the engine cylinder head, spray fuel under high pressure into the individual combustion chambers. Pressurized fuel, delivered by the fuel injection pump, unseats a spring-loaded needle valve inside the injector, and the fuel is atomized as it escapes through the injector opening into the engine's combustion chamber. If the fuel injector does not operate properly, the engine may misfire, or cause other driveability problems.

A leak in the injection pump–to–injector high–pressure fuel line can cause many of the same symptoms as a malfunctioning injector. Inspect for a leak in the high–pressure lines before checking for a malfunctioning fuel injector.

WARNING: THE INJECTION PUMP SUPPLIES HIGH–PRESSURE FUEL OF UP TO APPROXIMATELY 45,000 KPA (6526 PSI) TO EACH INDIVIDUAL INJECTOR THROUGH THE HIGH–PRESSURE LINES. FUEL UNDER THIS AMOUNT OF PRESSURE CAN PENETRATE THE SKIN AND CAUSE PERSONAL INJURY. WEAR SAFETY GOGGLES AND ADEQUATE PROTECTIVE CLOTHING. AVOID CONTACT WITH FUEL SPRAY WHEN BLEEDING HIGH–PRESSURE FUEL LINES.

WARNING: DO NOT BLEED AIR FROM THE FUEL SYSTEM OF A HOT ENGINE. DO NOT ALLOW FUEL TO SPRAY ONTO THE EXHAUST MANIFOLD WHEN BLEEDING AIR FROM THE FUEL SYSTEM.

To determine which fuel injector is malfunctioning, run the engine and loosen the high–pressure fuel line nut at the injector (Fig. 21). Listen for a change in engine speed. If engine speed drops, the injector was operating normally. If engine speed remains the same, the injector may be malfunctioning. After testing, tighten the line nut to 30 N·m (22 ft. lbs.) torque. Test all injectors in the same manner one at a time.

Once an injector has been found to be malfunctioning, remove it from the engine and test it. Refer to the Removal/Installation section of this group for procedures.

After the injector has been removed, install it to a bench–mount injector tester. Refer to operating instructions supplied with tester for procedures.

The opening pressure or "pop" pressure should be 15,000–15,800 kPa (2175–2291 psi). If the fuel injector needle valve is opening ("popping") to early or to late, replace the injector.

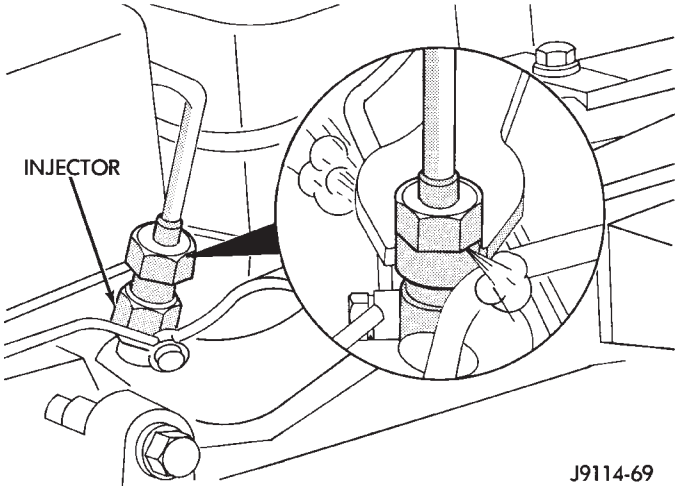


Fig. 21 Typical Inspection of Fuel Injector

FUEL INJECTOR SENSOR TEST

The fuel injector sensor is used only on the fuel injector for the number–1 cylinder (Fig. 22). It is not used on the injectors for cylinders number 2, 3, or 4.

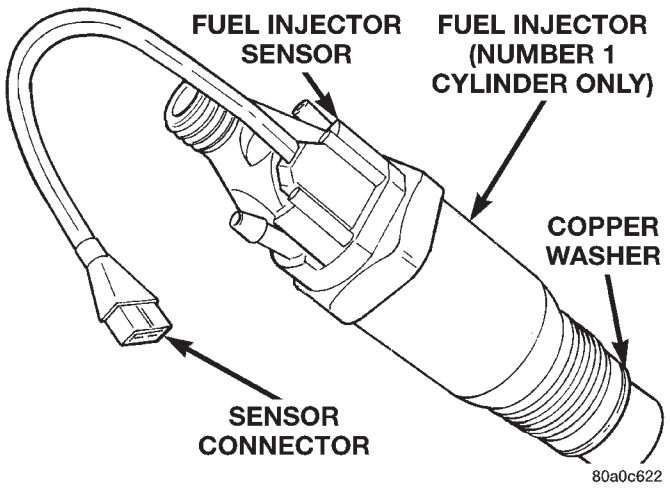


Fig. 22 Fuel Injector Sensor Location

To test the sensor, unplug the sensor connector (Fig. 22) from the engine wiring harness. Check resistance across terminals. Resistance should be 110 ohms ± 10 ohms at 20°C (68°F). Replace sensor if specification cannot be met.

FUEL INJECTION PUMP TEST

The injection pump is not to be serviced or the warranty may be voided. If the injection pump requires service, the complete assembly must be replaced.

Incorrect injection pump timing (mechanical or electrical) can cause poor performance, excessive smoke and emissions and poor fuel economy.

DIAGNOSIS AND TESTING (Continued)

A defective fuel injection pump, defective fuel timing solenoid or misadjusted mechanical pump timing can cause starting problems or prevent the engine from revving up. It can also cause:

- Engine surge at idle
- Rough idle (warm engine)
- Low power
- Excessive fuel consumption
- Poor performance
- Low power
- Black smoke from the exhaust
- Blue or white fog like exhaust
- Incorrect idle or maximum speed

The electronically controlled fuel pump has no mechanical governor like older mechanically controlled fuel pumps. Do not remove the top cover of the fuel pump, or the screws fastening the wiring pigtail to the side of the pump. **The warranty of the injection pump and the engine may be void if those seals have been removed or tampered with.**

FUEL SUPPLY RESTRICTIONS

LOW–PRESSURE LINES

Restricted or Plugged supply lines or fuel filter can cause a timing fault that will cause the PCM to operate the engine in a "Limp Home" mode. See the introduction of the Fuel Injection System in this group for more information on the Limp Home mode. Fuel supply line restrictions can cause starting problems and prevent the engine from revving up. The starting problems include; low power and blue or white fog like exhaust. Test all fuel supply lines for restrictions or blockage. Flush or replace as necessary. Bleed the fuel system of air once a fuel supply line has been replaced. Refer to the Air Bleed Procedure section of this group for procedures.

HIGH–PRESSURE LINES

Restricted (kinked or bent) high–pressure lines can cause starting problems, poor engine performance and black smoke from exhaust.

Examine all high–pressure lines for any damage. Each radius on each high–pressure line must be smooth and free of any bends or kinks.

Replace damaged, restricted or leaking high–pressure fuel lines with the correct replacement line.

CAUTION: The high–pressure fuel lines must be clamped securely in place in the holders. The lines cannot contact each other or other components. Do not attempt to weld high–pressure fuel lines or to repair lines that are damaged. Only use the recommended lines when replacement of high–pressure fuel line is necessary.

FUEL SHUTDOWN SOLENOID TEST

Since diesel fuel injection does not use spark plugs to start combustion, the only way to stop the engine is to cut off the fuel supply. This is done with the Fuel Shutdown Solenoid. If the engine cranks, but refuses to start, it may be caused by a defective fuel shutdown solenoid.

The fuel shutdown solenoid is not controlled or operated by the PCM. Voltage to operate the solenoid is supplied from the ignition (key) switch.

NOTE: Although the fuel shutdown solenoid is not operated by the PCM, if the Fuel Shutdown Solenoid has been disconnected, and the key turned on, the PCM will sense that the solenoid is not in the circuit, and will switch to a "Limp Home" mode. After reconnecting the solenoid, the PCM will have to be reset by clearing the codes with the DRBIII scan tool, or disconnecting the vehicle's battery for several minutes. The DRBIII scan tool is the preferred method for resetting the PCM. Refer to the 1998 GS 2.5L Diesel Powertrain Diagnostic Manual for procedure.

The fuel shutdown (shut–off) solenoid is used to electrically shut off the diesel fuel supply to the high–pressure fuel injection pump. The solenoid is mounted to the rear of the injection pump (Fig. 23).

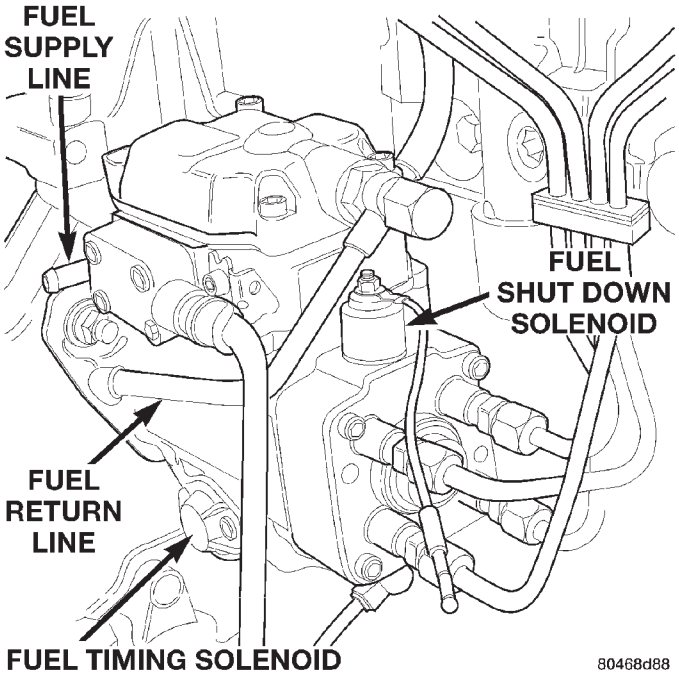


Fig. 23 Fuel Shutdown Solenoid Location

The solenoid controls starting and stopping of the engine regardless of the position of the accelerator pedal. When the ignition (key) switch is OFF, the solenoid is shut off and fuel flow is not allowed to the fuel injection pump. When the key is placed in the ON or

DIAGNOSIS AND TESTING (Continued)

START positions, fuel supply is allowed at the injection pump.

(1) Disconnect the electrical pigtail connector (test connector) (Fig. 23) from the main engine wiring harness. Do not disconnect wiring directly at solenoid.

(2) Connect the leads of a voltmeter between a good ground and the disconnected engine wiring harness.

(3) Turn the key to the ON position. Do not attempt to start engine.

(4) 12V+ should be observed at wiring harness. If not, refer to Group 8, Wiring for wiring schematics and repair as necessary.

(5) Turn the key to the START position. 12V+ should be observed at wiring harness. If not, refer to Group 8, Wiring for wiring schematics and repair as necessary. The fault may be in the ignition (key) switch.

12V+ must be observed in both the ON and START positions. If 12V+ was observed, proceed to the next step.

(6) With key still in the ON position, connect and disconnect the wiring harness to the solenoid. As this is done, a clicking noise should be heard coming from the solenoid. If not, replace solenoid. Refer to Fuel Shutdown Solenoid in the Removal/Installation section of this group for procedures.

HIGH-PRESSURE FUEL LINE LEAK TEST

High–pressure fuel line leaks can cause starting problems and poor engine performance.

WARNING: DUE TO EXTREME FUEL PRESSURES OF UP TO 45,000 KPA (6526 PSI), USE EXTREME CAUTION WHEN INSPECTING FOR HIGH–PRESSURE FUEL LEAKS. DO NOT GET YOUR HAND, OR ANY PART OF YOUR BODY NEAR A SUSPECTED LEAK. INSPECT FOR HIGH–PRESSURE FUEL LEAKS WITH A SHEET OF CARDBOARD. HIGH FUEL INJECTION PRESSURE CAN CAUSE PERSONAL INJURY IF CONTACT IS MADE WITH THE SKIN.

Start the engine. Move the cardboard over the high–pressure fuel lines and check for fuel spray onto the cardboard (Fig. 24). If a high–pressure line connection is leaking, bleed the system and tighten the connection. Refer to the Air Bleed Procedure in this group for procedures. Replace damaged, restricted or leaking high–pressure fuel lines with the correct replacement line.

CAUTION: The high–pressure fuel lines must be clamped securely in place in the holders. The lines cannot contact each other or other components. Do not attempt to weld high–pressure fuel lines or to repair lines that are damaged. Only use the recommended lines when replacement of high–pressure fuel line is necessary.

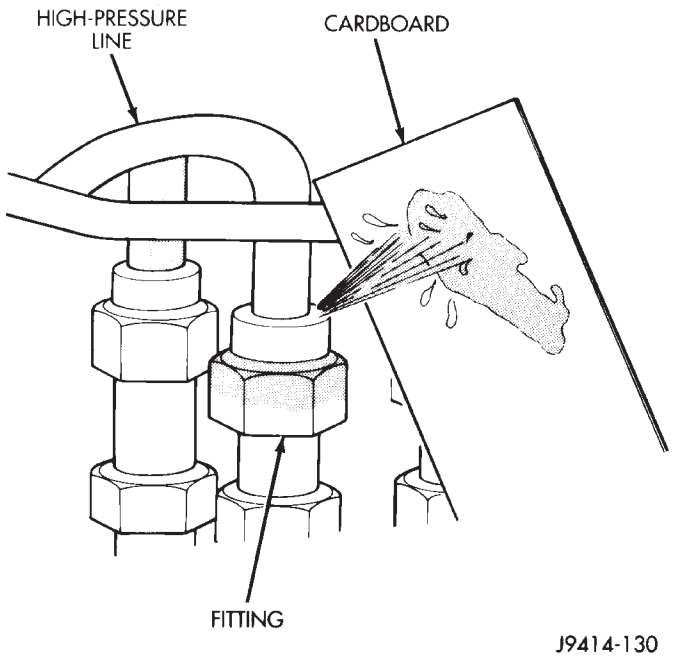


Fig. 24 Typical Test for Leaks with Cardboard

WASTEGATE (TURBOCHARGER)

Refer to Group 11, Exhaust System and Intake Manifold for information.

SERVICE PROCEDURES

AIR BLEED PROCEDURES

AIR BLEEDING AT FUEL FILTER

A certain amount of air may become trapped in the fuel system when fuel system components are serviced or replaced. Bleed the system as needed after fuel system service according to the following procedures.

WARNING: DO NOT BLEED AIR FROM THE FUEL SYSTEM OF A HOT ENGINE. DO NOT ALLOW FUEL TO SPRAY ONTO THE EXHAUST MANIFOLD WHEN BLEEDING AIR FROM THE FUEL SYSTEM.

Some air enters the fuel system when the fuel filter or injection pump supply line is changed. This small amount of air is vented automatically from the injection pump through the fuel drain manifold tubes if the filter was changed according to instructions. Ensure the bowl of the fuel filter/water separator is full of fuel

It may be necessary to manually bleed the system if:

- The bowl of the fuel filter/water separator is not partially filled before installation of a new filter
- The injection pump is replaced

SERVICE PROCEDURES (Continued)

- High–pressure fuel line connections are loosened or lines replaced
- Initial engine start–up or start–up after an extended period of no engine operation
- Running fuel tank empty

FUEL INJECTION PUMP BLEEDING

(1) If the fuel injection pump has been replaced, air should be bled at the overflow valve before attempting to start engine.

(a) Loosen the overflow valve (Fig. 25) at the rear of the injection pump.

(b) Place a towel below the valve.

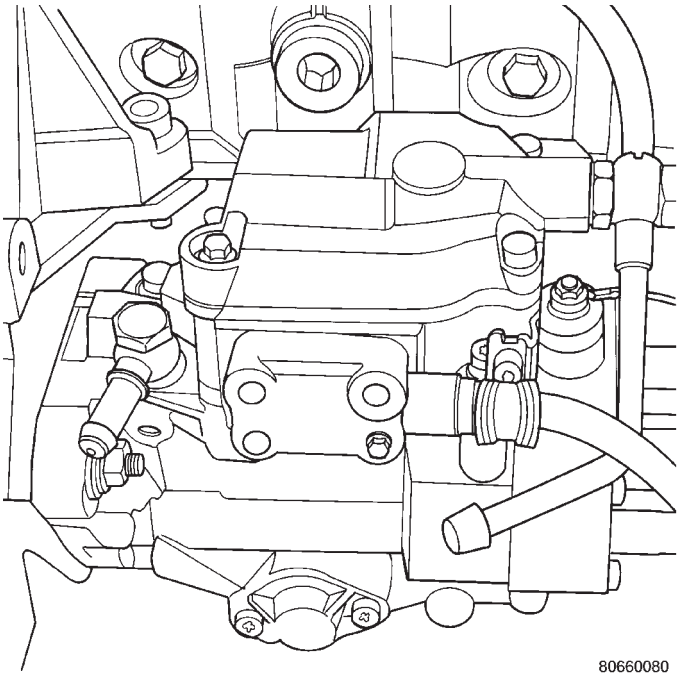


Fig. 25 Overflow Valve

WARNING: WHEN CRANKING THE ENGINE TO BLEED AIR FROM THE INJECTION PUMP, THE ENGINE MAY START. PLACE THE TRANSMISSION IN NEUTRAL OR PARK AND SET PARKING BRAKE BEFORE ENGAGING THE STARTER MOTOR.

CAUTION: Do not engage the starter motor for more than 30 seconds at a time. Allow 2 minutes between cranking intervals.

(2) Crank the engine for 30 seconds at a time to allow air trapped in the injection pump to vent out the fuel injector drain tubes. Continue this procedure until the engine starts. Observe the previous WARNING and CAUTION.

(3) Tighten overflow valve.

HIGH–PRESSURE FUEL LINE BLEEDING

WARNING: THE INJECTION PUMP SUPPLIES HIGH–PRESSURE FUEL OF APPROXIMATELY 59,000 KPA (8,557 PSI) TO EACH INDIVIDUAL INJECTOR THROUGH THE HIGH–PRESSURE LINES. FUEL UNDER THIS AMOUNT OF PRESSURE CAN PENETRATE THE SKIN AND CAUSE PERSONAL INJURY. WEAR SAFETY GOGGLES AND ADEQUATE PROTECTIVE CLOTHING AND AVOID CONTACT WITH FUEL SPRAY WHEN BLEEDING HIGH–PRESSURE FUEL LINES.

WARNING: DO NOT BLEED AIR FROM THE FUEL SYSTEM OF A HOT ENGINE. DO NOT ALLOW FUEL TO SPRAY ONTO THE EXHAUST MANIFOLD WHEN BLEEDING AIR FROM THE FUEL SYSTEM.

Bleed air from one injector at time.

(1) Loosen the high–pressure fuel line fitting at the injector (Fig. 26).

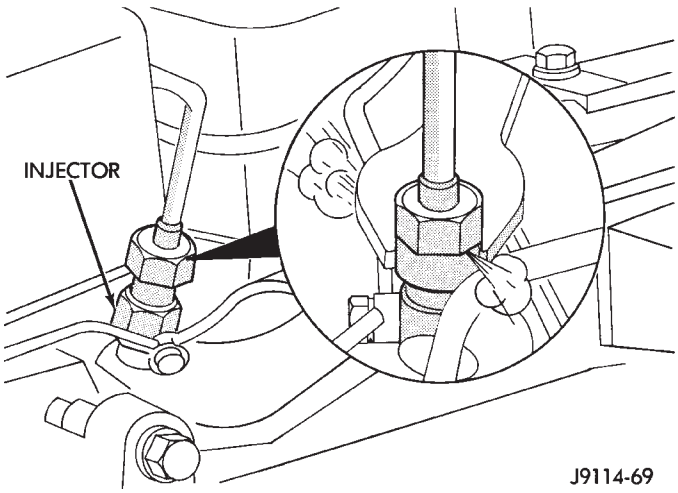


Fig. 26 Bleeding High–Pressure Fuel Line—Typical

(2) Crank the engine until all air has been bled from the line. **Do not operate the starter motor for longer than 30 seconds. Wait 2 minutes between cranking intervals.**

(3) Start the engine and bleed one injector at a time until the engine runs smoothly.

FUEL INJECTION PUMP TIMING

Refer to Removal/Installation and Adjusting Fuel Pump Timing in this Group.

REMOVAL AND INSTALLATION

ACCELERATOR PEDAL

CAUTION: Be careful not to damage or kink the cable core wire (within the cable sheathing) while servicing the accelerator pedal or throttle cable.

REMOVAL

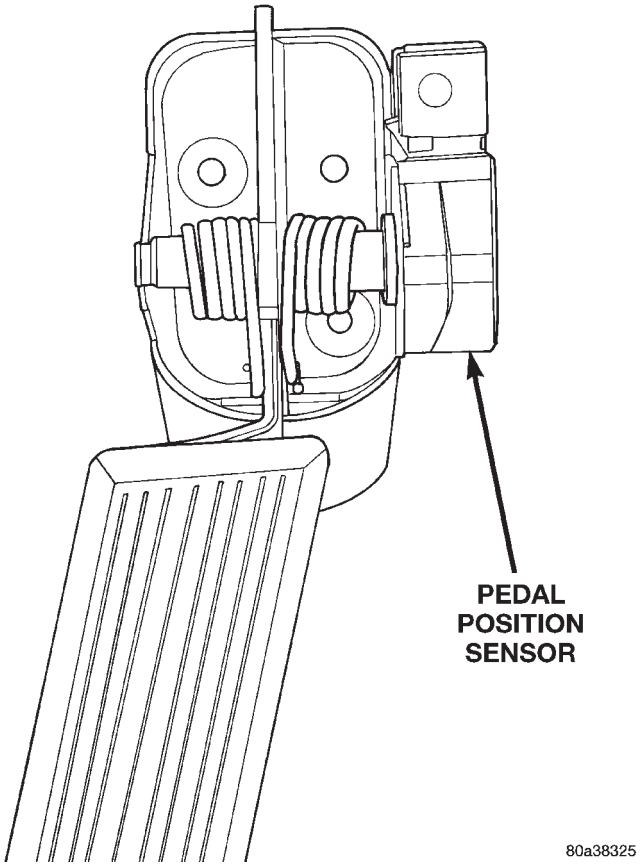


Fig. 27 Accelerator Pedal Mounting-Typical

(1) Disconnect electrical connector.
(2) Remove accelerator pedal mounting bracket nuts. Remove accelerator pedal assembly.

INSTALLATION

(1) Place accelerator pedal assembly over studs protruding from floor pan. Tighten mounting nuts to 5 N·m (46 in. lbs.) torque.
(2) Connect electrical connector.
(3) Before starting the engine, operate the accelerator pedal to check for any binding.

AIR CLEANER ELEMENT

REMOVAL

(1) Remove hose clamp at Mass Air Flow Sensor.
(2) Remove hose from Mass Air Flow Sensor.
(3) Loosen 2 clamps holding air cleaner housing halves together.
(4) Remove left side of air cleaner housing.
(5) Remove element from air cleaner housing.

INSTALLATION

(1) Install a new element in housing.
(2) Position left side of housing.
(3) Snap clamps into place.
(4) Install hoses and clamps.

FUEL DRAIN TUBES

The fuel drain tubes (Fig. 28) are low–pressure type.

Pull each tube from the injector for removal. Push on for installation. Clamps are not required for these tubes.

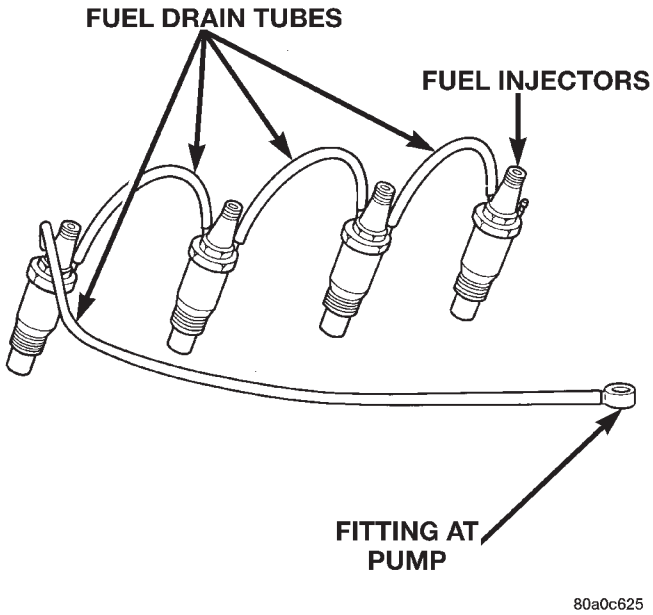


Fig. 28 Fuel Drain Tubes

FUEL FILTER/WATER SEPARATOR

The fuel filter/water separator is located in the engine compartment on the right side near the shock tower. (Fig. 29).

The fuel filter/water separator assembly contains the fuel filter, fuel heater element, and fuel drain valve (Fig. 29).

DRAINING WATER FROM FILTER BOWL

Moisture (water) collects at the bottom of the filter/separator in a plastic bowl. Water entering the fuel injection pump can cause serious damage to the pump. **Note that the bulb will be illuminated for approximately 2 seconds each time the key is initially placed in the ON position. This is done for a bulb check.**

REMOVAL AND INSTALLATION (Continued)

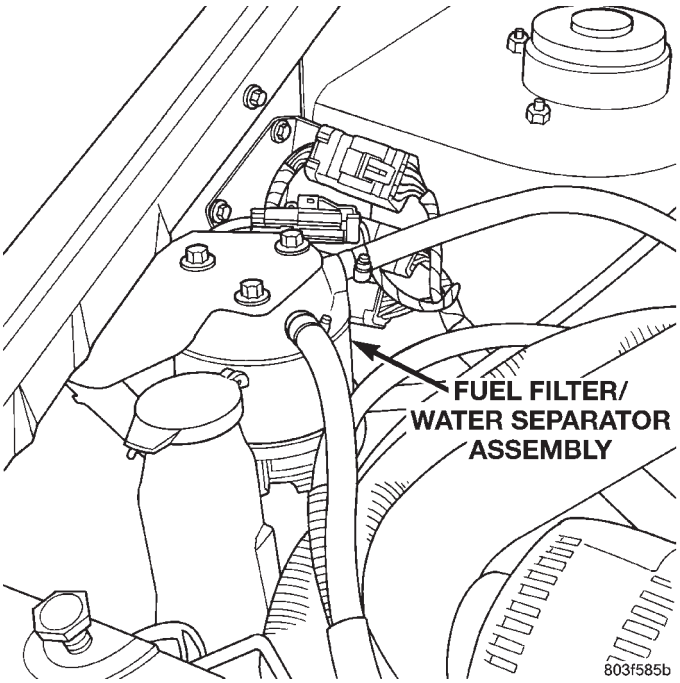


Fig. 29 Fuel Filter/Water Separator Location

WARNING: DO NOT ATTEMPT TO DRAIN WATER FROM THE FILTER/SEPARATOR WITH THE ENGINE HOT.

(1) The bottom of the filter/separator bowl is equipped with a drain valve (Fig. 29). The drain valve is equipped with a fitting. Attach a piece of rubber hose to this fitting. This hose is to be used as a drain hose.

(2) Place a drain pan under the drain hose.

(3) With the engine not running, open the drain valve (unscrew—drain valve has right hand threads) from the filter/separator bowl. To gain access to this fitting, the two filter–to–mounting bracket nuts (Fig. 29) may have to be loosened a few turns.

(4) Hold the drain open until clean fuel exits the drain.

(5) After draining, close drain valve.

(6) Remove rubber drain hose.

(7) Dispose of mixture in drain pan according to applicable local or federal regulations.

FUEL FILTER REMOVAL

(1) Drain all fuel and/or water from fuel filter/water separator assembly. Refer to the previous Draining Water From Filter Bowl.

(2) Unplug the electrical connectors at bottom of plastic bowl.

(3) Remove plastic bowl from bottom of fuel filter (unscrews).

(4) Remove fuel filter from bottom of filter base (unscrews).

FUEL FILTER INSTALLATION

(1) Clean bottom of fuel filter base.

(2) Apply clean diesel fuel to new fuel filter gasket.

(3) Install and tighten filter to filter base. The beveled part of the rubber gasket should be facing up towards the filter base.

(4) Clean the inside of bowl with a soap and water mixture before installation. Carefully clean any residue between the two metal probes at the top of the water–in–fuel sensor. Do not use chemical cleaners as damage to the plastic bowl may result.

(5) Pour diesel fuel into the plastic bowl before installing bowl to bottom of fuel filter. Do this to help prevent air from entering fuel injection pump while attempting to starting engine.

(6) Install filter bowl to bottom of filter.

(7) Install the electrical connectors at bottom of bowl.

(8) Tighten the filter–to–mounting bracket nuts (Fig. 29) to 28 N·m (250 in. lbs.) torque.

FUEL HEATER

If the fuel heater element needs replacement, the plastic filter bowl assembly must be replaced. Refer to Fuel Filter/Water Separator for information.

FUEL HEATER RELAY

The fuel heater relay is located in the PDC. For the location of the relay within the PDC (Fig. 30), refer to label on PDC cover.

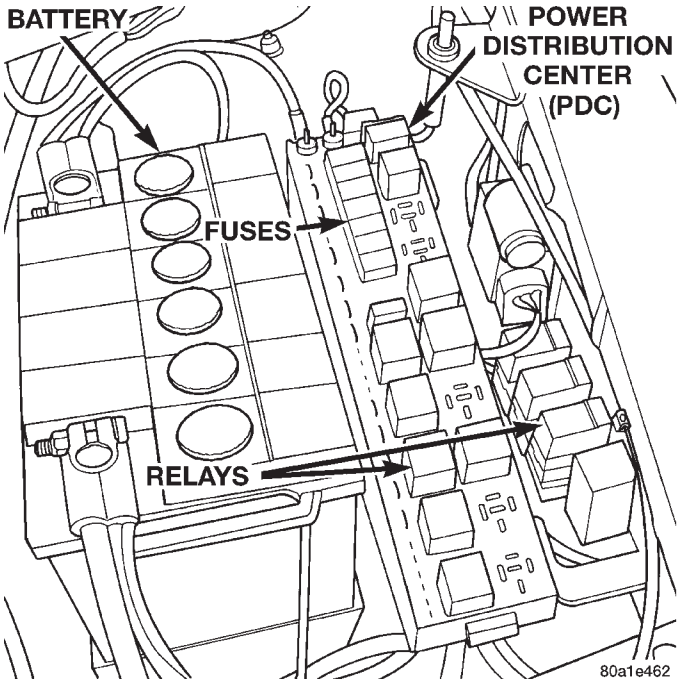


Fig. 30 Power Distribution Center (PDC) Location

REMOVAL AND INSTALLATION (Continued)

FUEL LEVEL SENSOR

REMOVAL

Remove fuel reservoir module. Refer to Fuel Reservoir Module in this section.

(1) Depress retaining tab and remove the level sensor connector from the **BOTTOM** of the fuel module electrical connector (Fig. 31).

NOTE: The pump module harness on TOP of flange is not serviceable or removable.

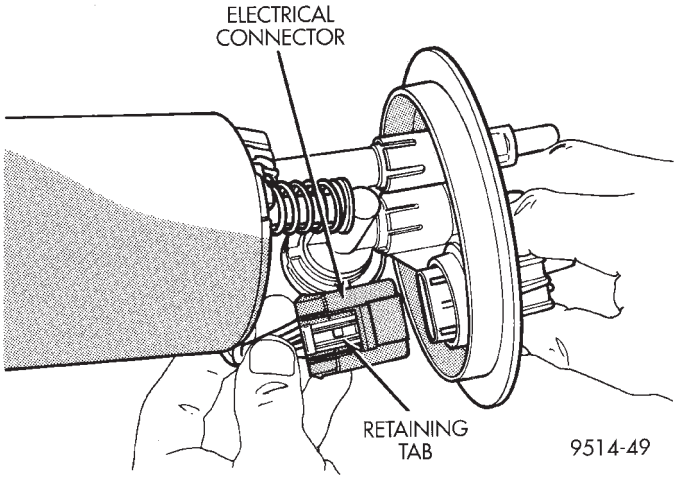


Fig. 31 Fuel Module/Level Sensor Electrical Connector

(2) Pull off blue locking wedge (Fig. 32).

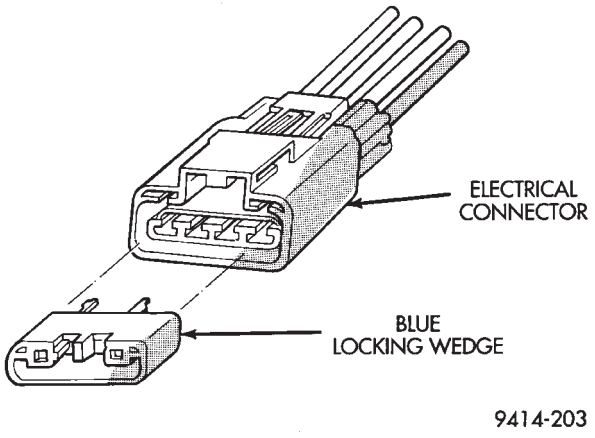


Fig. 32 Wire Terminal Locking Wedge

(3) Using a small screwdriver lift locking finger away from terminal and push terminal out of connector (Fig. 33).

(4) Push level sensor signal and ground terminals out of the connector (Fig. 34).

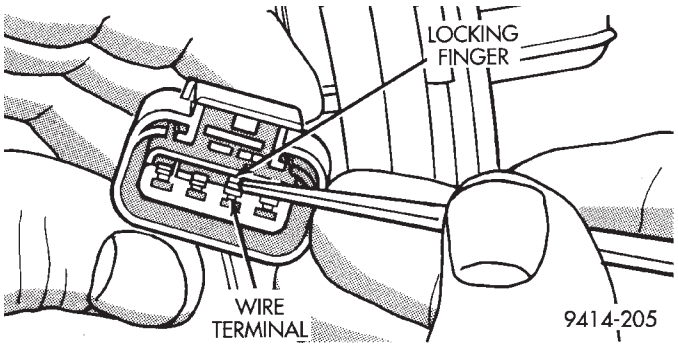


Fig. 33 Wire Terminal Locking Finger

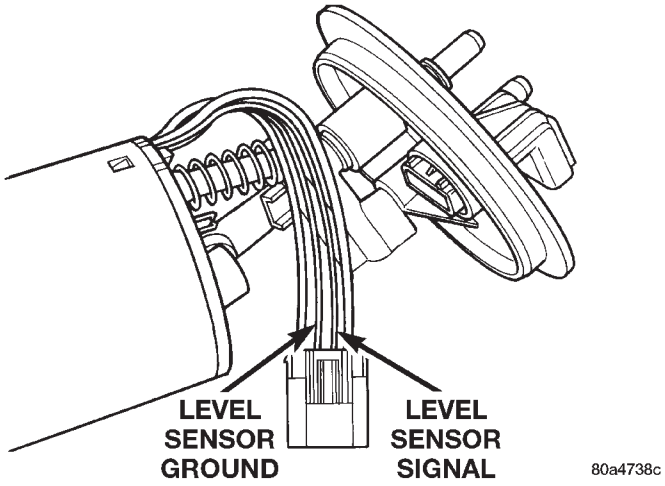


Fig. 34 Removing Wires From Connector

(5) Insert a screwdriver between the fuel module and the top of the level sensor housing (Fig. 35). Push level sensor down slightly.

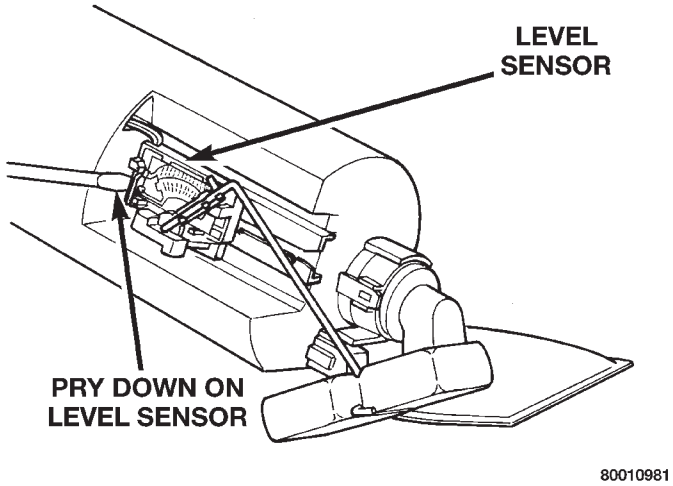


Fig. 35 Loosening Level Sensor

(6) Slide level sensor wires through opening fuel module (Fig. 36).

(7) Slide level sensor out of installation channel in module.

REMOVAL AND INSTALLATION (Continued)

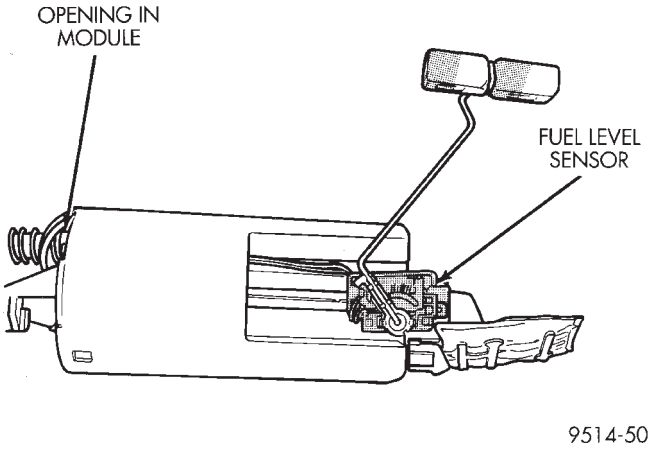


Fig. 36 Level Sensor Removal/Installation

INSTALLATION

(1) Insert level sensor wires into bottom of opening in module.

(2) Wrap wires into groove in back of level sensor (Fig. 37).

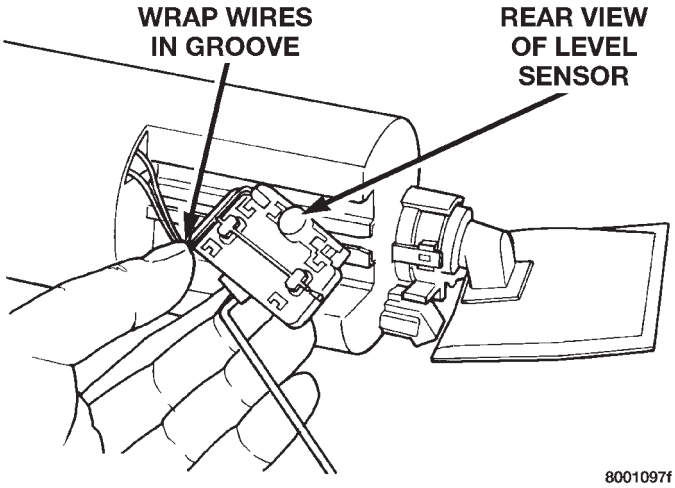


Fig. 37 Groove in Back Side of Level Sensor

(3) While feeding wires into guide grooves, slide level sensor up into channel until it snaps into place (Fig. 38). Ensure tab at bottom of sensor locks in place.

(4) Install level sensor wires in connector. Push the wires up through the connector and then pull them down until they lock in place. Ensure signal and ground wires are installed in the correct position.

(5) Install locking wedge on connector.

(6) Push connector up into bottom of fuel module electrical connector.

(7) Install fuel module. Refer to Fuel Reservoir Module in this section.

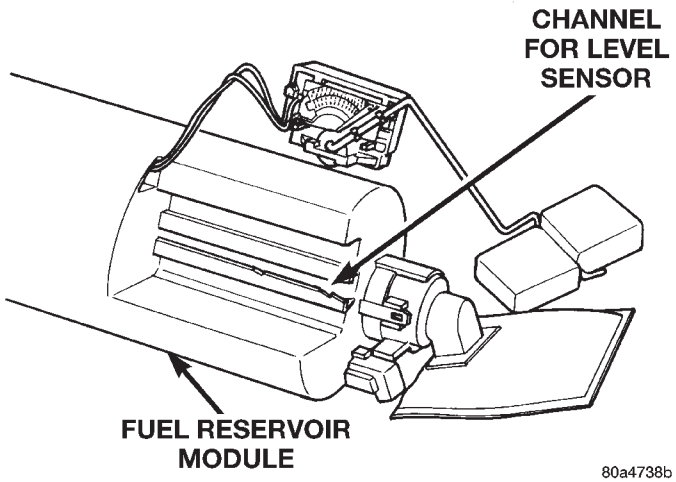


Fig. 38 Installation Channel

FUEL INJECTION PUMP

REMOVAL

(1) Disconnect negative battery cable at battery.

(2) Thoroughly clean the area around the injection pump and fuel lines of all dirt, grease and other contaminants. **Due to the close internal tolerances of the injection pump, this step must be performed before removing pump.**

(3) Remove the engine accessory drive belt. Refer to Group 7, Cooling System for procedures.

(4) Remove the generator assembly.

(5) Remove the rubber fuel return and supply hoses from metal lines at pump (Fig. 39).

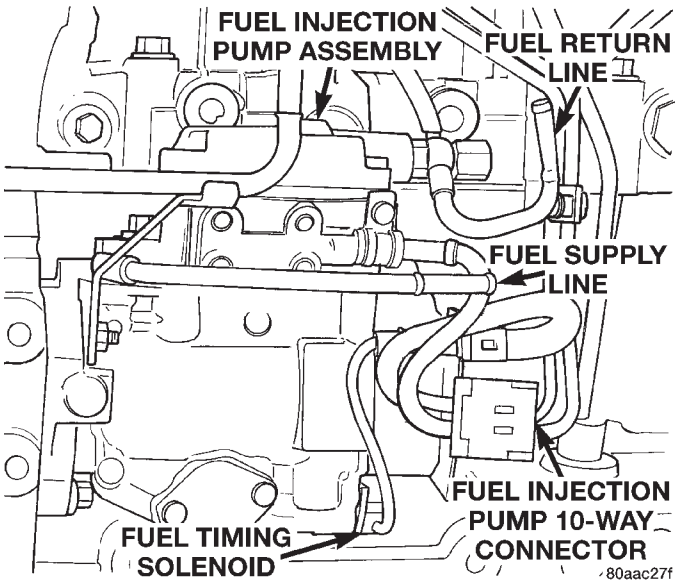


Fig. 39 Overflow Valve and Fuel Shutdown Solenoid

(6) Remove the electrical connector at engine coolant temperature sensor (Fig. 40).

(7) Disconnect the Fuel Injection Pump electrical connector at fuel pump. (Fig. 39).

REMOVAL AND INSTALLATION (Continued)

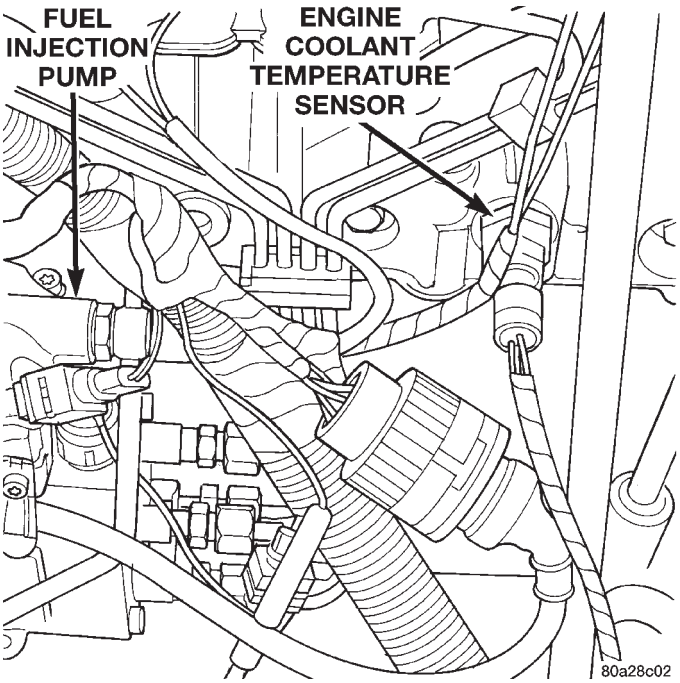


Fig. 40 Engine Coolant Temperature Sensor

(8) Disconnect the main engine wiring harness from the glow plugs.

(9) Disconnect the four high–pressure fuel lines from the fuel injection pump. Also disconnect fuel lines at the fuel injectors. For procedures, refer to High–Pressure Fuel Lines in this group. Place a rag beneath the fittings to catch excess fuel.

(10) Remove plug from timing gear cover.

(11) The "Top Dead Center" (TDC) compression firing stroke must be determined as follows:

(a) Remove the valve cover, refer to Group 9, Valve Cover Removal/Installation.

(b) Remove the right front tire and splash shield. Using a socket attached to the end of crankshaft, rotate the engine (counter—clockwise as viewed from front).

(c) Rotate the engine until cylinder #4 rockers are in between movement.

(d) Remove rocker arm assembly.

(e) Remove valve spring and keepers. **CAUTION: When the piston is at TDC there is only 2 mm (.080 thousand) clearance between the valve and piston.**

(f) Let the valve set on top of piston. Install a dial indicator to the top of the valve stem.

(g) Rotate engine back and forth to find the TDC position with the indicator on the valve stem. Mark the damper and timing cover for TDC.

NOTE: On later model 1997 engines, a hole in the bottom of the clutch housing can be lined up with a hole in the flywheel, allowing the engine to be held at TDC with a special alignment tool, part # VM1035.

(12) Remove injection pump drive gear nut (Fig. 41) and washer. **CAUTION: Be very careful not to drop the washer into the timing gear cover.**

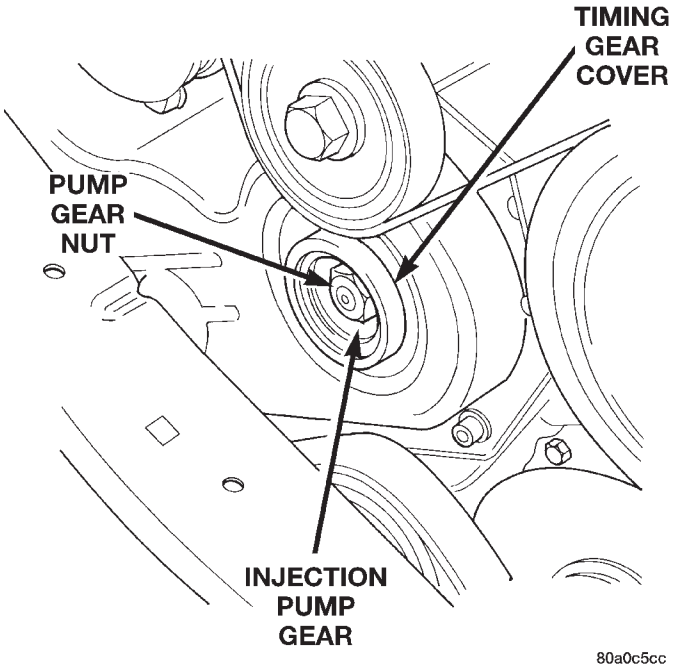


Fig. 41 Removing Pump Drive Gear Nut

(13) A special 3–piece gear removal tool set VM.1003 (Fig. 42) must be used to remove the injection pump drive gear from the pump shaft.

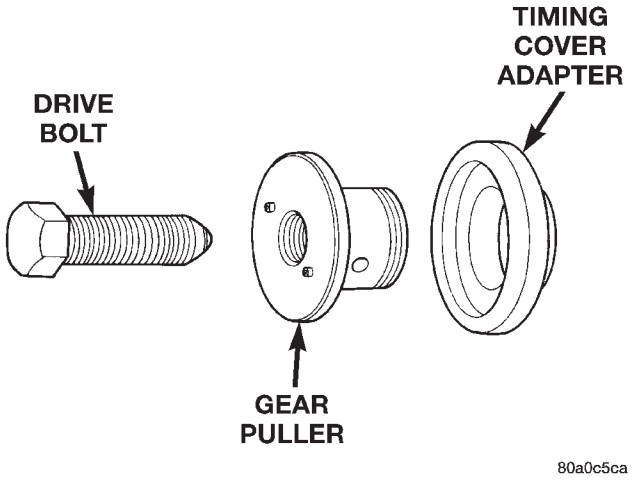


Fig. 42 Pump Gear Tools

(a) Thread the adapter (Fig. 43) into the timing cover.

(b) Thread the gear puller into the injection pump drive gear (Fig. 43). This tool is also used to hold the gear in synchronization during pump removal.

(c) Remove the three injection pump–to–gear cover mounting nuts (Fig. 44). **CAUTION: This step must be done to prevent breakage of the**

REMOVAL AND INSTALLATION (Continued)

three injection pump mounting flanges while gear is being removed.

(d) Install the drive bolt into the gear puller (Fig. 43). Tighten the drive bolt to press (remove) the drive gear from injection pump shaft while driving injection pump rearward from timing gear cover mounting studs.

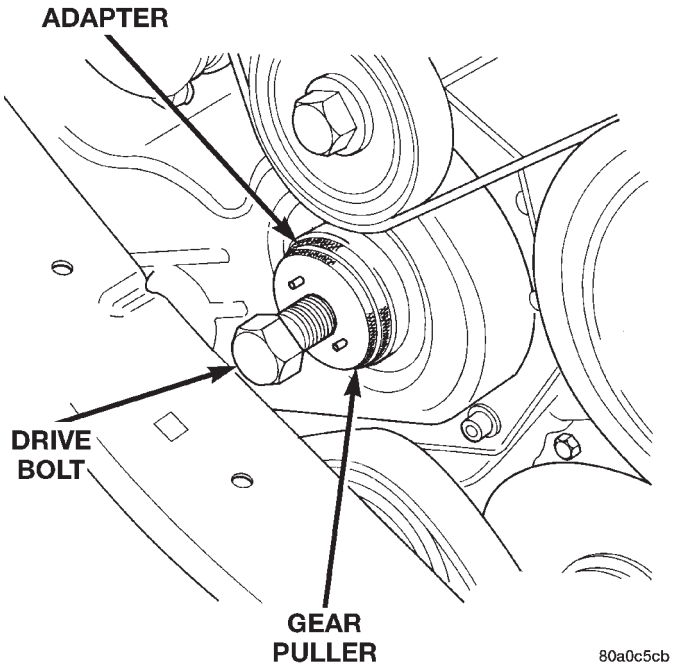


Fig. 43 Installing Pump Drive Gear Removal Tools

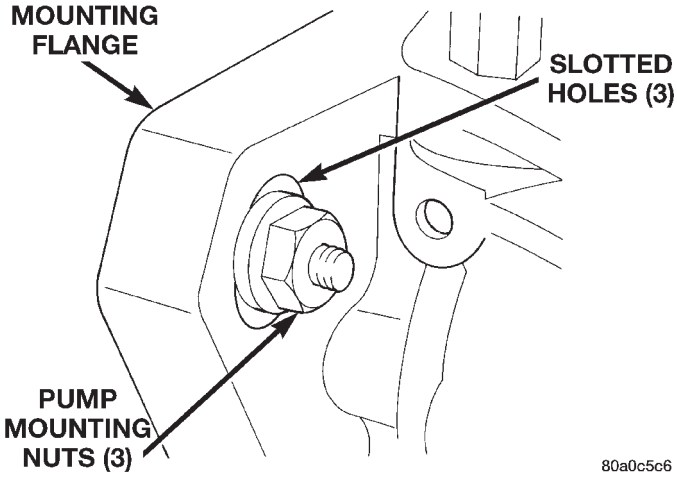


Fig. 44 Injection Pump Mounting Nuts

(14) Remove pump from engine. **Do not rotate engine while gear puller is installed. Engine damage will occur.**

INSTALLATION/ADJUSTING PUMP TIMING

(1) Clean the mating surfaces of injection pump and timing gear cover.

(2) Install a new injection pump–to–timing gear cover gasket.

(3) Remove the gear removing bolt (drive bolt) from gear puller. **CAUTION: Do not remove the special gear puller or timing cover adapter tools from timing cover at this time. Gear misalignment will result.**

(4) Place the key way on the pump shaft to the 11 o'clock position as viewed from the front of pump. Install the pump into the rear of timing gear cover while aligning key way on pump shaft into pump gear.

(5) Install and snug the 3 injection pump mounting nuts. This is not the final tightening sequence.

(6) Remove the special gear puller and adapter tools from timing gear cover.

(7) Install the injection pump drive gear nut and washer. Tighten nut to 88 N·m (65 ft. lbs.) torque.

(8) Remove access plug and plug washer at rear of pump (Fig. 45). Thread special dial indicator adapter tool VM.1011 (Fig. 46) into this opening. Hand tighten only.

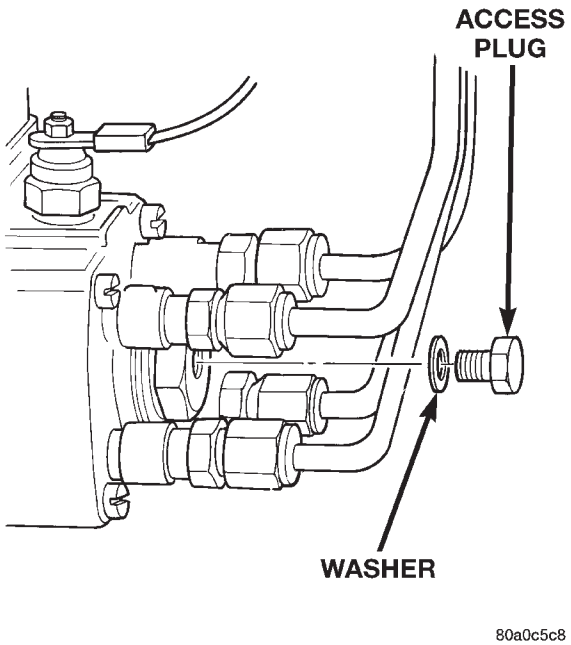


Fig. 45 Access Plug at Rear of Pump

(9) Attach special dial indicator tool VM.1013 into the adapter tool (Fig. 46).

(10) Using a socket attached to the end of crankshaft, rotate the engine (counter—clockwise as viewed from front) until thedial indicator stops moving. This rotation is about 20° to 30°.

(11) Set the dial indicator to 0 mm. Be sure the tip of dial indicator is touching the tip inside the adapter tool.

(12) Very slowly rotate the crankshaft clockwise until movement on dial indicator needle has stopped. **Do not rotate crankshaft after needle movement has stopped. Engine should be at TDC at this point**

(13) Check the TDC dial indicator for TDC.

REMOVAL AND INSTALLATION (Continued)

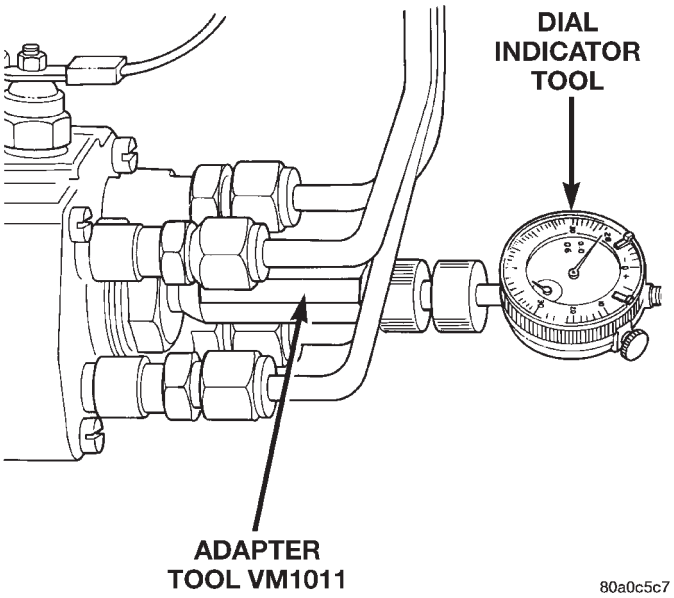


Fig. 46 Installing Dial Indicator and Special Adapter Tools

(14) Gauge reading should be at 0.60 mm. If not, the pump must be rotated for adjustment:

(a) Loosen the three injection pump mounting nuts at the mounting flanges. These flanges are equipped with slotted holes. The slotted holes are used to rotate and position the injection pump for fuel timing. Loosen the three nuts just enough to rotate the pump.

(b) Rotate the pump **clockwise** (as viewed from front) until .60 mm is indicated on the dial indicator gauge.

(c) Tighten the three pump mounting nuts to 30 N·m (22 ft. lbs.) torque.

(d) Recheck the dial indicator after tightening the pump mounting nuts. Gauge should still be reading 0.60 mm. Loosen pump mounting nuts and readjust if necessary.

(15) Remove dial indicator and adapter tools.

(16) Install access plug and washer to rear of injection pump.

(17) Install plug at timing gear cover.

(18) Remove dial indicator from valve stem.

(19) Install valve spring and keepers.

(20) Install rocker arm assembly and tighten nuts.

(21) Install and connect the four high–pressure fuel lines to the fuel injection pump. Also connect fuel lines at the fuel injectors. For procedures, refer to High–Pressure Fuel Lines in this group.

(22) Install electrical connector at engine coolant temperature sensor.

(23) Connect electrical connector at fuel shutdown solenoid.

(24) Connect the main engine wiring harness to the glow plugs.

(25) Connect the fuel timing solenoid pigtail harness to the engine wiring harness.

(26) Connect the overflow valve/banjo fitting (fuel return line assembly). Replace copper gaskets before installing.

(27) Connect the rubber fuel return and supply hoses to metal lines at pump. Tighten hose clamps to 2 N·m (20 in. lbs.) torque.

(28) Install generator assembly.

(29) Install engine accessory drive belt. Refer to Group 7, Cooling System for procedures.

(30) Install negative battery cable to battery.

(31) Start the engine and bring to normal operating temperature.

(32) Check for fuel leaks.

FUEL INJECTORS

Four fuel injectors are used on each engine. Of these four, two different types are used. The fuel injector used on cylinder number one is equipped with a fuel injector sensor (Fig. 47). The other three fuel injectors are identical. **Do not place the fuel injector equipped with the fuel injector sensor into any other location except the cylinder number one position.**

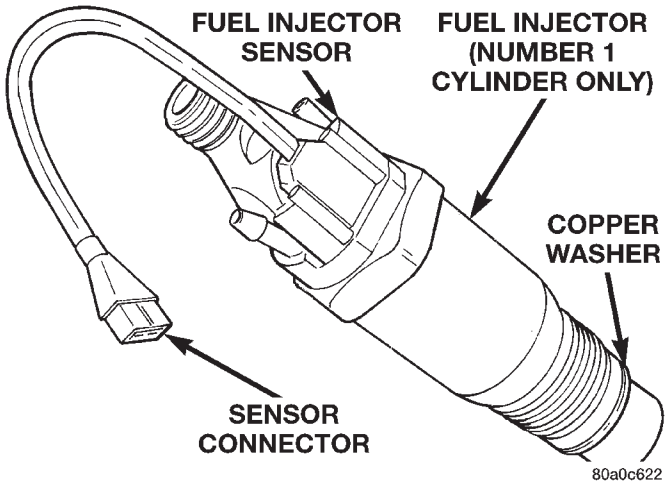


Fig. 47 Fuel Injector Sensor—Number–1 Cylinder

REMOVAL

(1) Disconnect negative battery cable at battery.

(2) Thoroughly clean the area around the injector with compressed air.

(3) Remove the fuel drain hoses (tubes) at each injector (Fig. 48) being serviced. Each of these hoses is slip–fit to the fitting on injector.

(4) Remove the high–pressure fuel line at injector being removed. Refer to High–Pressure Fuel Lines in this group for procedures.

(5) Remove the injector using special socket tool number VM.1012A. When removing cylinder number

REMOVAL AND INSTALLATION (Continued)

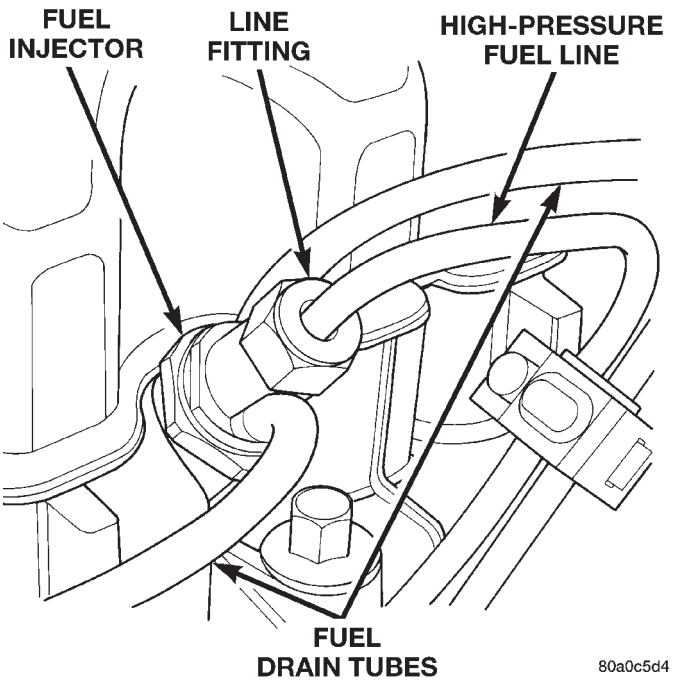


Fig. 48 Fuel Injector—Typical

one injector, thread the wiring harness through the access hole on the special socket (Fig. 49).

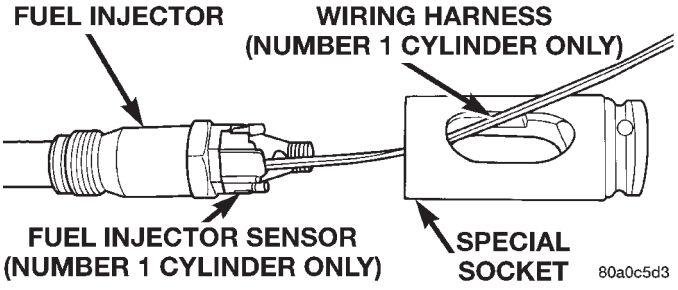


Fig. 49 Wiring Harness Through Socket

(6) Remove and discard the copper washer (seal) at bottom of injector (Fig. 47).

INSTALLATION

(1) Clean the injector threads in cylinder head.

(2) Install new copper washer (seal) to injector.

(3) Install injector to engine. Tighten to 70 N·m (52 ft. lbs.) torque.

(4) Install high–pressure fuel lines. Refer to High–Pressure Fuel Lines in this group for procedures.

(5) Install fuel drain hoses (tubes) to each injector. Do not use clamps at fuel drain hoses.

(6) Connect negative battery cable to battery.

(7) Bleed the air from the high–pressure lines. Refer to the Air Bleed Procedure section of this group.

FUEL SHUTDOWN SOLENOID

The solenoid is mounted to the rear of the injection pump (Fig. 50).

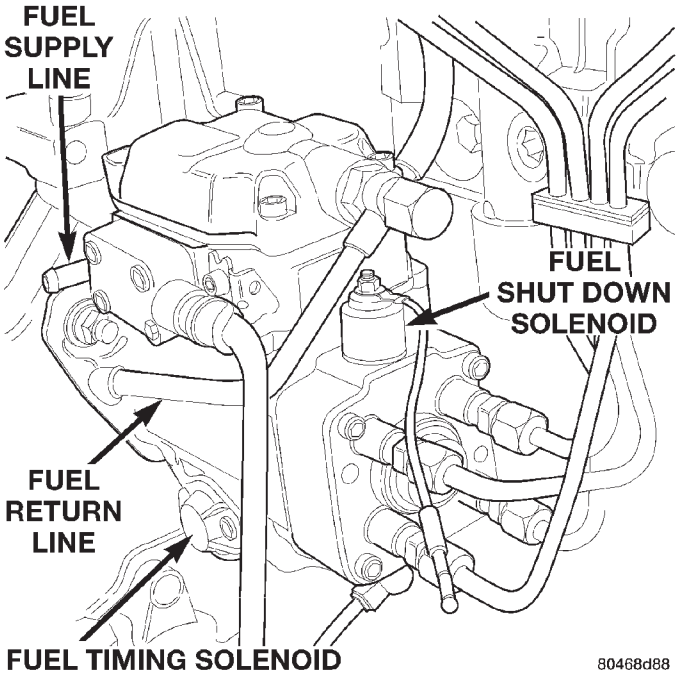


Fig. 50 Fuel Shutdown Solenoid Location

REMOVAL

(1) Thoroughly clean the area around the solenoid with compressed air.

(2) Disconnect the fuel return line and banjo fitting above the solenoid by removing (un–threading) the overflow valve (Fig. 50). Place a towel below the valve before removal. Discard old sealing washers after removal.

(3) Disconnect the electrical connector nut (Fig. 50).

(4) Remove wiring at solenoid.

(5) Remove solenoid from injection pump.

INSTALLATION

(1) Install solenoid into injection pump.

(2) Install wiring and nut at solenoid.

(3) Install new sealing washers to banjo fitting.

(4) Install overflow valve, banjo fitting and fuel return line to pump.

(5) Bleed air from system. Refer to Air Bleed Procedures in this section of the group.

FUEL TANK

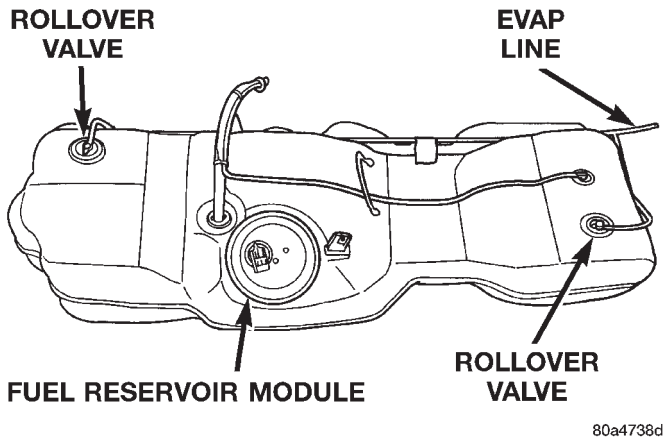
REMOVAL

(1) Disconnect negative cable from battery.

(2) Insert fuel siphon hose into fuel filler neck and push it into the tank.

(3) Drain fuel tank dry into holding tank or a properly labeled **diesel** safety container.

REMOVAL AND INSTALLATION (Continued)



Fuel Tank

(4) Raise vehicle on hoist.

(5) Disconnect both the fuel fill and fuel vent rubber hoses at the fuel tank.

(6) Disconnect fuel supply and return lines from the steel supply line (Fig. 51).

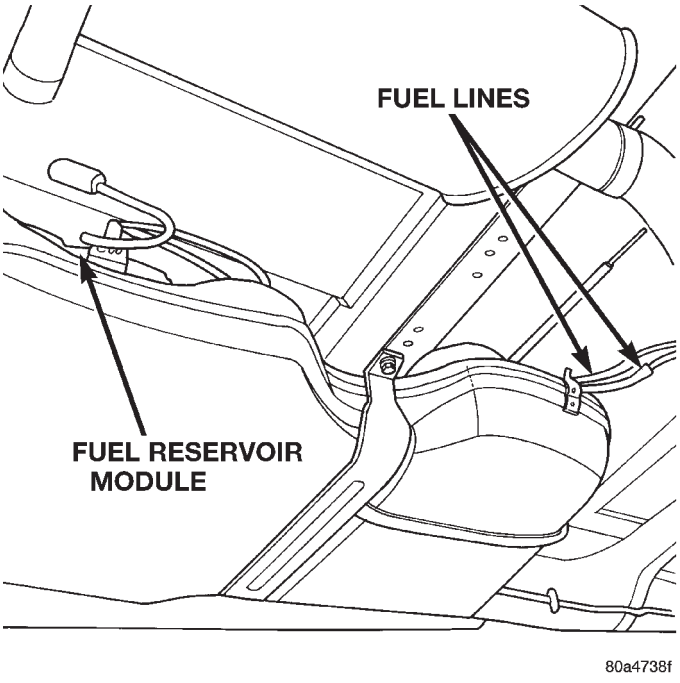


Fig. 51 Fuel Tank and Lines

The fuel reservoir module electrical connector has a retainer that locks it in place.

(7) Slide electrical connector lock to unlock (Fig. 52).

(8) Push down on connector retainer (Fig. 53) and pull connector off module.

(9) Use a transmission jack to support fuel tank. Remove bolts from fuel tank straps.

(10) Lower tank slightly. Carefully remove filler hose from tank.

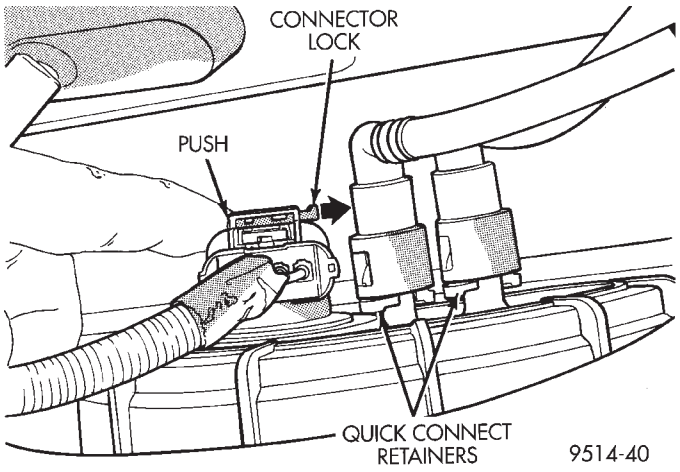


Fig. 52 Fuel Line Retainers and Pump Connector Lock

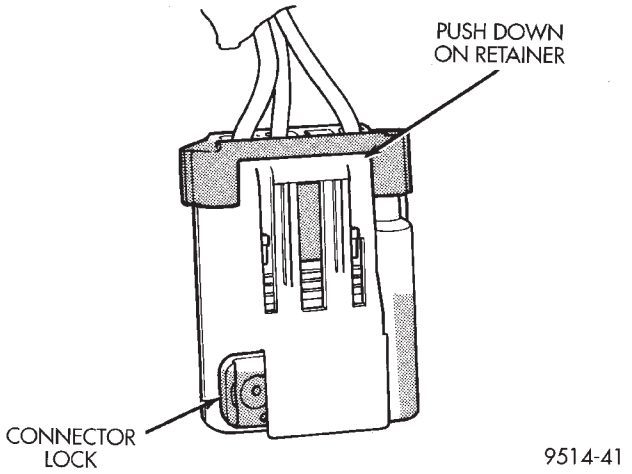


Fig. 53 Module Connector Retainer and Lock

(11) Lower the fuel tank. Remove clamp and remove fuel filler tube vent hose. Remove fuel tank from vehicle.

INSTALLATION

(1) Position fuel tank on transmission jack. Connect fuel filler tube vent hose and replace clamp.

(2) Raise tank into position and carefully work filler tube into tank. A light coating of clean engine oil on the tube end may be used to aid assembly.

(3) Feed filler vent line thru frame rail. Careful not to cross lines.

(4) Tighten strap bolts to 54 N·m (40 ft. lbs.) torque. Remove transmission jack.

CAUTION: Ensure straps are not twisted or bent before or after tightening strap nuts.

(5) Connect module electrical connector. Place retainer in locked position.

(6) Lubricate the fuel supply and return lines with clean 30 weight engine oil, install the quick connect

REMOVAL AND INSTALLATION (Continued)

fuel fitting. Refer to Tube/Fitting Assembly in the Fuel Delivery section of this Group.

(7) Attach filler line to filler tube. Pull on connector to make sure of connection.

(8) Fill fuel tank, replace cap, and connect battery negative cable.

FUEL RESERVOIR MODULE

REMOVAL

WARNING: THE FUEL RESERVOIR OF THE FUEL MODULE DOES NOT EMPTY OUT WHEN THE TANK IS DRAINED. THE FUEL IN THE RESERVOIR WILL SPILL OUT WHEN THE MODULE IS REMOVED.

(1) Disconnect negative cable from battery.

(2) Insert fuel siphon hose into fuel filler neck and push it into the tank.

(3) Drain fuel tank dry into holding tank or a properly labeled **diesel** safety container.

(4) Raise vehicle on hoist.

(5) Use a transmission jack to support the fuel tank. Remove bolts from fuel tank straps. Lower tank slightly.

(6) Clean area around fuel reservoir module and tank to keep dirt and foreign material out of tank.

(7) Disconnect fuel lines from fuel module by depressing quick connect retainers with thumb and fore finger (Fig. 54).

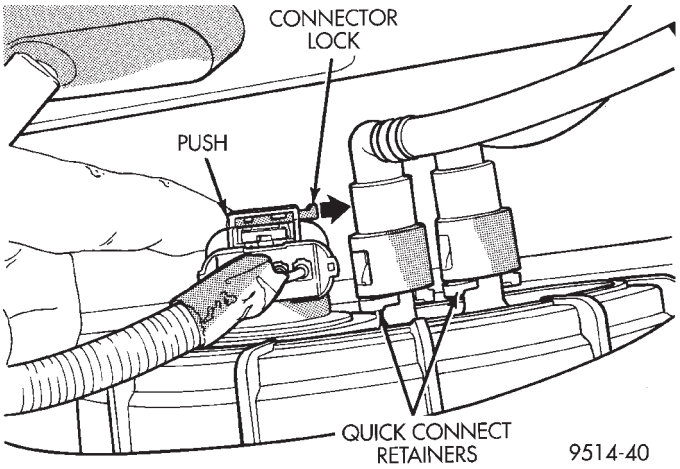


Fig. 54 Fuel Line Retainers and Pump Connector Lock

(8) Slide module electrical connector lock to unlock.

(9) Push down on connector retainer (Fig. 55) and pull connector off module.

(10) Using Special Tool 6856, remove plastic locknut counterclockwise to release pump module (Fig. 56).

(11) Carefully remove module and O-ring from tank (Fig. 57).

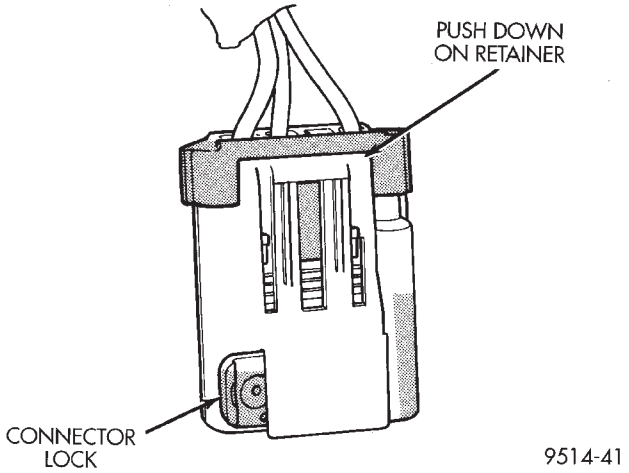


Fig. 55 Module Connector Retainer and Lock

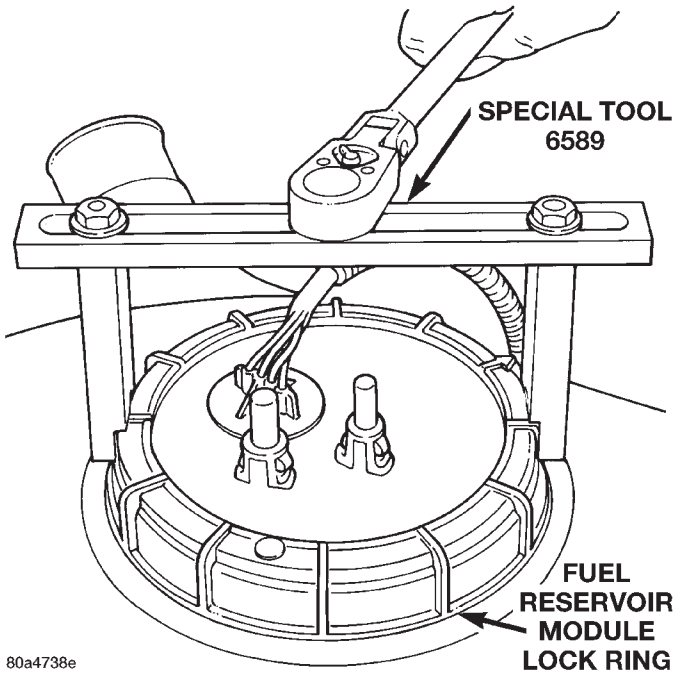


Fig. 56 Fuel Reservoir Module Lock Nut Removal

(12) Discard old O-ring.

INSTALLATION

(1) Wipe seal area of tank clean and place a new O-ring seal in position on pump.

(2) Position fuel reservoir module in tank with locknut.

(3) Tighten locknut to 58 N·m (43 ft. lbs.).

(4) Connect fuel lines.

(5) Plug in electrical connector. Slide connector lock into position.

(6) Raise fuel tank, install bolts into fuel tank straps and tighten.

(7) Lower vehicle on hoist.

(8) Connect negative cable from battery.

(9) Fill fuel tank. Check for leaks.

(10) Install fuel filler cap.

REMOVAL AND INSTALLATION (Continued)

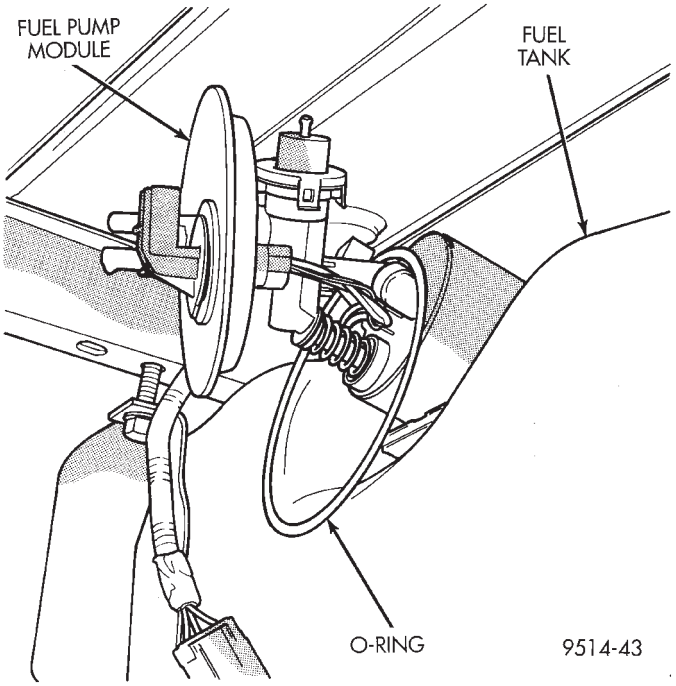


Fig. 57 Fuel Reservoir Module Removal

HIGH-PRESSURE LINES

All high–pressure fuel lines are of the same length and inside diameter. Correct high–pressure fuel line usage and installation is critical to smooth engine operation.

CAUTION: The high–pressure fuel lines must be clamped securely in place in the holders. The lines cannot contact each other or other components. Do not attempt to weld high–pressure fuel lines or to repair lines that are damaged. Only use the recommended lines when replacement of high–pressure fuel line is necessary.

REMOVAL

(1) Disconnect negative battery cable from battery.

(2) Remove the necessary clamps (Fig. 58) holding the lines to the engine.

(3) Clean the area around each fuel line connection. Disconnect each line at the top of each fuel injector (Fig. 59).

(4) Disconnect each high–pressure line fitting at each fuel injection pump delivery valve.

(5) Very carefully remove each line from the engine. Note the position (firing order) of each line while removing. **Do not bend the line while removing.**

CAUTION: Be sure that the high–pressure fuel lines are installed in the same order that they were removed. Prevent the injection pump delivery valve holders (Fig. 58) from turning when removing or installing high–pressure lines from injection pump.

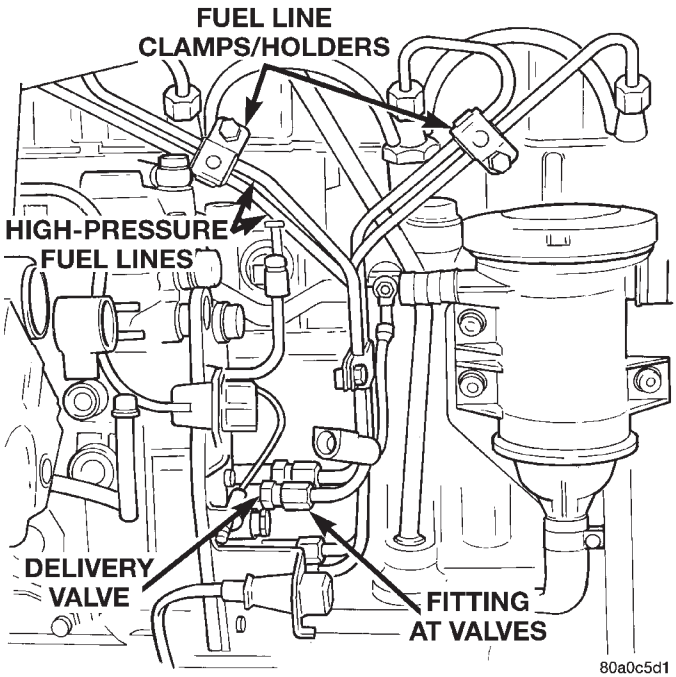


Fig. 58 Fuel Lines and Clamps/Holders

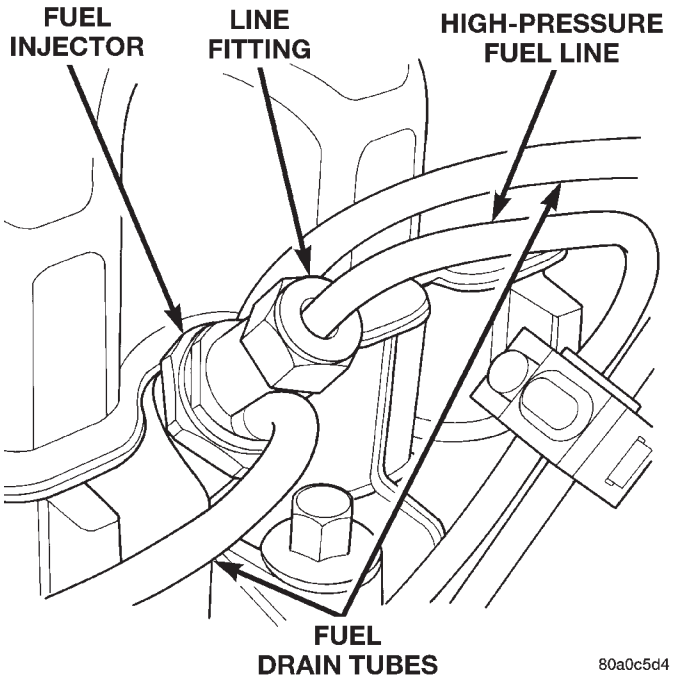


Fig. 59 Fuel Lines at Fuel Injectors

INSTALLATION

(1) Carefully position each high–pressure fuel line to the fuel injector and fuel injection pump delivery valve holder in the correct firing order. Also position each line in the correct line holder.

(2) Loosely install the line clamp/holder bolts.

(3) Tighten each line at the delivery valve to 30 N·m (22 ft. lbs.) torque.

(4) Tighten each line at the fuel injector to 30 N·m (22 ft. lbs.) torque.

REMOVAL AND INSTALLATION (Continued)

Be sure the lines are not contacting each other or any other component.

(5) Tighten the clamp bracket bolts to 24 N·m (18 ft. lbs.) torque.

(6) Bleed air from the fuel system. Refer to the Air Bleed Procedure section of this group.

SPECIFICATIONS

FUEL TANK CAPACITY

75 Liters (20.0 Gals.)

Nominal refill capacities are shown. A variation may be observed from vehicle to vehicle due to manufacturing tolerances, ambient temperatures and refill procedures.

IDLE SPEED

900 rpm ±25 rpm with engine at normal operating temperature.

FUEL INJECTOR FIRING SEQUENCE

1–3–4–2

FUEL SYSTEM PRESSURE

Peak Injection Pressure/Fuel Injection Pump Operating Pressure: 40,000–45,000 kPa (5801–6526 psi).

Opening Pressure of Fuel Injector: 15,000–15,800 kPa (2175–2291 psi).

FUEL DELIVERY SYSTEM—2.0L ENGINE

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FUEL DELIVERY SYSTEM

Refer to the Fuel Delivery Sytem in the Fuel Delivery Section of group 14 for the 2.4/3.0/3.3/3.8L engines for more information.

FUEL PUMP MODULE

Refer to the Fuel Pump Module for the 2.4/3.0/3.3/3.8L engines in the Fuel Delivery System section of group 14.

ELECTRIC FUEL PUMP

Refer to the Electric Fuel Pump for the 2.4/3.0/3.3/3.8L engines in the Fuel Delivery System Section of group 14 for more information.

FUEL LEVEL SENSOR

Refer to the Fuel Level Sensor for the 2.4/3.0/3.3/3.8L engines in the Fuel Delivery System section of group 14 for more information.

FUEL PRESSURE REGULATOR

Refer to the Fuel Pressure Regulator for the 2.4/3.0/3.3/3.8L engines in the Fuel Delivery System section of group 14 for more information.

FUEL INJECTORS

Refer to the Fuel Injectors for the 2.4/3.0/3.3/3.8L engines in the Fuel Delivery System section of group 14 for more information.

FUEL TANK

Refer to the Fuel Tank for the 2.4/3.0/3.3/3.8L engines in the Fuel Delivery System section of group 14 for more information.

PRESSURE-VACUUM FILLER CAP—2.0L ENGINE

Refer to the Pressure-Vacuum Filler Cap for the 2.4/3.0/3.3/3.8L engines in the Fuel Delivery System section of group 14 for more information.

QUICK-CONNNECT FITTINGS—2.0L ENGINE

Refer to the Quick Connect Fittings for the 2.4/3.0/3.3/3.8L engines in the Fuel Delivery System section of group 14 for more information.

DIAGNOSIS AND TESTING

FUEL PUMP PRESSURE TEST—2.0L ENGINE

Refer to the Fuel Pressure Test for the 2.4/3.0/3.3/3.8L engines in the Fuel Delivery System section of group 14 for more information.

FUEL LEVEL SENSOR—2.0L ENGINE

Refer to the Fuel Level Sensor for the 2.4/3.0/3.3/3.8L engines in the Fuel Delivery System section of group 14 for more information.

DIAGNOSIS AND TESTING (Continued)

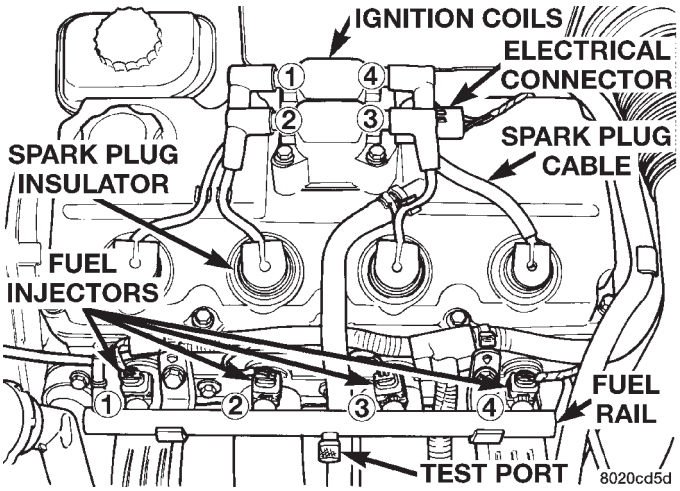

Fig. 1 Fuel Pressure Test Port—2.0L

FUEL INJECTORS—2.0L ENGINE

Refer to the Fuel Injectors for the 2.4/3.0/3.3/3.8L engines in the Fuel Delivery System section of group 14 for more information.

SERVICE PROCEDURES

FUEL SYSTEM PRESSURE RELEASE PROCEDURE—2.0L ENGINE

Refer to the Fuel System Pressure Release Procedure for the 2.4/3.0/3.3/3.8L engines in the Fuel Delivery System section of group 14 for more information.

HOSES AND CLAMPS—2.0L ENGINE

Refer to Hoses and Clamps for the 2.4/3.0/3.3/3.8L engines in the Fuel Delivery System section of group 14 for more information.

QUICK-CONNNECT FITTINGS—2.0L ENGINE

Refer to the Quick Connect Fittings for the 2.4/3.0/3.3/3.8L engines under Service Procedures in the Fuel Delivery System section of group 14 for more information.

REMOVAL AND INSTALLATION

FUEL FILTER—2.0L ENGINE

Refer to the Fuel Filter for the 2.4/3.0/3.3/3.8L engines under Removal and Installation in the Fuel Delivery System section of group 14 for more information.

FUEL PUMP MODULE—2.0L ENGINE

Refer to the Fuel Pump Module for the 2.4/3.0/3.3/3.8L engines under Removal and Installation in the Fuel Delivery System section of group 14 for more information.

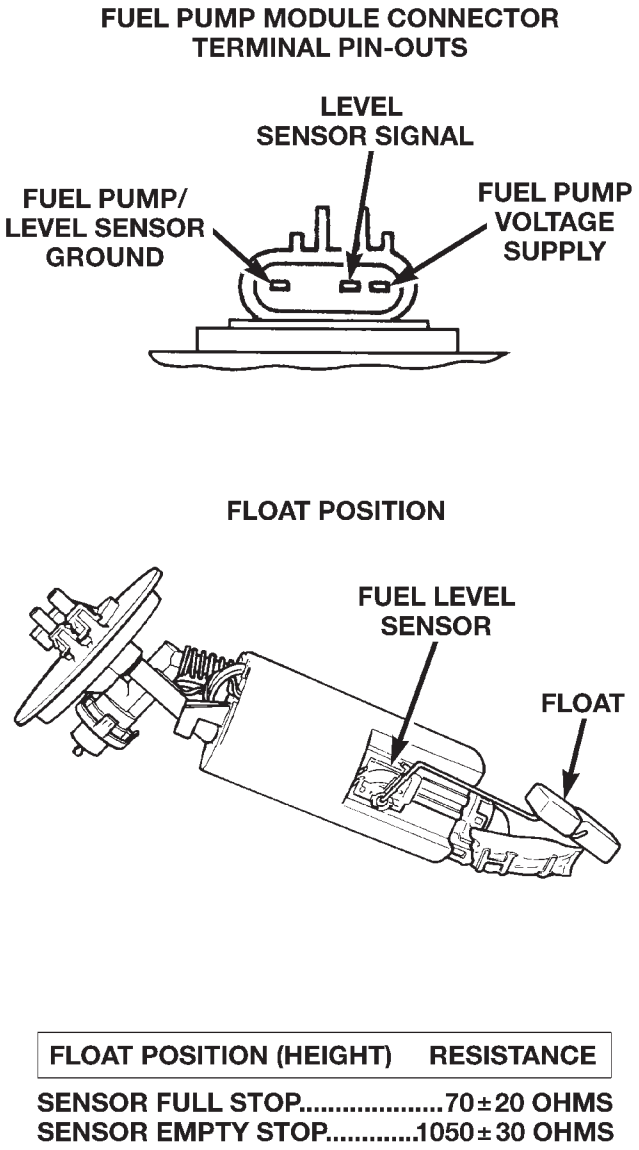

Fig. 2 FUEL LEVEL SENSOR DIAGNOSIS

FUEL PRESSURE REGULATOR—2.0L ENGINE

Refer to the Fuel Pressure Rgulator for the 2.4/3.0/3.3/3.8L engines under Removal and Installation in the Fuel Delivery System section of group 14 for more information.

FUEL PRESSURE REGULATOR—2.0L ENGINE

Refer to the Fuel Pressure Regulator for the 2.4/3.0/3.3/3.8L engines under Removal and Installation in the Fuel Delivery System section of group 14 for more information.

REMOVAL AND INSTALLATION (Continued)

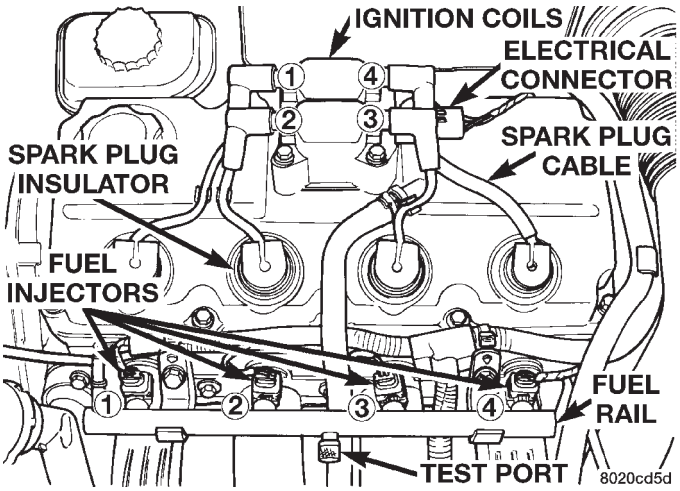

Fig. 3 Fuel Pressure Test Port—2.0L

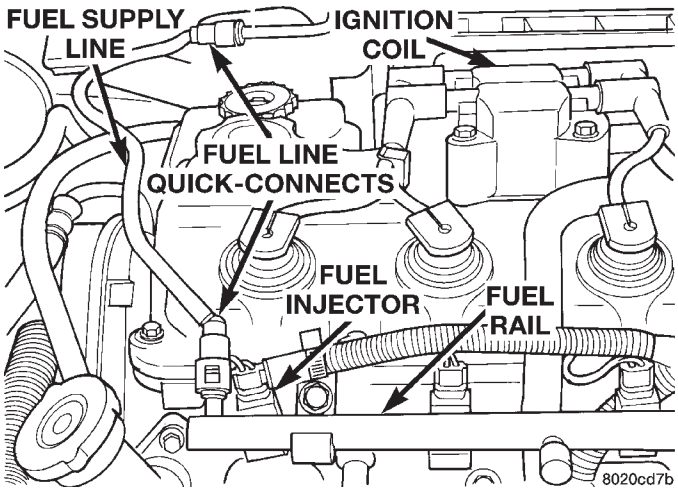

Fig. 4 Fuel Rail and Injectors

FUEL LEVEL SENSOR—2.0L ENGINE

Refer to the Fuel Pump Inlet Strainer for the 2.4/3.0/3.3/3.8L engines under Removal and Installation in the Fuel Delivery System section of group 14 for more information.

FUEL TANK—2.0L ENGINE

Refer to the Fuel Tank for the 2.4/3.0/3.3/3.8L engines under Removal and Installation in the Fuel Delivery System section of group 14 for more information.

FUEL INJECTORS

REMOVAL

(1) Disconnect negative cable from battery.

(2) Release fuel system pressure. Refer to Fuel System Pressure Release procedure in this section.

(3) Disconnect fuel supply tube from rail. Refer to Quick-Connect Fittings in the Fuel Delivery section of this group.

(4) Disconnect electrical connectors from fuel injectors (Fig. 4).

(5) Remove fuel rail mounting screws.

(6) Lift rail off of intake manifold. Cover the fuel injector openings in the intake manifold.

(7) Remove fuel injector retainer (Fig. 5).

(8) Pull injector out of fuel rail. Replace fuel injector O-rings (Fig. 6).

INSTALLATION

(1) Apply a light coating of clean engine oil to the upper O-ring.

(2) Install injector in cup on fuel rail.

(3) Install retaining clip.

(4) Apply a light coating of clean engine oil to the O-ring on the nozzle end of each injector.

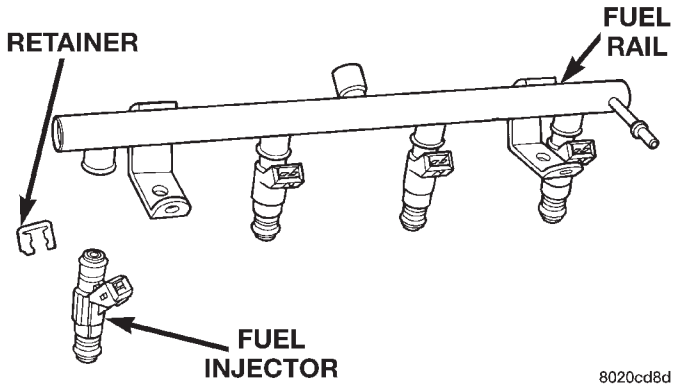

Fig. 5 Fuel Injector Retainer

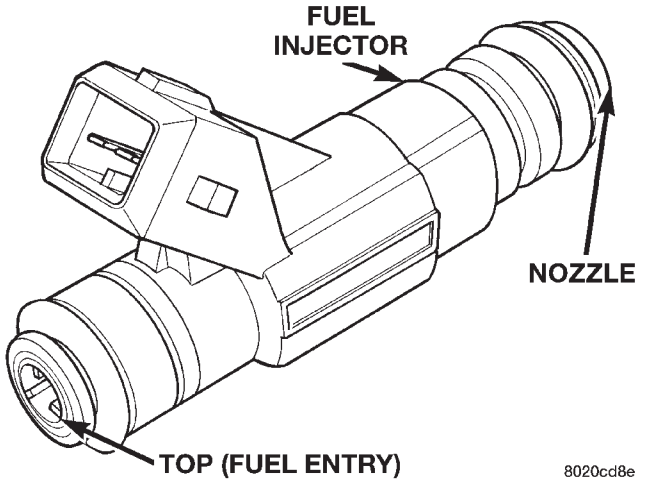

Fig. 6 Fuel Injector O-Rings

(5) Insert fuel injector nozzles into openings in intake manifold. Seat the injectors in place. Tighten fuel rail mounting screws to 22.5 N·m ± 3 N·m (200±30 in. lbs.).

(6) Attach electrical connectors to fuel injectors.

REMOVAL AND INSTALLATION (Continued)

(7) Connect fuel supply tube to fuel rail. Refer to Quick Connect Fittings in the Fuel Delivery Section of this Group.

ACCELERATOR PEDAL

Refer to the Accelerator Pedal for the 2.4/3.0/.3.3/ 3.8L engines under Removal and Installation in the Fuel Delivery section of group 14 for more information.

TORQUE SPECIFICATION

DESCRIPTION	TORQUE
Accelerator Pedal to Dash Nuts	12 N·m (105 in. lbs.)
Fuel Pump Module Locknut	58 N·m (43 ft. lbs.)
Fuel Tank Strap Bolts	54 N·m (40 ft lbs.)
Fuel Rail Bolts	23 N·m (195 in. lbs.)
Ignition Coil Mounting Bolts	11 N·m (95 in. lbs.)
Intake Manifold Bolts	11 N·m (95 in. lbs.)
Throttle Control Shield	5.6 N·m (50 in. lbs.)

FUEL INJECTION SYSTEM—2.0L ENGINE

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INTRODUCTION—2.0L ENGINE

Refer to the Introduction for 2.4/3.0/3.3/3.8L engines under General Information in the Fuel Injection System section of group 14 for more information.

MODES OF OPERATION—2.0L ENGINE

Refer to the Modes of Operation for 2.4/3.0/3.3/3.8L engines under General Information in the Fuel Injection System section of group 14 for more information.

DESCRIPTION AND OPERATION

SYSTEM DIAGNOSIS—2.0L ENGINE

Refer to System diagnosis for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

POWERTRAIN CONTROL MODULE—2.0L ENGINE

Refer to the Powertrain Control Module for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

AIR CONDITIONING PRESSURE TRANSDUCER—PCM INPUT—2.0L ENGINE

Refer to the Air Conditioning Pressure Transducer for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

AIR CONDITIONING SWITCH SENSE—PCM INPUT—2.0L ENGINE

Refer to the Air Conditioning Switch Sense for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

AUTOMATIC SHUTDOWN (ASD) SENSE—PCM INPUT—2.0L ENGINE

Refer to the Automatic Shutdown (ASD) Sense for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

BATTERY VOLTAGE—PCM INPUT—2.0L ENGINE

Refer to the Battery Voltage for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

CAMSHAFT POSITION SENSOR—PCM INPUT—2.0L ENGINE

Refer to the Camshaft Position Sensor for 2.4L engine under Description and Operation in the Fuel Injection System section of group 14 for more information.

CRANKSHAFT POSITION SENSOR—PCM INPUT—2.0L ENGINE

Refer to the Crankshaft Position Sensor for 2.4L engine under Description and Operation in the Fuel Injection System section of group 14 for more information.

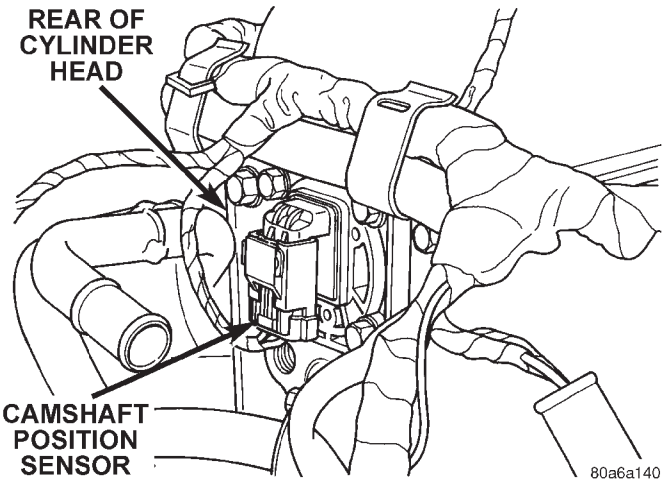

Fig. 1 Camshaft Position Sensor—2.0L Engine

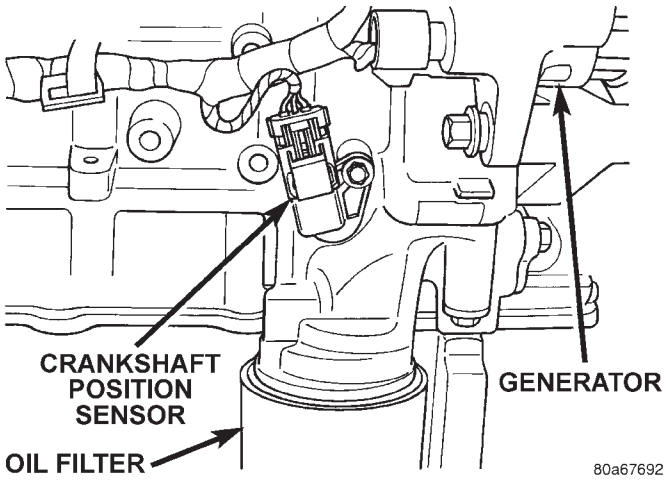

Fig. 2 Crankshaft Posistion Sensor—2.0L engine

ENGINE COOLANT TEMPERATURE SENSOR—PCM INPUT—2.0L ENGINE

The coolant temperature sensor threads into the rear of the cylinder head, next to the camshaft position sensor (Fig. 3). New sensors have sealant applied to the threads.

Refer to the Engine Coolant Temperature Sensor for the 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

HEATED OXYGEN SENSOR—PCM INPUT—2.0L ENGINE

Refer to the Heated Oxygen Sensor for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

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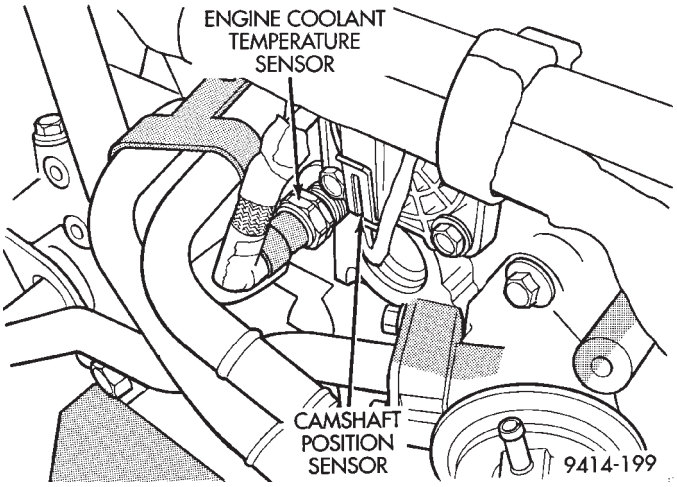


Fig. 3 Engine Coolant Temperature Sensor—2.0L engine

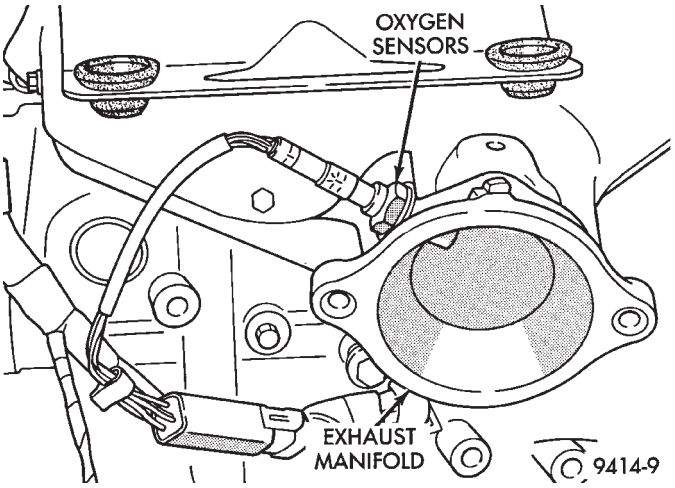


Fig. 4 Upstream Heated Oxygen Sensor—2.0L Engine

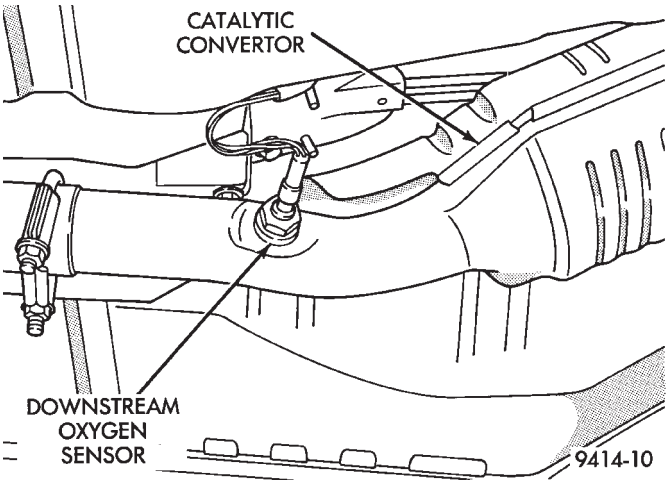


Fig. 5 Downstream Heated Oxygen Sensor—2.0L Engine

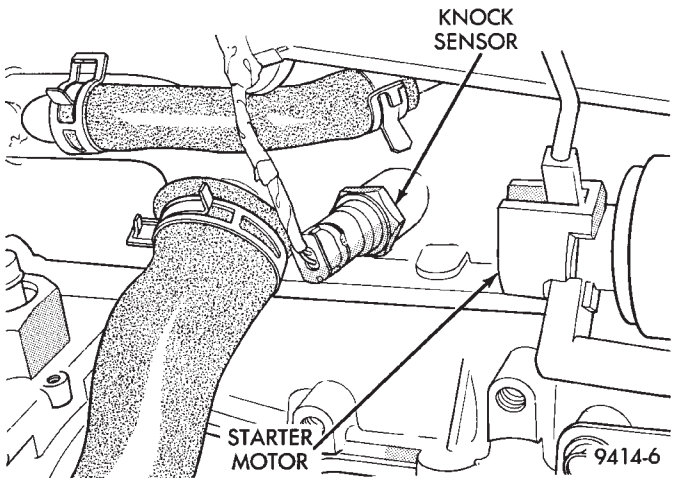


Fig. 6 Knock Sensor—2.0L engine

KNOCK SENSOR—PCM INPUT—2.0L ENGINE

Refer to the Knock Sensor for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

MANIFOLD ABSOLUTE PRESSURE (MAP SENSOR)—PCM INPUT—2.0L ENGINE

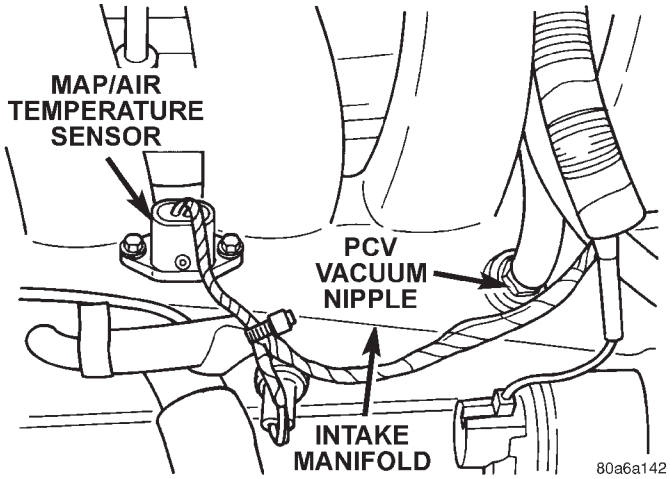


Fig. 7 MAP/IAT sensor—2.0L engine

Refer to the Manifold Absolute Pressure and Intake Air Temperature sensors for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

SPEED CONTROL—PCM INPUT—2.0L ENGINE

Refer to the Speed Control for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

DESCRIPTION AND OPERATION (Continued)

THROTTLE POSITION SENSOR/ IDLE AIR CONTROL MOTOR—PCM INPUT—2.0L ENGINE

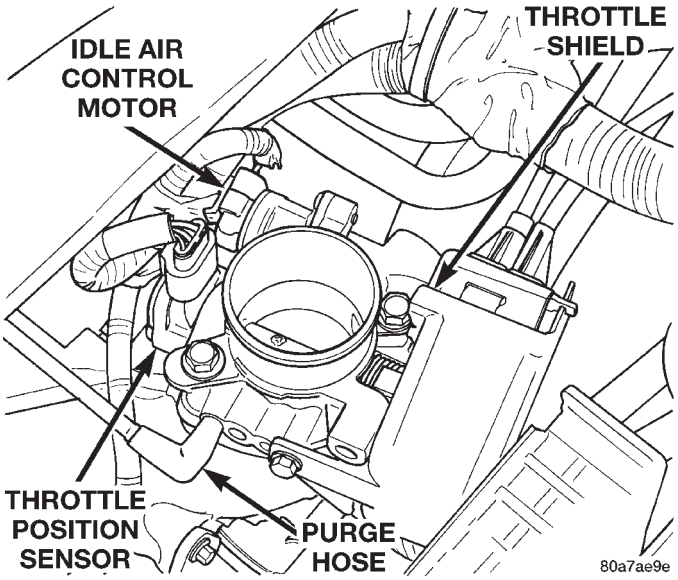


Fig. 8 Throttle Position Sensor/Idle Air Control motor—2.0L engine

Refer to the Throttle Control and Idle Air Control motor for the 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

AIR CONDITIONING (A/C) RELAY—PCM OUTPUT—2.0L ENGINE

Refer to the Air Conditioning relay for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

GENERATOR FIELD—PCM OUTPUT—2.0L ENGINE

Refer to Generator Field for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

AUTOMATIC SHUTDOWN RELAY—PCM OUTPUT—2.0L ENGINE

Refer to Automatic Shutdown Relay for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

FUEL PUMP RELAY—PCM OUTPUT—2.0L ENGINE

Refer to the Fuel Pump Relay for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

STARTER RELAY—PCM OUTPUT—2.0L ENGINE

Refer to the Starter Relay for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

IDLE AIR CONTROL MOTOR—PCM OUTPUT—2.0L ENGINE

Refer to the Idle Air Control Motor for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information. Refer to (Fig. 8) for component location

ELECTRONIC EGR TRANSDUCER—PCM OUTPUT—2.0L ENGINE

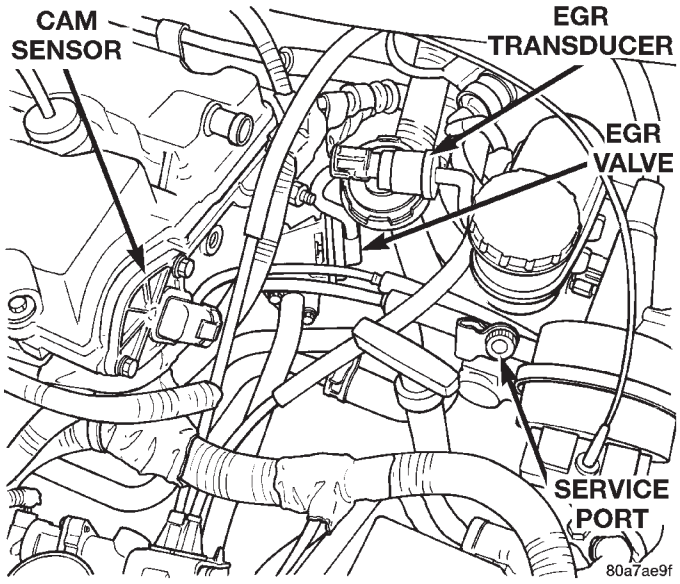


Fig. 9 Electronic EGR Transducer—2.0L engine

Refer to the Electronic EGR Transducer for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

DATA LINK CONNECTOR—PCM OUTPUT—2.0L ENGINE

Refer to the Data Link Connector for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

FUEL INJECTORS—PCM OUTPUT—2.0L ENGINE

Refer to the Fuel Injectors for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

DESCRIPTION AND OPERATION (Continued)

IGNITION COIL—PCM OUTPUT—2.0L ENGINE

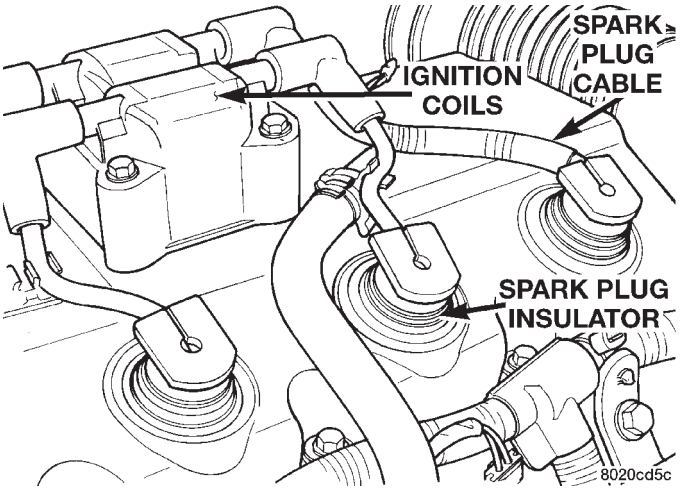


Fig. 10 Ignition Coil—2.0L engine

Refer to the Ignition Coil for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

MALFUNCTION INDICATOR (CHECK ENGINE) LAMP—PCM OUTPUT—2.0L ENGINE

Refer to the Malfunction Indicator Lamp for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

RADIATOR FAN CONTROL MODULE—PCM OUTPUT—2.0L ENGINE

Refer to the Radiator Fan Control Module for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

SPEED CONTROL SOLENOIDS—PCM OUTPUT—2.0L ENGINE

Refer to the Speed Control Solenoids for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

TACHOMETER—PCM OUTPUT—2.0L ENGINE

Refer to the Tachometer for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

THROTTLE BODY—2.0L ENGINE

Refer to the Throttle Body for 2.4/3.0/3.3/3.8L engines under Description and Operation in the Fuel Injection System section of group 14 for more information.

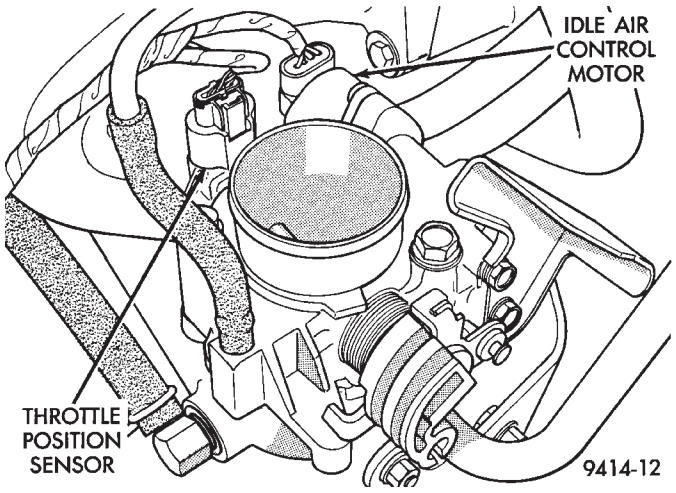


Fig. 11 Throttle Body—2.0L engine

DIAGNOSIS AND TESTING

VISUAL INSPECTION—SOHC

Before diagnosing or servicing the fuel injection system, perform a visual inspection for loose, disconnected, or misrouted wires and hoses. A thorough visual inspection that includes the following checks saves unnecessary test and diagnostic time.

(1) Inspect the battery connections. Clean corroded terminals.

(2) Check the 2 PCM 40-way connector for stretched wires on pushed out terminals

(3) Open the Power Distribution Center (PDC). Check for blown fuses. Ensure the relays and fuses are fully seated in the PDC. A label on the underside of the PDC cover shows the locations of each relay and fuse.

(4) Verify the throttle cable operates freely.

(5) Check the electrical connections at the idle air control motor and throttle position sensor.

(6) Check hose connections between the PCV valve, vacuum port - intake manifold and the oil separator (Fig. 13).

(7) Inspect the electrical connections at the MAP sensor/intake air temperature sensor and the (Fig. 14).

(8) Inspect the fuel injector electrical connections (Fig. 15).

(9) Inspect the ignition coil electrical connector. Ensure the spark plug insulators are firmly seated over the spark plugs (Fig. 16).

(10) Check the electrical connection to the radiator fan.

(11) Inspect for corrosion on the electrical connections at the starter motor solenoid. Check the ground cable connection below the starter motor (Fig. 17).

(12) Inspect the air cleaner filter element. Replace as necessary. Check the air induction system for restrictions.

DIAGNOSIS AND TESTING (Continued)

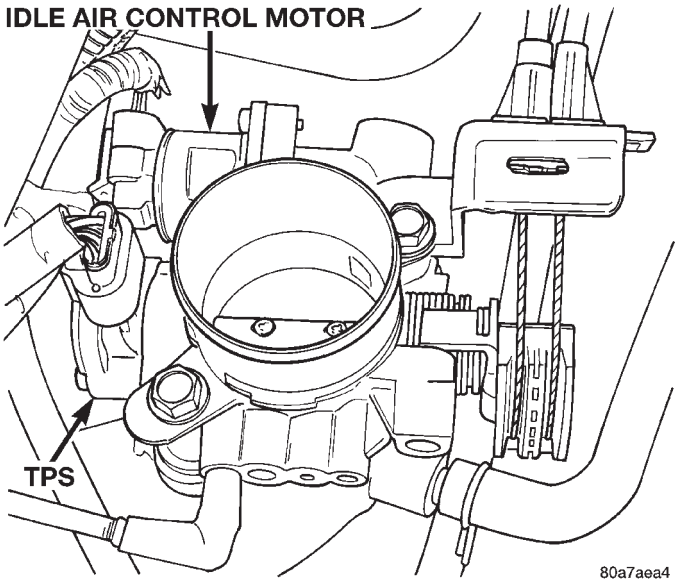


Fig. 12 Idle Air Control Motor and Throttle Position Sensor—Typical

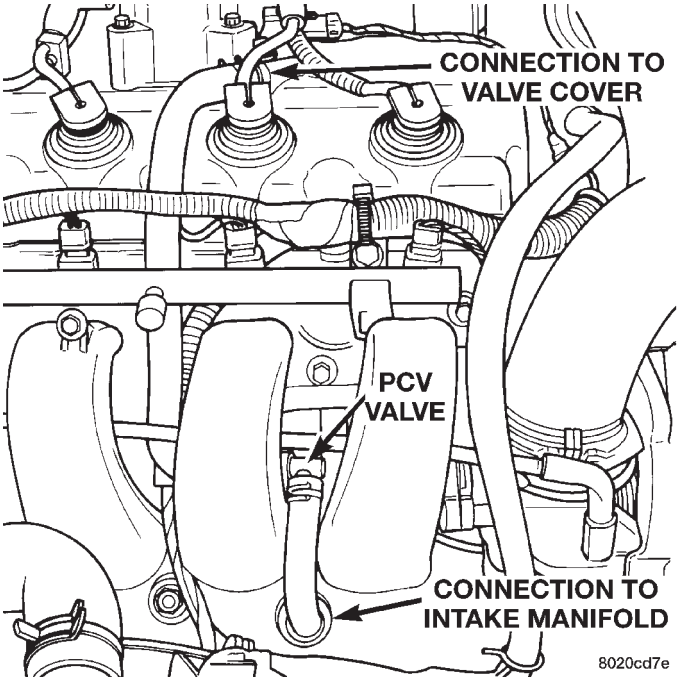


Fig. 13 PCV Valve

(13) Check the electrical connection at the knock sensor (Fig. 18).

(14) Check the electrical connections at the camshaft position sensor and engine coolant temperature sensor (Fig. 19).

(15) Check the electrical connector at the Electronic EGR Transducer. Inspect the vacuum and back pressure hoses at the solenoid and transducer for leaks (Fig. 20).

(16) Inspect the electrical connections at the generator (Fig. 21). Check the generator belt for glazing or damage.

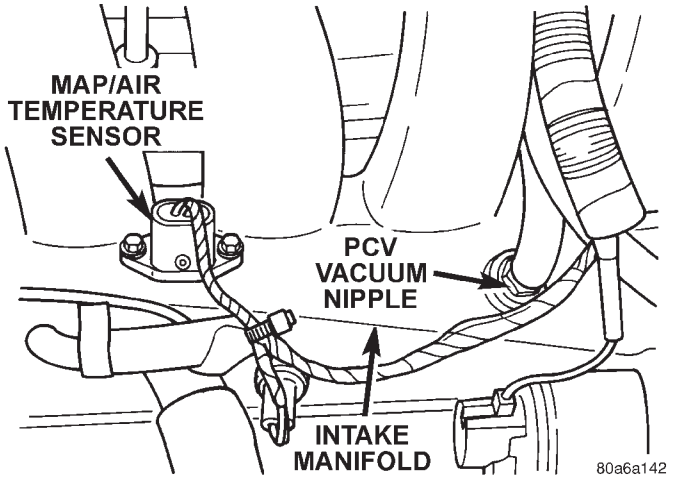


Fig. 14 MAP/Intake Air Temperature Sensor

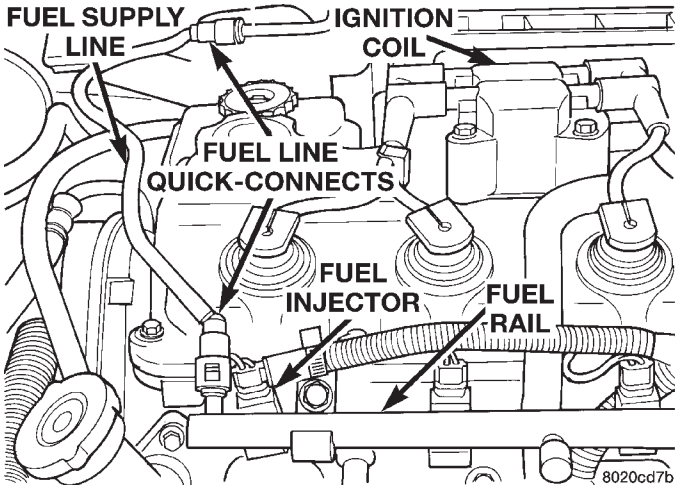


Fig. 15 Fuel Injectors

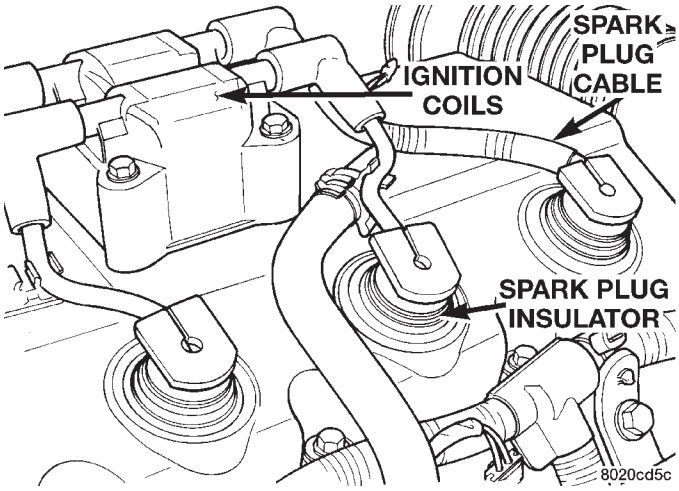


Fig. 16 Ignition Coil and Spark Plugs—Typical

(17) Inspect the electrical connector at the crankshaft position sensor (Fig. 22).

(18) Check the electrical connection at the vehicle speed sensor (Fig. 23).

DIAGNOSIS AND TESTING (Continued)

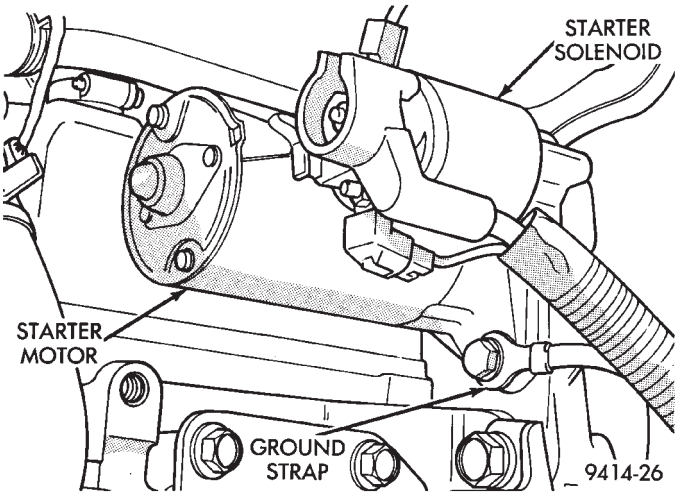


Fig. 17 Starter Motor and Ground Strap

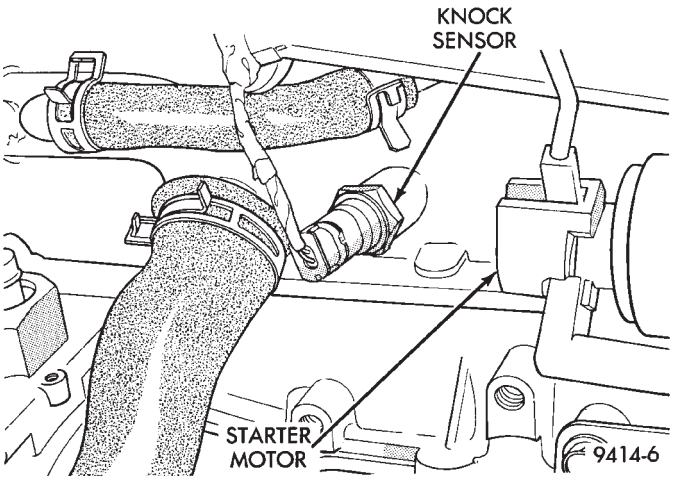


Fig. 18 Knock Sensor

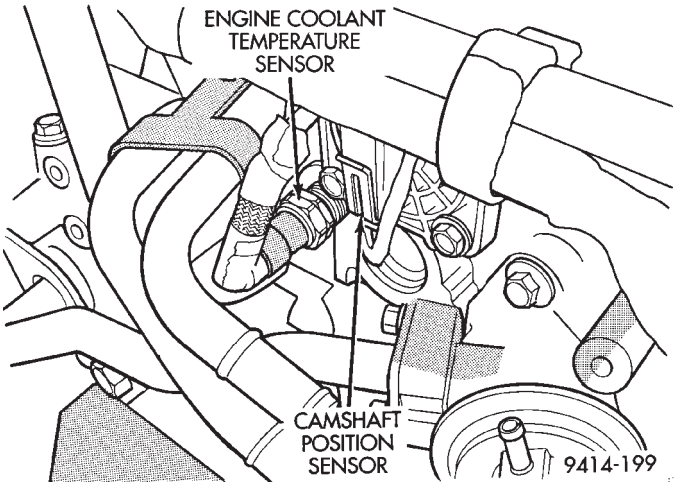


Fig. 19 Camshaft Position Sensor and Engine Coolant Temperature Sensor

(19) Check the electrical connection at the power steering pressure switch on the power steering gear housing (Fig. 24).

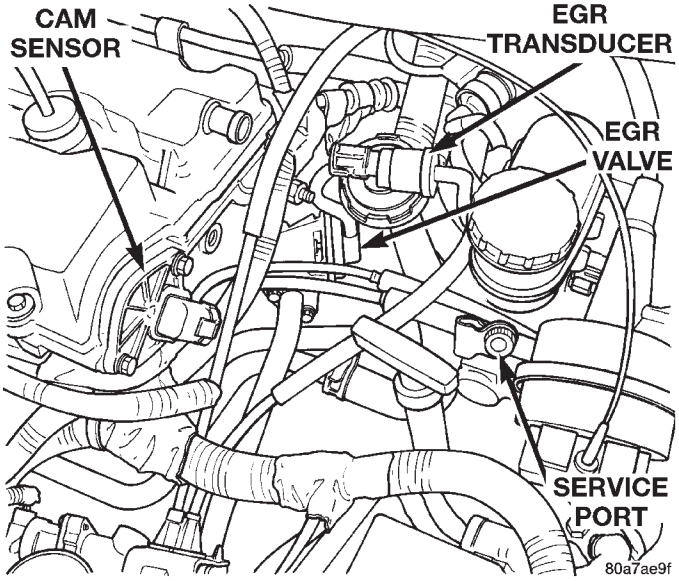


Fig. 20 Electronic EGR Transducer

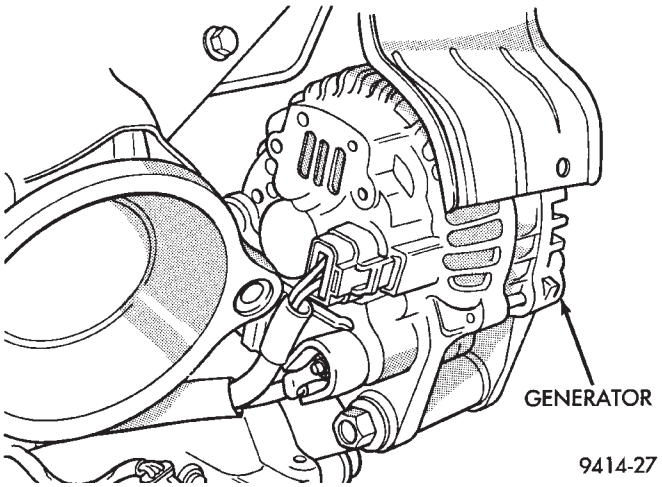


Fig. 21 Generator

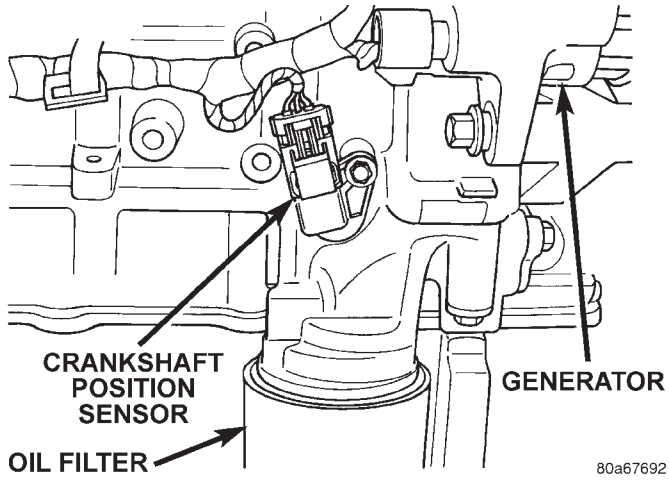


Fig. 22 Crankshaft Position Sensor

DIAGNOSIS AND TESTING (Continued)

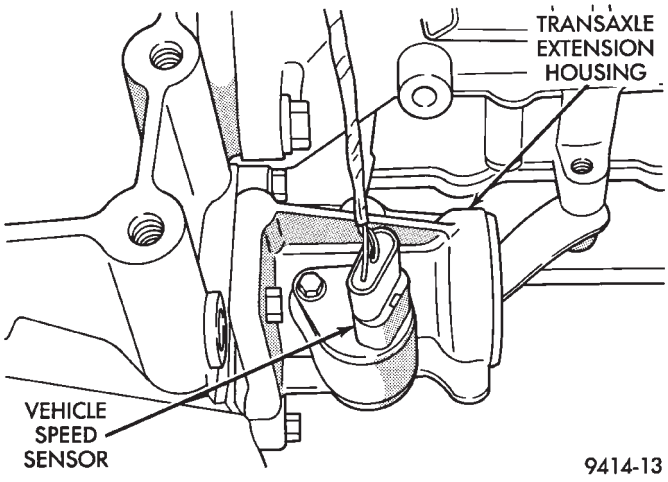


Fig. 23 Vehicle Speed Sensor

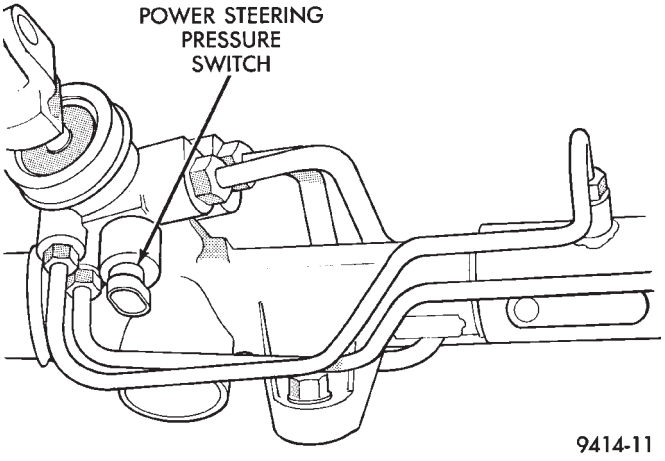


Fig. 24 Power Steering Pressure Switch

(20) Inspect the electrical connections at the upstream and downstream heated oxygen sensors (Fig. 25) and (Fig. 26).

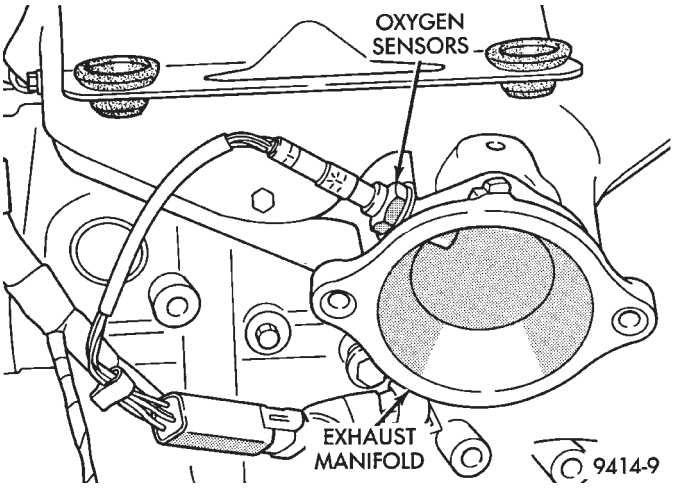


Fig. 25 Upstream Heated Oxygen Sensor

(21) Inspect the fuel pump module electrical connection at the fuel tank for corrosion or damage (Fig. 27). Check for pinched, kinked or damaged fuel supply tube.

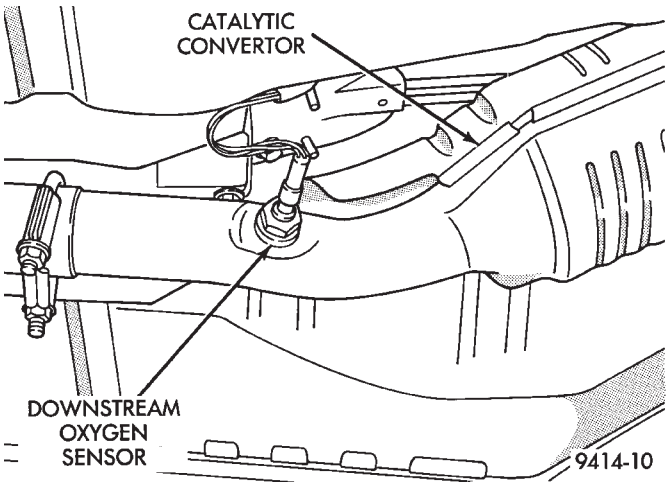


Fig. 26 Downstream Heated Oxygen Sensor

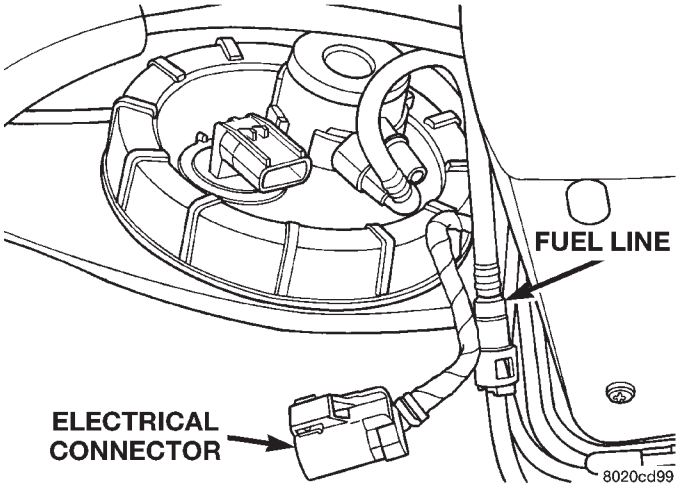


Fig. 27 Fuel Pump Module Electrical Connector

(22) Inspect the connections to the speed control servo, if equipped. Refer to Group 8H, Vehicle Speed Control.

(23) Inspect the connection at the battery temperature sensor.

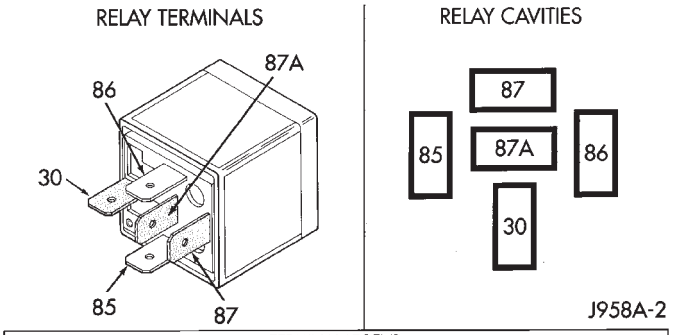
ASD AND FUEL PUMP RELAYS—2.0L ENGINE

Refer to the ASD and Fuel Pump Relays for 2.4/3.0/3.3/3.8L engines under Diagnosis and Testing in the Fuel Injection System section of group 14 for more information.

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR—2.0L ENGINE

To perform a complete test of the MAP sensor and its circuitry, refer to the DRB scan tool and appropriate Powertrain Diagnostics Procedures manual. To test the MAP sensor only, refer to the following:

DIAGNOSIS AND TESTING (Continued)



TERMINAL LEGEND	
NUMBER	IDENTIFICATION
30	COMMON FEED
85	COIL GROUND
86	COIL BATTERY
87	NORMALLY OPEN
87A	NORMALLY CLOSED

Fig. 28 ASD and Fuel Pump Relay Terminals

CAUTION: When testing the MAP sensor, be sure that the harness wires are not damaged by the test meter probes.

(1) Test the MAP sensor output voltage at the MAP sensor connector between terminals 1 and 4 (Fig. 29). With the ignition switch ON and the engine not running, output voltage should be 4 to 5 volts. The voltage should drop to 1.5 to 2.1 volts with a hot, neutral idle speed condition. If OK, go to next step. If not OK, go to step 3.

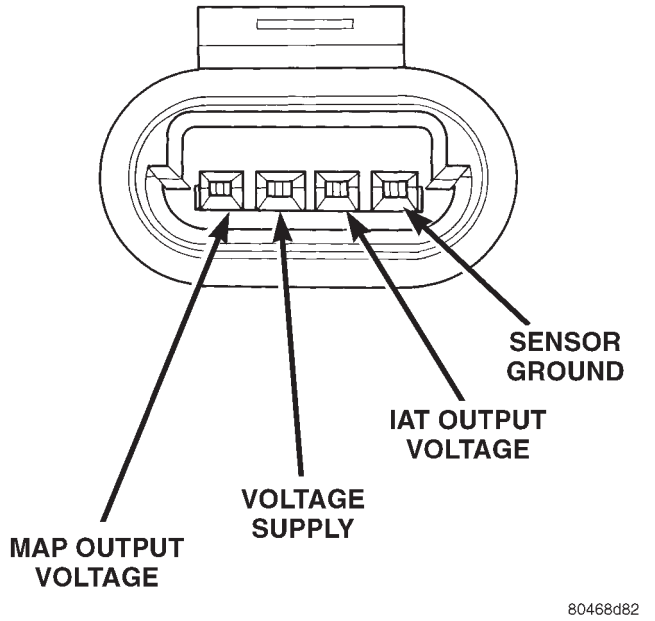


Fig. 29 MAP Sensor Connector

(2) Test PCM terminal 36 for the same voltage described in the previous step to verify wire harness condition. Repair as required.

(3) Test the MAP sensor ground circuit at sensor connector terminal 1 and PCM terminal 43. If OK, go to next step. If not OK, repair as required.

(4) Test MAP sensor supply voltage between sensor connector terminals 3 and 1 with the key ON. The voltage should be approximately 5 volts (±.5V). Five volts (±.5V) should also be at terminal 61 of the PCM. If OK, replace MAP sensor. If not OK, repair or replace the wire harness as required.

KNOCK SENSOR—2.0L ENGINE

The knock sensor output voltage to the PCM can be read with the DRB III scan tool. Sensor output should be between 80 mV and 4 volts with the engine running between 576 and 2208 rpm. If the output falls outside of this range a DTC will be set.

CAMSHAFT AND CRANKSHAFT POSITION SENSOR

Refer to Group 8D, Ignition for Diagnosis and Testing of Camshaft and Crankshaft Sensors.

ENGINE COOLANT TEMPERATURE SENSOR

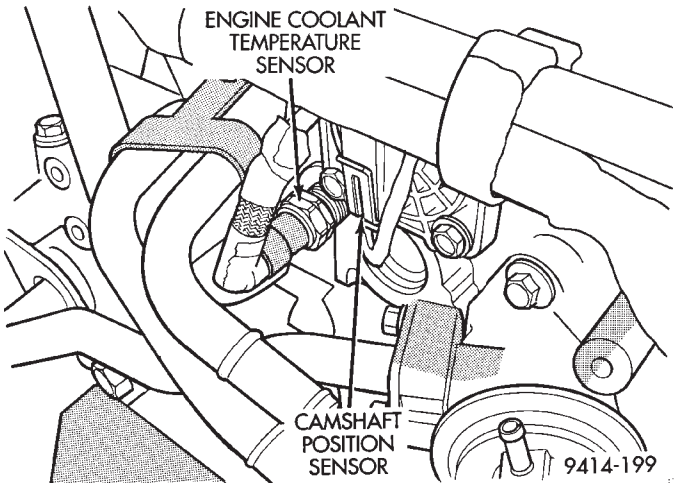


Fig. 30 Engine Coolant Temperature Sensor Location—SOHC

Refer to the Engine Coolant Temperature sensor for the 2.4/3.0/3.3/3.8L engines under Diagnosis and Testing in the Fuel Injection System section of group 14 for more information.

THROTTLE POSITION SENSOR

To perform a complete test of the this sensor and its circuitry, the DRB III scan tool is the best method. To test the throttle position sensor only, refer to the following:

The Throttle Position Sensor (TPS) can be tested with a digital voltmeter (DVM). The center terminal of the sensor is the output terminal. One of the other terminals is a 5 volt supply and the remaining terminal is ground.

DIAGNOSIS AND TESTING (Continued)

Connect the DVM between the center and sensor ground terminal. Refer to Group 8W - Wiring Diagrams for correct pinout.

With the ignition switch in the ON position, check the output voltage at the center terminal wire of the connector. Check the output voltage at idle and at Wide-Open-Throttle (WOT). At idle, TPS output voltage should be approximately 0.38 volts to 1.2 volts. At wide open throttle, TPS output voltage should be approximately 3.1 volts to 4.4 volts. The output voltage should gradually increase as the throttle plate moves slowly from idle to WOT.

Check for spread terminals at the sensor and PCM connections before replacing the TPS.

THROTTLE BODY MINIMUM AIR FLOW

(1) Turn ignition key to Off.

(2) Disconnect the PCV valve hose from the intake manifold nipple (Fig. 31). Cap the PCV vacuum nipple.

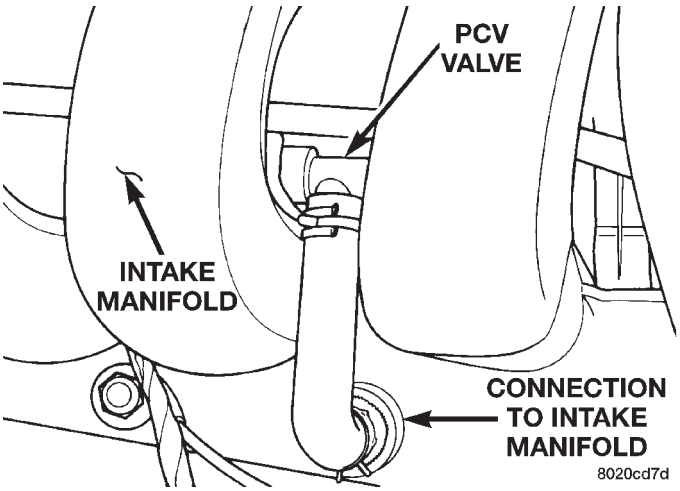


Fig. 31 PCV Vacuum Nipple

(3) Disconnect purge hose from the nipple on the throttle body (Fig. 32).

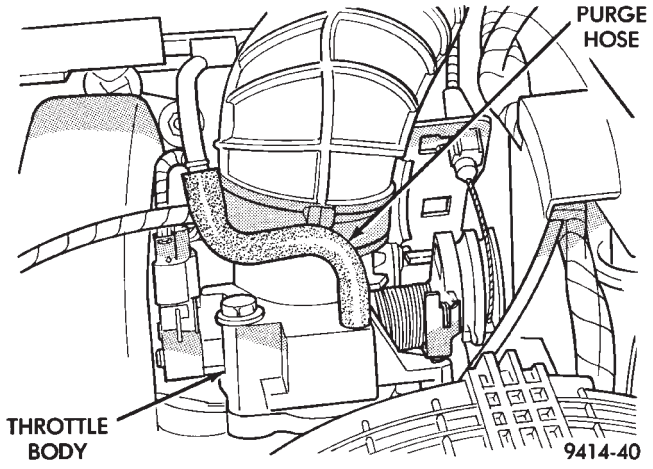


Fig. 32 Purge Hose

(4) Use a piece of hose to attach Air Metering Orifice 6457 (0.125 in. orifice) to the purge nipple on the throttle body (Fig. 33).

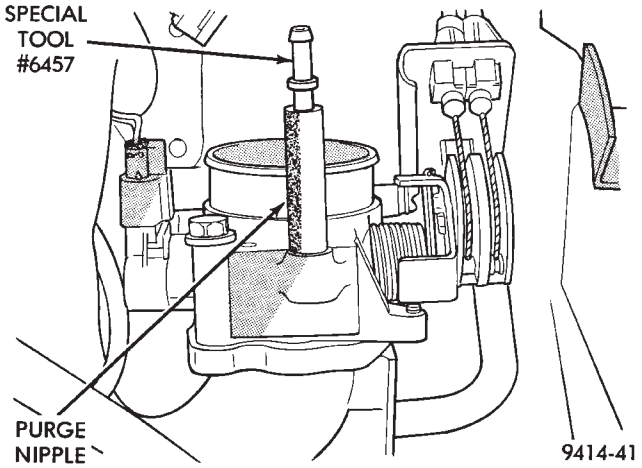


Fig. 33 Orifice 6457 Attached to Purge Nipple

(5) Ensure that all accessories are off.

(6) Connect the DRB scan tool to the data link connector inside the passenger compartment.

(7) Run engine in Park or Neutral until the cooling fan has cycled on and off at least once (180°F).

(8) Using the DRB scan tool, access Minimum Airflow Idle Speed.

(9) The following will then occur:

- Idle air control motor will fully close
- Idle spark advance will become fixed
- PCM will go open loop enriched
- DRB scan tool displays engine RPM

(10) If idle RPM is within the range shown in the Idle Specification chart, throttle body minimum airflow is set correctly.

IDLE SPECIFICATION —2.0L ENGINE

Odometer Reading	Idle RPM
Below 1000 Miles	550–1300 RPM
Above 1000 Miles	600–1300 RPM

(11) If idle RPM is above specifications, use the DRB scan tool to check idle air control motor operation. If idle air control motor is OK, replace throttle body. If idle air flow is below specification, shut off the engine and clean the throttle body as follows:

WARNING: CLEAN THROTTLE BODY IN A WELL VENTILATED AREA. WEAR RUBBER OR BUTYL GLOVES, DO NOT LET MOPAR PARTS CLEANER COME IN CONTACT WITH EYES OR SKIN. AVOID INGESTING THE CLEANER. WASH THOROUGHLY AFTER USING CLEANER.

DIAGNOSIS AND TESTING (Continued)

(a) Remove the throttle body from engine.

(b) While holding the throttle open, spray the entire throttle body bore and the manifold side of the throttle plate with Mopar Parts Cleaner. **Only use Mopar Parts Cleaner to clean the throttle body.**

(c) Using a soft scuff pad, clean the top and bottom of throttle body bore and the edges and manifold side of the throttle blade. **The edges of the throttle blade and portions of the throttle bore that are closest to the throttle blade when closed, must be free of deposits.**

(d) Use compressed air to dry the throttle body.

(e) Inspect throttle body for foreign material.

(f) Install throttle body on manifold.

(g) Repeat steps 1 through 14. If the minimum air flow is still not within specifications, the problem is not caused by the throttle body.

(12) Shut off engine.

(13) Remove Air Metering Orifice 6457. Install purge hose.

(14) Remove cap from PCV valve. Connect hose to PCV valve.

(15) Remove DRB scan tool.

SPECIFICATIONS

TORQUE

DESCRIPTION	TORQUE
Air Cleaner Wingnut	1.5 N·m (15 in. lbs.)
Air Cleaner Mount. Stud-To-Throtl. Body	10 N·m (90 in. lbs.)
Crankshaft Position Sensor Mounting Bolts	8 N·m (70 in. lbs.)
Engine Coolant Temperature Sensor	18 N·m (165 in. lbs.)
IAC Motor-To-Throttle Body Bolts	7 N·m (60 in. lbs.)
MAP/IAT Sensor	2 N·m (20 in. lbs.)
MAP/IAT Sensor	3 N·m (30 in. lbs.)
Oxygen Sensor	28 N·m (20 ft. lbs.)
Powertrain Control Module (PCM) Mounting Screws	4 N·m (35 in. lbs.)
Throttle Cable Cover	4.5 N·m (40 in. lbs.).
Throttle Body Mounting Bolts	23 N·m (200 in. lbs.)
Throttle Position Sensor Mounting Screws	2 N·m (20 in. lbs.)
Vehicle Speed Sensor Mounting Bolt	2.2 N·m (20 in. lbs.)

FUEL INJECTION SYSTEM—2.5L DIESEL ENGINE

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GENERAL INFORMATION

INTRODUCTION

This section will cover components either regulated or controlled by the Powertrain Control Module (PCM). The fuel heater relay, fuel heater and fuel gauge are not operated by the PCM. These components are controlled by the ignition (key) switch. All other fuel system electrical components necessary to operate the engine are controlled or regulated by the PCM. Refer to the following PCM description for more information.

Certain fuel system component failures may cause a no start, or prevent the engine from running. It is important to know that the PCM has a feature where, if possible, it will ignore the failed sensor, set a code related to the sensor, and operate the engine in a “Limp Home” mode. When the PCM is operating in a “Limp Home” mode, the Diesel Glow Plug lamp on the instrument panel will be constantly illuminated, and the engine will most likely have a noticeable loss of performance. An example of this would be an Accelerator Pedal Position Sensor failure, and in that situation, the engine would run at a constant 1100 RPM, regardless of the actual position of the pedal. This is the most extreme of the three “Limp Home” modes.

In addition to indicating that the glow plugs are hot enough to start combustion, the Glow Plug Lamp is also used in the diagnosis of the PCM, and when

illuminated constantly, it usually indicates a problem has been detected somewhere within the fuel system. The DRBIII scan tool is the best method for communicating with the PCM to diagnose faults within the system.

DESCRIPTION AND OPERATION

POWERTRAIN CONTROL MODULE (PCM)

The Powertrain Control Module (PCM) is mounted in the center consule to a bracket located in front of the Air Bag Module (Fig. 1).

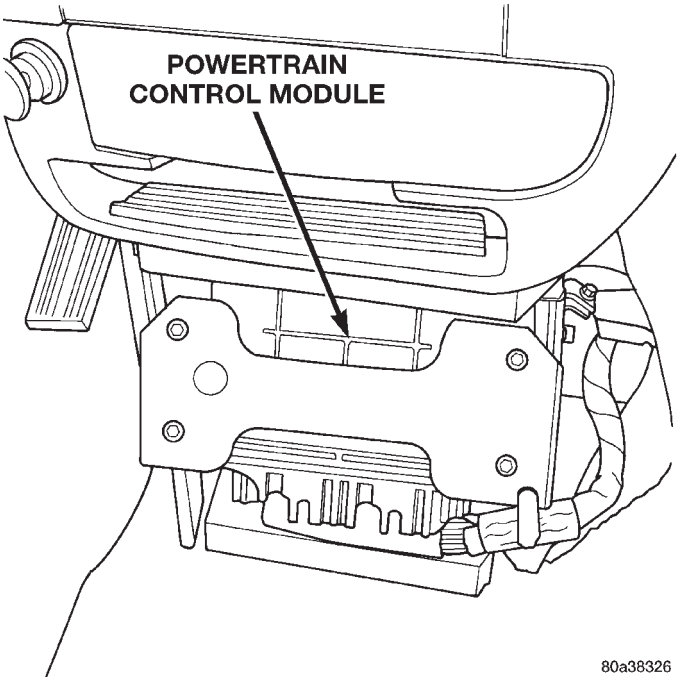

Fig. 1 PCM Location

The PCM is a pre–programmed, dual micro–processor digital computer. It will either directly operate or partially regulate the:

- Speed Control
- Speed Control LED lamp
- Fuel Timing Solenoid
- Glow Plug Relay
- Glow Plugs
- EGR Solenoid
- Glow Plug Lamp
- Diesel PCM Relay
- Air Conditioning Operation
- Tachometer
- Exhaust Gas Recirculation (EGR) Solenoid

The PCM can adapt its programming to meet changing operating conditions.

The PCM receives input signals from various switches and sensors. Based on these inputs, the PCM regulates various engine and vehicle operations through different system components. These components are referred to as **PCM Outputs.** The sensors and switches that provide inputs to the PCM are considered **PCM Inputs.**

PCM Inputs are:

- Air Conditioning Selection
- Theft Alarm
- Clutch Switch
- Diesel PCM Relay
- ISO-Protocol
- Control Sleeve
- Fuel Temperature
- Boost Pressure Sensor
- Accelerator Pedal Sensor
- EGR
- A/C Pressure
- Engine Coolant Temperature Sensor
- Low Idle Position Switch
- 5 Volt Supply
- Vehicle Speed Sensor
- Sensor Return
- Glow Plug
- Engine Speed Sensor (rpm)
- Fuel Injector #1 Sensor
- Starter Signal
- Brake Switch
- Speed Control Switch Position
- Power Ground
- Signal Ground
- Ignition (key) Switch Sense
- Battery Voltage
- SCI Receive (DRB scan tool connection)

PCM Outputs:

After inputs are received by the PCM, certain sensors, switches and components are controlled or regulated by the PCM. These are considered **PCM Outputs.** These outputs are for:

- A/C Clutch Relay (for A/C clutch operation)
- Speed Control LED
- Data Link Connectors (for DRB scan tool)
- Diesel PCM Relay
- Diesel PCM Sense
- Accelarator Pedal
- 5 Volts Supply
- Glow Plug Relay
- Fan Relay
- Fuel Quantity
- Fuel Timing Solenoid
- Fuel Shut-Off Solenoid
- Engine Speed Sensor
- Glow Plug Lamp (malfunction indicator lamp)
- Exhaust Gas Recirculation (EGR) Solenoid
- Glow Plug Relay
- Tachometer
- SCI transmit (DRB scan tool connection)

DESCRIPTION AND OPERATION (Continued)

BOOST PRESSURE SENSOR

The Boost Pressure Sensor is mounted to the top of the intake manifold. (Fig. 2) It is a sensor that measures both manifold vacuum and turbo boost, and it also contains an integrated intake air temperature sensor. The Boost Pressure Sensor takes the place of the Mass Air Flow (MAF). In the Intake Air Temperature Sensor component, there is a ceramic element that changes its resistance based on temperature. The ceramic element is part of an electronic circuit connected to the PCM, and has a voltage applied to it. The ceramic element is exposed to the air inside the intake. This air has a cooling effect on the ceramic element, and its resistance changes. This causes the voltage flowing through the intake air temperature circuit to vary. The voltage signal produced by the Intake Air Temperature Sensor changes inversely to the temperature, and is measured by the PCM. As a general rule, when the temperature of the air in the intake is high, the voltage signal produced by the Intake Air Temperature Sensor is low. The component of the Boost Pressure Sensor that measures manifold vacuum and turbo boost produces a voltage signal that is proportional to the pressure in the inake manifold. When the intake manifold pressure is low, the voltage is low, and when the pressure is high, the voltage is high. The PCM uses the voltage signals from the Boost Pressure Sensor, and the Intake Air Temperature Sensor to determine the amount of air flowing through the intake manifold.

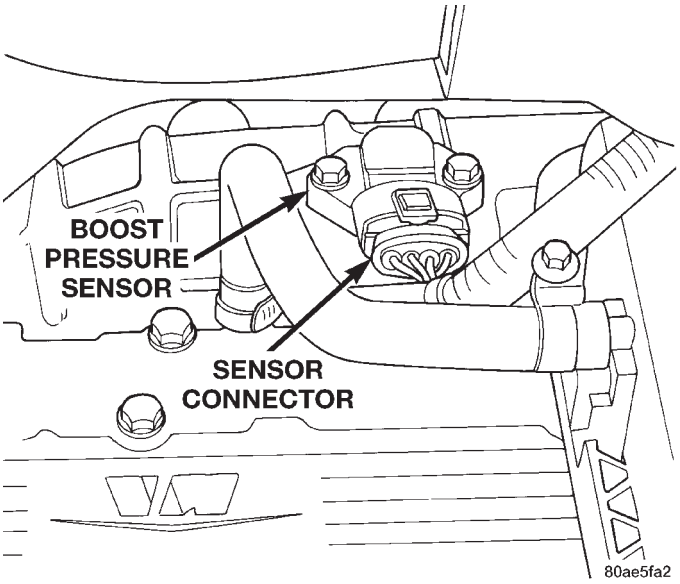

Fig. 2 Boost Pressure Sensor Location

VEHICLE THEFT ALARM

The PCM can learn if the vehicle has a Vehicle Theft Alarm (VTA) system. Once it detects the vehicle having VTA, **the controller can ONLY BE USED ON VEHICLES WITH VTA.**

If the PCM is put it on a vehicle without VTA the Glow Plug Lamp will start to blink and the vehicle will not start.

The PCM cannot be flashed to remove the VTA.

BATTERY VOLTAGE—PCM INPUT

The battery voltage input provides power to the PCM. It also informs the PCM what voltage level is being supplied by the generator once the vehicle is running.

The battery input also provides the voltage that is needed to keep the PCM memory alive. The memory stores Diagnostic Trouble Code (DTC) messages. Trouble codes will still be stored even if the battary voltage is lost.

SENSOR RETURN—PCM INPUT (ANALOG GROUND)

Sensor Return provides a low noise Analog ground reference for all system sensors.

SIGNAL GROUND—PCM INPUT

Signal ground provides a low noise ground to the data link connector.

IGNITION CIRCUIT SENSE—PCM INPUT

The ignition circuit sense input signals the PCM that the ignition (key) switch has been turned to the ON position. This signal initiates the glow plug control routine to begin the “pre–heat” cycle.

START SIGNAL—PCM INPUT

This input tells the PCM that the engine starter is being operated. This in turn will start the glow plug “post–heat” cycle.

POWER GROUND

Provides a common ground for power devices (solenoid and relay devices).

NEEDLE MOVEMENT OR INSTRUMENTED FIRST INJECTOR—PCM INPUT

This input from the PCM supplies a constant 30 mA electrical current source for the first injector sensor. It will vary the voltage to this sensor when it senses a mechanical movement within the injector needle (pintle) of the number–1 cylinder fuel injector. When this voltage has been determined by the PCM, it will then control an output to the fuel timing solenoid (the fuel timing solenoid is located on the fuel injection pump). Also refer to Fuel Injection Pump for additional information.

The first injector sensor is a magnetic (inductive) type.

DESCRIPTION AND OPERATION (Continued)

The first injector sensor is used only on the fuel injector for the number–1 cylinder (Fig. 3). It is not used on the injectors for cylinders number 2, 3, or 4.

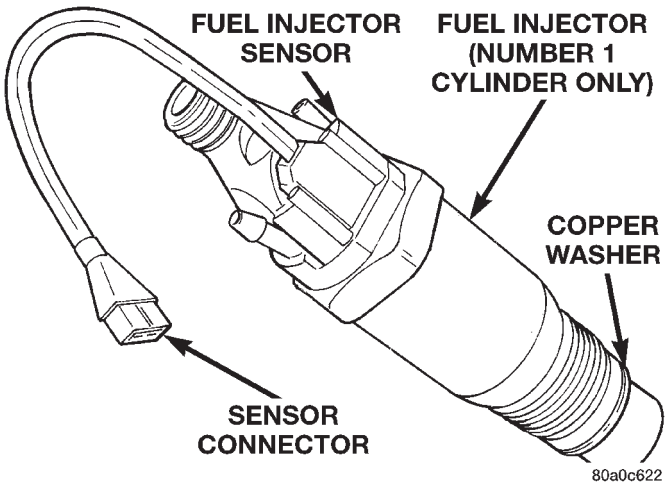

Fig. 3 Fuel Injector Sensor

FUEL INJECTOR SENSOR—GROUND

Provides a low noise ground for the fuel injector sensor only.

ENGINE COOLANT TEMPERATURE SENSOR—PCM INPUT

The 0–5 volt input from this sensor tells the PCM the temperature of the engine coolant. Based on the voltage received at the PCM, it will then determine operation of the fuel timing solenoid, glow plug relay, electrical vacuum modulator (emission component) and generator (charging system).

The sensor is located on the side of the #3 cylinder head near the rear of fuel injection pump (Fig. 4).

ENGINE SPEED SENSOR—PCM INPUT

The engine speed sensor is mounted to the transmission bellhousing at the left/rear side of the engine block (Fig. 5).

The engine speed sensor produces its own output signal. If this signal is not received the engine will not start by the PCM.

The engine speed sensor input is used in conjunction with the first injector sensor to establish fuel injection pump timing.

The flywheel has four notches at its outer edge (Fig. 6). Each notch is spaced equally every 90°. The notches cause a pulse to be generated when they pass under the speed sensor (Fig. 6). These pulses are the input to the PCM. The input from this sensor determines crankshaft position (in degrees) by monitoring the notches.

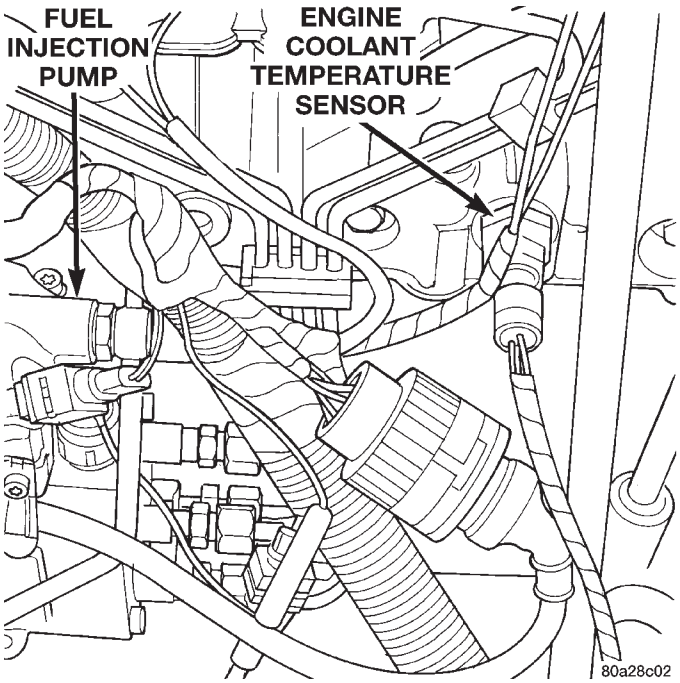

Fig. 4 Engine Coolant Temperature Sensor Location

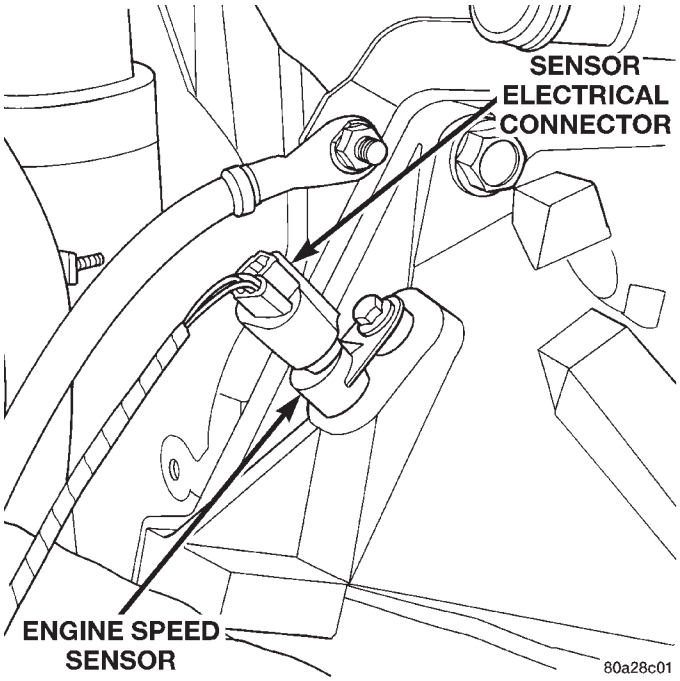

Fig. 5 Engine Speed Sensor Location

The sensor also generates an rpm signal to the PCM. This signal is used as an input for the Diesel relay for control of the generator field, vehicle speed control, and instrument panel mounted tachometer.

If the engine speed sensor should fail, the system is unable to compensate for the problem and the car will stop.

DESCRIPTION AND OPERATION (Continued)

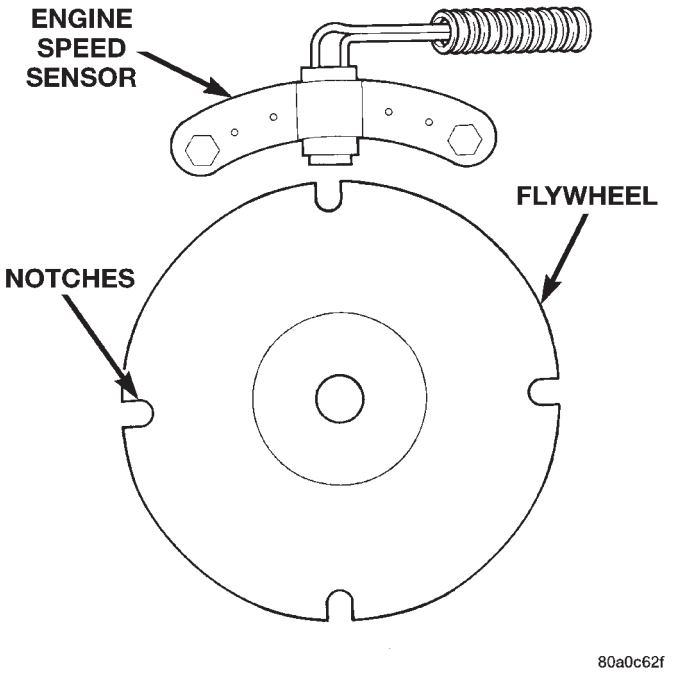

Fig. 6 Speed Sensor Operation

AIR CONDITIONING (A/C) CONTROLS—PCM INPUTS

The A/C control system information applies to factory installed air conditioning units.

A/C REQUEST SIGNAL: When either the A/C or Defrost mode has been selected and the A/C low and high–pressure switches are closed, an input signal is sent to the powertrain control module (PCM). The PCM uses this input to cycle the A/C compressor through the A/C relay.

If the A/C low or high–pressure switch opens, the PCM will not receive an A/C request signal. The PCM will then remove the ground from the A/C relay. This will deactivate the A/C compressor clutch. Also, if the engine coolant reaches a temperature outside normal of its normal range, or it overheats, the PCM will deactivate the A/C clutch.

BRAKE SWITCH—PCM INPUT

When the brake light switch is activated, the PCM receives an input indicating that the brakes are being applied. After receiving this input, the PCM is used to control the speed control system. There is a Primary and a Secondary brake switch. The Secondary brake switch is closed until the brake pedal is pressed.

DATA LINK CONNECTOR—PCM INPUT AND OUTPUT

The 16–way data link connector (diagnostic scan tool connector) links the Diagnostic Readout Box (DRB) scan tool with the PCM. The data link connector is located under the instrument panel near the bottom of steering column (Fig. 7).

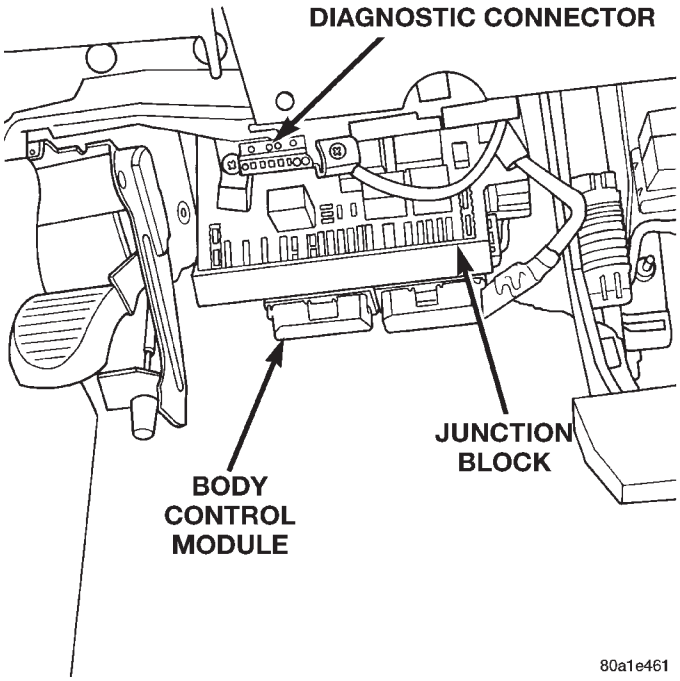

Fig. 7 Data Link Connector Location

VEHICLE SPEED SENSOR—PCM INPUT

The vehicle speed sensor (Fig. 8) is located in the extension housing of the transmission. The sensor input is used by the PCM to determine vehicle speed and distance traveled.

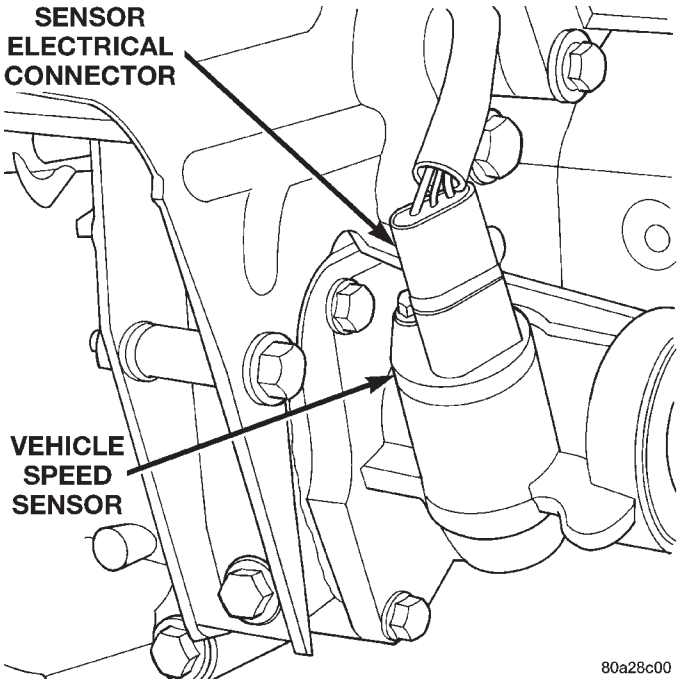

Fig. 8 Vehicle Speed Sensor—Typical

DESCRIPTION AND OPERATION (Continued)

The speed sensor generates 8 pulses per sensor revolution. These signals, in conjunction with a closed throttle signal from the throttle position sensor, indicate a closed throttle deceleration to the PCM. When the vehicle is stopped at idle, a closed throttle signal is received by the PCM (but a speed sensor signal is not received).

In addition to determining distance and vehicle speed, the output from the sensor is used to control speed control operation.

SPEED CONTROL—PCM INPUTS

The speed control system provides five separate inputs to the PCM; On/Off, Set, Resume/Accel, Cancel, and Decel.. The On/Off input informs the PCM that the speed control system has been activated. The Set input informs the PCM that a fixed vehicle speed has been selected. The Resume input indicates to the PCM that the previous fixed speed is requested.

Speed control operation will start at 50 km/h–142 km/h (35–85 mph). The upper range of operation is not restricted by vehicle speed. Inputs that affect speed control operation are vehicle speed sensor and throttle position sensor.

Refer to Group 8H for further speed control information.

DIESEL PCM RELAY—PCM INPUT

A 12 volt signal at this input indicates to the PCM that the Diesel relay has been activated. The Diesel relay is located in the PDC. The PDC is located next to the battery in the engine compartment. For the location of the relay within the PDC, refer to label on PDC cover.

This input is used only to sense that the Diesel relay is energized. If the PCM does not see 12 volts + at this input when the Diesel relay should be activated, it will set a Diagnostic Trouble Code (DTC).

FIVE VOLT POWER—PCM OUTPUT

This circuit supplies approximately 5 volts to power the Accelerator Pedal Postion Sensor, Mass Air Flow Sensor, and A/C Pressure Sensor.

ENGINE COOLANT GAUGE—PCM OUTPUT

Refer to the Instrument Panel and Gauges group for additional information.

ENGINE OIL PRESSURE GAUGE—PCM OUTPUT

Refer to the Instrument Panel and Gauges group for additional information.

GLOW PLUG LAMP—PCM OUTPUT

The Glow Plug lamp (malfunction indicator lamp) illuminates on the message center each time the ignition (key) switch is turned on. It will stay on for about two seconds as a bulb test.

If the PCM receives an incorrect signal, or no signal from certain sensors or components, the lamp BLINKS. This is a warning that the PCM has recorded a system or sensor malfunction. It signals an immediate need for service. There are only 5 HARD faults that can turn on this lamp to make it blink.

Fig. 9 Glow Plug Lamp Symbol

SPEED CONTROL—PCM OUTPUTS

These two circuits control the fuel quantity actuator to regulate vehicle speed. Refer to Group 8H for Speed Control information.

AIR CONDITIONING RELAY—PCM OUTPUT

This circuit controls a ground signal for operation of the A/C clutch relay. Also refer to Air Conditioning (A/C) Controls—PCM Input for additional information.

The A/C relay is located in the Power Distribution Center (PDC). The PDC is located next to the battery in the engine compartment. For the location of the relay within the PDC, refer to label on PDC cover.

FUEL TIMING SOLENOID—PCM OUTPUT

The fuel timing solenoid is located on the bottom of the fuel injection pump (Fig. 10).

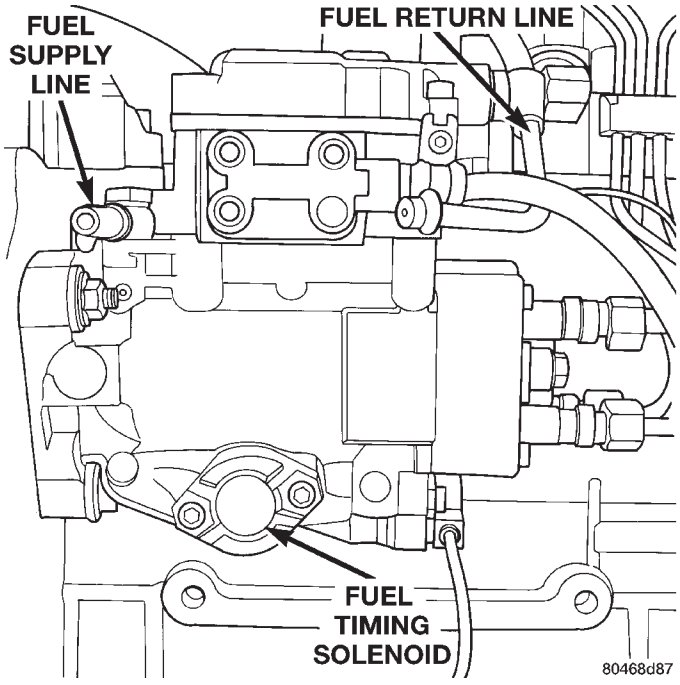

Fig. 10 Fuel Timing Solenoid

This 12+ volt, pulse width modulated (duty–cycle) output controls the amount of fuel timing (advance) in the fuel injection pump. The higher the duty-

DESCRIPTION AND OPERATION (Continued)

–cycle, the lower the advance. The lower the duty–cycle, the more advanced the fuel timing.

The duty–cycle is determined by the PCM from inputs it receives from the fuel injector sensor and engine speed sensor.

TACHOMETER—PCM OUTPUT

The PCM supplies engine rpm values to the Body Controller that then supplies the instrument cluster mounted tachometer (if equipped). Refer to Group 8E for tachometer information.

GLOW PLUG RELAY—PCM OUTPUT

The glow plug relay is located in the engine compartment on the left–inner fender (Fig. 11).

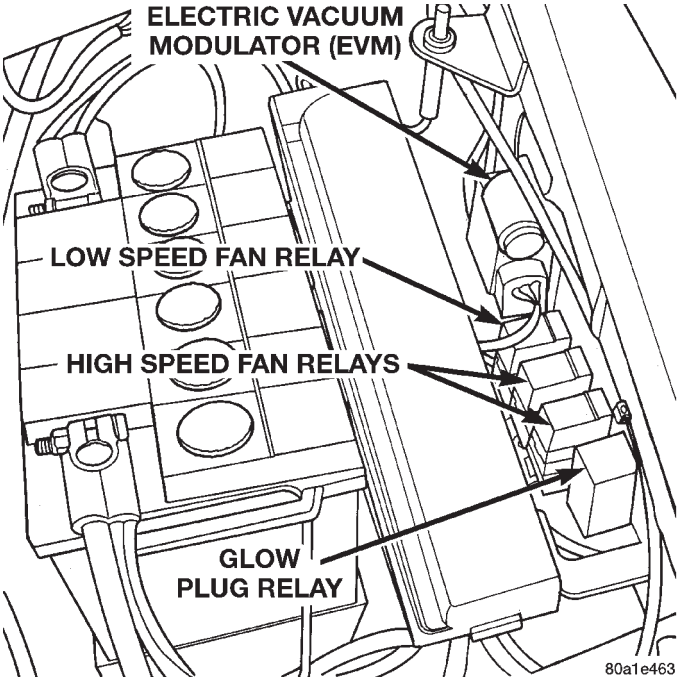

Fig. 11 Glow Plug Relay Location

When the ignition (key) switch is placed in the ON position, a signal is sent to the PCM relating current engine coolant temperature. This signal is sent from the engine coolant temperature sensor.

After receiving this signal, the PCM will determine if, when and for how long a period the glow plug relay should be activated. This is done before, during and after the engine is started. Whenever the glow plug relay is activated, it will control the 12V+ 100 amp circuit for the operation of the four glow plugs.

The Glow Plug lamp is tied to this circuit. Lamp operation is also controlled by the PCM.

With a cold engine, the glow plug relay and glow plugs may be activated for a maximum time of 200 seconds. Refer to the following Glow Plug Control chart for a temperature/time comparison of glow plug relay operation.

In this chart, Pre–Heat and Post–Heat times are mentioned. Pre–heat is the amount of time the glow plug relay circuit is activated when the ignition (key) switch is ON, but the engine has yet to be started. Post–heat is the amount of time the glow plug relay circuit is activated after the engine is operating. The Glow Plug lamp will not be illuminated during the post–heat cycle.

GLOW PLUG CONTROL

ENGINE COOLANT TEMPERATURE KEY ON	WAIT-TO-START LAMP ON (SECONDS)	PRE-HEAT CYCLE (GLOW PLUGS ON) (SECONDS)	POST-HEAT CYCLE (SECONDS)
-30 C	15 SEC.	45 SEC.	200 SEC.
-10 C	8 SEC.	35 SEC.	180 SEC.
+10 C	6 SEC.	25 SEC.	118 SEC.
+30 C	5 SEC.	20 SEC.	70 SEC.
+40 C	4 SEC.	16 SEC.	60 SEC.
+70 C	3 SEC.	16 SEC.	20 SEC.

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GLOW PLUGS

Glow plugs are used to help start a cold or cool engine. The plug will heat up and glow to heat the combustion chamber of each cylinder. An individual plug is used for each cylinder. Each plug is threaded into the cylinder head above the fuel injector (Fig. 12).

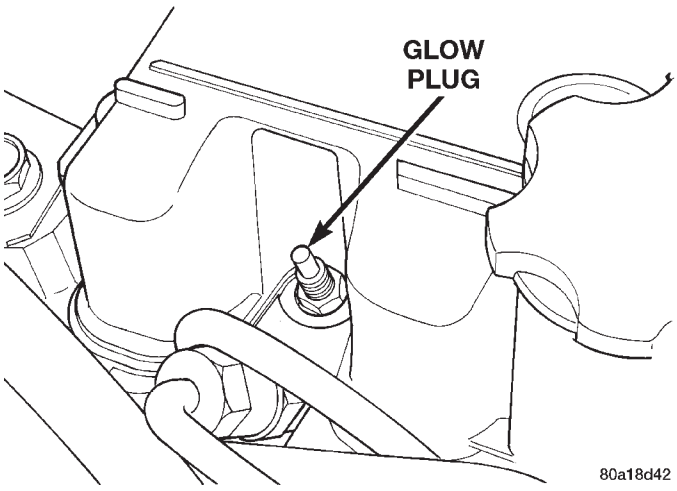

Fig. 12 Glow Plug

Each plug will momentarily draw approximately 25 amps of electrical current during the initial key–on cycle. This is on a cold or cool engine. After heating,

DESCRIPTION AND OPERATION (Continued)

the current draw will drop to approximately 9–12 amps per plug.

Total momentary current draw for all four plugs is approximately 100 amps on a cold engine dropping to a total of approximately 40 amps after the plugs are heated.

Electrical operation of the glow plugs are controlled by the glow plug relay. Refer to the previous Glow Plug Relay—PCM Output for additional information.

EXHAUST GAS RECIRCULATION (EGR) SOLENOID—PCM OUTPUT

This circuit controls operation of the Exhaust Gas Recirculation (EGR) solenoid. The EGR solenoid (Fig. 11) controls operation of the EGR valve.

Refer to Group 25, Emission Control System for information. See EGR solenoid.

DIAGNOSIS AND TESTING

DIESEL DIAGONSTICS

The PCM controller does engine off diagonstics tests, which may be heard for about 60 seconds after turning the key off.

DIESEL PCM RELAY TEST

To perform a test of the relay and its related circuitry, refer to the DRB scan tool. To test the relay only, refer to Relays—Operation/Testing in this section of the group.

Diagnostic Trouble Codes: Refer to On-Board Diagnostics in Group 25, Emission Control System for a list of Diagnostic Trouble Codes (DTC's) for certain fuel system components.

ENGINE SPEED SENSOR TEST

To perform a test of the engine speed sensor and its related circuitry, refer to the DRB scan tool.

Diagnostic Trouble Codes: Refer to On-Board Diagnostics in Group 25, Emission Control System for a list of Diagnostic Trouble Codes (DTC's) for certain fuel system components.

ENGINE COOLANT TEMPERATURE SENSOR TEST

The sensor is located on the side of cylinder head near the rear of fuel injection pump (Fig. 13).

For a list of Diagnostic Trouble Codes (DTC's) for certain fuel system components, refer to On-Board Diagnostics in Group 25, Emission Control System. To test the sensor only, refer to the following:

(1) Disconnect wire harness connector from coolant temperature sensor.

(2) Test the resistance of the sensor with a high input impedance (digital) volt–ohmmeter. The resistance (as measured across the sensor terminals) should be less than 1340 ohms with the engine warm. Refer to the following Sensor Resistance (OHMS) chart. Replace the sensor if it is not within the range of resistance specified in the chart.

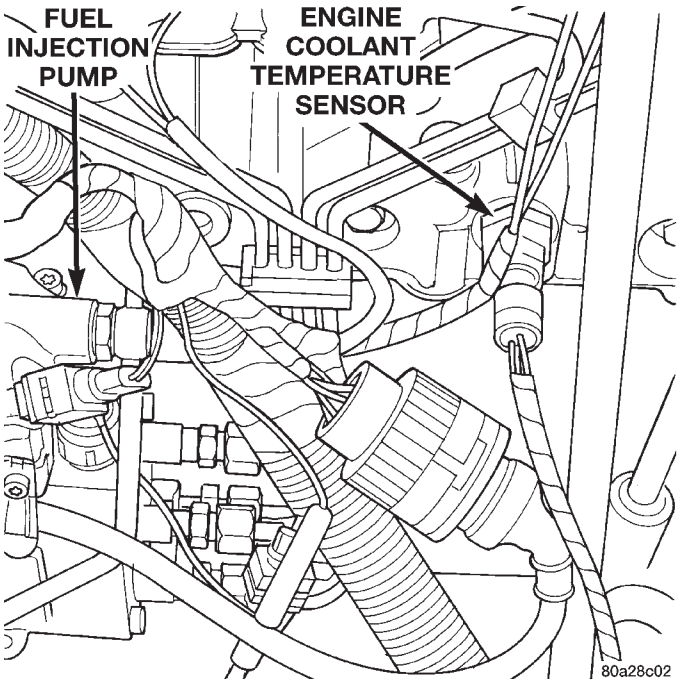

Fig. 13 Engine Coolant Temperature Sensor Location

SENSOR RESISTANCE (OHMS)

TEMPERATURE		RESISTANCE (OHMS)	
C	F	MIN	MAX
−40	−40	291,490	381,710
−20	−4	85,850	108,390
−10	14	49,250	61,430
0	32	29,330	35,990
10	50	17,990	21,810
20	68	11,370	13,610
25	77	9,120	10,880
30	86	7,370	8,750
40	104	4,900	5,750
50	122	3,330	3,880
60	140	2,310	2,670
70	158	1,630	1,870
80	176	1,170	1,340
90	194	860	970
100	212	640	720
110	230	480	540
120	248	370	410

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(3) Test continuity of the wire harness. Do this between the PCM wire harness connector and the sensor connector terminal. Also test continuity of wire harness to the sensor connector terminal. Refer

DIAGNOSIS AND TESTING (Continued)

to Group 8W for wiring connector and circuitry information. Repair the wire harness if an open circuit is indicated.

(4) After tests are completed, connect electrical connector to sensor.

GLOW PLUG TEST

Hard starting or a rough idle after starting may be caused by one or more defective glow plugs. Before testing the glow plugs, a test of the glow plug relay should be performed. This will ensure that 12V+ is available at the plugs when starting the engine. Refer to the Glow Plug Relay Test for information.

For accurate test results, the glow plugs should be removed from the engine. The plugs must be checked when cold. **Do not check the plugs if the engine has recently been operated. If plugs are checked when warm, incorrect amp gauge readings will result.**

Use Churchill Glow Plug Tester DX.900 or an equivalent (Fig. 14) for the following tests. This tester is equipped with 4 timer lamps.

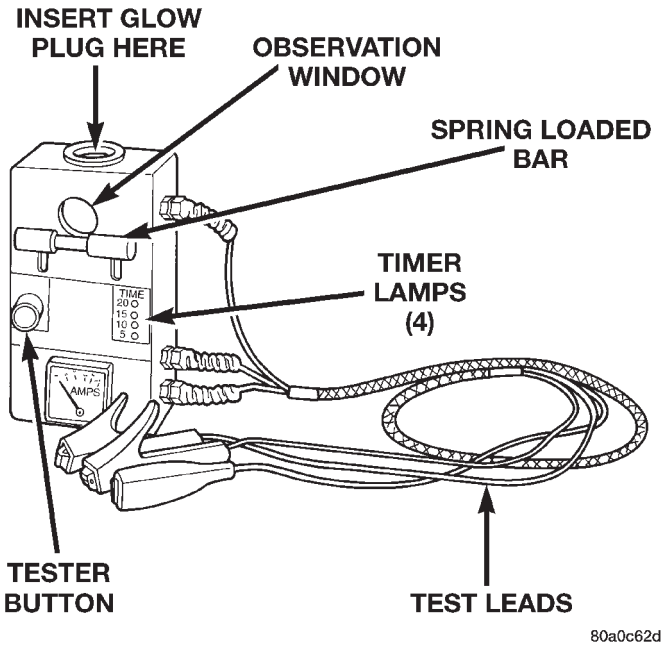

Fig. 14 Typical Glow Plug Tester

(1) Remove the glow plugs from the engine. Refer to Glow Plug Removal/Installation.

(2) Attach the red lead of the tester to the 12V+ (positive) side of the battery.

(3) Attach the black lead of the tester to the 12V– (negative) side of the battery.

(4) Fit the glow plug into the top of the tester and secure it with the spring loaded bar (Fig. 14).

(5) Attach the third lead wire of the tester to the electrical terminal at the end of the glow plug.

(6) When performing the test, the tester button (Fig. 14) should be held continuously without release for 20 seconds as indicated by the 4 timer lamps. Each illuminated lamp represents a 5 second time lapse.

(a) Press and hold the tester button (Fig. 14) and note the amp gauge reading. The gauge reading should indicate a momentary, initial current draw (surge) of approximately 25 amps. After the initial surge, the amp gauge reading should begin to fall off. The glow plug tip should start to glow an orange color after 5 seconds. If the tip did not glow after 5 seconds, replace the glow plug. Before discarding the glow plug, check the position of the circuit breaker on the bottom of the plug tester. It may have to be reset. Reset if necessary.

(b) Continue to hold the tester button while observing the amp gauge and the 4 timer lamps. When all 4 lamps are illuminated, indicating a 20 second time lapse, the amp gauge reading should indicate a 9–12 amp current draw. If not, replace the glow plug. Refer to Glow Plug Removal/Installation.

(7) Check each glow plug in this manner using one 20 second cycle. If the glow plug is to be retested, it must first be allowed to cool to room temperature.

WARNING: THE GLOW PLUG WILL BECOME EXTREMELY HOT (GLOWING) DURING THESE TESTS. BURNS COULD RESULT IF IMPROPERLY HANDLED. ALLOW THE GLOW PLUG TO COOL BEFORE REMOVING FROM TESTER.

(8) Remove the glow plug from the tester.

GLOW PLUG RELAY TEST

The glow plug relay is located in the engine compartment on the left–inner fender (Fig. 15).

When the ignition (key) switch is placed in the ON position, a signal is sent to the PCM relating current engine coolant temperature. This signal is sent from the engine coolant temperature sensor.

After receiving this signal, the PCM will determine if, when and for how long a period the glow plug relay should be activated. This is done before, during and after the engine is started. Whenever the glow plug relay is activated, it will control the 12V+ 100 amp circuit for the operation of the four glow plugs.

The Glow Plug lamp is tied to this circuit. Lamp operation is also controlled by the PCM.

With a cold engine, the glow plug relay and glow plugs may be activated for a maximum time of 200 seconds. Refer to the Glow Plug Control chart for a temperature/time comparison of glow plug relay operation.

DIAGNOSIS AND TESTING (Continued)

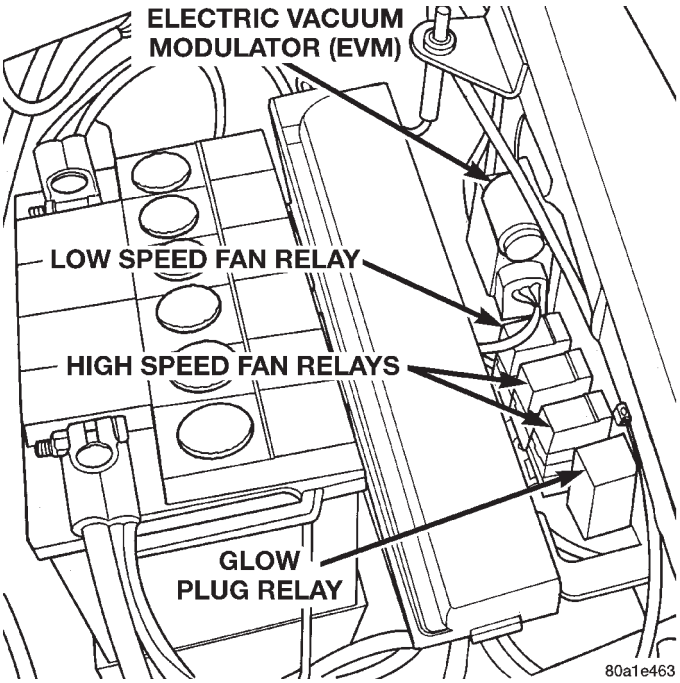

Fig. 15 Glow Plug Relay Location

In this chart, Pre–Heat and Post–Heat times are mentioned. Pre–heat is the amount of time the glow plug relay circuit is activated when the ignition (key) switch is ON, but the engine has yet to be started. Post–heat is the amount of time the glow plug relay circuit is activated after the engine is operating. The Glow Plug lamp will not be illuminated during the post–heat cycle.

TESTING:

Disconnect and isolate the electrical connectors (Fig. 16) at all four glow plugs. With the engine cool or cold, and the key in the ON position, check for 10–12 volts + at each electrical connector. 10–12 volts + should be at each connector whenever the PCM is operating in the pre–heat or post–heat cycles (refer to the following Glow Plug Control chart). **Be very careful not to allow any of the four disconnected glow plug electrical connectors to contact a metal surface. When the key is turned to the ON position, approximately 100 amps at 12 volts is supplied to these connectors.** If 10–12 volts + is not available at each connector, check continuity of wiring harness directly to the relay. If continuity is good directly to the relay, the fault is either with the relay or the relay input from the PCM. To test the relay only, refer to Relays—Operation/Testing in this section of the group. If the relay test is good, refer to the DRB scan tool.

Diagnostic Trouble Codes: Refer to On-Board Diagnostics in Group 25, Emission Control System for a list of Diagnostic Trouble Codes (DTC's) for certain fuel system components.

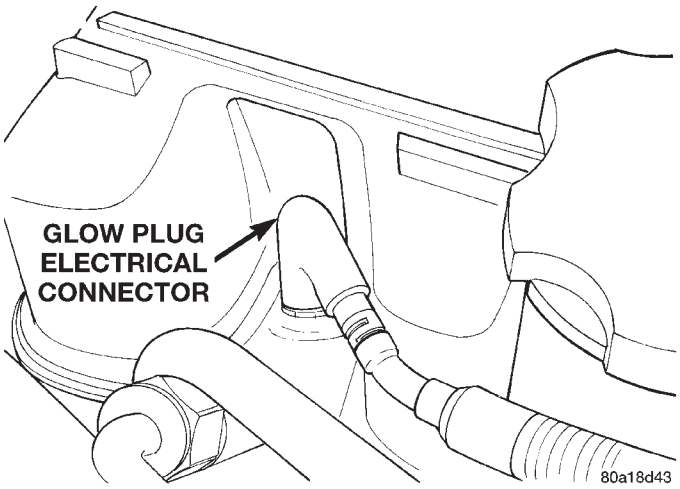

Fig. 16 Wiring Connection at Glow Plug

GLOW PLUG CONTROL

ENGINE COOLANT TEMPERATURE KEY ON	WAIT-TO-START LAMP ON (SECONDS)	PRE-HEAT CYCLE (GLOW PLUGS ON) (SECONDS)	POST-HEAT CYCLE (SECONDS)
-30 C	15 SEC.	45 SEC.	200 SEC.
-10 C	8 SEC.	35 SEC.	180 SEC.
+10 C	6 SEC.	25 SEC.	118 SEC.
+30 C	5 SEC.	20 SEC.	70 SEC.
+40 C	4 SEC.	16 SEC.	60 SEC.
+70 C	3 SEC.	16 SEC.	20 SEC.

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RELAYS—OPERATION/TESTING

The following description of operation and tests apply only to the Diesel PCM and other relays. The terminals on the bottom of each relay are numbered (Fig. 17).

OPERATION

- Terminal number 30 is connected to battery voltage. For both the Diesel and other relays, terminal 30 is connected to battery voltage at all times.
- The PCM grounds the coil side of the relay through terminal number 85.
- Terminal number 86 supplies voltage to the coil side of the relay.
- When the PCM de-energizes the Diesel PCM and other relays, terminal number 87A connects to terminal 30. This is the Off position. In the off position, voltage is not supplied to the rest of the circuit. Terminal 87A is the center terminal on the relay.

DIAGNOSIS AND TESTING (Continued)

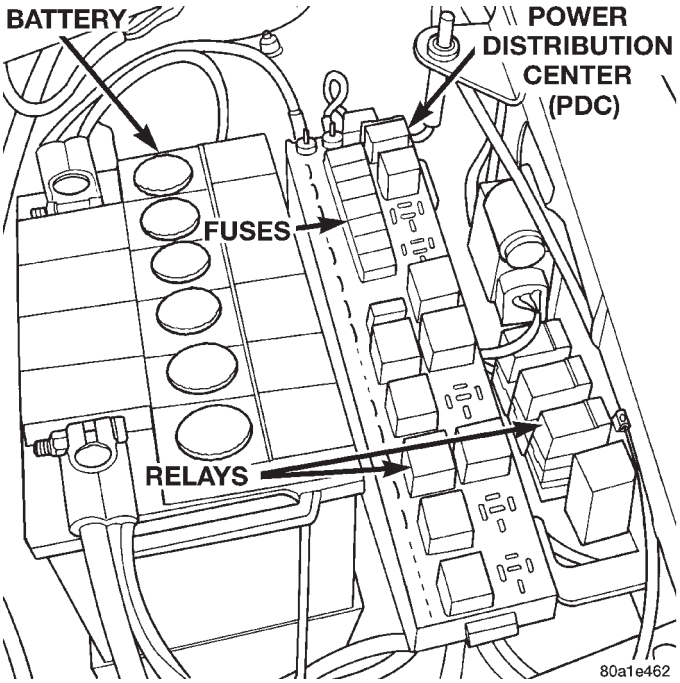

Fig. 17 Diesel PCM and Other Relay Terminals

• When the PCM energizes the Diesel PCM and other relays, terminal 87 connects to terminal 30. This is the On position. Terminal 87 supplies voltage to the rest of the circuit.

TESTING

The following procedure applies to the Diesel PCM and other relays.

(1) Remove relay from connector before testing.

(2) With the relay removed from the vehicle, use an ohmmeter to check the resistance between terminals 85 and 86. The resistance should be between 75 ±5 ohms.

(3) Connect the ohmmeter between terminals 30 and 87A. The ohmmeter should show continuity between terminals 30 and 87A.

(4) Connect the ohmmeter between terminals 87 and 30. The ohmmeter should not show continuity at this time.

(5) Connect one end of a jumper wire (16 gauge or smaller) to relay terminal 85. Connect the other end of the jumper wire to the ground side of a 12 volt power source.

(6) Connect one end of another jumper wire (16 gauge or smaller) to the power side of the 12 volt power source. **Do not attach the other end of the jumper wire to the relay at this time.**

WARNING: DO NOT ALLOW OHMMETER TO CONTACT TERMINALS 85 OR 86 DURING THIS TEST.

(7) Attach the other end of the jumper wire to relay terminal 86. This activates the relay. The ohmmeter should now show continuity between relay terminals 87 and 30. The ohmmeter should not show continuity between relay terminals 87A and 30.

(8) Disconnect jumper wires.

(9) Replace the relay if it did not pass the continuity and resistance tests. If the relay passed the tests, it operates properly. Check the remainder of the Diesel PCM and other relay circuits. Refer to group 8W, Wiring Diagrams.

BOOST PRESSURE SENSOR

If the boost pressure sensor fails, the PCM records a DTC into memory and continues to operate the engine in one of the three “limp-in” modes. When the PCM is operating in this mode, a loss of power will be present, as if the turbocharger was not operating. The best method for diagnosing faults with the boost pressure sensor is with the DRB III scan tool.

Diagnostic Trouble Codes: Refer to On-Board Diagnostics in Group 25, Emission Control System for a list of Diagnostic Trouble Codes (DTC’s) for certain fuel system components.

VEHICLE SPEED SENSOR TEST

To perform a test of the sensor and its related circuitry, refer to DRB scan tool.

Diagnostic Trouble Codes: Refer to On-Board Diagnostics in Group 25, Emission Control System for a list of Diagnostic Trouble Codes (DTC’s) for certain fuel system components.

DIAGNOSTIC TROUBLE CODES

For a list of Diagnostic Trouble Codes (DTC’s), refer to Group 25, Emission Control System for information. See On-Board Diagnostics.

REMOVAL AND INSTALLATION

DIESEL PCM RELAY

The Diesel PCM relay is located in the PDC. For the location of the relay within the PDC, refer to label on PDC cover.

A/C CLUTCH RELAY

The A/C clutch relay is located in the PDC. For the location of the relay within the PDC, refer to label on PDC cover.

ENGINE SPEED SENSOR

The engine speed sensor is mounted to the transmission bellhousing at the rear of the engine block (Fig. 18).

REMOVAL

(1) Disconnect the harness (on the sensor) from the main electrical harness.

REMOVAL AND INSTALLATION (Continued)

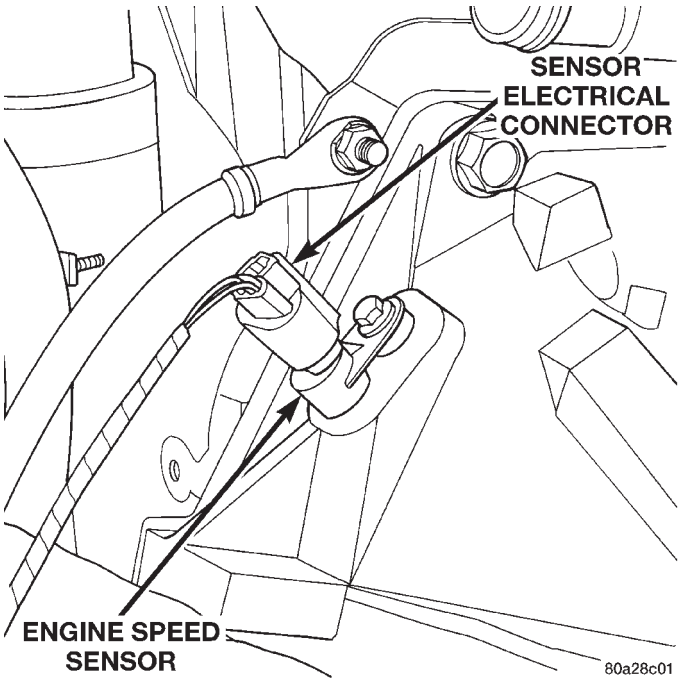

Fig. 18 Engine Speed Sensor

(2) Remove the sensor mounting bolts.
(3) Remove the sensor.

INSTALLATION

(1) Install the sensor flush against the opening in the transmission housing.
(2) Install and tighten the sensor mounting bolt to 19 N·m (14 ft. lbs.) torque.
(3) Connect the electrical connector to the sensor.

ENGINE COOLANT TEMPERATURE SENSOR

The sensor is located on the side of cylinder head near the rear of fuel injection pump (Fig. 19).

REMOVAL

WARNING: HOT, PRESSURIZED COOLANT CAN CAUSE INJURY BY SCALDING. COOLING SYSTEM MUST BE PARTIALLY DRAINED BEFORE REMOVING THE COOLANT TEMPERATURE SENSOR. REFER TO GROUP 7, COOLING.

(1) Partially drain cooling system. Refer to Group 7, Cooling.
(2) Disconnect electrical connector from sensor.
(3) Remove sensor from cylinder head.

INSTALLATION

(1) Install a new copper gasket to sensor.
(2) Install sensor to cylinder head.
(3) Tighten sensor to 18 N·m (13 ft. lbs.) torque.
(4) Connect electrical connector to sensor.
(5) Replace any lost engine coolant. Refer to Group 7, Cooling System.

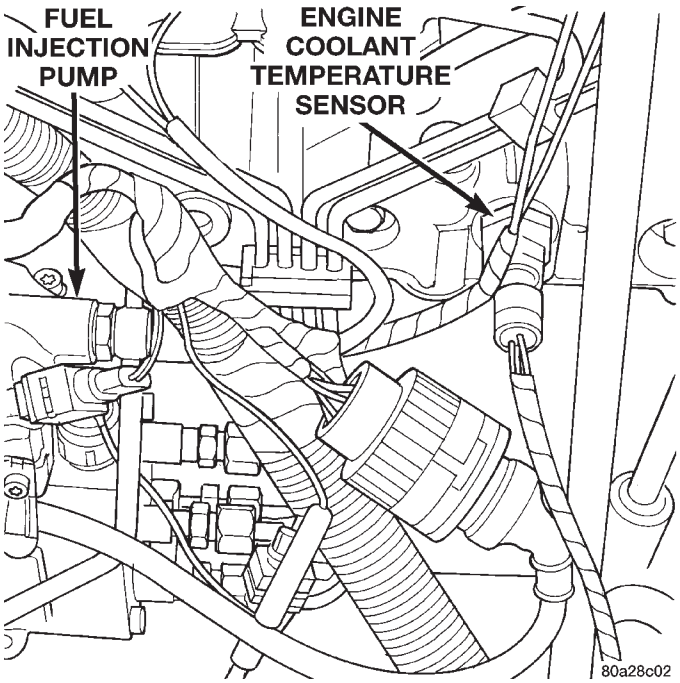

Fig. 19 Engine Coolant Temperature Sensor Location

GLOW PLUGS

The glow plugs are located above each fuel injector (Fig. 20). Four individual plugs are used.

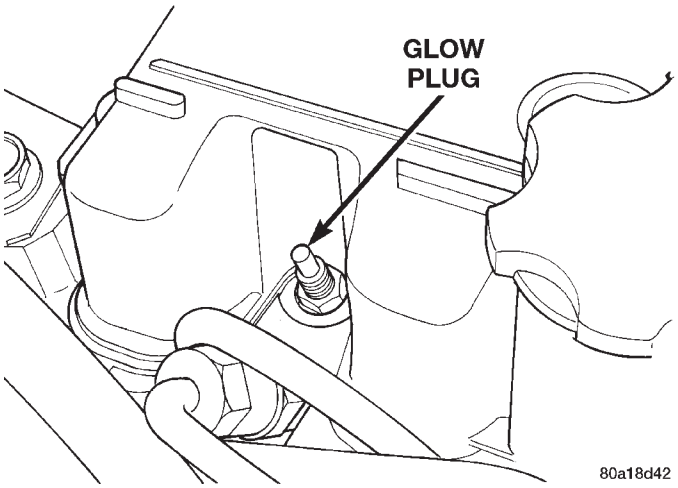

Fig. 20 Glow Plug

REMOVAL

(1) Disconnect the negative battery cable at the battery.
(2) Clean the area around the glow plug with compressed air before removal.
(3) Disconnect electrical connector (Fig. 21) at glow plug.
(4) Remove the glow plug (Fig. 20) from cylinder head.

REMOVAL AND INSTALLATION (Continued)

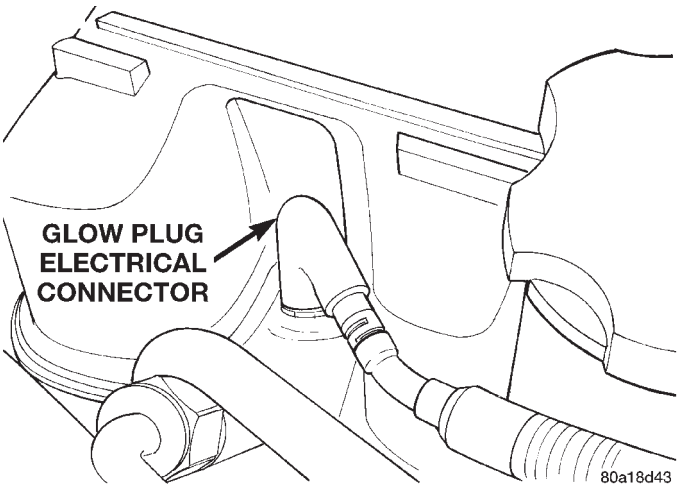

Fig. 21 Glow Plug Electrical Connector

INSTALLATION

(1) Apply high–temperature anti–seize compound to glow plug threads before installation

(2) Install the glow plug into the cylinder head. Tighten to 23 N·m (203 in. lbs.) torque.

(3) Connect battery cable to battery.

GLOW PLUG RELAY

The glow plug relay is located in the engine compartment on the left–inner fender (Fig. 22).

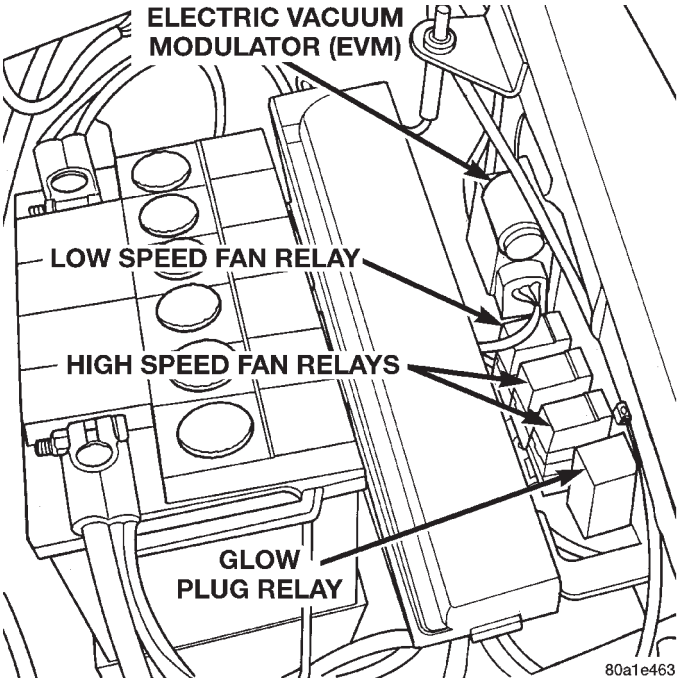

Fig. 22 Glow Plug Relay Location

REMOVAL

(1) Disconnect the negative battery cable at the battery.

(2) Remove relay mounting bolt.

(3) Disconnect electrical connector at relay and remove relay.

INSTALLATION

(1) Check condition of electrical connector for damage or corrosion. Repair as necessary.

(2) Install electrical connector to relay.

(3) Install relay to inner fender.

(4) Connect battery cable to battery.

POWERTRAIN CONTROL MODULE (PCM)

The PCM is mounted to a bracket located in the center consule in front of the air bag module (Fig. 23).

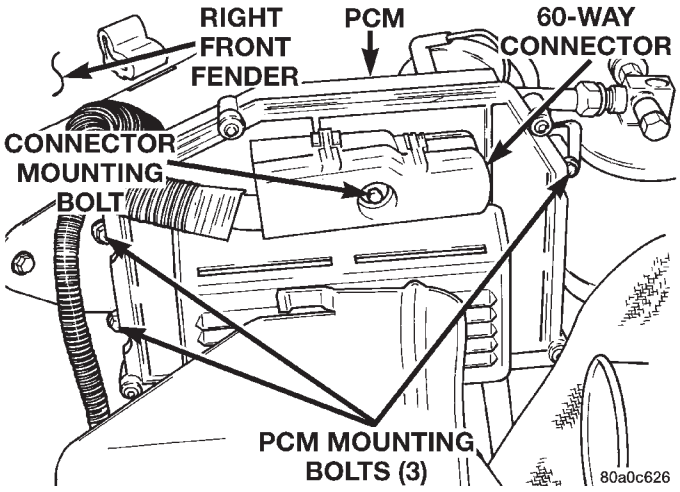

Fig. 23 PCM Location

REMOVAL

(1) Disconnect the negative battery cable at the battery.

(2) Loosen the 68–Way connector (Fig. 23). The electrical connector has a sliding bar which moves inward to lock or outward to unlock.

(3) Remove the electrical connector by pulling straight out.

(4) Remove PCM.

INSTALLATION

(1) After the PCM electrical connector has been separated from the PCM, inspect the pins for corrosion, being spread apart, bent or misaligned. Also inspect the pin heights in the connector. If the pin heights are different, this would indicate a pin has separated from the connector. Repair as necessary.

(2) Engage 68–way connector into PCM. Move slide bar to lock connector.

(3) Connect negative cable to battery.

VEHICLE SPEED SENSOR

The vehicle speed sensor (Fig. 24) is located on the extension housing of the transmission.

REMOVAL AND INSTALLATION (Continued)

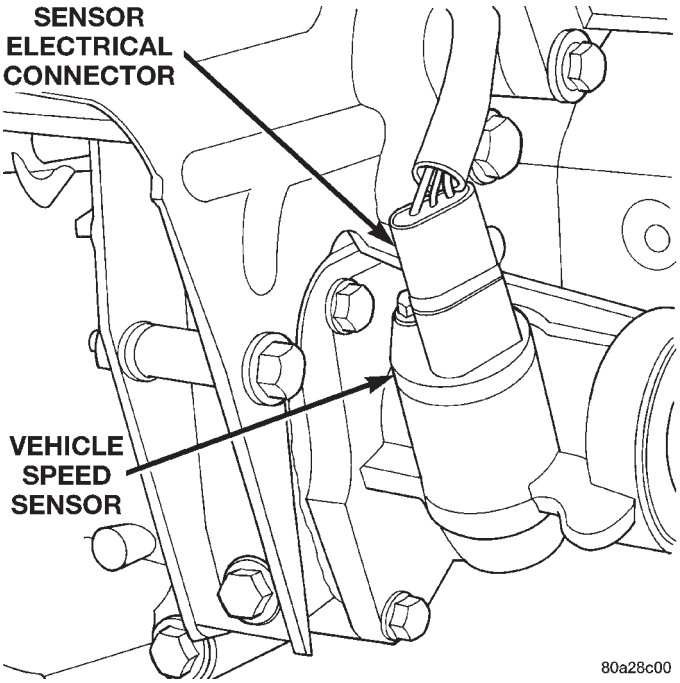

Fig. 24 Vehicle Speed Sensor Location—Typical

REMOVAL

(1) Raise and support vehicle.

(2) Clean the area around the sensor before removal.

(3) Disconnect the electrical connector from the sensor (Fig. 25).

(4) Remove the sensor mounting bolt (Fig. 25).

(5) Pull the sensor from the speedometer pinion gear adapter for removal.

INSTALLATION

(1) Install new sensor into speedometer gear adapter.

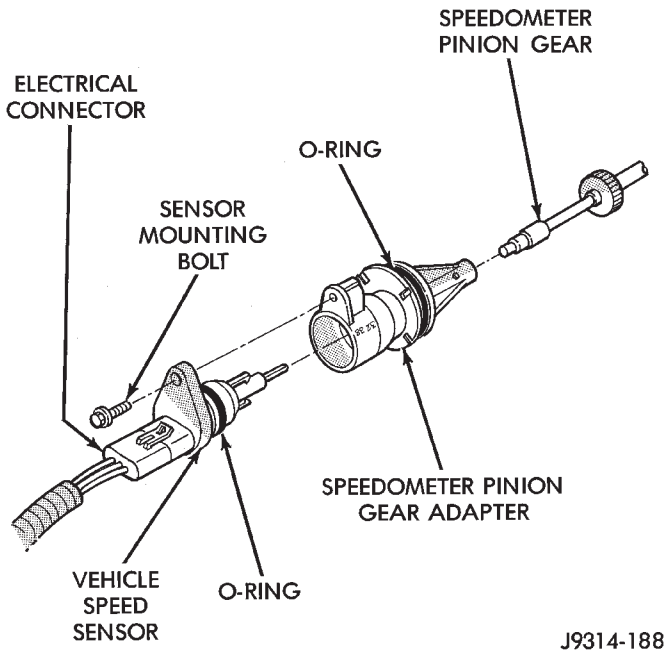

Fig. 25 Sensor Removal/Installation—Typical

(2) Tighten sensor mounting bolt. To prevent damage to sensor or speedometer adapter, be sure the sensor is mounted flush to the adapter before tightening.

(3) Connect electrical connector to sensor.

SPECIFICATIONS

GLOW PLUG CURRENT DRAW

Initial Current Draw: Approximately 22–25 amps per plug.

After 20 seconds of operation: Approximately 9–12 amps per plug.

SPECIFICATIONS (Continued)

TORQUE CHART—2.5L DIESEL

DESCRIPTION	TORQUE
Accelerator Pedal Bracket Mounting Nuts	5 N•m (46 in. lbs.)
Banjo-Type Fittings	19 N•m (14 ft. lbs.)
Engine Coolant Temperature Sensor	18 N•m (13 ft. lbs.)
Engine Speed Sensor Bolts	19 N•m (14 ft. lbs.)
Fuel Hose (Tube) Clamps For Rubber Hose	2 N•m (20 in. lbs.)
Fuel Injector	70 N•m (52 ft. lbs.)
Fuel Injector Line At Injector	30 N•m (22 ft. lbs.)
Fuel Injector Line At Injector Pump	30 N•m (22 ft. lbs.)

DESCRIPTION	TORQUE
Fuel Injection Pump Mounting Nuts	30 N•m (22 ft. lbs.)
Fuel Injection Pump Drive Gear	88 N•m (65 ft. lbs.)
Fuel Line Clamp Bracket Bolts	24 N•m (18 ft. lbs.)
Fuel Tank Nuts	11 N•m (100 in. lbs.)
Glow Plugs	23 N•m (203 in. lbs.)
Powertrain Control Module Mounting Bolts	1 N•m (9 in. lbs.)
Throttle Position Sensor Mounting Bolts	7 N•m (60 in. lbs.)
Vehicle Speed Sensor Mounting Bolt	3 N•m (26 in. lbs.)

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